MASSACHUSETTS DIVISION OF MARINE FISHERIES

SPORTFISHERIES TECHNICAL ASSISTANCE PROGRAM

Massachusetts Bay Smelt Spawning Habitat Monitoring Program

Assessment of Rainbow Smelt Egg Mortality at Town Brook, Quincy, April 1997

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Introduction

The following assessment provides an estimate of the short-term population impact on Town River smelt resulting from a water diversion in April, 1997. Work conducted during a flood control project (DEP File No. 59-196) diverted water from sections of the Town River used as spawning habitat by smelt during the peak spawning season. The water diversion occurred on April 23rd and lasted for approximately a week (DMF 1997). Water flows recorded at the U.S. Geological Survey gauge station located near Miller Stiles Road indicated that levels dropped from 11 cfs on April 23rd to 1.1 cfs on April 24th. This dewatering created unsuitable conditions for smelt egg survival throughout the entire range of spawning habitat in the Town Brook/Town River system.

Observations I made on April 26th and May 1st provide a basis for estimating egg densities and egg mortality. The model used for population level impacts is the "Equivalent Adult Method" (Boreman 1997). Survival parameters used were derived from the Stone and Webster smelt population model developed for assessing nuclear power plant impacts on the Jones River, Plymouth, smelt run (Saunders 1981).

Spawning Habitat Measurements

The spawning habitat for smelt in the Town River was documented during 1988 and 1989 under the Massachusetts Bay Smelt Spawning Habitat Monitoring Program (B. Chase, project leader). Measurements of stream substrate where egg deposition was previously documented were conducted on July 28, 1997 by B. Chase and DMF Technician, Jeff Plouff. The wetted perimeter method was used to measure spawning habitat area (m^2). The Town River was divided into zones of spawning activity separated by landmarks of streets and tidal influence. The river was further divided into distinct morphological reaches with a maximum length of 60 meters. For each reach, midstream lengths were measured and wetted perimeter widths were measured 1-3 times every 20 m, depending on the straightness of the river.

Area is calculated for each reach and all reaches are summed to produce an area measurement for each zone. Egg densities were calculated only for zones 2-6 in 1997. It is assumed that no eggs were deposited in zones 1, 7 and 8 during 1997. Smelt enter zone 1 during very strong spawning runs (only seen in 1989). Zones 7 and 8 were altered in the early 1990s by the flood control project and no longer offer suitable spawning habitat, although a few dead eggs were found on the gabion substrate covering in 1997 in zone 7. The following table provides spawning habitat area measurements.

Table 1. Spawning Habitat Measurements

	Length (m)	Area (m^2)	Notes
Zone 1	-	-	Upstream of Revere St.
Zone 2	102.0	260.6	Bigelow St. to Revere St.
Zone 3	83.0	248.4	Miller Stiles Rd to Bigelow St
Zone 4	214.5	746.0	Chamber of Commerce property
Zone 5	101.0	418.5	Intertidal to Washington St.
Zone 6	90.0	471.0	Intertidal to tunnel
Zone 7	180.0	-	Intertidal gabion
Zone 8	-	-	Rt. 3A intertidal

These zones are divided into two categories: primary spawning habitat (zones 2, 3 and 4) and intertidal spawning habitat (zones 5 and 6). Zones 1, 7 and 8 were not used in the assessment. The total substrate available within the primary spawning habitat is 1,255 m^2, and 889.5 m^2 is available within the intertidal spawning habitat. Two levels of assumed egg coverage are applied: 100% and 75% for the primary habitat and 50% and 25% for the intertidal. This is done to allow for variation in egg deposition and to account for the less suitable habitat found in the intertidal zones. Applying these percent-ages to the areas and converting to cm^2 results in total areas of spawning habitat where eggs were deposited of 16,997,500 cm^2 for the 100/50% coverage and 11,636,250 cm^2 for 75/25% coverage.

Smelt Egg Density

No direct measurements of smelt eggs killed during the water diversion were possible. Observations were made after the diversion of millions of desiccated eggs that were exposed to air and millions of eggs that were clumped together decomposing in pools. Three levels of egg densities were selected based on my observations and previous egg collections and were used to calculate total egg losses. The low density level is an actual measurement from Town River egg collections on May 5, 1997. Eggs were collected on 15 trays (1,858 cm^2 each) and a stratified estimate of 50,112 eggs was made (minimum 95 % CI of $\pm$ 2,592 eggs). This level is well below that observed on April 26th during the diversion. The high level was derived from egg tray data collected in the Fore River, Weymouth, on April 18, 1995, which represents a better than average spawning run for Massachusetts Bay. The medium density is my estimate of the egg density (roughly 100 eggs/in^2) that best approximates actual conditions at the time of the diversion.

Table 2. Egg Densities and Total Egg Estimates

Density	Eggs/cm^2	Egg Total (100/50%)	Egg Total (75/25%)
Low	2.0	33,995,000	23,272,500
Medium	15.5	263,461,250	180,361,875
High	31.0	526,922,500	360,723,750

Equivalent Adult Method

The Equivalent Adult Method is a model used to assess human-induced sources of mortality on fish populations. For the situation in Town River it is a simple application because a single event of mortality impacted one age group. The following model is used to forecast losses up to age 2, the age that smelt fully recruit to the spawning population:

$$N_a = \mathrm{Sum}^{n}_{i=1} \; (N_i \times S_i)$$

N_a = equivalent number of age 2 smelt recruited to spawning stock from age group impacted (eggs deposited during diversion)
N_i = number of individuals at each age following the impact
S_i = survival rate for each age group

Table 3. Estimated Losses of Adult Smelt

Age	S_i	Low Density	Medium Density	High Density
		(100/50%)	(100/50%)	(100/50%)
Egg	0.036	1,223,820	9,484,605	18,969,210
Larvae	0.070	85,667	663,922	1,327,845
Age 1	0.070	5,997	46,475	92,949
Age 2	0.454	2,723	21,099	42,199
		(75/25%)	(75/25%)	(75/25%)
Egg	0.036	837,810	6,493,028	12,986,055
Larvae	0.070	58,647	454,512	909,024
Age 1	0.070	4,105	31,816	63,632
Age 2	0.454	1,864	14,444	28,889

This model contains several assumptions that may result in biases. The foremost is the survival rate for eggs of 3.6%. This was selected to be consistent with a recent Massachusetts Bay assessment on smelt mortality (Saunders 1981). This is probably a high survival rate for eggs and may positively bias the results. Conversely, a negative bias may exist from the assumption that no smelt survive past age 2.

Alternative Assessment

An alternative mortality assessment was conducted to compare to the Equivalent Adult Method. This model is a simple back-calculation of egg estimates to the adult females that deposited the eggs. A value for smelt fecundity is divided by the total egg estimate from Table 2 to produce the total number of females depositing eggs at the time of the diversion and a sex ratio value is applied to the number of females to estimate the number of males. The fecundity used was 31,400 eggs per Age 2 female. This was selected from the modal fecundity of Age 2 smelt in the Parker River, Massachusetts Bay (Clayton 1976). An unbiased sex ratio of 1.1 males to 1.0 females was also selected from a Parker River study (Murawski and Cole 1976).

Applying these values to the medium egg densities from Table 2 results in estimates of 8,390 females and 9,229 males for the 100/50% egg coverage and 5,744 females and 6,318 males for the 75/25% egg coverage. Therefore, the range of medium estimates for Age 2 smelt by back-calculation (12,062-17,619) is similar to the Adult Equivalency Method forecast (14,444-21,099). Whereas, the latter assessment may be positively biased due to a high egg survival rate, the alternative assessment is probably conservative because eggs displaced from the spawning grounds (turnover rate) are not converted into back-calculated adults. It is **recommended** for the purposes of determining a valuation of adult losses associated with the egg kill that the medium range of 12.1 to 21.1 thousand age 2 smelt is used.

Valuation of Population Impacts

The average weight for a two year smelt in the Jones River, Plymouth is approximately 40 g (Lawton et al. 1990). Converting to pounds results in approximately eleven age 2 smelt per pound. Converting the medium range of age 2 smelt from numbers to pounds results in a range of 1,067 to 1,861 pounds. A commercial value for smelt of $2.75/pound was taken from the average price of smelt at three North Shore fish markets during January 1998. Assuming a weight loss of 20% for dressed smelt results in a commercial valuation range of $2,347 to $4,094.

It is important to consider that the above valuation does not consider recreational or ecological values of population impacts. Recreational values are not well documented, but clearly smelt fishermen place a higher value on smelt than what they would pay by simply buying the fish at a market. For use as a baitfish, anglers in Maine paid between $0.30 and $1.00 per smelt over 10 years ago (Akielaszek et al. 1985). Ecological values in local food chains are very difficult to assess, yet adult smelt are an important forage target for gamefish and water fowl. There is also no consideration to natural mortality losses (benefits as food sources) for larvae and age 1 smelt in the assessment of commercial losses. Although no references are available to account for recreational and ecological losses, the associated economic values certainly exceed the commercial value and the combined values probably exceed $1 per adult smelt.

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