**PROGRESS REPORT**

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

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

**Project I:** **DIADROMOUS FISH INVESTIGATIONS**

**Job 4:** **STOCK ENHANCEMENT OF THE NEW HAMPSHIRE RAINBOW SMELT RESOURCE**

Objective: To release hatchery-reared, oxytetracycline-marked Rainbow Smelt *Osmerus mordax* for population enhancement.

Period Covered: January 1, 2019 - December 31, 2019

ABSTRACT

The New Hampshire Fish and Game Department, in collaboration with the Aquaculture Research Center (ARC) at the University of New Hampshire released a total of 2,517,500 oxytetracycline-marked Rainbow Smelt *Osmerus mordax* larvae into Great Bay Estuary in 2019. A total of 22 male and 16 female smelt were captured by fyke netting and delivered to the ARC. Of the smelt captured, most of the males and half of the females were in reproductive condition and the remainder of the fish were post-spawned (spent). To supplement enhancement efforts an additional 2.5 million oxytetracycline marked fry were imported from Harmon Brook Smelt Hatchery.

INTRODUCTION

Anadromous Rainbow Smelt *Osmerus mordax* are an important recreational fish in New Hampshire and were of high commercial value, historically. They are small anadromous fish that live in nearshore coastal waters and spawn in the spring in tidal rivers immediately above the head of tide in freshwater (Kendall 1926; Murawski et al. 1980; Buckley 1989). Anadromous smelt serve as important prey for recreational, commercial, and culturally valuable species, such as Atlantic Cod *Gadus morhua*, Atlantic Salmon *Salmo salar*, and Striped Bass *Morone saxatilis* (Clayton et al. 1978; Kircheis and Stanley 1981; Stewart et al. 1981; Kirn 1986; O'Gorman et al. 1987). The range of smelt

historically extended from Chesapeake Bay to Labrador (Kendall 1926; Buckley 1989); but over the last century, the range has contracted and smelt are now only found east of Long Island Sound, and recent studies suggest it may only extend as far south as Buzzards Bay, Massachusetts (Enterline et al. 2012).

Rainbow Smelt have supported culturally important commercial and recreational fisheries throughout New England since at least the 1800s. Concerns have risen about the population status of smelt in recent years. High numbers of smelt that once supported commercial fisheries in New England have declined precipitously since the late 1800s to mid-1900s (Enterline et al. 2012). The current status of Rainbow Smelt populations for the majority of the Gulf of Maine is not well known. There has been a 15-20 year decline in the Massachusetts Bay region smelt populations. New Hampshire's commercial landings of Rainbow Smelt, once as high as 110,000 thousand pounds in the mid-1960's, declined to less than 30,000 pounds by the mid-1970's, and rapidly declined from there.

The National Oceanic and Atmospheric Administration listed Rainbow Smelt as a federal Species of Concern in 2004 as a result of over-harvest, water quality and habitat degradation, inaccessibility to spawning grounds, and possible disease issues. New Hampshire also lists anadromous smelt as a Species of Special Concern. Although smelt population declines have been widely documented, the causes are not well understood. In the federal listing of smelt, factors identified as potential contributors included structural impediments to their spawning migration (such as dams and blocked culverts) and chronic degradation of spawning habitat due to storm water inputs that include toxic contaminants, nutrients, and sediment (Chase and Childs 2001).

Further evidence of the decline of Rainbow Smelt can be derived from a survey of historically active spawning sites throughout ME, using a study from the 1970s (Flagg 1974) as a valuable baseline for comparison. A recent survey found that 13% of the historically active spawning streams no longer support smelt spawning, and most of the streams that remain active now support smaller runs than they did historically (Enterline et al. 2012). The substantial decline in strong spawning runs warrants concern and attention throughout their range, including New Hampshire waters.

The New Hampshire Fish and Game Department (NHFG) monitors the Rainbow Smelt resource in New Hampshire's Great Bay Estuary and its tributaries with a fishery dependent creel survey in the winter months and a fishery independent survey during the spring spawning. The winter creel survey selects for older

fish in the population and fails to capture the presence of younger fish in the population, whereas age-1 fish are captured in the spring survey. Data collected from both monitoring programs are used to monitor trends in relative abundance and age, sex, and size structure of the fishery and spawning run. Limited fishing opportunities due to more frequent years of limited ice conditions have reduced the amount of data collected annually by the creel survey and generally declining catches in the spring spawning survey are further evidence of Rainbow Smelt population declines in New Hampshire.

In an effort to enhance population levels of Rainbow Smelt, NHFG in cooperation with the University of New Hampshire (UNH), will collect gravid adult smelt during the spawning run to be used as broodfish. The broodfish will be spawned in hatchery conditions and larvae will be released into tributaries of Great Bay Estuary. It is the goal of this project to produce approximately 500,000 Rainbow Smelt larvae to be stocked annually, which from previous work done with the species will require collection of about 200–300 gravid females. Success of the stock enhancement effort will be measured through otolith marking and examination of corresponding age classes in successive years to calculate the proportion of those age classes captured in the spring spawning run and juvenile finfish seine surveys.

PROCEDURES

Rainbow Smelt were captured by fyke net (See Project I-2) in the Oyster, Squamscott, and Winnicut rivers during their spawning migrations and transported by truck to the Aquaculture Research Center (ARC) at UNH. Additionally, supplemental fry were imported from Harmon Brook Farm and Smelt Hatchery (Canaan, Maine). These fry were produced from approximately 390 female broodfish captured from the Addison River system (Washington County, Maine). All broodfish were strip spawned and the embryos incubated according to the methods of Ayer et al. (2005). Eggs were stripped into polystyrene plastic dishes by applying slight ventral pressure and fertilized with milt from 3-5 males (0.2-0.5 ml), activated with ~50 ml well water and swirled gently for 2 minutes. Fertilized eggs were transferred into a tannic acid solution (150 μL/L) and gently swirled for 10 minutes to remove adhesiveness according to the methods of Rottman et al. 1988. Fertilization success was assessed by microscopic examination 4-6 hours post-fertilization. Embryos were incubated in 5 L MacDonald hatching jars held at 10ºC until hatch (10-12 days post fertilization; DPF). During implementation of this project, a

preliminary oxytetracycline (OTC) marking experiment was conducted on fry 1-day post hatch with concentrations of 400, 600, and 800 ppm for 4, 5, and 6-hour durations. Survival declined at concentrations ≥ 600 ppm (54%), and subsequent markings were conducted at 500 ppm for 6 hours, with survival ≥ 90%. Marking was conducted in 30 L conical tanks at 0 ppt and maintained at ~10ºC using ice packs. Oxytetracycline was buffered with potassium phosphate and sodium phosphate dibasic dihydrate (1:1:1 with OTC). Larvae spawned at UNH were released in the Oyster River (Jackson landing) and acclimation was accomplished by floating shipping bubbles or bags at the shoreline and slowly adding river water for 30-45 minutes. Final release was performed at the end of a pier to allow fry to drift in the current and avoid natural predators at the grassy shoreline. Larvae from Harmon Brook Farm were transported by truck to four different sites surrounding the Great Bay Estuary (Oyster, Squamscott, and Winnicut rivers, and Great Bay Proper, Fig 1.4-1). Sites were selected based on stocking truck access and to represent a variety of environmental conditions that may favor larval feeding or dispersal. Acclimation efforts were conducted on the truck by exchanging tank water with river water using buckets. Release of fry was accomplished by connecting a 3-inch diameter PVC pipe from a gate valve on the holding tank out into the current, away from the shoreline. Fry activity was observed at all release sites to monitor swimming behavior upon release.

Following each natural spawning season, NHFG captured juvenile smelt during annual seine surveys and euthanized them for otolith processing at UNH. The young of the year (YOY) smelt otoliths were dissected, mounted on glass slides, sanded and viewed under a Zeiss fluorescence microscope with appropriate filter sets (FITC, 495-519 nm). Fish and resulting otoliths were kept in opaque storage throughout all possible stages of processing and viewing to avoid potential light degradation of the mark.

RESULTS

During spring fyke net sampling in 2019, 22 male and 16 female Rainbow Smelt broodstock were collected and transported by truck to the Aquaculture Research Center (ARC) at UNH (Table 1.4-1). Most of the males were in spawning condition and released milt with slight pressure applied to the ventral surface. Eight of the 16 females in 2019 were gravid. Fertilization rates ranged from 1-88% and the variation was likely due to egg quality as sperm motility approached 100% from all males examined. To supplement NHFG

collection efforts, an additional 2.5 million marked fry were imported from Harmon Brook Smelt Hatchery. Fry were marked with OTC and post-marking counts indicated survival was ≥ 90%, and mortalities were likely due to handling and transferring between containers. Approximately 2,517,500 larvae in 2019 were released at four different spawning sites during the project period, including Oyster River (Jackson Landing), Squamscott River, Winnicut River, and Great Bay Estuary (Table 1.4-2 and Figure 1.4-1). Water temperatures ranged between 8-10ºC which closely matched marking and incubation temperatures.

In 2019, less than 200 YOY smelt otoliths, respectively, were collected from the juvenile seine survey and processed to determine if OTC markings were present. Processing for OTC marks is currently underway.

DISCUSSION

Collection of broodfish for this project was anticipated to be done solely through the spring Rainbow Smelt fyke netting project conducted by the NHFG. While catches in the fyke nets were higher than in recent years (See Project I-2), many were not sexually mature (1 yr old) and catches were heavily skewed towards males. From previous laboratory studies conducted at the ARC, it was estimated that to reach the target of 500,000 Rainbow Smelt larvae, it would require between 200 and 300 gravid females; roughly 2,000 larvae per female. However, only eight gravid females were captured in 2019, with variable spawning success (Table 1.4-1). While the target number of larvae was not achieved from broodstock originating in NH rivers alone, the hatchery rearing process was successful at producing approximately 2,200 larvae/female.

An alternate source of Rainbow Smelt was found through a hatchery in Maine (Harmon Brook), which had a system in place for capturing wild adult Rainbow Smelt in spawning condition. It was determined by NHFG that this method of supplying broodfish would require the issuance of an importation permit by NHFG. The low collection of adult females through fyke netting in 2019 and previous years made it clear that a consistent alternate source of broodfish or supplemental source of YOY will need to be incorporated in future years, as opposed to being considered as a backup source. Similar to 2018, proper permitting allowed for the successful importation of approximately 2.5 million marked fry produced using 390 wild-caught female broodstock by Harmon Brook Hatchery. Fry were released strategically in tributaries around the Great Bay Estuary (Table 1.4-1; Fig 1.4-1). Through this collaboration, the target of 500,000 stocked Rainbow Smelt was again exceeded and similar methods

will be followed in future years of the project.

The project will be conducted again in 2020 and stocking efforts should now focus on obtaining greater numbers of juveniles during subsequent NHFG annual seine surveys compared to very few YOY smelt in all years of the project. Using the small numbers collected, detailed protocols have been developed at UNH to efficiently process YOY smelt and analyze for OTC marks but numbers of smelt processed should reflect the numbers released. Additionally, there may be a greater benefit to the Rainbow Smelt resource if additional work to investigate what life history stage or environmental constraint may be driving the consistently low abundance levels in New Hampshire waters.

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Table 1.4-1. Rainbow Smelt broodfish collection date, river source, sex, count (N), % viable broodfish (holding eggs or running milt), estimated egg fertilization rate, fry counts post oxytetracycline marking, 2019.

| Year | Collection date | River | Sex | N | % viable | % eggs fertilized | Fry marked |
|---|---|---|---|---|---|---|---|
| 2019 | 3/20/2019 | Winnicut | F | 10 | 40 | 17-27 | 17,500 |
| | | | M | 12 | 75 | | |
| | 3/22/2019 | Winnicut | F | 6 | 66 | 1-88 | |
| | | | M | 10 | 70 | | |
| | 4/1/2019 | Imported (Maine) | NA | NA | NA | - | 2,500,000 |
| | | | | | Total 2019 | 1-88 | 2,517,500 |

Table 1.4-2. Rainbow Smelt fry stocking site, release date, and number of marked fry, Great Bay Estuary, NH, 2019.

| Year | Stocking site | Release date | Marked fry |
|---|---|---|---|
| 2019 | Oyster River | 4/4/2019 | 17,500 |
| | Oyster R., Squamscott R., Great Bay Estuary and Winnicut R. | 6/12/2019 | 2.5 million |

Figure 1.4-1. Location of Rainbow Smelt fry stocking sites in Great Bay estuary, NH, 2019.