Natural Energy Laboratory of Hawaii Authority

Annual Report 1992

Message From The Chairman

Located adjacent to the ocean on the most westerly point of the Big Island, this unique facility has gained international fame as the center of practical OTEC development and as the only place in the subtropics or tropics where temperate marine species can be cultured on a commercial basis. The Laboratory is unique because of its ability to supply abundant cold, nutrient-rich seawater, its resources of relatively inexpensive lease land for research and development projects, its excellent infrastructure of skilled administrative support personnel and its superior analytical laboratory. Keahole Point is also blessed with one of the highest levels of solar insolation anywhere in the United States. The NELHA exists to provide researchers and entrepreneurs with these natural resources and the infrastructural support to help bring innovative ideas to fruition. Commercial activities utilizing these natural resources are welcomed, with several small companies either well-established or in a start-up phase already in existence.

During the past year another mariculture research company has moved into commercial production at Keahole Point and four new research projects—strawberry culture, oysters/shrimp culture, copepods, and open-cycle OTEC have been established. The Alcan International Ltd. research project, which successfully determined the feasibility of using an aluminum alloy for closed-cycle OTEC heat exchangers with electrolytically generated chlorine as a biofouling control agent, was disassembled. Plans are now underway for the practical implementation of the project results in a demonstration OTEC plant to be installed at NELHA in 1993.

Ground was broken for the open-cycle OTEC demonstration plant in December and construction has continued with completion scheduled for November, 1992. Operation of the two OTEC plants will be another step in developing the acceptability of OTEC as a commercial alternative energy source. Keahole Point will be the place for the world to observe both open- and closed-cycle OTEC systems in operation.

This is a time for us to look to the future. The number and variety of research and commercial projects which have been approved to locate at Keahole Point within the next few years will significantly increase our stature in science and technology and will further our mission of economic development and diversification of Hawaii.

The NELHA is primarily concerned with providing an opportunity to research development and start-up commercial activities. We have no in-house research as a matter of policy. There has been a need, however, for a laboratory where the operators of the various activities can go for advice, for experimental work on a particular problem or on a new project. The 1992 Congress will provide the first step in that direction by authorizing the establishment of the "Spark M. Matsunaga Renewable Energy and Ocean Technology Center."

I, and others, are seeking major commitments of funding in Japan and from Congressional appropriation to build and operate the laboratory. As planned, this research facility will focus on the materials science problems confronting the efficient implementation of renewable energy and on marine biotechnology. The 50 or so scientists from the U.S. and Japan at the laboratory will be committed to finding ways to generate sustainable resources of energy and food needed by a growing world population. Keahole Point and NELHA are an ideal location for such a world-class facility. The laboratory will employ about 200 local residents at full operation and will, because of the planned for exceptional quality of its scientists, become a magnet for high technology businesses.

TABLE OF CONTENTS

Introduction ..... Page 3

Keahole Point Facility ..... Page 5

Puna Geothermal Facility ..... Page 7

1992 Major Achievements ..... Page 8

Project Developments ..... Page 12

NELHA Employees ..... Page 20

NELHA Board of Directors ..... Page 21

Financial Statement ..... Page 22

Past Research Projects ..... Page 23

Publications ..... Page 26

Introduction

Welcome to the Natural Energy Laboratory of Hawaii Authority. NELHA's history is rich with change. In 1974 the State lawmakers established the NELH facility on 322 acres as a center for research and development of natural alternative energy resources. In 1984, they recognized the potential and set aside another 548 acres of adjacent land to establish the HOST Park as a center for large scale commercialization of technologies utililizing the natural resources. In 1990, the State lawmakers decided it was time to write some new pages in our history book. They created NELHA, merging the two facilities together for research, development and commercial applications.

The NELHA is a public corporate entity attached administratively to the Department of Business, Economic Development & Tourism. The governing body of the authority consists of nine voting members from the private and public sectors. The members are selected on the basis of their knowledge, interest and proven expertise in the fields of finance, commerce, corporate management, marketing, engineering, real estate development, property management, aquaculture and science. The Executive Director serves as the chief executive officer and is appointed by the Authority. The staff consists of numerous experienced professionals and technicians.

The NELHA Board of Director's mission statement:

> *To develop and diversify Hawaii's economy by providing sites, resources and support services for public and private sector energy and ocean related research and commercial activity in an environmentally sound and culturally sensitive manner.*

Left: An aerial view of NELHA facilities

Keahole Point Facility

The ocean floor drops off quite rapidly at Keahole Point, allowing access to deep seawater close to shore. To take advantage of this resource NELHA operates and maintains pipelines and pumping stations which deliver seawater from depths of 50 feet (15 meters) with a temperature of 77–83°F (25–28°C) and 2,000 feet (610 meters) with a temperature of 43°F (6°C). At this time, there are three deep seawater pipelines in operation with a total capacity of 17,100 gallons per minute and two surface seawater pipelines with a distribution capacity of 11,300 gallons per minute.

SEAWATER SUPPLY SYSTEMS

	WARM SEAWATER		COLD SEAWATER		
Diameter: inches	12	28	12	18	40
Intake Depth: feet	49	69	1913	2031	2215
Length from Shore: feet	303	535	5794	6181	6284
Capacity: gal./min.	1600	9700	1100	2600	13400

Temperature is just one of the important qualities of the deep seawater. The deep seawater comes from below the photic zone at the bottom of the thermocline. This is an area below the reach of sunlight and where there is no mixing with surface seawater. These factors combined with a low oxygen content result in fewer living organisms and a relatively pathogen-free environment. It is also very rich in the nutrients needed to sustain growth in micro- and macro-algae. These characteristics are useful for many applications.

Keahole Point receives more sunshine than any other U.S. coastal location, making it attractive to projects requiring abundant solar radiation. A mild climate and low rainfall reduce costs of construction and operation. West Hawaii's neighboring Keahole Point Airport as well as a nearby deep-water port, make the import and export of products quick and efficient.

Left: Keahole Point Lighthouse

A subdivision for commercial projects which attracts aquaculture and high technology developments includes a full range of infrastructure: access roads, potable water, electric power, ocean water, intake and distribution pipes, pumping stations, disposal systems and a return ocean water system.

NELHA provides a wide range of services for its tenants. These services include clerical support, technical support and rental of equipment such as trucks, cranes, generators and aquaculture tanks. NELHA also maintains laboratory space, a library, conference room, postal services and cost effective high technology communication systems.

Staff members furnish support in the field of ocean and atmospheric environmental monitoring and ocean energy applications. Ocean environmental data has been collected at Keahole Point since 1980. In 1987, the Cooperative Environmental Monitoring Program (CEMP) was designed to monitor the surface and deep sea water supplies pumped ashore. The program expanded to include sampling and analysis of offshore waters, coastal waters and groundwater sites around NELHA. The analytical laboratory provides quarterly reports presenting all data collected along with annual graphical interpretations. NELHA's analytical laboratory has grown to become Hawaii's leader in environmental water quality analysis. The laboratory assists tenants and state agencies with both analytical chemistry and bacterial assays.

NELHA remains an official National Weather Service Observation station, reporting daily readings of temperature and rainfall. Since January of 1985, a data logger system has provided continuous atmospheric measurements of many environmental variables. This data is processed to produce summary charts and tables for distribution to interested researchers and potential NELHA tenants.

Above: Staff Support

Puna Geothermal Facility

NELHA operates the Puna Geothermal Facility (PGF), a four-acre site twenty-five miles south of Hilo on the Kilauea Rift Zone of the Puna District. PGF was established for research, development and commercialization of alternate uses of geothermal resources. Currently, the site includes the HGP-A geothermal well and the Noi'i O Puna Geothermal Research Center for the development of new technologies and businesses.

In 1989, the experimental electric generating plant fueled by the HGP-A well was closed down. Left without a source of heat, most of the research projects at the Noi'i O Puna Geothermal Research Center were forced to cease operations. NELHA intends to develop a new heat source so that more research projects can be established at the site.

Above: Puna Geothermal Facility

1992
Major Achievements

During the year we've been hearing a lot about the recession, about hard times, about unemployment lines and we have been feeling the pinch right along with everyone else. We recognize that money matters are paramount in a tight market. In this section, we have focused directly on business concerns and projects which have been derived from years of planning. We believe that close attention to planning will not only help us keep projects on track, it will also give our tenants more confidence in our ability to deliver the product on time for their use.

PIPELINE CORRIDOR

This year NELHA installed permanent electrical power to the 18-inch deep seawater pipeline. The pipeline was deployed in 1987 and has required an emergency generator for its operation. An 800-foot-long corridor was constructed from the NELHA access road to the 18-inch shore crossing. This corridor is used for the buried 18-inch pipeline, electrical conduits and an additional surface seawater pipeline and pump station.

24-INCH/28-INCH SURFACE SEAWATER SYSTEM

To start this project off, NELHA personnel constructed a natural stone retaining wall to protect anchailine ponds. The wall was completed and a blessing ceremony was performed. The surface seawater system was extended to all active project locations on Keahole Point. This system will give NELHA significant new sources of both deep and surface seawater, thus increasing the reliability of delivery and flexibility of systems operations.

POTABLE WATER SYSTEM CAPACITY INCREASE

NELHA's freshwater distribution system was modified by the addition of 1,100 feet of 8-inch diameter and 1,300 feet of 4-inch ductile iron water pipe. These increases will meet NELHA's projected requirements for potable water for the next 10 years.

ANALYTICAL LABORATORY EXPANSION

The Analytical Laboratory has been significantly expanded to accommodate the increased requirements of the Cooperative Environmental Monitoring Program. Salinity, temperature, alkalinity, pH, nutrient, TOC and coliform bacteria assays are performed at NELHA. New equipment includes a gas chromatograph, a total nitrogen analyzer and a new state of the art autoanalyzer. The laboratory building is being completely remodeled to accommodate the new equipment and the seven employees now performing analyses.

Right: Laboratory Support Staff

VARIABLE SPEED DRIVES

Variable speed drives were installed on two of the seawater pumps. One controls the output of a 35-horsepower surface seawater pump, and the other controls a 77-horsepower deep seawater pump. The variable speed drives allow precise control of the volumes of water pumped, thus allowing NELHA to deliver water to tenants in the exact quantities and pressures required.

OTEC EXPERIMENTAL APPARATUS TRENCH

This seawater return disposal trench was constructed for the open-cycle OTEC Experimental Apparatus. The trench is 100 feet long by 10 feet wide. It is capable of percolating 16,100 gpm of seawater into the rock strata. This is the total flow of water required for the open-cycle OTEC apparatus.

RECONSTRUCTION OF HEADER TANKS

The pressure at which seawater is delivered to the tenants is controlled by how high the water level is maintained in the header tanks. In our efforts to reduce the cost of pumping seawater we reduced the elevation maintained in the tanks. This required relocating the low level alarm transmitters and corresponding adjustment of the water level indicators. Along with these modifications, the tanks supporting structures and related equipment were refurbished to prevent further corrosion.

SOLAR HOT WATER SYSTEM

A solar hot water system was built and installed by the personnel of NELHA. The solar collector utilized Alcan Aluminum Company's roll-bonded® heat exchanger, which is installed on top of the building. The system operates without the use of any electrical power. Water is circulated between the solar collector and a storage tank by a photovoltaic panel powered pump.

REMOVAL OF 50,000 GALLON WATER TANK

Several years ago a tenant erected a 50,000 gallon steel aquaculture tank within the NELHA facility. The tank had not been in service for over two years and was in disrepair. The operations and maintenance division disassembled the tank and disposed of it, thus removing any possible safety hazards and clearing the area for other uses.

STORAGE BUILDING

A new storage building was designed and erected to house all pipe fittings, valves, flanges and other maintenance and construction materials. The 960-square-foot building provides protection from the elements, thereby prolonging shelf life.

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

A Supplemental Environmental Impact Statement for an 83-acre exchange parcel was filed with the Office of Environmental Quality Control to permit the Land Use Commission to reclassify the property from conservation to urban district. This will allow NELHA to develop the property for research and commercialization of ocean related technologies. The purpose is to ensure that environmental concerns are given appropriate consideration in decision making along with economic and technical considerations. The filing of the statement enhanced environmental consciousness, cooperation and coordination with the public, county and state agencies.

NELHA MARKETING

NELHA's marketing section supports the facility with advertising, literature, direct mail promotions, tours, and exhibits at trade shows. Major trade show exhibits include *Ocean's '91, Aquaculture '92* and *Pacon '92.* To access foreign market potential, television specials were conducted by Quantum, a television series from Australia Broadcasting Corporation; Wonderstruck, a Canadian Broadcasting Corporation; and Channel 12, a Tokyo Television Production. Visitors were hosted from many countries including Australia, Canada, China, France, Germany, Japan, New Zealand, Sweden, Taiwan and Philippines.

NELHA EDUCATIONAL PROGRAM

For many years, NELHA has hosted school children of all ages and offered the schools an additional resource of quality instruction. This year besides hosting numerous schools, we expanded our educational program with a focus on community awareness and student outreach. One of the goals outlined was to foster ocean and related technologies. Special programs were adopted by going to the schools to give interactive presentations and to offer our knowledge, services and expertise in particular sciences.

Above: Lecture Tours

Project Developments

Potential economic benefits from aquaculture and other products which utilize the cold water discharge from an operating OTEC plant have prompted research and development. Support facilities at NELHA include the unique cold seawater distribution systems and numerous tanks and other equipment for growing various species of plants and animals. A number of research projects from both public and private sectors have found significant potential for commercialization of certain species of marine plants and animals. These projects use various combinations of the important properties of the deep cold seawater: low temperature, high nutrient content and lack of pathogens.

OTEC-Related Research Projects

CLOSED CYCLE OTEC

ALCAN International Heat Exchanger Research.

Since April of 1986, ALCAN has been testing an array of heat exchanger elements incorporating various aluminum alloys and several multi-tube heat exchanger elements which were monitored for heat transfer and corrosion. ALCAN personnel controlled system parameters and operated the data collection system by telephone modem from their Kingston, Ontario, Canada laboratory.

As part of the development of a closed-cycle aluminum heat exchanger pilot plant at NELHA, ALCAN and the Marconi Division of General Electric Company of Great Britain (GEC-Marconi) proposed the use of aluminum alloy Roll bond® heat exchanger plates for OTEC. They have been testing elements for such heat exchangers at NELHA since January 1989. The data indicates that the units work well in seawater and that a proposed aluminum cladding protects the material from corrosion in the deep seawater.

ALCAN in cooperation with Hawaiian Electric Company and Makai Ocean Engineering are now planning to design and build a 100-kw OTEC plant using existing seawater supplies at NELHA.

OPEN-CYCLE OTEC

210-kw OC-OTEC Experimental Apparatus

A ground-breaking ceremony was held for the successor to the 1988 Heat Mass Transfer Scoping Test Apparatus (HMTSTA) which provided data on the evaporator and condenser components of the OC-OTEC process. Past experiments demonstrated that OC-OTEC is technically feasible but only minimal operational data were obtained. The 210-kw OC-OTEC experiment will operate for up to 24 months answering questions concerning operation of an OC-OTEC plant.

The plant design consists of a 31-foot vertical concrete vacuum structure which will produce about 3% atmospheric pressure. Steam produced by this process will drive a turbine-generator unit located on the top of the vacuum structure. A unique radial inflow turbine has been designed and constructed for this experiment. Testing to assess the performance of an OC-OTEC system, demonstrate the feasibility of the low pressure OC-OTEC turbine, as well as the high efficiency vacuum compression subsystem is scheduled to begin the first quarter of 1993.

PICHTR (Pacific International Center for High Technology Research) is a non-profit organization in the State of Hawaii which designed and will operate the experiment with funding from the U.S. Department of Energy and the State of Hawaii.

Above:
Open-Cycle OTEC

Other Energy-Related Projects

Horizontal Directional Drilling Demonstration

In August of 1991, NELHA, working with the Hawaii Institute of Geophysics at the University of Hawaii at Manoa, contracted with a horizontal drilling company from Olathe, Kansas to perform an exploratory program. The demonstration was to evaluate the feasibility of using the horizontal drilling and reaming technique for cutting through Hawaii's hard, abrasive and open structured basalt.

This technique is being considered for possible use in deployment and installation of pipelines required at NELHA's Keahole Point location. Directional drilling would protect the pipelines from high surf and strong currents as well as protect offshore coral reef formations from temporary environmental damage caused by more traditional pipeline installation methods.

The project successfully drilled one pilot hole from a site on shore to a destination 320 feet offshore and 30 feet below sea level. Divers replaced the drilling bit with a 26-inch-diameter, roller-cutter, reamer bit. The reamer was pulled and rotated 20 feet back into the sea bed in a successful demonstration that reaming is feasible in this type of geographical structure.

Horizontal directional drilling is being evaluated for future pipeline installation at Keahole Point and in other applications in Hawaii.

Above: Horizontal Drilling Rig

SOGI INTERNATIONAL

Sogi International is researching the distillation of ethanol from cane sugar molasses. By applying heat collected by solar panels, the system produces a vapor from fermented cane sugar molasses. The vapor is then exposed to coils carrying the deep seawater which condense it to the liquid state. Ethanol can be used directly in a modified car engine or mixed with gasoline to produce gasohol for automobile fuel.

THERMAL RECOVERY SYSTEMS

Thermal Recovery Systems has developed a freon recycling system. The project utilizes the abundant sunlight at NELHA's Keahole Point location to power a solar still which boils the "dirty" freon recovered from commercial air conditioners after years of use, and uses the cold seawater to condense the purified freon for resale. The resultant product is equivalent in purity to that originally obtained from the manufacturer.

SCIENTIFIC OBSERVATION HOLE PROGRAM

The Scientific Observation Hole Program (SOH) conducts site analysis of core and fluid samples recovered from observation holes. The objectives of this effort are to provide data that will be used in the assessment of Hawaii's geothermal resource base and in the development of identified geothermal reservoirs for electrical power production.

Above: Solar desalination experiment

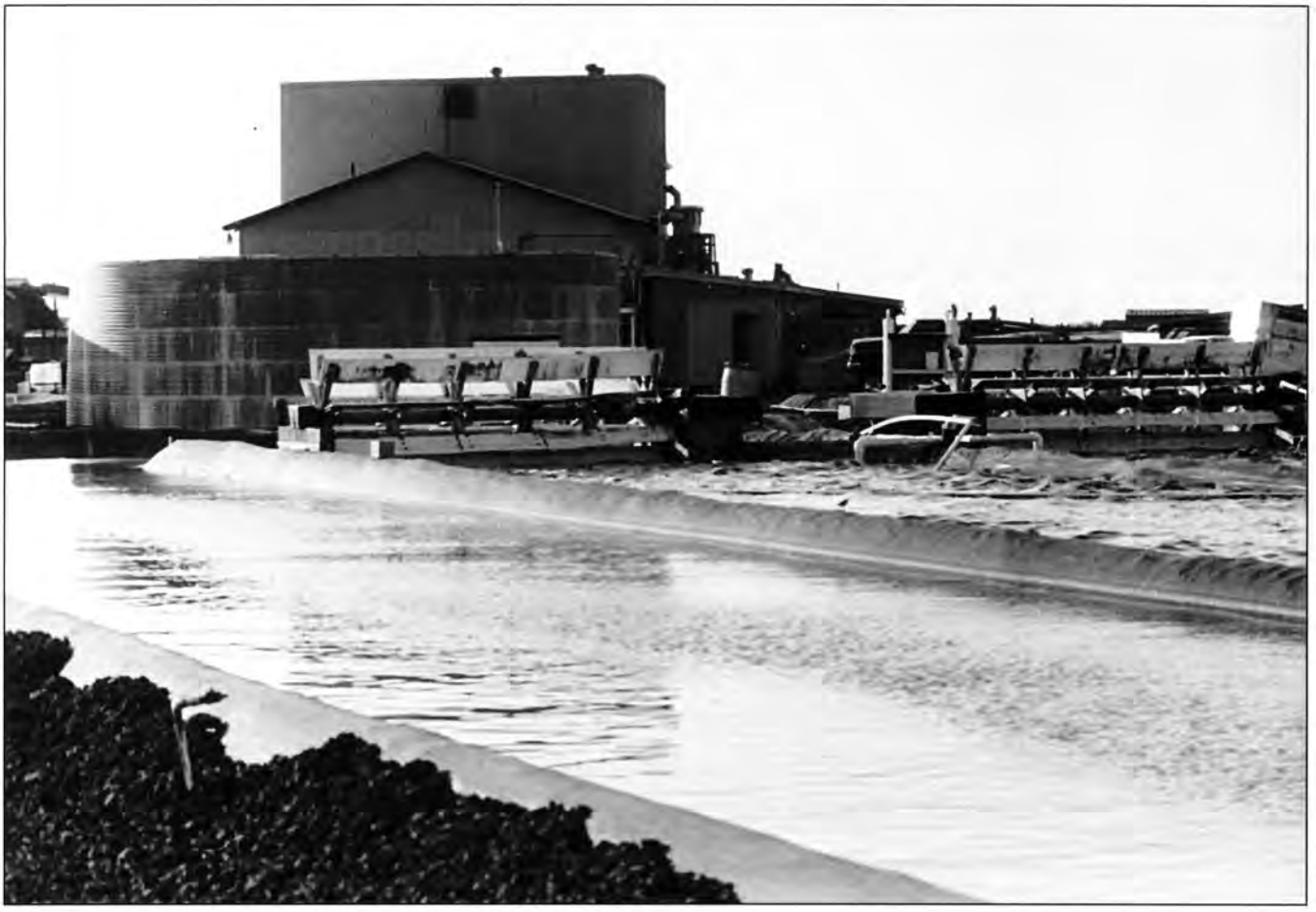
Commercial Projects

AQUACULTURE ENTERPRISES

Aquaculture Enterprises (AE) is currently growing Maine *Homarus Americanus* and European *Homarus gammarus* lobsters. They also grow hybrid lobsters which are the result of cross breeding Maine and European lobsters. These have a unique coloration and are being studied to determine their growth rate and disease resistance characteristics.

In addition to research on growing Maine lobster, AE is operating a rejuvenation stop for fishery lobsters. These lobsters experience only a 24-hour out-of-water shipping time between harvest in Maine and reintroduction to the 6° seawater at Keahole Point. AE has designed and tested a stacked tray system which allows holding densities of 30 ponds per square foot of tank space. Fishery lobsters will be held for periods of 2 days to 2 weeks, fed, inspected, repackaged and air freighted in 2,200 pound capacity containers to Seoul, Hong Kong, Taipei and Singapore. AE intends to ship lobsters to Southeast Asia destinations beginning in November 1992. Currently these lobsters are being test marketed to Kohala Coast resorts, local restaurants and supermarkets.

Above: Aquaculture Enterprises



Above: Cyanotech Corporation

CYANOTECH CORPORATION

Cyanotech Corporation produces several high value products from microalgae such as phycobiliprotein and Spirulina. Phycobiliprotein are florescent pigments which are extracted from microalgae and are used by diagnostic industries as cell markers or tags.

Spirulina is a microalgae used as a food supplement containing very high amounts of natural betacarotene, vegetable protein, essential amino acids, vitamin B-12 and minerals. Cyanotech sells bulk Spirulina throughout the world to natural products formulators and distributors.

This year the company began to sell at the retail level in health food stores across the U.S. and under the newly formed label Nutrex, a wholly owned subsidiary. Nutrex sells pure Spirulina in three forms—tablets, capsules, and powder. This line has also been expanded to introduce four new products, each utilizing Spirulina combined with one or more natural ingredients to enhance the nutritional benefits.

HAWAIIAN SUN-DRIED FISH JERKY

Hawaiian Sun-Dried Fish Jerky has been providing a local favorite since 1988. The fish jerky is prepared from locally caught fish, marinated in a hot-n-spicy or mild teriyaki seasoning.

The company has designed a lightweight solar drying unit to benefit from the

abundant sunshine available at Keahole Point. The solar drying units supply a product in a shorter time than traditional oven methods and eliminate the need for electricity.

Hawaiian Sun-Dried Fish Jerky can be found in local grocery stores, supermarkets, health food stores, island specialty shops and vending machines throughout the State of Hawaii.

OCEAN FARMS OF HAWAII INC.

Ocean Farms of Hawaii has conducted proprietary cold water aquaculture experiments and commercial production at NELHA for many years. The aquaculture farm raises red abalone, sea urchins, giant kelp, king and silver salmon and oysters. Abalone, oysters and salmon have been sold to restaurants throughout Hawaii.

ROYAL HAWAIIAN SEA FARMS

Royal Hawaiian Sea Farms (RHSF) has been in business since 1987 and commercially produces "limu" or edible sea vegetables including ogo *(Gracilaria),* nori *(Porphyra)* and ele'ele *(Enteromorpha)*. Production of these nutritious delicacies has consistently reached over a ton a week. They are sold in seafood markets, grocery stores and are served in many fine restaurants. Their sea vegetables are available in Hawaii, California, Washington and Nevada.

RHSF has recently diversified into the commercial production of salt water tilapia and milkfish *(Chanos)*. In addition their biologists continue to research and develop aquaculture for a variety of marine organisms, with current work focusing on edible sea cucumbers also known as namako *(Stichopus)* and warm water abalone *(Haliotis)*.

SEATECH CONTRACTING INC.

In 1989, Seatech Contracting Inc. established an office at Keahole Point. The company's emphasis is on marine construction and commercial diving, specifically associated with underwater piping and pumping systems. Seatech is the first support company to locate at Keahole Point and they have assisted in surveying construction, deployment, inspection and repair of the pipelines that have been installed. They provide highly skilled services to NELHA, its tenants and other companies in the state.

UWAJIMA FISHERIES/YONEZAWA SUISAN

Uwajima Fisheries/Yonezawa Suisan has developed a facility to grow flounder, *Hirame,* through an inclusive structure of concrete tanks, pumping and plumbing systems.

The hirame has a light delicate, white meat and its composition provides a good meat ratio, allowing for approximately 65% of the flounder to be utilized. Uwajima Fisheries market their 1½ to 2 lb. hirame in sushi bars and speciality markets through a Honolulu distributor.

Research Projects

AQUACULTURE TECHNOLOGY INC.

Aquaculture Technology Inc. (ATI) is investigating the commercial co-production of marine shrimp and oysters in a symbiotic integrated system. The design reduces the amount of labor and water needed while increasing the product output. ATI's first crop of shrimp will be test marketed in November 1992 to Big Island retailers.

COMMON HERITAGE CORPORATION

Common Heritage Corporation (CHC) is company formed by Dr. John Craven, former Chairman of the NELH Board. The purpose of CHC is to organize management teams and to serve as project manager or coordinator for the development of projects which utilize deep ocean water as a resource and leading to "self-sufficiency" in tropical island and costal communities.

Currently, CHC is expanding on some initial research performed at Keahole Point on the cultivation of temperate and alpine species of plants. Utilizing the deep seawater, CHC installed small pipelines on the surface of strawberries beds. Condensation forms on the pipes and saturates the soil while lowering the soil temperature and enhancing the metabolic activity and thus productivity of the crops.

D/S VENTURES

This project continues to test the feasibility of land-based namako (sea cucumber) production. Previous projects elsewhere have been unsuccessful in achieving full larval development of these organisms. These Kona businessman are researching whether the seawater temperatures available at Keahole Point might affect the development of larvae.

HAWAII CULTURED PEARLS

Hawaii Cultured Pearls, since 1987, has been investigating the culture of various species of pearl oysters. Cold and warm seawater supplied by NELHA have provided suitable mixtures to allow the company to assess different factors important to each species chosen by the company.

Hawaii Cultured Pearls completed the research phase of their project and are evaluating the accumulated data. They plan to apply the information to a commercial project sometime in the future.

Above: Marine shrimp

NELHA Employees

The best way to evaluate an organization is through its employees. The source of energy, the way we think and feel about this facility is in part a reflection of ourselves.

The vital element behind the managerial efficiency of NELHA is the staff. One of the outstanding features of our employee relations is the group activities which foster a sense of pride in one's job. These group activities include small group meetings to discuss working problems, to find solutions or to improve conditions. The subjects of these discussions range from individual personal problems to overall corporate management. It also extends to social gatherings and volunteer activities.

The promotion of these small group meetings is an essential aspect of NELHA's management philosophy. It contributes not only to the high work morale but also to NELHA's growth.

Above: NELHA Employees

Board of Directors

Albert Simone, Chairman
President
University of Hawaii at Manoa

John Corbin, Vice Chairman
Manager, Aquaculture Development Program
Dept. of Land and Natural Resources

William W. Paty
Chairperson, Board of Land and Natural Resources
State of Hawaii

Sophie Ann Aoki-Robertson
Executive Director, Friends of the Future

Lorraine Inouye
Mayor, County of Hawaii

Raymond Lum
Senior Vice President, First Hawaiian Bank
Information and Technology Division

Murray E. Towill
Director, Dept. of Business, Economic Development and Tourism
State of Hawaii

Donald Thomas, Ph.D
Associate Geophysicist
Hawaii Institute of Geophysics
University of Hawaii at Manoa

Richard West
Vice President and Regional Manager, Bank of Hawaii

Financial Statement

For Fiscal Year Ended June 30, 1992

OPERATING FUNDS	STATE	FEES	PRIVATE	TOTAL
Kona Facility				
Operational Support	2,044,716			2,044,716
Project Fees:				
Aquaculture Projects		256,322		256,322
Other Projects		38,229		38,229
DOH Contracts		98,022		98,022
Puna Facility				
Operational Support	137,400			137,400
Project Fees		2,813		2,813
OPERATING TOTAL	2,182,116	385,386		**2,567,502**

CAPITAL IMPROVEMENTS	STATE	FEDERAL	PRIVATE	TOTAL
Kona Facility				
Infrastructure Improvements	649,000			649,000
Building Design	199,000			199,000
Pipeline Additions	1,327,000			1,327,000
Slant Drill Demonstration	2,376,000			2,376,000
New Projects & Expansions	3,500,000	3,500,000	155,000	7,155,000
Puna Facility				
Wellhead Refurbishment	75,000			75,000
Building Refurbishment	175,000			175,000
CAPITAL IMPROVEMENT TOTAL	**8,301,000**	**3,500,000**	**155,000**	**11,956,000**

Past Research Projects

Keahole Point

MINI-OTEC Demonstration — (01/79 to 12/79)

Funding Source — State of Hawaii

Demonstrated net power production from closed-cycle OTEC. Generated > 10 kw net electricity on a floating platform moored in the NELH Offshore Research Corridor.

Argonne Test Project — (07/81 TO 09/87)

Funding Source — DOE/DPED, DOE funding via SERI since 07/83

Studied heat transfer variations, biofouling control measures for closed-cycle OTEC, researched corrosion of candidate heat exchanger materials and analyzed incoming seawater. Found that biofouling in warm seawater repeatedly reduces heat transfer to unacceptable level within 20 days. Chlorine levels as low as 70 ppb for 1 hr/day found to control the problem. Aluminium alloys show pitting corrosion in cold seawater, but not in the warm seawater.

OTEC Aquaculture: Trout and Salmon — (01/82 to 11/84)

Funding Source — UHSG, MAC, DPED

Investigation on growing salmon and trout yielded >0.5 lb. fish per gallon per minute of deep seawater. It identified optimum temperatures, photoperiods, flow rates and studied smoltification parameters for salmon. First to spawn trout successfully in seawater.

OTEC Chlorination — (06/82 to 06/83)

Funding Source — HNEI

Investigated the effects of low level chlorination on the marine food chain. Found that in tropical seawater chlorine kinetics differ markedly from other seawater, the required concentration of the chlorine is much less than in temperate water, and only trace levels of halogenated organics are produced in chlorinated tropical seawater.

Alcoa Corrosion — (01/83 to 01/85)

Funding Source — Alcoa

Studied the effects of corrosion in flowing seawater and the effects of brushing in warm and cold seawater on various aluminum alloys.

Heat and Mass Transfer Research — (06/83 to 12/90)

Funding Source — SERI/DOE, PICHTR

Efficiency of spout evaporators and condensers in a seawater system are similar to those found using freshwater in Colorado tests. They promise high efficiency, however, for open-cycle OTEC.

Gas Desorption Research — (06/83 to 06/84)

Funding Source — SERI/DOE

Used a packed column to study composition and removal of dissolved gases in seawater at various temperatures and pressures. The "height of transfer units" which measure the power required to remove dissolved gases are about 50% less with seawater than predicted from freshwater data.

Algae CO_2 Uptake — (7/88 to 12/89)

Funding Source — EPRI

Studied the use of algae to remove carbon dioxide from fossil fuel exhaust gases. Hoped to develop ways to optimize algal CO_2.

Polyculture Experiment — (11/88 to 1990)

Funding Source — Sea Farms of Hawaii

Demonstration of patent concept for a tank farm design. Allows for harvesting of multiple level tanks to increase production density.

Microalgae Testing — (05/90 to 1990)

Funding Source — Microbio Resources

Tested the growth of proprietary strains of *Dunaliella* and *Haematococcus,* microalgae. To gather productivity data for these strains under the light and temperature regimes at NELH.

MIST-LIFT Process — (06/83 to 12/83)

Funding Source — SERI/DOE

Mist generator with seawater works well without clogging, and the vapor-mist coupling may provide up to 100 m of lift from 20 c.

CWP/AST Phase III — (04/83 to 05/85)

Funding Source — NOAA/DOE

Deployed and monitored an 8-ft. diameter Fiberglass reinforced plastic (frp) cold-water pipeline down a slope off Keahole Point. Data were collected on forces on the pipe and its foundation under varying environmental conditions.

OTEC Agriculture — (01/84 to 6/84)

Funding Source — UHSG

Grew Strawberries and various vegetables with freshwater condensing on pipes carrying cold seawater. Seasonal cycling can also be achieved by controlling water flow rate.

Giant Clam Culture — (08/85 to 08/86)

Funding Source — Marine Animal Association, Waikiki Aquarium

Studied the effects of Hawaiian environment on giant clam growth.

Opihi Culture — (10/86 to 01/89)

Funding Source — W.H. Magruder

Investigation and demonstration of opihi (Hawaiian limpets) growth. Opihi reproduced and grew well in sprays of deep seawater.

Macroalgae Investigation — (05/ 86 to 01/87)

Funding Source — HNEI, ADP

Investigated the use of macroalgae to remove most of the excess nutrients from return seawater at NELH. Algae mats were found to be effective.

Phytoplankton Study — (09/86 to 09/87)

Funding Source — Office of Naval Research

Studied the occurrence of a symbiotic cyanobacterium in the cells of certain diatom populations in surface seawater.

Puna Facility

Bottom Heating System — (04/86 to 04/88)

Funding Source — DOE, Private Donations

Utilizing the geothermal waste heat seed propagation and plant growth was significantly accelerated with heated soil. Commercial potential high.

Green Papaya Powder Drying — (04/86 to 10/88)

Funding Source — DOE, Private Donations

Experimental dryer worked well with all types of fruits and the cost savings using the geothermal waste heat make commercial potential high.

Lumber Drying — (04/86 to 01/88)

Funding Source — DOE, Private Donations

Developed methods and drying schedules for local hardwoods. Drying was possible within 4 to 5 weeks.

Cloth Dyeing by Geothermal Steam — (04/86 to 11/87)

Funding Source — DOE, Private Donations

Utilized flashed brine to dye silks and experimented with local dye sources. Hawaiian steam produces brilliant colors and sets dyes fast in Japanese silk.

Hawaiian Glass Making — (04/86 to 10/87)

Funding Source — DOE, Private Donations

Made glass from the silica by-product of the HGP-A well. Formula developed produced excellent art glass and was distributed to UHM and artists statewide.

Atmospheric Corrosion — (12/86 to 4/87)

Funding Source — UHM

Identified corrosiveness of geothermal environment to allow for better materials selection. HGP-A corrosion is uniquely determined by physiochemical conditions of site environment. Corrosion rate accelerated by presence of hydrogen sulfide, chloride and sulfate ions at site.

Media Steam Sterilization and Drying — (03/88 to 12/89)

Funding Source — DOE, Private Donations

Utilized the brine/steam to produce a growing medium for plant growth. Pasteurized potting mix comprised mostly of lava cinder and shredded coconut husks would be used as alternative to imported sterile soil from mainland.

Electrodeposition of Minerals — (03/88 to 12/89)

Funding Source — DOE, Private Donations

Researched the use of liquid brine samples to produce mineral deposits via electrolysis. Sufficient traces of calcium deposit on test specimens were found by this method.

Silica Bronze CASTING — (03/88 to 07/89)

Funding Source — DOE, Private Donations

Research developed techniques to separate, dry and wash silica from geothermal brine for use as a refractory material in bronze casting.

Downhole Coaxial Heat Exchanger — (11/90 to 6/91)

Funding Source — PICTHR, Private Donations

To investigate the commercial viability of the DCHE technology, which provided a method of transfer of heat in the well to the surface circulating fluid in a closed system. After seven days of continuous operation, the temperature of the outlet water was stable at 13.5 degrees Celsius increase over the temperature of the inlet water. This data supported the theory.

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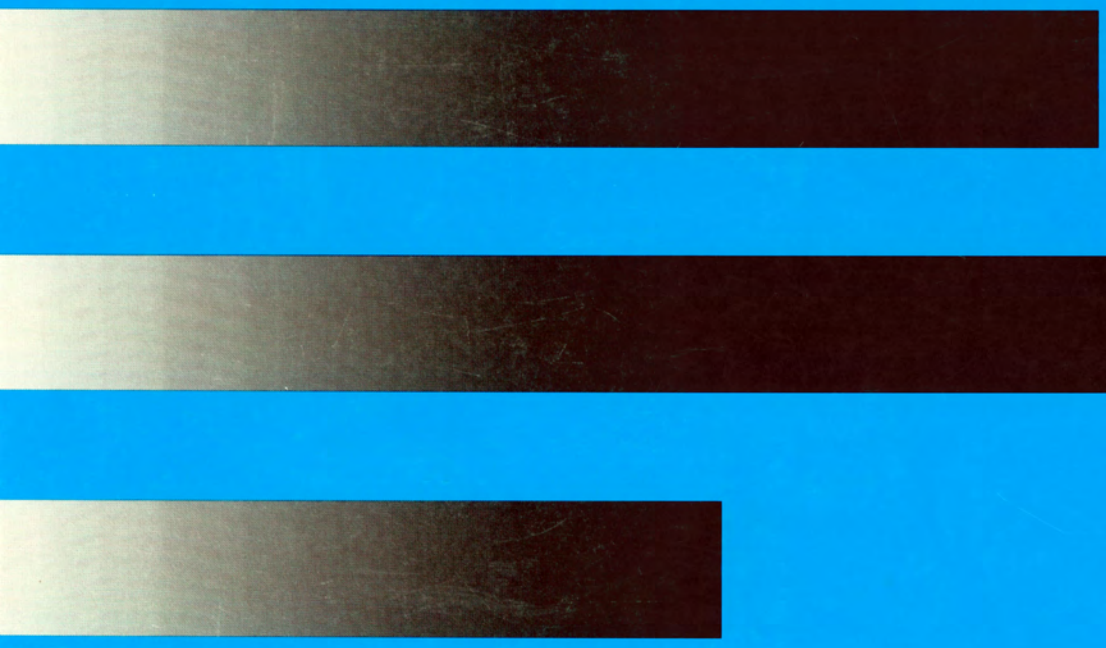
TERI LEICHER

It's been good taking this journey with you. Thank you for joining us.
"Whatever you can do
Or dream you can, begin it
Boldness has Genius
Power and magic in it."
Goethe



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