Department of Agriculture, Trade and Consumer Protection
Division of Agricultural Development
Agricultural Development & Diversification Program (ADD)
Grant Project Final Report

Contract Number: 22071

Grant Project Title: Evaluation of lake herring (*Coregonus artedii*) propagation on a commercial-scale for the aquaculture industries of Northern Wisconsin

Amount of Funding Awarded: $23,546

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Please use the following questions as a guide for writing your grant project final report. In your final report, please answer each question as it relates to your grant project.

What was the original intent of the grant?

This goal of this project was to build upon culture techniques that had been independently developed under research conditions and establish viable commercial culture practices for the propagation of lake herring using new aquaculture technologies. The project was conducted by the Red Cliff Tribal Hatchery and the University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility (NADF) as a joint project so that commercial scale production systems were employed to evaluate and demonstrate different culturing parameters to maximize lake herring production.

What did you want to accomplish with the grant?

The results of this project area being developed into a best rearing practices protocol for lake herring produced in commercial-scale production systems.

How was it expected to benefit Wisconsin Agriculture?

Lake herring would be a new commercially grown species for the aquaculture industry in northern Wisconsin. While conducting the market survey we were able to identify the economic impact that farm-raised lake herring would have on the consumer market and its potential for market expansion into the baitfish and stocking programs throughout the Great Lakes.

What makes this project work important or significant?

Lake herring represent a potential new species for Wisconsin aquaculture once protocols for culture techniques including hatching and rearing can be established. There have been several experimental studies conducted with lake herring where wild gametes were collected then hatched in laboratories and larvae reared in various size tanks. Generally, these studies showed differences in temperature (0 -12°C) for incubation, differences in temperature of rearing (3-21°C) and differences in food offered (live brine shrimp, zooplankton and dry diets), with each project identifying optimal conditions to maximize survival and growth of cultured lake herring. Our project combined the results of these studies using new aquaculture technologies to commercially produce lake herring at high propagation numbers and with great success.

What steps did you take to reach your goal?

1) About 2 million lake herring eggs were collected on December 12, 2007. Half of the eggs were fertilized using the dry fertilization and half using the wet fertilization method. Also, dry fertilized eggs were further divided into three test groups to examine the effect of iodine treatment, as a pathogen disinfectant, on egg survival.

2) Approximately 2.0 liters of water hardened eggs (approx. 200,000) were placed into Bell jar and Heath tray incubators for development. Water conditions were monitored for oxygen, dissolved gases, temperature and pH. Flow rate was constant at 2.5 L/min and raised to 4.6 L/min once the eggs reached eye-up stage. A formalin drip was used when fungal infection was noted on the eggs. The formalin drip controlled any notable fungal infection so that infection did not influence the results. Eggs incubated in the Bell jars showed the highest survival rates. Few of the eggs incubated in the Heath tray incubators survived until hatch.

3) Based on the higher survival of eggs from fertilization to eye-up stage, only dry fertilized eggs that hatched were used in the fry production component. Following hatch, all fry were placed into flow-through aquaculture rearing systems for feed training in late January 2008. Four brands of early life stage feed were tested: Inve Proton™ #2, Aquafauna Bio-Marine Artemac™ #2, Silver Cup™ trout fry starter, and Purina Aquamax™ trout fry starter. The best feeding regime was to hand feed 8x per day that resulted in the fry production lasting 48 days.

4) Fingerling and grow-out production was conducted in recirculating aquaculture systems where temperature could be controlled with greater precision and lake herring food consumption was lowest yet growth was the greatest. Even though Inve Proton™ and Aquafauna Bio-Marine Artemac™ feed resulted in the best survival and growth by lake herring fry, neither manufacturer produces fingerling or adult fish food suitable for lake herring. Therefore, fingerling and adult lake herring were fed Silver Cup™ grow-out diet. Survival and growth of lake herring to adult size was very good and some lake herring, age 2, attempted to spawn in the tanks in December 2009. This is quite remarkable, since wild lake herring in Lake Superior to not reproduce until ages 3-4.

5) Economic analysis - (October-February, 2008-09)

Surveys were sent to three groups of potential lake herring businesses and agencies: 1) bait dealers, 2) fish processing, and 3) fish stocking programs. General bait dealer responses included enthusiasm for the potential availability of commercially produced lake herring. Samples of cultured lake herring were shown and all bait dealers rated them in the highest quality. The greatest market potential appears to be in winter months and at a size of 7-9 inch fish. Bait dealers indicated they could use about 10,000 lbs of lake herring that would bring in about $5,000 to $15,000 in additional income.

Fish processors preferred adult lake herring (5-6 years old) with half of the processors also selling roe. Currently, lake herring sells for $0.30-$0.40 for a dressed (eviscerated) fish or $3.50-$4.00 per pound. Also, current wild harvest must target adult lake herring to collect roe, with the adults averaging 5-6 years in age. Most fish processors were not interested in commercially-raised lake herring since wild harvested lake herring from Lake Superior are readily available (Note: with the detection of VHS in Lake Superior lake herring, the status & availability of wild fish may change rapidly).

All fish stocking programs contacted believed there is a need for raising lake herring for rehabilitation stocking. Stocking programs prefer small lake herring (0-1 year old) with each agency indicating they would need 100,000 to millions of fish each year. Since rehabilitation stocking is based on the concept that after a few years the fish will have established themselves in the "wild" and would naturally reproduce, we asked each program how long they would need commercially-raised lake herring. The need ranged from 4 – 10 years.

6) Outreach/Extension – Progress throughout the project was shown during Aquaculture Field Days and Open House at the Red Cliff Tribal Hatchery and Northern Aquaculture Demonstration Facility in June 2008 & 2009. Results were also presented at the Wisconsin Chapter of the American Fisheries Society annual meeting in Duluth, MN in January 2009 and at the Aquaculture America Conference in San Diego, CA, March 2010. NADF investigators have also collaborated with or are in the process of developing partnerships with the USGS in Michigan, wholesale bait dealers in WI, and the Ohio State University to further develop the results of this project and investigate markets for commercially grown lake herring.

What challenges did you face?

At the conclusion of this project and while the final report was being written, Lake Superior tested positive for viral hemorrhagic septicemia (VHS) a potentially lethal aquatic virus of fish. Lake herring tested positive for the virus. Initially, this may tarnish the reputation of lake herring as a commercially viable species for Wisconsin aquaculture. Also, it may increase the need for testing lake herring to see if they carry the disease, even at inland commercial aquaculture facilities. Ultimately, this may increase the need for additional lake herring propagation and further the research conducted during this project.

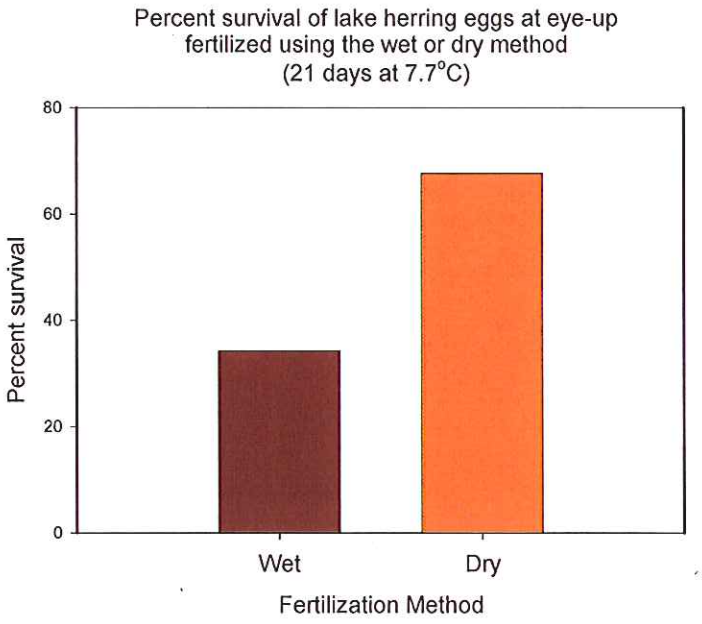
What would you do differently?

Based on the availability of staff, it was difficult to coordinate all activities among the Red Cliff Tribal Hatchery and the NADF. If I were to do the project again, I would conduct all production at one facility where there could be greater control over staffing and methodology.

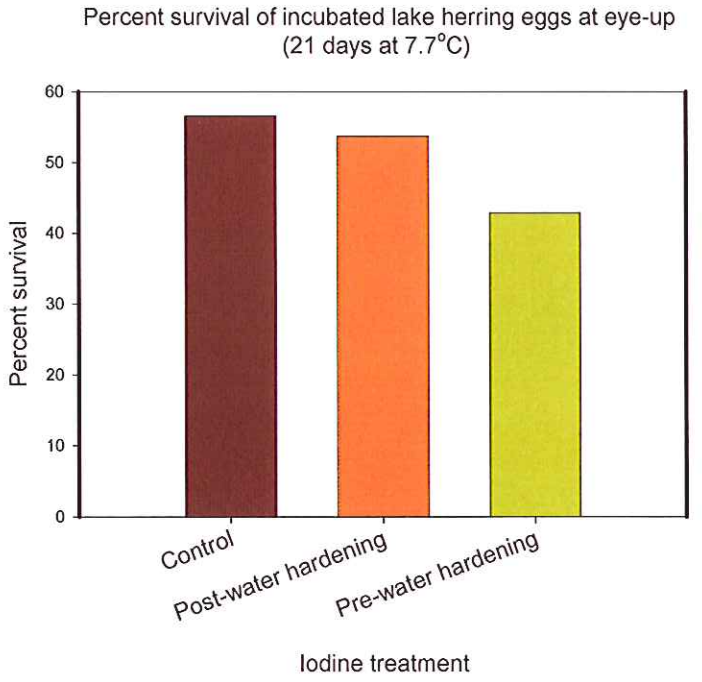
What were you able to accomplish?
All objectives outlined in the grant proposal were accomplished, including:

1. Egg collection to establish seed stock for commercial propagation.
2. Egg incubation which included testing wet and dry fertilization methods and testing iodine disinfection on egg survival.
3. Fry production where four commercially available feeds were tested for promoting optimum growth.
4. Fingerling and grow-out production was tested in commercial-scale flow-through culture systems.
5. An evaluation of lake herring markets including bait, food, and rehabilitation/stocking businesses and programs.
6. An outreach program where farm days, tours, and presentations to commercial, scientific and public sectors were offered.

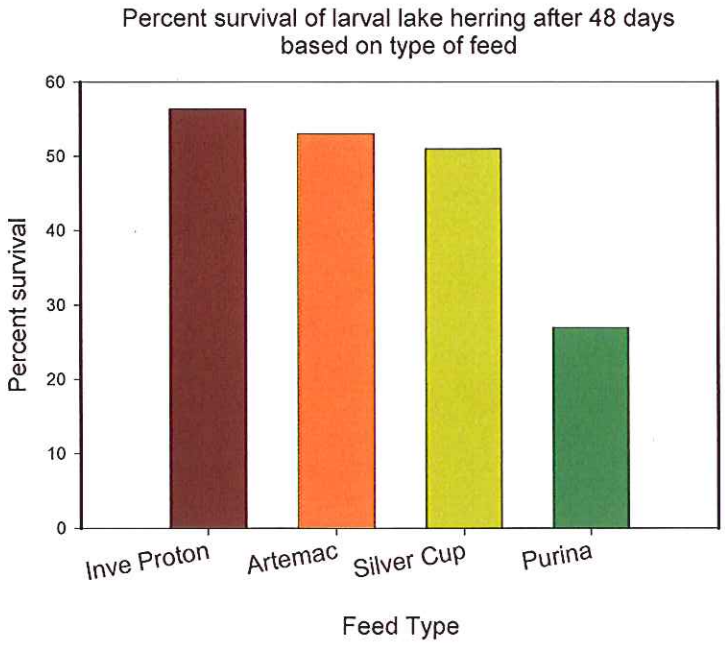
Wet and dry fertilization methods were tested and lake herring eggs incubated in Bell jar incubators at 7.7°C, with water flow ranging from 2.5 – 4.6 L/min, dissolved oxygen at 11 mg/L, and pH at 7.8. Total number of eggs surviving to eye-up stage was significantly different ($p<0.001$), with the dry fertilization treatment eggs showing greatly than 30% better survival than wet fertilized eggs.



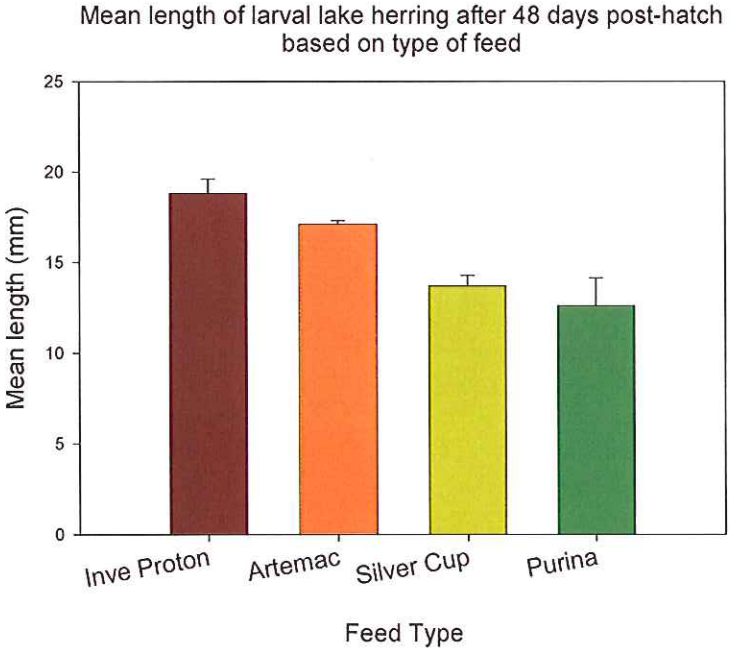
Two disinfection methods were tested with eggs being treated with iodophor either before water hardening or after. Lake herring eggs that were untreated (control) and eggs treated with iodophor after water hardening showed significantly greater survival ($p=0.011$) to eye-up, while eggs treated with iodophor before water hardening showed 10-15% less survival to the eye-up stage.

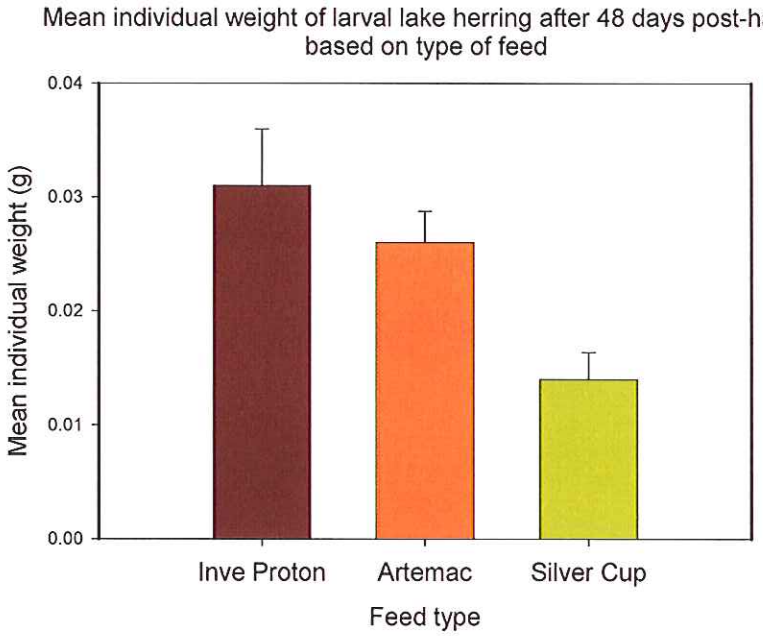


Larval (fry) lake herring were raised on one of four fry diets for 48 days at 11°C, with dissolved oxygen at 10 mg/L and pH = 7.8. Lake herring fry raised on Inve Proton™ #2 showed the highest survival at 57%, with Aquafauna Bio-Marine Artemac™ #2 raised lake herring having 52% survival, and Silver Cup™ trout fry starter fed lake herring fry having 50% survival. Lake herring fry fed Purina Aquamax™ trout fry starter had significantly less survival ($p<0.05$) with only 25% surviving 48 days.

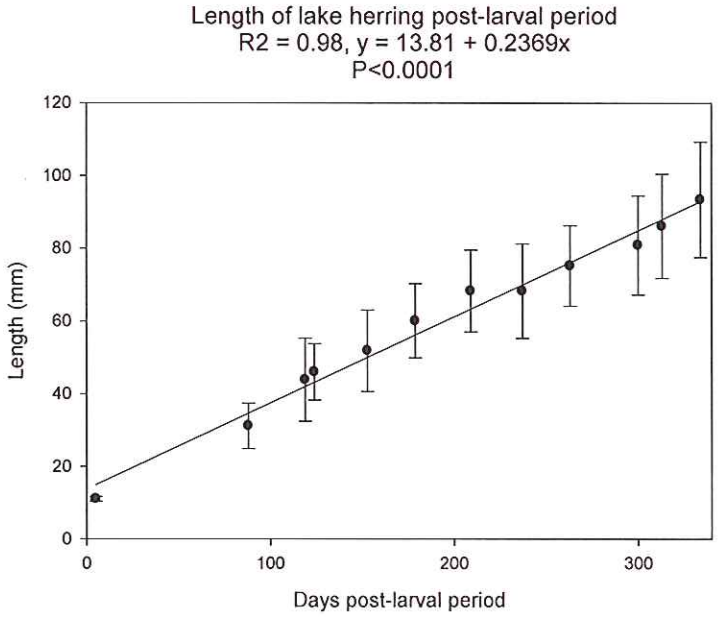


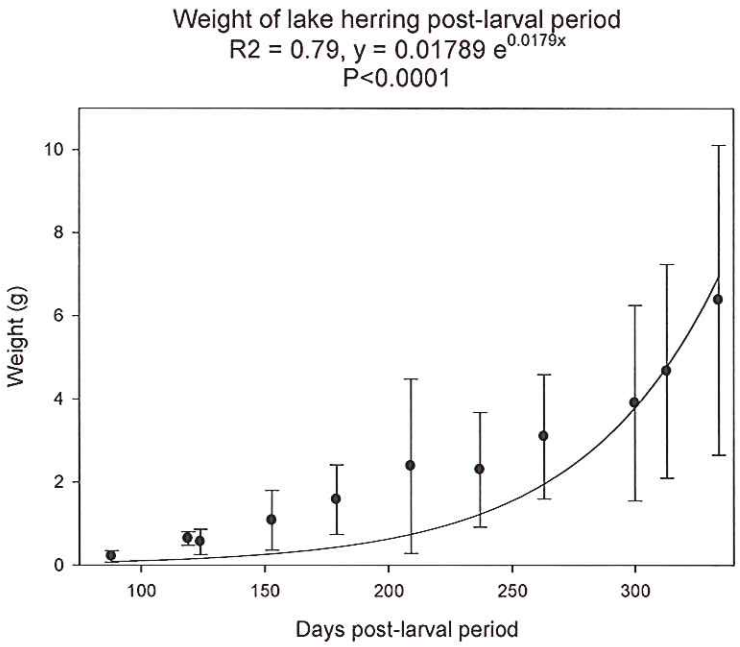
Larval (fry) lake herring showed significantly greater growth ($p<0.05$), both length and weight, when raised on a diet of Inve Proton™ #2 when compared to all other feed types. Lake herring fry fed Artemac™ #2 also showed significantly greater growth ($p<0.05$), both length and weight, than lake herring fry fed either Silver Cup™ or Aquamax™ trout fry starter.





Lake herring fingerlings were raised in flow-through tanks for 334 days and fed commercially available Silver Cup™ trout growers diet. Lake herring showed a significant increase in length (11.0 – 93.0 mm; $p<0.0001$, $R^2 = 0.98$) and a significant increase in weight (0.2 – 6.4 g; $p<0.0001$, $R^2=0.79$) during the fingerling grow-out period.





Lake herring adults continue to be raised in recirculating tank systems at the NADF. After approximately two years, some of the adult lake herring began to spawn, which is a significant observation since wild lake herring usually do not spawn until 3-4 years of age.

Based on the results of the project we can conclude that the dry fertilization method was more successful with >62% of eggs reaching the eyed stage. Disinfecting eggs with iodine after water hardening resulted in better survival to the eyed stage. Using Inve Proton™ #2 feed resulted in the highest survival and growth of larval lake herring. Commercial propagation of fingerling lake herring in flow-through tanks resulted in faster growth than what was previously reported for wild lake herring during the same time period. Overall, commercial propagation of lake herring using modern culture techniques can be very successful. Depending on the market demand for lake herring products, the techniques described in this report can be successfully applied to commercial lake herring production and could provide for aquaculture development of diversification for the aquaculture industries of Northern Wisconsin.

What do you plan to do in the future as a result of this project?

Currently, some of the lake herring produced from this project will remain at the NADF and be used for educational and outreach programs. We are also working with researchers from the Ohio State University to develop a follow-up research program examining the use of cultured lake herring in rehabilitation/stocking programs in the Great Lakes and how this may help alleviated Thiamine Deficiency Complex (TDC) seen in predatory fish that consume thiaminase-rich alewife instead of lake herring (cisco).

What information or additional resources are needed to commercially develop this enterprise?

Until the status and implications of VHS infection of lake herring and other Lake Superior fish can be fully understood, further commercial development of lake herring production may be on hold. The greatest potential we discovered for commercial production of lake herring appears to be as an alternative bait fish. Most food fish needs, including roe, for lake herring are currently being met by commercial harvest from the western Great Lakes. Of course, with the detection of VHS, wild populations may rapidly decline or be banned from sale or export and this may increase the interest in commercial production of lake herring as a food fish.

How should the agricultural industry use the results from your grant project?

The culture guide will be publically available for download at the UW-Stevens Point, Northern Aquaculture Facility website (http://aquaculture.uwsp.edu). This guide could be used by anyone in the agricultural industry that is interested in raising lake herring. Also, the results of the market survey could be used by the agricultural industry to direct marketing and focus of commercial lake herring production to those sectors that displayed the greatest areas for growth; primarily, baitfish and supplemental stocking.