

USE OF GEOTHERMAL ENERGY FOR AQUACULTURE PURPOSES

PHASE III - FINAL REPORT

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ABSTRACT

This project, financed by the Pacific Northwest Regional Commission (PNRC), was designed to provide information to evaluate the best methods to use for intensive aquaculture of freshwater prawns, *Macrobrachium rosenbergii*, using geothermal energy. The freshwater prawn is a tropical organism and is native to southeast Asia. Earlier projects at Oregon Institute of Technology have shown the feasibility of culturing this aquatic animal in geothermal water. This phase of the project was designed to investigate intensive culture of this animal as well as the advantages of growing rainbow trout, ornamental tropical fin fish, and mosquito fish, *Gambusia affinis*, for vector control using geothermal energy.



FRESHWATER PRAWN (*macrobrachium rosenbergii*)
Eight months growth in OIT pond

The research data collected on the prawns was obtained from the stocking and sampling of two 0.2-ha (half-acre) ponds constructed as a part of the project. The ponds are equipped with recording monitors for temperature and flow. The geothermal energy used is the geothermal effluent from the Oregon Institute of Technology heating system. This water is of potable quality and ranges in temperature from 50 to 70°C. The geothermal water used in the ponds is controlled at 27°C, $\pm$ 2°C, by using thermostats and solenoid valves. A small building next to the ponds contains facilities for hatching larvae prawns and tanks for growing post-larvae prawns. The hatchery facility makes the project self-sustaining. The hatchery was obtained as part of an earlier PNRC project.

INTRODUCTION

Aquaculture feasibility is more than a simple measure of the compatibility of an organism to its aquatic environment. For commercial purposes, it involves the development of harvest-able yields and the application of those yields along with current market values, capital, and operation costs to a program geared at resolving the true economic feasibility of that venture.

Phase III of this research program at Oregon Institute of Technology was initiated to supply potential investors and commercial operations with technical assistance and information on yearly harvests and pond densities of prawns that could be used for compilations of baseline data.

In order to obtain results which would be similar to that of a commercial operation, two 0.2-ha (half-acre) ponds were constructed and stocked with 48,000 post-larval (PL) prawns. Growth and density data has been gathered and is presented along with initial harvest information.

Other research information has been gathered during this phase of the operation and involves initial investigations with our ability to raise warm-water crops such as ornamental tropical fish or winter crops of Salmonid species, trout, in geothermally-heated ponds. Two manuals were also prepared as a part of the investigation to provide technical information on geothermal aquaculture to the public.

Phase III of the project "Use of Geothermal Energy for Aquaculture Purposes," funded by the Pacific Northwest Regional Commission, was initiated in an effort to construct commercial-size ponds, stock them with prawns, and determine what yields could be obtained on a yearly basis for each 0.2 ha (half acre) of pond and raceway system. With this type of information available to the public, it would be possible to provide investors with the necessary information required to perform economic feasibility studies for potential geothermal commercial prawn farms. These aquatic farms could utilize geothermal water to maintain a constant tropical temperature of 27°C (80°F), $\pm$ 2°C, in an aquatic environment which would provide optimum growth rates for prawns.

METHODS AND MATERIALS

Construction of the commercial-size ponds was completed in September of 1980. The two ponds are 0.2-ha (half-acre) ponds measuring 30.5 m wide by 64 m long and 1.2 m in depth (100 ft x 210 ft x 4 ft) installed on the Oregon Institute of Technology campus and plumbed to receive the college's geothermal effluent (Figure 1). The geothermal distribution system to each pond is designed to

provide uniform heating to each pond and one which would present the least amount of obstruction for a continuous seine harvest operation (Figure 2). The design of this system was engineered so that each pond would receive a flow of 528 L/m (160 gpm) of 57.2°C (135°F) water to meet heating requirements of this area. This flow has been substantiated through recordings from the project's electromagnetic flow meter (Figure 3). Final preparations for utilization of the new commercial-size ponds were accomplished by moving the hatchery building to the site in order to provide the project with post-larval (PLs) prawns. These PLs are available for a program oriented towards a continuous harvesting and restocking program; since, the project developed its own supply of gravid females.

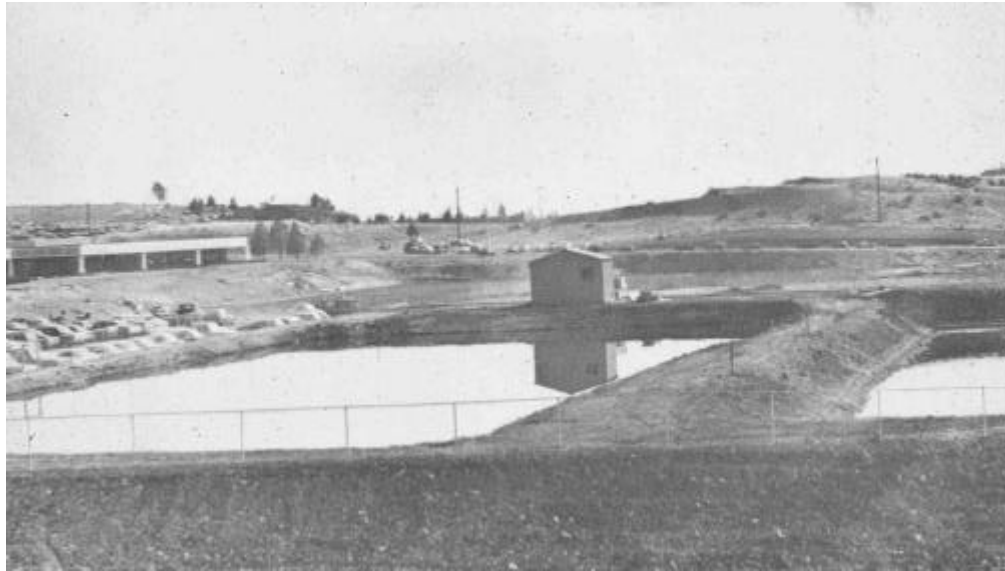


Figure 1. Two 1/2-acre geothermal aquaculture ponds at OIT.



Figure 2. Geothermal distribution system.



Figure 3. Flow is measured by an electromagnetic flow meter.

In October 1980, the ponds were filled with water, fertilized with barnyard manure, and allowed to age three weeks before planting 48,000 PLs ordered from Hawaii. All of the shipment was planted in one pond.

In November, severe weather conditions produced ambient air temperatures, as low as -15°C (5°F), and it was discovered that there was not enough geothermal energy to maintain both ponds at 27°C (80°F), but the other pond could only be maintained at 15.6°C (60°F).

It was decided that when both ponds could be maintained at 27°C in the spring of 1981, that the prawn crop would be divided equally between both ponds.

Due to territorial and cannibalistic behavior of prawns, a substrate of cured manzanita brush was placed in the ponds to determine if its application could provide more space for the individual prawns and reduce cannibalism (Figure 4). The brush was weighted and nylon rope attached so that it could be removed from the ponds when seining was done. Subsequent observations and harvests have shown that the prawns do prefer the areas around and in this brush substrate to the open pond areas. Utilization of a substrate, such as manzanita, provides much the same space as individual cage and intensive culture systems do where higher than normal densities are observed.

When it became obvious that both ponds could not be maintained at 27°C (80°F) through the winter months, correspondence was initiated to see if the pond, without prawns, could be used for rearing trout. Permission was granted by the Pacific Northwest Regional Commission to proceed with this type of research and 20,000 fingerling trout at 44 fish per 0.45 kg (1 pound) were supplied by the Oregon Department of Fish and Wildlife, Klamath Trout Hatchery. The trout were planted on January 7, 1981, in the vacant 0.2-ha (half-acre) pond. The pond temperature was maintained at 15.7°C (60°F) $\pm 2^{\circ}\text{C}$ through this research period.



Figure 4. Manzanita brush used as substrate in aquaculture pond.

RESULTS AND DISCUSSION

On March 16, 1981, the Oregon State Department of Fish and Wildlife removed 462 kg (930 pounds) of trout averaging 25.5 fish per kilogram (11.6 fish/pound) (Figures 5 and 6). The remaining trout were removed on April 24, 1981, averaging 14.7 fish per kilogram (6.7 fish/pound) with a total weight of 384 kg (840 pounds). The initial weight of trout when received was 90 kg (200 pounds) and the total weight of all trout removed was greater than 800 kg (1,770 pounds). The rate of growth for the trout reared in geothermally-controlled ponds was approximately three times greater than that observed at the state trout hatchery where fish of the same age and strain were cultured in 7.2°C (45°F) water.

At the conclusion of the trout experiment, the pond was drained and the pipes for the distribution and heating system were changed by enlarging the size of the orifices. This change would allow for an increase in the volume of supply water, so pond temperature could be maintained at 27°C (80°F) if an adequate supply of geothermal effluent was available. The pond was then refilled and approximately 3,000 prawns for pond #1 were transferred into it.

Research information as to growth rates and yields of the prawns stocked on November 18, 1981, in the 0.2-ha (half-acre) ponds have been recorded and are as follows:

Samples were obtained through a random grab technique using a bobbinet seine with a 0.95 cm (3/8 in.) mesh opening. Weight of the post-larval prawns when stocked on November 18, 1980, averaged 0.4 grams each.

<u>Date</u>	<u>Average Weight</u>
February 8, 1981	1.3 grams
May 25, 1981	11.8 grams
July 2, 1981	11.5 grams
August 28, 1981	15.8 grams



Figure 5. Trout samples being collected for growth rate data.



Figure 6. Stocking-size trout being collected for U.S. Department of Fish and Wildlife.

Data obtained through these random grab samples indicates that a one-year grow-out period is required to raise prawns to a market-able size of 40 to 50 grams each. However, prawns do not exhibit a uniform growth pattern in pond culture systems, and a “bull/run” phenomenon occurs; where, some prawns grow several times faster than others. Because of this phenomenon, a selective harvest operation was initiated on August 3, 1981, using a seine net with a 2.5 cm (1 in.) mesh size (Figures 7 and 8). This type of harvesting has allowed for the netting of market-size prawns, while leaving the smaller prawns in the pond to continue growing. Results from the selective harvest were as follows:

<u>Date</u>	<u>Total Weight</u>
August 3, 1981	20.5 K (45 pounds)
August 24, 1981	4.5 K (10 pounds)
September 16, 1981	18.1 K (40 pounds)



Figure 7. Seining prawn samples for growth data.

Growth data from previous experiments at Oregon Institute of Technology has yielded results which were 1.4 times greater than the present data. However, during Phase III, we did not reach the expected rates and feel that the largest factors that led to the poor yields were the inconsistent and interrupted supply of primary and secondary heating water. These deficiencies were the result of campus construction projects and geothermal shutdowns. Each time the temperature of the ponds dropped below 27°C (78°F), the growth of the prawns was slowed down or stopped. Adverse metabolic changes were the result of thermal shock and, for several days up to a week, the prawns would not eat. Even though growth rates were less than normal, they are still equal to those obtained in Hawaii; where, yearly yields have been reported at 1,800 kg (3,900 pounds) of whole prawns per 0.4 ha (1 acre) of pond.



Figure 8. Collection of seined prawns (July 2, 1981).

In order for a commercial geothermal prawn operation to be economically feasible, a resource evaluation would have to be performed as to quantity and quality of water available, site location, and size of the operation. It is our consensus that a prawn farm should have a minimum pond surface area of 4.0 ha (10 acres).

As for market potential, correspondence with a seafood broker in San Francisco, California, indicates a large demand exists for prawns as he is willing to pay from \$7 to \$9 per 0.5 kg (per pound) for a fresh constant supply of whole prawns in the size range of 18 to 24 whole prawns to the kg (8 to 10 prawns/pound). His only stipulation was that he would need to have a minimum supply of 5,000 kg (10,000 pounds) per month.

Other information related to the economics of geothermal prawn operations, such as labor force requirements, hatchery costs and operations, and harvesting techniques have been presented in earlier publications funded by the Pacific Northwest Regional Commission and the Geo-Heat Center at Oregon Institute of Technology. These publications are, *Geothermal Aquaculture Project* - a feasibility study; *A Layman's Guide to Geothermal Aquaculture*; *Geothermal Aquaculture: A Guide to Freshwater Prawn Culture*; and *Use of Geothermal Energy for Aquaculture Purposes*.

Although acceptable growth rates for the prawns have been attained in this phase of the aquaculture project, they have fallen behind previously recorded data due to temperature fluctuations in the ponds. As reported earlier in this report, one aspect which leads to optimum growth occurs when the prawns are subjected to a constant thermal environment which enhances their maturation process. We believe that more favorable data could be obtained in future research; since, some of the problems associated with water supply for the project have been remedied. One of the major reasons for interruptions of

primary and waste geothermal water was due to construction projects on campus. These have been completed and regular geothermal flows have resumed.

When favorable conditions exist for prawn growth, harvest-able size bulls, large males, can be seined out of the system at eight months past the post-larval stage. In an ideal prawn operation, the culturist would stock only the faster growing “bulls,” <15 cm in his grow-out system, and possibly utilize the “runts,” >5 cm as a supplemental food source. To achieve this type of system, the farm would need some primary grow-out ponds to raise PLs to a juvenile stage before stocking them in production ponds. If additional funding were available to continue the project, yields for this type of stocking system could be investigated.

Upon completing construction of the two 0.2-ha (half-acre) ponds, the previous demonstration ponds built as part of an earlier PNRC project became available for new research programs. Since most aquarium fish are tropicals that are imported to the West Coast from the Far East or Florida, we elected to see if they could be reared in a geothermally-controlled environment. The two small ponds were filled with geothermal effluent water and heated to a temperature of 25.5°C (78°F).

On January 14, 1981, ten Firemouth Cichlids (*Cichlasoma meeki*), eight Gold Sailfin Mollies (*Mollesia Sp.*), and several species of goldfish including Orandas, Shubunkins, and Comet Tails were placed in these smaller ponds. The mollies were unable to adapt to our geothermal waters, but survival of the cichlids and goldfish were above 90% for a five-month research period. During this time, the goldfish exhibited exceedingly fast growth rates--Comet Tails grew from 6.35 cm (2 ½ in.) in length and a weight of 1 oz. to a length of 27.94 cm (11 in.) and a weight of 12 oz., and the Firemouth Cichlids, which are egg layers, have produced approximately 4,000 offspring.

Other aquatic crops that also need investigation as to viability and yields include several other species of tropical aquarium fish and plants, plus yields of other types of food fish such as tilapia, in geothermally-controlled environments. Once this type of information is available to the public, potential investors can utilize this data to determine the feasibility of using geothermal waters for an aquaculture venture.