**GREAT RIVER HYDRO, LLC**

# ILP Study 18
# American Eel Upstream Passage Assessment

## *Supplement #2 to Study Report*

**In support of Federal Energy Regulatory Commission Relicensing of:**

Wilder Hydroelectric Project (FERC Project No. 1892-026)
Bellows Falls Hydroelectric Project (FERC Project No. 1855-045)
Vernon Hydroelectric Project (FERC Project No. 1904-073)

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| | |
|---|---|
| °C | Degrees Celsius |
| CFS | cubic feet per second |
| FERC | Federal Energy Regulatory Commission |
| FWS | U.S. Department of the Interior – Fish and Wildlife Service |
| GPM | Gallons per minute |
| GRH | Great River Hydro, LLC |
| ILP | Integrated Licensing Process |
| In | Inches |
| NHFGD | New Hampshire Fish and Game Department |
| PVC | Polyvinyl chloride |
| RSP | Revised Study Plan |
| TransCanada | TransCanada Hydro Northeast Inc. |
| USGS | United States Geological Survey |
| VANR | Vermont Agency of Natural Resources |
| VFWD | Vermont Fish & Wildlife Department |
| VY | Vermont Yankee Nuclear Power Plant |

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# 1.0 INTRODUCTION

This document provides supplemental results from observations made during 2017 as part of the American Eel Upstream Passage Assessment (ILP Study 18) conducted originally in 2015 (Normandeau, 2016a) and supplemented in 2016 (Normandeau, 2016b) in support of Federal Energy Regulatory Commission (FERC) relicensing for the Wilder Hydroelectric Project (FERC Project No. 1892), Bellows Falls Hydroelectric Project (FERC No. 1855), and Vernon Hydroelectric Project (FERC No. 1904).

# 2.0 STUDY GOALS AND OBJECTIVES

As stated in the Revised Study Plan (RSP), the goal of Study 18 was to provide baseline data on the presence of American Eels attempting to move upstream of the Wilder, Bellows Falls, and Vernon projects and the locations where they congregate while attempting upstream passage.

The goal of the 2017 supplemental effort was to collect information on upstream migrating eels at Vernon throughout the upstream migration season and when the Vernon fish ladder was operated on a normal seasonal schedule (mid-April to mid-July). During the 2015 study, the fish ladder was operated continuously for Study 17 (Upstream Passage of Riverine Fish Species Assessment) throughout the American Eel migratory season. The 2016 supplement effort did not begin in time to capture the entire upstream migration season.

Objectives for the 2017 supplemental effort were to:

- conduct systematic surveys of eel presence/abundance at Vernon tailrace and spillway locations in order to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures; and
- collect eels with a site-specifically designed temporary eel ramp trap installed near the upstream fishway entrance, an area that had been identified from the 2015 surveys and from upstream passage data collected in 2015 in Study 17 as the primary area of potential eel concentration, to assess whether eels can be collected and passed in substantial numbers.

A consultation call was held with the Aquatics working group on May 11, 2017 in which the proposed scope of the 2017 supplemental study was discussed. The 2017 study was designed to repeat the 2015 and 2016 studies.

# 3.0 METHODS

## 3.1 Visual Surveys

Visual surveys were conducted weekly at night, on foot or from a boat downstream of Vernon dam, from June 1, 2017 through November 6, 2017. Visual surveys began at least one-half hour after sunset, and complete surveys took approximately 1 to 2 hours. Survey site locations were similar to those observed in 2015 and 2016 (see Figure 4.1-1), but survey site numbers differed slightly in 2017. The study design

included survey sites in areas where eels were likely to congregate (e.g., fishway, relatively quiescent areas with leakage flows) below the dam. However, the overall survey was designed to systematically observe virtually all of the downstream face of the dam as well as specific leakage flow areas, the fish ladder when in operation, fish ladder entrance, and a riprapped area downstream of the fishway entrance (Table 3.1-1). Certain locations could not be accessed under specific conditions for safety reasons (e.g., below spill gates during spilling conditions) and were omitted from surveys when necessary. The trash/ice sluice (site 12) could not be observed because of continuous discharge of approximately 500 cfs throughout the study period from a former construction bypass located deep below the trash sluice that suffered bulkhead damage/failure. The fish ladder (site 15) was omitted from surveys after it was dewatered on August 7, 2017.

Data collected included date and time of survey, general notes on weather conditions, moon phase, and any pertinent operational conditions that limited observations (e.g., open spill gates), survey site, time of observation, presence / absence of eels, and when present, estimated number, and length class distribution. Visually estimated lengths of eels observed were assigned to one of four classifications: <6 inches, 6-12 inches, 12-18 inches, and >18 inches.

Table 3.1-1. American Eel upstream passage visual survey site locations, Vernon Dam.

| Site No. (18-V-xx) | Description |
|---|---|
| 01 | Tainter Gate 1 (large), apron, and bedrock |
| 02 | Tainter Gate 2 (large), apron, and bedrock |
| 03 | Stanchion Bay 1, apron, and bedrock |
| 04 | Stanchion Bay 2, apron, and bedrock |
| 05 | Stanchion Bay 3, apron, and bedrock |
| 06 | Hydraulic Floodgate Bay, apron, and bedrock |
| 07 | Hydraulic Panel Bay and apron |
| 08 | Tainter Gate 3 (small) and apron |
| 09 | Tainter Gate 4 (small) and apron |
| 10 | Tainter Gate 5 (small) and apron |
| 11 | Tainter Gate 6 (small) and apron |
| 12 | Trash Sluice outfall area |
| 13 | Fishway entrance/ eel ramp base |
| 14 | Riprap bank at downstream bend of fishway |
| 15 | Fishway |

## 3.2 Temporary Eel Ramp Trap

Initial site selection for installation of a temporary eel ramp trap was made during a site visit and consultation of Great River Hydro (TransCanada at the time) and

Normandeau with staff from FWS, VFWD, and USGS on July 20, 2016. The eel ramp design was based on the Haro (2013) generic temporary eel ramp trap design modified for the site (Figure 3.2-1).

The ramp framework was constructed from 6063 aluminum channel, 37 feet long, 18.5 inches wide, and 3.5 inches high. The framework supported Milieu elver ramp climbing substrate (http://www.milieuinc.com/products) and was covered, except for the bottom 8 feet, with 0.25-inch thick PVC sheet. The substrate was composed of a molded ABS plastic tray with three sections (overall width of 18 inches) with staggered 1-inch diameter PVC vertical studs. The ramp was installed at an angle of approximately 36 degrees parallel to the downstream face of the dam with its base adjacent to the corner formed by the fish ladder entrance. At minimum tailwater elevation the point where the ramp met the water surface was less than one foot from the wall, and at a tailwater elevation five feet higher than minimum, it terminated approximately seven feet from the wall. The ramp was supported by two davits mounted on the dam deck, and secured to the wall near its base with an angle bracket. The overshoot at the top of the ramp fell to a drop-off hopper designed to funnel eels to a 32-gallon collection tank with standpipe. The collection tank was designed to reintroduce water drained through the standpipe to the ramp. The climbing substrate was wetted by three 0.5-inch diameter flexible hoses, and a fourth hose provided additional water to the drop-off and collection hopper. Attraction water was introduced near the base of the ramp via a 1-inch diameter pipe that was perforated along the lower 6 feet. The overall expected flow rate was 0.08-0.1 cfs (35-50 gpm) supplied by a continuous duty submersible pump. An additional attraction flow of approximately 60 gpm, supplied by a second submersible pump, was introduced by splashing down the wall adjacent to the ramp base.

The eel ramp was operated continuously from June 1 to November 8, 2017 under VFWD Scientific Collection Permit #S-2017-CG and NHFGD Scientific License #F2017-90.

## 3.3 Environmental and Operations Data

Vernon dam operational discharge data were provided by Great River Hydro. Water temperature and dissolved oxygen point samples were recorded weekly from the eel ramp trap collection hopper, and water temperature loggers (Onset HOBO TidbiT V2) were deployed in the tailrace near the base of the ramp from June 1 – November 8, 2017 to continuously record water temperature (15-minute increment). Daily percent lunar illumination data were obtained from the U.S. Naval Observatory (http://aa.usno.navy.mil/data/docs/MoonFraction.php).

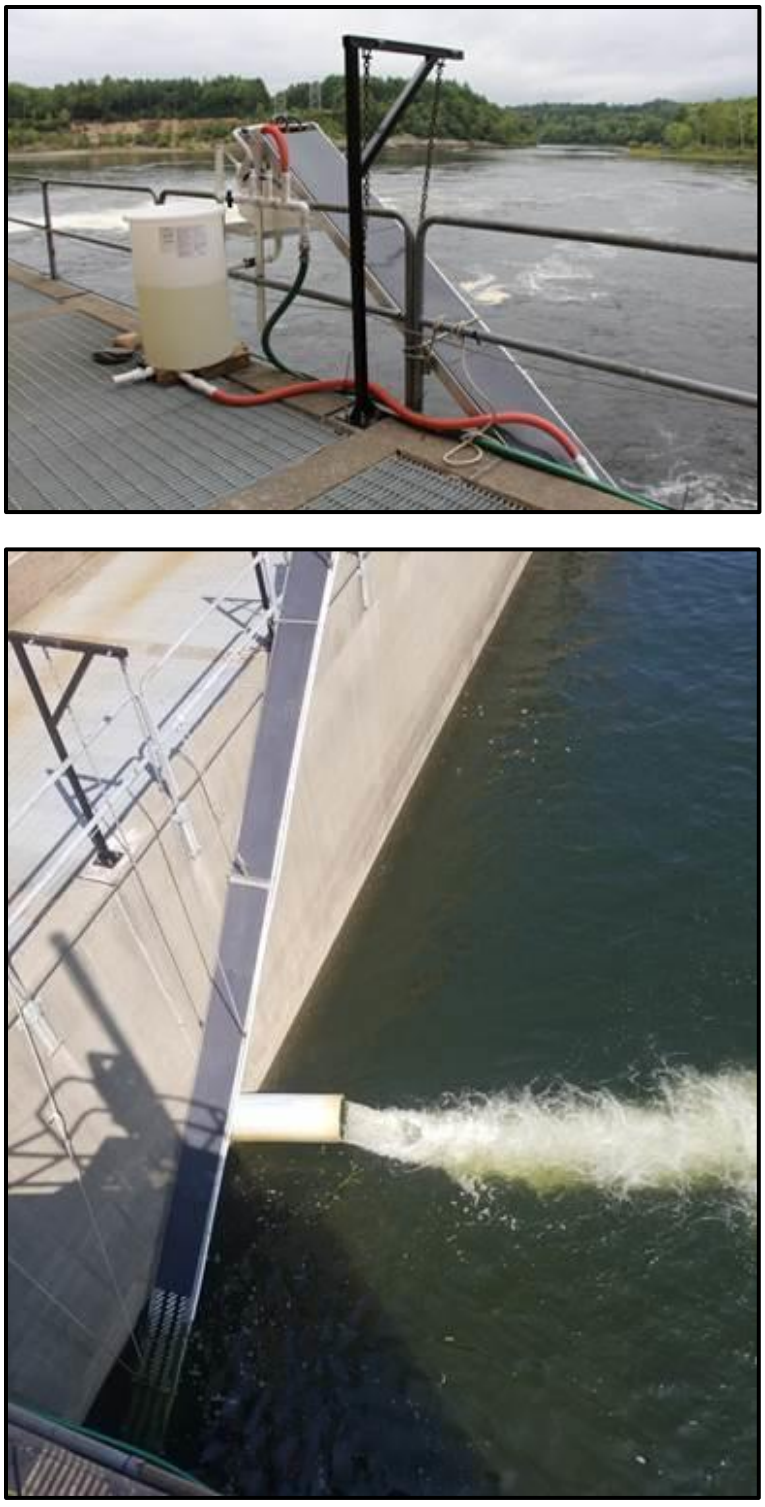

Figure 3.2-1. Vernon temporary eel ramp trap.

# 4.0 RESULTS AND DISCUSSION

## 4.1 Visual Surveys

Over the 23 weeks of visual surveys conducted from June 1, 2017 through November 6, 2017, 148 eels were observed at Vernon dam (Table 4.1-1, Figure 4.1-1). The greatest number of eels observed in a single survey was 22 on June 28. Eels were observed at 11 of the 15 survey sites. The greatest number of eels (summed for all surveys) were observed in the fishway (site 15, N = 82, 55.4% of total), the apron of Tainter gate 3 and the submerged flood gate below it (where most of the count was observed, site 08, N = 21, 14.2%); and the apron of Tainter gate 4 and the submerged flood gate below it (where most of the count was observed, site 09, N = 12, 8.1%, Table 4.1-1). Eels within the fishway were generally observed in two locations, at the visitor's viewing window, located at a large turn-pool in the fish ladder, or the counting room window. At the visitor's window, eels were observed to be actively swimming, but frequently appeared to be circling in the large turn pool. In the counting room window, eels usually appeared to be resting.

Generally, eels were observed at three distinct site types: the fishway (site 15), an area in the vicinity of the submerged flood gates below four Tainter gates and one of the hydraulic panels (sites 07 – 11), and in the bedrock outcrop below the Tainter gates and stanchion bays (sites 01 – 04, Table 4.1-2). After the fishway, eels were most frequently observed in the submerged flood gates, where 47 eels were observed collectively (32% of the total). As noted during 2015 and 2016 surveys, researchers felt that eels observed in that location did not appear to be seeking flow or otherwise actively migrating at the time of observation, but instead appeared to be seeking refuge in the submerged structures. Overall, 19 eels (13% of the total) were observed in the bedrock outcrop and because the area was characterized by rivulets of running water and an increase in elevation, those eels appeared to be actively migrating.

### 4.1.1 Fishway Dewatering Observation

During the 2017 upstream passage season, 581 eels were counted using the Vernon fishway through VANR's Vernon fish passage monitoring[1]. Following the anadromous fish upstream passage season, the fishway was dewatered on August 7, 2017. Observations made during the dewatering (by J. Griffin, Great River Hydro) demonstrated a relatively large number of eels and Sea Lamprey ammocoetes using or residing in the facility. Ammocoetes were observed both in draining water and in association with fine sediment deposits (Figure 4.1-2). A 4-minute, 11-second video recording of eels passing downstream through the orifice in the first weir downstream of the counting room was used to estimate an index of abundance and size of eels. Approximately 115-120 eels were counted moving downstream through the orifice. The distribution of total lengths of eels was estimated using the National Institutes

[1] Source: (https://www.fws.gov/r5crc/pdf/2017_counts/CT_River_Fishway_Count_Rpt_11_07_17.pdf), accessed December 5, 2017

of Health's digital image processing program Image-J (https://imagej.nih.gov/ij/) with the known dimensions of the orifice to establish scale (Figure 4.1-2). Eels visible in eight screen-capture images from the video, with time separation of at least 10 seconds, were measured and are further described in section 4.3.3.

Table 4.1-1. Number of eels observed during nighttime visual surveys by site location and date, 2017[a].

| Date | Site Number[b] | | | | | | | | | | | | | | | Total by Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12[c] | 13 | 14 | 15[d] | |
| 6/1 | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | N/A | | | 0 | 0 |
| 6/7 | | | | | | | | | | | | N/A | | | 0 | 0 |
| 6/14 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 3 | 2 | 0 | N/A | 0 | 0 | 9 | 19 |
| 6/22 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 0 | N/A | 0 | 0 | 11 | 19 |
| 6/28 | 0 | 0 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | 12 | 22 |
| 7/5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | | | 12 | 12 |
| 7/13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | N/A | 0 | 0 | 15 | 18 |
| 7/19 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | 14 | 15 |
| 7/27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | N/A | 0 | 0 | 5 | 8 |
| 8/2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | N/A | 0 | 0 | 2 | 5 |
| 8/7 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | 0 | 4 |
| 8/14 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 1 | N/A | 0 | 0 | 2 | 8 |
| 8/23 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 1 | 0 | N/A | 0 | 0 | N/A | 14 |
| 8/30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 2 |
| 9/7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | | | N/A | 0 |
| 9/13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 0 |
| 9/19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 1 |
| 9/26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 1 |
| 10/3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 0 |
| 10/9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 0 |
| 10/16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 0 |
| 10/24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 0 |
| 11/6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N/A | 0 | 0 | N/A | 0 |
| **Total by Site** | **2** | **5** | **5** | **7** | **0** | **0** | **3** | **21** | **12** | **9** | **2** | **0** | **0** | **0** | **82** | **148** |

a. Survey site numbers can be referenced to site numbers in Figure 4.1-1.

b. Sites not visited during a given date due to safety concerns are marked by shaded cells.

c. Site (trash sluice) not surveyed for entirety of 2017 due to continuous ~500 cfs discharge through a deep gate immediately below sluice.

d. Site (fish ladder) not surveyed after August 7 when the fish ladder was dewatered.

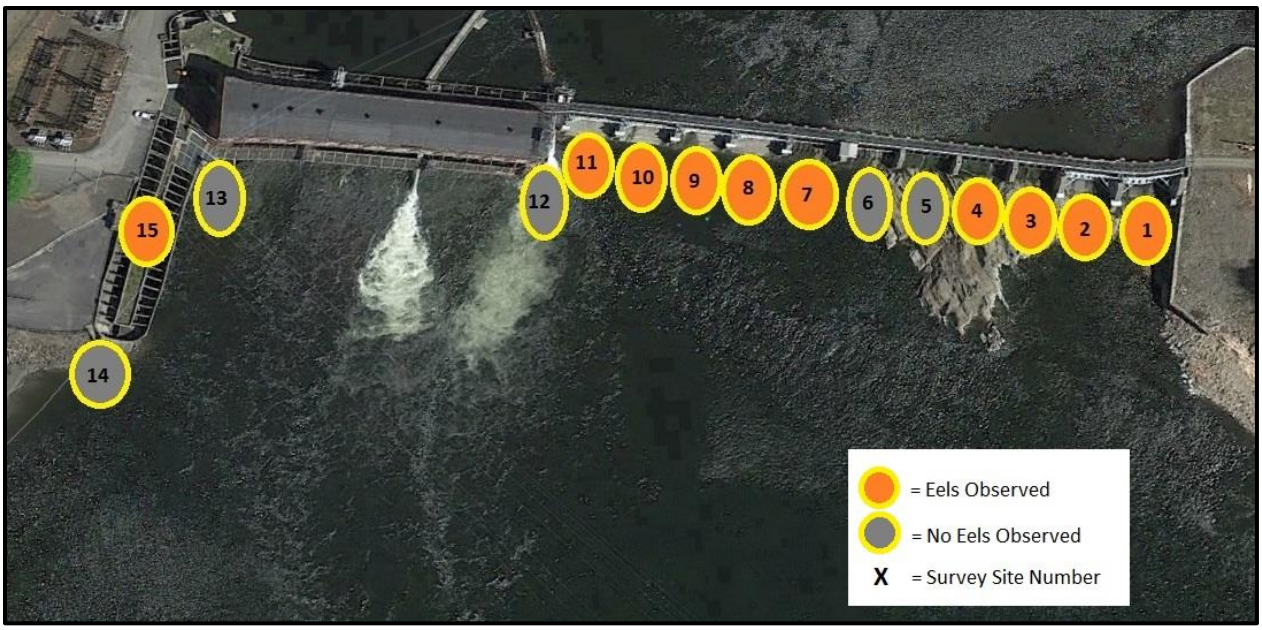


Figure 4.1-1. Vernon nighttime visual survey sites, 2017.

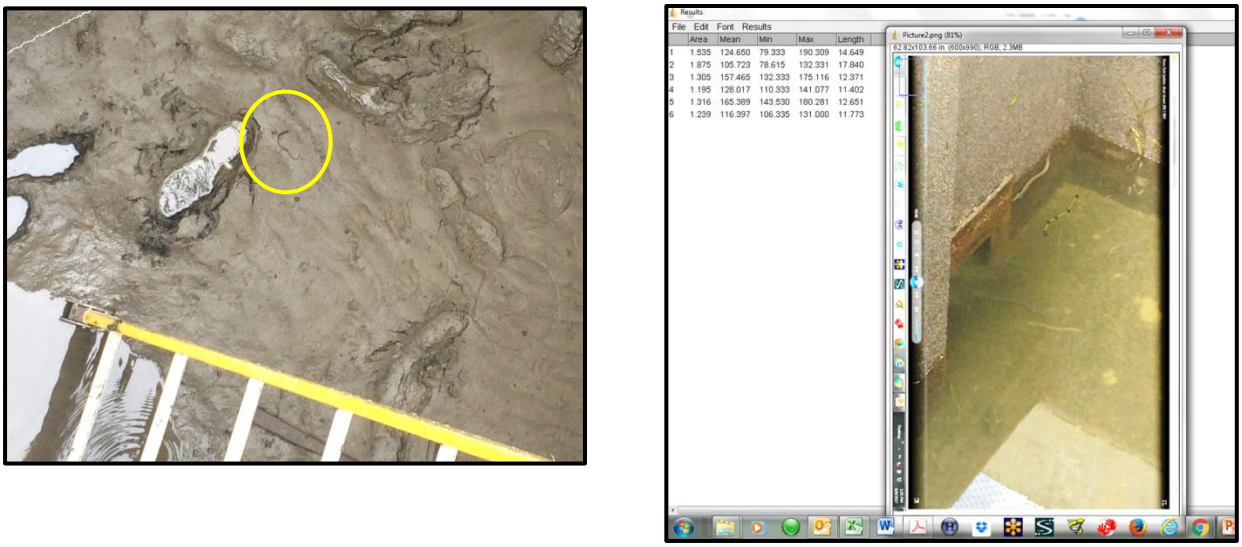

Figure 4.1-2. Examples of Sea Lamprey ammocoetes in a fine sediment deposit (left) and American Eels passing downstream through an orifice, with length estimation using Image-J software (right) during the Vernon fishway dewatering, August 7, 2017.

## 4.2 Temporary Eel Ramp Trap

The temporary eel ramp trap was operated continuously from June 1 to November 8, 2017 and was checked daily, Monday through Friday for catch with the exception that during the first week of operation it was checked daily per requirements of the VFWD Scientific Collection Permit. Overall, 123 eels were collected from the ramp trap from July 5 to September 19. The majority were collected on August 21 (n=43) and August 23 (n=45, Figure 4.2-1), after dewatering of the Vernon fishway. After processing, all eels were released to the Connecticut River from the canoe portage access upstream of Vernon dam.

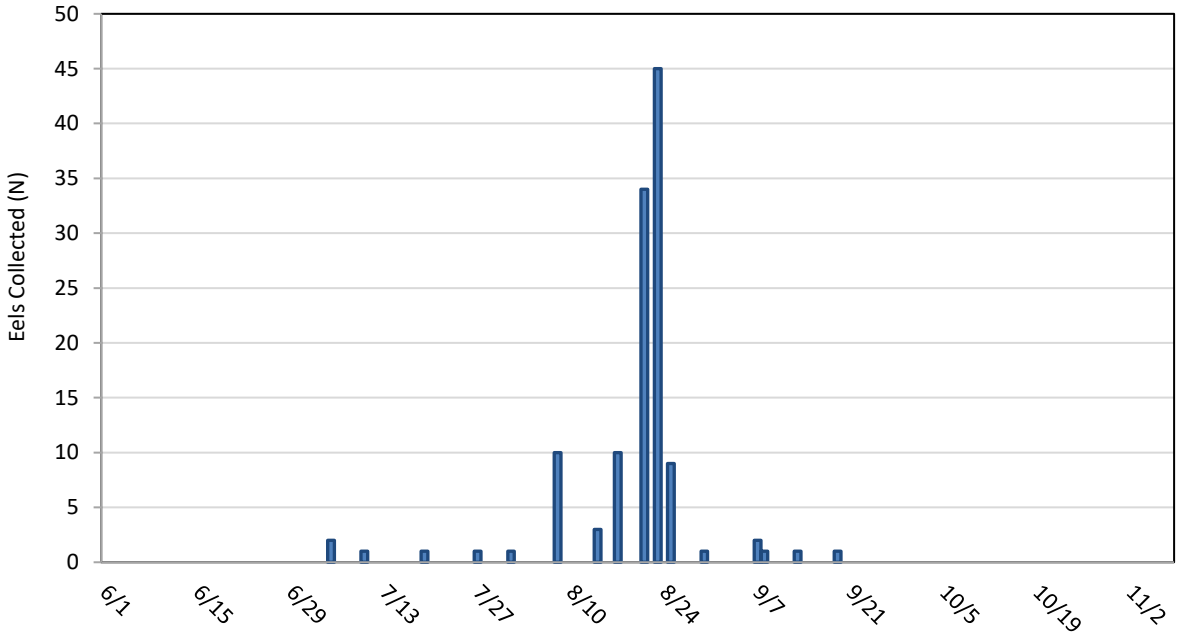


Figure 4.2-1. Number of eels collected by date from the Vernon dam eel ramp trap from June 1 – November 8, 2017.

## 4.3 Length Distribution of Eels

### 4.3.1 Length Distribution of Eels Observed in Visual Surveys

Eels classified in the 6-12 inch size group dominated the visual observations, contributing 61% of all eels observed (Table 4.3-1, Figure 4.3-1). Eels classified in the 12-18 inch group accounted for 35% of the total. One eel was classified in the smallest group, <6 inches, and four eels (3%) were classified in the largest group, >18 inches. The length classification of the eel <6 inches was verified by both biologists conducting the survey. At the fishway survey site (15), the majority of eels observed fell within the 12-18 inch size class. At all remaining sites where observations were made, the majority of eels were within the 6-12 inch size class. All four of the eels greater than 18 inches were observed in the fishway. The one eel

under 6 inches was viewed actively swimming up the bedrock immediately below Tainter gate 1 (site 1) on the New Hampshire side of the dam.

### 4.3.2 Length Distribution of Eels Collected in the Vernon Ramp Trap

Eels collected from the ramp trap ranged from 6.5 to 14.2 inches and averaged 9.6 inches. Overall, the dominant proportion (90%) of eels observed in visual surveys were from 6 to 12 inches long. In the fish ladder, however (site15), the majority were 12 – 18 inches (Figure 4.3-2).

### 4.3.3 Length Distribution of Eels Observed During Fishway Dewatering

Lengths were estimated for 43 (of approximately 120) eels observed in the Vernon fishway during dewatering using digital images. Estimated total lengths ranged from 6.9 to 21.7 inches and averaged 13.2 inches (Figure 4.3-2). Similar to visual survey results for site 15, the majority (56%) of estimated eel lengths fell in the 12–18 inch classification (Figure 4.3-3). This may suggest that larger eels use the fish ladder more than some other monitoring sites, perhaps due to their relative ability to navigate the velocities there.

Table 4.3-1. Length classified counts of eels observed by survey site in nighttime visual surveys, 2017.

| | | **Fishway** | **Flood Gates Below Tainter Gates & Hydraulic Panels** | | | | | **Rocks Below Tainter Gates & Stanchion Bays** | | | | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site number:** | | **15** | **11** | **10** | **9** | **8** | **7** | **4** | **3** | **2** | **1** | |
| Size Class (in.) | < 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | 6 - 12 | 33 | 2 | 8 | 10 | 19 | 3 | 7 | 3 | 5 | 1 | 91 |
| | 12 - 18 | 45 | 0 | 1 | 2 | 2 | 0 | 0 | 2 | 0 | 0 | 52 |
| | > 18 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| **Total** | | **82** | **47** | | | | | **19** | | | | **148** |

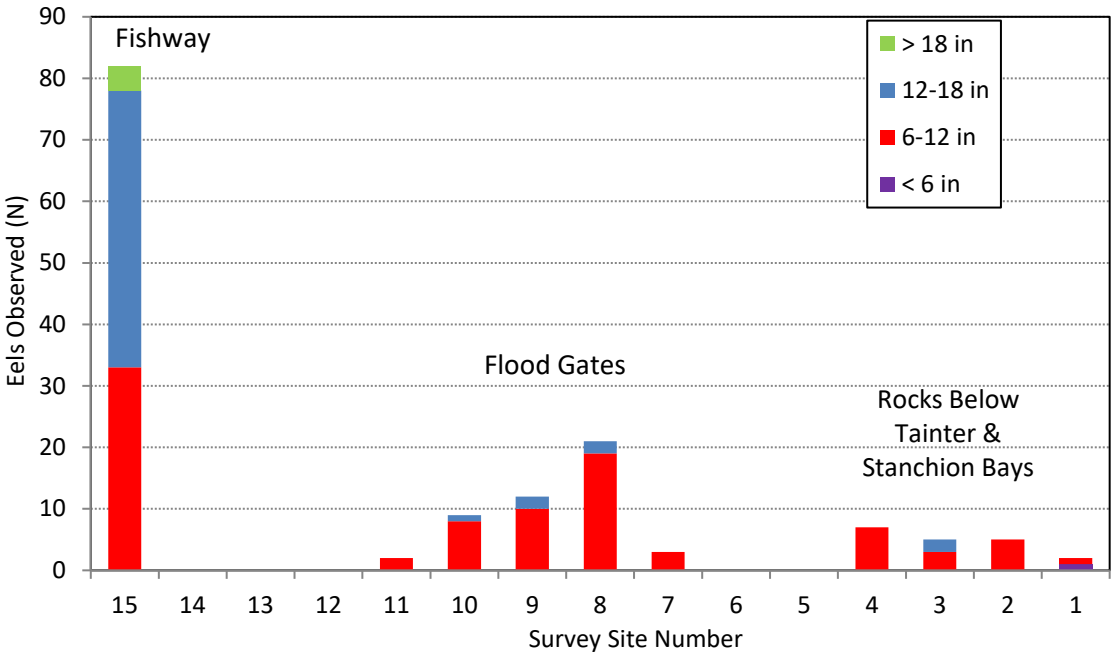


Figure 4.3-1. Length classified counts of eels observed by survey site in nighttime visual surveys, June 1 – November 8, 2017.

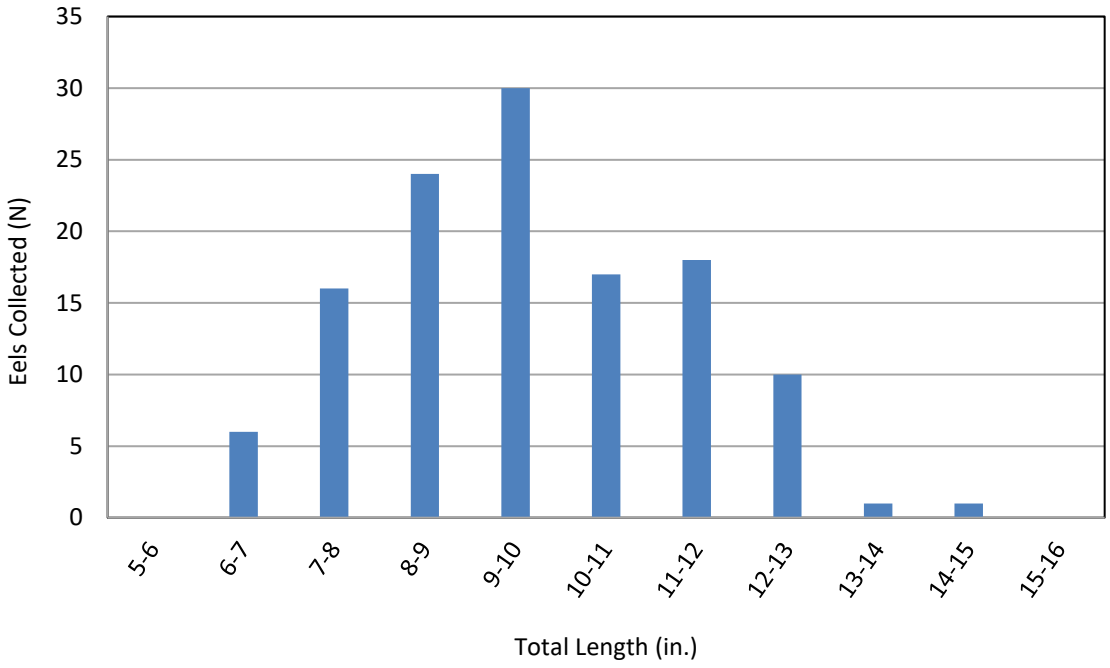


Figure 4.3-2. Length distribution of eels collected from the Vernon dam eel ramp trap from June 1 – November 8, 2017.

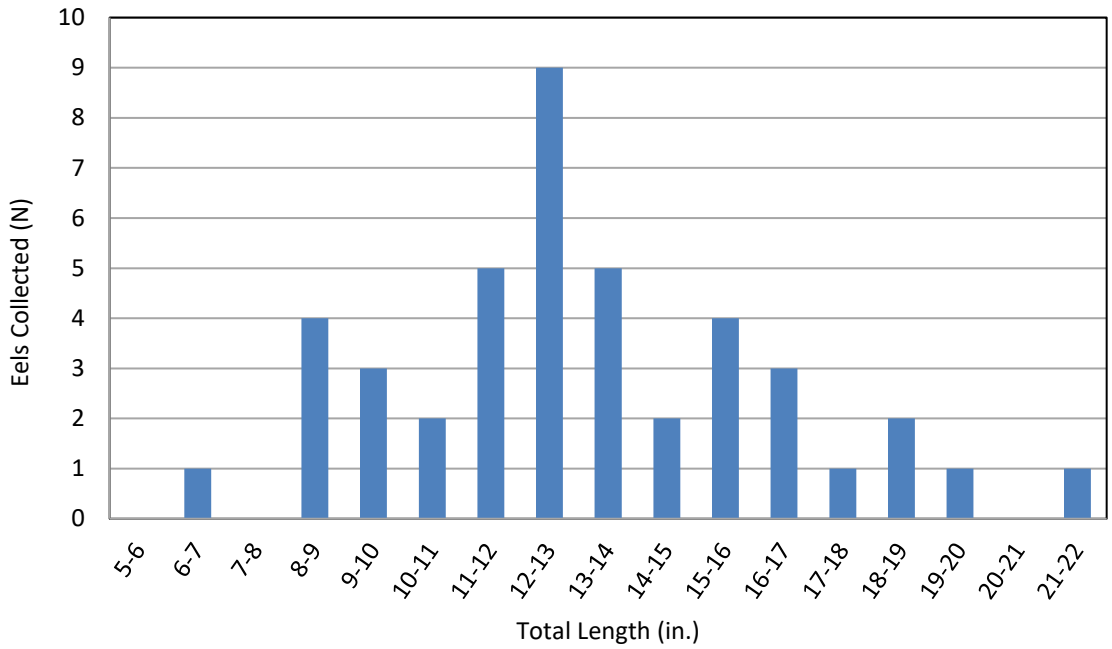


Figure 4.3-3. Length distribution of eels observed in the Vernon fishway during dewatering, August 7, 2017.

## 4.4 Environmental Conditions

The majority of eels observed in visual surveys occurred from mid-June to late August, coincident with the highest observed water temperatures (Figure 4.4-1). The majority of eels collected in the ramp trap occurred during the month of August, later than most observed in visual surveys, and after the fishway was dewatered. All eel collections occurred when water temperatures were relatively high, and 92% (113 of 123) were collected when temperatures exceeded 23°C. Dissolved oxygen quality remained good throughout the study (Figure 4.4-2).

For many diadromous fish species, including American Eel, periods of significant precipitation that lead to higher levels of river discharge may correlate with increased migration volume (Welsh and Liller, 2013). In 2017, local precipitation fell below the 10-year monthly average during June through September, but was higher than average during October (Table 4.4-1). In general, however, the 2017 season was characterized by relatively high and variable river flows in the late spring and early summer, including two distinct periods of spill conditions. Operationally controlled moderate to low flow conditions occurred from early July through late October. A high flow/spill event dominated the end of the season in late October and early November. In general, the greater proportion of eels observed in visual surveys were observed during periods of higher and more variable flows in June and July, however that result may be biased because inside the fishway was eliminated as an observation site after it was dewatered in early August. Visual observation of eels in the fishway is relatively easy compared to other survey sites, not only because of the apparent abundance of eels there, but because the underwater windows allow viewing at a depth that would not be visible at other sites. Observation of eels at other survey sites is generally limited to wetted margins and to depths that could be penetrated with high intensity red lights, which varies with turbidity and air entrainment. As a result, the proportion of eels observed in the fish ladder may be biased.

Lunar illumination has been suggested as a potential covariate with hydraulic conditions influencing upstream eel migration. Low light conditions are thought to promote eel movement, but even with higher levels of lunar illumination, low light conditions can persist from a variety of factors such as increased cloud cover and turbidity (Welsh and Liller, 2013). At Vernon, eel observations were distributed across all moon phases. However, peak collections from the ramp trap on August 21 and 23 (trapped between August 18 – 23), 64% of the seasonal total, occurred during a period of low lunar illumination (Figure 4.4-2).

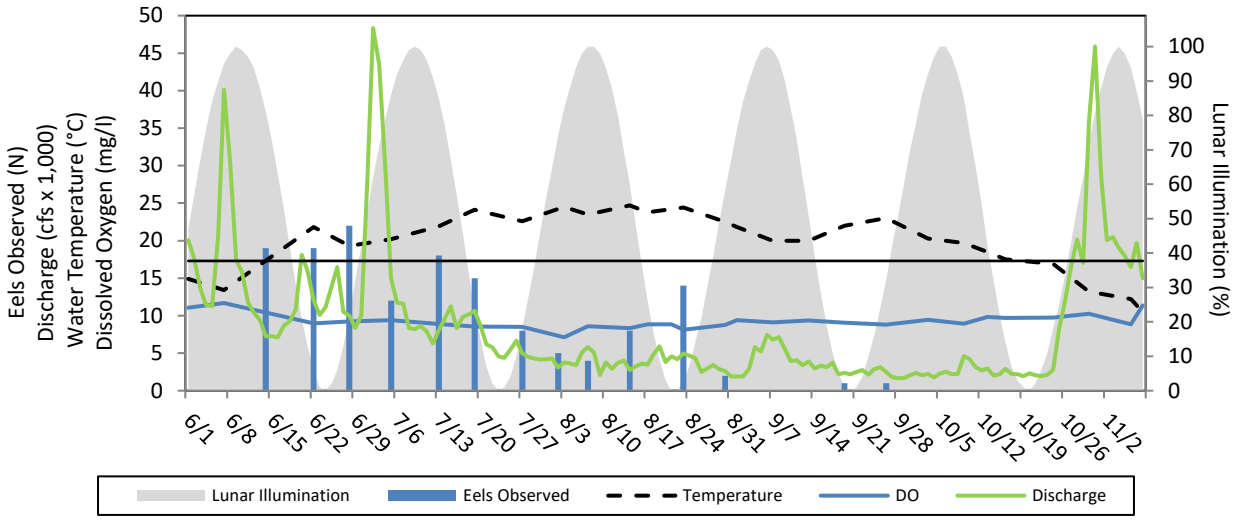


Figure 4.4-1. Number of eels observed in visual surveys by date, with water temperature, dissolved oxygen, lunar illumination, and total discharge. Horizontal line indicates maximum project controlled (non-spill) discharge.

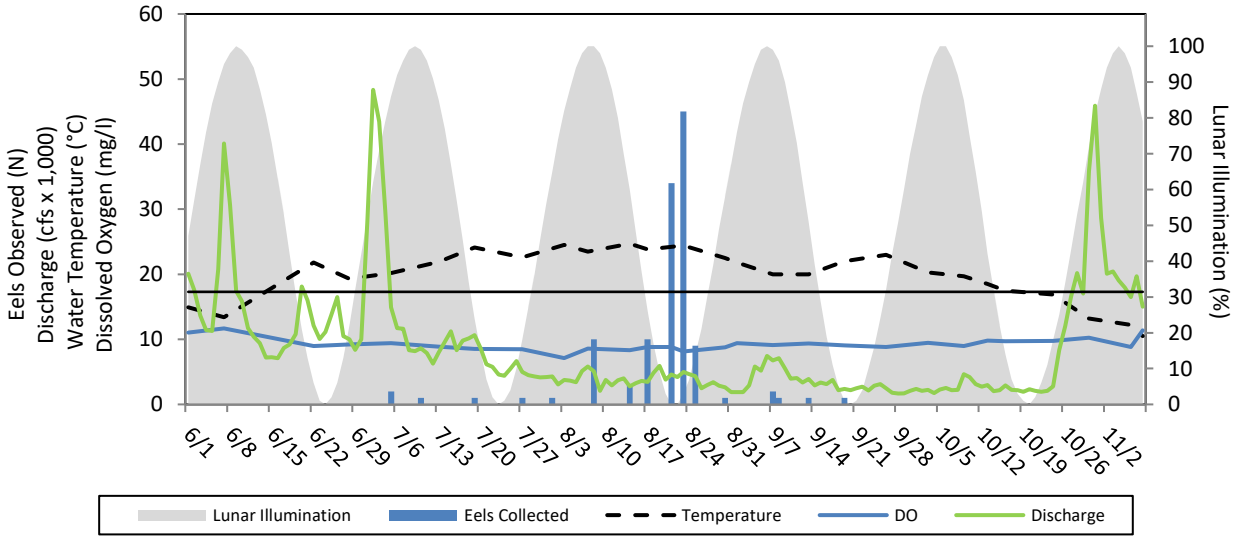


Figure 4.4-2. Number of eels collected from the Vernon eel ramp trap by date, with water temperature, dissolved oxygen, lunar illumination, and total discharge. Horizontal line indicates maximum project controlled (non-spill) discharge.

Table 4.4-1. Monthly cumulative precipitation (inches) at Vernon during June – October 2017 and 10-year average.

| | Jun | Jul | Aug | Sep | Oct |
|---|---|---|---|---|---|
| **2017** | 2.03 | 0.88 | 2.54 | 2.37 | 3.80 |
| **10 YR Avg. (inches)** | 3.79 | 4.65 | 3.60 | 3.66 | 3.34 |
| **% of 10 YR Avg.** | 54 | 19 | 71 | 65 | 114 |

## 5.0 STUDY CONCLUSIONS

Systematic surveys of eel presence/abundance at the Vernon tailrace and spillway in 2017 did not identify any large aggregations of eels staging in pools or attempting to ascend wetted surfaces. However, the majority of eels observed were in the fishway and in areas characterized by leakage flow from stanchion bay gates that drain through the rock outcrop. As in the 2015 and 2016 evaluations, the fishway appeared to be the dominant aggregation point. Some eels observed in the fishway, particularly those observed in the visitor's window, were active, but many, particularly those observed in the counting room window, were sedentary. It is not known how effectively eels ascend the fishway. Based on the anadromous fish passage seasonal count of 581 eels counted using the Vernon fishway, however, some number evidently does successfully ascend it. It is not clear whether the observed sedentary eels were simply resting before continuing upstream migrations, failed to ascend the upper fishway, or were residing for some period in the fishway. A minimum of 115 eels were observed moving downstream of the fishway during its dewatering. Among eels observed in locations other than the fishway, those that were in wetted areas of the rock outcrop in the spillway most closely represented migratory behavior since they had clearly ascended to survey points at higher elevations than downstream water surface elevations.

The Vernon temporary eel ramp trap, operated during late spring, summer and fall, collected 123 eels. Most of those were collected a couple of weeks after dewatering of the fishway, and it is possible that eels that abandoned the fishway then increased the abundance of eels available to collection by the ramp trap. However, it is notable that cessation of fishway operations along with reduced total and operational discharge during the summer resulted in reduced competing flow to the ramp trap, so it was potentially more effective during that period.

The abundance of eels available at Vernon is unknown, and the rate of dispersion via upstream migration of juvenile eels in the Connecticut River has not been documented. It is reasonable, however, to assume abundance at Vernon is substantially less than at downstream barriers, and that their size distribution is larger. Oliveira (1997) reported restricted movement by juvenile American Eels from their initial collection sites, and White and Knights (1997) found that, upstream of the head of tide, the number up immigrating eels decreased rapidly and the average size and age increased, and that the effect of manmade barriers was greater than distance alone. Eel passage counts at the first dam on the Connecticut River, Holyoke

Dam (river mile 87) were in the tens of thousands for the past five years (Normandeau, 2017). In 2014, FirstLight collected and subsequently released nearly 6,000 juvenile eels upstream of Turners Falls dam (river mile 122, Kleinschmidt and Gomez and Sullivan, 2016), though no directed eel trap/passage has been conducted there since 2014.

## 6.0 LITERATURE CITED

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