Study Report
for the
Fish Assemblage Assessment

Lawrence Project (FERC No. 2800)

Prepared For
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1 Introduction

Essex Company, LLC (Essex), a subsidiary of Patriot Hydro, LLC, is the Licensee, owner, and operator of the Lawrence Hydroelectric Project, which is Federal Energy Regulatory Commission (FERC or Commission) Project No. 2800 (Project or Lawrence Project). The Project was licensed by the Federal Energy Regulatory Commission (FERC or Commission) on December 4, 1978 (with an effective date of December 1, 1978), and the license expires on November 30, 2028. The Lawrence Project is located at river mile (RM) 29 of the Merrimack River in the City of Lawrence in Essex County, Massachusetts.

In accordance with 18 C.F.R. § 5.15, Essex has initiated studies and information gathering activities as provided in the study plan and schedule approved by the Commission. Among the studies completed during 2025 was the Fish Assemblage Assessment, the objectives of which were identified by the Commission in their May 10, 2024, Study Plan Determination (SPD). This report describes the Licensee's implementation of the study plan and schedule, the data collected, and any variances from the study plan and schedule.

2 Study Objectives

Within their May 10, 2024 SPD, FERC recommended that Essex:

- Compile information from existing fish assembly study data,
- Summarize the fishery data from all required fishery studies identified in the May 10 2024, SPD for the Lawrence Hydroelectric Project, and
- Assess the information for any data gaps in the fisheries information.

3 Basin Description and Study Area

The Merrimack River Basin extends from the White Mountain region of northern New Hampshire to southeastern Massachusetts. The Merrimack River Basin has a total drainage area of approximately 5,010 square miles and is the fourth largest river basin in New England (MEOEEA 2001). The majority of the watershed lies within New Hampshire (3,800 square miles). The Lawrence Project has a gross drainage area of 4,672 square miles and a net drainage area of 4,460 square miles after accounting for the 214-square-mile watershed attributed to the Boston and Worcester water supply (U.S. Geological Survey [USGS] 2023).

The 115-mile-long Merrimack River is formed by the confluence of two major rivers, the Pemigewasset and Winnipesaukee, in Franklin, New Hampshire. From the confluence, it flows southward for approximately 78 miles in New Hampshire, turns abruptly eastward at the New Hampshire-Massachusetts border, and flows in a northeasterly direction for approximately 40 miles before draining into the Atlantic Ocean near Newburyport, Massachusetts. The final 22 miles of the river, downstream of Haverhill, Massachusetts, are tidally influenced (U.S. Army Corps of

Engineers (USACE) 2003, New Hampshire Department of Environmental Services (NHDES) 2019).

The Lawrence Project is located on the Merrimack River in the City of Lawrence in Essex County, Massachusetts and is the first dam on the Merrimack River, approximately 29 river miles (RM) from the Atlantic Ocean, and approximately 11 RM downstream of the Lowell Hydroelectric Project (FERC No. 2790). Figure 3-1 presents the approximate FERC Project Boundary and nearby tributaries and landmarks.

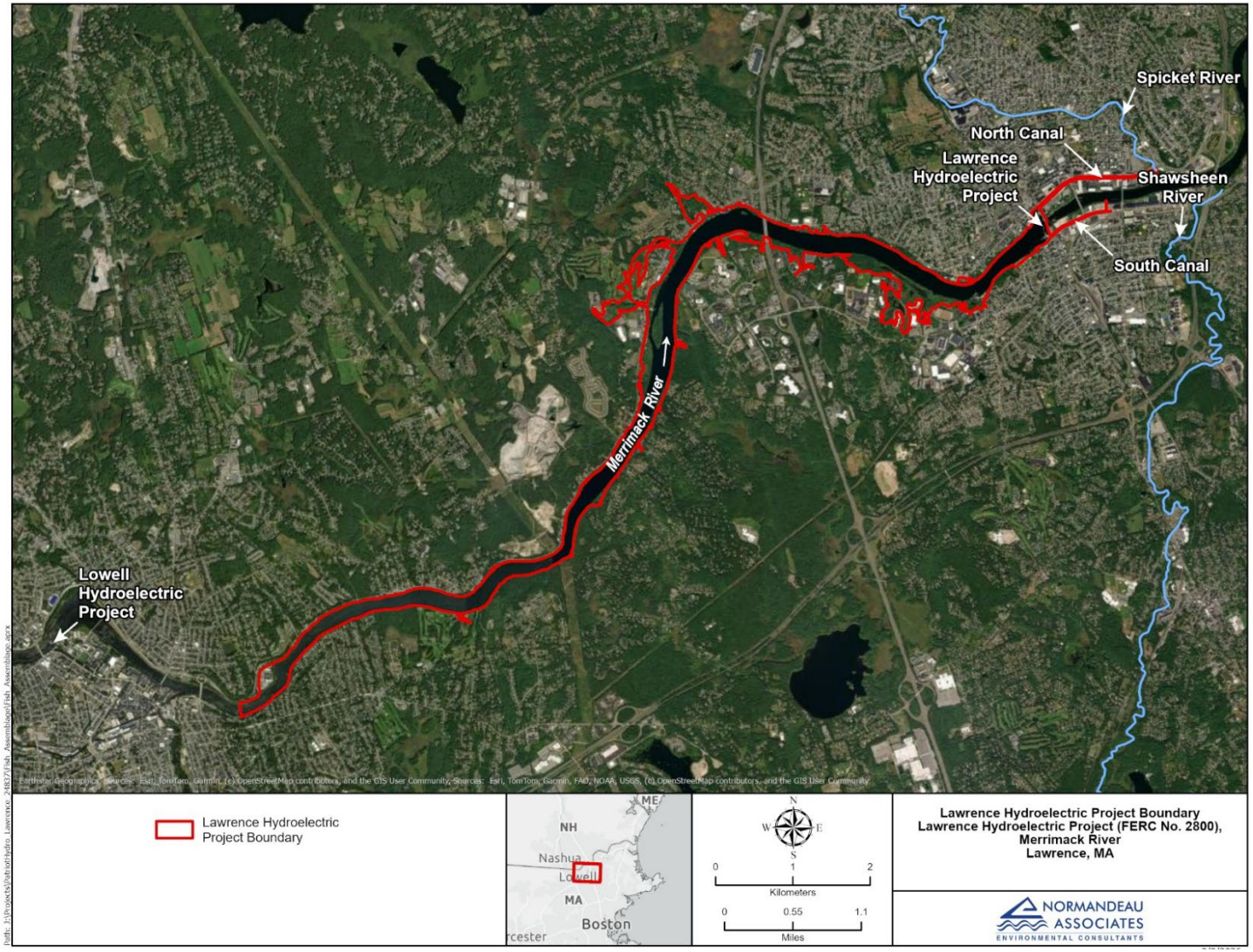

Figure 3-1. Lawrence Project boundary with major tributaries and general project landmarks.

4 Study Methods

4.1 Literature Review

Existing information on fish and aquatic resources was previously summarized in the Preliminary Application Document (PAD) prepared by Essex and filed with the Commission on June 16, 2023. Information previously presented within the PAD was used as a starting point for characterizing known and historically present fish species within the Merrimack River Basin. Where available, additional fish assemblage information was used to supplement the breadth of information available to describe the existing community in the Project reaches upstream and downstream of Essex Dam. Data searches targeted online information either not included in or released following issuance of the PAD. In addition, available fish community information collected as part of additional Project relicensing studies was considered. Available information was screened to ensure both proximity to the Lawrence Project as well as timeliness (i.e., targeted studies within the last 20 years (2005 to 2025).

4.2 Fish Community Composition and Life Histories

Following compilation of fish assemblage information from all included resources, a comprehensive list of fish species was assembled to provide a description of the Project area fish community. Fish species were assessed relative to a number of classifications, including:

- Native vs. nonnative species,
- Diadromous vs. resident species, and
- Spatial distribution in relation to Essex Dam (i.e., upstream, downstream, or both).

In addition, life histories descriptions for family groups were assembled using available literature sources.

5 Results

5.1 Literature Review

Information gathered from the Massachusetts Executive Office of Energy and Environmental Affairs (MEOEEA) 2001 Report titled "Merrimack River: A Comprehensive Watershed Assessment Report" was summarized in the PAD and presented 34 native fish species in the Merrimack River Basin, nine of which are diadromous and at least fourteen of which are introduced species. The PAD identified Alewife, American Eel, American Shad, Striped Bass and Sea Lamprey are currently managed diadromous species that are found at the Lawrence Project during certain life stages. Currently, Endangered Species Act (ESA) listed fish species downstream of the Project include Atlantic Sturgeon and Shortnose Sturgeon.

In addition to information compiled within the PAD, past completed studies and historical information were reviewed and compiled to define fish assemblage of the Merrimack River fishery resources in the Project area. Limits set for relevant data included studies/reports where data was collected within the last 20 years and restricting the special distribution to studies where the data collected was 1) within the project boundary, 2) immediately upstream of the Project boundary (i.e. Lowell Project boundary), or 2) data from the lower reaches of tributaries that enter within close proximity to the Project boundary.

Based on these search parameters, nine sources were identified for inclusion in this assessment:

- MassWildlife. 2009. Fish sampling data collected by boat electrofishing from the Merrimack River upstream and downstream of Lawrence Project. August and September 2009. Data provided by MassWildlife.
- Maietta, R. J., J. Ryder, and T. Prior. 2014. Technical Memorandum: 2010 Probabilistic Monitoring Fish Population Survey. Report Prepared by the Division of Watershed Management Watershed Planning Program.
- Normandeau Associates, Inc. (Normandeau). 2020. Technical Report for the Fish Assemblage Study – Lowell Hydroelectric Project (FERC No. 2790). Report Prepared for Boott Hydropower, LLC.
- Normandeau Associates, Inc. (Normandeau). 2025a. Initial Study Report for the Freshwater Mussel Habitat Assessment and Survey – Lawrence Project (FERC No. 2800). Report Prepared for Essex Company, LLC.
- Normandeau Associates, Inc. (Normandeau). 2025b. Initial Study Report for the Upstream American Eel Passage Siting Study – Lawrence Project (FERC No. 2800). Report Prepared for Essex Company, LLC.

- Normandeau Associates, Inc. (Normandeau). 2026a. Updated Study Report for the Anadromous Upstream Fish Passage Assessment – Lawrence Project (FERC No. 2800). Report Prepared for Essex Company, LLC.
- Normandeau Associates, Inc. (Normandeau). 2026b. Updated Study Report for the Diadromous Fish Behavior, Movement, and Project Interaction Study – Lawrence Project (FERC No. 2800). Report Prepared for Essex Company, LLC.
- Normandeau Associates, Inc. (Normandeau). 2026c. Updated Study Report for the Sturgeon Distribution and Project Interaction Study – Lawrence Project (FERC No. 2800). Report Prepared for Essex Company, LLC.
- Annual Merrimack River Fish Passage Counts at the Lawrence Project. Essex Company, LLC.

A summary of each resource is provided in the following sections.

5.1.1 MassWildlife 2009 Fisheries Sampling Data

MassWildlife conducted boat electrofishing surveys at three stations in the Lawrence Project impoundment and three downstream of the Project between August 28 and September 18, 2009. Each station consisted of 15-minutes of electrofishing effort with all fish captured identified to species.

Downstream effort included electrofishing stations approximately 1.5 and 1.8 miles below Essex Dam in the vicinity of the Shawsheen River and an electrofishing station approximately 9 miles downstream of Essex Dam near Haverhill, MA. Upstream sampling was conducted at two locations in the project impoundment approximately 2.9 and 3.3 miles upstream of Essex Dam and another 8 miles upstream of Essex Dam and in the vicinity of the upstream extent of the impoundment.

A total of 933 fish representing 24 species were collected at all stations including 19 species in the impoundment and 22 from stations below Lawrence Project (Table 5-1). Two species present in the upstream stations, Black Crappie and Alewife, were not collected at any of the three downstream stations while five species, Atlantic Salmon, Brown Bullhead, Redfin Pickerel, White Catfish, and White Sucker, were observed at downstream stations but not collected in the Project impoundment. At downstream stations the three most numerically abundant species included Smallmouth Bass, Spottail Shiner, and American Eel. In the impoundment, Centrachids (Pumpkinseed, Smallmouth Bass, and Redbreast Sunfish) were the most abundant species collected.

Table 5-1. Boat electrofishing catch from sample locations located upstream and downstream of Essex Dam as reported by MassWildlife from August and September 2009.

Sampling Area in Relation to Essex Dam	Alewife	American Eel	Atlantic Salmon	Black Crappie	Bluegill	Brown Bullhead	Chain Pickerel	Common Carp	Fallfish	Green Sunfish	Largemouth Bass	Northern Pike	Pumpkinseed	Redbreast Sunfish	Redfin Pickerel	Rock Bass	Sea Lamprey	Smallmouth Bass	Spottail Shiner	Tessellated Darter	White Catfish	White Sucker	Yellow Bullhead	Yellow Perch	Total
1.5 miles DS		5			3	1	1	7			4	1	1	4		1	1		1	1	4	2		1	38
1.8 miles DS		74	3		23			20		5	9	1	17	19	2	4	2	79	192	1		5	1	5	462
9.0 miles DS		10			3			5	2		1		1	42		1		78			1				144
Downstream - Total		*89*	*3*		*29*	*1*	*1*	*32*	*2*	*5*	*14*	*2*	*19*	*65*	*2*	*6*	*3*	*157*	*193*	*2*	*5*	*7*	*1*	*6*	*644*
2.9 miles US	1	5		1	29		2	10		10	4	2	68	43		2	4	37					2	15	235
3.2 miles US		1		1	1		2				2		3	5			1	6		1				2	25
8.0 miles US		1						6	1		1	1		2		1	1	11	1	1				1	28
Upstream - Total	*1*	*7*		*2*	*30*		*4*	*16*	*1*	*10*	*7*	*3*	*70*	*50*		*3*	*6*	*54*	*1*	*2*			*2*	*18*	*285*
Total	1	96	3	2	59	1	5	48	3	15	21	5	90	115	2	9	9	211	194	4	5	7	3	24	932

5.1.2 Probabilistic Monitoring Fish Population Survey

During late summer and early fall of 2010, fish population surveys were conducted at 27 stations across northeastern and eastern Massachusetts. At each station, electrofishing was conducted within a reach between 70 -100 meters in length. Among those station locations, one (Station MA09A-111) was located in proximity to the Lawrence Project area.

Station MA09A-111 was located on the Shawsheen River, approximately 850 meters downstream of Winthrop Avenue (Route 114) in Lawrence. The Shawsheen River flows into the Merrimack River approximately 1.5 miles downstream of the Essex Dam and the Project boundary. Ten fish species were collected including Fallfish, American Eel, Bluegill, Redbreast Sunfish, White Sucker, Largemouth Bass, Tessellated Darter, Yellow Bullhead, Chain Pickerel, and Sea Lamprey. Fallfish were the most abundant (n=50), in contrast to Yellow Bullhead, Chain Pickerel and Sea Lamprey which each had only one individual collected.

5.1.3 2019 Lowell Hydroelectric Project Fish Assemblage Study

A fish assemblage study was conducted during 2019 in support of the FERC relicensing for the Lowell Hydroelectric Project (FERC No. 2790). The Lowell Project is located at RM 41 on the Merrimack River in the City of Lowell, Massachusetts, situated approximately 11 miles upstream of the Lawrence Project. The goal of the Lowell Fish Assemblage Study was to characterize the fish community in areas affected by the Lowell Project, specifically the impoundment and bypassed reach.

Specific objectives included:

- Field sampling to describe the fish assemblage structure, distribution, and abundance within the Project affected area along spatial and temporal gradients; and
- A comparison of historical records of fish species occurrence in the Project area to results of this study.

The study area for the Lowell assemblage study included the mainstem Merrimack River from the Pawtucket Dam to the upper extent of the Project's impoundment located approximately 23 river miles upstream and the Project's 0.7-mile-long bypassed reach. The bypassed reach ends approximately 1.6 miles upstream of the Lawrence project boundary. Resident fish species were collected during spring, summer and fall 2019 by use of boat electrofishing, backpack electrofishing, gill nets and standard minnow traps.

Fish sampling within the Lowell impoundment and bypassed reach during 2019 resulted in the identification of 24 fish species. Eighty-eight percent of the fish species collected were identified as resident freshwater species (n = 21) and the remaining (n = 3) were diadromous species. Based on information presented in Hartel et al. (2002), species observed during the 2019 fish sampling considered to be native to the Merrimack River watershed in Massachusetts represented 53 percent of the total catch across all seasons (12 species, 1,249 individuals). Conversely, species classified

by Hartel et al. (2002) as introduced to the Merrimack River watershed represented 47 percent of the total catch across all seasons (12 species, 1,119 individuals) (Table 5-2).

As part of the study's historic data review, it was noted that during the last 150 years, over 15non-indigenous species such as Largemouth Bass, Smallmouth Bass, Walleye, Common Carp, Rainbow Trout, Brown Trout, various catfish species and goldfish have been established through human interactions within the Merrimack River. Tables 5-3 and 5-4 present the total number of individuals and species collected within the impoundment and bypassed reach during the study period as well as percent composition.

Twenty-two fish species were collected in the Lowell impoundment when considering all sampling segments within the 23 mile stretch upstream of the Pawtucket Dam. Centrarchid species were the most abundant within impoundment habitat with Redbreast Sunfish, Pumpkinseed, and Smallmouth Bass representing the three most frequently sampled species. Sampling in the bypassed reach resulted in the collection of 14 fish species. Fallfish, Smallmouth Bass and Spottail Shiner were the three most numerically abundant species in that reach.

Table 5-2. Classifications for fish species recorded within the impoundment and the Pawtucket Dam bypassed reach at the Lowell Hydroelectric Project, 2019.

Common Name	Freshwater Resident	Diadromous	Native	Introduced
Alewife		X	X	
American Eel		X	X	
Black Crappie	X			X
Bluegill	X			X
Brown Trout	X			X
Channel Catfish	X			X
Common Carp	X			X
Fallfish	X		X	
Golden Shiner	X		X	
Largemouth Bass	X			X
Longnose Dace	X		X	
Margined Madtom	X			X
Pumpkinseed	X		X	
Redbreast Sunfish	X		X	
Rock Bass	X			X
Sea Lamprey		X	X	
Smallmouth Bass	X			X
Spottail Shiner	X			X
Tessellated Darter	X		X	
Walleye	X			X
White Perch	X		X	
White Sucker	X		X	
Yellow Bullhead	X			X
Yellow Perch	X		X	
Total	**21**	**3**	**12**	**12**

Table 5-3. Total count and percent composition of species collected upstream of Pawtucket Dam during the Lowell Fish Assemblage Study, 2019.

Common Name	Total Count	Percent Composition
Alewife	113	6.1
American Eel	17	0.9
Black Crappie	5	0.3
Bluegill	122	6.6
Channel Catfish	1	0.1
Common Carp	5	0.3
Fallfish	143	7.7
Golden Shiner	13	0.7
Largemouth Bass	41	2.2
Lepomis spp.	4	0.2
Margined Madtom	9	0.5
Pumpkinseed	155	8.4
Redbreast Sunfish	378	20.5
Rock Bass	7	0.4
Sea Lamprey	21	1.1
Smallmouth Bass	227	12.3
Spottail Shiner	424	23
Tessellated Darter	31	1.7
Walleye	1	0.1
White Perch	1	0.1
White Sucker	55	3
Yellow Bullhead	54	2.9
Yellow Perch	20	1.1
Total	**1,847**	

Table 5-4. Total count and percent composition of species collected within the bypassed reach downstream of Pawtucket Dam during the Lowell Fish Assemblage Study, 2019.

Common Name	Total Count	Percent Composition
American Eel	33	6.3
Bluegill	3	0.6
Brown Trout	1	0.2
Fallfish	210	39.9
Largemouth Bass	2	0.4
Lepomis spp.	1	0.2
Longnose Dace	2	0.4
Margined Madtom	17	3.2
Redbreast Sunfish	13	2.5
Sea Lamprey	1	0.2
Smallmouth Bass	107	20.3
Spottail Shiner	88	16.7
Tessellated Darter	10	1.9
White Sucker	33	6.3
Yellow Bullhead	5	1
Total	**526**	

5.1.4 2024 Lawrence Hydroelectric Project Freshwater Mussel Habitat Assessment and Survey

A Freshwater Mussel Habitat Assessment and Survey (Mussel Study) was completed during 2024 for the Lawrence Hydroelectric Project, and the full study report was submitted to FERC as part of the Initial Study Report (ISR) on April 28, 2025. The study area included the sections of the mainstem Merrimack River from (1) Essex Dam up to the upstream extent of the Lawrence Project impoundment, and (2) the 1.5 mile reach immediately downstream of the Essex Dam to the Lawrence I-495 Bridge.

The primary goal of the Mussel Study was to determine the presence, location and species of freshwater mussels that inhabit Project-affected aquatic habitats within the Merrimack River. Field efforts focused on surveys to characterize the distribution, composition, and relative abundance of freshwater mussels and non-native bivalves in the Lawrence Project area. The specific field-based objectives of the study were to:

- Determine the species composition, relative distribution, and abundance of freshwater mussel species in the Project area,
- Assess the available habitat within the nearshore areas; and

- Document the presence/ absence of Corbicula (a non-native species) in the designated survey areas.

A companion desktop analysis submitted as part of the ISR focused on a review of potential host-fish for documented mussel species through review of relevant publications and concurrent fish data collected in the Project area.

Survey methodology consisted of semi-quantitative, timed searches using snorkel or diving techniques depending on water depth. Field sampling associated with the Mussel Survey were conducted during two periods during 2024: August 19-23 and September 10-11. In addition to the detailed observations on freshwater mussels species and their habitat, divers also recorded anecdotal observations of fish species made during mussel surveys. These observations noted the presence of Micropterus spp. and Lepomis spp. in mussel search areas located upstream of Essex Dam and juvenile American Eels and Tessellated Darter downstream of the dam.

5.1.5 2024 Lawrence Hydroelectric Project Upstream American Eel Passage Siting Study

The American Eel Upstream Passage Siting Study (Eel Study) was completed during 2024 and the full study report was submitted to FERC as part of the April 28, 2025 ISR. The Eel Study consisted of three components: visual nighttime surveys, electrofish sample collection, and deployment of temporary eel traps. The study area included the section of the Merrimack River located immediately downstream of Essex Dam including the tailrace, the North and South Canals and associated Project structures.

Sampling took place over a period of ten weeks starting in early June and ending in early August of 2024. Electrofishing sampling locations included (1) the North Canal, (2) the Merrimack River from below the dam to the point of confluence with the Spicket River, and (3) the lower Spicket River from the terminus of the North Canal to its confluence with the Merrimack River. The North and South Canals are positioned in the Lawrence Project boundary and the furthest spot electrofishing occurred outside of the project boundary, approximately 1 mile downstream from the powerhouse and dam. In addition to enumerating and measuring American Eel, all non-anguillid fish species were netted, identified to species, counted, and total length to the nearest millimeter (mm) was recorded.

Total counts for each species and sampling location are presented in Table 5-5. Across all sampling dates and locations, 309 fish were captured, representing a total of 17 species, and 9 families. Fish species collected during electrofish sampling represent both diadromous migratory species as well as resident warmwater species typical of a freshwater habitat. In addition to American eels, two additional diadromous species were captured (Sea Lamprey and Alewife). Members of the family Centrarchidae were the most abundant, resulting in over 50% of the composition. Leucisidae and Catostommidae were the second and third largest families in the composition (n = 13%, n = 10%).

The Spicket River backpack electrofishing events occurred on July 26th and August 21st from its confluence with the Merrimack River to the outlet of the North Canal and yielded 102 individuals representing 14 species. Across both sampling efforts, 72 American eels were caught. The remaining catch included 12 resident species, and one diadromous species. Excluding American Eel, the dominant species belonged to the Centrarchidae (n = 37%) and Leuciscidae families (n=30%).

Boat electrofishing occurred in the mainstem of the Merrimack River downstream of the Project. on July 26th and August 21st and yielded 110 individuals representing 13 species. A total 57 American Eels were captured in addition to one diadromous species (Alewife), and 12 resident species. Excluding American Eels, members of the Centrarchidae family were the largest contributor to species composition (n = 36%), followed by Cyprinidae and Catostomidae families.

The North Canal backpack electrofishing event occurred on August 8th and yielded 97 individuals representing six species. Diadromous species (American Eel, n = 72) dominated the sample with the remaining composition consisting almost entirely of members from the family Centrarchidae (*Lepomis spp.*, n = 18; *Micropterus spp*., n = 7).

Table 5-5. Species counts from electrofish sampling conducted as part of the 2025 American Eel Upstream Passage Siting Study at Lawrence.

Species	Number of Individuals			
	North Canal	Spicket	Tailrace	Total
Alewife			5	5
American Eel	72	43	57	172
Bluegill	8	4	2	14
Common Carp			11	11
Fallfish		5	1	6
Golden Shiner		2		2
Green Sunfish	3	3		6
Largemouth Bass	5	2	1	8
Margined Madtom		4	1	5
Pumpkinseed	7	3	1	11
Redbreast Sunfish		8	1	9
Sea Lamprey		2		2
Smallmouth Bass	2	1	19	22
Spottail Shiner		17	1	18
Tessellated Darter		3		3
White Sucker		5	9	14
Yellow Bullhead			1	1
Total	**97**	**102**	**110**	**309**

5.1.6 2025 Lawrence Hydroelectric Project Upstream Anadromous Fish Passage Assessment

Essex conducted the Upstream Anadromous Fish Passage Assessment during spring 2025 and the full study results are included as part of the Updated Study Report filed with the Commission as part of the Lawrence Project relicensing effort. The goal of this study was to determine the impact of the Lawrence Project on the upstream migration of anadromous fish species. Specific objectives for this study were designed to better understand the Project approach, tailrace residence duration and overall effectiveness of the existing fish lift facility at the Project for upstream passage of American Shad and Sea Lamprey. Collection efforts for American Shad consisted of boat electrofishing in the section of the Merrimack River downstream of Essex Dam extending from just upstream of the confluence with the Spicket River to the Lawrence I-495 Bridge (approximately 1.0 to 1.4 miles downstream of Essex Dam) and Sea Lamprey were collected from the upstream fish lift.

Biological information collected during the radio tagging process for both American Shad and Sea Lamprey are presented in Tables 5-6 and 5-7, respectively. In total, 404 American shad and 51 Sea Lamprey fish were radio tagged and released downstream of the Lawrence Project. American Shad lengths ranged from 354 to 568 mm and Sea Lamprey ranged from 612 mm to 808 mm.

Table 5-6. Summary of American shad tagged and released as part of the Lawrence Upstream Anadromous Fish Passage Assessment, 2025.

Release Date	No. Fish	Sex		Total Length (mm)		
		%M	%F	Min.	Max.	Mean
20-May	28	71%	29%	415	559	481
21-May	35	54%	46%	427	555	493
22-May	5	80%	20%	466	500	476
23-May	31	61%	39%	416	526	468
26-May	35	83%	17%	397	564	482
28-May	41	80%	20%	413	540	484
29-May	33	79%	21%	381	545	465
30-May	54	89%	11%	405	547	469
1-Jun	45	67%	33%	409	561	479
13-Jun	97	54%	46%	354	568	474
Total	404	69%	31%	354	568	477

Table 5-7. Summary of Sea Lamprey tagged and released as part of the Lawrence Upstream Anadromous Fish Passage Assessment, 2025.

Release Date	No. Fish	Sex		Total Length (mm)		
		%M	%F	Min.	Max.	Mean
15-Jun	26	73%	27%	626	808	694
17-Jun	25	76%	24%	612	757	684
Total	51	75%	25%	612	808	689

5.1.7 2025 Lawrence Hydroelectric Project Fish Behavior, Movement, and Project Interaction Study

Essex conducted the Diadromous Fish Behavior, Movement, and Project Interaction Study (Project Interaction Study) during spring 2025 and the full study results are included as part of the Updated Study Report filed with the Commission as part of the Lawrence Project relicensing effort. The goal of the Project Interaction Study was to assess Project-related effects on the behavior of diadromous fish species in and around the Lawrence Project. Specifically, this study sought to (1) assess tagged fish distribution and movement in the Project tailrace and proximal downstream reach, (2) determine the extent of alosines behavioral modification due to predator presence and extent of passage related delay, and (3) assess passage outcomes following alosine behavioral modifications as it relates to predator presence. Four diadromous fish species were targeted as part of this study: Alewife, Blueback Herring, American Shad, and Striped Bass. Collection efforts these species consisted of boat electrofishing in the section of the Merrimack River downstream of Essex Dam extending the Duck Bridge downstream to the Lawrence I-495 Bridge (approximately 0.75 to 1.4 miles downstream of Essex Dam).

Biological information collected during the acoustic tagging process for all four diadromous species are presented in Table 5-8. In total, 934 individuals representing the four diadromous species were acoustically tagged and released downstream of the Lawrence Project. Mean lengths of those individuals were 293 mm for Alewife, 253 mm for Blueback Herring, 480 mm for American Shad and 734 mm for Striped Bass.

Electrofish efforts conducted as part of the Project Interaction Study took place over twelve dates during the months of April, May and June. In addition to the target diadromous fish species, anecdotal observations of non-target fish species made in the reach downstream of Essex Dam included:

- White sucker: numerous individuals
- Shortnose Sturgeon: single individual observed on April 30, 2025 along the western shoreline downstream of the Duck Bridge

Table 5-8. Summary of biological information for Alewife, Blueback Herring, American Shad and Striped Bass tagged and released as part of the Lawrence Project Interaction Study, 2025.

Species	Tagged Individuals	Min Length (mm)	Max Length (mm)	Mean Length (mm)
Alewife	335	238	333	293
American shad	199	397	564	480
Blueback Herring	300	223	297	253
Striped Bass	100	365	1,067	734

5.1.8 2025 Lawrence Hydroelectric Project Sturgeon Distribution and Project Interaction Study

Essex conducted the Sturgeon Distribution and Project Interaction Study (Sturgeon Study) during 2025, and the full study results are included as part of the Updated Study Report filed with the Commission as part of the Lawrence Project relicensing effort. As identified in the RSP and FERC's SPD, the goal of the Sturgeon Study was to determine if Atlantic or shortnose sturgeon are interacting with the Lawrence Project. In their SPD, FERC recommended that Essex (1) determine if Atlantic and shortnose sturgeon are present between the project dam and the I-495 Lawrence Bridge; (2) if present, quantify the duration and seasonality of sturgeon presence in the study reach; (3) identify any project-related effects; and (4) evaluate the need for upstream sturgeon passage at the project. The final study approach for the Sturgeon Study during 2025 consisted of (1) mobile side-scan sonar surveys during the spring spawning period (last week of March through the first week of May), (2) acoustic telemetry of both Shortnose and Atlantic Sturgeon, and (3) a feasibility assessment of monitoring for sturgeon using a fixed side-scan sonar in the Project tailrace.

Six mobile side-scan sonar (SSS) surveys collected overlapping imagery nearly bank-to-bank from the I-495 Lawrence Bridge to the boat launch area between April 4 and May 20, 2025. The vessel, equipped with a pole-mounted 600 and 1600 kHz EdgeTech 4225si SSS, surveyed in navigable waters along five parallel transects which ran longitudinally up and down the river. After initial selection of 169 target detections, ten target detections were classified as sturgeon by two or more independent reviewers from April 10 to April 20. The SSS-derived length measurements of these ten sturgeons averaged 101 cm and ranged from 76 to 135 cm.

Essex coordinated acoustic tagging efforts with staff from the USGS to occur during spring 2025. USGS staff conducted gill net sampling in the lower Merrimack River (mainstem river in Haverhill and the Joppa Flats region in the lower river in Newburyport) between April 18 and May 28, 2025. During that timeframe, a total of 54 sturgeon were tagged with either an InnovaSea 69 kHz transmitter, an ATS JSATS transmitter, or both. Sampling targeted the collection and tagging of adult Shortnose Sturgeon and sub-adult and juvenile Atlantic Sturgeon (Table 5-9). Essex monitored for potential upstream movements by tagged sturgeon within the Merrimack River using a series of InnovaSea 69 kHz stationary hydrophones deployed in the vicinity of the I-495 Bridge, Duck Bridge, Route 28 Bridge and the Project tailrace as well as the ATS JSATS receiver array installed as part of the Diadromous Fish Behavior, Movement, and Project Interaction Study. InnovaSea receivers were in place from late March through mid-November and JSATS receivers were installed from early April through mid-September.

Tagged Sturgeon JSATS ID: 26069:

This adult Shortnose Sturgeon was dual-tagged (InnovaSea ID 42290; JSATS ID 26069) by USGS personnel in the Joppa Flats region on May 14, 2025. At the time of tagging this individual was 874 mm in total length and the sex was undetermined. Shortnose Sturgeon 26069 was detected on

June, 21 2025 by a JSATS receiver deployed downstream of the I-495 bridge (Station 1) from approximately 11:00 until 20:30. This fish was not detected any further upstream nor on any subsequent dates during the 2025 monitoring effort. Figure 5-1 presents the temporal and spatial distribution of detection events for this individual during spring 2025.***Tagged Sturgeon InnovaSea ID: 20910***:

This male Shortnose Sturgeon was originally tagged by USGS during 2016 at RM 6.8 of the Merrimack River was detected in the reach downstream of Essex Dam during April. It was initially detected by the InnovaSea receiver installed just downstream of the Duck Bridge (Station 4) on April 22, 2025. Following this initial detection, Sturgeon 24350 was subsequently detected by an InnovaSea receiver installed in the downstream end of the tailrace channel (Station 7) with the majority of those detections occurring on April 25. The fish's last detection from the InnovaSea receivers operated by Essex during the 2025 season occurred on April 27 at the Duck Bridge (Station 4; Figure 5-2).

Table 5-9. Summary of biological information Shortnose and Atlantic Sturgeon tagged and released as part of the Lawrence Sturgeon Distribution and Project Interaction Study, 2025.

Sturgeon Species	Life Stage	Count	Min Length (cm)	Max Length (cm)	Mean Length (cm)
Shortnose	Adult	39	80.4	112.5	99.5
Atlantic	Sub-Adult	8	91.5	144.8	110.0
	Juvenile	7	87.5	95.0	92.4

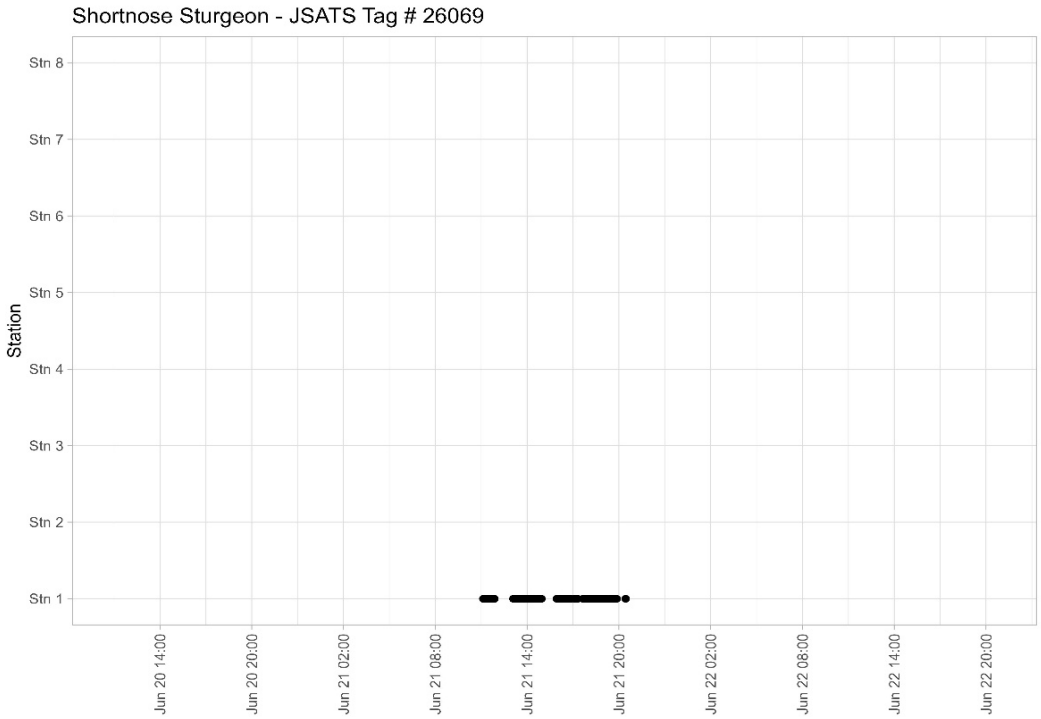

Figure 5-1. Detection history for tagged Shortnose Sturgeon ID 26069 in the section of the Merrimack River downstream of Essex Dam as determined by JSATS receiver detections from Station 1 (downstream of I-495 Bridge) to Station 8 (downstream of powerhouse).

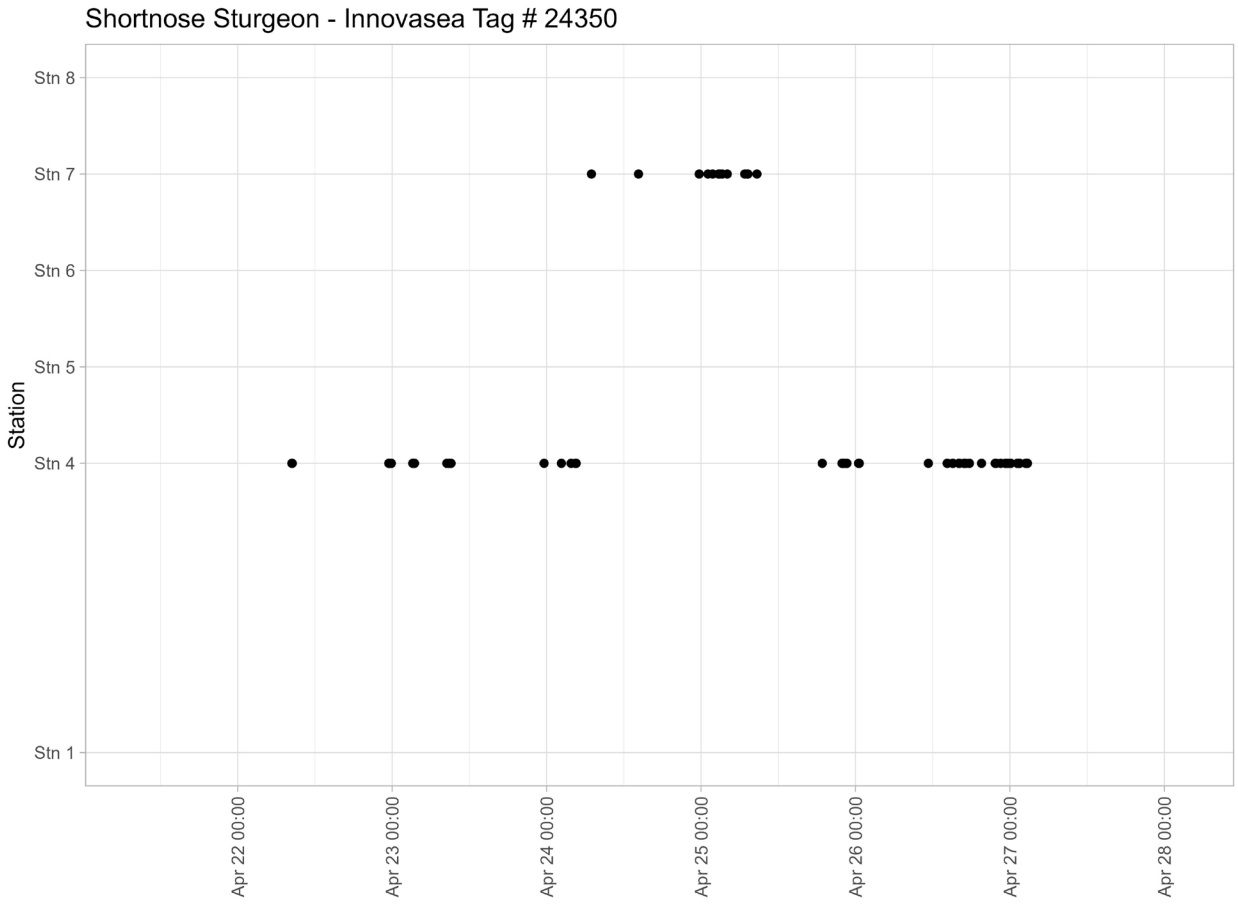

Figure 5-2. Detection history for tagged Shortnose Sturgeon 24350 in the section of the Merrimack River downstream of Essex Dam as determined by InnovaSea receiver detections from Station 1 (downstream of I-495 Bridge) to Station 8 (downstream of powerhouse).

5.1.9 The Annual Essex Dam Fish Lift Counts

Beginning in 1983, diadromous fish species have been documented annually at the Essex Dam in Lawrence. Species enumerated since the initial passage year have included American Shad, river herring (i.e., Alewife and Blueback Herring) and Atlantic Salmon. Upstream passage counts were initiated for American Eel in 2012 and for Sea Lamprey and Striped Bass in 2018. Table 5-9 presents annual diadromous fish counts at Essex Dam for the twenty-year period from 2005 to 2025. Annual counts for the years from 2005 through 2018 were obtained based on visual count estimates of each hopper lift during the season. Annual counts for Striped Bass and Sea Lamprey during 2018 and for all species from 2019 to present are based on camera counts from the viewing window. In addition to counted species, large individuals of Northern Pike have been observed in the Lawrence fish lift early spring and are rarely reported upstream of Lowell (Technical Committee 2021).

Table 5-10. Annual diadromous fish passage counts at Lawrence for the period from 2005 to 2025.

Year	River Herring	American Shad	American Eel	Atlantic Salmon	Striped Bass	Sea Lamprey
2005	99	6,382	--	34	--	--
2006	1,257	1,205	--	91	--	--
2007	1,169	15,876	--	74	--	--
2008	108	25,116	--	119	--	--
2009	1,456	23,199	--	81	--	--
2010	518	10,442	--	85	--	--
2011	740	13,835	--	402	--	--
2012	8,992	21,396	6,969	137	--	--
2013	17,359	37,149	915	22	--	--
2014	57,213	38,107	1,788	75	--	--
2015	128,692	89,467	8,124	13	--	--
2016	417,240	67,528	1,981	6	--	--
2017	91,616	62,846	17,738	5	--	--
2018	449,346	28,302	267,353	10	119	4,278
2019	43,108	19,450	81,179	15	14	9,508
2020	87,150	52,239	93,058	1	62	9,733
2021	96,429	64,162	9,296	0	10	6,263
2022	19,319	36,731	48,648	0	39	6,877
2023	10,315	28,438	17	14	17	1,910
2024	13,467	17,550	168	2	38	5,347
2025	17,021	26,374	34,129	5	19	913
Total	**1,462,614**	**685,794**	**571,363**	**1191**	**318**	**44,829**

5.2 Fish Community Composition and Life Histories

When available records reported over the last 20 years are considered, a total of 37 fish species across 13 families were identified from the general region of the Merrimack River encompassing the Lawrence Project. Fish present included both diadromous and resident species (Table 5-10). Eight resident fish species were reported from previously sampled locations located only upstream of Essex Dam. An additional 23 species were reported in previous studies as being present in Merrimack River reaches both upstream and downstream of Essex Dam with those individuals representing eleven families representing both native and introduced species as well as freshwater resident and diadromous species. Six fish species were reported from previously sampled locations located only downstream of Essex Dam, representing four freshwater resident species (Brown Bullhead, Blacknose Dace, Redfin Pickerel, and White Catfish) and two native diadromous species (Shortnose and Atlantic Sturgeon).

Table 5-11. Merrimack River fish assemblage for the Lawrence Project region as summarized from available information sources.

Common Name	Scientific Name	Freshwater Resident	Diadromous	Native	Introduced	Records for Upstream Only	Records for Downstream Only	Records for Upstream and Downstream
Alewife	*Alosa pseudoharengus*		X	X				X
American Eel	*Anguilla rostrata*		X	X				X
American Shad	*Alosa sapidissima*		X	X				X
Atlantic Salmon	*Salmo salar*		X	X				X
Atlantic Sturgeon	*Acipenser oxyrinchus*		X	X			X	
Black Crappie	*Pomoxis nigromaculatus*	X			X	X		
Blueback Herring	*Alosa aestivalis*		X	X				X
Bluegill	*Lepomis macrochirus*	X			X			X
Brown Bullhead	*Ameirius nebulosus*	X		X			X	
Brown Trout	*Salmo trutta*	X			X	X		
Chain Pickerel	*Esox niger*	X		X				X
Channel Catfish	*Ictalurus punctatus*	X			X	X		
Common Carp	*Cyprinus carpio*	X			X			X
Eastern Blacknose Dace	*Rhinichthys atratulus*	X		X			X	
Fallfish	*Semotilus coporalis*	X		X				X
Golden Shiner	*Notemigonus crysoleucas*	X		X		X		
Green Sunfish	*Lepomis cyanellus*	X			X			X
Largemouth Bass	*Micropterus salmoides*	X			X			X
Longnose Dace	*Rhinichthys cataractae*	X		X		X		
Margined Madtom	*Noturus insignis*	X			X	X		
Northern Pike	*Esox lucius*	X			X			X
Pumpkinseed	*Lepomis gibbosus*	X		X				X
Redbreast Sunfish	*Lepomis auritus*	X		X				X
Redfin Pickerel	*Esox americanus*	X		X			X	

Common Name	Scientific Name	Freshwater Resident	Diadromous	Native	Introduced	Records for Upstream Only	Records for Downstream Only	Records for Upstream and Downstream
Rock Bass	*Ambloplites rupestris*	X			X			X
Sea Lamprey	*Petromyzon marinus*		X	X				X
Shortnose Sturgeon	*Acipenser brevirostrum*		X	X			X	
Smallmouth Bass	*Micropterus dolomieu*	X			X			X
Spottail Shiner	*Hudsonius hudsonius*	X			X			X
Striped Bass	*Morone saxtillus*		X	X				X
Tessellated Darter	*Etheostoma olmstedi*	X		X				X
Walleye	*Sander vitreus*	X			X	X		
White Catfish	*Amerius catus*	X			X		X	
White Perch	*Morone americana*	X		X		X		
White Sucker	*Catostomus commersoni*	X		X				X
Yellow Bullhead	*Ameiurus natalis*	X			X			X
Yellow Perch	*Perca flavescens*	X		X				X
Total		**28**	**9**	**22**	**15**	**8**	**6**	**23**

5.2.1 Anguillidae

Belonging to the Anguillidae family, the American Eel is a catadromous species with adults spending their life in freshwater until reaching sexual maturity and then migrating downstream to the Sargasso Sea to spawn. Spawning typically occurs during autumn or winter, after which the adult eel dies (USFWS 2021). American Eels are primarily benthic and are known to inhabit a variety of habitats including estuaries and rivers where they use various substrates such as rock, silt, mud, wood and vegetation (Shepard 2015, Langdon et al. 2006). American Eels can tolerate a wide range of temperatures between 39° and 77° Fahrenheit (F) but are sensitive to low dissolved oxygen levels (Baensch and Riehl 1995).

American Eels are opportunistic benthic feeders that are mainly active at night. Varying by body size, eels feed on a variety of aquatic insects, macroinvertebrates and fish (Shepard 2015). They serve as prey species for larger fish including Striped Bass, Black Bass, Common Carp and Northern Pike (Technical Committee 2021).

American Eels are documented both upstream and downstream of Essex Dam. Since 2012, there has been estimated over 500,000 American Eels that have passed the Lawrence Project. During the 2018 passage season, there were an estimated 267,353 eels that were documented, and the most recent passage year, 2025, estimated 34,129 eels.

5.2.2 Acipenseridae

Currently, the Atlantic Sturgeon in the Gulf of Maine Distinct Population Segments (DPS) is listed as threatened under the Endangered Species Act and the shortnose sturgeon is listed as endangered. According to the Massachusetts Endangered Species Act, the Atlantic Sturgeon is listed as Endangered (NOAA 2023).

A portion of the Project boundary is listed by The National Oceanic and Atmospheric Administration (NOAA) as Critical Habitat for Atlantic sturgeon. The critical habitat includes waters from Essex Dam downstream to where the Merrimack River discharges into the Atlantic Ocean. Critical habitat for Shortnose Sturgeon has not been designated. According to the January 2023 Information for Planning and Consultation (IPaC) search, the USFWS has not designated critical habitats in the vicinity of the Lawrence Project (NOAA 2016). During 2025, a Shortnose Sturgeon was documented in the tailrace of Lawrence Dam.

Shortnose Sturgeon adults migrate upstream to rivers from April to May. Following spawning, adults move back downstream to the lower river and estuaries and unlike Atlantic Sturgeon, Shortnose Sturgeon tend to spend little time in the ocean. Shortnose Sturgeon use their four barbels to search for food in sandy muddy substrates of rivers and use a vacuum-like mouth to suck up prey including insects, crustaceans, worms and mollusks.

The Atlantic Sturgeon is an anadromous species spending majority of their life in the marine environment but migrating upstream in the spring and early summer to spawn. Historically, the Merrimack River supported habitat for reproduction (MassWildlife 2025a). Atlantic Sturgeon do not spawn every year and spawning intervals range from 1-5 years for males and 2-5 years for females (Gilbert 1989, Hildebrand and Schroeder 1928)). Once hatched, young can spend up to 4 years before gradually moving toward the ocean (Scott and Crossman 1973).

5.2.3 Catostomidae

White Sucker (*Catostomus commersoni*) was the only member of the Catostomidae family present in project waters, occurring in both upstream and downstream reaches.

White Sucker are wide ranged and found in a variety of high and low gradient habitats, from large rivers and lakes to smaller ponds and streams. They are generally tolerant of degraded environmental conditions including pollutants and siltation (Langdon et al. 2006). This species can attain ages in excess of 15 years and lengths up to 25 inches, although typical adults range from 12-20 inches (Scott and Crossman 1973).

Spawning takes place during spring (typically around early May to early June) when water temperatures reach 50°F and adults migrate up tributaries to higher gradient riverine sections or even along windswept regions of lakes where they utilize rocky, shallow areas with moderate current (Langdon et al. 2006). No nests are prepared and no parental care is provided for the eggs scattered along the bottom of these spawning areas, which incubate for approximately one week (Becker 1983). Larval White Suckers migrate from spawning sites about 2 weeks after hatching and exist in the upper portions of the water column where they feed on plankton and invertebrates. At the length of approximately 1 inch, they relocate to benthic habitats typically feeding on a variety of small aquatic insects (particularly midges), mollusks, algae and crustaceans (Langdon et al. 2006) and play an important role in the early stages of the food chain (Becker 1983).

5.2.4 Centrarchidae

Centrarchids are warmwater fish found in warm, rocky vegetated lakes, ponds and streams with slow flow (Scott and Crossman 1973). Species belonging to the Centrarchidae family were found both upstream and downstream of the Lawrence Project. Centrarchids present within project influenced waters can be further split into the genuses Ambloplites (Rock Bass), Micropterus (Smallmouth Bass, Largemouth Bass), Pomoxis (Black Crappie), and Lepomis (sunfishes).

Rock Bass are typically found in warm, slow moving water in streams with available cover. This species prefers to feed on crayfish and fish, but will also feed on aquatic insect larvae, amphipods and crustaceans. Spawning typically begins in June when water temperatures are between 60°-70°F (Langdon et al. 2006). The Black Crappie prefers warmer water with vegetation and a muddy or sandy bottom and is usually associated with clear waters, absence of noticeable current and abundant cover (Langdon et al. 2006, Warren 2009). Spawning begins when water temperatures

reach 66°-68°F in May or June. Black Crappie adults may feed on a variety of food including insect larvae, crustaceans and fish, of ranging sizes (Langdon et al. 2006).

Smallmouth Bass are commonly found in clear, cool runs and pools of small to large rocky rivers (Warren 2009). They are relatively intolerant of low pH, being absent in water when pH is less than 5.5. Largemouth Bass also inhabit clear, warm and shallow streams residing on mud substrates with aquatic plants in slow rivers. They are moderately acid tolerant and have been found in waters with pH values anear 5.0 (Langdon et al. 2006). Both Largemouth and Smallmouth Bass are opportunistic top carnivores, whose adult diet's includes feeding on primarily fish, crayfish, shrimp, and large aquatic insects (Warren 2009). Spawning for both species occurs in the spring and begins when temperatures reach 55°-73°F for Smallmouth Bass and 60°F for Largemouth Bass (Langdon et al. 2006).

The genus Lepomis includes sunfish which can spawn multiple times throughout the spring and summer months. They feed on plankton, bottom invertebrates and small fish (Helfrich et al. 2005). Bluegill is often the most abundant species in this family in part due to it being the most tolerant Lepomis species to adverse conditions including low dissolved oxygen and high temperatures (Warren 2009). The diet of sunfish generally includes aquatic insects, small fish, crustaceans, zooplankton and snails (Langdon et al. 2006).

5.2.5 Clupeidae

Members of the Clupeidae family found within the Project vicinity include American shad as well as river herring, consisting of Alewife and Blueback Herring. These species are all anadromous and migrate to rivers to spawn.

Blueback Herring and Alewife both spawn from April to August (Langdon et al. 2006). Blueback Herring often select to spawn in the mainstream flow while alewife spawn over sand and gravel bottoms along the shore bank eddies or deep pools (Langdon et al. 2006, ASMFC 2009). Following spawning, adult Blueback Herring return to the ocean and once water temperature reaches 72°F, the eggs hatch within 2-3 days. Within one month of hatching, they migrate downstream to the ocean. At 72°F, Alewife eggs hatch in 3 days and 6 days if water temperature is 60°F.

American Shad are anadromous and live most of their lifespan in marine waters before migrating up rivers to spawn (Langdon et al. 2006). Once water temperatures reach 50°F, mature adults will migrate upstream and spawn from May to July when the water temperature reaches 54°-70°F. After spawning, adults abandon the eggs and migrate back to the ocean. During the following fall, newly hatched, juvenile shad will leave freshwater and migrate downstream to the ocean. American Shad are planktivorous, feeding on zooplankton, small fish, fish eggs and bottom dwelling invertebrates (Langdon et al. 2006).

River herring numbers have varied whereas American Shad counts have been more stable throughout the period of record for passage counts at Essex Dam. Throughout the period of record,

River herring counts peaked at an estimated 449,346 fish during 2018 and American Shad peaked at 89,467 during 2015. Over the last four years, annual river herring counts have been under 20,000 fish and American Shad counts have ranged from 17,550 to 36,731.

5.2.6 Cyprinidae

Species belonging to the Cyprinidae family present within the vicinity of the Project area include Goldfish and Common Carp, considered to be old world large-bodied carps that occupy lakes and large rivers near vegetation. They can tolerate low dissolved oxygen levels and are very tolerant to most forms of pollution (Langdon et al. 2006). Goldfish and Common Carp both spawn for extended period of time from late spring to mid-summer, with spawning temperatures between 63°-82° F for common carp and 77°—85° F for Goldfish. Both species are omnivorous, with carp mainly feeding on snails, worms, insect larvae, crustaceans and algae while Goldfish feed on small snails, insect larvae, phytoplankton and aquatic vegetation (Langdon et al. 2006).

Historic data review established within the 2019 Lowell Fish Assemblage report notes Goldfish as an introduced species within the Merrimack River, with no observed Goldfish within reviewed reports for the purposes of this study. Common Carp were observed within impacted project waters occurring in the upstream reach.

5.2.7 Esocidae

Chain Pickerel, Redfin Pickerel and Northern Pike, members of the Esocidae family, are generally solitary ambush predators, waiting for prey hidden amongst vegetation (Langdon et al. 2006). The diet for young pickerel includes feeding on crustaceans and aquatic insects but over time it expands to fish and crayfish. Adults have also been known to prey upon small rodents, snakes and frogs (Langdon et al. 2006).

For Chain Pickerel and Redfin Pickerel, spawning occurs in shallow, vegetated, areas during the months of April or May after ice out when water temperatures range from 47°-52°F for Chain Pickerel and 50°F for Redfin Pickerel (Scott and Crossman 1973, Langdon et al. 2006). Both species were found downstream of the Project area.

Northern Pike are widely distributed through New England lakes, ponds, and rivers. They are rarely spotted upstream of Lowell, but large individuals are occasionally seen in the Lawrence fish lift during early spring (Technical Committee 2021). The diet of Northern Pike consists primarily of other fishes, including other pikes, but they may also consume ducks, mice, rats, frogs, snakes and crayfish (USFWS 2023).

Northern Pike spawn during April and May when water temperatures are around 39°-50°F. After spawning, adults return to deeper waters. Eggs hatch after approximately 10-14 days and fry remain in the spawning area until they reach 2-3 inches long when they move to deeper habitats (USFWS 2023).

5.2.8 Leuciscidae

Species in the family Leuciscidae known to be present in the Merrimack River include the Spottail shiner (Bemis et al. 2023), Golden Shiner, Eastern Blacknose Dace and Fallfish, all of which are native minnows that are found in a variety of habitats. Longnose Dace and Blacknose Dace are commonly found in cobble substrates among riffles of moderate to quick flowing streams. They feed on small aquatic invertebrates, terrestrial insects and algae, whereas Spottail Shiner can be found in a variety of habitats such as rocky moderate-gradient streams to large slow lakes and rivers (Langdon et al. 2006).

Fallfish are the largest and longest-lived minnows and commonly found in riverine habitat in steep cool waters with rock and gravel substrates, with deep pool and lake habitat use in the fall and winter months (MassWildlife, 2025b). Fallfish have been observed both upstream and downstream of the Project and are known to feed on aquatic insects, terrestrial insects, small fish, crayfish and algae. Spawning for members of this family ranges from late April through July and water temperatures vary from 55°-72°F depending on species (Langdon et al. 2006).

5.2.9 Ictaluridae

Yellow Bullhead, Brown bullhead, White Catfish, Channel Catfish and Margined Madtom are members of the Ictaluridae family all present within the vicinity of the Project area.

Observed both upstream and downstream of the Project area, Yellow Bullhead occur in the shallow clear water of slow streams preferring muck and gravel substrates with abundant vegetation. This species is tolerant of low dissolved oxygen and high-water temperatures but intolerant of silt and turbidity (Langdon et al. 2006, Scott and Crossman 1973). Yellow Bullhead spawn in the spring late May to early June and are considered scavengers that feed on crustaceans, aquatic insects, mollusks and fish (Scott and Crossman 1973).

Brown Bullhead were caught downstream of Lawrence but have not been documented upstream. This species prefers a muddy substrate in clear or turbid water. Similar to the Yellow Bullhead, this species is tolerant of low dissolved oxygen and high temperatures. Spawning takes place in late May and June when water temperatures are above 70°F (Langdon et al. 2006).

White Catfish were documented 1.5 miles downstream of Lawrence. This species are omnivorous and eat aquatic plants, benthic invertebrates and small fishes. They are freshwater but often occur in estuaries. Spawning occurs when temperatures reach around 70° - 86°F (Smithsonian Environmental Research Center n.d).

Study reports indicate that Channel Catfish are present upstream of the Lawrence dam. This species prefer clear water and are often found in deep water with sand to rubble substrate. This species is tolerant of low dissolved oxygen and high temperatures (Langdon et al. 2006). Channel Catfish spawn during summer when water temperature reaches 75°F. A variety of food is consumed including aquatic insect larva, crayfish, mollusks and fish (Langdon et al. 2006).

The Margined Madtom is commonly found in rocky areas of medium sized streams and small rivers (NHFGD 2026). They inhabit riffles with moderate to swift flow and feed upon insects and fish and have been found upstream of the Lawrence Project (Smith 1985). Fish mature by age 2 and spawn in during the spring in May and June (Helfrich et al. 2005).

5.2.10 Moronidae

The family Moronidae is the temperate bass family and includes White Perch and Striped Bass.

White Perch are semi-anadromous found along the Atlantic shore in the ocean as well as brackish estuarine waters and river mouths (Technical Committee 2021, Langdon et al. 2006). Smaller individuals feed on aquatic insect larvae while larger individuals have a diet that includes small fish and fish eggs. White Perch spawns in late spring and early summer at temperatures 50°-60°F (Langdon et al. 2006). Currently, White Perch is present upstream of the Lawrence Project.

Striped Bass are anadromous and begin migrating to rivers in April, spawn in late spring and typically stay until mid-June. The diet of Striped Bass changes overtime, with young feeding on zooplankton, older fish feeding on crustaceans, shrimp, worms and insects, and adults feeding mainly on fish (Langdon et al. 2006). Striped Bass are a desirable game fish present in the Merrimack River watershed and are also an important predator known to prey on American Eel juvenile American Shad and river herring, which has influenced the population size of river herring (Technical Committee 2021). Throughout the period of record for Striped Bass (2018-2025), there have been an estimated 318 fish that have passed the Lawrence dam, with peak count occurring in 2018.

5.2.11 Percidae

Three members of the Percidae family are represented in catch records from prior Merrimack River studies in the vicinity of the Project: Yellow Perch, Walleye, and Tessellated Darter.

Yellow Perch are a temperate species that commonly occur in lakes and rivers, occupying a variety of habitats and depths. Yellow Perch require clear waters and are intolerant of excessive turbidity; however, they are tolerant of low oxygen and pH (Langdon et al. 2006, HDR 2023). Young Yellow Perch feed on zooplankton, but eventually feed on benthic invertebrates, and other fish as they age. Spawning for Yellow Perch occurs at night during early spring after ice out. Yellow Perch typically begin spawning when temperatures reach 44°F (Langdon et al. 2006).

Walleye are occasionally caught in the lower Merrimack River (Technical Committee 2021). Walleye are found in both rivers and lakes varying in geography, geology, and land use across a wide latitudinal range, which largely affects growing season and life history strategies. Habitat preference is generally given to large (>100-hectare), cool-water bodies with high turbidity, gravel and/or sandy substrate, extensive littoral areas, and ample cover such as boulders, logs, and vegetation (Scott and Crossman 1973, McMahon et al 1992). Past studies have shown Walleye present upstream of the Project.

In northern latitudes, Walleye spawn in spring when water temperatures range between 41°-45°F and may begin spawning under ice or just following ice-out (Bozek et al. 2011). Spawning typically occurs along shorelines in shallow, mid-lake reefs or in rapids and riffles of rivers where there is adequate flow and oxygen for egg development. Walleye are broadcast spawners and adhesive eggs sink into crevices within the substrate. No parental care is provided, and first-year survival is generally low (< 1%). After hatching, larvae are negatively buoyant and can only withstand minimal water velocities. Feeding on small zooplankton begins before the yolk sac is completely absorbed. Once free swimming, young walleye move into open water and feed on zooplankton, then eventually benthic invertebrates and other fishes as they grow of size ((Bozek et al. 2011, HDR 2023).

Tessellated Darter inhabit cool to warm waters preferring areas of little to no current in rivers. This species is tolerant of environmental conditions and is found along shorelines with mud or sand substrate. Spawning occurs in the spring at water temperatures of 50° – 59° F. The tessellated darter feeds on small crustaceans, aquatic insect larvae and fish eggs (Langdon et al. 2006). This study found that Tessellated Darter are present both upstream and downstream of the Lawrence Project.

5.2.12 Petromyzontidae

A member of the family Petromyzontidae, the Sea Lamprey is an anadromous, semelparous species that spends majority of their life cycle in freshwater streams before migrating to the ocean. As adults, they migrate upstream during the spring when temperatures exceed 40°F to spawn before subsequently dying (Technical Committee 2021). Spawning occurs in riffle habitats with sandy and cobble river substrate with adequate flow (Technical Committee 2021). After 2-3 weeks, eggs hatch and the ammocoetes drift downstream to still or slow velocity water burrowing in the sand and mud substrate (Langdon et al. 2006, Technical Committee 2021). Sea Lamprey are filter feeders that consume plankton, pollen and other organic material suspended in the water column (Langdon et al. 2006).

Sea Lamprey have been counted at the Lawrence Project since 2018. During the 2020 passage season, there was an estimated 9,733 Sea Lamprey that passed upstream. However, annual counts in subsequent years have dipped, with an estimated 913 individuals passing during 2025.

5.2.13 Salmonidae

The Lawrence Project boundary sits within identified Essential Fish Habitat for Atlantic Salmon, defined by The Magnuson-Stevens Fishery Conservation and Management Act of 1976 as “those waters with substrates necessary to fish for spawning, breeding, feeding, or growth to maturity” (16 U.S.C. 1802, CFR § 600.10). Historically there was a large effort to restore the population of sea-run salmon in the Merrimack, but in 2014 the USFWS ended its collaborative effort and shifted management focus to alosines (Technical Report 2021).

Annual Atlantic Salmon counts at the Project have varied ranging from 0 to 402 fish over the past 20 years. Atlantic Salmon are an anadromous species historically native to most coastal rivers northeast of the Hudson River in New York (NOAA 2023). Habitat for early life stages generally consists of relatively large and cool rivers with extensive gravel substrate. Peak spawning typically occurs in late October and November, with optimal water temperatures ranging from 39F° to 50°F. Parr reside in the river and after one to three years, they undergo morphological changes to prepare for migrating to the ocean where adults remain until they return to their natal rivers to spawn (Langdon et al. 2006, HDR 2023). In freshwater, fry feed on plankton but as they grow their diet shifts to aquatic insects and small fish. In the ocean, smolts and adults feed on insects, shrimp, and fishes such as herring, sand lances, and capelin (NOAA 2023).

Identified upstream of the Lawerence Project, brown trout, another member of the Salmonidae family, are an introduced species that prefer mild gradient streams with deep pools and an ideal temperature of 53°- 66°F. The Massachusetts Trout Stocking Report for 2025 indicates Rainbow Trout have been stocked in Forest Lake and the Spicket River in Methuen as well as lakes and rivers in Haverhill. Stocking also occurred in Groton lakes and rivers with Brown Trout and Rainbow Trout (MassWildlife, 2025c). Spawning occurs during the fall when temperatures reach 44°-48°F. Trout feed on a variety of aquatic and terrestrial insects when young but transition their diet to feeding on more fish as they grow (Langdon et al. 2006).

6 Summary

The Lawrence Hydroelectric Project is located at river mile 29 of the Merrimack River in the City of Lawrence in Essex County, Massachusetts, is owned and operated by Essex Company, LLC. In accordance with 18 C.F.R. § 5.15, Essex has initiated studies and information gathering activities as provided in the study plan and schedule approved by the Commission. Among the studies completed include the Fish Assemblage Assessment, the objectives of which were identified by the Commission in their May 10, 2024, Study Plan Determination (SPD).

Objectives for this study included the compilation of information from existing fish assembly study data, summarizing the fishery data from all required fishery studies identified in the May 10, 2024 Study Plan Determination, and assessing the information for potential data gaps. Compiling all existing fish survey data and collected data provides information on the existing fish assemblage in the Project area that can be used to define the affected environment, assess project effects on fish resources, and identify any license conditions for protecting fish resources.

Current existing fish species found in the Project area and greater Merrimack River watershed along with data collected from additional sources and past studies were reviewed. Sources included the Pre-Application Document, 2010 Probabilistic Monitoring Fish Population Survey, 2019 Lowell Hydroelectric Project Fish Assemblage Study, 2024 Lawrence Hydroelectric Project Freshwater Mussel Habitat Assessment and Survey, 2024 Upstream American Eel Passage Siting Study, 2025 Lawrence Hydroelectric Project Upstream Anadromous Fish Passage Assessment,

2025 Lawrence Hydroelectric Project Fish Behavior, Movement, and Project Interaction Study, 2025 Lawrence Hydroelectric Project Sturgeon Distribution and Project Interaction Study, and historic annual fish passage counts at Lawrence Dam.

When available records reported over the last 20 years are considered, a total of 37 fish species across 13 families were identified from the general region of the Merrimack River encompassing the Lawrence Project. The Merrimack River is home to a diverse assemblage of fish species, including both cold water and warm water species, and provides a migratory corridor for many diadromous species. Eight resident fish species were reported from previously sampled locations located only upstream of Essex Dam. An additional 23 species were reported as being present in Merrimack River reaches both upstream and downstream of Essex Dam with those individuals representing ten families representing both native and introduced species as well as freshwater resident and diadromous species. Six fish species were reported only downstream of Essex Dam, representing four freshwater resident species (Brown Bullhead, Blacknose Dace, Redfin Pickerel, and White Catfish) and two native diadromous species (Shortnose and Atlantic Sturgeon).

This desktop study has characterized the general fish assemblage found in the vicinity of the Lawrence Hydroelectric Project area. Information is available on both resident and diadromous species located within the Project area both upstream and downstream of Essex Dam and review of this information does not indicate any significant data gaps at this time.

7 Variances from the FERC Approved Study Plan

The Fish Assemblage Assessment was not proposed by Essex in their April 10, 2024 RSP but was recommended by FERC in their May 10, 2024, SPD. To address that recommendation Essex adopted the study goals and objectives as noted by FERC in the SPD and this report has been prepared in a manner to address those requests.

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