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James E. Johnson, David G. Fielder,
Matthew Hughes, and Randy Espinoza

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Pilot Cisco Egg Take and Culture Study

James E. Johnson[1] and David G. Fielder

Michigan Department of Natural Resources, Alpena Fisheries Research Station
160 E. Fletcher St. Alpena, Michigan 49707

Matt Hughes

Michigan Department of Natural Resources, Wolf Lake State Fish Hatchery
34270 C.R. 652, Mattawan, Michigan 49071

Randy Espinoza

Michigan Department of Natural Resources, Thompson State Fish Hatchery
944 South State Hwy. M149, Manistique, MI 49854

Summary

This is the last in a series of reports on a pilot project to experimentally culture Ciscoes (previously known as Lake Herring, *Coregonus artedi* Lesueur) on a small scale. The objectives of the pilot study were to: 1) Determine the spawning date(s) of wild donor populations; 2) Collect broodstock and improve methods of broodstock collection; 3) Improve spawn-taking efficiency and determine the number of eggs that can be fertilized per day using a portable spawning trailer; 4) Improve fertilization rates; 5) Develop and refine egg incubation methods and temperatures; 6) Determine appropriate rearing densities for production level culture; 7) Determine whether fingerling Ciscoes can be OTC marked using Chinook Salmon fingerling marking protocols; and 8) Determine optimal size and timing of stocking. This document focuses on results from 2010–11 while providing recommendations based on the synthesis from previous results reported for 2006, 2007, and 2008.

On November 12 and November 13, 2010, 773,000 eggs were taken from 60 pairings of live ripe Cisco adults for the final experimental production year. Fertilization rate averaged 44% for eggs from the two collection dates combined. The eggs were incubated at 7.6°C at Thompson State Fish Hatchery and transferred to Wolf Lake State Fish hatchery shortly after they reached the eyed stage. The eyed eggs were incubated at about 7.5°C at Wolf Lake where there were serious losses of eggs and hatching fry as well as a high incidence of fry deformities likely from incubating at water temperatures that were too high, caused by failure of a chiller. Only 9,495 fingerlings remained and these were successfully OTC marked and stocked on June 21 in Thunder Bay. Two OTC-marked Cisco adults were sampled at the Thunder Bay stocking site in November 2011; both were mature females and were estimated to have originated with the 2008 and 2009 stocking events.

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[1] Retired

Based on all of the information collected to date, our recommendations on Cisco culture are as follows:

- Egg availability is limited by the relatively small size of the Upper St. Marys River population of Ciscoes. Up to 1,000,000 eggs can be taken from this egg source.
- An alternate source of Cisco eggs should be located to increase the number of eggs that could be collected while also providing redundancy that would better assure that production numbers of eggs were collected in any given year;
- Broodstock, unless running ripe, should be staged to ripeness in trap-net pots;
- Methods used for Walleye egg incubation are appropriate for Cisco eggs;
- High losses of eggs after the eye-up stage and fry deformities followed chiller breakdowns that led to incubation temperatures that were probably too warm for this species;
- After hatch, rearing methods and feeding are similar to those for Chinook Salmon;
- Cisco fry accepted OTC-laced diet in the hatchery in 2011 resulting in good to excellent marks.

Most of the initial small-scale rearing objectives have been achieved. The remaining questions are those pertaining to scale and include:

- How can live-capture spawner collection (trapnetting, electrofishing) success be improved as live fish are essential to assure good egg quality?
- The current Baie de Wasai egg source is not sufficient to meet stocking goals of the reintroduction proposal. What other egg sources should be considered and should these potential alternative egg sources be explored? Which ones are acceptable from fish health and genetics perspectives? Alternative broodstock sources that should be considered and fully evaluated include:
    - Lower St. Marys River/Drummond Island;
    - Lake Huron—Georgian Bay/North Channel, Ontario;
    - Lake Superior—Apostle Island offshore source.
- Can satisfactory fry survival be realized with a stable rearing temperature of approximately 7.5 degrees C? Is a colder regime desirable?
- What are appropriate rearing densities for optimal production of Ciscoes?
- What is required to rear Ciscoes at production numbers?

Introduction

This is the last in a series of reports on experimental, small-scale, culture of Ciscoes. Pilot-level Cisco culture was attempted annually 2006–2010. Results of the 2010–11 Cisco culture cycles are reported below by each objective of the November 2009 Fisheries Division study plan, *"Developing Cisco culture methods for reintroduction stocking in Michigan – addressing remaining fish culture questions."*

According to the November 2009 study plan, the approach is to adaptively test methods and integrate what is learned in subsequent years. Basic egg collection and rearing issues unrelated to scale were to be examined first, with production-scale issues to be examined after satisfactory information on the basic questions were collected.

Objective: Determine Spawning Date(s) for Baie de Wasai Cisco Stock

In 2009, we reviewed sampling data collected by DNR Fisheries Division 1994–2009 and the annual pilot-study reports from 2006, 2007, and 2008 for the Baie de Wasai Cisco spawning stock.

From these data, we concluded that peak spawning occurs between November 7 and November 19 and that water temperature was not a reliable predictor of spawning date. The specific objective for future work is to test whether these initial conclusions about date and temperature are reliable predictors of spawning date and whether, by fine-tuning spawning collection dates, we can improve our ability to collect gametes for production-scale rearing for Cisco.

The 2010 experience.–Netting began on November 7. Ripe females appeared in the gear on November 11. Spawn taking was conducted over the next two days, November 12 and November 13. By November 13, spent females were appearing in the catch. Water temperatures were unusually warm in 2010, ranging from 7–8°C. The spawning period in 2010, an exceptionally warm year, was not much different from past years, suggesting that date, more than water temperature, dictates spawning time.

Objective: Collect Broodstock and Improve Methods of Broodstock Collection

In 2008, we were able to take 40–50 ripe females in one day of netting in the St. Marys River using two 1,200–1,500-ft gill nets. Based on this initial effort, future work was designed to test if this level of broodstock collection should be expected annually and if this level is sustainable for the population. The analysis of alternate methods for collecting adults such as electrofishing, pound nets, and trap nets was also determined to be important for next steps of the pilot program. Given the issues with ripeness in 2008, additional work investigating the feasibility of holding live adults until the majority ripened was included in subsequent years, a step that could allow a greater number of fish to be spawned.

The 2010 experience.–We used two large (ten foot brails) trap nets and up to four 300-ft gill nets to collect broodstock. The trap nets could not be set perpendicular to shore as we had hoped due to gale-force winds, which dictated another orientation of the nets, with the pots set downstream of the leads. Though not set as desired, the trap nets were successful in monitoring the run. Nets were checked every 2 to 3 days to determine stage of maturity of the collected Ciscoes. These nets eventually contributed nearly half the total catch of broodstock, the balance being caught in the gill nets. It was determined that healthy but green Ciscoes could be held in the trap nets until they eventually staged up to ripeness. Such fish were marked using numbered anchor tags for later identification. A few apparently healthy (based on external appearance) green fish were transferred from gill nets, tagged, and placed in trap nets, but few of these survived. Most trap-net caught fish remained healthy, based on external appearance, after being held for up to a week in the trap-net pots.

Had it been possible to set the trap nets perpendicular to the shore near the best spawning grounds, trap-net catches likely would have been considerably higher. Unlike gill nets, the trap nets were large, heavy, and require a crew of three people working a half day to deploy or remove each net. Once set and fishing, the trap nets were considerably easier than gill nets to operate and fish.

The experience of gill nets killing the majority of the Cisco catches was again documented in 2010. This was in spite of efforts to minimize handling stress by cutting the gill-net mesh to remove live fish from the nets.

If trap net fishing effectiveness can be improved, and weather conditions permit safe transfer of the catch to the spawning station, it appears this operation as presently configured (crew size and gear) is capable of taking approximately 1,000,000 eggs over a three-day spawning period. Uncertainty remains as to whether the Baie de Wasai stock is capable of producing appreciably more broodstock than what was collected in 2010. Gillnetting since 1995 has revealed only one sand bar at this site that has consistently produced significant numbers of ripe fish. Therefore, if more than approximately 1,000,000 eggs are needed, an additional site should be selected. Peck Island, immediately north of Drummond Island in Potagannissing Bay, was identified in earlier work as a productive site for spawning-phase Ciscoes.

Weather conditions were exceptionally good in 2010. In most years, less-than-ideal weather typically reduces how many spawning pairs can be delivered per day by significantly slowing the trip from the netting site to the spawn-taking trailer. Poor weather, which increases the delivery time, also increases stress on the broodstock and could in turn adversely affect egg quality.

We recommend finding a site for the spawning trailer closer to the Baie de Wasai (Sugar Island) spawning area. This would greatly ease logistics by avoiding the three to four mile run from the nets to the Sault Ste. Marie access site, saving time and reducing stress on the fish. Additional egg collection sites will probably be needed if more than 1,000,000 eggs are to be targeted in the future.

Objective: Improve Spawn-taking Efficiency and Determine the Number of Eggs that can be Fertilized per Day Using the Trailer

A spawning trailer was used in 2006-08, which was sufficient to house a single spawn-taking operation (one pairing at a time) and a collection of at least 200,000 eggs per day. The peak of the spawning period appears to be only 2–3 days. Based on the initial 2006-08 work, we planned additional efforts to determine if a single trailer could be used to take up to 1,000,000 eggs during this brief window of availability of ripe fish. We also looked to determine if multiple spawning crews may be necessary and if additional sheltered space for spawn-taking crews may be needed. We also planned to evaluate in 2010 methods for increasing the number of eggs that can be fertilized per day.

The 2010 experience.–In 2010, a total of 60 Cisco male-female pairs were spawned on November 12 and 13. On November 12 (Lot 1), 39 live pairs were collected that yielded 474,010 eggs (mean yield = 12,154 eggs per female). On November 13 (Lot 2), 21 live pairs were collected that provided a total of 299,025 eggs (mean yield = 14,239 eggs per female).

We were more selective in choosing fish for the egg take in 2010 than in 2008; yet the daily egg take rate in 2010 was much higher than in 2008, averaging 387,000 per day. Only live fish were deposited in the holding cages at the egg taking station in 2010 and only females that were clearly running ripe were used for spawn taking. These selection criteria resulted in more rejected fish and therefore were a limiting factor in the number of pairs spawned per day. By moving the incubation location to Thompson State Fish Hatchery, which was closer to the egg taking site than Wolf Lake State Fish Hatchery, it was possible to take eggs for a two-day period and shuttle eggs to Thompson State Fish Hatchery each day. We conclude that, using the same trailer as in prior years, and transferring the eggs each day to Thompson State Fish Hatchery, spawning up to 50 pairs of fish per day is feasible and would be sufficient to produce about 500,000 eggs per day.

The peak spawning period for this broodstock appears to last for only two to three days; therefore, it appears that a single spawning trailer, under optimal conditions, is capable of taking a maximum of about 1.5 million green eggs per year from this source.

Objective: Improve Fertilization Rates

Eggs were taken during 2006–08 for the pilot project, but only in 2008 were egg quality (ripeness) and eye-up levels acceptable. It now seems clear that the 2006 and 2007 efforts were too early in the spawning run and most eggs were not ripe. During 2010, we tested whether the 2008 eye-up levels from eggs taken later in the spawning run could be reproduced.

The 2010 experience.–As in 2008, eggs were collected from females that flowed freely or flowed with minimal coaxing. Those that required "minimal coaxing" may have not been quite ready for spawning, which could affect fertility rate.

Eggs were also experimentally collected by Lake Superior State University (LSSU) staff and students from 15 pairings of recently dead fish. Of these pairings, only a few females were considered free flowing or in optimal spawning condition. Examination of the gills was used to determine length of time deceased. The whiter the gills appeared, the longer the fish were assumed to have been dead. Efforts were made to use fish for the LSSU experiment that still had some red coloration in the gills. Fertilization rate of eggs from these dead pairs averaged only 2%. We cannot be sure how much morbidity of the broodstock or degree of ripeness contributed to the low fertilization rate. Many females used for this experiment were not in optimal stage of ripeness which appears to be critical for obtaining good fertilization rates. Also, fish were spawned by different people (LSSU staff) than were conducting the Department of Natural Resources (DNR) egg take, which could result in differing fertilization rates as procedures may not have been consistent. Nevertheless, it seems likely that egg quality, and perhaps sperm motility, declines very rapidly after death of the parent stock.

Based on the pilot-project experience of 2006–2010, the use of live fish, in optimal spawning condition, is essential for optimizing egg quality.

Objective: Develop and Refine Egg Incubation Methods and Temperatures

Fielder and Hughes (2009) produced an egg viability of 56% by rearing eggs at 2.8°C and experienced high egg losses when temperatures oscillated more than a few degrees per day or exceeded about 10°C. Pangle (2003) successfully incubated Cisco eggs at 7.8°C. Incubation at temperatures below about 5°C for prolonged periods would probably cause spring fingerlings to be too small to mark in time for the prescribed June stocking period, with the 1.5-mm OTC-medicated pellet feed. Fielder and Hughes (2009), therefore, recommended locating Cisco culture where a consistent supply of relatively cold water is available. Given the previous work and literature review, the 2010 study would evaluate Cisco eye-up rates at the available water temperature (7.5°C) at Thompson State Fish Hatchery, after which the eggs were to be transferred to Wolf Lake Hatchery for hatching and rearing.

The 2010–11 experience.–The eggs were incubated in McDonald jars to eyed stage at Thompson State Fish Hatchery. Water temperature was 7.6°C, with flows adjusted until slight movement of eggs was observed, which is the same as the protocol for Walleye eggs. Flows were slowly and slightly increased as the eggs developed. Similar to Walleye, we increased flows later in the incubation phase, rolling eggs to get the less dense dead eggs to rise to the upper portion of the jars for removal by siphoning. Fertilization rates after 9 days, or approximately 65 temperature units (TU), were 46% for Lot 1 (Day 1 egg take) and 42% for Lot 2 (Day 2 egg take). Egg viability rates in 2008 for eggs incubated in 10°C water was only 11%, but was 56% for eggs chilled in 3°C water. Fertilization rates of both Lot 1 and Lot 2 were lower than those reported by the University of Wisconsin—Stevens Point, Northern Aquaculture Demonstration Facility (G. Fischer, unpublished data), where up to 62% survival from egg to fry stage was reported. Our use of some possible green females whose eggs did not flow freely may have contributed to our lower fertilization rate.

Eggs were considered eyed by November 29 (125 TU). Samples taken from both lots on December 2 (155 TU) were 66% and 41% viable, Lots 1 and 2, respectively. On December 6 (195 TU), a final sample was taken from both lots to determine the number of viable eggs prior to transfer to Wolf Lake State Fish Hatchery. Results indicated viability rates of 60% and 52% for Lots 1 and 2, respectively. The difference in viability at fertilization and eye-up can be attributed to egg mortality with dead eggs removed over time, therefore increasing the number of viable eggs left in each lot. Based on the original number of eggs received by Thompson State Fish Hatchery, an estimated 38.5% of the Lot 1 eggs and 31.9% of Lot 2 survived to the end of the Thompson State Fish Hatchery rearing period (Table 1).

Table 1.–Rearing history of three lots of Cisco eggs at Thompson State Fish Hatchery, November–December 2010.

	Lot 1 (11-12-10)	Lot 2 (11-13-10)	From dead brood (11-13-11)
Eggs received (liters)	5.35	2.85	2.25
Eggs per liter	88,600	104,921	104,921
Total eggs	474,010	299,025	236,072
Jars used	3	1	1
Females used	39	21	15
Eggs per female	12,154	14,239	15,738
Fertility 11/23/10 (65 TU)	46.1%	42.0%	2.7%
Eye-up date/TU	11/26/10 (125 TU)	11/26/10 (125 TU)	
Viability 12/2/10 (155 TU)	65.6%	40.8%	Did not estimate
Viability 12/6/10 (195 TU)	60.0%	52.0%	Did not estimate
Transfer to Wolf Lake			
12/06/10 eyed eggs	182,330	95,499	Discarded
Percent survival	38.5	31.9	

The eyed eggs were transferred to the Fish Health Lab at Wolf Lake State Fish Hatchery on December 6. The two lots were combined prior to transfer. All eggs received a 100 ppm iodine bath for 10 minutes upon arrival. Of a total of 487,536 eggs transferred, 277,829 were considered viable. Eggs were placed in jars on 7.6ºC chilled water. Dead eggs that had collected at the surface of each jar were siphoned off daily.

On December 13, it was discovered that the water chiller had failed sometime in the night and the water temperature had slowly increased to the base temperature of 11ºC. The chiller was restarted and water temperature was reduced back to 7.6ºC over the course of 8 hours. The following morning the chiller was not running again and water temperature was back to 10ºC. At this point, the eggs were at approximately 247 TU. Based on previous years' information, eggs were expected to begin hatching at 265 TU. Given the eggs were very close to hatch (based on TU) and the problems with the chiller, eggs were transferred to jars in the incubation room at the main hatchery building and put on unchilled spring water at 11ºC. On December 16 (267 TU), only a small percentage of eggs had hatched. The jar battery allows newly hatched fry to swim out of the incubation jars, into and through a covered settling trough, and into the tail end of an indoor rearing unit. Lights were placed at the end of the covered settling trough to attract fry, which are photopositive, to the end of the trough where the pipe going to the rearing tank was located. Lights were also placed at the upper end of the rearing tank to attract fry, allowing the removal of dead or deformed fry which settled to the bottom and end of the tank. A screen was installed in the tank to confine fry to the lower third of the rearing unit (Figure 1).

Several days passed and very little additional hatching was observed. Of those fry that did hatch, the majority appeared weak and deformed and were unable to swim out of the jar. Hatch then increased over the next several days. While many fry were unable to swim out of the jar or out of the settling trough, healthy fry were evident in the head of the rearing tank, schooling under the light. Peak hatch was seen on December 26th (387 TUs) which was well beyond the expected 265 TUs. To keep the incubation stage of this summary separate from the fry–fingerling culture stage, the TUs were accumulated separately for each stage. Therefore, the accumulation of TUs was reset on January 1 or when eggs were considered completely hatched. On January 3 (33 TUs), it was decided that any remaining unhatched eggs would most likely never hatch and all eggs remaining were discarded. It was evident that a large percentage of fry were deformed in some manner and most likely would not survive. Enumeration of unhatched eggs could not be done due to the presence of deformed and dead fry in the jars. The actual number of fry in the rearing tank could not be estimated. By January 28 (308 TUs), the majority of the deformed fry had died and been removed. The number of remaining fry could not be inventoried as a result of their small size. The fry that remained appeared to be accepting feed and were growing slowly. Over the next 10 days, mortality remained high but actual numbers of fish still could not be determined due to their small size. The inventory appeared to be reduced based on visual observations.

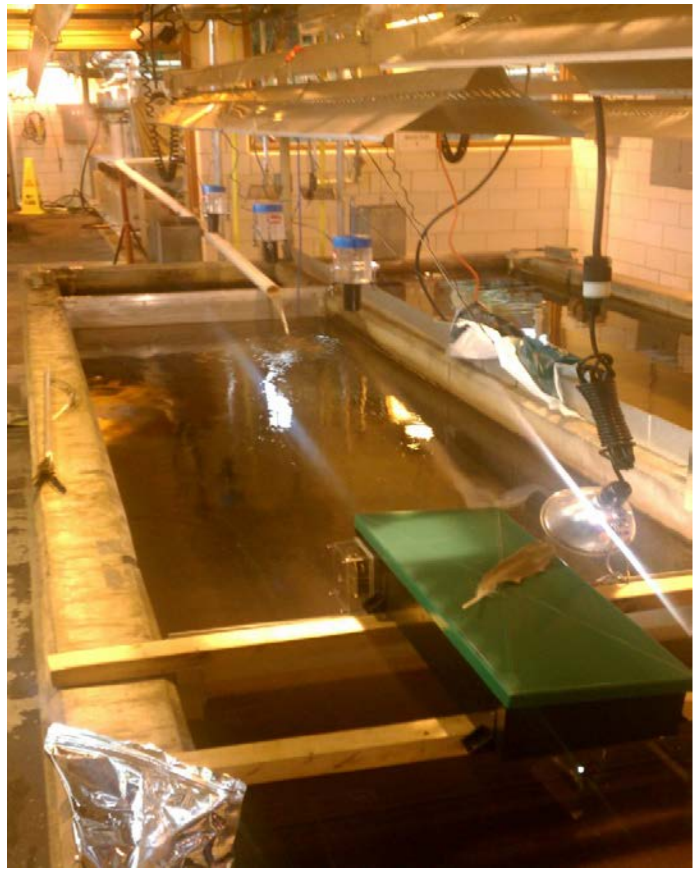

Figure 1.–Rearing trough used Dec 16–Feb 11.

On February 11 (462 TUs since hatch) all fry were transferred into two 2-ft circular tanks (Figure 2) to aid in tank cleaning and feeding efficiency.

After transfer to the 2-ft circular tanks, feeding appeared to improve and fish looked like they were growing, however due to the small size of the fish, this assessment is based solely on visual observations. On March 24 (913 TUs since hatch), it was determined that tank densities needed to be reduced based on visual observations and all fingerlings were hand counted back into the lower half of one indoor rearing tank (TK02). Total inventory on March 24 was estimated to be 11,190 fingerlings. Total weight of fish was not determined as fish cannot be handled out of water at this life stage. A length/weight sample was taken on March 29 (968 TUs). Fingerlings averaged 2.84 cm in length and 5,356 fish/kg on this date. Compared to 2008–09 growth rates (0.0255 cm/day), 2010 fry grew 28% slower (.0183 cm/day); the cause for the reduced growth rate is unknown.

Figure 2.–Two-foot circular raceway where fry were reared February 11–March 24.

Incubation results this year were similar to those reported for Wolf Lake State Fish Hatchery ambient incubation temperatures in 2008–09 (Fielder and Hughes 2009). In that study, Cisco egg viability was 11% for a group of eggs incubated at 10ºC (ambient) while 40% of eggs incubated at 3ºC (chilled) were viable. The ambient-temperature group in 2008–09 may also have been affected by temperature shock and, as with the 2010–11 group, a large proportion fry hatched in ambient water were deformed. The incubation work conducted in 2010–11 seems to confirm that incubation temperatures near or above 7.5 C can cause excessive mortalities and deformities. Additional information is needed to determine the optimal rearing temperatures (at and below 7.5 C) required to achieve adequate survival and still meet stocking size/date targets for production scale rearing. Incubation temperatures have implications on when fish would be available for stocking. The timing of stocking (optimal date and size) also needs additional evaluation.

Objective: Determine Appropriate Rearing Densities for Production Level Culture

There were indications that optimal rearing density for Ciscoes may be less than for other salmonids, but Fielder and Hughes (2009) could not rigorously test this observation, given the relatively small numbers of fingerlings they worked with. Based on the earlier work, we developed a study objective to test rearing densities approximating production conditions to allow for the documentation of rearing protocols and costs per fish for culturing ciscoes. This rearing density experiment would require larger numbers of fingerlings than previously produced.

The 2010–11 experience.–Insufficient fish were available to complete testing for this objective. This is still an outstanding issue that needs further experimentation.

Objective: Determine Whether Fingerling Ciscoes Can be OTC Marked Using Chinook Salmon Fingerling Marking Protocols

Oxytetracycline (OTC) marking using OTC-laced feed formulated for Chinook Salmon was used successfully to mark Cisco fingerlings in 2007 and 2008 (Fielder and Hughes 2009). Based on the previous work, we developed an objective to evaluate the effectiveness of double marking—marking fry by OTC emersion followed by marking at fingerling stage using OTC formula feed. Multiple marks (marking both fry and fingerling-stage marks) can also be used to identify year classes, stocking sites, or other stocking parameters. The Alpena Fisheries Research Station is equipped to process either otoliths (from fry marking) or vertebrae (from OTC-laced feed) for mark detection.

The 2010–11 experience.–An oxytetracycline (OTC) mark was administered by feeding at 2% of body weight with 1.5 mm pellets of prepared feed containing 6% Terramycin 100®. Terramycin 100® is composed of 100 g oxytetracycline dihydrate per 454 g of formula. As with marking of Chinook Salmon fingerlings, this OTC diet was administered after fingerlings had reached an average weight of about 2.76 g (weight range 0.38 g–6.00 g). The OTC diet was fed over two periods, June 9–12 and June 15–18. Fish were then stocked on June 21. The OTC mark is not immediately detectable after administration; therefore, a sample of 31 marked fish was held at Wolf Lake State Fish Hatchery an additional 30 days after mark administration to allow the marking to fully occur. This sample was then sent to the Alpena Fisheries Research Station for estimation of marking rate and mark quality. All fish displayed the mark with 30 of the marks classed as “Excellent” and one classed as a “Good” mark. Marks are classed as “Excellent” if the mark was clearly fluorescent and continuously visible around the perimeter of the vertebral centrum (Figure 3). “Good” marks were either strongly fluorescent or continuous but did not meet both criteria. Marks are classed as “Poor” if they are detectable, but neither fluoresced well, nor are represented by a continuous ring around the vertebral centrum (Johnson et al. 2010). An example of an “Excellent” mark and the one ‘Good” mark from the 2011 Cisco cohort are illustrated in Figure 3.

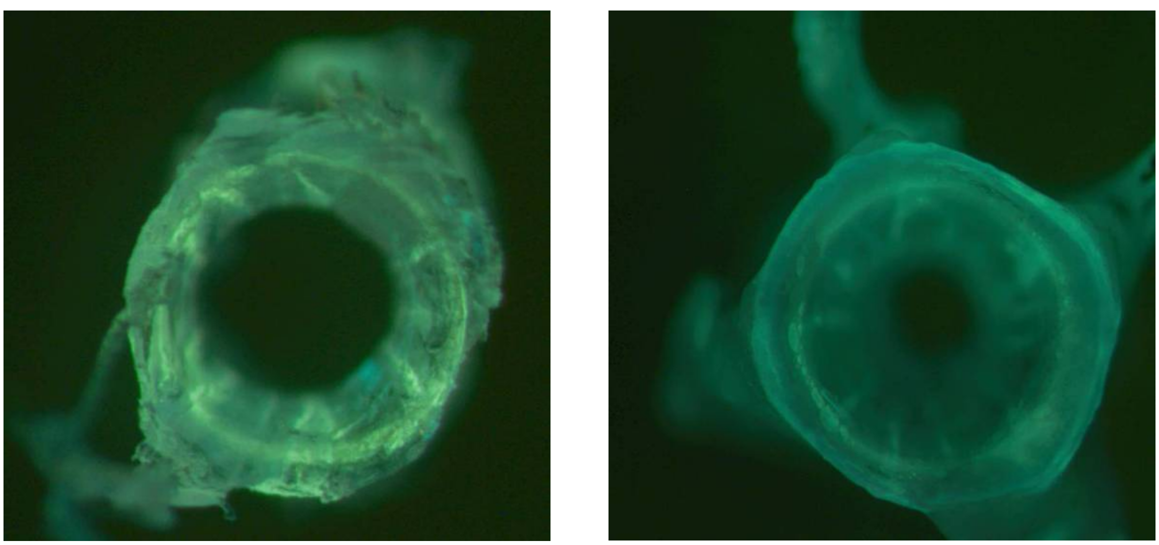

Figure 3.–“Excellent” OTC mark (left) and “Good” mark (right).

As with 2008–09, the fish took OTC-laced feed well and the marking rates and mark qualities were satisfactory. Based on the information to date, marking Cisco fingerlings with OTC using the methods developed for Chinook Salmon fingerlings is clearly feasible. Not enough fry survived to permit experiments with fry emersion marking.

Objective: Determine Optimal Size and Time of Stocking

To date, advanced spring fingerling Cisco have been stocked in late June or early July. Our hypothesis, based on years of experience with Walleye stocking, is that stocking as fingerlings bypasses mortality sources, resulting from low plankton concentrations and predation, from the receiving waters and thus means fewer fish need be stocked to establish a spawning stock than if fry stage were stocked. In some instances of Walleye stocking, stocking fry produced no evidence of survival, while fingerling stocking made significant contributions (Fielder 1992, Paragamian and Kingery 1992). In other instances, the number of fry required to produce the same year class strengths as those produced by fingerling stockings was orders of magnitude higher. For example, Heidinger et al. (1987) showed that relative survival of Walleye fingerlings was from 16 to 62 times higher than for fry stocking in Illinois reservoirs. Thus, stocking the fingerling life stage means far fewer eggs need be taken than for fry life-stage stocking, which is an important consideration in light of the difficulties and stock limitations surrounding the present egg supply. A study could be designed to evaluate optimal size and time of year to stock if a larger egg supply was available. Such a study would involve comparing survival rates achieved, for example, with two fingerling sizes at two or three different stocking sites over a period of several years of study. Unfortunately, insufficent fish were available to implement such a study design in 2010-11.

The 2010–11 experience.–A total of 9,495 fingerlings Ciscoes was stocked on June 21 at the West Dock (Lafarge Corp.) stocking site in Thunder Bay Lake Huron. These fish weighed 146.55/kg on the stocking date. The history of Cisco stocking to date is given in Table 2.

Table 2.–Number, length, and weight of OTC-marked Cisco fingerlings reared at the Wolf Lake State Fish Hatchery and stocked at the Lafarge West Dock in Thunder Bay at Alpena.

Stocking date	Number stocked	Average length (cm)	(in)	Total weight stocked (kg)
07/24/2008	6,240	9.7	3.8	40
07/14/2009	40,012	8.07	3.2	144.1
06/21/2011	9,495	7.47	2.9	29.45
Total	55,747			

Thunder Bay Cisco Stocking Evaluation Results

Small-mesh gill nets (2.5–3.5 inch mesh) were set at the West Dock Channel stocking site off the Lafarge Cement Plant November 3–4 and again November 10–11, 2011. Gill-net effort totaled 350 ft each day. A total of three Ciscoes were caught, all in spawning condition. On November 3–4, two Ciscoes were caught, one male the other female, measuring 439 and 346 mm respectively (17.3 and 13.6 inches); the female was OTC marked and two years old (stocked in 2009). The unmarked male was estimated, based on otoliths, to be 14 years old. The third fish, caught November 10–11, was an OTC-marked 336 mm (13.2 inch) female that was three years old (stocked in 2008). The two stocked females were mature, but not yet in ripe condition. Their average length of 341 mm represents rapid growth. Both OTC-marked Ciscoes were caught within 100 meters of the stocking site, suggesting there may be imprinting to stocking sites.

Another small-mesh 300-ft gill net was also set on one of 25 newly installed mitigation spawning reefs in Thunder Bay on November 10–11 but this net caught no Ciscoes. Any future stocking strategies should consider stocking (and imprinting) fingerlings on the newly constructed mitigation reefs in Thunder Bay.

The amount of gill-net effort was small, which was dictated by the small amount of time available for Cisco assessment in fall 2011. In future years a more systematic survey should target a variety of potential spawning sites in Thunder Bay and employ several thousand feet of gill-net effort. Peak spawning dates are probably similar to the St. Marys River, thus such an assessment should target the mid-November time period.

Discussion and Recommendations

Weather conditions in 2010 were ideal for spawn taking. Winds were light (≤10 mph), which meant transport of broodstock by boat was done quickly with minimal stress to the fish. During 2006–08 spawn-taking operations, winds were high enough that the four-mile trip by boat from the nets at Baie de Wasai to the egg taking site at Osborn Access Site, Sault Ste. Marie was slow and rough, stressing the fish, and slowing the spawn-taking operation (figures 4 and 5). Locating the spawn-taking site closer to the broodstock source (Baie de Wasai) would speed the spawn-taking operation, thus increasing the number of eggs that can be taken per day and decreasing the amount of stress imposed on the broodstock during boat transport. Future work should include examining the availability of locations on the shore of Sugar Island at Baie de Wasai that could be used as a spawn-taking base.

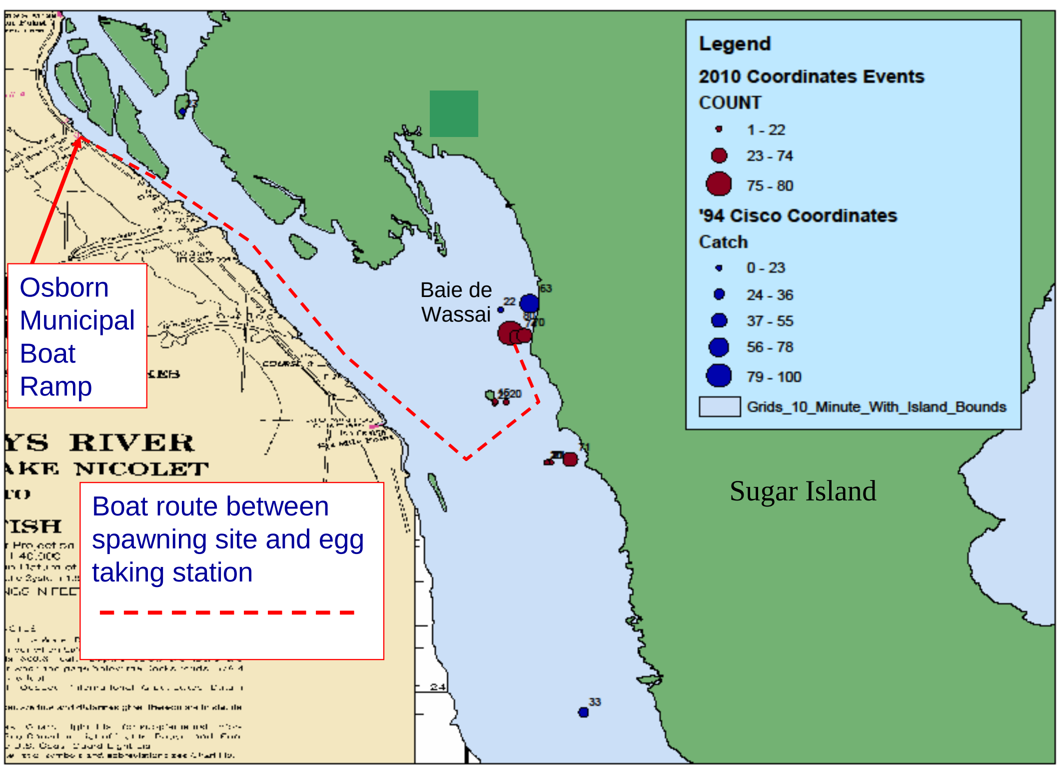

Figure 4.–Location of broodstock collection site at Baie de Wasai and the egg taking station at Osborn Access Site. The travel distance by boat between the two locations is 4.5 miles. Gillnetting sites during the 1994 Cisco spawning study and during 2010 are scaled using size to indicate catch rate in number of fish per 1,000 ft of net.

Figure 5.–Weather conditions during 2010 were excellent, unlike previous spawn-taking events. Here, Cisco broodstock are being delivered to the Osborn Ramp egg taking site in November 2008.

Whether trap nets are efficient in taking Cisco broodstock has yet to be determined because we were unable to orient the trap nets correctly in 2010. Relatively calm weather, rarely experienced this time of year, needs to be targeted for setting these nets. Targeting such weather opportunities as early as late October would increase the likelihood of setting the nets so that they fish correctly. In 2010 we determined that Ciscoes can be held and staged to ripeness for at least a week in trap nets with minimal escapement or mortality.

Additional information is needed concerning other broodstock collection methods including nighttime electrofishing. However, electrofishing requires relatively calm weather and the DNR's electrofishing boats are not designed for working large, open waters in rough conditions. If conditions permit, we could request cooperation from the Chippewa-Ottawa Resource Authority to evaluate nighttime electrofishing using their electrofishing unit. All collected broodstock should be stored in trap-net pots.

During the pilot study years, we found only one specific site in Baie de Wassai where good numbers of ripe Ciscoes could be sampled (Figure 4). Green Ciscoes were collected in a variety of locations but this was the only site where fish were commonly in spawning condition during the egg take. This spawning site is only large enough to accommodate one or, at most, two trap nets. This indicates the Baie de Wasai population may be too small to supply more than about 1,000,000 eggs per year. We therefore suggest that alternative sources of eggs be evaluated as Cisco rearing is scaled up to production levels, which will probably require more than 1,000,000 eggs per year. Potential broodstock sources for this evaluation could include other Lake Huron (Georgian Bay, Drummond Island) and Lake Superior populations (i.e. the Apostle Islands broodstock).

Whether the St. Marys River Ciscoes are likely to colonize Lake Huron's pelagic zone is unclear. Although Ciscoes are common in the St. Marys River, North Channel, and the Les Cheneaux Islands, they are not sampled in either bottom trawling or midwater trawling conducted annually in the pelagic waters off of Detour by the United States Geological Survey Great Lakes Science Center. Koelz (1929) used morphometrics (meristic measurements of distances between various appendages and body parts) to distinguish what may have been separate stocks of Ciscoes in the upper Great Lakes and showed that the nearshore and riverine Ciscoes of the North Channel and St. Marys River differed from the Main Basin pelagic stocks, while the pelagic types of both Lake Huron and Lake Superior seemed to be similar to each other. This finding suggests there were functionally distinct stocks of Ciscoes in the offshore and nearshore waters of the upper lakes (Yule et al. unpublished manuscript). Supplementing St. Marys River eggs with eggs from a pelagic stock would improve the likelihood of reestablishing both nearshore (St. Marys) and offshore varieties of Ciscoes in Lake Huron, while increasing the number of eggs available for culture. A search for a pelagic broodstock should be done and should include life history, genetics, and fish health aspects.

Fielder and Hughes (2009) produced their highest eye-ups by incubating eggs at 2.8ºC. The Northern Aquaculture Demonstration Facility (Greg Fischer, personal communication) achieved good eye-ups with 8ºC incubation temperatures. Our eye-up rates in 2010–11 were not as high as Fischer's, but early egg incubation temperatures were probably not the cause. More likely, the cause was low spawner abundance and the necessity of using females that may have not been fully ripe. Our very low hatch rates were similar to those reported by Fielder and Hughes (2009) for 10ºC incubation temperatures and may have been caused by temperature rises following chiller failures, when temperatures rose above 10ºC. We recommend that egg incubation be conducted using water supplies that are colder than 8ºC. Experimental culture at temperatures of 5ºC and 7.6ºC could be compared with respect to eye-up, hatch rates, and fingerling size at stocking. For this year's rearing cycle, we used a single chiller and the chiller failed twice. In future, if water chillers are used, there should be redundancy so that if one chiller fails there is an automatic backup. Based on the experience of Fielder and Hughes (2009), rearing temperatures after hatch may not be as critical and could be maintained near 10ºC; this could make it possible to produce fingerlings large enough to take OTC feed prior to the June stocking date, even if colder temperatures (for example 5ºC) were required during egg incubation.

If future collections at Baie de Wasai are as successful as in 2010, and egg fertilization and survival rates can be boosted to about 50%, there could be as many as 200,000 to 500,000 fry to accommodate, which would mean production-level raceway space will be needed.

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