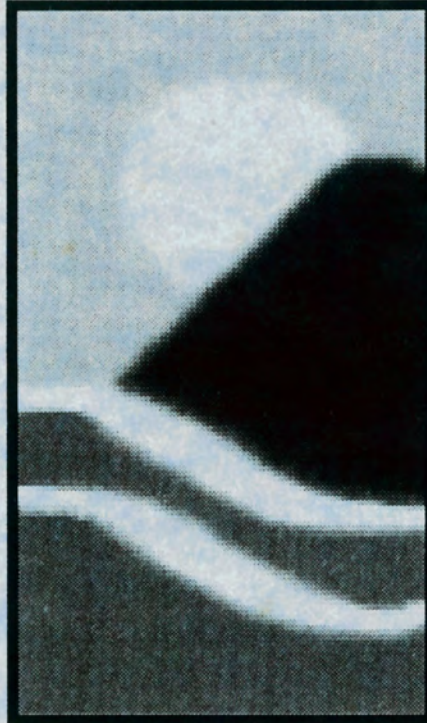


The Natural Energy Laboratory of Hawaii Authority

1996 Annual Report



N E L H A

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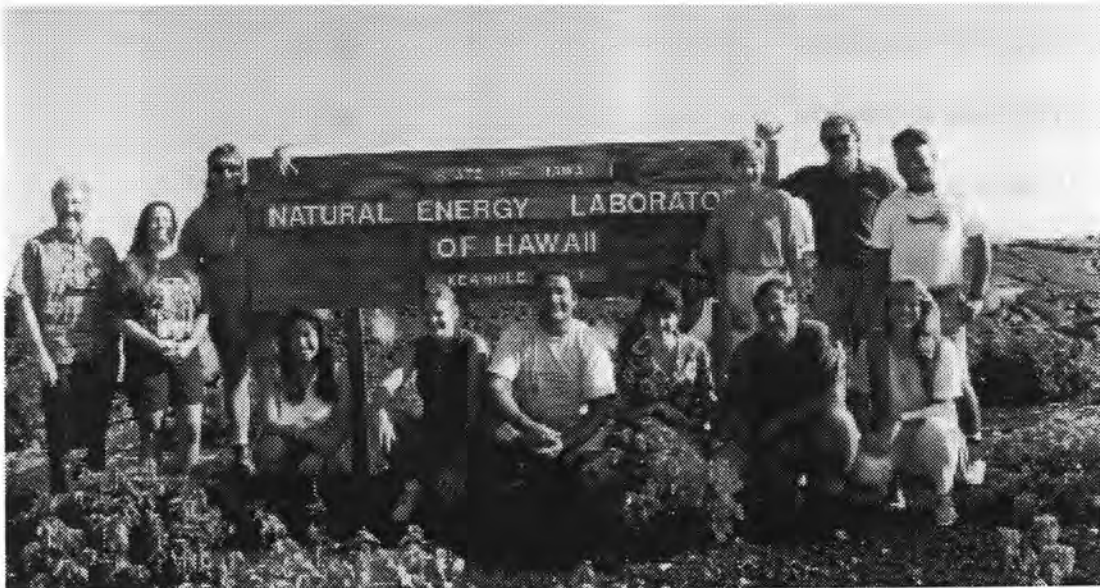
TEAMWORK

Coming together is a beginning

Keeping together is progress;

Working together is success.

- Henry Ford



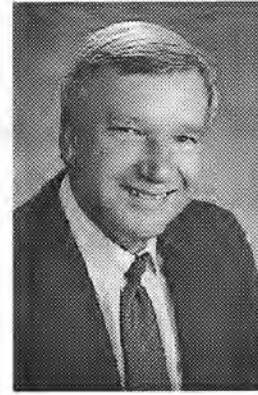
The individuals that make up the staff at NELHA are dedicated employees of the State of Hawaii, all working together to achieve the mission of NELHA. As members of the Kona community, the staff have a natural desire to work as a team to support the economic development activities taking place at Keahole Point.

NELHA's Mission

**"To develop and diversify the Hawaii economy
by providing resources and facilities
for energy and ocean related research, education
and commercial activities in an environmentally sound
and culturally sensitive manner."**

MESSAGE FROM THE CHAIRMAN

The 1995-96 fiscal year was a period of transition for the Natural Energy Laboratory of Hawaii Authority. As a result of the state fiscal crisis of 1995, NELHA's staff was reduced by one third, and the facility's budget was dramatically reduced. Despite the cuts, NELHA rose to the challenge and experienced vital growth during the fiscal year. Three new tenants have received final approval to start their research or commercial projects on-site and six additional tenants have received preliminary approval for their projects. Four of NELHA's current tenants received approvals to option additional lands for expansion this past year.



This fiscal year heralded the addition of new programs located on-site as well as new collaborations between NELHA and other agencies. The National Defense Center of Excellence for Research in Ocean Sciences (CEROS) was transferred to NELHA's authority, and its administrative offices are now located at Keahole Point. The West-Hawaii Sea Grant Extension Office moved its headquarters to NELHA to better serve its target population. The University of Hawaii Small Business Development Center began hosting workshops at NELHA and providing consulting on-site to assist the development of small business on the Big Island. NELHA has also worked closely with the Kona-Kohala Chamber of Commerce and the Hawaii Island Economic Development Board to promote sustainable economic development on the Big Island of Hawaii.

During the past year NELHA staff have improved and expanded the facility's infrastructure to service the growing operations of current tenants as well as new businesses that are making plans for projects on-site. The onshore extension of the warm seawater pipeline is already providing service to NELHA tenants. Completion of the onshore crossing for a new seawater delivery system in HOST park brings NELHA one step closer to providing seawater to tenants who are ready to locate in that section of the facility.

Looking ahead toward the new millenium, NELHA is developing plans for the full development of the facility. NELHA's marketing efforts are promoting the facility's unique natural resources to attract industries that will create economic diversification, export income, and diversify employment for the State of Hawaii. The Board of Directors is about to begin a new strategic planning process to identify the key needs of the growing and changing NELHA facility. The administration requirements, marketing plans, infrastructure plans, and industry demands will all be reviewed with the goal of creating a facility that will provide valuable economic benefits to the State of Hawaii and can sustain itself entirely from tenant revenues.

It has been an honor serving on the NELHA Board. While my tenure is complete at the end of June 1996, I look forward to following the exciting growth taking place at the most unique ocean science and technology park in the world. Thanks to all of NELHA's dedicated staff, hardworking tenants, and loyal friends for your support!

A handwritten signature in dark ink, appearing to read 'Rick West'.

Rick West
Chairman of the Board

BOARD OF DIRECTORS

Richard West, Chairman

Vice President and Regional Manager
Bank of Hawaii

Diane Quitiquit, Chair-Elect

Representing, Stephen Yamashiro, Mayor
County of Hawaii

John Corbin, Vice-Chair

Manager
Aquaculture Development Program
Department of Land and Natural Resources

Donald Thomas, Ph.D., Research Advisory Chair

Associate Geophysicist
Hawaii Institute of Geophysics
University of Hawaii at Manoa

Mason Young

Representing Michael D. Wilson, Director
Department of Land and Natural Resources

Sophie Ann Aoki

Executive Director
Friends of the Future

Steven Chu

Department of the Attorney General

Maurice Kaya

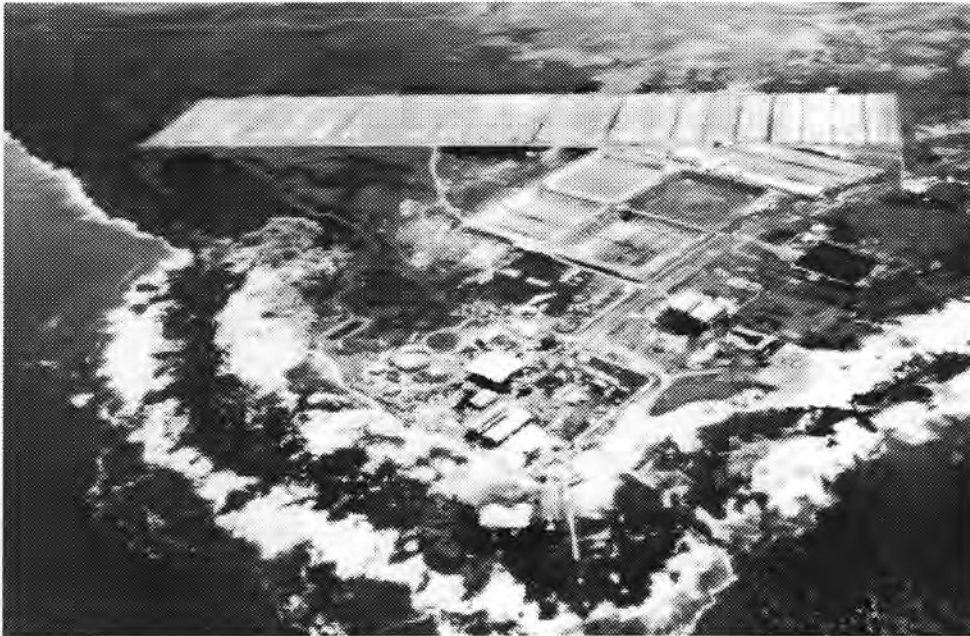
Representing Seiji F. Naya, Director
Department of Business, Economic Development &
Tourism

Ralph Moberly

Representing, Kenneth P. Mortimer, President
University of Hawaii at Manoa

1996
The Year in Review

1996 NELHA TODAY



Twenty years ago, Keahole Point wasn't much more than a lava wasteland. In 1979, staff who worked at Keahole Point had to travel down a rough jeep road 45 minutes each way to get to work. Today it is about a five minute trip from Queen Kaahumanu Highway to the administration building at NELHA. Along the way, one passes a remarkable array of businesses that have transformed the lava landscape into a highly productive region. Product sales from NELHA businesses have climbed to more than \$13 million and approximately 130 staff are employed by NELHA tenants.

In addition to the recognition NELHA has gained through the commercial businesses on-site, Keahole Point is known as the premier location in the world for research and development of Ocean Thermal Energy Conversion (OTEC). The 210kW (gross) open-cycle OTEC plant operated by the Pacific International Center for High Technology Research (PICHTR) is the only one of its kind in the world. Valuable operational data has been gathered for the commercialization of this technology which some day may contribute energy, fresh water, and food to populations across the Pacific region. NELHA has proudly supported the development of this technology, as well as the integrated seawater utilization that has fostered new commercial projects on-site.

While OTEC research continues today at Keahole Point, much of the focus of the facility has evolved to support commercial development. Two deep seawater pipelines have a capacity of pumping up to 15,900 gallons per minute ($1.08\text{m}^3/\text{s}$) of seawater ashore from about 2000 ft (600 m) depth. Two surface seawater pipelines can pump more than 12,600 gallons per minute ($.86\text{m}^3/\text{s}$). With a deep seawater temperature of about 43° F (6°C) and surface seawater temperature from 76°F to 82°F (24.5-27.5°C), marine plants and animals from a variety of climates can be grown in one location. The purity and high nutrient content of the deep water are also important in many applications.

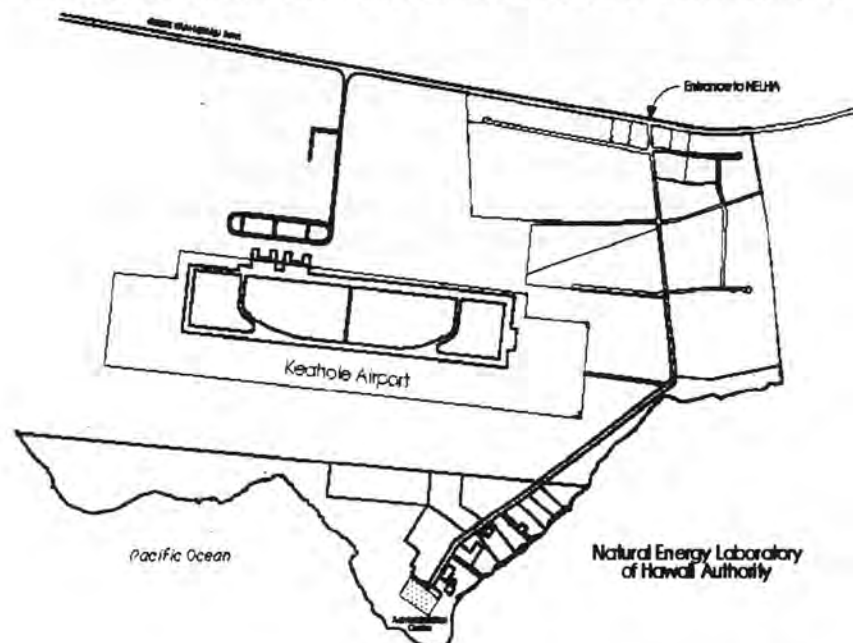
1996 NELHA TODAY

Twenty-two tenants conduct research, educational, and commercial activities at NELHA, an attached agency of the State Department of Business, Economic Development and Tourism (DBEDT). A couple of the businesses are publicly held corporations, some are limited corporations, and others are sole proprietorships. One tenant, the West Hawaii Explorations Academy, is a project of the State Department of Education.

Fiscal year 1996 was a pivotal year for NELHA. The year began with a downsizing of NELHA staff from 30 to 20 positions as a result of the state fiscal crisis. A 45% cut in NELHA's general fund support required a reorganization of budget priorities in order to maintain current infrastructure and provide support to tenant projects. In spite of the cuts, NELHA staff supported the location of three new tenants to the facility, and the expansion of four established tenants. Six additional projects received preliminary approval to locate their enterprises at NELHA, and many of the current tenants are expanding their operations.

Management functions for the facility include: operating and maintaining the physical structures and equipment; planning and engineering capital improvements and expansion for the facilities; monitoring the environmental impact of facility operations; 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



OPERATIONS

As with all of the departments at NELHA, the staff reductions that took place near the beginning of the year had a significant impact on the Operations department. The crew was reduced from sixteen to nine.

Initially, adjusting to such a large labor loss was frustrating. Contracting out the janitorial and commercial diving tasks has alleviated some of the burden of maintaining the large NELHA complex. The remaining tasks were prioritized, and by midyear most of the challenges were being met, due to a conscientious crew that is dedicated to achieving its goals. The talented operations staff is now proud to be doing more with less and confident that it can support the needs of NELHA and help it to achieve its goals well into the next millenium.

The Operations staff continue to provide critical core support for the facility by managing all plant and equipment, assuring the delivery of deep and surface seawater, electricity, freshwater, and supplying other operational support needed by our tenants. The Operations department has also traditionally been responsible for the operation and maintenance of all buildings, landscaped grounds, mobile and fixed equipment, air-conditioning systems, roadways, and safety and security for the facility.

The most critical responsibility of the Operations Department is the operation and maintenance of the seawater distribution systems. For most of the present tenants at NELHA, the constant supply of warm surface and cold deep seawater is critical. Many tenants would be severely impacted if the flow of these resources were to be interrupted for more than 1-2 hours, day or night. The dedication of the Operations staff ensures an uninterrupted supply of seawater to tenants 24 hours a day, 365 days a year.

The staff includes skilled planners, mechanics, electricians, and maintenance workers who labor together to fulfill NELHA's mission. Many of the improvements at NELHA over the years have been completed using the lab's "self help" philosophy. Staff members combine their talents to complete projects that might otherwise have to be contracted out. Following are some of the highlights and accomplishments realized during fiscal year 1996.

OPERATIONS

IMPROVEMENTS TO SEAWATER SYSTEMS

Many improvements were made within the past year to enhance NELHA's surface and deep seawater delivery systems. Inside the main compound, a lot of the old "spaghetti" (piping) was removed or replaced. The research compound header tanks and rusty towers supporting them were removed, thus making the delivery systems fully pressurized and closed to the atmosphere.

Work was begun and is continuing on replacing the 32" ductile iron discharge manifolds on NELHA's largest seawater system. High density polyethylene plastic replacements have been fabricated and are being installed to replace the iron pipe which is failing from seawater intrusion and corrosion.

The 28" surface seawater delivery pipeline was extended an additional 760 ft by Operations Department staff who purchased the material and joined the pipe sections together with a rented heat fusion machine. The new pipe section was buried in a trench excavated by a private contractor. This capital improvement project will allow NELHA to provide seawater for development of new areas.

NELHA's skilled staff are capable of completing many of the engineering and operational projects of the facility on a "self-help" basis. Pictured here is NELHA Operations Manager, Jan War, operating the machine that fusion welded sections of pipeline together to extend the warm seawater line more than 750 ft.



OPERATIONS

At the Kau Pump Station, the surface seawater system was automated to respond to changes in water pressure. As the pressure fluctuates, a sensor signals a special controller to speed up or slow down the motor(s) driving the pumps. In this way, no electricity is wasted and demands are precisely met. Extensive improvements have also been made to the vacuum priming system to increase its capacity and efficiency.

LABORATORY BUILDING REFURBISHMENT

A new roof was installed on NELHA's oldest building. Work is now underway to renovate and refurbish the air conditioning system installed in 1979. All of the doors and handrails surrounding the Laboratory Building have been refurbished with a fresh coat of paint and other cosmetic repairs.

IMPROVEMENTS TO RESEARCH & FARM COMPOUNDS

The Research Farm and Research Compound are areas established by NELHA to incubate small businesses and help them to grow. Work continues within both incubator compounds to upgrade basic utilities and provide more short term project space for rent. Two seawater disposal wells were excavated within the Research Farm and connected to NELHA's newest tenants there. Flowmeters have been installed to monitor seawater usage.

OFFICE IMPROVEMENTS & CONSTRUCTION

The addition of CEROS under NELHA's umbrella led to a need for more administrative space which was met by renovating some existing offices in the administration building and constructing a new office within the storage mezzanine. The move also created an opportunity to form an "Ops Room", where all of the Operations staff can work together out of a common area.

MICROTUNNELING

The shoreline crossing for the future seawater pipelines that are designed to serve projects in the HOST Park area has been nearly completed this year. NELHA's contractor, NOVA Group, Inc. of Napa, California, has constructed two parallel 66-in diameter tunnels which extend from 30 ft deep in a pump station 460 ft onshore to a breakout through the seafloor 570 ft offshore at a depth of 80 ft.

The contractor has used "micro-tunneling" technology, in which an autonomous tunneling machine is pushed into the tunnel by large jacks mounted in a dry pit. A 50-ft deep "launching shaft" was constructed about 5 ft back from the coastline and lined with "sheet piles" so that it could be "de-watered". The contractor first completed two tunnels onshore from this launching shaft to a 30-ft deep reception shaft 460 ft back from the water. They then completed the two offshore tunnels which are being joined in the launching shaft with the onshore sections. At the completion of construction, the launching shaft will be back-filled, leaving no permanent disruption at the shoreline. Though the project is behind schedule and the contractor is significantly over budget, NELHA has a fixed price contract and the funding for the follow-on pipeline installation remains delayed. The contractor now plans to complete the project in November 1996.

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 large land area set aside for the HOST Park. They will initially provide the large volumes of water needed to support new companies that are planning to locate in HOST Park. 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.

ENGINEERING

SEA WATER SYSTEMS

Makai Ocean Engineering, Inc. (M.O.E.), of Waimanalo Oahu, has nearly concluded the five remaining tasks of its continuing engineering services contract:

- 1) Engineering oversight of the NOVA Group, Inc. contract for installation of the micro-tunnel shore crossing for the planned HOST Park 55-in diameter pipelines. M.O.E. has provided consultant engineering services, acting as NELHA's engineer for this project.
- 2) Planning and oversight of the submersible dives required to complete the design of the 55-in diameter pipelines. M.O.E. personnel served as engineering observers on the dives, which were conducted in December 1995.
- 3) Conceptual design of the seawater distribution systems for the HOST Park area. M.O.E. continues to provide guidance and engineering assistance to plan development for distributing the water from the 55-in diameter pipelines throughout the HOST Park area. They are working with civil engineering consultants, Reid and Associates, Inc., who are designing the access roads and utilities for the area.
- 4) Review and upgrade design of existing onshore seawater distribution systems. The NELHA onshore seawater distribution systems had grown piecemeal to meet changing demands over the last 15 years, so the existing system was unnecessarily complex and inefficient. M.O.E. engineers have worked with NELHA personnel to develop and implement a simpler yet more flexible system.
- 5) Review of situation and recommendations for utilization of existing offshore seawater pipelines. M.O.E. has examined alternative uses for the six pipelines (none now operational) which NELHA acquired following the bankruptcy of Ocean Farms of Hawaii. Though these lines were all installed for pumping deep seawater, their diameters are too small to do so efficiently and several of them have additional mechanical problems. Possible alternatives which M.O.E. is investigating include: pumping of surface seawater, back-up to other deep seawater pipes, or discharge of used seawater below the 100 fathom depth where it will have negligible environmental impact. The final report on this task, which incorporates data from the submersible dives conducted in December 1995, is due early in FY 97.

ENGINEERING

SUBMERSIBLE DIVES

NELHA contracted with the Hawaii Undersea Research Laboratory of the University of Hawaii at Manoa to provide their PISCES V submersible for a series of five dives, two surveying the intended route for NELHA's future 55-in diameter pipelines and three inspecting the nine existing deep seawater pipelines. These dives, were successfully conducted in December 1995, using the old "LRT" (Launch, recovery and transport) vehicle which was retired following the dives. These dives have provided vital information for the final design of the future 55-in diameter pipelines as well as important operational information on the state of the presently operating pipeline

ACCESS ROADS AND UTILITY DESIGN

Reid and Associates, Inc. of Kailua-Kona has completed about 46% of their contract to provide civil engineering design services for the access roads and utilities for the build-out of NELHA's HOST Park area. The contract also includes tasks for the final design of NELHA's emergency generator system and planning for the provision of access and utilities to the presently inaccessible northern section of the NELHA property.

ANALYTICAL LABORATORY



The water at Keahole Point is the best-monitored ocean water in the state, and perhaps in the nation. As the ocean water is NELHA's most important resource, it is vital that we ensure that its quality remains pristine. NELHA's environmental impact statement requires a Comprehensive Environmental Monitoring Program (CEMP) which is conducted by NELHA chemists and microbiologists.

NELHA's Analytical Laboratory is a certified environmental laboratory, performing chemistry and bacteriological sampling, analysis and data management. The laboratory produces high quality, legally defensible, analytical data for NELHA, its tenants, other state and federal agencies, and other clients as required.

The lab was originally established in the early 1980's as a sampling station for the collection of seawater samples. These samples were part of oceanographic research projects at The University of Hawaii at Manoa and a research and development project supporting Ocean Thermal Energy Conversion (OTEC) at NELHA. In 1986, in anticipation of future growth in both OTEC and other tenant projects, the Special Management Area (SMA) permit and Conservation District Use Agreement (CDUA) permit mandated that an on-site environmental monitoring plan be established. The Comprehensive Environmental Monitoring Program (CEMP) was developed and in 1988 it was implemented. The laboratory equipment and space were upgraded to accommodate the analytical support needed to perform the environmental chemistry and bacteriological analyses dictated in the CEMP and to provide similar analytical services for NELHA tenants and other government agencies.

A staff of two chemists and one microbiologist execute the CEMP. This thorough program results in some of the best monitored ocean water in the state, perhaps in the nation. Following are some of the highlights of this year's efforts.

ANALYTICAL LABORATORY

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

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

Though reduced funding has eliminated the contract work in chemistry and bacteriology for the State Department of Health Blue Waters Monitoring Program, NELHA is negotiating a contract to begin in FY 97 with Department of Transportation Airports Division for sampling and analyses of new groundwater monitoring wells at Keahole Airport.

The Analytical Laboratory provided another 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

NELHA's administrative staff provide contracting, permitting, fiscal, personnel, general clerical, planning, public relations and educational support to the facility. The staff works closely with the NELHA Board of Directors, DBEDT and other government agencies to fulfill NELHA's many reporting requirements.

During fiscal year 1996 the NELHA administration completed several policy documents to foster better organization and understanding of the facility. The Standard Rental and Use Fees document outlines lease and rental fees and policies for NELHA tenants. A NELHA Policies and Procedures Manual outlines standard operating procedures for employees and for the facility.

The administration worked closely with the National Defense Center of Excellence for Research in Ocean Sciences (CEROS) during the past year to assist their relocation to NELHA. CEROS is now under the authority of NELHA, and the Director of CEROS reports to the NELHA Board of Directors.

FISCAL OFFICE

The NELHA fiscal staff works closely with the State of Hawaii Department of Budget and Finance, the Department of Accounting and General Services, and DBEDT to manage the financial resources of NELHA.

An accountant and account clerk work with the NELHA staff to prepare and execute annual and biennium budgets, including Capital Improvement Projects (CIP). The fiscal office also performs accounts receivable, accounts payable, inventory, and revenue projections for NELHA.

ADMINISTRATION

Fiscal staff receive many requests from the state government offices and the legislature regarding the budget of the facility and program effectiveness. This department coordinates many of the responses for these requests and serves as a liaison for operational and financial audits of the program. The past year has been particularly challenging for the fiscal office due to the additional fiscal responsibility for CEROS and a reduced staff due to the state budget crisis.

As NELHA moves forward to implement plans for an economically self-sustaining facility, the fiscal office provides critical data and guidance for the administration to meet its goals.

MARKETING

The target markets to which NELHA promotes itself include aquaculture, alternative energy, biotechnology, ocean instrumentation, and ocean research projects producing niche or high value products. These organizations may benefit from a "made in Hawaii" label or simply from the unique resources available on-site. NELHA promotes itself as the only facility in the world providing strong year-round sunlight, cold deep and warm surface seawater in one location. The availability of these three resources in one location create a unique environment that fosters the development of research, commercial and educational projects.

To raise awareness about the facility, NELHA utilizes a variety of marketing tools such as display ads in industry journals; direct mail; displays and presentations at conferences; publicity in television, radio and newspapers; networking with industry leaders; marketing through world wide web pages, internet newsgroups, internet listservs; and holding public presentations and on-site seminars. A marketing video completed this year provides potential tenants with a visual introduction to the facility. Videos are made available to serious potential tenants and are also being distributed to marine laboratories, universities, and industry organizations around the nation.

ADMINISTRATION

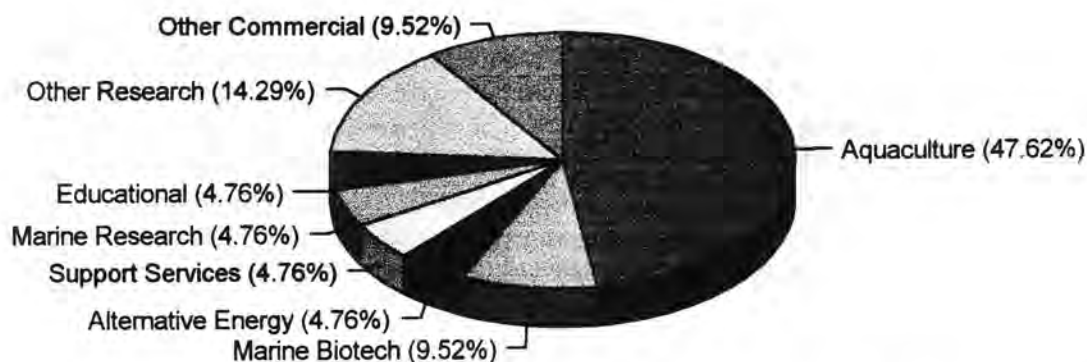
MARKETING

During the past year, two new tenants have established a presence at NELHA, High Health Aquaculture and JT R&D. A third project received final Board approval to begin a research project on site, began work, and then discontinued the project. An existing research project from prior fiscal years, the University of Kiel project, completed its current phase of research during FY 1996. Taylor United, Cyanotech, Aquasearch, and Common Heritage Corporation all received board approval to option additional land at NELHA accounting for approximately 170 acres in options, while Cyanotech exercised existing options and expanded operations during the fiscal year. Six additional tenants have received preliminary approval for their projects and are in the process of preparing final proposals or locating funding for their ventures.

The Marketing Department provides assistance to potential tenants in helping to locate start-up funding, preparing proposals and business plans, and in locating assistance through other state agencies such as the Aquaculture Development Program, DBEDT's Immigrant Investor Program, DBEDT's Business Action Center, the University of Hawaii-Hilo Small Business Development Center (UH-SBDC), the Kona-Kohala Chamber of Commerce, the Department of Labor and Industrial Relations, and other organizations. A Small Business Resource Center at NELHA provides business assistance literature, houses outlines for business and marketing plans, and provides a computer for tenant and potential tenant use. Information on aquaculture, energy, ocean science, and general business is located in the library adjacent to the business resource center.

An informal agreement with the UH-SBDC provides space for their business consulting experts to provide free consulting services on site at NELHA. Occasional workshops on doing business in Hawaii are also offered on site.

NELHA Tenant Mix By Number of Tenants



* Marine Biotech includes microalgae production

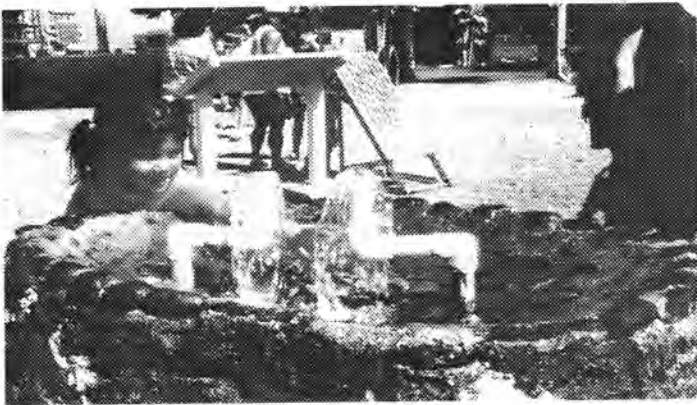
ADMINISTRATION

PUBLIC RELATIONS & PUBLIC EDUCATION

Educational Tours

As part of its commitment to education, NELHA provides presentations about the facility to adult visitors, groups, and school children. Public tours are offered each week to inform visitors of the ocean and solar development at NELHA. Visitors view a video about the facility and learn about the process of creating energy through Ocean Thermal Energy Conversion (OTEC). A focus on the economic development contributions of the environmentally friendly activities of NELHA's tenants helps to meet a growing demand for eco-tourism activities in Hawaii. Interactive exhibits provide visitors with an insight into the activities of NELHA's tenants. The facility hosted approximately 6,000 adult and student visitors during the fiscal year. A self-guided tour was developed to accommodate visitors who were unable to attend the regular public presentation.

The West Hawaii Explorations Academy (WHEA) students also offered educational tours to school children this year through its Aloha Kai Education Team. WHEA high school students teach kindergarten through sixth grade students about the use of cold seawater and warm seawater at NELHA. The younger students also learn about the importance of marine invertebrates and plants to Hawaii's reef community, and how to identify a variety of reef invertebrates.



NELHA's educational exhibits provide visitors with an interactive experience during their visit to NELHA. This fountain demonstrates the temperature difference between the cold deep and warm surface seawater pumped up at Keahole Point. (left)

During the Fourth Annual Open House NELHA staff lectured visitors on the unique uses of the resources at Keahole Point. Children enjoyed the exhibits and having their faces painted with symbols relating to NELHA activities. (right)



ADMINISTRATION

Open House, Earth Day, & Other Special Events

Extra-curricular events helped generate additional interest in the Keahole Point facility. The fourth annual Open House, held during Energy Awareness Month in October, was a great success and brought hundreds of individuals to the facility. An Independent Power Forum was held at NELHA in April sponsored by DBEDT's Energy, Resources and Technology division. This forum delivered information on how to provide your home with a source of energy independent of the utility company. Also in April, NELHA participated in an "Earth Fair" at Lanihau Center to celebrate Earth Day and raise awareness about the earth-friendly developments at Keahole Point.

"Serve America" Clean-Up

Each week throughout the month of May, NELHA hosted approximately one hundred students from Kealahou Intermediate who assisted NELHA with clean-up projects. The students chose NELHA as the focus of their "Serve America" award. Throughout the month the students were involved in beach clean-ups, weeding along the NELHA entrance road, and general clean-up around the facility. Prior to their service, NELHA provided the students with an introduction to some of the staff who work at Keahole Point. This career exploration helped to stimulate the desire to explore new career ideas and to set goals for higher education.

Media Exposure

NELHA received significant exposure from the media during the past fiscal year. The Star-Bulletin, Honolulu Advertiser, Pacific Business News, Big Island Television and West Hawaii Today all provided excellent coverage of NELHA's activities. The facility also received excellent exposure in Success Magazine, The San Francisco Examiner, Popular Science and Fish Farming News. Site visits from journalists representing the Associated Press, the Wall Street Journal, and BBC gathered information for future stories and features on NELHA.

ADDITIONAL ACTIVITIES AND ACCOMPLISHMENTS AT NELHA

'The Information Superhighway' comes to NELHA

NELHA and several of its tenants joined the growing number of organizations that have developed a presence for themselves on the internet. The world wide web provides visitors to your site not only with information about your organization, but also with visuals and possibly sound and video. The electronic medium can provide an inexpensive means of communicating your message to local, national and international audiences and can be changed or adapted inexpensively and easily. The Natural Energy Laboratory utilizes its web page as a marketing tool to reach potential tenants for the facility. The page also provides an educational service to anyone interested in aquaculture, ocean thermal energy conversion, marine biotechnology and other activities that are current or potential uses of the NELHA resources. The following web pages provide information about NELHA and its tenants:

**The Natural Energy Laboratory
of Hawaii Authority**

[Http://bigisland.com/nelha](http://bigisland.com/nelha)

Aquasearch Inc.

[Http://www.aquasearch.com](http://www.aquasearch.com)

Common Heritage Corp.

[Http://www.aloha.com/~craven](http://www.aloha.com/~craven)

Cyanotech Corp.

[Http://www.cyanotech.com](http://www.cyanotech.com)

ADDITIONAL ACTIVITIES AND ACCOMPLISHMENTS AT NELHA

The National Defense Center of Excellence for Research in Ocean Sciences (CEROS)



The National Defense Center of Excellence for Research in Ocean Sciences (CEROS) moved its headquarters from Honolulu to Keahole Point this fiscal year. The physical move paralleled the organization's administrative transfer from the High Technology Development Corporation (HTDC) to NELHA. CEROS now has offices on the second level of NELHA's administration building.

CEROS was created through a Department of Defense Appropriation Act in 1993 which directed a cooperative effort between the Defense Advanced Research Projects Agency (DARPA) and HTDC for the purpose of conducting research and development activities of interest to the Department of Defense (DoD). CEROS fosters technology development and commercial use of ocean research facilities in Hawaii. By encouraging participation of Hawaii companies with special expertise that may apply to DoD requirements, CEROS advances the State's goals of expanding technology-based industries. CEROS provides grants to highly specialized organizations in Hawaii with recognized expertise in ocean-related research relevant to national defense.

The CEROS mission for ocean research and technology development consists of the following:

- Encourage leading edge research and development in ocean sciences;
- Support the Department of Defense;
- Use the exceptional ocean research facilities in Hawaii;
- Involve highly specialized small businesses with recognized expertise in ocean-related research; and
- Develop regular access to the ocean science expertise and facilities at the University of Hawaii.

ADDITIONAL ACTIVITIES AND ACCOMPLISHMENTS AT NELHA

CEROS FUNDING

Since 1993, CEROS has funded 38 projects. The allocation of CEROS funding among the five technical topic areas identified in the legislation that originally funded CEROS is as follows:

<u>Project Topic Area</u>	<u>FY93</u>	<u>FY94</u>	<u>FY95</u>	<u>Total</u>
Shallow Water Surveillance Technologies	2,327,326.00	1,875,659.00	2,239,870.00	6,442,855.00
Ocean Environment Preservation	460,196.00	1,093,795.00	2,482,118.00	4,036,109.00
New Ocean Platform and Ship Concepts	757,250.00	1,064,600.00	751,793.00	2,573,643.00
Ocean Measurement Instrumentation	1,000,058.00	435,000.00	223,870.00	1,658,928.00
Unique Properties of the Deep Ocean Environment	0.00	621,459.00	206,960.00	828,419.00
<i>Subtotal</i>	<i>4,544,830.00</i>	<i>5,090,513.00</i>	<i>5,904,611.00</i>	<i>15,539,954.00</i>
Administration	477,132.00	305,461.00	595,000.00	1,377,593.00
Management Reserve	48,038.00	54,000.00	254,211.00	356,249.00
<u>TOTAL</u>	<u>5,070,000.00</u>	<u>5,449,974.00</u>	<u>6,753,822.00</u>	<u>17,273,796.00</u>

In February 1996, and addiitonal \$6,399,100 in funding was released to DARPA for the CEROS FY96 program. This funding will support eleven projects under the FY96 Core program.

CEROS operates under the oversight of the NELHA Board of Directors, which sets broad goals, develops policy, and provides guidance for the CEROS program. CEROS programs and management are also reviewed and evaluated by DARPA as the CEROS grantor, will full recognition and encouragement of NELHA.

SERVICES AVAILABLE TO NELHA TENANTS

OPERATIONS and MAINTENANCE

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

ENGINEERING

Piping Design
Site Development
Computer Aided Drafting
Electrical Systems Analysis
Construction of Structures

ANALYTICAL LABORATORY

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

ADMINISTRATION

Clerical Support
Leases and Service Contract Support
Telecommunication Support
Fiscal Support
Graphic Design
Educational Programs
Business Development & Marketing Assistance

FOSTERING ECONOMIC DEVELOPMENT AT NELHA

The mission of NELHA is to promote economic development and diversification through supporting its tenants who are utilizing the unique resources available at Keahole Point. These resources are:

Cold Deep Seawater- NELHA is the only site in the world which consistently brings ashore large amounts of cold, deep seawater for use in Ocean Thermal Energy Conversion (OTEC) and a variety of aquaculture and associated projects. This seawater is about 43°F (8°C), virtually pathogen-free, and has high concentrations of inorganic nutrients.

Warm Surface Seawater- NELHA consistently brings ashore large amounts of warm ocean water. The water is rated class AA and ranges in temperature from 76-82°F (24.5-27.5°C).

Sunshine- Keahole Point has the highest solar insolation of any coastal site in the United States.

These resources are being utilized at Keahole Point to support industries that are not only new to Hawaii but to the world as well. NELHA staff believe that many of the uses of the resources at NELHA have not yet been recognized. The ready availability of a large "cold-sink" at the same site as sunshine provides opportunities for creative engineering of systems for enhancing plant and animal growth, cooling buildings and industrial processes, desalinating seawater and myriad other chemical and physical processes. One of the more interesting developments that is finding commercial success is the production of algae.

ALGAE

For many aquaculture companies, algae is an unwanted inhabitant in culture tanks. The "weeds" take hold in the tank and creates a burden to the culturists who have to keep the growing environment clean for their product. Several companies at NELHA, however, are exploiting the environment at Keahole Point to grow micro- and macro- algae as their primary product.

Microalgae

Microalgae are microscopic plants that grow very fast. Over 30,000 different species of microalgae have been identified yet only a few have been commercially developed. A variety of different uses exist for microalgae including food supplements, pharmaceutical uses, diagnostic and tagging purposes, pigments, and even energy production. The food supplement application is the most significant use of microalgae today. Because of the conducive growing environment, NELHA is one of the best locations in the world to grow microalgae. The NELHA facility is positioned to foster the development of this industry well into the next century.

FOSTERING ECONOMIC DEVELOPMENT AT NELHA

Both Aquasearch Inc. and Cyanotech Corporation were attracted to the NELHA facilities because of the ideal conditions for growing their microalgae products. The pristine water and high sun are two factors that work in their favor. In addition, the low rainfall (less than 15 inches per year) keeps the culture ponds from being flooded, while the available ground water provides fresh water for certain strains of algae culture.

Taylor United Hawaii is a subsidiary of Taylor United Inc. of Shelton, Washington. The company established a shellfish nursery/hatchery at NELHA in order to produce seed from manila clams and other shellfish year round. The strong sun and clean water available at NELHA provide an excellent environment for growing the food which supports the growth of clam seed-- microalgae. The company has recently renovated a large tank at NELHA in which it is growing nearly 300,000 gallons of algae to feed to its clams and oysters. When the shellfish reach a certain size they are shipped back to Puget Sound for grow out in the ocean.

Macroalgae

Macroalgae are larger aquatic plants, such as seaweed, that can be utilized for food, medicine and other purposes. Just as Keahole Point is ideal for microalgae production, it is also excellent for macroalgae production. Royal Hawaiian Sea Farms Inc. and Uwajima Fisheries Inc. are both growing macroalgae on-site. Several varieties are in production and are being marketed as food products. Future production by these or other companies could include the production of macroalgae for pharmaceutical and cosmetic purposes.

COLD SEAWATER AIR CONDITIONING

One of the most cost-effective uses of cold seawater is for air conditioning buildings. NELHA saves nearly \$4,000 in electricity charges each month by using cold seawater to air condition the laboratory and administration buildings. Several tenants take advantage of this technology which can be as simple as utilizing a recycled automobile radiator. This concept has excellent potential where a cluster of developments can collectively take advantage of the cold seawater pumped ashore. The capital expended on such a project could be amortized relatively quickly.

ALTERNATIVE ENERGY

The Natural Energy Lab is famous worldwide for the pioneering efforts that have taken place on site in Ocean Thermal Energy Conversion (OTEC). The steep drop-off at Keahole Point allows close access to the deep seawater. The temperature difference between the deep and surface seawater can be converted to useful forms of energy such as electricity. The same intense sun that warms the water is also valuable for development of solar energy technologies. By fostering the development of alternative energy, NELHA is contributing to a more sustainable future.

FOSTERING ECONOMIC DEVELOPMENT AT NELHA

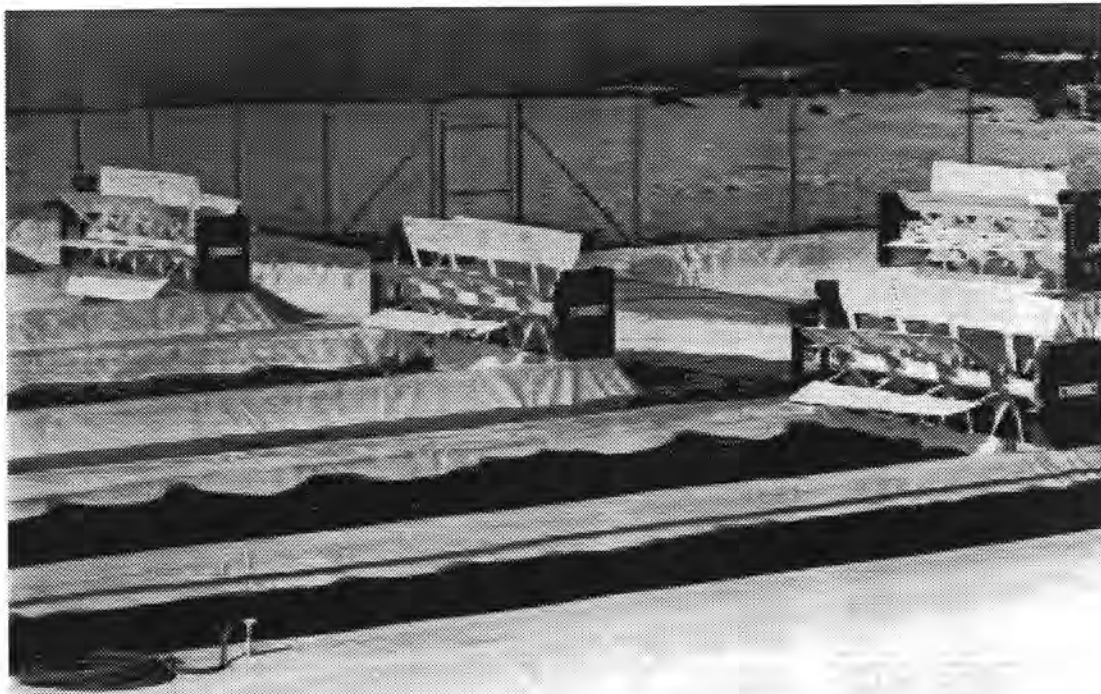
AQUACULTURE & MARINE BIOTECHNOLOGY

Aquaculture

The agricultural revolution that domesticated numerous land plants several centuries ago, may soon find its counterpart in the aquacultural revolution. In the future, more and more aquatic plants and animals will be grown in controlled environments. Many of the tenants at NELHA are involved in aquaculture, growing plants or organisms in water. It is a relatively new industry that is growing in importance world-wide as world fisheries are over-harvested. As the natural fisheries become stressed, there is a growing need for products to replace or supplement the catch. NELHA is the only site in the world that provides both cold deep and warm surface seawater in one location, in effect permitting tropical reef fish and Maine lobsters to be cultured adjacent to each other without the cost of chilling or warming the water.

Marine Biotechnology

A growing number of health professionals are finding cures and medications for human disease through the extraction of compounds from living organisms. Many of these medications can be found in aquatic plants and animals. NELHA provides an ideal environment for marine biotechnology firms that are developing these products.



NELHA TENANTS

NELHA TENANTS

NELHA exists to serve the tenants who lease land and utilize resources available at Keahole Point for a variety of activities. The individuals who are involved in the various research, commercial and educational activities at NELHA are leaders in their fields. A number of them are known world-wide for their efforts. Their expertise is breaking new ground in areas of alternate energy production, mass algae production, aquaculture, agriculture, astrophysics, natural antibiotic development and other key areas of research.

Their economic impact on the local economy utilizing standard economic multipliers for their capital improvement expenditures and annual revenues is in excess of \$41 million annually.

These pioneers are setting the pace for the world. They are the beginning of what NELHA hopes will be a fully developed ocean science and technology community at Keahole Point.



Aquasearch produces astaxanthin, a red pigment from microalgae, for use in the farm raised salmon and shrimp industry.

Aquasearch Inc. Aquasearch is engaged in the development of proprietary, cost-effective, photobioreactor technology for the industrial cultivation of microalgae, and in research and development of products derived from microalgae. The company was formed by a group of scientists at the Scripps Institution of Oceanography in La Jolla, California in 1989, and currently utilizes expert scientific advice from some of the world's leading scientists. The initial microalgal product is *astaxanthin*, a natural pigment which gives shrimp and salmon their characteristic pink color.

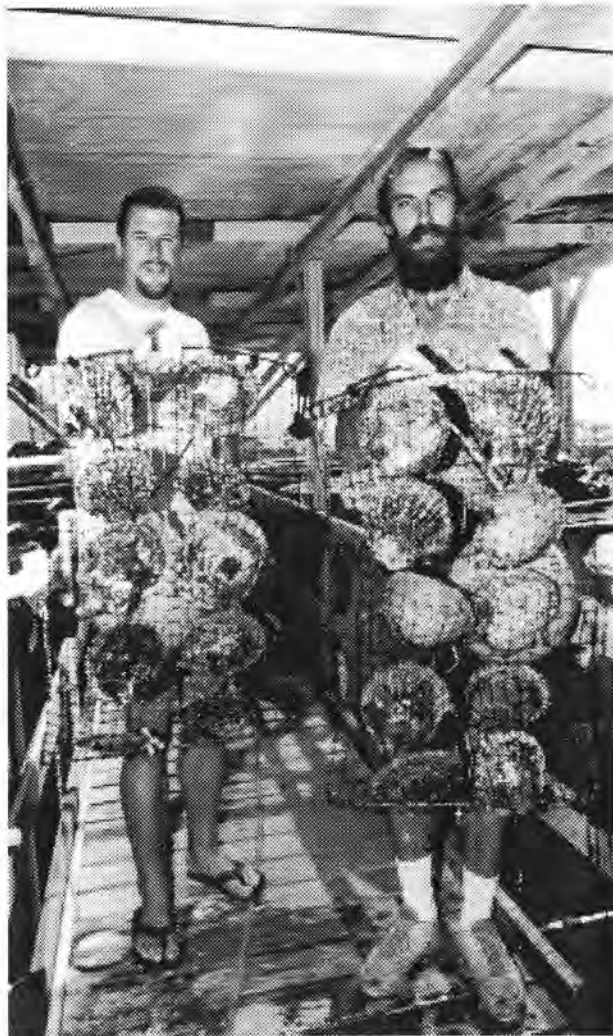
During the past fiscal year, Aquasearch has had three significant developments. First, it has produced and completed shipments of *astaxanthin* which are believed to be the largest produced quantity of natural *astaxanthin* from any supplier. Second, on May 14, 1996 Aquasearch entered into a three-year Distribution and Development Agreement with Cultor of Finland, in which Cultor will market, sell, and distribute Aquasearch's natural *astaxanthin* on a

NELHA TENANTS

worldwide basis. And third, on July 30, 1996, Aquasearch was awarded a U.S. Patent for the Aquasearch Growth Module, a proprietary system for producing microalgae.

The company is currently exploring the engineering and technical issues required to make significant expansions of its astaxanthin production. In addition, the company believes it has identified several markets in which additional pigments from microalgae might be sold and, based on industry sources, estimates the value of these markets to be in excess of \$500 million annually.

Aquasearch believes that its established research and development capabilities, strategic alliances, market development capabilities and patent protection combine to provide a strong business base. If you have internet access you can reach Aquasearch at <http://www.aquasearch.com>



Black Pearls Inc. staff with oyster broodstock at NELHA.

Black Pearls Inc. has developed 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 a combination land/ocean growout system. The company has also developed a remote quarantine hatchery system which now allows expansion of pearl farming into many islands in the Pacific. Broodstock are flown to the hatchery, spawned, and the larvae are then reared under state-approved quarantine conditions. Once the spat settle, they are flown back to the farm site. A commercial pearl farm has been established in the Marshall Islands using remote hatchery methods. Black Pearls Inc. is also working with an established pearl farm operation in The Philippines to build and operate a gold-lip pearl oyster hatchery there.

NELHA TENANTS

Common Heritage Corporation (CHC), 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. If you have internet access, you can reach CHC at: <http://www.aloha.com/~craven>

Cultured Technologies Inc. is involved in research of a number of aquaculture species, with primary emphasis presently on the pearl oyster.

Cyanotech Corporation develops and commercializes natural products from microalgae. The Company is currently producing microalgal products for the nutritional supplement and immunological diagnostics markets and is also developing microalgae-based products for the aquaculture feed/pigments and biopesticide markets. Nutrex, Inc., the Company's wholly-owned subsidiary, produces and markets a line of Spirulina-based nutritional products for the retail market. The Nutrex products are the only microalgae products in the world that are certified organic.

Last year was very busy for Cyanotech. The Company doubled production of its nutrition supplement Spirulina Pacific™, began pilot production of the red aquaculture pigment *astaxanthin*, commenced laboratory production of a genetically engineered microalgae which kills mosquito larvae, and successfully completed a public offering which netted the Company \$10.6 million. If you have internet access you can reach Cyanotech Corp. at: <http://www.cyanotech.com>



Cyanotech Corporation is growing 650 metric tons of Spirulina annually in long algal raceways. Paddlewheels keep the spirulina moving in the pond in order to reach the sunlight which is responsible for the high production levels of the microalgae.

NELHA TENANTS

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.

Hawaiian Bred Tropicals is involved in research to investigate breeding techniques for ornamental reef fish. Their success will help to supply the commercial aquarium market, reducing its current pressure on the natural reef population.

Helium As A Groundwater Tracer- Dr. L. Stephen Lau, retired Director of the Water Resources Research Center of the University of Hawaii at Manoa, and Prof. Aly El Kady of the WRRC have initiated an experimental program at NELHA to investigate the use of helium as a groundwater tracer. Initial experiments in the open-cycle OTEC disposal trench have demonstrated that the helium travels with the groundwater and is easily detected at very low levels. This is possible because the lack of naturally occurring helium in Hawaiian groundwater makes the measurement noise level extremely low. The researchers have applied to the National Science Foundation for funding to expand the program. NELHA anticipates that this new technology will enable us to trace how the seawater from our disposal trenches enters the ocean.

High Health Aquaculture's mission is to develop and supply certified pathogen-free broodstock to the world's shrimp hatcheries. As a new tenant at NELHA, the majority of their time has been spent on facility development. By the end of 1996, they plan to complete their first phase facility that includes basic infrastructure (water, air, electrical and security systems) and broodstock rearing tanks. A shrimp reproduction system has already been installed. In addition to facility development, the company has worked on developing new stocks of pathogen-free shrimp. With the assistance of Dr. Jim Brock, the company has established certified stocks of *P. stylirostris* and *P. vannamei* from the Oceanic Institute. The company's motto is: Healthy shrimp are profitable shrimp.

NELHA TENANTS



Indo-Pacific Sea Farms specializes in the Giant Tridacna Clam, native to Palau.

Indo-Pacific Sea Farms' (IPSF) mission is to develop and commercialize innovative technologies for sustainable production of reef-dwelling organisms. IPSF's present research and development emphasis is on photosynthetic molluscs and cnidarians, primarily giant tridacnid clams and scleractinian (reef-building) corals. These photosynthetic animals derive nutrition from their association with microscopic algal symbionts called zooxanthellae. Cultivation requirements for the plant-animal consortium are similar to those of free-living microalgae, and include tropical sunlight, warm surface seawater and a carefully controlled concentration of deep sea water to control temperature and supplement essential inorganic nutrients such as nitrogen and

phosphorus. IPSF uses no commercial feeds and produces no seawater pollution with this novel approach. The products produced by IPSF are currently in demand in the seafood and aquarium industries and also have potential biomedical applications.

Island Traders, Inc. uses the abundant sunshine at Keahole Point to produce sun-dried fish jerky. 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. Island Traders is producing its product in a shorter time than standard methods and without the use of electricity.

JT R&D is establishing a facility at Keahole Point to design and manufacture oil-less clean fluid-components for Life Support Systems Divisng equipment. The types of tools may include instruments with 'seawater resistant' aluminum alloy, plastic ceramic and composite materials.

Kona Bay Oyster & Shrimp produces blue shrimp and american and pacific oysters. They continue to develop work begun by Aquaculture Technology Inc. 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.

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 Pacific 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

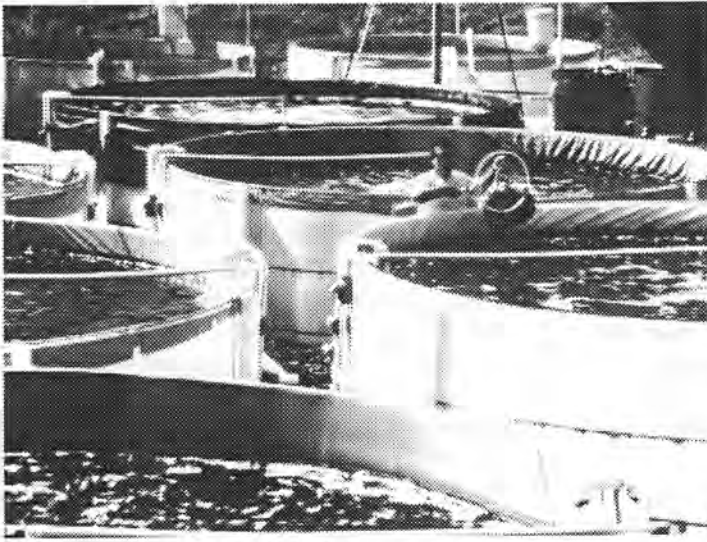
Marine Science Research Center (MSRC), from the State University of New York at Stony Brook, is investigating the feeding activity of a group of planktonic animals, collectively called copepods. Living in the surface and deep seawater, copepods form an important link in the marine food web by passing 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.

Ono Take Corporation, performs research on 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. The company is also experimenting with hydroponic lettuce, watercress, and other products.

Pacific International Center for High Technology Research (PICHTR). PICHTR's 210 kW open-cycle OTEC facility has concluded its third year of successful operation. The primary objective is to continue operation of the plant to gather life cycle data for the major components (turbine and high speed vacuum compressors) and to acquire experience in the operation of OTEC plants for the production of electricity and desalinated water. Another objective is to continue dissemination of the knowledge acquired by publishing articles in professional journals and interacting with the general public during tours of the facility. The experimental work was sponsored by the State of Hawaii and the federal Department of Energy. The open-cycle OTEC plant has produced up to 255 kilowatts (kW), using 150 kW to operate the plant and resulting in up to 100 kW of usable electrical power and 7,000 gallons of fresh (desalinated) water per day. These are world records for OTEC.

With funding from the State of Hawaii, PICHTR, the Hawaiian Electric Company, and the Defense Advanced Research Project Agency of the U.S. Department of Defense, PICHTR completed the construction of a 50 kW Closed Cycle OTEC experimental apparatus in 1996. The plant was designed to test roll-bonded aluminum heat exchangers designed and manufactured by ALGOODS of Canada. Unfortunately, during plant shakedown, the aluminum heat exchangers developed pits which rendered them inoperable. ALGOODS is fulfilling their contractual obligation to re-furbish the units so the testing can resume.

NELHA TENANTS



Royal Hawaiian Sea Farms grows tons of "sea vegetables," for local families in these large tanks at their facility.

Royal Hawaiian Sea Farms, Inc. has been in business since 1987 and commercially produces limu, or edible sea vegetables. Sales of these popular nutritious delicacies have consistently reached over a ton per week. A pickled ogo (**Gracilaria**) product is being processed under the "Waimanalo Ko-Ko" brand. In addition to limu, RHSF also produces salt water tilapia (**Tilapia**) and milkfish (**Chanos**). Intensive applied research is being conducted to investigate the potential of commercially producing edible sea cucumbers (**Stichopus**), the Hawaiian limpet- opihi (**Cellana**), and warm water abalone (**Haliotis**).

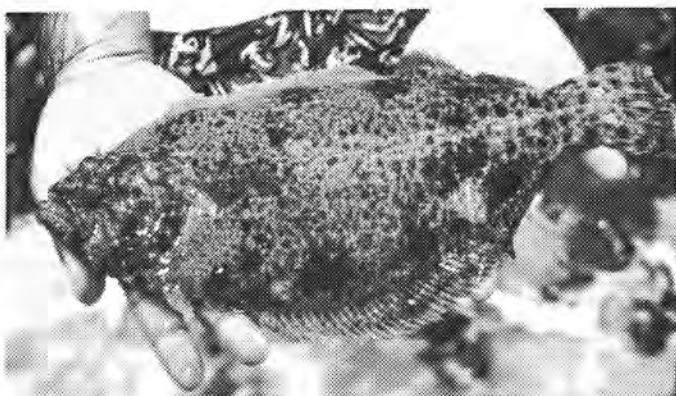
SeaTech Contracting, Inc. is a general and environmental contracting/marine construction company with an emphasis in commercial diving. They were the first support company to locate at Keahole Point and provide highly skilled services to NELHA, its tenants and companies in the surrounding area. Seatech's skills center around underwater surveys, underwater piping and pumping systems, dredging, drilling and salvage. This past year, Seatech has invited instructors from the Clean Islands Council to NELHA to qualify their employees for HAZWOPER First Response oil spills. The Natural Energy Lab now stands ready, with the only contracting team on the Big Island, to handle hazardous oil spills along the coast of Kona and Kohala.

Taylor United Inc. is a family owned and operated shellfish company with its headquarters in Shelton, Washington. Their manila clam and pacific oyster facility at NELHA serves as a nursery for only a small segment of the life of the juvenile shellfish. They raise the larvae in their hatchery in Washington and send them to Hawaii just after they have settled out of their swimming cycle. At this stage they are about 250 microns in size. At the NELHA facility, Taylor United raises the shellfish up to 5 mm size on screens and in sand raceways. They are then shipped back to the Pacific Northwest for growout. The cold and the warm seawater provided by NELHA are utilized to achieve exact temperatures needed for shellfish growout, and the year round warm climate allows a year-round growing season for the shellfish. Future plans include an expansion of their nursery in order to produce up to 400 million juvenile clams and 10 million juvenile oysters over the next year.

"Taylor wanted us to produce 100 million clam seed this year. I thought we'd do well if we could produce 50 million. Three-quarters through the year we have already produced 150 million clam seed, far exceeding our goals. "

Mark Weigardt, Taylor United Hawaii

NELHA TENANTS



This Japanese flounder, or hirame, is grown by Uwajima Fisheries, Inc. The fish is delicious for sashimi or sushi.

Uwajima Fisheries, Inc. (UFI) has developed a facility for growing hirame, a flounder highly prized by the Japanese for sashimi and sushi.

Uwajima Fisheries markets their 1 1/2 to 2 lb hirame through a Honolulu distributor who supplies the Oahu sushi market and is also beginning to export the product to the west coast of the US. UFI manages the maturation and spawning of their broodstock for 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 a strict Specific Pathogen Free 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 Threadfin (Moi).

The University of Kiel has conducted experiments on optimizing the production of hydrogen by photovoltaic electrolysis of seawater using inexpensive components. They have also performed research on the extraction of trace amounts of heavy metals from seawater.

West Hawaii Explorations Academy (WHEA), is a High School Program for Hawaii students, sponsored by the State Department of Education and partly funded by the National Science Foundation. 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. This is the third year for the school and the site is expanding. In addition to a trailer which functions as a computer laboratory, a portable classroom is being constructed. Rather than attend classes, students receive credit for working on projects such as aquaculture, cold water agriculture, alternative energy development, alternative vehicle construction, aquarium construction and many others. Students are encouraged to take on NELHA tenant research projects or seek volunteer employment with tenants. The Explorations Academy works with the Workforce 2000 committee and is a model for the "School-to-Work" national movement.



High School students from WHEA serve as mentors for elementary students through educational tours provided by WHEA's Aloha Kai Educational Group.

NELHA FINANCIAL POSITION

STATEMENT OF OPERATIONS NIIII

(For the period July 1, 1995- June 30, 1996)

REVENUES

General Funds

State Funds	\$1,022,687.00
Restrictions	<u>(\$21,466.00)</u>
Subtotal	\$1,001,221.00

Special Funds

Land Use Fees	\$192,996.17
Reimburseables	\$419,500.77
Interest Received	\$41,561.30
Vending Machine Sales	\$273.76
T-Shirt Sales	\$0.00
Percentage Rents	<u>\$0.00</u>

Subtotal \$654,332.00

Total Revenue \$1,655,553.00

EXPENDITURES

General Funds

Salaries	\$785,700.00
Kona Operations	\$201,194.72
Puna Operations	<u>\$13,092.14</u>

Subtotal \$999,986.86

Special Funds

Operations	<u>\$561,693.85</u>
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Total Expenditures \$1,561,680.71

FINANCIAL POSITION

Special Fund Balance July 1, 1995	\$1,046,018.20
State General Fund Appropriations	\$1,001,221.00
Special Fund Revenues	<u>\$654,332.00</u>
	\$2,701,571.20

General Fund Expenditures	\$999,986.86
Special Fund Expenditures/journal entries	\$561,693.85
Unrequired G/F Returned to St Treasury/DBEDT	<u>\$1,234.14</u>
	\$1,562,914.85

Ending Special Fund Balance 6/30/95 \$1,138,656.35

PROJECT APPLICATION PROCEDURES

Project Application Procedures

NELHA welcomes applications from individuals, businesses, research organizations, and educational facilities desiring to perform research, commercial or educational activities at Keahole Point. The professional and skilled staff at NELHA apply their scientific and business knowledge to assist tenants during all phases of operation from research and development to product commercialization. The NELHA staff assists projects through a smooth transition from R&D to a fully operational business.

Project Approval

Projects that wish to locate at NELHA should follow the procedures outlined in the Project Initiation Packet (PIP). A preliminary proposal is submitted to the NELHA Board of Directors for approval. Projects must fit within the mission of NELHA, utilizing the unique resources available on-site, while not harming the environment. The Board seeks projects that will make significant contributions to the advancement of research, education or economic development for the region. Research projects require only the preliminary stage of approval. Commercial projects must complete a second stage approval that includes the submission of a business plan and financial projections. Individuals or businesses with an interest in starting a project at NELHA are invited to submit a proposal that follows the outline in the PIP.

Incubation For Start-Up Businesses

NELHA is the only ocean, science and technology park of its kind in the world. The objective of the facility is to encourage economic development and diversification through the management of a state owned facility which leases land and provides services for projects whose operations require the unique resources available at Keahole Point. Through the support NELHA provides to business start-ups, it is incubating the development of new industries that are offering alternatives to tourism and traditional agriculture in Hawaii.

PAST RESEARCH PROJECTS

- **Keahole Point**
- **Puna Research Center**

PUBLICATIONS

- **Keahole Point**
- **Puna Research Center**

Past Research Projects at 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 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 70ppb 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.

* ATMOSPHERIC CORROSION- (07/81 to 03/83)

FUNDING SOURCE- UH Foundation

Investigated the effects on a variety of metals of long term exposure to the marine atmosphere.

* 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/ORN/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 Keahole Point

* 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 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.

* MILOLII DESALINATION- (06/88 to 10/89)

FUNDING SOURCE- Hawaii County Economic Opportunity Council (State Funds)

Developed and tested a desalination apparatus for installation in the isolated village of Milolii in the Ka'u District.

Past Research Projects at Keahole Point

*** 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.

*** ETHANOL FROM BAGASSE- (06/89 to 08/94)**

FUNDING SOURCE- Sogi International

Developed solar distillation using cold seawater for condensation to distill ethanol from sugar cane bagasse for use as a motor fuel.

*** MAHIMAHU CULTURE- (06/89 to 06/91)**

FUNDING SOURCE- Hawaii Seafood Growers

Raised Mahimahi (dolphin fish) in tanks 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.

Past Research Projects at 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.

Past Research Projects at Puna Research Center

* 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

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.

Publications resulting from work at Keahole Point:

Berger, Leslie Ralph and Joyce A. Berger, June 1986, Countermeasures to Microbiofouling in Simulated Ocean Thermal Energy Conversion Heat Exchangers with Surface and Deep Ocean Waters in Hawaii , *Applied & Environmental Microbiology*, P. 1186-98.

Boxshall, G.A., J. Yen and J.R. Strickler. in press. Functional significance of the sexual dimorphism in the array of setation elements along the antennules of *Euchaeta rimana* Bradford. *Bulletin of Marine Science*.

Brewer, Wm. A., Jack P. Huizingh and Jane E. Sexton, NO 1/85, Hawaii's OTEC Park Triggers High-Tech Aquaculture Development , *Info-Fish Marketing Digest*, p. 18-21.

Craven, J.P., Mar 8-11, 1994, Coldwater agriculture as a component of a deep ocean water recovery system , *Conference Proceedings: Oceanology International '94*, Brighton, U.K., Vol 5, No. 17, 9p.

Creber, D.K., Mar 8-11, 1994, Design considerations for a closed-cycle OTEC plant for Keahole Point, Hawaii , *Conference Proceedings: Oceanology International '94*, Brighton, U.K., Vol 5, No. 9, 20p.

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

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

Daniel, T.H., Nov. 12-14, 1985, Aquaculture Using Cold OTEC Water , *Oceans '85 Conference Record*, Marine Technology Soc., San Diego, Ca., p. 1284-89.

Daniel, T.H., Sept. 23-25, 1986, Operational Experience with the Cold Water Pipe at the Natural Energy Laboratory of Hawaii , *Oceans 86 Conference Record*, Marine Technology Soc., Washington, D.C., p. 185-90.

Daniel, T.H., November 1988, Ocean Thermal Energy Conversion and the Natural Energy Laboratory of Hawaii , in Fast, A.W. and K.Y. Tanoue, eds., *OTEC Aquaculture in Hawaii*, UH Seagrant, p.5-48.

Daniel, T.H., April 1989, New Seawater Delivery Systems at the Natural Energy Laboratory of Hawaii , *Solar Engineering*, A.H. Fanney and K.O. Lund, eds., Am. Soc. of Mech. Engrs., Book No. H00467-1989, p. 323-330.

Daniel, T.H., Jun 1-6, 1992 An Overview of Ocean Thermal Energy Conversion and its Potential By-products , presented at Pacific Congress on Marine Science and Technology - PACON '92, Kailua-Kona, Hawaii, published in *Recent Advances in Marine Science and Technology*, 92, ed. by Narendra K. Saxena, PACON INTERNATIONAL, Honolulu, 1993, p.263-272.

Daniel, T.H., April 1993, Current Projects and Environmental Programs at NELH/HOST , Invited Paper at Twelfth Big Island Science Conference, UH Hilo.

Daniel, T.H., Mar 8-11, 1994, Deep Ocean Water Utilization at the Natural Energy Laboratory of Hawaii Authority , *Conference Proceedings: Oceanology International '94*, Brighton, U.K., Vol 5, No. 16, 13p.

Daniel, T.H., April 1996, Analyzer and Fiberglass Enclosure Protect the Operation of Ocean Thermal Energy Plant, *Instrumentation and Control Systems*, p. 73-75.

Daniel, T.H., Mar 22-25, 1994, The Promise of OTEC and Its By-Products , Paper G17 in *Global Environment and Friendly Energy Technology 1994: Proceedings of the 1994 Mie International Forum and Symposium*, ed. by Shimizu, Y., K. Seizo and M. Hoki, Tsu, Mie, Japan, p. 516-518.

DiChristina, Mariette, May 1995, Sea Power, *Popular Science*, p.70-73.

Fast, Arlo W. and Karen Y. Tanoue, November 1988, eds., *OTEC Aquaculture in Hawaii*, UNIH-SEAGRANT-MR-89-01, UH Seagrant College Program, Honolulu, 178p.

Fields, D.M. and J. Yen, Gyrotaxis: Implications of Copepod Feeding Currents on the Spatial Orientation of their Prey , *J. Plankt. Res.*, In Press.

Fields, D. and J. Yen, 1993, Outer Limits and Inner Structure: The 3-Dimensional Flow Fields of *Pleuromamma xiphias* , *Bull. Mar. Res.*, 53:84-95.

Fields, D.M. and J.Yen. 1995 The escape behavior of *Pleuromamma xiphias* from a quantifiable fluid mechanical disturbance. *Mar. Freshw. Behav. Physiol.* 25.

Fields, D.M and J. Yen. in press. Gyrotaxis: Implications of copepod feeding currents on the spatial orientation of their prey. *J. Plankton Res.*

Fitzpatrick, N.P., V. Hron, E. Hay and F.A. Johnson, 11-13 December, 1989, Alcan's Ocean Thermal Energy (OTEC) Program , presented at: 9th Miami International Congress on Energy & Environment, 11p.

Frederick, Ronald M., Dec. 1995, Microtunneling Meets Mother Nature, *Civil Engineering*, ASCE, p. 36-39.

Gassie, D.V., P.H. Lenz, J. Yen, and D.K. Hartline, 1993, Mechanoreceptors in Zooplankton First Antennae: Electrophysiological Techniques , *Bull. Mar. Res.*, 53:96-105.

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

Hachmuth, C.A., Aug 9-10, 1991, "On the Properties of Deep Sea Water at Keahole Point", *Proceedings of The International Forum on Deep Sea Water*, Kochi Prefecture, Japan.

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

Halloran, R., May 22, 1990, Tapping Ocean's Cold for Crops and Energy , *N.Y. Times*, p. C4.

Hawaii Public Television KHET, Kona Cold: It's the Water , 1/2 hour videotape in Series: Facets of Science, Filmed July 1989, Broadcast Feb 1990.

Johnson, F.A., Nov. 1989, A 250 KW Closed Cycle Land Based Ocean Thermal Energy Plant , presented at International Conference on Ocean Energy Recovery, Hawaii Natural Energy Institute, Honolulu, 5 p.

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

-
- Kearney, T.J. and F.J. Sansone**, 1985, Analysis and Formation Mechanisms of Mixed N-Halogenated Methylamines, presented at the Fifth Conf. on Water Chlorination, Williamsburg, Va., 3-8 June, 1984. in *Water Chlorination: Environmental Impact and Health Effects*, Vol. 5, R.L. Jolley, et al. (eds).
- Krock, H.-J. and M.J. Zapka**, April, 1986, Gas Evolution in Open Cycle OTEC, *Proceedings of 5th Symposium on Offshore Mechanics and Arctic Engineering*, Tokyo, Japan, p. 612-17.
- Larsen-Basse, J.**, April, 1983, Corrosion of Some Aluminum Alloys in Cold and Warm OTEC Waters, presented at Corrosion 83, Paper No. 66, NACE.
- Larsen-Basse, J.**, March, 1983, Effect of Biofouling and Countermeasures on Heat Transfer in Surface and Deep Ocean Hawaiian Waters - Early Results from the Seacoast Test Facility, presented at ASME/JSME Thermal Engineering Joint Conference, Honolulu, Volume 2, p 285-9.
- Larsen-Basse, J. and T.H. Daniel**, August, 1983, OTEC Heat Transfer Experiments at Keahole Point, Hawaii, 1982-1983, presented at Oceans '83, San Francisco, Ca.
- Larsen-Basse, Jorn and Sanjeev Jain**, Sept 1986, Aluminum Alloys as Potential O.T.E.C. Heat Exchanger Materials, *Oceans 86 Conference Record*, Marine Technology Soc., Washington, D.C., p. 191-195.
- Larsen-Basse, Jorn, Sanjeev Jain, Joyce A. Berger and Leslie R. Berger**, March, 1987, Effect of Marine Microbiofouling and Countermeasures on Corrosion of Some Aluminum Alloys Under OTEC Heat Exchanger Conditions, *Proceedings: Corrosion 87 Paper #346*, NACE, San Francisco.
- Larsen-Basse, J., N. Sonwalkar and A. Seki**, Sept. 1986, Preliminary Seawater Experiments with Open Cycle O.T.E.C. Spout Evaporation, *Oceans 86 Conference Record*, Marine Technology Soc., Washington, D.C., p.202-6.
- Lau, L.S. and A.I. El Kady**, 1995, Injected Helium Technology for Near-shore Environmental Water Monitoring (ABS), *EOS- Transactions of the AGU*, 76 (46), H41D-11, p. F246.
- Lee, C.K.B. and S.L. Ridgway**, May 1983, Vapor/Droplet Coupling and the Mist Flow (OTEC) Cycle, *J. Solar Energy Engrng.*, v. 105, p.181-6.
- Lenz, P.H. and J. Yen**, 1993, Distal Setal Mechanoreceptors of the First Antennae of Marine Copepods, *Bull. Mar. Res.*, 53:170-179.
- Link, H.**, February 1989, Operational Experience of the OC-OTEC Experiments at NELH, SERI/TP-253-3480, Solar Energy Research Institute, 9 p.
- Mencher, F.M., R.B. Spencer, J.W. Woessner, S.A. Katase and D.K. Barclay**, 1983, Growth of Nori (*Porphyra tenera*) in an Experimental OTEC-Aquaculture System in Hawaii, *J. World Maricul. Soc.*, 14:458-470.
- Miller, J.N. and J.F. Walters**, August, 1983, Zooplankton Populations and Water Chemistry from a Shallow (4.3m) and Deep (600m) Pumped Water Discharge, Keahole, Hawaii, UH Environmental Center.
- Miller, Paul**, Oct. 1995, Project of the Year: Nova Group Battles Waves for Seawater Recovery Tunnels, *Trenchless Technology Magazine*, P. 26-28.
- Nebraska Educational Telecommunications**, OTEC, 7 minute 20 second video on NELHA, Filmed March 1995, Broadcast April 1995.

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

Parks, Noreen, August 1996, Bounty from the Sea, *Earth Magazine*, p. 50-55.

Penney, T.R. and D. Bharathan, Jan. 1987, Power from the Sea, *Scientific American*, p. 86-92.

Penney, T.R. and T.H. Daniel, 1988, Energy from the Ocean: A Resource for the Future, in Science and the Future: 1989 Yearbook, Encyclopaedia Britannica, p. 98-111.

Pitzer, P., August 1989, The Ocean Source, *Spirit of Aloha*, Aloha Airlines,

Prakash, A., J. Craven, N. Fitzpatrick, and E. Hay, August 1989, Recent Advances in Ocean Thermal Energy Conversion (OTEC) Technology and OTEC-Based Aquaculture, Presented at Carribean conference, 5p.

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

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

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

Sansone, F.J., S.V. Smith, J.M. Price, T.W. Walsh, T.H. Daniel and C.C. Andrews, April, 1988, Long-term Variation in Seawater Composition at the Base of the Thermocline, *Nature*, v. 332, No. 6166, p. 714-717, 21.

Seki, Arthur, Byron Aufer, Roger Fujioka, Peter Ono and Patrick Takahashi, Sept. 1986, OTEC Heat Exchanger Biofouling Control by Ultraviolet Irradiation, *Oceans 86 Conference Record*, Marine Technology Soc., Washington, D.C., p. 232-37.

Smith S.V., et al., April 1986, Time Series Measurements of Nutrients in Deep Seawater, *PACON 86 Proceedings*, Marine Technology Soc., Honolulu, p. x-x.

Stein, M., A. Okubo, and J. Yen, A Mathematical Model of the Copepod Feeding Current: A Fluid Dyanmical Approach, *J. Plankt. Res.*, In press.

U.S. Dept. of Energy, March 1990, The Potential of Renewable Energy: An Interlaboratory White Paper, SERI/TP-250-3674, OTEC: Appendix D, p. D1-D12.

Vega, L.A., and D.E. Evans, Mar 8-11, 1994, Operation of a Small open-cycle OTEC experimental facility, *Conference Proceedings: Oceanology International '94*, Brighton, U.K., Vol 5, No. 7, 16p.

Yen, J. and J.R. Strickler. 1996. Advertisement and concealment in the plankton: What makes a copepod hydrodynamically conspicuous? *Invert. Biol.* 115 (3): 191-205.

Publications from work at the Puna Research Center

Wilkins, G.A., J. Muller, A. Lowe, and L. Findley, Jun 1-6, 1992, Directional Drilling Through Lava at Keahole Point, Hawaii: Accomplishments and Projections , *Proc. Pacific Congress on Marine Science and Technology - PACON '92*, Kailua-Kona, Hawaii.

Yen, J., P.H. Lenz, D.V. Gassie, and D.D. Hartline, 1992, Mechanoreception in Marine Copepods: Electrophysiological Studies on the First Antennae , *J. Plankt. Res.*, V. 14, No. 4, p. 495-512.

Beck, Andrea Gill, October 1988, Direct Heat Debuts in Hawaii: The community Geothermal Technology Program , *Geothermal Research Council TRANSACTIONS*, V. 12, p. 3-7.

Beck, Andrea Gill, October 1989, Experiments in Direct Use at Noi'i O Puna , *Geothermal Resources Council TRANSACTIONS*, V. 13, p. 3-9.

Beck, Andrea Gill, August 1990, Direct Use in Hawaii: Perspectives and Prospects , *Geothermal Resources Council TRANSACTIONS*, V. 14, Pt.1, p. 751-4.

Baughn, E.C., August 1983, HGP-A Single Stage Direct Flash Geothermal Power Plant Overhaul Assessment

Baughman, E.C., April 27, 1984, "Two-Day Shutdown of March 20 and 21, 1984, interoffice correspondence.

DeCarlo, E.H., and C. Ronay, 1986, Separation of Silica from Scale Geothermal Fluids by Adsorptive Bubble Technique, submitted to *Separation Science*.

Hawaiian Electric Light Company, Inc., December 1985, Chemistry, Scale and Performance of the Hawaii Geothermal Project-A Plant, Electric Power Research Institute Report No. AP-4342.

Kroopnik, P., R.W. Buddemeier, D. Thomas, L.S. Lau and D. Bills, 1978, Hydrology and Geochemistry of a Hawaiian Geothermal System, HGP-A, Hawaii Institute of Geophysics Technical Report No. 78-6.

Morrow, J.W., D.M. Thomas and H.D. Burkard, June 19-24 1988, Ambient H₂S Monitoring in the Vicinity of Hawaii's first Geothermal Power Plant, presented at the 81st Annual Meeting of the Association Dedicated to Air Pollution Control and Hazardous Waste Management.

Mottle, M.J., and H.D. Holland, 1978, Chemical Exchange During Hydrothermal Alternation of Basalt by Saltwater - I. Experimental Results for Major and Minor Components of Sea Water .

Mottle, M.J., H.D. Holland and R.F. Corr, 1979, "Chemical Exchange during Hydrothermal Alternation of Basalt by Sea Water - II. Experimental Results for Fe, Mn and Sulfur Species."

Nuti, P., May 1987, Crevice Corrosion Evaluation of Some Stainless Steel Alloys in Tropical Surface and Deep Ocean Seawaters. M.S. Thesis, Department of Mechanical Engineering, University of Hawaii at Manoa.

Nuti, P., K.M. Htun and J. Larsen-Basse, December 1985, Crevice Corrosion from Some Stainless Steels in Hawaiian Surface and Deep Ocean Seawaters. Abstract presented at International Conference on Fatigue, Corrosion Cracking, Fracture Mechanics and Failure Analysis, Salt Lake City.

Research Corporation of the University of Hawaii, 1981, "HGP-A Wellhead Generator, Proof of Feasibility Project, 3 MW Wellhead Generator, Plant Data Manual, Vol. I .

Seki, A., B. Chen, P. Takahashi and J. Woodruff, 1986, Noi'i O Puna: Geothermal Research in Hawaii Proceedings of the Eleventh Annual Workshop on Geothermal Reservoir Engineering. Stanford University Press, Stanford.

Seki, A., B. Chen, P. Takahashi and J. Woodruff, 1985, Noi'i O Puna: Geothermal Research in Hawaii, Proceedings of the Seventh New Zealand Geothermal Workshop. University of Auckland Geothermal Institute in conjunction with Centre for Continuing Education, Auckland.

Thomas, D.M., 1985, Status Summary of the HGP-A Generator Facility, .

Thomas, D.M., 1987, A Geothermal Model of the Kilauea East Rift Zone, U.S.G.S. Prof. Paper 1350, Ch. 56, pp 1507-25.

Thomas, D.M., 1987, Hydrothermal Systems in Hawaii, in *G.S.A. Decade of North American Geology Volume: The Eastern Pacific Ocean and Hawaii*.

NELHA EMPLOYEES

NELHA EMPLOYEES [July 1995- June 1996]

Robert Shleser
Executive Director

Bean, Christine *Administrative Assistant*
Brown, Donna *Account Clerk III*
Daniel, Thomas *Scientific/Technical Program Manager*
Deverse, Kimber *Chemist III*
Dunse, Monica *Microbiologist III*
Espinueva, Georgette *Secretary IV*
Galt, Ernest *Maintenance Mechanic II*
Greenlees, Adrienne *Public Information Specialist II*
Haleamau, Karin *Groundskeeper II*
Hetherington, Gisela *Chemist III*
Kaniho, Sheryll *Accountant V*
Kochy, Robert *Maintenance Mechanic II (Puna)*
Kolman, Alan *Utility Electrician*
McQuigg, Presley *Water Systems Foreman*
Mitchell, Anthony *Maintenance Mechanic I*
Oshiro, Scott *Engineering Project Coordinator*
Pierce, Eugene *Electrician II*
Placek, James (Buddy) *Electrical Engineer*
Vail, Mark *Vehicle/ Construction Equipment Mechanic I*
War, Jan *Operations Manager*

A Tribute...

In the first quarter of FY 1996, staff positions at NELHA were reduced from thirty-one to twenty. While two of the positions were vacant at the time, eight of the positions were occupied, requiring NELHA to terminate their positions. NELHA would like to take this opportunity to recognize these individuals. Each of them made significant contributions to our growing facility. Their years of service and dedication helped shape NELHA into the world-class facility that it is today. **Mahalo!**

Stanley (Miles) Anderson served NELHA from September 9, 1988 to August 31, 1995. Miles supervised NELHA's water quality laboratory and helped establish many of the quality control programs of the lab. Under his supervision, the NELHA laboratory gained recognition for quality service to NELHA tenants, and exceptional monitoring service to the state.

Henry Hua served NELHA as an electrician from May 11, 1987 to August 31, 1995. His electrical expertise provided excellent support to the facility. Henry's knowledge of computers also provided NELHA with an in-house expert when trouble shooting was required.

Melanie Kelekolio supported many of the day to day activities of the laboratory as the Laboratory Assistant from January 1, 1992 to August 31, 1995. Called upon to perform a variety of activities as part of her daily schedule, she was always willing to help as needed.

Harvey Low was a member of NELHA's Operations Department and worked as a Maintenance Helper from June 1, 1989 to August 31, 1996. His contributions were critical to many of NELHA's projects.

Rosalinda McKee developed and maintained much of the landscaping around NELHA as a Groundskeeper from October 1, 1990 to August 31, 1996. Her support helped maintain much of the sprawling 870 acre facility.

George Pai, usually referred to as 'Uncle George' by NELHA staff, provided General Labor support to NELHA from December 1, 1989 to August 31, 1996. As a member of the NELHA Operations crew, he provided critical support to many of the self-help projects initiated by the staff.

Jan Weber served in the fiscal department as an Account Clerk from January 13, 1992 to August 31, 1996. Heading up the accounts receivables section, she helped ensure prompt payments from tenants.

Herman Wohlfeil worked in the Laboratory as a microbiologist from August 1, 1989 to August 31, 1996. His understanding of the science of microbiology provided an invaluable service to NELHA tenants and to the Comprehensive Environmental Monitoring Program (CEMP) of NELHA.

A Timeline...

The history of NELHA is a long and varied one. It began in 1967 when the National Marine Fisheries Service (NMFS) established the Hawaii Fisheries Laboratory (HFL) in Kaneohe, Hawaii. The HFL was the first of its kind in the United States, and it was the only one of its kind in the Pacific. The HFL was established to provide a place where scientists could study the biology and ecology of the Hawaiian Islands. The HFL was the first of its kind in the United States, and it was the only one of its kind in the Pacific. The HFL was established to provide a place where scientists could study the biology and ecology of the Hawaiian Islands.

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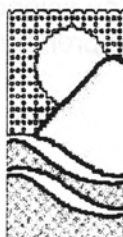
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Layout: NELHA



**Natural Energy Laboratory of Hawaii Authority
at Keahole Point**

**73-4460 Queen Kaahumanu Hwy. Suite 101
Kailua-Kona, Hawaii 96740
Telephone: (808) 329-7341
Fax: (808) 326-3262**

**e-mail: nelha@ilhawaii.net
web site: <http://bigisland.com/nelha>**