The Natural Energy Laboratory of Hawaii

1985 annual report

The Natural Energy Laboratory of Hawaii

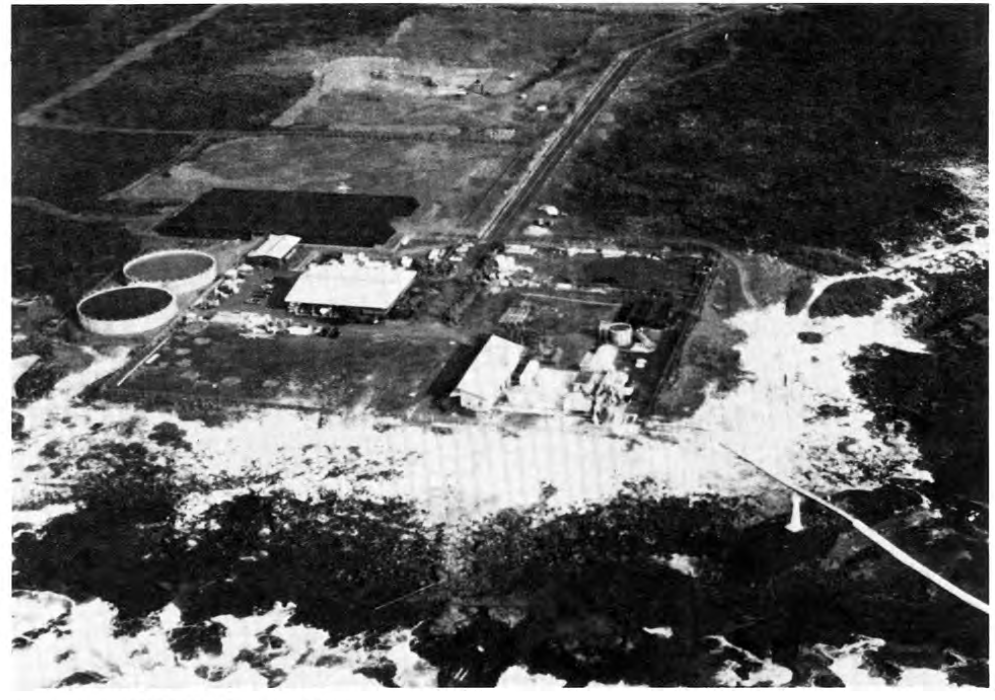
1985 Annual Report

To:

The Honorable George R. Ariyoshi
Governor of Hawaii

The Honorable Richard S. H. Wong
President of the Senate

The Honorable Henry H. Peters
Speaker of the House of Representatives



Aerial view of NELH, February 1985.

Board of Directors

June 30, 1985

John P. Craven
Director of the Law of the Sea Institute, University of Hawaii at Manoa

Philip Helfrich
Director, Hawaii Institute of Marine Biology

Kent M. Keith
Director of Planning and Economic Development and State Energy Resources Coordinator, State of Hawaii

Alan Konishi
Director of Research and Development, County of Hawaii

Gregory Mooers
Deputy Managing Director, County of Hawaii

Susumu Ono
Chairperson and Member, Board of Land and Natural Resources, State of Hawaii

Patrick K. Takahashi
Professor of Civil Engineering and Director of the Hawaii Natural Energy Institute, University of Hawaii at Manoa

Contents

Japanese Crown Prince Hitachi visits NELH, June 1985.

Preface

The Natural Energy Laboratory of Hawaii (NELH) has continued to expand Fiscal Year 1985.

The Laboratory remains unique in its ability to supply large volumes of both warm surface seawater at 24-28°C and cold deep seawater at 8-10°C. The seawater supply systems have again functioned continuously throughout the year, amassing totals of 1442 days and 1158 days of flow for the warm and cold water, respectively.

The closed-cycle OTEC biofouling and corrosion experiments at NELH have continued under the supervision of Argonne National Laboratory (ANL) with Department of Energy (DOE) support. The consistently high quality data from these experiments has demonstrated the possibility of substantial cost savings in future OTEC plants. They have provided unique time series of biofouling and corrosion data for various materials in seawater and information on the effects of various countermeasures.

Arrangements have been completed for a major new experiment at NELH to be conducted by ALCAN International, Ltd. This major aluminum producer plans to install large test heat exchangers in both the warm and cold water streams at NELH. Their system has been designed to collect biofouling and corrosion data automatically and then transmit them by telephone modem to the ALCAN laboratory outside of London, England. This project represents a major new industrial partner in the development of OTEC and also introduces a new type of experimentation utilizing modern communications techniques.

The open-cycle OTEC experiments begun in FY83 with funding from the Solar Energy Research Institute (SERI) have produced encouraging results indicating that the heat and mass transfer in open-cycle seawater systems approximates that predicted from previous experiments with fresh water. Gas desorption studies have provided a preliminary indication that the energy required to deaerate seawater may be 50% less than had been anticipated based upon freshwater data. An experimental "mist-lift" apparatus has demonstrated the feasibility of generating a seawater mist and has indicated that coupling does exist between the mist and a rising vapor stream. Current plans call for construction of a major new Open Cycle Test Facility at NELH.

Several aquaculture experiments continue to demonstrate exciting possiblities for using the deep cold water being pumped ashore at NELH. Salmon, rainbow trout, Maine lobster, nori and abalone have been grown successfully. Groundbreaking for a 21-acre commercial demonstration module for abalone production took place at the beginning of the fiscal year. Their project is now well under way, as evidenced by the new construction and production at their site. A second firm which had contacted NELH at the end of last fiscal year, has invested more than $750,000 in a new microalgae production facility at NELH. Their initial experimentation indicates that *Spirulina* and other algae will grow well in NELH's cold deep seawater and high level of solar insolation. Several other commercial aquaculture firms are now negotiating for sites at NELH. Research projects to investigate the culturing of giant clams, oysters and lobster were also approved. Other proposed projects include culturing of clams, marine shrimp, mahi-mahi and nori seaweed.

The NELH water quality laboratory has produced unique data on the characteristics of the water being pumped, and plans are now underway for a significant expansion and improvement of the water quality laboratory facilities. This expansion will allow both continued monitoring of the incoming water streams and improved service to the growing cadre of laboratory clients.

DOE continues its plans for installation of 30" cold and warm water pipes to supplement the present 12" system. Several major engineering firms responded to a formal request for proposals to design and install this pipeline. Plans include downstream use of the seawater for aquaculture and agriculture experiments.

Cyanotech Microalgae Facility dedication, July 1985.

Legislation passed by the 1985 Hawaii State Legislature allows NELH to manage and operate other facilities involved in utilizing Hawaii's natural energy resources. As a result, NELH has assumed management responsibility for the Puna Geothermal Facility located near Hilo on the eastern side of the Big Island. The overall plan is to develop this facility in a manner similar to NELH at Ke-ahole Point, but utilizing the geothermal resources at the site. NELH has provided an on-site manager for the facility and is in the process of finalizing use agreements with five initial users.

As a direct result of the successful research and development at NELH, the High Technology Development Corporation (HTDC) is planning development of a "Hawaii Ocean Science and Technology Park" (HOST Park) on state land adjacent to NELH. This park will provide sites where successful NELH research projects can pursue commercial-scale development. Initial plans include installation of pipelines to provide cold and warm seawater for park users, as well as grading, roads, electricity, fresh water and similar infrastructure.

In summary, this fiscal year has been a very productive and successful one. The future promises continued expansion of research and development, demonstration, and commercialization activities at NELH.

John P. Craven
Chairman
NELH Board of Directors

Abbreviations

ANL	Argonne National Laboratory
BLNR	Board of Land and Natural Resources, State of Hawaii
CIP	Capital Improvement Projects (State of Hawaii)
CWP	Cold water pipe
DOE	U.S. Department of Energy
DOT	Department of Transportation, State of Hawaii
DPED	Department of Planning and Economic Development, State of Hawaii
DUMAND	Deep Underwater Muon and Neutrino Detection Project
EES	Energy Extension Service (DOE via DPED)
ERDA	Energy Research & Development Administration (preceded DOE)
FRP	Fiberglass-reinforced plastic
GPM	Gallons per minute
HAF	Hawaiian Abalone Farms (affiliate of Monterey Abalone Farms)
HD&C	Hawaiian Dredging & Construction Co., A Dillingham Company
HECO	Hawaiian Electric Company
HELCO	Hawaii Electric Light Company, Hilo
HGP-A	Hawaii Geothermal Project - Well "A"
HIMB	Hawaii Institute of Marine Biology, UHM
HNEI	Hawaii Natural Energy Institute at UHM
HOST	Hawaii Ocean Science and Technology Park
HTDC	High Technology Development Corporation (State of Hawaii)
JHU/APL	Johns Hopkins University, Applied Physics Laboratory
LMSC	Lockheed Missiles and Space Company, Inc.
MAC	Marine Affairs Coordinator, State of Hawaii
NELH	Natural Energy Laboratory of Hawaii
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSF	National Science Foundation
OTEC	Ocean Thermal Energy Conversion
RCUH	Research Corporation of the University of Hawaii
RDA	R & D Associates, Marina del Rey, CA
SERI	Solar Energy Research Institute
UHM	University of Hawaii at Manoa
UHSG	University of Hawaii Sea Grant Program

Introduction

This report summarizes the Fiscal Year 1985 activities at the Natural Energy Laboratory of Hawaii.

NELH was created by the Hawaii State Legislature in 1974 as a facility for research, development and demonstration of natural energy resources and other compatible scientific and technological investigations. It is presently located on 322 acres of state-owned land at Ke-ahole Point, adjacent to Ke-ahole airport on the Kona coast of the Island of Hawaii. This site was chosen because of the nearby availability of cold, deep ocean water; a warm ocean surface layer not subject to strong seasonal cooling; high annual solar insolation; accessibility to logistical support through airports, harbors, and highways; and the presence of adjacent, suitable undeveloped land. Ke-ahole Point uniquely meets all of these criteria.

NELH is governed by a Board of Directors consisting of the Director of Planning and Economic Development of the State of Hawaii, the State Marine Affairs Advisor, the Chairperson of the Board of Land and Natural Resources, two officers or employees of the University of Hawaii appointed by the President of the University, and two County officials appointed by the Mayor of Hawaii.

The Board is responsible for maintaining NELH property, reviewing and approving proposals from prospective users, and planning and coordinating the development of the NELH site. While NELH personnel may provide technical assistance, the primary function of NELH is to make facilities and resources available for the research, development and pilot testing of innovative new technologies and businesses. Legislation passed in May 1984 permits onsite commercialization of successful research and development projects. Additional legislation passed in 1985 permits NELH to develop and operate additional facilities involved in alternate energy activities.

The Board has engaged the services of the Research Corporation of the University of Hawaii to provide administrative services. Plans call for the NELH eventually to become self-supporting through collection of users' fees.

NELH welcomes proposals from both the public and private sectors. With the approval of the Board, users may arrange to share existing facilities or construct their own. Areas of planned expansion are closed- and open-cycle OTEC, cold water aquaculture and agriculture, desalination, solar ponds, direct solar energy applications, and marine materials and equipment testing. The Appendix contains the NELH Policy on Project Acceptance. Inquiries concerning NELH should be addressed to the Executive Director at 220 South King Street, Suite 1280, Honolulu, Hawaii, 96813.

Summary of Activities

Institutional Developments

Subleases

A formal 21.3-acre ground sublease for the Hawaiian Abalone farms (HAF) was negotiated and approved by the NELH Board and by BLNR. Following the precedent set by this lease, a sublease was also negotiated with Cyanotech Corporation for expansion of their 15-acre microalgae production facility.

Funding

State fiscal support of NELH continued at approximately constant levels throughout Fiscal Year 1985, however State funding for the coming FY86 was reduced by 20 percent. Federal DOE support has continued for the OTEC biofouling and corrosion and open-cycle experiments, with funding through the Solar Energy Research Institute (SERI) and technical guidance from Argonne National Laboratory (ANL). User fees from aquaculture projects have begun to contribute to the operating budget. We anticipate that the proportion of support from smaller projects will continue to grow as NELH operations expand.

Staff Changes

The laboratory staff has been augmented this year by the addition of a data analysis engineer. This work, formerly funded through the University of Hawaii at Manoa (UHM), is now funded from the laboratory operating budget since all of the work is done at NELH. The core staff of the laboratory at Ke-ahole Point now consists of ten and one-half positions, including seven personnel able to provide direct project technical support.

Mr. Jack P. Huizingh became the first permanent executive director of NELH in October of 1984. He has established an office in Honolulu where he and Barbara Hill, the new NELH secretary, direct laboratory activities and conduct the laboratory's liaison with the legislature, other state agencies and prospective facility users. These are the first two positions established by the legislature for NELH.

Puna Geothermal Facility

The Puna geothermal development project consists of a geothermal well, power plant and research facility located in the Puna District near Hilo on the Big Island of Hawaii.

The HGP-A geothermal well was drilled in 1976 and produces 110,000 lbs/hr of mixed liquid/steam flow at a wellhead pressure of 175 psia and temperature of 186°C (366°F). The power plant began operation in 1982 and generates 2.0 to 2.5 net megawatts of electricity. In 1985, a 2000 square foot laboratory building and a 1400 square foot test pad were constructed to house research projects which utilize the geothermal resources for power and non-power applications.

The 1985 legislature enacted a revision to the NELH statute to permit NELH to develop and operate more than one facility involved in natural energy resources. Subsequent to the change in statute, the three member HGP-A Geothermal Development Group agreed to transfer its management responsibility for the Puna Geothermal Facility to NELH. Following the transfer, Jan C. War, Operations Manager of the Kona facility, was made manager of the Puna Geothermal Facility. At this writing five projects have been scheduled to use the facility in 1986.

The overall development plan for the facility is similar to that of the NELH at Ke-ahole Point. The Puna Geothermal Facility will provide for research, development, and commercialization of alternate uses of geothermal resources and for the development of new technologies and businesses at the site.

HOST Park

The High Technology Development Corporation was formed by the Hawaii State Legislature in 1983 and began planning in November 1984 for the Hawaii Ocean Science and Technology (HOST) Park. This facility is to be developed on 547 acres of state-owned land adjacent to NELH

along the access road and will provide space and infrastructure for the large-scale commercialization of projects which have performed successful research and pilot-scale development at the laboratory.

NELH has cooperated with HTDC in the joint funding of an Environmental Impact Statement for the proposed HOST Park and the planned expansion of NELH. This EIS, along with related updates of existing NELH permits will help to ensure the orderly development of both facilities. NELH has also contracted the preparation of an updated master plan to serve for the coming years of site development.

Initial infrastructure of the proposed HOST park will include a large diameter cold seawater pipeline and supply systems. Current plans call for installation of the pipeline near the existing NELH cold seawater system so that cross-connections can be included which will provide redundancy and enhanced reliability of the NELH seawater supplies.

Facility Developments and Status

Coldwater Supply System

NELH remains the only facility in the United States, and possibly the world, supplying a continuous flow of cold deep seawater. At year's end, our pumping system, which now includes three pumps, is operating well. Continuous flow was maintained throughout the year, except for a 37 hour interruption caused by damage from large waves in January. As of June 30, 1985, coldwater experiments have run for 1,158 days. A third submersible pump installed in March 1985 adds redundancy and some added pumping capacity to the existing two pump system. Maintenance problems with the system this year have involved the cables and connectors in the electrical power supply for the pumps. Two new larger capacity pumps have been delivered and will bring the cold sea water system up to the design capacity of 1,300 gallons per minute (gpm).

New Coldwater Pipeline

DOE is proceeding with its plans to install a new coldwater pipeline at NELH with a diameter of approximately 30 in. (76 cm) and a pumping capacity near 6,000 gpm (22,000 l/m). A cooperative agreement has been signed between DOE and NELH for the installation of this pipeline.

Hawaiian Abalone Farm (HAF) has begun installing pipelines and pumping systems as FY85 ends. They are assembling a mile-long (1.6 km) polyvinyl chloride (PVC) pipe 15 in. (38 cm) in diameter along the NELH access road. This pipe will be deployed just south of the existing NELH pipeline along the seafloor down to approximately 2,000 ft. (600 m) depth. HAF has received NELH approval-in-concept to install two 15 in. (38 cm) diameter pipes, two 24 in. (60 cm) diameter pipes and one 36 in. (91 cm) diameter pipe.

An additional cold water pipe at NELH is planned for the HOST Park. Present plans call for installation of a 24 in. (60 cm) diameter pipe as part of the initial HOST Park infrastructure. Negotiations are underway to ensure that all pipelines will incorporate crossover systems to allow emergency backup of all systems.

Bud Placek checks the cold water pump panel.

Water Quality Laboratory Improvements

Plans for a complete re-organization and renovation of the NELH water quality laboratory have been completed. A $160,000 State CIP appropriation will permit renovation of existing laboratory space, construction of a new external "wet lab" and the purchase of needed new laboratory equipment. The design and the bid package were prepared, and a construction contract was awarded in August 1985.

Electrical Distribution System Improvements

Five metered 480 volt three phase circuits were installed on the NELH test pad, using State CIP funds. This system now provides metered power distribution to lab projects, thus improving both the load balancing and our utilities accounting.

Visitor Program Improvements

The County of Hawaii provided funding for the preparation of an "information kiosk" at the highway entrance to NELH. Erected in January 1985, this structure includes three sign panels describing OTEC and its potential; the various past, present and future laboratory projects; and the rules for access to and use of the NELH property and the shoreline areas.

Our visitor information program, funded largely by the Federal Energy Extension Service through the State Department of Planning and Economic Development, has greatly expanded and improved this year. In addition to conducting regular public tours for individuals and groups, our public relations officer has also coordinated preparation of instructional aids and made many informational presentations to community groups and schools around the island (on laboratory acitivities).

Abalone Commercial Production Module Facilities

Hawaiian Abalone Farms has continued expansion of their commercial demonstration module on 21.3 acres of open land adjacent to the NELH laboratory compound. Initial facilities include two large million-gallon kelp tanks and several acres of shade cloth structure which covers abalone growout tanks. The first of four 4-acre kelp ponds has been excavated, and the first cold seawater pipeline is under construction.

Microalgae Culture Facilities

In January of 1985, Cyanotech Corporation began construction of their commercial production ponds for microalgae growout. Five acres of land were prepared and four large oval raceways have been built. Large paddle wheels maintain continuous water circulation in the cultures. A process building has also been constructed at their site.

Cyanotech microalgae raceways.

Facility Capabilities

As of June 30, 1985, NELH had the following operational support capabilities:

Warm Seawater Supply

- 2,000 gpm
- 24°C to 28°C

Cold Seawater Supply

- 1,100 GPM (three 640 gpm pumps)
- Expandable to 1,300 gpm
- 8.5°C to 10.5°C (constant, depends on total flow)

Water Chemistry Laboratory

- Flow
- Temperature
- Salinity
- Suspended Solids
- pH and Alkalinity
- Nutrients
- Dissolved Oxygen
- Biochemical Oxygen Demand (BOD)
- Residual Chlorine

Technician Support

- Mechanical
- Electronic/Instrumentation/Electrical
- Laboratory
- Diving

Steve Wilson maintains the backup generators.

Kent Merrill prepares for diving operations.

Facilities

- Laboratory Space (in & outdoor)
- Warehouse Space
- Office Space
- Shops: Electronics, Machine
- Large vacuum pumps and open-cycle experimental chambers
- Aquaculture tanks (All plumbed with warm and cold seawater):
  10 ea. 600-gallon fiberglass tanks
  5 ea. 1,000-gallon plastic lined steel tanks
  10 ea. 3 cu. m. (800 gallon) rectangular tanks, each divided into 1 cubic meter sections
  Various tanks, larval basins and growout baskets designed for the culture of lobster
- A 20 ft. X 50 ft. inflatable building
- Offshore research corridor
- 24-ft. workboat with trailer
- 3 Automatically started diesel generators for facility backup
- 2 Trailer-mounted 10 kw generators for field work
- Trailer-mounted 100 kw 440V three-phase generator
- 2 PDP/11-23 Computers for on-line heat transfer processing

- IBM-PC with graphics printer, color monitor and word processing, spreadsheet and high-level language software.

Vehicles

- 2 Fork lifts
- 3 Trucks
- Electric utility vehicle
- Station wagon

Communication

- Private VHF system with all vehicles, boat and handheld units
- NEC 1648 Phone System with 6 CO lines and 14 extensions
- Computer based modem for electronic mail communications

Environmental Monitoring

- Wind, temperature, rainfall
- Solar insolation
- 2 Multi-channel data loggers

Permits in Place

- Approved Offshore Research Corridor
- Conservation District Use Application for coastal and submerged land
- Special Management Area Use Permit for coastal lands
- DOT Harbors Division Shore Waters Construction Permit
- Environmental Impact Statement/Environmental Assessment for the whole facility
- NPDES Discharge Permit for seawater effluents
- United States Army Corps of Engineers Permits

Public Information

- Tours available
- Public lectures
- Brochures and information packets

Cathy Yamashita greets visitors between typing and answering the phone.

Research Activities and Results

Table 1: **Summary of Research Projects at NELH**

Project Name	Objectives	Sponsor Institutions(s)	Funding Source(s)	Investigator(s)	Dates	Results	Status 6/85
Buoy Fouling and Corrosion Studies	Study fouling and corrosion of OTEC Heat Exchanger Materials	UHM, HNEI, JHU/APL	HNEI, DOE, NSF/ERDA, UHSG, MAC	J. Larsen-Basse, F. Munchmeyer	76-79	Biofouling became significant after an initial incubation period of several weeks.	Completed
Mini-OTEC	Demonstrate net power production from OTEC	DPED, LMSC, Dillingham Corp.	State of Hawaii, various companies	E. Grabbe	1/79-12/79	First successful production of net power from OTEC. Generated more than 10Kw net on a floating platform moored in the NELH Offshore Research Corridor.	Completed
Argonne Test Project	Heat transfer monitoring and biofouling control Microfouling studies Corrosion studies Macrofouling studies Water Quality Analyses	UHM/ANL UHM/ANL UHM/ANL UHM/ANL NELH/ANL	DOE/DPED DOE funding via SERI since 7/83	J. Larsen-Basse L.R. Berger J. Larsen-Basse E.A. Kay T. Daniel	7/81-present	1. Biofouling in warm surface water repeatably reduces heat transfer to unacceptable level within 20 days. 2. Only 70 ppb chlorine applied for 1hr/day controls the biofouling. 3. No reduction in heat transfer (i.e. biofouling) has occurred over 3 years of continuous cold water flow. 4. Aluminum alloys do not show pitting corrosion in surface water, but do in deep water.	Continuing
Simplex Corrosion	Measure corrosion of samples installed on offshore buoy.	UHM	Simplex Wire & Cable Co.	J. Larsen-Basse	7/81-3/82	Measured corrosion on several alloys installed on offshore buoy.	Completed
UH Atmospheric Corrosion Project	Monitor and analyze corrosion of samples in NELH marine atmosphere	HNEI	UH Foundation	J. Larsen-Basse	7/81-3/83	Collected corrosion data on several aluminum alloys.	Completed
OTEC Aquaculture Fish	Investigate parameters of growing salmon and trout in deep cold water	HIMB	UHSG, MAC, DPED	A. Fast	1/82-11/84	1. Grew more than ½lb. fish per gallon deep water. 2. Found optimum temperatures, photo-periods and flow rates. 3. Studied smoltification parameters. 4. Spawned trout successfully in seawater.	Completed
OTEC Aquaculture Macroalgae	Demonstrate culture of nori *(Porphyra tenera)* and ogo *(Gracilaria spp.)*	HIMB	UHSG, MAC, DPED	F. Mencher, R. Spencer	1/82-3/83	1. High nori growth rates (35% mass increase per day) initially and 40-60 gm/m^3/day in high density (2-3kg/m^3) tanks. 2. Optimum photoperiods and temperatures were determined.	Completed
Abalone Culture	Investigate feasibility of commercial abalone culture in Hawaii	Monterey Abalone Farms	Monterey Abalone Farms	G. Lockwood	2/82-present	1. Abalone and kelp *(Macrocystis)* to feed them can be grown in the deep cold water. 2. The high nutrient content of the deep water results in high protein in kelp. 3. The lack of pathogens in the deep water permits its use without filtration. 4. A commercial development module has been initiated.	Continuing
OTEC Chlorination	Study the effects of low level chlorination on the marine food chain	UHM	HNEI	F.J. Sansone	6/82-6/83	1. Chlorine kinetics in tropical seawater differ markedly from results with other seawater. 2. Reaction of the chlorine with the water takes much longer than in temperate water. 3. Only trace levels of halogenated organics are produced in chlorinated NELH water.	Completed
Maine Lobster Culture	Validation of Hawaii as site for Northern Lobster *(Homarus americanus)* culture	Sanders Associates Inc.	Sanders Associates, DPED	M. Thays	9/82-10/83	1. Maine lobster grow well in the Sanders culture system using temperature control obtained by mixing surface and deep water. 2. Present economics indicated this culture would be unprofitable.	Completed
Cable Corrosion	Investigate corrosion of candidate materials for deep sea cables	Parson's Hawaii	DOE/HECO	J. Larsen-Basse	1/83-present	Various candidate cable materials show expected corrosion in seawater.	Continuing
ASTM Corrosion	Monitor corrosion of metals in the ocean offshore of Ke-ahole Point	ASTM	NELH	J. Larsen-Basse	6/83-6/89	First samples submitted to ASTM.	Continuing
Alcoa Corrosion	Study the corrosion of various aluminum alloys in flowing seawater	Alcoa	Alcoa	B. Liebert	1/83-present	Analysis of proprietary samples continues. Effects of brushing in warm and cold water are being studied.	Continuing
Open-cycle OTEC							
Heat and Mass Transfer Research	Study efficiency of spout evaporators and condensers by measuring heat and mass transfer in seawater system	UHM/HNEI	SERI/DOE	J. Larsen-Basse	6/83-present	1. Seawater results are similar to those with fresh water in Colorado. 2. Spout evaporators and condensers promise high efficiency for OC-OTEC.	Continuing
Gas Desorption Research	Use a packed column to study composition of dissolved gases in seawater at various temperatures and pressures	UHM/Look Lab.	SERI/DOE	H-J. Krock	6/83-6/84	1. Dissolved gas compositions confirm predictions. 2. The "height of transfer units" which measure the power required to remove dissolved gases are about 50% less with NELH seawater than predicted from freshwater data.	Continuing (now combined with heat and mass transfer study)
Mist-lift Process	Demonstrate operation of the mist-lift cycle with seawater	R&D Associates, Marina del Rey, CA	SERI/DOE	S.L. Ridgway	6/83-12/83	1. Mist generator works well without clogging. 2. Vapor-mist coupling approximates predictions - up to 100m. of lift may be available from 20°C.	On Hold
CWP/AST Phase III	Deploy and monitor 1/3 scale FRP CWP down slope off Ke-ahole Point.	HD&C/NOAA	NOAA/DOE	I. Sandison	4/83-5/85	Deployment successful. Data collection begun.	Continuing
OTEC Agriculture	Grow strawberries in fresh water condensing on pipes carrying cold seawater	UHM	UHSG	S. Siegel M. Vitousek	1/84-6/86	Strawberries grow well with high sugar content. Seasonal cycling can be controlled by water flow rate.	On Hold
Microalgae Culture	Develop commercial microalgae culture techniques in seawater	Cyanotech Corporation	Cyanotech Corporation	G. Cysewski	7/84-present	*Spirulina* grows well in seawater. Commercial production imminent.	Continuing
Macroalgae Study	Study growth of macroalgae in surface and deep water	UHM-HNEI	HNEI	F. Mackenzie C. Agegian	1/85-6/85	Macroalgae efficiently utilize high deep water nutrient concentrations	Completed
Giant Clam Culture	Study effects of Hawaiian environment on giant clam growth	Marine Animal Assoc./Waikiki Aquarium	Private	M. Dailey	8/85-8/86	Preliminary: Clams grow well in Hawaii	Beginning
Nori Culture	Develop commerical nori culture techniques for Hawaii	Aquaculture Concepts	Private	S. Katase	8/85- ?	Preliminary: Nori spores will germinate in NELH seawater	Beginning

Table 1 summarizes the research activities at NELH.

OTEC Research

The ongoing biofouling and corrosion research initiated in 1981 by Argonne National Laboratory (ANL) has continued this year with DOE support through both ANL and the Solar Energy Research Institute (SERI) under the technical direction of ANL and Dr. Jorn Larsen-Basse of UHM. The open-cycle OTEC research initiated last year by SERI and Dr. Larsen-Basse has also continued and expanded. Additional projects have continued on cold water pipes and on the environmental impacts of proposed OTEC experiment expansion.

Closed-cycle OTEC

Heat transfer, biofouling and corrosion — These experiments use 1" diameter piping loops in the laboratory, each of which contains a heat transfer monitor and through each of which seawater flows continuously at 4.5 ft/sec or 6 ft/sec. Throughout FY85, the main system ran at its design capacity of 12 warm water and 6 cold water loops. An independent system added this year contains three additional loops for a SERI-sponsored study of non-chemical biofouling control. One of these loops, operated by researchers from HNEI, has an ultra-violet fouling control apparatus; one contains an ultrasonic control experiment run by the Applied Physics Lab of The Johns Hopkins University (JHU/APL); and the third serves as a control. These three loops are controlled by a second PDP-11/23 computer using software similar to the main system.

Ajay Bhargava operates the computer taking biofouling data.

Cullen Tendick designs electronic control systems.

Warm Water — Warm seawater has flowed through 12 experimental loops throughout FY85. In addition to the 7 loops run since July 1981, 5 loops started in 1984 also contain heat transfer monitors (HTMs) and samples designed to test different alloys and new heat exchanger enhancements. Both spirally-fluted ("korodense"-enhanced) and rectangular cross-section ("Trane"-type) tubes are being tested. Two of the HTMs have been combined into one loop this year to determine variations in the biofouling control provided by chlorine as it passes through the system. Water from a temporary intake with a submersible pump installed more than 600 ft. offshore in January 1984 flowed through one loop until October, when both the primary and backup pumps failed. This experiment did exhibit an incubation period before the onset of the first biofouling cycle, as expected from earlier results obtained using an offshore buoy at Ke-ahole Point. Subsequent fouling cycles initiated rapidly, indicating that the biofouling characteristics of the water from 600 ft. offshore do not differ significantly from those of the NELH primary warm water supply which is pumped from 300 ft. out.

Biofouling Countermeasures — Continued experimentation in FY85 has further confirmed the efficacy of intermittently-applied low chlorine levels for effective biofouling control. Only 70 parts per billion (ppb) of residual chlorine applied for one hour per day appears to almost completely control the biofouling of tubes made from several candidate heat exchanger materials. In addition, the same low intermittent chlorination schedule can remove established biofouling films. These results, combined with the improved understanding of the chemical dynamics of chlorine in tropical water obtained from Dr. Sansone's chlorination studies at UHM, continue to indicate that chlorine can control OTEC biofouling without adverse environmental effects. These results have also been confirmed for rectangular cross-section and spirally-fluted tubes used in enhanced heat exchanger designs.

Cold Water Results — Cold water flow for continued research on biofouling and corrosion was nearly uninterrupted in FY85. The data generally corroborated the previously obtained results: no biofouling and significant pitting corrosion of most aluminum alloys in the cold water. These results continue to indicate that biofouling will not be a serious problem in OTEC condensers and that care will be required in the selection of aluminum alloys which resist corrosion on the cold water side. Testing of both rectangular cross-section and spirally-fluted tubes also continued in the cold water.

Coupon Analysis — Dr. Jorn Larsen-Basse's study of the corrosion of candidate heat exchanger materials has continued to indicate that aluminum will work well in warm surface water, but only alloy 5052 shows acceptably low corrosion in the cold deep water. Dr. L. Ralph Berger's continued analysis of the biofouling films has produced spectacular electron micrographs of the fouling organisms and shown how they grow on the corrosion layers. Some skeletal forms appear to remain on the surfaces even after removal of all heat transfer resistance by chlorination.

Macrofouling Studies — The study of corrosion and macrofouling under slow-flow conditions has produced interesting data throughout FY85. Three warm water and three cold water troughs carry seawater at about 1 ft/sec (0.3 m/sec) past samples which are extracted periodically for both biofouling and corrosion analyses. Dr. E. Alison Kay of the UHM Zoology Department is responsible for the macrofouling analyses. Dr. Larsen-Basse is combining these corrosion studies with those described below for the Deep Ocean Cable Materials study.

Kinetics of Chlorine in Seawater — Dr. Francis J. Sansone has continued research at UHM using NELH seawater samples in attempts to understand the kinetics and fate of chlorine in tropical seawater. Results continue to indicate that potential environmental impacts of chlorination at an OTEC plant would be minimal because of the low levels required and because of the lack of significant production of the halogenated organics found when other seawaters are chlorinated.

Open-cycle OTEC

Heat and Mass Transfer and Gas Sorption Kinetics — These studies continued experimentation at NELH on the properties and efficiencies of spout evaporators and condensers and on the dissolved gas contents of both the warm and cold seawater. Heat and mass transfer data collected under Dr. Larsen-Basse's direction by researchers from UHM and SERI have continued to replicate the results obtained earlier at SERI with fresh water. These results indicate the potential for very high efficiencies in spout evaporators and condensers. At year's end, plans are nearing completion for a major new experimental apparatus using larger tanks and more sophisticated instrumentation to continue these experiments.

In FY84, researchers from SERI and Look Laboratory of Ocean Engineering discovered that much less energy is required to extract the dissolved gases from seawater than had previously been known to be required to perform the same process with fresh water. This year, Look Lab Director Dr. Hans-Jurgen Krock and graduate student Manfred Zapka constructed and installed a seawater deaeration device which further demonstrated the ease of removal of dissolved gases from both warm surface and cold deep seawater. They also ran comparison tests using fresh water which was stored in the extra warm water header tank and run through the same plumbing and equipment as the seawater. These tests verified the earlier results, indicating

that the parasitic losses required for gas removal from open cycle systems will be significantly less than had been assumed in previous studies.

Mist Lift — Though the FY84 experiments indicated that the mist lift apparatus assembled at NELH by Dr. Stuart Ridgway of R & D Associates in Marina del Rey, California worked as predicted, SERI elected not to fund further experimentation in FY85. Dr. Ridgway has maintained close contact with NELH, and the apparatus remains installed at the laboratory. Sandblasting and painting of the apparatus was accomplished late in FY85 under a separate SERI contract. The apparatus remains erected at NELH awaiting further experimentation.

OTEC Coldwater Pipe Test

NELH is the site of Phase III of the One-third Scale Cold Water Pipe At-Sea Test Program funded by DOE through NOAA's Office of Ocean Engineering. This program has been conducted by Hawaiian Dredging & Construction Company (HD&C). Phase I involved construction of a 400 ft. (122 m) long by 8 ft. (2.4 m) diameter piece of pipe using fiberglass-reinforced-plastic (frp). Phase II, conducted off Waikiki, Oahu in April 1983, suspended the pipe from a surface platform and measured the forces and moments under various wave and current conditions.

In Phase III, an 80 ft. (24 m) long section of the pipe was deployed down a 40-degree sloping bottom off NELH. A year-long program was planned to monitor the forces on the pipe and its foundation under varying environmental conditions. However, multiplexer housing failure and lightning from an electrical storm damaged the electronics in the underwater data collection systems. Recognizing the usefulness of further data, particularly under strong wave and current conditions typical of the winter months, the system was repaired and the DOE has left the pipe and its sensors installed at NELH. Present plans call for redeployment of the underwater instrumentation and reinitiation of the data collection beginning in October 1985.

This project has collected environmental data on waves and currents off Ke-ahole Point which are particularly helpful to the ongoing efforts to understand and forecast the offshore environment. Pursuit of the understanding is rewarding scientifically, while the forecasting is needed for engineering projects such as pipeline installations. These data have been recorded by a stand-alone computer system, which is connected via a telephone modem with the Honolulu offices of Edward K. Noda and Associates, HD&C's subcontractor for data collection. The researchers thus have complete control of the data acquisition system from Honolulu and only minimal time is required for on-site work. Such systems allow projects to minimize the costs of doing research at NELH and reduce the direct involvement of NELH staff in the research.

Environmental Impact Studies

In the fall of 1984, the University of California at Berkeley (UCB) Marine Sciences Group conducted a large experiment to study the existing oceanographic conditions off Ke-ahole Point. The data collected have served as input for modeling the effects of large-volume intakes and discharges on the nearshore region. A full report on these studies is in preparation at the end of FY85. These studies will also support an Environmental Assessment document being prepared by UCB to cover installation of additional DOE seawater pipelines at NELH.

A State Environmental Impact Statement was also prepared by the Traverse Group for NELH to cover the planned expansion of NELH activities. The EIS was accepted by the Governor in September 1985. This EIS, combined with a new master plan currently in preparation, will be used to update existing NELH environmental and site permits and to apply for new permits to cover planned expansions of NELH and user activities

OTEC Aquaculture Research

Potential economic benefits from aquacultural by-products which might be grown in the coldwater discharge from an operating OTEC plant have prompted the development of facilities for research into cold water aquaculture. These include the unique NELH cold seawater supply system and several types of tanks and other equipment for growing various species of plants and animals. These facilities have attracted a number of research projects from both the private and public sectors investigating the potential utilization of the deep cold water. Significant potential appears to exist for commercialization of several species of aquatic plants and animals, utilizing the properties of low temperature, high nutrient content and lack of pathogens that are found in the deep cold water.

Fish — Dr. Arlo Fast and his associates from the University of Hawaii's Hawaii Institute of Marine Biology concluded their research on the growth of salmon and rainbow trout in the deep cold water in the fall of 1984. Major results of their two-and-one-half years of experimentation include: 1) steelhead trout and salmon grow well in the cold deep seawater, 2) photoperiod has little effect on salmon smoltification, but lower water temperatures appear to accelerate the process and to minimize the time spent by the fish in freshwater, and 3) manipulation of temperature and photoperiod can induce spawning of steelhead trout in seawater, thus eliminating another freshwater requirement in their life cycle.

The researchers now feel that they have sufficient data to design fish aquaculture systems in conjunction with future OTEC plants. A publication now in preparation will summarize the results of all of the coldwater aquaculture research at NELH, including the previous projects which investigated growth of nori (seaweed) and Maine lobster. That report will include an analysis of the economics of raising the various species, both independently and in conjunction with an OTEC plant.

Some large trout and salmon remaining from this project have been maintained by NELH staff as "PR fish" to demonstrate to those on public tours that the fish do grow well in NELH's cold deep seawater.

Abalone — In May 1984, Hawaiian Abalone Farms (an affiliate of Monterey Abalone Farms of California) signed a long-term lease for 21.3 acres of land adjacent to the NELH compound and began development of a "Commercial Demonstration Module" of an abalone production facility. The formal groundbreaking for this facility on June 30, 1984 was attended by the Governor, the Mayor of Hawaii County and many state and local political and business leaders. This culminated more than two years of research at NELH which had indicated the suitability of the deep cold water for abalone culture. They have built two large 1-million gallon tanks for initial growout of kelp to be fed to the abalone and installed several acres of abalone growing tanks covered by shadecloth.

At year's end, HAF has nearly completed excavation of the first of four 4-acre kelp ponds. These ponds will be lined and filled with about 20 million gallons each of cold deep water for kelp production. HAF has begun installation of their own deep seawater pipelines and pumping systems. In June of 1985, a mile-long pipe was assembled from 15-in. diameter PVC along the NELH access road.

This company's research has successfully demonstrated the useful properties of the deep cold water being pumped at NELH for aquaculture of marine mollusks. The purity of the water permits successful growout without expensive water purification processes. The high levels of dissolved inorganic nutrients in the deep water provide rapid kelp growth rates. The deep water is always colder than needed, so temperature can be inexpensively maintained throughout the system by controlling the coldwater flow to balance heat gained from the Hawaiian climate.

Microalgae — Cyanotech Corporation, of Woodinville, Washington, approached NELH in June 1984 about establishing a facility to grow microalgae at Ke-ahole Point. They broke ground in January and held a formal dedication of their completed facility in July of 1985. Their facilities have been developed on 5 acres of a planned 15-acre parcel located on the landward side of the NELH access road, approximatley ½-mile from the main laboratory compound. Though the microalga *Spirulina* normally grows in fresh water, Cyanotech's research within the NELH compound demonstrated that their proposed culture of *Spirulina* in seawater should work even better than initially forecast. In August they made their first commerical harvest of *Spirulina* for sale to mainland healthfood wholesalers. They have also begun experimentation on the culture of *Dunaliella*, another microalga which has the highest known natural concentration of beta carotene. Beta carotene is a vitamin A precursor

widely used in pharmaceutical preparations. Negotiations have been completed for a long term commercial lease of 15-acres of NELH land.

Giant Clams —- Dr. Murray D. Dailey of California State University, Long Beach has begun a project in cooperation with the Waikiki Aquarium to investigate the feasibility of culturing giant clams *(Tridacna spp)* in Hawaii. About 2,000 specimens brought from Palau are growing in raceways constructed at NELH in August 1985. The experiments are designed to investigate how the growth rate of these animals in captivity is affected by several parameters such as the temperature, nutrient content and flow rate of the water, the incident light spectrum and the specimen spacing.

Nori seaweed — The success of the 1982-84 UH Sea Grant-sponsored research project on the growth of the seaweed nori *(Porphyra tenera)* in suitable mixtures of deep and surface water has led to the formation of a company which proposes development of a commercial-scale nori production facility at NELH. In cooperation with some of the largest Japanese nori producers, they plan commercialization if tests are successful. Initial experiments were conducted in August 1985.

Oysters — American Sea Ranch, Inc. planned to establish a shellfish hatchery at NELH using the purity of the deep cold water to produce high quality larvae. The company is a producer of shellfish in the Pacific Northwest. They began growing Pacific oysters *(Crasostrea gigas)* at the laboratory in January 1985. Though the oysters grew well, the project was formally terminated in June 1985 for administrative reasons.

OTEC Agriculture

The strawberry beds installed in FY84 to investigate using the cold freshwater which condenses on the pipes carrying cold seawater to irrigate agricultural crops have not been used in FY85. Analysis completed this year of the initial experimental data has confirmed the preliminary results, that sufficient water condenses from the ambient air at Ke-ahole Point to provide adequate irrigation for optimum strawberry growth, that the strawberries grown using this cold condensed water consistently have about five times the sugar content of control plants watered with ambient temperature tap water, and that varying the cold seawater flow changes their root temperatures enough so that the plants can be made to go dormant and to begin blooming again over a period as short as two weeks. Drs. Siegel and Vitousek of UHM plan to propose further experimentation with both strawberries and other crops.

Water Analysis

The program of weekly sampling and analysis of the surface and deep water supplies and of the mixed discharge from the laboratory has continued throughout FY85 with funding from DOE. Initial analysis of the unique three-year computerized data set of water quality parameters measured at the laboratory produced results which led HNEI to sponsor research to clarify the nature of the short-term variability in the deep water parameters. Hourly sampling conducted for two days in April 1985 under the direction of Dr. Stephen Smith of the UHM Oceanography Department has shown a strong variation with about 24-hour-period in the concentrations of the dissolved inorganic nutrients and in the salinity of the deep water. Unexpectedly, the variations in all of these parameters are highly correlated, possibly indicating that they are caused by large vertical motions of the water at the 2,000 ft. (600 m) intake depth. It appears that these data may represent the first measurement of an oceanic internal wave using the water chemistry at a fixed site. These measurements also suggested techniques for filtering the diuranl variability from the three year time series of the variables, and initial results indicate significant variations with period in excess of two years, at least in the nutrient concentrations. Experimentation is planned for early FY86 to further define these variablities. NELH also plans continued weekly sampling and updating of the computer data base for use by researchers at NELH and throughout the scientific community.

Other Research

Environmental Measurements

NELH remains an official National Weather Service observation station, reporting daily observations of temperature and rainfall. Since January 1985, a new data logger system has provided continuous measurements of many environmental variables. Hourly averages of direct and diffuse solar insolation, air temperature and humidity, surface and deep water temperatures, and wind vector speed and direction, as well as daily averages and maxima and minima of all these variables and daily total rainfall are recorded on tape cassettes for transfer each week to NELH's IBM PC where they are processed to produce charts and tables for distribution to HNEI for incorporation into the state-wide sensor network and to other interested researchers.

Deep Sea Cable Corrosion

This project, sponsored by DOE through a contract with Hawaiian Electric Company and sub-contract with Parson's Hawaii, has contracted with Dr. Larsen-Basse of UHM to monitor corrosion of several candidate materials proposed for jacketing the deep sea cables required for inter-island power transmission. Measurements of the electric potential changes on samples installed in troughs which have warm and cold water flows of about one ft/sec (30 cm/sec) yield estimates of expected corrosion rates in the ocean. The troughs used for this experiment also serve as test vessels for the macrofouling analyses conducted by Dr. Kay in conjunction with the OTEC research program. A new phase of this project is beginning at year's end with the expected arrival of new samples of proposed cable designs for installation offshore of Ke-ahole Point.

Alcoa Corrosion Project

Aluminum Company of America is funding Dr. Bruce Liebert of UHM Mechanical Engineering to conduct a three-year project to measure corrosion of proprietary aluminum alloys in rapidly flowing seawater (6 ft/sec). Coupons of several alloys, some brushed periodically, are sampled on a regular basis and analyzed for corrosion. The program will continue until January 1986.

ASTM Corrosion Tests

NELH is participating in a five-year international inter-laboratory research program on the global variability of the corrosivity of seawater. ASTM has supplied a rack holding samples of steel, aluminum and copper-nickel which NELH personnel have deployed near the cold water pipe offshore of Ke-ahole Point. Specimens are collected at regular intervals and sent for analysis and comparison with similar samples deployed elsewhere. This research is being coordinated by Dr. Larsen-Basse of UHM.

Miscellaneous Aquaculture

Six of the 1,000-gallon tanks constructed in 1982 for chlorine uptake experiments continue to be used for various aquaculture experiments. Some are being used for nori experiments, and some for culture of microalgae for oyster food, while others contain cultures of Hawaiian limpets ("opihi"). Some of the 1 cu. m. nori tanks contain growing oysters and others are providing microalgae cultures for Cyanotech's experiments. These tanks and the 1,000 sq. ft. inflatable building erected to house the completed lobster pilot project remain available for use by new aquaculture projects.

Barbara Lee works on oxygen analyses.

Publications Resulting from Research at NELH

Brewer, Wm. A., Jack P. Huizingh and Jane E. Sexton, "Hawaii's OTEC Park Triggers High-Tech Aquaculture Development", Info-Fish Marketing Digest, No. 1/85.

Daniel, T.H., "Ongoing Experiments at the Natural Energy Laboratory of Hawaii, Ke-ahole Point," presented at the 7th Big Island Science Conference, UH Hilo, April, 1983.

Daniel, T.H., "OTEC and Cold Water Aquaculture Research at the Natural Energy Laboratory of Hawaii," Proc. of the Pacific Conf. on Marine Technology - PACON 84, Marine Technology Soc., April, 1984, p. MRM2/47-52.

Daniel, T.H., "Aquaculture Using Cold OTEC Water," presented at the 8th Big Island Science Congress, UH Hilo, April, 1985.

Grau, E. Gordon, Arlo W. Fast, Richard S. Nishioka, Howard A. Bern, David K. Barclay and Steven A. Katase, "Variations in Thyroid Hormone Levels and in Performance in the Seawater Challenge Test Accompanying Development in Coho Salmon Raised in Hawaii," presented at Intrntl. Smoltification Workshop, sponsored by E.O.C., Stirling, Scotland, 3-6 July 1984, published in *Aquaculture*, 1985.

Hallanger, L.W., "Capabilities and Potential of the OTEC Seacoast Test Facility," presented at the 8th Ocean Energy Conference, Washington, D.C., June, 1981.

Kearney, T.J., "Analysis and Formation Mechanisms of N-Halomethylamines: Application to Seawater Chlorination," M.S. Thesis in Oceanography, UHM, August, 1983.

Kearney, T.J. and F.J. Sansone, "Analysis and Formation Mechanisms of Mixed N-Halogenated Methylamines," presented at the Fifth Conf. on Water Chlorination, Williamsburg, Va., 3-8 June, 1984. To be published in *Water Chlorination: Environmental Impact and Health Effects*, Vol. 5, R.L. Jolley, et al. (eds.) in 1985.

Larsen-Basse, J., "Corrosion of Some Aluminum Alloys in Cold and Warm OTEC Waters," presented at Corrosion 83, Paper No. 66, NACE, April, 1983.

Larsen-Basse, J., "Effect of Biofouling and Countermeasures on Heat Transfer in Surface and Deep Ocean Hawaiian Waters - Early Results from the Seacoast Test Facility," presented at ASME/JSME Thermal Engineering Joint Conference, Honolulu, March, 1983, Volume 2, pp. 285-9.

Larsen-Basse, J. and T.H. Daniel, "OTEC Heat Transfer Experiments at Ke-ahole Point, Hawaii, 1982-1983," presented at Oceans '83, San Francisco, Ca., August, 1983.

Lee, C.K.B. and S.L. Ridgway, "Vapor/Droplet Coupling and the Mist Flow (OTEC) Cycle," *J. Solar Energy Engineering*, v. 105, May, 1983, pp. 181-6.

Mencher, F.M., R.B. Spencer, J.W. Woessner, S.A. Katase and D.K. Barclay, "Growth of Nori (*Porphyra tenera*) in an Experimental OTEC-Aquaculture System in Hawaii," *J. World Maricul. Soc.*, 14:458-470, 1983.

Miller, J.N. and J.F. Walters, "Zooplankton Populations and Water Chemistry from a Shallow (4.3m) and Deep (600m) Pumped Water Discharge, Ke-ahole, Hawaii," UH Environmental Center, August, 1983.

Panchal, C.B., H.S. Stevens, L.E. Genens, D.L. Hillis, J. Larsen-Basse, S. Zaidi and T.H. Daniel, "Biofouling and Corrosion Studies at the Seacoast Test Facility in Hawaii," Proc. MTS-IEEE Oceans 84 Conf., Washington, D.C., September, 1984.

Ridgway, S.L., "Projected Capital Costs of a Mist Lift OTEC Power Plant," presented at ASME Winter Meeting, New Orleans, December, 1984.

Sansone, F.J. and T.J. Kearney, "Unusual Chlorine Kinetics of Tropical Seawater, and the Potential Environmental Effects," Proc. of the Pacific Cong. on Marine Technology - PACON 84, Marine Technology Soc., Honolulu, April, 1984, pp. MRM2/35-39.

Sansone, F.J. and T.J. Kearney, "Chlorination Kinetics of Surface and Deep Tropical Seawater," presented at the Fifth Conf. on Water Chlorination, Williamsburg, Va., 5 June, 1984. Published in *Water Chlorination: Environmental Impact and Health Effects*, Vol. 5, R.L. Jolley, et al. (eds.), 1985.

Future Plans

Upgrade of Cold Seawater Supply System

The new submersible pumps delivered in FY85 will be installed early in FY86. These will bring the present 12 in. (30 cm) diameter coldwater pipeline to its maximum capacity of 1,300 gpm (4,900 l/m). These pumps, specified using the experience of more than two years of coldwater pumping, should improve the system reliability significantly.

New Cold Seawater Supplies

DOE plans a significant expansion of OTEC research facilities to be developed around a new cold seawater supply system at NELH. A conceptual design for the new 30 in. (76 cm) in diameter pipeline and the associated pumping and support facilities was completed in FY85, and several companies are preparing bids to SERI for the final design and construction of the "STF Upgrade."

Hawaiian Abalone Farms is preparing to install its own seawater system to meet its needs. The first of their mile-long 15-in. diameter pipelines was assembled along the NELH access road for planned deployment in July of 1985. Another 15-in. line and two larger 24-in. lines are also planned for deployment.

The HOST Park is also planning cold seawater supply lines, and the first increment will probably include a 24-in. diameter pipeline extending offshore from NELH property. This pipeline will also include interconnections with the NELH system for emergency backup purposes. The present schedule calls for initiation of coldwater flow by October 1986.

NELH has responsibility for coordinating these various pipeline plans. Required cross-connection of new and existing systems will provide mutual backup capabilities. The Board commissioned a study to establish the pipeline capacity of the existing Ocean Research Corridor off Ke-ahole Point and is using the results to aid prospective users in site selection.

Closed-cycle OTEC

DOE (ANL) plans to continue the present biofouling and corrosion experiments through the remaining two years of a planned five year program. In addition, DOE continues through SERI, to fund the investigation of non-chemical biofouling control methods being conducted by HNEI and Johns Hopkins University Applied Physics Laboratory (JHU/APL). Continued operation is planned for all 21 existing seawater loops.

Open-cycle OTEC

SERI is now preparing to expand their open-cycle tests at NELH. These tests will involve expansion of research into both heat and mass transfer and gas sorption kinetics. Three large pressure vessels will be fabricated and assembled at NELH for experimentation with large volumes of seawater and under more controlled conditions than are possible with the existing apparatus. The new design allows sufficient flexibility so that experimenters can use either the present seawater system or the planned 30-in. diameter "Upgraded" supply.

At year's end, the Pacific International Center for High Technology Research (PICHTR) is preparing a proposal to build an operating open-cycle demonstration plant at NELH. Initial designs utilize the planned 30-in. diameter STF-upgrade pipe to provide a gross output around 165 kW. A technical session in August 1985 discussed design possibilities for this project.

Pending Commercial Projects

Alcan Aluminium, Ltd. — After two years of planning and discussion, Aluminium of Canada has begun preparations for a large scale test of aluminum heat exchanger elements. Several multi-tube heat exchangers of various alloys will be installed in the laboratory for continuous monitoring of heat transfer and corrosion with 6 ft/sec (2 m/sec) flow of both warm and cold water. NELH has installed new seawater supply lines for this experiment, which has been designed to

eliminate the need for costly booster pumps to maintain the flow. Argonne National Laboratory is supporting this research by making the heat transfer instrumentation available to Alcan. Researchers at Alcan's British laboratory outside London will conduct the experiment, which has been designed so that both data and experiment control information will be transmitted automatically over the telephone. System components have been constructed in the UK and in New Jersey. Plans now call for initiation of the installation in the fall of 1985.

Villiage Marine Technology, Inc. — This company from the Los Angeles area has approached NELH about testing their desalination systems at the laboratory. We anticipate initiation early in 1986 of experimentation using the cold water in a reverse osmosis system. This will test both the suitability of such equipment for cold-water applications and the possibility of systems which might use the static pressure available at depth in the ocean to drive the reverse osmosis process.

West Coast Lobster Company — This company from Southern California proposes to initiate a lobster growout and hatchery operation on 5 acres of land to be leased from NELH. The proposed technology is similar to that tested in 1982-83 by Sanders Associates. Tentative plans call for establishing their facility along the ocean side of the access road, outside the NELH compound. Initial construction is planned for January 1986.

Other Aquaculture — Other companies continue to approach NELH about the possibility of growing algae, clams, scallops and other aquatic products using the deep cold water at the laboratory. Negotiations have begun with several projects. NELH foresees expansion which could rapidly utilize available seawater and infrastructure at Ke-ahole Point.

DUMAND — The DUMAND (Deep Underwater Muon and Neutrino Detection) project plans to deploy a large array of sensors in the deep ocean off Ke-ahole Point in 1987. The power and data cables for the project will terminate at NELH, and plans are developing for a data collection and analysis facility at the laboratory. This system will be one of the largest ocean engineering projects ever undertaken.

Jan War checks out the water quality data on the PC.

Budget Summary

Project Funding Support Summary FY85

	STATE	FEDERAL	OTHER
A. **Operational Support**	$226,570		
B. **Funded Positions**	44,328	$8,200	
C. **Ocean Energy**			
1. OTEC Experiments			
Closed- and Open-cycle		400,047	
2. Non-Chemical Biofouling		876	
3. CWP At Sea Test		9,958	
E. **Aquaculture**			
1. OTEC Coldwater Fish		1,962	
2. UH Macroalgae Study		1,575	
3. Private Development Projects			$35,894
F. **Other**			
1. Alcoa Corrosion			1,422
SUBTOTALS:	$270,898	$421,043	$38,891
TOTAL OPERATING BUDGET:		$700,832	
Capital Improvement Funding			
A. **Site Studies**	$30,000		
B. **Site Development**	160,000		
TOTAL CIP FROM STATE:	$190,000		

Appendix

NELH Policy on Project Acceptance

The criteria for acceptance of projects at NELH shall be based upon the projects' relation to the development of natural energy resources and upon their utilization of those resources that are available at Ke-ahole Point. Projects that are only tenuously related to alternate energy development and/or do not require the resources that are available shall be referred to the appropriate governmental agency for action and recommendations.

Illustrative examples include:

OTEC research

High priority, alternate energy development plus uses available NELH resource (deep cold seawater).

Solar pond power systems

High priority, alternate energy development plus uses available NELH resource (high solar radiation).

Cold water aquaculture

Medium priority, may be an adjunct to OTEC research plus utilizes available NELH resource (deep cold seawater).

Solar desalination

Medium priority, indirectly energy related and utilizes available NELH resource (high solar radiation).

DUMAND

Medium priority, tenuous relation to energy but requires proximity to undisturbed deep ocean.

Note: The 1984 Hawaii State Legislature enacted changes to the NELH legislation which allow commercialization of projects at the laboratory. Leasing of NELH land for commercial purposes can now be approved by the Board of Directors, provided that some initial phases of the research are accomplished at the laboratory.

Kelen Dunford (right) conducts a tour.

Staff

June 30, 1985

Honolulu

Jack P. Huizingh
Executive Director

Barbara Hill
Secretary

Site Addresses:

Honolulu
Central Pacific Plaza
220 S. King St., Suite 1280
Honolulu, Hawaii 96813

Kona
Ke-ahole Point
P.O. Box 1749
Kailua-Kona, Hawaii 96745

Puna
Facilities Manager: Jan C. War
P.O. Box 2172
Pahoa, Hawaii 96778

Kona

Thomas H. Daniel
Laboratory Director

Jan C. War
Operations Manager

Cullen Tendick
Electronics Engineer

Ajay Bhargava
Data Analysis Engineer

James W. Placek
Electronics Technician

Stephen B. Wilson
Facilities Maintenance

Kent Merrill
Mechanical Technician

Barbara J. Lee
Laboratory Technician

Catherine Yamashita
Secretary/Receptionist

Daniel Lehfeldt
Groundskeeper

Kelen Dunford
Public Relations Officer
(½ time, Energy Extension Service)