FINAL REPORT

Evaluation of the Entrainment Reduction Performance of a 3-mm Wedgewire Screen at Merrimack Station

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1.0 Introduction

Public Service Company of New Hampshire doing business as Eversource Energy (PSNH) operates Merrimack Station using two (Unit 1 and Unit 2) once-through cooling water intake structures (CWISs) to obtain condenser cooling water from the Hooksett Pool section of the Merrimack River in Bow, New Hampshire under an existing National Pollutant Discharge Elimination System permit (NPDES Permit NH0001465) issued by the United States Environmental Protection Agency (USEPA). This report provides the results of a wedgewire test screen performance and evaluation study that was designed to be conducted for 13 consecutive weeks from Monday 8 May through Sunday 6 August 2017 using the methods and procedures specified in the Confirmatory Scope Description (Normandeau Attachment 2 to ENERCON April 2017) and subsequent project-specific Standard Operating Procedures (SOP Rev 0; Normandeau April 2017) for evaluation of the entrainment reduction performance of narrow-slot wedgewire screens if designed, installed and operated at Merrimack Station. Delays in securing and testing all equipment displaced implementation of the full study design into week 3 (Monday, 22 May through Sunday, 28 May 2017), and the program was extended for four additional weeks in August through week 17 (Monday, 28 August through Sunday, 3 September 2017). Accordingly, this report presents the results of the wedgewire test screen performance and evaluation study at Merrimack Station from 15 consecutive weeks of testing (weeks 3 through 17) beginning Monday, 22 May 2017 and continuing through Sunday, 3 September 2017.

2.0 Materials and Methods

The field equipment and laboratory procedures were conducted following standard methods described in the project-specific SOP (Normandeau April 2017; Revision 0). An overview of the study design and methods is presented in this section.

2.1 Wedgewire Test Screen Entrainment Sampling

A single 3-mm slot width wedgewire ("test") screen affixed to the top of a tripod base was deployed in the Merrimack River offshore and slightly upstream from Merrimack Station Unit 1 CWIS at a location considered representative of the proposed Unit 1 wedgewire screen array (ENERCON 2017). The 3-mm test screen was installed with the long axis of the screen set parallel to the predominant current direction in the relevant river cross-sectional cell derived from analysis of the frequency distribution of current directions observed during the acoustic Doppler current profiler (ADCP) study performed during the entrainment seasons of 2009 and 2010 (Figure 2-1; Normandeau Attachment 2 to ENERCON 2017). The 3-mm test wedgewire screen was attached to a six-inch diameter hose connected to a flange at the bottom center of the screen and then ran along the river bottom to a shoreline pumping platform located on the stairway along the north side of the Unit 1 CWIS bulkhead (Figures 2-2 and 2-3).

The test screen was a model T-12 wedgewire screen manufactured by Johnson Screens, 12.5 inches in diameter and 35 inches long overall, equipped with z-alloy wedgewire screen fabric (Figures 2-2 and 2-3). The T-12 Johnson screen has two filtering sections, one on either side of a central riser pipe, and each filtering section was about 12 inches long (Figure 2-3). The filtering surface consisted of wedgewire bars wrapped around the circumference of the cylindrical screen 3 mm apart, so that the slots between the wedgewire bars were perpendicular to the long axis of the screen's cylinder. The test screen was equipped with shallow truncated cone deflector caps on the upstream and downstream ends to decrease turbulence and deflect debris around the screen. Baffles inside the wedgewire screen were designed to equalize the flow distribution along the full length of the filtering sections, limiting the through-slot velocity to the designed maximum over the entire filtering surface. The suction flow for each test screen provided the designed through slot velocity of 0.4 feet per second (fps;

ENERCON 2017). Through-slot velocity was confirmed and recorded during the testing period using a Signet magnetic flow meter on the pump suction.

The sampling hose made a horizontal run to the west from the offshore test location and then turned up to the lower platform of the access stairs on the north side of the Unit 1 CWIS to a sampling pump located there. The discharge flow from this sampling pump passed through 4-inch PVC or flex-hose pipe and two 90° elbows into the top of a water-filled tank containing a sampling net with 0.300-mm mesh (Figure 2-4). Volume sampled by the test system was measured by a factory-calibrated Signet flowmeter mounted in a straight run of PVC pipe between the sampling pump and the collection tank. A target test sample volume of 100 m^3 (±10%) was established as the standard sampling unit that was filtered through a 300 µm mesh plankton net to represent the contents of each sample collected during a two-hour interval at a flow rate of about 220 gallons per minute (gpm) to 240 gpm. The collection net was cylindrical with a short conical section at the lower end tapering to the cod end collection cup. The net's shape was designed to maximize the filtering surface area, thus reducing the through-mesh velocity, and to allow the net to balloon outward away from the incoming stream of water to reduce the risk of net abrasion to the ichthyoplankton.

2.2 Entrainment Control Samples

In-plant control samples ("control") were paired in two-hour time intervals throughout each sampling day with the test 3-mm wedgewire screen samples and collected from the Unit 1 CWIS using the same sampling equipment and procedures from the May 2006 through June 2007 entrainment study (Normandeau 2007) and as used for the test wedgewire screen samples. In-plant control samples were taken from a 3-inch raw-water tap drawing un-chlorinated ambient cooling water from the condenser supply/circulating water pump discharge within the Unit 1 CWIS (Figure 2-5, top panel). Water in the 3-inch diameter tap, at ambient circulating water pressure, flowed from the tap into a sample collection tank located on the floor of the Unit 1 pump house (Figure 2-5, bottom panel). The control sampling flow discharged from the collection tank into a sump where it was pumped to drain into the Unit 1 CWIS traveling screen washwater sluice located on the south side of the Unit 1 CWIS. Volume sampled by the control system was measured by a second factory-calibrated Signet flowmeter mounted in a straight run of pipe between the tap valve and the collection tank. As with the 3-mm wedgewire screen test samples, a target control sample volume of about 100 m^3 was filtered for the control samples and the contents were collected in each two-hour interval at a flow rate of about 220 gpm to 240 gpm. Also as with the 3-mm wedgewire screen test samples, control samples were filtered through a 0.300-mm mesh cylindrical collection with a short conical section at the lower end tapering to the cod end collection cup.

2.3 Sampling Design and Schedule

The Merrimack Station wedgewire screen study was scheduled for 13 consecutive weeks of sampling beginning Monday, 8 May and continuing through Sunday, 6 August 2017 (Normandeau Attachment 2 to ENERCON April 2017). This 13 week period was observed to represent 97% of the annual entrainment abundance at Merrimack Station, Units 1 and 2 combined (Normandeau 2007). Each matching set of planned samples consisted of one 100 m^3 sample taken from the 3-mm wedgewire test screen plus one 100 m^3 sample from the Unit 1 CWIS control (i.e., a pair of samples in each two-hour set). Three consecutive days were planned to be sampled within each scheduled sampling week, representing 72 consecutive hours, with each pair of samples collected concurrently within a two-hour time period. The full planned sampling design for each site was 12 two-hour periods per day, 3 days per week for 13 weeks, to provide 468 matched test/control pairs (936 total samples; Table 2-1). Delays in securing and testing all equipment displaced the start of the full study design into week 3 (Monday, 22 May through Sunday, 28 May 2017, and the program was extended for four additional weeks in August through week 17 (Monday, 28 August through Sunday, 3 September 2017). Accordingly, the wedgewire test screen performance and evaluation study was performed at the Merrimack Station Unit 1 CWIS for 15 consecutive weeks of testing (weeks 3 through 17) beginning

Monday, 22 May 2017 and continuing through Sunday, 3 September 2017 (Table 2-1). The complete sampling design for weeks 3 through 17 was 12 two-hour periods per day, 3 days per week for 13 weeks, to provide 540 matched test/control pairs of entrainment samples, or 1080 total samples.

2.4 Sample Collection Procedures

At the start of each scheduled weekly 72-hour sampling interval, the pumping system for the 3-mm wedgewire test screen was started, the valve controlling the Unit 1 CWIS control sample discharge was opened, and continuous constant flow was established into each sampling tank. Adjustments were made to the pumping rate for the test wedgewire screen to provide the designed through slot velocity of 0.4 fps and deliver a sampling flow of about 50 m^3/hour (220 gpm to 240 gpm) to obtain a 100 m^3 sample during each consecutive two-hour period of pumping. Similarly, adjustments were made to the flow rate for the Unit 1 CWIS control sample to provide a sampling flow of about 50 m^3/hour (220 gpm to 240 gpm) to obtain a 100 m^3 sample during each consecutive two-hour period of sampling. Weekly summary statistics of actual sample volumes for weeks 3 through 17 are shown in Table 2-2.

The target test sample volume of about 100 m^3 for each two-hour test or control sample was determined at the beginning and end of each week of sampling by a timed volumetric method of calculating flow volume to confirm the accuracy of the Signet flow meters. Each flowmeter performance was checked by filling an empty collection tank to the overflow ports of a measured and known volume (e.g., the outer barrel sampler tank shown in Figures 2-4 and 2-5 holds 320 gallons to the overflow). The time required to fill the tank with 320 gallons until it begins to overflow was recorded to the nearest 0.1 second and used to calculate the flow rate in gpm for comparison with the Signet flow meter reading for the same calibration period.

Each 100 m^3 entrainment test or control sample was pumped into a 0.300 mm mesh net suspended in a tank sampler (Figure 2-4) filled with ambient water to buffer the flow and help ensure that ichthyoplankton were in good condition for identification and enumeration, and so the overall percentage of damaged eggs and larvae remained below the target level of 15%. Each net was changed out frequently (about every 20 minutes) with a clean net and washed into a collection jar during each two-hour sample to help minimize damage to the collected ichthyoplankton due to turbulence in the net. At the end of each two-hour sampling interval, the remaining material in the collection net was washed into the sample jar to terminate the two-hour sample, and replaced with a clean net to begin the next two-hour sample collection. Each net removed from the collection tank was washed down with filtered water from the outside to concentrate the sample material in the cod end collection cup, the sample was then rinsed into one or more labeled jars and preserved with a final concentration of 6% buffered formalin. Sampling was nearly continuous during each sampling day, with only about one minute needed to switch nets at the end of each two-hour sampling interval and the beginning of the next.

Ambient water temperature (nearest 0.1°C) and dissolved oxygen concentrations (nearest 0.1 mg/l) of the water in the 3-mm test screen sampling tank and in the Unit 1 CWIS control tank were measured and recorded once during each two-hour sampling period (Table 2-3).

2.5 Laboratory Analysis

Each entrainment sample represented the contents of about 100 m^3 of ambient water that had been withdrawn from Hooksett Pool of the Merrimack River and filtered through a 0.300 mm mesh net during about two-hours of sampling, washed into a one-liter sample container, and preserved at a final concentration of 6% buffered formalin (or 95% ethanol). Samples with high abundances (at least 400 eggs and 400 larvae) were subsampled in the laboratory for eggs or larvae (or both). These quotas applied to the total count of all species combined, not to individual species. For samples which contained low numbers of larvae but a high total volume of detritus and other plankton (more than 400 ml settled volume), a maximum of one-half of the sample was sorted. The reliability of the selected splitting method was documented by finding no statistically significant difference ($p \leq 0.05$) in a test of randomly selected split pairs, using a paired comparison method like a Chi-square test. The unanalyzed portion of any split sample, and the sorted and identified material from each sample processed, will be retained for a period of one year following delivery to, and acceptance of, the final report by PSNH. After one year all or some of the samples will be disposed of, with written permission from PSNH.

The enumeration of already dead organisms artificially inflates the densities of eggs and larvae found in entrainment samples. The exclusion of these dead organisms therefore is important when processing each ichthyoplankton sample, to provide the most accurate and representative estimates of entrainment densities and abundance. Fish eggs and larvae which were dead prior to capture and preservation exhibit changes in their physical characteristics that can be observed under microscopic examination and therefore used by Normandeau's Biological Laboratory in the sorting and identification procedures to distinguish ichthyoplankton eggs and larvae that were alive at the time of collection and preservation from those that were dead. Only ichthyoplankton that were alive at the time of collection were identified to the lowest practical taxon and enumerated. Any damaged fragments of a larva were counted only if it includes the head, to prevent double counting of any larvae broken during sample processing.

Eggs and larvae were identified to the lowest practical taxon and counted by life stage (eggs, yolk-sac larvae, post yolk-sac larvae, young-of-the-year, yearling or older, or unidentified). An unidentified life stage was assigned when one or more characteristics needed to differentiate the life stage was missing, such as the yolk sac on a damaged specimen. Up to 30 eggs and 30 larvae per taxon were measured from each sample for total length (TL) in mm for eggs and larvae, and for the limiting dimension, referred to as "Body Depth". Body Depth for larvae was defined as the largest limiting dimension besides total length from each larva among the following: body depth, head depth, head width, and body width. Body Depth for eggs was the diameter for a round egg, and if the egg was oval, both maximum and minimum lengths were measured. The 30 eggs and 30 larvae measured per taxon were selected randomly from all eggs and all larvae of that taxon regardless of life stage.

The number and percentage of intact and damaged specimens were determined by taxon and life stage and used to evaluate the ability of the field methods to provide samples with damaged specimens less than 15%. The presence of damaged specimens could cause a taxon to be assigned to a higher taxonomic category than species (e.g., genus or family) if one or more distinguishing features are absent and more than one similar species were identified in the samples. Furthermore, the ichthyoplankton identification using traditional morphological features and meristics for some species do not allow identification to the species level of taxonomy, e.g., Carp and Minnow family (Cyprinidae), Blueback Herring/ Alewife (*Alosa aestivalis*/*Alosa pseudoharengus*), or Sunfish Family (*Lepomis* sp.). A voucher collection of ichthyoplankton eggs and larvae identified to the level of taxonomy for this project was archived as a reference collection (Table 2-4), retained along with the entrainment samples for one year, and disposed of as specified earlier for the unanalyzed portion of entrainment samples.

Each technician's counts were verified by a quality control (QC) continuous sampling plan with a 10% Average Outgoing Quality Limit (AOQL), meaning that fewer than 10% of the counts in the final data could exceed tolerance (U.S. Department of Defense 1981). Tasks subject to QC are both sorting and identification. A sorted sample failed the QC inspection if the QC inspector found that 10% or more of the eggs and larvae in the sample had been missed by the sorter. All additional organisms found during sorting QC were added to the sample vials before the identification phase. The identifications for a sample failed the QC inspection if the QC inspector found that 10% or more of the eggs and larvae in the sample exceed the tolerance criteria for counting, identification, or life stage determination. Counts, identifications, and life stage determinations for any samples failing identification QC were corrected on the data sheets before data entry.

Questionable measurement data were identified on an individual specimen basis by assigning a "valid" code, to allow analysts the option of excluding the questionable measurements without excluding the entire sample. Questionable measurement data, such as when body-depth-to-length ratios were unreasonably lower or higher than daily quartile values, may be identified as either "outliers" inappropriate for analysis or "extreme values" invalid for analysis. Outliers were defined as either more than 1.5 times the interquartile range (IQR) below Q1 or more than 1.5 IQR above Q3; extreme values were defined as either more than 3 IQR below Q1 or more than 3 IQR above Q3 (Tukey 1977).

Laboratory data were double-keyed and verified by data entry software. Preliminary data files were checked systematically by error-checking software and manual inspection to identify and resolve questionable values. Final data files were subjected to 1% AOQL inspection against the original data sheets.

2.6 Water Velocity Measurements

A site-specific current velocity study was performed coincident with the 3-mm wedgewire screen entrainment reduction performance study to characterize the Merrimack River sweeping flows and the consistency of the current direction during the 2017 entrainment sampling test period. Continuous three-dimensional water velocity measurements of a nominal five-foot above bottom layer were made by downward-looking ADCPs at Merrimack Station upstream and downstream of the 3-mm wedgewire test screen (Figure 2-6; ADCP sites referred to as "Upstream" and "Downstream" herein). The ADCPs were mounted in a downward-facing orientation on four-legged frames anchored on the river bed of the Merrimack River at locations proposed by ENERCON as representative of the sites that potential full scale wedgewire screen arrays might be deployed (Figure 2-7). Downward-facing ADCPs were specified because the design of the full-sized 3-mm wedgewire screens proposed for installation at Merrimack Station Units 1 and 2, places the wedgewire screen arrays for Merrimack Station Unit 1 and Unit 2 flush with the river bed and up to roughly five feet above the bed. To adequately sample this lower portion of the water column, the ADCPs had to be deployed facing downward. The instrument deployment frames were constructed of aluminum so as not to interfere with the ADCPs' compasses. Each frame consists of two nine-foot tall A-frame sides connected by a 12 foot cross beam (Figures 2-7 and 2-8). The ADCPs were mounted on the underside of the cross beam at the midpoint for unobstructed acoustic coverage of the water column between the transducers and the river bottom. The frame design allows for undisturbed water flow through the ADCP sampling region (Figure 2-7). The ADCP frames were deployed from a vessel, and stabilized by divers by placing sandbags on the bottom rails (Figure 2-8). After the frames were in place and stable, the divers securely attached the ADCPs to the mounting plates.

A Teledyne RD Instruments (TRDI) 1200 kHz Workhorse Sentinel ADCP was deployed at each of the two locations prior to the start of entrainment sampling, and remained installed for the measurement river current velocity throughout the sampling period, with the exception of brief monthly periods while the instruments were being serviced and data were downloaded. The two ADCPs were initially deployed on 22 May 2017. The instruments were calibrated and tested before deployment for electronics verification following the procedures outlined in the equipment technical manual, which include compass tests and beam geometry tests to ensure proper alignment during deployment and monitoring. The pre-deployment compass calibration tests resulted in an overall error of 2.0° for each of the ADCPs, which is below the 5.0° error maximum recommended by the manufacturer (TRDI 2011, TRDI 2016). Additionally, both ADCPs passed all system and sensor tests at the time of compass calibration. The ADCPs have a velocity resolution of 0.001 m/s (0.0033 ft/s) and velocity accuracy of 0.25% of the water velocity ± 0.0025 m/s (0.0082 ft/s). For clarity and consistency, velocity data are presented to two decimal places throughout this report.

The instruments were serviced and data were downloaded on 2 June 2017, 13 July 2017, 25 July 2017, and 13 September 2017. The current velocity data presented herein cover the period from 22 May 2017 to 25 July 2017. During the service trip on 13 September 2017 it was discovered that the

Upstream ADCP failed to record data on the onboard computer data card after re-deployment on 25 July 2017. After consulting with the manufacturer (TRDI), diagnostic procedures were performed on both ADCPs and results were sent back to TRDI for further review. It was determined that the most likely reason for the failure was a fault in the data card due to firmware; no operational issues were found with either ADCP in the diagnostic output. Due to the missing observations from the Upstream ADCP for the monitoring period from 25 July through 13 September 2017, the data series from the Downstream ADCP was truncated to match the available data from the Upstream ADCP (i.e., 22 May to 25 July 2017) to provide coincident data from the two ADCP stations for statistical analyses of identical observation periods from the two locations in this report. The use of identical observation periods in velocity measurement analysis provides the best insight into variation (if any) due to location within the nearfield area of the Merrimack Station CWISs, without the confounding effects of different observation periods between the two locations. Velocity measurements were averaged over ten minute intervals ("ensembles") in roughly 1-foot depth cells for the near-bottom layer (nominally five feet above bottom) representing the hydraulic zone of influence of the full-scale wedgewire screen models as specified by the engineering design. In addition to water velocity measurements, the ADCP recorded pressure and temperature measurements as well. Table 2-5 presents the sampling scheme and deployment metadata for each ADCP sampling site (location).

3.0 Data Analysis Methods

Data analyses were performed on the ichthyoplankton taxa (including all taxa combined) and life stages (including all life stages combined) enumerated in each valid (Use Code = 1) sample. Each entrainment sample collected was assigned a Use Code (1, 2, or 5) in the field and in the laboratory that defined its use in analytical tasks. Use Code = 1 samples were entrainment collections from which valid data were collected and no sampling problems were encountered. This means that each entrainment sample collected was representative of the two hour collection period in that the sample represents the entire contents of ichthyoplankton eggs and larvae collected in the water flow supplied to the sample collection device. A Use Code = 1 entrainment sample has no loss of any ichthyoplankton in the sample, and no interruption of water flow during the collection interval. Use Code = 2 samples were collections in which there were sampling problems encountered relating to either the accurate measurement of sample duration or volume, but ichthyoplankton are caught. For example, if an unknown part of the sample was spilled when transferring it from the collection cup into a sample jar, or the sample volume is unknown, this sample would be classified as Use Code = 2. Use Code = 2 samples were few (after week 2; Table 2-1) and were excluded from all calculations and analyses in this report. Use Code = 5 samples were void samples where the entire contents of the sample was lost or not collected. An example of a Use Code = 5 sample was when a thunderstorm occurred during the sampling period and it was judged unsafe to send a technician to collect a two-hour sample as scheduled on the Unit 1 CWIS bulkhead during the storm. Use Code = 5 samples were excluded from all analysis.

In addition to performing all analyses on valid (Use Code = 1) samples, ichthyoplankton individuals collected in the 3-mm wedgewire screen test and Unit 1 CWIS control samples that exceeded the limiting dimensions for USEPA's definition of entrainment were excluded from analysis. USEPA defines entrainment in the 316(b) Regulations at §125.92(h) as:

> *"Entrainment means any life stages of fish and shellfish in the intake water flow entering and passing through a cooling water intake structure and into a cooling water system, including the condenser or heat exchanger. Entrainable organisms include any organisms potentially subject to entrainment. For the purpose of this subpart, entrainment excludes those organisms that are collected or retained by a sieve with maximum opening dimension of 0.56 inches. Examples of sieves meeting this definition include but are not limited to a 3/8-inch square mesh or a ½ by ¼ mesh. A facility must use the same mesh size when counting entrainment as is used when counting impingement."*

This exclusion applied to just two fish collected in the present study that were in the yearling and older age class: a 55-mmTL Bluegill with limiting body dimensions of 9.0 mm width and 1.0 mm depth, and an 85-mmTL Margined Madtom with limiting body dimensions of 16.5 mm width and 14.3 mm depth that would not fit through a 14.2 mm (0.56 in) sieve opening as specified for entrainment in the 316(b) Regulations.

3.1 Entrainment Density Estimates

Counts of eggs and larvae in entrainment samples were converted to densities for each taxon, based on actual sample duration and the flow rate in each sample. Densities (D, number of organisms per 100 m^3) were calculated for each Use Code = 1 (valid) sample analyzed using:

$$D_{gtliw} = \frac{100x_{gtliw}}{v_{giw}}$$

where D_{gtliw} = density of life stage l of taxon t in sample i in gear g in week w,

x_{gtliw} = number of life stage l of taxon t in sample i in gear g in week w

v_{giw}= volume of sample i in gear g in week w.

Mean weekly densities were calculated as:

$\bar{D}_{gtlw} = \sum_{i=1}^{n} D_{gtliw}/n_{gw}$ (mean density of taxon t, life stage l in gear g in week w)

$\bar{D}_{gtw} = \sum_{l} \bar{D}_{gtlw}$ (mean density of taxon t in gear g in week w)

where n_{gw} = number of samples analyzed for gear g in week w.

Mean densities for taxa, life stages, gear, and overall were calculated as:

$\bar{\bar{D}}_{gtl} = \sum_{N_g} \bar{D}_{gtlw}/N_g$ (taxon t, life stage l for gear g)

$\bar{\bar{D}}_{gt} = \sum_{N_g} \bar{D}_{gtw}/N_g$ (taxon t for gear g)

$\bar{\bar{D}}_{g} = \sum_{t} \bar{D}_{gtw}$ (overall for gear g)

where N_g= number of weeks of sampling for gear g.

3.2 Life Stage Specific and Overall Wedgewire Screen Efficacy

The observed overall reduction (efficacy, E) in entrainment due the wedgewire screen was calculated from the overall mean densities:

$E_{tl} = \left[1 - \frac{\bar{\bar{D}}_{WWtl}}{\bar{\bar{D}}_{Atl}}\right] \times 100\%$ (overall reduction of taxon t, life stage l)

$E_{l} = \left[1 - \frac{\sum_t \bar{\bar{D}}_{WWtl}}{\sum_t \bar{\bar{D}}_{Atl}}\right] \times 100\%$ (overall reduction of life stage l)

$E_{t} = \left[1 - \frac{\sum_l \bar{\bar{D}}_{WWtl}}{\sum_l \bar{\bar{D}}_{Atl}}\right] \times 100\%$ (overall reduction of taxon t)

$E = \left[1 - \frac{\bar{\bar{D}}_{WW}}{\bar{\bar{D}}_{A}}\right] \times 100\%$ (overall reduction)

where $\bar{\bar{D}}_{WW}$ = overall mean density for wedgewire screens (i.e., g = Wedgewire)

$\bar{\bar{D}}_{A}$ = overall mean density for control used to represent ambient density (i.e., g = Ambient)

3.3 Length-specific Density

Length-specific densities (D_L) for each species in each sample were calculated as:

$$D_{gtLiw} = \sum_l D_{gtliw} f_{gtlLiw}$$

where f_{gtlLiw}= fraction of life stage *l* of taxon *t* in sample *i* from gear *g* in week *w* of length *L*.

Length-specific weekly mean densities were determined by averaging the length-specific sample densities over all samples collected in a week:

$$\bar{D}_{gtlLw} = \sum_{i=1}^{n_{gw}} D_{gtlLiw} \Big/ n_{glw}$$

Larvae that were identified to taxon with an unidentified life stage were not measured. Therefore for each taxon, the mean weekly unidentified life stage larval density was allocated to length bins using the proportion of the mean weekly length bin density of measured larvae. The mean weekly density for the unidentified osteichthyes/unidentified life stage classification was allocated to the mean weekly density using the proportional contribution of each taxon and life stage (excluding eggs) to the overall mean weekly density. All eggs were assumed spherical, and the diameter measurement was used as the length measurement in the above equation to provide diameter-specific weekly mean egg densities.

To compare the length frequencies from the test wedgewire screen and the control and to compare observed length-specific wedgewire screen efficacy between Merrimack Station and Indian Point Energy Center ("Indian Point")(Mattson et. al. 2014, and 2015), the same methods used for the Indian Point wedgewire screen study were followed where weekly length-specific densities were summed across the sampling weeks:

$$\bar{\bar{D}}_{gtlL} = \sum_{w=1}^{15} \bar{D}_{gtlLw}$$

Following the allocation of unidentified life stage larvae, yolk-sac larvae (YSL) and post yolk-sac larvae (PYSL) were summed for each taxon for larval length-specific analyses.

Following the same procedure used for length-specific densities, limiting-dimension specific densities were calculated using diameter (eggs) and the maximum body depth or width (YSL and older) measurements instead of total length.

3.4 Length-Specific Wedgewire Screen Efficacy

Length-specific densities were summed across taxa and life stages for the family groupings shown in Table 2-4:

$$\bar{\bar{D}}_{gflL} = \sum_{t_f} \bar{\bar{D}}_{gt_f lL}$$

where t_f is all taxa (*t*) within family *f* (Table 2-4). The densities within each length bin were summed for all life stages:

$$\bar{\bar{D}}_{gfL} = \sum_{l} \bar{\bar{D}}_{gflL}$$

Observed length-specific entrainment reductions (efficacy, *E*) for the most abundant ichthyoplankton families (i.e., those comprising more than 10% of the total) were estimated from Use code = 1 (valid) samples as:

$$E_{fL} = \left[1 - \frac{\bar{\bar{D}}_{WWfL}}{\bar{\bar{D}}_{AfL}}\right] \times 100\% \qquad \text{(length-specific efficacy for family } f \text{ at length } L\text{)}$$

where WW and A indicate wedgewire and ambient gear, respectively.

Following the same procedure used for length-specific efficacies, limiting-dimension specific efficacies were calculated using limiting-dimension specific densities.

3.5 Water Velocity

Measurements from the ADCPs deployed at Merrimack Station were used to characterize the nominal near-bottom velocity field both upstream and downstream of the 3-mm wedgewire test screen. Both ADCPs sampled the water column in 10-minute ensembles, averaging 300 acoustic transmissions, or "pings", per ensemble (Table 2-5). Data stored in raw binary data files were retrieved on 2 June 2017, 13 July 2017, 25 July 2017 and 13 September 2017 while servicing the instruments on site. The raw ADCP data were first reviewed in WinADCP software (v. 1.14, Teledyne RD Instruments) and then exported as MATLAB binary data files for post-processing (MATLAB Software, Mathworks; Natick, MA). Data collected while the ADCPs were out of the water before and after deployment were excluded from the data files for processing. As outlined above in Section 2.6, the current velocity data presented herein span 22 May 2017 to 25 July 2017, due to the data card malfunction in the Upstream ADCP.

Current velocity data were also flagged by the ADCP based on internal system quality threshold parameters defined in the operating software and set up prior to deployment. These parameters include a fish detection (or "false target") threshold, acoustic signal correlation threshold, and an error velocity threshold, all of which provide QC checks on the data collected for velocity processing on the instrument computer. These onboard QC parameters were set to the manufacturer default settings prior to deployment, which were specified to provide robust quality filters for the purposes used in the present study (TRDI 2011, 2016). Data that violated any of the quality thresholds were flagged by the ADCP with a value of "-32768", marking them invalid. Invalid measurements were excluded from all analyses. Post-processing of the ADCP data was performed in MATLAB software utilizing specialized processing routines developed by Normandeau to further QC the data collected and ensure data integrity.

After the data from each download were exported and processed through QC checks, all velocity data were depth-averaged to yield a representative current velocity field for the nominal near-bottom layer representing the water column roughly five feet above the river bed. This region has been specified as the potential hydraulic zone of influence of the full scale wedgewire screen array for installation at Merrimack Station (ENERCON 2017). Each downloaded data file was processed in this workflow and the data files from each site were concatenated to yield the complete time series of near-bottom current velocity from each site for the analysis data set. Brief gaps of up to a few hours exist in each time series on the days of instrument servicing while the data were downloaded.

To express the current velocity in relation to the primary river axis, as relevant to the full-scale design of the wedgewire screen array, the principal component axes for each site were determined by principal component analysis (Thomson and Emery 2014). All velocity data from each ADCP were then rotated into the site-specific along-channel axis determined by the principal component decomposition, yielding the along- and across-channel velocity components at each ADCP site. The along-channel component of the current velocity is referred to here as the "sweeping velocity" (v_{sweep}) which is calculated as:

$$v_{sweep} = v_E \cos\theta + v_N \sin\theta \ ,$$

where v_E and v_N are the east and north velocity components, respectively, and θ is the principal river axis determined for each site by principal component analysis of the velocity data. Decomposition of the velocity field into principal component axes allows for expression of the data such that the maximum amount of velocity variance is aligned with the major principal axis (towards the angle θ; Thomson and Emery 2014). Note that the sweeping velocity can have negative values, which indicate that the along-channel component of the river velocity is upstream. All directions referenced herein are with respect to true north.

Additionally, water level variation was investigated by removing the calculated mean water depth from each pressure time series to determine the fluctuations in river water level at both the upstream and downstream ADCP sites. Because the ADCPs were both lowered in the deployment mounts on 2 June 2017, an offset was applied to the pressure data collected from 22 May 2017 to 2 June 2017 to account for the removal of the mean water depth from the time series.

4.0 Results

Sampling equipment installation delays resulted in no entrainment sampling being conducted at either the 3-mm wedgewire screen test or Unit 1 control locations during the first planned week of the study (week 1; Monday, 8 May through Sunday, 14 May 2017; Table 2-1). The sampling equipment (e.g., pumps, tanks, flowmeters, etc.) was tested and field technicians were trained during most of the second planned week of the study (week 2; Monday, 15 May through Sunday, 21 May 2017), and the full study design was first implemented beginning during the third week of the study (week 3; Monday, 22 May through Sunday, 28 May 2017; Table 2-1). Therefore, the results of the 3-mm wedgewire screen performance evaluation for Merrimack Station Unit 1 presented in this report represent the study performed during weeks 3 through 17, which represent the period from Monday, 22 May through Sunday, 3 September 2017 (Tables 2-1 and 2-2). The completed sampling design from weeks 3 through 17 was designed to provide 540 pairs of test/control Use Code = 1 entrainment samples at the Merrimack Station Unit 1 CWIS (1080 total samples), while the completed design provided 529 Unit 1 control samples and 532 3-mm wedgewire screen test samples for analysis (Tables 2-1 and 2-2). The mean sampled volumes for the Use Code = 1 Unit 1 control and 3-mm wedgewire screen test samples were 106.8 m^3 and 107.2 m^3, respectively (Table 2-2).

4.1 Wedgewire Screen Performance

4.1.1 Species Composition

A total of 7,439 ichthyoplankton specimens were collected in the 3-mm test and Unit 1 control entrainment samples processed from weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017) of the 3-mm wedgewire screen evaluation at Merrimack Station Unit 1 (Table 4-1). A total of 6,709 individuals were collected in the Unit 1 control samples, and a total of 730 individuals were collected in 3-mm wedgewire test screen samples (Table 4-1). The ichthyoplankton sampled represent 18 distinct fish species, one taxonomic grouping of two fish species (Blueback Herring/Alewife) that were not differentiated to species in the laboratory, and nine taxonomic groupings of ichthyoplankton identified to the genus level or higher. White Sucker (1492/6709 = 22%) was the most abundant taxon in the Unit 1 control samples among the total for all life stages combined of all taxa, followed in decreasing percentage of the total by the Carp and Minnow family (1267/6709=19%), *Lepomis sp.* (1094/6709=16%), and the *Lepomis sp.*/Crappie species group (592/6709=9%; Table 4-1). The Carp and Minnow family (368/730=50%) represented half of the ichthyoplankton from the of the total number of individuals enumerated among all life stages combined of all taxa in the 3-mm wedgewire screen test samples, followed by Tessellated Darter (59/730=10%; Table 4-1).

Of the individuals for which life stage was determined, the larval life stage most common in the Unit 1 control samples was the PYSL stage representing 87% (3548/4089) of the individuals collected and identified in Use Code = 1 samples (Table 4-1). The smaller YSL was the most common identified life stage in the 3-mm wedgewire screen test samples, representing 48% (188/389) of the individuals collected and identified in Use Code = 1 samples (Table 4-1). By taxon and life stage combined together, White Sucker PYSL represented 35% (1441/4089) of the Unit 1 control samples, and the Carp and Minnow Family YSL represented 38% (149/389) of the 3-mm wedgewire screen test samples (Table 4-1). The unidentified life stage comprised 39% (2620/6709) of the total taxa and life stage individuals collected in the Unit 1 control samples and 46% (341/730) of the 3-mm wedgewire screen taxa and life stages enumerated (Table 4-1). These unidentified life stage assignments were predominantly either YSL or PYSL that could not be distinguished unequivocally due to damaged specimens with one or more distinguishing features absent.

4.1.2 Entrainment Density

The mean weekly entrainment density expressed as numbers of individuals per 100 m^3 for all taxa and life stages combined peaked during week 6 (Monday, 12 June through Sunday, 18 June 2017) at 35.05 individuals/100 m^3 and week 7 (Monday, 19 June through Sunday, 25 June 2017) at 34.68 individuals/100 m^3 for the Unit 1 control samples, when ichthyoplankton from the Carp and Minnow family were most abundant (13.59/100 m^3 and 9.71/100 m^3, respectively; Table 4-2). The mean weekly density for the 3-mm wedgewire screen test samples exhibited a primary peak of 7.40 individuals/100 m^3 during week 6 (Monday, 12 June through Sunday, 18 June 2017; Table 4-2) and a secondary peak of 3.02 individuals/100 m^3 during week 4 (Monday, 29 May through Sunday, 4 June 2017; Table 4-2). The highest individual taxon density was White Sucker with 19.93 individuals/100 m^3 during week 4 (Monday, 29 May through Sunday, 4 June 2017) for the Unit 1 control, and Carp and Minnow family with 4.96 individuals/100 m^3 during week 6 (Monday, 12 June through Sunday, 18 June 2017) for the 3-mm wedgewire test screen samples (Table 4-2).

The overall weekly mean ichthyoplankton density estimates for weeks 3 through 17 combined (Monday, 22 May through Sunday, 3 September 2017) for each taxa group and life stage are shown in Table 4-3. The highest overall mean density in the Unit 1 control samples was for post yolk-sac larvae (6.43 PYSL/100 m^3), with White Sucker (2.74 PYSL/100 m^3) as the dominant taxon within that life stage. Low ichthyoplankton densities were observed at the Unit 1 control site for eggs, young of the year (YOY), and yearling and older (YROL). The mean densities of ichthyoplankton from weeks 3 through 17 combined were considerably lower in the 3-mm wedgewire test screen samples relative to the Unit 1 control samples, most noticeably for the yolk sac (0.34 YSL/100 m^3) and post yolk-sac (0.23 PYSL/100 m^3) life stages (Table 4-3). The highest 3-mm wedgewire test screen density estimate for weeks 3 through 17 combined was 0.61 fish/100 m^3 for the unidentified life stage category while the highest density estimate for control samples was 2.74 fish/100 m^3 for White Sucker post yolk-sac larvae (Table 4-3).

4.1.3 Life Stage Specific and Overall Wedgewire Screen Efficacy

The overall reduction (efficacy) in entrainment of ichthyoplankton at the Merrimack Station Unit 1 CWIS due to the operation of the 3-mm wedgewire test screen was estimated for weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017) for each life stage and taxon group and for all taxon groups and life stages combined (Table 4-3). The egg life stage was the only life stage with an estimated mean density from weeks 3 through 17 combined that was higher for the 3-mm wedgewire test screen (0.13 eggs/100 m^3) compared to the Unit 1 control (<0.01 eggs/1000 m^3), although estimates for both sites were extremely low compared to larval life stages. The higher egg densities for the 3-mm wedgewire screen test samples resulted from the entrainment of just 24 Carp and Minnow Family eggs during study weeks 3 through 7 combined and just 44 American Shad eggs during study weeks 6 through 10 combined. The Carp eggs are demersal and adhesive (Scarola 1987), and the American Shad eggs are demersal (Able and Fahay 1998), suggesting the near bottom location of the 3-mm wedgewire test screen may have been exposed to a higher density of eggs than the Unit 1 control samples which withdraw water throughout the water column. Furthermore, eggs do not exhibit avoidance behavior, so their entrainment density would likely be directly proportional to their ambient density.

The life-stage specific efficacy for all ichthyoplankton taxa combined for the 3-mm wedgewire test screen relative to the Unit 1 control was 64.1% for YSL, 96.4% for PYSL, 56.2% for YOY, 100.0% for YROL, and 86.8% for the unidentified life stage (UNID; Table 4-3). For all ichthyoplankton taxa and all life stages combined (i.e., EGGs, YSL, PYSL, YOY, YROL, UNID), the 3-mm wedgewire test screen reduced overall mean Unit 1 CWIS entrainment density by 89% during weeks 3 through 17 combined (Table 4-3). For all of the larval life stages combined (i.e., excluding EGGs), the 3-mm wedgewire test screen reduced overall Merrimack Station Unit 1 CWIS entrainment density by 90% during weeks 3 through 17 combined.

Based on paired t-tests using concurrently collected (i.e., pairs) of Use Code = 1 Unit 1 control and 3-mm wedgewire screen test samples during each of the survey weeks 3 through 17, entrainment density for the 3-mm wedgewire test screen was significantly lower ($p < 0.01$) than the control entrainment density for each week 3 through 14 (Table 4-4). The entrainment density at both sites was zero or nearly zero at one or both locations during weeks 15 and 16, and zero at both sites during week 17 (Table 4-4), which resulted in non-significant weekly mean entrainment differences between the test and control sites during those weeks of extended testing.

4.1.4 Length Frequencies

The weekly total length frequency distributions of all larval taxa combined collected and measured from the Unit 1 control and 3-mm wedgewire screen test entrainment samples is shown in 1-mm length bins in Table 4-5, and the summary of morphological measurements (i.e., length, depth, width) for all measured individuals is shown in Table 4-6. These length frequency tables reveal that the Unit 1 control samples not only caught more individual larvae within most length bins and weeks compared to the 3-mm wedgewire test screen samples, but that the Unit 1 control samples caught disproportionately more larvae in the larger 1-mm length bins, particularly those bins above 9-mm (Table 4-5). This observation is consistent with the expected performance of the 3-mm wedgewire screen which was installed at Merrimack Station Unit 1 in a configuration to encourage behavioral avoidance of the test screen by the largest and strongest swimming larvae (Normandeau Memorandum, Attachment 1 to ENERCON 2016).

There were too few eggs collected during the present study to make inferences about the entrainment reduction performance of the 3-mm wedgewire test screen for this earliest life stage. The single egg collected in the Unit 1 control samples that could be identified was from the Carp and Minnow Family and had a maximum diameter of 1.2 mm (Table 4-6). For the 3-mm wedgewire screen test samples, Tessellated Darter eggs (n=5) were all 1.6 mm in diameter, Carp and Minnow Family eggs (n=23) were 1.2 to 1.3 mm in diameter, and American Shad eggs (n=41) were 2.5 to 3.9 mm in diameter (Table 4-6). There was apparently some egg extrusion for the spherical American Shad eggs collected in the 3-mm wedgewire test screen samples because the maximum egg diameter observed of 3.9 mm was larger than the 3.0 mm slot width of the test wedgewire screen (Table 4-6).

4.1.5 Length-Specific Entrainment Densities

Although ichthyoplankton eggs were generally low in abundance and observed in just a few weeks, egg diameter-specific densities for each taxa were summed across weeks 3 through 17 combined (Table 4-7), and for each week for all taxa combined (Table 4-8) to allow comparisons of limiting dimensions of the eggs collected and measured from samples taken from the Unit 1 control and 3-mm wedgewire screen test locations. Only one 1.2 mm diameter Carp and Minnow Family egg was measured from the Unit 1 control samples (Table 4-7). For the 3-mm wedgewire test samples, Tessellated Darter and Carp and Minnow Family eggs were between 1.2 and 1.6 mm in diameter, with the peak abundance in the 1.2 mm length bin (Table 4-7). American Shad egg abundance was highest in the 3.3 mm to 3.5 mm length bins (Table 4-7). As noted above, there was apparently some egg extrusion for the spherical American Shad eggs through the 3-mm slot width wedgewire test screen, because nearly all of the American Shad eggs collected and measured were in egg diameter bins 3.0 mm or larger (Table 4-7). The Tessellated Darter eggs and Carp and Minnow Family eggs were all collected in the 3-mm wedgewire screen test samples during week 3 through 7 (Monday, 22 May through Sunday, 25 June 2017), reaching a peak abundance in the 1.2 mm diameter bin during week 4 (Monday, 29 May through Sunday, 4 June 2017; Table 4-8). The American Shad eggs from the 3-mm wedgewire screen test samples were collected during week 6 through 10 (Monday, 12 June through Sunday, 16 July 2017), reaching a peak density of 0.19 eggs/100 m^3 in the 3.3 mm egg diameter bin during week 9 (Monday, 3 July through Sunday, 9 July 2017; Table 4-8).

Length-specific larval (YSL, PYSL, and unidentified larval stage combined), YOY and YROL abundances were estimated for each taxon based on mean weekly length-specific entrainment densities summed across the full study period (weeks 3 through 17; Monday, 22 May through Sunday, 3 September 2017) (Table 4-9; Figure 4-1). For the Unit 1 control samples, larval abundance were highest in the 4.0 to 5.9 mm total length range, with Carp and Minnow Family larvae, *Lepomis sp.* and Crappie species the dominant taxa in that size range (Table 4-9; Figure 4-1). A second peak in length specific larval abundance was observed in the Unit 1 control samples in the 14.0 to 15.9 mm length bins and consisting mainly of White Sucker larvae. For 3–mm wedgewire test samples, larval entrainment abundance peaked in the 4.0 to 4.9 mm length bin, which was 92% Carp and Minnow family larvae (Table 4-9; Figure 4-1). Abundance of larvae 7.0 mm or greater from the 3-mm wedgewire test screen samples was relatively low compared to Unit 1 control samples, indicating that the Unit 1 control samples were entraining larger larvae than the 3-mm wedgewire test screen at Merrimack Station (Table 4-9; Figure 4-1). Few entrainment-sized YOY and YROL fish were collected in the Unit 1 control or 3-mm wedgewire screen test samples, and YROL fish were collected only in the control samples (Table 4-10). Fish densities in all YOY and YROL size bins were all relatively low compared to larval densities. Larvae from all taxa combined collected in the 3-mm wedgewire screen test samples were generally smaller in length compared to those collected in the Unit 1 control samples during all survey weeks (Table 4-11).

4.1.6 Length-Specific Wedgewire Screen Efficacy

The length-specific entrainment reduction (efficacy) of the four most abundant taxonomic families (Sunfish, Carp and Minnows, Suckers, and Perch and Darters; all life stages combined) for the 3-mm wedgewire test screen relative to the Unit 1 control are shown in Table 4-12. For each of the four families, the 3-mm wedgewire test screen generally demonstrated high efficacy (> 70% reduction) for nearly all 1-mm total length classes where individuals were collected in both the test and control samples (Figure 4-1). Based on the relationship between total length and limiting dimension observed in the test and control samples, the 3-mm wedgewire test screen demonstrated high efficacy for length classes which theoretically should have been able to physically pass through the smallest wedgewire screen dimension (3 mm). For the Sunfish family, individuals ≥15 mm in total length would be expected to have a limiting body dimension >3 mm, and would therefore not be considered susceptible to entrainment by the wedgewire screen. However, the cumulative wedgewire efficacy was 95.9% for sunfish <15 mm (Table 4-12, Figure 4-1). The cumulative wedgewire efficacy below the respective estimated exclusion length for each of the other families was 78.2% for Carp and Minnows <16 mm, 98.8% for Suckers <20 mm and 86.6% for Perch and Darters <17 mm (Table 4-12, Figure 4-1). For all taxa combined, although no individual <12 mm in total length had a limiting dimension >3 mm, the cumulative wedgewire efficacy for lengths <12 mm was 86.9%. High efficacy of the wedgewire screen was also demonstrated by the high efficacy values for fish with limiting dimensions of much less than the 3-mm slot size (Figure 4-2). The cumulative efficacy for fish with limiting dimensions <3 mm was >90% for all taxa and life stages combined. These high efficacy values suggest that fish small enough to pass though the wedgewire screen were able to actively and successfully avoid entrainment by the test screen, which was consistent with the expected performance of the 3-mm wedgewire screen in the tested configuration (Normandeau Memorandum, Attachment 1 to Enercon 2016).

4.2 Water Velocity

The data from the two ADCPs were obtained to provide supplemental environmental observations relevant to the potential deployment locations of two full-scale wedgewire screen arrays at Merrimack Station Units 1 and 2. The installation of each ADCP in Hooksett Pool of the Merrimack River was at a location proposed by ENERCON as representative of the site that potential full scale wedgewire screen arrays might be deployed at Merrimack Station Unit 1 and Unit 2. The sweeping (along-channel) current velocities and water level were analyzed from continuous records to provide a characterization of near-bottom river flow at the Upstream and Downstream ADCP sites at Merrimack Station from 22 May 2017 to 25 July 2017. River velocity time series parameters are shown in Figure 4-3 and Table 4-14 presents summary statistics of the near-bottom sweeping velocities and current direction data. As noted above in Sections 2.6 and 3.4, the Upstream ADCP failed to record data during the period spanning 25 July 2017 through 13 September 2017. Therefore the current velocity data analyses presented in this report were performed on the period of coincident data between the two sites (i.e., 22 May through 25 July 2017) to eliminate statistical biases when comparing the two locations introduced by sampling different river conditions during different time periods

The river currents at both sites were primarily unidirectional along the northwest-southeast axis, with very minor differences, likely controlled by the local river geometry. The top panel of Figure 4-3 shows the sweeping velocity over the entire continuous ADCP monitoring period from 22 May to 25 July 2017. The principal axes of current direction determined for each site are also indicated in the top panel in Figure 4-3 and in Figure 4-4. Specifically, Figure 4-4 shows a nearly unidirectional current direction of 133.7 degrees from true north for both the Upstream ADCP and 132.2 degrees from true north for the Downstream ADCP, with the Downstream ADCP current velocity exhibiting notably more directional variation. Accordingly, the current direction standard deviations were 1.8˚ and 3.1˚ for the Upstream and Downstream sites, respectively (Table 4-14). The increased directional variation can also be seen in the second panel of Figure 4-3 as well as in Figure 4-4, which presents the current direction frequency distribution for the study period along with the respective principal axes. The sweeping velocity vector components accounted for 99.31% and 98.63% of the observed current velocity variance at the Upstream and Downstream ADCP sites, respectively, indicating that the major axis flow accounted for almost all of the current velocity variance.

Overall, the near-bottom current velocities from both ADCP sites were very similar, with the Upstream ADCP site exhibiting slightly higher mean sweeping velocity magnitude and more consistent velocity direction than the downstream ADCP. The Upstream ADCP had a median (50%) sweeping velocity of 1.29 fps and the Downstream ADCP had a median (50%) sweeping velocity of 1.19 fps (Table 4-14). Note that the central tendency of the two ADCP sites is represented by the median and not the mean because the frequency distributions of the observed velocity measurements at both the Upstream ADCP and Downstream ADCP sites were not normally distributed. The increase in directional variability observed at the Downstream ADCP site has a direct effect on the lower sweeping velocity statistics; i.e., the less consistent the current direction, the lower the percent of velocity variance (and energy) accounted for by the principal velocity component, or sweeping velocity. Empirical cumulative distribution functions of the sweeping velocity at both sites are presented in Figure 4-4. The higher currents at the Upstream ADCP can be clearly seen in the distribution plots.

The mean water depth from the period of concurrent data collection (22 May 2017 to 25 July 2017) was removed from each depth record to determine the representative comparative change in water level throughout the study duration for the present ADCP monitoring period, and the resulting data are presented in the third panel of Figure 4-3. The peaks in water level are concurrent with peak river velocity. These events were associated with heavy rain events in the upper and nearby Merrimack River drainage. Depressed water temperature values also reflect these rain events during the report period, as presented in the fourth panel of Figure 4-3, and show a concurrent decrease in temperature during the high velocity events. Overall, the water temperature data also indicated a diel variation likely due to solar radiation as well as a seasonal increase throughout the study period.

5.0 Summary

Recent publicly available information describing the entrainment reduction performance of wedgewire screens reveals that, when designed, installed, and operated to take advantage of certain ambient conditions, their biological efficacy is enhanced beyond their previously described performance as passive filters (EPRI 2003). As passive filters, wedgewire screens reduce entrainment primarily by excluding fish eggs and larvae due to narrow slot width openings being less than the physical limiting dimensions of the organisms in the intake flow (EPRI 2003; Mattson et al., 2011, 2014, and 2015). In addition to physical exclusion, wedgewire screens also reduce entrainment by behavioral avoidance swimming ability of larvae, and by hydraulic bypass of eggs and larvae (Mattson et al. 2011).

Applied research in both a laboratory flume and in the Hudson River estuary using test wedgewire screens demonstrated that their entrainment reduction performance is related to three factors (Mattson et al. 2011, 2014, 2015):

1. physical exclusion by the slot width of passive eggs and larvae,
2. behavioral avoidance of the intake flow by the actively swimming larvae, and
3. the hydraulic bypass of eggs and larvae due to sweeping flow of river currents along the surface of the wedgewire screen when they are installed so the river flow is in a direction perpendicular to the slot openings (i.e., parallel to the slot width).

Wedgewire screens (Johnson Screens Model T-12 and T-18; 12 inches and 18 inches in diameter, respectively) with slot widths of 2, 3, 6, and 9 mm were tested in a large hydraulic flume using approximately 450,000 fish larvae (including 207,000 White Sucker larvae) and an equal number of neutrally buoyant 1 mm diameter beads (representing fish eggs) at flume velocities of 0.25, 0.50, 1.0, 1.5, and 2.0 feet per second (fps), with through-slot velocities of 0.25 and 0.50 fps, for a total of 24 combinations of slot width, flume velocity, and through-slot velocity among 4,647 individual tests. Physical exclusion was observed to reduce entrainment in a direct relation to limiting dimensions of the test subjects, particularly passive test subjects like beads (eggs) and anesthetized larvae (Mattson et al. 2011). Fish eggs, larvae, or juveniles with a greatest body depth larger than the slot width were physically excluded and not entrained. Behavioral avoidance was observed to be higher for the two smaller slot widths (2-mm and 3-mm) and for a lower through-slot velocity (Mattson et al. 2011 and 2015). Overall, avoidance and hydraulic bypass were higher at higher ratios of sweeping velocity to through-slot velocity, with typically 80% or more of the larvae 12 mm in total length or larger capable of actively swimming to avoid entrainment at a ratio of sweeping velocity to slot velocity greater than 1:1 (Mattson et al. 2011 and 2015). These mechanistic flume studies demonstrated that hydraulic bypass and avoidance were the prevailing modes of the entrainment reduction effectiveness for wedgewire screens if installed with the river flow perpendicular to the slot width and a sweeping velocity to slot velocity ratio of 1:1 or greater (Mattson et al. 2011 and 2015).

Field testing of a 2-mm Johnson Screens Model T-12 wedgewire screen conducted during the 2011 entrainment season in the Hudson River estuary at Indian Point confirmed the entrainment reduction performance observations from the laboratory flume tests. Entrainment sampling was performed at Indian Point *in situ* for 96 continuous hours each week for 24 consecutive weeks from mid-April through mid-September 2011 (Mattson et al. 2014 and 2015). A total of 1,104 pairs of two-hour pumped samples (100 m^3 each) were collected from a 2-mm slot width wedgewire test screen with a 0.25 fps through-slot velocity deployed 35 feet below the water surface and paired with control samples from coincident 1 m^2 Tucker trawl tows (300 m^3 each) deployed at 35 feet of depth and into the prevailing current immediately upstream from the test wedgewire screen. A total of 31 ichthyoplankton taxa and 275,245 individuals (83% post yolk-sac larvae) were collected and analyzed from these pairs of Hudson River samples filtered through a 300 micron mesh net. Larval avoidance of the test screen was observed to increase with increasing larval length for the most abundant species (Striped Bass, 35%; and Bay Anchovy, 28%) as predicted in the flume, and the overall entrainment reduction for 2-mm wedgewire screens at Indian Point was estimated to be 78% (Mattson et al. 2015).

The study described in this report presents the results of the wedgewire test screen performance and evaluation study in Hooksett Pool of the Merrimack River at Merrimack Station Unit 1 from 15 consecutive weeks of testing (weeks 3 through 17) beginning Monday, 22 May 2017 and continuing through Sunday, 3 September 2017 using methods comparable to the Indian Point field studies from 2011 (Mattson et al. 2014 and 2015). A single Johnson Screens model T-12 3-mm slot width wedgewire ("test") screen affixed to the top of a tripod base was deployed in the Merrimack River offshore and slightly upstream from the Merrimack Station Unit 1 CWIS at a location considered representative of a proposed Unit 1 full-scale wedgewire screen array. The 3-mm test screen was 12.5 inches in diameter, 35 inches long, and was installed 20.375 inches above the river bottom with the long axis of the screen set parallel to the predominant current direction. A sampling hose made a horizontal run to the west from the offshore 3-mm wedgewire screen test location to the lower platform of the access stairs on the north side of the Unit 1 CWIS to a sampling pump located there. The discharge flow from this sampling pump passed into the top of a water-filled tank containing a sampling net with 0.300-mm mesh. The collection net was cylindrical with a short conical section at the lower end tapering to the cod end collection cup. In-plant control samples were taken from a 3-inch raw-water tap drawing un-chlorinated ambient cooling water from the condenser supply/circulating water pump discharge within the Unit 1 CWIS. Water in the 3-inch diameter tap, at ambient circulating water pressure, flowed from the tap into a second sample collection tank with a 0.300-mm mesh plankton net located on the floor of the Unit 1 pump house. Volume sampled by the 3-mm wedgewire screen test and Unit 1 control systems was measured by a factory-calibrated Signet flowmeter. A target sample volume of about 100 m^3 for each pair of 3-mm wedgewire screen test and Unit 1 control samples was filtered through the 0.300-mm mesh plankton net in each two-hour interval at a flow rate of about 220 gpm to 240 gpm. The completed sampling design from weeks 3 through 17 (Monday, 22 May 2017 through Sunday, 3 September 2017) was designed to provide 540 pairs of valid (Use Code = 1) test/control entrainment samples at the Merrimack Station Unit 1 CWIS (15 weeks x 3 days per week x 12 samples per day for test or control = 1080 total samples), while the completed design provided 529 Unit 1 control samples and 532 3-mm wedgewire screen test samples for analysis. The mean sampled volumes for the Use Code = 1 Unit 1 control and 3-mm wedgewire screen test samples were 106.8 m^3 and 107.2 m^3, respectively, reflecting the consistency of the field methods that provided valid samples.

Each preserved sample was received in Normandeau's Biological Laboratory and processed to separate (sort) the fish eggs and larvae (ichthyoplankton) from the other ambient material and debris. The ichthyoplankton in each sample were identified to the lowest practical taxon (species, but depending on the taxon, genus or family) and counted by life stage (eggs, yolk-sac larvae, post yolk-sac larvae, young-of-the-year, yearling or older, or unidentified). An unidentified life stage was assigned when one or more characteristics needed to differentiate the life stage were missing, such as the yolk sac on a damaged specimen. Up to 30 eggs and 30 larvae per taxon were also measured from each sample for total length in mm (TL) for eggs and larvae, and for the limiting dimension, referred to as "Body Depth". Body Depth for larvae was defined as the largest limiting dimension besides total length from each larva among the following: body depth, head depth, head width, and body width. Body Depth for eggs was the diameter for a round egg, and if the egg was oval, both maximum and minimum lengths were measured. The 30 eggs and 30 larvae measured per taxon were selected randomly from all eggs and all larvae of that taxon in that sample regardless of life stage.

The ichthyoplankton sampled from Hooksett Pool of the Merrimack River represented 18 distinct fish species and 10 higher taxonomic categories (genus or family). A total of 7,439 ichthyoplankton specimens were collected in the 3-mm wedgewire screen test and Unit 1 control entrainment samples processed from weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017), with 6,709 individuals (90%) collected in the Unit 1 control samples, and a total of 730 individuals (10%) collected in 3-mm wedgewire test screen samples. Since sampling was paired in time and consistent volumes were sampled during each two-hour interval, this large reduction observed between the total number of ichthyoplankton collected and enumerated in the 3-mm wedgewire screen and the Unit 1 control is a gross reflection of the large reduction in entrainment afforded by the use of a 3-mm wedgewire screen at Merrimack Station.

The life-stage specific abundance results from this study further support the efficacy of the 3-mm wedgewire screen at reducing entrainment at Merrimack Station in a manner consistent with previous laboratory observations for Indian Point wedgewire screen study (Mattson et al. 2011, 2014, 2015). Abundance of the larger and stronger swimming post-yolk sac larval life stage of ichthyoplankton entrained from the Merrimack River was considerably less than the abundance of the weaker swimming yolk sac larvae in coincident 3-mm wedgewire screen samples compared to the Unit 1 control samples. Specifically, White Sucker (1492/6709 = 22%) was the most abundant taxon in the Unit 1 control samples among the total for all life stages combined of all taxa, while the Carp and Minnow family (368/730=50%) represented half of the total ichthyoplankton taxa from the total number of individuals enumerated among all life stages combined in the 3-mm wedgewire screen test samples. The larval life stage most common in the Unit 1 control samples was the post yolksac larvae stage representing 87% of the individuals collected and identified at both locations combined in Use Code = 1 samples. The smaller yolk-sac larvae was the most common identified life stage in the 3-mm wedgewire screen test samples, representing 48% of the individuals collected and identified in Use Code = 1 samples at both locations combined.

By taxon and life stage combined together, White Sucker post yolk-sac larvae represented 35% of the Unit 1 control samples, and the Carp and Minnow Family yolk-sac larvae represented 38% of the 3-mm wedgewire screen test samples. The unidentified life stage comprised 39% of the total taxa and life stage individuals collected in the Unit 1 control samples and 46% of the 3-mm wedgewire screen taxa and life stages enumerated. These unidentified life stage assignments were predominantly either yolk-sac or post yolk-sac larvae that could not be distinguished unequivocally due to damaged specimens with one or more distinguishing features absent.

Lower overall ichthyoplankton densities observed in the 3-mm wedgewire screen samples compared to coincident (i.e., paired) Unit 1 control samples collected and processed by the same methods are a direct reflection of the efficacy of the 3-mm wedgewire screen at reducing entrainment at Merrimack Station in a manner consistent with previous laboratory observations for Indian Point wedgewire screen study (Mattson et al. 2011, 2014, 2015). Simply stated, fewer ichthyoplankton larvae were entrained per unit volume of water withdrawn into the 3-mm wedgewire screen from the same Merrimack River water mass than were entrained in the same volume of water sampled from within the Unit 1 CWIS at Merrimack Station. Specifically, the overall mean weekly entrainment density expressed as numbers of individuals per 100 m^3 for all taxa and life stages combined peaked during week 6 (Monday, 12 June through Sunday, 18 June 2017) at 35.05 individuals/100 m^3 and week 7 (Monday, 19 June through Sunday, 25 June 2017) at 34.68 individuals per 100 m^3 for the Unit 1 control samples, when ichthyoplankton from the Carp and Minnow family were most abundant (13.59/100 m^3 and 9.71/100 m^3, respectively). The mean weekly density for the 3-mm wedgewire screen test samples was much lower than observed in the unit 1 control samples and exhibited a primary peak of 7.40 individuals per 100 m^3 during week 6 (Monday, 12 June through Sunday, 18 June 2017) and a secondary peak of 3.02 individuals per 100 m^3 during week 4 (Monday, 29 May through Sunday, 4 June 2017). The highest individual taxon density was White Sucker with 19.93 individuals per 100 m^3 during week 4 (Monday, 29 May through Sunday, 4 June 2017) for the Unit 1 control, and Carp and Minnow family with 4.96 individuals/100 m^3) during week 6 (Monday, 12 June through Sunday, 18 June 2017) for the 3-mm wedgewire test screen samples. The highest overall mean density in the Unit 1 control samples was 6.43 individuals per 100 m^3 for post yolk-sac larvae, with White Sucker (2.74 post yolk-sac larvae per 100 m^3) the dominant taxon within that life stage.

Low ichthyoplankton densities were observed at the Unit 1 control site for eggs, young-of-the-year, and yearling and older life stages. The overall mean densities of ichthyoplankton from weeks 3 through 17 combined were considerably lower in the 3-mm wedgewire test screen samples relative to the Unit 1 control samples, most noticeably just 0.34 individuals per 100 m^3 for the yolk sac and 0.23 individuals per 100 m^3 for post yolk-sac larval life stages. The highest 3-mm wedgewire test screen density estimate for weeks 3 through 17 combined was 0.61 fish per 100 m^3 for the unidentified life stage category while the highest density estimate for control samples was 2.74 fish per 100 m^3 for White Sucker post yolk-sac larvae.

The overall reduction (efficacy) in entrainment of ichthyoplankton at the Merrimack Station Unit 1 CWIS due to the operation of the 3-mm wedgewire test screen estimated for weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017) was 89% for all ichthyoplankton taxa and life stages combined. Most fish species found in Hooksett Pool of the Merrimack River have demersal and adhesive eggs or are nest builders, thus removing their eggs from exposure to entrainment. Therefore, if the few eggs collected in this study were removed from the efficacy calculation, the 3-mm wedgewire test screen reduced overall Merrimack Station Unit 1 CWIS entrainment density by 90% during weeks 3 through 17 combined. The life-stage specific entrainment reductions for the 3-mm wedgewire screen were 64.1% for yolk-sac larvae, 96.4% for the larger post yolk-sac larvae, 56.2% for the relatively few young-of the year sampled, 100.0% for the even fewer yearling or older fish sampled, and 86.8% for the unidentified life stage. Based on paired t-tests using concurrently collected (i.e., pairs) of Use Code = 1 Unit 1 control and 3-mm wedgewire screen test samples during each of the survey weeks 3 through 17, entrainment density for the 3-mm wedgewire test screen was significantly lower ($p < 0.01$) than the control entrainment density for each week 3 through 14. The entrainment density at both sites was zero or nearly zero at one or both locations during weeks 15 and 16, and zero at both sites during week 17, which resulted in non-significant weekly mean entrainment differences between the test and control sites during those weeks of extended testing.

Length frequency distributions of the ichthyoplankton entrained from Hooksett Pool of the Merrimack River revealed that the Unit 1 control samples not only caught more individual larvae within most length bins and weeks compared to the 3-mm wedgewire test screen samples, but that the Unit 1 control samples caught disproportionately more larvae in the larger 1-mm length bins, particularly those bins above 9-mm. This observation is consistent with the expected performance of the 3-mm wedgewire screen which was installed at Merrimack Station Unit 1 with the long-axis of the test screen set parallel to the predominant sweeping flow direction and the 3-mm slot openings perpendicular to this sweeping flow direction. This installation configuration was demonstrated to enhance behavioral avoidance of the test screen by the largest and strongest swimming larvae (Mattson et al. 2011 and 2015). There were too few eggs collected during the present study to make inferences about the entrainment reduction performance of the 3-mm wedgewire test screen for this earliest life stage. However, there was apparently some egg extrusion for the spherical American Shad eggs collected in the 3-mm wedgewire test screen samples because the maximum egg observed diameter of 3.9 mm was larger than the 3.0 mm slot width of the test wedgewire screen. Taxon, life stage, and length specific densities corroborated the observations of length frequency analysis for both the 3-mm wedgewire screen test samples and Unit 1 control samples.

The 3-mm wedgewire test screen demonstrated high length-specific efficacy for nearly all length classes within each of the four most abundant taxonomic families and all taxa combined. Most notably, high efficacy was demonstrated for length classes which were physically small enough to pass through the smallest wedgewire screen dimension (3 mm). The 3-mm wedgewire test screen excluded 95.9% of Sunfish, 78.2% of Carp and Minnows, 98.8% of Suckers, and 86.6% of Perch and Darters that were small enough to pass through the 3 mm slot. For all taxa combined, the 3-mm wedgewire test screen excluded 86.9% of all fish of entrainable size. These high efficacy values suggest that fish of entrainable size were able to actively and successfully avoid passing through the test screen, which is consistent with the expected performance of the 3-mm wedgewire screen in the tested configuration.

The appropriate ambient conditions to enhance entrainment reduction performance of a 3-mm wedgewire screen system were confirmed in this study to be present in Hooksett Pool of the Merrimack River near the cooling water intake structures at Merrimack Station Units 1 and 2 during the 2017 field study. The river currents measured in Hooksett Pool at both the Upstream and Downstream ADCP monitoring stations during a comparable monitoring period from 22 May to 25 July 2017 at both locations proposed by ENERCON as representative of the sites that potential full scale wedgewire screen arrays might be installed were nearly unidirectional at 133.7 degrees and 132.2 degrees from true north, respectively. Furthermore, the median sweeping velocities of 1.29 fps for the Upstream ADCP and 1.19 fps for the Downstream ADCP were both well in excess of the design through slot velocity of 0.4 fps for the 3-mm wedgewire screens under consideration at Merrimack Station. A sweeping velocity to slot velocity ratio of 3.2 and 3.0 were observed at the Upstream and downstream ADCP monitoring stations, respectively, both well in excess of the 1:1 ratio observed to be effective in the Indian Point flume studies (Mattson et al. 2011).

The Hooksett Pool location of the Merrimack Station CWIS for Unit1 and Unit 2 was confirmed to be ideal for effective entrainment reductions of installed 3-mm wedgewire screens based on the overall reduction observed of 89% efficacy in this study, and the comparability of these results to previous studies for Indian Point. First, 88% of the entrained organisms collected at Merrimack Station during the 2005-2007 study were post yolk-sac larvae and just 1% were eggs (Normandeau 2007), and post yolk-sac larvae exhibited the greatest entrainment reduction performance for the 3-mm wedgewire screen tested in this study compared to the Unit 1 control. Fish larvae in the post yolk-sac larval life stage are the largest fish larvae of each taxon, and this life stage consistently demonstrated the greatest reductions in entrainment in the flume and field studies (Mattson et al. 2011, 2014, and 2015). Second, White Sucker (24%) and Carp and Minnows (28%) were the predominant (52%) fish taxa in the Merrimack Station entrainment samples from the 2005-2007 study (Normandeau 2007) and in the present study, and both of these taxa were the principal test organisms in the Indian Point flume studies (Mattson et al. 2011), providing confidence that the observed Indian Point entrainment reductions are directly applicable to explaining the entrainment reduction performance of the 3-mm wedgewire screen tested at Merrimack Station in this study. Third, this study observed relatively high (sweeping velocity to slot velocity ratios of 3.0 to 3.2) and consistent (133.7 degrees and 132.2 degrees from true north) sweeping velocity in the flow-regulated Merrimack River at Merrimack Station during the predominant seasonal period of entrainment (22 May to 25 July 2017) when an estimated 78.9% of the annual total entrainment was previously observed to occur (Normandeau 2007), providing assurance of consistent high performance of a full scale 3-mm wedgewire screen array if installed and operated in Hooksett Pool of the Merrimack River to reduce ichthyoplankton entrainment.

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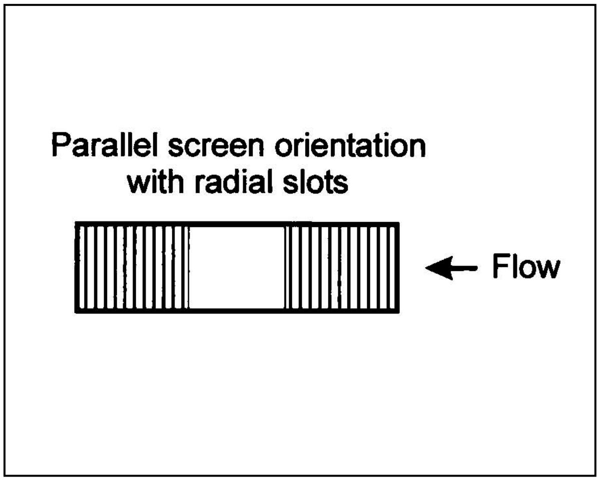

Figure 2-1. Orientation of T-12 3-mm wedgewire test screen for Merrimack Station Unit 1 is shown on the right with the long axis of the screen set parallel to the predominant Merrimack River flow direction and the slot openings perpendicular to the sweeping flow.

Figure 2-2. T-12 3-mm wedgewire test screen installed in the Merrimack River near the Merrimack Station Unit 1 CWIS. The screen was mounted on a tripod with the six-inch flange below the screen.

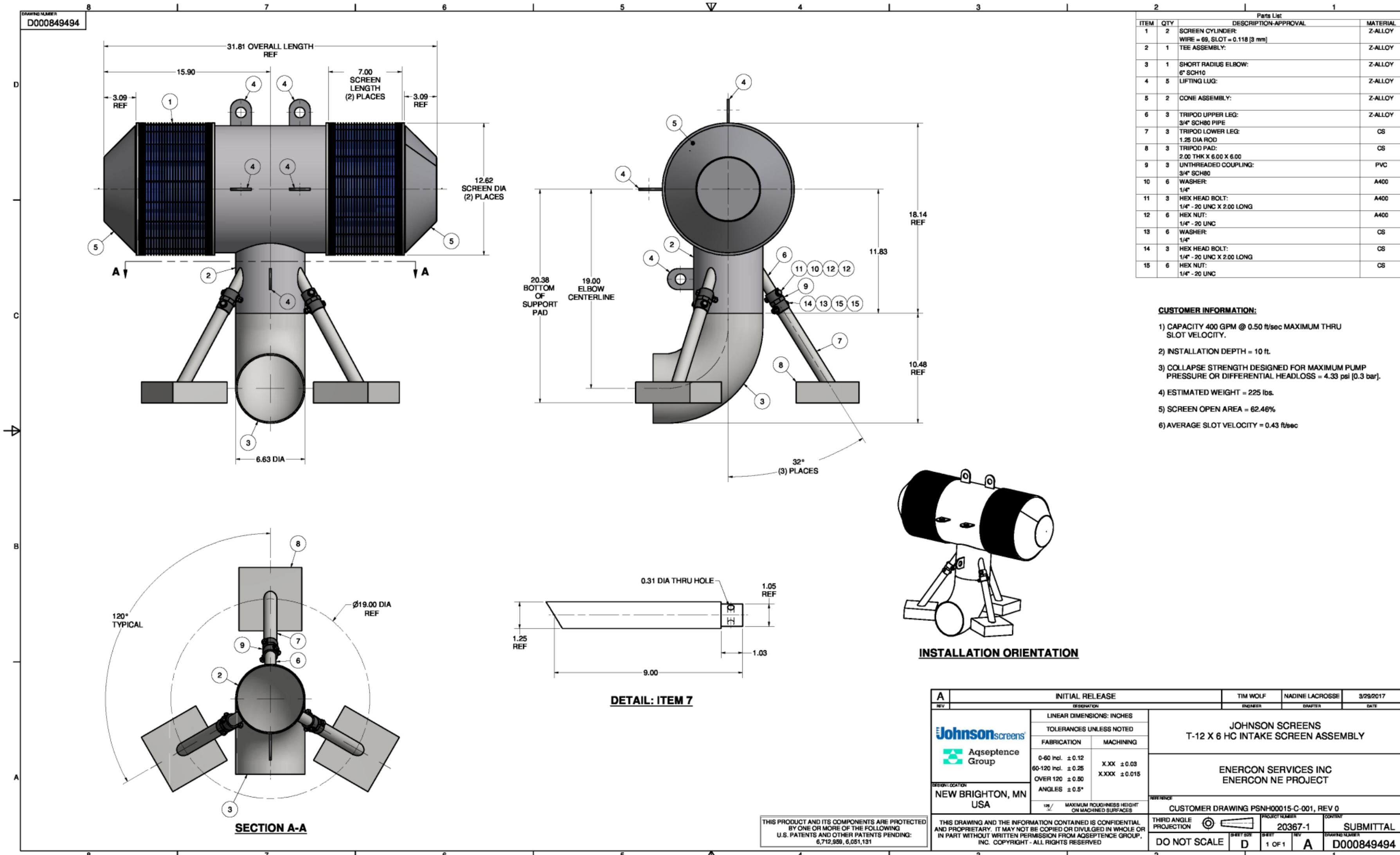

Figure 2-3. Engineering drawing showing the 3-mm wedgewire test screen and tripod mount for Merrimack Station Unit 1.

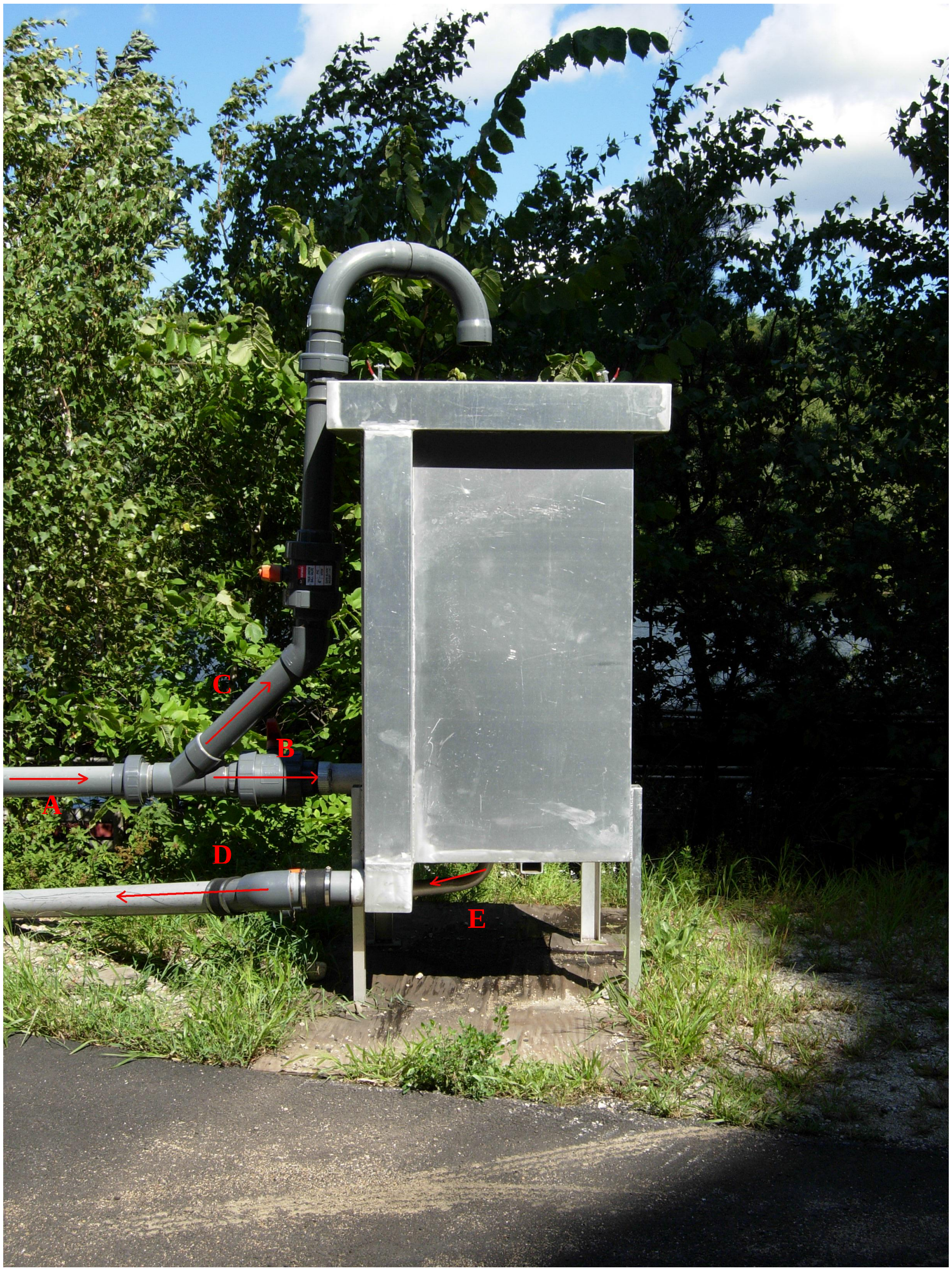

Figure 2-4. Diagram of Merrimack Station entrainment sampler showing flow path through collection tank for entrainment abundance sampling at Unit 1. A: Intake flow to sampling tank, C: Top fill filters down through conical net and sample is collected in cod end, and D: Drain line connected to tank stand pipe. Note: flow path B and E are used for survival sampling and not used for abundance sampling.

Figure 2-5. Location of the tap (top panel) supplying condenser flow into the entrainment sampling tank (bottom panel) from the main condenser supply lines within the CWIS control sampling location at Merrimack Station Unit 1.

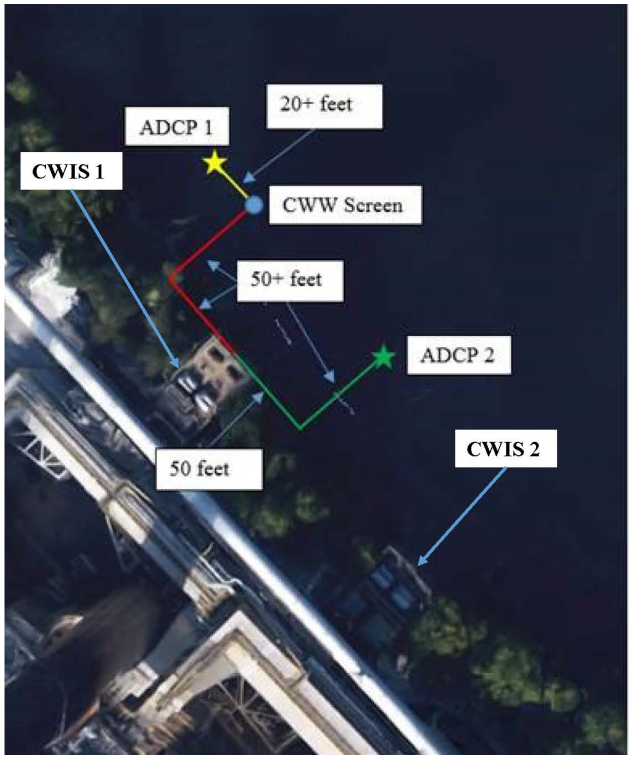

Figure 2-6. Approximate location of the Cylindrical Wedgewire Screen near the Merrimack Station Unit 1 CWIS, and the ADCPs deployed in the Merrimack River near the Unit 1 CWIS during 22 May to 31 August 2017.

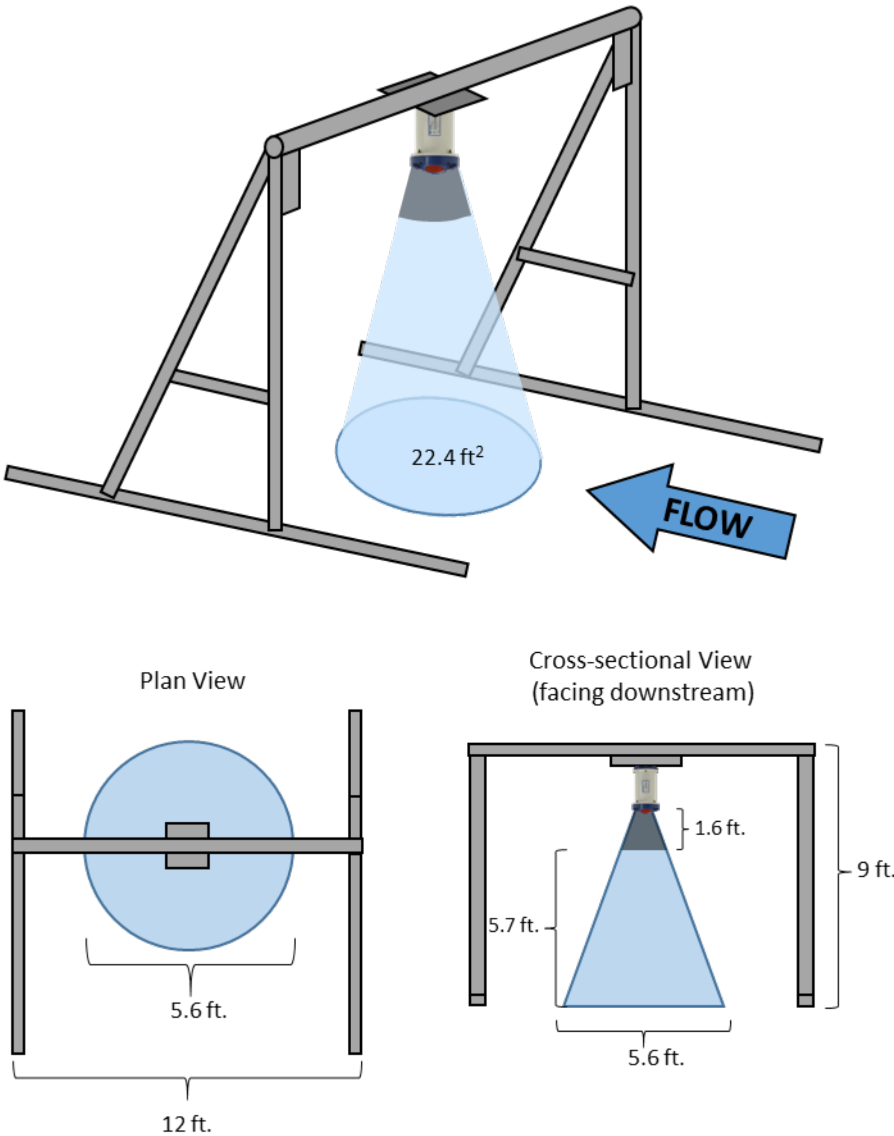

Figure 2-7. Schematic of design and approximate dimensions of the aluminum frames used to mount two ADCPs for stationary downward-looking data collection in the Merrimack River, NH near the Merrimack Station Unit 1 CWIS during 22 May to 31 August 2017. The ADCP sampling volume is indicated in light blue, and the blanking distance (unsampled region) in front of the transducer shaded gray. Note: both ADCPs were lowered on the frame by approximately two feet on 2 June 2017 due to low water levels and maintained at this elevation through 31 August 2017.

Figure 2-8. Completed assembly (upper photo) and deployment (lower) of the mounting frame used for ADCP data collection in the Merrimack River, NH near the Merrimack Station Unit 1 CWIS during 22 May to 31 August 2017.

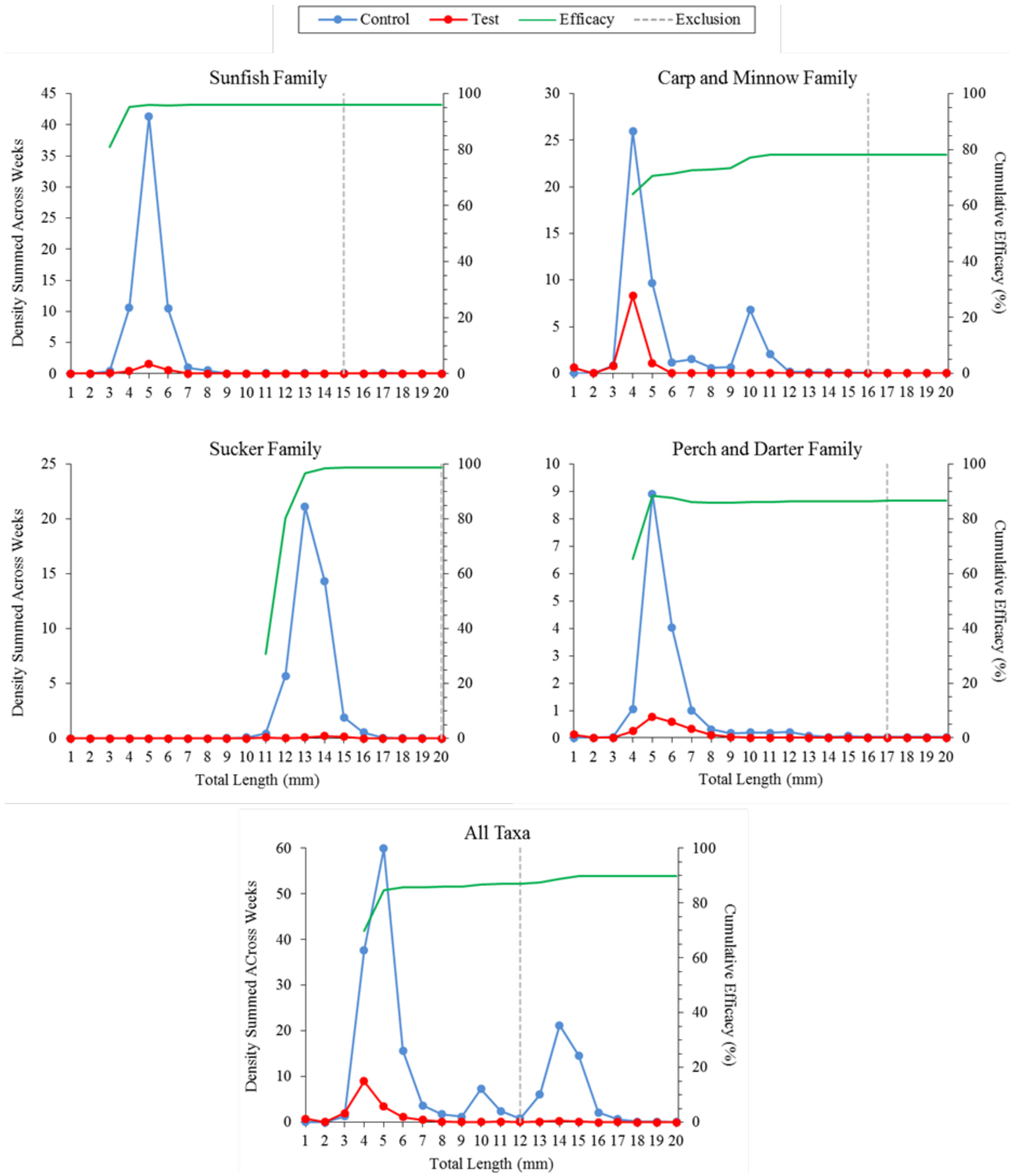

Figure 4-1. Length-specific ichthyoplankton entrainment densities summed across study weeks 3 through 17 (weeks beginning Monday, 22 May through Sunday 3 September 2017) and cumulative wedgewire screen efficacy for abundant families and all taxa for all life stages combined, estimated from the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) samples. The exclusion line indicates the length above which an individual would be excluded from entrainment based on an expected limiting dimension >3 mm Note: Length bin label is the integer value (i.e., length bin 5 includes 5.0 to 5.9 mm in total length).

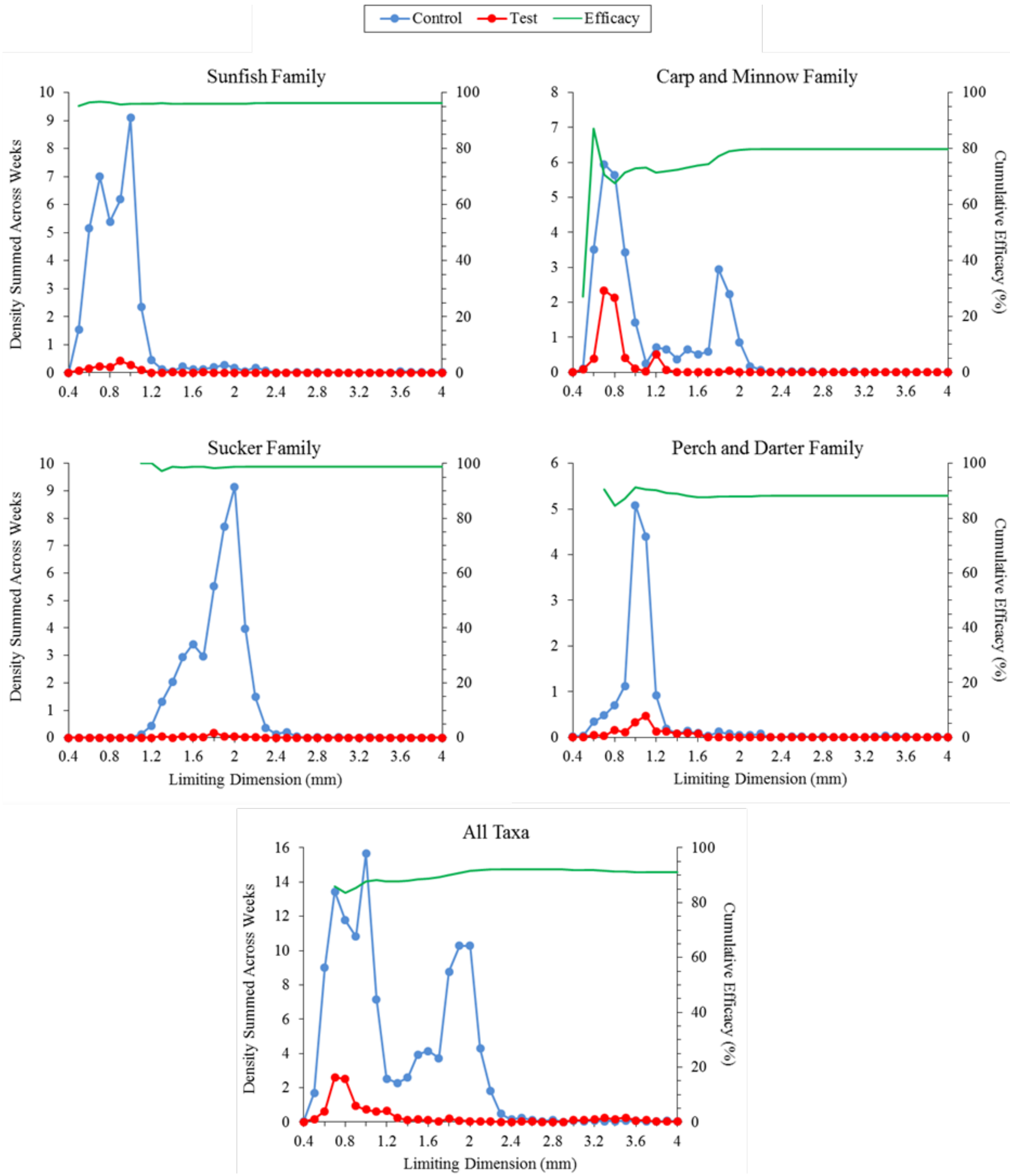

Figure 4-2. Limiting dimension-specific ichthyoplankton entrainment densities summed across study weeks 3 through 17 (weeks beginning Monday, 22 May through Sunday 3 September 2017) and cumulative wedgewire screen efficacy for abundant families and all taxa for all life stages combined, estimated from the Unit 1 control and 3-mm wedgewire test screen samples collected at Merrimack Station.

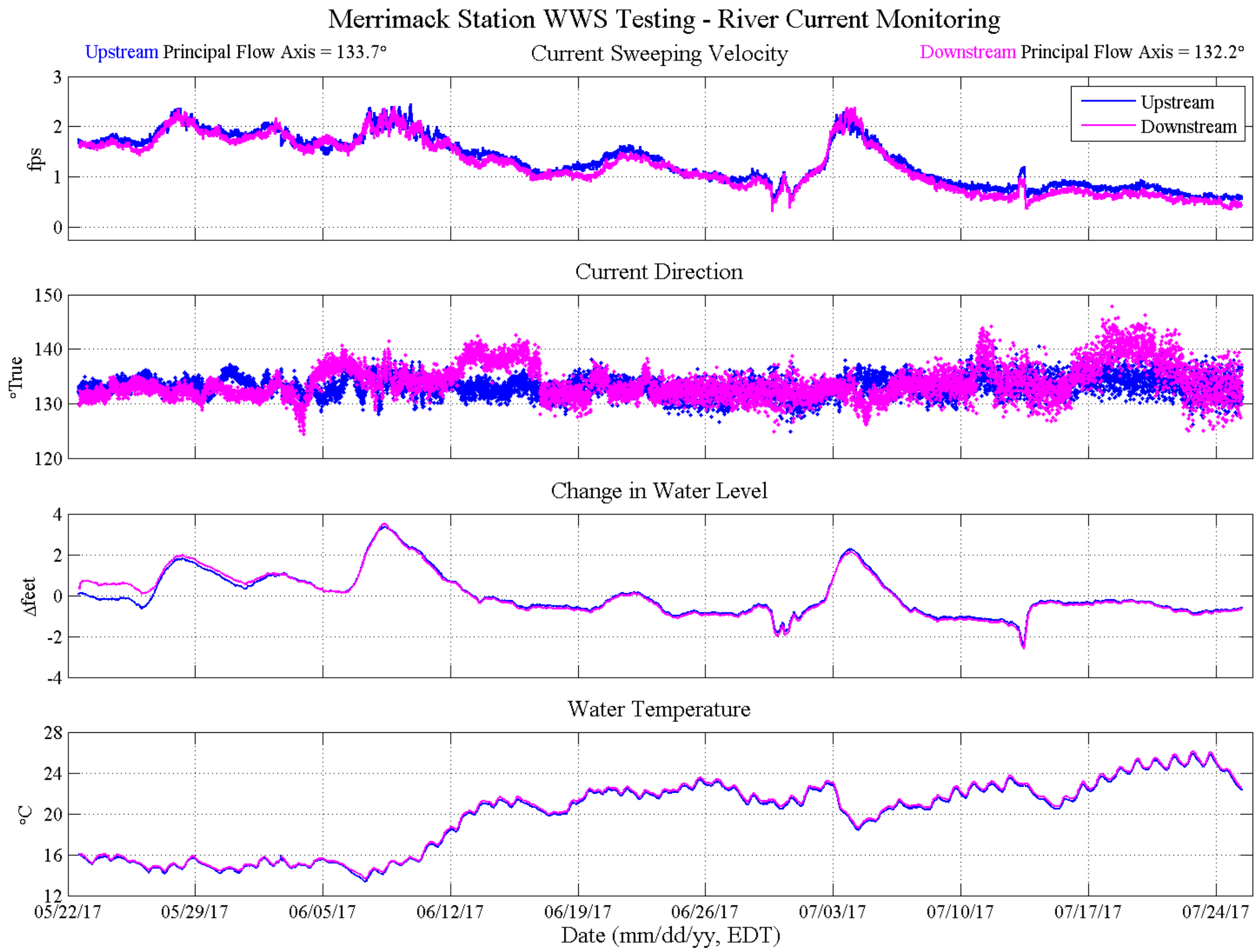

Figure 4-3. Time series plots of river current sweeping velocity, current direction, relative change in river water level, and water temperature measured by the ADCPs at the Upstream and Downstream deployment sites in the Merrimack River near the Merrimack Station Unit 1 CWIS during 22 May to 25 July 2017.

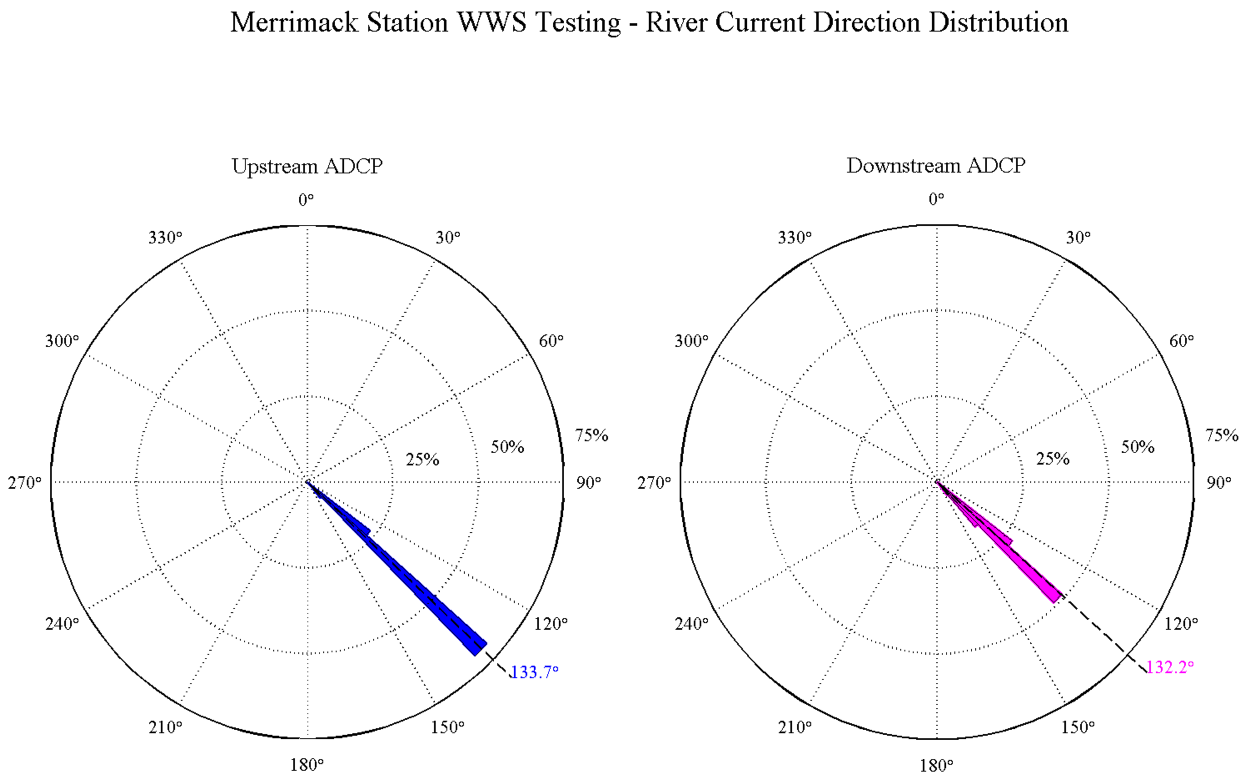

Figure 4-4. River current directional frequency distribution as measured by the ADCPs at the Upstream and Downstream deployment sites in the Merrimack River near the Merrimack Station Unit 1 CWIS during 22 May to 25 July 2017.

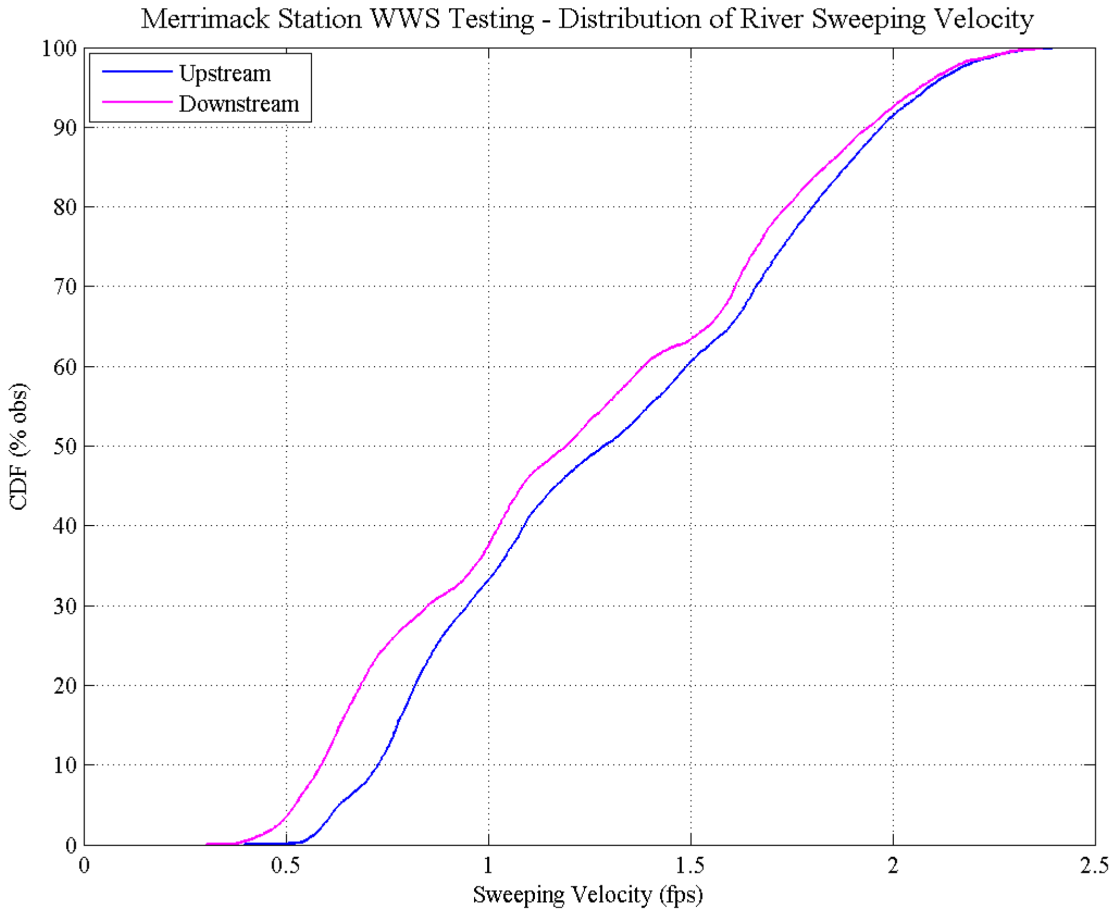

Figure 4-5. Cumulative distribution functions (% of observations) of current sweeping velocity measured by the ADCPs at the Upstream and Downstream deployment sites in the Merrimack River near the Merrimack Station Unit 1 CWIS during 22 May to 25 July 2017.

Table 2-1. Weekly schedule and number of 3-mm wedgewire screen (test) and Merrimack Station Unit 1 (control) samples planned and realized for weeks 1 through 17 (Monday, 8 May through Sunday, 3 September 2017).

Sampling Date (Monday of week)	Week Number	Location	Planned Samples	Number of Samples Collected in Field			Number of Samples Processed in Lab			
				USE_CD = 1 (good)	USE_CD = 2 (limited)	USE_CD = 5 (void)	USE_CD = 1 (sort)	USE_CD = 1 (ID)	USE_CD = 2 (sort)	USE_CD = 2 (ID)
8-May	1	Test	36	NS	NS	NS	NS	NS	NS	NS
		Control	36	NS	NS	NS	NS	NS	NS	NS
		Total	72	NS	NS	NS	NS	NS	NS	NS
15-May	2	Test	36	20	5	4	0	0	0	0
		Control	36	8	26	1	0	0	1	1
		Total	72	28	31	5	0	0	1	1
22-May	3	Test	36	36	.	.	36	36	.	.
		Control	36	35	1	.	34	34	1	1
		Total	72	71	1	.	70	70	1	1
29-May	4	Test	36	36	.	.	36	36	.	.
		Control	36	36	.	.	36	36	.	.
		Total	72	72	.	.	72	72	.	.
5-Jun	5	Test	36	33	3	.	33	33	3	3
		Control	36	36	.	.	36	36	.	.
		Total	72	69	3	.	69	69	3	3
12-Jun	6	Test	36	36	.	.	36	36	.	.
		Control	36	36	.	.	36	36	.	.
		Total	72	72	.	.	72	72	.	.
19-Jun	7	Test	36	35	1	.	35	35	1	1
		Control	36	35	1	.	35	35	1	1
		Total	72	70	2	.	70	70	2	2
26-Jun	8	Test	36	36	.	.	36	36	.	.
		Control	36	36	.	.	36	36	.	.
		Total	72	72	.	.	72	72	.	.
3-Jul	9	Test	36	36	.	.	36	36	.	.
		Control	36	36	.	.	36	36	.	.
		Total	72	72	.	.	72	72	.	.
10-Jul	10	Test	36	36	.	.	36	36	.	.
		Control	36	36	.	.	36	36	.	.
		Total	72	72	.	.	72	72	.	.
17-Jul	11	Test	36	36	.	.	36	36	.	.
		Control	36	36	.	.	36	36	.	.
		Total	72	72	.	.	72	72	.	.
24-Jul	12	Test	36	33	2	1	33	33	2	2
		Control	36	35	.	1	35	35	.	.
		Total	72	68	2	2	68	68	2	2
31-Jul	13	Test	36	35	.	1	35	35	.	.
		Control	36	35	.	1	35	35	.	.
		Total	72	70	.	2	70	70	.	.
7-Aug	14	Test	36	36	.	.	36	36	.	.
		Control	36	36	.	.	36	36	.	.
		Total	72	72	.	.	72	72	.	.
14-Aug	15	Test	36	33	.	3	33	35	.	.
		Control	36	34	.	2	34	35	.	.
		Total	72	67	.	5	67	70	.	.
21-Aug	16	Test	36	36	.	.	36	36	.	.
		Control	36	34	2	.	34	36	2	2
		Total	72	70	2	.	70	72	2	2
28-Aug	17	Test	36	36	.	.	36	35	.	.
		Control	36	36	.	.	36	35	.	.
		Total	72	72	.	.	72	70	.	.
22-May to 28-Aug	**3-17**	**Test**	**540**	**529**	**6**	**5**	**529**	**529**	**6**	**6**
		Control	**540**	**532**	**4**	**4**	**531**	**531**	**4**	**4**
		Total	**1,080**	**1061**	**10**	**9**	**1060**	**1060**	**10**	**10**

(continued)

Table 2-1. (Continued)

NS = not sampled
USE_CD = 1 Sample collected as specified in SOP; Good for all analytical tasks
USE_CD = 2 Sample collected but not as specified in SOP; Good for limited analytical tasks depending on deviation
USE_CD = 5 Attempted to collect sample but void, no sample collected; not used for any analysis

Table 2-2. Weekly number of valid (Use Code = 1) samples and sampled volume used to estimate entrainment densities for the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) during study weeks 3 through 17 (Monday, 22 May through Sunday 3 September 2017).

Week	Starting Monday	Number of Samples (N) and Volume Sampled (m^3)							
		Unit 1 Control				3-mm Wedgewire Screen Test			
		N	Min	Mean	Max	N	Min	Mean	Max
3	**22-MAY-2017**	36	77.5	108.5	138.6	35	99.0	108.1	181.1
4	**29-MAY-2017**	36	98.3	106.0	116.3	36	102.5	107.5	113.0
5	**05-JUN-2017**	36	98.3	106.0	116.3	36	102.5	107.5	113.0
6	**12-JUN-2017**	33	97.6	106.4	121.3	36	64.3	108.2	119.6
7	**19-JUN-2017**	36	101.9	109.7	119.3	36	96.5	107.7	115.4
8	**26-JUN-2017**	35	102.5	110.5	115.4	35	102.8	109.6	112.7
9	**03-JUL-2017**	36	101.5	107.0	115.7	36	100.4	105.3	108.8
10	**10-JUL-2017**	36	104.2	108.9	114.3	36	95.8	104.1	110.7
11	**17-JUL-2017**	36	92.4	107.9	116.0	36	93.3	105.2	115.7
12	**24-JUL-2017**	36	100.3	105.0	111.6	36	104.4	108.0	110.8
13	**31-JUL-2017**	33	101.8	109.3	119.5	35	98.5	106.7	114.5
14	**07-AUG-2017**	35	63.8	102.9	109.7	35	100.1	107.4	114.8
15	**14-AUG-2017**	36	100.7	104.3	121.9	36	103.4	106.8	109.7
16	**21-AUG-2017**	33	72.1	98.9	113.8	34	99.5	110.3	119.3
17	**28-AUG-2017**	36	83.0	109.6	207.7	34	101.9	107.4	114.3
All	**ALL**	529	63.8	106.8	207.7	532	64.3	107.2	181.1

Table 2-3. Weekly summary statistics of water quality data collected with entrainment samples for the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) during study weeks 3 through 17 (Monday, 22 May through Sunday 3 September 2017).

Week	Starting Monday	Location	Water Temperature (˚C)				Dissolved Oxygen (mg/L)			
			N	Min	Mean	Max	N	Min	Mean	Max
3	**22-May-2017**	**Test**	36	14.4	15.3	15.7	36	7.5	8.8	9.8
		Control	36	14.2	15.3	15.7	36	8.1	9.1	10.7
4	**29-May-2017**	**Test**	36	14.2	14.8	15.6	36	8.5	9.2	10.1
		Control	36	14.3	14.9	16.8	36	9.0	9.4	10.0
5	**05-Jun-2017**	**Test**	36	13.3	14.5	15.6	34	8.5	9.7	10.9
		Control	36	13.3	14.5	15.7	34	8.5	9.8	10.7
6	**12-Jun-2017**	**Test**	36	20.2	20.9	21.3	36	7.3	8.1	9.1
		Control	36	20.1	21.0	21.3	36	7.6	8.3	9.2
7	**19-Jun-2017**	**Test**	36	21.3	21.9	22.4	36	7.3	7.7	8.5
		Control	36	21.6	22.1	22.5	36	7.4	8.0	8.4
8	**26-Jun-2017**	**Test**	35	20.1	21.1	22.5	35	6.0	7.2	8.0
		Control	35	20.4	21.3	22.6	35	7.3	7.7	7.9
9	**03-Jul-2017**	**Test**	36	18.5	20.0	21.4	36	7.1	7.9	8.8
		Control	36	18.5	20.0	21.4	36	7.3	8.0	8.8
10	**10-Jul-2017**	**Test**	36	21.2	22.4	23.6	36	6.6	7.3	8.7
		Control	36	21.3	22.6	23.6	36	7.1	7.7	8.2
11	**17-Jul-2017**	**Test**	36	23.3	24.4	25.4	36	6.6	7.1	7.7
		Control	36	23.4	24.5	25.3	36	7.0	7.5	7.9
12	**24-Jul-2017**	**Test**	36	21.2	23.3	25.6	36	6.4	6.8	7.5
		Control	36	21.3	23.6	25.8	36	7.0	7.3	7.6
13	**31-Jul-2017**	**Test**	22	24.2	25.1	26.3	21	6.6	7.5	9.5
		Control	22	24.5	25.4	26.2	22	6.6	7.6	9.9
14	**07-Aug-2017**	**Test**	36	21.1	22.8	24.2	32	5.1	7.2	9.5
		Control	36	22.3	23.2	24.1	35	7.0	7.7	9.8
15	**14-Aug-2017**	**Test**	36	21.4	23.1	24.2	36	5.2	6.4	8.2
		Control	35	22.5	23.5	24.2	36	6.3	7.0	7.5
16	**21-Aug-2017**	**Test**	36	22.2	23.2	24.1	36	5.5	6.6	7.7
		Control	36	22.3	23.5	24.0	36	6.4	7.0	7.5
17	**28-Aug-2017**	**Test**	36	18.5	20.0	21.0	36	5.7	7.2	8.4
		Control	36	19.4	20.6	21.4	36	7.0	7.6	8.3

Table 2-4. Common and scientific names of each taxon of ichthyoplankton caught during entrainment sampling at the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) during study weeks 3 through 17 (Monday, 22 May through Sunday 3 September 2017).

Family	Taxon	Scientific Name
Carps and Minnows	Blacknose Dace	*Rhinichthys atratulus*
	Carp and Minnow Family	*Cyprinidae*
	Common Shiner	*Luxilus cornutus*
	Fallfish	*Semotilus corporalis*
	Golden Shiner	*Notemigonus crysoleucas*
Freshwater Eels	American Eel	*Anguilla rostrata*
Herrings	Alosa Species	*Alosa sp.*
	American Shad	*Alosa sapidissima*
	Blueback Herring/Alewife	*Alosa aestivalis/A. pseudoharengus*
	Herring Family	*Clupeidae*
North American Catfishes	Madtom Species	*Noturus sp.*
	Margined Madtom	*Noturus insignis*
	Yellow Bullhead	*Ameiurus natalis*
Perches and Darters	Tessellated Darter	*Etheostoma olmstedi*
	Walleye	*Sander vitreus*
	Yellow Perch	*Perca flavescens*
Suckers	Sucker Family	*Catostomidae*
	White Sucker	*Catostomus commersonii*
Sunfishes	Black Crappie	*Pomoxis nigromaculatus*
	Bluegill	*Lepomis macrochirus*
	Largemouth Bass	*Micropterus salmoides*
	Lepomis Species	*Lepomis sp.*
	Lepomis Species/Crappie Species	*Lepomis sp./Pomoxis sp.*
	Rock Bass	*Ambloplites rupestris*
	Smallmouth Bass	*Micropterus dolomieu*
	Sunfish Family	*Centrarchidae*
Temperate Basses	White Perch	*Morone americana*
n/a	Unidentified Osteichthyes	n/a

Table 2-5. Deployment information and sampling configuration for the two ADCPs deployed in the Merrimack River near the Merrimack Station Unit 1 CWIS from 22 May to 13 September 2017. The available data series were truncated to analyze the identical period from 22 May to 25 July 2017 at each site for direct comparability of location in this report.

Site	ADCP S/N	Latitude	Longitude	Depl. #	Start Date	End Date	Pings per Ensemble	Ensemble Length (minutes)	# Ensembles
Unit 1 (Upstream)	7109	43˚ 08.5446'	073˚ 28.0878'	1	5/22/2017	6/2/2017	300	10	1,599
				2	6/2/2017	7/13/2017	300	10	5,873
				3	7/13/2017	7/25/2017	300	10	1,734
				4	7/25/2017	9/13/2017	300	10	0*
Unit 2 (Downstream)	256	43˚ 08.5188'	071˚ 28.0596'	1	5/22/2017	6/2/2017	300	10	1,593
				2	6/2/2017	7/13/2017	300	10	5,864
				3	7/13/2017	7/25/2017	300	10	1,737
				4	7/25/2017	9/13/2017	300	10	7,184

*The Upstream ADCP failed to record data from 25 July 2017 to 13 September 2017 due to a firmware issue with the data card.

Table 4-1. Number of ichthyoplankton individuals enumerated in entrainment samples collected at the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites during survey weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017).

	Control							3 mm Wedgewire Screen						
Taxon / Life Stage[1]	Egg	YSL	PYSL	YOY	YROL	UNID	ALL	Egg	YSL	PYSL	YOY	YROL	UNID	ALL
Alosa Species	0	0	1	0	0	9	10	0	0	0	0	0	1	1
American Eel	0	0	0	0	2	0	2	0	0	0	0	0	0	0
American Shad	0	3	8	0	0	0	11	43	1	0	0	0	0	44
Black Crappie	0	1	122	1	0	5	129	0	0	1	0	0	0	1
Blacknose Dace	0	0	10	0	0	1	11	0	0	0	0	0	0	0
Blueback Herring/Alewife	0	0	24	0	0	7	31	0	0	0	0	0	1	1
Bluegill	0	0	1	0	3	0	4	0	0	0	0	0	0	0
Carp and Minnow Family	1	143	208	0	0	915	1267	23	149	26	0	0	170	368
Common Shiner	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Fallfish	0	0	326	0	0	7	333	0	0	2	0	0	0	2
Golden Shiner	0	0	1	0	1	0	2	0	0	0	0	0	0	0
Herring Family	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Largemouth Bass	0	3	3	3	0	1	10	0	0	1	0	0	0	1
Lepomis Species	0	6	926	0	0	162	1094	0	2	36	0	0	14	52
Lepomis Sp./Crappie Species	0	1	229	0	0	362	592	0	0	9	0	0	7	16
Madtom Species	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Margined Madtom	0	0	0	2	1	0	3	0	0	0	0	0	0	0
Rock Bass	0	0	27	0	0	1	28	0	0	0	0	0	0	0
Smallmouth Bass	0	0	3	0	0	0	3	0	0	0	0	0	0	0
Sucker Family	0	0	7	0	0	4	11	0	0	0	0	0	0	0
Sunfish Family	0	0	5	0	0	0	5	0	0	0	0	0	0	0
Tessellated Darter	0	317	40	0	0	90	447	5	34	13	0	0	7	59
Unidentified Osteichthyes	1	0	26	0	0	1041	1068	1	1	1	0	0	139	142
Walleye	0	0	12	0	0	0	12	0	0	0	0	0	0	0
White Perch	0	1	1	0	0	0	2	0	0	4	0	0	0	4
White Sucker	0	37	1441	0	0	14	1492	0	1	16	0	0	1	18
Yellow Bullhead	0	0	0	11	0	0	11	0	0	0	5	0	0	5
Yellow Perch	0	3	126	0	0	0	129	0	0	14	0	0	1	15
Total	**2**	**515**	**3548**	**17**	**7**	**2620**	**6709**	**72**	**188**	**123**	**6**	**0**	**341**	**730**

Table 4-2. Mean weekly ichthyoplankton densities (all life stages combined, including unidentified) estimated from the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) samples collected during study weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017).

		Weekly Mean Control Entrainment Density (#/100 m^3)														
Taxon	**Week:**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Alosa Species		.	.	.	.	0.05	.	0.05	0.19	0.03	.	.	.	.	.	.
American Eel		.	.	.	0.02	.	.	.	0.03	.	.	.	.	.	.	.
American Shad		.	.	.	.	.	0.08	0.05	0.05	0.03	0.08	.	.	.	.	.
Black Crappie		0.08	0.42	0.14	1.95	0.62	.	0.08	0.05	.	.	.	.	.	.	.
Blacknose Dace		.	.	.	0.13	0.15	.	.	.	.	.	.	.	.	.	.
Blueback Herring/Alewife		.	0.03	.	0.15	0.21	0.05	0.08	0.18	0.08	.	.	.	0.03	.	.
Bluegill		.	.	.	.	0.05	.	0.03	.	.	.	.	.	.	.	.
Carp and Minnow Family		0.08	3.70	4.35	13.59	9.71	0.92	0.64	0.05	0.08	0.06	0.44	0.03	0.03	.	.
Common Shiner		.	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.
Fallfish		.	.	0.52	6.92	0.96	.	0.05	0.03	.	.	.	.	.	.	.
Golden Shiner		.	.	.	.	0.03	.	0.03	.	.	.	.	.	.	.	.
Herring Family		.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.
Largemouth Bass		.	.	.	.	0.13	0.03	0.05	0.03	0.03	.	.	.	.	.	.
Lepomis Species		.	.	0.08	0.50	7.63	7.43	0.41	0.92	7.98	3.34	0.44	0.35	0.03	.	.
Lepomis Sp./ Crappie Sp.		0.08	0.18	0.17	2.42	5.59	4.64	0.54	0.29	0.85	0.59	.	.	.	.	.
Madtom Species		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Margined Madtom		.	.	.	.	.	.	.	.	0.03	0.03	0.05	.	.	.	.
Rock Bass		.	.	.	.	.	0.52	0.10	.	0.11	.	.	.	.	.	.
Smallmouth Bass		.	.	.	.	.	.	0.07	.	.	.	.	.	.	.	.
Sucker Family		.	.	0.32	.	.	.	.	.	.	.	.	.	.	.	.
Sunfish Family		.	.	.	0.05	0.03	0.03	0.02	.	.	.	.	.	.	.	.
Tessellated Darter		3.51	3.06	1.61	3.50	0.46	0.03	.	.	0.03	.	.	.	.	.	.
Unidentified Osteichthyes		0.64	1.34	0.91	4.44	8.82	5.53	0.90	0.72	2.96	1.19	0.72	0.40	.	.	.
Walleye		0.34	.	.	.	.	.	.	.	.	.	.	.	.	.	.
White Perch		.	.	0.03	.	0.03	.	.	.	.	.	.	.	.	.	.
White Sucker		14.66	19.93	6.65	1.15	0.05	0.03	.	.	.	.	.	.	.	.	.
Yellow Bullhead		.	.	.	.	.	.	0.05	0.15	0.08	.	.	.	.	.	.
Yellow Perch		2.39	0.64	0.03	0.20	0.18	.	.	.	.	.	.	.	.	.	.
All Taxa		**21.77**	**29.29**	**14.82**	**35.05**	**34.68**	**19.29**	**3.14**	**2.68**	**12.27**	**5.29**	**1.64**	**0.78**	**0.09**	**.**	**.**

(continued)

Table 4-2. Continued.

		Weekly Mean Wedgewire Screen Entrainment Density (#/100 m^3)														
Taxon	**Week:**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Alosa sp.		.	.	.	.	.	.	.	0.03	.	.	.	.	.	.	.
American Eel		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
American Shad		.	.	.	0.32	0.05	0.03	0.75	0.03	.	0.03	.	.	.	.	.
Black Crappie		.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.
Blacknose Dace		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Blueback Herring/Alewife		.	.	.	.	.	.	.	0.03	.	.	.	.	.	.	.
Bluegill		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carp and Minnow Family		0.14	1.99	0.82	4.96	1.73	0.08	0.05	.	.	.	0.08	.	.	.	.
Common Shiner		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fallfish		.	.	0.05	.	.	.	.	.	.	.	.	.	.	.	.
Golden Shiner		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Herring Family		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Largemouth Bass		.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.
Lepomis sp.		.	.	0.10	0.05	0.13	0.11	0.14	0.05	0.21	0.61	.	.	.	.	.
Lepomis sp./ Crappie Sp.		.	0.10	0.02	0.10	0.10	.	0.11	.	.	.	.	.	.	.	.
Madtom Species		.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	.
Margined Madtom		.	.	.	.	.	.	.	.	.	.	0.08	.	.	.	.
Rock Bass		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Smallmouth Bass		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sucker Family		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sunfish Family		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tessellated Darter		0.42	0.41	0.27	0.34	0.19	.	.	.	.	.	.	.	.	.	.
Unidentified Osteichthyes		0.05	0.18	0.15	1.53	0.75	0.37	0.16	0.19	0.13	0.19	0.19	.	0.03	.	.
Walleye		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
White Perch		.	0.03	.	0.05	0.03	.	.	.	.	.	.	.	.	.	.
White Sucker		0.06	0.23	0.23	0.03	.	.	.	.	.	.	.	.	.	.	.
Yellow Bullhead		.	.	.	.	.	.	.	0.03	.	0.03	0.03	.	0.03	0.03	.
Yellow Perch		0.28	0.08	0.07	0.03	.	.	.	.	.	.	.	.	.	.	.
All Taxa		**0.94**	**3.02**	**1.75**	**7.40**	**3.01**	**0.58**	**1.21**	**0.35**	**0.34**	**0.88**	**0.37**	**.**	**0.05**	**0.03**	**.**

Table 4-3. Fish entrainment densities at Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites sampled during study weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017), and life stage specific efficacy of the 3-mm wedgewire screen provided as the percent reduction in entrainment density for the test relative to the control densities.

	Density (#/100 m^3)														Life Stage Specific Efficacy (% Reduction from Control Site)						
	Unit 1 Control Site (Ambient)							Test Site (3-mm Wedgewire Screen)													
Taxon \ Life Stage[1]	EGG	YSL	PYSL	YOY	YROL	UNID	ALL	EGG	YSL	PYSL	YOY	YROL	UNID	ALL	EGG	YSL	PYSL	YOY	YROL	UNID	ALL
Alosa sp.			<0.01			0.02	0.02			<0.01			<0.01	<0.01			100.0			90.8	91.5
American Eel					<0.01		<0.01					<0.01		<0.01					100.0		100.0
American Shad	<0.01	0.01	0.01				0.02	0.08	<0.01	<0.01				0.08	*	65.6	100.0				-320.9[2]
Black Crappie		<0.01	0.21	<0.01		0.01	0.22		<0.01	<0.01	<0.01		<0.01	<0.01		100.0	99.2	100.0		100.0	99.2
Blacknose Dace			0.02			<0.01	0.02			<0.01			<0.01	<0.01			100.0			100.0	100.0
Blueback Herring/Alewife			0.04			0.01	0.05			<0.01			<0.01	<0.01			100.0			85.3	96.6
Bluegill			<0.01		<0.01		0.01			<0.01		<0.01		<0.01			100.0		100.0		100.0
Carp and Minnow Family	<0.01	0.26	0.38			1.61	2.24	0.04	0.27	0.05			0.30	0.66	-2164[2]	-3.52[2]	87.5			81.2	70.7
Common Shiner			<0.01				<0.01			<0.01				<0.01			100.0				100.0
Fallfish			0.55			0.01	0.56			<0.01			<0.01	<0.01			99.4			100.0	99.4
Golden Shiner			<0.01		<0.01		<0.01			<0.01		<0.01		<0.01			100.0		100.0		100.0
Herring Family						<0.01	<0.01						<0.01	<0.01						100.0	100.0
Largemouth Bass		0.01	0.01	0.01		<0.01	0.02		<0.01	<0.01	<0.01		<0.01	<0.01		100.0	66.7	100.0		100.0	90.1
Lepomis Species		0.02	1.63			0.29	1.94		<0.01	0.06			0.02	0.09		77.5	96.0			91.6	95.2
Lepomis sp./Crappie Sp.		<0.01	0.40			0.62	1.02		<0.01	0.02			0.01	0.03		100.0	96.1			97.8	97.1
Madtom Species				<0.01			<0.01				<0.01			<0.01				*			*
Margined Madtom		<0.01		0.01			0.01		<0.01		<0.01			0.01		*		51.3			27.6
Rock Bass			0.05			<0.01	0.05			<0.01			<0.01	<0.01			100.0			100.0	100.0
Smallmouth Bass			<0.01				<0.01			<0.01				<0.01			100.0				100.0
Sucker Family			0.01			0.01	0.02			<0.01			<0.01	<0.01			100.0			100.0	100.0
Sunfish Family			0.01				0.01			<0.01				<0.01			100.0				100.0

(continued)

Table 4-3. Continued.

Taxon \ Life Stage[a]	Density (#/100 m³) Unit 1 Control Site (Ambient) EGG	YSL	PYSL	YOY	YROL	UNID	ALL	Test Site (3-mm Wedgewire Screen) EGG	YSL	PYSL	YOY	YROL	UNID	ALL	Life Stage Specific Efficacy (% Reduction from Control Site) EGG	YSL	PYSL	YOY	YROL	UNID	ALL
Tessellated Darter	<0.01	0.58	0.07			0.16	0.81	0.01	0.06	0.03			0.01	0.11	*	89.6	63.1			92.5	86.7
Unidentified Osteichthyes	<0.01	<0.01	0.04			1.86	1.91	<0.01	<0.01	<0.01			0.25	0.26	6.6	*	92.3			86.3	86.3
Walleye			0.02				0.02			<0.01				<0.01			100.0				100.0
White Perch		<0.01	<0.01				<0.01		<0.01	0.01				0.01		100.0					-90.9[b]
White Sucker		0.07	2.74			0.03	2.83		<0.01	0.03			<0.01	0.04		97.5	98.8			94.2	98.7
Yellow Bullhead				0.02			0.02				0.01			0.01				51.0			51.0
Yellow Perch		0.01	0.22			<0.01	0.23		<0.01	0.03			<0.01	0.03		100.0	87.5			*	86.9
All Taxa	**<0.01**	**0.94**	**6.43**	**0.03**	**0.01**	**4.64**	**12.05**	**0.13**	**0.34**	**0.23**	**0.01**	**0.00**	**0.61**	**1.33**	**-3471[2]**	**64.1**	**96.4**	**56.2**	**100.0**	**86.8**	**89.0**

[a] YSL=Yolk-sac larvae; PYSL=Post yolk-sac larvae; YOY=Young of the year; YROL=Yearling or older; UNID=Unidentified

[b] Negative efficacies are not considered biologically meaningful due to small sample size. Reductions here should be considered zero.

*Efficacy indicated where control density was zero (cannot divide by zero). Reductions here should be considered zero.

Table 4-4. Paired t-test results for the difference in ichthyoplankton entrainment densities (all taxa and life stages combined) estimated from concurrently collected (i.e., paired) samples from Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) samples at Merrimack Station for each of the study weeks 3 through 17 (Monday 22 May through Sunday 3 September 2017).

Week	Mean Density in #/100 m^3 for Control (N fish)	Mean Density in #/100 m^3 for Test (N fish)	Mean Density Difference in #/100 m^3 (Control-Test)	DF	t-value	Pr > |t|[a]
3	22.68 (836)	0.94 (34)	21.74	33	5.820	< 0.0001
4	29.29 (1105)	3.02 (118)	26.27	35	4.480	< 0.0001
5	14.82 (519)	1.72 (57)	13.10	32	4.320	0.0001
6	35.05 (1388)	7.40 (288)	27.65	35	4.450	< 0.0001
7	34.84 (1317)	3.04 (114)	31.80	33	7.210	< 0.0001
8	19.29 (738)	0.58 (22)	18.71	35	9.310	< 0.0001
9	3.14 (123)	1.21 (45)	1.93	35	3.210	0.0028
10	2.68 (104)	0.35 (13)	2.34	35	8.300	< 0.0001
11	12.28 (467)	0.34 (13)	11.94	35	6.440	< 0.0001
12	5.29 (190)	0.90 (32)	4.39	32	3.000	0.0051
13	1.64 (57)	0.37 (14)	1.27	34	3.750	0.0007
14	0.78 (29)	0.00 (0)	0.78	35	2.970	0.0053
15	0.09 (3)	0.03 (1)	0.06	30	1.050	0.3011
16	0.00 (0)	0.03 (1)	-0.03	33	-1.000	0.3246
17	0.00 (0)	0.00 (0)	0	35	--	--

[a] T-test results with a probability of a greater t (Pr>[t]) less than 0.05 are considered significantly different.

Table 4-5. Weekly total length frequency of ichthyoplankton larvae (yolk-sac and post yolk-sac, all taxa combined) measured from samples collected at the Merrimack Station Unit 1 control and 3-mm wedgewire screen (test) sites during study weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017). The integer value of each length bin is shown (e.g., 3 = 3.0 to 3.9 mm, etc.).

Site	Week	Length Bin (mm)																							
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Control	3		6	67	85	24	1	3	3	4	8	79	199	117	17	1									
	4	1	65	114	20	8	8	2	5	1	6	40	199	134	14	5									
	5	3	92	93	5	4	1	1	6	11	1	23	91	87	12	5		1							
	6	8	381	171	28	14	9	10	116	38	3	8	12	12	4	1	3		1						
	7	17	235	402	93	22	7	5	16	6	4	1	1	1	1	2	1	1	1						
	8		32	259	80	12	9				1	1	1		1						1		1		
	9		8	28	8	3	3	2	3	1	1	2		3	2	1	1			1	1		1		1
	10		3	31	11	2	4	7	1				1			1									
	11		42	234	36	5	3	1									1								
	12		11	87	31	3	4											1	1						
	13		10	15	1		1																		
	14		1	9	1																				
	15		1	1																					
	16																								
	17																								
Test	3		1	6	10	2							2												
	4	3	37	21	4			1		2	1		2	2											
	5	3	17	13	1	3	2			2		2	2	3											
	6	6	100	13	1	5	1					1													
	7	5	40	8	2	1	1																		
	8		2	3																					
	9		1	6	3																				
	10			1		1																			
	11			6	2																				
	12		1	14	8	1																			
	13		2						1																
	14																								
	15																								
	16																								
	17																								

Table 4-6. Summary of ichthyoplankton morphological measurements used for length and limiting dimension specific density estimates of the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites during study weeks 3 through 17 (Monday, 22 May through Sunday 3 September 2017). For hatched fish, length is the total length along body axis, depth and width are the largest cross-sectional body measurements. For eggs, width is the maximum diameter.

Life Stage[1]	Taxon	Control												Test											
		Length				Depth				Width				Length				Depth				Width			
		N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max
Egg	American Shad	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	41	2.5	3.4	3.9
	Carp and Minnow Family	.	.	.	.	.	.	.	.	1	1.2	1.2	1.2	.	.	.	.	.	.	.	.	23	1.2	1.2	1.3
	Tessellated Darter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	1.5	1.6	1.6
YSL	American Shad	3	8.6	8.9	9.2	1	0.9	0.9	0.9	1	1.1	1.1	1.1	1	7.2	7.2	7.2	1	0.7	0.7	0.7	.	.	.	.
	Black Crappie	1	4.8	4.8	4.8	1	0.6	0.6	0.6	1	0.9	0.9	0.9	.	.	.	.	.	.	.	.	.	.	.	.
	Carp and Minnow Family	131	3.5	4.7	5.9	128	0.5	0.7	1.0	121	0.5	0.8	1.9	130	3.6	4.5	5.4	136	0.5	0.7	1.1	120	0.5	0.7	0.9
	Largemouth Bass	3	3.7	5.2	7.8	2	0.7	0.8	0.9	2	0.8	0.9	0.9	.	.	.	.	.	.	.	.	.	.	.	.
	Lepomis sp.	7	4.6	5.4	6.2	7	0.5	0.7	1.0	4	0.9	1.0	1.1	2	5.4	5.5	5.6	2	0.7	0.8	0.9	1	1.1	1.1	1.1
	Lepomis sp./Crappie Sp.	1	4.4	4.4	4.4	1	0.7	0.7	0.7	1	0.8	0.8	0.8	.	.	.	.	.	.	.	.	.	.	.	.
	Margined Madtom	.	.	.	.	.	.	.	.	.	.	.	.	1	10.1	10.1	10.1	1	2.6	2.6	2.6	1	2.3	2.3	2.3
	Tessellated Darter	276	4.1	5.7	6.8	233	0.8	1.0	1.2	253	0.8	1.0	1.2	30	4.0	5.5	6.3	22	0.9	1.0	1.2	24	0.9	1.0	1.2
	White Perch	1	4.1	4.1	4.1	1	0.5	0.5	0.5	1	0.5	0.5	0.5	.	.	.	.	.	.	.	.	.	.	.	.
	White Sucker	37	12.5	13.9	15.0	37	1.1	1.4	2.5	36	1.3	1.8	2.0	1	12.2	12.2	12.2	1	1.2	1.2	1.2	1	1.3	1.3	1.3
	Yellow Perch	3	3.6	4.4	5.4	3	0.4	0.6	0.8	2	0.5	0.7	0.8	.	.	.	.	.	.	.	.	.	.	.	.
PYSL	Alosa Species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	American Shad	7	16.7	21.0	26.4	7	1.8	2.3	3.1	6	2.0	2.7	3.9	.	.	.	.	.	.	.	.	.	.	.	.
	Black Crappie	104	3.7	5.1	18.5	74	0.5	0.9	4.0	15	0.4	1.1	2.7	.	.	.	.	1	0.7	0.7	0.7	.	.	.	.
	Blacknose Dace	10	8.3	9.9	11.2	10	1.0	1.3	1.7	10	1.3	1.8	2.1	.	.	.	.	.	.	.	.	.	.	.	.
	Blueback Herring/Alewife	20	4.5	10.3	24.8	8	0.8	1.3	3.5	2	1.7	2.4	3.1	.	.	.	.	.	.	.	.	.	.	.	.
	Bluegill	1	13.9	13.9	13.9	1	2.8	2.8	2.8	1	2.2	2.2	2.2	.	.	.	.	.	.	.	.	.	.	.	.
	Carp and Minnow Family	191	3.9	5.6	16.1	140	0.5	0.8	2.5	109	0.5	0.9	3.1	20	4.3	4.9	5.8	16	0.5	0.7	1.0	17	0.7	0.8	1.0
	Common Shiner	1	12.5	12.5	12.5	1	1.7	1.7	1.7	1	2.0	2.0	2.0	.	.	.	.	.	.	.	.	.	.	.	.
	Fallfish	195	6.1	10.6	15.5	171	0.9	1.4	2.4	154	1.2	1.8	2.7	2	11.1	11.2	11.2	2	1.5	1.6	1.7	2	1.9	1.9	1.9
	Golden Shiner	1	7.7	7.7	7.7	1	0.9	0.9	0.9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Largemouth Bass	3	3.9	10.3	22.9	2	1.0	3.1	5.1	2	1.0	2.6	4.2	1	4.1	4.1	4.1	1	0.7	0.7	0.7	.	.	.	.
	Lepomis sp.	817	4.1	5.6	8.5	521	0.5	0.9	5.5	85	0.6	1.1	1.9	35	3.9	5.6	8.4	20	0.6	0.9	1.7	9	0.7	1.0	1.5
	Lepomis sp./Crappie Sp.	196	3.5	5.1	8.9	71	0.5	0.8	1.5	13	0.7	0.8	1.0	8	4.0	4.6	6.9	5	0.5	0.7	1.1	.	.	.	.
	Rock Bass	20	7.3	7.9	10.2	21	1.0	1.8	2.2	20	1.6	1.8	2.2	.	.	.	.	.	.	.	.	.	.	.	.
	Smallmouth Bass	3	15.5	16.3	17.8	3	3.7	4.2	4.8	3	3.2	3.4	3.5	.	.	.	.	.	.	.	.	.	.	.	.
	Sucker Family	2	14.5	15.2	15.8	2	1.3	1.8	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sunfish Family	4	8.0	11.9	17.2	3	2.0	2.6	3.8	1	2.4	2.4	2.4	.	.	.	.	.	.	.	.	.	.	.	.
	Tessellated Darter	34	5.2	6.3	8.3	35	0.6	1.0	1.4	31	0.9	1.1	1.6	13	5.9	7.1	8.2	15	0.8	1.1	1.4	14	1.0	1.3	1.5
	Walleye	12	10.5	12.3	13.8	12	1.2	1.7	2.1	11	1.0	1.7	2.5	.	.	.	.	.	.	.	.	.	.	.	.

(continued)

Table 4-6. Continued.

Life Stage[1]	Taxon	Control												Test											
		Length				Depth				Width				Length				Depth				Width			
		N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max	N	Min	Mean	Max
PYSL (continued)	White Perch	1	5.0	5.0	5.0	1	0.7	0.7	0.7	.	.	.	.	4	3.8	5.2	7.5	2	0.6	0.7	0.7	2	0.5	0.7	0.8
	White Sucker	1034	10.7	14.8	22.6	946	0.8	1.5	3.4	658	0.8	1.9	3.1	16	11.6	14.3	15.9	16	0.9	1.5	2.1	13	1.5	1.8	2.2
	Yellow Perch	116	4.8	8.2	20.7	89	0.6	1.2	3.9	51	0.4	1.0	3.6	13	5.6	7.0	9.8	10	0.6	0.8	1.0	6	0.6	0.8	1.3
Unid. Larvae	Alosa Species	7	8.0	8.8	10.0	.	.	.	.	.	.	.	.	1	7.4	7.4	7.4	.	.	.	.	.	.	.	.
	Black Crappie	1	4.0	4.0	4.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Blacknose Dace	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Blueback Herring/Alewife	4	5.2	7.2	8.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carp and Minnow Family	593	3.6	4.8	8.5	51	0.6	0.8	1.2	44	0.7	0.9	1.6	75	3.6	4.4	5.6	7	0.6	0.7	1.0	13	0.6	0.8	1.0
	Fallfish	4	8.2	10.2	11.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Herring Family	1	10.3	10.3	10.3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Largemouth Bass	1	4.1	4.1	4.1	1	0.8	0.8	0.8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lepomis sp.	149	4.4	5.5	6.7	21	0.6	0.9	1.1	1	1.1	1.1	1.1	14	5.1	5.7	6.4	.	.	.	.	1	0.9	0.9	0.9
	Lepomis sp./Crappie Sp.	293	3.9	5.4	6.8	35	0.7	0.9	1.0	5	0.7	0.9	1.1	5	3.9	5.4	6.5	3	0.7	0.9	1.0	1	0.8	0.8	0.8
	Rock Bass	.	.	.	.	1	1.9	1.9	1.9	1	1.9	1.9	1.9	.	.	.	.	.	.	.	.	.	.	.	.
	Sucker Family	2	13.6	13.7	13.8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Tessellated Darter	45	4.5	5.5	6.9	5	0.9	1.0	1.1	29	0.9	1.0	1.3	6	4.7	5.1	5.5	.	.	.	.	3	1.0	1.0	1.1
	White Sucker	1	11.7	11.7	11.7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Yellow Perch	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
YOY	Black Crappie	1	23.0	23.0	23.0	1	5.7	5.7	5.7	1	4.3	4.3	4.3	.	.	.	.	.	.	.	.	.	.	.	.
	Largemouth Bass	3	23.0	29.3	39.0	3	4.8	6.1	7.5	3	3.8	5.5	7.1	.	.	.	.	.	.	.	.	.	.	.	.
	Madtom Species	.	.	.	.	.	.	.	.	.	.	.	.	1	12.7	12.7	12.7	1	2.6	2.6	2.6	1	3.1	3.1	3.1
	Margined Madtom	5	16.8	20.3	29.0	4	3.5	4.2	5.7	5	3.9	4.5	6.4	2	17.6	17.7	17.8	2	3.5	3.6	3.7	2	4.0	4.3	4.5
	Yellow Bullhead	11	12.2	14.6	16.7	11	2.6	3.1	3.7	11	3.0	3.4	4.3	5	13.7	14.4	15.3	5	2.8	3.0	3.2	5	3.2	3.3	3.4
YROL	American Eel	1	198.0	198.0	198.0	1	9.5	9.5	9.5	1	9.7	9.7	9.7	.	.	.	.	.	.	.	.	.	.	.	.
	Bluegill	2	30.0	33.0	36.0	2	7.9	9.2	10.4	2	5.3	6.4	7.4	.	.	.	.	.	.	.	.	.	.	.	.
	Golden Shiner	1	68.0	68.0	68.0	1	13.6	13.6	13.6	1	7.7	7.7	7.7	.	.	.	.	.	.	.	.	.	.	.	.

1. YSL=Yolk-sac larvae; PYSL=Post yolk-sac larvae; YOY=Young of the year; YROL=Yearling or older; UNID=Unidentified life stage

Table 4-7. Diameter-specific densities for ichthyoplankton eggs collected at the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites summed across study weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017). Density values of zero have been replaced with '.' for visual clarity.

Site	Taxon	Egg Diameter (mm)																														
		1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0
Control	American Shad	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carp and Minnow Family	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Tessellated Darter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	All Taxa	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Test	American Shad	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	0.11	0.08	0.06	0.21	0.14	0.25	0.08	0.11	0.03	0.03	.
	Carp and Minnow Family	.	.	0.52	0.08	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Tessellated Darter	.	.	.	.	.	0.05	0.08	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	All Taxa	.	.	0.52	0.08	.	0.05	0.08	.	.	.	.	.	.	.	.	0.03	.	.	.	.	0.11	0.08	0.06	0.21	0.14	0.25	0.08	0.11	0.03	0.03	.

Table 4-8. Weekly mean diameter-specific densities (number of eggs/100 m^3) for ichthyoplankton eggs (all taxa combined) collected at the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites during study weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017). Density values of zero have been replaced with '.' for visual clarity.

Site	Week	Egg Diameter (mm)																														
		1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0
Control	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	4	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Test	3	.	.	0.11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	4	.	.	0.36	0.08	.	0.05	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	5	.	.	0.03	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.02	0.05	0.11	0.08	0.05	.	.	.
	7	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	.	.	.	.	0.03	.
	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	0.06	0.08	0.06	0.19	0.09	0.14	.	0.05	0.03	.	.
	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.
	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4-9. Length-specific densities of fish larvae (yolk-sac, post yok-sac, and unidentified larval stage combined) collected in entrainment samples at the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites summed across study weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017). The integer value of each length bin is shown (e.g., 3 = 3.0 to 3.9 mm, etc.) and density values of zero have been replaced with '.' for visual clarity.

		Length Bin (mm)																							
Site	**Taxon**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Control	*Alosa sp.*	.	.	.	.	.	0.22	0.04	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	American Eel	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	American Shad	.	.	.	.	.	0.07	0.04	.	.	.	.	.	.	0.03	.	0.04	0.04	0.03	0.04	.	.	0.04	.	0.04
	Black Crappie	0.18	2.89	0.30	0.17	.	0.03	0.03	.	.	.	0.03	.	.	0.04	0.04	0.04	.	.	.	.	.	.	.	.
	Blacknose Dace	.	.	.	.	.	0.10	.	0.19	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Blueback Herring/Alewife	.	0.04	0.03	.	0.13	0.07	0.25	0.17	0.06	0.03	0.03	.	.	.	.	.	.	.	.	.	.	0.04	.	.
	Bluegill	.	.	.	.	.	.	.	.	.	.	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carp and Minnow Family	0.82	25.94	9.66	1.09	1.17	0.38	0.11	0.04	0.04	0.04	0.04	0.04	.	0.04	.	.	.	.	.	.	.	.	.	.
	Common Shiner	.	.	.	.	.	.	.	.	.	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Fallfish	.	.	.	0.07	0.33	0.07	0.55	6.57	1.96	0.07	0.07	0.04	0.04	.	.	.	.	.	.	.	.	.	.	.
	Golden Shiner	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Herring Family	.	.	.	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Largemouth Bass	0.07	0.10	.	.	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.04	.	.	.	.
	Lepomis sp.	.	2.47	28.81	7.79	0.20	0.18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lepomis sp./Crappie Sp.	0.18	5.11	12.20	2.51	0.06	0.12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Madtom Sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Margined Madtom	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Rock Bass	.	.	.	.	0.70	0.18	.	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Smallmouth Bass	.	.	.	.	.	.	.	.	.	.	.	.	0.07	.	0.04	.	.	.	.	.	.	.	.	.
	Sucker Family	.	.	.	.	.	.	.	.	.	.	0.09	0.06	0.06	.	.	.	.	.	.	.	.	.	.	.
	Sunfish Family	.	.	.	.	.	0.04	.	.	0.06	.	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.
	Tessellated Darter	.	1.00	8.55	2.81	0.15	0.06	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Walleye	.	.	.	.	.	.	.	0.03	0.10	0.15	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.
	White Perch	.	0.03	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	White Sucker	.	.	.	.	.	.	.	0.03	0.09	0.44	5.59	21.04	14.26	1.91	0.54	0.06	0.03	0.03	.	0.04	.	.	.	.
	Yellow Bullhead	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Yellow Perch	0.03	0.05	0.37	1.22	0.85	0.25	0.18	0.17	0.09	0.06	0.03	0.03	0.06	0.03	0.03	0.03	0.03	0.03	.	.	.	.	.	.
	All Taxa	1.28	37.64	59.96	15.66	3.67	1.78	1.20	7.30	2.43	0.83	5.97	21.21	14.49	2.04	0.68	0.16	0.10	0.10	0.04	0.08	.	0.07	.	0.04

(continued)

Table 4-9. Continued

Site	Taxon	Length Bin (mm)																							
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Test	*Alosa sp.*	.	.	.	.	0.12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	American Eel	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	American Shad	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Black Crappie	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Blacknose Dace	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Blueback Herring/Alewife	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bluegill	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Carp and Minnow Family	0.75	8.29	1.09	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Common Shiner	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Fallfish	.	.	.	.	.	.	.	.	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Golden Shiner	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Herring Family	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Largemouth Bass	.	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lepomis sp.	0.05	0.13	1.47	0.43	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Lepomis sp./Crappie Sp.	0.03	0.27	0.04	0.13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Madtom Sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Margined Madtom	.	.	.	.	.	.	.	0.07	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Rock Bass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Smallmouth Bass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sucker Family	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Sunfish Family	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Tessellated Darter	.	0.25	0.74	0.35	0.23	0.08	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Walleye	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	White Perch	0.03	0.03	0.03	.	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	White Sucker	.	.	.	.	.	.	.	.	0.08	0.03	0.09	0.21	0.14	.	.	.	.	.	.	.	.	.	.	.
	Yellow Bullhead	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Yellow Perch	.	.	0.03	0.24	0.11	0.03	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	All Taxa	0.86	9.01	3.41	1.14	0.52	0.13	0.03	0.07	0.14	0.03	0.09	0.21	0.14	.	.	.	.	.	.	.	.	.	.	.

Table 4-10. Length-specific densitiesof young of the year (YOY) and yearling and older (YROL) fish collected in entrainment samples at the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites summerd across study weeks 3 through 17 (Monday, 22 May through Sunday, 3 September 2017). The integer value of each length bin is shown (e.g., 12 = 12.0 to 12.9 mm, etc.) and density values of zero have been replaced with '.' for visual clarity. Note the largest two length bins are not continuous with the series.

Life Stage	Site	Taxon	Length Bin (mm)																													
			12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	68	198
YOY	Control	Black Crappie	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Largemouth Bass	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.
		Madtom Species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Margined Madtom	.	.	.	.	0.03	0.03	.	0.03	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.
		Yellow Bullhead	0.02	0.10	0.03	0.08	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		All Taxa	0.02	0.10	0.03	0.08	0.08	0.03	.	0.03	.	.	.	0.06	.	.	0.03	.	.	0.03	.	.	.	.	.	.	.	.	.	0.03	.	.
	Test	Black Crappie	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Largemouth Bass	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Madtom Species	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Margined Madtom	.	.	.	.	.	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Yellow Bullhead	.	0.06	0.06	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		All Taxa	0.03	0.06	0.06	0.03	.	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
YROL	Control	American Eel	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03
		Bluegill	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	.	0.03	.	.	.	.	.
		Golden Shiner	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.
		All Taxa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.03	.	.	.	.	.	0.03	.	.	.	0.03	0.03
	Test	American Eel	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Bluegill	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Golden Shiner	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		All Taxa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4-11. Length-specific larval densities (larvae/100 m^3) for all taxa combined collected in entrainment samples at the Merrimack Station Unit 1 (control) and 3-mm wedgewire screen (test) sites during each study week 3 through 17 (Monday, 22 May through Sunday, 3 September 2017). The integer value of each length bin is shown (e.g., 12 = 3.0 to 3.9 mm, etc.), and density values of zero have been replaced with '.' for visual clarity.

Site	Week	Length Bin (mm)																							
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Control	3	.	0.17	2.27	2.67	0.74	0.03	0.09	0.08	0.10	0.25	2.78	7.17	4.14	0.58	0.03	.	.	.	.	.	.	.	.	.
	4	0.04	2.38	4.04	0.64	0.27	0.22	0.05	0.14	0.03	0.24	2.01	10.61	6.83	0.78	0.29	.	.	.	.	.	.	.	.	.
	5	0.11	3.12	3.01	0.19	0.09	.	0.03	0.16	0.36	0.04	0.77	2.94	2.95	0.42	0.19	.	0.03	.	.	.	.	.	.	.
	6	0.33	16.38	6.48	1.01	0.57	0.27	0.48	6.01	1.63	0.09	0.26	0.37	0.42	0.12	0.03	0.09	.	0.03	.	.	.	.	.	.
	7	0.80	10.93	15.93	3.87	0.94	0.25	0.18	0.75	0.27	0.14	0.03	0.03	0.04	0.03	0.07	.	0.03	0.03	.	.	.	.	.	.
	8	.	1.49	12.30	3.88	0.59	0.45	.	.	.	0.04	0.04	0.04	.	0.03	.	.	.	.	.	0.04	.	0.04	.	.
	9	.	0.37	1.11	0.30	0.11	0.11	0.07	0.12	0.04	0.04	0.08	.	0.11	0.07	0.04	0.04	.	.	0.04	0.04	.	0.04	.	0.04
	10	.	0.11	1.15	0.48	0.07	0.18	0.26	0.04	.	.	.	0.04	.	.	0.04	.	.	.	.	.	.	.	.	.
	11	.	1.62	8.81	1.34	0.18	0.10	0.03	.	.	.	.	.	.	.	.	0.04	.	.	.	.	.	.	.	.
	12	.	0.44	3.34	1.17	0.11	0.11	.	.	.	.	.	.	.	.	.	.	0.04	0.03	.	.	.	.	.	.
	13	.	0.55	0.88	0.05	.	0.05	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	14	.	0.06	0.60	0.06	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	15	.	0.03	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Test	3	.	0.03	0.21	0.39	0.06	.	.	.	.	.	.	0.06	.	.	.	.	.	.	.	.	.	.	.	.
	4	0.08	1.10	0.63	0.11	.	.	0.03	.	0.08	0.03	.	0.06	0.05	.	.	.	.	.	.	.	.	.	.	.
	5	0.08	0.54	0.41	0.05	0.10	0.06	.	.	0.05	.	0.06	0.10	0.08	.	.	.	.	.	.	.	.	.	.	.
	6	0.37	5.03	0.45	0.03	0.17	0.04	.	.	.	.	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.
	7	0.33	1.81	0.30	0.07	0.04	0.04	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	8	.	0.20	0.30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	9	.	0.04	0.26	0.13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	10	.	.	0.12	.	0.12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	11	.	.	0.25	0.08	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	12	.	0.03	0.48	0.27	0.03	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	13	.	0.22	.	.	.	.	.	0.07	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4-12. Length-specific wedgewire screen efficacy for the four most abundant taxonomic families and for all taxa combined based on length-specific weekly entrainment densities (all life stages combined) summed across all study weeks 3 through 17 (22 May through 3 September 2017) . The integer value of each length bin is shown (e.g., 3 = 3.0 to 3.9 mm, etc.).

Length Bin (mm)	Sunfish Family				Carp and Minnow Family				Sucker Family				Perch and Darter Family				All Taxa			
	Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)	
	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.
1	0.00	0.00			0.03	0.60	-2164.2	-2164.2	0.00	0.00			0.00	0.13			0.03	0.73	-2643.1	-2643.1
2	0.00	0.00			0.00	0.00		-2164.2	0.00	0.00			0.00	0.00			0.00	0.03		-2743.6
3	0.43	0.08	81.0	81.0	0.82	0.75	8.6	-59.0	0.00	0.00			0.03	0.00	100.0	-344.4	1.28	1.95	-52.3	-106.7
4	10.58	0.43	95.9	95.4	25.94	8.29	68.0	64.0	0.00	0.00			1.06	0.25	76.4	65.3	37.64	9.01	76.1	69.9
5	41.32	1.52	96.3	96.1	9.66	1.09	88.7	70.6	0.00	0.00			8.92	0.77	91.4	88.5	59.96	3.41	94.3	84.7
6	10.46	0.56	94.6	95.9	1.16	0.00	100.0	71.5	0.00	0.00			4.03	0.58	85.5	87.7	15.66	1.14	92.7	85.8
7	1.00	0.00	100.0	95.9	1.53	0.00	100.0	72.6	0.00	0.00			1.01	0.33	67.0	86.3	3.67	0.52	85.7	85.8
8	0.55	0.03	94.9	95.9	0.56	0.00	100.0	73.0	0.00	0.00			0.31	0.10	66.8	85.9	1.78	0.13	92.6	85.9
9	0.03	0.00	100.0	95.9	0.66	0.00	100.0	73.4	0.00	0.00			0.18	0.03	84.1	85.9	1.20	0.03	97.7	86.0
10	0.04	0.00	100.0	95.9	6.80	0.00	100.0	77.2	0.03	0.00	100.0	100.0	0.19	0.00	100.0	86.0	7.30	0.07	99.0	86.8
11	0.06	0.00	100.0	95.9	2.03	0.05	97.4	78.1	0.09	0.08	11.0	30.7	0.19	0.00	100.0	86.2	2.43	0.14	94.3	86.9
12	0.00	0.00		95.9	0.14	0.00	100.0	78.1	0.44	0.03	93.9	80.3	0.21	0.00	100.0	86.4	0.85	0.05	93.9	86.9
13	0.07	0.00	100.0	95.9	0.11	0.00	100.0	78.2	5.68	0.09	98.4	96.8	0.08	0.00	100.0	86.5	6.08	0.15	97.6	87.4
14	0.00	0.00		95.9	0.07	0.00	100.0	78.2	21.11	0.21	99.0	98.5	0.03	0.00	100.0	86.5	21.23	0.27	98.7	88.9
15	0.07	0.00	100.0	96.0	0.04	0.00	100.0	78.2	14.32	0.14	99.0	98.7	0.06	0.00	100.0	86.5	14.57	0.16	98.9	89.8
16	0.04	0.00	100.0	96.0	0.04	0.00	100.0	78.2	1.91	0.00	100.0	98.7	0.03	0.00	100.0	86.6	2.12	0.00	100.0	89.9
17	0.11	0.00	100.0	96.0	0.00	0.00		78.2	0.54	0.00	100.0	98.8	0.03	0.00	100.0	86.6	0.71	0.05	92.4	89.9
18	0.04	0.00	100.0	96.0	0.00	0.00		78.2	0.06	0.00	100.0	98.8	0.03	0.00	100.0	86.6	0.16	0.00	100.0	89.9
19	0.00	0.00		96.0	0.00	0.00		78.2	0.03	0.00	100.0	98.8	0.03	0.00	100.0	86.6	0.12	0.00	100.0	89.9
20	0.00	0.00		96.0	0.00	0.00		78.2	0.03	0.00	100.0	98.8	0.03	0.00	100.0	86.7	0.10	0.00	100.0	89.9
21	0.00	0.00		96.0	0.00	0.00		78.2	0.00	0.00		98.8	0.00	0.00		86.7	0.04	0.00	100.0	89.9
22	0.04	0.00	100.0	96.0	0.00	0.00		78.2	0.04	0.00	100.0	98.8	0.00	0.00		86.7	0.08	0.00	100.0	89.9
23	0.05	0.00	100.0	96.0	0.00	0.00		78.2	0.00	0.00		98.8	0.00	0.00		86.7	0.05	0.00	100.0	89.9
24	0.00	0.00		96.0	0.00	0.00		78.2	0.00	0.00		98.8	0.00	0.00		86.7	0.07	0.00	100.0	89.9
25	0.00	0.00		96.0	0.00	0.00		78.2	0.00	0.00		98.8	0.00	0.00		86.7	0.00	0.00		89.9
26	0.03	0.00	100.0	96.0	0.00	0.00		78.2	0.00	0.00		98.8	0.00	0.00		86.7	0.06	0.00	100.0	89.9

[a]Negative efficacies are not considered biologically meaningful due to small sample size, and efficacy cannot be calculated where control density is zero (cannot divide by zero); both of these cases should be considered a 0% reduction.

Table 4-13. Limiting-dimension specific wedgewire screen efficacy for the four most abundant taxonomic families and for all taxa combined based on limiting-dimension specific weekly entrainment densities (all life stages combined) summed across all study weeks 3 through 17 (22 May through 3 September 2017).

Limiting Dimension (mm)	Sunfish Family				Carp and Minnow Family				Sucker Family				Perch and Darter Family				All Taxa			
	Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)		Summed Density		Efficacy[a] (%)	
	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.	Control	Test	Bin	Cum.
0.4	0.00	0.00			0.00	0.00			0.00	0.00			0.02	0.00	100.0	100.0	0.02	0.00	100.0	100.0
0.5	1.55	0.08	95.1	95.1	0.11	0.08	27.2	27.2	0.00	0.00			0.03	0.00	100.0	100.0	1.71	0.18	89.5	89.6
0.6	5.14	0.16	96.9	96.5	3.50	0.39	88.9	87.0	0.00	0.00			0.34	0.05	84.0	86.1	8.99	0.63	93.0	92.4
0.7	7.00	0.23	96.8	96.6	5.95	2.34	60.7	70.6	0.00	0.00			0.48	0.03	94.2	90.6	13.45	2.62	80.5	85.8
0.8	5.39	0.19	96.4	96.6	5.64	2.13	62.3	67.5	0.00	0.00			0.71	0.16	76.9	84.5	11.77	2.51	78.7	83.5
0.9	6.19	0.42	93.2	95.7	3.43	0.41	88.1	71.3	0.00	0.00			1.13	0.11	90.7	87.0	10.82	0.94	91.4	85.3
1.0	9.09	0.28	96.9	96.1	1.43	0.11	92.0	72.8	0.00	0.00			5.09	0.34	93.4	91.2	15.66	0.73	95.4	87.8
1.1	2.35	0.11	95.5	96.0	0.26	0.03	90.2	73.0	0.13	0.00	100.0	100.0	4.39	0.47	89.2	90.5	7.15	0.61	91.5	88.2
1.2	0.45	0.00	100.0	96.1	0.71	0.52	26.2	71.4	0.45	0.00	100.0	100.0	0.92	0.13	85.6	90.1	2.52	0.65	74.0	87.7
1.3	0.13	0.00	100.0	96.1	0.66	0.08	88.3	72.0	1.30	0.05	96.1	97.3	0.18	0.13	29.9	89.3	2.28	0.26	88.8	87.7
1.4	0.05	0.03	49.7	96.0	0.38	0.00	100.0	72.4	2.03	0.00	100.0	98.7	0.08	0.07	12.0	88.8	2.60	0.10	96.1	88.0
1.5	0.22	0.00	100.0	96.0	0.65	0.00	100.0	73.2	2.93	0.05	98.2	98.5	0.14	0.10	24.7	88.2	3.94	0.16	96.0	88.4
1.6	0.11	0.00	100.0	96.1	0.52	0.00	100.0	73.8	3.42	0.03	99.2	98.7	0.09	0.08	15.0	87.7	4.14	0.10	97.5	88.9
1.7	0.13	0.03	80.9	96.0	0.59	0.00	100.0	74.5	2.96	0.03	99.0	98.8	0.03	0.00	100.0	87.7	3.74	0.05	98.6	89.3
1.8	0.19	0.00	100.0	96.0	2.95	0.00	100.0	77.3	5.52	0.19	96.6	98.2	0.12	0.00	100.0	87.8	8.78	0.19	97.9	90.0
1.9	0.28	0.00	100.0	96.0	2.24	0.05	97.9	78.9	7.68	0.05	99.3	98.5	0.08	0.00	100.0	87.9	10.27	0.10	99.0	90.9
2.0	0.18	0.00	100.0	96.1	0.86	0.00	100.0	79.5	9.16	0.05	99.4	98.7	0.05	0.00	100.0	87.9	10.28	0.05	99.5	91.6
2.1	0.05	0.00	100.0	96.1	0.18	0.00	100.0	79.6	3.98	0.03	99.4	98.8	0.05	0.00	100.0	88.0	4.28	0.03	99.4	91.9
2.2	0.18	0.00	100.0	96.1	0.07	0.00	100.0	79.7	1.48	0.02	98.3	98.8	0.08	0.00	100.0	88.0	1.80	0.02	98.6	92.0
2.3	0.08	0.00	100.0	96.1	0.00	0.00		79.7	0.37	0.00	100.0	98.8	0.00	0.00		88.0	0.47	0.00	100.0	92.0
2.4	0.00	0.00		96.1	0.03	0.00	100.0	79.7	0.13	0.00	100.0	98.8	0.00	0.00		88.0	0.16	0.00	100.0	92.1
2.5	0.00	0.00		96.1	0.03	0.00	100.0	79.7	0.20	0.00	100.0	98.8	0.02	0.00	100.0	88.1	0.25	0.03	89.5	92.0
2.6	0.03	0.00	100.0	96.1	0.02	0.00	100.0	79.7	0.04	0.00	100.0	98.8	0.03	0.00	100.0	88.1	0.11	0.03	76.9	92.0
2.7	0.00	0.00		96.1	0.02	0.00	100.0	79.7	0.00	0.00		98.8	0.00	0.00		88.1	0.05	0.00	100.0	92.0
2.8	0.03	0.00	100.0	96.1	0.00	0.00		79.7	0.02	0.00	100.0	98.8	0.03	0.00	100.0	88.1	0.13	0.00	100.0	92.0
2.9	0.00	0.00		96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.00	0.00		88.1	0.00	0.00		92.0
3.0	0.00	0.00		96.1	0.00	0.00		79.7	0.03	0.00	100.0	98.8	0.00	0.00		88.1	0.08	0.11	-44.8	92.0
3.1	0.00	0.00		96.1	0.03	0.00	100.0	79.7	0.00	0.00		98.8	0.00	0.00		88.1	0.05	0.11	-106.6	91.9
3.2	0.00	0.00		96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.00	0.00		88.1	0.08	0.14	-84.7	91.8
3.3	0.00	0.00		96.1	0.00	0.00		79.7	0.03	0.00	100.0	98.8	0.03	0.00	100.0	88.1	0.05	0.24	-354.2	91.6
3.4	0.00	0.00		96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.03	0.00	100.0	88.1	0.05	0.17	-223.7	91.5
3.5	0.00	0.00		96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.03	0.00	100.0	88.2	0.08	0.25	-226.6	91.3
3.6	0.05	0.00	100.0	96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.03	0.00	100.0	88.2	0.08	0.08	-3.2	91.2
3.7	0.02	0.00	100.0	96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.00	0.00		88.2	0.02	0.11	-327.9	91.1
3.8	0.03	0.00	100.0	96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.00	0.00		88.2	0.05	0.03	47.4	91.1
3.9	0.00	0.00		96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.02	0.00	100.0	88.2	0.08	0.03	66.9	91.1
4.0	0.03	0.00	100.0	96.1	0.00	0.00		79.7	0.00	0.00		98.8	0.00	0.00		88.2	0.05	0.03	48.9	91.1

[a]Negative efficacies are not considered biologically meaningful due to small sample size, and efficacy cannot be calculated where control density is zero (cannot divide by zero); both of these cases should be considered a 0% reduction.

Table 4-14. Summary statistics and principal component axes of river sweeping velocity measured by two ADCPs deployed in the Merrimack River near Merrimack Station Unit 1 from 22 May to 25 July 2017[1]. Units are feet per second unless otherwise noted.

Site	Min	Mean	Max	s.d.	N	1%	10%	25%	50%	75%	90%	99%	Principal Axis (˚True)	Principal Variance (%)	Direction s.d. (˚)
Upstream	0.40	1.32	2.46	0.48	9183	0.56	0.73	0.87	1.29	1.73	1.97	2.26	133.7	99.31	1.8
Downstream	0.30	1.24	2.41	0.51	9174	0.43	0.59	0.75	1.19	1.67	1.94	2.25	132.2	98.63	3.1

[1]The Upstream ADCP failed to record data from 25 July 2017 to 31 August 2017 due to a firmware issue with the data card.