1993 Project Abstract
FOR THE PERIOD ENDING JUNE 30, 1995
This project was supported by the MN Future Resources Fund.

TITLE: Minnesota Aquaculture Development Program (MADP)
PROGRAM MANAGER: Ying Q. Ji
ORGANIZATION: Minnesota Department of Agriculture
LEGAL CITATION: M.L. 93 Chpt. 172, Sect. 14, Subd. 3(g)
APPROPRIATION AMOUNT: $230,000

Statement of Objectives

To administer a grant program that funds projects which evaluate and develop environmentally sound aquaculture systems.

Results

The grant review process and industry recommendations, which included peer review and review by the Minnesota Aquaculture Commission, resulted in the funding of four projects. All four projects provide information which is applicable to the aquaculture industry, and all four have the potential to lessen the environmental impact of fish production.

1. *Demonstration of the FIS-C Aquacultural Bioenergetics Model for Estimating Waste Loads and Optimizing Feeding at Two Commercial Rainbow Trout Farms:* Natural Resources Research Institute, with Trout Air Rec. Center and Wildsprings Trout Farm.

   The study adapted an effluent model (FIS-C) for assessing the impacts of fish waste loads for rainbow trout and tested the model at two Minnesota commercial aquaculture facilities. The model provides method of estimating the magnitude and seasonality of discharges from fish farms and also has excellent potential for predicting the effects of different waste collection strategies. The model predicted that waste loading at one site was dominated by wasted food, while egested and excreted material dominated the waste loads from the other facility. Measured waste loadings were within the range expected from literature surveys. Model results could be used to suggest improvements in system efficiency. The model could be used by future growers to predict impacts for regulatory agencies and to design systems that minimize those impacts.

2. *Production of Horticultural Products from Aquaculture Wastes:* Minnesota Aquafarms, Inc. and Bemidji State University.

   Fish mortalities and manure were collected for development of a marketable compost by Bemidji State University. The application of selected microbial culture/enzyme solutions speeded the composting process and resulted in a high nutrient value end product. The final product of the experiment was a superior compost material which met all MPCA standards and had a N:P:K ratio of 2.5:0.8:0.2. However, overall analysis indicated that this composting method remains economically infeasible due to several factors including the expense and difficulty of dewatering waste materials, the high-cost of culturing innoculum species, and the competitive nature of the compost market.

3. *Field evaluation of an energy efficient aeration device for aquaculture:* St. Anthony Falls Hydraulic Laboratory, University of Minnesota, with Minnesota Aquafarms, Inc. cooperating.

   A new aeration concept developed at the St. Anthony Falls Hydraulic Laboratory can significantly reduce the operating costs for aeration in aquaculture and other applications. This study investigated application of this technology in deep-water fish farming. This research indicated that energy savings of 30 percent or more are possible. The results of the field studies provided valuable data that will be useful for the design and implementation of improved aeration systems for a broad range of applications.

4. *Development of a Cold Temperature Feed Regime for Aquaculture:* Minnesota Aquafarms, Inc.

   This study investigated feeding strategies for rainbow trout and chinook salmon at water temp's. below 4 degrees C. Because outdoor Minnesota fish farms are forced to operate in less than optimal conditions, the regime's developed could reduce costs, improve production, and lessen environmental impacts. Rainbow trout fed daily had significant weight gains over the study period. Those with reduced rations maintained stable body weight. There was no significant change in body weight of chinook salmon regardless of ration. The study indicated that salmon stop growing altogether at 2 degrees C, and that body weight and form can be maintained with feeding frequency of only twice per month. Therefore any feed fed to those fish beyond twice per month is wasted. Adopting this new regime could save a one million pound grower $36,000 annually in labor costs alone.

Project Results Use and Dissemination

All project reports will be reproduced, bound and offered widely through our aquaculture newsletter free of charge.

Project #1. The results have presented to the Combined North Central and Ninth Annual MN Aquaculture Conference (Feb. 1995). The results will be submitted to the Journal of Aquaculture and Progressive Fish Culturist. Results may be applied to all sorts of culture systems for assessing the sizing or siting of facilities, feed waste, oxygen demand, waste load, species mixes, size classes...

Project #2. Results presented to 95th American Society for Microbiology Annual Meeting (May 1995), 1995 American Society of Agronomy (Oct. 1995). If improved, methods may be adopted by the aquaculture industry, fish processing plants, and resorts.

Project #3. Will be offered for presentation at 10th Annual MN Aquaculture Conf. and a "notes" type submittal prepared for an industry journal. Can be used to improve the return from any rainbow trout/chinook salmon facility with cold water conditions.

Project #4. Is an extension of work described at two ASME symposium articles. Two peer reviewed journal articles are now being prepared on this phase of the studies. Results will be useful for the design of improved aeration devices for a number of applications.

Date of Report: July 1, 1995

LCMR Final Workprogram Update Report

I. Project Title: Minnesota Aquaculture Development Program

Program Manager: Ying Q. Ji
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Address: 90 W Plato Blvd., St. Paul, MN 55107
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A. Legal Citation: M.L. 93 Chpt. 172, Sect. 14, Subd. 3(g).

Total Biennial LCMR Budget: $230,000.
Balance: $84,279

Appropriation Language: This appropriation is from the future resources fund to the commissioner of agriculture to conduct a grant program for the evaluation and development of environmentally sound aquaculture systems.

B. LMIC Compatible Data Language: N/A

C. Status of Match Requirement: N/A

II. Narrative:

Aquaculture is a rapidly developing industry in Minnesota as well as in the United States. There have been millions of dollars of private funds invested in Minnesota aquaculture in recent years. Little is being done in the state for infrastructure building and for developing new and more efficient technology to facilitate this young and fledgling industry. This project is a grant program that will encourage evaluation and research of environmentally sound aquaculture production systems. Administration of the grant process will be accomplished through consultation with the Minnesota Aquaculture Commission, peer review recommendation, and other administrative procedures, to ensure the quality of proposals funded. One to one matching will be required on research grants. All projects funded under this program will be demonstrated to their fullest extent to their end users and beneficiaries.

III. Statement of Objectives:

A. Administration of grant program and facilitation of demonstration.
B Grants for evaluation and development of aquaculture technology.

IV. Objectives:

A. Title of Objective: Administration of Grant Program and Facilitation of Demonstrations.

A.1. Narrative: Well established and accurate execution of granting process are essential for the success of the Minnesota Aquaculture Development Program. There will be three components under this objective: establishment of granting process, administering of funds and funded projects and facilitation of demonstration of funded projects.

A.2. Procedures:

A process of calling for and evaluation of proposals and on funding decisions will be established and published. The process will be consistent with applicable state laws and regulations. Rules governing the granting process will be adopted if necessary.

Once granting processes and funding criteria are established and published, calls for proposals will be sent out. All proposals will be screened according to granting rules and criteria. Screened proposals will be sent to no less than three peer reviewer from a pool of experts the department will maintain. Both proposals and comments from reviewers will be presented to the Minnesota Aquaculture Commission for consultation. The final funding decision will be made based on reviews from peers and recommendations from the commission.

Staff (a part time staff person will be hired to administer this program) will be working with grantees on technical merits of conducting the projects(s) on a regular basis. All funded projects will under-go a review by department staff and grantees will be required to submit progress reports on a regular basis to ensure compliance with the proposed objective(s). Whenever appropriate, results from projects funded by the program will be demonstrated their fullest extent to fish farmers and prospective fish farmers. Staff will also facilitate on-site demonstration of funded projects when feasible and summarize and publish project results if appropriate.

A.3. Budget:

a. Amount budgeted: $45,000
b. Balance: $34,279

A.4. Timeline:

A.5. Status: The granting process was established and a solicitation (RFP) was published in the State Register and widely publicized to the aquaculture community through our newsletter, the *Aqua Culture News*. We modified the process to include a "pre-proposal". The purpose of the pre-proposal was to screen out projects that clearly did not fit program eligibility requirements so that applicants did not waste time developing a full proposal if their idea was ineligible for funding under the MADP guidelines.

There were 21 pre-proposals submitted, totaling $600,000. Thirteen met the grant criteria and were invited to submit full proposals. Eleven of the 13 were developed into full proposals. The titles, dollar amounts and matching funds are listed on the next page.

The proposals were then reviewed by department staff and peer reviewers. A part time worker was hired to oversee the review process and facilitate project review activities.

Reviewers were selected to peer review proposals based on their area of expertise. Their comments and ratings of proposals were recorded on an 8 question review sheet which was constructed according to the funding criteria. Reviewer comments were compiled and presented at the Minnesota Aquaculture Commission (MAC) meeting along with each proposal.

At the MAC meeting, department staff went through all proposals and received oral and written comments from MAC members. MAC members who were direct applicants to the grant program were excused from attending the meeting to avoid any conflict of interest. However, members did not attend the meeting were encouraged to provide written input.

List of Full Proposals

Proposal Title	$ Amount Requested	Matching
Membrane Biofilm Filter	$30,000	$30,000
Solid Waste Removal in Submerged Filter Recirculating Aquaculture Systems	26,500	49620
Field Evaluation of an Energy Efficient Aeration Device	40,000	49,620
Production of Horticultural Products from Aquaculture Wastes	34,208	34644
Spray Irrigation of Decant Water from Fish Manure Storage Ponds	26,700	34,020
Development of a Cold Temperature Feeding Regime in Aquaculture.	25,170	152,760
Yellow Perch Culture Using Dried feed in Recirculating Systems	25,600	25,600
Natural Wetland Treatment as means of Fish Culture Effluent Disposal	10,000	20,000
Estimating Fish Feeding and Waste by FIS-C Bioenergetics Model	43,985	44,119
Improved Encapsulated Ascorbic Acid for Aquaculture Diet	28,245	35,150
On-Farm Demonstration of Recirculating Aquaculture Technology	60,000	138,200
Proposal Total	$350,408	$600,113

The MAC produced two rankings of proposals. One was based on the specific merits of the proposals. It was evaluated utilizing a three question evaluation sheet. It resulted in a ranking order. The other ranking was of the top five from that first process.

The MAC recommended that the demonstration of research progress and results of 3(f) project (a targeted funding area) be delayed pending progress of that project. MAC also recommended that $50,000 from the grant budget be set-aside for that purpose. A decision was made to accept the MAC's recommendation because 1) a sequential on-farm demonstration will be more meaningful than a simultaneous demonstration; and 2) the systems being evaluated on the University Campus have been increased to a semi-production size which may reduce the need for demonstration on another site.

Both peer and MAC reviews ranked the same four projects highest among the 11 considered. Based on both those results, the budget and reduced timeline available, four proposals were selected for funding which represented a total request of $143,362. The title, proposed dollar amounts, and matching fund commitments are listed below in the order of ranking. The ratio of matching funds to the grant funds requested for these four projects was almost 2:1.

Funded Projects Listed in Priority Order	$ Amount Funded	Matching
1. Demonstration of the FIS-C Aquacultural Bioenergetics Model for Estimating Waste Loads and Optimizing Feeding at Two Commercial Rainbow Trout Farms	$43,123	$44,119
2. Production of Horticultural Products from Aquaculture Wastes	31,708	34,644
3. Field Evaluation of an Energy Efficient Aeration Device Aquaculture	40,000	49,620
4. Development of a Cold Temperature Feed Regime for Aquaculture	20,169	152,760
Total	$135,000	$281,143

Two of the four projects (no's. 2 & 4 above) were awarded to Minnesota Aquafarms, Inc. (MAI). Both of the proposals represented sound scientific study with the potential to benefit the industry beyond MAI. However, the economic status of MAI deteriorated during the course of the study period, and there was some resultant impact on the timliness of project reporting. The situation was monitored closely as the company entered into Chapter 11 bankruptcy proceedings and subsequently into Chapter 7 liquidation. The potential to cancel the two MAI contracts for non-performance was considered, but the principal investigator, Mr. Dwight Wilcox, persuaded a company suitor- Inter Tribal Business Network - to fund completion of the work. Mr. Wilcox also enlisted the assistance of Bemidji State University (Dr. Fu Hsian Chang) in order to complete project number 2. That workplan change was approved by the department. MAI has since been purchased by the Inter Tribal group. Internal department discussions are underway to ensure the legality of grant reimbursement to the new interest because the grant projects are funded on a reimbursement basis due to the need to document the one-to-one match concurrent with the grant fund expenditures. Department counsel and the Attorney General's office were consulted several times during the grant period to ensure that the matter was handled correctly and consistent with state law.

The progress of all four projects were monitored by visits and contact with the principal investigators involved. A final reporting format was assembled and disseminated to grantee's. Final reports were received from all four grantee's and were subsequently reviewed. All four projects have complied with the final reporting requirements. The results should contribute to Minnesota aquaculture and add to Minnesota's economic and environmental well-being.

Printing and report dissemination arrangements were made which included designing and ordering printed covers, making arrangements for report duplication and mailing, formatting each report to achieve consistency in the combined format, improving binding capabilities to allow for combinations of reports to be assembled and mailed as requested, and identifying events and target groups with whom to offer the report. Arrangements are being made to

facilitate further demonstration and dissemination of project results at events such as the Tenth Annual Minnesota Aquaculture Conference, to be held in March of 1996 in Alexandria.

A.6. Benefits: The benefits of achieving this objective include: 1) the department establishes a mechanism for facilitating a catalytic program which is necessary for industry development, 2) the quality of objective B below will be ensured, 3) individuals who carry out the funded projects will benefit by having technical staff involved in the project, and 4) fish growers will benefit by having a thorough facilitation of demonstration and publishing of funded projects.

B. Title of Objective: Grants for Evaluation and Development of Aquaculture Technology.

B.1. Narrative: Aquaculture is a new industry. It has great potential in the state as a supplier of healthy food and as a significant contributor to state's economy, especially in rural areas. There are presently no well established practices and technology for successful aquaculture production in a northern climate. This initiative will fund project(s) to develop and evaluate aquaculture practices and technology suited for Minnesota.

B.2. Procedures:

Administrative granting procedures are outlined under objective A.

Targeted funding areas will include demonstration of research progress and results of M.L. 93 Chpt. 172, Sect. 14, Subd. 3(f) project (Alternative Aquaculture Methods), development of indoor aquaculture techniques of recirculating systems, pond management practices in cold climate, development of culture techniques of certain species of fish, and other appropriate areas.

The basic criteria for qualified proposals are: 1) proposed project falls within the areas of evaluation or development of practical production methodology or have a significant effect on the evaluation and development of the technology. 2) environment and natural resource concerns are adequately addressed; 3) at least one to one dollar match (in-kind included) is provided in the proposed project; and 4) demonstration of project and its results is built in when applicable. Specific criteria for emphasis of funding areas and for qualifying proposals will be proposed by the department staff, reviewed by LCMR, consulted with the Minnesota Aquaculture Commission before approval by the commissioner.

The final targeted grant size will be between $30,000 to $50,000. Patents and royalties resulting from projects funded by moneys from this proposal are subject to laws and regulations applicable to the Future Resources Fund.

B.3. Budget:

a. Amount budgeted: $185,000
b. Balance: $50,000. The monies (balance) earmarked, as a target funding area, for demonstration of the 3(f) project were never spent due to the MAC recommendation against concurrent demonstration of on-going research and the delay associated with the no-money extension of that project.

B.4. Timeline:

	7/93	1/94	6/94	1/95	6/95
Granting Process	**********				
Fund Administration		**********	**********	**********	

B.5. Status: The following is a short summary of results from all four MADP projects.

1. *Demonstration of the FIS-C Aquacultural Bioenergetics Model for Estimating Waste Loads and Optimizing Feeding at Two Commercial Rainbow Trout Farms:* Natural Resources Research Institute.

The Natural Resources Research Institute (NRRI) has been working on an aquacultural effluent model (FIS-C) for assessing the actual and potential impacts of chinook salmon waste loads since 1989. FIS-C is based on a bioenergetics model where growth = (consumption - waste loads - respiration losses), where waste losses are egestion and excretion, and metabolic costs are incorporated into respiration losses. The model provides a novel way of estimating the magnitude and seasonality of discharges from fish farms because it can discriminate between waste fractions and also has excellent potential for predicting the effects of different waste collection strategies.

This study developed the FIS-C model for rainbow trout, an economically important species in Minnesota aquaculture, assessed its accuracy for two different successful commercial trout farms, and initiated the development of an extension bulletin for disseminating results to the aquaculture industry.

The FIS-C model was parameterized for rainbow trout. Both the published literature and direct measurements of a variety of physiological and environmental parameters were used to calibrate the model for two distinctly different commercial aquaculture facilities. The model predicted that waste loading at one site was dominated by wasted food (ration > consumption), while egested and excreted material dominated the waste loads from the other

facility (consumption = ration). The model predictions were reasonable and discrepancies between predicted and observed values were explainable on the basis of the different ways the two operators manage their facilities. Measured waste loadings were within the range expected from literature surveys, although this range is wide. Model results could be used to suggest improvements in system efficiency, potentially resulting in decreased waste loads.

2. *Production of Horticultural Products from Aquaculture Wastes:* Minnesota Aquafarms, Inc. and Bemidji State University.

Environmentally sound handling/utilization of manure, processing wastes, and mortalities can be difficult and expensive for fish producers. Composting has been demonstrated to be an effective option for disposal of processing wastes, but there has not been an effort to compost both fish parts and manure together in order to produce a marketable horticultural product and take care of both wastes concurrently.

Fish mortalities and fish manure was collected from a commercial fish farm (Minnesota Aquafarms, Inc.) for composting by Bemidji State University at two different formulations (high and low carbon). Those fish farm wastes were combined with coarse and fine aspen sawdust which is a readily available and inexpensive by-product of the local lumber industry. The application of selected microbial culture/enzyme solutions was incorporated into the experimental design to speed the composting process and to encourage a high nutrient value end product.

The materials were set-up into six compost piles inside a building and regularly sampled for a variety of experimental variables (i.e. temp., height, pH). The final product of the experiment was a superior compost material which met all MPCA standards and had a N:P:K ratio of 2.5:0.8:0.2. However, overall analysis indicated that this composting method remains economically infeasible as a commercial venture due to several factors including the expense and difficulty of dewatering waste materials, the high-cost of culturing innoculum species, and the competitive nature of the compost market.

3. *Field evaluation of an energy efficient aeration device for aquaculture:* St. Anthony Falls Hydraulic Laboratory, University of Minnesota.

A new aeration concept developed at the St. Anthony Falls Hydraulic Laboratory can significantly reduce the operating costs for aeration in aquaculture applications. This concept has been thoroughly evaluated in laboratory studies over a period of several years. This research indicated that energy savings of 30 percent or more are possible. This study investigated the application of this technology to the development of an aeration system for use in deep water fish farming. Performance measurements were made using procedures established by the American Society of Civil Engineers which is the standard of the industry.

This project was a joint venture between the Saint Anthony Falls Hydraulic Laboratory (SAFHL) and Minnesota Aquafarms, Inc. (MAI). SAFHL was the lead institution in the program. The project was carried out in four phases: 1) Design and laboratory evaluation of a configuration specifically tailored for use in the fish pens of Minnesota Aquafarms, 2) Construction of a prototype system, 3) Operation and evaluation of the prototype system and comparing its performance and energy efficiency against that of the existing aeration system, and 4) Data analysis and final report.

The results of the field studies provided valuable data that will be useful for the design and implementation of improved aeration systems for a broad range of aquaculture applications. Significant information concerning the differences in the operational characteristics of aeration devices with circular and rectangular planform has been obtained. This information will be useful in developing improved versions of the system.

4. *Development of a Cold Temperature Feed Regime for Aquaculture:* Minnesota Aquafarms, Inc.

Feed and feeding labor are among the primary costs in fish farming. Overfeeding results in wasted feeds and reductions in water quality. Underfeeding results in slow growth. The cost of providing food to fish is substantial because of the amount of labor involved in feed handling and distribution. Therefore, strategies must be developed that can maximize feed conversion rates and minimize the associated labor expenses. Most research has been developed for feeding fish at or near to their optimal growth temperature. These sources provide an excellent guide for optimizing growth at near optimal temperatures.

However, rates for feeding at cooler temperatures are thought to be less accurate due to extrapolation beyond the range of previous research. Because outdoor Minnesota fish farms will be forced to operate in less than optimal conditions, verification of feeding regimes and development of strategies for feeding fish in cold water temperatures could reduce costs, improve production, and lessen environmental impacts from farm activities here.

In this study, rainbow trout and chinook salmon received daily, twice per month, and once per month feeding during periods with water temperature below 4 degrees C.

Rainbow trout fed daily had significant weight gains over the study period. Those with reduced rations maintained stable body weight. There was no significant change in body weight of chinook salmon regardless of ration frequency. The study indicated that the salmon stop growing altogether at 2 degrees C, and that body weight and form can be maintained with feeding frequency of only twice per month. This means that any feed fed to those fish beyond

twice per month would be wasted. Adopting this revised feeding regime could save a one million pound grower as much as $36,000 annually in labor costs.

It would have been nice to extend the period of study to include a few more summer months in order to include some results of "compensatory growth" response of the test fish. The data indicated that fish which added length but no weight over the cold-water study period were beginning to add weight at a "compensatory" pace. In other words, their addition of skeletal structure over the cold water period on minimal rations allowed them to add weight at a faster pace once the water temperature warmed.

B.6. Benefits: 1) Entrepreneurs and researchers will benefit by provision of an opportunity to try out new ideas; 2) individual fish farmers will benefit from interactions with academicians involved in research; and 3) fish farmers at large will benefit from findings of new and improved aquaculture production technology. The state will benefit from industry development which means economic development in rural areas and safe provision of healthy food.

V. Evaluation: Evaluation of this program can be based upon how well the funds are administered to conduct aquaculture projects, what these projects are and how well these projects are being carried out. Whether or not these projects bear any fruits for day to day fish farming operations.

In the long run, the program will be evaluated by whether or not it has a significant positive effect on Minnesota aquaculture development. This can be measured in terms of number of operations in the state and quantity and quality of fish produced as a healthier food for consumers, and in terms of its contribution to state's economy.

VI. Context:

A. Aquaculture development in the state has focused on policy setting in terms of ownership of farmed raised fish and the regulatory environment of fish farming operations and the impact of aquaculture on the environment and natural resources. Aquaculture projects have been funded by the Agriculture Utilization Research Institute, the Natural Resources Research Institute and LCMR recommended funds. There is no systematic effort in the development of production technology suitable for Minnesota.

B. The Minnesota Aquaculture Development Grant Program will be a catalyst for practical technology development of environmentally sound aquaculture. The funding will help facilitate efforts to explore aquaculture production practices and feasibility for Minnesota production. This program is supplementary to other on-going efforts that it fills the need for coordinated technology development to realize the potential set out by the aquaculture development policy.