Executive Summary

In 2014 sampling was largely postponed due to extremely high water levels. However, several drifting lake whitefish eggs were captured during a single sampling event on April 24th using benthic positioned D-frame driftnets. Collected eggs were subsequently hatched in the lab indicating overwinter survival of lake whitefish eggs is possible in the Menominee River. In 2015, a total of 699 recently hatched larval lake whitefish were captured in the Menominee River from April 2nd to April 25th 2015. Four different collection methods were attempted due to river conditions that made sampling using standard drift nets difficult. We observed that the peak of drift activity for larval whitefish occurred on April 17th. The highest concentrations of larval whitefish were observed at the top of the river column and in downstream back-water areas, where they were likely entrained due to hydrodynamic forces (eddies etc.) until the end of the sample period. Our research achieved its primary objective in terms of determining that lake whitefish are successfully producing offspring to the drifting larval stage in the lower section of the Menominee River. Using flow estimates from nearby gauging stations, and our various forms of sampling, we estimate between 241,000 and 805,000 larval whitefish were produced in the Menominee River in 2015.

Introduction

Lake whitefish (Coregonus clupeaformis), henceforth whitefish, have been a highly valued food resource in the Great Lakes for thousands of years (Ebener et al., 2008). Unfortunately, whitefish populations suffered declines due to overexploitation, invasive species, and loss of spawning habitat. Some whitefish populations have recovered in part due to strong recruitment events (late 1990’s/early 2000’s) and restrictions that curbed fishing related mortality. Management of whitefish is complicated by the species’ life history; adults spawn from late October through early December on near-shore gravel reefs 2-18 m in depth where eggs overwinter (Becker 1983). Adults tend to exhibit a high degree of natal philopatry (i.e., return to where they were born) resulting in genetically differentiated subpopulations.
Large numbers of whitefish also historically spawned in tributaries. Interestingly, while river migrating and spawning whitefish ecotypes were extirpated by the late 1800s, a modest number of spawning adults have recently been observed in tributaries of Lake Michigan in the Menominee, Oconto, Peshtigo and Fox Rivers.

Wisconsin DNR fisheries staff are currently in the early stages of describing this newly “found” spawning population as the population continues to re-establish itself. However, one aspect that is essentially unknown is that of the larval stage. Because most whitefish stocks in Lake Michigan spawn in lentic environments, little information exists for larval life history characteristics in a lotic environment. Larval life history has been described for several Lake Michigan stocks (Hoagman 1973; Claramunt et al. 2010) including the North/Moonlight Bay (NMB) stock, the primary spawning stock in Wisconsin waters. This recolonization event in the Menominee River presents an excellent opportunity to not only characterize the larval outmigration, but to also draw comparisons to existing information collected from the NMB larval population. This information is key to proper management and protection of the various life history stages of whitefish in the Menominee River and will provide information that may be of utility for restoration efforts in other rivers where whitefish runs existed historically.

This project sought to address the following objectives (in order of priority): (1) Characterize larval whitefish outmigration from Menominee River with respect to timing, abundance, and vertical distribution. Compare/contrast biological characteristics (e.g. development) and abundance of larvae between the Menominee River and NMB (baseline site sampled historically) spawning populations. (2) Describe lotic/lentic conditions of the Menominee River (physical/chemical) to evaluate impact on the success and timing of larval emergence. For example, determining river flow as it relates to the timing of larval drift. (3) Evaluate substrate in the Menominee River spawning locations to help understand the substrate characteristics that are important to whitefish spawning success. (4) Explore larval production in some or all of the following rivers: Fox, Peshtigo, and Oconto; locations where there is anecdotal evidence that whitefish are being found during the November spawning period or have spawned historically.

Connection of this project to Great Lakes Priorities

This project addresses the Great Lakes Council of Governors’ Priority (CGLG) priority, “Restore to environmental health the areas of concern identified by the IJC as needing remediation.” Specifically, the project will focus on the lower Fox and Menominee Rivers (both AOCs) to investigate the ecological and life history characteristics of a native species in a specific habitat that historically supported robust whitefish populations; areas that now present opportunities for population-specific restoration. This project, on several fronts, also addresses the CGLG priority, “Enhance fish and wildlife by restoring and protecting coastal wetlands and fish and wildlife habitats”. It will specifically contribute to the recommended action for Habitat and Species by contributing to the Wisconsin Strategy of tributary restoration. It evaluates riverine habitats and native species populations that were decimated by logging activities, pollution and dams. While lake whitefish as a species (at the Lake Michigan-wide level) is not threatened, the tributary-specific spawning populations were decimated and now, by virtue of a relatively healthy lake population, have the potential to be restored with proper conservation efforts.

Methods

Larval whitefish eggs deposited in the fall incubate over winter with number of days post fertilization depending on water temperature. For whitefish, the number of degree-days required during the incubation period in field based settings is largely unavailable because the exact time of spawning is unknown. The behavior of Coregoninae yolk sac larvae also appears to differ from those of other river-spawning migratory species. For example, Salmoninaceae and Acipenseridae larvae stay in the river substratum for days to weeks between hatching and swim-up stage. However, larvae of Coregonus spp. have only a very small yolk sac and start to swim immediately after hatching (Næsje et al. 1986) around 14-17 mm in length. For this reason, sampling for out-migrating larval whitefish began as early in the
spring as possible (i.e., ice out). Larvae were collected using D-frame drift nets (bottom width = 76 cm, height = 53 cm, length = 3.4 m, mesh size = 1.6 mm), which is the standard assessment tool for collecting drifting larvae.

Nets were placed a short distance (i.e., less than 1 km) below areas used for spawning based on observations and collections of adults. Many fish species exhibit nocturnal drifting behavior during the larval stage. However, whitefish eggs were found to hatch at equal rates during light and dark periods and yolk sac larvae began to swim immediately after hatching. For this reason, larval drift sampling was conducted primarily during the day. However, several samples were conducted at night during the primary drift period to capture drift periodicity over a 24 hour period. River discharge and water temperature were tracked in real-time through the late winter and early spring using data downloaded from nearby United States Geological Survey gauging stations.

Pearson’s correlation coefficient was calculated between larval whitefish length and survey day to determine if there was a relationship between hatch date and size. A general linear model with larval length as the dependent variable and sampling method and date as the dependent variables was performed to determine if fish lengths were different between sampling methods and sampling dates.

Sidescan sonar surveys were conducted in August of 2015 using a Starfish Seabed Imaging System. Survey tows generally lasted 10 minutes and tow paths were oriented parallel to the rivers banks. The survey area was generally from the hydroelectric dam to 200 meters downstream of the highway 41 bridge, and north of Stephenson Island, encompassing both sides of Boom Island. Post processing of sidescan sonar was conducted using SonarTRX (LEI. Corp), where beam angle and boat position was corrected.

As part of the first project objective to characterize larval whitefish outmigration from Menominee River with respect to timing, abundance, and vertical distribution, we planned to sample the North/Moonlight Bay (NMB) baseline site to compare/contrast biological characteristics (e.g. development) and abundance of larvae between the Menominee River and NMB spawning populations. Wisconsin DNR staff conducted nonnet larval sampling on nine days over the course of approximately six weeks beginning April 9, 2015 and ending May 13, 2015. This period was chosen in attempt to gather data from early, middle, and late part of the larval emergence period. Three baseline sites in the North/Moonlight Bay area were sampled based on historical surveys including Baileys Harbor, Moonlight Bay, and Rowley Bay. Three samples were taken within each of the geographic sites. With the exception of the first and last week where Moonlight Bay was not sampled, all sites were sampled weekly though not always the same day. Larval samples were enumerated and preserved in 95% non-denatured ethanol. The volume of water sampled during each tow was calculated in cubic meters of water using a flowmeter. The number of larvae captured in the tow was calculated by dividing the number captured by the volume of water sampled. Water temperature sensors were also deployed at two locations in the NMB area and Menominee River to collect temperature data during the spawning, incubation and post-hatch periods. Temperatures were recorded every 3 hours in the Menominee River and every 4 hours in the North/Moonlight Bay area. Water temperatures in the NMB area were generally warmer on
average until the last month where the Menominee River increased more quickly. However, sensors in the NMB area were placed in approximately 20’-25’ water depths while the sensors in the Menominee River were placed in 4’-5’ water depths.

Results and Discussion

Larval whitefish outmigration with respect to timing, abundance, and vertical distribution

Unfortunately, several extraordinary natural events precluded us from conducting a detailed and seasonal quantitative assessment of larval whitefish production during 2014. First, focal tributaries remained completely ice covered or were treacherous due to floating ice until mid-April. This was nearly one month beyond our initial projected start date. The winter of 2014 was the coldest or second coldest on record for much of Wisconsin, including the Green Bay area. Once ice conditions improved, total river discharge across all tributaries was extremely high and remained high until larval whitefish migration was likely over. High river discharge was partly the result of record snowfall in many northern Wisconsin watersheds in 2014 (the same for 2008 and 2013) followed by significant rainfall. The figure included above shows river discharge for the Menominee River over the last 10 years, including 2014 to illustrate these issues. The dashed line in the middle of the figure represents the maximum flow conditions for our sampling gear. This threshold was based on previous experience sampling for larval lake sturgeon. Note that in 2014 USGS river discharge estimates were unavailable due to ice until April 15, and after ice out, river conditions never dropped below our sampling threshold during projected larval whitefish outmigration. Thresholds for larval drift sampling is river specific and were likewise exceeded on other tributaries.

Despite the limited sampling due to high water levels in 2014, we sampled for whitefish larvae on April 24, from 2:00 pm to 4:00 pm at a river discharge of ~10,300 cfs. Two D-frame nets were set close to the Stephenson Island boat ramp, and 2 D-Frame nets set below the walk bridge to Stephenson Island. While majority of time was spent retrieving nets downstream and resetting upstream, three eggs were collected that were verified to be larval whitefish after hatching in the lab (see picture above).

While sampling in 2014 was limited, larval whitefish sampling was successfully conducted in 2015 by modifying the survey methods. Larval whitefish surveys were performed from 4/2/2015-4/25/2015 during the midday hours in the Menominee River from Boom Island to the river mouth. D-frame drift nets were either placed on the bottom to passively sample drifting larvae or actively towed at the surface by a boat. Passive drift nets were placed at 12 locations perpendicular to Stephenson Island from April 2nd - 6th and tethered to the highway 41 bridge on April 7th-9th at 4
Due to high water and few larvae being collected in bottom drift nets, trawls were conducted from April 7th through April 25th. Trawls consisted of towing an inverted d-frame drift net (76cm x 53cm) alongside a boat, at the surface, for 10 minutes. Trawling was standardized at six locations across the river channel. Water volume for each tow was quantified using a flowmeter attached to the mouth of the net. Each tow was then standardized by dividing the total number of whitefish larvae captured by the volume of water sampled (LWF/m³). Supplemental trawling was conducted at 12 sites between the highway 41 bridge and the river mouth. Total estimates of larval output were calculated using average daily water volumes from USGS gauging station and 95% confidence values for the average number of larval whitefish per cubic meter of water. Total daily water volumes were divided by 5 to adjust for the trawls sampling depth.

A total of 699 larval whitefish were captured in the Menominee River in 2015. Over the course of sampling in 2015, four methods were used due to river conditions that made sampling using drift nets difficult. Drift nets set at 12 standardized locations captured 8 larval whitefish over 10 days of sampling. Drift nets that were tethered to the highway 41 bridge at four locations captured a total of 79 larval whitefish over 7 days of sampling. While, towing drift nets at 6 standard locations captured 187 larval whitefish and exploratory tows at 11 locations captured 433 larvae in 9 and 7 days of sampling, respectively. Total number of whitefish larvae per cubic meter of water was calculated using the flow data collected at the mouth of each net for both drift and towed sampling techniques. Number of larval whitefish per cubic meter of water ranged from 0-0.42 WF/m³ (figure above left) peaking on day nine of sampling during the
exploratory sampling conducted downstream of the highway 41 bridge. Of the three sites sampled in NMB, Baileys Harbor and Rowley Bay had the higher average number of larvae over time (figure previous page right). Interestingly the timing of peak hatch from the NMB larval population was similar to the timing of peak hatch from the Menominee River larval population, April 15th and April 17th respectively. However, inherent differences between the lotic and lentic environments between these locations (e.g. wind speed/direction on Lake Michigan) can make direct comparisons somewhat difficult. The peak of drift activity coincided with increasing water temperatures at the Menominee River gauging station, water temperatures rose from 4.5 to 10 degrees Celsius over the 6 day period around peak drift. Water Flows were also high, >250 m³/sec, during peak drift activity. An indication that rising water temperature and high flow conditions may contribute to larval emergence and drift (figure previous page left).

Length characteristics of capture whitefish larvae

The mean length of larval whitefish captured from standard trawls and exploratory trawls was 12.8 and 13.3 mm, respectively (figure below left). There was a significant correlation between length of larval whitefish and sampling day. With larger larval whitefish captured as the season progressed for both the standard and experimental trawls (N = 187, p = 0.029, r = 0.160; N = 433, p > 0.001, r = 0.214, respectively). Only sample date returned a significant interaction with larval length in a general linear model using sample date and trawl locations as explanatory variables for larval length(F = 2.343, p = 0.017). Mean larval whitefish lengths from the NMB surveys conducted by the WDNR ranged from 14 to 16.5 mm. Mean length as well as variation in length generally increased during the period of sampling (figure below right) suggesting most hatching had occurred by late in the sampling period.
Substrate characteristics of likely spawning areas

Sidescan images were entered into ArcGIS (ESRI Corp.) and georectified, benthic substrate are primarily cobble and stone with interspersed finer substrates north and east of Stephenson Island and east of the Highway 41 bridge. Substrates in the area between Stephenson Island and the hydroelectric facility cover a wide range of hard substrate types from cobble and rock to gravel and areas of exposed bedrock near to the dam. Since preferred spawning substrates of river-run whitefish have not yet been assessed we cannot quantify the extent of suitable spawning habitat from the current survey. However, the wide variation in hard substrates likely offers at least some suitable habitat for whitefish spawning. Sidescan mosaics have been shared with the WIDNR for future habitat characterization work (figure to right).

Conclusion

This is the first survey to document successful reproduction of whitefish in the Menominee River since their extirpation in the early 20th century. Combining our survey results with average daily outflow volumes from USGS gauging stations, we estimate the total Menominee River larval whitefish output in 2015 ranged between 241,000 and 805,000 fish. Our larval production estimate makes a number of assumptions, including a lack of within day periodicity for larval drift and that we performed sufficient sampling to obtain an adequate estimate of mean daily larval output. However, these assumptions are likely offset by the fact that our sampling was only performed on the uppermost portion (upper ~20%) of the water column. While whitefish larvae are known to vertically migrate post-hatch, we have no way of knowing how many whitefish larvae passed just below our sampling gear in the remaining ~80% of the water column. A large number of whitefish larvae were also captured downstream during supplemental trawling, and were likely entrained in backwater eddies. The effect of this larval entrainment on growth and survival is unknown and needs to be investigated further. Finally, now that successful production of river-spawned larvae has been documented in the Menominee River, an important next step is to assess the relative contribution of this and other river spawning stocks to the greater Green Bay whitefish metapopulation.