Cornell University
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Health and Safety

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October 27, 2015

Chuck Nieder
Steam Electric Unit Leader
NYSDEC, Bureau of Habitat
625 Broadway 5th Floor
Albany, NY 12233-4756

Re: Lake Source Cooling SPDES Permit (NY 024 4741)
Biomonitoring Status Report

Dear Mr. Nieder:

This letter constitutes the Biomonitoring Status Report for the Cornell University Lake Source Cooling (LSC) facility, which is being submitted in accordance with SPDES Permit NY 024 4741 Special Conditions: Biological Monitoring Requirements section, Item 8.

The status report must include a description of the operational status of the facility during the preceding two years and compliance with Biological Requirements 1 through 6 outlined in the Special Conditions: Biological Monitoring Requirements section of the LSC SPDES Permit.

The Lake Source Cooling facility has operated normally over the preceding two years and has not experienced any abnormal conditions at the LSC facility. The operation of the facility was also considered normal during the Entrainment Characterization Study that took place from April – August 2014, and therefore the Entrainment Characterization Study was presumed to be representative of normal operations.

Item 1 of the Special Conditions: Biological Monitoring Requirements section of the LSC SPDES Permit required that Cornell: submit a plan for an Entrainment Characterization Study, implement the plan, and submit a final report after the study was concluded.

- The Entrainment Characterization Study plan was submitted to the NYSDEC on January 30, 2014, within the deadline of Feb. 1, 2014. The plan was reviewed by NYSDEC and approved on February 10, 2014 via correspondence from Michael Calaban to James R. Adams, former Director of Utilities at Cornell University.
- The study was performed in April – August 2014 in accordance with the SPDES permit and work plan approved by NYSDEC. The study was performed successfully and had relatively few changes to the schedule. Any significant changes were brought to NYSDEC's attention and approval received by NYSDEC, when required.
- A final report was submitted to the NYSDEC on April 9, 2015, well within the deadline of 9 months (May 31, 2015) from the completion of data collection. The report contained all data required by the NYSDEC.

The NYSDEC reviewed the final report and submitted a letter to Cornell on May 5, 2015, stating that the study demonstrated that the current LSC intake design, location and operation results in a reduction in entrainment in excess of 95 percent from the full flow calculation baseline. Therefore, the NYSDEC determined that the "existing intake meets requirements of Best Technology Available under 6 NYCRR 704.5, NYSDEC Commissioner's Policy No. 52 and Part 316(b) of the Federal Clean Water Act."

Based on the determination by the Department that the LSC intake met the performance goals of CP-52, Items 2-6 of the Special Conditions: Biological Monitoring Requirements section were not required to be implemented, as stated directly in the SPDES permit.

The above summary demonstrates that Cornell complied with all requirements of the LSC SPDES Permit Special Conditions: Biological Monitoring Requirements Items 1-6. Per the SPDES permit and NYSDEC's determination letter from May 5, 2015, if the Department determines that the performance goals of CP-52 have been met, the Department will modify the SPDES permit to (1) identify the current location, design, construction, and capacity of the cooling water intake structure as BTA, thereby meeting the requirements of 6 NYCRR Part 704.5, and (2) remove Biological Monitoring Requirements 2-6 from the Permit. Cornell is currently pursuing this next step with NYSDEC so that the LSC SPDES Permit reflects the current status of the Biological Monitoring Requirements.

Please contact me should you have any questions regarding this Biomonitoring Status Report.

Sincerely,

Cheryl Brown
Environmental Project Manager

cc: Division of Water SPDES Compliance Information Section
Regional Water Engineer, NYSDEC Region 7
Jeff Myers, NYSDEC
William S. (Lanny) Joyce, Cornell University
Clifford E. Kraft, Cornell University
Patrick O. McNally, Cornell University

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LETTER OF TRANSMITTAL

DATE: 4/9/2015

TO: Steam Electric Unit Leader
NYSDEC, Bureau of Habitat
625 Broadway 5th Floor
Albany, NY 12233-4756

We are sending you (attached):

Copies	Date	Title / Description
2	3/31/2015	Cornell University Lake Source Cooling Facility Entrainment Characterization Study April Through August 2014 prepared in compliance with LSC SPDES Permit # NY 0244741
2	3/31/2015	Compact Disc including field data files (MS Excel format) supporting the Cornell University Lake Source Cooling Facility Entrainment Characterization Study April Through August 2014

REMARKS: This transmittal satisfies Item 1 of the Special Conditions for Biological Monitoring Requirements in the LSC SPDES Permit # NY 0244741, which requires the submittal of an *Entrainment Characterization Study* Final Report within 9 months of completion of data collection. Additionally, the SPDES permit requires that all data collected during the Entrainment Study be provided to the DEC in an agreed upon electronic format. Therefore, a CD of the field data is enclosed and this data will also be emailed to the NYSDEC.

Cheryl Brown

Cheryl Brown
Environmental Project Manager

cc: w/o field data compact disc enclosure:

Division of Water SPDES Compliance Information Section
Regional Water Engineer, NYSDEC Region 7
Jeff Myers, NYSDEC
Chuck Nieder, NYSDEC
Michael Calaban, NYSDEC
William S. (Lanny) Joyce, Cornell University
Clifford Kraft, Cornell University

CORNELL UNIVERSITY LAKE SOURCE COOLING FACILITY
ENTRAINMENT CHARACTERIZATION STUDY
APRIL THROUGH AUGUST 2014

Prepared for

New York State Department of Environmental Conservation
Division of Fish, Wildlife and Marine Resources,
Bureau of Habitat, Steam Electric Unit
625 Broadway, 5th Floor
Albany, NY 12233

Submitted by

Cornell University
Energy and Sustainability, Utilities Section
Humphreys Service Building
Ithaca, NY 14850

Prepared by

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March 31, 2015

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1.0 INTRODUCTION

The Cornell Lake Source Cooling (LSC) facility is designed to withdraw up to 2 cubic meters per second (46 million gallons per day) of water from Cayuga Lake at a depth of approximately 76 m to cool campus buildings. Lake water at that depth is approximately 4 °C year round. The cold water pumped from the lake bottom is passed through heat exchangers located in a shoreline facility. The cold water from deep in the lake absorbs heat from a second loop of circulating water, which is used to cool portions of the Cornell Campus as well as the Ithaca High School. The system began operation in 2000.

The LSC facility operates under State Pollutant Discharge Elimination System (SPDES) permit number NY 00244741, with an Effective Date (EDP) of May 1, 2013. The *Special Conditions: Biological Monitoring Requirements* section of the permit required Cornell University to submit to the New York State Department of Environmental Conservation (NYSDEC) by February 1, 2014 an approvable plan for an *Entrainment Characterization Study* at the LSC facility. In accordance with the SPDES Permit, the required study plan must "include a schedule for implementation, standard operating procedures for data collection, and a final report. At a minimum, the study must include:

a) Duration – April through August during 2014
b) Intensity – at least one 24 hour collection made in every seven calendar day period through the study duration
c) All samples will be analyzed for ichthyoplankton and juvenile fish
d) Concurrent samples shall also be collected in the near shore zone so as to provide a baseline density of ichthyoplankton, and basis for comparison with entrainment samples.
e) The final report shall be submitted within 9 months of completion of data collection and include a summary table of the total number of fish entrained by species and life stage based upon continuous operation of all pumps at full rated flow and actual operation and cooling water volume over the study period. All data collected during the entrainment study must be provided to the department in an agreed upon electronic format."

Cornell University submitted a study plan to the NYSDEC on January 29, 2014 and received written approval of the plan in a letter dated February 10, 2014 (letter from M. Calaban, NYSDEC Bureau of Habitat, to J. Adams, Cornell University, Energy and Sustainability). This document presents the results of Cornell University's entrainment characterization study conducted from April through August 2014 pursuant to that study plan.

1.1 Background

1.1.1 Project Location and Description

The LSC facility is located at the southern end of Cayuga Lake in the City of Ithaca, Tompkins County, NY. The structure housing the heat exchange facility is located along the east shore near the extreme south end of the lake. The facility's intake structure is located immediately above the lake bottom approximately 3.2 km north-northwest, approximately 1.4 km from the east shore, and in approximately 76 m of water. The intake is an octagonal structure made up of 2.0 mm wedge- wire screen panels, positioned 3 m above the lake bottom. Each screen panel is 2.4 m high by 1.2 m wide. The intake has a solid cap so that water is withdrawn from the horizontal plane only. The design intake velocity is 0.15 m/s (0.50 feet per second) with 50% of the area of the slots plugged (velocity = 0.08 m/s or 0.25 fps when clean). A 1.6-m diameter HDPE pipe extends from the intake structure along the lake bottom for a distance of approximately 3.2 kilometers, connecting to the on-shore heat exchange facility. Cleaning of the screen panels is done manually (typically using remote robotic tools), but this has seldom been necessary.

Within the shore-based facility, the cold lake water circulates through heat exchangers, where it absorbs heat from water in the closed-loop chilled water pipeline extending from Cornell's central cooling system (and Ithaca High School) to the LSC facility. The system is designed so that Cayuga Lake water does not mix with the closed-loop campus chilled water system, as the two water loops are separated by the stainless steel plates of the heat exchangers. The chilled water then circulates back to high school and the Cornell campus through 3.9 km of buried pipeline. The warmed lake water is returned to Cayuga Lake via a 152-m outfall pipe that extends off-shore from the facility, terminating with a 23-m diffuser submerged at a depth of 2.7 m.

1.1.2 Source Water Body

Cayuga Lake is situated in a steep-sided, glacially carved valley in the Oswego River drainage basin of Central New York. The lake is long and narrow, extending 61.4 km north from Ithaca to the lake's outlet into the Seneca River. Maximum lake width is 6.4 km and maximum depth is 132.6 m. With a total lake volume is 9.4 billion m^3 and a mean depth of 54.5 m, Cayuga Lake has a large volume of deep water that remains cold year round.

Cayuga Lake supports both warm-water and cold-water fish communities. The cold-water fish community, which includes water column (pelagic) and bottom-oriented (benthic) species, has lake trout (*Salvelinus namaycush*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and Atlantic salmon (*Salmo salar*) as the primary sportfish. Dominant cool-water and warm-water sportfish include smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), chain pickerel (*Esox niger*), northern pike (*Esox lucius*), yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*) and various sunfish (*Lepomis* spp.). Important forage species include alewife (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), and white sucker (*Catostomus commersonii*). A list of fish species known from the lake is provided in Table 1.

1.2 Objectives

The objective of this study was to characterize the near-shore ichthyoplankton community of Cayuga Lake in the vicinity of the LSC facility and document current levels of ichthyoplankton entrainment at the LSC facility. The near-shore ichthyoplankton community was characterized with regard to species composition, density, and life stage. Similar information for entrained ichthyoplankton was collected during concurrent sampling of the LSC facility intake water. These data are provided to the NYSDEC in order to determine if the current location, design, construction, and capacity of the LSC facility water intake structure meet best technology available (BTA) standards, thereby satisfying the requirements of 6 NYCRR Part 704.5 and the NYSDEC Commissioner's Policy CP-#52.

2.0 METHODS

2.1 Near-shore Ichthyoplankton Community Sampling

2.1.1 Sampling Location and Frequency

Sampling of the near-shore ichthyoplankton community occurred along the east side of Cayuga Lake in the vicinity of the LSC facility. A single "station" was sampled during each event, with a station consisting of, at a minimum, the distance covered during a 5-minute net tow averaging approximately 1 m/s (for a minimum distance of 300 m). An individual sampling effort consisted of one tow of a bongo-style two-net array at a depth of 2 m below the surface. The station sampled during each event encompassed a constant depth contour to the extent possible given aquatic macrophyte growth and other obstacles. The target depth contour was 3 m so that the nets were sampling just above the lake bottom when the nets were deployed at a depth of 2 m. However, as submerged macrophytes grew up through the water column during the summer, the station location shifted slightly (approximately 20 m) off-shore to avoid clogging the nets with vegetation. This resulted in an increase in water depth of approximately 0.5 m at the station, but the actual sampling depth was maintained at approximately 2 m regardless of total water depth. GPS coordinates were recorded at the beginning and end of each tow.

The sampling schedule called for conducting at least one 24-hour collection weekly from the first week in April through August 2014. A 24-hour collection consisted of three daytime and three nighttime sampling efforts within a 24-hour period. At the onset of the sampling program, the daytime sampling efforts began at approximately 1000 hr, 1200 hr, and 1400 hr, and the nighttime sampling efforts began at approximately 2200 hr, 0000 hr, and 0200 hr. Beginning with the sampling event that occurred on April 22-23, 2014, the timing of sample collections was changed to begin at approximately 1100 hr, 1200 hr, and 1300 hr for daytime sampling, and at approximately 2300 hr, 0000 hr, and 0100 hr for nighttime sampling. This change was made to make more efficient use of field crew time and was approved by the NYSDEC Bureau of Habitat prior to making the change (email from C. Nieder, NYSDEC, to C. Brown, Cornell University, April 21, 2014).

The sampling scheme resulted in the collection of 12 samples (six duplicate bongo-style net tows) during each 24-hour collection. If conditions arose due to weather, lake conditions, or gear malfunction that precluded conducting a sampling event as originally scheduled, the sampling event was conducted as soon as possible thereafter within the scheduled week once the issue preventing sampling was resolved. If a 24-hour sampling event could not be completed within its scheduled week, the sampling event was not conducted so as to maintain the regular weekly sampling schedule. Reasons for the omission of a sample were fully documented and reported to the NYSDEC within one week of any sampling event that was missed.

2.1.2 Sampling Gear and Protocol

Near-shore ichthyoplankton samples were collected from a 17-ft center-console motor boat equipped with a transom-mounted GPS/sonar unit (Humminbird Model 597 ciHD). Two bongo-style conical plankton nets (designed for oblique tows) were used. Each net was 2.0 m long with a mouth opening of 0.3-m, 500-μm mesh, and a detachable cod-end bucket. A mechanical flow meter was attached in the center of the mouth of one of the nets to determine the amount of water filtered through the nets during each tow. A 5-kg depressor was used to maintain the desired depth. The net array was deployed from the stern of the boat.

Tow speed of the sampling gear was maintained at approximately 1 m/s and was monitored using a GPS unit with a stern-mounted transducer. Before net deployment, the mechanical flow meter was checked for correct operation and beginning numbers were recorded. Once deployed, the sample start time began when the nets reach the desired depth (2 m). The length of time for each tow was measured with a stopwatch, and GPS coordinates were recorded at the beginning and end of each tow. During the sampling event, tow velocity, depth, and tow-line angle were monitored to ensure the net was fishing properly and at the correct depth.

At sample completion, the net was retrieved and the number of revolutions of the mechanical flow meter was recorded. Any tow for which there was apparent net damage, loss of sample, or improper deployment was considered invalid and was repeated. If a tow was considered acceptable, the nets were washed down from the outside to concentrate the sample in the detachable cod-end bucket. The sample contents of each net were then transferred to a labeled, 1-L sample jar and preserved in 95% ethanol with Rose Bengal stain.

In summary, the near-shore ichthyoplankton sampling program involved conducting six sampling efforts during each weekly 24-hour sampling event from April through August 2014. Sampling occurred at a depth of 2 m, and two samples (side-by-side bongo-style nets) were collected during each tow. This resulted in 12 individual net samples per weekly sampling event.

2.1.3 Water Quality Measurements

Water-quality conditions were recorded during each sampling effort. Parameters measured included water temperature (°C), dissolved oxygen concentration (mg/L) and percent saturation, and specific conductance (µS/cm). Each parameter was measured *in situ* at the 2-m depth from the surface using hand-held, portable meters calibrated to the manufacturers' specifications.

2.2 Ichthyoplankton Entrainment Monitoring

2.2.1 Sampling Location and Frequency

Sampling of the ichthyoplankton entrained at the LSC facility intake occurred at a pre-existing, integrated sampling system inside the facility. Water traveling through the main intake pipe from the facility's wet well was withdrawn from the main intake pipe via an integrated sampling line. This is the same sampling system that was used for biological monitoring for the entrainment of ichthyoplankton at the facility from 2000-2005.

Weekly in-plant ichthyoplankton entrainment sampling was conducted concurrently with near-shore ichthyoplankton community sampling. The sampling schedule called for conducting at least one 24-hour collection weekly from the first week in April through August 2014. A 24-hour collection was comprised of three 8-hour sampling efforts. The first sampling effort began at approximately 0800 hr and ended at approximately 1600 hr. The second sampling effort began at approximately 1600 hr and continued to approximately 0000 hr of the following day. The third sampling effort began at approximately 0000 hr and end at approximately 0800 hr. If conditions arose that precluded conducting a sampling event as originally scheduled, the sampling event was conducted as soon as possible thereafter within the scheduled week once the issue preventing sampling was resolved. If a 24-hour sampling event could not be completed within its scheduled week, the sampling event was not conducted so as to maintain the regular weekly sampling schedule. If delays in the near-shore community sampling were experienced, the in-plant entrainment sampling was also delayed such that the sampling was conducted concurrently. Reasons for the omission of a sample were fully documented and reported to the NYSDEC within one week of any sampling that was missed.

2.2.2 Sampling Gear and Protocol

Water withdrawn from the main intake pipe via the integrated sampling line was split into two equal-sized sample pipes, each of which in turn discharged into a 2.0-m long plankton net with a mouth opening of 0.3-m, 500-µm mesh, and a detachable cod-end bucket. The two plankton nets were suspended vertically, mouth end up, in a water-filled tank to reduce damage to collected ichthyoplankton. Sampled flow was monitored by a flow meter and recorded after each sample collection. The integrated sampling line diverts approximately 1% of the plant inflow to the net array.

At sample completion, each net was inspected for net damage, loss of sample, or improper deployment. When an acceptable sample was collected, the net was washed down from the outside to concentrate the sample in the detachable cod-end bucket. The sample contents of each net were then transferred to a labeled, 1-L sample jar and preserved with 95% ethanol with Rose Bengal stain.

In summary, the proposed in-plant entrainment sampling program involved deploying two nets simultaneously during each weekly 24-hour sampling event from April through August 2014, concurrent with the near-shore in-lake sampling. Each 24-hour sampling event was comprised of three contiguous 8-hour sampling efforts. This resulted in six individual net samples per weekly sampling event.

2.2.3 Water Quality Measurement

Water quality conditions of facility intake water were measured during each sampling effort. Parameters measured included water temperature (°C), dissolved oxygen concentration (mg/L) and percent saturation, and specific conductance (µS/cm). Each parameter was measured *in situ* at approximately 2 m from the surface in the plant's wet well using hand-held, portable meters calibrated to the manufacturers' specifications.

2.3 Laboratory Analysis

All preserved near-shore and in-plant ichthyoplankton samples were transported to a laboratory on Cornell University's campus and analyzed as follows.

2.3.1 Sample Sorting

Each sample was rinsed through a 500-µm sieve to remove all traces of preservative. Ichthyoplankton (all fish larvae and eggs) were sorted from sample debris by placing the sample in a tray and using a dissecting microscope to systematically search the sample for ichthyoplankton. All such organisms were removed, sorted into like groups, placed in labeled vials, and preserved in 95% ethanol.

2.3.2 Sample Identification and Measurement

After sorting, the fish larvae and eggs were identified to the lowest practical taxon (with a target level of species) and enumerated. Fish larvae life stage was categorized as yolk sac, post yolk sac, or juvenile. Only whole larvae, parts of larvae with a head, or pieces of larvae with a substantial portion (more than half) of the body present were counted. Total length was recorded for all fish species/life stages (excluding eggs) except for those that were damaged to such a degree that total length could not be determined. Measurement of eggs was not included as part of the proposed work plan for this investigation, but a subsample of eggs (the first 15 from each weekly sampling event) was measured to aid in taxonomic identification. All ichthyoplankton were preserved and archived following identification.

2.4 Data Analysis

The *Special Conditions: Biological Monitoring Requirements* of the LSC facility SPDES permit specify that the results of the *Entrainment Characterization Study* should include "a summary table of the total number of fish entrained by species and life stage based upon continuous operation of all pumps at full rated flow and actual operation and cooling water volume over the study period." These data were generated using the calculations described in the sections below. Examples of these calculations are provided in Appendices A and B.

2.4.1 Density Calculations

Densities (number of organisms per 100 m^3) of ichthyoplankton in the near-shore zone of Cayuga Lake in the vicinity of the LSC facility and in the intake water of the facility were calculated for each fish species and life stage for each sample (i.e., each individual net collection). Density was calculated by dividing the sum of the total number of a fish species life stage collected by the total sample volume in m^3 and multiplying by 100. The mean density for each fish species and life stage for a 24-hour sampling event were calculated by averaging the density values from the individual net samples collected over the 24-hour period. A mean density value for the 12 near-shore net samples and a mean density value for the six in-plant net samples were calculated for each 24-hour sampling event.

2.4.2 Full-rated Flow Entrainment Estimate

An estimate of ichthyoplankton entrainment for the period of the study assuming all pumps were operated at the full-rated flow was calculated by multiplying the mean density (no./100 m^3) of each fish species life stage for a given 24-hour sampling event by the total volume of the full-rated flow expressed in units of 100 m^3 per day. This yielded an estimate of the total number of each fish species life stage potentially entrained under full-rated flow conditions during the 24-

hour sampling event. This value was then multiplied by 7 to obtain an estimate of the total number of fish entrained by species and life stage for the week (7-day period) encompassing the 24-hour sampling event. This weekly estimate of entrainment under full-rated flow was calculated for each weekly 24-hour sampling event using each of the mean density estimates obtained via the near-shore sampling and the in-plant sampling. Summing the weekly estimates over the 22-week sampling program provided estimates of the total number of fish entrained by species and life stage based upon continuous operation of all pumps at full rated flow during the course of the study (April through August).

The estimate derived from the in-plant data represents potential entrainment resulting from operation of the plant at full-rated flow with the current intake location and technology. The estimate derived from the near-shore data represents the entrainment calculation baseline, which is the potential entrainment that would occur at the LSC facility assuming that: the cooling water system was designed as a once-through system and; the opening of the cooling water intake structure was located at, and the face of a standard 3/8-inch mesh conventional traveling screen was oriented parallel to, the shoreline and near the surface of the lake; and the intake was operated at its full-rated capacity (NYSDEC 2011).

2.4.3 Actual Operation Flow Entrainment Estimate

An estimate of ichthyoplankton entrainment for the period of the study under actual operation flows was calculated in the same manner as for the full-rated flow entrainment estimate except the mean density (no./100 m^3) of each fish species life stage for a given 24-hour sampling event was multiplied by the actual operation flow expressed in units of 100 m^3 per day rather than the by the full-rated flow. The estimate derived from the in-plant data provides an estimate of actual entrainment resulting from operation of the plant during the period of study with the current intake location and technology. The estimate derived from the near-shore data represents the potential entrainment that would occur at the LSC facility assuming that: the cooling water system was designed as a once-through system and; the opening of the cooling water intake structure was located at, and the face of a standard 3/8-inch mesh conventional traveling screen was oriented parallel to, the shoreline and near the surface of the lake; and the intake was operated at actual flow levels occurring during the course of the study (NYSDEC 2011).

3.0 RESULTS

3.1 Near-shore Ichthyoplankton Community

The near-shore ichthyoplankton community was successfully sampled during 21 of the 22 scheduled sampling efforts. The only sampling effort for which sampling was not successfully completed was the effort scheduled for the first week of April. Hazardous boating and sampling conditions caused by the presence of ice and high abundance of large debris in the water at the south end of Cayuga Lake precluded collection of samples during the first week of scheduled sampling. Results from sampling conducted in the second week of April were used to estimate ichthyoplankton densities for the first week of April. Date, time, location, volume, and water chemistry data for ichthyoplankton samples collected in the near-shore zone of Cayuga Lake are presented in Appendix C.

At least nine distinct fish taxa representing four different life stages were collected from the near-shore zone of Cayuga Lake (Table 2). Organisms identified as Clupeidae were not considered an additional taxon because they were presumed to be either alewife or gizzard shad but could not be definitively classified as such. Two groups of cyprinids were counted as separate taxa based on yolk sac form (club-shaped vs. cylindrical) and overall body shape (stocky or stout vs. narrow or slender). Cyprinid group A had characteristics suggesting they may be common carp or goldfish. Cyprinid group B had characteristics suggesting they may be one or more types of shiner, the most likely species being golden shiner or spottail shiner. All sunfish collected were characterized as *Lepomis* spp. because they had not reached a point in their development that allowed for species level identification. Likely species of *Lepomis* include bluegill, pumpkinseed, and possibly redbreast sunfish.

Taxa collected as yolk sac larvae included alewife, herring species (alewife or gizzard shad), minnow species (both group A and group B), sunfish species, yellow perch, and walleye. Taxa collected as post yolk sac larvae were alewife, gizzard shad, minnow species (both group A and group B), sunfish species, rainbow smelt, and round goby. Alewife was the only species collected as juveniles. None of the eggs collected could be definitively identified to a specific taxon, nor could the viability of collected eggs be determined. However, based on the size of collected eggs and the timing of collection, most if not all of the eggs collected were considered those of alewife and/or gizzard shad. The mean size of eggs collected in near-shore ichthyoplankton tows was 0.8 mm (range 0.6-1.3), with 84% (37 of 45) of the eggs being 0.7-1.0 mm in diameter. Alewife and gizzard shad eggs typically range in size from 0.8-1.3 mm and 0.7-1.1 mm, respectively (Smith 1985). These are the only two species with eggs that typically measure 0.7-1.0 mm, are relatively common in Cayuga Lake, typically spawn in the lake habitats, and typically spawn during the period in which eggs were collected.

3.1.1 Near-shore Ichthyoplankton Catch Composition and Density

Near-shore ichthyoplankton sampling resulted in collection of 987 early life stage organisms (45 eggs, 940 larvae and 2 juveniles) during the 21 sampling events conducted from April through August 2014 (Table 3). Round goby comprised the majority of the catch, representing 57.3% of the community. All round gobies collected were post yolk sac larvae. Alewife was second in abundance, representing 28.5% of the community, with nearly 91% of all alewife being post yolk sac larvae, 9% being yolk sac larvae, and <1% being juveniles. Sunfish species comprised 5.1% of the catch, with 78% of all sunfish species being post yolk sac larvae and 22% being yolk sac larvae. Unidentified eggs and larvae represented 4.8% of the catch, with unidentified eggs accounting for 96% of this total. Yellow perch (all collected as yolk sac larvae) represented 2.9% of the catch, and all other species life stages each comprised <1% of the catch.

Weekly estimates of ichthyoplankton density ranged from 0.0 organisms/100 m^3 to 132.4 organisms/100 m^3 (Table 4). Round goby post yolk sac larvae had the highest individual weekly density (95.7 organisms/100 m^3) of any species life stage and was consistently high (>15 organisms/100 m^3) in seven of the nine weeks sampled in July and August. Alewife post yolk sac larvae and unidentified eggs were the only other life stages to exceed 15 organisms/100 m^3 in any week. Alewife post yolk sac larvae density was 26.7-49.5 organisms/100 m^3 in late July through early August and 28.4 organisms/100 m^3 in the third week of August. Unidentified eggs reached a maximum density of 16.0 organisms/100 m^3 in the third week of June. All other species life stages had weekly densities <10.0 organisms/100 m^3 and usually <3.0 organisms/100 m^3.

3.1.2 Seasonal Patterns in Catch Composition

No ichthyoplankton were collected from April 1 through the first sampling event in May (Table 3). Rainbow smelt post yolk sac larvae and walleye yolk sac larvae were the first species life stages collected (on May 7) and were not collected thereafter (Figures 2 and 3). Yellow perch yolk sac larva was the next species life stage to be collected. Yellow perch yolk sac larvae were first collected on May 28, peaked in density on June 4 and were not collected after June 19 (Table 4, Figure 4). Unidentified eggs were first collected on June 10, peaked in density on June 19, were not collected for the next three weeks, and were collected at low densities from the middle to the end of July (Figure 5).

Herring species were first collected (as a yolk sac larva) on June 19, and the first alewife yolk sac larva was collected on June 24 (Figures 6-8). No herring species were collected the week of July 1, but various alewife life stages were collected from July 8 through August 26, with yolk sac larvae density peaking on July 29 and post yolk sac larvae density peaking the following week on August 6 (Figures 8 and 9) . One juvenile alewife was collected on August 19 and August 26 (Figure 10). Gizzard shad was collected only once, as a post yolk sac larva, on July 29 (Figure 11).

Minnow species group A and group B were both collected for the first time on June 19 and on only one other occasion each, July 1 for group A and July 22 for group B (Figures 12-15). There was no evident trend in density for either group given that only one or two individuals were collected on each date. Round goby post yolk sac larvae were first collected on July 1 and were collected in each of the remaining eight weeks of the sampling program (Figure 16). Round goby post yolk sac larvae density peaked on July 29 at 95.7 organisms/100 m^3 but remained relatively high >15 organisms/100 m^3 through August. Sunfish species post yolk sac larvae were first collected on July 8, peaked in abundance on August 6, and were last collected on August 13 (Figure 17). Sunfish yolk sac larvae were collected from July 22 through August 13 (Figure 18). The only unidentified fish larvae were collected on August 6 (Figure 19).

3.1.3 Catch Size Distribution

Size distributions for fish species collected in larval fish tows are provided in Table 5. Only five taxa (sunfish, alewife, round goby, yellow perch, and unidentified egg) were collected in sufficient numbers to reflect potential growth trends over time. However, only alewife showed a trend of increasing mean size over time, and this trend was quite gradual (Figures 20-23). The lack of trends in the other taxa was likely due to either a prolonged period of spawning and hatching, resulting in overlap of yolk sac and post yolk sac life stages, post yolk sac larvae being less susceptible to capture with increasing length, or a combination of these factors. The size of unidentified eggs did not show any increasing or decreasing tendencies, suggesting that the majority of these eggs were from the same taxon or from taxa that have similar egg sizes (Figure 24). The two eggs that exceeded 1.0 mm appeared to be in later stages of development than all of the other eggs, so it is unknown if these larger eggs were from different species or were larger than the rest because they were closer to hatching.

3.1.4 Estimates of Entrainment for a Hypothetical Near-shore Intake

Sampling of the near-shore ichthyoplankton community was conducted to estimate densities of near-shore ichthyoplankton fish species life stages so these data could be used to calculate potential entrainment of ichthyoplankton if the LSC facility intake was located in the near-shore zone of Cayuga Lake in the vicinity of the facility. Entrainment estimates for this hypothetical intake location were derived for the daily full-rated flow of the facility (172,800 m^3) and for actual daily operation flows for the period of April 1 through August 31, 2014. Operation of the LSC facility with a near-shore intake at full-rated flow would result in entrainment of 5,760,310 fish of all life stages (Table 6). Calculated weekly entrainment peaked during the week of July 29 at 1,601,522 organisms and was estimated to be greater than 900,000 organisms for the week prior to and following that week. A secondary calculated peak occurred the week of August 19 with 835,318 organisms expected to be entrained. These peaks correspond to the periods of highest abundance of post yolk sac larvae of round goby and alewife, respectively.

Operation of the LSC facility with a hypothetical near-shore intake at actual operational flow during April through August 2014 would result in entrainment of 3,383,887 fish of all life stages

(Table 7). Weekly entrainment was predicted to peak during the week of July 29 at 907,790 organisms and was greater than 500,000 organisms for the week prior to and following that week. A secondary peak was predicted to occur during the week of August 19 with 531,509 organisms entrained. These peaks correspond to the periods of highest abundance of post yolk sac larvae of round goby and alewife, respectively.

3.2 LSC Facility Intake Ichthyoplankton Community

The ichthyoplankton community in the vicinity of the LSC intake was successfully sampled by in-plant entrainment netting during 21 of the 22 scheduled sampling efforts. The only sampling effort for which sampling was not successfully completed was the effort scheduled for the first week of April. Hazardous boating and sampling conditions caused by the presence of ice and high abundance of large debris in the water at the south end of Cayuga Lake precluded collection of samples in the lake during the first week of scheduled sampling. Sampling within the LSC plant was not conducted since it was not possible to simultaneously collect a paired set of lake samples. Results from sampling conducted in the second week of April were used to estimate in-plant ichthyoplankton densities for the first week of April. Date, time, volume, and water chemistry data for in-plant ichthyoplankton entrainment samples collected in the Lake Source Cooling facility are presented in Appendix D.

Only two distinct fish taxa representing two different life stages were collected in the in-plant entrainment samples (Table 2). Yellow perch yolk sac larvae and unidentified eggs were the species life stages found in the intake samples. Diameter of the eggs subsampled and measured for length ranged from 0.7 to 1.0 mm. Yellow perch eggs are typically 3.5 mm in diameter (Scott and Crossman 1973), therefore the unidentified eggs were presumed to represent at least one species other than yellow perch.

3.2.1 LSC Facility Intake Ichthyoplankton Catch Composition and Density

In-plant ichthyoplankton sampling resulted in the collection of 252 early life stage organisms (246 eggs and 6 yolk sac larvae) during the 21 in-plant ichthyoplankton sampling events conducted from April through August 2014 (Table 8). Yellow perch represented 2.4% of the catch, occurred only as yolk sac larvae, and were the only yolk sac larvae collected. Unidentified eggs represented 97.6% of the catch. None of the eggs collected could be definitively identified to a specific taxon, nor could the viability of collected eggs be determined. However, based on the size of collected eggs and the timing of collection, most if not all of the eggs collected were likely those of alewife and/or gizzard shad.

The mean diameter of unidentified eggs collected in in-plant entrainment samples was 0.8 mm (range 0.7-1.0). Alewife and gizzard shad eggs typically range in size from 0.8-1.3 mm and 0.7-1.1 mm, respectively (Smith 1985). Eggs of other species known to be common in Cayuga Lake and that spawn from spring and/or summer in lake habitats are all typically larger than those collected in the in-plant entrainment samples (Table 9). The near-shore ichthyoplankton sampling showed that yolk sac larvae of alewife and gizzard shad were first collected on June 19 and continued to be collected through August 6. Unidentified eggs were first collected in the in-plant entrainment samples on June 10 and continued to be collected through July 29. It is reasonable to expect that eggs of alewife and gizzard shad would begin to be collected just prior to the presence of yolk sac larvae in the lake and would cease being collected just prior to when collection of yolk sac larvae ceased. Given that no other species known to be relatively abundant in Cayuga Lake have eggs that typically range in size from 0.7-1.0 mm, typically spawn in lake habitats, and spawn from the second week in June through July, it was concluded that the unidentified eggs were likely those of alewife and/or gizzard shad.

Weekly estimates of intake ichthyoplankton density ranged from 0.0 organisms/100 m^3 to 6.54 organisms/100 m^3 (Table 10). Unidentified eggs had the highest density overall and for every week during which ichthyoplankton were collected in in-plant entrainment samples. Yellow perch yolk sac larvae density was quite low (<0.1 organisms/100 m^3) on both occasions when they were collected.

3.2.2 Seasonal Patterns in Catch Composition

No ichthyoplankton were collected in in-plant entrainment samples from April 1 through the week of June 4 (Table 8). Unidentified eggs were the first species life stage collected (on June 10) and were collected for six consecutive weeks (through July 15) and again during the week of July 29. Unidentified egg densities showed an early peak during the eight week period in which they were collected and a gradual decline thereafter. Yellow perch yolk sac larvae were first collected on June 24, when they were at their maximum density, and again the following week. No ichthyoplankton were collected in in-plant entrainment samples after July 29.

3.2.3 Catch Size Distribution

Unidentified eggs had a mean diameter of 0.8 mm (range = 0.7-1.0) and showed no trend in mean size over time (Table 11, Figure 27). Yellow perch yolk sac larvae had a mean length of 5.8 mm (range = 5.4-6.2) and were collected on only two occasions in numbers too low for meaningful trend analysis.

3.2.4 Estimates of Entrainment at the Existing LSC Intake

Estimates of entrainment at the existing LSC intake were derived for the daily full-rated flow of the facility (172,800 m^3) and for actual daily operation flows for the period of April 1 through August 31, 2014. Operation of the LSC facility with its current intake location at full-rated flow would result in entrainment of 253,209 fish of all life stages (Table 12). Weekly entrainment peaked during the week of June 24 at 79,168 organisms and was relatively high (over 58,000 organisms) for the week prior to and following that week. Slightly more than 6,000 of the entrained organisms were yellow perch yolk sac larvae. The remainder (97.6% of all entrained organisms) consisted of unidentified eggs.

Operation of the LSC facility with its current intake location at actual operational flow during April through August 2014 resulted in estimated entrainment of 158,180 fish of all life stages (Table 13). Weekly entrainment peaked during the week of June 24 at 52,952 organisms and declined steadily thereafter. No entrainment occurred after the week of July 29. Slightly more than 4,000 of the entrained organisms were yellow perch yolk sac larvae. The remainder (97.4% of all entrained organisms) consisted of unidentified eggs.

4.0 SUMMARY OF FINDINGS

The ichthyoplankton community of the near-shore zone of Cayuga Lake differs greatly in species composition and abundance from the community susceptible to entrainment at the LSC facility intake. At least nine distinct fish taxa representing four different life stages were collected from the near-shore zone of Cayuga Lake during this investigation compared to a minimum of only two distinct fish taxa representing two different life stages in LSC facility entrainment samples. This is not unexpected, since few fish species in the lake are capable of reproducing at the depth and water temperatures found in the vicinity of the LSC intake. Most of the fish species in the lake spawn in the lake's shallow littoral zone or in tributaries. Consequently, the vast majority of fish larvae use the shallow littoral zone as nursery habitat. The remoteness of the intake (approximately 600 m off the lake's west shore and at a depth of 76 m) in relation to the littoral zone of the lake makes it unlikely that larvae of littoral zone or tributary fishes will venture into the area of the intake before they are of a size at which they would not fit through the intake's 2-mm spacing wedge-wire screen or be able to swim out of the intake flow field. The exception to this would be eggs of broadcast spawning fish that are carried offshore by surface currents and then settle to the bottom in the open lake before having time to hatch.

Round goby and alewife larvae dominated the littoral zone ichthyoplankton community. Sunfish species larvae, unidentified eggs (likely of alewife), and yellow perch larvae were also relatively abundant at times in the littoral zone fish community. The ichthyoplankton community entrained at the LSC facility was dominated by unidentified eggs (likely alewife). Yellow perch larva was the only other fish species life stage entrained and comprised only 2.4% of all entrained ichthyoplankton.

As discussed previously (see Section 3.2.1), given the size of the collected eggs and the timing of when they were collected, it is highly likely that all of the collected eggs were those of alewife and possibly gizzard shad. This assumption is further supported by the results of a 2006-2007 entrainment and ichthyoplankton study conducted at the AES Cayuga Generating Station located on Cayuga Lake approximately 19 kilometers north of the LSC facility. That investigation found that alewife eggs and larvae dominated both the ichthyoplankton and early life stage entrainment collections, accounting for 94% of the eggs and 76% of the larvae collected in ichthyoplankton samples and 99% of the eggs and 39% of the larvae in entrainment samples (HDR 2010). These results were consistent with the results from historical entrainment sampling conducted at the generating station in the 1990s (NYSEG 1994 and NYSEG 1997).

The density of ichthyoplankton in the littoral zone was an order of magnitude greater than that in the entrainment samples. The density of ichthyoplankton in the littoral zone is reflective of the density of ichthyoplankton that would potentially be entrained if the LSC facility intake was located in the near-shore zone of Cayuga Lake in the vicinity of the facility. Estimates of ichthyoplankton entrainment at a hypothetical near-shore intake were 5,760,310 organisms at the LSC facility full-rated flow and 3,383,887 organisms at the actual operation flow for the period of April 1 through August 31, 2014. Estimates of ichthyoplankton entrainment at the existing LSC facility intake were 253,209 organisms at the LSC facility full-rated flow and 158,180 organisms at the actual operation flow for the period of April 1 through August 31, 2014. Thus, the operation of the LSC intake at its existing location results in an overall 95.6% reduction in entrainment of ichthyoplankton at full-rated flow and an overall 95.3% reduction in entrainment of ichthyoplankton at the actual operation flow for the period of April 1 through August 31, 2014.

The greater than 95% reduction in entrainment of ichthyoplankton at the existing LSC facility intake versus a similarly operated near-shore intake assumes that all of the ichthyoplankton entrained at the existing intake location are viable and therefore would contribute to the fish community as a whole if not lost to entrainment. The actual viability of the entrained ichthyoplankton could not be determined given the logistics of this investigation. However, examination of the composition of the entrained ichthyoplankton catch and the life history requirements of the species likely represented in the catch strongly suggests that the unidentified eggs entrained during this investigation would have been lost to the overall fish community regardless of being entrained due to the environmental conditions (i.e., consistently cold temperature) in the vicinity of the existing LSC intake.

Influent water temperature for the LSC facility intake measured during sampling events ranged from 2.3-5.4 °C from April 9 through August 26, 2014. Mean daily influent water temperature for the LSC facility intake measured during normal plant operation also never exceeded 5.4 °C during this period. Unidentified eggs were first collected in the in-plant entrainment samples on June 10 and were not collected after July 29. Influent water temperature for the LSC facility intake measured during sampling events for this period ranged from 4.3-4.6 °C. Alewife eggs require water temperatures above 6.7 °C to hatch (Edsall 1970), and gizzard shad eggs fail to hatch at water temperatures below 7.8 °C (Williamson and Nelson 1985). The water temperature at the LSC intake when eggs were collected (4.3-4.6 °C) never reached the level at which alewife or gizzard shad eggs could hatch. Thus, any eggs of these species ending up in the vicinity of the LSC intake should be considered unviable and lost to the overall fish community regardless of being entrained or not. If the entrained eggs are considered unviable and therefore not lost to the overall fish community as a result of entrainment, the performance of the LSC facility intake in comparison to a near-shore intake improves to a 99.9% reduction in entrainment of ichthyoplankton at both the full-rated flow and the actual operation flow.

In summary, the ichthyoplankton at the LSC facility intake was limited to unidentified eggs and yellow perch yolk sac larvae, compared to eggs and larvae of a minimum of nine distinct fish taxa collected in net tows in the near-shore zone of Cayuga Lake. Density of ichthyoplankton at the LSC facility intake was an order of magnitude less than that found in the near-shore zone. Based on densities of ichthyoplankton entrained at the LSC intake and densities of ichthyoplankton in the Cayuga Lake near-shore zone, the operation of the LSC intake at its existing location results in an overall 95.6% reduction in entrainment of ichthyoplankton at full-rated flow and an overall 95.3% reduction in entrainment of ichthyoplankton at the actual operation flow for the period of April 1 through August 31, 2014. If eggs presumed to be those of alewife and/or gizzard shad are considered unviable and discounted from the LSC intake facility entrainment densities, the effectiveness of the LSC facility in reducing entrainment in comparison to a near-shore intake improves to 99.9%.

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Table 1. Scientific and common names of fish species reported from Cayuga Lake, NY. (Sources: Chiotti 1980, HDR 2010a, HDR 2010b, Smith 1985, http://www.dec.ny.gov/animals/84622.html)

FAMILY	SCIENTIFIC NAME	COMMON NAME
Petromyzontidae—lampreys	*Petromyzon marinus*	Sea lamprey
Acipenseridae—sturgeon	*Acipenser fulvescens*	Lake sturgeon
Lepisosteidae--gars	*Lepisosteus osseus*	Longnose gar
Amiidae--bowfins	*Amia calva*	Bowfin
Anguillidae--freshwater eels	*Anguilla rostrata*	American eel
Clupeidae--herrings	*Alosa pseudoharengus*	Alewife
	Dorosoma cepedianum	Gizzard shad
Ictaluridae--bullhead catfishes	*Ameiurus natalis*	Yellow bullhead
	Ameiurus nebulosus	Brown bullhead
	Ictalurus punctatus	Channel catfish
	Noturus flavus	Stonecat
	Noturus gyrinus	Tadpole madtom
	Noturus insignis	Margined madtom
	Noturus miurus	Brindled madtom
Catosotmidae--suckers	*Catostomus commersoni*	White sucker
	Hypentelium nigricans	Northern hog sucker
	Moxostoma sp	Redhorse
Cyprinidae--carps and minnows	*Cyprinus carpio*	Common carp
	Cyprinella analostana	Satinfin shiner
	Luxilus cornutus	Common shiner
	Notropis atherinoides	Emerald shiner
	Notropis hudsonius	Spottail shiner
	Notropis spilopterus	Spotfin shiner
	Notemigonus crysoleucas	Golden shiner
	Pimephales notatus	Bluntnose minnow
	Rhinichthys atratulus	Blacknose dace
	Rhinichthys cataractae	Longnose dace
	Scardinius erythrophthalmus	Rudd
	Semotilus atromaculatus	Creek chub
	Semotilus corporalis	Fallfish
Salmonidae—trouts	*Coregonus artedi*	Cisco
	Coregonus clupeaformis	Lake whitefish
	Oncorhynchus mykiss	Rainbow trout
	Salmo salar	Atlantic salmon
	Salmo trutta	Brown trout
	Salvelinus fontinalis	Brook trout
	Salvelinus namaycush	Lake trout

Table 1. Continued.

FAMILY	SCIENTIFIC NAME	COMMON NAME
Osmeridae--smelts	*Osmerus mordax*	Rainbow smelt
Umbridae--mudminnows	*Umbra limi*	Central mudminnow
Esocidae--pikes	*Esox lucius* *Esox niger*	Northern pike Chain pickerel
Percopsidae--trout-perches	*Percopsis omiscomaycus*	Troutperch
Fundulidae--killifishes	*Fundulus diaphanus*	Banded killifish
Atherinidae--silversides	*Labidesthes sicculus*	Brook silversides
Gasterosteidae--sticklebacks	*Culaea inconstans*	Brook stickleback
Percichthyidae--temperate basses	*Morone americana* *Morone chrysops*	White perch White bass
Centrarchidae--sunfishes	*Ambloplites rupestris* *Lepomis auritus* *Lepomis gibbosus* *Lepomis macrochirus* *Micropterus dolomieu* *Micropterus salmoides* *Pomoxis nigromaculatus* *Pomoxis annularis*	Rock bass Redbreast sunfish Pumpkinseed Bluegill Smallmouth bass Largemouth bass Black crappie White crappie
Percidae--perches	*Etheostoma olmstedi* *Perca flavescens* *Percina caprodes* *Sander vitreus*	Tesselated darter Yellow perch Logperch Walleye
Scianidae--Drums	*Aplodinotus grunniens*	Freshwater drum
Cottidae--sculpins	*Cottus bairdii* *Cottus cognatus*	Mottled sculpin Slimy sculpin
Gobiidae--gobies	*Neogobius melanostomus*	Round goby

Table 2. Scientific and common names and life stages of ichthyoplankton collected in the near-shore zone of Cayuga Lake (in-lake samples) and at the LSC facility (in-plant samples) from April 1 through August 31, 2014.

Scientific Name	Common Name	Life Stage	Sample Type	
			In-lake	In-plant
Clupeidae	Herring spp.	Post yolk sac larvae Yolk sac larvae	X X	
Alosa pseudoharengus	Alewife	Juvenile Post yolk sac larvae Yolk sac larvae	X X X	
Dorosoma cepedianum	Gizzard shad	Post yolk sac larvae	X	
Cyprinidae Group A	Minnow Group A spp.	Post yolk sac larvae Yolk sac larvae	X X	
Cyprinidae Group B	Minnow Group B spp.	Post yolk sac larvae Yolk sac larvae	X X	
Osmerus mordax	Rainbow smelt	Post yolk sac larvae	X	
Lepomis spp.	Sunfish spp.	Post yolk sac larvae Yolk sac larvae	X X	
Perca flavescens	Yellow perch	Yolk sac larvae	X	X
Sander vitreus	Walleye	Yolk sac larvae	X	
Neogobius melanostomus	Round goby	Post yolk sac larvae	X	
Unidentified	Unidentified fish	Larvae Egg	X X	 X

Table 3. Total number of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) calculated from larval fish tows from the near-shore zone of Cayuga Lake in the vicinity of Cornell University's Lake Source Cooling facility, April through August 2014. Page 1 of 2

Taxon	**Life stage**	**Sampling Date**											
		4/1/14	**4/9/14**	**4/17/14**	**4/22/14**	**5/2/14**	**5/7/14**	**5/13/14**	**5/20/14**	**5/28/14**	**6/4/14**	**6/10/14**	**6/19/14**
Sunfish spp.	pys												
	ys												
Herring spp.	pys												
	ys												1
Alewife	juv												
	pys												
	ys												
Gizzard shad	pys												
Minnow Group A	pys												1
	ys												2
Minnow Group B	pys												1
	ys												
Round goby	pys												
Rainbow smelt	pys						1						
Yellow perch	ys									9	19		1
Walleye	ys						1						
Unidentified fish	larv												
	egg											1	36
TOTAL							**2**			**9**	**19**	**1**	**42**

Table 3. Continued. Page 2 of 2

Taxon	Life stage	Sampling Date										Total Catch [No. (%)]
		6/24/14	7/1/14	7/8/14	7/15/14	7/22/14	7/29/14	8/6/14	8/13/14	8/19/14	8/26/14	
Sunfish spp.	pys			2	3	6	3	21	4			39 (4.7)
	ys					5		5	1			11 (0.4)
Herring spp.	pys			1				2				3 (0.3)
	ys							1				2 (0.2)
Alewife	juv									1	1	2 (0.2)
	pys			20		2	58	110	15	48	2	255 (25.8)
	ys	1			2	3	17	1				24 (2.4)
Gizzard shad	pys						1					1 (0.1)
Minnow Group A	pys											1 (0.1)
	ys		1									3 (0.3)
Minnow Group B	pys											1 (0.1)
	ys					1						1 (0.1)
Round goby	pys		35	2	7	140	207	39	38	59	39	566 (57.3)
Rainbow smelt	pys											1 (0.1)
Yellow perch	ys											29 (2.9)
Walleye	ys											1 (0.1)
Unidentified fish	larv							2				2 (0.2)
	egg				2	5	1					45 (4.6)
TOTAL		**1**	**36**	**25**	**14**	**162**	**287**	**181**	**58**	**108**	**42**	**987 (100.0)**

Table 4. Density (no./100 m^3) of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) calculated from larval fish tows from the near-shore zone of Cayuga Lake in the vicinity of Cornell University's Lake Source Cooling facility, April through August 2014. Page 1 of 2

Taxon	Life stage	Sampling Date											
		4/1/14	**4/9/14**	**4/17/14**	**4/22/14**	**5/2/14**	**5/7/14**	**5/13/14**	**5/20/14**	**5/28/14**	**6/4/14**	**6/10/14**	**6/19/14**
Sunfish spp.	pys												
	ys												
Herring spp.	pys												
	ys												0.47
Alewife	juv												
	pys												
	ys												
Gizzard shad	pys												
Minnow Group A	pys												0.44
	ys												0.88
Minnow Group B	pys												0.44
	ys												
Round goby	pys												
Rainbow smelt	pys						0.51						
Yellow perch	ys									3.98	8.31		0.47
Walleye	ys						0.44						
Unidentified fish	larv												
	egg											0.47	16.02
TOTAL							**0.95**			**3.98**	**8.31**	**0.47**	**18.72**

Table 4. Continued. Page 2 of 2

Taxon	Life stage	Sampling Date									
		6/24/14	**7/1/14**	**7/8/14**	**7/15/14**	**7/22/14**	**7/29/14**	**8/6/14**	**8/13/14**	**8/19/14**	**8/26/14**
Sunfish spp.	pys			0.92	1.39	2.78	1.37	9.17	2.14		
	ys					2.26		2.32	0.55		
Herring spp.	pys			0.43				0.84			
	ys							0.47			
Alewife	juv									0.51	0.47
	pys			8.44		0.91	26.69	49.50	8.55	28.40	1.04
	ys	0.45			0.84	1.42	7.69	0.47			
Gizzard shad	pys						0.46				
Minnow Group A	pys										
	ys		0.49								
Minnow Group B	pys										
	ys					0.48					
Round goby	pys		15.79	0.94	3.28	64.39	95.67	16.93	20.77	40.15	19.90
Rainbow smelt	pys										
Yellow perch	ys										
Walleye	ys										
Unidentified fish	larv							0.84			
	egg				0.84	2.32	0.51				
TOTAL		**0.45**	**16.28**	**10.74**	**6.35**	**74.55**	**132.40**	**80.53**	**32.02**	**69.06**	**21.40**

Table 5. Minimum, maximum, and mean length of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) of fish species collected in larval fish tows from the near-shore zone of Cayuga Lake in the vicinity of Cornell University's Lake Source Cooling facility, April through August 2014.

Taxon	Life stage	Time frame	Length (mm)			No. measured
			Minimum	Maximum	Mean	
Sunfish spp.	pys, ys	7/8/14 - 8/13/14	3.9	6.5	5.5	50
Herring spp.	pys, ys	6/19/14 - 8/6/14	5.4	7.8	6.5	3
Alewife	juv, pys, ys	6/24/14 – 8/26/14	2.9	20.2	8.7	281
Gizzard shad	pys	7/29/14	18.8	18.8	18.8	1
Minnow Group A	pys, ys	6/19/14 – 7/1/14	6.2	6.9	6.5	3
Minnow Group B	pys, ys	6/19/14 – 7/22/14	6.0	6.7	6.4	2
Round goby	pys	7/1/14 – 8/26/14	5.5	9.9	7.4	566
Rainbow smelt	pys	5/7/14	8.9	8.9	8.9	1
Yellow perch	ys	5/28/14 – 6/19/14	5.5	7.2	6.0	30
Walleye	ys	5/7/14	7.8	7.8	7.8	1
Unidentified fish	larv	8/6/14	5.2	5.4	5.3	2
Unidentified fish	egg	6/10/14 – 7/29/14	0.6	1.3	0.8	45

Table 6. Estimated number of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) that would have been entrained from April through August 2014 under full-rated flow if the Cornell University Lake Source Cooling facility intake was located in the near-shore zone of Cayuga Lake. Page 1 of 2

Taxon	Life stage	Sampling Date											
		4/1/14	**4/9/14**	**4/17/14**	**4/22/14**	**5/2/14**	**5/7/14**	**5/13/14**	**5/20/14**	**5/28/14**	**6/4/14**	**6/10/14**	**6/19/14**
Sunfish spp.	pys												
	ys												
Herring spp.	pys												
	ys												5628
Alewife	juv												
	pys												
	ys												
Gizzard shad	pys												
Minnow Group A	pys												5331
	ys												10663
Minnow Group B	pys												5331
	ys												
Round goby	pys												
Rainbow smelt	pys						6194						
Yellow perch	ys									48143	100561		5628
Walleye	ys						5352						
Unidentified fish	larv												
	egg											5676	193809
TOTAL							**11546**			**48143**	**100561**	**5676**	**226391**

Table 6. Continued.

Taxon	Life stage	Sampling Date										April-August Total
		6/24/14	7/1/14	7/8/14	7/15/14	7/22/14	7/29/14	8/6/14	8/13/14	8/19/14	8/26/14	
Sunfish spp.	pys			11176	16844	33616	16608	110871	25931			215047
	ys					27327		28006	6669			62002
Herring spp.	pys			5220				10121				15341
	ys							5703				11332
Alewife	juv									6189	5628	11817
	pys			102131		10982	322882	598758	103462	343469	12529	1494214
	ys	5406			10155	17124	93068	5703				131457
Gizzard shad	pys						5622					5622
Minnow Group A	pys											5331
	ys		5878									16540
Minnow Group B	pys											5331
	ys					5826						5826
Round goby	pys		191008	11417	39702	778856	1157216	204767	251242	485660	240719	3360586
Rainbow smelt	pys											6194
Yellow perch	ys											154332
Walleye	ys											5352
Unidentified fish	larv							10172				10172
	egg				10155	28049	6125					243813
TOTAL		**5406**	**196886**	**129943**	**76858**	**901780**	**1601522**	**974101**	**387304**	**835318**	**258876**	**5760310**

Table 7. Estimated number of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) that would have been entrained from April through August 2014 under actual operation flow if the Cornell University Lake Source Cooling facility intake was located in the near-shore zone of Cayuga Lake. Page 1 of 2

Taxon	Life stage	Sampling Date											
		4/1/14	**4/9/14**	**4/17/14**	**4/22/14**	**5/2/14**	**5/7/14**	**5/13/14**	**5/20/14**	**5/28/14**	**6/4/14**	**6/10/14**	**6/19/14**
Sunfish spp.	pys												
	ys												
Herring spp.	pys												
	ys												2865
Alewife	juv												
	pys												
	ys												
Gizzard shad	pys												
Minnow Group A	pys												2714
	ys												5428
Minnow Group B	pys												2714
	ys												
Round goby	pys												
Rainbow smelt	pys						2177						
Yellow perch	ys									16536	47354		2865
Walleye	ys						1881						
Unidentified fish	larv												
	egg											2965	98653
TOTAL							**4058**			**16536**	**47354**	**2965**	**115238**

Table 7. Continued.

Taxon	Life stage	Sampling Date										April-August Total
		6/24/14	7/1/14	7/8/14	7/15/14	7/22/14	7/29/14	8/6/14	8/13/14	8/19/14	8/26/14	
Sunfish spp.	pys			7725	10474	22070	9414	61416	12941			124039
	ys					17940		15514	3328			36782
Herring spp.	pys			3608				5607				9215
	ys							3159				6024
Alewife	juv									3938	3351	7289
	pys			70599		7210	183019	331674	51633	218548	7459	870142
	ys	3615			6315	11242	52754	3159				77085
Gizzard shad	pys						3187					3187
Minnow Group A	pys											2714
	ys		4125									9553
Minnow Group B	pys											2714
	ys					3825						3825
Round goby	pys		134060	7892	24687	511329	655944	113428	125382	309023	143307	2025053
Rainbow smelt	pys											2177
Yellow perch	ys											66755
Walleye	ys											1881
Unidentified fish	larv							5634				5634
	egg				6315	18414	3472					129818
TOTAL		**3615**	**138186**	**89825**	**47790**	**592031**	**907790**	**539590**	**193284**	**531509**	**154117**	**3383887**

Table 8. Total number of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) calculated from entrainment netting at Cornell University's Lake Source Cooling facility, April through August 2014.

Taxon	Life stage	Sampling Date											
		4/1/14	4/9/14	4/17/14	4/22/14	5/2/14	5/7/14	5/13/14	5/20/14	5/28/14	6/4/14	6/10/14	6/19/14
Yellow perch	ys												
Unidentified fish	egg											22	58
TOTAL												**22**	**58**

Taxon	Life stage	Sampling Date										Total Catch [No. (%)]
		6/24/14	7/1/14	7/8/14	7/15/14	7/22/14	7/29/14	8/6/14	8/13/14	8/19/14	8/26/14	
Yellow perch	ys	5	1									6 (2.4)
Unidentified fish	egg	73	62	25	5		1					246 (97.6)
TOTAL		**78**	**63**	**25**	**5**		**1**					**252 (100.0)**

Table 9. Egg diameter of fish species that are common in Cayuga Lake and spawn during spring and/or summer in lake habitat. (Sources: Scott and Crossman 1973, Auer 1982, Becker 1983, Smith 1985)

Species	Egg size (mm)
Alewife	0.8-1.3
Gizzard shad	0.7-1.1
Pumpkinseed	1.0
Golden shiner	1.0-1.4
Spottail shiner	1.0-1.4
Bluegill	1.1-1.4
Smallmouth bass	1.2-2.5
Trout-perch	1.3-1.9
Creek chub	1.4-1.7
Common carp	1.5
Common shiner	1.5
Largemouth bass	1.5-1.7
Rock bass	1.7-1.9
Chain pickerel	2.0
Longnose gar	2.1-3.2
Slimy sculpin	2.3-2.6
Northern pike	2.5-3.0
Brown bullhead	3.0
Round goby	3.4-3.8
Yellow perch	3.5

Table 10. Density (no./ 100 m^3) of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) calculated from entrainment netting at Cornell University's Lake Source Cooling facility, April through August 2014. Page 1 of 2

Taxon	Life stage	Sampling Date											
		4/1/14	**4/9/14**	**4/17/14**	**4/22/14**	**5/2/14**	**5/7/14**	**5/13/14**	**5/20/14**	**5/28/14**	**6/4/14**	**6/10/14**	**6/19/14**
Yellow perch	ys												
Unidentified fish	egg											1.85	5.11
TOTAL												**1.85**	**5.11**

Taxon	Life stage	Sampling Date									
		6/24/14	**7/1/14**	**7/8/14**	**7/15/14**	**7/22/14**	**7/29/14**	**8/6/14**	**8/13/14**	**8/19/14**	**8/26/14**
Yellow perch	ys	0.42	0.08								
Unidentified fish	egg	6.13	4.72	2.00	0.45		0.18				
TOTAL		**6.54**	**4.80**	**2.00**	**0.45**		**0.18**				

Table 11. Minimum, maximum, and mean length of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) of fish species collected from entrainment netting at Cornell University's Lake Source Cooling facility, April through August 2014.

Taxon	Life stage	Time frame	Length (mm)			No. measured
			Minimum	**Maximum**	**Mean**	
Yellow perch	ys	5/28/14 – 6/19/14	5.4	6.2	5.8	6
Unidentified fish	egg	6/10/14 – 7/29/14	0.7	1.0	0.8	81

Table 12. Estimated number of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) entrained from April through August 2014 by the Cornell University Lake Source Cooling facility intake under full-rated flow.

Taxon	Life stage	Sampling Date											
		4/1/14	4/9/14	4/17/14	4/22/14	5/2/14	5/7/14	5/13/14	5/20/14	5/28/14	6/4/14	6/10/14	6/19/14
Yellow perch	ys												
Unidentified fish	egg											22384	61828
TOTAL												**22384**	**61828**

Taxon	Life stage	Sampling Date										April-August Total
		6/24/14	7/1/14	7/8/14	7/15/14	7/22/14	7/29/14	8/6/14	8/13/14	8/19/14	8/26/14	
Yellow perch	ys	5072	969									6041
Unidentified fish	egg	74096	57092	24158	5479		2132					247168
TOTAL		**79168**	**58061**	**24158**	**5479**		**2132**					**253209**

Table 13. Estimated number of fish eggs, yolk sac larvae (ys), post yolk sac larvae (pys), unidentified life stage larvae (larv), and juveniles (juv) entrained from April through August 2014 by the Cornell University Lake Source Cooling facility intake based on actual operation flow.

Taxon	Life stage	Sampling Date											
		4/1/14	4/9/14	4/17/14	4/22/14	5/2/14	5/7/14	5/13/14	5/20/14	5/28/14	6/4/14	6/10/14	6/19/14
Yellow perch	ys												
Unidentified fish	egg											11691	31472
TOTAL												**11691**	**31472**

Taxon	Life stage	Sampling Date										April-August Total
		6/24/14	7/1/14	7/8/14	7/15/14	7/22/14	7/29/14	8/6/14	8/13/14	8/19/14	8/26/14	
Yellow perch	ys	3392	680									4073
Unidentified fish	egg	49559	40071	16699	3407		1208					154107
TOTAL		**52952**	**40751**	**16699**	**3407**		**1208**					**158180**

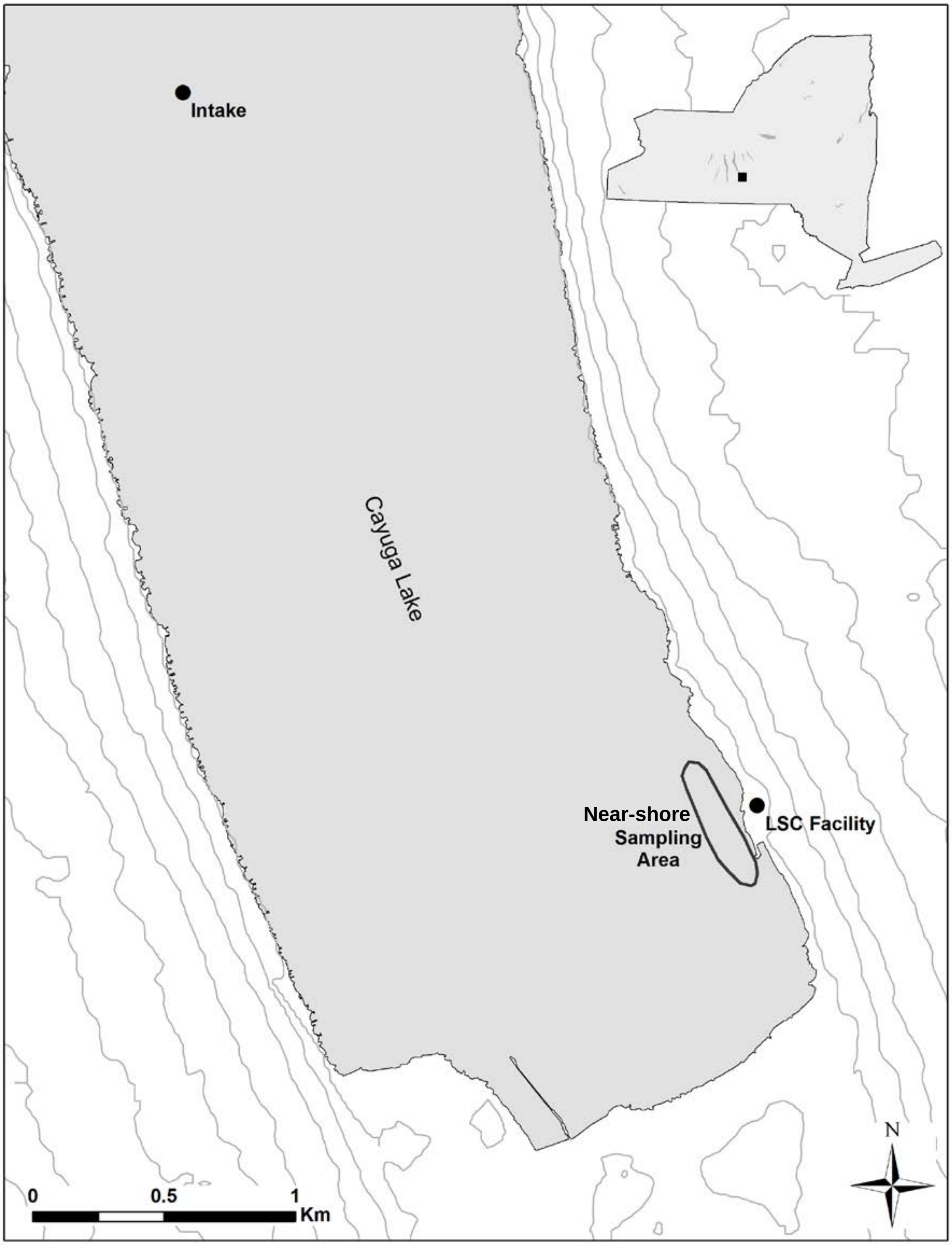

Figure 1. Location of Cornell University's Lake Source Cooling facility and intake and the area within the near-shore zone of Cayuga Lake, NY, sampled for ichthyoplankton from April through August 2014.

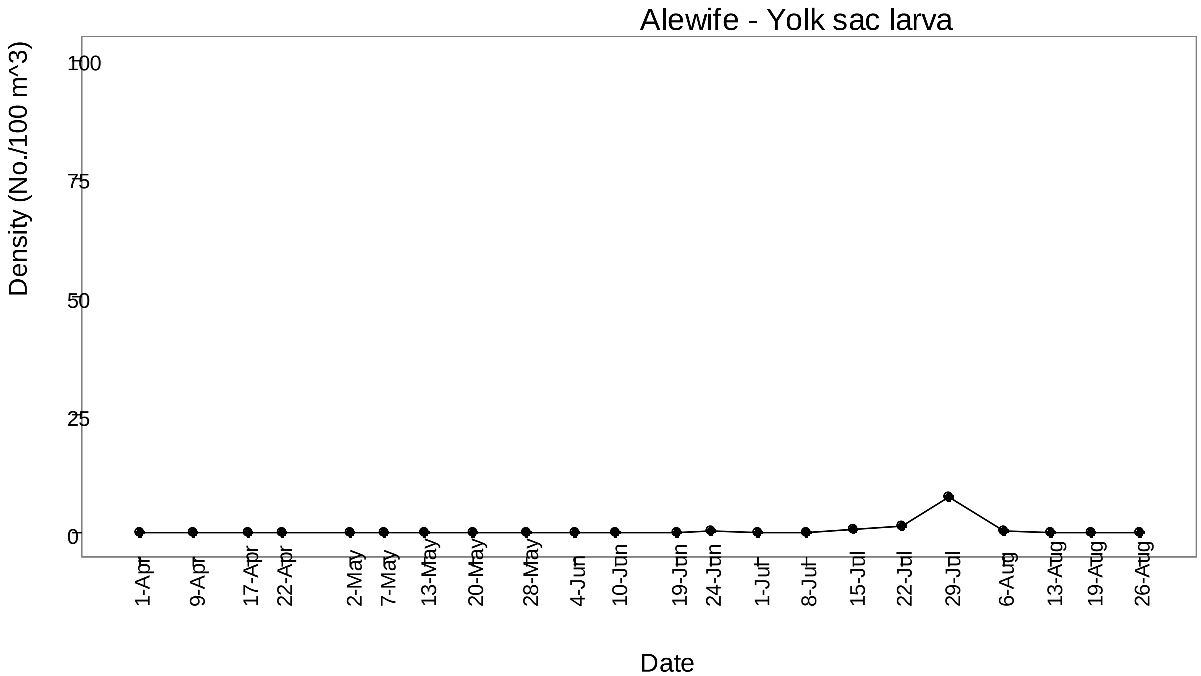

Figure 2. Alewife yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

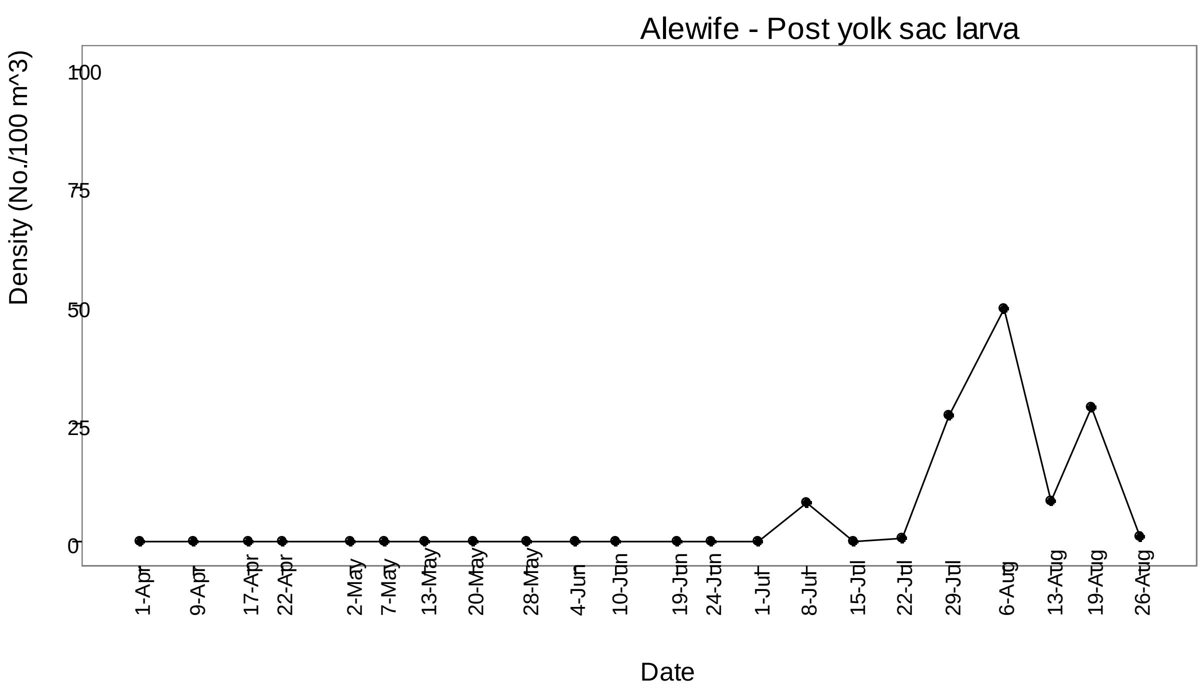

Figure 3. Alewife post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

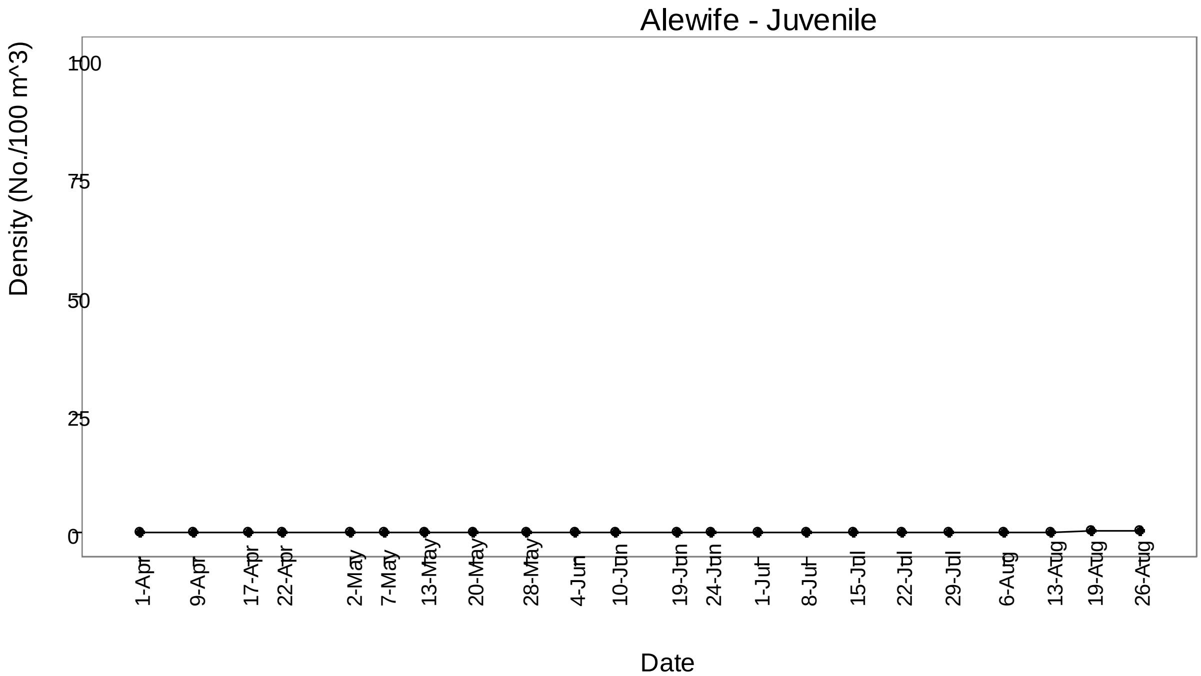

Figure 4. Alewife juvenile density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

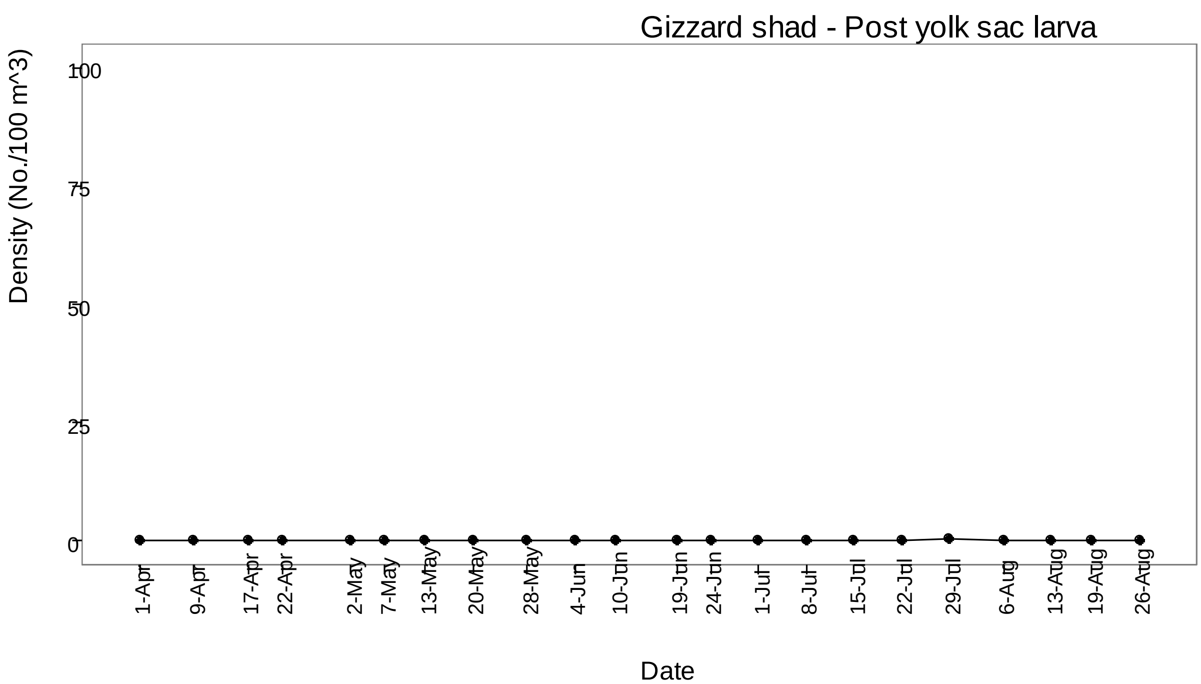

Figure 5. Gizzard shad post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

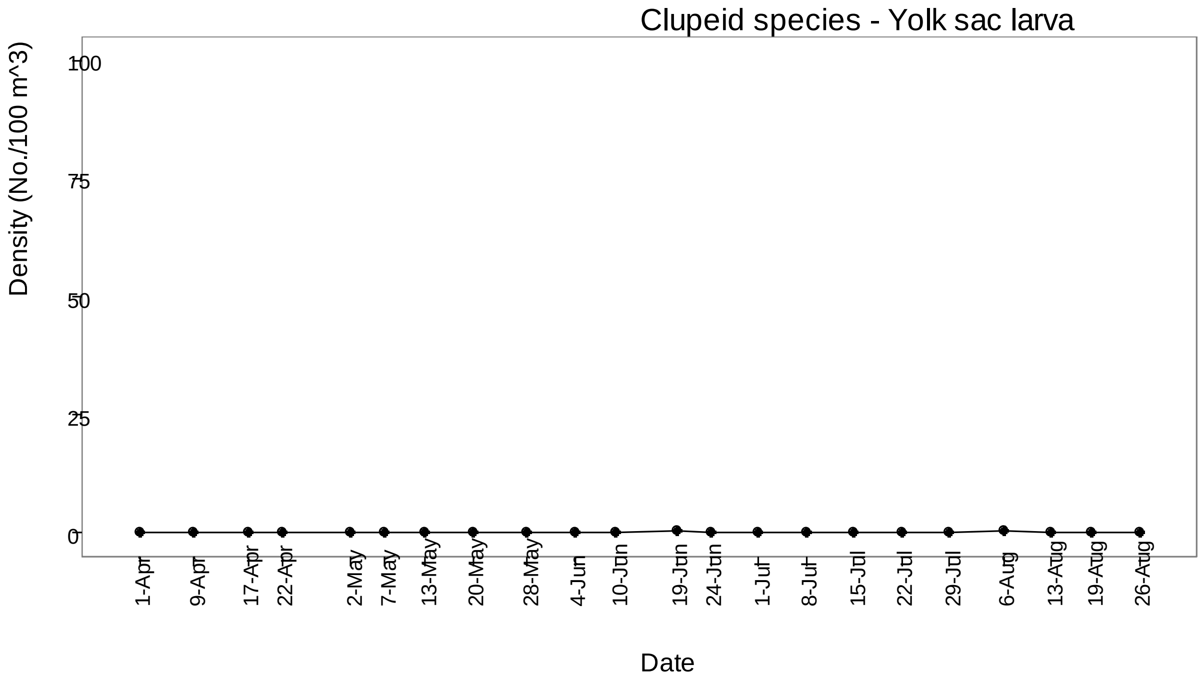

Figure 6. Clupeid (herring) species yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

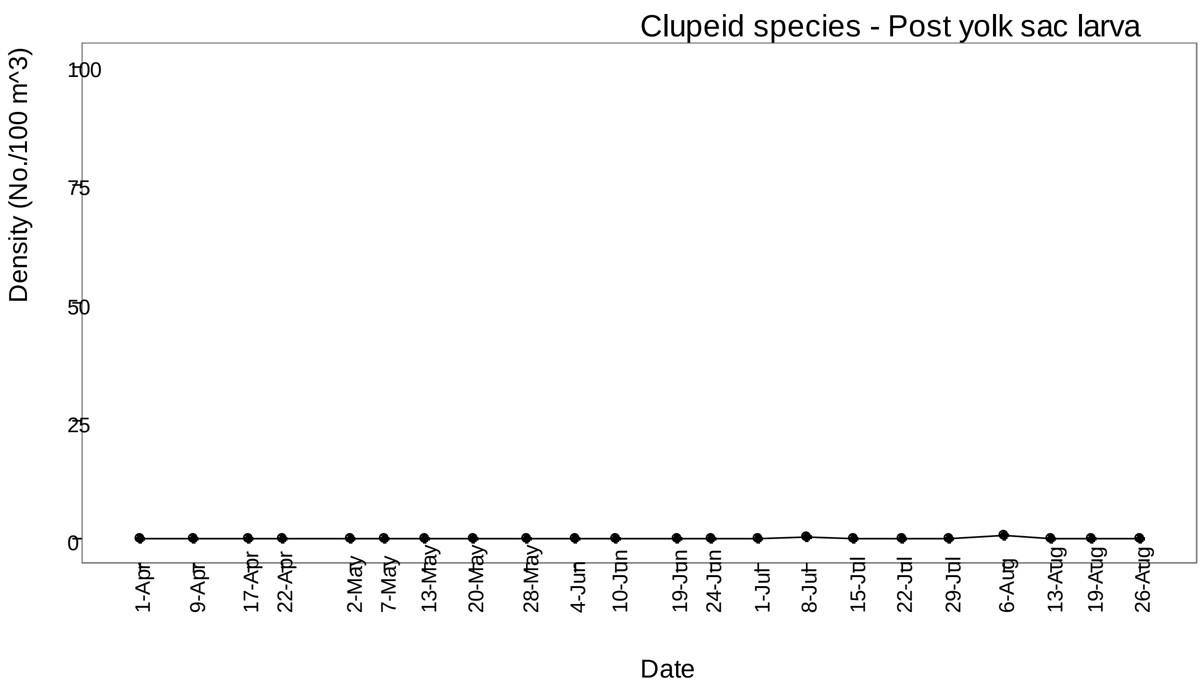

Figure 7. Clupeid (herring) species post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

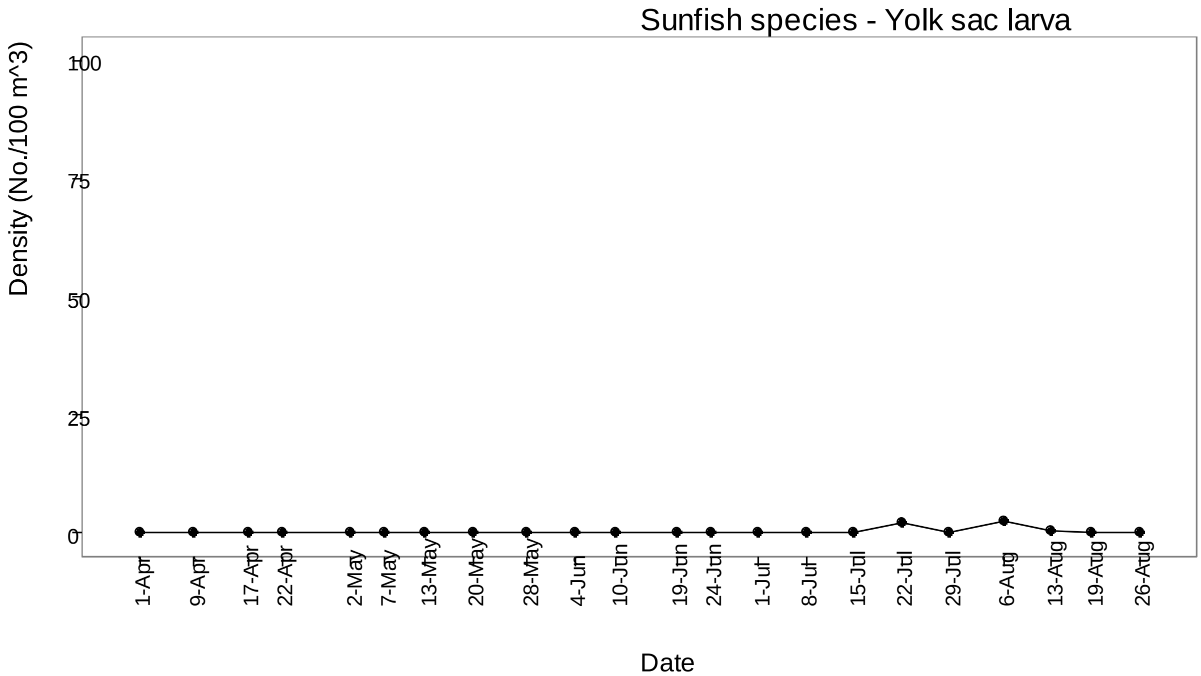

Figure 8. Sunfish species yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

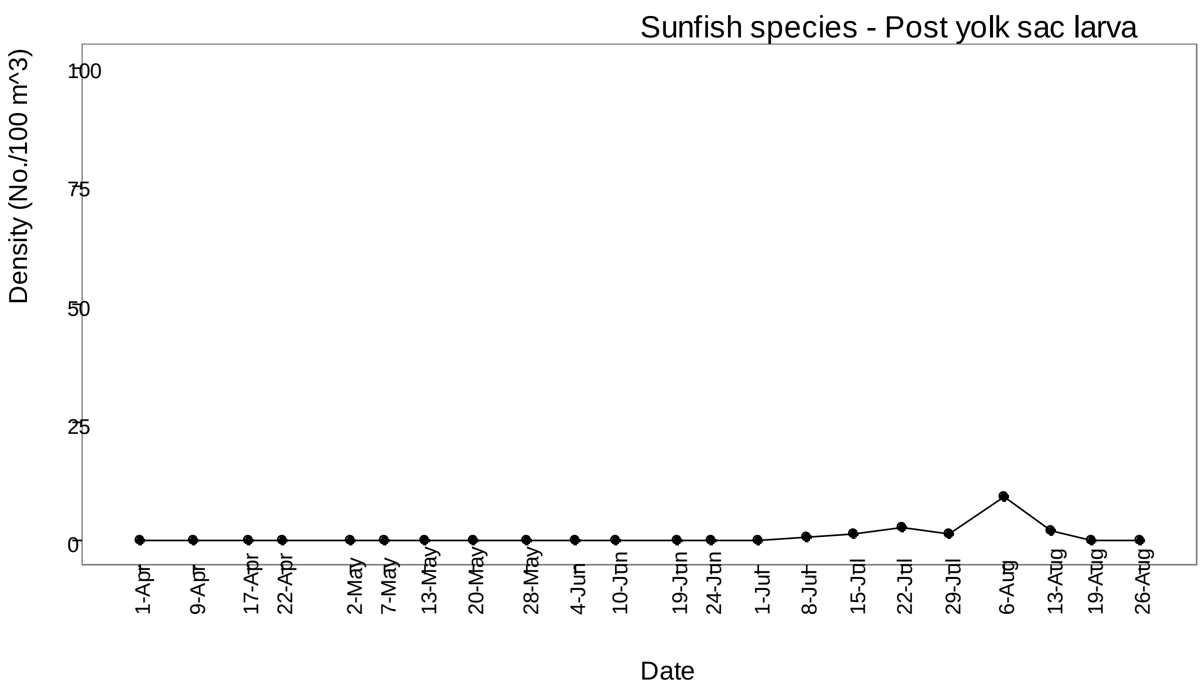

Figure 9. Sunfish species post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

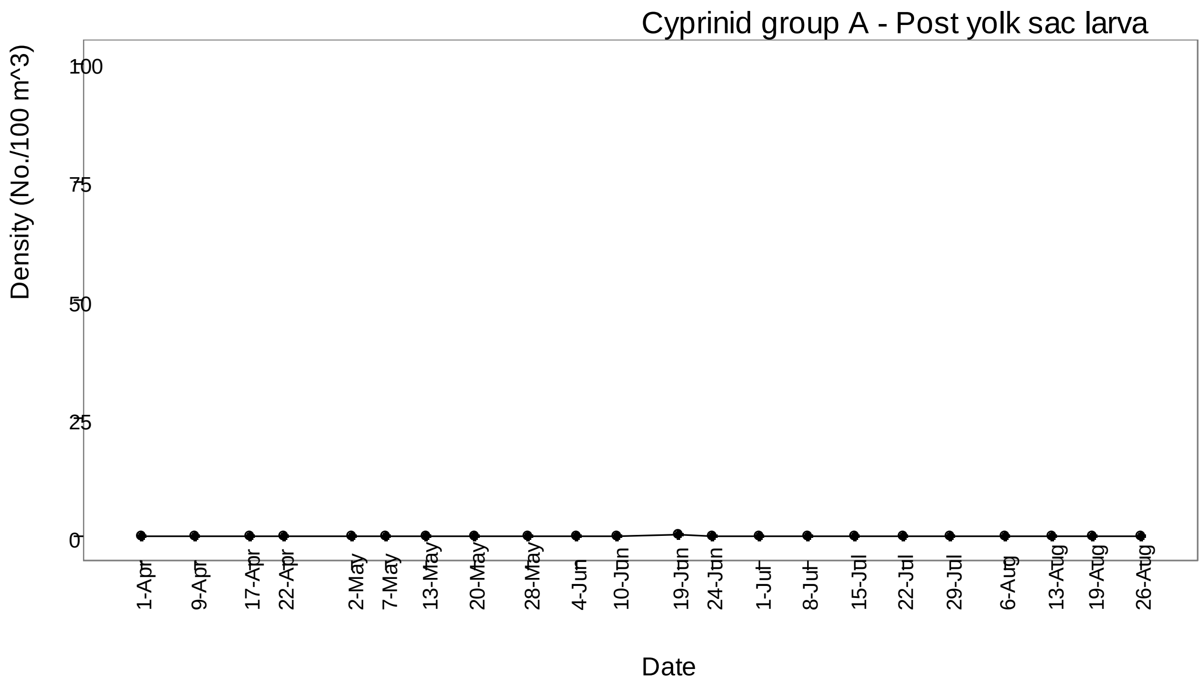

Figure 10. Cyprinid group A yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

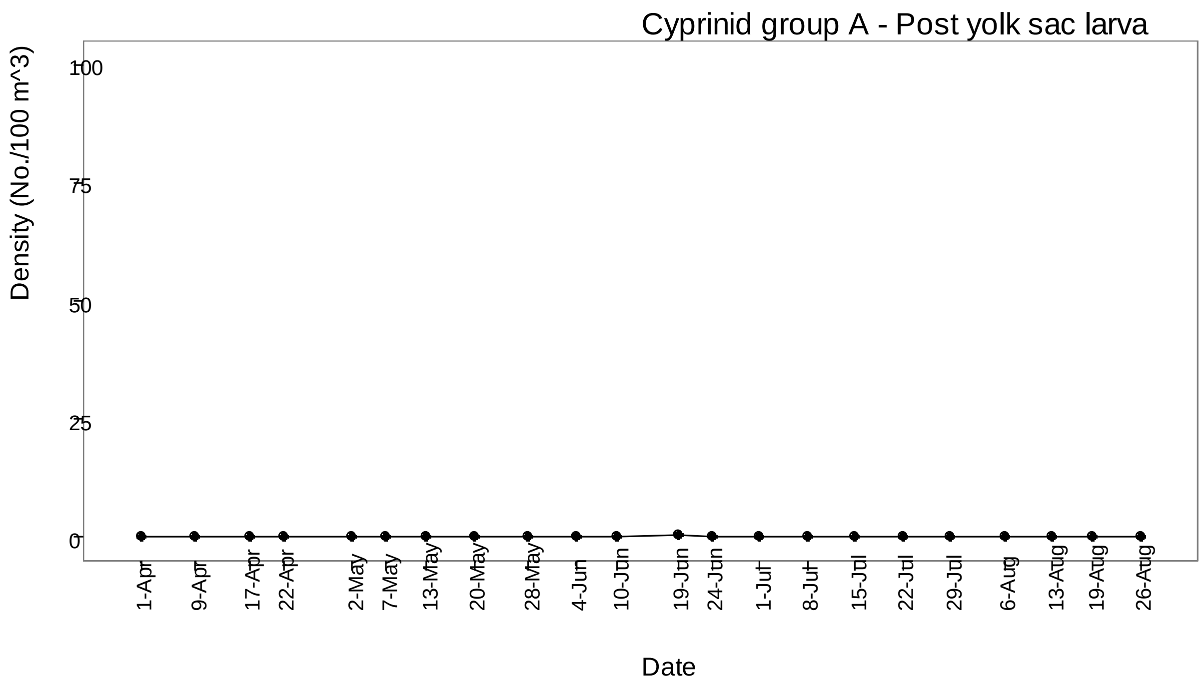

Figure 11. Cyprinid group A post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

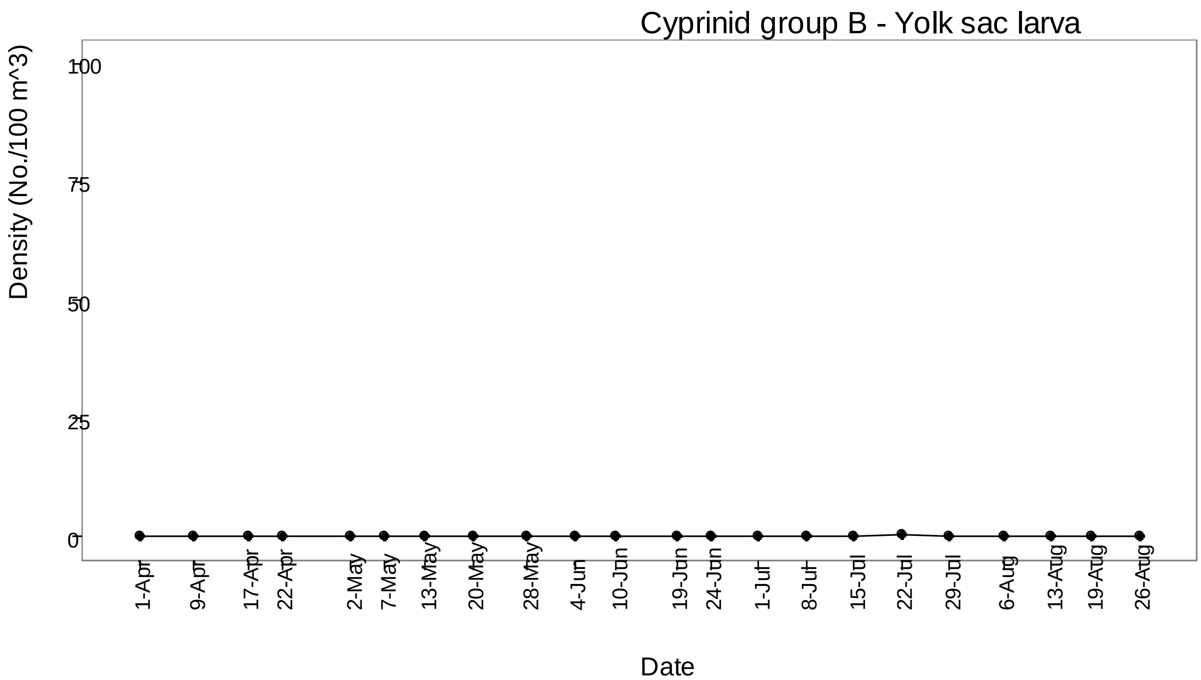

Figure 12. Cyprinid group B yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

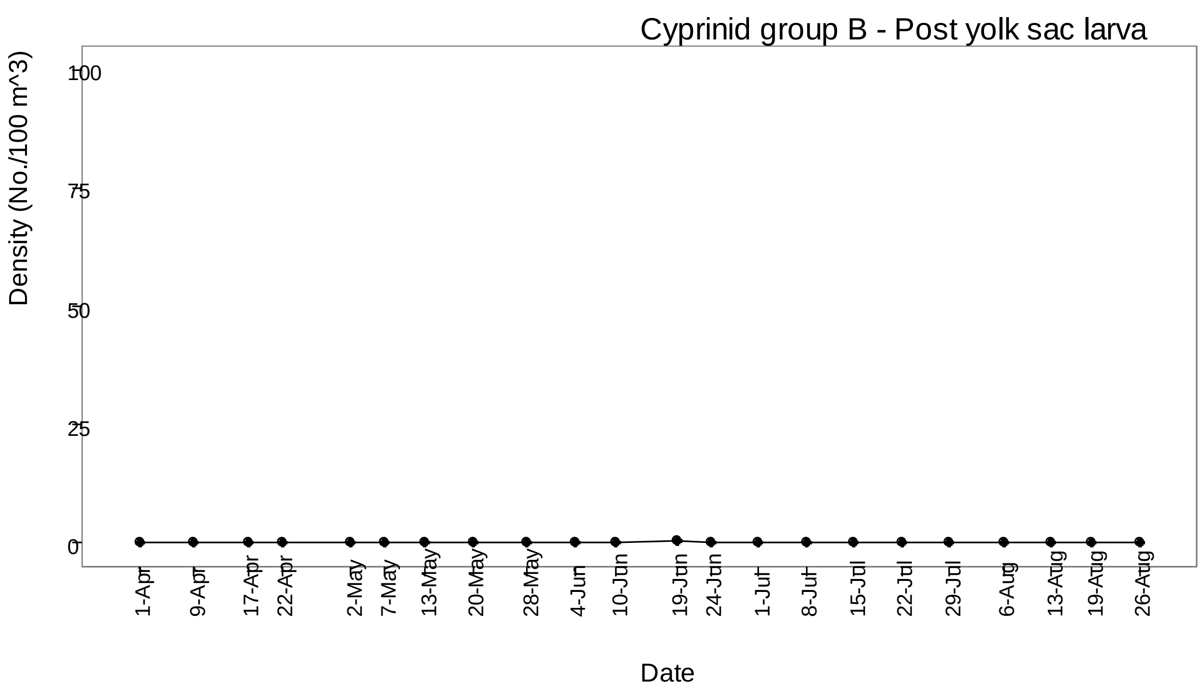

Figure 13. Cyprinid group B post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

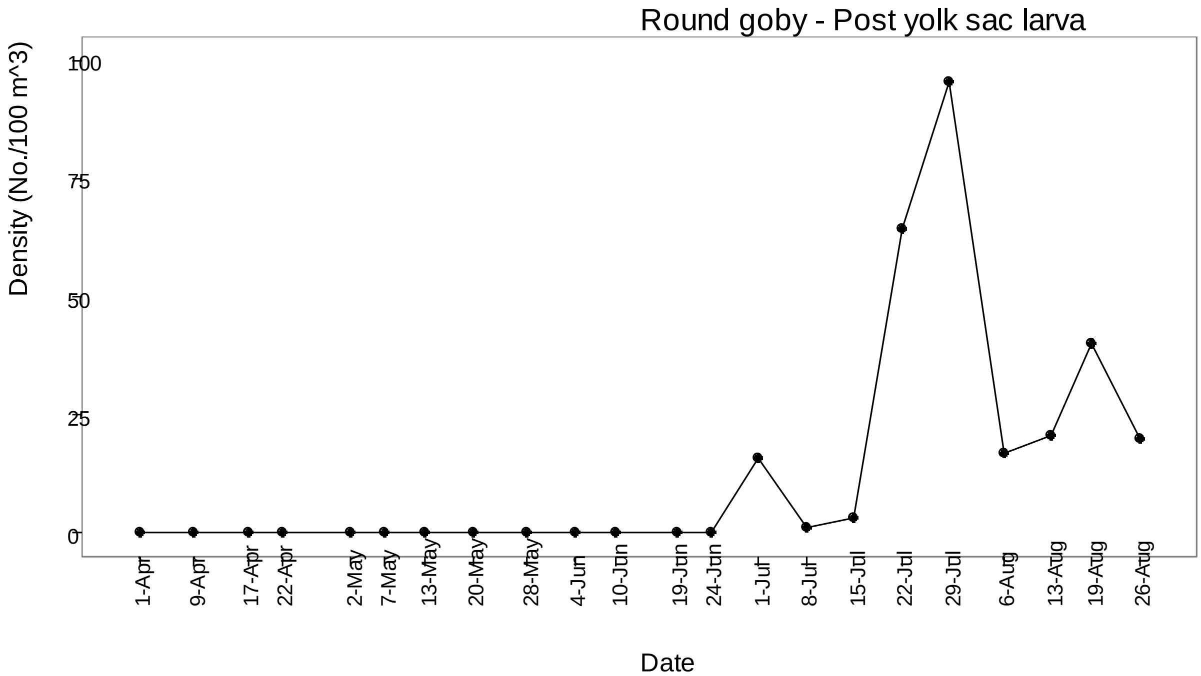

Figure 14. Round goby post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

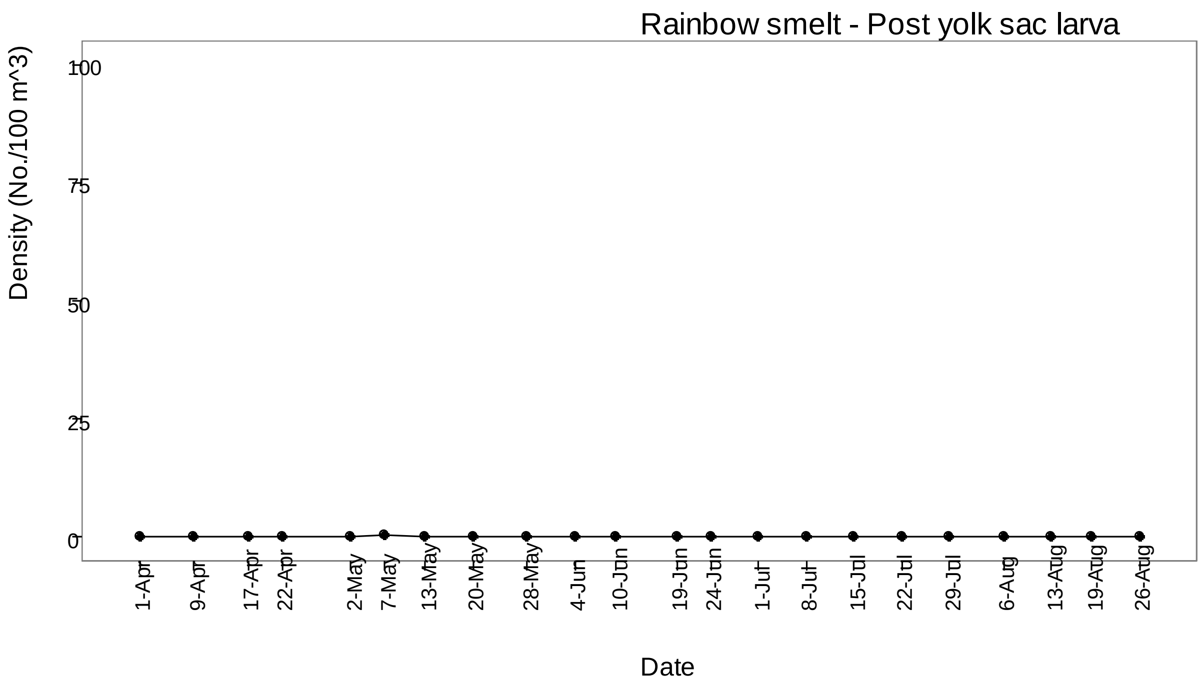

Figure 15. Rainbow smelt post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

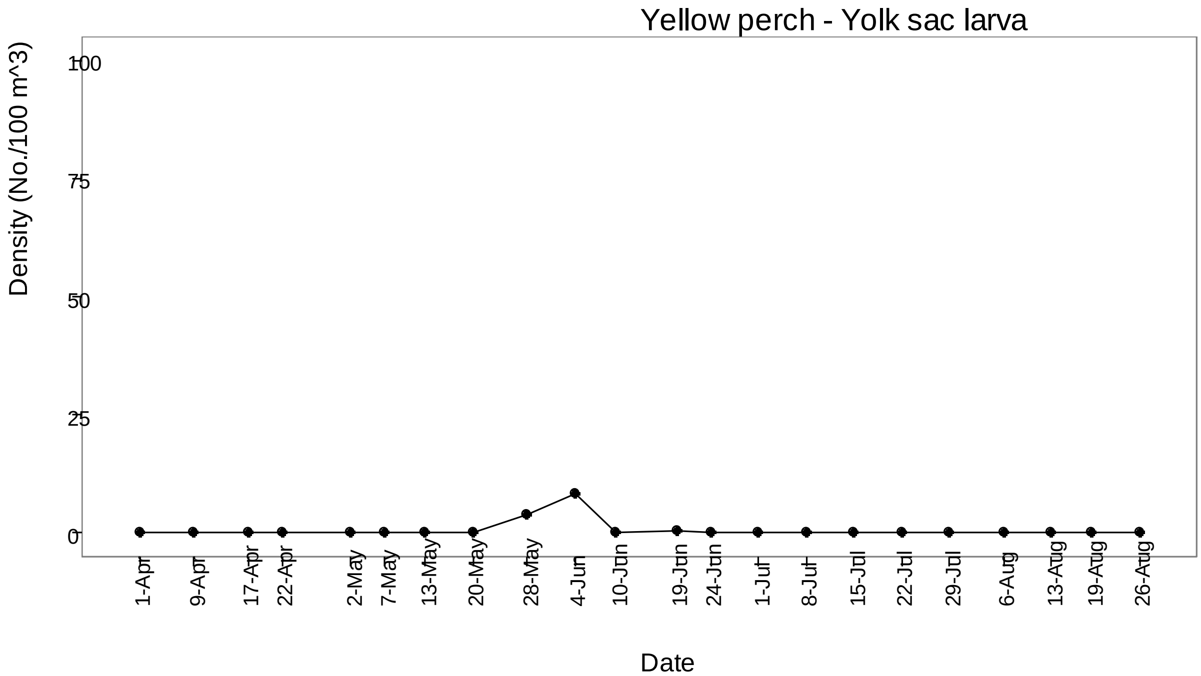

Figure 16. Yellow perch yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

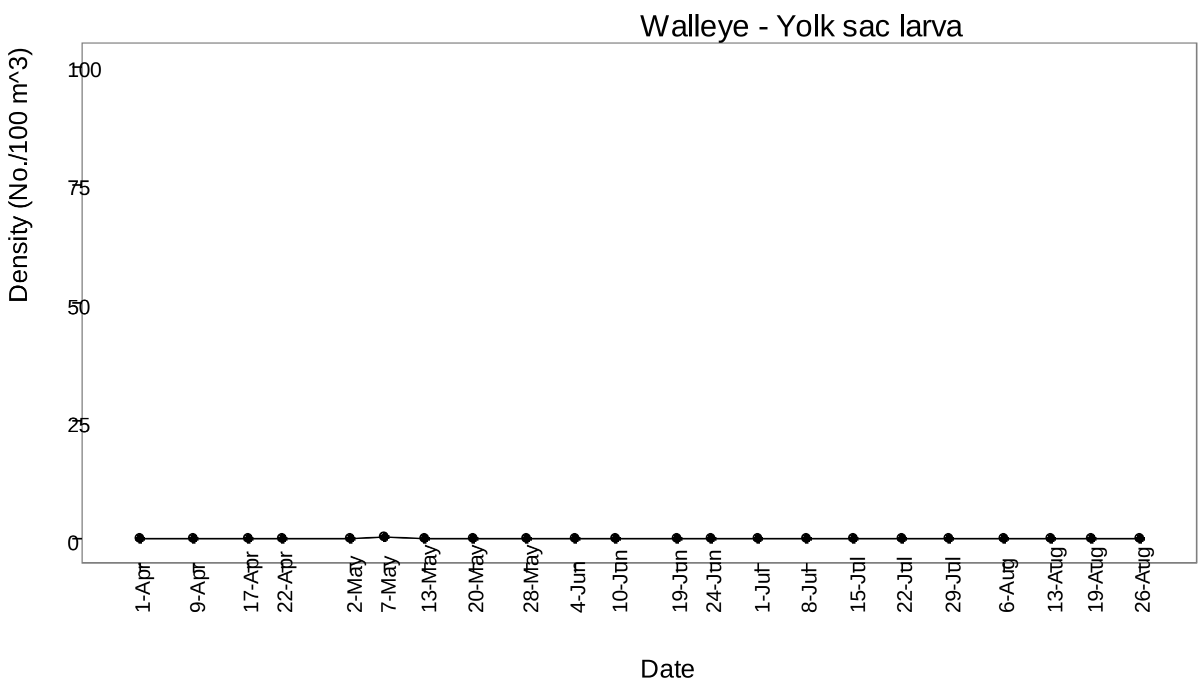

Figure 17. Walleye post yolk sac larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

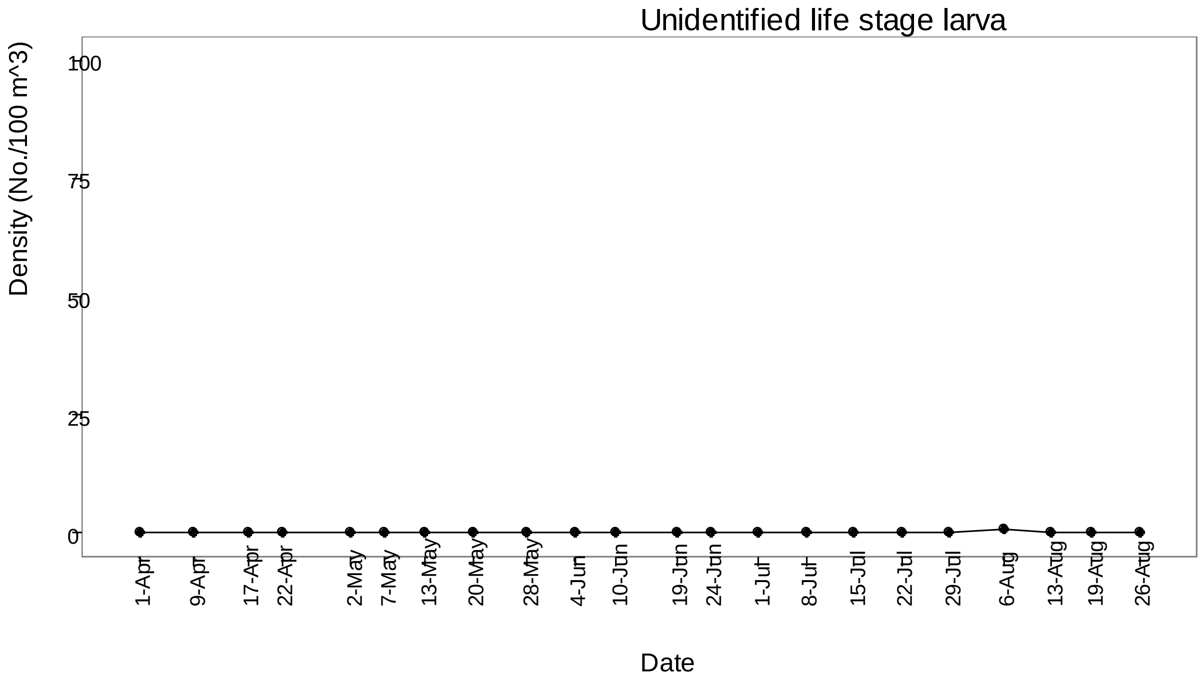

Figure 18. Unidentified life stage fish larva density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

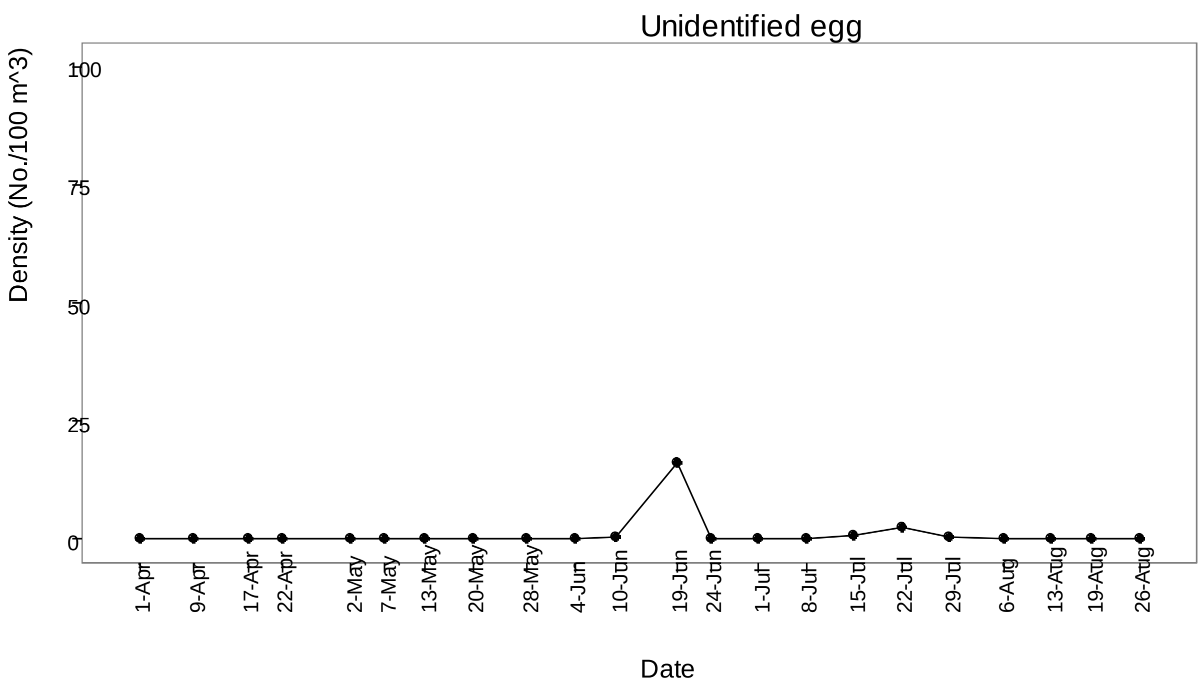

Figure 19. Unidentified fish egg density (organisms/100 m^3) in the near-shore zone of Cayuga Lake, NY, April through August 2014.

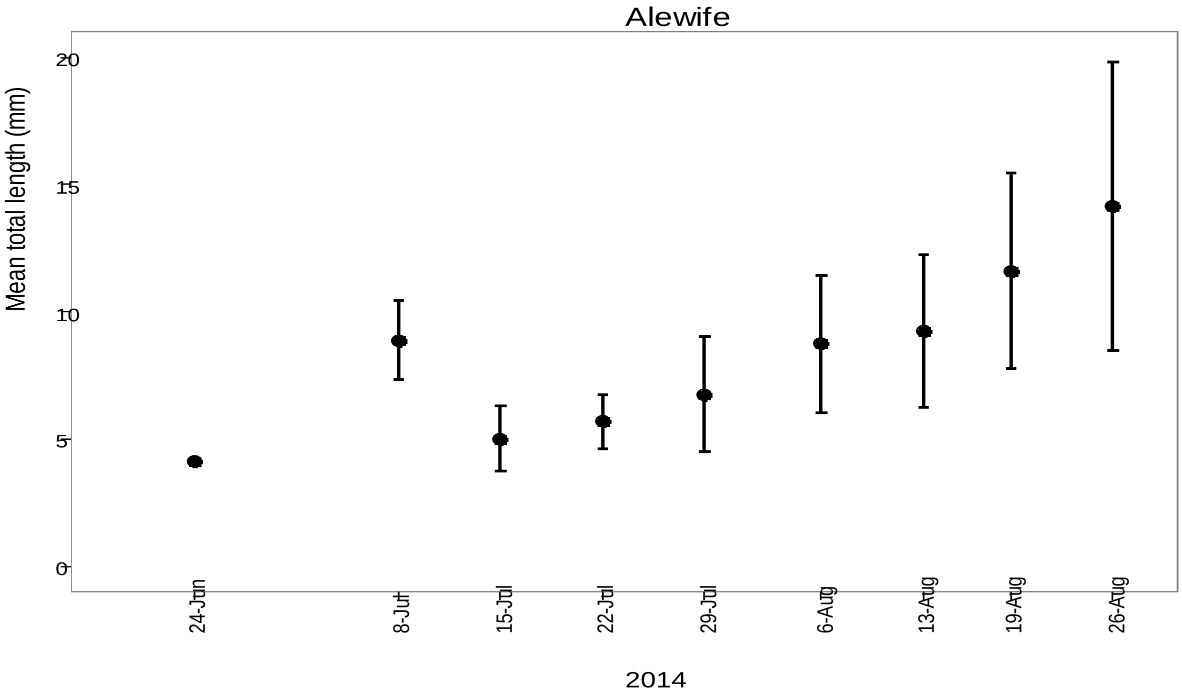

Figure 20. Mean length of alewife early life history stages collected in the near-shore zone of Cayuga Lake, NY, April through August 2014. Error bars show one standard deviation.

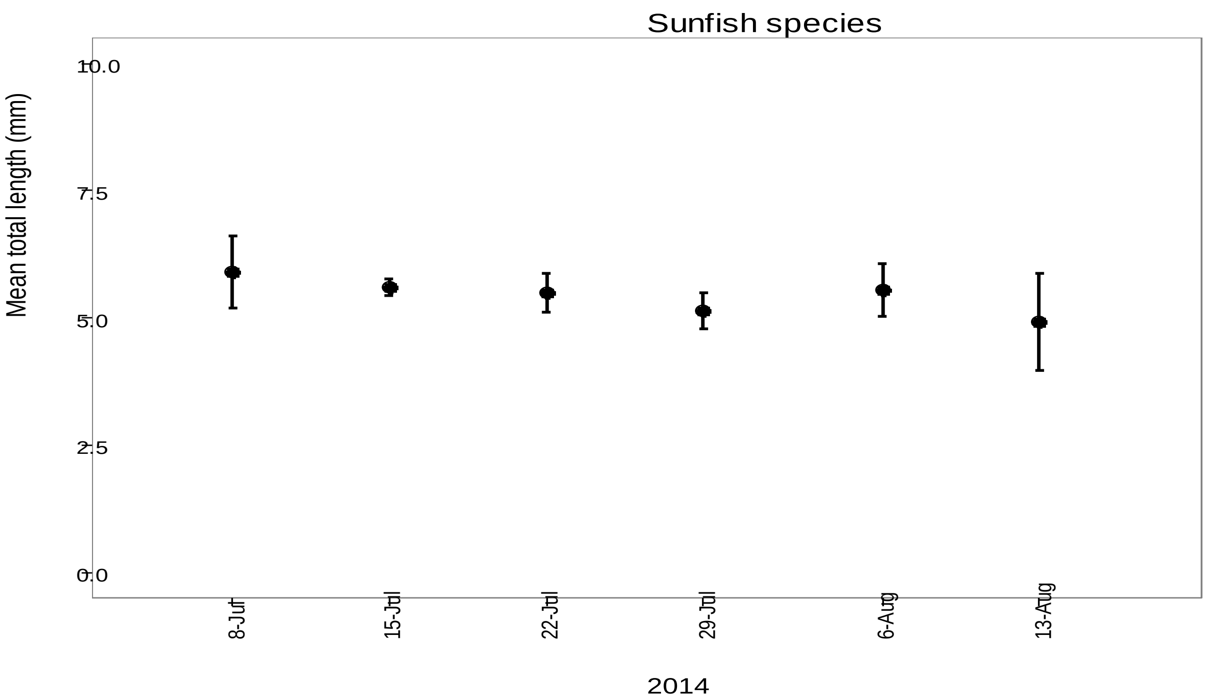

Figure 21. Mean length of sunfish species early life history stages collected in the near-shore zone of Cayuga Lake, NY, April through August 2014. Error bars show one standard deviation.

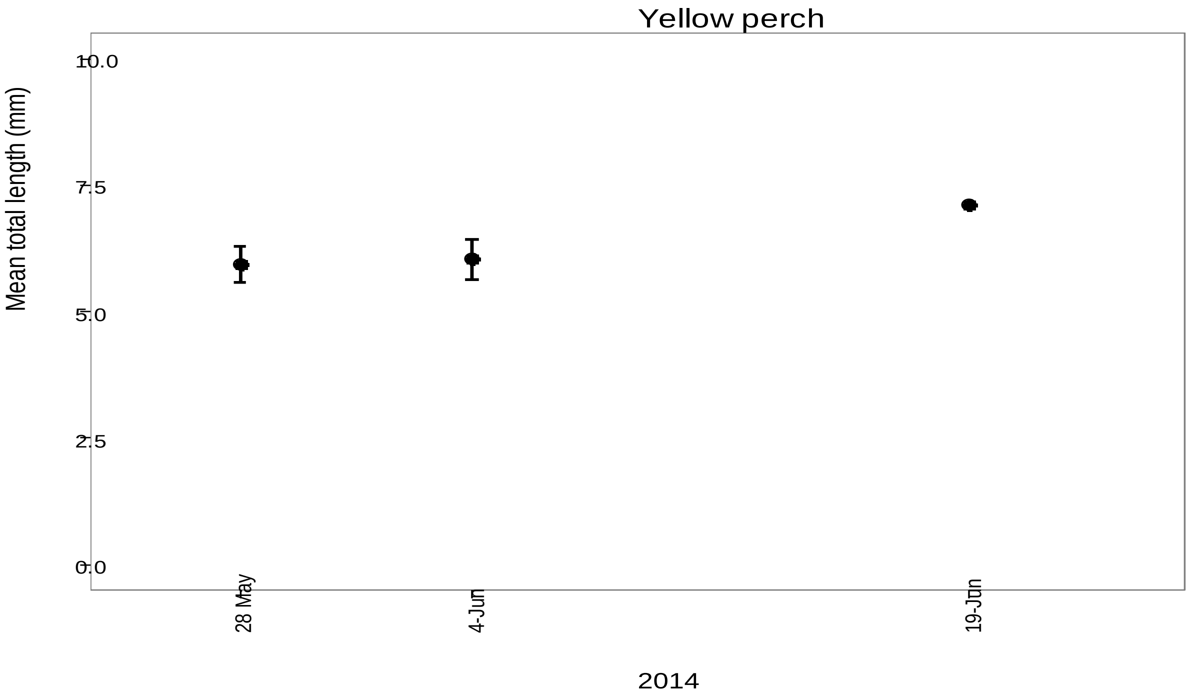

Figure 22. Mean length of yellow perch early life history stages collected in the near-shore zone of Cayuga Lake, NY, April through August 2014. Error bars show one standard deviation.

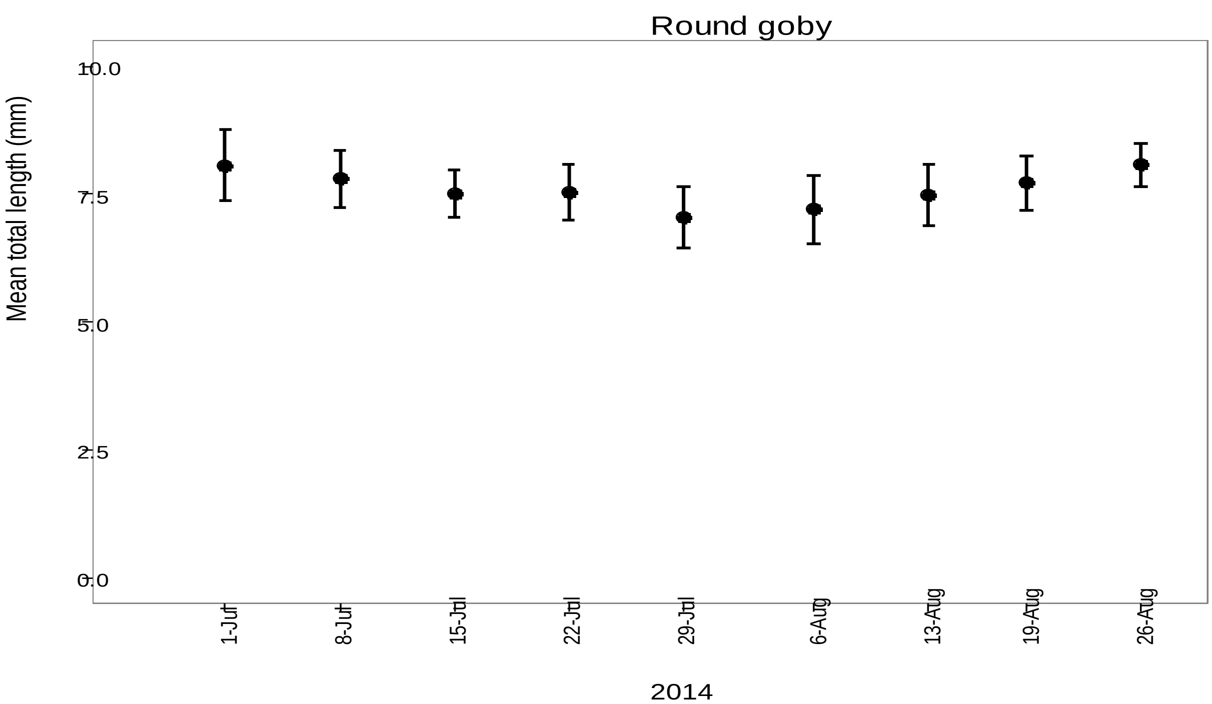

Figure 23. Mean length of round goby early life history stages collected in the near-shore zone of Cayuga Lake, NY, April through August 2014. Error bars show one standard deviation.

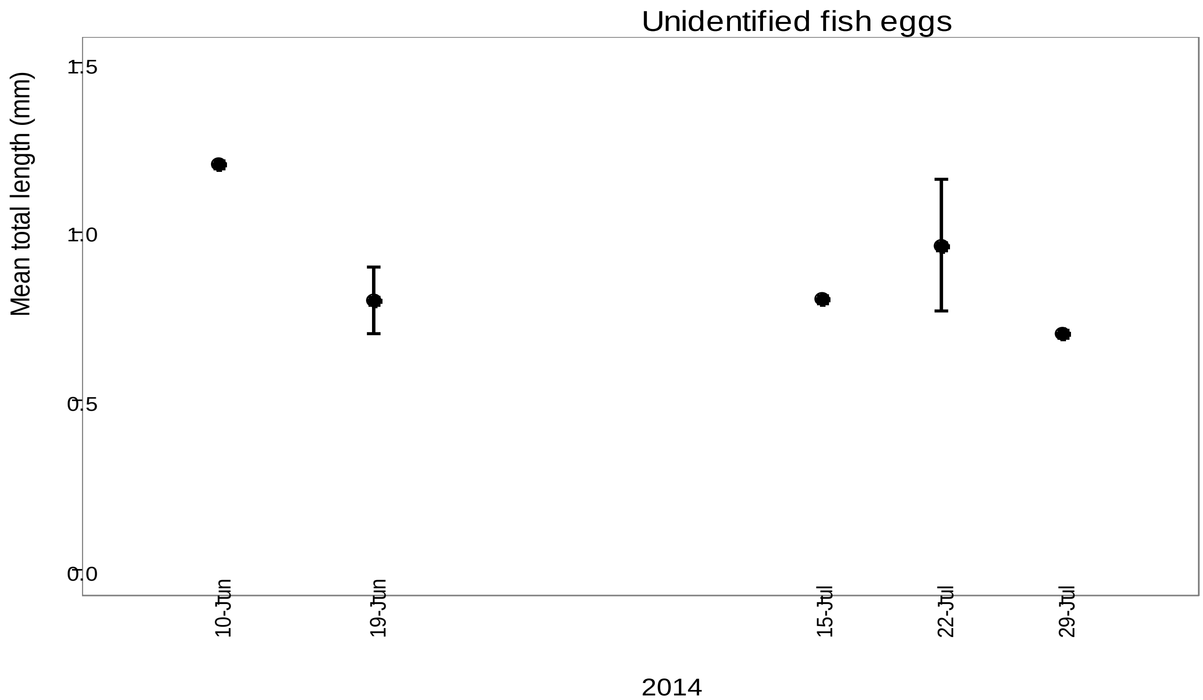

Figure 24. Mean length of unidentified fish eggs collected in the near-shore zone of Cayuga Lake, NY, April through August 2014. Error bars show one standard deviation.

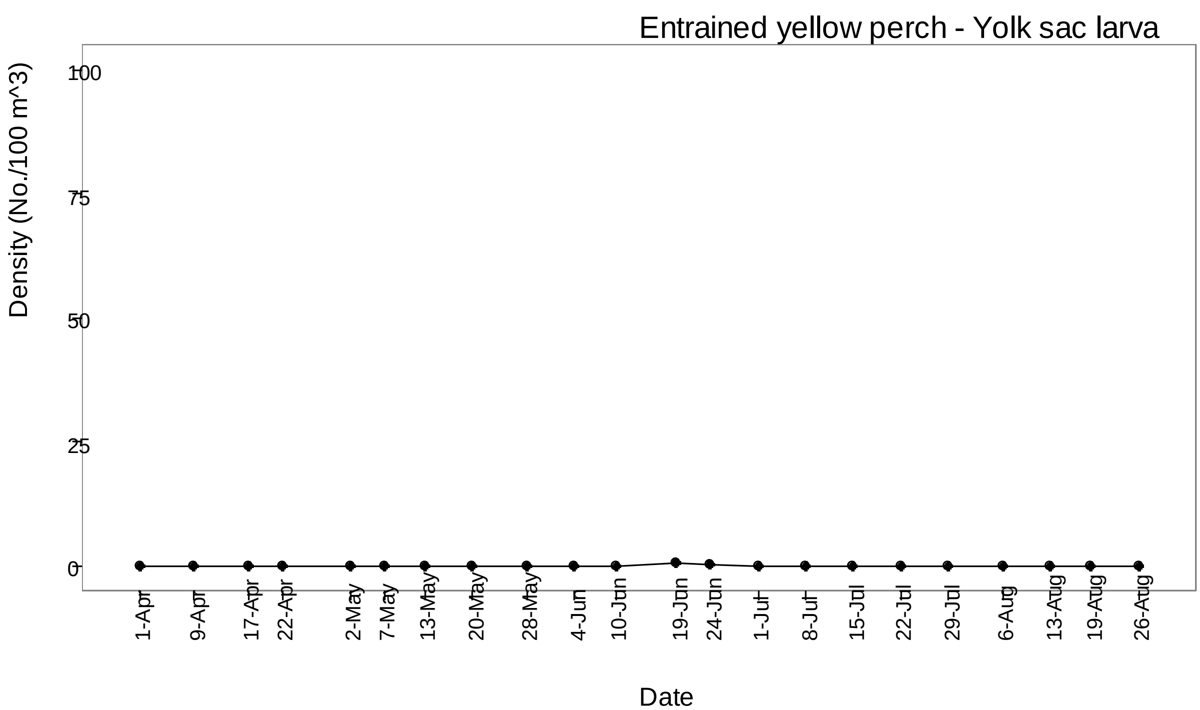

Figure 25. Density (organisms/100 m^3) of yellow perch yolk sac larva entrained in the Cornell University LSC intake, Cayuga Lake, NY, April through August 2014.

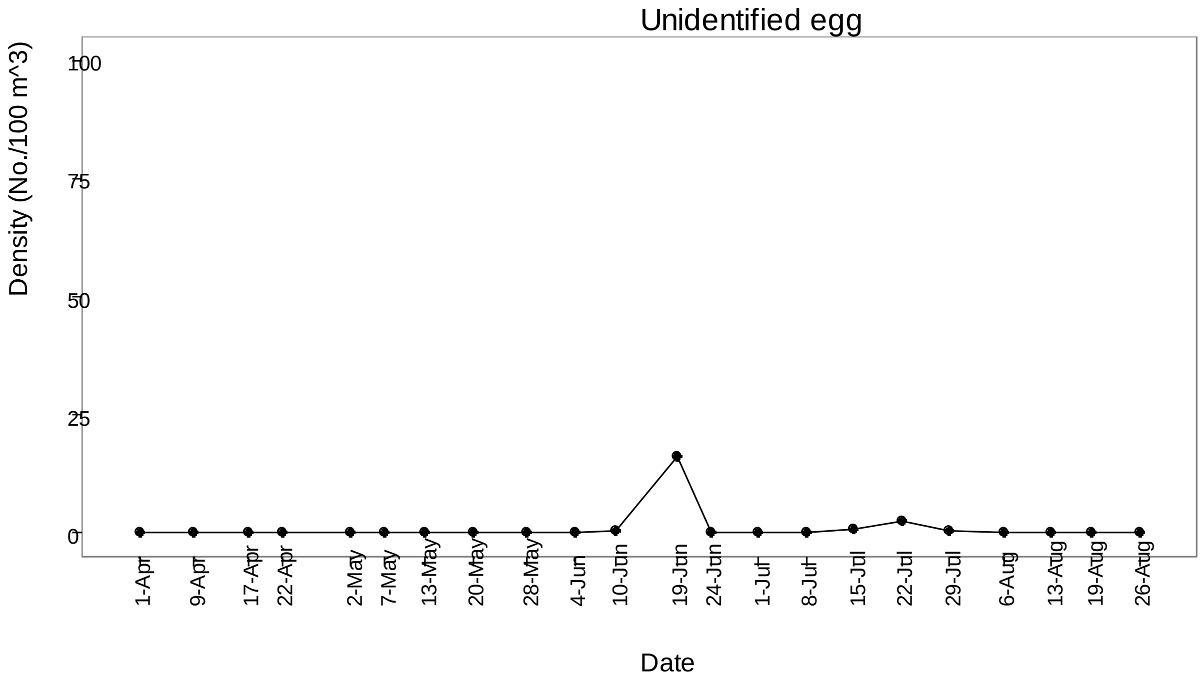

Figure 26. Density (organisms/100 m^3) of unidentified fish eggs entrained in the Cornell University LSC intake, Cayuga Lake, NY, April through August 2014.

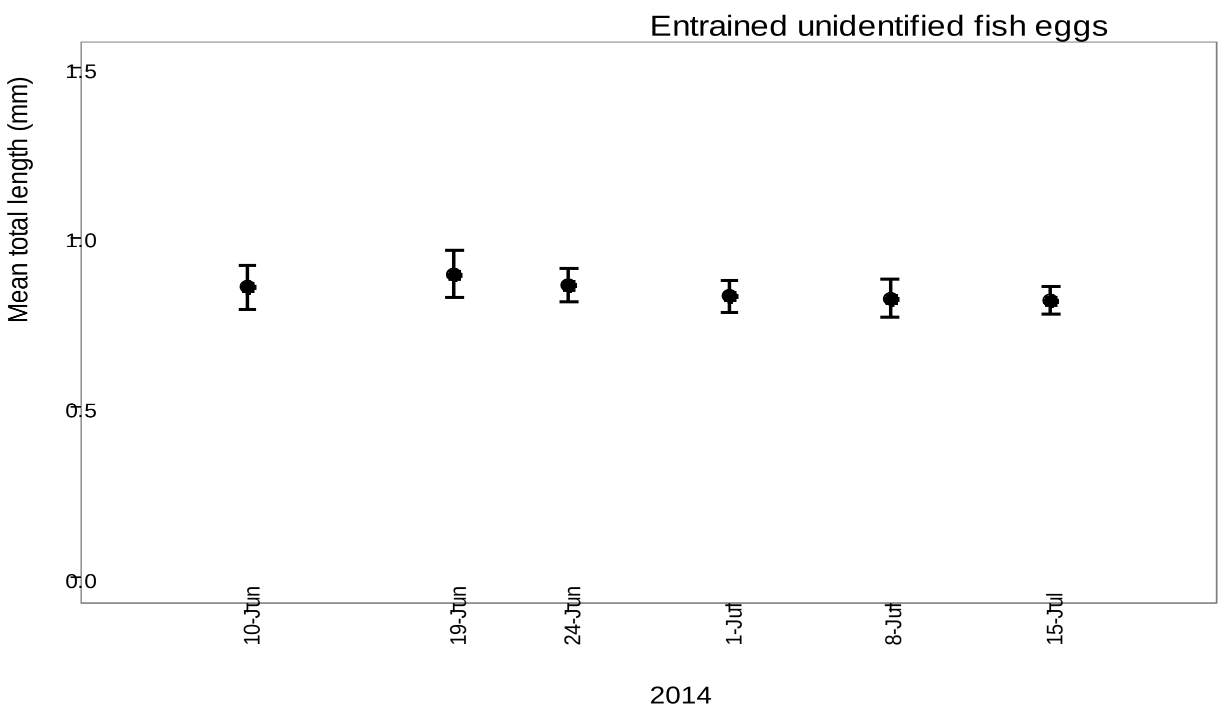

Figure 27. Mean length of unidentified fish eggs entrained in the Cornell University LSC intake, Cayuga Lake, NY, April through August 2014. Error bars show one standard deviation.

APPENDIX A

Example of Density Calculation (No./100 m^3) for Near-shore Ichthyoplankton Samples

Density of Species A, post yolk sac larvae life stage for a 24-hour sampling event:

The number of Species A post yolk sac larvae per 100 m^3 is determined for each net tow. The daily mean density for Species A post yolk sac larvae is determined by averaging the density value obtained for each individual net sample.

Catch for a 24-hour Sampling Event

Net No.	**Time (hours)***	**Vol. Sampled (m3)**	**No. collected**	**No./m^3**	**No./100 m^3**
1	1000	60	1	0.017	1.67
2	1000	60	2	0.033	3.33
1	1200	55	0	0.000	0.00
2	1200	55	3	0.055	5.45
1	1400	65	2	0.031	3.08
2	1400	65	1	0.015	1.54
1	2200	60	1	0.017	1.67
2	2200	60	3	0.050	5.00
1	0000	55	0	0.000	0.00
2	0000	55	2	0.036	3.64
1	0200	60	1	0.017	1.67
2	0200	60	2	0.033	3.33
Mean				0.025	2.53

* - Time at initiation of sampling

Full-rated Flow Entrainment Estimate for Near-shore Ichthyoplankton Samples

Estimated daily entrainment of Species A post yolk sac larvae under full rated flow conditions is calculated by multiplying the daily mean density of 2.53/100 m^3 by the full-rated flow of the LSC facility (172,800 m^3) and dividing by 100.

(2.53 x 172,800)/100 = 4,372 post yolk sac larvae of Species A entrained per day

Estimated weekly entrainment of Species A post yolk sac larvae under full rated flow conditions is calculated by multiplying the daily estimate by 7.

4,372 x 7 = 30,604 post yolk sac larvae of Species A entrained per week.

Estimated total entrainment of Species A post yolk sac larvae under full rated flow conditions for the duration of the study period (April-August) is calculated by summing the 22 individual weekly estimates derived from the weekly 24-hour sampling events.

Actual Operation Flow Entrainment Estimate for Near-shore Ichthyoplankton Samples

Estimated daily entrainment of Species A post yolk sac larvae under actual operation flow conditions is calculated by multiplying the daily mean density of 2.53/100 m^3 by the actual operation flow that occurred during the 24-hour period during which a sampling event occurred and dividing by 100. In this example, an actual operation flow of 138,240 m^3 (80% of full-rated flow) is used.

(2.53 x 138,240)/100 = 3,497 post yolk sac larvae of Species A entrained per day

Estimated weekly entrainment of Species A post yolk sac larvae under actual operation flow conditions is calculated by multiplying the daily estimate by the daily actual operation flow for each day of the week represented by that sample. Calculation for a hypothetical week in which flow ranged from 80-100% of full-rated flow would be as follows.

Day	Daily Mean Density (No./m^3)	Daily Actual Flow (m^3)	Est. Daily Entrainment
1	2.53	138,240 (80%)*	3,497
2	2.53	138,240 (80%)	3,497
3	2.53	146,880 (85%)	3,716
4	2.53	172,800 (100%)	4,372
5	2.53	155,520 (90%)	3,935
6	2.53	155,520 (90%)	3,935
7	2.53	138,240 (80%)	3,497
Total			26,449

* - Represents percentage of full-rated flow

Estimated total entrainment of Species A post yolk sac larvae under actual operation flow conditions for the duration of the study period (April-August) is calculated by summing the 22 individual weekly estimates derived from the weekly 24-hour sampling events.

APPENDIX B

Example of Density Calculation (No./100 m^3) for In-plant Ichthyoplankton Samples

Density of Species A, post yolk sac larvae life stage for a 24-hour sampling event:

The number of Species A post yolk sac larvae per 100 m^3 is determined for each net. The daily mean density for Species A post yolk sac larvae is determined by averaging the density value obtained for each individual net sample.

Catch for a 24-hour Sampling Event

Net No.	Time (hours)*	Vol. Sampled (m^3)**	No. collected	No./m^3	No./100 m^3
1	0800	288	1	0.003	0.35
2	0800	288	2	0.007	0.69
1	1600	288	0	0.000	0.00
2	1600	288	3	0.010	1.04
1	0000	288	2	0.007	0.69
2	0000	288	1	0.003	0.35
Mean				0.005	0.52

* - Time at initiation of sampling

** - Example assumes 1% of full-rated flow is sampled by both nets combined. Actual operation flow from the biomonitoring station flow meter will be used.

Full-rated Flow Entrainment Estimate for In-plant Ichthyoplankton Samples

Estimated daily entrainment of Species A post yolk sac larvae under full rated flow conditions is calculated by multiplying the daily mean density of 0.52/100 m^3 by the full-rated flow of the LSC facility (172,800 m^3) and dividing by 100.

(0.52 x 172,800)/100 = 899 post yolk sac larvae of Species A entrained per day

Estimated weekly entrainment of Species A post yolk sac larvae under full rated flow conditions is calculated by multiplying the daily estimate by 7.

899 x 7 = 6,293 post yolk sac larvae of Species A entrained per week.

Estimated total entrainment of Species A post yolk sac larvae under full rated flow conditions for the duration of the study period (April-August) is calculated by summing the 22 individual weekly estimates derived from the weekly 24-hour sampling events.

Actual Operation Flow Entrainment Estimate for In-plant Ichthyoplankton Samples

Estimated daily entrainment of Species A post yolk sac larvae under actual operation flow conditions is calculated by multiplying the daily mean density of 0.52/100 m^3 by the actual operation flow that occurred during the 24-hour period during which a sampling event occurred and dividing by 100. In this example, an actual operation flow of 138,240 m^3 (80% of full-rated flow) is used.

(0.52 x 138,240)/100 = 719 post yolk sac larvae of Species A entrained per day

Estimated weekly entrainment of Species A post yolk sac larvae under actual operation flow conditions is calculated by multiplying the daily estimate by the daily actual operation flow for each day of the week represented by that sample. Calculation for a hypothetical week in which flow ranged from 80-100% of full-rated flow would be as follows.

Day	Daily Mean Density (No./m^3)	Daily Actual Flow (m^3)	Est. Daily Entrainment
1	0.52	138,240 (80%)*	719
2	0.52	138,240 (80%)	719
3	0.52	146,880 (85%)	764
4	0.52	172,800 (100%)	899
5	0.52	155,520 (90%)	809
6	0.52	155,520 (90%)	809
7	0.52	138,240 (80%)	719
Total			5,438

* - Represents percentage of full-rated flow

Estimated total entrainment of Species A post yolk sac larvae under actual operation flow conditions for the duration of the study period (April-August) is calculated by summing the 22 individual weekly estimates derived from the weekly 24-hour sampling events.

Appendix C. Date, time, location coordinates, volume sampled, and water chemistry conditions for ichthyoplankton samples collected in the near-shore zone of Cayuga Lake, NY, April through August 2014.

Sample date	Time start	Time end	UTM start N	UTM start W	UTM stop N	UTM stop W	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (μS)
4/9/14	10:02	10:07	42°28.229’	76°30.268’	42°28.338’	76°30.361’	18.1	6.6	11.7	96	337
4/9/14	12:01	12:06	42°28.205’	76°30.261’	42°28.327’	76°30.373’	17.2	6.1	12.4	100	339
4/9/14	14:00	14:05	42°28.202’	76°30.244’	42°28.331’	76°30.375’	18.5	6.6	12.0	97	342
4/9/14	22:00	22:05	42°28.220’	76°30.229’	42°28.336’	76°30.345’	16.6	5.3	12.1	95	324
4/10/14	0:09	0:14	42°28.181’	76°30.218’	42°28.310’	76°30.312’	17.5	5.7	12.0	96	329
4/10/14	1:57	2:03	42°28.213’	76°30.232’	42°28.347’	76°30.333’	18.4	4.0	13.1	99	336
4/17/14	10:06	10:11	42°28.215’	76°30.244’	42°28.318’	76°30.330’	19.0	6.0	11.6	93	361
4/17/14	12:01	12:06	42°28.194’	76°30.235’	42°28.313’	76°30.346’	19.3	7.3	11.6	96	363
4/17/14	13:58	14:04	Not collected	Not collected	42°28.317’	76°30.304’	18.3	8.0	11.9	99	367
4/17/14	22:03	22:08	42°28.216’	76°30.249’	42°28.348’	76°30.350’	18.8	6.8	12.0	98	370
4/18/14	0:08	0:13	42°28.214’	76°30.245’	42°28.348’	76°30.357’	19.6	6.4	11.9	97	374
4/18/14	1:58	2:04	42°28.211’	76°30.247’	42°28.339’	76°30.354’	17.9	6.2	11.8	95	350
4/22/14	11:00	11:05	42°28.165'	76°30.224'	42°28.312'	76°30.340'	20.3	8.5	11.6	100	390
4/22/14	11:59	12:04	42°28.196'	76°30.228'	42°28.327'	76°30.350'	20.2	8.5	12.2	100	391
4/22/14	12:58	13:03	42°28.175'	76°30.220'	42°28.311'	76°30.327'	19.9	8.5	11.9	99	392
4/22/14	23:02	23:07	42°28.192'	76°30.233'	42°28.334'	76°30.350'	20.4	8.2	12.1	100	402
4/23/14	0:14	0:19	42°28.200'	76°30.233'	42°28.333'	76°30.343'	19.1	7.7	12.4	100	402
4/23/14	1:10	1:15	42°28.177'	76°30.218'	42°28.300'	76°30.323'	17.4	7.3	11.9	99	418
5/2/14	11:02	11:07	42°28.214'	76°30.253'	42°28.361'	76°30.369'	19.7	8.9	11.5	100	396
5/2/14	12:02	12:07	42°28.170'	76°30.227'	42°28.331'	76°30.328'	20.8	9.3	11.6	100	397
5/2/14	13:02	13:07	42°28.172'	76°30.230'	42°28.299'	76°30.336'	16.6	9.3	11.8	100	396
5/2/14	23:04	23:09	42°28.159'	76°30.222'	42°28.306'	76°30.334'	19.2	9.4	11.1	100	402
5/3/14	0:10	0:15	42°28.161'	76°30.218'	42°28.306'	76°30.319'	18.5	9.0	12.0	100	403
5/3/14	1:08	1:13	42°28.141'	76°30.222'	42°28.285'	76°30.313'	17.9	8.9	11.5	99	404
5/7/14	11:05	11:10	42°28.171'	76°30.230'	42°28.309'	76°30.328'	19.6	10.7	11.6	100	405
5/7/14	12:04	12:09	42°28.120'	76°30.198'	42°28.263'	76°30.293'	18.0	10.0	11.7	100	404
5/7/14	13:01	13:06	42°28.154'	76°30.211'	42°28.284'	76°30.310'	16.3	9.4	11.7	100	406
5/7/14	23:00	23:05	42°28.166'	76°30.211'	42°28.307'	76°30.318'	18.8	8.3	12.5	100	407
5/8/14	0:10	0:15	42°28.178'	76°30.236'	42°28.319'	76°30.327'	17.7	9.1	12.1	100	404

Sample date	Time start	Time end	UTM start N	UTM start W	UTM stop N	UTM stop W	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (µS)
5/8/14	1:01	1:06	42°28.169'	76°30.220'	42°28.294'	76°30.324'	16.6	8.7	12.2	100	400
5/13/14	10:58	11:03	42°28.192'	76°30.218'	42°28.321'	76°30.313'	17.0	8.7	12.1	100	407
5/13/14	12:02	12:07	42°28.173'	76°30.244'	42°28.327'	76°30.345'	18.6	8.7	12.8	100	406
5/13/14	13:03	13:08	42°28.171'	76°30.220'	42°28.317'	76°30.334'	18.4	8.6	11.9	100	406
5/14/14	0:20	0:25	42°28.157'	76°30.206'	42°28.281'	76°30.307'	16.5	7.4	12.5	99	408
5/14/14	1:23	1:28	42°28.168'	76°30.215'	42°28.305'	76°30.322'	17.9	8.8	11.9	100	405
5/14/14	1:50	1:55	42°28.186'	76°30.225'	42°28.319'	76°30.325'	17.9	8.8	11.9	100	405
5/20/14	11:00	11:05	42°28.165'	76°30.216'	42°28.327'	76°30.339'	21.6	12.0	10.8	100	364
5/20/14	12:04	12:09	42°28.189'	76°30.238'	42°28.326'	76°30.335'	17.4	11.6	10.8	100	366
5/20/14	13:06	13:11	42°28.178'	76°30.229'	42°28.317'	76°30.341'	16.6	11.7	10.9	100	369
5/20/14	23:00	23:05	42°28.189'	76°30.219'	42°28.339'	76°30.337'	19.9	14.4	10.3	100	367
5/21/14	0:06	0:11	42°28.190'	76°30.228'	42°28.332'	76°30.339'	18.5	13.7	10.5	100	367
5/21/14	1:04	1:09	42°28.177'	76°30.233'	42°28.324'	76°30.329'	19.0	13.3	10.9	100	371
5/28/14	11:03	11:08	42°28.193'	76°30.230'	42°28.360'	76°30.362'	20.8	15.5	10.0	100	411
5/28/14	12:00	12:04	42°28.210'	76°30.244'	42°28.340'	76°30.349'	16.5	15.0	10.1	100	398
5/28/14	12:57	13:02	42°28.185'	76°30.229'	42°28.330'	76°30.341'	17.8	14.5	10.2	100	395
5/28/14	22:58	23:03	42°28.173'	76°30.219'	42°28.314'	76°30.327'	18.8	15.6	10.0	100	394
5/29/14	0:09	0:14	42°28.179'	76°30.217'	42°28.329'	76°30.334'	19.2	14.6	10.1	100	395
5/29/14	1:00	1:05	42°28.174'	76°30.229'	42°28.325'	76°30.330'	19.0	14.5	10.2	100	396
6/4/14	11:01	11:06	42°28.194'	76°30.223'	42°28.343'	76°30.344'	20.5	14.4	10.5	100	397
6/4/14	12:01	12:06	42°28.180'	76°30.226'	42°28.337'	76°30.345'	19.7	14.2	10.5	100	397
6/4/14	13:01	13:06	42°28.199'	76°30.224'	42°28.342'	76°30.335'	18.5	14.2	10.3	100	395
6/4/14	23:05	23:10	42°28.162'	76°30.217'	42°28.312'	76°30.323'	19.1	14.9	10.0	100	399
6/5/14	0:09	0:14	42°28.174'	76°30.215'	42°28.333'	76°30.340'	20.2	14.9	10.0	100	397
6/5/14	1:00	1:05	42°28.181'	76°30.224'	42°28.328'	76°30.334'	17.8	15.0	9.9	100	389
6/10/14	11:00	11:05	42°28.166'	76°30.218'	42°28.331'	76°30.342'	20.2	18.1	9.3	99	363
6/10/14	11:56	12:01	42°28.189'	76°30.230'	42°28.340'	76°30.346'	17.8	18.1	9.4	100	354
6/10/14	12:58	13:03	42°28.158'	76°30.231'	42°28.311'	76°30.321'	17.6	18.2	9.5	100	358
6/10/14	23:00	23:05	42°28.163'	76°30.217'	42°28.305'	76°30.327'	17.5	19.8	8.8	97	353

Sample date	Time start	Time end	UTM start N	UTM start W	UTM stop N	UTM stop W	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (µS)
6/11/14	0:03	0:05	42°28.181'	76°30.222'	42°28.349'	76°30.342'	20.3	19.0	9.2	100	358
6/11/14	1:01	1:06	42°28.203'	76°30.232'	42°28.339'	76°30.328'	16.5	19.1	9.3	100	370
6/19/14	10:58	11:03	42°28.188'	76°30.221'	42°28.335'	76°30.333'	17.6	17.6	9.4	100	377
6/19/14	11:59	12:04	42°28.170'	76°30.226'	42°28.319'	76°30.329'	17.8	18.0	9.4	100	377
6/19/14	13:00	13:05	42°28.163'	76°30.228'	42°28.310'	76°30.329'	15.9	18.8	9.3	100	360
6/19/14	22:59	23:04	42°28.187'	76°30.229'	42°28.337'	76°30.338'	18.2	18.6	9.2	98	372
6/20/14	0:02	0:07	42°28.174'	76°30.219'	42°28.322'	76°30.319'	17.9	18.4	9.3	100	374
6/20/14	0:59	1:04	42°28.174'	76°30.211'	42°28.321'	76°30.318'	18.9	18.4	9.3	100	378
6/24/14	11:00	11:05	42°28.161'	76°30.210'	42°28.309'	76°30.321'	19.1	13.4	9.6	92	393
6/24/14	12:01	12:06	42°28.163'	76°30.216'	42°28.321'	76°30.315'	19.6	13.5	9.6	92	393
6/24/14	12:57	13:02	42°28.181'	76°30.215'	42°28.334'	76°30.331'	19.8	13.1	9.6	92	393
6/24/14	22:55	23:00	42°28.170'	76°30.212'	42°28.315'	76°30.316'	18.6	12.4	10.3	97	393
6/25/14	0:00	0:05	42°28.171'	76°30.215'	42°28.322'	76°30.330'	19.7	11.9	10.4	98	394
6/25/14	0:19	0:24	42°28.179'	76°30.222'	42°28.335'	76°30.334'	19.9	12.0	10.5	98	394
7/1/14	10:57	11:02	42°28.171'	76°30.211'	42°28.313'	76°30.324'	18.7	16.4	9.6	98	394
7/1/14	11:59	12:04	42°28.149'	76°30.219'	42°28.309'	76°30.327'	20.1	17.0	9.5	99	393
7/1/14	13:00	13:05	42°28.159'	76°30.221'	42°28.327'	76°30.319'	20.7	18.0	9.4	99	392
7/1/14	22:59	23:04	42°28.175'	76°30.210'	42°28.329'	76°30.324'	19.9	15.7	9.8	100	393
7/2/14	0:09	0:14	42°28.177'	76°30.218'	42°28.309'	76°30.326'	17.2	15.8	9.8	100	397
7/2/14	0:58	1:03	42°28.167'	76°30.225'	42°28.306'	76°30.314'	17.3	15.6	9.9	100	396
7/8/14	10:59	11:04	42°28.337'	76°30.327'	42°28.202'	76°30.233'	19.3	20.1	9.3	100	391
7/8/14	11:59	12:04	42°28.181'	76°30.217'	42°28.339'	76°30.331'	20.2	20.0	8.9	99	390
7/8/14	12:57	13:02	42°28.172'	76°30.215'	42°28.329'	76°30.317'	19.8	20.1	8.8	98	380
7/8/14	22:58	23:03	42°28.176'	76°30.222'	42°28.320'	76°30.315'	18.8	18.3	9.4	99	390
7/9/14	0:00	0:05	42°28.178'	76°30.220'	42°28.326'	76°30.325'	18.4	18.2	8.9	99	393
7/9/14	0:57	1:02	42°28.183'	76°30.224'	42°28.319'	76°30.316'	17.7	18.2	9.5	100	394
7/15/14	10:58	11:03	42°28.156'	76°30.216'	42°28.311'	76°30.325'	19.9	19.2	8.6	95	396
7/15/14	12:00	12:05	42°28.157'	76°30.222'	42°28.306'	76°30.307'	18.8	19.0	9.1	97	396
7/15/14	12:58	13:03	42°28.179'	76°30.222'	42°28.331'	76°30.332'	19.7	19.0	8.7	94	396

Sample date	Time start	Time end	UTM start N	UTM start W	UTM stop N	UTM stop W	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (µS)
7/16/14	0:02	0:07	42°28.181'	76°30.212'	42°28.327'	76°30.329'	18.4	19.2	8.8	96	396
7/16/14	0:58	1:03	42°28.161'	76°30.220'	42°28.310'	76°30.317'	17.8	19.3	8.7	95	397
7/22/14	11:02	11:07	42°28.177'	76°30.212'	42°28.319'	76°30.312'	17.4	19.9	8.5	95	
7/22/14	12:03	12:08	42°28.180'	76°30.218'	42°28.325'	76°30.327'	17.6	19.8	8.7	96	393
7/22/14	13:03	13:08	42°28.182'	76°30.213'	42°28.331'	76°30.324'	17.8	19.8	8.5	96	392
7/22/13	23:00	23:05	42°28.193'	76°30.215'	42°28.337'	76°30.323'	18.8	21.0	8.5	96	391
7/23/13	0:00	0:05	42°28.180'	76°30.215'	42°28.312'	76°30.318'	17.3	22.1	8.6	96	397
7/23/13	1:02	1:07	42°28.183'	76°30.217'	42°28.320'	76°30.326'	17.9	21.0	8.5	95	395
7/29/14	11:09	11:14	42°28.168'	76°30.217'	42°28.327'	76°30.325'	19.6	21.5	7.6	83	403
7/29/14	12:01	12:06	42°28.179'	76°30.217'	42°28.325'	76°30.329'	16.5	21.4	6.5	74	402
7/29/14	13:04	13:09	42°28.187'	76°30.205'	42°28.328'	76°30.323'	18.4	21.2	7.4	83	402
7/29/14	22:57	23:02	42°28.182'	76°30.208'	42°28.326'	76°30.331'	17.9	21.5	7.4	84	398
7/30/14	0:01	0:06	42°28.169'	76°30.214'	42°28.318'	76°30.319'	17.3	21.4	7.5	86	400
7/30/14	0:59	1:04	42°28.183'	76°30.211'	42°28.332'	76°30.327'	18.8	21.4	7.3	84	398
8/6/14	11:15	11:20	42°28.189'	76°30.220'	42°28.325'	76°30.323'	18.2	22.6	8.3	98	403
8/6/14	12:25	12:30	42°28.189'	76°30.210'	42°28.326'	76°30.331'	20.2	22.8	8.4	97	389
8/6/14	13:12	13:17	42°28.179'	76°30.225'	42°28.325'	76°30.336'	17.7	23.2	8.3	97	394
8/6/14	23:01	23:06	42°28.196'	76°30.217'	42°28.339'	76°30.321'	19.9	23.0	8.1	95	401
8/7/14	0:01	0:06	42°28.183'	76°30.210'	42°28.329'	76°30.322'	17.0	22.9	8.0	95	404
8/7/14	0:56	1:01	42°28.189'	76°30.214'	42°28.339'	76°30.333'	19.8	22.9	7.7	91	404
8/13/14	11:04	11:09	42°28.172'	76°30.215'	42°28.333'	76°30.334'	18.6	15.7	7.8	73	399
8/13/14	12:02	12:07	42°28.188'	76°30.212'	42°28.330'	76°30.334'	15.9	15.6	7.9	81	400
8/13/14	13:03	13:08	42°28.181'	76°30.205'	42°28.333'	76°30.332'	17.2	16.8	7.6	80	402
8/13/14	23:14	23:19	42°28.185'	76°30.224'	42°28.315'	76°30.324'	15.6	18.6	8.3	93	435
8/14/14	0:14	0:19	42°28.188'	76°30.217'	42°28.330'	76°30.334'	13.4	18.1	8.4	87	409
8/14/14	0:47	0:52	42°28.191'	76°30.212'	42°28.313'	76°30.325'	15.1	17.9	7.4	81	408
8/19/14	11:04	11:09	42°28.183'	76°30.208'	42°28.351'	76°30.349'	14.4	19.7	8.5	95	387
8/19/14	12:02	12:07	42°28.191'	76°30.215'	42°28.323'	76°30.335'	10.1	20.0	8.5	94	388
8/19/14	13:01	13:06	42°28.179'	76°30.206'	42°28.314'	76°30.334'	12.5	20.3	8.5	95	384

Appendix C. Continued.

Sample date	Time start	Time end	UTM start N	UTM start W	UTM stop N	UTM stop W	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (µS)
8/19/14	23:01	23:06	42°28.179'	76°30.211'	42°28.308'	76°30.327'	9.6	20.7	8.5	97	381
8/20/14	0:08	0:13	42°28.181'	76°30.251'	42°28.303'	76°30.355'	15.2	20.8	8.5	95	383
8/20/14	1:01	1:06	42°28.177'	76°30.255'	42°28.310'	76°30.367'	16.3	20.6	8.9	99	383
8/26/14	11:04	11:09	42°28.170'	76°30.243'	42°28.323'	76°30.345'	17.5	19.8	7.8	83	394
8/26/14	12:00	12:05	42°28.182'	76°30.259'	42°28.338'	76°30.373'	18.4	20.8	7.6	85	388
8/26/14	13:01	13:06	42°28.169'	76°30.239'	42°28.333'	76°30.366'	17.1	20.5	8.5	94	384
8/26/14	22:57	23:02	42°28.180'	76°30.253'	42°28.327'	76°30.364'	15.2	19.9	7.8	86	383
8/27/14	0:01	0:06	42°28.169'	76°30.252'	42°28.320'	76°30.355'	17.8	20.7	8.4	95	383
8/27/14	0:58	1:03	42°28.177'	76°30.283'	42°28.333'	76°30.365'	17.9	20.2	8.7	96	383

Appendix D. Date, time, volume sampled, and water chemistry conditions for in-plant ichthyoplankton entrainment samples collected in the Lake Source Cooling facility, April through August 2014.

Sample date	Time start	Time end	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (µS)
4/9/2014	7:57	15:59	139.8	3.4	12.8	97	415
4/9/2014	16:10	23:39	130.7	3.4	12.6	95	409
4/9/2014	23:50	8:00	142.3	2.3	12.8	93	409
4/17/2014	8:00	15:58	138.9	5.2	12.9	99	406
4/17/2014	16:09	23:41	131.7	3.7	12.5	95	405
4/17/2014	23:49	8:01	143.1	3.8	12.5	95	405
4/22/2014	7:57	16:00	140.3	4.7	13.6	100	408
4/22/2014	16:08	23:47	134.9	4.2	12.8	98	408
4/22/2014	23:54	8:00	142.5	3.6	13.5	100	408
5/2/2014	8:10	16:02	136.6	5.4	13.2	100	406
5/2/2014	16:08	23:46	133.1	5.0	12.4	98	407
5/2/2014	23:54	8:10	144.1	5.3	12.8	100	407
5/7/2014	8:01	16:00	172.3	4.6	13.5	100	405
5/7/2014	16:08	23:46	202.6	4.5	12.9	100	406
5/7/2014	23:54	8:00	142.0	4.5	13.4	100	406
5/13/2014	7:58	16:01	385.1	4.6	13.1	100	397
5/13/2014	16:12	23:57	362.8	4.6	12.8	100	401
5/13/2014	23:59	8:00	214.6	4.4	13.2	100	405
5/20/2014	7:58	15:59	232.2	4.4	12.9	100	399
5/20/2014	16:04	23:44	219.9	4.5	12.9	100	403
5/20/2014	23:51	8:02	158.6	4.5	13.2	100	404
5/28/2014	8:04	15:51	135.3	4.4	13.0	100	404
5/28/2014	15:59	23:46	136.2	4.5	12.9	100	404
5/28/2014	23:54	8:00	141.1	4.5	12.9	100	404
6/4/2014	7:55	16:00	291.0	4.1	13.0	100	400
6/4/2014	16:08	23:51	262.8	4.5	12.9	100	402

Sample date	Time start	Time end	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (μS)
6/4/2014	23:58	7:30	164.9	4.5	12.9	100	403
6/10/2014	7:59	16:00	399.9	4.6	12.8	100	397
6/10/2014	16:07	23:43	363.3	4.5	12.9	100	401
6/10/2014	23:51	8:00	359.2	4.4	12.9	100	403
6/19/2014	7:59	15:58	399.0	4.5	12.9	100	398
6/19/2014	16:05	23:42	260.8	4.5	12.9	100	404
6/19/2014	23:50	8:00	144.1	4.5	12.8	100	405
6/24/2014	7:57	15:57	393.2	4.5	12.9	100	403
6/24/2014	16:04	23:35	401.2	4.5	12.8	100	403
6/24/2014	23:43	8:02	397.7	4.4	12.9	100	405
7/1/2014	7:59	16:02	452.2	4.5	13.1	100	399
7/1/2014	16:10	23:49	424.3	4.4	13.0	100	403
7/1/2014	23:58	8:00	416.1	4.4	12.9	100	404
7/8/2014	8:02	16:00	429.0	4.3	13.0	100	401
7/8/2014	16:07	23:40	364.9	4.3	13.0	100	404
7/8/2014	23:47	8:00	339.5	4.3	13.0	100	404
7/15/2014	8:01	15:58	428.3	4.3	12.7	100	404
7/15/2014	14:06	23:41	350.6	4.3	13.1	100	405
7/15/2014	23:50	8:23	268.0	4.3	12.5	100	406
7/22/2014	7:59	16:01	370.3	4.3	12.4	93	400
7/22/2014	16:08	23:42	362.0	4.3	11.6	93	403
7/22/2014	23:49	8:04	399.8	4.3	11.7	92	405
7/29/2014	8:13	15:59	252.9	4.4	12.2	95	406
7/29/2014	16:05	23:35	237.6	4.4	12.9	99	406
7/29/2014	23:41	8:15	189.2	4.4	12.8	99	408
8/6/2014	8:01	16:01	407.0	4.4	12.6	99	401
8/6/2014	16:10	23:43	286.7	4.4	12.3	96	404
8/6/2014	23:40	8:00	175.4	4.4	12.2	95	407

Appendix D. Continued.

Sample date	Time start	Time end	Volume sampled (m^3)	Water temp. (°C)	Dissolved oxygen (ppm)	Dissolved oxygen (%)	Specific conductance (µS)
8/13/2014	7:56	15:57	431.5	4.4	12.3	97	405
8/13/2014	16:05	23:49	319.5	4.5	12.7	98	405
8/13/2014	23:56	8:00	170.3	4.5	12.8	99	407
8/19/2014	8:01	16:00	352.1	4.3	12.1	96	400
8/19/2014	16:07	23:44	379.1	4.4	12.4	97	404
8/19/2014	23:52	8:03	357.1	4.4	11.7	93	407
8/26/2014	7:58	15:56	391.9	4.4	11.4	88	400
8/26/2014	16:03	23:41	367.8	4.4	12.4	95	405
8/26/2014	23:49	8:00	339.6	4.4	12.0	92	406