

**The
Natural
Energy
Laboratory
of Hawaii
Annual
Report
1975**



The Natural Energy Laboratory of Hawaii Annual Report 1975

TO Governor, State of Hawaii; Mayor, County of Hawaii
and Board of Directors, NELH

BY James H. Jones, Scientific Director, NELH

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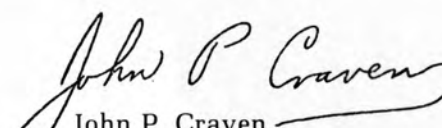
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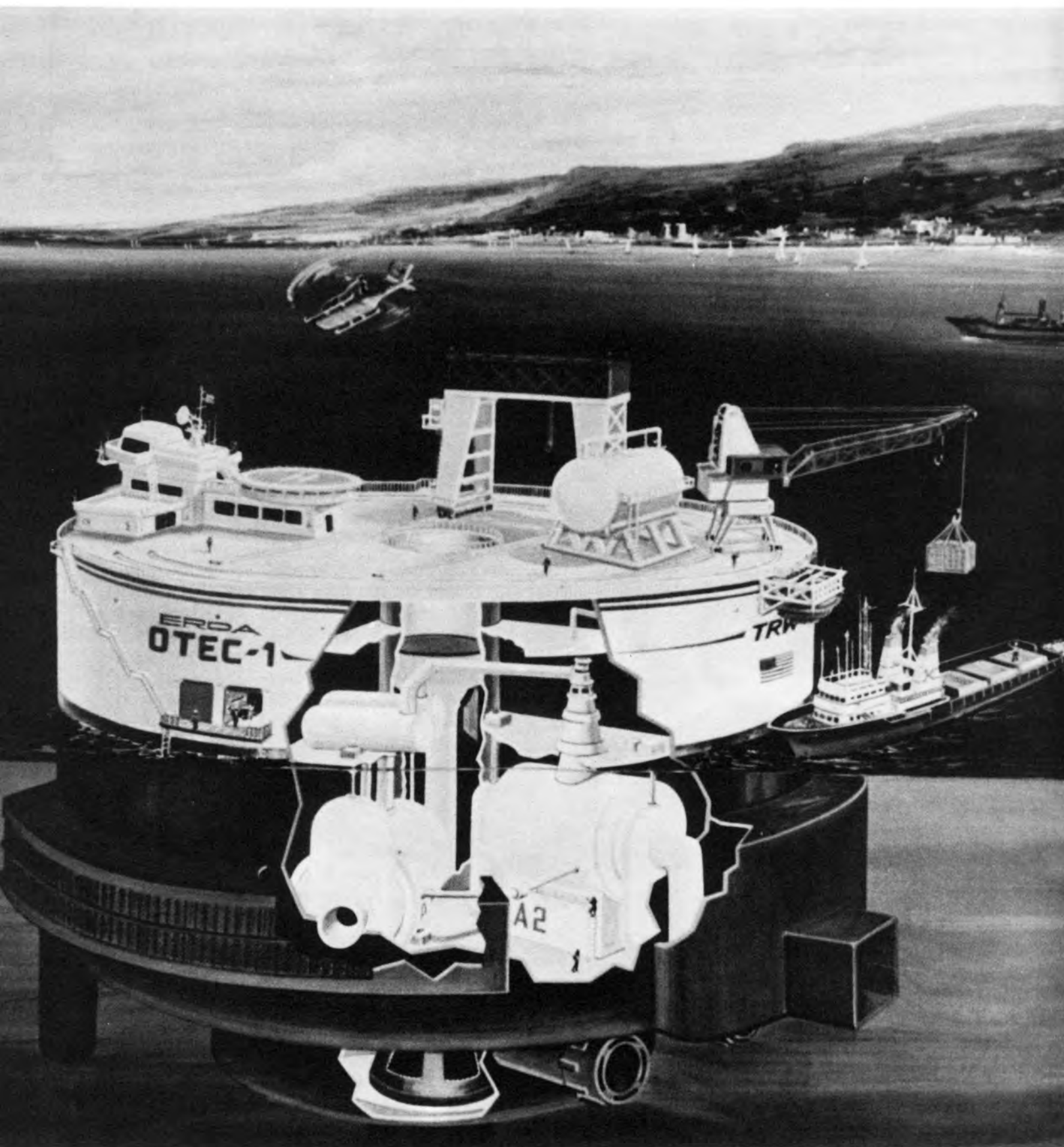


Foreword

The First Annual Report of the Natural Energy Laboratory of Hawaii covers a period of far-sighted planning for a facility whose future is assured, although the details of its establishment and constitution are as yet in the planning stages. Our nation is embarked on a major program to develop natural solar resources as a basis for a substantial portion of its energy needs, and there is a high level of enthusiasm by all who have examined the possibilities for Ke-ahole Point as an ideal site for carrying out natural energy development and demonstration projects.

In these days of legitimate environmental concern, a new facility must undergo a substantial period of environmental assessment, public review, and public understanding. It is for this reason that these evaluative and review mechanisms are set into motion well in advance of our society's perception that such facilities are urgently required. The development of the Natural Energy Laboratory of Hawaii is one such example. It is too early for wide recognition of the wisdom of the Governor and the Legislature in creating the Laboratory and the Board of Directors of NELH and in organizing and planning for this substantial facility. This advance planning places Hawaii in a position to move ahead in ocean and solar energy research and development projects as Federal energy programs crystallize. The Natural Energy Laboratory of Hawaii will be ready for the job—geographically, politically, and environmentally.


John P. Craven
Marine Affairs Coordinator
State of Hawaii



Introduction

The annual report of the Natural Energy Laboratory of Hawaii was prepared in order to inform state and federal officials and other interested parties of progress in the establishment of the Laboratory. Included in this report are a short account of the events leading to the establishment of the Laboratory and a summary of research and development studies.

There is unquestionably a need for an establishment with the proper facilities for studying solar energy alternatives. During the past year many top-level industrial scientists and federal scientific administrators have taken a critical look at the Keahole site. The unanimous opinion is that the characteristics of that location are superior to those of any others under consideration.

A recent statement by Dr. Robert Seamans, Administrator for the Energy Research and Development Administration (ERDA), compares the energy research organization with the American space program which Dr. Seamans organized in the early 1960's: "I would say the oil embargo of a few years ago was the 'Sputnik' for energy in America... which sparked this country's determination to win the space race." In extending this analogy, we are confident that the Natural Energy Laboratory of Hawaii will be as crucial to ERDA as the Kennedy Space Center was to the space program.

John P. Keppeler
 John P. Keppeler
 Chairman, Board of Directors
 Natural Energy Laboratory of Hawaii

Narrative Summary

This first annual report summarizes the activities associated with the Natural Energy Laboratory commencing with the approval of the enabling legislation on June 14, 1974. This legislation located the laboratory on a parcel of state land makai of the Ke-ahole airport on the island of Hawaii. The laboratory is presently under the direction and management of a consortium consisting of the Department of Land and Natural Resources, the County of Hawaii, the University of Hawaii, and the Marine Affairs Coordinator. The Marine Affairs Coordinator was assigned the responsibility of structuring the consortium and for details of establishing the laboratory.

The site for the Natural Energy Laboratory of Hawaii was chosen after a careful review of all the criteria necessary for its successful operation. Some of the most important criteria were: nearby availability of cold, deep ocean water; a warm ocean surface layer not subject to strong seasonal cooling; high annual solar radiation; accessibility to logistical support including major airports, harbors, and highways; and adequate quantities of undeveloped land suitable for mariculture and aquatic bioconversion. Among the eight other

sites investigated, the state-owned Ke-ahole Point site is unique in fulfilling all of these major criteria.

This past year's activities have focused on identifying potential users of the laboratory. Considerable effort has been devoted to studies of the laboratory as a candidate site for an ocean thermal energy conversion (OTEC) land-based engineering test facility. No such facility now exists, but one would be essential to the development of this energy alternative. A proposal for a test facility was submitted to the federal Energy Research and Development Administration for funding. This large proposal is still pending at this time. However, significant OTEC heat-exchanger biofouling experiments are currently being initiated at Ke-ahole with federal funds and environmental site studies have been in progress for over two years.

More recently the laboratory has broadened its objectives to include a mariculture program utilizing the nutrients in the cold water discharge from an OTEC facility. This ocean energy systems approach is currently being refined, and a new proposal with this broad view will be submitted for funding in the near future.

of Hawaii interests. John P. Keppeler, Managing Director of the County of Hawaii, named chairman. First board meeting held on February 5, 1975.

MARCH 1975

Three-man staff appointed by the board to coordinate laboratory development.

APRIL 1975

Publication of information brochure describing the attributes of the Ke-ahole site and the State of Hawaii for research, development, and demonstration (RD&D) of natural energy projects.

Site visit to Hawaii by representatives of TRW. Preliminary discussions of a joint ocean thermal energy conversion (OTEC) project.

State legislature appropriates additional funds for NELH planning and facilities.

MAY 1975

Site visit to Hawaii by representatives of Lockheed Missiles and Space Company, Inc. Preliminary discussions of feasibility of a joint OTEC project, Lockheed and Hawaii.

Representatives from Hawaii attend third Workshop on Ocean Thermal Energy Conversion, Houston, Texas. Preliminary concepts and environmental studies of an OTEC land-based facility at NELH outlined at the public meeting.

Meeting of Dr. Fujio Matsuda (President, University of Hawaii), Dr. Richard Cyert (President, Carnegie-Mellon University), Dr. John S. Foster (Vice President, TRW, Inc.), with Dr. Robert Seamans, Director of ERDA. Results of meeting indicated ERDA would be responsive to a proposal from a UH/CMU/TRW consortium to provide an integrated RD&D OTEC program.

JUNE 1975

NELH Board authorizes Scientific Director to coordinate efforts among Hawaii researchers and TRW and CMU researchers to write an OTEC Critical Research and Test Project proposal.

JULY 1975

OTEC proposal to ERDA drafted with RCUH as the prime contractor and UH, CMU, and TRW as subcontractors. Total first-year budget request \$7,842,400.

RFP issued for an environmental assessment (EA) and a Phase I Master Plan for the NELH at Ke-ahole Point.

AUGUST 1975

Preliminary OTEC Proposal submitted to ERDA for funding. Approval of NELH participation in the UH/CMU OTEC biofouling project at Ke-ahole Point.

SEPTEMBER 1975

Interview and selection of consultant to prepare EA for the NELH.

OCTOBER 1975

R.M. Towill announced as consultant for EA. Neighbor Island Consultants (NIC) chosen for the job of preparing a Phase I Master Plan for the NELH.

Public information workshop sponsored by West Hawaii civic organizations at the Keauhou Beach Hotel, Keauhou, Kona, Hawaii.

NOVEMBER 1975

Preliminary efforts to qualify the NELH as a field station for a Solar Energy Research Institute

(SERI) soon to be established by ERDA. Contacts with mainland consortiums encouraging.

Site visit to Hawaii and the NELH by Dr. John M. Teem, ERDA Assistant Administrator for Solar, Geothermal, and Advanced Energy Systems, and Dr. Robert Cohen, ERDA Program Director for Ocean Thermal Energy Conversion.

DECEMBER 1975

Permits requested from appropriate agencies for NELH to locate small diesel-electric generators at Ke-ahole Point and a temporary power cable across the shoreline to the UH/CMU OTEC biofouling ocean buoy just offshore.

JANUARY 1976

EA and Phase I Master Plan NELH accepted. Copies of both sent to all members of legislature, top state officers, and appropriate federal officers.

Capital improvement funds for NELH in the amount of \$750,000 requested of state legislature.

FEBRUARY 1976

Suggestion by outside sources that ERDA may decide to use a floating OTEC test platform. Lockheed and TRW contacted by NELH, suggesting that Hawaii could provide best logistic and site support for these platforms.

James H. Anderson (V.P. Sea Solar Power, Inc.) brought to Hawaii to demonstrate model OTEC plant and to discuss their prospective projects with state officials.

Work commences on a full environmental impact statement (EIS) for the NELH.

Testimony by Dr. H.H. Marvin, ERDA Director of the Division of Solar Energy to House Subcommittee on Energy Research that facility concept and site definition for an OTEC engineering test facility will be completed by September 1976 with a site selection announced by April 1977.

MARCH 1976

Site visit by Professor Oswald A. Roels (Lamont-Doherty Geological Observatory of Columbia University, Palisades, N.Y., and Principal Investigator of the St. Croix, Virgin Islands deep ocean water mariculture project). Prof. Roels gave positive indications that he would be very interested in establishing the next generation artificial upwelling mariculture project at Ke-ahole Point.

APRIL 1976

State legislature appropriates \$750,000 for capital improvements at NELH.

Activity Highlights

JUNE 1974

Approval of Act 236, SLH 1974, establishing a natural energy laboratory for the State of Hawaii at Ke-ahole Point, Hawaii. Responsibility and expenditure of funds directed to State Marine Affairs Coordinator.

JULY 1974

Release of planning funds consisting of \$50,000 from the State and \$50,000 from the County of Hawaii.

JANUARY 1975

The Research Corporation of the University of Hawaii chosen to provide immediate corporate structure and financial and management functions.

FEBRUARY 1975

A six-man Board of Directors was appointed, representing State, County of Hawaii, and University

Potential Users Summary

- ERDA via a consortium proposal of RCUH, TRW, Inc., Carnegie-Mellon University, and the University of Hawaii: Engineering Test Facility for OTEC.
- Scripps Institute of Oceanography: Use of deep sea water for fresh water distillation and cool dry air for air conditioning.
- Naval Undersea Center: Open sea mariculture/kelp program, an extension to Hawaii of work presently on-going off California.
- ERDA/Sea Grant: Oswald Roels marine pastures, a by-product of floating OTEC power plants.
- ERDA/Sea Grant: Hawaii and Oswald Roels: Establishment of a multi-species mariculture economic demonstration project at Ke-ahole Point using approximately 25,000 gallon/minute of sea water drawn from a depth of 1500 to 2000 feet.
- The University of Arizona, Environmental Research Laboratory: Establishment of a salt water high intensity shrimp mariculture operation.
- Pacific Power and Protein, Inc.: Their ultimate plans are to build a full-scale OTEC power plant and establish a mariculture operation at Palmyra Island (located approximately 1,000 miles south of Hawaii). They would use NELH as a test and development site.
- University of Hawaii, Hawaii Institute of Marine Biology: Controlled plankton growth experiments in a large water column simulator system (chemostat).
- Lockheed/Hawaii: Floating platforms for an OTEC test facility.
- Testing and development of a wave-powered generator and deepwater pump in trade wind seas off Ke-ahole Point.

Budget Summary

RESEARCH PROJECTS AND DEVELOPMENTAL FUNDS EXPENDED IN HAWAII				
	State of Hawaii	County of Hawaii		Federal
MAC	\$ 5,000	\$ 5,000	NSF/RANN/ERDA	\$ 48,600
DPED	10,000	50,000	SG	111,594
HNEI	6,686		NSF/ERDA	39,000
HNEI	7,598		ERDA	36,000
UH(SG)	9,625		SG	37,000
MAC	10,000		SG	39,000
MAC	10,000			
MAC	108,000			
Total	\$166,909	\$55,000		\$311,194

MAC	State of Hawaii Marine Affairs Coordinator
DPED	State of Hawaii Department of Planning and Economic Development
HNEI	Hawaii Natural Energy Institute
UH	University of Hawaii
NSF/RANN	National Science Foundation/Research Applied to National Needs
SG	National Sea Grant Program
ERDA	Energy Research and Development Administration

NELH Related Studies

REPORT ON AQUACULTURE AND OCEAN ENERGY SYSTEMS FOR THE COUNTY OF HAWAII

Investigators: Prof. Kaare R. Gunderson, Dr. Robert Q. Palmer, UH. Agency (\$): County of Hawaii (\$5,000) / State of Hawaii (\$5,000). Year: July 1971-December 1972.

A State/County-supported survey of coastal areas on the island of Hawaii has resulted in the selection of Ke-ahole Point as the potentially most suitable site for an ocean thermal energy pilot plant and a pilot plant aquaculture station. Factors which were considered included: bathymetry and horizontal distance to deep water; suitability of adjacent coastal land for building of the laboratory and production ponds; ownership of land and likely availability; stability of climatic conditions with maximum of yearly sunshine hours; closeness to transportation and lodging centers. Of eight sites considered, Ke-ahole Point was found by far the most suitable. The land here is owned by the State of Hawaii and consists of about 240 acres, fairly level lava-covered coast land between the new Ke-ahole Airport and the shoreline. A depth of 700 meters is reached 1.6 km offshore at this location. Several commercial flights daily connect Ke-ahole with Honolulu and Hilo within 45 minutes flight time. Kailua town, with hotels, service facilities, and a harbor, is located three miles south on the sunny, low-precipitation Kona Coast. The coastal waters on this leeward side of the island are fairly calm and offer maximum stability during installation of deep water pipes and pumps.

AN EVALUATION OF OCEANOGRAPHIC AND AND SOCIO-ECONOMIC ASPECTS OF A NEARSHORE OCEAN THERMAL ENERGY CONVERSION PILOT PLANT IN SUB-TROPICAL HAWAIIAN WATERS

Investigators: Karl H. Bathen, with R.M. Kamins, D. Kornreich, J.E.T. Moncour, UH. Agency (\$): NSF/RANN/ERDA (\$48,000). Year: 1975.

This study was particularly concerned with local bathymetry to the 2000 foot depth, nearshore and offshore thermal density stratification to 1500 feet, nutrient concentrations in the water column, local nearshore benthic biota, plankton community composition and productivity, seasonal circula-

tion patterns around Ke-ahole Point, local wave and swell conditions, and the local meteorological conditions at Ke-ahole throughout the year. The concluding part of the oceanographic work involved an evaluation of the potential environmental impact a 10-MW pilot plant located at or just off Ke-ahole Point would have on the local, characteristically subtropical waters.

The three-part socio-economic program was concerned with examining the legal aspects of a nearshore OTEC plant. The applicable law, federal interests, licenses and permits, opposing interests, legislative experience and site conditions were considered.

CORROSION AND FOULING RENEWAL

Investigator: Jorn Larsen-Basse, UH, Mechanical Engineering. Agency (\$): HNEI (\$7,598). Year: 1976.

A simple and efficient test method for stress corrosion cracking was developed and checked out in the laboratory. A small specimen rack has been constructed and emplaced in the ocean at a water depth of 20 feet near the shore at Ke-ahole Point. The rack holds an initial set of specimens for study of general corrosion. An additional set of general corrosion specimens has been placed in a lava tube where there is considerable water motion and heavy aeration of the water. It was expected to recover the specimens in mid-February for initial studies of corrosion rate and fouling removal. A second set of specimens will be emplaced at a later time.

A PILOT ENGINEERING STUDY ON OTEC

Investigators: Theodore T. Lee, UH, Ocean Engineering. Agency (\$): HNEI (\$6,686). Year: 1976.

The materials and equipment for the OTEC working model have been procured with the help of funds from other sources, and fabrication was completed by the end of February. The model is to be used for determining the dynamic response of the platform-pipe-mooring system, hydrodynamic aspects, and thermal diffusion under the combined action of wind, waves, and currents. Supporting analytical studies have also been initiated.

THE OCEANIC INSTITUTE'S OTEC OCEAN STRUCTURE SCALE MODEL PROJECT

Investigator: Joe A. Hanson, Oceanic Institute.
Agency (\$): SG (\$111,594) / UH (\$9,725) / OI (\$4,907). *Year:* 1975-76.

The term "OTEC Ocean Structure" is used here to encompass not only the platform, but also the water pipes and the station-keeping mechanism, whether it be mooring or dynamic positioning. These three components are so closely coupled hydrodynamically that they must be treated as one system in order to avoid a possibility of catastrophic seakeeping behavior in early floating OTEC installations. The concern is that this is a new species of ocean engineering problem, and this concern stems from the following observations:

1. The contained water mass of the structure is a very large proportion of the total mass.
2. This water mass is in motion and is hydrodynamically coupled to the structure to a greater or lesser extent depending on the design employed. It was concluded that some preliminary scale model tests would help confirm or deny these suspicions. The work is now well underway and will be completed by July 1976.

FOULING AND CORROSION IN OTEC HEAT EXCHANGERS

Investigators: J. Fetkovich, Carnegie-Mellon University; F. Munchmeyer, UH, Mechanical Engineering. *Agency (\$):* NSF/ERDA (\$160,000) (\$39,000 is UH share). *Year:* 1976.

One of the most essential elements in demonstrating the economic feasibility of OTEC is to establish that scaling, biofouling, and corrosion can be held in check for the life of the plant without adding excessively to the capital or operating costs. Studies of fouling and corrosion must be done in the ocean under conditions approximating those expected to exist in practice. Test apparatus, consisting of heat exchanger tubes operating under various conditions of water flow velocity and utilizing different antifouling methods, is to be operated submerged in the ocean at Ke-ahole Point.

The tests will be done under conditions simulating those in the evaporator where, because of the higher temperature and greater abundance of sea life and dissolved oxygen in the surface waters, fouling and corrosion are expected to be most severe.

OPERATIONAL SEA STATE AND DESIGN WAVE CRITERIA FOR OCEAN THERMAL ENERGY CONVERSION PROJECTS

Investigator: C.L. Bretschneider, UH, Ocean Engineering. *Agency (\$):* ERDA (\$36,000). *Year:* 1976.

This project is to acquire environmental data on winds, waves, and currents for specified areas. The specific zones of interest include the Atlantic, Pacific, and Gulf Coasts of the Continental United States, the Hawaiian Islands, and all other oceanic areas (including the Indian Ocean) situated between 20° North and 20° South latitudes. These locations have primarily to do with potential selections of ocean thermal energy conversion (OTEC) project sites.

OCEAN ENERGY RELATED WAVE STUDIES

Investigator: Robert Grace, UH, Civil and Ocean Engineering. *Agency (\$):* 1975: MAC (\$10,000) / SG (\$37,000), 1976: MAC (\$10,000) / SG (\$39,000).

The studies concern three aspects of local wave conditions: (1) Hawaii wave climate and wave predictions; (2) wave-induced sub-surface water motions; and (3) effects of wave forces on pipelines. While all three aspects have many important applications, it is the third one that is especially vital to future ocean energy projects, as many different methods and ideas of tapping ocean energy, or using the ocean in connection with energy-generation (for cooling, especially) require that pipelines be laid through shallow, near-shore surf zones. A point of interest in connection with this project is that the Australian Bureau of Meteorology is cooperating with this project by sending reports of waves and swells they observe that appear to be heading toward Hawaii.

PROJECT SUPPORT FOR NATURAL ENERGY LABORATORY OF HAWAII

Investigators: James H. Jones, NELH; John P. Craven, Marine Programs, MAC; William Coops, Research Corp of the UH. *Agency (\$):* County of Hawaii (\$50,000), State of Hawaii (\$108,000). *Year:* 1975-76.

This project was established to assist the University of Hawaii, the State of Hawaii, and such other institutions as may be required, in preparing proposals for submission to federal agencies or

any other out-of-state sources as may be concerned with establishment of a land- or sea-based ocean thermal energy conversion test system and the establishment of complementary energy options as they may become appropriate. This project also assists in conducting analytical studies required to supply information for these proposals and past contract award studies as may be required for the successful initiation of these projects.

This project also prepares the terms and conditions under which the Natural Energy Laboratory at Ke-ahole Point, Hawaii, may be proposed as a site for the conduct of natural energy projects by other corporations, institutions, or entities seeking to do research, development, or demonstration for the federal government or other institutions or entities which sponsor natural energy research.

OTEC CRITICAL RESEARCH AND TEST PROJECT

Investigators: John P. Craven, UH, Marine Programs; RCUH Principal Contractor; TRW, CMU, and UH Subcontractors. *Agency (\$):* ERDA (\$7,842,000).

The limits of theoretical study have been reached insofar as OTEC feasibility is concerned. From this point on, a concurrent and interactive system design and technology development program is needed, directed toward an interim goal of having an OTEC demonstration plant operating in the early 1980's. Such a demonstration plant, to confirm system performance and system effectiveness characteristics and establish capital investment requirements and operation/maintenance costs, is considered to be essential in order to attract private capital for the design, construction, and deployment of commercial scale OTEC plants and achieve an ultimate goal of 20,000 MWe in production capacity by the year 1990. Under this concept, a closed-cycle technology development program will be pursued by a university/industry team whose effort will be directed toward the reduction of technical performance and cost uncer-

A FURTHER EVALUATION OF THE OCEANOGRAPHIC CONDITIONS FOUND OFF KE-AHOLE POINT, HAWAII, AND THE ENVIRONMENTAL IMPACT OF NEARSHORE TROPICAL ENERGY CONVERSION PLANTS ON SUBTROPICAL HAWAIIAN WATERS

Investigator: Karl H. Bathen, UH, Ocean Engineering. *Agency (\$):* DPED (\$10,000.) *Year:* 1975.

This is an extension of the previous project providing further definition of existing oceanographic conditions off Ke-ahole Point and the conducting nearshore tests for both a 100- and 240-megawatt OTEC floating power plant off the Point. Field efforts were completed to compare the 1975 summer thermal vertical structure and the profile of nearshore currents down to the 550m (1800 ft.) depth to 1974 observations.

Proposals Submitted for Funding (1976-77)

tainties, i.e., resolution of crucial issues affecting the economic viability of OTEC plants, and the collection of vital engineering data necessary for the high confidence, low risk design of a demonstration scale plant. The system design effort, which will draw upon the results of the technology development program and lead to the design and construction of an OTEC demonstration plant, will be pursued as a parallel effort by industry.

CONTINUATION OF OTEC BIOFOULING AND CORROSION

Investigators: J. Fetkovich, Carnegie-Mellon University; F. Munchmeyer, UH, Mechanical Engineering. *Agency (\$):* ERDA (\$250,000).

This proposed work is not only a continuation of the initial work at Ke-ahole Point, but an extension into the following areas: studies of the fouling problem in other parts of the ocean; development of portable fouling test apparatus, and standard fouling test methods; deep water fouling and corrosion tests; establishment of another test facility, similar to that at Ke-ahole, at another ocean location; continuing corrosion and materials studies.

DEFINITION OF OCEANOGRAPHIC,
BIOLOGICAL, AND METEOROLOGICAL
TEMPORAL VARIATIONS IN HAWAII
SUBTROPICAL WATERS AND THE
IMPORTANCE OF THESE VARIATIONS IN
ENVIRONMENTAL IMPACT ANALYSIS FOR
OTEC TESTS

Investigator: Karl H. Bathen, UH, Ocean Engineering. *Agency (\$):* ERDA (\$161,900).

This proposal is an extension of previous work with specific emphasis on biological and meteorological data. Attention will be focused on describing diurnal and seasonal variations in the water column from the surface to a depth of 2,000 feet. The environmental analysis will be concerned with expanding prediction of the cold water discharge plume behavior and geometry and also with potential bio-stimulation in the mixed layer.

TESTING AND MONITORING THE ISAACS/
CASTEL WAVE POWERED GENERATOR IN
TRADE WIND SEAS OFF KE-AHOLE POINT

Investigators: James H. Jones, NELH; John D. Isaacs, Scripps Institute of Oceanography. *Agency (\$):* DPED (\$45,000).

The purpose of this proposal is to bring to Hawaiian waters for testing, a device for extracting energy from ocean waves. This device has been tested successfully on a number of occasions off Southern California. In general, the wave spectrum is different in a trade wind regime, and the total wave energy is more consistent and generally greater than it is off California. The wave-powered generator will be moored for a period of approximately two months during the summer of 1976. Throughout the period, pump performance, electrical power produced, flow and pressure characteristics at the turbine, buoy heave response and check-valve behavior, and the prevailing sea state at the buoy will all be monitored. Expected results from this study include a better understanding of the practicability of wave energy and various fundamentals such as the nature of

the unsteady flow in pipes and attendant losses. In addition, important information will be gained toward a design of a buoy capable of bringing nutrient-rich water from the 1,000-foot depth level to the surface.

ENVIRONMENTAL SURVEY OF BENTHIC
ECOSYSTEM AT KE-AHOLE POINT

Investigator: S. Arthur Reed, UH, Biology. *Agency (\$):* DPED (\$25,625).

The objective of this survey is to quantitatively characterize the coral reef community and associated macroinvertebrates, and reef fish populations in the marine waters at Ke-ahole Point, Hawaii. The survey will include the reef from shore to approximately a 100-foot depth using scuba gear. This survey will also provide a description of the present habitats in the area of the proposed thermal power generator in terms of the micromolluscan assemblages present in the sediment.

EFFECTS OF BIOFOULING ON AN APL DESIGN
OTEC HEAT EXCHANGER

Investigators: James H. Jones, NELH; Peter P. Pandolfini, Applied Physics Laboratory, Johns Hopkins University. *Agency (\$):* Sea Grant (\$60,000), MAC (\$30,000).

This proposal deals with the investigation of the biological fouling effect of the tropical ocean water on the waterside of the APL OTEC heat exchanger elements. The Applied Physics Laboratory will design and build the test section to be used; NELH will provide a testing site at Ke-ahole Point as well as supply tropical ocean water typical of the environment in which the OTEC heat exchanger will operate. Organic material that has settled in the test environment will be collected and analyzed for composition and identification. The tests and final report will be a joint responsibility of APL and NELH.