PROGRESS REPORT

State: **NEW HAMPSHIRE** **Grant**: **F-61-R-24/F21AF00591**

Grant Title: **NEW HAMPSHIRE'S MARINE FISHERIES INVESTIGATIONS**

Project 2: **MARINE RECREATIONAL FISHERIES MONITORING**

Job 1: **MONITORING OF THE RAINBOW SMELT RESOURCE AND WINTER ICE FISHERY**

Objective: To annually monitor the resource of Rainbow Smelt *Osmerus mordax* and its fishery in the Great Bay Estuary system.

Period Covered: January 1, 2021 – December 31, 2021

ABSTRACT

During the 2021 winter ice fishing season the NHFG conducted one investigation to monitor the Rainbow Smelt *Osmerus mordax* resource through fishery-dependent data in the Great Bay Estuary by producing catch and harvest estimates with a goal maximum proportional standard error of 30. In 2021, 102 anglers were interviewed and reported a yearly mean catch per unit effort of 1.9 Rainbow Smelt per angler hour. Using the reported trip information provided by smelt anglers along with angler counts, the estimated effort was 484 trips, resulting in 3,521 fish harvested. Across locations, the number of days of favorable ice conditions and observed smelt fishing activity ranged between zero and 39 and the lack of fishing effort resulted in a low ice-on index (366). Habitat degradation and water quality are concerns as the relative abundance index of catch per unit effort remains low.

INTRODUCTION

New Hampshire's Great Bay Estuary traditionally provides a winter recreational Rainbow Smelt *Osmerus mordax* fishery. In 1977, complaints from anglers concerning the quality of the fishery led to an investigation by the New Hampshire Fish & Game Department (NHFG). Length and age data were obtained from the catch of anglers during the winter fishery. These data were compared with earlier studies of Rainbow Smelt in the Great Bay area (Warfel et al. 1943; Krochmal 1949). When an absence of age-2 Rainbow Smelt was observed in 1977,

indicating possible recruitment problems, an emergency closure to the taking of Rainbow Smelt was enacted except during the winter ice fishery. The management decision reduced fishing mortality and protected the spawning run, while providing the opportunity to obtain information by creel survey. This action was followed by a 5-year study of the Rainbow Smelt resource and fishery from 1979 to 1983 under Federal Aid Project F-36-R. The results of that study illustrated a general decline in CPUE (fish/angler hour). Only one year out of five had a normal age distribution (more age-2 fish than older age classes) in the winter ice fishery. The egg deposition was, at best, one-sixth of the level considered to be optimal, roughly 13 eggs/cm^2 (Rothschild 1961; McKenzie 1964).

A statewide fisheries management plan for Rainbow Smelt was written in 1981 (NHFG 1981). The objectives for the sea-run Rainbow Smelt portion of the management plan included:

1. Maintain or increase the sea-run population of Rainbow Smelt
2. Provide for a sea-run recreational Rainbow Smelt fishery

Management measures implemented following development of the plan included closure of the fishery to net and weir harvesters from March 1 to December 15, a daily possession limit of 10 liquid quarts, and implementation of a Rainbow Smelt egg transfer program. When data from the 2014 smelt creel survey indicated that CPUE had fallen to the lowest level on record, management measures were taken to reduce the harvest in subsequent years. Beginning in 2015 the daily possession limit became four liquid quarts. To evaluate the effectiveness of the management measures and detect trends in resource abundance, a creel survey of the recreational ice fishery is conducted annually (except 1983–1986), coastal harvest logbooks are used to monitor bow net harvest of Rainbow Smelt (See Project III-2), and a Rainbow Smelt egg deposition survey was conducted annually from 1979 to 2007. The egg deposition survey was terminated in 2007 because of poor correlation with the catch data; it was reinstated in 2014 under Project I-2 with updated procedures.

PROCEDURE

The winter Rainbow Smelt Fishing Creel Survey is conducted from roughly ice-in to ice-out, which typically occurs between the months of December and March. Four areas of major Rainbow Smelt angling activity were identified and surveyed throughout the project period: the Lamprey, Squamscott, and Oyster—Bellamy rivers, as well as Great Bay proper. The Depot Road/Winnicut River sites continue to be included as these historical fishing areas in isolated parts of

Great Bay have the potential for continued fishing effort.

The survey was designed using a schedule of random two-hour survey periods between 0600 and 2400 hours. Locations are weighted by relative fishing effort from previous years and then randomly selected. After a location is selected, the AM and PM tide is alternated by day and an offset is randomly assigned. Times that fall outside of two hours before or five hours after the high tide are eliminated due to the lack of fishing activity around low tide. At least one survey is scheduled for each day of the week with supplemental surveys added to ensure each location is surveyed at least once during each weekday period and once during a weekend. Additionally, beginning in 2009, an instantaneous count method was conducted during each day of the winter ice fishery. The counts are obtained separately from the creel survey activities by driving to each of the four locations and counting the number of anglers actively participating in the fishery after the scheduled creel survey is completed.

All anglers, or a subsample, are interviewed for catch and effort (hours fished) information during an assigned survey. The information collected is expanded by strata (weekend/weekday, location, and month) to provide estimates of catch, effort, and CPUE by month and location. Length and sex information, weight measurements, and scales for aging are taken weekly from samples of angler harvest. Scales are double aged using a QImaging microscopy camera and Image-Pro software, and according to methods described by Bailey (1964).

RESULTS

In 2021, the NHFG conducted one investigation to monitor the Rainbow Smelt *Osmerus mordax* resource through fishery-dependent data in the Great Bay Estuary by producing catch and harvest estimates with a goal maximum proportional standard error of 30. The resulting data produced a harvest estimate of 3,521 smelt with an associated proportional standard error of 10.7.

In 2021, the recreational ice fishery targeting Rainbow Smelt began in January and continued into March (Table 2.1-1). The number of days of favorable ice conditions and observed smelt fishing activity ranged between zero and 39 days between the four survey locations. The ice-on index of 366 was the second lowest in a decade (Table 2.1-2). A total of 102 anglers were interviewed, with estimates of 484 total trips and 1,882 total angler hours for the 2021 season (Table 2.1-1).

The 2021 angler catch data produced a catch rate of 1.9 smelt/angler hour, a decrease from 2019, the most recent year with fishing activity (Table 2.1-2 and Figure 2.1-1). The distribution across sampling locations indicated that effort was greatest at the Squamscott River, accounting for 77.3% of the total

trips; while catch was greatest at the Oyster River, with 60.4% of all smelt caught (Tables 2.2-3 and 2.1-4).

During the project period, 186 scale samples were aged (Table 2.1-5). Age-2 fish accounted for the majority of smelt at 64.1% of the harvest, weighted by catch estimates. Age-3 fish made up 21.0% of the harvest, age-4 fish accounted for 13.3%, and age-5+ accounted for 1.6% of the smelt harvest in 2021.

DISCUSSION

The concerning trends that were found in the original study under Federal Aid Project F-36-R, namely the general decline in CPUE, skewed age distributions and declining egg deposition, are still problems today. The CPUE is used as an indicator of smelt abundance and has varied greatly in the survey's time series from a high of 10.6 smelt per angler hour (1995) to a low of 0.3 smelt per angler hour in both 2014 and 2015 (Table 2.1-2 and Figure 2.1-1). With a CPUE of 1.9 smelt per angler hour, 2021 was below the average for the time series (Figure 2.1-1). Caution must be taken when interpreting these results, as there was limited and concentrated effort with the majority of fishing taking place at one access site along the Squamscott River, and only two locations with fishing effort, the estimates may not represent the smelt population as a whole.

Another positive sign was the large percentage of age-2 fish taken during the 2021 season. The catch composition could indicate a good recruitment year for the 2019 year-class. A majority of age-2 fish only occurred one other year during the past decade, with three out of the five years with data showing a skewed age distribution with the majority being age-3 fish (Table 2.1-5).

The effort, as measured by angler trips, varies annually. Many factors can affect the magnitude and distribution of fishing effort in a given year. One important factor is the seasonal ice conditions. The ice-on index is a measure of time where fishable ice is present along with angler activity where historically, was a relative comparison of season length. However, as effort has declined, the ice-on index is now more heavily influenced by angler activity. Ice conditions during the 2021 fishing season were favorable from late-January through early-March, however, effort was observed at only two locations, resulting in a low ice-on index value (Table 2.1-2).

Recent harvest and CPUE estimates suggest a continued decline in the Great Bay Rainbow Smelt population (Table 2.1-2 and Figure 2.1-1). There are many known factors contributing to the decline of anadromous species like Rainbow Smelt, including the presence of dams, overfishing, and pollution (Enterline et al. 2012). Overfishing is not likely a driving factor in recent declines in the Rainbow Smelt abundance. Taking into account that five of the winters since 2012 have not provided enough ice cover to allow for fishing and an expanded age

structure is evident in the 2021 catch and over the past decade (Table 2.1-5). The NHFG took preemptive action in response to the initial observations and investigation in the 1970's. Season and gear restrictions and bag limits protect the spawning run and prevent overfishing during the winter ice fishing season. Monitoring under this project enabled NHFG to observe catch trends and promptly enact restrictions when needed to continue to allow a responsible harvest. A more plausible cause is low recruitment caused by other anthropogenic factors.

The NHFG continues to work with towns and other stakeholders to move toward removal of dams on New Hampshire's coastal rivers whenever feasible. The head-of-tide dam on the Winnicut River was removed in 2009, the Exeter River's Great Dam complex in 2016, and the Bellamy River's Sawyer Mill Dam complex in 2020. The NHFG monitors the smelt spawning run under Project I-2; the annual CPUE of Rainbow Smelt has increased since 2016 in both the Winnicut and Squamscott rivers, compared to previous sampling years.

Pollution is a more difficult factor to mitigate. Water quality parameters such as dissolved oxygen, turbidity, and pH are monitored by the NHFG under Project I-2, along with a fishery-independent measure of the spawning run strength. Nutrient criteria have been developed for the Great Bay Estuary, which designated water quality in the entire estuary as impaired (Enterline et al. 2012). High nutrient levels, specifically nitrogen, are detrimental to the eelgrass within the bay, which acts as nursery habitat for juvenile fish but also stabilizes sediment and improves overall water quality. Between 1981 and 2016, eelgrass distribution in the Great Bay declined overall by 31% (PREP, 2018). Towns that border Great Bay are being regulated to improve wastewater facilities but non-point source pollution is a large issue with the continued urbanization of the coastal and estuarine landscape, and accounts for 68% of the nitrogen load in the Great Bay Estuary (PREP, 2018). It is difficult to pinpoint which factors are causing the greatest impact on the health of the smelt population, thus addressing all areas of concern with careful management and working toward improving impaired waters and degraded spawning and nursery habit are imperative.

In conclusion, the disconcerting trends observed in New Hampshire's smelt fishery in the late 1970's and early 1980's, such as low CPUE and a general paucity of age-2 fish, are still evident over the past decade. During years with favorable ice conditions, estimates of fishing effort remains low. The CPUE hit all-time lows for two years during the past decade and remains below the time-series average. Monitoring of the Rainbow Smelt fishery as well as environmental monitoring by the NHFG is integral to the continued management of this species.

REFERENCES

Bailey, M.M. 1964. Age, growth, maturity, and sex composition of the American Smelt of western Lake Superior. Trans. Am. Fish. Soc. 93: 382—395.

Enterline, C.L., B.C. Chase, J.M. Carloni, and K.E. Mills. 2012. A Regional Conservation Plan for Anadromous Rainbow Smelt in the U.S. Gulf of Maine. Maine Department of Marine Resources. 42-73.

Krochmal, S.B. 1949. Ecology of the Smelt, *Osmerus mordax* (Mitchell), in Great Bay New Hampshire. Master's Thesis. Univ. N.H., Durham. 78pp.

McKenzie, R.A. 1964. Smelt life history and fishery in the Miramichi River, New Brunswick. Fish. Res. Bd. Can. Bull. #144. 77pp.

New Hampshire Fish and Game Department (NHFG), 1981. Fisheries Management Plan for Rainbow Smelt (*Osmerus mordax*). Appendix I. New Hampshire Fish and Game Department, Concord

PREP (Piscataqua Region Estuaries Partnership). 2018. State of Our Estuaries Report 2018. 9—23. https://www.stateofourestuaries.org/2018-reports/sooe-full-report

Rothschild, B.J. 1961. Production and survival of eggs of the American Smelt, *Osmerus mordax* (Mitchill), in Maine. Trans. Am. Fish. Soc. 90: 42—48.

Warfel, H.E., T.P. Frost, and W.H. Jones. 1943. The Smelt, *Osmerus mordax*, in Great Bay, New Hampshire. Trans. Am. Fish. Soc. 72: 257—262.

Table 2.1-1. Estimates of catch, effort, and CPUE, by weekend or weekday, month, and location for the marine recreational Rainbow Smelt ice fishery in New Hampshire, 2021

		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
January		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. interviewed anglers	*n*	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
Fishable days	*d*	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Average trip length	*t*		4.00																
Average inst. count	*c*		3.00																
Estimated angler hours	*h = (c*12)*d*	0	72	72	0	0	0	0	0	0	0	0	0	0	0	0	0	72	72
Estimated trips	*E = h/t*	0	18	18	0	0	0	0	0	0	0	0	0	0	0	0	0	18	18
Catch per angler hour	*CPUE*		0.0														0.0	0.0	0.0
Estimated smelt caught	*C = h*CPUE*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg fish weight (kg)	*w*																		
Estimated harvest (kg)	*H = C*w*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
February		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. interviewed anglers	*n*	38	37	75	0	0	0	11	8	19	0	0	0	0	0	0	49	45	94
Fishable days	*d*	19	9	28	0	0	0	14	8	22	0	0	0	0	0	0	33	17	50
Average trip length	*t*	3.35	4.21					5.00	4.75										
Average inst. count	*c*	3.68	3.67					2.14	1.86										
Estimated angler hours	*h = (c*12)*d*	840	396	1,236	0	0	0	360	178	538	0	0	0	0	0	0	1,200	574	1,774
Estimated trips	*E = h/t*	251	94	345	0	0	0	72	38	110	0	0	0	0	0	0	323	132	455
Catch per angler hour	*CPUE*	1.3	0.3	1.0				2.7	6.6	3.9							1.7	2.2	1.9
Estimated smelt caught	*C = h*CPUE*	1,076	112	1,188	0	0	0	959	1,166	2,125	0	0	0	0	0	0	2,035	1,278	3,313
Avg fish weight (kg)	*w*	0.041	0.041					0.042	0.042										
Estimated harvest (kg)	*H = C*w*	44	5	49	0	0	0	40	49	89	0	0	0	0	0	0	84	54	138
		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
March		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. interviewed anglers	*n*	3	1	4	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4
Fishable days	*d*	7	2	9	0	0	0	0	0	0	0	0	0	0	0	0	7	2	9
Average trip length	*t*	3.00	4.50																
Average inst. count	*c*	0.29	0.50																
Estimated angler hours	*h = (c*12)*d*	24	12	36	0	0	0	0	0	0	0	0	0	0	0	0	24	12	36
Estimated trips	*E = h/t*	8	3	11	0	0	0	0	0	0	0	0	0	0	0	0	8	3	11
Catch per angler hour	*CPUE*	8.6	0.3	5.8													8.5	0.3	5.8
Estimated smelt caught	*C = h*CPUE*	205	3	208	0	0	0	0	0	0	0	0	0	0	0	0	205	3	208
Avg fish weight (kg)	*w*	0.041	0.041																
Estimated harvest (kg)	*H = C*w*	8	0	8	0	0	0	0	0	0	0	0	0	0	0	0	8	0	8
		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
Total		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. interviewed anglers		41	42	83	0	0	0	11	8	19	0	0	0	0	0	0	52	50	102
Fishable days		26	13	39	0	0	0	14	8	22	0	0	0	0	0	0	40	21	61
Est angler hours		864	480	1,344	0	0	0	360	178	538	0	0	0	0	0	0	1,224	658	1,882
Estimated trips		259	115	374	0	0	0	72	38	110	0	0	0	0	0	0	331	153	484
Catch per angler hour		1.5	0.2	1.0				2.7	6.6	3.9							1.8	1.9	1.9
Estimated smelt caught		1,281	115	1,396	0	0	0	959	1,166	2,125	0	0	0	0	0	0	2,240	1,281	3,521
Estimated harvest (kg)		52	5	57	0	0	0	40	49	89	0	0	0	0	0	0	92	54	146
Percentage of catch		57.2%	9.0%	39.6%	0.0%	0.0%	0.0%	42.8%	91.0%	60.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Percentage of hours		100.0%	73.0%	94.6%	0.0%	0.0%	0.0%	29.4%	27.0%	28.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Percentage of trips		78.2%	75.2%	77.3%	0.0%	0.0%	0.0%	21.8%	24.8%	22.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			

Table 2.1-2. Estimates of catch and effort with associated proportional standard error (PSE) and CPUE for the marine recreational Rainbow Smelt ice fishery in New Hampshire during fishing years 2012 through 2021.

Year	Months of fishery	Ice-on index	# trips	Angler hours	Angler hours PSE	Estimated harvest (number)	Estimated harvest PSE[a]	Estimated harvest (kg)	CPUE (fish/hr)
2012	*A lack of fishable ice resulted in insufficient data*								
2013	*A lack of fishable ice resulted in insufficient data*								
2014	D-M	1,698	1,014	3,694	13.5	1,078	10.3	88	0.3
2015	J-M	600	187	723	16.8	202	24.8	15	0.3
2016	*A lack of fishable ice resulted in insufficient data*								
2017	*A lack of fishable ice resulted in insufficient data*								
2018	J-F	1,056	706	2,551	17.5	5,116	6.0	849	2.0
2019	J-M	336	410	1,350	24.8	3,639	5.9	198	2.7
2020	*A lack of fishable ice resulted in insufficient data*								
2021	J-M	366	484	1,882	15.9	3,521	10.7	146	1.9

[a] Harvest PSE values were recalculated in 2021 and differ from previous reports.

Table 2.1-3. Rainbow Smelt catch by area (percent of total catch) for the marine recreational Rainbow Smelt ice fishery in New Hampshire during fishing years 2012 through 2021.

Year	Great Bay	Lamprey R.	Oyster R. —Bellamy R.	Winnicut R. —Depot Rd.	Squamscott R.	Total catch
2012	*A lack of fishable ice resulted in insufficient data*					
2013	*A lack of fishable ice resulted in insufficient data*					
2014	1.2	0.0	0.0	0.0	98.8	1,078
2015	11.8	0.0	0.0	0.0	88.2	202
2016	*A lack of fishable ice resulted in insufficient data*					
2017	*A lack of fishable ice resulted in insufficient data*					
2018	0.0	0.0	0.0	0.0	100.0	5,116
2019	0.0	0.0	0.0	0.0	100.0	3,639
2020	*A lack of fishable ice resulted in insufficient data*					
2021	0.0	0.0	60.4	0.0	39.6	3,521

Table 2.1-4. Fishing effort by area (percent of total trips) for the marine recreational Rainbow Smelt ice fishery in New Hampshire during fishing years 2012 through 2021.

Year	Great Bay	Lamprey R.	Oyster R. —Bellamy R.	Winnicut R. —Depot Rd.	Squamscott R.	Total trips
2012	*A lack of fishable ice resulted in insufficient data*					
2013	*A lack of fishable ice resulted in insufficient data*					
2014	11.2	0.8	4.6	0.0	83.4	1,014
2015	2.1	0.0	10.2	0.0	87.7	187
2016	*A lack of fishable ice resulted in insufficient data*					
2017	*A lack of fishable ice resulted in insufficient data*					
2018	1.3	0.0	0.0	0.0	98.7	706
2019	0.0	4.4	0.0	0.0	95.6	410
2020	*A lack of fishable ice resulted in insufficient data*					
2021	0.0	0.0	22.7	0.0	77.3	484

Table 2.1-5. Age distribution of harvested Rainbow Smelt, weighted by catch estimates from the marine recreational Rainbow Smelt ice fishery in New Hampshire during fishing years 2012 through 2021 (sexes combined).

	Percent at age					
Year	Age-1	Age-2	Age-3	Age-4	Age-5+	Sample size
2012	*A lack of fishable ice resulted in insufficient data*					
2013	*A lack of fishable ice resulted in insufficient data*					
2014	1.5	22.8	50.5	24.3	0.9	119
2015	0.0	38.7	48.3	9.0	4.0	37
2016	*A lack of fishable ice resulted in insufficient data*					
2017	*A lack of fishable ice resulted in insufficient data*					
2018	0.0	16.4	57.0	23.7	2.9	401
2019[a]	0.0	51.5	11.2	29.2	8.1	181
2020	*A lack of fishable ice resulted in insufficient data*					
2021	0.0	64.1	21.0	13.3	1.6	186

[a] Values differ from previous reports due to a data review.

Figure 2.1-1. Harvest and catch per angler hour of harvested Rainbow Smelt from the marine recreational Rainbow Smelt ice fishery in New Hampshire during fishing years 1978 through 2021.