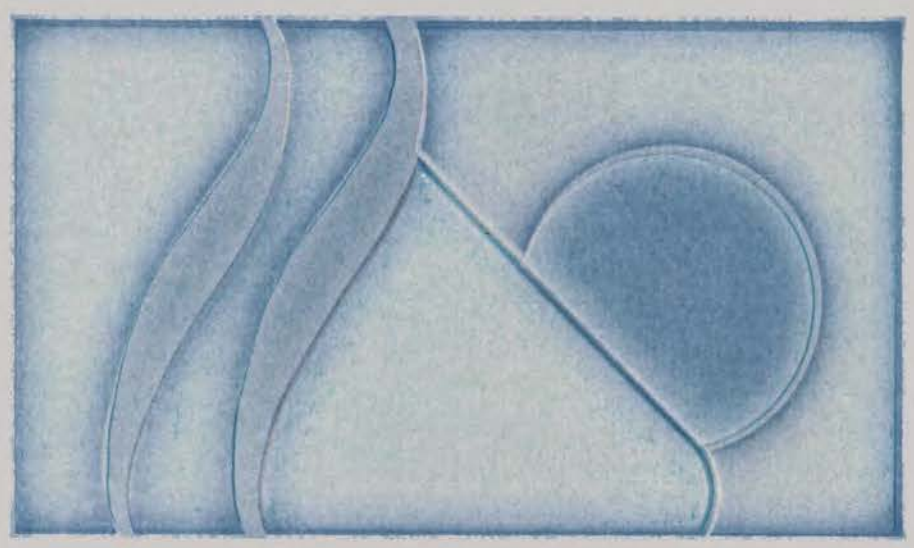
1994 ANNUAL REPORT

NATURAL ENERGY LABORATORY OF HAWAII AUTHORITY

NELHA



"The mission of the Natural Energy Laboratory of Hawaii Authority is to develop and diversify the Hawaii economy by providing resources for energy and commercial activities in an environmentally sound and culturally sensitive manner."

MESSAGE FROM THE CHAIRMAN

1994 marked the Natural Energy Laboratory of Hawaii's 20th anniversary. It was a year of reflection, contemplation and reexamination not only for our progress as a State entity, but as a people. It was a time for all of us to reflect upon the growth of the early years and a time to contemplate our desires for the future. It was a time to reexamine our strategic plans and the mission which we as an entity wish to achieve.

As part of this process, we took some dramatic steps: we changed the operational composition and introduced a new structure stressing Total Quality, employee relations and tenant satisfaction.

We are pleased at the results. More importantly, we feel that NELHA is now positioned to achieve even better results. NELHA will continue to be a pioneer in the development of ocean related technologies including renewable energy and aquaculture. Many of the projects located here have given us a worldwide reputation as a location for innovation and commercial applications. We will not relax our efforts to continue this trend.

The changes brought about at NELHA have required foresight, persistence and a fresh orientation to the management of business. We have learned many lessons and have come through this process with renewed strength and greater wisdom.

While much remains to be accomplished, NELHA has clearly come a long way. We are determined to go much further.

In closing, we would like to recognize the efforts of an individual who has been an important contributor at NELHA. Clare Hachmuth resigned after four years of service, having served as an employee and as Executive Director. We will miss Clare's wise counsel and dedication.

Rick West
Chairman of the Board

MESSAGE FROM THE DIRECTOR

Since taking over the helm as Executive Director of the Natural Energy Laboratory of Hawaii Authority (NELHA), I have been impressed with the optimism, dedication, creativity, and entrepreneurial spirit of our Board of Directors, tenants, and staff members. Our people - our tenants, our Board members, and our staff - are the single greatest reason for the success of the Authority.

While I was not present to witness the accomplishments of NELHA during Fiscal Year 1994, its record of progress speaks for itself. Seven large businesses were received as tenants, and four other interested companies are in the process of finalizing their proposals to become tenants. Other commercial companies continue to show interest in developing businesses dealing with aquaculture and microalgae at NELHA.

Because most of the 322 acre Natural Energy Laboratory of Hawaii (NELH) portion of the Authority is already occupied or under lease options for expansion by current tenants, future tenants must be located in the yet undeveloped lands of the 548 acre Hawaii Ocean Science and Technology (HOST) Park portion of the NELHA. Implementing this will require the availability of seawater.

The first phase of the seawater expansion system into the HOST Park area was started this year and is expected to be completed by next Spring. This phase of installing two 55 inch diameter seawater pipes under the coastline beginning from a point 460 feet onshore at a depth of 32 feet to a point 540 feet offshore at a depth of 80 feet. The next phase will involve installation of a deep seawater pipeline from the seaward end of the 55 inch pipes to a depth of 3000 feet and building of a pumping station at the onshore end of the pipes to HOST Park. The completion of this seawater system, along with a seawater distribution system for the HOST Park, are the most critical requirements for expansion of NELHA.

The vision of the Legislature has supported NELHA's expansion into HOST Park by funding the first phase of the new seawater expansion system. I look forward to working with you, as well as the NELHA Board of Directors and staff, to build and sustain a great facility that will enhance the economy of Hawaii.

Robert K.U. Kihune
Executive Director

FOREWORD

TWENTY YEARS AGO, WE WERE ISSUED A CHALLENGE: Create a facility to develop our natural energy resources and demonstrate their application to our problems. NELHA has now developed into the world's leading center for research, development and commercialization of Ocean Thermal Energy Conversion (OTEC) and related uses of deep ocean water. We have met many challenges in the process of achieving this success.

We continue to meet the challenges that arise in dealing with nature and with people. Our commitment to success will never waiver. But, like all facilities, we must change as the world changes.

We believe that now is the time to make a change - to transform NELHA into a facility for the 21st Century. Much of the new NELHA comes from a simple reorganization. Some of it, however, is brand new. As we have made changes, we have tried to preserve the elements that have made this facility successful.

In this Annual Report, you will see some examples of accomplishments which are the product of the hard work of the Board of Directors and the staff of NELHA. All of these changes and accomplishments combine to create a profile of the people who have shaped this organization. We invite you to visit. With your continued support, we will be NELHA for the 21st century.

BOARD OF DIRECTORS

Richard West, Chairman
Vice President and Regional Manager
Bank of Hawaii

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

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Bill Cook
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Cook's Discovery

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

Mufi Hannemann
Director
Department of Business, Economic Development & Tourism

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

Stephen Yamashiro
Mayor
County of Hawaii

TWENTY YEARS OF CHANGE

During the past twenty years, this organization has metamorphosed in many ways. On June 14, 1974, State legislators approved Act 236 which established an independent non-profit corporation, the Natural Energy Laboratory of Hawaii at Keahole Point.

The site was chosen after a careful review of the criteria necessary for successful development of ocean thermal energy conversion (OTEC) and related technologies. The most important considerations were: nearby availability of cold, deep ocean water; a warm ocean surface layer not subject to strong seasonal cooling; high year-round solar radiation; accessibility to logistical support, including airports, harbors, and highways; and adequate quantities of neighboring undeveloped land suitable for aquaculture and related projects.

The initial funds consisted of $50,000 from the State and $50,000 from the County of Hawaii. The Research Corporation of the University of Hawaii (RCUH) was chosen to provide immediate corporate structure and financial and management functions. The initial staff consisted of three individuals appointed by the Board of Directors. They worked on planning and development of the Keahole Point site. This planning developed recommendations which were submitted to the 1975 legislature. In April 1976, the legislature appropriated $750,000 for capital improvements at the site. The land was rezoned for urban use, and NELH was underway.

Mini-OTEC, operating in NELH's offshore research corridor in 1979, provided the world's first production of net OTEC power. This project, sponsored by the State of Hawaii in cooperation with Dillingham
Corporation, Lockheed Ocean Systems and other private companies, brought worldwide attention to the Keahole Point site.

In 1980, the Seacoast Test Facility was established as a joint project of the State of Hawaii and the U.S. Department of Energy. Initial construction produced a laboratory building, a test pad, a power center, and the beginning of an industrial building. The major initial experimental effort focused on the Argonne Test Project which performed research on biofouling countermeasures and materials corrosion of potential ocean thermal energy conversion (OTEC) heat exchanger materials. The first two OTEC aquaculture experiments

were also initiated with funding from the State and the University of Hawaii Sea Grant College program. The first of many commercial aquaculture ventures also began with the initiation of deep seawater pumping in 1982.

The organization grew so that it could respond more efficiently to the growing needs of the experimental programs. By 1983 it included a total of eight full-time people.

By the mid-80's, NELH had become recognized as the site of a series of firsts:

The world's first net power OTEC plant;
The first demonstration of cold seawater aquaculture in the tropics;
The first demonstration of air conditioning using deep ocean water;
The first demonstration of fresh water agriculture based on condensate and cold produced by deep ocean water; and
The first demonstrations of environmentally benign control of biofouling and of the suitability of aluminum construction in OTEC heat exchangers.

Legislators responded to this NELH success story by, in 1986, expanding our mission to include management responsibility for the Puna Geothermal Facility, located more than 100 miles away on the eastern side of the Big Island.

Also at this time, the Hawaii Ocean Science and Technology (HOST) Park was established by Hawaii's High Technology Development Corporation (HTDC) on 548 acres of land adjacent to NELH. HOST Park was set up to allow large scale commercialization of technologies developed at NELH. The legislature appropriated more than $15 million for the seawater systems and infrastructure of this new facility.

As 1990 drew to a close, HOST Park and NELH were merged into a new entity: NELHA. The merger set in motion a flurry of activity. The list of tenants grew, with a concomitant increase in private sector employment. Land use and operating revenues also continued to increase.

1994 NELHA TODAY

1994 NELHA TODAY

The Natural Energy Laboratory of Hawaii Authority (NELHA) provides essential support services for all of its tenants. There are currently two facilities: The Keahole Point Facility and The Puna Research Center (Noi' i' O Puna). A total of 33 employees provide a wide range of skills and work experience to support the needs of each tenant and to accomplish program objectives.

Today, the Keahole Point facility is the only place in the tropics where cold seawater is being pumped ashore. It is the only place where research and development are being performed on the commercial potential of deep ocean water for energy production, air conditioning, industrial cooling, cooled tropical agriculture, and a wide range of unique aquaculture projects. NELHA currently operates three deep pipelines which can pump a total of up to 17,100 gallons per minute (1.08 m^3/s) of seawater ashore from about 2000 ft (600 m) depth. Three surface seawater pipelines have a capacity of more than 13,600 gallons per minute (0.86 m^3/s) . The deep seawater temperature is nearly constant at about 43°F (6°C) and the surface water temperature ranges from 77°F to 83°F (24.5°C - 27.5°C).

The Puna Research Center (Noi i O Puna) is also unique in having the HGP-A geothermal well, one of the hottest and deepest in the world. Though it is no longer producing power, the well and the neighboring research buildings provide a unique opportunity to monitor the geothermal reservoir which supplies a significant fraction of the Big Island's electricity.

Management functions for these two facilities include: operating and maintaining the infrastructure; planning and engineering capital improvements and expansions for the facilities; providing analytical laboratory services to tenants and other governmental agencies; negotiating rental and lease agreements; processing accounts receivable and payable; marketing available parcels of land, building spaces and services; and educating the community by providing materials, tours and lectures for various age groups.

This report addresses some of the significant accomplishments achieved in each of these management areas during Fiscal Year 1994.

OPERATIONS

The core of the facility is the Operations and Maintenance Section. A team of 17 individuals combines materials, machinery and manpower to keep the facility running 24 hours a day, every day of the year, providing seawater, electricity, freshwater and other services needed by our tenants. Their primary accomplishment is the uninterrupted service they provide our tenants. Other recent accomplishments include:

Assisted the PICHTR project with modifications to the NPPE Open Cycle OTEC Power Plant and control room.

Assisted with the "shore landing" of a specially fabricated 30 kilometer fiber optic cable for the DUMAND (Deep Underwater Muon and Neutrino Detector) project. The cable was routed ashore through a slant-drilled pipe and thence into the Hale He'ena laboratory building.

Completed preliminary planning and design work in support of several incoming tenant projects.

Completed several utility and seawater improvements to enhance and support tenant operations:

Cross-connected the 28-in surface seawater distribution pipeline to the 20-in surface seawater pipeline at a 22-acre site. This included the installation of an 18-in seawater valve to isolate the four-acre ponds from the remainder of the plumbing system.

Purchased and installed a new 25 hp submersible pump in the 18-in deep seawater pump station.

Rewound and converted three 88 hp submersible pump motors to 77 hp in order to meet low pressure pumping requirements.

OPERATIONS

Recovered and refurbished three pumps from an abandoned offshore pump station.

Completed a major cleanup operation within a 22 acre area vacated by a former tenant. This included draining a four-acre aquaculture pond and cleaning the seabottom area surrounding two offshore pump stations.

Initiated the installation of a new facility alarm and control system by installing 4,500 ft of signal cable from the 24-in surface seawater pump station to the Administration Building and to the main pump control building.

Upgraded the telephone and signal wire conduits along the access road.

Completed facility improvements, including:

Purchased, permitted and constructed a fuel service depot within the main NELHA compound. A two compartment concrete tank was installed for gasoline and diesel fuel dispensing to support a mobile fleet of vehicles and heavy equipment.

Installed utilities, seawater and potable water to the analytical laboratory wet bench work area. This included compressed gas and air lines to support the requirements of various analytical equipment.

Installed a telephone service and pay phone unit at the NELHA beach and restroom complex.

Installed electric power and potable water to a new storage building.

Purchased and refurbished two surplus military vehicles for general utility, security patrol and tenant use.

Landscaped the grounds surrounding the newly constructed Hale He'ena laboratory building.

Began in-house repairs and issued a refurbishment contract to rust-treat and repaint the exterior or the Industrial/Administration Building.

Rebuilt and refurbished a 15 ton, 4-wheel-drive hydraulic crane.

ENGINEERING

The engineering section has provided routine support to several tenant projects while significantly increasing the size and quality of the available library of Computer Aided Design and Drafting (CADD) drawings available for staff and tenant use. This drawing library allows rapid reproduction of appropriate land use plots and engineering drawings for permitting, regulatory and construction projects of tenants and NELHA staff.

Fiscal Year 1994 marked the initiation of the Ka'u pump station, which houses the seawater pumps for the newly installed surface water intake adjacent to the 18-in backup deep seawater pipeline system. This state of the art facility, designed by NELHA's engineering section, incorporates variable speed drives with complete supervisory control to ensure a continuous flow of seawater into the distribution system at appropriate pressures and flow rates.

In addition, the first significant new building within the NELH compound since 1981, the Hale He'ena Laboratory building, was completed on schedule and within budget in December 1993. This building, which houses the DUMAND project as well as additional laboratory and office space and a conference room, was nominated for the engineering project of the year by the Kona-Kohala Chapter of the Hawaii Society of Professional Engineers. It's seawater air-conditioning sets the standard against which all future such systems will be judged.

The biggest engineering project of this year has been the initiation of the shoreline crossing which is the first component of the installation of new surface and deep seawater pipelines designed to serve projects in the HOST Park area. Following drawing and bid package preparation and a thorough bid selection process, NELHA

contracted with NOVA Group, Inc. of Napa, California for the construction of two parallel 66-in diameter tunnels which will extend from 32 ft deep in a pump station 460 ft onshore to a breakout through the seafloor 540 ft offshore at a depth of 80 ft.

The contractor is using "micro-tunneling" technology, in which an autonomous tunneling machine is pushed into the tunnel by large jacks mounted in a dry pit. The pit, or "launching shaft", has been constructed about 5 ft back from the coastline and is lined with "sheet piles" so that it can be "de-watered". The contractor plans to begin tunneling from this launching shaft in late summer or early fall, and project completion is scheduled for December 1994.

Micro-Tunneling appears to provide a cost-effective, environmentally benign mechanism for bringing large pipelines through the shoreline area. Alternative solutions, including above-ground pipelines, trenching and directional drilling are much more costly and/or more harmful to the environment. Micro-tunneling will allow us to bring large pipelines ashore with no permanent disturbance of the shoreline area. Plans actually call for establishing a public beach park over the area where the pipelines pass under the shoreline.

This project will provide the shore crossings for the two pipelines which are needed to serve the land area set aside for the HOST Park. They will initially provide the large volumes of water needed to operate an OTEC plant to be constructed by KAD Partners. This plant will provide electricity to pump the water to the rest of the KAD Partners projects and also to other users in the NELHA facility. NELHA is requesting capital improvement funds to allow completion of the whole pipeline system in the next biennium. This is the most important step towards allowing the full utilization of NELHA's facilities at Keahole Point.

ANALYTICAL LABORATORY

NELHA's Analytical Laboratory collects and disseminates the information needed to protect our valuable seawater and groundwater resources. This laboratory has the most forward-looking multi-disciplinary environmental monitoring team in the state of Hawaii. Some highlights of this year's efforts include:

A full year of NELHA's Comprehensive Environmental Monitoring Program (CEMP) was completed, and all quarterly reports were submitted on time.

Analytical services were provided to many tenants, including Black Pearls, Inc., Cyanotech Inc., Uwajima Fisheries, Inc. and Aquaculture Technology, Inc.

New software automates the data acquisition and processing on the Technicon Auto Analyzer. This significantly decreases the time required for inorganic nutrient analyses and streamlines the QA/QC Process.

A new micro-balance, installed and calibrated a year ago, provides consistently accurate results.

The laboratory autoclave has been upgraded to accommodate State of Hawaii laboratory certification requirements for assay of environmental bacteriology.

A full year of contract work in chemistry and bacteriology was performed on the State Department of Health Blue Waters Monitoring Program.

NELHA provided the sampling equipment and analyses for offshore seawater collected as part of an environmental monitoring program near the sewage outfall. This was done under a services contract for analytical chemistry with the County of Hawaii Waste Water Treatment Plant.

The Analytical Laboratory provided a full year of analyses of environmental samples from Penrhyn Atoll in the Cook Islands. The U.S. Agency for International Development is funding this project to promote the development of pearl farming.

ADMINISTRATION

The administration of any facility depends upon the interconnections between different components of the management. The Contracts, Fiscal, Marketing, Personnel and Education functions work together to support the tenants and the staff of NELHA. An overview of this year's accomplishments follows.

CONTRACTS AND PERMITTING

The NELHA Strategic Plan was completed and published. It addresses the mission, objectives, goals and strategies for improving the facility.

The Facilities Use Manual has been updated and distributed.

Administrative Rules were drafted and sent to the Board of Directors, the Attorney General and the Legislative Reference Bureau for review.

Eight leases and Facilities Use Agreements were negotiated and executed with several different tenants.

Fifteen construction and negotiated service agreements were executed for a variety of capital improvement projects and consultant services.

Numerous land use permit applications were filed with the County of Hawaii Planning Department, the Department of Land and Natural Resources, the U.S. Army Corps of Engineers, the Hawaii Coastal Zone Management Office, the Land Use Commission and the Department of Health.

ADMINISTRATION

FISCAL OFFICE

The fiscal staff continues to do a superb job of managing the financial resources of NELHA. Their responsibilities include day-to-day management and oversight of:

Collection and disbursement of money
Inventory of fixed and movable assets
Petty cash
Special fund
Accounts payable and accounts receivable
Purchasing
Budgeting

MARKETING

Strategies have been developed to attract and promote ocean and solar related research and commercial activities. Updating of the Project Initiation Packet aimed at prospective tenants has improved our communication of the details of the process. Other activities have included:

The second annual Open House held during Energy Awareness Month in October was a success, with more than 400 people attending the three-hour event.

NELHA representatives attended the Hawaii County Fair, the Kona Coffee Festival, the World Aquaculture Society in New Orleans, Oceanology International '94 in Brighton England, The Mie International Forum and Symposium (MIFS 94) in Tsu City, Mie Prefecture Japan, Oceans '93 in Victoria B.C., and MTS '93 in Long Beach California.

Our Kona Facility hosted over 3,000 visitors throughout the year from the continental United States, Europe, South America, Japan, and Taiwan.

ADMINISTRATION

EDUCATIONAL PROGRAM

NELHA has a strong commitment to the education of our community and the rest of the world. We have an active program of scheduled public tours for tourists and local people, supplemented by requested tours and lectures for special groups. During this Fiscal Year, members of the NELHA staff:

Hosted more than 100 school groups and educational events, with a total audience of more than 3,600. Attendees included students, teachers and administrators from institutions throughout the State of Hawaii, the continental U.S. and Japan. Activities included on-site presentations, tours, out-reach programs (e.g. interactive classroom presentations and teacher-educator workshops), career shadowing for high school students, independent special projects, development of curriculum materials, career fairs, and educational exhibit booths.

Presented a one-hour guest appearance on the Hawaii Inter-active Television System (HITS) program called "The Science Club", sponsored by the Department of Education Distance

Learning Technology program.

Served as resource advisor at Power Trek '93, an environmental and educational leadership training camp held in August 1993 at Kilauea Military Camp. This annual event is sponsored by DBEDT Energy Division and the National Energy Educational Development (NEED) Program.

Participated as judge for the Kealakehe Intermediate School Science Fair.

PERSONNEL

Several Personnel changes occurred during this fiscal year. Each of the individuals who moved on has made important contributions to the progress of NELHA. The changes were:

Kent Merrill, Engineering Project Coordinator, resigned in October to pursue a computer aided design career in civil engineering.

After years of contract work for NELHA, Robert Kochy was hired as a Maintenance Mechanic for the Puna Research Center in November 1993.

Scot Oshiro was hired as Engineering Project Coordinator in December 1993.

John Sullivan, Engineering Manager, resigned in January 1994 to pursue his career in pipeline installation.

Clare Hachmuth, Executive Director, resigned in March 1994 to become Vice President and co-owner of Energy Resources, Inc.

Thomas Daniel, Scientific/Technical Program Manager, was appointed as Acting Executive Director.

David (Steve) Pargett, Electrician II, resigned in May 1994 to pursue a career in cellular communications.

Eugene Pierce was hired in July 1994 to fill the vacant Electrician II position.

Robert K.U. Kihune was selected in July 1994 to become the new Executive Director of NELHA.

NELHA SERVICES

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 Structures

ANALYTICAL LABORATORY

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

ADMINISTRATION

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

NELHA TENANTS

NELHA TENANTS

The most important assets of NELHA are the commercial and research projects located at Keahole Point. Major research achievements have been accomplished in OTEC experimentation. Aquaculture projects using various combinations of the properties of deep cold seawater (low temperature, high nutrient content and a lack of pathogens) have produced significant economic and scientific results. Many of these projects are still developing and have the potential to become important contributors to the States economy.

Pacific International Center for High Technology Research (PICHTR). It has been more than a year since PICHTR's small experimental ocean thermal energy conversion (OTEC) plant at Keahole Point first transformed the solar energy stored in the ocean waters into useful electricity. The success of this plant has been helpful in improving the credibility of OTEC. The experimental program has been sponsored by the federal government and the State of Hawaii. The budget over the last eight years has been 12 million dollars, of which about half was used for equipment and the remainder for design, analysis and three years of shakedown operations. The open-cycle OTEC plant has produced up to 255 kilowatts (kW), using 150 kW to operate the plant and resulting in 100 kW of usable electrical power and 7,000 gallons of fresh (desalinated) water per day. These are world records for OTEC. The next step required before OTEC power can be produced commercially is to design, build and operate a pre-commercial plant to determine how many hours per year an OTEC plant can work (capacity factor) before major repairs are required (life cycle). This last step requires a commitment of 100 million dollars for the construction and operation of a larger 5 megawatt (MW) demonstration plant which could supply 5,000 residents with electricity. With continued development support, OTEC can play a major role in the energy future of our state.

Kona Cold Lobsters Ltd (KCL), imports live Maine lobsters and rejuvenates them using deep seawater. A typical air shipment from Maine to Keahole Point has the lobsters out of the water for 24-30 hours. Lobsters are inspected, weighed and fed before being distributed to customers throughout the Hawaiian Islands and select Asian destinations. KCL also grows Maine lobsters from eggs to market size on a prototype scale. This research is multidisciplinary involving reproduction, husbandry, nutrition, pathology and habitat design.

NELHA TENANTS

Aquaculture Technology, Inc. produces Blue shrimp and the Pacific oyster. They continue to investigate the commercial co-production of marine shrimp and oysters in a symbiotic system. The design reduces the amount of labor needed while increasing the product output.

Hawaii Sun-Dried Fish Jerky's, Inc. uses the abundant sunshine at Keahole Point to produce this local favorite. The fish jerky is prepared from locally caught fish, marinated in a hot-n-spicy or mild teriyaki seasoning and dehydrated with the use of specially designed solar drying units. Hawaiian Sun Dried Fish Jerky is producing its product in a shorter time than standard methods and without the use of electricity.

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 have consistently reached over a ton per week. The company has 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. is a General and Environmental Contracting/Marine Construction company with an emphasis in commercial diving. They were the first support company to locate at Keahole Point and provide highly skilled services to NELHA, its tenants and companies in the surrounding area. Seatech's skills center around underwater surveys, underwater piping and pumping systems, dredging, drilling and salvage.

Cyanotech Corporation is a leader in marine biotechnology, using proprietary production and processing systems to produce algal products for world-wide nutritional and pharmaceutical markets. The Company's current products include Spirulina Pacifica, a high protein nutritional product, and phycobiliproteins, fluorescent pigments used in immunological diagnostics. Nutrex, Inc., the Company's wholly-owned subsidiary, produces and markets a line of Spirulina-based nutritional products for the retail consumer market. Cyanotech is also developing commercial microalgal

production systems for beta-carotene, an antioxidant supplement which studies have shown to reduce the risk of cancer and heart disease, and astaxanthin, a natural red food pigment used in the salmon aquaculture industry to impart a natural pink color to salmon flesh.

Black Pearls Inc. is developing the technology to grow black-lip pearl oysters, **Pinctada margaritifera**, and produce valuable black pearls in Hawaii and other islands in the South Pacific. Following successful hatchery development, they are now investigating the feasibility of commercial pearl farming in Hawaii using land- and ocean-based systems. They are also developing a remote quarantine hatchery system which will allow expansion of pearl farming into many islands in the Pacific. Broodstock are flown to the hatcheries, spawned, and the larvae are then reared in deep OTEC water without coming into contact with Hawaiian surface water. Once the spat settle, they are flown back to the farm site. The first pearl farm with this type of operation is being set up in the Marshall Islands, with plans to expand to islands in Kiribati.

Uwajima Fisheries, Inc. (UFI) has developed a facility for growing "Hirame", a flounder highly prized by the Japanese for sashimi. The Hirame has a light, delicate white meat. The animal has a good meat ratio, allowing approximately 60% of the flounder to be utilized. Uwajima Fisheries markets their 1 1/2 to 2 lb Hirame through a local Honolulu distributor. UFI is managing the maturation and spawning of their broodstock and is currently working on year round production of eggs. UFI utilizes the NELHA surface and cold deep seawater for the semi-intensive polyculture of marine shrimp, milkfish and ogo. With this system they are currently producing a high quality superior product. This company also experimented with white shrimp, *P. vannamei*, utilizing strict SPF quarantine protocol. They are currently marketing certified pathogen free broodstock throughout the mainland USA and Central and South America. UFI has also experimented in broodstock management, spawning, larval rearing and growout of Pacific Treadfin (Moi). Intensive test marketing of Moi in 1994 has indicated the feasibility of commercial production.

NELHA TENANTS

Marine Science Research Center (MSRC), from the State University of New York at Stony Brook, is investigating the feeding activity of a group of planktonic animals, collectively called copepods. Living in the surface and deep seawater, copepods form an important link in the marine food web by passing nutrients from single cell plant life to populations of larger animals such as fish. However, the animals small size (<2mm) offers a considerable challenge to this study. Using a high magnification video optics setup constructed with He-Ne laser illumination, the MSRC researchers are able to observe and quantify the feeding behavior of these animals and their responses to fish predation. Funding is provided by the National Science Foundation and the Office of Naval Research.

West Hawaii Explorations Academy, is an integrative learning laboratory, sponsored by the State Department of Education for Kona's secondary students. Tenth through Twelfth grade students work and study full-time at Keahole Point throughout the school year. They collaboratively team with peers, staff, mentors, community members and employers. Rather than attending classes, students receive credit for working on projects which may include aquaculture and cold water agriculture, alternative energy development, alternative vehicle research, and learning about marine environments. Also included in the program is a major school-to-work component, including a full-time vocational counselor. After initial training, students are encouraged to take on NELHA tenant research projects or seek part-time employment at one of the Keahole Point enterprises.

Ono Take Corporation, is a research corporation investigating the cultivation of shitake and other mushrooms. The focus of this research is on the use of temperature control to optimize the yield of mushrooms. Cold seawater allows Ono Take to manipulate precisely the micro-climate of the grow house, creating appropriate environments for each stage of fungal development.

DUMAND, the Deep Underwater Muon and Neutrino Detector, is a project uniting high energy particle physics scientists from the United States, Japan and Europe. Exploring a new field called high energy neutrino astrophysics, they will collect data on subatomic particles. The scientists are deploying an array of sensors more than three miles deep in the ocean to detect

neutrinos and other particles which pass through the earth and the ocean. Analysis will provide a better understanding of the stellar reactions which produce these particles.

Sogi International, Ltd. continues research on the solar distillation of ethanol for motor fuel from sugar cane molasses. Cold seawater greatly improves the condensing efficiency of the still apparatus. The researchers have modified a car to run on a wide range of mixtures of ethanol and gasoline.

An **Environmental Protection Agency Toxicity Project** has investigated a method to determine whether an effluent is toxic to the environment. A native Hawaiian fish, "Iao" or *Prenesus insularum*, whose larvae are relatively sensitive to toxins, was tested as an indicator organism.

The University of Kiel, working with researchers from the University of Hawaii at Manoa, has conducted experiments on optimizing the production of hydrogen by photovoltaic electrolysis of seawater using inexpensive components. They have also initiated research on the extraction of trace metals from seawater.

Common Heritage Corporation, is dedicated to manage, whenever and wherever it can, those environmentally sustainable innovations in ocean technology which will redound to the benefit of the world community of human beings. One such innovation is the new field of coldwater agriculture, which uses deep seawater as a coolant to manipulate soil and air temperatures. Agriculture species that otherwise could not thrive in the coastal desert can now be successfully grown. Common Heritage maintains a coldwater demonstration garden at NELHA in which over 100 species of high value food crops such as strawberries, asparagus, artichokes, basil and gourmet lettuces have thrived. Extrapolation of agricultural systems based on these processes into commercial production holds great promise for coastal communities with access to deep ocean water.

NELHA FINANCIAL POSITION

STATEMENT OF OPERATIONS

(For the period July 1, 1993 - June 30, 1994) Estimates subject to Audit

REVENUES

STATE FUNDS	$1,870,194.00
	$1,870,194.00

SPECIAL FUND

Dep. 6/93 Cr. 7/93	$15,071.64
Land Use Fees	$142,807.54
Reimburseables	$392,045.22
Other Projects	$1,140.38
Interest Received	$6,662.56
Vending Machine	$560.36
T-shirt Sales	$622.50
Special Fund Revenue	$558,910.20
TOTAL	$2,429,104.20

EXPENDITURES

GENERAL FUND

Salaries	$1,096,264.82
Kona Operations	$749,049.38
Puna Operations	$19,742.44
	$1,865,056.64

SPECIAL FUND

Kona Operations	$292,311.12
CIP Proviso	$350,000.00
BOH Payment	$120,631.23
	$762,942.35

TOTAL EXPENDITURES	$2,627,998.99

FINANCIAL POSITION

Special Fund Balance July 1, 1994	$468,988.40
State General Fund Appropriations	$1,870,194.00
Special Fund Revenues	$558,910.20
	$2,898,092.60
General Fund Expenditures	$1,865,056.64
Special Fund Expenditures	$762,942.35
Return to State Treasury	$5,137.36
Special Fund Balance July 1, 1994	$264,956.25

PROJECT APPLICATION PROCEDURES

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 must give final approval to all project proposals. Initially, all proposals must 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.

PAST RESEARCH PROJECTS

PUBLICATIONS

Past Research Projects at NELHA

* 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, 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. Aluminum 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, however, for open-cycle OTEC.

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

Past Research Projects at NELHA

* 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 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 the 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. Algal 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.

* 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 uptake.

* POLYCULTURE EXPERIMENT - (11/88 to 12/90)
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.

Past Research Projects at NELHA

* MICROALGAE TESTING - (05/90 to 12/90)
FUNDING SOURCE - Microbio Resources
Tested the growth of proprietary strains of Dunaliella and Haematococcus, microalgae. Gathered productivity data for these strains under the light and temperature regimes at NELH.

* FREON RECYCLING - (01/90 to 05/93)
FUNDING SOURCE - Thermal Recovery Systems, Ltd.
Developed system to recycle used freon from air conditioners by cold seawater assisted solar distillation.

* NAMAKO (SEA CUCUMBER) CULTURE - (01/86 to 12/92)
FUNDING SOURCE - D.S. Ventures, Ltd.
Investigated culture of sea cucumbers, a Chinese delicacy.

PUNA RESEARCH CENTER

* BOTTOM HEATING SYSTEM - (04/86 to 04/88)
FUNDING SOURCE - DOE, Private Donations
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 Donations
Experimental dryer worked well with all types of fruits. The cost savings achieved using geothermal waste heat make the 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.

Puna Research Center

* ATMOSPHERIC CORROSION - (12/86 to 4/87)
FUNDING SOURCE - UHM
Quantified the corrosiveness of the geothermal environment to allow for better materials selection. HGP-A corrosion is uniquely determined by physicochemical conditions of the environment at the site. The corrosion rate is accelerated by the 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 sterile growing medium for plant growth. A pasteurized potting mix comprised mostly of lava cinder and shredded coconut husks would be used as an 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. Significant traces of calcium were deposited on test specimens 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 - PICHTR, Private Donations
Investigated the commercial viability of the DCHE technology, which provides a method of transferring heat from the well to the surface by circulating fluid in a closed system. After seven days of continuous operation, the temperature of the outlet water stabilized at 13.5 degrees Celsius above the inlet water temperature. These data agreed with the theoretical design predictions.

* SCIENTIFIC OBSERVATION HOLES - (05/90 - 4/94)
FUNDING SOURCE - HNEI
Used the Puna Research Center facilities for storage, cutting and archiving of the core samples recovered in the SOH drilling program.

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NELHA EMPLOYEES

NELHA EMPLOYEES

Robert K.U. Kihune
Executive Director

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*