Northfield Mountain Station
99 Millers Falls Road
Northfield, MA 01360
Ph.: (413) 659-4489
Fax: (413) 659-4459
Email: Douglas.Bennett@firstlightpower.com

Douglas Bennett
Director MA Hydro Operations
Northfield Mountain/Turners Falls Project

December 21, 2018

VIA ELECTRONIC FILING

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

Re: FirstLight Hydro Generating Company, Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485).
Response to Comments

Dear Secretary Bose:

Pursuant to the regulations of the Federal Energy Regulatory Commission (FERC or the Commission), Title 18 Code of Federal Regulations (18 C.F.R) §5.15(f), FirstLight Hydro Generating Company (FirstLight) encloses for filing this response to comments on FirstLight's various addendums filed between April 3, 2017 and May 1, 2018. FirstLight's response to comments is due within 30 days or by December 23, 2018. Because December 23rd falls on a Sunday, and December 24 and 25 are federal holidays, the due date falls to December 26, 2018.

On August 10, 2018 FERC issued its Revised Process Plan and Schedule requiring FirstLight to hold a Study Report Meeting on October 9, 2018 to discuss the previously filed addendums. Table 1 lists the various addendums filed between April 3, 2017 and May 2, 2018

Table 1: Addendums filed with FERC between April 3, 2017 and May 1, 2018

Study No.	Name
3.3.1	Instream Flow Studies in Bypass Channel and below Cabot Station
3.3.2	Evaluate Upstream and Downstream Passage of Adult American Shad
3.3.15	Assessment of Adult Sea Lamprey Spawning within Turners Falls Project and Northfield Mountain Project Area
3.1.2	Northfield Mountain/Turners Falls Operation Impact on Existing Erosion and Potential Bank Instability
3.3.20	Ichthyoplankton Entrainment Assessment at the Northfield Mountain Pumped Storage Project
3.5.1	Baseline Inventory of Wetland, Riparian and Littoral Habitat in the Turners Falls Impoundments and Assessment of Operational Impacts on Special-Status Species
3.3.9	Two-Dimensional Modeling of the Northfield Mountain Pumped Storage Project Intake/Tailwater Channel and Connecticut River Upstream and Downstream of the Intake/Tailrace

FirstLight held its Study Report Meeting on October 9, 2018 and filed its meeting summary on October 24, 2018 per Commission regulations. Stakeholder comments on the meeting summary and addendums were due by November 23, 2018. The purpose of the comment opportunity following the submission of the meeting summary is to give relicensing participants an opportunity to request modifications to approved studies or propose new studies (18 C.F.R. § 5.15(c)(4)). Requests for modifications to approved studies must demonstrate good cause and meet the criteria of 18 C.F.R. § 5.15(d) and (e), as appropriate. Requests for new studies must demonstrate extraordinary circumstances per § 5.15(f) as well as meet the criteria of § 5.15(e).

Table 2 lists the comments received.

Table 2: Stakeholders Comments on various Addendums

Commenter	3.3.1	3.3.2	3.3.15	3.1.2	3.3.20	3.5.1	3.3.9
United States Fish and Wildlife Service	x		x		x		
National Marine Fisheries Service	x		x		x		
Massachusetts Division of Fisheries & Wildlife/ Natural Heritage and Endangered Species Program[1]	x					x	
Connecticut River Conservancy (CRC)[2]				x			

[1] This agency filed a revised comment letter, dated December 7, 2018, to correct minor errors in its comments related to Addendum 2 of Study 3.3.1.
[2] The CRC letter discussed only Study No. 3.1.2 and indicated at the end of the letter that no further analysis was required.

Study 3.1.2

On October 14, 2016, FirstLight filed Study No. 3.1.2 *Northfield Mountain/Turners Falls Operation Impact on Existing Erosion and Potential Bank Instability* (a.k.a. Erosion Causation Study). The CRC filed several comments on the Erosion Causation Study stating that several portions of the study were either incomplete or were not conducted to the approved study plan. On February 17, 2017 FERC issued its *Determination on Requests for Study Modifications and New Studies*. In its Determination, FERC reviewed all of the CRC comments and concluded that no modifications to the Erosion Causation Study were needed.

FirstLight filed a report with FERC in April 2017 entitled "*Evaluating the Impact of Increasing the Useable Storage Volume of the Upper Reservoir on Streambank erosion in the Turners Falls Impoundment*". In CRC's comment letter regarding the April 2017 report, it stated that the study results were "flawed" and that "Study 3.1.2 and this evaluation of using the expanded upper reservoir has led to erroneous conclusions". FirstLight conducted Study 3.1.2 and the assessment of expanded Upper Reservoir operations per the FERC-approved study plan. CRC simply disagrees with the findings. Accordingly, no further response to CRC's comments is needed. FirstLight will address CRC's interpretations of the study results at the appropriate time in this proceeding.

Study 3.3.9

FERC's June 29, 2016 Determination letter stated:

> *We recommend that FirstLight consult with the fisheries agencies after the other fish migration studies have been completed to determine if additional analysis of the modeling results is necessary to describe how velocities and flow fields near the Northfield Mountain Project intake/tailrace may be affecting fish migration.*

FirstLight consulted with the agencies and stakeholders at the October 9, 2018 meeting. Because no comments were filed on Study 3.3.9, no further analysis is necessary.

Study 3.3.2

No comments were filed on Study 3.3.2. Thus no further analysis is necessary.

Studies 3.3.1, 3.3.15, 3.3.20, and 3.5.1

The comments received on the various other addendums (Studies 3.3.1, 3.3.15, 3.3.20, and 3.5.1) can be generally categorized in three ways as (a) a statement requiring no further response or information, (b) a request for further information or (c) the commenter's interpretation of the study results. The attached responsiveness summary includes all of the comments received, but generally addresses only those comments requesting further information. FirstLight will address the commenters' interpretations of the study results at the appropriate time in this proceeding.

FirstLight is filing this document with FERC electronically. To access the document on FERC's website (http://www.ferc.gov), go to the "eLibrary" link, and enter the docket number, P-1889 or P-2485. FirstLight is also making the document available for download at the following weblink: http://www.northfieldrelicensing.com/Pages/Documents2018.aspx.

In addition to this electronic filing with FERC, a paper copy of the document is available to the public at the Northfield Mountain Visitor Center at 99 Millers Falls Road, Northfield, MA 01360 during regular business hours.

If you have any questions regarding the above, please do not hesitate to contact me. Thank you for your assistance in this matter.

Sincerely,

Douglas Bennett
Director of MA Hydro Operations

Attachments: Responsiveness Summary

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TABLE OF ATTACHMENTS

Study No. 3.3.1 Instream Flow Studies in Bypass Channel and below Cabot Station

Commenter	Comment	Response
USFWS-1	Addendum 2: IFIM Study for Mussels in Reach 5 On July 28, 2017, FL submitted a revised study plan (RSP) that addressed comments from stakeholders (including the U.S. Fish and Wildlife Service [Service]). In the RSP, FL proposed to quantify the relationship between project operations and aquatic habitat and shear stress for three state-listed freshwater mussel species in Reach 5. *Comments and Recommendations*: The Service supports the comments and recommendations submitted by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) and requests that FERC direct FL to address the recommended analyses contained therein.	See MDFW responses.
USFWS-2	Addendum 3: Assessment of Yellow Lampmussels in Reach 3 This report builds on the instream flow analysis for the state-listed yellow lampmussel that FL undertook in previous Study 3.3.1 reports. The specific objectives were to provide weighted usable area (WUA) versus flow output (tabular and graphic) and combined suitability index maps for juvenile and adult lampmussels as well as two habitat guilds (deep-fast and deep-slow, intended to be representative of host fish habitat suitability). *Comments and Recommendations:* The Service supports the comments and recommendations submitted by the NHESP and requests that FERC direct FL to address the recommended analyses contained therein.	See MDFW responses.
USFWS-3	Addendum 4: New Sea Lamprey Weighted Usable Area Curves This addendum provides new Habitat Suitability Index (HSD curves for sea lamprey. The revised curves incorporate empirical data collected during Study 3.3.15. Based on the new HSI curves, FL developed new WUA versus flow curves in Reaches l, 2, 3, and 4. Appendix A of the addendum provides habitat versus flow curves based on the original and revised HSI curves for each study reach. The new/revised HSI curves translate into a substantial increase in the amount of suitable habitat within each study reach. *Comments and Recommendations:* The addendum provides results of a steady state analysis for each of the four reaches. Two of the four study reaches are influenced by hydropeaking operations (Reaches 3 and 4) and, therefore, supplemental analyses such as persistence/dual flow and/or habitat time series are appropriate and necessary to assess how peaking operations affect the availability of sea lamprey spawning habitat (similar to the analyses that were conducted using the original HSI curves and reported in previous addendums to Study 3.3.1). In particular, the Reach 4 steady state WUA versus flow curve suggests that peaking operations in the latter half of the spawning season may dramatically reduce the amount of suitable spawning habitat. **We request that FL undertake and provide the results of these supplemental analyses in a revised addendum.**	Persistent habitat maps for Reach 3 and dual flow results for Reach 4 for the new Sea Lamprey Spawning HSI curves will be filed with FERC by **March 1, 2019.**
NMFS-1	Addendum 4: Updated Sea Lamprey HSI curves and WUA maps FirstLight provide persistence maps and dual flow maps be created for reaches 3 and 4, which are subject to hydropeaking operations. FirstLight provide the results of this supplemental analysis in a revised addendum similar to the filings submitted as addendum attachments on May 3, 2017 (Accession Number 20170403-5617). This output will aid in assessing direct impacts on sea lamprey spawning habitat.	See USFWS-3.
MDFW-1	Addendum 2: IFIM Study for Mussels in Reach 5 (filed May 1 2018) FL modeled weighted usable area (WUA) within Reach 5 as a whole for the three target state-listed mussel species and both juvenile and adult lifestages. For juvenile lifestages, results show that after reaching a maximum at approximately 6,000 cfs (~82 million square feet; low Holyoke Impoundment), WUA decreases for Reach 5 as a whole with increased Cabot flows (~60-62 million square feet WUA at full Project capacity). **Although modeling WUA for Reach 5 as a whole is useful, we request that FL model WUA separately within each of the three (3) sub-reaches and provide modeling results for review.** Modeling WUA separately within each sub-reach will help clarify where reductions in WUA occur in Reach 5 and confirm that WUA decreases with increasing proximity to Cabot Station as argued in the Division's comments herein. The Division previously requested that this updated analysis be performed in a May 2018 call with FL to discuss the Addendum. This updated analysis would not require any additional data collection.	In its request MDFW has asked for additional analysis relative to breaking out subreaches of Reach 5 in the IFIM study. FirstLight has evaluated this request in light of the overall IFIM Study design, the consultation record relative to this study and FERC criteria for study modifications. As described below, based on this analysis FirstLight is opposed to the study modification as proposed by MDFW. The river reach potentially effected by Cabot Station operations includes a total of approximately 33 miles of the Connecticut River extending from the immediate vicinity of Cabot Station to the Dinosaur Footprints constriction area located upstream of Holyoke Dam. FirstLight compiled a mesohabitat map of this approximate 33-mile segment and presented it in the original Revised Study Plan approved by FERC; it was also presented again in the Study Plan developed to assess Mussels in Reach 5. MDFW approved both of these study plans. Based on the mesohabitat map, this approximate 33-mile reach of the river was divided into three representative reaches (Reaches 3, 4, and 5) each representing slightly different mesohabitats per IFIM study protocol. Per IFIM protocol an overall habitat vs flow relationship for each representative reach would be developed by multiplying the weighted usable area per foot of study site, by the length of the reach with the appropriate macrohabitat within that reach, to come up with a WUA vs flow relationship for that reach. To determine overall WUA vs flow relationship for the river segment potentially effected by Cabot Station operations, IFIM protocol would call for summing the WUA from all representative reaches studied for a given target species at a given flow to develop a total WUA vs flow relationship for the segment. For the segment potentially effected by Cabot Operations this would include Reaches 3 and 5 as agreed to in consultation with MDFW (see response to MDFW-11).

Commenter	Comment	Response
		Based on the concept of representative reaches and the consultation record for the study FirstLight does not believe this study modification is warranted. Also, as noted FirstLight's cover letter, requests for modifications to approved studies must demonstrate good cause and meet the criteria of 18 C.F.R. § 5.15(d) and (e), as appropriate (listed below). MDFW failed to address the study criterion. 18 C.F.R. § 5.15(d) and (e) **(d)** ***Criteria for modification of approved study.*** Any proposal to modify an ongoing study pursuant to paragraphs (c)(1)-(4) of this section must be accompanied by a showing of good cause why the proposal should be approved, and must include, as appropriate to the facts of the case, a demonstration that: **(1)** Approved studies were not conducted as provided for in the approved study plan; or **(2)** The study was conducted under anomalous environmental conditions or that environmental conditions have changed in a material way. **(e)** ***Criteria for new study.*** Any proposal for new information gathering or studies pursuant to paragraphs (c)(1)-(4) of this section must be accompanied by a showing of good cause why the proposal should be approved, and must include, as appropriate to the facts of the case, a statement explaining: **(1)** Any material changes in the law or regulations applicable to the information request; **(2)** Why the goals and objectives of any approved study could not be met with the approved study methodology; **(3)** Why the request was not made earlier; **(4)** Significant changes in the project proposal or that significant new information material to the study objectives has become available; and **(5)** Why the new study request satisfies the study criteria in § 5.9(b).
MDFW-2	Addendum 2: IFIM Study for Mussels in Reach 5 (filed May 1 2018) FL modeled WUA within Reach 5 as a whole under both high and low Holyoke Impoundment water surface elevations (WSEL). Results suggest that Holyoke Impoundment WSELs do not have a measurable effect on WUA for adult mussels in Reach 5. However, the lower Holyoke Impoundment WSELs do appear to reduce WUA for juvenile mussels. Lower Holyoke Impoundment elevations are implemented by HG&E (Holyoke Project FERC No. 2004) to moderate the magnitude of WSEL changes at Rainbow Beach associated with upstream Cabot peaking operations. The lower Holyoke Impoundment elevations implemented by HG&E are intended to reduce impacts to the state- and federally-listed Puritan Tiger Beetle. The observed decreases in WUA for juvenile mussels in Reach 5 suggest that lower Holyoke Impoundment WSELs may result in unintended impacts to juvenile mussels from increased velocities and shear stress in Reach 5.	FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-3	Addendum 2: IFIM Study for Mussels in Reach 5 (filed May 1 2018) Host fish for state-listed mussels predominantly fall into the Shallow Slow, Deep Slow, and Deep Fast Guilds. FL results show that Reach 5 provides limited habitat for the Shallow Slow and Deep Fast Guilds (<5 million square feet). However, what little habitat is present in Reach 5 for the Shallow Slow Guild appears to be eliminated at flows above 6,000 cfs; for the Deep Fast Guild, this occurs at flows closer to 13,000cfs. Perhaps more significantly, FL results show a significant decrease in WUA for the Deep Slow Guild, from a peak of more than 70 million square feet (at approximately 2,000cfs, Low Boundary Conditions) to approximately 10 million square feet at approximately 16,000cfs (full Project capacity). This represents an 85% decrease in WUA for the Deep Slow Guild during maximum peaking operations; all three mussel species have host fish belonging to the Deep Slow Guild. **To better understand the effects of Cabot operations on state-listed mussel host fish guilds, we request that FL provide additional figures similar to Figure 4.13 and 4.14, but which show WUA as a percentile based curve (with percent of maximum WUA on the vertical axis).** Although these significant effects cannot be seen as presented, we anticipate that reductions in WUA for the Shallow Slow and Deep Fast Guilds at higher flows will be almost as significant as the decrease in WUA for the Deep Slow Guild.	MDFW requested % peak WUA curves for the state-listed mussel host fish guilds (with percent of maximum WUA on the vertical axis). 3.3.1 Attachment A includes the requested plots. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.

Commenter	Comment	Response
MDFW-4	Shear Stress Analysis Mapping FL results confirm that shear stress does not appear to be a limiting factor for adult mussels. This finding supports the Division's previous comments on Study Report 3.3.16 (dated December 15, 2016) in which we noted that adult mussels are adapted to tolerating higher velocities and shear stress. Once established, adult mussels are able to withstand higher flows due to their larger mass, ability to anchor/burrow into substrates, and overall contribution to bedload stability. However, FL results also confirm that shear stress does limit habitat suitability for juvenile mussels. These results are consistent with the Division's previous comments, which highlighted that juvenile settlement and colonization is the lifestage most sensitive to shear stress and that juvenile recruitment may be significantly reduced during the summer settlement period (which would otherwise be characterized by natural low flow conditions) by Cabot peaking operations (Daraio et al. 2010a & b, French & Ackerman 2015, Morales et al. 2006 & 2013, FL – comments from Delphi Panel). The Division posited that significantly increased flows and elevated shear stress during the summer months due to current Cabot peaking operations would preclude mussels from colonizing otherwise suitable habitats. As a result, state-listed mussel species are excluded from colonizing areas of otherwise suitable habitat, thereby restricting the distribution of these species within the Project area and compromising the viability of remaining populations in the lower portions of Reach 5.	The comment does not include a request for more information. FirstLight disagrees with certain MDFW's interpretations of the study findings and will address MDFW's comment at the appropriate time in this proceeding.
MDFW-5	Shear Stress Analysis Mapping FL results confirm that shear stress increases with increasing proximity to Cabot Station. Within the range of Project operations, significant shear stress exceedance for juvenile mussels is observed in the Dry Brook sub-reach, moderate shear stress exceedance for juvenile mussels is observed in the Hatfield sub-reach, and minimal exceedance is observed in the Mitch's Island sub-reach (Appendix E-1).	The comment does not include a request for more information. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-6	Shear Stress Analysis Mapping Increased shear stress effects with increasing proximity to Cabot Station mirrors both the distribution and relative abundance of state-listed mussels in Reach 5. During three separate survey events (2005, 2009 and 2013) for state-listed mussels in Reach 5 (Twelve Year Summary Rare Mussel Survey Report 2003-2014, Holyoke Project FERC No. 2004), no state-listed mussels have been observed in the Dry Brook sub-reach (Figure 2.3-2). Only a few (3 total animals) have been observed in the Hatfield sub-reach, all within the southern-most transect at River Mile 99.27; this location (22.73 miles south of Cabot Station) represents the northern-most current observation of a live state-listed mussel in the Connecticut River despite extensive surveys conducted by FL (Reaches 3 and 4) and HG&E (Reach 5). Relying solely on presence/absence, as depicted in Figure 2.3-2, provides an incomplete picture because abundance (as well as catch per unit effort) of state-listed mussels doesn't increase significantly (>10 mussels per survey transect) until reaching River Mile 94.87 (4.5 miles further downstream and 27.23 miles south of Cabot Station). The greatest density of rare mussels (>50 mussels per survey transect) were observed in the Mitch's Island sub-reach (south of River Mile 92.97, 29.03 miles south of Cabot Station), where FL results indicate that shear stress thresholds for juvenile mussels are generally not exceeded within the range of Project operations. This clearly shows that Cabot peaking operations are directly impacting the distribution and abundance of state-listed mussels in significant portions of Reach 5 by reducing juvenile settlement and colonization within otherwise suitable habitats.	The comment does not include a request for more information. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-7	Discussion FL argues that study results support their previous assertion that operations do not affect distribution and abundance of state-listed mussels in Reach 5. Instead, FL argues that current mussel distributions in Reach 5 are constrained more by reach characteristics during high flow events outside of Project control. FL also argues that the reductions in WUA at higher flows is minor compared to the total extent of habitat in Reach 5. These assertions are in direct conflict with and unsupported by their own study results, which document that: Host fish represent a necessary component of a mussel's reproductive life cycle; impacts to the distribution and abundance of host fish have the potential to significantly impact the distribution and abundance of state-listed mussels. Habitat availability for state-listed mussel host fish in Reach 5 shows significant decreases within the limits of Project operations. For the Deep Slow Guild, in which all three mussel species have host fish, WUA decreases by approximately 85% during maximum peaking operations from Cabot Station and Station 1. This shows that Project operations negatively impact the distribution and abundance of host fish species and inhibit their ability to inhabit otherwise suitable habitats in Reach 5. Given the severity of these impacts, it is likely that host fish are even more severely impacted in Reach 3 and 4 with increasing proximity to Cabot Station. Impacts to host fish further limit the ability of state-listed mussels to colonize and or persist in otherwise suitable habitats in Reach 3, 4 and the northern portions of Reach 5.	The comment does not include a request for more information. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-8	Discussion For Reach 5 as a whole, WUA for juvenile mussels reaches a maximum at flows around 6,000cfs (approximately 82 million square feet) but decreases with increased flows thereafter until reaching 60-62 million square feet at full Project capacity. A 25% WUA loss is not "minor," but rather, represents a significant and problematic impact to habitat for state-	The comment does not include a request for more information. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.

Commenter	Comment	Response
	listed mussel species in Reach 5. When the 25% loss in WUA for juvenile mussels is added to the 85% loss WUA for host fish (Deep Slow Guild), impacts to state-listed mussels become even more significant. In addition, it is likely that much of this decrease in WUA for juvenile mussels and host fish occurs in the upper 50-60% of Reach 5, where live state-listed mussels have not been observed during three separate HG&E surveys (2005, 2009 and 2013) despite the presence of otherwise suitable habitat. If the WUA analysis were completed for each sub-reach (as recommended above), it is likely that a much higher reduction in WUA would be observed for the Dry Brook and Hatfield sub-reaches, which collectively account for over 50% of Reach 5's overall length. On the other hand, it is likely that WUA for juvenile mussels and host fish is much less affected in the Mitch's Island sub-reach, where state-listed mussels have been observed in significant numbers.	
MDFW-9	<u>Discussion</u> Shear stress for juvenile mussels appears to be a limiting factor in the upper two sub-reaches of Reach 5 at summer flows above 5,000cfs. The one portion of Reach 5 where shear stress does not appear to represent a limiting factor for juvenile mussels – in the vicinity of Mitch's Island, the sub-reach furthest downstream from Cabot Station – is also the only portion of Reach 5 where mussels have been observed in significant numbers.	The comment does not include a request for more information. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-10	<u>Discussion</u> FL results demonstrate that Project operations – and peaking from Cabot Station and Station 1 during the summer months specifically – result in elevated velocities and shear stress. Flow related variables (velocity, shear stress, depth) experienced by mussels at high flows represent factors likely to impact mussel populations (Layzer & Madison 1995, Hardison & Layzer 2001, Morales et al 2006, Allen & Vaughn 2010, Daraio et al. 2010, and Maloney et al. 2012). Elevated velocities and shear stress are, in turn, precluding settlement and colonization of juvenile state-listed mussels within significant portions of the Connecticut River (the native range for these mussels), with significant impacts to distribution and abundance. Severe impacts are documented in the 22.73 miles of the Connecticut River between Cabot Station and the Mill River confluence, representing the northernmost area where live state-listed mussels have been observed. Additional impacts to distribution, abundance and long-term persistence are presumed to occur in the lower 50% of Reach 5 as well.	The comment does not include a request for more information. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-11	<u>Discussion</u> FL results confirm that the effects of Project operations on state-listed mussels begin to attenuate in Reach 5 with increasing distance from Cabot Station. Likewise, FL results confirm that operational effects on state-listed mussels do occur in Reach 5 and increase within increasing proximity to Cabot Station. The significant effects observed in the Dry Brook and Hatfield sub-reaches indicate that Project effects are likely to be even more significant in Reach 4, where assessment of operational effects on mussels was not conducted. State-listed mussels were not observed in the upper 50% of Reach 5 during HG&E surveys, nor were any observed during FL's field surveys of Reaches 3 and 4. With observations of relic, adult Yellow Lampmussel shells throughout Reach 4 over the last 40 years, and given that the study results indicate operational effects increasing with increasing proximity to Cabot Station**, the Division recommends that the Reach 5 mussel assessment be expanded to include Reach 4.** This would greatly improve our understanding of how Project operations affect shear stress (juvenile mussels) and WUA (juvenile mussels and host fish guilds) with increased proximity to Cabot Station, and would allow development of more informed flow recommendations that are appropriately protective of state-listed mussel species downstream of Cabot Station. FL already collected transects throughout Reach 4 as part of the IFIM study, so additional data collection may not be necessary.	FERC approved Revised Study Plan –Study No. 3.3.16 *Habitat Assessment, Surveys and Modeling of Suitable Habitat for State-Listed Mussel* in February 2014. Objective 1 of the study states: *Delineate, through field surveys, populations of state-listed mussels and suitable habitat from Cabot Station downstream to the Route 116 Bridge in Sunderland. Characterize the distribution, abundance, demographics, and habitat use of these populations. Identify potential habitat for state-listed species based on habitat preference of each species.* In 2014, a habitat assessment of this reach (Reach 4 in the IFIM study) was conducted using NHESP's Endangered Species Habitat Assessment Guidelines. Results of the assessment, and a map of mussel surveys sites were discussed with NHESP on July 16, 2014 to reach concurrence on where suitable habitat likely existed and the most effective survey techniques. This discussion resulted in concurrence on 26 mussel survey locations. An interim report that addressed Objective 1 was filed with FERC as Appendix A to the Updated Study Report Summary for Study 3.3.16. The interim report stated that no live state-listed mussels were recorded in Reach 4. In October 2016, FirstLight filed Study 3.3.1, the Instream Flow Study. On page 1-2 of the study it states: *Lastly, the screening level assessment for state and federally listed mussels in Reach 5 is included in this report. A similar analysis was originally contemplated for Reach 4; however, no state and/or federally listed mussels were documented in this reach during recent surveys, so the analysis within Reach 4 was deemed unnecessary.* Comments were received on Study 3.3.1 and on January 17, 2017 FirstLight filed its responsiveness summary. As part of its response, FirstLight agreed to file an addendum to the report to address commenter concerns. Relative to mussels, on August 23, 2017, FirstLight filed a letter with FERC discussing its consultation with NHESP and USFWS and reaching agreement on how to evaluate mussels in Reach 5. Attached to the letter was a revised study plan for evaluating mussels in Reach 5 only; not Reach 4. NHESP is now requesting to expand the assessment of state-listed mussels in Reach 4, yet no live mussels were detected. Similar to the upper portions of Reach 5 (Dry Brook)—see MDFW-1 response above, Reach 4 does not contain preferred macrohabitats for Yellow Lampmussel, which is stable, level, sandbar areas. Reach 4 generally contains higher gradients than the upper portions of Reach 5, and contains few sandy areas. Though mussels could occasionally colonize the small amount of habitat available in the reach, the higher gradients and lack of sandy substrates would naturally limit colonization and population growth in the reach. Therefore, FirstLight does not believe it is appropriate to expand the assessment of state-listed mussels in Reach 4.

Commenter	Comment	Response
		As noted by FirstLight in its cover letter, requests for modifications to approved studies must demonstrate good cause and meet the criteria of 18 C.F.R. § 5.15(d) and (e), as appropriate. These regulations are included in FirstLight's response to MDFW-1. MDFW requests a mussel assessment in Reach 4, but failed to address the study criterion.
MDFW-12	Addendum 3: Assessment of Yellow Lampmussels in Reach 3 (filed May 1, 2018) The Division appreciates the additional analyses undertaken by FL to assess operational effects on state-listed mussels in Reach 3, consistent with comments provided by the Division on and before June 9, 2017. As detailed below, however, we offer additional information and analyses to clarify what the analyses indicate and recommend minor amendments to the study report. FL results indicate that the total WUA for adult state-listed mussels in Reach 3 remains relatively stable across a range of flows within the range of Project capacity. For juvenile mussels, the results are mixed but generally reaffirm that total WUA for Reach 3 as a whole is not significantly affected by increased Cabot flows.	The comment does not include a request for more information.
MDFW-13	Addendum 3: Assessment of Yellow Lampmussels in Reach 3 (filed May 1, 2018) Based on a review of WUA figures presented in the report (Appendix B-1), the location of suitable habitat for adult Yellow Lampmussels within Reach 3 does not change significantly with varying Cabot and Bypass flows. This suggests that habitat persistence for adult Yellow Lampmussels is not significantly impacted by increased Cabot flows. This finding supports the Division's previous comments on Study Report 3.3.16 (dated December 15, 2016) in which we noted that adult mussels are adapted to tolerating higher shear stress and once established, are able to withstand higher flows due to their larger mass, ability to anchor/burrow into substrates, and overall contribution to bedload stability.	The comment does not include a request for more information.
MDFW-14	Addendum 3: Assessment of Yellow Lampmussels in Reach 3 (filed May 1, 2018) Based on a review of WUA figures presented in the report (Appendix B-1), it appears that habitat persistence for juvenile Yellow Lampmussels is significantly impacted by variable flows in Reach 3. To illustrate, we qualitatively compared combined habitat suitability index maps for juvenile Yellow Lampmussels (see selected example figures below) across a variety of Cabot flows (2,500 cfs, 4,500 cfs, 7,000 cfs, and 14,000 cfs) while holding Bypass flows constant at 3,000cfs (selected as an approximation of estimated minimum natural summer flows). This qualitative assessment concluded that: i. The primary area of suitable habitat for juvenile Yellow Lampmussels at lower flows (Cabot flows <4,500cfs and Bypass flows = 3,000 cfs) occurs in the lower portions of Reach 3 (west of Smead Island south to the Railroad Bridge) and exhibits little change between Cabot flows of 2,500cfs and 4,500cfs (Figures A and B, below). ii. When Cabot flows increase to 7,000 cfs (Figure C, below), the figures show a modest decrease in suitable habitat for juvenile Yellow Lampmussels in the lower portions of Reach 3 (primarily in the main channel) and a modest increase in suitable habitat in the northern portions of Reach 3 (north of Cabot Station and south of Rock Dam). iii. When Cabot flows increase to 14,000 cfs (representing close to maximum Cabot flows during full generation; Figure D, below), the figures show a significant decrease in suitable habitat in the lower portions of Reach 3 (including the loss of most suitable habitat west of Smead Island) and a significant increase in suitable habitat in the northern portions of Reach 3 (close to Cabot Station and just south of Rock Dam). The Division's review of the figures presented in the report (Appendix B-1) finds that increasing Cabot flows results in a significant shift of suitable habitat from the southern to the northern portions of Reach 3. The increase in suitable habitat north of Cabot Station is likely due to the back up of water, which would effectively reduce flow velocity and shear stress upstream of Cabot Station. The shift in the location of suitable habitat for juvenile mussels with peaking Cabot flows – which tends to occur on a daily basis during the summer months – likely renders otherwise suitable habitats in the southern portion of Reach 3 inaccessible to juvenile mussels. Larvae and juveniles would typically be in the water column during relatively consistent, low summer flows in an unregulated river. Peaking summertime flows (May/June through September) create variable and abnormally high flows on a regular basis during the summer months. As a result, Project operations significantly reduce habitat persistence and reduce the ability of juvenile mussels to settle, establish and or colonize otherwise suitable habitats.	The comment does not include a request for more information. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-18	Addendum 3: Assessment of Yellow Lampmussels in Reach 3 (filed May 1, 2018) Overall, these results strongly suggest that relying solely on total WUA to assess potential impacts of Project operations on state-listed mussels would be misleading because the location of suitable habitat changes considerably across variable Cabot flows. **Therefore, and in order to better understand operational effects, it is necessary for FL to assess habitat persistence for juvenile Yellow Lampmussels in Reach 3 within the full range of Project operations. This habitat persistence analysis should be completed for Reach 4 and 5 as well, given the observed effects of Project operations in Reach 5 as detailed above. This analysis should be limited to between June 1 and September 31 in order to focus on the critical time of juvenile settlement into suitable habitat.**	FirstLight will conduct the persistent habitat mapping of juvenile Yellow Lampmussels in Reach 3 over a range of Project Operations and will file it with FERC on **March 1, 2019**. MDFW also requests that a habitat persistence analysis be completed for mussels in Reach 4 and 5. As part of Study No. 3.3.16, a mussel survey was conducted in Reach 4. Because no state-listed mussels were found in Reach 4, FL is not proposing to conduct dual flow analysis in Reach 4 for mussels. For Reach 5, FL provided dual flow tables for all mussels in its Addendum 2 filing (IFIM Study for Mussels in Reach 5).

Commenter	Comment	Response
	In an unregulated river, early-stage juveniles that establish themselves in suitable habitat during the summer months grow quickly and burrow deeply into the river bottom prior to the onset of higher winter/spring flows. Rapid growth of other *Lampsilis* species is well established in peer-reviewed literature (Haag & Rypel, 2011; Larson et al. 2014), indicating that a one (1) year old animal is of a size and shear stress tolerance more similar to adults. For example, juveniles are typically <1mm in size at the time they detach from host fish and are seeking to settle and establish themselves in suitable habitat. Haag & Rypel (2011) present length at age data for two native populations of *Lampsilis teres* (a closely related species to Yellow Lampmussels) from the Sipsey River in Alabama and the St. Francis River in Arkansas. One year old animals in both populations were 20-25 mm in size (on average, measured in terms of shell length); two year- old animals were between 40-100 mm in size. Similarly, Larson et al. (2014) present the mean length of two year old *Lampsilis siliquoidea* grown for the first year in cages in the St. Croix River, and the second year in raceways at the Genoa National Fish Hatchery, Wisconsin. The average size of animals was between 35-40 mm after two years of growth. As a result, shear stress and velocity affect juvenile mussels differently during the early juvenile lifestage (when juveniles are extremely small and seeking to establish themselves in suitable habitat) versus the later juvenile lifestage (when they are grown significantly in size and securely established in the river bottom), at which point they are more similar to adults. As a result, a cohort analysis of juvenile habitat suitability is representative only during the time of settlement for the early juvenile lifestage (between June 1 and September 31), whereas natural high flow events are only drivers of habitat suitability for adults and later lifestage juveniles and need not be included in the analysis. Inclusion of winter/spring high flows for settling juveniles would overestimate the amount of unsuitable habitat, as the early juvenile lifestage would not normally be present during these times. Habitat persistence models should evaluate early lifestage juvenile habitat suitability only within the discrete time period of June 1 through September 31, and compare these habitats with those of host fish guilds and adult habitat suitability models. This analysis would not require additional data collection. The Division previously requested this habitat persistence analysis in our December 15, 2016 comments in which we recommended that supplemental analyses should "provide additional information relative to the overall quantity of suitable habitat and how much of that habitat persists between various base/peak flow combinations."	Though the summer period is considered critical for juvenile settlement and colonization, the state-listed freshwater mussels have a juvenile lifestage that lasts for at least two years. During this time, they still require adequate depth, velocity, substrate, and shear stress for an additional 20+ months after settling and burrowing so that they can hold in place, feed, grow, and develop into adults. Their distribution of persistent habitat would therefore be confined to areas containing suitable depth, velocity, and substrate for the entire period that the mussel is in the juvenile life stage. Juvenile mussel habitat would be further constrained by high flow events that result in swift water flow (high shear stress) that could dislodge burrowed juvenile mussels. For that reason, FL will conduct the persistent habitat mapping for yellow lampmussels in Reach 3 for two-year cohorts. Further habitat analyses performed will include the critical settling stage, but will also include the remaining 20 months of a juvenile cohort lifestage using criteria agreed-upon during a phone conversation with MA NHESP on May 25, 2018. The criteria for the settlement portion of the juvenile life-stage includes the original juvenile habitat suitability criteria for depth, velocity, and substrate, along with juvenile shear stress (10 dynes/cm^2). The criteria for the post-settlement portion of the juvenile life-stage includes the original juvenile habitat suitability criteria for depth, velocity, and substrate, but incorporates adult shear stress (150 dynes/cm^2) to account for them being larger and burrowed during this time. FL interpretation of the study results suggest that shear stress criteria (at 10 dynes/cm^2) had relatively limited effects on habitat for juvenile mussels; this was due to relatively low flows that typically occur during the summer period, including those provided by generation. FirstLight disagrees with MDFW's interpretation of the study findings and will address it at the appropriate time in this proceeding.
MDFW-19	<u>Addendum 4: New Sea Lamprey Weighted Usable Area Curves</u> For this addendum FL developed new Habitat Suitability Index (HSI) curves for Sea Lamprey. These revised curves were then used to calculate new Wetted Usable Area (WUA) versus flow curves for Reaches 1, 2, 3, and 4. Use of the new HSI curves lead to a substantial increase in the amount of suitable habitat within each study reach. However, the results are of steady state analysis for each of the four reaches while two of the four reaches are influenced by hydropeaking operations (3 and 4). In particular, the Reach 4 steady state WUA versus flow curve suggests that peaking operations in the latter half of the spawning season may dramatically reduce the amount of suitable spawning habitat available. FL should preform supplemental analyses such as persistence/dual flow and/or habitat time series to assess how peaking operations affect the availability of Sea Lamprey spawning habitat in these reaches. FL did conduct similar analyses using the original HSI curves as reported in previous addendums to Study 3.3.1. **We request that FL undertake and provide the results of these supplemental persistence/dual flow and/or habitat time series analyses in a revised addendum.**	See USFWS-3.

Study No. 3.3.15 Assessment of Adult Sea Lamprey Spawning within Turners Falls Project and Northfield Mountain Project Area

Commenter	Comment	Response
USFWS-1	Re: Sea Lamprey Spawning Survey Addendum 1 to this study focused on assessing inundation and exposure at the seven sea lamprey redd locations documented in the vicinity of Stebbins Island during the 2015 field surveys associated with Study 3.3.15. Redd bed channel elevations were compared to water surface elevations (WSELs) at the closest HEC-RAS transect to a particular redd and evaluated at an hourly time step for the period January 1,2000 through September 30,2015. For the three transects closest to the redds, hourly WSELs from May 20 to July 3l (the sea lamprey spawning period) were used to develop WSEL duration curves. Based on the analysis, two redds were dewatered approximately 11 to 14 percent of the time, two were dewatered 5 to 8 percent of the time, and three were dewatered about I to 2 percent of the time. According to FL, redd dewatering is a function of releases from the Vernon project (FERC No. 1904) as well as water surface elevations in the Turners Falls Impoundment (in addition to other variables). *Comments & Recommendations:* Figures 2-2 (nests 219-l and 219-2),2-3 (nests 182 and 217) and 2-4 (nests 220, 221,and 222) portray water surface elevation duration curves based on hourly modeled data for the period May 20 through July 31, with one curve representing l5 water years (2000 through 2015). In order to better understand how interannual variability may influence the amount of time WSELs are below the redd bed elevations, we request that FL revise each figure to have separate curves for each water year.	3.3.15 Attachment A includes elevation duration curves for nests 219-1 and 219-2, nests 182 and 217 and nests 220, 221, and 222 for individual years from 2000-2015 (excluding 2010 in which NFM was inactive). The water surface elevations are based on hourly hydraulic modeling.
NMFS-1	Re: Sea Lamprey Spawning Survey FirstLight revise each figure to present separate curves for each water year to present the annual variability. Separating the annual data will better depict annual variability and the time WSELs are below the redd bed elevations. This output will help evaluate the potential affects that project operations have on sea lamprey spawning and productivity.	See USFWS-1.

Study No. 3.3.20 Ichthyoplankton Entrainment Assessment at the Northfield Mountain Pumped Storage Project

Commenter	Comment	Response
USFWS-1	The purpose of Addendum 1 is to provide an analysis of potential ichthyoplankton entrainment at the NMPS Project under FL's proposed expanded Upper Reservoir operating range. FL used its existing operations model to evaluate changes in the volume of water used for pumping and generating under current operations and proposed expanded operations. Hydrology for water year 2002 and the pump and generation schedule for 2009 were selected as being representative model input data. In order to determine how NMPS would have operated, given the 2002 hydrology but with the expanded upper reservoir storage capacity, FL operations personnel modified the 2009 pump/generation schedule based on professional judgement. The volume of water pumped under the expanded operations scenario then was used to estimate the amount of ichthyoplankton entrained. Results of the analysis show that under expanded operations, greater volumes are pumped over a shorter time than under baseline conditions, with much larger fluctuations (i.e., larger magnitude peaks and valleys) that occur less frequently.	The comment does not include a request for more information.
USFWS-2	FL states that water year 2002 was chosen because flows were generally lower than average relative to the recent period of record (1975 to 2015). Actually, when looking at the period of time when early life stages of American shad are in the River, 2002 falls within the normal range (Attachment A).	No Attachment A was provided in the filing. The comment does not include a request for more information
USFWS-3	It is unclear why FL chose only a single water year to model. In order to better understand the variability in entrainment potential under expanded operations, several water years should be modeled, representing a range of hydrologic conditions. In addition, no explanation is given for using operation personnel's professional judgement versus changing parameters (i.e., upper and lower Upper Reservoir elevation limits) within the operations model to assess how much more water would have been pumped under the expanded operations scenario.	The comment does not include a request for more information. However, relative to FL choosing a single year to model, FirstLight notes the following: The timing, magnitude and duration of water pumped to the Upper Reservoir are independent of the magnitude of water flowing by the Northfield tailrace. Pumping is driven by market conditions, irrespective of flow. Given this, FirstLight did not simulate multiple years. Regarding using operation personnel’s professional judgement vs changing parameter in the operations model, the operations model was changed to allow the Upper Reservoir to operate over a wider band.
USFWS-4	The modeled entrainment estimates were based on entrainment data collected in 2016. Our May 12,2017 comment letter on the 2016 report detailed a number of concerns we had with the methodology, analyses, and results of that report, including: Only 3 percent of the validation samples (n=l) were collected when all four units were pumping and only 18 percent (n=6) when three units were pumping. Further, offshore sampling only collected ichthyoplankton in three of the 11 sample nights, while eggs and/or larvae were collected in seven of 12 sample nights. Ichthyoplankton was collected in both locations (offshore and in intake water samples) on only two of seven sample nights. On those two occasions, densities were dramatically different; in week 24, larval density was 0.311/100m^3 in the offshore samples and 2.48/100m^3 in the intake sample and in week 25, density of larvae in the offshore samples was 10.96/100m^3, whereas it was only 1.33/100m^3 in the intake samples. These results call into question the validity of the underlying assumption that the intake water was representative of ichthyoplankton density in the River near the NMPS intake.	The comment does not include a request for more information; however, FirstLight is addressing some issues raised in the comment. Ichthyoplankton densities in the source waterbody and entrainment samples are often different. The entrainable life stages of fish tend to have highly variable, non-random spatial distributions. The patchiness of the spatial distribution of eggs and larvae originates with spawning activity, which releases eggs in dispersed patches, theoretically ranging in size from the spawning area of a single female to the entire area of spawning activity associated with major hydrographic features (Smith and Richardson 1977). Local and wide scale water motions may disperse or concentrate these patches, and localized mortality from starvation or predation may create open areas within patches. Later larvae and early juveniles of some species may also move to preferred depths or aggregate into schools as swimming ability develops. These processes can cause early life stage densities to vary over relatively small spatial scales, potentially resulting in non-random “microdistributions” within the hydraulic zone of influence. Such variations in spatial distribution, coupled with hydraulic conditions that depend on intake type, design, and operation, as well as waterbody hydrodynamics, may result in variations in entrainment rates in densities of organisms approaching the face of the intake structure (EPRI 2014). Patchy distribution common for eggs and larvae could account for the difference between the entrainment and offshore collections. In addition, net avoidance in the waterbody is common as motile larvae are capable of avoiding sampling gear (e.g., plankton nets) but the potential for avoidance is substantially reduced during entrainment sampling as sample water is drawn from intake piping with reduced area and higher velocities that do not permit volitional movement by larvae. EPRI (2014) indicates that there is little question that larger planktonic organisms can and do avoid traditional plankton nets in open water sampling. Such a phenomenon is well documented in the scientific literature (Smith and Richardson 1977; EPRI 2004). Active gear avoidance can occur when organisms detect the collection device in sufficient time so as to permit the organism to swim out of the path of the collection device and avoid capture. Detection can occur as a result of visual cues or through sensing of vibration or hydrostatic pressures produced by the passage of the collection device through the water. Studies of this phenomenon demonstrate that avoidance increases among larger individuals (EPRI 2004). A case of active gear avoidance was documented by a study comparing density estimates of larval anchovies in waters off Hawaii collected using a bridled 1-m net to concurrent densities obtained using a large larval purse seine. The results of this comparison found that densities of larvae as small as 7 mm long made using the towed net were only 10 percent of those made using the purse seine (EPRI 2004). Larvae especially larger larvae, can avoid the offshore plankton nets, but not the entrainment net as the entrained larvae are well mixed and distributed.
USFWS-5	Only 13 percent (n=6) of entrainment samples were collected when all four units were pumping. This small sample size makes it difficult to assess a potential relationship between entrainment density and number of units pumping. Under expanded operations, **it is reasonable to assume more units will be operating more frequently; therefore, it is important to understand if a relationship exists and what its implications might be. If (on a per unit volume of water basis) increasing the number of units pumping increases the density of entrained ichthyoplankton, that information needs to be incorporated into the model.**	See Figures 1 and 2 in USFWS-14 (below). These figures matched the sample density with hourly flow. More units pumping will have a larger pumping rate (cfs) and a larger ratio of NFM to Connecticut River flow. There is no correlation between operations and entrainment densities. Entrainment is a function of the time of year and spawning conditions in the river. Therefore, more fish spawning in the river means higher entrainment.
USFWS-6	Flow data from the Montague USGS gage were used in assessing if a relationship existed between river flow and entrainment rate. As noted below, flows at the Montague gage are impacted by Cabot Station operations and may not be	See USFWS-14 (below).

<table>
<tr><th>Commenter</th><th>Comment</th><th>Response</th></tr>
<tr><td></td><td>reflective of conditions in front of the NMPS intake. Hydraulic modeling in the vicinity of the NMPS intake shows that the direction and magnitude of flow vectors change depending on the amount of flow coming downstream, water surface elevation in the Turners Falls impoundment, and how much NMPS is either pumping or discharging. Entrainment modeling should take these factors into account, as they influence the susceptibility of ichthyoplankton to entrainment.</td><td></td></tr>
<tr><td>USFWS-7</td><td>In the addendum, FL employs a new method of estimating entrainment. When estimating entrainment based on data collected in 2015 and 20l6, FL calculated weekly mean entrainment density using a parametric distribution (negative binomial), whereas a quantile based extrapolation was used in the addendum. According to FL, the new method was intended to account for uncertainty within a week.</td><td>The comment does not include a request for more information; however, FirstLight is addressing some issues raised in the comment.

2016 proved to be a different year from 2015. We entrained larvae in 2016 and not in 2015, also the population sustained weekly egg production over a longer period in 2016 than in 2015. This trend is corroborated with the CT DEEP’s observation that 2016 had the highest juvenile abundance index on record (Personal Comm. Jacque Benway). The sample densities showed discrepancy as well. In 2015 densities peaked at calendar week 24, the same as 2016, however the median densities differed considerably. With no median density greater than 0.1 org/m^3 in 2015 (3.3.20 Attachment A, Figure 1), 2016 saw median egg densities greater than 0.1 org/m^3 (3.3.20 Attachment A, Figure 2) in weeks 23 and 24. This is an interesting find because the sample sizes were smaller in 2016 with only 50 cubic meters pumped. This suggests entrainment events occur randomly, with low frequency, and are of short duration.

We also had considerably more variability between samples within a night in 2016 than we did in 2015. With a majority of the 2016 samples having zero organisms, the statistical fitting that we enjoyed in 2015 was not able to be repeated in 2016 as indicated in the report. Therefore, a non-parametric method was adopted to compare entrainment between years based on percentiles (quantiles).</td></tr>
<tr><td>USFWS-8</td><td>FL states that the model output shows the volume of water pumped (Figure 4.1-1) under expanded operations has larger peaks and valleys, but fewer of them relative to baseline conditions. Based on our count of the peaks shown in Figure 4.1-1, there are 23 under the baseline condition and 24 under the expanded operations condition.</td><td>The comment does not include a request for more information.</td></tr>
<tr><td>USFWS-9</td><td>While the report provides a figure (Figure 4.3-2) of extrapolated organism counts by week under baseline and expanded operations, it does not report an actual estimate of the number of eggs and larvae entrained based on the total volume pumped during the l0-week study period.</td><td>The expanded calculations used a quantile extrapolation method (see USFWS-7) with 2016 total weekly densities that bracketed the median entrainment density and median expanded flow with the best case (10% entrainment density and 10% expanded flow) and worst case (90% entrainment density and 90% expanded flow) scenarios. The total egg and larval extrapolation under expanded operations is found in Table 1. The rationale behind this is that it is unclear what expanded operations may be in the future, nor do we know what future egg and larval production would be, so rather than extrapolating on an hourly flow in a specific calendar year, we extrapolated on a weekly aggregate statistic to account for potential uncertainty within a calendar week. The best case expanded flow scenario is 10% (upper reservoir already near capacity at start of pumping), while the worst case is 90% (upper reservoir nearly empty at start of pumping).

Table 1 total egg and larval extrapolation under expanded operations<table><tr><th>Life stage</th><th>10%</th><th>50%</th><th>90%</th></tr><tr><td>Egg</td><td>4,669,813</td><td>7,423,140</td><td>13,093,620</td></tr><tr><td>Larvae</td><td>2,340,313</td><td>4,191,404</td><td>8,658,078</td></tr></table></td></tr>
<tr><td>USFWS-10</td><td>The Service's concerns relative to how FL estimates adult equivalents can be found in our May 12, 2017 comment letter and remain unchanged.</td><td>This comment does not request additional information, but FirstLight provides the following response.

The approved study plan for Study 3.3.20 indicated that survival fraction data for all life stages of American shad entrained will be compiled from EPA (2004). For the second year of study, stakeholders requested that river specific survival fractions from Crecco et al (1983) be used for calculating egg and larval survival. As requested, these were used for the egg and larval stages. Current comments request the in-river juvenile stage now be split out from the estuarine- marine juvenile life stage. The stakeholders requested that a 98% daily survival for in-river juvenile shad for 70 days based on Crecco et al. (1983) be used.

FirstLight used the egg and larval mortality rates from Crecco et al. (1983) as requested but used the EPA (2004) mortality estimates for the juvenile stage as we believe this is a more accurate estimate of juvenile mortality. The same authors, Vic Crecco and Tom Savoy, Connecticut Department of Energy and Environmental Protection, revisited their juvenile shad mortality estimate in a published paper, Savoy and Crecco (2004). They indicated that a dramatic and unexpected decline in American Shad abundance occurred in the Connecticut River since 1992. They attributed this decline to increased predation in the Connecticut River from 1992 to 2002. They concluded that future stock assessments consider time varying natural mortality rates brought about by shifts in predation.

Stakeholders requested juvenile equivalent estimates for the period of freshwater residency should be separated out because a peer-reviewed, river-specific rate exists in Crecco et al. 1983. However, since the authors of this estimate have revisited the mortality rates and concluded that it has shifted over time, we believe that using the more recently published EPA (2004) mortality rates is a better estimate of juvenile mortality. This is a regional estimate of mortality that includes both in-river and estuarine-marine juvenile life stages. Using this estimate with a larger sample size should better account for annual variations in mortality and provides a standard metric for comparing losses among species, years, and regions.</td></tr>
</table>

<table>
<tr><th>Commenter</th><th>Comment</th><th>Response</th></tr>
<tr><td></td><td></td><td>EPRI. (2014). Entrainment Abundance Monitoring Technical Support Document: Updated for the New Clean Water Act 316(b) Rule. Technical Report No. 3002001425. Palo Alto, CA.

Savoy, T.F., and V.A. Crecco. 2004. Factors Affecting the Recent Decline of Blueback Herring and American Shad in the Connecticut River in The Connecticut River Ecological Study (1965-1973), revisited: ecology of the lower Connecticut River 1973-2003. American Fisheries Society Monograph 9. Bethesda, Maryland</td></tr>
<tr><td>USFWS-11</td><td>In our May 12, 2017 letter, we questioned the usefulness of analyzing flow data from the Montague USGS gage, which is downstream of the Turners Falls Dam and influenced by Cabot Station's operations. Rather, any analysis aimed at assessing a potential relationship between ichthyoplankton entrainment and river flow should be based on the combined discharges from the Vernon Project, the Ashuelot River, and the Millers River (accounting for travel time) because they would better represent flows moving past the NMPS intake. The addendum does not contain a re-analysis using the requested flow data; therefore, we do not believe FL has fully complied with FERC's January 22, 2015 directive.</td><td>Shown in 3.3.20 Attachment B are the following two graphs which fully comply with FERC's January 22, 2015 directive.:
The combined flow from the Vernon Project, Ashuelot and Millers Rivers (two graphs for 2015 and 2016). Note that these graphs do not account for travel time.
The density of egg and larve during the two study periods.</td></tr>
<tr><td>USFWS-12</td><td>Recommendations: We request that FL provide entrainment estimates for water years 2013, 2015 and 2016, which represent "wet," "normal," and "dry" years, respectively. Years 2015 and 2016 have the added benefit of empirical entrainment data to use as a basis for comparison.</td><td>Because FL has provided entrainment estimates already for 2015 and 2016, FL assumes that the request is seeking entrainment estimates for 2013, 2015 and 2016 under expanded Upper Reservoir operations. As noted above, the pump/generating schedule of Northfield Mountain is independent of the flow in the TFI.</td></tr>
<tr><td>USFWS-13</td><td>Recommendations: In order to maintain consistency with previously reported results, we request that FL estimate entrainment using the same methodology outlined in the 2015 and 2016 reports (i.e., provide tabular data of weekly summed extrapolations of eggs and larvae similar to Table 4.3-3 of the 2016 report) for baseline and expanded operation conditions.</td><td>See USFWS-7 for explanation. 2016 saw considerably more variability in counts than in 2015 and unfortunately the statistical fitting we enjoyed in 2015 was not able to be repeated in 2016. In 2016, we adopted a more traditional extrapolation method, with weekly total sample densities between observations interpolated with a linear spline see (see 3.3.20 Attachment C, Figures 1 and 2). Sample densities were taken as the total number of organisms entrained over all samples in a night divided by the total amount of sample water drawn within that night. After interpolating densities, the number of eggs and larvae entrained was extrapolated by multiplying the daily density by total volume pumped that day. The larvae used in the 2015 entrainment density calculations was found in offshore sampling. Table 1 contains the total number of eggs and larvae entrained using this method. Note these estimates are within the best and worst case scenarios in USFWS-9.

Table 1. Yearly extrapolation sum for eggs and larvae using interpolated densities
<table>
<tr><th>Life stage</th><th>Year</th><th>Organisms Entrained</th></tr>
<tr><td>Eggs</td><td>2015</td><td>6,811,199</td></tr>
<tr><td>Larvae (captured during offshore sampling)</td><td>2015</td><td>324,194</td></tr>
<tr><td>Eggs</td><td>2016</td><td>9,540,205</td></tr>
<tr><td>Larvae</td><td>2016</td><td>5,175,833</td></tr>
</table></td></tr>
<tr><td>USFWS-14</td><td>Recommendations: We reiterate our request that FL should include river discharge (based on the combined discharges from the Vernon Project, the Ashuelot River, and the Millers River) when analyzing the 2015 and 2016 data to determine if a relationship exists between ichthyoplankton entrainment and river flow. Further, the analysis should not be based on average daily flow; instead, we recommend using hourly flows to correlate flows that were occurring during the time the ichthyoplankton samples were being collected.</td><td>See USFWS-11 for sample densities superimposed onto the hydrographs for 2015 and 2016. Sample densities were matched with the inflow to the TFI (Vernon + Ashuelot + Millers) within the hour the sample started for 2015 and 2016, and a series of figures showing correlation between flow and densities were produced. The first figure (see 3.3.20 Attachment D, Figure 1) shows organism density as a function of pump rate. Note that there does not appear to be a correlation between sample density and hourly flow rate. We also plotted organism density as a function of the ratio of NFM to Connecticut River flow (see 3.3.20 Attachment D, Figure 2). Note, there does not appear to be a relationship between the ratio of NFM to Connecticut River flow and organism density. Even when NFM is pumping at a flow up to 7 times more than what is available in the Connecticut River, entrainment densities do not increase. Entrainment density is a function of time of year and the current spawning activities in the Turners Falls Impoundment at Stebbins Island just downstream of Vernon Dam, and is not a function of operations at Northfield Mountain.</td></tr>
<tr><td>NMFS-1</td><td>FirstLight estimate entrainment using the same methodology outlined in the 2015 and 2016 reports (i.e., provide tabular data of weekly summed extrapolations of eggs and larvae similar to Table 4.3-3 of the 2016 report, for the baseline and expanded operation conditions).</td><td>For explanation see USFWS-7 and USFWS-13. For a breakout by week, see below: The (*) indicates that in 2015, offshore sampling provided larval densities as no larvae were entrained.
<table>
<tr><th></th><th colspan="2">2015</th><th colspan="2">2016</th></tr>
<tr><th>Week No</th><th>Eggs</th><th>Larvae*</th><th>Eggs</th><th>Larvae</th></tr>
<tr><td>19</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>20</td><td>0</td><td>0</td><td>0</td><td>50,957</td></tr>
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<tr><td>23</td><td>776,989</td><td>58,334</td><td>2,494,418</td><td>503,818</td></tr>
<tr><td>24</td><td>3,715,583</td><td>243,869</td><td>1,242,874</td><td>535,689</td></tr>
<tr><td>25</td><td>1,237,465</td><td>21,991</td><td>436,871</td><td>48,074</td></tr>
<tr><td>26</td><td>233,349</td><td>0</td><td>116,624</td><td>68,191</td></tr>
<tr><td>27</td><td>46,438</td><td>0</td><td>116,240</td><td>23,324</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Commenter</th><th>Comment</th><th>Response</th></tr>
<tr><td></td><td></td><td><table><tr><td>28</td><td>0</td><td>0</td><td>17,431</td><td>34,862</td></tr><tr><td>29</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>30</td><td>0</td><td>0</td><td>0</td><td>0</td></tr></table></td></tr>
<tr><td>NMFS-2</td><td>The Connecticut River discharge used in the model should combined discharges from the Vernon project, Miller River (USGS # 01166500) and Ashuelot River (USGS # 01161000).</td><td>See USFWS-3</td></tr>
<tr><td>MDFW-1</td><td>The Division agrees with and fully supports the analysis, comments, and recommendations of the US Fish and Wildlife Service as expressed in their letter of November 23, 2018.</td><td>See USFWS-1, USFWS-2 and USFWS-3.</td></tr>
</table>

Study No. 3.5.1 Baseline Inventory of Wetland, Riparian and Littoral Habitat in the Turners Falls Impoundments and Assessment of Operational Impacts on Special-Status Species

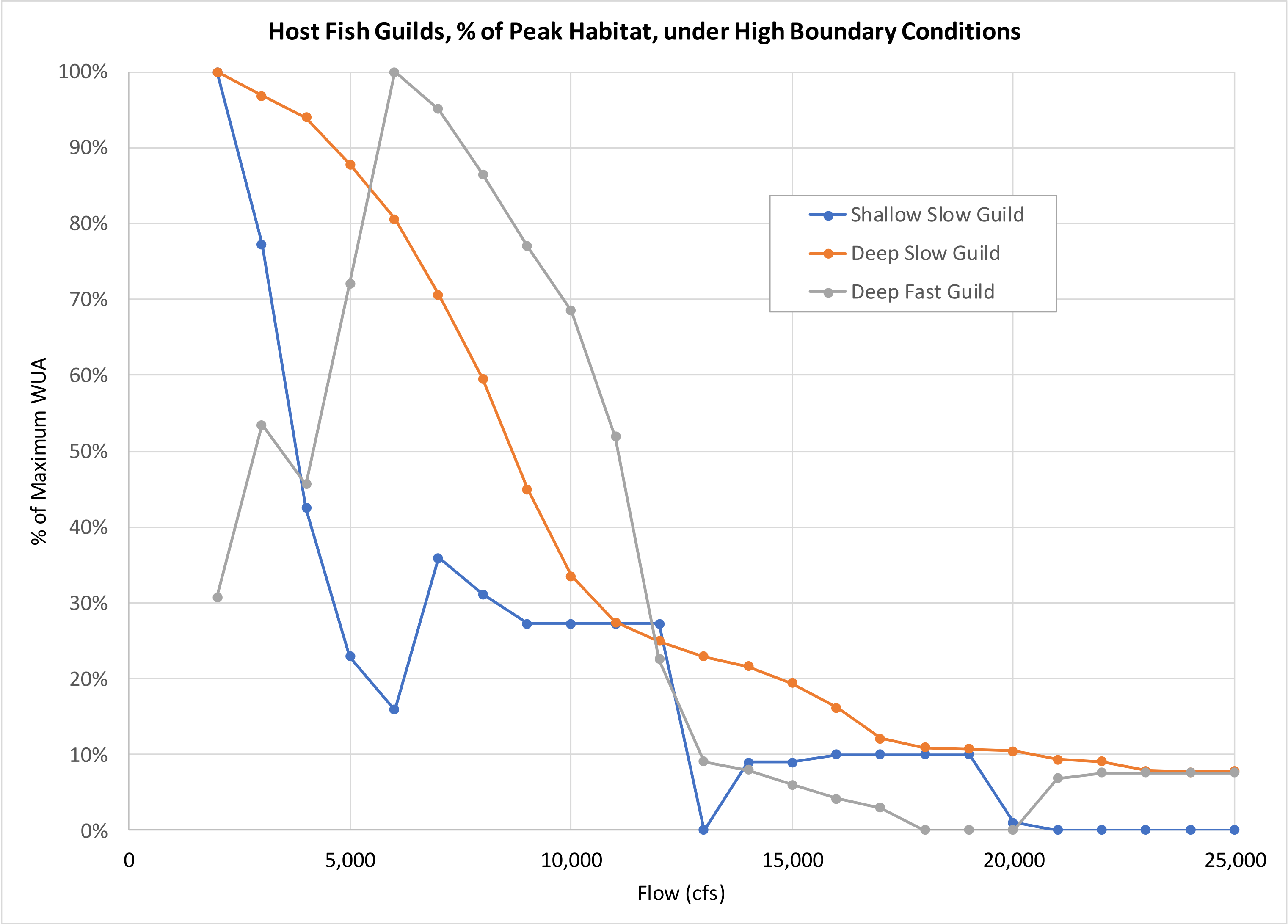
Commenter	Comment	Response
MDFW-1	Addendum 2 (filed April 2017) The Division appreciates the updated analyses undertaken by FL to assess operational effects on Cobblestone (CTB) and Puritan Tiger Beetles (PTB), consistent with the Division's December 15, 2016 comments. As detailed below, however, we offer additional information and analyses to clarify what the analyses indicate and recommend minor amendments to the study report. A review of CTB and PTB life cycles and natural history demonstrate that both species are adapted to maximize their productivity and long-term persistence in the context of a natural hydrograph. After spring high flows, flows in an unregulated river would generally decrease steadily starting in May/June until reaching annual lows in late September and early October. Therefore, suitable habitats for tiger beetles would not typically experience significant inundation between June and October except during isolated summer rainfall events. Rainfall events would typically result in short, isolated periods of inundation followed by a return to steady, lower flows. As a result, the majority of suitable habitat for CTB and PTB would typically be available for long, extended periods of time between June and October. The adult active period in the Connecticut River occurs between June 21 and September 7, with the majority of adults emerging and completing their life cycle between July 1 and August 31. This time period overlaps with steadily decreasing summer flows, indicating that adult beetles have adapted to emerge, forage, mate, and lay eggs when habitat availability is consistently high and generally increasing. Adult beetles are predominately active during daylight hours and are most active when temperatures are highest, with approximately 9:00am – 8:30pm representing the core daily active period. Adult beetles survive between 1 and 4 weeks, with adults emerging continuously across this active period, rather than in a single annual emergence event. Therefore, a typical adult would be able to successfully complete its life cycle – foraging, mating, and egg laying – in between isolated large summer rainfall events. Even with large summer rain events, continuous emergence assists the species in minimizing the chances of full reproductive failure in any given year. On a long time-scale, reproductive failure of a population could occur during an abnormal, consistently high water year, but would be offset by recolonization from other sites. PTB have a two-year life cycle (Abbott 2003), including embryonic egg development and three instar stages (in the same burrow) before emerging as an adult two years afterward. First instars hatch from eggs in late summer and molt to second instars within 2-4 weeks, all during the first active season. After over-wintering, second instars molt to third instars the following spring and remain in this instar stage for a year before pupating and emerging as adults the following summer. Successful instar molting, overwintering, and overall survival is highly dependent on foraging success, and larvae forage during both day *and* night hours. Although less well studied, CTB are thought to exhibit a substantially similar life history to that of PTB. Omland (2002) suggests that specific sand texture characteristics are likely required for tiger beetle larvae to successfully construct and maintain burrows through the three instar stages. Larval stages tolerate less variation in abiotic conditions than adults (Pearson 1988; Rodriguez et al., 1998), such as soil composition, soil moisture, and temperature. As a result, larval burrows tend to be concentrated in the upper 25% (vertical range) of suitable habitat, with little to no vegetation.	The comment does not include a request for more information.
MDFW-3	Addendum 2 (filed April 2017) Tables 2.2-1 and 2.2-2 (Study Report Addendum filed October 2016) illustrate the extent of potential habitat available at each elevation for CTB in Montague as well as the percent of days that each elevation was inundated for 24 hours. Tables 2.3-1 and 2.3-2 provide the same information for PTB at Rainbow Beach. In the Division's December 15, 2016 comments, we requested that the FL provide related figures showing the percent of time that potential habitat is inundated for less than 24 hours but more than 0 hours, per the following categories: 1-5, 6-9, 10-14, and 15+ (with all associated raw numerical data provided in an editable spreadsheet). FL provided these updated figures and associated raw data in Addendum 2.	The comment does not include a request for more information.
MDFW-4	Addendum 2 (filed April 2017) Based on updated figures and the raw data provided in Addendum 2, the Division revised and updated FL's Tables 2.2-1 and 2.2-2 (CTB) and Tables 2.3-1 and 2.3-2 (PTB) to illustrate the mean number of hours that each elevation is inundated during July and August (see Tables A and B, below). We selected the primary adult active season (July 1 through August 31) for illustrative purposes, although adults have been documented to emerge as early as June 21 and remain active as late as September 7. The FL Tables 2.2-1 and 2.2-2 (CTB) and Tables 2.3-1 and 2.3-2 (PTB) assume a greater extent of habitat than is practically available to either species. For example, data indicate that mean flows seldom decrease below 2,500 cfs, so any potentially suitable habitats for CTB in Montague below 106 ft are almost always inundated and therefore not typically	FirstLight appreciates the additional information on the active seasons and habitat elevations and will utilize this information in the supplemental analysis that will be filed by FirstLight on **March 1, 2019.**

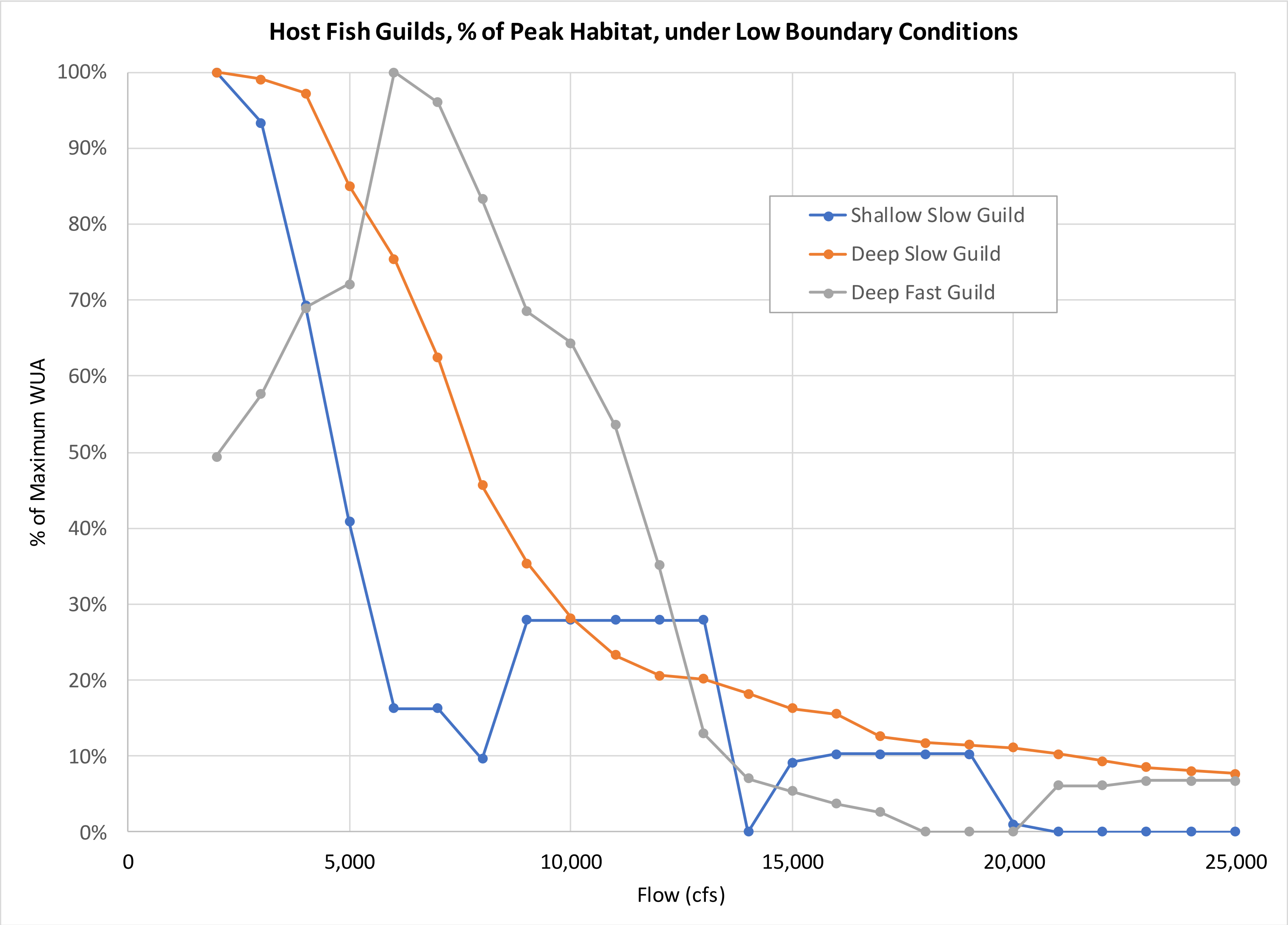
Commenter	Comment	Response
	available; therefore, it should be excluded as suitable habitat. For PTB, suitable habitat generally ends at an upper elevation of approximately 104ft; elevations above this are thickly vegetated and therefore generally unsuitable for the species. Therefore, the updated tables below (Tables A and B) have been revised to more accurately cover the range of suitable habitats that are actually available to the species at both sites. We also designated elevational ranges of suitable habitat according to their potential usage by adult and larval lifestages. For example, as larval burrows tend to be concentrated in the upper 25% (vertical range) of suitable habitat with little to no vegetation, for CTB we assume that larval habitats occur above an elevation of approximately 110ft. For PTB, we assume that larval habitats occur above approximately 102.75ft (and below 104ft, where habitats become thickly vegetated). Adults use all suitable habitats for the range of different but necessary life functions (e.g., foraging, sheltering, mating, egg-laying, etc.); the loss of access to portions of the elevational range constitutes an important loss of habitat.	
MDFW-5	Cobblestone Tiger Beetles: FL results and the Division's Table A (below) indicate that, at maximum generation from Station 1 and Cabot Station (2,210cfs + 13,728cfs = 15,938cfs, plus Deerfield flows), nearly 100% of available CTB habitat for both lifestages is inundated. Within the Project's operational range, WSELs at this site can fluctuate over six (6) feet. Given that the CTB site is immediately below Cabot Station, Cabot Station releases have little to no attenuation and result in almost immediately and severe inundation of both adult and larval CTB habitat. Under current summer operations, Cabot peaking tends to begin in the late morning and continue until late evening, meaning that suitable habitats are inundated for much of the core daily adult active period. These impacts are reflected in the mean daily inundation data shown in Table A (below), which confirms that significant portions of suitable habitats are inundated on a daily (or near daily) basis. On average, nearly 100% of available habitat for both lifestages (elevation 106-112ft) is inundated for 10.4 hours per day in July and 7.6 hours per day in August. Approximately 75% of available adult habitat (elevation 106-110ft) is inundated for an average of 14.7 hours per day in July and 11.7 hours per day in August. For larvae, the data suggest that approximately 45% of larval habits (elevation 110-111ft) are inundated an average of 12.8 hours a day in July and 9.6 hours a day in August.	The comment does not include a request for more information.
MDFW-6	Puritan Tiger Beetles FL results and Table B (below) indicate that, at maximum generation from Station 1 and Cabot Station (15,938cfs plus Deerfield flows), nearly 90% of available adult habitat and >30% of available larval habitat for PTB at Rainbow Beach is inundated on a daily (or near daily) basis during the adult lifestage. For example, at maximum generation, approximately 90% of available adult habitat (elevation 100-103.25ft) and >30% of available larval habitats (elevation 102.75-103.75ft) are inundated an average of 6.3 hours per day in July and 4.6 hours per day in August. At more modest Project flows of 12,000cfs (approximately equal to flows from Station 1, four (4) Cabot Units, and the Deerfield River), 64% of available adult habitat is inundated an average of 9.0 hours per day in July and 6.0 hours per day in August. Comparing Tables A and B, it is apparent that inundation of PTB habitats at Rainbow Beach exhibits considerably more variation around the mean than are observed in Montague. The variation around the mean indicates that hydraulics at Rainbow Beach are more complicated than the simple flow vs. WSEL relationship presented in the Addendum. This likely reflects both distance from Cabot Station and, in particular, the effects of Holyoke Impoundment levels on the flow vs. WSEL relationship at Rainbow Beach. HG&E reduces Holyoke Impoundment elevations (Holyoke Project FERC No. 2004) in response to upstream Cabot peaking operations in order to moderate the magnitude of WSEL changes at Rainbow Beach and reduce impacts to PTB habitats. By drawing down the Holyoke Impoundment in advance of the arrival of peaked flows released from Cabot Station, current Holyoke operations aim to reduce the magnitude of habitat inundation at Rainbow Beach caused by Cabot Station. T**herefore, in order for operations of FL to be fully represented, the Division recommends that FL conduct a more thorough hydraulic analysis for Rainbow Beach to account for how Project operations interact with the range of Holyoke Impoundment levels. This will allow FL to better assess the magnitude, duration and frequency of habitat inundation for PTB. In addition, we recommend that the analysis include a range of modeling runs in which Cabot peaking occurs on top of varying baseline river flows (e.g., 2,000cfs, 4,000cfs, 6,000cfs, 8,000cfs, and 10,000 cfs).**	FirstLight agrees that the WSEL fluctuation at Rainbow Beach is a complex combination of baseflow, length and magnitude or peaking flows, Holyoke impoundment level management, the hydraulic constriction near Dinosaur Footprint as well as the attenuation of flows traveling about 25 miles downstream from Cabot Station to Rainbow Beach. FL plans to utilize the HEC-RAS hydraulic model to provide additional details on how Cabot Station generation flows are attenuated, in many situations, by the time they reach Rainbow Beach. Somewhat similar to the MDFW comment, FirstLight plans to model Cabot Station flows, with variations in the magnitude and duration, under a range of base flows in the Connecticut under varying Holyoke impoundment levels to provide additional information on habitat inundation at Rainbow Beach. To complete the additional analyses that MDFW has requested and to provide additional details of the complexities at Rainbow Beach, a supplemental analysis will be filed by FirstLight on **March 1, 2019.**
MDFW-7	Puritan Tiger Beetles FL results clearly show that both species are experiencing regular and substantial inundation of adult habitats on a daily or near daily basis during July and August. **To better elucidate Project effects on key adult behaviors, we recommend that FL limit its assessment of the extent, duration and frequency of inundation to the typical daily adult active period (9:00am – 8:30pm), excluding the hours outside this period.**	To respond to this comment about inundation occurring between 9:00am and 8:30pm, a supplemental analysis will be filed by FirstLight on **March 1, 2019**. However, Firstlight proposes to use the hours of 9:00am to 8:00pm since the hydraulic model is based on hourly data.

Commenter	Comment	Response
MDFW-8	Puritan Tiger Beetles FL results clearly show that both species are experiencing regular and substantial inundation of larval habitats on a daily or near daily basis during July and August; however, the analysis does not sufficiently cover the full period of larval activity. **FL should provide updated tables, modeled after the Table A and B, showing the mean number of hours per day (including one standard deviation) larval habitats are inundated between May 15 and October 15 (with each month assessed separately)**. This should provide a better understanding of how larvae are affected by Project operations. Because larvae are active during both day and night, and given the more complex hydraulics effecting PTB at Rainbow Beach, the updated should be used to assess the extent, duration and frequency of larval habitat inundation for all hours (day and night).	FirstLight agrees that current and proposed Project operations result in flow fluctuations downstream of the Project. To respond to this comment, a supplemental analysis will be filed by FirstLight on **March 1, 2019**.
MDFW-9	Puritan Tiger Beetles Potential impacts to both species can only be fully understood by comparing managed conditions under current and proposed Project operations to the natural, unmanaged flow conditions that CTB and PTB are adapted to (see Comment #1). Peaking flows under current Project operations create variable high flows on a daily or nearly daily basis, particularly between July and October when flows would consistently decrease after spring freshets until reaching annual lows in September and October, with little variation from day to day. The Project's peaking flows represent a highly abnormal hydraulic regime that diverges greatly from the conditions to which CTB and PTB are adapted. FL results clearly show that both species are experiencing regular and significant inundation of adult and larval habitats, resulting in significant impacts to habitat availability, habitat suitability, and key behaviors. To better understand potential Project impacts on both species, the Division is currently preparing an additional, supplemental analysis to simulate natural flow regimes as well as habitat persistence over time and space both with and without flow manipulation. The Division will provide the results of this supplemental analysis to FERC for review as soon as possible.	The comment does not include a request for more information.

STUDY NO. 3.3.1 ATTACHMENTS

Attachment A: % Peak WUA versus Flow Plots for three Host Fish Guilds under High and Low Holyoke Boundary Conditions




Host Fish Guilds, % of Peak Habitat, under Low Boundary Conditions
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of Maximum WUA
0
5,000
10,000
15,000
20,000
25,000
Flow (cfs)
Shallow Slow Guild
Deep Slow Guild
Deep Fast Guild

STUDY NO. 3.3.15 ATTACHMENTS

Attachment A: Elevation Duration Curves of Sea Lamprey Spawning Nests below Vernon Station

Elevation Duration Curves at Sea Lamprey Spawning Locations 219-1 and 219-2 (Upstream side of Stebbins Island) from May 20 to July 31 for Years 2000-2015 (based on hourly modeled data)

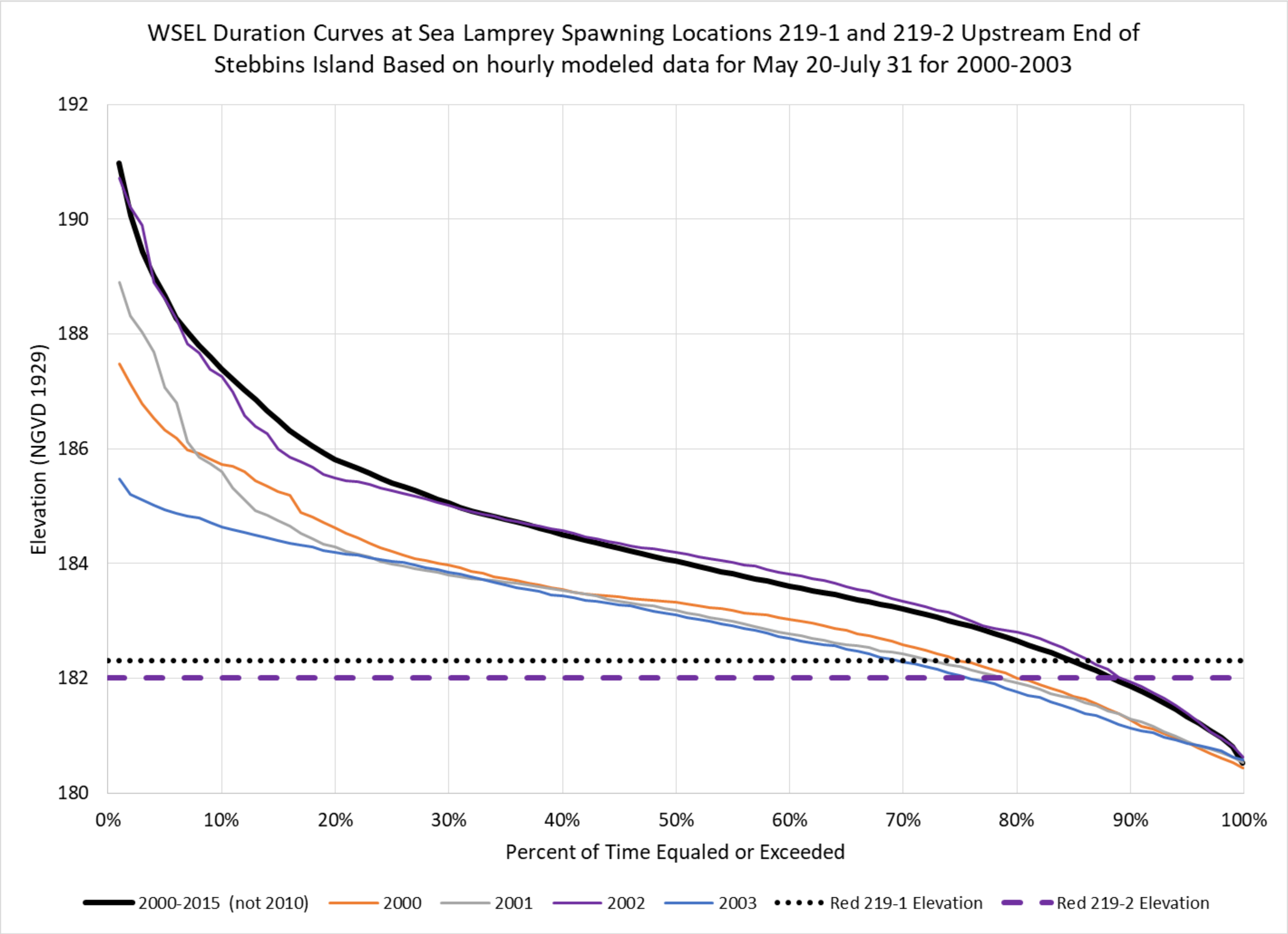
- Years 2000-2003
- Years 2004-2007
- Years 2008-2012
- Years 2013-2015

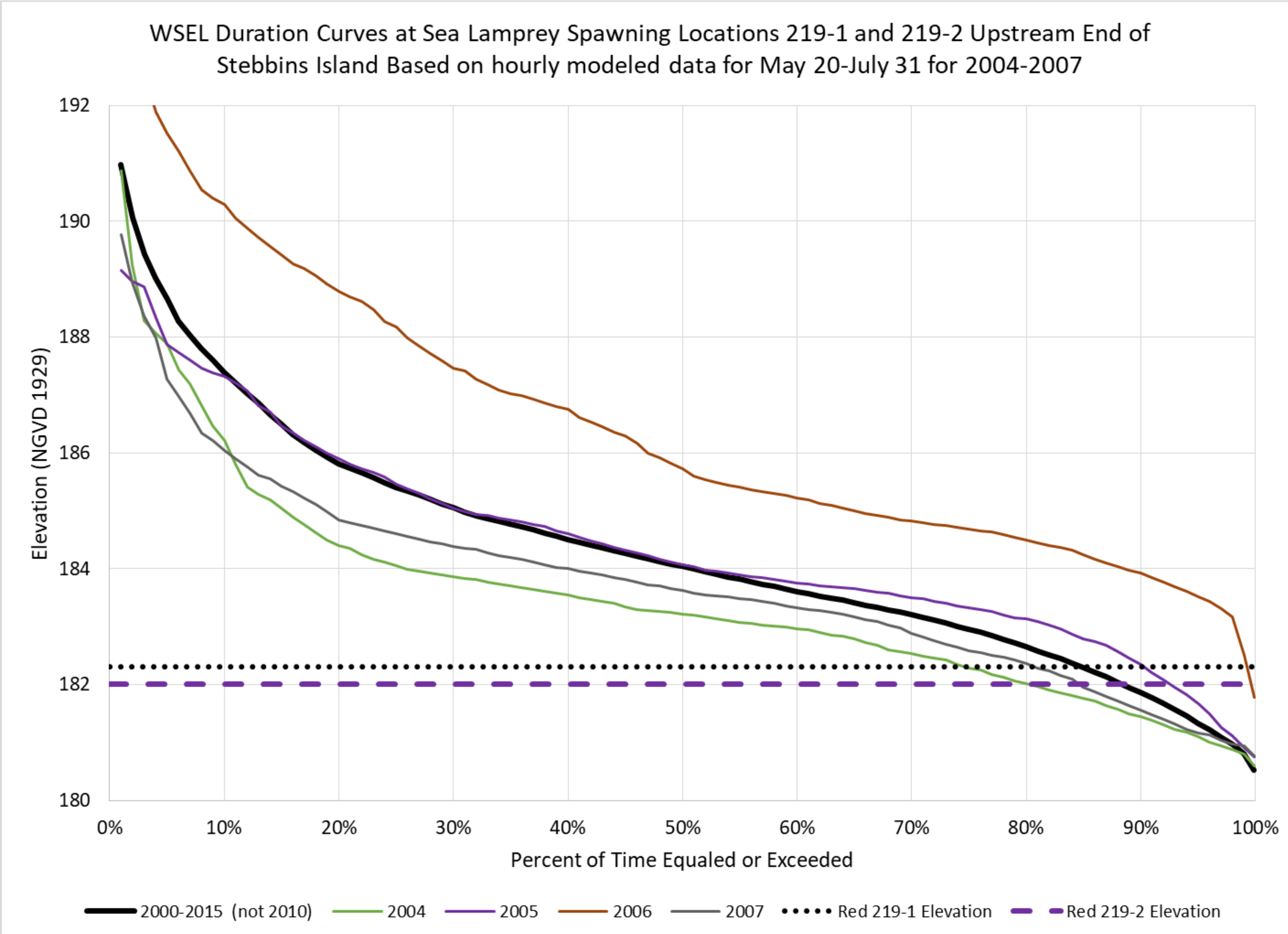
Elevation Duration Curves at Sea Lamprey Spawning Locations 182 and 217 (Left side of Stebbins Island) from May 20 to July 31 for Years 2000-2015 (based on hourly modeled data)

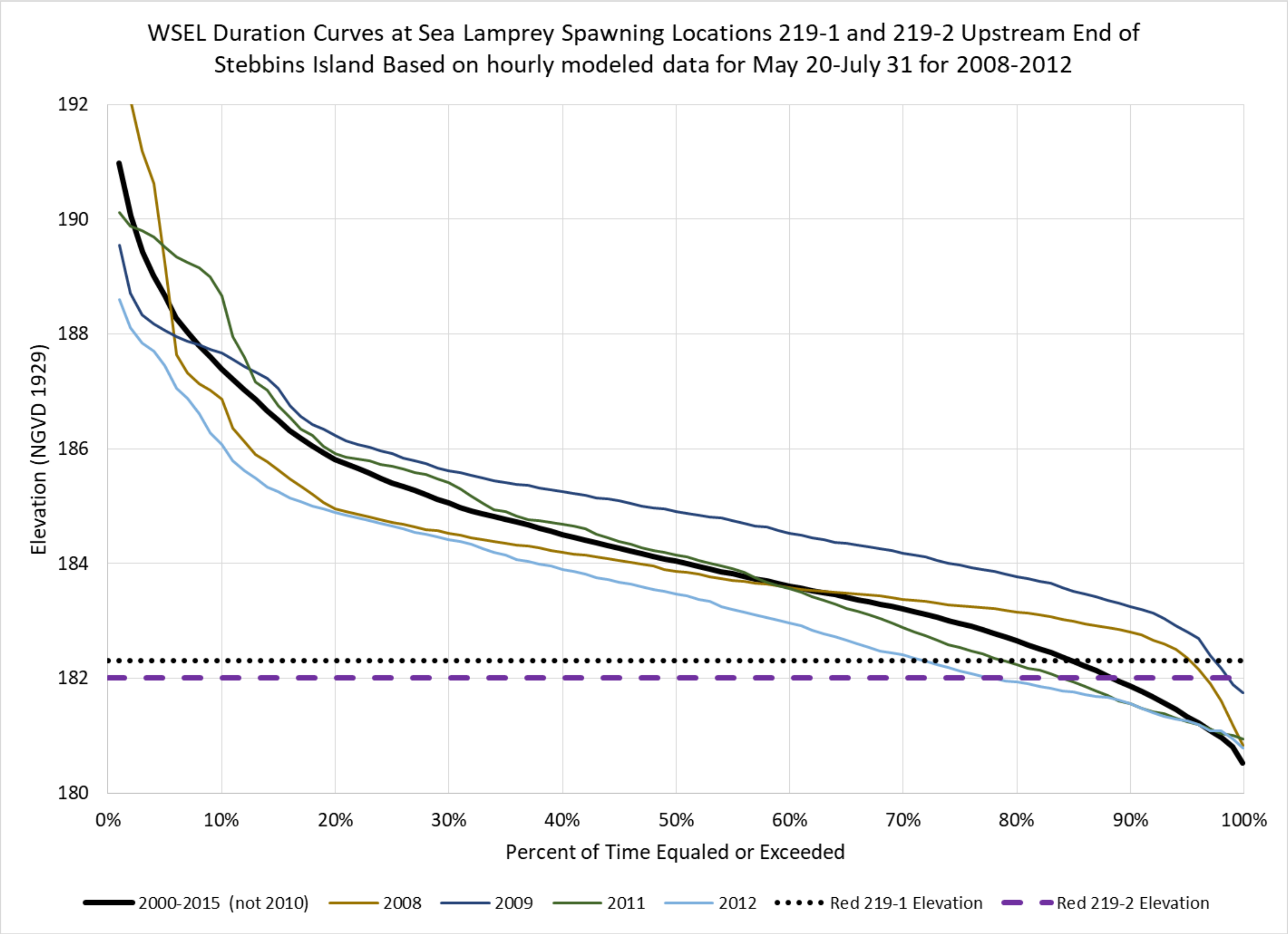
- Years 2000-2003
- Years 2004-2007
- Years 2008-2012
- Years 2013-2015

Elevation Duration Curves at Sea Lamprey Spawning Locations 220, 221, and 222 (Right channel of Stebbins Island) from May 20 to July 31 for Years 2000-2015 (based on hourly modeled data)

- Years 2000-2003
- Years 2004-2007
- Years 2008-2012
- Years 2013-2015


WSEL Duration Curves at Sea Lamprey Spawning Locations 219-1 and 219-2 Upstream End of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2000-2003
Elevation (NGVD 1929)
192
190
188
186
184
182
180
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2000
2001
2002
2003
Red 219-1 Elevation
Red 219-2 Elevation


WSEL Duration Curves at Sea Lamprey Spawning Locations 219-1 and 219-2 Upstream End of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2004-2007
192
190
188
186
184
182
180
Elevation (NGVD 1929)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2004
2005
2006
2007
Red 219-1 Elevation
Red 219-2 Elevation


WSEL Duration Curves at Sea Lamprey Spawning Locations 219-1 and 219-2 Upstream End of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2008-2012
Elevation (NGVD 1929)
192
190
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186
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0%
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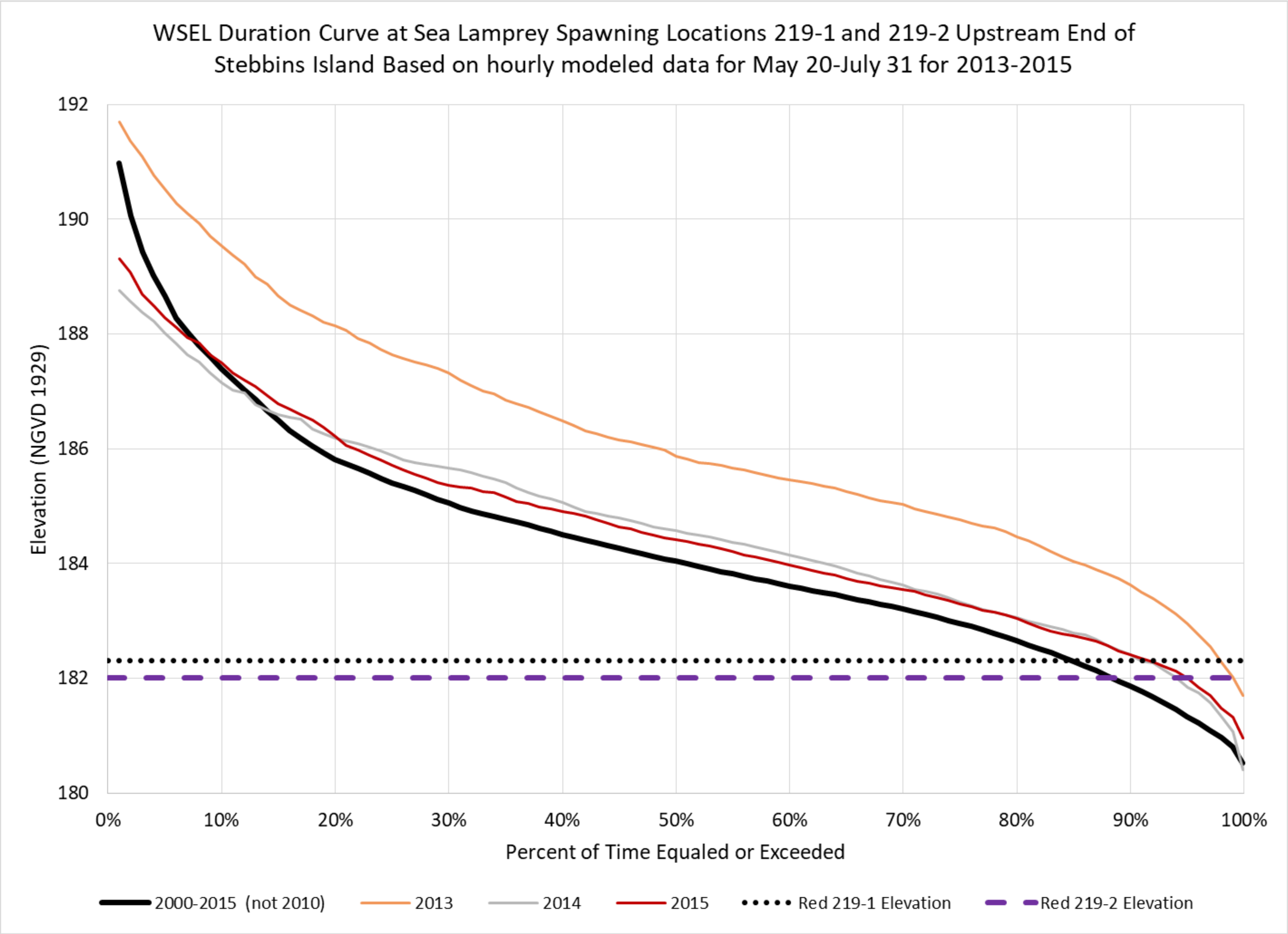
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2008
2009
2011
2012
Red 219-1 Elevation
Red 219-2 Elevation


WSEL Duration Curve at Sea Lamprey Spawning Locations 219-1 and 219-2 Upstream End of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2013-2015
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80%
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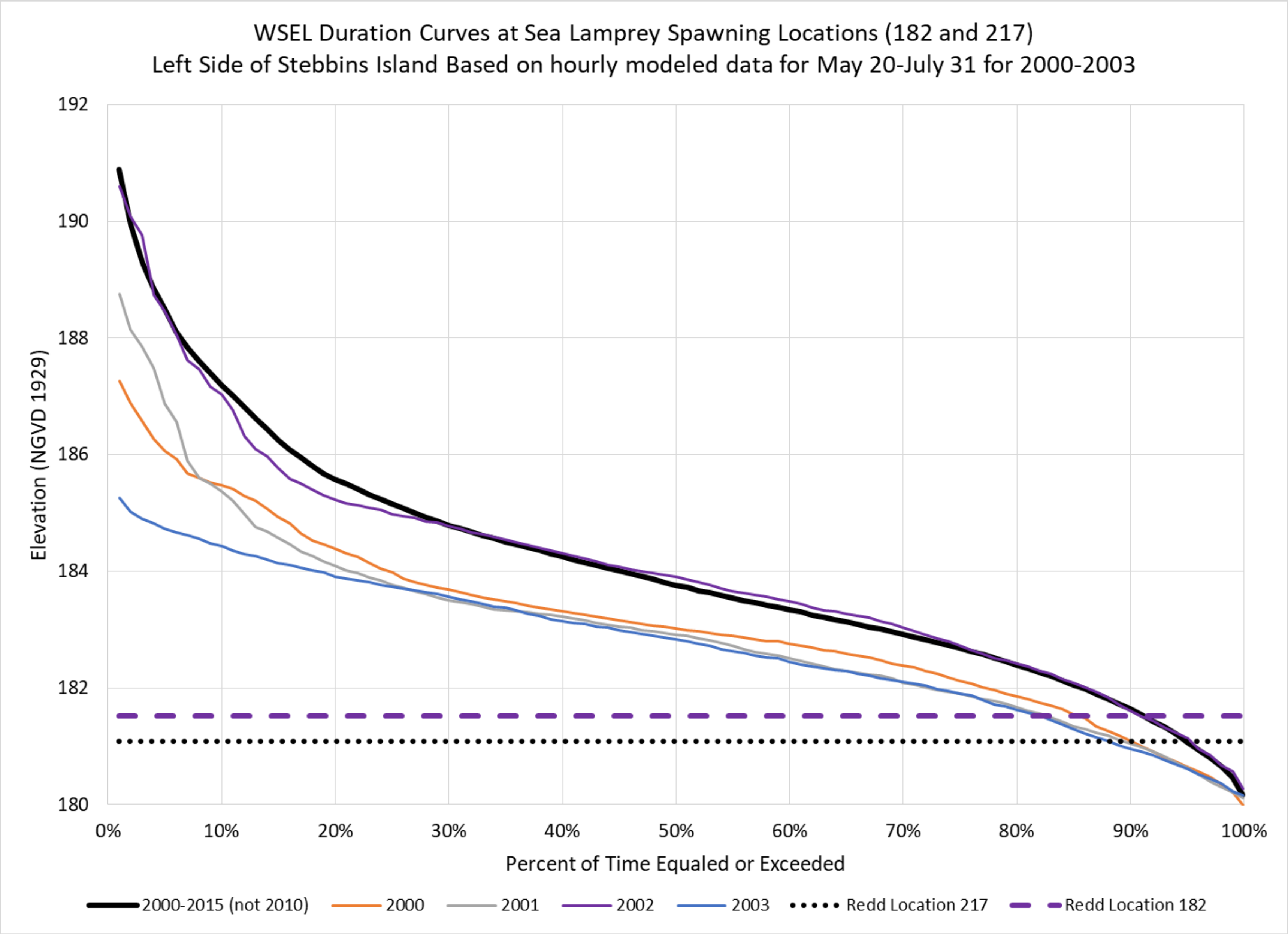
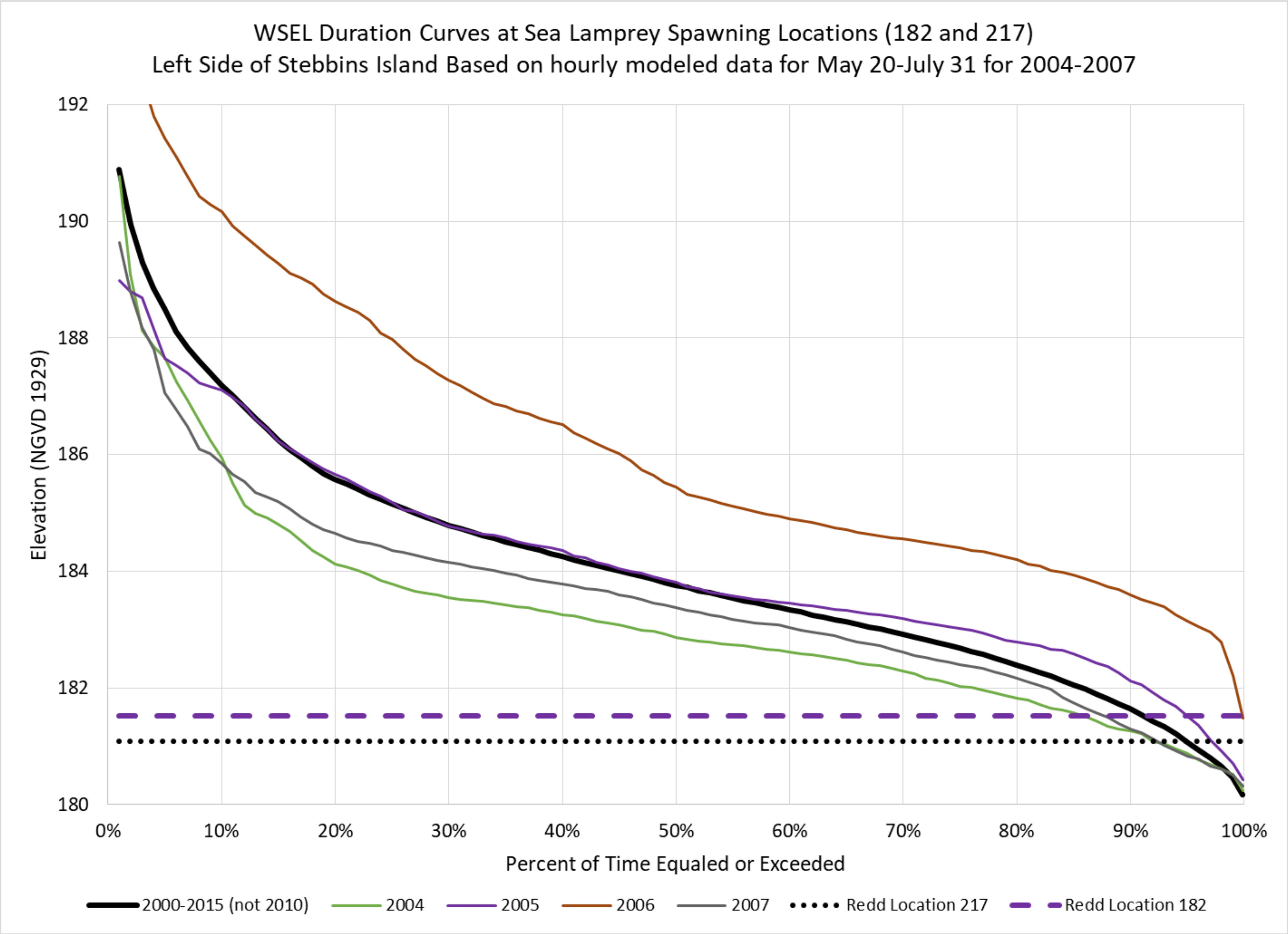
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2013
2014
2015
Red 219-1 Elevation
Red 219-2 Elevation


WSEL Duration Curves at Sea Lamprey Spawning Locations (182 and 217)
Left Side of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2000-2003
Elevation (NGVD 1929)
192
190
188
186
184
182
180
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2000
2001
2002
2003
Redd Location 217
Redd Location 182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Left Side of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2004-2007
Elevation (NGVD 1929)
192
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Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
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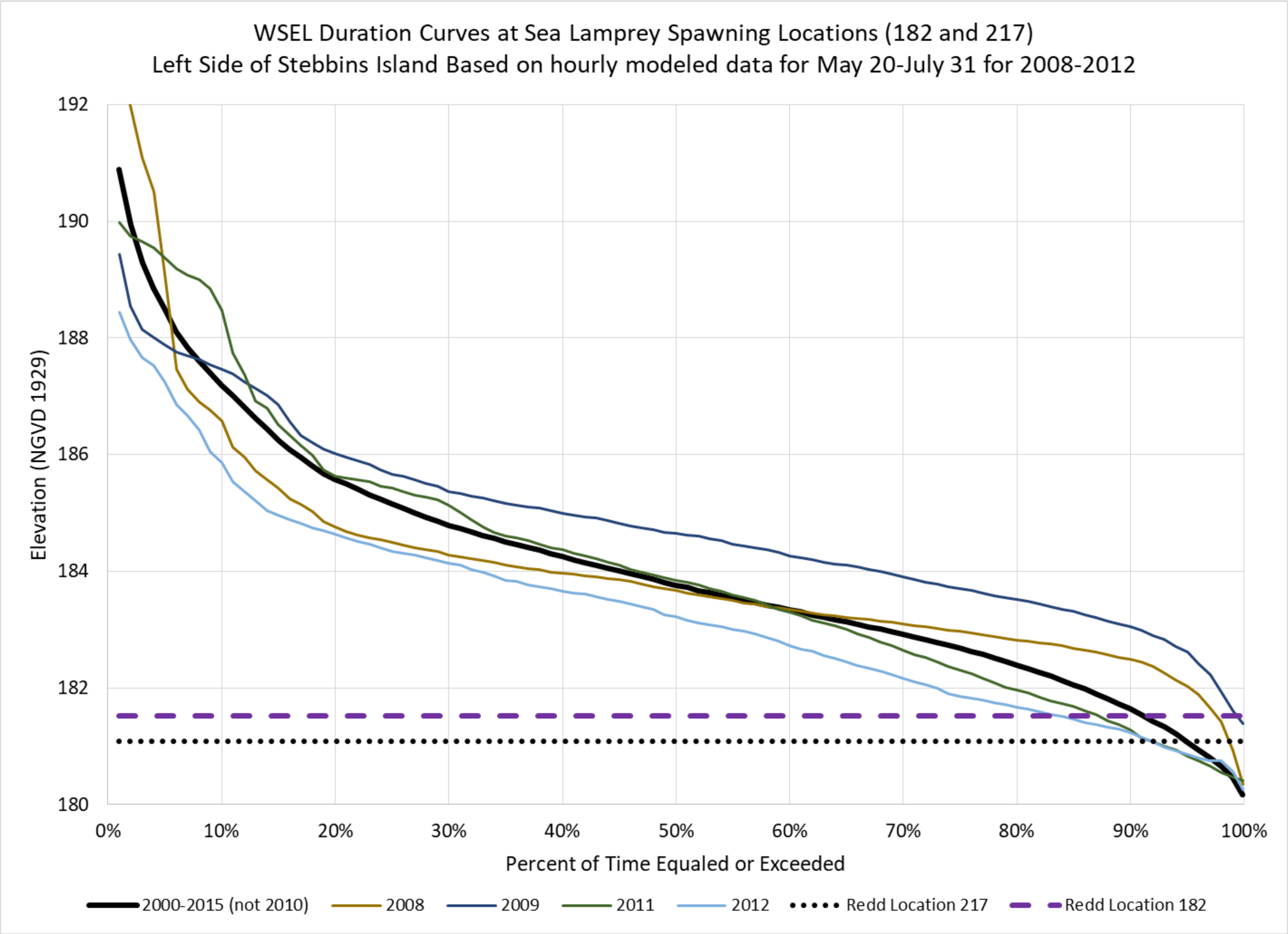
2007
Redd Location 217
Redd Location 182


WSEL Duration Curves at Sea Lamprey Spawning Locations (182 and 217)
Left Side of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2008-2012
Elevation (NGVD 1929)
192
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186
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40%
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60%
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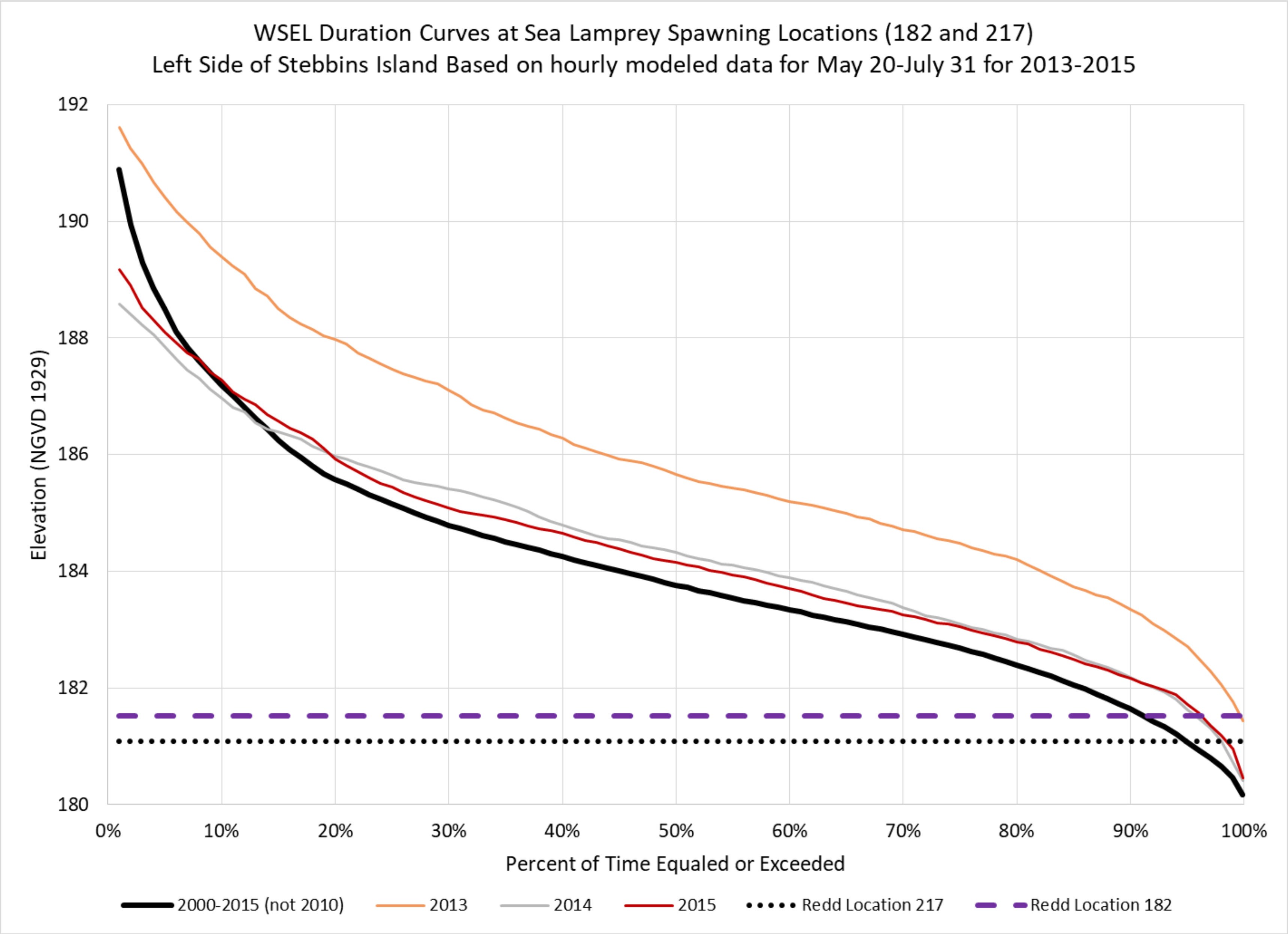
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2008
2009
2011
2012
Redd Location 217
Redd Location 182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Left Side of Stebbins Island Based on hourly modeled data for May 20-July 31 for 2013-2015
Elevation (NGVD 1929)
192
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0%
10%
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30%
40%
50%
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90%
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
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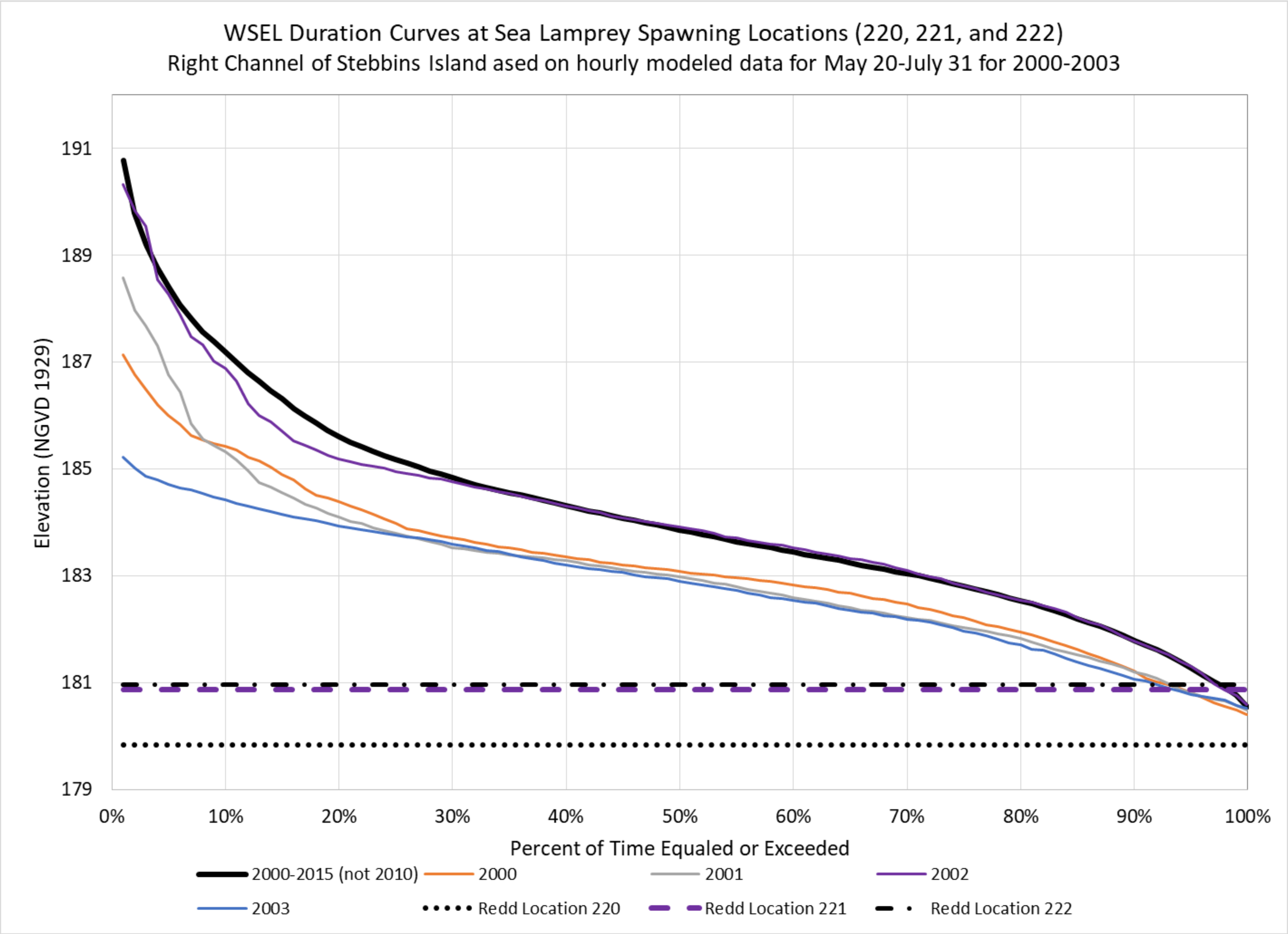
2014
2015
Redd Location 217
Redd Location 182


WSEL Duration Curves at Sea Lamprey Spawning Locations (220, 221, and 222)
Right Channel of Stebbins Island ased on hourly modeled data for May 20-July 31 for 2000-2003
Elevation (NGVD 1929)
191
189
187
185
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179
0%
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50%
60%
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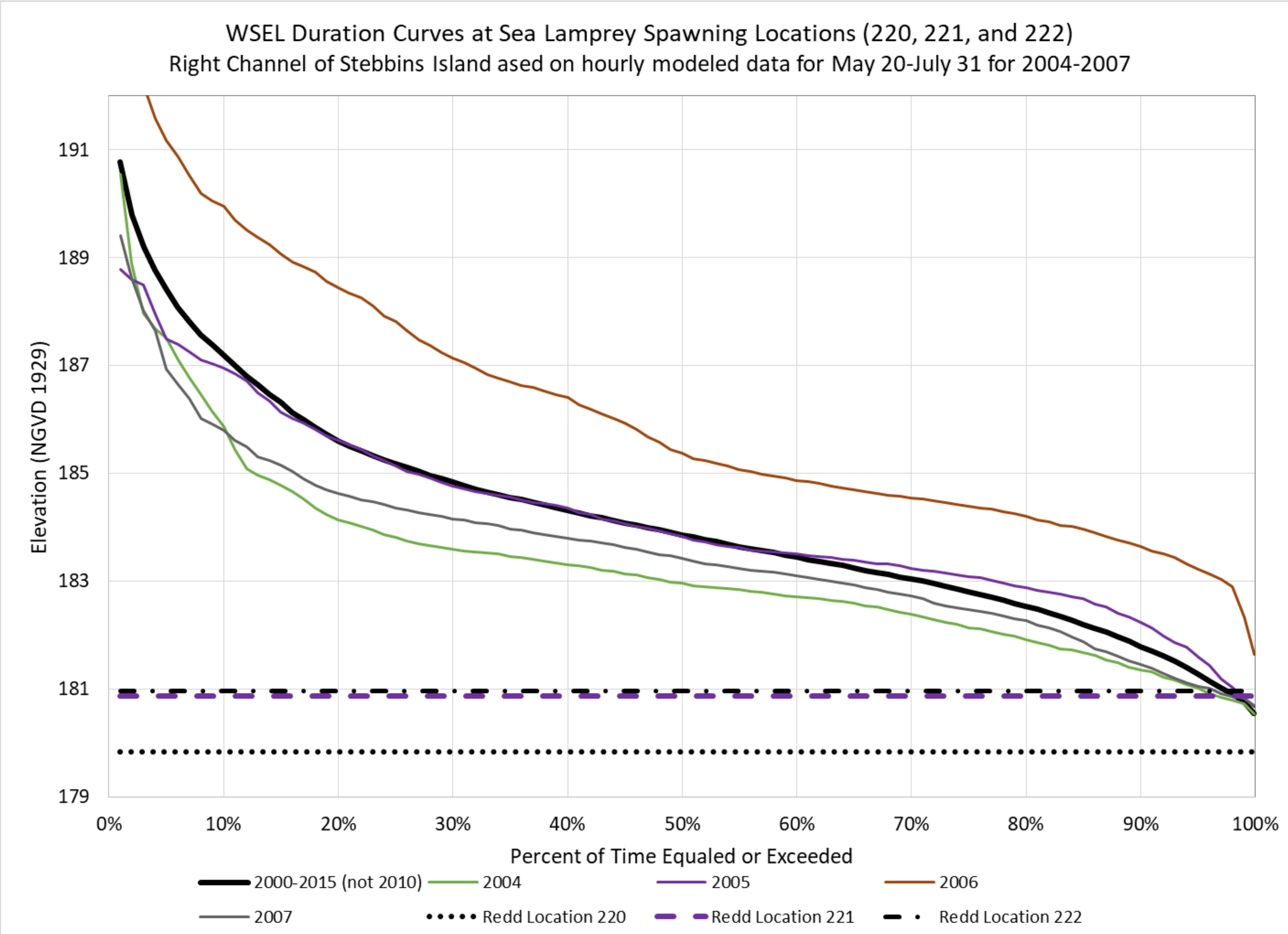
80%
90%
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2000
2001
2002
2003
Redd Location 220
Redd Location 221
Redd Location 222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Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
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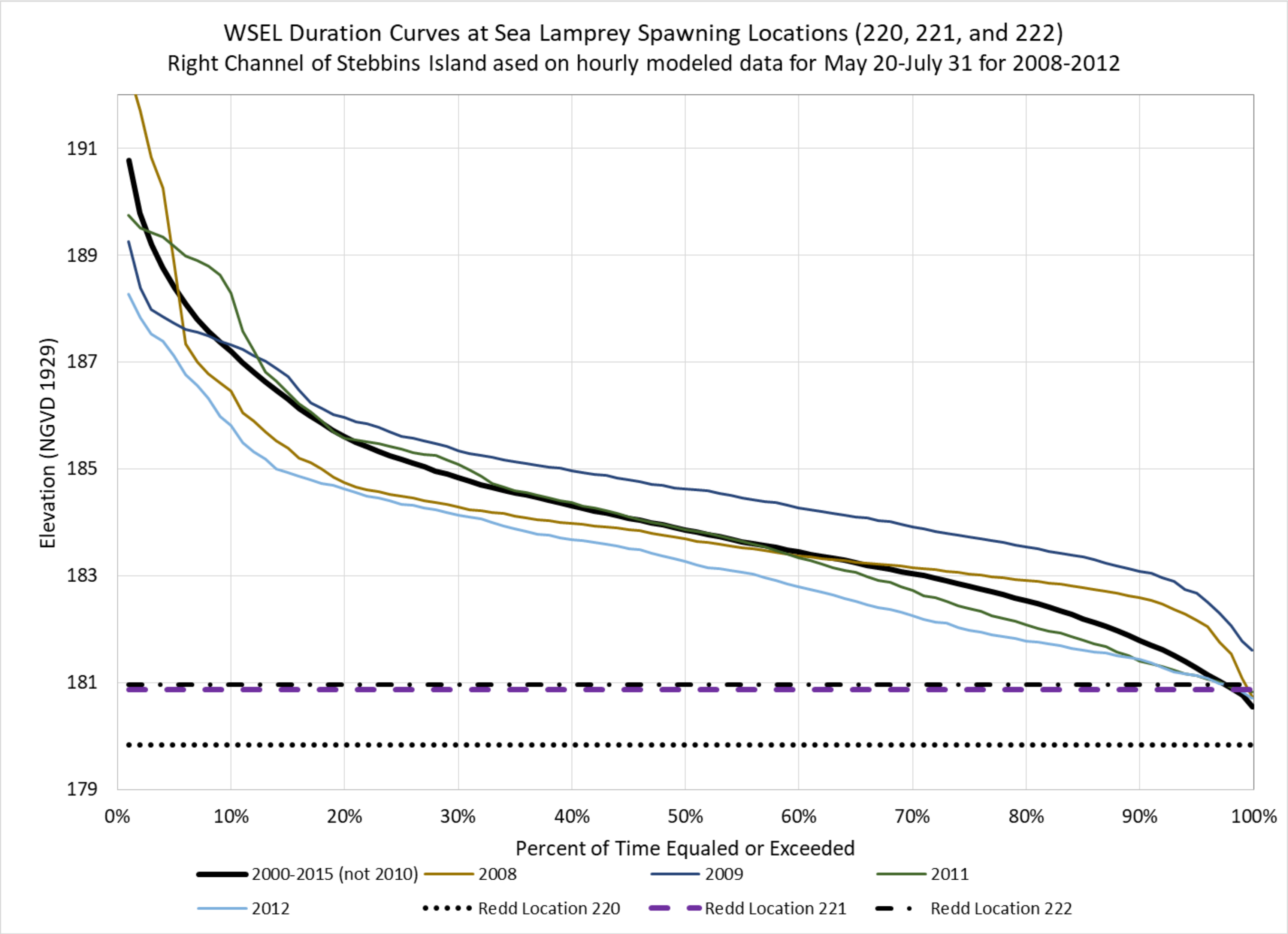
Redd Location 220
Redd Location 221
Redd Location 222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Percent of Time Equaled or Exceeded
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Redd Location 220
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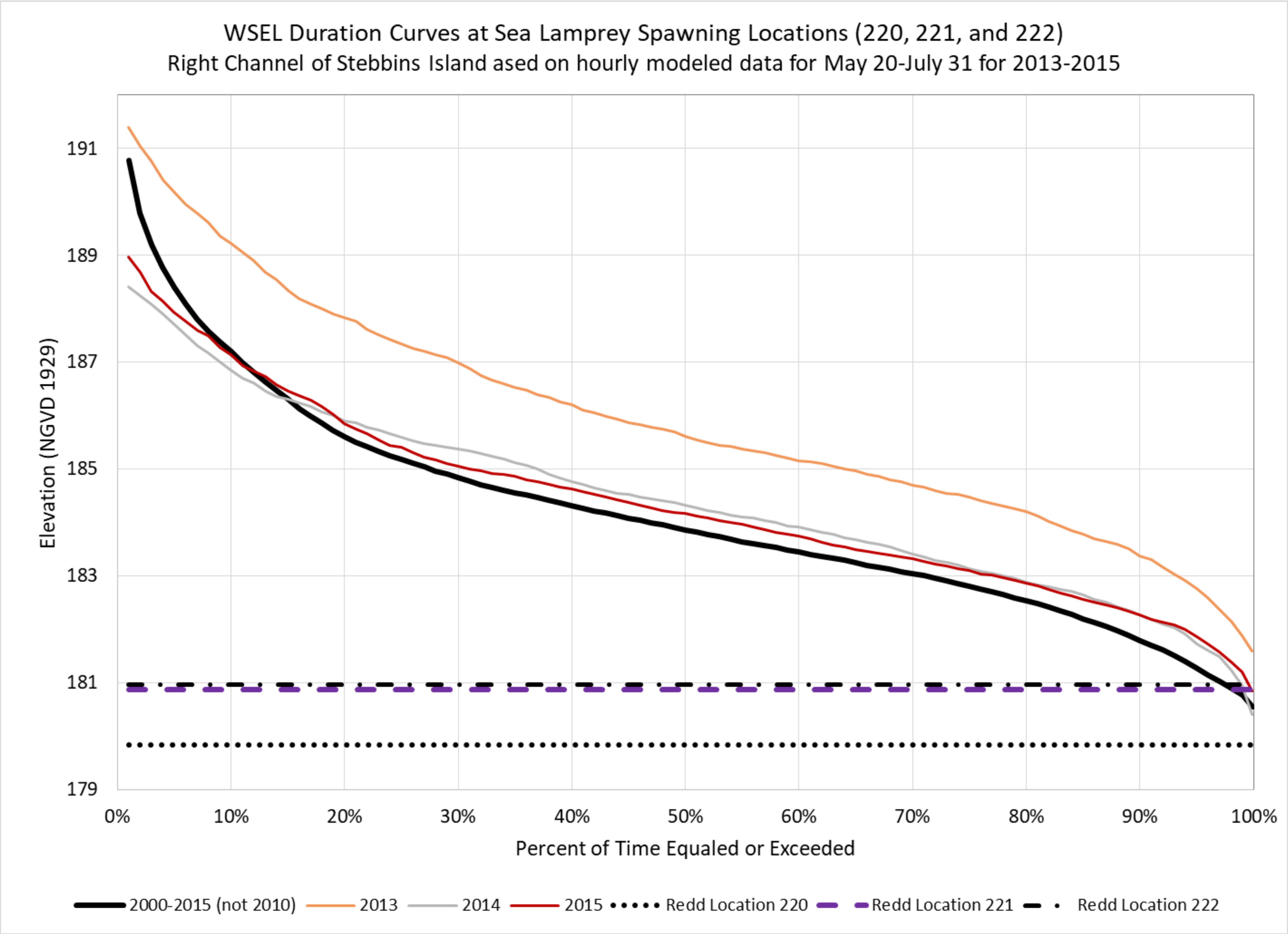
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80%
90%
100%
Percent of Time Equaled or Exceeded
2000-2015 (not 2010)
2013
2014
2015
Redd Location 220
Redd Location 221
Redd Location 222

STUDY NO. 3.3.20 ATTACHMENTS

Attachment A: Weekly Total Densities by Lifestage for 2015 and 2016 (Figure 1 and 2)

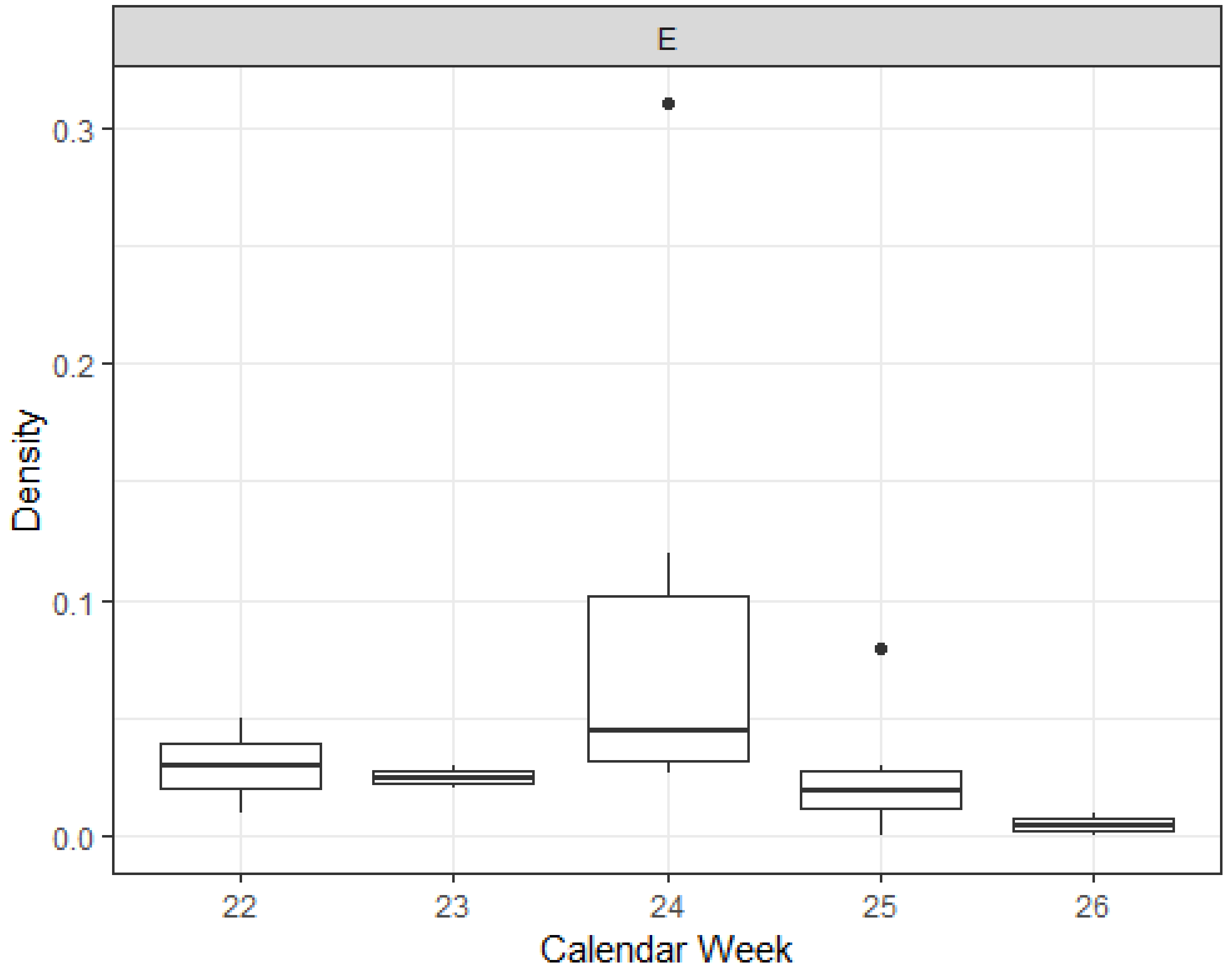

Figure 1 weekly sample density distributions (org/m^3) for 2015.

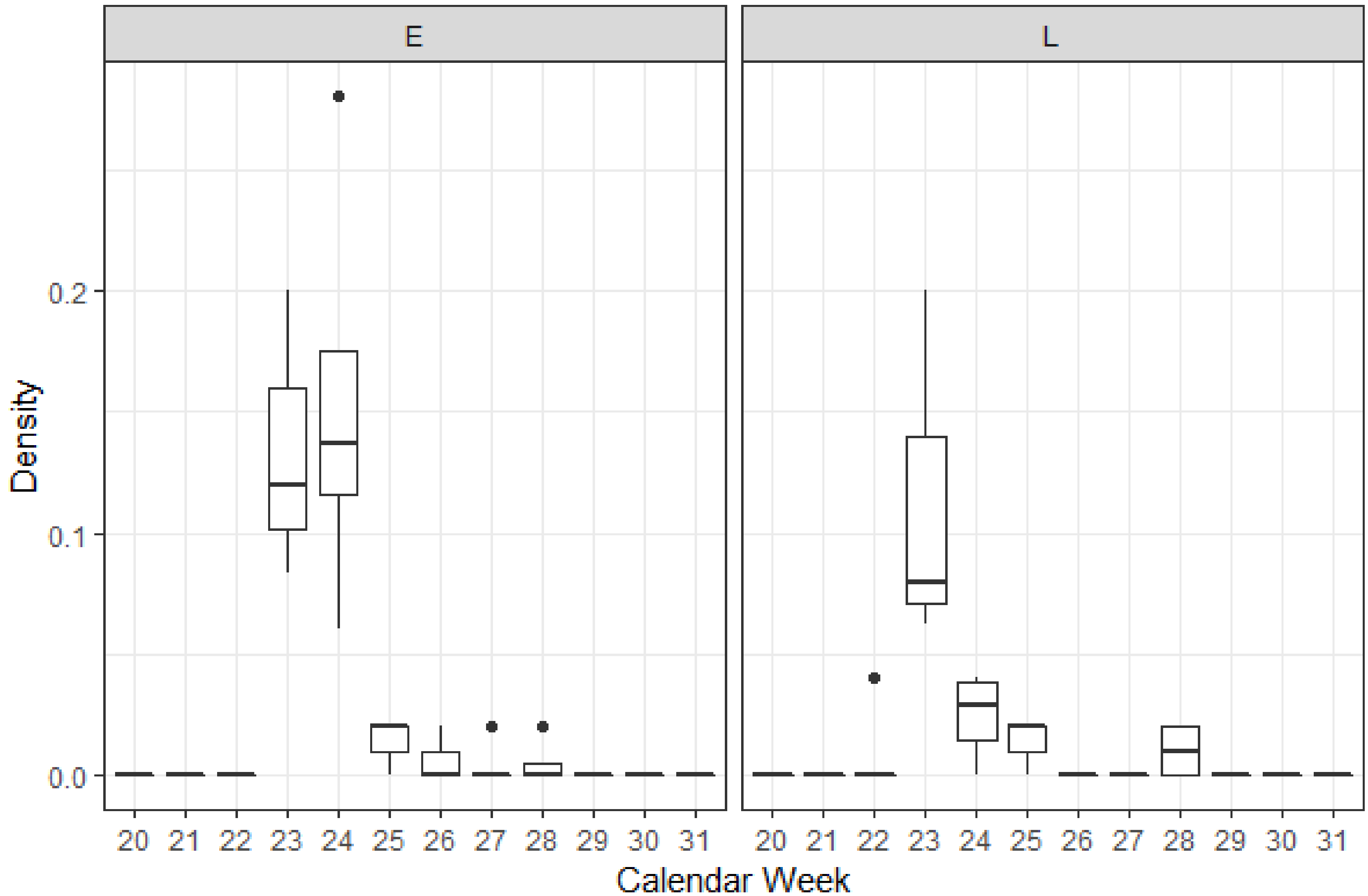

Figure 2 Weekly sample densities by life stage (org/m^3) for 2016

Attachment B: Vernon Discharge + Ashuelot River + Millers River in 2015 and 2016

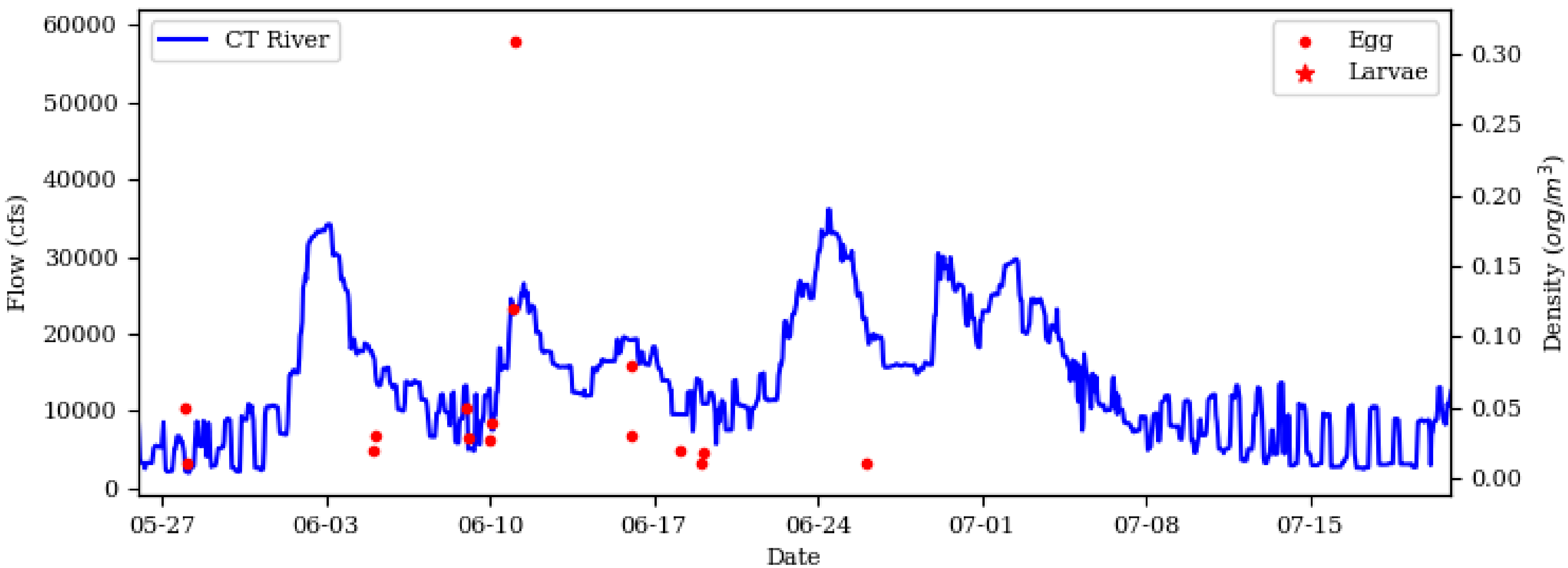

Figure 1 shows the 2015 times series of flow with entrainment densities superimposed. No larvae were found in entrainment samples in 2015.

(The Connecticut River flow shown on the plot above equates to Vernon Discharge + Ashuelot River + Millers River)

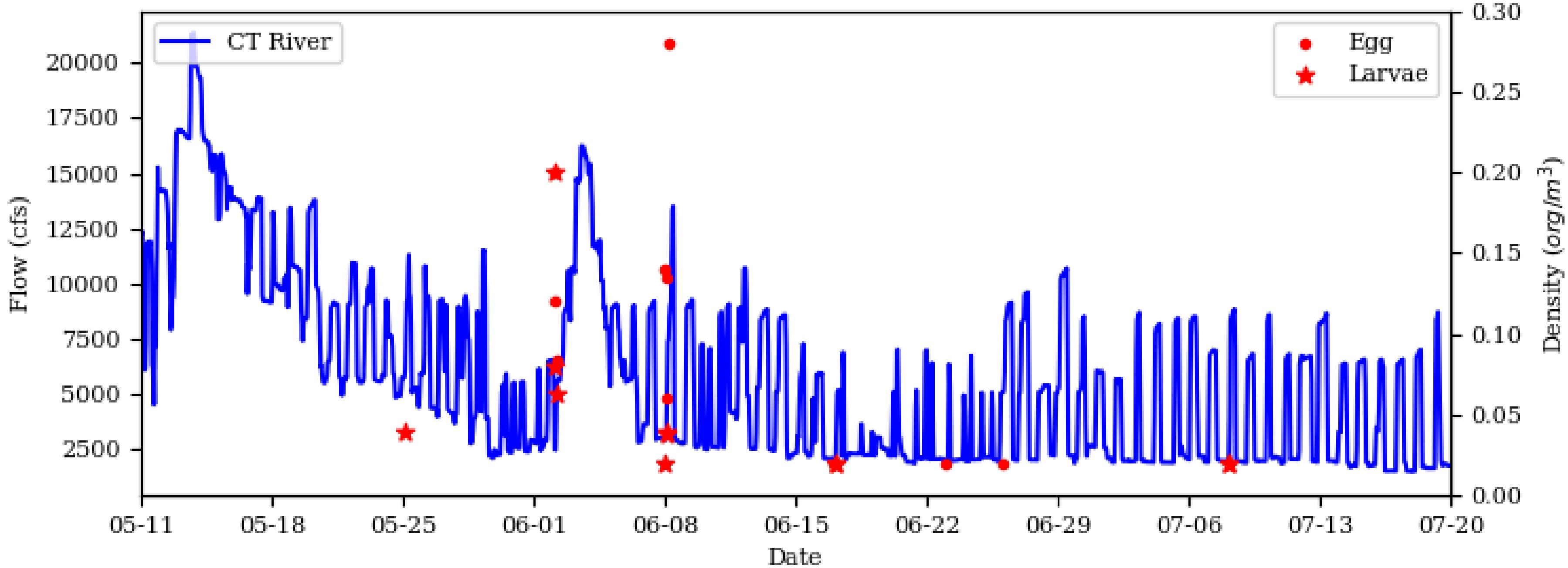

Figure 2 shows the 2016 times series of flow with entrainment densities superimposed.

(The Connecticut River flow shown on the plot above equates to Vernon Discharge + Ashuelot River + Millers River)

Attachment C: 2015 and 2016 Interpolated Daily Density

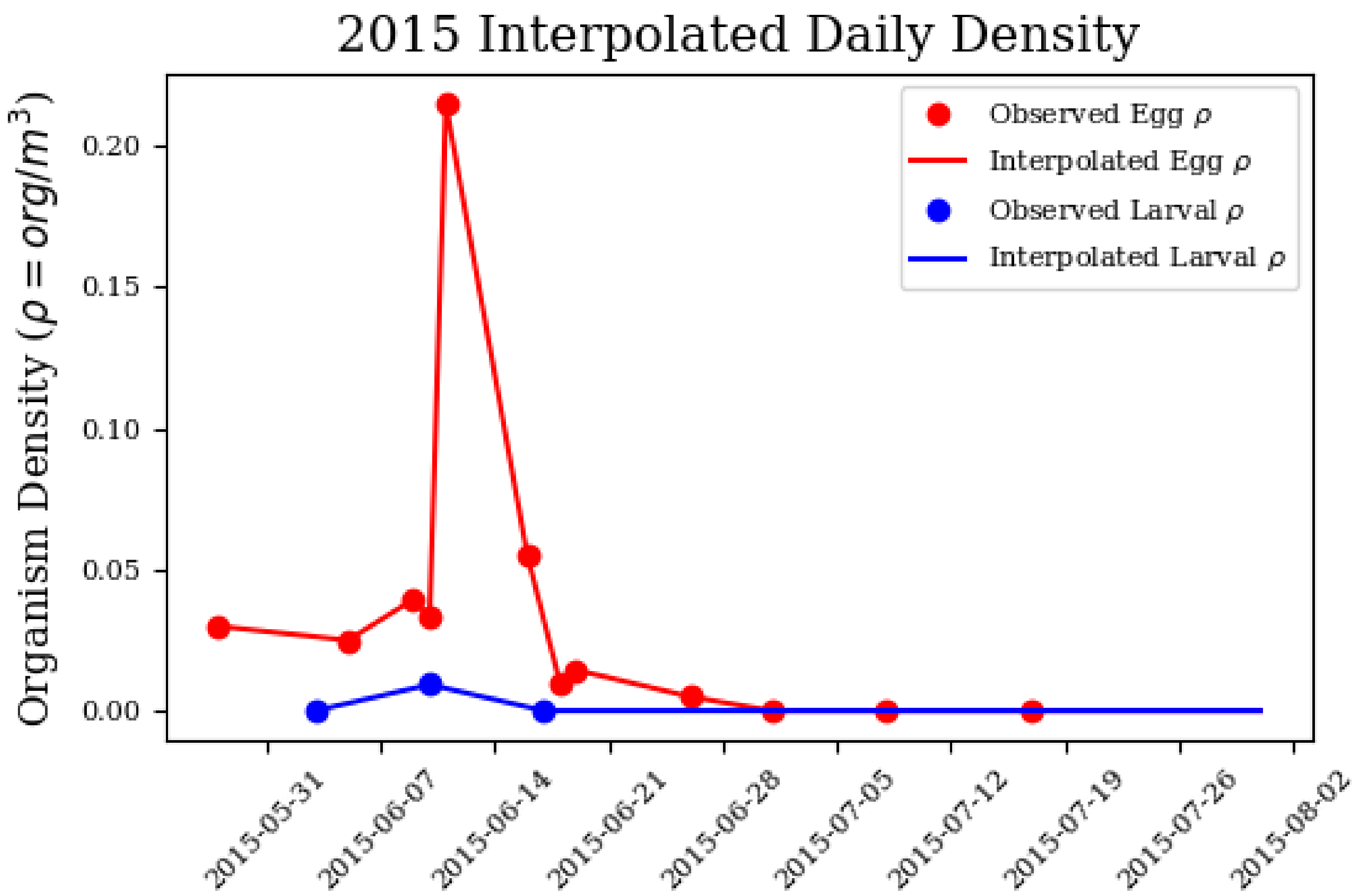

Figure 1. Interpolated total daily organism densities for 2015

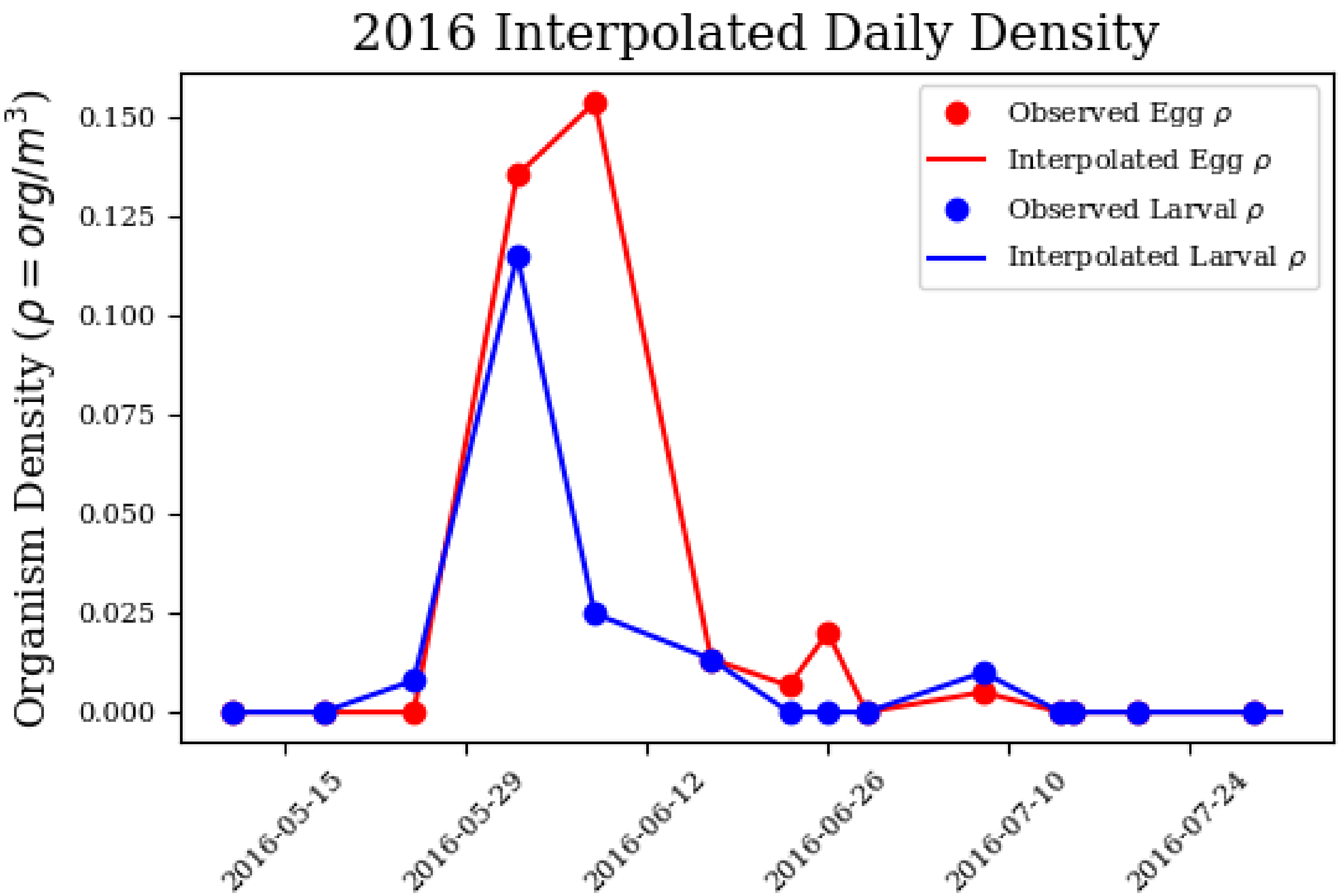

Figure 2. Interpolated total daily organisms densities for 2016

Attachment D: Organism Density as a Function of Pumping Rate (2015 and 2016)

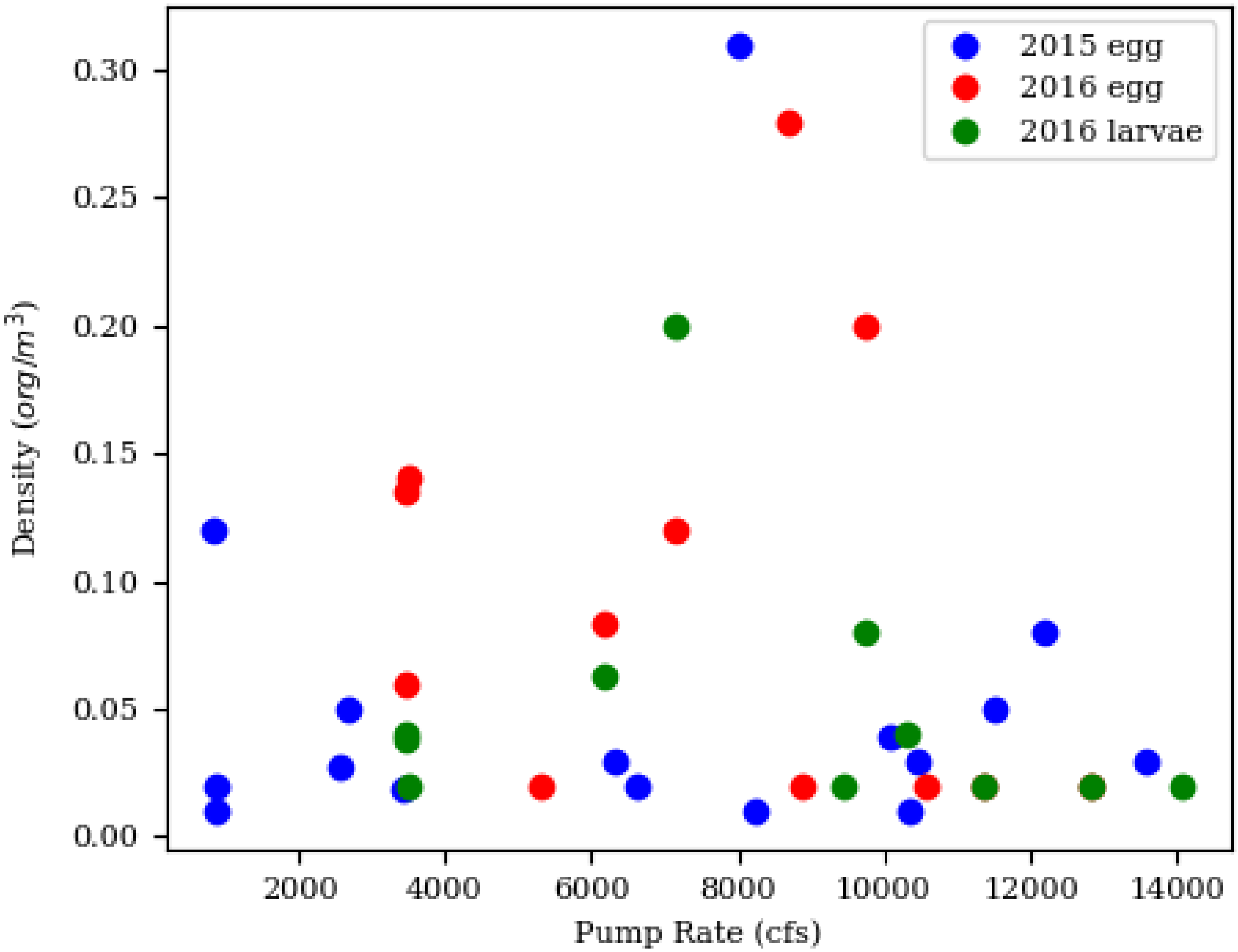

Figure 1. Depiction of organism density as a function of pumping rate (cfs).

Note that there does not appear to be any correlation between variables.

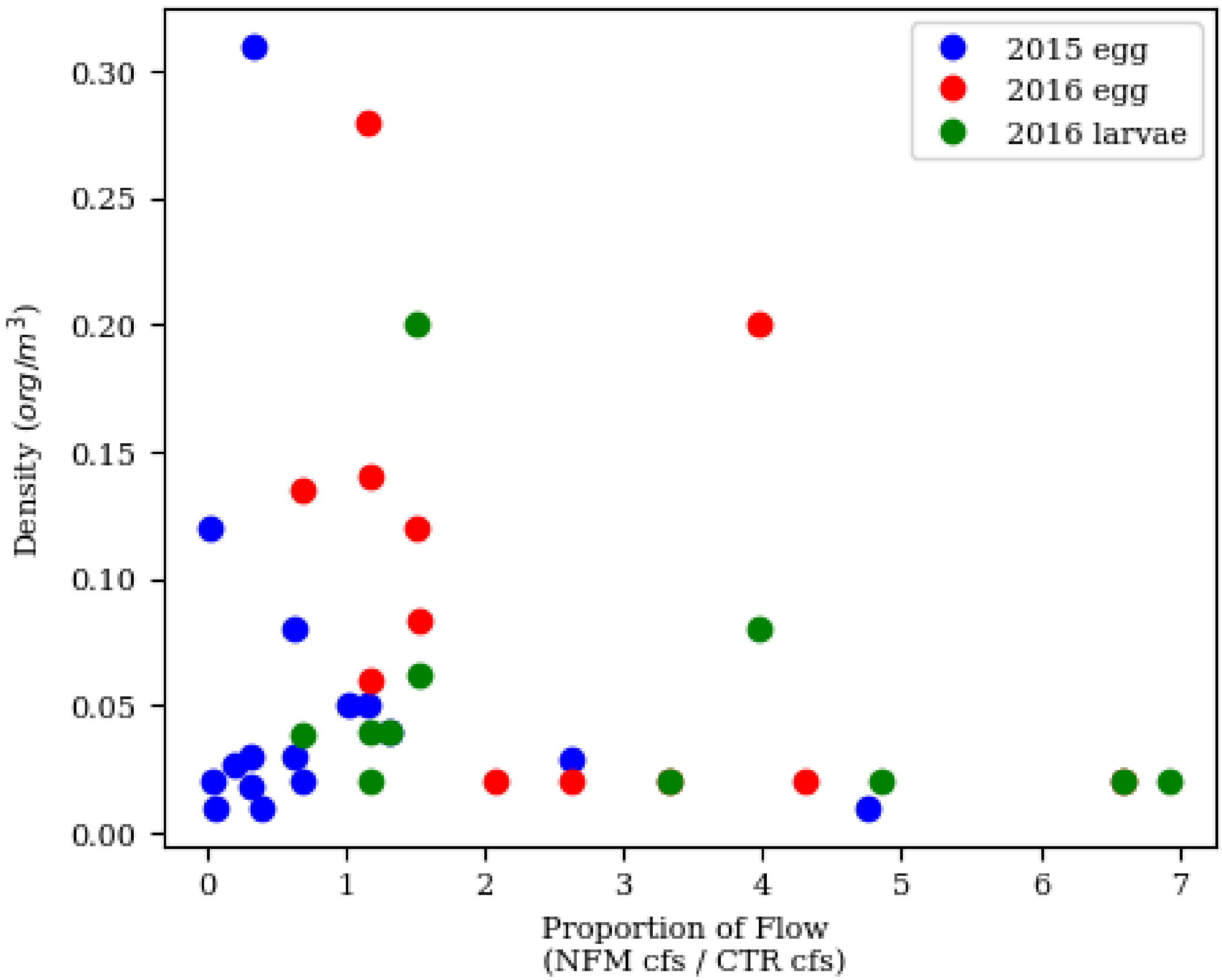

Figure 2. Depiction of the relationship between organism density and the ratio of Northfield Mountain Pumping Flow to Connecticut River discharge (Vernon Discharge + Ashuelot River + Millers River) within the Turners Falls Impoundment.

Note that there does not appear to be a relationship between these two variables