Development of Black-Lip Pearl Oyster Farming in Micronesia

General Information

Reporting Period October 1, 2001– September 30, 2003 (final report)

Funding Level **$56,428**

Participants

FSM Component

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RMI Component

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Peter Fuchs, CFO, Ramsey Reimers Enterprises, Inc. (RRE)

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Virgil Alfred, Manager, Black Pearls of Micronesia, Inc. (BPOM) and Owner, Mid-Pacific Pearls

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Pearl Farming Bioeconomic Study

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Senator Gerson Lekka and Chief Magistrate George Stephens
Nukuoro Pearl Farm

Objectives

This project has three basic components:

1. Hatchery technology development and training in the Federated States of Micronesia (FSM)
2. Hatchery technology and training in the Republic of the Marshall Islands (RMI)
3. Bioeconomic study of Micronesian pearl farms

Hatchery technology development and training in the FSM

The overall goal of this component was to introduce pearl oyster hatchery technology into Pohnpei via a demonstration and training hatchery that will also provide spat to potential farmers and researchers.

1. **Demonstration and seed supply.** Installation of a simple pearl oyster hatchery into the existing MERIP facility for seed supply, demonstration and training purposes. The hatchery is intended to be of appropriate size and technology level that it can be operated and replicated in the Micronesia context.

2. **Training and technology transfer.** Transfer pearl oyster hatchery methodology to marine science students, marine resource management personnel and private sector individuals on Pohnpei and throughout the region.

Hatchery technology and training in the RMI

The overall goal of this component was to both produce pearl oyster spat to supply the industry as a bridging strategy until a permanent hatchery operation could be re-established and to make local operation and oversight of the hatchery possible in the future so as to eliminate the dependence on foreign entities.

1. **Demonstration and seed supply.** Provide a means to rescue the Marshall Islands pearl industry through a short term effort to revive hatchery operations and document procedures for hatchery operation and production.

2. **Training and technology transfer.** Transfer pearl oyster hatchery methodology to local aquaculturists, marine science students, marine resource management personnel and private sector individuals in Majuro with the goal of creating sustainable local capacity to operate pearl oyster hatcheries.

Bioeconomic study of Micronesian pearl farms

The overall goal of this component was to gain a clearer understanding of the economics of pearl farming to better guide development and research efforts.

1. Model the economics of Hawaii / Micronesian pearl farms to inform decision making, management practices and financial strategies.

Anticipated Benefits

FSM component

This work was intended to transfer hatchery technology to the FSM through demonstration and training. Capacity building was a key element and was intended to build a cadre of trained individuals who can contribute to industry development through research, training, education or farming in the future. Long-term benefits will also include hatchery and farm facilities at PATS that are open to all members of the public who wish to learn more about pearl farming technology.

RMI component

Due to the closure of the BPOM pearl oyster hatchery in 2000, the industry greatly needed a temporary source of pearl oyster spat until a permanent hatchery operation could be re-established. The BPOM hatchery was the RMI's principal source of pearl oyster spat, and local pearl farms are already looking at a two year gap in pearl harvests in the near future. Furthermore, the BPOM hatchery considered all their technology to be proprietary, and no local group of trained individuals existed who could continue hatchery operations.

Bioeconomic Study component

Pearl farming has been a risky, yet potentially lucrative endeavor in the South Pacific, Australia, Japan and other countries. The industries are now suffering from a host of problems impacting their long-term economic feasibility due to recent changes and trends. The Hawaiian and Micronesia industries are significantly different, but little information exists to inform farmers, researchers or technical assistance providers. The results of this work will help farmers choose better management strategies, reduce costs, plan financial strategies and identify areas of sensitivity for future focus. This work targets only the production aspects of the industry, but will be integrated into a wider study of global economics and marketing.

Principal Accomplishments

FSM component

Objective 1 - Demonstration and seed supply. Installation of a simple pearl oyster hatchery into the existing MERIP facility for seed supply, demonstration and training purposes. The hatchery is intended to be of the appropriate size and technology level so that it can be operated and replicated in the Micronesian context.

A simple pearl oyster hatchery was installed at MERIP.

A simple pearl oyster hatchery was set up at the existing MERIP facility. A new seawater system specifically for delivery to the larval rearing tanks was installed. All supplies and equipment were ordered, and the protocols were put into place. A storeroom at MERIP was converted into an algae room and in August 2001, it was stocked with four species of microalgae from CSIRO in Hobart, Australia (*Isochrysis galbana, Chaetocerus muelleri*, *Pavlova salina* and *Tetraselmis suecica*). Algae room operations were initiated utilizing 500 ml, 2-L and 15-L containers.

One successful spawn was obtained in February 2002.

Spawning was attempted on three separate occasions in January and February 2002 with only one successful spawn in February 2002. A total of 46 broodstock were collected from the wild and kept in three separate locations in the lagoon. Fertile eggs totaling 22.98 million were obtained from the successful spawn and 3.6 million D-stage larvae were stocked into six 300-L rearing tanks 24 hours after spawning occurred (the maximum for the available tank space). The larvae were reared to metamorphosis using the newly designed hatchery and algae room. Survival to day 27 was 5 % and did not differ appreciably from survival rates reported in the literature (Southgate and Ito, 1998; Alagarswami et al 1989). Approximately 100,000 larvae were taken through metamorphosis. Once eyed larvae were transferred to setting tanks, they were disturbed as little as possible, and population estimates were conducted infrequently. On day 71 post-spawn, 46,000 spat were removed from setting tanks and placed in spat bags. The majority of these spat were placed on a longline in the lagoon for further growout. Some spat were then moved into spat bags in raceways with flow-through seawater and supplemental drip-feeding of algae for further land-based nursery training and education purposes.

Objective 2 - Training and technology transfer. Transfer pearl oyster hatchery methodology to marine science students, marine resource management personnel and private sector individuals on Pohnpei and throughout the region.

Pearl oyster hatchery methodology was transferred to MERIP staff biologists and local students.

During this period, four MERIP staff biologists (three expatriates and one Micronesian) received full training in all aspects of design, installation and operation of a pearl oyster hatchery including microalgae culture, pearl oyster spawning techniques, larval rearing and land-based nursery techniques. Two Micronesian technicians were also trained to assist the biologists in all of these tasks. Fourteen Micronesian students from MERIP also received training in these techniques through organized classroom and practical demonstrations. Seven senior students were able to observe larval and spat development and observe rearing techniques during months 7-10, until they graduated in May 2002. Another group of seven students (class of 2003) had similar exposure to the project in months 7-10, plus hands-on training in axenic algae culture, flask preparation, autoclave operation, spawning induction, egg sampling and enumeration, measurements using an ocular micrometer and stage micrometer and spat husbandry in months 13-14.

Total staff hours spent on this project was estimated at 120 hours per week for biologists and 30 hours of assistance from technicians. This labor included all algae culture, larval rearing, data collection, cleaning, seawater system maintenance, training, and aquaculture education. Members of the local community routinely visited the laboratory, especially on Sundays. Staff and students explained to community members what this project was about and asked that the tanks, which are exposed to the public, not be tampered with in any way. No tampering or vandalism occurred during this larval rearing run.

This project was initially going to conduct a workshop to teach spawning and hatchery techniques for black-lip pearl oysters. Due to the loss of the regional aquaculture extension position in Pohnpei, this segment of the work was cancelled. There were no other personnel available to execute this work. A new MERIP staff member, Tomoaki Yamada, was trained during this time. Mr. Yamada is teaching the aquaculture course at MERIP as well as providing laboratory and field training exercises for the students in the afternoon. One former MERIP staff member, Matang Ueanimatang, has taken a position as Aquaculture Extension Agent at the College of the Marshall Island/University of Hawaii at Hilo and is currently using the knowledge gained from this project to raise black-lip pearl oysters at the college aquaculture facility. He is working with both a Land Grant researcher and a biologist from Robert Reimers Enterprises on a joint hatchery project. He will also be responsible for training college students.

RMI component

Objective 1. Demonstration and seed supply. Provide a means to rescue the Marshall Islands pearl industry through a short-term effort to revive hatchery operations and to document procedures for hatchery operation and production.

The original focus of this project had been to develop a means to reduce predation by *Cymatium* snails on pearl oyster spat and biofouling removal costs. When the BPOM pearl oyster hatchery closed, these experiments were no longer possible due to the lack of oyster spat. Efforts were then made to revive operations at the BPOM hatchery. To complicate matters, the hatchery had been out of operation for nearly two years and had been suffering from certain infrastructure and operational problems even before its closure. Thus, a great deal of planning and coordination was required to determine how to get the hatchery back into operation as much as possible before the consultant arrived in Majuro so that his time could be used as efficiently as possible. The hatchery and algae lab were cleaned, equipment and laboratory supplies were repaired or replaced, and the water and air systems were put back into operation. No uncontaminated algae culture existed at Majuro, so cultures were imported from PATS, The Oceanic Institute and UH Hilo. Local personnel assisted in all efforts.

Additionally, it was necessary to develop a series of agreements between private sector partners and public sector partners regarding use of the facility, contributions of matching funds and in-kind match, and allocation of pearl oyster spat. It was also necessary to find strategic ways to execute the work given the limited availability of funds and support for this effort. It should be noted that the private sector partners (RRE, BPOM and Mid-Pacific Pearls) and the public sector partners (CMI, Land Grant and PRTP) dedicated a significant amount of funds and effort to the initiative. Many individuals who were not obligated to do so, voluntarily spent a great deal of time preparing for and participating in this work.

Broodstock pearl oysters were collected and spawning attempts made. Local personnel assisted in all efforts. Pearl oysters are rare at many Micronesian atolls, and obtaining sufficient broodstock for spawning attempts is often difficult. Complicating this, is the desirability of using only broodstock from the same atoll at which farming is to take place given that significant genetic heterogeneity may exist. In the case of Majuro, pearl oysters have been imported into Majuro from other countries and farmed there, so farmed and even wild stocks of pearl oysters from Majuro have uncertain heritages. Stocks at the Majuro farm also suffer from chronic mortality of an unknown origin. In the case of Arno atoll, the farmed pearl oysters are sourced from Jaluit. In order to adhere as closely as possible to recommended guidelines to use local stock and because it was so difficult to obtain wild stocks in Majuro with known origins, it was decided to use broodstock from Arno.

Spawning pearl oysters proved to be difficult, but one successful spawn was achieved in August 2002, and the spat were used for research at CMI.

Arrangements were made to visit the RRE Arno farm in early July and attempt spawning. This was planned to coincide with the time around the full moon, when spawning attempts usually yield the best results. Six spawning attempts were made during July, August and September, and all but the final one were unsuccessful because of lack of gonad development. Pearl oysters from Arno, Majuro and Jaluit were tried. Additionally, the team also attempted to source pearl oysters from Likiep and other atolls, but failed due to transportation difficulties. Conditioning of the collected pearl oysters was also attempted using methods previously used by Wise and Horbushko. The final and only successful spawning attempt was made on August 26 using collected pearl oysters. The quality of this spawn was rather poor. On day 6, 6 million larvae remained. Wise supervised larval rearing until he was forced to leave Majuro on September 2 due to having another assignment pending. Care of the hatchery was then taken up by Sebastian Horbushko, Rod Bourke and Manoj Nair. The CMI/UHH Aquaculture Extension Agent, Matang Ueanimatang, arrived and took over principal hatchery duties. Ueanimatang had been previously employed at the pearl oyster hatchery in Kiribati, after completion of his teacher training at PATS where he was trained in the FSM component of this project.

Pearl oyster spawning has not been observed to be so difficult in any of the situations previously encountered by the members of the technical team. Successful spawns

were reported for this season by BPOM. The universally poor spawning conditions of pearl oysters from several Marshallese atolls and the fact that regeneration of gonadal material did not occur during the consultant's three-month stay caused great concern among members of the technical team because this was a previously unobserved phenomena. Spawning tends to peak with water temperature, and regeneration of gonadal material occurs within a month or so. Development of gonad material also has been empirically observed to coincide with the monthly lunar cycle. One possible hypothesis is that the beginning of El Niño may have raised water temperatures for a prolonged period thus resulting in the extended barren period. At the same time, coral bleaching was observed by a CMI survey team on several Marshallese atolls. Previously, the Marshalls and the FSM have been largely unaffected by bleaching events believed to be provoked by high water temperatures that have so severely impacted the South Pacific coral reefs. If this hypothesis holds, then it indicates the cyclic climatic events, perhaps exacerbated by global climate warming, may be a threat to the pearl oyster industry and other marine resources. Further research is needed on the topic, as well as development of cost-effective methods for conditioning pearl oysters to avoid future delays in hatchery production.

Difficulties were also encountered at the larval rearing stage due to several reasons. The hatchery's water system was poorly designed and allowed pumping only at certain hours and did not allow for sufficient storage of reserve water. The quality of water in the area surrounding Woja was dubious because of contamination from human and agricultural activities. High mortality began on Day 8 and continued. Antibiotics were administered after Day 8 in an attempt to curb mortality. High and sudden mortality appears to have been a chronic problem during previous years at the BPOM hatchery and no successful larval run had ever been done without the use of antibiotics. Given that antibiotic use is not common in pearl oyster hatcheries, it indicates that there is a serious underlying problem. By Day 20, 300,000 larvae remained and these were smaller than would be expected at this age. Metamorphosis occurred over a prolonged period as is typical with *P. margaritifera*. By the time the spat were between 0.5 and 1.0 cm DVM, only about 1,000 remained (Day 42). It was decided jointly by the partners that since so few spat were produced, it did not make sense to divide them among the industry partners. Instead, the spat were donated to CMI to begin the demonstration farm sponsored by the MSI Sea Grant and the USDA IFAFS projects.

Objective 2 - Training and technology transfer. Transfer pearl oyster hatchery methodology to local aquaculturists, marine science students, marine resource management personnel and private sector individuals in Majuro with the goal of creating a sustainable local capacity to operate pearl oyster hatcheries.

All phases of the hatchery renovation, preparation for spawning, spawning and larviculture were used for the dual purpose of training and demonstration. The

Pearl oyster hatchery methodology was transferred to individuals from government and private agencies.

consultant trained three technicians from MIMRA and BPOM, the CMI/UHH Aquaculture Extension Agent and the Land Grant Aquaculture Researcher in hatchery operations, algal culture and larval rearing. The consultant also taught at CMI and trained marine science students. Fifteen CMI students were involved in some phase of this work and six of them worked as interns at MIMRA before they left to attend college in the U.S. in early 2003.

Industry members from RRE, BPOM and Mid-Pacific Pearls also received training and participated in these efforts. Significant exchange among biologists who work in aquaculture and pearl culture also occurred, and this contributed greatly to efforts in the region. The gathering and sharing of information among so many biologists at this level may be among the first of its kind in the Pacific region, where opportunities to exchange information is rare and often prohibited by the tendency towards secrecy among workers in this area.

The dire situation that resulted from closure of the BPOM hatchery was partially due to the fact that the operators of this hatchery maintained all information related to its operation as an industrial secret. While hatchery methods for pearl oysters are not otherwise unknown, this information has not been widely disseminated. There is usually a large body of information related to any specific hatchery that needs to be known in order to operate that particular facility. The BPOM hatchery had many quirks, and an apparent tendency for pearl oyster spawns to require special treatment to assure survival. Thus, part of this effort included the drafting and publishing of an operations manual specific to the BPOM hatchery to be used for reference by future operators. Wise wrote a description of the procedures used for spawning and larviculture, while Haws and Ellis assisted with literature research, editing and graphics. This was completed in October 2003, although numerous copies of the draft document had been widely disseminated to stakeholders so that the information could be made available to them in a timely manner.

Bioeconomic Study component

Objective 1 - Model the economics of Hawaii/Micronesian pearl farms to inform decision making, management practices and financial strategies.

Final data collection occurred in January 2002 when Dr. Fong, M. Haws, S. Ellis and other collaborators in this effort were able to visit the RMI and FSM under funding from the USDA/IFAFS project. They were assisted by the Reimers family, Virgil Alfred and Bobby Muller in the RMI, and the Nukuoro Pearl Farm representatives, Senator Gerson Lekka and Chief Magistrate George Stephens, in the FSM. The final data collection was somewhat impeded by the serious illness of Virgil Alfred (BPOM farm manager) and the long absence of the Nukuoran

The bioeconomic model was completed and the results were presented to farmers.

Pearl Farm representatives who spent several long periods on Nukuoro Island. Communication with Nukuoro Island is nearly impossible, and this hindered data collection and review. Additionally, marketing study data collected under the IFAFS project was incorporated into the model so that post-production returns would be as accurate as possible. This work was concluded in August 2003, and the model was finalized shortly thereafter. The model was developed and has been reviewed and tested by the work group. A final model using Excel has been produced and can be easily used by any person adept at use of this software.

Work Planned

FSM component

All objectives of the FSM component of the work were met and exceeded in 2002, when the final work was completed.

RMI component

All objectives of the planned work were met and exceeded as of the end of 2002, with the exception of the publication of the hatchery operations manual, which was completed in October 2003.

Bioeconomic Study component

While all CTSA-funded work has been completed, this effort is being continued under funding provided by USDA/IFAFS and contributions from the University of Alaska Fairbanks at Kodiak. Marketing studies that will contribute to the post-production side of the economic model were conducted on the Eastern Seaboard of the U.S. and in Europe in July-August 2004. Data on prices were incorporated into the final version of the model. Some marketing studies will continue using non-CTSA funding during 2004 to keep the model updated as world pearl markets fluctuate.

Impacts

FSM component

It has been clearly established that a small-scale, cost-effective hatchery can be successfully operated in the FSM using local personnel.

RMI component

CTSA has recently placed a consultant in the RMI to continue with production of pearl oyster spat for the RMI farms. Technical personnel who provide services to the region under other programs (E. Ellis, S. Ellis and M. Haws) and local staff trained by David Wise are working to support the new CTSA effort. This new RMI effort is based at two facilities: 1) the College of the Micronesia Arrak Marine Science Center, which has a small, multipurpose hatchery, and 2) the Wotje hatchery, which is currently being put back into operation. Both of these facilities benefited from the work of David Wise and his local counterparts. The RMI-based and visiting personnel, which include Danny Wase (MIMRA), Don Hess (CMI), Simon Ellis (UHH), Maria Haws (UHH), Rod Bourke, Sebastian Horbuskcho and Ramsey Reimers (RRE), Bobby Muller (BPOM), Matang Ueanimatang (CMI) and Manoj Nair (CMI-Land Grant) are currently working with the new CTSA consultant, Rand Dybdahl, to provide support and guidance for his efforts to spawn pearl oysters to supply the RMI pearl farms. These individuals have also worked to provide financial resources to support the CTSA hatchery effort in the RMI.

The hatchery manual authored by David Wise, Simon Ellis and Maria Haws was printed by CMI and has been used extensively in the RMI by the new hatchery operators, Rand Dybdahl, Manoj Nair and MIMRA staff.

Bioeconomic Study component

The model has contributed significantly to the knowledge and ability of pearl farmers and of technical assistance providers to make business management decisions because this model is the first of its kind. The outcomes of the model predict that pearl farms will generally tend to break even in three to five years with profits accruing thereafter. This is using the most conservative predictions and world market price data. In reality, local markets, which are currently absorbing all of the Micronesia production, range from three to four times higher than this with the result that farms become financially self-sufficient earlier than predicted by the model. This information has already been helpful in finding support and garnering interest in pearl farm development from prospective pearl farmers, funding agencies and private investors. Key information such as labor costs, prices and equipment costs have revealed key points of sensitivity that are helping pearl farmers become more efficient and cost-effective.

The results of the model and the process involved in its development were presented to regional stakeholders during the regional IFAFS Collaborative Alliance Meetings in January 2003 (Pohnpei) and July 2003 (Kodiak, Alaska). Further outreach will be conducted under other funding in 2004.

Publications in Print, Manuscripts, and Papers Presented

Wise, D., S. Ellis and M. Haws. 2003. Pearl Oyster Hatchery Operations Manual: Guide to the Woja Pearl Oyster Hatchery. College of the Marshall Islands.

Publications resulting from this work will be submitted to peer-reviewed journals in January 2004.

Literature Cited

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Southgate, P. C. and M. Ito. 1998. Evaluation of a partial flow-through culture technique for pearl oyster (*Pinctada margaritifera* L.) larvae. Aquaculture Engineering 18:1-7.