American Fisheries Society Symposium 69:859–862, 2009

The Spawning Habitat of Anadromous Rainbow Smelt: Trouble at the Tidal Interface

Bradford C. Chase*
Massachusetts Division of Marine Fisheries
1213 Purchase Street, 3rd Floor, New Bedford, Massachusetts 02740, USA

Anadromous rainbow smelt *Osmerus mordax* depend on discrete spawning riffles near the tidal interface to deposit demersal, adhesive eggs. In many rivers, these locations are also centers of human development where watershed alterations have degraded water and substrate quality. The degradation of spawning habitat could reduce a fitness advantage in the life history of diadromous fish that depend on the integrity of freshwater habitats (Gross 1987). Smelt populations at the southern end of their range have declined sharply in the past 30 years, and in southern New England, some runs are now barely detectable. A monitoring project was conducted on the Gulf of Maine coast of Massachusetts, in response to growing concerns over the status of smelt, to document spatial occurrence and temporal use of smelt spawning habitat, identify influences on smelt spawning success, and develop recommendations on habitat restoration.

All freshwater drainages (N = 162) from the Cape Cod Canal to New Hampshire were surveyed to select spawning habitat monitoring stations. Sixty-four selected monitoring stations were visited twice each week from March 1 through May 31 for one to three seasons. Observations of deposited smelt eggs formed the basis for delineating smelt spawning habitat. Egg monitoring focused on the first riffle upstream of tidal influence. Once smelt eggs were identified, monitoring was expanded to record the upstream and downstream limits of egg deposition, resulting in spawning habitat measurements of river length and substrate area for each river. Water chemistry was measured at each station visit, and streamflow measurements and ichthyoplankton samples were collected at some stations.

* Corresponding author: brad.chase@state.ma.us

Smelt spawning habitat was identified at 45 locations (mapped by Global Positioning System coordinates reported by Chase 2006) in 30 river systems (Figure 1). Smelt spawning began at riffle habitat near the interface of saltwater and freshwater, with few exceptions. Spawning progressed upstream beyond the tidal influence as far as a kilometer and typically ceased at physical barriers to passage. The size of spawning habitats varied widely, although most were less than 200 m in stream length and less than 1,000 m^2 in substrate area. Only five locations provided 10,000–15,000 m^2 of spawning substrate.

he typical spawning period was from mid-March until mid-May. Egg deposition typically peaked in April and was intermittent in early March and late May. The temporal range when smelt eggs were present was March 3 to May 28. The spawning period of smelt in Massachusetts begins earlier and extends more than twice the duration as found in their northern range (McKenzie 1964; Trencia et al. 2005). The average water temperature at the onset of spawning runs was 5.3°C. However, water temperature, the onset of spawning, and the duration of the spawning period varied widely, with some dependence on the size of spawning habitat and seasonal weather. Smelt larvae were present in the tidal waters downstream of the spawning habitat from April 14 through May 31.

Water temperature, dissolved oxygen, pH, salinity, and specific conductivity were measured and compared to Massachusetts Surface Water Quality Standards. All water temperature and dissolved oxygen measurements were supportive of aquatic life, both favorably influenced by the cool air temperature and higher discharge during the spring freshet. Routine violations to the pH criterion (<6.5) were observed in most rivers in the South Coastal Basin, raising concerns about egg survival. Evidence of cul-

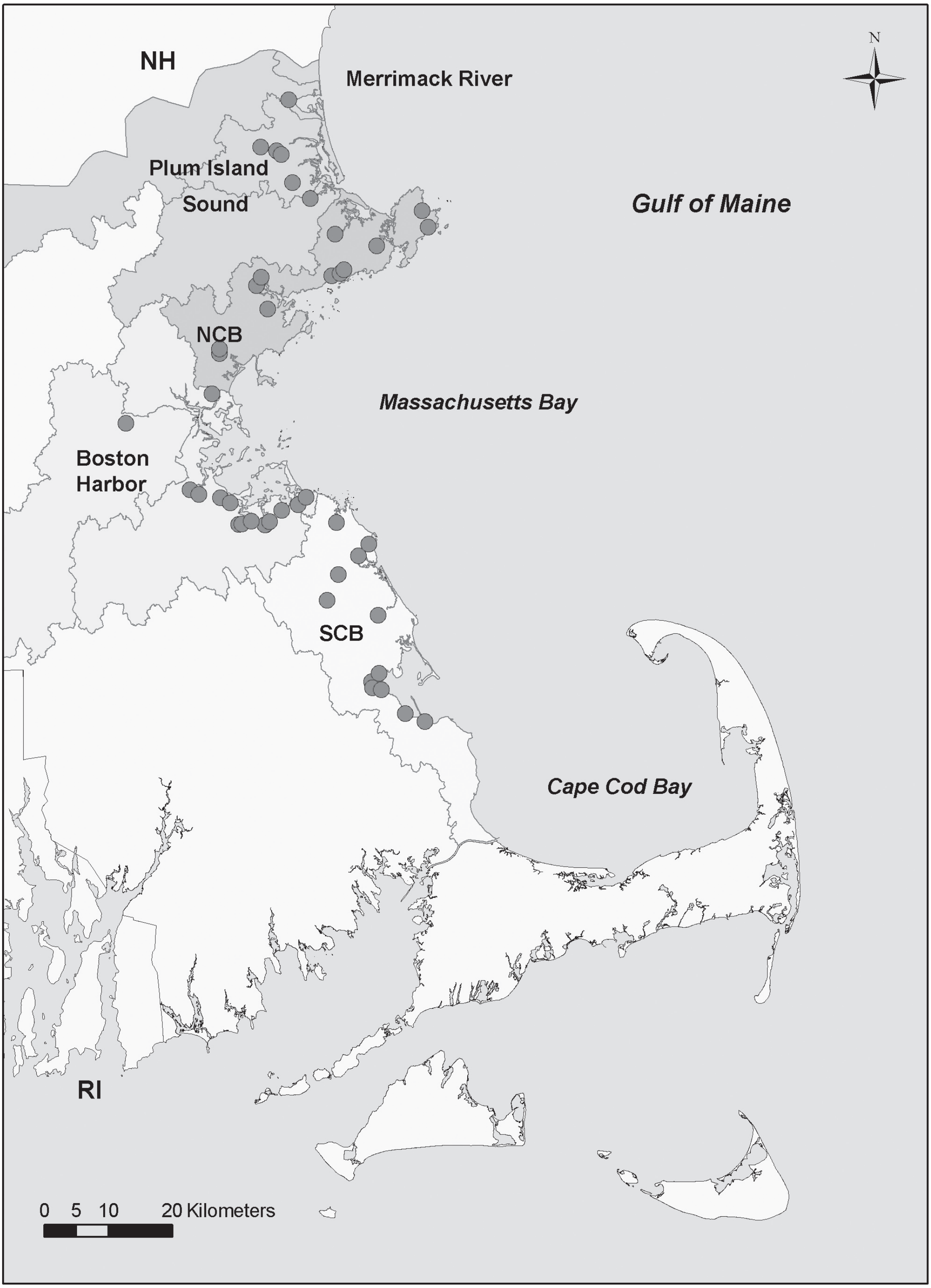

Figure 1.—Location of smelt spawning habitat on the Gulf of Maine coast of Massachusetts. Dots indicate the 45 locations designated as smelt runs in the study area. NCB = North Coastal basin; SCB = South Coastal basin.

tural eutrophication was found with high nutrient concentrations at spawning locations (subset of six rivers). All sampled rivers had total dissolved phosphorus (TDP) concentrations, and four of six rivers had nitrite + nitrate concentrations that exceeded predicted concentrations (6.4 μg/L TDP; 0.267 mg/L N+N; Sosiak 2002) that would cause nuisance periphyton biomass. The downstream limits of spawning routinely experienced tidal influence but were not typically exposed to the salt wedge. In locations where eggs received saline water, the cause was human alterations such as bridge constrictions, flood control structures, and dams.

Nine physical and chemical conditions were identified as degrading the stream habitat for migrating adults and egg survival: sedimentation, eutrophication, passage impediments, channel alterations, stream flow reduction, stormwater, tidal influence, vegetative buffer loss, and acidification. These conditions were ranked in each smelt run, resulting in the highest summed scores for sedimentation and eutrophication. The effects of eutrophication, in the form of excessive periphyton growth, on spawning substrata were nearly ubiquitous. The cumulative effect from all the negative influences is the reduction in the quantity and quality of spawning habitat. It is hypothesized that the degradation of smelt spawning habitat is causing lower egg survival and chronic reduction of smelt recruitment. Eutrophication may be the most significant threat because the periphyton growth can result in spawning substrate that is poorly suited for a life history depending on a demersal, adhesive egg with a long incubation period.

Most smelt spawning locations have been modified to accommodate transportation routes, stormwater drainage, and property development. Reduced presence of stream channelization, crossings, and passage impediments was highly favorable towards maintaining natural riffle habitat. A synopsis of monitoring provided a description of favorable smelt-spawning habitat: a deep-channel estuary that allows the salt wedge to meet a moderate gradient riffle at the tidal interface, unimpeded passage upstream to the freshwater zone with ample vegetative buffer and canopy, and an extended pool-riffle complex that limits egg crowding and provides shelter. This scenario was only approximated in the Fore River, the largest smelt run in the study area, because of common riparian and channel alterations. Only 1 of 45 spawning locations had no riparian or channel alterations. Other positive features recorded were substrate conditions that increased flow turbulence, velocity, and increased surface area for egg deposition. Riffle habitat with turbulent water velocity (0.5–0.8 m/s), coarse cobble (10–20 cm diameter), and aquatic moss *Fontinalis* spp. were suitable for adult attraction, egg attachment, and egg survival.

A large number of smelt-spawning locations were documented on the Gulf of Maine coast of Massachusetts. However, most locations suffered from a variety of stressors. The relation of spawning habitat degradation to smelt population decline remains unknown for this poorly assessed species. Robust smelt fisheries of the 1960s and 1970s were followed by sharply declining fisheries and smelt runs in the 1980s and 1990s, a period of extensive coastal development and improved industrial point source water quality but declining stormwater quality. Concerns for smelt have increased in New England, resulting in the 2004 designation of smelt as a species of concern under the Endangered Species Act review process based on decreased harvest records and distribution truncation (NOAA 2004). The degradation of spawning habitat is a likely contributor to the present status of smelt runs and fisheries. The deposition of demersal, adhesive eggs in freshwater riffles near the tidal interface is an important adaptation of smelt life history. This reproductive process may be at risk because of chronic degradation of spawning substrates in developed watersheds in Massachusetts. The documentation of smelt spawning habitat, in an accessible geographic information system database, will help resource managers protect these habitats.

References

Chase, B. C. 2006. Rainbow smelt (*Osmerus mordax*) spawning habitat on the Gulf of Maine coast of Massachusetts. Massachusetts Division of Marine Fisheries, Technical Report No. 30, Gloucester.

Gross, M. R. 1987. Evolution of diadromy in fishes. Pages 14–25 *in* M. J. Dadswell, R. J. Klauda, C. M. Moffitt, R. L. Saunders, R. A. Rulifson, and J. E. Cooper, editors. Common strategies of anadromous and catadromous fishes. American Fisheries Society, Symposium 1, Bethesda, Maryland.

McKenzie, R. A. 1964. Smelt life history and fishery in the Miramichi River, New Brunswick. Bulletin of Fisheries Research Board of Canada No. 77.

NOAA (National Oceanic and Atmospheric Administration). 2004. Species of concern in the northeast region. National Marine Fisheries Service, Proactive Conservation Program, Silver Spring, Maryland.

Sosiak, A. 2002. Long-term response of periphyton and macrophytes to reduced municipal nutrient loading to the Bow River (Alberta, Canada). Canadian Journal of Fisheries and Aquatic Sciences 59:987–1001.

Trencia, G., G. Verreault, M. Legault, and V. Tremblay. 2005. L'eperlan arc-en-ciel (*Osmerus mordax*) anadrome du sud de l'estuaire du Saint-Laurent. Le Naturaliste Canadien 129(1):86–94.