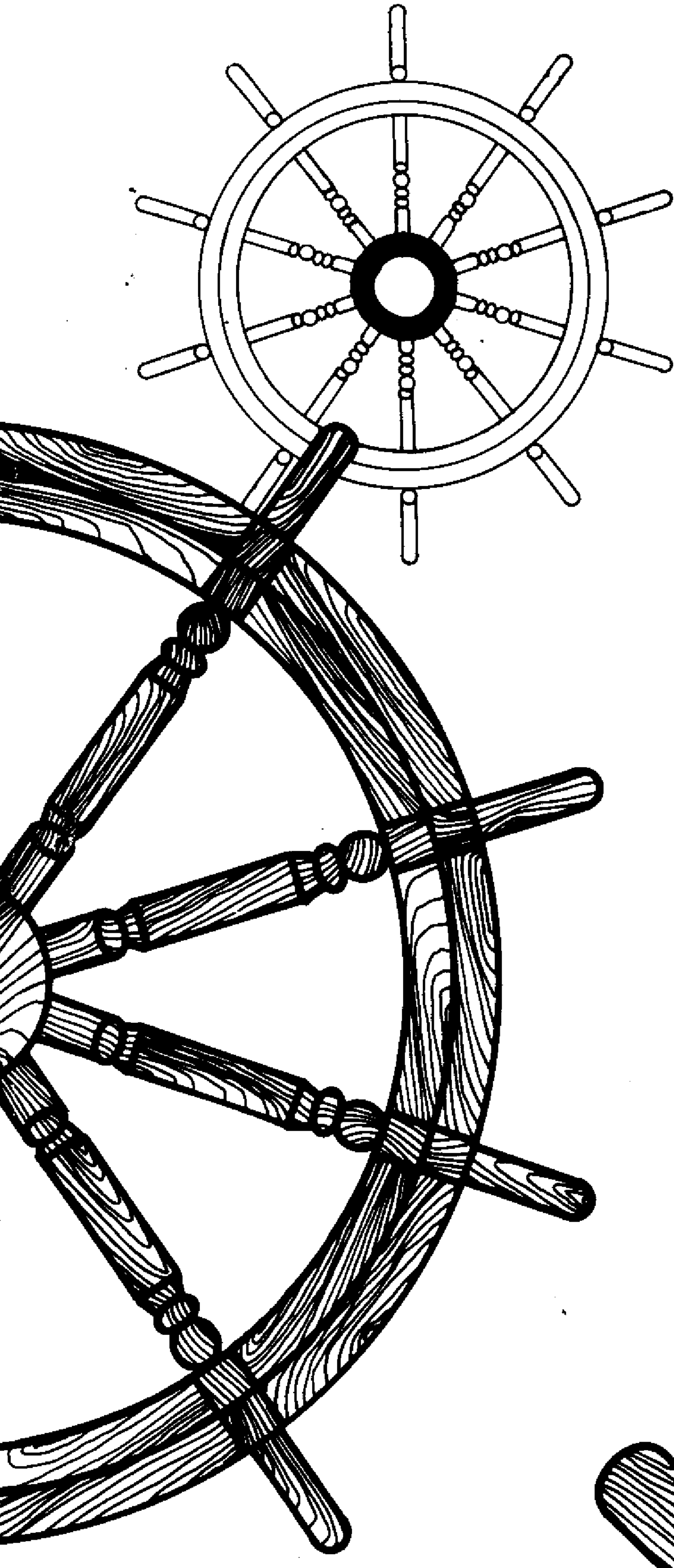
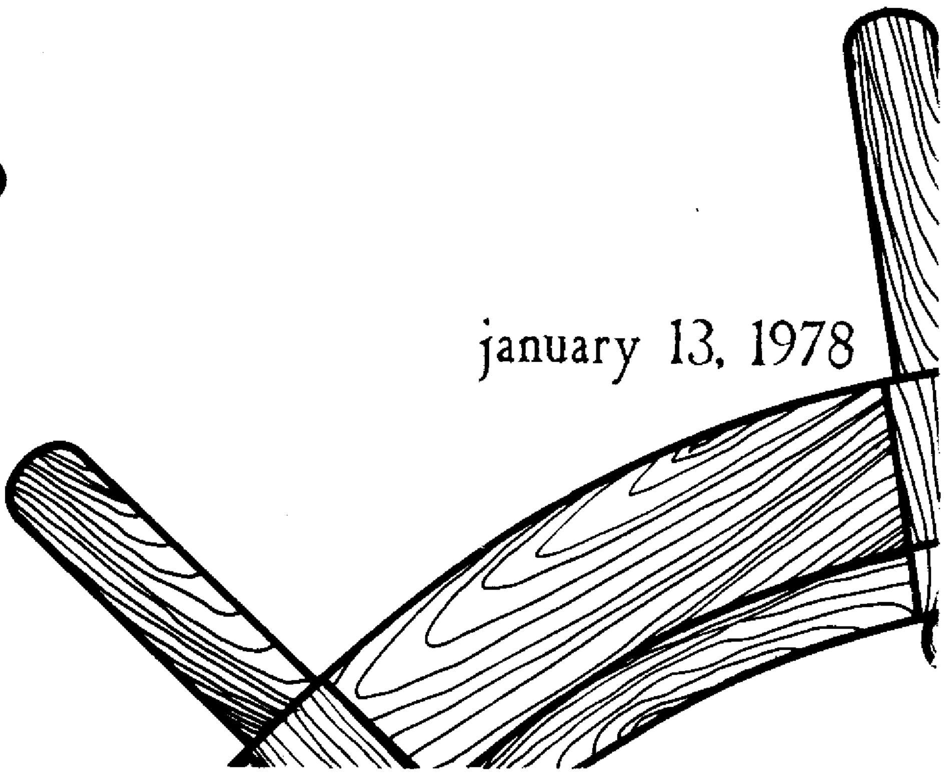


proceedings of the third annual

student symposium on marine affairs

january 13, 1978



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PROCEEDINGS OF THE

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ON MARINE AFFAIRS

Sea Grant Miscellaneous Report
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PREFACE

This volume of the proceedings of the Third Annual Student Symposium on Marine Affairs, which will be held on January 13, 1978, at the University of Hawaii Manoa campus, contains thirty-two papers in eight categories: coastal zone management--use and misuse, marine resources--precious corals and pearls, prawn aquaculture, alternative marine energy sources, ocean engineering--engineered systems, recreational facilities, marine biology, and options in aquaculture.

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

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

Rose Pfund, Coordinator
Student Symposium on Marine Affairs

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COASTAL ZONE MANAGEMENT: USE & MISUSE

COASTAL ZONE MANAGEMENT: KANEOHE BAY

by Vicki M. Shigekane, University Laboratory School

INTRODUCTION

At the turn of the century, scientists and naturalists referred to Kaneohe Bay as the "Coral Gardens", because of the beautiful and fascinating corals that flourished in the bay. Then, it was considered one of the finest estuaries in Hawaii. It supported a wide and rich variety of marine and plant life. It was also extensively used for recreational purposes, such as swimming, diving, fishing, etc.

Today, due to man-made and natural effluents, Kaneohe Bay is anything but a flourishing garden. It is a dying garden, and if badly needed action isn't taken soon, the bay will soon be dead.

By the compiling of information obtained from newspaper articles, published reports, and films, I will discuss the problems of the bay and analize the effect of the present modifications on the situation, and whether or not it is enough of an improvement.

RESULTS OF RESEARCH

Over the past several years, the coral growth rate in Kaneohe Bay has been in a rapid decline. This decline in growth is the result of many contributing factors, the main ones being: 1) Poorly treated sewage effluent from two main out falls, and 2) excessive soil runoff. The following is an explanation of why those factors are so harmful to the ecosystem of the bay.

The first problem of sewage is attributed to the fact that the treatment of raw sewage at both the Kaneohe municipal sewage treatment plant and the Marine Corps Air Station plant are quite inefficient. The 3.5 million gallons of sewage that enters the bay daily[1] is either given primary treatment, in which the large particles are removed from the sewage, or secondary treatment, in which the remaining sewage is further decomposed.

These methods of treatment do not decompose phosphorous and nitrogen compounds in raw sewage, so consequently the levels of these compounds in the water are too high. The amounts of phosphorous and nitrogen dumped into the bay exceed State water quality standards. Nitrogen alone exceeds the standards by as much as ten times the maximum. In the year 1970, phosphorous levels near the outfall of the municipal sewage treatment in Kaneohe were more than twice the level in 1966.[2]

Nitrogen and phosphates are harmful to corals because they serve as nutrients for algae, especially a species of algae called "green bubble algae" (Dictyosphaeria cavernosa). In closed waters such as Kaneohe Bay, over-abundance of food, as provided by the nitrates and phosphates, can have adverse effects on its ecosystem. The algae may grow to conditions where they seriously deplete the oxygen supply in the water. Hence the marine life populations will slowly die off.

The green bubble algae pose other problems also. The huge masses of algae spread over and cover the coral skeletons and the living coral. This blocks out the sunlight to the corals' polyps. Without this sunlight, the polyps cannot carry on photosynthesis, which is vital to their life processes. If the living corals are killed off, it naturally follows that the rest of the marine life in the bay, that depend on the activity of the polyps for their oxygen supply, will also decrease in number.

The coral beds of Kaneohe Bay are further threatened by algae in still another fashion. The bubble algae were found to change the pH balance in the coral skeletons. This change brings about the dissolving of and breaking up of the white skeletons, which are principally composed of calcium carbonate, ($CaCO_3$), better known as limestone.

The second problem facing Kaneohe Bay, is the problem of excessive amounts of soil that is eroded by the seasonal rains during the wet winter months, and washed into the bay.

As a result of the heavy rains in February of 1969, many acres of raw, red eroding soil widely scarred the Kaneohe watershed. During the rainy season in February, University of Hawaii scientists monitored one of the ten major streams that empties into the bay. They found that in just 24 hours, that particular stream carried approximately 10,000 tons of sediment from the bare land.[3]

The sediment from that one stream alone was enough to cover each square yard of the bay's bottom with two pounds of soil, if evenly distributed.[4] Most corals and marine life are not able to withstand such heavy sedimentation, as it has a smothering effect, especially on coral heads. By burying the coral, the fish and other marine life are cut off from their food supply and source of shelter.

So much soil was eroded from the land for the dimple reason that the land developers were too cheap to go and replant the land areas that they had bulldozed and cleared for houses and highway construction projects. They left the land denuded without any forethought as to the possibilities of its soil to get washed away. So, as a result of poor planning, irreversible erosion damage occurred.

According to measurements taken by Dr. Ken Roy in 1970, the average depth of the water in Kaneohe Bay had decreased five feet since 1927, due to such heavy sedimentation. See graph.

It is quite difficult for the corals to make a reasonable come back, and replenish the bay with its beauty. Because the bay bottom is covered with the soft silt and mud, the new corals cannot become estableshed upon so unstable and shifting a bottom.

Dr. James E. Maragos, of the Hawaii Institute of Marine Biology, had conducted a study of the growth patterns of corals in Kaneohe Bay. He collected several colonies of the six most abundant species of corals, among them being the dominant species of finger coral, (Porites compresa), and transplanted them on metal platforms. These platforms were placed in twenty-five (25) different areas within the bay, and were allowed to multiply.

The finger coral species comprises ninety(90) per cent of the total living mass of corals in the bay. Yet when the coral transplants were placed in the southern sectors of the bay, they all died within a short time. These experiments were performed seasonally for a whole year with the same results.

Two of the five other species of coral, transplanted into the southern sectors of the bay, used in the experiment, died quickly also. Two others had survived but were in poor health or failed to grow, and the last species had survived and grew, but it had displayed some signs of abnormal growth.

Dr. Maragos further related that all the corals that were transplanted into other sectors of the bay had survived and grown with no abnormalities. But, he added, "...had I not periodically removed bubble algae from the platforms in the middle bay, the transplanted corals would have been smothered and killed."[5]

DISCUSSION

In this discussion, I would like to bring up some of the alternatives that may be considered to save Kaneohe Bay from deteriorating further.

The topic I would like to discuss is the problem of the inefficient sewage treatments. One alternative is to change the existing plant to include tertiary treatment, which would remove most of the bothersome nitrates and phosphates from the effluent. But the draw-back on this is that the cost to install the facilities to handle tertiary treatment is phenomenal, not to mention the cost of its maintenance.

Another suggestion is that the sewage from the municipal plant be pumped over to the outfall in Kailua, where it is discharged into the open ocean, and can be carried off by the currents, rather than sitting and collecting at the bottom of the bay as it is now. The draw-back on that, too, is money. The money needed to finance these changes are to come from the Hawaii tax payer. For any abatement program approved by the Federal Water Quality Administration, the Federal gevernment will pay 55 per cent of the cost. The State would then pay 25 per cent, and the City would pay the remaining 20 per cent. Which, in short, means that the cleaning up of Kaneohe Bay and other endangered areas, depends on whether or not the State and City officials feel it is a cause worthy of that much money.

Pertaining to the erosion problems, there have been ordinances and laws drawn up to discourage any land developers from not properly replanting cleared land. Ordinance Number 3968 sets down guidelines as to how deep or how high up they may grade, excavate, or fill land for construction. In Article Number 2 of Ordinance Number 3968, Section 23-2.2 says:

> ...a drainage and erosion control plan prepared by an engineer, showing the general scheme for controlling erosion and disposal of run-off water, to include drainage devices such as terraces, berms, ditches, culverts, subsurface mulching, sprigging, or sodding..."

This type of ordinance is all fine and good, but without sufficient enforcement of these rules and regulations, there can be no improvement in the situation.

CONCLUSIONS

I would like to conclude this paper by saying that from the information I recieved while researching this paper, I can say that I now know all of the facts involved with Kaneohe Bay and its problems, and that I honestly believe that something definitely should be done in order to save its corals (what's left of it, that is) from extinction, and it should be done immediately.

Diseases Possibly Associated with Pollution in Water--

Typhoid and Paratyphoid fever
Dysentery
Streptococcal sore throat
Diseases of Gastro-intestinal tract
Hepatitis
Viral infections
Dermotophytosis (Athlete's Foot)
Conjunctivitis and Ophthalmia
Stye
Other inflammatory diseases of the eye
Inflammatory diseases of the ear
Other acute respiratory infections
Influenza with digestive manifestations
Gastro-entheritis
Boil and carbuncle
Jaundice

FOOTNOTES

[1]R. E. Johannes, "Sewage and Soil Erosion Compound Bay's Problem", Honolulu Star Bulletin, Sept. 26, '70, pg. B-20.

[2]R. E. Johannes, article.

[3]R. E. Johannes, article.

[4]R. E. Johannes, article.

[5]James E. Maragos, "Kaneohe Bay Corals Are Being Smothered", Honolulu Star Bulletin, Sept. 25, '70, pg. D-14.

Graphs:

Stphen V. Smith, Keith E. Chave, and Dennis T. O. Kam, Atlas of Kaneohe Bay: A Reef Ecosystem Under Stress, National Sea Grant Program, 1973, Pgs. 28, 30, 35, 36.

Other:

Final Impact Statement for Kaneohe-Kailua Sewer System, by the Environmental Engineer, Dept. of Publec Works, City & County of Honolulu, Apr. 1974, Pgs. B-23, C-24, 25.

Helfrich, Philip, Ph.D,"Crisis in the Gardens", Honolulu Star Bulletin, Sept. 23, '70, Pgs. C-1.

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THE COASTAL ZONE MANAGEMENT PROGRAM OF HAWAII 1974-1977

by Daria K. Young, Sacred Hearts Academy

INTRODUCTION

The purpose of this paper is to give you a little background into what the coastal zone management program is and to show how it might affect the water and land surrounding the islands. The program is now in its third year of planning and it still isn't finished yet. The program started in 1974 and it is eligible for a developing or planning grant for up to three years. I hope this report will prove to be knowledgeable for all who wish to know about this program.

The Coastal Zone Management Act (CZM) of 1972's national policy is "to preserve, protect, develop, and restore the resources of the coastal zones; to encourage and assist the states in the development and implementation of management systems; for all Federal agencies engaged in programs affecting coastal zones to cooperate with the respective states; and to encourage the participation of both the general public and various public agencies in program development."*

According to this act, the development of this program must include:

1) An identification of boundaries of the coastal zone subject to the management program.

2) A definition of what shall constitute permissible land and the use of water within that coastal zone, which will have a direct and significant impact on the coastal waters.

3) A list and designation of areas of particular concern within the coastal zone.

4) An identification of the means by which the State proposes to exert control over the land and water uses, also including a list of relevant constitutional provisions, legislative enactments, regulations, and judicial decisions.

5) Broad guidelines on priority in certain areas, telling specifically the uses of lowest priorities.

6) A description of the organizational structure which is to carry out this management program. The responsibilities and interrelations of local, areawide, State, and regional agencies in the management process.

The decision-making goals for the three key aspects of the management program are 1) to determine the inland boundary for the coastal zone, 2) to select a State agency to receive Federal funds when the CZM (Coastal Zone Management) Act is carried out, and 3) to determine how Areas of Particular Concern (APC) are to be designated and governed.

The inland boundary plan has been planned for the entire state to be in the coastal zone. The CZM Act calls for the State eventually to be designated for inland boundary for management purposes. Hawaii lies between a coastal zone that is either broadly defined to include all the State or narrowly defined to include only a narrow coastal strip.

The Narrowly Defined Coastal Zone's advantages are that they allow Federal and State comprehensive planning and management for the areas needing it the most and they permit County and State regulatory programs that focus on CZM problem. Some disadvantages are that it is hard to define the zone, many significant coastal areas and activities are excluded, and the State cannot use CZM planning and management funds whenever coastal significance arise.

Broadly Defined Coastal Zone's advantages are integration of CZM program with statewide planning efforts, CZM planning and management funds which can help other funds in the State, allowing the Stat fo cooperate with Federal on the CZM, and so the CZM program may have control over all coastal land and water. The disadvantages are that it might be hard to put the State General Plan and the CZM program together because they both involve the entire state and if they set controls it will interfere with other State and City controls.

The Department of Planning and Economic Planning (DPED) is the administrative lead agency. They will have to coordinate and provide financial support for the CZM planning. It will not be a regulatory power while the program is being carried out.

Areas of Particular Concern (APC) are to give governmental bodies power to deal with special situations some situations are

1) When there are cumulative impacts that regular management cannot handle.

2) When a rare resource is endangered.

3) When very hazardous or unhealthy conditions are created.

4) When pieces of regulation cannot be put together to form a response to a threatening situation.

5) When the State or national interest in resources is ignored.

During the second year of coastal zone planning major coastal problems were analyzed, especially the management of coastal resources, coastal hazards, shoreline development and to compile data to support CZM planning. During the third year, the program was supposed to have an analysis on the changes in present land and water use's regulatory system was to be discussed and new tools would be found for preserving resources, trying to put together ideas on the impact of coastal zone lands and water.

There are seven coastal resource categories which are recreational resources, historic resources, scenic and open space resources, coastal ecosystems, economic uses coastal hazards, and managing development. Recreational resources main objectives are to provide a balanced selection of coastal recreation open to all and to see that all recreational activities are able to comply with the conservation of coastal resources and with other land and water around it. But the basic problem is for the government to keep up with the demand for coastal recreation and to maintain the quality of this recreation. The exisiting recreational supply system is ineffcient, not funded, or supported by land use controls. The cateogory of Historic Resource is to protect and preserve historic and pre-historic resources in the coastal zone which influence American and Hawaiian history and culture. The present regulatory system has no concept of preserving these landmarks. Archaeological impacts are viewed as a minor concern and funding in the past is not adequate so there is no way the goals of the State Historic Preservation Program could be met. Scenic and open space resources are to protect, preserve, and if possible to restore the coastal scenic and open reources. Governmental systems do not protect valued resources and needless damage to prperty cannot be prohibited. The increase in the cost of the land near the coast is due to all the litter that is thrown on accessible land to coastal areas. Coastal ecosystems are to protect valuable coastal ecosystems from any harm and to minize adverse impacts on all coastal ecosystems. The main problem is that there is no conservation for coastal lands so many times there is needless waste. The Federal, State, and County need to inform people about this needless waste of Hawaii's natural resources. Economic uses are to provide growth and development of essential facilities and public improvements in the coastal zone with social and environmental objectives. The main problem here is that shoreline sites are useful in many ways commericial, industrial, and for transportation such as harbors, sewage plants, power plants, resorts, fisheries, aquaculture operations, and oceanographic reasearch which all rely on water, but which one should have priority? Many times there are conflicts because of this. But what must be kept in mind is to have something for the good of the community but also to keep the island beautiful. Coastal hazards are to reduce hazard to life and property from tsunami, storm waves,stream flooding, subsidence, and lava flow. Until recently the government has not been aware that the land near hazardous situations must be restricted because too many lives and properties were lost because people were living in danger zones. The Federal Flood Insurance Program has also restricted the use of these lands. The last resource category is managing development the main objective is to improve the coordination of governing land and water use managing to eliminate wasted time and to improve communication and public participation in managing coastal resources and hazards. The problem here is that the present way of planning, locating, and operating private and public facilities in the coastal zone takes too much time and money. To solve most of these problems in all categories there must be organization and a more indept look at these categories before deciding what to do.

Hawaii's caselaw relating to coastal lands and waters has been completed during its second year. The review has covered both substantial (protection of public interest in coastal resources and activities) and procedural (adminstrative actions dealing with planning and management of public resources).

Review of the case law on substantial standards dealt with protection of specific resources and activities. Resources examined were ownership and use of beached, navigable waters and tidal lands, fisheries, surface waters, mineral resources, artesian water, and the disposition of public lands. Protections of activities were reviewed according to reserved rights, statutory rights, and customary usages. The case law on procedural standards for planning and management of public resources was reviewed applicable to : the nature and role of general planning, adminstrative procedure and due process, standing, and zoning estoppel (a variant of the "taking issue" involving frustration of an expectation or investment).

The courts must be prepared to take an active role in deciding many questions in this program. They must protect both the public resources and the rights of individual affected parties.

CONCLUSION

This program will have a great effect once it is put into effect. It has a great potential here on the islands because we rely on the sea for many of our resources. This program will control the uses of these resources so that there is not needless waste and to save the resources so that other generations may be able to share the kind of resources that we have. The courts will play a big role in deciding who will be given the right to the use of some of these lands surrounding the islands. They will have a great influence on the controversial cases concerning these lands.

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Footnote

*Department of Planning and Economic Development, Hawaii Coastal Zone Management Program. 1976. pg. 2

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SEWAGE TREATMENT PLANTS ON OAHU, HAWAII

by Clarence Blizzard III, University Laboratory School

ABSTRACT

In the United States today clean water is becoming harder and harder to find. This is not only true in the big states of New York and Chicago, but it is also true here in Hawaii . The nation's water pollution problems and wastewater problems have continued even though many new treatment plants have been built. In 1972 under the amendments to the Federal Water Pollution Control Act thousands of treatment plants were to be built by 1977 , not just built but built better. Both Primary and Secondary treatment are required in Hawaii as on the mainland, but in some states it isn't working well enough ,water is still getting filthier and filthier. This can only be solved with better study programs to create better designs that will give even more efficiency in wastewater treatment. We must also keep pursueing better and better ideas until we catch up with the growing water pollution. Although Hawaii has done well thus far, it could be better. My paper will explore the characteristics of three of the City and County of Honolulu's sewage plants

INTRODUCTION

"Under the 1972 amendments to the Federal Water Pollution Control Act, thousands of waste treatment plants were to be built across the nation in order to control or prevent water pollution."[1] The law authorized grant of approximately nineteen billion dollars to build new and improved sewage treatment plants.

"According to the law, every sewage treatment system must meet federal standards by July, 1977."[2] "Many businessmen and city officials complained that the deadline was unreasonable ."[3] "They argued that in many cases the deadlines either could not be met at all or could be met only at too high a cost for consumers and taxpayers."[4] "In an answer to these complaints Congress voted to give the cities six more years —until July 1, 1983—to meet the intermediate deadline."[5] The final deadline for both cities and industries to have the "best available" antipollution equipment is July 1, 1984. Also limits have been set on the amount and quality of effluents to protect the waterways.

In the sewage plants of Hawaii either primary treatment or secondary treatment , or both are being given. There are On-site systems in Hawaii also, they include , cesspools,septic tanks, aerobic systems, non-water systems, package treatment plants, and treatment lagoons.

METHODOLOGY

The research for this paper included a personal interview, the reading of selected books, pamphlets, and articles, and visitations to the three plant sights. The results of my research are presented here.

BACKGROUND INFORMATION

Sewage treatment plants have been used for almost a hundred years. There are two basis stages of treatments, the Primary stage and the Secondary stage. In the Primary stage of the basic treatment the sewage travels through a number of screens. The screens remove large objects floating in the sewage. After the sewage has been screened it then flows to what is called a grit chamber , where grit, sand, cinders, and small stones are allowed to settle to the bottom of the tank. When all the grit is removed the sewage still contains organic and inorganic matter in the sewage in liquid and solid form . The sewage then travels to a sedimentation tank and is allowed to set for awhile to let the rest of the solidified organic and inorganic material fall to the bottom of the tank. This residue is called sludge. To complete the primary stage of process the effluent is chlorinated to kill the disease causing bacteria in it.

"The secondary stage removes up to 90 percent of the organic matter in sewage by making use of the bacteria in it ."[6] "The two principal techniques used in the secondary stage are trickling filters and the activated sludge."[7] After the sewage leaves the sedimentation tank in the primary stage of treatment, it flows or is pumped to a facility using one or the other of these processes.

A trickling filter is a bed of rocks from three to six feet deep through which the sewage passes. "Bacteria gather on these rocks and multiply until they can consume most of the organic matter in the sewage."[8] The cleaner water seeps through the pipes in the bottom of the filter for further treatment .

" The trend today is toward the use of the activated sludge process instead of trickling filters."[7]

"This process speeds up the work of the bacteria by bringing air, and bacteria laden sludge into close contact with the sewage."[10]

After the sewage leaves the settling tank it goes to an aeration tank where it is mixed with air and sludge loaded with bacteria and allowed to remain for several hours. During this time, the bacteria breaks down the organic matter.

"The sludge, now activated with additional millions of bacteria and other tiny organisms, can be used again by returning it to an aeration tank for mixing with new sewage and ample amounts of air."[11]

The activated sludge process, like most other techniques, has its advantages and limitations. The size of the units necessary for this treatment is small, thereby requiring less land space and the process without flies and odors. "But it is more costly to operate than the trickling filter."[12]

Lots of oxygen is needed in order for the activated sludge process to be effective. Three methods are used to to mix air with sewage and biologically active sludge in the aeration tanks. The first, is mechanical aeration, the second is the forced air method and the third is a combination of the forced air method and mechanical aeration. The final step in this process is the addition of chlorine.

Other traditional methods are lagoons, sometimes called stabilization or oxidation ponds, They can be used to treat sewage in the secondary stage or they may be combined with some other process. When used with other basic treatments,lagoons can be very effective.

Septic tanks are also used to treat the sewage from individual homes.

Hawaii's traditional system is the flushing toilet. The toilet is connected to the public sewer system.. The sewer system consists of pipes, pumps, and treatment plants. The flushing toilets and connecting system uses a lot of water and the system costs a lot of money to construct and maintain. They aren't liked much because of the expenses involved . Construction of sewage treatment plants affect land uses and increase the water consumption. The traditional system is needed for densely populated areas, but, newer approaches must be tested.

On-site systems use little or no water and don't require expensive sewage linking. On-site systems include, cesspools, septic tanks,and aerobic systems.

Cesspools are the most widely used on-site system in Hawaii today. a cesspool is a pit in the ground that receives untreated waste from residents. They work well in rural areas, they are popular because they are inexpensive and easy to install. They are also unreliable at times . They get clogged sometimes and require pumping at private or public expense.

With a septic tank wastes from a home go into an airtight tank in the ground . this tank retains the solid and organic waste materialsto be digested . The solids are eventually pumped out, but this occurs after a number of years.There is some treatment of wastes and liquids that are discharged over a large land area allowing the soil to take out the pollutants. There are very few sceptic tanks in Hawaii because of the large amount of land that they require.

Waste enters an aerobic system where bacteria feed on organic wastes. Air supplies to the bacteria keeps them alive. As the bacteria grow and die waste solids accumulate and must be removed. By confining wastes in a closed tank there is less danger of polluting the ground water supply or nearby coastal waters. Aerobic systems are environmentally sound. The costs of pumping , repairs and energy make them more expensive than cesspools and sceptic tanks.

The Wahiawa Sewage Treatment Plant

The Wahiawa sewage treatment plant uses the Activated Sludge process with Anaerobic Digestion.[13] On an average day at the Wahiawa plant 1.4 million gallons of sewage pass through the plant. During peak periods at the plant the flow is increased to 2.6 million gallons a day.[14] Once the sewage goes through the Primary treatment and the Activated Sludge process , the excess sludge must be broken down, this is done in an Anaerobic Digestor, then the sludge is dewatered and disposed of at a sanitary landfill.[15]

At the Wahiawa plant sewage is tested weekly according to NPDES permit requirements.[16] Phosphates are tested for in the sewage, but no tests for arsenic,mercury, or radioactive wastes, the plant has it's own laboratory for operational control analysis.

Seven men work at the plant on a three part twenty -four hour shift, seven days a week.[17] Three to four men work the 7:00am to 3:30 pm shift. One man from 3:00pm to 11:00pm,and one man from 11:00pm to 7:00am. There is also a relief shift of one man.

The Wahiawa sewage treatment plant is the most advanced plant on the Island and puts its treated waters into Lake Wilson Reservoir, where it is used among other things as water for irrigation purposes. The quality of the effluents released by the plant must also meet the requirements of the NPDES which is administered by the State Department of Health.

In the case of an emergency the plant has a dual power source and dual equipment but if a tank should break down the plant must be shut down until repairs are made.[18] The cost to run the Wahiawa plant for one year is $115,988.[19]

THE PEARL CITY SEWAGE TREATMENT PLANT

On an average day tne Pearl City sewage treatment plant carries approximately 6.5 million gallons of untreated sewage.[20] This plant uses primary treatment and anaerobic digestors for total flow, and the activated sludge secondary treatment and aerobic digestion for four million gallons of the total flow per day.[21] On a peak day, the average amount of sewage treated is ten million gallons. When the sewage treatment process at Pearl City is completed, the sludge is broken down in an anaerobic digestor, dried in sand beds and disposed of at a sanitary landfill or city dump and is converted into fertilizer.[22] Sewage samples are tested daily, Tuesday thru Friday according to NPDES permit requirements.[23] The Treatment plant does have its own laboratory for operational control analysis but the plant dosen't test for phosphates. arsenic, mercury or radioactive wastes . The Pearl City treatment plant's last inspection by the federal government was in November 1977.[24]

The plant has a two part 14 hour shift, seven days a week, with a total of six men on the crew.[25] There's one man on relief shift, two to three men on the seven to three thirty shift, and one man on the three to eleven shift. To run the Pearl City sewage treatment plant it costs $ 85,661 thousand dollars per year. If an emergency should occur the Pearl City plant has dual equipment and an emergency generator on the new expansion phase of the treatment plant.[26]

THE SAND ISLAND SEWAGE TREATMENT PLANT

The phase 2 construction of the Sand Island sewage treatment plant is still in progress and should be complete sometime in June 1978. So far only the screening units are being operated. After screening the sewage is discharged into a deep ocean outfall.[27]

The Sand Island plant has an average flow of 70.0 million gallons of raw sewage per day. During a peak period the plant takes in on the average approximately 90.0 million gallons per day. When the plant is finished in June 1978 it will be using Advanced Primary Treatment with a Sludge Heat Treatment and Incineration.[28] The sewage will be tested weekly and whenever the NPDES requires it done.[29]

CONCLUSION

The research presented here in this paper provides a general picture of the types of wastewater treatment plants on Oahu . I feel that a satisfactory representation of the primary and secondary treatments are used in the three plants and On-site approaches. My research however, provides only baseline information and further study programs are needed to be conducted of all existing plants in order to improved the sewage plants that we already have. Alternative disposal systems must be considered from both an economic or conservation standpoint.

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SHORELINE BOUNDARIES AND HOW THEY AFFECT US

by Arno L. Hawman, Pahoa High School

INTRODUCTION

Few people are aware of the boundary lines of beaches and coastal areas in general in the state of Hawaii.

The reason I chose this topic was because of my own curiosity, aroused by an experience I had on a Boy Scout hike along the north Kona coastline. While hiking we came across many no trespassing signs, keep out signs, and one fence that ran into the water at high tide.

Another thing that aroused my curiosity was talking with the Marine Science teacher at Pahoa High School, Mrs. Sandra White, who told me that the management of the Mauna Kea Beadh Hotel were asking people on the beach, who were not staying at the hotel, to leave. I was curious about their rights and mine. I wanted to know what rights I had to that beach or any beach.

In this report, I am trying to answer all of my own questions that I am hoping other people think about, at least, once in awhile. I hope I am answering everyone elses' questions, as well as, my own.

When people would talk about the shoreline around me, my ears would automatically perk up, because I wanted to learn something. It finally got to the point, I just had to do it myself. When I first started my research, I was very confused. I didn't know which answer was right because I encountered a variety of ideas.

PROBLEM

Where does the boundary line between public and private property along the shoreline lie? Why aren't more people aware of the laws concerning the shoreline? Why hasn't the government tried to inform the people of the laws? The people in Hawaii rely on the sea for many things. In order to get to the sea, you must cross the land. Do you have the right of access to the sea?

METHODS AND MATERIALS

My first step, was to ask people what they knew about the boudnary line along the Hawaiian coast. I recieved four different answers.

The second step, was to go to the school library and look for useful information concerning the problem. I came across two books that turned out to be worthwhile. Principles and Practices of Hawaiian Real Estate and a law book containing information on coastal management.

The third step, was to meet with a lawyer, Douglas Halsted, who provided me with various law books. The only book I was able to acquire a large amount of useful information from was Vol. 50 of the Hawaii Reports. Most of my information came from the case- In Re-Application of Ashford. Mr. Halsted directed me to the nearest tax map office, where I spent time looking at maps of shoreline property. These maps were not of much use, because the shoreline was not clearly defined.

The fourth, and last step, was to write letters to Life of the Land, the Sierra Club-Hawaii Chapter, and the Legislative Reference Bureau. I didn't recieve much useful information from these sources, however, the Legislative Reference Bureau did send me a list of cases to check out. This I did. The Sierra Club referred my letter and myself, to another person who is involved in coastal zone management. This person was to reply to my questions, but has not to date.

DISCUSSION

I feel that what people have told me about the shoreline boundary is all correct information. But if you want to sit down and study the books and notes for awhile you find out that they are all just as wrong as they are right. This is because there are so many right answeres to the question, "Where is the boundary line between public and private property on the shoreline?" If there was a set regulation there wouldn't be so much confusion.

People should do more to keep themselves informed about what is going on around them. Mauna Kea Beach Hotel is in a law suite at the present time because of their practice in regard to shoreline access. The hotel's inattention to the laws is what has it in the mess it is in at the present time.

If you own beach property, it would be very advisable to learn as much as you can about shoreline boundaries. Check your land document and see what it has to say. That might be as far as you have to go. If you don't want to do this, then you have no right to say who's trespassing and who isn't unless he walks accross your property to get to the shore. And even this is debatable, if an acient trail was through your property.

It is also advisable to check out beach access rights. If you are blocking people from going to the beach you might be in as much trouble as Mauna Kea Beach Hotel is in for asking people to leave the beach. The Hotel is also being sued for blocking beach access.

RESULTS OF RESEARCH

When I asked the people about shoreline boundries, the first answer was, that there was no public property other than the water.

The second answer, was the mainland law which really has no effect on us here in Hawaii. The mainland law states that a surveyor must survey the property and determine the boundary line. The third answer, was the boundary line was the vegetation line. And the fourth answer, was the boundary line was the limu line, which is the debris line caused by the wash of the waves at normal high tide.

The library boods I found, stated that the boundary was most commonly the limu line or vegetation line. However, the law in effect when the property is sold has a great deal of effect on the seaward boundary. The way the document was written effects the boundary also. If the document states the makai boundary as being along the sea, then the boundary line is the debris line. If the document states the boundary line as being water line at high tide, then that is what it is.

From the case In Re-Application of Ashford from Volume 50 Hawaii Reports, which Mr. Halsted provided me with, kamaaina witnesses are allowed to state their opinions because the court wants to maintain ancient tradition, custom and practice. The Ma Ke Kai, or seaward boundary, is usually identified as the limu line.

I did not recieve any new information from any of the people I wrote to, but I would like to thank the Sierra Club and Legislative Reference Bureau for an acknowledgement of my letters.

CONCLUSION

I have concluded that the boundary line, or Ma Ke Kai, is the limu line, unless the property deed says otherwise. Or the property was purchased when the law was different.

I have also concluded that I have the right to walk down the beach and not be bothered by property owners. Property owners ought to be aware of these laws concerning the shoreline for their own safety. For my own protection, it is a good idea that I known them too.

There ought to be one consistent regulation governing the shoreline of the entire state. It would cut confusion and disputes down to a minimum.

People are not aware of the laws concerning the shoreline because they don't try to be informed. I am now more aware of the laws, because of the research I have done.

I have concluded that most shoreline property owners with beach property, in most cases, must have some sort of public access. They do not have the right to stop people from going to the beach. They do, however, have the right to stop you or me from crossing their property.

All of the answers I got from the people I asked, or out of books were all right answers, yet they were wrong in different situations where different laws were in effect.

The state of Hawaii should clarify its shoreline boundary laws for the benefit of all.

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IS METAL A POLLUTION?

by Melanie J. Stanphill, Kubasaki High School

INTRODUCTION

The main part of this report will center around the Minamata incident which sparked off the issue of mercury poisoning. In this report I will answer what happened and why. Afterwards I will discuss whether metals are a danger to man and his enviroment or not.

The problem is that a disease that was first noticed in 1950 did not really surface until the 1970's. The disease, once people heard about it, caused a scare from fish for the time being. What happened to it? Are metals still a menace to the enviroment? What caused the disease? What does it do to people? These are the questions I will answer in the following report.

A company named Chisso, that produces petro-chemicals and plastics, dumped regularly in the Minamata area its drainage. Between the company and Minamata was a drainage channel which went into the bay. As far back as 1950 people noticed unusual happenings in the bay's water. Fish were dying in great amounts and some of the sea plant life was also dying. By 1952, the situation was growing worse. There were now to be seen large patches of dead fish floating on the water. The dead fish weren't just in the bay, but also in the Shiranui Sea. Cuttlefish in the bay were becoming so weak that children were able to catch them with their bare hands.

In the following year the cats in the Minamata area started to become sick. The people in the area began to call the sickness "the dancing disease"[1] or "the cat's disease"[2]. The reason was that the cats staggered about, salivating and then they would turn around in violent circles. After this they would collapse and die. After five years of this all of the cats had disappeared, and this deadly disease took on another form.

In April of 1956, a five year old girl from Minamata fell ill with irregular speech and symptoms like those of delirium. In about five weeks members of the neighboring families had the same symptoms. By that summer an epedemic of this strange disease had broken out. Most of the affected people were from Minamata or surrounding villages.

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1 and 2 came from Natural History-June July 1975

The diseased people had had the symptoms for many years before anyone really noticed. The Kumamoto University Medical School came to investigate the case of the outbreak of the disease. They found out it was a type of heavy-metal poisoning that was in the fish and shellfish they were eating. By 1956, fifty-two people had this painful disease, out of these fifty-two, twenty-two died. When examined a high amount of mercury was found in the victims.

Way back then, a few people were worried and they found out what was causing it. Was this the end of the matter? Will this always be the end of the matter? No. In fact five years later, in 1971, scientists of FDA found that eighty-seven percent of the swordfish had more mercury than federal guidelines will allow. So the officials asked the swordfish industry to hold all shipments of swordfish for analynis. The next step was to recommend the public to stop eating swordfish. This and many earlier reports of contaminated fish as salmon, tuna, and other seafood showed the public there was another form of pollution....metal pollution.

WHEN DO METALS BECOME A POLLUTANT?

Every living thing has many different metals in their bodies in various concentrations. If you take the human as an example we contain almost every metal element there is. Most of these are needed for everyday good body health. There are three instances that metals are considered a pollutant. They are when they are in the wrong place, wrong time or wrong concentrations. When these conditions are present, it may harm our environment or health. Even though we mainly worry about the harmful effects on man, it is normally man who causes the metal pollution.

Every year man get rid of as much mercury into oceans, rivers, and lakes as is carried to the oceans by all the world's rivers.

The rivers get the mercury from the form of mercury compounds. This is washed away from the soil and from natural resources that are eroded through rain and wind. One of the greatest causes of putting mercury into the atomsphere is through the burning of fuels. After these causes, this is only a small part of all mercury put into nature. The oceans have so much mercury that is always there, that if man didn't add any mercury at all into the bodies of water the mercury level would still be higher than the FDA considers safe for humans. The main problem with man's contributions to this problem is that they have a heavy concentration so they are more dangerous.

Found in many river and lake sediments there are large amounts of dangerous mercury compounds and many people have tried to find a way to get rid of the poisonous affects of this. At one time people thought that the mercury compounds used for agriculture and industry were harmless because of am experiment that showed it was safe. But the experiments done at that time also said that the mercury compounds were not held in the tissues of humans, fish, or birds that are in the human food chain. Yet this sounds contradictory because of the Minamata episode. But scientists considered this and many other cases of mercury poisoning, that were appearing in many other parts of the world, that there was more to it.

They re-did some of the experiments they were doing and this time they found large amounts of methylmercury. This is one of the most poisonous kinds of mercury because this is held in animal tissues. This mercury came from the methane-forming bacteria that lies in lake and river sediments. This bacteria changes the less poisonous forms of mercury into the dangerous methlymercury.

So when the mercury gathers in the body it combines with enzymes and this then gets in the way of norm l life activity like breathing, thinking, etc. There seems to be no way to stop this problem. Even if the mercury compounds in agriculture weren't used any more, the river has so many of these compounds now, that they would continue to produce methylmercury for hundreds of years to come.

In the ocean alone the mercury content of the water in the deepest ocean, the fish in this area compared to others, doesn't seem to determine the amount of mercury in certain fish. Also, the species of the fish and the size don't help in the matter of concentration of mercury. In the same species of fish the mercury levels may be naturally high in some and not in others.

CONCLUSION

To conclude this report I can say that metals in the ocean and rivers are a threat to man and the enviroment. There is no recent information on this topic, and I assume that there is now research being done to solve the matter of mercury poisoning. To solve this problem we could stop using methlymercury-forming materials in agriculture, so that future generations would live mercury free. But, it seems there is no way we can stop the mercury in fish that are in the ocean because they are beyond our control. I hope in the near future that something will be done to clear this problem from the earth because it is a pollution and we have enough as it is.

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MARINE RESOURCES :
PRECIOUS CORALS & PEARLS

THE PEARL: THE GEM OF THE SEA

by Doris S. Kwan, Kubasaki High School

Though there exists a number of precious stones, each assessed by their beauty, rarity and value, a perfect pearl of some size is certainly one of the rarest of all gems. Although pearls are of organic origin, they are principally composed of mineral matter. A pearl is a gem that is created by a mollusc by an accident of nature thus being unique of such as rubies, diamonds and emeralds. Also unlike other gems, a pearl is admired not for its sparkle and glitter, but instead, for its rich luster and irridescence.

Ever since the early uses of the pearl were discovered, men have sought to discover the origin of it. Similarily, I had also been intrigued by questions about this unique sphere. Therefore, I decided to research this topic of much discussion in this report. The following is an informatory sketch of the pearl that will cover its history, its uses to man, its production, and the kinds of pearls in existence.

Because of the immense amount of information on this subject, I have endeavored to present this paper in a factual, concise manner which will hopefully prove to be as fascinating a topic as I have found it to be.

"Materials and Methods"

Materials used in completing this report were encyclopedias, books, charts and maps. Thorough research of knowledge on this topic of pearls was needed in order to comprehend the areas of the pearl that were covered. After this was done, the topic was split into different sections and I decided upon the depth of presentation, the extent of detail needed to explain my subject sufficiently. Then the report was written in a logical, self explanatory manner.

The Pearl: Gem of the Sea

The history of the pearl is a long one, even dating back to thirty-five hundred years before the birth of Christ and possibly further. It is mentioned in the literature of ancient India as well as in that of China. Yet, while the Singalese, Persians, Egyptians and Greeks all recognized the pearl as a rare gem, it was the most popular with the Romans. In fact, the pearl was so valued that even a law was instituted forbidding the wearing of pearls by all except those who had attained a certain rank in the empire.

In ancient and medieval history, pearls were religious symbols of purity, harmony, humility, and the gift of life. " The unblemished pearl is one of the most ancient symbols of perfection."[1] Pearls were also used in medicine and magic not to mention ornamentally. Pearls were thought to have medicinal value in soothing heart and stomach disorders when coupled with certain herbs. Pearl dust was believed to be beneficial to the eyes. Today, pearls are not only gems of romance and love, but are still used in medicine, decoration, and even as fertilizer.

The origin of pearls was subject of much speculation by many early writers. The belief that they were formed by rain drops falling into certain shells and afterwards hardened by the secretion of the animal was a popular belief. While another theory was that a pearl was a gallstone created by a diseased oyster. However, it was not until after two centuries of a world wide argument that the truth was discovered. In 1907, a Japanese scientist, Tokichi Nishikawa solved the mystery of the pearl.

1 Encyclopaedia Britannica Vol. 17
Encyclopaedia Britannica Inc. 1971, Pg. 504

Before anything is said about the production of a pearl, let us first examine the animal that produces it so that we may understand fully all that is involved. Theoretically, all bivalves are capable of producing pearls yet only those that are produced by pearl oysters are acceptable to be called gems. Those produced by other bivalves, though rarely found, are lusterless, crude and rather ugly. The pearl oyster belongs to the mussel family. The most important species being the Margaritifera vulgaris which yields the fine Persian, Red Sea, and Malay pearls, the Margaritifera maxima which produces the Australian pearl, the Margaritana margaritifera which are found in rivers producing what we call the fresh water pearl, and the specie found and cultivated in Japan, Pinctada martensii.

During the bi-yearly spawning, millions of young oysters are liberated. Though, true to nature's laws, only some will survive. These will cling to rocks and other submarine objects by means of their byssus, a glandular secretion of tough fibers. Bearing favorable conditions, the oyster will begin to build its shell which will consist of four main layers. The periostracum being the outer most layer, the prismatic layer consisting of calcite or aragonite with conchyolin (a horny substance), the nacreous layer composed of calcium carbonate and usually refered to as "mother-of-pearl", and lastly, the innermost layer, the hypostracum.

After the shell is completed, there is little more for the oyster to do than to stay in the shell and feed. When feeding, the oyster will relax its powerful adductor muscle and open its shell to consider any suitable food that passes by. If by any chance, a foreign object such as a grain of sand, parasite, or fragment of rock gets lodged inside of the oyster, an irritation is set up and the oyster will attempt to expel the object or isolate it. If this is not possible then the oyster will proceed to cover the irritant with layers of the same substance as its shell. Thus as a result of such an accident, the gem we know as the pearl is created.

Contrary to many people's beliefs, all pearls do not form into spherical shapes. "Nearly 40 per cent of the harvested pearls have no commercial value, and of the remaining 60 per cent, perhaps only 5 or 10 per cent will be flawless, round, white jewels."[2] The most valuable therefore the most desirable shapes are round, drop, and pear-shaped pearls. If an irritant such as a ooring parasite for example, is positioned between the shell and the mantle (inner shell layer), the produced pearl will be connected to the shell and therefore must be cut away. This will naturally leave a flat surface from where it was cut off. These shapes are called blister pearls and are commonly used in rings, earrings, pendants, and such settings that are able to hide the flat side. Also, quite commonly, pearls will assume strange, irregular, and sometimes interesting shapes. Usually these shapes, refered to as baroque, are caused by the shape of the pearl's nucleus. Unless they are of unusual luster, baroque pearls are of little value.

There are three types of pearls in existence. They are the natural pearl, the imitation pearl, and the cultured pearl. A brief description of each kind will be given in the next few paragraphs.

Natural pearls are those which have been formed without any human factor involved. It is these pearls which are accidents of nature, produced entirely without the help of man. Natural pearls are often called "Oriental" pearls, the reason being that most of the pearl-bearing species of oyster come from Japan and the Far East. The hues of natural pearls can range from a white to a rosee and even black. Black pearls are very rare though.

2 Pearls, Jo Mary McCormick
Sterling Publishing Co., Inc. 1966, Pg 74

Imitation pearls developed as a part of the pearl industry but are now classed as costume jewelry. These pearls are in no way related to natural pearls. This is not to say that imitation pearls are of no value. In fact, some imitations are made with fine materials such as mother-of-pearl shell, conch shell and coral, but unfortunately, most are made with inexpensive chemicals. "Quality ranges from the very beautiful "Majorca" pearls made in Spain to cheap, shoddy and peeling white balls of plastic."[3]

The making and marketing of cultured pearls in recent years is largely due to the work of Japanese noodle-maker turned vegetable peddler, Kokichi Mikimoto. It was he who first succeeded in cultivating pearl oysters and devising an ingenious method of producing a cultured whole pearl. He simply used an artificial irritant, usually mother-of-pearl beads and inserted them within the oyster. The oyster was taken care of for approximately 3 years then harvested. From this system arose the largest of all pearl industries. Since the cultured pearl is actually formed by the oyster, one cannot say that the pearl is synthetic. It is the product of an alliance between man and oyster. Even now, the cultured pearl is sometimes called, after its discoverer, Mikimoto pearls.

Whether the pearl is natural, imitation, or cultured, they are all used as jewelry but that is where, as you have just read, the resemblance ends.

3 Pearls, Jo Mary McCormick
Sterling Publishing Co., Inc. 1966, Pg 75

Summary

Pearls have played a large role all through man's history. They had many uses then and today, the pearl is still a source of delight and is of use to man. A little was presented in this report not only of the history and uses of the pearl, but also about the oyster and the formation of a pearl. Three types of pearls were discussed. These were the natural pearl, the imitation pearl and the cultured pearl respectively. In addition to this, we have seen how man is able to work with nature to change the production of pearls from an accident to an industry.

My recommendations to the governments whose countries have pearl industries is to standardize the quality of export pearls in order to keep pearl prices and values consistent world wide. I also recommend that those governments institute laws that would make mandatory that pearls be labeled natural, cultured, or imitation to protect businesses as well as consumers from any false representation.

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PRECIOUS CORALS IN HAWAII

by Maia Chang, University Laboratory School

ABSTRACT

This paper discusses the precious coral industry in Hawaii. The old and new harvesting systems are described and also the danger of over- harvesting.

INTRODUCTION

This paper talks about the 3 types of precious coral, the problem of over-harvesting, and other information regarding the precious coral industry of Hawaii.

METHOD OF RESEARCH

Information for this paper came from The U.H. Sea Grant Program, The Department of Planning and Economic Development, and an interview with Mr. Boh Bartko, co-inventor of the harvesting system for the Star II.

RESULTS

The precious coral industry has been around for a long time. It was not until recent years that the beautiful jewelry made from the coral became popular. Pink, gold, and black coral, all havested near the Hawaiian Islands are the 3 species that are the basis for the local coral industry; an industry that may gross 11 million this year. The tourists identify the jewelry with the Hawaiian Islands, and buy a lot of it, thus practically doubling the local market this year.

All of the big coral beds are owned by the state. Anyone with a special permit can harvest shallow water precious coral by scuba diving, but there is a limitation to how much coral they can bring up. With the deep water coral, harvested with the Star II, a submersible, they need to have a license and the operators of the sub have to file a report every month to the state division of fish and game of how much coral they brought up. They are also required to renew their license every year.

The dredging method was the only method of harvesting coral until the Star II. They would wrap huge rocks weighing about 20 kg with heavy wire and attach them to nets. Then they dragged them across the ocean floor and the coral would get tangled up in the nets and hauled up to the boats. A lot of coral is lost while being hauled up and this method also destroys much of the remaining coral. The Star II is now the only mithod used for harvesting coral in Hawaii. Dredging has been outlawed because it is wasteful and destructive, while with the Star II, they can be selective and choose the big trees and leave the small ones to grow. The Star II is a small 2-man submersible. It has a basket built in front, a coral cutter blade, and a manipulator that puts the coral in the basket. It is all monitored by remote control inside the sub. The Star II is only designed for depths of 1,200 ft. 1,600 ft down there are hundreds of beds of coral they can't reach. They are actually getting only the first layer. A 70 foot support ship, tows the sub out and back. They maintain communications with the ship throughout the dive. There aren't too many people involved in the dive, only one man in the sub, two on the support ship, and 3 divers on the launch and recovery platform, but they are all very highly skilled and trained.[1]

Coral is made by tiny animals called Polyps. What they basically do, is to take the calcium out of the water, then deposit calcium carbonate (limestone) around the lower half of their bodies. As new polyps grow, the limestone formation becomes larger and larger thus producing the skeleton that we know as coral.

Corallium Secondum, more commonly known as Pink coral is found between depths of 1200 to 1600 feet deep. The average tree is 12" to 15" high but may grow as large as 2½ feet high.[2] About 75% of pink coral is harvested locally.[3] Maui divers who are now the largest precoius coral manufacturers in the world have harvested more than 1,200 kgs of pink coral annually.[4] Prior to 1972 the industry was almost totally dependant on Japan for their pink coral. But, in 1972 the Star II, had begun operating. This, together with the pink coral resources, essentially freed the local industry from their dependance on Japan.

At 1200 feet, pink coral looks like a combination of orange, yellow red, and on the tips a light yellow. All coral is more colorful underwater because of the animal life surrounding it. It is quite easy to tell wether it is pink or gold underwater, regardless of the lack of light. Because of the branch formation, shape, and the light they give off.[5]

Pink coral is the largest selling of the precious corals because of its pretty color. There are many shades of it, some so light that they look white, but the largest selling of the pink is a very light pink called Angels Skin by the retailers.

Harvesting the pink coral, off Makapuu point, led to the discovery of gold coral which resulted in an economic boost to the coral industry. Gold coral, otherwise called Parazoan Thus, is found at the same depths as pink coral. The difference in pink and gold coral, other that the color factor, is their difference in size. While pink coral grows to a maximum height of 2½ feet, the average height of a gold is 4-6 feet high and may grow up to 10 feet. Underwater, gold coral is yellowish green and has a bio-luminecencse about it. The color reflects the light soil is easy to see. Gold coral has a range of colors; tan, bronze, gold, olive, and a near black, all have great commercial potential.[6]

The Makapuu bed of pink coral, discovered in 1965, is the largest bed of pink and gold ever found. It is approximately 6 miles away from shore and covers about 1.4 square miles. It is an ideal place for coral because of it's cool currents and hard rock bottom, washed clean of silt and sand. When Maui Divers go out looking for coral beds, they look for places like Makapuu with the right bottom contour. It has to be somewhere quite close to a major harbor so they can operate with the harbor and service their equipment there. If it takes too long to get back from where they harvest, it's uneconomical, so they try to find coral beds nearby.

The last of the precious corals is the Antipathes Grandis, black coral. When the industry started out, all they used was black until the pink and gold were discovered. There are two types of black coral, deep and shallow water. The deep water black is shiny in its natural state. The shallow water black has to be shined and polished to get the shiny effect.

The majority of black coral is in the Auau Channel off Maui, and the southern half of Kauai. There is more black coral in the ocean than any other coral. Scuba divers harvest it at about 100-300 feet deep. Black coral is primarily used for jewelry, but there are still some sales of undersized colonies as curios, especially in Maui. The deep water black, harvested with the sub, looks deep dark red underwater. It is the hardest to see of the three corals because it gives off the least light. The average size of a black tree is about 6 feet but they grow up to 10 feet high.

The problem of over-harvesting is small but growing. There is a conservation law now in effect that states just how much coral you can bring up. Maui divers can harvest up to 2,200 lbs of coral a year but even so, there are thousands of small trees left to grow and replenish themselves. There are also small beds of coral distributed all around the islands. There is no serious danger of extinction because these beds and numerous others are too far away for Maui divers or anyone else to harvest.

Black coral may be endangered but only off Maui Point. Since people harvest them frequently and sell them as curios, serious depletion of the black there may occur.

Coral, in its original state is not sold. The new ruling of the state says it is illegal to sell coral as curios. Sometime you may see a tree in a store window. These are not for sale but are just advertisement for the stores jewelry.

If the over-harvesting should get ou of hand, there are many ways to solve the problem. A few are:

1) Increase the limitations on harvesting for everyone. This will present problems because the coral industry will most certainly object to this unless they are as consious of the problem as we are. Otherwise this seems like the best idea.

2) To permit only store retailers of personal business operators to harvest the coral. This idea seems logical but we can expect a strong refusal from the public who will probably feel they have as much of a right to harvest as others.

3) Have certain seasons for harvesting. For example, harvest only during summer and winter. This way the coral will be allowed to replenish itself. A drawback to this method is that the companies might feel cheated out of 2 seasons of harvesting and complain.

4) Ban harvesting for a few years till the coral can be replenished. This should be done immediately if the coral starts getting sparce. This will certainly make the companies most unhappy, but if the situation gets so out of hand it is the only alternative.

These are just a few of the things we could do if the problem of over-harvesting gets serious.

CONCLUSION

At the present time there appears to be no danger of serious depletion of the precious corals. However, steps should be taken to inventory the situation periodically.

FOOTNOTES

[1]Bartko, Bohdan. Interview on November 15th, 1977, by Maia Chang.

[2]Bartko Interview.

[3]Thompson, norrie. Rose Coral. Hawaii Department of Planning and Economic Developement. Spring 1976.

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PRECIOUS CORALS OF HAWAII

by Letitia K. S. Dang, Sacred Hearts Academy

INTRODUCTION

Can our precious coral resources become extinct? Are our precious coral resources being used wisely? In my report on precious corals in Hawaii, I explain briefly how the use of certain coral came about, its growth rate and how its being harvested. I also tell where and how much coral is found around the islands. But most important I tell how much is used and what it is used for.

THE HAWAIIAN CORAL INDUSTRY

In Hawaii, there are presently, four different types of living corals, which are under exploitation. These are the black corals, the pink corals, the gold corals, and the stony or reef-building corals.

The black corals are harvested by scuba divers at great depths, generally between 30 and 80 meters. The black coral is primarily the main one used in the manufacture of jewelry. If the use of black coral is not controlled, there may be a decrease of it in resources off Lahaina.

The black coral industry began in 1958 in Hawaii, when Jack Ackerman and Larry Windley discovered the beds off Lahaina, Maui. Since then the harvest of black coral has increased from year to year gradually. The main place of harvest is the Auau Channel off Maui and the southern half of Kauai. The divers are required to have a commercial fishing license, but there are no regulations to the amount they harvest.

Pink and gold coral are presently harvested with a small two-man submersible, named Star II. The Maui Divers of Hawaii, Ltd., harvest approximately 1,200 kilograms of pink coral every year.

Before, the Hawaiian Coral Industry got their pink coral from Japan, but through the development of natural resources, we don't have to depend on Japan for the pink coral anymore.

Gold coral was first introduced in the late 1974, since then its marketing has been successful. The amount of gold coral taken from the sea was about 300 kilograms annually.

Both pink and gold corals in Hawaii are harvested at depths between 350 and 400 meters, generally at distances greater than 3 miles from shore. The state of Hawaii now has authority to regulate landings, but can not prevent U.S. nationals from harvesting the resources outside of 3 miles of each island.

The stony or reef-building corals are harvested by scuba divers. Current state law prohibits the taking of stony corals from the shoreline area and the ocean inside of 304 meters off shore and at depths of less than 9 meters. Outside of these limits the harvesting of stony coral for domestic or curio purposes is legal in all countries. Commercial harvest is legal in all countries except the City and County of Honolulu, where a permit is required. However, because the state does not have the man power for adequate patrol, it is virtually impossible to determine where corals are collected and for what purposes.

BLACK CORAL

The history of black coral goes back generally thousands of years. Apparently the commercially available supply of black coral was rather limited until the advent of scuba in the early 1950's. In 1958 a large bed of black coral was discovered off Maui by Jack Ackerman and Larry Windley of Maui Divers of Hawaii. Since that time a vigorous although small, black coral jewelry industry has flourished in Hawaii.

GROWTH

There are two types of black corals, the Antipathes dichotoma and the Antipathes grandis species. The average annual rate of increase in height over a 3.5 year period was 6.42 centimeters for the A. dichotoma and 6.12 centimeters for the A. grandis. This means between the two species there is not much difference, due to the size or placement on a reef. The growth rate of a colony is due to its health and not its enviroment.

HARVEST

Black corals are harvested by scuba divers at depths of 30-80 meters. There are no government restrictions on the number of divers, but nevertheless the job and its dangerous nature, has not been a competitive one. There are about 10-12 known divers in Hawaii, plus a unknown number of amature divers, who dive occasionally for coral.

Most divers work in pairs, using which they have a small boat, ranging in cost between $4,000-$15,000, depending on its size. Other required equipment which they have is air tanks, a regulator, a depth gauge, fins, mask, a sledge hammer, a hatchet, and a decompression meter.

There is no regular season for diving. The number of days on which they dive depends on the weather and varies from month to month ranging from 0-30 days and averaging about 10 days per month.

Colonies of black coral are dislodged from the bottom with an ax or sledge hammer. Rarely saws or powerheads are used. Most divers tie the coral to lift tags and float the colonies to the surface. During a dive, which usually lasts 10-20 minutes, depending on the depth, a diver usually gets 1-2 trees. A daily harvest averages 9 pounds, but may range from 0-100 pounds. With the present price of black coral at $7.50 per pound, a diver will average about $70.00 per day, but may make as much as $750.00 per day.

To date the black coral supply has always been greater than the demand, the reason for the small number of divers, which depend on black coral as a steady source of income. Most divers, have other part time jobs or depend on other resources of the sea.

DISTRIBUTION AND ABUNDANCE

The known geographic range for both *Antipathes dichotoma* and *Antipathes grandis* in the Hawaiian Islands extends between the island of Hawaii and Niihau, but studies show that it also extends northwest of the Niihau island.

The depth ranges of both species are 30-85 meters and 45-146 meters, respectively require modification at the lower limit. Based on recent observations from Star II off Hawaii, Maui, Molokai, and Kauai, it is now resonably certain that the lower depth limit at both species is about 110 meters. Since 110 meters is close to the top of the major thermocline in Hawaiian waters, temperture may play a rôle in determining the lower depth limit of these species.

Within the depth ranges, both species are highly aggregated and are mostly found on or under vertical drop-offs. Where such features are found, such as off Maui and Kauai, both species are particularly abundant. This means that their abundance is related to habitat space and that a positive relationship may exist between abundance and recruitment, least until the habitat is fully saturated. Off Oahu, sediments have covered many submarine terraces and notches thereby significantly reducing the habitat of both species. This may be the reason why there is hardly any black coral off Oahu.

PRODUCTION

The coral divers do not have a special buyer or agent. They sell their coral to anyone who will pay the price. In most cases, coral jewerly manufactures buy the black coral from them individually.

To some extent, the group of black divers acts as a monopoly. Since this is the only significant source of black coral. Though these divers have not become formally organized, they make joint decisions with regard to price. There is a limit to which the divers can increase the supply price because futher increase in supply price may lead to a decrease in demand and/or importation of non-local resources. Such considerations have tended to stablize the price of raw black coral.

If there were any large change in supply or demand, the price may go up in the supply of coral. It all depends if the coral fishing gets better and can meet the demands. But if coral fishing gets better and the demand is low, the prices for raw coral will be lowered.

LANDINGS AND RESOURCE MANAGEMENT

The amount of black coral landed in Hawaii yearly primarly depends on local consumer demand. According to a survey about 85% of local coral jewelry sales were to tourists. The total annual landings have varied from about 5,000 to 7,000 kilograms.

Because it appears likely that the demand for black coral will continue to increase, some sources of resource management will have to be necessary.

While establishing an annual quota for conserving the resource, it may be difficult to enforce. Divers may stockpile landings and/or attempt to create an export market. A better thing to do is to establish a size limit.

If the size limit is sufficiently greater than the size at reproductive maturity, a protected period for reproduction is assured, this is sometimes called a "reproductive cushion."

BLACK CORAL JEWERLY

When the first black coral jewelry was made, the manufactures attention was toward tourist. The tourist bought the black coral jewelry because it was as exotic product found in the deep sea in Hawaii. However, as the local people got more exposed to it , they saw it as a scarce, natural precious stone. The people from Japan preferred black coral to pink coral, because they don't have black coral but large amounts of pink coral. For other tourist it was considered a souvenir from Hawaii.

Black coral is sold in jewelry in such items as, branch pins, tie-tacks, cuff-links, rings, pendants and almost any other type of jewelry. Black coral is also sold loosely in bags for the tourist to take home.

PINK CORAL

The use of pink coral dates back to pre-Christian times. The Italians, Tibetanese, Chinese, Indians, Persians and Japanese used the coral because of its commercial value, but also because it was supposed to have mystical powers. Before 1830 most pink coral came from the Mediterranean Sea. But in the last century Japan, Okinawa, and Taiwan have become the major producers.

Scarcity of coral beds in Japan lead them to discover an enormous bed at 400 meters on the Milwaukee Banks, 500 miles northwest of the Midway Island in the Hawaiian Archipelago.

In 1966 Dr. Vernon E. Brook and Dr. Theodore C. Chamberlain of the University of Hawaii discovered a pink coral bed at 1,200 to 1,500 feet in the Molokai Channel, 6 miles off Makapuu, Oahu.

From 1966 to 1969 several firms were involved in harvesting the pink coral in Hawaii. The colors collected ranged from pink to almost white. Only 10% of the shade of pink, referred to as "Hawaiian angelskin" was harvested. The harvesting stopped in 1969 due to bad weather and no records were kept of how much was collected. Since then, the pink coral jewerly industry has been flourishing in Hawaii, although temporily dependent on imported pink coral.

GROWTH

Measurement of the growth for Corallium secundum (pink coral) after one year is about 0.9 centimeters. Scientists get their measurements by growth rings, which is not a very precise method, but the only they have. The growth rate depends on the health of the coral and its placement on a reef, not on its environment.

HARVEST

The method by which we harvest our pink coral in Hawaii is the same as the Japanese technique. They use tangle nets attached to stones, which are dragged across the bottom where the stones serve to dislodge the coral, after which it is entangled in the nets. This method obviously is a hit and miss operation. It is also not too economically successful, because dredging vessels locally have employed only one line per haul. Japanese vessels have up to 16 lines a vessel. We must increase our efforts for better harvesting to become competitive.

The University of Hawaii is planning to collect coral with a submersible. This will allow selective harvest and also will help us conserve the resource.

DISTRIBUTION AND ABUNDANCE

The geographic range for pink coral extends from the Hawaiian Islands to the Milwaukee Banks. The depth range is about 350 to 475 meters, but some colonies have been found as shallow as 230 meters. Most of the pink coral are found in patches at the 200-fathom contour on the Oahu side of the Molokai Channel. Bottom currents are bi-directional and range between 0 and 150 centimeters.

The entire bed of pink coral estimates about 80,000 colonies. But the estimate standing crop is about 26,000 kilograms in the Makapuu bed.

IMPORTED PINK CORAL

Except for the time between 1966 and 1969 when a small amount of pink coral was harvested locally, Hawaii's coral industry depends mainly on imported resources. The imports included three categories of pink coral: cruel or raw coral; coral polished, but unset; and coral jewelry.

Hawaii's inported coral came mainly from Japan, Taiwan, and Hong Kong, with a small exception which a small amount came from Okinawa and Italy.

LANDINGS AND RESOURCE MANAGEMENT

Landings over the past 3 years have averaged about 1,200 kilograms, which is slightly high. The maximum landing should be around 1,000 kilograms per year, so that there is enough time for the coral to mature in growth.

At the present time there is no need to limit how much is being harvested, because the cost to operate a submersible is doing the job. What would be more useful would be the prohibition of all forms of dredging for precious corals because it can ruin the habitat.

A jurisdictional base for management of the pink coral fishery by the United States had been established in 1958, by the Geneva Convention on the Contiental Shelf. Since the pink coral fishery is just outside of the state's territoral sea, its management should become the responsibility of the western Pacific Reginal Council.

PINK CORAL JEWERLY

Pink coral is sometimes considered a precious stone. The pink coral industry started in the same manner of the black coral industry with the thought of tourist sales. Pink coral also has a souvenir value, even though it seems more of a precious stone. The pink coral labeled as "genuine Hawaiian angelskin" are imported from Japan, although it has been harvested in the Hawaiian Archipelago by Japanese fisherman.

Pink coral is found in almost any type of jewelry you can think of. It is also sold in branches as souvenirs for the tourist, to take back with them.

STONY CORALS

There are many types of stony corals some of them listed in the order of importance are Pocillapora meandrina, Pocillapora damicornis, Fungia sctaria, Portes lobata and Montipora verrucosa. Out of them one is of commercial use, that is the Pocillapora meandrina species. Pocillopora damicornis and Fungia scutaria are found in shallower waters and are protected by the law.

The Pocillopora meandrina species is found mainly on the leeward side of the islands of Oahu and Hawaii. The minimum diameter of colonies of the Pocillopora meandrina is about 16 meters.

Stony corals or reef-building corals, which are used by the construction industry are not in danger of being overharvested, although small colonies of Pocillopora meandrina, Pocillopora damicornis and Fungia sctaria are preferred for a number of reasons and it could become locally extinct.

GOLD CORAL

Gold coral was first discovered in 1967 and was not of commercial use until 1974 when an entire bed of gold coral trees was found off Kaena Point on the island of Oahu.

Gold coral is extremely rare and they are occasionally found among the pink coral trees. The gold coral trees are cut and polished in the same manner as the pink corals. It is also made into jewerly, in such forms of rings, earrings, pendants and so on.

CONCLUSIONS

If our precious coral resources are not limited in harvesting, they could become extinct. Naturally, Hawaii would not want to lose a main resounce like coral. Coral may be abundant now, but maybe in the future years it will be no more. What will happen then? Hawaii should start preserving the coral now and so there will be some for later on.

Ways in which Hawaii could preserve its natural coral resource are, first, to limit the amount of harvesting and second, to make coral reservations, which coral could be grown, just like plantations in which grow plants for people to eat.

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PRAWN AQUACULTURE

PRAWN FARMING IN HAWAII

by Leslie R. Kop, Sacred Hearts Academy

Introduction

Aquaculture is not some mysterious science. It has many practical uses and it may be one of the most rewarding field in which science can make an immediate and lasting contribution to mankind.

For thousands of years man has farmed on land and has neglected the sea. Aquaculture, as an important addition to the world's food supply, also has the responsibilities for protection of the seas and the coastal areas.

The purpose of this paper is to discuss the major aspects of prawn aquaculture in the State of Hawaii.

Introduction of Prawns

In 1965 the Fish and Game Division of the State of Hawaii imported 36 giant fresh water prawns (Macrobrachium rosenbergii) from Malaysia. After a thorough investigation of the physical and biological characteristics and after a number of trials, a technique was developed. The state scientists can now hatch eggs and rear them through the life cycle. More than 2 million prawns of 5 generations have been produced from 36 originally imported prawns.

Advantages

The advantages of this particular species over the many others are

1. it readily adapts to a wide range of salinity
2. it is amenable to culture techniques
3. it breeds throughout the year under natural conditions
4. a large female can produce as many as 80 thousand eggs
5. the female carries and cares for eggs thus resulting in relatively high hatching success
6. it has a relatively short larval life
7. it is a fast-growing omnivore, feeding on both animal and plant materials
8. taste test done by an independent laboratory in New York indicated that the frozen fresh water prawn was more delectable than frozen salt water shrimp. Although it is technically feasible to produce prawns in Hawaii, the economic feasibility of this production has yet to be determined[1]

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1. Shang, Dr. Yung Cheug. "Some Economic Aspects of Fresh Water Prawn Farming In Hawaii," proceedings Kauai aquaculture conference. June 25, 1972. pg 14.

Major Steps Involved in Prawn Production on a Commericial Scale

There are two major steps involved in prawn production on a major commercial scale: 1) producing of juvenile prawns (eggs to a stockable size) in a hatchery and 2) growing stockable juvenile prawns in ponds to market-size.

The first step is to estimate the cost to the farmers in producing juvenile prawns. The production of juvenile prawn involves the building of tanks, the constructing of a laboratory, and the purchasing of different kinds of equipment. There are also yearly costs in operating the hatchery. It is estimated that construction costs of a hatchery facility, with the space of producing 16 million juvenile prawns, would be about $170,000. Equipment costs would be around $21,000 and the yearly operation cost would be in the area of $70,000. The production cost of juvenile prawns is estimated to be about $6 per thousand. However, if both the death rate of juvenile prawns and the length of the production cycle can be reduced, an annual production of 23 million is likely. Then, the cost of production would be reduced to about $5 per thousand.

The next step is to estimate how much it would cost the farmer to produce juvenile prawns in ponds to market-size. For a 10 acre farm construction, cost of ponds is estimated at about $4,000 per acre. The cost depends on the slope of the land, type of soil, and amount of clearing work. The yearly operating cost (including the cost of juvenile prawns) is estimated to be about $4,300 and the equipment cost would be about $700 per acre. The estimated annual production of prawns is about 3,000 lb. per acre. The cost of production of prawns to market-size is about $1.90 per lb. With more experience and studies, the death rate may be reduced and annual production of 4,000 lb. per acre may be possible. Then, the cost of production would be reduced to about $1.50 per lb.

Market Potential

The success of this industry depends on the market potential of prawns. It is estimated that the local market potential is less than half a million pounds at the price range of $1.60 to $2.00 per lb. If the cost of prawns is about the same as that of shrimp,which is equivalent to about $1.20 per lb. in live weight, the local use may be over 0.5 million pounds under a sufficient market promotion program.

There is a potential market on the U.S. mainland and in Japan. However, it is not likely that locally produced prawns can compete with shrimp of comparable size in those markets at this time unless production cost is reduced and/or the price of shrimp is increasing there. With the demand of shrimp greater than the supply, shrimp prices have been increasing rapidly during the past few years in the United States as well as in the world market. This helps to supply some promise for prawn farming in the future.

Observations (Research) 1965-1974

From 1965 to September, 1968, the research into prawn biology and a number of trials, scientists succeeded in developing a practical mass-culture technique and building up a breeding stock that could fill predicted needs for both research and industry. The research allowed completion of the animal's life cycle, that is, rearing from egg to adult. It was found when placed in ponds for the grow-out phase, that is, to grow from small juveniles to marketable prawns, the period of time is 6 to 7 months. Total time to market was approximately 9 months.

1969 through 1971, several small private ponds on Oahu were experimentally stocked with juvenile prawns. Harvesting of these ponds at the end of 9 months produced ponds at the rate from 3,200 to 4,000 lb. per acre per year. Data from these studies were used to develop a production schedule for the ponds based on a cyclic program.

During the 1969 through 1970 time period attempts were made to reduce labor by using 5,000 -gallon larval rearing tanks. Though management of mater quality proved a problem with these larger tanks, the total cost of producing 1,000 juvenile prawns was reduced to $1.93. In October 1970, under terms of agreement, about 260,000 juvenile prawns were stocked in ponds of Fishfarms Hawaii at Kihei, Maui, to test the effectiveness and economics of prawn food. Destroying storms wiped out this crop, suspending the experiement.

However, in April 1971, 4 ponds were reconstructed. In 1971 and 1972 research work continued on a continuous cycling method of prawn culture. Progress was made in cooperation with Gentaro Ota, pond owner, who produced an average of 300 lb. of marketable prawns per acre per month.

In 1973 new larval-rearing facilities at the Anuenue Fisheries Research Center were completed. With these facilities, more than 2 million juvenile prawns per 40-day rearing cycle were provided to stock approximately 100 acres of ponds.

By 1974 several more pond owners had entered into cooperation agreements with the Anuenue Fisheries Research Center and received juveniles to stock their ponds. An estimated 2,700,000 juveniles were produced for distribution to farmers. As a result of the research and development of prawns, there is an economically feasible aquacultural industry in Hawaii.

Conclusion

Fresh water prawn is a new product. For any individual or firm wanting to start a commercial prawn business, it is neccessary that the operation be advised and supervised by a person specifically trained in the culture of prawns. At present, only a few persons within the State of Hawaii have this knowledge.

Aquaculture can provide financial benefits to the state. It can provide an increased form of income through production for local and export markets. Federal funding can generate research and training, thereby creating new jobs for those who are able to work in this field and reducing independence on imports of fish, seafood, and other products. It is very probable that Hawaii can be a leader in this field.

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AQUACULTURE: THE PROBLEMS, POTENTIAL, AND DEVELOPMENTS IN RAISING *MACROBRACHIUM ROSENBERGII*

by Wendell M. Hino, University Laboratory School

Foreword (or Ward Four in the State Hospital)

My decision to waste my time and effort by doing research on Hawaii's prawn industry stems from the fact that the dumb shrimps are raised to be eaten.

At Anuenue Fisheries, I saw the experiments and research projects that were used to gather the data that is presented in my reference material.

All this took place a few years ago when they pioneered the methods that the commercial prawn farmers use today. I was surprised to hear about the progress and new developments made since then.

Recently, however, the aquaculture industry has shown that it can stand on its own two feet. No longer are prawns raised only by guys with backyard swimming pools and bathtubs. Prawns make me sick.

"Eh, we go crabbing in da Ala Wai!"

Introduction

Aquaculture has, and always will be an important subject to consider when Hawaii's economy is concerned. The Division of Fish and Game of the Department of Land and Natural Resources has been trying to establish aquaculture as a major industry, and has conducted research on aquaculture in cooperation with other State agencies and private individuals. If successful, such an industry would provide jobs and income for the residents of this state and make the State of Hawaii more self-sufficient.

This paper focuses on and analyzes the problems, development, and aquaculture potential of one of the animals used in aquaculture research, the Malaysian prawn.

Methods of Research

There weren't any experimental or controversial research methods used in the preparation of this paper. Data was gathered from other reports that were actual field studies, or the results obtained from the production records of the prawn farmers.

Because there was a lack of suitable material at the library, I requested and received reference material through the mail from Takuji Fujimura and Anuenue Fisheries. Others who were involved with aquaculture offered papers and pamphlets on the subject.

Although this paper covers most of the important topics concerning prawn farming and summarizes the content of these four recent reports, it should be noted that the original data from which my generalizations are made are not my own.

Results

The Malaysian prawn, Macrobrachium rosenbergii, was selected for use in the aquaculture industry because it has a number of advantages over many other crustaceans. The species is perennial, and "is widely distributed in most of the Indo-Pacific Region."[1] It inhabits both fresh and brackish water regions, and thrives in either turbulent or calm waters.

[1] "Aquaculture: Macrobrachium rosenbergii." Flyer by Sea Grant

Macrobrachium rosenbergii adapts to a relatively wide range of temperatures[2] once it reaches its juvenile stage, and this makes it possible for it to raised almost anywhere in the State. The hatching success of Malaysian prawn eggs is high because the female prawn carries her eggs, thereby resulting in minimal loss of the eggs to predators.

In addition, Macrobrachium rosenbergii needs less than thirty-five days metamorphose from larva to juvenile, and this metamorphosis can be achieved in only twenty-two days under ideal conditions. It is also a fast-growing species; some individuals reach market size[3] in only seven months.

Because of its excellent potential for success in Hawaii's aquaculture industry,[4] it was inevitable that the Malaysian prawn would be introduced to the State. Many obstacles lay in the path to success. Solutions had to be found to the existing economic and biological constraints, yet a prawn industry, if successful, would be a great asset to Hawaii's economy; the problems were well worth solving.

Thirty-six Macrobrachium rosenbergii were brought to Hawaii from Penang, Malaysia by Mr. Takuji Fujimura in 1965 for the research and the development of mass-culture techniques, a critical requirement in the domestication of an aquatic species.

After four years of intensive research of the biological characteristics of the species and the economics of rearing juvenile prawns at a hatchery, a mass-rearing technique was perfected. At Anuenue Fisheries Research Center

[2] From a range of 15 to 35 degrees Centigrade; max. growth achieved at 31° C
[3] Those larger than 11 cm. in length or 30 g. in weight.
[4] Hawaii's aquaculture industry is essentially in the experimental stage.

on Sand Island, where the largest and most intensive effort has taken place, the mass-rearing project progressed from the research and developmental stage to the point of practical application after numerous rearing trials and experiments were conducted.

The first commercial venture began in 1971 using juvenile prawns provided by the State's hatchery. Presently, Anuenue Fisheries "can adequately fulfill the needs of a commercial operation of almost any size in Hawaii, and although research activities will be continued, primary emphasis will be given to the assisting and encouraging the private sector in the actual commercial production of fresh-water prawns."[5]

There are now about a dozen prawn farmers in Hawaii, and data obtained by harvesting their ponds at the end of nine months by Fisheries Station scientists in cooperation with the farmers was used to develop a production schedule which entails selective harvesting and periodic restocking of the pond to maintain a level population growth cycle.

Despite the major advances made by the prawn industry, comprehensive cost evaluations conducted by Anuenue Fisheries investigating the crucial economics of the rearing trials suggest that by "reducing the labor cost through biotechnological innovations, they can lower their production costs."[6] Labor "accounts for 42% of the total annual operating expenses for a one-acre

[5] Fujimura, Takuji, 1974. Development of a Prawn Culture Industry in Hawaii

[6] Shang, Y. C., 1972. Economic Feasibility of Fresh Water Prawn Farming in Hawaii.

farm and about 23% for a 100-acre farm. Efficiency of labor increases in large-scale operations."[7]

In addition to the problems of labor efficiency, there are limiting factors that must be minimized or overcome to decrease the costs of production and to increase the profit margin for the prawn farmers.

These limiting factors are: (a) lack of an inexpensive compounded feed; (b) competition among "bulls" for choice sites within the pond due to their territorialistic behavior; (c) susceptibility of newly-molted prawns to injury; (d) overloading or underloading of a pond because of initial over or under-stocking; and (e) the (future) market for prawns both locally and world-wide.

Research done to minimize any of these factors will assist in providing the industry with new technology to reduce costs, minimize the risks of loss to investors, and make the expansion of a prawn farm a lot easier.

Competition among "bulls"[8] could be minimized by providing suitable artificial shelter. Territorialistic behavior is probably instinctive but loss of prawns due to injuries sustained through fighting could be reduced by providing (adequate) shelter relative to the number of prawns kept in the pond.

Overloading and underloading of ponds, like the problem of competition, could be minimized by careful planning and by accurate monitoring of the prawn population within each pond. Although it "appears that the female prawns do not exhibit territorialistic behavior and that their growth rates do

[7] Shang, Y. C. and Fujimura, Takuji, 1977. 'The production economics of freshwater prawn farming in Hawaii, p. 101.

[8] Large sexually mature male prawns.

not appear to be affected by the presence or absence of 'bulls', results indicate that monthly culling of market size prawns provided an environment for faster growth among those remaining, both males and females, by reducing competition for food, oxygen, and space."[9] Underloading, obviously, would not suffice for economical reasons; a pond should support an amount of prawns equal to its food, oxygen, and living space capacity. Overloading causes the unnecessary loss of prawns due to competition and it also advocates slow growth.

The feed used for Macrobrachium rosenbergii and the cost of it will remain to be a major problem until someone comes up with a better feed than the chicken broiler starter that is now being used as the basic food for prawns in Hawaii.

"The price of the feed in Hawaii is about U. S. $o. 12 per lb."[10] Feed is a major cost item. On the average, it accounts for about 20% of the annual cost for a prawn farmer. Converted money-wise, feed costs are about forty cents per pound of prawn harvested. It is also important to note that part of the feed serves indirectly as nutrient fertilizer, the base of the food chain. Not all of the feed is consumed, and the plankton that thrive on this supply of nutrients presemably contributes to prawn growth.

The problem of protecting the newly molted prawns is relatively unimportant. Having a soft shell after molting is characteristic of the species, and therefore there is little hope of changing a physical characteristic like

[9] Fujimura, Takuji, June 30, 1974. Development of a Prawn Culture Industry in Hawaii, p. 9 and Figure 6, Length of frequency distribution.

[10] Shang, Y. C. and Fujimura, Takuji, 1977. "The production economics of freshwater prawn (Macrobrachium rosenbergii) in Hawaii.

this one. However, by providing more shelter, the loss of prawns could be reduced because of the protection offered.

The ease of harvesting[11] is given first consideration, but factors such as site selection are the most critical factors in prawn farming. Things such as availability of quality water, soil that is impermeable to water, and the relative flatness of the land are important considerations.

Construction and equipment costs comprise a major part of the prawn farmers initial expenses, but become minor once the farm becomes established and is in operation. As with other expenses, it decreases with the increase in farm size.

Although both construction and operating costs have risen over 30% within the past five years, the annual rates of return increase in relation to farm size as the size of the farm increases. Large farms benefit from more efficiency in resource utilization, which reduces the operating costs, which in turn increases profit.

Conclusion

Macrobrachium rosenbergii has excellent potential in the aquaculture industry because farming it has been proven to be profitable. As new developments are perfected and progress is made in efficiency, farming freshwater prawns will be even more profitable.

As the chances for profits rise, more people will be willing to commit their land and investments toward the industry. By becoming a major industry, prawn farming will help make the State of Hawaii more self sufficient and such an industry will also create jobs for Hawaii's unemployed.

[11] By selective seining.

There is a potential market for prawns in Japan and on the U. S. mainland, and the money generated by this export would further strengthen our economy. No longer will Macrobrachium rosenbergii be thought of as another "dumb shrimp"; I believe the Freshwater Prawn is a swimming goldmine.

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To Takuji Fujimura and Anuenue Fisheries Research Center, Department of Land and Natural Resources for their assistance in obtaining reference material, and to the "Aquaculture Office" at the University of Hawaii for the use of their excellent research materials in addition to their assistance and advice in the preparation of this report.

AQUACULTURE: PRAWNS IN HAWAII

by Dianne F. Kiyabu, Sacred Hearts Academy

INTRODUCTION

One of the biggest problems facing the world today is feeding the billions of people who populate it. Sources of animal protein have become more difficult to find, so man has turned more to the waters of the world to seek answers to his problem.[1] This, in turn, has resulted in another difficulty: overfishing of many species with the end result being the extinction or endangering of some types of marine life.[2]

Within recent years, man has returned to the waterways of the Earth in a new capacity, as a farmer rather than as a fisherman. This was the birth of aquaculture as a science. Laboratories all over the world, especially since the 1950's, have concentrated on the cultivation of aquatic animals.[3] In early experiments, fry, or baby fish, were collected from the sea and then raised on farms until they were ready for market.[4] This eased the problem somewhat, but not enough to counterbalance the overfishing of adult fish and shellfish in oceans, rivers, and lakes.[5] Some success was achieved during the 1950's, again, when scientists were able to breed captive parents fish and shellfish.[6]

It is a historical fact that aquaculture was practiced in Hawaii long before Western man came to her shores. It is estimated that there were 340 to 360 fishponds maintained by the Hawaiians before the coming of Captain Cook, producing mullet and milkfish.[7] The concept of fishing rights in ponds was called konohiki.

Hawaii is still the leader in aquaculture, especially in the raising of the Malaysian prawn, os Macrobrachium rosenbergii. The Fish and Game Division of the State of Hawaii brought in thirty-six of the great freshwater prawns in 1965.[8]

STATEMENT OF PROBLEM

Why was this particular species of prawn chosen to be cultured experimentally in Hawaii? First of all, this prawn flourishes in both fresh and brackish water,[9] and it is also very responsive to artificial culture techniques. Other advantages are that these animals breed throughout the year, and one large female alone can produce 80,000 eggs.[10] Because the female carries and cares for the eggs she lays, there is a high rate of success in hatching of the eggs.[11] Also, this species has a short larval life and is a quick growing omnivore.[12]

The "Udang Galah", as the prawn is called in Malaysia, is distributed in most subtropical and tropical areas of the Indo-Pacific region.[13] This means that their natural home environment is very similar in climate to their adoptive environment in Hawaii.

A big plus for the Malaysian prawn is its very superior taste. It has been highly recommended by people from the countries of Asia and the Far East.[14] In one taste test, conducted by an independant New York laboratory, frozen freshwater prawns were judged to be much more delectable than frozen salt water shrimp.[15]

Prawn are considered a luxury food item and would probably be purchased mainly by hotels and restaurants, more than by consumers.[16] The wholesale price of importing prawns with heads on is $2.00 per pound, which is roughly equivalent to $4.00 per pound with heads off. If they are locally grown, the cost comparison would be $2.30 per pound with heads to $2.50 per pound without heads.[17] This shows that it would indeed be an advantage to grow the prawns locally.

RESEARCH

Research on Macrobrachium rosenbergii was started by the Department of Land and Natural Resources in 1965 when Mr. Takuji Fujimura, Chief of the Anuenue Fisheries Research Center, Division of Fish and Game, first brought thirty-six of the giant prawn to Hawaii from Penang, Malaysia.[18]

Since then scientists have found that a very good place to raise prawn is in earthen ponds. The earthen ponds vary in shape, the bottom slopes varying from .75m (2.5') to 1.4m (4.6') at the deep end. The embankment also slopes. Grass is grown on the perimeter of the ponds for stabilizing the bank, providing shelter for young or moulting prawn, and in some cases it is a supplemental food for the prawn. Water is supplied constantly and a rich bloom of algae is kept up to help with cleaning the water. It also acts as the base of the food web in the pond.[19] Delivering the water is done through a pipe coming from the main line. The pipe runs to the "head" of the ponds. The main line is connected to a well or a water source.[20]

Brine shrimp in its larval stage can be used as food for freshwater prawn, and are easily raised.[21] The prawn feed consists of 90% broiler starter to 10% shrimp feed. The feed is loaded onto the bed of a truck; while one man drives the other shovels the food into the ponds as they are passed.[22]

LIFE CYCLE

The life cycle of prawns goes from egg to adult to spawning to more eggs. The embryonic development takes approximately 20 days. The larval development takes 30-35 days. The larval stage requires brackish water.[23] Larvae need saline water to survive, but juveniles and adults stages are euryhaline to a considerable degree. Prawn spawn in brackish water and when hatched move to fresher water. Larval prawn do best at 24.4-30.6° Centigrade. There appears to be wide agreement that 28° Centigrade is preferred for larval rearing.[24] The best temperature for 60-day juveniles is 30-31° Centigrade with 29-33° Centigrade acceptable.[25]

After completing a pre-mating moult mature females are ready to be bred. Located in the dorsal and lateral parts of the cephalothorax the ripe ovaries are visible as large, orange-colored egg masses. Average-sized females may lay as many as 60,000 eggs. Females who are larger may produce eggs twice in 5 months, sometimes even more often. When a female completes a moult she is vulnerable to attack from other female prawns. If there is a male in the same pond he will protect her from all attacks. A male prawn may protect 4-6 prawns at the same time. The eggs are carried for about 15-17 days and on the 18th or 19th day the eggs hatch. The eggs of the unmated females soon drop from their pleopods.[26]

The cost for producing juvenile prawns of 8mm average length is equal to about $6.63 per thousand. The labor is 77% of the total cost. Suggestions for the reduction of labor costs through biotechnical innovations would reduce production costs.[27] The State of Hawaii appropriated $110,000, in 1976, for temperature control and enclosure of the freshwater prawn hatchery at Anuenue Fisheries Research Center.[28]

In the future, research will be jointly funded by the State and Federal Governments. They will focus their efforts on developing:

1- inexpensive compounded feed,

2- a harvesting and sorting device,

3- a domesticated prawn,

4- methods to diagnose and treat prawn disease and

5- a prototype of a semi-automatic or full automatic freshwater prawn hatchery.[29]

CONCLUSION

In conclusion, I feel that aquaculture has a very bright future in Hawaii, particularly in the raising of the Malaysian prawn. If better food and feeding methods could be found, more efficient harvesting techniques evolved, automation of hatcheries developed, and prawn diseases controlled, production costs would decrease. This would make the prawn available to an even greater market and thus alleviate some problems in sustaining Hawaii's people as well as its economy.

FOOTNOTES

1- Shang, Yung Cheng, Economic Feasibility of Freshwater Prawn Farming in Hawaii, p.1

2- Ibid.

3- Ibid.

4- Ibid.

5- Ibid.

6- Ibid.

7- Department of Planning and Economic Development, Hawaii Aqauculture Planning Program; Interim Report: 1977, p.6

8- Shang, op. cit., p.2

9- Goodwin, Harold L., Aquaculture of Freshwater Prawns, p.8

10- Shang, op.cit., p.2

11- Ibid.

12- Ibid.

13- DPED, op. cit., p.122

14- Ibid.

15- Shang, op. cit., p.42

16- Ibid., p.36

17- Ibid.

18- Carbin, John S., Aquaculture in Hawaii, p.34

19- Gibson, Richard T. and Jaw-Kai Wang, An Alternative Prawn Production Systems Design in Hawaii, p.2

20- Ibid., p.5

21- DPED, op.cit., p.8

22- Gibson, op. cit., p.8

23- Ibid., p.9

24- Carbin, op.cit., p.37

25- Goodwin, op. cit., p.8

26- Sea Grant College Program, Student Symposium on Marine Affairs, p.124

27- Carbin, op. cit., p.37

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AQUACULTURE: SOLUTION TO FISH DISEASES AND WASTE AND INCREASE OF SEAFOOD SUPPLY

by Judith D. Seo, University Laboratory School

ABSTRACT

Seafood resources have been depleting rapidly and it is expected that the supply of seafood in our market will be further reduced due to increasing fish diseases, spoilage caused by poor storage techniques, and the increasing contamination of the fish resources from undesirable chemical substances discharged into our oceans and rivers.

Although presently, aquaculture supplys only 10% of available seafood in the market, there are definite signs that seafood supply will increase through the use of aquaculture. This would alleviate some of the problems of the seafood shortage.

INTRODUCTION

The per capita consumption of seafood has been increasing despite the higher prices. We need more seafood in the market, yet the fishing resources are already being harvested to their greatest extent in the United States.

My paper discusses the following aspects of why the supply of seafood in our market decreased and how to increase needed seafood supply in the market by aquaculture.

Part 1: Fish Diseases and Contamination

Part 11: Fish Spoilage and Handling

Part 111: Fish Consumption and Prices

Part 1V: Aquaculture: Its' Future

Part V: Conclusion

METHODOLOGY

The research of this paper is based on the examination of articles, books newspaper clippings, Seagrant reports, and personal interviews with specialists in aquaculture.

PART 1: FISH DISEASES AND CONTAMINATION

Marine animals, like human beings, have diseases which are difficult to control. Most common fish diseases are bacterial infections such as salmonella. This particular bacteria causes diarrhea. Nearly every type of cancer also has been found in fishes; affecting the stomach, nervous system and skin, as well as the other organs. Fish have high cholesterol levels, thus they are also prone to heart diseases. Another infection-causing organisim is the tape worm. This worm will cause inflamation of the brain and the surrounding membranes. Fish are also affected by allergies. Of course there are numerous other diseases that cause depletion of the supply of the fish resources.[1]

During the last 10 to 20 years, fish diseases have multiplied due to fish contamination by undesirable chemical substances. It is well publicized that contaminated fish-cake was sold in the Hawaiian market in 1971. This caused a number of health problems in our community.[2]

The Monsanto Co., the nation's leading supplier of polychlorinated biphenyl; used as an electric insulator, said it would stop the production of chemicals such as this because of the possible hazardous effects on marine animals. The Allied Chemical Corp. has been discharging Keepone and other chemical wastes into Virginia's James River.[3] This

1. University of Hawaii, "Fish and Humans Share a Common Heritage--Diseases", July, 1976.

2. Honolulu Advertiser, "Perilous Chemicals Will Be Phased Out", Oct. 6, 1976.

3. Honolulu Advertiser, "Firm Fined $13.2 Million For Polluting Virginia River", Oct. 6, 1976.

action caused a horrendous amount of undesirable environmental problems. These are only a few instances where negative outcomes were caused by chemical substances in our fishing waters. It has been said that more fish diseases and contaminations are expected to occur in our surroundings; particularly along the coast lines in developing countries where industries' waste are not controlled or properly treated. All of these wastes and discharges of harmful chemicals will reduce fishing resources and therefore will reduce the supply of seafood in our market.

PART 11: FISH SPOILAGE AND HANDLING

After a fish is caught, there are many steps which must be taken before that fish is served at your dinner table. Soon after being caught, fish must be cooled quickly at a temperature near 32^{o}F. or colder. This means that a mechanical refrigeration unit must be available until the fresh fish can be transported to their various destinations.[4]

Figure 1 indicates that after the fish are caught, they must be transferred to land. Some fish will be frozen and others must reach their coastal buyers, local dealers and markets as fresh seafood. Of course other fish may be canned through a number of mechanical processes. Even after local

4. Hawaii Fish 'n Facts, "Handling Frozen Seafood in the Retail Store", A Seagrant/Food Technology Product, University of Hawaii, August, 1973.

fish dealers obtain the fish, these fish must be kept in the store until they are purchased. There is a problem of storage and display. The poor handling of seafood results in a loss of quality of the fish; many times spoilage occurs and the fish then become waste.

Todays' problems of proper handling of fish are even more complicated due to the fact that our vessels must go far out to sea. Handling fish requires the utmost care and the proper use of temperatures.

PART 111: FISH CONSUMPTION AND PRICES

As Table 1 indicates, the per capita consumption of fish in 1975 was 12.1 pounds in the United States. The consumption of meat and poultry in 1975 was 160 pounds for meat and 50 pounds for poultry. The annual growth rate of fish consumption per capita is much less than that of meat and poultry.

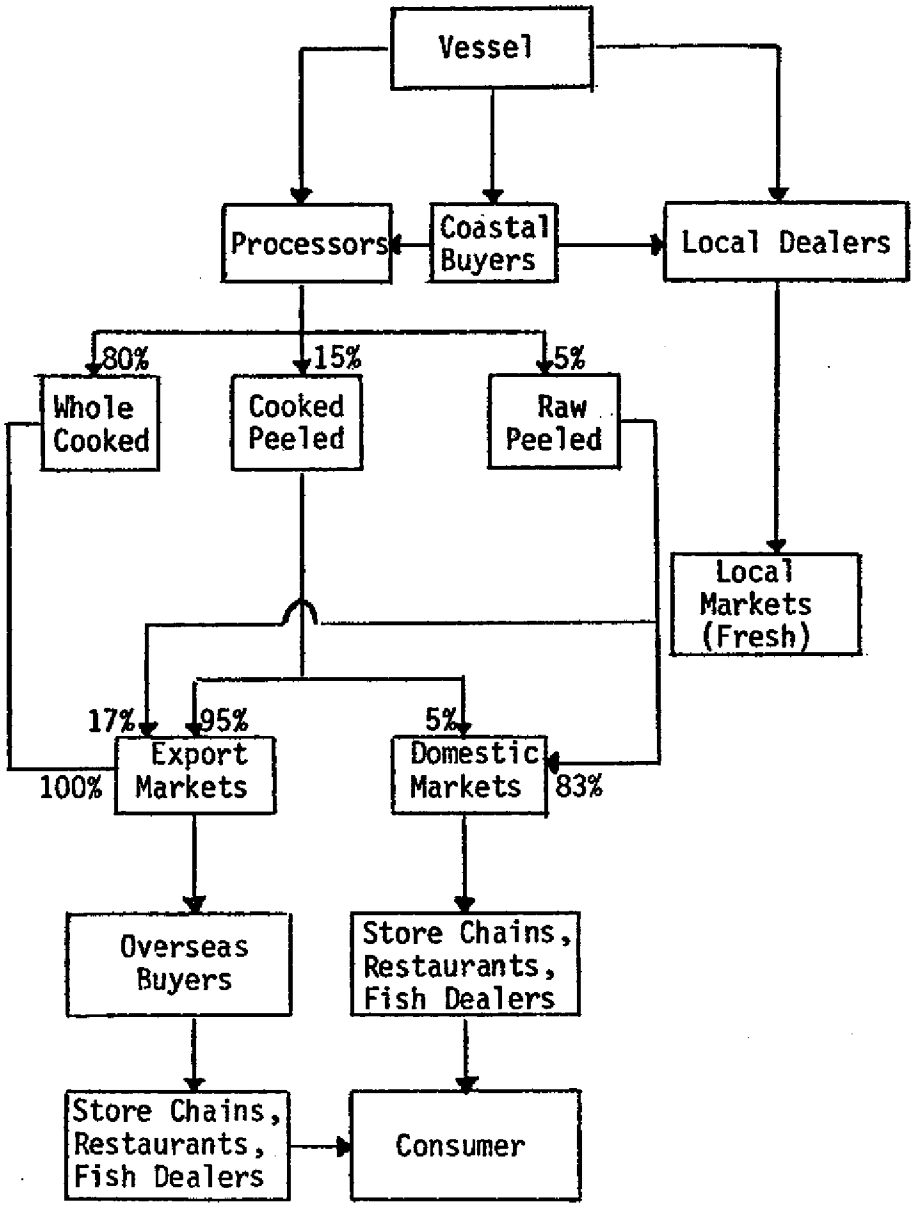
The data of Table 2 indicates that consumer prices have gone up 81.7 percent, food prices are up 99.3 percent, whereas poultry prices have risen only 51.9 percent; meat and fish prices, on the other hand, have increased 104.0 and 139.2 percent, respectively.

If one looks at the projected world real prices for selected seafoods between 1965 and the year 2000, in Table 3,

Figure 1

MARKETING CHANNELS FOR MAINE SHRIMP

(Percentages based on 1971-2 data)



Source: Dunham, Wallace C. and Walter P. Stinson, "Market Structure Analysis of the Maine Shrimp Industry"; Orono, Maine: University of Maine, Life Sciences and Agriculture Experiment Station, Bulletin 705, June 1973, p. 27.

This figure was provided by Professor Richard E. Peterson from his article on "Marketing Economics in Aquaculture", which will be submitted for publication. (University of Hawaii).

Table 1

U.S. PER CAPITA CONSUMPTION OF MEAT, POULTRY, AND FISH, 1950-1975*
(pounds per year, retail weight)

Year	Meat	Poultry	Fish				
			Total	Fresh and Frozen	Canned	Cured	Fresh and Frozen as % of Total
1950	137	25	11.8	6.3	4.9	0.6	53.4
1955	153	27	10.5	5.9	3.9	0.7	56.2
1960	146	33	10.3	5.7	4.0	0.6	55.3
1965	150	42	10.8	6.0	4.3	0.5	55.6
1970	166	50	11.8	6.9	4.5	0.4	58.5
1975	160	50	12.1	7.5	4.2	0.4	62.0
Annual Growth Rate (%)	0.6	2.8	0.1	0.7	-0.6	-1.6	0.6

*Fish consumption excludes amounts harvested and consumed by recreational fishermen.

Fish consumption data source: U.S. Department of Commerce, Fisheries of the United States, 1976

Meat and poultry consumption data sources: U.S. Department of Agriculture, U.S. Food Consumption (1976) and Donald P. Cleary, "Demand and Price Structure for Shrimp," Bureau of Commercial Fisheries, U.S. Department of Agriculture, Working Paper No. 15 (June 1969).

This table was provided by Professor Richard E. Peterson, University of Hawaii, from his article, "Marketing Economics in Aquaculture", which will be submitted for publication.

Table 2

U.S. RETAIL PRICE INDEXES FOR FISH, MEAT, POULTRY AND ALL FOODS, 1960-1975
(Index 1960=100)

Year	Fish	Meat	Poultry	All Food	Consumer Price Index
1960	100.0	100.0	100.0	100.0	100.0
1965	106.8	107.7	94.7	107.3	106.5
1970	138.8	134.9	101.4	130.6	131.1
1971	153.2	133.8	102.0	134.5	136.8
1972	166.9	148.2	103.3	140.3	141.3
1973	191.5	184.7	144.8	160.7	150.1
1974	220.8	188.2	137.4	183.8	166.5
1975	239.2	204.0	151.9	199.3	181.7
1975 Real Price*	1.32	1.12	.84	1.10	
Annual Growth Rate (%)	5.99	4.87	2.83	4.70	4.06

*The 1975 real price of fish, for example, is 239.2/181.7 = 1.32

Source: U.S. Department of Agriculture, U.S. Food Consumption, 1976

This table was provided by Professor Richard E. Peterson, University of Hawaii, from his article, "Marketing Economics in Aquaculture", which will be submitted for publication.

Table 3

PROJECTED WORLD REAL PRICES FOR SELECTED SEAFOODS, 1965-2000
(Cents per pound)

Species	1965-7	1970	1980	1990	2000	Annual Price Increase (percent)
Clams	3.5	3.5	3.7	4.2	4.8	0.96
Crabs	12.0	12.0	21.0	80.0	114.0	7.06
Fish meal	1.0	1.1	2.1	5.7	7.8	6.42
Groundfish	6.0	8.9	15.0	23.0	28.0	4.78
Halibut	25.0	28.0	36.0	45.0	52.0	2.24
Lobster	63.0	67.0	97.0	147.0	311.0	4.96
Salmon	24.0	24.0	28.0	32.0	38.0	1.40
Scallops	7.2	7.2	7.4	7.5	7.6	0.16
Shrimp	37.0	42.0	52.0	67.0	94.0	2.87
Tuna	16.0	16.0	20.0	25.0	30.0	1.92

Source: Bell, Frederick et al., "The Future of the World's Fisheries Resources: Forecasts of Demand, Supply and Prices to the Year 2000 with a Discussion of Implications for Public Policy;" Washington, D.C.: National Marine Fisheries Service, Working Paper No. 71-1, December 1970.

This table was provided by Professor Richard E. Peterson, University of Hawaii, from his article, "Marketing Economics in Aquaculture", which will be submitted for publication.

it is apparent that the annual real price increase expected is approximately 3 to 4 %.

The fish and shellfish with the largest expected annual real price increases are crabs; 7.06%, fish meal; 6.42%, and lobster; 4.96%.

The analysis of these tables indicate that the kinds of seafoods needed in the market have been identified in terms of the price of the product. Mainly, the higher priced items are those with an increasing demand and a very limited supply.

PART 1V: AQUACULTURE; ITS' FUTURE

Aquaculture is the solution to many problems cited previously. Aquaculture allows man to raise seafood for commercial purposes by controlling the environment. Optimum temperature, nutrition, breeding and control of diseases would yield a bountiful supply of seafood. Another positive aspect of aquaculture is that spoilage problems could be eliminated. Storage problems would also be eliminated since seafood would be harvested on land where refrigeration facilities would be readily available. Perhaps of greatest importance is the fact that we could raise specific types of fish; those which are most demanded in the market. Indeed, aquaculture would not only increase our supply of seafood, but would help to alliviate food shortages in the world.

However, aquaculture activities are not easy. The success of aquaculture depends on proper research and the ability to overcome many technical problems such as environment-control and other factors which were mentioned earlier.

PART V: CONCLUSION

In view of the depleting fish resources in our oceans and rivers and the increasing cost of obtaining seafoods, aquaculture is a definite solution in providing the market with an increasing supply of much demanded seafoods.

In the same manner that"green houses" are used in the florist industry, aquaculture would allow man to control the environment and raise the kinds of seafood which are most desired.

Aquaculture has been found to be successful in providing almost 100% of the seafood requirement of Israel.[5]

I believe that through proper research and by encouraging business investments in this field, aquaculture will prove to be a benefit to all mankind.

5. Ka Leo O Hawaii, "Aquaculture is Way to Meet the World's Demand for Fish", Dec. 7, 1977.

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ALTERNATIVE MARINE ENERGY SOURCES

OCEAN THERMAL ENERGY CONSERVATION

by Anjulie C. Fong, Sacred Hearts Academy

Ocean Power, an Alternative Source of Energy

Oil is the world's main source of energy. 75% of America's energy comes from it. Over 90% of Hawaii's energy also come from this same source. 30 to 40% of this energy is wasted often needlessly.[1] As population continues to expand and countries keep up toward a higher standard of living, the demand for oil is expected to exceed its production capabilities during the early 2000's. World governments are presenting programs for conservation, reduction, and elimination of wasted energy to their people while researchers are encouraged to find alternative sources of energy.

Since oceans cover about 71% of the earth's surface and 97% of the earth's water is in the ocean, there is no way man can avoid using it as a major energy source.[2] Theoretically, huge amounts of energy can be gotten from the ocean waters. The magnitude of this energy is further reinforced by winds, changes in barometric pressure, rotation of the earth, and earthquakes. Successful ocean energy projects would mean: 1) an almost inexhaustible natural fuel source; 2) no fuel cost except for the cost of construction and maintance of the plant because water will be the free source of energy production; 3) clean energy production with no pollution generated; 4) very little disruption to the earth; and 5) no heat generated except for consumed electricity.[3]

Hydropower is not a new idea. Paddlewheels were driven by water to grind corn as early as 1100 A.D. Later, water was used to generate electricity for farmers and small industry. Presently, hydropower supplies 20% of America's electrical power.[4] Scientifically, energy can be extracted from the ocean through the forces of tides, currents, waves, and from the different temperatures of the water.

1. Tides

The concept of tidal power deals with a great amount of water rushing into an inland bay, reservior, dam, or esturary at the high tide and becoming trapped in it. This causes a difference in the water level between the inland area and the sea. After a few hours this water is allowed to receed back into the ocean.[5] It is only at very high tides and during either the high tide (half cycle) or the high and low tide (complete cycle), that energy is produced.

During the half tide cycle, water flows through sluice gates and spins turbines that are connected to drive shafts to produce electricity for 6 hours (the number of hours it takes for all of the trapped water to pass through the sluice gates). During the complete tide cycle, water flows through a control gate that channels the high tide, to turn the turbines until the water reaches a specific level and the tide has fallen to a specific point. When this happens the control gate is closed and a gate on the opposite side of the dam opens to allow the trapped water to flow back into the ocean while spinning the turbines on its way out.[6]

In 1956, 36 years after America first considered a tidal power project, France built the simplest experimental type of a tidal plant on the Rance River. Using 24 turbines as pumps to raise the water to a higher level so that more energy could be produced. This plant began operating in 1967. Information of all kinds were gathered from this plant but nothing has been done to extend this project. The Kislet Inlet on the White Sea in U.S.S.R. is the only other place of a working tidal project.[7]

Canada's Bay of Fundy has the greatest tidal range (a difference of 50 feet between a high and low tide) and is often talked of as an ideal site for a tidal project.[8] In 1919 a Canadian and an American separately made studies of the area and presented their findings and proposed projects to their respective governments. They were not able to convince many supporters about their research but through the years that followed, on and off study groups have been formed to evaluate the possibility of such a projected. Had their plans been put into effect and jointly, reports show that if a gigantic plant was developed on this site, it could provide Canada's Maritime Power Pool with most of its electrical energy need for this century and electrical energy for the southeastern portion of Canada to Maine, New Hampshire, Massachusetts, and possibly Vermont.[9]

In 1955 England proposed a tidal project on the Severn Estuary for an output of energy which was to be controlled by an operator rather than the tides. Their plan was similar to America's plans for the Bay of Fundy, except on a much smaller scale. An estimation of 12% of England's daytime electrical consumption could be produced by mid-1980 at a cost which by today's standard would be considered economical.[10] Other possible tidal sites are the Gulf of San Jose in Argentina, the Yellow Sea off the west coast of Korea, and Collier Bay in Australia.

2. Currents

Portions of ocean water that move in a continuous direction covering a distance sometimes up to thousands of miles are called currents. There are surface currents that flow at different speeds and in different directions at the same time. The northern flowing Gulf Stream current in the deep waters between Florida and Bimini 150 to 400 feet down is America's site for a current project. Plans to construct 200 large turbines resembling windmills are to be positioned under the sea at a specific level where the fast moving current can rotate the turbine's blades to generate electricity. Current projects have never been tested but appears to be the easiest method to produce alternative energy.

3. Waves

Waves continuously move vertically in an up and down motion except when they break horozontally at the shoreline. They have no weight and are not a moving mass of water. Tides, wind, submarines, volcanic eruptions and earthquakes cause waves.[11] Wave power can be turned into many kinds of useable energy: 1) energy that is sent ashore by relaying cables for land use; 2) turning water into hydrogen by electrolysis; and 3) used to extract a supply of cheap and limitless amount of uranium for nuclear power.[12]

England is most interested in this power source because it has a useable shoreline of 900 miles that recieves much wave activity during the winter just when the demand for energy is highest. England already has an experimantal machine that can rotate with the motion of the waves to generate electricity. However, to build a working structure that would equal a power station is still a long way off. A powerful wave station would be technologically simple to build and could be built faster than a nuclear power station for energy. Wave power is seen by the English as something like an insurance policy taken out just in case there is a disastrous nuclear accedent that would make it impossible to build nuclear power stations.[13]

America's Isaac Wave Pump last year produced 100-500 watts of electrical energy in Kaneohe's waters. State funds are being sought for to build a larger experimental pump. A practical use for this pump would be to raise nutrient-rich ocean water for aquaculture projects besides being used to turn energy for other kinds of uses already mentioned.[14]

4. OTEC (Ocean Thermal Energy Conversion)

OTEC os a form of solar energy by which tropical ocean surface water (70degrees F) and deep cold water (40 degrees F) provide the energy to generate electricity. Researchers prefer using OTEC's closed cycle concept where a working fluid is used as the heat exchanger to generate electricity instead of using the vaporized warm water to move the turbines in the open cycle concept. OTEC plants could produce hundreds of megawatts of electrical power, hydrogen gas, chlorine and ammonia. Ke-ahole Point in Kawaihae Harbor on the Big Island has been chosen for the proposed project site because: 1) this site requires a relative short cold water pipe; 2) Hawaii's surface water temperature is about the same year round; 3) Hawaiian waters are not exposed to hurricanes that would damage the platform; and 4) the floating vessels will not be in International waters.[15]

In general, ocean projects have received very little support from public and private power. Reasons for these are many: 1) energy plans seem revolutionary and people are reluctant to accept these new ideas and changes; 2) the theories are feasible but actual operations are a long way off; 3) costs of these large plants run into the billions of dollars; 4) not enough suitable places exist for these plans; 5) demand for energy can not depend on tide cycles. 6) Politicians who allocate funds rarely look beyond election year and would cut funds when energy problems seem to be working themselves out; 7) all out support for specific projects could throw existing energy supplies into a panic and they will try to earn as nuch as possible in the limited time left to them.

While people are discussing the pros and cons of ocean power, oil is depleting rapidly. Arab countries own 58% of the world's oil. Since they provide 80% of non-Communist Countries supply of oil, these countries are being placed in a sensitive position and international tensions are high.[16] If nuclear energy is to be chosen as the new main power, the whole world will be placed in an even more serious circumstances. Electricity seems to be the best alternative main source of energy for international independence and peace. It is available in great quantities from the oceans and ready for the taking.[17]

To respond to the changes in the energy system, scientists and engineers must be allowed to experiment with their ideas for solving the problem. It takes years to develop new energy technologies but the key to the future energy supplies in in new technology. Researchers must seriously and objectively evaluate their proposed projects so that money and time, which are limited, can be put to good use. Projects where chance of success are small or improbable and way-out schemes that offer fantastic opportunities should not be given any considerations.[16]

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Foot Notes

1. Comprehensive Energy Program p. 2
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4. Ibid p. 138
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OTEC: AN ALTERNATE SOURCE OF ENERGY AT KE-AHOLE

by Lisa M. McPherson, Pahoa High School

ABSTRACT

As more and more research is done on the sea, we begin to discover ways in which the sea can help us. We are now just learning how to use the precious resources the sea has to offer. One of these resources is Ocean Thermal Energy Conversion. This source could help Hawaii greatly in becoming an energy exporter.

INTRODUCTION

Today, while we are more dependent on energy then we were a century ago, we do not have as much energy as in the past. We have used up practically all of our energy producing resources, such as oil. In Hawaii, oil is our chief source of energy. Because of this, we are forced to find other ways of producing energy from whatever resources we have.

Here in Hawaii research is being done on several alternative energy sources. One source that interested me the most was Ocean Thermal Energy Conversion (OTEC)--which is a type of Solar Energy. The name OTEC was given by the National Science Foundation-Research Applied to National Needs (NSF/RANN). This name is the one used now instead of the half dozen or so names earlier given by others.

OTEC interested me more than the other types of energy because I was curious to know how it worked and how it was possible to produce energy from the sea. I've been very concerned about the energy shortage and decided to report on OTEC because the day is coming when we will surely have to rely on other sources of energy.

MATERIALS AND METHODS

The first place I tried looking for information on OTEC, was the library. Since OTEC is fairly new there were no books on the subject. I looked through The Reader's Guide hoping to find some magazine articles about it, but found nothing. This is when I finally called the Marine Advisory Agent for west Hawaii. He had just about everything I needed, in pamphlets, reports on alternative energy sources, and many other types of information.

RESULTS OF RESEARCH

An OTEC plant can be put anywhere there is deep water with a significant temperature difference of 40°F. The surface waters should be about 70°F to 85°F and the temperature of the water below the 2000 foot depth should be 40°F or less. In the OTEC process, the warm surface ocean waters provides the heat source and the deep cold waters provides the heat sink.

Ocean Thermal Energy Conversion is a type of Solar Energy. The equipment used to convert this energy operates like a steam turbine but uses a low boiling point liquid sush as ammonia or propane, usually in a closed-cycle system. The system used to produce this energy is known as the Rankine cycle. Which was developed by William John Macquorn Rankine. The following are steps on how the Rankine cycle functions:

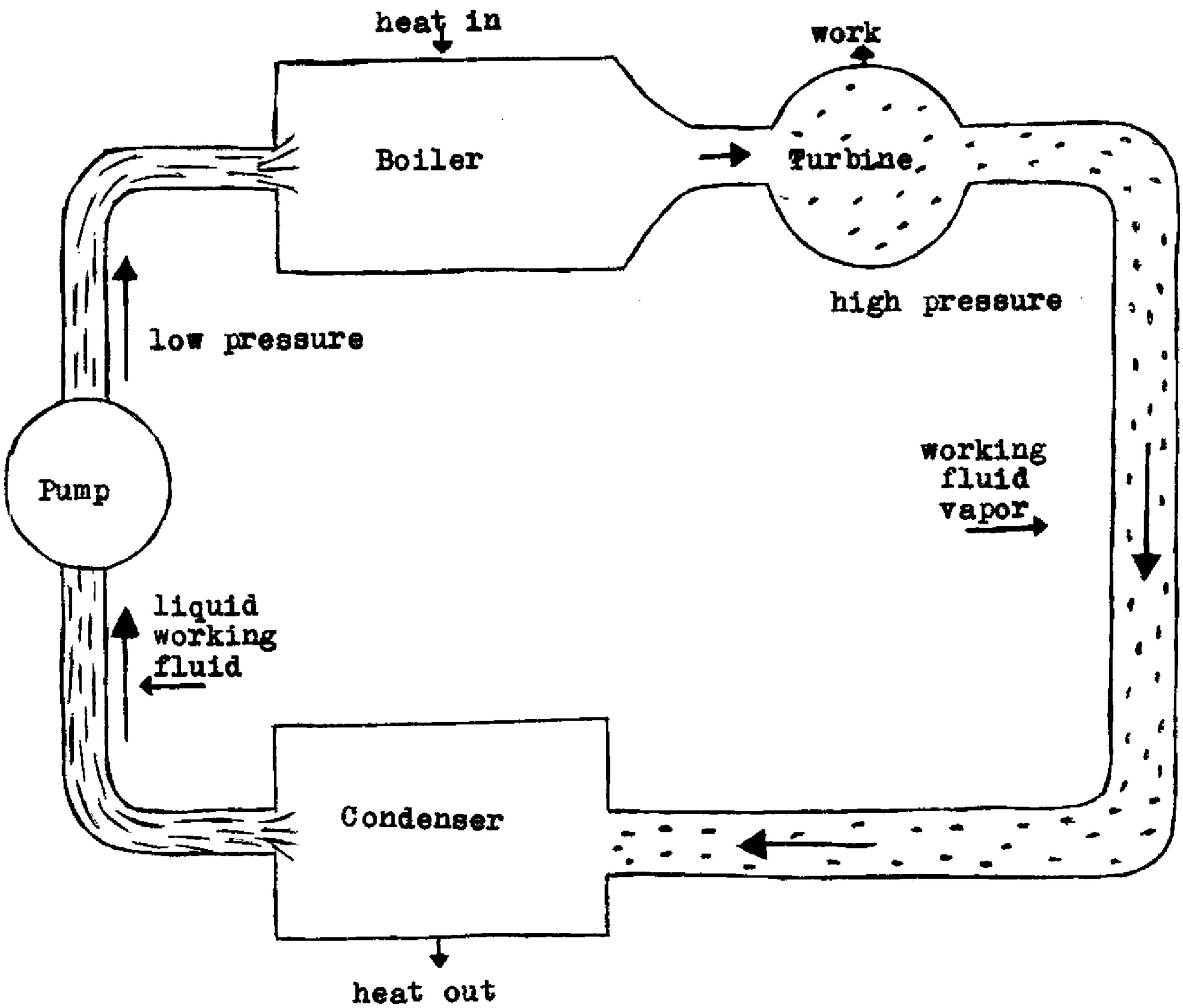
Step:1: The ammonia or propane is turned into a vapor by the warm surface waters, in sections called evaporators or boilers.

Step 2: The vapor with increased pressure passes through the turbine. Where its energy runs the electrical generators.

Step 3: After the vapor has passed through the turbine, cooler because energy has been used. The next step is for it to be change back into a liquid by the cold ocean water at the 2000 foot depth. This section is called the condenser.

Step 4: After passing through the condenser its then pumped back into the boiler, where it starts all over again in an endless cycle.

It takes much work to produce this energy. Huge amounts of warm and cool water have to be pumped into a machine which has a low efficiency level. Also energy is lost through friction. The expected efficiency of a closed Rankine cycle is probably about 1 to 2 percent. This is very low when compared with the 35 to 40 percent expected by a steam turbine power plant. However supporters of the project point out that this fuel is free and almost inexhaustable.



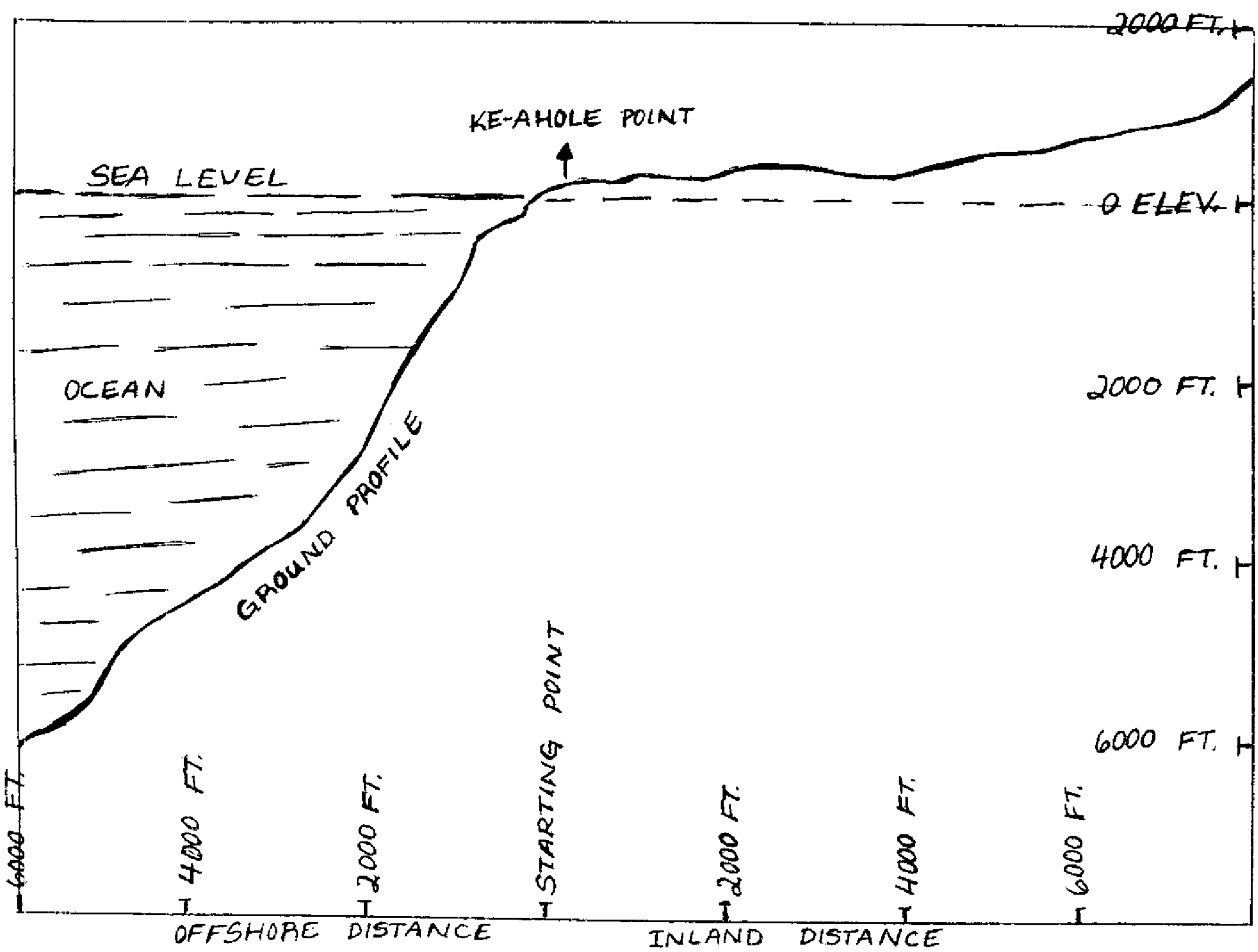
Simplified Diagram of a Closed Rankine Cycle.

*This diagram was copied from a report by the Committee on Alternate Energy Sources for Hawaii, which is called Alternate Energy Sources for Hawaii.

At Ke-ahole point, located in the Kona district on the island of Hawaii a facility is now being constructed--for a number of research projects. All of which contribute to the development of alternate energy systems. These systems are Ocean Thermal Energy Conversion, Biomass, and Direct Solar Energy. The name of this project is The Natural Energy Laboratory of Hawaii (NELH). Out of the eight sites investigated, Ke-ahole met all of the major requirments. The following are some of these requirments: the nearby access to deep cold ocean water; a warm ocean surface; which is not subject to strong seasonal cooling; high yearly solar radiation; easy access to airports, harbors, and highways; and much undeveloped land suited for mariculture and aquatic bioconversion.

The 160 acres granted to this project are state owned, and if necessary more land can be given, without any cost. The site is next to the state airport, which is already served with a main highway. There is also water and electricity within easy access. The area is easy to get to,,and has a flat terrain, which causes no construction or environmental problems. This land has good industrial potential, therefore, agreeing with the future plans for this area.

Ke-ahole is extremely well suited for OTEC, two studies on the site clearly pointed out this fact. The offshore area is unique, because just a half mile offshore the depth of the water drops steeply to 2500 feet. At a mile offshore the depth drops nearly a mile deep. There are few places around the world that have these types of offshore features. Another good reason why Ke-ahole is suited for OTEC, is because it is in the tropic zone. Throughout the whole year, the surface waters maintain a temperature of 73°F to 83°F. The temperature of the water at 2500 feet down, is extimated at 41°F. Further down, in the depths, colder water can be found.



*This diagram was taken from a synopsis prepared by Hawaii Leeward planning Conference on the Ke-ahole Energy Research Facility.

The major project for the Natural Energy Laboratory of Hawaii is OTEC. This federal project is a phased research and development program of the Energy Research and Development Administration (ERDA). The first phase begins with small scale experiments in existing facilities. Then goes on to construction of a land based facility to test components and subsystems and finally the major objective of the OTEC program. To develop a fullscale floating prototype plant for beginning operation in the early 1980's. The hull of this plant will be about 350 feet in diameter and 172 feet high. The generated power will be transmited to shore by a underwater electrical cable.

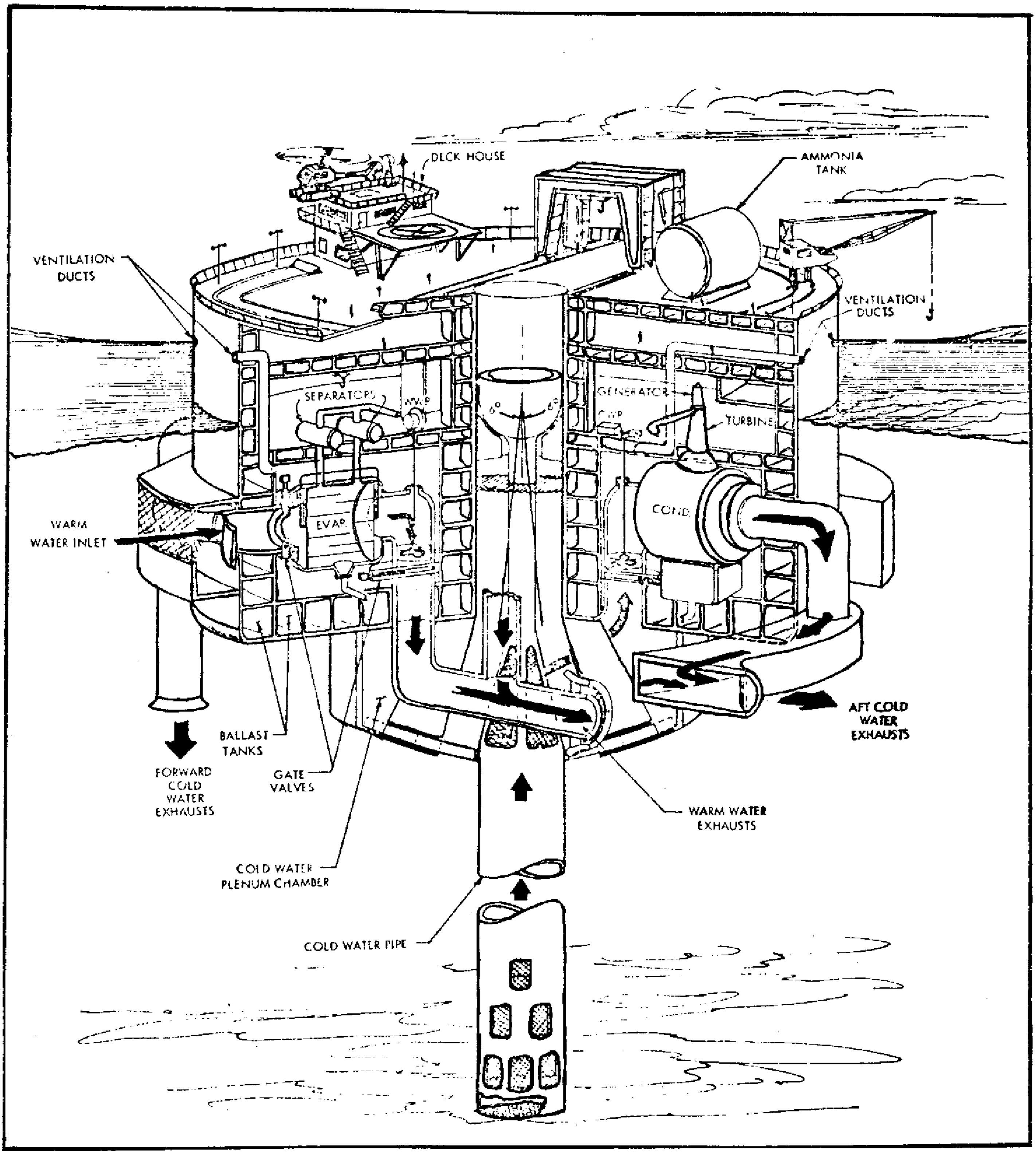


Diagram of a floating OTEC plant

*This diagram was taken from the Environmental Impact Statement for the Natural Energy Laboratory of Hawaii, at Ke-ahole point, Hawaii

DISCUSSION

A floating prototype OTEC plant will cause certain impacts on the marine enviroment. The following is alist of some of the impacts that may be expected.

1. Cold water discharge from the floating OTEC plant will cause the surface waters around the discharge area to cool. The maximum temperature decrease will be about 0.6°F to 1.2°F. This surface cooling will result in the increase of heat flow from the atmosphere to the water, making the air temperature lower by about 1°F, at the surface. The effects of this atmospheric heat loss has not been tested.

   This thermal impact can be decreased by returning mixed discharge water to a depth the temperature is the same.
2. If there is a noticable temperature change within the normal everyday fluctuation in an area 11/16 square miles around the OTEC plant, its considered a significant temperature change. The maximum temperature change in the mixed layer was figured to be less than or equal to 1 F.
3. In Hawaiian waters, zooplankton fluctuations are oppromimately 100 percent. The phytoplankton fluctuations are unknown, but is estimated to be about the same. A normal background flunctuation of 25 percent was estimated and it was concluded that the cold water discharge would be significant in biostimulation in an area of .6 to 1.7 square miles around the OTEC plant.
4. Another impact, is the possible damage to the plankton and larval stages of organisms. Which is caused by the temperature decrease and the shock of the warm surface

water as they pass through the heat exchangers. The average temperature of Hawaii surface waters is about 75°F. The temperature drop expected through the heat exchangers has not been tested yet, but a drop of 4-5°F has been mentioned.

5. The large floating OTEC plant may be an obstacle for boats, but the surface area taken up when compared to the space of the offshore waters, proves it can be avoided.
6. The large amount of nutrient rich water that is brought to the surface could become a valuable by product if the development of open ocean mariculture is combined with plant development. The lack of land and abundant water supply are the major obstacles to successful aquaculture in Hawaii. Open oceam mariculture solves the land problem and the OTEC plant will supply the nutrient rich water needed.
7. The opproximate electrical production at this time for the island of Hawaii is 124 milliwatts and for the state 1,250 milliwatts. The available power we have now will be greatly increased by an OTEC plant, generating 100 to 1,000 milliwatts of power.

The Environmental Task Force of the Committee on Alternate Energy Sources for Hawaii formed a set of standards to judge the significance of the impacts by alternate energy systems. OTEC was rated as one of the least damaging alternate energy systems.

*These impacts were taken from the Environmental Impact Statement for the Natural Energy Laboratory of Hawaii at Ke-ahole point, Hawaii.

CONCLUSION

When first hearing about Ocean Thermal Energy Conversion, I wondered how it was possible to convert energy from the sea. Now that I have done research on OTEC and have written about it, I have come to the conclusion that OTEC is an excellent energy source. One of the reasons I feel this way is its free and practically inexhaustable supply. Unlike other energy sources, it will not run out. To me, this is a very important fact. We would not have to worry about finding other sources of energy.

To produce energy from an OTEC plant, takes much work, but has a low efficiency—which means the amount of energy produced is low. Since the energy is inexhaustable, and does not cause pollution, it has very little impact on the marine environment.

Looking into Ocean Thermal Energy Conversion, has made me aware of the amount of research that is being done on alternate energy systems. Hawaii has a great alternate energy protential which could make us self sufficient in the future. Also, we could become a leader in alternate energy research and development.

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HYDROGEN: DREAM FUEL FOR HAWAII'S FUTURE

by Edward R. Souza and Tracy M. Ban, Honokaa High School

ABSTRACT

With the inevitable approach of another world-wide energy crisis, man must look for new sources of energy or improve the ones we have now. Solar panels, wind and wave generators, ocean thermal energy conversion plants, geo-thermal wells, and nuclear reactors will probably provide for Hawaii's electrical energy in the future. But this technology can only be used for producing heat and electricity and cannot be used for the majority of our motor vehicles. Although there are some electric cars now in use, they have limited range and low performance. According to General Motors, it will be 10 to 20 years before electric cars will have sufficient range for use by the general public.[1] But even if the range problems were overcome, these electric motors will not have enough power to be used in our trucks, tractors, and farm equipment. Neither can electricity be used to power our jet planes.

What we need is a new kind of combustable fuel source. It has to be plentiful, easy to extract, can be produced at a reasonable cost, and is clean burning. In this day and age, such a fuel would be considered a "dream fuel". One fuel source comes pretty close to being a "dream fuel". In fact, we are literally "swimming" in it.

INTRODUCTION

The "dream fuel" we are referring to is hydrogen. It is plentiful, in fact, it is the most abundant element in the universe. In Hawaii we are surrounded by an ocean of it, hydrogen being one of the components of water. Hydrogen can be extracted through electrolysis. It can be produced economically. Also, the burning of hydrogen leaves water vapor as its byproduct, not carbon monoxide or sulfer dioxide as is the case with coal or oil.

Our proposal is for the state to build several small processing plants near the ocean, where hydrogen would be extracted from ocean water that has been pumped into tanks. This hydrogen would be delivered to the homes of owners of hydrogen operated vehicles, much like the way natural gas is delivered to people who live in rural areas. Alterations to automobiles to adapt it to the use of hydrogen fuel would be somewhat costly, but only because the parts needed are not in mass production. When the parts are being mass produced, the cost of converting an automobile to hydrogen use will be much less than it is now.

The state would provide automobiles to a select group of people. It would be better if these people had their own homes so that storing the hydrogen would not be a problem as would be the case for apartment dwellers. The vehicles would be provided on a rental basis, the state making the rent and the cost of hydrogen cheaper than it costs to run gasoline powered automobiles to attract potential renters. As these vehicles begin to catch on, more rentals will be made. Private oil companies would see this as a better future than is oil and would build their own plants. Consumers will see this as a cheaper way of driving than conventional gasoline powered vehicles. Then slowly this hydrogen industry will be established.

We have presented our proposal. Now we will look into the process involved in making the conversion. We will start with a look at electrolysis.

USING ELECTROLYSIS TO EXTRACT HYDROGEN

Electrolysis is the process where a certain amount of electrical energy is used to accomplish a chemical change. Because a current of electrical energy must be maintained, it is essential to have a complete circuit. An electrolytic conductor, placed in a field of two electrodes will do the trick. The chemical reaction will take place at the electrodes, submerged in the electrolytic solution.[2] A power source is engaged to supply current to the electrodes as indicated by the arrows in Figure 1.

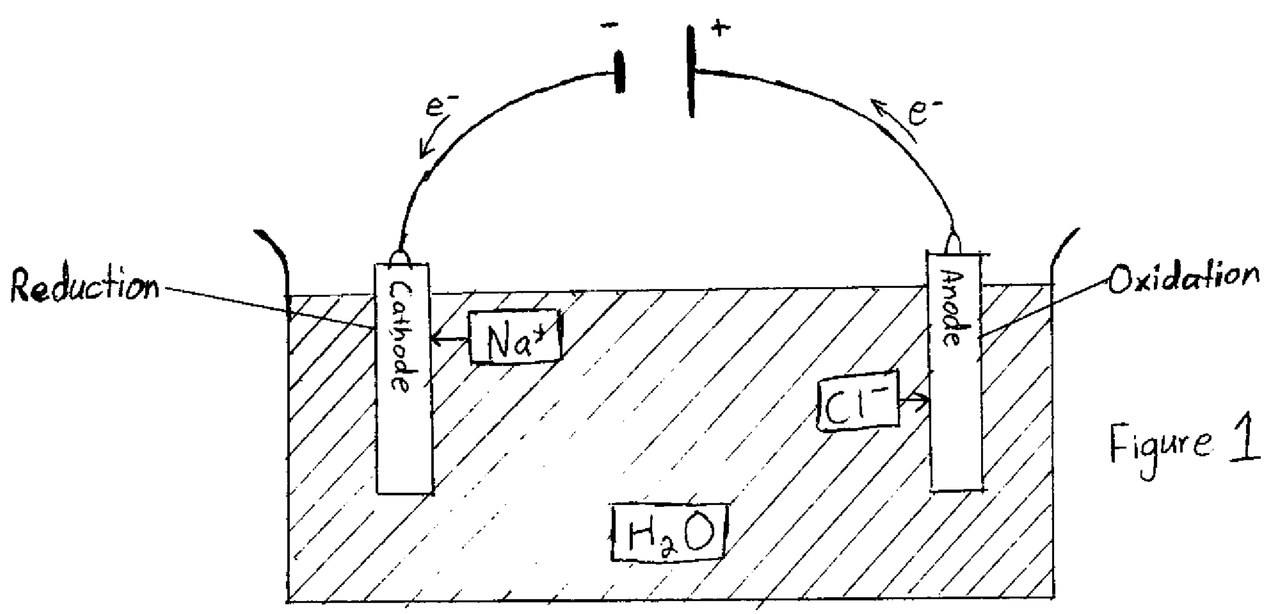


Figure 1

The electrons will drain away from the anode and will accumulate at the cathode.

The reduction process of electrolysis occurs at the cathode. In this process, a molecule or ion accepts electrons and is thereby reduced.[3]

Another process which occurs in electrolysis is called oxidation. The process takes place at the anode. In it, instead of an ion or molecule gaining electrons, it must give it up.[4]

Now we shall talk about the solution that we will be using in our prototype.

ELECTROLYSIS OF THE AQUEOUS SOLUTION NaCl

In the electrolysis of the aqueous solution NaCl, which is the ocean water solution of which we will be extracting the hydrogen, we will not only produce hydrogen gas, but we will also produce chlorine gas. This solution of aqueous NaCl is composed of Na^+ and Cl^- ions, along with H_2O molecules and small amounts of H^+ and OH^- ions.

We said that the process of reduction occurs at the cathode. Instead of the Na^+ undergoing reduction, in this type of solution the H_2O molecules go through the process, producing hydrogen gas. Thus we have the process $2H_2O + 2e^- \longrightarrow H_2(gas) + 2OH^-$ occuring.

At the anode, oxidation causes the Cl^- ions to produce chlorine gas with the reaction $2Cl^- \longrightarrow Cl_2(gas) + 2e^-$ occuring.

Thus, given the reduction process $2H_2O + 2e^- \longrightarrow H_2(gas) + 2OH^-$ occuring at the cathode, and the oxidation process

$2Cl^- \longrightarrow Cl_2(gas) + 2e^-$ occuring at the anode, the overall reaction can be stated as $2Cl^- + 2H_2O \xrightarrow{electrolysis} H_2(gas) + Cl_2(gas) + 2e^-$. This illustrates the production of hydrogen gas at the cathode, and chlorine gas at the anode.[5]

THE PROCESSING PLANT

Now that the electrolytic process has been explained, here are two proposals that we have made for the building of the processing plants:

(A) The plant, built near the ocean, would contain several, each with one anode cable and one cathode cable (Figure 2). Ocean water would then be pumped into these tanks. When the tanks are filled, the current would be applied to the ocean water solution, causing gas bubbles to form at the tips of the electrodes. Both cables connecting the electrodes to the power source would be covered with glass tubing to catch the gases being emitted from the solution(Figure 3). Pumps will then pressurize the gases to their storage tanks.

On the cathode cable, the hydrogen gas will be attracted up the tubing into one storage tank while the anode cable will attract the chlorine gas into its storage tank.

Care must be taken when storing and handling either of the gases. Hydrogen gas is very explosive and chlorine gas is poisonous.

(B) Figure 4 shows our other model. It works on the same principal except that the electrodes, tanks, and pipeline units are placed underground, below sea level. This will eliminate the need for pumping ocean water into the tanks because in this position, gravity is sufficient to cause the water to flow into the tanks. This will greatly reduce the cost of operating such a plant. It will, however, make repairs more difficult due to having to dig underground to repair pipes, valves, etc.

Figure 2

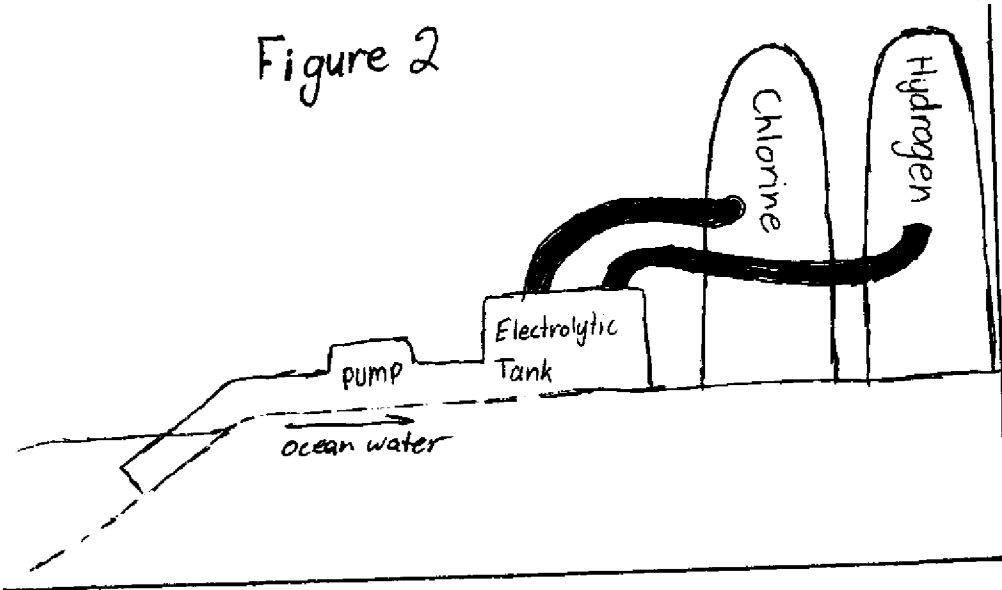


Figure 3

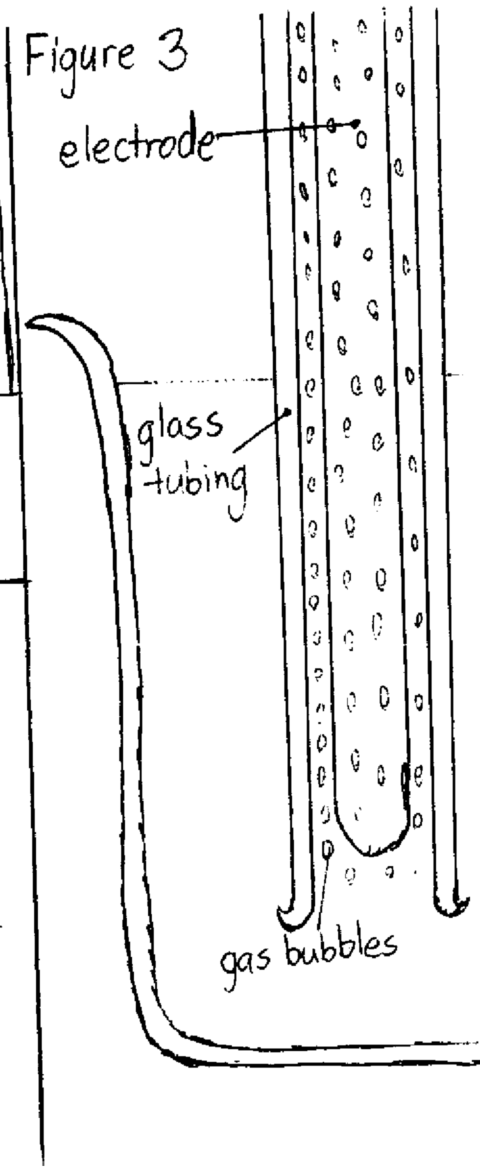
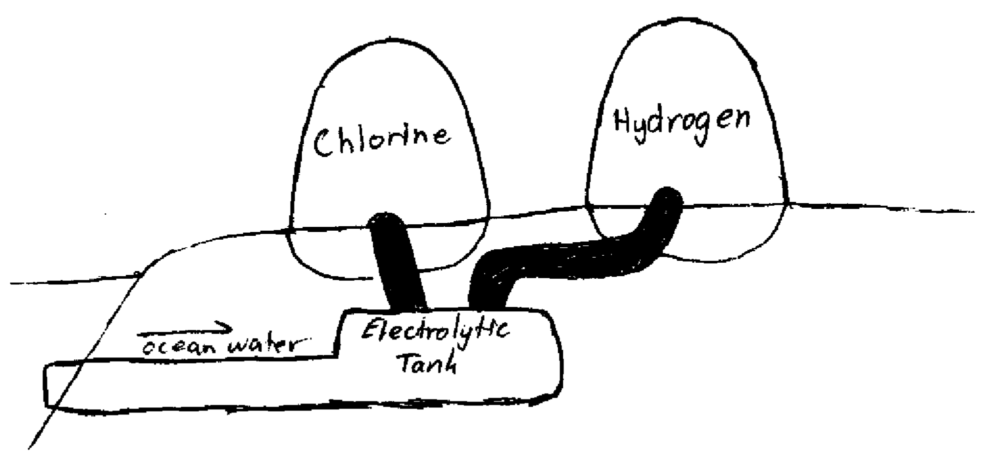


Figure 4



THE EXTRACTED PRODUCT

The chlorine gas in one of the storage tanks can be sold as a raw material to industries that use chlorine in their manufactures. This will generate a moderate amount of income that will help to keep the costs of running the plant down.

The hydrogen, which is stored in the other tank, is in a highly explosive state. It will be too risky to use in automobiles because an accident that causes a break in the fuel tank could cause an explosion. The Brookhaven National Labratory has found a solution to this problem through the use of metal alloys known as metal hydrides.[6] This substance soaks up the hydrogen gas and stores the fuel in solid form. Not only will this make the fuel much safer to use, it will also allow much more hydrogen to be stored in the same amount of space. In fact, 40 times as much hydrogen can be stored in a container in the hydride form than can be stored in the gaseous form.[7]

This hydrogen can know be delivered to the homes of hydrogen car owners, to be stored in tanks in their garage or yard. When the owner is low on fuel, he can refill his tank at home. When the hydrogen industry becomes better established, he can fill his tank at his local gas station.

USING THE HYDROGEN AS A FUEL

There is no need for specially built cars to run on hydrogen, according to Roger Billings, head of the Billings Energy Corporation. He say's that any car can be converted or modified for use with hydrogen by adding a gaseous carburetor, changing the timing and plug gap, and making provision for water induction.[8]

Hydrogen fuel is 2.75 times more dense in energy than is gasoline. This gives hydrogen a better efficiency rating. Billing's estimates that hydrogen engines are 50 percent more efficient than gasoline engines.[9]

However, while our model electrolysis plant uses electricity produced by alternate energy sources, Billings' model plant calls for electricity produced through coal gassification. Producing electricity from coal gassification is cheaper than is from produ- electricity from alternate energy sources, at least at the present time. But we chose not to use coal because it will again make Hawaii dependent on outside sources. Besides that, the extraction of coal through strip mining has been coming under increased criticism from enviromentalists and conservationists, and their may be legislation to prevent strip mining which will make the coal harder to extract, more expensive to produce, and harder to find. We also disagree with the practice of strip mining.

Billings' coal model generating plant produces hydroge at the rate of 31 to 52 cents per gallon of gasoline equivalent.[10] We don't know how much the hydrogen from our plant will cost except that it is sure to be more expensive. In years to come, however, the increased technology will provide hydrogen for us at a lower price.

CONCLUSION

We believe that hydrogen will become our next major source of fuel. The advantages are much more evident than the disadvantages. In the not too distant future, all of our vehicular fuels will be powered by hydrogen.

It is reasonable to believe that the OPEC nations will again raise their oil prices making our gasoline even more expensive. But even if they don't, we will soon run out of crude oil. The technology for hydrogen as a fuel source is here now to develope on. We hope our government won't wait until the last minute to use it.

FOOTNOTES

[1]Bruce Posner,"Detroit Takes EV.....Decade Away" Science Digest, September, 1977, p. 78

[2]Michell J. Sienko and Robert A. Plane,Chemistry(McGraw Hill Book Co., Inc., 1961) p.278

[3]Ibid. p.279

[4]Ibid. p. 281

[5]Ibid. p. 282

[6]Peggy Luedtke,"Hydrogen" Science Digest, October, 1977 p. 71

[7]Ibid. p.71

[8]Ibid. p.69

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OCEAN ENGINEERING: ENGINEERED SYSTEMS

HOW THE ISLAND OF HAWAII CAN ACQUIRE A DECOMPRESSION CHAMBER

by Scott D. Snider, Pahoa High School

ABSTRACT

Men have been exploring the great underwater with the help of SCUBA gear for over a decade. A lot of diving is done on the island of Hawaii. This along with other things makes the accident rate of diving go up. I think for the saftey of diving and personal enjoyment of the ocean, Hawwaii should try to aquire a decompression chamber. This would make skeptics happy and could help save someones life or at least help prevent partial or total paralisis. A decompression chamber would make diving, for work or play, safer and more enjoyable.

INTRODUCTION

I think one of the most enjoyable sports in Hawaii is diving. For someone who has never experienced the depths of the ocean, going diving would be one of the most exhilerating things one could do. There are so many things to do and see that you could never see or do it all even if you spent your whole life at it.

When I go diving the one thing I see the most is other divers enjoying the same sport as I am. With this big percentage of people diving it is likely there will be accidents. The accident that occurs in diving that makes the use of a decompression chamber nessescary is a disease known as the bends. The bends are caused by surfacing to fast with nitrogen in your bloodstream. This disease can leave you paralized or dead. If you were a diver wouldn't you feel safer knowing that in case of an accident there would be a chamber waiting for you? This is why I am doing a study on how we can aquire a decompression chamber on the island of Hawaii.

METHODS OF RESEARCH

My methods of research are few but the sources are good. The first thing I did after making my topic decompression chambers was to attend a meeting at Hilo Hospital with all the people there being specialists on the subject of decompression chambers. Also I had an interview with Nick Berg, a specialist on the construction and use of a decompression chambers. I also made inquiries to Dr. Craven, Marine Affairs coordinater, for information on the subject. With these efforts I have come up with this paper.

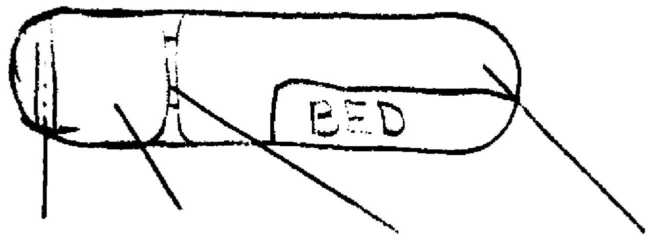
RESULTS OF RESEARCH

First I will try to explain what a decompression chamber is. It is a chamber where when a person has a diving accident involving the bends he can be put in this chamber and the pressure inside is made equal to that of 165 ft. below sea level or five atmospheres. The pressure is then released according to the instructions of a doctor trained in the bends and to the U.S. Navy Standard Air Decompression tables.

The bends is actually caused by ascending to fast with nitrogen in your blood stream. The acsending causes a decrease in pressure making the nitrogen expand, usually in the joints. This disease can cause partial or total paralasis or even death.

The type of chamber to be aquired is a double lock model. This allows, by means of a partition within the chamber, the ability to put medical supplieis or even a doctor into the chamber without changing the pressure in the patient s compartment.

It works like this:



Hatch no. 1 Chamber no. 1 Hatch no.2 Chamber no.2

After the correct pressure has been obtained in chamber 2 the the doctor in chamber 2 needs supplies for the patient so he tells the outside doctor, via telephone, and the outside doctor puts the supplies in chamber no. 1 and makes the pressure the same as in chamber no.2. Then the doctor in chamber no.2 can get the supplies by opening hatch no.2 and not change the pressure in chamber no.2 thus not further endangering the patient.

The need for two doctors is great because not only is the second doctor, on the outside, needed for opinion but for making sure the inside doctor is doing the right things to the patient. After the inside doctor reaches a pressure equal to that of 90 ft. he suffers nitrogen narcosis and his judgement is not always up to par.

This is a chart on the total cost of running a chamber for one year.

Item No.	Description	Parts or service
1.	Gas sampling (2per year)	$269
2.	Misc. parts est.	675
3.	Replacement filters 3/year	243
4.	Compressor overhaul/year	680
5.	Oil expendables. ect.	50

6.	Refurbish 4 1500 cu ft cylinders every two years	$945
7.	Replace oxegen sensor once	172
8.	Recalibrate 6 gages once per year	243
9.	One-man day/month Ocean Tech 12 months	1299
10.	One engineer day/month	2593
		----- +
		$7169

This is estimated cost to run a decompression chamber for one year. These figures have come from MR. Henry Horn who works at Makai Ocean Engineering Inc. They are based on what it cost them to run thier own decompression chamber they have at Makai Range.

At the beggining of the efforts to get a chamber on the island of Hawaii the proposed spot was Kona Hospital but because of the Hospitals location, At 15,000 ft above sea level, it woult be quite dangerous to take a bends victum up that high because of the lower pressure at that altitude. The lower pressure would further enlarge the nitrogen causing a more severe case of decompression sickness.

I think that if the state could not get the the bill for a chamber passed through legislature we should look at other alternitives such as using the plan Maui civers folowed in order to get thiers. What they did was to form a diving club and have dues and money-making projects until they had enough funds to buy and maintain a decompression chamber.

Some of my ideas would be to suggest to dive shop owners to form a club and see if we too could collect funds for a chamber. I think that we could also put up posters around diving areas explaining our ideas and needs. This way we could aquire more members for the club and also to let people know something is being done to get a chamber.

Another method I thought of was to have someone go out to different companies and see if we could get donations. I think If they were able to see our need for a decompression chamber they might think of donating something they might even be interested in sponcer-ing our drive to get a chamber. Another approach would be to ask the stste to get one for the hospital and write it off as a medical expense. I have also been told that if the state could see the value in getting achamber they might try harder to come up with funds for it

CONCLUSION

I hope that one of my plans can be used for a better course of action in the hard fight to aquire a decompression chamber. I have explained what a chamber does and what it is used for. I have also stressed the value of getting achamber fot the island of Hawaii. I hope somebody with influence can see this paper and help us take action in getting a chamber. After all if you were a diver wouldn t you feel safer knowing that if you were in a diving acciden there would be a place for you to go to prevent serious damage to your body? I know I would.

Bibliography

INTERVIEWS

Nick Berg	Owner of Kona Charter Boats and Diving Service
Pete Hendricks	West Hawaii Marine Advisory Agent
Donald Wood	Woody's Aquatic Service

CORRESPONDENCE

Dr. Craven	Marine Affairs Coordinator
Henry Horn	Makai Ocean Engineering, Inc.

HOPE I: THE WAVE OF THE FUTURE

by Dean K. Aoki, Lahainaluna High School

Abstract: Someday the world as we know it shall be too crowded for people expand outward on land. We will have to expand out into the deep reaches of outerspace. People will begin to believe that we can no longer live on this earth and be free to roam around and do what we please. Millions of dollars more will be spent on the all ready over budgeted space program. The question is, "Do we really have to depend on outerspace being our new sanctuary, when there is still room on this earth to live?" Where? you might ask. The oceans is the answer. Sure sooner or later we will be moving into outerspace, but innerspace seems to be the more logical answer at the time.

By building underwater cities we will be increasing the living area a 100%. Because we will be moving underwater, we will need a better means of transportation. I claim that my vehicle is one of the ideal methods of transportation.

Introduction: The cities under the water will not be built in waters with great depths because of the pressure factor. It is for that reason that my vehicle need not be able to stand great pressures. My vehicle will be pollution free as I will later demonstrate. The prototype model will be designed to carry two passengers.

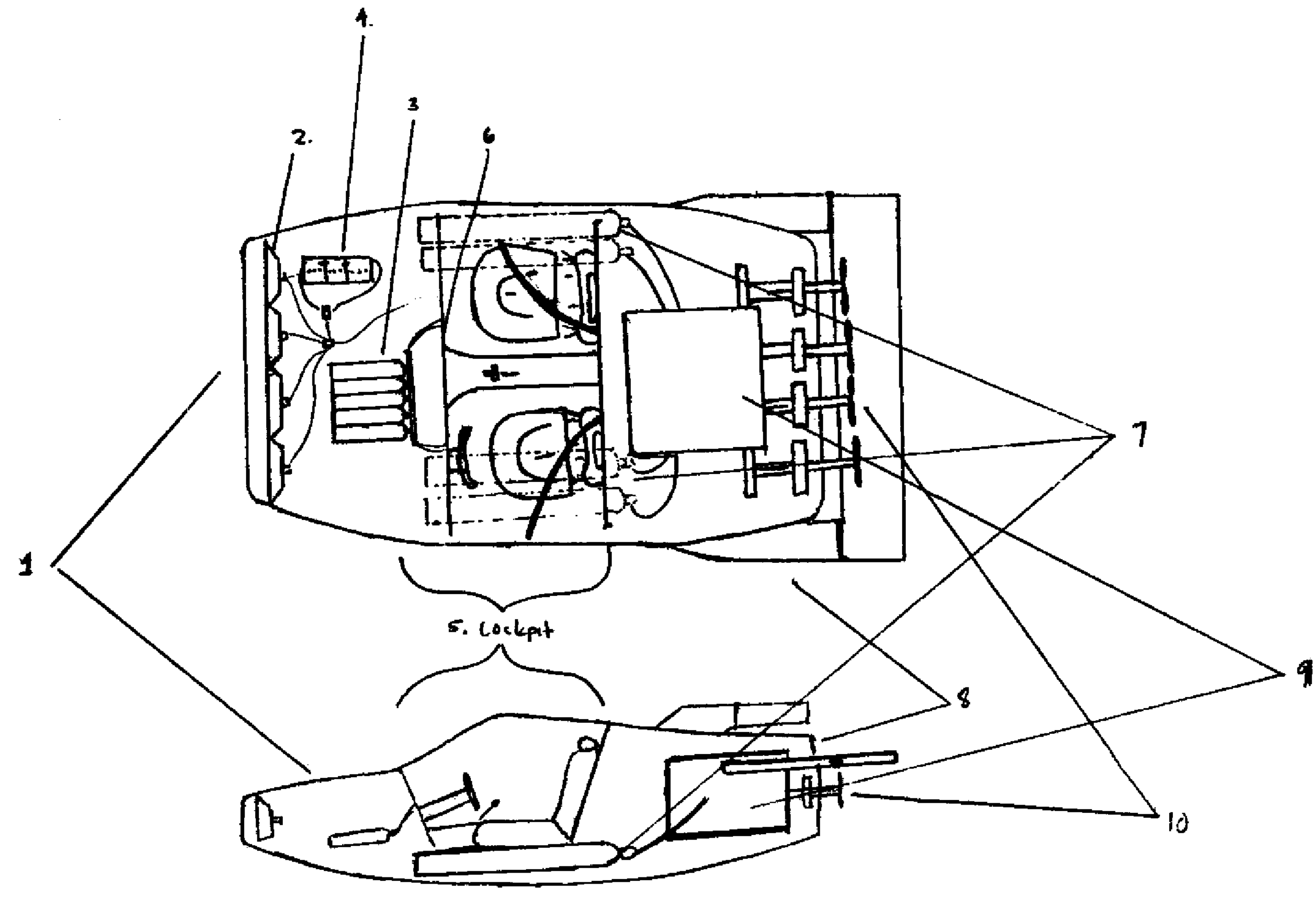
The present systems of underwater transportation are submersibles such as submarines, diving bells, scuba-gear and other vehicles which are operated by men using scuba-bear. The vehicles and equipment were quite limited as to who may operate them. In the case of the submaring, it is a very bulky, overly adequate machine for the purpose of personal transportation. The people who may use the submarine is also limited to naval personnel and researchers who own their own submarine. About the only obtainable apparatus that an ordinary, everyday kind of person could pick up is scuba-gear. The scuba-gear holds many disadvantages as a means of transportation, for if you take into consideration long distance travel, scuba-gear will definitely be ruled out.

My theory creates a vehicle that will operate on similar principles of a submarine. Its likenesses will be that the vehicle will control its depth by means of buoyancy. It will take in and remove water as balast. Other principle will be discussed later in the paper. It will be powered by a Hydrogen-Oxygen Combustion Engine. Appropriately the vehicle will be named HOPE I (H-hydrogen, O-oxygen, P-prototype, E-engine).

Since HOPE I is a prototype model, it will have a seating capacity of 2 persons. The basic design of HOPE I is illustrated in Fig. 1.

Design:

1. Front end infront of cockpit
    2. Lighting system
    3. Tanks for oxygen
    4. Bateries to power accesseries
5. Cockpit
    6. Instrument panel
    7. Tanks for fuel
8. Rear end behind cockpit
    9. Combustion engine
    10. Propellers



The most important dimension of HOPE I is that it is being powered by a hydrogen and oxygen fueled combustion engine. Both the hydrogen and the oxygen shall be tanked separately and on opposite sides of the vehicle. My combustion engine will work on the same principles of the gasoline engine.

In the gasoline engine the fuel is pumped into the combustion chamber in a gaseous state. My fuel shall all ready be in the gaseous state and injected into the chamber. The hydrogen and oxygen at high pressure will burn by itself when mixed, giving off a large amount of heat. However, if a spark is introduced in the presence of the mixture, the hydrogen and oxygen will explode violently. The oxygen itself supports the combustion of the hydrogen fuel. As in the gas engine each chamber shall contain a piston. During the explosion the piston is forced downward turning a drive-shaft, which in turn rotates the set of four blade type propellers in the rear. Acceleration is controlled by the amount of fuel being fed into the engine. The driver of the vehicle can control the fuel consumption by a lever in the cockpit.

The whole system is a closed system, meaning that there will be no exhaust expelled from the vehicle. The product of the reaction $H_2 + O_2$ is H_2O which is water; therefore, even if the socalled exhaust was expelled out of HOPE I, it would be a non pollutant. There is a small chance that oil from lubrication may enter the exhaust water, it is for that reason that the water is not exhausted out of the moving vehicle.

Discussion: With the use of hydrogen and exygen as a fuel, the present fuel crisis will not play a role with the running of HOPE I. Today, researchers are looking for new types of fuels and oil substitutes. My belief is that hydrogen-oxygen will be one of the answers. The H_2-O_2 fuel is recycleable through the process of electrolysis; therefore, there will always be a supply of fuel. Also, as long as there is a supply of water there will be fuel to run my vehicle.

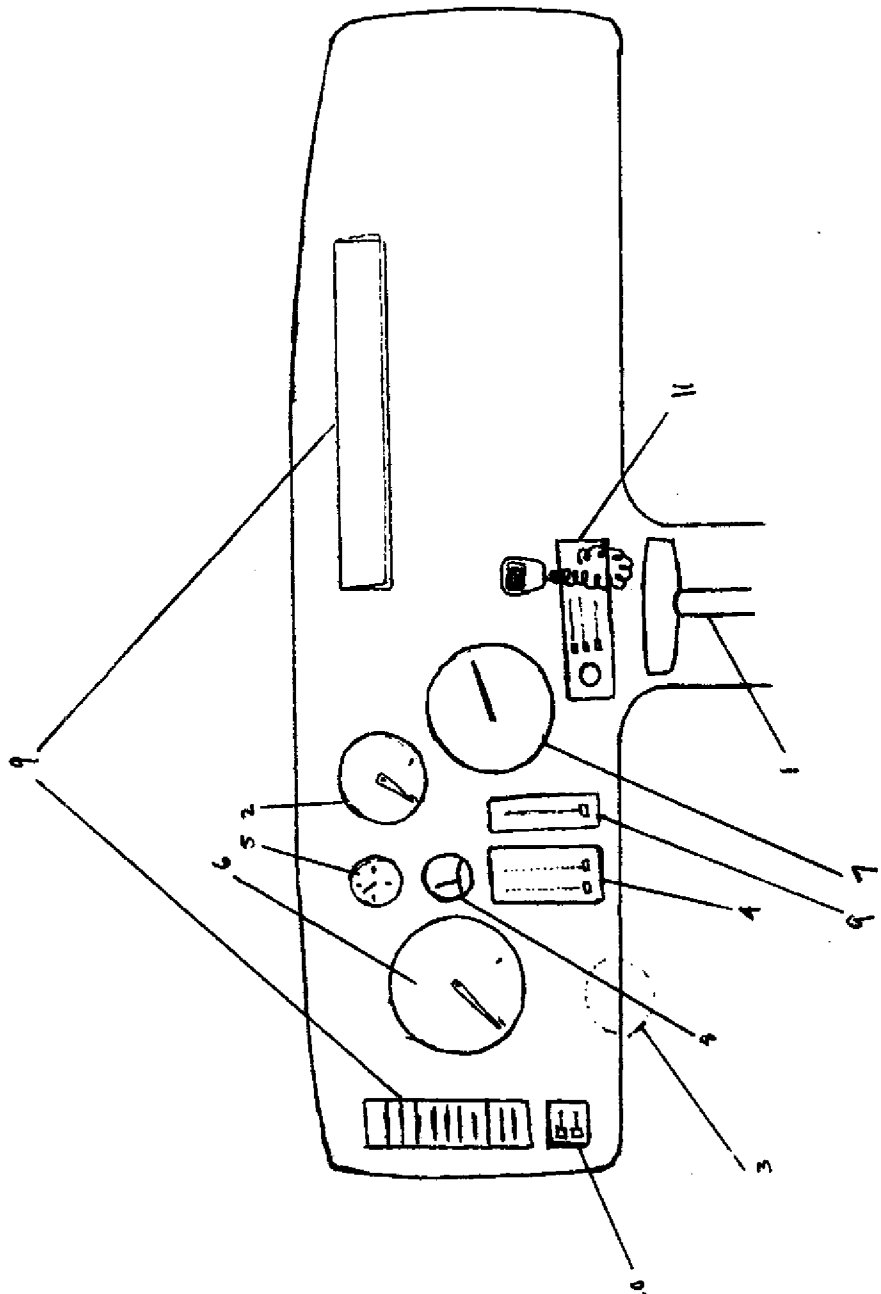
Cockpit: Inside the cockpit the HOPE I will resemble a car. It will have standard bucket style seats with two over the shoulder harnesses so that the driver and the passenger may be strapped in. The instrument panel will contain the following:

1. Slideshift--purpose of the shift is to control the speed at which the vehicle should travel. Sliding it backwards will decrease the power and sliding the shift forward will increase the power.
2. RPM scale--a scale to measure how hard the engine is working against the current.
3. Directional control--controls the left-right, up-down movement of HOPE I.
4. Balast control--controls the intake and releasing of balast.
5. Directional compass--to gain bearings and to plot courses.
6. Speed indicator-- to indicate the speed of HOPE I.
7. Sonar--necessary for underwater travel, to detect underwater objects, depth of the water, and to locate distance underwater.
8. Pressure guage--measures the inside and outside pressures.
9. Air conditioner--controls temperature, pressure and amount of air inside the cockpit.
10. Light switch--turns lights on and off.
11. 2-way radio--for emergencies and communications purposes.

**See illustration #2

Illustration #2

**The directional control is not shown because it will block out the view of the instrument panel. The streering control is similar to that of a car's steering system.



Inside the cockpit: The pressure in the cockpit shall not be a great factor because of the shallow depths involved. One atmosphere pressure would be the desirable pressure. The oxygen will be held in tanks located in the frontend of the vehicle. The oxygen will be pumped into the cockpit through an air conditioning system to regulate the amount of breathable gas in the cockpit. The exygen mixture will be approximately 20% of the total gas in the cockpit while the other 80% will be the original nitrogen gas which was introduced when the vehicle was at the surface. My system will not remove the nitrogen and the nitrogen will not react with the K_2O filter or the activated charcoal leaving the nitrogen a constant. However the CO_2 gases which is produced by our own breathing system will be removed by a filter.

By recycling the air in the cockpit the gases wi remain a constant 20% oxygen and 80% Nitrogen, with the Carbon dioxide being extracted out. The carbon dioxide will react with the K_2O filter to produce K_2CO_3. The total reaction is: $K_2O + CO_2 == K_2CO_3$.

Also by using activated charcoal, the oders caused by human perspiration, tanked gases and enclosed compartments will be removed.

**The potassium oxide filter and the activated charcoal will be changed periodically.

Lighting system: The lighting system is a basic headlight similar to that of a car. It is rectangular shaped and runs along the front of the vehicle. The light is divided into four section. (See Fig. 1) The two outside portions of the l ight are used for clear water dives. It may be used during the day if the cloudiness of the water impares the vision. The inner lights are used in addition to the outer lights. Together they produce a high beam for use in cloudy waters during the night or for better vision in clear water during the night. The frame of the vehicle will extend beyond the lights protecting it from damage. A wire mesh will also be place infront of the light preventing debris coming in contact with the lights.

Safety Margin: In case of a malfunction the cockpit along with the front end will be jettisonned. The bridges which hold the cockpit with the rear end will be broken by a small explosing. The rear end and under the cockpit containers which holds the balast will remain underwater. The cockpit will remain shut and at a stable pressure. However, the possibility of the bends will be ruled out because the cabin pressure will be one atmosphere, the same as the surface pressure. When it is considered safe the exit hatch may be open from the inside.

Conclusion: The design of HOPE I is fairly simple. I did not do research on the cost factor of the HOPE I and I am unable to put even an extimate cost on the vehicle. I believe that my vehicle would be the most convinient means of underwater transportation in the future.

The fuel comsuption of my vehicle is unestimated but it is minimal. While the abundancy of oils to produce gasoline is depleating, my vehicle will suffer no set backs. HOPE I being a hydrogen-oxygen fuel vehicle, it is not dependent on oils. Though the prototype model has parts that are lubricated by oil at the present time, it will not always use oils. New types of lubrications are being developed that are even better than oil.

The reason for my decision in designing an indepently powered vehicle over a station powered vehicle such as a cable car is because of mobility. My vehicle will be totally mobile while the cable type car will have to follow a laid out path. But I do not rule out the idea of a cable car type submersible for intercity transportation.

HOPE I is a non poluting vehicle with its closed system engine with an exhaust of H_2O. I believe that HOPE I will be the vehicle of the future, because of the fact that the exhaust is H_2O and the abundancy of H_2 and O_2.

Though my vehicle is designed for underwater transportation, its principles may be incorporated into a land vehicle. That is why I believe that HOPE I is the wave of the future.

<u>Reference Materials:</u>

1. Interview with Mr. Donald Chaney--Science teacher at Lahainaluna

   The use of hydrogen and oxygen as a fuel.

2. World Book Encyclopedia Copyright 1970 "N"
3. World Book Encyclopedia Copyright 1970 "S"
4. World Book Encyclopedia Copyright 1970 "H"

TSUNAMIS IN THE HAWAIIAN ISLANDS

by Keith Kanetani, Hilo High School

ABSTRACT

Since Hawaii is affected constantly with tsunamis generated locally and from places around the Pacific, averaging one every seven years, it is only fitting to make others aware about the causes, locations and the damages done by the past tsunamis. In the past thirty years six major tsunamis smashed into the islands causing severe damages amounting to millions of dollars. This paper will give some detail facts about the past tsunamis.

INTRODUCTION

Hawaii has been affected with tsunamis dating back to 1813. Since then, many tsunamis have been recorded, but some of them were so small that they hit the islands unnoticed. During the 19th century, numerous tsunamis were reported in newspapers and other news medias, but news traveled slowly in those days and as a result, causes, effects and dates were often scrambled. For instance, if there was an earthquake in Chile, it would take months before it would be known in Hawaii. Toward the end of the 19th century, seismological stations became available and the establishment of the Volcano Observatory in 1912 brought a number of scientists to the islands, who began to make studies on earthquakes and tsunamis. The observatory was established by Dr. T.A. Jaggar, a noted volcanologist. The April 1, 1946 tsunami which originated from the Aleutians, killed 600 people in Hawaii crystallizing the need for a reliable tsunami warning system. In 1948 the Tsunami Warning System was established and has provided warnings of on coming tsunamis. Locally generated tsunamis with localized effects occured in 1869, 1872, 1878, 1903, 1908, 1919, 1921 and 1924. Most of the tsunamis were triggerd by volcanic activity and associated earthquakes of Kilauea and Mauna Loa.

METHODOLOGY

To study the past tsunamis and the devastating effects that it brought to the Hawaiian islands. This paper has been compiled from historical accounts, newspaper archives, charts and other reports. The study points out some of the more destructive waves that hit the islands in the past 163 years.

LOCATION OF THE HAWAIIAN ISLAND

The Hawaiian islands are located in the north central position of the pacific ocean and lies about 2, 300 miles southeast of the United States. The main Hawaiian group of islands consists of: Niihau, Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and Hawaii together with adjacent islets which stretches over a distance of nearly two thousnd miles. All the major islands are inhabited except for Kahoolawe. Long ago two other islands were in the chain, those were Nihoa and Necker, they were inhabited by Polynesians, but now these islands are uninhabited.

TSUNAMIS IN GENERAL

Tsunamis are not always gigantic, it's only when the waves are approaching the shore that it turns into distructive monsters. The average height of a tsunami in the open sea is only about 2-3 feet. During the 1946 tsunami at Hawaii, the crew of a freighter parked about a mile off shore watched the waves break over the buildings, but as far as they could tell there was nothing going by them. Test on tsunamis confirms that the surge velocity is determined by the oceans topgraphy. Tsunamis maintain their strenght for such great distances. The great Krakatoa volcanic explosion in 1883 produced tsunami waves that traveled two or three times around the globe.

In order for a tsunami watch to be instituted, the earthquake magnitude has to be equal or greater than 7.0 on the Richter scale. No one can really predict a tsunami or say that there's a typical tsunami. Every tsunami is different, but there are some common factors. One example is that tsunmis are a seres of waves, you can get some idea why a tsunamis is a series of waves by recalling what happens when you drop a pebble into a pond of water. It produces widening circles, and a tsunami is the same thing, only on a colossal scale.

TSUNAMI DETECTOR

Scientist in the state of Hawaii are developing a new device that will alert people about approaching tsunamis. This deep water sensor will be able to detect tsunamis that are approaching. This sensor will also probe for seismic mechanisms that causes these tsunamis. This device that is being experimented on, will be placed of the ocean bottom, far away from the shore itself. Deep water sensors on the ocean floor around the Hawaiian islands should enable scientist to predict more accurately what will happen and what the amplitude will be before it actually strikes. A gauge will be connected to the shore via satellite or with a cable that will run along the ocean bottom. The estimated cost of this complex deep-water detector will run up to about $80,000 to $90,000, and should be completed in about a year. Cooperative ventures with the Russians will take place next fall. The instrument will be placed in a seismically active place on the bottom of the ocean floor.

Other reasearch is also being done to determine the effects on various Hawaiian coastlines from tsunamis from different parts of the ocean. Other equipment is also being devised to trigger a warning to Hawaiian areas from locally generated earthquakes.

What they hope to accomplish by doing this is to make something that will refine the warning system and reduce false alerts. They don't want to warn people needlessly, otherwise the people may become complacent and ignore the warnings as happened in Hilo prior to the 1960 tsunami in which 61 individuals perished.

DAMAGES DUE TO TSUNAMIS

Devastating effects have been experienced in Hawaii due to two major tsunamis within the past twenty years, namely the 1946 Aleutian tsunami and the 1960 Chilean one, which wiped out the town of Hilo.

There are three types of damages that are produced by tsunamis. These are:

1) Tsunami inundation as a rapid high tide. Usually houses are swept completely off their foundation and vessels would be carried inland and grounded.

2) A combination of 1 and 3. Here, the major effect would be flooding as a tidal inundation, however backflow may occur and erosion and local impact damage such as caused by 3 may occur.

3) Severe tsunami damage due to very high water velocities everywhere. Buildings and houses are completely destroyed, land and vegetation is stripped and eroded and rock, coral and other debris are left scattered. The third type is the most destructive and this was the case in the 1960 Chilean tsunami that struck Hilo.

Usually it is not the first wave that causes the damages, but the later waves. Such a thing happened in the May 22,1960 tsunami that struck Hilo. At 6:47 pm the U.S. Coast and Geodetic Survey Magnetic Observatory issued a seismic sea wave warning and estimated it to reach Hilo at about midnight. At 8:30 pm the sirens were sounded, warning the people to evacuate low-lying areas for higher grounds. At 12:13 am the first wave struck at four-plus feet and at 12:46 am the second wave crested at about nine-plus feet and a turbulent, retreat from the Wailoa estuary into the bay began. The second wave topped the Hilo breakwater sea-wall and flooded an area near the center of the business district. The water continued to pour out of the estuary until 1:00 am, when measurements were taken, the tape showed that the level was seven feet below the pre-water level. By 1:02 am, a distant rumble could be heard and as peoples eyes searched the darkness for the source, all that could be seen was a pale wall of tumbling water. The crest of the third and the largest wave could be seen with the dim lights that were shining from the town of Hilo. The wave seemed to grow as if moved steadily towards the shore. At 1:04 am the 35 feet high nearly vertical front smashed into the town of Hilo. All that could be seen was blue-white flashes which showed the location of the tsunami front. At 1:05 am, the wave reached the power plant and after a brief greenish electrical arch, Hawaii was plunged into complete darkness. By 2:15 am, the height of the waves had deminished sufficiently and it appeared safe to enter the devastated streets. This experience was described by three trained observers: J.P. Eaton, D.H. Richter and W.U. Ault.

CONCLUSION

In general, the most distructive tsunami that inundated the Hawaiian Islands was the April 1, 1946 one. This tsunami was the most distructive on the records for the state of Hawaii. Water elevation rose as high as 50 feet and inundated up to half a mile. The tsunami that hit the islands in May 22, 1960, which originated in Chile was also severe, however, it's effects were felt mainly along the southern shores of the islands. The run-up of both of these tsunamis were recorded around coastlines of the major islands.

The inundation caused by a tsunami can be determined by the following:

1) The wave elevations at the different coastlines (or other datum seaward of the coastlines)

2) The character of the waves. (whether it is a bore or a non-bore surge)

3) The beds profile and the roughness of the oceans topography over which the waves travels.

Due to the paucity of tsunami records along the coast-lines of the islands until recent times, no one is able to make long-term statistical predictions. It is found that Honolulu, Kahului and Hilo have sufficiently long records such that these predictions can be made.

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IS TSUNAMI PROTECTION ADEQUATE IN HAWAII?

by Alison M. Miyashiro, University Laboratory School

INTRODUCTION

Is tsunami protection adequate in Hawaii? Since the state of Hawaii is highly susceptible to tsunamis, we must protect and warn the people living on the coast and their property.

This paper will study the possible methods of protecting Hawaii's coast from tsunami damage.

METHODS OF RESEARCH

Information from this paper was obtained from research pamphlets and annual reports. I was also aided by an interview with Professor Doak Cox of the University of Hawaii and he supplied me with much information. Professor Cox is an expert on tsunamis.

RESULTS OF RESEARCH

Is tsunami protection adequate in Hawaii? The answer to that question is, no. Somewhat protected, yes, but guaranteed from harm, no. Hawaii or anywhere else is susceptible to tsunamis and will never be fully protected.

Tsunamis are only predictable to a certain point, for example, knowing the approximate time the tsunami will hit and maybe its speed. What scientists are unable to predict are how big the tsunami will be, how far inland it will go and finally, the most important thing, how much damage it will do.

One of the best ways to protect a tsunami hazard area is through zoning or restricted land use. Much attention is now being focused on this subject here on Oahu. Zoning of a certain area would mean to restrict land use on the coast. This way, when the tsunami hits, the damage to that area would be way less. If that coastal region had been densely populated and highly developed, the damage to that area might be in millions of dollars and maybe lives.[1]

Another way to avoid as much damage from tsunamis as possible is to construct buildings on raised ground. For example, on the Big Island of Hawaii the Hilo Civic Center is presently built on raised ground.[2] After a tidal wave wiped out that area, the people of Hilo filled in the land, higher than it originally had been and built their Civic Center on that elevated ground.

Now, if a tidal wave should hit this area, the Civic Center will most likely be safe from harm.

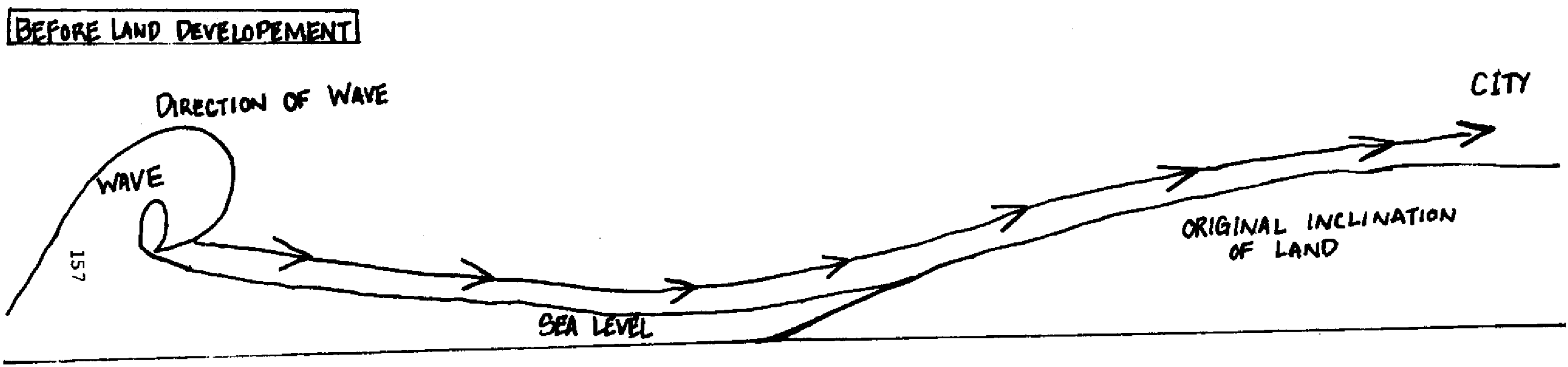
The three steps of this technique are:

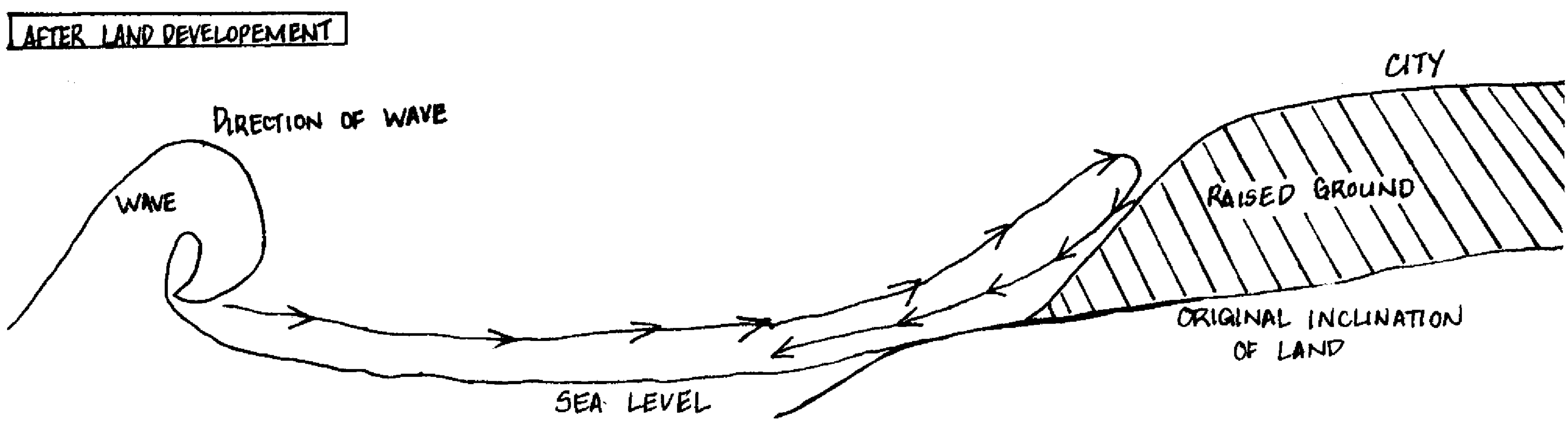
1. The tsunami hits and the wave goes inland.
2. But there is a sudden inclination in the land.
3. So that, hopefully, the wave does not have enough speed and power to go over the land and the water recedes back into the ocean. (see diagram).

One other way to protect coastal property from tsunami damage is to have the buildings constructed on stilts or above the tsunami water level. By constructing buildings above the ground, when the tsunami hits, the water will go under the building and hardly damage the property.

Another way to protect buildings constructed on the coast would be to build waterproof walls around the building. These walls would have to be high enough and strong enough so that water from the tsunami could not damage the building. Since the height and power of tsunamis are unpredictable at this time, this method of protection is not definitely tsunami-proof.[3]

RAISED GROUND DIAGRAM





CONCLUSION

After stating the different alternatives for protection against tsunamis, I think we should start using some of these methods of protection on our coast. During previous tidal waves Hawaii has had many people hurt and much property damages.

I feel that many lives and property could have been saved from previous tsunamis had the protection and warning system been more adequate. I feel that a warning system is not enough protection for a coastal region. Actual protection from the waves is needed not just sirens. Perhaps if methods of protection mentioned in my report had been used, many people in all those tsunamis could have been saved.

FOOTNOTES

[1]Professor Doak Cox, interviewed by Alison Miyashiro (Environmental Center - University of Hawaii, Honolulu, Hawaii) November, 1977

[2]Cox, Interview

[3]Cox, Interview

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RECREATIONAL FACILITIES

PROBLEMS IN CHOOSING THE LOCATION
OF A BOAT RAMP IN LAHAINA

by Lee H. Taylor, Lahainaluna High School

ABSTRACT:

There are inadequate facilities in Lahaina for small and private boats at the present time. So it was proposed to build a small boat ramp. But in the planning and the actual building of the boat ramp many problems are sure to arise. The site which was selected is an old burial ground. There will be added demands for public utilities. There will be greatly increased traffic in the area. The paved parking area will add to the storm run off to the area drainage area. Also There are people that live near the facinity and noise will probably be a problem. I suggest either they do away with the present plan or find a more suitable location in the Lahaina area.

INTRODUCTION:

The Mala Warf Boat Launching Facility started out to be a total relocation of the present harbor. Through many years of correspondence, instead of moving the whole harbor, the plans were changed to make a small boat ramp. The facility will consist of a 2-lane launching ramp, two rigging docks, rock groins for wave protection, 51-boat and trailer parking stalls, 4-automobile parking stalls, a boat washdown area with two spaces, a single story comfort station with shake roof and split face block walls, landscape planting and irrigation and the repaving of the access drive from Front Street. With all the problems that this project has been confronted with, I assume that they will not go along with the original plan. It is not very economical to stay with the present plans. It behoves me to say that it will be better for the county and for the people that live next or near to the future ramp that they find some where else before they start something they will be sorry for. Because from the comments I heard from the people that live around, there will be alot of complaints, after this ramp is built.

PROCEDURE OF RESEARCH:

I went to the Maui Planning Commission and asked them for any files on the "Mala Warf Project." I used the minutes from the public hearing, staff reports and a file and also looked into newspaper articles which I got from the Maui News.

RESULTS:

In my research I found that one of the main reasons to build is the traffic problem that parked cars and boat trailers cause on the road passing the historic courthouse and the elementary school. The parked tour buses also cause a traffic hazard. There are tourists standing in the middle of the road taking pictures and crossing the street where there is no crosswalk. Another problem is the school buses that must pass to get to the school. They just barely make it with the tour buses, but with the cars and trailers the buses have to back up before they can make it. It is also a safty hazard to the school children. Then the problem of over crowding has come up.

The over crowded harbor is another reason why a small boat launch should be built. There are cars and trailers waiting in line for their turn at the ramp. There are also commercial boats there, such as charters and fishing boats for tourists and two glass bottom boats for cruising. And on the out skirts of the harbor there are people surfing. When fishermen and independent seamen come back with fish and coral they need somewhere to wash their catches, which the present harbor does not have a good facility and soon this will become a health problem.

At first, the planning commission proposed to restore the Lahaina beach back to its original condition. But this is very illogical and most expensive all this alternate was discarded. So it was decided to scale down the problem by taking away some of the boats. Then the idea of a small boat ramp came too. But of course in building any project problems will arise.

The main problem no matter what you build there is a little five letter word which makes the difference between you building or not, is "money" which also is a major factor in this project. The project has $200,000 to spend but already have $400,000 spent.

A large percentage will go to "the dead" in that they have 53 private graves and they must be moved to accommodate the project. First they must identify as many graves as possible and they'll make a "common grave" for all of the unknowns. And thus far only three people responded to the notice that was published. Besides this, an archeologist must be present during construction and if any artifacts are found that have any historic value to the Hawaiian culture, construction will have to stop until the archeologist is sure beyond the reason of a doubt. Also if they find sand underneath the ground, the sand must be sifted. As for the three graves that were identified, those graves will have to be moved to a privated cemetary. [1]"This poses a big problem for us and target is $300,000. We figure $60,000 for the reinternment program; $15,000 for the archaiological - $375,000 and appropriation is $200,000. You asking how we are going to do it. As of now, we intend to borrow, beg - get from a Statewide fund..."
It also must include 11 large crown shade trees which are tolerant to ocean conditions and planted in stratigic location. A Demptser Dumpster must be present painted earth color.

Before you can build anything you must have certain permits to do certain things. In this case they also must have Impact statements which state items you must have and procedures you must go through during construction.

The Impact Statements are as follows:

Economic Impact: The project will create short term employment during the construction phase.

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[1] Quotation from Mr. Nam from the "Minutes of the Public Hearing"

Natural Impact: The project will result in the removal of approximately 1.25 acres of Keawe and natural vegetation. Also in the process of grading and construction the boat launching facility will require the removal of 53 scattered historical graves which can be identified as a cultural resource.

Social Impact: The project will create minimal impact on existing services e.g. (water, sewer, ect.). It should be noted that a positive impact will result relative to providing a much needed launching facility will generate increased automobile traffic in the area.

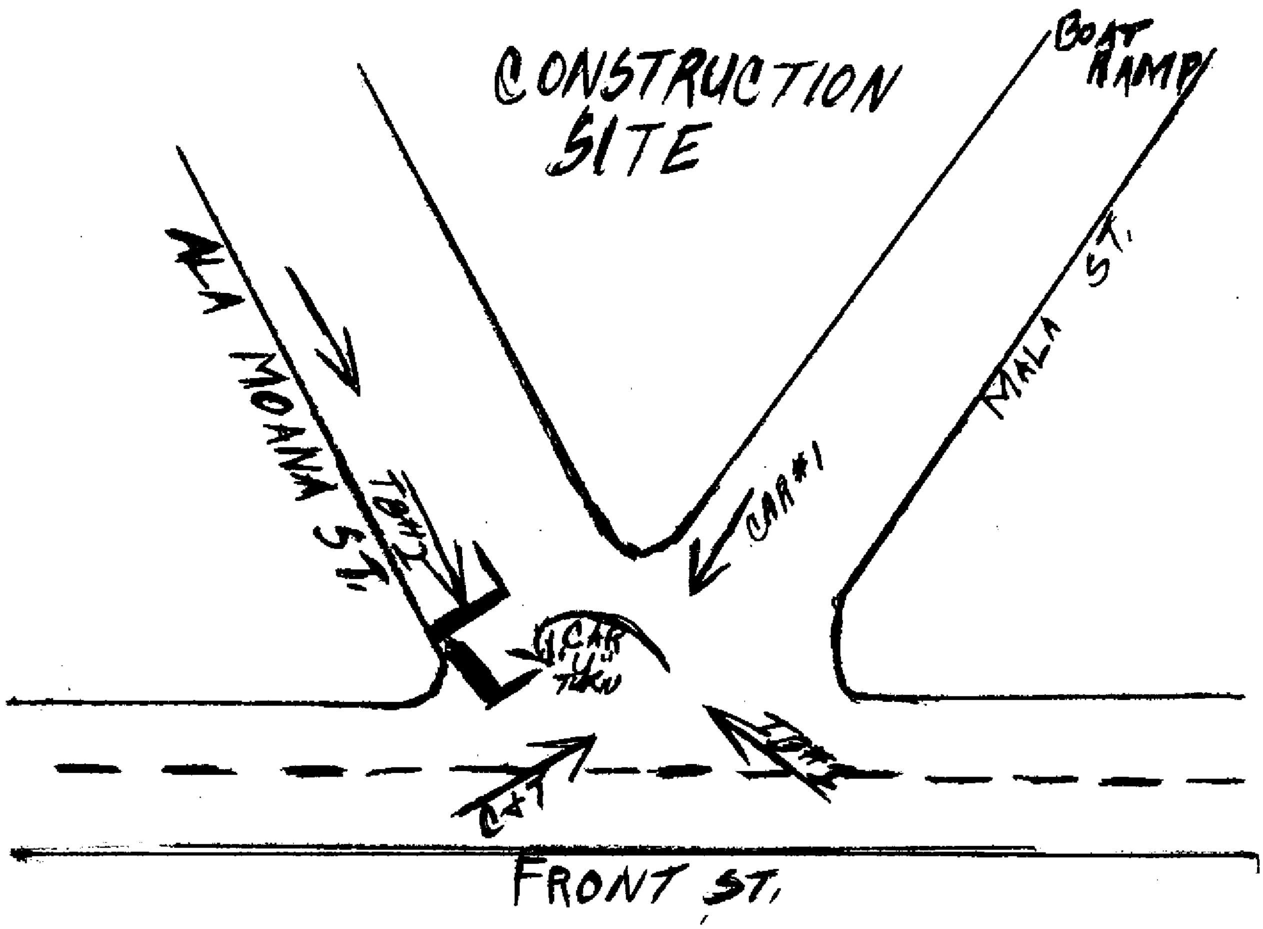
Environmental Impact: Indicates that the 53 graves will be relocated to a private cemetary following notification of surviving relatives, also that a Phase 1 archeological survey involving intensive site work should be conducted prior to construction.

Cumulative Impact: The addition of a significant asphalt paved area will contribute increased storm runoff which will be disposed by sheet flow into Kahoma Stream and the ocean. Also, the facility will generate increased automobile traffic in the area.

They have not yet the permit from the Corps of Egineers, which permit them to go into the sea when they build. So they need this permit for the two groins which go into the water.

Another problem is the intersection that leads to the ramp. it is a very confusing and dangerous intersection. There can be one car coming from the ramp its self (car #1), tour bus coming off of Front Street and approaching Ala Moana Street, (TB #1).

From the opposite direction comes a car and trailer off from Front Street to Mala (the boat ramp), which I will call "C & T". You also have another tour bus coming from Ala Moana Street toward the intersection, (TB#2). And many people use this intersection to make "U" turns. In this intersection there is no medial strip, and a section just above there is a construction site. In my illustration will show you how deadly this intersection can become.



CONCLUSION:

In view of the circumstances that surround the boat ramp project, they should either do away with the whole plan due to the danger at the intersection described earlier, also there will be a delay on construction if any artifacts that have historic value at the burial site. There probably will have a traffic congestion due to the length of the car and trailer, which is approximately 45 feet. They also should move the boat ramp somewhere, where a better access road could be built. It should have the entrance on the one end and the exit on the other end. I suggest that either of the alternates are used instead of the present plan and location. I believe that the cost will far exceed the estimated cost,therfore the plans will either be changed or disreguarded

PADDLING AND SWIMMING AT ALA MOANA BEACH PARK

by Lester W.K. Luahiwa, University Laboratory School

INTRODUCTION

My paper is on a problem dealing with paddling in Ala Moana Beach Park. The tourists and other swimmers are complaining to the Parks and Recreation Department about canoes being hazardous to pedestrian swimmers. They are complaining that the canoes get in the way of swimmers and should paddle somewhere else.

The paddlers feel that they don't get in the way of the swimmers. They say that they try to stay away from where the swimmers are. There are about two to three hundred paddlers that use the beach in the afternoons from 3 pm until 8 pm. The paddling season usua-ly lasts from mid-January to early August. Each canoe is about 30 feet long and one and a half feet wide. They also weigh around 400 pounds. This makes it hard for the canoe clubs to handle sometimes because they have to keep everyone alert for the swimmers. It is especially a problem when there are more than three canoe clubs and each club has about four or more canoes. They really have to form a dependable system to keep everything running smoothly and make sure nobody gets hurt.

The Parks and Recreation Department tried to notify the State about this problem because the friction between the two parties might keep tourists away from the beach. This migh affect trouism around the Ala Moana Beach area. This report will capture what both of the parties have to say about their side of the situation. It will also show the State's part in this problem and what is being done to solve it.

METHODS OF RESEARCH

First I went to Ala Moana Beach and interviewed a couple of tourists and a couple of canoe paddlers. I also went to the Department of Parks and Recreation and interviewed John Tomita who is concerned with this problem. Then I watched the canoes practice for one hour and observed both parties'reactions. I also talked with John Kapua who is the president of the canoe club Hui o Kai 'Koo. He filled me in on some of the details of the story. He also helped me get interviews with the coaches from the canoe clubs.

RESULTS OF RESEARCH

Some paddlers say that they try to stay away from pedestrians on the beach and in the water. But with more than three canoe clubs paddling in generally the same area, and when each club has about four canoes in the water at the same time, it makes keeping track of each paddler's actions hard.

Walter Kaapuni is the head coach for Kamehameha Canoe Club, which practices at Ala Moana Beach. Walter says that he tells the members of his club to be careful when carrying the canoes from the beach to the water. Each club has great respect for all the canoes and each canoe must be carried from its resting place, on the beach, to the water. Before lifting these 400 pound fiberglass structures Walter says, "A path to the beach is picked where there is less people, but still being careful not to hit anyone on the beach."

Walter also tells his steersmen from each crew to be alert at all times. A steersman is the sixth person at the back end of the canoe. He is the person that controls the canoe by sticking his paddle either on the left or right side of the canoe which makes the back end of the canoe swing left or right. "The swimmers have plenty of room to swim," says Walter.

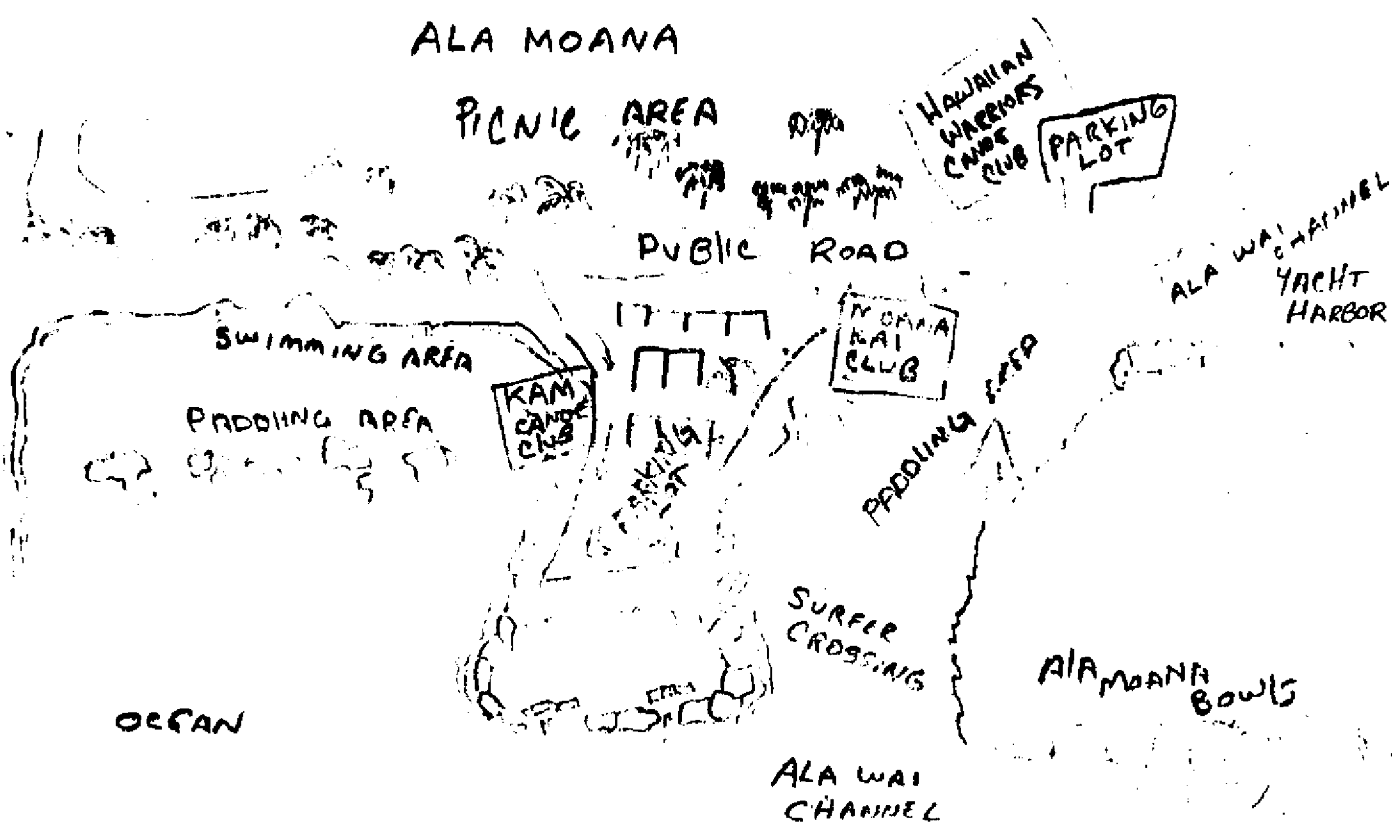
Walter also tries to supervise every practice session. Walter says that he and his club members are making an effort to stay out of the way from swimmers.

James Prescott is the steersman for the boy's 18 year old of Kamehameha. He has been paddling at Ala Moana for five years. He says, I never ran any swimmers over in all the time I been at Ala Moana." James says that most of the swimmers are near the shore. "When we are finished practicing our sprints outside and it's time to come in, I look for a spot where there is less people, and paddle slowly to and from the beach. I am always trying to stay alert."

Sammy Steamboat is head coach for the Hawaiian Warriors, who also practice at Ala Moana Beach along with Moana Kai and a couple of other canoe clubs. "We don't have too many problems with swimmers, because we don't practice in Ala Moana Beach. We paddle on the other side of Magic Island, in the Ala Wai channel away from most of the swimmers." Sam also tells me that they have to watch out for boats going in and out of the channel. "The canoes also have to watch out for surfers paddling across the channel. The surfers are the ones we mostly have to watch because most of their season is in the summer when the waves are up. So there's a lot of young kids constantly paddling across the channel."

The Hawaiian Warriors have four practice canoes and two racing canoes. The Warriors don't have too much trouble with crowds when carrying the canoes to the water because their canoes are away from the sandy beach area. The Warriors still have to make a path when moving the boats to practice, though. This is because the boats are across the street from the water and all the members have to give a hand. They have to have enough people to carry the canoes because if a canoe is dropped it could lead to weeks of repair. The members have to stop the on-coming traffic when moving the canoes.

Below is a map showing each position of all the canoe clubs and surrounding land marks of the area that this report is about. This map should help you understand the situation better.



Map of Ala Moana Area

The past few paragraphs were some comments and statements from the paddlers' feeling towards this situation. The following paragraphs contain some of the comments and points from the tourists or swimmers.

"We don't want to make trouble with any of the people. We just want a little consideration," says Mike Peterson, a regular swimmer at Ala Moana. He swims every afternoon, Monday through Friday for exercise. Mike has never been hit or run over by any canoe, but he saw a few situations where paddlers have to hold water or put on the brakes to avoid hitting swimmers.

Gene Chong is also a person that swims at Ala Moana beach a lot. "The canoes are hazardous to small children playing near the shoreline," says Gene. Gene syas when the canoes are near the shore where children are playing, the canoes have to be more careful. "When children are playing and having fun, they aren't aware of canoes around them." Gene also says that the canoes should rendevous elsewhere before an accident occurs.

These next few paragrapsh will be on what I observed while watching the clubs practice. I also watched for the behavior of both parties in action.

I observed that the canoes moved slowly with caution when close to the shoreline. The paddlers also seemed to be alert not to hit anyone. The canoes try to stay right outside of the swimmers. But they still have to be alert because their still are a few swimmers outside. The only time the canoes sprint or pick up the pace is when they get about 250 feet away from the shoreline, which is pretty far away from most of the swimmers.. The steersmen always seem to be alert. They always keep an eye on all sides around the canoe when the canoes are moving in the water. Each canoe uses the same route as the boat before them. These routes are picked by the coach and every steersman or at least the steersmen in the first canoe must know the route before leaving the beach.

All of the canoe clubs try to keep all members and equipment together in one place. This makes it easier for the coaches to run a practice session. Some paddlers go all over the beach and sometimes get into trouble with the other clubs and sometimes the tourists, too. Competition paddling will only work if all the members stay and work together so the coasches try to keep everybody together. Keeping everybody together will keep the members out of trouble.

The Department of Parks and Recreation has been receiving complaints from swimmers that the beach is dangerous for swimmers. Mr. John Tomita from the Department of Parks and Recreations says, "The problem here is that the canoe clubs are too far apart from each other." John says that the complaints were rapidly coming in to the Department before, but slowed down after a while. John alsosays that his Department has tried to notify some state officials after studying the problem a bit. This is because if more canoe clubs come to Ala Moana or if more members join, then there will be more paddlers and canoes occupying the waters.

John also tells me that, "the state officials have not paid much attention to this problem yet but if they let it go long enough they will because fighs might break out between paddlers and swimmers." This might lead to gang fights and threats among each other and less tourists would come around the Ala Moana area. Then small stores as well as big ones around Ala Moana might be affected. People might lose jobs and boat rides and other tourist attractions might go out of business. This is when the state will wake up and be aware.

CONCLUSION AND RECOMMENDATIONS

I think that if a restricted area could be reserved for the canoes to practice and keep the swimmers out of the area, then there will be no swimmers that will get in the way. The are must be big enough and fit for paddling first before they decide where the area should be. To keep swimmers away, signs could be posted and markers could be put out so both parties know where the boundaries are. They could also fence an area on land big enough to hold all the paddling equipment. This can result in less damage to the heavily respected canoes.

The Parks and Recreation Departemnt is trying to find another location for the canoe clubs. But it's hard to find a suitable beach. The officials still are trying to decide if moving the canoe clubs is the right thing to do. Since paddling season is over now the state has until next season to find a solution.

This is the conclusion to my report. I've showed the arguments, facts, and my observations towards this problem, and also what I think should be done in this situation.

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Chong, Gene, Interview with Lester Luahiwa, Ala Moana Beach Park, November 12, 1977.

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Peterson, Mike, Interview with Lester Luahiwa, Ala Moana Beach Park, November 12, 1977.

Prescott, James, Interview with Lester Luahiwa, Ala Moana Beach Park, November 12, 1977.

Steamboat, Sammy, Interview with Lester Luahiwa, Ala Moana Beach Park, November 12, 1977.

Tomita, John, Interview with Lester Luahiwa, Department of Parks and Recreation, November 16, 1977.

THE FUTURE OF LAHAINA HARBOR

by Glenn S. Kishi, Lahainaluna High School

ABSTRACT

I asked the people of Lahaina some questions about the small boat harbor in Lahaina. I asked questions about the problems of an expansion of the harbor and a new harbor. Although the results of the questions that I asked were good, no signifcant conclusion that would serve the public well could be drawn. But I found that I could give my personel conclusion. Which is that we should not expand the harbor nor should a new harbor be made.

INTRODUCTION

Lahaina is known as a small town that's on the verge of becoming a small city. On its way to becoming this small city, it is experiencing some problems in keeping its historic appearance while permitting modern development. One of these problems concerns Lahaina's small boat harbor.

In the past, there have been many requests, for expansion or even relocation of the harbor. This seemed feasible, but surfers and ocean scenery lovers and some others have come into conflict with the boaters.

In my paper I will try to see whether or not a harbor extension or a new harbor is feasible according to the people of Lahaina. I will try to show how the people feel about the harbor and show what are the good and bad points for some alternative plans of action.

METHOD OF RESEARCH

I wrote a questionaire to find different views of people about the Lahaina Harbor. I interviewed people from the harbor and areas around the harbor. Basically I tried to get people who have had some form of contact in the area of the harbor such as boaters, divers, swinners, and residents of Lahaina. I also interviewed some people who didn't ordinarily come in contact with the harbor in hopes of getting different opinions and views.

I got my idea from last years symposium, but I decided to interview people because the subject that I chose, the

Lahaina Harbor, is more in an opinion stage rather than an effects and consequences stage.

In my paper I limited the possible solutions to: (1) retaining the present harbor, (2) expanding the present harbor, (3) relocating the harbor to other areas of Lahaina, and (4) relocating some present classes of harbor users to Maalaea.

RESULTS OF RESEARCH

I found out that most of the people don't want to see the Lahaina Harbor expanded because of several reasons. One is that most of the boats looking for room to dock here are from other islands or the mainland. Some of those people who come here don't pay taxes but send their children to our public schools. Some bring in contraband. Another opinion that was stated strongly was these other island and mainland visitors who take away dock space are really hurting the local commercial fishermen and some of the people who live here because the local markets have to bring in fish and other seafoods from some other port, raising the cost of these seafoods here. The boaters and some local residents agreed that the present harbor should be expanded for the reason that there would be more dock space and that the charter boats could bring in more money.

For the concerns of scenery and the biological balance of the ocean, some boaters and some local residents said that it wouldn't harm the area, if certain precautions are carried out and depending on what tools they use to build the harbor with, for example, a suction dredge. The others said that if studies are performed, pollution and destruction of the scenery could be avoided. Those who felt the biological balance would be harmed felt that oil and fumes from boat engines, garbage, sewage and other wastes from boats would harm fishes and other ocean life.

I wondered if people would like to see other sites developed for boats currently docked at Lahaina. Again most of the local people said no and only a few boaters and local people said yes. Those who said no, said that you would only be moving the present problems to the other site. Those who said yes, said that they would like to see Maalaea or another site developed because the other site would accomodate the boats that don't have a place to dock.

Some of the places that were sugested for a new harbor were at the Mala Wharf area, in front of Lahaina as recommended by a survey team of engineers, and Maalaea Harbor.

Those who were involved with some ocean related activities said that a new harbor or an expansion of the harbor would destroy their activities. Those concerned with surfing aired their views when prime areas of surfing were threatened with destruction.

"A prime surfing site will be destroyed by dredging and harbor construction as proposed for Maalaea Bay. . . . Specifically, the modifications to the existing harbor that threaten the surfing area are the extended south breakwater and the new entrance channel."

"It is recommended that the proposed plan for harbor modications not be implemented and that alternatives be found, in view of the social cost, present and future usage of the surf sports area."[1]

"A proposed relocation of the existing boat harbor to a new site on the northwest side of the present boat harbor channel would destroy several surfing sites in an extensive area used in both summer and winter seasons. The existing harbor is a source of serious pollution. Many surfers complain of infections from the area. Reef dredging, alteration of currents and jetty construction threaten to reproduce Honolulu's waterfront problems in the Lahaina area."[2]

A similar question was asked of boaters on how the harbor would affect them. The answers varied so greatly that no significant conclusion could be drawn.

CONCLUSION

Judging from the views that I received I could not justify a recommendation either for or against an expansion or relocation of the harbor. But judging from the information that I have, I can give my personal conclusion. I believe that a new harbor shouldn't be built nor should the present harbor be extended. I feel that the present harbor should be modernized and managed properly in regard to upkeep, sanitation, and land and ocean traffic. I also think that the local commercial fishermen and boaters should have priority to docking stalls. Although the Lahaina Harbor isn't a commercial fishing harbor I think a small section should be left aside for them.

FOOTNOTES

[1] "SURF PARAMETERS Final Report" John Kelly, Research Consultant, James K. K. Look Laboratory of Oceanographic Engineering, Technical Report No. 33, November 1973, pg. 208, "Maalaea".

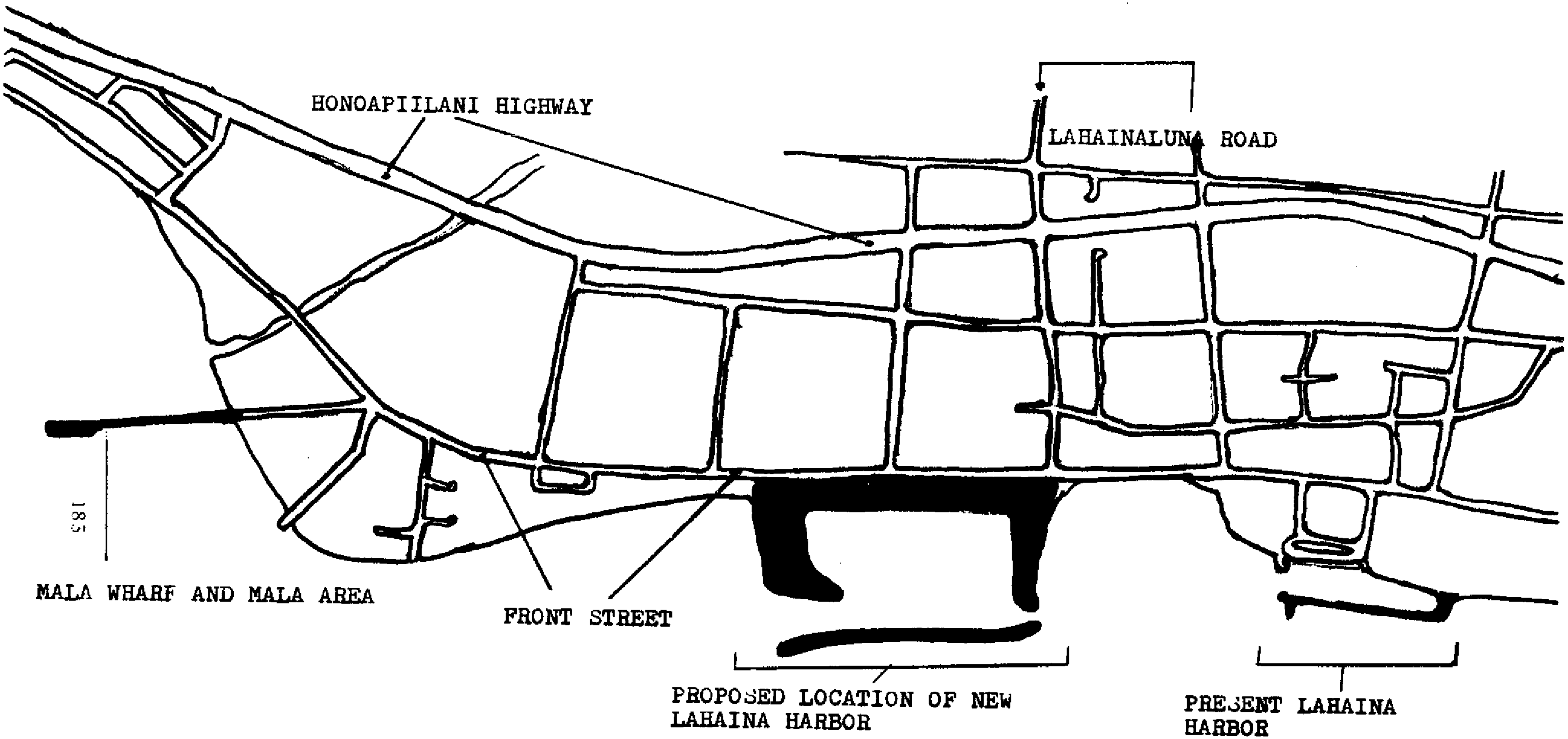
[2] "SURF PARAMETERS Final Report" John Kelly, Research Consultant, James K. K. Look Laboratory of Oceanographic Engineering, Technical Report No. 33, November 1973, pa. 208, "Lahaina".

STATISTICAL SUMMARY OF INTERVIEWS

Area of Interest	Boaters	Divers, Surfers and Swimmers	Local residents who have no contact with Harbor
Number Interviewed	3*	7*	4*
In Favor of Expanding Harbor	2 of 3	0 of 7	0 of 4
In Favor of Relocating Harbor	1 of 3	0 of 7	3 of 4
Locations Choosen for Alternate Site:			
Mala	none	2+	2
Lahaina	none	2	none
Maalaea	none	1	none
Other Site	2	none	1
Wants no Harbor built	1	3	1
Number Who Believe Biological Balance Would be Disturbed	0 of 3	5 of 7	3 of 4

*The lack of people interviewed could have some effect on results.

+2 sites were suggested by one person.



MAP SHOWS POSSIBLE LAHAINA HARBOR LOCATIONS

MAP TAKEN FROM-LAHAINA, COMMUNITY
DEVELOPMENT PLAN BOOKLET.

SCALE: ¼ MILE

- NORTH

SAMPLE OF QUESTIONNAIRE USED

This is a questionnaire concerning the Lahaina Harbor. Please answer these questions as best you can.

1. Are you a resident of Lahaina? Of Maui?

2. Do you wish to see the current Lahaina Harbor expanded? Why?

3. Where do you want to see it built? Why?

4. Do you think, if there is a new harbor, that it will harm the environment so far as scenery or the biological balance of the ocean is concerned? Explain.

5. Do you think Maalaea Harbor or other site should be developed?

6. If you are a surfer or do any ocean related activities, how do you feel the new or the expansion of the harbor will affect you, the activity, or the site?

7. If you are a boater what do you think of the present harbor? How will a new or an expansion of a harbor affect you?

8. How important is the harbor to you? In what ways do you make use of the harbor?

Thank you for answering my questionnaire.

RICHARDSON CENTER, HILO, HAWAII

by Arlene D. Bazell, Pahoa High School

ABSTRACT

Our islands are surrounded with waters abundant with life, and yet oceanography is only beginning to become a career in Hawaii. A center trying to arouse public awareness was formed - the Richardson Estate Ocean Center. It is my wish to present to the public a guide for the center, a guide telling people about Richardson Center, about the plant life and the abundant sea life. Perhaps this will inspire others to do a guide for similar marine recreation areas. Then there will be no reason for people not to know of the importance of our oceans.

INTRODUCTION

Oceanography, a large field, is beginning to open up here in Hawaii. Our islands are the perfect spot for this field. Our ocean is filled with abundant and fertile life in one of the best climates, the tropics. But before oceanography can be expected to expand anymore, one other thing is needed - public awareness. Only when people realize the importance of our oceans and the opportunities the ocean holds, can we, expect people to consider the field. So how do we arouse the publics curiosity into discovering the field? Through marine recreation!

The idea was offered to the Pahoa Marine Science class by Mrs. Sandra White when she spoke of the upcoming symposium. There had been a guide done for the Kaena Point Walk, for those who didn't know their way. A similar project could be done for Richardson Estate Ocean Center. Knowledge of the center needed to be brought to the public. The center is run by the county but funds are limited and several times the center was nearly closed down. This is where the public is so important. They can help the center stay in existance by various ways. Groups and organizations, the public, in families or individuals, can help by volunteering ideas, work, time and talent. If nothing else, by letting the councilmen know how important the center is to them, would be of help.

This project was well worth the work it was going to take. A guide could be created with several benefits. The center could gain the recognition much needed. Perhaps a guide would draw in more people and maybe, with the center being such a public interest place, the funds would be stabilized. Working on creating the guide would give me the experience of the struggle of a publication as well as teach me as much as I hoped to teach the public. Finally, It would do the main thing it was intended for. The guide would present another form of marine recreation. It would offer information on the terestrial and marine life at the center, and many people do consider learning, recreational.

METHODS

So I took up on the idea, volunteering the next three months to much more than I expected. First I attempted to set up a schedule. I decided what I wanted to show the people. Starting inside the center, go out and around the side, toward and around one of the many fish ponds to the left of the building, back toward the center, down the path which leads to a good swimming area, then eventually back again. This should be a total of 20 - 30 minutes of walking and learning. Along the way I'd give pictures, descriptions and basic uses of the plants.

Once at the end of the trail, I'd take the readers into the water, literally or just descriptively, once again giving basic descriptions, drawings and uses of the algae, anemones and fish so plentifully found at Richardson Center.

The next step was to take guava stakes, tops painted white with black numbers, and decide exactly where they should be put. The first would be where the Aloe, surrounded with coconut trees. The next at one of the many ancient Fish ponds where mullet and koi can still be found. The third, at a brackish water pond where a fresh water stream slowly seeps in. An ideal spot for youngsters to swim and play in the sand. The other stakes continuing down the path would point out plants such as bananas, Chinese palms, Halas, Monstera, Bowstring Hemp, Cannas, Ti's, Laua'e, Taro vines, Hau, Iron wood, Milo, and Chinese Almond.

In order to give the drawings, descriptions, and uses of these plants, I had a lot to find out. The drawings I did all by myself, first in pencil, next in pen using a form of carbon to transfer it onto paper in a darker form.

The descriptions and uses I couldn't begin to work until I had the common and scientific names, true, I could have gone through, book after book, and found what I needed, but thanks to Mrs. Hanna BOWMAN, that task was simplified. We toured the center and she gave me both common and scientific names for almost all of the plants. After this, it was much easier to gather the needed information.

Once, I had the names, I next needed to gather as much information on the plants, I decided to point out to my readers. From this information I cut it back to a brief description and a few of the more important uses. Next, was to write it out in a presentable way so it could keep the readers interest stirred. Then to put it into order as to what goes where, and where and how much space to leave for pictures.

Now the only thing that could be done, after reading it over and over again, was to type it up in hopes that no mistakes were overlooked or pages left out.

The typed copy was read over by myself, my teacher, and parents, for mistakes. Many were found and several pages needed to be done over. And they were, over and over again.

Over and over again made success so sweet when I handed in a final total of 37 pages, blessed and cursed by us all.

RESULTS

The end was sweet, when I had a 37 page guide to show for the nights and days of hard work by myself and those who helped me. The project was well worth the effort.

However, this was truely not the end, but instead the beginning. The guide was next to be sent, to Sea Grant, through Mr. Harold Takata, to be published and distributed to Richardson Center. The guide would be offered to the public, as originally intended, to help arouse pulic awareness of our oceans, through marine recreation.

Along with the guide, Richardson Center also has an album I did in conjunction with the guide. To Identify Algae by a drawing is nearly impossible. But, yet, the center has so many species growing in the water that they could not be omitted. So instead, I collected, dried and mounted several of the more commonly found Algae and compiled them into an album. It is my hope that as people find others which have not been previously collected, they will donate them to the center to be dried and added to the collection. In this way the collection will be continuously updated with new species.

Along with the Algae, the Album also has some of the photographs I took of the center.

CONCLUSION & RECOMMENDATIONS

With this guide, besides teaching a little which may not have been known already, perhaps it will encourage someone to do a similar guide elsewhere.

In hopes that someone does decide to do a similar project, I'd like to give a few suggestions:

1. Give yourself time. A year would be best. Three months, I found was not enough time to do it calmly and completely. If it has to be rushed through, doing it night and day, the project becomes a menace. Make the project a pleasant and rewarding task, by giving yourself plenty of time.
2. Before you do anything else on the guide, be sure to schedule yourself. Write out exactly what needs to be done, and set up dates for completion for each thing. And stick to the schedule! Don't leave it to pile up in the last week. It won't work that way.

3. If you work with a partner or partners set a rule - work first, play later. And get the work done. Be sure you know your partner well. Know that he or she will be able and eager to do the much needed work. Split the work up evenly. Know exactly who does what before you start.

   If you decide to work alone, be sure to take along a friend for the sake of safety. If you'll be working in the water make sure your friend is a strong swimmer. You may get into trouble in the water and you want to be sure your friend will be able to help.

4. The final and perhaps most important suggestion is this: Don't give up, there will be times of hard luck, you don't count on, like differences of opinions, colds, lousy weather, family responsibilities, or other commitments. There will be times when the work seems to swamp you, but push to get through. You'll realize when the whole ordeal is over, every ounce of work you put in was well worth it.

Perhaps, now, with my guide and others that may be inspired, the public awareness will be increased. People will realize the importance of our oceans, for economical, educational, and recreational aspects.

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MARINE BIOLOGY

THE SEA URCHIN IN HAWAII

by Derrick J. Ignacio, Pahoa High School

ABSTRACT

This paper explores the sea urchin populations in the Kawaihae and Kapoho areas on the island of Hawaii. I have been diving for two years and have become most interested in sea urchins. Is there a way to use sea urchins in the food industry? Another question is, if there is a market for the sea urchin, what kind of market? This report is based on four kinds of sea urchins living in Kawaihae and Kapoho areas. I will explain which ones might be used in aquaculture. I will also explain what they look like and how they live and reproduce.

METHOD OF RESEARCH

My purpose was to search out and identify the different sea urchins in Kawaihae and Kapoho areas. I made a more thorough survey of Kapoho. I made five dives to get enough information on sea urchins living in these waters. My first three dives were made at Kawaihae. Two of the dives were made during the day and the third was at night. These dives were made over the weekend of October 8 and 9, 1977.

The first dive on October 8, was early in the morning. The purpose was to harvest and look around for different species of sea urchins. This dive lasted about one hour of diving off a reef area at a depth of 10 to 15 feet. The species that was harvested was the Diadema, locally known as black spiney sea urchin or vauna.

The second dive was made at night on October 8, during the hours of 8:30 to 11:30. The purpose was to look for night species of sea urchins. The dive covered an area about 3/4th of a mile along the shoreline.

The third dive was during the day on October 9. It was made during the early afternoon hours. This dive was to harvest the Diadema and to look around for different species.

The other two dives were made at Kapoho on November 12, 1977. The dives were in the afternoon. The first dive was made in a tidal pool. I marked with string an area of 10 x 10. Then I counted the species in this area. Since the bottom was of rock and sand, I then brushed away about 3 inches of the sand to look for urchins under the sand.

The last dive later that afternoon was in an area closer to the reef. It was too rough to mark out an actual area, so in an estimated 10 x 10 area, I counted all of the sea urchins I could see.

RESULTS OF RESEARCH

The first survey in October in the Kawaihae area, I found many blackish blue sea urchins (Diadema.) The results showed 45 to 60 in a 10 by 10 area. Some of these sea urchins almost touch each other. The Kapoho survey in November showed nearly the same results, but the count was down to 35 or less. The shape of the blackish blue sea urchin is round and the size of its skelton is 3-4 inches. The needles are 3 to 6 inches long. I found only one sand dollar on each of the two Kapoho dives. It had short spines. The sand dollars were white and brown in color, flat, round and about 4 inches in diameter.

In the first of the Kapoho dives, I found two pencil slate sea urchins. They were of a redish color. The skelton is round and has needles like a fat pencil.

The last type of sea urchin found was a white sea urchin. The sea urchin was almost the same as the blackish one but has stronger needles or spines. I found this one right on the shoreline.

REPRODUCTION OF SEA URCHINS

All echinoids are dioecious, and the majority display no sexual dimorphism. In regular echinoids, there are five gonads. Sperm and eggs are shed into the sea water by the contraction of the muscle layers of the gonads, and fertilization takes place in the sea water. As in asteroid, spawning in temperate species takes place in the spring and early summer. Brooding sea urchins retain their eggs on the peristone or around the periproct and use the springs in holding the eggs in position. The heart urchins and the brooding species of sand dollars brood their eggs in deep concavities on the petaloids.

Sea urchins live mostly near rocky shores, feeding on algae and decaying materials and serving as one of the many kinds of scavengers that keep the sea bottom from becoming foul. The tube feet of the sea urchin end in suckers and are long and slender, extending beyond the spines. Both are used in locomotion, the tube feet being moved by changes in pressure in the water vascular system and by muscles; the spines are moved by muscles. Five teeth are seen around the mouth.

Sand dollars belong to the same class as sea urchins but are flattened and covered with short spines. They move by means of the spines and small tube feet on both surfaces of the body. The large tube feet which protrude from the five double rows of holes on the upper surface are respiratory. The animals swallow sand and digest the organic material contained in it.

DISCUSSION OF THE POSSIBILITIES OF PRODUCTION OF SEA URCHINS

In Hawaii today, there are some uses of the sea urchins. The pencil slate sea urchin is being used to make necklaces. Some people make the necklaces and sell them to the tourists in Hilo and the other islands. They sell for $5.00 or less. The production of this looks limited as not too many people buy these. Kapoho is a good possibility for production of the pencil slate sea urchin.

Another one for the possibilities of production is the blackish-blue spiney sea urchin as a food product. But perhaps only a few people will buy it. A quart sized jar could sell for about $50.00. To harvest the sea urchin isn't easy. You have to look for a place like Kawaihae. You have to dive in water 15 to 20 feet deep. It takes about 3 buckets full to make one jar of the edible portion of the sea urchin. The meat from the sea urchin looks like body fat. It is utilized as food in some parts of the world. *Pratt states "over 100,000 dozen sea urchins are yearly brought into the fish markets of Marseilles." This production might be possible if more people could be taught to eat it. There is no market yet in the store in Hawaii but only the people who go diving for this sell it to other people.

The sea urchin could help the job market. For you would need divers and then people to collect the fat from the sea urchin. Already some jobs are due to the sea urchin. Tourists buy necklaces and take them back with them. In order to farm sea urchins you would need a big salt water pond that has a high rate of algae and the right kinds of decaying material and help in farming and harvesting the product.

The spiney needles can be easily removed by a wire basket. You put all the blackish blue sea urchins that will fit into the basket and shake well until all the needles are removed. You then remove the fat from the shell. All of this takes time and the sea urchin wouldn't be a fast crop.

CONCLUSIONS AND RECOMMENDATIONS

My research revealed that Kawaihae and Kapoho resources of sea urchins vary in number and type. Some areas may be filled but other areas can have hardly any. One place may have only one kind of sea urchin while the other can have two to three kinds of sea urchins. In researching this topic I have found that their are limits to producing sea urchins as food. I feel that trying to start it will be hard to do, because I don't think people will be that eager to try it as food at the present time. I feel that some day sea urchins may be a part of the food list. The food market is slowly looking for new and better food-resources in the sea. I feel the sea urchin should be studied more thoroughly.

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SHARK'S

by Wayne C. Plumline, Kubasaki High School

An extensive genius of fishes of the ray family, found widely distributed in the ocean, but most abundantly within the tropics. The body is elongated in most species, the tail is thick and fleshly, and the teeth are generally large, sharp, and formed for cutting. The skin is scaleless, but usually is very rough with thornlike tubercles, and is used in making shagreen. They swim with great speed for long distances, often pursuing ships for the sake of securing the offal and waste materials thrown overboard. Some deep-sea species attain an enormous size and are noted for their voracity in devouring other forms of sea life. All species are more or less destructive of food fishes and do immense damage to the fisheries. The most powerful of the man-eating species is the White Shark (Carcharodon carcharias), of the warm seas. It is found in the water's off the southerly coasts of th United States, where it attains a length of 40 feet. It scents food for some distance and is readily attracted by blood or decomposing bodies. Other large species of shark's are the tiger shark, the blue shark, the hammerhead shark, and the common dusky shark.

Dangerous Species:

The Great Hammerhead Shark (Sphyrna mokarran), is a full-bellied animal that grows as long as fifteen feet, perhaps longer. There are four or five different species, with the great hammerhead the largest and most dangerous, and their profiles are all quite similar. The tails are huge and tower higher than the first dorsal fin, whichin turn is proportionately taller than the first dorsal fin of most other big sharks.

The pectoral fins, on the other hand, are proport ionately smaller, perhaps because their guiding and balancing function is shared with the head. Thus, where other sharks must rely primarily on their pectoral fins for aid in banking, climbing, and turning, hammerheads also employ their heads.

The Great Blue Shark (Prionace glauca), is probably the easiest dangerous species, other than the hammerhead, for the biologist to identify. For one thing, it is by far the thinnest; only about 175 pounds at nine feet, as againest 300 or 400 for the same length mako shark and 700 or 800 pounds for a comparable white shark. The blue shark's colouring is also distinctive; it is in fact almost the prettiest of all.. The back is a stunning indigo, the sides bright blue mixed with silver near the tail—all set off by a snow-white belly.

The Great White Shark (Carcharodon carcharias), is by far one of the most difficult species to identify. To a man in a boat or even in the water, its profile could well be that of an adult brown, mackerel, or perhaps even a mako shark, so closely do these resemble one another at first glance. Closer study would, of course, show the differences, but this is seldom possible (or desireable) in open water.

You can't tell one by its colour either, for white sharks are seldom white. Younger ones are usually dull brown, adults slate grey to almost black on top and dirty white below. The misnomer may have originated long ago, when sailors saw their white bellies flash when they rolled over, and began to call the whole fish white. The name took hold, or so the story goes, and has since become so firmly rooted that no amount of truth or logic can change it. Actually, occasional large specimens may be pale grey or lead white, but they are the exceptions rather than the rule.

How, then, can you spot a white shark?

First study drawings and photographs, then look for a rather stout body with a curving back and a short, pointed snout. The gill slits will be very long, the eyes small, the petoral fins wide and deep, giving an impression of great power. Located at the peak of the back, the first dorsal fin will be a sharp, equilateral triangle, while the tail will be strong, stubby, and almost evenly proportioned on top and bottom. The quickest means of identification (though not found on every individual) is a pronounced black spot on the axis, or armpit, of each pectoral fin. The teeth are also distinctive—even triangles with sawtooth edges—but they are less obvious at first glance.

The Tiger Shark (Galeocerdo cuvier), is rather graceful, with a long sweeping tail with a large upper lobe and a streamlined body marked in youth with the vertical stripes that give it its name. These stripes are actually composed of dark spots fused together; with age, the dark colours spread until back and sides are solid grey or greyish brown. The belly, which is set well forward, is light grey or white.

Examined close-up, the tiger shark loses some of its charm. The head is blunt, short, very wide and rounded, and withal quite brutal, while the mouth is huge—four-fifths the width of the head—and filled with five or six rows of big, coarse teeth, teeth so sharp and numerous, eighteen to twenty-four per row, that they can cut through even the shells of tutles.

Tiger sharks' teeth are shaped like valentine hearts lying on their sides and are in effect little curved saws; some naturalists claim they are the most efficient teeth of any dangerous species of shark.

The Mako Shark (Isuropsis mako), is slender, lightning fast, quite brave and aggressive. It, prefers warm and temperate waters inshore and off in the Pacific and Indian Oceans. The mako's deep blue colouring, which looks cobalt or ultramarine in the water, fits in perfectly with the open sea that it prefers to the paler waters close to shore. This vivid blue tells it apart from all other shark species but the blue shark, which is almost the exact same colour but different in profile. Its belly is snow white.

<u>Protection Against Sharks:</u>

Since the outbreak of World War II, and afterwards marine biologists from all over the world began studying and experimenting with new ways to protect servicemen and bathers from the possibility of shark attack. The biggest thing discovered or was thought to be the biggest thing discovered, was a substance called Shark Chaser. It was issued mainly to servicemen at sea and piolets. It was later found to be useless against a determined attack, and was shortly afterwards discarded.

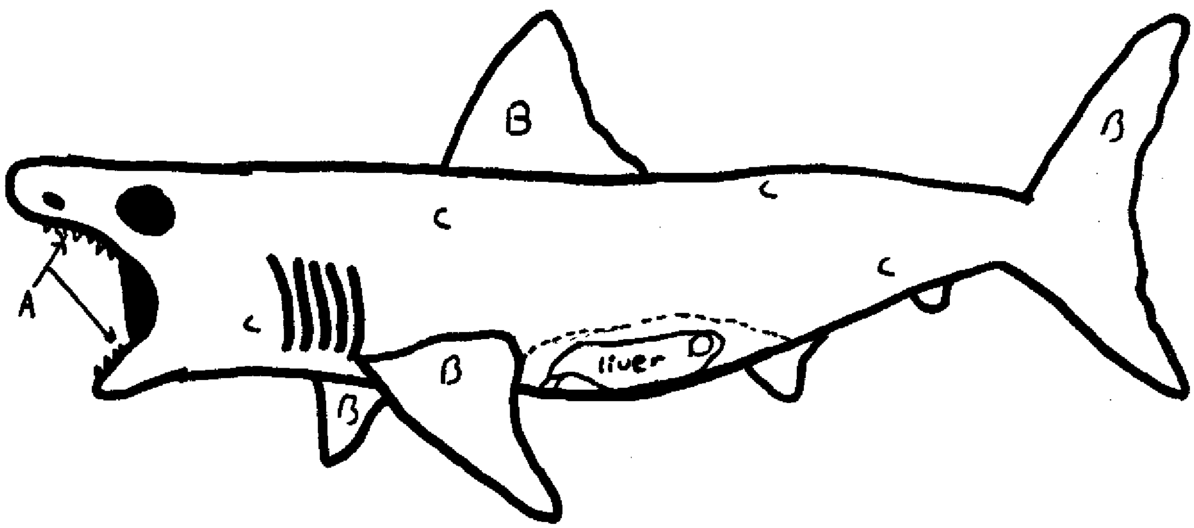
Other methods of protection were soon discovered, but, even they weren't totally efficient. Below are a few of them:

1) Meshing: A process in which two large post are set up and a very large net is placed between the post in order to keep sharks away from popular bathing resorts.

2) Watch Tower: This is where a very large observatory is set up, and contains four or more lifeguards with binoculars and when one of them spots a shark entering the area, a alarm is then set off to clear water.

3) Air Patrol: Its where planes fly at low altitude and when they spot a shark, they drop a streamer to warn the lifeguards. (Similar to the watch tower—but a greater distance of viewing).

Economical Uses of the Shark:



A) Jewelry

B) Shark-fin Soup

C) Tough Leather:
   shoes
   boots
   wallets
   luggage
   golfbags

D) Vitamin A

CROWN-OF-THORNS (RELATION TO THE FAR EAST REGION)
by William L. Krumpelman II, Kubasaki High School

Crown-of-Thorns
(Threat to Coral Reefs)

Introduction

"Man, long familiar with pestilence and natural catastrophe, now faces perhaps the most unusual plague of this century. Populations of large, coral-eating starfish are increasing at a phenomenal rate in tropical seas thousands of miles apart. Scientists find no precedent nor can they agree on a reason for these spontaneous infestations. Yet if the starfish plague continues, some experts predict that eventually entire coral reefs may crumble from wave action and disappear, endangering the island homes of hundreds of thousands of people."[1]

The crown-of-thorns (Acanthaster planci) is one of the most spectacular predators on coral reefs. These tough-bodied sea stars crawl relentlessly over coral reefs and devour the living coral animals called polyps by exerting their stomachs over them on the spot. The crown-of-thorns is a tough-bodied, spiny sea star with 12-20 legs.

> "Unlike most sea stars, the crown-of-thorns has sharp, venom-bearing spines, which protect it against most of its predators. The spines consist of calcium carbonate and organic material and are held erect by muscles. Glandular tissue is reported to be contained within the spines themselves and can secrete a toxin into the water or into the tissue of the would-be victim."[2]

When a person is punctured by the crown-of-thorns spines, he will experience pain, redness, swelling, some muscle para-

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[1]Jon N. Weber, "Coral Killer puzzles science", Smithsonian, April 1970, p.30

[2]Jacques Cousteau, The Ocean World of Jacques Cousteau, Volume 6, p.111

-lysis, nausea, and possible vomiting. In addition to the venomous spines the crown-of-thorns has another poisonous chemical in the skin covering its entire body. The spines are very sharp and when slightly grazed by the spine it may leave a cut in that spot. When cut by these spines, force the cut to bleed because then you will be getting the outer coating of the crown-of-thorns out of the cut and will help to stop infection.

The starfish moves across reefs, going as far as 820 feet a week devastating all the living coral polyps in the area. Crown-of-thorns usually eat at night, exerting its stomach inside out and on the coral to feed. When the starfish is finished eating, all that is left is the dead remains of the corals skeleton that is made of calcium carbonate. Acanthaster planci eats usually on the outer reefs that protect the islands. These are the fringing and barrier reefs. They usually move toward the land area after eating the outer reef. You may find a crown-of-thorns at the deepest depth of about 70 meters.

"The very first discovery was on Okinawa, reported by a fisherman in 1942, then later in 1957 Dr. Myoko reported a great population explosion on Okinawa's reefs. The first discovery of great importance of the starfish plague occurred at a popular tourist resort on Green Island, Australia. This resort is located on the 1,250-mile long reef called the Great Barrier Reef. In 1960 one single large crown-of-thorns was found near the southern end of the reef at Green Island. Around this starfish was the remains of live coral. Noone really realized untill sometime later that the crown-of-thorns ate the live coral polyps."[3]

In the following years (1960-1964) the increase of crown-of-thorns had almost tripled. More scares in the reef were reported and a great concern was given to the devastation of the reef. By this time the implications were almost evident. If no measures of investigation would have been done, the whole reef might have been destroyed in a couple of months. More scientists were trying to find out their destruction rate and how to stop them.

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[3]Jon N. Weber, "Coral Killer puzzles science", Smithsonian, April 1970, pp. 31-32.

The crown-of-thorns killed about 90% of the coral on the northwestern part of a 100-mile coastline on Guam in 1967. Crown-of-thorns also invaded 300 miles of Australia's Great Barrier Reef. This was the worlds most extensive example of the destruction of coral reefs. These islands also were invaded by the star fish: Malaysia, New Guinea, Palau, Saipan, Truk, the Ryukyu island chain, Japan, Fiji, Tahiti, Tuamotu Archipelago, Phillipines, Taiwan, all Indonesian islands, and some places even on the eastern coast of Africa. Many scientist and oceanographers were very concerned with the behavior and its eating habits. One concerned Biologist wrote this note,

> "The attacks are occurring throughout the Pacific, into the Indian Ocean, and almost to the coast of east Africa. It appears that all of the tropical reefs of the Pacific area are in real danger."[4]

"Many biologists concerned about the population explosion of the crown-of-thorns, were seeking reasons why there was so many of these sea stars. After extensive studying many scientists found alot of different solutions. One was that some of the crown-of-thorns natural predators (The giant triton trumpet shell, puffer fish, parrot fish, the mollusk helmet, and one type of a small shrimp) are being greatly reduced by collecters around the world. Scientist James A. Sugar calculated that shell collectors took at least 100,000 tritons from the Great Barrier Reef between 1949-1959. They say that they are trying to find out whether it's possible to grow these animals on a special triton farm. If it is, we'll seed them as adults along the Great Barrier Reef".[5]

When watching a triton catch and eat a crown-of-thorns is quite a thrill. First the triton locates the crown-of-thorns then pursues it. The mollusk first seized the starfish, holding it between the shell and its foot. Then the triton tears the starfish to shreds and devours it. Later he will spit out the spines.

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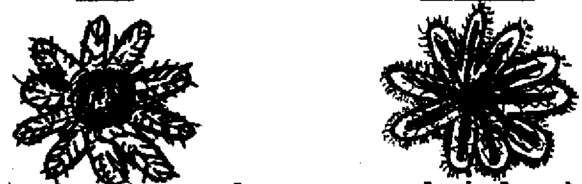
[4]Jon N. Weber, "Coral Killer puzzles science", Smithsonian, April 1970, p.35

[5]James H. Sugar, "Starfish Threaten Pacific Reefs", National Geographic, March 1970, p. 351

Some people argue over the fact that a triton can move faster than a crown-of-thorns, but it is true that the triton can move faster. The crown-of-thorns can only move about a foot per minute when competing for food.

Fig 1 Crown-of-Thorns Diagram:



Dead coral means real danger to many people on coral islands and atolls in the pacific region. When the crown-of-thorns eats the live coral, all that is left behind is the coral skeleton which eventually the storm waves would wash away the shoreline and possibly the whole island. Before this could happen the islanders would have to leave or starve to death. They get their livelyhood from the seas products. When the reef dies so does the amount of fish in that region. The coral reef is the sustaining factor of all ocean life on atolls.

"The possibility that such a disaster might strike the Pacific Islands Trust Territory, administered by the United States, prompted the U.S. Department of the Interior to send out an international team of more than 60 scientists and divers to study the problem in the summer of 69'. The project, managed by the Westinghouse Ocean Research Laboratory of San Diego, California, was set up to survey the damage caused by the crown-of-thorns".[6]

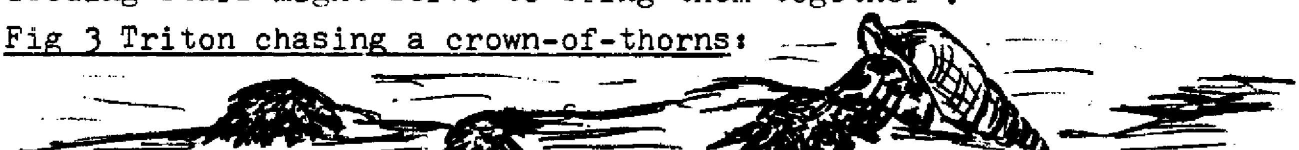
Fig 2 Part of the Crown-of-Thorns:

"No real theory up to date can be used to tell the starfish plague and its wide distribution. Some scientists think that the population explosion has no unusual cause but that it only was a natural disaster. Other theories were given but none seemed to really answer it. Many scientists in Australia seem to think the over-collection of the great triton shell was the main reason

[6]James H. Sugar, "Starfish Threaten Pacific Reefs", National Geographic, March 1970, p. 344

for this breakout. But on other islands in the pacific, though not many shell collecters there, were equally infested with the crown-of-thorns. Other theories have been made by scientists concerning mans disturbance. American marine biologists, together with government agencies, examined all earlier conclusions ---- pollutants, blasting and dredging, shell collecting, spearfishing, and their effects on the predators of seastars. Some scientists say that typhoons were responsible for the redistribution of the food supply of predators on sea stars. This "environmental disturbance" idea now awaits experimental tests. Very recently another hypothesis was offered: that a chemical attraction among feeding stars might serve to bring them together".[7]

Fig 3 Triton chasing a crown-of-thorns:



Scientist suggested that the destruction of reefs by blasting and dredging to create new airfields or to enlarge existing facilities may have removed normal encrusting organisms from wide reaches of the coral reefs. In these circumstances the Acanster planci has a chance of laying her eggs and most of them growing to adult stage. However during WWII's heavy sea, air, and ground bombardment, you would expect to see a population rise of the crown-of-thorns, but there was none. Dredging and mining are not heavy to the islands but the use of pesticides is. These pesticides have a wide effect while in the ocean. Some kill fish, some increase the rate of developement, and some make the creature turn out abnormally. So the crown-of-thorns might have been effected by the pesticides by having a vast increase in population.

"In his office at the university of Guam, Dr. Chesher told me that man may be responsible in another way for the invasion. "By killing the coral in the process of blasting channels or dynamiting for fish", Dr. Chesher said, "he has perhaps altered the underwater environment in favor of the sea-stars survival."[8]

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[7]James H. Sugar, "Starfish Threaten Pacific Reefs", National Geographic, March 1970, p. 347

[8]James H. Sugar, "Starfish Threaten Pacific Reefs", National Geographic, March 1970, p. 347

Dr. Chesher explained that many of the <u>Acanthaster planci</u> that are spawned by the female starfish (Spawning usually occurs from July-August) may never make it to adulthood. Usually the coral polyps eat the starfish larvae. Many other predators eat its larvae. But if the coral is killed by mans devastation, the starfish won't have any predators in larvae stage thus leaving many to become full mature adults. The result from this action is called a population explosion.

> "Support for my hypothesis," Dr. Chesher pointed out, "comes from the fact that infestations in Guam, Rota, and Ponape were first discovered near blasting or dredging sites."9

Many other scientists have given their hypothesises about how the reef may be being destroyed by mans use of atomic energy and by pesticide residues washed into the oceans by rivers and strems form land. But to all the theories and hypothesises all can be figured into a basic category. This category is the place of mans activities.

<u>Ways of killing Crown of Thorns</u>

There are many different ways of killing the crown-of-thorns but the chemicals you may use may be effective to other living organisms in the water and the things that eat the crown-of-thorns. One way is to use a formaldyhyde gun.. This is like a shot but it is inserted into the heart of the Acanthaster planci. This gun was used extensively by scientists and divers on Guam in 1967-1970. Also it was used in Australia on the breakout of starfish on the Great Barrier Reef. Many scientists say that this formaldyhyde also has effects on the balance of nature in ocean life. Bleach can also be used. The bleach can kill it almost automatically. But the bleach kills coral polyps and also many other living organisms. **Amonia was also tried but it really had no effect.** The most effective way, found by many people, is to stab the starfish and bring it ashore. When you get it ashore let it set above the hightide mark to dryout and rott away. <u>Warning</u> Many divers have thought that you could kill the starfish by cutting it in half. But like

9James H. Sugar, "Starfish Threaten Pacific Reefs", <u>National Geographic</u>, March 1970, p. 347

all starfish they also have radial symetry. This is when a star fish is cut in half it will regenerate and become two starfish. This would not help solve our problem but only make it worse.

I think that if man takes away all the crown-of-thorns that he will alter the whole food chain of the seas. With the crown-of-thorns gone what would its predators eat? Thus what would happen to them ? Would they too go out of existance? All these questions should be also taken into concideration when trying to solve the problem with the crown of thorns.

Acanthaster planci on Japan

The very first report in Japan on the crown of thorns was in 1942 by a local village fisherman. He was out one day pulling in his nets when he noticed an unusual type of starfish. He brought it back to be studed. Later in 1957 Dr. Myoku reported a great population increase in the Ryukyu islands. Thats when the study of *Acanthaster planci* really got to work to try to save the coral reefs.

"In the Yaeyama Islands, the aggregation of *Acanthaster planci* has been seen only on the reefs around Hatoma Island and those south of Taketomi Island (Fig 5). It was in 1972 that an unusual high density aggregation was first noticed around Hatoma island. Since then, in spite of the great controlling effects, the population has kept its high density level there. In July 1974, a large population of Acanthaster appeared in the vicinity of Taketomi Island and it grew very rapidly. As above, the devastation of coral communities due to *Acanthaster's* predation is seen locally on some restricted reefs. In the Okinawa Islands, however, almost all of the coral reefs along the western coast have been devastated already. In the area between Iriomote and Ishigake Islands, so called Seki-Sei Lagoon, *Acanthaster* shows a gradual increase. The Yaeyama Islands is well known for its beautiful and large-scaled coral reefs in Japan, and we can see a variety of marine life there. The area will be designated as a national marine park by the Environmental Agency of the Japanes Government."

"Some efforts to remove *Acanthaster* from the high density area have been conducted by the Environmental Agency and Okinawa Prefectural Government. During 5 to 12 of February in 1975, a

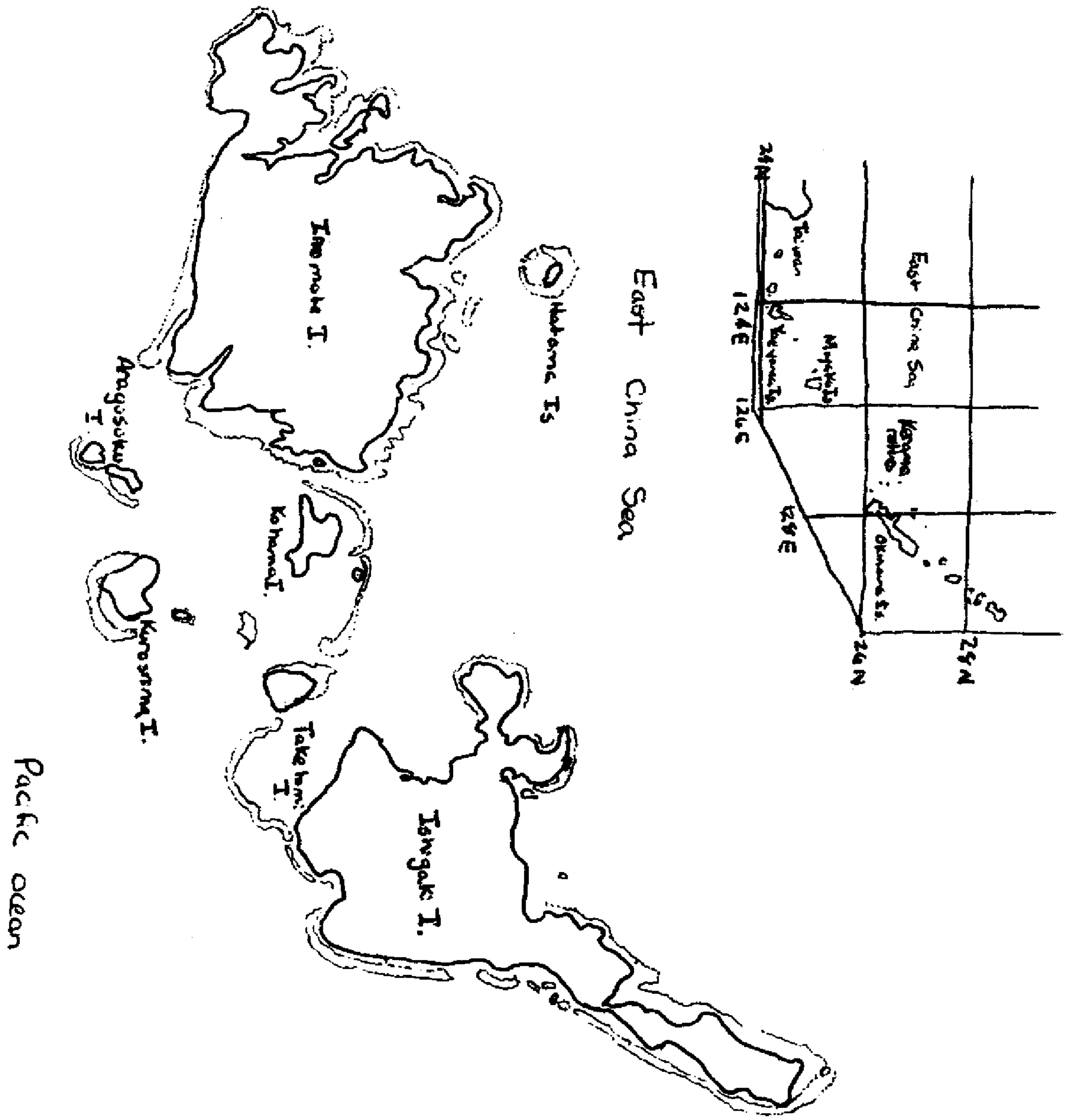

Fig. 5 Map of Yaeyama Islands. Insertion shows location of islands.

total of 5,117 starfishes were removed from reefs around Hatoma Island and 15 days from March 10-29, 9,147 starfishes were killed. These 9,147 were taken from the southern reef of Taketomi Island. During these control works some observations of the population were done".[10]

The purpose of the present work on Okinawa about the Acanthaster

[10]Sesoko Marine Science Laboratory, Techical Report No. 4, December 1976

is to try to study the population increase and the removing of the seastar. All this is being done under control works, but not the cause of the outburst of the *Acanthaster* population. Also the Ecological distribution, density, and degree of damage of corals are delt with.

Principally the starfishes were removed from the living sites by means of hand spears. The starfishes were landed and a part of the population was taken as a sample for later analysis. Number of arms, maximum diameter excluding spines and fresh body weight were recorded. In advance of the removing works, 10 minutes snokelings were done at 14survey points around Hatoma Island and 15 points south to Taketomi Island to know the density. Distribution and feeding were also recorded. And in 23 days of removing works the similar survey was done in the area of the removing works.[11]

The present work was done during the removing work, consequently only the brief observations were available. Because the removing starfish was done in the wide area in 23 days we could get general of the distribution and the effect to corals. At present in the Yaeyama Islands, only around Hatoma Island and on the reef south of Taketomi Island the high density population was seen. In these areas intereferehce with coral communities due to *Acanthaster* is gradually progressing. In the following, the status of thes areas is mentioned.

A. Area around Hatoma Island

On the southern reefs an abnormally high density population of starfish was first recognized in 1972, and a total of 10,850 starfishes were removed by Taketomi town. Further in 1973, the joint control team of Taketomi Town and Ishigaki City killed 52,650 starfishes. In spite of these efforts however, the high density status have continued up to the present works.[12]

B. Area south of Taketomi Island

The distribution of starfishes in March of 1975 is shown in Fig. 8. It was in June of 1974 when the high density population of

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[11]Sesoko Marine Science Laboratory, Technical Report No. 4, December 1976

[12]Sesoko Marine Science Laboratory, Technical Report No. 4, December 1976

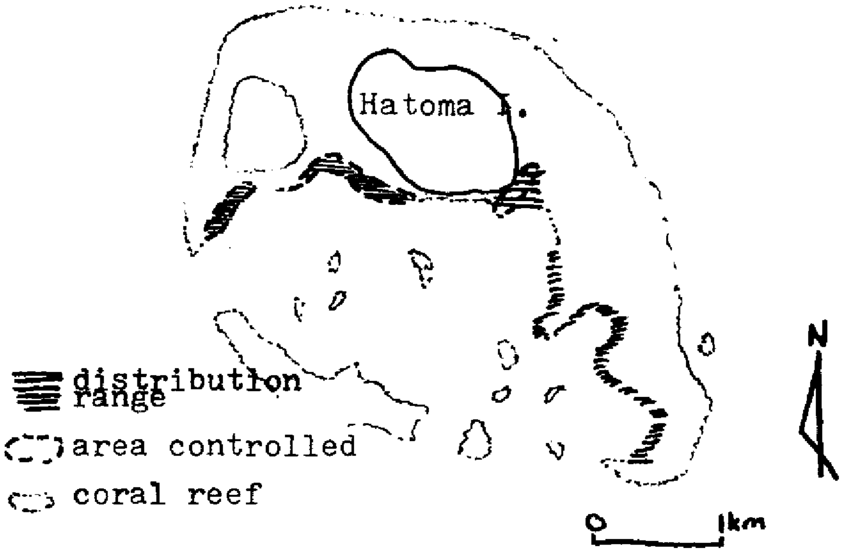

Fig. 6 Distribution range of Acanthaster planci in February, 1975 around Hatoma Island. Starfishes concentrated on the inner reef slope to form zonal distribution.

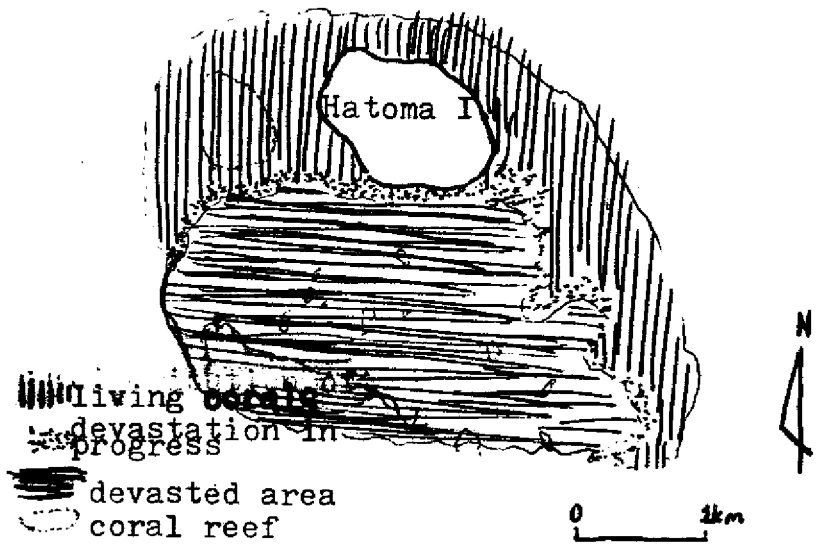

Fig. 7 Regional status of the devastation of coral communities due to Acanthaster planci around Hatoma Island, February 1975.

starfishes was first observed, and at that time only 5 to 6 individuals were counted in 10 minute surveys even at the highest density area. About only 9 months later, they increased up to 10 to 23 individuals per 10 minute survey.

Corals were damaged more intensely at the deeper bottom than at th shallower. At the shallower part just below low water line where the corals showed a good growth, many starfishes were removed. At the shallower part, comparatively many starfishes were seen in contrast to the number of feeding scars, most of which were of small size. And further, many starfishes were collected from the coral patch without any feeding scars. [13].

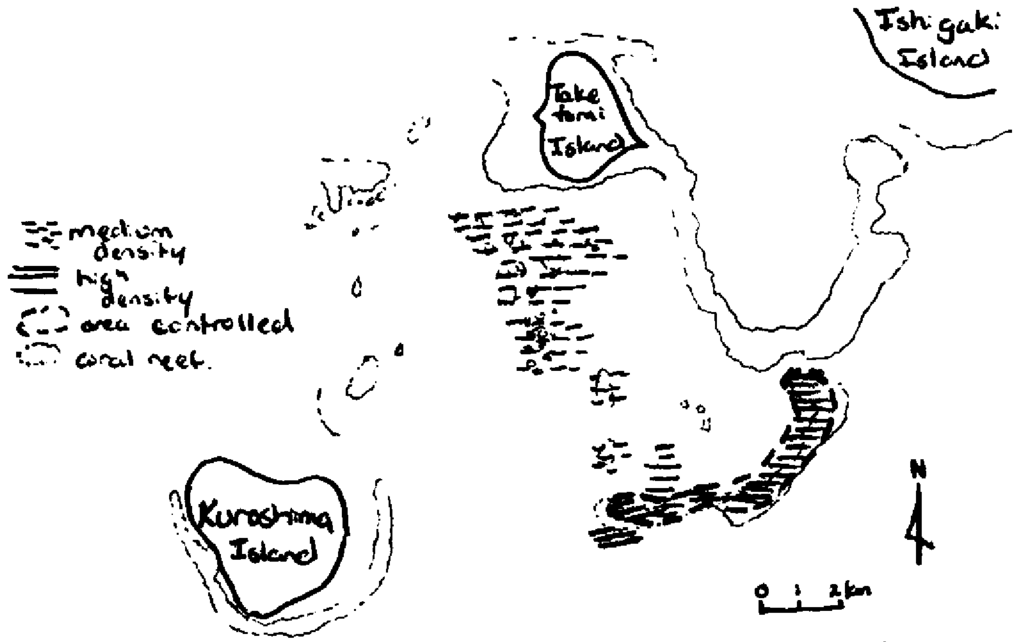

Fig. 8. Distribution range of Acanthaster planci around Taketomi Island. High density areas are seen on the patch reefs and barrier reefs southeast to the island.

Summary

1. In the Yaeyama Island, high density Acanthaster populations was observed only in the restricted area of the reefs around Hatoma and Taketomi Islands. In the Gatoma area, some control efforts were done in February of 1975 and removed 5,117 starfishes, and in March of the same year 9,147 starfishes were captured from the reefs wouth to Taketomi Island.

2. In 1972, the high density of Acanthaster population was noticed on the southern reef off Hatoma Island and that population consumed almost all of the corals growing deeper than 2m, except the outer reef margin. And now they proceeded almost to the shore line of the island. They aggregated along the inner reef margin

[13]Sesoko Marine Science Laboratory, Technical Report No. 4, December 1976

to form a narrow band.

3. On the inner margin of the reefs southeast to taketomi Island a quantity of starfishes were observed just below the low water mark. There were few feeding scars in comparison with the density of starfish and the feeding scars were mostly of small size. Many starfishes were captured from the luxuriant coralgrowths of almost 100% coverage without any sign of feeding scars.

4. In the high density area, tabular acropora were more frequently fed om than branching corals, but it does not mean that the coral communities of tabular acroporans were always attacked first.

5. Most starfishes had 15 arms and there was no difference in the number of arms between the Hatoma and Taketomi populations.

6. Average diamerers of starfishes in Hatoma and Taketomi areas were 31.24±0.28cm and 24.65±0.28cm respectively. Most of the star fishes in Hatoma area were larger than 30cm and those less than 21cm were extremely few.

7.Population around Taketomi area was mostly of 24cm class and here again those starfishes less than 21cm are relatively few and comprises only 14% of the population. But in a particular site of the reef there was a population of smaller individuals less than 20cm.[14]

Fig [redacted] 9

Year	Killed	People Used	Killed per Person
1969	400	30	13.3
1970	60	30	2.0
1971	42,500	469	90.6
1972	199,300	808	234.8
1973	1,271,687	1,625	782.6
1974	834,945	825	1,012.1
1975	805,442	1934	416.5
1976	120,387	136	884.5
Total	3,264,821	5,867	3,486.1

This chart refers to the amount killed on Okinawa.

[14]Sesoko Marine Science Laboratory, Technical Report No. 4, December 1976

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THE EFFECT OF PALYTOXIN FROM *PALYTHOA VESTISUS* ON RAJI CELLS

by Allen I. Hori, Waimea High School

ABSTRACT

Death or continued viability of raji cells after introduction of palytoxin from Palythoa vestisus was investigated and compared to the responses of normal lymphocytes under the same conditions. Palytoxin was found to have an enhancing effect, in most cases, on the growth of raji cells (undifferentiated stem cells) and an enhancing effect, in a few cases, on the growth of normal lymphocytes. A possible morphological change in the palytoxin treated raji cells was also seen.

INTRODUCTION

Lymphomas are defined as malignant tumors that involve the lymphatic system instead of a particular body organ. Included in the classification of lymphoma are Lymphosarcoma, Hodgkin's Disease and leukemia. Among the malignant diseases, lymphomas are about the most sensitive to irradiation and medications, however, they remain incurable with uncommon instances of recovery. The actual cells used in toxicity tests in this project are raji cells (premature lymphoid cells) from cancer patients. These cells are not yet differentiated. However, since they are removed from patients who have diseases related to lymphoma, the cells are more likely than not to develop into cancerous tissues.

Palytoxin is a sea toxin from the soft coral Palythoa vestisus. This zoanthid, formerly called Zoanthus vestisus Verrill is found abundantly in waters surrounding the Hawaiian Islands, American Samoa and Tahiti. Numerous studies have been done in relation to the soft coral Palythoa vestisus and to palytoxin itself. Mistysyn (1972) examined extracted lipids from P. vestisus through chromatography while Sheikh (1969) isoalted compounds found in palytoxin. Imoto (1974) worked with P. vestisus and its antibacterial properties. However, no apparent studies have been done with palytoxin and its effect on lymphoma cells.

Sheikh reveals that the Hawaiian warriors used the toxin from P. vestisus on their spear tips and that it was previously believed to be an algae and not a coelenterate. He also points out that palytoxin is toxic to mice, resulting in paralysis of the hind legs, respiratory difficulty, gasping, convulsions and finally death. Futhermore, inhalation of the toxic powder caused a strong burning sensation and bleeding of the nasal passages, and mucus from P. vestisus polyps caused redness and itching of tender parts of the skin.

Other marine toxins have been tested on lymphoma cells and resulted in reduced viability of the lymphoma cells (holuthurin from the cuverian tubules of Actinopyga mauritiana, Okada, 1975) thus setting a precedent to the purpose and execution of this project. Therefore it is the purpose of this project to investigate the reactions of lymphoma cells and also normal lymphocytes to palytoxin under controlled, laboratory conditions. After isolating the palytoxin, preliminary toxicity tests will be made on the crayfish, Procambarus, to test for its toxicity and subsequently the toxin will be introduced to raji cells and to normal lymphocytes.

MATERIALS AND METHODS

Preparation of Palytoxin: Polyps of the soft coral Palythoa vestisus were collected twice from the mud flats at Wailupe Beach Park, on the east side of Oahu, in the midmorning at low tide with water level not exceeding two feet. The first collection was transported, rocky bases intact, to the lab and the polyps were severed before use. The second collection was severed off the rocks while still submerged within their environment and transported to the lab for processing.

The polyps were cleaned of debris and soaked overnight in enough methanol to cover them. The liquid was then decanted, filtered by vacuum filtration and kept as extract I. Collection #1 was then ground with mortar and pestle, soaked overnight for two nights in 15% methanol/chloroform (vol/) with subsequent filterings. Collection #2 was soaked three times in the same solution and filtered accordingly. The extracts were then combined and filtered once more by vacuum filtration. Observed was a division of greenish-yellow and brown liquids. The greenish-yellow liquid was assumed to be sea water excreted by the polyps and the brownish liquid was the liquid form of crude palytoxin. This portion was then evaporated on a rotary vacuum evaporator. The residue was removed from the evaporation flask and redissolved in 10 ml. of distilled water which became the final extract of crude palytoxin.

Prior to introducing the toxin to the various cells, this form of the crude palytoxin was filtered using a Millipore Swinnex Filtration Apparatus to eliminate any bacteria or yeast which could possibly contaminate the culture.

Toxicity tests on *Procambarus*: Preliminary toxicity tests on *Procambarus* to test palytoxin's toxicity were carried out. *Procambarus*, average weight of 15.0 g., were placed in heavy glass dishes with enough stream water to cover them. Dosages of one-tenth milliliters, two-tenth milliliters and three-tenth milliliters of separate toxin dilutions were injected into separate crayfish using sterile syringes. A total of twenty-four crayfish were inoculated with dosages and dilutions as follows:

six crayfish:
0.1cc - full strength
1:2
1:4
1:8
1:10
saline - control

six crayfish:
0.2cc - same

twelve crayfish:
0.3cc - same

All concentrations were diluted using crustacea saline solution. Controls were set up, injecting the crayfish with saline solution at 0.1cc, 0.2cc, and 0.3cc respectively. The weight of the individual crayfish, time inoculated, reactions and time of death were recorded. Death was dtermined by the absence of movement of the gills and tail swimmerets.

Toxicity tests on cells were run. Two trials were run on both the raji cells and the normal lymphocytes separately. A total of four tests were carried out and are identified as follows:

Test I - Toxicity tests on raji cells
Viability tests on raji cells

Test II - Toxicity tests on normal lymphocytes
Viability tests on normal lymphocytes

Test III - Toxicity tests on raji cells
Viability tests on raji cells

Test IV - Toxicity tests on normal lymphocytes
Viability tests on normal lymphocytes

Tests I and II were run in parallel as were Tests III and IV. Normal lymphocytes used in Tests II and IV were obtained from different people.

Toxicity tests on raji cells: To examine the actions of palytoxin on raji cells, 0.2 ml of raji cells, 0.2 ml of sterile Eagles Minimal Essential Medium and 0.2 ml of the appropriate toxin dilution were combined in sterile test tubes and incubated at 37 C for a total of twenty four hours. Dilutions used were full strength, 1:10, 1:100 and a control consisting of 0.2 ml of sterile saline, 0.2 ml of Eagles Minimal Essential Medium and 0.2 ml of raji cells was made. Tests I and II had viability tests done at two, four, ten and twenty-four hours after the introduction of the toxin while Tests III and IV had viability tests done at one, four, seven and twenty-four hours after introduction of the palytoxin.

Viability tests on raji cells: After the appropriate time interval, 0.08 ml of saline, 0.01 ml of the cell-toxin mixture and 0.01 ml of Trypan Blue were placed in a test tube for counting under a hemacytometer. The viable cells remained colorless while the dead cells appeared stained blue. The dead cells appeared blue because they were no longer capable of sustaining the function of their membranes thus allowing the Trypan Blue to permeate into the cell and identify it as dead.

Preparation of normal lymphocytes: The whole blood was centrifuged as 1000 RPM for five minutes. The interphase layer was then pipetted out into sterile tubes. This was then layered on 3 ml of Lympho Prep and centrifuged at 1600 RPM for thirty minutes. The interphase layer was pipetted again into sterile tubes and washed three times by adding an equal amount of Hanks BSS and centrifuging at 1000 RPM for ten minutes.

Toxicity tests on normal lymphocytes: To test the effects of palytoxin on normal lymphocytes, the procedures remained the same as when testing with the raji cells. Toxin dilutions and control remained constant.

Viability tests on normal lymphocytes: Viability tests dealing with normal lymphocytes remained the same as the viability

TABLE I
PERCENTAGE OF VIABLE RAJI CELLS
(TOXICITY TESTS ON RAJI CELLS)

CON	%VIABLE	2 HRS	4 HRS	10 HRS	24 HRS
TEST I:					
f.s.	100%	26%	37%	44%	81%
1:10	100%	42%	37%	74%	67%
1:100	100%	30%	39%	68%	49%
C	100%	79%	51%	40%	42%

CON	%VIABLE	1 HR	4 HRS	7 HRS	24 HRS
TEST III:					
f.s.	100%	42%	94%	100%	03%
1:10	100%	73%	19%	69%	42%
1:100	100%	46%	35%	37%	25%
C	100%	54%	46%	35%	46%

KEY

f.s. = full strength
C = control

TABLE II
NUMBER OF VIABLE NORMAL LYMPHOCYTES
(TOXICITY TESTS ON NORMAL LYMPHOCYTES)

CON	%VIABLE	2 HRS	4 HRS	10 HRS	24 HRS
TEST II:					
f.s.	100%	157%	143%	121%	50%
1:10	100%	171%	114%	121%	271%
1:100	100%	100%	136%	114%	50%
C	100%	114%	150%	279%	179%

CON	%VIABLE	1 HR	4 HRS	7 HRS	24 HRS
TEST IV:					
f.s.	100%	36%	44%	27%	13%
1:10	100%	49%	30%	54%	33%
1:100	100%	20%	14%	24%	36%
C	100%	20%	23%	34%	31%

KEY

f.s. = full strength
C = control

tests performed with raji cells.

DISCUSSION OF RESULTS

Crayfish were used to test for palytoxin's toxicity. Dosages of 0.1cc, 0.2cc and 0.3cc of palytoxin diluted to 1:2, 1:4, 1:8 and 1:10 and full strength were injected into separate crayfish. The length of time between inoculation and death, their weight and reactions were recorded.

In this study, palytoxin, at its weakest dilution used (1:10) proved to be lethal as did stronger concentrations. The control showed no toxic effects. The crayfish were originally aggressive and responsive when provoked. However, the treated group all showed signs of being sluggish, having a loss of balance and, in some cases, paralysis.

Palytoxin was then introduced at different dilutions to both raji cells and to normal lymphocytes. Single doses of 0.2 ml of toxin at 1:10, 1:100 and full strength dilutions were used. The toxin had varied effects on the raji cells. Immediately after introduction of the palytoxin, the majority of the cells showed greatly lowered viability. As the hours elapsed, a proliferation of viable cells was noted and finally after a twenty-four hour period, another drop (gradual) in viable cells was noted.

One explanation for the fluctuations of the viable cells could be that palytoxin exhibits selective toxicity, killing certain cells while allowing other cells to continue living, multiplying and thus causing the rising number of viable cells. An assumption stating that palytoxin does exhibit selective toxicity might be valid because the control shows a gradually dying pattern.

Results of the tests done with normal lymphocytes were inconclusive since too great a variation was shown in the data. It is interesting to note that the normal lymphocytes used in Test II were from a female, approximately 23 years of age while the normal lymphocytes used in Test IV were from a male, approximately 19 years old. This difference could have a bearing on the condition of the lymphocytes and on their reactions to palytoxin.

Futhermore, the great difference in the data from the tests on normal lymphocytes could have resulted from experimental error such as contamination or miscalculation.

In contrast with the work done with normal lymphocytes, a consistent pattern can be seen in the data from the tests carried out with raji cells. This pattern of initial killing (reduced viability) followed by a proliferation of the raji cells could be justified by stating that the raji cells were obtained from the same culture thus insuring uniformity and consistency prior to the introduction of the palytoxin.

As an additional follow-up exercise of the project, a cytological study using a hemacytometer was made to observe individual cells, both raji cells and normal lymphocytes under the present treated and untreated states. This step may have been the most significant of all. When comparing untreated raji cells to treated raji cells, a definite morphological difference was observed. The untreated raji cell smear appeared like ordinary undifferentiated lymphoid cells which are large with nucleoli present, but when the treated raji cell smear was observed, a noticable size decrease (approximately three microns) and an alteration in the maturation (development of undifferentiated lymphoid cell to a normal lymphocyte) of the cell was seen. Instead of the nucleoli being present in the immature raji cells, only a large dominating nucleus could be found. In an untreated raji cell, nucleoli and large cell size are apparent; however, a treated raji cell appears to have instead of nucleoli, a nucleus, thus suggesting that it has matured into a normal lymphocyte, changing its morphology. This differentiation of the raji cell maturing into a normal lymphocyte could be attributed to palytoxin; however, a definite statement is inappropriate due to the many variables involved in the present study. Additional tests and controls must be examined to gather more conclusive data on this aspect of differentiation. No differentiation as such could be seen in the normal lymphocytes.

A change in the staining quality was quite apparent in the raji cells also. All smears of the raji cells were prepared in the same manner. In the treated raji cells, especially at full strength, the raji cells stained extremely heavily, appearing almost black. This heaviness decreased as the concentrations of the palytoxin decreased. This further suggests that palytoxin, although enhances the growth of raji cells, changes their basic structure, and also the chemical structure of the raji cells causing the treated group to react differently to the stain thus appearing almost black as opposed to the pimk and light purple colors seen on staining of the untreated raji cells.

Since a great deal of work has been done with the constituents of Palythoa vestisus, definite future work could include refining the method of palytoxin preparation, retesting its toxicity on raji cells and possibly tissues which provide additional information on the effects and nature of palytoxin.

CONCLUSION

Results of experiments contained within this research project show that palytoxin has an enhancing effect on raji cells causing them to proliferate at various stages of their development and that it may alter the morphology and staining quality of the raji cells.

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PHOTORECEPTION AND BEHAVIOR PATTERNS IN HERMIT CRABS

by Bridget J. Kennealy and Gordon H. Okamura, Pahoa High School

ABSTRACT

Do hermit crabs really change shells?

If so, what is the reason for this?

What kind of eating habits does the hermit crab have?

What kind of photoreception do they exhibit?

These are some of the questions we aim to answer in this paper.

INTRODUCTION

The hermit crab is a decapod crustacean belonging to the suborder Anomura. They are notable for their habit of sheltering themselves in gastropod shells. They do this to cover their unprotected abdomen. The hermit crab probably had it's origin in forms which used crevices and holes for protection. A hermit will make use of other protective shells if no suitable shell can be found. Some have been seen with their abdomens stuck in half of a coconut or in joints of bamboo.

The abdomen of a hermit crab is made to fit in the spiral chamber of a gastropod shell. The abdomen is asymmetrical and soft, except for the tip. Here it is calcified to form an anchor so the hermit can hold a firm grip on the inside of a shell.

The claws are built heavily and formed so that when it withdraws into it's shell it closes the opening of the shell. The first two pair of legs are very slender in porportion to the length. They're used for walking. The last two are very small for adjusting the shell and cleaning the body.

Since the hermit crabs are always out growing their shells, sometimes there is competition for shells of suitable size. The crabs will always use empty shells and never try to kill the organism occupant. Although two hermits will fight for the possession of an empty shell. Usually the bigger hermit will win.

When the hermits grow too big for it's shell it does not leave the old shell untill a new one is found. The hermit crab locates a shell with it's eyes. It then inspects it with the chelae, inserting on into the interior. If the shell looks suitable it will try it out. If the fit, weight, and movability is bad, he will go back to it's old shell and search for another.

Most hermit crabs are marine animals, they can be found almost anywhere. Although a few species have become adapted for on the land. They run in size from 1/2 inch to 18 inches. Large groups of hermits often crawl areas of the ocean floor where seashells are abundant.

METHODS OF RESEARCH

To answer the questions we have, we set up a couple tanks. One tank is to watch the hermits change shells and another to find out the kind of photoreception the hermit crabs display.

The first tank was studied every day for about a month to see when the Hermit changed their shells. Also in this tank the eating habits were observed. The hermits were fed about three times a week. They were fed many different things to see what they would eat. Things like shrimp, dead fish, and even algaes that were living on the rocks.

In the second tank the experiments on photoreception was performed. About fifty crabs were put into this tank. First, two large rocks were set in the middle of the aquarium to see if the crabs prefered to stay in the open or under cover.

Then the rocks were taken out of the tank and half the tank was shaded with the other half light. This was done to see if the hermits preferred to stay in the light or the dark. Then some pieces of shrimp were put into the lighted region to see what their reaction would be.

This experiment took about one hour and a half.

RESULTS OF RESEARCH

After observing the first tank it was found that the crabs grew out of their shells in about a months time. They preferred the gastropod shells more than any other kind of shell but the correct size was the most important criteria.

The hermit crabs ate almost anything providing it was edible. They really kept the tank clean.

In the second tank it was found that within twenty minutes the crabs were on or under the rocks that were placed in the middle of the tank. Just this does not denote photonegativity. It could be that the crabs would rather climb on a rock than crawling in the sand.

Therefore, a second experiment was undertaken. It was found that the crabs tended to stay in the shaded region of the tank. When the food was put in the light region some of the crabs came out of the dark to recieve food but they immediately took it back into the dark to eat it.

CONCLUSION

We have found through research and experiments that the hermit crabs do change their shells. The reason for this is that the crabs grow out of their shells and it is necessary to find a new one as soon as possible as to protect their soft abdomen which is very delicate and it needs protection. The crabs will also look for a new home if their shells are cracked or broken.

It was also found that hermit crabs are scavengers of the ocean. They will eat almost anything so they help to keep the ocean floor free from alot of debree. The hermit crab is an aminore.

It was also observed that the hermit crab is a very smart and clean animal.

From the results of the photoreception experiments it was concluded that the hermit crab prefers the dark to the light. They would rather blend into their envirment, like climbing on the rocks or staying in the dark. I think it's just a natural instinct to hide from it's predators. I think that this adaptive advantage for photonegative responses is in many animals. Hiding in the dark and coming out only for food is just instinct. Maybe they think they are more secure thinking they are less visible. All this is just a natural way of protecting themselves.

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OPTIONS IN AQUACULTURE

AQUACULTURE: A POTENTIAL IMPACT

by Francine Kaneta, Sacred Hears Academy

INTRODUCTION

Some problems involved with aquaculture are that it is timely, there might be success in one type of farming than in others, competiton may arise between private organizations and public agencies, and also questions such as these may come about--Is there any future for aquaculture?, Is it economical?, And, Is is worth it?

Modern-day aquaculture has been defined by the National Oceanic and Atmospheric Administration as: "The culture or husbandry of aquatic animals or plants by private industry for commercial purposes or by public agencies to augment natural stocks.[1] Current aquaculture has been around for no more than 15 years. But, a form of aquatic farming has been in the Hawaiian islands for more than 800 years. This dates back to old Hawaii; the people raised fish in very large ponds. Food for animals resulted from natural productivity of the ponds.

Literature research has been the method used to evaluate the information used for this research paper.

RESEARCH AND DEVELOPMENT

A. Idea of Aquaculture

The idea for farming the sea has not come about just recently. It has been around since the times of the Polynesians. These Polynesians, not only the Hawaiians, developed a form of aquatic farming that would supply them sufficiently for a number of weeks to years. With the use of unpolluted streams, ponds, and the ocean, the Hawaiians were able to keep numerous amounts of fish and shellfish to supply their family or the village in which they lived.

B. Animals Researched[2]

There are four organizations in the State of Hawaii which conduct basic and applied scientific research on aquaculture. These organizations are the State Department of Land and Natural Resources, the Hawaii Institute of Marine Biology of the University of Hawaii, and the Oceanic Institute. Other agencies fund research and development activities but do not conduct on-going research themselves. Such organizations are the International Center for Living Aquatic Resource Management of the Rockefeller Foundation and the State Marine Affairs Coordinator. The various State task forces for economic development on the Neighbor Islands may also fund research and development.

The approaches to research and the particular species being investigated have been different for each of the major organizations. The Hawaii Institute of Marine Biology, for example, evaluated numerous local species of fish and shellfish to determine their potential for aquaculture. However, the Anuenue Fisheries Research Center of the Department of Land and Natural Resources and the Oceanic Institute have esch focused its research efforts on developing the aquaculture potential of one selected species: the Malaysian prawn, and the mullet respectively.

Regarding all the species being investigated, three categories are evident: (1) Species such as mullet and milkfish which, mass-cultured, would provide large amounts of low-cost food protein. This approach is aimed at exporting the technology to developing countries; (2) Species such as prawns, moi, mullet and milkfish which, when mass-cultured, would provide moderate or high-priced food fish and/or shellfish to be sold by private enterprise. This approach is aimed at developing an aquaculture industry in the State and gaining benefits therfrom, such as employment, a diversified economic base, and expanded tax base, etc.; (3) Species such as topminnows shich, when mass-cultured, would provide a more plentiful bait supply for catching food fish, i.e., a live-bait supply for the Hawaii tuna fishery.

C. Amount of Funding Involved[3]

Some 25 or so animal species have been investigated in the course of aquaculture research in Hawaii. A funding summary for the years 1962-1976 is given in Table I. Approximately $5.3 million has been spent by the organizations carrying out Hawaii-based animal aquaculture research programs. Another $1.25 million has been spent on plant aquaculture. However, much of this research has been carried out elsewhere in the Pacific. The largest portions of the Federal, State and private funds have been spent since 1970,

Table I.--SUMMARY OF R&D FUNDING FOR AQUACULTURE IN HAWAII THROUGH FY 75-76a/

ORGANIZATIONS	FEDERAL NOAA SEA GRANT	FEDERAL OTHER	STATE	PRIVATE	TOTALS
SEA GRANT COLLEGE, U.H.					
ANIMAL AQUACULTURE	$1,301,400	---	$ 872,600b/	$ 13,600	$2, 187,600
PLANT AQUACULTURE	734,300	---	111,800	421,000c/	1, 260,100
DLNR	167,500	286,200	373,200	---	826,900
OCEANIC INSTITUTEd/	783,500	141,000	10,000	819,000	1,753,500
MAC	---	---	144,700e/	289,500	434,200
TASK FORCES	---	---	70,000	---	70,000

a- All figures founded to the nearest hundred.

b- Includes $97,000 from State MAC Office as match for Sea Grant Fuds.

c- Includes $135,100 which could not be differentiated into State and Private, however, it is assumed that these funds were mostly private.

d- Funding figures include all types of expenditures, i.e. capital construction, salaries, operating expenses and supplies.

e- Includes $11,000 in County funding. Total Mac Funding is $231,700.

and hence have influenced research and development in Hawaii for only five years.

D. Development of Private Organizations[5]

Pre-1970 Hawaii aquaculture was largely a limited-scale commercial operation of old Hawaiian fishponds by a few individuals. However, with the recent advances in basic and applied research on the fresh-water Malaysian prawn made by scientists at Anuenue Fisheries Research Center, a surge of interest in prawn aquaculture has taken place. Since 1973 the number of commercial aquaculturists in the Islands has approximately doubled from 8 to 16. Virtually all of these entrepreneurs have selected the Malaysian prawn as their crop. Several of Hawaii's large international corporations are interested in aquaculture but they are uncertain of the risks involved. Their viewpoint can be described as one of watchful waiting.

POTENTIAL IMPACT AREAS FOR AQUACULTURE[6]

A. Research and Development

Hawaii is one of the few places in the United States where large-scale research programs in tropical aquaculture are being carried out. Furthermore, Hawaii's unique geographic position and ethnic mix make it a logical focal point from which to disseminate Western biotechnical expertise to the Pacific Basin and in turn benefit from the thousands of years of pragmatic Eastern aquaculture experience.

B. Land and Water Use

Aquaculture can provide new uses for idle and agricultural land. It could also provide alternative, or make available additional, uses for bodies of fresh and salt water, as well as ground water. In addition, it is complementary to State open-space policies and State and County programs to develop new and needed industries on the Neighbor Islands.

C. Economic Development

Aquaculture could supply the needs of sizable sectors of the State market for aquatic food products as well as provide a worldwide export product, e.g., prawns and oysters to Japan. Aquaculture could serve the State's need for a more diversified economy and also the State's desire for greater independence from Mainland and foreign imports. It could also provide jobs for a small portion of Hawaii's skilled and semi-skilled labor force.

D. Development of Stocks of Sport Fish, Bait Fish and Ornamental Fish

A. Sport Fish: Aquaculture could provide fish (marine and freshwater) and shellfish to satisfy the increasing recreational fishing pressure on wild populations.

B. Bait Fish: Culture of alternative bait fish (topminnows, shad, tilapia) in hatchery operations could allow substantial expansion of the tuna industry locally as well as establishing rearing techniques for expansion of tuna fisheries around the Pacific.

C. Ornamental Fish: Development of the culture of aquarium fish (marine and freshwater) in Hawaii could satisfy a small local market and provide, in the case of marine reef species, an export product for the huge Mainland market.

POLICIES FOR FUTURE GROWTH[7]

A. Less Reliance on Imports from the Mainland

"Approximately 80 percent of all goods and services purchased in Hawaii are shipped into the State" (Ref.27). The State is seeking to lessen this reliance on imports, particularly in the area of food products.

B. Greater Diversification of the Economy, Particularly the Agriculture Sector

Diversification of the economic base theoretically leads to a situation of greater stability of the economy. The State is interested in diversifying the economy as a whole and the agricultural sector in particular, i.e., expand to cultivation of other crops in addition to pineapple and sugarcane.

C. Preserve Prime Agricultural Lands

Hawaii was the first state to adopt a general plan and a land use law (1961). The law focused particular attention on "encouraging orderly and efficient development of land for urban use, with least possible encroachment on prime agricultural land."

D. Encourage Economic Development of the Neighbor Islands

Neighbor Island economies are tied to agriculture, particularly pineapple and sugarcane. Alternative and supplemental industries are needed in those areas where phasing out of these large scale agricultural practices are occurring.

CONCLUSION

I think aquaculture is a good field for many people to go into. It provides us with many jobs, and an abundance of different species of marine life that are good for nutrition.

Aquaculture can be economic and can be taught to developing countries in order for them to have a great food supply.

I hope aquaculture will progress more and develop into a major source of food for Hawaii instead of relying on imports from the Mainland and different countries such as Japan.

FOOTNOTES

[1]John S. Corbin, Aquaculture in Hawaii (Department of Planning and Economic Development, State of Hawaii, 1976),p. 1

[2]Ibid. p. 5

[3]Ibid. pp. 5-7

[4]Ibid. p. 6

[5]Ibid. p. 10

[6]Ibid. pp. 31-32

[7]Ibid. pp. 25-26

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SEAWEED
VEGETATION FROM THE SEA

by Scott T. Tsutsui, Pahoa High School

ABSTRACT

Seaweed or Limu, however you choose to call it, has been around a long, long time. There are many uses for this vegetation from the sea. Some are edible, some are not, some are big, some are small but anyway you look at it, these weeds from the sea will still be around for a long time to come and we must learn to take advantage of the uses and potential of seaweed.

SEAWEED
VEGETATION FROM THE SEA

Introduction

I have a beach house down at Kapoho, Hawaii and I always walk along the sea shore and explore it. The most common thing I see around is the seaweed or limu, it's all over the place, in tide pools, on the rocks, by the waves, etc. You can find seaweed all over the islands on mostly every beach. Since the seaweed is such a common plant on the sea shore and that most people who walk along the beach and find seaweed plants don't know much about it, I thought I would do some research on it and since I am exposed to the ocean enviroment a lot, I could get a better understanding of the seaweed.

In the olden times in Hawaii, limu was an important part of the Hawaiian diet. It was the third component of a nutritionally balanced diet consisting of fish and poi, together they furnished the necessary protiens, carbohydrates and minerals for an adequate nutrition. The limu primarily supplied variety and interest but they also added significant amounts of vitamins.

There are many different kinds of edible limu here in Hawaii and I have made a table of the most common edible Hawaiian algae.

TABLE 1
(Limu with Hawaiian names)

Scientific Names	Hawaiian Names
1. Enteromorpha prolifera	'ele'ele
2. Ulva fasciata	papahapaha
	pahapaha
	palahalaha
	pakaiea
3. Codium edule	wawae'iole
	'a'ala

TABLE 1 (cont.)

Scientific Names	Hawaiian Names
4. Dictyopteris plagiogramma	lipoa
5. Sargassum echinocarpum	kala
6. Porphyra	pahe'ehe'e
	lua'u
	pahe'e
7. Asparagapsis taxiformis	kohu
	lipehe
	koko
	lipu'akai
8. Grateloupia filicina	huluhuluwaena
	pakeleawa'a
9. Gracilaria coronopifolia (ogo; Japanese)	Manauea
10. Ahnfeltia Parvipapillata	lipe'epe'e
11. Laurencia nidifica	mane'one'o

OTHER USES OF LIMU

Limu kala, Sargassum species, is frequently used on open coral cuts. It is chopped or chewed and applied as poultice. Limu kala was also used by priests (Kahuna) in rituals. Neck leis can be made by limu kala.

The green sea lettuce, Ulva fasciata, was used as adornment in olden times in the hula and given the name of "pahapaha O polihale" after the locality where it was used in western Kauai.

Limu lipe'epe'e (Laurencia species) was kapu to hula dancers as pe'epe'e means hidden (referring to it's nestling habits) and it was believed that the secrets of the hula would be hidden from the dancers who ate the seaweed.

AGAR, ALGIN, CARRAGEENAN

Agar, algin, and carrageenan are extracted from several species of marine algae and is the basis of a multi-million dollar industry in the United States. Seaweed is used in various parts of the world as food, as fodder, and as fertilizer but in the United States it's chief value is for these three colloids. Of these three, agar is undoubtedly the best known, like algin and carrageenan, agar is widely used in food processing as an emulsifier, stabilizer, gelling agent, or thickener. Although agar may be extracted from at least twenty-eight species of red seaweeds, the known source is the algae Gelidium. Much of the agar used in the United States today is imported. Only one firm, the American Agar and Chemical Company of San Diego, produces agar in the United States.

The second colloid, carrageenan is also extracted from red algae. Carrageenan is used principally as a thickener, stabilizer, and gelling agent in food and food products, pharmaceuticals, cosmetics, paints, and textile sizings. In recent years, the carrageenan industry has grown more rapidly than that of any other seaweed product. Nearly half of the world's annual production of carrageenan of 8,640 metric tons is produced in the United States.

Algin, which is the general name for alginic acid and it's derivatives. It is extracted from large brown algae, principally the large kelp Macrocystis and Laminaria. The largest manufacturer of algin in the United States is the Kelco Company of San Diego, and is estimated to be producing from Macrocystis approximately 3,900 metric tons of algin per year, at a value of nearly ten million dollars.

SEAWEED
VEGETATION FROM THE SEA

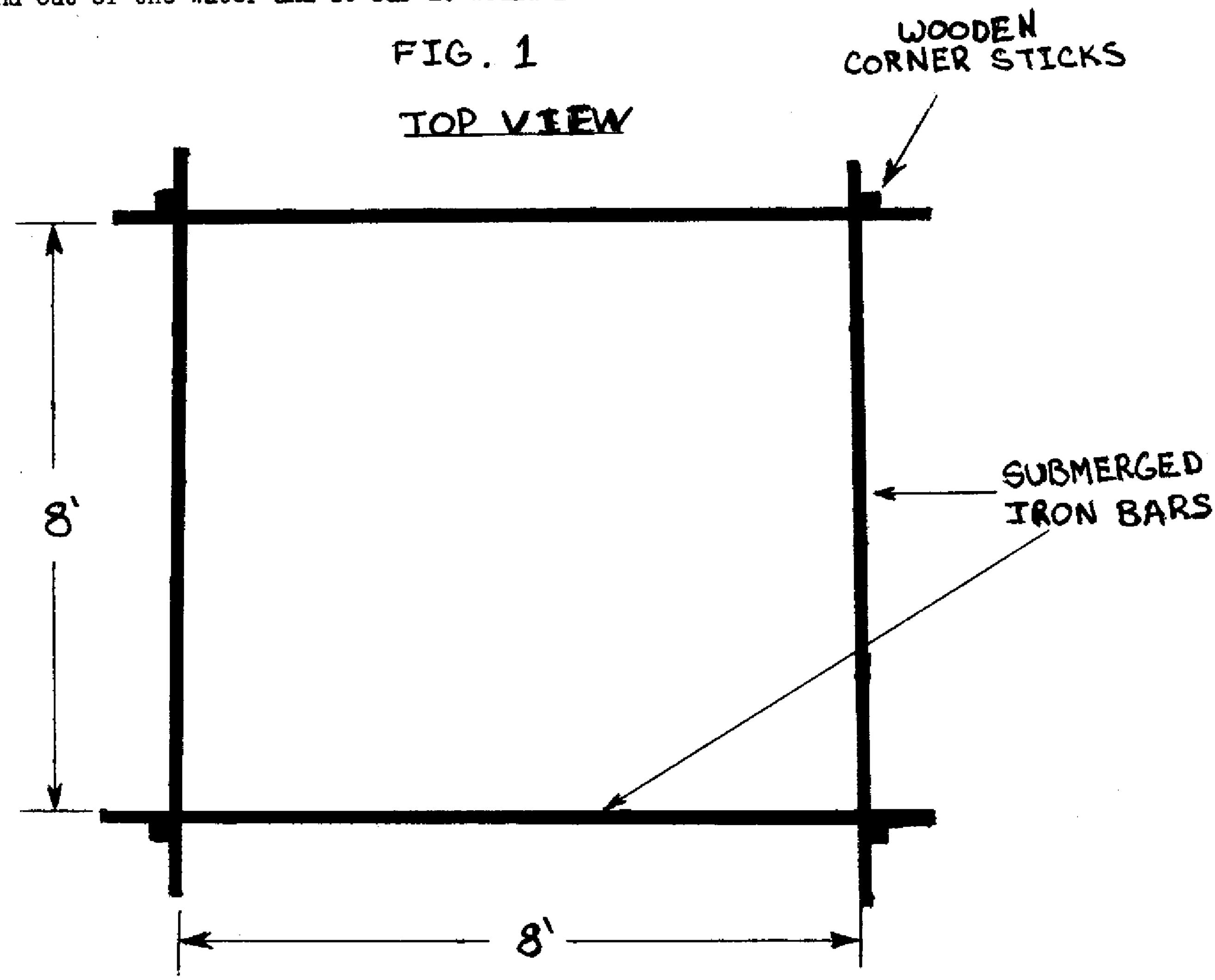
Materials and Methods

THE GROWTH OF LIMU

I made and experiment at my beach house down in Kapoho, Hawaii. The purpose of my experiment was to see how much limu would grow in a period of time. I measured an eight feet by eight feet square in water of about two to three feet in depth. I used iron bars and wooden sticks to mark off the square, I submerged the iron bars to form the square at the bottom and on each corner I secured a wooden stick with wire so the sticks would be sticking straight up and out of the water and so far it would look like this:

FIG. 1

TOP VIEW



Materials and Methods

After I completed that stage, I the secured four more wooden sticks between each two corner sticks and I also secured those sticks with wire and it would look like this:

FIG. 2.
TOP VIEW

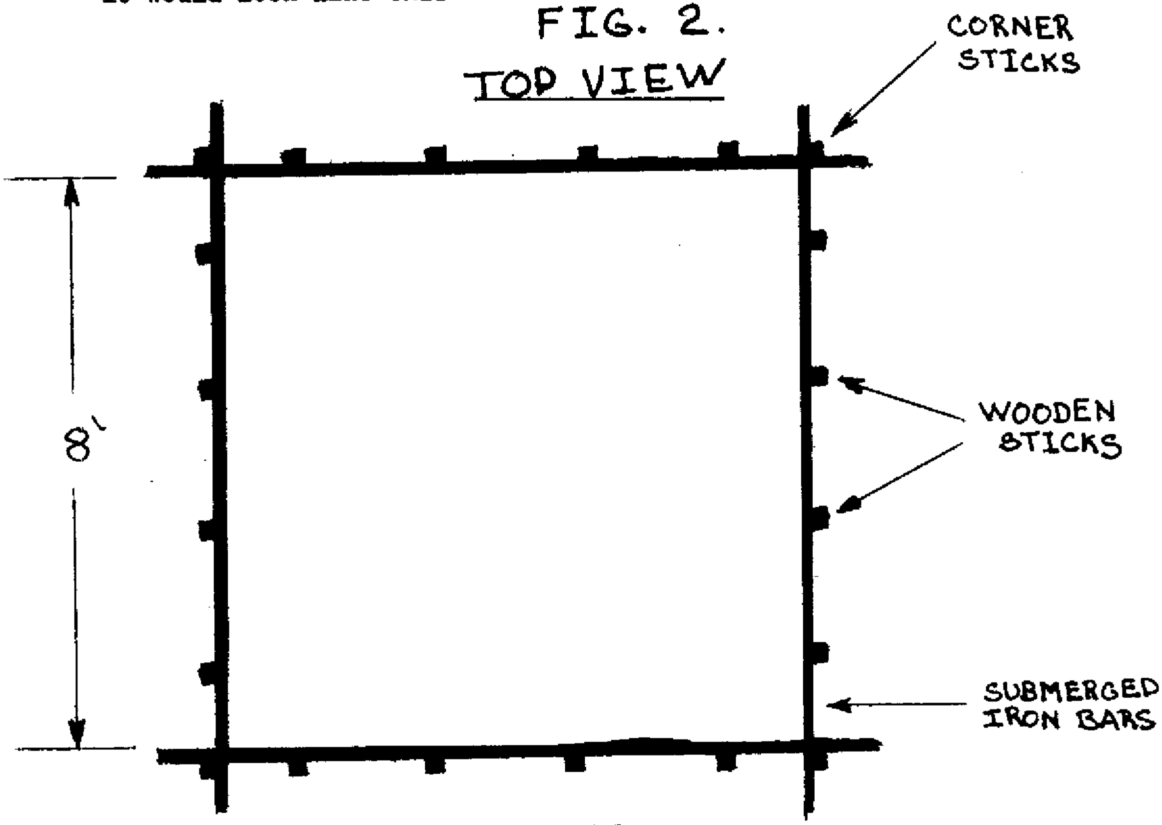
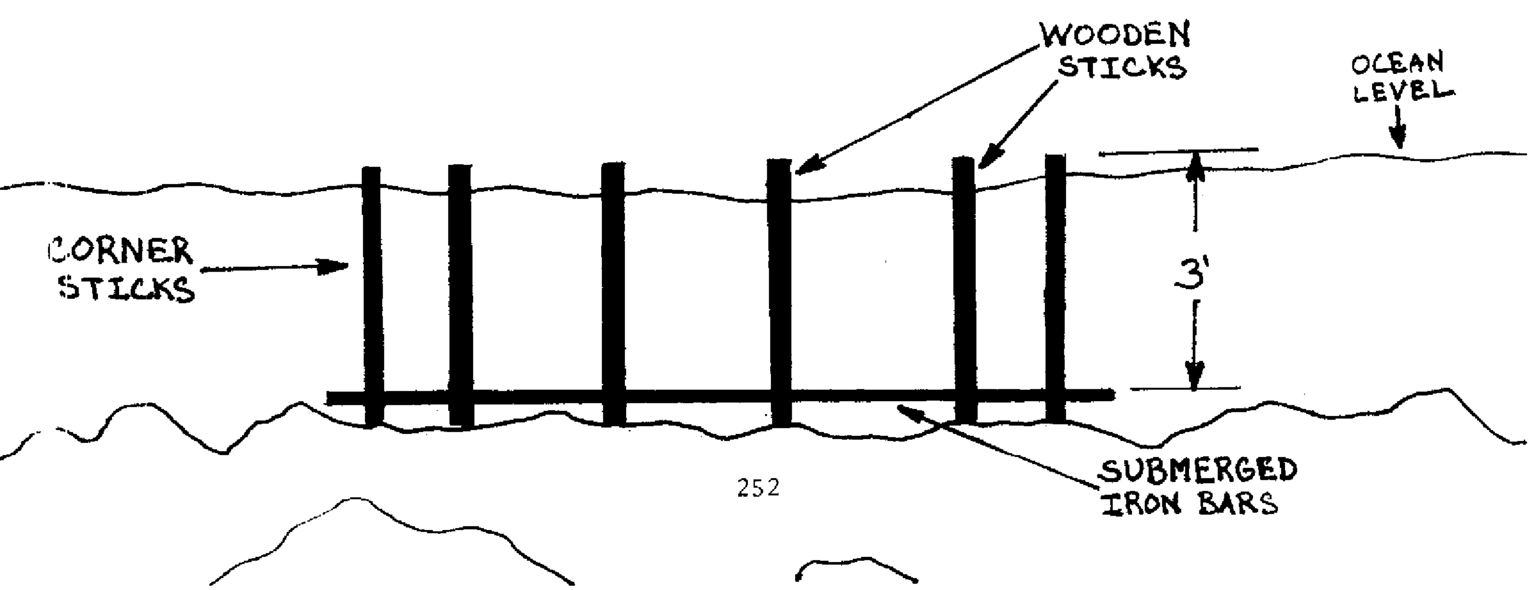


FIG. 3.
SIDE VIEW



Materials and Methods

The next and final stage went like this. After I had all the sticks in place I connected pieces of string from one stick to the stick that is exactly across it so it would look like a checker board. I Also connected a piece of string from one stick to the one right next to it and all the way around the square for support and I put floaters on the corner sticks so it would be easy to find when I come and check it.

FIG. 4.
TOP VIEW

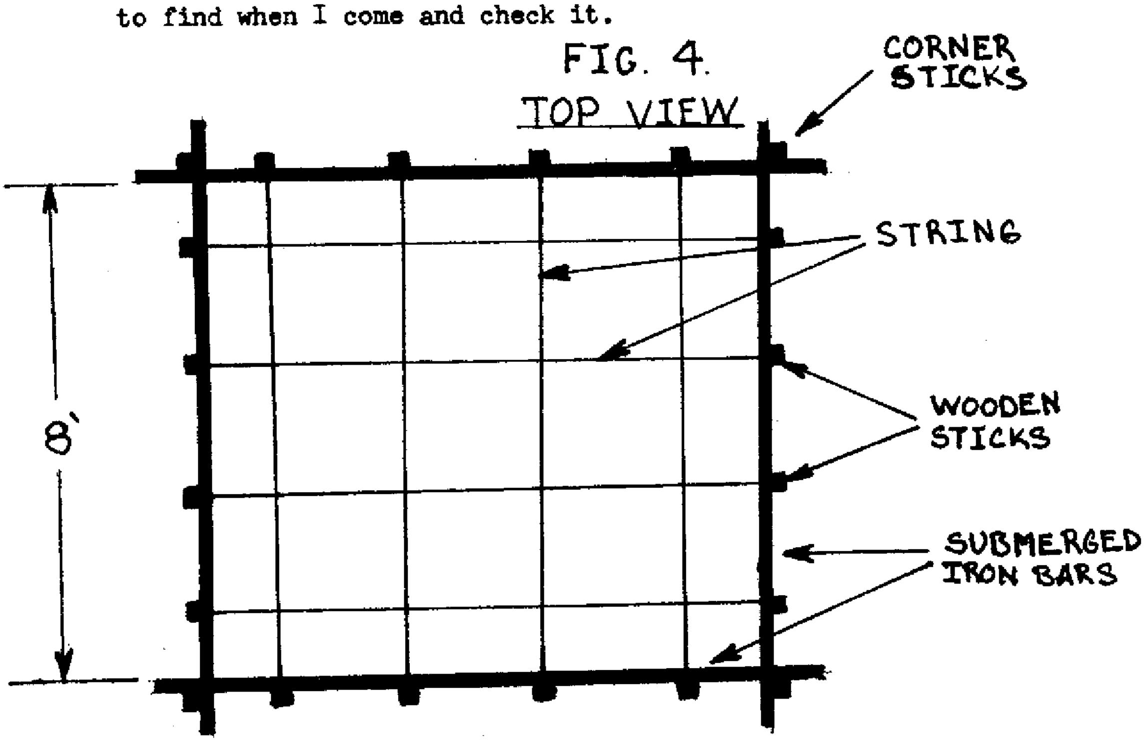
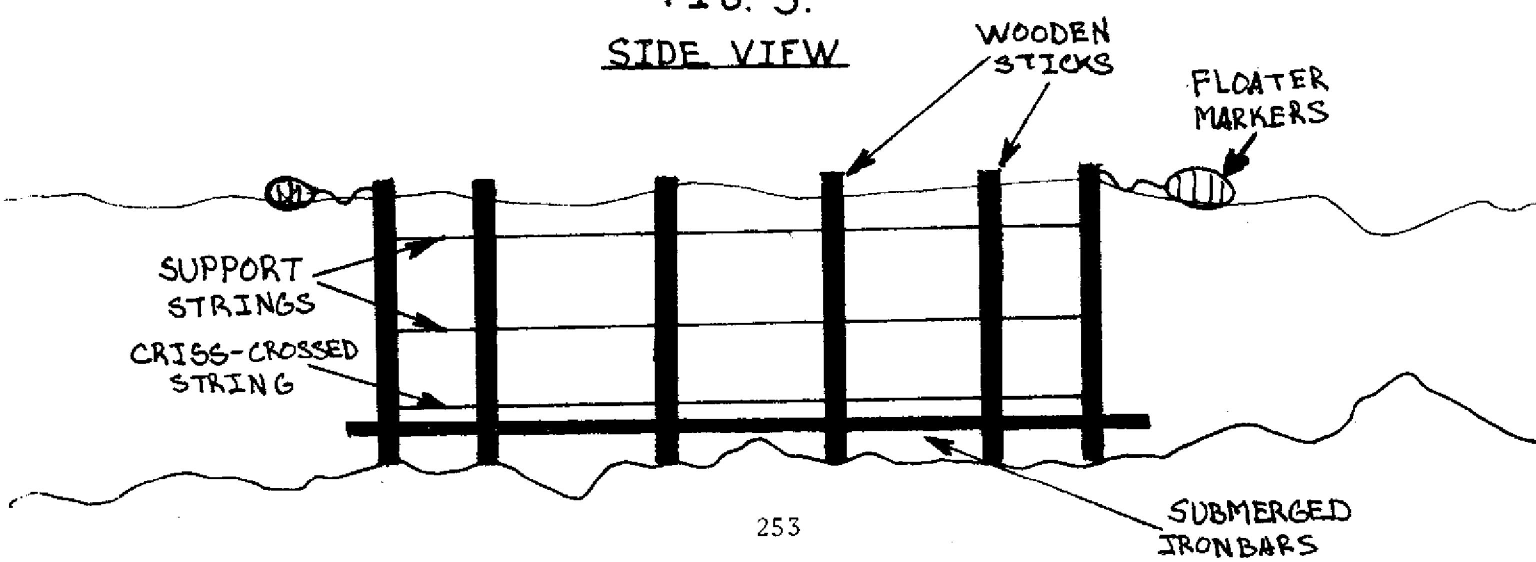


FIG. 5.
SIDE VIEW



SEAWEED
VEGETATION FROM THE SEA

Results of Research

After I had all of that set up I gathered various species of limu. The only ones I could gather was the limu kala (sargassum echinocarpum), limu wawae'iole (Codium edule) and the limu lipoa (Dictyopteris plagiogramma). I then set them in the square and observed them for three weeks. I came and checked the limu each week if there was any growth or change and I made a chart and kept records on it, the chart looked something like this:

LIMU GROWTH CHART

	Limu Kala	Limu Wāwae'iole	Limu Lipoa
1st Week	NO CHANGE	NO CHANGE	NO CHANGE
2nd Week	Growth of about ½ an inch.	Growth of about ¼ an inch, hardly any change.	Growth of about ½ an inch.
3rd Week	Growth of about ¾ an inch.	Growth of about ¼ an inch.	Growth of about ½ an inch.
Conclusions	Growth of about 1¼ to 1½ within a 3 week period of time.	Growth of about ½ to ¾ inch within a 3 week period of time.	Growth of about 1 inch within a 3 week period of time.

SEAWEED
VEGETATION FROM THE SEA

Conclusion

This investigation was not one of the most accurate experiments but I gained a little knowledge and a better understanding of the growth rate of these various species of limu by seeing it for myself and doing all the testing by myself. Maybe if I had set up this experiment for a longer period of time then maybe I would have come up with a much better and much more accurate conclusion. I hope people will become more aware of the uses and potentials of seaweed and have a better understanding of these weeds from the sea.

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HAWAIIAN AQUACULTURE: BRIGHT FUTURE

by Lyle M. Miyasaki, Lahainaluna High School

ABSTRACT

Aquaculture has been highly touted as an industry that could make Hawaii rich. It also has been labeled as high-risk. It has been shown that its good side clearly outweigh its bad side. By developing aquaculture, the people of Hawaii will be happier because there will be more jobs and a greater Hawaiian income.

INTRODUCTION

"Aquaculture is not some esoteric science with little or no practical application; on the contrary, it may be the most practical and most rewarding field in which science can make an immediate and lasting contribution to mankind."

That quote, by John P. Craven, the State Marine Affairs Coordinator, really tells us something about aquaculture. Aquaculture, it is said, has an unlimited variety of ways it could help the people of Hawaii. Not only will it create new jobs, it will bolster the economy of Hawaii. Unfortunately, too few people have embarked on the journey of aquaculture.

METHOD OF RESEARCH

I got most of my information from a series of newspaper articles by Bruce Benson. I went about reading it and my other sources then picked out my most important facts and quotes. I then arranged them in an orderly way.

In my paper, I will try to find out why most people are skeptical, to say the least, about going into aquaculture, and to give reasons for, at least, trying it.

THE ADVANTAGES

Raising fish, shrimp, prawns, oysters, etc, the way farmers raise chickens and pigs is not unrealistic. All it would take is some people with the enthusiasm and urge to do it. Here is the urge: It is estimated that an acre of sugarcane in Hawaii may produce a crop worth $1,000. That same acre, put into prawn raising, 3,000 pounds of prawns worth $12,000 would be produced yearly. That is $11,000 more than sugarcane, sounds interesting doesn't it? But that's only dealing financially, what about the employment view? Robert Schmitt, the State statistician, came up with these figures: "50,000 acres were planted in pineapple in 1975 to provide 4,195 direct jobs for a ratio that is the same as aquaculture--1 position for every 10 acres. The 221,400 acres planted in sugarcane provided 9,640 jobs for a ratio of 1 position for each 22 acres." Dr. Bob Shleser, the aquaculture coordinator for the Department of Planning and Economic Development, said of a rough survey that there are about 200,000 acres suitable for use in aquaculture. That, theoretically, comes out to about 54,000 new jobs.[1]

There are two major aquaculture farms in Hawaii, they are owned by Dr. Ken Kato. One project, in Laie, Oahu, grows prawns, the other, in Kihei, Maui, grows catfish. Both projects have been doing okay and are expected to grow. I have been out to the Kihei catfish farms. I observed that they have a lot of ponds which are full of catfish. The year that I went was 1974, the group that I was with were allowed to catch the fish and keep them--we payed 70¢ a pound. The day we went, we were one of the first there, by the time we were leaving, there was a line of cars the full length of the road leading to the main highway from the fishfarms. It was that popular!

There is also another need for the expansion of aquaculture. Some economists predict that of the major sugarcane plantations, half of them are heading in the general direction of failure.

That could mean the loss of as many as 6,000 jobs--pushing the unemployment rate up to an unreasonable 15 per cent.[2]

Financially, aquaculture is a big producer, but what about financial backing? Well, on Sand Island, Oahu, (in 1970) Takuji Fujimura and Henry Okamoto, using State and Federal funding, developed farm and culture techniques to the point where they can complete a prawn's cycle of life. There are also some private corporations that have helped out with financial aid and land to work on. C. Brewer and Co. has invested $2 million and 300 acres of ponds on 450 acres of land at their now defunct sugarcane plantation at Kilauea, Kauai for prawn production. It will be the biggest prawn farm in the world.

Likewise, the Hawaii State Legislature, earlier this year, (1977) has appropriated a majority of $1 million for aquaculture spending in 1977-78. Also, some members of congress said that Hawaii has shown enough possibilities for a major portion in an up-and-coming national aquaculture plan.

So, there are two major reasons why aquaculture is needed by Hawaii: economy (Hawaiian income), labor (employment), and because the State and Federal governments plus private corporations have interest in it, there is added incentive.

But, there are still some people who are opposed to aquaculture. For many different reasons, they are afraid or say it does not prove itself yet.

THE RISKS

Why are people afraid? What is the reason? Well, one thing is that aquaculture hasn't really proved itself physically. On paper it all works out fine, but who knows what will happen in the real world.

One of the reasons could be the fact that only a few of the people here know how to go about raising prawns and fish, and there aren't too many colleges that teach about aquaculture. There are a lot of things that you should know about the raising of fish and prawns. For example:

To raise mullet from its larva stage to a full-grown adult, you must have the right size of living organisms from the beginning. They must be small enough for the larvae to accept it but also big enough to contain enough protein for them to grow. Then, there is the phytoplankton of which the living organisms feed on. In Craig Paulsen's office, for example, in the Oceanic Institute on Makapuu Point, Oahu, there is a very expensive microscope used to monitor the phytoplankton. Which just goes to show that it does take a lot of monitoring of the phytoplankton, using expensive and complicated equipment--requiring knowledge and time.

There is also the threat of disease wiping out the entire population of a project. Substances in the water such as fungi, parasites, viruses, and worms may cause disease.

So far, marine biologists have done very little research and have made little progress in the study of the diseases that afflict fish. Besides the substances listed previously, natural and man-made pollutants, and improper feeding can also have adverse affects on your "crop".

The one thing aquaculture farmers fear the most is disease caused by parasites. These parasites live off other creatures.

The controlling and preventing of the appearance of parasites is very difficult. Catfish live in murky water. For the farmer to see the fish, then to determine if it is afflicted, is even more difficult. If a farmer does notice his fish of prawns are sick, he then would have to identify the cause. Then get a cure.

There, the two basic reasons why people are hesitant to go into aquaculture. The first one, the lack of knowledge, is the one that is the more serious of the two. The second, the uncertainty of decimation of the ranks of fish by disease. And since modern aquaculture is relatively new, people are still not sure of its capabilities.

CONCLUSION

It may have seemed that I was knocking land farming, I wasn't. I just wanted to point out that there is a bright outlook on aquaculture as compared to agriculture.

While inflation steadily rises and the unemployment picture begins to look bleaker every day, wouldn't it be wise to consider aquaculture as a good alternative to the sugar industry?

If I were to go into aquaculture, what would I raise? I'd raise either lobster or crab, or opihi. It would be very challenging. Getting the lobster to reproduce in captivity isn't something simple. I think that the opihi would sell good, the same goes for the lobster and crab.

I think that I have shown that the good side of aquaculture outweighs the bad side. And that aquaculture in Hawaii really does have a bright future.

FOOTNOTES

1. from the second of four articles by Bruce Benson, The Honolulu Advertiser, May 31, 1977

2. from the second of four articles by Bruce Benson, The Honolulu Advertiser, May 31, 1977

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THE EEL CONTROVERSY

by Lana L. Watanabe, Aiea High School

Hawaii, an island in the Pacific Ocean blessed with beautiful beaches, tons of fresh water fishes and fauna, and a booming tourist industry. Will this exotic wonderland be effected by the importation of 50,000 "unagi" eels for experimental or other scientific purposes? This issue brought about many different kinds of view points.

Although this eel bill has passed the state House by a slim margin of 26 to 24. It was voted unanimously to veto the bill by the state Senate Committee on Energy and Natural Resources.

The main objective of this experiment was to see whether or not raising eels in Hawaii for local consumption as well as exportation to other countries would be profitable.

The intention of the state was to import American eels known by their common names;freshwater eel and silver eel or by their scientific name, Anguilla rostrata. They are from the Anguillidae family and its length may vary from four to five feet. It inhabits all rivers east of the Rocky Mountains, from Mexico north to Maine. The other range is from West Indies and south to Central America to Brazil.

The migration of this American eel is quite peculiar for it can spawn in salt water, although, they live in fresh water. It is possible for them to do this probably because they have a body mucus which helps protect the eels against damage from such a change.

The main controversy between the opponents and proponents of the bill is the concern of endangering the ecological balance of our Hawaiian waters, if some of the eels should escape and settle themselves in surrounding waters.

According to vertabrate zoologist, Alan C. Ziegler, non-escape of some eels would be close to impossible; no matter through the eels's own capability to leave their ponds or through flooding or other disasters.

Another issue brought up by the opponents of the bill was the occurance of frequent poaching of eels to colonize in reservoirs, home ponds, streams, as well as other watercourses that will definitely bring about the inhabitancy of a ravenous predator which could abolish the Malaysian prawn aquaculture industry established here.

The Malaysian prawn or better known as Macrobrachuim Rosenbergii are giant prawns that are raised at Kahuku, Oahu. They are edible, therefore, invasion of eels would certainly deteriorize the market for Malaysian prawns.

Not only do they fear the destruction of our Malaysian prawn industry but also the fresh water fishes and fauna, as well, if such an incident should occur.

After all the comments from the opponents of the bill were heard, the proponents backed up their points by stating that the eels will be bred in tanks instead of ponds. They affirmed that the tank's rims will be curved inwards and the entire top will be covered with screen and will be placed in a basin where water seeping out of the tanks will be drained through the ground.

In a report administered by Japan Airlines in 1975, Hawaii, with its ideal climatic conditions would be the choice place for such a cultivation as eels.

Having Europe and Japan as the chief consumer, the eel market now is about 60,000 metric tons, and as proponents of the bill stated it would start a "new multi-million dollar industry for Hawaii".[1]

However, Hawaii would be confronted by a dilemma if Japan, being the suppliers of elvers (young stock) should raise their prices; then Hawaii would either have to pay these ridiculous prices or forgo this program.

The mullet culture was suggested as an investment which would guarantee a successful industry.

The eel controversy will still remain until the 1978 session of the Ninth State Legislature when the bill can be re-surfaced again.

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1. Sea Grant Newsletter; Eels: A Slippery Subject, April '77.

CONCLUSIONS REACHED

Although there is a chance of this eel bill to re-surface again in the next session of the Ninth State Legislature, we should keep in mind the prospects of such an industry that would be established here.

I feel the real success in such a program is to venture into it with an open mind and hope for the best. After all, no industry at first started from the top; but with determination and pride it worked its way up.

Eel raising may become a multi-million dollar industry for already there are many kinds of food products on the market made from them. They will become a delicacy for Hawaii's finest restaurants as well as gain popularity in the sea food category.

All this can happen if they choose to venture into a potential industry with an optimistic foresight rather than with a pessimistic view.

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