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February 16, 2021

Ms. Shannon Ames, Executive Director
Low Impact Hydropower Institute
C/O NPCM
P.O. Box 211
Sterling, MA 01564

Subject: LIHI Recertification for the Medway Project (FERC No. 2666; LIHI Certificate No. 65), Orono Project (FERC No. 2710; LIHI Certificate No. 66), and Stillwater Project (FERC No. 2712; LIHI Certificate No. 67); Response to Maine Department of Marine Resources Comments

Dear Ms. Ames:

Black Bear Hydro Partners, LLC (Black Bear) herein files responses to comments provided by the Maine Department of Marine Resources (MDMR) for the Medway, Orono, and Stillwater Project LIHI recertification applications. The Medway Project (FERC No. 2666) is licensed to Black Bear, while the Orono Project (FERC No. 2710) and the Stillwater Project (FERC No. 2712) are licensed to Black Bear; Black Bear SO, LLC; and Black Bear Development Holdings, LLC, who are affiliates of Brookfield Renewable (Brookfield).

Black Bear submitted Initial LIHI Applications for recertification of the Medway Project on June 30, 2020, and for the Stillwater and Orono Projects on July 6, 2020. Following Intake Reviews, revised LIHI Applications for recertification were submitted on November 13, 2020 (for Stillwater and Orono) and on November 30, 2020 (for Medway). During LIHI's final reviews of the revised applications, an email inquiry was sent to the MDMR by Pat McIlvaine on December 14, 2020. MDMR provided a response to the inquiry on January 30, 2021, which was provided to Black Bear on February 2, 2021. Black Bear provides responses to MDMR's comments below.

MDMR Comment: *It is our opinion that BBHP has been accommodating in making modifications at some, but not all, passage facilities or project operations. It is also important to note that while BBHP has been accommodating in carrying out the required monitoring at most projects, the pace of monitoring studies has been very slow as BBHP have chosen an iterative approach. This approach has resulted in monitoring for one aspect (E.g. route of passage or survival) for often only one species, lifestage, and direction of migration in a given year (E.g. downstream juvenile alewife route of passage). Due the slow pace of monitoring studies, BBHP lacks the required information to determine if fish passage is safe, timely, and effective for many species and lifestages and the Orono, and Stillwater projects. This also means that MDMR and other resource agencies lack the required information to inform recommendations for modification of passage facilities or project operations for many species and lifestages and the Medway, Orono, and Stillwater projects. In addition, some of the monitoring completed by BBHP has been under non-normal project operations (E.g. spill at a project during a downstream study in a year with exceptionally low flow that was below station capacity), which makes the result irrelevant to normal operational conditions.*

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Bear Response: Black Bear strongly disagrees that it has been accommodating in making modifications at only "*some, but not all, passage facilities or project operations*". Below is a list of modifications implemented at Stillwater and Orono in response to agency concerns and in follow-up to Black Bear's annual evaluations of the new Project fish passages since Brookfield's acquisition of the Projects in 2014. Please note that this list does not include modifications undertaken on Brookfield's other lower Penobscot River Projects (Milford and West Enfield), which are also numerous and comprehensive.

Stillwater

- Hired dedicated seasonal staff and a full-time fisheries biologist to supervise, inspect, monitor and operate the Stillwater downstream fish passage facilities and upstream eel passage.
- Implemented increased downstream fish passage capacity and 2 weeks of spill in May to facilitate downstream Atlantic salmon smolt passage.
- Repaired gaps in the trashracks at Stillwater A Station to prevent eel entrainment.
- Instituted annual dive inspections of the trashracks for both Stillwater powerhouses to ensure integrity prior to the eel outmigration season.
- Installed stop logs to increase the depth of the Stillwater B downstream fishway plunge pool.
- Increased the height of the Stillwater B plunge pool wall to prevent water and fish from spilling over the top and onto ledges below.
- Extended the climbing substrate at the entrance to the upstream eel passage based on the first-year study results.
- Conducted surveys of the spillway bypass area during raising and caulking of the flashboards to search for and relocate stranded fish.
- Amended the Stillwater Project FERC license to redirect minimum flows in order to enhance upstream eel passage.

Orono

- Hired dedicated seasonal staff and a full-time fisheries biologist to supervise, inspect, monitor and operate the Orono upstream and downstream fish passage facilities and upstream eel passage.
- Made operational changes to substantially increase the number of river herring trapped and then trucked upstream from the Orono fish trapping facility, including:
    - Utilizing dedicated seasonal fish passage staff to operate the facility and transport fish upstream.
    - Purchased additional transport trucks and trailers.
    - Refined operations, including (1) increasing the number of fish per truck load based on MDMR river herring trucking procedures, and (2) use of underwater cameras to improve overall efficiency resulting in more fish moved during peak migration days.
- Implemented increased downstream fish passage capacity and 2 weeks of spill in May to facilitate downstream Atlantic salmon smolt passage.
- Instituted annual dive inspections of the trashracks to ensure integrity prior to the eel outmigration season.
- Instituted annual external engineering inspections of fish lift hoists, cables, etc. prior to the start of operations to reduce the risk of catastrophic failure.

- Implemented a significant pre-season operational and maintenance start-up procedure, an end of season shut-down procedure, and bolstered the spare parts inventory for the fish lift.
- Increased the height of the blocking screen upstream of the fish lift hopper to ensure that fish cannot pass over the screen during times of extremely high tailwater elevations.
- Replaced a 90 degree turn in the Orono downstream fishway with a rounded curve to streamline flows and reduce water overtopping and loss of fish over the fishway wall.
- Modified (shortened by 6 feet) the steel discharge flume of the downstream passage to reduce turbulence at the entrance to the fish lift in order to improve fish attraction.
- Modified the wedge-wire screen floor in the downstream fish passage/fish lift auxiliary water flow transition box with a punch plate overlay to reduce debris load and provide supplemental protection for downstream fish migrants.
- Implemented procedures during impoundment maintenance drawdowns to prevent dewatering of the Orono Project bypass area.
- Conducted surveys of the spillway bypass area during raising and caulking of boards to search for and relocate stranded fish.
- Prioritized operation of Station A over Station B at the Orono Project during the smolt downstream migration window based on empirical study survival results.

Black Bear also fully disagrees that "*the pace of monitoring studies has been very slow*". While Black Bear has taken an iterative and prioritized approach to the studies, as discussed in greater detail below, we note that in just the 6 years that Brookfield has owned and operated the lower Penobscot assets, we have conducted at least one year of study of each target species (Atlantic salmon, alosines and eels) for each life stage (juvenile and adult) in each direction (upstream and downstream) at each Project, as appropriate.

Species	**Stillwater Upstream**	**Stillwater Downstream**	**Orono Upstream**	**Orono Downstream**
Salmon - juvenile	*NA*	2014-2018	*NA*	2014-2018
Salmon - adult	*NA*	*Required 10 yrs following smolt enhancements*	2014 & 2015	*Required 10 yrs following smolt enhancements*
Shad - juvenile	*NA*	*By proxy - 2020 alosine study*	*NA*	*By proxy - 2020 alosine study*
Shad - adult	*NA*	2017 & 2018	--	2017 & 2018
River herring - juvenile	*NA*	2015* & 2020	*NA*	2015* & 2020
River herring - adult	*NA*	2018	2015	2018
Eel - adult	*NA*	2014* & 2016	*NA*	2014* & 2016
Eel - juvenile	2014*, 2016 & 2017	*NA*	2014* & 2016	*NA*

* Pilot or qualitative studies

The table above is not an exhaustive list, as several qualitative studies and/or pilot studies have also been conducted. A detailed listing of the qualitative and quantitative studies conducted on the new Stillwater and Orono fish passages, which were completed and put into operation in 2014 (and in 2016 for the new upstream eel ladders) is below. Each of these studies was determined and implemented in consultation with the resource agencies:

- 2014:
  - Qualitative investigations of American eel upstream passage at the Stillwater Project (site location survey)
  - Qualitative investigations of American eel upstream passage at the Orono Project (site location survey)
  - Adult eel presence study via electrofishing and netting surveys at the Stillwater Project
  - Adult eel presence study via electrofishing and netting surveys at the Orono Project
  - Qualitative assessment of fish passage through the downstream surface fishways using underwater video at the Stillwater Project
  - Qualitative assessment of fish passage through the downstream surface fishways using underwater video at the Orono Project
  - Quantitative paired-release Atlantic salmon smolt downstream study at the Stillwater Project
  - Quantitative paired-release Atlantic salmon smolt downstream study at the Orono Project
  - Radio telemetry study to evaluate upstream passage of adult Atlantic salmon at the Orono Project
- 2015:
  - Radio telemetry study to evaluate the upstream passage of adult river herring at the Orono Project
  - Radio telemetry study to evaluate upstream passage of adult Atlantic salmon at the Orono Project
  - Pilot tagging study of juvenile alosines at the Orono Project
  - Pilot tagging study of juvenile alosines at the Stillwater Project
  - Underwater video camera monitoring of the Stillwater downstream low-level American eel fishway
  - Underwater video camera monitoring of the upstream fish lift entrances at the Orono Project
  - Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Stillwater Project
  - Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Orono Project
- 2016:
  - Downstream eel passage radio telemetry study at the Stillwater Project
  - Downstream eel passage radio telemetry study at the Orono Project
  - Quantitative video monitoring of upstream juvenile eel passage at the Stillwater Project
  - Quantitative video monitoring of upstream juvenile eel passage at the Orono Project

- Nighttime surveys of upstream juvenile eel passage at the Stillwater Project
- Nighttime surveys of upstream juvenile eel passage at the Orono Project
- Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Stillwater Project
- Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Orono Project

- 2017:
  - Radio telemetry study of adult American shad downstream passage at the Stillwater Project
  - Radio telemetry study of adult American shad downstream passage at the Orono Project
  - Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Stillwater Project
  - Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Orono Project
  - Quantitative video monitoring of upstream juvenile eel passage at the Stillwater Project
  - Nighttime surveys of upstream juvenile eel passage at the Stillwater Project.
- 2018:
  - Radio telemetry study of adult river herring downstream passage at the Stillwater Project
  - Radio telemetry study of adult river herring downstream passage at the Orono Project
  - Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Stillwater Project
  - Radio telemetry study to evaluate Atlantic salmon smolt downstream passage at the Orono Project
- 2019: Studies conducted at other lower Penobscot River Projects
- 2020:
  - Evaluation of downstream juvenile alosine passage route utilization at the Stillwater Project
  - Evaluation of downstream juvenile alosine passage route utilization at the Orono Project
  - Desktop assessment of juvenile alosine passage survival at the Stillwater Project
  - Desktop assessment of juvenile alosine passage survival at the Orono Project

In addition, Black Bear has collaborated with MDMR to collect upstream fish lift tallies at the Orono Project since 2014, including the trucking of river herring upriver from Orono. As of 2020, 138 Atlantic salmon, 24 American shad and 558,857 river herring have been trucked from the Orono Project fish lift since operations began in 2014.

Regarding the iterative approach, Black Bear consults with the agencies annually to determine the specific fish passage concerns given the previous year's studies, any structural or operational modifications that may be considered, and the preferences for study focus for the upcoming fish passage season. As outlined in FERC's October 4, 2017 and May 15, 2018 letters regarding the study plans, Black Bear has "*used and continues to use a collaborative and prioritized approach to the studies which you state have been productive, met the requirements, allowed for study adjustments and improvements to facilities, and allowed the studies to* *adaptively focus on current fish passage needs, fish availability, and priorities*." FERC, in these letters, also acknowledges "*the adaptive nature of the study proposals relative to the availability of the fish and management goals, and note that you have made modifications to facility operations and structures based on the results of the studies in order to improve passage conditions as required by the respective fish passage effectiveness articles for each project. Depending on the study results and any corresponding modifications, it may be necessary for you repeat studies to ensure the facility passes fish effectively*." As a current example, Black Bear has proposed (subject to operational constraints) to the resource agencies to prioritize Station B unit operations over Station A to improve downstream fish passage survival from June to October based on the 2020 juvenile alosine study results.

It is worth noting that there are studies that are either deliberately delayed, or which are determined by proxy. Specifically, Black Bear is beholden to the March 8, 2012 Species Protection Plan (SPP) and the August 31, 2012 National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) for Atlantic salmon and Atlantic and shortnose sturgeon for the lower Penobscot River Projects. Black Bear is also a signatory to the 2004 Lower Penobscot Settlement Agreement (Settlement Agreement), as is MDMR, which outlines agreed-upon provisions for upstream and downstream fish passage implementation, testing and improvements. In accordance with the 2012 BiOp, Atlantic salmon downstream kelt studies will be conducted 10 years following implementation of the final enhancements for smolt outmigration, which will be the subject of Section 7 Endangered Species Act consultation reinitiation anticipated to be undertaken in 2022. Additionally, upstream adult shad studies have been attempted on other rivers with inconclusive results due to handling effects and indeterminate passage motivations. As a result, Black Bear will continue to delay these studies in deference to river herring as a proxy until such time as study methodologies for this species improve.

MDMR Comment*: MDMR recommends that LIHI certification for Medway be delayed or be contingent on completion of improvements to downstream passage for eels.*

Black Bear Response: Black Bear continues to work with the agencies to understand passage conditions for downstream migrating eels at the Medway Project (see attached "*2020 Evaluation of Downstream Passage Effectiveness for Adult American Eel*"). Black Bear agreed, at MDMR's request, to include a dead eel drift component to the 2020 investigation, whereby an additional group of freshly dead eels were radio-tagged and released at Medway Dam. These eels were used to classify live study eels passing the Project based on their downstream transit duration relative to the drift duration, the purpose being to incorporate potential delayed eel mortalities from dam passage into the Project survival estimate. However, this methodology did not include any natural or tagging-related mortality effects; was likely an over-estimate of mortalities, as some eels that travelled in excess of the median drift duration were also noted as having variable travel times and directions (i.e. some study eels travelled upstream in some reaches, which would indicate they are not dead); and due to low West Branch flows during the fall 2020 study, downstream passage route options for radio-tagged adult eels were limited to the downstream bypass or the Project turbines. As a result, this study was conducted under worst case conditions for out-migrating eels.

Black Bear objects to a delay or contingent certification of the Medway Project pending "*completion of improvements*", as passage conditions and baseline effects are not yet fully understood. Black Bear is happy to continue its consultation with the agencies on the need for further investigation and potential operational or structural improvements at the Project, and to provide LIHI with updates on that progress as part of its Annual Certification Statement.

MDMR Comment: *MDMR has reviewed the study reports and we do not agree that the 2015 study findings are sufficient to prove that upstream passage for Atlantic salmon at Orono is safe, timely, and effective. The 2014 and 2015 studies were not designed to explicitly assess fish passage at the Orono Project. The studies were assessments of the Milford fishway, which used fish that were captured at the top of the Milford fishway and placed them downstream in order to re-approach the Milford fishway. Due to the study design the results of the study are biased towards fish that had already approached Milford and therefore are a biased assessment of the Orono Project as fish were unlikely to be motivated to pass the project. MDMR recommends further studies to determine passage is safe, timely, and effective for Atlantic salmon at Orono.*

Black Bear Response: While Black Bear will continue to conduct the requisite studies to evaluate effectiveness, we would like to clarify that, pursuant to the terms of the Settlement Agreement, of which MDMR is also a signatory, the intent of the Orono upstream fish trapping facility, specifically, is not as a traditional fish passage, but rather "*to gain access to any fish that are attracted to spill or minimum flow releases at the dam*". This is supported by the 2012 BiOp, which states "*the purpose of the fish trap is not to serve as a traditional fishway, but rather as an evacuation device that will remove fish that are attracted to the spillage in the Orono bypass reach*", and "*there is no upstream performance standard at the Orono Project*" under the expectation that "*no more than 33% of the migrating adult Atlantic salmon attracted to the discharge from either of the two (Orono) powerhouses will be harassed due to significant delay (more than 48 hours)*"[1]. FERC's March 27, 2014 "*Order Modifying and Approving Revised Species Protection Plan and Revised Atlantic Salmon Passage Study Plan*" also acknowledges this, stating "*(t)here is no performance standard for upstream passage effectiveness at the Orono Project, as the management goal is for Atlantic salmon to avoid the Stillwater Branch and pass upstream at the Milford Project*."

In 2014 and 2015, Black Bear conducted upstream adult Atlantic salmon monitoring to determine whether significant delay (lasting more than 48 hours) occurs at the Orono Project tailrace; a study plan was previously developed in consultation with the agencies, including NMFS and MDMR, and submitted to FERC on September 13, 2013. As stated in FERC's March 27, 2014 letter of approval, "…*to evaluate if delay is occurring downstream of the Orono Project, the licensee would study the movements of radio-tagged adult Atlantic salmon…Tagged salmon that swim within 200 meters downstream of the Milford Dam would be tracked to determine their success in using the upstream passage facility. Mobile telemetry may also be employed to locate fish not detected by the stationary receivers. Approximately 20 to 40 adult Atlantic salmon captured from the Milford Project fishlift and confirmed to have been released as juveniles upstream of the Milford Project would be gastrically radio-tagged and released downstream of the Milford and Orono dams. While this may introduce behavioral bias into the study from fish that have already experienced the Milford Project fishway, the licensee notes that this represents the most effective opportunity to capture upstream migrating adults.*"

[1] National Marine Fisheries Service. August 31, 2012. Biological Opinion and Incidental Take Statement for the Orono (2710), Stillwater (2712), Milford (2534), West Enfield (2600) and Medway (2666) Projects.

The results of the 2014 Study were: "*Upstream migration timing of adult tagged Atlantic salmon was evaluated for the 28 fish that retained radio tags and migrated upstream to the Milford Project. Of these fish, 14 (50%) were detected at either one of the Orono Project tailraces or in the Orono spillway before being detected at the Milford Project. The maximum elapsed time spent by 13 of these fish at the Orono Project was 11.8 hours…The last fish spent an elapsed time of 249.7 hours at Orono over the span of multiple visits back and forth between Milford and Orono when the Milford fish lift was not operational. This fish was successfully recaptured at Milford soon after the fish lift was back in operation, so the extensive period of time this fish required to pass Milford after release at the Orono boat launch was not attributed to delay caused by the Orono Project. Therefore, no significant migration delay due to the presence of the Orono Project was apparent from the data collected in 2014*."[2] The results of the 2015 Study reaffirmed those found in 2014: "*Forty-six (46) of 49 (94 percent) tagged salmon were detected at the Orono Project for 1.0 to 50.5 hours (average 10.5 hours); 29 adult salmon were detected in the Orono tailraces (18 at Orono A and 11 at Orono B) at high power, but for less than 12 hours. Two salmon were detected at the Orono Project for approximately 50 hours, but at low power, indicating they were likely in the main stem Penobscot River. The Orono Project did not delay upstream migration of adult salmon in 2015*."[3]

No concerns with the intent or outcome of the 2014 and 2015 studies were received from NMFS or MDMR at the time, and FERC accepted both studies. As such, Black Bear considers its obligations for the effects of the Orono Project on upstream-migrating Atlantic salmon to be complete.

MDMR Comment: *Downstream eel passage was studied at the Stillwater and Orono projects in 2016. At Orono, all eels went over the spillway or through the lower level bypass, but the Orono project also spilled water for all but ten days of the study even though river flows were below station capacity. Spill at Orono is not normal given the river flows during the study period and thus the study results are not relevant for normal operations. At Stillwater most eels went over the spillway or through the bypasses, but 12% went through turbine A. MDMR requested examination of the rack, but there is no record if BBHP carried out this examination. In summary, the estimated survival rates were high, but operations at Orono were not normal and survival to a downstream receiver was not adjusted for excessive time to reach the receiver as was done in the 2020 Medway study (see below).*

Black Bear Response: The downstream eel passage studies were conducted that the Stillwater and Orono Projects in 2016 in accordance with the 2016 Quantitative Downstream American Eel Passage Study Plan, approved by FERC Order issued July 29, 2016 and prepared in consultation with the agencies, including MDMR who provided minor comments regarding sample size as discussed below. A draft of the downstream eel passage study report was sent to the agencies, including MDMR, and the PIN on February 21, 2017 and a meeting

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[2] Black Bear Hydro Partners, LLC. March 24, 2015. Atlantic Salmon Species Protection Plan – 2014 Annual Report for Project No. 2710, 2712, 2534, 2600 and 2666 (Orono, Stillwater, Milford, West Enfield and Medway Hydroelectric Projects).

[3] Black Bear Hydro Partners, LLC. May 31, 2016. Atlantic Salmon Species Protection Plan – 2015 Annual Report for Project No. 2710, 2712, 2534, 2600 and 2666 (Orono, Stillwater, Milford, West Enfield and Medway Hydroelectric Projects).

was held with the agencies and PIN at MDMR's office on February 28, 2017. No comments were received from MDMR on the report, which was accepted by the FERC on May 31, 2017.

Black Bear understands that MDMR now has concerns with the prevalence of "spill" during the 2016 downstream eel passage study, and has agreed to re-examine the raw data and operational information to better clarify the hydrologic and passage conditions at the Project at the time of the study.

It is worth noting that, given the reallocation of flows to the Stillwater Branch of the Penobscot River pursuant to the Settlement Agreement, flows in excess of station capacity occur at the Orono Project approximately 20% of the time in September and approximately 40% of the time in October. At Stillwater, flows in excess of station capacity occur at the Project approximately 20% of the time in September and almost half of the time in October. MDMR's statement that the study results "*are not relevant for normal operations*" given the spill flows encountered are incorrect.

Regarding "*excessive time to reach the receiver*", please see Black Bear's response to the Medway eel study comment above. At the request of MDMR, Black Bear agreed to a dead eel drift component of the 2020 Medway eel study. However, the 2016 downstream eel passage study conducted at Orono and Stillwater, which was conducted in consultation with the resource agencies and PIN, did not include a similar dead eel drift component. Upon its review of the 2016 study plan, MDMR's only request was that "*the sample size be increased to 50 eels for the downstream American eel telemetry study of the Milford Project and another 50 for the study of the Stillwater and the Orono Projects. For the latter two projects, all eels could be released above Stillwater. This sample size would be consistent with recent recommendations studies conducted at the Ellsworth Project and NMFS's recommendation for sample size in that study*". Black Bear then modified the 2016 study plan to accommodate MDMR's request.

Regarding the gaps in the Stillwater A trash racks and MDMR's assertion that Black Bear did not follow through with remedial measures, please find the attached documentation:

1.) July 31, 2017 weekly fish passage report to the agencies (including MDMR) indicating that a dive inspection of the Stillwater A trash rack discovered some gaps
2.) September 6, 2017 e-mail to the agencies indicating Black Bear's intention to draw down the Stillwater headpond to repair the gaps in the Stillwater A trash racks
3.) September 11, 2017 weekly fish passage report to the agencies (including MDMR) indicating that the trash rack repairs were successfully completed.
4.) April 12, 2018 FERC filing of the 2017 annual diadromous fish passage report for alosines and American eels, which describes the discovery of gaps and repair of the Stillwater A trash racks in the cover letter.

***MDMR Comment**: In the Medway study, the median time for freshly-dead tagged eels to drift from the release site (below the powerhouse) to a downstream receiver (M8) was determined. Tagged live eels that reached M8 in a period of time exceeding the median drift time were classified as a project mortality.*

Black Bear Response: Again, please see Black Bear's response to the Medway eel study comment above. Black Bear agreed to a drift component of the 2020 Medway eel study at the request of MDMR, but normal eel migration behavior (which is sporadic and based on environmental cues) must be considered when interpreting the study data, rather than simply characterizing all study eels that exceed the dead eel median drift time as mortalities.

MDMR Comments: *The number of river herring returning to the Penobscot River has increased dramatically since the completion of the Penobscot Restoration project. Due in part to the increased river herring return, the Orono Fishway has been overwhelmed by river herring and resulted in a fish kill during the 2018 season. As a result of this fish kill event, BBHP convened a meeting with resources agencies. In the 2019 and 2020 seasons, BBHP committed more staff time to the trucking effort at the Orono project.*

In response the fish kill event and the meeting with resources agencies, MDMR developed the following recommendations that BBHP complete in order to improve upstream passage at Orono.
BBHP stated that BBHP staff devoted:
1) Multiple full or partial days assisting with passage studies; namely shad and river herring tagging;
2) Multiple full or partial days on fish cleanup efforts after fish kill; and
3) Multiple full or partial days looking for and recovering stranded fish after drawdowns at the Orono, Stillwater, and Milford Facilities;
4) Partial/most of a day handling a sturgeon captured at the Milford facility.
All these activities occurred during the river herring run. Much of the time that could have been spent trapping and trucking river herring from the Orono facility was lost due to these activities. The lost time due to the lack of dedicated full time Orono staff decreased the number of fish transported, and therefore successfully passed the project, for that season.
MDMR recommends that BBHP Dedicate full time staff (3-4 persons) to the Orono Facility during the trapping and transport season and use additional staff for activities required at their other projects.

Black Bear Response: Firstly, the river herring mortality event in 2018 was not a result of the Orono fishway being "*overwhelmed by river herring*"; this is a mischaracterization of the event to support MDMR's narrative that the Orono fish trap is insufficiently staffed.

As outlined in Black Bear's November 13, 2020 Revised LIHI Application for the Stillwater and Orono Projects, on May 24, 2018, a mortality event involving approximately 50,000 alewife and one Atlantic salmon occurred during a routine drawdown necessary for the safe installation of public safety boat barriers at the Orono impoundment. Under normal circumstances (i.e. in previous years), reduced outflows from the fish passage facility into the bypass reach that resulted from drawdowns for the installation of boat barriers had not resulted in fish stranding issues. However, during this event, a large number of upstream migrating alewife were present in the bypass reach and became stranded. Agencies that were consulted on the event, including MDMR, did not indicate any concerns or propose any corrective actions at the time. In fact, MDMR responded to a press inquiry by stating, "*While we hate to see this, it's not a big deal from a resource standpoint. It's more of a nuisance. Brookfield contacted MDMR as soon as fish were found dead at the Orono facility*". The incident was reported to FERC on June 19, 2018, with the inclusion of notifications and updates that Black Bear provided to the agencies at the time of the event. Black Bear's proposals for voluntary corrective actions included (1) updating Brookfield's internal environmental risk assessment for the Orono Project, (2) incorporating environmental risks into job planning, (3) updating the drawdown procedure to accommodate the consideration of fish passage season risks, and (4) to provide additional training to staff. On October 30, 2018, FERC concluded that the event was not a violation of the Orono Project license.

As outlined in our response above, the intent of the Orono upstream fish trapping facility, specifically, is not as a traditional fish passage. Pursuant to the Settlement Agreement, of which Black Bear and MDMR are signatories, the licensees:

> *"will have no obligation to install additional upstream fish passage facilities for anadromous species on the Stillwater Branch during the term of the licenses for the Orono and Stillwater projects. If information collected by the licensee demonstrates that more fish are arriving at the Orono Project than might be accommodated by the fish trapping measures in place, the licensee will convene a special meeting with the Restoration Interests to discuss the scope of the problem, if any, and discuss reasonable solutions. To the extent that the Parties are in general agreement that resolution requires minor operational adjustments, the licensee agrees to implement those measures or modifications in cooperation with the Restoration Interests, subject to any necessary regulatory approvals. To the extent that the Parties are in general agreement that resolution of identified problems can only be addressed by construction of new or additional facilities or by major modifications in operations, the licensee agrees to cooperate and petition the FERC for the appropriate license amendments, provided that the licensee receives the funding for such modifications*."

As demonstrated by the above extensive list of operational and structural modifications made to the Orono upstream fish trapping facility since 2014, along with the general trend of increased numbers of alewives trapped and transported upstream annually, the licensees continue to meet their obligations under the Settlement Agreement, and will continue to do so with the expected cooperation of the signatories (referenced in the Settlement Agreement as the "Restoration Interests") including MDMR.

Black Bear employs five seasonal fishway technicians managed by one full-time fisheries biologist primarily to manage, oversee, and operate the Milford fish lift and Orono fish trap, in addition to other responsibilities for oversight of volitional fishways and downstream passage facilities on the lower Penobscot River and Union River. In addition, on April 13, 2017, and at FERC's request, Black Bear submitted an updated fish passage Operations and Maintenance Plan for the Orono Project, which incorporated improved fish transport protocols for the Orono fish trapping facility. Black Bear has continued to follow these protocols, and has successfully and substantially increased the numbers of river herring handled and transported at the Orono fish lift facility since operations began in 2014.

MDMR Comments*: BBHP stated that at times, the river herring did not start running until late morning/early afternoon and that much staff time was spent waiting for fish to enter the trap. Similar run timing is observed at Milford. MDMR recommends that BBHP coordinate their crew hours with river herring run timing to maximize efficiency in moving fish. This could be accomplished by daily observations at the Orono Facility. If crew observations confirm that the river herring are not moving until afternoon, staff starting times could be shifted to later in the day.*

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Black Bear Response: Since 2014, Black Bear has continually adapted the Orono fish lift and trap and truck processes to improve efficiency, without sacrificing the safety of staff operating the facility or fish that pass through it. The daily schedule of the Brookfield seasonal fish passage staff at Orono has evolved in response to the increasing number of river herring returning to the Penobscot River annually. Each morning, a technician is dispatched to conduct the initial daily inspection of the facility and to begin lifting and preparing the first truck load(s) of fish of the day. The two other technicians arrive at the Orono facility by mid-morning following their inspections at other fish passage facilities. The timing of their arrival at Orono is adjusted each day based on observations/feedback from the technician at the lift (i.e. if the fish are moving earlier than usual). The fish passage technicians regularly work 10-12 hours per day during the peak of the river herring migration, often well into the evening.

In consideration of the terms that were agreed to in the Settlement Agreement, Black Bear is clearly meeting its obligation for trapping and transporting fish at the Orono site, and has incorporated measures well beyond what was agreed to in the Settlement Agreement, when the signatories determined that Black Bear would be responsible only for "*minor operational modifications*". Black Bear intends to propose an upstream river herring passage study at Orono in 2021, which should help the signatories determine the future of fish passage through the Stillwater Branch.

MDMR Comments: *BBHP stated that they do not always operate the Orono fishway with the attraction water operational. It was mentioned that this was to prevent overcrowding of the hopper. At other facilities like Benton Falls, which also struggles at times to handle the numbers of fish present at the facility, MDMR/Benton Falls Hydro has had success by raising the entrance gate to create a velocity barrier to restrict fish passage. This provides a method for metering the rate of fish entering the trap facility while still maintaining attraction flow to attract other species such as Atlantic salmon and shad. Operating with no attraction flow will limit other fish species from being attracted to the fishway entrance. MDMR recommends that BBHP investigate varying entrance gate settings as an alternative to current practice and report results to DMR for further discussion. MDMR recognizes that there may still be times which attraction water must be operated at a reduced level or off if necessary.*

Black Bear Response: As MDMR suggests, Black Bear has continually experimented (with some success) with a variety of entrance gate settings to meter the number of river herring entering the lower flume and fish lift hopper. However, raising the entrance gate increases the velocity of water discharging over the gate, thus resulting in significant turbulence just downstream where the attraction water collides with the discharge from the downstream passage flume/and or water spilling over the dam. To address this turbulence issue and improve overall fishway effectiveness, in 2020 Black Bear, in consultation with the agencies, shortened the downstream passage discharge steel flume by approximately 6 feet to move the landing area of the downstream passage discharge further away from the fish lift entrance. In addition, Brookfield fish passage technicians constantly monitor fish lift progress throughout the day in terms of the amount of time (and number of lifts) required for each tank load of approximately 1,000 river herring to be captured. Minor adjustments are regularly made to entrance gate and attraction water settings to improve the efficiency of the lifting/sorting/trucking process. Black Bear has and continues to offer/request that MDMR staff visit the Orono facility to view the fish lift process firsthand and offer real time advice.

Black Bear would also point out that the Benton Falls facility is volitional in that all fish that are lifted pass directly into the headpond without any manual sorting. That is not the case at Orono, where upstream passage is intentionally reliant upon a trap, sort and truck system. As indicated previously, the Orono fish lift facility was not intended or designed to move high numbers of fish in a timely fashion, but rather to evacuate fish (specifically focused on Atlantic salmon) that are attracted to the Orono Dam.

MDMR Comments: *BBHP staff have also state verbally that fish are able to access the hopper area even with the V gates closed, to the point of overcrowding the hopper, and for this reason attraction water is not run over night. If fish access to the hopper is due to damage or malfunction of the V-gates, MDMR would request that repairs be made. If this is due to improper engineering, many of the gates at the Milford facility had to be lined with lobster wire to prevent fish from passing through the gates. MDMR would like to see this issue addressed such that attraction water can be run overnight and throughout the day for the following reasons:*
1) It has been observed at the Milford facility, that salmon tend to move when alewives are not running hard. At Milford, salmon are typically captured in the morning prior to heavy alewife movements. Having the attraction water running overnight at the Orono Facility would attract salmon to the facility throughout the night and in the early morning, such that they should be at the gates waiting when staff arrive in the morning. This is standard practice at other projects.
2) Running attraction flow over night would provide attraction for river herring to help maximize earlier lifts. MDMR understands that when Orono staff arrive on site, they turn on the attraction water to the fishlift. Fish below the dam must then "reorient" to the new flow regime, which creates lost hours for attracting fish during the early morning. This is missed opportunity with respect to trapping and trucking fish. There are always fish more driven than others. This will also increase efficiency and the numbers of fish that BBHP can move.

Black Bear Response: Again, Black Bear reminds MDMR that the Orono fish lift is not intended as a fish passage facility. If the MDMR believes that a fish passage facility should be installed at the Orono Project, Black Bear welcomes the opportunity to have a meeting with the "Restoration Interests" to determine the appropriate locations, designs and funding sources for said facilities at both the Orono and Stillwater Projects as outlined in the Settlement Agreement.

MDMR Comments: *In summary MDMR recommends:*
1) Dedicated staff (3-4 persons) specific to the Orono Facility utilized for trap and transport of river herring and salmon during the river herring season
2) Staff time optimized to match river herring daily run timing during the season
3) Repairs and/or modifications to the trap/V-gates to eliminate fish entering the hopper area while the V-gates are closed:
4) Investigate varying entrance gate settings in attempts to optimize hopper lifts and to limit overcrowding the hopper;
5) Run attraction water 24 hours per day as prescribed by designs.
6) Provide weekly reports for the site that document the following metrics: fish passage numbers, fish passage operations and changes in fish passage operations at the facility, project operations and changes in operations at the facility, number of staff and numbers of hours per staff dedicated to fish passage operations, and flow conditions.

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Black Bear Response: Black Bear has responded to the first five recommendations in the above sections. Regarding recommendation #6, Brookfield will continue to voluntarily provide its weekly fish passage reports to resource agencies, including MDMR, and the Penobscot Indian Nation (PIN), as they provide total weekly and seasonal counts of six species, identification of Atlantic salmon broodstock, documentation of the total number of fish released upstream vs downstream, weekly operational status of the fish passages, as well as any operational changes of note. In addition, Black Bear will continue to promptly notify the agencies of any significant issues, such as an equipment failures, minimum flow excursions, headpond elevation deviations, modification of run-of-river operations, or mortality events, and will include the agencies and PIN in any investigative reports and proposed remediation measures filed with FERC.

MDMR Comments: *Stillwater - MDMR recommends that LIHI certification for Stillwater be delayed or be contingent on committing to a prudent timeline to complete the additional studies of downstream passage as identified in our responses to your questions below.*

Orono - MDMR recommends that LIHI certification for Orono be delayed or be contingent on A) carrying out the below recommendations for upstream passage, in addition to B) committing to a prudent timeline to complete the additional studies as identified in our responses to your questions below. In addition, any documentation of the Orono project impact should include an acknowledgement of the presence of American eel and Sea lamprey within Zone 1, 2, and 3 of the Project.

Medway - MDMR recommends that LIHI certification for Medway be delayed or be contingent on completion of improvements to downstream passage for eels.

Black Bear Response: Black Bear objects to a delay or contingent certification by LIHI of the Orono, Stillwater and Medway Projects as suggested by MDMR. Black Bear has provided responses to MDMR's comments regarding downstream eel passage studies at the Stillwater Project, MDMR's recommendations for Orono upstream fish trap operations and additional upstream studies, and MDMR's recommendations for improvements for downstream migrating eels at Medway. Black Bear is happy to continue its consultation with the agencies on the need for further investigation and potential operational or structural improvements at the Projects, and to provide LIHI updates on that progress as part of its Annual Certification Statements for the Stillwater, Orono and Medway Projects.

Please call me at (207) 755-5606 or email at kelly.maloney@brookfieldrenewable.com or Kevin Bernier at (207) 951-5006 or kevin.bernier@brookfieldrenewable.com if you have any questions or need additional information regarding this submittal.

Sincerely,

Kelly Maloney

Kelly Maloney
Manager, Compliance - Northeast

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Attachments
- 2020 Medway Eel Study Report
- July 31, 2017 weekly fish passage report
- Sept 6, 2017 e-mail to the agencies
- September 11, 2017 weekly fish passage report
- April 12, 2018 filing of the 2017 annual diadromous fish passage report for alosines and American eels

Cc: S. Michaud, N. Stevens, S. Mascarenas, K. Bernier, J. Cole; Black Bear

Black Bear File: HSSE 4b/6/Penobscot

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February 15, 2021

Medway Project
FERC No. 2666

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Electronically Filed

RE: Medway Project (FERC No. 2666), Article 405;
2020 Evaluation of Downstream Passage Effectiveness for Adult American Eel

Dear Secretary Bose:

Black Bear Hydro Partners, LLC (Black Bear), an affiliate of Brookfield Renewable (Brookfield) and licensee for the Medway Project (FERC No. 2666) on the West Branch of the Penobscot River in Maine, is filing this final study report: *Evaluation of Downstream Passage Effectiveness for Adult American Eel at the Medway Project,* which was conducted in the fall of 2020. This study was required pursuant to Article 405 of the Medway Project license (issued on March 29, 1999) and the Commission's October 6, 2020 approval of the study plan for this evaluation.

In an April 18, 2019 update to the Commission, Black Bear proposed to cumulatively study downstream eel passage at the Medway Project in conjunction with an evaluation of adult eel passage at the Mattaceunk Project, which is located about 7 miles downriver on the mainstem of the Penobscot River. In its September 26, 2019 reply, the Commission agreed that there is substantial logic for a comprehensive, multi-project study, as it may require fewer eels, reveal larger-scale migration patterns, and necessitate fewer resources. However, the Commission also agreed with the Penobscot Indian Nation (PIN) that downstream eel passage evaluations at the Medway Project should resume, stating both that it could not anticipate when a license would be granted for the Mattaceunk Project (which would trigger downstream eel passage study requirements), and that the requirements of the Medway Project are not contingent on those at Mattaceunk, or vice versa. Thus, the Commission stated that the Medway Project requirements must stand independently and be fulfilled, and that Black Bear should anticipate resuming the downstream eel study at the Medway Project in the fall of 2020.

Accordingly, Black Bear then consulted with the resource agencies[1] and PIN to develop the "*Study Plan for the Evaluation of Downstream Passage Effectiveness for Adult American Eel* at *the Medway Project"* for the fall of 2020, which was submitted to the Commission on June 15, 2020. The Commission approved the study plan on October 6, 2020, with the condition that the study would need to be repeated in fall of 2021 if less than the 38 study eels needed for a statistically meaningful assessment passed the Medway Project during the fall 2020 study.

[1] United States Fish and Wildlife Service (USFWS); Maine Department of Marine Resources (MDMR); Maine Department of Inland Fisheries and Wildlife (MDIFW); Maine Department of Environmental Protection (MDEP); National Marine Fisheries Service (NMFS); Bureau of Indian Affairs (BIA)

The downstream eel passage study was conducted at the Medway Project between October 15 and November 18, 2020. A total of 50 radio-tagged adult silver eels were released upstream of the Project, and 49 of those were observed passing downstream of Medway Dam. Monitoring of adult eel movements focused on residence time prior to passage, passage route selection, and an estimation of downstream passage survival at the Project. The median period of residence for radio-tagged eels upstream of the dam was 7.4 hours, with 62% passing downstream within the first 24 hours of their initial detection. Most radio-tagged eels passed downstream via the turbines, and there was one observation of an adult eel passing downstream via the bypass. Downstream passage survival for the entire Project reach (~500 feet upstream of the dam to the first downstream receiver) was estimated at 92.0% (75% CI = 88.0-96.0%).

As detailed in the report, an additional group of freshly dead eels were radio-tagged and released immediately downstream of Medway Dam and were used to classify live eels passing the Project based on their downstream transit duration relative to the drift duration, the purpose being to incorporate potential delayed eel mortalities from dam passage into the Project survival estimate. Based on this comparison, and when considering test eels as mortalities that exhibited both (1) a migration time from Medway Dam to a monitoring station 3 miles downriver that was in excess of that observed for the dead tailrace release eels, and (2) failure to reach (or a prolonged duration of time to reach) a monitoring station 7.5 miles downriver, the adjusted estimate of Project survival was 84.0% (75% CI = 78.0-90.0%).

Neither of these two estimates of downstream passage survival for adult eels at the Medway Project include any background (i.e., natural) or tagging-related mortality. As a result, these estimates should be viewed as minimum estimates of total Project survival (i.e., due solely to Project effects) for adult eels passing the Medway Project. In addition, due to low West Branch flows during the fall 2020 study, downstream passage route options for radio-tagged adult eels were limited to the downstream bypass or the Project turbines. As a result, this study was conducted under worst case conditions for out-migrating eels.

A draft of this report was distributed for resource agency and tribal review on December 15, 2020. As requested by Black Bear on January 13, 2021, and as approved by the Commission on February 9, 2021, the deadline for filing this report was extended to February 15, 2021, thereby providing the resource agencies and PIN with a 60-day review period. A consultation meeting was remotely held on January 27, 2021 with the resource agencies and PIN to present and review the study results and to answer questions. Responses to questions and comments received during the January 27th meeting are provided in Appendix D of the attached report, while correspondences associated with the agency and tribal reviews of the report are provided in Appendix E. Finally, a copy of the PowerPoint slides prepared and presented by Normandeau Associates at the January 27th meeting are provided in Appendix F. Where appropriate, the report has been revised based on the comments received.

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As acknowledged in the Commission's October 6, 2020 study plan approval for this downstream eel passage evaluation, this study provided information on the routes of passage utilized by downstream-migrating eels at the Medway Project and estimated their survival. However, the Commission further stated that Black Bear would be required to "*assess and potentially improve passage efficiency through the turbines or modify the downstream passage facilities to improve its effectiveness*" if the study determined that eels were not finding the bypass weir. Therefore, based on the 2020 study results and consistent with resource agency and PIN requests detailed in the Commission's October 6, 2020 letter, Black Bear intends to conduct a Hi-Z balloon tag study in 2021 of adult eels at the Medway Project to better document turbine passage survival and turbine-induced injuries. A study plan will be developed and provided to the resource agencies and PIN for 30-day review by April 15, 2021, thereby allowing Black Bear to submit a final study plan to the Commission by May 15, 2021.

Please feel free to contact me by e-mail at Kevin.Bernier@brookfieldrenewable.com or by phone at (207) 951-5006 if you have any questions or comments.

Sincerely,

Kevin Bernier

Kevin Bernier
Senior Compliance Specialist

Attachment

cc: S. Ledwin, G. Wippelhauser, M. Simpson, C. Clark; MDMR
D. McCaw, J. Banks; PIN
J. Rosset; B. Sojkowski; USFWS
J. Murphy, D. Dow; NMFS
K. Dunham, K. Gallant; J. Perry; MDIFW
K. Howatt, C. Sferra; MDEP
H. Peterson, C. Mokhtarzadeh; BIA
S. Michaud, N. Stevens, R. Brochu, J. Cole, R. Dill, K. Maloney, L. Macomber; Brookfield
D. Trested; Normandeau

Brookfield File: HSSE 4a/2666/01

Study Report
for the
Evaluation of Downstream Passage Effectiveness for Adult American Eel

Medway Project (FERC No. 2666)

Prepared For
Black Bear Hydro Partners, LLC
Milford, Maine

Prepared By
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February 2021

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1 Introduction

Black Bear Hydro Partners, LLC (Black Bear), an affiliate of Brookfield Renewable (Brookfield), owns and operates the Medway Hydroelectric Project (FERC No. 2666) on the West Branch of the Penobscot River. By order dated March 29, 1999, the Federal Energy Regulatory Commission (FERC) issued the current license for the Medway Project. Articles 404 and 405 of the license required (1) detailed design drawings of the licensee's proposed upstream and downstream American eel passage facilities, along with construction and operation schedules, and (2) a plan for post-construction studies to monitor the effectiveness of the passage facilities. In compliance with the license articles, the licensee filed with FERC the "Medway Hydroelectric Project American Eel Passage Plan" on September 29, 1999. The 1999 study plan provided a description of the downstream passage facility (i.e., bell mouth weir opening in the abandoned fishway gate) and schedule for operation (August 1 through November 15). The Medway eel passage and effectiveness monitoring plan was approved via FERC order on April 24, 2000.

The effectiveness monitoring plan identified the need to determine if adequate numbers of migrating adult eels could be trapped at a location upstream of the Project to use for effectiveness studies. The licensee conducted video monitoring of the downstream fish passage from 2000 to 2003. Specifically, a video camera with infrared lighting was positioned facing downward to monitor the area from the end of the bell mouth weir (fishway discharge) to a point about ten feet downstream. Even with the surface of the flume covered with a white reflective background, the combination of poor image quality and rapid passage of water through the observation area made it impossible to clearly differentiate eels from moving water and background.

The licensee then attempted to capture study animals at a former eel weir location on Millinocket Stream, about 14 miles upstream of the Medway Project. The licensee summarized trapping efforts for the 2004 to 2006 time period (which resulted in insufficient numbers of eels being collected) in their Downstream Eel Passage Effectiveness Assessment Report filed with FERC on March 7, 2007. In a March 27, 2007 Order, FERC concurred with agency and licensee recommendations to postpone evaluation and monitoring efforts for five years. The licensee was further ordered to report to FERC by March 1, 2012 on consultation efforts related to downstream eel passage at Medway.

In conformance with the March 27, 2007 order, the licensee provided an update to FERC on consultation efforts related to eel evaluations at the Medway Project on March 26, 2012. In that correspondence, the licensee committed to a 2012 field effort to further understand eel distribution and abundance upstream of the Project. The licensee filed a report detailing the 2012 silver eel collection efforts upstream of Medway with FERC on March 28, 2013, along with an additional silver eel collection report on March 31, 2014 that detailed a second year of sampling effort. Despite a range of sampling techniques, collections of silver eels upstream of Medway were limited to a small number of individuals during both sampling years.

Out of basin eels were radio-tagged for downstream eel passage studies conducted on the Lower Penobscot River at the Milford, Stillwater and Orono projects during 2016, and that methodology proved successful for evaluation of passage at those locations. As a result, the out of basin methodology was subsequently implemented at the West Enfield Project during the 2017 outmigration period. In correspondence dated September 26, 2019, FERC acknowledged previous acceptance of insufficient numbers of test eels in the Project area to conduct a meaningful passage evaluation. However, considering the successful out of basin approach implemented on the lower river projects, FERC requested that the licensee consult with the resource agencies[1] and the Penobscot Indian Nation (PIN) to develop downstream eel passage study methods for implementation at the Medway Project in 2020.

Study Plan Development:

Prior to performing the downstream passage evaluate for adult American eels at Medway, the licensee developed a draft study plan[2], which was distributed to the resource agencies and PIN on February 26, 2020. The licensee requested that any comments related to the draft 2020 Evaluation of Downstream Passage Effectiveness for Adult American Eel Study Plan be submitted in writing by March 30, 2020. The draft study plan was discussed during a conference call between Black Bear, the resource agencies, and PIN on March 18, 2020. Following receipt and incorporation of agency comments, the final study plan was filed with FERC on June 15, 2020.

Study Report Development:

The 2020 Medway downstream eel passage study was conducted following the methodologies presented in the FERC-filed study plan, and a draft report summarizing results from that effort was distributed to the agencies and PIN on December 15, 2020. Previous to that distribution, the licensees for the Milford, Stillwater, and Orono Projects (each affiliated with Brookfield, including Black Bear) distributed two draft reports summarizing the results of downstream juvenile alosine studies at those Projects on December 10, 2020. As part of those draft report distributions Black Bear indicated a virtual meeting would be held in early January to discuss and requested receipt of written comments by January 11, 2021 (alosine reports) and January 14, 2021 (Medway eel report). At the request of the agencies and PIN, the licensees for the Milford, Stillwater, and Orono Projects submitted a time extension request to the Commission on December 28, 2020 for submittal of the annual eel and alosine study report for these lower Penobscot facilities. The Commission approved this request on January 11, 2021, thereby extending the report submittal deadline to February 15, 2021. Black Bear intended to hold a

[1] Maine Department of Inland Fisheries & Wildlife (MDIFW); Maine Department of Marine Resources (MDMR): Maine Department of Environmental Protection (MDEP); United States Fish and Wildlife Service (USFWS); National Marine Fisheries Service (NMFS); Bureau of Indian Affairs (BIA)

[2] Normandeau (Normandeau Associates, Inc.). 2020. Study Plan for the Evaluation of Downstream Passage Effectiveness for Adult American Eel at the Medway Project (FERC No. 2666). Plan prepared for Black Bear Hydro Partners, LLC.

single virtual meeting to review and discuss the results from all 2020 fish passage studies (including the Medway downstream eel passage study). As a result, Black Bear submitted a time extension request to the Commission on January 13, 2021 seeking to extend the report submittal deadline to February 15, 2021.

A consultation meeting to discuss the 2020 study results was held virtually on January 27, 2021, and Normandeau provided an overview of the study methods and results to representatives from Brookfield, NMFS, USFWS, MDMR, MDEP and the PIN. A summary of questions and comments from the January 27 meeting is provided in Appendix D. Correspondence related to the distribution of the draft study report, as well as written comments received following agency review, are provided in Appendix E. A copy of the PowerPoint slides presented by Normandeau at the January 27, 2021 meeting is also provided in Appendix F.

2 Project Description

The Medway Project is located in the town of Medway, Penobscot County, Maine, on the West Branch of the Penobscot River. Medway Dam spans the West Branch approximately 0.6 miles upstream of its confluence with the East Branch of the Penobscot River. The Project impoundment is 1.2 miles in length with a surface area of approximately 101.5 acres. The Medway Dam is an L-shaped concrete gravity structure consisting of a 343 foot-long spillway section with an average height of 20 feet, a fishway and log sluice section, a 64 foot-long forebay wall section, and a 170 foot-long intake section covered with bar racks with 2.25 inch clear spacing. The intake section leads directly to the powerhouse that is an integral part of the dam. The spillway section is topped by 68 inch-high wooden flashboards. The powerhouse contains five vertical Francis turbines, each with a capacity discharge of 690 cfs. The units have a runner diameter of 8.7 feet, a rotational speed of 100 rpm, and a gross head of 18.9 feet at full pond. Downstream passage at the Project consists of a sluice gate, which was retrofitted with a 3 foot wide by 6 foot tall bell mouth weir and flume that has been operated since 2000. The bypass entrance is located at the end of the spillway adjacent to the forebay. The weir constricts down to a 5-inch opening, can pass approximately 15 cfs of flow, and sits in the top portion of the water column. The Project is operated in run-of-river mode with a full impoundment elevation of 260.3 ft MSL.

3 Downstream American Eel Passage

3.1 Study Objectives

The objectives of the 2020 downstream passage evaluation for adult American eels at Medway were to:

1. Evaluate project residence time immediately upstream of the Project,
2. Quantify downstream passage route selection, and
3. Estimate total Project survival.

3.2 Field Methodology

3.2.1 Radio Telemetry Equipment

Downstream passage of radio-tagged adult American eels at the Medway Project was documented via a series of stationary radio telemetry receivers. Installed radio telemetry equipment included Orion receivers, manufactured by Sigma Eight, as well as SRX receivers manufactured by Lotek. Receivers were installed following consideration of the detection requirements for the specific area of coverage, as well as the attributes of the receiver model. The Orion receiver is a broadband receiver capable of monitoring multiple frequencies simultaneously within a 1-MHz band, and it is most useful for monitoring tagged fish in areas where movement through the monitoring zone can occur quickly (e.g., the downstream bypass). Although Lotek receivers have a greater detection range than Orion receivers, they can only monitor a single frequency at a time and require frequency switching, which decreases detection efficiency in areas where fish may pass at high rates of speed. As part of monitoring adult downstream eel passage at Medway, Lotek receivers were used at locations requiring longer range and where the intended detection areas are characterized by relatively slow transit speeds for tagged fish (e.g., the approach area in the Medway headpond).

Several types of antennas were used for this study, including aerial Yagi antennas and custom-made underwater antennas (dropper antennas). Yagi antennas were primarily used to confirm the presence of radio-tagged eels within the Project forebay and spillway areas, as well as at the downstream monitoring stations where detection across the full width of the river was required. Dropper antennas were placed at appropriate depths within downstream passage routes and were used to determine route selection (e.g., via the downstream bypass system). Dropper antennas were custom built by stripping the shielded end of RG58 coaxial cables.

Adult silver-phase eels were tagged using transmitters manufactured by Sigma-Eight (model TX-PSC-I-450). The TX-PSC-I-450 transmitters measured approximately 12 x 12 x 46 mm, weighed 8.5 g, and had an estimated battery life of 357 days at the programmed 2.0 second burst rate. Transmitters for this study operated on one of two distinct frequencies (149.400 or 149.340 MHz).

3.2.2 Monitoring Stations

A total of nine stationary receiver locations were installed at Medway, as well as at points downstream of the Project. Each monitoring station consisted of a data-logging receiver, antenna, and a power source. Each was configured to receive transmitter signals from a designated area continuously throughout the study period. During installation of each station, range testing was conducted to configure the antennas and receivers in a manner which maximized detection efficiency at each location. The operation of the system as a whole was confirmed during installation and throughout the study period by using beacon tags. These beacon tags were stationed at strategic locations within the detection range of either multiple or single antennas and emitted a signal at a programmed time interval. These signals were detected and logged by the receivers and used to record the functionality of the system throughout the study period. Although each monitoring station was installed in a manner which limited the ability to detect transmitters from unwanted areas, the possibility of such detections did still exist. As a result, behavioral data collected in this study (i.e., duration at a specific location or passage route) were inferred based on the signal strength and the duration and pattern of contacts documented across the entire detection array.

The locations of the monitoring stations for downstream passage of adult American eels at the Project are outlined below and presented visually in Figure 3-1.

Monitoring Station M1: Station M1 consisted of aerial coverage and was installed in a manner which detected radio-tagged eels as they approached within 200 m of the upstream side of Medway Dam. Detections from this location were used to determine when eels arrived at the Project dam and were a component of the determination of residence time upstream of the dam and prior to passage.

Monitoring Station M2: This station consisted of aerial coverage and was installed in a manner which detected radio-tagged eels as they entered the powerhouse intake area. Detections from this location were used to help inform on downstream passage via the turbine units.

Monitoring Station M3: Station M3 consisted of a single receiver and underwater drop antenna for coverage of the downstream eel bypass. Detections on this receiver were used to identify eels passing downstream via this route.

Monitoring Station M4: Station M4 consisted of a single receiver and underwater drop antenna for coverage of the forebay sluice gate. This station was installed to identify eels passing downstream via this route in the event that this gate was open during the 2020 evaluation.

Monitoring Station M5: This station consisted of aerial coverage and was installed in a manner which detected radio-tagged eels as they entered the powerhouse discharge area. Detections from this location were examined relative to the sequence of previous detections at Stations M2, M3, and M4 to determine downstream passage via the turbine units.

Monitoring Station M6: Station M6 consisted of aerial coverage and was installed in a manner which detected radio-tagged eels following passage downstream of Medway Dam via the spillway. In the event that spill conditions were present at Medway Dam during the study period, detections from this receiver (and an absence of detections at M2, M3, M4, and M5 at the time of passage) were used to identify eels passing downstream via the spillway.

Monitoring Station M7: Station M7 consisted of aerial, cross-river coverage and was installed in a manner which detected radio-tagged eels following passage and as they moved towards the Nicatou Bridge located just downstream of Medway Dam. Detections from Station M7 were used to help confirm the presence of radio-tagged individuals downstream of the dam following passage at one of the available routes.

Monitoring Station M8: Station M8 served as a first stationary receiver location downstream of Medway, and detections from this location were used to inform on downstream passage survival of radio-tagged eels. Station M8 was installed approximately 3.0 miles downstream of Medway Dam off of Dickey Moore Road in Medway, Maine. Station M8 consisted of a single receiver and aerial antenna installed to ensure full coverage of the river (i.e., bank to bank).

Monitoring Station M9: This station consisted of aerial coverage and was installed facing upstream in a manner to detect radio-tagged eels as they approached the Mattaceunk Project dam (Weldon Dam). Detections from Station M9 were used to inform passage survival determination for radio-tagged eels following downstream passage at Medway.

3.2.3 Tagging and Release Procedures

Adult silver-phase American eels were obtained from a commercial trapping operation on the St. Croix River in eastern Maine. Study eels were transported by truck on October 12th from the St. Croix River by the vendor to a temporary tank facility established downstream of Medway at the West Enfield Project. Transported eels were held for at least 24 hours prior to any tagging. In advance of tagging, eels were visually examined; healthy eels suitable for tagging were then anesthetized in a clove oil and ethanol solution. Eels were held and visually monitored in the anesthesia bath until sufficiently sedated. Once sedated, eels were removed from the bath and placed in a specially designed restraining holder (Figure 3-2). The total length and eye diameter (horizontal and vertical; nearest 0.1 mm) were measured. A previously described correlation between eye size, body length, and gonad development was used to confirm whether individuals were mature and could be considered as active “silver phase” outmigrants (Pankhurst, 1982). This eye index relationship (I) was described using the formula:

$$I = \left[\frac{\left(\frac{A+B}{4}\right)^2 \pi}{L}\right] * 100$$

where A = horizontal eye diameter, B = vertical eye diameter, and L = total body length. Silver-phase American eels typically have an eye index between 6.0 and 13.5, with a bronze coloration along the lateral line that separates the dark, silver back from the white belly. Although eels collected from the St. Croix have a high probability of being silver eels based on the weir methodology used to collect them, eye measurements were recorded regardless.

For tagging, an incision was made off-center on the ventral surface of the individual. A hollow needle was inserted into the incision and pushed through the body wall just off the ventral mid-line and at a point posterior to the incision. The antenna was then fed through the needle and gently pulled so that the transmitter enters the body cavity. The needle was pulled through the body wall and removed from the antenna. The transmitter was positioned by pulling the antenna so that it lay directly under the incision. The incision was closed with two or three interrupted sutures. A small amount of an antibacterial ointment was applied to the incision site to prevent infection. Following tagging, each individual was transferred to a second holding tank supplied with ambient river water for an additional 24-hour observation/recovery period.

A total of 50 radio-tagged adult American eels were transported by truck from the holding tank at West Enfield and released into the West Branch of the Penobscot River towards the upper extent of the Medway Project impoundment (roughly one-half mile below the East Millinocket dam at the former East Millinocket Mill site). Two separate release events were conducted: one on October 15 and one on October 16, with each event consisting of 25 radio-tagged individuals. Both releases were conducted during the evening hours (~ 17:45 hrs).

3.2.4 Data Collection

3.2.4.1 Stationary Telemetry Data

Data were off-loaded from receivers using a laptop computer and stored on a removable memory stick. Data downloads occurred weekly during the period from the initial tag and release date until November 15, 2020, following closure of the Medway downstream bypass. Backup copies of all telemetry data files were made prior to receiver initialization. Field tests to ensure data integrity and receiver performance included confirmation of file integrity, confirmation that the last record was consistent with the downloaded data (beacon tags were critical to this step), and lastly, confirming that the receiver was operational upon restart and actively collecting data post download. The field data collection procedures were part of the overall project QA/QC standards. Within a data file, transmitter detections were stored as a single event (i.e., single data line). Each event included the date and time of detection, frequency, ID code, and signal strength.

3.2.4.2 Manual Telemetry Data

To provide supplemental detection information to the stationary receiver data set, manual tracking was conducted during the monitoring period. Manual tracking was conducted by foot/truck in accessible areas located immediately upstream and downstream of the Medway Dam on each receiver download date. In addition, a single boat-based manual tracking event was conducted on November 18, 2020, which covered the section of the Penobscot upstream of Medway Dam to the release site, and then downstream of Medway Dam to Weldon Dam.

3.2.4.3 River and Project Operational Data

In addition to the manual and stationary radio telemetry data, river and project operations data were collected during the 2020 evaluation period. River temperature was recorded on an hourly basis via a logger installed into the Medway headpond just upstream of the powerhouse.

Project discharge (unit and waste), unit operations (total cfs), and downstream bypass settings were obtained from Brookfield upon completion of the study period. The Project was operated under "baseline" conditions for the study period (i.e., units in operation and downstream bypass system open).

During development of the study plan, the resource agencies requested additional site and passage condition information at Medway during the eel monitoring period. This included lunar cycle, precipitation, bypass approach velocity, and photographs of downstream passage routes taken during receiver download events.

3.2.4.4 Downstream Drift and Travel Assessment

In addition to the 50 radio-tagged eels released upstream of Medway, a total of six freshly dead and four live adult American eels were radio-tagged and released downstream of Medway Dam during the 2020 study period. Concurrent with each upstream release group, a total of three freshly dead individuals and two live individuals were radio-tagged and released downstream. On a given eel release date, downstream test eels were released as follows:

- One (1) whole-body dead radio-tagged eel released into the downstream bypass;
- One (1) whole-body dead radio-tagged eel released into the discharge of an operating turbine unit;
- One (1) partially severed dead radio-tagged eel released into the discharge of an operating turbine unit;
- One (1) live radio-tagged eel released into the downstream bypass; and
- One (1) live radio-tagged eel released into the discharge of an operating turbine unit.

The downstream progression of these individuals was recorded by stationary receivers M8 and M9.

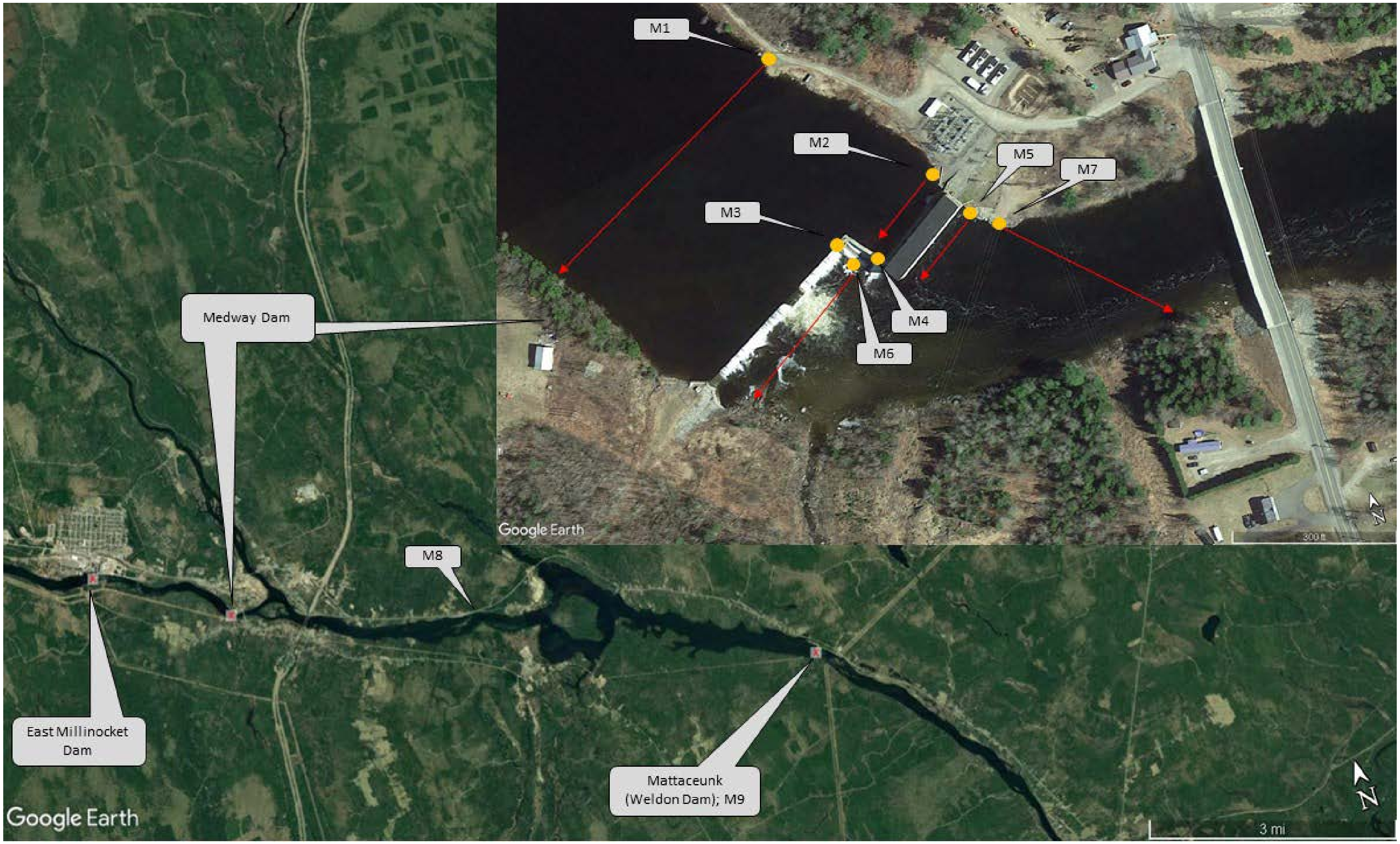


Figure 3–1. Approximate locations and coverage areas for Monitoring Stations installed for evaluation of downstream passage of adult American eels at Medway during 2020.

Figure 3–2. Restraint device for holding and positioning adult silver eels during radio-tagging.

3.3 Analysis and Reporting

3.3.1 Upstream Residency Time and Downstream Passage Routes

Following completion of field data collection and processing, a complete record of all valid detections for each uniquely coded radio-tagged silver eel was generated, and the pattern and timing of detections in these individual records was reviewed. For the full set of radio-tagged eels released into the West Branch upstream of Medway Dam, the arrival, passage times, and downstream route of passage were determined. In instances where a specific passage route was not clearly defined by the available data, the passage route for that individual was classified as “unknown”.

The stationary telemetry dataset collected using the monitoring stations described above also permitted the evaluation of residence time for radio-tagged silver eels between any two adjacent monitoring stations both prior to and following downstream passage. Passage duration through any defined river reach was calculated as the duration from initial detection at the stationary receiver on the upstream end of the reach until initial detection at the stationary receiver on the downstream end of the reach. For radio-tagged eels which approached Medway Dam, a ‘project residence duration’ was defined as the duration of time from initial detection at the dam (i.e., detection at Monitoring Station M1) until successful downstream passage at the Project.

3.3.2 Parameter Estimates for Evaluation of Project Survival

Survivorship (*Phi*) and detection (*p*) probabilities were estimated for eel passage at Medway using a Cormack-Jolly Seber model (CJS) constructed in Program MARK (White and Burnham 1999). Parameter estimates for *Phi* and *p* were obtained using the encounter histories constructed for each radio-tagged individual indicating their presence or absence at detection locations from the approach receiver (i.e., 200 m upstream of the dam) through the first receiver downstream of the Project (i.e., Station M8). The CJS model generated reach-specific survival estimates for radio-tagged eels released upstream of Medway from:

a) the point 200 m upstream of the dam until passage downstream; and
b) from passage by the dam until the first downstream receiver (i.e., Station M8).

The joint probability of the two reach-specific survival estimates was used as the estimate of total Project survival. This approach assumed that the background mortality (i.e., natural mortality such as predation) was negligible for adult eels in the 200 m reach upstream of the dam, as well as the reach downstream of the dam to Station M8, and that the observed losses are attributable solely to Project effects. The use of this assumption resulted in a minimum estimate of total Project survival for adult American eels passing downstream of the Medway Dam.

To evaluate survival using Program MARK, a suite of candidate models were developed based on whether survival, recapture (i.e., detection), or both, vary or are constant among stations. Models run included:

- *Phi*(t)*p*(t): survival and recapture may vary between receiver stations;
- *Phi*(t)*p*(.): survival may vary between stations; recapture is constant between stations;
- *Phi*(.)*p*(t): survival is constant between stations; recapture may vary between stations;
- *Phi*(.)*p*(.): survival and recapture are constant between stations;

Where;

- *Phi* = probability of survival
- *p* = probability of detection
- (t) = parameter varies
- (.) = parameter is constant

Prior to comparison among models, a goodness of fit test was conducted for the "starting model" (i.e., the fully parameterized model) using the function RELEASE within Program MARK. Akaike's Information Criterion (AIC) was used to rank the models as to how well they fit the observed mark-recapture data. Lower AIC values denote a more explanatory yet parsimonious fit than higher AIC values.

Drift information collected from freshly-dead eels intentionally released downstream of the Project (see Section 3.2.4.4) was reviewed during the compilation of encounter histories. Test eels reaching Station M8 in a duration of time longer than the median duration recorded for dead individuals released directly in the tailrace were classified as a Project mortality.

Models were subsequently prepared which evaluated the downstream passage success of adult eels at Medway as follows:

- All eels – based on detection of individuals from upstream release groups at Stations M1, M8, and M9;
- All eels – adjusted for median "travel time" for freshly dead eels released in the Medway tailrace to reach Station M8 (i.e., test eels with downstream travel times in excess of median drift duration manually adjusted to reflect a mortality at the Project); and
- All eels – by downstream passage route (where sample size was adequate).

4 Results

4.1 Penobscot River Conditions and Project Operations

Figure 4-1 presents Medway Station flow (i.e., the sum of unit discharge) and water temperature for the period October 15 to November 15, 2020. Medway Station flow ranged between 1,996 and 3,958 cfs during the fall study period. Mean daily river flow was below station capacity at 3,045 cfs and 2,867 cfs on the two dates of release for radio-tagged silver eels (October 15 and October 16). Water temperatures ranged between 12.4 and 4.6°C from the time of first release until the end of monitoring period. Mean daily Penobscot River temperatures were 11.6-12.5 °C on the two release dates for radio-tagged adult eels.

Turbine units in the Medway powerhouse were in operation throughout the study period. Due to relatively low flow conditions in the West Branch of the Penobscot River, there were no significant spill events during the monitoring period. Figure 4-2 provides the daily cumulative precipitation (as recorded at the USGS gage station 451031069185301 near Dover-Foxcroft, Maine) versus mean daily total flow at Medway. Precipitation events in excess of 0.25 inches were limited to October 16-17, November 1-3, and November 15. Precipitation on October 16-17 coincided with the presence of radio-tagged eels upstream of Medway Dam and resulted in a minor (~500 cfs) increase in mean daily total flow at Medway. The downstream bypass was operated normally throughout the study period, passing a relatively constant 15 cfs until closure on November 15. An approach velocity was measured at 7.0 ft/s for the Medway downstream bypass on October 15. The measurement was taken at approximately 3 feet of depth and 2.5 feet in front of the entrance.

Table 4-1 provides a summary of moon phase, rise, and set times during the Medway eel monitoring period. Releases were conducted under a waning crescent (October 15) and new moon (October 16). As requested by the resource agencies, a series of site photographs of potential passage routes were taken by staff conducting receiver downloads throughout the monitoring period. Those photographs can be found in Appendix C.

Table 4–1. Lunar phase and rise/set times for study period – October 15-November 15, 2020

Date	Moon Rise	Moon Set	Moon Phase[3]
10/15/20	3:57AM	4:41PM	Waning Crescent
10/16/20	5:19AM	5:07PM	New Moon
10/17/20	6:42AM	5:35PM	Waxing Crescent
10/18/20	8:04AM	6:07PM	Waxing Crescent
10/19/20	9:26AM	6:45PM	Waxing Crescent
10/20/20	10:43AM	7:31PM	Waxing Crescent
10/21/20	11:51AM	8:25PM	Waxing Crescent
10/22/20	12:48PM	9:26PM	Waxing Crescent
10/23/20	1:33PM	10:32PM	First Quarter
10/24/20	2:09PM	----	Waxing Gibbous
10/25/20	2:39PM	11:38PM	Waxing Gibbous
10/26/20	3:03PM	12:45AM	Waxing Gibbous
10/27/20	3:24PM	1:49AM	Waxing Gibbous
10/28/20	3:43PM	2:52AM	Waxing Gibbous
10/29/20	4:03PM	3:54AM	Waxing Gibbous
10/30/20	4:23PM	4:57AM	Waxing Gibbous

Date	Moon Rise	Moon Set	Moon Phase
10/31/20	4:44PM	5:59AM	Full Moon
11/1/20	5:08PM	7:02AM	Waning Gibbous
11/2/20	5:36PM	8:06AM	Waning Gibbous
11/3/20	6:09PM	9:09AM	Waning Gibbous
11/4/20	6:51PM	10:10AM	Waning Gibbous
11/5/20	7:41PM	11:07AM	Waning Gibbous
11/6/20	8:40PM	11:57AM	Waning Gibbous
11/7/20	9:47PM	12:40PM	Waning Gibbous
11/8/20	10:58PM	1:17PM	Last Quarter
11/9/20	----	1:48PM	Waning Crescent
11/10/20	12:13AM	2:15PM	Waning Crescent
11/11/20	1:30AM	2:40PM	Waning Crescent
11/12/20	2:48AM	3:05PM	Waning Crescent
11/13/20	4:08AM	3:31PM	Waning Crescent
11/14/20	5:31AM	4:01PM	Waning Crescent
11/15/20	6:54AM	4:35PM	New Moon

[3] Data obtained from:
https://www.weatherforyou.com/reports/index.php?forecast=solunar&zipcode=04462&pands=&place=millinocket&state=me&country=us&smon=11&syear=2020&submit=Go

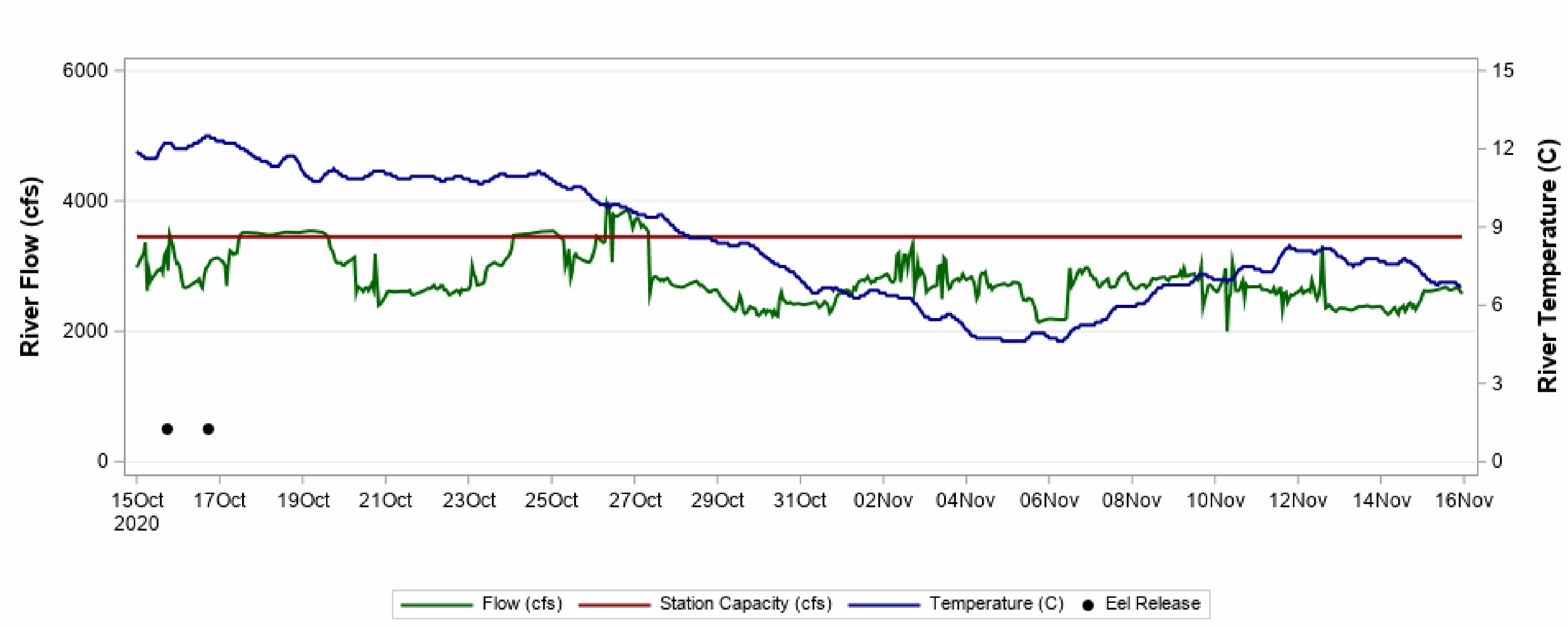


Figure 4-1: Total flow and water temperature as recorded at Medway for the period October 15 to November 15, 2020.

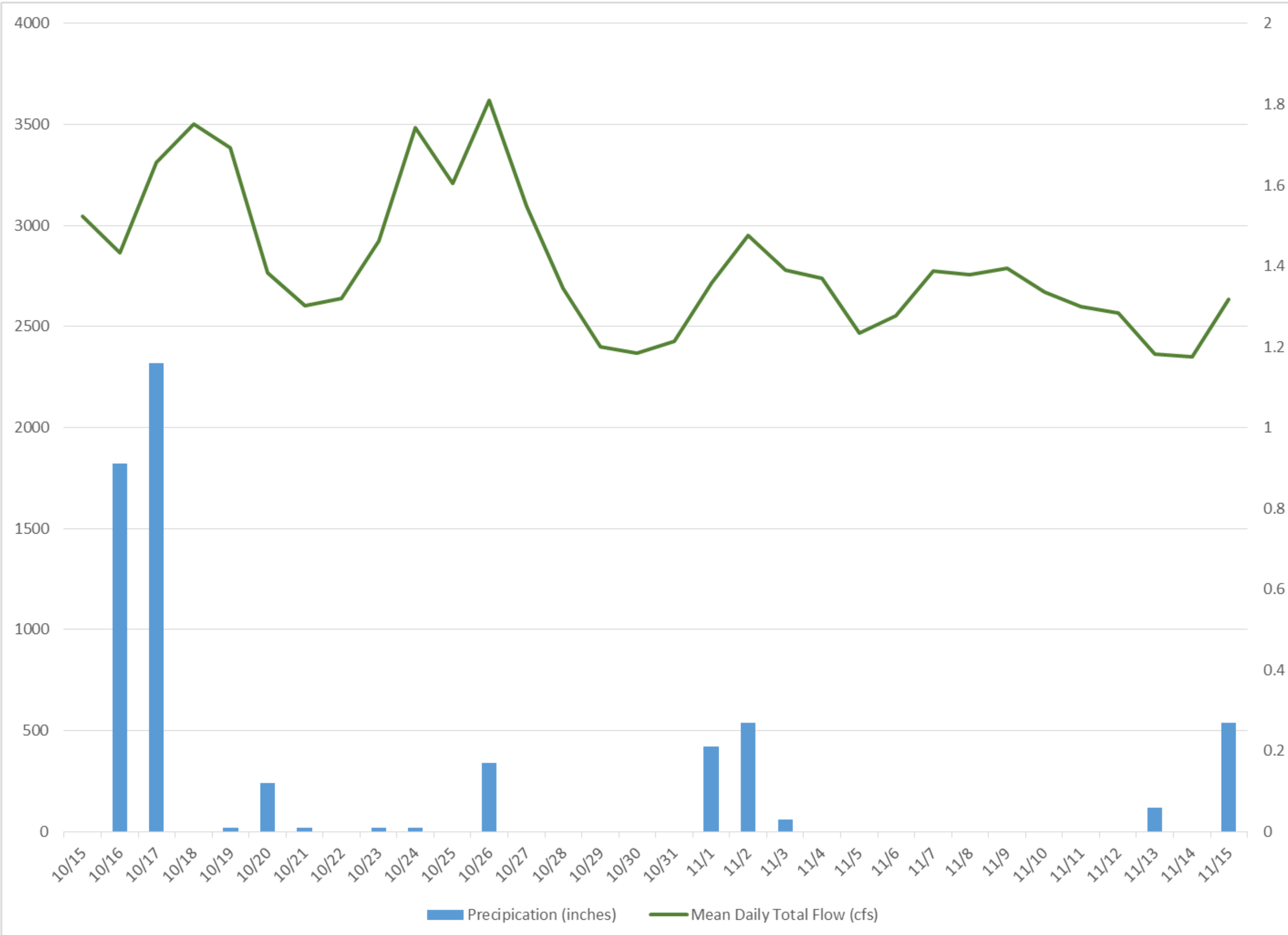


Figure 4-2: Daily precipitation (as recorded at Dover-Foxcroft) and mean daily total flow at Medway for the period October 15 to November 15, 2020.

4.2 Monitoring Station Functionality

Radio-tagged adult American eels were released upstream of Medway into the West Branch of the Penobscot River beginning on October 15, 2020, and the study plan called for continuous monitoring at each stationary receiver location until completion of the downstream passage season (i.e., removal of the downstream bypass facility on November 15). With the exception of a single location (Station M1), each of the radio telemetry monitoring stations installed to evaluate eel passage at Medway during the fall study operated without issue for the full period.

The Lotek receiver installed at Station M1 suffered an internal malfunction following its initial installation and pre-release check, which caused an interruption in coverage for the upstream approach from 1700 on October 15 until 1000 on October 16. Upon identification of this issue, the initial receiver was removed and replaced with a second Lotek unit. The replacement receiver operated without interruption for the duration of the monitoring period. It should be noted that the receiver failure at Station M1 resulted in missing "approach" data at the 200 m mark upstream of Medway Dam for individuals from the first release group. Although Station M1 was offline at the time of approach for those individuals, detections were still available from receivers operating at Stations M2 through M9; as a result, downstream passage route selection could still be determined. Initial detections from the set of receivers monitoring the area upstream of Medway (i.e., Stations M2, M3 or M4) were used as a surrogate for "arrival time", and estimates of upstream project residence time were calculated using those values.

4.3 Medway Project Residence and Downstream Passage

A total of 50 silver-phase American eels were delivered to holding tanks at West Enfield on October 12, 2020 (Table 4-2). Eels were held overnight and then visually evaluated the following day to ensure they were active in the tank following transport. Eels were tagged and released in two groups of 25 individuals each. Releases upstream of Medway occurred on October 15 and 16. Eels obtained and tagged as part of the 2020 passage evaluation ranged in length from 646 to 960 mm, with the majority of individuals between 700-800 mm (Figure 4-3). Eye index values recorded as part of this study (6.2-13.4) were all within the reported range (6.0-13.5) for outmigrating eels. A listing of tagging and biocharacteristic information for eels released during the 2020 study is provided in Appendix A.

4.3.1 Return Duration

A summary of the approach durations (i.e., the duration of time from release into the river until arrival at Medway Dam as primarily determined by detection at Station M1) for radio-tagged eels released upstream of Medway on October 15 and 16 is provided in Table 4-3 and illustrated in Figure 4-4. As described in Section 4.2, the first detection at Station M2, M3, or M4 was used as a surrogate for arrival time at the dam to evaluate approach duration for some eels released on October 15. When adult eels from both releases are considered, the median approach duration was 5.5 hours (range = 4.2 hours to 4.4 days).

4.3.2 Project Residence Time

The duration of time radio-tagged individuals were present upstream of Medway was determined for all individuals which approached and eventually passed downstream. Upstream residence duration was calculated as the duration of time from release until confirmed downstream passage via one of the available routes. When all individuals are considered, upstream residence time prior to downstream passage ranged between 5.1 hours to 4.5 days (median = 7.4 hours; Table 4-4; Figure 4-5). Of the radio-tagged eels which approached Medway Dam, 62% passed in fewer than 24 hours following initial detection at the dam. A total of 16% of outmigrating American eels took greater than two days (48 hours) to pass downstream of Medway following initial detection at the dam.

4.3.3 Downstream Passage

A summary of passage route utilization for the 50 radio-tagged silver eels released upstream of Medway Dam is presented in Table 4-5. The majority of individuals passed downstream of the dam via the turbines (84%). In addition, one individual (2%) passed via the downstream bypass. Although confirmed to have passed downstream based on detections at Stations M8 and M9, six eels had inconclusive passage routes, and one individual had not passed downstream of Medway Dam as of the removal of monitoring equipment on November 18. No radio-tagged eels were detected using the spillway or the forebay sluice, as there was no spill recorded and the forebay sluice gate was restricted to minimal leakage during the study period.

Radio-tagged silver eels were observed passing downstream of Medway Dam between the dates of October 15 and October 21 (Figure 4-6). The majority of individuals passed downstream at dusk or at night, with two peaks in the number of downstream passage events during the hours of 1900 and 0200 (Figure 4-7).

4.3.4 Downstream Transit Durations

Two monitoring stations were installed downstream of the Project for the purpose of detecting radio-tagged adult eels following passage at Medway Dam. Those receivers were located approximately 3.0 miles downstream of the dam (Monitoring Station M8) and 7.5 miles downstream (Monitoring Station M9). Monitoring Station M9 was located at Weldon Dam and recorded arrival times for radio-tagged adult eels at the downstream end of the study reach. The range of downstream transit times through these reaches are presented in Table 4-6. Median transit times for radio-tagged eels downstream of Medway were 8.1 and 11.4 hours, respectively, for the reaches from Medway to Station M8 and from Station M8 to Station M9. Of the 49 radio-tagged adult silver eels which passed downstream at Medway, 44 (90%) were determined to have reached Weldon Dam. Downstream transit times for those individuals ranged between 3.0 hours to 23.0 days (median = 29.5 hours; Figure 4-8).

4.3.5 Downstream Drift and Live Eel Assessment

Table 4-7 provides a summary of the release schedule and date-time of first detection for the drift eels to arrive at monitoring stations downstream of Medway (Stations M8 and M9). A total of six freshly dead, radio-tagged American eels were released immediately downstream of Medway Dam during the 2020 evaluation period. These individuals were placed either directly into the upper portion of the discharge from an active turbine unit or into the discharge of the downstream bypass. Of the six freshly dead eels radio-tagged eels released at Medway, three were subsequently detected downstream at Station M8 (3.0 miles downstream of the tailrace) and one was eventually detected at Station M9 (located at Weldon Dam, 7.5 miles downstream of the tailrace). The median duration for a freshly dead radio-tagged eel to drift following its release in the Medway tailrace downstream to Station M8 was 38.7 hours (range = 30.6 – 79.0 hours). The single freshly dead radio-tagged eel reaching Station M9 did so in 2.7 days. Of the three freshly dead eels radio-tagged eels which did not drift the full distance from the tailrace to Station M8, two remained stationary in the Medway tailrace and one was undetected.

In addition to the six freshly-dead eels, a group of four live eels were radio-tagged and released directly into the upper portion of the discharge from an active turbine unit or into the discharge of the downstream bypass (Table 4-7). All four individuals were detected at Station M8 (3.0 miles downstream of the tailrace) and three of the four were eventually detected at Station M9 (located at Weldon Dam, 7.5 miles downstream of the tailrace). Transit from the Medway tailrace to Station M9 at Weldon Dam ranged from 4.2 to 26.7 hours.

4.3.6 Project Survival

4.3.6.1 Project Survival – All Eels

The CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with downstream movements of radio-tagged adult American eels approaching Medway Dam (Table 4-8). The reach-specific survival estimates at Medway ranged between 1.0-0.94 among river reaches from release to dam approach, dam approach to passage, and passage to the first downstream receiver (Table 4-9). The detection efficiency for telemetry receivers recording passage of adult eels at Medway and the remote riverside locations ranged from 1.00 to 0.52. The poor detection efficiency rate (0.52) was estimated for the approach receiver (Station M1) and can be directly attributed to the lack of approach detections for eels released on October 15 when the receiver malfunctioned. However, detection was 1.00 at Station M1 for eels approaching on or after October 16, as well as for the downstream passage receivers at Medway and Station M8.

The CJS-derived survival estimates for the two Medway project reaches (i.e., dam approach (Station M1) to passage; passage to first downstream receiver (Station M8)) were 0.98 and 0.94 (Table 4-9), which resulted in an estimate of survival for the entire project reach (~500 feet upstream of the dam to the first downstream receiver) of 92.0% (75% CI =88.0-96.0%). This estimate of downstream passage survival for adult eels at Medway includes any background (i.e., natural) or tagging-related mortality for the species in the reach from the approach receiver to the first downstream receiver. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., those due solely to project effects).

An estimate of survival for the final study reach (i.e., passage from Station M8 to M9) cannot be estimated using the CJS model used to determine passage survival at the Project. In lieu of that, a point estimate was generated based on the number of eels determined to have passed downstream of Station M8 and subsequently detected at Station M9. When those detections are considered, 96% of radio-tagged eels detected at Station M8 (44 of 46 individuals) were subsequently detected at Weldon Dam.

Three of the 49 radio-tagged eels which were confirmed to have passed downstream at Medway failed to reach the first downstream monitoring station (Station M8). Of the silver eels failing to reach the downstream station, all three were known to have passed Medway Dam via the turbines. The route-specific estimate of passage survival for silver eels passing via the Medway turbine units was calculated at 92.8% (75% CI = 88.1-97.6%).

4.3.6.2 Project Survival – Adjustment for Drift

As described in Section 3.3.2, an adjusted estimate for downstream passage survival of adult American eels at Medway was generated following the manual modification of the individual encounter histories for test eels with downstream travel times to Station M8 in excess of the median drift duration observed for freshly dead radio-tagged eels released downstream of the Project (38.7 hours; Section 4.3.5). Based on this assumption, 12 test fish were adjusted because they exhibited downstream transit durations from Medway to Station M8 greater than 38.7 hours (n = 12; range = 47.9 – 650.7 hours).

When informed using the adjusted encounter histories, the CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with the adjusted downstream movements of radio-tagged adult American eels approaching Medway Dam (Table 4-10). The reach-specific survival estimates at Medway ranged between 1.0-0.69 among river reaches from release to dam approach, dam approach to passage, and passage to the first downstream receiver (Table 4-11).

The adjusted CJS-derived survival estimates for the two Medway project reaches (i.e., dam approach (Station M1) to passage; passage to first downstream receiver (Station M8)) were 0.98 and 0.69 (Table 4-11), which resulted in an estimate of survival for the entire project reach (~500 feet upstream of the dam to the first downstream receiver) of 68.0% (75% CI = 60.0-76.0%). This estimate of downstream passage survival for adult eels at Medway includes any background (i.e., natural) or tagging-related mortality for the species in the reach from the approach receiver to the first downstream receiver. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., those due solely to project effects).

An adjusted estimate of survival for the final study reach (i.e., passage from Station M8 to M9) cannot be estimated using the CJS model used to determine passage survival at the Project. In lieu of that, a point estimate for the adjusted scenario was generated based on the number of eels determined to have passed downstream of Station M8 and subsequently detected at Station M9. When those detections are considered, 97% of radio-tagged eels detected at Station M8 (33 of 34 individuals) were subsequently detected at Weldon Dam.

4.3.6.3 Project Survival – Modified Adjustment for Drift

The downstream passage durations for the 12 test fish (identified in Section 4.3.6.2) which moved downstream from Medway to Station M8 in greater than 38.7 hours were subsequently examined for the reach from Station M8 to Station M9. During that review it was determined that the duration of time for eight of those twelve individuals to move from Station M8 to M9 was comparable (i.e., within the quartile range (P25 = 3.9 hours; P75 = 25.9 hours)) observed for upstream released live radio-tagged eels which approached Station M8 at a shorter duration than observed for freshly dead eels released in the tailrace. The remaining four individuals were determined to have (1) a duration from Medway to Station M8 in excess of that observed for the freshly dead tailrace release individuals, and (2) failure to reach or a prolonged duration of time to reach Station M9.

Encounter histories for those four individuals were modified to reflect mortality following passage at Medway. When informed using the modified-adjusted encounter histories, the CJS model *Phi(t)p(t)* provided the best fit for the observed mark-recapture data associated with the modified -adjusted downstream movements of radio-tagged adult American eels approaching Medway Dam (Table 4-12). The reach-specific survival estimates at Medway ranged between 1.0-0.86 among river reaches from release to dam approach, dam approach to passage, and passage to the first downstream receiver (Table 4-13).

The adjusted CJS-derived survival estimates for the two Medway project reaches (i.e., dam approach (Station M1) to passage; passage to first downstream receiver (Station M8)) were 0.98 and 0.86 (Table 4-13), which resulted in an estimate of survival for the entire project reach (~500 feet upstream of the dam to the first downstream receiver) of 84.0% (75% CI = 78.0-90.0%). This estimate of downstream passage survival for adult eels at Medway includes any background (i.e., natural) or tagging-related mortality for the species in the reach from the approach receiver to the first downstream receiver. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., those due solely to project effects).

A modified -adjusted estimate of survival for the final study reach (i.e., passage from Station M8 to M9) cannot be estimated using the CJS model used to determine passage survival at the Project. In lieu of that, a point estimate for the modified -adjusted scenario was generated based on the number of eels determined to have passed downstream of Station M8 and subsequently detected at Station M9. When those detections are considered, 95% of radio-tagged eels detected at Station M8 (42 of 44 individuals) were subsequently detected at Weldon Dam.

4.3.7 Manual Tracking

In addition to the continuous monitoring provided by the nine stationary receivers installed throughout the Project area and operated from the date of first release (October 15) through the completion of the downstream passage season at Medway (November 15), a total of ten manual detections representing nine individuals were recorded during the study period. Appendix B contains a listing of manual detections along with manual location information, as well as their last known river reach as determined by the stationary receivers.

One individual was recorded on multiple occasions in the Medway headpond and did not pass downstream through Medway Dam during the monitoring period. A total of eight individuals were located a single time within the reach downstream of Medway. Of those, three were detected near to Medway Dam, one in the reach between Medway and Station M8, and four in the reach between Station M8 and M9. Of the eight individuals detected between Medway and Weldon Dams, only four were radio-tagged eels originally released upstream of Medway. The remaining four individuals had been released directly into the discharge from the turbine units.

Table 4–2. Summary of tagging and release information for adult American eels radio-tagged and released upstream of Medway during October 2020

Silver Eels	Release Group	
	#1	#2
Release Location	0.5 mi Upstream of Project	
Release Date	15-Oct-20	16-Oct-20
Release Time	17:22	17:43
River Temperature (°C)	12.2	12.5
Station Discharge (cfs)	3219	2992
Spill Flow (cfs)	0	0
No. Tagged Released	25	25
Min. Total Length (mm)	675	646
Max Total Length (mm)	960	928
Mean Total Length (mm)	795	788

Table 4–3. Minimum, maximum, and quarterly percentiles (P 25, P 50 (median), and P 75) for the observed duration of time for radio-tagged adult American eels to approach Medway following release

Release Group	Approach Duration (hrs)					
	n	Min	Max	P 25	Median	P 75
15-Oct	17	4.3	38.1	5.5	5.7	6.0
16-Oct	26	4.2	106.4	5.1	5.4	6.6
All	**43**	**4.2**	**106.4**	**5.1**	**5.5**	**6.3**

Table 4–4. Minimum, maximum and quarterly percentiles (P 25, P 50 (median), and P 75) for radio-tagged adult American eel upstream residence duration prior to downstream passage at Medway

Release Group	Upstream Residence Duration (hrs)					
	n	Min	Max	P 25	Median	P 75
15-Oct	18	5.1	53.2	6.1	6.4	29.1
16-Oct	25	5.3	107.1	6.6	11.0	37.1
All	**43**	**5.1**	**107.1**	**6.1**	**7.4**	**29.1**

Table 4–5. Summary of downstream passage route distribution for radio-tagged adult American eels at Medway during October 2020

Passage Route	No. of Individuals	Percentage
DS Bypass	1	2
Turbines	42	84
Spillway	0	0
Forebay Sluice	0	0
Unknown	6	12
Did Not Pass	1	2

Table 4–6. Minimum, maximum and quarterly percentiles (P 25, P 50 (median), and P 75) for radio-tagged adult American eel downstream transit duration following downstream passage at Medway

River Reach	Downstream Transit (hrs)					
	n	Min	Max	P 25	Median	P 75
Medway to Station F9 (Weldon)	38	5.2	628.5	20.0	29.5	53.3
Medway to F8	40	2.0	650.7	3.1	8.1	48.4
Station F8 to F9 (Weldon)	44	3.0	550.9	4.0	11.4	24.4

Table 4–7. Summary of the downstream drift distance and duration for freshly dead and live radio-tagged silver eels released in the Medway tailrace during the October 2020 downstream passage assessment

Release Date	River Condition		Frequency (ID)	Total Length (mm)	Release State	Station F8 Arrival		Station F9 Arrival		Drift Duration (hours)		
	Station Flow (cfs)	Spill (cfs)				Date	Time	Date	Time	Medway to M8	M8 to M9	Medway to M9
15-Oct	3,219	0	149.440 (150)	688	Alive – Bypass	10/15	21:43	10/16	1:56	4.4	4.2	8.6
			149.440 (154)	690	Alive – Tailrace	10/21	1:10	-	-	127.8	-	-
			149.440 (151)	741	Dead – Tailrace	-	-	-	-	-	-	-
			149.440 (152)	711	Dead – Bypass	10/19	0:21	-	-	79.0	-	-
			149.440 (153)	925	Dead – Severed, Tailrace	10/16	23:55	10/19	16:03	30.6	64.1	94.7
16-Oct	2,992	0	149.400 (158)	697	Alive – Bypass	10/17	19:30	10/18	22:12	25.8	26.7	52.5
			149.400 (157)	845	Alive – Tailrace	10/17	4:21	10/18	2:28	10.6	22.1	32.8
			149.440 (155)	735	Dead – Tailrace	10/18	8:25	-	-	38.7	-	-
			149.440 (156)	846	Dead – Bypass	-	-	-	-	-	-	-
			149.440 (159)	961	Dead – Severed, Tailrace	-	-	-	-	-	-	-

Table 4–8. CJS model selection criteria for downstream passage of adult American eels at Medway during October 2020

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t)p(t)	126.31	0.00	0.76	1.00	4	1.74
Phi(.)p(t)	128.67	2.36	0.24	0.31	3	6.19
Phi(t)p(.)	187.72	61.42	0.00	0.00	3	65.25
Phi(.)p(.)	188.60	62.29	0.00	0.00	2	68.2

Table 4–9. Reach-specific survival probability estimates (*Phi*), standard errors and likelihood 75 and 95% confidence intervals for radio-tagged adult American eels approaching and passing Medway Dam during October 2020

Reach	Reach Length (mile)	*Phi*	SE	95% CI		75% CI	
Release – US of Medway	1.3	1.00	0.00	-	-	-	-
–US of Medway to DS of Medway	0.2	0.98	0.02	0.87	1.00	0.94	0.99
Pass - Station M8	3.0	0.94	0.03	0.83	0.98	0.89	0.97

Table 4–10. Adjusted CJS model selection criteria for downstream passage of adult American eels at Medway during October 2020

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t)p(t)	156.69	0.00	1.00	1.00	4	5.15
Phi(.)p(t)	186.47	29.79	0.00	0.00	2	39.12
Phi(t)p(.)	209.79	53.11	0.00	0.00	2	62.44
Phi(.)p(.)	240.14	83.46	0.00	0.00	2	92.79

Table 4–11. Adjusted reach-specific survival probability estimates (*Phi*), standard errors and likelihood 75 and 95% confidence intervals for radio-tagged adult American eels approaching and passing Medway Dam during October 2020

Reach	Reach Length (mile)	*Phi*	SE	95% CI		75% CI	
Release – US of Medway	1.3	1.00	0.00	-	-	-	-
–US of Medway to DS of Medway	0.2	0.98	0.02	0.87	1.00	0.94	0.99
Pass - Station M8	3.0	0.69	0.07	0.55	0.81	0.61	0.76

Table 4–12. Modified-adjusted CJS model selection criteria for downstream passage of adult American eels at Medway during October 2020

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
Phi(t)p(t)	136.93	0.00	0.99	1.00	4	4.24
Phi(.)p(t)	145.87	8.94	0.01	0.01	2	17.35
Phi(t)p(.)	196.13	59.21	0.00	0.00	2	67.62
Phi(.)p(.)	207.42	70.49	0.00	0.00	2	78.91

Table 4–13. Modified-adjusted reach-specific survival probability estimates (*Phi*), standard errors and likelihood 75 and 95% confidence intervals for radio-tagged adult American eels approaching and passing Medway Dam during October 2020

Reach	Reach Length (mile)	*Phi*	SE	95% CI		75% CI	
Release – US of Medway	1.3	1.00	0.00	-	-	-	-
–US of Medway to DS of Medway	0.2	0.98	0.02	0.87	1.00	0.94	0.99
Pass - Station M8	3	0.86	0.05	0.73	0.93	0.61	0.76

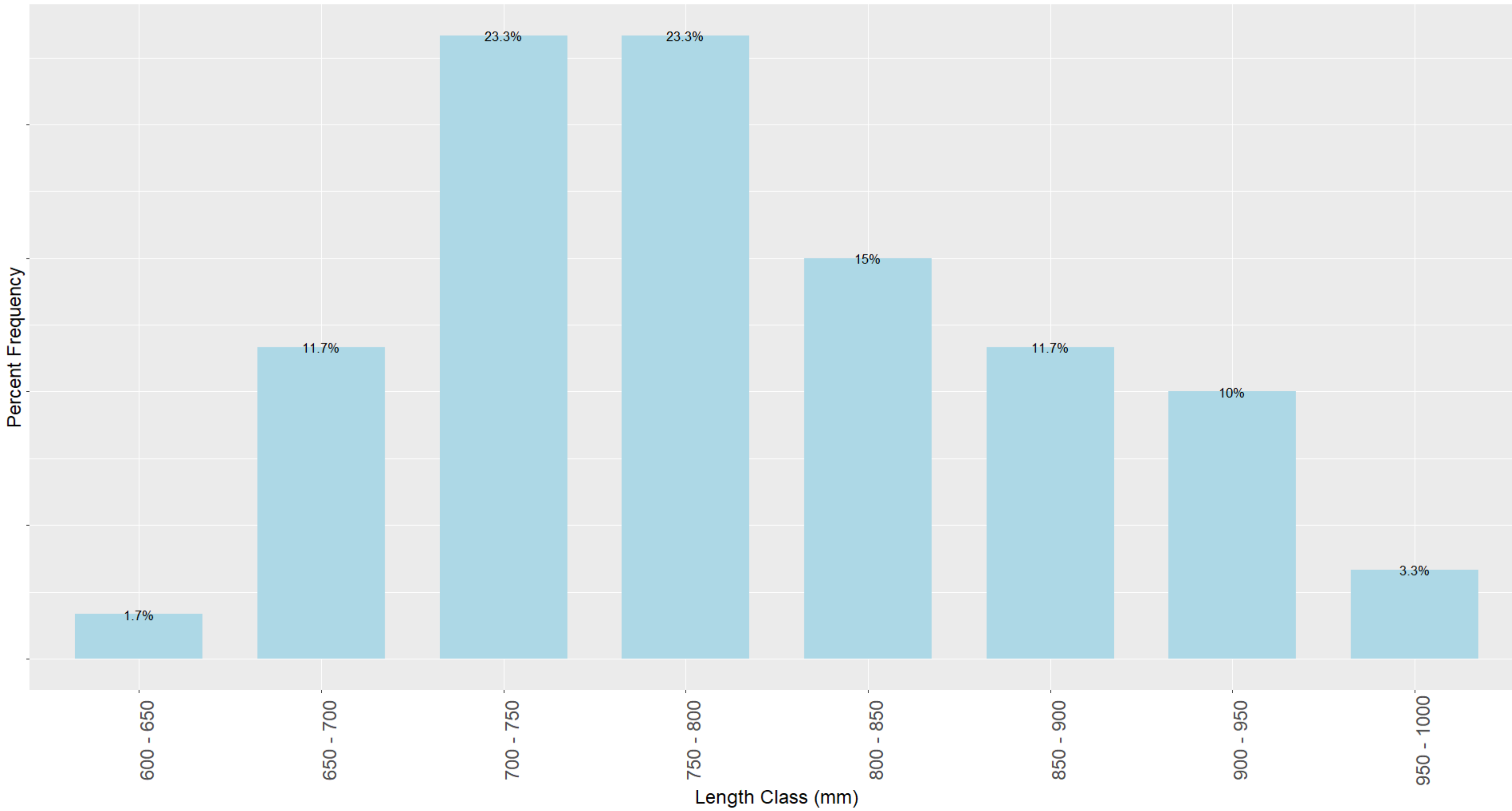


Figure 4-3. Frequency distribution of total length (50 mm length classes) for radio-tagged adult American eels released upstream of Medway.

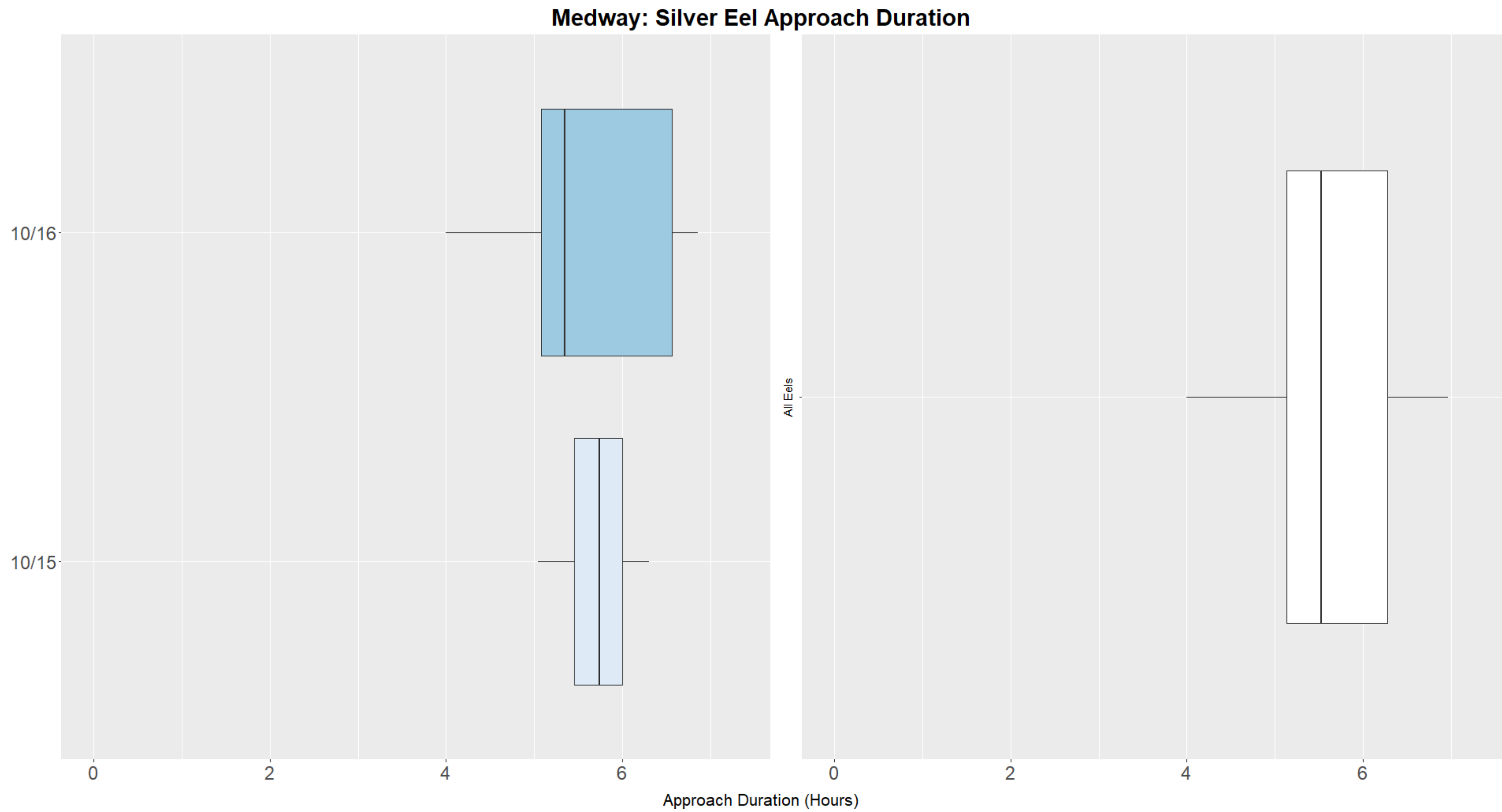


Figure 4-4. Boxplot showing approach duration for radio-tagged adult American eels at Medway prior to downstream passage, October 2020. [4]

[4] The solid line represents the median while left and right portions of the box represent the first and third quartiles, respectively. Whiskers extend to the range of the data within the interquartile range (quartile*1.05) such that outliers outside of this range are not displayed.

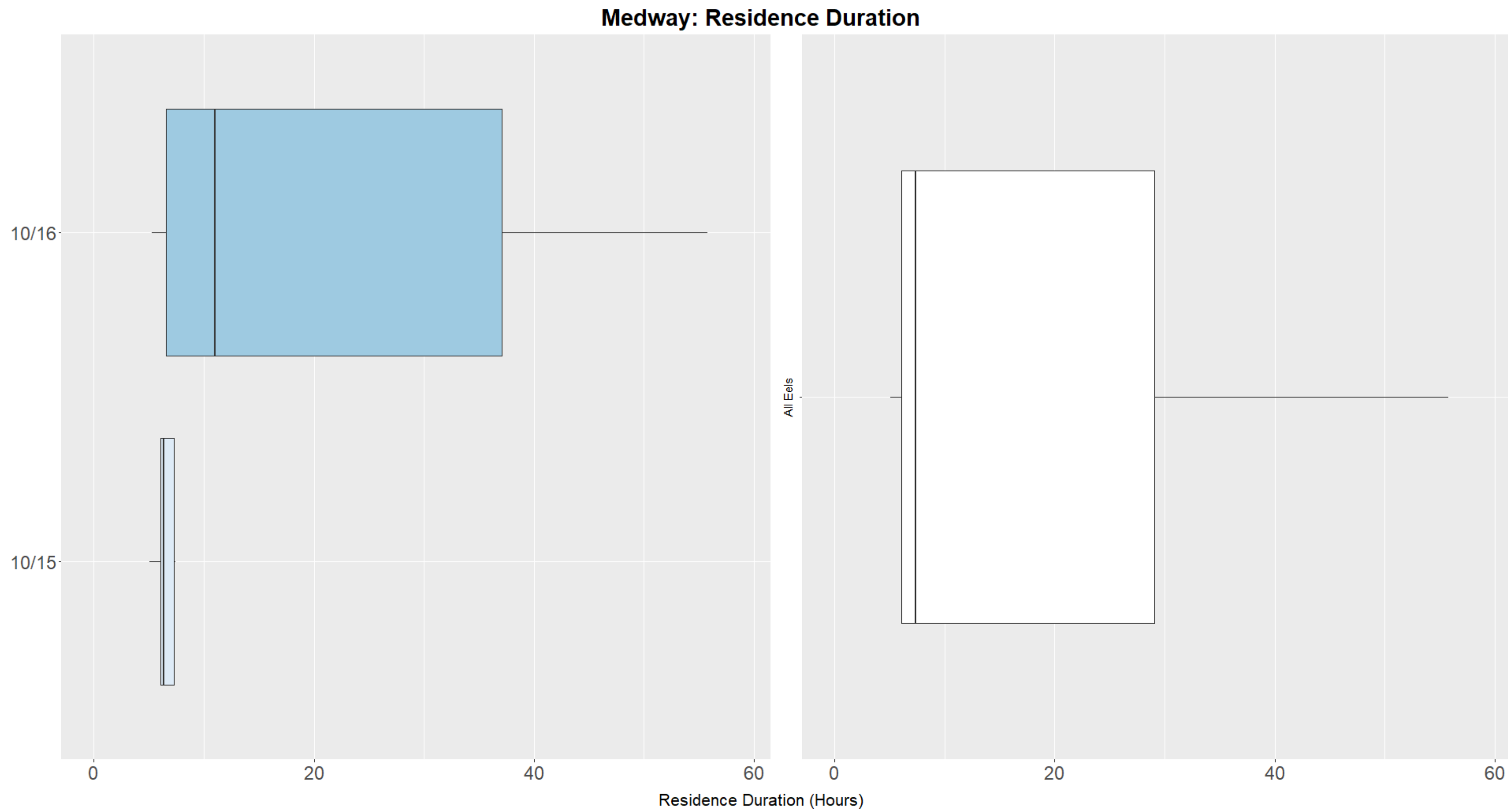


Figure 4-5. Boxplot showing upstream residence duration for radio-tagged adult American eels at Medway prior to downstream passage, October 2020. [5]

[5] The solid line represents the median while left and right portions of the box represent the first and third quartiles, respectively. Whiskers extend to the range of the data within the interquartile range (quartile*1.05) such that outliers outside of this range are not displayed.

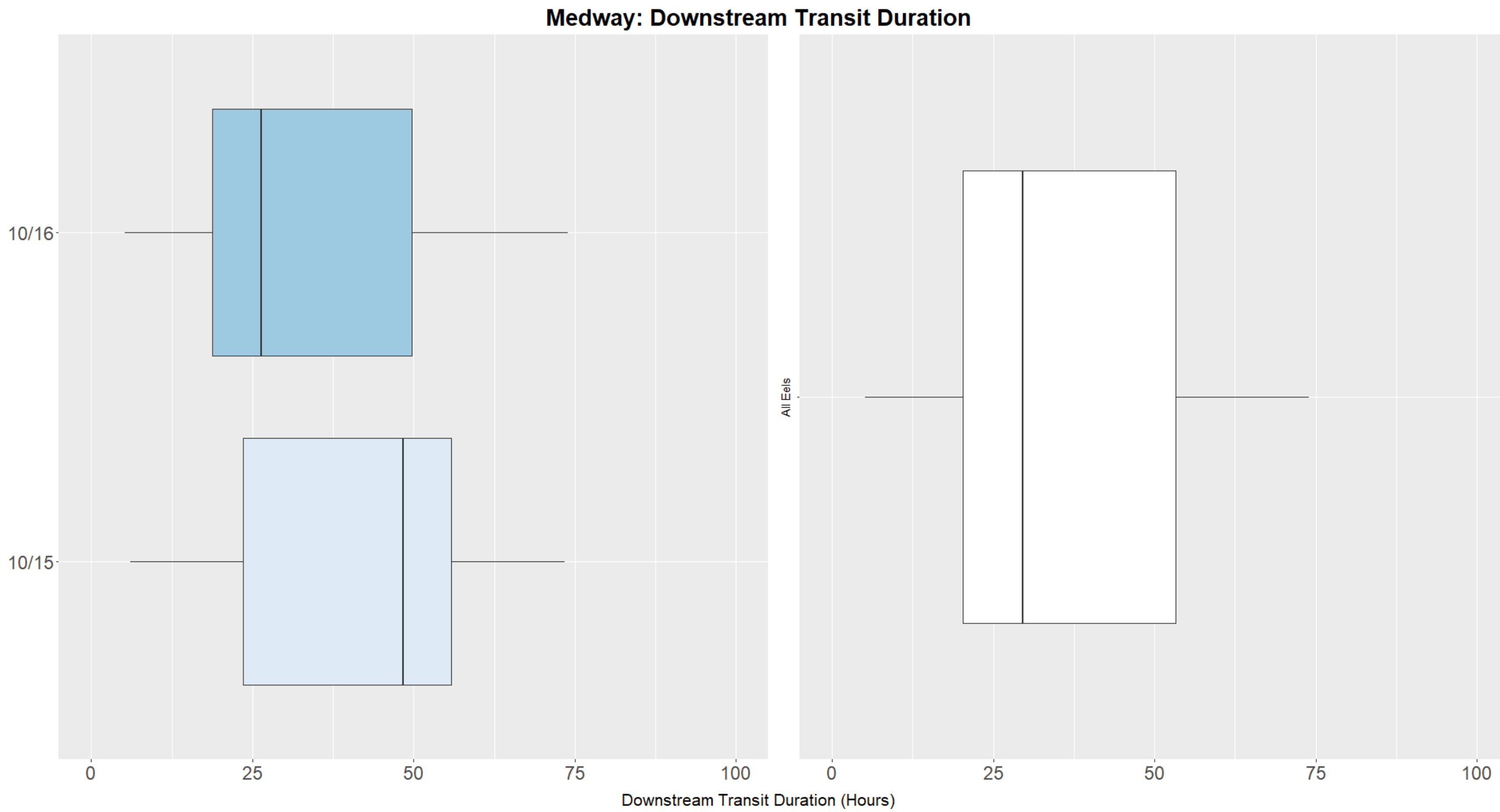


Figure 4-6. Boxplot showing transit duration for radio-tagged adult American eels following downstream passage at Medway until detection at Station M9 during October, 2020. [6]

[6] The solid line represents the median while left and right portions of the box represent the first and third quartiles, respectively. Whiskers extend to the range of the data within the interquartile range (quartile*1.05) such that outliers outside of this range are not displayed.

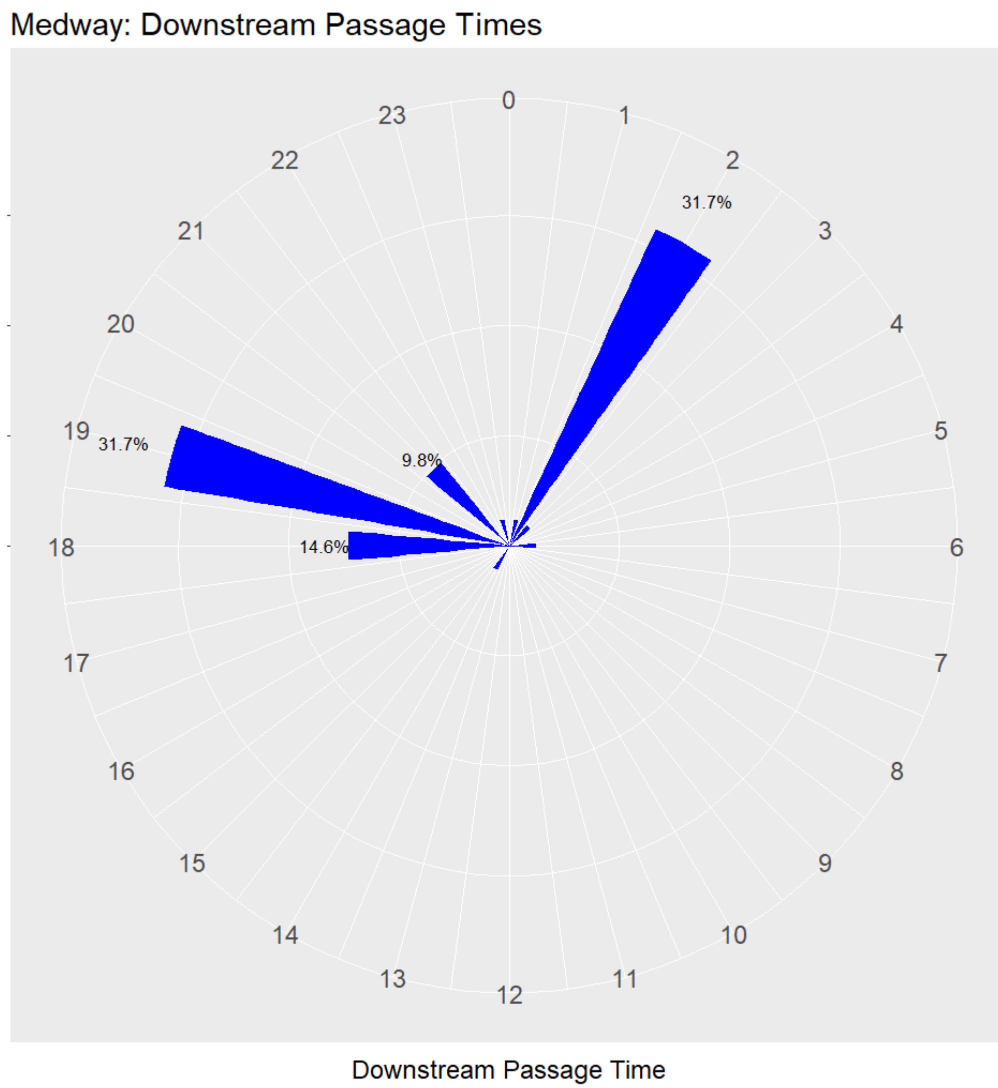


Figure 4-7: Distribution of downstream passage hour for radio-tagged adult American eels at Medway during October 2020.

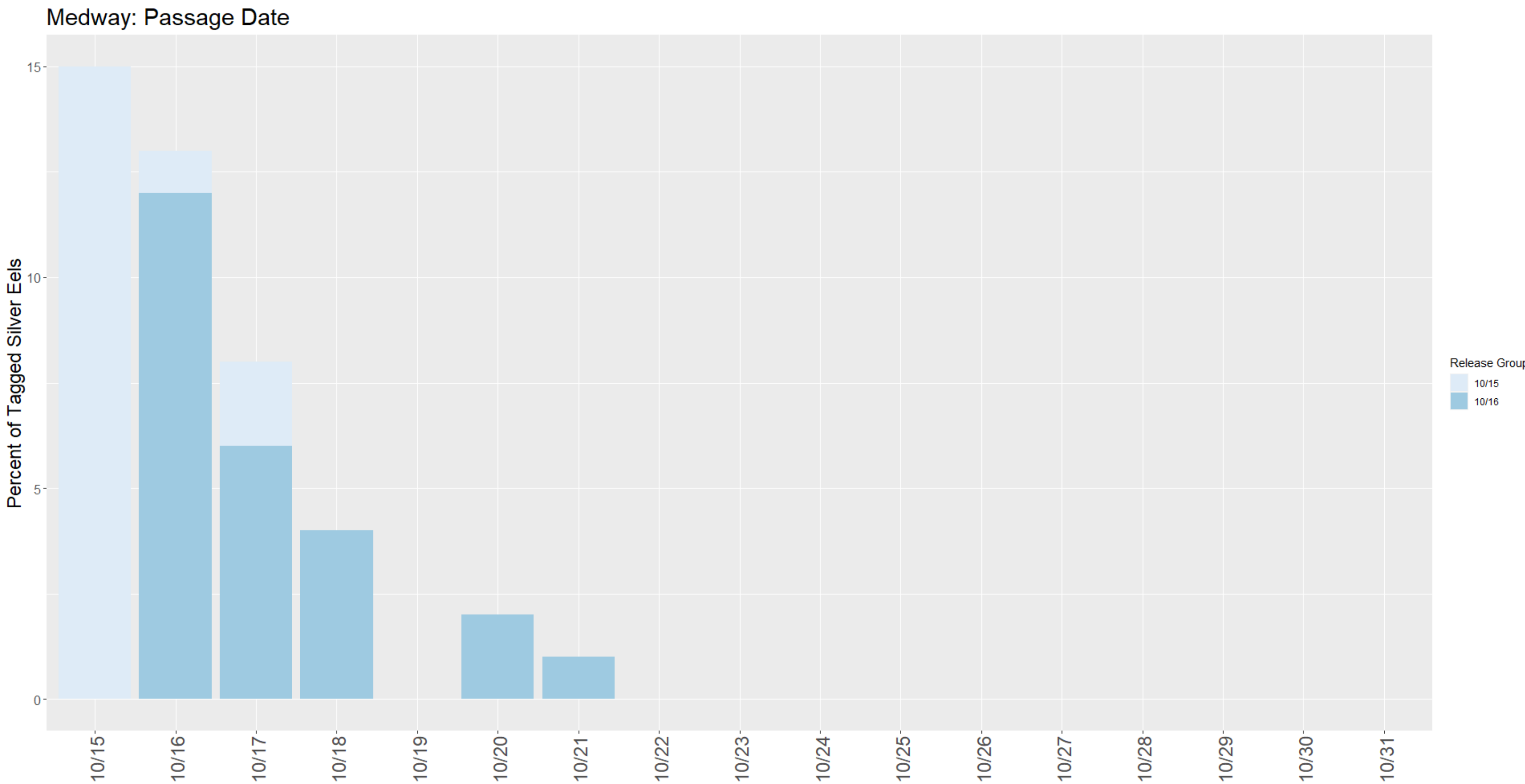


Figure 4-8: Distribution of downstream passage dates for radio-tagged adult American eels at Medway during October 2020.

5 Summary

A total of 50 adult silver eels were obtained from a commercial vendor operating on the St. Croix River in eastern Maine and were transported for evaluation of downstream passage at the Medway Hydroelectric Project on the West Branch of the Penobscot River. All 50 individuals were surgically tagged and released upstream of the Project on one of two release dates in mid-October, 2020. Downstream passage effectiveness was evaluated using radio telemetry between the dates of October 15 and November 18. Monitoring of adult eel movements focused on residence time prior to passage, passage route selection, and an estimation of downstream passage survival at the Project.

Downstream passage was observed for the majority of radio-tagged eels released upstream of Medway and occurred over a range of dates from October 15 to October 21. The median period of residence for radio-tagged eels upstream of the dam was 7.4 hours, with 62% passing downstream within the first 24 hours of their initial detection. Based on low West Branch flows and operational conditions at Medway, downstream passage route options for radio-tagged adult eels tagged during this study were limited to the downstream bypass or the operating turbines. As a result, this study was conducted under worst case conditions for outmigrating eels. Most radio-tagged eels passed downstream via the turbines, and there was one observation of an adult eel passing downstream via the bypass. Downstream passage survival for the entire project reach (~500 feet upstream of the dam to the first downstream receiver) was estimated at 92.0% (75% CI = 88.0-96.0%).

An additional group of freshly dead eels were radio-tagged and released immediately downstream of Medway. The median duration for those individuals to drift downstream to Station M8 (38.7 hours; range = 30.6 – 79.0 hours) was used to classify live eels passing Medway based on their downstream transit duration relative to the drift duration. Individuals whose downstream transit duration exceeded 38.7 hours (n = 12) were considered as Project mortalities at Medway; the adjusted model results produced a project survival of 68.0% (75% CI = 60.0-76.0%). A second adjusted model (i.e., the revised-adjusted model) was developed which considered only test eels which exhibited (1) a duration from Medway to Station M8 in excess of that observed for the freshly dead tailrace release individuals, and (2) failure to reach or a prolonged duration of time to reach Station M9 as a Project mortality at Medway. When that assumption was made, the revised-adjusted estimate of project survival was 84.0% (75% CI = 78.0-90.0%).

None of the three estimates of downstream passage survival for adult eels at Medway include any background (i.e., natural) or tagging-related mortality for the species in the reach from the approach receiver to the first downstream receiver. As a result, these estimates should be viewed as minimum estimates of total project survival (i.e., due solely to project effects) for adult eels at the Project.

6 Appendices

Appendix A. Transmitter and length information for adult Silver Eels radio-tagged and released upstream of Medway during October, 2020.

Tag ID	Frequency	Horizontal Eye (mm)	Vertical Eye (mm)	Length (mm)	Release Date	Release Time	Location
150	149.440	9.23	8.61	688	15-Oct	17:22:00	Alive-Bypass
154	149.440	7.97	6.76	690	15-Oct	17:22:00	Alive-Tailrace
152	149.440	8.95	8.24	711	15-Oct	17:22:00	Dead-Bypass
153	149.440	10.92	9.95	925	15-Oct	17:22:00	Dead-Severed-Tailrace
151	149.440	9.90	9.10	741	15-Oct	17:22:00	Dead-Tailrace
30	149.400	9.18	8.71	745	15-Oct	17:22:00	Upstream
31	149.400	10.15	9.95	832	15-Oct	17:22:00	Upstream
32	149.400	9.01	8.79	778	15-Oct	17:22:00	Upstream
33	149.400	9.95	9.25	767	15-Oct	17:22:00	Upstream
34	149.400	9.15	9.59	774	15-Oct	17:22:00	Upstream
35	149.400	9.41	9.30	794	15-Oct	17:22:00	Upstream
36	149.400	9.29	8.42	705	15-Oct	17:22:00	Upstream
37	149.400	9.26	9.26	860	15-Oct	17:22:00	Upstream
38	149.400	9.23	9.23	790	15-Oct	17:22:00	Upstream
39	149.400	10.20	10.04	960	15-Oct	17:22:00	Upstream
40	149.400	10.72	10.45	912	15-Oct	17:22:00	Upstream
41	149.400	9.59	9.59	726	15-Oct	17:22:00	Upstream
55	149.440	11.74	11.38	922	15-Oct	17:22:00	Upstream
56	149.440	9.35	9.36	701	15-Oct	17:22:00	Upstream
57	149.440	9.07	9.27	817	15-Oct	17:22:00	Upstream
58	149.440	9.03	8.75	735	15-Oct	17:22:00	Upstream
59	149.440	8.78	8.76	696	15-Oct	17:22:00	Upstream
60	149.440	10.97	10.09	899	15-Oct	17:22:00	Upstream
61	149.440	9.12	8.90	675	15-Oct	17:22:00	Upstream
62	149.440	11.08	9.89	947	15-Oct	17:22:00	Upstream
63	149.440	8.67	8.12	722	15-Oct	17:22:00	Upstream
64	149.440	8.08	7.94	716	15-Oct	17:22:00	Upstream
65	149.440	8.79	8.64	752	15-Oct	17:22:00	Upstream
66	149.440	10.21	9.44	807	15-Oct	17:22:00	Upstream
67	149.440	10.17	9.54	851	15-Oct	17:22:00	Upstream
157	149.400	9.29	8.83	845	16-Oct	17:43:00	Alive-Bypass
158	149.400	9.09	8.98	697	16-Oct	17:43:00	Alive-Tailrace
156	149.400	10.62	10.60	846	16-Oct	17:43:00	Dead-Bypass
159	149.400	10.91	10.19	961	16-Oct	17:43:00	Dead-Severed-Tailrace
155	149.400	9.47	9.37	735	16-Oct	17:43:00	Dead-Tailrace
42	149.400	8.01	8.44	734	16-Oct	17:43:00	Upstream
43	149.400	10.65	10.35	903	16-Oct	17:43:00	Upstream
44	149.400	10.66	9.73	888	16-Oct	17:43:00	Upstream
45	149.400	8.85	9.61	791	16-Oct	17:43:00	Upstream
46	149.400	9.13	8.94	646	16-Oct	17:43:00	Upstream
47	149.400	9.69	8.86	756	16-Oct	17:43:00	Upstream
48	149.400	10.42	9.06	805	16-Oct	17:43:00	Upstream
49	149.400	9.74	9.43	796	16-Oct	17:43:00	Upstream

Tag ID	Frequency	Horizontal Eye (mm)	Vertical Eye (mm)	Length (mm)	Release Date	Release Time	Location
50	149.400	9.03	9.37	754	16-Oct	17:43:00	Upstream
51	149.400	10.55	9.97	884	16-Oct	17:43:00	Upstream
52	149.400	11.73	10.78	846	16-Oct	17:43:00	Upstream
53	149.400	12.33	12.19	880	16-Oct	17:43:00	Upstream
54	149.400	10.05	9.45	708	16-Oct	17:43:00	Upstream
68	149.440	10.88	10.17	878	16-Oct	17:43:00	Upstream
69	149.440	9.50	9.01	654	16-Oct	17:43:00	Upstream
70	149.440	10.63	9.40	798	16-Oct	17:43:00	Upstream
71	149.440	10.24	9.05	772	16-Oct	17:43:00	Upstream
72	149.440	10.95	11.10	928	16-Oct	17:43:00	Upstream
73	149.440	9.91	9.48	677	16-Oct	17:43:00	Upstream
74	149.440	8.72	8.60	782	16-Oct	17:43:00	Upstream
75	149.440	8.45	8.12	715	16-Oct	17:43:00	Upstream
76	149.440	8.72	8.28	815	16-Oct	17:43:00	Upstream
77	149.440	8.50	8.20	701	16-Oct	17:43:00	Upstream
78	149.440	8.90	8.12	821	16-Oct	17:43:00	Upstream
79	149.440	9.76	9.73	780	16-Oct	17:43:00	Upstream

Appendix B. Listing of manual tracking detections within the Medway Project area.

Date	Time	Frequency	ID	Original Release	Manual Location	Project Reach	Tracking Method
11/4	9:18	149.440	64	Upstream	Headpond	Release Site – M1	Truck
11/4	9:20	149.400	159	Downstream-Turbine (dead)	Tailrace	Medway to M7	Truck
11/18	8:35	149.440	64	Upstream	Headpond	Release Site – M1	Boat
11/18	11:54	149.440	151	Downstream-Turbine (dead)	Nicatou Bridge	Medway to M7	Boat
11/18	11:54	149.400	55	Upstream	Nicatou Bridge	Medway to M7	Boat
11/18	12:09	149.440	62	Upstream	(45.5969, -68.5127)	M7 – M8	Boat
11/18	12:12	149.400	155	Downstream-Turbine (dead)	(45.5942, -68.5011)	M8 – M9	Boat
11/18	12:20	149.440	154	Downstream-Turbine (alive)	(45.5915, -68.4804)	M8 – M9	Boat
11/18	12:36	149.400	45	Upstream	(45.5786, -68.4316)	M8 – M9	Boat
11/18	12:40	149.400	74	Upstream	(45.5747, -68.4194)	M8 – M9	Boat

Appendix C. Medway passage route photo series – October 13 through November 18, 2020.

10/13/2020
(Pre-Release)

M2: Intakes

M4: Forebay Sluice

M3: DS Bypass

M3: DS Bypass Sluice

10/15/2020
(Pre-Release)

M2: Intakes

M4: Forebay Sluice

M3: DS Bypass

M3: DS Bypass Sluice

10/16/2020
(One Release Event)

M2: Intakes

M4: Forebay Sluice

M3: DS Bypass

M3: DS Bypass Sluice

10/20/2020
(All Eels Released)

M2: Intakes

M4: Forebay Sluice

M3: DS Bypass

M3: DS Bypass Sluice

10/26/2020
(All Eels Released)

M2: Intakes

M4: Forebay Sluice

M3: DS Bypass

M3: DS Bypass Sluice

11/4/2020
(All Eels Released)

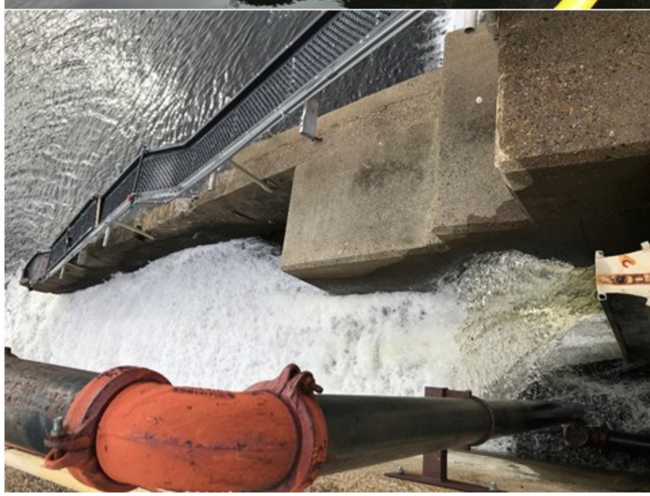
M2: Intakes
M4: Forebay Sluice
M3: DS Bypass
M3: DS Bypass Sluice

11/12/2020
(All Eels Released)

M2: Intakes

M4: Forebay Sluice

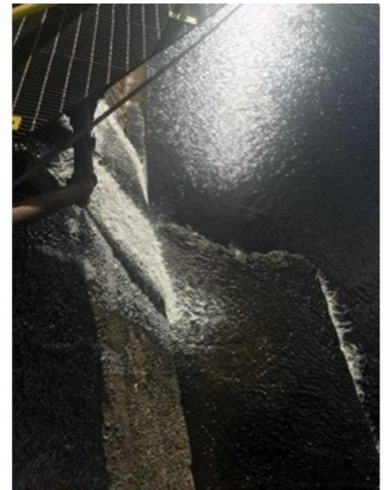
M3: DS Bypass



M3: DS Bypass Sluice

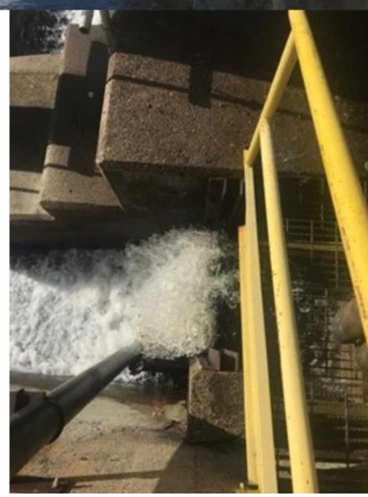
11/18/2020
(All Eels Released)

M2: Intakes



M4: Forebay Sluice

M3: DS Bypass



M3: DS Bypass Sluice

Appendix D. Summary of questions and topics discussed at the January 27, 2021 resource agency and PIN study discussion meeting.

General Discussion:

As part of the PowerPoint presentation (Appendix F) Normandeau included an additional review of downstream passage survival incorporating the drift information collected from the radio-tagged eels released directly into the tailrace. Based on observations of drift rates between the downstream stations an additional estimate of survival was generated. Section 4.3.6 of this report has been updated to reflect this.

Question 1: *Were any of the dead eels released directly in the Medway tailrace detected downstream at Weldon?*

Response 1: Yes, one of the six eels released dead in the Medway tailrace was detected at Weldon Dam and took 64 hours to drift that distance.

Appendix E. Correspondence related to the distribution and comment on the draft Medway downstream eel passage study report.

From: Bernier, Kevin
Sent: Tuesday, December 15, 2020 2:02 PM
To: Gail Wippelhauser <gail.wippelhauser@maine.gov>; Casey.Clark@maine.gov; Mitch Simpson <Mitch.Simpson@maine.gov>; Daniel McCaw <dan.mccaw@penobscotnation.org>; John.Banks@penobscotnation.org; Harold Peterson <harold.peterson@bia.gov>; Antonio Bentivoglio <antonio_bentivoglio@fws.gov>; Kenneth J Hogan <kenneth_hogan@fws.gov>; Jeff.Murphy@noaa.Gov; donald.dow@noaa.gov; Bryan Sojkowski <Bryan_Sojkowski@fws.gov>; Kathy Howatt <Kathy.howatt@maine.gov>; Christopher Sferra <Christopher.Sferra@maine.gov>; Jason Valliere <Jason.Valliere@maine.gov>; Kevin Dunham <Kevin.Dunham@maine.gov>; John Perry <john.perry@maine.gov>; Julianne Rosset (julianne_rosset@fws.gov) <julianne_rosset@fws.gov>; Gallant, Kevin <Kevin.Gallant@maine.gov>; Sean M Ledwin - Maine Department of Marine Resources (Sean.M.Ledwin@maine.gov) <Sean.M.Ledwin@maine.gov>
Cc: Maloney, Kelly <Kelly.Maloney@brookfieldrenewable.com>; Brochu, Robert <Robert.Brochu@brookfieldrenewable.com>; Cole, James <James.Cole@brookfieldrenewable.com>; Drew Trested <dtrested@normandeau.com>; Stevens, Nate <Nathan.Stevens@brookfieldrenewable.com>; Michaud, Steve <Stephen.Michaud@brookfieldrenewable.com>; Macomber, Lance <Lance.Macomber@brookfieldrenewable.com>; Osborne, Michael <Michael.Osborne@brookfieldrenewable.com>; Mapletoft, Thomas <Thomas.Mapletoft@brookfieldrenewable.com>; Kessel, Miranda <Miranda.Kessel@brookfieldrenewable.com>
Subject: Medway Project downstream eel passage draft study report

As promised, attached is Normandeau's draft report on the downstream eel studies conducted this fall at the Medway Project. Please provide any comments on this report **by January 14, 2021**. As indicated below, we will be scheduling a Teams Meeting for early January to discuss these reports.

Thank you, Kevin Bernier

Document Accession #: 20210113-5138 Filed Date: 01/13/2021

Brookfield
Renewable

January 13, 2021

FERC No. 2666
Article 405

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

RE: Medway Project (FERC No. 2666), Article 405; Time Extension Request for American Eel Downstream Passage Study Report

Dear Secretary Bose:

On June 15, 2020, Black Bear Hydro Partners, LLC (Black Bear), licensee for the Medway Project on the West Branch of the Penobscot River in Maine and an affiliate of Brookfield Renewable (Brookfield), submitted to the Commission a "*Study Plan for the Evaluation of Downstream Passage Effectiveness for Adult American Eel*" at the Medway Project. This study plan was in reply to a September 26, 2019 Commission letter requesting that Black Bear conduct a downstream eel study at the Medway Project in the fall of 2020. The study was completed in the fall of 2020, and a draft study report was distributed to resource agencies[1] and the Penobscot Indian Nation (PIN) for review on December 15, 2020.

At the request of the agencies and PIN, licensees for the Milford, Stillwater, and Orono Projects (each affiliated with Brookfield, including Black Bear) submitted a time extension request to the Commission on December 28, 2020 for submittal of an annual eel and alosine study report for these lower Penobscot facilities. The Commission approved this request on January 11, 2021, thereby extending the report submittal deadline to February 15, 2021. A meeting has been scheduled for January 27, 2021 with the agencies and PIN to review and discuss the lower Penobscot eel and alosine study report. Consistent with past years, Black Bear intends to also review and discuss the results from the Medway downstream eel passage study at this meeting. Therefore, Black Bear is also requesting a time extension request to February 15, 2021[2] for submittal of the Medway Project downstream eel passage report in order to incorporate any comments and discussions that result from the January 27 meeting, and to provide the agencies and PIN with sufficient time to then provide any written comments that they have.

[1] United States Fish and Wildlife Service (USFWS); Maine Department of Marine Resources (MDMR); Maine Department of Inland Fisheries and Wildlife (MDIFW); Maine Department of Environmental Protection (MDEP); National Marine Fisheries Service (NMFS); Bureau of Indian Affairs (BIA)

[2] Although the Commission has not responded, Black Bear's June 15, 2020 *"Study Plan for the Evaluation of Downstream Passage Effectiveness for Adult American Eel"* indicated a report submittal date of January 15, 2021

1024 Central Street
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Brookfield
Renewable

Please feel free to contact me at kevin.bernier@brookfieldrenewable.com or call me at (207) 951-5006 if you have any questions or comments on this extension of time request.

Sincerely,

Kevin Bernier
Senior Compliance Specialist

cc: S. Michaud, N. Stevens, R. Brochu, J. Cole, R. Dill, K. Maloney. L. Macomber; Black Bear
D. Trested; Normandeau

Black Bear File: HSSE 4a/2666/01

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STATE OF MAINE
DEPARTMENT OF MARINE RESOURCES
21 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0021

JANET T. MILLS
GOVERNOR

PATRICK C. KELIHER
COMMISSIONER

January 8, 2021

Kevin Bernier
Senior Compliance Specialist
Brookfield Renewable
1024 Central Street, Millinocket, ME 04462

Dear Kevin:

I have reviewed the Draft Study Report for the Evaluation of Downstream Passage Effectiveness for Adult American Eel for the Medway project (FERC No. 2666) for the Department of Marine Resources.

Major findings of the study were:

1) 84% (42/50) of the eels passed through the turbines;
2) 12% (6/50) of the eels passed by an unknown route, but turbine passage seems likely since rack spacing is 2.25-inch clear spacing;
3) 2% (1/50) of the eels used the bypass;
4) 2% (1/50) of the eels did not pass; and
5) When adjusted for transit time > 38.7 hours, 61-76% (75% CI) of the eels survived from passage to Station M8.

I have the following recommendations:

1) Please include a line showing the Medway station hydraulic capacity in Figure 4-1.
2) Please add the sample size to each table.
3) Please include the reach-specific survival estimate from station M8 to M9 in Table 4-9 and Table 4-11.
4) Please add clarification in the descriptions for Table 4-9 and 4-11. The report states that Station M1 was not functioning from 1700 on 10/15 to 1000 on 10.16 and that Stations M2, M3, or M4 were used as surrogates for "arrival time." However, the reaches in Table 4-9 and 4-11 only list Station M1.

Sincerely,

Gail Wippelhauser, Ph. D.
Marine Resources Scientist III

OFFICES AT 32 BLOSSOM LANE, MARQUARDT BUILDING, AUGUSTA, MAINE
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PHONE: (207) 624-6550 FAX: (207) 624-6024

From: Rosset, Julianne [mailto:julianne_rosset@fws.gov]
Sent: Monday, January 11, 2021 3:37 PM
To: Bernier, Kevin <Kevin.Bernier@brookfieldrenewable.com>; Gail Wippelhauser <gail.wippelhauser@maine.gov>; Casey.Clark@maine.gov; Mitch Simpson <Mitch.Simpson@maine.gov>; Daniel McCaw <dan.mccaw@penobscotnation.org>; John.Banks@penobscotnation.org; Peterson, Harold S <Harold.Peterson@bia.gov>; Bentivoglio, Antonio <antonio_bentivoglio@fws.gov>; Hogan, Kenneth J <kenneth_hogan@fws.gov>; Jeff.Murphy@noaa.Gov; donald.dow@noaa.gov; Sojkowski, Bryan <Bryan_Sojkowski@fws.gov>; Kathy Howatt <Kathy.howatt@maine.gov>; Christopher Sferra <Christopher.Sferra@maine.gov>; Jason Valliere <Jason.Valliere@maine.gov>; Kevin Dunham <Kevin.Dunham@maine.gov>; John Perry <john.perry@maine.gov>; Gallant, Kevin <Kevin.Gallant@maine.gov>; Sean M Ledwin - Maine Department of Marine Resources (Sean.M.Ledwin@maine.gov) <Sean.M.Ledwin@maine.gov>
Cc: Maloney, Kelly <Kelly.Maloney@brookfieldrenewable.com>; Brochu, Robert <Robert.Brochu@brookfieldrenewable.com>; Cole, James <James.Cole@brookfieldrenewable.com>; Drew Trested <dtrested@normandeau.com>; Stevens, Nate <Nathan.Stevens@brookfieldrenewable.com>; Michaud, Steve <Stephen.Michaud@brookfieldrenewable.com>; Macomber, Lance <Lance.Macomber@brookfieldrenewable.com>; Osborne, Michael <Michael.Osborne@brookfieldrenewable.com>; Mapletoft, Thomas <Thomas.Mapletoft@brookfieldrenewable.com>; Kessel, Miranda <Miranda.Kessel@brookfieldrenewable.com>
Subject: Re: [EXTERNAL] Medway Project downstream eel passage draft study report

Hi Kevin,

The United States Fish and Wildlife Service (Service) has reviewed the Medway Hydroelectric Project (FERC No. 2666) *Evaluation of Downstream Passage Effectiveness for Adult American Eel,* which Black Bear Hydro Partners, LLC (BBH) emailed to the agencies on December 15, 2020. The Service has the following comments.

85 percent of the tagged eels, or 42 out of 50, passed through the Project's turbines while 2 percent of the tagged eels, or 1 out of 50, used the existing downstream bypass. When adjusted for transit time, model results indicate 60 to 76 percent of eels survived passage at Medway to Station M8 (the first receiver downstream of the Project). After reviewing the study, the Service recommends BBH provide the following, additional, information (1) total survival of tagged eels (not adjusted for drift) detected at monitoring Station M9; and (2) clarification about the descriptions for Tables 4-9 and 4-11 as the reaches in these tables only list Station M1 while the report itself states M1 was not functioning and Stations M2, M3, and M4 were used as surrogates. Additionally given the results of the evaluation, the Service recommends BBH arrange a meeting with the agencies in February 2021 to discuss next steps (i.e., proposed operational changes, structural changes, etc).

Thank you for this opportunity to comment. If you have any questions, please feel free to contact me.

Kind regards,

Julianne

Julianne Rosset
USFWS Fish and Wildlife Biologist
Migratory Fish/Hydropower
306 Hatchery Road, East Orland, ME 04431
603-309-4842 (cell)
fws.gov/mainefieldoffice/|facebook.com/usfwsnortheast/

From: Sferra, Christopher [mailto:Christopher.Sferra@maine.gov]
Sent: Tuesday, January 12, 2021 8:58 AM
To: Bernier, Kevin <Kevin.Bernier@brookfieldrenewable.com>; Wippelhauser, Gail <Gail.Wippelhauser@maine.gov>; Clark, Casey <Casey.Clark@maine.gov>; Simpson, Mitch <Mitch.Simpson@maine.gov>; Dan McCaw <dan.mccaw@penobscotnation.org>; John.Banks@penobscotnation.org; Harold Peterson <harold.peterson@bia.gov>; Bentivoglio, Antonio <antonio_bentivoglio@fws.gov>; Kenneth J Hogan <kenneth_hogan@fws.gov>; jeff.murphy <jeff.murphy@noaa.gov>; donald.dow <Donald.Dow@noaa.gov>; Sojkowski, Bryan <bryan_sojkowski@fws.gov>; Howatt, Kathy <Kathy.Howatt@maine.gov>; Valliere, Jason <Jason.Valliere@maine.gov>; Dunham, Kevin <Kevin.Dunham@maine.gov>; Perry, John <John.Perry@maine.gov>; Rosset, Julianne <julianne_rosset@fws.gov>; Gallant, Kevin <Kevin.Gallant@maine.gov>; Ledwin, Sean M <Sean.M.Ledwin@maine.gov>
Cc: Maloney, Kelly <Kelly.Maloney@brookfieldrenewable.com>; Brochu, Robert <Robert.Brochu@brookfieldrenewable.com>; Cole, James <James.Cole@brookfieldrenewable.com>; Drew Trested <dtrested@normandeau.com>; Stevens, Nate <Nathan.Stevens@brookfieldrenewable.com>; Michaud, Steve <Stephen.Michaud@brookfieldrenewable.com>; Macomber, Lance <Lance.Macomber@brookfieldrenewable.com>; Osborne, Michael <Michael.Osborne@brookfieldrenewable.com>; Mapletoft, Thomas <Thomas.Mapletoft@brookfieldrenewable.com>; Kessel, Miranda <Miranda.Kessel@brookfieldrenewable.com>
Subject: RE: Medway Project downstream eel passage draft study report

Hello all,

MDEP has reviewed the Medway downstream eel passage draft study report and concurs with the comments provided by the fisheries resource agencies (NMFS, USFWS and MDMR). MDEP has no further comments on the report at this time. Thanks and have a good week.

Christopher Sferra (he/him)
Environmental Specialist III, Hydropower Unit
Bureau of Land Resources
Maine Department of Environmental Protection
Cell: (207) 446 – 1619
www.maine.gov/dep

From: Dan McCaw [mailto:Dan.McCaw@penobscotnation.org]
Sent: Thursday, January 14, 2021 11:27 AM
To: Bernier, Kevin <Kevin.Bernier@brookfieldrenewable.com>
Cc: Jeff Murphy - NOAA Federal <jeff.murphy@noaa.gov>; Clark, Casey <Casey.Clark@maine.gov>; Ledwin, Sean M <Sean.M.Ledwin@maine.gov>; Sferra, Christopher <Christopher.Sferra@maine.gov>; Kathy Howatt (Kathy.howatt@maine.gov) <Kathy.howatt@maine.gov>; Dunham, Kevin (Kevin.Dunham@maine.gov) <Kevin.Dunham@maine.gov>; julianne.rosset@fws.gov; John Banks <John.Banks@penobscotnation.org>; John Perry (john.perry@maine.gov) <john.perry@maine.gov>; Joseph Zydlewski <josephz@maine.edu>
Subject: Medway eel study 2020

Good morning Kevin,

The Penobscot Indian Nation (PIN) has reviewed the Study Report for the ***Evaluation of Downstream Passage Effectiveness for Adult American Eel at the Medway Project*** **(FERC No. 2666**).

The PIN concurs with the questions and comments provided by the resource agencies to date. The PIN would also like to submit these additional comments and questions on this long overdue assessment.

1) Were any of the tagged study animals detected at the West Enfield, Stillwater, Orono, or Milford facilities?
2) If so, what passage route did they take at the facilities, and what were the detections downstream of those facilities?
3) Is it possible to see a table that contains each of the study fish, and all of its' detections from Medway to lower Penobscot River and the end of the telemetry receivers set up in 2020? The West Enfield, Stillwater, Orono and Milford facilities were all extensively wired up with telemetry receivers for project specific studies and should have been able to detect these tagged eels. The USFWS, in their letter dated 3/23/2020, stated the importance of gathering data on these study fish at the lower Penobscot River projects, and the PIN strongly agreed with the need for comprehensive studies in the PIN letter dated 3/19/2020. In the future, comprehensive studies will be needed (see FERC Order approving this study plan, dated 6/15/2020) to determine the cumulative effects of these facilities on adult eels, and any preliminary information or insight would be valuable to examine before those plans are drafted in consultation with the agencies.

4) Maine DMR comments on the study plan, dated 3/30/2020, suggested that the time limit for study fish to be determined as dead was 8.7 hours from passing the Medway project to arrival at the Mattaceunk project. MDMR calculated a live, healthy adult American eel could make it to the Mattaceunk facility in 8.7 hours, not including the increased rate of travel due to water currents. Can you explain how this number fits into the data from your dead drift study, and why it was not used to determine which study fish were indeed deceased?
5) Is it possible to determine potential injury of study fish based on their time of travel to the Mattaceunk project, or other projects downstream, and then consider them as a delayed mortality as the goal of safe passage at the Medway facility was not realized?
6) The USFWS stated in their comments, dated January 11th, 2021, that; *"Additionally given the results of the evaluation, the Service recommends BBH arrange a meeting with the agencies in February 2021 to discuss next steps (i.e., proposed operational changes, structural changes, etc).*" The PIN strongly supports these comments from USFWS. The FERC stated in their Order from 6/15/2020, that when it comes to the downstream bypass, the, "intent is for eels to avoid passing through the turbines at all". It is clear from these study results that the downstream bypass is near completely ineffective in attracting and safely transporting downstream migrants. The PIN suggests that the licensee immediately commence the design of an angled rack structure and dedicated bypass similar to the system installed at the Stillwater B project downstream, which has successfully deterred multiple species of fish at multiple life stages from passing through the turbines. The bypass at the Stillwater B project has proven to be the most efficient bypass structure at any hydro facility in Maine and should be used as a blueprint for the construction of angled racks at other facilities. The construction of such a facility will eliminate the costly, and lengthy process of assessing injury, delayed mortality, and the effectiveness of the bypass under alternative flow conditions. The studies conducted in 2020, under no spill conditions, gave the bypass the best chance to be successful, and it completely failed. The PIN looks forward to these important design discussion and planning efforts.

Please feel free to reach out at any time with any questions you may have.

Sincerely,

Dan McCaw

Daniel E. McCaw
Fisheries Program Manager

Penobscot Indian Nation
Department of Natural Resources
12 Wabanaki Way

Indian Island, Maine 04468-1254

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Written comments on the draft Medway eel passage study report were provided by MDMR, USFWS, MDEP and the PIN. Questions or requests related to the technical draft report are reproduced here along with the associated response.

Question 1: *Please include a line showing the Medway station hydraulic capacity in Figure 4-1.*

Response 1: The Medway powerhouse contains a total of five vertical Francis turbines, each with a capacity discharge of 690 cfs. A reference line for the station capacity (3,450 cfs) has been added to Figure 4-1.

Question 2: *Please add the sample size to each table.*

Response 2: As requested, Tables 4-3, 4-4 and 4-6 have been updated to include a column for sample size.

Question 3: *Please include the reach-specific survival estimate from station M8 to M9 in Table 4-9 and Table 4-11.*

Response 3: Language related to the reach-specific survival estimate from Station M8 to M9 has been added to Section 4.3.6 of the final report.

Question 4: *Please add clarification in the descriptions for Table 4-9 and 4-11. The report states that Station M1 was not functioning from 1700 on 10/15 to 1000 on 10/16 and that Stations M2, M3, or M4 were used as surrogates for "arrival time." However, the reaches in Table 4-9 and 4-11 only list Station M1.*

Response 4: Row labels in Tables 4-9 and 4-11 have been edited to reflect general descriptions of eel locations.

Question 5: *Were any of the tagged study animals detected at the West Enfield, Stillwater, Orono, or Milford facilities?*

Response 5: As discussed at the March 18, 2020 study plan meeting and described in Appendix B of the Medway eel study plan, downstream progress of radio-tagged individuals was monitored from the release site upstream of Medway, through passage at Medway, and until detection at the upstream face of Weldon Dam. No stationary receivers were installed to monitor passage of adult eels at Projects in the lower portion of the Penobscot River.

Question 6: *Maine DMR comments on the study plan, dated 3/30/2020, suggested that the time limit for study fish to be determined as dead was 8.7 hours from passing the Medway project to arrival at the Mattaceunk project. MDMR calculated a live, healthy adult American eel could make it to the Mattaceunk facility in 8.7 hours, not including the increased rate of* *travel due to water currents. Can you explain how this number fits into the data from your dead drift study, and why it was not used to determine which study fish were indeed deceased?*

Response 6: As described in the study plan, the use of a desktop calculated “travel” speed for an eel released downstream of Medway to reach Station M9 at Weldon Dam was passed over in favor of drift data for freshly-dead radio-tagged adult eels released immediately downstream of Medway and in river conditions comparable to those being experienced by test fish released upstream of Medway. The use of empirical data related to drift duration and magnitude was considered to be a more accurate estimate than the desktop approach, which assumed a fixed rate of travel in a straight line from point A to point B.

Question 7: *Is it possible to determine potential injury of study fish based on their time of travel to the Mattaceunk project, or other projects downstream, and then consider them as a delayed mortality as the goal of safe passage at the Medway facility was not realized?*

Response 7: The adjusted and modified-adjusted survival estimates (Section 4.3.6) are attempts to quantify latent estimates of project passage success for adult eels at Medway. These modifications assumed variance in observed rates of travel to a downstream monitoring station are representative of eel condition, and eels failing to reach the downstream location within a defined threshold of time are considered “mortalities”.

Appendix F. PowerPoint presentation slides from the January 27, 2021 resource agency and PIN study discussion meeting.

Evaluation of Downstream Passage Effectiveness for Adult American Eel

Medway Hydroelectric Project (FERC No. 2666)

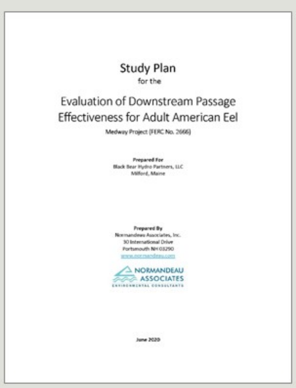
Prepared For:
Black Bear Hydro Partners, LLC
1 Bridge Street
Milford, ME 04461

Prepared By:
Normandeau Associates, Inc.
30 International Drive
Portsmouth, NH 03801

NORMANDEAU ASSOCIATES ENVIRONMENTAL CONSULTANTS

Study Development and Objectives

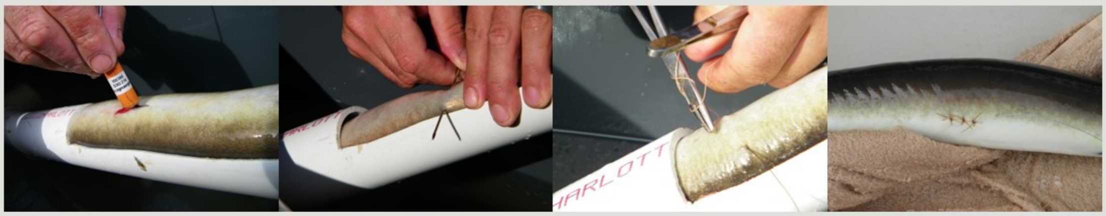
- As specified in the current FERC License, Black Bear required to conduct a post-construction study to evaluate effectiveness of existing downstream passage facility at Medway for eel passage
- Multiple sampling years to identify source for collection of test fish in the basin were unsuccessful
- Out-of-basin eels utilized for passage studies at Lower Penobscot locations
- Draft plan distributed to resource agencies for review and final version filed with FERC June 15, 2020


Study Plan
for the
Evaluation of Downstream Passage Effectiveness for Adult American Eel
Medway Project (FERC No. 2666)

Study Objectives:
- Evaluate residence time from arrival until downstream passage for radio-tagged adult American eels at Medway;
- Determine the proportional downstream passage route selection of radio-tagged adult American eels at Medway; and
- Estimate the downstream passage survival for radio-tagged adult American eels from the point 200 m upstream of Medway dam to the first stationary receiver downstream of Medway

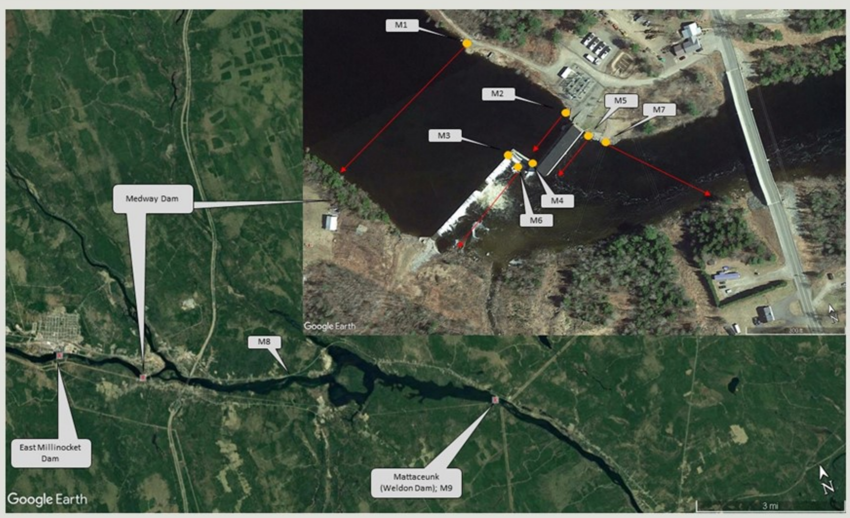
Methodology: Tagging and Release

- Eel tagging:
  - Individuals imported from St. Croix River, Maine and transported to holding facility established at West Enfield (October 12)
  - Surgically tagged following standard procedures
  - Held for a 24-hr period post tagging to visually evaluate prior to release
- Eel releases:
  - Transported by truck to shoreline ~0.5 miles downstream of East Millinocket Dam
  - Downstream releases into discharge of DS bypass or active turbine
  - Conducted during evening hours



Methodology: Monitoring at Medway

- Installed and maintained nine receivers
  - Approach
  - Downstream bypass
  - Forebay sluice
  - Intake
  - Tailrace
  - Spillway
  - Downstream locations (x2)



Methodology: Data Analysis

Data Analysis – Downstream:

- *Upstream Residence Duration:* calculated as differential between release at point upstream of Medway and arrival at the Project (i.e., "approach")
- *Project Residence Duration:* calculated as differential arrival at the Project (i.e., "approach") and downstream passage
- *Downstream Passage Route:* based on evaluation of the spatial and temporal distribution of time-stamped detections from final, filtered data set (coupled with operations data)
- *Downstream Passage Survival:* estimated using Cormack-Jolly Seber model run in Program MARK (eels only)

Release → Approach → Dam → DS #1 → DS #2

- CJS models: all eels; adjusted eels; route-specific

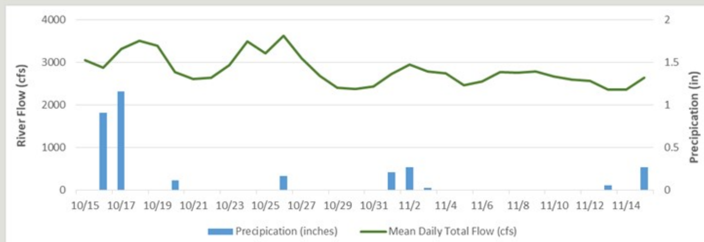
*This approach resulted in estimates that included background mortality (i.e., natural mortality, such as predation) along with any tagging-related mortalities or tag regurgitations for eels within 200 m upstream of the Project, as well as the reach downstream of the dam to the first downstream receiver. This resulted in minimum estimates of total project survival (i.e., attributable to project effects) for adult eels.

Study Results: Tagging and Release

- A total of 60 adult eels radio-tagged and released at one of three release locations
- Two release dates: October 15 & 16
- Upper end of the Medway impoundment (n = 50)
- Downstream/Drift Assessment (n = 10)
  - Whole-body, dead at bypass (n = 2)
  - Whole-body, dead in turbine discharge (n = 2)
  - Partially severed, dead in turbine discharge (n = 2)
  - Live at bypass (n = 2)
  - Live at turbine discharge (n = 2)
  - Rate of travel and downstream extent of dead drift monitored to help inform estimates of passage survival

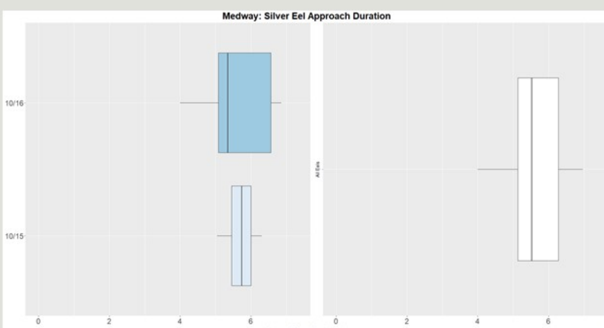
Study Results: River & Operational Conditions

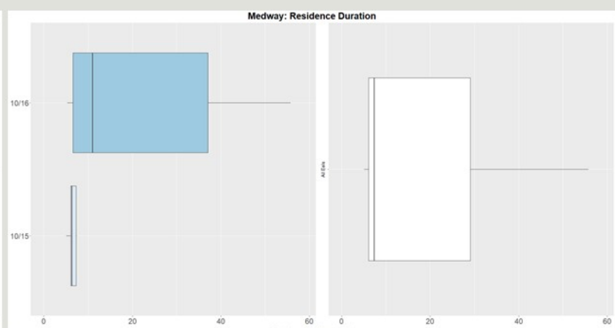
- Study ran from October 15 to November 15
- Downstream bypass open (~15 cfs) and available throughout study period (closed Nov. 15 per operations plan)
  - ~7 fps, 3'depth, 2.5' in front
- Turbines operated throughout study
- No significant spill events
- Limited precipitation events >0.25"
  - Oct 16-17, Nov 1-3, Nov 15
- River temperature declined over the course of the monitoring period



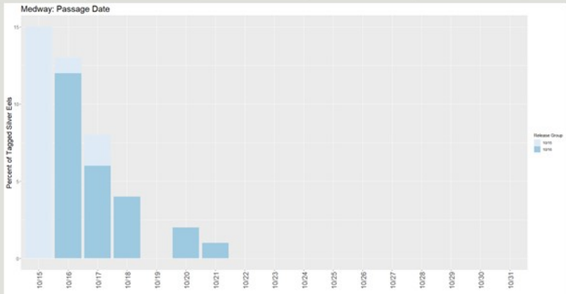
Study Results: Medway Eels

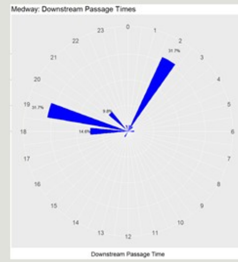
- 100% of tagged eels moved DS and approached the dam
- Median approach duration = 5.5 hrs (P25-P75 = 5.1-6.3 hrs)
- Relied on stations M2-M4 for initial detection of eels from release 1 due to issue with approach receiver
- Median residence = 7.4 hrs (P25-P75 = 6.1-29.1 hrs)
- 62% passed within 24 hours of initial detection
- 16% took longer than 48 hours to pass downstream following their initial detection



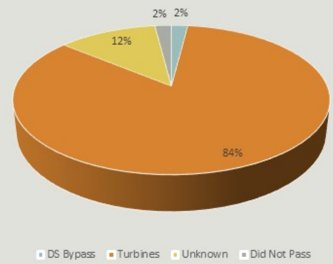


Study Results: Medway Eels





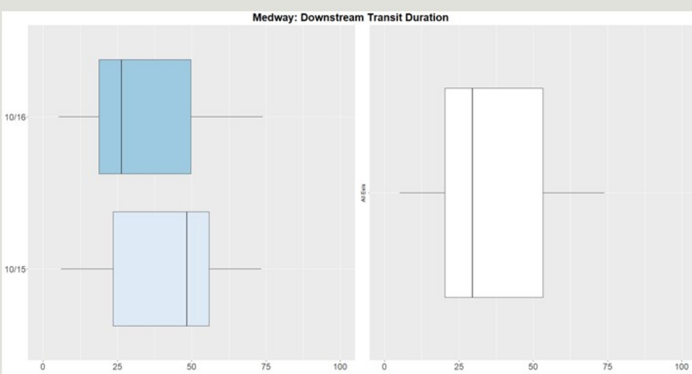
- Passage events recorded from October 15 through October 21
- Primarily evening/night hours - 1900-0200
- Majority utilized turbines for downstream passage (84%)
- Single individual used DS bypass
- One eel had not passed at end of monitoring (Nov 15)



Study Results: Medway Eels

Downstream Detection (Test):

- 90% detected 12 km downstream at M9 (Weldon)
- Median travel to M9 = 11.4 hrs (P25-P75 = 4.0-24.4 hrs)



Downstream Detection (Tailrace group):

- Four of ten detected at M9 (Weldon)
  - 3 live, 1 dead (partially severed)
- Seven of ten detected at M8
  - 4 live, 3 dead (bypass, tailrace (whole), tailrace (partially severed))
- Median drift time for dead eels to M8 = 38.7 hours
- 12 test eels had a travel time > median drift to reach M8

Study Results: Medway Eels

Downstream Passage Effectiveness:

- Estimates include project effects, background mortality or any other losses from the "approach" receiver 200 m upstream of Medway to Station M8 located ~5 km downstream of Medway

Model	S_1	S_2	S	75% CI
All Eels	98.0%	93.9%	92.0%	88.0-96.0%
Adjusted	98.0%	69.4%	68.0%	60.0-76.0%
Turbine only	100.0%	92.8%	92.8%	88.1-97.6%

- Adjusted estimate assumed mortality for 12 individuals at passage (based on time to reach M8)
  - Of those 12 eels – 8 had a transit time from M8 to Weldon within the set of values bracketed by P25-P75 (3.9-25.9 hrs) observed for eels reaching M8 in less time than drift fish (7 of the 8 less than median of 15 hrs)
  - Single dead eel reaching Weldon took 64 hours to "travel" from M8 to M9
  - Only 4 individuals with long duration to reach M8 exhibited a prolonged duration (or failed) to reach Weldon

Summary

- Medway eel passage study was conducted using out of basin eels from the St. Croix (similar to previous Licensee studies at West Enfield, Milford, Stillwater and Orono
- Tagged eels approached and passed downstream relatively quickly following release
- Downstream passage options during 2020 study were limited to turbine or DS bypass
  - Majority of eels passing downstream utilized turbine units
- Downstream passage survival estimated at 92% based on detection at first DS receiver
- Applicability of dead drift duration to first station to "adjust" survival estimate?
  - Criteria may have overestimated losses for the reach from passage to first DS receiver based on review of continued rates of DS movement to Weldon

Fishway Operations Weekly Report

Project Name: Stillwater A & B
Fishway Facility: Downstream fishways
Date: 7/31/2017

Species	#'s Detected this week	Season Total
Atlantic Salmon (MSW):	NA	NA
Atlantic Salmon (1SW):	NA	NA
River Herring:	NA	NA
American Shad:	NA	NA
Striped Bass:	NA	NA
Sea Lamprey:	NA	NA
American Eel (eel ladder):	NA	NA

Weekly Operational Status:

The downstream fishways at both powerhouses remained open most of the week. They were each closed for a few hours one day last week while divers inspected the trashracks and downstream eel passages in preparation for silver eel passage season. Some small gaps were observed in the Stillwater A trashrack which will be addressed.

Note:

Weekly Fishway Operations report to be provided to NMFS and MDMR personnel each Monday by 1200.

From: Bernier, Kevin
To: "Jeff Murphy (Jeff.Murphy@noaa.gov)"; "Kathy Howatt (Kathy.howatt@maine.gov)"; "Steve Shepard (Steven_Shepard@fws.gov)"; "Daniel McCaw (dan.mccaw@penobscotnation.org)"; "Donald Dow (Donald.Dow@noaa.gov)"; "John Perry (john.perry@maine.gov)"; "Nels Kramer (gordon.kramer@maine.gov)"; "Mark Caron (mark.caron@maine.gov)"; "Gail Wippelhauser (gail.wippelhauser@maine.gov)"; "Sean McDermott (Sean.McDermott@noaa.gov)"; "John Banks (John.Banks@penobscotnation.org)"; Jason Mitchell (jason.mitchell@penobscotnation.org); Dunham, Kevin; D"Auria, Danielle; Beth Swartz (Beth.Swartz@maine.gov); Mitch Simpson (Mitch.Simpson@maine.gov); Carl Wilson (Carl.Wilson@maine.gov); Dan Kusnierz (Dan.Kusnierz@penobscotnation.org)
Cc: Brochu, Robert; Osborne, Michael; Cole, James; Maloney, Kelly; Mapletoft, Thomas; Dill, Richard; Trudell, Justin; Zarrella, Antonio; Farrington, Stephen
Subject: Stillwater drawdown for trashrack repairs
Date: Wednesday, September 06, 2017 4:38:00 PM

As you may know, several eels were monitored passing through the Stillwater A hydro units during last fall's downstream eel passage radio telemetry studies. As a result, Black Bear Hydro Partners, LLC (Black Bear) committed in the April 2017 diadromous fish passage report to FERC to inspect the Stillwater A trash racks for any gaps or bends that eels are able to pass through and make necessary repairs as soon as river conditions allow in 2017. As reported in the July 31 weekly report, a dive inspection in late July confirmed that several small gaps exist in the Stillwater A trashracks.

Black Bear intends to draw down the Stillwater impoundment one to two feet tomorrow, September 7th (and possibly Friday, September 8th) to enable divers to make these repairs to the trashracks and to water plug some areas of leakage in the division walls between the hydro units. The downstream fishway flows will be adjusted during this brief drawdown to ensure its continued operation.

I apologize for the short notice - please let me know if you have any questions or concerns.

Kevin Bernier
Senior Compliance Specialist
North America

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Fishway Operations Weekly Report

Project Name: Stillwater A & B
Fishway Facility: Downstream fishways
Date: 9/11/2017

Species	#'s Detected this week	Season Total
Atlantic Salmon (MSW):	NA	NA
Atlantic Salmon (1SW):	NA	NA
River Herring:	NA	NA
American Shad:	NA	NA
Striped Bass:	NA	NA
Sea Lamprey:	NA	NA
American Eel (eel ladder):	NA	NA

Weekly Operational Status:

The downstream fishways at both powerhouses remained open and in good condition all week. The headpond was lowered on Thursday and Friday while divers were in the headpond. During this time gaps in the trashrack at powerhouse A were addressed and corrected to help prevent fish entrainment. Additional stoplogs were removed from the downstream fishways to maintain flows during this time.

Note:

Weekly Fishway Operations report to be provided to NMFS and MDMR personnel each Monday by 1200.

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April 12, 2018

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

Subject: Stillwater Project (FERC No. 2712); Orono Project (FERC No. 2710); Milford Project (FERC No. 2534); 2017 Diadromous Fish Passage Report for Alosines and American Eels

Dear Secretary Bose:

Black Bear Hydro Partners, LLC (Black Bear) is filing this 2017 Diadromous Fish Passage Report for Alosines and American Eels for the Milford, Stillwater, and Orono hydroelectric projects, which are located on the Penobscot River in Maine. The report is being filed on behalf of the licensees for these projects, who are affiliates of Brookfield Renewable. The Milford Project (FERC No. 2534) is licensed to Black Bear, while the Stillwater Project (FERC No. 2712) and the Orono Project (FERC No. 2710) are licensed to Black Bear; Black Bear SO, LLC; and Black Bear Development Holdings, LLC.

Pursuant to Commission Orders "*Amending License and Revising Annual Charges*" for the Orono and Stillwater Projects (both dated September 14, 2012) and "*Approving Fish Passage Design Drawings Under Articles 407 and 408*" for the Milford Project (dated October 9, 2012), the licensees constructed and installed upstream and downstream fish passage systems at the Milford, Stillwater (downstream only), and Orono Projects in 2013 and 2014 to facilitate the passage of diadromous fish species on the Penobscot River. To evaluate the performance of the new fish passage facilities at passing alosines (collectively American shad, blueback herring, and sea run alewives) and American eels (also required by the 2012 Commission Orders), the licensees performed qualitative monitoring studies in 2014.

Based on the results of these qualitative studies, the licensees developed a plan for quantitative studies in 2015 (approved by the Commission on February 25, 2015), including (1) a radio-telemetry study to evaluate the upstream and downstream passage of adult blueback herring and sea run alewives at the Milford and Orono projects, (2) a pilot tagging study of juvenile alosines, (3) underwater video camera monitoring of the Stillwater downstream low-level American eel fishway, (4) underwater video camera monitoring of the upstream fish lift entrances at the Milford and Orono projects, and (5) continued annual upstream fishway counts at the Orono and Milford fish lifts. The final report on these 2015 studies was submitted to the Commission on April 14, 2016, along with a plan for continued quantitative studies (to evaluate downstream eel passage) in 2016.

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In 2016, Black Bear conducted a downstream eel passage radio telemetry study at the Milford, Stillwater, and Orono projects. The eel study report was filed with the Commission on April 13, 2017, as part of the *2016 Final Diadromous Fish Passage Report for Alosines and American Eels*. Downstream passage survival was approximately 88 percent for adult eels released above Milford Dam and 85 percent for adult eels released above Stillwater Dam. In light of the observation of some eel mortalities at the Stillwater A powerhouse, and at the request of the United States Fish and Wildlife Service (USFWS), the one inch spacing trash racks at the facility were inspected by divers for gaps during the last week of July in 2017. Several gaps/holes discovered during that inspection were subsequently repaired by divers on September 7th and 8th, 2017.

The 2017 diadromous fish study activities, which were developed through consultation with the resource agencies[1] and the Penobscot Indian Nation (PIN), included (1) continued collaboration with MDMR to collect upstream fish lift tallies of fish at the Milford Project (see Table 1), (2) continued counts of migratory fish that use the Orono fish lift (see Table 1), and (3) a radio telemetry study of adult American shad downstream passage at the Milford, Stillwater, and Orono Projects. Additional diadromous fish passage studies conducted by the licensees at these Projects in 2017, which have been separately reported to the Commission, included a fourth year of downstream Atlantic salmon smolt studies at all three projects (see the final study report submitted to the Commission on March 23, 2018 as part of the *"Atlantic Salmon Species Protect Plan, 2017 Annual Report"*), and the monitoring of upstream passage of juvenile American eels at Milford and Stillwater (see the *"2017 American Eel Upstream Passage Operating and Monitoring Report"*, submitted to the Commission on March 26, 2018).

Table 1. Annual quantitative counts of American shad and river herring at the Milford and Orono project fish lifts in the lower Penobscot River, Maine.

	Milford				
Species	**2014**	**2015**	**2016**	**2017**	**Total**
American shad	805	1,806	7,862	3,868	14,341
River Herring	187,429	589,503	1,259,384	1,256,061	3,292,377

	Orono				
Species	**2014**	**2015**	**2016**	**2017**	**Total**
American shad	0	1	6	0	7
River Herring	2,075	19,016	78,700	90,483	190,274

[1] "Resource agencies" collectively refers to the representatives from: Maine Department of Inland Fisheries and Wildlife (MDIFW), Maine Department of Marine Resources (MDMR), Maine Department of Environmental Protection (MDEP), USFWS, and National Marine Fisheries Service (NMFS).

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A draft study plan for the adult shad study, *Assessment of Adult American Shad Outmigration at the Milford, Stillwater and Orono Projects, Penobscot River, Maine (2017)*, was distributed to the resource agencies and PIN for review and comments on April 6, 2017. The study plan was discussed on April 11, 2017 during a consultation meeting held by Black Bear with the resource agencies and PIN for the broader purpose of discussing the overall "Quantitative Assessments of Alosine Passage Effectiveness" at the three projects. Responses to comments from the meeting, as well as responses to written comments provided by the resource agencies and PIN, are included in Appendix B of the final study plan; where appropriate, the study plan was revised based on those comments. The final study plan, submitted to the Commission on May 15, 2017, was acknowledged by the Commission on October 4, 2017.

A draft study report for the 2017 adult shad study (*2017 Assessment of Adult American Shad Outmigration at the Milford [FERC No. 2534], Stillwater [FERC No. 2712] and Orono [FERC No. 2710] Projects, Penobscot River, Maine)* was distributed to the the resource agencies and PIN on December 1, 2017. Black Bear then hosted a meeting on December 21, 2017 to present and discuss the results of the 2017 study (slides presented at the meeting are included in Appendix G of the attached final report). Responses to comments and questions received at the time of the meeting, as well as responses to the written comments provided by the agencies and PIN, are included in the appendices of the attached final report. Where appropriate, the final report was revised based on those comments.

As required by the 2012 Commission Orders, the licensees intend to continue quantitative evaluations of the new fish passage facilities at the Orono, Stillwater, and Milford Projects for passing alosines and American eels in 2018. As described in the *"Stillwater, Orono and Milford Diadromous Fish Passage Quantitative Study Plan for 2018"*, which Black Bear submitted to the Commission on March 16, 2018[2], the licensees intend to study the downstream passage of adult river herring at all three projects in 2018[3]. In addition, and based on results of the 2017 downstream shad passage study at Milford, the licensee intends to conduct a second year of downstream adult shad study at that project. In consultation with the agencies and PIN, Black Bear has installed two windows in the outer trash racks, each with a minimum width of 4 feet and capable of passing 140 cfs of flow. The windows will provide outmigrating adult shad an opportunity to pass through the outer trash rack at Milford without having to pass through the 4-inch clear spacing trash rack bars. This should improve the ability of shad to access the downstream fish passage weirs, which are contiguous with Milford Station's inner trash racks and lead to the tailrace.

[2] On February 7, 2018, the Commission approved Black Bear's request for a 30 day extension of time for submittal of the 2018 Stillwater, Milford and Orono Diadromous Fish Passage Quantitative Study Plan.

[3] Evaluation of Downstream Passage of Adult River Herring at the Milford, Stillwater and Orono Projects and Adult American Shad at the Milford Project, Penobscot River, Maine (2018)

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In 2018, Black Bear also intends to continue to collaborate with MDMR to collect upstream fish lift tallies of migratory fish at the Milford Project, and will continue to report counts of migratory fish that use the Orono fish lift as well.

In correspondence dated December 28, 2016, the Commission requested that Black Bear continue to report progress towards obtaining fishway certifications from the USFWS. As part of the ongoing process, in 2017 Black Bear consulted with the USFWS on several occasions, including a meeting to compare "pre-fishway construction" versus "as-built drawings" of the upstream and downstream fish passage facilities for each of the projects, and a site inspection of the Stillwater upstream eel passage. At the request of USFWS, Black Bear also developed as-built drawings of the Milford upstream eel ramp certified by a professional engineer, confirmed the slopes of the Stillwater eel upstream passage, and updated the daily fish passage inspection worksheet for the Stillwater facility to include measurements of depth of stop logs and calculated flows for the downstream passage. Black Bear continues to work with USFWS towards the goal of certification for the fish passage facilities at the Orono, Stillwater, and Milford Projects.

Finally, the PIN, in its comments on the draft 2018 diadromous fish passage study plan referenced above, requested that final reports for the 2018 diadromous fish passage studies be submitted to the Commission by December 1, 2018. Black Bear agrees that the deadline for reporting the 2018 results should be moved up from the current April 15, 2019 deadline (for reporting on previous year diadromous fish passage activities and studies), as in addition to allowing adequate time for agency and tribal review, Black Bear needs adequate lead time for purchase of equipment (tags) and for securing consultant services for that year's diadromous fish studies, if needed. However, PIN's proposed December 1, 2018 date does not provide sufficient time for current year data analysis and report writing, given that any studies would likely extend late into the field season of 2018, and noting that Black Bear needs to provide the agencies and PIN at least 30 days to review and comment on the draft report. Thus, Black Bear proposes a filing date of January 15, 2019 for the final 2018 study report (3 months earlier than the current deadline), and then a March 1, 2019 filing date for any 2019 study plan. Chronologically, this proposed schedule aligns the completion of the final 2018 study report ahead of completion of the 2019 study plan (as PIN suggested), and it allows adequate time for consultation with the resource agencies and PIN.

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Please feel free to call me at (207) 723-4341, x118 if you have any questions or comments.

Sincerely,

Kevin Bernier
Senior Compliance Specialist

Attachment

cc: S. Ledwin, M. Simpson, J. Valliere; MDMR
D. McCaw; PIN
S. Shepard, A. Bentivoglio; USFWS
S. McDermott, J. Murphy, D. Dow, R. Saunders; NMFS
N. Kramer, J. Perry, K. Dunham; MDIFW
K. Howatt, E. Sroka; MDEP
A. Zarrella, N. Stevens, R. Brochu, J. Cole, R. Dill, K. Maloney; Black Bear
D. Trested; Normandeau Associates

Black Bear Files: 2534/1; 2710/1; 2712/1

Assessment of Adult American Shad Outmigration at the Milford (FERC No. 2534), Stillwater (FERC No. 2712) and Orono (FERC No. 2710) Projects, Penobscot River, Maine

Prepared For:
Black Bear Hydro Partners, LLC
Black Bear SO, LLC
Black Bear Development Holdings, LLC
Milford, Maine

Submitted:
January 2018

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1.0 Introduction

Affiliates of Brookfield Renewable (Brookfield) own and operate hydroelectric projects in the Penobscot River watershed pursuant to licenses issued by the Federal Energy Regulatory Commission (FERC). Among those projects, the Milford (FERC No. 2534) Project is licensed to Black Bear Hydro Partners, LLC (Black Bear) and the Stillwater (FERC No. 2712) and Orono (FERC No 2710) Projects are licensed to Black Bear, Black Bear SO, LLC, and Black Bear Development Holdings, LLC.

Pursuant to the amended licenses for each project and a 2004 settlement agreement between the licensees, state and federal agencies, Penobscot Indian Nation (PIN), and other stakeholders, the licensees developed a comprehensive upstream and downstream fish passage program to facilitate the passage of diadromous fish species in the Penobscot River. FERC license amendment orders for Orono, Stillwater and Milford contain Articles 411, 408 and 409, respectively; requiring Black Bear to develop study plans to monitor the effectiveness of the fish passage facilities. All fish passage monitoring plans are to be developed in consultation with the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), PIN, Maine Department of Marine Resources (MDMR), and Maine Department of Inland Fisheries and Wildlife (MDIFW).

A Diadromous Fish Passage Study Plan (DFPSP) describing studies to evaluate the performance of the new fish passage facilities for alosines and American eels was approved by FERC on February 11, 2014. Pursuant to the DFPSP, the licensees performed qualitative monitoring studies in 2014 to evaluate the use of the new fishways and to assess the availability of alosines and adult eels for future quantitative studies at the three hydroelectric projects. In 2015, the licensee proposed and performed quantitative radio tagging studies of upstream migrating adult river herring at Milford and Orono and conducted a pilot downstream radio tagging study of juvenile alosines. Neither study provided meaningful results, as 90 percent of the radio tagged adult river herring fell back downriver after tagging/release and did not return, and almost all of the juvenile river herring (including tagged and control fish) died with 48 hours. Based on the 2015 study results, the licensee did not propose any quantitative tagging studies of alosines for 2016 but did continue quantitative tallies of alosine species of fish at the Milford and Orono fish lifts, as well as conducted video monitoring of the West Enfield upstream fishway counting window to enumerate the diadromous species of fish migrating past that project. It should be noted that based on concerns from the stakeholders regarding the assumed small remnant population of adult shad in the lower Penobscot River, the licensees did not propose to perform quantitative passage studies on American shad until notified by the stakeholders that there were enough fish available to perform studies.

In the first three years of operation of the new fish lift at the Milford Project, over 10,000 adult American shad were passed upstream at the Milford Dam, including nearly 8,000 in

2016. Downstream migrating adult shad have subsequently been observed in the head ponds of the Orono, Stillwater and Milford projects. This study was intended to quantitatively assess downstream passage of adult shad at Orono, Stillwater and Milford.

A draft study plan for this evaluation was submitted to NMFS, USFWS, MDMR, MDEP and the PIN on April 6, 2017 and was reviewed during an alosine passage meeting held in Bangor on April 11, 2017. All comments received were addressed in the final study plan, which was filed with FERC on May 15, 2017. The 2017 field evaluation was conducted following the criteria presented in the final study plan and a draft report summarizing findings from that effort was distributed by Black Bear on December 1, 2017. Representatives from Black Bear, Normandeau, resource agencies, and the PIN met on December 21, 2017 to review and discuss the 2017 study results. A number of questions and additional information requests were made at that time, and those meeting items are summarized in Appendix D. Black Bear requested that any additional written comments be submitted no later than December 31, 2017. Correspondence related to the distribution of the draft study report, as well as all written comments received, are presented in Appendix E. Responses related to written questions or requests for additional information are provided in Appendix F, and a copy of the PowerPoint slides prepared and presented by Normandeau at the December 21, 2017 agency meeting is provided in Appendix G.

1.1 Study Objectives

The objectives of the 2017 downstream passage evaluation for adult American shad in the lower Penobscot River were to (1) evaluate project residence time immediately upstream of the Milford, Stillwater and Orono Projects, (2) quantify downstream passage route selection at the Milford, Stillwater and Orono Projects and (3) estimate total project survival of adult shad passing downstream of the Milford, Stillwater and Orono Projects.

2.0 Project Descriptions

2.1 Milford Project (FERC No. 2534)

Following removal of the downstream Great Works and Veazie dams in 2012 and 2013, respectively, the Milford Project dam, located in the towns of Milford and Old Town, Maine, became the lowermost and first dam on the main stem of the Penobscot River. The Milford Project is a run-of-river project that has a generating capacity of 7,800 kilowatts (kW), six generating units, a minimum hydraulic capacity of 500 cfs, and a maximum hydraulic capacity of 6,730 cfs. The downstream fish passage facilities at the Milford Project consist of two surface bypass flumes passing through the powerhouse wall at the west end and center of the powerhouse. The entrances are located at the face of the interior full-depth trashracks, which have 1-inch clear spacing. Each surface bypass is capable of passing up to 280 cfs. The licensee also installed a low-level bypass for American eels at the bottom of the trashracks, directly below the surface bypass entrance at the center of the powerhouse. The two surface bypasses were open for the duration of the adult shad outmigration period; however, per the fishway operation periods specified in the Milford license, the low-level bypass was not open during the study. A bypass sluice for downstream passage is also located at the downstream end of the exit flume of the upstream fish passage facility. This sluice can be used for downstream passage of outmigrating fish that incidentally end up in the exit flume. In addition to the downstream fish passage facilities, non-generational flow can also be passed via a 25 foot wide bottom-opening sluice gate located adjacent to the mid-channel side of the powerhouse. When fully opened under normal headpond conditions, the sluice gate is capable of passing approximately 2,000 cfs.

2.2 Stillwater Project (FERC No. 2712)

The Stillwater Project is a run-of-river project located on the Stillwater Branch of the Penobscot River in Orono, Maine, approximately 3.7 river kilometers upstream from the confluence of the Stillwater Branch with the main stem of the Penobscot River. The confluence of the Stillwater Branch with the Penobscot River is approximately 53 river kilometers upstream from the Atlantic Ocean, and 8 river kilometers downstream of the Milford Project. The project has a generating capacity of 4,179 kW, a minimum hydraulic capacity of 100 cfs, and a maximum hydraulic capacity of 3,498 cfs. Powerhouse A located on the west shore has four generating units, and the new Powerhouse B located on the east shore has three units.

In 2013, the licensees replaced the downstream bypass facility at the Stillwater A powerhouse and constructed a new downstream passage facility at the Stillwater B powerhouse. The new downstream passage provisions include full-depth trash racks with 1-inch clear spacing at the powerhouse intakes, as well as a single surface bypass and a single low-level bypass (for American eels) at both powerhouses. Per the fishway operation periods specified in the Stillwater license, the low-level bypasses were not operational during the shad study. At Stillwater A, the surface bypass entrance is located at the left side of the intake (looking downstream) between the forebay wall and trashracks. The bypass discharges into the tailwater through a 36-inch-diameter conduit. At Stillwater B, the entrance to the surface bypass is located at the downstream-most end of the trashracks, perpendicular to the face of the trashracks. Prior to the 2017 passage season, the downstream fishway at Stillwater B was modified to increase survival of fish using this route by: (a) increasing the height of the plunge pool wall (to reduce the likelihood of fish landing on top of the wall, or splashing overboard, and (b) by installing stop logs downstream of the plunge pool area (in an existing slot) to back water up, thereby increasing the depth of the plunge pool and reducing the height of fall for fish. An attraction flow of 70 cfs was provided to each of the bypasses during the study. The two Stillwater surface bypasses were open for the duration of the adult shad outmigration period.

2.3 Orono Project (FERC No. 2710)

The Orono Project is a run-of-river project located on the Stillwater Branch just upstream from the confluence with the main stem of the Penobscot River in Orono, Maine. Powerhouse A is equipped with four generating units, and new Powerhouse B is equipped with three units. The total generating capacity of the project is 6,518 kW; it has minimum and maximum hydraulic capacities of 100 cfs and 3,822 cfs, respectively. A new downstream fish passage system at the Orono Project, which was commissioned in 2014, consists of full-depth angled trashracks with 1-inch clear spacing across both of the powerhouse intakes, a single downstream surface bypass, and a single low-level bypass for American eels. Per the fishway operation periods specified in the Orono license, the low-level bypass was not operational during the shad study. An attraction flow of 150 cfs is provided to the downstream surface bypass through an 8-foot-wide, adjustable entrance. The Orono surface bypass was open for the duration of the adult shad outmigration period.

3.0 Study Methodology

3.1 Overview

Radio-telemetry was used for the evaluation of upstream residence time, downstream passage route, and project survival of adult American shad at the Milford, Stillwater and Orono Projects during 2017. For this evaluation, it was expected that downstream movements of approximately 200 radio-tagged adult shad, released at three separate locations, would be evaluated at the three project locations (Figure 3.1-1). As radio-tagged shad in the Penobscot River upstream of Milford have the ability to move upstream to the West Enfield Project (FERC No. 2600), additional stationary telemetry coverage of the tailrace, upstream fishway, and headpond at that location was incorporated into the study design.

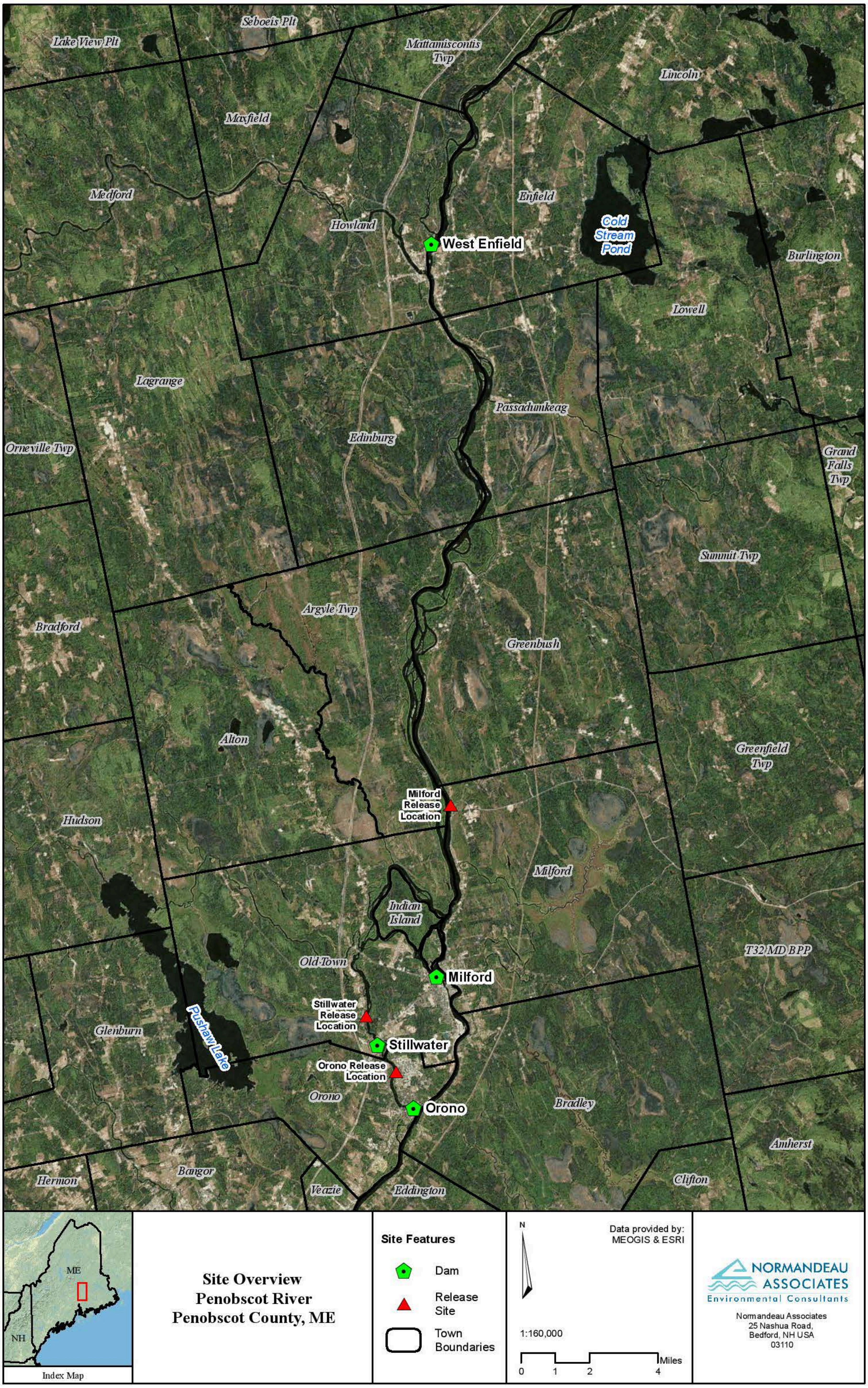

Figure 3.1-1. 2017 radio-tagged adult American shad Penobscot River release locations relative to the West Enfield, Milford, Stillwater and Orono Projects.

3.2 Radio Telemetry Equipment

The occurrence of radio-tagged adult shad in the vicinity of the West Enfield, Milford, Stillwater, and Orono Projects was documented via a series of stationary radio-telemetry receivers. Installed radio-telemetry equipment included Orion receivers, manufactured by Sigma Eight, as well as SRX400 and SRX800 receivers manufactured by Lotek. Receivers were installed following consideration of the detection requirements for the specific area of coverage, as well as the attributes of the receiver model. Orion receivers are broadband receivers capable of monitoring multiple frequencies simultaneously within a 1-MHz band; they were utilized for monitoring tagged fish in areas where movement through the monitoring zone was anticipated to be of short duration (e.g., turbine unit intakes and bypasses). Although Lotek receivers have a greater detection range than Orion receivers, they are limited to coverage of a single frequency at any one time and require frequency switching, which decreases detection efficiency in areas where fish may pass at high rates of speed. As part of monitoring adult shad passage at Milford, Stillwater and Orono, Lotek receivers were used at locations requiring longer range and where the intended detection areas could be characterized by relatively slow transit speeds for tagged fish (e.g., dam approach areas in headponds).

Several types of antennas were used for this study, including three-, four- and six-element Yagi antennas, as well as custom-made underwater antennas (dropper antennas). Three- and four-element Yagi antennas were primarily used to confirm the presence of shad within forebay and spillway areas. Six-element Yagi antennas were used at the downstream monitoring stations where detection across the full width of the river was required. Dropper antennas were placed at appropriate depths within structures and were used to determine points of passage (e.g., downstream bypasses). Dropper antennas were custom built using RG-58 coaxial cable.

American shad tagged during this study were fitted with Pisces radio-transmitters (model TX-PSC-I-80) manufactured by Sigma-Eight. Each transmitter measured approximately 26 x 10 x 10 mm, weighed 4.0 g, and had an estimated battery life of 64 days when set at a 2.0 second burst rate. Transmitters for this evaluation were uniquely coded and operated on one of two frequencies (150.760 or 150.780 MHz).

3.3 Monitoring Stations and Antenna Arrangements

Radio telemetry antennas and receivers were set up at specific locations to aid in determination of residence time and downstream passage at the Milford, Stillwater and Orono facilities, as well as at two locations downstream of each project to aid in determination of passage survival. Coverage at West Enfield consisted of stationary receivers covering the tailrace, upstream fishway, and headpond. Each monitoring station consisted of a data-logging receiver, one or more antennas, and a power source, and was configured to receive transmitter signals from a designated area continuously throughout the study period. During installation of each station, detection range testing was conducted to configure the antennas and receivers in a manner that maximized detection efficiencies at each of the routes and locations. The operation of the system as a whole was confirmed during installation and throughout the study period by using beacon tags. A number of beacon tags were stationed at strategic locations within the detection range of multiple antennas, and each emitted a signal at a programmed time interval. These signals were detected and logged by the receivers and used to record the functionality of the system throughout the study period. Although each monitoring station was installed in a manner which limited the ability to detect transmitters from unwanted areas, the possibility of such detections did still exist. As a result, behavioral data collected in this study (i.e., duration at a specific location or passage route) were inferred based on the signal strength and the duration and pattern of contacts documented across the entire detection array.

The antenna arrays located at the Milford, Stillwater and Orono Projects were positioned to detect all tagged fish that approached within ~200 meters of the upstream face of the dam, considering logistical and acoustic constraints. In general, a forebay or "approach" antenna or pair of antennas was used to detect radio-tagged shad as they arrived at the dam. A series of antennas were installed at potential passage points to detect radio-tagged individuals as they moved downstream of the dams and helped facilitate the identification of specific passage routes and times. A pair of antenna arrays were positioned at intervals downstream of the dam and spaced so that their detection areas did not overlap. These stations provided information on continued downstream movement following project passage. The first of these downstream antenna arrays was positioned far enough downstream to avoid false positive detections due to dead tagged fish. The position of the second downstream array was multiple kilometers downstream from the first downstream array.

A total of 32 stationary radio-telemetry receivers were installed on the lower Penobscot River to monitor downstream adult shad passage during 2017 comprising 31 unique monitoring stations (identified in this report as S1-S31). Descriptions and placement of the individual monitoring stations as installed for the 2017 adult shad passage field evaluation can be found in Appendix A.

3.4 Capture, Tagging, and Release Procedures

Adult American shad intended for use in this evaluation were obtained from the Milford Dam fish lift during June, 2017. Following capture in the secondary lift, fish were dip-netted from the sorting tanks and visually assessed to determine their suitability for tagging. Any individuals exhibiting excessive scale loss or other signs of significant stress were not selected for tagging. Individuals deemed acceptable for tagging were quickly measured (total length, nearest mm), and gender was determined (when possible) by gently expressing eggs or milt from running-ripe fish[1]. Radio transmitters were inserted gastrically. To facilitate gastric implantation, transmitters were affixed to a flexible tube with their trailing antenna running through the hollow center. The transmitter and leading edge of the flexible tube were gently pushed through the mouth and down to the stomach. Once in place, the tube was removed leaving the transmitter antenna trailing from the mouth. Following tagging, fish were immediately transferred to a stocking vehicle filled with aerated Penobscot River water (Figure 3.4-1). Truck water was salted to aid in reduction of osmotic stress to tagged individuals.

Figure 3.4-1. American shad transport tank used during tag and release efforts associated with Lower Penobscot adult shad outmigration evaluation.

Radio-tagged adult shad were transported by truck to one of three release locations (Figure 3.1-1). A total of 116 tagged, adult shad were released into the mainstem Penobscot at the public boat launch located approximately 8.5 km upstream of Milford Dam in Costigan, Maine. Two additional groups of 50-radio-tagged individuals were released into the Stillwater Branch at (1) the Old Town Water District property located approximately 1.5 km upstream of Stillwater Dam, and (2) the University of Maine boat launch located approximately 2.3 km upstream of Orono Dam. Following arrival at the release location, tagged fish were sluiced directly into the river to avoid any further netting or handling (Figure 3.4-2). The date and time of each release was recorded.

[1] On tagging dates with high air temperatures, the collection of length, weight and gender information was bypassed to reduce handling time and associated stress prior to tagging and release.

Figure 3.4-2. Direct release of radio-tagged adult shad into Penobscot River via sluice chute from truck tank.

3.5 Data Collection

3.5.1 Stationary Telemetry Data

Data files were off-loaded from receivers using a laptop computer and were stored on removable memory sticks. Data downloads occurred several times per week during June 2017 and then once weekly through July 2017. A final data download occurred in mid-August. Field tests to ensure data integrity and receiver performance included confirmation of file integrity prior to initialization of any receiver, plus manual confirmation that the receiver was operating upon restart and actively collecting data post download. Individual tag detections were stored in the receivers as a single event (i.e., single data line). Each event included the date and time of detection, frequency, ID code, and signal strength.

3.5.2 Manual Telemetry Data

Based on prior handling and tagging experience with adult American shad, individuals released into the mainstem Penobscot and Stillwater Branch were expected to demonstrate a range of behaviors following release, including immediate or delayed continued upstream migration or immediate downstream migration from the release site (i.e., "fall back"). To provide supplemental detection information to the stationary receiver data set, manual tracking was conducted once weekly from late June, 2017 through July, 2017. A final manual search took place in mid-August. These weekly efforts targeted accessible sections of the mainstem Penobscot River from Milford upstream to West Enfield and the Stillwater Branch between Gilman Falls and Orono. Manual tracking was shore (truck, foot) based.

3.5.3 Tag Retention Assessment

A total of 25 adult shad were tagged with dummy transmitters to evaluate retention rates. Fish for this effort were collected and handled identical to those selected for in-river release. Following tagging, dummy tagged shad were transferred to one of the holding tanks at the Milford lift facility and were maintained overnight. Any occurrences of tag regurgitation or mortality were recorded the following day.

3.5.4 Downstream Drift Assessment

A group of dead adult shad were radio-tagged and released downstream of the Milford (n=5), Stillwater (n=6) and Orono (n=5) projects during the 2017 study period. Dead, radio-tagged shad were released directly into the downstream fishways at each of the three projects to simulate natural passage. These locations were selected as the most likely routes of downstream passage under baseline river conditions, i.e., where waste spill is probably absent and the 1-inch rack spacing on the unit intakes reduces the likelihood of entrainment of adult shad. Downstream detections of these individuals were recorded via both the downstream stationary receivers as well as during the weekly manual tracking events.

3.5.5 River and Project Operational Data

In addition to the manual and stationary radio telemetry data, river and project operations data were collected during the 2017 evaluation period. Mainstem river temperature was recorded via an Onset thermal logger installed in the vicinity of the exit flume to the Milford fishway. Project discharge (unit and waste), unit operations (total cfs and percent gate), downstream bypass settings, as well as extent and location of spill were also recorded. The Milford, Stillwater and Orono projects were operated under "baseline" conditions for the June-early August period (i.e., units in operation and downstream bypasses open). In the event the licensees needed to open any additional spill for operational reasons, the date and time of opening and closing were recorded.

3.6 Data Analysis

3.6.1 Data Processing

Tag detections in each downloaded stationary telemetry data file were validated through a series of site-specific and logical criteria: These criteria included:

1. Signal strength threshold level of the detection,
2. Frequency of the radio-tag signals per unit of time, and
3. Spatial and temporal characteristics of each individual detection with respect to the full series of detections at monitoring stations within the entire detection array.

To determine the signal strength threshold for a valid tag signal, power levels associated with background noise were recorded at each monitoring station prior to the release of radio-tagged fish. These "false" signals are typically received at relatively low power levels, and they are removed from the analysis using a series of data filters. The frequency of the signal detections for an individual radio tag was examined at each monitoring station, such that over a set period of time, there are an adequate number of detections to rule out an isolated false detection (e.g. at least 3 detections within 1 minute). Finally, the spatial and temporal distribution of detections across multiple monitoring stations was examined to verify that the pattern of detections was occurring in a reasonable manner (i.e., time for a fish to have relocated within the time between the detections).

3.6.2 Upstream Residency Time and Downstream Passage Route

Following the completion of data file processing, a complete record of all valid stationary receiver detections for each radio-tagged shad was generated. Detections obtained from manual tracking were incorporated and used to ensure that the observed time series for each individual was logical (spatially and temporally). The pattern and timing of detections in these individual records were reviewed, and a route of passage as well as project arrival and passage times were assigned to each radio-tagged shad. Intake racks at the Milford, Stillwater and Orono projects are 1-inch clear spacing and should exclude adult American shad from downstream passage. As a result, turbine passage was not considered among the potential downstream routes at Milford, Orono or powerhouse B at Stillwater. Based on observations of outmigrating eels passing through the turbines at Stillwater powerhouse A during fall 2016, downstream passage of adult American shad could have potentially occurred at that location during this study. The intake racks at Stillwater A were inspected and repaired on July 27-28, 2017. In the instance that a downstream route could not be clearly determined from the collected data, the passage event for that particular fish was classified as 'unknown'.

Where data were available, forebay residence times and downstream transit times were calculated for shad at each Project dam. Forebay residence times were calculated as the duration of time from the initial upstream detection on the approach monitoring station (i.e., 200 m upstream of dam) until the final detection at one of the monitored passage routes (e.g., bypass, turbine). Downstream transit times were calculated as the duration of time from passage at one of the Project locations until the initial detection at each of the two downstream locations.

3.6.3 Parameter Estimates for Evaluation of Project Survival

Survivorship (*Phi*) and detection (*p*) probabilities were estimated for the Milford, Stillwater and Orono Projects using a Cormack-Jolly Seber model (CJS) constructed for each Project using Program MARK (White and Burnham 1999). Parameter estimates for *Phi* and *p* were obtained using the encounter histories constructed for each radio-tagged shad indicating their presence or absence at detection locations from the approach receiver (i.e., 200 m upstream of the dam) through the second receiver located downstream for each of the three Projects. These CJS models generated reach-specific survival estimates (Figure 3.7-1) for radio-tagged shad from:

a) the point 200 m upstream of the dam until passage downstream; and
b) from passage by the dam until the first downstream receiver.

The joint probability of the two reach-specific survival estimates was used as the estimate of total project survival. This approach resulted in estimates that included background mortality (i.e., natural mortality, such as predation) along with any tagging-related mortalities or tag regurgitations for adult American shad within 200 m upstream of each Project, as well as the reach downstream of the dam to the second downstream receiver. This resulted in minimum estimates of total project survival (i.e., attributable to project effects) for adult shad at each project.

To evaluate survival using Program MARK, a suite of candidate models were developed based on whether survival, recapture (i.e., detection), or both vary or are constant among stations. Models included:

- *Phi*(t)*p*(t): survival and recapture may vary between receiver stations;
- *Phi*(t)*p*(.): survival may vary between stations, recapture is constant between stations;
- *Phi*(.)*p*(t): survival is constant between stations, recapture may vary between stations;
- *Phi*(.)*p*(.): survival and recapture are constant between stations;

Where;

- *Phi* = probability of survival
- *p* = probability of detection
- (t) = parameter varies
- (.) = parameter is constant

Prior to comparison among models, goodness of fit testing was conducted for the 'starting model' (i.e., the fully parameterized model) using the function RELEASE within Program MARK. Within RELEASE, outputs from Test 2 and Test 3 combine to provide goodness of fit information for the fully time dependent model. If the χ^2 results from Test 2, Test 3, or the overall result (Test 2 + Test 3) are significant, then the test assumptions are violated and the fully time dependent model does not provide adequate goodness of fit. To accommodate for the lack of fit, a measure of how much extra binomial noise (i.e., variation) exists in the data is needed. This value, the variance inflation factor ($\hat{c}$), can be estimated within MARK and used to correct for any minor over-dispersion.

Akaike's Information Criterion (AIC) was used to rank the models as to how well they fit the observed mark-recapture data. Lower AIC values denote a more explanatory yet parsimonious fit than higher AIC values. Assuming the assumptions of the model with the lowest AIC value are reasonable with regards to this study, it was selected for the purposes of generating MARK-derived survival estimates.

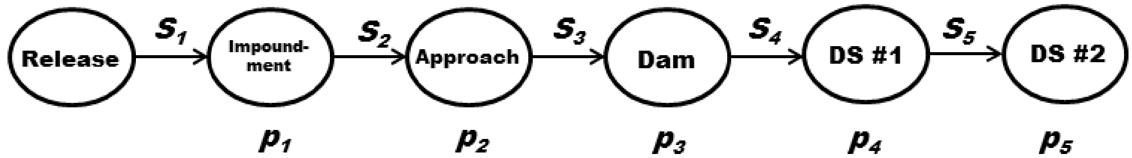

Figure 3.7-1. Schematic of the general mark-recapture model used to estimate survival and detection probabilities for radio-tagged American shad at West Enfield, Milford, Stillwater and Orono during 2017.

4.0 Study Results

4.1 Transmitter Retention and Downstream Drift Assessments

4.1.1 Transmitter Retention Assessment

A total of 26 adult American shad were tagged with dummy transmitters on June 20, 2017. One individual (adult female shad, 550 mm total length) regurgitated its transmitter immediately following tagging and release into the holding tank. The transmitter was recovered, and a final total of 25 dummy-tagged adult shad were housed in one of the sorting tanks at the Milford fish lift facility. This group of fish was maintained for approximately 18 hours from 1650 on June 20 to 1045 on June 21. Adult shad selected for this test ranged in total length from 420-550 mm (mean = 493 mm) and were roughly 50:50 male to female. There were no instances of tag regurgitation for any of the 25 individuals following the 18 hour holding period. Following the retention test, transmitters were gently removed from all fish and they were released upstream of Milford Dam. Based on the absence of any observations of delayed tag regurgitation during the holding test, there were no adjustments made to any of the passage survival estimates.

4.1.2 Downstream Drift Assessment

Milford:

A total of five dead adult American shad were radio-tagged and released into the downstream fish bypasses at Milford. Two individuals were released via the bypass in bay #7 (located near the mid-point of the powerhouse intake rack) on June 16th, and three were released via the bypass in bay #2 (located towards the river side of the powerhouse intake rack) on June 21. All five individuals were detected from the tailrace vicinity during manual tracking events up through July 18th, and four of the five were present during the final tracking event conducted on August 16th. The single individual not contacted after the 18th of July was not detected at Monitoring Station S12, which is the first stationary receiver downstream of Milford and is located approximately 2.4 km below the dam.

Stillwater:

A total of six dead adult American shad were radio-tagged and released into the downstream bypasses at Stillwater on June 21, 2017. Three individuals were released in the downstream bypass at powerhouse A and three in the downstream bypass at powerhouse B. During the July 6th manual tracking event, all three individuals at powerhouse A and two of the three at powerhouse B were present in the vicinity of the tailraces downstream. During the July 25th manual tracking event, one of the three individuals at powerhouse A and two of the three at powerhouse B were present in the immediate tailrace. One of the six dead shad released at Stillwater reached Monitoring Station S23, approximately 1.6 km downstream of Stillwater. That individual was initially detected at that location on August 6th, 46 days following its release at the powerhouse.

Orono:

A total of five dead adult American shad were radio-tagged and released into the downstream bypass at Orono on June 21, 2017. Four of the five were still present in the vicinity of the project tailrace area during the final tracking events on July 25th and August 16th. The fifth dead shad was not detected in the tailrace area following its initial release on June 21. However, this individual was not recorded at Monitoring Station S13, located approximately 1.8 km downstream of Orono, suggesting that it settled somewhere within the initial downstream reach.

4.2 Penobscot River Conditions

The first group of radio-tagged adult American shad were released into the Penobscot River on June 13th, and full telemetry monitoring continued through August 15, 2017. Figure 4.2-1 presents the Penobscot River flows as measured at the USGS gage in West Enfield, Maine (USGS 01034500) for the 2.5 month period of June-August 15, 2017. During that period, Penobscot River flows ranged between 2,960 – 15,500 cfs (mean = 6,751 cfs; median = 6,750 cfs). Penobscot River flows trended down with time, with the mean monthly flow dropping from 8,237 cfs in June, to 6,776 cfs in July, to 3,728 cfs in the first half of August (median values of 7,780 cfs in June, 6,590 cfs in July, and 3,690 cfs in August).

Hourly temperature readings collected for the duration of the study period from the Milford headpond are presented in Figure 4.2-2. Penobscot River water temperatures during the monitoring period ranged between 15.6 °C and 26.9 °C (mean = 22.3 °C; median = 22.7 °C), and between 19.3 °C and 24.1 °C on tagging and release dates.

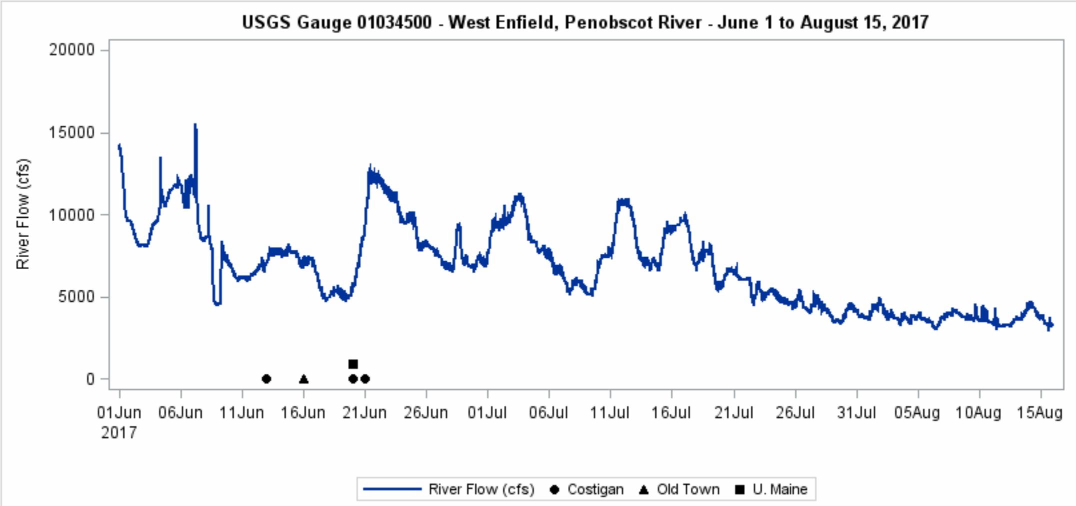

Figure 4.2-1. Penobscot River flow as recorded at the USGS West Enfield gauge for the period June 1 – August 15, 2017.

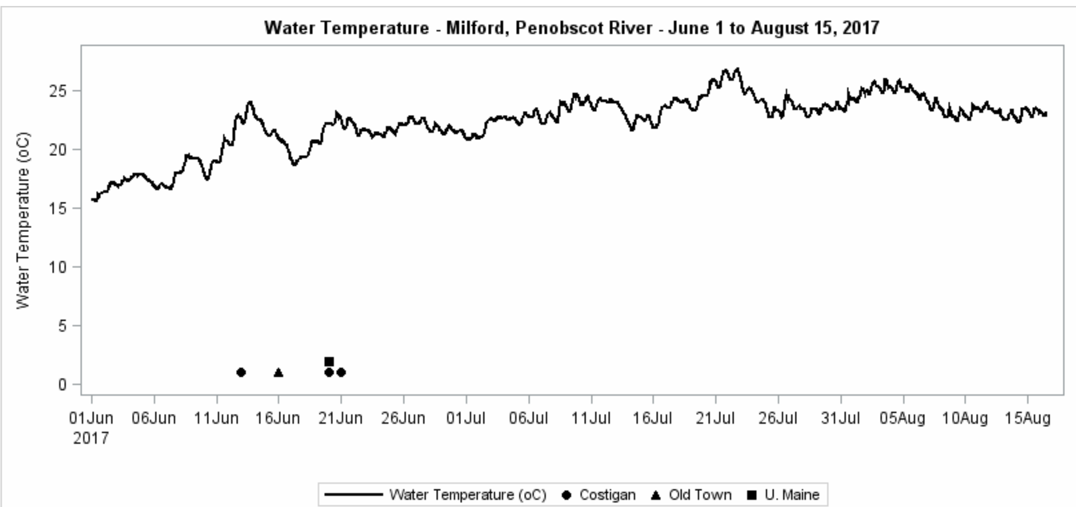

Figure 4.2-2. Penobscot River temperature as recorded from the Milford Dam headpond for the period June 1 to August 15, 2017.

4.3 Penobscot River Project Operations

4.3.1 West Enfield

Total river flows at West Enfield are presented in Figure 4.3-1; for the period of time from the initial release of tagged adult shad (June 13th) through mid-August, river flows were below the station capacity of 13,460 cfs. As a result, outflow downstream of West Enfield was limited to the two turbine units, the downstream bypass (approximately 160 cfs), and the upstream fish way (approximately 135 cfs). The West Enfield upstream fishway operated continuously during the adult shad monitoring period until August 7, 2017, when it was closed and drained for scheduled annual maintenance.

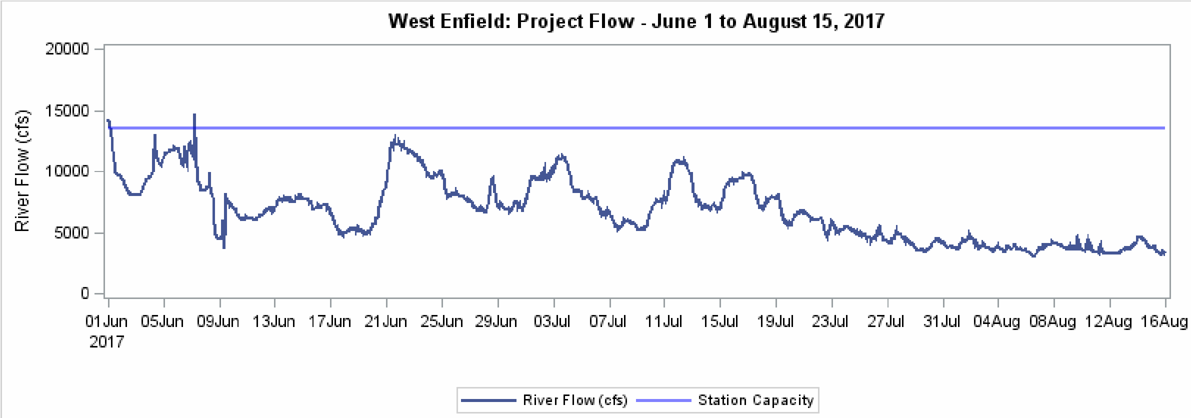

Figure 4.3-1. Total flow (cfs) at West Enfield relative to station capacity for the period June 1 to August 15, 2017.

4.3.2 Milford

Total river flows at Milford are presented in Figure 4.3-2; flows exceeded the station capacity of 6,730 cfs periodically during the period of time from the initial release of tagged adult shad (June 13th) through mid-August. At the onset of the study period, outflow through the project was via a combination of the six turbine units, two downstream bypasses (approximately 500 cfs), and the upstream fishway (approximately 200 cfs). River flows and several curtailments of generation periodically necessitated that either the sluice gate be opened or the Obermeyer section of dam be lowered during the study period. Figure 4.3-3 displays the difference in reported total flows at Milford relative to the station capacity of 6,730 cfs. Reported time periods where either the sluice or Obermeyer gates were open are also displayed.

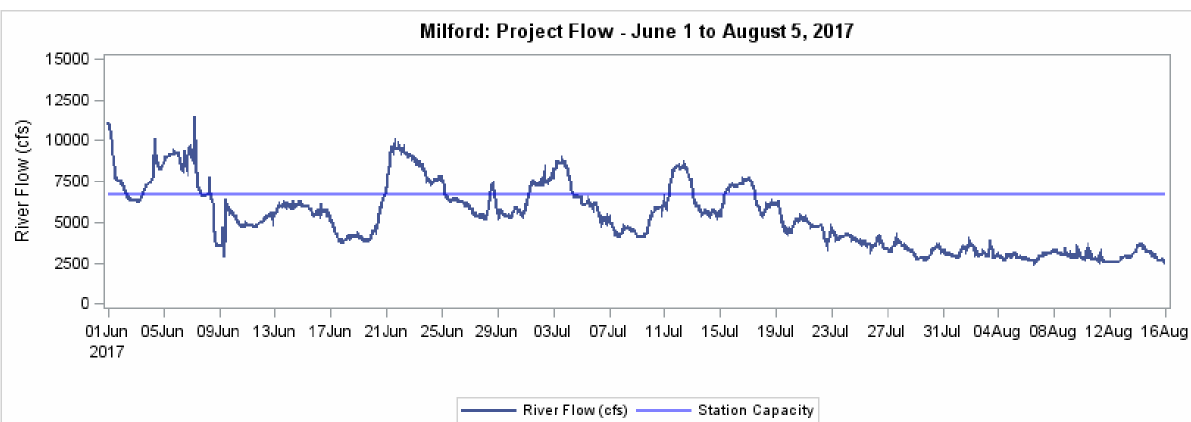

Figure 4.3-2. Total flow (cfs) at Milford relative to station capacity for the period June 1 to August 15, 2017.

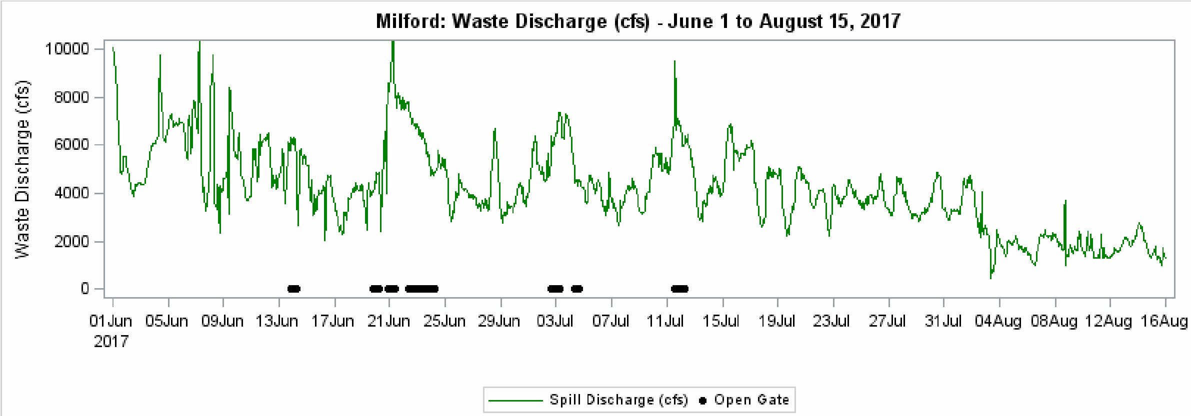

Figure 4.3-3. Difference in flow (cfs) for reported total flow and station capacity at Milford for the period June 1 – August 15, 2017. Periods where project gates were reported as open are indicated by black bars.

On June 20, 2017, a breach in the spillway section of the Milford Dam was discovered and triggered a repair operation. As part of that operation, headpond levels at Milford were drawn down. Figure 4.3-4 presents headpond elevations as reported by Black Bear for the study period (June 1 to August 15, 2017). Normal full pond at Milford is 101.7 feet. The Milford headpond was drawn down approximately one foot from June 20 through August 3 as work crews were operating in the reach downstream of the spillway. The headpond was drawn down approximately 3.5 feet below normal full pond on August 3 and remained in that state through the end of the monitoring period for radio-tagged shad. The necessary headpond level manipulations for providing appropriate working conditions for the ongoing dam repairs resulted in changes to the total flows available to pass through the downstream bypasses. The surface bypass in Bay 2 of the Milford powerhouse will pass approximately 280 cfs at normal pond, 218 cfs when drawn down one foot and 75 cfs when drawn down 3.5 feet. The surface bypass in Bay 7 of the Milford powerhouse will pass approximately 216 cfs at normal pond, 171 cfs when drawn down one foot and 59 cfs when drawn down 3.5 feet.

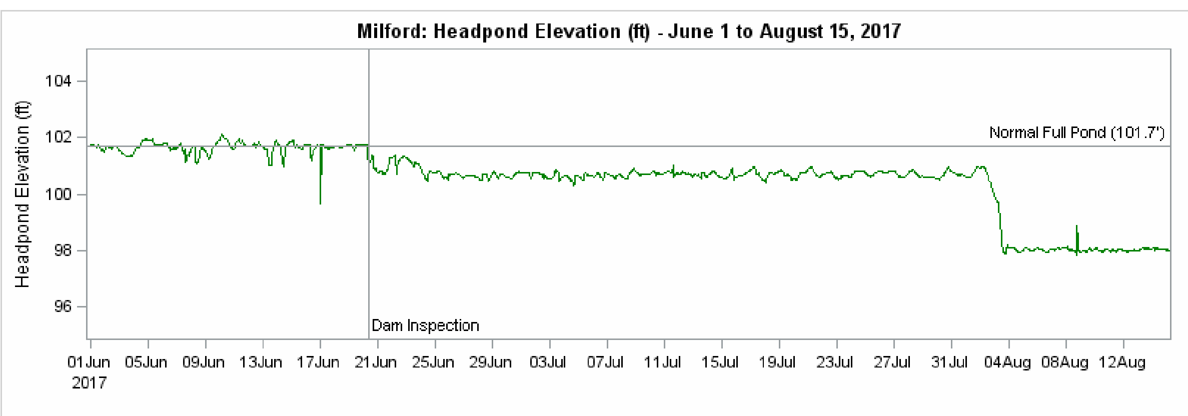

Figure 4.3-4. Milford headpond elevation (ft) for the period June 1 – August 15, 2017.

4.3.3 Stillwater

Total river flows at Stillwater are presented in Figure 4.3-5, and for the majority of the study period were less than the station capacity of 3,458 cfs (powerhouses A and B, combined). As a result, discharge downstream of Stillwater was limited to the turbine units associated with powerhouses A and B and the flow through the downstream bypasses (approximately 70 cfs each). Any periods of total river flow exceeding station capacity would have resulted in overtopping of the project flashboards.

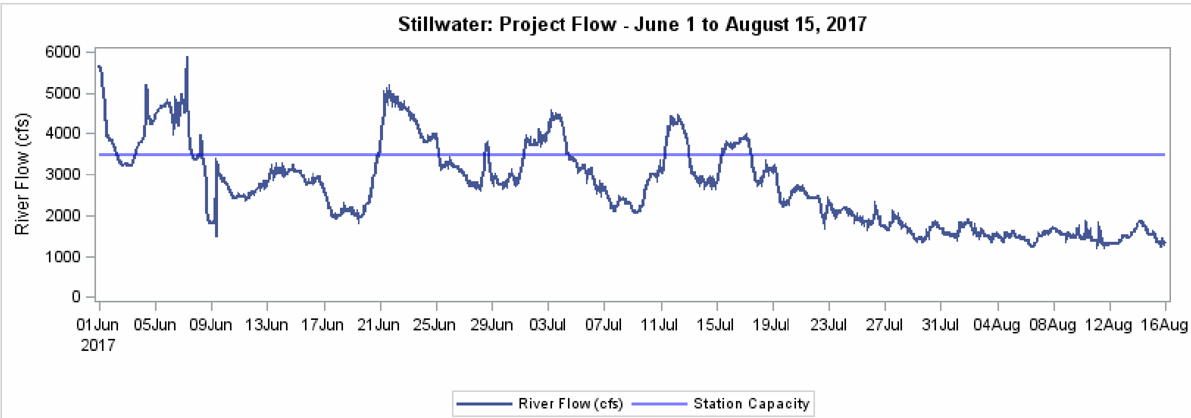

Figure 4.3-5. Total flow (cfs) at Stillwater relative to station capacity for the period June 1 to August 15, 2017.

4.3.4 Orono

Total river flows at Orono are presented in Figure 4.3-6; flows for the majority of the study period were less than the station capacity of 3,822 cfs (powerhouses A and B, combined). As a result, discharge downstream of Orono was limited to the turbine units associated with powerhouses A and B, and the downstream bypass (approximately150 cfs). Any periods of total river flow exceeding station capacity would have resulted in overtopping of the project flashboards.

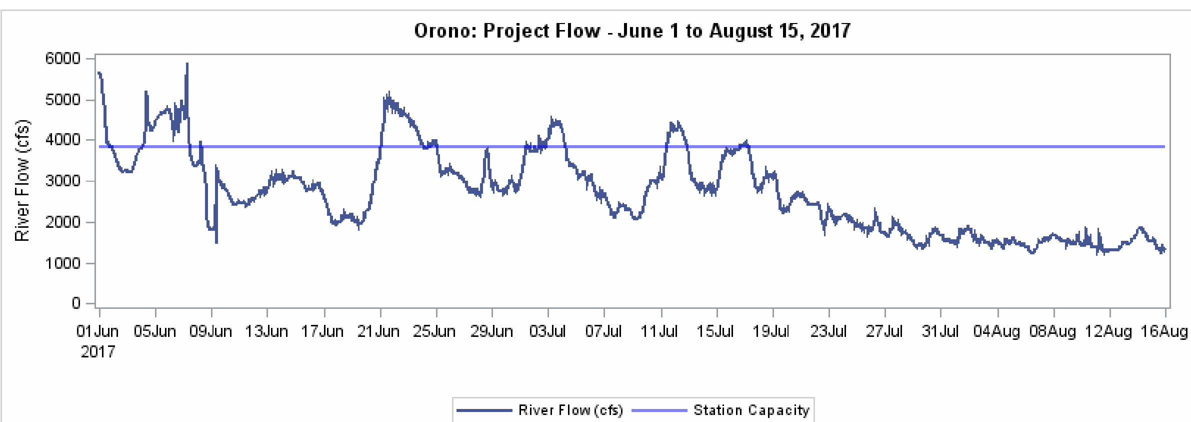

Figure 4.3-6. Total flow (cfs) at Orono relative to station capacity for the period June 1 to August 15, 2017.

4.4 Monitoring Station Functionality

Radio-tagged adult American shad were released into the Penobscot River beginning on June 13, 2017, and the study plan called for continuous monitoring at project locations through July, 2017. Normandeau conducted weekly checks and downloads of all stationary receivers during that period. Figure 4.4-1 presents the coverage provided by each of the 31 radio-telemetry stations installed for detection of radio-tagged shad at the West Enfield, Milford, Stillwater and Orono Projects for the period from June 12 to July 31, 2017. Station coverage was determined by a combination of beacon transmitter detections and observations reported by field personnel conducting the receiver checks and data downloads. The majority of monitoring stations operated with no issues for the duration of the primary study period (June 12 to July 31).

Inconsistencies in coverage were noted at two monitoring locations:

- Coverage was lost from 1500 hrs on July 20 through 1200 hrs on July 25 at Monitoring Station S8 (Milford downstream bypass - center entrance) due to an interruption of the power supply. Detection data collected at the Milford intakes and tailrace did not indicate any adult shad which passed during this time period. A review of all passage times indicated that no radio-tagged adult shad passed downstream at Milford later than July 17th. As a result, this outage had no impact on the overall passage results for Milford.
- Similarly, coverage was lost from 1400 hrs on July 26 through July 31 at Monitoring Station S28 (Orono powerhouse B intake) due to an interruption of the power supply. Detection data collected at the Orono powerhouse B tailrace did not indicate any adult shad passing during this time period. A review of all passage times indicated that no radio-tagged adult shad passed downstream at Orono later than July 25th. As a result, this outage had no impact on the overall passage results for Orono.

Following the completion of the intended study period, additional stationary data were collected at Monitoring Stations S1-S31 from August 1 through August 15, 2017 to ensure that the full outmigration of radio-tagged adult shad through the Penobscot was monitored. Receivers were allowed to operate independently during this period. At several locations (Monitoring Stations S9, S11, and S22), the receiver memory capacity was exceeded prior to final study termination on August 15th. Additionally, battery power supplies at most remote locations (Monitoring Stations S1, S5, S12 S13, S14, S15, S23, S24, and S31) expired prior to August 15th (average termination date of August 10, 2017). The majority of onsite monitoring stations operated with no issues. It should be noted that the final passage dates for radio-tagged adult shad were July 17th at Milford, July 24th at Stillwater, and July 25th at Orono.

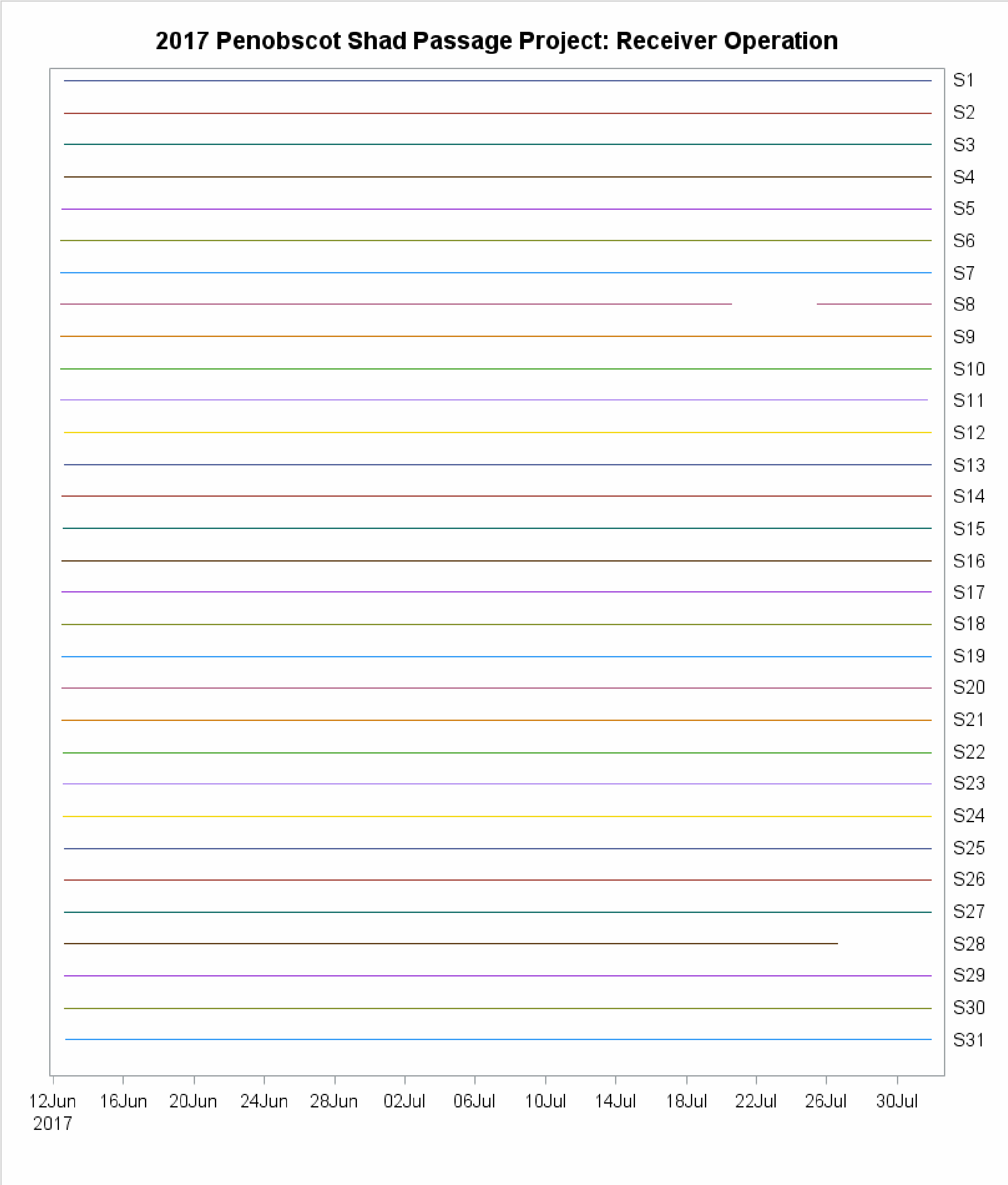

Figure 4.4-1. Coverage for Monitoring Station S1 through S31 installed in association with evaluation of downstream adult American shad passage at Milford, Stillwater and Orono Projects (June 12-July 31, 2017).

4.5 Capture, Tagging and Release

A total of 216 adult American shad were radio-tagged following collection at the Milford upstream fish lift during 2017 (Table 4.5-1). A total of 116 radio-tagged individuals were released at the Costigan boat launch upstream of Milford Dam over three dates: June 13 (n = 38), June 20 (n = 63), and June 21 (n = 15). A total of 50 radio-tagged individuals were released upstream of Stillwater Dam at the Old Town Water District property on June 16, and an additional 50 were released upstream of Orono Dam at the University of Maine boat ramp on June 20. Radio-tagged shad ranged in total length from 378-560 mm (Table 4.5-1), with the majority measuring between 510-524 mm (Figure 4.5-1).

Table 4.5-1. Summary of collection and biological information (total length and gender) for adult American shad radio-tagged and released into the Penobscot River (June 2017).

	Project		
	Milford	Stillwater	Orono
Release Location	Costigan Ramp	Old Town Water District	U. Maine Ramp
Release Dates	June 13, 20, 21	June 16	June 20
Number Released	116	50	50
% Male	37.1%	44.0%	44.0%
% Female	30.2%	56.0%	56.0%
% Undetermined	32.8%	0.0%	0.0%
Min. Total Length (mm)	420	378	410
Max. Total Length (mm)	560	556	560
Mean Total Length (mm)	492	490	493

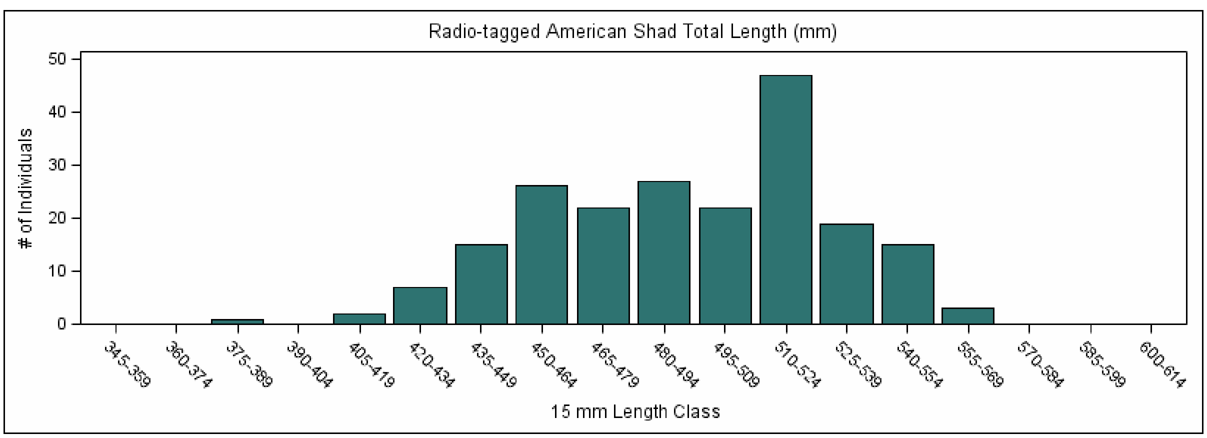

Figure 4.5-1. Total length frequency distribution for adult American shad collected at the Milford fish lift and radio-tagged prior to release into the Penobscot River, June 2017.

4.6 Shad Movements, Passage and Survival

Stationary telemetry data collected at Monitoring Stations S1-S31 on the Penobscot River were used to evaluate adult shad movements during 2017. Information was used to identify downstream passage routes for radio-tagged shad at Milford, Stillwater and Orono. Passage route distribution, project residence duration, transit times, and the temporal distribution of passage events are presented (by project) below. In addition, detection information for radio-tagged shad which approached West Enfield was examined.

4.6.1 West Enfield

Radio-tagged adult American shad were not released upstream of West Enfield. However, individuals released at both the Costigan boat ramp (upstream of Milford) and at the Old Town Water District property (upstream of Stillwater Dam) had the potential to migrate upstream and interact with the West Enfield Project. A total of 11 of the 116 radio-tagged adult shad (9.5%) released at Costigan were detected in the tailrace at West Enfield, along with 1 of the 50 radio-tagged shad (2%) released at the Old Town Water District property on the Stillwater Branch. Radio-tagged adult shad which were released at the Costigan ramp and ascended the 29.7 km reach of the Penobscot to arrive at West Enfield did so in an average of 81.6 hours (range = 33.3 – 185.2 hours; median = 76.8 hours). The single radio-tagged adult shad originally released into the Stillwater Branch and subsequently detected at West Enfield passed upstream through the Stillwater Branch (including Gilman Falls – likely where Pushaw Stream flows into the Stillwater Branch at the western side of the Gillman Falls Dam) and the mainstem reach in 186.5 hours. If it is assumed that this individual passed up and around Orson Island, then the total distance traveled was approximately 46.3 km. A listing of these arrival durations is presented in Table 4.6-1.

Of the twelve radio-tagged adult shad detected at West Enfield, none were detected by the stationary monitoring equipment within the upstream fishway or headpond. Stationary telemetry detections for this group of fish were limited to Monitoring Station S2, which covered the section of the project tailrace downstream of the project intakes. A period of tailrace residence for each of these individuals was calculated as the duration of time from their initial detection at Monitoring Station S2 until the final detection at Monitoring Station S2. The tailrace residency durations for radio-tagged adult American shad at West Enfield ranged from approximately 10 minutes to 141.1 hours (mean = 36.1 hours; median = 5.6 hours).

Following initial detection within the immediate tailrace area downstream of the powerhouse, the majority of radio-tagged shad did not remain there for the duration of the calculated tailrace residence time, but rather made a series of movements in and out of the immediate tailrace area (see example time series plots for radio-tagged shad 150.760 (22) and 150.760 (68) in Figures 4.6-1 and 4.6-2). As a result, the period of actual residence in the vicinity of the West Enfield tailrace (and associated proximity to the fishway entrance) was the sum of several shorter durations which represent all or a percentage of the calculated tailrace residency duration. To examine this, the "cumulative residence duration" was determined for each individual relying on the ability to identify the breaks in the detection time series for a particular individual to indicate when that fish was or was not present in the detection field of the receiver. Since signal transmissions during a period of residence within the detection zone of a receiver can go unrecorded for a variety of reasons (e.g., receiver scan time, signal collision, background interference, etc.), it was not appropriate to set a threshold interval between detections equal to the transmission rate of the tags (Castro-Santos and Perry 2012). To determine the appropriate threshold interval for Monitoring Station S2, the intervals between all successive detections for each individual at that location was calculated. In theory, sequential detections within a particular zone should be some multiple of the burst rate for the transmitters being used, with longer intervals decreasing in frequency of occurrence. For Monitoring Station S2, a threshold interval for determining continued presence was identified as the 95th percentile of the observed set of interval durations (Figure 4.6-3) and was determined to be 21 seconds. This threshold value was used to delineate when each period of residence was started and completed for a tagged individual. The departure of a radio-tagged shad from the West Enfield tailrace was determined when the time interval between successive detections exceeded the 21-second threshold interval for that zone. Cumulative tailrace residence duration for adult radio-tagged shad at West Enfield ranged from approximately 10 minutes to 11.5 hours (mean = 2.5 hours; median = 0.6 hours). A listing of these tailrace residence duration and related cumulative tailrace residence durations is presented in Table 4.6-1.

Following their final detection at the West Enfield tailrace, 10 of the 12 radio-tagged shad were subsequently detected outmigrating past downstream hydroelectric projects (9 at Milford and 1 at Stillwater). Transmitters for the two individuals not detected at the downstream hydroelectric projects were determined to be stationary in the mainstem Penobscot River in the vicinity of its confluence with the Passadumkeag River for the remainder of the study, suggesting they either shed their transmitters or died following presumed spawning. Each of the 10 radio-tagged shad which descended the mainstem Penobscot following time at large upstream were detected at Monitoring Station S4 located approximately 34.5 km downstream of West Enfield. The departure duration for these fish ranged from 71.4 hours to 583.5 hours (mean = 258.8 hours; median = 231.5 hours).

Table 4.6-1. Summary of approach, residence, and departure durations for radio-tagged adult American shad which approached West Enfield from downstream release sites, June-July 2017.

Shad ID	TL (mm)	Gender	Release Location	Release Date	Arrival Duration (hrs)	Tailrace Residence Duration (hrs)	Cumulative Tailrace Residence Duration (hrs)	Departure Duration (hrs)
150.760 (22)	490	.	Costigan	6/13/2017	40.3	91.5	5.6	295.4
150.760 (47)	530	.	Costigan	6/13/2017	94.1	141.1	5.1	71.4
150.760 (68)	540	F	Costigan	6/21/2017	49.7	45.9	2.0	296.4
150.760 (91)	465	M	Old Town	6/16/2017	186.5	1.5	0.6	400.7
150.760 (195)	510	F	Costigan	6/20/2017	103.9	0.1	0.1	135.3
150.780 (36)	510	.	Costigan	6/13/2017	185.2	79.9	2.9	199.7
150.780 (123)	450	M	Costigan	6/20/2017	45.1	0.3	0.3	.
150.780 (125)	510	F	Costigan	6/20/2017	105.3	9.2	0.7	263.3
150.780 (128)	440	M	Costigan	6/20/2017	65.3	2.0	0.4	583.5
150.780 (146)	500	M	Costigan	6/20/2017	98.9	0.3	0.1	163.2
150.780 (147)	440	M	Costigan	6/20/2017	76.8	1.2	0.5	179.3
150.780 (157)	510	F	Costigan	6/20/2017	33.3	59.9	11.5	.

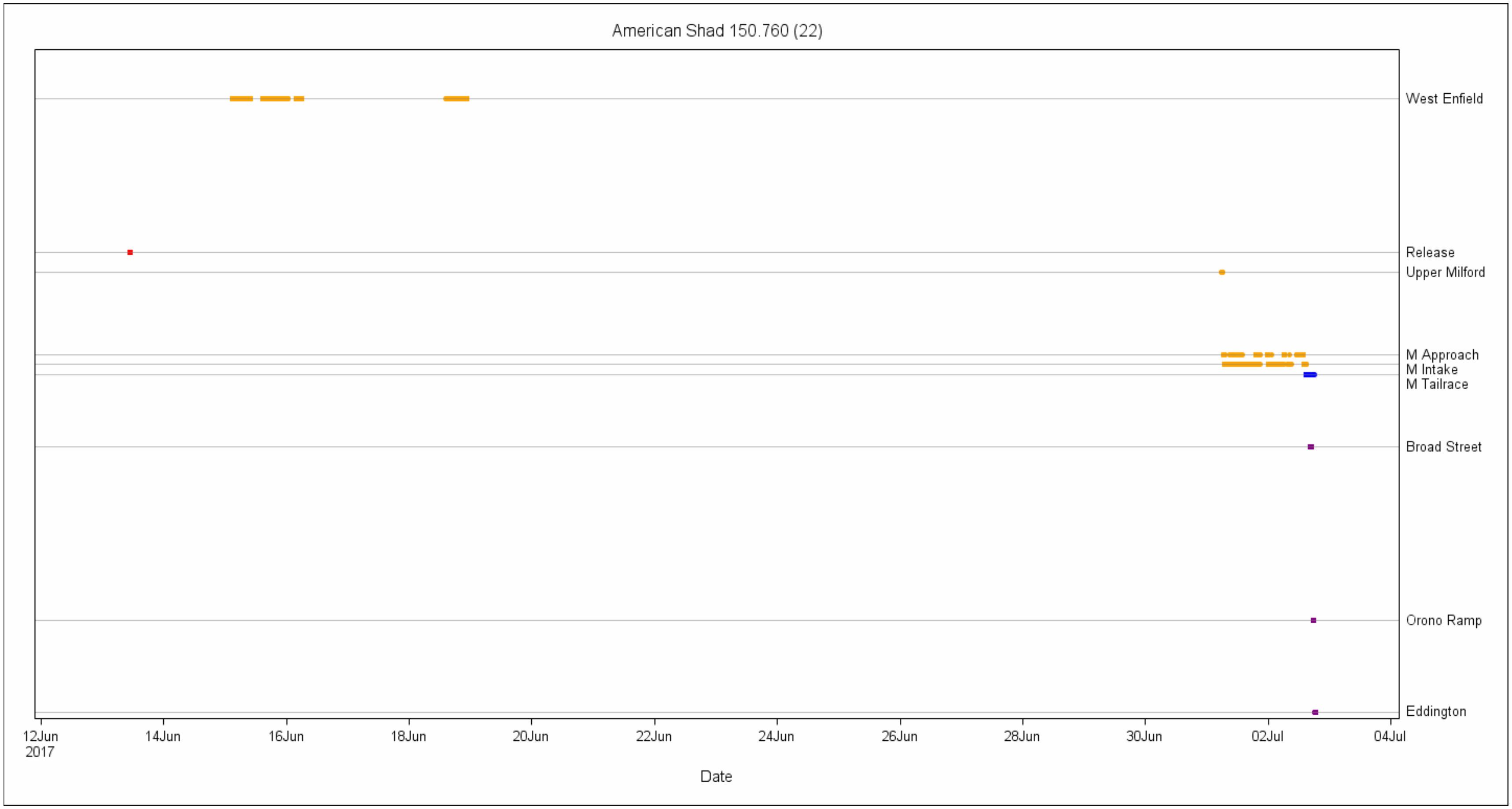

Figure 4.6-1. Telemetry detection time series for radio-tagged shad 150.760 (22). Red indicates release, orange indicates mainstem detections between West Enfield and Milford, blue indicates mainstem detections immediately downstream of Milford and purple indicates mainstem detections at downstream detection locations.

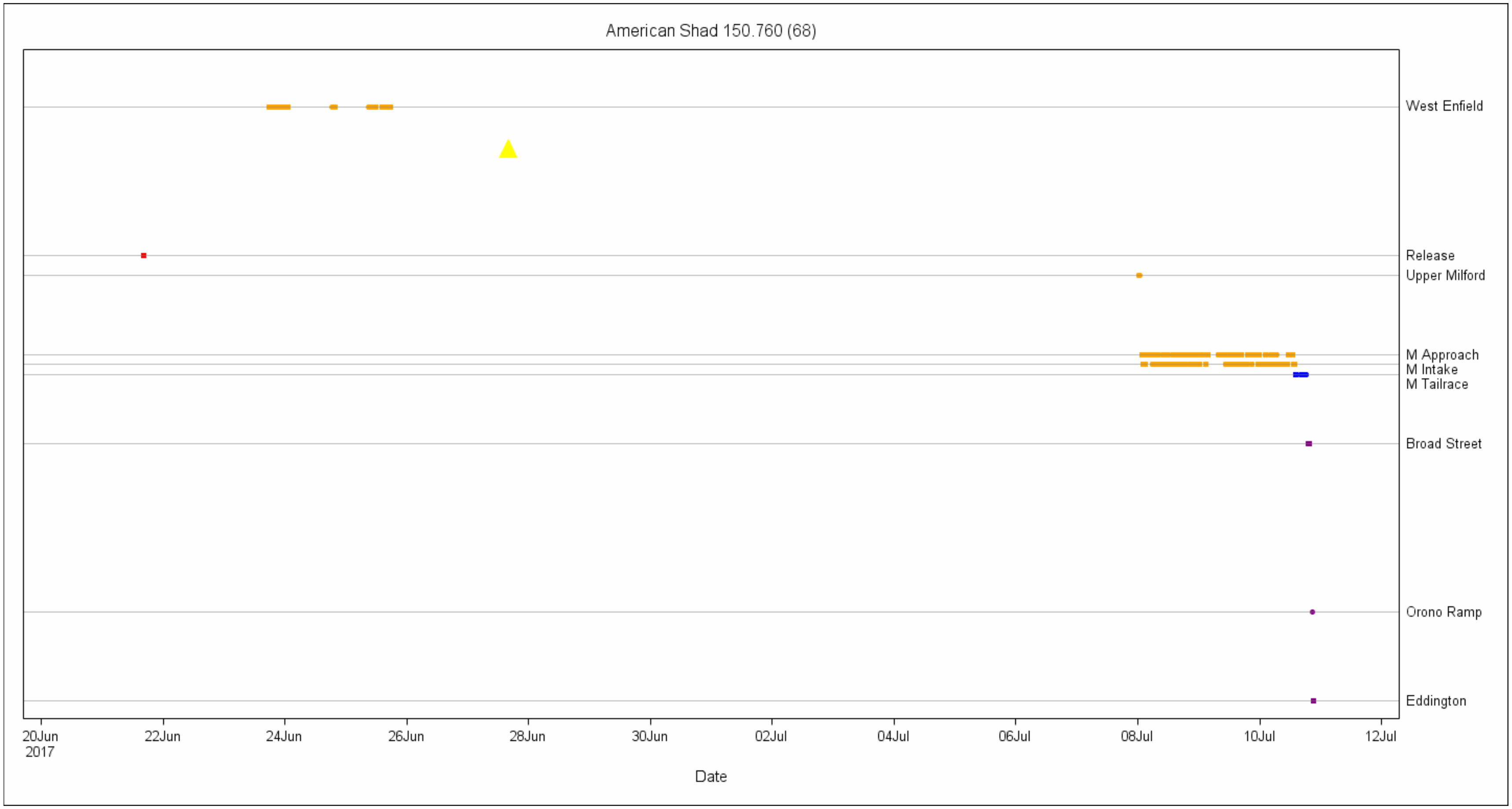

Figure 4.6-2. Telemetry detection time series for radio-tagged shad 150.760 (68). Red indicates release, yellow indicates manually determined positions, orange indicates mainstem detections between West Enfield and Milford, blue indicates mainstem detections immediately downstream of Milford and purple indicates mainstem detections at downstream detection locations.

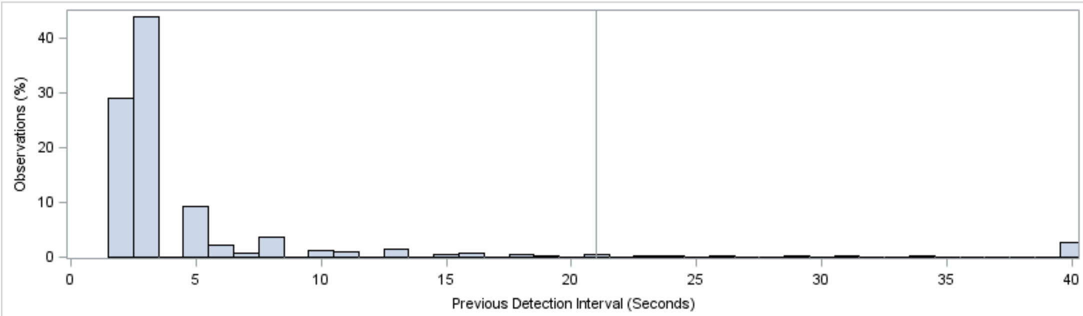

Figure 4.6-3. Frequency distribution (%) of intervals since last detection of radio-tagged adult shad transmitting in the West Enfield tailrace detection zone. Vertical line indicates the unique threshold interval used to delineate new period of residence.

4.6.2 Milford

A total of 116 radio-tagged adult American shad were released at the Costigan boat ramp for the purpose of evaluating downstream passage at Milford. Of the total, eighteen individuals were not detected at Monitoring Station S5, indicating that they did not approach Milford Dam. Of that subtotal, eight individuals went undetected at all stationary receivers, as well as during manual tracking events, and the remaining ten were limited to detections at receivers upstream of Monitoring Station S5 and manual detections throughout the study period. An additional thirteen individuals originally released at the Costigan boat ramp passed downstream via the Stillwater Branch. Of those individuals, 8 of the 13 (61%) were detected at Monitoring Station S5, prior to their outmigration through the Stillwater Branch

These totals were partially offset by five radio-tagged adult shad originally released at the Old Town Water District property which ascended the Stillwater Branch prior to downstream passage at Milford. As a result, a total of 90 radio-tagged adult shad approached Milford and had the opportunity to pass downstream. Residence time, downstream passage route, and passage survival for this group of adult shad are presented in the following sub-sections.

4.6.2.1 Project Returns and Forebay Residence Duration

Figure 4.6-4 presents the distribution of returns for radio-tagged adult American shad to the area upstream of Milford Dam (as determined by initial detection at the approach receiver – Monitoring Station S5) during 2017. Radio-tagged shad returned to Milford Dam between the dates of June 13 and July 29, 2017, with the majority returning during the latter half of June and first half of July.

A forebay residency duration was determined for all individuals which approached and passed downstream of Milford; it was calculated as the duration of time from initial detection at the approach to the dam (i.e., Monitoring Station S5) until confirmed passage at one of the available downstream passage routes (Table 4.6-2). Information was available to calculate a forebay residency time for 81 of the 90 radio-tagged shad which approached and had an opportunity to pass Milford Dam[2]. When those individuals are considered, forebay residence duration from initial approach detection until downstream passage at Milford ranged between 0.3 hours and 606.8 hours (mean = 93.5 hours; median = 39.2 hours). The majority of radio-tagged shad which approached Milford were determined to remain in the general area of the dam (as evidenced by detections at the project intakes and approach receivers). Figures 4.6-5 and 4.6-6 present the detection time series for two radio-tagged adult shad which approached Milford. The individual in Figure 4.6-5 is an example of a radio-tagged shad with a relatively longer forebay residence time, whereas the individual depicted in Figure 4.6-6 passed the project relatively soon after arrival.

A number of radio-tagged shad (n=20) were determined to have moved back upstream for a period of time following their initial detection in the dam area, as evidenced by detections at the upper end of the Milford impoundment (i.e., Monitoring Station S4; see example time series for fish 150.760 (23) in Figure 4.6-7). The forebay residence time for all individuals was adjusted to reflect these periods of time away from the immediate dam area. When the adjusted forebay residence durations are considered, duration for all radio-tagged individuals upstream of Milford ranged between 0.3 hours and 483.7 hours (mean = 77.5 hours; median = 37.1 hours; Table 4.6-2). Approximately 40% of radio-tagged shad passed downstream of Milford within 24 hours of initial approach detection, and 56% had done so within 48 hours of initial detection (Figure 4.6-8).

4.6.2.2 Downstream Passage

Passage routes for the 90 radio-tagged adult shad detected immediately upstream of Milford are presented in Table 4.6-3. The majority of individuals (52 of 90; 58%) passed downstream of Milford via the sluice gate. Lesser numbers of shad were determined to have used the downstream bypasses (15 of 90; 17%) and Obermeryer gate (1 of 90; 1%). Figure 4.6-9 provides the distribution of passage dates for radio-tagged shad at Milford. Individuals passed downstream of the dam between the dates of June 14 and July 17. Daily peaks in downstream passage coincided with dates of sluice gate operation (Figure 4.6-9).

There were seven individuals which approached Milford but did not pass downstream. Of those individuals, one departed to points upstream of the Milford dam area and did not return during the monitoring period. Six radio-tagged shad remained present within the Milford forebay area following their initial detection. Of that total, three showed a pattern of short detection at the Milford approach receiver followed by a prolonged period of

[2] Of the 9 individuals that approached Milford for which a forebay residence time could not be calculated, 7 did not successfully pass the project, and the downstream passage time could not be determined for the other two.

detections at the Milford intake receiver, which may suggest that these individuals died upriver and drifted downstream. Two of the six shad showed a pattern of movement between the approach and intake receivers for a period of time following initial detection, suggesting they either died or regurgitated their transmitter at some point while in the project area. The last individual was only detected at the approach receiver, where it became stationary for the remainder of the study.

4.6.2.3 Downstream Transit Durations

Three monitoring stations were installed downstream of Milford for the purposes of detecting radio-tagged adult shad following passage at the Project. Those receivers were Monitoring Stations S12, S13, and S31 located approximately 2.4, 9.5, and 13.2 km downstream of Milford Dam, respectively. Transit times for the reach between Milford and the first downstream Monitoring Station (S12) were calculated as the duration from time of passage at Milford until detection at S12. Transit times for the reaches between Monitoring Stations S12 and S13, and S13 to S31, were calculated as the duration between detection times at the two locations. The minimum, maximum, mean and median transit times through these three reaches are presented in Table 4.6-4. The majority of radio-tagged adult shad moved through each of the three reaches from the Milford tailrace downstream in less than four hours (Figure 4.6-10).

4.6.2.4 Passage Survival

The CJS model $S(t)p(.)$ provided the best fit for the observed mark-recapture data associated with downstream movements of radio-tagged adult American shad approaching Milford Dam (Table 4.6-5). The reach-specific survival estimates at Milford ranged between 1.00-0.830 among river reaches from upper impoundment to dam approach, dam approach to passage, passage to the first downstream receiver, and from the first to the second downstream receiver (Table 4.6-6). The detection efficiency for telemetry receivers at monitoring stations at the upper end of the Milford impoundment, approach, dam, and first and second downstream locations was estimated at 0.992 (SE = 0.0045; 95% CI = 0.976-0.997).

The CJS-derived survival estimates for the two Milford project reaches (dam approach to passage and passage to first downstream receiver) were 0.923 and 0.830 (Table 4.6-6), which resulted in an estimate of survival for the entire project reach (~200 meters upstream of the dam to the first downstream receiver) of 76.6% (75% CI = 71.1-82.2%). This estimate of downstream passage survival for adult American shad at Milford includes background mortality (i.e., natural mortality) for the species in the reach from the approach receiver to the first downstream receiver, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival (i.e., due solely to project effects) for adult American shad at Milford.

As noted in Section 4.6.2.2, examination of the time series of detections for 3 of the 90 radio-shad suggested that they were not alive upon entry into the Milford project area. When those three individuals are excluded from evaluation of total project survival at Milford, the estimate of survival for the entire project reach increases to 79.2% (75% CI = 73.5-83.9 %). That estimate is based upon reach specific survival estimates of 0.955 (SE = 0.022; 95% CI = 0.884-0.984) from the dam approach to passage and 0.830 (SE = 0.041; 95% CI = 0.734-0.987) from dam passage to the first downstream receiver.

Due to the limited numbers of individuals passing Milford via non-spill routes, CJS models were not constructed on a route-specific basis. However, it should be noted that all 53 radio-tagged adult shad passing Milford via spill were detected at each of the three downstream stations. Of the 15 shad determined to have passed Milford via the downstream bypass, only five were detected at any of the downstream monitoring stations. Of those, two were detected as far downstream as the second receiver, but neither was determined to have reached Eddington.

Table 4.6-2. Summary of the calculated forebay residence durations for radio-tagged adult American shad which approached and passed downstream at Milford, June-July 2017.

Shad ID	TL (mm)	Gender	Release Location	Release Date	Forebay Residence (hrs)	Adjusted Forebay Residence (hrs)
150.760 (20)	460	.	Costigan	6/13/2017	34.8	34.8
150.760 (22)	490	.	Costigan	6/13/2017	32.2	32.2
150.760 (23)	460	.	Costigan	6/13/2017	266.2	85.5
150.760 (24)	470	.	Costigan	6/13/2017	124.8	124.8
150.760 (25)	440	.	Costigan	6/13/2017	97.7	24.4
150.760 (26)	490	.	Costigan	6/13/2017	82.3	75.8
150.760 (27)	480	.	Costigan	6/13/2017	7.2	7.2
150.760 (28)	420	.	Costigan	6/13/2017	176.8	176.8
150.760 (30)	510	.	Costigan	6/13/2017	0.9	0.9
150.760 (45)	475	.	Costigan	6/13/2017	502.8	483.7
150.760 (46)	480	.	Costigan	6/13/2017	169.8	169.8
150.760 (47)	530	.	Costigan	6/13/2017	212.4	200.3
150.760 (49)	.	.	Costigan	6/13/2017	61.3	50.5
150.760 (51)	.	.	Costigan	6/13/2017	159.8	159.8
150.760 (53)	.	.	Costigan	6/13/2017	98.3	98.3
150.760 (56)	.	.	Costigan	6/13/2017	606.8	355.6
150.760 (57)	.	.	Costigan	6/13/2017	184.9	182.5
150.760 (68)	540	F	Costigan	6/21/2017	60.4	60.4
150.760 (72)	505	F	Old Town	6/16/2017	32.2	32.2
150.760 (79)	448	M	Old Town	6/16/2017	20.1	20.1
150.760 (91)	465	M	Old Town	6/16/2017	10.7	10.7
150.760 (108)	530	F	Costigan	6/20/2017	37.1	37.1
150.760 (109)	510	F	Costigan	6/20/2017	1.0	1.0
150.760 (110)	460	M	Costigan	6/20/2017	4.8	4.8
150.760 (111)	430	M	Costigan	6/20/2017	105.5	105.5
150.760 (112)	510	F	Costigan	6/20/2017	9.6	9.6
150.760 (113)	480	M	Costigan	6/20/2017	84.2	84.2
150.760 (115)	480	M	Costigan	6/20/2017	4.8	4.8
150.760 (116)	510	F	Costigan	6/20/2017	124.9	124.9
150.760 (118)	510	F	Costigan	6/20/2017	255.2	255.2
150.760 (119)	460	M	Costigan	6/20/2017	6.2	6.2
150.760 (120)	470	M	Costigan	6/20/2017	199.2	199.2
150.760 (133)	530	F	Costigan	6/20/2017	3.0	3.0
150.760 (134)	530	F	Costigan	6/20/2017	275.6	272.1
150.760 (136)	540	F	Costigan	6/20/2017	2.1	2.1
150.760 (137)	550	F	Costigan	6/20/2017	2.7	2.7
150.760 (141)	470	M	Costigan	6/20/2017	11.0	11.0
150.760 (142)	430	M	Costigan	6/20/2017	31.7	31.7

Shad ID	TL (mm)	Gender	Release Location	Release Date	Forebay Residence (hrs)	Adjusted Forebay Residence (hrs)
150.760 (143)	500	F	Costigan	6/20/2017	2.0	2.0
150.760 (144)	530	F	Costigan	6/20/2017	11.5	11.5
150.760 (190)	510	F	Costigan	6/20/2017	17.9	17.9
150.760 (191)	490	M	Costigan	6/20/2017	150.5	150.5
150.760 (194)	520	M	Costigan	6/20/2017	144.9	144.9
150.780 (20)	440	M	Costigan	6/21/2017	8.1	8.1
150.780 (23)	530	F	Costigan	6/21/2017	3.9	3.9
150.780 (24)	510	F	Costigan	6/21/2017	33.6	33.6
150.780 (26)	480	M	Costigan	6/21/2017	42.7	42.7
150.780 (27)	470	M	Costigan	6/21/2017	83.3	79.9
150.780 (28)	490	M	Costigan	6/21/2017	3.1	3.1
150.780 (29)	510	M	Costigan	6/21/2017	56.7	38.0
150.780 (31)	460	M	Costigan	6/21/2017	60.3	60.3
150.780 (33)	540	.	Costigan	6/13/2017	167.5	163.5
150.780 (34)	460	.	Costigan	6/13/2017	3.2	3.2
150.780 (35)	515	.	Costigan	6/13/2017	31.5	31.5
150.780 (36)	510	.	Costigan	6/13/2017	59.8	59.8
150.780 (37)	530	.	Costigan	6/13/2017	7.7	7.7
150.780 (40)	520	.	Costigan	6/13/2017	157.7	116.4
150.780 (41)	460	.	Costigan	6/13/2017	39.2	39.2
150.780 (43)	440	.	Costigan	6/13/2017	3.8	3.8
150.780 (44)	450	.	Costigan	6/13/2017	4.6	4.6
150.780 (58)	.	.	Costigan	6/13/2017	8.2	8.2
150.780 (63)	486	M	Old Town	6/16/2017	0.3	0.3
150.780 (71)	484	M	Old Town	6/16/2017	152.8	152.8
150.780 (121)	510	F	Costigan	6/20/2017	208.4	90.6
150.780 (122)	550	F	Costigan	6/20/2017	2.1	2.1
150.780 (125)	510	F	Costigan	6/20/2017	148.1	144.5
150.780 (127)	510	M	Costigan	6/20/2017	80.0	78.9
150.780 (130)	430	M	Costigan	6/20/2017	0.3	0.3
150.780 (131)	450	M	Costigan	6/20/2017	11.0	11.0
150.780 (145)	530	F	Costigan	6/20/2017	103.6	49.8
150.780 (146)	500	M	Costigan	6/20/2017	24.6	24.6
150.780 (147)	440	M	Costigan	6/20/2017	32.6	12.7
150.780 (148)	520	F	Costigan	6/20/2017	1.2	1.2
150.780 (149)	530	F	Costigan	6/20/2017	155.7	155.7
150.780 (151)	430	M	Costigan	6/20/2017	4.5	4.5
150.780 (152)	470	M	Costigan	6/20/2017	196.5	42.3
150.780 (153)	510	M	Costigan	6/20/2017	467.3	467.3
150.780 (154)	470	M	Costigan	6/20/2017	267.5	267.5
150.780 (156)	480	M	Costigan	6/20/2017	426.3	108.5
150.780 (158)	430	M	Costigan	6/20/2017	6.4	6.4
150.780 (164)	510	F	Costigan	6/20/2017	83.5	83.5

Table 4.6-3. Summary of downstream passage routes for radio-tagged adult American shad at Milford, June-July 2017.

Passage Route	Release Location			Percent Passage
	Costigan	Old Town	All	
Sluice Gate	48	4	52	57.8%
Obermeyer Gate	1	0	1	1.1%
Bypass Bay # 2	0	0	0	0.0%
Bypass Bay # 7	15	0	15	16.7%
Unknown	14	1	15	16.6%
Did not pass	7	0	7	7.8%
Total	**85**	**5**	**90**	**100.0%**

Table 4.6-4. Minimum, maximum, mean, and median transit times (hrs) for radio-tagged adult American shad moving through the Penobscot River downstream of Milford, June-July 2017.

River Reach	Release Location	Downstream Transit Times (hrs)				
		Minimum	Maximum	Mean	Median	n
Milford to Station S12	Costigan	0.5	15.9	3.5	1.5	63
	Old Town	1.0	3.4	2.3	2.9	5
	All	0.5	15.9	3.4	1.5	68
Station S12 to Station S13	Costigan	1.0	43.5	2.9	1.5	63
	Old Town	1.0	7.1	2.5	1.4	5
	All	1.0	43.5	2.9	1.5	68
Station S13 to Station S31	Costigan	0.4	8.0	1.1	0.6	61
	Old Town	0.4	12.7	3.8	0.7	5
	All	0.4	12.7	1.3	0.6	66

Table 4.6-5. CJS model selection criteria for the 2017 adult American shad passage at Milford.

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
S(t)*p*(.)	185.846	0.000	0.605	1.000	4	4.044
S(t)*p*(t)	186.698	0.852	0.395	0.653	6	0.804
S(.)*p*(.)	225.216	39.370	0.000	0.000	2	47.472
S(.)*p*(t)	225.893	40.047	0.000	0.000	4	44.091

Table 4.6-6. Milford reach-specific survival probability estimates (S), standard errors and likelihood 75 and 95% confidence intervals for radio-tagged adult American shad approaching the project, June-July, 2017.

Parameter	Reach	Reach Length (km)	*S*	SE	95% CI		75% CI	
S_1	S4 to S5	3.5	1.000	0.000	-	-	-	-
S_2	S5 to Milford	0.3	0.923	0.028	0.846	0.964	0.884	0.950
S_3	Milford to S12	2.4	0.830	0.041	0.734	0.897	0.777	0.873
S_4	S12 to S13	7.1	1.000	0.000	-	-	-	-

S4 = Upper Milford impoundment

S5 = Approach to Milford Dam

S12 = First detection station downstream of Milford

S13 = Second detection station downstream of Milford

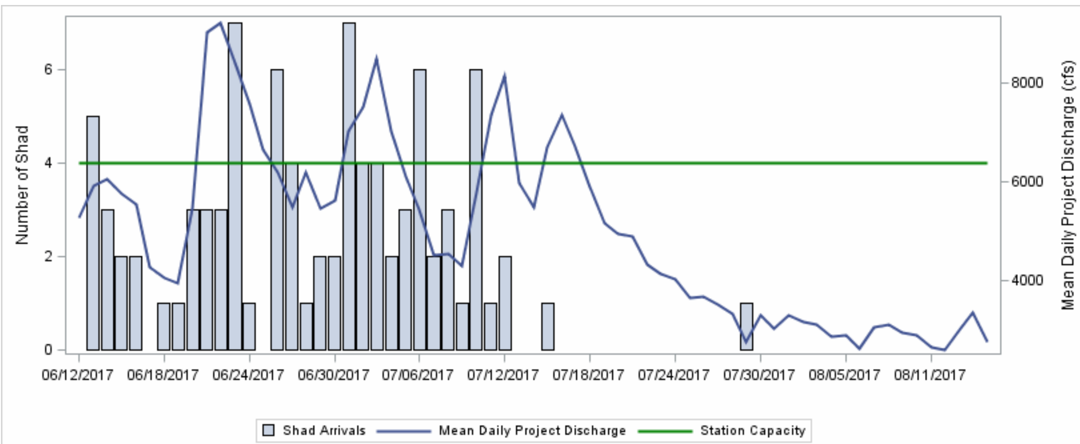

Figure 4.6-4. Distribution of return dates for radio-tagged shad approaching the Milford dam during their downstream migration. Station discharge (cfs) included for reference.

Figure 4.6-5. Telemetry detection time series for radio-tagged shad 150.760 (28). Red indicates release, orange indicates mainstem detections upstream of Milford, blue indicates mainstem detections immediately downstream of Milford and purple indicates mainstem detections at downstream detection locations.

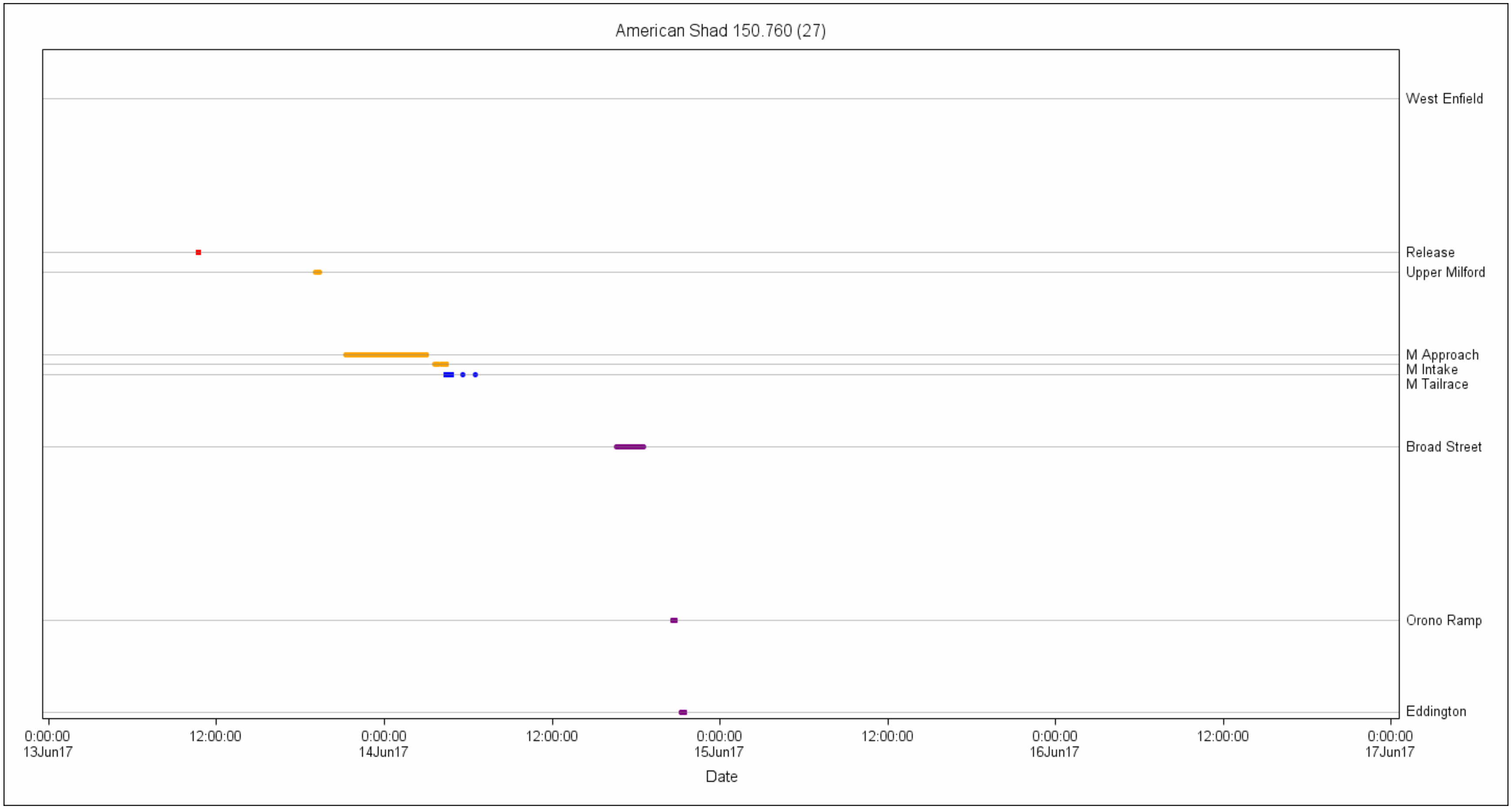

Figure 4.6-6. Telemetry detection time series for radio-tagged shad 150.760 (27). Red indicates release, orange indicates mainstem detections upstream of Milford, blue indicates mainstem detections immediately downstream of Milford and purple indicates mainstem detections at downstream detection locations.

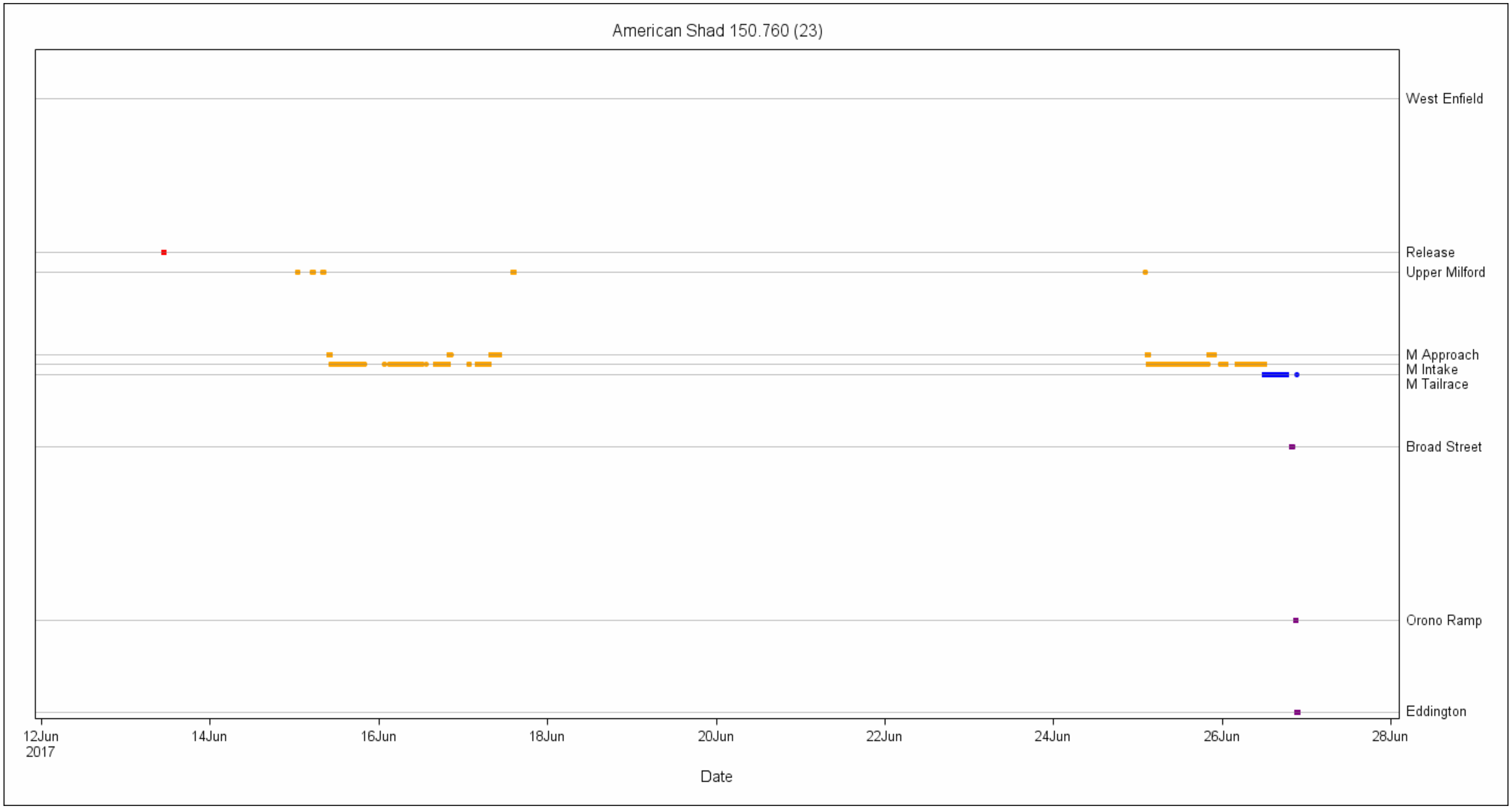

Figure 4.6-7. Telemetry detection time series for radio-tagged shad 150.760 (23). Red indicates release, orange indicates mainstem detections upstream of Milford, blue indicates mainstem detections immediately downstream of Milford and purple indicates mainstem detections at downstream detection locations.

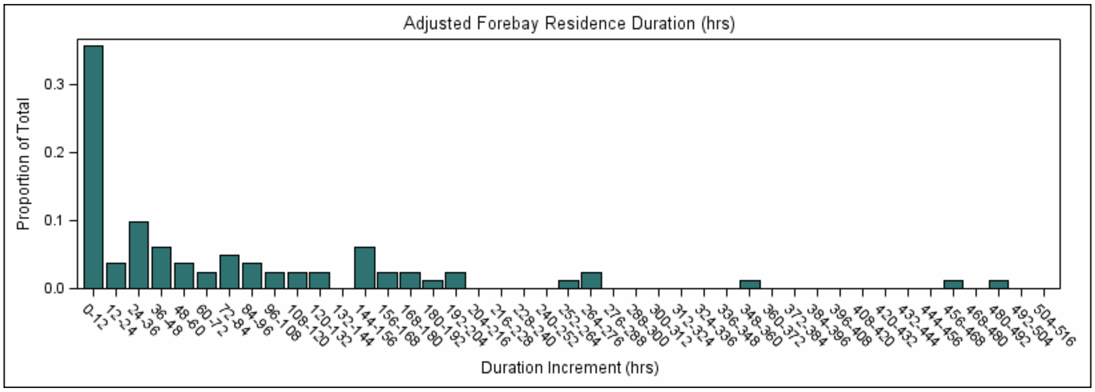

Figure 4.6-8. Frequency distribution of adjusted forebay residence duration prior to downstream passage for radio-tagged adult American shad at Milford, June-July 2017.

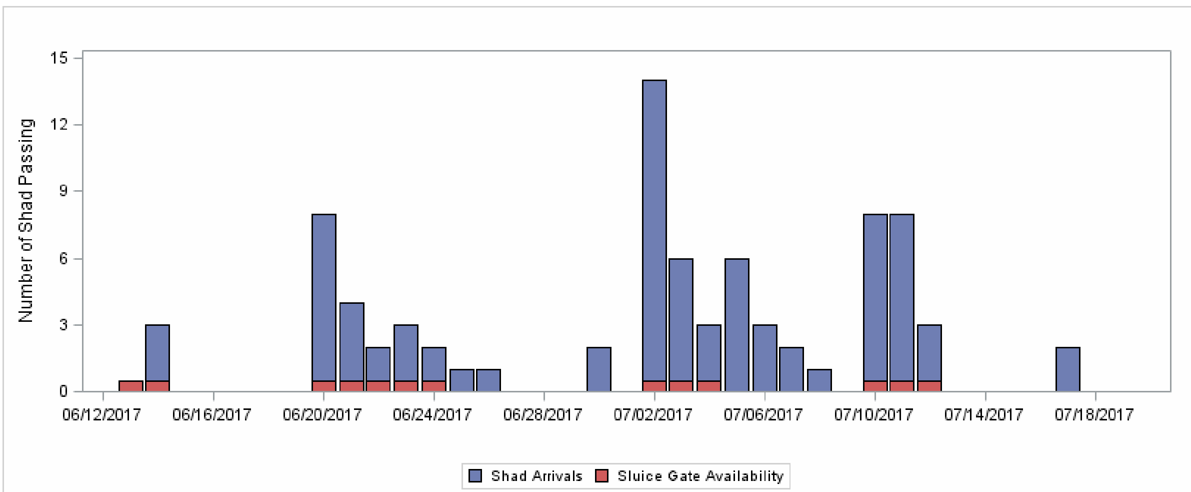

Figure 4.6-9. Distribution of downstream passage dates for radio-tagged shad at Milford, June-July 2017. Dates with sluice gate operation are highlighted.

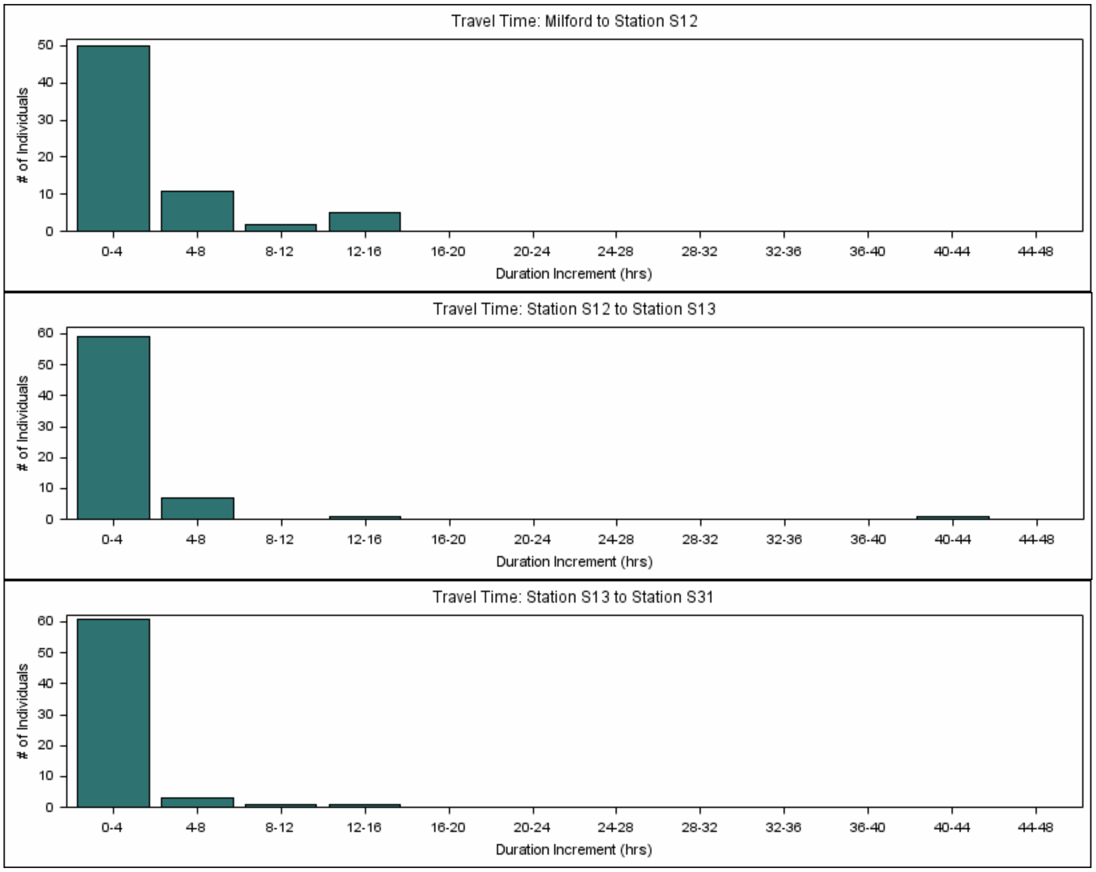

Figure 4.6-10. Frequency distribution of travel times for radio-tagged adult American shad through three defined sections of the Penobscot River located downstream of Milford, June-July 2017.

4.6.3 Stillwater

A total of 50 radio-tagged adult American shad were released at the Old Town Water District property for the purpose of evaluating downstream passage at Stillwater. Of that total, fourteen individuals were not detected at Monitoring Station S15 indicating that they did not approach Stillwater Dam. Of that subtotal, four individuals were determined to have passed upstream of Gilman Falls and out of the Stillwater Branch (prior to downstream passage at Milford), six individuals went undetected at all stationary receivers, as well as during manual tracking events, and the remaining four were limited to detections at receivers upstream of Monitoring Station S15 and manual detections. In addition to the four individuals who did not approach Stillwater prior to ascending the Stillwater Branch and entering the mainstem upstream of Milford Dam, one additional radio-tagged adult shad (following a period of residence just upstream of Stillwater Dam) also departed the Stillwater Branch and eventually passed downstream via Milford. Downstream passage for those five individuals was included in Section 4.6.2. The 35 radio-tagged adult American shad released at the Old Town Water District property and determined to have subsequently approached Stillwater were supplemented by an additional thirteen individuals originally released at the Costigan boat ramp which subsequently moved into the Stillwater Branch. As a result, a total of 48 radio-tagged adult shad approached Stillwater and had the opportunity to pass downstream. Residence time, downstream passage route, and passage survival for this group of adult shad are presented in the following sub-sections.

4.6.3.1 Project Returns and Forebay Residence Duration

Figure 4.6-11 presents the distribution of returns for radio-tagged adult American shad to the area upstream of Stillwater Dam (as determined by initial detection at the approach receiver – Monitoring Station S15) during 2017. Radio-tagged shad returned to Stillwater between the dates of June 14 and July 24, 2017, with the majority returning June 16-19, which corresponded to the days immediately following release into the study reach.

A forebay residency duration was determined for all individuals which approached and passed downstream of Stillwater and was calculated as the duration of time from initial detection at the approach to the dam area (i.e., Monitoring Station S15) until confirmed passage at one of the available downstream passage routes (Table 4.6-7). Information was available to calculate a forebay residency time for 46 of the 48 radio-tagged shad which approached Stillwater[3]. When those individuals are considered, forebay residence duration from initial approach detection until downstream passage at Stillwater ranged between 0.4 hours and 413.9 hours (mean = 133.7 hours; median = 112.7 hours).

[3] A forebay residency time was not calculated for two individuals who were determined to have approached Stillwater but did not successfully pass the project.

The majority of radio-tagged shad (30 of 48) which approached Stillwater were determined to have moved back upstream for one or more periods of time following their initial detection in the dam area, as evidenced by detections at the upper end of the Stillwater impoundment (i.e., Monitoring Station S14; see example time series for fish 150.760 (74) in Figure 4.6-12 and for fish 150.760 (85) in Figure 4.6-13). The forebay residence time for all individuals was adjusted to reflect these periods of time away from the immediate dam area. When the adjusted forebay residence durations are considered, duration for all radio-tagged individuals upstream of Stillwater ranged between 0.4 hours and 355.8 hours (mean = 84.6 hours; median = 51.6 hours; Table 4.6-7). Approximately 35% of radio-tagged shad passed downstream of Stillwater within 24 hours of initial approach detection, and 43% had done so within 48 hours of initial detection (Figure 4.6-14).

4.6.3.2 Downstream Passage

Passage routes for the 48 radio-tagged adult shad detected immediately upstream of Stillwater Dam are presented in Table 4.6-8. The vast majority of individuals (43 of 48; 90%) passed downstream of Stillwater via the downstream bypass associated with powerhouse B. Lesser numbers of shad used the downstream bypass at powerhouse A (2 of 48; 4%), and a single individual was determined to have passed via the turbine units at powerhouse A. Figure 4.6-14 provides the distribution of passage dates for radio-tagged shad at Stillwater. Individuals were recorded passing downstream of Stillwater Dam between the dates of June 16 and July 24. Peaks in downstream passage events coincided with dates with increases in mean daily discharge (Figure 4.6-15).

There were two individuals which approached Stillwater but did not pass downstream. Both of these individuals departed to points upstream of the Stillwater Dam area and did not return during the monitoring period. One of the two individuals was determined to have become stationary in the vicinity of Gilman Falls, and likely represented either a regurgitated transmitter or a natural mortality.

4.6.3.3 Downstream Transit Durations

Two monitoring stations were installed downstream of Stillwater Dam for the purpose of detecting radio-tagged adult shad following passage at the Project. Those receivers were located approximately 1.6 (Monitoring Station S23) and 3.9 (Monitoring Station S24) km downstream of Stillwater Dam. Transit times for the reach between Stillwater and the first downstream Monitoring Station (S23) were calculated as the duration from time of passage at Stillwater Dam until detection at S23. Transit times for the reach between Monitoring Stations S23 and S24 were calculated as the duration between initial detection at both locations. The minimum, maximum, mean and median transit times through these two reaches are presented in Table 4.6-9. The majority of radio-tagged shad moved through the reaches from Stillwater to Monitoring Station S23 (96%) and from S23 to S24 (84%) in less than four hours (Figure 4.6-16).

4.6.3.4 Passage Survival

The CJS model *S*(t)*p*(t) provided the best fit for the observed mark-recapture data associated with downstream movements of radio-tagged adult American shad approaching Stillwater Dam (Table 4.6-10). The reach-specific survival estimates at Stillwater ranged between 1.00-0.958 among river reaches from release to dam approach, dam approach to passage, and passage to the first downstream receiver (Table 4.6-11). Detection efficiency varied among detection locations, ranging between 97.8-100.0% (Table 4.6-12).

The CJS-derived survival estimates for the two Stillwater project reaches (dam approach to passage and passage to first downstream receiver) were 0.958 and 1.000 (Table 4.6-11), which resulted in an estimate of survival for the entire project reach (~200 meters upstream of the dam to the first downstream receiver) of 95.8% (75% CI = 91.7-97.9%). This estimate of downstream passage for adult American shad at Stillwater includes background mortality for the species in the reach from the approach receiver to the first downstream receiver, along with any tagging-related mortalities or transmitter regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival for adult American shad at Stillwater.

A review of downstream detections for radio-tagged shad passing Stillwater Dam indicated that all survived. Losses at the project were attributed to individuals whom were initially detected within the dam area, but failed to pass downstream.

Table 4.6-7. Summary of the calculated forebay residence durations for radio-tagged adult American shad which approached and passed downstream at Stillwater, June-July 2017.

Shad ID	TL (mm)	Gender	Release Location	Release Date	Forebay Residence (hrs)	Adjusted Forebay Residence (hrs)
150.760 (29)	520	.	Costigan	6/13/2017	48.7	48.7
150.760 (52)	.	.	Costigan	6/13/2017	133.3	51.0
150.760 (54)	.	.	Costigan	6/13/2017	197.1	107.8
150.760 (55)	534	F	Old Town	6/16/2017	236.7	182.0
150.760 (66)	500	M	Costigan	6/21/2017	0.4	0.4
150.760 (67)	530	F	Costigan	6/21/2017	1.4	1.4
150.760 (73)	505	F	Old Town	6/16/2017	26.5	6.4
150.760 (74)	446	M	Old Town	6/16/2017	298.6	165.5
150.760 (75)	556	F	Old Town	6/16/2017	139.2	139.2
150.760 (76)	514	F	Old Town	6/16/2017	308.5	290.5
150.760 (77)	509	F	Old Town	6/16/2017	45.1	19.8
150.760 (78)	535	F	Old Town	6/16/2017	364.4	249.8
150.760 (80)	479	M	Old Town	6/16/2017	257.4	194.1
150.760 (81)	530	F	Old Town	6/16/2017	22.0	22.0
150.760 (82)	504	F	Old Town	6/16/2017	207.5	187.0
150.760 (85)	505	F	Old Town	6/16/2017	222.7	60.4
150.760 (86)	470	M	Old Town	6/16/2017	124.4	123.6
150.760 (87)	441	M	Old Town	6/16/2017	132.2	132.2
150.760 (88)	478	M	Old Town	6/16/2017	332.4	331.1
150.760 (90)	515	F	Old Town	6/16/2017	110.2	68.0
150.760 (94)	461	M	Old Town	6/16/2017	5.5	5.5
150.760 (95)	521	F	Old Town	6/16/2017	115.2	52.2
150.760 (114)	490	M	Costigan	6/20/2017	48.3	48.3
150.760 (135)	460	M	Costigan	6/20/2017	3.7	3.7
150.760 (140)	500	F	Costigan	6/20/2017	43.5	41.0
150.760 (192)	530	F	Costigan	6/20/2017	0.4	0.4
150.780 (32)	550	.	Costigan	6/13/2017	45.8	45.8
150.780 (59)	480	M	Old Town	6/16/2017	123.3	24.1
150.780 (60)	491	F	Old Town	6/16/2017	50.7	46.7
150.780 (61)	516	F	Old Town	6/16/2017	98.4	12.9
150.780 (64)	445	M	Old Town	6/16/2017	277.2	58.8
150.780 (65)	464	F	Old Town	6/16/2017	86.6	79.5
150.780 (67)	480	F	Old Town	6/16/2017	139.4	68.7
150.780 (68)	378	M	Old Town	6/16/2017	281.5	163.8
150.780 (69)	501	F	Old Town	6/16/2017	281.0	88.6
150.780 (96)	442	M	Old Town	6/16/2017	389.3	355.8

Shad ID	TL (mm)	Gender	Release Location	Release Date	Forebay Residence (hrs)	Adjusted Forebay Residence (hrs)
150.780 (98)	474	M	Old Town	6/16/2017	0.7	0.7
150.780 (100)	511	F	Old Town	6/16/2017	23.8	23.8
150.780 (101)	414	M	Old Town	6/16/2017	131.1	72.2
150.780 (103)	474	M	Old Town	6/16/2017	28.0	8.7
150.780 (104)	488	F	Old Town	6/16/2017	212.2	136.8
150.780 (105)	458	M	Old Town	6/16/2017	413.9	126.6
150.780 (106)	452	M	Old Town	6/16/2017	103.7	7.9
150.780 (126)	510	F	Costigan	6/20/2017	16.9	16.9
150.780 (128)	440	M	Costigan	6/20/2017	1.5	1.5
150.780 (150)	470	M	Costigan	6/20/2017	21.6	21.6

Table 4.6-8. Summary of downstream passage routes for radio-tagged adult American shad at Stillwater, June-July 2017.

Passage Route	Release Location			Percent Passage
	Costigan	Old Town	All	
Turbines - A	1	0	1	2.1%
Bypass - A	1	1	2	4.2%
Turbines - B	0	0	0	0.0%
Bypass - B	11	32	43	89.6%
Spill	0	0	0	0.0%
Did not pass	0	2	2	4.2%
Total	**13**	**35**	**48**	**100.0%**

Table 4.6-9. Minimum, maximum, mean, and median transit times (hrs) for radio-tagged adult American shad moving through the Stillwater Branch of the Penobscot River downstream of Stillwater, June-July 2017.

River Reach	Release Location	Downstream Transit Times (hrs)				
		Minimum	Maximum	Mean	Median	n
Stillwater to Station S23	Costigan	0.3	4.4	1.2	0.9	12
	Old Town	0.3	6.0	1.3	1.1	33
	All	0.3	6.0	1.3	0.9	45
Station S23 to Station S24	Costigan	0.2	22.7	4.6	1.1	12
	Old Town	0.5	165.4	7.5	1.1	33
	All	0.2	165.4	6.8	1.1	45

Table 4.6-10. CJS model selection criteria for the 2017 adult American shad passage at Stillwater.

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
S(t)*p*(t)	30.328	0.000	0.755	1.000	2	0.000
S(t)*p*(.)	33.139	2.811	0.185	0.245	2	2.811
S(.)*p*(t)	35.852	5.524	0.048	0.063	2	5.524
S(.)*p*(.)	38.642	8.313	0.012	0.016	2	8.313

Table 4.6-11. Stillwater reach-specific survival probability estimates (S), standard errors and likelihood 75 and 95% confidence intervals for radio-tagged adult American shad approaching the project, June-July, 2017.

Parameter	Reach	Reach Length (km)	*S*	SE	95% CI		75% CI	
S_1	Release to S15	1.4	1.000	0.000	-	-	-	-
S_2	S15 to Stillwater	0.3	0.958	0.029	0.848	0.990	0.909	0.981
S_3	Stillwater to S23	1.6	1.000	0.000	-	-	-	-

S15 = Approach to Stillwater Dam

S23 = First detection station downstream of Stillwater

Table 4.6-12. Detection efficiency estimates for monitoring locations installed to detect radio-tagged adult American shad at Stillwater for evaluation of downstream passage, June-July 2017.

Parameter	Location	*p*	SE	95% CI		75% CI	
p_1	SW Approach	1.000	0.000	-	-	-	-
p_2	Stillwater	1.000	0.000	-	-	-	-
p_3	SW - DS #1	0.978	0.022	0.861	0.997	0.934	0.993

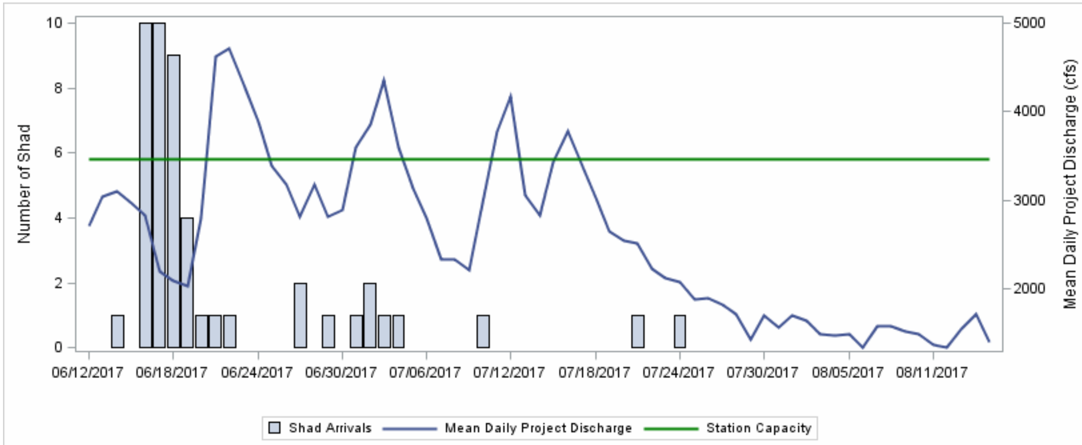

Figure 4.6-11. Distribution of return dates for radio-tagged shad approaching the Stillwater dam during their downstream migration. Station discharge (cfs) included for reference.

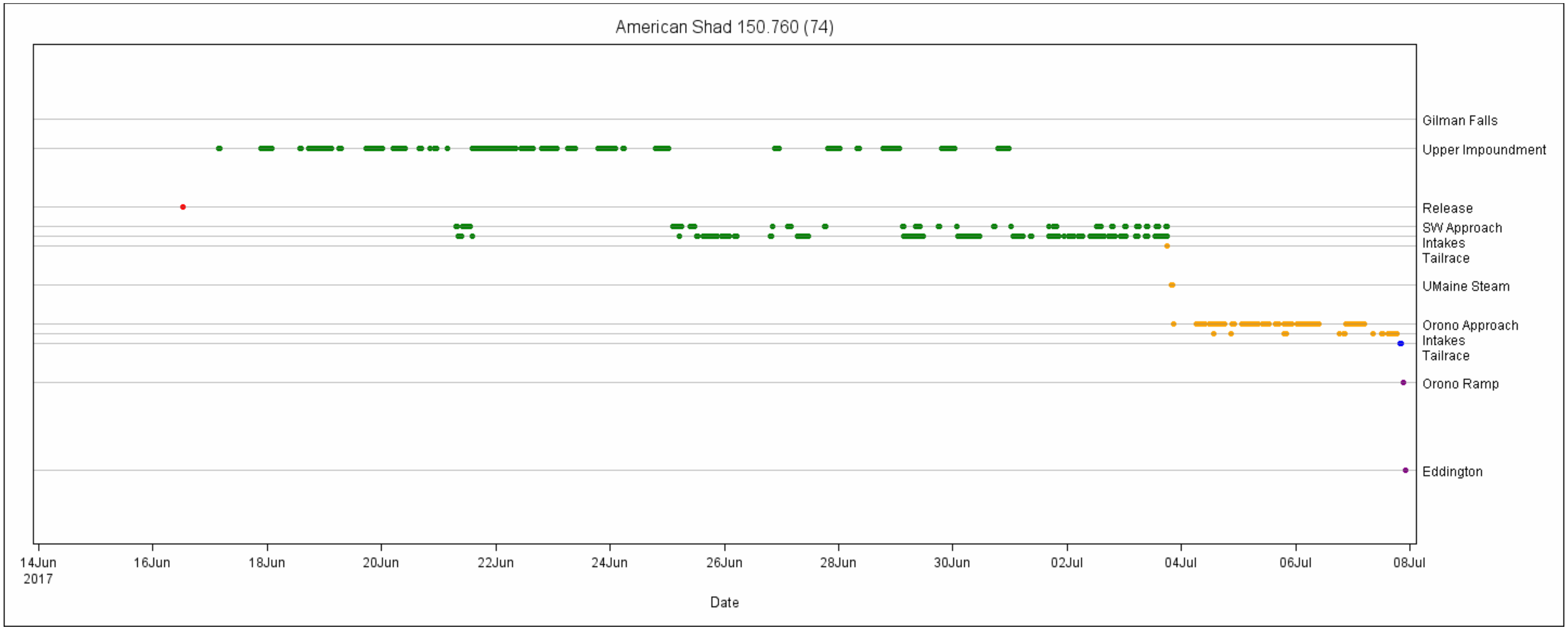

Figure 4.6-12. Telemetry detection time series for radio-tagged shad 150.760 (74). Red indicates release, green indicates detections upstream of Stillwater, orange indicates detections between Stillwater and Orono, blue indicates detections downstream of Orono and purple indicates detections at the mainstem downstream detection locations.

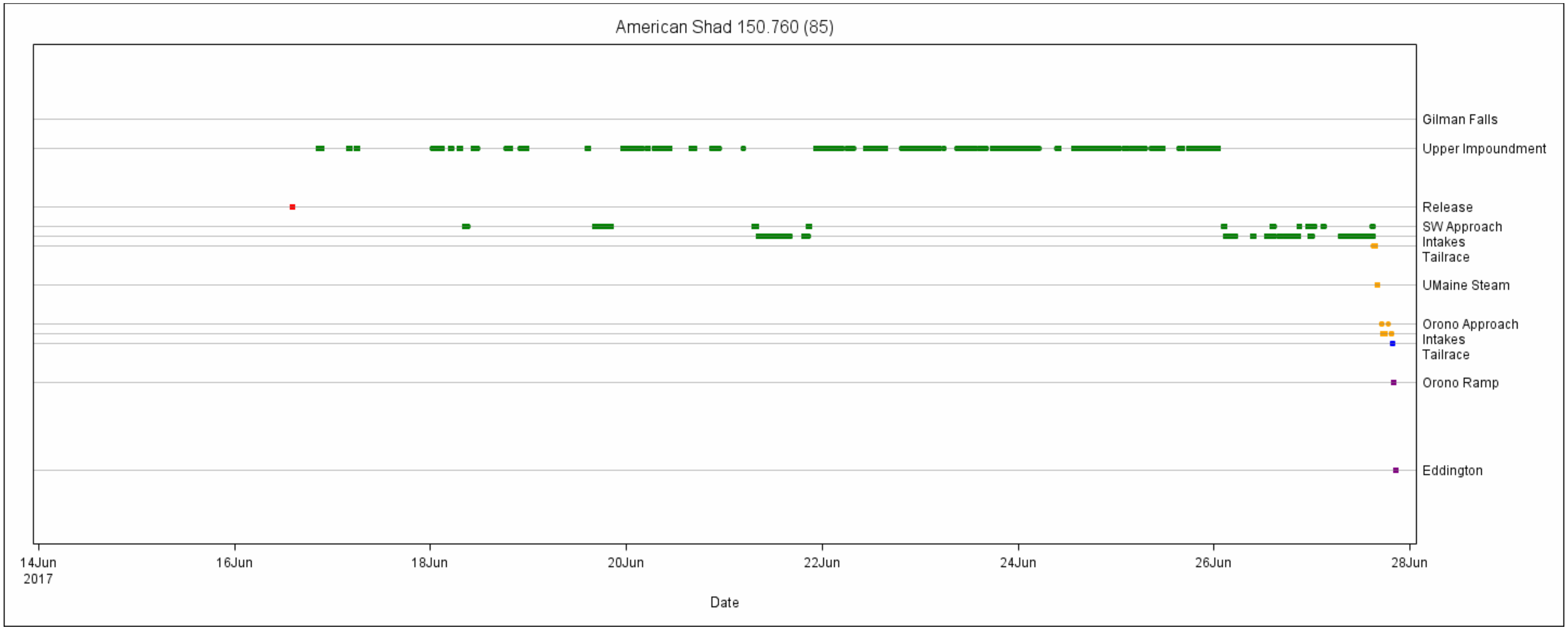

Figure 4.6-13. Telemetry detection time series for radio-tagged shad 150.760 (85). Red indicates release, green indicates detections upstream of Stillwater, orange indicates detections between Stillwater and Orono, blue indicates detections downstream of Orono and purple indicates detections at the mainstem downstream detection locations.

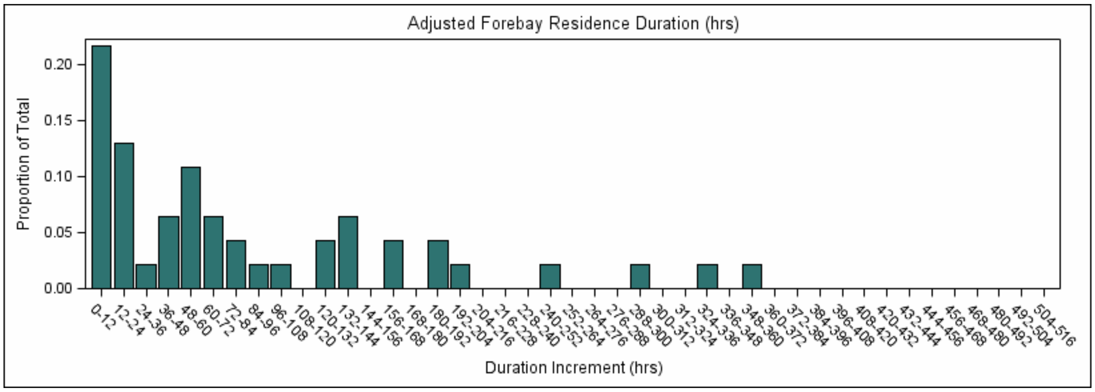

Figure 4.6-14. Frequency distribution of adjusted forebay residence duration prior to downstream passage for radio-tagged adult American shad at Stillwater, June-July 2017.

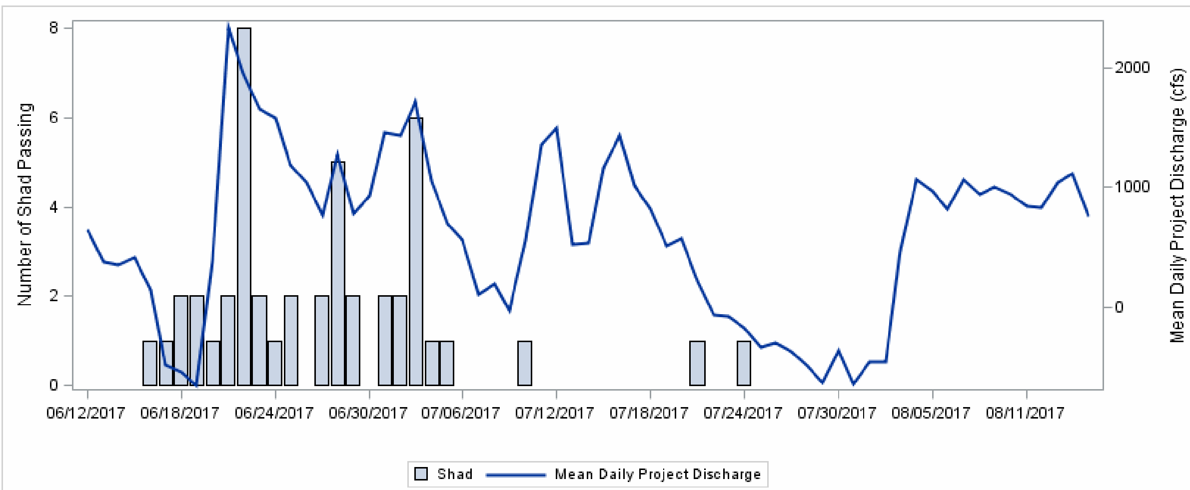

Figure 4.6-15. Distribution of downstream passage dates for radio-tagged shad at Stillwater, June-July 2017.

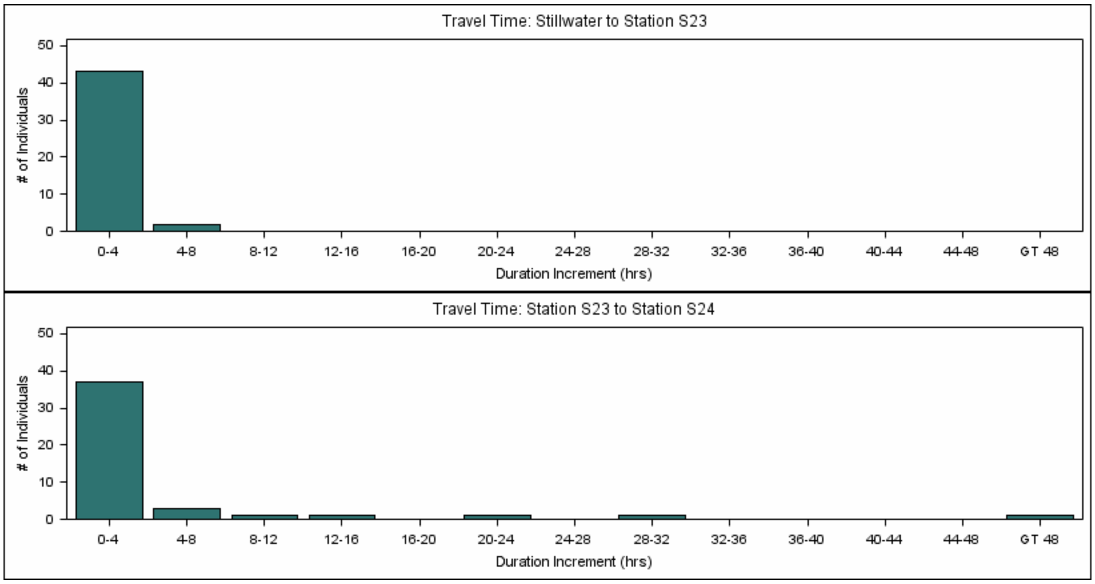

Figure 4.6-16. Frequency distribution of travel times for radio-tagged adult American shad through two defined sections of the Stillwater Branch of the Penobscot River located downstream of Stillwater, June-July 2017.

4.6.4 Orono

A total of 50 radio-tagged adult American shad were released at the University of Maine boat launch for the purpose of evaluating downstream passage at Orono. Of that total, two individuals were not detected at Monitoring Station S24 indicating that they did not approach Orono Dam. Detections for these two individuals were limited to stationary locations upstream of the dam, as well as manual detections during study tracking events. The 48 radio-tagged adult American shad released at the University of Maine boat launch and determined to have subsequently approached Orono were supplemented by an additional 46 shad that successfully passed Stillwater Dam, thirteen originally released at the Costigan boat ramp (which subsequently moved into the Stillwater Branch) and 33 originally released at the Old Town Water District property. As a result, a total of 94 radio-tagged adult shad approached Orono and had the opportunity to pass downstream. Residence time, downstream passage route, and passage survival for this group of adult shad are presented in the following sub-sections.

4.6.4.1 Project Returns and Forebay Residence Duration

Figure 4.6-17 presents the distribution of returns for radio-tagged adult American shad to the area upstream of Orono Dam (as determined by initial detection at the approach receiver – Monitoring Station S24) during 2017. Radio-tagged shad returned to Orono between the dates of June 16 and July 25, 2017. The majority of individuals approached Orono on June 21 and 22, which corresponded to the days immediately following release into the study reach.

A forebay residency duration was determined for all individuals which approached and passed downstream of Orono Dam and was calculated as the duration of time from initial detection at the approach to the dam area (i.e., Monitoring Station S24) until confirmed passage at one of the available downstream passage routes (Table 4.6-13). Information was available to calculate a forebay residency time for 89 of the 94 radio-tagged shad which approached Orono[4]. When those individuals are considered, forebay residence duration from initial approach detection until downstream passage at Orono ranged between 0.3 hours and 360.9 hours (mean = 72.7 hours; median = 37.4 hours).

The majority of radio-tagged shad (55 of 94) which approached Orono were determined to have moved back upstream for one or more periods of time following their initial detection in the dam area as evidenced by detections at Monitoring Station 23, which was located in the vicinity of the University of Maine boat launch release site (see example time series for fish 150.760 (199) in Figure 4.6-18 and for fish 150.780 (167) in Figure 4.6-19). The forebay residence time for all individuals was adjusted to reflect these periods of time away from the immediate dam area. When the adjusted forebay residence durations are considered,

[4] A forebay residency time was not calculated for five individuals who were determined to have approached Orono but did not successfully pass the project.

duration for all radio-tagged individuals upstream of Orono Dam ranged between 0.3 hours and 161.6 hours (mean = 31.1 hours; median = 18.5 hours; Table 4.6-13). Approximately 60% of radio-tagged shad passed downstream of Orono within 24 hours of initial approach detection and 80% had done so within 48 hours of initial detection (Figure 4.6-20).

4.6.4.2 Downstream Passage

Passage routes for the 94 radio-tagged adult shad detected immediately upstream of Orono Dam are presented in Table 4.6-14. The majority of individuals (87 of 94; 93%) passed downstream of Orono via the downstream bypass. Two individuals were confirmed to have passed the dam, but a passage route could not be clearly determined. Individuals passed downstream of the dam between the dates of June 18 and July 28. The majority of radio-tagged adult shad passing Orono did so by July 7th (Figure 4.6-21).

There were five individuals which approached Orono but did not pass downstream. Of that total, two showed a pattern of detection at the Orono approach receiver followed by a prolonged period of weak signal strength detections at the Orono downstream bypass receiver, which may suggest that these individuals died upriver and drifted downstream into the rack area at the entrance to the powerhouse B penstock. Manual detections during the study period confirmed the presence of these transmitters in the intake rack area. Two of the five shad showed a pattern of movement between the approach and intake receivers for a period of time following initial detection, suggesting they either died or regurgitated their transmitter at some point while in the project area. The last individual was only detected at the approach receiver, where it remained stationary for the duration of the study.

4.6.4.3 Downstream Transit Durations

Two monitoring stations were installed downstream of Orono Dam for the purpose of detecting radio-tagged adult shad following passage at the Orono Project. Those receivers were located approximately 1.8 (Monitoring Station S13) and 5.5 (Monitoring Station S31) km downstream of Orono Dam. Transit times for the reach between Orono Dam and the first downstream Monitoring Station (S13) were calculated as the duration from time of passage at Orono until detection at S13. Transit times for the reach between Monitoring Stations S13 and S31 were calculated as the duration between detections at both locations. The minimum, maximum, mean and median transit times through these two reaches are presented in Table 4.6-15. The majority of radio-tagged adult shad passing Orono moved through the reaches from the dam to Monitoring Station S13 (73%) and from S13 to S31 (87%) in less than four hours (Figure 4.6-22).

4.6.4.4 Passage Survival

The CJS model $S(\mathrm{t})p(\mathrm{t})$ provided the best fit for the observed mark-recapture data associated with downstream movements of radio-tagged adult American shad approaching Orono Dam (Table 4.6-16). The reach-specific survival estimates at Orono ranged between 1.00-

0.890 among river reaches from release to dam approach, dam approach to passage, and passage to the first downstream receiver (Table 4.6-17). Detection efficiency varied among detection locations, ranging between 98.7-100.0% (Table 4.6-18).

The CJS-derived survival estimates for the two Orono project reaches (dam approach to passage and passage to first downstream receiver) were 0.947 and 0.890 (Table 4.6-16), which resulted in an estimate of survival for the entire project reach (~200 meters upstream of the dam to the first downstream receiver) of 84.3% (75% CI = 79.8-88.3%). This estimate of downstream passage for adult American shad at Orono includes background mortality for the species in the reach from the approach receiver to the first downstream receiver, plus any tagging-related mortalities or transmitter regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival for adult American shad at Orono.

As noted in Section 4.6.4.2, examination of the time series of detections for 3 of the 94 radio-shad may suggest that they were not alive upon entry into the Orono dam area. When those three individuals are excluded from evaluation of total project survival at Orono, the estimate of survival for the entire project reach increases to 87.0% (75% CI = 82.4-91.2%). That estimate is based upon reach specific survival estimates of 0.978 (SE = 0.015; 95% CI = 0.916-0.994) from the dam approach to passage, and 0.890 (SE = 0.033; 95% CI = 0.804-0.938) from dam passage to the first downstream receiver.

A review of downstream detections for all radio-tagged shad passing Orono Dam indicated that nine of the 87 shad passing via the downstream bypass were undetected at the downstream stations.

Table 4.6-13. Summary of the calculated forebay residence durations for radio-tagged adult American shad which approached and passed downstream at Orono, June-July 2017.

Shad ID	TL (mm)	Gender	Release Location	Release Date	Forebay Residence (hrs)	Adjusted Forebay Residence (hrs)
150.760 (29)	520	.	Costigan	6/13/2017	6.7	2.1
150.760 (32)	440	M	U. Maine	6/20/2017	75.5	51.7
150.760 (33)	550	F	U. Maine	6/20/2017	8.9	8.9
150.760 (34)	540	F	U. Maine	6/20/2017	9.8	9.8
150.760 (35)	550	F	U. Maine	6/20/2017	12.7	12.7
150.760 (36)	540	F	U. Maine	6/20/2017	77.9	60.4
150.760 (37)	560	F	U. Maine	6/20/2017	46.3	38.4
150.760 (38)	410	M	U. Maine	6/20/2017	10.0	1.6
150.760 (39)	420	M	U. Maine	6/20/2017	37.5	16.7
150.760 (40)	490	F	U. Maine	6/20/2017	222.0	125.0
150.760 (41)	520	F	U. Maine	6/20/2017	115.0	18.5
150.760 (42)	540	F	U. Maine	6/20/2017	2.6	2.6
150.760 (43)	530	F	U. Maine	6/20/2017	15.1	15.1
150.760 (44)	460	M	U. Maine	6/20/2017	33.9	30.5
150.760 (52)	.	.	Costigan	6/13/2017	23.6	23.5
150.760 (54)	.	.	Costigan	6/13/2017	15.9	9.6
150.760 (55)	534	F	Old Town	6/16/2017	47.5	39.8
150.760 (58)	480	M	U. Maine	6/20/2017	301.5	58.5
150.760 (59)	450	M	U. Maine	6/20/2017	355.7	36.7
150.760 (60)	520	M	U. Maine	6/20/2017	120.7	2.5
150.760 (61)	450	F	U. Maine	6/20/2017	16.2	14.7
150.760 (62)	460	F	U. Maine	6/20/2017	4.7	4.7
150.760 (63)	500	F	U. Maine	6/20/2017	104.2	103.0
150.760 (64)	510	F	U. Maine	6/20/2017	336.7	69.6
150.760 (65)	470	M	U. Maine	6/20/2017	18.9	14.0
150.760 (66)	500	M	Costigan	6/21/2017	0.7	0.7
150.760 (73)	505	F	Old Town	6/16/2017	20.1	1.8
150.760 (74)	446	M	Old Town	6/16/2017	93.7	93.7
150.760 (75)	556	F	Old Town	6/16/2017	5.9	5.9
150.760 (76)	514	F	Old Town	6/16/2017	18.3	13.1
150.760 (77)	509	F	Old Town	6/16/2017	171.9	140.7
150.760 (78)	535	F	Old Town	6/16/2017	0.4	0.4
150.760 (80)	479	M	Old Town	6/16/2017	1.0	1.0
150.760 (81)	530	F	Old Town	6/16/2017	23.3	23.3
150.760 (82)	504	F	Old Town	6/16/2017	0.3	0.3
150.760 (85)	505	F	Old Town	6/16/2017	2.5	2.5
150.760 (86)	470	M	Old Town	6/16/2017	6.6	6.2
150.760 (87)	441	M	Old Town	6/16/2017	31.1	31.1
150.760 (88)	478	M	Old Town	6/16/2017	27.1	27.1
150.760 (90)	515	F	Old Town	6/16/2017	0.8	0.8
150.760 (95)	521	F	Old Town	6/16/2017	256.1	51.9

Shad ID	TL (mm)	Gender	Release Location	Release Date	Forebay Residence (hrs)	Adjusted Forebay Residence (hrs)
150.760 (114)	490	M	Costigan	6/20/2017	10.8	10.8
150.760 (135)	460	M	Costigan	6/20/2017	0.6	0.6
150.760 (140)	500	F	Costigan	6/20/2017	16.8	16.8
150.760 (196)	540	F	U. Maine	6/20/2017	18.4	18.4
150.760 (197)	500	M	U. Maine	6/20/2017	0.4	0.4
150.760 (199)	490	M	U. Maine	6/20/2017	162.2	38.5
150.780 (32)	550	.	Costigan	6/13/2017	20.0	20.0
150.780 (59)	480	M	Old Town	6/16/2017	15.1	15.1
150.780 (60)	491	F	Old Town	6/16/2017	1.3	1.3
150.780 (61)	516	F	Old Town	6/16/2017	21.2	19.7
150.780 (64)	445	M	Old Town	6/16/2017	0.7	0.7
150.780 (65)	464	F	Old Town	6/16/2017	6.4	6.1
150.780 (67)	480	F	Old Town	6/16/2017	6.3	6.3
150.780 (68)	378	M	Old Town	6/16/2017	37.8	37.8
150.780 (69)	501	F	Old Town	6/16/2017	96.2	22.3
150.780 (96)	442	M	Old Town	6/16/2017	81.4	67.7
150.780 (98)	474	M	Old Town	6/16/2017	44.3	44.3
150.780 (100)	511	F	Old Town	6/16/2017	90.7	43.3
150.780 (101)	414	M	Old Town	6/16/2017	37.4	36.0
150.780 (103)	474	M	Old Town	6/16/2017	1.0	1.0
150.780 (104)	488	F	Old Town	6/16/2017	24.5	22.9
150.780 (105)	458	M	Old Town	6/16/2017	42.6	42.6
150.780 (106)	452	M	Old Town	6/16/2017	51.0	6.8
150.780 (126)	510	F	Costigan	6/20/2017	0.8	0.8
150.780 (128)	440	M	Costigan	6/20/2017	144.1	144.1
150.780 (165)	440	M	U. Maine	6/20/2017	193.1	161.6
150.780 (166)	540	F	U. Maine	6/20/2017	181.7	29.5
150.780 (167)	530	F	U. Maine	6/20/2017	184.7	62.2
150.780 (168)	490	M	U. Maine	6/20/2017	39.6	34.1
150.780 (169)	510	F	U. Maine	6/20/2017	6.1	6.1
150.780 (170)	510	F	U. Maine	6/20/2017	7.5	7.5
150.780 (171)	500	F	U. Maine	6/20/2017	309.9	44.3
150.780 (172)	480	M	U. Maine	6/20/2017	74.6	17.2
150.780 (173)	440	M	U. Maine	6/20/2017	72.3	38.7
150.780 (174)	450	M	U. Maine	6/20/2017	49.8	45.1
150.780 (175)	470	M	U. Maine	6/20/2017	72.6	52.1
150.780 (176)	500	M	U. Maine	6/20/2017	10.9	10.9
150.780 (177)	520	F	U. Maine	6/20/2017	64.4	14.1
150.780 (178)	460	M	U. Maine	6/20/2017	156.8	20.3
150.780 (179)	470	M	U. Maine	6/20/2017	186.5	50.0
150.780 (181)	500	F	U. Maine	6/20/2017	41.2	16.0
150.780 (182)	520	F	U. Maine	6/20/2017	165.3	101.5
150.780 (183)	470	M	U. Maine	6/20/2017	110.1	6.1
150.780 (184)	480	F	U. Maine	6/20/2017	125.4	21.6
150.780 (185)	490	F	U. Maine	6/20/2017	360.9	95.9

Shad ID	TL (mm)	Gender	Release Location	Release Date	Forebay Residence (hrs)	Adjusted Forebay Residence (hrs)
150.780 (187)	460	M	U. Maine	6/20/2017	177.8	13.3
150.780 (188)	510	F	U. Maine	6/20/2017	165.0	45.1
150.780 (189)	440	M	U. Maine	6/20/2017	101.5	77.3

Table 4.6-14. Summary of downstream passage routes for radio-tagged adult American shad at Orono, June-July 2017.

Passage Route	Release Location				Percent Passage
	Costigan	Old Town	U. Maine	All	
Turbines - A	0	0	0	0	0.0%
Turbines - B	0	0	0	0	0.0%
Bypass	10	32	45	87	92.6%
Spill	0	0	0	0	0.0%
Unknown	0	0	2	2	2.1%
Did not pass	3	1	1	5	5.3%
Total	**13**	**33**	**48**	**94**	100.0%

Table 4.6-15. Minimum, maximum, mean, and median transit times (hrs) for radio-tagged adult American shad moving through the Penobscot River downstream of Orono, June-July 2017.

River Reach	Release Location	Downstream Transit Times (hrs)				
		Minimum	Maximum	Mean	Median	n
Orono to Station S13	Costigan	0.5	23.6	5.1	1.7	10
	Old Town	0.4	23.7	4.5	3.0	27
	U. Maine	0.6	26.9	4.3	1.9	41
	All	0.4	26.9	4.5	1.9	78
Station S13 to Station S31	Costigan	0.5	3.3	1.0	0.8	10
	Old Town	0.5	9.4	2.5	1.1	27
	U. Maine	0.5	102.8	3.9	0.7	41
	All	0.5	102.8	3.1	0.9	78

Table 4.6-16. CJS model selection criteria for the 2017 adult American shad passage at Orono.

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	No. Parameters	Deviance
S(t)*p*(t)	118.415	0.000	0.808	1.000	3	0.000
S(t)*p*(.)	121.289	2.874	0.192	0.238	3	2.874
S(.)*p*(t)	138.869	20.454	0.000	0.000	2	22.488
S(.)*p*(.)	141.970	23.555	0.000	0.000	2	25.589

Table 4.6-17. Orono reach-specific survival probability estimates (S), standard errors and likelihood 75 and 95% confidence intervals for radio-tagged adult American shad approaching the project, June-July, 2017.

Parameter	Reach	Reach Length (km)	*S*	SE	95% CI		75% CI	
S_1	Release to S24	2.3	1.000	0.000	-	-	-	-
S_2	S24 to Orono	0.3	0.947	0.023	0.879	0.978	0.913	0.968
S_3	Orono to S13	1.8	0.890	0.033	0.804	0.938	0.843	0.921

Table 4.6-18. Detection efficiency estimates for monitoring locations installed to detect radio-tagged adult American shad at Orono for evaluation of downstream passage, June-July 2017.

Parameter	Location	*p*	SE	95% CI		75% CI	
p_1	OR Approach	1.000	0.000	-	-	-	-
p_2	Orono	1.000	0.000	-	-	-	-
p_3	OR - DS #1	0.987	0.013	0.916	0.998	0.961	0.996

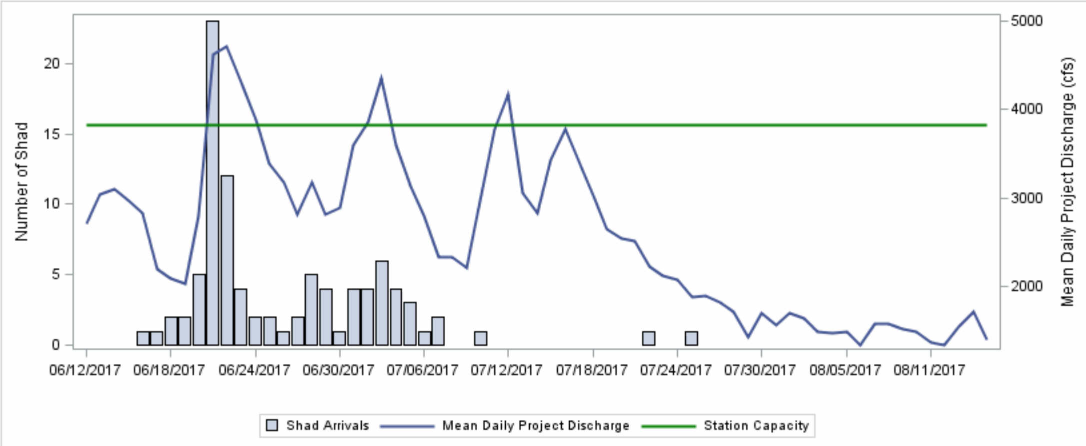

Figure 4.6-17. Distribution of return dates for radio-tagged shad approaching the Orono dam during their downstream migration. Station discharge (cfs) included for reference.

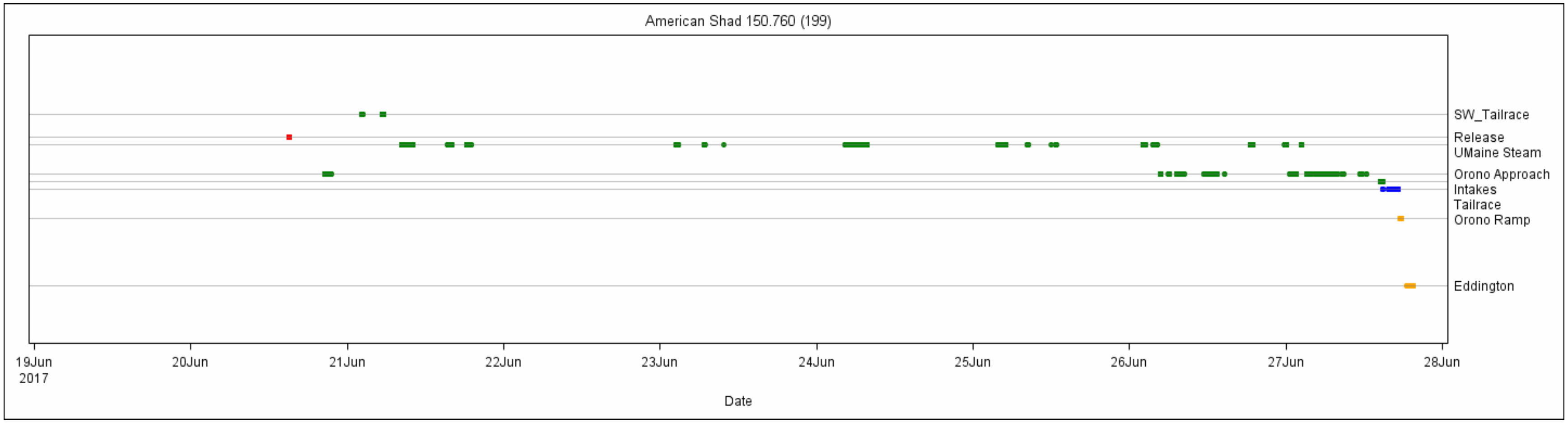

Figure 4.6-18. Telemetry detection time series for radio-tagged shad 150.760 (199). Red indicates release, green indicates detections upstream of Orono, blue indicates detections downstream of Orono and purple indicates detections at the mainstem downstream detection locations.

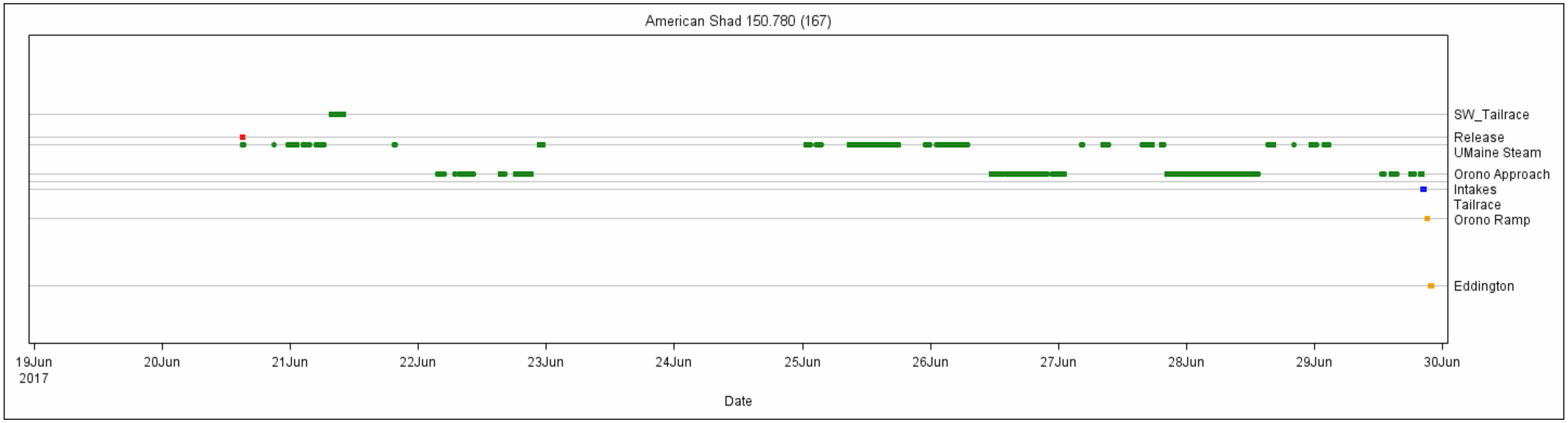

Figure 4.6-19. Telemetry detection time series for radio-tagged shad 150.780 (165). Red indicates release, green indicates detections upstream of Orono, blue indicates detections downstream of Orono and purple indicates detections at the mainstem downstream detection locations.

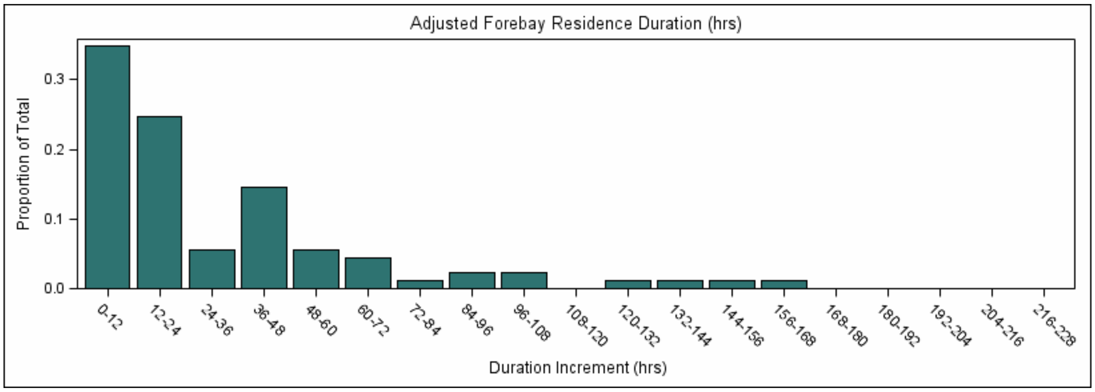

Figure 4.6-20. Frequency distribution of adjusted forebay residence duration prior to downstream passage for radio-tagged adult American shad at Orono, June-July 2017.

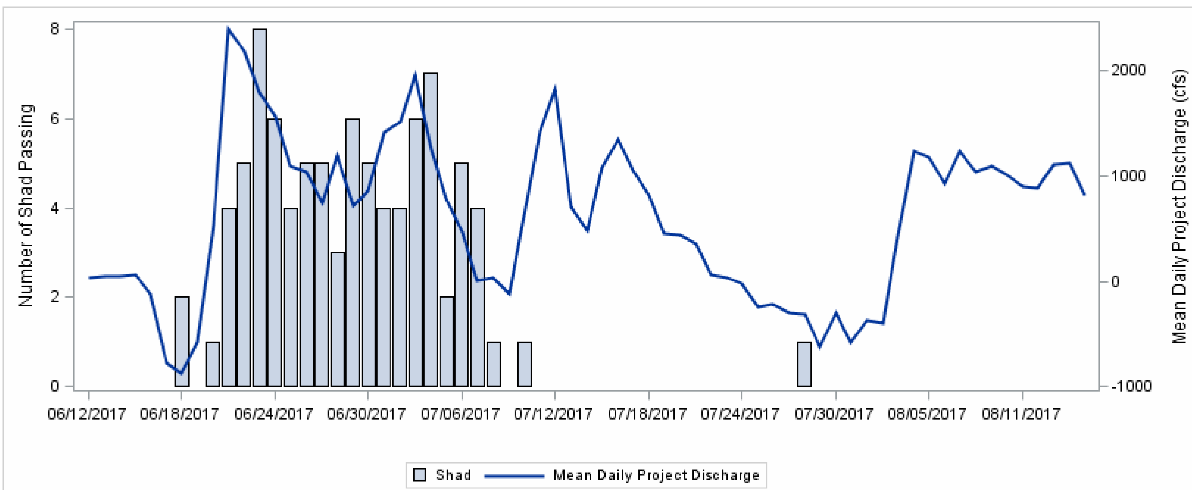

Figure 4.6-21. Distribution of downstream passage dates for radio-tagged shad at Orono, June-July 2017.

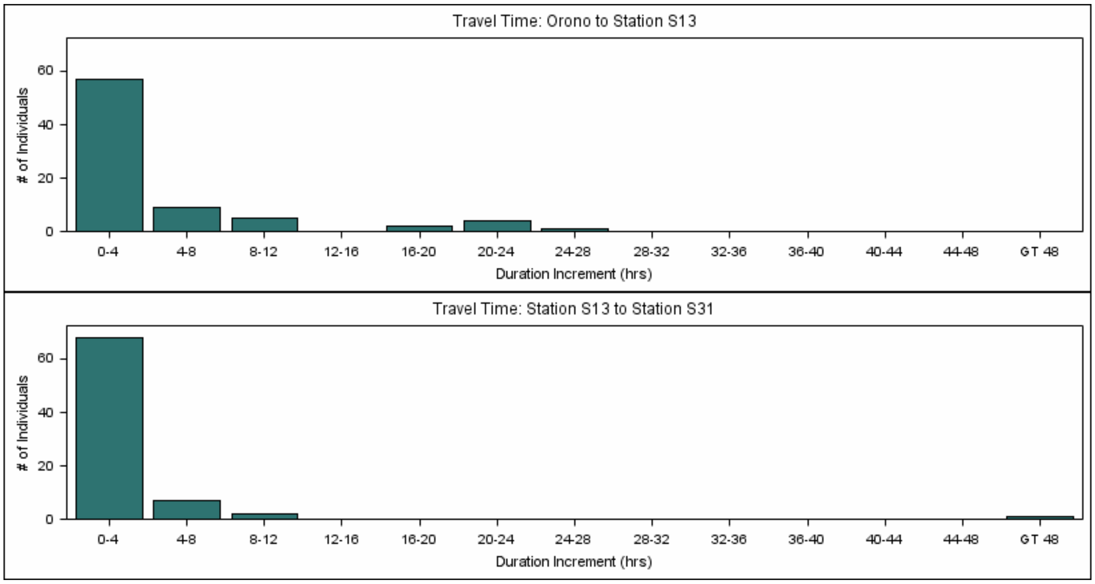

Figure 4.6-22. Frequency distribution of travel times for radio-tagged adult American shad through two defined sections of the Stillwater Branch and Penobscot River located downstream of Orono, June-July 2017.

4.8 Additional Movement Data

In addition to the stationary telemetry data, manual tracking was conducted weekly following release of all study fish in late June and through July. A final tracking event was conducted at the time stationary receivers were removed. Manual tracking was conducted on June 27, July 6, July 12-13, July 18-19, July 25-26, and August 15-16. Manual tracking consisted of land-based efforts (i.e., foot and truck) and attempted to cover the reach from West Enfield to the end of the study reach downstream of Milford Dam, as well as the Stillwater Branch from Gilman Falls to Orono.

A total of 146 manual detections were recorded across all tracking dates representing a total of 65 individual radio-tagged shad. The full reach of the Stillwater Branch and the mainstem Penobscot (from the lower receiver up to West Enfield) was divided into 0.25 mile segments. Field notes and coordinates were converted to locations and placed within the nearest segment. Appendix C presents a full listing of all recorded manual locations during this study.

The majority of locations (96 of the 146 total) were from individuals located in the approach-intake reach upstream of Milford, Stillwater and Orono Dams, or in the three project tailraces. In addition to those locations, individuals were noted in the area immediately downstream of Gilman Falls, in the vicinity of the mainstem island complex located upstream of Costigan, and in the mainstem river near the confluence with the Passadumkeag River (downstream of West Enfield). A few individuals were regularly detected from the mainstem near the Costigan release site, suggesting they may have died or regurgitated their transmitter soon after release. There were no similar detections for radio-tagged shad near the Old Town Water District property or the University of Maine boat launch release sites.

5.0 Summary

A total of 216 adult American shad were collected at the Milford fish lift and radio-tagged for evaluation of downstream passage at Milford, Stillwater and Orono during June-July 2017. Fish were released at one of three locations, upstream of Milford at the Costigan boat launch, upstream of Stillwater Dam at the Old Town Water District, or upstream of Orono Dam at the University of Maine boat launch. River conditions during the study period were generally within station capacities. In a number of instances with increased river flows associated with generational curtailment events, Black Bear opened additional gates at Milford.

Radio-tagged shad exhibited a range of movements following release into the Penobscot River. A proportion of individuals ascended the mainstem as far upstream as the West Enfield tailrace. Of shad released into the mainstem Penobscot, approximately 11% were determined to have moved to the Stillwater Branch and passed downstream through the Stillwater and Orono projects. Conversely, 10% of radio-tagged shad released upstream of Stillwater moved upstream past Gilman Falls and eventually passed downstream through Milford Dam. Residence within the immediate dam areas (i.e., the 200 m approach area upstream of the dam) was not always continuous, and shad at all three project locations made forays to points back upstream following their initial arrival at the dam. When these behaviors are accounted for, the median adjusted residence time prior to downstream passage was 37 hours at Milford, 51 hours at Stillwater, and 18 hours at Orono.

Downstream passage occurred primarily via the downstream bypasses at both Stillwater and Orono. At Stillwater, the vast majority of fish utilized the bypass facility located at powerhouse B. Downstream passage at Milford was closely related to operation of the sluice gate. Although individuals did use the downstream bypass at Milford, the majority of shad passed during the periods of operation where the sluice gate was opened to allow for passage of excess river flows. Five of the 15 shad determined to have passed Milford via the downstream bypass were detected at the downstream monitoring stations. Of the ten individuals passed via the downstream passage facility and not detected downstream, eight were confirmed to have done so on dates when the project trash racks were cleaned. As rack debris can be sluiced down those passages, it is possible that those individuals were entrained on the intake racks at the time of cleaning and were dead prior to passage through the bypass (and subsequent stationary presence in the tailrace).

A series of CJS models were used to generate estimates of downstream passage survival for adult American shad at the three project locations. These estimates of downstream passage for adult American shad included background mortality for the species in the reach from the approach receiver to the first downstream receiver, along with any tagging-related mortalities or transmitter regurgitations, and thus reflect mortalities not solely due to project effects. As a result, these estimates should be viewed as minimum estimates of total project survival for adult American shad. When corrected to remove a limited number of individuals suspected to have been deceased upon entry into the dam areas, these estimates were 79.2% (75% CI = 73.5-83.9 %) at Milford, 95.8% (75% CI = 91.7-97.9%) at Stillwater, and 87.0% (75% CI = 82.4-91.2%) at Orono. Losses at Milford were driven by lower survival of individuals passing downstream via the downstream bypass as well as individuals which approached but did not pass the dam. Survival following passage at Stillwater Dam was high, but the overall project survival estimate was lowered by the occurrence of individuals which approached the dam but did not pass downstream. Shad losses at Orono resulted from a combination of individuals passing via the downstream bypass that did not reach the downstream monitoring stations, as well as individuals which approached but did not pass the dam. Results from the downstream drift tests at all three project locations support the assumption that the downstream antenna arrays were positioned far enough downstream to avoid false positive detections due to dead tagged fish floating downriver.

6.0 References

Castro-Santos, T., and R. Perry. 2012. Time to event analysis as a framework for quantifying fish passage performance. Pages 427-452 *in* N.S. Adams, J.W. Beeman, and J.H. Eiler, editors. Telemetry Techniques: A Users Guide for Fisheries Research. American Fisheries Society, Bethesda, Maryland.

Appendix A

Location and descriptions of stationary radio-telemetry monitoring stations deployed in the Penobscot River and Stillwater Branch for detection of radio-tagged adult American shad passing Milford, Stillwater and Orono Dams during 2017

A total of 31 stationary telemetry stations were installed at and around the West Enfield, Milford, Stillwater and Orono Projects during 2017. The following provides a written description of the set up and intended detection field for each station.

Monitoring Station S1: This station consisted of a single receiver and aerial coverage of the upstream approach area at West Enfield and provided cross-river coverage of the headpond area at a point approximately 200 m upstream of the dam.

Monitoring Station S2: This station consisted of a single receiver and aerial coverage of the area immediately downstream of the West Enfield powerhouse.

Monitoring Station S3: This station consisted of a single receiver and underwater drop coverage of the West Enfield upstream fishway and was intended to provide detection information for any radio-tagged shad ascending from the tailrace.

Monitoring Station S4: This station consisted of a single receiver and aerial, cross-river coverage at a point located in the vicinity of the upper end of the Milford impoundment. This station was located along the eastern bank, approximately 3.5 km upstream of the Milford Project dam.

Monitoring Station S5: This station consisted of two receivers and aerial coverage of the upstream approach area and provided cross-river coverage of the Milford headpond area. One receiver was installed at a point approximately 700 m upstream of the dam (and along the eastern shoreline), and the second receiver was located at a point along the western shoreline and approximately 200 m upstream of the dam.

Monitoring Station S6: This station consisted of a single receiver and aerial coverage of the area immediately upstream of the Milford powerhouse and provided detection information for radio-tagged adult shad present in that area.

Monitoring Station S7: This station consisted of a single receiver and underwater drop coverage of downstream bypass A (located towards the western end of Milford powerhouse) and provided detection information for radio-tagged adult shad as they passed downstream via that route.

Monitoring Station S8: This station consisted of a single receiver and underwater drop coverage of downstream bypass B (located towards center of Milford powerhouse) and provided detection information for radio-tagged adult shad as they passed downstream via that route.

Monitoring Station S9: This station consisted of a single receiver and aerial coverage of the area immediately downstream of the Milford powerhouse, and when coupled with detection information collected at Stations S5-S8 and S10-S11, was used to identify passage through the powerhouse turbine units.

Monitoring Station S10: This station consisted of a single receiver and aerial coverage of the sluice gate adjacent to the Milford powerhouse.

Monitoring Station S11: This station consisted of a single receiver and aerial coverage of the region downstream of the Milford spillway and was mounted on the downstream end of the wing wall forming the eastern side of the sluice gate sluice. The antenna was oriented perpendicular to flows coming over the spill sections of the Milford Dam.

Monitoring Station S12: This station consisted of a single receiver and aerial, cross-river coverage at a point approximately 2.4 km downstream from the Milford powerhouse tailrace. This receiver was located along the eastern bank of the river and served as the first downstream detection location for adult shad passing Milford.

Monitoring Station S13: This station consisted of a single receiver and aerial, cross-river coverage at a point approximately 9.5 km downstream from the Milford powerhouse tailrace. Station S13 was located on the western shoreline, approximately 7.1 km downstream from Station S12. Note that Station S13 (the second detection station downstream of Milford) also served as the first detection station downstream of Orono.

Monitoring Station S14: This station consisted of a single receiver and aerial, cross-river coverage at a point located in the vicinity of the upper end of the Stillwater impoundment. This station was installed along the western shoreline at a point approximately 3.9 km upstream of the Stillwater Dam.

Monitoring Station S15: This station consisted of a single receiver and aerial coverage of the Stillwater upstream approach area and provided cross-river coverage of the headpond area at a point approximately 200 m upstream of the dam. The receiver was located at a private residence along the western shoreline.

Monitoring Station S16: This station consisted of a single receiver and aerial coverage of the area immediately upstream of Stillwater powerhouse A and provided detection information for radio-tagged adult shad present in that area.

Monitoring Station S17: This station consisted of a single receiver and underwater drop coverage of the downstream bypass located at Stillwater powerhouse A and provided detection information for radio-tagged shad as they passed downstream via this route.

Monitoring Station S18: This station consisted of a single receiver and aerial coverage of the area immediately downstream of Stillwater powerhouse A, and when coupled with detection information collected at Stations S16 and S17, was used to infer turbine passage through powerhouse A.

Monitoring Station S19: This station consisted of a single receiver and aerial coverage of the area immediately upstream of Stillwater powerhouse B and provided detection information for radio-tagged adult shad present in that area.

Monitoring Station S20: This station consisted of a single receiver and underwater drop coverage of the downstream bypass located at Stillwater powerhouse B and provided detection information for radio-tagged adult shad as they passed downstream via that route.

Monitoring Station S21: This station consisted of a single receiver and aerial coverage of the area immediately downstream of Stillwater powerhouse B, and when coupled with detection information collected at Stations S19 and S20, was used to infer turbine passage through powerhouse A.

Monitoring Station S22: This station consisted of a single receiver and aerial coverage of the region downstream of the Stillwater spillway. The aerial antenna was located along the eastern shoreline at a point approximately 0.1 km downstream of the spillway.

Monitoring Station S23: This station consisted of a single receiver and aerial, cross-river coverage at a point approximately 1.6 km downstream from the Stillwater Project. This receiver was located along the eastern bank of the river and served as the first downstream detection location for adult shad passing Stillwater.

Monitoring Station S24: This station consisted of a single receiver and aerial, cross-river coverage at a point approximately 3.9 km downstream from the Stillwater Project. Station S24 was located approximately 2.3 km downstream from Station S23. Note that Station S24 (the second detection station downstream of Stillwater) also served as the upstream approach station associated with passage at the Orono Project.

Monitoring Station S25: This station consisted of a single receiver and underwater drop coverage of the Orono downstream bypass and provided detection information for radio-tagged adult shad as they passed downstream via that route.

Monitoring Station S26: This station consisted of a single receiver and aerial coverage of the area immediately upstream of Orono powerhouse A and provided detection information for radio-tagged adult shad present in that area.

Monitoring Station S27: This station consisted of a single receiver and aerial coverage of the area immediately downstream of Orono powerhouse A, and when coupled with detection information collected at Stations S25 and S26, was used to infer passage through powerhouse A turbine units.

Monitoring Station S28 This station consisted of a single receiver and aerial coverage of the area immediately upstream of Orono powerhouse B and provided detection information for radio-tagged adult shad present in that area.

Monitoring Station S29: This station consisted of a single receiver and aerial coverage of the area immediately downstream of Orono powerhouse B, and when coupled with detection information collected at Station S27, was used to infer passage through powerhouse B turbine units.

Monitoring Station S30: This station consisted of a single receiver and aerial coverage across the Orono Project spillway. The aerial antenna was installed on the powerhouse B structure and provided coverage across the bypass channel at a point approximately 0.15 km downstream of the dam.

Monitoring Station S31: This station consisted of a single receiver and aerial, cross-river coverage at a point approximately 5.5 km downstream from Orono Project. This receiver was located at the public boat launch in Eddington on the eastern bank of the river and served as the second downstream detection location for shad passing Orono.


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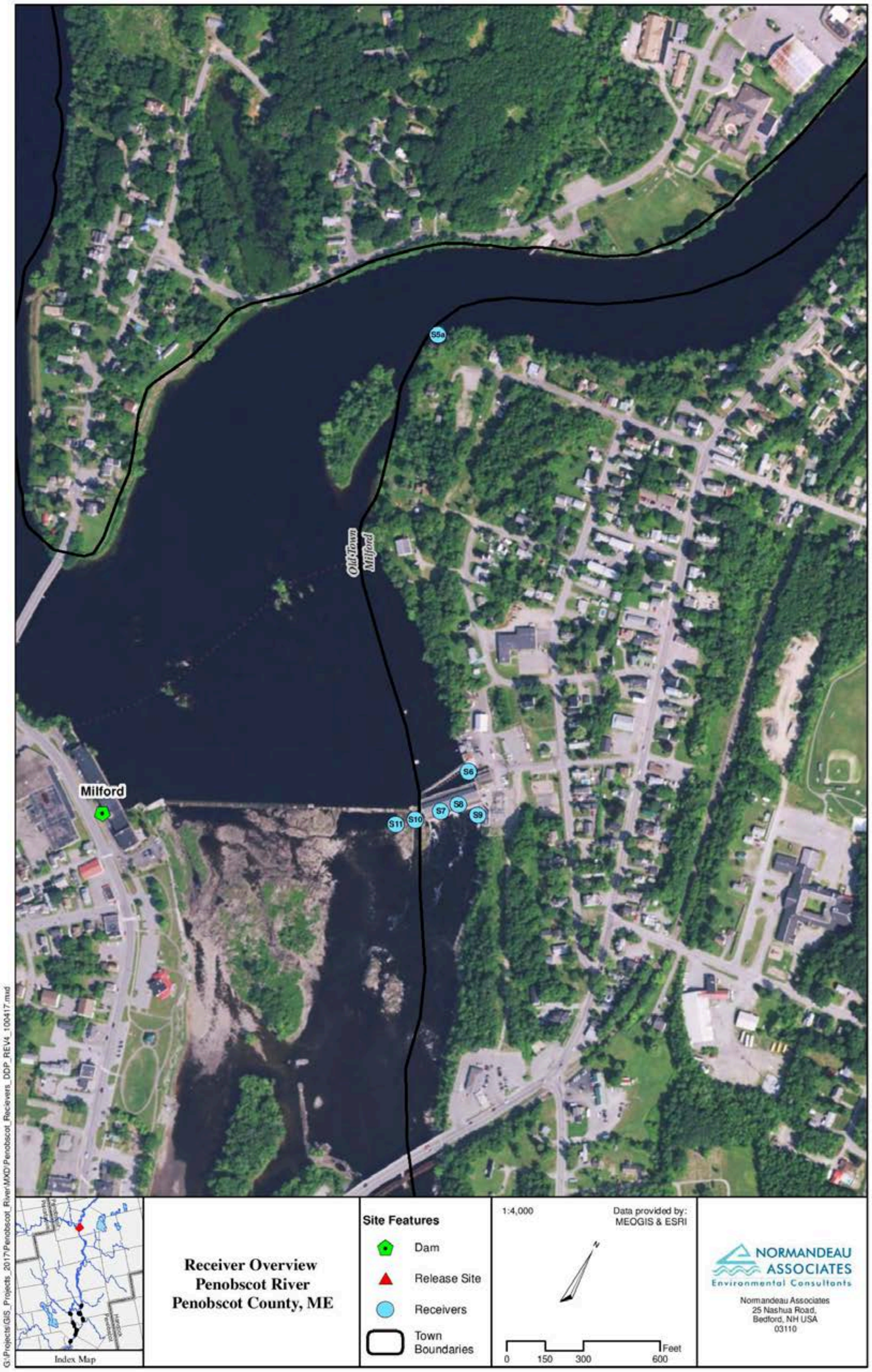
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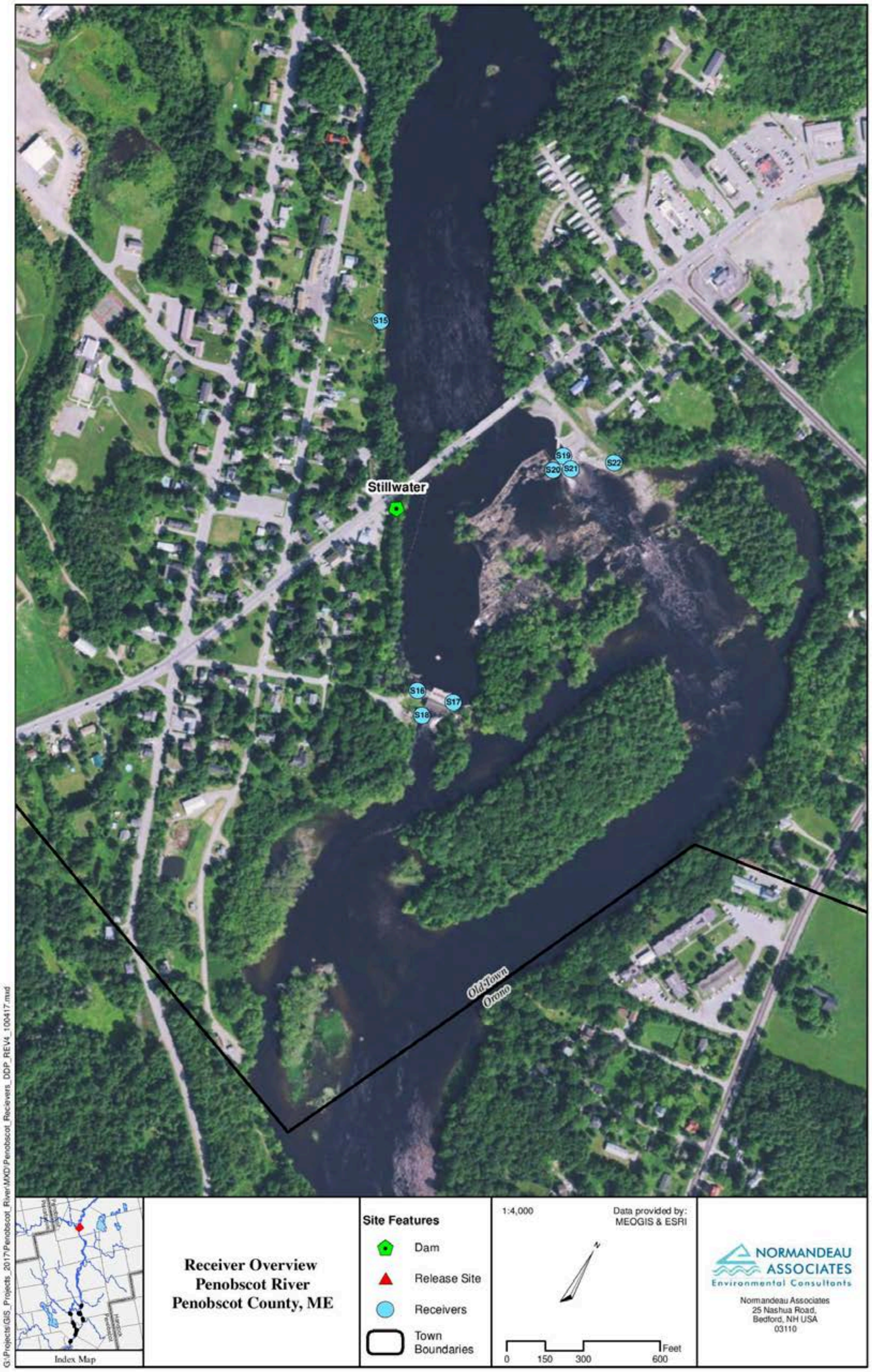
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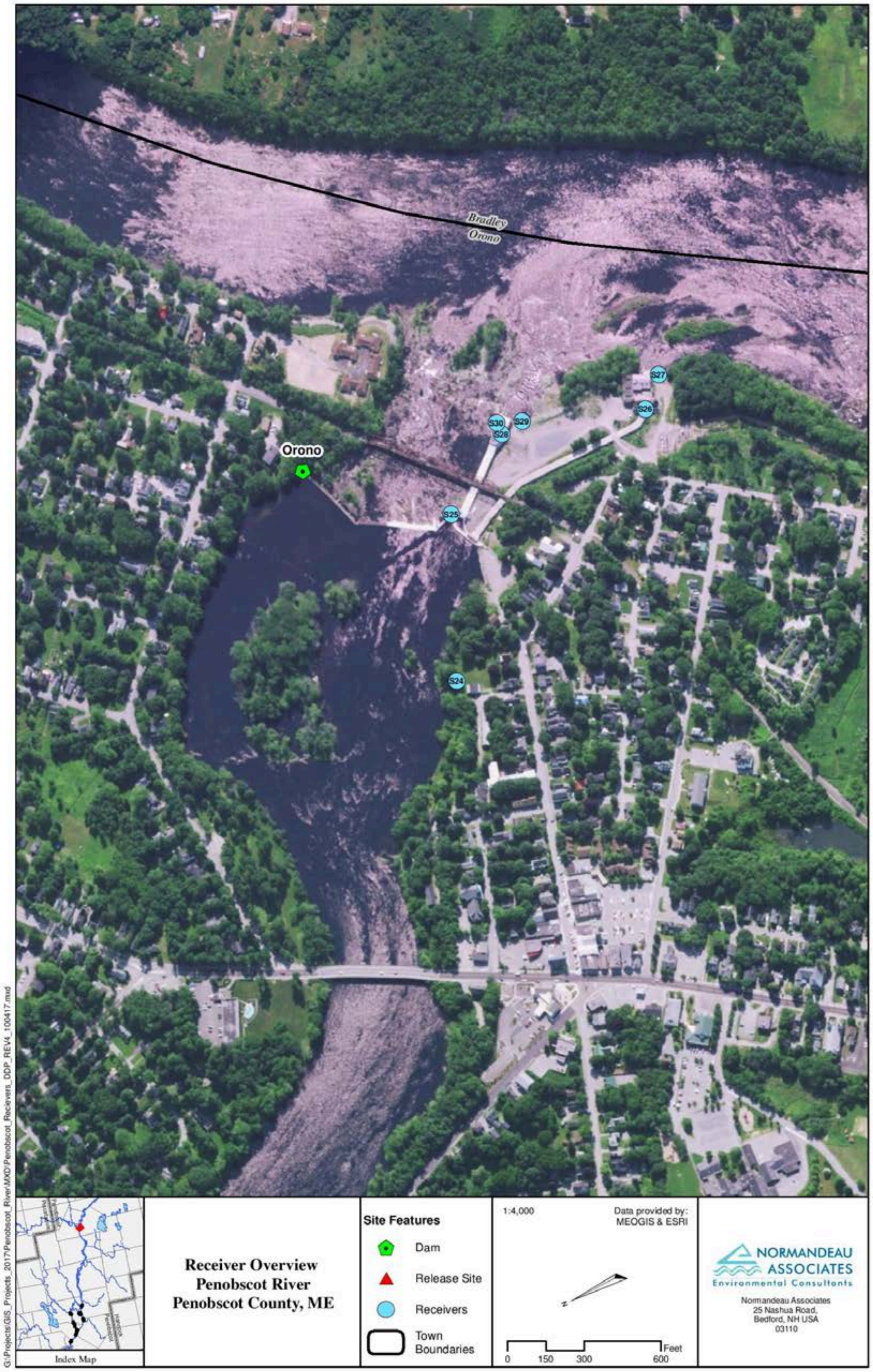
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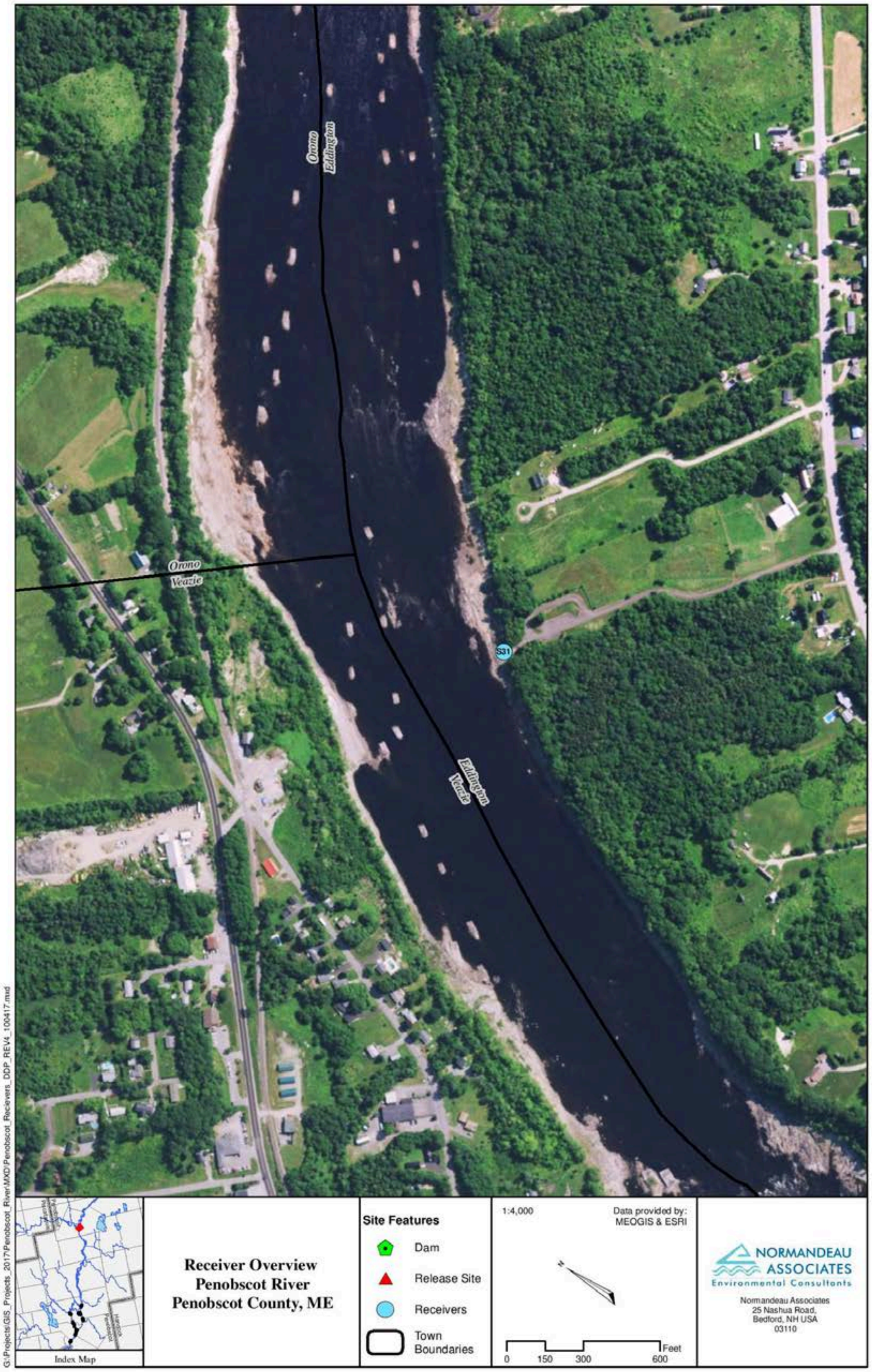

Orono
Eddington
Orono
Veazie
Eddington
Veazie
S31
Index Map
Receiver Overview
Penobscot River
Penobscot County, ME
Site Features
Dam
Release Site
Receivers
Town Boundaries
1:4,000
Data provided by:
MEOGIS & ESRI
0
150
300
600
Feet
NORMANDEAU ASSOCIATES
Environmental Consultants
Normandeau Associates
25 Nashua Road,
Bedford, NH USA
03110

Appendix B

Tag and release information for radio-tagged adult American shad – Penobscot River 2017

Frequency	Code	TL	Gender	Release Date	Release Location	Milford			Stillwater			Orono		
						Arrive	Pass	Route	Arrive	Pass	Route	Arrive	Pass	Route
760	20	460	.	6/13/2017	Costigan	7/1/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
760	21	490	.	6/13/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
760	22	490	.	6/13/2017	Costigan	7/1/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
760	23	460	.	6/13/2017	Costigan	6/15/2017	6/26/2017	Bypass	.	.	.	.	.	.
760	24	470	.	6/13/2017	Costigan	6/30/2017	7/5/2017	Bypass	.	.	.	.	.	.
760	25	440	.	6/13/2017	Costigan	6/16/2017	6/20/2017	Sluice Gate	.	.	.	.	.	.
760	26	490	.	6/13/2017	Costigan	7/8/2017	7/11/2017	Sluice Gate	.	.	.	.	.	.
760	27	480	.	6/13/2017	Costigan	6/13/2017	6/14/2017	Sluice Gate	.	.	.	.	.	.
760	28	420	.	6/13/2017	Costigan	6/13/2017	6/21/2017	Sluice Gate	.	.	.	.	.	.
760	29	520	.	6/13/2017	Costigan	6/15/2017	.	.	6/18/2017	6/20/2017	Bypass B	6/20/2017	Bypass	6/21/2017
760	30	510	.	6/13/2017	Costigan	6/24/2017	6/24/2017	Sluice Gate	.	.	.	.	.	.
760	31	470	.	6/13/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
760	45	475	.	6/13/2017	Costigan	6/20/2017	7/11/2017	Unknown	.	.	.	.	.	.
760	46	480	.	6/13/2017	Costigan	6/14/2017	6/21/2017	Sluice Gate	.	.	.	.	.	.
760	47	530	.	6/13/2017	Costigan	6/26/2017	7/5/2017	Bypass	.	.	.	.	.	.
760	48	.	.	6/13/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
760	49	.	.	6/13/2017	Costigan	6/18/2017	6/20/2017	Sluice Gate	.	.	.	.	.	.
760	50	.	.	6/13/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
760	51	.	.	6/13/2017	Costigan	6/14/2017	6/20/2017	Sluice Gate	.	.	.	.	.	.
760	52	.	.	6/13/2017	Costigan	.	.	.	6/16/2017	6/21/2017	Bypass B	6/21/2017	Bypass	6/22/2017
760	53	.	.	6/13/2017	Costigan	6/16/2017	6/20/2017	Unknown	.	.	.	.	.	.
760	54	.	.	6/13/2017	Costigan	.	.	.	6/14/2017	6/23/2017	Bypass B	6/23/2017	Bypass	6/23/2017
760	56	.	.	6/13/2017	Costigan	6/15/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
760	57	.	.	6/13/2017	Costigan	6/26/2017	7/3/2017	Unknown	.	.	.	.	.	.
780	32	550	.	6/13/2017	Costigan	6/24/2017	.	.	6/27/2017	6/29/2017	Bypass B	6/29/2017	Bypass	6/30/2017
780	33	540	.	6/13/2017	Costigan	6/13/2017	6/20/2017	Sluice Gate	.	.	.	.	.	.
780	34	460	.	6/13/2017	Costigan	6/13/2017	6/14/2017	Sluice Gate	.	.	.	.	.	.
780	35	515	.	6/13/2017	Costigan	6/19/2017	6/20/2017	Sluice Gate	.	.	.	.	.	.
780	36	510	.	6/13/2017	Costigan	7/2/2017	7/5/2017	Bypass	.	.	.	.	.	.
780	37	530	.	6/13/2017	Costigan	6/13/2017	6/14/2017	Sluice Gate	.	.	.	.	.	.
780	38	450	.	6/13/2017	Costigan	6/27/2017	.	No Pass	.	.	.	.	.	.
780	39	460	.	6/13/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	40	520	.	6/13/2017	Costigan	6/14/2017	6/20/2017	Sluice Gate	.	.	.	.	.	.

Frequency	Code	TL	Gender	Release Date	Release Location	Milford			Stillwater			Orono		
						Arrive	Pass	Route	Arrive	Pass	Route	Arrive	Pass	Route
780	41	460	.	6/13/2017	Costigan	7/1/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	42	530	.	6/13/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	43	440	.	6/13/2017	Costigan	6/20/2017	6/21/2017	Sluice Gate	.	.	.	.	.	.
780	44	450	.	6/13/2017	Costigan	6/23/2017	6/23/2017	Sluice Gate	.	.	.	.	.	.
780	58	.	.	6/13/2017	Costigan	6/23/2017	6/24/2017	Unknown	.	.	.	.	.	.
760	108	530	F	6/20/2017	Costigan	6/21/2017	6/22/2017	Unknown	.	.	.	.	.	.
760	109	510	F	6/20/2017	Costigan	6/20/2017	6/20/2017	Unknown	.	.	.	.	.	.
760	110	460	M	6/20/2017	Costigan	7/12/2017	7/12/2017	Unknown	.	.	.	.	.	.
760	111	430	M	6/20/2017	Costigan	6/21/2017	6/25/2017	Bypass	.	.	.	.	.	.
760	112	510	F	6/20/2017	Costigan	6/23/2017	6/23/2017	Bypass	.	.	.	.	.	.
760	113	480	M	6/20/2017	Costigan	7/8/2017	7/11/2017	Sluice Gate	.	.	.	.	.	.
760	114	490	M	6/20/2017	Costigan	.	.	.	6/27/2017	6/29/2017	Bypass B	6/30/2017	Bypass	6/30/2017
760	115	480	M	6/20/2017	Costigan	7/10/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
760	116	510	F	6/20/2017	Costigan	7/2/2017	7/7/2017	Bypass	.	.	.	.	.	.
760	117	460	M	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
760	118	510	F	6/20/2017	Costigan	6/23/2017	7/4/2017	Unknown	.	.	.	.	.	.
760	119	460	M	6/20/2017	Costigan	7/10/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
760	120	470	M	6/20/2017	Costigan	6/22/2017	6/30/2017	Bypass	.	.	.	.	.	.
760	133	530	F	6/20/2017	Costigan	7/3/2017	7/3/2017	Unknown	.	.	.	.	.	.
760	134	530	F	6/20/2017	Costigan	7/6/2017	7/17/2017	Bypass	.	.	.	.	.	.
760	135	460	M	6/20/2017	Costigan	7/9/2017	.	.	7/10/2017	7/10/2017	Bypass B	7/10/2017	Bypass	7/10/2017
760	136	540	F	6/20/2017	Costigan	6/23/2017	6/23/2017	Sluice Gate	.	.	.	.	.	.
760	137	550	F	6/20/2017	Costigan	7/6/2017	7/6/2017	Unknown	.	.	.	.	.	.
760	138	560	F	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
760	139	530	F	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
760	140	500	F	6/20/2017	Costigan	6/28/2017	.	.	7/2/2017	7/3/2017	Bypass B	7/4/2017	Bypass	7/4/2017
760	141	470	M	6/20/2017	Costigan	7/6/2017	7/6/2017	Unknown	.	.	.	.	.	.
760	142	430	M	6/20/2017	Costigan	7/5/2017	7/6/2017	Bypass	.	.	.	.	.	.
760	143	500	F	6/20/2017	Costigan	7/3/2017	7/3/2017	Sluice Gate	.	.	.	.	.	.
760	144	530	F	6/20/2017	Costigan	7/2/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
760	190	510	F	6/20/2017	Costigan	7/1/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
760	191	490	M	6/20/2017	Costigan	6/26/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
760	192	530	F	6/20/2017	Costigan	.	.	.	7/4/2017	7/4/2017	Bypass A	7/5/2017	No Pass	.

Frequency	Code	TL	Gender	Release Date	Release Location	Milford			Stillwater			Orono		
						Arrive	Pass	Route	Arrive	Pass	Route	Arrive	Pass	Route
760	193	470	M	6/20/2017	Costigan	6/27/2017	.	No Pass	.	.	.	.	.	.
760	194	520	M	6/20/2017	Costigan	6/29/2017	7/5/2017	Bypass	.	.	.	.	.	.
760	195	510	F	6/20/2017	Costigan	.	7/3/2017	Sluice Gate	.	.	.	.	.	.
780	121	510	F	6/20/2017	Costigan	6/26/2017	7/5/2017	Bypass	.	.	.	.	.	.
780	122	550	F	6/20/2017	Costigan	7/3/2017	7/3/2017	Sluice Gate	.	.	.	.	.	.
780	123	450	M	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	124	500	F	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	125	510	F	6/20/2017	Costigan	7/6/2017	7/12/2017	Sluice Gate	.	.	.	.	.	.
780	126	510	F	6/20/2017	Costigan	6/21/2017	.	.	7/1/2017	7/1/2017	Bypass B	7/1/2017	Bypass	7/1/2017
780	127	510	M	6/20/2017	Costigan	7/7/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
780	128	440	M	6/20/2017	Costigan	7/17/2017	.	.	7/21/2017	7/21/2017	Unit A	7/22/2017	Bypass	7/28/2017
780	129	440	M	6/20/2017	Costigan	7/15/2017	.	No Pass	.	.	.	.	.	.
780	130	430	M	6/20/2017	Costigan	6/21/2017	6/21/2017	Sluice Gate	.	.	.	.	.	.
780	131	450	M	6/20/2017	Costigan	7/2/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	132	470	M	6/20/2017	Costigan	7/12/2017	.	No Pass	.	.	.	.	.	.
780	145	530	F	6/20/2017	Costigan	6/28/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	146	500	M	6/20/2017	Costigan	7/1/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	147	440	M	6/20/2017	Costigan	7/1/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	148	520	F	6/20/2017	Costigan	6/22/2017	6/22/2017	Spill	.	.	.	.	.	.
780	149	530	F	6/20/2017	Costigan	7/5/2017	7/11/2017	Unknown	.	.	.	.	.	.
780	150	470	M	6/20/2017	Costigan	7/1/2017	.	.	7/24/2017	7/24/2017	Bypass B	7/25/2017	No Pass	.
780	151	430	M	6/20/2017	Costigan	7/10/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
780	152	470	M	6/20/2017	Costigan	6/27/2017	7/5/2017	Bypass	.	.	.	.	.	.
780	153	510	M	6/20/2017	Costigan	6/22/2017	7/11/2017	Sluice Gate	.	.	.	.	.	.
780	154	470	M	6/20/2017	Costigan	7/6/2017	7/17/2017	Bypass	.	.	.	.	.	.
780	155	520	F	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	156	480	M	6/20/2017	Costigan	6/23/2017	7/11/2017	Sluice Gate	.	.	.	.	.	.
780	157	510	F	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	158	430	M	6/20/2017	Costigan	7/10/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
780	159	520	F	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	160	480	M	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	161	510	M	6/20/2017	Costigan	7/5/2017	.	Unknown	.	.	.	.	.	.
780	162	510	F	6/20/2017	Costigan	6/27/2017	.	No Pass	.	.	.	.	.	.

Frequency	Code	TL	Gender	Release Date	Release Location	Milford			Stillwater			Orono		
						Arrive	Pass	Route	Arrive	Pass	Route	Arrive	Pass	Route
780	163	510	M	6/20/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	164	510	F	6/20/2017	Costigan	6/26/2017	6/30/2017	Bypass	.	.	.	.	.	.
760	66	500	M	6/21/2017	Costigan	6/28/2017	.	.	7/3/2017	7/3/2017	Bypass B	7/3/2017	Bypass	7/3/2017
760	67	530	F	6/21/2017	Costigan	.	.	.	6/22/2017	6/22/2017	Bypass B	6/22/2017	No Pass	.
760	68	540	F	6/21/2017	Costigan	7/8/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
780	20	440	M	6/21/2017	Costigan	7/10/2017	7/10/2017	Sluice Gate	.	.	.	.	.	.
780	21	500	M	6/21/2017	Costigan	7/29/2017	.	No Pass	.	.	.	.	.	.
780	22	460	M	6/21/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	23	530	F	6/21/2017	Costigan	7/3/2017	7/3/2017	Sluice Gate	.	.	.	.	.	.
780	24	510	F	6/21/2017	Costigan	7/10/2017	7/12/2017	Sluice Gate	.	.	.	.	.	.
780	25	520	F	6/21/2017	Costigan	6/23/2017	.	No Pass	.	.	.	.	.	.
780	26	480	M	6/21/2017	Costigan	7/7/2017	7/8/2017	Unknown	.	.	.	.	.	.
780	27	470	M	6/21/2017	Costigan	6/29/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	28	490	M	6/21/2017	Costigan	7/4/2017	7/4/2017	Sluice Gate	.	.	.	.	.	.
780	29	510	M	6/21/2017	Costigan	6/30/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	30	500	M	6/21/2017	Costigan	.	.	No Detect	.	.	.	.	.	.
780	31	460	M	6/21/2017	Costigan	7/9/2017	7/11/2017	Sluice Gate	.	.	.	.	.	.
760	55	534	F	6/16/2017	Old Town	.	.	.	6/19/2017	6/28/2017	Bypass A	6/28/2017	Bypass	6/30/2017
760	72	505	F	6/16/2017	Old Town	7/1/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
760	73	505	F	6/16/2017	Old Town	.	.	.	6/16/2017	6/18/2017	Bypass B	6/18/2017	Bypass	6/18/2017
760	74	446	M	6/16/2017	Old Town	.	.	.	6/21/2017	7/3/2017	Bypass B	7/3/2017	Bypass	7/7/2017
760	75	556	F	6/16/2017	Old Town	.	.	.	6/20/2017	6/25/2017	Bypass B	6/25/2017	Bypass	6/26/2017
760	76	514	F	6/16/2017	Old Town	.	.	.	6/19/2017	7/2/2017	Bypass B	7/2/2017	Bypass	7/3/2017
760	77	509	F	6/16/2017	Old Town	.	.	.	6/17/2017	6/18/2017	Bypass B	6/18/2017	Bypass	6/26/2017
760	78	535	F	6/16/2017	Old Town	.	.	.	6/17/2017	7/2/2017	Bypass B	7/2/2017	Bypass	7/2/2017
760	79	448	M	6/16/2017	Old Town	7/6/2017	7/7/2017	Unknown	.	.	.	.	.	.
760	80	479	M	6/16/2017	Old Town	.	.	.	6/17/2017	6/28/2017	Bypass B	6/28/2017	Bypass	6/28/2017
760	81	530	F	6/16/2017	Old Town	.	.	.	6/18/2017	6/19/2017	Bypass B	6/19/2017	Bypass	6/20/2017
760	82	504	F	6/16/2017	Old Town	.	.	.	6/18/2017	6/27/2017	Bypass B	6/27/2017	Bypass	6/27/2017
760	83	512	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
760	84	490	M	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
760	85	505	F	6/16/2017	Old Town	.	.	.	6/18/2017	6/27/2017	Bypass B	6/27/2017	Bypass	6/27/2017
760	86	470	M	6/16/2017	Old Town	.	.	.	6/17/2017	6/22/2017	Bypass B	6/22/2017	Bypass	6/22/2017

Frequency	Code	TL	Gender	Release Date	Release Location	Milford			Stillwater			Orono		
						Arrive	Pass	Route	Arrive	Pass	Route	Arrive	Pass	Route
760	87	441	M	6/16/2017	Old Town	.	.	.	6/16/2017	6/22/2017	Bypass B	6/22/2017	Bypass	6/23/2017
760	88	478	M	6/16/2017	Old Town	.	.	.	6/19/2017	7/3/2017	Bypass B	7/3/2017	Bypass	7/4/2017
760	89	521	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
760	90	515	F	6/16/2017	Old Town	.	.	.	6/17/2017	6/21/2017	Bypass B	6/21/2017	Bypass	6/21/2017
760	91	465	M	6/16/2017	Old Town	7/11/2017	7/11/2017	Sluice Gate	.	.	.	.	.	.
760	92	546	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
760	93	512	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
760	94	461	M	6/16/2017	Old Town	.	.	.	6/16/2017	6/17/2017	Bypass B	6/17/2017	No Pass	.
760	95	521	F	6/16/2017	Old Town	.	.	.	6/17/2017	6/22/2017	Bypass B	6/22/2017	Bypass	7/3/2017
780	59	480	M	6/16/2017	Old Town	.	.	.	6/16/2017	6/22/2017	Bypass B	6/22/2017	Bypass	6/22/2017
780	60	491	F	6/16/2017	Old Town	.	.	.	6/29/2017	7/1/2017	Bypass B	7/1/2017	Bypass	7/1/2017
780	61	516	F	6/16/2017	Old Town	.	.	.	6/19/2017	6/23/2017	Bypass B	6/23/2017	Bypass	6/24/2017
780	62	508	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
780	63	486	M	6/16/2017	Old Town	7/4/2017	7/4/2017	Sluice Gate	6/18/2017	.	.	.	.	.
780	64	445	M	6/16/2017	Old Town	.	.	.	6/17/2017	6/28/2017	Bypass B	6/28/2017	Bypass	6/28/2017
780	65	464	F	6/16/2017	Old Town	.	.	.	6/18/2017	6/22/2017	Bypass B	6/22/2017	Bypass	6/22/2017
780	66	507	M	6/16/2017	Old Town	.	.	.	6/18/2017	.	No Pass	.	No Detect	.
780	67	480	F	6/16/2017	Old Town	.	.	.	6/18/2017	6/24/2017	Bypass B	6/24/2017	Bypass	6/24/2017
780	68	378	M	6/16/2017	Old Town	.	.	.	6/16/2017	6/28/2017	Bypass B	6/28/2017	Bypass	6/30/2017
780	69	501	F	6/16/2017	Old Town	.	.	.	6/16/2017	6/28/2017	Bypass B	6/28/2017	Bypass	7/2/2017
780	70	502	F	6/16/2017	Old Town	.	.	.	6/17/2017	.	No Pass	.	No Detect	.
780	71	484	M	6/16/2017	Old Town	6/26/2017	7/2/2017	Sluice Gate	.	.	.	.	.	.
780	96	442	M	6/16/2017	Old Town	.	.	.	6/18/2017	7/5/2017	Bypass B	7/5/2017	Bypass	7/8/2017
780	97	503	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
780	98	474	M	6/16/2017	Old Town	.	.	.	6/16/2017	6/16/2017	Bypass B	6/16/2017	Bypass	6/18/2017
780	99	479	M	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
780	100	511	F	6/16/2017	Old Town	.	.	.	6/18/2017	6/19/2017	Bypass B	6/19/2017	Bypass	6/23/2017
780	101	414	M	6/16/2017	Old Town	.	.	.	6/16/2017	6/22/2017	Bypass B	6/22/2017	Bypass	6/24/2017
780	102	518	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
780	103	474	M	6/16/2017	Old Town	.	.	.	7/2/2017	7/3/2017	Bypass B	7/4/2017	Bypass	7/4/2017
780	104	488	F	6/16/2017	Old Town	.	.	.	6/17/2017	6/25/2017	Bypass B	6/25/2017	Bypass	6/26/2017
780	105	458	M	6/16/2017	Old Town	.	.	.	6/16/2017	7/3/2017	Bypass B	7/4/2017	Bypass	7/5/2017
780	106	452	M	6/16/2017	Old Town	.	.	.	6/17/2017	6/22/2017	Bypass B	6/29/2017	Bypass	7/1/2017

Frequency	Code	TL	Gender	Release Date	Release Location	Milford			Stillwater			Orono		
						Arrive	Pass	Route	Arrive	Pass	Route	Arrive	Pass	Route
780	107	526	F	6/16/2017	Old Town	.	.	.	.	.	No Detect	.	No Detect	.
760	32	440	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/24/2017
760	33	550	F	6/20/2017	U. Maine	.	.	.	.	.	.	7/2/2017	Bypass	7/2/2017
760	34	540	F	6/20/2017	U. Maine	.	.	.	.	.	.	7/4/2017	Bypass	7/4/2017
760	35	550	F	6/20/2017	U. Maine	.	.	.	.	.	.	7/7/2017	Bypass	7/7/2017
760	36	540	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/25/2017
760	37	560	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/20/2017	Bypass	6/22/2017
760	38	410	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/21/2017
760	39	420	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/29/2017	Bypass	7/1/2017
760	40	490	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/30/2017
760	41	520	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/25/2017
760	42	540	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/21/2017
760	43	530	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/22/2017	Bypass	6/23/2017
760	44	460	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/23/2017
760	58	480	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	7/4/2017
760	59	450	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/22/2017	Bypass	7/7/2017
760	60	520	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/23/2017	Bypass	6/28/2017
760	61	450	F	6/20/2017	U. Maine	.	.	.	.	.	.	7/7/2017	Bypass	7/7/2017
760	62	460	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/26/2017	Bypass	6/26/2017
760	63	500	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/25/2017
760	64	510	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	7/5/2017
760	65	470	M	6/20/2017	U. Maine	.	.	.	.	.	.	7/2/2017	Bypass	7/3/2017
760	196	540	F	6/20/2017	U. Maine	.	.	.	.	.	.	7/6/2017	Bypass	7/6/2017
760	197	500	M	6/20/2017	U. Maine	.	.	.	.	.	.	7/3/2017	Unknown	7/3/2017
760	198	520	F	6/20/2017	U. Maine	.	.	.	.	.	.	.	No Detect	.
760	199	490	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/20/2017	Bypass	6/27/2017
780	165	440	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/29/2017
780	166	540	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/29/2017
780	167	530	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/22/2017	Unknown	6/29/2017
780	168	490	M	6/20/2017	U. Maine	.	.	.	.	.	.	7/5/2017	Bypass	7/6/2017
780	169	510	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/24/2017	Bypass	6/24/2017
780	170	510	F	6/20/2017	U. Maine	.	.	.	.	.	.	7/1/2017	Bypass	7/2/2017
780	171	500	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	7/4/2017

Frequency	Code	TL	Gender	Release Date	Release Location	Milford			Stillwater			Orono		
						Arrive	Pass	Route	Arrive	Pass	Route	Arrive	Pass	Route
780	172	480	M	6/20/2017	U. Maine	.	.	.	.	.	.	7/3/2017	Bypass	7/6/2017
780	173	440	M	6/20/2017	U. Maine	.	.	.	.	.	.	7/1/2017	Bypass	7/4/2017
780	174	450	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/23/2017
780	175	470	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/20/2017	Bypass	6/23/2017
780	176	500	M	6/20/2017	U. Maine	.	.	.	.	.	.	7/3/2017	Bypass	7/3/2017
780	177	520	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/24/2017
780	178	460	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/23/2017	Bypass	6/29/2017
780	179	470	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/29/2017	Bypass	7/6/2017
780	180	510	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	No Pass	.
780	181	500	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/23/2017
780	182	520	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/22/2017	Bypass	6/29/2017
780	183	470	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/26/2017
780	184	480	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/27/2017
780	185	490	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	7/6/2017
780	186	540	F	6/20/2017	U. Maine	.	.	.	.	.	.	.	No Detect	.
780	187	460	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/22/2017	Bypass	6/29/2017
780	188	510	F	6/20/2017	U. Maine	.	.	.	.	.	.	6/20/2017	Bypass	6/27/2017
780	189	440	M	6/20/2017	U. Maine	.	.	.	.	.	.	6/21/2017	Bypass	6/25/2017

Appendix C

Summary of manual radio-telemetry detections recorded for adult American shad in the Stillwater Branch and mainstem of the Penobscot River, June-August 2017.

Frequency	Code	Date	Time	Release Location	Branch	RM*
150.760	24	6/27/2017	15:15:00	Costigan	Mainstem	16.50
150.760	24	7/12/2017	13:46:00	Costigan	Mainstem	8.25
150.760	24	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.760	24	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	31	6/27/2017	14:50:00	Costigan	Mainstem	13.75
150.760	45	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.760	48	7/6/2017	11:21:00	Costigan	Mainstem	13.50
150.760	48	7/13/2017	8:57:00	Costigan	Mainstem	13.50
150.760	48	7/19/2017	10:37:00	Costigan	Mainstem	13.25
150.760	50	6/27/2017	15:15:00	Costigan	Mainstem	16.50
150.760	50	7/13/2017	8:49:00	Costigan	Mainstem	16.50
150.760	50	7/19/2017	10:25:00	Costigan	Mainstem	16.50
150.760	68	6/27/2017	16:00:00	Costigan	Mainstem	27.00
150.760	91	7/6/2017	10:41:00	Old Town	Mainstem	27.00
150.760	108	7/6/2017	13:10:00	Costigan	Mainstem	8.25
150.760	108	7/12/2017	13:50:00	Costigan	Mainstem	8.25
150.760	108	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	110	7/12/2017	16:45:00	Costigan	Mainstem	7.25
150.760	111	7/12/2017	13:46:00	Costigan	Mainstem	8.25
150.760	111	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.760	111	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	113	7/6/2017	11:06:00	Costigan	Mainstem	15.75
150.760	115	7/6/2017	11:11:00	Costigan	Mainstem	15.25
150.760	116	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.760	116	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.760	116	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	118	7/12/2017	13:46:00	Costigan	Mainstem	8.25
150.760	118	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.760	118	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.760	118	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	119	6/27/2017	15:26:00	Costigan	Mainstem	17.00
150.760	120	7/6/2017	13:10:00	Costigan	Mainstem	8.25
150.760	120	7/12/2017	13:46:00	Costigan	Mainstem	8.25
150.760	120	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.760	120	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.760	120	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	134	7/6/2017	13:20:00	Costigan	Mainstem	8.50
150.760	134	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.760	193	7/6/2017	11:24:00	Costigan	Mainstem	13.00
150.760	194	7/12/2017	13:46:00	Costigan	Mainstem	8.25
150.760	194	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.760	194	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	195	6/27/2017	16:24:00	Costigan	Mainstem	27.50
150.780	20	6/27/2017	15:15:00	Costigan	Mainstem	16.50
150.780	20	7/6/2017	11:03:00	Costigan	Mainstem	16.75
150.780	23	6/27/2017	14:41:00	Costigan	Mainstem	13.00

Frequency	Code	Date	Time	Release Location	Branch	RM*
150.780	25	7/12/2017	13:39:00	Costigan	Mainstem	8.50
150.780	25	7/19/2017	11:15:00	Costigan	Mainstem	8.50
150.780	25	7/25/2017	14:10:00	Costigan	Mainstem	8.50
150.780	25	8/16/2017	12:00:00	Costigan	Mainstem	8.50
150.780	31	7/6/2017	11:16:00	Costigan	Mainstem	13.75
150.780	36	7/6/2017	13:10:00	Costigan	Mainstem	8.25
150.780	36	7/12/2017	13:46:00	Costigan	Mainstem	8.25
150.780	36	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.780	36	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.780	39	7/6/2017	11:09:00	Costigan	Mainstem	16.00
150.780	39	7/13/2017	8:49:00	Costigan	Mainstem	16.50
150.780	63	6/27/2017	16:00:00	Old Town	Mainstem	27.00
150.780	121	6/27/2017	16:00:00	Costigan	Mainstem	27.00
150.780	123	6/27/2017	16:00:00	Costigan	Mainstem	27.00
150.780	123	7/6/2017	10:41:00	Costigan	Mainstem	27.00
150.780	123	7/13/2017	8:15:00	Costigan	Mainstem	27.00
150.780	124	7/13/2017	7:36:00	Costigan	Mainstem	26.25
150.780	124	7/26/2017	10:40:00	Costigan	Mainstem	26.50
150.780	132	7/12/2017	13:39:00	Costigan	Mainstem	8.50
150.780	132	8/16/2017	12:00:00	Costigan	Mainstem	8.50
150.780	145	6/27/2017	14:50:00	Costigan	Mainstem	13.75
150.780	149	7/6/2017	13:20:00	Costigan	Mainstem	8.50
150.780	153	7/6/2017	13:20:00	Costigan	Mainstem	8.50
150.780	154	7/6/2017	13:20:00	Costigan	Mainstem	8.50
150.780	154	7/12/2017	13:53:00	Costigan	Mainstem	8.50
150.780	154	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.780	154	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.780	154	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.780	156	7/6/2017	11:23:00	Costigan	Mainstem	13.00
150.780	157	7/6/2017	10:35:00	Costigan	Mainstem	29.75
150.780	157	7/13/2017	14:13:00	Costigan	Mainstem	29.75
150.780	157	7/19/2017	10:00:00	Costigan	Mainstem	29.75
150.780	157	7/26/2017	10:40:00	Costigan	Mainstem	29.75
150.780	159	6/27/2017	14:50:00	Costigan	Mainstem	13.75
150.780	159	7/6/2017	11:16:00	Costigan	Mainstem	13.75
150.780	159	7/19/2017	10:35:00	Costigan	Mainstem	13.75
150.780	160	7/13/2017	8:25:00	Costigan	Mainstem	24.00
150.780	162	7/12/2017	16:58:00	Costigan	Mainstem	8.75
150.780	164	7/12/2017	13:46:00	Costigan	Mainstem	8.25
150.780	164	7/19/2017	11:30:00	Costigan	Mainstem	8.25
150.780	164	7/25/2017	14:00:00	Costigan	Mainstem	8.25
150.780	164	8/16/2017	12:00:00	Costigan	Mainstem	8.25
150.760	35	7/6/2017	12:45:00	U. Maine	Stillwater	2.50
150.760	60	7/6/2017	12:15:00	U. Maine	Stillwater	0.00
150.760	60	7/18/2017	17:45:00	U. Maine	Stillwater	0.00
150.760	60	7/25/2017	17:00:00	U. Maine	Stillwater	0.00

Frequency	Code	Date	Time	Release Location	Branch	RM*
150.760	61	7/6/2017	12:45:00	U. Maine	Stillwater	2.50
150.760	62	7/12/2017	16:15:00	U. Maine	Stillwater	0.00
150.760	67	7/6/2017	12:25:00	Costigan	Stillwater	0.25
150.760	67	7/12/2017	16:10:00	Costigan	Stillwater	0.25
150.760	67	7/18/2017	18:20:00	Costigan	Stillwater	0.25
150.760	67	7/25/2017	18:10:00	Costigan	Stillwater	0.25
150.760	77	7/6/2017	12:25:00	Old Town	Stillwater	0.00
150.760	77	7/12/2017	16:10:00	Old Town	Stillwater	0.00
150.760	77	7/18/2017	18:20:00	Old Town	Stillwater	0.00
150.760	77	7/25/2017	18:10:00	Old Town	Stillwater	0.00
150.760	78	7/12/2017	16:10:00	Old Town	Stillwater	0.00
150.760	89	7/12/2017	17:25:00	Old Town	Stillwater	5.25
150.760	89	7/26/2017	11:32:00	Old Town	Stillwater	5.25
150.760	90	7/6/2017	12:15:00	Old Town	Stillwater	0.00
150.760	90	7/18/2017	17:00:00	Old Town	Stillwater	0.00
150.760	90	7/25/2017	17:00:00	Old Town	Stillwater	0.00
150.760	92	7/12/2017	17:17:00	Old Town	Stillwater	5.75
150.760	92	7/19/2017	11:45:00	Old Town	Stillwater	5.75
150.760	92	7/26/2017	11:25:00	Old Town	Stillwater	5.75
150.760	94	7/6/2017	12:25:00	Old Town	Stillwater	0.25
150.760	94	7/18/2017	18:25:00	Old Town	Stillwater	0.25
150.760	94	7/25/2017	18:15:00	Old Town	Stillwater	0.25
150.760	192	7/6/2017	12:25:00	Costigan	Stillwater	0.25
150.760	192	7/12/2017	16:10:00	Costigan	Stillwater	0.25
150.760	192	7/18/2017	18:25:00	Costigan	Stillwater	0.25
150.760	192	7/25/2017	18:15:00	Costigan	Stillwater	0.25
150.760	197	7/12/2017	16:15:00	U. Maine	Stillwater	0.00
150.760	197	7/18/2017	17:45:00	U. Maine	Stillwater	0.00
150.760	197	7/25/2017	17:00:00	U. Maine	Stillwater	0.00
150.780	66	7/12/2017	17:17:00	Old Town	Stillwater	5.75
150.780	66	7/19/2017	11:45:00	Old Town	Stillwater	5.75
150.780	66	7/26/2017	11:25:00	Old Town	Stillwater	5.75
150.780	70	7/6/2017	12:50:00	Old Town	Stillwater	2.75
150.780	70	8/16/2017	14:45:00	Old Town	Stillwater	2.75
150.780	96	7/6/2017	12:25:00	Old Town	Stillwater	0.25
150.780	99	7/12/2017	17:17:00	Old Town	Stillwater	5.75
150.780	99	7/26/2017	11:25:00	Old Town	Stillwater	5.75
150.780	107	7/6/2017	12:50:00	Old Town	Stillwater	2.75
150.780	107	7/12/2017	14:30:00	Old Town	Stillwater	2.75
150.780	107	7/25/2017	15:15:00	Old Town	Stillwater	2.75
150.780	107	8/16/2017	14:45:00	Old Town	Stillwater	2.75
150.780	128	7/25/2017	18:15:00	Costigan	Stillwater	0.25
150.780	168	7/6/2017	12:25:00	U. Maine	Stillwater	0.25
150.780	168	7/18/2017	17:45:00	U. Maine	Stillwater	0.00
150.780	168	7/25/2017	17:00:00	U. Maine	Stillwater	0.00
150.780	172	7/6/2017	12:25:00	U. Maine	Stillwater	0.25

Frequency	Code	Date	Time	Release Location	Branch	RM*
150.780	179	7/6/2017	12:25:00	U. Maine	Stillwater	0.25
150.780	180	7/6/2017	12:25:00	U. Maine	Stillwater	0.25
150.780	180	7/12/2017	16:10:00	U. Maine	Stillwater	0.25
150.780	180	7/18/2017	18:25:00	U. Maine	Stillwater	0.25
150.780	180	7/25/2017	18:15:00	U. Maine	Stillwater	0.25
150.780	186	7/6/2017	12:45:00	U. Maine	Stillwater	2.50
150.780	186	7/12/2017	14:30:00	U. Maine	Stillwater	2.50
150.780	186	7/25/2017	15:15:00	U. Maine	Stillwater	2.50

***Stillwater Branch River Mile Markers**

0.00	Orono Tailrace
0.25	Orono Intakes to Approach Receiver
1.50	U. Maine Boat Launch Release Location
2.50	Stillwater Tailrace
2.75	Stillwater Intakes to Approach Receiver
3.50	Old Town Water District Release Location
5.75	Downstream Gilman Falls

***Mainstem River Mile Markers**

8.25	Milford Tailrace
8.50	Milford Intakes to Approach Receiver
13.75	Costigan Boat Launch Release Location
16.50	Lower portion of island complex (White Squaw Is.)
27.00	Confluence of Passadumkeag River
31.00	West Enfield Tailrace

Appendix D

Summary of discussion questions from the December 21, 2017 meeting to discuss the draft Penobscot River shad report.

Question 1: *Were there any untagged shad released simultaneously with the radio-tagged shad upstream of Milford, Stillwater or Orono?*

Answer 1: No, releases consisted of radio-tagged individuals only.

Question 2: *Did the downstream drift assessment utilize the stationary receivers located downstream of each project?*

Answer 2: Yes, frequencies for the transmitters inserted into the dead shad released at the three dams were included in the scan settings for all downstream receivers.

Question 3: *Where were the dead shad obtained from*?

Answer 3: These individuals were mortalities from the Milford fish lift's upper flume.

Question 4: *What was the range of detection probabilities observed for the radio-telemetry receivers, and do good values at your detection locations provide better study results*?

Answer 4: Detection probabilities observed during the downstream shad passage evaluation at Milford, Stillwater and Orono ranged from 98-100%. A study with higher detection effectiveness will produce passage estimates with a tighter confidence interval than a study where detection efficiency is low among stations.

Question 5: *What happens to the gastric tags on a long-term basis?*

Answer 5: Although the fate of the transmitters in this study is unknown, American shad are considered a species with a high potential for retaining gastric transmitters. In general, adult American shad are not actively feeding during their upstream spawning migration, and as a result, the presence of the transmitter will have no effect. It is possible that long-term retention of gastric transmitters may induce a reaction of "fullness" in a fish. Tags affect food intake in proportion to the tag:fish weight ratio, although it seems likely that this effect is a function of the relative volumes of tag and stomach (Thorsteinsson 2002[5]). In general, biotelemetry studies strive to maintain a transmitter weight less than 2% of the fish weight. Assuming a 1,500 g (3.5 pound) shad, the 4 gram transmitters used in this study were well below that threshold.

Question 6: *Why is gender determined*?

Answer 6: Gender information is good to have and may be helpful in evaluating any trends or patterns in passage that may be observed during the course of the study. There are physical size differences between male and female adult shad.

Question 7: *Were there any areas where detections of radio-tagged shad were concentrated during the manual tracking events?*

Answer 7: The majority of locations were from individuals located in the approach-intake reaches upstream of Milford, Stillwater and Orono Dams, or in the three project tailraces. In addition to those locations, individuals were noted in the area immediately downstream of

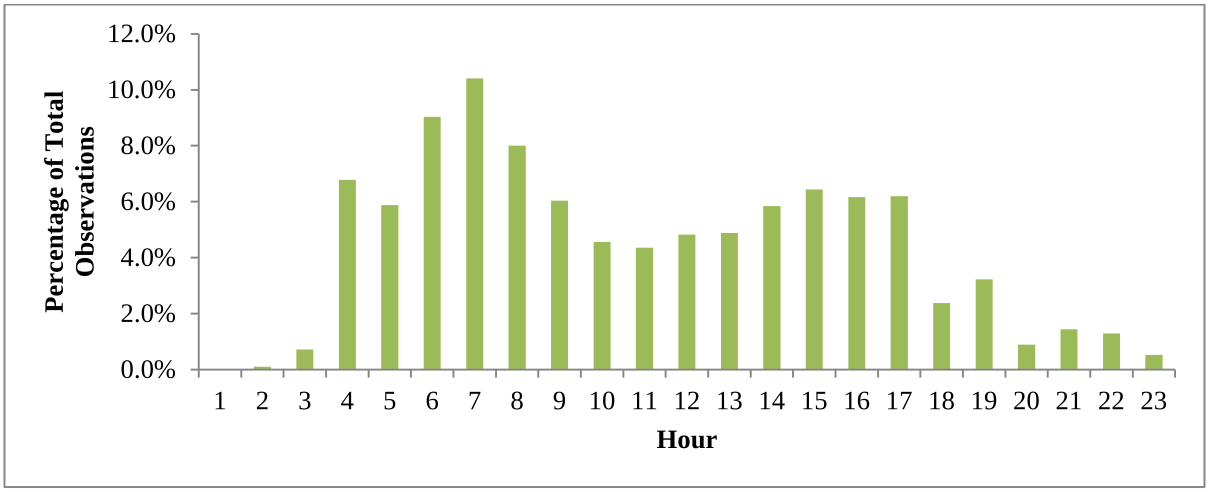
[5] Thorsteinsson, V. 2002. Tagging Methods for Stock Assessment and Research in Fisheries. Report of Concerted Action FAIR CT.96.1394 (CATAG). Reykjavik. Marine Research Institute Technical Report (79), pp 179.

Gilman Falls, in the vicinity of the mainstem island complex located upstream of Costigan, and in the mainstem river near the confluence with the Passadumkeag River (downstream of West Enfield).

Question 8: *It appeared that radio-tagged shad which approached West Enfield did so for periods of time, dropping back, and then returning. What time of day did the shad approaches occur?*

Answer 8: Correct, radio-tagged shad appeared to be moving in and out of the detection field covering the area downstream of the West Enfield powerhouse. The full series of detections for radio-tagged shad in the West Enfield tailrace was examined, and the hour of each observation was determined. The frequency distribution of detections by hour is presented below. In general, the pattern of detections was bi-modal with peaks in tailrace presence during the early morning hours (e.g. 0700) and late afternoon hours (e.g., 1500-1700). The proportion of observations dropped off during the overnight hours.

Figure A8. Frequency distribution of radio tag detections (by hour) for adult American shad in the West Enfield tailrace.



Question 9: *The Milford data seemed to indicate that radio-tagged shad were not finding a way out, is that accurate?*

Answer 9: Yes, the tagged shad demonstrated searching behavior as evidenced by the back and forth series of detections between the approach and intake receivers. The movements of these fish are not like those of smolts, since smolts are tagged at a point in time where they are going to exhibit directed downstream movement. These shad were intercepted on their way upstream to spawn, and thus, post-release movements are likely a combination of continued spawning and eventual outmigration behavior.

Question 10: *Any ideas on when spawning may have occurred?*

Answer 10: No, not based on this telemetry data set.

Question 11: *Did schools of radio-tagged shad hold together*?

Answer 11: We would regularly detect more than one individual radio-tagged shad at some locations during manual tracking (e.g., forebay areas upstream of each dam). In those instances, we could not determine if those fish were schooling. Observations of downstream passage events occurred individually, and there was no evidence of tagged fish passing in a group.

Question 12: *How were shad able to pass downstream via the Milford turbine units if there is one inch spacing on the inner racks?*

Answer 12: These may have been dead individuals impinged on the racks, and the tags were forced through during rack cleaning operations, or there may be locations where gaps or a hole is present (although Black Bear checks these annually to ensure integrity). Individuals passing via the turbine units were identified based on sequential detections from the unit intakes to the tailrace. It is possible that individuals meeting those criteria and missed during their use of an alternative route (e.g., downstream bypass) could be falsely assigned to turbine passage. As requested during the meeting, the final report has been edited to classify these fish as route "unknown" based on the assumption that turbine passage for adult shad is not feasible at Milford based on the one inch rack spacing.

Question 13: *It seems the majority of tagged shad passed Milford via the sluice gate. Was flow there only available when needed?*

Answer 13: Flow through the sluice gate during the shad passage period was available only during generation curtailments at the station, which are regulated by the ISO schedule and are outside of the control of Black Bear.

Question 14: *Was 2017 a "normal" year for the number of curtailments*?

Answer 14: No, there were more generation curtailments during 2017 than occurred in previous years.

Question 15: *Were spill gates at Milford opened during the study for the purposes of facilitating downstream shad passage?*

Answer 15: No, gate openings were available only during the generation curtailment periods. Outside of those windows, the station was operated under the "baseline" conditions described in the study plan, i.e., units in operation and downstream bypasses open.

Question 16: *Were daily counts collected as described in the study plan*?

Answer 16: The study plan described making observations for the purposes of detecting large numbers of adult shad milling upstream of project locations. Headpond observations were made at Milford, Stillwater and Orono as a part of the normal daily fish passage inspection process, and a summary of pertinent alosine observations from the three locations is provided here:

Table A16-1. Alosine related daily observation records pulled from 2017 daily project log for Milford.

Date	Time	Headpond Elevation (ft)	Tailwater Elevation (ft)	River Flow (cfs)	River Temp (°C)	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Hinged Gate Spill	Obermeyer Spill	Log Sluice Open	Downstream Bay 2 Flow (cfs)	Downstream Bay 7 Flow (cfs)	Total Downstream passage flow (cfs)	Comments
06/02/2017	4:30 PM	101.71	81.70		17.3	OFF	OFF	ON	ON	ON	ON	NO	NO	NO	280	232	512	SHAD ARE STARTING TO BE PASSED UPSTREAM.
06/28/2017	4:50 PM	100.45	81.63		22.4	ON	ON	OFF	ON	ON	ON	NO	NO	NO	206	170	376	30 AMS AND 200 RIV MILLING ALONG OUTER TRASHRACK
07/01/2017	7:15 AM	100.78	81.41		20.9	ON	ON	OFF	ON	ON	ON	NO	NO	NO	225	186	411	50 RIV AND 40 AMS MILLING ALONG OUTER TRASHRACK.
07/04/2017	2:30 PM	100.46	82.23		22.7	OFF	OFF	ON	ON	ON	ON	NO	NO	YES	206	170	376	NO SIGN OF SHAD OR RIV MILLING ALONG OUTER TRASH RACK.
07/10/2017	2:00 PM	100.78	80.81		24.4	OFF	OFF	OFF	OFF	ON	ON	NO	NO	YES	225	186	411	STILL 150 - 200 AMS ALONG OUTER TRASHRACK.
07/17/2017	8:15 AM	100.83	82.22	5938	23.7	ON	ON	ON	ON	ON	ON	NO	NO	NO	231	191	422	AMS MILLING ALONG OUTER TRASHRACK.
07/18/2017	3:00 PM	100.73	81.21	4338	24.4	ON	OFF	ON	ON	OFF	ON	NO	NO	NO	225	186	411	50 AMS MILLING ALONG OUTER TRASHRACK
07/19/2017	2:00 PM	100.73	81.36	5769	24.0	ON	ON	ON	ON	OFF	ON	NO	NO	NO	225	186	411	SAW 10-20 AMS PASS ALONG THE OBERMEYER NEAR THE UPSTREAM EELWAY

Table A16-2. Alosine related daily observation records pulled from 2017 daily project log for Stillwater.

		Downstream Fishway Powerhouse A			Downstream Fishway Powerhouse B			
Date	Time	Status	Flow Adequate (Y/N)	Clear of Debris (Y/N)	Status	Flow Adequate (Y/N)	Clear of Debris (Y/N)	Comments
6/11/2017	9:10	Open	Y	Y	Open	Y	Y	Thousands of returning RIV at DS entrance A, some debris in the way, removed, fish down the fishway. 3 RIV on ledges below station B fishway.
6/15/2017	8:30	Open	Y	Y	Open	Y	Y	Station A lots of adult RIV along trashrack. Cleared debris from DS entrance and the school went through. 4 new adult RIV morts on ledges by station B.
6/19/2017	8:15	Open	Y	Y	Open	Y	Y	Observed downstream fishway A 3:10 - 3:25 saw a large school of RIV swim by DS fishway twice without going down. Station B 3:27 - 3:42 saw nothing.
6/22/2017		Open	Y	Y	Open	Y	Y	RIV at DS fishway A entrance
6/23/2017	11:00	Open	Y	Y	Open	Y	Y	Observed school of about 400 RIV milling around at station A trash rack but not going down the fishway. No fish observed at station B in 15 min observation.
6/25/2017	11:30	Open	Y	Y	Open	Y	Y	Observed DS passage for 15 minutes at each station, did not see any RIV swimming around trash racks or using the DS passage. Removed a large log from the entrance to the DS fishway A.
6/27/2017	9:10	Open	Y	Y	Open	Y	Y	Observed a school of around 1000 RIV swimming back and forth around DS fishway A for 15 min without going down, past front and side entrance at least 10 times. Station B no fish observed in 15 min.
6/29/2017	11:00	Open	Y	Y	Open	Y	Y	Observed area around DS fishway A for 15 minutes at 11:00, saw a school of 10 shad swim along the trashracks, past the fishway and log sluice twice. Saw no fish in 15 min observation at station B.
6/30/2017	14:00	Open	Y	Y	Open	Y	Y	Thousands of adult RIV and a few shad milling around at DS fishway A, seemed like 1 big school.
7/1/2017	8:45	Open	Y	Y	Open	Y	Y	2 shad swimming back and forth on racks at station A.
7/2/2017	10:30	Open	Y	Y	Open	Y	Y	RIV at DS fishway A entrance
7/3/2017	17:00	Open	Y	Y	Open	Y	Y	Observed DS fishway A and area around it, saw a school of ~300 RIV milling around trash racks and swam by entrance to fishway without going down it a few times. No fish seen in 10 min observation at station B.
7/4/2017	9:45	Open	Y	Y	Open	Y	Y	Observed DS fishways A and B for 15 min each and saw no schools of shad or RIV.
7/8/2017	7:30	Open	Y	Y	Open	Y	Y	Watched for fish for 10 mins at each station, saw nothing.
7/9/2017	9:00	Open	Y	Y	Open	Y	Y	2 people watched for shad and RIV at both powerhouses for 10 min in the morning, saw 30 shad at station A, nothing at station B. One person watched for 10 min each at both stations in the afternoon and saw nothing. 1 STB mort wedged in the sluice gate.
7/10/2017	9:00	Open	Y	Y	Open	Y	Y	removed grizzly bar at DS fishway A at 9:00 to see if it encourages shad passage. Watched for 10 min, saw school of 30 fish pass by 3x from trash rack, past DS entrance and toward the island and back. Sawthe same school of 30 shad at 4pm. At station B, 200 adult RIV were seen using the DS fishway within a 10 min period in the morning, and 17 shad were seen passing downstream at 4 pm.
7/11/2017	8:40	Open	Y	Y	Open	Y	Y	Survey 8:45-8:50 no sign of shad (poor visibility). PM survey; 15:24, 12 shad swimming in pool above log sluice, 1000 JRIV swam into DS fishway.
7/12/2017	8:45	Open	Y	Y	Open	Y	Y	8:45 - No sign of shad or RIV at either station (poor visibility). 14:00 - observed fishway and trash racks for 10 minutes and saw no fish at either station.
7/13/2017	8:30	Open	Y	Y	Open	Y	Y	Rainy day, no fish seen milling at either station during a morning and afternoon observation.
7/14/2017	13:40	Open	Y	Y	Open	Y	Y	No fish seen passing either fishway during a 15 min observation.
7/17/2017	10:00	Open	Y	Y	Open	Y	Y	Some JRIV showing.
7/18/2017	9:00	Open	Y	Y	Open	Y	Y	Saw JRIV jumping near log sluice.
7/19/2017	10:00	Open	Y	Y	Open	Y	Y	No fish seen during a 10 min observation at either powerhouse.
7/21/2017	8:00	Open	Y	Y	Open	Y	Y	Bass rising in the headpond. No sign of shad.
7/22/2017	7:30	Open	Y	Y	Open	Y	Y	2 People, 15 min at each station, no fish seen milling near the DS fishways or trashracks, but saw what is probably bass feeding on JRIV in the tailrace.
7/26/2017	8:30	Open	Y	Y	Open	Y	Y	8:30 - JRIV showing in great numbers. 1:00 - Bass feeding in headwater and tailwater.
7/27/2017	9:00	Open	N	Y	Open	N	Y	No fish seen. Reduced flow through the fishways for dive inspections of low level entrances and trashracks.
7/31/2017	14:00	Open	Y	Y	Open	Y	Y	Log removed from DS fishway A entrance. Observed HP at both powerhouses, for 3 min each site. No fish seen.
8/1/2017	7:50	Open	Y	Y	Open	Y	Y	Observed DS fishways for 5 minutes, no sign of any fish.
8/3/2017	10:30	Open	Y	Y	Open	Y	Y	Few thousand JRIV near log sluice.

Date	Time	Downstream Fishway Powerhouse A			Downstream Fishway Powerhouse B			Comments
		Status	Flow Adequate (Y/N)	Clear of Debris (Y/N)	Status	Flow Adequate (Y/N)	Clear of Debris (Y/N)	
8/4/2017	7:45	Open	Y	Y	Open	Y	Y	Some JRIV in headpond.
8/5/2017	10:00	Open	Y	Y	Open	Y	Y	Spill over boards, we saw ~30 JRIV passing at 9:45 at DS fishway B.
8/6/2017	7:30	Open	Y	Y	Open	Y	Y	Surveyed 10 mins saw no activity at either powerhouse
8/12/2017	8:30	Open	Y	Y	Open	Y	Y	JRIV in headpond
8/15/2017	8:00	Open	Y	Y	Open	Y	Y	10 minute survey no fish in headpond, bass jumping at station B tailwater. Downstream eelway opened for the season at 2 pm.
8/19/2017	11:00	Open	Y	Y	Open	Y	Y	JRIV in headpond
8/20/2017	11:00	Open	Y	Y	Open	Y	Y	Still JRIV hanging out in headpond

Table A16-3. Alosine related daily observation records pulled from 2017 daily project log for Orono.

Date	Headpond Elv. (ft)	Tailwater Elv. (ft)	River Flow (cfs)	Water Temp (oC)	Spill (Y/N)	Station A (%)				Station B (%)			Downstream Fishway		Comments
						U1	U2	U3	U4	U1	U2	U3	(Open/Closed)	Clear of Debris?	
6/2/2017	71.64	42.85		15.5		0	74	0	0	95	93	92	Open	Y	RIV 100 going down at 7:30
6/4/2017	71.51	43.09		17.6		0	59	0	79	70	88	88	Open	Y	Alewives returning downstream in good numbers. Downstream transition box full of them.
6/11/2017	73.04	43.37		19.1	N	0	98	0	74	95	89	88	Open	Y	Thousands of returning RIV using DS.
6/26/2017	72.98	42.49		22.1	N	0	0	0	98	67	88	88	Open	Y	200 RIV in downstream transition box.
7/1/2017	73.10	40.74		21.5	N	0	0	0	85	70	71	71	Open	Y	Adjusted US entrance gate to 14" at 1:00 PM, to experiment. 30-40 RIV in downstream transition box
7/2/2017	73.00	42.78		20.9	N	0	0	0	85	80	88	89	Open	Y	50 RIV in downstream transition box.
7/27/2017	73.10	41.98	2354	23.4	Y	0	99	0	0	90	88	88	Open	Y	Shad in DS, maybe a dozen or so. Adjusted the 8' gate and they went down.
7/29/2017	72.96	42.20	2112	22.9	N	0	99	0	0	75	88	88	Open	Y	A few shad in DS at 8:30.
7/30/2017	72.96	42.28		23.1	N	0	99	0	0	55	88	88	Open	Y	Some shad hanging out in DS

Question 17: *Date, time and discharge of gate openings were supposed to be included in the study report. Is that information available*?

Answer 17: Spill information at Milford in the draft report was provided in graphical format (Figure 4.3-3). The tabular format of that data is provided here:

Table A17. Date and time for the opening and closing of spill gates due to generation curtailment periods at Milford during the 2017 shad passage study.

	Gate Open		Gate Closed			Mean
Gate	Date	Time	Date	Time	Opening	Discharge (cfs)
Sluice	6/13/2017	2030	6/14/2017	0730	full open	2,029
Sluice	6/20/2017	1915	6/21/2017	0800	full open	1,661
Sluice	6/22/2017	0830	6/22/2017	1330	full open	1,661
Sluice	6/22/2017	1530	6/24/2017	0800	open 2.5 ft	683
Sluice	7/2/2017	1420	7/3/2017	0730	full open	1,661
Sluice	7/4/2017	1700	*	*	*	1,661
Sluice	7/10/2017	1400	7/10/2017	1500	open 2 ft	560
Sluice	7/11/2017	1355	7/12/2017	0740	full open	1,661
Obermeyer	6/19/2017	~1900	6/19/2017	~0700	-	-
Obermeyer	6/21/2017	0700	6/21/2017	0900	-	-
Obermeyer	6/22/2017	0700	6/22/2017	0900	-	-

Question 18: *Prioritization of the sluice is not in the Milford O&M Plan. What is the advantage of passing flows via that structure rather than passing flows over the dam?*

Answer 18: The Standard Operating Procedures for passage of river flows in excess of station capacity is included in the Milford Operation and Flow Monitoring Plan which was filed with FERC on July 9, 2013. The sluice gate provides a safer passage route for downstream passage of fish rather than spilling them over the dam where they could potentially hit ledge areas. In addition, passage of spill flows over the western side of the dam can reduce far field attraction to the fish lift entrance as well as lead to stranding events when flows through that reach are terminated.

Question 19: *The study plan indicated the Licensee would consult with the resource agencies if any gates were required to be opened to deal with lack of downstream passage. Why wasn't that done?*

Answer 19: As described in the study plan, "Should the licensees need to open any additional sluice passage based on observations of large numbers of adult shad milling upstream of a particular Project and following consultation with the resource agencies, the date and time of opening, date and time of closing, and the estimated discharge will be recorded and provided in the study report." There were no spill flows provided at Milford during the 2017 study that were initiated for any reason other than the generation curtailment periods that were outside of Black Bear's control.

Question 20: *On the Stillwater Branch, did tagged shad pass both facilities similarly?*

Answer 20: No, when observations are generalized, tagged shad approaching Stillwater were resident for a longer period of time than those passing at Orono. As noted at the meeting, the draft report did not present the estimates of upstream residency duration for individual shad passing at both Stillwater Branch project locations. Residency durations at Stillwater and Orono were available for a total of 42 radio-tagged shad. As evidenced from the table below, the majority (83%) of those had a shorter residence time at Orono than was observed at Stillwater. For those (35) individuals, the observed residence duration at Orono was equivalent to, on average, 16% of the time spent upstream of Stillwater. The forebay residence estimates in Table A20 represent the duration of time from initial detection at the dam until known passage downstream.

Table A-20. Forebay residency durations (hours) for radio-tagged shad confirmed to have approached and passed downstream of both the Stillwater and Orono Projects.

Frequency	Code	Release Location	Forebay Residency Duration (hrs)	
			Stillwater	Orono
760	29	Costigan	48.7	6.7
760	52	Costigan	133.3	23.6
760	54	Costigan	197.1	15.9
760	55	Old Town	236.7	47.5
760	66	Costigan	0.4	0.7
760	73	Old Town	26.5	20.1
760	74	Old Town	298.6	93.7
760	75	Old Town	139.2	5.9
760	76	Old Town	308.5	18.3
760	77	Old Town	45.1	171.9
760	78	Old Town	364.4	0.4
760	80	Old Town	257.4	1.0
760	81	Old Town	22.0	23.3
760	82	Old Town	207.5	0.3
760	85	Old Town	222.7	2.5
760	86	Old Town	124.4	6.6
760	87	Old Town	132.2	31.1
760	88	Old Town	332.4	27.1
760	90	Old Town	110.2	0.8
760	95	Old Town	115.2	256.1
760	114	Costigan	48.3	10.8
760	135	Costigan	3.7	0.6
760	140	Costigan	43.5	16.8
780	32	Costigan	45.8	20.0
780	59	Old Town	123.3	15.1
780	60	Old Town	50.7	1.3
780	61	Old Town	98.4	21.2
780	64	Old Town	277.2	0.7
780	65	Old Town	86.6	6.4

Frequency	Code	Release Location	Forebay Residency Duration (hrs)	
			Stillwater	Orono
780	67	Old Town	139.4	6.3
780	68	Old Town	281.5	37.8
780	69	Old Town	281.0	96.2
780	96	Old Town	389.3	81.4
780	98	Old Town	0.7	44.3
780	100	Old Town	23.8	90.7
780	101	Old Town	131.1	37.4
780	103	Old Town	28.0	1.0
780	104	Old Town	212.2	24.5
780	105	Old Town	413.9	42.6
780	106	Old Town	103.7	51.0
780	126	Costigan	16.9	0.8
780	128	Costigan	1.5	144.1

Question 21: *MDMR noted that shad were observed milling within the bypass at Orono. Were boards pulled in order to pass these fish downstream, potentially influencing residence times and passage results?*

Answer 21: There was a single date (July 27, 2017) where the operations log indicates that stop logs in the downstream bypass were pulled to flush shad out of that structure (see Table A16). No radio-tagged individuals were determined to have passed downstream of Orono on that date. Thus, downstream passage events recorded at Orono are a reflection of volitional passage.

Question 22: *Was it possible to tell how much time was spent at the grizzly rack entrance versus inside of the grizzly racks?*

Answer 22: No, the array deployed during 2017 did not provide the resolution for that type of analysis.

Question 23: *If you were to repeat this study effort, is there anything you would do differently?*

Answer 23: The 2017 study examined baseline operational conditions at Milford, Stillwater and Orono and provided valuable information on downstream passage at all three project locations. As noted in question 22, better resolution of the spatial and temporal distribution of shad in the vicinity of the Milford rack structure and intakes would be beneficial in helping to clarify passage via the powerhouse at that location.

Question 24: *Can we tell how much water passed through the sluice gate?*

Answer 24: Sluice flow was available only during curtailment periods during the 2017 study period. During most events, the sluice was fully opened. Total discharge would be a function of the degree of opening coupled with headpond level at that time. When the headpond is full and the sluice is fully opened, it passes approximately 2,000 cfs. See Table A-17 for the 2017 study period estimated sluice flow values.

Appendix E

Correspondence related to distribution and comment on the draft Penobscot River shad report.

From: Dill, Richard [mailto:Richard.Dill@brookfieldrenewable.com]
Sent: Friday, December 01, 2017 2:17 PM
To: Simpson, Mitch; Jeff Murphy - NOAA Federal; Donald Dow - NOAA Affiliate; Wippelhauser, Gail; Daniel McCaw (dan.mccaw@penobscotnation.org); Steve Shepard (Steven_Shepard@fws.gov); Kramer, Gordon; Howatt, Kathy; Perry, John; Sean McDermott - NOAA Federal; Jason Valliere (jason.valliere@maine.gov); Dunham, Kevin; Carl Wilson (Carl.Wilson@maine.gov); Dan Kusnierz (Dan.Kusnierz@penobscotnation.org); Dan Tierney (dan.tierney@noaa.gov)
Cc: Brochu, Robert; Cole, James; Maloney, Kelly; Bernier, Kevin; Drew Trested; Sears, Michael
Subject: 2017 draft adult American shad downstream passage report, Lower Penobscot; 2017 draft Stillwater Dam upstream eel passage monitoring report

Please find attached Normandeau's draft report covering Brookfield's 2017 adult American shad downstream passage study conducted at the Milford, Stillwater, and Orono projects, as well HDR's draft report of the Stillwater Dam upstream eel monitoring study. I will send out a doodle poll in the near future for scheduling a meeting to discuss these reports and gather comments. Formal written comments for the reports are due by December 31, 2017. We intend to finalize the reports and make plans for the 2018 field season in early January.

Thanks, and feel free to contact Kevin or I with any questions.

Richard Dill
Compliance Specialist

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Brookfield

National Marine Fisheries Service:

From: Jeff Murphy - NOAA Federal [mailto:jeff.murphy@noaa.gov]
Sent: Thursday, December 28, 2017 11:26 AM
To: Dill, Richard
Cc: Simpson, Mitch; Donald Dow - NOAA Affiliate; Wippelhauser, Gail; Daniel McCaw (dan.mccaw@penobscotnation.org); Steve Shepard (Steven_Shepard@fws.gov); Kramer, Gordon; Howatt, Kathy; Perry, John; Sean McDermott - NOAA Federal; Jason Valliere (jason.valliere@maine.gov); Dunham, Kevin; Carl Wilson (Carl.Wilson@maine.gov); Dan Kusnierz (Dan.Kusnierz@penobscotnation.org); Dan Tierney (dan.tierney@noaa.gov); Brochu, Robert; Cole, James; Maloney, Kelly; Bernier, Kevin; Drew Trested; Sears, Michael
Subject: Re: 2017 draft adult American shad downstream passage report, Lower Penobscot; 2017 draft Stillwater Dam upstream eel passage monitoring report

Hello Richard - Thank you for seeking our input on the draft 2017 American shad and American eel study reports. I don't have any comments on the upstream eel passage report at the Stillwater Project. I have a few questions/comments concerning the downstream shad study conducted at the Milford, Stillwater, and Orono Projects below. Thank again, Jeff.

- All Projects - I'm not sure that it's appropriate to adjust forebay residency duration at each project for shad that encountered the projects but did not pass downstream during their first attempt.
- Is it possible to calculate forebay residency duration at Milford separately for those fish that passed via the waste gate vs other routes of passage?
- The estimated survival of shad at Milford (76.6%) and relatively long forebay residency time (mean = 93.5 hours) indicate that additional measures are necessary to protect downstream migrants at the project.
- We are quite pleased with the survival of American shad at the Stillwater Project (95.8%) and use of the downstream fishway (90%). A mean forebay residency time of 133.7 hours suggest that downstream migrants are somewhat reluctant to enter the downstream fishway at Powerhouse B.
- We are encouraged with the survival of American shad at the Orono Project (84.3% - 87.0%) and quite pleased with use of the downstream fishway (93%). We also note that mean forebay residency duration at Orono (72.7 hours) was lower than either Milford or Orono.
- We look forward to working with you to develop plans for the 2018 field season.

United States Fish and Wildlife Service:

From: Shepard, Steven [mailto:steven_shepard@fws.gov]
Sent: Friday, December 29, 2017 2:38 PM
To: Dill, Richard
Cc: Simpson, Mitch; Jeff Murphy - NOAA Federal; Donald Dow - NOAA Affiliate; Wippelhauser, Gail; Daniel McCaw (dan.mccaw@penobscotnation.org); Kramer, Gordon; Howatt, Kathy; Perry, John; Sean McDermott - NOAA Federal; Jason Valliere (jason.valliere@maine.gov); Dunham, Kevin; Carl Wilson (Carl.Wilson@maine.gov); Dan Kusnierz (Dan.Kusnierz@penobscotnation.org); Dan Tierney (dan.tierney@noaa.gov); Brochu, Robert; Cole, James; Maloney, Kelly; Bernier, Kevin; Drew Trested; Sears, Michael
Subject: Re: 2017 draft adult American shad downstream passage report, Lower Penobscot; 2017 draft Stillwater Dam upstream eel passage monitoring report

The Service provides the following comments on Lower Penobscot River American shad downstream passage testing and Stillwater Project upstream eel passage testing.

American shad in in the northern portion of the range are iteroparous and spawning runs entering Maine rivers typically contain a significant proportion of repeat spawners. Downstream shad passage at Milford incurred high mortality and long delays. It appears that many shad were unable or unwilling to use the downstream bypass and were delayed until the waste gate was fully open. These Milford Project impacts are a problem, particularly the mortalities, since most shad are expected to pass via the mainstem of the Penobscot River. Survival estimates at the Stillwater and Orono projects were better than Milford, however delays at these projects were also quite long for some shad. Mortality and delay returning to the ocean reduce the survival and fitness of post-spawners and thereby impact future shad reproduction in the Penobscot River.

With regard to the Stillwater upstream eel fishway monitoring and evaluation, the night observations and video estimates indicate that large numbers of upstream migrants are attracted to the fishway and successfully pass upstream. The Service has typically required the standard eel fishway effectiveness test noted in the MDMR comments. This test complements night observations of eel passage and behavior. The effectiveness test consists of confining test groups of 100 eels in a tank at the fishway entrance near dusk and capturing all of the migrant eels passing that night. The Service has not defined a specific effectiveness metric, but most eel fishway effectiveness tests approach 100% passage in one night. The design of the Stillwater upstream eel fishway may not lend itself to such a test. We will assess the ability to conduct the standard test, or an alternative test, with MDMR.

The Service also concurs with MDMR and NOAA comments on the subject fish passage studies.

Maine Department of Marine Resources:

From: Wippelhauser, Gail [mailto:Gail.Wippelhauser@maine.gov]
Sent: Friday, December 29, 2017 1:03 PM
To: Dill, Richard; Simpson, Mitch; Jeff Murphy - NOAA Federal; Donald Dow - NOAA Affiliate; Daniel McCaw (dan.mccaw@penobscotnation.org); Steve Shepard (Steven_Shepard@fws.gov); Kramer, Gordon; Howatt, Kathy; Perry, John; Sean McDermott - NOAA Federal; Valliere, Jason; Dunham, Kevin; Wilson, Carl; Dan Kusnierz (Dan.Kusnierz@penobscotnation.org); Dan Tierney (dan.tierney@noaa.gov)
Cc: Brochu, Robert; Cole, James; Maloney, Kelly; Bernier, Kevin; Drew Trested; Sears, Michael
Subject: RE: 2017 draft adult American shad downstream passage report, Lower Penobscot; 2017 draft Stillwater Dam upstream eel passage monitoring report

Hi Richard:

Here are DMR's comments on the shad downstream study and eel upstream passage study reports. We look forward to ongoing consultation in 2018.

Comments on the shad study

Additional measures are needed to protect downstream migrants at the Milford Project for the following reasons:

- More than half of the shad (58%) passed via the waste gate, a potentially safe route that may not be available in the future as frequently as it was in 2017;
- Even the adjusted forebay residence time was long for nearly half of the tagged fish (56% passed within 49.8 h, but 44% required up to 20 days). This delay is of concern because the forebay provides neither spawning nor foraging habitat, and the minimum migration speed for shad in the river below Milford is 0.2km/h.
- Estimated survival (76.6%) was lowest on the mainstem where presumably most of the shad will pass.

Passage at the Stillwater and Orono Projects was encouraging, but delay is a concern at Stillwater.

At the Stillwater Project, the majority of the shad (94%) used the downstream bypasses, and survival was high (95.8%). However, adjusted forebay residence was long for nearly half of the tagged fish (50% passed within 51.5 h, but 50% required up to 15 days to pass).

At the Orono Project, the majority of the shad (93%) used the bypass, adjusted forebay residence time was the least (75% passed within 45 h) of all the projects, and estimated survival was intermediate (84.3%).

Comments on eel study

MDMR typically requires effectiveness testing of each newly installed eel passage. The protocol has been to place a known number of eels into an escape-proof cage (not as easy as it sounds) at the base of the fishway at dusk and collect the eels at the top the following morning.

Gail Wippelhauser, Ph. D.
Marine Resources Scientist
Maine Department of Marine Resources
#172 State House Station
Augusta, ME 04333

Phone: 207-624-6349 Fax: 207-624-6501
email: gail.wippelhauser@maine.gov

Maine Department of Environmental Protection:

From: Howatt, Kathy [mailto:Kathy.Howatt@maine.gov]
Sent: Friday, December 29, 2017 2:40 PM
To: Dill, Richard
Cc: Sroka, Eric
Subject: RE: 2017 draft adult American shad downstream passage report, Lower Penobscot; 2017 draft Stillwater Dam upstream eel passage monitoring report

Richard,
Thank you for the opportunity to review these study reports and to attend the study report meeting last week at Milford. I have reviewed MDMR's comments, and concur; the Department has nothing to add.
Kathy

Kathy Davis Howatt
Hydropower Coordinator
Bureau of Land Resources, Land Division
Maine Department of Environmental Protection
Phone: 207-446-2642
kathy.howatt@maine.gov

Correspondence to and from this office is considered a public record and may be subject to a request under the Maine Freedom of Access Act. Information that you wish to keep confidential should not be included in email correspondence.

PENOBSCOT NATION

DEPARTMENT OF
NATURAL RESOURCES

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Richard Dill

Compliance Specialist

Brookfield Renewable

1024 Central Street,

Millinocket, Maine 04462

12/29/2017

RE: 2017 Draft Adult American Shad Downstream passage report (FERC # 2534), 2017 Draft Stillwater Dam (FERC-2712) Upstream American eel passage monitoring report

Dear Mr. Dill,

The Penobscot Indian Nation (PIN) would like to submit the following comments with regards to studies conducted at the Milford and Stillwater, and Orono (FERC-2710) Dams on the Penobscot River in 2017. Please reach out with any questions you may have at your convenience.

<u>2017 Draft Adult American Shad Downstream Passage Report</u>

This study was conducted as proposed in the May 15th, 2017 Study plan submitted by the licensee, with several exceptions. The PIN would like to point out these inconsistencies between the study plan and the draft study report and ask specific questions with regards to each item.

1) The use of the "Waste gate" at the Milford facility as a potential downstream passage route was not identified in the Project Description Section 2.1 of the Study plan. However, its use as such is described in the draft report's Project Description's Section 2.1. Indeed, 58% of the shad that passed the Milford dam passed via the waste gate. Can the licensee describe the change in thought/use /prioritization with regards to the Waste gate from the study plan through the draft report time-frame? Did the licensee feel the waste gate was a safe option for passage? Was it operated under "baseline" conditions as described in the study plan? Will the waste gate be available for future years? Can operation of the waste gate be standardized for each passage season and its effectiveness assessed as such?

100% Processed Chlorine Free

2) The Study plan describes, in the response to agency comment section, page B3, response # 6, the licensee states that it intends "to take an adaptive approach if needed, and will consult with the resource agencies throughout the study period to avoid unwanted fish kills". This language is also repeated closely in Section 3.2.4.5, River and Project Operational Data. In Section 3.2.4.5, the licensee states that "should the licensees need to open any additional sluice passage based on observations of large numbers of adult shad milling upstream of a particular Project, and following consultation with the resource agencies, the date and time of opening and closing and the estimated discharge will be recorded and provided in the study report." This consultation did not happen during the course of the study. In addition, the waste gate at the Milford dam was operated many times during the study period, without agency notice or consultation. The licensee explained in the draft study report that the waste gate was opened for operational purposes or curtailment of generation in Sections 3.5.5 and 4.3.2. This specific issue was addressed in a 12/21/17 meeting with the agencies and the licensee. At that meeting, the licensee described how even though the intent was to operate under "baseline conditions", generation curtailments outside of the licensees control dictated a need for spill. This spill has been prioritized by the licensee to occur at the waste gate first, in order to provide safer downstream passage for fish. This prioritization of spill through the waste gate was explained to the agencies at the 12/21/17 meeting, and it was also explained that although this is the policy, is it not written down in any Operations or fish passage protocol or plan for the Milford dam. The PIN would request that any data for the waste gate usage during the study period be provided in the final report as described in the study plan. The PIN also requests that plans and protocols for prioritization of spill at the Milford dam be developed in consultation with the agencies and submitted to FERC for approval.
3) The Study plan describes, in the response to agency comment section, page B3, response # 7, the licensee states that the daily, visual observations for milling shad upstream of the projects would be recorded and provided in the draft report. These daily observations from the three facilities over the course of the study period were not included in the final report. The PIN would request that this information be provided in the final report.
4) The Study plan describes, in the response to agency comment section, page B3, response # 8, the licensee states that any manipulations to dam operations outside of the "baseline conditions" would be recorded. This information does not appear in the draft report and should be summarized in the final report.

The PIN understands many of these items overlap in the study plan and draft report, and therefore some of the comments and questions are repetitive.

In general, the PIN believes the operation of the Milford project during the study period was wildly inconsistent with the study plan and that a degree of gamesmanship was being undertaken by the licensee to safely get adult American shad past the facility. Shad were probably milling in front of the Milford powerhouse for weeks without using the downstream bypasses, as they had been observed by the licensee in 2016, who specifically utilized the waste gate at that time to pass adult shad observed holding in front of the Milford trash racks. How can downstream passage be assessed and improved upon if the operations, techniques and passages being evaluated are changed mid study?

Section 4.1.2.

The downstream drift assessment states that the vast majority of dead shad released were found within the project tailrace through the end of the study period. This information seems counterintuitive concerning the drift of a large bodied fish like an adult American Shad. The PIN requests that the licensee compare these results with other studies to see if the information gained was consistent with other assessments and would ask that this information be provided in the final report.

Section 4.6.2.

Also, in the draft report, it is stated in Section 4.6.2.2 that 12%, or 11 adult had passed via the turbine units. The trash racks at Milford are full depth, 1" clear spacing. How does the licensee explain how these fish could have passed through such a space? The PIN in concerned these adult shad were impinged and killed on the racks, and only the tags passed through as their bodies decomposed. The PIN would like to see the disposition of these fish changed to mortalities in the final report and the survival numbers adjusted accordingly.

The report also states in this section that perhaps eight tagged shad were released upstream of the Milford dam and never contacted again. Can the licensee provide any explanation as to the disposition of these fish and how the manual tracking strategy and stationary tracking arrays could be adjusted to cure this issue in the future?

2017 Draft Stillwater Dam upstream eel passage monitoring report

The PIN concurs with the comments provided to date by the Maine Dept. of Marine Resources, the National Marine Fisheries Service, and the US Fish and Wildlife Service. The PIN looks forward to setting evaluation criteria for the assessment of upstream passage of juvenile eels, and the creation of upstream studies that get at passage efficiency and not just counts.

The Penobscot Indian Nation appreciates the opportunity to comment on these studies. The PIN looks forward to a study plan for 2018 that includes the assessment of downstream passage for adult and juvenile shad, alewife, and blueback herring. The PIN also looks forward to the 2018 study plan for assessing the upstream passage of American eel, American shad, alewife and Blueback herring at the Milford project. Studies conducted recently in Maine have shown that adult herring can be radio tagged and expected to continue to migrate upstream. These studies were conducted in 2015 and 2016 at the West Buxton Project (FERC # 2531) on the Saco River, and the Shawmut Project (FERC #2322) in the Kennebec River, respectively. These studies need to be conducted on the Penobscot River as well, as outlined by license article 409 of the Milford license.

Sincerely,

12/29/17

Daniel McCaw

Fisheries Program Manager

Penobscot Indian Nation

Appendix F

Responses to written questions received on the draft Penobscot River shad report.

Question 1 (NMFS): *All Projects - I'm not sure that it's appropriate to adjust forebay residency duration at each project for shad that encountered the projects but did not pass downstream during their first attempt.*

Response 1: The calculation of forebay residency duration was contemplated during preparation of the draft report. The starting methodology defined forebay residency as the duration from initial detection at the approach receiver until confirmed downstream passage at the dam. This approach has worked well during Atlantic salmon smolt evaluations, where upon release tagged smolts will demonstrate a directed downstream migration. The adult shad in this evaluation were intercepted during their upstream spawning migration; they were then tagged, handled, and released. Tagging of adult alosines during their spawning migration frequently results in a proportion of the sample size exhibiting "fall back" behavior (i.e., downstream movement) immediately following tagging. However, a proportion of those individuals would be expected to recommence their directed upstream spawning movement after a period of time (likely related to recovery from tagging stresses). This behavior was observed during an evaluation of adult shad movement on the Kennebec River, where a proportion of tagged fish reinitiated their upstream migration following a period of residence at a point downstream of their release location (Normandeau 2016[6]).

When taken into account, this previously observed behavior suggests that a portion of individuals detected within the reach upstream of each dam may have been in a post-tagging fall back/recovery period during their initial detection at the dam. Following their "recovery" period, a percentage of these fish moved back upstream to presumably continue with spawning behavior. The adjusted forebay residency time was an attempt to provide an estimate of time spent in the vicinity of the dam, where it was assumed that downstream passage was actively being attempted, and to remove intervening periods of upstream residence which may be related to spawning. Alternatively, it is also possible that these fish could not find suitable downstream passage during their initial attempt, and that the intervening periods of time spent upstream and out of the project impoundment were a continuation of their searching behavior for a downstream route. As there is really no way to distinguish these behaviors, the draft report presented the estimates of forebay residency duration and adjusted forebay residency duration in order to provide the reader with a more complete picture of observed behavioral patterns.

Question 2 (NMFS): *Is it possible to calculate forebay residency duration at Milford separately for those fish that passed via the sluice gate vs other routes of passage?*

Response 2: Yes, please see Table R2 below:

[6] Normandeau (Normandeau Associates, Inc.) 2016. Assessment of upstream American shad passage at the Lockwood Project, Kennebec River, Maine. Report prepared for Merimil Limited Partnership.

Table R2: Minimum, maximum, median and mean forebay residency and adjusted forebay residency durations for radio-tagged adult American shad at Milford (by passage route) during the 2017 evaluation.

Passage Route	Forebay Residency Duration (hrs)				Adjusted Forebay Residency Duration (hrs)			
	Min	Max	Median	Mean	Min	Max	Median	Mean
Sluice Gate	0.3	606.8	32.2	77.2	0.3	467.3	31.5	61.4
Obermeyer Gate	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Downstream Bypass	9.6	275.6	144.9	154.0	9.6	272.1	105.5	122.8
Unknown	1.0	502.8	28.6	94.8	1.0	483.7	28.6	93.3

Question 3 (PIN): *The use of the "waste gate" at the Milford facility as a potential downstream passage route was not identified in the Project description Section 2.1 of the study plan. However, its use as such is described in the draft report's project description Section 2.1. Indeed, 58% of the shad that passed the Milford Dam passed via the waste gate. Can the licensee describe the change in thought/use/prioritization with regards to the waste gate from the study plan through the draft report timeframe? Did the licensee feel the waste gate was a safe option for passage? Was it operated under "baseline" conditions as described in the study plan? Will the waste gate be available for future years? Can operation of the waste gate be standardized for each passage season and its effectiveness assessed as such?*

Response 3: As discussed during study plan development, the goal of the 2017 evaluation was to focus on "baseline" conditions (i.e., turbines in operation and downstream bypasses open). As a result, the Milford project description provided in the study plan focused specifically on those two downstream route options. During the period of time where radio-tagged shad were present upstream of the project, Black Bear operated Milford within this "baseline" condition with the exception of several generation curtailment periods imposed by ISO New England. These curtailment periods necessitated the passage of inflow via spill rather than by generation. As explained by Black Bear operations personnel at the December 21, 2017 study discussion, the ISO New England generation curtailment periods are outside of the control of Black Bear. When generation is curtailed, the station prioritization route for passing inflows is (1) sluice gate, (2) Obermeyer gate, and (3) hinge (flashboard) gates. Black Bear has historically prioritized use of the sluice gate for passage of spill flows up to 2,000 cfs, which is the maximum capacity of that structure under normal full pond conditions. This gate has been prioritized, as it provides relatively safe downstream passage into an area free of ledge and unlike options on the western side of the river it does not contribute to a reduction of far field attraction at the upstream fish lift or lead to potential stranding events at the time spill is terminated.

With regards to future use of the sluice gate for downstream passage at Milford, Black Bear intends to continue prioritizing its operation for spill events before utilizing the Obermeyer gate and hinged flashboard section of the dam to pass flows.

Question 4 (PIN): *The PIN would request that any data for the waste gate usage during the study period be provided in the final report as described in the study plan. The PIN also request that plans* *and protocols for prioritization of spill at the Milford Dam be developed in consultation with the agencies and submitted to FERC for approval.*

Response 4: The draft study report provided the timing of sluice gate usage in graphical format (see Figure 4.3-3). As requested, that same data is provided in tabular format in Table A17 of Appendix D of this final report.

Per the current *Operations and Flow Monitoring Plan* for the Milford Project, a protocol for prioritized operation of the sluice gate for flows exceeding hydraulic capacity has already been established and approved by FERC.

Question 5 (PIN): *The study plan describes, in the response to agency comment section, page B3, response # 7, the licensee states that the daily, visual observations for milling shad upstream of the projects would be recorded and provided in the draft report. These daily observations from the three facilities over the course of the study period were not included in the final report. The PIN would request that this information be provided in the final report.*

Response 5: Black Bear fish passage personnel conducted daily fishway checks throughout the study period at Milford, Stillwater and Orono. Observations related to shad and alosines are provided in Tables A16-1 (Milford), A16-2 (Stillwater), and A16-3 (Orono) in Appendix D of this final report.

Question 6 (PIN): *The downstream drift assessment states that the vast majority of dead shad released were found within the project tailrace through the end of the study period. This information seems counterintuitive concerning the drift of a large-bodied fish like an adult American shad. The PIN requests that the licensee compare these results with other studies to see if the information gained was consistent with other assessments and would ask that this information be provided in the final report.*

Response 6: Based on observations from the 2017 downstream drift evaluation, timely detection of known dead individuals at the downstream monitoring stations did not occur at any of the three projects. Most individuals (4 of 5 at Milford, 3 of 6 at Stillwater and 4 of 5 at Orono) were still within the detectable range for manual tracking equipment when looking downstream from the project dams. It has been suggested that downstream drift of dead fish is impacted by a number of factors including river discharge, current patterns downstream of a project, magnitude and frequency of flood pulses, river morphology (i.e., the degree of channel sinuosity), substrate composition, fish species and size and decay rate (Havn et al. 2017[7]). The downstream drift of freshly-dead adult American shad has been previously examined at Holyoke Dam on the Connecticut River (Bell and Kynard 1985[8]). Under the unique set of river discharge conditions at their study location, Bell and Kynard (1985) observed all freshly-dead adult shad to settle out in an area of reduced flow between 0.6-1.3 km downstream of the project.

[7] Havn, T.B., F. Okland, M.A.K. Teichert, L.. Heermann, J. Borcherding, S.A. Saether, M. Tambets, O.H. Diserud, and E.B. Thorstad. 2017. Movements of dead fish in rivers. Animal Biotelemetry (2017) 5:7.

[8] Bell, C.E., and B. Kynard. 1985. Mortality of adult American shad passing through a 17-megawatt Kaplan turbine at a low-head hydroelectric dam. North American Journal of Fisheries Management 5:33-38.

Question 7 (PIN): *Also, in the draft report, it is stated in Section 4.6.2.2 that 12% or 11 adults had passed via the turbine units. The trash racks at Milford are full depth, 1" clear spacing. How does the licensee explain how these fish could have passed through such a space? The PIN is concerned these adult shad were impinged and killed on the racks, and only the tags passed through as their bodies decomposed. The PIN would like to see the disposition of these fish changed to mortalities in the final report and the survival numbers adjusted accordingly.*

Response 7: As previously stated in response to Question 12 in Appendix D of this report, it is likely these fish may have been dead individuals which were impinged on the racks and the tags forced through during rack cleaning operations, or there may be locations where gaps or a hole is present (although Black Bear checks these annually to ensure rack integrity). Individuals passing via the turbine units were identified based on sequential detections from the unit intakes to the tailrace. It is possible that individuals meeting those criteria and missed during their use of an alternative route (e.g., downstream bypass) could be falsely assigned to turbine passage. As requested during the meeting, the final report has been edited to classify these fish as route "unknown" based on the assumption that turbine passage for adult shad is not feasible at Milford based on the one inch rack spacing.

Of the 11 individuals which were classified as "turbine passed" in the draft report, four did not reach any of the stationary receiver stations downstream of Milford. The remaining seven individuals were determined to have passed all three downstream stationary receivers located approximately 2.4, 9.5, and 13.2 km downstream of Milford. The median transit time for those 7 individuals from initial appearance in the tailrace until detection at the first downstream monitoring station was 1.5 hours, which is identical to the median transit time from passage to the first downstream receiver for all other radio-tagged shad successfully passing Milford via known (non-turbine) passage routes. The survival estimates presented in the draft report classify the four individuals not reaching the downstream receiver as "mortalities", and they have a negative effect on the total project survival estimate. The calculated durations of time from passage until downstream detection, coupled with observations obtained during the downstream drift assessment at Milford, do not support reclassification of the seven "turbine passed" shad detected at the downstream monitoring stations as mortalities.

Question 8 (PIN): *The report also states in Section 4.6.2 that perhaps eight tagged shad were released upstream of the Milford Dam and never contacted again. Can the licensee provide any explanations as to the disposition of these fish and how the manual tracking strategy and stationary tracking arrays could be adjusted to cure this issue in the future?*

Response 8: There are a number of reasons fish can go unrecorded following release, including transmitter failure or removal from the system via an avian predator or recreational angling. Alternatively, these fish may have simply moved to locations either outside of the tracking area (e.g., tributary habitat), or locations where access for tracking (both stationary and manual) was poor. Manual tracking of the study reach was conducted via foot and truck during 2017. Access via these methods is available for the majority of the mainstem river reach upstream of Milford. However, access to some portions of the reach is better than others due to roadway proximity and landowner permissions. Manual tracking efforts for this study were designed with the project objectives in mind, which were the determination of forebay residence duration, passage route selection, and passage survival at the project. Should future projects require detailed tracking on non-project area movements, more labor and cost intensive tracking methods, such as boat or aerial searches, could be considered. Additional stationary receivers could be added to the study design dependent on future evaluation objectives.

Appendix G

PowerPoint slides prepared for and presented by Normandeau at the December 21, 2017 meeting to discuss the draft Penobscot River shad study report.

Assessment of Adult American Shad Downstream Passage Route Selection and Survival

LOWER PENOBSCOT RIVER PROJECTS

- Milford Project, FERC No. 2534
- Stillwater Project, FERC No. 2712
- Orono Project, FERC No. 2710

NORMANDEAU ASSOCIATES
Environmental Consultants

STUDY OBJECTIVES & OVERVIEW

2017 Adult American Shad Study

Three primary study objectives:

1. Evaluate project residence time in the area immediately upstream of Milford, Stillwater and Orono
2. Quantify downstream passage route selection at Milford, Stillwater and Orono
3. Estimate the passage survival of adult American shad moving downstream at Milford, Stillwater and Orono

NORMANDEAU ASSOCIATES
Environmental Consultants

Study Plan for the Assessment of Adult American Shad Outmigration at the Milford, Stillwater and Orono Projects, Penobscot River, Maine (2017)

Study overview:

- Agency reviewed study plan filed with FERC May 2017
- Adult shad obtained at Milford lift and equipped with radio-transmitters
- Project approach and downstream passage monitored via a series of aerial and underwater antennas connected to receivers at Milford, Stillwater and Orono
- Additional coverage installed at West Enfield (tailrace, fish ladder, headpond)
- Conducted manual tracking weekly during study period

NORMANDEAU ASSOCIATES
Environmental Consultants

METHODOLOGY
Tagging and Release

- Following capture in secondary lift fish were dip-netted from sorting tank and visually examined to determine suitability for tagging
- Quick determination of TL and gender
- Radio-transmitters inserted gastrically
- Immediately transferred to stocking truck loaded with salted, recirculating Penobscot River water

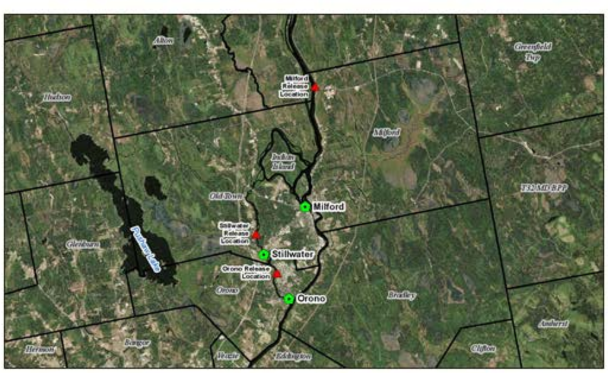
Handling controls: tagged and maintained a set of tank controls to evaluate retention
  - Overnight evaluation; n = 25

Drift evaluation: tagged freshly dead shad and released through downstream bypasses to evaluate downstream drift distances
  - n = 5 (M), 6 (SW), 5 (Or)

NORMANDEAU ASSOCIATES
Environmental Consultants

METHODOLOGY
Release Information

- Three release locations
  - Costigan boat launch (n = 116)
  - Old Town water district (n = 50)
  - U. Maine boat launch (n = 50)
- Release dates
  - Upstream Milford – June 13, 20 & 21
  - Upstream Stillwater – June 16
  - Upstream Orono – June 20

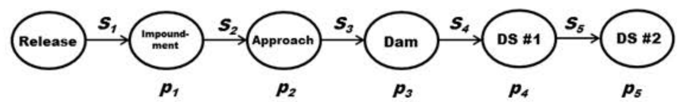


Radio-tagged shad were sluiced directly from truck into river to avoid additional netting and handling

NORMANDEAU ASSOCIATES
Environmental Consultants

METHODOLOGY
Data Analysis

- Upstream Residence Duration: calculated as differential between initial detection at 200m mark upstream of dam and confirmed downstream passage
- Downstream Passage Route: based on evaluation of the spatial and temporal distribution of time-stamped detections from final, filtered data set
- Passage Survival: estimated using Cormack Jolly Seber (CJS) models run in Program MARK (White and Burnham 1999)
  - Suite of four candidate models run for each group which allowed both parameters to vary or remain constant
    - S(t)p(t): survival and recapture allowed to vary between receiver stations;
    - S(t)p(.): survival may vary between stations, recapture held constant between stations;
    - S(.)p(t): survival is constant between stations, recapture allowed to vary between stations;
    - S(.)p(.): survival and recapture held constant between stations.
  - Goodness of fit conducted for the "starting model" (i.e., most parameterized) and over-dispersion of data corrected with variance inflation factor ($\hat{c}$) if necessary
  - Akaike's Information Criteria (AIC scores) used to rank models and one with lowest value selected to represent project

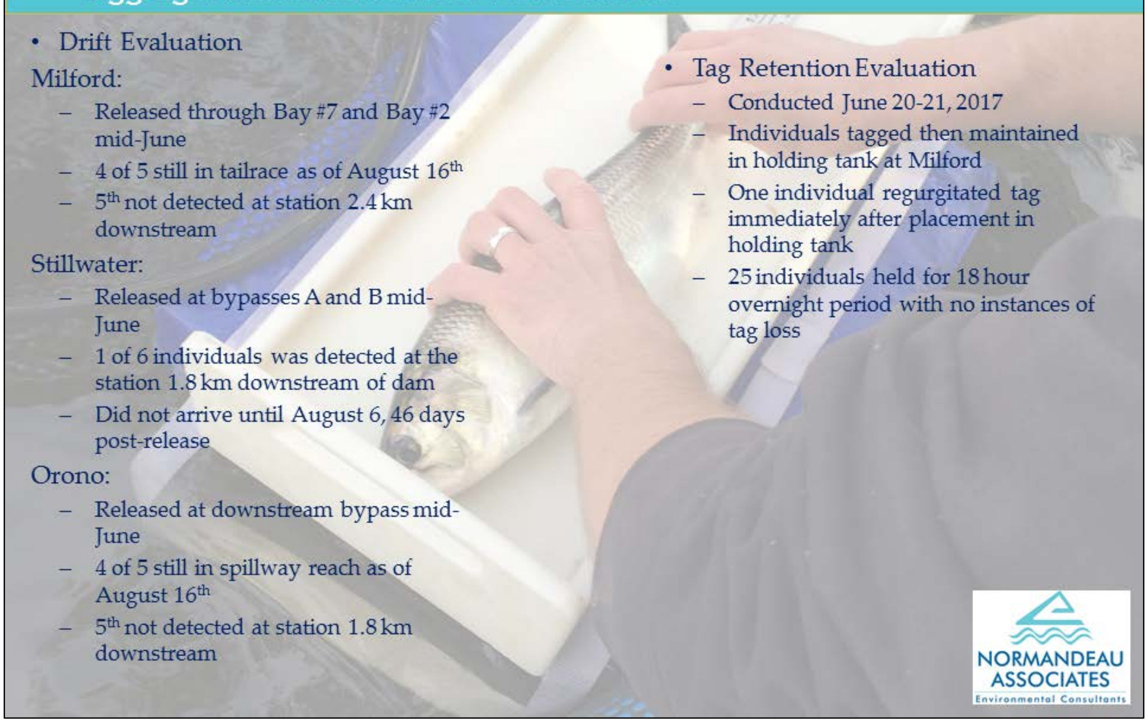


Project survival* calculated as the joint probability of S_3*S_4

*This approach resulted in estimates that included background mortality (i.e., natural mortality, such as predation) along with any tagging-related mortalities or tag regurgitations for adult American shad within 200 m upstream of each Project, as well as the reach downstream of the dam to the first downstream receiver. This resulted in minimum estimates of total project survival (i.e., attributable to project effects) for adult shad at each project.

NORMANDEAU ASSOCIATES
Environmental Consultants

RESULTS
Tagging Retention and Drift Evaluation



- Drift Evaluation

Milford:
- Released through Bay #7 and Bay #2 mid-June
- 4 of 5 still in tailrace as of August 16th
- 5th not detected at station 2.4 km downstream

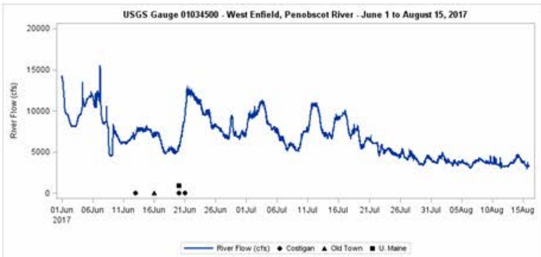
Stillwater:
- Released at bypasses A and B mid-June
- 1 of 6 individuals was detected at the station 1.8 km downstream of dam
- Did not arrive until August 6, 46 days post-release

Orono:
- Released at downstream bypass mid-June
- 4 of 5 still in spillway reach as of August 16th
- 5th not detected at station 1.8 km downstream

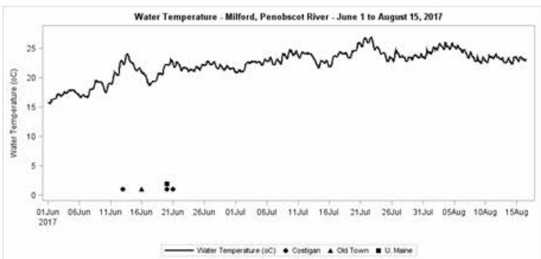
- Tag Retention Evaluation
  - Conducted June 20-21, 2017
  - Individuals tagged then maintained in holding tank at Milford
  - One individual regurgitated tag immediately after placement in holding tank
  - 25 individuals held for 18 hour overnight period with no instances of tag loss

NORMANDEAU ASSOCIATES
Environmental Consultants

RESULTS
River Conditions



- USGS W. Enfield gauge (Jun 1 – Aug 15)
- Observed flows – 2,960-15,500 cfs
- Mean flow = 6,751 cfs
- Trended downward during study period



- Onset temp logger – Milford headpond
- Ranged 15.6-26.9 °C for study period
- Ranged 19.3-24.1 °C on tagging dates

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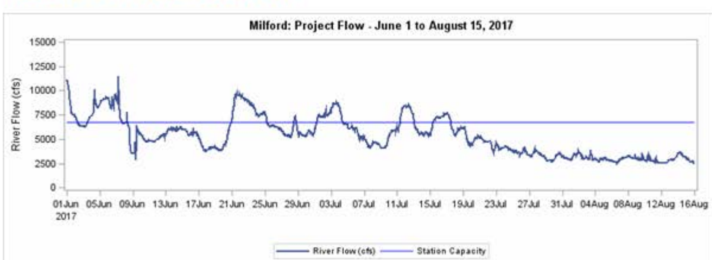
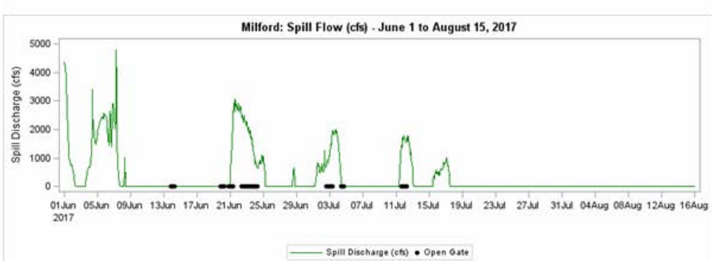
RESULTS
Project Operations

- Milford, Stillwater and Orono operated under "baseline" conditions (i.e., units operating, bypasses open)
- In the event additional spill gates needed to be opened for operational purposes the dates and times were recorded





Milford:

- Discharge via units, bypasses (~500 cfs) and fishway (~200 cfs)
- River flow and generational curtailments periodically necessitated additional spill

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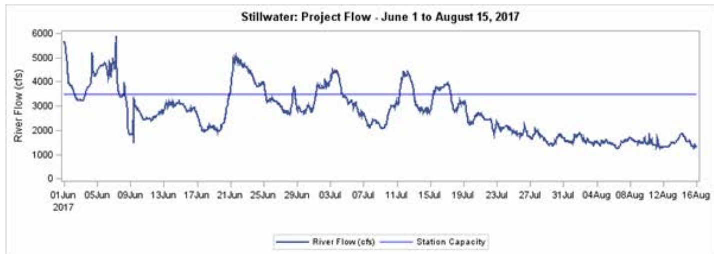
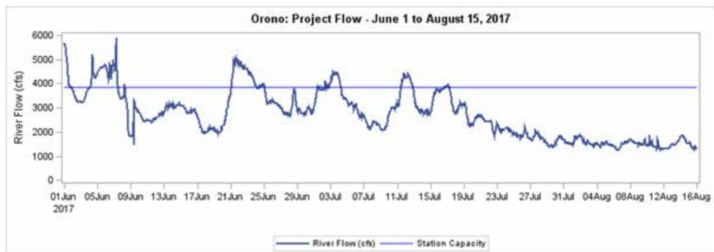
RESULTS
Project Operations

Stillwater:
- Discharge via turbines and bypasses A and B (~70 cfs each)
- Flows in excess of station resulted in overtopping of flashboards



Orono:
- Discharge via turbines and bypass A (~150cfs)
- Flows in excess of station resulted in overtopping of flashboards



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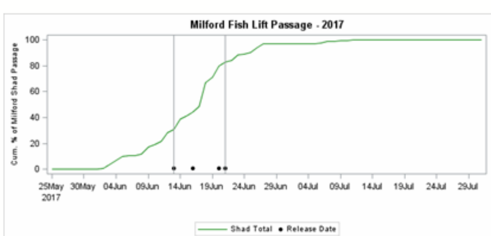
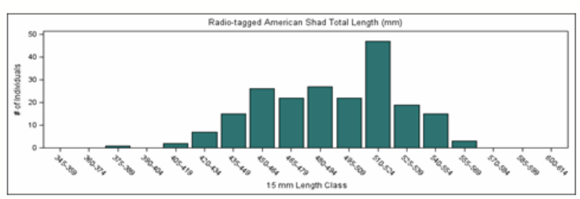
RESULTS
Releases of Radio-tagged Shad

	Project		
	Milford	Stillwater	Orono
Release Location	Costigan Ramp	Old Town Water District	U. Maine Ramp
Release Dates	June 13, 20, 21	June 16	June 20
Number Released	116	50	50
% Male	37.1%	44.0%	44.0%
% Female	30.2%	56.0%	56.0%
% Undetermined	32.8%	0.0%	0.0%
Min. Total Length (mm)	420	378	410
Max. Total Length (mm)	560	556	560
Mean Total Length (mm)	492	490	493





- Tag dates bracketed the 30th-82nd% of 2017 annual passage at Milford

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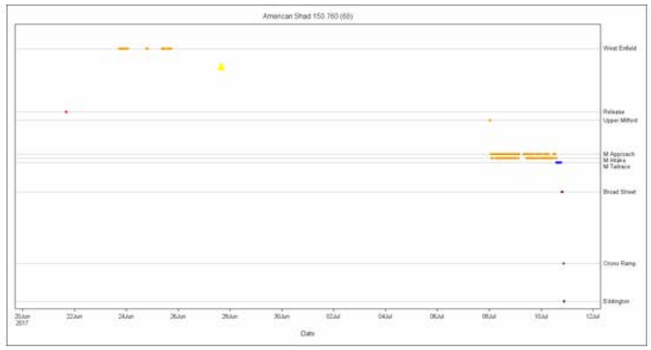
RESULTS
Shad Movements - West Enfield

Radio-tagged shad free to move upstream to West Enfield

- Observed 11 of 116 (9.5%) released upstream of Milford and 1 of 50 (2%) released upstream of Stillwater to reach West Enfield tailrace
- Time to ascend 29.7 km from Milford release to tailrace ranged 33-185 hours (median = 77 hours)
- No detections in fish ladder or headpond
- Tailrace residence duration (initial to final detection) ranged from 10 minutes to 141 hours (median = 5.6 hours)
- Also calculated "cumulative tailrace residence duration" – more representative of time spent in the actual receiver detection field (required identification of a threshold interval based on observed durations of time between successive detections)
- Cumulative tailrace residence duration ranged from 10 minutes to 11.5 hours (median = 0.6 hours)
- Ten of 12 detected outmigrating at downstream projects covering the 34.5 km from West Enfield to receiver at upper end of Milford impoundment in 231 hours (median) (range = 71-584 hours)



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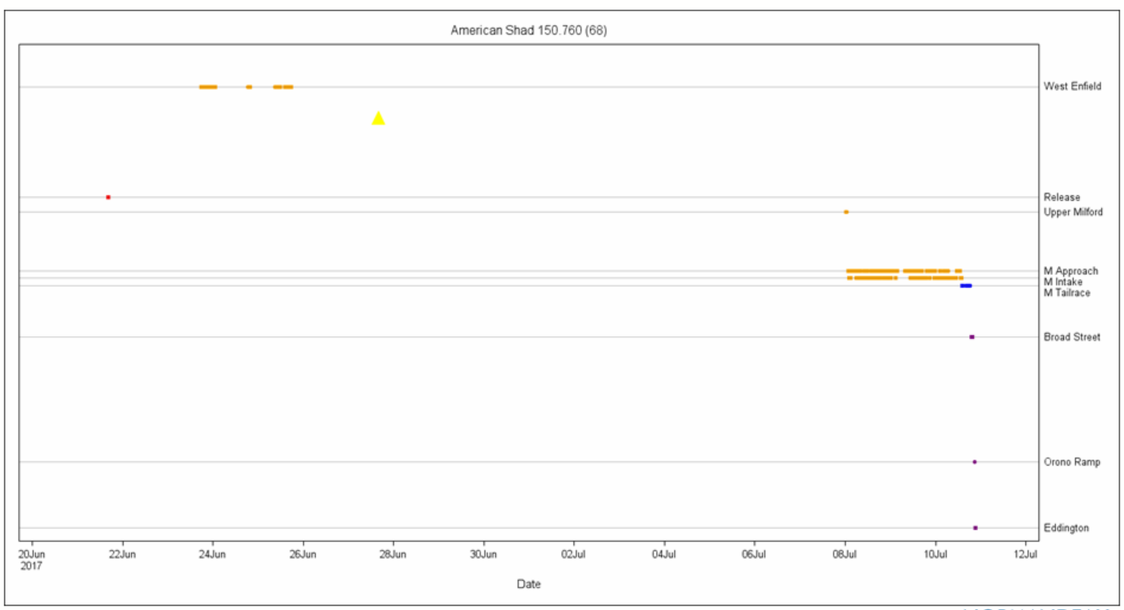
RESULTS
Shad Movements - West Enfield



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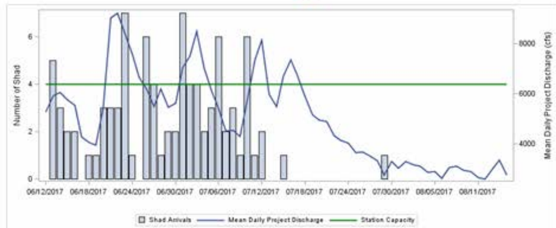
RESULTS

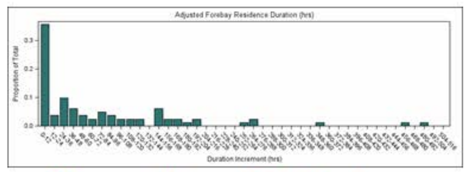
Shad Movements & Passage - Milford

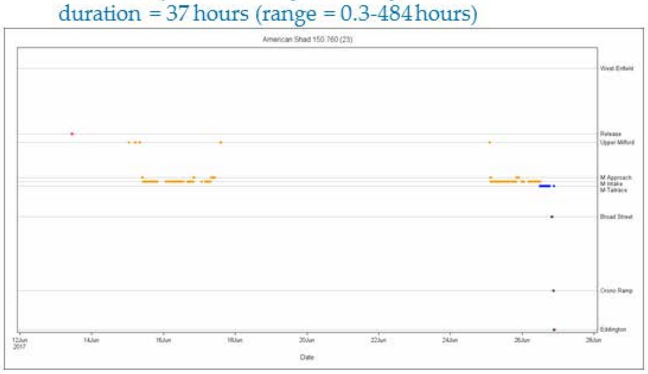
Reported values based on 90 radio-tagged individuals (85 from Costigan, 5 from Old Town)

- Observed return dates – June 13 – July 29
- Median forebay residency duration = 39 hours (range = 0.3-606 hours)



- "Adjusted" forebay residency durations calculated for 20 individuals with observed periods of time outside of the project impoundment
- Median adjusted forebay residency duration = 37 hours (range = 0.3-484 hours)





- When considering adjusted forebay residency durations
  - 40% passed within 24 hours of adj. res. time
  - 56% passed within 48 hours of adj. res. time

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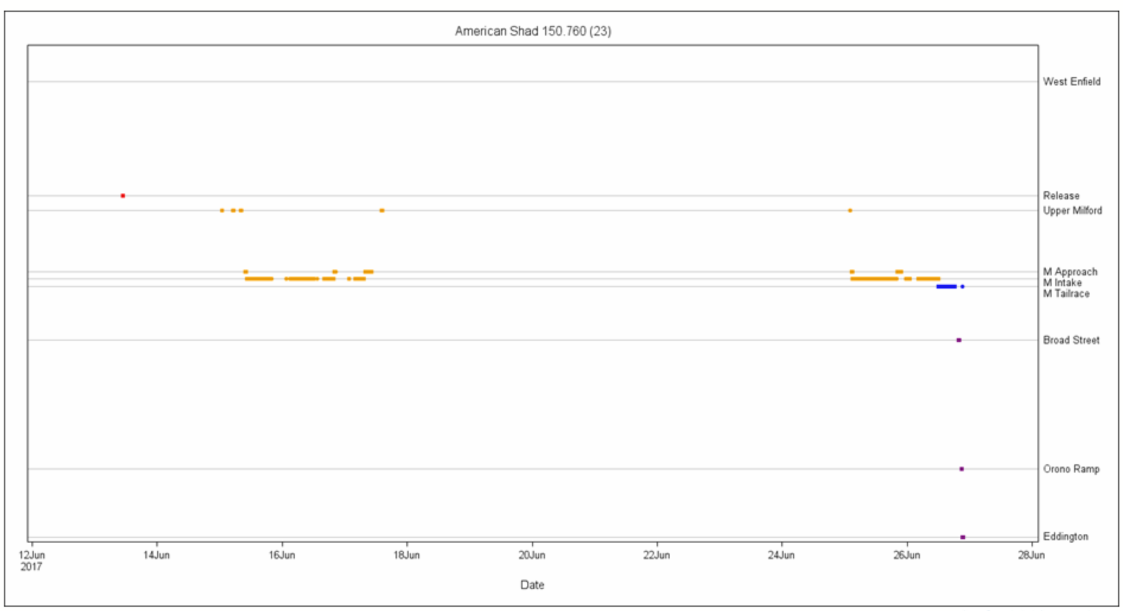
RESULTS

Shad Movements & Passage - Milford



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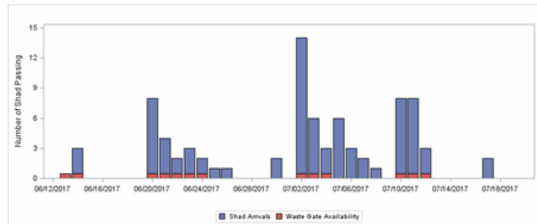
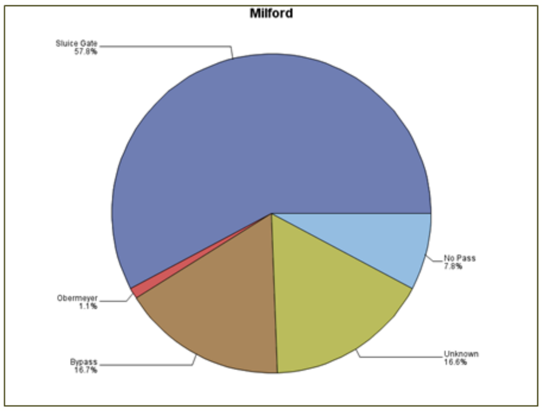
RESULTS

Shad Movements & Passage - Milford

- Downstream passage events ranged from June 14 to July 17
- Sluice gate was the dominant route of passage
- Peaks in downstream passage events coincided with dates with sluice gate availability





- 7 individuals approached but did not pass
- 1 departed back upstream with no return
- 3 approached and detected continuously from intake receiver – suggests dead and drift
- 2 moved back and forth from approach to intake receiver
- 1 detected only at approach receiver

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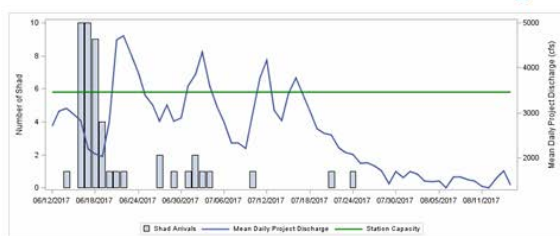
RESULTS

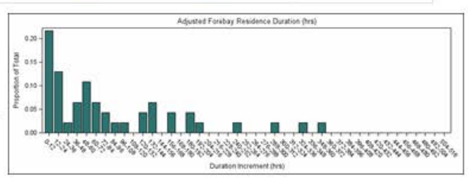
Shad Movements & Passage - Stillwater

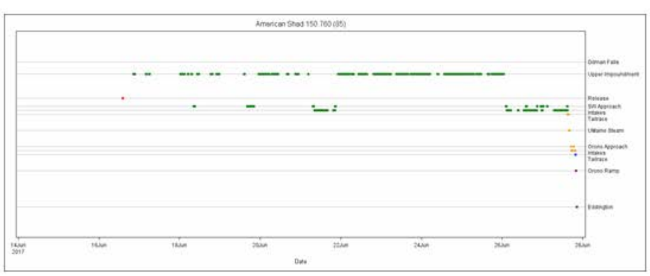
Reported values based on 48 radio-tagged individuals (35 from Old Town, 13 from Costigan)

- Observed return dates – June 14 – July 24
- Median forebay residency duration = 112 hours (range = 0.4-414 hours)



- "Adjusted" forebay residency durations calculated for 30 individuals with observed periods of time outside of the immediate upstream project area
- Median adjusted forebay residency duration = 52 hours (range = 0.4-356 hours)





- When considering adjusted forebay residency durations
  - 35% passed within 24 hrs of adj. res. time
  - 43% passed within 48 hrs of adj. res. time

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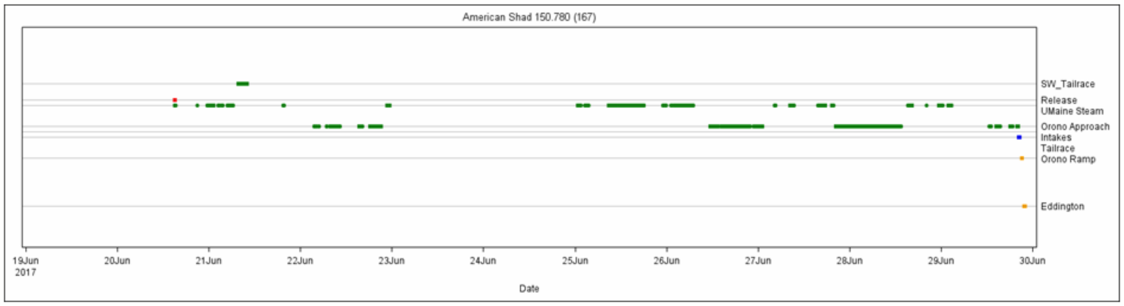
RESULTS

Shad Movements & Passage - Stillwater



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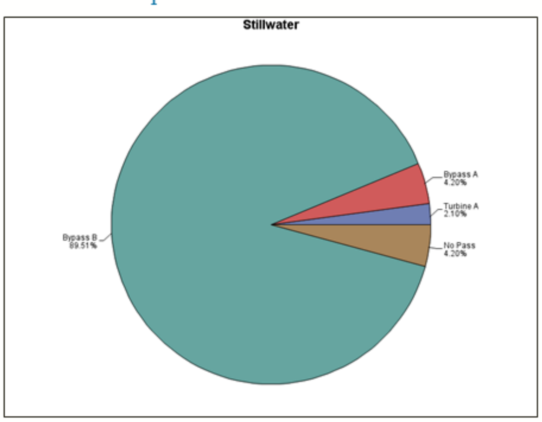
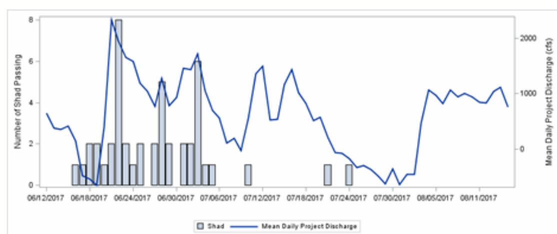
RESULTS

Shad Movements & Passage - Stillwater

- Downstream passage events ranged from June 16 to July 24
- Downstream bypass at powerhouse B was the dominant route of passage
- Three individuals utilized passage routes at powerhouse A





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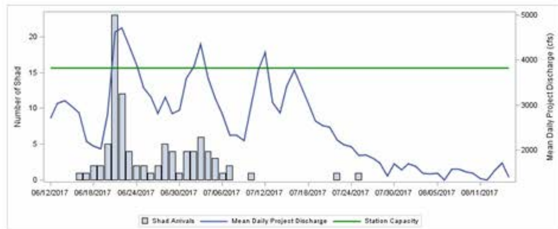
RESULTS

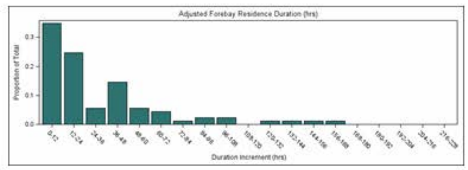
Shad Movements & Passage - Orono

Reported values based on 94 radio-tagged individuals (48 from U. Maine, 33 from Old Town, and 13 from Costigan)

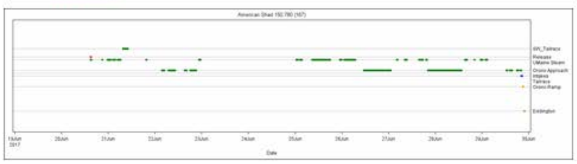
- Observed return dates – June 16 – July 25
- Median forebay residency duration = 37 hours (range = 0.3-361 hours)



- "Adjusted" forebay residency durations calculated for 55 individuals with observed periods of time outside of the immediate upstream project area (back to release site and in some cases Stillwater tailwater)
- Median adjusted forebay residency duration = 19 hours (range = 0.3-162 hours)



- When considering adjusted forebay residency durations
  - 60% passed within 24 hours of adj. res. time
  - 80% passed within 48 hours of adj. res. time



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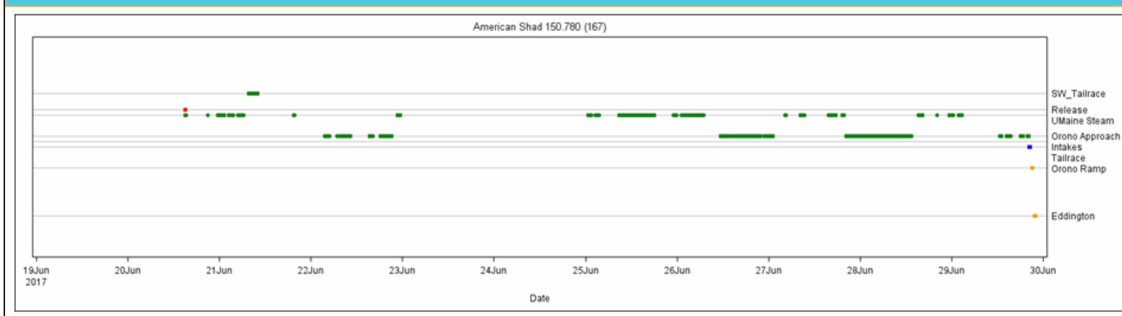
RESULTS

Shad Movements & Passage - Orono



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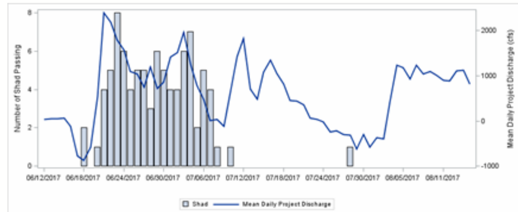
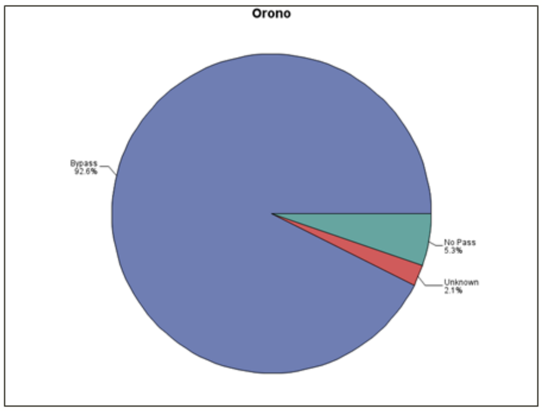
RESULTS

Shad Movements & Passage - Orono

- Downstream passage events ranged from June 18 to July 28
- The downstream bypass was the dominant route of passage





- 5 individuals approached but did not pass
- 3 approached and detected continuously from intake receiver – suggests dead and drift
- 1 moved back and forth from approach to intake receiver
- 1 detected only at approach receiver

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RESULTS

Shad Project Survival - Milford, Stillwater & Orono

Survival estimates include project effects, background mortality and any tag related losses

Project	Model	n	Estimate	75% CI
Milford	Full	90	76.6%	71.1-82.2%
	Reduced	87	79.2%	73.5-83.9%
Stillwater	Full	48	95.8%	91.7-97.9%
Orono	Full	94	84.3%	79.8-88.3%
	Reduced	91	87.0%	82.4-91.2%

- Full models include all fish which approached a given project
- Reduced models exclude individuals which were likely dead on arrival at the project area based on pattern of detections

Percentage detected downstream by passage route

Project	Route	n	% Detected
Milford	Spill	53	100.0%
	Bypass	15	33.3%
Stillwater	Bypass B	43	100.0%
	Bypass A	2	100.0%
	Turbine A	1	100.0%
Orono	Bypass	87	89.7%

- 8 of 10 shad passing via Milford bypass but not detected at downstream receivers did so on dates where trash racks were cleaned
  - Possible that those individuals were entrained on racks and dead prior to passage (and subsequent stationary presence in tailrace)
- Losses at Stillwater attributed only to individuals which approached but failed to pass the dam

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