BB-95-02

MOLOKAI AQUACULTURE INDUSTRY

Contract # GA00508

Site and Project Reviews

April 24–26, 1996

Submitted to

Office of Economic Development
County of Maui
200 South High Street
Wailuku, Maui, HI 96793

Prepared by

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July 30, 1996

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EXECUTIVE SUMMARY

In 1993 a cooperative agreement was made between Maui County and the University of Hawaii's Sea Grant Extension Service in which both institutions would pool their resources to address the problems associated with the stimulation of aquaculture enterprises as one means of diversifying Maui County's economy. In July 1994, a full-time extension agent, Dr. Robert Howerton, was hired to provide technical assistance to practicing aquafarmers throughout Maui County and to oversee seven individual projects initiated and supported by Maui County. An additional project was added during the reporting period. A review of the projects receiving support from Maui County from April 1995 to April 1996 was conducted on April 24-25, 1996 and their current status, future prospects are summarized in this report. A summary of the activities of the cooperative agreement for the period July 1995 through June 1996 is also presented. Major accomplishments during the reporting period were:

Project Accomplishments

* Thirty-one people are currently employed full-time or part-time in an aquaculture activity on Molokai.

* Commercial production and marketing of show guppies.

* Establishment and operation of a multi-species freshwater fish hatchery.

* Independent hatchery production of specific pathogen free *Penaeus vanamei*.

* Establishment and operation of small-scale hatchery for production of the ogo *Gracilaria parvispora*.

* Production of manual documenting ogo (*Gracilaria parvispora*) life history and culture process.

* Establishment and operation of small-scale hatchery for production of limu manuea (*Gracilaria coronofolia*).

* Establishment of commercial scale hatchery for the production of the freshwater prawn *Macrobrachium rosenbergii*.

* Hatchery production of 49,000 moi (*Polydactylus sexfilis*) fry.

* Construction and operation of a reservoir for an integrated aquaculture/agriculture growout system.

Extension Agent Howerton's Accomplishments

* Facilitated the development of Valley Isle Breeders Exchange, an ornamental fish cooperative established on Maui.

* Initiation and development of aquaculture education program for primary and secondary schools on Molokai.

* Publication of Molokai Aquaculture Newsletter for aquafarmers.

* Responded to a total of 618 requests for technical assistance in the form of verbal consultations, written material and site visits in Maui County, the state and abroad.

* Conducted six workshops (tilapia culture, ornamental fish culture (n=2), water quality management, and tank construction using high density polyethylene (n=2)) during the reporting period.

* Invited as a speaker and session moderator at the annual World Aquaculture Society meeting held in Bangkok, Thailand, January 26-28, 1996.

* Invited as a speaker at the Annual Pacific Rim Association Resource, Conservation & Development (USDA) meeting held in Kona, Hawaii, November 6-7, 1995.

* Appointed as a member of the Advisory Committee and Core Group of the Maui County Rural Community Leadership Program.

* Invited as a participant of Maui Pacific Center Conference on "Sustainable Living in the Aquatic Continent", September 19 -23, 1995.

* Appointed as a member of the USDA Center for Tropical and Subtropical Aquaculture Technical Advisory Committee.

* Appointed as a member of the Board of Directors, Hui O Loko I'a, a community based organization mandated to restore traditional Hawaiian fishponds.

INTRODUCTION

Diversification of agricultural activities within the State of Hawaii is viewed by public administrators and the private sector as one means of alleviating the dependence of Hawaii's economy on tourism. Aquaculture has been recognized as the fastest growing sector in the statewide program for agricultural expansion and diversification. The role of the Aquaculture Extension Program of the Sea Grant Extension Service at the University of Hawaii at Manao (SGES, UHM) is to provide technical support to Hawaii's aquafarmers, to serve as an information conduit to farmers, educators and researchers, and to assist new farmers with planning and initial operations. Additional objectives as part of the extension network are to develop cooperative projects between private and public sectors, identify new species for industry expansion, and overcome constraints that may impact the industries future expansion. Community outreach and public education are also important components of the aquaculture extension program. All of the activities are focused on establishing the aquaculture industry in Hawaii as a significant contributor to the State's economy.

Maui County also aspires to diversify its economy through development of alternatives to dependence on tourism, and the stimulation of aquaculture enterprises is one means by which it hopes to achieve its goal. This is particularly true for the island of Molokai where economic conditions have deteriorated over the last 10 years. "Hotel vacancy rates are the highest among the islands, small businesses have languished and disappeared, the official unemployment rate as of December 1995 is 9.1% and 20% of Molokai's households receive some sort of public assistance" (Whitney, 1996). In 1993 a cooperative agreement was made between Maui County and the University of Hawaii Sea Grant Extension Service in which both institutions would pool their resources to address the aforementioned problems. In July 1994, Dr. Robert Howerton was hired as full-time extension agent to provide technical assistance to practicing aquafarmers throughout Maui County and to oversee seven individual projects initiated on Molokai and supported by the county. An additional project on Maui was added during the reporting period. A formal site review of the projects receiving support from Maui County was conducted on April 24-25, 1996 and their current status and future prospects are summarized in this report. The projects as a whole have been summarized and form the basis of this report.

PROJECT OBJECTIVES

Successful completion of the proposed Maui County project is dependent on the completion of five objectives:

Objective #1: Hiring of a Sea Grant Extension Agent.
Objective #2: Conduct a Community Involvement Workshop.
Objective #3: Review Proposals.
Objective #4: Extension Support.
Objective #5: Project Evaluation.

Progress Towards Objectives

Objectives 1-3 had been achieved by the end of July 1994 and a total of nine individual projects were identified, seven of which were receiving support from Maui County. A review of the individual projects was conducted on April 27-28, 1995 and a report was submitted to Maui County in May of 1995. A meeting with the Maui County Aquaculture Industry Advisory Council was held on May 18, 1995 and the status of the projects and future activities were discussed. An additional project on Maui was added. It was found that delays in hiring of the full-time extension agent for Maui County, change in staffing at Sea Grant Extensions Service, University of Hawaii and delays in initiating all of the individual projects resulted in all projects being at varying stages of completion. It was advised that a request for a no-cost extension of the overall project be generated to provide adequate time to see all projects achieve their stated objectives. The project no-cost extension will expire in December 1996.

Future Prospects

All of the projects (n=8) receiving support from Maui County appear well on their way to being completed, however, additional technical assistance will be required to see that the project investigators achieve economic self sufficiency. Likewise, it is clear from the community on Molokai that the revitalization of the numerous Hawaiian fishponds remains one of their highest priorities. The focus of the current projects was for individual investigators to develop their own aquaculture enterprises. Support for traditional Hawaiian fishpond activities was not addressed as some technical assistance for this type of activity was being provided under the auspices of the Hawaiian Fishpond Revitalization project administered by The Oceanic Institute. Financial support for the fishpond project, however, has been discontinued and the fishponds remain in a state of disrepair. Recently, a great deal of interest in development of an ornamental fish industry within the state has being generated and numerous requests for technical assistance are currently being received from both Maui and Molokai.

Recommendations

1) Solicit continued support for the Maui County extension agent to provide technical assistance for projects already underway and for new initiatives throughout Maui County.

2) Solicit funding to establish baseline water quality parameters in Hawaiian fishponds in order to address the strict regulations established under the Federal Clean Water Act.

3) Work cooperatively with SGES, UHM to transfer the technology to be documented in the operation of a Hawaiian fishpond of the *loko kuapa* style.

4) Solicit collaborative work with others such as the State aquatic veterinarian, College of Tropical Agriculture and Human Resources (CTAHR), School of Ocean and Earth Science and Technology (SOEST), Aquaculture Development Program (ADP), and the United States Department of Agriculture Center for Tropical and Subtropical Aquaculture (CTSA)) to address site specific restraints to aquafarmers in Maui County.

Objective #4: Extension Support

Selected projects would be provided ongoing extension support to provide oversight and technical assistance. This would include, but not be limited to, facility planning and design, seed stock acquisition, production management and feeding, harvesting, and marketing.

Progress Towards Objectives

A total of 618 requests for technical assistance were responded to during the reporting period of July 1995 through June 1996 and a detailed description of the responses are provided in Appendix 1. Technical assistance was provided in the form of verbal consultations, written requests and site visitations. A summary of the types of technical assistance and the areas serviced is provided in Figures 1-2. Thirty-nine percent of the responses were in the form of verbal consultations, 2.6% were in the form of written material, and 58.4% were in the form of site visits. The high percentage of responses in the form of site visits reflects a conscious effort by the extension agent to work directly with aquafarmers as well as carrying out follow up site visits to gauge progress.

While the requests for technical assistance are primarily focused on the activities on Molokai, technical assistance was also provided to other islands in the state as well as abroad. In summary, 61.6% of the responses were on Molokai, 24.8% were made to the island of Maui, and 13.6% were provided to other islands within the state and abroad. Two highlights were the invitation of Dr. Robert Howerton as an invited speaker to the Pacific Rim Resource Conservation and Development meeting held in Kona (November 6-7, 1995) and as an invited speaker and session moderator at the World Aquaculture Society meeting held in Bangkok, Thailand, (January 26-28, 1996).

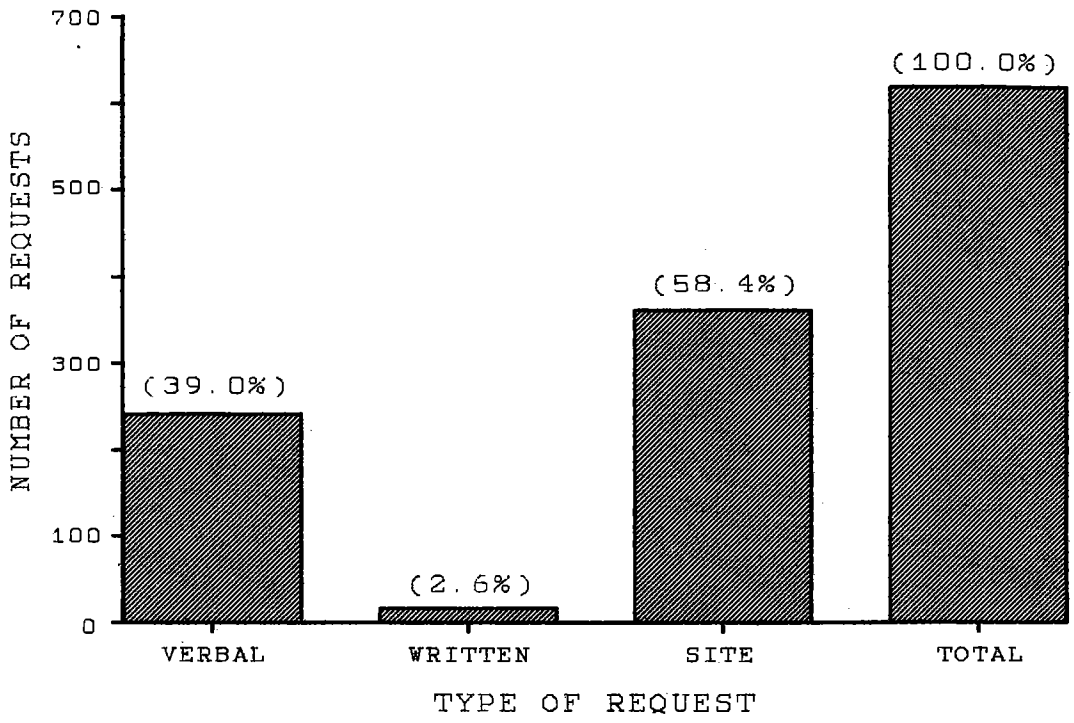


Figure 1. **Summary of type of responses for technical assistance provided by the Maui County extension agent between June 1995 - July 1996.**

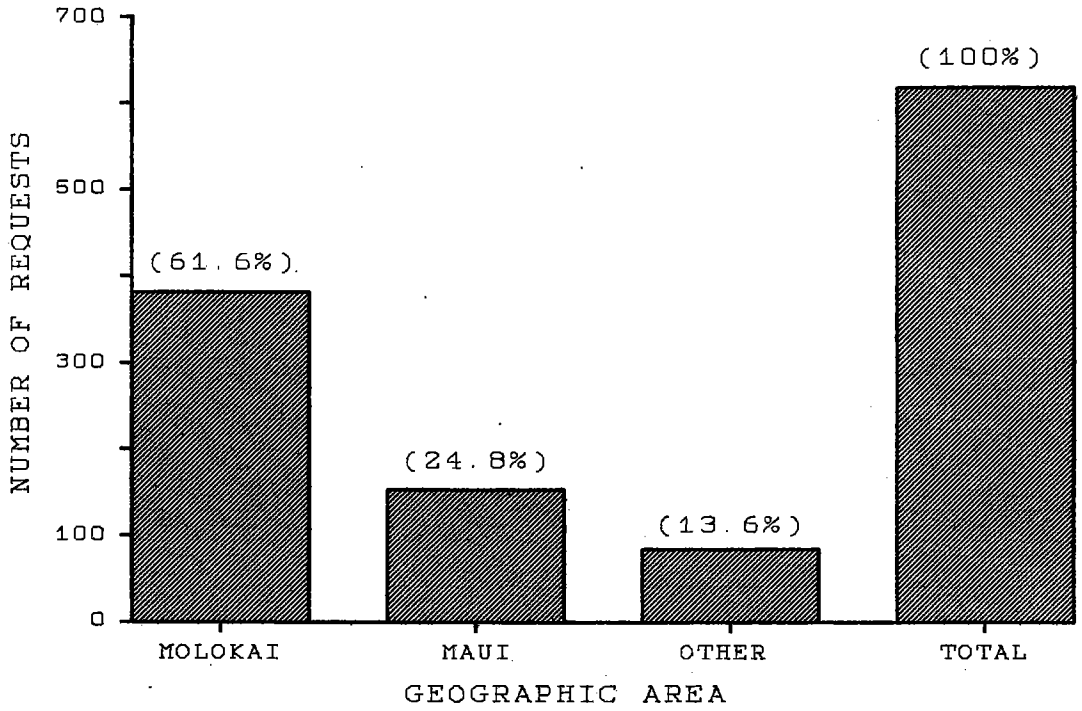


Figure 2. **Summary of locations from which technical assistance were responded to by the Maui County extension agent between June 1995 - July 1996.**

Dissemination of information also takes place in the form of organizing workshops and providing aquafarmers and opportunity to meet and interact with numerous individuals with technical expertise in various areas of aquaculture. Six workshops were held covering tilapia culture, ornamental fish culture (n=2), water quality management, and the construction of tanks using high density polyethylene (n=2) were conducted during the reporting period. Invited speakers were Drs. Gordon Grau and Christopher Brown of the Hawaii Institute of Marine Biology, SOEST, and Brian Cole of the Ornamental Fish Project supported by CTSA, Dr. Kevin Hopkins, University of Hawaii, Hilo, and Rich Bailey, SGES, UHM.

Future Prospects

The dissemination of technology in the form of verbal consultations, site visits, and literature constitutes the major activity by the extension agent and will continue to be the main area of activity. Additional workshops featuring other individuals with technical expertise are currently being planned (e.g., Dr. Harry Ako, Department of Environmental Biochemistry, CTAHR; Dr. Aecio D'Silva, University of Arizona; Dr. James Brock, Aquaculture Development Program).

Recommendations

See recommendations for objectives 1-3.

Objective #5: Project Evaluation

Final reports summarizing individual project goals, objectives, accomplishments and budgets will be prepared by participants and reviewed by Sea Grant prior to submission to the Maui County Department of Economic Development.

Progress Towards Objectives

A formal site review of the individual projects supported by Maui County took place between April 24-25, 1996 and the focus of the evaluations were the activities conducted since April, 1995. The review team consisted of Drs. Clyde Tamaru (Sea Grant Extension Service UHM) and Robert Howerton (Sea Grant Extension, Maui County). Ms. Enid Kagesa (fiscal officer for SGES, UHM) was invited as a participant of the review team to familiarize herself with the individual project investigators and projects. Seven projects on Molokai were evaluated during the two day visit and one project on Maui was reviewed separately by Drs. Tamaru and Howerton during the month of May. The progress towards the objectives and future prospects for each of the individual projects has been summarized as follows:

Contract: #8990017. Field Methods for Spore Culture of Limu Manuea *Gracilaria coronopifolia*, Project Investigator: Richard Tollefsen, Award: $26,153

Project Description

The overall goal of the project is to develop a culture system for Limu manuea in which the major growout phase is accomplished in fishponds or on the fringing reef instead of in land based tank systems. Although the overall goals of this project are similar to that of another limu project concurrently receiving Maui County support, it differs in that the species targeted for culture is native to Hawaii. A copy of the proposal with terms of reference for the project is presented in Appendix 2.

Progress Toward Objectives

The first three technical objectives stated in the proposal had been achieved at the time of the site visit. A working method for spore settling on substrates, including nylon ropes, basaltic rocks, and coral chips, was successfully achieved with the most successful of the spore settling substrates identified as the nylon rope (Fig. 3). The second technical objective has also been completed where sporelings were grown to juvenile size (Fig. 4), although growth rates were sporadic and many viable spores that had settled on the substrates did not grow at all. The third objective, to grow out juvenile plants to mature harvestable size plants was also achieved, although results were varied. A number of plants reached harvestable size but at each stage of development mortalities have occurred, limiting production. Due to limited production the fourth objective has not been completed.

Future Prospects

The principal investigator has shown that it is technically feasible to grow edible limu on the reef flats and in Hawaiian fishponds. There has been difficulty in generating the level of production that would make this project economically viable. Obstacles to increasing production include disease (e.g., Gall syndrome), predation from limu-eating fish, security (theft), and biofouling on substrates from other limu species and sponges.

Figure 3. Setup for settling of spores on planting substrates.

Figure 4. Planting of nylon ropes containing ogo spores on the reef flat.

Recommendations

1) Increase length of time substrate material is exposed to spores in the hatchery. This may increase the number of viable spores that settle on substrates.

2) Develop a more secure and protected nursery area in which the substrates are initially positioned. This may increase survival.

3) During the critical nursery phase (1-4 months), introduce a "weeding program" in which other species of limu which compete for space, light, and nutrients are removed from the substrate material. This may create a more favorable environment for limu manuea to become established.

Contract: #8990018. Shrimp Maturation Technology Transfer Project, Molokai Sea Farms, Project Investigator: Steve Chaiken, Award: $26,000

Project Description

There is a great need to develop seed production of marine shrimp post-larvae for stocking into growout ponds on Molokai, throughout the state, and abroad. The major objectives of the project are to transfer developed technologies for maturation, spawning, and post-larvae production of *Penaeus vannamei*. The project plans to take advantage of technologies for shrimp maturation and post-larvae production already developed at The Oceanic Institute. Successful completion of the goal of the project (i.e., establish shrimp maturation at Molokai Sea Farms) would provide the opportunity for creating a self-sustaining marine shrimp culture industry on Molokai. A copy of the proposal with terms of reference is presented in Appendix 3.

Progress Toward Objectives

At the time of the 1995 site review, procurement and installation of equipment and modification of the existing maturation facility was only 60% complete and the recommendation had been made to acquire a no-cost extension to complete all of the objectives (n=6) of the project. At the time of the 1996 site review, all of the objectives of the project were completed with only the target number of 750 x 10^3 post-larvae/month not being met. Current production estimates range between 250-350 x 10^3 post-larvae/month. Photographs of the maturation facility, spawning tanks, larval-rearing tanks and stocked growout ponds are presented in Figures 5-8. Achievement of the target number of post-larvae will require continued refinement of the technology that takes into account on site conditions. This can be achieved without continued financial support from Maui County. Shrimp post-larvae are being used to stock the production ponds at Molokai Sea Farms as well as being distributed to other interested farmers on Molokai.

Figure 5. Shrimp maturation facility at Molokai Sea Farms.

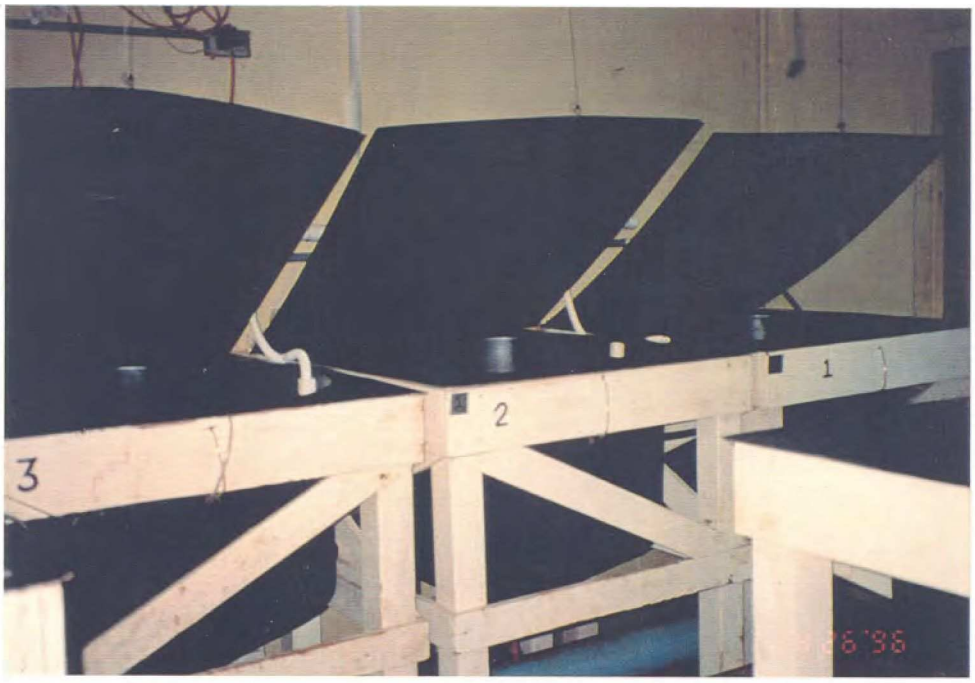


Figure 6. Shrimp spawning tanks at Molokai Sea Farms.

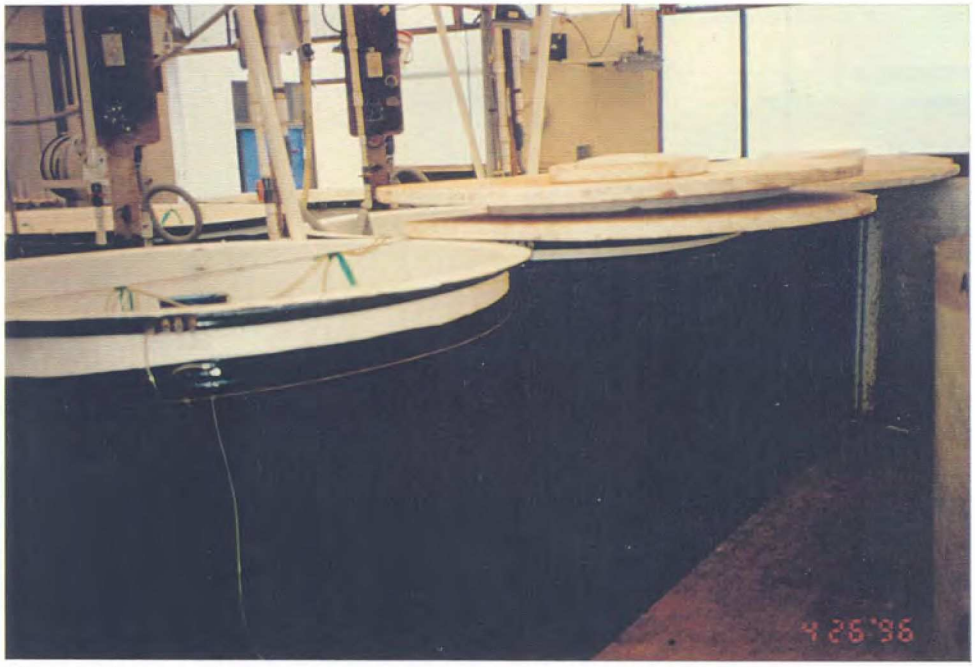


Figure 7. Shrimp larval rearing tanks at Molokai Sea Farms.

Figure 8. Shrimp growout ponds stocked with "home grown" shrimp postlarve at Molokai Sea Farms.

At the time of the site review, 60% of the growout space at Molokai Sea Farms had been stocked with "home grown" post-larvae. Samples of the shrimp being produced on site in four shrimp maturation tanks and five growout ponds were sent to the State aquatic veterinarian as soon as possible after the site review (May 7, 1996) and screened for the presence of specific pathogens that plague the shrimp industry throughout the United States and abroad. No indication of the presence of IHHNV, TSV, BP, NHP or other significant diseases/pathogens were found in the shrimp sampled at Molokai Sea Farms. A copy of the report is provided in Appendix 4.

Future Prospects

With the establishment of a maturation facility and spawning of broodstock, Molokai Sea Farms is an independent producer of shrimp post-larvae that can provide seed stock for other shrimp farms. As the shrimp currently being produced on site are free of specific pathogens, the hatchery can also serve as one of the few hatcheries in the world that produce specific pathogen free (SPF) shrimp. Currently the demand for SPF shrimp worldwide is very high. Continued refinements should improve production of post-larvae and provide an additional avenue for marketing shrimp by Molokai Sea Farms and potential employment opportunities as the farm increases productivity.

Recommendations

1) It is in the best interest of Molokai Sea Farms to maintain the SPF status and to seek recommendations from The Oceanic Institute Shrimp program and the State aquatic veterinarian on farm management practices and preventive measures to insure their SPF status.

2) Recommended practices should be implemented and strictly adhered to.

3) Continue to refine hatchery production of post-larvae to achieve target production of 750,000 post-larvae/month.

4) In addition to commercial production of shrimp, SPF broodstock and/or post-larvae should be marketed.

Contract: #8990019. Development of Methods for the Cultivation of the Edible Limu *Gracilaria parvispora*, Project Investigator: Colette Machado, Award: $27,280

Project Description

This project builds on one previously supported by the Aquaculture Development Program (ADP), the National Coastal Research Institute (NCRI), and the U.S. Department of Agriculture (USDA). The principal investigator is working on a cooperative agreement with the University of Arizona to build and operate a hatchery and growout facility for the limu, *Gracilaria parvispora*. Sub-objectives of the project are to document the developed technology and begin transfer of the technology to the community via a community outreach program. A copy of the proposal with the terms of reference is presented in Appendix 5.

Figure 9. Ogo hatchery of Ke Kua'aina Hanauna Hou.

Progress Toward Objectives

A small-scale hatchery for settling carpospores onto substrates such as nylon ropes or rock chips has been established on site and is fully operational (Fig. 9). The hatchery consists of four 1000-l tanks that can produce enough spore-laden ropes or stone pebbles to be used to plant two to four acres of pond space per year. Spore-coated pebbles or ropes are placed into penned areas

that prevent the entry of predators (fish and turtles) in the adjacent lagoon. They are also distributed to other individuals in the community for growout in fishponds or on the reef flat. At present five other individuals participate in the growout phase with the project investigators. Products grown by individual farmers are sold back to the project at $3.00/lb. Seedlings stocked at the project site are grown over the course of 25-50 weeks, depending upon the season. The amount of water motion, nutrients and turbidity have been found to effect the rate of growth and subsequent time to harvest. At harvest, the plants are cut so that approximately 5 cm remain on the substrate. The holdfast remains attached and grows back to harvest size which takes from 4-10 weeks. Harvested plants are being sold as fresh ogo at local markets or as a value added product (limu salsa). A draft manual documenting the life cycle of the ogo and the culture process has been produced and final printing is in progress (see Appendix 6). The growout activities differ from the intensive culture methods used by other farms in the state. However, the extensive growout phase currently practiced does not require the use of electricity to power blowers, which is a major consideration for the island of Molokai. At the time of the previous site visit, ogo production was relatively low, ranging between 10-160 lbs/week. The project investigator, in collaboration with staff from the University of Arizona, has employed a variation in the growout method that can be characterized as a semi-continuous harvesting procedure. First, 10 lbs of ogo are stocked into laundry baskets (Fig. 10) and these are then placed overnight in a bath containing inorganic fertilizers (diammonium phosphate, ammonium nitrate) after which they are then returned to baskets (4'x5'x2, n=40) in the growout area in the adjacent lagoon. After one week each basket is harvested and the ogo again removed and weighed. It is then restocked with 10 lbs of ogo with the residual ogo representing harvestable product. The entire process is then repeated. The project investigators report that this process has significantly improved their overall production over the previously reported amounts with consistent production of approximately 100 lbs/week.

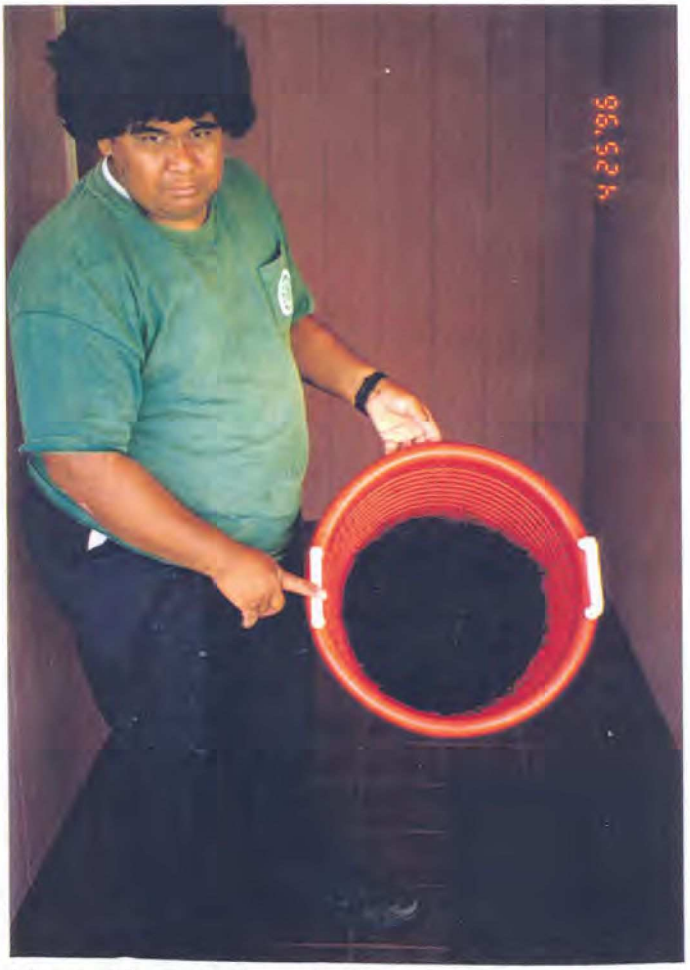


Figure 10. Culture basket used for culturing of ogo.

In addition, the project investigators have been able to construct a new facility on site that contains office space and certified kitchen (Fig. 11) to be used to produce their own value added products with the cultured ogo. During periods when the kitchen is not used for ogo processing it can be rented to other individuals for production of other products thus making available a processing capability without the high initial start-up costs.

Figure 11. Newly built certified kitchen and office of Ke Kua'aina Hanauna Hou.

Future Prospects

The project itself does not produce ogo on the scale reported by other farms operating in Hawaii (e.g., between 500 and 1000 lbs/week). The project investigators seek to achieve similar production levels by establishing a community based growout system that would employ approximately 25 individual growers. Growers would receive hatchery produced seedlings and technical assistance during the growout phase and market their product back to the project for the production of value added products or the sale of fresh product. This represents a source of both food on the table or a supplemental income to participating growers. It is anticipated that with the establishment of the certified kitchen, a large number of growers can be accommodated.

Recommendations

1) Expand hatchery facilities to increase production of seeded substrate.

2) Continue to solicit additional farmers to participate in the growout phase to increase overall production.

3) Establish additional value added products (e.g., kim chee ogo, namasu ogo).

4) Continue to experiment with means of improving overall growout of ogo.

Contract: #8990020. Molokai Multi-Purpose Hatchery Project, Palaau Prawn and Shrimp Co., Project Investigator: Rebecca Bishop-Yuen, Award: $33,171

Project Description

Palaau Prawn and Shrimp Co. proposes to build a small, multi-purpose hatchery for the production of fish and prawn seed stock to support a commercial farm that is currently under construction as well as other brackish and freshwater culture activities on the island of Molokai. The target species initially proposed are the red tilapia (*Oreochromis mossambicus*) and the freshwater prawn (*Macrobrachium rosenbergii*). A copy of the proposal with the terms of reference is presented in Appendix 7.

Progress Toward Objectives

At the time of the 1995 site visit the construction of the hatchery had been significantly delayed due to the lengthy process for the acquisition of permits required for the operation of the farm at which the proposed hatchery is to be located. During this reporting period considerable progress was made, as all of the required permits had been obtained and the drainage system for the entire farm had been completed. Pumps for the saltwater and brackishwater wells were installed (Fig. 12) and the infrastructure for the hatchery (airlines, plumbing, tanks) were installed (Fig. 13) and operational. *Macrobrachium rosenbergii* broodstock (n=150) had also been obtained and were being held in a maturation tank (Fig. 14). Four acres of ponds were filled and ready to receive post-larvae for growout (Fig. 15). In addition to the hatchery, living quarters, an office, a storage facility and a workshop have also been established on site.

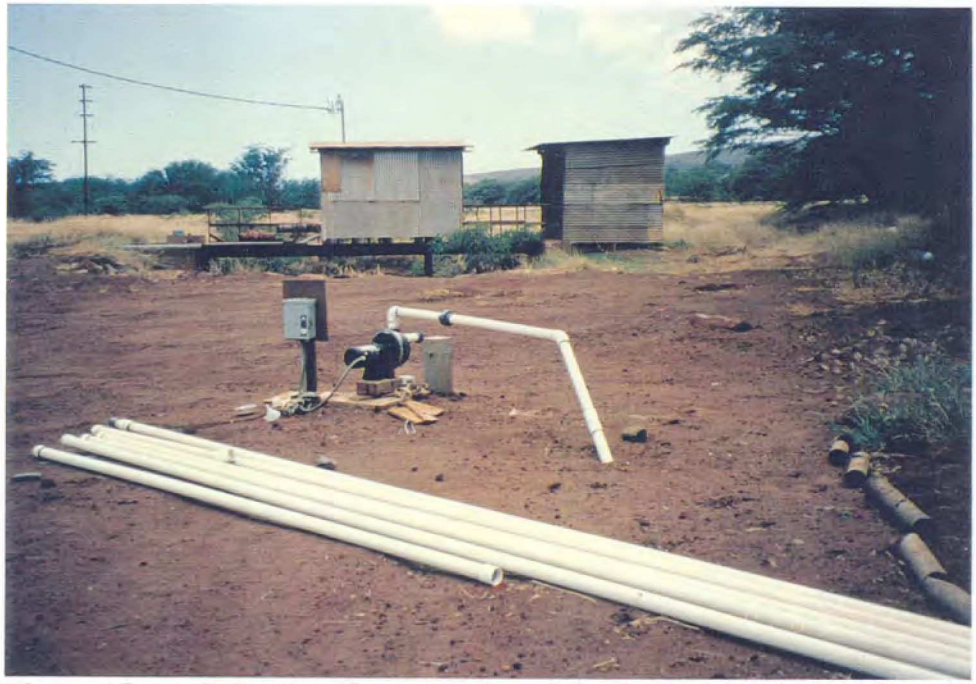


Figure 12. Saltwater (foreground) and freshwater (background) wells at Palaau Prawn and Shrimp Farm.

Figure 13. Outdoor hatchery established at Palaau Prawn and Shrimp Farm.

Figure 14. Broodstock holding tank stocked with *M. rosenbergii* at Palaau Prawn and Shrimp Farm.

Figure 15. Growout ponds at Palaau Prawn and Shrimp Farm.

One potential problem that must be resolved is the seawater well that delivers water to the hatchery. At present it does not produce water with the required salinity for *M. rosenbèrgii* spawning or to conduct larval rearing of the resulting nauplii. Corrective action must be taken (e.g., drilling the well deeper) before the hatchery can be self-sustaining. At present, a closed-cycle hatchery run is being planned using seawater from the neighboring marine shrimp farm.

Guppies initially had been introduced on to the farm to control for mosquitos. The guppies have proliferated to the point where they now pose as a source of additional income in the form of feeder fish or aquarium guppies. Markets on Oahu were investigated and linkages are being made with a wholesaler on Oahu to supply feeder and show guppies to the aquarium market in the state. The potential for using the feeder guppies as a secondary source of income is substantial.

Future Prospects

At present, a closed cycle hatchery run is being planned to produce post-larvae from the established hatchery. The seawater required will be obtained from a neighboring shrimp farm, stored in a holding tank and diluted as needed for hatchery use. Fortunately, the post-larvae production of *M. rosenbergii* does not require full strength seawater. The project investigators possess considerable expertise and can manage the hatchery despite this temporary set-back. Additional growout ponds are gradually being filled and sealed and it is anticipated that the entire pond area at the farm will be completed by the end of the year. With the acquisition of additional funds, the well is to be repaired. This would allow the hatchery to produce not only enough post-larvae for the farm but for stocking of other farms throughout the state and abroad.

As mentioned previously, the ponds already filled have been stocked with guppies as a source of mosquito control and have proliferated in the pond environment. These guppies already can be marketed as either show guppies (at a price of $0.20 each) or as feeder guppies (at a lower price of $0.03 each) depending on size and quality. It is anticipated that the marketing of the feeder guppies alone can cover the feed costs for growout of the freshwater prawns, as it is estimated that the demand for these are approximately 5-10 x 10^3 per week on Oahu alone. When the farm is in full production, the number of feeder guppies that can be produced should not only be sufficient to cover the demand on Oahu but allow for the shipping of feeders to the much larger mainland market. Moreover, if the guppies are of suitable quality (color, shape, size) they can also be marketed as show guppies, serving as an additional source of income.

Recommendations

1) Proceed with the closed cycle hatchery production of *M. rosenbergii* post-larvae and establish post-larvae and prawn production at the farm.

2) With the acquisition of additional funds repair the well and establish full-scale hatchery operations for post-larvae of *M. rosenbergii*.

3) Work with SGES agent(s) to establish other fish species (e.g., tilapia, ornamentals) suitable for the prawn growout ponds allowing diversification of the farm's production.

Contract: #8990021. Molokai Finfish Hatchery Seed Production Project, Molokai Sea Farms, Project Investigator: Steve Chaiken, Award: $14,000

Project Description

The project proposes to develop a hatchery technology for moi (*Polydactylus sexfilis*), historically an important fish species and a highly prized game fish. The State of Hawaii, in collaboration with The Oceanic Institute, is actively engaged in developing a hatchery technology for this species to promote culture activities and for stock enhancement purposes. A copy of the proposal and the terms of reference of the project are presented in Appendix 8.

Progress Toward Objectives

Findings of the 1995 site review revealed that 75% of the modifications to existing infrastructure had been achieved, no broodstock were on site, and no live feeds (including phytoplankton culture) production was in progress. At that time the project was also receiving additional support from two other agencies (United States Department of Agriculture and the State Of Hawaii Aquaculture Development Program). Because of the lack of progress, it was recommended by the Molokai Aquaculture Advisory Council that the project be terminated with further recommendation that Molokai Sea Farms focus on the other project (Contract #8990018). Molokai Sea Farms would be reimbursed only for expenditures to the date of notification of the decision and to a maximum of $7,000. In fulfillment of Molokai Sea Farms contractual obligations to the two other funding sources and Maui County, the project personnel did complete several of the objectives. During the reporting period, construction and production of live feed production facilities were completed, starter cultures of the phytoplankton (*Nannochloropsis oculata*), rotifers and spawned moi eggs were acquired from The Oceanic

Institute, and four larval-rearing trials utilizing eight 1000-l larval-rearing tanks during each rearing trial were completed. In summary, approximately 49,000 moi fry were produced during the four rearing trials with overall survival averaging 13.6% per tank (range: 0%-33%). Moi fry resulting from the larval-rearing trials are currently being grown out to market size (e.g., one pound) in 18' diameter canvas lined plywood tanks. Commercial feeds are being supplemented with a diet of frozen mollies collected from the shrimp production ponds on the farm site (Fig. 16). A final report has been generated summarizing the activities and a copy is presented in Appendix 9.

Figure 16. Steve Chaiken feeding cultured moi with feeder mollies.

Future Prospects

Successful production of moi fry and determination of a rearing protocol that takes into account site specific restraints were significant achievements of the project investigators. However, part of the hatchery requirements to make the project successful is the establishment and maintenance of a moi broodstock. Currently, Molokai Sea Farms is still dependent on spawned eggs from an outside source, (i.e., The Oceanic Institute). As the latter institution is engaged in research and development, this source of moi eggs will no longer exist as research priorities shift. This underscores the importance of establishing a broodstock of moi capable of producing fertilized eggs on site. As the hatchery production of moi fry improves another area that should be addressed is growout of the species. Moi are characteristically high-level carnivores and the quantitative and qualitative feed requirements for growout are currently under investigation through research supported by the CTSA. Molokai Sea Farms can now incorporate their developed fry production capability with growout trials to test the economic feasibility of artificially propagating moi.

Recommendations

1) Establish moi broodstock and spawned egg production at Molokai Sea Farms.

2) Conduct growout trials with commercially available feeds either separately or in supplemented with "home grown" products (e.g., frozen mollies, excess shrimp, trash fish).

3) Market cultured moi.

4) Conduct economic analysis of complete cycle of artificial propagation of moi.

Contract: #8990024. Freshwater Finfish Hatchery, Loko Ia Kalo, Project Investigator(s): Scott Kauhanaehaonokawailani Adams, Noah Kuohe, Miles Kina, Award: $10,800

Project Description

The project investigators have proposed the introduction and cultivation of two freshwater fish species, red hybrid tilapia (*Oreochromis mossambicus*) and the Asian catfish (*Clarias fuscus*) for the purpose of home consumption and/or sale. The major objective of the project is the construction of a freshwater fish hatchery that would be required for production of seed necessary for stocking in growout ponds. A long-term objective is to be a source of seed for growout to other prospective farmers in the community. A copy of the proposal with the terms of reference for the project is presented in Appendix 10.

Progress Toward Objectives

At the time of the previous site visit the hatchery building had been constructed but still required was the installation of tanks, airlines, water, and aeration systems. At the time of the 1996 site review, all projects objectives had been completed with a fully operational hatchery (Fig. 17) and various species of broodstock - red hybrid tilapia, chinese catfish, koi, blue and opaline gouramis, and swordtails - were on site. The ornamental species were a contribution from the CTSA funded Ornamental Fish Project. Spawning trials of blue gouramis were in progress as well as the induced spawning of Chinese catfish (Fig. 18). Separate spawning trials had already been completed at the time of this report resulting in 8×10^3 and 13×10^3 hatched fry, respectively. Tilapia fry and catfish fry have been delivered to at least seven backyard aquaculture farmers and the project investigators have stocked their own growout facility over the course of the reporting period.

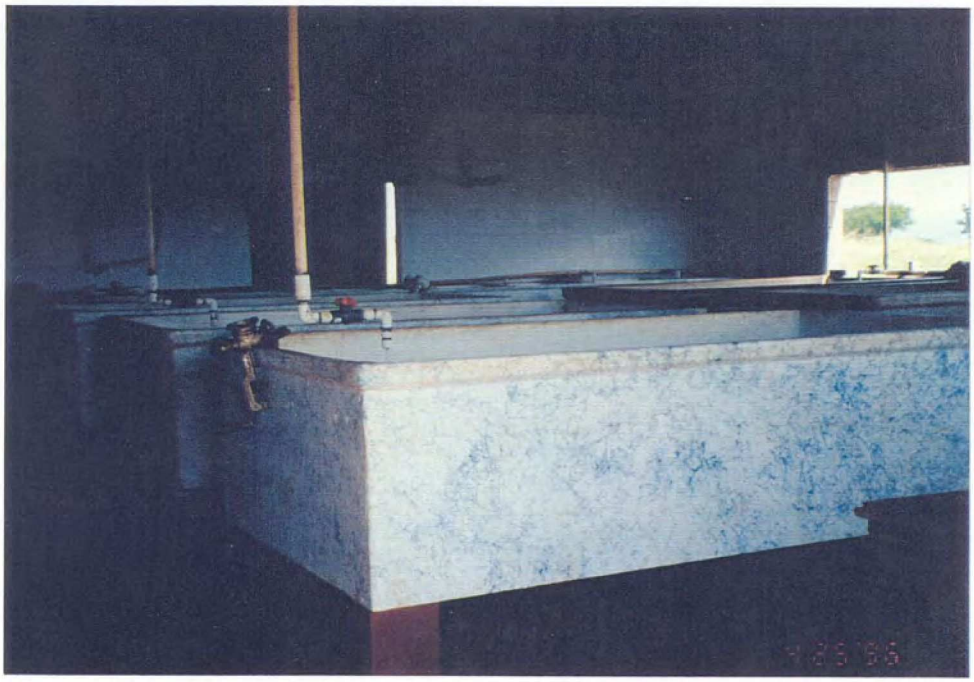


Figure 17. Operational freshwater fish hatchery of Loko I'a Kalo.

Figure 18. Scott Adams stripping ovulated oocytes from a Chinese catfish female.

Figure 19. Swordtail fry production tank stocked with broodstock (n =1250) swordtails.

Figure 20. Growout facility (net cages) for swordtails.

Under the auspices of the CTSA funded Ornamental Fish Project, a commercial swordtail production module (Figs. 19-20) was already in place and in operation at the time of the site review. Swordtail fry production was estimated at 4-13 x 10^3 fry per month. Furthermore, the project investigators have secured additional funds to expand the existing hatchery facility. The increased hatchery area will be used for larval production and nursery culture activities.

One tour of the hatchery facility by Molokai High School Vocational Education and Biology students (n=19) was completed during this reporting period. In addition, one lecture on general aquaculture was conducted by the project investigators at Kualapuu Elementary School to an audience of approximately 150 students.

Future Prospects

The project seeks to take advantage of a 35-acre Hawaiian Homestead award of which 10 acres are currently in agricultural use. Means to develop the remaining 25 acres using integrated agriculture/aquaculture activities are being planned. Operation of the multi-species fish hatchery will allow production of seed necessary to fulfill the aquaculture component of the integrated agriculture/aquaculture goals of the farm. While the project investigators have completed the construction and operation of the hatchery, the limited growout space on site is insufficient for the production capabilities of the hatchery, requiring expansion of the existing growout facilities. Project investigators are now working with a broad number of species that differ in culture requirements and they will need to gain additional experience in all facets of hatchery operations (e.g., live feeds production, larval culture, nursery culture, disease management).

Recommendations

1) Facilitate construction of growout facilities for stocking of the various seedstock currently present on site.

2) Continue to work with the SGES extension agent(s) to gain experience in all facets of hatchery and growout activities.

3) Conduct spawning trials of the various species to gain additional experience in hatchery operations.

4) Market fry to additional farmers on Molokai and throughout the state.

Contract: #8990025. Ornamental Fish Production in Tanks, Project Investigator: Edwin Medeiros, Award: $4,000

Project Description

The project seeks to establish a breeding population of fancy guppies and a production system for fancy guppies to augment an established business dedicated to the collection and distribution of marine tropical fish. A copy of the proposal with terms of reference is prented in Appendix 11.

Progress Toward Objectives

During the reporting period two 20' diameter production tanks were completed (Fig. 21) and had been stocked with red fancy guppy broodstock (75 females and 25 males) from Florida. Fry production and growout were conducted within the tanks built under the auspices of the

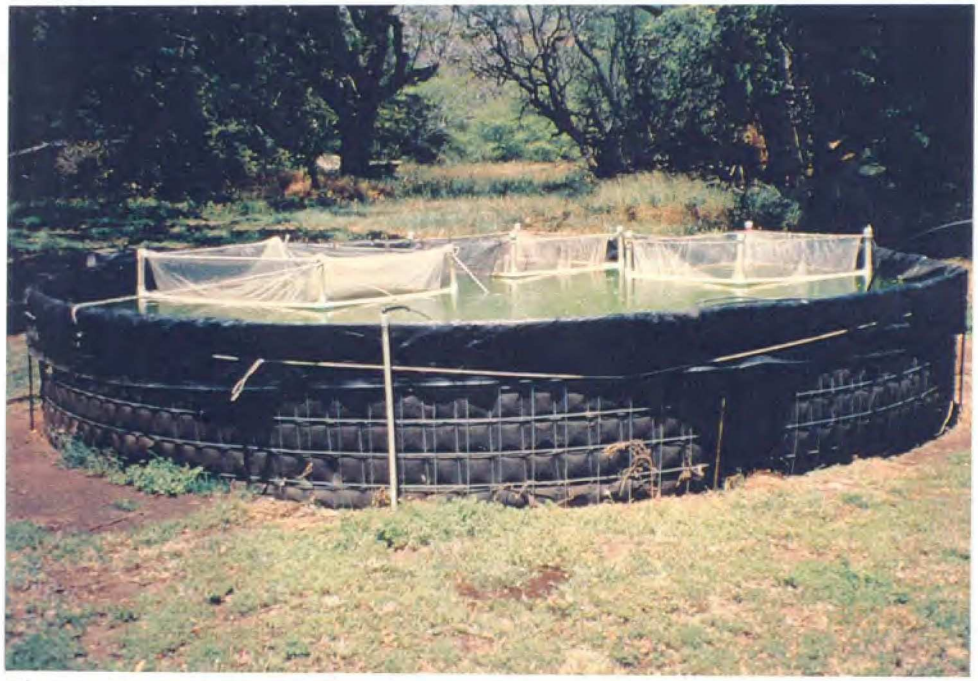


Figure 21. One of two guppy fry production and growout tanks established at Friendly Isle Fish Company.

current project. Since the last site visit, the project investigator forged a working relationship with a distributor based on Oahu and at the time of this report had already grossed in excess of $5200 from the sale of 13 x 10^3 pairs (26,000 guppies) at $0.40/pair. The estimated monthly production of marketable guppies is approximately 3-4 x 10^3 fish (Fig. 22). It should be emphasized that the funds generated already exceed the entire amount of project funds requested. Profits generated from the sale of the guppies have been put back into the project to expand current facilities to include growout ponds (Fig. 23). Increased production capabilities will greatly enhance current yields of guppies as well as provide opportunities for diversifying the species to be cultured on the farm. The project investigator has already established linkages with local guppy breeders on Oahu. He has also received technical assistance from the private sector and broodstock of another strain of guppy to complement the existing broodstock. This diversification of strains is necessary to provide a broader variety of products and the project investigator appears to be well on his way to establishing commercial quantities and quality of guppies to sustain the project without any further financial assistance.

Figure 22. Ed Medeiros showing his cultured guppies ready for harvest.

Future Prospects

The investigator is also a participant with the CTSA funded Ornamental Fish Project and has received support in the form of materials and broodstock to establish a livebearer module capable of producing approximately 20-30 x 10^3 swordtail fry per month. The module is designed for use with any of the four main livebearers (swordtails, guppies, platties and mollies) in the aquarium trade. When completed, the module can be incorporated into the current guppy production to further enhance productivity by introducing other livebearer species. It must be emphasized that the ornamental fish industry is very diverse and to be sustainable, a wide variety

Figure 23. Growout pond established at Friendly Isle Fish Company.

of species and/or strains must be produced in sufficient quantity and quality. However, the project investigator has demonstrated noteworthy foresight in his planning for expansion and diversification while building on his successes and appears to be well on his way to achieving his long term objectives.

Recommendations

1) Consult with CTSA funded Ornamental Fish Project and incorporate culture techniques to improve livebearer production.

2) Work with SGES staff to plan out "best case" scenario of livebearer production using on site facilities.

3) With the expansion of growout facilities, investigate polyculture opportunities to continue to diversify production on the farm.

4) Continue collaborative efforts with selected breeders of livebearers within the state in order to maintain a diversity of livebearers.

Contract: #8990049 **Kaupakalua Farms: Integrated Aquaculture Project, Project Investigator; Jesse Chitran, Award: $3,500**

Project Description

The overall goal is to develop an integrated agriculture aquaculture production unit that can be used as a demonstration for other farmers interested in conserving water resources while producing a variety of crops. Moreover, another important objective is to use the facility as an educational tool for youth groups to learn alternative farming techniques. A copy of the proposal with terms of reference for the project is presented in Appendix 12.

Progress Towards Objectives

All of the specific objectives of phase one have been completed. A reservoir (25' x 30') has been completed and was filled with rainwater runoff (Fig. 24). The water held in the reservoir is being used to irrigate hydroponic tables, taro plants and banana plants. The reservoir itself is stocked with tilapia and water hyacinths which serve as a "biological filter". The first crop of hydroponicaly grown watercress and taro were planted during the reporting period and at the

Figure 24. Photograph of constructed reservoir and adjacent hot house.

time of the site inspection approximately $500.00 worth of watercress had been sold. The taro was still being cultured.

A mold problem developed during the past winter season and has resulted in reduced productivity from the hydroponic tables. Additional units have been purchased and are currently being installed to increase production. An innovative use of recycled ground glass obtained from the Maui Recycling Center is being conducted in the hydroponic tables. The project investigator has found that the recycled glass is a suitable growth medium in the hydroponic tables.

Tours involving the Paia Youth Center and Ka Lima O Maui were conducted during the reporting period and a small-scale educational program has been initiated. Three individuals from the Ka Lima O Maui vocational program have begun working with the project investigator on a part-time basis.

Future Prospects

Currently there is little competition in Maui County for organically grown fruits and vegetables. Kaupakalua Farms intends to capitalize on this situation and will attempt to demonstrate the feasibility of the alternative farming techniques developed which in turn can be used by other farmers. With the integration of agriculture and aquaculture, organically grown produce and fish can be marketed with a minimum expenditure on water.

Recommendations

1) Increase production of tilapia culture in the reservoir system by increasing stocking density and feeding rates. This will result in a concomitant increase in dissolved nutrient availability in the effluent water being used to irrigate crops.

2) Work closely with the Paia Youth Center and Ka Lima O Maui and continue to expand the educational-vocational training program for youngsters.

Future Prospects for the Project

A final report summarizing the activities, accomplishments, and future prospects of the entire project will be generated for review by Maui County Department of Economic Development and Maui County Aquaculture Industry Advisory Council. Discussions are planned between all participating institutions for other areas of collaborative efforts.

Recommendations

See Objectives #1-3.

LITERATURE CITED

Whitney, S. 1996. Moloka'i Dreaming. Honolulu Magazine, August 1996. p. 48.

APPENDICES

Appendix 1. Detailed Summary of Responses to Technical Assistance

Activities Report for Dr. Robert Howerton
Sea Grant Extension Service, Maui County
Reporting Period July 1995 - June 1996.

JULY 1995

7/3/9 Site visits-Ed Medeiros, discussion of water quality problems; D. Tollefsen, potential biofouling of limu ropes; Desmund Manaba, well site.

7/6/95 Presentation at Maui County Council, Economic Development, Tourism, and Environment Committee meeting.

7/7/95 Attended Molokai Aquaculture Alliance meeting.

7/7/95 Received call from Jim Shipe- Kaanapali Golf Course concerning aquatic plant problem in lagoon. Suggested sources for grass carp. Discussed site visit on next trip to Maui.

7/7/95 Discussed tilapia workshop for Molokai with Dr. Kevin Hopkins.

7/8/95 Attended Gundle tank construction workshop at Windward Community College. Met Francis Hun & Ass. of Boke Farms.

7/10/95 Received call from Goodhues east side. Made appointment for site visit on 7/18.

7/10/95 Received phone call from David Moore-University of Arizona. Discussed Machado's limu project. Moore will be on Molokai 7/17.

7/10/95 Call to Bob Johnson. Discussed possibility of purchasing welding gun and material for Maui County.

7/10/95 Call from Joe Kennedy. Needed info on tilapia production. Collected info. made site visit.

7/11/95 Call from Ed Medeiros. Site visit (ornamentals). Discussed possibility of building ponds to grow prawns or shrimp.

7/12/95 Call from Ed Medeiros. Site visit. Started pond construction, delivered info on pond construction.

7/13/96 Attended CES workshop on turfgrass and ground cover production at Plant Materials Center.

7/13/95 Call from Pat Rocco, Maui County. Dept. Of Parks & Rec. Sent info about ornamental ponds at Iao Park. Arranged for site visit during next trip to Maui.

7/14/95 Site visits with Dr. Hopkins (UH-Hilo), Dr. Grau (HIMB). Manae, Kahinapohaku Fishpond, Ualapue Fishpond.

7/15/95 Tilapia Workshop at Hoolehua Rec. Center- 17 participants. Site visits- Hoolehua, Palaau, Kawela with visiting researchers.

7/17/95 Call from Colleen Church- info. Sent on backyard tank culture.

7/17/95 Call from Jessie Chitran--info on hydroponics requested and sent. Call from David Moore-discussion of limu project.

7/18/95 Site visit in Waialua with Goodhues concerning potential aquaculture.

7/18/95 Site visit in Manae-Desmund Manaba discussed hatchery site.

7/18/95 Discussed Haw'n fishponds with Bill Monahan of Hui O Loko I'a.

7/19/95 Site visit to Jack Ewing-Kawela. Discussion about backyard ornamental fish production. Gave him info about tank construction.

7/22/95 Attended hatchery workshop at WCC-Oahu.

7/24/95 Received call from Jessie Chitran-Maui information on tank construction, water quality sent.

7/24/95 Phone call from Dennis Mitchell about water quality problem in hatchery. Gave me the name of Maui County Board of Water Supply Supervisor.

7/24/95 Called David Craddick (Maui County Board Water Supply) passed on concerns. He said he would follow up about possible chlorine spike.

7/25/95 Site visits to Hoolehua (Loko I'a Kalo) water quality problems. Palaau (Chaiken) fiscal matters. Manae (Manaba) hatchery discussions.

7/26/95 Received call from Ernest Rebello- Tri-Isle RC&D- concerning potential aquaculture projects for Maui County.

7/26/95 Discussed educational aquaculture project with Brian MacCafferty for Paia Youth Center, Maui. Information sent

7/27/95 Site visits- Honouliwai Fishtrap, Kahinapohaku Fishpond- discussion with Lani Caparida about permit process. Hoolehua- Loko I'a Kalo- discussion about spawning Chinese catfish. Palaau- Mark & Becky Yuen- prawn broodstock.

7/28/95 Phone call from Manny Aruda, Maui. Interested in doing small-scale aquaculture. Information sent will visit site next Maui trip.

7/28/95 Site visit with Ray Clarke, NMFS. Moomomi Native Haw'n Fishing Sanctuary. Discuss possible assistance with educational program, Wayde Lee, Mac Poepoe. Toured Loko I'a Kalo and Palaau Shrimp & Prawn Co. with Clarke.

7/30/95 Site visit Loko I'a Kalo- discuss tilapia culture, pond construction, USDA proposal.

7/31/95 Meeting with Kip Dunbar- discuss Haw'n fishponds.

AUGUST 1995

8/1/95 Site visits Hoolehua- Loko I'a Kalo, water quality, Kawela- Medeiros, ornamental fishes. Meeting with Walter Ritte about Haw'n fishponds (permits).

8/2/95 Site visit Pukoo, limu project- data collection, meeting with David Moore University of Arizona.

8/3/95 Site visit, Chaiken-discuss Maui County moi contract. Hoolehua, Dan Marcellino--backyard tanks, water quality. Meeting with Dean Fujii, MCDC (Maui County contracts).

8/4/95 Meeting with Dean Fujii, MCDC (Maui County contracts).

8/7/95 Discussion with George Costa, Maui--shrimp culture, hatchery. Information sent.

8/7/95 Received a call from Dale Sarver about USDA proposal to be submitted to MAA. Discussed requirements, budget etc.

8/7/95 Received a call from Fil Ke (Molokai), backyard aquaculture. Site visit (water tested) and information provided.

8/7/95 Meeting with Bill Puleloa, discussed Moomomi subsistence fishing area.

8/7/95 Phone call to Ray Clarke (NMFS) to discuss Moomomi subsistence fishing area, Saltonstall-Kennedy funding.

8/8/95 Phone call from Manual in Honomuni requesting site visit.

8/8/95 Phone call from Desmund Manaba requesting site visit.

8/8/95 Phone call to Bob Johnson (Maui County OED) discussed Molokai aquaculture projects and County Council site inspection.

8/8/95 Site visit to Manae-- Desmund Manaba to look at potential well sites, progress on hatchery.

8/8/95 Site visit Pukoo, collect data on limu project.

8/8/95 Site visit Honomuni Valley--Manual looked at small inland pond, discussed possible restoration, weed control, restocking, water quality parameters.

8/9/95 Meeting with Yuens (Molokai) about MAA proposal for pearl oyster project.

8/9/95 Phone call from Chris Brown (HIMB) to discuss possible collaborative projects on Molokai.

8/9/95 Phone call to Sol Kaholahalahala's office about Maui County council site inspection itinerary and date.

8/9/95 Phone call from Denise Light (SCS) about MAA proposal for integrated ag-aquaculture project.

8/9/95 Information request for tilapia culture from David Brown, Maui. Information sent.

8/9/95 Phone call from Willie Lansford, Maui. Discussion about potential project funds for ornamental fish project.

8/16/95 Site visit, Hoolehua (Loko I'a Kalo). Collaboration and discussion about USDA research proposal.

8/16/95 Discussion with Glenn Teves (CES) about requirements for USDA aquaculture research projects.

8/17/95 Pick up Gundle material to build ornamental fish tanks. Material dropped off at Ed Medeiros. Discussion of construction date.

8/17/95 Site visit Palaau. Molokai Sea Farms, water quality problems, weed infestation. Recommendations given.

8/17/96 Site visit Palaau. Discussions with Yuen's about permitting problems.

8/17/95 Site visit Hoolehua. Discussion about Gundle tank construction and tank placement.

8/18/95 Kaunakakai dock. Pick up remainder of Gundle tank material.

8/18/95 Site visit One Alii Fishpond. Status of stocked mullet fingerlings, data collection.

8/19/95 Site visits to backyard fishtank sites, Hoolehua vicinity. Attended Aqua-Hui meeting, discussions about marketing strategy, water quality, fingerling sources.

8/21/95 Site visit Manae. Desmund Manaba shrimp farm check up on status of well and hatchery construction. Confirmation about County Council site inspection.

8/21/95 Site visit Manae. Dicky Tollefsen discussion about status of limu project, County Council site inspection.

8/21/95 Phone call from Collette Machado- Cancellation from County Council Site inspection.

8/21/95 Phone call to Council Services confirming itinerary for Council Site inspection.

8/22/95 Site visit to Ed Medeiros, Steve Chaiken, Yuens, Loko I'a Kalo to discuss County Council site inspections.

8/23/95 Maui County Council Site inspection tour of all County funded projects.

8/24/95 Site visit Hoolehua, Loko I'a Kalo. Discussions on USDA aquaculture research proposal.

8/24/95 Phone call from Harry Hasegawa about potential markets for Chinese catfish. Made suggestions. Asked about possibility of raising ornamental fish. Suggested he call Brian Cole (SGES).

8/24/95 Attended Molokai Water Commission Meeting (evening).

8/25/95 Site visit, One Alii Fishpond. Visual inspection of net pen and mullet fingerlings.

8/25/95 Meeting with One Alii Fishpond hui. Discussed future plans and status of fishpond permits.

8/25/95 Meeting with Dean Fujii (Molokai Community Development Corporation) To discuss progress and fiscal status of Maui County funded projects.

8/28/95 Site visit to Hale O Lono, collect growth data on pearl oysters.

8/28/95 Phone call from Lahainaluna Vo-tech instructor to discuss student projects. Agreed to give presentation during next Maui visit.

8/28/95 Attended Molokai Aqua. Alliance meeting (evening).

8/28-29/95 Sea Grant Retreat (Oahu).

8/31/95 Phone call from Manny Aruda (Maui). Information requested on start up of aquaculture. Information sent.

8/31/95 Phone call from Jesse Chitran (Maui). Requested sources of hydroponic info. Sent information and gave him UH Ag. Eng. phone number for additional info.

SEPTEMBER 1995

9/1/95 Site visit Hoolehua (Loko I'a Kalo) status check .

9/1/95 Site visit Kawela (Ed Medeiros) stocked prawns in small ponds. Gave general information on prawn culture.

9/1/95 Phone call Hamp Merril (University of Arizona)- potential collaboration with Loko I'a Kalo. Asked about status and other possible collaboration with integrated ag/aquaculture projects on Moloka'i and Maui. Gave him names and numbers.

9/5/95 Phone call Nedra Brooks (Maui). Inquired about information on Rainbow trout. Information sent. Set up appointment for site visit.

9/5/95 Phone call Manny Aruda (Maui). Information requested on ornamental fish culture. Information sent. Set up appointment for site visit.

9/5/95 Site visit Hoolehua (Loko I'a Kalo) Picked up equipment from Scott Adams to be used by Ed Medeiros.

9/5/95 Site visit Hoolehua (Dan Marcellino) Tested water quality. Having chronic mortalities.

9/5/95 Site visit Kawela (Ed Medeiros) Drop off nets for sampling.

9/6/95 Maui trip Site visits- Kaupakaula Farms (Jessie Chitran) discussed integrated hydroponic-aquaculture system design.

9/6/95 Maui site visit with Nedra Brooks. Discussed possibilities about how to utilize the ponds on site.

9/6/95 Maui met with Manny Aruda. Inquired about starting up aquaculture tank, what species to raise. Gave general info.

9/6/95 Maui site visit with Madeline Joseph. Discussed using aquaculture as tool for home schooling kids.

9/6/95 Maui- met with Brian McCafferty about incorporating aquaculture into Paia Youth Center activities, setting up a demonstration facility.

9/6/95 Maui- site visit with Robert Gann. Discussed his integrated system and potential expansion.

9/7/95 Maui- site visit Kaanapali Golf Course (Jim Shipe) weed infestation in lagoons. Recommended grass carp for control, will send him sources.

9/7/95 Maui-site visit Dennis Mitchell. Discussed an ornamental fish coop for Maui. Met with Willie Lansford about potential funding sources.

9/7/95 Maui-site visit Dr. Dennis Brown, discussed production techniques for his backyard ponds.

9/8/95 Meeting with Buddy Keala- discussed Haw'n fishpond permitting process, potential research projects.

9/8/95 Site visit (Hoolehua)- Lew Meteliz SG Computer Specialist helped upgrade Loko I'a Kalo computer. Also helped upgrade programs etc. on my computer.

9/10/95 Site visit Kawela (Ed Medeiros) Meteliz helped on computer work.

9/11/95 Site visit Kawela (Ed Medeiros)- discussed ornamental swordtail project, feeding regime, data collection.

9/11/95 Visit with Yuen's to discuss SW well problems.

9/11/95 Phone call from Joe Kennedy, set up an appointment for site visit.

9/11/95 Phone call from Phil Ke, discussed water quality problems. Set up appointment.

9/12/96 Site visit, Joe Kennedy. Discussed pond construction feeding practices, water quality in tilapia ponds.

9/12/96 Site visit, Phil Ke. Water quality and DO testing. Suggested feeding practices, using effluent water for fruit trees.

9/12/95 Meeting with Dean Fujii (MCDC) discussed fiscal matters on Maui County grants.

9/13/95 Phone call from Bob Johnson (MCOED) discussed upcoming Maui Pacific Center Conference & Maui County fiscal matters. Updated him on Molokai aquaculture projects.

9/13/95 Phone call Victor Reyes (Maui) discussed start up of backyard tank- information sent, Set up appointment for next visit to Maui.

9/13/95 Site visit Hoolehua (Loko I'a Kalo)

9/13/95 Attended Maui County Budget hearing- testified on aquaculture funding.

9/14/95 Phone call Ed Bartholomew- discussed pump requirements on ornamental pools, gave recommendations and sent information.

9/15/95 Attended Molokai Ice House meeting- discussed purchase and sales of aquaculture products with MIH board members.

9/15/95 Phone call Marilyn Jackson (Maui) request for info on backyard tanks- info sent.

9/16/95 Site visits (Hoolehua vicinity) visited all backyard hui members, tested water. Attended Aquaculture Hui meeting.

9/18-9/23/95 Attended Maui Pacific Center Meeting on Maui- Sustainability of the Aquatic Environment.

9/25/95 Phone call Simeon Aleop (Maui) requested info on starting up aquaculture- info sent.

9/25/95 Meeting with Dean Fujii (MCDC) discussed fiscal matters on Molokai contracts and progress reports.

9/25/95 Site visit Ed Medeiros- worked on ornamental fish project.

9/25/95 Phone call Ernie Rebello (USDA Tri-Isle RC&D) discussed possible aquaculture projects for Maui & Molokai, funding sources, priorities. Tour Molokai projects during his next visit.

9/25/95 Phone call from Denise Light (USDA-SCS) discussed integrated ag-aquac. proposal for MAA.- research objectives etc. Set an appointment for 9/26.

9/25/95 Phone call from Charlotte Nakamura (Maui -CES). Film crew coming to Molokai would like to tour aquaculture operations. Called and set up itinerary with producers for 9/28.

9/26/95 Phone call from Dr. Claude Boyd (Auburn University - Fisheries) Invitation to attend WAS meeting as panel member and moderator.

9/26/95 Site visit Hoolehua (Loko I'a Kalo) check status of hatchery construction, tanks.

9/27/95 Site visit Pukoo (Colette Machado) Checked limu growth, production.

9/27/95 Site visit Manae (Dicky Tollefsen) Checked limu growth, production. Worked with student help on data collection and analysis.

9/27/95 Site visit Manae (Desmund Manaba) Status of well, permits, hatchery.

9/28/95 Site visits with film crew to all aquaculture facilities including Haw'n fishponds.

9/29/95 Site visit Manae (Dicky Tollefsen) Worked with student help on data analysis, experimental design.

9/29/95 Site visit Honouliwai (Hal Fuji) Inland pond discussed possible sources of mullet fry for restocking.

9/29/95 Phone call Kip Dunbar. Discussed management strategy for his Haw'n fishpond. Potential sources of fry.

OCTOBER 1995

10/2/95 Phone call from Tim Herring (Ag Eng. Ext. Agent) Discussed status of Backyard Aqua Hui. Possible workshop dates.

10/2/95 Phone call from Dr. Aecio D'Silva (U. Of Arizona) Wanted to know status of MAA-USDA grant proposal. Discussed time frame and progress of Loko I'a Kalo project.

10/2/95 Phone call from Brooks Takenaka (Oahu Fish Auction). Discussed visit to Molokai on 10/6. Wanted to meet with aquac. Producers and ICE House about products. Set up appointments.

10/2/95 Meeting with Walter Ritte (DBEDT) Discussed status of permitting process for Haw'n fishponds. Potential restoration of a couple of ponds, Management of Ualapue Fishpond.

10/3/95 Phone call from Jack Macquire (Maui) Requested information about backyard aquaculture- info sent.

10/3/95 Phone call Harry Hasegawa (Hana, Maui) Requested information about potential markets for Chinese catfish. Names and numbers given.

10/3/95 Phone call Wendy Wiltse (EPA) Discussed West Maui watershed management project- limu infestations on the beach, water quality issues, golf course run off.

10/4/95 Phone call Dr. Grau (HIMB) talked about coming to a tilapia workshop on Molokai. Possible collaboration on research projects.

10/4/95 Meeting with Dean Fujii (MCDC) Discussed fiscal matters concerning Molokai contracts, progress reports from projects.

10/4/95 Site visit Hoolehua (Loko I'a Kalo) Status of hatchery. Checked on chronic mortality of ornamentals, Tested water quality.

10/4/95 Phone call from Don Aimsworth (MCC instructor) Wants to do projects on Molokai incorporating alternative energy. Gave him names of potential cooperators. Set up appointment for his visit 10/6.

10/5/95 Phone call Linda Gusman discussed backyard hui's on all islands.

10/5/95 Phone call Marvin Hanchett (Maui) discussed status of Hana backyard hui. Still looking for markets for fish.

10/5/95 Phone call Glenn Teves (CES) Discussed MAA-USDA grant proposals.

10/5/95 Site visit Hoolehua (Loko I'a Kalo) picked up MAA-USDA grant proposal.

10/6/95 Meeting with Brooks Takanaka (Oahu Fish Auction) toured some aquaculture facilities, talked with farmers. Met at Molokai Ice House.

10/6/95 Meeting with Don Aimsworth (MCC) took him to Loko I'a Kalo to discuss alternative energy options.

10/9-10/13/95 Attended Oceanic Institute U.S.-Asian Interchange Conference on Fish Diseases (Oahu).

10/9/95 Meeting with Ray Clarke (NMFS) discussed Moomomi Fishing Subsistence Project on Molokai. Possible cooperation with Sea Grant for technical assistance on Educational program.

10/16/95 Phone call from Richard Bishop (Washington) will be on island 10/18 wants to discuss aquaculture potential on Molokai. Specifically interested in bivalve project.

10/16/95 Phone call John Pye (MCC-MOP coordinator) Projects for Molokai students or possibly Maui MOP students who want to work on Molokai.

10/17/95 Phone call Allen Tom (NMFS Whale Sanctuary) phone survey about whale sanctuary. Discussed Haw'n fishpond fronting his office in Kihei. (Ownership, restoration)

10/18/95 Meeting with Richard Bishop (Washington) . Discussed oyster projects, funding sources, collaboration with Black Pearl Oyster project. Gave him contact names & numbers.

10/18/95 Site visit to Palaau meet with Yuens and Bishop to talk about pearl oysters.

10/18/95 Site visit Chaiken (Palaau) Check on status of moi and shrimp hatchery project. Discuss oysters with Bishop and Chaiken, possible land-based production using shrimp effluent.

10/19/95 Phone call Ernie Rebello. Requested info. On tank construction and sample budgets of Maui County projects already funded. Information sent.

10/19/95 Phone call to Clyde Tamaru to discuss Maui County projects.

10/ 20/95 Site visit Kahinapohaku Fishpond with Lani Caparida, Ohana representative. Discussed problems with permitting, plans they have for the pond, restoration process.

10/23/95 Phone call to Hawaii Aquaseed discussing availability of shrimp and prawn Pls.

10/23/95 Phone call to Ed Medeiros relaying info on availability of prawn seedstock.

10/23/95 Phone call to Becky Yuen relaying info. On availability of seedstock.

10/24/95 Maui to attend RCL Advisory Committee meeting. Discussed tentative workshops, lecturers, potential candidates.

10/25/95 Site visit Manae (Tollefsen). Check status of limu project. Go over data with student help.

10/25/95 Site visit Manae (Manaba) Check status of hatchery, permits, well.

10/25/95 Site visit Pukoo (Machado) Check status of limu project.

10/25/95 Site visit Kawela (Medeiros) Check status of guppy project.

10/25/95 Phone call from Bill Monahan (Hui o Loko I'a). Discussed fishpond status. Offered to donate dredger to Sea Grant.

10/26/95 Phone call from Pam Tumpap (RCL) discussing potential candidates from Molokai for RCL classes.

10/26/95 Phone call from Hamp Merril (Univ. Of Arizona). Would like to meet me on Maui (10/30) to do a number of site visits of integrated projects.

10/26/95 Phone call from Jim McCalvaney (Sustainable Tech.) Maui. Discussed his project and how to integrate aquaculture into recycling program.

10/27/95 Phone call from Carlton Pang (Kihei) asked about availability of HCG. Told him to contact Rich Bailey.

10/27/95 Phone all from Bill Monahan (Hui O Loko I'a) Discussion about shipment of equipment donated to Sea Grant.

10/27/95 Phone call to Billy Richards (Oceanic Inst.) Discussion about shipment of fishpond equipment to Molokai.

10/30/95 Maui trip. Meeting with Hamp Merril (U of Arizona) at Sustainable Technologies (Jim McCalvaney). Discussed integrated ag-aquacult. , using effluents.

10/30/95 Site visit Maui. Kaupakalua Farms (Jessie Chitran). Water quality testing, feeding records, data analysis.

10/30/95 Site visit Maui. (Robert Gann) . Integrated organic farm. Recommendations on water quality, feeding, harvesting, marketing.

10/30/95 Site visit Maui (Madeline Joseph). Discussions on setting up backyard tank. Using aquaculture as tool to teach children for at home schooling.

10/30/95 Site visit Maui. (John Tallman). Tilapia culture, rec. On integrating ag-aquacult.

10/31/95 Attended Board meeting of Tri-Isle RC&D, Maui. Discussion of variety of projects being funded on Maui.

10/31/95 Maui. Meeting with Ernie Rebello (Tri-Isle RC&D). Discussed potential funding for educational project for Paia Youth Center, tank construction. Site visit to Paia, meeting with Brian MacCafertty Youth Center Coordinator.

10/31/95 Site visit to Kealia Fish farm with Ernie Rebello, Kathy Smith (USF&W). Discuss plans for site after USF&W take it back over. Potential educational program.

NOVEMBER 1995

11/1/95 Meeting with Dr. Mark Merrifield (UH Ocean Eng.) Discussed Haw'n fishpond research, circulation studies. Site visits to five fishponds.

11/2/95 Meeting with Dr. Aecio D'Silva, Dr. Gene Maughn, Dr. Hamp Merril (U. Of Arizona). Discussed potential collaborative research projects on Molokai. Site visits to East side aquaculture and agriculture Projects.

11/3/95 Site visits w./ U. Of Arizona researchers to ag and aquac. Projects on South side and Hoolehua and Palaau vicinity.

11/4/95 Meeting with Dr. D'Silva to learn his aquaculture computer program.

11/6-7/95 Invited speaker to Pacific Rim RC&D Annual meeting (Kona). Gave presentation on Molokai aquaculture projects, Haw'n fishponds.

11/8/95 Oahu Attend Sea Grant Staff meeting.

11/8/95 Oahu. Meeting with Ms. Angela Williams (UH Small Business Dept) about potential workshop series on Molokai.

11/8/95 Meeting with Ted Walsh (UH Analytical Services) about water quality research for Haw'n fishponds.

11/9/95 Site visit Manae (Tollefsen) Work with student help on data collection, analysis.

11/9/95 Site visit Manae (Manaba). Status of hatchery construction. Asked about supply sources.

11/9/95 Phone call to Bill Monahan (Hui O Loko I'a). Asked about status of hui, fishpond slide availability.

11/13/95 Site visit Hoolehua (Loko I'a Kalo). Discussed tilapia hatchery and nursery design. Availability of HCG for catfish spawning. Ornamental fish project.

11/13/95 Site visit Palaau (Chaiken) Status check on moi and shrimp project.

11/13/95 Site visit Palaau (Yuens) Problems with pond construction. Gave recommendations.

11/13/95 Site visit Kawela (Medeiros) Check up on ornamental fish project.

11/13/95 Phone call to Jim Sweeney (Oceanic Inst.) Requesting info on shrimp hatchery and larval rearing.

11/14/95 Attended Ag. Leadership Advisory Committee Meeting (Maui).

11/15/95 Site visit Kawela (Medeiros) data collection, pick up equipment.

11/15/95 Site visit Hoolehua (Loko I'a Kalo) drop off equip. Data collection.

11/16/95 Meeting with Ernie Rebello (Tri-Isle RC&D). Site visits around Molokai. Meeting with Zelly Duvachelle (Pukoo) about potential educational project with inland Haw'n fishpond on property.

11/17/95 Meeting with Ronnie Sei (UH Small Business Dept.) About workshops for Molokai. Site visits to meet potential clientele.

11/19/95 Phone call Kaupakaula Farm (Jessie Chitran) Returned call he requested info. On pond construction, info sent.

11/20/95 Maui Site visit. Kaupakalua Farm (Jessie Chitran) Status check.

11/20/95 Site Maui visit Makawao. (Robert Gann) check out system, gave rec. On stocking rate, feeding rates, effluent discharge for ag plants.

11/20/95 Maui site visit. Haiku. Brooks Fresh H2O Farm (Nedra Brooks).

11/20/95 Maui site visit. Haiku. (Manny Aruda). Backyard tank info. Potential species.

11/21/95 Maui site visit. Kaanapali Golf Course (Jim Shipe). Weed problem check up.

11/21/95 Maui presentation (Lahainaluna High School) General aquaculture to Vo-Tech program.

11/21/95 Maui meeting with Ed Bartholomew (Lahainaluna teacher).

11/22/95 Maui meeting with Simeon Aleop. Potential backyard tank set-up. Will send info.

11/22/95 Maui meeting with Victor Reyes. Potential tilapia farm. Will send info.

11/24/95 Site visit Kawela (Medeiros). Get set up for tank construction.

11/24/95 Site visit Hoolehua (Loko I'a Kalo) pick up jig for tank construction.

11/25/95 Tank construction Workshop.

11/27/95 Phone call from Oceanic Institute (Billy Richards). Shipment of mullet fingerlings.

11/27/95 Site visit Honouliwai Fishpond (Ed Tanaka) Discussion on status of ADP initiate for permits.

11/28/95 Info sent to Victor Reyes, tilapia, start-up, general.

11/28/95 Info sent to Simeon Aleop, general, backyard, species

11/28/95 Site visit Manae (Tollefsen) Status check.

11/28/95 Site visit Manae (Manaba) Status check.

11/29/95 Phone call from Dr. Grau (HIMB) Discussion of potential collaborative research on Molokai.

11/29/95 Phone call from Oceanic Institute (Billy Richards). Delay in shipment of .mullet fingerlings for One Alii Fishpond.

11/30/95 Site visit Kawela (Medeiros) status check

11/30/95 Site visit Hoolehua (Loko I'a Kalo) status check

DECEMBER 1995

12/2/95 Site visit Hoolehua (Loko I'a Kalo) harvesting of fish.

12/3/95 Meeting with Joe Manaba information requested on sources of equip for hatchery.

12/4/95 Phone call from David Brown (Maui). Information requested on oopu. Info sent

12/4/95 Phone call from Dr. Maynard (UH-MOP) inquiring about status of MOP program on Maui.

12/4/95 Site visit Hoolehua (Loko I'a Kalo).

12/5/95 Site visit Palaau (Yuens) status check.

12/5/95 Site visit Palaau (Chaiken) status check.

12/6/95 Pick up HDPE tank from Kawela drop off at Hoolehua.

12/6/95 Phone call from Dr. Holland (HIMB) Inquired about DAR personnel on Molokai.

12/6/95 Phone call from Robbie Guard (MCOED) Inquired on status of aquacult. projects.

12/7/95 Site visit Pukoo (Machado) Collect data with David Moore (U. Of Arizona). Discuss experimental design for limu project.

12/7/95 Phone call from Kevan Main (Trop. Reg. Aqua. Center.). Request to review research projects.

12/7/95 Phone call from Bill Monahan (Hui O Loko I'a). Requested a meeting during next trip to Molokai.

12/8/95 Site visit Hoolehua (Loko I'a Kalo) install plumbing in HDPE tank.

12/8/95 Phone call from Lucia Davis (Lanai Backyard hui). Requesting info on potential markets for catfish.

12/8/95 Phone call from Harry Hasegawa (Hana). Requested info on potential markets for catfish.

12/11/95 Attended In-Service training on Maui (CES) about Internet on-line services.

12/12/95 Site visit Hoolehua (Loko I'a Kalo) Plumbing on HDPE tank.

12/12/95 Site visit Palaau (Chaiken) water quality testing.

12/13/95 Phone call to Jim Sweeney (OI) requesting info on shrimp feeds for Chaiken.

12/13/95 Phone call from Robert Gann (Maui) requesting info on feed sources. Info given.

12/13/95 Phone call to Quin Li about possibly purchasing catfish from hui's on Molokai, Maui, Lanai.

12/14/95 Phone call to MCOED concerning RCL Advisory committee meeting, possible candidates for program.

12/15/95 Maui attend Maui County RCL Ag leadership training session.

12/16/95 Meeting on Oahu with Steve Olson (NCRI) discussion of proposals submitted to NCRI from Molokai.

12/18-19/95 Maui to attend RCL Ag leadership Training program.

12/20/95 Phone call from Dennis Mitchell (Maui) Discussion of ornamental fish hui for Maui.

12/20/95 Meeting with Buddy Keala. Discussion of Ha'wn fishpond educational program.

12/20/95 Meeting with Kip Dunbar to discuss Ha'wn fishponds, status of permitting process.

12/20/95 Phone call to Billy Richards (OI) Discuss status of equipment donated to Molokai Sea Grant.

12/21/95 Site visit Manae (Manaba). Work on design considerations for shrimp hatchery.

12/22/95 Phone call to Harry Hasegawa (Hana). Discuss shipping of live catfish to market in Honolulu. Packing requirements etc.

12/22/95 Phone call from Marvin Hanchett-Ching (Hana) discuss marketing of Hana hui fish.

12/22/95 Site visit Hoolehua (Kanue) talked about marketing aqua-hui fish on Oahu. Gave contact names and numbers.

12/27/95 Site visit Palaau (Kennedy). Recommendations on pond improvement, feed rates, water quality.

January 1996

1/3/95 Phone call from Hasegawa (Hana) reccommendations on packing and shipping of catfish for Oahu market.

1/3/95 Phone call to Chitran (Makawao) update on integrated project.

1/4/96 Site Visit Palaau (Chaiken). Problems with shrimp hatchery design. Gave Recommendations.

1/4/95 Phone call from Harry Hasegawa (Hana) requesting me to ensure catfish make connecting flight to Oahu.

1/4/95 Airport ensure shipment of catfish from Hana made flight to Oahu market. Transfer fish from airport to Hoolehua.

1/5/95 Hoolehua to airport- pack & transfer Hana catfish to airport for Oahu market.

1/5/95 Kawela (Medeiros) assist in packing of ornamentals for shipment.

1/6/95 Hoolehua to airport- pack & transfer catfish to airport for Oahu market.

1/6/96 Phone call to Hasegawa (Hana) letting him know fish were sent.

1/6/96 Phone call to Quin Li (Oahu) letting her know fish were shipped.

1/8/96 Site visit Hoolehua (Kahue) assist in packing catfish for Oahu market

1/8/96 Phone call to Quin Li (Oahu) fish shipments & payment schedule to producers.

1/8/95 Phone call from Monahan (Hui O Loko I'a) Status of hui possibility of putting me on board of directors.

1/9/95 Phone call from Sarver (Black Pearls of Hawaii). Inquiry about status of USDA MAA proposal.

1/9/95 Phone call to Tallman (Maui) letting him know about availability of ornamental fish.

1/9/95 Phone call to Lansford (Maui) letting him know about availability of ornamental fish.

1/10/96 Site visit Kawela (Ewing) water quality testing. Discussion about potential of ornamental fish production.

1/10/95 Phone call to Hasegawa (Hana) Discussion of fish shipments, payment schedule, availability of catfish fry.

1/11/95 Site visit Hoolehua (Loko I'a Kalo) work on tanks.

1/11/95 Site visit Kawela (Medeiros) work on tanks.

1/12/95 Phone call from Dr. Boyd (Auburn University) discussing agenda at upcoming WAS meeting.

1/12/96 Phone call from Robert Gann (Maui) inquiring about availability of County funds for projects.

1/13/96 Airport trip to ensure transfer of fish from Maui To Oahu market.

1/13/96 Site visit to Hoolehua (Loko I'a Kalo) work on tanks.

1/15/96 Phone call from Hasegawa (Hana) fish shipment to Oahu.

1/15/96 Phone call to Quin Li (Oahu) Fish shipment from Hana to Oahu.

1/15/96 Pick up and pack fish at Loko I'a Kalo take to airport to ship to Oahu.

1/15/96 Site visit to Palaau (Yuens) Discuss status of project.

1/15/96 Phone call from MacCafferty (Maui) Wants to see aquaculture facilities on Molokai.

1/16-17/96 Oahu trip to prepare slides for WAS meeting and meet with Sea Grant Communications Office.

1/18/95 Tour all aquaculture sites with Brian MacCafferty (Maui).

1/18/96 Attend Molokai Aquaculture Alliance Meeting.

1/21/96 Attend Keanae Community (Maui) meeting to discuss apple snail problem.

1/22/96 Phone call to MCOED (Guard) to discuss Keanae meeting and other Maui Aquaculture projects.

1/23/96 Phone call to Lansford (Maui) to discuss funding for ornamental fish project, sources of supplies.

1/23/96 Phone call from Linda Gusman inquiring about source of prawn Pls. Told her Yuens were not ready. Suggested her to contact Hawaii Aquaseed.

1/24/96 Phone call from Monahan (Maui, Hui O Loko I'a) about dates for visit of Haw'n fishpond sites meetings with potential fishpond managers, educational workshops.

1/24/96 Phone call from Hamp Merril (U of Arizona) will be on Molokai 2/5 wants to meet with farmers.

1/26-2/2/96 Attended WAS meeting gave presentation on Haw'n fishponds.

FEBRUARY 1996

2/5/96 Toured aquaculture facilities with Merril (U. Of Arizona) Met with farmers about integrated farms, alternative energy.

2/6/96 Phone call from Davis (Molokai High School) Discussed possibility of incorporating aquaculture into Vo-tech curriculum. Field trips for kids.

2/7/96 Attend RCL advisory Committee Meeting on Maui.

2/8/96 Phone call from Chitran (Maui) Inquire about sources of feed. Information given.

2/9/96 Visit form Dr. Benny Ron (HIMB) toured aquaculture facilities (East Side)

2/10/96 Toured Palaau and Hoolehua Facilities with Dr. Ron.

2/12/96 Phone call from David Kamalani (Maui) inquired about start up aquac. Information sent.

2/12/96 Site visit Hoolehua (Loko I'a Kalo) water quality testing.

1/12/96 Site visit Kawela (Medeiros) water quality testing, inspection of prawns.

2/13/96 Site visit Hoolehua (Loko I'a Kalo) Data collection on ornamental fish project.

2/13/96 Site visit Kawela (Medeiros) data collection ornamental fish project.

2/13/96 Phone call to Chitran (Maui) information on marketing of fish.

2/13/96 Phone call to Johnson (Maui Econ Dev. Board) Discussion of RCL program.

2/13/96 Phone call from Aruda (Maui) Inquiring about information on tank backyard set-up. Info sent.

2/14/96 Site visit Palaau (Yuens) status check.

2/14/96 Phone call from Wendy Wiltse (EPA, Maui) Discussion of West Maui Watershed Management program.

2/14/96 Phone call to Lansford (Maui) Discussion about setting up ornamental Fish hui. Availability of ornamental fish broodstock.

2/15/96 Site visit Hoolehua (Loko I'a Kalo) construction of net pens.

2/15/96 Site visit Kawela (Medeiros) construction of net pens.

2/15/96 Site visit Palaau (Yuens) transfer of guppies from Medeiros.

2/15/96 Attend Molokai Aquac. Alliance meeting.

2/15/96 Phone call from Brooks (Maui) Inquiry about status of proposal submitted to MCOED. Relayed that proposal still under review process.

2/15/96 Phone call to Army Corp. Of Eng. Requesting info on Water Quality permit.

2/15/96 Phone call to Dr. Holland (HIMB) requesting info on papio tracking project.

2/16/96 Site visit (Hale o Lono) Data collection on pearl oysters.

2/16/96 Phone call to Army Corp of Eng. Discussion of water quality permitting process.

2/16/96 Meeting with Kalipi (Ualapue pond manager) discussing permitting process.

2/17/96 Site visit Ualapue fishpond.

2/19/96 Phone call from Hasegawa (Hana) about fish shipments to Oahu. Potential ornamental fish production.

2/20/96 Site visits with Senator Inouye group from D.C.

2/20/96 Attended Molokai Aquaculture Alliance meeting

2/20/96 Phone call from Tumpap (Maui) discussing RCL applications, orientation scheduled for 2/24.

2/21/96 Phone call from Young (ADP) requesting info on fishpond ownership. Info sent.

2/21/96 Meeting with Caparida (Kahinapohaku fishpond hui) status of permitting process.

2/21/96 Phone call from Adams (Loko I'a Kalo) info request on alternative ornamental species. Phone call to Cole (SGES) info relayed.

2/21/96 Site visit Tollefsen (Manae) project status check-up.

2/22/96 Site visit Hoolehua (Loko I'a Kalo) drop off catalogues. Check on project status.

2/22/96 Site visit Palaau (Yuen) Status check, discuss pearl oyster data, schedule. Prawn Pl availability.

2/23/96 Phone call to Hawaii Aquaseed about prawn & shrimp availability.

2/23/96 Phone call from Mitchell (Maui) discussed setting up ornamental fish hui for Maui.

2/23/96 Phone cal from Sarver (Black pearl oyster, Kona) status of MAA-USDA proposal.

2/23/96 Phone call from Masser (Auburn Univ.) Inquired about possible collaborative projects in Hawaii.

2/23/96 Phone call to Sweeny (OI) about availability of shrimp Pls. Discussed status of Chaiken hatchery.

2/24/94 Attended orientation meeting for RCL (Skybridge).

2/26/95 Meeting with Fujii (MCDC) discuss Maui County aquaculture budgets.

2/26/95 Phone call to Robbie Guard (MCOED) to discuss projects itinerary for visit.

2/27-28/96 Trip to Oahu, meet with HIMB personnel, Hawaii Pacific University personnel, OI staff.

2/29/95 Phone call from Young (ADP) discuss NCRI water quality proposal.

MARCH 1996

3/1/96 Pick up ornamental fish at airport for Medeiros, Loko I'a Kalo. drop off at Kawela Hoolehua. Arrange for catfish to make transfer to Oahu market from Hana.

3/1/96 Phone call to Hasegawa (Hana) coordinating catfish shipment.

3/1/96 Phone call to Qyen Li (Oahu) coordinating catfish shipment.

3/1/96 Phone call from Costa (Maui) requesting info on shrimp hatchery. Info sent.

3/1/96 Phone call from Nunes (Maui) requesting fishpond slides. Slides sent.

3/2/96 Site visit Hoolehua (Loko I'a Kalo) check on status of ornamental fish shipment. Water quality testing.

3/2/96 Site visit Kawela (Medeiros) check on status of ornamental fish shipment. Water quality testing.

3/4/96 Phone call from Davis (Molokai High School) requesting field trip for Vo-tech class. Set up appointment to discuss dates, itinerary.

3/4/96 Phone call from Mitchell (Maui) requesting sources for antibiotics. Sources given.

3/4/96 Phone call from aqua hui requesting sources for catfish fry. Sources given.

3/4/96 Phone call to Mokuleia Fish farm inquiring as to availability of catfish fry.

3/5/96 Site visit Hoolehua (Loko I'a Kalo) status check. Drop off info about hatchery management.

3/5/95 Site visit Palaau (Yuen) Status check. Drop off info on pond construction.

3/5/96 Site visit Kawela (Medeiros) status check. Growth data for prawns.

3/5/96 Phone call Tumpap (RCL) Discussing workshop series, dates status of Molokai participants.

3/5/96 Phone call to Sweeny (OI) inquiring about shrimp permits, SPF shrimp certification. Species salinity tolerances.

3/5/96 Site visit Hoolehua (Loko I'a Kalo) pick up equipment, feeds.

3/5/96 Site visit Kawela (Medeiros) drop off equip., feeds.

3/6/96 Phone call from Robbie Guard (MCOED) to set itinerary for visit on 3/7.

3/6/95 Phone call from Yamashiro (RCL) discuss dates for RCL workshop series. Date for visit to meet with participants from Molokai.

3/6/95 Phone call to Dale Sarver to inform him of upcoming MAA meeting to discuss USDA proposals.

3/7/96 Site visits with Robbie Guard of MCOED. Status check on all Maui County funded projects.

3/8/96 Phone call from Shimoda (HIMB) inquiring about collaborative feeds experiment. With farmers on Molokai.

3/8/96 Site visit Hoolehua (Loko I'a Kalo) Inquire about feeds experiment with HIMB.

3/8/96 Site visit Kawela (Medeiros) Inquire about feeds trials on farm.

3/8/96 Phone call from Eileen Crozier (Maui) inquiring about start up aquac info. Info sent.

3/11/96 Phone call from Marvin Hanchett-Ching inquiring about availability of catfish fry. Sources given.

3/11/96 Phone call from Lee (Molokai High School) inquiring about field trip for Biology class.

3/13/96 Attend MAA meeting.

3/13/96 Phone call from Okazaki (RCL) discussed RCL workshop dates and next Advisory Committee meeting.

3/14/96 Trip to Molokai High School to meet with Biology teacher, Vo-Tech instructor to discuss field trip dates and itinerary.

3/15/96 Site visit Hoolehua (Loko I'a Kalo) to discuss high school field trip, summer program with high school students.

3/15/96 Phone call from Jane Yamashiro (RCL) itinerary for visit on 3/19. Meeting with RCL participants.

3/18/95 Phone call from John Whittenburg (Maui) inquiring about methods for tilapia control/eradication. Information given.

3/19/96 Visit from Jane Yamashiro, RCL coordinator. Meeting with Molokai participants, site visits to aquaculture facilities.

3/20/96 Phone call from Ray Clarke (NMFS) discussed status of Moomomi Subsistence Fishing Area and possible cooperation with Moomomi group.

3/20/96 Meeting with potential Haw'n fishpond operators, discussed permitting problems. Best management practices, fry sources.

3/21/96 Phone call from Dr. Borski (North Carolina State Un.) Requesting info on tilapia sex-reversal. Info sent.

3/22/96 Site visit Pukoo (Machado) project status check.

3/22/96 Site visit Manae (Tollefsen) project status check.

3/22/96 Site visit Manae (Manaba) project status check.

3/25/96 Site visit Kawela (Medeiros) pick up equipment, project status check.

3/25/96 Site visit Palaau (Yuen) drop off equipment, project status check.

3/27/96 Attend Kamalo Haw'n Homestead Meeting.

3/28/95 Site visit to pick up guppies from Medeiros to be taken to Kawela (Liko Gram-Bush).

3/29/96 Site visits to all projects with Dr. Meryl Broussard (USDA).

APRIL 1996

4/1/96 Site visit Kawela (Medeiros). Quarantine inspection with Guy Naguy (DLNR) for stocking of marine shrimp.

4/2/96 Meeting with Hui O Kuapa to discuss status of Ualapue fishpond, future projects, responsibilities.

4/2/96 Phone call from Yamashiro (RCL) about upcoming RCL meeting, itinerary.

4/3/96 Site visits to Haw'n fishponds with researchers from UH Ocean Eng. Dept.

4/4-4/6/96 RCL workshop on Maui.

4/8/96 Site visit to Manae (Tollefsen) Discussion of new experiments, project completion report.

4/8/96 Attended Molokai Water Resources meeting.

4/8/96 Phone call from Chitran (Maui) requesting info on ornamental fish. Info sent.

4/9/96 Meeting with Tom Matayoshi (Molokai Reservoir Mgt). Discussed tilapia infestation in reservoir control techniques.

4/9/96 Phone call from Colleen Church (Hana) requesting info. on water quality. Info sent.

4/10/96 Meeting with SCS personnel about water resources on Molokai.

4/10/96 Meeting with Haw'n Research personnel about salt tolerant turf grass.

4/11/96 Site visit Hoolehua (Loko I'a Kalo). Pick up equipment.

4/11/96 Site visit Palaau (Yuen) drop off equipment.

4/11/96 Site visit Palaau (Chaiken) Project status check. Discussed distribution of marine shrimp PI's to other farmers on Molokai.

4/15/96 Received phone call from Ms. Inouye (Kaunakakai Elementary School) requesting presentation to kindergarten class on aquariums. Set up a date (4/16).

4/15/96 Site visit Honouliwai Fishtrap (Tanaka). Discussion of restoration plans.

4/15/96 Phone call to Paul Bass (OI) asking about availability of milkfish, mullet fry.

4/15/96 Phone call to Dr. Helsley (Sea Grant) discussed long term plans for Maui County aquaculture program.

4/16/96 Presentation to Kaunakakai kindergarten class about balanced ecosystems, aquarium maintenance.

4/16/96 Phone call from Ms. Fujii about presentation to Kualapuu Elementary School. Set up date for 4/17.

4/17/96 Presentation to Kualapuu 4th grade class on aquaculture & fisheries.

4/17/96 Phone call from Linda Gusman (Oahu) asking about Molokai farmers who may want prawn Pl's. Inquired with farmers.

4/17/96 Presentation to Kamalo Homesteaders about backyard aquaculture and commercial aquaculture opportunities on Molokai.

4/17/96 Phone call from Harry Hasegawa (Hana) inquiring about availability of Chinese catfish fry. Sources given.

4/18-20/96 Attend RCL workshop on Maui.

4/22-23/96 Attend CTSA Technical Committee Meeting (Oahu).

4/24/96 Phone call to Willie Lansford (Maui) discussed ornamental fish workshop to be held on Maui.

4/24-25/96 Site inspection by Dr. Tamaru & Ms. Kagesa (SGES). Site visits to all Maui County funded projects.

4/26/96 Site visit Chitran (Maui) discussed incorporating fish culture into ag farm.

4/26/96 Site visit Dennis Mitchell (Maui) discussed feeds for angelfish fry.

4/26/96 Site visit Willie Lansford (Maui) ornamental fish producer.

4/26/96 Site visit Bruce Bowman (Maui) Aquatic plant producer, discussed expanding to include ornamental fish.

4/27/96 Ornamental fish workshop on Maui.

4/29/96 Phone call to Jim Sweeny (OI) Inquired as to availability of marine shrimp Pls for Manaba. OI will work with Manaba farm when they come on line.

4/29/96 Site visit Hoolehua (Loko I'a Kalo) drop off feeds. Status check.

4/29/96 Site visit Kawela (Medeiros) Status check. Check water quality in prawn ponds.

4/30/96 Site visit Hoolehua (Loko I'a Kalo) data collection on ornamental fish project.

4/30/96 Site visit Palaau (Yuen) Status check.

4/30/96 Phone call from Manaba requesting aquaculture supply catalogues.

4/30/96 Phone call from Tom Linker (Molokai) inquired about information of fish catch statistics in Hawaii. Gave him sources to contact.

4/30/96 Phone call from Dennis Elberth (Florida) Inquired about starting up an aquaculture operation on Molokai. Discussed use of Haw'n fishponds, gave him other contacts.

MAY 1996

5/1/96 Site visit Honomuni (Garcia/Fuji) Consultation on weed removal, species stocking, siltation.

5/1/96 Site visit Manae (Tollefsen) Project status check, relayed info from principal investigator.

5/1/96 Site visit Manae (Manaba) drop off catalogues.

5/1/96 Site visit Hoolehua (Loko I'a Kalo) drop off aquaculture videotapes.

5/2/96 Site visit Manae (Manaba) discussion of what types of supplies needed for hatchery.

5/2/96 Site visit Hoolehua (Loko I'a Kalo) check catfish for spawning.

5/2/96 Attend MAA meeting.

5/3/96 Phone call from Tim Meyer discussed strategy for utilizing Meyer's Lake in Kalae. Stocking with large mouth bass for fee fishing.

5/3/96 Meeting with Tom Matayoshi (Molokai Irrigation Manager) to discuss Molokai reservoir and tilapia infestation. Gave suggestions for control.

5/3/96 Site visit Hoolehua (Loko I'a Kalo) go over spawning calculations.

5/3/96 Phone call from Willie Lansford (Maui) discussed Valley Isle Breeders Exchange (VIBE) a new on. Fish coop. Gave him names of contacts of people who may be interested in membership.

5/6/96 Phone call from Jesse Chitran (Maui) inquired about pump info. Info was faxed.

5/6/96 Phone call from Becky Yuen inquiring about local sources of grass carp.

5/6/96 Phone call to Dave Barclay (Big Isle) inquired about availability of grass carp.

5/6/96 Phone call to Bailey (SGES), inquired about availability of grass carp.

5/6/96 Site visit to Palaau (Yuen) gave her info. On grass carp sources.

5/6/96 Site visit Palaau (Chaiken) inquired about availability of catfish fry and broodstock. Inquired as to interest in obtaining milkfish fry from CTSA project.

5/7/96 Phone call from Jack Ewing (Kawela) asking me to check his water quality.

5/7/96 Picked up 50 guppies from Medeiros to give to Liko Gram-bush.

5/7/96 Site visit Kawela (Gram-bush) dropped off guppies and discussed production and tank construction.

5/7/96 Site visit to Kawela (Ewing) checked water quality, discussed guppy production methodology.

5/9/95 Phone call from Dennis Mitchell (Maui) Discussion of contacts for the VIBE group. Possible feed experiments with angelfish fry.

5/10/96 Site visit Hoolehua (Loko I'a Kalo) check on catfish fry, water quality check. Discussed feeding schedule for catfish fry.

5/10/96 Site visit Pukoo (Machado) Status check on limu project.

5/10/96 Phone call from Dennis Elberth (Florida) inquiring about availability of Haw'n fishponds for culture of invertebrates. Gave him a list of potential ponds and owners.

5/13/96 Phone call from Scott Adams (Loko I'a Kalo) asking for a water quality check due to catfish fry mortalities.

5/13/96 Site visit Hoolehua (Loko I'a Kalo) check water quality, suggested to cut down densities.

5/13/96 Site visit Kawela (Medeiros) rec. for pond preparation prior to receiving marine shrimp Pls.

5/14/96 Site visit Manae (Manaba) status check on well drilling.

5/14/96 Site visit Palaau (Yuen) Relayed info on availability of well drilling rig. Phone conversation with Robbie Guard (MCOED) discussing new Sea Grant contract requirements.

5/14/96 Phone call from Dr. Aecio D'Silva (U. Of Arizona) inquired about status of USDA-MAA grant proposal with Loko I'a Kalo.

5/15/96 Phone call to Dr. Broussard (USDA-Washington DC) inquiring about status of USDA-MAA proposals. Was told that all proposals are in USDA procurement office.

5/15/96 Phone call to Dr. D'Silva (U. Of Arizona) passed on info as to status of grant proposals.

5/15/96 Phone call from Fil Ke asking for a site visit to check water quality.

5/16/96 Site visit Kaunakakai (Fil Ke) check water quality discussed water quality management use of effluent water for irrigation.

5/16/96 Site visit Palaau (Chaiken) check on availability of marine shrimp Pls, catfish broodstock.

5/16/96 Site visit Kawela (Medeiros) passed on info as to when marine shrimp Pls will be ready, checked on status of ponds gave fertilizer rec.

5/17/96 Picked up approximately 30,000 shrimp Pls from Palaau and transferred to Kawela. Pl's stocked in ponds after acclimation to ambient salinity.

5/19/96 Site visit to Manae (Manaba) passed on info as to availability of shrimp Pls when site is ready.

5/20/96 Picked up shrimp feed from Chaiken for Medeiros.

5/20/96 Attended Molokai Water Resources meeting.

5/21/96 Site visit Honouliwai (Tanaka) discussed status of fishpond permitting process water quality 401 permit.

5/21/96 Site visit Manae (Tollefsen, Manaba) status check. prep for site inspection

5/21/96 Site visit Palaau (Chaiken, Yuen) status check prep for site inspection.

5/21/96 Site visit Hoolehua, Kawela (Loko I'a Kalo, Medeiros) status check, prep for site inspection.

5/21/96 Phone call from Dr. Giovanini (Maui) inquiring as to availability of ornamental fish from CTSA project. Gave him Brian Cole's number to contact.

5/21/96 Phone call to Dennis Mitchell discussed ornamental fish hui for Maui.

5/22/96 Site inspection by Sea Grant personnel from Oahu, Washington DC.

5/23/96 Phone call from Leonard Young (ADP) discussed water quality sampling for Ha'wn fishponds.

5/24/95 Phone call from Manny Aruda (Maui) set up site visits on Molokai for his visit on 5/27.

5/24/96 Site visit Manae (Manaba) discussed MAA-USDA project, tank construction interest in milkfish from CTSA project.

5/24/96 Site visit Kawela (Medeiros) status check on marine shrimp ponds, water quality check and recommendations on weed eradication.

5/24/96 Phone call from Chitran (Maui) requesting feed sources. Info given.

5/24/96 Phone call from Madeline Joseph (Maui) requesting sources of tilapia fry. Info given.

5/27/96 Site visits to Hoolehua, Kawela. Palaau with Manny Aruda from Maui.

5/28/96 Site visit to Hoolehua (Loko I'a Kalo) check on catfish fingerlings, disease treatment.

5/28/96 Meeting at Molokai High School with Vo-Tech instructor, Biology teacher to set up dates for field trips.

5/28/96 Site visit Kawela (Medeiros) check up on shrimp ponds.

5/29/96 Meeting with Kamalo Hawaiian Homestead Association. Discussed assistance in setting up backyard tanks with interested homesteaders.

5/30/96 Phone call to Mokuleia Farms inquiring as to source of Nutra Feeds.

5/30/96 Phone call from Ms. Inouye, Kaunakakai Kindergarten teacher. Asked me to guide them in field trip to Medeiros Farm. 5/31.

5/31/96 Field trip with kindergarten class to Medeiros Farm.

5/31/96 Meeting with Dean Fujii at Molokai Occupational center. Discussed setting up integrated aquaculture-ag project for the Center.

JUNE 1996

6/3/96 Field trip with Molokai High School Vo-Tech and Biology classes to Ualapue fishpond and Hoolehua (Loko I'a Kalo).

6/4/96 Meeting with Craig Swift of Lokahi Pacific About availability of Ag. Loans to aquaculture farmers.

6/4/96 Phone call to Maui Board of Water Supply about charging ag. Rates for aquaculture operations.

6/4/96 Site visit Hoolehua (Loko I'a Kalo) help in collecting tilapia fry.

6/4/96 Site visit Kawela (Medeiros) status check on shrimp ponds.

6/5/96 Meeting with high school instructor Mike Takis about setting up small ponds or tanks for students for next school year.

6/5/96 Meeting with Molokai High School Vo-Tech coordinator about incorporating aquaculture into curriculum next school year.

6/6/96 Collect water quality sample from Loko I'a Kalo for Dr. Brock to test for disease.

6/6-6/7/96 Oahu meeting with Dr. Helsley (Sea Grant) discussed long term plans for Maui County. Meeting with Dr. Maynard to discuss MOP projects for Molokai MCC MOP students.

6/8/96 Site visit Hoolehua (Loko I'a Kalo) spawn catfish.

6/10/96 Site visit Kawela (Medeiros) collect data on shrimp growth, check water quality, feeding recommendations.

6/11/96 Site visit Hoolehua (Loko I'a Kalo) status of catfish spawn, start up brine shrimp culture.

6/14-15/96 Attend RCL workshop on Maui.

6/18/96 Site visit Hoolehua (Loko I'a Kalo) status check on catfish fry.

6/19/96 Site visit Hoolehua (Moke Kim) discussed tank construction, pond construction on his homestead land.

6/20/96 Site visit Palaau (Chaiken) Status check.

6/21/96 Site visit Kawela (Medeiros) pick up guppies for Jack Ewing.

6/21/96 Dropped off guppy broodstock to Jack Ewing (Kawela).

6/24/96 Phone call from Dennis Elberth. Site visit to Kupeke fishpond for possible leasing and using land site for tank culture.

6/25/96 Site visits with Dennis Elberth to Molokai farms.

6/26/96 Worked on tank repairs at Medeiros farm.

6/27/96 Worked on tank repairs at Loko I'a Kalo.

6/27/96 Phone call from Dr. Broussard (USDA, Washington DC) updating me on USDA-MAA grant proposal status.

Table 1. Summary of responses to requests for technical assistance between July 1995 - June 1996

Area	Verbal	Written	Site Visits	Totals
Molokai	73	8	300	381
Maui	98	8	47	153
Other	70	0	14	84
Total	241	16	361	618

Appendix 2. Contract: #8990017 Field Methods for Spore Culture of Limu Manuea *Gracilaria coronopifolia*

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990017

Moloka'i Community Development Corporation

(FULL NAME OF: Firm, Association, Performing Group, or Individual)

P.O. Box 1509, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s)	(State Scope in Detail)	
see attachments		

Date(s)	Time(s)	Place(s)
August 1, 1994- December 31,1995		

The remuneration for the service(s) agreed to herein at the rate of $ 26,153 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

Substitution of any date(s) and/or place(s) of service(s) herein provided, may be made if mutually acceptable and agreed to between the Corporation and the Contractor; such change(s), if any, shall not affect the validity of this agreement.

2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

Cancellation by the Contractor of the service(s) to be provided herein, or any one or more of a series, shall render this Contract void, and a new Contract may be prepared by the Corporation to cover the service(s) to be given, if any.

The Corporation reserves the right to cancel this agreement at any time after commencement of services if the Contractor neglects to perform as specified.

The balance of any remuneration and other allowances, if any, due shall be paid upon completion of the service(s) herein provided upon submission of invoices in triplicate, or upon certification by the director of the program or the activity that the service(s) have been completed. The total remuneration paid, and the other reasonable incidental expenses, if any, shall be considered full compensation for basic services rendered, including overhead, profit and taxes.

ETHICS DECLARATION

I declare that I am not a Legislator, elected or appointed officer, or that this firm is not owned or controlled by any Legislator, elected or appointed officer, compensated or uncompensated, member of a State board or commission, or other employee of the State of Hawaii.

I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

The Contractor understands that, if he/she is engaging in business or performing services within the State of Hawaii, the remuneration includes an amount to cover 4% State General Excise Tax and license fee (Chapter 237, H.R.S. 1969, as amended), and he agrees to pay the required assessments to the State Department of Taxation, 425 Queen Street, Honolulu.

Any product resulting from work under this contract shall be the sole property of the Research Corporation of the University of Hawaii, and shall be at its discretion, disposed of in accordance with Research Corporation of the University of Hawaii/University of Hawaii/Federal Copyright Patent Policies.

The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 43

Field Methods for Spore Culture of Limu Manuea (*Gracilaria coronopifolia*) in Hawaii

Proposal Submitted by

Richard Tollefsen

August, 1993

Attachment 1

This consulting agreement is to cover the objectives of the proposal entitled "Field Methods for Spore Culture of Limu Manuea (Gracilaria coronopifolia) in Hawaii submitted by Mr. Richard Tollefsen. A copy of the proposed work is attached detailing specific goals and objectives to be accomplished.

The contractor agrees to provide up to 30% of the spore laden coral chips for distribution to other interested growers on Moloka'i. Distribution of requested coral chips will be coordinated through the Moloka'i Aquaculture Advisory Alliance in conjunction with the Sea Grant aquaculture extension agent on Moloka'i.

The project will receive payment of $26,153.00, that will be used in conjunction with $10,000 from the National Coastal Resources Institute to accomplish the outlined objectives. There will be $14,153.00 advanced to the consultant. Following the receipt and acceptance of a six month progress report an additional $ 11,000 will be made available to the consultant. The final payment of $1,000 will be made after the receipt and acceptance of a final report.

The methods developed in this proposal, if successful, will potentially apply to other species of Gracilaria as well. At present the international supply of Gracilaria for agar extraction is in transition from chiefly wild-harvested material to aquaculture material. This transition is in response to diminished supplies of wild stocks due to over harvesting in Chile and Asia. Present aquaculture methods are rudimentary, ranging from stock enhancement in locations where local species grew prolifically before over harvesting, to vegetative pond culture which multiplies an original stocking by 3-4 fold for harvest. These methods depend upon the availability of large quantities of wild stock to initiate cultures. The development of spore methods will represent an important step towards a sustainable culture system which does not depend upon the wild harvest.

Goals and Objectives

The overall goal is to develop an aquaculture system for Limu Manuea in which the major growout phase is accomplished in fishponds on the reef rather than in tanks on land. The fishponds are a unique Hawaiian resource, theoretically available to coastal residents for aquaculture without major investment. The problem of rebuilding the ponds is serious for fish culture but does not apply to seaweed culture.

The technical objectives are 1) develop a working method for spore capture on substrates using land-based tanks; 2) develop a pond-based, protected nursery system for growing out sporelings into juvenile plants; 3) develop a growout method for producing mature, harvest size plants (250 g) from juvenile plants; 4) determine how many times the mature plants can be partially harvested and regrown vegetatively before they lose vitality and must be replaced. Concurrently with developing the methods, data will be collected on the basic growth cycle of Limu Manuea; This data will be used to define the overall culture cycle of this species. By project end, the life

Background and Justification

Limu Manuea is the traditional, edible Gracilaria species of the Hawaiians. It is still highly prized but wild stocks on the reef have been depleted by over harvesting and no satisfactory aquaculture method has been developed, hence supplies are severely limited. The proposed project will compliment work underway with the other traditional Gracilaria species in Hawaii; long ogo (Gracilaria parvispora) and will build on laboratory studies of spore development in G. coronopifolia that have been conducted by Dr. Celia Smith of the University of Hawaii. It will utilize the facilities and expertise of Richard Tollefsen who has worked to set up a prototype Gracilaria hatchery on Molokai over the past two years.

The full background and justification for developing Limu (seaweed) culture as a mini industry for coastal residents of Hawaii has been presented to NCRI in previous proposals and reports and will not be repeated here. The present proposal aims to 1) focus additional attention on an important limu species that has not been adequately studied from an aquaculture perspective; and 2) to develop simple field procedures to capture released spores and grow sporelings to adult size using the resources of the fishponds and reefs available to coastal residents.

Technically, there is sound justification for concentrating on sporeling culture of Limu Manuea. This species is a prolific spore-producer. Cystocarpic plants with which to initiate spore cultures appear to be available throughout the year. Furthermore, attempts to grow this species in loose tank or cage culture from vegetative fragments have not been successful. The thalli lose vitality with repeated subculturing; The logical method for aquaculture of this species would appear to be a form of batch culture in which spores are captured on suitable substrates, grown to adult size and harvested.

substrates before sporulating material is introduced; and 3) coral chips with sand added after sporulation has occurred. The experiment will utilize six trays per treatment. Glass slides (3 per tray) will be used to quantify spore settling. The slides will be placed on top of the chips, under the sand in the case of treatment 2. Fertile plant material will be placed over each tray (100 g per tray) for 72 hours, then removed. Trays will be placed in the fishpond for growout. Results will be quantified by the number of initial spores settling onto the slides and by percentage of coral chips that develop visible juvenile plants after 90 days.

Experiment 2: Definition of Life Cycle of Limu Manuea. At present it is not clear how much time is needed to grow a settled spore into a juvenile plant, how long the juvenile plant requires to reach harvest size, and how many times the plants can be cut back and regrown before they must be replaced. Using the best method for spore settling and development from Experiment 1, 6 traps will be inoculated and observed for 6 months. Early development will followed using a compound microscope: later development, up to the juvenile stage will be followed using a dissecting microscope; and development of the juvenile plants to adult size will be followed using direct visual observation and measurement of plants. Detailed notes on the growth and development of the plants at each stage will be taken and the process will be documented through photographs. The results of the experiment will be used by growers and hatchery managers as a guide to normal growth and development.

Experiment 3: Bottom Plants versus Cage Planting of Limu Manuea. While good growth rates of long ogo have been achieved in cage culture, it is not clear that cages provide the best environment for development of Limu Manuea. Sporelings naturally develop from bottom plantings. If large patches of bottom plantings can be established by outplanting spore-coated chips, this would constitute a simpler and less expensive system than cage culture. (The two methods are not incompatible since some ponds have too much silt to accommodate bottom culture whereas others have firm bottoms).

cycle and culture requirements of this species will be much better defined than they are at present.

Methodology

Hatchery and growout experiments will be conducted at a suitable fishpond site still to be determined; examples of suitable sites are Ualapue Fishpond, where tanks are already installed and Panahaha Pond, which has a prototype hatchery facility. Experiments will be conducted by Richard Tollefsen. He will seek the active collaboration of Dr. Celia Smith who has developed background information on the sporulation process for this species. The University of Arizona will provide additional technical guidance and advice.

The hatchery will be operated to produce as many spore-coated substrates as possible over a one year period. This stock of sporelings will be distributed to a network of potential growers in the community. The production goal will be to produce approximately 20 trays of inoculated, coral chip substrates per week (150 chips per tray - 3,000 chips per week). While the hatchery is producing spore-coated substrates, it will also be used to conduct experiments to define the culture requirements, and those experiments will be used to modify the production system in an iterative process. Below are examples of experiments that will be conducted during the project.

Experiment One: Limu Manuea Spore Settling; Spore settling proceeds readily under a variety of conditions but the experience so far is that few spores develop into mature plants. Overgrowth of the substrates by epiphytes is a major problem. Sand placed over the substrates appears to be protective. Preliminary observations are that spores can settle through a layer of sand, attach to a rock substrate and emerge through the sand approximately 70 days later. This experiment will follow up on those observations to develop a working method. Three treatments will be : 1) coral chip substrates placed in trays without sand; 2) coral chips with sand added over the top of the

The working group that will receive and administer the funds for this effort is to be determined; examples of qualified groups with which Richard Tollefsen can work are the Molokai CDC and Hui O'Kuapa. The University of Arizona will provide technical assistance and guidance upon request. The involvement of Dr. Celia Smith would also be highly desirable should she be able to participate.

Budget

The hatchery facilities; microscopes and other infrastructure are already available. Four large tanks have been set up at Ualapue Pond and two smaller tanks plus an aerator and sea water intake are available at Panahaha Pond. the University of Hawaii has provided microscopes. What is needed for the project to proceed are salary support for Richard Tollefsen, a small amount of money for additional supplies such as trays and an operating budget to cover electrical costs, gasoline and other expenses. The University of Arizona does not require additional funding; The funding requirements for Dr. Smith need to be determined separately from the present proposal.

Salary Support for Richard Tollefsen:

The suggested salary is based on the existing scale of Limu Worker compensation at Ke Ku'aina and is similar to the salary received by Mr. Tollefsen when he worked for Hui O'Kuapa and the University of Arizona. Two rates are given; one) if he works as a independent contractor and two) if he works as an employee for an organization that provides fringe benefits equal to 30% of base pay.

Eighteen trays containing inoculated chips (3 treatments, 6 trays per treatment) will be placed in the ponds. 1) in floating cages, using three wire baskets with 2 trays each; 2) on a firm, pebble bottom; 3) and on a sandy bottom. A location will be sought which provides both bottom types in close proximity so that the three treatments can be placed next to each other for comparison. Results will be quantified after 90 days and 6 months by the number of plants developing into visible juveniles, and by the number and weight of plants after growout.

Experiment 4: Growout of Juveniles into Adults in Different Pond Environments. The intention of the program is to provide juvenile plants to as many potential growers as possible. These individuals will attempt to grow market size plants in a number of different pond types and other reef locations. The experiment will attempt to define the best growout conditions by following the fate of spores in the different environments This will require an active outreach program in which stocked ponds are visited, the condition of the plants checked and documented by weighing and measuring at monthly intervals, and environmental conditions monitored in a subsample of different environments. Water motion and nutrient content will be quantified at monthly intervals in 3 ponds representing the range of conditions.

Time Schedule

Hatchery production and the research experiments will commence as soon as funding is secured. It is desirable to begin no later than October 1 in order to take advantage of the University of Arizona' presence on Molokai in the last year of NCRI funding.

Project Organization

Program/Activity: **Maui County Aquaculture**

8/11/94
Date

By _____
Program Coordinator

Research Corporation of the University of Hawaii

9/13/94
Date

By _____

ACCEPTED:

_____
Executive Director (MCDC)

Aug. 2, 1994
Date

_____
Contractor

Aug. 1, 1994
Date

Is Consultant a U.S. citizen?
Yes ✓ No _____

If U.S. citizen, provide Social Security No. 575 42 1506

Type of Entity

Corporation	✓	Non-Profit	✓
Partnership		Government	
Trust		Estate	
Individual		Sole Proprietorship	

Tax Payer Identification Number: 99-0293966

Distribution of Executed Copies
1. Original & Invoices - Research Corporation
2. Copy - Program/Activity
3. Copy - Contractor

Budget Sheet

Salary and Benefits	$24,366.00
Equipment: Water disinfection & reservoir	3,000.00
Trays, fertilizers and other supplies	3,000.00
Operating expenses	2,500.00
	$32,866.00
Administrative Fee of 10%	3,287.00
TOTAL BUDGET REQUEST	$36,153.00

Appendix 3. Contract: #8990018. Shrimp Maturation Technology Transfer Project

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990018

Moloka'i Community Development Corporation

(FULL NAME OF: Firm, Association, Performing Group, or Individual)

P.O. Box 1509, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s)	(State Scope in Detail)
see attachments	

Date(s)	Time(s)	Place(s)
August 1, 1994- January 31,1995		

The remuneration for the service(s) agreed to herein at the rate of $ 26,000 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

Substitution of any date(s) and/or place(s) of service(s) herein provided, may be made if mutually acceptable and agreed to between the Corporation and the Contractor; such change(s), if any, shall not affect the validity of this agreement.

2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

Cancellation by the Contractor of the service(s) to be provided herein, or any one or more of a series, shall render this Contract void, and a new Contract may be prepared by the Corporation to cover the service(s) to be given, if any.

The Corporation reserves the right to cancel this agreement at any time after commencement of services if the Contractor neglects to perform as specified.

The balance of any remuneration and other allowances, if any, due shall be paid upon completion of the service(s) herein provided upon submission of invoices in triplicate, or upon certification by the director of the program or the activity that the service(s) have been completed. The total remuneration paid, and the other reasonable incidental expenses, if any, shall be considered full compensation for basic services rendered, including overhead, profit and taxes.

ETHICS DECLARATION

I declare that I am not a Legislator, elected or appointed officer, or that this firm is not owned or controlled by any Legislator, elected or appointed officer, compensated or uncompensated, member of a State board or commission, or other employee of the State of Hawaii.

I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

The Contractor understands that, if he/she is engaging in business or performing services within the State of Hawaii, the remuneration includes an amount to cover 4% State General Excise Tax and license fee (Chapter 237, H.R.S. 1969, as amended), and he agrees to pay the required assessments to the State Department of Taxation, 425 Queen Street, Honolulu.

Any product resulting from work under this contract shall be the sole property of the Research Corporation of the University of Hawaii, and shall be at its discretion, disposed of in accordance with Research Corporation of the University of Hawaii/University of Hawaii/Federal Copyright Patent Policies.

The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 44

Attachment 1

This consulting agreement is to cover the objectives of the proposal entitled " Shrimp Maturation Technology Transfer Project" submitted by Moloka'i Sea Farms. A copy of the proposed work is attached detailing specific goals and objectives to be accomplished. This project will be carried out in accordance to the proposal with the following modifications.

The contractor agrees to provide up to 30% of post larvae produced for other interested growers on Molokai free of charge. This provision for distribution of post larvae will apply during the six month duration of the project and for an additional six months following the contract period. Distribution of requested post larvae will be coordinated through the Moloka'i Aquaculture Advisory Alliance in conjunction with the Sea Grant aquaculture extension agent on Moloka'i.

The project will receive $ 26,000. Payments will be made on a reimbursement basis following submission of duplicate invoices and receipts for equipment and supplies purchased. A final report will be expected after six months. The final payment of $1,000 will be made after the receipt and acceptance of the final report.

Shrimp Maturation Technology Transfer Project

PROJECT SUMMARY

Molokai's long-term aquaculture success is highly dependant on consistent seed availability and hatchery productivity . Shrimp seed production has been totally dependant on The Oceanic Institute (OI) to provide fertilized shrimp eggs. The supply of these surplus eggs is not always available and has left Molokai aquaculture operations in vulnerable position.

The Oceanic Institute is committed to transferring its marine shrimp maturation technology to Molokai Sea Farms (MSF). Local residents will receive training in establishing and operating a shrimp maturation facility. Guidance and supervision will be provided by Molokai Sea Farms hatchery staff and The Oceanic Institute's maturation technicians.

Existing facilities at Molokai Sea Farms (MSF) will be modified to meet the specifications of The Oceanic Institute's technology. Environmental parameters will be artificially manipulated to provide conditions that will allow egg production year-round. Seawater systems will be adjusted to meet strict water quality standards. Mature specific pathogen-free (SPF) broodstock will be transferred from The Oceanic Institute's quarantine facility.

After acclimation, broodstock will be ablated, tagged and monitored for ovarian development. Feed rates, water exchange and water quality will be monitored daily. Females with egg development will be checked daily for mating. Mated females will be put in spawning tanks. Data will be recorded on total eggs, percent hatch, total naupli production and female spawning frequency.

Healthy naupli will be reared in the hatchery. Naupli production will be targeted to be sufficient to keep Molokai shrimp farms operating at 100% capacity. Larval rearing will take place utilizing naupli from The Oceanic Institute until MSF maturation system becomes productive.

Post-larvae produced in the hatchery will be distributed to shrimp farms in Maui County at no charge throughout the duration of this project.

Future government assistance for Molokai shrimp seed production will not be necessary as economic self sufficiency is expected at the conclusion of this project.

FACILITY DISCRIPTION

Molokai Sea Farms is owned and operated by Steve Chaikin and located at Pala'au on the south shore of Moloka'i. The site consists of 50 acres of aquaculture land with twenty growout ponds totalling 18 acres, two broodstock ponds, 12-ton shrimp hatchery, (6) 18' nursury tanks, five water sources (3 salt, 2 fresh), a processing area, machine shop, feed storage, office and manager's quarters. The majority of the farm has been operated as an intensive shrimp farm with all production ponds equipped with an automated aeration system.

KEY PERSONEL

Steve Chaikin, project manager, has a Bachelor's of Science degree in Business Administration from the University of Colorado. For the past four years he has been developing Molokai Sea Farms into a viable aquaculture operation. He has been responsible for reconstructing the marine shrimp hatchery into much more efficient and less labor intensive operation. He also successfully conducted the Marine Shrimp Hatchery Technology Transfer Project. It involved local residents with no previous aquaculture experience. They were provided training and have become qualified hatchery technicians. This project was implemented with the cooperation of The Oceanic Institute and Maui County.

Steve Chaikin is currently the Vice President of Hawaii Aquaculture Association, and a member of the Aquaculture Industrial Advisory Board of the Center for Tropical and Subtropical Aquaculture. He is a founder member of the Molokai Community Development Corporation and of the Molokai Aquaculture Advisory Committee. He served as a member on the Economic Development Committee of the Governor's Molokai Fishpond Task Force and is one of three board members of Pacific Marine Farms, the largest oyster producer in New Zealand.

Greta Martinez, hatchery manager, has a Bachelor's of Science degree in Biology from the State University of New York at Stony Brook (SUNY). For the past five years she served as the hatchery manager for the USDA Marine Shrimp Research Facility at The Oceanic Institute in Hawaii. She was instrumental in establishing the larval rearing facility and development of The Oceanic Institute's protocol for larval rearing of Penaeus vannamei. Before that, she worked in Ecuador, the leading country in shrimp farming in the western hemisphere. She assited in the supervision of the construction of a 10 million per month post larval production facility and operated as manager of its algae production department. Her hatchery skills have achieved an overall larval rearing survival of approximately 70%. Published papers include: Effects of Paprika Supplementation In Broodstock Diet on Shrimp P. vannamei Larval Performance, Greta Martinez, James Sweeney, James Wyban, The Oceanic Institute, Makapu'u Point, Waimanalo, Hawaii (in press, 1992); Behavioral Aspects of the Salt Marsh Snail Hydrobia totteni in relation to it's environment, SUNY at Stony Brook, 1983; The Aquaculture Aspects of Crassostrea virginica From Fertilization to Marketing, SUNY at Stony Brook, 1982.

PROBLEM

The shrimp farms that have developed on Molokai have been plagued with the inconsistency of available seed. During 1991 and early 1992 while The Oceanic Institute was providing shrimp nauplii (hatched shrimp eggs), the farms operated at 100% capacity with all 24 production ponds fully stocked. The nauplii were reared at Molokai Sea Farms hatchery until they reached postlarval stage, at which time they were either stocked into the ponds or distributed to Ohia Shrimp Farm.

Shrimp Hatchery technology is now well established on Molokai and markets have been developed. A strong demand exists for small "popcorn shrimp" which is sold to ethnic markets. This type of shrimp has a much lower production cost and faster turnover rate, but seed must be consistently available and economically produced.

In 1992 The Oceanic Institute changed their research priorities and were no longer able to proivide commercial quantities of nauplii on a regular basis to commercial farmers. As a result, the shrimp farms on Molokai are currently not in production until a reliable and economic seed production system can be established. It is not cost effective or reliable to attempt to purchase large quantities of seed on a regular basis from off-island.

NEEDS

Need to bring shrimp production on Molokai back to full capacity which will provide approximately 5 full-time positions.

Need to develop a highly productive and economically efficient matruation system on Molokai that will enable us to complete the life cycle and produce independent of outside sources.

Need to transfer The Oceanic Institute's matruation technology to Molokai and train local residents.

Need to produce 750,000 post-larvae per month.

GOAL

Establish shrimp maturation system at Molokai Sea Farms. Successful implementation of this goal will enable Molokai Sea Farms to produce seed without having to depend on any other source.

SCOPE OF WORK

MSF will procure and install equipment to develop a fully functional shrimp maturation facility. MSF will procure tank liners, thermostate controlled submersible heaters, flow meters and necessary electrical and plumbing supplies. This equipment will be recommended to MSF by OI staff.

OI will ship approximtely 160 SPF broodstock to MSF maturation facility.

MSF will implement OI maturation procedures, procure necessary maturation supplies and feed. Maturation training will begin at the time of the broodstock transfer, and continue periodically throughout the duration of the project. MSF will follow all directions and training as provided by OI to produce shrimp naupli. Any procedural adjustments by MSF must first be approved by OI.

MSF will supply shrimp postlarvae to other farms in Maui County at no cost throughout the duration of this project.

WORKPLAN

To modifyMolokai Sea Farms systems to meet the specification of The Oceanic Institute's shrimp maturation technology – month one and two.

To transfer SPF broodstock from The Oceanic Institute's quarantine facility to MSFs maturation facility – month three.

To transfer maturation technology to Molokai hatchery staff – begin month one and continue for the duration of the project.

Ablation of broodstock – beginning of month four.

Achieve broodstock spawning and utilize Molokai-produced eggs for larval rearing – month four through month twelve.

Refine maturation system and improve technicians' skills – month four through twelve

EVALUATION

Maturation will be evaluated on whether viable spawns are produced in quantities sufficient to support hatchery needs. Current postlarvae needs are 750,000 per month. Naupiii requirements are 1 to 1.5 million per month.

STAFF REQUIREMENTS

One staff member will be required to carry out the goals of this project. Wage is to be $8 per hour. Responsibilities include managing and implementing maturation operations.

BUDGET

Salary	8,320
Fringe (FICA (employer), W.C., TDI, HMSA)	2,496
Utilitities 1.9 kw per hour at .28	2,321
Feed	3,400
Hatchery Supplies (see attached sheet)	8,560
Fuel (seawater pumping station)	450
Maintenance (water pumps and seawater pumping station access road)	500
Total	**$26,047**

Molokai Sea Farms Marine Shrimp Maturation System

(2) 14' Maturation Tanks, 30 mil, Aquaculture Supply $350 each	$700.00
Shipping	150.00
(2) Wood & Hardware, UH Ag. Eng. (see listing) $337 each	674.00
Shipping selected Items	25.00
(2) Plumbing for Drain & Overflow, UH Ag. Eng. (see listing) $275 each	550.00
Shipping selected Items	25.00
(2) Plumping for incoming water, plus valve, est $30 each	60.00
Air Pump for Maturation and Spawning L29, Aquatic Eco Systems	272.00
Shipping	30.00
(2) Flow-meters, Area Systems, $44 each	88.00
Shipping	10.00
(4) Digital Thermometers, 2 Mat. 1 Sp. 1 Res., Area Systems, $35 each	140.00
(2) Dimmer controlled lights, switches, wire, est. $25 each	50.00
Framing, & Plastic for Maturation Encloser, est	100.00
Small Refrigerator/Freezer, Squid, Bloodworms, Mussels, est	500.00
Shipping	60.00
Scale, Damark	40.00
Cleaver & Chopping Block, est	30.00
Shipping	10.00
Space Heater, Temp. control for spawning room. 5E199, Grainger	50.00
Shipping	20.00
(2) Nets, Aquatic Eco Systems, $20 each	40.00
Shipping	20.00
Female Broodstock Cage, pipe, fittings, netting, est.	20.00
(20) Airstones/Airline Spawning & Mat.., Glass, Pets Pacifica, est	71.00
Shipping	5.00
Siphon Hose & Plumbing, est	25.00
(2) Push Brooms, est $20.00 each	40.00
Nauplii Counter, Aquatic Eco Systems	15.00
(3) Insulating material, 2 Mat, 1 Res est.$ 25 each	75.00
Shipping	30.00
Nauplii Rinsing bucket, est	30.00
Alconox, EDTA, Acid, chlorine, cleaning brushes, est.	70.00
Shipping (selected items)	25.00
Filters cartridges, spawning 1carton 1u, Harington	121.00
Shipping	20.00
(5) Clip-on lights, collecting nauplii, est $10 each	50.00
(2) 5 mil pipet pumps est $ 20 each	40.00
(4) 5 gal. buckets est.$ 5 each	20.00
Reservoir Liner, 30 mil, 21', Aquatic Eco Systems	609.00
Shipping est	250.00
Plywood & Hardware, UH Ag. Eng. x 1.5	505.00
Plumbing for Drain and overflow, UH Ag. Eng. x1.5	412.00
Additional drain line 140' 1.01 per ft. Hikiola	140.00

Reservoir cover 99%, Pak unlimited	225.00
Shipping	35.00
Incomming water 3" shutoff valve, Aquatic Eco Systems.	110.00
Incomming water float valve, Aquatic Eco Systems.	130.00
Shipping	20.00
Piping & Fittings, 2" ,180', Reservoir to Maturation tanks, est	100.00
Reservoir Heater, 12 kw, Aquatic Eco Systems.	422.00
Indicating Thermostat with Wx. box Aquatic Eco Systems.	336.00
Magnetic contact/ overload protector & Electrical Supplies	175.00
Shipping	45.00
Delivery Pump, Aquacenter	230.00
Solar re-circulating pump, Aquacenter	235.00
Shipping	30.00
Solar system, Heat collector, Heat exchanger, timer, plumbing etc., est	250.00
TOTAL	$ 8,560.00

Program/Activity: Maui County Aquaculture

8/11/94
Date

By _____
Program Coordinator

Research Corporation of the University of Hawaii

9/1/94
Date

By _____

ACCEPTED:

_____
Executive Director (MCDC)

Aug. 2, 1994
Date

_____
Contractor

7-29-94
Date

Is Consultant a U.S. citizen?
Yes X No _____

If U.S. citizen, provide Social Security No. 575-94-3130

Type of Entity

Corporation	✓	Non-Profit	✓
Partnership		Government	
Trust		Estate	
Individual		Sole Proprietorship	

Tax Payer Identification Number: 99-0293966

Distribution of Executed Copies
1. Original & Invoices - Research Corporation
2. Copy - Program/Activity
3. Copy - Contractor

Appendix 4. Report on the Results of Disease Screening of Cultured Shrimp

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
AQUACULTURE DEVELOPMENT PROGRAM
335 MERCHANT STREET, ROOM 348
HONOLULU, HAWAII 96813
(808) 587-0030 TELEPHONE
(808) 587-0033 FAX

July 2, 1996

Mr. Steve Chaikin
Molokai Sea Farms
P.O. Box 560
Kaunakakai, Hawaii 96748
Fax: 553-5216

FACSIMILE MESSAGE
Page 1 of 2 pages

Dear Steve:

This is a report for the shrimp samples collected from Molokai SeaFarms for disease/pathogen evaluation on May 7, 1996 (case 96-143). Hemolymph (five/tank) or pleopod (five/tank) specimens were collected from broodstock *P. vannamei* in four reproduction tanks (uno, dos, tres, quatro). A total of 10 shrimp were sampled in each reproduction tank for a total of 40 animals. Juvenile to subadult *P. vannamei* were collected from five ponds (alpha, bravo, 3, 5, 7). Twenty five shrimp were collected from each pond. Pleopod specimens were gathered from each shrimp. Following pleopod harvest the animal was killed by injection and immersion in Davidson Fixative. Hemolymph and pleopod specimens were evaluated for IHHNV DNA using dot-blot hybridization assay (Shrimp Probe Kit, DiagXotics, Inc.). The Davidson preserved shrimp were examined histopathologically for diseases/pathogens.

The gene probe and histopathology results are given in Table I. Forty broodstock sampled from four reproduction tanks and 125 juvenile/sub-adults from five ponds tested negative for IHHNV by dot blot hybridization. In total, 165 shrimp were evaluated for IHHNV and all samples showed negative reactions. There were no significant lesions or pathogens detected in the tissues of the 70 juvenile/subadult shrimp examined from the five ponds.

The findings did not indicate the presence of IHHNV, TSV, BP NHP or other significant diseases/pathogens in the shrimp sampled from Molokai SeaFarms.

Sincerely,

James A. Brock, D.V.M.
Aquaculture Disease Specialist

cc: Mr. John S. Corbin
Dr. Clyde Tamaru

Table I. Histopathology and IHHNV Gene Probe Results for *Penaeus vannamei* Sampled from Molokai Seafarms on May 7, 1996 (case 96-143)

SOURCE	LIFE STAGE	TEST	NO. TESTED	FINDINGS
Rep.[1] T-1	Broodst.[2]	GP[3]	10	Negative
Rep. T-2	Broodst.	GP	10	Negative
Rep. T-3	Broodst.	GP	10	Negative
Rep. T-4	Broodst.	GP	10	Negative
Pond Alpha	Juvenile	GP/ Histo	25/20	Negative/NAF[4]
Pond Bravo	Subadult	GP/ Histo	25/10	Negative/NAF
Pond 3	Subadult	GP/ Histo	25/10	Negative/NAF
Pond 5	Subadult	GP/ Histo	25/10	Negative/NAF
Pond 7	Juvenile	GP/ Histo	25/20	Negative/NAF

1. Rep. = reproduction; 2. Broodst. = broodstock;
3. GP = gene probe; 4. NAF = no abnormalities found

Appendix 5. Contract: #8990019: Development of Methods for the Cultivation of the Edible Limu *Gracilaria parvispora*

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990019

Ke Kua'aina Hanauna Hou
(FULL NAME OF: Firm, Association, Performing Group, or Individual)

Star Route 265, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s)	(State Scope in Detail)	
see attachments		
Date(s)	**Time(s)**	**Place(s)**
August 1, 1994- December 31,1995		

The remuneration for the service(s) agreed to herein at the rate of $ 27,280 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

Substitution of any date(s) and/or place(s) of service(s) herein provided, may be made if mutually acceptable and agreed to between the Corporation and the Contractor; such change(s), if any, shall not affect the validity of this agreement.

2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

Cancellation by the Contractor of the service(s) to be provided herein, or any one or more of a series, shall render this Contract void, and a new Contract may be prepared by the Corporation to cover the service(s) to be given, if any.

The Corporation reserves the right to cancel this agreement at any time after commencement of services if the Contractor neglects to perform as specified.

The balance of any remuneration and other allowances, if any, due shall be paid upon completion of the service(s) herein provided upon submission of invoices in triplicate, or upon certification by the director of the program or the activity that the service(s) have been completed. The total remuneration paid, and the other reasonable incidental expenses, if any, shall be considered full compensation for basic services rendered, including overhead, profit and taxes.

ETHICS DECLARATION

I declare that I am not a Legislator, elected or appointed officer, or that this firm is not owned or controlled by any Legislator, elected or appointed officer, compensated or uncompensated, member of a State board or commission, or other employee of the State of Hawaii.

I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

The Contractor understands that, if he/she is engaging in business or performing services within the State of Hawaii, the remuneration includes an amount to cover 4% State General Excise Tax and license fee (Chapter 237, H.R.S. 1969, as amended), and he agrees to pay the required assessments to the State Department of Taxation, 425 Queen Street, Honolulu.

Any product resulting from work under this contract shall be the sole property of the Research Corporation of the University of Hawaii, and shall be at its discretion, disposed of in accordance with Research Corporation of the University of Hawaii/University of Hawaii/Federal Copyright Patent Policies.

The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 43

Attachment I

This consulting agreement is to cover the objectives of the proposal entitled " Development of Methods for the Cultivation of the Edible Limu Gracilaria Parvispora" submitted by Ke Kua'aina Hanauna Hou and University of Arizona. A copy of the proposed work is attached detailing specific goals and objectives to be accomplished.

The contractor agrees to provide up to 30% of sporelings produced for other interested growers on Moloka'i. Distribution of requested sporelings will be coordinated through the Moloka'i Aquaculture Advisory Alliance in conjunction with the Sea Grant aquaculture extension agent on Moloka'i.

The project will receive $ 27,280. There will be $ 13,000 advanced to the consultant. Following the receipt and acceptance of a six month progress report an additional $ 13,280 will be made available to the consultant. The final payment of $1,000 will be made after the receipt and acceptance of a final report.

BUDGET

The project and budget will be administered by KKHH with technical assistance provided by the UA. UA will suggest vendors for supplies and materials, further develop experimental procedures, analyses, and reporting as well as physically assisting with experiments when on-island and consulting by phone and Fax at other times. University of Arizona participation is funded by NCRI and UA is not seeking additional funds from Maui County or USDA. The biologist will work directly for Ke Kua'aina.

Materials & Operational Funds

2 Circular nursery tanks or raceways	1,200
Plumbing Modifications	300
Utilities (to run additional tanks)	2,000
Misc. supplies	500
Subtotal	4,000

Labor

Biologist (@ $32,000/yr)	
(12 months, 50% time)	16,000
ERE (30%)	4,800
Subtotal	20,800
Labor & Materials	24,800
Overhead (10%)	2,480
Total Request	27,280

Ke Kua'aina Hanauna Hou
Star Route 265
Kaunakakai, Moloka'i, Hawai'i 96748
(808) 558-8393 phone • (808) 558-8453 fax

PROPOSAL FOR RESIDENT BIOLOGIST TO ASSIST IN DEVELOPMENT OF METHODS FOR CULTIVATION OF THE EDIBLE LIMU GRACILARIA PARVISPORA ON MOLOKAI

SUBMITTED BY KE KUA'AINA HANAUNA HOU

AND

UNIVERSITY OF ARIZONA

Budget Request: $27,280

Proposed Start Date: September 1, 1993

August 1993

INTRODUCTION AND JUSTIFICATION

Ke Kua'aina Hanauna Hou (KKHH) and the Moloka'i Limu Project is assisting in the development of a cottage industry of limu production based in the traditional fishponds on Moloka'i. The initial target species are Gracilaria parvispora (long ogo) and Gracilaria coronopifolia (Limu Manuea). These traditional species supplied the bulk of "ogo" used in the islands until the wild stocks were overharvested. Today, an imported species from Florida, Gracilaria tikvaheae, cultured on land in tanks, meets the demand. Yet the imported species does not have the same taste and texture as the traditional ogo's and the local species can be sold at a premium price when available. The project is attempting to introduce these species into a sustainable aquaculture system utilizing the unique coastal resources of Molokai: a network of 40 families will grow limu in the fishponds of the south shore of the island and value-added, brand-name limu products will be marketed throughout the islands and ultimately on the mainland and in Japan.

Several vegetative methods have been demonstrated and test marketing has been conducted in Honolulu. The production goals are set at 1,000 pounds per week to be achieved within three years. However, the vegetative method has two significant problems. First, after a given period of growth the seaweed seems to lose its vitality and the batch declines. Second, the vegetative method depends on collecting starter material from the wild and transferring it to production baskets. This puts additional demand on the wild stocks. The project has instituted a hatchery operation to provide continuous starter material by using cystocarpic thalli to cultivate new plants. These plants will be grown to harvest size then cropped by cutting them back, and replaced with new material when they are no longer productive. The concept is to release spores onto suitable substrates and then to nurse the juvenile plants up to a stage where they can be transferred out into the ponds. This would be analogous to a seedling and nursery operation which would protect young plants from grazers, reduce overgrowth by competing algae and fertilize on a schedule which would induce rapid development.

The feasibility of spore culture of these two species was demonstrated by Doty et al. (1986) in experiments conducted at Anuenue Fisheries Research Station over a three year period. They found that spores readily attached to small pebbles and other substrates. The pebbles were broadcast onto the reefs of Oahu and Molokai. This was apparently the first introduction of Gracilaria parvispora to Molokai and there are now several scattered naturalized populations of this species on the reef, descended from that effort. Doty et al.'s methods have been adopted by the Molokai Limu Project in the design and operation of a hatchery to produce 15,000 spore-coated pebbles per year to meet the project production goal. The success Doty et al. (1986) achieved in spore-settling has been verified in the present effort with G. parvispora and by Dr. Celia Smith, working with G. coronopifolia. Photomicrographs of stages in spore developing are in the figures at the end of the proposal.

A significant research question which must still be addressed is to define the culture conditions necessary to raise the sporelings to juvenile stages at which point they can be distributed to growers for outplanting into ponds. Doty et al. (1986) disseminated spore-coated pebbles onto

the reef immediately after spores settled; under these conditions, very few mature plants developed and the procedure did not constitute an adequate aquaculture methodology. It is clear that a protected nursery stage is needed to allow the sporelings to develop to sufficient size that they can survive predation and overgrowth by epiphytes before they are placed out in ponds or on the reef. Lab trials at the University of Arizona with G. parvispora have been able to raise plants up to a size of 1 cm with first branching visible within 90-100 days after spore settling. It is this first, critical, 100 day period that is the focus of the present proposal.

Maui County has provided critical support for the Limu Project in past years. It supplied tanks, operating funds and a local position to assist during the first two years of research. The critical need at the present time is for a resident, trained biologist to participate in the day-to-day development of procedures and data collection to ensure that the hatchery, nursery and growout phases come on line in time to meet production requirements. There is also a need for additional tanks and a small amount of operational funds to extend the nursery phase (the period before sporelings are placed out in fishponds). The present budget request is for half the salary support for a resident biologist - the other half is being sought through funds earmarked for Molokai aquaculture development through USDA.

RESEARCH GOALS AND OBJECTIVES

The principal investigators from the University of Arizona, assisted by a resident project biologist on Molokai, will conduct research trials during the large-scale production trials which are now beginning at Puko'o and which will be extended to other locations through creation of a growers' network of 40 families. The objectives are: 1) quantify growth and survival of the sporelings over the hatchery, nursery and growout stages; 2) quantify sporeling requirements for light, water motion, water exchange, and fertilization during the nursery phases; 3) quantify epiphyte and contaminant problems during the hatchery and nursery phases; and 4) based on research results, recommend detailed hatchery and nursery protocols to raise sporelings in high survival for outplanting and distribution to the growers network.

The hatchery system as it is presently configured utilizes a direct seawater intake which passes through a combination sand and oystershell filter. The water then enters a settling/ storage tank where heavier particulates can settle before the water gravity feeds to hatchery tanks. The settling/storage tank is plumbed to allow continuous recycle through the filter if desired. Based on the information we have at present, a preliminary protocol for sporeling production has been adopted. Pebbles are placed in plastic trays in tanks and inoculated by overlaying them with cystocarpic, mature thalli which release spores. During the first 72 hours the tanks are covered but after spore settling has occurred the cover is removed and the tank is fertilized. The trays are then spread in a single layer into additional holding tanks where the spores are allowed to establish on the pebbles for an additional 10 days. After 14 days the trays are removed to make room for the next hatch. The trays are placed out in fishponds. They are cleaned daily and fertilized weekly. This protocol will be evaluated and modified through the direct, daily participation of the project biologist with Ke Kua'aina limu workers in the hatchery operation.

It is already clear that the longer the spore-coated substrates are kept in clean culture in tanks, the greater the survival rate when they are placed out in ponds. The plants are microscopic in size during the first 60 days and tend to be overgrown by faster-growing, filamentous algal species. The existing configuration of tanks limits the residence time of trays to two weeks. Funding is requested to construct additional nursery space using the methods Ke Kua'aina learned at the circular tank workshop on Oahu.

Principal investigators from the University of Arizona will spend 6 months on site during the first 12 months of hatchery operation. The biologist will keep a day log of operations and collect data on all aspects of the hatchery and nursery. This effort will be critical to making the Molokai effort a success and will provide valuable data for the development of sporulation methods to advance Gracilaria aquaculture elsewhere.

METHODOLOGY

Following are examples of specific experiments that will be conducted during the first production year.

1. **Contamination Experiments.** We propose to install an in-line UltraViolet sterilizer unit and then test directly and indirectly for levels of algal contamination that would affect the growth and survival of cultured limu. The experiment will utilize a control and 3 treatment levels to determine efficacy of UV treatment.

Water in the storage tanks will be recycled through the filter for 4 hours. A control tank will be filled with water which passes through the UV unit without power. Then one hatch tank will be filled with water which is recycled with the UV unit on for 10 minutes. A third tank will filled with water which is recycled with the unit on for 20 minutes, and the fourth tank will be filled after 30 minutes of operation.

The degree of contamination will be measured directly by collecting samples of the water as the tanks are filling and fertilizing the sample with a standard F/2 algal medium. After 24 hours, samples will be taken and cell counts conducted using visible microscopy and a standard hemocytometer. The degree of contamination will be measured indirectly by taking spore counts on microscope slides placed in the hatch tanks. Tanks with heavy contamination will have reduced spore counts as the sporelings succumb to competitors.

If the initial trial does not demonstrate a significant difference between treatments, the period of exposure to the UV unit will be extended. When a significant difference is apparent, the experimental procedure will be repeated twice more to further develop the method and to procure publishable data.

2. **Duration of Hatchery Phase.** Once spores are settled it is not clear how long the pebbles must spend in the tanks before they can be placed out in the fishponds. Three trays per treatment will be removed from a test tank at weekly intervals for 4 weeks after inoculation and

placed out in random block design in the fishpond. Trays will be inspected weekly for growth, survival and degree of contamination. The experiment will be repeated to verify conclusions.

3. **Water Motion Requirements During Nursery Phase.** Experiments have shown that the vegetative cultures respond positively to water motion up to the highest levels measured, 6-10 cm/sec. However, the sporeling water motion requirements may be different due to their different surface area to volume ratio. Preliminary lab experiments have suggested that best sporeling development occurs at low water motion levels (2-5 cm/sec) up until plants are 2-4 cm in size. The water motion requirements will be defined by placing trays at locations in Puko'o Fishpond that vary in natural water motion due to different exposure to the trade winds; water motion will be quantified by placing clod cards in trays at weekly intervals. Three locations using 3 trays per location will be used and growth, survival and degree of contamination will be measured after 4 weeks. Survival and growth of sporelings placed in fishponds will be compared to sporelings from the same hatches placed in protected nursery tanks over the same period.

4. **Fertilization Requirements During Nursery Phase.** The natural levels of fertility in eutrophic reef waters may be sufficient to support growth without supplementation with chemical fertilizers. Weekly samples of reef water will be analyzed for nitrate, ammonia and phosphate at the 3 sites selected for the water motion experiment. In addition, 1 tray per treatment will be removed and fertilized weekly then replaced, and compared to the non-fertilized trays.

5. **Photographic Atlas of Sporeling Development.**

Color micrographs will be taken to document all stages in the growth of the sporelings, significant contamination problems, and other aspects of the hatchery and nursery phases of development.

6. **Final Protocol for Hatchery and Nursery Operations.** The observations gained during the project will be used to develop a complete protocol for setting up and operating a G. parvispora hatchery and nursery. The results will be presented in the form of a Hatchery Manual that will give complete instructions for successful results.

PROJECT ORGANIZATION

The Molokai Limu Project was initiated in 1989 under funding from the National Coastal Research Institute (a NOAA agency). The original 2-year project was extended for 2 additional years based on the technical success acheived during the original project period and the community support the project received. The NCRI funding provides technical assitance from the University of Arizona to the working partner, KKHH. The working partner has received a Financial Assistance Award from the Department of Health and Human Services to implement the project in the community over a three year period. NCRI funding expires in June, 1994 at which time KKHH will be without technical assistance. The present proposal is aimed at providing a resident biologist to conduct research to fill gaps in methodology and to transfer the

knowledge gained to the local practicioners, so that at project end the needed expertise is in the hands of the residents.

BUDGET

The project and budget will be administered by KKHH with technical assistance provided by the UA. UA will suggest vendors for supplies and materials, further develop experimental procedures, analyses, and reporting as well as physically assisting with experiments when on-island and consulting by phone and Fax at other times. University of Arizona participation is funded by NCRI and UA is not seeking additional funds from Maui County or USDA. The biologist will work directly for Ke Kua'aina.

Materials & Operational Funds

2 Circular nursery tanks or raceways	1,200
Plumbing Modifications	300
Utilities (to run additional tanks)	2,000
Misc. supplies	500
Subtotal	4,000
Labor	
Biologist (@ $32,000/yr) (12 months, 50% time)	16,000
ERE (30%)	4,800
Subtotal	20,800
Labor & Materials	24,800
Overhead (10%)	2,480
Total Request	27,280

BIOLOGIST POSITION

QUALIFICATIONS

The biologist will need to have prior familiarity with algal culture techniques, microscopy, and general lab skills. Minimum requirement should be a BS in Marine Sciences or similar academic field of study and work experience with algal culture. Working knowledge of statistical analysis, especially ANOVA's, will also be required. Work direction and experimental designs and plans will developed with research staff from the University of Arizona who are acting as technical assistants to Ke Kua'aina Hanauna Hou and the Moloka'i Limu Project.

JOB DESCRIPTION

The applicant will be expected to develop and execute a series of controlled trials to further develop algae reproduction techniques. Applicant will need to be able to take direction from written and oral instructions provided by KKHH and UA. Experience with word processing (WordPerfect or Microsoft Word) spreadsheets (LOTUS, QPRO, or EXCEL) will be needed. Working knowledge of statistical analysis, especially ANOVA's, will also be required. A final report will be prepared which will document the experimental methods and results along with statistical analyses. The conclusions will include the description of the state-of-the-art as developed for the system.

REFERENCES

Doty, M. S., J. R. Fisher, E. K. Zablockis, B. J. Cook and I. A. Levine. 1986. Experiments with Gracilaria in Hawaii, 1983-1985, University of Hawaii Botanical Science Paper No. 46, Honolulu, 486 pp.

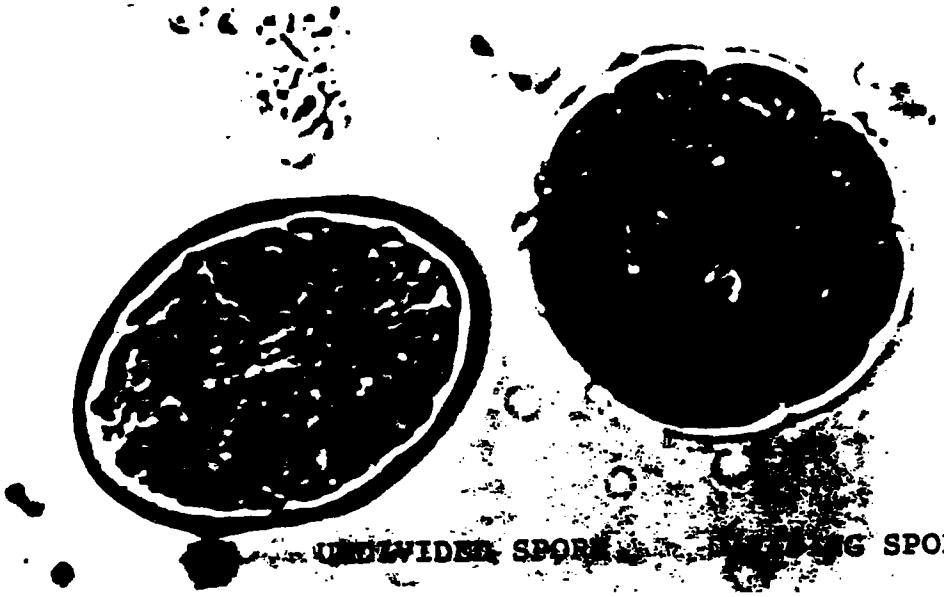
Gracilaria parvispora

1. The smallest piece, on the left side of the photo, was grown at the Environmental Research Laboratory from a spore. Sporulating material was brought from Hawaii to Tucson where the spores were collected and early growth began on glass slides.

2. The four larger pieces to the right in the photo were also grown in Tucson at the Environmental Research Laboratory. These four pieces were not grown from spores. They were cultured from the small holdfasts (initial diameter approximately 1 centimeter) which were saved from the sporulating material following collection of spores.

GRACILARIA PARVISPORA SPORELINGS ON SLIDE (60 Days)

GRACILARIA PARVISPORA SPORES DIVIDING ON MICROSCOPE SLIDE



UNDIVIDED SPORE DIVIDING SPORE

Program/Activity: Maui County Aquaculture

8/11/94
Date

By _____
Program Coordinator

Research Corporation of the University of Hawaii

9/13/94
Date

By _____

ACCEPTED:

Cheryl Y. Machado
Contractor

7/28/94
Date

Is Consultant a U.S. citizen?
Yes ✓ No _____

If U.S. citizen, provide Social Security No. 575-56-9442

Type of Entity

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Partnership	_____	Government	_____
Trust	_____	Estate	_____
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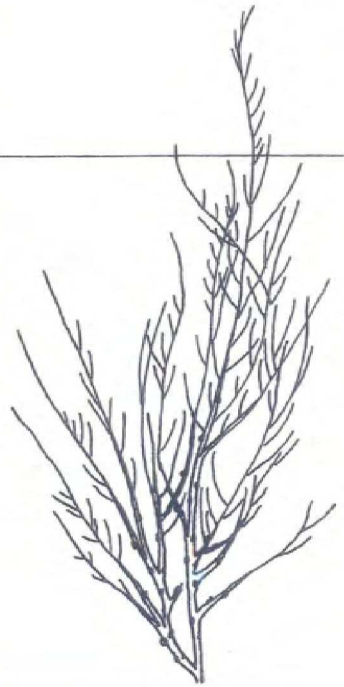
Distribution of Executed Copies
1. Original & Invoices - Research Corporation
2. Copy - Program/Activity
3. Copy - Contractor

Appendix 6. Copy of Draft Manual for *Gracilaria* Spore Culture

Atlas of *Gracilaria* Spore Culture

Edward P. Glenn, Ph.D.
David W. Moore
Colette Y. Machado
Kevin M. Fitzsimmons
Sandra E. Menke



ATLAS OF *GRACILARIA* SPORE CULTURE

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David W. Moore
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Molokai, HI 96748-0741

August, 1995

Project funding is based, in part, from: National Coastal Resources Research and Development Institute; Aquaculture Development Program; Maui County; United States Department of Agriculture; and State of Arizona.

Acknowledgments: We wish to thank Mridula Gupta for graphic assistance; and to the Ke Kua'aina Hanauna Hou staff for their project assistance; Sherman Napolean, Jr. Myron Akutagawa, Gandharva Ross, Decklan Kekoa, Isaac Lin Kee, and Leiff Kaulia.

Cover: Left and Right; Hawaiian youth, Gandharva Ross, Summer Research Associate inspecting his *Gracilaria* crop grown from spores in a Molokai fish pond. Center; *Gracilaria/parvispora*/long/ogo.

TABLE OF CONTENTS

Illustrated Guide to the Spore Culture of *Gracilaria*

Introduction

Gracilaria is a red seaweed sold as a high-value seafood in many parts of Asia and the Pacific. It is also the raw material from which the gel, agar, is produced; agar is the main thickening agent used in Japanese cooking and is a common additive to prepared foods in the United States and Europe as well. Agar is also the familiar medium on which micro-organisms are cultured (agar plates).

The world supply of *Gracilaria* no longer meets the demand. Much of the supply still comes from the harvest of wild beds in Asia and South America, notably Chile, but these beds have been over-harvested. Increasingly, aquaculture supplies are supplementing the wild harvest. By 1991, one-third of the *Gracilaria* harvest came from aquaculture. As wild beds continue to be diminished, it is likely that the majority of *Gracilaria* will soon come from aquaculture.

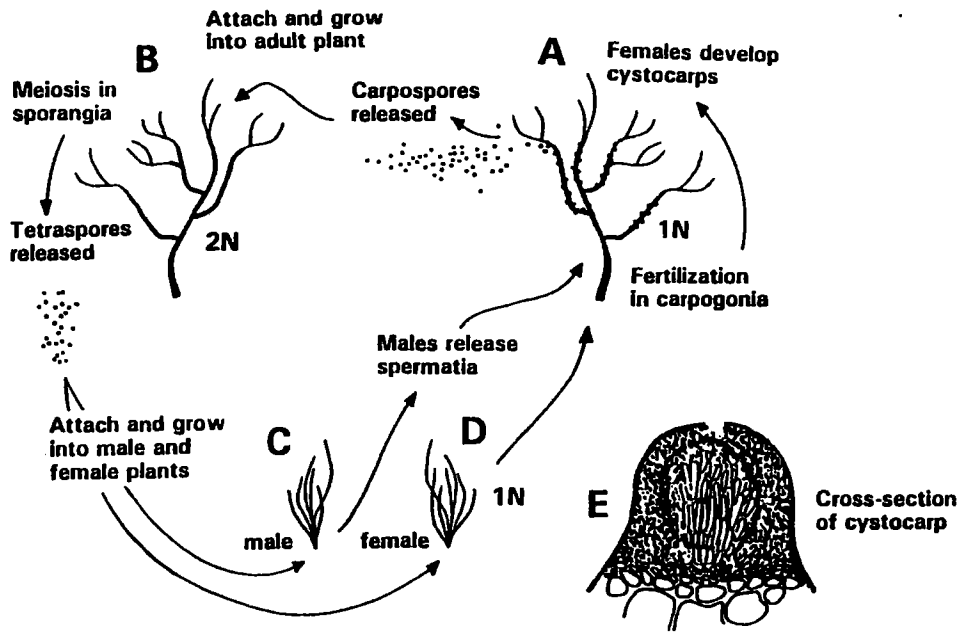
Gracilaria aquaculture represents a new economic opportunity for coastal residents of tropical and subtropical coastlines around the world. The *Gracilaria* market is not limited by geography, but is served by countries as far from each other as Chile, South Africa, France and Indonesia. Aquaculture methods are still being developed. There is no "best way" of growing *Gracilaria* - practitioners are still experimenting, developing methods that work at their location for their particular species of *Gracilaria*.

Most *Gracilaria* farmers practice some form of vegetative culture. In vegetative culture, plants are not reproduced by spores. Instead, fragments of plants are grown in floating cages, on ropes, or broadcast into ponds or tanks, and are allowed to grow to harvest size. Vegetative methods have the advantage of simplicity. However, 20% or more of the harvest must be used to restart the cultures for the next round of growth. Vegetative methods are inefficient not only because a large amount of seaweed must be used for replanting, but because diseases and pest organisms become established on the plants, and by replanting fragments of these plants, disease and pest populations soon become overwhelming and the farmer must restart his cultures using *Gracilaria* harvested from the sea rather than from his own farm. This can help deplete the local beds of *Gracilaria* which are generally already under stress from wild-crop harvesters.

This brief manual presents a "better way" to grow *Gracilaria*, using the natural spore shedding that occurs in most species. These spores, analogous to the seeds used to grow land crops, can be settled onto ropes, coral chips, fishing line, rocks or almost any other type of substrate, and grown into mature plants for harvest. The mature plants, in turn, provide a source of further spores to restart cultures, as well as *Gracilaria* for sale. Spore culture of *Gracilaria* is self-contained and can be practiced even where *Gracilaria* does not grow naturally, or where the wild supplies have been depleted. Spore culture can also be used as an inexpensive method to repopulate natural stands of *Gracilaria* that have been over-harvested. Spore culture has been used for other types of seaweeds but is only recently attracting interest as a method or growing *Gracilaria*.

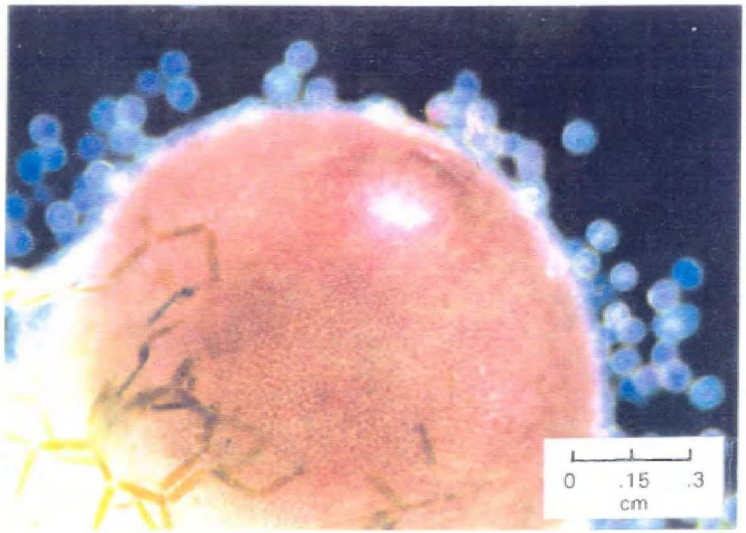
The manual relies on pictures as much as words to convey the message. The concepts are relatively simple and there is no single, right way of carrying out spore culture: numerous modifications in methodology, utilizing local materials and suited to local conditions, are possible at each step. Pictures convey these alternate possibilities better than words. The manual is based on methods that have been developed to grow the edible species, *Gracilaria parvispora*, or long ogo, in Hawaii. The method makes use of the traditional Hawaiian fishponds that ring the fringing reefs of Molokai and some other islands to grow the sporelings to harvest size. However, these methods can be adapted to other types of *Gracilaria* and growout facilities.

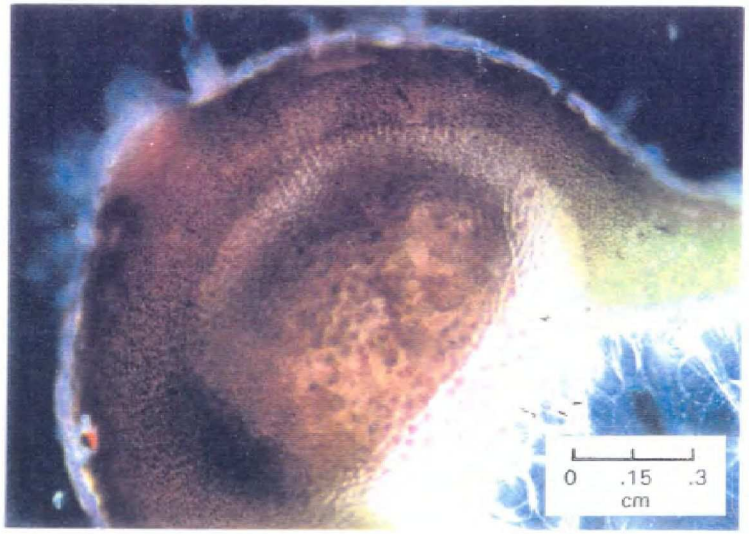
GRACILARIA LIFE CYCLE



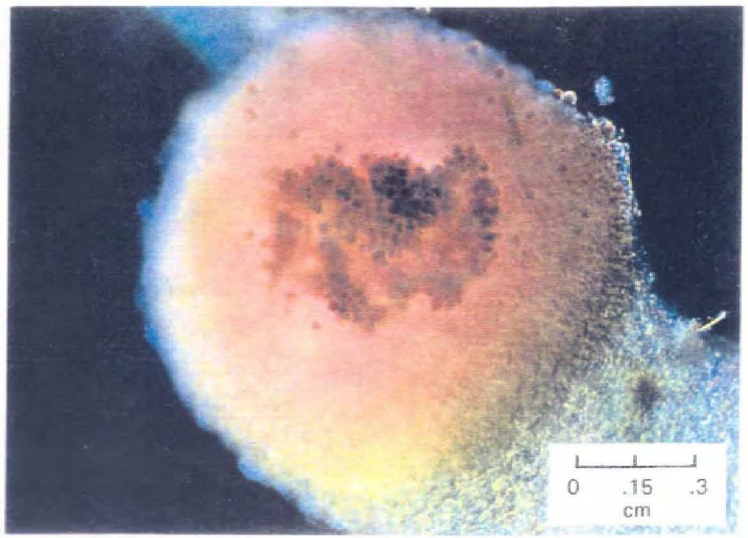
Red seaweeds have a type of life cycle called an isomorphic alternation of generations. Isomorphic means the different life stages look the same superficially. An alternation of generations means that a haploid generation of plants (containing one copy of each chromosome in the nucleus) gives rise through sexual reproduction to a diploid generation (containing two copies of each chromosome, one from the mother and one from the father). These life stages are designated 1N and 2N, respectively, for the number of copies of each chromosome. Unlike other seaweeds, red seaweeds such as *Gracilaria* have <u>two</u> diploid life stages rather than just one. One diploid stage does not look like the other stages: it consists of small bumps growing on adult (haploid) plants. Each bump is called a cystocarp, and it grows from a fertilized egg attached to a female plant. A female plant usually contains hundreds of cystocarps distributed all over the thallus (A). Although they look like part of the parent plant, cystocarps are actually separate small plants growing on the mother plant (E).

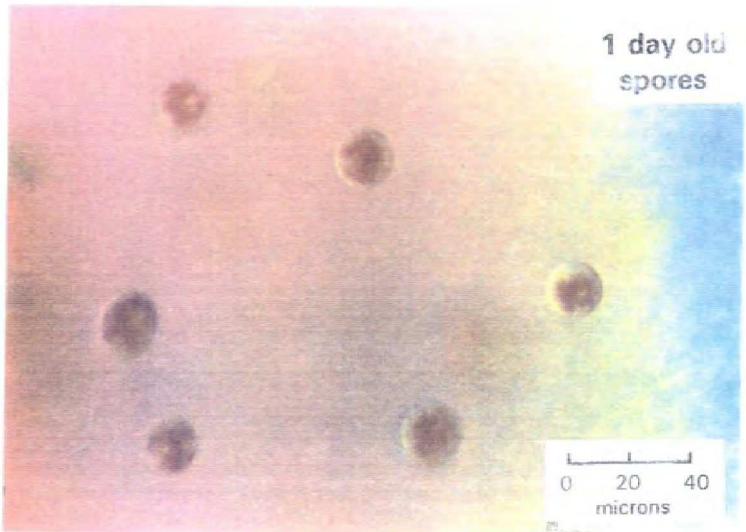
The cystocarps produce single-celled spores, called carpospores, which are released into the water. They are sticky, and as soon as they attach to an object in the water they begin to grow. They grow into mature, diploid plants called tetrasporophytes (the second diploid stage)(B). Tetrasporophyte plants have single-celled, spore-producing bodies distributed over their surface (but not visible without a microscope). The spore-producing cells undergo meiosis and release haploid spores called tetraspores. The tetraspores attach and grow into male or female gametophytes (C,D). To the naked eye, male and female gametophytes are indistinguishable from tetrasporophytes. However, the males produce spermatia which are carried by the water current to the females, which bear eggs. The eggs are fertilized and grow into cystocarps, which release carpospores, thereby starting the life cycle all over.

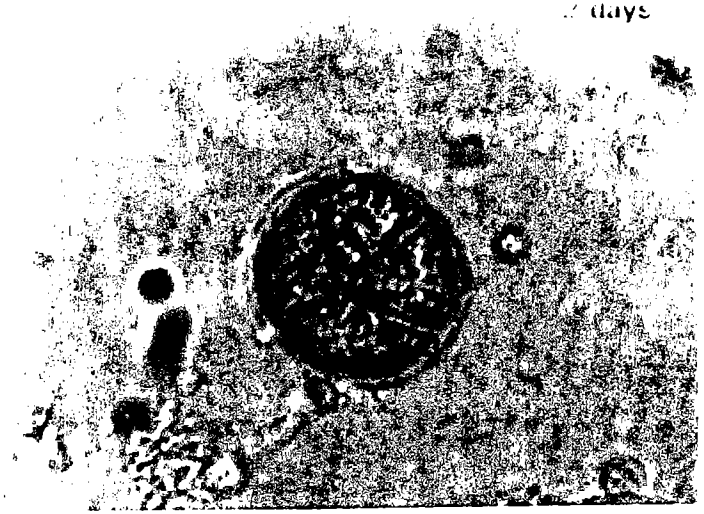




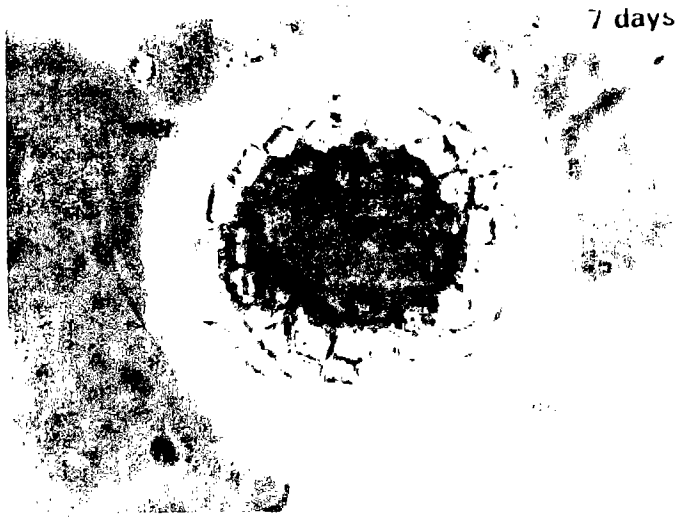
Cystocarps and spores



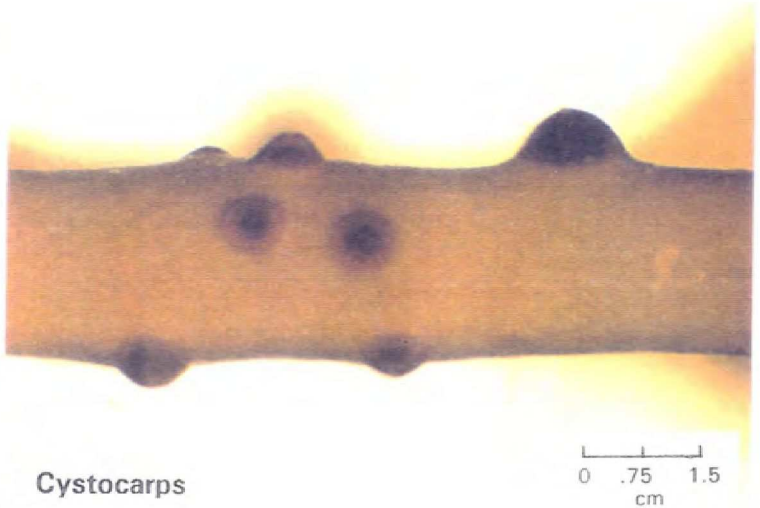




Dividing spores

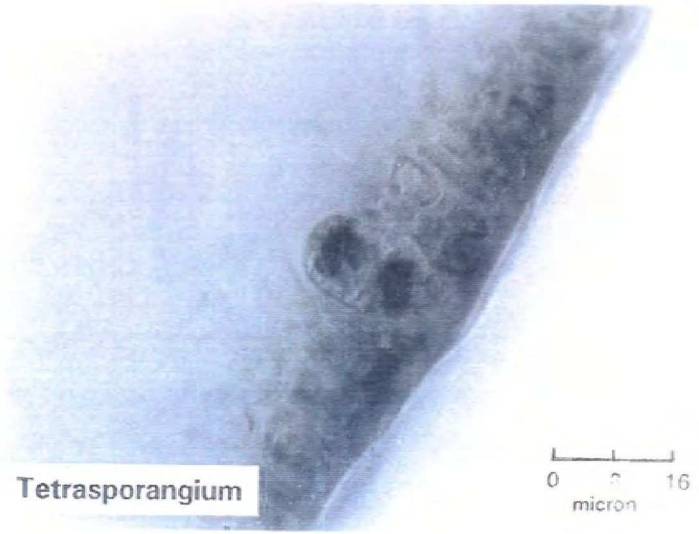


Cystocarpic plant

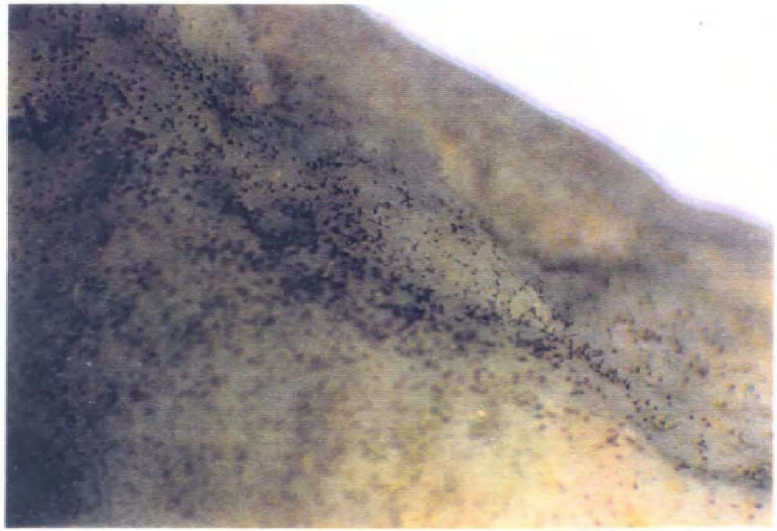


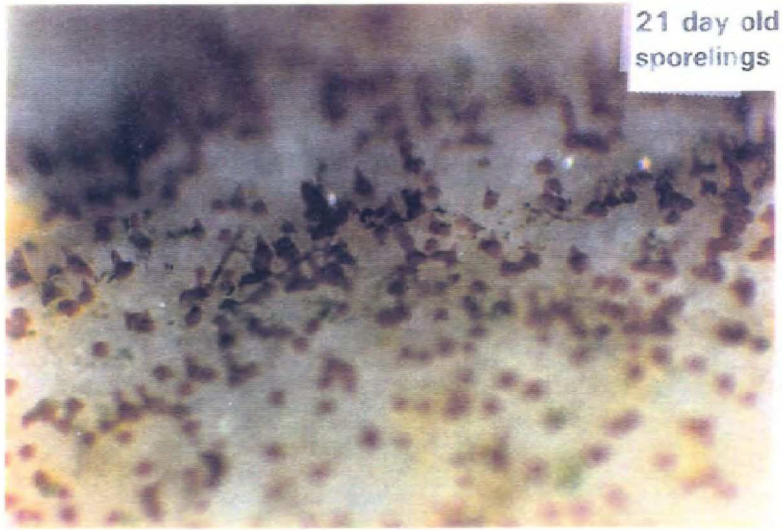
Cystocarps

Tetrasporophyte

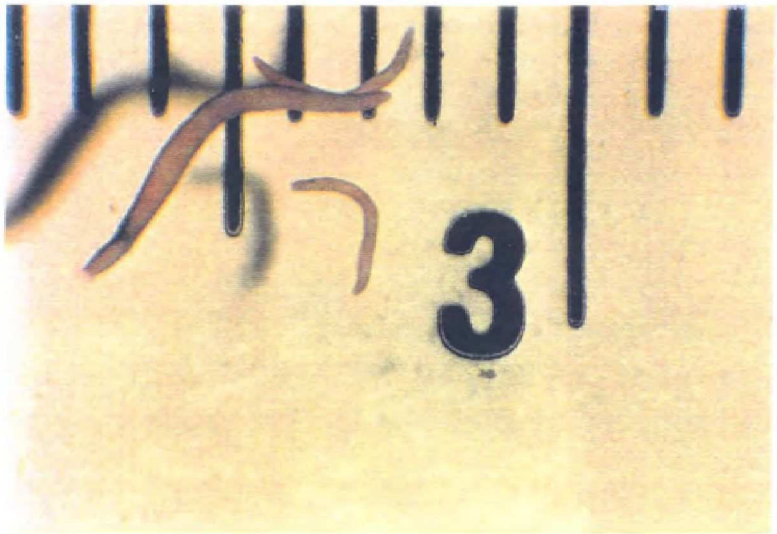


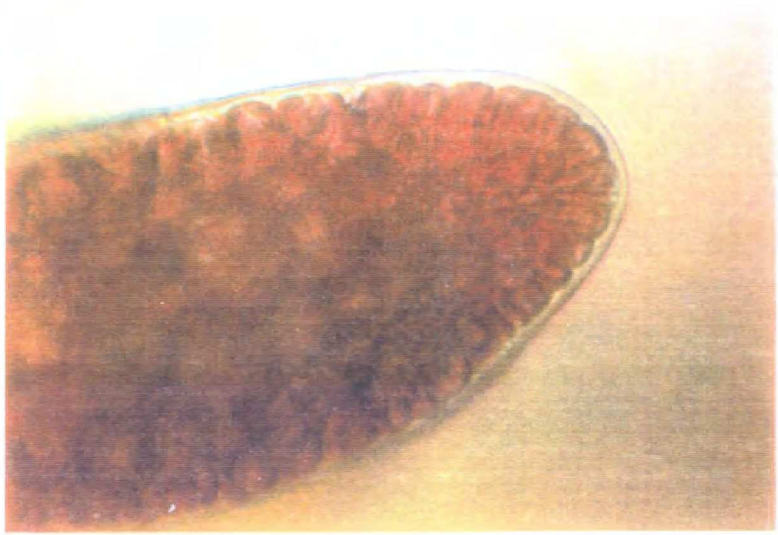
Tetrasporangium





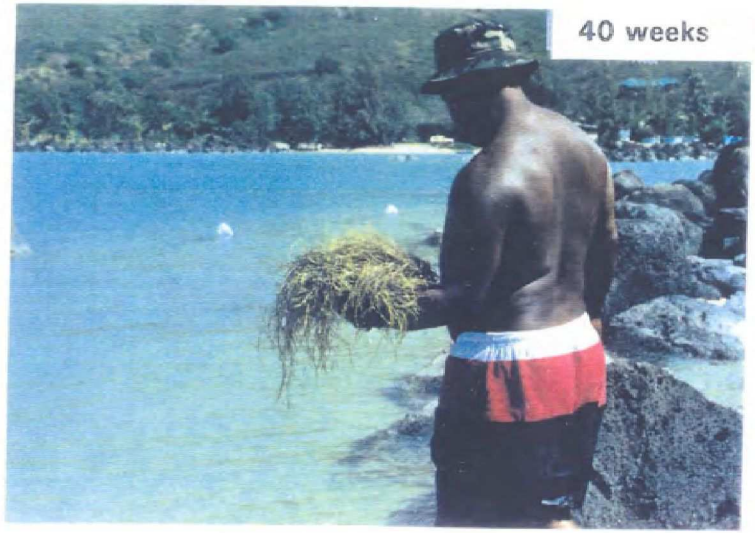
Sporelings on rocks





Sporelings

Young plants



Medium plants

Large plant

Completing the Life Cycle in Culture - Overview

Although the life cycle may seem complicated, completing the life cycle in aquaculture is not difficult. Only a few steps are involved:

1) Hatchery

A simple hatchery is needed to settle carpospores onto substrates that are then planted out in the ocean to grow into harvest plants. Typically, the hatchery is nothing more than a tank filled with seawater, with aeration to keep the algae alive. The substrates are any materials on which the farmer wants *Gracilaria* plants to grow. Spores will readily attach to any material that is not toxic: the farmer chooses the substrates based on convenience of planting and harvesting. Typical substrates are pebbles or coral chips which are broadcast onto pond bottoms or lines which are strung between stakes in the ocean.

Substrates are placed at the bottom of the hatchery tank, and female *Gracilaria* plants containing cystocarps are laid over the substrates. The tank is covered with shade cloth, to keep competing organisms from growing, and incubated for 3-4 days. During this time, spores are released from the cystocarps and attach to the substrates.

2) Planting

The spore-coated substrates are removed from the tank and are planted out into the ocean as quickly as possible (to avoid stressing the young sporelings). In the illustration, two types of plantings are shown: spore-coated rocks are broadcast onto the pond bottom; and spore-coated lines are tied between stakes.

3) Growout

The sporelings grow slowly at first, but many eventually become mature plants. Since the rocks and lines are inexpensive and do not require any maintenance during the growout period, a less-than-perfect success rate is acceptable. Plants are ready for first harvest approximately 25-50 weeks after planting out, depending upon their growth rate. Growth rate is determined by time of year (faster in summer than winter), amount of water motion, nutrients and water clarity.

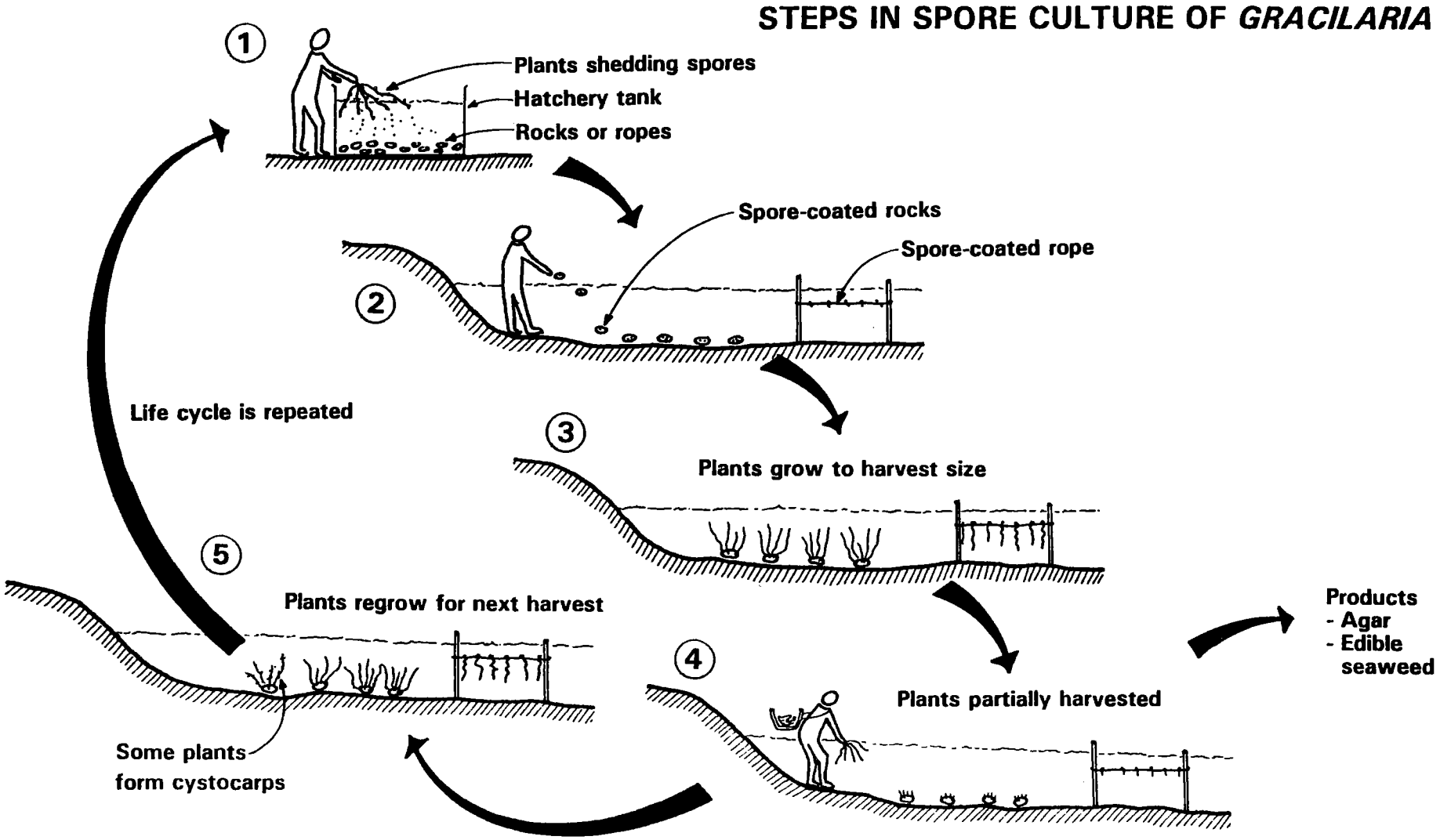
4) First Harvest

At first harvest, plants are cut back to within 5 cm of the holdfast, leaving enough material behind to produce a second crop. Nearly all the plants at the first harvest will be tetrasporophytes (smooth plants without cystocarps), since they all grew from carpospores.

5) Regrowth and Subsequent Harvests

Plants require 4-10 weeks to grow back to harvest size after they are cut back. The farmer watches his crop, and schedules his harvests accordingly. There is no fixed number of harvests that can be taken, since *Gracilaria* plants will continue to grow indefinitely. However, with time the rocks or lines become covered over with competing organisms and the quality and quality of the harvested material declines. After 2-3 years, most substrates will need to be replaced with fresh material from the hatchery. The farmer can broadcast new rocks or attach new lines over top of the old ones which may still be producing a harvest, minimizing the time between harvests. When the old substrates need to come out, the new ones will already be in place producing a harvest.

The hatchery operation requires a continual supply of cystocarpic plants to release carpospores. Over time, the farmer will notice that approximately 10% of his harvest plants are females bearing cystocarps. These arise as second-generation plants, from the release and growth of tetraspores by the tetrasporophytes which are the majority of plants. The tetraspores settle and grow on the same substrates that are already growing plants. The tetraspores grow into male and female gametophytes, and the females produce eggs which are fertilized and grow into cystocarps. The farmer culls these cystocarpic plants from each harvest, and uses them to start new hatches. In this system, it is not necessary for the farmer to deliberately produce male and female plants in a hatchery: that occurs in the pond by the natural release of spores. The farmer need only collect the cystocarpic plants and use them in the hatchery.


STEPS IN SPORE CULTURE OF *GRACILARIA*
1
Plants shedding spores
Hatchery tank
Rocks or ropes
Spore-coated rocks
Spore-coated rope
2
Life cycle is repeated
3
Plants grow to harvest size
5
Plants regrow for next harvest
Some plants form cystocarps
4
Plants partially harvested
Products
- Agar
- Edible seaweed

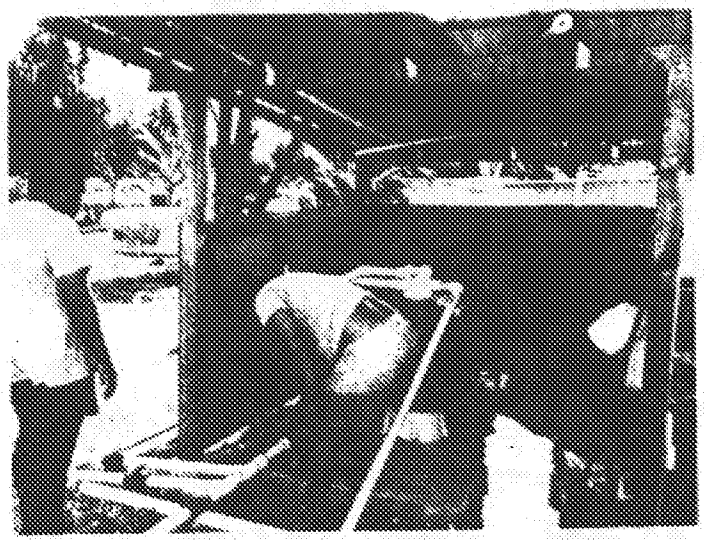
Hatchery Details and Alternatives

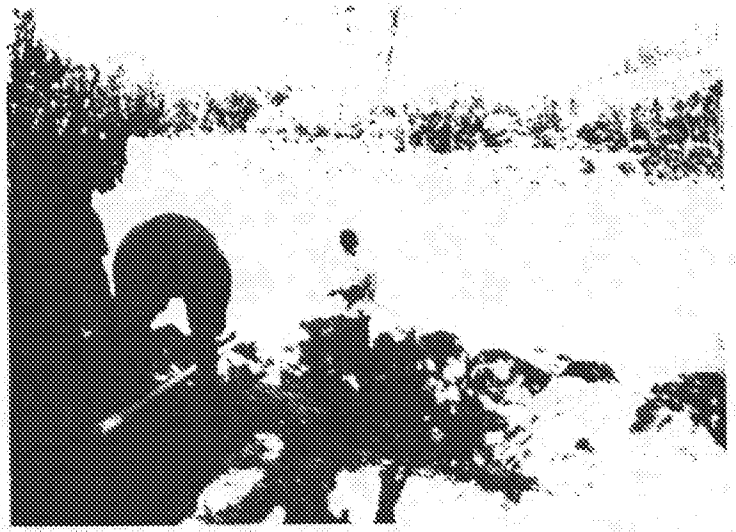
A tank hatchery using 4, 1000 liter tanks (1.5 m diameter, 0.6 m depth), can accommodate 48 plastic trays (40 x 40 cm) each containing 100-200 pebbles or coral chips to be coated with spores. This hatchery can produce approximately 3600 spore-coated rocks or chips per week, enough to plant 1-2 ha of pond per year. The substrates to be coated are washed in bleach solution and sun-dried prior to use, and placed in a single layer in trays. Hatch tanks are scrubbed with bleach solution, rinsed, and filled with filtered seawater prior to use. Since the seawater is not changed during a hatch, very little intake capacity is needed to support a hatchery. The illustrations show an intake capable of delivery 200 liters/minute of water. This intake is used to support tank cultures as well as the hatchery and is far larger than is needed for the hatchery alone, which could be served with a portable, submersible pump capable of delivery 10-20 liters/minute, similar to a garden hose. The sand filter removes large particles but not micro-organisms. Aseptic techniques are not necessary.

Trays are placed in a single layer in the bottom of tanks, and overlaid with cystocarpic plants that release spores into the water. The cystocarpic plants are hand-cleaned before use, to remove other algae, sponges or other contaminating organisms. Approximately 2 kg of plants per tank is sufficient (100-200 g per tray). A clean microscope slide is placed in each tray to estimate the success of spore settling. The tanks are aerated sufficient to keep the water moving but not so much that the plants are moved off the trays. This can be accomplished using a small air blower and several airstones per tank, of the type used in home aquaria. Shade cloth is used to block out 75% of the sunlight.

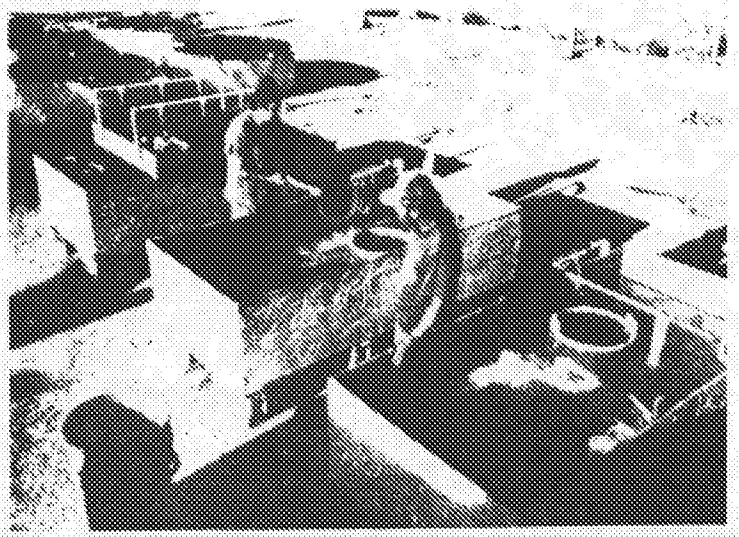
After 3 days the slides are counted for spores under a compound microscope. Spores are visible as red, dividing cells attached firmly to the slide (contaminating organisms can be washed under the tap, leaving behind attached spores). Spore density should range from 200 to 7,000 per cm^2 - even the lowest density is sufficient to indicate that all the rocks or chips were well coated with spores. Nearly every hatch produces numerous spores, but occasionally only a few spores are found on the slides. These hatches should be repeated using fresh cystocarpic material.

As the pictures show, hatches can be carried out in square tanks, or ropes can be substituted for rocks and chips. Ropes can be coiled loosely in tanks and turned every day during the hatch, or they can be strung on frames to ensure even spore coating. Thin nylon rope (0.5 diameter) is inexpensive and durable. The hatchery procedure can even be carried out in the pond, using floating baskets to hold the trays, which are overlain with cystocarpic thalli.





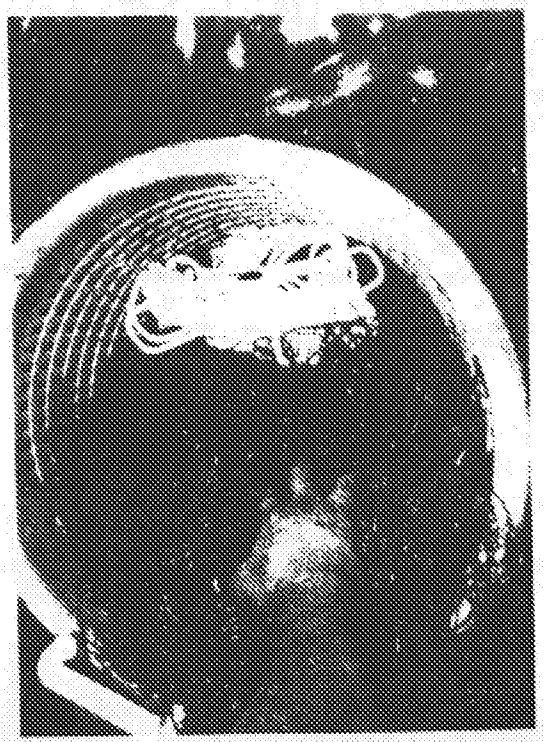
Setting up hatchery



Setting up a coral clap hatch in trays

Setting Up a Hatch

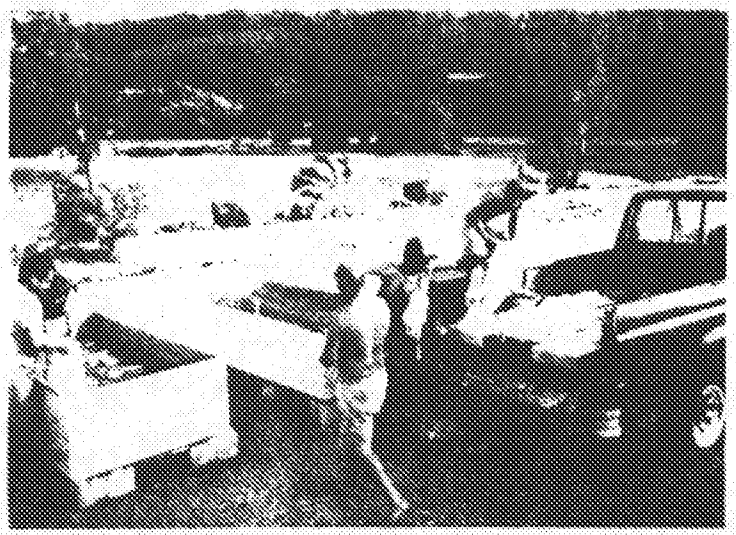
Rocks & ropes to be coated with spores



Cystocarpic plants

Hatch in progress

Planting trays in a pond



Planting out spore-coated ropes

Rope hatch using frame

Frame with spores placed in penned section of pond

Growout of Plants on Rocks and Ropes

When it is confirmed that spore settling was adequate, the trays or ropes are removed from the tanks and hauled to the planting area. The sporelings can be exposed briefly to air without dying, hence the trays can be hauled dry in a pickup truck bed as illustrated. If they are to be out of the water for more than a few minutes, they should be moistened with seawater occasionally to prevent their drying. Ropes can be hauled in plastic garbage cans partially filled with seawater.

Rocks or chips are broadcast into a penned section of pond (to keep out fish and turtles that eat *Gracilaria*) and the trays are returned to the hatchery, where they are washed in bleach prior to reusing. The cystocarpic material from the hatch can be reused for subsequent hatches, but should be replaced after 3-4 weeks as the plants tend to lose vigor over time and produce fewer spores. Approximately 10 rocks or chips per square meter is the minimum density that will produce a good crop; but the density can be much higher if sufficient rocks or chips are available. *Gracilaria* grows best when plants are crowded together to form a closed cover in which competing organisms have difficulty establishing.

Ropes or lines are strung between stakes driven into the pond bottom, or stretched between concrete blocks that anchor each end. Lines 10-30 m long are convenient to handle, and a spacing of 1 m between lines allows room for harvesting and tending the lines.

Gracilaria will grow under a variety of water conditions. It responds positively to water motion, yet the best place to grow the crop may be in an area of reduced water motion, since these areas tend to have lower growth of competing organisms. Shallow water (less than 1 m) is easiest to use if rocks or chips are broadcast onto the bottom, but lines can be stretched out in deeper water, using plastic milk jugs as floats. Growth is fastest in clear water, due to better light penetration, but good crops can also be produced in very murky water (visibility under 0.3 m). Murky water tends to discourage the growth of competing organisms.

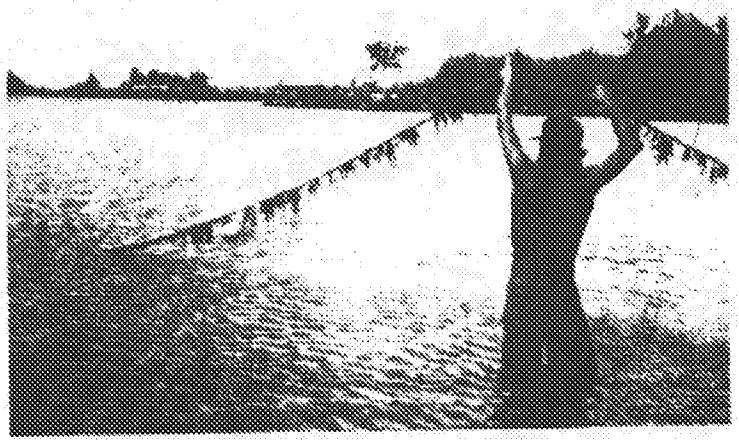
Depending upon water conditions, lines require 20-25 weeks to produce their first crop. Rocks and chips are slower, since they are on the bottom of the pond where they become partly covered with sand and silt, and they require 40-50 weeks before they can be harvested. In general, attempting to do weekly maintenance on the plantings is impractical. The most important single step a farmer can do to encourage a successful crop is to surround the planting area by an enclosure to keep out fish and turtles, which can completely eliminate a crop. A plastic fence using 2 cm mesh is sufficient; inexpensive materials can be used, and it should be expected that the fence will need to be replaced or repaired following storms.

The farmer will have to experiment to find the best locations in a pond or on the reef to plant out a crop.

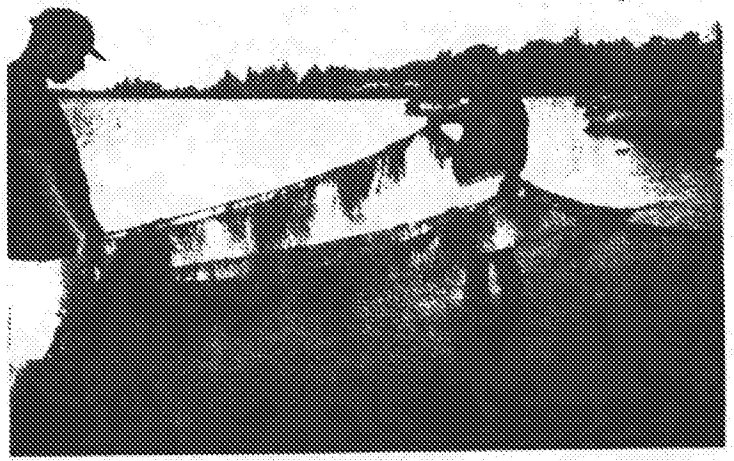
40 week old plants

Growth on rocks

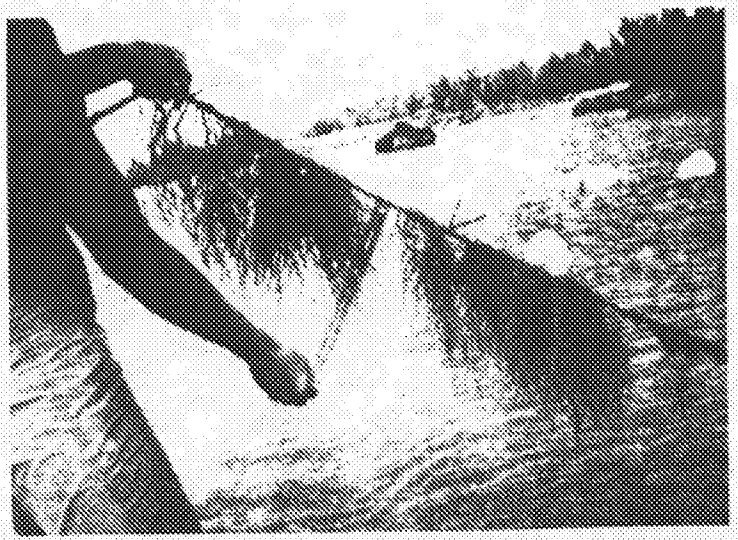
10 week
old plants

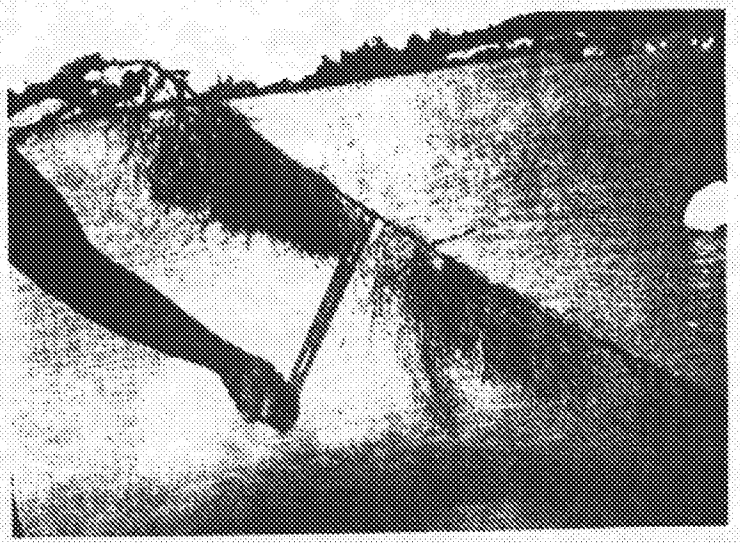


20 week
old plants



Growth on ropes



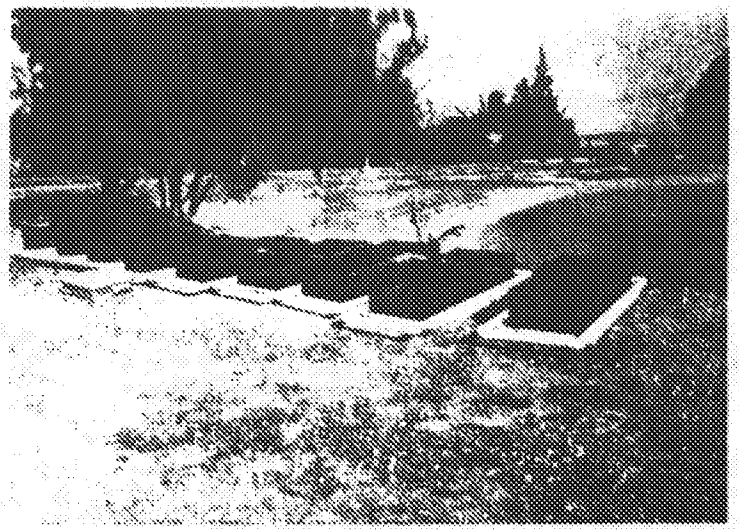


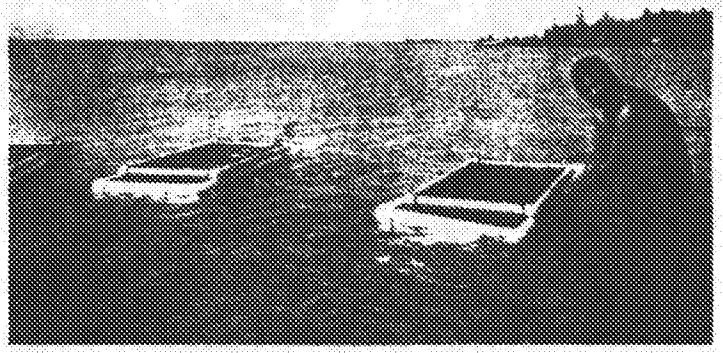
Harvest plants washed onto beach . . .

Growing on nets . . .

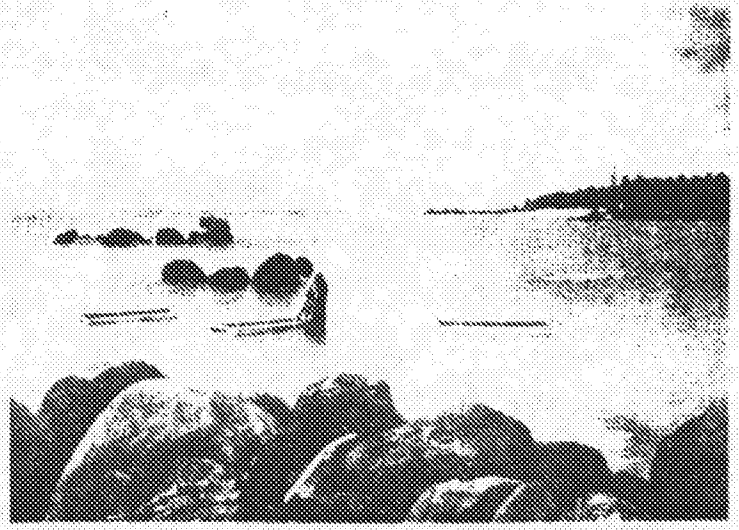
. . . concrete blocks . . .

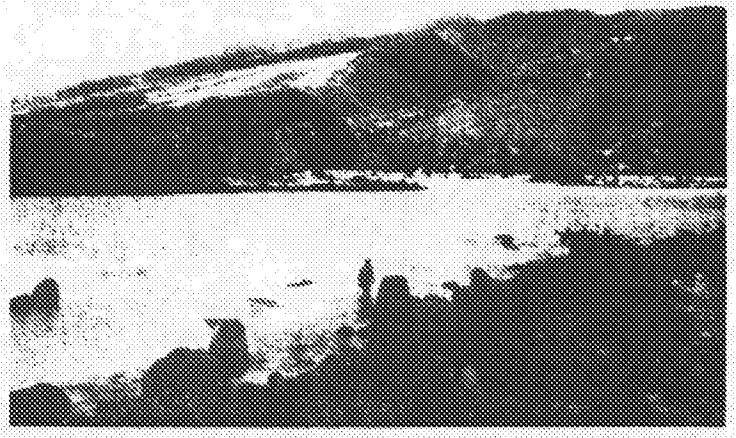
or unattached





Setting out baskets to multiply stocks





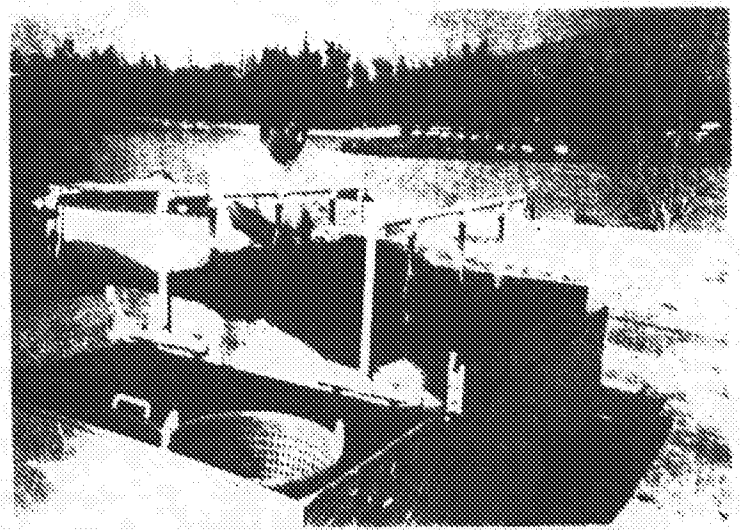
First Harvest, Subsequent Harvests and Gathering Cystocarpic Material to Complete the Life Cycle

Approximately 40-60% of rocks and chips develop harvestable plants (the rest are lost in the sand, overgrown with fouling organisms, or the sporelings are lost to predation). The success rate with lines is lower - approximately 30-40% of lines produce harvestable crops. The attrition rate of individual sporelings is high. Substrates may have several thousand sporelines per cm^2 to start, but have 2-5 at harvest, but this is enough to produce a dense growth of plants. At first harvest, plants are 30-50 cm long and are cut back to 5 cm. The remainder left on the rock, chip or rope is allowed to regrow for a subsequent harvest.

The yield of *Gracilaria* is in the range of 500-1,000 grams (fresh weight) per square meter of pond at first harvest. In Hawaii, the wholesale price for long ogo is $6 per kilogram, so the return at first harvest is $2.50-5.00 per m^2. If a farmer wished to gross $50,000 per year in sales, 1-2 ha of planted area would be required based on the return from the first harvest. However, the rocks, chips and ropes develop new crops much more quickly than the first crop, because the amount of starting material is greater for subsequent crops. Individual substrates can remain productive indefinitely. Some rocks continue to produce plants for many years. This is partly from regrowth of plants from their holdfasts after they are harvested, and partly from spore recruitment from shedding plants.

If plants are to be sold as seafood, they are cleaned under a jet of seawater, removing contaminating organisms, sand, silt and dead portions of plants by hand. Cleanliness and freshness are the most important factors influencing the price a farmer can obtain for *Gracilaria*. *Gracilaria* harvested for agar production is handled differently. It is usually washed to remove sand, gross contaminants removed by hand, and then dried in bulk on the shore. The factors controlling price are gel content, gel quality, and degree of contamination.

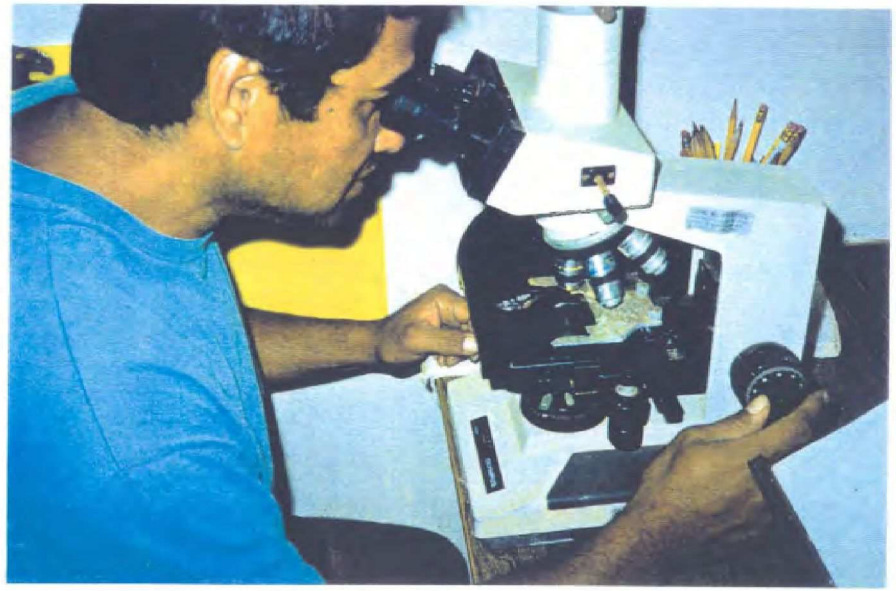
After the first year of operation the farmer will notice that not all the plants are smooth. Approximately 10% of the harvest will consist of cystocarpic plants that grew from tetraspores released by mature tetrasporophytes. These plants are culled out and used in the hatchery. Even though the percentage of cystocarpic plants may be low, there should be sufficient to maintain an active hatchery program, since each individual cystocarp can release hundreds of spores over the hatchery period of 3 days.

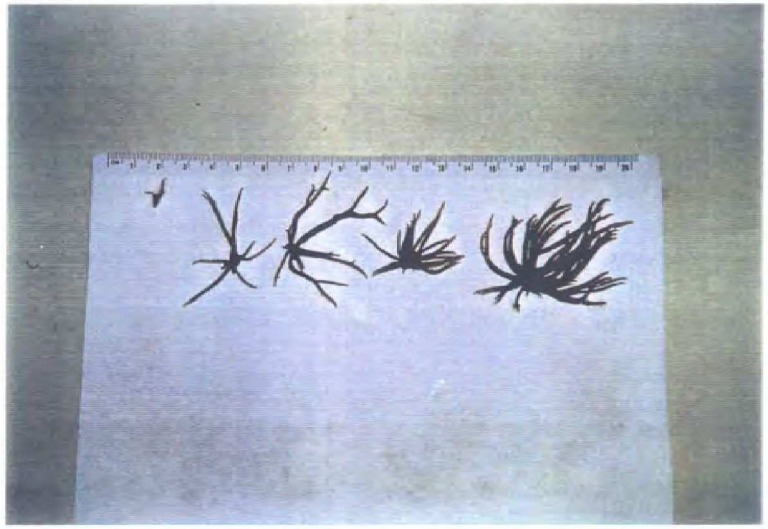


Data Collection and Record Keeping

Crop logging is an important part of running a successful farm. Each individual hatch should be documented in permanent notebooks, noting the source of cystocarpic material, the handling of the hatch if there were modifications in procedure, the number of spores recorded on test slides, and the exact location the substrates were planted out, so they can be relocated to determine the success rate from that hatch. A planting map showing where on the reef or in a pond hatches are located is helpful in keeping track of the crops. The status of each hatch should be checked every 2-4 weeks and recorded, to determine which ones are producing crops and which ones are not. Unsuccessful crop can be overplanted with new substrates. The yield of harvestable *Gracilaria* and of cystocarpic material from each hatch should be recorded at first harvest and for subsequent harvests; when yields decline, it is time to overplant the substrates with new material.

Finally, the farmer must keep track of the amount sold and the price obtained. Careful record keeping will reveal seasonal and spatial production patterns that the farmer can use to maximize yield and profits. Summer is peak production time in Hawaii, for example, but the time period from Thanksgiving to Super Bowl Sunday is when the prices are highest. A farmer may discover that a late summer crop can be left for harvest in fall and winter to maximize returns.



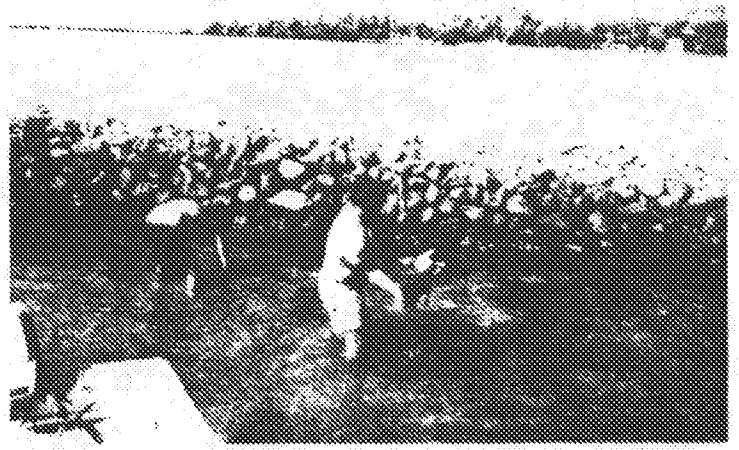


Community Involvement

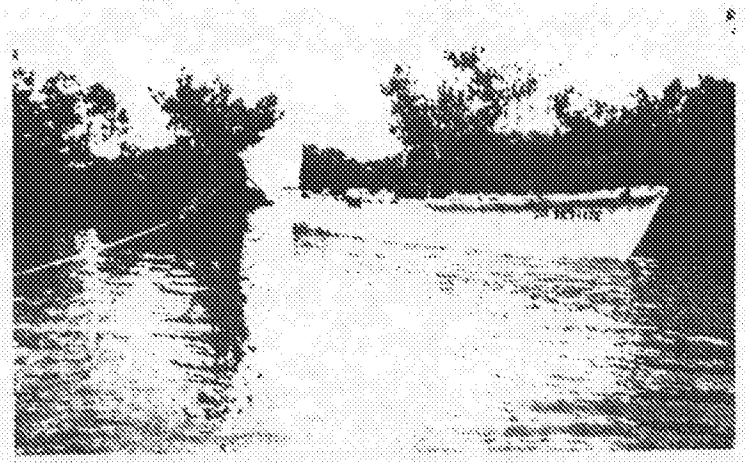
Gracilaria farming is normally a community activity. Large areas of ponds, reef flats or bays are needed to grow crops. In Chile, whole villages may be involved in growing and harvesting *Gracilaria* at favored locations. Farmers frequently pool their crops for sale to buyers. Spore culture is especially suited for this type of diffused activity, since a central hatchery can supply many farmers with spore-coated substrates. The hatchery can form the nucleus of a cooperative activity which may also involve extension services, assistance in acquiring leases to ponds or other growout areas, pooling crops for sale and other supports.

On Molokai, spore culture of long ogo is being developed as a minibusiness for the coastal residents, many of whom are native Hawaiians. The motivation was to find an economic use for the traditional Hawaiian fishponds on the island's south reef, which enclose several hundred hectares of water. A nascent network of ogo growers is developing around the central hatchery, which also provides cleaning facilities, cold storage, shipping and preparation of value-added ogo products, such as "Limu Salsa", which multiplies the returns from each pound of ogo.

Spore culture is a sustainable form of *Gracilaria* culture, which is needed to replace the current harvest practices which are depleting the natural beds faster than they can replenish. It can play a role in fostering community cohesion and economic resilience in rural coastal regions that are challenged to develop cash economies without destroying the resources that make these areas valuable.



Planting spores in Hawaiian fishponds



Appendix 7. Contract: #8990020. Molokai Multi-Purpose Hatchery Project

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990020

Moloka'i Community Development Corporation

(FULL NAME OF: Firm, Association, Performing Group, or Individual)

P.O. Box 1509, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s)	(State Scope in Detail)	
see attachments		

Date(s)	Time(s)	Place(s)
August 1, 1994- December 31,1995		

The remuneration for the service(s) agreed to herein at the rate of $ 33,171 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

Substitution of any date(s) and/or place(s) of service(s) herein provided, may be made if mutually acceptable and agreed to between the Corporation and the Contractor; such change(s), if any, shall not affect the validity of this agreement.

2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

Cancellation by the Contractor of the service(s) to be provided herein, or any one or more of a series, shall render this Contract void, and a new Contract may be prepared by the Corporation to cover the service(s) to be given, if any.

The Corporation reserves the right to cancel this agreement at any time after commencement of services if the Contractor neglects to perform as specified.

The balance of any remuneration and other allowances, if any, due shall be paid upon completion of the service(s) herein provided upon submission of invoices in triplicate, or upon certification by the director of the program or the activity that the service(s) have been completed. The total remuneration paid, and the other reasonable incidental expenses, if any, shall be considered full compensation for basic services rendered, including overhead, profit and taxes.

ETHICS DECLARATION

I declare that I am not a Legislator, elected or appointed officer, or that this firm is not owned or controlled by any Legislator, elected or appointed officer, compensated or uncompensated, member of a State board or commission, or other employee of the State of Hawaii.

I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

The Contractor understands that, if he/she is engaging in business or performing services within the State of Hawaii, the remuneration includes an amount to cover 4% State General Excise Tax and license fee (Chapter 237, H.R.S. 1969, as amended), and he agrees to pay the required assessments to the State Department of Taxation, 425 Queen Street, Honolulu.

Any product resulting from work under this contract shall be the sole property of the Research Corporation of the University of Hawaii, and shall be at its discretion, disposed of in accordance with Research Corporation of the University of Hawaii/University of Hawaii/Federal Copyright Patent Policies.

The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 41

Attachment I

This consulting agreement is to cover the objectives of the proposal entitled " Moloka'i Multi-Purpose Hatchery Project" submitted by Palaau Prawn and Shrimp Company. A copy of the proposed work is attached detailing specific goals and objectives to be accomplished.

The contractor agrees to provide up to 30% of the finfish fingerlings and prawn post larvae produced for other interested growers on Moloka'i. Distribution of requested finfish fingerlings and post larvae will be coordinated through the Moloka'i Aquaculture Advisory Alliance in conjunction with the Sea Grant aquaculture extension agent on Moloka'i.

The project will receive $ 33,171. There will be $ 22,000 advanced to the consultant. Following the receipt and acceptance of a six month progress report an additional 10,171 will be made available to the consultant. The final payment of $1,000 will be made after the receipt and acceptance of a final report.

APPLICATION

FOR

MOLOKAI MULTIPURPOSE HATCHERY PROJECT
(Project Title)

FISCAL YEAR 1993/94

Date of Application: August, 1993

GRANTING AGENCY

Maui County
Office of Economic Development (MCOED)
200 South High Street
Wailuku, Maui, Hawaii 96793
(808) 243-7710

I. APPLICANT

NAME: PALAAU PRAWN AND SHRIMP CO.

ADDRESS: P.O. Box 978

Kaunakakai, HI 96748

PHONE: (808) 567-9064

PROJECT DIRECTOR: Rebecca Bishop-Yuen

PHONE: (808) 567-9064 FAX 567-9064

II. Has the Applicant applied for any other funds from the County of Maui for this fiscal year? Yes __ No X

III. FOR MCOED USE ONLY

DATE RECEIVED: _____

CONTRACT NUMBER: _____

CERTIFICATION

The Applicant certifies that the data in this application are true and correc and that the Applicant shall comply with the assurances set forth in this application

Name, title and address of official(s) authorized to sign for applican organization:

APPLICANT: Palaau Prawn and Shrimp Co.

PROJECT TITLE: Molokai Multipurpose Hatchery

NAME OF AUTHORIZED REPRESENTATIVE: Rebecca Bishop-Yuen

TITLE: Sr. Biologist

Rebecca Bishop-Yuen
(Signature of Authorized Representative)

August, 1993
(Date)

MOLOKAI MULTIPURPOSE HATCHERY PROJECT

PROJECT SUMMARY: Palaau Prawn and Shrimp Company proposes to build and operate a small Multipurpose hatchery. The objective of the project is to: produce fish and prawn seedstock to support the associated commercial farm that is being built, to assist other community members with brackish and freshwater culture facilities and generally promote aquaculture on the Island.

At present there are no genetically pure Red Tilapia or Macrobrachium rosenbergii on the Island of Molokai. Virtually all of the fresh and brackish water culturists on the Island (both those with facilities and those who are planning to begin operations) have expressed a desire to culture some Tilapia and Macrobrachium should the seedstock be available. The primary beneficiary would be the Palaau Prawn and Shrimp Company which is in the beginning phase of it's existence. There are 20 (possibly 30) acres of Tilapia and Macrobrachium production capacity planned. The goal is to have the hatchery producing Fry and Post Larvae so that ponds can be stocked immediately upon completion. The primary considerations to building the hatchery now at Palaau, Molokai are to avoid the inconvenience and expense of buying and shipping seed stock from Oahu or Maui, and to have an immediate supply of high quality animals to work with. The cost from outside will be about $ 0.15 to $0.18 each for high quality Tilapia fry and $24/ 1,000 for Marcrobrachium PL's. Survival also tends to be lower when animals must be boxed and sent by air.

The project will entail buying and installing tanks, pipes, drains, operations equipment, digging a small bore salt water well, procuring brooodstock and operating the hatchery. The fry and PL's produced will be used primarily to stock the Palaau Prawn & Shrimp production facility. All surplus produced within the scope of the grant can be distributed to other facilities for experimental purposes, free of charge.

As the title indicates this hatchery is designed as a multi purpose facility. Although the primary function for year one is the production of Tilapia with Macrobrachium rosenbergii to be cultured in the effluent water: we see future production To include the Hawaiian Black Lipped Oyster, Panaeid spp., and possibly other marine and fresh water species.

AGENCY DESCRIPTION: Palaau Prawn and Shrimp Company is a sole proprietorship owned by Mark Yuen (See Appendix A: resumes) Rebecca Bishop-Yuen will be the only paid hatchery staff member. Although there is no legal relationship our associates include:

Dr. Jim Brock
State Aquaculture Veterinarian
Anuenue Fisheries Research Center
Area 4, Sand Island
Honolulu, HI 96813

Mr. Michael Fujimoto
Director, Anuenue Fisheries Research Center
Area 4, Sand Island
Honolulu, HI 96813

Dr. Dale Sarver
President
Black Pearls Inc.
P.O. Box 525
Holualoa, HI 96725

These associates will function as an advisory board, providing technical advice and support. All have visited the site, reviewed the site data and endorsed the total project.

THE SITE: (See appendix B, location map) is in the Palaau section of Molokai. The land is owned by the Molokai Ranch and under lease to the Yuens, Palaau Prawn and Shrimp Company. The climatic conditions are close to ideal. The site is on the leeward side of the Island, it is generally sunny, 1.4" average annual precipitation so an open old fashioned green water hatchery is practical. The land is well exposed and receives wind from all directions. It is quite flat; with a slope of 3': 2,600'. Construction of ponds poses no problems technically. The soil type is mala silty clay with field stone. (After many years of ag use the stones have been removed and piled up around the perimeter. Bed rock is reached at 5-6'. Water for the ponds and fresh water for the hatchery will be pumped from the Hoolehua Well So. (Molokai Ranch Well #1 on some maps) The well has been used for many years by Hawaiian Research and has a sustainable yield of at least 1100gpm. (PP&S has a water use permit for 865,000gpd), the temperature is 25 to 28 degrees C, salinity 0.9 to 1.1 ppt., is chemically balanced in all other parameters and it has a functional 75 HP pump and electrical panel. To promote more rapid growth, higher reproductive levels and reduce disease parameters for the Tilapia they will be managed at 15ppt salinity so a small bore salt water well is required.

At the beginning of the lease negotiations with the Ranch an eight week bio toxicity/bio accumulation study was done. Post larval Macrobrachium rosenbergii from AFRC were exposed to site well water and soil from 3 different

locations. The results were favorable in terms of growth and survival and bio accumulation of heavy metals. The bioassay was performed by the Yuens using an extended EPA protocol and the tissues analyzed by Aecos Inc, Kailua, HI. No experimental work was done with the Tilapia as a breeding population exists in the (pit) well.

PROBLEM/NEED, TARGET GROUP AND COMMUNITY RESOURCES:

The economic need satisfied by this proposed project can most succinctly be described as "time is money". If this grant is awarded Tilapia and Macrobrachium culture can begin almost immediately. The 10 acre production increment that is under construction at this time can be stocked from the Molokai Hatchery which is intended to operate year around at slightly lower cost than the State or commercial hatcheries. Although Palaau Prawn and Shrimp and the other Molokai farmers can purchase seedstock from outside, their costs will be less and their management strategy more flexible if working with an on Island hatchery. Tilapia fry are available from several sources but are quite dear. Macrobrachium rosenbergii are available from the State Macrobrachium Hatchery which operates only during the summer months, and the commercial hatchery has not yet begun operations.

If this proposal is not funded PP&S will purchase seedstock at full market value from outside for it's initial stocking. The following year, after the initiation of cash flow, it will be able to build and operate a hatchery independently. It could then stock itself as well as sell to other farmers. Although there is a Tilapia farm on Maui it would facilitate other Maui County farmers getting into the aquaculture business if seedstock were available locally.

GOALS AND OBJECTIVES:

The specific goals of this project are threefold:

Phase one: Build a small (50MT, 10,000 fry/mo., Tilapia: 24MT, 600,000PL's/6 week cycle, Macrobrachium) hatchery. The design is finalized (except for an electrical plan which must be engineer certified and approved by the Co.), the materials and supplies list is complete and ready to order. It should take six to eight weeks from receipt of the funds to complete the construction phase. The measure of accomplishment for this phase is simple; are there tanks with water in them?

Phase two: Purchase Tilapia broodstock and berried female Macrobrachium from MRTC or Kahuku Prawn Co,hatch the larvae and begin hatchery operations. The criteria used for judging

this phase of the operation are: Number of fry produced, tank survival, apparent health and costs.

Phase Three: Stock the PL's in ponds. Using standard practices of good animal care they will be cultured and monitored for growth and survival. The ultimate evaluation of a project such as this is long term economic viability for the farm as a whole.

Should this project be funded the growers who will profit are those who have facilities that are operational or will be in the near future. They include; Joe Santos, Zellie Duevachelle, Joe Kennedy, Scott Adams, Molokai High School and Palaau Prawn and Shrimp Co.

TIME TABLE FOR COMPLETION OF TASKS
MOLOKAI MULTIPURPOSE HATCHERY

PHASE 1

Project/task	Week 1	2	3	4	5	6	7	8
Salt water well: Mobilize, bore	X		X--					
Order Tanks receive & install	X			X----				
Order Pipes Receive & install	X		X----------					
Order Equipment Receive and Install	X			X			X-------	
Purchase operations equipment.	X				X			X
Buy materials, assemble shack, build center drain	X----------							

PHASE TWO

Project/task	Month 2	3	4	5	6	7	8	9	10	11	12
Purchase Tilapia Broodstock		X									
Spawn & grow Tilapia			X----------								
Purchase Mac females	X				X			X			
Hatch		X-			X-			X-			

Project/task	Month 2	3	4	5	6	7	8	9	10	11	12
Culture Mac Larvae	X------			X------				X------			
Stock Ponds				X----------			X	---------		X	-----

PHASE THREE

Project/task	Month 2	3	4	5	6	7	8	9	10	12
Culture Tilapia			X----------							
Harvest Tilapia							X----------			
Culture Prawns				X----------						
Harvest Prawns									X---------	

The economic impact of establishing a Tilapia/Macrobrachium rosenbergii reproduction facility on Molokai is in itself not as significant as providing the opportunity for commercial production. Although there is some fluctuation in the Tilapia market because of a number of producers, they are relatively easy to produce in a high density situation. Of course they can always be sold, and usually quite profitably because of reasonable production costs. Macrobrachium has remained absolutely stable in the marketplace since the first pond began sales in 1969. The retail price has risen reflecting inflation. The wholesale price now stands between $8.50 and $13.00/pound whole fresh shrimp. The higher value represents live animals; which because of the logistics of transportation is not practical for the bulk of Molokai production. As discovered in the market survey done for the PP&S commercial production business plan, the hotels and retailers on Maui and Lanai are extremely enthusiastic about the possibility of regular shipments of fresh locally grown fish and prawns. It is not possible at this time to project how many acres of production the Maui Co. markets can absorb. It is however estimated that the Oahu markets could absorb another 60 acres of production.

EVALUATION: This is a very simple straightforward project. Phases 1 and 2 are simple complete or incomplete, seed production or no seed production, within budget or over budget?

Phase 3 (data), the growout of Tilapia and Macrobrachium should be compared and contrasted to data collected from other farms within the State. The final criterion whereby the success or failure of this effort is

judged is in the marketplace. Is seedstock produced at a cost equal to or less than other hatcheries? Is it cost effective for PP&S and the client farmers to procure seed from the Molokai hatchery? Can farmers profitably operate commercial production units on the Island of Molokai?

Our research indicates that aquaculture generally has the potential to become a very sound asset in helping to diversify Molokai' economic structure.

STAFFING REQUIREMENTS: Due to the fact that this project costs more than is allowable from County funds it has been decided to remove all labor costs from this budget and finanace them from the Palaau Prawn and Shrimp Co. OHA loan.

Administrative tasks will be performed by the grantee at no charge, and labor provided at no charge by the farm owner Mark Yuen.

BUDGET:

Increment 1

All of the supplies and equipment required to build the hatchery are considered start up costs. The funds are needed almost immediately as many suppliers require full or partial payment prior to assembling shipments. All of the items except materials for the shack must be purchased off Island. Some items, such as the submersible salt water pump must be obtained from the mainland.

Electrical	$ 3,000
Salt Water Well, 6"X100'	6,000
1 HP transfer pump	450
2 HP 316SS well pump	2,200
Blower	860
Pipes and fittings	1,600
Drainage canal	310
Reservoir tanks (3) 15' diameter	4,620
Larval rearing tanks (3) 2MX4M	5,286
Spawning tanks (3) 6' diameter	1,650
Shade cloth & supports	448
Tank Covers	300
Shack & slab for artemia	725
TOTAL INCREMENT 1	27,449

Increment 2a

Although the following equipment and supplies are all operations related they need extended lead time as they are to be shipped from the mainland. Funds for these items would be considered start up and be required at the very beginning.

Microscope	1,400
pH meter	500

Nytex	57
Heaters (2) 2KW	350
Increment 2a	2,307

Increment 2b
These items are to be purchased locally and the funds for their procurement should be available week 6.

Freezer	400
Refrigerator (used)	250
Filter	106
Misc, nets, buckets, air stones etc.	150
Increment 2b	906

TOTAL INCREMENT 2 3,213

The total expenditure for the development of the physical plant is $30,662. The expected lifetime of the hatchery with proper maintenance is about 10 years for the mechanical portions, and 15 or more for the tanks. The hatchery could produce up to 120,00 Tilapia fry and 5.2 million Mac. PL's/year if operated at maximum capacity. That is enough to stock 30 to 75 acres per year depending upon stocking density and management strategies. It should be sufficient for Molokai' needs for some time.

INCREMENT 3, is the operations portions of this budget. It varies from month to month because of different activities so will be presented on a monthly basis.

	Month											
Item	1	2	3	4	5	6	7	8	9	10	11	12
Fish Broodstock	250											
Mac Females			70			70			70			70
Fish Food			75	75	75	100	100	100	100	100	100	100
Fish			150	150		150	150		150	150		150
Artemia	170				170			170			170	

MONTHLY TOTALS for requested operating funds

1	2	3	4	5	6	7	8	9	10	11	12
170	0	545	225	245	320	250	270	320	250	270	320

Excess operating expenses that will be financed from PP & S working capital for a total of $15,275.

Item	1	2	3	4	5	6	7	8	9	10	11	12
Electricity			295	150	75	295	150	75	295	150	75	295
misc.	75	75	75	75	75	75	75	75	75	75	75	75
Labor	1960	960	960	960	960	960	960	960	960	960	960	960
	2035	1035	1330	1185	1110	1330	1185	1110	1330	1185	1110	1330

Total requested operations budget for a 12 month period $ 3,185

Total financing required for this project: $ 49,122

Due to the fact that only a portion of this sum is potentially available from County funds I have broken these costs down to those specifically attributable to the production of Tilapia (finfish budget) and those specifically attributable to the production of Macrobrachium (shrimp reproduction budget). The surplus, most easily removed from the operations budget will be financed through the general Palaau Prawn and Shrimp working capital loans.

The list of things required specifically for Macrobrachium culture is quite short, therefore it will be itemized.

Spawning tanks	$ 1,650
Transfer pump	450
Freezer	400
Heaters	350
Filter	106
Microscope	1,400
Fish	1,050
Artemia	340
Berried Females	280
TOTAL MACROBRACHIUM	**$ 6,026**

All other expenses are directly related to the culture of Tilapia.

TOTAL TILAPIA $27,821

TOTAL REQUESTED FROM THE COUNTY FOR THIS BUDGET $33,847

Financial Statements: N/A New Company

Future Economic Self Sufficiency: This project will become self sufficient within 12 months of initiation. It will

continue to support the PP&S production facility for it's lifetime.

Multi Year Funding: N/A

Past performance: N/A as this is a new company. The only way to predict the future performance of this venture is to judge the previous performance of the individuals involved while engaged in similar activities under other circumstances.

CURRICULUM VITAE

REBECCA BISHOP-YUEN
P.O. BOX 978
Kaunakakai, HI 96748
Phone; (808)567-6031
262-5353

EDUCATION;

Chico Sr. High		1963
College of the Siskiyous	AA Biology	1965
Cal State University	BA Biolgy	1969
Cal State University		1972

CAREER RELATED EXPERIENCE;

6/90 - 12/91 **Pacific Sea Farm; Kahuku, HI.**
Reproduction manager; Maturation, larval rearing, algal culture and all related tasks were my responsibility. Spp. Penaeus vannamei & stylirostris. PL production five million/mo.

11/89 - 6/90, full time **Aecos; Kailua, HI.**
6/90 - present, part time
Title "Utility Person". Lab work (chemical and biological), field studies, taxonomy and all of the bio-toxicity work. Book keeping, billing, typing, reports and other administrative type tasks. Part time, continued resonsibility for bio-toxicity tests when possible and special field assignments.

10/88 - 10/89 **Kahuku Shrimp Co.; Kahuku, HI.**
Hatchery Manager; Redesign and renovate a small hatchery for P. vannamei. (1.5 million PL's/mo.) Also worked in the high density culture of same.

4/88 - 10/88 **Dept. of Commerce, Government of Guam, Tamuning, Guam**
Aquaculture Consultant; Redesign and renovate existing facility for the culture of Macrobrachium rosenbergii. Initiate hatchery culture of prawns and the training of technicians.

9/85 - 9/87 **Laboratorio Champmar, Manta, Ecuador**
Hatchery Manager; Select site, secure permits, design, build and operate a hatchery and maturation facility for the production of P. vannamei PL's. Production, 8.5 million/mo.

4/83 - 9/85 Full time mother and housewife, part time aquaculture consultant. **Orca Sea Farm,** Palaau, HI. Program development and maturation and hatchery design. Asia Resources Ltd. Columbo, Sri Lanka; Site selection and

program planning. Review data for initial selection of India farm sites also.

3/80 - 3/83 — Central Enterprises Ltd, Hong Kong, (Guam Aqua Research)

For the first year, (prior to hiring an administrative manager) title; "General Manager". Responsible for all administration, finances, construction and biology; which at that time was limited to testing the performance of Penaeus monodon in a clean supersaturated oxygen environment. Thereafter responsibilities included supervising the growout experiments, analyzing the data and writing reports, running the hatchery and assisting the other Sr. Biologist in shrimp maturation. Specific goals were growth, survival and disease profiles, nutrtition and water quality management in various species of fish (spp. Tilapia, Lates calcarifer,) and Shrimp (spp. Penaeus monodon, merguiensis, indicus, orientalis, vannamei, & Metapenaeus ensis) in high biomass situations, and looking at maturation and hatchery reliability in the same species of shrimp.

3/76 - 1\80 — Anuenue Fisheries Research Center, Honolulu, HI

Fisheries Technician; Duties included field extension, service aquaculture research and manager of the Macro-brachium rosenbergii hatchery. (4 million PL's/mo.)

1978 & 1979 — CONSULTANT; Trafalgar Housing Ltd. Universidad Federal de Pernambuco, Brazil Red Lobster Inns, San Pedro Sula, Honduras

Site surverys and selection, facility design, program development, troubleshooting existing hatcheries and fact finding missions. Locations; China, Malaysia, Brunei, Taiwan, Singapore, Thailand, Hong Kong, Brazil and Honduras.

12/73 - 2/76 — Brelje & Race Laboratory, Santa Rosa, Calif.

Head Technician, Duties included supervising technicians and conducting chemical, bacteriological and microscopic analyses of waters and wastewaters.

7/72 - 8/73 — University of Calif., Davis, UC Bodega Marine Lab.

Laboratory Assistant,; Larval culture of Homerus americanus, maintenance of the system (semi-open), animal management and basic aquaculture research.

Summary of Employment 1965 to 1972;

Research Technician:	University of Calif. San Diego Sonoma State Hospital, Eldridge, CA
Laboratory Assistant: Lab. and T.A.	Windsor Vineyards, Healdsburg, CA Calif. State University, Chico

CURRICULUM VITAE

MARK YUEN
P.O. BOX 978
Kaunakakai, HI 96748

EDUCATION

High School: Kailua High School, 1968

College: 1972-1980, Six full and part time semesters. Courses is vocational carpentry, then general education and biology from Maui Community College, Windward Community College, Santa Rosa Jr. College and The University of Guam.

Military Service: 1968-1972. U.S. Navy. Trained in aircraft maintenance, hydrolics and radio communication. Last 18 months of duty organized and captained the Navy surf team.

CAREER RELATED EXPERIENCE

April 1991-April 1992; Fisheries Coordinator, DBED, State of Hawaii. Organized the farmers, potential farmers and community volunteers to form a CDC for the Island of Molokai. Wrote proposals to secure financing for Aquaculture development projects. I am presently preparing an Aquaculture development strategy for the Island of Molokai.

May 1990 - April 1991: Production Manager, Pacific Sea Farms, Kahuku, HI. Responsible for all aspects of commercial shrimp production. Duties included supervision of farm workers, management strategy, interactions with administration and reproduction departments, data management and sales.

Species utilized: Peneaus vannamei.

November 1988 - May 1990: Shrimp Farm Manager (November 1988 - November 1989) Prawn Farm Manager (December 1989 - May 1990), Kahuku Prawn Company, Kahuku, HI. Responsible for construction and renovation of facilities and management of high intensity shrimp grow-out. Duties included supervision of farm workers, field work and marketing.

Species utilized: Peneaus vannamei, & Macrobrachium rosenbergii.

April 1988 - October 1988: Consultant for Department of Commerce, Government of Guam, Tamuning, Guam. Six month contract to redesign, renovate and repair the Guam Aqua Research facility.

December - 1987 - April 1988: Special Hire Fisheries Technician, Anuenue Fisheries Research Center, Honolulu, HI. Duties included construction and installation of artificial reefs.

January 1985 - July 1987: Consultant for various shrimp farms in Ecuador, South America. Advised farmers on management strategies and procedures. Also distributed aquaculture chemicals for Laboratorio H & H.

January 1, 1984 - December 31, 1984: Pond Manager, ORCA Sea Farms, Palaau, HI. Responsible for all pond operations. Duties included pond preparation, stocking, transfers, harvests and samples, supervision of workers and plans.

Species utilized: **Peneaus vannmei,**

March 1904: Consultant for Marine Resources Asia Ltd., Colombo, Sri Lanka. Collaborated with a partner on a feasibility study, site selection and technical prospectus for a shrimp farm.

July 1980 - May 1983: Operations Manager, Guam Aqua Research Inc., Fadian Pt., Guam. Responsible for all equipment repairs, maintenance, raceways management, modification and adaptation of facilities to fullfill specific experimental requirements, supervision of all raceway personnel and feed preperation.

Species utilized: Lates calcarifer Tilapia spp., Peneaus orientalis, P. vannamei, P. Merguiensis, P. semisulcatus, P. monodon, and Metapeneaus ensis.

February 1977 - February 1980: Field Extension Agent, Anuenue Fisheries Research Center, Honolulu, HI. Responsible for propogation in hatchery and grow-out systems. Duties included culture of animals, conducting experiments and advising the public on site selection, farm design, pond management theory and marketing distribution and quality control.

Species utilized: Macrobrachium rosenbergii, Tilapia spp Algal spp., catfish and **Peneaus spp.**

September 1972 - September 1973: Apprentice Carpenter, Maui Community College Apprentice Program, Kahului, HI.

Program/Activity: **Maui County Aquaculture**

8/11/94
Date

By _____
Program Coordinator

Research Corporation of the University of Hawaii

9/14/94
Date

By _____

ACCEPTED:

_____
Executive Director (MCDC)

Aug 2, 1994
Date

_____
Contractor

29 July 94
Date

Is Consultant a U.S. citizen?
Yes ✓ No _____

If U.S. citizen, provide Social Security No. 573 62-8241

Type of Entity

Corporation	✓	Non-Profit	✓
Partnership	_____	Government	_____
Trust	_____	Estate	_____
Individual	_____	Sole Proprietorship	_____

Tax Payer Identification Number: 99-0293966

Distribution of Executed Copies
1. Original & Invoices - Research Corporation
2. Copy - Program/Activity
3. Copy - Contractor

Appendix 8. Contract: #8990021. Molokai Finfish Hatchery Seed Production Project

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990021

Moloka'i Community Development Corporation

(FULL NAME OF: Firm, Association, Performing Group, or Individual)

P.O. Box 1509, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s)	(State Scope in Detail)	
see attachments		

Date(s)	Time(s)	Place(s)
August 1, 1994- December 31,1995		

The remuneration for the service(s) agreed to herein at the rate of $ 14,000 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

Substitution of any date(s) and/or place(s) of service(s) herein provided, may be made if mutually acceptable and agreed to between the Corporation and the Contractor; such change(s), if any, shall not affect the validity of this agreement.

2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

Cancellation by the Contractor of the service(s) to be provided herein, or any one or more of a series, shall render this Contract void, and a new Contract may be prepared by the Corporation to cover the service(s) to be given, if any.

The Corporation reserves the right to cancel this agreement at any time after commencement of services if the Contractor neglects to perform as specified.

The balance of any remuneration and other allowances, if any, due shall be paid upon completion of the service(s) herein provided upon submission of invoices in triplicate, or upon certification by the director of the program or the activity that the service(s) have been completed. The total remuneration paid, and the other reasonable incidental expenses, if any, shall be considered full compensation for basic services rendered, including overhead, profit and taxes.

ETHICS DECLARATION

I declare that I am not a Legislator, elected or appointed officer, or that this firm is not owned or controlled by any Legislator, elected or appointed officer, compensated or uncompensated, member of a State board or commission, or other employee of the State of Hawaii.

I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

The Contractor understands that, if he/she is engaging in business or performing services within the State of Hawaii, the remuneration includes an amount to cover 4% State General Excise Tax and license fee (Chapter 237, H.R.S. 1969, as amended), and he agrees to pay the required assessments to the State Department of Taxation, 425 Queen Street, Honolulu.

Any product resulting from work under this contract shall be the sole property of the Research Corporation of the University of Hawaii, and shall be at its discretion, disposed of in accordance with Research Corporation of the University of Hawaii/University of Hawaii/Federal Copyright Patent Policies.

The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 41

Attachment I

This consulting agreement is to cover the objectives of the proposal entitled " Moloka'i Finfish Hatchery Seed Production Project" submitted by Moloka'i Sea Farms. A copy of the proposed work is attached detailing specific goals and objectives to be accomplished.

The project will receive $ 14,000. The monies will be distributed as reimbursements after receipts have been approved. As agreed with other funding agencies, the Department of Business & Economic Development (DBED) will provide an additional $ 8000 after 25,000 catfish fry (> one inch) have been distributed to other interested growers on Moloka'i. Distribution of requested catfish fry will occur with six months of funds becoming available and will be coordinated through the Moloka'i Aquaculture Advisory Alliance, Office of Hawaiian Affairs (OHA), and in conjunction with the Sea Grant aquaculture extension agent on Moloka'i. All moi fingerlings and fry produced during the duration of this contract will be made available to other interested growers on Moloka'i. Distribution of requested moi fingerlings and fry will be coordinated through the Moloka'i Aquaculture Advisory Alliance and in conjunction with the Sea Grant aquaculture agent on Moloka'i.

A final payment of $1,000 will be made after the receipt and acceptance of a final report.

MOLOKA'I FINFISH HATCHERY TECHNOLOGY TRANSFER PROJECT 1992/93

I. Project Summary

For aquaculture to be successful in Hawaii, we must produce products that compete favorably in our global economy, or produce products that are not imported and serve our local market. For at least the past decade the majority of marine finfish research and development in Hawaii has concentrated on milkfish (*Chanos chanos*) and striped mullet (*M. cephalus*). These have not been good aquaculture products because of their low market value and import competition.

For aquaculture to progress, we must aggressively pursue the development of alternative high value species. Moi (*Polydactilus sexfilis*) is an indigenous species and is especially well suited because of its reproductive and growth characteristics, high market value and the fact that it is not imported.

The Hawaii Institute of Marine Biology (HIMB) began investigating moi as a potential aquaculture species in the early '70's. Subsequent research has found that spawning occurs among captive fish on a predictable lunar rhythm so the elaborate procedures required to induce spawning in some species are unnecessary. This lunar spawning rhythm makes the time of spawning predictable, and the prolonged natural spawning season assures an ample supply of eggs for commercialization. Moi is a protandrous hermaphrodite; which is advantageous in that cultured fish will be harvested as males before significant amounts of energy have been utilized for egg production.

The rapid growth rates and efficient food conversion which have so far been documented for captive fish are very encouraging, especially when one considers that the specific nutritional requirements for *P. sexfilis* are still unknown. Researchers have found that moi have a wide range of tolerance to different salinities which permits culturing in a wide range of settings. The fishes acceptance of artificial dry feed means that dietary composition can be manipulated with the goal of producing a cost effective diet which can be compounded locally. Growout trials have been conducted in tanks, earthen ponds, ancient Hawaiian fishponds and cages at Hawaii Institute of Marine Biology (HIMB), The Oceanic Institute (OI) and 'Ualapue Fishpond on Moloka'i. Growth has been very encouraging with marketable fish being achieved in less than one year.

Recent work, at HIMB as well as the literature indicates that moi is an attractive candidate for production if the larval rearing techniques can be successfully transferred to a commercial facility. Molokai Sea Farms, one of the largest aquaculture facilities in the state, is especially well suited to conduct this technology transfer project because of our commercial orientation and cost effective approach towards research and development.

Equally important, though, is our ability to keep our growout production costs at a minimum. On our island of Moloka'i we have over sixty ancient Hawaiian fishponds which average about twenty acres in size. Our competitive advantage lies in the fact that these ponds are the only allowable use of the ocean for commercial aquaculture production in Hawaii. By eliminating land costs, pond construction, well installations, pumps and plumbing infrastructure, electrical, aeration equipment, utility bills and the like we can compete very favorably. These ancient Hawaiian fishponds receive water exchange at each change of the tide. Five of these ponds are targeted for restoration, and one is already in production. The Governor has assembled a Task Force specifically to facilitate the restoration of the ponds. By combining the ability to produce high value species with low cost production systems we can compete favorably in Hawaii's lucrative fresh seafood market.

The target species, mai (*P. sexfilis*), was very popular in Hawaii until natural stocks became depleted by the early '70s. Today this fish is in high demand with retail prices of occasional catches exceeding $10/lb whole fish. The necessary technology will be transferred to Molokai Sea Farms by project consultants, Dr. Chris Brown and Jose Nunez of HIMB (see consulting agreement). Molokai Sea Farms will provide existing hatchery facilities and be in charge of implementation of the project. Molokai Community Development Corporation will administer the project. Maui County Department of Economic Development will provide operational funds with additional infrastructure provided by DBED&T CBED. All aquafarmers in Maui County will benefit by being provided with economically viable seed on a rotational basis. Hatchery production is expected to be sufficient to provide for current seedstock needs.

II. Agency Description

Molokai Community Development Corporation

Molokai Community Development Corporation will be the administrator of this project and is a non-profit community based organization established to promote and facilitate economic development of aquaculture on Moloka'i. Emphasis will be to utilize our existing resources which include: fifty-eight ancient Hawaiian fishponds, thirty-five modern earthen ponds, 14,000 acres of reef flat, fresh water lake, 4,000 square ft. hatchery and a labor force knowledgeable in local fisheries. Specific objectives are:

- The restoration and operation of Moloka'i's ancient Hawaiian fishponds
  - to revitalize their cultural and historical significance
  - to maintain and preserve these ponds for the enjoyment and benefit of future generations
  - to coordinate restoration efforts to achieve a meaningful, cultural, historical, recreational, scenic and economically viable complex

- To administer research projects and to demonstrate economic potential of various indigenous species. Explore utilization of our 14,000 acres of reef flat, wetland taro patches and freshwater lake.

- To supply aquafarmers with a reliable source of seed, and to concentrate on species that will achieve profitability in the shortest period of time.

- To conduct local aquaculture workshops and training programs.

Molokai Sea Farms

Molokai Sea Farms, is owned and operated by Steven Chaikin, and located at Pala'au on the island of Moloka'i. The site consists of 150 acres of prime aquaculture land with twenty growout ponds (18 acres), two broodstock ponds, 12-ton shrimp hatchery, spawning tanks, five water sources (3 salt, 2 fresh), a processing area, machine shop, feed storage, office and managers quarters. The majority of the farm is being operated as an intensive shrimp farm with all production ponds equipped with automated aeration equipment.

Steve Chaikin, project director, has successfully operated Molokai Sea Farms since 1988. He has developed the operation and is currently in production with white shrimp *P.vannamei*, Chinese catfish *C. fucus*, milkfish *C.chanos*, and seaweed *G. parvespora*. His knowledge in developing and managing hatchery systems that reduce labor inputs has been a major factor in the efficiency of the operation. He instigated and implemented the Molokai Shrimp Seed

Technology Transfer Project which successfully transferred The Oceanic Institute's larval rearing technology to Molokai Sea Farm's hatchery staff. He co- founded the Molokai Aquafarmer's Community Development Corporation and is urrently the vice president of the Hawaii Aquaculture Association (HAA).

Greta Martinez, hatchery manager, has for the past five years served as the hatchery manager for the USDA Marine Shrimp Consortium Research Facility at The Oceanic Institute in Hawaii. She was instrumental in establishing the larval rearing facility and development of The Oceanic Institute's protocol for larval rearing of *Peneaus vannamei*. She has agreed to resign her post and work with Molokai Sea Farms developing new candidate species for commercial production. Her hatchery skills are among the finest in the state and has achieved overall larval rearing survival of approximately 70%. Published papers include: Effects of Paprika Supplementation In Broodstock Diet On Shrimp Peneaus vannamei Larval Performance, Greta Martinez, James Sweeney, James Wyban, The Oceanic Institute, Makapu'u Point, Waimanalo, Hawaii (in press 1992) Behavioral Aspects Of The Snail Hydrobia totteni In Relation To It's Environment, University of New York, Stonybrook, 1983; The Aquaculture Aspects of Crassostrea virginica From Fertilization To Marketing, State University of New York at Stonybrook, 1982. (See curriculum vitae.)

Dr. Chris Brown and Jose Nunez, are the project consultants and currently manage the larval rearing research facility at HIMB on Coconut Island. They are currently refining the larval rearing protocol of mot and are anxious to see their research efforts transferred for commercialization. See consulting agreement and curriculum vitae.

III. Problem/Need, Target Group and Community Resources

Problems/Needs

- Need jobs that are consistent with local values and culture.
- Need jobs that do not place locals in a subservient position.
- Need the restoration of the ancient Hawaiian fishponds to achieve economic viability.
- Need to transfer technology to Moloka'i to produce high value species.
- Need to provide technical training.
- Need to establish larval rearing production systems to support commercial production.
- Need to produce and distribute economically viable seed to aquafarmers in Maui County.
- Need to build a strong foundation for successful aquaculture.
- Need to implement productive economic development projects on Moloka'i.
- Need to work together to achieve common goals.

Target Group

- Maui County Aquaculture Community
  - 'Ualapue Fishpond - Hui O Kuapa - Billy Kalipi, Jr.
  - Hono'uliwai- Ahupua'a 'O Hono'uliwai - Stanley Halama
  - Kahinu Pohaku - Stafford Caparida
  - Keawanui - Billy Kalipi, Sr.
  - 'Ipu Ka'iola - Kip Dunbar
  - Molokai Sea Farms - Steve Chaikin
  - Ohia Shrimp Farm - Ella Mae Camacho
  - Any other Maui County resident interested in raising finfish

Community Resources

- 4,000 sq. ft. hatchery
- 60 ancient Hawaiian fishponds (many restorable to economic viability)
- Ancient Hawaiian fishpond restoration projects already underway

- The Governor's Fishpond Task Force
- Two aquaculture farms in production and ready for expansion
- 14,000 acres of reef flat which can be utilized for large scale economic development
- Labor force waiting for this kind of challenge
- Maui County Department of Economic Development
- The Oceanic Institute - technical assistance
- The Hawaii Institute of Marine Biology - technical assistance
- Dr. Jim Brock, State Veterinarian, Aquaculture Development Program, DLNR
- Charles Crocker, Aquaculture Engineering Extension Agent, College of Tropical Agriculture and Human Resources.
- Rich Bailey, Aquaculture Extension, Sea Grant College, University of Hawaii
- Dean Tota, Aquaculture Marketing Specialist, Aquaculture Development Program, DLNR
- Joan Chatterton, Aquaculture Accounting Specialist, College of Tropical Agriculture and Human Resources, UH
- Bob Agres, Community Based Economic Development, DBED&T
- Linda Colburn, Community Based Economic Development, OHA
- Chris Van Bergeijk, Community Based Economic Development, OHA
- Carol Wyban, Consultant for the Governor's Moloka'i Fishpond Task Force

IV. Goals and Objectives

Goals

1. To transfer finfish larval rearing technology to Moloka'i
2. To establish an operational finfish hatchery on Moloka'i.
3. To provide economically viable seedstock to local aquafarmers.
4. To utilize Moloka'i's unique economic resources.

Technical Objectives

The specific technical objective is to develop an optimum mai (*P. sexfilis*) larval rearing protocol to support commercial production, utilizing a scientific research approach. Optimum protocol means finding and establishing the life sustaining, maximum growth/survivorship regimes necessary for culturing *P. sexfilis* in captivity. This will be achieved for the purpose of obtaining commercial quantities of mai fry to stock in earthen ponds, tanks, ancient Hawaiian fishponds and cages and subsequently to grow and market mai for the lucrative fresh seafood market in Hawaii. This will supply a demand that is currently not being met. Research will be directed towards areas that have not been sufficiently addressed in previous research. Technical questions that this effort will answer include :

- optimum larval rearing stocking densities
- optimum larval rearing feeds
- optimum feeding frequencies
- techniques for reducing cannibalism
- optimum aeration/water circulation/exchange rates
- larval rearing growth data
- susceptibility of mai larvae to disease and parasitic infection
- overall survival
- spawning in relation to lunar cycle
- egg production in earthen ponds, compared to indoor tank
- average percent viability of eggs

Community Objectives

Implementation of this project witll lay the foundation for the community to particiapte in the creation of a new industry on Moloka'i. Specific community objectives include:

- provide new and challenging jobs
- provide high quality training
- arrange for school tours of hatchery operations
- produce and distribute high quality seed to Maui County Aquafarmers
- allow the restoration of the ancient Hawiian fishponds to become economically viable
- produce a manual on the protocol for larval rearing of moi for distribution
- establish Moloka'i as the center of aquaculture development in Hawaii

Technical Workplan

Molokai Sea Farms broodstock ponds, finfish maturation tanks, finfish larval rearing facility and laboratory will be utilized. Approximately one hundred live broodstock will be captured from the wild by local fisherman and transported to the research site by oxygenated hauling tanks. This is expected to take one to four weeks. Fish will be stocked in two earthen ponds 400 sq. meters each, and in one indoor maturation tank (8,000 liters). Care will be taken to equally divide sexually mature males (20-25 cm) and functioning females (30-40 cm). Stocking will be of a male to female ratio of 2:1. The two earthen ponds will receive continuous water flow from a salt water well with 30ppt salinity and an average temperature of 26°C.

Aeration will be provided by Oxyflow bars powered by a 1hp Roots airblower. The indoor maturation tank will receive continuous 28° C sea water flowing from a temperature controlled reservoir. Circulation and aeration will be provided by air lifts. Broodstock will be fed twice daily: squid, trout chow and smelt. A total of 5lbs of feed per every 40 broodstock animals. Egg catchers with mesh of 500um in diameter will be installed in the sea water outflow in ponds and maturation tank and checked daily. One additional airlift egg catcher will be installed during the four days prior and four days after the (last quarter) of the lunar cycle. During this period egg catchers will be checked four times daily.

Nine 2-ton cyclindroconical insulated fiberglass larval rearing tanks (LRTs) will be utilized for larval rearing. Sea water will be pumped into four 20-ton reservoirs, aerated and heated to 28°C. Filtration will be provided by two sand filters and four cartridge filters down to 1 micron. Sand filters will be back flushed daily, and cartridges changed and autoclaved daily to remove biological build-up. Aeration will be provided by 1hp Roots blower through three 2-inch airstones per LRT. If necessary temperature will be manipulated using submersible heaters as well as 300 watt halogen lights installed above each LRT. Tank covers will be utilized as needed. Each LRT and supporting equipment will be color coded to avoid cross contamination between LRTs. Water exchange will take place through nitex exchange screens placed in the center drain. Pure cultures of microalgae will be maintained in test tubes in Molokai Sea Farm's refrigerated algae room. These cultures will be grown out utilizing 500 ml flasks, 20 l carboys, 250 l fiberglass cylinders and then pumped to outdoor 14' x 3' mass algae culture tanks. The microalgae will be used to maintain rotifer cultures. *Chlorella* sp. will be the species of choice because of its hardiness compared to other species that have previously been used (May R.C., 1977). *Artemia* will be hatched in four 400l cylindroconical hatching tanks. Rotifers (*Brachionus plicatilis*) will be cultured in four to six 1,000 l tanks using the "batch" culture method used at OI (Rotifer and Microalgae Culture Systems, Fulks & Main 1991)

Five larval rearing runs will be conducted. Each run will last 35 days. Nine LRTs will be used for each run. The first set of three will be used as a control. The second set of three will receive modification number one (treatment 1) and the third set of three will receive modification number two (treatment 2). The set that averages the largest number of healthy larvae at the end of the run will be used as the control for the subsequent run and new treatments will be tested. This will continue for five larval rearing runs.

The focus of this work plan will be to evaluate the new treatments and there effects on growth and survival. Specifically we will test different larval densities, enriched *artemia*, feed type and frequency and measure to reduce cannibalism.

Larval Rearing Run #1

1) Collect eggs from egg catcher and analyze quality by taking a subsample to determine the fertilization rate.

2) Stock best quality eggs in LRTs at a density of 30 eggs/ liter.

3) Provide gentle aeration. Eggs hatch in about 24 hrs.

4) Inoculate algae (Chlorella) at 100,000 cells/ml and maintain density between 100,000 and 500,000 cells/ml throughout the duration of the run with diminishing density or cutting supply towards the end.

5) Keep sea water temperature between 25° and 28° C.

6) Salinity to be maintained at 30 ppt.

7) Add Rotifers (Brachionus plicatilis) starting on day 1 at 5/ml increasing density up to 20/ml or more if needed. up to day 20.

8) Add *Artemia* twice daily starting at day 8 at a density of .1/ml maintaining it at .1/ml. More will be added if needed.

9) Starting at day 20. *Artemia* will be reduced as formulated feed, (trout chow or shrimp feed ground to approx 1mm) is introduced.

10) Sea water flow will be continuous at about 1 l/min.

11) Size of water exchange screen to be used will initially be 200 microns and increase to 700 micron by the end of the run.

12) Tanks will be siphoned and cleaned daily beginning at day 7.

13) Record larval rearing data daily: temperature, salinity, dissolved oxygen, algal density, rotifer density, *Artemia* density, population estimate.

14) Measure larvae (standard length SL) on day 10, 20 and 30.

15) Obtain other information such as deformities (opercular and scoliosis), pigmentation, changes in the pattern of pigmentation during development, cannibalistic tendencies and peaks at certain days.

The previous steps will be used for the three control tanks. The two treatments will be:
Treatment 1: second set of three tanks will be stocked at 20 larvae/1
Treatment 2: third set of three tanks will be stocked at 10 larvae/1

Larval Rearing Run #2

Best results from LR run #1 will be used as control.
Treatment 1: feed enriched Artemia (from an emulsion containing menhaden oil, *spirulina* and vitamins C

and E).
Treatment 2: same as treatment 1 but supplemented with fresh squid, ground to edible size.

Larval Rearing Run #3

Best results from LR run #2 will be used as control.
Treatment 1: feed three times daily.
Treatment 2: feed four times daily.

Larval Rearing Run #4

Best results from LR run #3 will be used as control.
Treatment 1: substantial increase of aeration and water circulation during cannibalistic periods.
Treatment 2: reduce sea water temperature by 3° C during cannibalistic periods.

Larval Rearing Run #5

Best results from LR run #4 will be used as control.
Treatment 1: use ground trout chow as sole food source starting day eight.
Treatment 2: use Hatch Fry Encapsulon I, II, III as sole food source starting day eight.

Spawning Data to be recorded for each pond and tank will include: percent egg hatch, number of eggs spawned, spawning frequencies and spawning dates.

At the completion of the project, all data will be compiled, analyzed and a final report with statistical and descriptive analysis of an optimum protocol for the larval rearing of *P. sexfilis* will be prepared for distribution.

Community Workplan

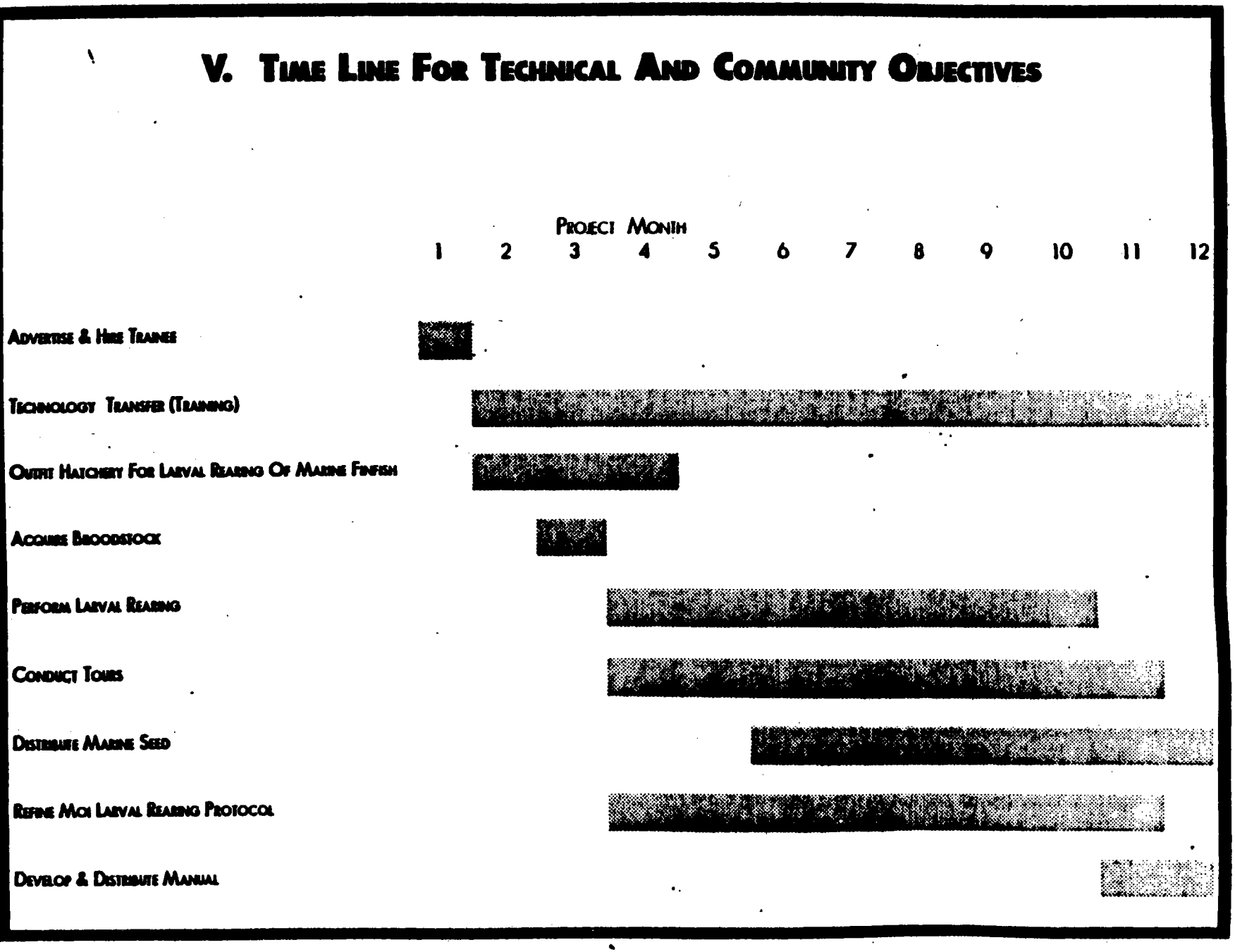
Advertisements will be place in local newspapers to hire a hatchery technician from within the community. Quality training will be provided by the project's technical consultants. Community resource personnel will be called upon to give additional technical support where necessary.

School officials of elementary, intermediate and high schools, as well as private and home schools will be invited for excursion visits while the hatchery is in operation. Students will have an opportunity to see limu, shrimp, catfish and marine finfish operations. The hatchery procedures will be toured with microscopes set up to observe algae, rotifers, artemia and larvae.

All local producers will be notified of the availability of mai fingerlings. Care will be taken to analyze each aquafaermer's needs and provide fingerlings that are the appropriate size for introduction to the site. Seed will be provided to any marine aquafarmer in Maui County at no charge and distributed on a rotational basis. Accurate records of seed distribution will be maintained. Technical assistance on mai growout procedures will be provided by project consultants to any aquafarmer upon request.

A manual on the protocol for larval rearing of mai will be produced and distributed to the Moloka'i Community Development Corporation, Department of Economic Development of Maui County, and any other aquafarmer that requests a copy.

V. Time Line For Technical And Community Objectives



VI. Evaluation

Goal 1 will be evaluated based on the productivity of the trainees. After several larval rearing runs under the direct supervision of Dr. Chris Brown, the trainees will perform the runs on their own. Their production will be compared and evaluated. Recommendations on improving their performance will be made.

Goal 2 will be evaluated on the performance and efficiency of the hatchery. Success will be determined by whether or not the hatchery is able to produce sufficient seedstock to meet farmer's demands and whether the hatchery can be successfully operated within the limits of the given budget.

Goal 3 will be evaluated on whether the aquaculture operations utilizing this seed become economically self-sustaining.

Goal 4 will be evaluated on the increase of ancient Hawaiian fishponds that are planned for restoration and operation.

VII. Staffing requirements

Two full-time positions will be necessary to carry out this project. This will allow staffing for a twelve-hour day, seven days a week.

Finfish hatchery manager will receive $8.00 per hour. Hatchery technician will receive $6.00.

The job responsibilities for the hatchery staff include: daily hatchery protocol, system management and maintenance, identifying and ordering the necessary supplies in a timely manner, record and analyze pertinent data, harvest and distribute fingerlings and interact with the research institutions to refine management skills.

VIII. Budget

Administration Fee	$7,500
Labor 2.0 - with minimum benefits	37,856
Utilities (4 kw@22¢@24 hrs.@365 days)	7,709
Supplies	6,000
Feed	4,835
Maintenance	2,500
Consultant Fees	8,100
Broodstock acquisition	500
Total	**$75,000**

X. Future economic self-sufficiency

The development of a sufficient number of viable aquaculture operations to support hatchery production is a medium term endeavor. Self-sufficiency should be expected in the 2 to 4 year range.

XI. Multi-Year Funding

Public support is necessary until the industry is well established or a state or county hatchery is built and able to meet farmers' demands. Reliability and dependability are essential during these developing years. Small farms cannot afford nor do they have the technical expertise to operate hatcheries. Larger farms are not inclined to promote competition by distributing seedstock. Hatchery operations are best served by a cooperative effort between the local government, research institutions and the industry.

XII. Past Performance

Three years ago, Moloka'i had no commercial aquaculture industry. The number one constraint was the lack of seedstock. The Moloka'i Shrimp Seed Production Project was implemented combining the efforts of The Oceanic Institute and Molokai Sea Farms. The project successfully removed the constraint and now Moloka'i in one of the largest shrimp producers in the state of Hawaii.

Shrimp larval rearing technology was successfully transferred from The Oceanic Institute. Local residents with no prior hatchery experience have received training and are now serving Moloka'i as qualified hatchery technicians. Moloka'i shrimp production has been steadily increasing and has achieved eighteen acres of intensive production. These increases are expected to continue. The Moloka'i Finfish Hatchery Technology Transfer Project will be modeled after the successes of the shrimp project.

Program/Activity: Maui County Aquaculture

8/11/94
Date

By _____
Program Coordinator

Research Corporation of the University of Hawaii

9/1/94
Date

By _____

ACCEPTED:

_____
Executive Director (MCDC)

Aug. 2, 1994
Date

_____
Contractor

7-29-94
Date

Is Consultant a U.S. citizen?
Yes X No _____

If U.S. citizen, provide Social Security No. 553-94-3130

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Appendix 9. Final Report on Moi Hatchery Trials

Final Report

Protocol Development for the Larval Rearing Of Moi

#8990021

Co-Investigator • Greta Martinez

Co-Investigator • Steve Chaikin

Molokai Sea Farms

Technical Advisor

Anthony C. Ostrowski, Ph.D.

&

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of

The Oceanic Institute

3/5/96

INTRODUCTION

The operation of a marine finfish hatchery can be a major undertaking. The infrastructure necessary is extensive and the mass production technology is demanding and very sophisticated. Aquaculture farms in Hawaii are usually limited in both personnel and the capital resources that are necessary to operate marine finfish hatcheries. The focus of this research project is to develop a protocol that is more consistent with the capabilities and limitations of local farmers. Successful marine aquaculture in Hawaii, including the operation and restoration of the ancient Hawaiian fishponds and utilization of the coastal reef flats, are dependent on more farmers becoming involved in the production of high value marine finfish seed.

The primary objective for the first year of this project is to develop a commercial protocol for the larval rearing of moi. We began with procedures that The Oceanic Institute has been developing. Our goal was to simplify the process and reduce labor and costs as much as possible while maintaining acceptable hatchery production. In each of the four larval rearing runs we tested the effect of eliminating or simplifying a particular treatment or process. Even though a new treatment may have resulted in a lower survival rate, if the time or cost saving were significant and survival rates were acceptable we elected to include it in the commercial protocol.

It is important to note that the conclusions drawn are based on our experience which is limited to four larval rearing runs of moi. The investigators do not profess to be experts in marine finfish larval rearing but rather typical of other farmers with basic hatchery skills. The commercial protocol included in this report has been developed to be utilized by others with similar levels of expertise. The larval rearing process has been simplified as much as possible to allow for a larger number of aquaculturists to get involved in the larval rearing of marine finfish.

RESEARCH OBJECTIVE

The specific technical objective is to develop an optimum moi (*Polydactylus sexfilis*) larval rearing protocol to support commercial production, utilizing a scientific research approach. Optimum protocol is defined as finding and establishing the life sustaining, maximum growth/survivorship regimes necessary for culturing *P. sexfilis* in captivity. This will be achieved for the purpose of obtaining commercial quantities of moi fry to stock in earthen ponds, tanks, ancient Hawaiian fishponds and cages and subsequently to grow and market moi for the lucrative fresh seafood market in Hawaii.

PROGRESS MADE TOWARD OBJECTIVE

Installations

As this is a commercial research project it was necessary to have all systems (hatchery, nursery, growout and broodstock) in place and operational prior to beginning the moi hatchery runs. The following is an updated listing of the system installations

Outdoor Algae Production Installations (28,000 gallon total capacity)

3 (18' diameter, 6000 gal. capacity) microalgae (*Nannochloropsis occulata*) tanks

4 (12' diameter, 2500 gal. capacity) microalgae (*N. occulata*) tanks.

All tanks were equipped with high volume aeration system, fresh and salt water supply, drainage system and pump connections for pumping microalgae to indoor rotifer tanks and larval rearing tanks.

Indoor Algae Production Installations

Our indoor algae room was outfitted with a larger cooling system, additional high wattage florescent lighting, larger shelving to accommodate 2 liter Erlenmeyer flasks and plumbing to allow microalgae to be pumped to the outdoor algae production tanks.

Rotifer Production Installations

(2) 500 gallon fiberglass tanks were installed and plumbed into the main hatchery water and air system as well as plumbed to receive microalgae from the outdoor algae production tanks.

(5) 250 gallon fiberglass tanks were plumbed to receive microalgae from the outdoor algae production tanks.

(1) 53 micron rotifer harvesting basket was constructed.

Larval Rearing

Larval rearing tanks were painted black and plumbed to receive microalgae from the outdoor algae tanks.

Nursery, Broodstock and Growout Installations (total capacity 100,000 gallons)

3 (28'), 9 (18'), 5 (12') diameter nursery / broodstock / growout tanks were installed.

Heavy equipment was brought in to prepare the sites and dig the trenches for drainage, water and air supply. Over 1/2 mile of water supply, drainage, and air lines were installed.

Two (50'X100') ponds were converted to reservoirs to provide water for the nursery, broodstock and growout tanks. Each pond has been equipped with two water pumps for added dependability.

MOI LARVAL REARING

Run #1

During the first run we refined our system and became familiar with the moi larval rearing process. We tested stocking densities to determine which would net the largest number of healthy fry in our system. We utilized a moi protocol developed at The Oceanic Institute (O.I.). Starter cultures of microalgae *(N. occulata)* and rotifers *(Brachionis plicatilis)* were obtained from O.I..

Algae cultures were grown out in (12) test tubes, (12) 500 ml Erlenmeyer flasks, (12) 2 L Erlenmeyer flasks, (8) 20 L carboys, (9) 250 L cylinders, (3) 12' and (2) 18' mass culture algae tanks. Reagent grade compounds of nitrate, phosphate, Fe-EDTA, and a variety of trace metals were mixed to provide nutrients for the indoor algae culture. Agricultural grade compounds, ammonium sulfate, monopotassium phosphate, urea, Fe- EDTA and a mixture of trace metals were combined to provide a nutrient mix for the outdoor algae tanks.

Rotifers were grown in two (2 ton) cylindroconical fiberglass tanks. Each tank was inoculated every other day, grown out for two days, harvested and restarted. Each day one of the two rotifer tanks was harvested. On day one, a tank would be filled with 400 L algae (target density 10 to 15 million cells per ml) pumped from the outdoor mass culture tanks and 200 L of freshwater. On day two each tank would again get 400 L algae and 200 L fresh water. Each evening both tanks would be supplemented with 30 - 60 grams of inactive bakers yeast.

Artemia cysts were hydrated in 400 L cylindroconical tanks for 30 hours, harvested and placed back in the tank for enriching an additional 12 hours.

Larval rearing took place in (6) 2 ton cylindroconical black fiberglass tanks. Filtered (1 micron) seawater was added to 1000 L. Fertilized moi eggs were added at densities of 15, 20, and 25 eggs per liter. Medium aeration was provided to keep eggs suspended. After hatching, aeration was reduced to a gentle flow and gradually increased throughout the run.

The following is the protocol used during the first larval rearing run.

Day	Algae	Feed	Water Exchange	Screen size
2 - 15	40 L	20 Rotifers/ml	10 %	300 micron
13 - 15	0	0.5 -1 *Artemia* /ml	10%	500 micron
15 - 20	0	4 -6 *Artemia* /ml	25-50%	500 micron
18 - 24	0	pinch process. feed	100%	500 micron
20 - 24	0	5-8 *Artemia* /ml	100%	500 micron

•Siphon tanks daily to remove dead larvae and white or red fungus
•Feeding levels checked four times daily
•Tank temperatures were maintained by covering or uncovering the tanks depending on ambient and tank water temperatures. Target temperature was 27°C.
•All *Artemia* was enriched with Gulf Industries Aqua Life Nutri-Pack Super DHA 30 from New Zealand
•Beginning on day 15 a pinch of high quality processed feed produced by Skretting in Norway was added twice daily to familiarize the larvae with processed feed.
•Harvest took place on day 24

Harvest data Run #1

Tank	density	# of eggs	Amount harvested	% Survival
1	25 / L	25,000	1727	7
2	20 / L	20,000	2880	15
3	15 / L	15,000	3280	22
4	25 / L	25,000	3140	13
5	20 / L	20,000	3050	15
6	15 / L	15,000	4020	27

Harvest Summary

Total number of fish harvested from tanks stocked at 15 /L	7,300*
Total number of fish harvested from tanks stocked at 20 /L	5,930
Total number of fish harvested from tanks stocked at 25 /L	4,867
Total number of fish harvested	18,097
Average % survival	16.7 %

* 15 eggs / L to be stocked in all tanks for run #2, #3 and #4.

Run #2

A number of changes were implemented for the second run. All mixing of algae nutrients was eliminated. Readily available commercial premixed algae nutrients were utilized. Outdoor algae production was significantly cut back. Only three 12' mass algae tanks were necessary and utilized only for the first two weeks of the run. During periods of no rotifer usage the indoor algae culture maintained the rotifers.

Addition of freshwater and yeast to the rotifer culture was eliminated. Rotifers fed at 20 /ml seemed excessive and led to a reduction of the water quality. Feeding was therefore cut in half to 10 /ml. Rotifer production typically exceeded our daily requirement and excess was frozen for use in the event of a rotifer or algae crash. For about the first ten days of the run the rotifers would reproduce in the larval rearing tanks at approximately the same rate as they were being eaten and removed through water exchange. Only occasional additions were required for some of the tanks.

Daily siphoning was eliminated prior to day 15 as to many larvae were being lost in the process. Siphoning began when accumulations warranted it.

Feed level checks were reduced to twice a day until day 20 when the tanks were checked three times per day. The high priced processed feed from Norway was replaced with a more economical larval diet from Florida Aqua Farms Inc.. The larval diet was introduced to the moi starting on day 18 with a pinch twice a day. The larval diet was increased slightly each day depending on the feeding response.

All tanks were stocked at a rate of 15 eggs per liter.

During Run # 2 we tested the effects of partial and total elimination of enriched *Artemia*. The enrichment of *Artemia* is a labor intensive operation and expensive.

Treatment #1 (control tanks 1 & 4) utilized exclusively enriched *Artemia*

Treatment #2 (tanks 2 & 5) utilized enriched *Artemia* only for the first half of the period in which the tanks received *Artemia* (day 13 through 18)

Treatment #3 (tanks 3 & 6) received exclusively non-enriched *Artemia*.

The results were as follows:

Harvest data Run #2

Tank	density	# of eggs	Amount harvested	% Survival
1	15 / L	15,000	1,100	7
2	15 / L	15,000	4,500	30
3	15 / L	15,000	3,350	22
4	15 / L	15,000	1,100	7
5	15 / L	15,000	2,700	18
6	15 / L	15,000	4,000	27

Harvest Summary

Total number of fish harvested from tanks treatment #1 (enriched *Artemia*)	2,200
Total number of fish harvested from tanks treatment #2 (partial enriched)	7,200
Total number of fish harvested from tanks treatment #3 (non-enriched)	7,350*
Total number of fish harvested	16,750
Average % survival	18.5%

*Treatment #3 non-enriched *Artemia* will be used in all tanks during runs 3 & 4

Run #3

Run #3 tested 2 different treatments of substituting processed feed for *Artemia*. The cost of *Artemia* has risen 600% during the last year and the availability in the future is uncertain.

Treatment #1 (Control tanks 1 & 4) utilized a pinch of processed larval diet starting at day 18 in addition to *Artemia* untill harvest

Treatment #2 (tanks 2 & 5) utilized processed feed same as treatment #1, but starting at day 21 processed feed completely replaced *Artemia*..

Treatment #3 (tanks 3 & 6) utilized processed feed same as treatment #1, but starting at day 19 processed feed completely replaced *Artemia*..

The results were as follows:

Harvest data Run #3

Tank	density	# of eggs	Amount harvested	% Survival
1	15 / L	15,000	1,800	12
2	15 / L	15,000	980	7
3	15 / L	15,000	20	0
4	15 / L	15,000	2,700	18
5	15 / L	15,000	460	3
6	15 / L	15,000	0	0

Harvest Summary

Total number of fish harvested from tanks treatment #1	(control)	4,500*
Total number of fish harvested from tanks treatment #2	(3 day substitution)	1,440
Total number of fish harvested from tanks treatment #3	(7 day substitution)	20
Total number of fish harvested		5,960
Average % survival		6.6%

*Treatment #1 utilized a pinch of processed larval diet starting at day 18 in addition to *Artemia* till harvest. This treatment will be used as the control during run #4.

Discussion: In our system substituting processed feed for *Artemia* did not work. The uneaten feed would rapidly attract fungus growth. It took one hour per day to siphon one tank and the levels of fungus left were still unacceptable. Moi larvae seemed to have little tolerance for fungus growth in the tank. It should be noted that The Oceanic Institute reportedly has had good success substituting processed feed for *Artemia*. Their system provides a good circular current which deposits the uneaten feed in one spot for easy siphoning.

Run #4

Run #4 investigated the total elimination and partial elimination of algae production facilities from the larval rearing process. Rotifers will be produced utilizing a combination of inactive brewers yeast and algae from green water tilapia tanks. Algae production is presently the most labor intensive and costly part of the larval rearing process.

Treatment #1 (Control tanks 1 & 4) utilized rotifers that were fed algae produced from our algae production facilities. Background algae put into larval rearing tanks also came from our algae production facilities

Treatment #2 (tanks 2 & 5) utilized rotifers that were fed algae from green water tilapia tanks supplemented by inactive brewers yeast. Background algae put into these larval rearing tanks came from our algae production facilities.

Treatment #3 (tanks 3 & 6) utilized rotifers that were fed algae from green water tilapia tanks supplemented by inactive brewers yeast. Background algae put into these larval rearing tanks also came from green water tilapia tanks.

The results were as follows:

Harvest data Run #4

Tank	density	# of eggs	Amount harvested	% Survival
1	15 / L	15,000	4,950	33
2	15 / L	15,000	1,125	7
3	15 / L	15,000	90	0
4	15 / L	15,000	30	0
5	15 / L	15,000	1,660	11
6	15 / L	15,000	150	1

Harvest Summary

Total number of fish harvested from tanks treatment #1	(control)	4,980
Total number of fish harvested from tanks treatment #2		2,785
Total number of fish harvested from tanks treatment #3		240
Total number of fish harvested		8,005
Average % survival		9%

Discussion: The production of rotifers from green water tilapia tanks supplemented with inactive bakers yeast worked satisfactory. However, pumping green water directly into the larval rearing tanks produced very poor results. As a result the total elimination of algae production is not possible, but for those aquaculturists without large scale algae production facilities green water tilapia tanks can provide an inexpensive alternative when combined with small scale algae production. We inoculated the 10 ton tilapia tanks with 250 grams of centrifuged algae to accelerate a bloom of *N. occulata.*

Production Summary

A total of 48,812 moi were produced from 24 tons of larval rearing capacity. Overall survival during the four larval rearing runs was 13.6%. Overall survival of the tanks that received treatments that will be included in the commercial protocol was 20.1 %.

It is important to note that the goal of this project was not to produce large quantities of moi but rather to test different treatments to determine those which produced the best results. Some of the treatments proved to be effective, others did not. The following are the production results from the tanks that received treatments which will be included in the commercial protocol for the larval rearing of moi.

Run /Tank	Larvae Harvested	% Survival
1 / 3	3,280	22
1 / 6	4,020	27
2 / 3	3,350	22
2 / 6	4,000	27
3 / 1	1,800	12
3 / 4	2,700	18
4 / 1	4,950	33
4 / 4	30	0
	24,130	20

8 tons of larval rearing capacity stocked at 15 eggs per liter produced 24,130 moi at an average survival of 20.11%.

Although systems vary greatly from facility to facility as does the expertise of the hatchery technician, utilizing the protocol that we have established during the course of this project, one can expect an overall survival of about 20%.

ECONOMIC ANALYSIS

Utilizing a 20.11% survival the 360,000 eggs that we stocked would produce 72,396 moi. Based on developing a nursery and growout technology that will produce an 80 % survival rate, 57,917 moi could be marketed. Current auction price for the moi is $7.10 per pound which would result in a gross income to the farmer of $ 411,409.00. It is important to note that the size of the larval rearing trials that we conducted were relatively small.

Although the cost of operating hatcheries vary significantly from facility to facility, based on the results of this project the investigators have concluded that current hatchery technology is adequate to produce moi larvae at a cost sufficient to support commercial production.

The economic viability of producing moi in Hawaii as a commercial aquaculture product is dependent on establishing a cost effective nursery and growout technology.

FUTURE DIRECTION

Further research is needed to address the nursery and growout stages of moi culture. Few growout trials have been successful due to a lack of understanding of the systems that are required to produce moi. Specifically we need to address the effectiveness of different types of feed, optimum salinity, growout densities, lighting, water exchange and oxygen requirements. Moi culture is significantly more sophisticated than most of the fish currently being produced in Hawaii. Additional work is needed to define and refine the systems necessary to support moi nursery and growout.

For marine finfish aquaculture in Hawaii to be sustainable for the long run it will necessitate developing low cost production systems. Due to the increasing competition in the global economy it will be necessary to utilize resources that have not been put to use in the past. To be competitive for the long term we will have to eliminate the infrastructure and energy required to simulate ocean conditions on the land and utilize the ocean for growout of high value marine finfish.

BUDGET

Feed	4,000.00
Supplies	3,000.00
Utilities	3,000.00
Equipment	4,000.00
TOTAL	$ 14,000.00

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We would like to acknowledge ADP and MAA who provided additional funding for this project. Also CTSA for their development of the technology and Anthony C. Ostrowski, Ph. D. and Paul Bass of The Oceanic Institute whose technical advise largely contributed to the success of this project.

Our harvest procedure was to lower the tank level to within several inches of the bottom, remove the water exchange screen at the center of the LRT and drain the moi into a 12" diameter PVC ring with 750 micron mesh at the bottom. The ring is 5" high and placed in a 4" high tub which allowed the fry to be submerged at all times during the draindown. When the density in the ring got too high the moi were rapidly rinsed out into a five gallon bucket. Population was estimated by counting 250 to 500 moi larvae and placing them in a 5 gallon bucket filled to 10 liters. Harvested animals were placed in another five gallon bucket filled to the same level until both buckets appeared equal in density. Counting each fish is risky and time consuming. Moi larvae do not handle stress well at this point.

Conclusion

This commercial moi larval rearing protocol is intended to be used as a guide. Conditions vary from facility to facility as do the techniques used by hatchery technicians. Certain procedures that work well at one site may not be effective at another. Even performing the same treatments at the same facility can produce varying results. Drawing concrete conclusions from a process that is inherently variable is a difficult task. Nevertheless, this protocol provides a place to begin. Hatchery operators should be encouraged to find better treatments and procedures, continuing to refine the protocol as new discoveries are made.

Appendix 10. Contract: #8990024. Freshwater Finfish Hatchery

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990024

Moloka'i Community Development Corporation

(FULL NAME OF: Firm, Association, Performing Group, or Individual)

P.O. Box 1509, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s)	(State Scope in Detail)
see attachments	

Date(s)	Time(s)	Place(s)
August 1, 1994- December 31,1995		

The remuneration for the service(s) agreed to herein at the rate of $ 10,800 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

Substitution of any date(s) and/or place(s) of service(s) herein provided, may be made if mutually acceptable and agreed to between the Corporation and the Contractor; such change(s), if any, shall not affect the validity of this agreement.

2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

Cancellation by the Contractor of the service(s) to be provided herein, or any one or more of a series, shall render this Contract void, and a new Contract may be prepared by the Corporation to cover the service(s) to be given, if any.

The Corporation reserves the right to cancel this agreement at any time after commencement of services if the Contractor neglects to perform as specified.

The balance of any remuneration and other allowances, if any, due shall be paid upon completion of the service(s) herein provided upon submission of invoices in triplicate, or upon certification by the director of the program or the activity that the service(s) have been completed. The total remuneration paid, and the other reasonable incidental expenses, if any, shall be considered full compensation for basic services rendered, including overhead, profit and taxes.

ETHICS DECLARATION

I declare that I am not a Legislator, elected or appointed officer, or that this firm is not owned or controlled by any Legislator, elected or appointed officer, compensated or uncompensated, member of a State board or commission, or other employee of the State of Hawaii.

I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

The Contractor understands that, if he/she is engaging in business or performing services within the State of Hawaii, the remuneration includes an amount to cover 4% State General Excise Tax and license fee (Chapter 237, H.R.S. 1969, as amended), and he agrees to pay the required assessments to the State Department of Taxation, 425 Queen Street, Honolulu.

Any product resulting from work under this contract shall be the sole property of the Research Corporation of the University of Hawaii, and shall be at its discretion, disposed of in accordance with Research Corporation of the University of Hawaii/University of Hawaii/Federal Copyright Patent Policies.

The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 41

Attachment I

This consulting agreement is to cover the objectives of the proposal entitled " Fresh Water Finfish Hatchery submitted by the Loko I'a Kalo Organization. A copy of the proposed work is attached detailing specific goals and objectives to be accomplished.

The contractor agrees to provide up to 30% of the finfish fingerlings produced for other interested growers on Moloka'i. Distribution of requested fingerlings will be coordinated through the Moloka'i Aquaculture Advisory Alliance in conjunction with the Sea Grant aquaculture extension agent on Moloka'i.

The project will receive $ 10,800. There will be $ 8,000 advanced to the consultant. Following the receipt and acceptance of a six month progress report an additional $ 1,800 will be made available to the consultant. The final payment of $1,000 will be made after the receipt and acceptance of a final report.

PROPOSAL

TO

COUNTY OF MAUI

FOR

FRESH WATER FINFISH HATCHERY

INTRODUCTION:

The backyard, as well as the commercial aquaculturalist on the Island of Molokai is non-existent due to a number of reasons. The first reason would be the lack of reliable and consistent supply of seed stock. A farmer has to acquire seed stock from abroad. Thus raising the cost of product to market size and delays of seed stock creates a hardship for farmer to stay in the business. The farmer is always at the mercy of the fry 's supplier. Secondly, the lack of interest in Aquaculture because of the unsuitable species available to farms without access to the ocean. Very few people in our community have access to these resources. Therefore, the majority of the people are limited to fresh water species.

Our enclosed survey shows a need for a fresh water finfish hatchery to supplement families diets and income on Molokai. Fresh and economical fish products are in demand in our community because the large percentage of our people are in the low income bracket. The ocean fish catches via to the fish market brings a very high price to the community. Few people can enjoy this product of the sea. Also the shoreline and deepsea fishes are depleting according to national statistics while most of the fishes are infected with poison. Obviously, many of the fishes made available to the public will be farmed in a closed controlled environment. The finfish hatchery will help diversify the production sector and create new market.

PART 1:

TITLE:

Introduction and cultivation freshwater finfish species, Oreochromis Mossambicus and clarius Fuscus. (Red Hybrid Talapia and Chinese cat fish)

PRINCIPLE INVESTIGATOR:

Loko I'a Kalo, Organization
Mr. Scott Kauhanehonokawailani Adams, Farmer and Partner
Mr. Noah Kuoha, Farmer and Partner
Mr. Miles B. Kina, Farmer and Partner

ASSOCIATE INVESTIGATORS:

Mr. Paul G. Olin, Aquaculture Extension Specialist
Mr. Cole C. Adams, Bachelor of Science in Marine Aquaculture.
Mr. Mark Yuen, Aquaculturalist
Ms. Rabecca Yuen, Aquculturalist

OBJECTIVES:

1. To construct hatchery and start obtaining brood stock for both species and prepare specific guidelines for preparation and submission of permit application.

2. To start cultivating of O. Mossambicus and Clarius fuscus species and conduct a second feasibility survey of prospect buyers for fry.

3. To conduct grow-outs at own facility and selling of fry.

4. To assist other farmers and to conduct seminars for Molokai High School Students in backyard fish culture.

BACKGROUND AND JUSTIFICATION:

Two shrimp farms and various restoration of ponds were supported by the State and County to improve the efficiency of raising aquatic animals. We need to continue these efforts for economical and diversification reasons. This can be realized by supporting the first fresh water finfish hatchery on Molokai. The result of supplying other aquafarmers on Molokai would bring more interest in the aquaculture field.

Many literatures on these specify fish products have be written and the production of fry are proven to have excellent results. For this reason, both species will grow without any problems.

ANALYSIS OF HATCHERY SITE:

The property is a 35 acres, 99 yrs lease to Maryan Kuoha from the Department of Hawaiian Home Lands. The 10 acres are presently used for farming activities which also includes a 1/2 acre shadehouse. The remaining 25 acres are not in use.

The hatchery as planned would include a 1 acre of land. The existing 50,000 gallon rubber lined fish pond project with an area for expansion of fish ponds would use approximately 2 acres. The waste water of the hatchery and fish ponds operation will gravity flow into Loi's, watercress, unchoy, other vegetables and fruit crops.

The hatchery site sits flat on the area then gradually slopes down hill 500 feet to the west of the proposed site.

WORK STATEMENT:

OBJECTIVE 1:

Project participants will initially summarize the review process, meet with other representatives at each level of review, and document their recommendations to insure permit application from the County to construct hatchery.

OBJECTIVE 2:

On receiving permit approval, partners will construct the finfish hatchery which includes fabricating the facility, and installing the necessary equipments and tanks, Paul Olin will be advised for broodstock delivery at the completion of the facility. Project participants along with Sea Grant Agents will cultivate and propagate both species in the enclosed hatchery.

OBJECTIVE 3: During the development period from larvae to fry. participants will advise and assist other farmers to develop their own grow-out systems. Project participants at this time will fill the first survey orders and execute another survey for prospect buyers. During the entire process, participants and consultant will develop and complete a marketing plan.

PROJECT SCHEDULE:

Sept - Oct, 1993:

Permits, construction of hatchery and its infrastructure, and obtaining broodstock of O. Mosambicus and Clarius. To be performed by project participants and consultants.

Nov - Dec, 1993:

Find solutions for problems in the hatchery facility. Propagate both species, fill first orders and research another survey of potential buyers.

Jan - Feb, 1994:

Assist other aquafarmers to develop their own grow-out system for home consumption and/or for profit. Sell and distribute fry. Start grow-out at own hatchery facility.

March -

Summary of successes and failures of hatchery operation for

LOKO I'A KALO ORGANIZATION

FRESH WATER FINFISH HATCHERY BUDGET

1. hatchery structure materials	3590.00
2. pvc sched 40 pipe & fittings	700.00
3. sand filters/# 50 mesh	670.00
4. feed	900.00
5. labor	1000.00
6. permits	240.00
7. incubator	400.00
8. laboratory equipment	400.00
9. electrical supplies	3000.00
TOTAL	10,800.00

Program/Activity: **Maui County Aquaculture**

8/11/94
Date

By _____
Program Coordinator

Research Corporation of the University of Hawaii

9/13/94
Date

By _____

ACCEPTED:

_____
Executive Director (MCDC)

Aug. 2, 1994
Date

Noah Kuoha
Contractor

7-29-94
Date

Is Consultant a U.S. citizen?
Yes ✓ No _____

If U.S. citizen, provide Social Security No. 576-06-3645

Type of Entity

Corporation	✓	Non-Profit	✓
Partnership		Government	
Trust		Estate	
Individual		Sole Proprietorship	

Tax Payer Identification Number: 99-0243966

Distribution of Executed Copies
1. Original & Invoices - Research Corporation
2. Copy - Program/Activity
3. Copy - Contractor

Appendix 11. Contract: #8990025. Ornamental Fish Production in Tanks

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990025

Moloka'i Community Development Corporation

(FULL NAME OF: Firm, Association, Performing Group, or Individual)

P.O. Box 1509, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s)	(State Scope in Detail)		
see attachments			
Date(s)		**Time(s)**	**Place(s)**
August 1, 1994- ~~December 31, 1995~~ June 30, 1996		CT = dgl EM =	

The remuneration for the service(s) agreed to herein at the rate of $ 4,000, together with applicable, reasonable incidental expenses shall not exceed $ -0-.

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Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990025

Moloka'i Community Development Corporation

(FULL NAME OF: Firm, Association, Performing Group, or Individual)

P.O. Box 1509, Kaunakakai, Moloka'i, Hawaii 96748

(ADDRESS)

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Service(s)	(State Scope in Detail)	
see attachments		

Date(s)	Time(s)	Place(s)
August 1, 1994- December 31,1995		

The remuneration for the service(s) agreed to herein at the rate of $ 4,000 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

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2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

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ETHICS DECLARATION

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I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

The Contractor understands that, if he/she is engaging in business or performing services within the State of Hawaii, the remuneration includes an amount to cover 4% State General Excise Tax and license fee (Chapter 237, H.R.S. 1969, as amended), and he agrees to pay the required assessments to the State Department of Taxation, 425 Queen Street, Honolulu.

Any product resulting from work under this contract shall be the sole property of the Research Corporation of the University of Hawaii, and shall be at its discretion, disposed of in accordance with Research Corporation of the University of Hawaii/University of Hawaii/Federal Copyright Patent Policies.

The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 42

Attachment I

This consulting agreement is to cover the objectives of the cooperative agreement between Friendly Isle Fish Company and UH Sea Grant extension service. A copy of the proposed work is attached detailing specific goals and objectives to be accomplished.

The contractor agrees to provide up to 30% of tropical fish produced for other interested growers on Moloka'i. Distribution of requested tropical fish will be coordinated through the Moloka'i Aquaculture Advisory Alliance in conjunction with the Sea Grant aquaculture extension agent on Moloka'i.

The project will receive $ 4,000. There will be $3,500 advanced to the consultant. Following the receipt and acceptance of a six month progress report the remainder of the monies ($500) will be made available to the consultant.

ORNAMENTAL FISH PRODUCTION IN TANKS

Cooperative agreement with Sea Grant Extension Service

and

Ed Medeiros of

Friendly Isle Fish Company

Background and Justification

The guppy (Xiphophorous maculatus) is a highly prized ornamental fish with an extensive world wide market. In the past, sources for the of fancy guppies for the U.S. market have generally been the far east. A small percentage of the U.S. market has been supplemented by domestic production, mainly in Florida. Recently, imports from the far east have fallen off dramatically due to extensive disease problems throughout the ornamental fish industry. Farm wholesale prices for fancy guppies range between $ 0.14 for common fancy to $ 1.25 for grade A pairs.

Moloka'i is in an excellent position to develop an industry producing tropical ornamental fish. This is an area of aquaculture that can utilize the vast amount of resources available on the island. .These resources include plentiful clean fresh water, excellent air freight infrastructure, and a high level of interest among farmers to diversify from traditional agriculture into aquaculture.

The aquaculture industry in Hawaii has grown dramatically in the past decade and now includes more than 50 farmers raising over 35 species of fish. During the same period of time there has been a decline in the aquaculture industry on Moloka'i. To benefit the aquaculture industry as a whole and the economy of Moloka'i in particular, it is essential to produce a variety of new species which can be competitively grown to supply both local and export markets.

The culture of ornamental tropical fish is a clean industry utilizing renewable resources with little environmental impact. Ornamental aquaculture produces a very high value low biomass commodity, consequently, the cost of importing feed and exporting the final product are a small component of overall production costs. Water requirements are low when compared to larger finfish production facilities. There is minimal environmental impact and these systems lend themselves to utilizing biological filtration systems if necessary, to even further reduce water usage.

There are businesses already established in Hawaii actively trans-shipping foreign and wild caught fish to mainland and international markets. An ornamental fish producer on Moloka'i can readily integrate with this marketing and distribution network. These fish have a high market value and Hawaii has the air connections to rapidly deliver products to domestic and international markets.

GOALS AND OBJECTIVES

1. Determine reproductive rates of the fancy guppy (Xiphophorous maculatus).

2. Determine growth rates.

3. Determine percent marketable fish produced.

METHODOLOGY

1. Overall reproductive rates will be determined by placing broodstock in cages (4 ft x 4 ft x 1 ft) within individual production units (12 ft diameter tanks). The sex ratio will be 4-5 females/male up to densities of 1200 per cage utilizing four cages in the production unit. After the first 15 day breeding cycle cages and broodstock will be moved to the next production unit. Reproductive rates will be determined by the following formula-- number of fry/ number of females/ number of days in reproduction cycle. This value will be listed as number of fry per female per day. Reproduction will be determined by a total fry count after a reproductive cycle has been initiated and fish have been determined to be market size (90-120 days).

2. Growth rates will be calculated by individually sampling 30 fry for both length and weight every thirty days after reproduction has been initiated. Sampling will continue every thirty days until fish reach market size. Fish will be fed to satiation twice daily using swim-up trout chow.

3. When fish reach market size (1-1 1/2 in.) they will be graded according to size , sex, and color pattern. Marketable percentages will be determined by the total count in each category.

PROJECT SCHEDULE

A) Install tanks, drain, water and air systems.

B) Order cage material and construct broodstock cages.

C) Purchase additional equipment and supplies.

D) Import sources of broodstock, purchase feed and initiate first breeding cycle.

E) Begin second breeding cycle and quantify initial measurements from first breeding cycle.

F) Quantify measurements and submit data in six month progress report.

BUDGET

Equipment

a) three tanks (12 ft diameter x 4 ft depth)	1500
b) blower	350
c) pvc pipe (air & water)	250
d) cage material (four cages)	200

Supplies

a) broodstock	500
b) feed	150
c) medications	100
d) miscellaneous	150
Salary	800
Total	4000

Program/Activity: **Maui County Aquaculture**

8/11/94
Date

By _____
Program Coordinator

Research Corporation of the University of Hawaii

9/13/94
Date

By _____

ACCEPTED:

_____
Executive Director (MCDC)

Aug. 2, 1994
Date

_____
Contractor

8-2-94
Date

Is Consultant a U.S. citizen?
Yes ✓ No _____

If U.S. citizen, provide Social Security No. 566-82-2448

Type of Entity			
Corporation	✓	Non-Profit	✓
Partnership		Government	
Trust		Estate	
Individual		Sole Proprietorship	

Tax Payer Identification Number: 99-0293966

Distribution of Executed Copies
1. Original & Invoices - Research Corporation
2. Copy - Program/Activity
3. Copy - Contractor

Appendix 12. Contract: #890049. Kaupakalua Farms: A Demonstration Integrated Aquaculture Project

Telephone: (808) 988-8300
Facsimile: (808) 988-8349

The Research Corporation of the University of Hawaii

CONSULTANT / PERSONAL SERVICES

Program/Activity: Maui County Aquaculture

Re: Purchase Order # 8990049

Kaupakalua Farms
(FULL NAME OF: Firm, Association, Performing Group, or Individual)

2555 Kaupakalua Rd. Haiku, Hawaii 96748
(ADDRESS)

hereafter known as Contractor, agrees to furnish the following service(s) for the Research Corporation on behalf of the UH Sea Grant Extension Service at the times and on the dates, or between the dates and the places hereinafter specified:

Service(s) (State Scope in Detail)

SEE ATTACHMENT I AND ATTACHED PROPOSAL ENTITLED: "KAUPAKALUA FARMS A DEMONSTRATION INTEGRATED AGRICULTURE AQUACULTURE PROJECT"

Date(s)	Time(s)	Place(s)
10/01/95 - 06/30/96*	As arranged	Kaupakalua Farms

*IT IS ANTICIPATED THAT AN EXTENSION WILL BE OBTAINED TO EXTEND PROJECT THROUGH APRIL 1997. IF EXTENSION IS OBTAINED, A MODIFICATION WILL BE PUT INTO PLACE.

The remuneration for the service(s) agreed to herein at the rate of $ 3,500 , together with applicable, reasonable incidental expenses shall not exceed $ -0- .

Substitution of any date(s) and/or place(s) of service(s) herein provided, may be made if mutually acceptable and agreed to between the Corporation and the Contractor; such change(s), if any, shall not affect the validity of this agreement.

2800 Woodlawn Drive, Suite 200 402, Honolulu, Hawaii 96822

An Equal Opportunity Employer

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The balance of any remuneration and other allowances, if any, due shall be paid upon completion of the service(s) herein provided upon submission of invoices in triplicate, or upon certification by the director of the program or the activity that the service(s) have been completed. The total remuneration paid, and the other reasonable incidental expenses, if any, shall be considered full compensation for basic services rendered, including overhead, profit and taxes.

ETHICS DECLARATION

I declare that I am not a Legislator, elected or appointed officer, or that this firm is not owned or controlled by any Legislator, elected or appointed officer, compensated or uncompensated, member of a State board or commission, or other employee of the State of Hawaii.

I, further, declare I have not participated in a State capacity, or that this firm has not been assisted or represented in this matter by an individual who has been involved in a State capacity, in the subject matter of this contract in the past years.

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The account(s) chargeable for the within service(s) is/are:

Project No. 8990 B.C. 42

Program/Activity: **Maui County Aquaculture**

19 Sept 95
Date

By R. Brock
Program Coordinator

Research Corporation of the University of Hawaii

_____
Date

By _____

ACCEPTED:

R.S. Chitran
Contractor, **R.S. Chitran**

Sept 6 1995
Date

Is Consultant a U.S. citizen?
Yes ✓ No _____

If U.S. citizen, provide Social Security No. 571606284

Type of Entity

Corporation	✓	Non-Profit _____
Partnership	_____	Government _____
Trust	_____	Estate _____
Individual	_____	Sole Proprietorship _____

Tax Payer Identification Number: 20031306
(State Retail License)

Distribution of Executed Copies
1. Original & Invoices - Research Corporation
2. Copy - Program/Activity
3. Copy - Contractor

Attachment I

This consulting agreement is to cover the objectives as detailed in the proposal entitled: "Kaupakalua Farms A Demonstration Integrated Agriculture Aquaculture Project." A copy of the proposed work is attached detailing the specific goals and objectives to be accomplished.

The contractor agrees to allow Sea Grant sponsored workshops to be held at Kaupakalua Farm. In addition, the contractor agrees to allow school groups and other public entities interested in integrated aquaculture-agriculture to tour the facility with ample notice.

The project will receive $3,500.00. There will be $3,250.00 advanced to the consultant. A progress report is to be received after six months. The final payment of $250.00 will be made after the receipt and approval of a final report.

KAUPAKALUA FARMS

A Demonstration Integrated Agriculture

Aquaculture Project

A Proposal submitted to Maui County Office of Economic Development

Kaupakalua Farms
Mr. R.S. Chitran
2555 Kaupakalua Rd.
Haiku, HI 96748
(808) 572-8886

INTRODUCTION

There is a need for the implementation of an integrated agriculture-aquaculture business on Maui. The integration of agriculture and aquaculture will lower the cost of traditional farming methods by promoting the conservation of water and by promoting organic farming methods.

This proposed demonstration project can serve as an educational model of alternative farming technologies that can be utilized at the primary and intermediate school levels and as an educational/vocational training model for secondary and collegiate levels. We intend to work in collaboration with the Paia Youth Center and the non-profit entity Ka Lima O Maui on this project. Ka Lima O Maui was founded in 1955 and is Maui's oldest non-profit organization. It provides vocational training and employment for disabled and economically disadvantaged adults.

The programs and services offered at Ka Lima are intended to assist people in moving towards independence and self-sufficiency. The organization places nearly 30 disabled and disadvantaged workers into employment each year. Ka Lima engages in a wide variety of work activities including laundry services, grounds crew maintenance, a plant nursery, a thrift store, paper recycling, and other work.

The Paia Youth Center Director lives adjacent to Kaupakulua Farms and has voiced interest in having it's members participate in this project.

Currently, there is little competition for home grown

organic food sources on Maui and there exists a burgeoning movement towards gaining self-sufficiency in food production for local consumption. Through the integration of our organic farming operation with "backyard" aquaculture, we will be able to demonstrate the feasibility of sustainable small-scale agriculture-aquaculture for Maui farmers.

OBJECTIVES

Our primary objective is to create an organic sustainable agri-aquaculture business that will serve as a demonstration and learning center for youth, disadvantaged persons and others interested in small-scale farming opportunities. This center will demonstrate self sustaining techniques for the home or community gardens raising fish and greens. Effluent waters from fish tanks rich in nutrients will be pumped into trays for growing vegetable produce and then reused again to irrigate ground crops such as taro, bananas, and papayas.

Through this efficient use of water we will be able to substantially reduce the amount of water the will be needed to grow these crops.

METHODS

Phase I (month 1-6)

A) Build a reservoir with rain catchment to supply water to fish tanks and for hydroponic production of salad greens and irrigation of ground crops. This reservoir will reduce the need for expensive county water. A backhoe will be used to level the site and grade for rain catchment. A liner will be installed in the reservoir to eliminate ground seepage. A pump, aerator and

pipes will be utilized to circulate water and add oxygen for fish and plants. Three (12 ft diameter) fish tanks are already available for fish production. The proposed reservoir will also be used for fish production.

B) Build hydroponic greens production system. Currently, we have three small fish tanks operating. Materials will be purchased to construct additional fish tanks and vegetable grow-out tables.

C) After construction is completed and production and sales have begun, Ka Lima O Maui members and Paia Youth Center members will assist in production and commercial aspects.

D) Begin sales of tilapia, catfish and fruit and vegetables.

Phase II (month 7-12)

A) Increase hydroponic production and employ Ka Lima O Maui and Paia Youth Center members to increase production thereby increasing the retail market.

B) Set up educational model for hands on demonstrations and workshops showing how to farm at home or at neighborhood community gardens.

Phase III (month 13-18)

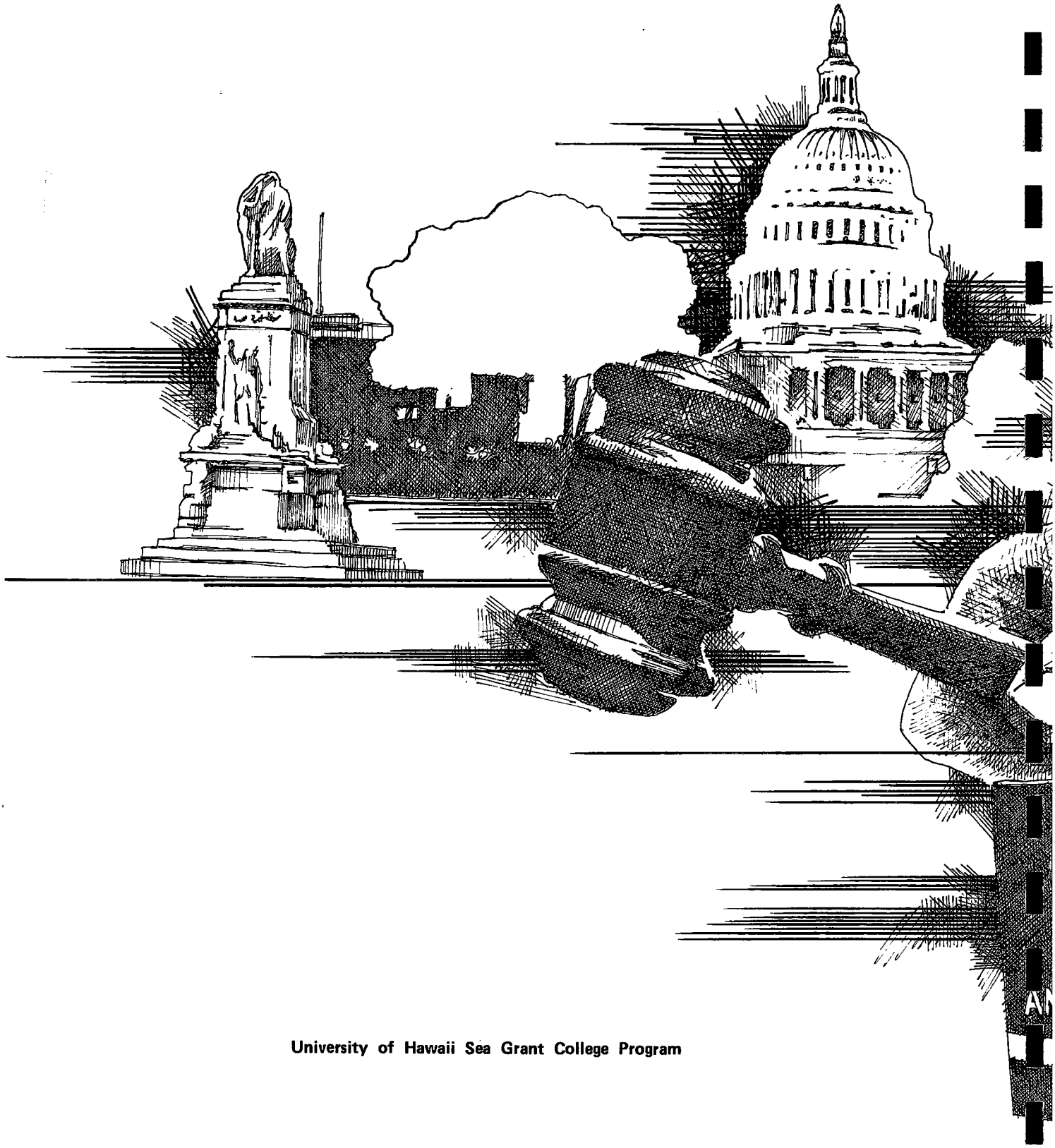
C) Cooperate with school system by offering model to teach youth a new concept of farming that does not use traditional methods of row crops. This would specifically address aquaculture and hydroponics showing the relationship between fish and vegetables.

EXPECTED RESULTS

It is envisioned that through the successful development and implementation of this integrated agriculture-aquaculture system, a model demonstration farm will be available for community members and other interested farmers to learn alternative farming techniques.

BUDGET

1. Reservoir Construction	
a) backhoe rental	300.00
b) liner	1250.00
c) pump	250.00
d) PVC pipe & fittings	300.00
2. Hydroponics System	
a) pump	250.00
b) cinder & sand	100.00
d) seed (vegetables)	200.00
3. Fish Production System	
a) seedstock	100.00
b) tank liners (two 12 ft diameter)	400.00
c) blower	350.00
TOTAL	3500.00



University of Hawaii Sea Grant College Program