Improving Sturgeon Farming in Hawaii, Year 1

General Information

**Reporting Period**  
October 1, 2002–July 31, 2004 (final report)

**Funding Level**  
<table>
<thead>
<tr>
<th>Year</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$18,635</td>
</tr>
</tbody>
</table>

**Participants**  
Kevin D. Hopkins, Ph.D.  
University of Hawaii at Hilo

Frank A. Chapman, Ph.D., Associate Professor  
University of Florida

Howard Takata  
dba Hawaiian Sturgeon & Caviar Company

Robert Kern and Ashley DeLoach  
Tropical Ponds of Hawaii

Ron Weidenbach  
Hawaii Fish Company

Jeff and Linda Koch  
Mokuleia Aquafarms

Brent Burkott  
Hawaii Farm Fresh Seafood

William Lansford and Jo Sosna  
Aquatic Ventures, Inc.
Objectives

1. **Training:** Improve the level of technical expertise of at least six Hawaiian fish farmers so that they can nurse, handle, stage, and if possible, spawn *Acipenser gueldenstaedti*.

2. **Establish Sturgeon Stocks:** Establish at least three (six preferred) populations of *A. gueldenstaedti* and one other Russian species at farms throughout Hawaii.

3. **Reducing Deformity:** Determine if increasing calcium concentrations in incubation water will reduce the incidence of deformity in yolk sac larvae and fingerlings.

4. **Hatchery Manual:** Prepare a preliminary hatchery manual for Russian sturgeons in Hawaii

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Principal Accomplishments

**Objective 1: Training:** *Improve the level of technical expertise of at least six Hawaiian fish farmers so that they can nurse, handle, stage, and if possible, spawn* *Acipenser gueldenstaedti.*

The first of two sturgeon reproduction and hatchery workshops was held at Hoowaiwai Farms and the Pacific Aquaculture and Coastal Resources Center (PACRC) on the island of Hawaii from March 10–11, 2003. This training was co-sponsored by the U.S. Agency for International Development/Initiative for Future Agriculture and Food Systems-funded project “Bridging Gaps to Insure Long-Term Viability of Small Tropical Mariculture Ventures in Hawaii and the U.S. Affiliated Islands.” The workshop was attended by 22 persons (14 farmers and 8 extension/outreach persons) plus 12 students from UHH and a local high school. The instructor was Dr. Frank Chapman from the University of Florida. Day 1’s hands-on activities involved eight-year-old *A. gueldenstaedti* and included seining, weighing, tagging with PIT tags, anaesthetizing, egg sampling via incision followed by suturing, and evaluation of the stage of egg maturation. During Day 2, a whole day of classroom lectures and discussions covered all aspects of sturgeon culture, concentrating on hatchery and nursery techniques. Also during this reporting period, detailed diagrams and instructions for assembly of standardized nursery systems were prepared and distributed to the farmers.

A second workshop was held over three days at Akolea Farms in Hilo in March 2004 just before the World Aquaculture Society meeting in Honolulu. Attendees included several farmers and students from an university aquaculture production
class. This workshop was led by Dr. William Shelton from the University of Oklahoma. The highlight of the training was an attempt to spawn a 100-lb female sturgeon with three males. Participants received hands-on experience in PIT tagging, staging of eggs (including determining the extent of migration of the nucleus), dosage computations and preparation of LH-RHa for injection, injection of the four fish, and observation of the fish after injection. Unfortunately, the female was not quite ready to spawn as the egg nucleus had migrated only about seventy-five percent of the way to the animal pole. Although a spawn was not obtained, the fish showed typical “courtship” behavior after injection. In addition to the hands-on training, Dr. Shelton also lectured on the MIST (minimally invasive surgical technique) for removal of ovulated eggs. It must be noted that the project did not have adequate funds for this second training, so the farmers paid for Dr. Shelton’s expenses.

An important side result of the training programs was the demonstration of sexual dimorphism and maturation of *A. gueldenstaedti* in Hawaii. However, this maturation does not appear to be synchronous, probably as a result of the constant 21°C water in which the fish are maintained. Twenty-six fish were sexed in 2003:

<table>
<thead>
<tr>
<th>Sex Ratio (n=26)</th>
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<tbody>
<tr>
<td>Female</td>
<td>54%</td>
</tr>
<tr>
<td>Male</td>
<td>31%</td>
</tr>
<tr>
<td>Unknown (probably male)</td>
<td>15%</td>
</tr>
</tbody>
</table>

The stage of egg maturation was determined based on a four-stage method in which stage 2 eggs are small (200 microns) with profuse adipose tissue, stage 3 eggs are starting to enlarge (1.5 to 2.5 mm) with uneven pigmentation, and stage 4 are large (3.0+ mm), pigmented eggs. Fourteen eight-year-old females were examined in 2003:

<table>
<thead>
<tr>
<th>Egg Maturation (n=14)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 2</td>
<td>14%</td>
</tr>
<tr>
<td>Stage 3</td>
<td>50%</td>
</tr>
<tr>
<td>Stage 3.5</td>
<td>21%</td>
</tr>
<tr>
<td>Stage 4</td>
<td>14%</td>
</tr>
</tbody>
</table>

**Objective 2: Establish Sturgeon Stocks: Establish at least three (six preferred) populations of *A. gueldenstaedti* and one other Russian species at farms throughout Hawaii.**

An opportunity arose to cooperate with sturgeon farmers in Florida to obtain eyed eggs from Russia. However, an earlier attempt to transship them from Florida had not been successful for a number of reasons. A test shipment (jointly-funded by the project and one of the farms) of 200+ *A. gueldenstaedti* fry was conducted in
late February. The fish arrived with minimal mortality and were eventually distributed to two new sturgeon farmers and one existing farm. The fish distributed to the two new farmers subsequently died. At one of the new locations, this was probably caused by highly acidic rainfall from the nearby active volcano. The cause of the deaths at the other new location is unknown. A dozen fish have survived at the other farm and have attained an average weight of 2.5 kg at 21 months of age. This growth rate is essentially the same as was observed with fish that the farm imported in 1995.

Two additional attempts were made to import sturgeon eggs or fry during 2003. In the first case, arrangements were made to obtain part of a shipment made to Rokaviar in Florida from Italy. Before transshipment from Florida could be made, massive mortalities started to occur precluding transshipment to Hawaii. In the second attempt, a Russian supplier was contracted to supply fish to both Dr. Chapman’s associates in Florida and this project. As it was extremely difficult to prepay the $2,000 downpayment to the Russian supplier using government funds, one of the cooperating farmers assumed all of the risk and made the downpayment with the hope that he would be reimbursed when a shipment was actually made. Unfortunately, the first part of the shipment to Florida was not successful and the supplier requested a delay to 2004.

In 2004, attempts to obtain fish from Russia were again unsuccessful. An order for 10,000 Siberian sturgeon, *A. baeri*, eggs was made with an alternate source in Austria. This source arranged a shipment of eggs from Italy that was received in

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**FIGURE 1.** Size of *Acipenser gueldenstaedti* at almost eight years of age. Note the sexual dimorphism.
After numerous attempts, project researchers were finally successful in obtaining viable sturgeon fry in June 2004. This shipment was funded by another cooperator with half of the eggs being sold at cost to the project.

Upon arrival, the shipping water temperature was 22°C with a calcium content of 54 mg/l and magnesium content of 20 mg/l (= a hardness of 171 mg/l as CaCO3). The cooperator placed his half of the eggs into a recirculating system on Oahu while the remaining eggs were shipped to Hilo. An estimated 6,500 eggs arrived in Hilo (19.25 eggs/ml). A sample indicated approximately 5% were dead or infertile. One hundred eggs were placed into an incubator using the farm’s ambient water (19°C, 4 mg/l Ca and 1 mg/l Mg). The remaining eggs were placed into an incubator with chilled water (15°C) to which calcium chloride and sodium bicarbonate had been added to increase calcium levels above 20 mg/l and buffer pH fluctuation, respectively.

Eggs incubated in the ambient water were markedly larger and showed faster development than the eggs at the lower temperature and higher calcium. First hatch occurred within 13 hours of stocking into the ambient water and was completed within another 24 hours. Only 22% of the eggs hatched in the ambient water. Approximately 36 hours after stocking, the first hatch was noted in the chilled water with almost 90% hatch within the next 24 hours. Fry were very active in both systems, and freshly hatched brine shrimp were added to both systems starting before the yolk plugs were shed. At ambient temperature, feeding was noted on Day 8 after hatch.

In the chilled system, at 5 days post hatch, inactive larvae were noted on the incubator floor. Within the next 24 hours, most of the fry settled to the bottom. TAN was 0.4 mg/l. Water exchange was not helpful, and most of the fry died. An examination of the dead fish showed that they still had their yolk plugs.

Surviving fry from the chilled water system were nursed for several more days until they were eating brine shrimp. At that time, 100 large fry were distributed to each of two private farms on Oahu and two private farms on the Big Island. Additionally, three batches of 100 were sent to the UH Hilo farm for use in an experiment on the effect of hardness on incidence of deformities (see Objective 4). The fish originally allocated to a farm on Maui and a third farm on Oahu were not delivered because the farmer did not complete the state-required permitting process.

To facilitate comparison, a standardized hatchery system was designed, materials were purchased by the project, and the system was constructed by the cooperators at the four farms and UH Hilo. System materials were also delivered to two other farms to which fish were allocated but not delivered. See figure 2 for a schematic of the system based on three 50-gallon culture tanks, filters, and a pump.

The distributed fish, which were survivors from the chill-water incubator, were stocked into the standardized systems (100 fish per system were shipped, but the
Siberian sturgeon populations have been started at four farms. Numbers surviving shipment is not clear for all farms) and cultured for 109–131 days. They were initially fed a combination of brine shrimp and Nutra ST feed before being weaned purely to the commercial diet. The average survival per system was remarkably consistent across the systems, only about 10%. The reason is unknown, but may be related to the overly high water temperature during egg transport. The bimodal distribution of average fish weights is also of interest and may reflect the commercial or research orientation of farms: Oahu #2 and Hawaii #1 are commercially oriented versus the research orientation of Hawaii #2 and UH Hilo. After this first year of the project, there were four Siberian sturgeon populations on two islands.

<table>
<thead>
<tr>
<th>Farm Location</th>
<th>Approx. Days</th>
<th>Total Remaining Fish</th>
<th>Average Weight (g)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oahu #1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Suspicion of <em>Trichodina</em> infection</td>
</tr>
<tr>
<td>Oahu #2</td>
<td>109</td>
<td>16</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Hawaii #1</td>
<td>110</td>
<td>11</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Hawaii #2</td>
<td>72</td>
<td>23</td>
<td>18</td>
<td>From 3 experimental systems (see objective 3)</td>
</tr>
<tr>
<td>UH Hilo</td>
<td>72</td>
<td>35</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>
Objective 3: Reducing Deformity: Determine if increasing calcium concentrations in incubation water will reduce the incidence of deformity in yolk sac larvae and fingerlings.

This particular research objective was developed because of substantial differences in deformity rate encountered with *A. gueldenstaedti* larvae in the mid-1990s. This simple experiment used the same standardized recirculating systems as the farmers did, with three tanks in each system. The difference was that Ca levels were varied in the experiment whereas the farmers used their ambient water. Nineteen fish, which survived transport, were stocked into each replicate. No significant levels of deformity were noted in any of the treatments. However, after removing the one replicate in each of two systems in which the fish died of anoxia because of clogged pipes, it is obvious from the analysis that increasing calcium levels had a positive effect on survival and growth.

<table>
<thead>
<tr>
<th>Average Calcium (mg/l)</th>
<th>Approx. Days</th>
<th>Average Survival (%)</th>
<th>Average Weight (g)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>72</td>
<td>16</td>
<td>7</td>
<td>Numbers adjusted for system failure</td>
</tr>
<tr>
<td>21</td>
<td>72</td>
<td>25</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>72</td>
<td>39</td>
<td>17</td>
<td>Numbers adjusted for system failure</td>
</tr>
</tbody>
</table>


Work on this objective started during this year and will be completed during Years 2 and 3 of the sturgeon project after results from those years are available. A sizable amount of literature has been collected and reviewed during Year 1. A listing of that material will be placed on the PACRC Web site early in 2005.

Work Planned

We plan to continue investigating alternative sources for sturgeon fry and/or eggs to begin this work. We also plan to look for alternative sites to carry out the investigations.
Impacts

This three-year project will provide the basic information needed for the establishment of a local sturgeon industry in Hawaii. This addition to the list of culture species would have advantages of a larger market niche: the mainstream, white tablecloth restaurant trade for both meat and caviar and the international markets for smoked sturgeon and caviar. Additionally, sturgeon is well suited to cool freshwater, which is abundant at higher elevations and on the windward sides of the various islands.

More precisely, the Year 1 project has had the following impacts:

- Farmers and potential farmers have attended two trainings on sturgeon reproduction and hatcheries. The second training was funded, in large part, by the farmers themselves.
- Four populations of Siberian sturgeon are surviving on two islands.
- It has been demonstrated that obtaining imported eggs or larvae is highly problematic at the present. This indicates that the farmers should plan to breed their own stock and not rely on imports.
- Growth and survival is clearly suboptimal at the ambient calcium levels on the island of Hawaii. Farmers must plan to increase those levels to improve growth and survival of young fish.
- Several farmers are actively trying to import sturgeon seedstock, in addition to the stock that will be used by the Year 2 and 3 sturgeon projects.

The successful completion of this project may have long-term positive implications for the Hawaii aquaculture industry. By providing a new, high-value freshwater aquaculture species, commercial farmers may be able to significantly increase farm revenue. As sturgeon take a number of years to reach market size and/or become sexually mature allowing roe to be harvested, it will be some time before the positive economic impacts of this project are seen.

Publications in Print, Manuscripts, and Papers Presented