Aquaculture Extension and Training Support for the U.S.-affiliated Pacific Islands with a Special Emphasis on Hatchery Propagation of the Black-lip Pearl Oyster (*Pinctada Margaritifera*), Year 15

General Information

Reporting Period August 1, 2004–July 31, 2005 (Year 15, final report)

Funding Level

Year	Amount	Year	Amount
1	$100,000	8	$75,000
2	$82,870	9	$85,000
3	$73,600	10	$85,000
4	$70,000	11	$75,600
5	$75,000	12	$100,520
6	$98,000	13	$114,300
7	$70,000	14	$70,000
		15	**$92,156**
		TOTAL	$1,267,046

Participants

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Objectives

The goal of this project was to assist the development of an economically sustainable aquaculture industry in the U.S.-affiliated Pacific Islands with an emphasis during the past two years on producing black-lip pearl oyster spat for the pearling industry in the Republic of the Marshall Islands (RMI). Another goal focused on training locals in hatchery methodology and pearl farm husbandry. Outlined below are the specific objectives:

1. Refine spawning and hatchery techniques, and provide a regular supply of black-lip pearl oyster spat to satisfy industry needs.

2. Improve spat survival and growth during the nursery phase.

3. Collect database on spat growth and survival to update and incorporate into an already funded cost production model for hatchery propagation and growout of black-lip pearl oyster spat.

4. Transfer technology by publishing a site-specific black-lip pearl hatchery manual and by providing extension training and support for black-lip pearl oyster culture. Conduct workshops in the RMI and other U.S.-affiliated Pacific Islands, such as Guam, American Samoa, and the FSM.

5. Extension training and support for other commercially important aquaculture species.

Principal Accomplishments

The major constraint to industry expansion has been removed, as spat have been successfully propagated during the period of the project at the Arrak Campus Hatchery of the College of Marshall Islands (CMI). The first hatchery run in June 2003, for example, produced more than three times the requested needs of settled spat for each of the two participating commercial pearling companies. The remaining spat were grown out on the Arrak demonstration pearl farm. After two years, these experimental pearl oysters at the time of this report have grown large enough (i.e. >100mm shell length) that they now could be seeded (i.e., a nucleus implanted) to produce cultured pearls. Thus, we have demonstrated the feasibility of the project to use hatchery-propagated spat to revive the pearling industry in the RMI.

The above success, however, was not reflected in the almost 0.5 million spat from the first two hatchery runs distributed to both of the two participating commercial companies, which claim that almost all of their spat died during initial growout. In return for providing them with free spat, the companies initially were meant to provide the project investigators with data on spat growth at different locations. Given the limited amount of feedback obtained from the companies, the growout advice provided by the principle investigator apparently went unheeded; the spat apparently went unattended; and the spat mortality apparently went beyond anything encountered in the investigator's previous 20 years of experience in growing out spat anywhere (on 18 other pearl farms in five countries).

Later, at a stakeholders meeting, the companies said that growing out spat "was too hard," and they agreed initially to let outer-island communities, interested in generating an alternative/supplementary income, grow out spat that they would then buy from the communities. However, towards the end of the first year of this project, the companies reneged on this agreement, thereby thwarting the outer-island communities' entree into pearling.

The two companies continued to withdraw support for the project when it became certain that CTSA funding could not be used to renovate the defunct commercial hatchery at Woja. At the first stakeholders meeting in April 2003, all had agreed that for producing pearl oyster spat during the first few hatchery runs, it seemed more expedient to convert the experimental sea cucumber hatchery at Arrak than to wait for the Marshall Islands Marine Resources Authority (MIMRA) to take control of the Woja hatchery and buy the necessary equipment to make it operational again. This equipment was finally ordered more than two years later, and the Woja hatchery is just now becoming operational in September 2005. Having committed themselves to renovate the Woja hatchery, the companies refused further project spat, even though the principal investigators (PIs) offered to grow out the spat to a larger size at the Arrak demonstration farm before distribution to the pearl farms, i.e., the PIs offered to take on additional responsibility to reduce spat mortality during initial growout.

This project can best be termed a qualified success, as the main technical objectives were met, but the vested stakeholders interpreted the outcomes as different from their expectations.

Objective 1: Refine spawning and hatchery techniques, and provide a regular supply of black-lip pearl oyster spat to satisfy industry needs.

At an April 2003 meeting, industry stakeholders agreed that the former commercially owned hatchery at Woja was in such a state of disrepair that it would be more expedient to modify the existing sea-cucumber hatchery at the CMI's Arrak campus for the project's first pearl oyster spawning trial and hatchery run. The initial improvisation culminated in a successful hatchery run in June 2003. The project scientists produced more than sufficient quantities of settled spat (1.07 million) to meet the immediate needs of existing farmers (the two commercial companies had each requested 100,000 spat, but each were given some 370,000 settled spat in the initial distribution and some 20 additional bags of spat in a second distribution upon request several weeks later). The remaining spat provided for experimental research and demonstration at the Arrak pearl farm.

With further modifications (e.g., the addition of an aeration system) and improvements (e.g., the purchase of water heaters and submersible pumps) to the Arrak hatchery, the project scientists conducted another successful pearl oyster spawning trial on May 15, 2004 that went like "clockwork." The tens of millions of fertilized eggs produced was, again, well beyond the carrying capacity of the Arrak hatchery, and the excess larvae were culled/discarded progressively to ensure that enough settled spat (small, post-larval pearl oysters) remained at Day 42 (June 30, when the spat had grown to an average size greater than 2.5 mm) to fulfill the RMI pearl industry's spat growout needs. The spat (>>100,000 for each of the two commercial farms, RRE and BPOM) were picked up by the commercial companies on June 30 and taken to their farms on Arno atoll for growout.

The comparative "ease" of the second hatchery run resulted from small refinements and "tricks of the trade" (e.g., light aeration in the larval tanks to aid the planktonic larvae to swim upwards in the water column as well as to evenly distribute their phytoplanktonic food) incorporated by the experienced PI into his standardized hatchery protocol (see site-specific manual, in prep.). It should be noted, however, that the improvements to the site were done "on the cheap," as everyone initially assumed that subsequent hatchery runs would take place at Woja once the renovations at that larger, "purpose-built" hatchery were completed.

The shortcomings of the Arrak hatchery's "temporary" refit became very apparent during the two major hatchery runs in 2005. Both of these hatchery runs were

severely curtailed when electrical power surges burnt out the UV sterilization units (the UV lights are used to "sterilize" incoming seawater during a water change of the larval rearing tanks), resulting in a major influx of competing protozoans and unwanted bacteria.

As the commercial companies were so adamant last year in declining our offers of further spat from our project, we drastically culled the numbers of pearl oyster larvae and switched back into experimental mode. We determined the growth of pearl oyster spat kept in the hatchery for a longer period before going to sea for further growout in order to salvage some information from both these hatchery runs (please see experimental results below, under Objective 2).

Objective 2: Improve spat survival and growth during the nursery phase.

The first pearl oyster hatchery run in 2005 was conducted between the spawning trial on Feb. 10 and April 27 (i.e., 75 days), when the remaining spat were removed from the Arrak nursery tanks and suspended on the longline on the demonstration pearl farm at Arrak. The hatchery run started with more than 6.5 million eggs released from just five ripe/gravid spawning females. On Day 5, however, a power surge burnt out the UV light bulbs. We salvaged the run by culling/discarding almost 90% of the larvae (i.e., we suspected that they may have been morbid if on the tank bottom or swimming weakly near it).

Switching into experimental mode, we saved the larvae swimming near the top of the water column and later removed them as spat from the hatchery settlement tanks on Day 45 (at which time the average spat shell length/dorso-ventral length or DVL was 2.44 ± 0.60mm with a range of 1.70 – 3.37mm; n = 126) to compare spat growth kept in the land-based nursery tanks with spat grown at sea on the demonstration pearl farm. On Day 75, the DVL of the spat kept in the nursery tanks was significantly greater compared to the DVL of spat taken to the farm. The DVL of the spat in the nursery tanks averaged 7.33 ± 1.20mm (range 3.40 – 12.23mm; n = 71), whereas the DVL of spat on the farm averaged 5.42 ± 0.91mm (range 3.48 – 6.92mm; n = 62).

This size difference seemingly reversed the results of several previous comparisons, where an initial growth spurt was seen when the spat taken to sea encountered more than just the four species of microalgal food in the limited diet of their hatchery counterparts. In this experiment, however, the incoming seawater was only filtered down to 25µ so that the seawater still contained algal food that supplemented the hatchery diet of four microalgae species. The spat grown at sea had no additional costs associated with their growout; whereas, the spat on land necessitated costs for food production and electrical power associated with pumping

seawater. In an earlier comparison that the PI had conducted in Western Australia, where electrical power was only $AUS0.06/kW hour, spat growout on land was simply not cost effective. It is likely even less cost effective in the RMI, where electrical power is charged at a rate of $US0.20/kW hour.

The last pearl oyster hatchery run for this project was conducted in 2005 between the spawning trial on May 25 and Aug. 9 (i.e., 75 days), when the few remaining spat were removed from the Arrak hatchery and suspended on the longline on the demonstration pearl farm at Arrak. The hatchery run started with more than 30 million eggs released from just three ripe/gravid spawning females. During the first week, however, a power surge, again, burnt out the UV light bulbs and their ballasts.

We, again, drastically culled the numbers of pearl oyster larvae and switched back into experimental mode to determine the growth of pearl oyster spat kept in the hatchery for a longer period than the usual 42 days after spawning before being taken to sea for further growout. At Day 75, the spat averaged a shell length (DVL) of 9.07 ± 1.74 mm (range 5.83 - 12.77mm; n = 54). The rather "stunted" growth of the spat also was not helped by their feed being composed of only three microalgae species instead of the usual four species. The fourth species had died/overheated, as the air conditioner in the algal room had not cooled efficiently for some time after the above power surge.

Neither of the above hatchery runs produced a number of settled spat sufficient enough to repeat the same growout experiments done at Arrak on optimum spat stocking density, types of containers, depths of hanging, onshore growout during nursery versus farm growout (see Appendix 1). The general applicability of the results of the Arrak experiments also suffered from having no comparable spat survival and growth data from other locations, as the commercial pearl farmers simply stated that all their spat had died.

Objective 3: Collect data on spat growth and survival to update and incorporate it into an already funded cost production model for hatchery propagation and growout of black-lip pearl oyster spat.

Data obtained from the small-scale experiments conducted at Arrak under Objectives 1 and 2 above have been recorded, tabulated in Excel-based worksheets and analyzed (see Appendix 1). But without a much larger database of results from the commercial companies, we would be most hesitant to try to extrapolate our possible anomalous (i.e., the growth rate of spat at Arrak is much less than the PI has recorded in five other pearling countries) experimental results into the cost production model of Dr. Quentin Fong.

Objective 4: Transfer technology by publishing a site-specific black-lip pearl hatchery manual and by providing extension training and support for black-lip pearl oyster culture. Conduct workshops in the RMI and other U.S.-affiliated Pacific Islands, such as Guam, American Samoa, and the FSM.

The draft outline of the hatchery manual was completed some time ago, but none of the seven local hatchery trainees were literate enough for a written manual to be of much use. The promised CMI graduates and government trainees never materialized. While the hatchery positions were advertised nationally, applicants were hired for their proximity to the rather "remote" Arrak hatchery (to minimize transportation difficulties) rather than for their academic credentials (i.e., none had completed high school).

As a consequence, almost all of the practical pearling training resulted from "hands-on" competency trials conducted after they were shown what to do in the hatchery or on the pearl farm. The original idea of translating the manual into the local language was scrapped when it was realized that there were no Marshallese word equivalents for any of the key hatchery apparatus.

The need for a site-specific pearl oyster hatchery manual is lessened further by the efforts to make over the Woja hatchery. The Arrak pearl oyster hatchery is effectively superseded. Now that the CTSA funding for this project has ceased, the new Director of MIMRA apparently has "told" the Dean of Land Grant that to make the Woja hatchery commercially viable, all pearl farmers should buy spat from that hatchery in future. The Arrak hatchery now may revert to use mainly for aquaculture extension training and experimental work on sea cucumbers or some other commercially important aquaculture species.

Throughout the past two years, the PIs have fielded a number of requests from the outer-island communities interested in pearl oyster mariculture as another source of income. In an attempt to benefit the RMI pearling industry as a whole, the PIs proposed that the outer-island communities be paid for growing out spat to a size required by the existing pearl farms. When the commercial companies later reneged on this agreement, the PIs conducted a series of radio programs/announcements and gave presentations to explain the concept of "satellite farming" (please see Impacts below) to the mayors of interested local governments. They wanted to give all atolls a chance to participate in the proposed pearling extension training at Arrak that was slated to begin after CTSA funding ceased in July 2005 (see Recommended Follow-up Activities below).

Objective 5: Extension training and support for other commercially important aquaculture species.

During the past two years, no formal requests have come to the PIs for extension training and support for commercial aquaculture species other than for pearl oysters. On behalf of the Rongelap Atoll Local Government, Dr. Nair, however, did attend a finfish mariculture workshop held in Indonesia before the 2005 World Aquaculture Society Conference.

Impacts

Black-lip pearl farming is one of the very few sustainable commercial aquaculture activities in the Republic of the Marshall Islands that can be undertaken by companies and by outer-island communities that traditionally have been dependent almost solely on copra for income generation. Additional economic opportunities may reverse the current trend of the outer islanders gravitating to the capital to seek work (more than 30% of the RMI's workforce is unemployed). To provide an alternative/supplementary income source on RMI's outer-islands, pearl farming is advocated because pearl oysters can be cultured using simple, relatively low-cost technology (i.e. many inexpensive farm longlines and pearl nets can be purchased for the equivalent capital cost of a single hatchery) that is suitable for small-scale operations/community-based production.

Extension training in all aspects of pearl farming can then be given to outer-island community representatives, who have already expressed an interest in pearl oyster hatchery propagation and growout husbandry techniques. The project concept of "satellite farming" involves technology transfer by providing hatchery-produced spat to community-based growout farmers on the outer islands. These groups can thereby supplement their incomes by growing out spat to sizes requested and paid for by larger commercial pearl companies or "wealthier" atoll communities wishing to "fast-track" their commercial pearling enterprises. The confidence and competence gained by the growout farmers should empower them to start their own pearl farm in the future at these outer-islands.

The ultimate end product, a cultured pearl, is high in value, non-perishable and easy to transport to well-established markets. If total pearl production in the RMI reaches worthwhile "critical value," buyers will come to attend pearl auctions as they do in more established pearling countries.

Recommended Follow-up Activities

Like most of the Micronesian Islands, the wild pearl oyster stock populations of all of the atolls in the RMI have been over fished in the past. So now all pearl farms are dependent on hatchery-produced spat. The College of the Marshall Islands Land Grant hatchery at its Arrak Campus, however, is now already established and capable of producing sufficient numbers of spat for the future needs of all of the outer-islands of the RMI. Arrak's existing demonstration pearl is located in the lagoon nearby, and outer-island community representatives can be accommodated in the former student dormitory adjacent to the Arrak Hatchery. Thus, pearling trainees can receive extension training in all aspects of hatchery propagation of pearl oysters and farm husbandry of spat during grow out at Arrak, before they are helped to establish pearl farms on their home atolls.

USDA Land Grant and United Nations Development Program funds have been sourced to defray most of the costs of the extension training, farm materials and airfares to and from the outer islands. The local governments of five atolls already have signed a memorandum to have their community nominated representative undertake the first extension training course that is slated to begin in August 2005.

Publications in Print, Manuscripts, and Papers Presented

Nair R., M. and R.E. Dybdahl. 2004. Status of black-lip pearl oyster farming in the Republic of the Marshall Islands. Proceedings of the World Aquaculture Society, Honolulu, Hawaii, March 1–5, 2004. Journal of Shellfish Research 23(1):304.

Nair, R. M. and Dybdahl, R.E. 2005. Atoll community based satellite black-lip pearl oyster, *Pinctada margaritifera*, farming model for alternative or supplementary income generation in the Republic of the Marshal Islands. Presentation at the World Aquaculture Society Conference, Bali, Indonesia, May 9-13, 2005.