PROGRESS REPORT

State: **NEW HAMPSHIRE** **Grant:** **F-61-R-22/F19AF00061**

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, 2019

ABSTRACT

During the 2019 winter ice fishing season, 161 anglers were interviewed and reported a yearly mean catch per unit effort of 2.7 Rainbow Smelt *Osmerus mordax* per angler hour. Using the reported trip information provided by smelt anglers along with angler counts, the estimated effort was 410 trips, resulting in 3,639 fish harvested. Across locations, the number of days of favorable ice conditions and observed smelt fishing activity ranged between zero and 53, and the lack of fishing effort resulted in a low ice-on index (336). 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, Oyster—Bellamy rivers, as well as Great Bay proper. The Depot Road/Winnicut River sites continue to be included as they have been historical fishing areas in isolated parts of Great Bay and there is potential for continued fishing effort in these two

locations.

The survey was designed using a random schedule of 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 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 2019, 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 53 days between the four survey locations. The ice-on index of 336 was the lowest in a decade (Table 2.1-2). A total of 161 anglers were interviewed, with estimates of 410 total trips and 1,350 total angler hours for the 2019 season.

The 2019 angler catch data produced a catch rate of 2.7 smelt/angler hour, an increase over 2018 and the highest catch rate since 2011 (Table 2.1-2 and Figure 2.1-1). An estimated 3,639 smelt (198 kg) were harvested (Table 2.1-3). The distribution across sampling locations indicated that both effort and catch was greatest at the Squamscott River with 95.6% of the angler trips and 100.0% of the smelt caught (Tables 2.2-3 and 2.1-4).

During the sampling period, 181 scale samples were aged (Table 2.1-5). Age-2 fish accounted for the majority of smelt at 51.5% of the harvest, weighted by catch estimates. Age-4 fish made up 29.2% of the harvest, age-3 fish accounted

for 11.2%, and age-5+ accounted for 8.1% of the smelt harvest in 2019 (Table 2.1-5).

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). The 2019 fishing season showed an increase in the CPUE, but remained below the average for the time series (Figure 2.1-1). While an increase in CPUE is a positive indication, both the effort and harvest estimates had high associated error values (Table 2.1-2). The 2019 effort estimate showed the highest percent standard error (24.8) in the past decade. 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 may not represent the smelt population as a whole.

Another positive sign was the large percentage of age-2 fish taken during the 2019 season. The catch composition could indicate a good recruitment year for the 2017 age-class. A majority of age-2 fish only occurred one other year during the past decade, with most years having 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 and was historically a relative comparison of season length, but as effort has declined the ice-on index is now more heavily influenced by angler activity. Ice conditions during the 2019 fishing season were favorable from January through mid-March, however, effort was concentrated at one access site, resulting in a decadal 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 four of the winters since 2012

have not provided enough ice cover to allow for fishing and an expanded age structure is evident in the 2019 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 started in 2018 and completing in 2020.

Pollution is a more difficult factor to mitigate. Water quality parameters such as dissolved oxygen, turbidity, and pH are being 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. Since 1996, the eelgrass distribution in the Great Bay Estuary has declined by 44% (Short 2016). 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 and estuarine 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.

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 general paucity of age-2 fish, are still evident. 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.

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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, 2019.

January		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. interviewed anglers	*n*	10	13	23	0	0	0	0	0	0	0	0	0	0	0	0	10	13	23
Fishable days	*d*	8	3	11	0	0	0	0	0	0	0	0	0	0	0	0	8	3	11
Average trip length	*t*	3.38	3.00																
Average inst. count	*c*	1.13	7.50																
Estimated angler hours	*h = (c*12)*d*	108	270	378	0	0	0	0	0	0	0	0	0	0	0	0	108	270	378
Estimated trips	*E = h/t*	32	90	122	0	0	0	0	0	0	0	0	0	0	0	0	32	90	122
Catch per angler hour	*CPUE*	3.3	7.3	6.2													3.3	7.3	6.2
Estimated smelt caught	*C = h*CPUE*	353	1,977	2,330	0	0	0	0	0	0	0	0	0	0	0	0	353	1,977	2,330
Avg fish weight (kg)	*w*	0.054	0.054																
Estimated harvest (kg)	*H = C*w*	19	108	127	0	0	0	0	0	0	0	0	0	0	0	0	19	108	127

February		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. interviewed anglers	*n*	40	42	82	0	1	1	0	1	1	0	0	0	0	0	0	40	44	84
Fishable days	*d*	19	9	28	0	1	1	0	1	1	0	1	1	0	0	0	19	12	31
Average trip length	*t*	3.62	3.39			2.00			2.00										
Average inst. count	*c*	0.68	3.22			3.00			0.00			3.00							
Estimated angler hours	*h = (c*12)*d*	156	348	504		36	36	0	0	0	0	36	36	0	0	0	156	420	576
Estimated trips	*E = h/t*	43	103	146	0	18	18	0	0	0	0	0	0	0	0	0	43	121	164
Catch per angler hour	*CPUE*	3.1	1.2	1.8		0.0			0.0								3.1	1.0	1.5
Estimated smelt caught	*C = h*CPUE*	481	409	890	0	0	0	0	0	0	0	0	0	0	0	0	481	409	890
Avg fish weight (kg)	*w*	0.054	0.054																
Estimated harvest (kg)	*H = C*w*	26	22	48	0	0	0	0	0	0	0	0	0	0	0	0	26	22	48

March		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. Interviewed Anglers	*n*	44	10	54	0	0	0	0	0	0	0	0	0	0	0	0	44	10	54
Fishable Days	*d*	10	4	14	0	0	0	0	0	0	0	0	0	0	0	0	10	4	14
Average Trip Length	*t*	3.17	3.50																
Average Inst. Count	*c*	2.90	1.00																
Estimated Angler Hours	*h = (c*12)*d*	348	48	396	0	0	0	0	0	0	0	0	0	0	0	0	348	48	396
Estimated Trips	*E = h/t*	110	14	124	0	0	0	0	0	0	0	0	0	0	0	0	110	14	124
Catch Per Angler Hour	*CPUE*	1.0	1.5	1.1													1.0	1.5	1.1
Estimated Smelt Caught	*C = h*CPUE*	349	70	419	0	0	0	0	0	0	0	0	0	0	0	0	349	70	419
Avg fish weight (kg)	*w*	0.054	0.054																
Estimated harvest (kg)	*H = C*w*	19	4	23	0	0	0	0	0	0	0	0	0	0	0	0	19	4	23

Total		Squamscott River			Lamprey River			Bellamy/Oyster River			Great Bay			Depot/Winnicut			Total		
		Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Total
No. interviewed anglers		94	65	159	0	1	1	0	1	1	0	0	0	0	0	0	94	67	161
Fishable days		37	16	53	0	1	1	0	1	1	0	1	1	0	0	0	37	19	56
Est angler hours		612	666	1,278	0	36	36	0	0	0	0	36	36	0	0	0	612	738	1,350
Estimated trips		185	207	392	0	18	18	0	0	0	0	0	0	0	0	0	185	225	410
Catch per angler hour		1.9	3.7	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	3.3	2.7
Estimated smelt caught		1,183	2,456	3,639	0	0	0	0	0	0	0	0	0	0	0	0	1,183	2,456	3,639
Estimated harvest (kg)		64	134	198	0	0	0	0	0	0	0	0	0	0	0	0	64	134	198
Percentage of catch		100.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%			
Percentage of hours		100.0%	90.2%	94.6%	0.0%	4.9%	2.7%	0.0%	0.0%	0.0%	0.0%	4.9%	2.7%	0.0%	0.0%	0.0%			
Percentage of trips		100.0%	92.0%	95.6%	0.0%	8.0%	4.4%	0.0%	0.0%	0.0%	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 2010 through 2019.

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)
2010	D-F	1,092	2,121	8,286	10.3	29,867	33.8	2,211	3.6
2011	D-M	1,398	3,269	11,886	12.4	65,331	20.2	3,361	5.5
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	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	1,056	706	2,551	17.5	5,116	23.8	849	2.0
2019	J-M	336	410	1,350	24.8	3,639	33.9	198	2.7

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 2010 through 2019.

Year	Great Bay	Lamprey R.	Oyster R. —Bellamy R.	Winnicut R. —Depot Rd.	Squamscott R.	Total catch
2010	41.8	0.0	4.8	NS	53.5	29,737
2011	8.2	0.4	14.6	NS	76.8	65,331
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	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	NS	100.0	3,639

NS = Not surveyed due to zero effort.

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 2010 through 2019.

Year	Great Bay	Lamprey R.	Oyster R. —Bellamy R.	Winnicut R. —Depot Rd.	Squamscott R.	Total trips
2010	33.4	1.3	14.2	NS	51.1	2,121
2011	7.4	4.5	22.6	NS	65.5	3,269
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	NS	83.4	1,014
2015	2.1	0.0	10.2	NS	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	NS	95.6	410

NS = Not surveyed due to zero effort.

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 2010 through 2019 (sexes combined).

	Percent at age					
Year	Age-1	Age-2	Age-3	Age-4	Age-5+	Sample size
2010	0.4	30.4	44.4	20.1	4.7	344
2011	0.3	54.3	31.6	11.9	1.9	529
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	16.0	57.4	24.2	2.4	401
2019	0.0	51.5	11.2	29.2	8.1	181

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 2019.