PROTECTING A THREATENED COASTAL FISH SPECIES THROUGH REGIONAL COLLABORATION

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Introduction

Rainbow smelt (*Osmerus mordax*) are small anadromous fish that live in nearshore coastal waters during much of the year and migrate to tidal rivers to spawn during the spring. They are a key prey species in marine food webs, as they are consumed by larger organisms such as striped bass, bluefish, and seabirds. In addition, smelt are valued culturally and economically, as they support important recreational and commercial fisheries.

The Atlantic Coast range of rainbow smelt has been contracting in recent decades. Historically, populations extended from the Delaware River to eastern Labrador and the Gulf of St. Lawrence (Buckley 1989). More recent observations indicate that rainbow smelt spawning populations have been extirpated south of Long Island Sound, and evidence of spawning activity is extremely limited between Long Island and Cape Cod, MA. In the Gulf of Maine region, spawning runs are still observed, but monitoring surveys as well as commercial and recreational catches indicate that these populations have also declined (e.g., Chase and Childs 2001). Many diverse factors could drive the recently noted declines in rainbow smelt populations, including spawning habitat conditions, fish health, marine environmental conditions, and fishing pressure. Few studies have assessed any of these potential threats or their joint implications.

In 2004, the National Marine Fisheries Service (NMFS) listed rainbow smelt as a species of concern. Subsequently, the states of Maine, New Hampshire, and Massachusetts were awarded a grant through NMFS's Proactive Conservation Program to gather new information on the status of rainbow smelt, identify factors that affect spawning populations, and develop a multi-state conservation program. This paper provides an overview of this collaborative project, highlighting key biological monitoring and threats assessment research that is being conducted throughout the Gulf of Maine.

Improving Regional Knowledge of Rainbow Smelt

Key research elements of this project focus on (1) understanding the distribution of smelt spawning habitats in Gulf of Maine rivers, (2) indexing the abundance of spawning runs in select rivers, and (3) identifying fish health and habitat conditions that may affect spawning success.

Many coastal rivers in all three states have been surveyed for evidence of spawning by smelt during the spring. Biologists and conservation officers visit sites in these rivers at low tide and observe the substrate for deposited smelt eggs. Efforts in Maine and New Hampshire involve qualitative assessments of spawning habitat use, while Massachusetts has documented the spatial and temporal extent of spawning as well as water chemistry conditions in all presumed spawning rivers throughout the season (Chase 2006,Chase 2009).

More intensive monitoring of spawning runs and habitat conditions has focused on fifteen index sites distributed from just south of Cape Cod in Massachusetts to near the Canadian border in Maine (Figure 1). The index sites were chosen to capture variation in the strength of spawning runs, stream quality, and watershed features. In each of these rivers, smelt spawning abundance and biological features as well as water quality conditions are routinely monitored. Fyke nets are used for the duration of the spawning season to sample smelt at each of the index sites. From these samples, the catch per unit effort can be assessed in each river, compared across the region, and tracked over time. In addition, biological data can be used to determine important population parameters such as the length distribution, sex ratios, and age structure of smelt in each river on weekly and seasonal time scales.

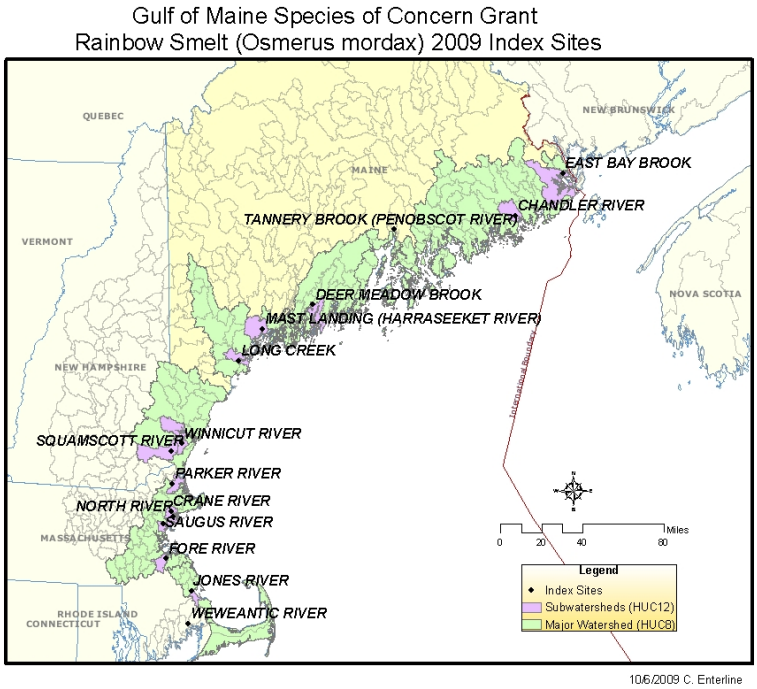

Figure 1. Location of fifteen index sites for monitoring rainbow smelt and spawning habitat conditions in Maine, New Hampshire, and Massachusetts.

Tissue samples are also collected from smelt in each river for further analyses of genetics and fish health. Results from these analyses will help identify the spatial distribution of genetically-distinct populations to inform potential stock enhancement decisions in the future. In addition, screening the type and body burden of bacterial and viral pathogens, parasites, and toxic contaminants (e.g., mercury, PCBs, heavy metals) provides information regarding the general health and possible diminished reproductive success of rainbow smelt in each river.

Water quality and habitat conditions are also documented at each index site. Water temperature, dissolved oxygen, pH, turbidity, and conductivity are measured with YSI 6000-series data sondes on a weekly basis at all sites and continuously at some locations. Weekly water samples are collected and processed for total nitrogen and total phosphorus concentrations. In addition, in-stream habitat characteristics such as channel width and depth, flow velocity, light penetration, and canopy cover are measured. Finally, periphyton standing stock and growth rates are measured from natural and artificial (i.e., ceramic tiles) substrates at each site.

Scaling to Watershed and Regional Levels

While field research elements of this project focus on 15 rivers, the ultimate goal is to use this information to protect spawning runs of rainbow smelt throughout the Gulf of Maine region. Extensive research has shown that watershed features, such as urbanization and agricultural use, can affect stream quality; in turn, stream quality can influence the spawning success of rainbow smelt (Fuda et al. 2007). Linking water quality and habitat factors that affect smelt populations to watershed conditions provides a means for applying findings from the 15 index sites to a broader area.

A GIS-based model that is driven by watershed features will capitalize on these linkages to provide an indication of which regional rivers may support spawning populations of rainbow smelt and which may be in need of conservation attention. This model will be based on data from the 15 index sites that were studied intensively as part of this project. Smelt population parameters and water chemistry in these rivers will be related to watershed features, such as population density, stream obstructions, land cover types, and impervious surface cover. Relationships established in these 15 rivers can be expanded to a regional scale, using the same watershed features to predict the likelihood of the occurrence of smelt spawning populations in rivers that were not monitored

intensively in the field. Model outputs will be validated using egg surveys conducted in rivers beyond the index sites.

The predictive GIS model will also be important for evaluating watershed-based strategies that may be incorporated into smelt conservation plans. For example, if stream obstructions are a key predictor of the presence or success of smelt spawning populations, the GIS can help identify streams in which the removal or restoration of obstructions would open the greatest extent of spawning habitat. Similarly, if a strategy for protecting rainbow smelt entails improving in-stream water quality, the GIS model can help identify regional watersheds that may be suitable focus areas for land protection and low-impact development practices to help minimize impervious surface cover.

Management Implications

A conservation plan to protect rainbow smelt throughout the Gulf of Maine region will be developed based on the integrated assessment of watershed and in-stream factors affecting spawning populations of rainbow smelt, combined with historical data and additional information available from other monitoring efforts. Conservation strategies will focus on five key areas:

- Protecting or improving spawning habitat conditions and water quality
- Restoring upstream passage and stream corridors
- Regulating commercial and recreational fisheries as needed
- Enhancing and re-introducing stocks to rivers with severely depleted populations
- Identifying additional research needs

Approaches for implementing these strategies will take a variety of different forms. Data collected from this project will be used to identify thresholds for nutrient concentrations and algal biomass that can be used by states and the US EPA to develop nutrient criteria to sustain smelt spawning populations. Further, knowledge of in-stream habitat conditions that support smelt spawning can be used to shape the design of river restoration projects. In addition, project outreach efforts and training initiatives will focus on informing local decision-makers about the types of best management practices and infrastructure design considerations that may promote smelt spawning success.

All three states participating in this project will be reviewing and revising commercial and recreational fishery regulations as needed to ensure that fishing effort is suitably aligned with the strength of smelt populations. In addition, stock enhancement techniques are being refined by the Massachusetts Division of Marine Fisheries. Combined with genetics and pathology information from this study, these stocking methods may be further developed and applied to re-introduce rainbow smelt in rivers throughout the Gulf of Maine following dam removals, culvert re-designs, or water quality improvements.

Finally, while this project provides critical new information on fish health, habitat conditions, and watershed factors that affect spawning populations of rainbow smelt, it does not investigate factors that may impact other life history stages. Ultimately, factors influencing the survival of rainbow smelt through larval, juvenile, and adult life history stages must also be considered to effectively protect this species. Future research priorities that focus on understanding how environmental conditions or predation affect smelt survival through these life stages in estuarine and coastal marine waters will help further advance regional conservation efforts.

The conservation plan for rainbow smelt will also recognize the value of regional collaboration. This project has demonstrated the efficiencies that are gained by pooling expertise and resources, coordinating research approaches, and jointly identifying appropriate conservation strategies. This collaborative approach will result in a regionally coherent plan for protecting rainbow smelt and may serve as a model for conservation planning for other species of concern.

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