**PROGRESS REPORT**

**State**: **NEW HAMPSHIRE** **Grant**: **F-61-R-21/F16AF00163**

**Grant Title**: **NEW HAMPSHIRE’S MARINE FISHERIES INVESTIGATIONS**

**Project I**: **DIADROMOUS FISH INVESTIGATIONS**

**Job 3**: **AMERICAN EEL YOUNG-OF-THE-YEAR SURVEY**

Objective: To characterize trends in annual recruitment of young-of-the-year American Eel over time in New Hampshire waters.

Period Covered: April 1, 2017 - March 31, 2018

ABSTRACT

The annual American Eel *Anguilla rostrata* young-of-the-year survey was conducted on the Lamprey River in Newmarket, New Hampshire, for the seventeenth consecutive year and on the Oyster River in Durham, New Hampshire, for the fifth consecutive year. A modified Irish elver ramp was installed under an overhanging section of the fish ladder in the Lamprey River below the Macallen Dam at the head-of-tide. A box trap was setup on the fish ladder at the Oyster River below the Mill Pond Dam at the head-of-tide. The survey was conducted for 10 weeks at both monitoring stations. A total of 4,354 young-of-the-year eels (4,324 glass and 30 brown) were caught in the Lamprey River; a decline from 15,621 observed in 2016. The total number of young-of-the-year eels captured by the box trap at the Oyster River in 2017 has declined by 96% compared to the record high count in 2014. The peak catch per unit effort was 151.7 young-of-the-year eels/hours soak time on the Lamprey River and 9.0 young-of-the-year eels/hours soak time on the Oyster River. At the Lamprey River, the mean length for young-of-the-year glass eels was 63.1 mm (n=205) and brown eels averaged 95.8 mm (n=17). At the Oyster River, the mean length for young-of-the-year glass eels was 62.4 mm (n=393) and brown eels averaged 97.4 mm (n=8). High variability in annual counts make characterization of trends over time difficult and data show that migration timing and rate are affected by changes in water temperature, river discharge, and lunar phase.

## INTRODUCTION

Worldwide declines of eels have been noted (Stone 2003) and a number of studies have drawn attention to a possible Atlantic coast decline in the American Eel *Anguilla rostrata* population. Castonguay et al. (1994) indicated that juvenile American Eel recruitment to the upper St. Lawrence River declined drastically between 1985 and 1992. Haro et al. (2000) also found evidence of a significant decline in the recruitment of American Eels over the same relative time period at various sites from Virginia to Nova Scotia. The lack of long-term American Eel abundance data caused this problem to be addressed by the Atlantic States Marine Fisheries Commission (ASMFC) where they recommended an annual American Eel young-of-the-year survey be conducted by each state on the east coast to collect baseline population data (ASMFC 2000a). Data from these studies are expected to be used to characterize trends in the annual recruitment of the American Eel on the Atlantic coast of North America.

Due to the mating strategy of the American Eel, where adult eels reproduce in the Sargasso Sea and the offspring migrate to freshwater rivers on the northeast coast of North America, trends in recruitment abundance at individual rivers may reflect abundance trends for the entire eel population (Castonguay et al. 1994). The ASMFC American Eel Technical Committee prepared a standard procedures sampling protocol for the young-of-the-year survey in 2000, which stated an objective to sample two locations per state or jurisdiction, but later noted that the purpose and objective of the survey would not be compromised if only one location was sampled. In 2001, the State of New Hampshire (NH) established an annual survey of young-of-the-year eels in the Lamprey River in Newmarket, NH. The goal of this survey is to help distinguish natural variation in annual recruitment and facilitate an understanding of possible long-term trends in eel numbers. Natural variation may be caused by events such as annual changes in ocean currents, river flow, or water temperature, while an overall decline in eel recruitment may be the result of anthropological impacts such as pollution, commercial harvesting, and habitat modification (Haro et al. 2000).

## PROCEDURES

The study was designed according to the ASMFC (2000b) procedures for the American Eel young-of-the-year survey. Sampling methods were updated in 2010 to be standardized with the ASMFC procedures. Each spring, since 2001, a modified Irish elver trap is installed under an overhanging section of the Lamprey River fish ladder below the head-of-tide Macallen Dam (approximately 21 miles from the mouth of the Piscataqua River). As of 2013, a box trap has been installed on the Oyster River fish ladder below the head-of-tide Mill Pond Dam, Durham, NH. Due to poor box trap design at the Oyster River in 2013 that prohibited ascending young-of-the-year eels from dropping into a collection bucket and a late start date, the 2013 data is not included in the time series. The Irish elver trap at the Lamprey River was placed in the enclosed protected area where young-of-the-year eels have been observed swimming through three holes at the base of a cement support wall. The box trap at the Oyster River is located in a more public location and young-of-the-year eels are protected within a locked plywood box. In both sampling locations young-of-the-year eels are drawn to the freshwater flowing down the trap's ramp. The young-of-the-year eels climb the trap's ramp through Enkamat material (an erosion prevention mat constructed of monofilament) and drop into a sampling bucket at the end of the ramp.

Both sampling stations were monitored daily four times per week, generally Monday through Thursday, when American Eels were first observed arriving. Department biologists monitored the Lamprey River sampling station and a volunteer group monitored the Oyster River station. American Eels that were collecting in the sampling bucket over the weekend were passed upstream each Sunday to initiate the four-day sampling period each week. The sampling design requires a six-week minimum sampling period. To assure sampling occurs during peak young-of-the-year migration period additional weeks may be sampled.

For the trap to attract young-of-the-year American Eels there must be approximately 1 to 2 mm of consistent freshwater flow down the Enkamat mesh lining the ramp. A garden hose provided the gravity-fed water supply to the ramp by connecting a screen-covered funnel, submerged in freshwater above each dam, to a perforated PVC tube placed along the upper horizontal surface of the ramp. The perforated PVC tube and hose distributes an even stream of water down the ramp. A long-handled bristle brush was used to clean the PVC pipe if it became clogged with debris or algae.

Each day of sampling, a qualitative judgment was made on the ramp performance. Ramp performance at the time of the survey was rated as good, fair, poor, or void. The ratings were an attempt to account for the effect of ramp performance on the number of captured young-of-the-year American Eels. A rating of good indicated a steady, even flow of water down the ramp; fair indicated more than 50% of the holes were clogged and flow restricted to one side of the ramp; poor indicated that more than 90% of the holes were clogged and very little water reached the trap entrance; and void indicated all of the holes were clogged and no water reached the trap entrance or that the trap was knocked over for any reason (e.g., tide, floods, etc.). Before the end of each sampling day, every effort was made to return the trap, if necessary, to good performance by cleaning the tube, adjusting the flow, or repositioning the trap.

Young-of-the-year American Eels represent a single year class and are divided into two stages: glass eels and brown eels (elvers). Glass eels generally range from 45 to 70 mm long and elvers range from 65 to 100 mm long. The glass eel stage was then classified further to one of seven pigmentation stages based on the methods of Haro and Krueger (1988). Each sampling day, the young-of-the-year eels were counted and a subsample of 60 eels (preferably glass eels) was measured and weighed twice per week. All eels were characterized as glass eels or elvers. All eels were then released above the head-of-tide dam into freshwater.

If the young-of-the-year American Eels in the bucket were too numerous to count, their numbers were estimated using a volumetric sampling technique recommended by the ASMFC (2000b) and similar to the method used by Jessop (2000). Young-of-the-year eels were placed into a graduated cylinder until an eel volume of 25 mL was reached. The young-of-the-year eels in the graduated cylinder were counted and released to freshwater. This was repeated six times and the mean number of eels per milliliter was calculated. The remaining young-of-the-year eels were then placed into a graduated cylinder and the total remaining volume of young-of-the-year eels was recorded. The final estimated number of young-of-the-year eels equals the total remaining volume of eels (mL) multiplied by the calibrated average number of eels per milliliter plus the number of eels counted in each 25 mL calibration.

Additionally, during each site visit, lunar phase and water temperature was recorded and a note was made if the dam’s flood gates were open. Discharge flows, recorded in cubic feet per second, were downloaded from the United States Geological Survey Lamprey River station located upstream from the sampling location to provide daily mean discharge for each sampling day.

## RESULTS

In 2017, monitoring stations were installed April 17 on the Lamprey and Oyster rivers. The elver traps were checked daily to note the presence of American Eels and the temperature of the water was recorded. The ramps and PVS tube were cleaned daily to assure of good flow performance. Young-of-the-year eels were first observed on April 18, 2017, at the Oyster River and April 26, 2017, at the Lamprey River. Both sampling sites were monitored until the fourth week of June; ten weeks of monitoring (Tables 1.3-1 and 1.3-2). A total of 4,354 young-of-the-year eels (4,324 glass and 30 brown) were caught in the Lamprey River and 621 young-of-the-year eels (610 glass and 11 brown) were caught in the Oyster River. Peak young-of-the-year eel abundances at both sampling sites occurred near a new moon and declining river discharge flows (Figures 1.3-1 and 1.3-2). The Lamprey River had one peak of eels on May 22, with a total of 3,185 eels (Table 1.3-1 and Figure 1.3-1). The Oyster River had two peaks, which occurred on May 3, with 205 eels and May 23, with 140 eels (Table 1.3-2 and Figure 1.3-2).

The peak CPUE was 151.7 young-of-the-year eels/hour soak time on the Lamprey River and 9.0 young-of-the-year eels/hour soak time on the Oyster River (Tables 1.3-3 and 1.3-4). The annual CPUE on the Lamprey was 4.5 young-of-the-year eels/hour soak time and the Oyster was 0.6 young-of-the-year eels/hour soak time. The daily mean river discharge ranged from 126 $ft^3/s$ to 898 $ft^3/s$ on the Lamprey River and from 5 $ft^3/s$ to 81 $ft^3/s$ on the Oyster River (Tables 1.3-1 and 1.3-2). Before eels were observed, fresh water temperatures on the Lamprey and Oyster rivers ranged between 11°C and 15°C. Freshwater temperature in the Lamprey and Oyster rivers ranged from 10°C to 24°C during the sampling period that eels were monitored. Ramp performance was rated good throughout all of the sampling period at both locations.

At the Lamprey River, the mean length for the young-of-the-year glass eels was 63.1 mm (n=205) and brown eels averaged 95.8 mm (n=17) (Table 1.3-5). Mean length for the young-of-the-year glass eels at the Oyster River was 62.4 mm (n=393) and brown eels averaged 97.4 mm (n=8) (Table 1.3-6). Glass eel pigmentation stages one through seven were observed at both rivers in 2017.

DISCUSSION

Young-of-the-year American Eel surveys typically have high variability in the number of American eels observed (Shepard 2014). The total number of young-of-the-year eels captured by the Irish elver ramp at the Lamprey River (4,354) in 2017 was lower than 2016 (15,621), but higher than the 1,959 sampled in 2015 (Table 1.3-3). The total number of young-of-the-year eels captured by the box trap at the Oyster River in 2017 has declined by 96% from the record high in 2014 (Table 1.3-4). The annual totals of young-of-the-year eels have been variable and no trend in recruitment is apparent in the Lamprey River; however, there is a declining trend in the Oyster River.

It has been shown that temperature plays an important role on glass eel migration into freshwater. Glass eels are sensitive to water temperature and are capable of detecting 1°C changes in water temperature (Kim et al. 2002).

Sorensen and Bianchini (1986), Moriarty (1987), and Haro and Krueger (1988), reported the onset of eel migration into freshwater coinciding with an increase in water temperature. Other studies have also observed a correlation between peaks in eel migrations and increased water temperatures (Gascuel 1986; Tongiorgi et al. 1986; Tosi et al. 1990; Martin 1995; Edeline et al. 2006). However, Sorensen and Bianchini (1986) observed that once water temperature exceeded a threshold of 10–15°C it appeared to have minimal, if any, influence on migration. Similar to these previous findings, elvers were observed in 2017 migrating in the Lamprey and Oyster rivers when freshwater temperatures were above 10°C (Tables 1.3-1 and 1.3-2). The temperature on the first day eels were observed in both the Lamprey and Oyster rivers was between the threshold range stated by Sorensen and Bianchini (1986). Elver migration into NH monitored rivers typically occurs when reaching a minimum water temperature threshold of 10–15°C.

River discharge and its effects on water velocity have been found to delay or prevent the upstream migration of elvers (Jessop 2000; Jessop and Harvie 2003). High levels of discharge could impede the upstream movement of glass eels in the Lamprey River. Overton and Rulifson (2009) observed higher numbers of eels when discharge was below 150 $m^3/s$ and no eels when discharge went over 650 $m^3/s$ in the Roanoke River, North Carolina. Although the discharge range on the Roanoke River is greater than both study sites in NH, the pattern of young-of-the-year eels decreasing at higher discharge rates is observed in both systems. During 2017, in the Lamprey River, the highest number of eels (97.9%) were observed in the trap when discharge levels were below 250 $ft^3/s$ (7.1 $m^3/s$), while at the Oyster River, 90.7% of eels were observed when discharge levels were below 45 $ft^3/s$ (1.3 $m^3/s$) (Figures 1.3-1 and 1.3-2). Heavy flows in April and May that may occur as a result of open flood gates at the dam on the Lamprey River, likely hinder eels from moving upstream in the beginning of their migration. These high flows could impede eels from approaching the entrance to the traps or may cause them to burrow into sediment and halt their upstream migrations. The flood gates at the Lamprey River were open during sampling between 4/26 to 4/28 and 5/8 to 5/17. During this period, only five eels were observed; suggesting that increased river discharge negatively impacts the upstream migration of young-of-the-year eels.

Lunar phase has been shown to impact elver migration. Deelder (1958), in a study of European Eels *Anguilla anguilla*, suggested that phases of the moon act upon the migration of European Eels in an indirect way when higher tides during the full or new moon carry them further upstream. The peaks in young-of-the-year American Eel density occurred near the new moon on both the

Oyster and Lamprey rivers (Figure 1.3-1 and 1.3-2). Typically, higher tides associated with a full moon are related to increased densities of young-of-the-year American Eels, but an increase in river discharge before the full moon could prohibit elvers from upstream migration. In May and June of this year, the observed increases in river discharge before the full moon could have slowed migration and explain the low American Eel densities in both rivers.

While the density of migrating young-of-the-year American Eels has been highly variable from year to year, mean lengths of young-of-the-year eels are consistent. Mean length of glass eels varies by latitude, with smaller glass eels in the southern portions of the range (Cairns et al. 2014). According to Cairns et al. (2014), the latitude for NH should have a mean length for glass eels around 60 mm. Mean lengths of glass eels on the Lamprey River were consistent with these findings between 2012 and 2017, ranging from 59.8 to 63.1 mm (Table 1.3-5). The mean lengths of glass eels at the Oyster River have also been consistent with Cairns et al. (2014), ranging from 59.2 to 62.4 mm between 2014 and 2017 (Table 1.3-6). The constancy of glass eel lengths from year to year can be attributed to latitude and the migration time from spawning grounds in the Sargasso Sea.

In summary, numbers of young-of-the-year American Eels returning were relatively low at both the Lamprey and Oyster rivers in 2017. The increases in river discharge at both sites in May and June may explain the decrease in eels. The high inter-annual variability of observed American eels makes characterization of trends difficult; however, there is a declining trend in the Oyster River. Environmental factors may be influencing the timing and abundance of young-of-the-year eel migration. Temperature plays a role in the timing of migration into freshwater, with movement beginning above a threshold level. River discharge can also affect the number of migrating glass eels observed at sampling stations, with high discharge rates decreasing glass eel densities and peak passage being associated with low flow rates. While many environmental factors influence the abundance of migrating young-of-the-year eels, mean length is associated with latitude. Further annual surveys in NH, combined with other states along the east coast of the U.S., will likely characterize trends in the young-of-the-year eel recruitment over time. The combination of these studies should allow the ASMFC to establish a qualitative appraisal of the annual recruitment of American Eel to the U.S. Atlantic coast.

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Table 1.3-1. Data collected from the American Eel young-of-the-year survey using a modified Irish elver trap in the Lamprey River, Newmarket, New Hampshire, 2017.

| Date | Soak time (h) | Freshwater temperature (°C) | Moon phase[a] | Daily mean discharge ($ft^3/s$)[b] | Ramp performance | Number of eels | | CPUE (# eels/hr soak time) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Glass | Brown | |
| 4/18/2017 | 24.25 | 15 | Last | 382 | good | 0 | 0 | 0.0 |
| 4/19/2017 | 24.75 | 13 | **Last** | 320 | good | 0 | 0 | 0.0 |
| 4/20/2017 | 24.25 | 12 | Last | 293 | good | 0 | 0 | 0.0 |
| 4/21/2017 | 21.50 | 12 | Last | 330 | good | 0 | 0 | 0.0 |
| 4/25/2017 | 22.00 | 11 | New | 389 | good | 0 | 0 | 0.0 |
| 4/26/2017 | 27.50 | 11 | **New** | 592 | good | 2 | 0 | 0.1 |
| 4/27/2017 | 19.50 | 11 | New | 756 | good | 0 | 0 | 0.0 |
| 4/28/2017 | 24.25 | 11 | New | 694 | good | 0 | 0 | 0.0 |
| 5/1/2017 | 25.00 | 15 | First | 392 | good | 10 | 0 | 0.4 |
| 5/2/2017 | 23.50 | 13 | First | 512 | good | 19 | 3 | 0.9 |
| 5/3/2017 | 24.00 | 12 | **First** | 643 | good | 4 | 0 | 0.2 |
| 5/4/2017 | 24.00 | 12 | First | 692 | good | 0 | 0 | 0.0 |
| 5/8/2017 | 27.00 | 13 | Full | 758 | good | 2 | 0 | 0.1 |
| 5/9/2017 | 21.00 | 12 | Full | 611 | good | 0 | 0 | 0.0 |
| 5/10/2017 | 24.25 | 12 | **Full** | 480 | good | 0 | 0 | 0.0 |
| 5/11/2017 | 25.50 | 12 | Full | 411 | good | 0 | 0 | 0.0 |
| 5/16/2017 | 25.50 | 12 | Last | 735 | good | 0 | 0 | 0.0 |
| 5/17/2017 | 26.50 | 14 | Last | 641 | good | 1 | 0 | 0.0 |
| 5/18/2017 | 20.50 | 16 | Last | 494 | good | 0 | 1 | 0.0 |
| 5/19/2017 | 24.75 | 19 | **Last** | 388 | good | 28 | 8 | 1.5 |
| 5/22/2017 | 21.00 | 18 | Last | 221 | good | 3,183 | 2 | 151.7 |
| 5/23/2017 | 22.50 | 18 | New | 239 | good | 916 | 7 | 41.0 |
| 5/24/2017 | 25.75 | 17 | New | 242 | good | 96 | 5 | 3.9 |
| 5/25/2017 | 21.75 | 17 | **New** | 230 | good | 44 | 4 | 2.2 |
| 5/30/2017 | 23.50 | 15 | First | 418 | good | 2 | 0 | 0.1 |
| 5/31/2017 | 23.00 | 15 | First | 354 | good | 0 | 0 | 0.0 |
| 6/1/2017 | 20.00 | 15 | **First** | 324 | good | 1 | 0 | 0.1 |
| 6/2/2017 | 24.00 | 16 | First | 315 | good | 2 | 0 | 0.1 |
| 6/5/2017 | 28.25 | 16 | First | 230 | good | 0 | 0 | 0.0 |
| 6/6/2017 | 22.50 | 15 | Full | 438 | good | 0 | 0 | 0.0 |
| 6/7/2017 | 25.00 | 13 | Full | 809 | good | 1 | 0 | 0.0 |
| 6/8/2017 | 22.00 | 14 | Full | 898 | good | 0 | 0 | 0.0 |
| 6/13/2017 | 26.25 | 22 | Full | 252 | good | 6 | 0 | 0.2 |
| 6/14/2017 | 22.25 | 22 | Full | 205 | good | 3 | 0 | 0.1 |
| 6/15/2017 | 24.00 | 23 | Last | 184 | good | 2 | 0 | 0.1 |
| 6/16/2017 | 30.50 | 23 | Last | 143 | good | 0 | 0 | 0.0 |
| 6/20/2017 | 24.00 | 22 | Last | 142 | good | 0 | 0 | 0.0 |
| 6/21/2017 | 24.00 | 22 | New | 143 | good | 1 | 0 | 0.0 |
| 6/22/2017 | 24.00 | 23 | New | 144 | good | 1 | 0 | 0.0 |
| 6/23/2017 | 24.00 | 23 | New | 126 | good | 0 | 0 | 0.0 |

[a] Moon phase in bold is the actual day of that moon phase.
[b] Provisional data subject to revision (http://waterdata.usgs.gov/nh/nwis/current/?type=flow).

Table 1.3-2. Data collected from the American Eel young-of-the-year survey using a box trap in the Oyster River, Durham, New Hampshire, 2017.

| Date | Soak time (h) | Freshwater temperature (°C) | Moon phase[a] | Daily mean discharge ($ft^3/s$)[b] | Ramp performance | Number of eels | | CPUE (# eels/hr soak time) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Glass | Brown | |
| 4/18/2017 | 26.00 | 14 | Last | 23 | good | 15 | 0 | 0.6 |
| 4/19/2017 | 23.50 | 12 | **Last** | 21 | good | 66 | 0 | 2.8 |
| 4/20/2017 | 26.00 | 13 | Last | 21 | good | 5 | 0 | 0.2 |
| 4/21/2017 | 21.50 | 10 | Last | 31 | good | 23 | 0 | 1.1 |
| 4/25/2017 | 22.00 | 11 | New | 26 | good | 18 | 0 | 0.8 |
| 4/26/2017 | 27.50 | 10 | **New** | 76 | good | 6 | 0 | 0.2 |
| 4/27/2017 | 19.50 | 10 | New | 69 | good | 19 | 0 | 1.0 |
| 4/28/2017 | 24.00 | 10 | New | 52 | good | 0 | 0 | 0.0 |
| 5/2/2017 | 24.00 | 11 | First | 56 | good | 17 | 0 | 0.7 |
| 5/3/2017 | 22.75 | 11 | **First** | 44 | good | 205 | 0 | 9.0 |
| 5/4/2017 | 24.00 | 10 | First | 30 | good | 0 | 0 | 0.0 |
| 5/5/2017 | 24.00 | 10 | First | 34 | good | 3 | 0 | 0.1 |
| 5/9/2017 | 26.00 | 10 | Full | 33 | good | 0 | 0 | 0.0 |
| 5/10/2017 | 22.00 | 10 | **Full** | 27 | good | 0 | 0 | 0.0 |
| 5/11/2017 | 24.00 | 10 | Full | 24 | good | 0 | 0 | 0.0 |
| 5/12/2017 | 23.00 | 10 | Full | 22 | good | 0 | 0 | 0.0 |
| 5/16/2017 | 26.50 | 11 | Last | 60 | good | 1 | 0 | 0.0 |
| 5/17/2017 | 21.50 | 14 | Last | 42 | good | 1 | 0 | 0.0 |
| 5/18/2017 | 24.00 | 16 | Last | 31 | good | 0 | 0 | 0.0 |
| 5/19/2017 | 24.00 | 19 | **Last** | 24 | good | 6 | 1 | 0.3 |
| 5/23/2017 | 27.00 | 16 | New | 22 | good | 137 | 3 | 5.2 |
| 5/24/2017 | 22.00 | 15 | New | 18 | good | 15 | 1 | 0.7 |
| 5/25/2017 | 23.00 | 14 | **New** | 16 | good | 34 | 0 | 1.5 |
| 5/26/2017 | 25.00 | 12 | New | 73 | good | 12 | 0 | 0.5 |
| 5/30/2017 | 27.00 | 13 | First | 21 | good | 1 | 0 | 0.0 |
| 5/31/2017 | 23.75 | 15 | First | 19 | good | 4 | 0 | 0.2 |
| 6/1/2017 | 21.00 | 12 | **First** | 33 | good | 0 | 0 | 0.0 |
| 6/2/2017 | 29.25 | 15 | First | 25 | good | 0 | 0 | 0.0 |
| 6/6/2017 | 27.00 | 11 | Full | 53 | good | 3 | 0 | 0.1 |
| 6/7/2017 | 21.75 | 10 | Full | 81 | good | 0 | 0 | 0.0 |
| 6/8/2017 | 26.25 | 13 | Full | 52 | good | 0 | 0 | 0.0 |
| 6/9/2017 | 26.00 | 16 | **Full** | 34 | good | 0 | 0 | 0.0 |
| 6/13/2017 | 27.25 | 24 | Full | 13 | good | 1 | 0 | 0.0 |
| 6/14/2017 | 21.75 | 22 | Full | 10 | good | 1 | 3 | 0.2 |
| 6/15/2017 | 23.75 | 20 | Last | 9 | good | 10 | 3 | 0.5 |
| 6/16/2017 | 24.50 | 18 | Last | 9 | good | 6 | 0 | 0.2 |
| 6/20/2017 | 23.00 | 21 | Last | 9 | good | 0 | 0 | 0.0 |
| 6/21/2017 | 24.00 | 20 | New | 8 | good | 1 | 0 | 0.0 |
| 6/22/2017 | 24.00 | 22 | New | 6 | good | 0 | 0 | 0.0 |
| 6/23/2017 | 24.00 | 22 | New | 5 | good | 0 | 0 | 0.0 |

[a] Moon phase in bold is the actual day of that moon phase.
[b] Provisional data subject to revision (http://waterdata.usgs.gov/nh/nwis/current/?type=flow).

Table 1.3-3. Annual summary of the American Eel young-of-the-year survey in the Lamprey River, Newmarket, New Hampshire, 2001–2017.

| Year | Monitoring period | Date and count first observed in trap | Peak CPUE (# eels/ hour soak time) | Date of peak CPUE | Total number observed during peak | Mean annual CPUE | Total number of eels observed during year |
|---|---|---|---|---|---|---|---|
| 2001 | May 1-June 7 | May 1 (4) | 111.8 | May 7 | 2,655[a] | 10.9 | 6,356[a] |
| 2002 | April 19-May 23 | April 19 (15) | 391.8 | April 20 | 9,600[a] | 30.0 | 17,799[a] |
| 2003 | April 22-July 31[b] | April 30 (5) | 65.6 | July 7 | 1,559[a] | 4.7 | 6,165[a] |
| 2004 | April 13-July 30 | April 20 (1) | 20.0 | July 8,9 | 490/525 | 3.5 | 5,252 |
| 2005 | April 18-July 28[c] | April 21 (1) | 12.7 | July 14 | 314 | 1.5 | 2,095 |
| 2006 | April 11-May 11[d] | April 14 (50) | 26.3 | April 25 | 571 | 5.5 | 2,637 |
| 2007 | April 26–July 26 | May 8 (6) | 18.9 | July 26 | 515[a] | 0.9 | 1,240[a] |
| 2008 | April 22–August 1 | May 22 (2) | 14.4 | July 10 | 231 | 1.0 | 1,361 |
| 2009 | April 21-June 18 | April 27 (1) | 100.4 | June 9 | 2,559 | 8.3 | 6,385 |
| 2010 | April 26-July 8 | April 26 (12) | 1.3 | May 26 | 25 | 0.2 | 208 |
| 2011 | May 3-July 29 | May 3 (3) | 14.4 | July 13 | 285 | 1.4 | 1,491 |
| 2012 | April 3-July 26 | April 23 (998) | 50.5 | April 23 | 998 | 2.8 | 4,213 |
| 2013 | April 16-June 14 | April 19 (1) | 244.1 | May 9 | 6,407 | 40.0 | 35,036 |
| 2014 | April 15-June 23 | May 5 (3) | 65.1 | June 11 | 1,806 | 12.7 | 8,449 |
| 2015 | April 15–June 24 | May 5 (4) | 13.8 | May 15 | 339 | 2.7 | 1,959 |
| 2016 | April 15-June 23 | April 20 (1) | 261.8 | May 17 | 7,396 | 17.1 | 15,621 |
| 2017 | April 17-June 23 | April 26 (2) | 151.7 | May 22 | 3,185 | 4.5 | 4,354 |

[a] Values estimated.
[b] Two of the weeks were checked only once per week.
[c] Irish elver ramp was removed on May 25 and 26 due to high tides and high precipitation.
[d] Irish elver ramp was destroyed due to floods.

Table 1.3-4. Annual summary of the American Eel young-of-the-year survey in the Oyster River, Durham, New Hampshire, 2014–2017.

| Year | Monitoring period | Date and count first observed in trap | Peak CPUE (#eels/hour soak time) | Date of peak CPUE | Total number observed during peak | Mean annual CPUE | Total number of eels observed during year |
|---|---|---|---|---|---|---|---|
| 2013 | May 14-July 25 | Data not included due to late start date and box trap design problems | | | | | |
| 2014 | April 15-June 24 | April 23 (47) | 159.1 | May 13 | 4,151 | 15.9 | 17,609 |
| 2015 | April 15-June 25 | May 4 (7) | 42.6 | May 13 | 1,034 | 7.0 | 5,266 |
| 2016 | April 15-June 23 | April 19 (2) | 31.9 | April 21 | 814 | 3.8 | 3,608 |
| 2017 | April 17-June 23 | April 18 (15) | 9.0 | May 3 | 205 | 0.6 | 621 |

Table 1.3-5. Mean lengths of sampled young-of-the-year American Eels by life stage in the Lamprey River, Newmarket, New Hampshire, 2011–2017.

| | | Year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2012 | | 2013 | | 2014 | | 2015 | | 2016 | | 2017 | |
| Life stage | Pigmentation stage | Mean length (mm) | Count of length | Mean length (mm) | Count of length | Mean length (mm) | Count of length | Mean length (mm) | Count of length | Mean length (mm) | Count of length | Mean length (mm) | Count of length |
| Glass | 1 | - | 0 | 59.5 | 48 | 63.1 | 18 | 59.0 | 3 | 57.9 | 96 | 62.4 | 16 |
| | 2 | 56.4 | 13 | 60.4 | 60 | 61.4 | 88 | 59.9 | 68 | 60.3 | 326 | 62.1 | 39 |
| | 3 | 58.6 | 219 | 61.0 | 59 | 61.2 | 77 | 60.6 | 93 | 61.0 | 170 | 62.9 | 36 |
| | 4 | 59.1 | 228 | 61.4 | 161 | 61.4 | 154 | 60.9 | 77 | 59.9 | 90 | 63.7 | 37 |
| | 5 | 58.9 | 193 | 61.2 | 133 | 60.0 | 144 | 59.8 | 76 | 58.9 | 145 | 63.3 | 50 |
| | 6 | 59.7 | 375 | 62.3 | 136 | 61.7 | 185 | 60.9 | 116 | 59.4 | 237 | 63.1 | 18 |
| | 7 | 62.9 | 209 | 62.1 | 162 | 63.5 | 116 | 63.7 | 84 | 62.2 | 115 | 65.8 | 9 |
| | Combined | 59.8 | 1,237 | 61.5 | 759 | 61.5 | 782 | 61.0 | 517 | 60.0 | 1,179 | 63.1 | 205 |
| Brown | - | 92.0 | 44 | 90.1 | 8 | 84.5 | 25 | 97.9 | 86 | 92.3 | 14 | 95.8 | 17 |
| Annual average (all stages) | | 60.9 | 1,281 | 61.8 | 767 | 62.2 | 807 | 66.3 | 603 | 60.4 | 1,193 | 65.6 | 222 |

Table 1.3-6. Mean lengths of sampled young-of-the-year American Eels by life stage in the Oyster River, Durham, New Hampshire, 2014–2017.

| | | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2014 | | 2015 | | 2016 | | 2017 | |
| Life stage | Pigmentation stage | Mean length (mm) | Count of length | Mean length (mm) | Count of length | Mean length (mm) | Count of length | Mean length (mm) | Count of length |
| Glass | 1 | 62.1 | 181 | 57.9 | 32 | 58.3 | 79 | 61.2 | 88 |
| | 2 | 60.8 | 168 | 59.6 | 72 | 59.5 | 245 | 62.8 | 165 |
| | 3 | 60.4 | 200 | 59.4 | 108 | 59.3 | 199 | 62.6 | 74 |
| | 4 | 60.4 | 183 | 58.9 | 77 | 58.6 | 158 | 63.3 | 38 |
| | 5 | 60.0 | 188 | 59.6 | 86 | 58.4 | 98 | 62.1 | 13 |
| | 6 | 60.3 | 170 | 59.5 | 55 | 59.3 | 50 | 61.9 | 8 |
| | 7 | 61.8 | 94 | 62.7 | 23 | 63.9 | 26 | 61.0 | 7 |
| | Combined | 60.8 | 1,184 | 59.4 | 453 | 59.2 | 855 | 62.4 | 393 |
| Brown | - | 98.4 | 8 | 93.9 | 88 | 97.2 | 105 | 97.4 | 8 |
| Annual average (all stages) | | 61.0 | 1,192 | 65.0 | 541 | 63.3 | 960 | 63.1 | 401 |

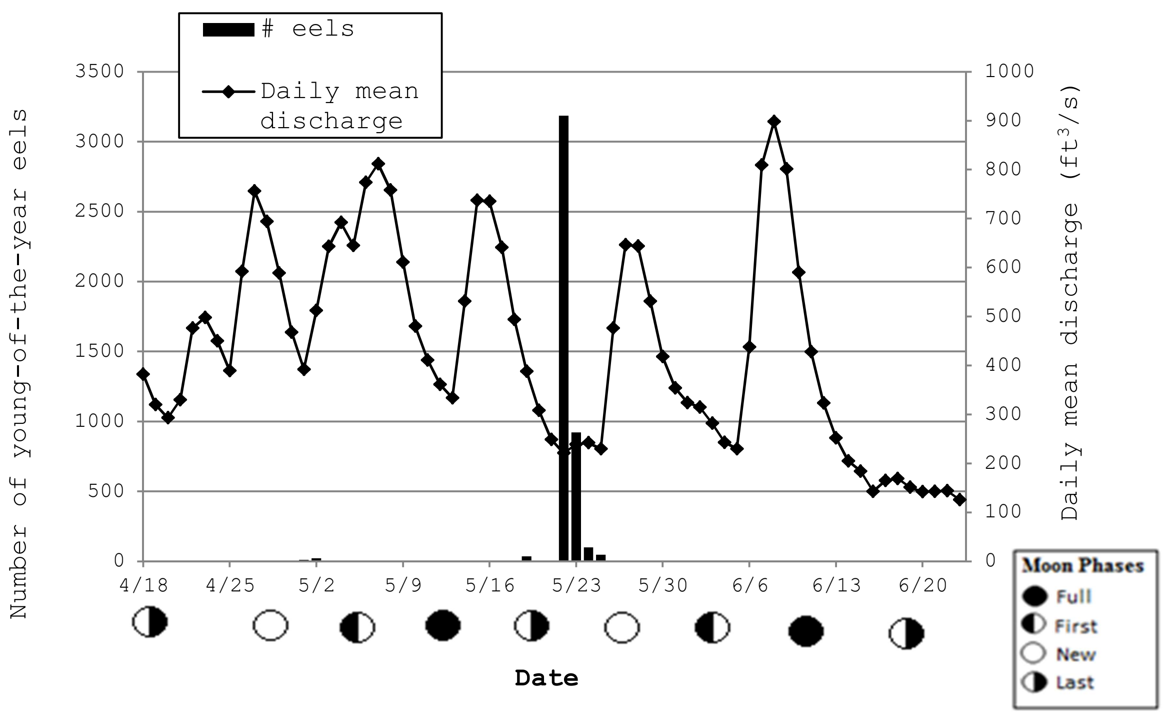


Figure 1.3-1. Daily mean discharge (ft$^3$/s) in the Lamprey River with the total number of American Eel young-of-the-year observed each sampling day, 2017.

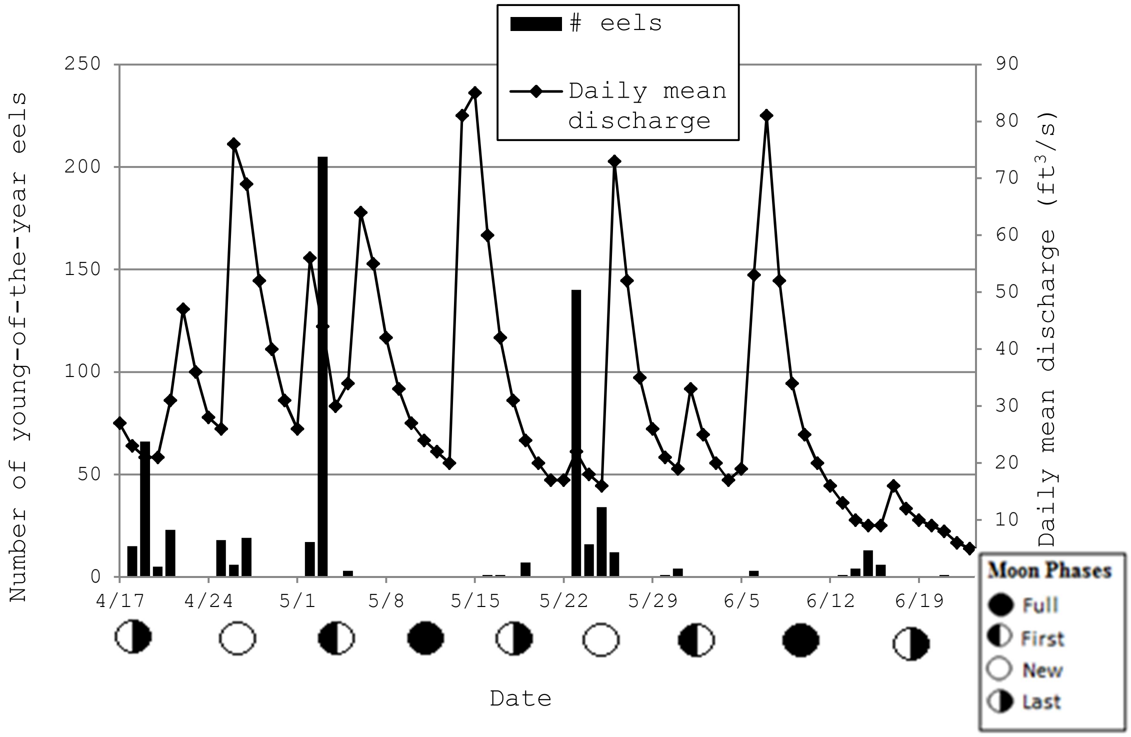


Figure 1.3-2. Daily mean discharge ($ft^3/s$) in the Oyster River with the total number of American Eel young-of-the-year observed each sampling day, 2017.