FINAL REPORT

State: **NEW HAMPSHIRE** **Grant:** **F-61-R-25/F22AF00514**

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, 2019 – December 31, 2023

ABSTRACT

Between January 1, 2019 and December 31, 2023, the New Hampshire Fish and Game Department conducted one investigation per year 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. During the 2019-2023 winter ice fishing seasons, 300 anglers were interviewed and reported a yearly mean catch per unit effort of 0.2 to 2.7 smelt per angler hour. The Ice-On Index ranged from 0 to 510, and there was no fishable ice in 2020 and 2023. Using the reported trip information provided by smelt anglers along with angler counts, the estimated effort ranged from approximately 194 to 1,014 trips, resulting in between 140 and 3,639 fish harvested. Both catch and effort estimates were low compared to historic values. A lack of fishable ice paired with low harvest in years with fishable ice make informing management decisions based on these data difficult.

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

Between January 1, 2019 and December 31, 2023, the New Hampshire Fish and Game Department conducted one investigation per year 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. A total of 300 anglers were interviewed during the winter smelt fishing seasons between 2019 and 2023 (Table 2.1-1). The number of interviews in years with fishable ice ranged from 37 anglers in 2022 to 161 anglers in 2019. The lack of ice in 2020 and again in 2023 resulted in zero fishing effort. Effort and catch were highest in 2019.

During years with fishable ice since 2013, the catch and effort was lowest in 2022 (Table 2.1-2 and Figure 2.1-1).

The Squamscott River produced the largest percentage of smelt caught in 2019 and 2022 with 100% of the catch. In 2021, the Oyster River had the largest

percentage of smelt caught with 60.4% of the catch (Table 2.1-3). No catch occurred in Great Bay, Lamprey River, or Winnicut River throughout the 5 year period (Table 2.1-3). No fishing effort occurred in Great Bay or Winnicut River throughout the sampling period. Minimal fishing effort (4.4%) occurred in the Lamprey River in 2019. The majority of fishing effort occurred in the Squamscott River with 100% of the effort in 2022, 77.3% in 2021, and 95.6% in 2019. The CPUE ranged from 0.2 smelt per hour fished in 2022 to 2.7 smelt per hour fished in 2019. All years were below the time series average of 3.6 (Figure 2.1-2

A total of 390 smelt were sampled from the recreational ice fishery for age, length, and sex data during the five year period (Table 2.1-4). The number of samples collected in years with fishing activity ranged from 23 smelt in 2022 to 186 smelt in 2021. The colored highlighted areas of Table 2.1-4 indicate the various year classes within the sampled population of the fishery.

DISCUSSION

Due to many factors, the 2019-2023 winter smelt fishing seasons resulted in low sample sizes for anglers interviewed as well as scales collected. This appears to be a continuing trend, with few fish being caught, and waning interest from smelt fishermen as the Rainbow Smelt resource remains depressed.

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 (Table 2.1-2 and Figure 2.1-2) from as high as 10.6 smelt per angler hour (1995) to a low of 0.2 smelt per angler hour in 2022. The only years in the survey's time series with a similar low CPUE were 2014 and 2015, both with a catch rate of 0.3 smelt per angler hour (Table 2.1-2).

The absence of 2-year-old smelt was also a concern stated in the original study. Skewed age distributions, where age-2 fish are not the dominant age class has occurred in 67% of the sampled years since 2013. Since 2013, there have been four years where age-3 and age-4 fish both account for a greater percentage of the catch than age-2 fish (Table 2.1-4). The lack of age-2 representation in the catch could indicate poor recruitment for a particular year class.

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. In

the past, the ice-on index correlated with the estimated number of fishing trips (r=0.87), but since 2005 the correlation has apparently weakened (r=0.59) (Figure 2.1-1). This is likely due to waning interest from anglers, presumably as a result of low resource levels rather than limited fishing opportunity.

Accessibility and productivity are other factors that influence the distribution of fishing effort. Over time, the effort (total trips) has fluctuated and shifted between locations. In the early 2000's, New Hampshire's remaining two operating smelt camps closed, coinciding with a shift in effort from the Lamprey River and Great Bay to the Squamscott River. Since the year 2013, the Squamscott River has been the preferred fishing location (Table 2.1-3). The Squamscott River has one of the most accessible of all the fishing sites, an area off of River Road in Stratham, New Hampshire. Nearly all of the fishing effort has occurred at this location since 2014.

The amount of effort observed at each of the locations is also influenced by the abundance of the resource annually. For example, data from fyke net sampling of the spawning run between 2019 and 2023 showed record catches in the Oyster River in 2019, the Squamscott River in 2021 and the Winnicut River in 2022 (see Project I-2). The catch in the Squamscott River coincided with the higher catches and the highest percentage of trips for the Squamscott River smelt fishery during that same time period (Table 2.1-3). In 2019 and 2022, 100% of the fishing effort occurred in the Squamscott River. This coincided with the high CPUE in the Squamscott River and across all stations over the past five years of sampling the spawning run.

Recent harvest and CPUE estimates suggest a continued decline in the Great Bay Rainbow Smelt population (Table 2.1-2). 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 four of the winters since 2019 have not provided enough ice cover to allow for fishing and an expanded age structure is evident in the 2018 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 see catch trends and prompt additional restrictions to continue to allow a responsible harvest. A more plausible cause is low recruitment caused by the other anthropogenic factors.

The Department is working with towns and other stakeholders to move toward

removal of dams on New Hampshire's coastal rivers whenever feasible, and in fact, the head-of-tide dam on the Winnicut River was removed in 2009 followed by the Squamscott River's Great Dam in 2016. The Oyster River's Mill Pond Dam has also been approved for future removal.

Pollution is a more difficult factor to mitigate. Water quality parameters such as dissolved oxygen, turbidity and pH are being monitored by the Department 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. Since 1996, the eelgrass distribution in Great Bay has declined by 37% (Short 2013). Towns that border Great Bay are being regulated to improve waste water facilities but non-point source pollution is a large issue with the continued urbanization of the coastal landscape. It is difficult to pinpoint which factors are causing the greatest impact on the health of the smelt population but with careful management and working toward improving impaired waters and degraded spawning and nursery habitat, the New Hampshire smelt population may be able to recover.

Due to lack of fishing in 2016 and 2017, there is only one year where egg deposition can be compared with the catch of age-2 fish (see Project I-2). Additional years of data are needed in order to make a meaningful comparison of these indices.

In conclusion, the disconcerting trends that were observed in New Hampshire's smelt fishery in the late 1970's and early 1980's, such as low CPUE and a paucity of age-2 fish, are still evident. During years with favorable ice conditions, estimates of both catch and effort remain low. The CPUE hit all-time lows for two years during the sampling period. Additional years of data are needed before a determination can be made on the appropriateness of using an egg deposition index as a predictor of future year-class abundance. Monitoring of the rainbow smelt fishery as well as the environmental monitoring by the Department 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

Piscataqua Region Estuaries Partnership (PREP). 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.

Short, Frederick T. 2016. Eelgrass Distribution in the Great Bay Estuary for 2014. PREP Reports & Publications. 352. https://scholars.unh.edu/prep/352

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 Number of anglers interviewed in the marine recreational Rainbow Smelt ice fishery in New Hampshire 2019 through 2023.

Year	# Anglers interviewed
2019	161
2020*	0
2021	102
2022	37
2023*	0

* insufficient ice

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 2013 through 2023.

Year	Months of fishery	Ice-on index	# trips	Angler hours	Angler hours PSE	Estimated harvest (number)	Estimated harvest PSE	Estimated harvest[a] (kg)	CPUE (fish/hr)
2013	*A lack of fishable ice resulted in insufficient data*								
2014	D-M	1,698	1,014	3,694	13.5	1,078	38.2	88	0.3
2015	J-M	600	187	723	16.8	202	35.7	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	1,044	706	2,551	17.5	5,116	23.8	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*
2022	*J-F*	*510*	*194*	*768*	*16.7*	*140*	*24.0*	*9*	*0.2*
2023	*A lack of fishable ice resulted in insufficient data*								

[a] Prior to 2009, the estimated total harvested weight of fish was 1/10 the catch estimate. Beginning in 2009, the weight measurements taken during sampling were used to calculate harvest weight (pounds converted to kg).

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 2013 through 2023.

Year	Great Bay	Lamprey R.	Oyster R. — Bellamy R.	Winnicut R. — Depot Rd.	Squamscott R.	Total catch
2013	*A lack of fishable ice resulted in insufficient data*					
2014	1.2	0.0	0.0	NS	98.8	1,078
2015	11.8	0.0	0.0	NS	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
2022	0.0	0.0	0.0	0.0	100.0	140
2023	A lack of fishable ice resulted in insufficient data					

NS = Not surveyed due to zero effort.

Table 2.1-4. Percent age distribution of harvested Rainbow Smelt from the marine recreational Rainbow Smelt ice fishery in New Hampshire during fishing years 2013 through 2023 (sexes combined).

	Percent at age					
Year	Age-1	Age-2	Age-3	Age-4	Age-5+	Sample size
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	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
2022	0.0	8.4	51.4	40.3	0.0	23
2023	*A lack of fishable ice resulted in insufficient data*					

[a] Raw age distribution from biological samples
[b] Calculated by weighting the sample distribution by catch estimates

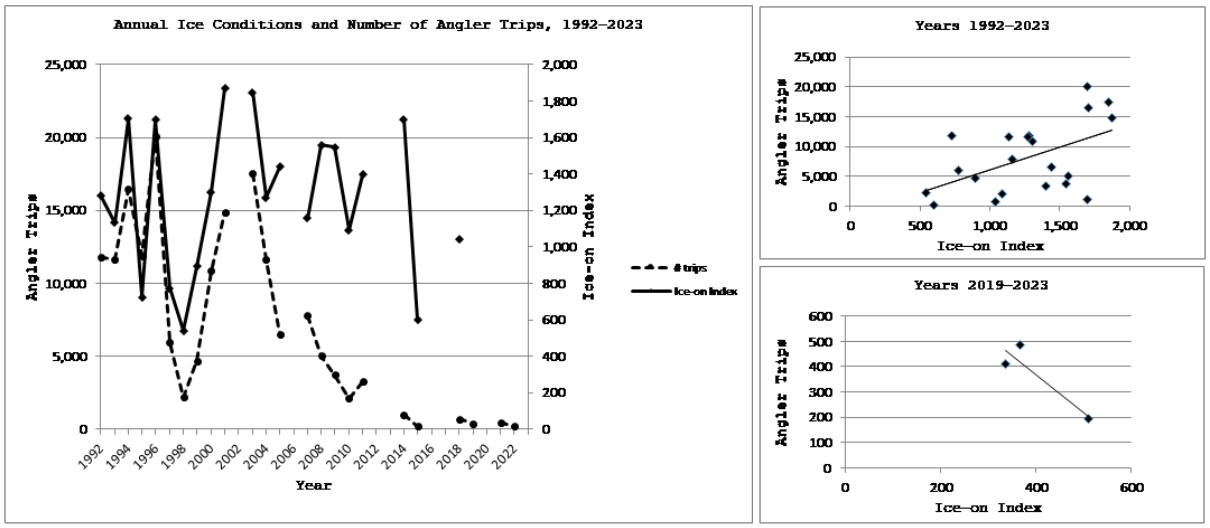

Figure 2.1-1 A comparison of annual ice conditions and fishing effort during marine recreational Rainbow Smelt ice fishery in New Hampshire, 1992 through 2023.

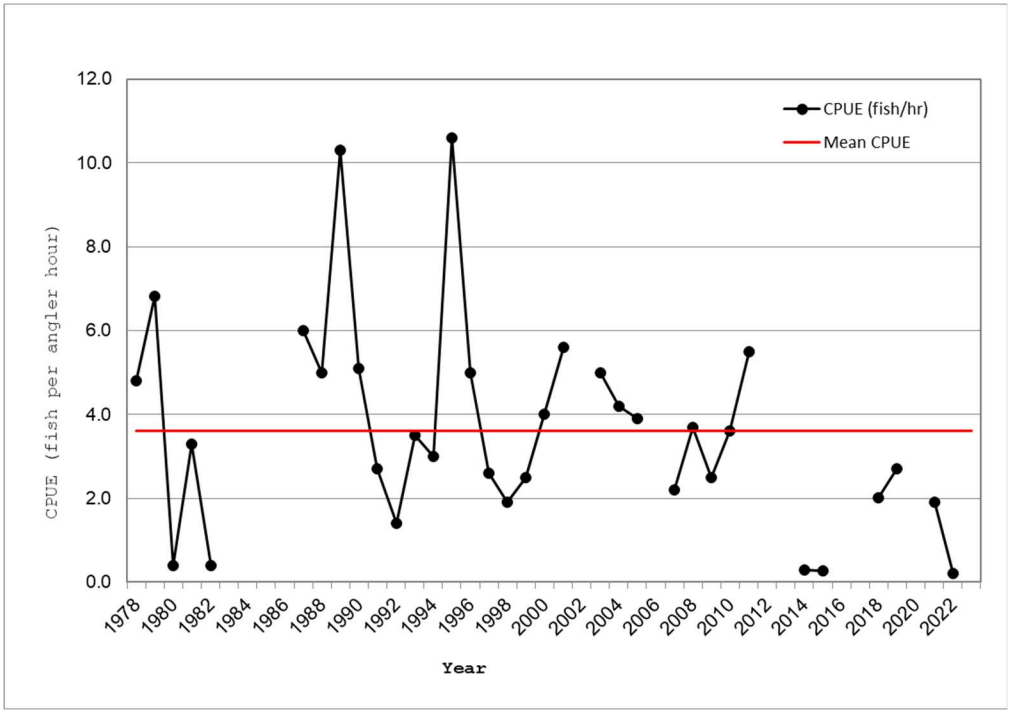

Figure 2.1-2. Catch per angler hour of Rainbow Smelt in the marine recreational Rainbow Smelt ice fishery in New Hampshire during fishing years 1978 through 2023.