March 31, 2017

VIA ELECTRONIC FILING

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: FirstLight Hydro Generating Company, FERC Project Nos. 2485 and 1889
March 16, 2017 Study Meeting Summary

Dear Secretary Bose:

Pursuant to the schedule set forth in the Federal Energy Regulatory Commission's (FERC or Commission) Revised Process Plan and Schedule (Revised Schedule) issued May 5, 2016 for relicensing the Turners Falls Hydroelectric Project and Northfield Mountain Pumped Storage Project, FirstLight Hydro Generating Company (FirstLight) filed two study reports on December 28, 2016 and three study reports on March 1, 2017. Pursuant to the Revised Schedule, on March 16, 2017 FirstLight held meetings to discuss the five reports. Attached as Attachment A is FirstLight's meeting summary.

In addition to the meeting summary, attached as Attachment B is the PowerPoint presentation made at the March 16, 2017 meeting. FirstLight is filing its meeting summary and PowerPoint presentation with the Commission electronically. To access the document on the FERC website (http://www.ferc.gov), go to the "eLibrary" link, and enter the docket number, P-1889 or P-2485, to access the document. FirstLight is also making the same available for download at the following website: http://www.northfieldrelicensing.com.

Sincerely,

Gus Bakas

Gus Bakas
Director- Massachusetts Hydro
FirstLight Power Resources, Inc.
99 Millers Falls Road
Northfield, MA 01360
Tel. (413) 422-5915/ Fax (413) 659-4459
E-mail: gus.bakas@firstlightpower.com

ATTACHMENT A: MEETING SUMMARY

Location: The Hotel Northampton, Northampton, MA
Date March 16, 2017
Attendance:

Federal Energy Regulatory Commission
Brandon Cherry (via phone)
Steve Kartalia (via phone)
Bill Connelly (via phone)
John Baummer (via phone)

United States Fish and Wildlife Service
John Warner
Melissa Grader
Ken Sprankle
Julianne Rosset

USGS Conte Lab
Alex Haro
Ted Castro-Santos

National Marine Fisheries Service
Bill McDavitt
Bjorn Lake
Jeff Murphy (via phone)

Massachusetts Division of Fish and Game
Caleb Slater
Jessie Leddick (via phone)
Peter Hazelton (via phone)

Massachusetts Department of Environmental Protection
Brian Harrington (afternoon)

The Nature Conservancy
Katie Kennedy

No Affiliation
Don Pugh
Karl Meyer
Jason Johnson

TransCanada
John Ragonese (via phone)
Jen Griffin (via phone)

Connecticut River Watershed Council
Andrea Donlon

Normandeau Associates
Steve Leach (via phone)

Foley-Hoag
Adam Kahn (via phone)

Appalachian Mountain Club
Norm Sims

Van Ness Feldman
Mike Swiger (via phone)

BioDrawversity
Ethan Nedeau

Kleinschmidt Associates
Chris Tomichek
Kevin Nebiolo
Alex Malvezzi

FirstLight
Doug Bennett
Jim Donohue
Gus Bakas
Bob Stira
Joe Lucas

Gomez and Sullivan Engineers
Tom Sullivan
Jason George
Mark Wamser
Kevin Miller (via phone)

Introductions, Meeting Purpose and Process Timeline

In advance of the meeting, the PowerPoint presentation was posted to the FirstLight website and was circulated via email to stakeholders. The PowerPoint presentation is attached as Attachment B.

Mark Wamser (Gomez and Sullivan) opened the meeting and welcomed everyone. Mark asked everyone to introduce themselves. Mark noted that there were five studies to cover, plus a discussion on the habitat suitability index curves for sea lamprey. Mark stated that he was going to try to stick to the agenda and noted that the only studies being discussed were the five studies that were filed with FERC in December 2016 and March 2017. He reminded folks that a few of these studies had been posted to the relicensing website before they were officially filed with FERC.

Don Pugh asked if there were going to be any discussions on juvenile shad studies and potential future work. Mark explained that FirstLight is deferring action on future work until July 31, 2017, to attempt resolution on the issue prior to July 31 as part of settlement negotiations.

Study No. 3.3.10- Assess Operational Impacts on Emergence of State-Listed Odonates (2nd Year)

Ethan Nedeau presented the slides for this study. Ethan described the eclosure process and stated that a lot was learned about odonate behavior during the study. For example, once the odonate leaves the water, it's not always a one-way trip - they sometimes turn around and go back into the water. Also, some species display a 2-phase movement where the larvae crawl out of the water at night and hide, then when conditions are right, they move again up the bank. Some larvae would crawl back to the water. Movement was tracked from crawling out of the water to flying away.

The 3 phases of the study were reviewed (i.e., 2014, 2015, 2016). Phase 3 was added to get more information on eclosure speed for state-listed species. Phase 3 included qualitative sampling at 8 sites between late May and mid-July. Critical protective rates were computed for species and species groups. Definitions for critical height percentiles, critical protective rates, max hourly rate of change and risk assessment were reviewed.

Emergence rates were higher in 2016 versus 2015. Intensive monitoring was performed. They worked in smaller areas as bird predation (by starlings, grackles and robins) was prevalent. There were 158 observations in 2016 of the entire emergence/eclosure process.

Crawl heights were the shortest for riverine species. The median crawl height was 5.5 ft. The median crawl distance was 12.5 ft. from the edge of water. There was variation in crawl distances, but it was the shortest for lentic species. The state-listed *Gomphus vastus* had 122 individual observations.

A conservative eclosure time of 2 hours was used for the risk assessment. Ethan clarified the rates were feet of elevation per hour for Ted Castro-Santos.

Melissa Grader asked if some of the riverine species were found in the Turners Falls Impoundment (TFI) and Ethan explained that *Stylurus amnicola* and other riverine species were known to occur throughout parts of the impoundment (based on studies in the 2000s). Barton Cove was the only lentic area. He reminded her that all species occurrences found during the FL study are in the report.

Andrea asked what if a certain species was only found in Barton Cove. Ethan explained that the analysis was done for all species at all representative locations regardless of whether they would be found in the locations' habitat.

Question arose on where the 0.23 ft. came from that was used in the analysis of boat wakes. Jason George explained that it was initially suggested by NHESP based on other studies, but the FL erosion study had a consistent number, so both sources supported this number.

Ethan explained the 0.23 ft. boat wake factor was not applied to Barton Cove nor at locations downstream from the dam. The former has a no wake zone, and areas downstream in the study area don't see much boat traffic. Also, boat wakes are not a consistent event but are more prevalent on the weekends, and later in the year (i.e., July-Aug).

Melissa Grader asked if the species that crawls a short distance, *Stylurus amnicola,* was ever found on exposed silt. Ethan did find it in silt and sometimes on the first piece of wood it encountered as an example. Pete Hazelton requested to repeat the questions.

Karl Meyer asked if some of the vertical climbing 2-phase migration distance was atypical. Ethan said it was not atypical.

Ted Castro-Santos asked about the water level data. Mark explained that calibrated hydraulic models were developed in the TFI and below Cabot, but not for the bypass reach. Jason explained that for the bypass reach, empirical water level data were used but that other studies were occurring in 2014-2015 that caused higher water level fluctuations than would be typical under normal conditions.

Andrea Donlon asked about why we didn't use the boat wake correction factor in Barton Cove when the erosion report pointed to boat wakes in this area. Ethan said they didn't see any boat wakes in this area and that it's a no wake zone.

Alex Haro asked about odonate behavior – how often did they turn around? Ethan explained that he wasn't sure how consistent of a pattern this was, and reasons are somewhat unknown. They did see this behavior a lot though; the odonates can go back and forth.

Andrea Donlon asked about Task 1, using existing studies to fill information gaps, and felt there wasn't enough analysis on previous studies. She wanted a literature search. Andrea wanted to know what species have been found in other studies. Ethan stated that the previous studies didn't necessarily look at the same parameters that the FL studies did and that the FL studies are relatively unique.

Norm Sims asked about the minimum flow in the bypass. Ethan stated emergence was observed during low flows, but would possibly be higher up on the banks if flows were higher (in other words, if odonates emerge at a time when water levels are high, then presumably they would eclose farther up the bank, but there is no proof of this).

John Warner asked if the model could be run to simulate water level fluctuations or proposed minimum flows. Tom stated that we'd have to use the predictive model for the bypass reach.

Ted Castro-Santos asked if we looked at the exposed rocks in the bypass reach for exuvia - it could put a larger population at risk 6 inches out of the water and water level change could be an issue. Ethan said that all field work was done on the banks, not in outcroppings in the middle of the river.

Jesse and Pete asked if the mean and median crawl height used 2014 data in the analysis. Ethan stated that they used 2015 to 2016 and crawl heights and distances were not a study goal in 2014.

Pete asked about the 2-phase emergence phenomenon and asked if there are data on odonates moving up on lower toe of bank. Ethan stated movement probably occurred overnight. Pete was interested in the movement and asked when movement starts. He said that eclosure time of *Stylurus* seemed to occur after 1 pm approximately 40% of the time. Ethan said movement starts late morning to around 1 pm and they rarely saw much activity after 2 pm.

Jesse said there was a lot of flow manipulation in the bypass reach in 2014 and 2015 and wanted to know if FirstLight can use the hydraulic model for areas below Rock Dam. Jason said using the transect closest to Cabot Station would be representative of the river below Rock Dam.

Andrea asked if there are other lentic species in the TFI, other than Barton Cove. She asked if any other species were observed in other studies. Ethan stated that some species found in previous studies weren't found because they are too rare. Andrea stated she was struggling with the first objectives to synthesize existing data.

Study No. 3.3.20- Ichthyoplankton Entrainment Assessment at the Northfield Mountain Pumped Storage Project (2nd Year)

Chris Tomicheck gave the 2nd year of ichthyoplankton presentation.

Chris stated there were 3 changes made to the sampling in 2016 compared to 2015. The first change was in 2015, they manipulated the flow to get 1, 2 and 3 units pumping and in 2016 there was no pumping manipulation, just normal operations. The second was more samples were collected each night (i.e., 2 samples at the powerhouse per night in 2015 over 100 m^3, versus 4 to 6 samples per night in 2016 over 50 m^3). The third change was more tows were performed at the intake each sampling event (i.e., 1 tow in 2015 versus 3 tows in 2016). But the general sampling techniques were the same.

Findings include a range of entrainment from 9 million in 2016 to 3 million eggs in 2015. There was an equivalent of 578 adults in 2016, which was higher than 2015. Chris noted that there is a high natural mortality for juvenile shad and that 2016 was the highest observed juvenile shad index.

Ken Sprankle asked about the survival rate based on the literature in Crecco and Savoy (4 versus 5 daily rates), and the EPA daily mortality rate of 2% - what was used? Ken said that when he used the Crecco rates, it indicated higher numbers.

Ken asked about relating operational affect to available river flow and noted the June 8th peak occurred with high flow. What's going on for flows in the immediate vicinity of Northfield Mountain? Mark stated we know releases from Vernon and Ashuelot River and modeling has been performed for data through 2015. Ken suggested the time lag is worth examining. Chris said they did use the Montague gage for river flow.

Don Pugh stated that relating entrainment at Northfield Mountain to the river gage at Montague was pointless. Chris stated they used the Montague gage as an indicator of general river flow. Mark reiterated that we have flow data for Vernon and the Ashuelot River, which would give some idea of the flow just upstream of the Northfield tailrace, but it would not reflect attenuation and lag. Andrea asked how it relates to the Montague gage. Don said there is no relationship. Chris said it generally represents flow in the Connecticut River. Bill M. asked if the model can show flow above Northfield Mountain. Mark said the model can show flow above Northfield Mountain and that there is a curve that shows attenuation. Mark said we have observed water surface elevation data from 2000 to 2015. Tom said it is possible to run a time series hydraulic model of the TFI using Vernon plus Ashuelot. Chris said the entrainment was an estimate that related sampling to river flow and asked how fine-tuned we are trying to make the estimate.

Ken asked if it would be worth reconsidering the analysis based on different flows. Tom boiled the discussion down: 1) can FL use a more localized flow for the analysis; and 2) if we agree, what's the level of effort?

More group discussion occurred on using the TFI hydraulic model for this analysis – what is the level of precision versus level of effort? Potential confounding factor includes travel time and attenuation if we only used Vernon releases plus Ashuelot River flows. Mark concluded that FL could extend the model to include the sampling periods, but asked stakeholders to include their comments in the FERC filing on the study.

Melissa Grader asked about the sampling validation. Were there flow vectors, was river net towing parallel to the river channel, etc.? Chris said the tows were done in the river parallel to flow noting that the plankton can be patchy in distribution. Alex Haro asked if sampling validation issues could be due to depth distribution. Chris said no, they did an oblique tow from top to bottom and noted that there is also net avoidance as a potential factor.

Andrea referenced the report and weekly summed tables of pump volume and noted that it was hard to compare the two years.

Bjorn Lake said the CT River Atlantic Salmon Commission (CRASC) has goals for fish passage and asked how entrainment would be related to any potential increase in shad passage at Turners Falls. Chris said that would be speculating but more fish equals more larvae. Andrea asked about the drift distance of eggs, and if there were other spawning sites in the TFI. Chris said the shad were documented to spawn at Stebbins Island, and shad are broadcast spawners so the early life stages can drift downstream.

Study No. 3.3.19- Evaluate the Use of an Ultrasound Array to Facilitate Upstream Movement to Turners Falls Dam by avoiding Cabot Station Tailrace

Alex Malvezzi and Kevin Nebiolo presented the slides for this study.

The ultrasound array was installed mid-April and terminated June 16, 2016. It broadcasted random noise. The test flows were activated at 7 am. Based on DIDSON camera observations, there was an immediate repelling effect, then shad acclimated after about 2 hours. A total of 311 shad were radio tagged and released downstream of the TF Project. Of those, 58 fish made it to the Telemetry Network for this study.

The 2017 proposed study involves different intervals of the deterrent signal using the ultrasound array and DIDSON like last year.

Ted asked about moving the shad up the bypass reach and how the results compared from 2016 to 2015. Bill Connelly (FERC) said to reference slide 44 and asked if the treatment works across flows. Kevin Nebiolo said they did not continue past 10 am in the analysis.

Bill Connelly asked about the Mann-Whitney statistical analysis and why an hourly assessment was not done. Kevin noted the Cabot Station counts were done daily. Bill McDavitt asked what was seen at the Conte receiver.

Kevin said for the Cox-regression, flows were significant and not the array being on or off. Ted asked if they analyzed the model with an interaction effect because it was univariate in the report. Kevin said they did not analyze the interaction effect. Since the main effect of array on/off was not significant, Kevin said that they did not bother with a model assessing the interaction.

Ken asked what the fish did up to 10 am. Kevin said the Cox regression looks at values of the covariate immediately prior to a fish moving, therefore the results will reflect the conditions of the system at the time of movement. Kevin stated that they did not go into finer-grained analysis than that. This was a pooled analysis, not an individual analysis.

Don Pugh raised questions. Was the ultrasound on continuously for 48 hours at 7 am? Asked what Slide 35 represents. Kevin explained it came from the Alden Lab based on their testing. Don asked if the study identified fish in versus out using the DIDSON. Kevin said they didn't and just looked at presence. They couldn't tell fish direction. Kevin said he would check with Bryan Apell who was knowledgeable in the DIDSON technology.

Don asked about the tables with the fish counts and if there is a decrease with fish movement towards sunset. Kevin said he didn't know offhand, but it would be in the table.

Additional group discussion occurred on the results and analysis. Don asked about T-7 (farfield) - Kevin said this was included. Don said in general the event from release doesn't tell much. Ted said near field assumed good coverage. We may have more data than we think.

Alex Haro noted that it seems 2016 results indicate ensonification may or may not work. If the study objective is to see if fish went up the bypass reach, he recommended another radio telemetry study instead of the DIDSON. But it may be a little late in the game to forego the DIDSON.

Karl asked regarding the direction the fish moving, if we could direct the fish based on a graduated sound field and speculate on fish movement. Kevin answered they did look at this, in cumulative incidents. There was no directional capability with ultrasound on a fixed location.

Andrea asked about the calendar in the report and what time bypass flows were provided.

Andrea asked if a CFD model was used in the analysis. Kevin said no.

Andrea asked if this was our study plan for 2017 and how to comment. Mark answered that she can provide comments. Mark said he would send the study plans shortly. Tom noted that this study was

worth looking at in light of moving into settlement but time is limited. John Warner also agreed that there was a tight timeline but noted comments are not due on the study report meeting until around May 30.

Tom said that FirstLight will develop a 2017 study plan for comment; but make it brief and refer to initial study plan as appropriate.

Regarding slide 43, Ted asked if it was just the first day. Kevin said he looked at the next day too.

Bob Stira asked regarding acclimation if the fish were moving around. Ted said a telemetry analysis would help.

-LUNCH BREAK-

Study No. 3.3.5- Evaluate Downstream Passage of American Eel (2-Year Study)

Alex Malvezzi and Kevin Nebiolo presented the slides for this study.

The eel study was done over 2 years. Alex reviewed the field methods. Bill McDavitt asked what the estimated velocities were in front of the DIDSON and Alex wasn't sure.

Melissa Grader asked if because the 40-meter range was rejected on the DIDSON, did this result in an underestimate? Alex said he will confirm with Bryan Apell.

Alex Haro asked if the eels were in all portions of the water column. In forebays they were typically in the bottom of the water column. However, all bets were off due to the high velocity. Asked if there were any data on distribution of fish in 10 m beam recognizing it's difficult to do. Alex said that there were 1 to 2 fish per day so the data wasn't that useful. He then asked if all the fish were moving downstream.

Don noted that the DIDSON was not working during high rain events. He asked if it effected the results and they may have missed a prime movement. Kevin said we looked at the extrapolation. Don asked what a linear spline was and Kevin explained it.

Bob Stira asked why they were seeing more fish in the 10 m range versus the 20 m range. Kevin wasn't sure. Alex said there was a higher resolution of camera range.

Melissa said the eels were detected on the first night and the last night insinuating that they did not capture the entire run.

Group discussion of the statistical methods and results.

Alex Haro noted that some of the terminology used in the report can be confusing (e.g., the term "survival"), and suggested a list of definitions and clarifications in future report iterations.

Melissa said few fish passed through spill or Station No. 1 and she'd be interested to know operational conditions. Tabular data would be helpful.

Katie asked if they looked at the correlation of variables. Kevin answered they did not.

Karl asked if they go over the Cabot emergency spillway and Kevin answered that it was unknown/speculation.

After the presentation, additional questions were posed. Ken noted the CJS model was coarse, and did not include detections in the Canal and Bypass. Kevin said the model was relatively simple. Ken asked if it could be better quantified.

Don asked how we ensure the droppers were secure. Alex M. said they used weighted coax and had no problems. Every time they checked them, they didn't move and there was a good range of droppers (about 50' at the bottom). Don asked if there were any telemetry station down. Kevin said he would get back to him.

Don asked at T-12, why there were no detections at Bascule No 1? Kevin said he would look into it.

Don asked to resolve if the number of fish in the TFI were 161 versus 164. Kevin said he would resolve this.

Jen Griffin noted that there should be a correction for the number of eels released in Bellows Falls (slide 56) because 50 were in the Bellows Falls impoundment and 20 were in the canal. Kevin said he would check, however that should not affect the regression analysis because all TransCanada fish were grouped into 1 release cohort.

Don asked if entrainment and movement into the impoundment were absorbing states. Kevin answered yes because each movement was assessed as a separate and independent event.

Ted asked if the clock was set back to zero for subsequent events.

Alex Haro had some comments regarding the study:

- First – the fish release from TransCanada (TC) and FL. Would like to see the flow chart of route selection and asked if that can be done for TC and FL separately – if similar, 2 different batches of fish would add confidence to results.
- Second – The graphical flow instead of proportion, list transit times to see how long it takes to get from one location to the next.
- Third – Difficulty detecting fish at Montague. Data after Montague is unknown number. It's not clear how many live fish were tracked because they went downstream.

Andrea asked if a pump unit was out at Northfield Mountain during the study. Doug Bennett said he thought that one unit was out starting August 31, 2015 until February 2016.

Discussion Regarding Habitat Suitability Index Curves for Sea Lamprey Spawning & Incubation

Chris Tomicheck explained the sea lamprey HSI curves. She stated FirstLight is proposing to develop new HSI curves for review based on stakeholder comments.

Bill M. asked if we planned to use data from all sites - 29 nests (i.e., mainstem versus tributary data).

John Warner suggested not to use Boyd Kynard's data because it's too shallow, taken in small tributaries.

Melissa said TC has data too and she recommends getting their data.

John Ragonese stated that TC is running their lamprey 2015 data through HEC-RAS to get depth and velocities. Tom Sullivan said FirstLight is reluctant to compile all this data – it feels like a research project not related to relicensing issues; we plan to look at all FirstLight's Connecticut River sites, and our tributary sites to update the curves. Mark said they will provide curves for review.

Don Pugh asked if we used mean depth per site. He wants data sheets to see the data sheets with the actual field measurements to see if lamprey are on the red.

Study No. 3.8.1- Operations Modeling Study

The Operations Modeling presentation was given by Kevin Miller (via phone) with support from Mark Wamser. Mark indicated this model reflects the current configuration of the Projects.

Bjorn asked about the calibration graphics…why there was deviation with reality versus the simulation on the peaks. Kevin M. said comparisons of model results on an annual time scale are more useful (e.g. annual WSEL and flow duration curve, annual generation). Slides 90 and 95 show that the model is still attempting to match peaking operations, however it was difficult to exactly match due to operational protocols on a day to day basis. Mark said they looked at incremental changes (i.e. comparisons of potential future operations to the baseline). Tom stated it's used for energy production simulation and that there are many variables in a river and electric system.

Katie asked why calibrate if there is such poor agreement between the baseline flows and observed flows from 2002? Mark noted that the baseline run while using hydrology from 2002, is no longer using all observed data from 2002 (e.g. uses 2009 pump/gen schedule). It was also noted that the peaking matched better on the calibration run (slide 90), as opposed to the baseline run (slide 95), because it used all observed data from 2002 (e.g. unit capacities from 2002, 2002 pump/gen schedule).

Katie noted that we are not using the optimization model. Norman Sims asked if Northfield Mountain was granted an increased use of the Upper Reservoir. Mark answered yes, under emergency conditions, that this is not reflected here, but they did look at it as part of the Addendum to Study 3.1.2, which will be submitted by April 3rd.

John Ragonese asked about slide 92, if the 2 red lines of minimum and maximum were absolute and if they weren't optimizing, running at the high end?

Kevin stated the max and min annual exceedance curves were a compilation of values at each percentile for the years 2000-2016 and that more recent years were closer to the max value.

John Ragonese asked for further explanation of deviations between the modeled and max/min lines plotted on slide 92. Kevin said that rules associated with flood operations (per the USACE Agreement) play a large role in the shape of the modeled line at the lower end (e.g. 80% to 100% exceedance) due to the assumptions related to the rate of reservoir drawdown. Kevin explained that the high end had more complicated rules to ensure the model does not exceed the maximum FERC operating level so some assumptions were made. However, the modeled TFI levels are still within the FERC operating range.

Karl asked a question for Doug regarding 2002 operations period and if it was still regulated. Doug said in 1998 it was deregulated.

Andrea said the report didn't show the hydrograph for TFI. Mark said to use caution because the model is not going to be exact. Andrea said the hydraulic model had operation scenarios, and asked if NM operations affect flows below Cabot. Doug answered they did at night because Turners Falls must reduce generation when Northfield Mountain pumps.

[End at 2:45 pm]

ATTACHMENT B: MEETING PRESENTATION

FirstLight Power Resources

Turners Falls Hydroelectric Project (FERC No. 1889)
Northfield Mountain Pumped Storage Project (FERC No. 2485)
March 2016 Study Report Meeting

March 16, 2017

Report Filings

- 5 reports filed
  - 2 reports filed on 12/28/2016
    - 2nd Year Odonates
    - 2nd Year Ichthyoplankton
  - 3 reports filed on 03/1/2017
    - Downstream Eel
    - Ultrasound Array
    - Operations Model

Relicensing Process - Next Steps

Study Report Meeting (Stakeholders and FirstLight)
- March 16, 2017

Study Report Meeting Summary Filed (FirstLight)
- March 31, 2017

Disagreements/Modifications to Study/Propose New Study (Stakeholders)
- May 1, 2017 (technically April 30, 2017, but falls on a Sunday)

File Responses to Disagreements (Stakeholders and FirstLight)
- May 30, 2017

FERC Issues Determination
- June 29, 2017

FirstLight Power Resources

Study Recap

FERC Filing Date	No. of Studies	Study Name Abbreviations
09/15/2014	2	Full River Reconnaissance, Rec Inventory
12/31/2014	2	Archaeological- Phase 1A only, Historic Structures
09/14/2015	9	Hydraulic Model Study, Aquatic Habitat Mapping, Tributary Access, Canal Drawdown, NFM Land Management, Whitewater, Day/Overnight Rec Facilities, Rec Study of NFM, Traditional Cultural Properties.
03/01/2016	13	Water Quality, US Passage Eel, Shad Spawning, CFD Modeling, River2D model of NFM tailrace, Odonates, Fish Assemblage, Cabot Emergency Gates, Ichthyoplankton, Terrestrial Wildlife & Botanical, RTE, Rec Use/User Survey, Land Use Inventory
10/14/2016	10	Erosion Causation, Sediment Monitoring, IFIM Study, US & DS Adult Shad, DS Juvenile Shad (Interim), Entrainment, Littoral Zone, Sea Lamprey Spawning, Mussels, Project Ops impact on Rec
12/28/2016		Supplemental Ichthyoplankton (Year 2), Supplemental Odonate Work (Year 2)
03/01/2017	3	DS Eel (2-year study), Ultrasound Array, Operations Model
Total	39	

Agenda

Time	Study Name
9:00-9:30 am	Introductions, Meeting Objectives, Schedule
9:30-10:15 am	Study No. 3.3.10 Assess Operational Impacts on Emergence of State Listed Odonates (2nd year)
10:15-10:30 am	15 minute break
10:30-11:15 am	Study No. 3.3.20 Ichthyoplankton Entrainment Assessment at the Northfield Mountain Pumped Storage Project (2nd year)
11:15-Noon	Study No. 3.3.19 Evaluate the Use of an Ultrasound Array to Facilitate Upstream Movement to Turners Falls Dam by avoiding Cabot Station Tailrace
Noon-1:00 pm	Lunch- on your own
1:00-2:00 pm	Study No. 3.3.5 Evaluate Downstream Passage of American Eel (2-Year Study)
2:00-2:30 pm	Discuss Process for Developing HSI Curves for Sea Lamprey (as required in FERC's February 17, 2017 Study Plan Determination Letter
2:30-3:00 pm	Study No. 3.8.1 Operations Model Report

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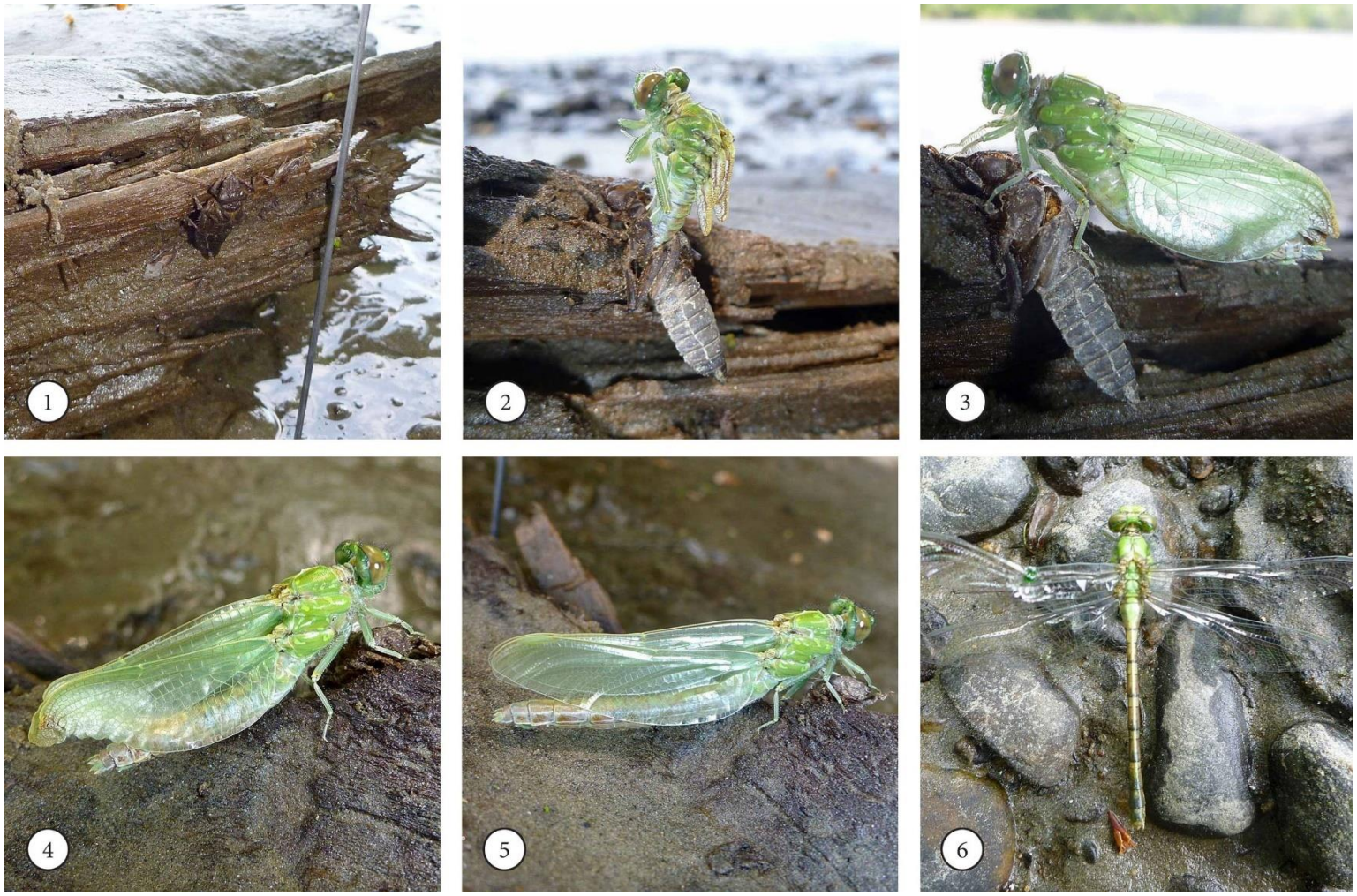
3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River



FirstLight Power Resources

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Study Objectives

- Conduct field surveys and synthesize existing data to characterize the odonate community and species emergence and eclosure behavior in the Project area.
- Assess the effects of Project operations, especially water surface elevation changes, on the emergence, eclosure, and habitat of state-listed odonate species and the odonate community.

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Phase 1 (2014)

- Qualitative surveys: species composition, habitat, and emergence behavior
- Phase 1 report filed with Updated Study Report (Sept. 2015)

Phase 2 (2015)

- Quantitative surveys: species composition, emergence and eclosure behavior, and habitat
- Related water surface elevation data to emergence behavior to assess potential operational impacts

Phase 3 (2016)

- Supplemental fieldwork: emergence and eclosure behavior for state-listed species, especially eclosure speed
- Modified the operational effects analysis based on additional eclosure speed data, computation of critical protective rates, and hydraulic model outputs

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Phase 2 Methods (2015)

- Quantitative sampling at 6 transects/site (5 sites); biweekly sampling from May to September
- For every exuvia/teneral: recorded vertical crawl height, horizontal crawl distance, substrate, and other basic information (time, date, etc.)
- Specimens were collected, individually labeled, and identified to species
- Emergence speed was recorded when possible
- Dataloggers recorded WSEL and water temperature at 15-minute intervals

Phase 3 Methods (2016)

- Qualitative sampling at 8 sites (late May to mid-July); recorded emergence/eclosure speed, vertical and horizontal crawl distances
- Computed **Critical Protective Rates** (CPRs) for species and species groups [critical height percentiles divided by eclosure duration (2.0 hrs)]
- CPRs compared to the 95th percentiles of the **Maximum Hourly Rate of Change** (MHR-95%) at sites in the impoundment, downstream from the dam, and bypass reach
- Operational effects analysis based on behavior (climbing height and eclosure time) and rate of water level changes.

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Critical Height Percentiles

- Computed based on quantiles (i.e., percentiles) of 5, 10, 20, 30, and 50% from the field-collected climbing height data.
- These are critical heights (units = ft) protective of 95, 90, 80, 70, and 50% of the population.

Critical Protective Rates (CPR)

- CPR = critical height percentiles divided by eclosure duration [2.0 hrs]
- units = ft/hr; computed for 50%, 70%, 80%, 90% and 95%

Maximum Hourly Rate of Change (MHR)

- Positive MHR for water levels from 4am to 5pm, May 15 to August 15
- Impoundment: from hydraulic model, 2000-2015; Downstream: from hydraulic model, 2008-2015; Bypass reach: from water level loggers, 2014-2015

Risk Assessment

- Compare CPRs to MHR-95% at sites in the impoundment, downstream from the dam, and bypass reach
- Analysis is therefore based on behavior (climbing height and eclosure time) and rate of water level changes

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

FirstLight Power Resources

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Species List and Sample Sizes (2015-2016)

Species	Abbreviation	2015 Phase 2 Survey Site					2016	Total
		1	2	3	4	5		
Basiaeschna Janata	BaJa	0	0	0	0	2		2
Boyeria vinosa	BoVi	58	3	11	6	0		78
Cordulegaster maculate	CoMa	0	0	0	1	0		1
Dromogomphus spinosus	DrSp	3	10	1	2	2	3	21
Epitheca princeps	EpPr	0	0	0	1	101		102
Gomphus abbreviates	GoAb	2	4	0	14	0		20
Gomphus vastus	GoVa	70	129	2	18	0	130	348
Hagenius brevistylus	HaBr	2	1	1	0	0		4
Libellula sp.	Lisp	0	0	0	0	6		6
Libellulinae (unidentified)	Li	0	0	0	0	12		12
Macromia illinoiensis	MaIl	3	2	6	2	1		14
Neurocordulia yamaskanensis	NeYa	3	8	4	6	2		23
Ophiogomphus rupinsulensis	OpRu	5	20	0	0	0		25
Perithemis tenera	PeTe	0	0	0	0	27		27
Stylurus amnicola	StAm	3	1	5	0	0	4	13
Stylurus spiniceps	StSp	23	25	9	5	0	21	83
		172	**203**	**39**	**55**	**153**	**158**	**779**

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

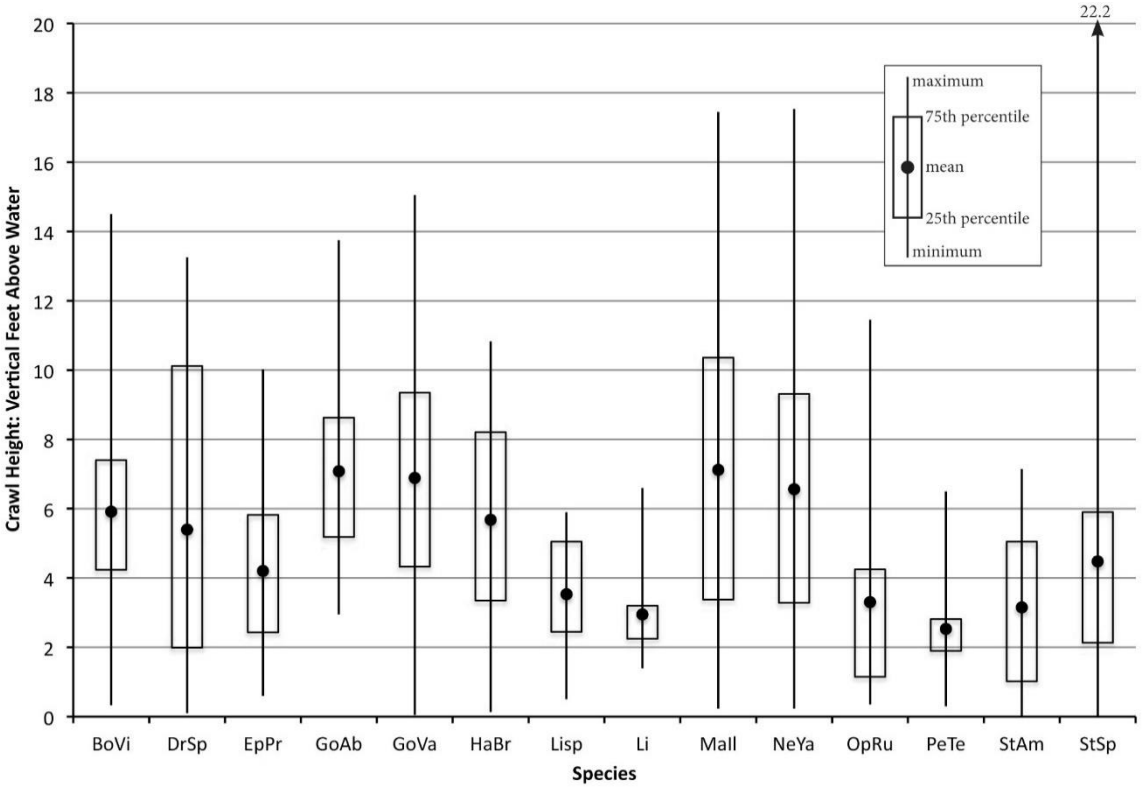
Crawl Height

Median height of 5.5 ft from the water surface

Shorter heights for more lentic species

Among riverine species: shortest for:

- *S. amnicola* (2.2 ft)
- *S. spiniceps* (3.4 ft)
- *O. rupinsulensis* (3.5 ft)



3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

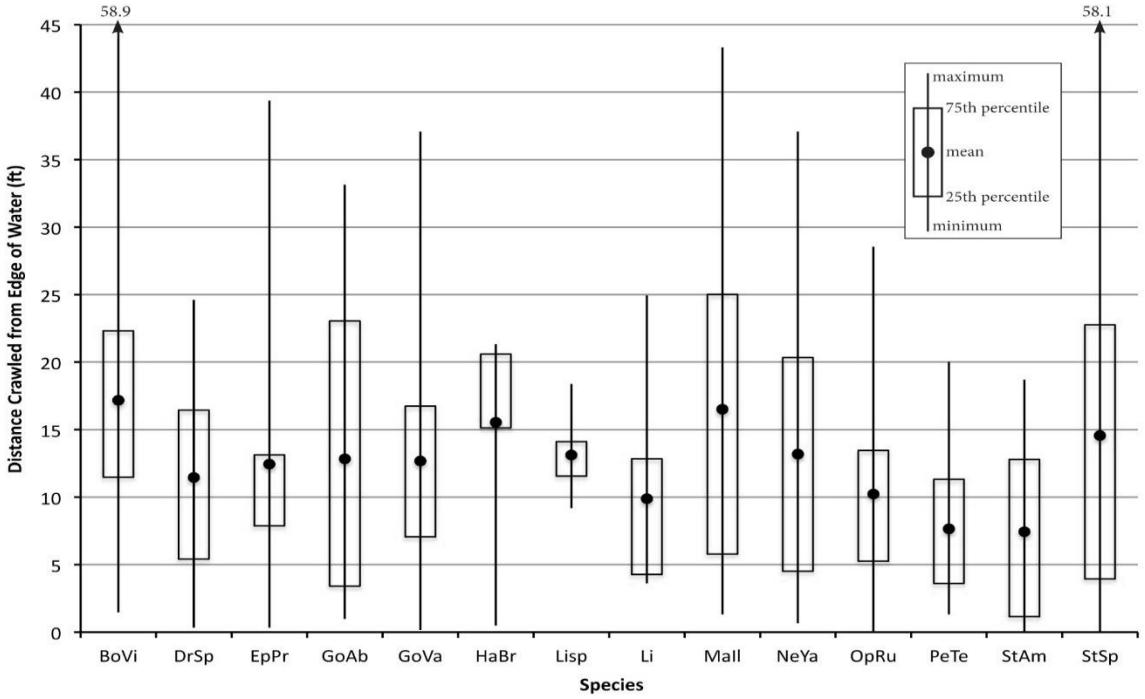
Crawl Distance

Median distance of 12.5 ft from the water's edge

Shorter distances for more lentic species

Among riverine species: shortest for:

- *S. amnicola* (4.1 ft)
- *O. rupinsulensis* (8.5 ft)



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3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Eclosure Speed Statistics

Species/Statistic	Eclosure Period Start-Free	Free-Flight	Start-Flight
Boyeria vinosa			
Sample Size	1	1	1
Min Time	0:30	0:54	1:24
Max Time	0:30	0:54	1:24
Average Time	0:30	0:54	1:24
Dromogomphus spinosus			
Sample Size	6	6	6
Min Time	0:10	0:21	0:41
Max Time	0:30	1:28	1:58
Average Time	0:22	0:47	1:10
Gomphus abbreviatus			
Sample Size	1	1	1
Min Time	0:30	0:46	1:16
Max Time	0:30	0:46	1:16
Average Time	0:30	0:46	1:16
Gomphus vastus			
Sample Size	130	122	122
Min Time	0:08	0:14	0:28
Max Time	0:30	1:34	1:45
Average Time	0:17	0:43	1:00
Libellulidae			
Sample Size	3	2	2
Min Time	0:30	0:25	0:55
Max Time	0:30	1:36	2:06
Average Time	0:30	1:00	1:30
Stylurus amnicola			
Sample Size	7	6	6
Min Time	0:09	0:15	0:29
Max Time	0:30	0:30	1:00
Average Time	0:21	0:24	0:43

Species/Statistic	Eclosure Period Start-Free	Free-Flight	Start-Flight
Stylurus spiniceps			
Sample Size	25	25	25
Min Time	0:07	0:16	0:24
Max Time	0:30	0:55	1:25
Average Time	0:13	0:28	0:41
Ophiogomphus rupinsulensis			
Sample Size	7	7	7
Min Time	0:30	0:07	0:37
Max Time	0:30	0:52	1:22
Average Time	0:30	0:20	0:50
Gomphus Group			
Sample Size	137	129	129
Min Time	0:08	0:14	0:28
Max Time	0:30	1:34	1:58
Average Time	0:17	0:43	1:01
Stylurus Group			
Sample Size	32	31	31
Min Time	0:07	0:15	0:24
Max Time	0:30	0:55	1:25
Average Time	0:14	0:27	0:42
All Species			
Sample Size	180	170	170
Min Time	0:07	0:07	0:24
Max Time	0:30	1:36	2:06
Average Time	0:18	0:39	0:58

FirstLight Power Resources

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Critical Height Percentiles and Critical Protective Rates

		Critical Height Percentiles (ft)					Critical Protective Rates (CPR)				
Species	**n**	**5%**	**10%**	**20%**	**30%**	**50%**	**95%**	**90%**	**80%**	**70%**	**50%**
B. vinosa	78	1.51	2.26	3.96	4.53	5.47	0.75	1.13	1.98	2.26	2.73
D. spinosus	21	0.13	0.15	1.84	2.50	2.83	0.06	0.08	0.92	1.25	1.42
E. princeps	102	0.93	1.46	2.12	2.60	4.00	0.47	0.73	1.06	1.30	2.00
G. abbreviatus	20	3.35	3.51	5.05	5.22	7.08	1.67	1.76	2.52	2.61	3.54
G. vastus	348	1.81	3.07	4.42	5.59	7.34	0.91	1.53	2.21	2.79	3.67
M. illinoiensis	14	0.75	1.60	3.14	3.67	6.98	0.38	0.80	1.57	1.83	3.49
N. yamaskenensis	23	1.12	1.71	2.69	4.03	5.63	0.56	0.86	1.34	2.02	2.82
O. rupinsulensis	25	0.43	0.79	1.11	1.31	3.45	0.22	0.40	0.56	0.65	1.73
S. amnicola	13	0.15	0.27	0.37	0.75	2.17	0.07	0.13	0.18	0.37	1.08
S. spiniceps	83	0.09	0.18	1.01	2.24	3.35	0.04	0.09	0.51	1.12	1.68
Aeshnidae	80	1.52	2.30	3.99	4.58	5.51	0.76	1.15	1.99	2.29	2.76
Gomphus	389	1.69	2.81	4.15	5.26	7.23	0.85	1.41	2.07	2.63	3.62
Libellulidae	45	1.00	1.44	1.78	1.94	2.50	0.50	0.72	0.89	0.97	1.25
Stylurus	100	0.08	0.17	0.67	2.14	3.29	0.04	0.08	0.34	1.07	1.65
Stylurus: 1.5-hr Critical Time											
S. amnicola	13	0.15	0.27	0.37	0.75	2.17	0.10	0.18	0.24	0.50	1.44
S. spiniceps	83	0.09	0.18	1.01	2.24	3.35	0.06	0.12	0.67	1.49	2.23
Stylurus	100	0.08	0.17	0.67	2.14	3.29	0.05	0.11	0.45	1.43	2.19

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Risk Assessment: Comparing CPRs to MHR-95%

(shading means CPR < MHR-95%)

			Maximum Hourly Rate of Change (ft/hr): 95th Percentile (MHR-95%)												
			Downstream from the Dam					Bypass Reach		Turners Falls Impoundment					
			Station (Downstream to Upstream)					Rock Dam		HEC-RAS Transect (Downstream to Upstream)					
	Critical Protective Rate		109.52	113.17	115.07	116.64	118.51	Below	Above	2895	14877	25845	31191	48441	56235	70507
Species/Group	Percentile	Value	0.45	0.62	0.65	0.85	1.25	2.54	3.02	0.89	0.81	0.74	0.72	0.66	0.65	0.66
G. abbreviatus	CPR-95%	1.67														
	CPR-90%	1.76														
	CPR-80%	2.52														
	CPR-70%	2.61														
	CPR-50%	3.54														
G. vastus	CPR-95%	0.91														
	CPR-90%	1.53														
	CPR-80%	2.21														
	CPR-70%	2.79														
	CPR-50%	3.67														
Gomphus Group	CPR-95%	0.85														
	CPR-90%	1.41														
	CPR-80%	2.07														
	CPR-70%	2.63														
	CPR-50%	3.62														

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Risk Assessment: Comparing CPRs to MHR-95%

(shading means CPR < MHR-95%)

			Maximum Hourly Rate of Change (ft/hr): 95th Percentile (MHR-95%)													
			Downstream from the Dam					Bypass Reach		Turners Falls Impoundment						
			Station (Downstream to Upstream)					Rock Dam		HEC-RAS Transect (Downstream to Upstream)						
	Critical Protective Rate		109.52	113.17	115.07	116.64	118.51	Below	Above	2895	14877	25845	31191	48441	56235	70507
Species/Group	Percentile	Value	0.45	0.62	0.65	0.85	1.25	2.54	3.02	0.89	0.81	0.74	0.72	0.66	0.65	0.66
S. amnicola	CPR-95%	0.07														
	CPR-90%	0.13														
	CPR-80%	0.18														
	CPR-70%	0.37														
	CPR-50%	1.08														
Stylurus Group	CPR-95%	0.04														
	CPR-90%	0.08														
	CPR-80%	0.34														
	CPR-70%	1.07														
	CPR-50%	1.65														
N. yamaskenensis	CPR-95%	0.56														
	CPR-90%	0.86														
	CPR-80%	1.34														
	CPR-70%	2.02														
	CPR-50%	2.82														

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Risk Assessment: Comparing CPRs to MHR-95%

(shading means CPR < MHR-95%)

			Maximum Hourly Rate of Change (ft/hr): 95th Percentile (MHR-95%)												
			Downstream from the Dam					Bypass Reach		Turners Falls Impoundment					
			Station (Downstream to Upstream)					Rock Dam		HEC-RAS Transect (Downstream to Upstream)					
	Critical Protective Rate		109.52	113.17	115.07	116.64	118.51	Below	Above	2895	14877	25845	31191	48441	56235	70507
Species/Group	Percentile	Value	0.45	0.62	0.65	0.85	1.25	2.54	3.02	0.89	0.81	0.74	0.72	0.66	0.65	0.66
D. spinosus	CPR-95%	0.06														
	CPR-90%	0.08														
	CPR-80%	0.92														
	CPR-70%	1.25														
	CPR-50%	1.42														
O. rupinsulensis	CPR-95%	0.22														
	CPR-90%	0.40														
	CPR-80%	0.56														
	CPR-70%	0.65														
	CPR-50%	1.73														
M. illinoiensis	CPR-95%	0.38														
	CPR-90%	0.80														
	CPR-80%	1.57														
	CPR-70%	1.83														
	CPR-50%	3.49														

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Risk Assessment: Comparing CPRs to MHR-95%

(shading means CPR < MHR-95%)

			Maximum Hourly Rate of Change (ft/hr): 95th Percentile (MHR-95%)												
			Downstream from the Dam					Bypass Reach		Turners Falls Impoundment					
			Station (Downstream to Upstream)					Rock Dam		HEC-RAS Transect (Downstream to Upstream)					
	Critical Protective Rate		109.52	113.17	115.07	116.64	118.51	Below	Above	2895	14877	25845	31191	48441	56235	70507
Species/Group	Percentile	Value	0.45	0.62	0.65	0.85	1.25	2.54	3.02	0.89	0.81	0.74	0.72	0.66	0.65	0.66
E. princeps	CPR-95%	0.47														
	CPR-90%	0.73														
	CPR-80%	1.06														
	CPR-70%	1.30														
	CPR-50%	2.00														
Aeshnidae Group	CPR-95%	0.76														
	CPR-90%	1.15														
	CPR-80%	1.99														
	CPR-70%	2.29														
	CPR-50%	2.76														
Libellulidae Group	CPR-95%	0.50														
	CPR-90%	0.72														
	CPR-80%	0.89														
	CPR-70%	0.97														
	CPR-50%	1.25														

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Additional Risk in Impoundment: Boat Wakes (0.23 correction factor)

Species/Group	Critical Protective Rate Percentile	Value	MHR-95% HEC-RAS Transect (Downstream to Upstream) 14877	25845	31191	48441	56235	70507
			1.04	0.97	0.95	0.89	0.88	0.89
G. abbreviatus	CPR-95%	1.67						
	CPR-90%	1.76						
	CPR-80%	2.52						
	CPR-70%	2.61						
	CPR-50%	3.54						
G. vastus	CPR-95%	0.91						
	CPR-90%	1.53						
	CPR-80%	2.21						
	CPR-70%	2.79						
	CPR-50%	3.67						
Gomphus Group	CPR-95%	0.85						
	CPR-90%	1.41						
	CPR-80%	2.07						
	CPR-70%	2.63						
	CPR-50%	3.62						
S. amnicola	CPR-95%	0.07						
	CPR-90%	0.13						
	CPR-80%	0.18						
	CPR-70%	0.37						
	CPR-50%	1.08						
Stylurus Group	CPR-95%	0.04						
	CPR-90%	0.08						
	CPR-80%	0.34						
	CPR-70%	1.07						
	CPR-50%	1.65						
N. yamaskenensis	CPR-95%	0.56						
	CPR-90%	0.86						
	CPR-80%	1.34						
	CPR-70%	2.02						
	CPR-50%	2.82						

Species/Group	Critical Protective Rate Percentile	Value	MHR-95% HEC-RAS Transect (Downstream to Upstream) 14877	25845	31191	48441	56235	70507
			1.04	0.97	0.95	0.89	0.88	0.89
D. spinosus	CPR-95%	0.06						
	CPR-90%	0.08						
	CPR-80%	0.92						
	CPR-70%	1.25						
	CPR-50%	1.42						
O. rupinsulensis	CPR-95%	0.22						
	CPR-90%	0.40						
	CPR-80%	0.56						
	CPR-70%	0.65						
	CPR-50%	1.73						
M. illinoiensis	CPR-95%	0.38						
	CPR-90%	0.80						
	CPR-80%	1.57						
	CPR-70%	1.83						
	CPR-50%	3.49						
E. princeps	CPR-95%	0.47						
	CPR-90%	0.73						
	CPR-80%	1.06						
	CPR-70%	1.30						
	CPR-50%	2.00						
Aeshnidae Group	CPR-95%	0.76						
	CPR-90%	1.15						
	CPR-80%	1.99						
	CPR-70%	2.29						
	CPR-50%	2.76						
Libellulidae Group	CPR-95%	0.50						
	CPR-90%	0.72						
	CPR-80%	0.89						
	CPR-70%	0.97						
	CPR-50%	1.25						

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

Stylurus: 2-hr versus 1.5-hr Critical Time

			Maximum Hourly Rate of Change (ft/hr): 95th Percentile (MHR-95%)												
			Downstream from the Dam Station (Downstream to Upstream)					Bypass Reach Rock Dam		Turners Falls Impoundment HEC-RAS Transect (Downstream to Upstream)					
	Critical Protective Rate		109.52	113.17	115.07	116.64	118.51	Below	Above	2895	14877	25845	31191	48441	56235	70507
Species/Group	Percentile	Value	0.45	0.62	0.65	0.85	1.25	2.54	3.02	0.89	0.81	0.74	0.72	0.66	0.65	0.66
S. amnicola	CPR-95%	0.07														
(2 hr critical time)	CPR-90%	0.13														
	CPR-80%	0.18														
	CPR-70%	0.37														
	CPR-50%	1.08														
Stylurus Group	CPR-95%	0.04														
(2 hr critical time)	CPR-90%	0.08														
	CPR-80%	0.34														
	CPR-70%	1.07														
	CPR-50%	1.65														
S. amnicola	CPR-95%	0.10														
(1.5 hr critical time)	CPR-90%	0.18														
	CPR-80%	0.24														
	CPR-70%	0.50														
	CPR-50%	1.44														
Stylurus Group	CPR-95%	0.05														
(1.5 hr critical time)	CPR-90%	0.11														
	CPR-80%	0.45														
	CPR-70%	1.43														
	CPR-50%	2.19														

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

RISK ASSESSMENT

Turners Falls Impoundment (TFI)

- The maximum hourly rates of change in the TFI appear to pose little threat to the Gomphus Group, except slight effects (MHR-95% > CPR-90%) for *D. spinosus*.
- Potential effects of hourly rates of change in the TFI are greatest for *S. amnicola*, *S. spiniceps*, and *O. rupinsulensis*.
- MHR-95% is typically only greater than CPR-90% or CPR-95% for *N. yamaskanensis*, *M. illinoiensis*, *E. princeps*, *B. vinosa*, and the Libellulidae that were documented in Barton Cove.
- The boat wake correction factor of 0.23 ft resulted in slightly higher risk for all species and species groups.

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

RISK ASSESSMENT

Downstream from Cabot Station

- Effects of Project operations on WSEL and rates of change diminish with increasing distance downstream from Cabot Station.
- Potential effects are highest for those species that eclose closer to the water, notably *S. amnicola*, the Stylurus Group, *O. rupinsulensis*, and *D. spinosus*.
- At Third Island, approximately 5 miles downstream from Cabot Station, and at the Route 116 Bridge, approximately 10 miles downstream from Cabot Station, maximum hourly rates of change do not appear to have a strong effect any of the Gomphus Group, and only slight effects on *M. illinoiensis* and *N. yamaskanensis*.

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

RISK ASSESSMENT

Bypass Reach

- Water level fluctuations resulting from Project operations appear to affect odonate emergence in areas of the Connecticut River closest to Cabot Station and in the bypass reach.

- Potential effects are highest within the bypass reach (upstream and downstream from Rock Dam), where MHR-95% exceeds the CPR-70% for the Gomphus Group, and CPR-50% for species such as *S. amnicola*, *S. spiniceps*, and *O. rupinsulensis*.

- However, flow manipulation in 2014 and 2015 for relicensing studies caused a higher frequency and magnitude of water surface elevation changes than would have been observed under more typical spring and summer conditions.

3.3.10-Assess Operational Impacts on Emergence and Eclosure of State-Listed Odonates in the Connecticut River

RISK ASSESSMENT

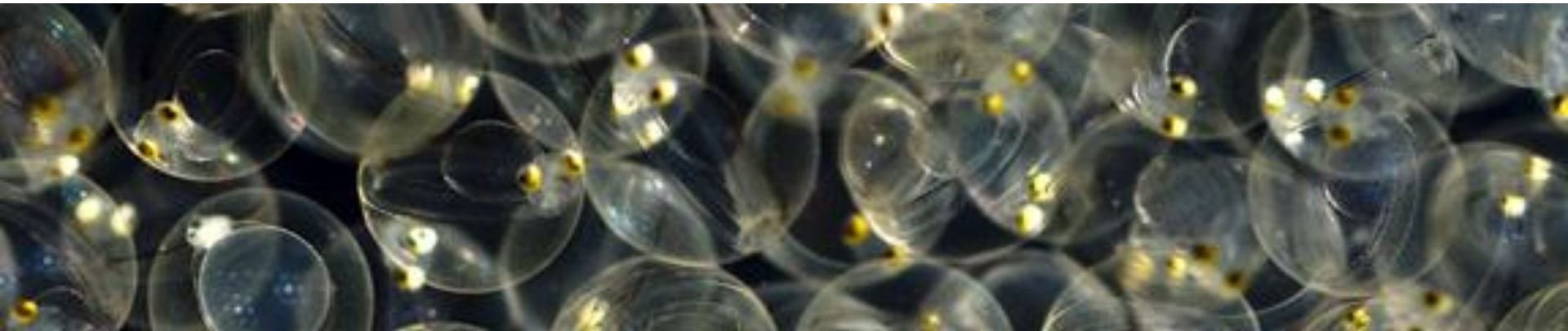
Timing of Peak Flows

- Analysis focused on MHR-95% for the period from 4am to 5pm, May 15 to August 15. Peak odonate activity from pre-dawn through early afternoon.
- At Cabot Station, operations typically release flows early-mid afternoon. MHR-95% statistics that include the late afternoon time period may be overly conservative for odonates whose peak activity is in the morning.
- Similar daily trends in the TFI, influenced by Northfield Mountain and Vernon.

3.3.20-Ichthyoplankton Study (2nd Year)

Study Objectives

- Calculate the number of American shad eggs and larvae entrained at the Northfield Mountain Project;
- Estimate the loss of adult and juvenile shad equivalents based on shad egg and larvae entrainment at the Northfield Mountain Project;
- Determine the temporal distribution of entrainment;
- Detect if there is a relationship between river flow and entrainment density.



3.3.20-Ichthyoplankton Study (2nd Year)

Entrainment Sampling
Sampling system consisted of PVC and rubber piping, a digital flowmeter, a1,000-liter plastic tank, and a 0.333 mm mesh plankton net. 50m^3 (13,250 gallons) of intake water at a rate of 3 and 3½ gal/sec was filtered for each sample. Approximately 1 hour to collect each sample.

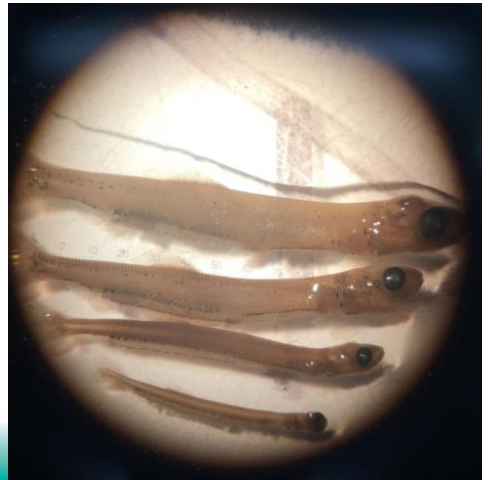
Offshore Sampling
Samples were collected in the intake/tailrace channel with a weighted 60-cm diameter paired bongo nets with 0.333 mm mesh deployed from a boat. Nets were towed obliquely until at least 100 m^3 of river water were sampled. General Oceanics flowmeters were suspended in the center of each net to measure the volume of river water filtered during each tow.

Sample Processing
Samples were sorted by biologists trained in ichthyoplankton identification with the aid of a dissecting microscope. American shad larvae and eggs were removed from the samples, identified and enumerated. A QC program designed to ensure that the Average Outgoing Quality Limit for sorting and identification is greater than 90% was followed.

3.3.20-Ichthyoplankton Study (2nd Year)

Findings

- 47 entrainment samples and 33 verification samples were collected from May 11 to July 29, 2016.
- The entrainment sample densities are the sample count divided by the sample volume.
- Eggs were first observed in the June 2 collections and were present through July 8. Egg density peaked June 8 when a density of 15.3 eggs per 100 m^3 was observed.
- Larvae were first observed in May 25 collections and were present through July 8. Larval density peaked June 2 when the density of 11.5 larvae per 100 m^3 was observed.
- Offshore sampling was conducted adjacent to Northfield Mountain intake on evenings corresponding with entrainment sampling. Three tows were collected each week.
- Overall shad egg and larval densities collected at the intake were lower than those collected in the entrainment samples.
- There was no temporal distribution of eggs or larvae entrained.
- No trend detected between river flow and entrainment density.



3.3.20-Ichthyoplankton Study (2nd Year)

Findings

- When extrapolated by the volume of water pumped during the spawning season over 9 million shad eggs and 5 million shad larvae were estimated to be entrained at the Northfield Mountain Project in 2016. In 2015, just over 3 million eggs and 500,000 larvae were entrained.

- Based on the entrainment estimate the number of equivalent juvenile and adult American shad lost to entrainment was estimated to be 2,093 juveniles or 578 adult American shad in 2016 compared to 2015 when 696 equivalent juvenile shad or equivalent 94 adults were lost to entrainment.

- American shad spawning strategy includes broadcasting large numbers of eggs which experience high natural mortality. Female American shad spawn between 150,000-500,000 eggs, with fecundity increasing with age, length, and weight. Only about 1 out of every 100,000 eggs survives to become a spawning adult.

- The higher shad ichthyoplankton densities in 2016 did not seem to effect year class strength as it coincided with the highest juvenile index recorded in 38 years. These juvenile indices have been positively correlated with recruitment levels of adult female shad returning 4-6 years later.

3.3.19-Ultrasound Array Study

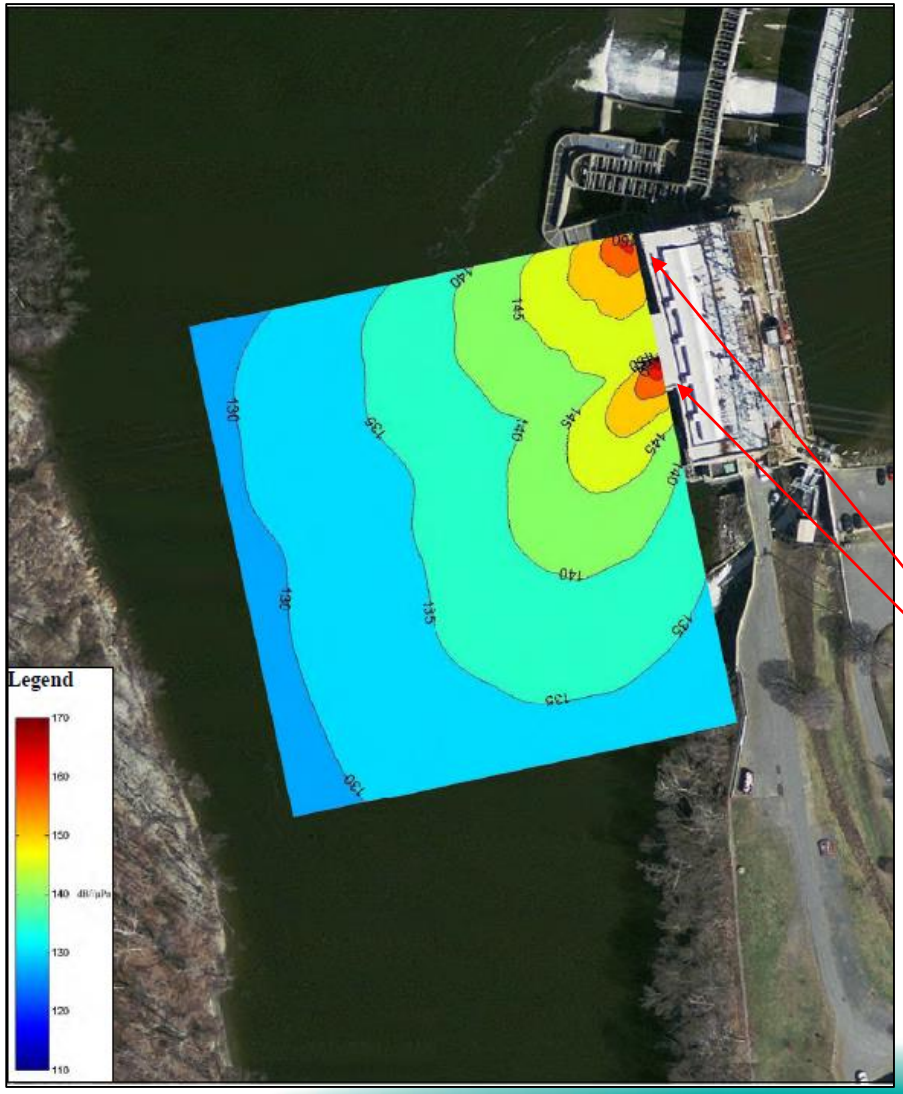
Study Objectives:

- Establish a high frequency sound (ultrasound) array across the entire Cabot Tailrace and determine the effect of the ensonified field on upstream migrating shad moving past Cabot Station
- Goal – Determine if an ultrasound barrier could be used to repel adult shad from the Cabot Station Tailrace and guide them to into the bypass reach to the Spillway Ladder.

Methods (overview):

1) Install ultrasound array in Cabot Tailrace
2) Monitor shad in the Cabot Ladder Entrance via DIDSON camera
3) Monitor tagged fish via radio telemetry

3.3.19-Ultrasound Array Study



Ultrasound Installation:

- Alden Lab and Scientific Solutions, Inc
- System included a power amplifier, underwater sound projectors (transducers), and a PC-based signal generator
- Signal – random noise signal band-limited to 122-128 kHz
- Pulse duration of 0.5 seconds

3.3.19-Ultrasound Array Study

Ultrasound and Flow Schedule:

- System was turned on at 7 am each activation day
- Proposed test flows in the Bypass Reach:
  - 4,400 cfs
  - 2,500 cfs
  - 1,500 cfs
  - 1,000 cfs
- The duration of ultrasound operation and test flows were: 2 days on 1 day off, per flow scenario. This test scheme was developed in consultation with stakeholders.
  - Meant to investigate how shad would respond to the signal over time (i.e. would acclimation occur).

May

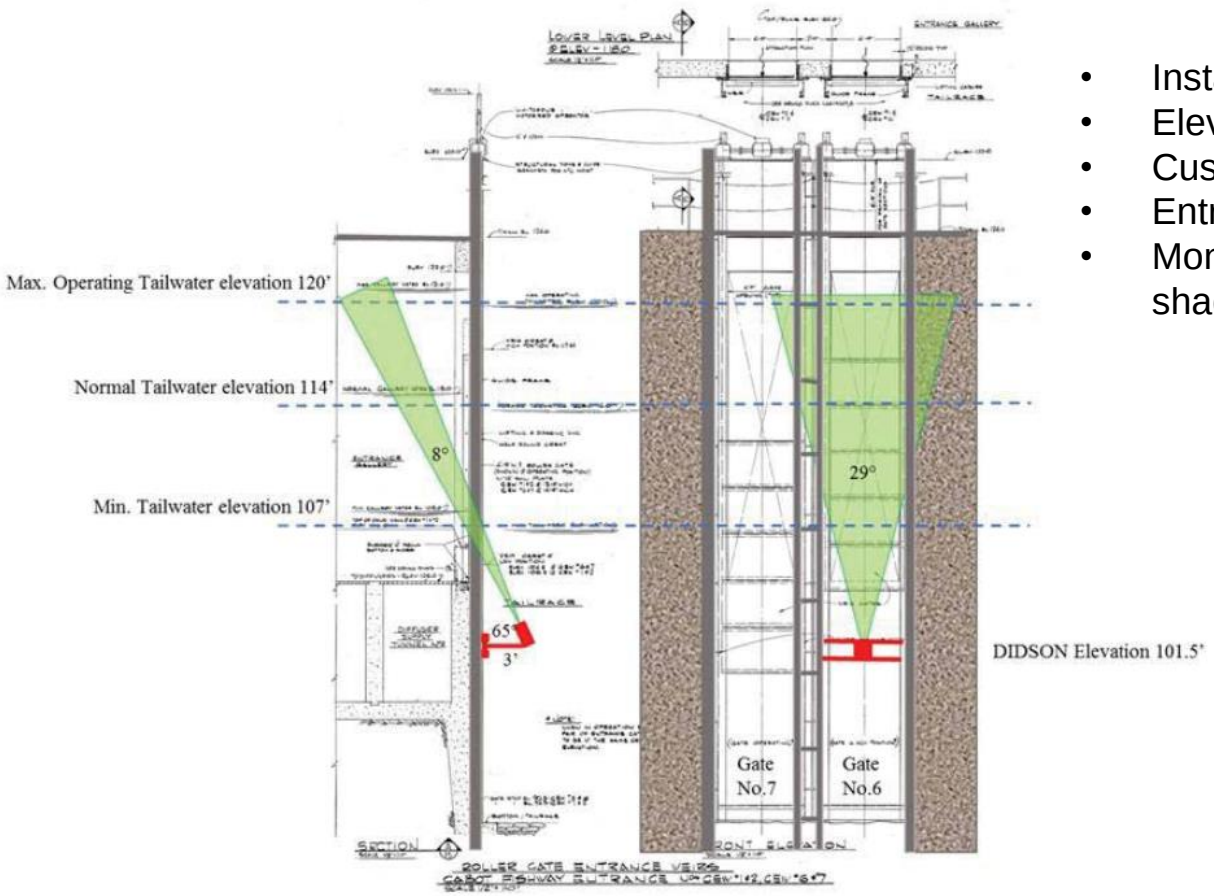
Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	
26	27	28	29	30		

	2,500 cfs (array on)
	4,400 cfs (array on)
	2,500 cfs (array off)
	4,400 cfs (array off)
	1,500 cfs (array on)
	1,000 cfs (array off)
	1,000 cfs (array on)
	1,500 cfs (array off)

3.3.19-Ultrasound Array Study



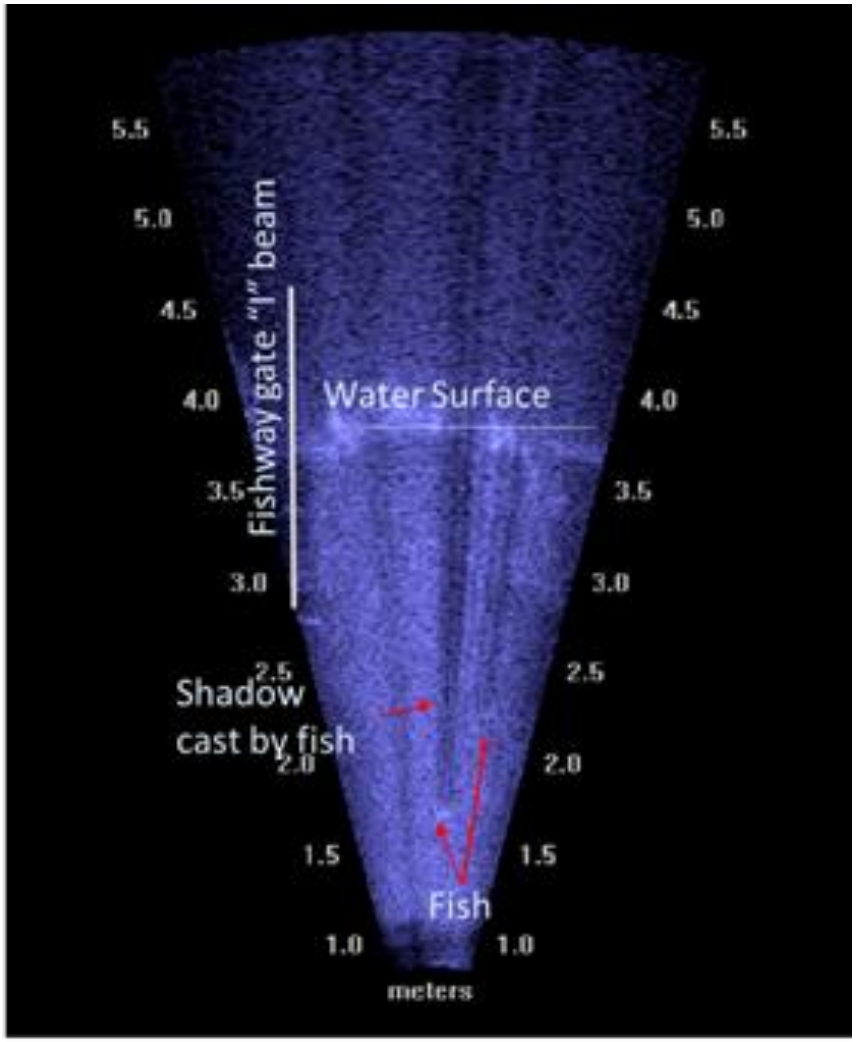
DIDSON Camera Installation:

- Installed at Cabot fishway entrance gate
- Elevation of 101.5 ft
- Custom bracket
- Entrance No. 6
- Monitor presence/absence of untagged shad

3.3.19-Ultrasound Array Study

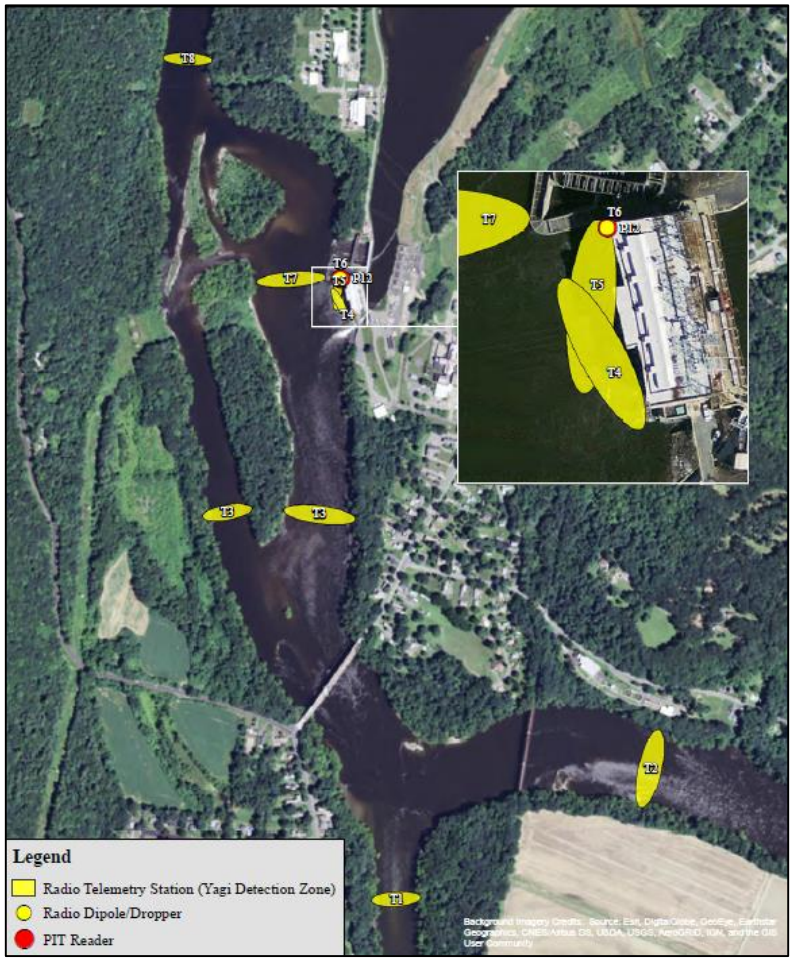
DIDSON Camera:

- Data collected using Sound Metric Corporation DIDSON operated at high resolution (1.8 MHz)
- Files written to an external hard drive
- Subsampling of the dataset included review of the first 15 minutes of every hour between sunrise and sunset
- Shad identified by the acoustic shadow cast as they move through beam
- QA/QC – files randomly selected to be re-sampled and targets recounted



3.3.19-Ultrasound Array Study

Fixed Telemetry Monitoring Stations: 12 Radio stations, 2 PIT stations



3.3.19-Ultrasound Array Study

Shad Tagging:

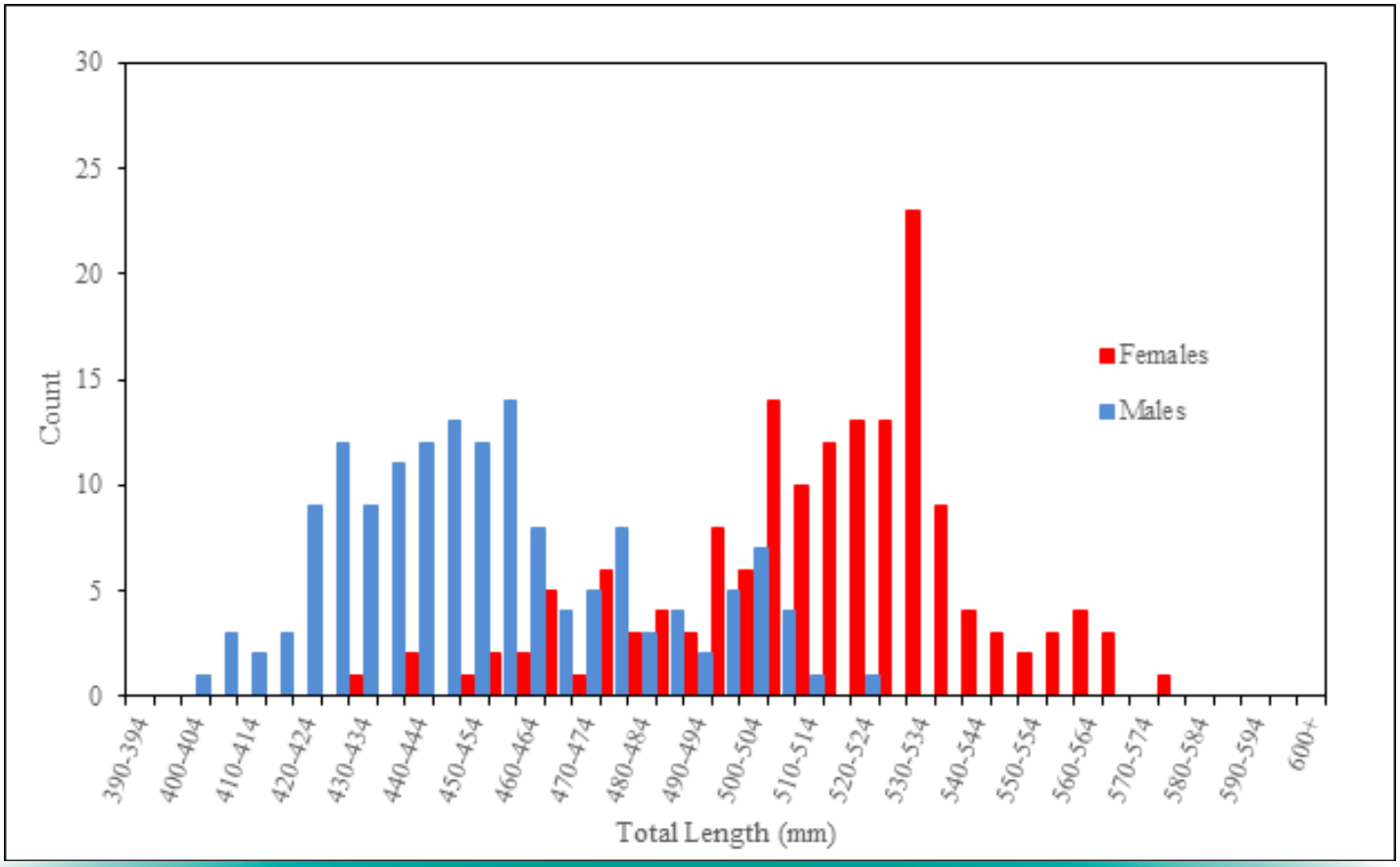
- Fish collected at Holyoke Dam fish lift trapping facility
- Esophageal implantation of radio tags and insertion of PIT tags anterior of anal vent
- Two release sites:
  - Holyoke impoundment fish lift exit flume
  - Downstream of Holyoke at Jones Ferry (part of NAI study)

Date of Collection/Release	Collection Location	Study Team	Release Location	Number of Double Tagged Shad
5/4/2016	Holyoke	KA	Upstream Holyoke	30
5/9/2016	Holyoke	NAI	Downstream Holyoke	24
5/10/2016	Holyoke	KA	Upstream Holyoke	30
5/11/2016	Holyoke	NAI	Downstream Holyoke	24
5/13/2016	Holyoke	NAI	Downstream Holyoke	24
5/17/2016	Holyoke	KA/NAI	Upstream/Downstream Holyoke	30/23
5/18/2016	Holyoke	NAI	Downstream Holyoke	25
5/20/2016	Holyoke	NAI	Downstream Holyoke	24
5/24/2016	Holyoke	KA/NAI	Upstream/Downstream Holyoke	28/25
5/27/2016	Holyoke	NAI	Downstream Holyoke	24
			TOTAL	**311**

3.3.19-Ultrasound Array Study

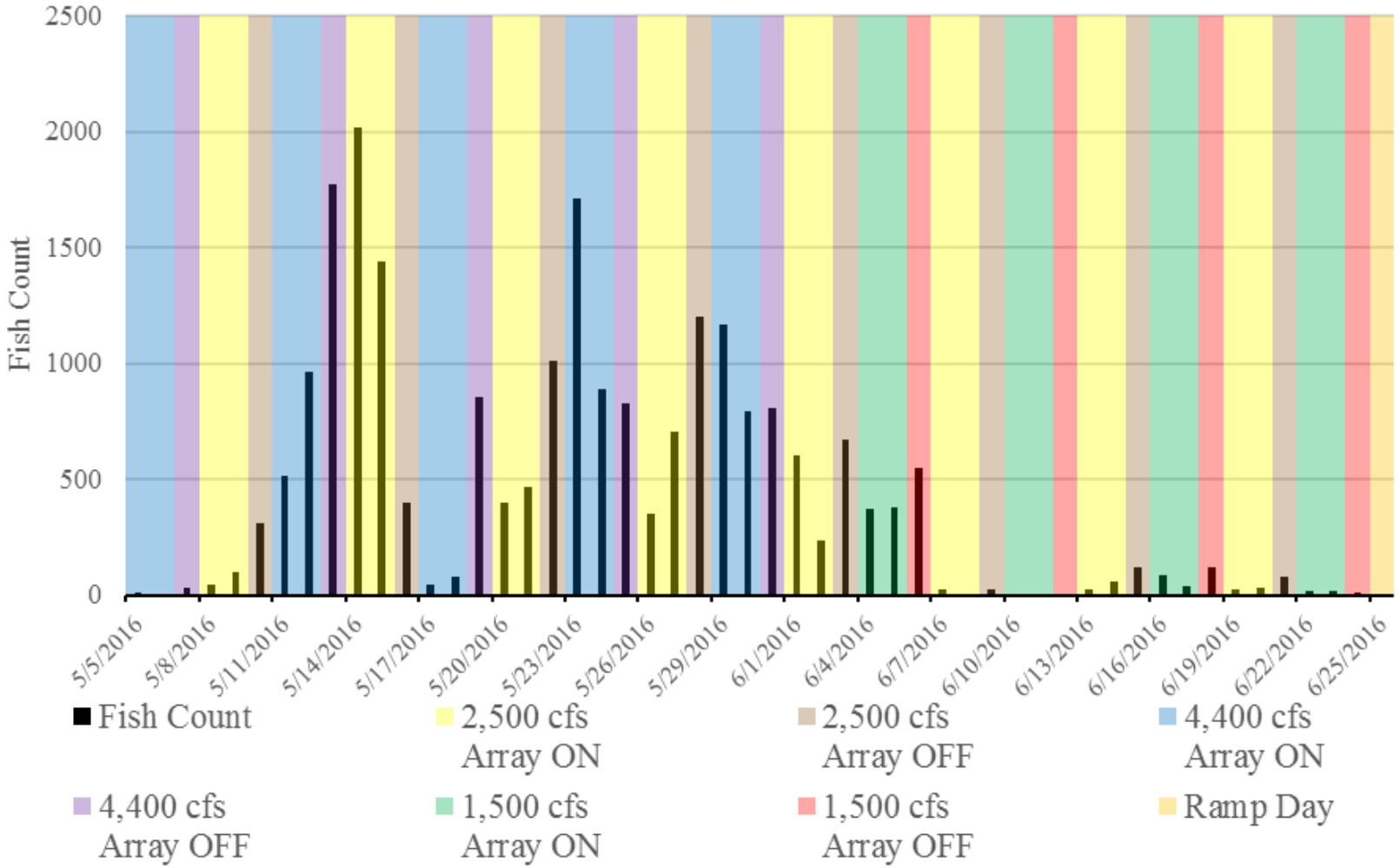
Results:

- Length frequency of 311 shad tagged for this study
- 153 males tagged (49%), mean total length = 454 mm
- 158 females tagged (51%), mean total length = 515 mm



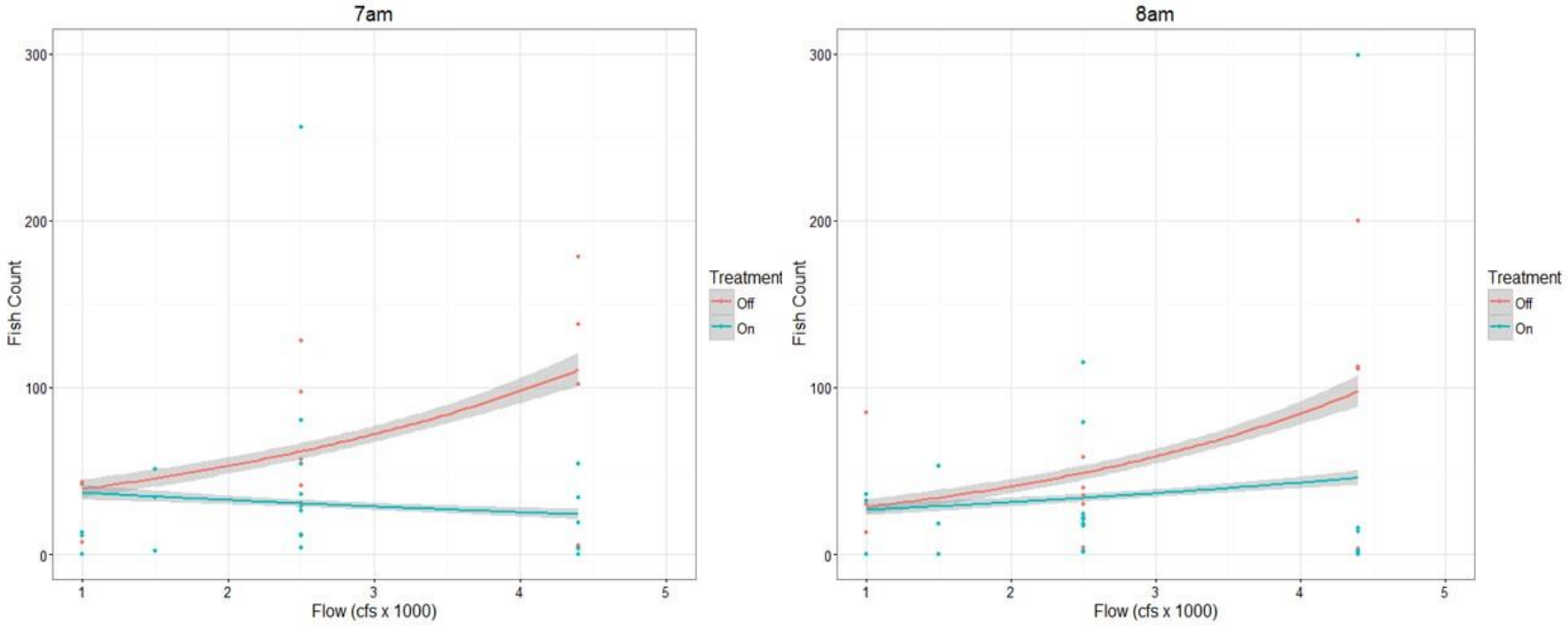
3.3.19-Ultrasound Array Study

DIDSON Results: Overall Raw Count Data



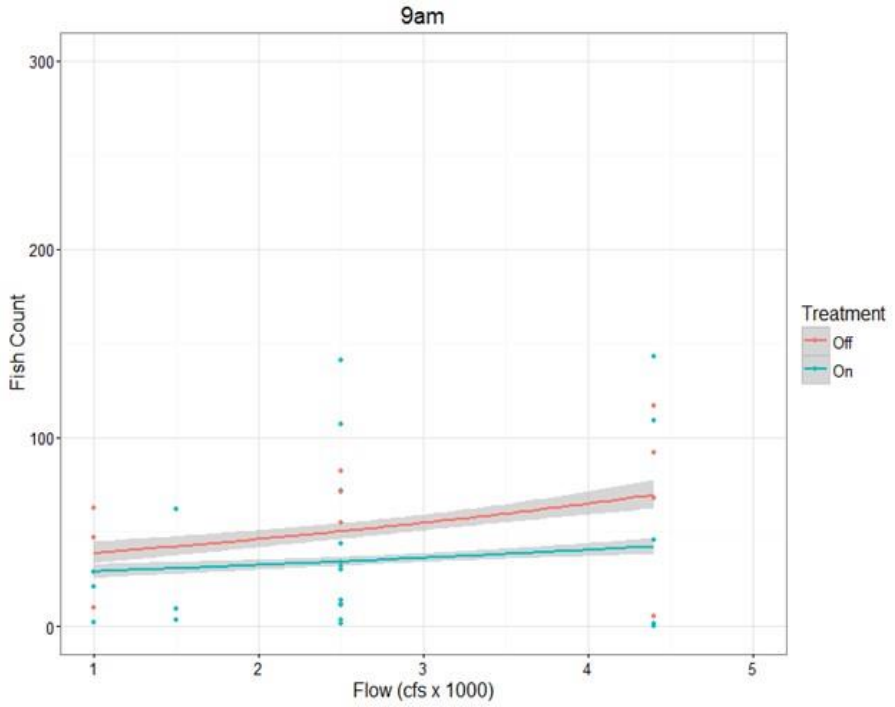
3.3.19-Ultrasound Array Study

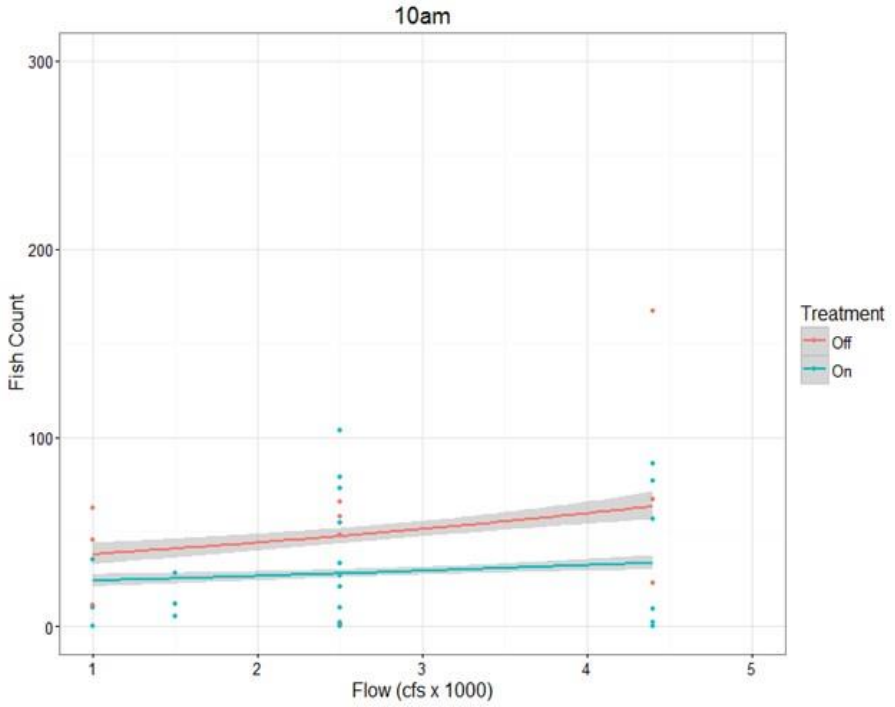
Hourly Analysis:



Hour	Coefficients	Estimate	Std. Error	Z value	P value
7:00 am	Intercept	3.36	0.10	35.31	<0.001
	Flow	0.31	0.03	11.28	<0.001
	Treatment On	0.38	0.13	2.89	0.004
	Flow:Treatment On	-0.43	0.04	-10.5	<0.001
8:00 am	Intercept	2.98	0.11	27.33	<0.001
	Flow	0.37	0.03	12.00	<0.001
	Treatment On	0.14	0.14	1.02	0.31
	Flow:Treatment On	-0.21	0.04	-5.01	0.001

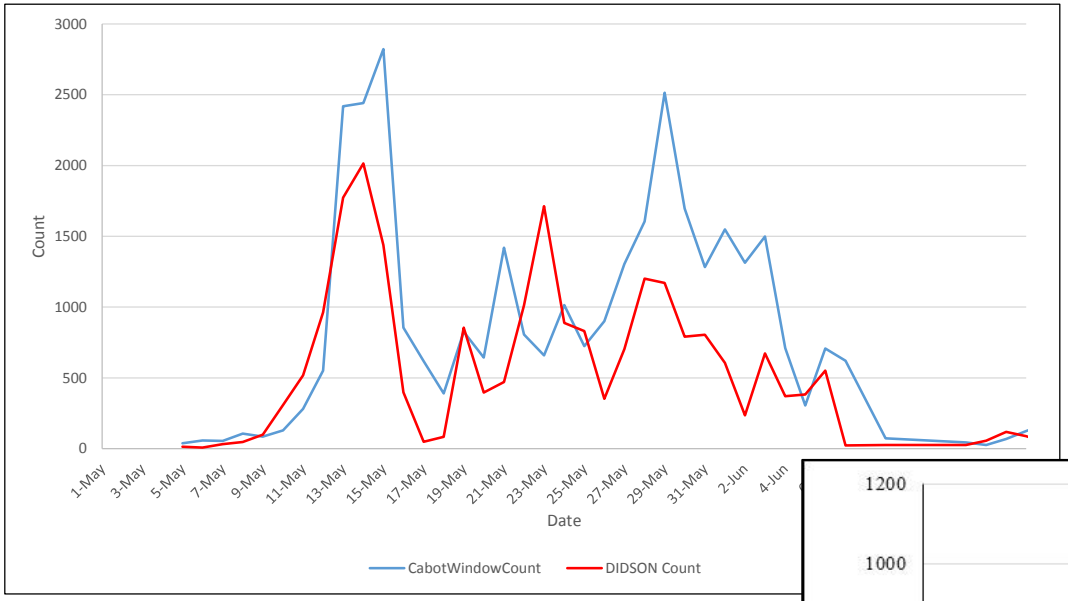
3.3.19-Ultrasound Array Study



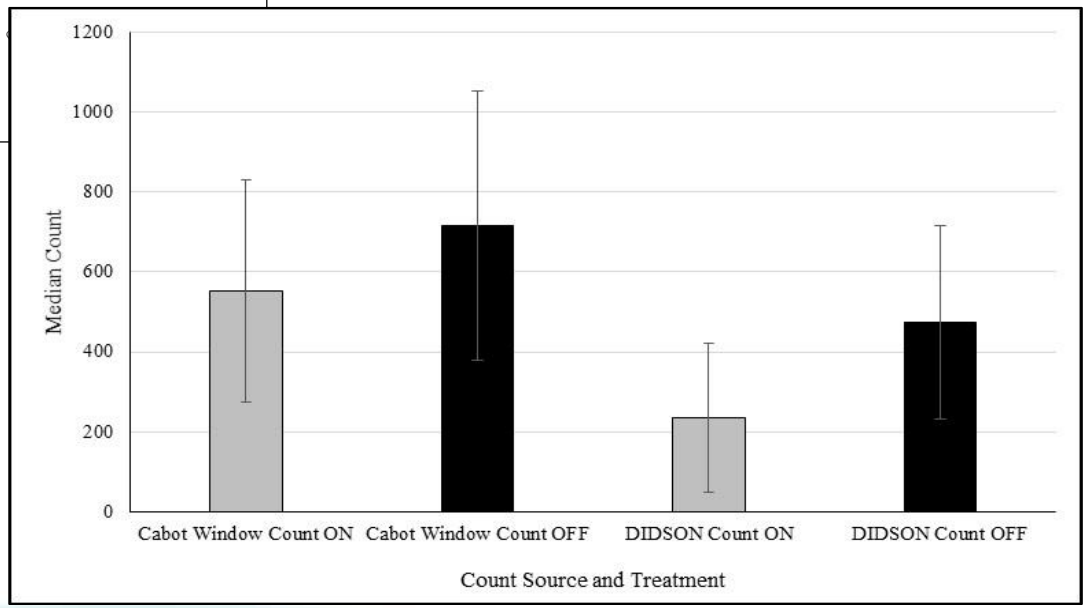


Hour	Coefficients	Estimate	Std. Error	Z value	P value
9:00 am	Intercept	3.47	0.10	34.51	<0.001
	Flow	0.17	0.03	5.66	<0.001
	Treatment On	-0.23	0.13	-1.70	0.09
	Flow:Treatment On	-0.06	0.04	-1.51	0.13
10:00 am	Intercept	3.49	0.10	33.94	<0.001
	Flow	0.15	0.03	4.80	<0.001
	Treatment On	-0.41	0.14	-2.86	0.004
	Flow:Treatment On	-0.05	0.04	-1.21	0.23

3.3.19-Ultrasound Array Study



- Comparison of Cabot Ladder Viewing Window counts and the DIDSON camera counts



- Median Daily Shad Counts (+/- Std Error) from May 5 to June 16, 2016
- Cabot viewing window and DIDSON camera under Array on/off conditions
- Mann-Whitney U test, there were no significant differences (Cabot window on/off p= 0.86), (DIDSON on/off p= 0.26)

3.3.19-Ultrasound Array Study

Telemetry Analysis:

- 33 out of 118 fish released upstream of Holyoke made it to the Telemetry Network
- 25 out of 193 fish released downstream of Holyoke made it to the Telemetry Network
- In total, 58 fish (18.6% of all releases) reached the Telemetry Network
- 39 fish entered the vicinity of the Ultrasound Array
- 29 of those fish moved upstream once detected in array (motivated by Bypass Flow, $p < 0.001$, HR = 1.46) and not Array being on or off ($p = 0.58$, HR = 0.83)

Conclusions:

- No significant difference between counts at the Cabot Fish Ladder when the system was on or off (Cabot viewing window and DIDSON counts)
- There was a significant difference between on and off DIDSON counts within the first 2 hours of the system being activated
- After 2 hours of the system being activated, there is no longer any difference and fish seem to have no problem swimming within or through the array

FirstLight Power Resources

3.3.19-Ultrasound Array Study

2017 Proposed Study

- Since there was a significant difference between on and off DIDSON counts within the first 2 hours of the system being activated during the 2016 study we plan to investigate using the Ultrasound array at different intervals less than 2 hours in 2017.
- The study is planned for 4 weeks during peak American shad passage (May-early June).
- On/Off schedule will be determined adaptively based on real time review of the DIDSON data in an attempt to minimize acclimation to ultrasound
- During the study bypass flows of 2,500 and 4,000 cfs will be provided.
- Ultrasound array and DIDSON camera will be set up similar to last year.
- Sound Metrics will investigate equipment upgrades designed to increase the sound pressure levels of the deterrent signal.

3.3.5-Downstream Passage of American Eel (2-Year Study)

Study Objectives:

- Characterize the general migratory timing and presence of silver-phase American Eel migrating past the Turners Falls and Northfield Mountain Projects relative to environmental factors and operations

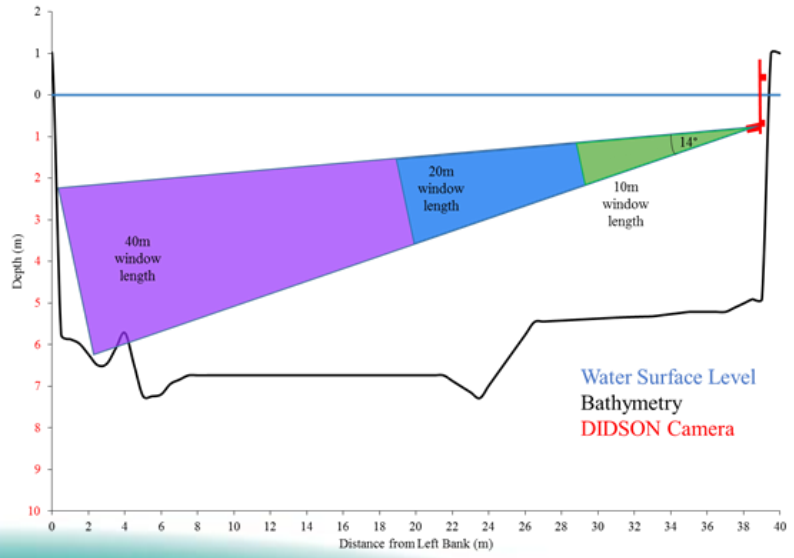
- Quantify movement rates and proportion of eel passing downstream via various passage routes at the Turners Falls and Northfield Mountain Projects as well as evaluate the proportion of eel entrained

- Evaluate survival of eel passed at the available routes of passage at the Turners Falls Project

3.3.5-Downstream Passage of American Eel (2-Year Study)

Migratory Timing:

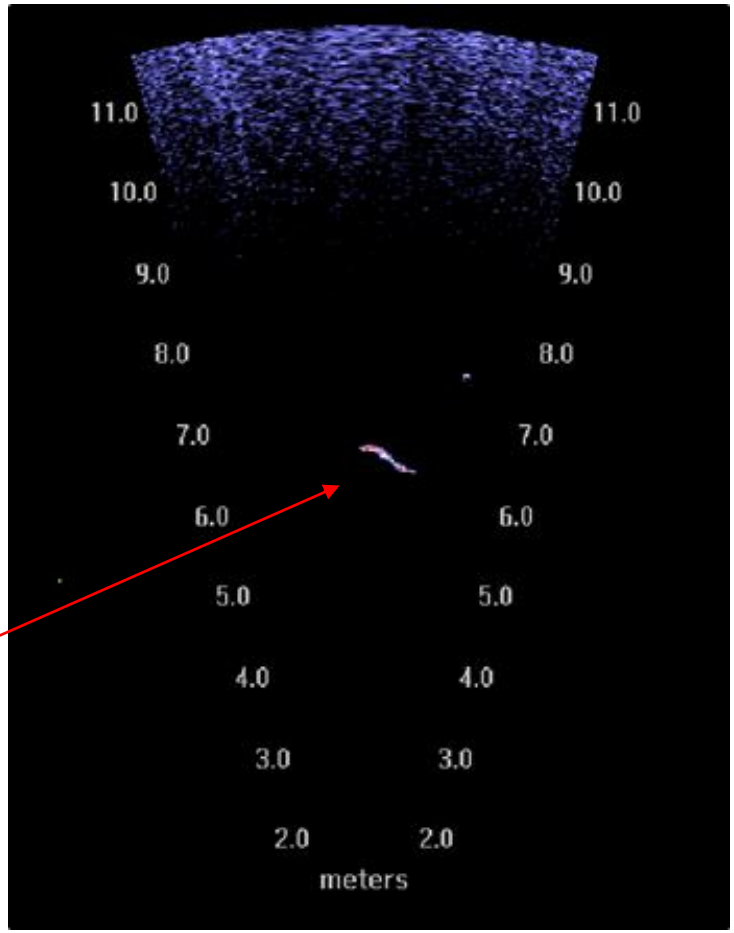
- Assessed using DIDSON camera
- Mounted to the west canal wall
- Data collection between August 1, and November 15, 2015 and 2016
- 3 ft depth, 3° upstream, 12° downward



3.3.5-Downstream Passage of American Eel (2-Year Study)

Data Analysis:

- Data processed using DIDSON v5.26.06 software by Sound Metrics Corp
- Data filtered to remove frames that did not contain targets of defined size
  - Convolved Samples Over Threshold (CSOT)
- Reduced file size and time of manual review
- Files reviewed from 1700 to 0500

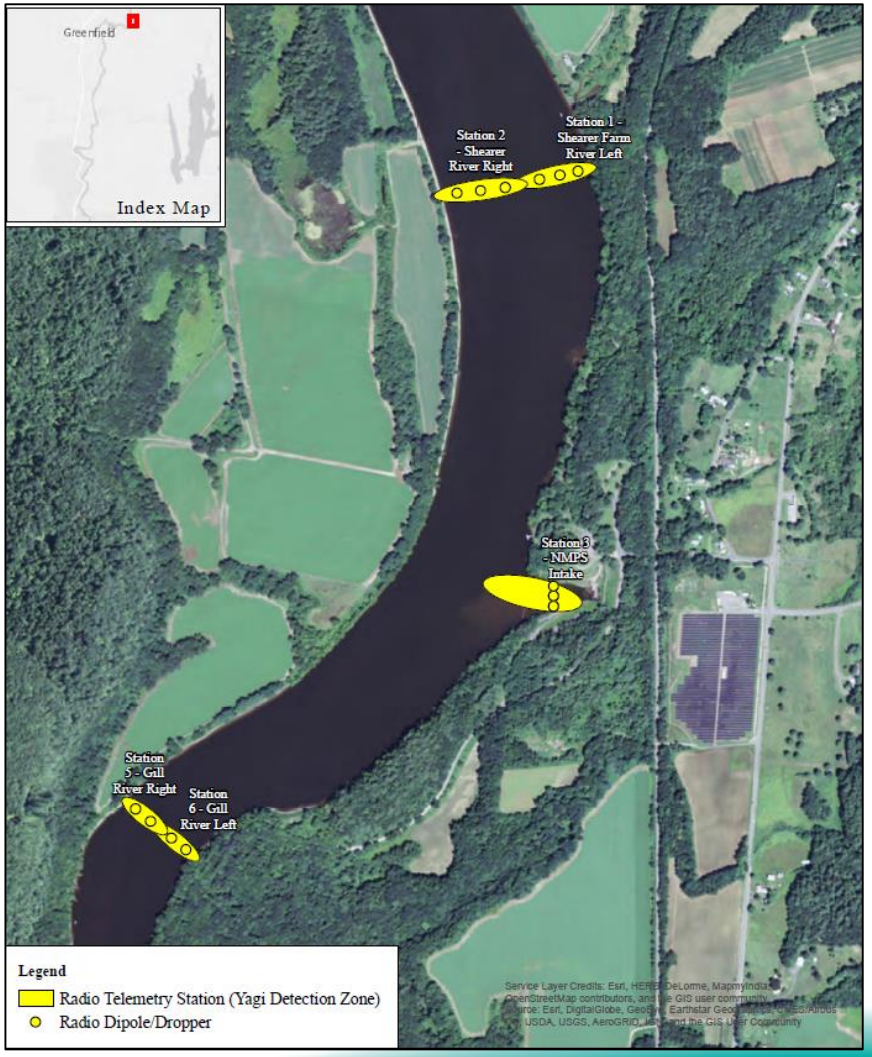


Example Eel target

- Length of 0.77m recorded in High Frequency mode

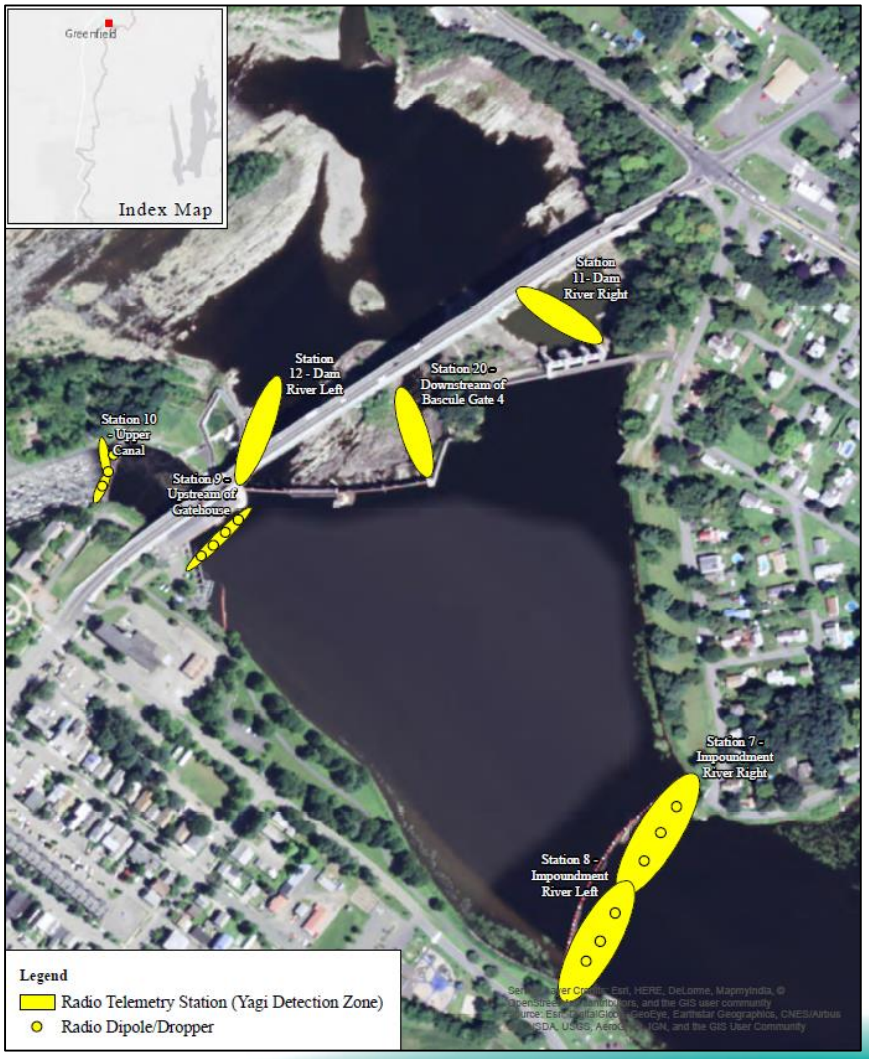
3.3.5-Downstream Passage of American Eel (2-Year Study)

Telemetry Stations: Upstream to Downstream



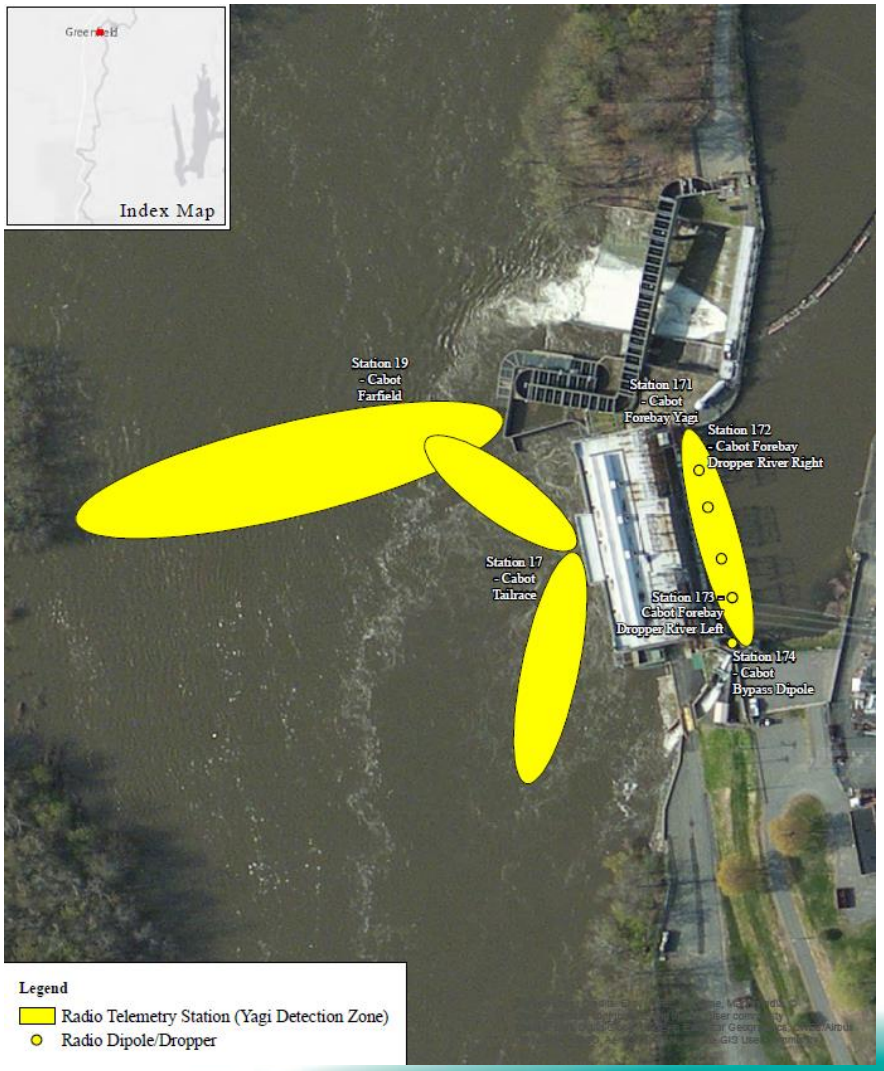
3.3.5-Downstream Passage of American Eel (2-Year Study)

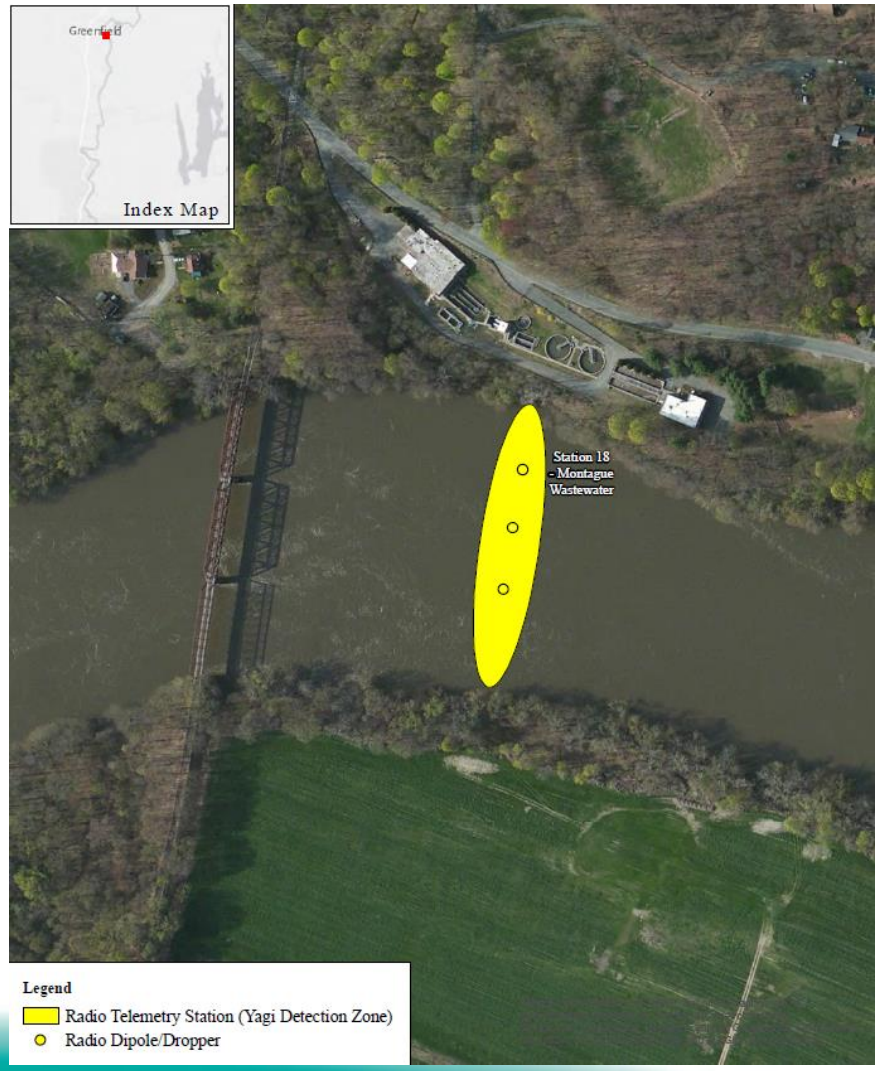
Telemetry Stations: Upstream to Downstream



3.3.5-Downstream Passage of American Eel (2-Year Study)

Telemetry Stations





3.3.5-Downstream Passage of American Eel (2-Year Study)

Eel Transport and Holding:

- Eels flown from Canada to Mass
- Held in three 1,000 gallon tanks
- Flow through ambient water from TFI
- Covered with 1/8 inch mesh to prevent escapement

3.3.5-Downstream Passage of American Eel (2-Year Study)

Eel Tagging:

- Tagged a total of 132 eel (2015)
- TX-PSC-I-80-M Pisces Transmitters (10x28mm)
- Two frequencies: 149.740 and 149.760
- An additional 165 Eel tagged by TransCanada

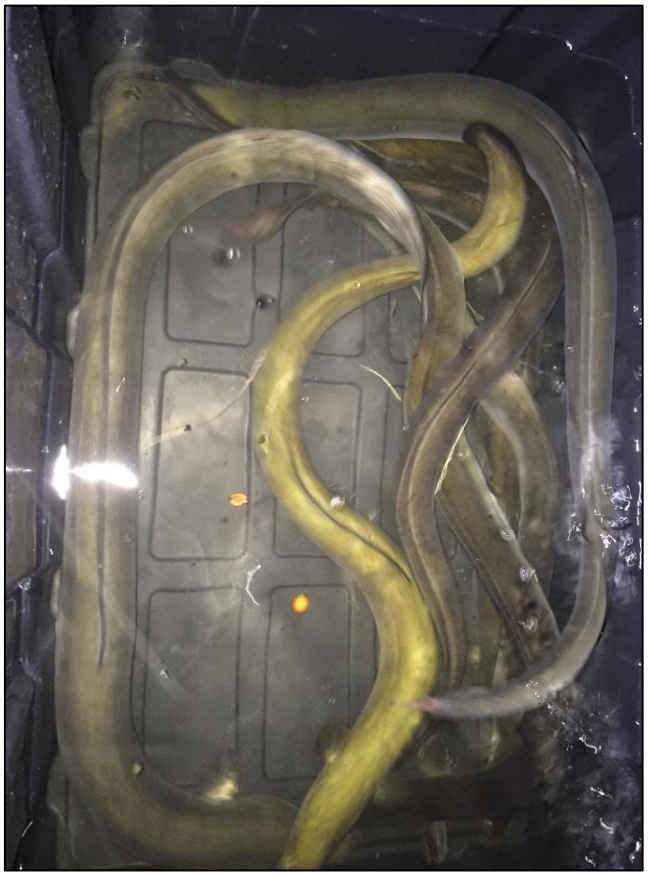
- Tags surgically implanted and sutured
- Eels anesthetized and allowed to recover for 6 to 8 hrs post tagging

3.3.5-Downstream Passage of American Eel (2-Year Study)

Eel Releases:

- Released over six days in the evenings between October 26 and November 4, 2015
- FirstLight Eels released at two sites:
  1) ~5 km upstream of NMPS Intake (n = 72)
  2) ~3 km upstream of Turners Falls Dam (n = 60)

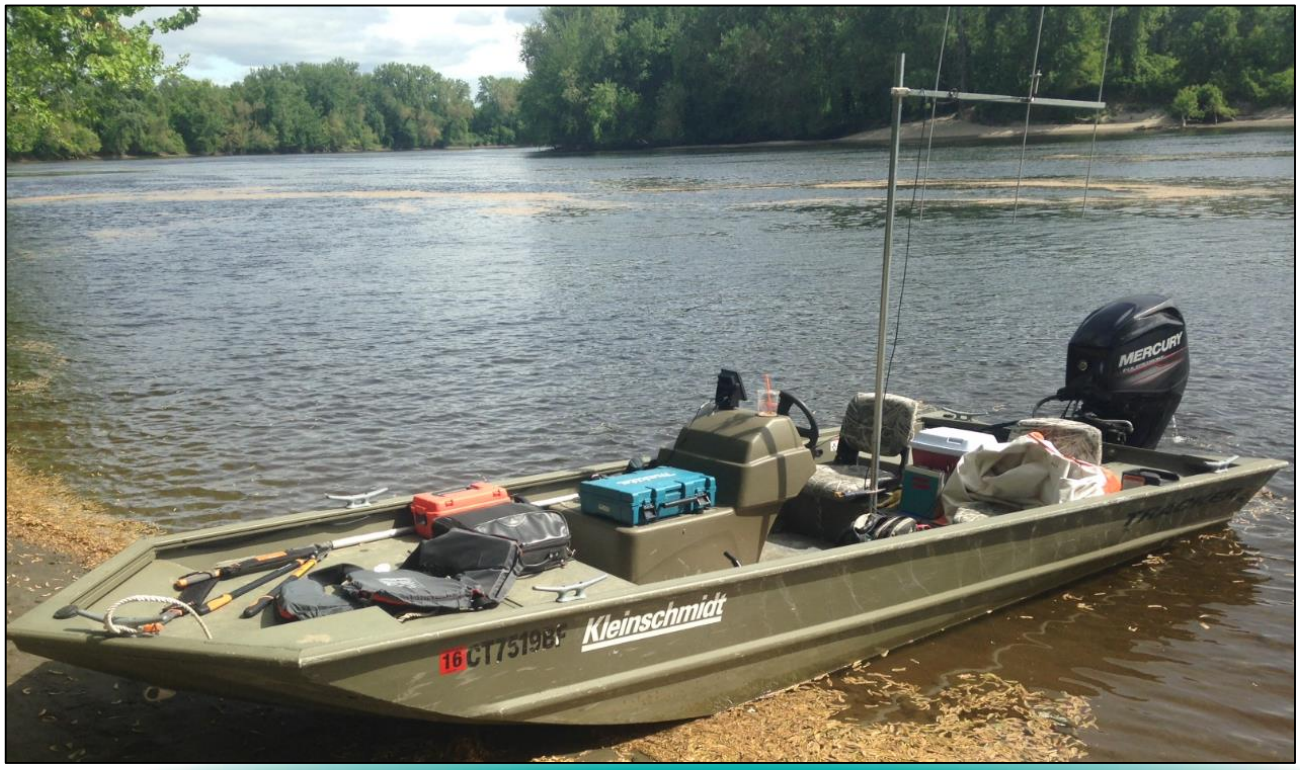
- TransCanada Eels released at four sites:
  1) Bellows Falls Impoundment (n = 48)
  2) Bellows Falls Canal (n = 17)
  3) Wilder Impoundment (n = 50)
  4) Vernon Impoundment (n = 50)



3.3.5-Downstream Passage of American Eel (2-Year Study)

Mobile Tracking:

- Eleven tracking events occurred between October 27 and November 19, 2015
- Performed twice weekly
- 5 km upstream of NMPS Intake to 5 km downstream of Cabot Station (excluded the TF bypass reach and power canal)



3.3.5-Downstream Passage of American Eel (2-Year Study)

Results

- DIDSON
- Overall Probability of Movement through Project
- Entrainment at NMPS
- Route Selection at Turners Falls Dam
- Escapement from Power Canal
- Turbine Survival (Hi-Z Tag)

3.3.5-Downstream Passage of American Eel (2-Year Study)

DIDSON

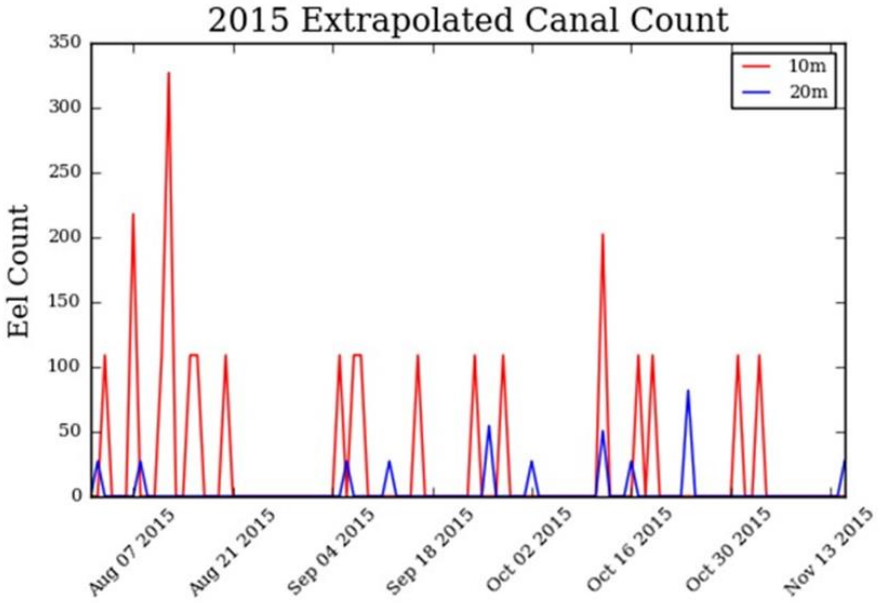
DIDSON Count Analysis

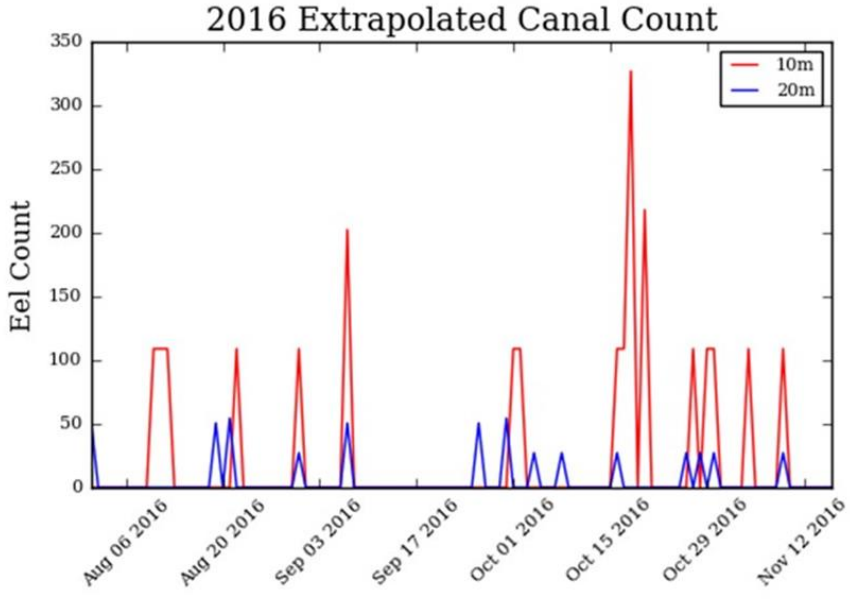
- With exception of annual canal drawdown, analyzed DIDSON camera data between 1700-0500 every day
  - 37,460 min. (2015)
  - 32,920 min. (2016)
- In total, 41 eels identified at 10 m range, 29 eels at 20 m range
- Raw counts were sparse
- Eel observed moving through canal between early August and mid-November during both years
  - 2015 – largest counts appeared in August
  - 2016 – largest counts mid-October

Extrapolated Counts by DIDSON range setting and year

Year	10 m	20 m
2015	2,382	378
2016	2,273	529

3.3.5-Downstream Passage of American Eel (2-Year Study)





3.3.5-Downstream Passage of American Eel (2-Year Study)

Overall probability of movement through project (CJS)

- 1) Impoundment recapture location consisted receivers of Shearer Farms (T1, T2), NMPS Intake (T3) , Gill Bank (T5, T6), the TFI Boat Barrier (T7, T8), and the Gatehouse (T9)
- 2) Project recapture location consisted of all receivers within the Bypass Reach (T20, T11, T12, T15) and Power Canal (T10, T13, T14, T171, T172, T173, T174)
- 3) Tailrace recapture location consisted of the two receivers within the tailrace (T17, T19)
- 4) Lower river recapture location at Montague (T18)
- 170 valid silver phased American Eel used
- 164 detected (recaptured) within impoundment
- 101 detected within the ‘project’
- 106 detected within the tailrace
- 10 detected at lower river

3.3.5-Downstream Passage of American Eel (2-Year Study)

CJS Estimated Arrival (survival) Rates ϕ

Parameter	Estimate (%)	Standard Error (%)	95% Confidence Interval	
			Lower Limit (%)	Upper Limit (%)
1: (ϕ) Release - Impoundment	1.0	0	1.0	1.0
2: (ϕ) Impoundment - Project	0.69	3.6	0.61	0.75
3: (ϕ) Project - Tailrace	0.91	2.8	0.85	0.97
4: (ϕ) Tailrace - Montague	0.31	110.36	0.0	1.0

CJS Estimated Recapture Rates p

Parameter	Estimate (%)	Standard Error (%)	95% Confidence Interval	
			Lower Limit (%)	Upper Limit (%)
5: (p) Impoundment	0.96	1.4	0.92	0.98
6: (p) Project	0.87	3.3	0.79	0.92
7: (p) Tailrace	1.0	0	0.99	1.0
8: (p) Montague	0.31	110.42	0.0	1.0

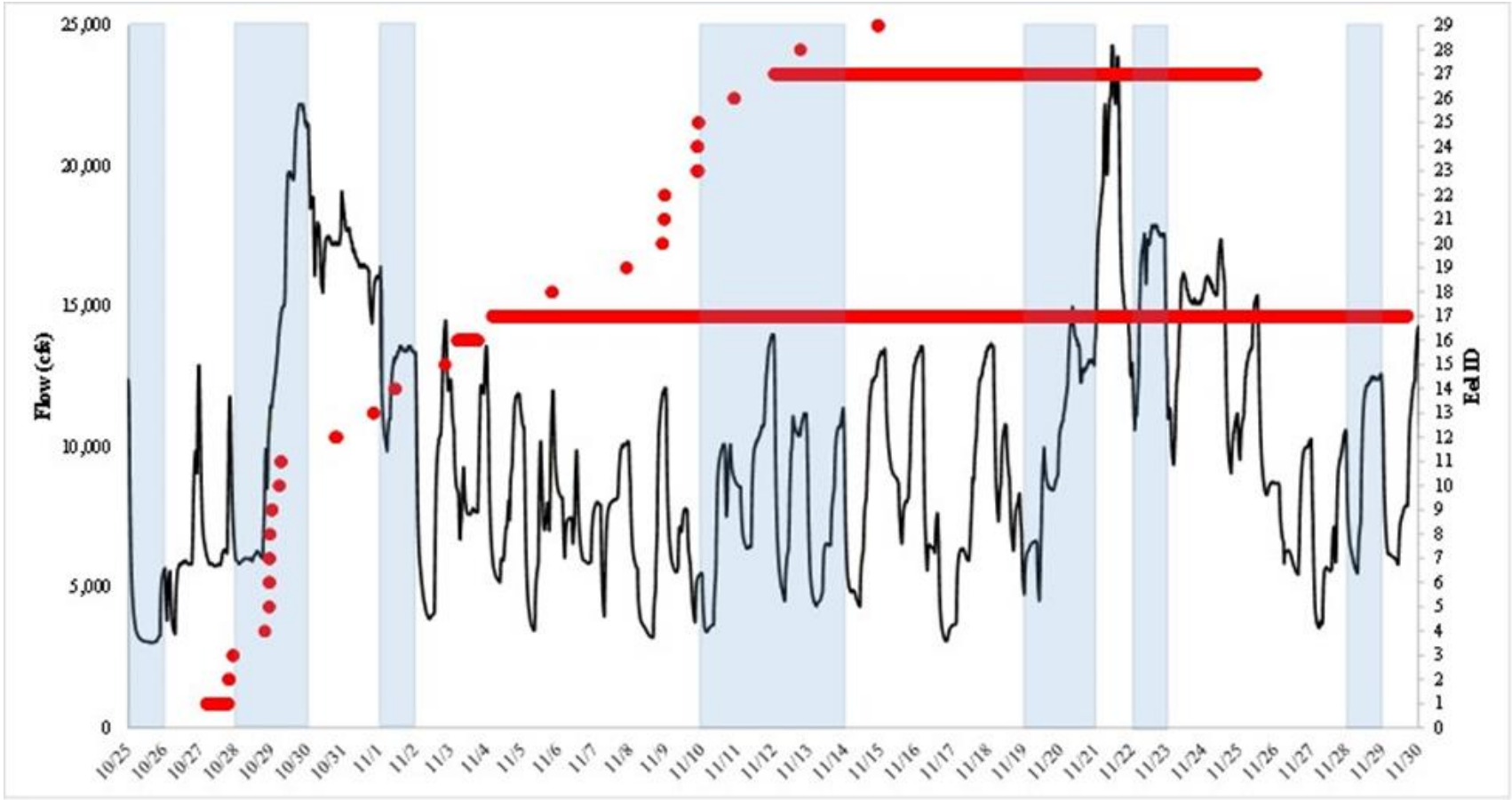
CJS estimates of arrival from release through the tailrace are 62.8% (1.0 * 0.69 * 0.91), which is very close to the raw count estimate of 62.4% (106/170). Therefore we have high confidence in the ability of the model to estimate survival through this reach, however due to limitations of the model and poor recapture at Montague, we lose confidence at the last station.

3.3.5-Downstream Passage of American Eel (2-Year Study)

What happened at Montague?

- All recaptured eel in Cabot Station tailrace were alive with no tags reverting to 11 second mortality signal
- After noting time at which eel left tailrace, searched for detections downstream at Montague Wastewater using the full dataset.
- 76 of the 106 eel detected in the tailrace were also detected at Montague, however only 10 made it through false positive reduction
  - Remaining fish classified as false positive because they were only detected once with no other detections in series
  - Of those 76 eel, 19 had detections after they left the tailrace – plausible?
- Cox PH fit to fish that transition into unknown state.
  - Best model found that fish are 67 times more likely to go missing from the tailrace at night when it rains

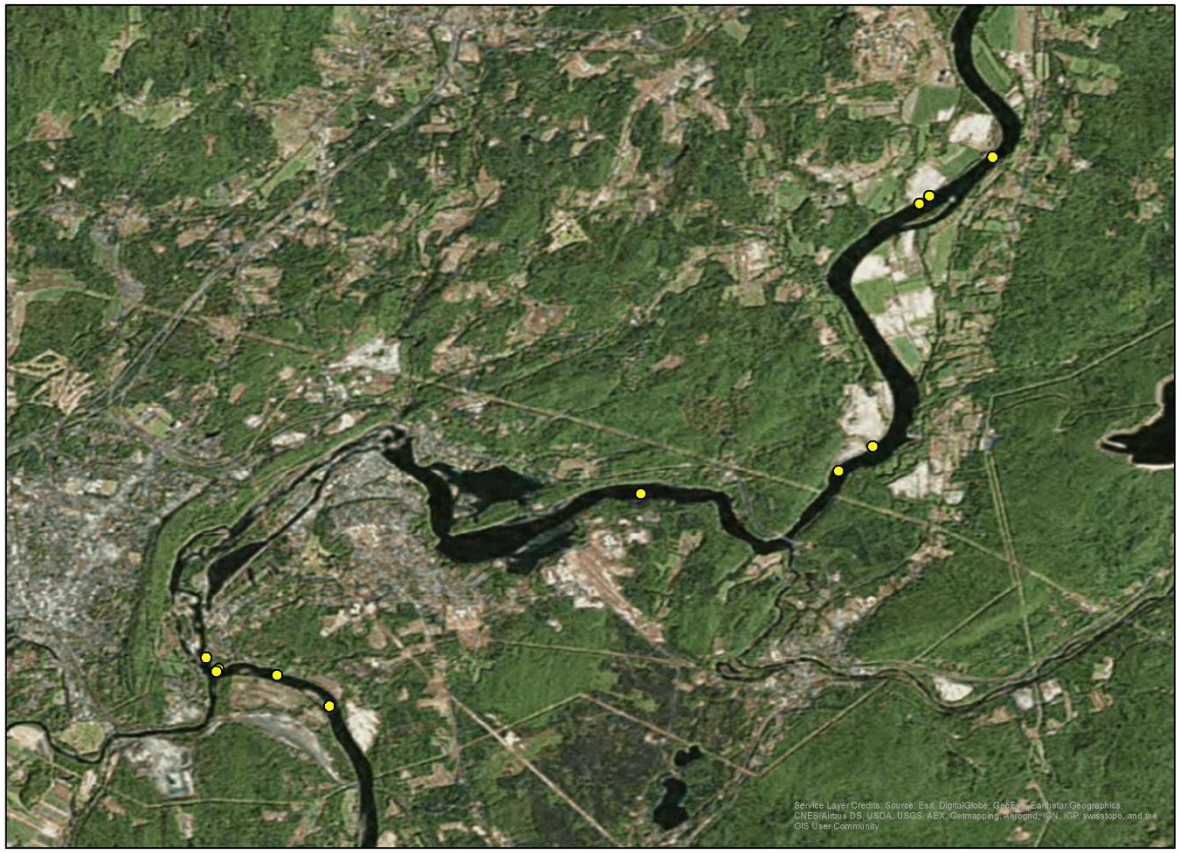
3.3.5-Downstream Passage of American Eel (2-Year Study)



3.3.5-Downstream Passage of American Eel (2-Year Study)

Mobile Tracking Mortalities

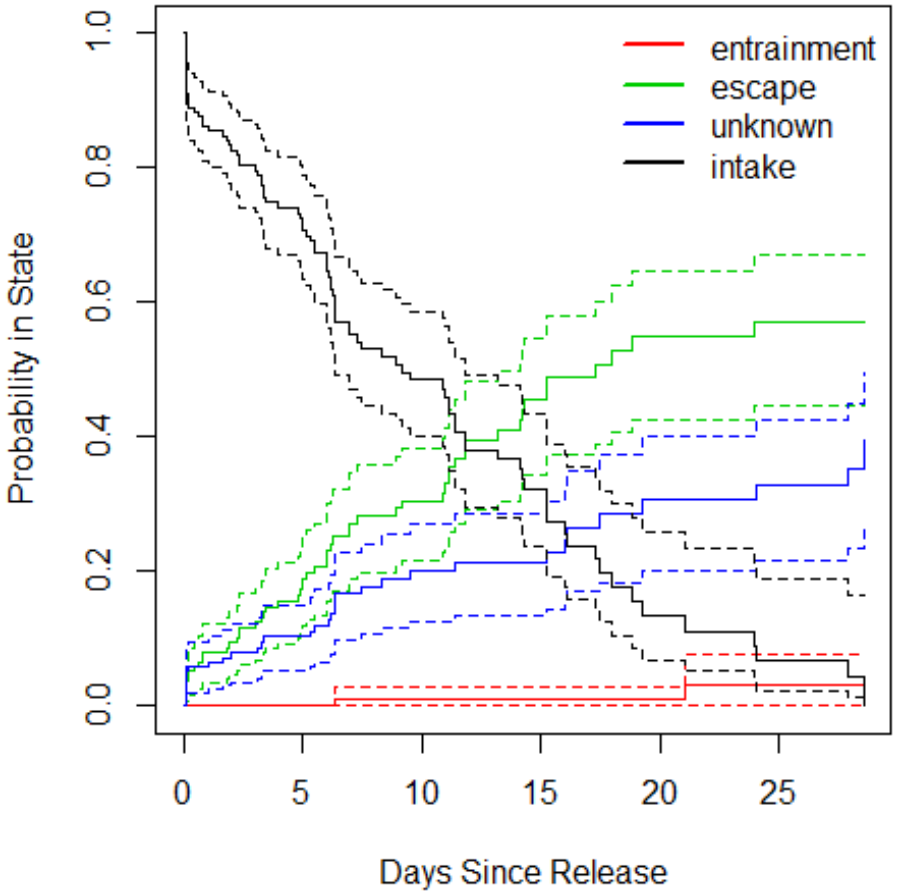
- 8 confirmed in impoundment
- 6 at or below Cabot Tailrace



3.3.5-Downstream Passage of American Eel (2-Year Study)

Entrainment at NMPS

- Fish are at risk of entrainment if they become attracted to the NMPS intake area (T3)
- Fish may transition from Shearer Farms (T1, T2) or Gill Bank (T5, T6)
- Modeled movement from the to the upper impoundment and CT River
- If a fish was last detected within the intake area before the end of the study, it was placed into an 'unknown' state
- Of the 170 valid American eel, 74 were attracted towards the intake, some more than once
  - 11 made 2 movements into the impoundment
  - 3 made 3 movements into the impoundment
- In total, 91 movements made from the intake
  - 55 escaped to the impoundment (55/91 = 60%)
  - 2 confirmed to have been entrained and detected at T4 (2/91 = 2%)
  - 34 transitioned into the unknown state (34/91 = 37%)



3.3.5-Downstream Passage of American Eel (2-Year Study)

Raw recapture counts within each reach by release cohort

Release Cohort	Intake	Impoundment	Entrainment	State-Unknown
TC	31	52	1	16
Lower Impoundment	11	48	1	3
Upper Impoundment	32	61	0	15
Sum	74	161	2	34

Descriptive statistics of event times (hours since release) from the NMPS intake to an absorbing state

Event	Min	25%	Median	75%	Max
Entrainment	153.3	241.3	329.3	417.3	505.3
Escape	2.2	50.2	131.3	267.6	575.5
Unknown State	2.3	10.1	138.7	261.6	685.0

3.3.5-Downstream Passage of American Eel (2-Year Study)

Cox PH output for time-to-impoundment

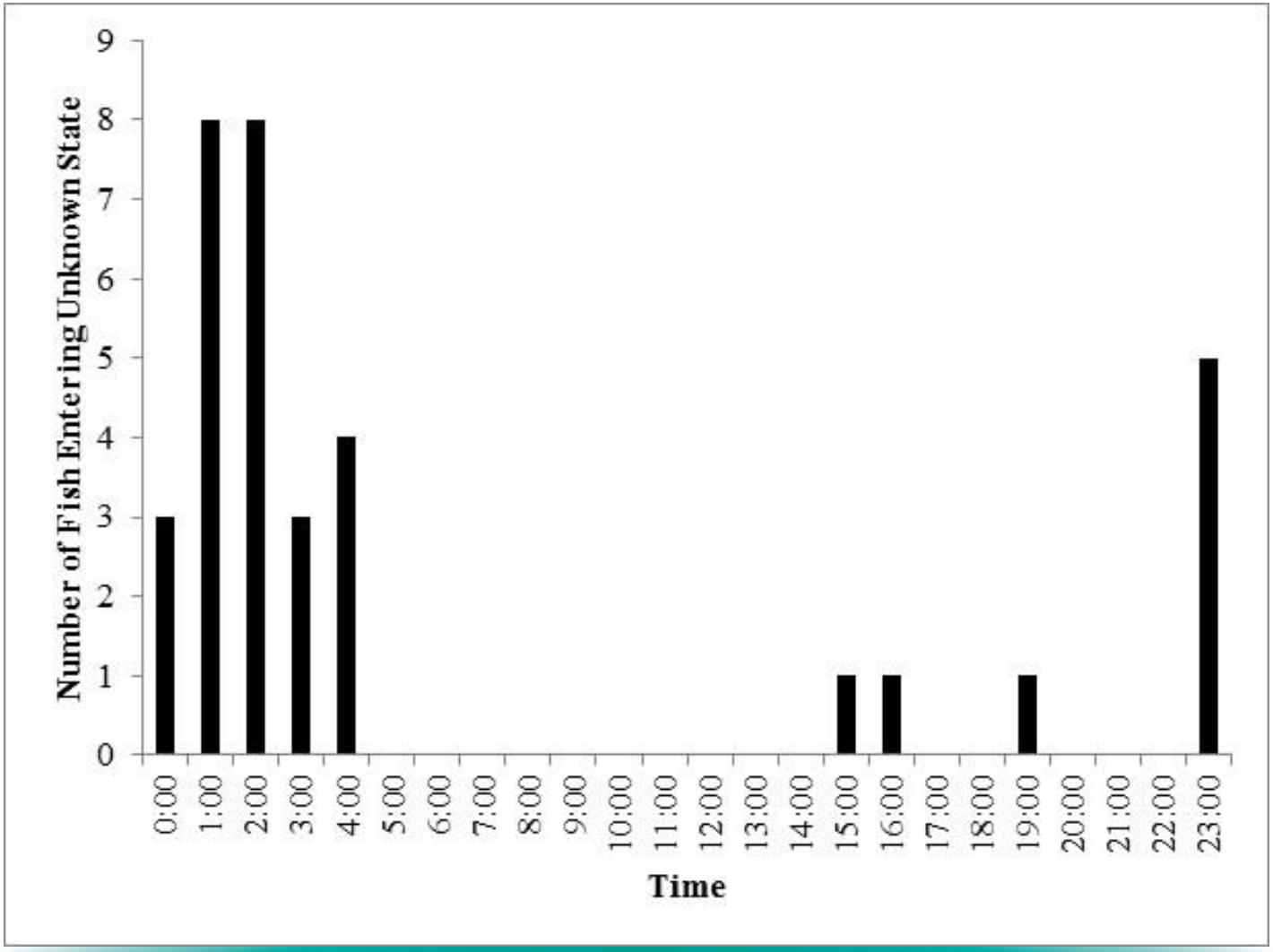
Model Number	Covariates	AIC	LR test	Hazard Ratio	SE	p	(+/-)
1	Rain (in)	822.13	0.06	2.86	0.54	0.051	(0.99,8.21)
2	NMPS ops (kcfs)	843.51	0.91	0.99	0.02	0.91	(0.93,1.06)
3	Diurnal (day)	822.92	<0.001	0.20	0.43	< 0.01	(0.08,0.46)
4	Night:Rain (in)	**818.97**	0.01	5.19	0.55	0.003	(1.74,15.43)
	Day:Rain (in)			0.29	1.53	0.42	(0.01,5.95)

Cox PH output for time-to-unknown state

Model Number	Covariates	AIC	LR test	Hazard Ratio	SE	p	(+/-)
1	Rain (in)	467.60	0.11	3.33	1.68	0.09	(0.81,13.58)
2	NMPS ops (kcfs)	**409.06**	<0.001	0.68	0.05	<0.001	(0.62,0.75)
3	Diurnal (day)	470.75	<0.001	0.05	1.01	0.003	(0.01,0.37)

3.3.5-Downstream Passage of American Eel (2-Year Study)

Were all fish that transitioned into the unknown state entrained?



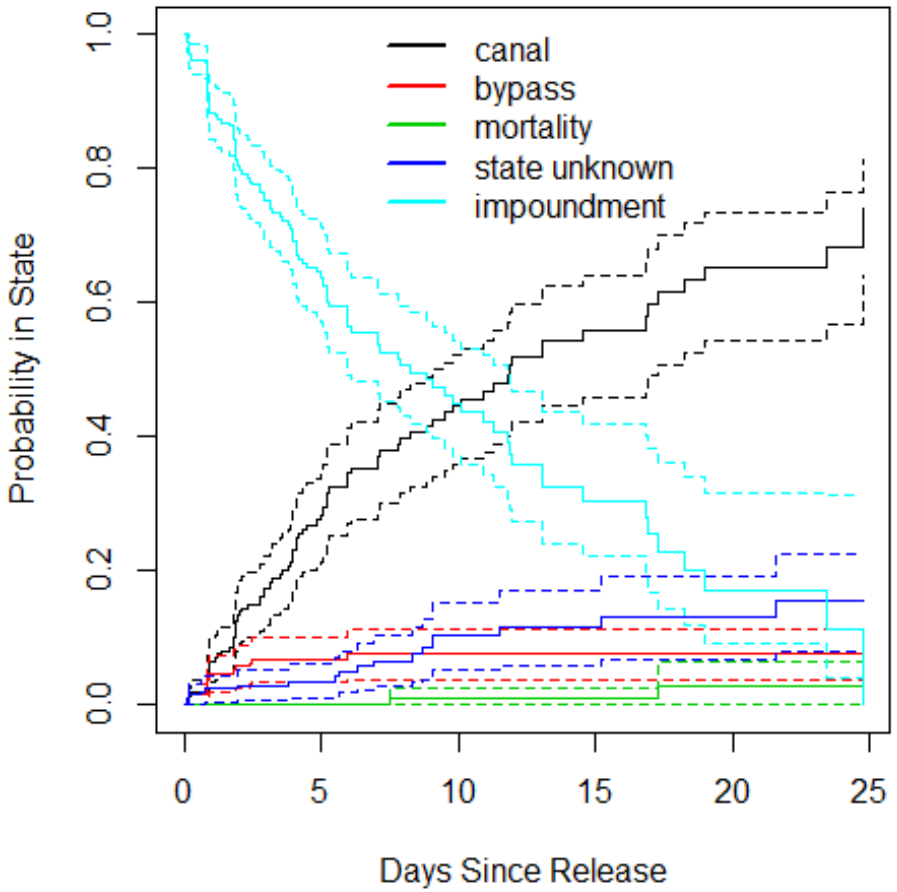
3.3.5-Downstream Passage of American Eel (2-Year Study)

Assessment of Passage at Turners Falls Dam

- Once arriving at TFD, fish can either pass through the gatehouse and into the power canal or they can pass over bascule gates and into bypass reach

- Some fish were found dead during mobile tracking, and some were never seen again (unknown state and presumed dead)

- Of 127 viable fish from all release cohorts,
  - 88 chose the canal (88/127 = 69%)
  - 16 chose the bypass (13/127 = 10%)



3.3.5-Downstream Passage of American Eel (2-Year Study)

Raw recapture counts within each reach by release cohort

Reach	TransCanada	Upper Impoundment	Lower Impoundment	All Cohorts
Impoundment	39	43	45	127
Canal	29	25	34	88
Bypass	2	7	4	13
Mortality	0	1	1	2
Unknown State	6	8	5	19

Descriptive statistics of event times (hours since release) from the TFI to an absorbing state

Event	Min	25%	Median	75%	Max
Canal	2.75	43.83	97.58	198.0	593.50
Bypass	20.10	21.11	32.67	53.83	143.50
Mortality	179.6	238.4	297.1	355.8	414.6
Unknown State	2.76	16.86	135.8	212.8	518.1

3.3.5-Downstream Passage of American Eel (2-Year Study)

Cox PH output for time-to-canal

Model Number	Covariates	AIC	LR test	Hazard Ratio	SE	p	(+/-)
1	Rain (in)	1647.84	0.001	4.18	0.42	< 0.001	(1.18,9.55)
2	Canal Flow (kcfs)	1678.07	< 0.001	1.11	0.03	< 0.001	(1.05,1.17)
3	Spill Flow (kcfs)	1683.06	0.004	1.10	0.02	< 0.001	(1.04,1.15)
4	Diurnal (Day = 1)	1636.65	< 0.001	0.10	0.42	< 0.001	(0.04,0.23)
5	Day:Rain (in)	**1634.166**	<0.001	0.11	1.55	0.172	(0.01,2.52)
	Night:Rain (in)			8.57	0.42	<0.001	(3.76,19.55)
6	Day: Canal Flow (kcfs)	1635.18	<0.001	0.85	0.07	0.02	(0.74,0.98)
	Night: Canal Flow (kcfs)			1.11	0.02	<0.001	(1.05,1.18)
7	Day: Spill Flow (kcfs)	1635.73	<0.001	0.76	0.26	0.292	(0.45,1.27)
	Night: Spill Flow (kcfs)			1.47	0.03	<0.001	(1.37.1.57)

3.3.5-Downstream Passage of American Eel (2-Year Study)

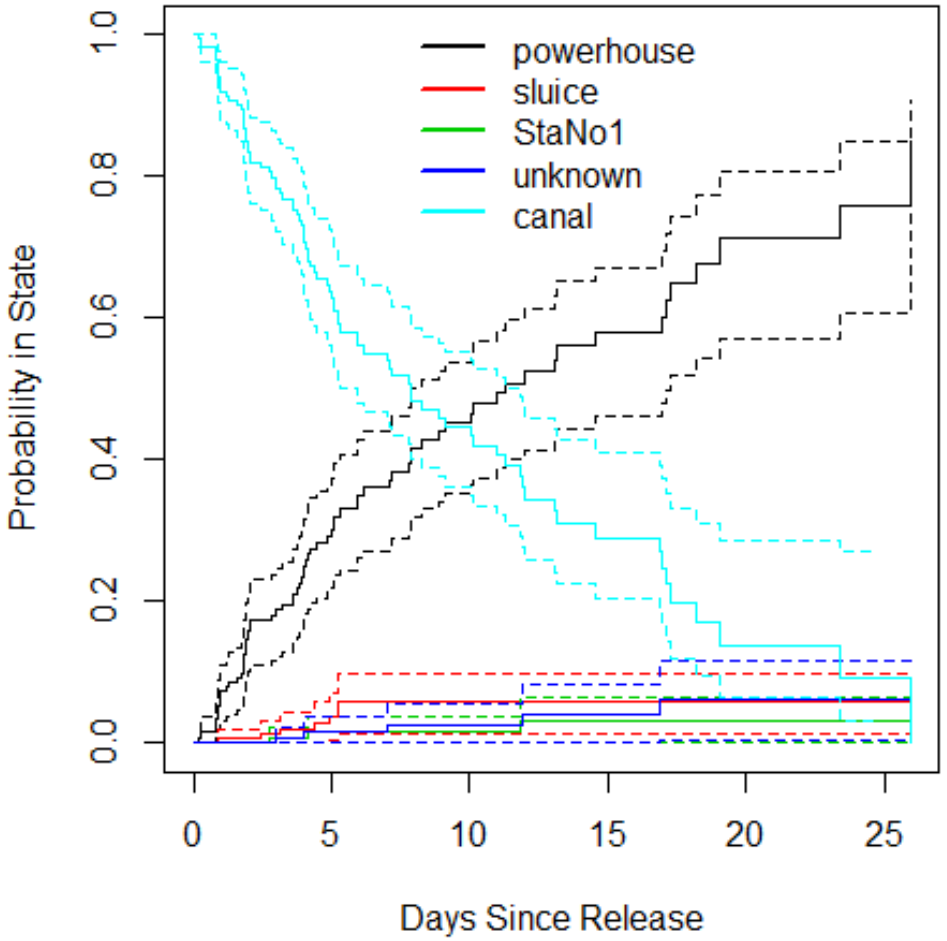
Cox PH output for time-to-bypass

Model Number	Covariates	AIC	LR test	Hazard Ratio	SE	p	(+/-)
1	Rain (in)	304.06	< 0.001	24.6	0.704	< 0.001	(6.19,97.76)
2	Diurnal (day)	305.29	< 0.001	0	3,772	0.996	(0, inf)
3	Spill Flow (kcfs)	313.82	0.003	1.19	0.04	< 0.001	(1.10,1.29)
4	Canal Flow (kcfs)	321.19	0.24	0.91	0.08	0.254	(0.78,1.07)
5	Rain: Spill Flow	300.38	< 0.001	2.18	0.14	< 0.001	(1.67, 2.86)
6	Day: Rain (in)	**295.71**	< 0.001	0.0	400	0.55	(0, inf)
	Night: Rain (in)			39.9	0.69	< 0.001	(10.3,155)

3.3.5-Downstream Passage of American Eel (2-Year Study)

Assessment of Passage Route through Canal

- Fish can pass via the Cabot Station Powerhouse, downstream bypass sluice or the Station No. 1 Powerhouse
- Final detection at T171, T172 or T173 followed by subsequent detections at T17 or T19 indicate passage through Cabot
- Final Detection at T174 with subsequent detections at T17 or T19 indicate passage via sluiceway
- Final Detection at T13 or T14 followed by detections at T15 indicate passage through Station No. 1
- Of 87 viable fish from all release cohorts
  - 72 passed via Cabot Station (72/87 = 83%)
  - 7 passed via sluiceway (7/87 = 8%)
  - 3 passed via Station No. 1 (3/87 = 3%)
  - 5 passed into tailrace via unknown route (5/87 = 6%)



3.3.5-Downstream Passage of American Eel (2-Year Study)

Raw recapture counts within each reach by release cohort

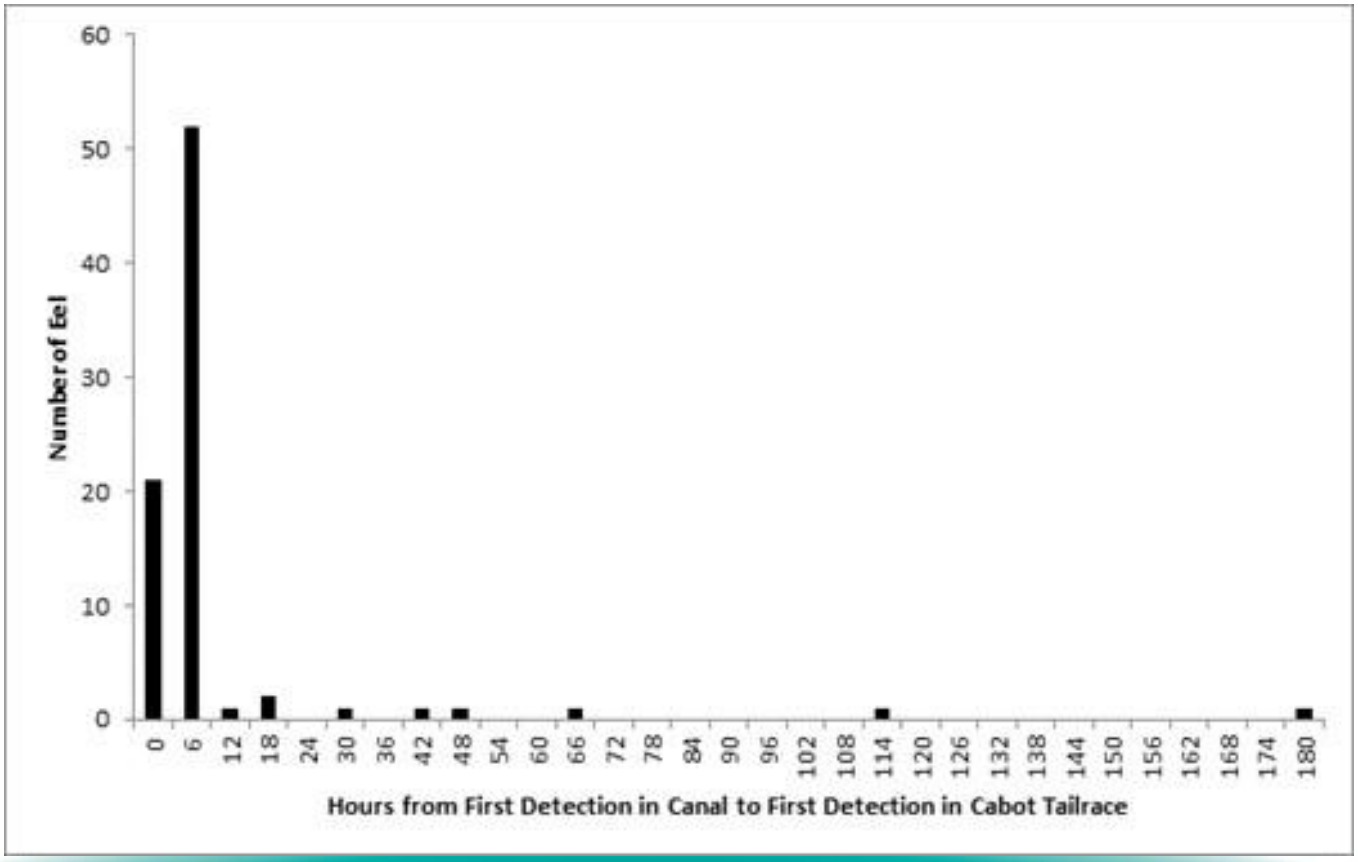
Route	TC	Upper Impoundment	Lower Impoundment	All Cohorts
Cabot Powerhouse	22	24	26	72
Downstream Bypass	4	0	3	7
Station 1 Powerhouse	2	0	1	3
Unknown Route	1	1	3	5

Descriptive statistics of event times (hours since release) from the Canal to an absorbing state

Event	Min	25%	Median	75%	Max
Cabot Powerhouse	4.71	44.14	96.37	191.50	622.80
Downstream Bypass	21.96	66.44	104.90	121.80	125.90
Station 1 Powerhouse	66.52	82.72	98.92	191.50	284.20
Unknown Route	70.83	94.98	169.10	285.00	404.20

3.3.5-Downstream Passage of American Eel (2-Year Study)

Histogram of durations for all fish within the canal. The durations in hours were calculated between the first detection in the canal and the first detection within Cabot Tailrace. It appears that as fish are motivated to move in the impoundment and into the canal that most migrate through in one event, majority of durations are 6 hours or less



3.3.5-Downstream Passage of American Eel (2-Year Study)

Cox PH output for time-to-powerhouse passage

Model Number	Covariates	AIC	LR test	Hazard Ratio	SE	p	(+/-)
1	Diurnal (Day = 1)	914.51	<0.001	0.10	0.52	<0.001	(0.04,0.29)
2	Canal Flow (kcfs)	913.39	<0.001	1.28	0.04	<0.001	(1.18,1.39)
3	Delta Canal Flow (1000 ft^3/s^2)	949.31	0.15	<0.001	116	0.13	(0.00,1.1*10^{22})
4	Day: Canal Flow (kcfs)	**895.57**	<0.001	1.01	0.08	0.94	(0.86, 1.18)
	Night: Canal Flow (kcfs)			1.26	0.04	<0.001	(1.16, 1.36)

3.3.5-Downstream Passage of American Eel (2-Year Study)

Turbine Survival Test Hi-Z Tag Study

Summary of 1-hour and 48-hour survival rates and 90% CI (+/-) for each study site.

Station	Number Released	1-hour Survival Rate (90% CI +/-)	48-hour Survival Rate (90% CI +/-)
Cabot Station Unit 2	50	98 (3.3)	96.0 (4.6)
Station No. 1 Unit 2/3	30	62.1 (14.8)	62.1 (14.8)
Station No. 1 Unit 1	30	90.0 (9.1)	90.0 (9.1)
Bascule Gate 1 (combined)	95	86.8 (5.8)	82.9 (5.9)
1,500 cfs	35	88.2 (4.0)	88.2 (4.0)
2,500 cfs	30	85.7 (7.4)	85.7 (7.4)
5,000 cfs	30	86.2 (10.5)	86.2 (10.5)
Bascule Gate 4 (combined)	95	90.5 (4.9)	88.4 (5.4)
1,500 cfs	35	88.6 (8.7)	82.9 (10.5)
2,500 cfs	30	90.0 (9.1)	90.0 (9.1)
5,000 cfs	30	93.3 (7.6)	93.3 (7.6)
Combined Controls	25	100	100

3.3.5-Downstream Passage of American Eel (2-Year Study)

Conclusions

- Potential for entrainment at NMPS, Cox PH states that fish are more likely to transition into the unknown state at night when pumping flow is greatest – follow the flow
  - 69% of the of the released eels were expected to arrive in either the Bypass Reach or Cabot Power Canal.
- Eel are motivated to move at night when it rains, and appear to continue migrating through flood pulse
- Fish overwhelmingly choose canal (69%) and overwhelmingly pass via Cabot Powerhouse (83%) – follow the flow
  - They do so relatively quickly < 6 hours suggesting a single migratory event
- Hi-Z turbine test suggests high survival through Cabot Station with > 90% survival after 48 hours
- DIDSON count data did not find a seasonal peak

Process for Developing Sea Lamprey HSI Curves

Habitat Suitability Criteria (Kynard and Horgan 2013):

Velocity		Depth		Substrate	
Velocity (fps)	SI Value	Depth (ft)	SI Value	Substrate Class	SI Value
0.00	0.00	0.00	0.00	Detritus – 1	0.00
0.30	0.00	0.13	0.00	Mud/soft clay – 2	0.00
1.28	0.34	0.46	0.50	Silt – 3	0.00
2.26	1.00	0.79	1.00	Sand – 4	0.04
3.25	0.86	1.12	1.00	Gravel – 5	1.00
4.23	0.30	1.44	0.60	Cobble/Rubble – 6	0.50
5.22	0.12	1.77	0.40	Boulder – 7	0.02
6.20	0.08	2.20	0.20	Bedrock – 8	0.00
6.23	0.00	2.30	0.00		

Kleinschmidt Study Spring/Summer 2015:

Mean Velocity = 1.76 fps Range = (0.82 to 2.99)

Mean Depth = 2.98 ft Range = (1.53 to 4.59)

Dominant Substrate = Cobble/Gravel

Process for Developing Sea Lamprey HSI Curves

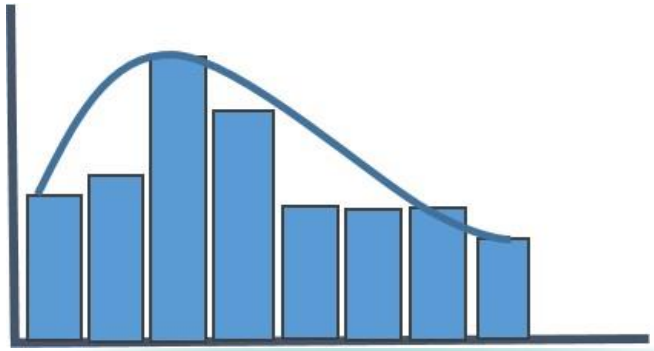
For sea lamprey spawning habitat suitability criteria for the PHABSIM model, there is interest in modifying the HSI curves, using observed data from the sea lamprey spawning study.

1. Propose to Develop Type II Utilization Curves
    a. Based on frequency analysis of fish observed and habitat variables measured.

2. Frequency curve is fit to a histogram then normalized so peak of the curve is 1.

3 Resulting function represents the probability of occurrence of variable given presence of fish.

4. Provide the new HSI curves to the stakeholders for their review.



FirstLight™
Power Resources

Developmental Resources

3.8.1-Operations Model

Study Goals and Objectives:

- To develop a baseline model of the Connecticut River Basin – specifically the reach from the Wilder Project to the Holyoke Project – which includes the following hydropower facilities:
  - TransCanada's Wilder, Bellow Falls, and Vernon Hydroelectric Projects,
  - FirstLight's Turners Falls Hydroelectric Project and Northfield Mountain Pumped Storage Project Project and
  - Holyoke Gas and Electric's Holyoke Hydroelectric Project

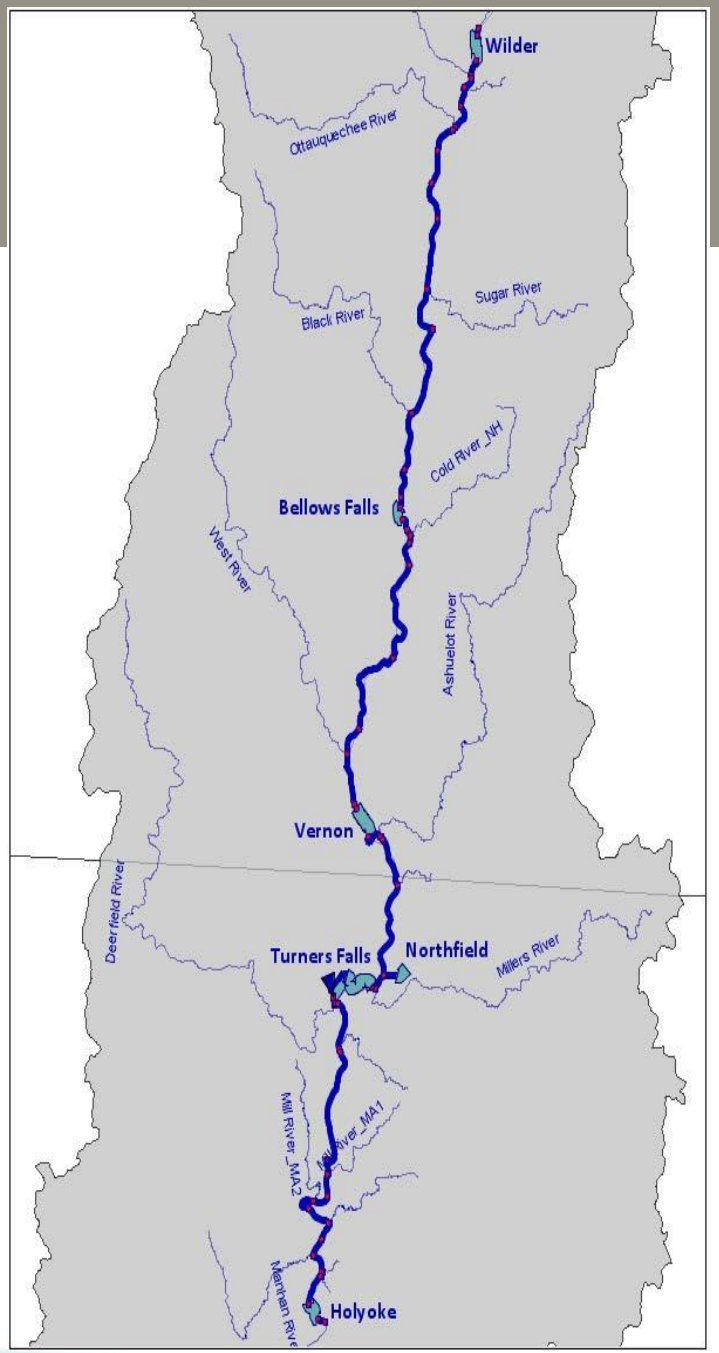
- The model will be used to determine the impact on hydropower generation and economics due to potential alternative modes of operation. Potential alternative modes of operation could include minimum bypass flows, changes in Turners Falls Impoundment (TFI) fluctuations, etc.

- Flow data generated from the model will be used to inform other studies, notably the instream flow study (habitat time series).

3.8.1-Operations Model

Model Development:

- Subset of Connecticut River Basin model
  - TransCanada Projects: Wilder, Bellows Falls, and Vernon
  - FirstLight Projects: Northfield Mountain and Turners Falls
  - Holyoke Gas and Electric Projects: Holyoke
- Model Updates
  - Physical (e.g. project configurations, reach routing)
  - Engineering (e.g. stage-storage-discharge rating curves, tailwater rating curves, power plant and pump capacities)
  - Operations data (e.g. pool fluctuation and flow release limitations)
- Data Collection (e.g. flows, WSELs)
  - USGS (gage observations and CRUISE simulation)
  - USACE (Connecticut River Basin model simulation)
  - FirstLight and TransCanada (observations)



3.8.1-Operations Model

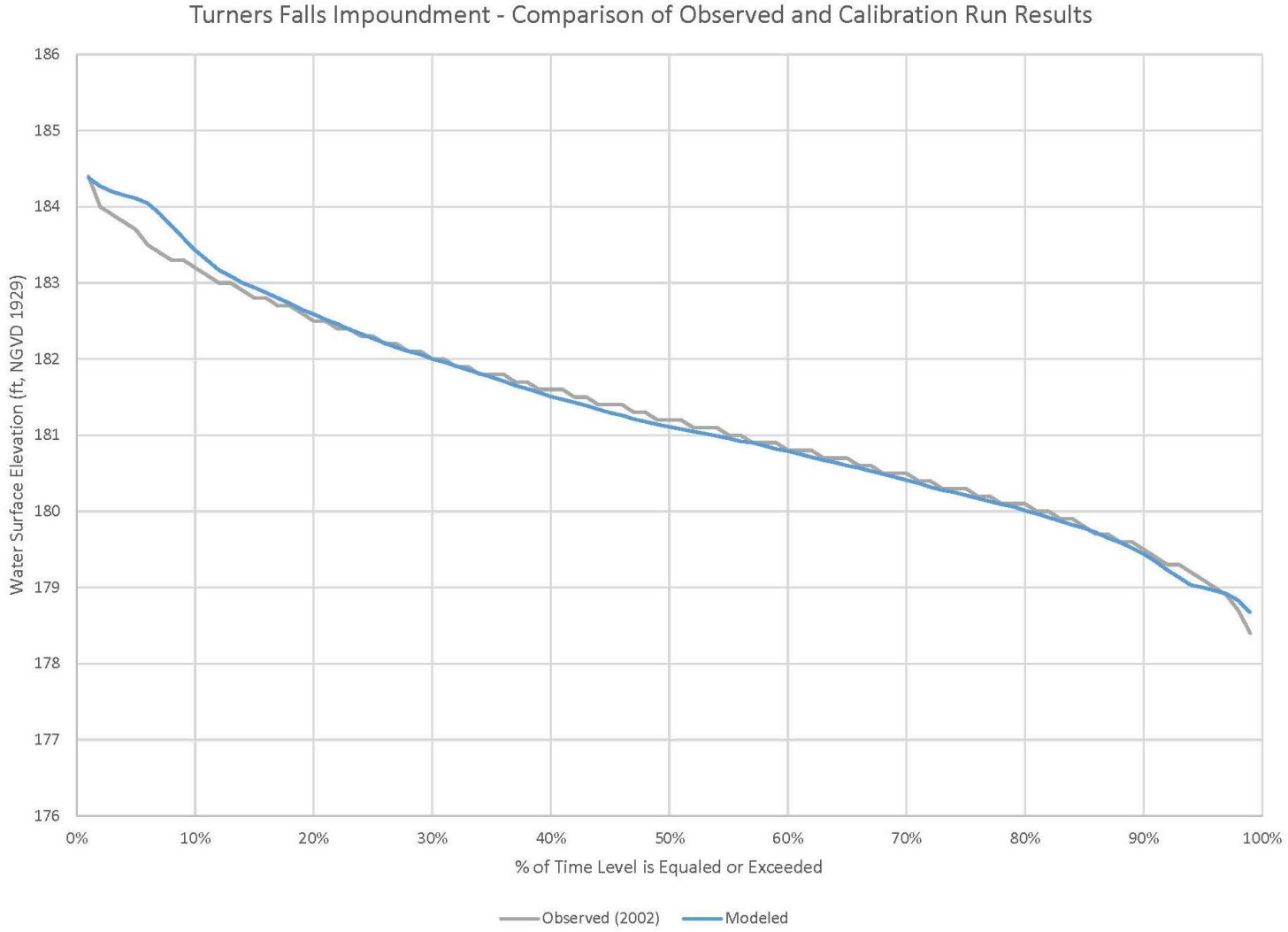
Model Calibration:

- Evaluated using calendar year 2002
  - Within available period of record for simulated flow data (USGS and USACE)
  - Flow duration curve at USGS Montague Gage generally representative of period of record from 1975-2016

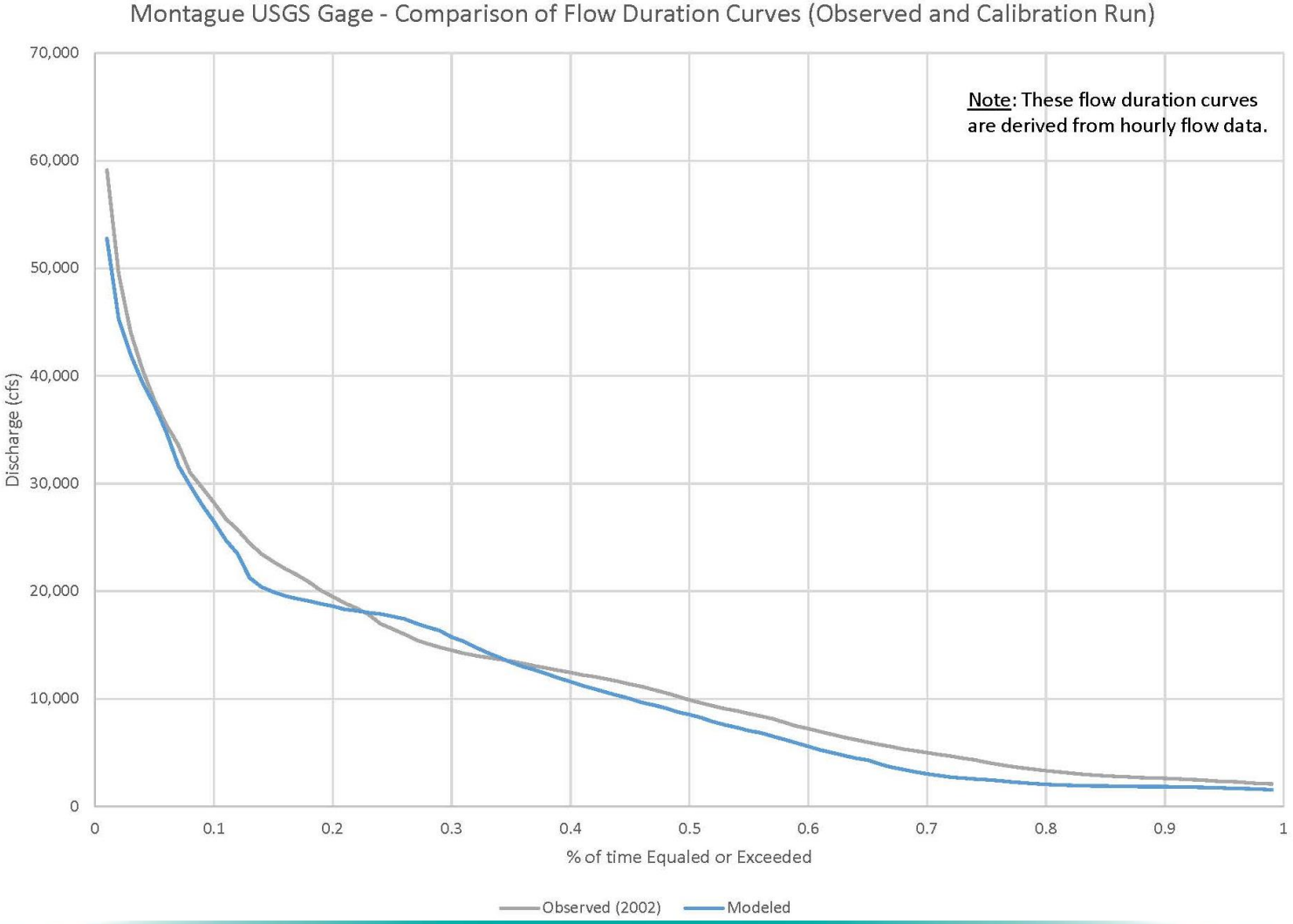
- Flow Inputs
  - Observed Vernon Discharge from TransCanada
  - Observed flows from Ashuelot, Millers, and Deerfield Rivers (all USGS gaged rivers)
  - Simulated flow data from USGS and USACE (only downstream of Turners Falls Project)

- Operations Data
  - Unit capacity and efficiencies consistent with machines circa 2002
  - Observed pumping and generation schedule for Northfield Mountain from 2002
  - Reservoir imbalance based on 2002 data

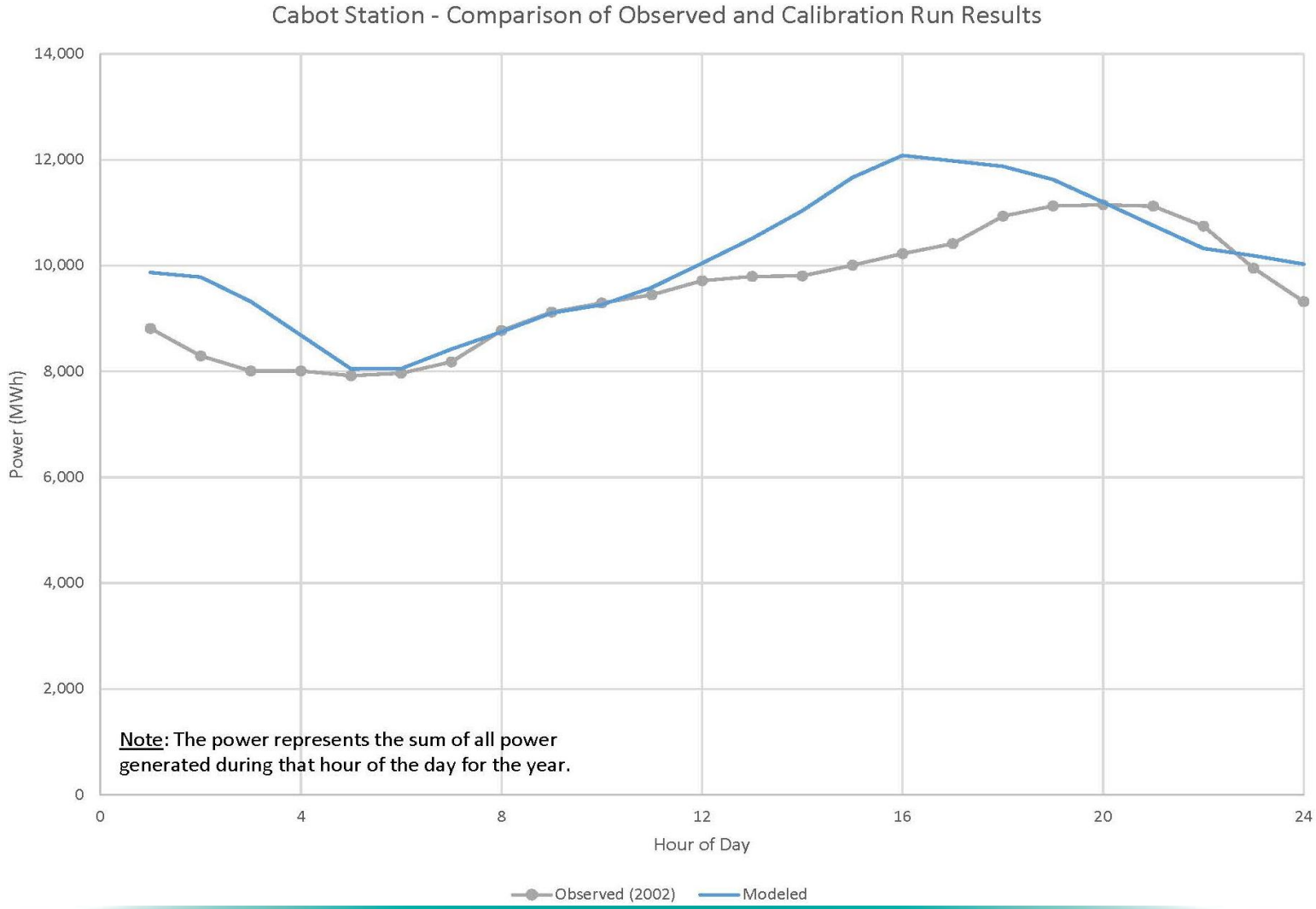
Calibration Results: TFI Annual Elevation Duration Curve (2002)



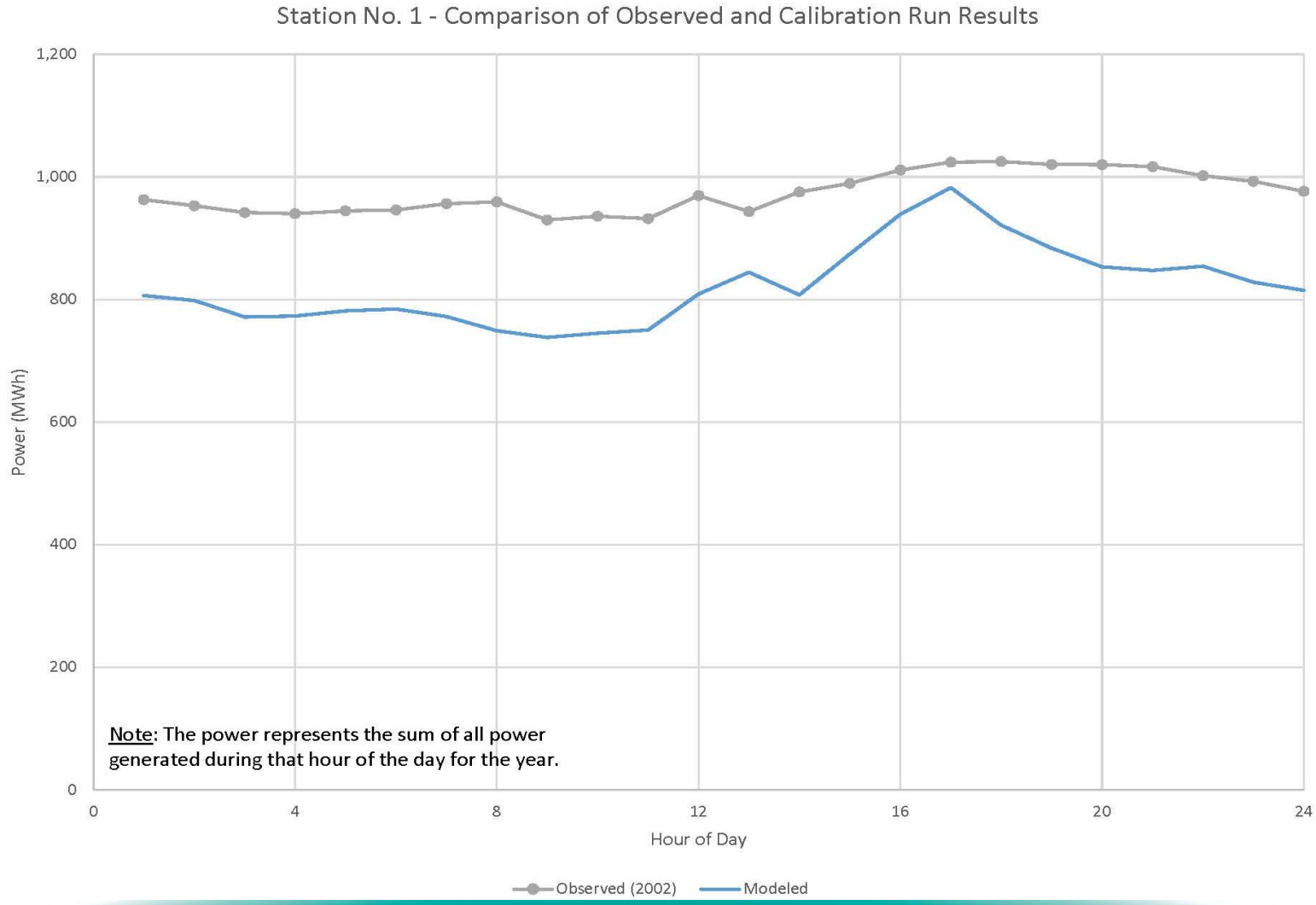
Calibration Results: Annual Flow Duration Curve at Montague Gage (2002)



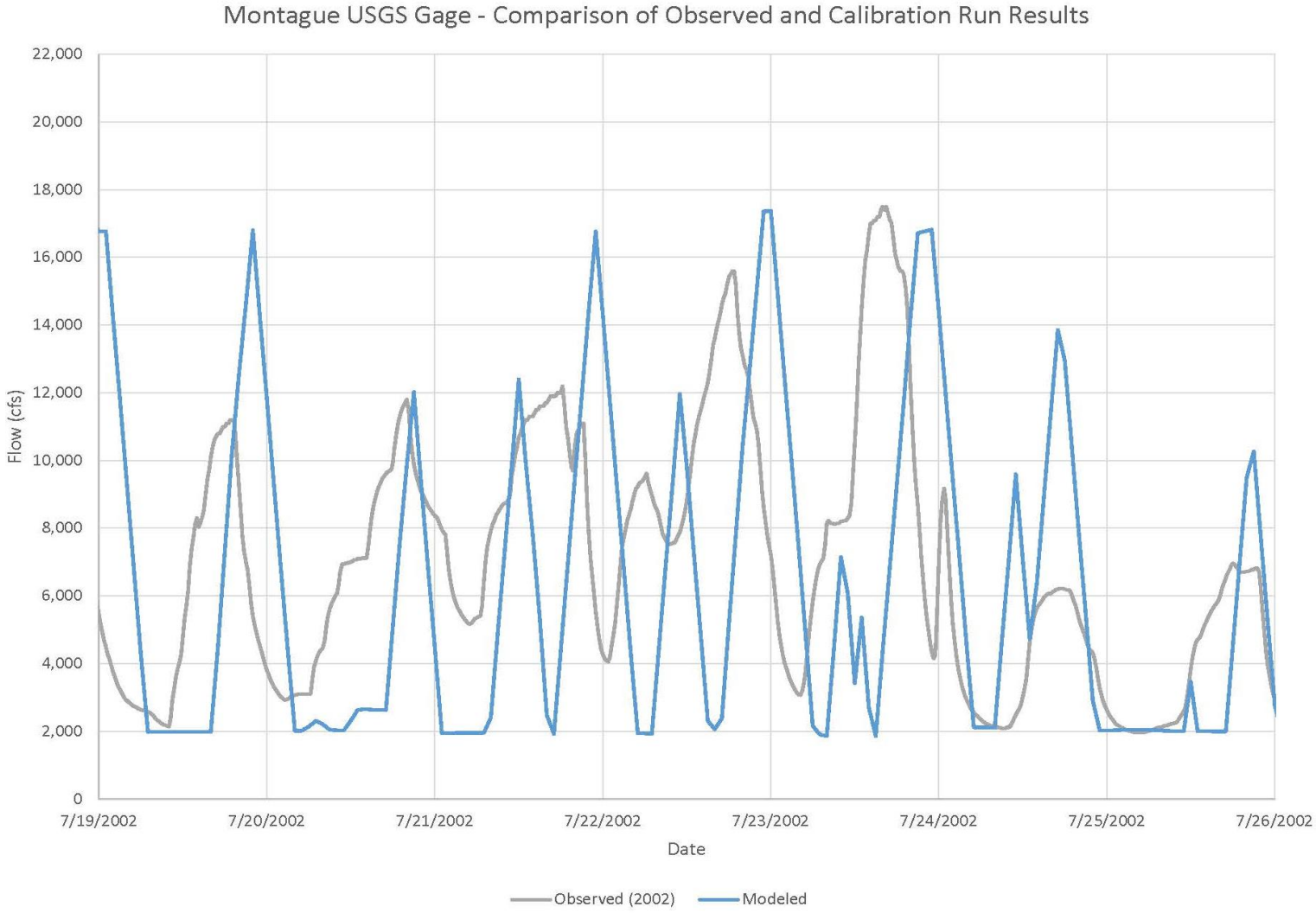
Calibration Results: Cabot- Timing of Generation during Day



Calibration Results: Station No. 1- Timing of Generation during Day



Calibration Results: Magnitude of Flows at Montague Gage

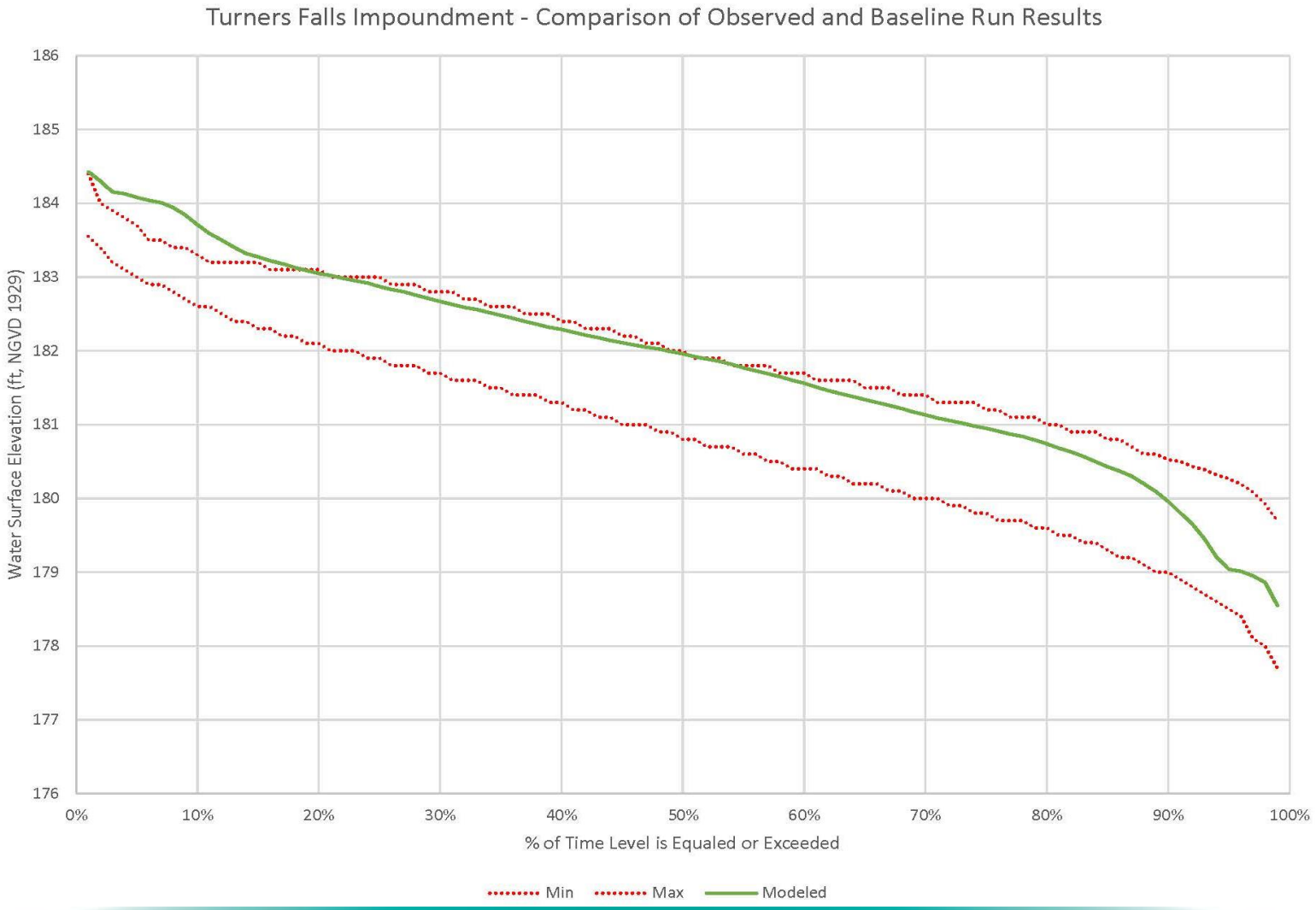


3.8.1-Operations Model

Calibration Results:

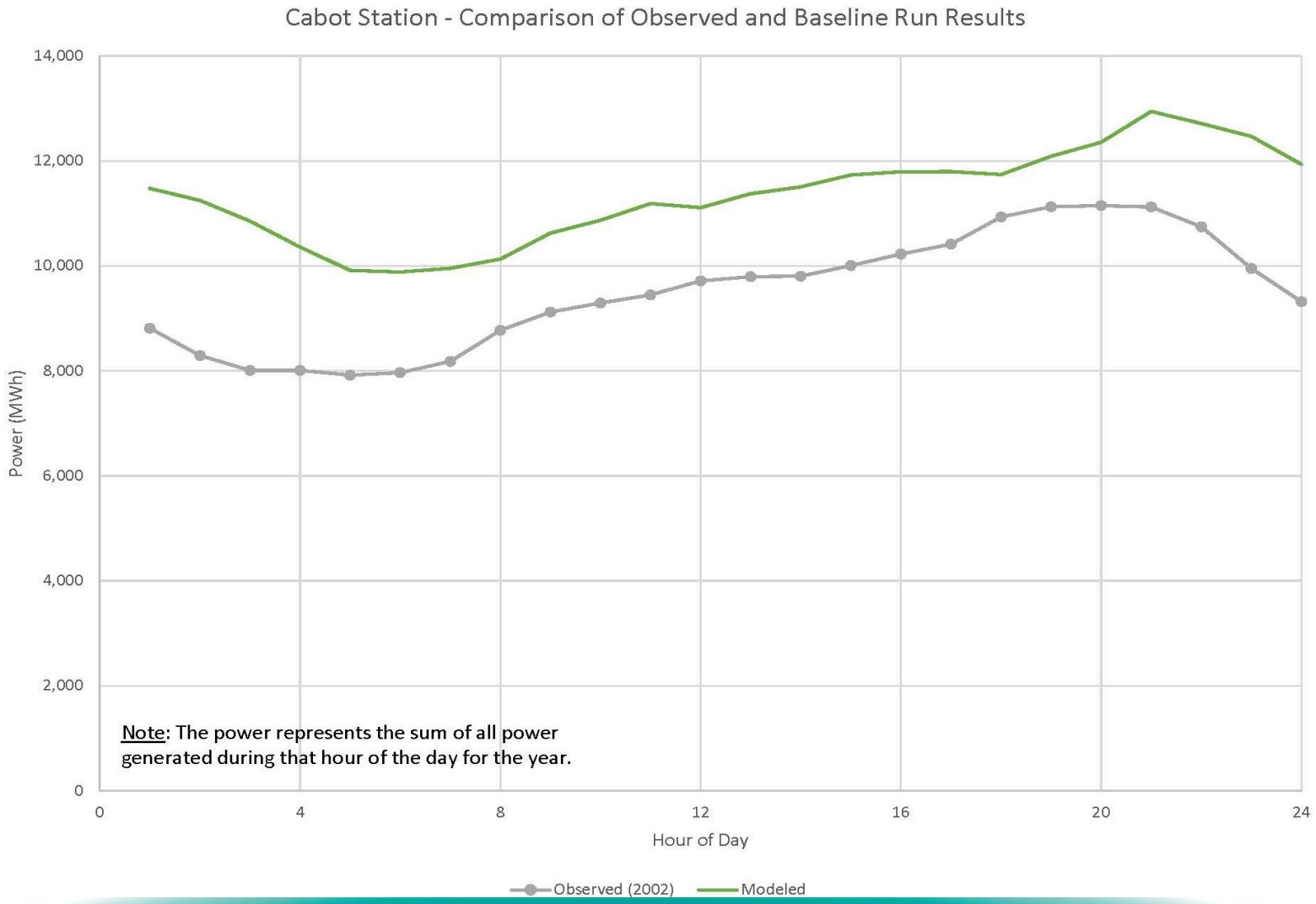
Project	Station	Observed Generation (MWh/yr)	Modeled Generation (MWh/yr)	Difference
Northfield Mountain	Northfield Station	1,327,953	1,294,774	-2.5%
Turners Falls	Cabot Station	228,123	242,179	+6.2%
	Station No. 1	23,368	19,730	-15.6%
Total		**1,579,444**	**1,556,682**	**-1.4%**

Baseline Results:



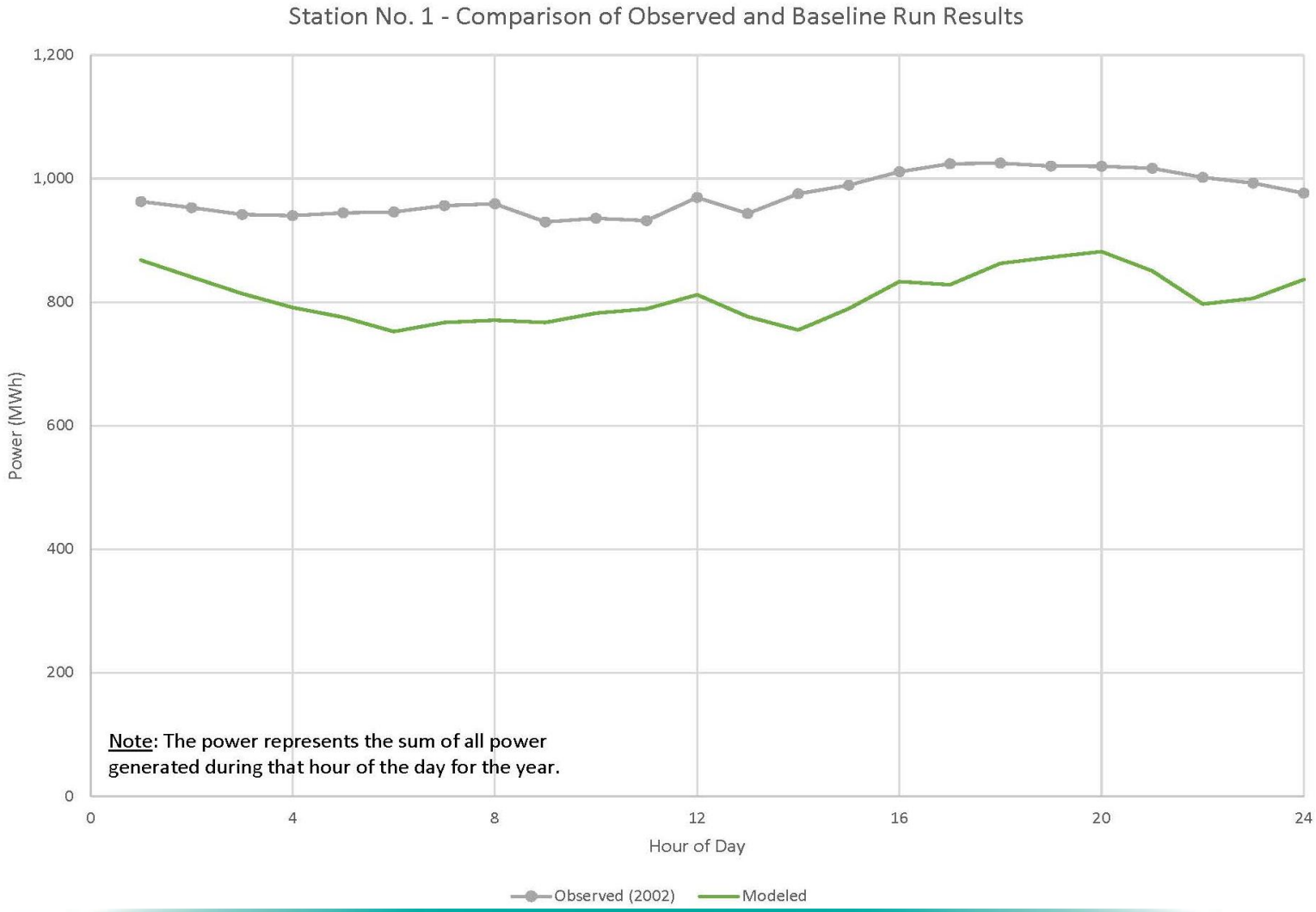
3.8.1-Operations Model

Baseline Results:



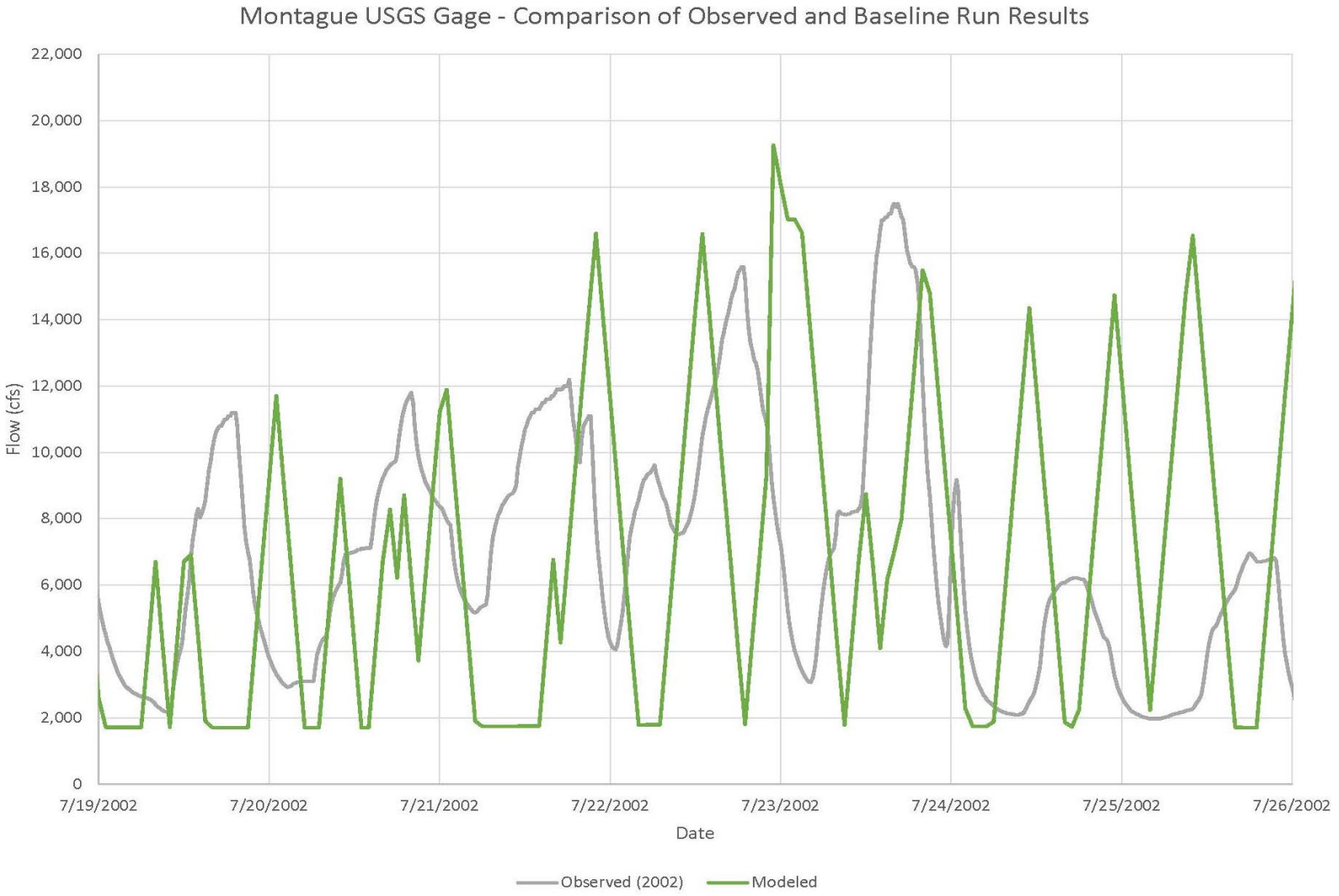
3.8.1-Operations Model

Baseline Results:



3.8.1-Operations Model

Baseline Results:



3.8.1-Operations Model

Baseline Results:

Project	Station	Modeled Generation (MWh/yr)
Northfield Mountain	Northfield Station	923,968
Turners Falls	Cabot Station	272,045
	Station No. 1	19,420
Total		**1,215,433**

3.8.1-Operations Model

Production Runs:

- Modifications to the baseline model may be made to evaluate the effects on generation, water surface elevations, and flows of a new operating regime
- The model may also be used to address stakeholder comments on other studies
- Changes to the FirstLight model necessary for completing future potential production runs could require that the calibration and baseline runs be reanalyzed.

3.8.1-Operations Model

Discussion:

- An existing model was modified to better simulate the operations of the Turners Falls and Northfield Mountain Projects
- Model calibration to calendar year 2002 provided acceptable agreement in TFI water surface elevations, as well as timing and total generation output
- A baseline run representing current operations provided results within the expected range
- The model may be used for future potential production runs