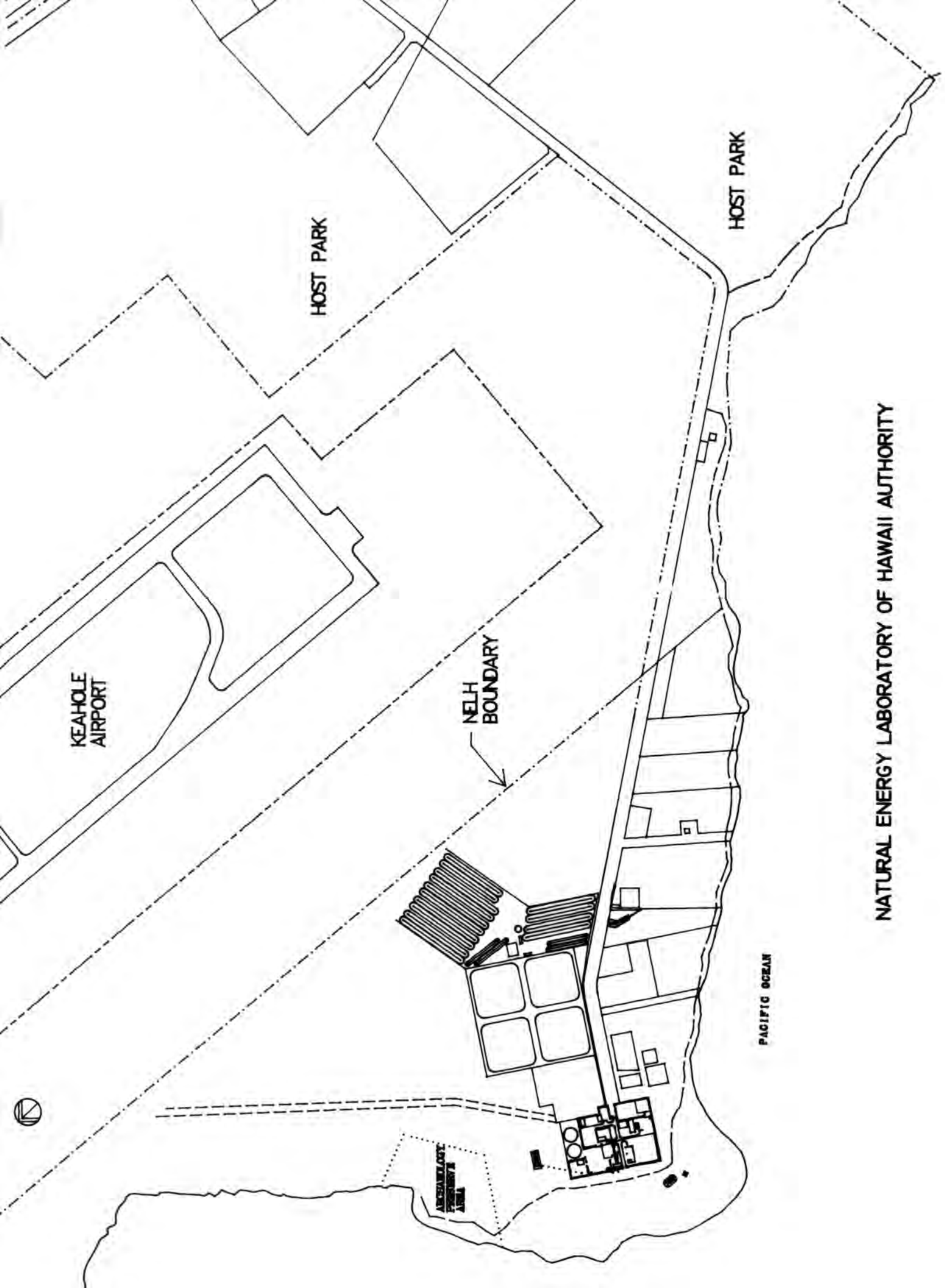






KEAHOLE
AIRPORT

HOST PARK

HOST PARK

NELH
BOUNDARY

ANCILLARY
FACILITY
AREA

PACIFIC OCEAN

NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY

I n t r o d u c t i o n



his facility was established in 1974 on 322 acres as a center for research and development of natural energy resources. In 1984, an additional 548 acres of land was set aside by the State of Hawaii for large scale commercialization of technologies utilizing our natural resources. Geothermal resources accessibility was acquired with the assignment of the HGP-A well and 4.1 surrounding acres. Today it is the only State operated facility specializing in providing sites, resources, and support services for public and private sector energy, geothermal and ocean related research and commercial activities. All of these activities are performed in an environmentally sound and culturally sensitive manner.

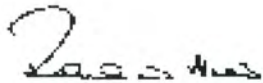
Natural Energy Laboratory of Hawaii Authority

1993 Annual Report

Message from the Chairman of the Board

oday, NELHA is a world class competitor and leader in research and development of OTEC and OTEC by-products such as air conditioning, desalination, cold water mariculture and agriculture. Commercial activities have prospered utilizing our resources which include relatively inexpensive lease land, reliable infrastructure, skilled administrative support personnel and a superior analytical laboratory. Despite the worldwide recession and scarcity of investment funds, NELHA continues to achieve quality in a competitive global economy. Whether our clients are small to mid-sized companies with relatively straightforward needs or multinational enterprises, NELHA is committed to their success.

We are continuing to support the establishment of a world class research institute for the efficient implementation of renewable energy. Over 50 internationally recognized scientists would be contributing to these research areas at the "Spark M. Matsunaga Renewable Energy and Ocean Technology Center", a component of the planned Center for a Sustainable Future. This center will be a magnet for high technology business on the island of Hawaii. As we move into our fourth year of operation as the Authority, we will continue to contribute to the development of natural resource utilization technologies and to the future of our community, state and nation.



Richard West
Chairman of the Board of Directors
Natural Energy Laboratory of Hawaii Authority

Board of Directors

Chair

Richard West
Vice President and Regional Manager
Bank of Hawaii

Vice Chair

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

Mufi Hannemann, Director
Department of Business, Economic
Development & Tourism

Keith Ahue, Chairperson
Board of Land and Natural Resources

Stephen Yamashiro, Mayor
County of Hawaii

Kenneth P. Mortimer, Ph.D. President
University of Hawaii at Manoa

Sophie Ann Aoki-Robertson
Executive Director
Friends of the Future

Bill Cook
President
Cook's Discovery

John Corbin, Administrator
Aquaculture Development Program
Department of Land and Natural Resources

Natural Energy Laboratory of Hawaii Authority

Keahole Point Facility

Puna Research Center

Keahole Point Facility



Selected as the Executive Director in 1990, Clare Hachmuth has brought to the NELHA an extraordinary level of experience, commitment and leadership, and has been the prime contributor to the success of this prodigious effort.

Prior to joining the NELHA, Ms. Hachmuth served in various engineering managerial capabilities in the oil and gas industry.

In 1974, a handful of farsighted researchers and state lawmakers recognized the need for a research and development facility for natural alternative energy. They realized the unique resources of the Big Island could spur the development of many high technology businesses. Today, the Natural Energy Laboratory of Hawaii Authority (NELHA) carries on this traditional focus, with a broader vision toward large scale commercialization of technologies utilizing the natural resources.

Located adjacent to the ocean at Keahole Point on the Big Island, this 870 acre establishment has several essential conditions that promote start-up energy and mariculture operations. These are: existing and planned buildings designed primarily for private and public research; the existing successful companies which stimulate entrepreneurship; and a strong business community that helps start-up companies survive the early critical years.

Infrastructure including seawater supplies is in place for commercial mariculture applications, marine microbiology, design, assembly and testing of

Keahole Point Facility

deep ocean sensing devices; and other forms of ocean science and technology applications.

Ms. Hachmuth holds a B.S. degree in chemical engineering and a master's degree in business administration.

West Hawaii's neighboring Keahole Airport as well as a nearby deep-water port, make the import of supplies and the export of products quick and efficient. An internal road into the airport is being considered as part of the NELHA master plan.



Services

NELHA provides competitive rents, on-site analytical laboratory assistance, shared support services, flexible leases and short term rental agreements which allow research companies to "graduate" from this nurturing environment to full scale commercialization.

Managing our safety, health and environmental responsibilities is not simply a measure of our values; it also makes good business sense. NELHA is actively engaged in ocean and atmospheric environmental monitoring and ocean energy applications. Ocean environmental data have been collected at Keahole Point since 1980. The Cooperative Environmental Monitoring Program (CEMP) at NELHA includes sampling and analysis of offshore waters, coastal waters and groundwater sites

Keahole Point Facility

at Keahole Point. Data collected from the CEMP are disseminated on a quarterly basis along with annual graphic interpretations.

NELHA also provides daily temperature and rainfall as an official National Weather Service Observation station. A data logger system provides continuous atmospheric measurements of many environmental variables.

New technologies and operational improvements are continuously pursued in our effort to be ever more responsive to the needs of our tenants.



The major resource for this facility is the cold, near pathogen-free, nutrient-rich seawater drawn from depths of 2,200 feet (670 meters) with a temperature of 43 degrees F (6 degrees C) and surface seawater from 50 feet (15 meters) with a temperature range of 77-83 degrees F (25-28 degrees C). There are three deep seawater pipelines in operation with a total capacity of 17,100 gallons per minute and three surface seawater pipelines with a capacity of 13,600 gallons per minute.

This water has value beyond its use for ocean

Keahole Point Facility

thermal energy conversion (OTEC) in which electrical energy is extracted from the temperature difference between the cold, deep ocean water and the warm surface seawater.

The deep seawater comes from below the photic zone where there are no plants to use up the essential nutrients in the water. The intake is also below the middle of the thermocline, so there is little natural mixing between the deep water and the nutrient-depleted surface waters. The resulting elevated nutrient levels, combined with a nearly total lack of pathogens and its cold temperature, make the deep seawater highly desirable for mariculture operations. Finned fish, mollusks, crustaceans, as well as micro- and macro-algae have been grown successfully in this deep water.

Another valuable application of deep seawater is air conditioning. NELHA's buildings are cooled by pumping seawater through a heat exchanger which chills water flowing through coils in the building air duct systems. The water then goes to aquaculture farms for their use. This method of air conditioning conserves energy and money.

P u n a R e s e a r c h C e n t e r



Energy is the cornerstone of economic development. Research, development and commercialization of geothermal resources have been promoted by the Puna Research Center, Noi'i O Puna. This four-acre site is located a short distance southeast of the town of Pahoa on the Kilauea Northeast Rift Zone.

Continuing evaluation of the geothermal resource in the East Rift Zone and monitoring of private geothermal power production are primary activities at the site.

Plans are underway to develop a new heat source for additional research projects and commercial businesses utilizing Noi'i O Puna.

Natural Energy Laboratory of Hawaii Authority

Analytical Laboratory
Operations

Engineering
Administration

Analytical Laboratory



The analytical laboratory provides an extensive list of services in both bacteriology and chemistry. This laboratory is certified by the State of Hawaii, Department of Health. It is housed in over 3,000 square feet of floor space dedicated to offices, bacteriology and chemistry departments and an indoor wet lab equipped with flowing surface and deep seawater. A 400 square foot covered outdoor wet lab is also available.

*Dr. Thomas H. Daniel,
Scientific and Technical
Program Manager, coordi-
nates multidisciplinary
teams performing extensive
environmental monitoring.
This division combines the
talents of full-time chemistry,
biology, physics, and com-
puter science professionals.*

*Dr. Daniel has been with
the NELHA for eleven years*

The chemistry department is equipped with a comprehensive array of analytical equipment including inorganic and organic nutrient analyzers, salinometers, an atomic absorption spectrophotometer and a gas chromatograph with mass spectroscopy. An extensive QA/QC program is in place which complies with State of Hawaii Laboratory certification requirements.

This year additional work was completed in the following areas:

Analytical Laboratory

and has an extraordinary level of experience which has contributed greatly to the success of this laboratory.

He holds a B.S degree in Electrical Engineering and an M.S. and a Ph. D in Physical Oceanography.

* The Cooperative Environmental Monitoring Program (CEMP) has been rewritten to include protocols of the West Hawaii Coastal Monitoring Task Force. This expanded program will include sampling and analysis of offshore waters, coastal waters and groundwater sites around NELHA.

* A new Microbiologist was hired to work on development of gas chromatography and mass spectroscopy (GC/MS) and GC flame ionization detector (GC/FID) techniques. The GC/FID project involves the application of a method for detecting specific biochemicals which are unique to species of bacteria. The GC/MS work involves application of a method for analysis of volatile and semivolatile organic compounds typical of those found in fuel.

* A new reagent water system was installed. This system produces 250 gallons per day and passed state laboratory certification.

Operations and Maintenance



Success is not determined by access to valuable natural resources but by the ability to manage those resources well. Maintaining seawater systems, inventory, scheduling projects and assisting the tenants are the main objectives of this department.

This year's highlights include:

- * Protection of the seawater systems is an absolute necessity. The 12", 18" and 24" seawater pipelines systems were capped with concrete along the shoreline sections to strengthen and prevent damage from seasonal storm swells.

- * The Interim Visitor Center area was enhanced with the installation of cold and surface seawater, drains, air, freshwater and electricity throughout the presentation area. Four live display tanks were also installed to house some of the living organisms grown by NELHA tenants.

- * The first floor of the Administration Building was refurbished, painted and two new office spaces

Jan C. War, has been the Operations Manager at NELHA for over 14 years. Armed with a Bachelors degree in Biology and a genuine interest in alternative energy resources and aquaculture has been responsible for combining materials, machines and manpower to provide efficient service to NELHA tenants.

Due to his dedication and years of employment at NELHA, the service to our

Operations and Maintenance

tenants has been exemplary.

Mr. War holds a B.S. degree in Biology with additional courses in Business and Administration. Raised in the islands, Mr. War has extensive diving and ocean recreation experience which explains his love for the sea.

were added to accommodate the expanding needs of the facility. The second floor was converted into a library, with connecting meeting and conference rooms and an office for the NELHA Executive Director.

* Variable Frequency Drive units were purchased and installed to control the speed of two seawater pumps. The variable frequency drives allow precision control of the output of each pump in order to match precisely the water requirements of tenants. The costs of the variable frequency drives will be paid back in three years or less from electrical energy savings.

* The 18" cold seawater system was made fully operational with a permanent source of electric power and two back up pumps installed to an offshore station mounted on the reef.

* A new 24" warm seawater system was completed and made operational with three conventional split case centrifugal pumps.

Engineering



The Engineering Section brings in-depth expertise in power, piping, equipment erection, electrical systems and instrumentation. Expertise is also offered in site development and in constructing materials handling, steel and concrete structures and water transportation systems. The projects completed this year have focused directly on infrastructure development to deliver better quality service to our customers.

John Douglas Sullivan has applied the theories and principles of science and mathematics to economical solutions of technical problems at NELHA.

His designs of ocean water air conditioning and ventilation, plan and design of ocean water systems and construction of buildings has literally opened new doors for the facility.

* Ka'u Pump Station - Constructed from lava rocks, this building houses the surface seawater pumping systems south of the main NELHA compound. The new surface seawater system provides increased delivery and flexibility for both deep and surface seawater. After completion of the shore crossing and connection to the 18-inch deep seawater pipeline, high pressure testing was conducted for a

E n g i n e e r i n g

Mr. Sullivan has 20 years of experience in the oil and gas industry and holds a bachelor of science degree in civil engineering.

12 hour period. This safety precaution is used to detect any leakage in the joints, fittings and adapters.

* Hale Ke'ena Lab Building - After years of planning and design, NELHA began construction of a new structure which will provide an additional 2,500 sq. ft. of specialized space for alternative energy research and other programs with specialized requirements for electrical power, electronic instrumentation and communication.

* All tenants will now be able to connect to the Hawaii Electric Light Company underground cable. This completes our commitment to the Department of Transportation's Airports Division to eliminate the use of overhead electrical power poles.

* A new vehicle fueling station was designed to support maintenance of all NELHA vehicles, trucks, cranes and bulldozers. This utility area includes supplies of air, electricity and water.

Administration

In 1990, when Eleanor Mirikitani took over as Administration Manager a restructuring was occurring at NELHA. She ably assisted in the smooth transition relying on her varied work experience from graphic artist, practicing attorney with over a decade in the criminal and civil law to administration.



There is a recognized need for strategic alliances with tenants, employees and other state and county agencies. Extensive in-house publications, communications to board members, educational programs and other media have been developed to raise the awareness of issues that affect the future of NELHA.

* During the fiscal year work continued on the draft Strategic Management Plan for NELHA. This plan will lay the foundation for further development of the facilities. It addresses the objectives, opportunities, obstacles and goals in order to improve the utilization of the facility. Publication is expected in late 1993 or early 1994.

* For each selected tenant, construction or maintenance project developed at NELHA, numerous contracts, leases and personal services agreements are executed. This year there were six lease agreements and twelve construction and personal services contracts executed.

Administration

Ms. Mirikitani oversees the execution of fiscal operations, personnel, marketing and education programs, and contract administration.

Ms. Mirikitani holds a Juris Doctor and a Masters Degree in Art.

* As part of our continuing marketing program NELHA hosted its 1st Annual Open House during Energy Awareness Week in October. Other special events were the Hawaii County Fair, Kona Coffee Festival, World Aquaculture Society 1993 and Marine Technology Society 1992. Throughout the year over 3,000 people visited the facility from around the continental United States and the world.

* Our fiscal office continues to coordinate and assist programs with the submission and implementation of operating and capital improvement project budgets.

* NELHA assists its tenants in obtaining permits for construction projects at various Federal, State and County levels. These permits include Conservation District Use Applications, Special Management Area Use Permit, Shoreline Setback Variances, State Land Use Commission approvals, and Federal Consistency Determinations under NELHA's U.S. Army Corps of Engineers General Permit.

NELHA SERVICES

ANALYTICAL LABORATORY

Certified Environmental Lab
Environmental Monitoring Services
Chemical Analysis
Microbiological Analysis
Microbiological Reference Library
Technical Assistance

OPERATIONS and MAINTENANCE

Seawater Systems
Equipment Rental and Repairs
Heavy Equipment Operators
Mechanical Technicians
Diving, Plumbing, Welding
Metal and Wood Shop
Fabrications
Automotive Repairs
Marine Operations

ENGINEERING

Piping Design
Site Development
Computer Aided Drafting
Electrical Systems Analysis
Digital and Circuit Design
Construction of Steel and Concrete Structures

ADMINISTRATION

Clerical Assistance
Leases and Service Contracts
Telecommunication Support
Fiscal Support
Graphic Design
Educational Programs

Natural Energy Laboratory of Hawaii Authority

Commercial Companies

Research Projects

Commercial Companies - Research Projects



Over the past decade, the growth at the Natural Energy Laboratory of Hawaii Authority (NELHA) has accelerated dramatically thanks to the high priority which the state gives to the search for alternate energy sources.

This quest for alternate energy resources has contributed to the growth of ocean thermal energy conversion (OTEC), geothermal energy utilization, aquaculture ventures, ocean engineering industries and marine research and development.

Today, NELHA is the location of 16 research projects and commercial companies generating annual revenues of more than \$5 million and employing nearly 80 workers. These industries are still coming into their own, and will eventually be an important part of the state's economy. Research work completed at the facility generates "spin off" effects in the form of new commercial companies which in turn attract support companies.

Cumulative capital investment by private companies totals over \$15 million. Federal and State capital improvements funds totalling \$35 million have been used for pipelines, pump stations, roads, research facilities and building construction during the past 16 years.

The companies listed below have each developed unique systems and methods of operations:

Pacific International Center for High Technology Research (PICHTR's) has designed and built the largest OTEC plant yet constructed. The 210-kw Open Cycle OTEC Experimental Apparatus has produced a record 255 kWe at the generator terminals, utilizing 152 kWe to operate the seawater pumps, vacuum compression pumps and auxiliaries. The corresponding net power is 103 kWe. This is accomplished with 8900 gpm of 27.5 degrees C surface seawater and 6300 gpm of 6.1 degrees C seawater from a depth of 700 meters and a pressure of 0.19 psi at the inlet to the vacuum

Commercial Companies - Research Projects

compression system. The operational phase of the project should continue for another two years.

Cyanotech Corporation is a leading manufacturer of marine products for worldwide nutritional and pharmaceutical markets, based on proprietary production and processing systems. The company's products include *Spirulina Pacifica*, a high-protein nutritional product, and phycobiliproteins, fluorescent pigments used in immunological diagnostics. They will also be culturing a microalgae for the production of astaxanthin, a natural red food pigment used mainly in the salmon aquaculture industry to give the natural pink color to salmon flesh. Presently, only artificial astaxanthin is being produced commercially.

Black Pearls Inc. is developing the technology to grow black-lip pearl oysters, *Pinctada margaritifera*, and produce valuable culture black pearls in Hawaii and other island in the South Pacific. Their successful hatchery is investigating the feasibility of commercial pearl farming in Hawaii using land and the ocean based systems.

Uwajima Fisheries, Inc. has successfully spawned their "Hirame" (Japanese Flounder) broodstock enabling the company to supply their own larvae. The brood stock raised on the site has spawned 10 times yielding approximately 2 million eggs. Research has begun on the ability to spawn out of season, allowing for year round production.

Aquaculture Enterprises, expanded its cold seawater holding and rejuvenation capability for imported live Maine lobsters to satisfy increased customer demand. Customers are located in the Hawaiian Islands, Pacific Islands, and select Asian destinations. Aquaculture Enterprises's lobster aquaculture research has successfully bred and hatched hybrid homarid lobsters. Prototype

Commercial Companies - Research Projects

juvenile growout systems provide nutrition, husbandry, pathology and habitat data for planned future commercialization.

Aquaculture Technology, Inc. produces Blue shrimp and the Pacific Oyster. Construction of four more polyculture modules for shrimp and oyster production has recently begun. Adding these modules will allow the corporation to produce approximately 250 lbs of shrimp and 4,000 oyster per week.

Hawaii Sun-Dried Fish Jerky's marinated fish is an island favorite using electricity free solar drying units which produce a product in a shorter time than conventional methods. This company will be relocating to a small kitchen and cold storage facility and an expanded drying area.

Royal Hawaiian Sea Farms, Inc. has been in business since 1987 and commercially produces "limu" or edible sea vegetables including five varieties of Ogo (*Gracilaria*), Nori (*Porphyra*) and Eleele (*Enteromorpha*). Sales of these popular nutritious delicacies has consistently reached over a ton per week. They have recently diversified into the commercial production of salt water tilapia (*Tilapia*) and milkfish (*Chanos*). In addition, intensive applied research is being conducted on edible sea cucumbers (*Stichopus*), opihi (*Cellana*) and warm water abalone (*Haliotis*).

SeaTech Contracting Inc. continues to emphasize marine construction and commercial diving associated with underwater piping and pumping systems. They also designed a program for the removal of ordnance left on the island of Kohoolawe.

Common Heritage Corporation continues to develop at a rapid pace. More than eighty vegetables have been tested and found to grow well with cold seawater pipes cooling the soil. The

Commercial Companies - Research Projects

Malta Project which investigated the efficacy of warmer cold water for improving crop growth, produced surprisingly good growth when the cold water was at 15 degrees centigrade rather than 8 degrees centigrade.

An **Environmental Protection Agency Toxicity**

Project investigated a method to determine whether an effluent is toxic to the environment. A marine organism, "lao" or *Prenesus insularum*, whose larvae are relatively sensitive to toxins was tested as an indicator organism.

The **State University of New York at Stony Brook** is conducting zooplankton studies using a "laser backed video imagery" system to detect and quantify the minute water flows associated with feeding by copepod zooplankton.

The **University of Kiel** (Germany) conducted experiments on optimizing the production of hydrogen by photovoltaic electrolysis of seawater using simple, available components.

Ono Take, Inc. has begun the construction of a facility to re-search mushroom culture using heat exchangers in a closed environment.

Sogi International, Ltd. continues research on the distillation of ethanol from sugar cane molasses. Heat collected in solar panels produces a vapor that is condensed into a liquid state by chilling with cold seawater.

D/S Ventures research has continued to test the feasibility of land-based "namako" or sea cucumber production and the effect of seawater temperatures on larvae development.

Commercial Companies - Research Projects

The status of NELHA businesses and research projects are as listed below:

PROJECT NAME	PRODUCT(S)	TYPE
Aquaculture Technology Inc.	Oysters, Shrimps	Precommercial
Black Pearls, Inc.	Black Lip Oysters	Research
Common Heritage Corporation	Strawberries and other Ag Products	Demonstration
Cyanotech Corporation	Spirulina, Phycobiliprotein	Commercial
D/S Ventures	Namako	Research
EPA Toxicity Test	Silverside Fish Evaluation	Research
Hydrogen production	Hydrogen	Research
Aquaculture Enterprises	Lobsters	Commercial
Ono Take, Inc.	Mushrooms	Research
Open Cycle OTEC (PICHTR)	Electrical Energy	Demonstration
Royal Hawaiian Sea Farms	'Ogo, Ele'ele, Tilapia, Nori	Commercial
SeaTech Contracting, Inc.	Offshore/onshore construction	Commercial
Sogi International, Ltd.	Ethanol production	Research
State University of New York- Stony Brook	Copepods	Research
Hawaii Sun Dried Fish Jerky	Dried fish	Commercial
Uwajima Fisheries, Inc.	Japanese flounder, Ogo	Commercial

Natural Energy Laboratory of Hawaii Authority

Financial Statement

Financial Statement

Statement of Operations (For the period July 1, 1992 - June 30, 1993)

Revenue		Expenditures	
State Appropriation Act 289	\$1,898,308	General Fund	
		Kona Facility Operations	\$1,692,974
		Encumbrances	\$51,971
Federal Funds (EPA Grant)	<u>\$38,000</u>	Outstanding Contracts	\$38,650
	\$1,936,308	Puna Facility Operations	<u>\$78,281</u>
			\$1,861,876
Special Fund		Special Fund	
Aquaculture	\$445,097	Kona Facility Operations	\$388,143
Other Projects	\$22,621	Encumbrances	\$42,538
Interest Received	\$15,743	Outstanding Contracts	\$71,493
Lab Contracts	<u>\$80,738</u>	EPA Project	\$38,000
	\$564,199		<u>\$540,174</u>
Total Revenues	\$2,500,507	Total Expenditures	\$2,402,050

Financial Position

Special Fund Balance (July 1, 1992)	\$401,022
State Appropriations FY 93	\$1,898,308
Federal Funds	\$38,000
Other Revenues	\$564,199
General Fund Expenditures	\$1,861,876
Special Fund Expenditures	\$502,174
Federal Fund Expenditures	\$38,000
Funds Returned to State Treasury	\$36,432
Special Fund Balance (July 1, 1993)	\$463,047

Project Application Procedures

NELHA welcomes applications from individuals, businesses, research organizations, and educational facilities desiring to perform research and/or development activities. NELHA recommends that those individuals or businesses interested in beginning a commercial enterprise first complete research and development at NELHA to evaluate the feasibility of the activity.

Assessment Criteria

NELHA is governed by a nine member board of directors which has final approval of applicants' project proposals. Initially, all applicants are required to meet established criteria:

- a. Projects which promise to accomplish a measurable impact in a specific area and for the purpose for which the applicant requested.
- b. Projects that are consistent with NELHA's identified fields of interest - alternate energy, aquaculture, biotechnology, and other fields which utilize deep or surface seawater, high solar insolation, or geothermal heat.
- c. Exemplary organizations with a history of achievements, technical expertise and good management.
- d. Projects that demonstrate a stable financial condition supported by current and full, certified, audited financial statements.

Project Initiation Procedure

Interested parties will be provided with the Project Initiation Procedures which detail the process required to establish a project at NELHA. A summary of the procedures follows:

1. Procedures for Commercial and Research Projects
 - a. Initial Consultation: Prior to initiating work on a written proposal, this session is designed to assist the interested parties in determining if the proposed project is appropriate for NELHA. A staff member is assigned to the applicant.
 - b. Preliminary Written Proposal: This preliminary proposal determines if the project is eligible for Board consideration. The preliminary proposal must contain the following information:

1. A narrative describing the project including a brief statement of the applicant's background, and a cost summary of the project.
2. A copy of the applicant's current financial statement and source of funding.
3. Estimates of demand on NELHA's infrastructure and resources.
4. Timing and implementation schedule
5. Summary of how the project will utilize NELHA's unique resources.
6. Management and staff resumes.

c. Time Table: The preliminary proposal must be submitted to the staff member at least three (3) weeks prior to the board meeting. Initial response to all inquiries will be made by NELHA within one week following the presentation to the board.

d. After initial "in concept" board approval, applicant files a final proposal including any special conditions or provisions set forth by the board.

II. Final Proposal Procedures

When applicant has been approved "in concept" by the board, a complete project proposal must be submitted containing the following information:

1. Detailed information including description of the project, including its purposes and objectives.
2. A detailed project budget extending over a 5 year period.
3. A timetable for implementation of the project.
4. A statement of sources of financial support, including amounts committed to date.
5. Construction, building plans and site development.
6. Current and projected industry standards; or application of research.
7. Impact on the environment, waste description and /or treatment.
8. Management and/or research staff resumes.
9. Marketing program and list of suppliers or customers.

III. Notification

Upon notification that the board has approved the project, a contract or lease must be executed between applicant and NELHA.

Natural Energy Laboratory of Hawaii Authority

NELHA Employees

NELHA Employees

Executive Director
Clare Hachmuth

Allen, Marcia *Public Information Specialist*
Anderson, Stanley (Miles) *Analytical Laboratory Supervisor*
Bean, Christine *Administrative Assistant*
Brown, Donna *Account Clerk II*
D'Amico, Michael *Security/Utility Worker*
Daniel, Thomas *Scientific/Technical Program Manager*
Deverse, Kimber *Analytical Laboratory Technician*
Dunse, Monica *Analytical Laboratory Bacteriologist*
Espinueva, Georgette *Clerk Typist II*
Galt, Ernest *Maintenance Mechanic II*
Hetherington, Gisela *Analytical Laboratory Chemist*
Hua, Henry *Electrician II*
Kaniho, Sheryll *Accountant*
Kaukini, Elia *Groundskeeper I*
Kelekolio, Melanie *Analytical Laboratory Assistant*
Kolman, Alan *Electrical Helper*
Low, Harvey *General Laborer*
Manago, Dawn *Secretary III*
Matsumura, Tyson *Security/Utility Worker*
McKee, Rosalinda *Groundskeeper II*
McQuigg, Presley *Water Systems Foreman*
Merrill, Kent *Engineering Project Coordinator*
Mirikitani, Eleanor *Administration Manager*
Mitchell, Anthony *Maintenance Mechanic I*
Pai, George *General Laborer*
Pargett, David (Steve) *Electrician II*
Placek, James (Buddy) *Electrical Engineer*
Randall, Marion (Steve) *Security/Utility Worker*
Sullivan, John *Engineering Manager*
Vail, Mark *Maintenance Mechanic II*
War, Jan *Operations Manager*
Weber, Jan *Clerk III*
Wilson, Stephen *Facility Maintenance Supervisor*
Wohlfeil, Herman *Analytical Laboratory Microbiologist*

Natural Energy Laboratory of Hawaii Authority

Past Research Projects

Keahole Point Facility
Puna Research Center

Keahole Point Facility

* 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
after 07/83

Studied heat transfer variations and 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. Cladding eliminates cold seawater pitting.

* 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 for open-cycle OTEC.

* GAS DESORPTION RESEARCH
(06/83 to 06/84)
FUNDING SOURCE - SERI/
ORNL/ DOE data.

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 energy required to remove dissolved gases are about 50% less with seawater than predicted from freshwater.

*ALGAE CO₂ 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 CO₂ uptake.

*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.

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* 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 Delta-T.

* 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 Associates, Waikiki Aquarium

Studied the growth of giant clams (*Tridachnidae* spp.) in the Hawaiian environment.

* 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.

*ZOOPLANKTON DYNAMICS
(08/91, 08/92, 05/93- 04/94)
FUNDING SOURCE - NSF/SUNY Stonybrook

Studied feeding and other behaviors of copepod zooplankton collected from the NELHA deep and surface seawater.

*COLD AG
(01/92 to 12/94)
FUNDING SOURCE - Common Heritage Corporation

Developed a tropical garden growing temperate plants using cold seawater to chill the roots.

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* BOTTOM HEATING SYSTEM
(04/86 to 04/88)
FUNDING SOURCE - DOE, Private

Seed propagation and plant growth were significantly accelerated with soil warmed by geothermal waste heat. Commercial potential appears high.

* GREEN PAPAYA POWDER DRYING
(04/86 to 10/88)
FUNDING SOURCE - DOE, Private

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

* LUMBER DRYING
(04/86 to 01/88)
FUNDING SOURCE - DOE, Private

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

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* CLOTH DYEING BY GEOTHERMAL STEAM
(04/86 to 11/87)
FUNDING SOURCE - DOE, Private

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

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

Quantified the corrosiveness of geothermal environment to allow for better materials selection. HGP-A corrosion is uniquely determined by physiochemical conditions of the environment at the site. The corrosion rate is 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

Utilized the brine/steam to produce a growing medium for plant growth. A 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

Researched the use of liquid brine samples to produce mineral deposits via electrolysis. Significant traces of calcium were deposited on test samples by this method.

* SILICA BRONZE CASTING
(03/88 to 07/89)
FUNDING SOURCE - DOE, Private

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

Investigated the commercial viability of the DCHE technology, which provides a method of transferring heat from 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 above the inlet water temperature. These data agreed with the theoretical design predictions.

*SCIENTIFIC OBSERVATION HOLES
(5/90 - 6/94)
FUNDING SOURCE - HNEI

Used the Puna Research Center facilities for storage, cutting and archiving of the core samples recovered in the SOH drilling program.

Publications Resulting From Research

Natural Energy Laboratory of Hawaii Authority

**At
Keahole Point Facility
Puna Research Center**

Keahole Point Facility

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