COMPLETION REPORT

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Population Indices of Rainbow Smelt Spawning Runs in Massachusetts.

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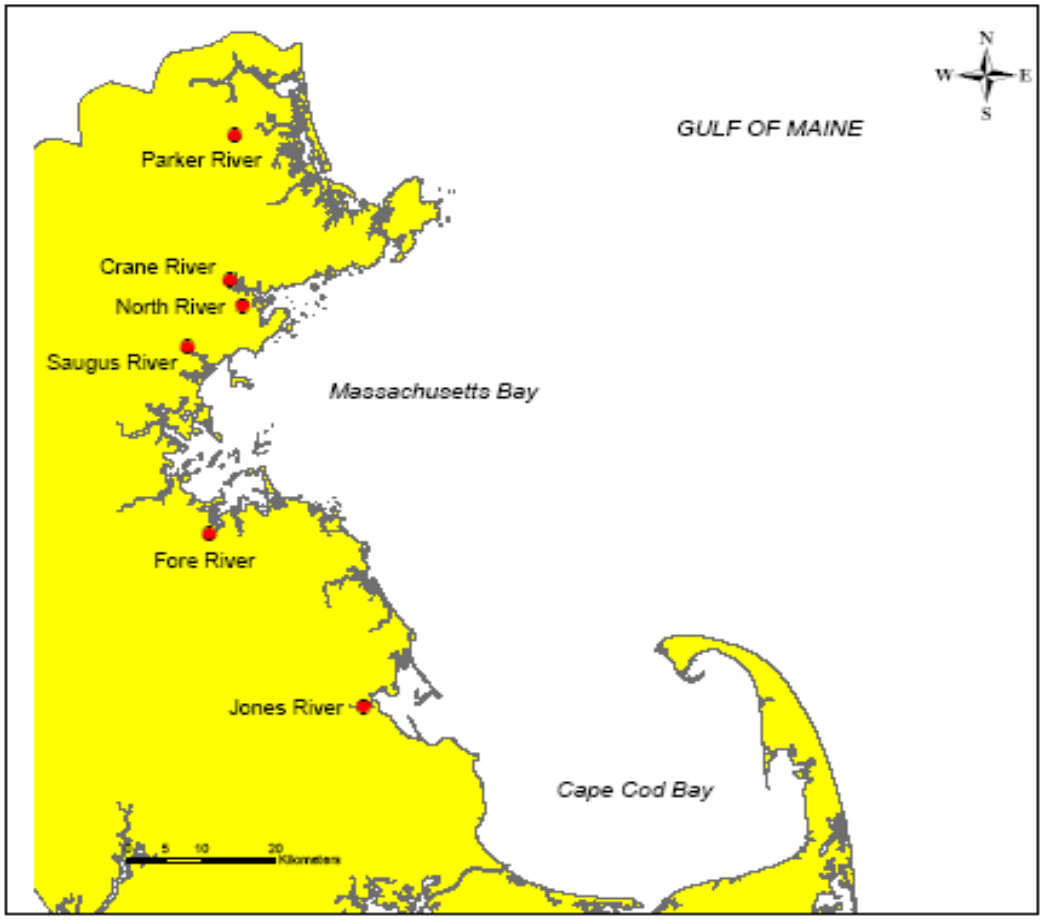
OBJECTIVE

A grant was received from the Protected Resources Division of NOAA Fisheries to conduct a two-year pilot study on anadromous rainbow smelt (*Osmerus mordax*) spawning runs in Massachusetts. Growing concerns over the apparent decline of smelt fisheries and spawning runs in Massachusetts and other New England states prompted our interest to gain information on these previously unassessed populations. The objective was to develop fyke net sampling protocols that could be adopted by the Massachusetts Division of Marine Fisheries (DMF) for an annual monitoring series to track smelt age composition and population indices of abundance. Other goals of the project were to integrate fyke net monitoring with restoration experiments, record data on other diadromous fish species, and to design standardized protocols that could be applied consistently throughout the smelt's range.

METHODS

Overnight sets were made with fyke nets in four rivers in 2004 and six rivers in 2005. The fyke nets were set in the intertidal zone below the downstream limit of smelt egg deposition. The net design and orientation were changed in 2005 based on the 2004 monitoring experiences. A small fyke net (2.5 ft. hoop entrance, and 3.3 ft wings) was set facing upstream two days each week in 2004. A larger net (4x4 ft. box frame entrance, and 4x4 ft. wings) was set facing downstream three days each week in 2005. Both nets had ¼ inch delta mesh throughout the net. The sampling period was March 7th – May 20th. All fish were counted, measured and released. A sub-sample of smelt was targeted weekly for scale collection (see "Field Sampling and Data Collection" in Appendix for specific details on sampling methods).

Figure 1. Smelt fyke net sampling stations on the Gulf of Maine coast



Study Area. We selected six rivers on the Gulf of Maine coast of Massachusetts where DMF had previously delineated smelt spawning habitat (Chase, 2006) to serve as fyke net stations (Figure 1 and Table 1). The following four rivers will be visited annually as long-term, population monitoring stations: Jones River (Kingston), Fore River (Braintree), Saugus River (Saugus), and Parker River (Newbury). These rivers were all formerly known as large smelt runs that supported sportfisheries for smelt. The Jones and Parker rivers are located in less urbanized watersheds and the only smelt runs in Massachusetts with historical smelt population data (Murawski and Cole, 1978; and Lawton et al., 1990). The Fore and Saugus rivers are located in more urbanized watersheds, and the Fore River is one of the few rivers in the study area with a large smelt run remaining that supports a viable sportfishery. The North River (Salem) and Crane River (Danvers) were selected as short-term, experimental restoration stations. These rivers are located in close proximity within the urban Danvers River watershed. Smelt eggs were not present during 1988-1990 spawning habitat monitoring in the North and Crane rivers (Chase, 2006), but following a DMF egg transfer project during 1995-1997, smelt eggs were found in both rivers (Chase et al., *In Prep*.). Given the small existing run of smelt and large amount of suitable spawning habitat, these stations were established to monitor the response of stocking smelt larvae marked with oxytetracycline (OTC) starting in 2005.

Table 1. Locations and summary information on smelt fyke net stations. Discharge data are average spring values from USGS gauges and DMF measurements from Chase (2006).

River	Watershed	Town	Latitude	Longitude	Drainage Area (km^2)	Discharge (cfs)	Channel Width (m)
Jones River	South Coastal Basin	Kingston	41° 59.760'	70° 43.399'	76.7	54.9	18.5
Fore River	Boston Harbor	Braintree	42° 13.353'	70° 58.391'	93.5	55.8	16.0
Saugus River	North Coastal Basin	Saugus	42° 28.078'	71° 00.461'	124.8	43.2	11.0
North River	North Coastal Basin	Salem	42° 31.328'	70° 54.696'	29.8	24.0	9.0
Crane River	North Coastal Basin	Danvers	42° 33.396'	70° 56.183'	14.8	19.1	5.5
Parker River	Parker River	Newbury	42° 45.027'	70° 55.694'	156.4	83.2	20.0

RESULTS

Fyke nets were successfully deployed twice weekly during 2004 in the Jones River, Fore River, North River, and Parker River. Of the 22 targeted hauls per river only 1-4 dates were missed in each river due to elevated flow. In 2005, the Crane River and Saugus River were added as sampling stations and relatively few of the targeted sets were missed due to high flow. The sampling and net design used in 2005 proved satisfactory for the project objectives and will be adopted by DMF during the 2006 season.

2004 Catch Summary

A total of 765 smelt were caught at the four stations (75 hauls) in 2004. At least 18 successful fyke net hauls were made in each of the four rivers sampled in 2004. Three sampling dates during early April were incomplete due to a rain storm that brought 4-6 inches of rain to the region. Smelt were caught in each river except the North, and large numbers of smelt were only caught in the Fore River (Table 2). A total of 17 species of fish were caught (5 diadromous, 4 estuarine, and 8 freshwater); with mummichog, American eel, and fourspine stickleback following smelt in terms of highest relative abundance (Table 3). The fyke net used in 2004 was successful in the Fore River where a strong smelt run was present. We suspected that the smelt catch in the Jones River and Parker River poorly represented those runs, in part due to the small size of the fyke net. Our experience in 2004 allowed us to redesign a larger fyke net that would be better suited to catch smelt in 2005.

2005 Catch Summary

In addition to using a larger fyke net in 2005, we increased our sets to three times per week to better represent the spawning run, and set the net facing downstream to catch only upstream migrating smelt. These changes were applied to the four rivers designated as long-term, population stations (Jones, Fore, Saugus, and Parker rivers). The North and Crane rivers were designated as short-term, restoration stations for experiments on stocking marked smelt larvae. For these two stations, the 2004 sampling design was repeated. A total of 3696 smelt were caught at six stations (164 hauls) in 2005 (Table 2). Smelt catches improved dramatically in the Fore, Jones and Parker rivers, with the deployment of the improved net and increased number of sets. A total of 21 species of fish were caught (7 diadromous, 6 estuarine, and 8 freshwater); with fourspine stickleback, mummichog, and threespine stickleback following smelt in terms of highest relative abundance (Table 3).

Table 2. Fyke net smelt catch summary for 2004 and 2005. Ages for all smelt with length data were allocated using age-length proportions primarily from the Fore River samples.

River	Total Catch (No.)	Hauls (No.)	CPUE (smelt/haul)	Length Sample (No.)	Age Sample (No.)	Male (%)	Female (%)	Age-1 (%)	Age-2 (%)	Age-3 (%)	Age-3+ (%)
2004											
Fore	740	18	41.1	640	295	81.0	18.9	93.5	4.5	2.0	
Jones	22	21	1.0	22	0	81.8	18.2	68.2	18.2	13.6	
Parker	3	18	0.2	3	0	100.0	0	66.7	33.3		
North	0	18	0								
2005											
Fore	2131	30	71.0	1050	274	0.79	0.21	0.17	0.82	0.01	
Parker	924	26	35.5	482	102	0.86	0.14	0.24	0.74	0.01	0.01
Jones	489	32	15.3	459	0	0.61	0.39	0.49	0.51		
Saugus	141	32	4.4	141	0	0.79	0.21	0.54	0.45	0.01	0.01
Crane	6	22	0.3	6	0	0.83	0.17	0.50	0.50		
North	5	22	0.2	5	0	0.60	0.40	1.00			

Table 3. Summary of smelt fyke net catches in 2004 (4 stations - 75 hauls) and 2005 (6 stations - 164 hauls). The total number caught per species and the percent frequency of occurrence (FOC) are reported.

Species Name	**Scientific Name**	**Type**	**2004 Catch** (No.)	**2004 FOC** (%)	**2005 Catch** (No.)	**2005 FOC** (%)
rainbow smelt	*Osmerus mordax*	Diadromous	765	25	3696	55
American eel	*Anguilla rostrata*	Diadromous	134	39	95	29
Atlantic tomcod	*Microgadus tomcod*	Diadromous	14	7	21	8
white perch	*Morone americanus*	Diadromous	1	1	17	7
lamprey	*Petromyzon marinus*	Diadromous	4	5	15	6
alewife	*Alosa pseudoharengus*	Diadromous			14	5
blueback herring	*Alosa aestivalis*	Diadromous			1	1
mummichog	*Fundulus heteroclitus*	Estuarine	201	24	237	42
fourspine stickleback	*Apeltes quadracus*	Estuarine	104	39	521	57
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	51	24	119	34
Atlantic herring	*Clupea harengus*	Estuarine			3	1
Atlantic silverside	*Mendia menidia*	Estuarine			2	1
killifish	*Fundulus majalis*	Estuarine			1	1
winter flounder	*Pseudopleuronectes americanus*	Estuarine	2	3		
yellow perch	*Perca flavens*	Freshwater	42	11	91	20
white sucker	*Catostomus commersoni*	Freshwater	2	1	67	16
bluegill	*Lepomis macrochirus*	Freshwater	2	3	42	8
pumpkinseed	*Lepomis gibbosus*	Freshwater	4	3	25	4
golden shiner	*Notemigonus crysoleucas*	Freshwater	4	5	17	7
redfin pickerel	*Esox americanus americanus*	Freshwater	4	5	6	4
yellow bullhead	*Ameiurus natalis*	Freshwater	2	1	5	3
banded sunfish	*Enneacanthus obesus*	Freshwater	3	4	1	1
sand shrimp	*Crangon septemspinosa*	Arthropod	2	3	29	7
green crab	*Carcinus maenas*	Arthropod	11	7	10	3
crayfish	*Cambarus sp.*	Arthropod	1	1	5	3
horseshoe crab	*Limulus polyphemus*	Arthropod			1	1
Total Fish Catch			1339		4996	

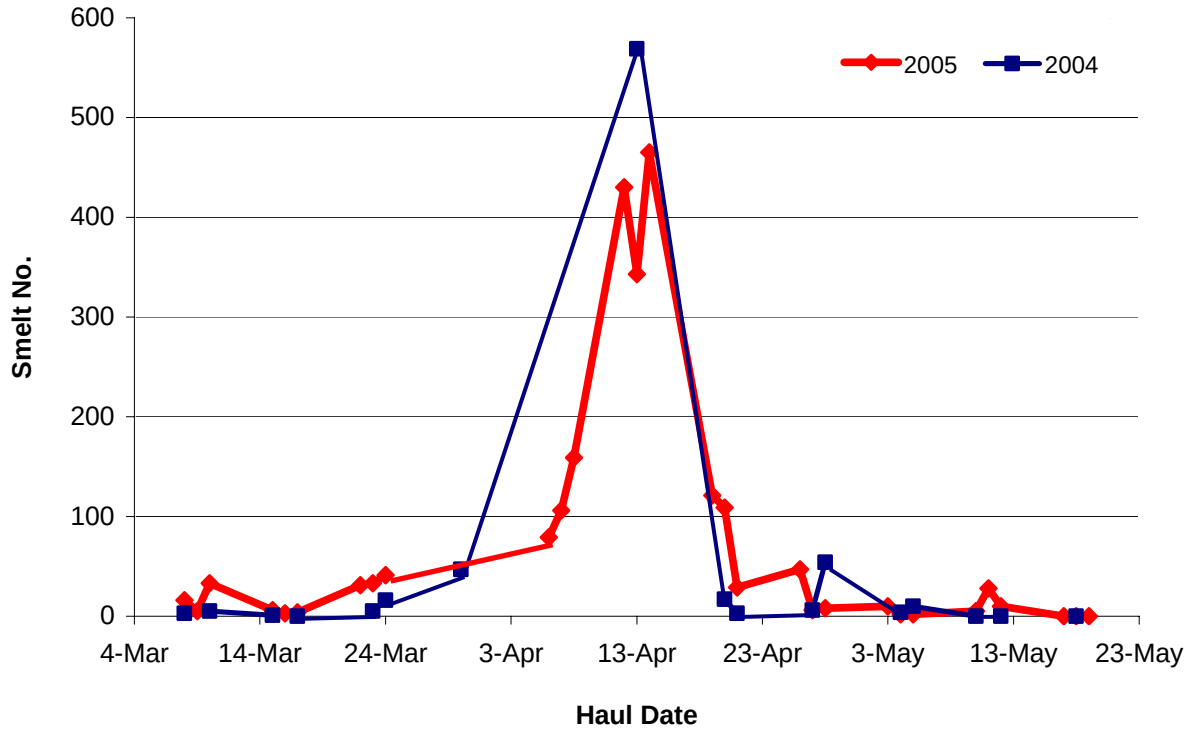
Station Summary

Jones River. Smelt catches in the Jones River increased from only 22 smelt in 2004 to 489 in 2005. The increase is most likely associated with the larger fyke net and more frequent deployments, and possibly a stronger run in 2005. Higher densities of smelt eggs were observed in 2005 at upstream riffles than in 2004. Only six fish species were caught in 2004 in contrast to 14 in 2005, and the low catch of smelt in 2004 was probably not proportional to the spawning run. Total fish richness (14) and diadromous fish richness (6) was highest among fyke net stations (Table A.1).

The larger fyke net used in 2005 was clearly more appropriate for the channel width at this station. With a wide river channel and salt marsh border, the Jones River station was not as likely to be disrupted by large rain events as the other stations. This station only missed one haul during each of the seasons due to high flow. The net did suffer substantial ice damage from ice floes during the first week of sampling in 2005. Overall, this station is well suited to the project objective of establishing a long-term population monitoring station.

Fore River. The Fore River was selected to characterize a river with one of the larger smelt runs in Massachusetts (Chase and Childs, 2001) and the catches supported this rank. The highest catch rate, relative abundance and frequency of occurrence (FOC) for smelt were found in the Fore River. (Tables 2-3). The larger net used in 2005 appeared to improve smelt catch rates in the Fore River but not to the degree found in the Jones and Parker rivers. Smelt were caught in each net set from March 7th through May 12th in 2005 and all but three sets during the same period in 2004. In both seasons, the net deployments were suitable to characterize the duration and peak of the smelt spawning period (Figure 2).

Figure 2. Fyke net smelt catch in the Fore River, 2004 - 2005.



For the two years combined, the Fore River had the highest catch (1.7/haul) and frequency of occurrence (42%) for American eel among fyke net stations. It is also the only station that did not show a decline in eel catch with the change in net size and orientation. The Fore River was the only location with routine catches of Atlantic tomcod, which were caught in low abundance in March and early April both seasons. It is the only station were fish species richness declined (from 10 species to 9 species) with the change in sampling design (Table A.2).

The fyke net location in the Fore River was moved in 2005 from under the Shaw Street bridge downstream 50 meters. This move was a substantial improvement given the treacherous flows found at the bridge constriction and the interest of placing the net downstream of the lower limit of smelt egg deposition. Few smelt eggs are deposited immediately downstream of the bridge. This location functioned well for fyke net deployments. There are two potential concerns from the net being visually exposed in a high traffic area and having an increased period when tidal influence covers the net. No evidence of tampering was noted in 2005 and careful scheduling minimized missed hauls due to high water. This location will be a valuable station for long-term monitoring interests.

Saugus River. The Saugus River was selected as a fourth population monitoring station and sampled for 32 hauls in 2005. Smelt were routinely present in Saugus River hauls (56% FOC) but at a low catch rate (4.4/haul) compared to the other population monitoring stations. The presence of alewife and white perch were documented in the Saugus River. The catches for both species were low but still highest among fyke net stations (Table A.3). Fish richness was ranked third among stations (11 species) and a relative high presence of freshwater yellow perch and white sucker were encountered at this tidal station. The Saugus River station is suitable for a long-term monitoring station and has the added benefit of local interest and support from the Saugus River Watershed Council and the property owners, the National Park Service Saugus River Iron Works.

North River. The small fyke net was set in the North River in both years using the same sampling design (facing upstream, two sets per week). No smelt were caught in the North River during 18 hauls in 2004, despite observations of low densities of smelt eggs at upstream spawning riffles. In 2005, five smelt were caught during three of 22 total hauls (Table A.4). American eel was the only other diadromous species caught in the North River. The eel catch per haul was second highest among all stations in 2004 and declined by over 100% in 2005. Mummichogs were the most common catch in terms of both relative abundance and FOC. Fish richness in the North River was among the lowest of the stations with a total of nine species.

The small net and sampling design used resulted in a high percentage of successful sets but was marginally suitable to establish the presence of smelt in a river where clearly a very small smelt run occurs. Water quality in the North River degrades severely following rain events. The fyke net set facing upstream was stressed by this run-off and debris load. This station will continue as an experimental restoration station and the larger net and improved design will be used in 2006.

Crane River. The Crane River was sampled only in 2005 as an experimental, restoration station. The small net was deployed in the Crane River in 2005 and produced low richness and abundance of fish during 22 hauls (Table A.5). Six adult smelt were caught in Crane River, the first documentation of adult smelt in the Crane River following an DMF smelt egg transfer project in the 1990s (Chase et al. *In Prep*.). Upstream spawning riffles were visited weekly and low densities of smelt eggs were observed during late March and April. Approximately 1.1

million smelt larvae hatched from Fore River eggs and marked with OTC were stocked in the Crane River in 2005. This station will adopt the larger net and improved sampling design in 2006 and will receive marked smelt larvae in 2006 and 2007.

Parker River. Smelt catches in the Parker River improved from only three in 2004 to 924 in 2005. Similar to the Jones River station, the Parker River catches improved substantially with the change in sampling design. It is also likely that the 2005 spawning run was stronger than the previous year because much higher smelt egg densities were observed at the spawning riffles upstream of the fyke net in 2005 than in 2004. Unlike the Jones River, 2005 catches did not have a large change in fish richness in 2004 (Table A.6). Both seasons produced catches of 5-6 species of freshwater fish that were swept over the dam at Central Street into the tidal zone. American eel was one of the few species with a large decline in catch rate from 2004 to 2005. Similar to the Jones and North rivers, more eels were caught in the smaller net set facing upstream in 2004. The Parker River was the only river that had catches of the anadromous sea lamprey. Lamprey were caught during both seasons in early April and catches of a few mature adults continued through the completion of sampling in mid-May.

The Parker River station will be a greater challenge than the other stations due to higher water depth at high tide, periodic presence of ice and large increases in discharge following rain events. The fyke net could not be set for the first two weeks of the 2005 season because thick ice was present in the tidal zone extending up to the downstream limit of spawning habitat. The presence of ice will be a reoccurring concern during cold winters and springs. Secondly, the discharge at this point in the watershed can increase an order of magnitude within a day of large rainfall. This was witnessed during both seasons with 3-5 inch rain events. Over a week was lost during the peak season in 2004 due to high flows that did not allow us to retrieve the fyke net. This will also be a reoccurring problem; however, it can be managed with careful monitoring of the weather. Overall, this station is valuable to the project as it represents the most northern and least developed watershed, and is one of the few Massachusetts rivers with historical smelt population data (Murawski and Cole, 1978).

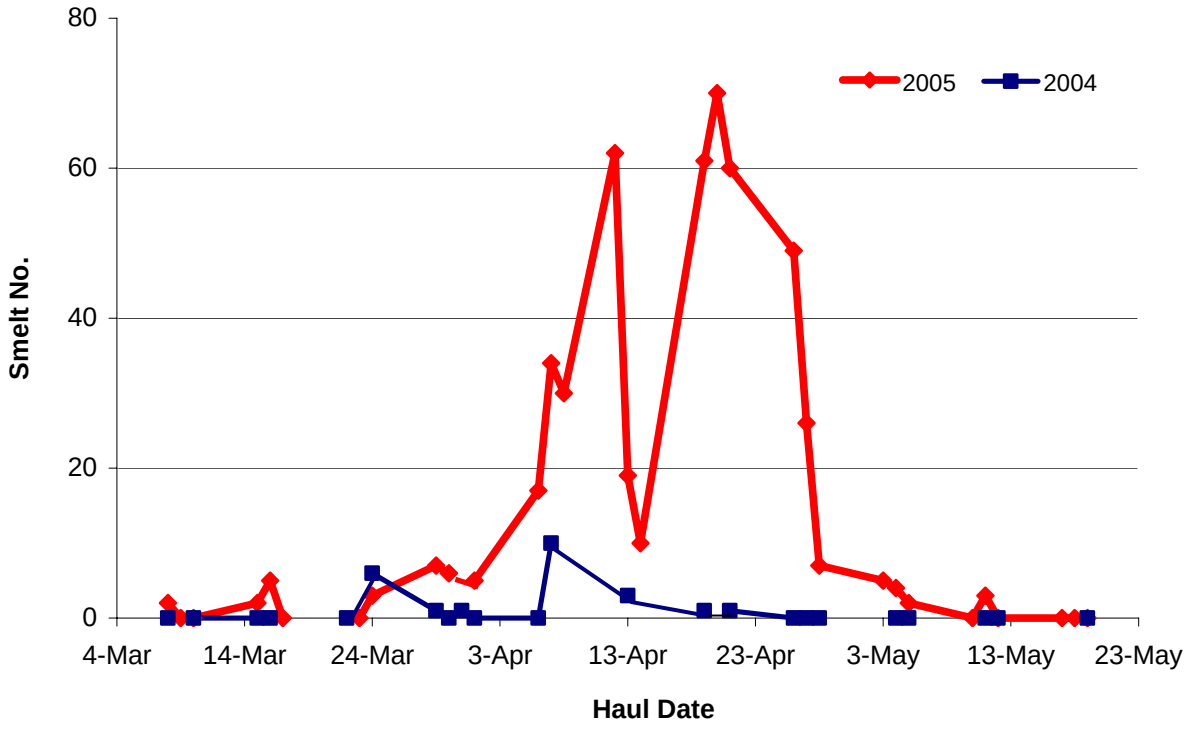
Smelt Catch-per-Unit-Effort (CPUE)

A primary goal of this project is to develop relative indices of smelt population abundance. Smelt catch-per-haul is a parameter that will be explored for utility in tracking annual trends in relative population abundance. To date, a smelt CPUE has been calculated for the entire sampling season and for the month of April, when catches are highest (Table 4). The 2004 data will likely represent a pilot effort and have little value to a long-term data series. This is because only the Fore River had more than a few smelt caught in 2004 and substantial changes were made to the sampling design in 2005. The standard deviations and coefficients of variation (CV) for smelt catch-per-haul were high; reflecting on a variety of biotic and abiotic influences on the smelt's spawning migration. The CPUE for April hauls had reduced CVs for most rivers, but still at high levels that raise concerns over discerning annual changes in spawning run strength. The 2005 April CPUE in the Jones River had the lowest variation, despite a sharp decline in catches during the peak run (Figure 3) that may have been associated with a 4 ^{o}C drop in water temperature during several cold nights.

Table 4. Smelt catch-per-unit-effort (catch per haul) in fyke net catches, 2004 and 2005.

River	Year	*SEASON* Hauls (No.)	Catch (No.)	CPUE	SD	CV	*APRIL* Hauls (No.)	CPUE	SD	CV
Fore	2004	18	740	41.1	132.67	323	6	108.2	226.63	210
Fore	2005	30	2131	71.0	124.01	175	12	158.5	162.30	102
Parker	2005	26	924	35.5	96.26	271	13	44.4	123.25	278
Jones	2005	32	489	15.3	21.80	143	12	37.1	22.35	60
Saugus	2005	32	141	4.4	7.64	174	13	10.4	9.89	95

Figure 3. Fyke net smelt catch in the Jones River, 2004 - 2005.



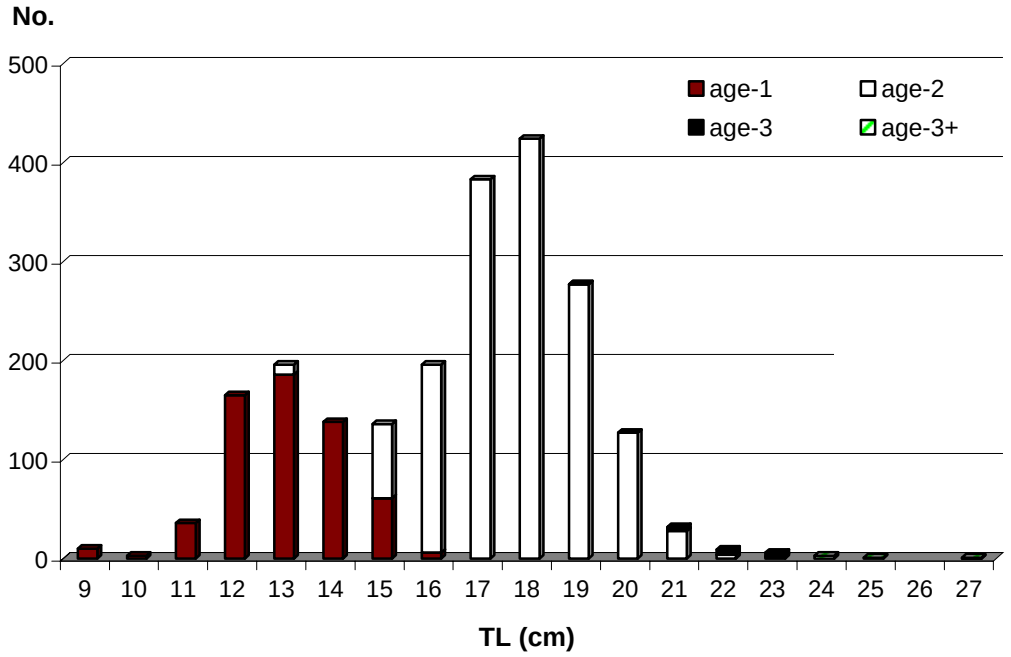
Smelt Length and Age Composition

Smelt age and length keys were developed for the Fore River in both 2004 and 2005 and a combined key was calculated for Fore River and Parker River smelt in 2005. These are the first estimates in Massachusetts of smelt age composition in 25 years when DMF assessed the spawning run the Jones River (Lawton et al., 1990). Age composition was based on combined sexes in 10 mm length intervals. The age and length data were also processed by sex and by 0.5 cm intervals but there were too many missing length intervals to produce an age-length key for both these categories. Concern exists over the potential bias to age composition estimates caused by male smelt participating for a longer period of spawning than females. Murawski et al. (1980) studied smelt movements and compared sex ratios in the Parker River smelt fishery and spawning run in the 1970s. Their results indicate that the much higher ratio of male to female smelt found in the spawning run than during the winter fishery is caused by the higher frequency of male repeat spawning. Therefore, the age composition reported is relative to the spring spawning runs. The contributions of age-1 and age-2 males are probably positively biased relative to the pre-spawning run population (Murawski and Cole, 1978).

2004 Age Composition. The 2004 age key shows a dominance of age-1 smelt (93.5%) that has not been previously reported and is likely inflated from sampling biases (Table A.7). Due to sporadic catches in the small fyke net, smelt scales were sampled on only four dates including one haul that accounted for over 70% of all aged and measured smelt. used in the key. This haul of 569 smelt in the Fore River on April 12th was dominated by age-1 smelt and overwhelmed the capacity of the small fyke net. Despite, this obvious bias to the age key , age-1 smelt were present at higher percentages than expected historically throughout the Fore River spawning run. This observation and comparisons of year class contributions to the 2005 age composition indicate that the 2003 year class may have been stronger than the 2002 and 2004 year classes and made up a higher than typical proportion of the spawning run as age-1 smelt. Very few smelt were found to be older than age-2 in 2004. Only 2% of the sample was age-3 and no age-4 smelt were aged. Because of the uncertain contribution of age-1 spawners, the 2004 age key has little long-term value for population monitoring. The 2004 efforts were valuable for our training with the ageing process and to improve sampling protocols for 2005.

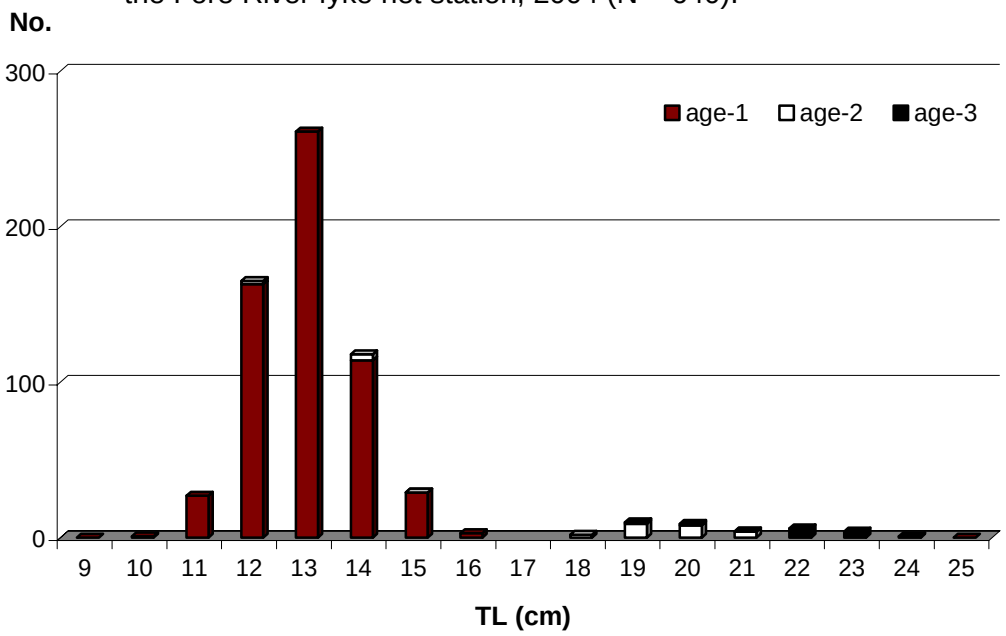
2005 Age Composition. Sampling distribution improved in 2005 as age samples were collected during nine hauls over seven weeks. Eight samples in the Fore River produced 274 aged smelt (Table A.8) and a single sample of 102 smelt was collected in the Parker River. An age-key was constructed with the 376 total aged smelt and applied to all measured smelt (N = 2143) in 2005 (Table A.9, Figure 4). The contribution of age-1 smelt was 16%, and age-2 smelt dominated the age composition (83%); a result more consistent with previously reported data. Similar to 2004, larger smelt were uncommon: only 5 smelt (1%) were aged as three year olds and no age-4 smelt were aged. Overall, the age composition for spawning run smelt during 2005 was similar to previous studies that aged smelt in Massachusetts (Murawski and Cole 1978; and Lawton et al. 1990) and New Hampshire (Grout and Smith 1994); although, with a higher than typical presence of age-1 and reduced presence of age-3 and older smelt.

Figure 4. Length and age frequency of rainbow smelt samples from all fyke net stations, 2005 (N = 2143).



The length and age frequency for all measured smelt in 2005 had distinct modes for age-1 and age-2 smelt. The 15 cm interval was a transition from age-1 to age-2 smelt: no 14 cm smelt were age-2 and few 16 cm smelt were age-1. The frequency of smelt over 20 cm was low, with very few age-3 or older smelt present. Large numbers of age-2 smelt occupied the 17 cm interval. In contrast, in 2004 the 17 cm interval was vacant and very few smelt were in the 16 cm interval (Figure 5). With more years of data, the monitoring series should provide annual trends on year class strength and growth rate analyses will be possible. An example of this potential can be seen with the length and age frequencies for individual rivers (Figure 6). The Jones River had modal peaks at the 12 cm interval for age-1 smelt and 18 cm interval for age-2 smelt and no age-3 smelt were recorded out of 459 samples. With a similar sample size, the modal peaks for Parker River smelt occurred at a larger size and older fish were represented in the spawning run. Despite the different sample sizes and dependence on Fore River smelt for ageing, each river had distinct length and age characteristics that with more years of data may be associated with river-specific recruitment and growth.

Figure 5. Length and age frequency of rainbow smelt samples from the Fore River fyke net station, 2004 (N = 640).



Sex Ratio

The sex ratio for all sexed smelt in 2004 (N = 665) was 4.3 males to 1.0 female and in 2005 (N = 2127) was 3.3 males to 1.0 female. The 2004 ratio was dominated by Fore River samples (N = 640). In 2005, the samples (N = 1036) from just the Fore River had a sex ratio of 3.8 males to 1.0 females. These ratios should be considered biased sex ratios because of the repeat spawning behavior of male smelt. The 2004-2005 ratios are lower but within the range of values found in previous smelt studies in Massachusetts. The Jones River study of 1979-1981 found spawning run ratios of 8.9, 4.0 and 9.0 males to 1.0 female, respectively (Lawton et al., 1990). The Parker River study found spawning run ratios of 8.0 and 8.6 males to 1.0 female in 1975 and 1976 and found a nearly 1:1 ratio during the winter smelt fishery (Murawski et al., 1980). The 2005 Jones River catch had far more females than the other rivers sampled. The higher percentage of females in the Jones River (39%) was a routine observation and not influenced by one or two catches with large numbers of females.

Figure 6a. Fore River smelt length and age frequency, 2005.

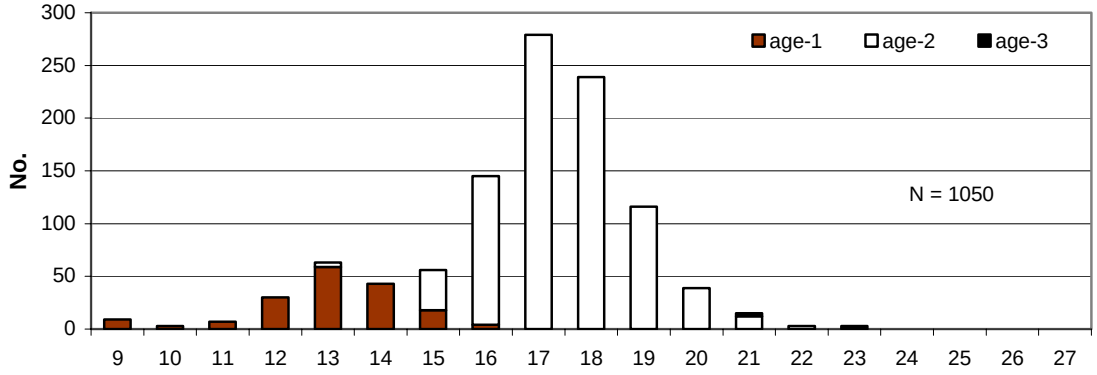


Figure 6b. Jones River smelt length and age frequency, 2005.

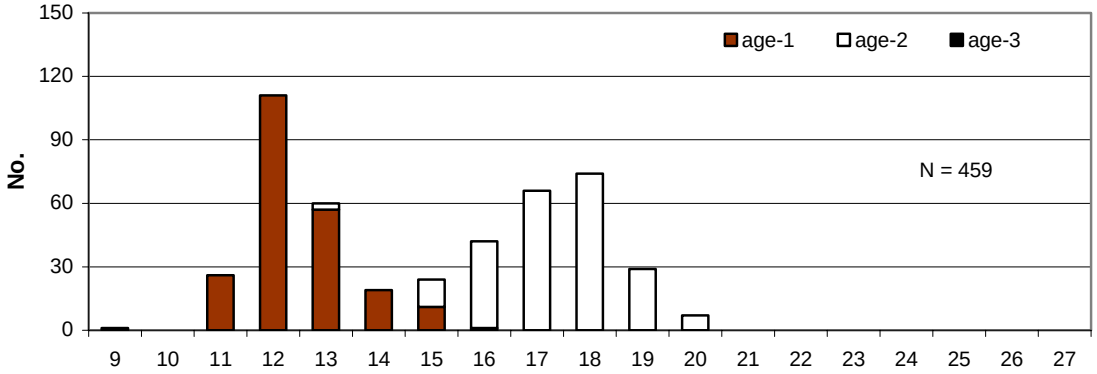


Figure 6c. Saugus River smelt length and age frequency, 2005.

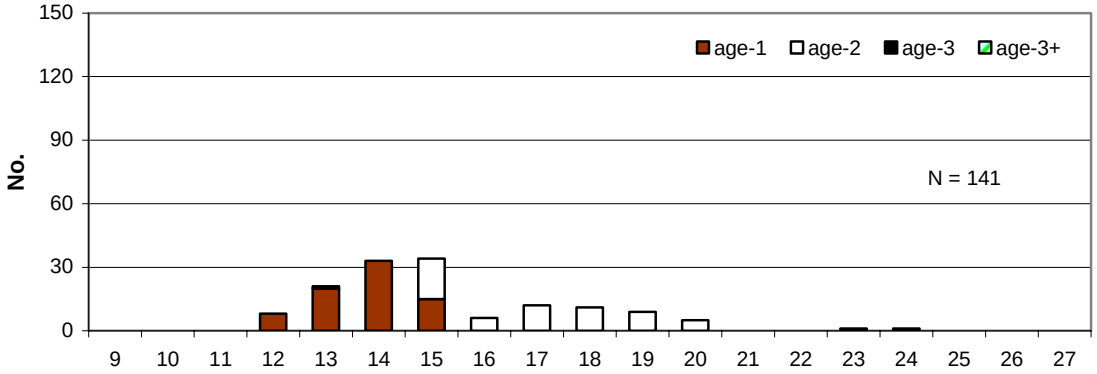
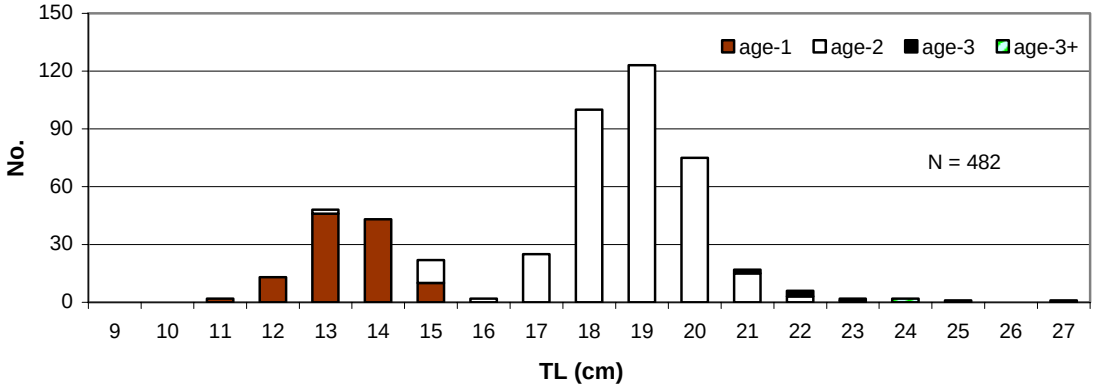


Figure 6d. Parker River smelt length and age frequency, 2005.



Smelt Length/Weight Relationships

Total length, fork length and weight measurements were taken for all smelt returned to the laboratory for ageing. The following size relationships were calculated with linear regression. Data for the length-weight were transformed logarithmically to straighten the curvilinear relation of fish length and weight. The fork length relationship will be used as needed to transform data from other sources. Data on length-weight will continue to be recorded and comparisons will be made with historical data sources and consideration will be given to estimating river, sex, or age-class specific condition indices.

$FL = (0.5584 + 0.9142)TL$ (Fore River smelt, N = 598, $R^2 = 0.996$)

$Log_{10}W = (-5.6671+3.1808)Log_{10}TL$ (Fore River smelt, N = 598, $R^2 = 0.971$)

Scale Ageing Quality Assurance.

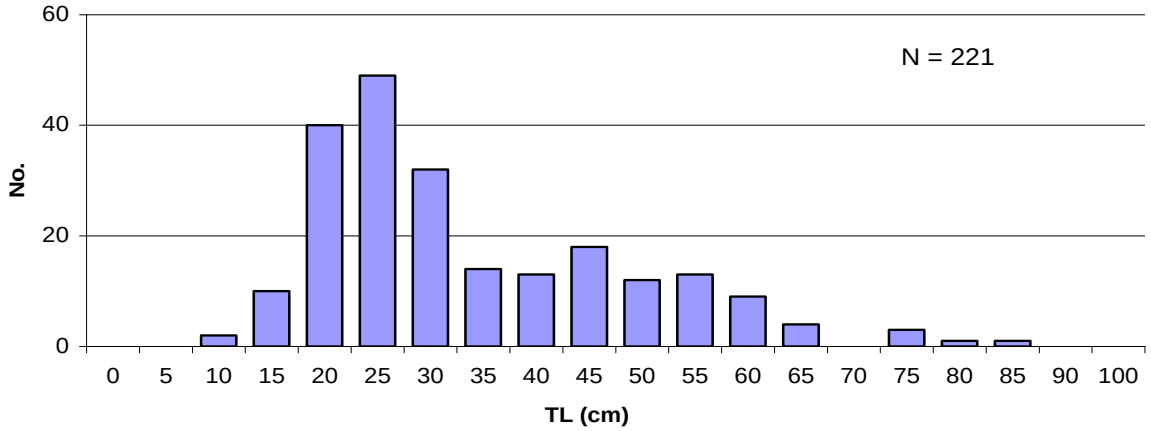
All scale samples were read by at least two readers. The primary author was responsible to audit all scale data entry and make age determinations on samples with the following criteria: samples with disagreements among readers, all age-3 samples, age-2 samples >22 cm, age-2 samples <15 cm, and age-1 >15 cm. Ageing precision was high for both sample seasons. The average sample ageing agreement among readers was 90% in 2004 and nearly 95% in 2005. The total precision for readers (percent correctly aged following quality assurance review) ranged from 88-95% in 2004 and 89-98% in 2005. The high precision was influenced by the presence of only three age classes among age samples. The age samples in 2004 were likely biased towards age-1 smelt because smelt were collected on only four dates and 70% of the samples came from one haul that was 90% age-1 smelt. This bias was reduced in 2005 as weekly samples were targeted and a total of nine samples were collected.

Other Diadromous Fish Species.

The fyke net catches provided useful data on the presence of six additional diadromous species (sea lamprey, American eel, Atlantic tomcod, white perch, alewife, and blueback herring). The project has shown promise in providing catch and size data for American eel, Atlantic tomcod, and white perch; species for which there is limited information and growing concern over the health of populations in Massachusetts. Eels were caught in each river, with relatively high frequency of occurrence but low relative abundance. Eels were typically present from late-March through May with a wide range of juvenile and adult sizes (Figure 7). The 2004 eel catch-per-haul with the small net facing upstream was more than twice the 2005 catch rate. It is not known whether the difference reflects the presence of more eels in 2004 or on a particular migratory behavior of yellow eels in spring.

A total of 35 tomcod were caught during the two seasons mostly from the Fore River except for two Jones River tomcod. Most tomcod were caught in March and early April. The size range was 110-216 mm. The average size was 154 mm, indicating that most of the captured tomcod were mature adults (Howe, 1971). None of the tomcod appeared ripe, and given their life history, their presence at the tidal interface may have been associated with post-spawning foraging.

Figure 7. American eel lengths from all fyke net stations, 2004-2005. Data are arranged in 5-cm bins.



Water Chemistry Measurements

Water chemistry was measured for the parameters listed in Table 8 using a calibrated YSI 6820 at the time of each haul. For the parameters measured, water quality conditions were adequate to support aquatic life, with the exception of violations of Massachusetts Surface Water Quality Criteria for pH (<6.5). The Jones River was routinely acidic with few measurements above the water quality criteria. For all rivers, 2005 measurements were less acidic than 2004. Dissolved oxygen was at or near saturation for all measurements. Base flows in the Jones and Parker River had very low conductivity while the North and Crane River were among the highest seen for smelt runs in Massachusetts (Chase, 2006). Base flow turbidity was low for all rivers but is highly influenced by rain events. The Crane River appeared to have the highest base flow turbidity and the North River appeared to be degraded most following precipitation. A YSI 6920 was deployed in the Parker River and Fore River to continuously record water chemistry each hour. These data have not been summarized for this report. Further evaluation of the haul-day measurements and continuous water chemistry recordings should provide greater insight on base flow conditions of water pH, conductivity, and turbidity and responses to rain events.

Table 8. Average water chemistry measurements at smelt fyke net locations, 2004 - 2005. Water chemistry was measured with a YSI 6820 during each haul date (N = 19, 2004 and 26-33, 2005).

River	Year	Water Temp. (C^o)	Sp. Cond. (mS/cm)	D.O. (% Sat.)	D.O. (mg/L)	pH	Turbidity (NTU)	Discharge (cfs)
Jones	2004	9.6	0.246	103.3	11.7	6.3	4.5	70.6
Jones	2005	9.0	0.222	108.9	12.7	6.5	5.5	83.6
Fore	2004	9.8	0.567	100.3	11.5	6.6	4.6	
Fore	2005	9.5	0.790	108.9	12.6	7.2	5.8	
North	2004	10.2	0.849	103.8	11.7	6.8	5.2	
North	2005	10.3	0.920	112.4	12.6	7.3	10.9	
Parker	2004	9.7	0.255	98.4	11.4	6.6	3.0	103.7
Parker	2005	10.1	0.250	106.8	12.2	7.1	5.0	97.4
Crane	2005	10.1	1.150	106.3	12.1	7.3	8.6	
Saugus	2005	8.9	0.740	105.2	12.3	7.5	9.2	60.0

DISCUSSION

We consider the two-year study to develop population indices for smelt spawning runs a success because a sampling protocol has been established that will be continued by DMF as an annual monitoring series. The series will produce population level data on a species that is valuable forage and has long-supported popular sportfisheries yet has received minimal attention relative to more economically valuable and higher profile gamefish. The need for this information has increased with recent concerns throughout New England over the status of smelt populations. Sampling will continue in 2006 with no changes to the net design and deployment. Minor adjustments will be made to improve age subsampling and evaluations will continue to isolate the most meaningful metrics to monitor population dynamics.

Similar smelt fyke net sampling has been reported twice previously in New England. A Master's thesis studied the Parker River smelt run during 1974 and 1975, compared spawning run age and length composition to data collected during winter smelt fisheries (Murawski and Cole, 1978). These data will be useful to evaluate changes in the Parker River smelt run and to consider adjustments to our spawning run age composition using winter unbiased sex ratios. New Hampshire Fish & Game conducted fyke net sampling in New Hampshire smelt runs during 1978-1983 (NHFG, 1984). This sampling series found fewer age-1 smelt and a higher percentage of age-3 and age-4 smelt than we recorded in 2004 and 2005. The New Hampshire data will also be valuable as a historical comparison for our monitoring series.

Catch Per Unit Effort Data. Additional years of sampling will be necessary to determine the best parameters for tracking annual change in relative abundance. With only three year classes representing nearly the entire spawning run, there may be potential track age class strength with less variability than total catch per haul. It is possible that a finer scale parameter, such as, age-2 female catches in April, will provide a useful index. The potential bias from males repeatedly returning to the spawning grounds may be less of a problem for CPUE analyses than for age composition. It should be a reasonable assumption that the percentage of repeat spawning among age classes is similar over time. We expect that within-river smelt CPUE should become a useful index; however, more information is needed to isolate the most appropriate parameters and to investigate the suitability of comparisons between rivers and efforts outside Massachusetts.

Smelt Ageing. The smelt age composition estimate improved substantially from 2004 to 2005 with changes in sampling design. The weekly target of 30-50 smelt samples for ten weeks should continue for the Fore River. We had concerns that the sampling approach or ageing methods may have been underestimating the presence of age-3 smelt. After two years of reviewing the ageing process and the age and length frequency data these concerns have diminished. Our aging precision is high and the lengths that should represent age-3 or older smelt are simply not common in the sampled runs. The bias to age composition presented by males that run up the river at an undetermined rate and different rate from females has not been resolved at this point. We believe the age composition data are still valuable in the context of being relative to the spawning runs in each river. We will investigate correcting this bias by applying unbiased sex ratios from data collected on winter fisheries as applied by Murawski and Cole (1978) in their Parker River study.

Positive Features of Fyke Net Study

Catch Composition. The 2005 fyke nets documented the presence of smelt in each river system, from only a few smelt in the degraded North and Crane River to several thousand in the expected large run of the Fore River. We had hoped to gain information on other species of fish, but had not expected the variety of fish observed (22 total species) and common presence of freshwater fish (8 species) at these intertidal habitats. In addition, we gained catch and size data on other diadromous fish (eel, tomcod, white perch) that are not routinely sampled in Massachusetts and have similar concerns over their population status.

Smelt Fyke Net. The re-designed fyke net used in 2005 was well-suited for the project's objective. The dimensions appeared to be appropriate to intercept a representative portion of the smelt moving upstream to spawn each night. With the exception of the large catch in 2004 (569 smelt in the small net), concerns on overharvest and capture mortality did not materialize. The 2005 nets were low cost, durable and easily deployed and retrieved (photograph on p.18).

Smelt CPUE. We expect that our catches of smelt are representative of each river's spawning run and will provide a useful relative index of smelt populations. The monitoring series should detect river specific changes in year class strength and large scale changes in population status.

Smelt Length and Age Key. Deriving age composition for any fish species requires a dedicated team to collect field samples and process the age structures. The grant funding and matching efforts of DMF allowed the complete processing of two years of samples in a little more than a year following the end of 2005 field sampling. Length and age data are fundamental to understanding smelt population dynamics and with the exception of two short-term studies in the 1970s, have not been available for this species in Massachusetts.

Smelt Eggs for Restoration. We conducted an investigation on laboratory culture and marking of smelt eggs concurrently with the fyke net study. All Fore River females collected during scale sampling were also used for egg collections. The use of the eggs is an added benefit from smelt that would routinely be sacrificed for ageing. Approximately 1.1 million smelt larvae marked with OTC were stocked in the Crane River in 2005 from this effort.

Negative Features of Fyke Net Study

Biased Sex Ratio. The uncertain repeat spawning frequency of male smelt presents a problem to the objective of determining the age composition of the true smelt population in each river. This concern will need to be addressed with additional analyses and decisions on data treatment. Either the age composition as recorded is accepted as an estimate relative to only the spawning run (not the true population), or the data could be adjusted proportionally using unbiased sex ratio data from past studies or winter fishery surveys in the region.

Frequency of Sampling. The CVs in CPUE data indicate that detecting annual changes may be difficult due to inherent variation in nightly run densities. It is possible that hauling the net more days per week may reduce this variation. Increasing the number of weekly hauls from three to four will be difficult given our staff size, traveling constraints and other assignments.

Potential Weather Complications. We were fortunate to experience little net damage and execute a high percentage of targeted net hauls. We did see a glimpse of the potential to have unsuccessful sets occur from the following: ice damage, ice presence, vandalism, predator damage to net, and river flow disruption. A week was lost in 2004 and nets were swept off station after a large rainfall. We had better planning for another large rainfall in 2005 and lost only a few days as we held back on setting the nets with the approaching storm. The potential exists to have substantial gear losses or harm to staff when deploying or retrieving fyke nets during spring rain pulses.

RECOMMENDATIONS

1. Despite high precision, the accuracy of ageing smelt using scales has not been investigated. Corroborative studies with otoliths and/or a validation study with known age smelt should be conducted to confirm the accuracy of age estimates.

2. With the inclusion of 2006 catch data, it will be possible to investigate CPUE parameters that may have less variance than the seasonal catch-per-haul data reported for 2004 and 2005. Logarithmic transformations may reduce the influence of zero catches and monthly gender and/or age-class indices may prove to be suitable for tracking relative abundance.

3. The process for field collecting smelt scale samples improved in 2005, reducing the bias introduced in 2004 from a single, large sample. In both years, our protocol called for weekly subsamples up to 50 fish drawn randomly from a mixed bucket with all smelt from a given haul. This protocol worked well in 2005, although some catches were dominated by just a few cm intervals of age-1 or age-2 smelt, resulting in the over-sampling of those sizes and relative few large smelt aged. For large catches, fixed stratified subsampling that collects the first five males and five females from each cm interval should reduce this concern.

4. The Fore River should continue to be targeted as the source for smelt scale samples. This river supports the largest run in the study area and has demonstrated catch numbers that will allow sample removals of about 300 smelt without obvious concern over sampling mortality. Despite the benefit of ageing smelt in each river, concern over sampling mortality does not justify this goal. Most sacrificed females in 2005 from the Fore River contributed eggs for the restoration experiment in the Crane River. This should continue in 2006, with consideration for supplements from the closest donors (Saugus River, Parker River) if necessary. An analysis should be conducted to determine the optimal sample size to construct an age-key each year.

5. Routine catch and size data collections for yellow eels, white perch, and tomcod are not presently made in Massachusetts. The fyke net series offers the potential to gain information on these diadromous fish that appear to be declining in Massachusetts and have a near void in baseline biological data. An evaluation should be made on developing a yellow eel CPUE from this series and consideration should be given to saving age structures for all net mortalities and possible scale collection from live white perch and tomcod.

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Smelt Fyke Net in the Fore River, Braintree, 2005.

APPENDIX

Population Indices of Rainbow Smelt Spawning Runs in Massachusetts.

Field Sampling and Data Collection *(March 2005)*

Sampling Period. March 8th - May 15th.

Fyke Net. The net is modified from 2004 nets: larger hoops, wings and mouth and has box frames for mouth and wings. Six hoops (2.5 ft. diameter) attached to box frame (4x4 ft.). Throats are attached to second hoop inside mouth and fourth hoop. Box frame wings (4x4 ft.) are attached to both sides of the box frame mouth. All meshes are 0.64 cm (1/4 in.). Wing poles will be set 2.5 m apart.

Deployment. The fyke nets will be set overnight and retrieved near low tide the next day. For each river, a mid-channel location will be selected and used for each deployment Sample dates will not be randomly selected because of the complexity of coordinating traffic, tide and other tasks. Both the setting and hauling of nets must be done at lower tides; therefore these criteria will be most important for scheduling deployments. Three overnight sets will be made each week (11 weeks, 33 sets) for population index rivers (Jones, Fore, Saugus, and Parker) and the 2004 schedule (2 sets per week) will be used for the Crane and North Rivers.

Sampling Stations. Jones River (Kingston), Fore River (Braintree), North River (Salem), and Parker River (Newbury). The sampling stations are located at the lower end of spawning habitat where tidal influence is present. The Crane River (Danvers) and North River (Salem) will be sampled with 2004 nets as restoration river stations.

Catch Processing. Empty the net cod-end into buckets. Separate by species. Count and measure all fish (TL, mm) and release. Count and release all decapods. Measure eels to nearest cm. With large catches of mummichogs, measure a random sample of up to 20 fish.

Field Data Recording. Record the time the nets soaked (nearest 0.25 hour), tide stage, moon stage, and water chemistry from YSI 6820 (temp., pH, conductivity, D.O., and turbidity)

Age/Sex subsample. Save dead smelt for age subsample and live smelt when catch exceeds 19. From 20 to 50 smelt, save all smelt for ageing. For catches over 50 smelt, separate a random sample by pouring from a mixed bucket. Of the remaining smelt, measure (TL, mm), sex and release up to 80 individuals. Count and release the remaining smelt. An exception will be made for large catches with dead smelt. In this case, save all dead smelt for age sampling and measure and release live smelt. In all cases, the smelt collected for ageing should be proportional to the number of smelt in each length class.

Laboratory Processing. Following net collections, the smelt will be processed that day or the next in Gloucester. The following data will be collected: sex, maturity, total length, fork length, weight, and scales. A fin clip will be saved from Jones River fish for genetic analysis.

Table A.1. Summary of smelt fyke net catches in the Jones River, in 2004 (21 hauls) and 2005 (32 hauls). Total number caught per species and frequency of occurrence (FOC) are reported.

Species Name	Scientific Name	Type	2004 Catch (No.)	2004 FOC (%)	2005 Catch (No.)	2005 FOC (%)
rainbow smelt	*Osmerus mordax*	Diadromous	22	29	489	72
American eel	*Anguilla rostrata*	Diadromous	17	38	12	28
white perch	*Morone americanus*	Diadromous	1	5	5	16
alewife	*Alosa pseudoharengus*	Diadromous			2	6
blueback herring	*Alosa aestivalis*	Diadromous			1	3
tomcod	*Microgadus tomcod*	Diadromous			2	6
fourspine stickleback	*Apeltes quadracus*	Estuarine	2	10	31	50
mummichog	*Fundulus heteroclitus*	Estuarine	3	10	27	28
threespine stickleback	*Gasterosteus aculeatus*	Estuarine			5	16
Atlantic herring	*Clupea harengus*	Estuarine			3	3
Atlantic silverside	*Mendia menidia*	Estuarine			2	6
yellow perch	*Perca flavens*	Freshwater	42	38	31	31
bluegill	*Lepomis macrochirus*	Freshwater			39	25
pumpkinseed	*Lepomis gibbosus*	Freshwater			23	13
green crab	*Carcinus maenas*	Arthropod	11	24	10	16
sand shrimp	*Crangon septemspinosa*	Arthropod	1	5	2	3
tadpole	*Amphibia*	Amphibian			2	6
Total Fish Catch			87		672	

Table A.2. Summary of smelt fyke net catches in the Fore River, in 2004 (18 hauls) and 2005 (30 hauls). Total number caught per species and frequency of occurrence (FOC) are reported.

Species Name	Scientific Name	Type	2004 Catch (No.)	2004 FOC (%)	2005 Catch (No.)	2005 FOC (%)
rainbow smelt	*Osmerus mordax*	Diadromous	740	67	2131	90
American eel	*Anguilla rostrata*	Diadromous	38	39	44	43
tomcod	*Microgadus tomcod*	Diadromous	14	28	19	37
fourspine stickleback	*Apeltes quadracus*	Estuarine	12	33	77	73
mummichog	*Fundulus heteroclitus*	Estuarine	1	6	45	53
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	4	22	6	10
winter flounder	*Pseudopleuronectes americanus*	Estuarine	2	11		
killifish	*Fundulus majalis*	Estuarine			1	3
yellow perch	*Perca flavens*	Freshwater			8	20
bluegill	*Lepomis macrochirus*	Freshwater	2	11	3	10
redfin pickerel	*Esox americanus americanus*	Freshwater	2	11		
golden shiner	*Notemigonus crysoleucas*	Freshwater	1	6		
sand shrimp	*Crangon septemspinosa*	Arthropod	1	6	27	33
horseshoe crab	*Limulus polyphemus*	Arthropod			1	3
crayfish	*Cambarus sp.*	Arthropod			1	3
Total Fish Catch			816		2334	

Table A.3. Fyke net catch in the Saugus River, Saugus, 2005 (32 hauls).

Species Name	Scientific Name	Type	Total Catch (No.)	Frequency of Occurrence (No. of Hauls)
rainbow smelt	*Osmerus mordax*	Diadromous	141	18
white perch	*Morone americanus*	Diadromous	12	7
alewife	*Alosa pseudoharengus*	Diadromous	11	5
American eel	*Anguilla rostrata*	Diadromous	8	7
fourspine stickleback	*Apeltes quadracus*	Estuarine	185	27
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	63	22
mummichog	*Fundulus heteroclitus*	Estuarine	21	10
yellow perch	*Perca flavens*	Freshwater	50	15
white sucker	*Catostomus commersoni*	Freshwater	37	13
redfin pickerel	*Esox americanus americanus*	Freshwater	4	4
crayfish	*Cambarus sp.*	Arthropod	1	1
Total Fish Catch			532	

Table A.4. Summary of smelt fyke net catches in the North River, in 2004 (18 hauls) and 2005 (22 hauls). Total number caught per species and frequency of occurrence (FOC) are reported.

Species Name	Scientific Name	Type	2004 Catch (No.)	2004 FOC (%)	2005 Catch (No.)	2005 FOC (%)
rainbow smelt	*Osmerus mordax*	Diadromous			5	14
American eel	*Anguilla rostrata*	Diadromous	33	44	16	36
mummichog	*Fundulus heteroclitus*	Estuarine	197	89	76	68
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	25	44	20	41
fourspine stickleback	*Apeltes quadracus*	Estuarine	5	28	1	5
golden shiner	*Notemigonus crysoleucas*	Freshwater	2	11	4	14
redfin pickerel	*Esox americanus americanus*	Freshwater	2	11		
yellow bullhead	*Ameiurus natalis*	Freshwater			1	5
banded sunfish	*Enneacanthus obesus*	Freshwater			1	5
leopard frog	*Rana sp.*	Amphibian	1	6		
Total Fish Catch			264		124	

Table A.5. Fyke net catch in the Crane River, Danvers, 2005 (22 hauls).

Species Name	Scientific Name	Type	Total Catch (No.)	Frequency of Occurrence (No. of Hauls)
rainbow smelt	*Osmerus mordax*	Diadromous	6	6
American eel	*Anguilla rostrata*	Diadromous	6	3
mummichog	*Fundulus heteroclitus*	Estuarine	58	13
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	14	10
fourspine stickleback	*Apeltes quadracus*	Estuarine	5	4
Total Fish Catch			89	

Table A.6. Summary of smelt fyke net catches in the Parker River, in 2004 (18 hauls) and 2005 (26 hauls). Total number caught per species and frequency of occurrence (FOC) are reported.

Species Name	Scientific Name	Type	2004 Catch (No.)	2004 FOC (%)	2005 Catch (No.)	2005 FOC (%)
rainbow smelt	*Osmerus mordax*	Diadromous	3	6	924	54
American eel	*Anguilla rostrata*	Diadromous	46	33	9	27
lamprey	*Petromyzon marinus*	Diadromous	4	22	15	38
alewife	*Alosa pseudoharengus*	Diadromous			1	4
fourspine stickleback	*Apeltes quadracus*	Estuarine	85	89	222	92
threespine stickleback	*Gasterosteus aculeatus*	Estuarine	22	33	11	23
mummichog	*Fundulus heteroclitus*	Estuarine			10	23
white sucker	*Catostomus commersoni*	Freshwater	2	6	30	50
golden shiner	*Notemigonus crysoleucas*	Freshwater	1	6	13	31
yellow bullhead	*Ameiurus natalis*	Freshwater	2	6	4	15
pumpkinseed	*Lepomis gibbosus*	Freshwater	4	11	2	8
banded sunfish	*Enneacanthus obesus*	Freshwater	3	17		
yellow perch	*Perca flavens*	Freshwater			2	8
redfin pickerel	*Esox americanus american*	Freshwater			2	8
green crab	*Carcinus maenas*	Arthropod	1	6		
crayfish	*Cambarus sp.*	Arthropod	1	6	3	12
tadpole	*Amphibia*	Amphibian	1	6		
Total Fish Catch			172		1245	

Table A.7. Rainbow smelt age and length composition for Fore River fyke net catches, 2004. No adjustsments were made for the size classes where age overlap was likely but not observed.

		Length	Age	AGE SUBSAMPLE						AGE COMPOSITION BY LENGTH		
TL (cm)	TL (mm)	Sample (No.)	Subsample (No.)	Age-1 (No.)	Age-2 (No.)	Age-3 (No.)	Age-1 (%)	Age-2 (%)	Age-3 (%)	Age-1 (No.)	Age-2 (No.)	Age-3 (No.)
10	100-109	1	1	1			1	0	0	1		
11	110-119	27	18	18			1	0	0	27		
12	120-129	165	73	72	1		0.9863	0.0137	0	163	2	
13	130-139	261	108	108	0		1	0	0	261		
14	140-149	118	60	58	2		0.9667	0.0333	0	114	4	
15	150-159	29	10	10	0		1	0	0	29		
16	160-169	3	1	1	0		1	0	0	3		
17	170-179	0	0									
18	180-189	2	2	0	2		0	1	0		2	
19	190-199	10	7	0	6	1	0	0.8571	0.1429		9	1
20	200-209	9	7	0	6	1	0	0.8571	0.1429		8	1
21	210-219	4	2	0	2	0	0	1	0		4	
22	220-229	6	3	0	0	3	0	0	1			6
23	230-239	4	3	0	0	3	0	0	1			4
24	240-249	1	0									1
Sum		640	295	268	19	8				598	29	13

Table A.8. Rainbow smelt age and length composition for the Fore River fyke net, 2005. No adjustsments were made for the size classes where age overlap was likely but not observed (ex. 14 and 22 cm).

		Length	Age	AGE SUBSAMPLE						AGE COMPOSITION BY LENGTH			
TL (cm)	TL (mm)	Sample (No.)	Subsample (No.)	Age-1 (No.)	Age-2 (No.)	Age-3 (No.)	Age-1 (%)	Age-2 (%)	Age-3 (%)	Age-1 (No.)	Age-2 (No.)	Age-3 (No.)	Age-3+ (No.)
9	90-99	9								9			
10	100-109	3								3			
11	110-119	7	1	1			1			7			
12	120-129	30	8	8			1			30			
13	130-139	63	15	14	1		0.93	0.07		59	4		
14	140-149	43	10	10			1			43			
15	150-159	56	18	6	12		0.33	0.67		18	38		
16	160-169	145	32	1	31		0.03	0.97		4	141		
17	170-179	279	80		80			1			279		
18	180-189	239	67		67			1			239		
19	190-199	116	24		24			1			116		
20	200-209	39	11		11			1			39		
21	210-219	15	5		4	1		0.80	0.2		12	3	
22	220-229	3	1		1			1			3		
23	230-239	3	2			2			1			3	
24	240-249												
25	250-259												
26	260-269												
27	270-279												
Sum		1050	274	40	231	3				173	871	6	

Table A.9. Rainbow smelt age and length composition for all fyke net catches, 2005. No adjustsments were made for the size classes where age overlap was likely but not observed (ex. 14 cm). All smelt >239 mm were assigned to age-3+ group.

		Length	Age	AGE SUBSAMPLE						AGE COMPOSITION BY LENGTH			
TL (cm)	TL (mm)	Sample (No.)	Subsample (No.)	Age-1 (No.)	Age-2 (No.)	Age-3 (No.)	Age-1 (%)	Age-2 (%)	Age-3 (%)	Age-1 (No.)	Age-2 (No.)	Age-3 (No.)	Age-3+ (No.)
9	90-99	10	0							10			
10	100-109	3	0							3			
11	110-119	36	1	1			1			36			
12	120-129	165	12	12			1			165			
13	130-139	196	20	19	1		0.95	0.05		186	10		
14	140-149	138	16	16			1			138			
15	150-159	136	22	10	12		0.45	0.55		61	75		
16	160-169	196	33	1	32		0.03	0.97		6	190		
17	170-179	383	83		83			1			383		
18	180-189	424	87		87			1			424		
19	190-199	277	59		59			1			277		
20	200-209	127	27		27			1			127		
21	210-219	32	9		8	1		0.89	0.11		28	4	
22	220-229	9	4		2	2		0.50	0.50		4	5	
23	230-239	6	3		1	2		0.33	0.67		2	4	
24	240-249	3	0										3
25	250-259	1	0										1
26	260-269	0	0										
27	270-279	1	0										1
Sum		2143	376	59	312	5				605	1520	13	5