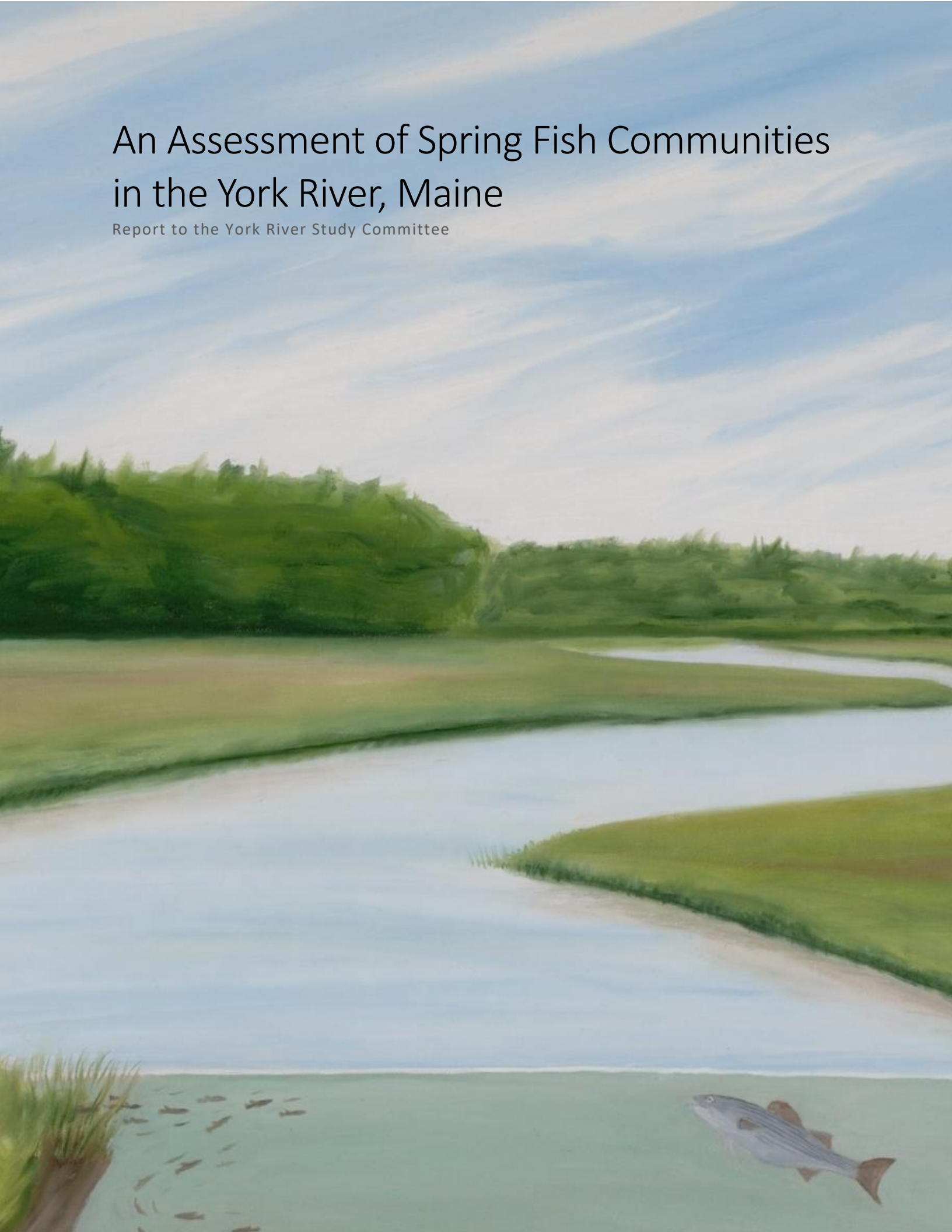
An Assessment of Spring Fish Communities in the York River, Maine

Report to the York River Study Committee



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Summary

The Wells National Estuarine Research Reserve carried out an assessment of fish species in the York River from April to June 2017 and identified previously undocumented spawning populations of alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) that may represent regionally important populations. These species have been identified by the National Marine Fisheries Service (NMFS) and Maine Department of Maine Resources (MDMR) as meriting special attention due to historical populations declines related to habitat degradation. The fact that the York River still supports sizable populations of these anadromous species indicates that habitat in the watershed is of sufficient quality to allow them to persist, despite historical impacts. This report makes recommendations for continued monitoring of these species populations and habitat and identifies specific restoration actions that should be taken to enhance the resiliency of the York River fishery.

Project Background and Objectives

The Wells National Estuarine Research Reserve (Wells Reserve) was contracted by the York River Study Committee (YRSC) to conduct a survey of fish Species of Greatest Conservation Need (SGCN) in the York River as part of a multi-year process by the YRSC to develop a Watershed Stewardship Plan (WSP) and evaluate the eligibility of a Partnership Wild and Scenic River designation by the U.S. Congress. The objective of the fish surveys was to generate up-to-date data on existing fisheries in the York River and identify the presence of SGCN which might merit special consideration for the WSP or Partnership Wild and Scenic Rivers designation.

SGCN is a designation used in the Maine 2015 Wildlife Action Plan (WAP) and represents a prioritization of species under greatest threat from primarily human induced habitat loss or change and requiring direct conservation actions to restore or sustain their populations (MDIFW 2015). Many of the fish species identified in the WAP as SGCN are diadromous, migrating between freshwater and marine environments to complete their life cycle. For these species, such as alewife, American eel, and rainbow smelt, access to high quality river habitat is critically important. Historic alterations to watershed landscapes, including the building of dams and road crossings, have had direct influence on the historical decline of these species throughout their range (Hall et al. 2011).

In 2001 the Wells Reserve conducted a study of fish inhabiting the York River. Though sampling during these species migrations was limited, researchers identified the presence of alewife, American eel (*Anguilla rostrata*), rainbow smelt, brook trout (*Salvelinus fontinalis*), and striped bass (*Morone saxatilis*) (Dionne et al. 2006). Data from this study were used to guide the location and timing of sampling in this 2017 study.

The sampling plan and subsequent data analysis and discussion for this study are focused primarily on two species, alewife and rainbow smelt. In addition to being Maine SGCN, they are also listed as Species of Concern by the National Marine Fisheries Service. This designation does not convey any legal protections; it indicates that the agency has concerns for the species

regarding danger of extinction or risk of becoming endangered, but that insufficient information is available to indicate a need to list as Threatened or Endangered (NOAA 2017). The historical occurrence of these species in the York River provides impetus for this study, to determine the current status of these imperiled species.

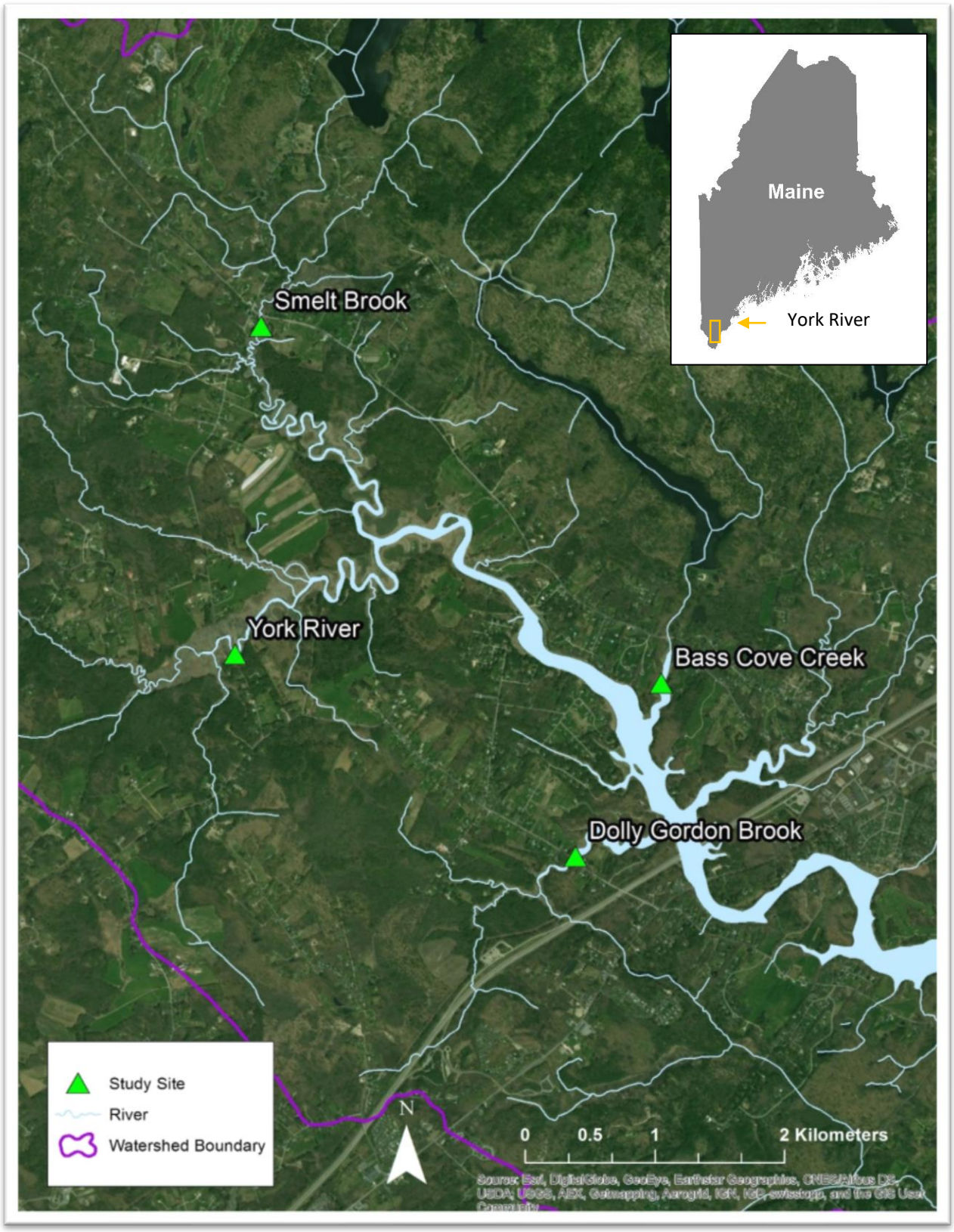
The York River Watershed drains approximately 87 km^2 in the towns of York, Kittery, Eliot, and South Berwick. There are approximately 114 km of perennial fresh water stream habitat, and another 44 km of tidal stream habitat. The York River consists of six major tributaries: Southside Brook, Dolly Gordon Brook, York River, Smelt Brook, Bass Cove Creek, and Cider Hill Creek. These streams drain to the York River estuary amidst approximately 2 km^2 of tidal marsh. This creates a diversity of tidally mixed areas, and potential migration routes for diadromous species. Most headwater streams in the York River watershed are in high gradient terrain among surrounding hills, and many have been found to support wild brook trout populations (Dionne et al. 2006). Most of the major tributaries have water supply impoundments as their source. These ponds are managed by the Kittery Water District as the drinking water supply for customers in Kittery and portions of York and Eliot.

Project Planning

Wells Reserve staff developed a sampling plan to target fish SGCN, with a focus on adult rainbow smelt and alewives during their respective migrations. This plan used a standardized fishing protocol developed for a regional smelt study conducted by Maine, New Hampshire, and Massachusetts state fisheries agencies (Enterline et al. 2012), modified to suit project needs. Fyke nets were deployed for three consecutive 24-hour periods each week and checked daily. Net openings faced downstream to capture fish migrating upstream, with net wings extending across approximately 7-45% of the channel, and cod ends located in areas of sufficient depth at low tide for captured fish to remain submersed. Nets were removed for the remaining four days each week. All fish were identified to the species level and total length and wet weight measurements were recorded for as many alewives and rainbow smelt as possible, and for the first 30 individuals of other species. When more than 30 individuals were sampled, or when it was logistically difficult to measure length and weight for rainbow smelt and alewives, bulk counts and bulk weights were taken. Individual lengths and weights were measured to the closest millimeter and tenth of a gram respectively, while bulk weight was measured to the nearest tenth of a gram, and larger fish were weighed to the closest 20 grams. Sex was recorded for all individually measured rainbow smelt and alewives when it could be determined. All captured fish were released upstream of the fyke net at each site.

Water quality monitoring stations were deployed near each fyke net to measure environmental conditions during sampling. We deployed YSI 6600 dataloggers vertically in 4-inch diameter PVC tubes secured to fence posts driven into the stream substrate. Each logger was equipped to measure water temperature, depth, and salinity at 15-minute intervals continuously during deployment. Loggers were replaced with newly calibrated instruments approximately every four weeks.

Figure 1. York River study sites and watershed location.



The surveys were carried out from the time the sample sites were ice-free in early April, through the first week of June. The goal was to sample as much of the migration of both rainbow smelt and alewives as possible with the project resources available.

It was expected that the field team would be able to access four sites each day, given constraints with access due to tidal fluctuations. Sampling locations were selected based on available information as to where target species were known to occur in the watershed or where habitat was expected to be suitable for spawning. Accessibility was equally important to maximize field efficiency, and so all sites were located immediately downstream of road crossings. Necessary landowner permissions were obtained for site access at the beginning of the project. Sites were located on the mainstem of the York River, Smelt Brook, Bass Cove Creek, and Dolly Gordon Brook (Figure 1). At the York River site, the net was set approximately 100 meters downstream of the bridge at Frost Hill Road extending across approximately 25% of the stream, in a tidally influenced area surrounded by salt marsh. In Smelt Brook the net was set approximately 50 meters downstream of the Cider Hill Road crossing, and extended across approximately 45% of the stream, in a tidally influenced reach adjacent to upland forest and freshwater marsh. At Bass Cove Creek the net was initially set approximately 150 meters downstream of the Cider Hill Road crossing, but low water levels after April 24th required the net to be relocated further downstream in a broad tidally influenced channel adjacent to narrow fringing marsh and upland forest and fields. The fyke net extended across approximately 7% of the stream. In Dolly Gordon Brook the net was located approximately 20 meters downstream of the Beech Ridge Road crossing and extended across approximately 12% of the stream, in a tidally influenced reach adjacent to fringing salt marsh and upland forest.

The fyke net and water quality station are deployed in Bass Cove Creek.

The fyke net is deployed in the mainstem of the York River.

The fyke net and water quality station are deployed in Dolly Gordon Brook.

The fyke net is deployed in Smelt Brook.

As a companion study during smelt spawning, the Wells NERR conducted a field assessment of rainbow smelt spawning habitat in study reaches, and a GIS desktop assessment of riparian habitat condition in the York River. The field assessment included the identification of potential spawning habitat upstream of each of the four study sites, and periodic surveys for smelt eggs during the smelt spawning run. The purpose of these surveys was to confirm presence and location of smelt spawning, and to inform future restoration and conservation efforts. The GIS analysis utilized publicly available landcover, conservation, and zoning data to identify the percentage of riparian land within 200 feet of all perennial streams that is vulnerable to future development.

An additional companion study was carried out during the smelt spawning season utilizing a new technology known as environmental DNA, or eDNA, where water samples are collected from streams and analyzed for the presence of DNA from fish species of interest. In this pilot study, water samples were collected throughout the smelt spawning season according to a protocol developed by University of Maine researcher Dr. Michael Kinnison (M. Kinnison, unpublished protocol). Samples were frozen and stored until they could be shipped to the Kinnison lab for analysis. The collection of eDNA samples simultaneously with fyke net sampling provided a useful method for confirming smelt eDNA results with conventional catch data. Eventually, eDNA methods could provide a cost-effective alternative to conventional sampling, or augment traditional studies with highly sensitive detection of target fish species.

Survey Results and Analysis

Sampling was carried out from ice-out on April 3rd through June 8th, except in the York River where sampling ended on May 18th due to loss of access (property owner permission rescinded). The sampling effort consisted of 111 samples (individual fyke net sets) and 2,701 hours of fishing effort (time nets fished). In total, 4,736 individual fish were sampled including 24 species. A total of 1,275 rainbow smelt and 670 alewives were sampled. Additional fish SGCN included 63 American eels, 18 brook trout, 4 striped bass, and 5 winter flounder (*Pseudopleuronectes americanus*). Catch data by site are included in Table 1.

A rainbow smelt captured in Smelt Brook on April 4th.

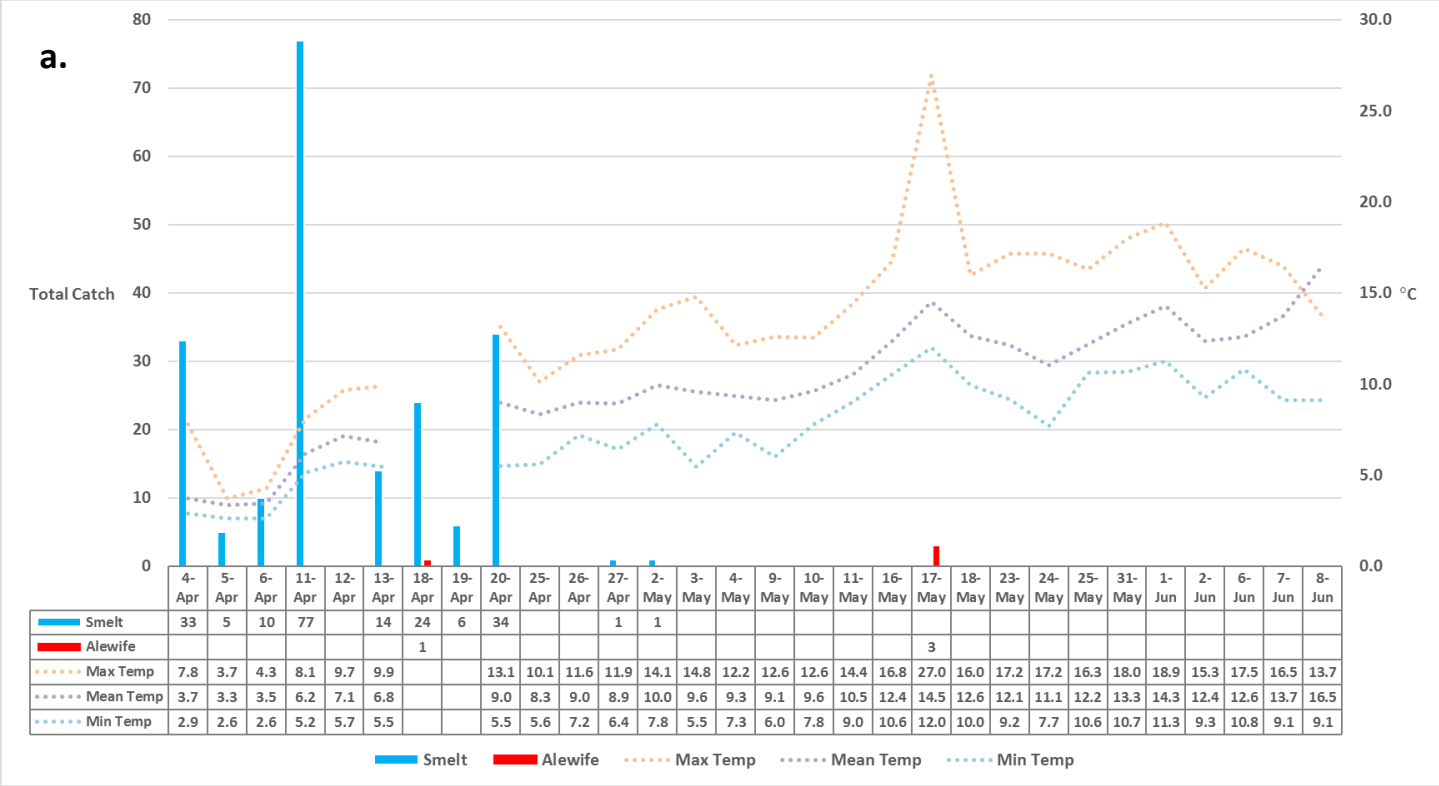
Rainbow smelt were sampled from April 4th to May 2nd, with the peak total catches occurring on April 12th (464) and 13th (447). Figure 2 includes daily smelt catch totals by site. Due to the timing of ice-out at our sampling sites and the occurrence of smelt in our first sample, it is unlikely that we were able to sample the beginning of the spawning run, and it therefore is not possible to determine the duration or onset of the run. However, based on our data we know that the run lasted at least 28 days and ended in early May. Based on information for nearby documented smelt runs, we expect that spawning in the York River likely began in mid to late March.

Sample Site	Bass Cove Creek	Dolly Gordon Brook	Smelt Brook	York River *	Total
# fyke net sets	30	30	30	21	111
SGCN Fish Species					
Alewife	4	7	532	127	670
American Eel	23	29	2	9	63
Brook Trout		1	16	1	18
Rainbow Smelt	171	10	396	665	1275
Striped Bass		3	1		4
Winter Flounder	1	4			5
Other Fish Species					
Atlantic Silverside	32	17		3	56
Atlantic Tomcod	1				1
Banded Killifish	16			1	17
Common Sea Robin		1			1
Common Shiner	2	16	6	22	46
Fourspine Stickleback	4	20	91	88	203
Grubby Sculpin		4			4
Mummichog	699	288	1	199	1187
Ninespine Stickleback		1		34	35
Pumpkinseed Sunfish			5		5
Threespine Stickleback	8	20	6	28	62
White Perch		3	4	2	9
White Sucker			14	39	53
Crustacean Species					
Sand Shrimp	65	135	1		201
Grass Shrimp		2			2
Invasive/Non-Native Species					
European Green Crab	313	427			750
Bluegill			1	57	58
Yellow Perch	9		2		11
Totals	**1348**	**988**	**1078**	**1275**	**4736**

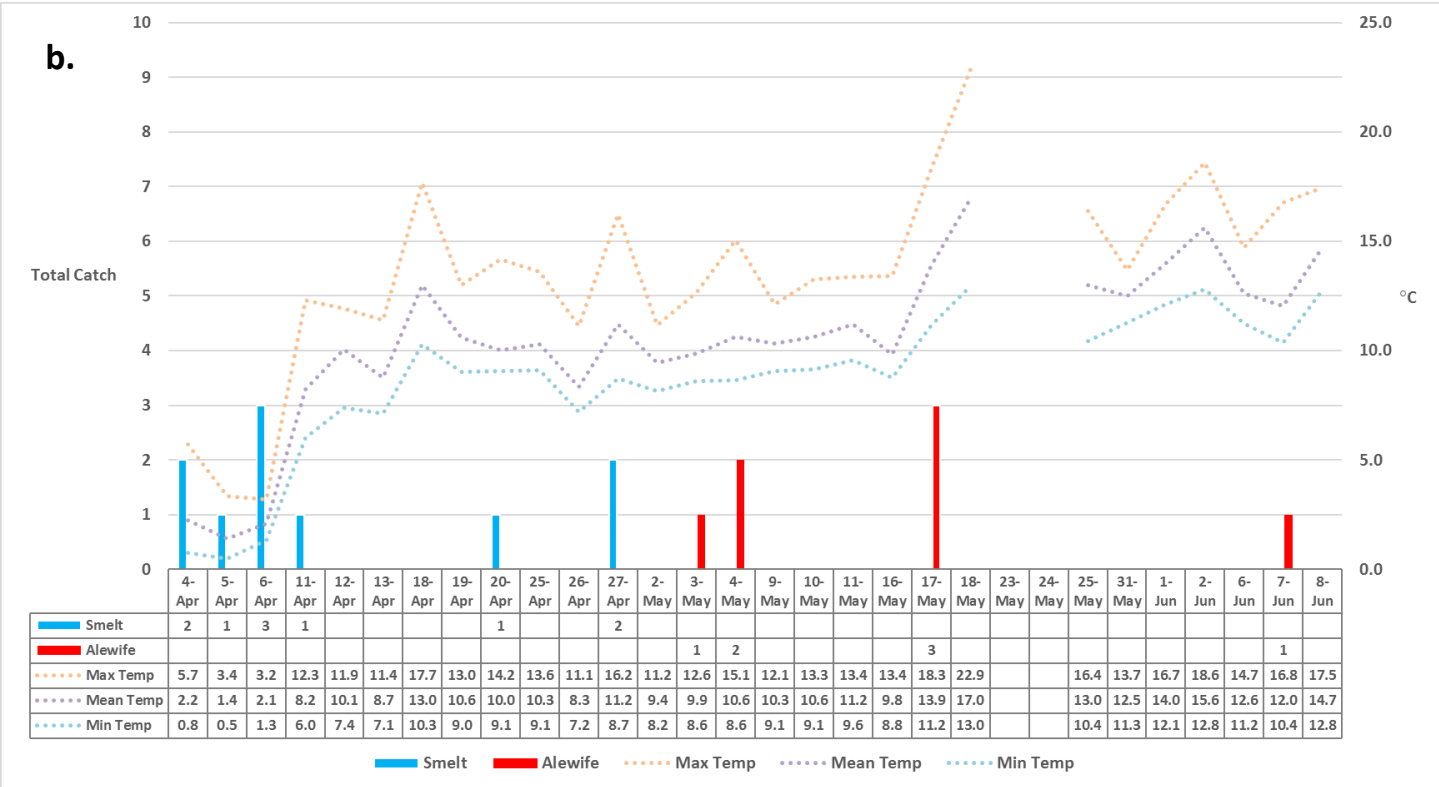
Table 1. Catch totals by site (*York River site discontinued after May 18th).

Of the 1,275 rainbow smelt sampled, sex was determined for 470 (37%). A total of 64 females and 406 males were identified. For the remaining individuals either sex was not determined, or they were part of a bulk count and sexing was not attempted. The overall mean length of males was 171 mm, and the overall mean length of females was 178 mm. The overall sex ratio of males to females was 6.4:1. Total length distribution and sex ratio by site are shown in Figure 3.

Figure 2. Daily smelt and alewife catch totals plotted with daily water temperature by site: a.) Bass Cove Creek, b.) Dolly Gordon Brook, c.) Smelt Brook, and d.) York River.

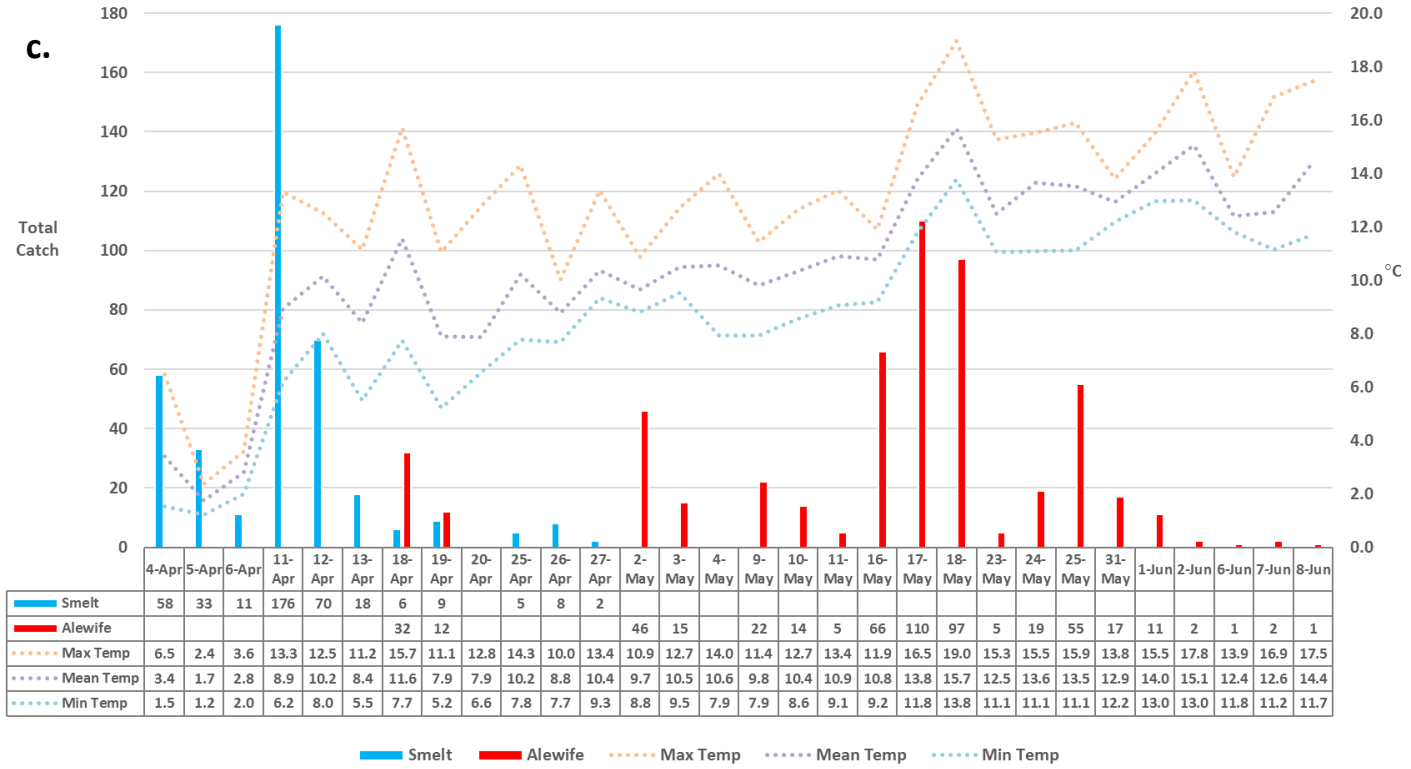


	4-Apr	5-Apr	6-Apr	11-Apr	12-Apr	13-Apr	18-Apr	19-Apr	20-Apr	25-Apr	26-Apr	27-Apr	2-May	3-May	4-May	9-May	10-May	11-May	16-May	17-May	18-May	23-May	24-May	25-May	31-May	1-Jun	2-Jun	6-Jun	7-Jun	8-Jun
Smelt	33	5	10	77		14	24	6	34			1	1																	
Alewife							1													3										
Max Temp	7.8	3.7	4.3	8.1	9.7	9.9			13.1	10.1	11.6	11.9	14.1	14.8	12.2	12.6	12.6	14.4	16.8	27.0	16.0	17.2	17.2	16.3	18.0	18.9	15.3	17.5	16.5	13.7
Mean Temp	3.7	3.3	3.5	6.2	7.1	6.8			9.0	8.3	9.0	8.9	10.0	9.6	9.3	9.1	9.6	10.5	12.4	14.5	12.6	12.1	11.1	12.2	13.3	14.3	12.4	12.6	13.7	16.5
Min Temp	2.9	2.6	2.6	5.2	5.7	5.5			5.5	5.6	7.2	6.4	7.8	5.5	7.3	6.0	7.8	9.0	10.6	12.0	10.0	9.2	7.7	10.6	10.7	11.3	9.3	10.8	9.1	9.1



	4-Apr	5-Apr	6-Apr	11-Apr	12-Apr	13-Apr	18-Apr	19-Apr	20-Apr	25-Apr	26-Apr	27-Apr	2-May	3-May	4-May	9-May	10-May	11-May	16-May	17-May	18-May	23-May	24-May	25-May	31-May	1-Jun	2-Jun	6-Jun	7-Jun	8-Jun
Smelt	2	1	3	1					1			2																		
Alewife														1	2					3									1	
Max Temp	5.7	3.4	3.2	12.3	11.9	11.4	17.7	13.0	14.2	13.6	11.1	16.2	11.2	12.6	15.1	12.1	13.3	13.4	13.4	18.3	22.9			16.4	13.7	16.7	18.6	14.7	16.8	17.5
Mean Temp	2.2	1.4	2.1	8.2	10.1	8.7	13.0	10.6	10.0	10.3	8.3	11.2	9.4	9.9	10.6	10.3	10.6	11.2	9.8	13.9	17.0			13.0	12.5	14.0	15.6	12.6	12.0	14.7
Min Temp	0.8	0.5	1.3	6.0	7.4	7.1	10.3	9.0	9.1	9.1	7.2	8.7	8.2	8.6	8.6	9.1	9.1	9.6	8.8	11.2	13.0			10.4	11.3	12.1	12.8	11.2	10.4	12.8

c.



	4-Apr	5-Apr	6-Apr	11-Apr	12-Apr	13-Apr	18-Apr	19-Apr	20-Apr	25-Apr	26-Apr	27-Apr	2-May	3-May	4-May	9-May	10-May	11-May	16-May	17-May	18-May	23-May	24-May	25-May	31-May	1-Jun	2-Jun	6-Jun	7-Jun	8-Jun
Smelt	58	33	11	176	70	18	6	9		5	8	2																		
Alewife							32	12					46	15		22	14	5	66	110	97	5	19	55	17	11	2	1	2	1
Max Temp	6.5	2.4	3.6	13.3	12.5	11.2	15.7	11.1	12.8	14.3	10.0	13.4	10.9	12.7	14.0	11.4	12.7	13.4	11.9	16.5	19.0	15.3	15.5	15.9	13.8	15.5	17.8	13.9	16.9	17.5
Mean Temp	3.4	1.7	2.8	8.9	10.2	8.4	11.6	7.9	7.9	10.2	8.8	10.4	9.7	10.5	10.6	9.8	10.4	10.9	10.8	13.8	15.7	12.5	13.6	13.5	12.9	14.0	15.1	12.4	12.6	14.4
Min Temp	1.5	1.2	2.0	6.2	8.0	5.5	7.7	5.2	6.6	7.8	7.7	9.3	8.8	9.5	7.9	7.9	8.6	9.1	9.2	11.8	13.8	11.1	11.1	11.1	12.2	13.0	13.0	11.8	11.2	11.7

d.

	4-Apr	5-Apr	6-Apr	11-Apr	12-Apr	13-Apr	18-Apr	19-Apr	20-Apr	25-Apr	26-Apr	27-Apr	2-May	3-May	4-May	9-May	10-May	11-May	16-May	17-May	18-May
Smelt	18	36	6	210	377	8	6	2	1	1											
Alewife							4	3	8	4			6	1		5	3	1	58	20	14
Max Temp	6.0	3.0	3.4	13.7	13.2	12.1	17.1	14.7	21.7	15.0	10.7	12.8	12.6	13.7	15.1	12.7	12.8	13.3	21.8	21.8	20.3
Mean Temp	3.3	1.7	2.9	9.9	11.4	10.1	15.0	11.5	10.7	11.4	9.4	10.3	10.8	10.7	11.7	10.8	10.9	11.7	11.4	13.3	18.6
Min Temp	1.8	1.2	2.5	7.5	10.1	7.3	11.4	8.9	9.1	10.0	8.3	9.3	9.1	9.7	9.8	8.1	8.9	10.0	7.3	7.3	17.4

An alewife is sampled at the York River on May 17th.

Alewives were sampled from April 18th to June 8th, with the peak total catches occurring on May 16th (124), May 17th (136), and May 18th (111). Figure 2 includes daily alewife catch totals by site. Due to the limited length of the study, we may have stopped sampling prior to the end of the alewife spawning run, though the catch had diminished to single digits by the last week of sampling, which was likely close to the end. Based on our data the onset of spawning was the week prior to our first catch on April 17th, and likely concluded after June 7th, with a minimum duration of 51 days. Of the total 670 alewives sampled, sex was determined for 167 (25%). A total of 17 females and 153 males were identified. For the remaining individuals either sex was not determined, or they were part of a bulk count and not attempted. The overall mean total length for females was 282 mm and the mean total length for males was 257 mm. The overall male to female sex ratio was 9:1. Total length distribution by sex, and sex ratio are shown in Figure 3 for Smelt Brook and York River (other sites excluded due to limited sex data).

Brook trout were sampled from April 20th to June 6th, with 61% (11 of 18 total) caught from May 9th to May 11th. The mean length was 151 mm, the max length was 247 mm, and the min length was 105 mm. Brook trout spawn in the fall so no sex data could be collected on these fish. Daily catch totals and total lengths for brook trout are shown in Table 2.

A brook trout is measured for total length at Smelt Brook on May 10th.

Water temperature, salinity, and depth were monitored at 15-minute intervals at each sample site throughout the study. Data were not available for Bass Cove Creek on April 18th - 20th and for Dolly Gordon Brook on May 23rd and 24th due to equipment malfunction. Water temperature is a key factor in determining the onset of spawning for rainbow smelt and alewives, and important for embryonic development. Water temperature at the onset of smelt spawning varies with geography, with a range of 4-6 °C for Massachusetts rivers, 3-6 °C in New Hampshire rivers, and 1.5-9 °C for Maine rivers (Enterline et al. 2012). Water temperatures at our study sites were all within these ranges at the beginning of our study, which was likely after the onset of spawning.

Smelt eggs incubate for a period of between 10-21 days, and a study of egg mortality found that smelt eggs could survive in water temperatures of up to 28.6 °C for short periods of time (Chase 2006, Barker et al. 1981). Water temperatures at our study sites did not approach this threshold within 21 days of the end of spawning (or within the total study period), except at BC01 where the maximum temperature reached 27 °C on May 17th.

Figure 3. Rainbow smelt length distribution and sex ratio: a.) Bass Cove Creek, b.) Dolly Gordon Brook, c.) Smelt Brook, and d.) York River.

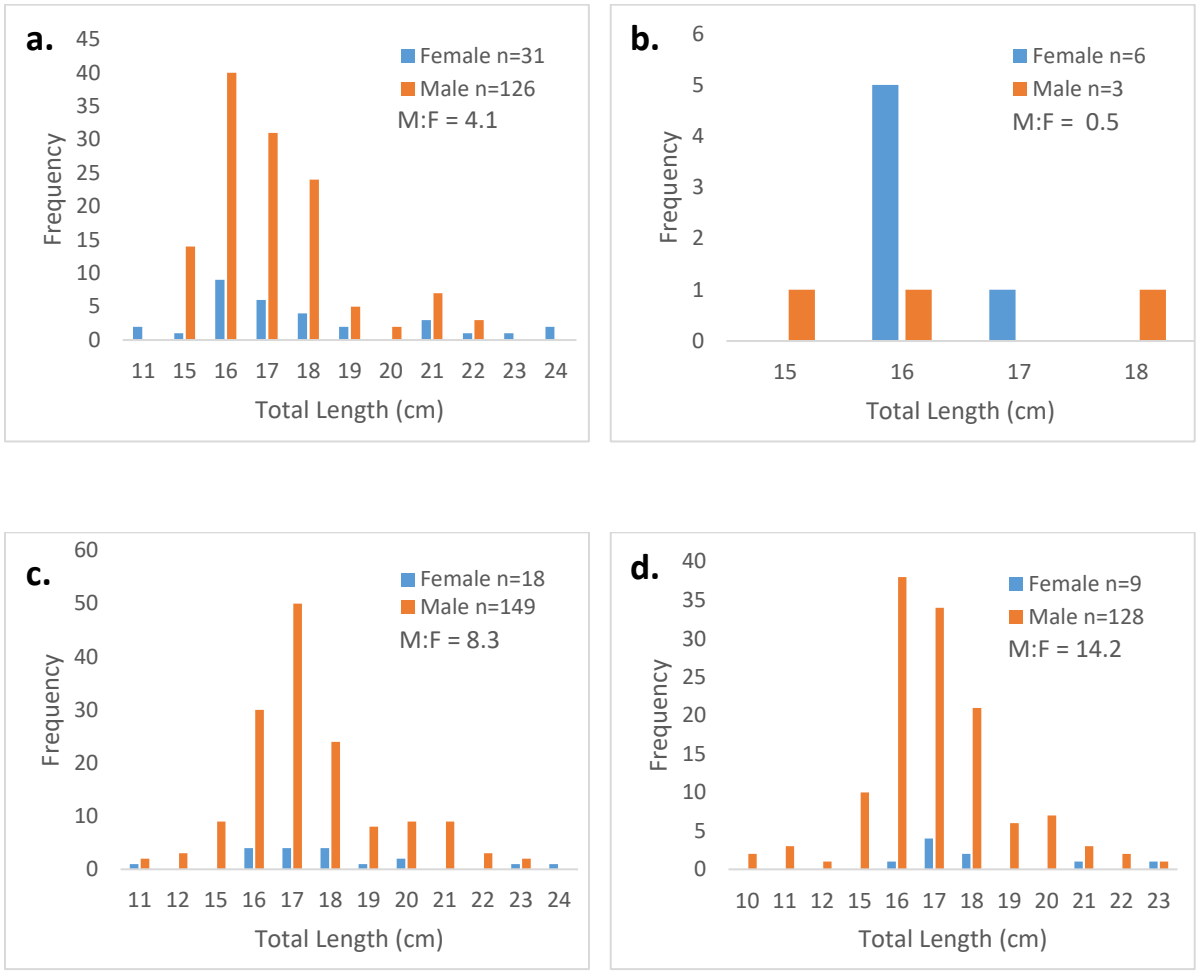
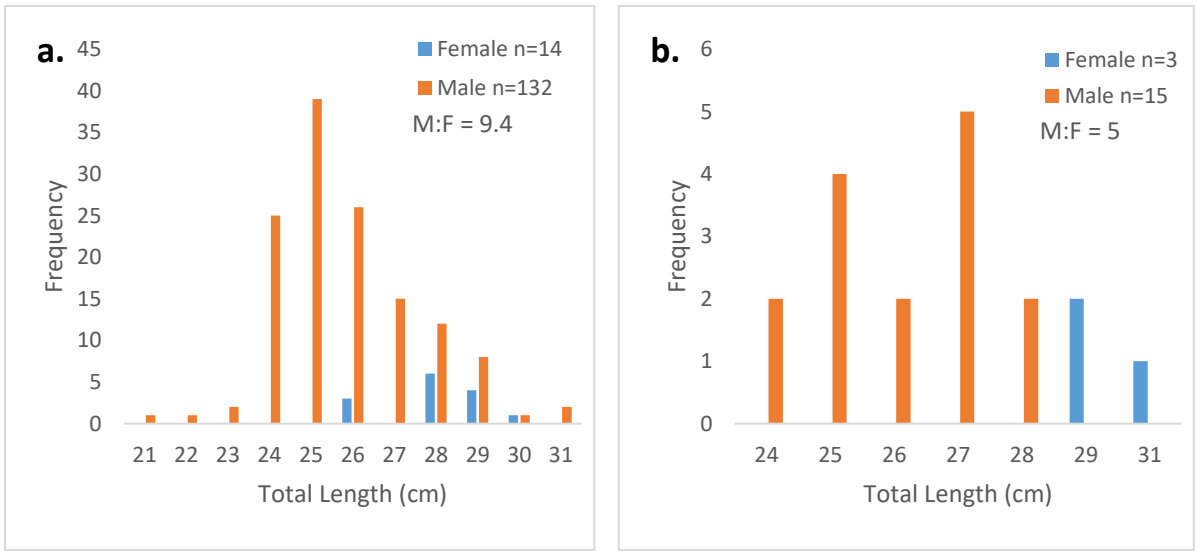


Figure 3. Alewife length distribution and sex ratio: a. Smelt Brook, and b. York River.



Date	Length (mm)	Dolly Gordon Brook	Smelt Brook	York River
20-Apr	158		1	
9-May	105		1	
	190		1	
	193		1	
	240			1
10-May	125		1	
	140		1	
	157		1	
	160		1	
	181		1	
	182		1	
11-May			1	
23-May			2	
24-May	135		2	
	212	1		
6-Jun			1	

Table 2. Daily brook trout catch and total length.

Salinity and depth were monitored primarily to help determine the proximity of our study sites to the head-of-tide in their respective streams. At Bass Cove Creek salinity ranged from 0-32.1 ppt and the mean salinity was 17.5 ppt, and water depth fluctuated up to 2.8 meters. At Dolly Gordon Brook salinity ranged from 0-28.4 ppt and the mean salinity was 8.2 ppt, and water depth fluctuated up to 2.8 meters. At Smelt Brook salinity ranged from 0-3.7 ppt and the mean salinity was 0.1 ppt, and water depth fluctuated up to 2.2 meters. At the York River salinity ranged from 0-8.5 ppt and the mean salinity was 0.3 ppt, and water depth fluctuated up to 2.9 meters. These data indicate that all of our sites were tidally influenced to varying degrees, with Smelt Brook being the least influenced and Bass Cove Creek being the most. None of the sites were located upstream of the head-of-tide and so we expect that all smelt and alewife spawning activity was taking place upstream of our sampling sites.

We compared the smelt data from our one-year study to those of a multi-year (2008 – 2011) study of rainbow smelt in Maine New Hampshire, and Massachusetts (Enterline et al. 2012). This comparison focuses on a subset of the New Hampshire and Maine sample sites that are in closest geographic proximity to the York River. These include the Oyster, Squamscott, and Winnicut Rivers in Great Bay, New Hampshire, and Long Creek and Mast Landing in Casco Bay, Maine. Where possible we have made our analysis comparable to this study, which is the best available information on regional smelt populations. We compared Catch Per Unit Effort (CPUE), median total length, and sex ratio. Enterline et al. 2012 calculated CPUE as the geometric mean of the average weekly catch per haul. For the York River data, we calculated the CPUE for each individual site, as well as for the entire watershed. The CPUE for the York River watershed was higher than the Winnicut and Squamscott Rivers but was lower than the rest of the sites. However, when individual study sites were compared, Smelt Brook had the second highest CPUE and the York River the fourth highest. Length of male smelt in the York River were comparable to the largest sizes in the other rivers, but length of females in the York River fell in the middle of the sizes from the other rivers. Except for Dolly Gordon Brook, which had a low sample size, York River sites had a higher male to female smelt sex ratio than in the other rivers. These statistics are compared in Table 3.

Site	CPUE	Median Length F (mm)	Median Length M (mm)	Sex Ratio M:F
Mast Landing	26.11	180	169	2.7
Long Creek	11.39	176	168	3.3
Oyster River	5.62	166	156	5.7
Winnicut River	1.64	na	na	na
Squamscott River	3.06	118	159	3.7
Bass Cove Creek	3.52	160	156	4.1
Dolly Gordon Brook	0.62	170	166	0.5
Smelt Brook	16.54	174	169	8.3
York River	7.94	171	167	14.2
York River Total	3.87	171	168	8.8

Table 3. Comparison of Rainbow smelt CPUE, length, and sex ratio between Enterline et al. 2012 and York River 2017.

We also wanted to compare our results with more recent data on nearby smelt runs. The New Hampshire Fish and Game Department conducts an annual assessment of rainbow smelt in the three Great Bay Rivers included in Enterline et al. 2012. We have included a comparison of the Great Bay and York River smelt populations, based on findings in the NHFG Progress Report (NHFG 2016). For this comparison we have examined CPUE and mean total length, and male to female sex ratio. The NHFG study used a different CPUE calculation for 2016, based on the geometric mean of catch per soak time (hours fished). The CPUE was higher for the York River sites (except Dolly Gordon Brook) than the other rivers. The mean length for both males and females was highest in the York River (except males in Dolly Gordon Brook). York River sites (except Dolly Gordon Brook) had a higher male to female ratio than the Oyster and Squamscott Rivers but much lower than that of the Winnicut River. These statistics are compared in Table 4.

A winter flounder captured at Bass Cove Creek.

Site	CPUE	Mean Length F (mm)	Mean Length M (mm)	Sex Ratio M:F
Oyster River	5.39	137	137	2.9
Winnicut River	4.44	136	139	30.3
Squamscott River	7.84	160	164	7.9
Bass Cove Creek	9.40	177	171	4.1
Dolly Gordon Brook	1.45	161	162	0.5
Smelt Brook	16.58	177	173	8.3
York River	11.47	182	168	14.2
York River Total	8.68	178	171	8.8

Table 4. Comparison of Rainbow smelt CPUE, mean length, and sex ratio between NHFG 2016 and York River 2017.

The NHFG report also listed the fish species bycatch data for the three rivers. The Winnicut River had a total of 8 species, the Squamscott River had a total of 19 species, and the Oyster River had a total of 17 species, while the York River had a total of 22 fish species. Some notable differences were that the York River study did not find any sea lamprey (important diadromous species) or blueback herring (Maine SGCN and NOAA SOC), while the other rivers lacked brook trout. The York River also did not have two invasive species, black crappie and chain pickerel, that the other rivers did have (though chain pickerel were found in the York River in 2001).

Field surveys of spawning habitat were carried out in Smelt Brook, York River, and Bass Cove Creek. Dolly Gordon Brook was not included due to the relatively low number of smelt in samples at that site and based on GIS data that indicated small likelihood of suitable spawning areas upstream. In the York River the first potential spawning area upstream of the fyke net was located just above the head-of-tide in a forested reach approximately 400 meters downstream of the Frost Hill Road crossing. No smelt eggs were observed during the survey of this area. In Smelt Brook the first potential spawning site upstream of the fyke net was located approximately 800 meters upstream of the Cider Hill Road Crossing in a forested reach adjacent to several homes. No smelt eggs were observed during the survey of this area. In Bass Cove Creek the first potential spawning area was identified directly downstream of the Cider Hill Road crossing in a high gradient reach adjacent to fringing salt marsh. Smelt eggs were observed in this area, which was tidally influenced. Many eggs were found out of water at low tide and appeard to be dead, but there were many also in the small low tide channel that were alive. Additional potential spawning habitat was identified approximately 100 meters upstream of the Cider Hill Road crossing on Bass Cove Creek.

The GIS analysis of riparian habitat is ongoing as of the writing of this report. Preliminary analysis shows that the amount of riparian land within the York River watershed that is vulnerable to future development is approximately 2,277 acres (34%).

We collected eDNA samples in Smelt Brook and the York River, upstream of the fyke net locations, from the first week of April until two weeks after smelt spawning finished. We were successful in detecting smelt in our eDNA samples at both sites. Preliminary results indicate that the method is sensitive enough to detect very small amounts of smelt DNA, as well as the increase and decrease in the quantity of eDNA in the stream as the smelt spawning run proceeded.

Discussion

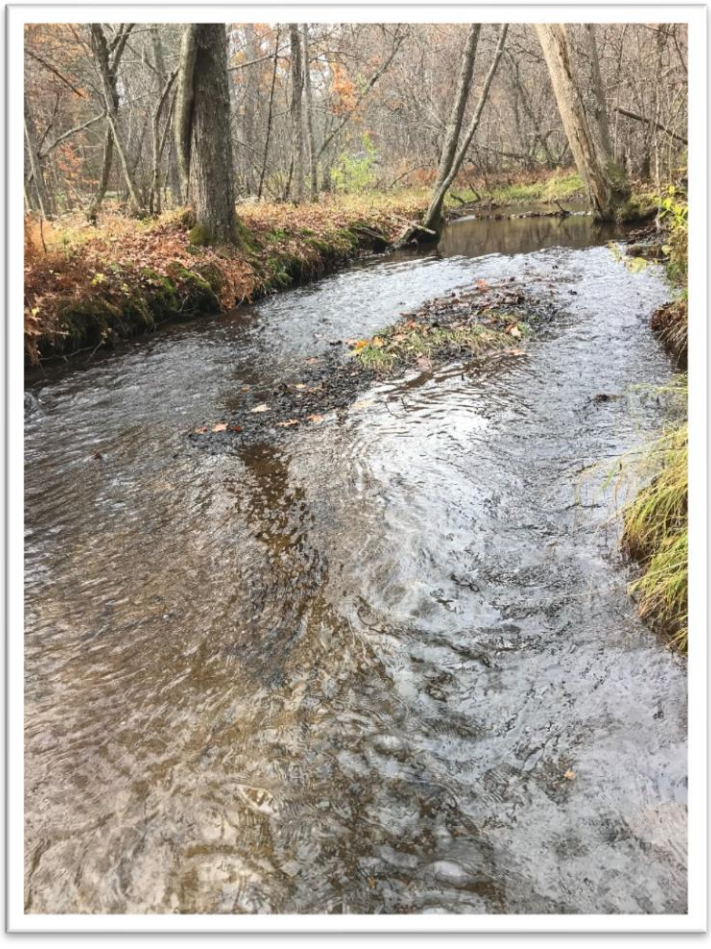
This study has shown that the York River supports a diverse fishery which includes at least five Maine Species of Greatest Conservation Need (alewife, American eel, brook trout, rainbow smelt, winter flounder), and three NMFS Species of Concern (alewife, American eel, rainbow smelt). The presence of spawning populations of both rainbow smelt and alewives indicates that there is productive habitat for anadromous species within the watershed. These species provide an important seasonal forage base for many aquatic and terrestrial species, including larger recreational and commercial fish species, marine and freshwater dependent mammals, and fishing birds. We were very pleased to document what appears to be a sizable run of rainbow smelt, a species that has undergone declines in Maine and elsewhere. Based on available information for other rivers in southern Maine (Aman 2016), the York River population appears to be largest between Great Bay, NH and Casco Bay, ME, and is likely an important contributor to the Gulf of Maine population. Our habitat surveys indicate that there is a diversity of spawning habitat for rainbow smelt in multiple tributaries to the York River, which likely enhances the resiliency of the population to future disturbances.

Smelt eggs appear as small white spheres, a few millimeters in diameter, attached to gravel in Bass Cove Creek. The opaque color indicates that these eggs are dead.

Standardized sampling used in this study provides a basis for comparison to other Gulf of Maine rainbow smelt populations and allows us to draw a few conclusions about the York River smelt:

- The spawning rainbow smelt population in the York River likely numbers in the tens of thousands. Enterline et al. 2012 noted that fyke net sampling efficiency was potentially very low, averaging 3.8% in one study of catch efficiency on the Fore River, MA.

- Relative abundance of smelt in the York River appears to be higher than Great Bay to the south, and lower than the Casco Bay to the north. These results generally conform to those of Enterline et al. 2012, who found that Maine rivers had higher relative abundance of smelt than those of New Hampshire and Massachusetts.
- The size of the smelt in the York River appears to be on the large end when compared to other nearby populations. We did not collect age data and so cannot determine if this is due to a high growth rate, or a larger percentage of older fish.
- The majority of rainbow smelt spawning is likely taking place in the upper York River mainstem, Smelt Brook, and Bass Cove Creek.
- The sex ratio of the smelt population is skewed toward males and is on the higher end when compared to adjacent systems. Enterline et al. 2012 noted that the number of females can be a limiting factor for productivity, and can indicate a population under stress, but also point out that male repeat spawning behavior introduces a bias into this population metric.



Gravel and riffle spawning habitat in Smelt Brook.

While preferred spawning habitat for alewives is in ponds and lakes, little of this habitat is accessible in the York River watershed due to the presence of dams. Despite this lack of access there is a spawning population of alewives numbering at least in the hundreds, likely making use of low velocity pools, riparian wetlands, and backwatered stream reaches. The large number of tributaries in the York River may be a contributing factor, supplying a larger amount of suitable habitat than might otherwise be available in a more linear river system. There was no available information on net efficiency for sampling alewives with fyke nets, but it may be a fair assumption that net avoidance is an issue with this species, and catch may be a small percentage of the total population. In which case, the spawning alewife population may number in the thousands. More study is needed to estimate alewife population size and identify available spawning habitat.

While we knew from previous studies that brook trout inhabit the upper reaches of the York River, it was encouraging to find them also utilizing the estuary and migrating between the tidal and freshwater reaches of Smelt Brook. We monitored 18 brook trout in our fyke nets, 16 of which were sampled in Smelt Brook. Most of these fish were caught prior to stocking of hatchery raised brook trout on May 12th (IFW 2017). Additionally, the size range of the brook trout we sampled were generally smaller than those of stocked fish. This indicates that the fish we sampled were likely from a wild population. The fact that they were captured moving upstream from the estuary is an indication that at least some of these fish may be utilizing estuarine habitat and could represent an anadromous population, a rare life history trait today, but once common in coastal streams (Dauwalter and McGurrin 2013). These findings merit further investigation into the use of estuarine habitat by brook trout, and a potential sea-run population.

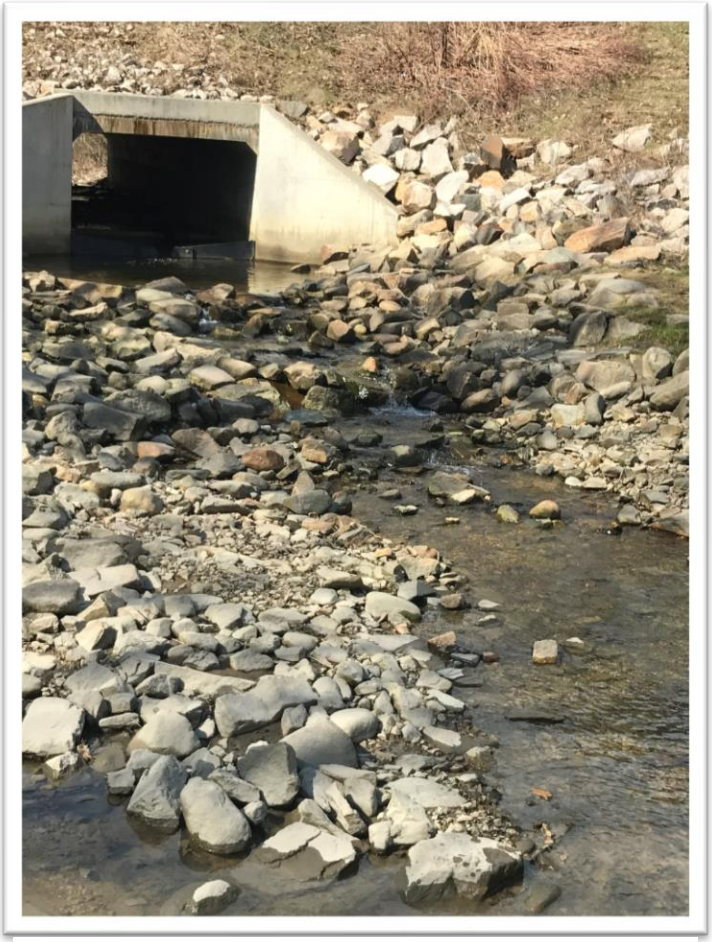
Field surveys of the potential spawning areas for rainbow smelt only located smelt eggs in Bass Cove Creek. Despite this, we are confident that the other potential spawning areas would be utilized by smelt, due to apparent quality, and location of this habitat, and the presence of stream barriers that would prevent accessing habitat further upstream. Our field surveys were limited and may not have coincided with peak egg deposition at those locations, or we simply didn't look in the right part of the stream. Further surveys will be needed to definitively locate smelt spawning areas in these streams. In Bass Cove Creek, the deposition of eggs in the tidally influenced reach below the culvert at Cider Hill Road is potentially problematic for egg survival since eggs deposited at high tide could be left out of water during low tide. Our surveys identified suitable spawning habitat upstream of the culvert, which would likely be utilized if smelt could get passed the culvert. Use of this non-tidal habitat would avoid mortality from being left out of water at low tide. Additionally, the upstream reaches were forested, and would generally provide better environmental conditions for egg survival.

The results of our GIS analysis of riparian habitat vulnerability indicate that approximately one third of these areas have the potential to be developed under current condition. Given the importance of this habitat for maintaining environmental conditions in adjacent streams, these areas should be considered for future protection where possible.

The results of the eDNA pilot study indicate that this method will be a useful tool for tracking the presence of rainbow smelt in coastal streams. The data collected in 2017 will provide a baseline for comparison of future monitoring and could allow eDNA to be used to monitor relative changes in population abundance.

Recommendations

Our analysis and conclusions for this study rely heavily on the work by the state fisheries agencies, which represent the most comprehensive assessment of diadromous fish populations and associated habitat, as well as the environmental conditions that influence them, in northern New England. We draw from the conservation strategies identified by these groups in making recommendations for future actions by the York River Study Committee and partners.



Tidally influenced smelt spawning area downstream of the Cider Hill Road crossing on Bass Cove Creek.

Enterline et al. 2012 carried out a GIS analysis of the correlation between watershed characteristics and smelt CPUE. They found that there is a correlation between watershed development (or lack of development) and smelt population size. Watersheds with a higher percentage of development in general showed an impact to their rainbow smelt populations when compared to those with a higher percentage of intact forested watershed area. They also observed that clearing of riparian vegetation creates adverse conditions for smelt egg deposition and survival. Stream flow was also found to be a critical factor in the success of rainbow smelt spawning. Finally, stream barriers that restricted access to smelt spawning habitat were shown to negatively impact spawning. These observations can be assumed to hold true for other diadromous species. Based on these observations, and findings of this report, the following recommendations should be considered for inclusion in the York River Watershed Stewardship Plan, most of which will have benefits for the entire range of fish SGCN present in the watershed:

- Additional data should be collected on the condition of anadromous fish species in the York River, including tributaries that were not sampled as part of this study, to develop a better understanding of the health and distribution of these populations. It would be useful to collect scale samples for aging of smelt to further compare with regional populations. Ideally, studies should be carried out on an annual basis to establish trends in smelt populations dynamics.
- Where possible, riparian habitat should be protected around spawning sites, particularly forested riffle and pool habitat in the higher productivity tributaries of Smelt Brook, Upper York River, and Bass Cove Creek. Efforts should be made to limit the urbanization of the York River watershed through land conservation, low impact development, and other measures to maintain forest areas.

- Man-made stream barriers should be replaced with adequately sized structures that contain natural substrate and provide unimpeded passage for migratory fish, ideally conforming to USFS Stream Simulation Design (USFS 2008). The road-stream crossings on major tributaries should be the focus of replacements efforts as these are likely to have the most negative impact for migratory fish. Priority sites include the crossings of Frost Hill Road and the York River, Route 91 and Smelt Brook, and Cider Hill Road and Bass Cove Creek. Because smelt have been documented to make upstream migrations to the spawning runs during low or outgoing tides when high tides do not coincide with nighttime hours (Enterline 2013), it is important that tidal crossings be passable during all tidal stages, not just high tides. Three priority crossings listed here all have perched outlets at low tide.
- As new information is generated on habitat and fisheries in the York River, these data should be referenced with available stream barrier database on the Maine Stream Habitat Viewer, to continue to prioritize road/stream crossings for upgrade. This MSHV is available online: https://webapps2.cgis-solutions.com/MaineStreamViewer/
- Discussions should begin with the Kittery Water District as the primary controller of in-stream flows, to make them aware of the importance of maintaining the appropriate flow conditions in the tributaries where water withdrawals occur. Flows during anadromous fish migrations (March through June, and October to December) should be maintained to adequately support spawning. Information on current stream flow management was not researched for this study but should be included in future assessment of anadromous and resident fish habitat in the York River watershed.
- Additional surveys should be conducted to identify the location of rainbow smelt and alewife spawning areas. Ideally, a comprehensive assessment of smelt spawning habitat should be conducted following Massachusetts Division of Marine Fisheries protocols (Chase 2010), to assess water quality at spawning locations and identify any degradation that could negatively impact smelt spawning success.
- Efforts should be made to improve spawning habitat where possible, and in particular to provide access upstream of the Cider Hill Road culvert on Bass Cove Creek so that spawning can occur above tidal influence.
- These strategies rely on community support, and therefore we recommend that education and outreach activities related to the fisheries resources in the York River be made to the communities. For this study, York High School students participated in fish sampling, and similar public engagement to should be pursued in the future to foster local appreciation for the unique resources of the York River.

The perched outlet of the Cider Hill Road culvert on Smelt Brook blocks upstream fish passage.

Project Outcomes

The following products were created and distributed as part of this project:

- Three presentations by Wells NERR staff to the York River Study Committee.
- Two online ESRI Story Maps were created for the York River, including as assessment of road/stream crossing infrastructure and restoration priorities, and summary data from the SGCN surveys.
  http://www.arcgis.com/apps/MapSeries/index.html?appid=5b59e95ed781426a81a4f5f9e239067d
  http://www.arcgis.com/apps/MapSeries/index.html?appid=89ad4817c0a6484099d6485820bcc704
- Two project articles on the Wells NERR blog:
  https://www.wellsreserve.org/blog/rainbow-smelt-in-the-york-river
  https://www.wellsreserve.org/blog/community-makes-york-river-fish-study-a-success
- Data from the SGCN surveys was shared with Maine DMR for inclusion in their statewide database.

- Spatial data layers were created for SGCN survey data and these data were shared with Maine DMR and project partners.
- Baseline eDNA data was collected which will provide a basis for future assessment with this novel new tool.
- 5 York High School students and their teacher were engaged in collecting SGCN study data during spring 2017 sampling. Their participation was covered in the press: http://www.seacoastonline.com/news/20170508/yhs-students-study-fish-species-in-york-river
- A complete report on the habitat assessment and GIS analysis will be made available to the YRSC when it is completed in spring 2018.

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Appendix A. York River Habitat and GIS Analysis

York River Habitat and GIS Analysis

Summary Report

Prepared by Jacob Aman and Susan Bickford
Wells National Estuarine Research Reserve
February 2018

Funding for this study was provided by the Maine Coastal Program, the Wells National Estuarine Research Reserve, and the Laudholm Trust.

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Background

The Wells Reserve carried out an assessment and analysis of fish Species of Greatest Conservation Need (SGCN) in the York River, Maine during the spring of 2017. This work was funded by the York River Study Committee (YRSC) which is seeking natural resource information to inform a watershed stewardship plan for the York River. The fish study provided information on the presence/absence, biological condition, and relative abundance of several important diadromous species, including rainbow smelt, alewife, American eel, and brook trout.

In addition to this study, a limited assessment of spawning habitat and riparian habitat condition was conducted to identify areas of the watershed that are most critical for supporting diadromous fish populations, and to further support efforts by the YRSC. This report summarizes the findings of the habitat assessment and is included as an appendix to the final report to the YRSC.

Spawning habitat in Bass Cove Creek

Habitat Assessment and GIS Analysis Methods

Potential spawning areas (PSA) for rainbow smelt were identified by walking upstream at the head-of-tide in each study tributary until the first area of riffle habitat with cobble and gravel substrate was identified (Chase 2010). Photographs were taken, and GPS coordinates were recorded at the downstream and upstream ends. A spatial data layer was created for the PSAs. Once potential spawning areas were identified, visual surveys were conducted to locate smelt eggs during the spawning run.

The accuracy of the GIS analysis was limited by the accuracy of the data, but it does provide a useful approximation of riparian areas and land cover types at the watershed scale. The analysis of riparian land condition utilized the National Land Cover Dataset (NLCD), Shoreland Buffer areas for the York River watershed, wetland features from the National Wetlands Inventory (NWI), and water features from the National Hydrography Dataset (NHD) (MRLC 2018, MDIFW 2018, USFWS 2018, USGS 2018). Spatial data were obtained online and edited and analyzed in ArcMap software (ESRI 2018).

The Shoreland Buffer feature for rivers (250 feet) and streams (75 feet) was obtained from the Beginning with Habitat program. Additional buffer features were created to include 250 feet around all ponds and wetlands with area greater than 10 acres. These features then were merged into one feature representing the state Shoreland Buffer established by the Mandatory Shoreland Zoning Act (MDEP 2018).

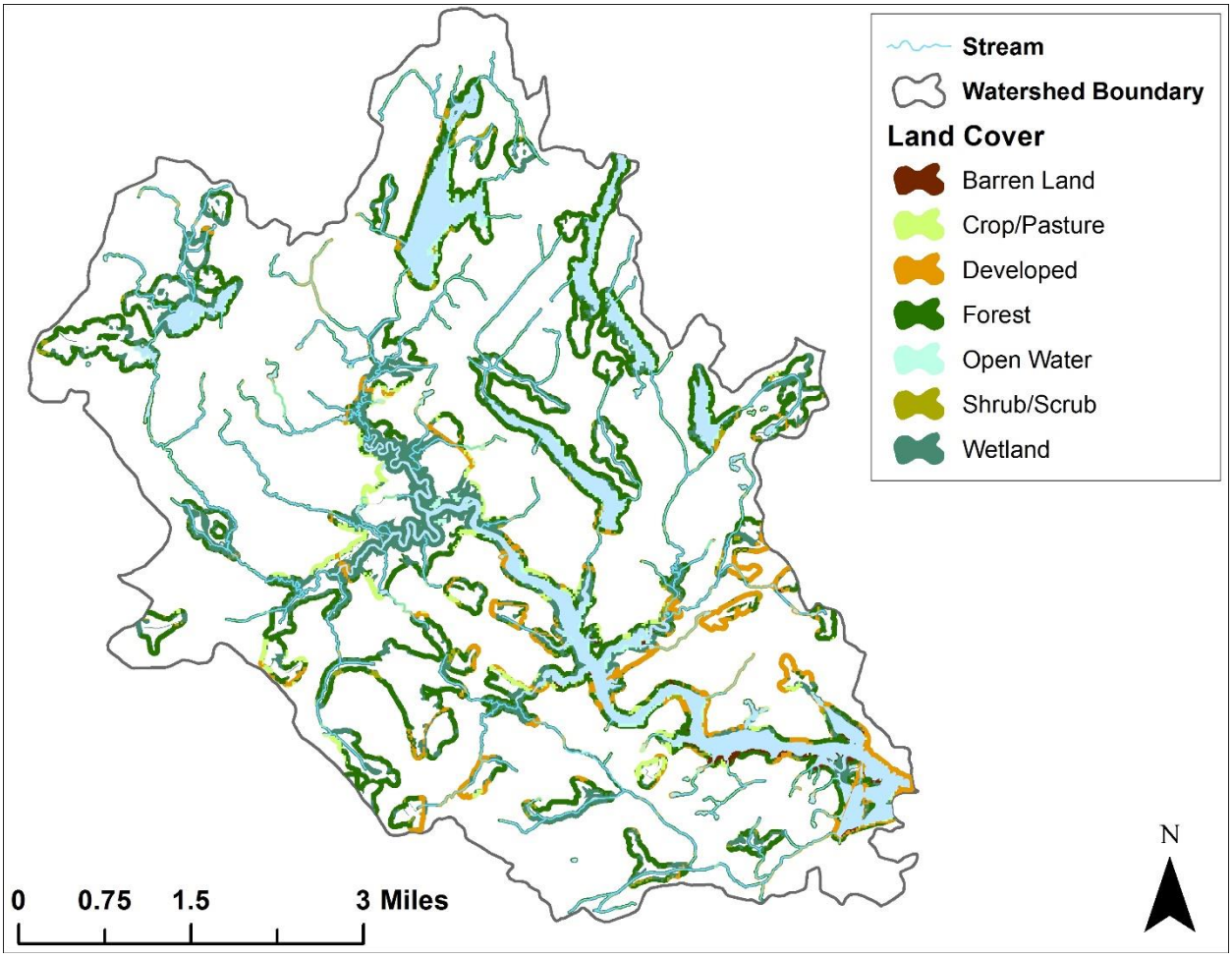

Figure 1. Shoreland Buffer landcover distribution.

The NLCD data are derived from a classification of aerial photos into generalized landcover types, such as wetlands, developed areas, and crops (Figure 1). The spatial resolution of the 2011 NLCD is 30 meters. The NLCD raster was converted to a polygon feature and clipped to include only the areas overlain by the Shoreland Buffer feature. The areas of each landcover type were measured and the percentage of each type calculated.

Study Results

Potential Spawning areas were identified in the upper York River, Smelt Brook, and Bass Cove Creek. Smelt eggs were found at Bass Cove Creek but not at the other PSAs. The PSA in the Upper York River is located downstream of the Frost Hill Road crossing. This reach is fully accessible to migrating rainbow smelt and the adjacent riparian habitat is intact. The Potential Spawning Area in Smelt Brook is located upstream of an area of freshwater marsh between Cider Hill Road and Linscott Road. Access to this habitat for migrating adult rainbow smelt is partially blocked by the culvert at Cider Hill Road. The first PSA in Bass Cove Creek is located immediately downstream of the Cider Hill Road crossing in a partially tidal reach adjacent to fringing marsh. A second PSA in Bass Cove Creek is located a short distance

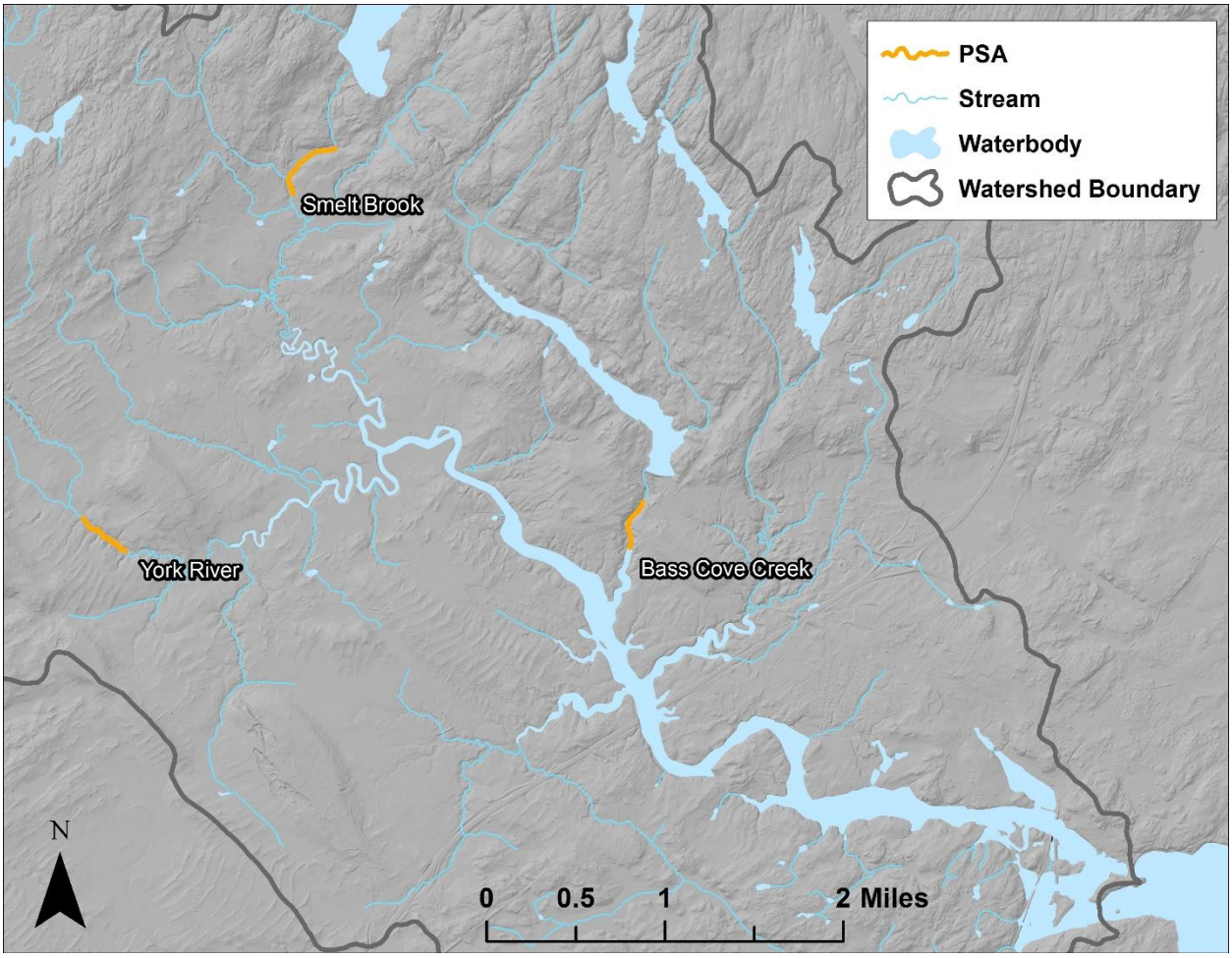

Figure 2. Potential Spawning Areas for rainbow smelt.

upstream of the Cider Hill Road culvert. Access to this habitat for migrating adult rainbow smelt is partially blocked by the culvert at Cider Hill Road. PSA locations are shown in Figure 2.

The Shoreland Buffer includes approximately 5,104 acres (24%) of the York River watershed. The areas of each landcover type in the Shoreland Buffer are shown in Figure 3. Forest and wetland landcover types account for 82% of the Shoreland Buffer. It is notable that the 1,926 acres of small wetlands in the Shoreland Buffer represent 74% of the total acreage of mapped wetlands in the York River watershed. Approximately 1,487 acres (29%) of the Shoreland Buffer are located on conserved land.

Discussion and Recommendation

The 2017 fisheries assessment in the York River identified a significant population of spawning rainbow smelt, however field observations did not identify the location of smelt eggs in two of the three tributaries where smelt were captured. The PSAs identified in this study may represent habitat that is not being utilized, and additional spawning areas could exist in these streams where the majority of spawning is taking place. The presence of stream barriers in Bass Cove Creek and Smelt Brook are likely preventing rainbow smelt from accessing upstream spawning areas. Future assessment work should be carried out to identify the location and extent of utilized spawning habitat in the York River. Efforts

should also be made to mitigate the effects of the stream barriers, wither through replacement or retrofits.

The condition of riparian habitat in the York River appears to be largely undeveloped, comprising mostly forest and small wetlands. Development in the riparian buffer is concentrated mostly in the southern area of the watershed near the town center of York and along the Route 1 and I-95 corridors. Almost one third of the riparian buffer is on conservation land, and this likely contributes to the intact state of riparian habitat. The landcover data used in this analysis is the best publicly available dataset, but it is course, with a 30-meter resolution. Development of a higher resolution landcover dataset would be useful to more accurately assess the condition of riparian habitat along individual small streams that provide important habitat for SGCN. Alternatively, riparian habitat condition in critical stream reaches could be assessed using field-based methods, which would provide much more detail on canopy density, vegetative cover, condition of stream banks, and other important habitat characteristics. While the shoreland buffer is afforded some protection from development by land use regulations, additional efforts should be made to sustain intact riparian habitat in critical locations and throughout the watershed.

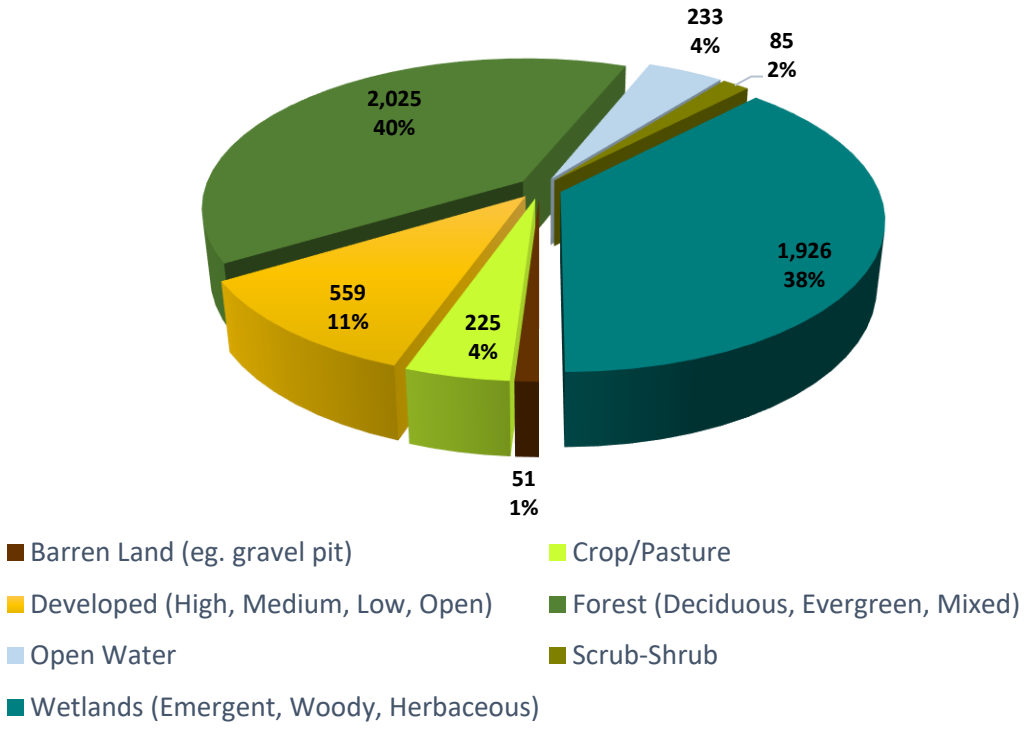

Figure 3. Shoreland Buffer landcover type acreage and percentage of total.

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