Evaluation of Largemouth Bass Habitat, Population Structure, and Reproduction in the Upper Housatonic River, Massachusetts

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EXECUTIVE SUMMARY

The mainstem Housatonic River originates in the city of Pittsfield, Massachusetts at the juncture of the East and West branches of the Housatonic River. This local network of channels has been influenced by both urbanization and industrial developments that have altered its physical characteristics through channelization, and its water quality characteristics through urban-runoff, effluent from wastewater treatment plants, and discharge from industrial manufacturing plants. The manufacturing facilities owned and operated by General Electric (GE) represent one of the largest industrial complexes in Pittsfield. The GE facility in Pittsfield historically used polychlorinated biphenyls (PCBs) during the construction and repair of electrical transformers. Although PCBs are no longer used at this site, sediments in the Housatonic River and portions of its floodplain now contain PCBs, and the U.S. Environmental Protection Agency (USEPA) and GE, together with the Massachusetts Department of Environmental Protection (MDEP), have been working actively to implement investigations and clean-up activities under a Consent Decree executed in 1999 and approved by the court in 2000. These activities cover three segments of the river: 1) the upper initial 0.5-mile segment adjacent to the GE facility on the East Branch of the Housatonic River, where GE has nearly completed clean-up activities; 2) the next 1.5 mile downstream to the confluence of the East and West branches of the Housatonic River, where USEPA will conduct clean-up activities; and 3) the "Rest of River" downstream of the confluence, where studies are still ongoing to assess the need for and potential extent of clean-up.

The USEPA has conducted a study that suggests that PCB concentrations have caused reproductive impairment in some Housatonic River largemouth bass in a laboratory setting (Tillitt and Papoulias 2001). However, there is a paucity of information regarding the potential effects of PCBs on largemouth bass at the population level. To evaluate this issue, R2 Resource Consultants, Inc. (R2), under contract to GE, conducted a two-year ecological study during 2000 and 2001 to evaluate habitat conditions and assess largemouth bass population structure and reproductive success in the portion of the "Rest of River" where the highest PCB concentrations have been found in sediments and fish tissue. According to USEPA guidance (USEPA 1999), ecological risk assessments should focus on evaluating adverse effects or risks of contaminants to local populations or communities of biota (as opposed to individual organisms), because the goal of remedial actions is to protect such populations and communities. The present study has attempted to address this issue directly by examining the local populations of largemouth bass that actually inhabit the river reach in question to evaluate potential evidence of impairment at the population level.

This study focused on the section of the Housatonic River from the confluence of the East and West branches downstream to Woods Pond Dam (the "Study Reach"), as well as the major stream branches and tributaries. Given the focus of this study to directly assess the largemouth bass population in this river section, the study did not include measurements of PCB concentrations in sediments or fish or attempt to correlate its findings with existing data on the distribution of such PCB concentrations. However, it is significant that the Study Reach has been shown to have the highest concentrations of PCBs in sediments and fish tissue within the "Rest of River," and that PCBs have been found, at a range of concentrations, in the river sediments throughout the mainstem and backwater areas that were specifically examined in this study. As a result, we would expect that if PCBs were adversely affecting the local largemouth bass population in this river segment, such effects would be evident in the structure and reproductive success of this largemouth bass population.

Studies conducted by R2 in 2000-2001 included the assessment of the quantity and quality of largemouth bass nursery habitat; identification of the periodicity, distribution, and success of largemouth bass spawning; estimation of young-of-year growth rates; description of the largemouth bass population structure and the overall fish community; and the identification of environmental conditions other than PCB concentrations that might influence the above parameters. The overall objectives of the two-year study were to determine if:

- the largemouth bass population in the Study Reach is self-sustaining;
- the largemouth bass population is dependent on tributary recruitment; and
- the attributes of growth, size-class structure, and reproduction of the largemouth bass population are similar to largemouth bass populations in other systems.

COMPARISON WITH OTHER SYSTEMS

The first two of the above objectives – whether there is a self sustaining largemouth bass population in the Study Reach and whether it is dependent on tributary recruitment – can be addressed using data collected from the Study Reach on reproduction, population, and habitat. To address the third objective regarding the attributes of that population, an assessment was conducted in the spring of 2000 to identify a potential reference stream that could be used as a comparison system for the upper Housatonic River. A reference stream or system should share similar characteristics and anthropogenic impacts to the Housatonic River, except for the presence of PCBs. Ten rivers were identified as preliminary candidates for reference systems, but due to a lack of similarity of a suite of attributes, such as drainage area, land use, mean annual flow, and game fish communities with the upper Housatonic River, a suitable reference stream comparison could not be identified (Appendix A). However, as largemouth bass are an important game fish, a substantial amount of information exists on key reproductive and population characteristics. Accordingly, we compared attributes of largemouth bass reproduction and growth and population structure in the Housatonic River with characteristics documented for largemouth bass in other systems. When possible, we limited our comparisons to populations in northern systems, although where applicable, we also discussed observations from populations in the Midwest and Southeast.

LARGEMOUTH BASS HABITAT

During the spring of 2000, landscape-scale and site-specific aquatic habitat assessments were conducted in the mainstem Housatonic River and its contiguous backwaters, the three major branches (East, West, and Southwest branches), and six tributaries (Moorewood, Sackett, Mill, Roaring, Yokun, and Felton brooks). During the landscape-scale assessments, primary habitat characteristics such as average bankfull width, stream gradient, habitat composition (i.e., pool, riffle, or glide), substrate, and aquatic cover were mapped. During the surveys of 13 specific sites, water quality, stream velocity, and physical attribute data were collected. The aquatic habitat assessments indicated that the majority of largemouth bass habitat was located in Woods Pond and the shallow backwater and wetland areas contiguous with the upper Housatonic River. Tributary habitat, in contrast, was generally too cold and/or too swift to support largemouth bass, except for areas at the confluences of the tributaries and the mainstem and within ponded areas of Moorewood Brook and Yokun Brook upstream of the railroad crossing. The majority of tributaries (Felton Brook, Roaring Brook, Mill Brook, and Sackett Brook) contained lotic-type habitat unsuitable for bass spawning or rearing.

LARGEMOUTH BASS DISTRIBUTION

The distribution and population structure of largemouth bass in the Housatonic River study area were investigated in June and late-July/early-August of 2000 and in October of 2001. During the 2000 surveys, largemouth bass in the mainstem and backwater sites were sampled by use of a boat electrofisher, and with a raft fitted with an electrofishing unit in the East Branch and West Branch. A backpack electrofishing unit was used in the tributaries. Fish sampling during 2001 was conducted only in mainstem and backwater sites between the confluence of the East and West branches and Woods Pond Dam. All fish collected during the surveys were subsequently released.

A total of 133 largemouth bass were collected during the summer sampling period of 2000. These fish were taken from mainstem sites (n=120), the East and West branches (n=10), and Moorewood and lower Mill brooks (n=3). Electrofishing efforts during October 2001 captured 239 largemouth bass. The distribution of largemouth bass was found to be consistent with our determination of available largemouth bass habitat. In general, largemouth bass were abundant in shallow, backwater habitats that were connected to the main channel. Largemouth bass collected in the main channel were typically associated with accumulations of downed wood. Largemouth bass were not found in the tributaries with the exception of tributary sites near large ponds or floodplain wetlands.

POPULATION STRUCTURE

Largemouth bass length and weight data were used to evaluate various population characteristics that are useful in determining population health and structure. The sampled population in 2000 contained a high proportion (69%) of large-size fish, whereas in 2001 young-of-year fish less than 100 mm total length comprised 78% of the population. During both 2000 and 2001, relatively few bass in the 140 to 280 mm size range were found. The higher abundance of young-of-year fish in 2001 was partly a result of differences in the sampling season between years. We collected fish during June and late-July/early-August in 2000 and in October in 2001. However, young-of-year were also collected in a separate sampling event in September 2000, and differences in relative abundances of young-of-year largemouth bass between years also indicated that 2001 produced a stronger year class than the previous year. Fluctuations in year-class strength are common in largemouth bass populations. In the upper Housatonic River, this observed fluctuation was likely the result of more stable water levels in 2001, which has been shown to create favorable spawning and rearing conditions for bass, resulting in stronger year classes.

The age-class structure of the largemouth bass population was determined with length-frequency histograms and supplemented with otolith and scale analyses. The otolith and scale analyses indicated that Housatonic River largemouth bass grow slower as they grow older, a phenomenon that is common to many fish species. This reduced growth at age resulted in an overlap of size classes among the older fish. For example, fish between 300 and 400 mm ranged in age from 4 to 13 years.

To provide an index of the proportion of largemouth bass that was of a fishable size to recreational anglers, a proportional stock density (PSD) was calculated for the population in 2000 and 2001. The Housatonic River largemouth bass population is relatively unexploited and all recreational fishing is catch-and-release. However, calculation of the PSD was useful in providing information regarding the balance of the adult size-class structure. The calculated PSD estimates for both 2000 (82) and 2001 (91) were relatively high compared to the commonly accepted range of 40 to 70 for a managed largemouth bass population (Gabelhouse 1984), and describe an adult largemouth bass population with a high proportion of large-size (older) fish. This is most likely due primarily to a lack of fishing pressure in this reach of the Housatonic River.

Relative weights (W_r) were used as an index of condition of the Housatonic River largemouth bass population in comparison to other populations. A mean W_r of 100 for a broad range of size groups generally describes fish in good condition (based on length-weight relationship) and may indicate ecological and physiological optimality or be used as a benchmark for comparing populations (Anderson and Neumann 1996). The mean W_r value for Housatonic River largemouth bass collected in 2000 was 109 and the mean W_r in 2001value was 117. These mean values, which exceeded the benchmark level of 100, indicate that the fish were "fit" (had a high length to weight ratio) and in comparable condition to largemouth bass in other systems.

REPRODUCTION

An intensive study of largemouth bass reproductive activity in the upper Housatonic River was completed in the spring and summer of 2001. Fifteen index sites were established during 2001 in backwater areas between New Lenox Road downstream to Woods Pond Dam. These sites contained a range of PCB concentrations in the sediments that are representative of the Study Reach. From May through July, these 15 sites were routinely monitored for the presence of largemouth bass nests, eggs within nests, larvae, broods, and young-of-year fish. Largemouth bass spawning was documented in each of these sites, and there were 94 observations of largemouth bass nests identified as active (i.e., nests guarded by an adult bass or containing eggs, sacfry, or swim-up larvae). Further, sites with active nests were subsequently observed to support broods of larval bass, which exhibited growth rates typical of other systems.

The Housatonic River largemouth bass population was observed to spawn over a 39-day period in relatively shallow water near the shoreline of calm backwater areas. The single highest density of nests (approximately 3.0 nests/100 meters of shoreline) within one index site was observed on June 12. The average peak density of nests across all index sites (1.24 nests/100 meters of shoreline) was observed on May 21 when the mean water temperature was 17.9°C. The first brood was found on May 21, 19 days after mean water temperatures increased above 15.5°C. A total of 145 brood observations were made during the index site surveys.

Growth rates for largemouth bass collected during the period from May 21 to July 11, 2001, were calculated in two-week intervals. There was a consistent increase in growth rates over the four two-week periods beginning with an initial rate of 0.20 mm/day between May 21 and June 3 and ending with a rate of 1.42 mm/day for the period between July 2 and 11. A strong relationship (r^2=0.99) was detected between two-week interval growth rates and water temperature. These rates were similar to estimated 2000 growth rates when, during mid-summer (July 2 to August 1), young-of-year largemouth bass grew an average of 0.64 mm/day, while during the fall growth period (August 1 to September 27), bass grew an average of 0.28 mm/day. The growth rates observed in the upper Housatonic River were comparable to growth rates determined for largemouth bass in laboratory studies and in other systems (Phillips et al. 1995; Kramer and Smith 1960; Coutant and DeAngelis 1983). At the end of the growing season, the average total length of young-of-year bass was smaller than the average lengths reported in other systems (Green 1982; McCaig and Mullan 1960; Grice 1959; Carlander 1977). This was not unexpected, since the upper Housatonic River is located near the northern limit of largemouth bass populations where, due to the strong correlation between growth and water temperature, the growing season would be expected to be shorter. Because growth rates for Housatonic River young-of-year largemouth bass are comparable to other populations, the smaller average total length achieved in the fall is believed to be associated with a shorter growing season in combination with differences in physical habitat characteristics (i.e., lacustrine versus riverine) and differences in local climate and topography.

At the end of the growing season in 2000 and 2001, young-of-year largemouth bass were collected from three habitat types in the Housatonic River: main channel, backwater, and transition habitats. Main channel habitats were generally deep and swift; backwater habitats were shallow, vegetated, and contiguous with the main channel; and transitional habitats were margin areas between the backwater and main channel. Catch-per-unit-effort (CPUE) estimates were used to describe the relative abundance and habitat preference of young-of-year fish within and between years. CPUE values at the end of the growing season in 2001 were higher than those in 2000, likely due to a stronger year-class in 2001. The overall average CPUE in 2001 was 0.54 fish/min, compared to 0.30 fish/min in 2000. In both years, CPUEs were significantly greater in backwater and transition areas than in the main channel. For example, in 2001, habitat-specific average CPUEs ranged from 0.16 fish/min in the main channel to 1.01 fish/min in backwater areas. Such habitat partitioning is common in river systems, and we noted that backwater areas, which were used for spawning and rearing during the summer, were also used by young-of-year largemouth bass in the fall. Although published estimates of young-of-year largemouth bass CPUEs are limited, the range of average CPUE estimates for the Housatonic River is within the ranges reported for other, non-PCB-impacted systems (Kohler et al. 1993 – 0.13 to 1.34 fish/min; Jackson and Noble 1995 – 0.2 to 2.2 fish/min).

ENVIRONMENTAL MONITORING

To assess the environmental conditions known to affect largemouth bass spawning success, egg and larval survival, and early-stage growth rates, measurements were collected of dissolved oxygen (DO) concentrations, pH, conductivity, water temperature, and flow conditions. In 2000, water quality measurements were limited to continuous water temperature recorders in the 13 site-specific habitat sites (mainstem, backwater, and tributary sites), flow data from the U.S. Geological Survey (USGS), and spot measurements of DO concentrations, pH, and conductivity collected using hand-held digital meters. A more intensive study of environmental conditions known to affect largemouth bass reproductive success was conducted in 2001. Continuous water temperatures were recorded within the mainstem and backwater sites on the Housatonic River from late March or mid-April through mid-October, 2001. In addition, nine continuous DO recorders were deployed in three backwater areas where largemouth bass nests were observed. At each of these three sites, a recorder was placed in the main channel just outside of the backwater area, and the other two units were placed within the backwater approximately 50 feet and 150 feet away from the shore. The DO recorders were deployed in June and maintained through mid-October 2001. The continuous DO monitors indicated that DO concentrations exhibited wide diurnal fluctuations in the backwater nursery habitats and fell to lethally low levels for extended periods of time during the summer of 2001.

Daily flow conditions for 2001 indicated that flows were below average during most of the year, and in particular during July through September. In contrast, flow conditions during 2000 were generally higher than average, and notably less stable during May through September. A high flow event in the spring of 2000 occurred shortly after the first observations of largemouth bass spawning activity. This event likely suspended spawning activities, perhaps as a result of high velocities and reductions in water temperature below the 15.5°C threshold for largemouth bass spawning. Percent daily overcast conditions were calculated using atmospheric data obtained from the Pittsfield Municipal Airport. A comparison of overcast days in 2001 with 2000 indicates a much higher incidence of overcast, cooler, and wetter conditions in 2000. The combination of water level fluctuations and low DO concentrations likely influenced differences in largemouth bass spawning success and year class strength between 2000 and 2001.

FISH COMMUNITIES

During electrofishing efforts, we identified and enumerated fish species other than largemouth bass. Our surveys indicated that the upper Housatonic River supports a diverse assemblage of fish species, which is dominated by centrarchids. During the two-year study, a total of 26 species were collected by R2 throughout the study area, which included the Housatonic River upstream of Woods Pond Dam, the East Branch and West Branch, and major tributaries. The fish community differed between the habitats sampled. In the mainstem river, the most abundant species in 2000 were bluegill and pumpkinseed, while yellow perch were most abundant in 2001. Eastern brook trout dominated the tributary communities, yet were absent from collections taken from the mainstem Housatonic River and East and West branches. Although the fish communities in the two branches and mainstem were numerically dominated by bluegill, the fish community in the two branches contained more dace and other small cyprinids than were found in the main river. Overall, the fish community in the upper Housatonic River mainstem was more representative of a Massachusetts lake than a river. This was not unexpected, since the upper 10-mile reach of the river is relatively flat and contains numerous backwaters and approximately 5 miles of impounded river behind Woods Pond Dam.

TROUT HABITAT

During the habitat assessments, a preliminary evaluation was made of the suitability of the study area to support resident self-sustaining trout populations. Although naturally spawned trout were found in the colder streams draining October Mountain, the mainstem Housatonic River was determined to be too warm to support viable resident trout populations. The mainstem river also generally lacked suitable gravel substrates needed by trout for spawning. The results of this preliminary analysis are presented in Appendix B.

SUMMARY

The results of this two-year study indicated that largemouth bass in the Study Reach of the upper Housatonic River are successfully reproducing in backwater areas and embayments within or directly connected to the mainstem river. Numerous nests were identified within the index sites established in the Study Reach. Broods of larval largemouth bass were found in all areas that were observed to contain active nests, and these fish exhibited growth rates dependent on water temperatures and had comparable growth rates to largemouth bass in other systems. A total of 145 broods was observed within the index sites between May 21 and July 4, 2001, and at the end of the growing season, the relative abundance of young-of-year largemouth bass was within the range of reported CPUEs for other systems. The combined observations of nests, broods, growth, and end-of-season abundance indicate that the upper Housatonic River largemouth bass population is self-sustaining.

In addition, the largemouth bass population was determined to be independent of tributary recruitment, as largemouth bass spawning habitat was abundant in backwater areas of the mainstem river, whereas the majority of tributaries (Felton Brook, Roaring Brook, Mill Brook, and Sackett Brook) contained lotic-type habitat unsuitable for bass spawning or rearing. Observations of young-of-year distributions supported this determination, as juvenile largemouth bass were abundant in the upper Housatonic River backwater areas where spawning was also observed.

The largemouth bass population in the Study Reach of the upper Housatonic River exhibited characteristics similar to largemouth bass populations in other systems, including separate measures of reproduction, growth, body condition, and population structure. Several of these attributes, including spawning periodicity, spawning success, growth, and year class strength, appeared to be influenced by environmental conditions, which typically affect largemouth bass populations in other systems. These environmental conditions included water level fluctuations, water temperatures, and DO concentrations. The apparent stronger year class produced in 2001 compared to 2000 is presumed to be a result of more stable water levels and water temperatures during the 2001 spawning season. Cloudier and colder weather during the 2000 growing season also likely resulted in reduced DO concentrations in the backwater nursery habitats and may have reduced young-of-year survival in 2000 as compared with 2001.

Additional observations of habitat conditions and the fish community indicated that the Housatonic River supports a fish community that is typical of many Massachusetts lakes. Numerically, the fish community was dominated by sunfish and yellow perch, and the fish community contained a large proportion of piscivorous, or top carnivore species, such as northern pike, chain pickerel, yellow perch, and largemouth bass. Warm water temperatures in the summer and a paucity of gravel substrates indicate that the Study Reach is not capable of supporting a self-sustaining resident trout population.

1. INTRODUCTION AND BACKGROUND

The Housatonic River is one of the major river systems in western Massachusetts. From its headwaters near the city of Pittsfield, the river flows in a southerly direction before entering and eventually passing through Connecticut and emptying into Long Island Sound. Like many rivers in the northeastern United States, the Housatonic River has been subjected to a variety of anthropogenic impacts, including those associated with timber harvesting, agriculture, industry, and urbanization. These factors have collectively and cumulatively influenced the physical and chemical characteristics of the river, which in turn have defined the diversity and abundance of its aquatic ecosystem. As a continuum (Vannotte et al. 1980), the aquatic communities in the Housatonic River at any one location are influenced by conditions that exist upstream, local to, and downstream of that point. Presently, the upper reaches of the river support a diverse, largely warmwater-coolwater fish assemblage, while sections of the lower river (in Connecticut) below several hydroelectric impoundments support a renowned coldwater trout fishery.

The mainstem Housatonic River originates in the city of Pittsfield, Massachusetts at the juncture of the East and West branches of the Housatonic River. This local network of channels has been influenced by both urbanization and industrial developments that have altered its physical characteristics through channelization, and its water quality characteristics through urban-runoff, effluent from wastewater treatment plants, and discharge from industrial manufacturing plants. The manufacturing facilities owned and operated by General Electric (GE) represent one of the largest industrial complexes in Pittsfield. The GE facility in Pittsfield historically used polychlorinated biphenyls (PCBs) during the construction and repair of electrical transformers. Although PCBs are no longer used at this site, sediments in the Housatonic River and portions of its floodplain now contain PCBs, and the U.S. Environmental Protection Agency (USEPA) and GE, together with the Massachusetts Department of Environmental Protection (MDEP), have been working actively to implement investigative and clean-up activities under a Consent Decree executed in 1999 and approved by the court in 2000. These activities cover three segments of the river: 1) the upper 0.5-mile segment adjacent to the GE facility on the East Branch of the Housatonic River, where GE has nearly completed clean-up activities; 2) the next 1.5 mile downstream to the confluence of the East and West branches of the Housatonic River, where the USEPA will conduct clean-up activities; and 3) the “Rest of River” downstream of the confluence, where studies are still ongoing to assess the need for and potential extent of clean-up.

1.1 STUDY CONTEXT

Studies conducted by GE and the USEPA have documented elevated concentrations of PCBs in a number of fish species, and in 1982 the Massachusetts Department of Public Health (MADPH) issued a fish consumption advisory for the river extending from Dalton, Massachusetts to the Connecticut border. That advisory remains in effect today. However, the presence of PCBs within various tissues and organs of fish does not necessarily mean that their populations are impaired.

Largemouth bass (*Micropterus salmoides*) are a top carnivore in the aquatic food chain in the Housatonic River, and they are an important game fish species. As part of the USEPA's ecological risk assessment of the "Rest of River" area, USEPA consultants conducted a laboratory study that suggests reproductive impairment in Housatonic River largemouth bass due to PCBs (Tillitt and Papoulias 2001; Meadows et al. 2001). However, substantive information is lacking regarding the effects of PCBs on the reproductive success, overall health, and population structure of largemouth bass *in situ*. PCBs are a hydrophobic compound and have been demonstrated to biomagnify through the food chain. As a consequence, higher trophic level receptors such as top-carnivores accumulate the highest concentrations of PCBs in their tissues. Fish embryos are exposed to PCBs via maternal transfer during oogenesis, and because these early life stages are the most sensitive to PCB exposure, reproductive impairment could occur. The concentrations of PCBs observed in largemouth bass in the Housatonic River have led to speculation that there is widespread reproductive failure of the bass population. If PCBs observed in largemouth bass in the Housatonic River have led to reproductive failure of the population, then the abundance of young bass in the river would be expected to be low, unless large numbers of fish are immigrating from uncontaminated source areas.

According to USEPA guidance (USEPA 1999), ecological risk assessments should focus on evaluating adverse effects or risks of contaminants to local populations or communities of biota (as opposed to individual organisms). As explained in that guidance, the reason for such focus is that the goal of remedial actions is to protect such populations and communities. Given this context, an understanding of largemouth bass populations specifically, and overall fish communities generally, in the upper Housatonic River will be important for determining the need for and extent of any remedial measures targeted for the "Rest of River."

An initial field study conducted by Chadwick & Associates (1994) assessed the aquatic habitat and the fish and invertebrate communities in the Housatonic River from the East and West branches downstream to the Connecticut border. In 2000 and 2001, R2 Resource Consultants, Inc. (R2), under contract to GE, completed a two-year study to evaluate various biotic and abiotic factors (other than PCB concentrations) influencing life history characteristics of the largemouth bass populations in the Housatonic River. Ancillary information was also collected and evaluated relative to describing the fish species assemblages in the river. The study was focused on that portion of the "Rest of River" that extends from the confluence of the East and West branches of the Housatonic River downstream to and including Woods Pond (Figure 1-1), hereafter referred to as the Study Reach.

Consistent with the appropriate focus of an ecological risk assessment on local populations and communities of biota (USEPA 1999), the overall goal of this study was to examine directly the structure and reproductive success of the Housatonic River largemouth bass population, as well as the fish community, in the Study Reach. As such, the study did not include measurements of PCB concentrations in sediments or fish tissue or attempt to correlate its findings with data on the distribution of such concentrations. It is important to note, however, that the Study Reach has been shown to have the highest concentrations of PCBs in sediments and fish tissue within the "Rest of River." Thus, it is reasonable to expect that if PCBs were having adverse effects on the local largemouth bass population in this reach, such population-level effects would be evident in the structure and reproductive success of that largemouth bass population.

The study was conducted over two years (2000-2001) and consisted of an evaluation of six interrelated study components. The components were: 1) an assessment of candidate reference streams (completed in 2000); 2) an assessment of aquatic habitats in the Housatonic River and major tributaries, which focused on describing the quantity and quality of largemouth bass habitat (completed in 2000); 3) largemouth bass population surveys (completed in both 2000 and 2001); 4) an *in situ* study of largemouth bass reproduction (completed in 2001); 5) fish community surveys (completed in 2000 and 2001); and 6) environmental conditions monitoring (completed in both 2000 and 2001).

These study elements were designed to address the following three questions relative to the largemouth bass population(s) in the Housatonic River:

1. Is the largemouth bass population in the Study Reach self-sustaining;
2. Is the largemouth bass population in the Study Reach dependent on tributary recruitment; and

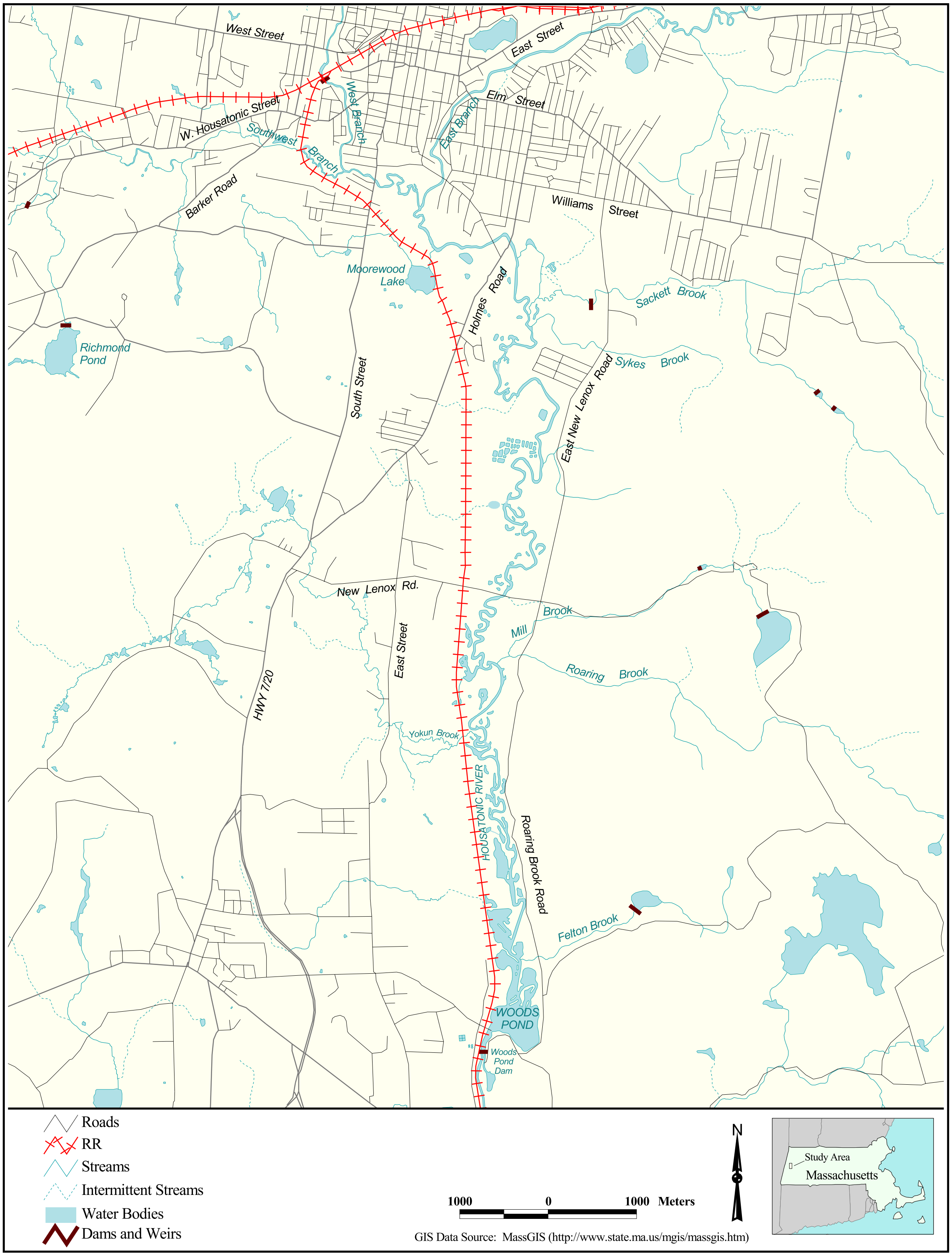


Figure 1-1. Map of the Housatonic River system in western Massachusetts that shows the major tributaries in the general area investigated during this study.

3. Are attributes of growth, population structure, and reproduction of the largemouth bass population similar to largemouth bass populations in other systems?

The 2000 study elements were focused in part on delineating the study area, defining study reaches (both within the mainstem Housatonic River as well as major tributaries), and selecting study sites and describing habitat and monitoring environmental conditions therein. We also completed fish surveys in selected segments of the mainstem river and tributaries to assess relative abundance, age class structure, growth rates, and size (length and weight) characteristics of the largemouth bass population. Preliminary information on largemouth bass reproduction was also collected, including the timing and location of spawning, and young of the year growth.

During the initial stages of the year 2000 study, we evaluated the potential for conducting a parallel investigation of study elements within a "reference stream" system from which to compare results from the Housatonic River system. For this, we identified and evaluated the suitability of a number of candidate reference streams for making comparisons with the upper Housatonic River system. The streams were evaluated relative to their similarity to the Housatonic River in terms of channel morphology, hydrology, and water quality characteristics as well as the types and degree of anthropogenic impacts affecting those systems, except for those resulting from PCBs. As will be described in more detail in Chapter 4, we determined from this assessment that a suitable reference stream was not available for comparison with the Housatonic River and a report discussing that conclusion is presented as Appendix A. Extensive data relating to largemouth bass population characteristics are available because it is a well-studied and managed game fish. Comparisons of largemouth bass population characteristics were therefore made relative to published information on bass from other systems. A synthesis of this information is presented in Chapter 3.

The aquatic habitat conditions in the Study Reach were assessed to evaluate the quantity and quality of largemouth bass spawning and rearing habitats present in the system. At the same time, we completed a review of the suitability of the Study Reach and its major tributaries to support trout populations. The results of the investigation on trout habitat suitability are presented in Appendix B. Habitat constraints, unrelated to potential PCB concentrations, can determine if a system can support self-sustaining populations of particular fish species, such as largemouth bass or trout. For example, the upper reaches of the Housatonic River contain a diverse, largely warmwater-coolwater fish assemblage, while the lower river in Connecticut supports a coldwater trout fishery. The habitat constraints of water temperature, in addition to the availability and quality of suitable rearing and spawning habitats are important determinants that can control the observed differences in fish communities between the upper and lower river.

Investigations into largemouth bass population structure and the overall fish community attributes in the Study Reach were conducted over two years, 2000 and 2001. The initial fisheries studies in 2000 were tied to assessments of habitat conditions, which occurred at the same time. In 2000, largemouth bass and the fish communities were sampled in locations within the mainstem river and within the major tributaries to the Study Reach. We continued the fisheries investigations in 2001, with a focus on evaluating largemouth bass reproduction and population characteristics, as well as collecting supplemental fish community information.

1.2 OBJECTIVES

The objectives of the two-year study were to address those questions posed in Section 1.1. Thus, the objectives were to determine if:

- The largemouth bass population in the Study Reach of the Housatonic River is self-sustaining;
- The largemouth bass population is dependent on tributary recruitment; and
- Attributes of growth, size-class structure, and reproduction of the largemouth bass population are similar to largemouth bass populations in other systems.

Specific objectives of the 2000 habitat and fisheries study on the Study Reach of the Housatonic River were to:

- Determine the suitability of habitats for largemouth bass;
- Identify areas used for largemouth bass reproduction;
- Identify any physical constraints (e.g., passage barriers/dams) that may limit fish movement and migrations within the mainstem river and between and within tributaries;
- Assess the relative abundance of young-of-year largemouth bass and overall population structure within mainstem and tributary habitats in the Study Reach; and
- Assess the fish community assemblages found within mainstem and tributary habitats in the Study Reach.

Based on the results of the 2000 habitat and fisheries study, R2 conducted a focused field study in 2001 to investigate the timing, distribution, and success of largemouth bass reproduction. Specific objectives were to:

- Determine if the largemouth bass spawning periods and nesting success in the Housatonic River are influenced by typical environmental conditions such as water temperature, dissolved oxygen, water levels, weather, and wave action;
- Quantify young-of-year growth rates and compare them to growth rates in other northern United States systems;
- Describe the size and age structure of the largemouth bass population and the condition of individual fish relative to other largemouth bass populations; and
- Collect information on other fish species captured during the fish surveys to evaluate overall fish community composition.

1.3 REPORT OUTLINE

This report is organized in seven chapters, which consist of:

Chapter 1 – **Introduction** (this section);

Chapter 2 – **Description of Study Area**, describes general physical and hydrological characteristics of the reach of the Housatonic River extending from the confluence of the East and West branches of the Housatonic River downstream to Woods Pond Dam;

Chapter 3 – **Largemouth Bass Life History**, summarizes the biology and ecology of largemouth bass;

Chapter 4 – **Methods**, describes field and analytical methods used during the study;

Chapter 5 – **Results**, presents major findings from each of the study elements;

Chapter 6 – **Discussion**, summarizes and discusses the results relative to findings from other studies; and
Chapter 7 – **References**, list of citations used in the report.

The report also contains seven appendices, which include supplemental data and supporting graphs and photographs. The appendices are listed below.

Appendix A – Assessment of Candidate Reference Streams;

Appendix B – Trout Habitat Suitability Analysis for the Upper Housatonic River;

Appendix C – Stevens/Greenspan DO Probe Reliability Assessment;

Appendix D – Fish Data (tabular listing of fish collected during the surveys by site);

Appendix E – Environmental Conditions Data (graphs and tables of water temperature, dissolved oxygen, and pH data collected by site);

Appendix F – Photographs (photographs of largemouth bass reproduction index sites, and fish species collected during electrofishing); and

Appendix G – Results of the Aquatic Habitat Assessment of the Upper Housatonic River and the Major Tributaries to the Study Reach.

2. DESCRIPTION OF STUDY AREA

The upper river segments of the Housatonic River are located within the Northeastern Highlands ecoregion (Omernik 1987) between the Taconic Mountain Range of eastern New York State and the Berkshire Hills of western Massachusetts. The principal study area focused on the portion of the Housatonic River system from the confluence of the East and West branches in Pittsfield, Massachusetts downstream to Woods Pond Dam on the mainstem Housatonic River (Figure 1-1). The mainstem Housatonic River originates in the city of Pittsfield, Massachusetts at the juncture of the East Branch and West Branch of the Housatonic River.

There are six relatively small tributaries that enter this section of the Housatonic River. These tributaries are Moorewood and Yokun brooks, which enter the Housatonic River from the west, and Sackett, Mill, Roaring, and Felton brooks, which drain the eastern basin (Figure 1-1).

Flows in the upper Housatonic River are measured at a USGS gaging station #01197500 near Great Barrington, which is downstream of Woods Pond Dam. Historical records indicate that the river at this location typically exhibits a range from approximately 1,500 cfs during April snowmelt to a baseflow of around 200 cfs during the summer months of July, August, and September.

2.1 STUDY REACH

The Study Reach encompasses an approximately 10-mile section of the Housatonic River extending from the confluence of the East Branch and West Branch in Pittsfield to Woods Pond Dam in Lenox Station, Massachusetts (Figure 1-1). The channel within this segment is bordered by an extensive floodplain that in places is up to 3,000 feet wide. The channel is low gradient (< 1%), highly sinuous, and has channel widths typically ranging from 45 to 100 ft. There are numerous oxbows, backwaters, and embayments within this reach of the river, with the majority located below New Lenox Road. At the downstream end of the Study Reach, Woods Pond is a shallow 56-acre impoundment maintained by the dam that was constructed in the mid-1800s. Concentrations of PCBs have been found in river sediment samples throughout this reach. The river is bordered for most of its length by a mixture of pastureland and mixed hardwood forests. October Mountain State Forest borders much of the eastern banks of the river reach below New Lenox Road extending to and including Woods Pond.

In most backwater areas of the Housatonic River, abundant cover is provided by submerged and floating vegetation. Cover in the main channel is relatively sparse, and is mainly provided by deep water and accumulations of downed trees along the stream edges. In general, large woody debris has been cleared from the river, and because this reach is popular with canoeists, wood continues to be cut and removed so that it does not impede boat travel. During high flow, vegetation along the shoreline meets the water, but during the summer, the river level drops and in many places muddy shorelines are exposed. Conversely, the low banks and broad floodplain allow the river to overtop and spread over primarily terrestrial vegetation on a rather frequent basis.

The extensive habitat surveys conducted in 2000 defined the overall habitat conditions and fish species composition throughout the Study Reach and adjoining tributaries. That information was used to design an intensive study of the lower five miles, from New Lenox Road to Woods Pond.

2.2 INDEX REACH

In 2001, a more intensive study on largemouth bass reproduction, growth, and population characteristics was focused on a smaller segment of the river within the Study Reach. The lower five-mile segment of the Study Reach was designated as an Index Reach and specific index sites within this reach were monitored during 2001. Surveys conducted in 2000 indicated that the Index Reach contained the majority of largemouth bass spawning habitat within the larger Study Reach. As in the Study Reach, a range of PCB concentrations occurs in the river sediments throughout the Index Reach. At the uppermost end of the Index Reach, near New Lenox Road, the river is relatively flat and meanders through a broad floodplain as the river flows through abandoned pastureland and forested bottom-land. In several sections within the Index Reach, the main channel becomes indistinct where the river broadens into old meanders, beaver impoundments, and tributary deltas (Figure 2-1). The lower section of the Index Reach includes Woods Pond and approximately one-mile of impounded river upstream of Woods Pond Dam.

In general, the floodplain surrounding the Index Reach extends from the railroad grade on the west to just short of Roaring Brook Road on the east. The main channel from New Lenox Road downstream through Woods Pond is generally U-shaped, mud-bottomed, and averages 10 to 15 feet deep and 85 feet across. The entire Index Reach, including the main channel, pond, and backwaters, is typically characterized by a soft mud bottom. The lower area (Woods Pond) is relatively shallow (1 to 3 feet deep) except for a deep hole (approximately 15 feet deep) in the eastern half. A deeper channel flows along the western half of Woods Pond. The other backwater areas upstream of Woods Pond are similarly shallow and rarely exceed three feet in depth during summer low flow conditions.

Figure 2-1. The aerial photo on the left shows the meandering pattern of the Housatonic River at the New Lenox Road crossing. The top right photo is a typical backwater on the river and the lower right photo is the main channel upstream of Woods Pond.

3. LARGEMOUTH BASS LIFE HISTORY

Largemouth bass are one of the most popular North American warmwater sport fishes (Anderson 1974), and because of this, their biology and ecology have been studied extensively, primarily with the goal of managing their populations for anglers. Several reviews have been published on largemouth bass life history, including Heidinger (1976), Stuber et al. (1982), and a collection of articles edited by Clepper (1975), including Aggus and Elliot (1975), Bulkley (1975), Carlander (1975), Eipper (1975), Heidinger (1975), MacCrimmon and Robbins (1975), and Summerfelt (1975).

This chapter is a summary of the literature on largemouth bass biology and ecology. The information presented in this chapter focuses on the ecology of largemouth bass in the northern part of their range in North America. Occasional references are also made to southern populations of largemouth bass and to smallmouth bass behavior. The purpose of this synthesis of the literature is to provide a context from which to compare with observations of Housatonic River largemouth bass, which are discussed in subsequent chapters.

3.1 RANGE

Largemouth bass are not native to the New England states or the Atlantic Seaboard north of the James River in Virginia (MacCrimmon and Robbins 1975), but they were widely released in this area as a desired game fish. Largemouth bass were first introduced to Massachusetts in the mid-1800s, and they have since become naturalized in the state. Public and private stocking programs have resulted in largemouth bass being a part of the fish community in most waters of the state, and it is often a common species in Massachusetts warmwater habitats (Hartel and Halliwell 1996).

Largemouth bass are native to much of the United States east of the Mississippi River, and were introduced over the remainder of their range. Their original, native distribution was bordered by the Atlantic Seaboard in the southeast, the Gulf of Mexico in the south, and up through the great plains in the west. The northern boundary included much of the Great Lakes basin, with the exception of Lake Superior. Largemouth bass are divided into two subspecies; the northern largemouth bass (*M. salmoides salmoides*) and the southern largemouth bass (*M. salmoides floridanus*). The subspecies can be separated using meristic counts of scales, number of pyloric caeca, and abdominal vertebrae (Heidinger 1976) or by electrophoresis (Maceina et al. 1988).

Although the larger *M. salmoides floridanus* has been widely stocked, it typically is restricted to southern waters because it is less tolerant of cold shock than northern largemouth bass (Maceina et al. 1988). Currently, largemouth bass are present in each of the fifty states, as well as Mexico and southern Canada.

3.2 HABITAT PREFERENCE

Largemouth bass are generally associated with warmwater ponds and lakes, as opposed to colder or flowing waterbodies. Largemouth bass are most abundant in low velocity areas with aquatic vegetation and other forms of cover (Stuber et al. 1982). In regions that are cold enough to have ice-cover in the winter, such as in Massachusetts, optimal lake habitats contain enough deep (> 6 m) oxygenated water to support overwintering bass (Stuber et al. 1982). In lakes that are too deep for aquatic plant growth, largemouth bass are usually limited to the weedy shorelines and shallow embayments (Carlander 1975). Optimal lake habitats contain extensive shallow areas with aquatic vegetation, which are the areas most preferred for spawning (Carr 1942).

Largemouth bass can also be found in riverine habitats, especially in large, low-gradient, slow moving rivers or in pools with soft bottoms and aquatic vegetation (Stuber et al. 1982). It is assumed that optimal riverine habitat contains a high percent (> 60%) of pool and backwater habitat (Stuber et al. 1982).

Whether largemouth bass are supported in a lake or river environment, the system must contain suitable areas for spawning, juvenile rearing, adult feeding, and winter refuge. Spawning takes place in nests constructed by males, usually in water that is between 1 to 4 feet deep and in areas protected from wind and waves, such as embayments or backwater sloughs (Heidinger 1975). There is generally no perceivable current in spawning areas. Nests are constructed in various substrates, including gravel, silt, and organic debris (Allen and Romero 1975). Areas that are protected by stumps, boulders, or some other structure are preferred as nesting sites (Carr 1942; Newburg 1975).

Cover is an important component of suitable habitat for both juvenile and adult largemouth bass. Juvenile bass use cover, such as aquatic weeds, as refuge from predators and adult largemouth bass generally orient themselves near larger cover, such as submerged logs, from which they ambush their prey.

3.3 FLOW AND WATER LEVELS

Largemouth bass are generally associated with slackwater areas, such as lakes or pools and backwater areas in rivers. Largemouth bass fry are especially intolerant of flowing water, and their optimal current velocities are less than 4 cm/sec (Stuber et al. 1982).

Fluctuating water levels can be either beneficial or detrimental to largemouth bass depending on the timing and severity of the fluctuation and on the life stage of the fish (Raibley et al. 1997). Increased water levels in the summer can benefit young-of-year production if it increases the amount of vegetated shallow water habitat (Aggus and Elliot 1975; Raibley et al. 1997; Kohler et al. 1993; Bayley 1995). Submerged shoreline vegetation can provide productive spawning and nursery habitat with abundant cover. On the other hand, decreased water levels in the summer can benefit the older age classes by forcing smaller prey fish (including young-of-year largemouth bass) out of the protective shallow areas and into the open where they can be captured more efficiently (Rogers and Bergersen 1995; Ploskey 1986).

In addition to high or low water level conditions, fluctuating water levels during the spawning season can reduce hatching success and result in weak year classes (Von Geldern 1971; Raibley et al. 1997). Lowered water levels during spawning can result in dewatered nests or increased wave action. Increased water levels during the period can result in decreased water temperatures. The highest levels of early life-stage survival have been observed to occur when water levels are relatively stable (Franklin and Smith 1963; Kohler et al. 1993).

3.4 REPRODUCTION

Sexual maturity in largemouth bass is more related to size than to age. Female largemouth bass reach sexual maturity when they attain a length of approximately 250 mm (10 inches) (Miranda and Muncy 1987), although males may be somewhat smaller. Growth rates are dependent on many things, including food supply, length of the growing season, and genetics. In general, largemouth bass living in the longer growing season of the southern United States may reach sexual maturity in one year, while those found in the northern United States may not reach sexual maturity until they are 3 or 4 years old (Heidinger 1975). Largemouth bass can spawn in consecutive years once they have reached sexual maturity.

Warming water temperatures in the spring trigger largemouth bass spawning activities. Largemouth bass initiate spawning 2 to 5 days after the daily mean water temperature reaches and remains above 15.5°C (60°F) (Kramer and Smith 1960, 1962). The duration of the spawning period has been observed to range from 26 days for a largemouth bass population in a New York lake (Schmidt and Fabrizio 1980) to 71 days in Mississippi (Goodgame and Miranda 1993).

After the male constructs the nest, spawning typically occurs near dusk or dawn (Carr 1942). The female leaves after spawning, and the male guards the nest continuously during incubation. Females may lay eggs in more than one nest, and more than one female may lay eggs in any given nest (Heidinger 1975). Fertilized eggs are demersal and adhesive, spherical (1.4 to 1.8 mm in diameter), yellow to orange and semi-opaque (Carr 1942). Largemouth bass fecundity is dependent on the size and age of the fish and can range from 5,000 to 82,000 eggs per female (Kelley 1962). High rates of fecundity are typically associated with species that experience naturally high rates of mortality in the early life stages, and most stream and pond fishes in New England exhibit this life-history strategy.

Eggs typically hatch within 3 to 4 days. The newly hatched sacfry remain on the bottom of the nest for approximately 10 days until they become free swimming larvae, referred to as swim-up fry. The fry remain schooled together in a brood from 26 to 31 days (Heidinger 1976).

Because of the concern regarding PCB concentrations in the river sediments within the Housatonic River study site, it is important to note that the potential effects of PCBs on largemouth bass reproduction are not believed to be a result of nest construction in these sediments and the subsequent laying of eggs within these nests. Rather, fish embryos are exposed to PCBs via maternal transfer of PCB-lipid compounds to the eggs during oogenesis.

3.5 HATCHING SUCCESS

In a natural setting, the most important factors of egg survival and nest success are the guarding and aeration of the nest by the male. The male largemouth bass fans the eggs with his body and fin movements to keep them aerated and silt free and protects the nest from predators, such as bluegill or crappie (Heidinger 1975). Instances in which the male was removed from the nest resulted in complete mortality of the eggs (Heidinger 1975; Bennett and Bowles 1985). In a laboratory setting, eggs from most nests exceeded 80% hatching success (Kelley 1968). In another study, three broods spawned in the laboratory exhibited 70, 80, and 90% hatching success (Carlson and Hale 1972).

Natural success rates of egg-to-hatch within a nest are highly variable and are dependent on the rate of fertilization and the guarding actions of the male bass. Mortality is generally associated with the male abandoning the nest in response to cooling water temperatures, which can result in predation of the eggs by bluegill and other fishes, hydra, fungus (*Saprolegnia*), or in anoxia and suffocation. Wave action during heavy winds can also result in destruction of nests and incubating embryos resulting in high or total mortality.

Assessing the rate of successful spawning is difficult to do *in situ*. A number of methods have been used to estimate success rates for a population (Bennett and Bowles 1985; Kramer and Smith 1962; Neves 1975). Regardless of the assessment method used, spawning success rates are highly variable and can be affected by a suite of environmental factors, such as water temperature and water levels.

In a Minnesota lake, largemouth bass egg survival in nests ranged from 29 to 94%, with an average survival rate of 79% (Kramer and Smith 1962). In the same Minnesota lake, the rate of successful nests varied from 0 to 100% across years and spawning periods (discontinuous spawning within one year). Kramer and Smith (1962) concluded that if there was more than one spawning period in any area, nest success was higher during the later periods. In a Utah reservoir, the egg-to-hatch success rates of actively guarded nests were relatively high (80 to 90%) (Miller and Kramer 1971). A two-year study on smallmouth bass in a Maine lake indicated that nesting success was between 67 and 77% (Neves 1975). These success rates included nests that were constructed but not used for spawning (13%), and nests with eggs that did not produce swim-up fry (10 and 33% in each year). In the Neves (1975) study, the primary cause of unsuccessful nests was believed to be lowered water levels, which resulted in nest desertion by the male and subsequent predation of the embryos. A two-year study on smallmouth bass nesting success in Lake Erie indicated that 33% of the nests successfully produced free-swimming larvae in 1982, and 87% of the nests were successful in 1983 (Goff 1986). The lower success rate in 1982 was attributed to more windy hours, which resulted in wave actions that disturbed the nests and incubating embryos.

The fungus *Saprolegnia* is ubiquitous in all freshwater systems, and infestation of eggs by this fungus is a common problem at hatcheries. The growing fungus is recognized by its fluffy white appearance, and although generally considered to be a fungus that consumes dead organic material, it can also spread to adjacent live eggs once it has become established on a colonization point (dead eggs) (Knotek 1995). A common practice in hatcheries is to quickly remove unfertilized or dead (opaque) eggs to reduce colonization of the fungus. A recent study on smallmouth bass indicated that *Saprolegnia* was a major source of egg mortality in a Virginia stream (Knotek 1995). Sharp decreases in water temperature were noted to result in largemouth bass nests quickly becoming covered with fungus in a long-term study on Lake George, Minnesota (Kramer and Smith 1962). It is likely that the mediating step was abandonment of the nest by the male, which resulted in anoxic conditions that allowed the fungus to colonize the eggs. *Saprolegnia* can also invade and colonize the body of most species of fish that have been subjected to some type of stress, such as handling injuries, malnutrition, temperature shock, or external parasitism (MOCZM 1995).

3.6 TEMPERATURE

Largemouth bass are a warmwater species and are active when water temperatures range from approximately 10 to 30°C (50 to 86°F) (Eipper 1975). When water temperatures are less than 10°C, adult largemouth bass have been observed to move into deeper water and to be relatively quiescent (Warden and Lorio 1975). Optimal temperatures for growth of young-of-year and yearling largemouth bass range from 25 to 29°C (77 to 84°F) (Niimi and Beamish 1974; Coutant and DeAngelis 1983). When water temperatures are at or below 15°C (59°F) the eggs will hatch, but the fry do not feed, and die of starvation (Strawn 1961). Because largemouth bass growth is dependent on water temperature, fish in northern lakes and rivers typically have lower growth rates than fish in southern waters (Carlander 1977; McCauley and Kilgour 1990; Beamesderfer and North 1995).

Largemouth bass spawning activities are triggered when water temperatures increase above 15.5°C. If water temperatures drop below 15.5°C during the spawning period, spawning activities cease until water temperatures again increase (Kramer and Smith 1962). It is not uncommon for a largemouth bass population to spawn during multiple periods in systems with fluctuating water temperatures. The success of each spawning period is, in part, dependent on the length of time water temperatures remain warm enough for the embryos and fry to fully develop before they leave the brood.

The embryo incubation time is dependent on water temperature. For example, at 10°C (50°F) it takes approximately 13.3 days for the eggs to hatch, while at 28°C (82°F) it can take only 1.2 days for the eggs to hatch (Heidinger 1975). Field observations indicate that hatching typically occurs from 3 to 4 days after egg deposition (Kramer and Smith 1960; Carr 1942). The larval bass are small at hatching with a total length of 3.4 mm (Carr 1942). After hatching, the larval bass are unable to right themselves, and receive all of their nourishment from their yolk sac. During this time, the adult male continues to guard and aerate the larval bass.

Just as with egg incubation, the rate of development of the larvae is dependent on the water temperature. In one study, the fry were free-swimming after 10 days at 20°C (68°F) and the yolk sac was absorbed after 13 days at the same temperature (Laurence 1969). When they become free swimming, larvae are approximately 6 mm (Kramer and Smith 1960).

3.7 PH

The pH of the water can limit the distribution of largemouth bass. A pH greater than 9.6 can prevent successful spawning by killing the eggs, larvae, fry, or food items (Newburg 1975). Bass do not spawn at a pH less than 5, spawn sparingly at pH 5.0 to pH 5.5, and a pH of less than 4.1 or greater than 10.2 is toxic (Eipper 1975).

3.8 DISSOLVED OXYGEN

Growth rates of bass are higher when dissolved oxygen (DO) concentrations are near saturation than when concentrations are lower or higher (Stewart et al. 1967). Low concentrations of DO can result in mortality to developing largemouth bass embryos. Although lethal concentrations vary with age following fertilization and water temperature, in general, concentrations of DO less than 2.5 mg/L are lethal (Dudley and Eipper 1975; Spoor 1977). Abnormally high levels of sacfry movement were observed at 3 mg/L of DO at 20°C and at 4 and 5 mg/L of DO at water temperatures between 23 and 24°C (Spoor 1977). Successful incubation and swim-up of sacfry require DO levels above 5 mg/L (Spoor 1977). Growth rates of juvenile bass are impaired at DO concentrations less than 4 mg/L (Stewart et al. 1967), and adult largemouth bass are also sensitive to low DO concentrations. Adult bass show some avoidance of DO concentrations near 4.5 mg/L, and definitely avoid waters with a DO concentration of 1.5 mg/L (Whitmore et al. 1960).

Adequate levels of dissolved oxygen are typically not a concern in flowing rivers where surface turbulence reaerates the water with atmospheric oxygen. However, in zero velocity water, such as backwater areas of floodplain rivers, bacterial respiration can exceed primary production resulting in reduced levels of dissolved oxygen (Fontenot et al. 2001). Zero to low velocity waters are preferred spawning areas for largemouth bass, and low levels of dissolved oxygen can affect the successful hatching of largemouth bass eggs, especially if decreased DO levels occur in conjunction with decreased water temperature and the abandonment of the nest by the adult male.

During incubation, the male bass guards the nest and fin movements create water currents over the developing embryos, which refresh the local oxygen concentration. If the male leaves the nest, unfanned nests can develop pockets of lethally low DO levels (Eipper 1975), and the eggs may die from insufficient oxygen (Newburg 1975). Males may abandon the nests during incubation if water temperatures drop below approximately 15°C. It is probable that embryo death, in these cases, is a result of decreased dissolved oxygen concentrations rather than low water temperatures (Dudley and Eipper 1975).

3.9 FOOD RESOURCES

Adult largemouth bass feed mainly on fish, although crayfish are also often a major food item. Yellow perch (*Perca flavescens*) and bluegill (*Lepomis macrochirus*) are common food items for largemouth bass in many areas (Newburg 1975). Largemouth bass can also feed on amphibians, snakes, and even small mammals. Fish community assessments in Massachusetts recognize largemouth bass as a top carnivore (Halliwell et al. 1999).

The predaceous nature of largemouth bass can make it a keystone predator, which regulates the abundance and size of prey-fish populations in small impoundments. For example, high densities of large-sized largemouth bass can result in population structures of bluegill and yellow perch that are dominated by small-sized individuals (Guy and Willis 1990, 1991). Conversely lakes that have higher densities of smaller-sized largemouth bass tend to result in communities of bigger-sized bluegill and other panfish (Anderson 1974; Novinger and Legler 1978; Gabelhouse 1984).

Larval largemouth bass must begin to eat within 6 days of becoming free-swimming, or they will die (Laurence 1969). This transition from endogenous to exogenous feeding can be a time of high mortality for juvenile fishes. The male bass remains with the swim-up fry as they begin to feed on small zooplankton for up to several weeks (Heidinger 1975). During this time the young fish swim together in a brood. The fry remain in a brood until they are approximately 32 mm long (Kramer and Smith 1962). At about this same size, the bass switch from a zooplankton diet to a diet of insects and small fish (including other larval largemouth bass) (Kramer and Smith 1962; Miller and Kramer 1971). Other studies have shown young-of-year largemouth bass begin to feed on fish when they attain approximately 40 mm total length (Shelton et al. 1979; Miller and Storck 1982).

3.10 MIGRATION AND LOCAL MOVEMENT

Although largemouth bass can colonize new habitats (Carlander 1975), most studies indicate that juvenile and adult largemouth bass move over relatively small distances (Lewis and Flickinger 1967; Rawstron 1967; Warden and Lorio 1975; Copeland and Noble 1994). Limited experimental evidence indicates that abundant food resources may result in smaller home ranges (Savitz et al. 1983). Home range is defined as the area usually occupied by an animal. In a study on supplemental stocking of young-of-year largemouth bass, the majority of fish that were tagged and released in specific embayments within a North Carolina lake (between 79 and 90%) were recaptured within 58 m of their release sites (Copeland and Noble 1994). In a Mississippi reservoir, home ranges of adult bass ranged from 30 to 100 m during the spring through fall seasons (Warden and Lorio 1975). This same study noted that, following tagging of the fish and release to the reservoir, the initial movement often encompassed the entire lake with the greatest average distance traveled (303 m) occurring in the spring, when water temperatures were increasing from 10 to 20°C. In a relatively small Illinois pond, Lewis and Flickinger (1967) found that 96% of recaptured tagged bass were within 91 m of the original point of capture. The majority of tagged largemouth bass in a California lake moved less than one mile from the point of tagging (Rawstron 1967).

Although largemouth bass exhibit relatively small home ranges, largemouth bass can travel over greater distances. For example, largemouth bass were reported to move up to 6.8 miles in the Mississippi River to overwinter in protected areas (Pilto 1988, as cited in Carlson 1992), and in a population in which most of the fish moved less than one mile, one fish had traveled 6 miles (Rawstron 1967). In addition, largemouth bass have been observed emigrating from lakes over spillways during the spring (Heidinger 1976). In Illinois impoundments, largemouth bass and other fishes moved into the current and over the spillway following heavy rain events (Louder 1958; Lewis et al. 1968). It is possible that these fish would continue to move downstream until they located suitable habitat.

In general, largemouth bass overwinter in offshore habitat and then return to shallower, shoreline habitats in the spring. In river systems, however, suitable winter habitat can be provided by deep water bays and at the mouths of tributaries (Carlson 1992; Raibley et al. 1997). Largemouth bass have been determined to prefer these types of areas for overwintering because they contained warmer water temperatures (Raibley et al. 1997) or reduced current velocities (Carlson 1992). During the winter, lower water temperatures result in lowered metabolic rates and reduced swimming endurance.

3.11 GROWTH RATES

The early development of largemouth bass from hatching to swim-up appears to be similar and consistent among populations, parental sizes, and environments. Larvae are 3.4 mm at hatching (Carr 1942) and between 6.1 and 6.3 millimeters at swim-up (Carr 1942; Meyer 1970; Goodgame and Miranda 1993). Following swim-up, growth rates of largemouth bass are correlated with water temperature, latitude, abundance and quality of prey, cohort density, age of the impoundment, and age of fish (Grice 1959; McCaig and Mullan 1960; Heidinger 1976; Coutant and DeAngelis 1983; He et al. 1994; Beamsderfer and North 1995). Generally, growth rates within a population are slower in colder waters or higher latitudes and individual growth rates are slower in each succeeding year of life. Growth rates are also generally higher in the initial years of impoundment (McCaig and Mullan 1960).

Early-stage growth rates under laboratory conditions can range almost tenfold; from 0.19 to 0.99 mm/day at constant water temperatures between 15.2 and 24.9°C (Coutant and DeAngelis 1983). In a North Carolina reservoir, growth rates varied from 1.04 mm/day for early-hatch fish to 0.85 mm/day for mid-hatch fish, to 0.51 mm/day for late-hatch fish (Phillips et al. 1995). Based on two-week interval estimates for largemouth bass in Minnesota lakes, young-of-year fish grew between 0.71 and 0.84 mm/day from the end of the sacfry stage until the broods dispersed (mean total length of 32.5 mm; Kramer and Smith 1960). Kramer and Smith (1960) calculated approximate growth rates for fish after brood dispersal until the end of the growing season as ranging from 0.22 to 0.44 mm/day.

Average total length of young-of-year largemouth bass at the end of the growing season was 78.7 mm in Micajah Pond, Massachusetts (Grice 1959), 97 and 102 mm in Quabbin Reservoir, Massachusetts (McCaig and Mullan 1960), 93 mm in Dryden Lake, New York (Green 1982), 110 m in Nogies Creek, Ontario (Hamilton and Powles 1979), and 85 mm from an unweighted mean of populations in Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania (Carlander 1977). This compares to an unweighted mean of 94 mm for Michigan, Minnesota, South Dakota, and Wisconsin populations, and 114 mm for midwestern populations in Iowa, Illinois, Indiana, Nebraska, and Ohio (Carlander 1977). A calculation based on a review of 698 largemouth populations in North America resulted in a mean total length of 112 mm for young-of-year, with a minimum size of 33 mm and a maximum of 271 mm (Beamesderfer and North 1995).

Variations in growth rates related to hatch date and food availability could result in multimodal length frequencies within a cohort. In a reservoir in Alabama and Georgia, a relatively long spawning period resulted in earlier hatched largemouth bass that were able to take advantage of abundant larval fish prey, which were too big to be consumed by the later-hatched largemouth bass (Shelton et al. 1979). By August, the largest young-of-year largemouth bass were 2 times as large as the smallest bass. A mathematical model based on these observations was developed by DeAngelis and Coutant (1982) to describe the effects of food availability and growth rates in relation to the development of bimodal size distributions within a cohort. The presence of two distinct size groups of young-of-year was also observed in an Ontario lake (Keast and Eadie 1985). At the end of the growing season in September, the largest individuals were 63 mm and the smallest were 37 mm (Keast and Eadie 1985). Differences in growth rates between early- and late-hatch largemouth bass have been associated with differences in their ability to make the transition from an invertebrate to a fish diet (Miller and Storck 1984; Phillips et al. 1995).

Early nesting can result in higher growth rates for the young-of-year largemouth bass and associated larger total length by the end of the growing season. This can translate to higher overwinter survival for the larger individuals (Gutreuter and Anderson 1985; Fullerton et al. 2000). However, a potential trade-off for early spawners is that lower and more variable water temperatures in the spring can make nest failure more likely (Goodgame and Miranda 1993).

3.12 MORTALITY

Limited information is available on natural mortality rates of largemouth bass. Highly fecund species, such as largemouth bass, exhibit high mortality rates in the first year and progressively lower mortality rates as the remaining fish outgrow the size ranges vulnerable to predation (e.g., Houde 1987). Survival to age 1 can be determined at several critical stages during the first year of life, namely during: 1) incubation; 2) swim-up and the transition to exogenous feeding; 3) rearing; and 4) overwintering. During the earliest weeks of life, mortality (Kramer and Smith 1962) and growth (Ludsin and DeVries 1997) rates can be major determinants of year class strength and subsequent recruitment (King et al. 1979; Green 1982; Gutreuter and Anderson 1985; Goodgame and Miranda 1993; Miranda and Hubbard 1994). On the other hand, high rates of survival during the initial life-stages may not result in a strong year class if survival rates during the later life-stages are low (Kohler et al. 1993).

Mortality rates are influenced by biotic (density-dependent) and abiotic (density-independent) conditions. Density-dependent conditions vary with population size and include factors such as food and habitat availability, predation, and disease. Density-independent factors include environmental conditions that can affect a population regardless of the population size, and include variables such as pollution, water temperature, weather conditions, flow, and dissolved oxygen concentrations. These conditions, which can determine mortality rates at different life stages, are sometimes referred to as "limiting factors" or "bottlenecks" to production.

Many studies have shown that annual variations in reproductive success of largemouth bass are largely related to abiotic conditions to which the developing embryos and larvae are exposed (Eipper 1975). In particular, the conditions of water temperature (Coutant and DeAngelis 1983; Bennett and Bowles 1985), water levels and flow (Bennett and Bowles 1985; Kohler et al. 1993; Raibley et al. 1997; Maceina and Bettoli 1998), wind (Miller and Kramer 1971; Goff 1986), and dissolved oxygen concentrations (Carlson and Siefert 1974; Dudley and Eipper 1975; Spoor 1977) can strongly influence the growth and survival during the early life stages. Available habitat, size at the end of the first growing season, and lipid reserves have been correlated with overwinter survival of young-of-year, or recruitment to age 1 (Aggus and Elliot 1975; Carlander 1975; Hightower et al. 1982; Bennett and Bowles 1985; Kohler et al. 1993; Miranda and Hubbard 1994; Ludsin and DeVries 1997; Fullerton et al. 2000).

Natural mortality rates can vary widely between populations, years, and age classes. A review of natural mortality rates (other than from angler harvesting) in six lakes across the United States indicated that annual mortality rates of adult largemouth bass ranged from 34 to 49% (Rawstron 1967). A study on a Georgia lake indicated annual survival for age 0 fish ranged from 18 to 20% and from 55 to 61% for age 1 largemouth bass (Hightower and Gilbert 1982).

3.13 POPULATION STRUCTURE AND ABUNDANCE

Several methods are used to describe the overall structure of a largemouth bass population including indices and measurements of age-class structure, size-class structure, abundance, density, and body condition or "fitness." The proportion of individuals in each age- or size-class is commonly used to define the structure of a population and to monitor a population over time (Anderson and Neumann 1996). This technique is frequently used in studies of largemouth bass populations to monitor year-class strength in response to reservoir operations (e.g., water level fluctuations) or other environmental perturbations, harvesting pressures, and food resources (e.g., stocking prey species). Because largemouth bass are such an important species for recreational fishing, fishery managers often use the proportional stock density (PSD) index to evaluate the size-class frequencies of largemouth bass populations (Gabelhouse 1984; Willis et al. 1993).

3.13.1 Proportional Stock Density

In general, PSD is a ratio of the number of catchable fish (quality) to the total number of mature fish (stock). Most PSD calculations of largemouth bass use stock (200 mm) and quality (300 mm) lengths, although specific management goals dictate the lengths of fish used to calculate PSD. According to Gabelhouse (1984), generally accepted PSD values for a balanced largemouth bass population range between 40 and 70, and systems managed for larger-sized bass could range from 50 to 80. It is important to note that PSD indices are widely used in the management of largemouth bass fisheries in ponds, lakes, and reservoirs.

In small impoundments, PSD values have been correlated with population density, carrying capacity, recruitment, growth rates, and survival, although variability in these relationships may result from differences in productivity and growing seasons (Willis et al. 1993). An increase in population density above carrying capacity tends to result in decreased PSD values (Willis et al. 1993) as a result of poor habitat availability or insufficient or inappropriate food resources (Gabelhouse 1984). Conversely, low population abundances can result in high PSD values (Willis et al. 1993). Low PSD values can also result from angler overharvest (Gabelhouse 1984). For example, a study was conducted on the impact of angler harvest on largemouth bass size structure in a Wisconsin lake, which was closed to all fish harvest during 1956-76 (Goedde and Coble 1981). During the unexploited years between 1974-76, the lake was dominated by large-sized bass (> 300 mm). When fishing resumed, the population structure shifted to one dominated by largemouth bass < 200 mm. This dramatic change in size-class structure reflected on the PSD values, which in 1974 was 72 and by 1979 had decreased to 16 (Table 3-1). Willis et al. (1993) also noted that study-design factors that could inadvertently influence PSD values, such as seasonal effects (highest PSDs during spring and fall), gear-related biases (size related bias due to gear selectivity), selection of sample sites (subjective sites yield greater sample sizes than random sites), and sample size.

A wide range of PSD values have been reported for largemouth bass throughout the mid-western, northern, and eastern United States (Table 3-1). PSD values are typically calculated for fish ≥ 200 and ≥ 300 mm. PSD values calculated for quality length (defined as ≥ 305 mm) largemouth bass collected from 25 Massachusetts ponds between 1992 and 1994 ranged from 3

Table 3-1. Comparison of largemouth bass relative weight (W_r) and proportional stock density (PSD) values from various studies. Unless otherwise noted, the mean W_r values shown describe a range of means that were calculated for 203 to 304 mm, 305 to 380 mm, and ≥ 381 mm length groups in each sample year; the PSD values describe a range of means that were calculated for fish ≥ 200 mm and ≥ 300 mm.

Reference	Sample Year	Location	Mean W_r	PSD
Chadwick & Associates (1994)	1993	Housatonic River, MA	100-110*	NA
Hartley (unpublished data)	1992-94	25 ponds in Massachusetts	80-212**	3-79+
Green et al. (1986)	1978-80	Tully Lake, NY	95-122	44-65
Green et al. (1986)	1978-80	Ronkonkoma Lake, NY	82-96	4-13
Green et al. (1986)	1978-80	Ballston Lake, NY	88-107	54-79
Green et al. (1986)	1978-80	White Lake, NY	91-98	5-23
Green et al. (1986)	1978-80	Mariaville Lake, NY	81-103	6-36
Green et al. (1986)	1978	St. Lawrence River, NY	105-106	NA
Green et al. (1986)	1978-80	Amawalk Lake, NY	96-106	69-94
Green et al. (1986)	1978-80	Copake Lake, NY	88-97	13-28
Green et al. (1986)	1978-80	Canadarago Lake, NY	95-108	26-83
Green et al. (1986)	1978-80	Waneta Lake, NY	95-108	42-66
Green et al. (1986)	1978	Lamoka Lake, NY	94-102***	58
Green et al. (1986)	1978-80	Chautauqua Lake, NY	91-111	44-90
Goedde and Coble (1981)	1974-79	Mid Lake, WI	NA	16-72++

* range of three W_r values from sites between the confluence of the East and West Branches of the Housatonic River and Woods Pond Dam.

** value based on mean W_r values calculated for < 203 mm, 203 to 304 mm, 305 to 380 mm, and ≥ 381 mm length groups.

*** value based on range of W_r values calculated for fish in the 203 to 304 mm length group only.

\+ range of values based on fish in the 305 to 380 mm length group.

++ values extrapolated from a plotted graph.

NA Not assessed

to 79 (Hartley unpublished data). Several New York lakes showed a wide range of largemouth bass PSD values from a study conducted between 1978 and 1980 (Table 3-1). Amawalk Lake exhibited the highest range of PSDs (69 to 94), while Ronkonkoma Lake (4 to 13), White Lake (5 to 23), and Copake Lake (13 to 28) had the lowest ranges of PSD values (Green et al. 1986).

3.13.2 Relative Weight

Relative weight (W_r) is another index that is commonly used by fisheries managers to assess the condition of largemouth bass. This index is valuable for determining the "robustness" and "well-being" of fish and is easily calculated from length and weight data (Liao et al. 1995). Fish in optimal condition are often "plump" and might be indicators of favorable environmental conditions (i.e., good habitat conditions and abundant prey), whereas thin fish might indicate less than favorable environmental conditions (Blackwell et al. 2000). The concept of W_r, presented by Wege and Anderson (1978), incorporates individual weights and a length-specific standard weight (W_s) of the species studied (Anderson and Neumann 1996). The first W_s equation was developed for largemouth bass (Wege and Anderson 1978) by fitting a curve to the 75th percentile weights using data compiled by Carlander (1977). Anderson and Neumann (1996) suggested that a mean W_r of 100 calculated over a broad range of size classes may represent a healthy fish population. To achieve a balanced largemouth bass population, a W_r target range of 95 to 105 was recommended by Anderson (1980, as cited in Blackwell et al. 2000) although Murphy et al. (1991) suggested this range only be used as a benchmark for comparison.

Relative weight is often presented as a mean by length groups or across an entire sample. Murphy et al. (1991) cautions that the use of mean W_r for an entire sample may mask important length-related trends in fish condition. Relative weight calculated by common length groups (stock, quality, etc.) provides an opportunity to easily compare data sets, whereas individual W_r values plotted against length may reveal length-related condition trends in the population (Blackwell et al. 2000). Liao et al. (1995) presented W_r data for individual pumpkinseed in order to identify significant relationships with fish length.

Similar to the PSD index, a breadth of W_r values have been reported for largemouth bass (Table 3-1). Hartley (unpublished data) calculated a range of mean W_r values from 80 to 212 for largemouth bass from 25 ponds in Massachusetts using < 203 mm, 203 to 304 mm, 305 to 380 mm, and ≥ 381 mm length groups. Other than the one lake with a W_r value of 212, only five other lakes had W_r values greater than 105 (range of 106 to 136). Green et al. (1986) calculated

Wr values, based on 203 mm, 305 mm, and 381 mm length groups, which ranged from 81 to 122 for eleven lakes and from 105 to 106 for the St. Lawrence River in New York. An earlier study on the Housatonic River estimated W_r values that ranged from 100 to 110 for largemouth bass collected from three sites between the confluence of the East and West Branches of the Housatonic River downstream to Woods Pond Dam (Chadwick & Associates 1994).

3.13.3 Abundance

Abundance and density of largemouth bass or other fish species can be estimated through a number of techniques (i.e., mark-recapture or removal), and the results are generally presented as numbers of fish or biomass per area. Alternatively, relative abundances can be estimated based on catch-per-unit-effort (CPUE). Electrofishing-based CPUE estimates are used as common indices of largemouth bass population densities (Coble 1992; McInerny and Degan 1993), and a correlation has been shown between electrofishing-based CPUE and estimates of abundance calculated by removal (Simonson and Lyons 1995). Prior to this work, a model based on electrofishing CPUE was developed for Ohio lakes, which determined the densities of largemouth bass over 199 mm long (Hall 1986). The results of this modeling effort indicated that CPUE could explain 83% of the variability in largemouth bass densities. Electrofishing is an easy and effective way to estimate relative abundance of largemouth bass, and CPUEs can also be used to describe largemouth bass habitat preference and relative reproductive success. Comparative estimates are scarce, however, for young-of-year largemouth bass CPUEs in other systems obtained using similar gear and during similar seasons.

Although other estimates may be available, only three published estimates of young-of-year largemouth bass CPUEs were found during a search of the literature. CPUEs of young-of-year largemouth bass collected from shoreline sites in a North Carolina reservoir ranged from 0.2 to 2.2 fish/min (Jackson and Noble 1995). These estimates were made using a hand-held electrofishing unit at night over the entire growing season. In a study on two Illinois lakes, CPUEs over three years ranged from 0.13 to 1.34 fish/min (Kohler et al. 1993). These estimates were made using a boat-mounted electrofishing unit in November (time of day was not specified). Electrofishing-based CPUEs from the Hudson River (Troy to Peekskill, New York) during 1987 through 1991 ranged from 0.013 to 0.16 fish/min (Nack et al. 1993). These estimates were made in August through October during daylight hours from an electrofishing boat.

4. METHODS

This chapter discusses the methods used by R2 in conducting the largemouth bass study in the Housatonic River. As noted in Section 1.1, an initial effort was completed to evaluate the feasibility of using a reference stream approach for making comparisons with the Housatonic River. The methods used and conclusions resulting from that evaluation are summarized in Section 4.1 and presented in Appendix A. Because, as will be noted, we did not find a suitable reference stream, the remaining sections describe the methods used in completing five interrelated studies focused on evaluating habitats, population structure, and life history characteristics of largemouth bass in the Housatonic River. The five studies included:

- Aquatic habitat assessment;
- Largemouth bass distribution, population structure, and growth rate study;
- Largemouth bass reproduction study;
- Fish community assessment; and
- Environmental conditions monitoring.

The initial studies conducted on the Housatonic River in 2000 were completed over approximately five months, extending from early May through the end of September. The 2001 studies were conducted over seven months, from late March through mid-October. In 2000 we focused on assessments of the aquatic habitat and largemouth bass population structure in the Housatonic River Study Reach, including the mainstem channel and major tributaries. Data collected during 2000 were also used to evaluate habitat suitability for trout species (Appendix B). The follow-up studies conducted in 2001 were aimed at evaluating environmental conditions, assessing the productivity and structure of the largemouth bass population, and gathering additional observations on the fish community.

In the spring of 2000, aquatic habitat assessments were conducted on the Housatonic River Study Reach, including the mainstem, the three major branches, and six tributary streams, in order to identify potential largemouth bass habitat (Figure 1-1). A critical determinant of largemouth bass habitat in this riverine system was the availability of spawning habitat. Data collected during the year 2000 surveys included (but were not limited to), habitat unit composition (pool, riffle, glide, etc.), reach length, stream gradient, water temperature, water depth, bankfull width, substrate composition, and aquatic cover composition.

In the spring and summer of 2001, largemouth bass spawning success, young-of-year growth, and general population attributes in the Index Reach of the Housatonic River were assessed by evaluating: 1) the distribution and timing of largemouth bass nesting; 2) largemouth bass young-of-year growth; 3) largemouth bass population structure; and 4) overall fish community attributes within the study area.

The influences of abiotic factors on largemouth bass spawning success and young-of-year growth were investigated in 2001 by collecting data on: 1) water temperature throughout the study site; 2) continuous dissolved oxygen concentrations and pH in selected locations within the main channel and backwater habitats; 3) flow and stage conditions; and 4) local cloud cover and air temperature.

4.1 CANDIDATE REFERENCE STREAM ASSESSMENT

The initial questions to be addressed by this study – whether there is a self-sustaining largemouth bass population in the Study Reach and whether the largemouth bass population in the Study Reach is dependent on tributary recruitment – can be evaluated using reproduction, population, and habitat data collected from the Study Reach and its tributaries. If there is a self-sustaining largemouth bass population in this reach, there are three potential lines of inquiry that can be used to assess whether that population is adversely affected by a given contaminant. These are: 1) the use of "control" segments within the "target" stream itself that are generally upstream of the zone of impact of the contaminant but are morphologically similar to the "test" stream segment; 2) the use of "reference" streams that share similar physical, hydrological, and geomorphological characteristics to the "test" stream, as well as similar anthropogenic impacts except for the contaminant(s) under evaluation; or 3) the use of existing and historical data and information obtained from a wide range of streams from which to compare fish population metrics with those in the "test" stream. The selection of a specific approach is largely dependent on the extent of available data, and the existence of suitable control segments or reference streams.

In this case, the use of an upstream control site for making comparisons of fish population characteristics in the Housatonic River was rejected due to significant differences in channel size and morphology in the upper segments (East Branch and West Branch) of the system not affected by releases from the GE facility in Pittsfield. We therefore focused our effort on finding a reference stream/river system that shared similar characteristics and anthropogenic impacts to the Housatonic River system, except for the presence of PCBs. The watershed and river qualities that were compared included drainage area, land use, mean annual flow, and game fish communities, among other attributes.

The reference stream assessment was conducted in March 2000 and the methods and results are presented in Appendix A. The results of our analysis suggested that it would be difficult to find a suitable reference stream that shared enough similarity with the overall system to warrant further consideration, because the upper Housatonic River system:

- is headwatered in an urban environment and is subjected to a variety of anthropogenic impacts (e.g., channelization, stormwater runoff, waste water discharge, and industrial discharge);
- has a number of small dams that affect the aquatic habitats and potentially isolate populations of fish;
- contains both coldwater and warmwater fishery habitats combined with warmwater mainstem habitats; and
- incorporates a unique combination of complex palustrine-riverine habitats.

As a result, we proceeded with a detailed study of the Housatonic River with the understanding that comparisons of largemouth bass population metrics would be made to other published and unpublished data and information sources.

As discussed in Chapter 3, a large amount of published research exists on largemouth bass biology and ecology because they are an important game fish. However, largemouth bass are distributed throughout the United States and southern Canada encompassing a range of conditions from subtropical warmwater systems to northern systems that have extensive ice cover during much of the winter. In addition, two subspecies of largemouth bass - the northern largemouth bass (*M. salmoides salmoides*) and the southern largemouth bass (*M. salmoides floridanus*) - have been widely introduced throughout the states. Regardless of subspecies, in the southern part of its range largemouth bass are larger and spawning starts when water *cools* to about 16°C in winter, whereas in the northern latitudes the bass are smaller and spawning is initiated in the spring when water temperatures *warm* (Heidinger 1976). Because of the potentially large differences in biology and ecology between largemouth bass in the southern and northern parts of their range, when possible, we compared observations from the Housatonic River with observations from other northern systems. In addition, we avoided comparisons with populations from systems known to contain elevated concentrations of PCBs, such as the Hudson River.

4.2 AQUATIC HABITAT ASSESSMENT

The aquatic habitat conditions in the upper Housatonic River system (Study Reach) (Figure 1-1) were assessed in 2000 to identify and describe the availability of largemouth bass habitat. In addition, habitat conditions were observed within the three main branches that form the Housatonic River, the East, West, and Southwest branches of the Housatonic River, which are upstream of the Study Reach. The habitat assessment encompassed two geographical scales, landscape- and site-specific.

The landscape-scale assessment involved habitat mapping, and was used to delineate overall reach characteristics in the mainstem Housatonic River, from its origin at the confluence of the East and West branches of the Housatonic River in the city of Pittsfield downstream (south) to Woods Pond Dam near the town of Lenox Station.

Site-specific habitat assessments were completed on several of the reaches and tributaries to provide more detailed information at locations subsequently assessed for fish use (Table 4-1). Some information gathered at the site-specific scale was relevant to describing the overall study area.

4.2.1 Habitat Mapping

The landscape-scale habitat mapping was completed using foot and boat surveys in May and June 2000. The mainstem river was surveyed in four sections, which included: 1) the reach from the confluence of the East and West branches downstream to Holmes Road; 2) the reach from Holmes Road south to New Lenox Road; 3) the river section from New Lenox Road south to Woods Pond; and 4) the Woods Pond area. Several backwater areas adjacent to the main channel were also surveyed. During the habitat mapping effort, surveys were also completed on the three main branches and on six major tributaries, including Moorewood Brook, Sackett Brook, Mill Brook, Roaring Brook, Yokun Brook, and Felton Brook (Table 4-1). Three of the four Housatonic River sections were field surveyed between May 5 and 7, 2000 from a small, flat-bottomed boat with an electric trolling motor, or from a self-propelled inflatable raft. A log jam at the lower boundary of the section of the mainstem reach between Holmes Road and New Lenox Road precluded the habitat survey during May; the section was subsequently surveyed on

Table 4-1. Housatonic River mainstem and tributary sample sites surveyed during May through September 2000.

Study Site	**Code**	**Location/Habitat Type**	**Mapping or Site-Specific Survey**
Lower Woods Pond	LWP	Lower Woods Pond, Housatonic River/Impounded	Both
Upper Woods Pond	UWP	Upper Woods Pond, Housatonic River/Impounded	Both
Upper New Lenox Road-Main Channel	UNLMC	Housatonic River above bridge at New Lenox Road, near EPRI plant/Main Channel River	Both
Upper New Lenox Road-Backwater	UNLBW	Newly formed backwater of the Housatonic River above New Lenox Road, near EPRI plant/Backwater	Both
Holmes Road	HR	Housatonic River near Canoe Meadows/Main Channel River	Both
East Branch	EB	East Branch Housatonic River upstream of confluence of W Branch/Channelized river tributary	Both
West Branch	WB	West Branch Housatonic River/Channelized river tributary	Both
Southwest Branch	SWB	Southwest Branch Housatonic River from Hungerford St. to mouth/ Non-channelized river tributary	Mapping
Moorewood Brook	MRB	The outlet of Moorewood Lake downstream of Holmes Road (right bank)/Floodplain tributary - lake outlet	Both
Sackett Brook	SB	Lower portion near confluence with Housatonic River (left bank)/Low-gradient tributary	Both
Upper Mill Brook	MBU	Left bank tributary draining northwest slope of October Mountain, upstream of road crossing/Steep tributary	Both
Lower Mill Brook	MBL	Left bank tributary draining northwest slope of October Mountain, downstream of road crossing/Low-gradient tributary	Both
Roaring Brook	RB	Left bank tributary draining west slope of October Mountain/Steep tributary	Both
Yokun Brook	YB	Right bank tributary downstream of New Lenox Road bridge/Steep tributary	Mapping
Felton Brook	FB	Left bank tributary draining west slope of October Mountain. Mouth is near Lower Woods Pond/Low-gradient tributary	Both

July 28, 2000. Data collected from the field surveys were supplemented by interpretation of USGS 1:25,000 topographic maps and recent (March 23, 2000) 1:500 scale aerial photographs.

The East, West, and Southwest branches of the Housatonic River were surveyed from a raft. The West and Southwest branches of the Housatonic River were surveyed from the first impassable dam downstream to their mouths; the East Branch from just upstream of the GE facility downstream to the confluence with the West Branch of the Housatonic River. The smaller tributaries were surveyed on foot from the mouth or floodplain connection of the tributary upstream to the upper limit of fish passage (e.g., dam or other barrier).

During the habitat mapping, sequential areas within the stream and river channels were delineated into riffle, pool, glide, cascade, and island complex habitats. These categories, as generally defined by Bisson et al. (1982) and Platts et al. (1983) include:

- Riffle – areas of predominantly fast water, in which surface agitation is notable;
- Pool – areas predominated by slow moving deep water;
- Glide – areas of relatively deep (compared to riffle), fast water in which surface agitation is minimal;
- Cascade – sections of stream containing turbulent, broken surface flow of water over a steeply inclined streambed, with water plunging from one point to another; and
- Island complex – stream channel sections containing one or more split channels.

At each of the above habitat units, nine standard measurements as described in Table 4-2 were collected to describe the quantity and quality of the aquatic habitat.

For riffle habitat units that were not dominated by sand, the percent embeddedness of the substrate was visually estimated, and for pool habitats, the residual depth was determined. These habitat attributes are defined below.

- Embeddedness (%) – Embeddedness is the percent to which the dominant substrates are covered with fine sediments (Platts et al. 1983). The extent of embeddedness was based on visual examination of gravel and cobble in the unit, and was grouped into categories of zero, 25%, 50%, or 100%.
- Residual pool depth (ft) – The residual pool depth was calculated as the maximum pool depth minus the water depth at the downstream hydraulic control, which was typically the crest of the pool tail (Lisle 1987).

Table 4-2. Measurements of habitat quantity and quality collected at each habitat unit surveyed in the Study Reach of the Housatonic River, 2000.

Habitat Parameter	**Description**
Habitat unit length (ft)	In the smaller tributaries that were surveyed on foot, specific lengths of each habitat type were measured (to the nearest foot) by extending a hip-chain along one side of the channel and noting the start and end of each habitat unit. In the river segments surveyed by boat, habitat lengths were visually estimated and then corrected based on observations of landmarks.
Wetted width (ft)	The wetted width, or distance from right to left water's edge, was recorded based on visual estimates calibrated with measurements taken with an expandable stadia rod or a fabric tape.
Bankfull width (ft)	The bankfull width, or distance from right to left ordinary high water mark (OHWM), was recorded based on visual estimates calibrated with measurements taken with an expandable stadia rod or a fabric tape. The OHWM was described by identifying topographical changes in bank slope, particle size distribution of the bank material, and the presence of perennial vegetation.
Channel gradient (%)	Where an obvious change in gradient occurred, the slope of the habitat unit was measured with the use of a clinometer or visually estimated.
Adjacent land use	The dominant land use and vegetation type along the left bank and right bank (facing downstream) were identified. Dominant land use was recorded as agriculture, urban, forest, or wetland. Vegetation type was recorded as woody, herbaceous, or mixed.
Bank condition	The condition of the left bank and right bank (facing downstream) was identified as armored, eroded, bedrock, or vegetated.
Aquatic habitat cover	Visual determinations were made of the relative percent of the aquatic habitat area with cover relevant to refugia for aquatic vertebrates. Types of aquatic cover included undercut banks, vegetation, wood, rock, and deep water (Bisson et al. 1982).
Substrate composition (dominant/subdominant)	The dominant and subdominant substrate composition was visually identified as bedrock, silt/organic, sand, small gravel, large gravel, cobble, or boulder. The size classes of each substrate type are provided in Table 4-3.
Water depth (ft)	The average water depth in each habitat unit during the survey was measured with a stadia rod.

Table 4-3. Substrate codes and sizes used in the habitat mapping and site-specific habitat surveys on the Housatonic River, 2000.

Code	Substrate	Size (cm)
1	Bedrock	--
2	Silt/organic	--
3	Sand	--
4	Small gravel	0.64-2.5
5	Large gravel	2.5-7.6
6	Cobble	7.6-30.5
7	Boulder	> 30.5

Ancillary measurements of water temperature (ºC) as well as notes on unique or critical habitats (e.g., off-channel areas or passage barriers) were also made during the landscape-scale habitat mapping. In addition, photographs were taken of representative areas during the surveys. In impounded areas where no obvious channel existed, such as embayments on the Housatonic River, lentic habitats were mapped using a small boat fitted with a trolling motor, USGS topographic maps (1:25,000), and aerial photographs.

The data collected during the habitat mapping were used to identify the extent and diversity of aquatic habitat types in the study area. At this scale, aquatic habitat types were delineated within areas accessible to the main channel and downstream of major migration barriers (dams, waterfalls). The suitability of each habitat type to support largemouth bass reproduction and rearing was assessed based on information gathered during the site-specific habitat surveys and fish observations as described below, and on published accounts of largemouth bass habitat needs (Bulkley 1975; Stuber et al. 1982; and Maceina and Bettoli 1998).

4.2.2 Site-Specific Habitat Surveys

To further evaluate the suitability of habitats identified during the landscape-scale habitat mapping for supporting largemouth bass, detailed measurements of water quality, physical conditions, and flow characteristics were collected at 13 study sites in May and June 2000 (Table 4-1, Figure 4-1). Water quality parameters measured at each site included DO concentrations (YSI Model 51B), pH and conductivity (Hanna Instruments HI9025 and HI9033) and water temperature using hand-held thermometers.

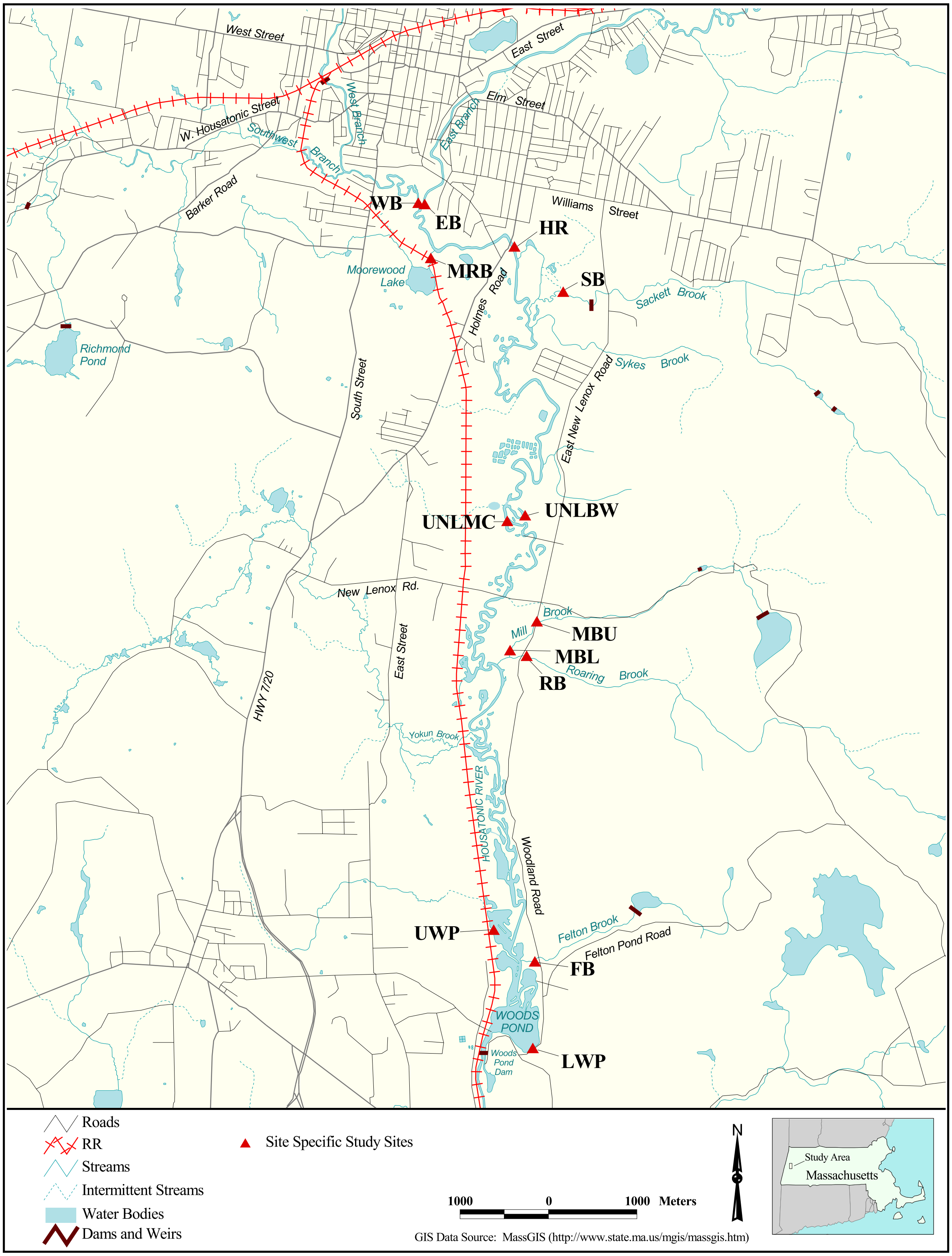


Figure 4-1. The locations of 13 study sites in the Housatonic River system assessed for habitat conditions in 2000.

Of the 13 study sites, two were located in Lower and Upper Woods Pond and were more similar to lentic (lake) than lotic (flowing water) habitat sites. The Upper Woods Pond site consisted of a shallow, backwater area, located off the right bank (facing downstream) of the main channel of the Housatonic River; its western margin was bounded by railroad tracks. The Lower Woods Pond site was located along the eastern and southern-most shoreline of Woods Pond. Site-specific habitat surveys in these two backwater sites focused on identifying the following four lentic habitat parameters:

- Average water depth (ft) – for the Upper Woods Pond site, the average water depth was determined by sounding with a stadia rod across a series of transects; for the Lower Woods Pond Site, a bathymetric map generated by Blasland, Bouck & Lee, Inc. (BBL) (1996) was validated with random soundings with a stadia rod.
- Embayment width and length – The boundaries of the study site were visually determined, and then scaled to aerial photographs, and GIS data maps.
- Substrate type – The substrate at the two Woods Pond sites were determined visually and with the use of a stadia rod used as a probe.
- Aquatic vegetation – The presence of submerged, emergent, and floating-leaved hydrophytes throughout the study site was noted.

In the 11 flowing-water sites (Table 4-1; Figure 4-1), habitat conditions were assessed along a length equal to at least five to seven channel widths, so that each survey site was representative of the larger reach (Plafkin et al. 1989; USEPA 1996; Platts et al. 1987). Site-specific physical conditions of the flowing water study sites included observations of available aquatic cover, substrate embeddedness, channel alteration, sediment scour or deposition, bank condition, riparian condition, and channel type.

The observations obtained from the site-specific surveys, habitat mapping, and aerial photographs were used to identify potential largemouth bass habitat within the study area. These areas were digitized onto an existing GIS map and quantified.

4.3 LARGEMOUTH BASS DISTRIBUTION, POPULATION STRUCTURE, AND GROWTH RATES

4.3.1 Adult and Juvenile Sampling

At each of the 13 locations where habitat conditions were assessed with site-specific data collections, the presence of largemouth bass was evaluated with the use of electrofishing techniques in 2000 during either a June or a late-July/early-August sampling event. An exception was the Holmes Road site, which was inaccessible due to low flow conditions. As a substitute, a site downstream from Holmes Road was electrofished (near the mouth of Sykes Brook).

Figure 4-2. Electrofishing boat used for the Housatonic River, 2000 and 2001 largemouth bass study.

Main channel areas and backwaters were sampled by a crew of three individuals using a Smith-Root type VI-A electrofisher powered by a 5000 watt generator, mounted on a 18-ft boat (Figure 4-2). In the small tributary study sites, a backpack electrofisher was used to collect bass and other fish. In the East Branch and West Branch sites where deeper pools limited wading, fish were collected with a raft-mounted Smith Root GPP unit powered by a 5 horsepower generator.

Figure 4-3. Largemouth bass on measuring board and tagged with a yellow, coded Floy type anchor tag, Housatonic River, 2000.

All electrofishing occurred during daylight hours, and fish stunned by the current were captured with long-handled nets. Netted fish were held in live wells (basins filled with river water) until the end of an electrofishing pass. Collected largemouth bass were anesthetized with Tricaine Methanesulfonate (MS-222), measured for total length (nearest mm – measuring board) (Figure 4-3), and weighed (nearest 10 g – spring balance; juvenile bass weighed to the nearest 0.5 g - digital balance). For largemouth bass larger than 200 mm, scale samples were taken from the left side of each fish above the lateral line and just posterior to the dorsal fin, and then secured in labeled envelopes. The presence of unusual wounds, lesions, or deformities was noted. For largemouth bass greater than 150 mm, a coded Floy-type anchor tag was inserted on the left side of the dorsal fish (Figure 4-3). Fish were subsequently allowed to recover and released back to the river.

4.3.1.1 Year 2000 Surveys

In 2000, the spring and summer electrofishing efforts were focused on the 13 river and stream sites where habitat attributes had been recorded during the site-specific habitat surveys (Figure 4-4). Although the first electrofishing event was scheduled to sample all sites during the week of June 4 through 13, a flood on June 6 limited access and success of this sampling event. Therefore a second sampling event was conducted during July 30 through August 2. Additional sites within the mainstem Housatonic River (including main channel and backwater areas), other than the 13 site specific habitat locations, were also sampled during the two electrofishing events (Appendix D, Table D-1). During electrofishing, all fish stunned by the electrical current, including species other than largemouth bass, were identified and enumerated. Fish observed during these efforts were used to describe the distribution of largemouth bass, the structure of the largemouth bass population, and the distribution and structure of the overall fish community.

An additional fall sampling event on September 26 and 27 targeted the collection of young-of-year largemouth bass. The September 2000 effort was coordinated with biannual young-of-year sampling by BBL. In September, fish were collected with a Smith-Root boat equipped with pulsed DC similar in configuration to that used for the previous samples. Prior to sampling in the fall, three habitat types within mainstem areas of the Housatonic River were identified as follows:

- **main channel –** shoreline habitat along the banks of the main channel. In general, the banks drop off quite steeply and this habitat was generally deep with swiftly flowing water. Overhanging trees and woody debris provided occasional areas of complex cover.
- **backwater –** shallow habitat in embayments or impounded areas. These areas were contiguous with the main channel, and were generally less than 3 feet deep, with slack water, and dense aquatic macrophytes.
- **transition –** edge habitats between the deep main channel and the shallow backwaters. Typically a submerged sand bar with or without vegetation was located parallel to the main channel at the “entrance” to each backwater. The areas were always associated with backwater areas and were electrofished along their margin with the main channel.

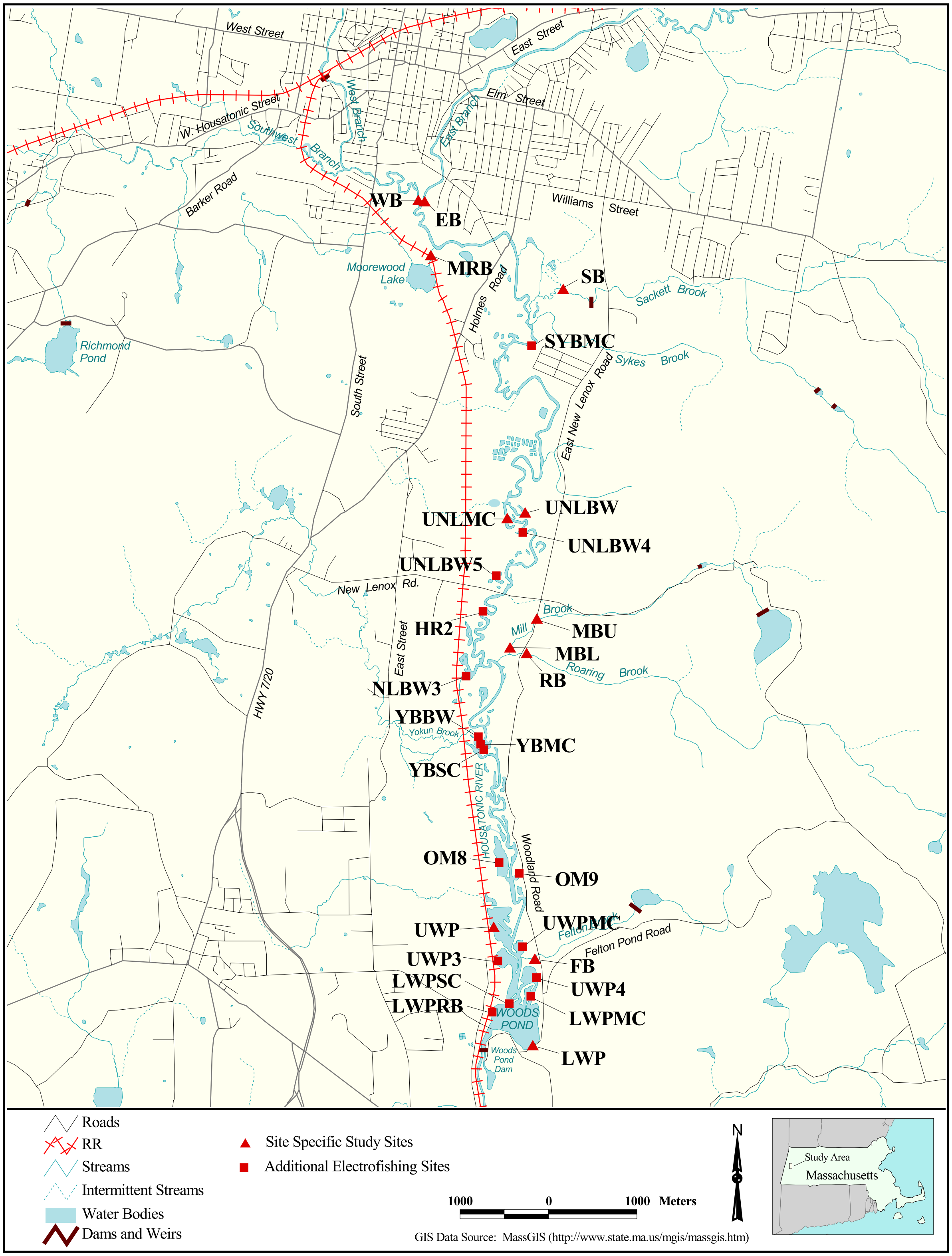


Figure 4-4. Map showing the June and July/August 2000 electrofishing locations on the Housatonic River.

The linear distance of each sampled transect as measured with a range finder, the habitat type, and the electrofishing seconds counted on the electrofishing unit (actual amount of time the water was energized) were recorded. The electrofishing transect locations sampled in September 2000 are shown in Figure 4-5. Young-of-year largemouth bass collected in September 2000 were used to calculate end of season growth rates and CPUEs.

In addition to electrofishing, fyke nets with 3/16-inch mesh were set across Felton and Moorewood brooks on 11 June 2000 to assess fish potentially emigrating out of these tributaries and into the Housatonic River. A beach seine (1/4-inch mesh) was also used in Felton Brook Reservoir and at spot locations in the Study Reach. In addition, dip nets and minnow traps were used to collect small-sized fish. Fish collected with the above sampling methods were generally used qualitatively to assess fish distributions.

4.3.1.2 Year 2001 Surveys

In 2001, one electrofishing event was conducted in the fall, during October 10 to 12, on the same mainstem Housatonic River locations sampled in September 2000. The sampling targeted all age classes of largemouth bass. The 2001 electrofishing surveys were conducted along 20 transects in the Housatonic River (Figure 4-5), representing main channel (n=7), backwater (n=7), and transitional habitats (n=6). The sampled transects included 12 of the 15 transects that were sampled in September 2000. Two of the year 2000 transitional habitat transects upstream of the New Lenox Road bridge were not resampled in 2001 since boat access was blocked by low water; we could not re-locate the marks to identify the third transect. The linear distance of each transect was measured with a range finder and with an onboard Global Positioning System (GPS).

4.3.2 Age and Growth

The age groups of largemouth bass collected in 2000 and 2001 were estimated using a Peterson length-frequency technique outlined by Anderson and Neumann (1996), where specific age classes exhibit definable modes in the length-frequency distribution. This method often reduces the effort required in determining age-class delineations compared with other methods (scales, otoliths), but this technique generally works best for the small size classes. Fish grow at variable rates, thus older age classes often overlap in length. Therefore, length-at-age was also evaluated with scale analyses. Scale samples from largemouth bass were taken from the left side, above the

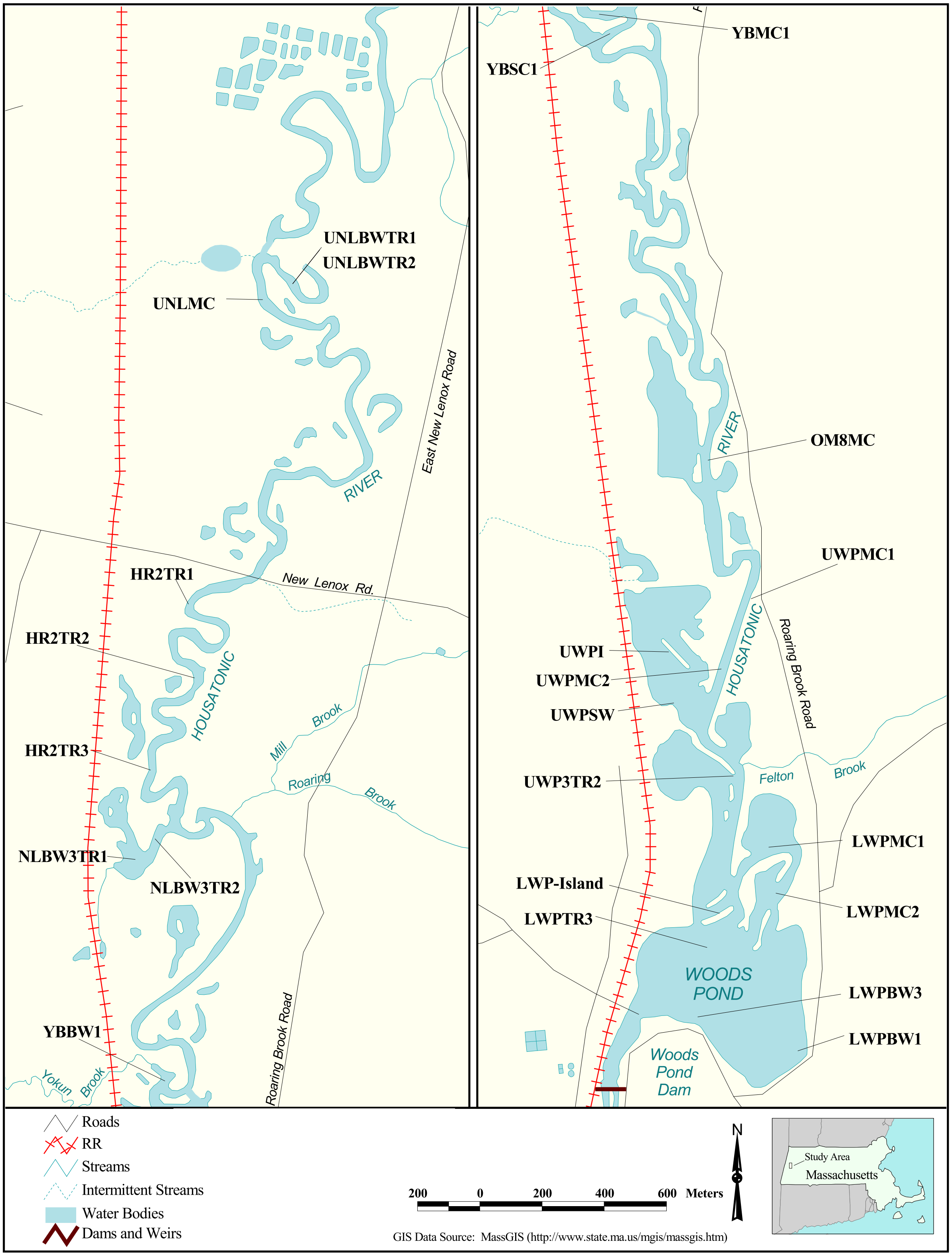


Figure 4-5. Transects used during fall electrofishing in the Housatonic River during 2000 and 2001.

lateral line and just posterior to the dorsal fin from each fish over 200 mm in 2000 and 2001, and from most fish over 100 mm in 2001. Scales were viewed under magnification with a microfilm reader (~48x), and the age of each fish was determined by counting the number of annulus marks (annuli) present on each scale. Annuli were counted along the axis, which provided the most unambiguous counts. Annuli were typically read from three to five scales per fish to verify age designations.

The differentiation of young-of-year and age 1 largemouth bass was determined based on length-frequency histograms and scale analyses completed on a subset of 35 juvenile fish that ranged between 82 and 200 mm total length. During analysis of scales from fish collected in 2000, it was determined that scale annuli counts were problematic for older bass, as annuli near the scale margin tended to merge. Therefore, analyses of these fish collected in 2000 were supplemented by examining sagittal otoliths from additional largemouth bass collected from the Housatonic River by BBL in 2000 for other purposes. Otoliths were immersed in glycerol or other immersion media, then examined under a stereoscope for growth patterns. Age data were also supplemented with estimates derived from scale and otolith counts from fish collected in the study area for the U.S. Fish and Wildlife Service (USFWS) and presented by Smithwood (1999).

Total length measurements of young-of-year largemouth bass collected from the Housatonic River study area during June through September 2000 and from the index sites during May through July and October 2001, were used to compute early life-stage and yearly growth rates. For the 2000 surveys, growth rates for young-of-year largemouth bass were calculated for two time-intervals (July 2 to August 1 and August 1 to September 27) and were based on fish captured in the Woods Pond area. Young-of-year growth rates for bass collected during May through July 2001 were estimated on a bi-weekly basis. Growth rates were calculated as the difference between the average starting and ending lengths during the respective interval periods. Growth rates during each time interval were divided by the number of days in that interval to obtain daily growth rates. Only population-wide growth estimates were possible, as individual broods of largemouth bass were not followed through the growing season.

The number of accumulated degree days over 10°C (50°F) was used to assess the potential relationship between growth and water temperature. Observations of largemouth bass reared under constant temperatures have shown that below water temperatures of 10°C largemouth bass exhibit negligible growth, and they have a nearly linear growth relationship to water temperatures in the range from 10 to 28°C (Strawn 1961). Degree days over 10°C were calculated as a running total of mean daily water temperatures (T) greater than 10°C, as shown in the following equation:

$$\text{Degree Days over } 10°C = \Sigma(T_i - 10°C)$$

where:
i = each day that T is greater than 10°C

4.3.3 Proportional Stock Density

To provide an index of the proportion of largemouth bass that was of a fishable size to recreational anglers, a Proportional Stock Density (PSD) (Gabelhouse 1984) was calculated. Although recreational fishing in the Housatonic River is limited to catch-and-release, PSD values are commonly used by fisheries managers to describe largemouth bass populations (Gabelhouse 1984), as discussed in Section 3.13.1. The PSD of largemouth bass in the Housatonic River was estimated according to the following equation:

$$PSD = \left(\frac{\#\ fish \geq \min quality length}{\#\ fish \geq \min stock length} \right) \times 100,$$

where:

quality length = as the minimum size bass most anglers like to catch (300 mm); and

stock length = approximate length at maturity (200 mm) (values reported in Anderson and Neumann 1996).

4.3.4 Relative Weight

Relative weights (W_r) were used as an index of condition, or well being, of the Housatonic River largemouth bass population in comparison to other populations (Wege and Anderson 1978) according to the expression:

$$W_r = (W/W_s) \text{ x } 100,$$

where:

W = weight of an individual fish; and

W_s = length-specific standard weight, derived from a linear length-weight relationship for the species as a whole (Anderson and Neumann 1996).

The following relationship was used to solve the term W_s for largemouth bass over 150 mm (Wege and Anderson 1978):

$$log_{10}W_s = -5.316 + 3.191(log_{10}TL)$$

where:

TL = total length

Relative weights were calculated for each fish and as a mean for all largemouth bass equal to or greater than 150 mm total length. The 150 mm standard represents the minimum applicable length defined by Wege and Anderson (1978) for largemouth bass. As discussed in Section 3.13.2, mean W_r of 100 for a broad range of size groups generally describes fish in good condition (Anderson and Neumann 1996). Anderson (1980, as cited in Blackwell et al. 2000) suggested W_r range of 95 to 105 for a managed largemouth bass population.

4.3.5 Catch-Per-Unit-Effort

The number of largemouth bass captured per unit effort time (or area) was used as an index of relative abundance among different habitat types. Because there are different catch efficiencies between electrofishing in streams with backpack units, and sampling mainstem habitats with boats, it was not possible to compare effort among these locations. Catch-per-unit-effort estimates of young-of-year largemouth bass (< 100 mm) were computed for three different habitats (Section 4.3.1.1) during the fall 2000 and 2001 surveys (Figure 4-5). For the September 2000 surveys, five main channel, five transition, and five backwater habitats were surveyed, while seven main channel, six transition, and seven backwater habitats were used for the October 2001 CPUE estimates.

4.4 LARGEMOUTH BASS REPRODUCTION

In 2000, incidental observations during habitat assessments and adult bass surveys were used to document the presence of reproductive behavior, nest construction, egg deposition, and successful hatching of largemouth bass within the Study Reach. In 2001 a more focused and extensive effort was conducted, based on these initial observations, to document timing, distribution, and success of largemouth bass reproduction within the Index Reach, as described in Chapter 2. This section focuses mainly on describing the methods used in 2001.

4.4.1 Year 2000 Surveys

In 2000, a variety of techniques were used to assess the distribution and success of largemouth bass reproduction within the Study Area. This preliminary assessment used observational transects (boat and shoreline), underwater remote video camera (Aqua-Vu) and recording equipment (Sony digital camcorder), and collections of young-of-year fish using fyke nets, beach seines, minnow traps, and dip nets. Young-of-year largemouth bass collected during this preliminary assessment were used to estimated growth rates. However, more detailed growth rate information was collected the following year.

4.4.2 Year 2001 Surveys

In 2001, 15 index sites were established within the Index Reach of the Housatonic River to monitor largemouth bass reproductive activity. All index sites were within areas where a range of PCB concentrations had been detected in the river sediments. Nonetheless, fish embryos are exposed to PCBs via maternal transfer during oogenesis and therefore potential effects from PCBs on the earliest life stages would be expected to originate from the spawning female and not from the nest materials.

From May through early July, the index sites were routinely monitored for the presence of nests, eggs within nests, larvae, broods, and young-of-year fish. Each index site was a transect between approximately 300 and 1,000 feet long, which paralleled the shoreline in water of zero velocity and where the water was shallow enough to clearly see the bottom. Following the completion of the nesting season, an additional index site (OM8E) was established for observing young-of-year largemouth bass along the eastern shoreline of the October Mountain backwater area. The index sites are described in Table 4-4 and Figure 4-6.

Most index sites were surveyed approximately twice a week between mid-May through the end of June. Surveys were conducted by two observers in a rowboat, while wearing polarized sunglasses to reduce surface water reflections.

Table 4-4. Largemouth bass nesting index sites surveyed during the 2001 growing season.

Housatonic River Backwater Location	Index Site Name	Length (m)	Duration of Observations	Frequency of Observations
New Lenox Backwater 3 (NLBW3)	NLBW3N	115	5/16/01 – 6/27/01 October electrofishing	12 times
	NLBW3E	134	5/16/01 – 6/27/01 October electrofishing	12 times
	NLBW3W	146	5/16/01 – 6/27/01 October electrofishing	12 times
October Mountain 2 (OM2)	OM2	93	5/10/01 – 6/27/01	12 times
October Mountain 7 (OM7)	OM7	104	5/16/01 – 6/19/01	7 times
October Mountain 8 (OM8)	OM8W	208	5/16/01 – 6/25/01	9 times
	OM8E	169	6/18/01 – 7/03/01	4 times
October Mountain 9 (OM9)	OM9	164	5/16/01 – 6/26/01	7 times
Upper Woods Pond (UWP)	UWPIE	143	5/15/01 – 7/03/01	10 times
	UWPIW	150	5/21/01 – 7/03/01	8 times
	UWPW	161	5/15/01 – 6/20/01	7 times
Upper Woods Pond 2 (UWP2)	UWP2	225	5/11/01 – 7/03/01	14 times
Upper Woods Pond 3 (UWP3)	UWP3E	167	5/14/01 – 6/20/01	7 times
	UWP3SW	270	5/11/01 – 6/20/01 October electrofishing	9 times
Upper Woods Pond 4 (UWP4)	UWP4	304	5/11/01 – 6/18/01 October electrofishing at mouth	5 times
Upper Woods Pond 5 (UWP5)	UWP5	214	5/24/01 – 6/25/01 October electrofishing at mouth	7 times

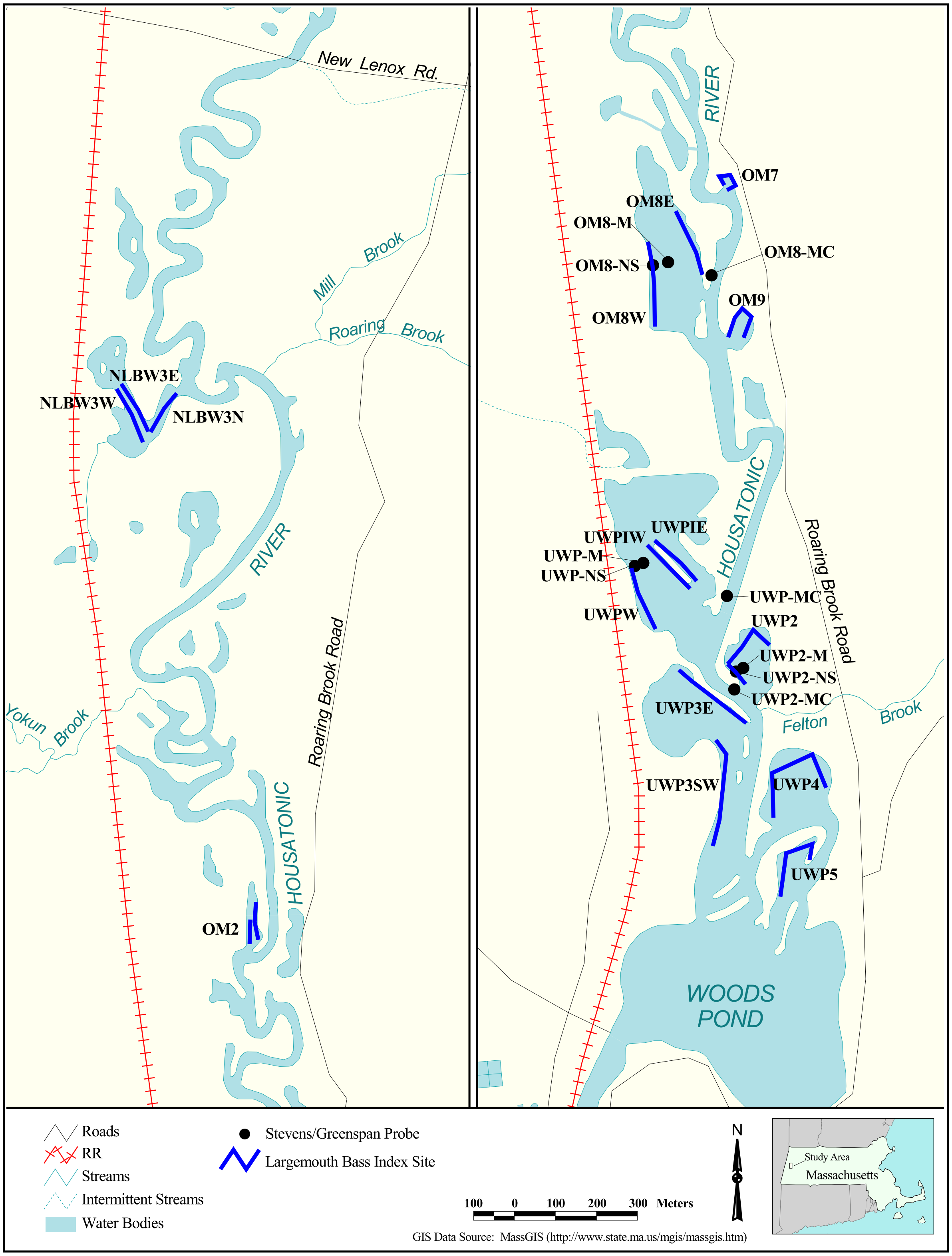


Figure 4-6. Site map that shows the locations of the index sites used for largemouth bass nest and young-of-year surveys in the Housatonic River and the nine Stevens/Greenspan probes.

4.4.2.1 Nest and Brood Observations

In 2001, largemouth bass nests were typically located by noting the presence of a guarding adult over a circular or oblong depression in the substrates where fine silts had been cleared away. A glass-bottom tube was sometimes used to improve visibility and confirm largemouth bass nest-egg-brood presence (Figure 4-7). Largemouth bass nests were defined as active nests if they were guarded by an adult bass, or if they contained eggs, sacfry, or newly brooding fish (swim-up larvae). Because other centrarchid species (primarily bluegill – *Lepomis macrochirus,* and pumpkinseed – *Lepomis gibbosus*) were also nesting and spawning at the same time as largemouth bass, active nests were counted only if an adult bass had been observed in association with the nest. Nest identification was also influenced by water clarity, aquatic vegetation, algae mats (which became especially problematic during the June surveys), and surface agitation caused by wind. In addition, flow and corresponding stage changes in the Housatonic River created boat access problems to some of the earlier detected nests due to shallow water (less than 6 inches). Indeed, some nests became dewatered as water levels decreased.

During the initial surveys in 2001, dark bottles were placed in close proximity to each nest as a means to relocate nests during subsequent surveys. However, this method proved unreliable, as bottles were rarely relocated, most likely because they became covered in a layer of silt. After this, all nests were marked with a small piece of yellow flagging tied on nearby emergent or shoreline vegetation.

At each active nest, the following observations were made: 1) water depth over the nest pit (inches); 2) nest width and length (inches); 3) nest substrate composition (silt, sand, coarse gravel, fine gravel, vegetation); 4) presence/absence of specific largemouth bass life stages (adult, eggs, sacfry, or swim-up larvae); and 5) general condition of the fertilized eggs (good/translucent, white, or fungused). Ancillary information recorded at each index site included time of day, weather, and water clarity. Measurements of water temperature, dissolved oxygen concentrations, and conductivity were also collected with a hand-held Hydrolab Quanta.

Live eggs were a translucent yellow, whereas white opaque eggs were presumed to be dead (Knotek and Orth 1998). Fungused eggs were recognized by white fluffy mycelia, which created a fuzzy look to the eggs. When possible, an estimated percentage of eggs in the nest that were either white or fungused was noted. If shallow water precluded a detailed look at the eggs, the condition was noted as “unknown.” However, if a nest contained eggs, which were

Figure 4-7. The top photograph shows a largemouth bass nest where the fine silt has been cleared from the gravel substrate. The bottom photograph shows the glass bottom viewing tube used from the boat to observe the nests.

predominantly white or covered in fungus it was typically obvious even if a detailed look was not possible. Therefore most conditions noted as "unknown" were likely eggs in good condition.

Observations were compiled to describe the timing of largemouth bass spawning in the Index Reach of the Housatonic River. Observations were also used to describe nest densities and overall reproductive success.

4.4.2.2 Larval and YOY Sampling

During transect observations (through July 11, 2001) at the largemouth bass index sites, larval and fingerling largemouth bass were collected with a dip net (Figure 4-8). Approximately 20 early-stage juvenile fish, which were still in large broods could easily be captured in one swipe of the net. These fish were placed in a measuring tray (Figures 4-9 and 4-10); the smallest and largest fish were visually separated; total lengths were measured to the nearest millimeter (Figure 4-11); and the fish were returned to the river.

Qualitative visual estimates of the number of fish in each brood were limited to noting a range of 1) greater than 1000 fish, 2) greater than 100 fish, or 3) less than 100 fish (Figure 4-12). Following dispersal from the brood, largemouth bass young-of-year were generally captured individually with the dip net, and each fish was measured for total length. Since the larger fish were able to better avoid the net by swimming and diving, it is likely that measurements represent an underestimation of the largest-sized young-of-year fish in the population. In an effort to minimize the potential bias associated with non-random dip net collections of larger fish, fine-gauge minnow traps baited with canned tuna or sardines were also used. Ten minnow traps were distributed within the index sites during the period from June 18 through July 11. The traps were placed where young-of-year were observed (Figure 4-13). To prevent the traps from sinking into soft sediments, floats were attached to the traps so that they maintained a position just below the surface of the water. The traps were set overnight and soak times recorded.

Observations were analyzed to describe early life-stage growth rates of largemouth bass in the Index Reach of the Housatonic River. Calculated growth rates were compared to growth rates observed for largemouth bass populations in other northern systems.

Figure 4-8. Dip net used to collect young-of-year fish at largemouth bass index sites in the Housatonic River.

Figure 4-9. Measuring tray used for fingerling largemouth bass collected with a dip net from the Housatonic River.

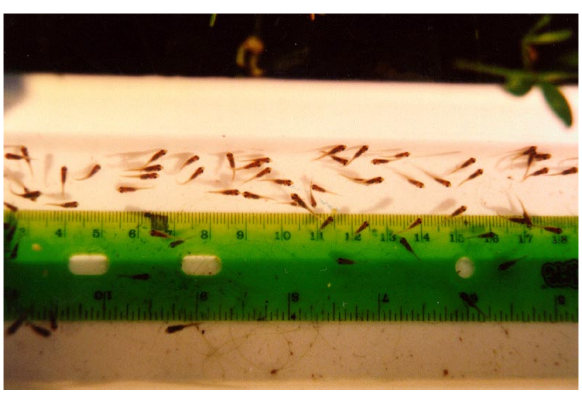


Figure 4-10. Fingerling largemouth bass in a measuring tray from a brood in the Housatonic River.

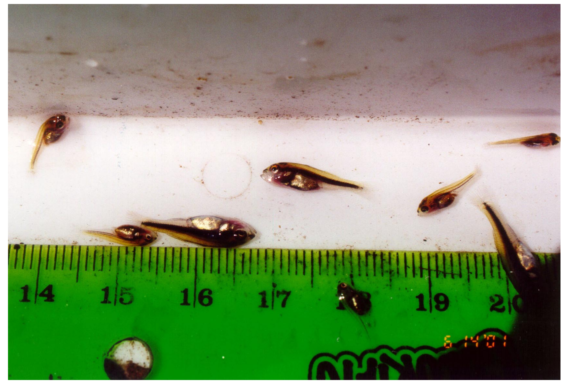


Figure 4-11. Largemouth bass ranging in size from 11 to 20 mm from a brood observed on June 13, 2001 in the Housatonic River.

Figure 4-12. A brood of largemouth bass is visible to the left of the lily pads.

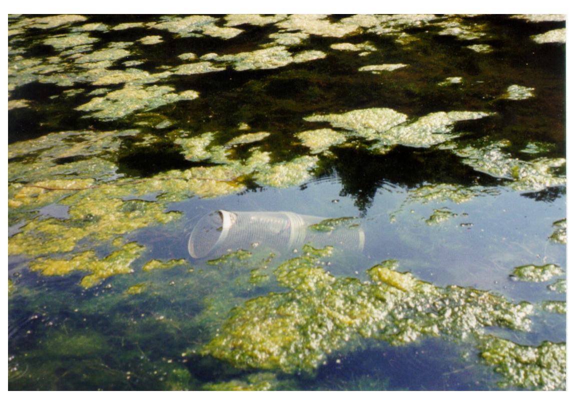


Figure 4-13. Minnow trap placed in shallow water in a backwater area of the Housatonic River.

4.5 FISH COMMUNITY SURVEYS

During the 2000 and 2001 electrofishing efforts to collect largemouth bass, other fish species stunned by the gear were collected, identified, and enumerated to assess the overall fish species composition in the Study Reach. Fish collected during the 2000 electrofishing efforts were identified and counted, but only spot measurements of lengths and weights were collected. During the October 2001 sampling, fish other than largemouth bass were measured to the nearest mm or grouped into species-specific size classes, and weights were collected from a subset of all fish larger than 200 mm. The fish community observed each year in the Housatonic River was analyzed to describe the overall species richness (number of species), trophic levels (food habits), and size classes (via length-frequency analysis) observed within each species. Size classes were not described for species such as minnows and shiners, which have short life spans. Four trophic categories were used to describe fish collected in the Housatonic River, including generalist (including omnivores), water column insectivore, benthic insectivore, and top carnivore (Halliwell et al. 1999; Whittier 1999).

4.6 ENVIRONMENTAL CONDITIONS MONITORING

In 2000, measurements of dissolved oxygen (DO) concentrations, pH, conductivity, and water temperature were collected using hand-held digital meters from the 13 locations examined during the site-specific habitat surveys. In addition, continuous water temperature recorders were installed at each of the 13 locations as discussed in the following subsection.

During the 2001 study, a more intensive effort was completed to collect measurements of five environmental conditions known to influence largemouth bass reproductive success. These conditions and the probable mechanism of influence included: 1) water temperature – influences timing of spawning, egg incubation success, and fry survival; 2) dissolved oxygen – influences egg incubation success, and larval and fry survival; 3) percent cloud cover – influences DO concentrations and therefore incubation success and larval and fry survival; and 4) flow regime – influences temperature and incubation. Methods used for data collection and acquisition are described below.

4.6.1 Water Temperature

Continuous water temperature recorders were used at 13 locations from May through September 2000 (Figure 4-14, Table 4-5). The recorders were deployed at the study sites between May 11

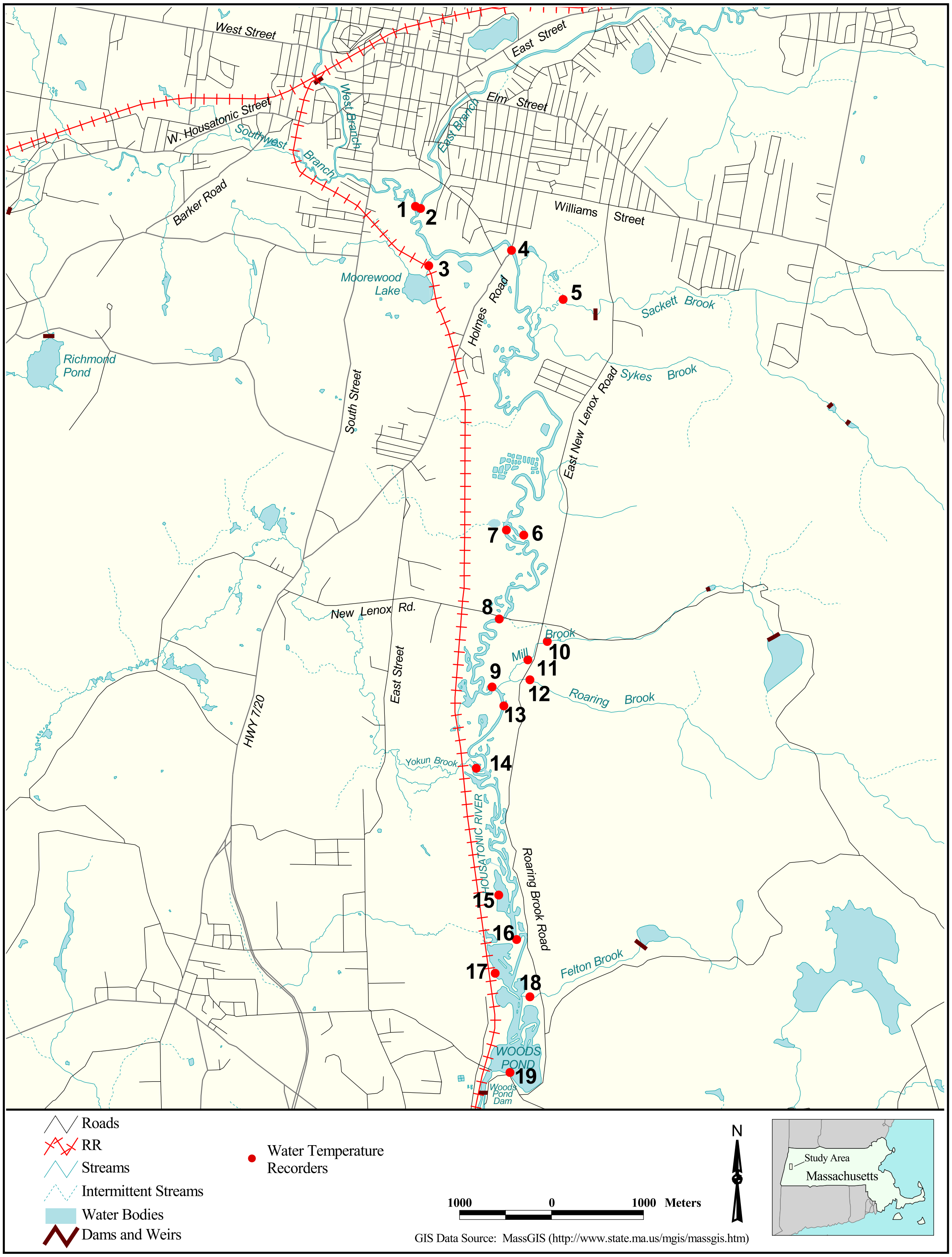


Figure 4-14. Map showing the location of continous water temperature recorders at the study sites in 2000 and within the Study Reach on the Housatonic River in 2001.

Table 4-5. Locations of continuous water temperature recorders on the Housatonic River in 2000 and 2001.

Site	**Year**	**Map Code**[1]
West Branch	2000, 2001	1
East Branch	2000, 2001	2
Moorewood Brook	2000	3
Housatonic River, Holmes Road	2000, 2001	4
Sackett Brook	2000	5
Housatonic River, Upper New Lenox Backwater	2000, 2001	6
Housatonic River, Upper New Lenox Main Channel	2000, 2001	7
Housatonic River, New Lenox Road	2001	8
Housatonic River, Upstream of Mill Brook	2001	9
Upper Mill Brook	2000	10
Lower Mill Brook	2000	11
Roaring Brook	2000	12
Housatonic River, Downstream of Mill Brook	2001	13
Housatonic River, Yokun Brook Outlet	2001	14
Housatonic River, OM8 Backwater	2001	15
Housatonic River, Downstream of OM8	2001	16
Housatonic River, Upper Woods Pond Backwater	2000	17
Felton Brook	2000	18
Housatonic River, Lower Woods Pond Backwater	2000, 2001	19

[1] = Map codes are located on Figure 4-14.

and 19, and were retrieved between September 25 and 27, 2000. The units (Onset Optic StowAway® Temp) were factory calibrated (± 0.1°C) and set to record water temperature at 33-minute intervals. The approximately five-inch-long recorders were secured in protective, weighted PVC sleeves, and each unit was anchored to permanent bankside structures (tree trunk or rock structure) with small diameter cable (10-20 feet long). The monitors were placed in the deepest water feasible, based on availability of bank-side anchor structures to nearest deep water. At deployment and retrieval, the water temperature, time, and date were recorded for each unit. One monitor installed on the mainstem Housatonic River upstream of the New Lenox Road (Site 7) site was lost, likely due to localized erosion, which dislodged the cable anchor.

The same style of water temperature recorders were installed at 12 locations during the 2001 growing season, from late March or mid-April to mid-October (Figure 4-14). The units were deployed and calibrated following the same protocol in 2000, except water temperatures were recorded at 36-minute intervals. One of the temperature monitors that was installed in the mainstem Housatonic River at the New Lenox Road (Site 8) was lost following its final retrieval on October 11, 2001, and therefore no data from this site were available for the period between July and October. Data retrieved from the other units were analyzed and graphed to show daily minimum, maximum, and average water temperatures at each location. Water temperatures from 2001 were also compared with water temperatures collected in 2000 during May through September within the Housatonic River and in several of the nearby tributaries.

4.6.2 Dissolved Oxygen

Nine continuous DO recorders (Stevens/Greenspan Model CS302) were deployed in three backwater areas (OM8, UWP, and UWP2) where largemouth bass nests and juvenile fish were observed (Figure 4-6). The recorders were deployed in June 2001 and maintained through mid-October. At each of the three sites, one unit was placed in the main channel just outside of the backwater area, and the other two units were placed within the backwater approximately 50 feet and 150 feet away from the shore. The probes were placed in water that was typically 3 feet deep either within the backwater or near the shore of the main channel. The buoyant probe ends were weighted so that they were approximately 2 feet under the water surface, and from 2 to 13 inches above the substrate. The recorders measured dissolved oxygen concentrations every 30 minutes in addition to measuring water temperature and pH. The Stevens/Greenspan DO probes were cleaned and calibrated to air-saturated DO values prior to each deployment. As a Quality Control (QC) check of probe consistency, probes were randomly reassigned to locations after they were pulled and the data downloaded. Occasionally the probes were cleaned *in situ* and replaced without downloading and recalibrating the units. The schedule of deployment, retrieval and *in situ* cleaning is shown in Appendix C.

An assessment was completed on the reliability of the Stevens/Greenspan units to measure DO concentrations over relatively long deployments in the river. The methods and results of this assessment are included in Appendix C. Based on these analyses, measurements of DO concentrations recorded within 24 hours of deployment and/or *in situ* cleaning were assumed to provide a conservative number of accurate readings. However, we also used graphical analyses of daily minimum, maximum, and average DO concentrations over time to illustrate relative differences among sites, even if some of the maximums were suppressed due to fouling.

4.6.3 Cloud Cover

Percent daily overcast conditions recorded at the Pittsfield Municipal Airport atmospheric station (National Climatic Data Center, WBAN #14763) were determined based on the number of daytime observations of overcast conditions compared to the total number of daytime observations. The average overcast conditions were compared graphically with the daily dissolved oxygen concentrations in the river and backwater sites. Possible correlations between these two parameters were investigated, including analyses of plotted changes in daily DO concentrations over the average 2-day percent cloud cover.

4.6.4 Flow

Daily discharge (flow) conditions were obtained from the U.S. Geological Survey (USGS) gaging stations on the mainstem Housatonic River near Great Barrington (#01197500) downstream of the study area. Although USGS data are made available on a daily basis, 2001 data are unverified and the USGS considers these data to be provisional.

5. RESULTS

This chapter presents the results of the two-year study of largemouth bass in the upper Housatonic River, organized in accordance with the five interrelated study elements as described in Chapter 4.

5.1 AQUATIC HABITAT ASSESSMENT

As discussed in Section 4.2, a detailed aquatic habitat assessment was conducted in 2000 for the mainstem Housatonic River and its associated backwaters, the three main branches to the upper Housatonic River, and the major tributaries. This assessment focused in particular on evaluating the suitability of the habitats for largemouth bass. The results of the aquatic habitat assessment are summarized in Table 5-1 and described in detail in Appendix G.

This assessment showed that, within the mainstem Housatonic River, suitable largemouth bass habitat is abundant in Woods Pond, in shallow backwater areas, and in the ponds and wetlands that are hydrologically connected to the river (Figure 5-1). The tributaries, however, do not have suitable habitat for largemouth bass except for the impounded areas at the mouths of Moorewood and Yokun brooks.

5.2 LARGEMOUTH BASS DISTRIBUTION, POPULATION STRUCTURE, AND REPRODUCTION

Characteristics of the largemouth bass population were examined in the Housatonic River Study Reach during 2000 and 2001. This section presents the results from surveys that documented largemouth bass distribution and population characteristics, young-of-year abundance and growth rates, and reproductive success and periodicity in sections of the Housatonic River.

5.2.1 Largemouth Bass Distribution

During June and late-July/August 2000, the distribution and characteristics of the largemouth bass population were assessed throughout the Study Reach of the Housatonic River and at the 13 specific study sites (Figure 4-4). The distribution of largemouth bass was consistent with our delineation of identified largemouth bass habitat. Largemouth bass were found throughout the mainstem habitats and in the study sites in the East and West branches of the Housatonic River (Appendix D, Table D-2). Largemouth bass were most abundant within these sites in shallow

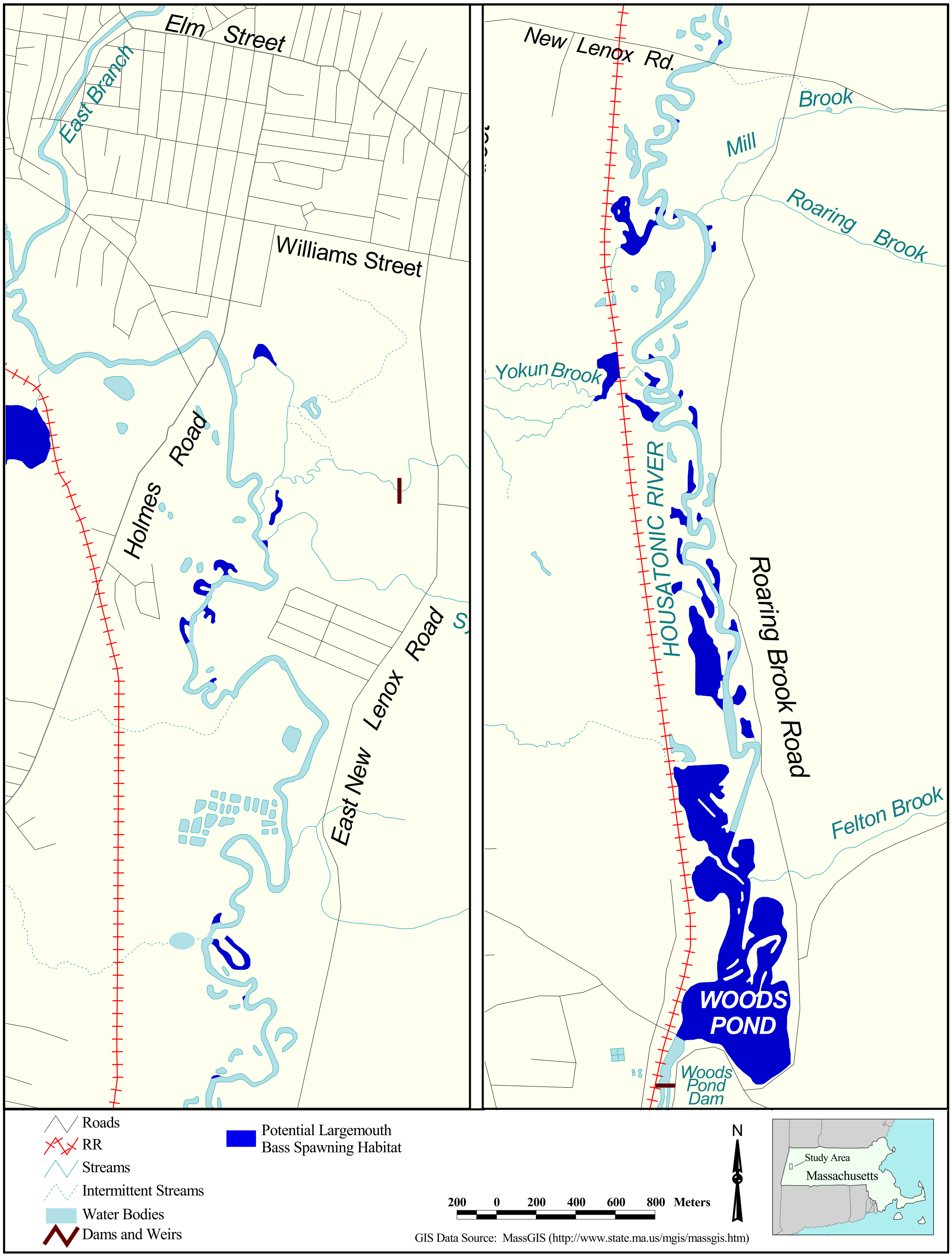


Figure 5-1. Habitat within the upper Housatonic River system that is suitable to support largemouth bass spawning.

Table 5-1. Landscape-scale aquatic habitat characteristics of the reaches surveyed on the Housatonic River system, 2000.

Reach	**Surveyed Length (ft)**	**Average Bankfull Width (ft)**	**% Gradient**	**Major Habitat Units**	**Substrate (Dom./Subdom.)**	**Aquatic Cover**
Housatonic River – upstream of Holmes Road	5,391 (~ 1 mile)	67	< 1	glide: 87% pool: 13%	sand/small gravel	undercut banks, deep water, small wood: 24%
Housatonic River – Holmes Road to New Lenox Road	26,876 (~ 5 miles)	75	< 1	predominantly glide	sand/small gravel	small wood, deep water: 30%
Housatonic River – New Lenox Road to Woods Pond	21,717 (~ 4 miles)	85	< 1	glide: 50% embayment: 50%	sand	aquatic vegetation, small wood, deep water: 30%
Housatonic River – Woods Pond	4,514	1,335	< 1	impounded: 100%	sand/small gravel	aquatic vegetation, deep water: 50%
East Branch, Housatonic River	10,229 (~ 2 miles)	50	< 1	glide: 88% riffle: 11%	sand/small gravel	vegetation, small wood: 5%
West Branch, Housatonic River – Mill St. to Southwest Branch	4,139	40	1	riffle: 63% glide: 32%	cobble/sand	small wood: 10-30%
West Branch, Housatonic River – Southwest Branch to East Branch	5,474 (~ 1 mile)	48	< 1	glide: 84% pool: 14%	sand/sm gravel	small wood: 10%
Southwest Branch, Housatonic River – Hungerford St. to Barker Road	15,079 (2.8 miles)	30	< 1	glide: 79% riffle: 10% debris complex: 8% pool: 3%	sand/sm gravel	small wood, deep water: 30%
Southwest Branch, Housatonic River – Barker Road to Clapp Park	1,481	34	< 1	glide: 94% riffle: 6%	sand	vegetation, deep water: 30%
Southwest Branch, Housatonic River – Clapp Park to West Branch	2,495	28	< 1	glide: 100%	sand/sm gravel	vegetation: 30%

Table 5-1. Landscape-scale aquatic habitat characteristics of the reaches surveyed on the Housatonic River system, 2000.

Reach	Surveyed Length (ft)	Average Bankfull Width (ft)	% Gradient	Major Habitat Units	Substrate (Dom./Subdom.)	Aquatic Cover
Moorewood Brook	505	10	< 1	glide: 70% pool: 30%	sand/small gravel	vegetation, small wood: 10%
Sackett Brook upstream of dam	1,700	29	1-2	riffle: 42% glide: 34% pool: 21%	large gravel/small gravel	small wood, rocks, vegetation: 5-10%
Sackett Brook downstream of dam	1,900	24	1	glide: 54% pool: 24% riffle: 15%	sand/small gravel	small wood, vegetation, undercut banks: 5-60%
Upper Mill Brook	1,445	19	1.5-6	riffle: 89% pool: 10%	large gravel/sand and boulder/cobble	wood, rock, vegetation: 20-40%
Lower Mill Brook	2,207	17	< 1	riffle: 27% pool: 23% glide: 17%	small gravel	undercut banks: 30%
Roaring Brook	1,924	23	1-4	riffle: 79% chute: 16% pool/glide: 5%	boulder	vegetation, rocks: 50-60%
Yokun Brook	1,920	26	1.5	riffle: 75% pool: 22%	cobble/sand	rocks, deep water: 10%
Felton Brook	694	14	< 1-4	riffle: 65% pool: 27% glide: 8%	cobble/small gravel and sand/small gravel	small wood, vegetation: 50-80%

backwater areas and near or in accumulations of downed wood. Largemouth bass were only collected in two tributary sites: Moorewood Brook, and in Lower Mill Brook where one largemouth bass was observed. No largemouth bass were observed in the Upper Mill Brook, Sackett Brook, Felton Brook or Roaring Brook study sites. The largemouth bass collected in Moorewood Brook were likely associated with Moorewood Pond, just upstream of the sampling location. The Lower Mill Brook site, although not identified as largemouth bass habitat, is just upstream of the floodplain wetland that Mill Brook flows through near its confluence with the mainstem Housatonic River.

Additional investigations on the distribution of largemouth bass were conducted on Felton Brook using a fyke net on 11 June 2000, and on the Felton Brook reservoir using minnow traps and beach seine on 11 June and 2 July 2000. No largemouth bass were captured in Felton Brook or the reservoir, although other species of fish were collected.

5.2.2 Largemouth Bass Population Structure

The data on fish length and weight were used to evaluate various population characteristics that are useful in determining population health and structure. These included an analysis of size and age class structure, proportional stock density, and relative weight.

5.2.2.1 Size Class Structure

Length-frequency histograms were constructed for both the 2000 and 2001 largemouth bass data. Length-frequency distributions can help to define population dynamics and in identifying problem conditions, such as year-class failures/low recruitment, differential age mortality and slow growth (Anderson and Neumann 1996). The distributions for 2000 and 2001 are displayed together in Figure 5-2. During the June and late-July/August 2000 electrofishing events, 133 largemouth bass were collected from the Study Reach and measured for total length (Appendix D, Table D-2). The 133 fish in 2000 included 10 largemouth bass collected just upstream of the Study Reach from the East Branch and West Branch study sites; however this figure does not include the three fish collected from Moorewood and Mill brooks. Of the 133 largemouth bass collected in 2000, 128 were 50 mm total length or greater (Figure 5-2). During the October 2001 electrofishing event, 239 largemouth bass greater than 50 mm total length were collected from within the Study Reach (Figure 5-2).

The 2000 length-frequency histogram depicts a tri-modal pattern that suggests specific size ranges for age 1+ (about 120-180 mm), age 2+ (about 180-240 mm), and age 4+ and older (> 260 mm) fish (Figure 5-2). The histogram for the fish collected in summer 2000 indicates that the Housatonic River largemouth bass population was characterized by a large proportion of larger, and presumably older, size classes of fish, with nearly 70% of the sampled population consisting of bass 300 mm or larger.

The pattern was different in 2001, when fish were collected at the end of the growing season. In 2001, the largest proportion of fish collected were young-of-year (< 100 mm), which represented over 75% of the catch. The fall 2001 electrofishing effort thus indicated a largemouth bass population that was at that time dominated by young-of-year fish. In 2001, as in 2000, a low proportion of fish were collected in the intermediate size classes from 180 to 280mm.

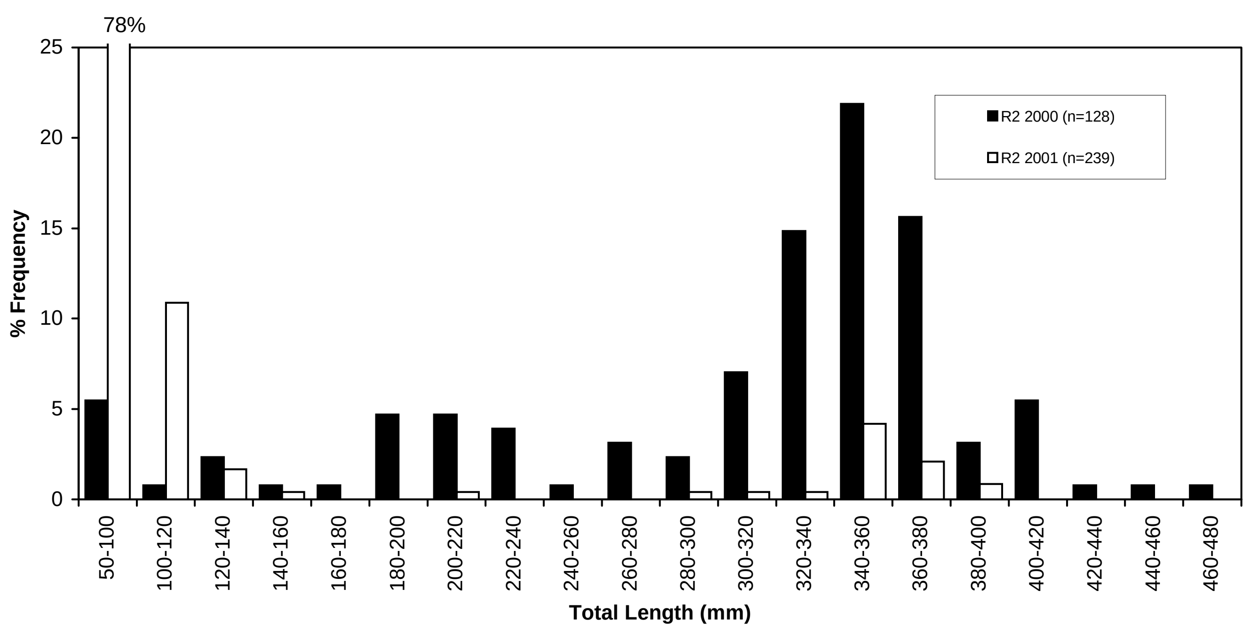


Figure 5-2. Length-frequency histogram of largemouth bass collected in the Housatonic River during June and late-July/August 2000 and October 2001 by R2.

5.2.2.2 Age Structure

An age versus total length analysis was completed using scale and otoliths from four largemouth bass collections sampled from the Housatonic River in: 1) 1998 and 1999 by the USFWS (n=69); 2) 2000 by R2 (n=83); 3) 2000 by BBL (n=24); and 4) 2001 by R2 (n=54) (Figure 5-3). The USFWS determined the age of 69 largemouth bass from otolith analyses. We used otoliths to determine the age of 24 fish collected by BBL in the Housatonic River in 2000. We used scales to age 83 fish collected by R2 in 2000 and 54 largemouth bass collected by R2 in 2001.

The results of the age analyses indicate that largemouth bass in the Housatonic River grow slower at older age classes, as is common for many species of fish. As a result, there is an overlap of sizes among the older year classes (Figure 5-3). For example, fish between 300 and 400 mm ranged in age from 5 to 7 years based on otoliths from the BBL data set, and between 4 and 13 years in the USFWS data set (Figure 5-3). Even age 3 fish ranged in size from 190 to 296 mm, based on all fish that were aged using either otoliths or scales.

Scale analysis was useful for aging largemouth bass younger than 6 years, but because of reduced growth at older ages, the ability to accurately distinguish annuli on older scales is diminished. Older ages are able to be determined via otoliths, but that requires sacrificing the fish. Based on the four data sets, the oldest largemouth bass collected from the Housatonic River was 14 years (aged from otoliths) as reported in the USFWS Housatonic River study (Smithwood 1999). The oldest largemouth bass collected in 2001 from the Housatonic River was estimated to be 8 years old (based on scales) (Appendix D, Table D-5). The oldest fish collected in 2000 from the Housatonic River was estimated to be 10 years (based on scales) (Appendix D, Table D-3) and 11 years (based on otoliths) from the BBL data set.

A comparison of size and age-class structure based on scale analysis for the Housatonic River population sampled by R2 in 2000 and 2001 was not conducted due to difficulties in accurately aging older fish. However, a comparison is shown between the data sets based on otoliths from the USFWS (Smithwood 1999) and the BBL 2000 fish collections (Figure 5-4). In the fall of 1998 and the spring of 1999, 69 largemouth bass were collected by the USFWS for toxicological analysis (USEPA) and a length-age study (Smithwood 1999). Collection methods were unspecified in the report but conversations with the USFWS revealed the electrofishing effort was focused on collecting larger size classes of largemouth bass (personal communication, Smithwood 2002). The study established “a-priori” sample sizes of different size classes of fish to collect, rather than sampling the population overall (personal communication, McKeon 2002).

Therefore, the USFWS data set is not necessarily representative of the true age-class structure of the population. The same is true of the BBL data set, since the largemouth bass collected by BBL in 2000 were all reproductively mature fish. Therefore, the fish collected by BBL and USFWS can not be used to describe the structure of the overall population. Nevertheless, because all of these fish were aged from otoliths, we plotted both data sets in Figure 5-4 to provide some basis for evaluating the size-class structure of the largemouth bass population in relation to its age-class structure.

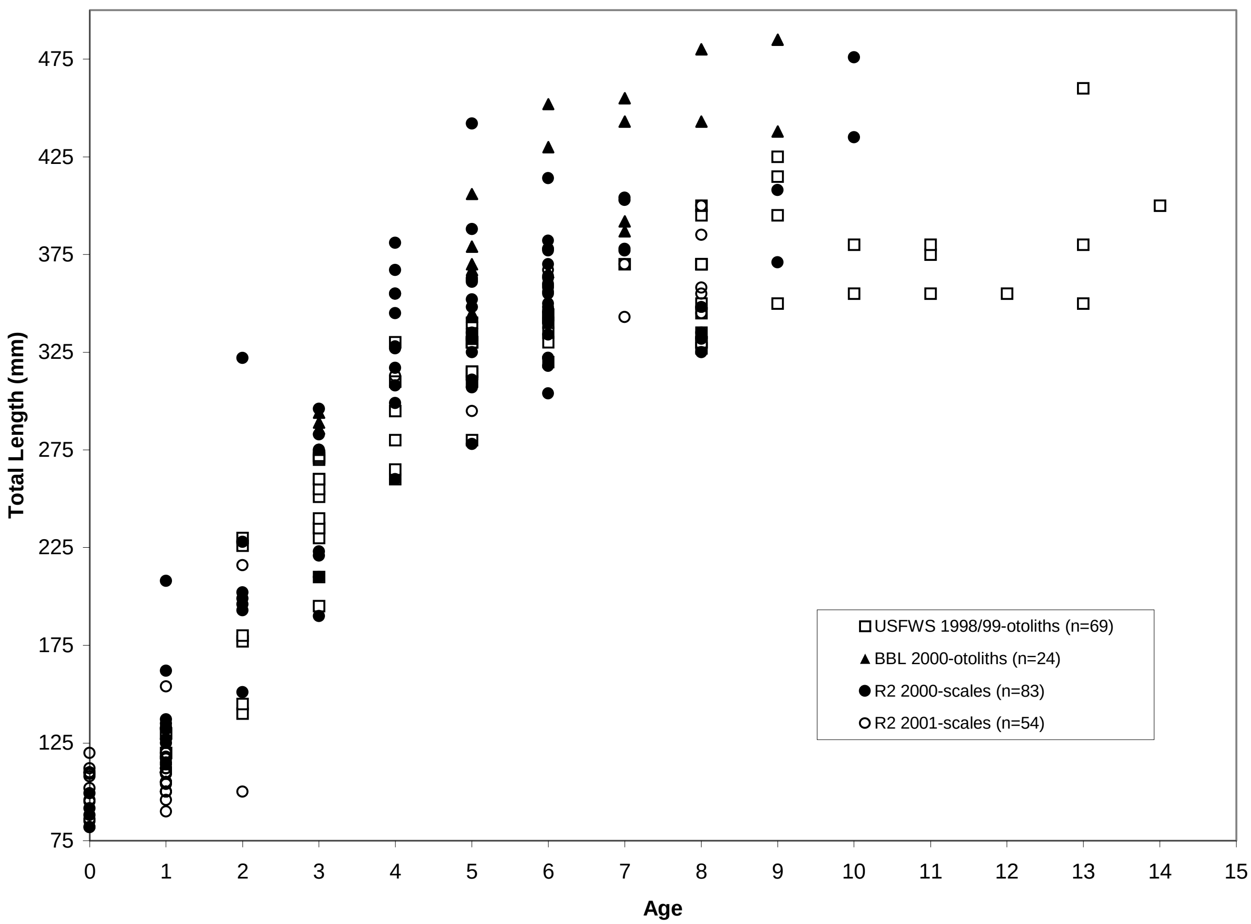
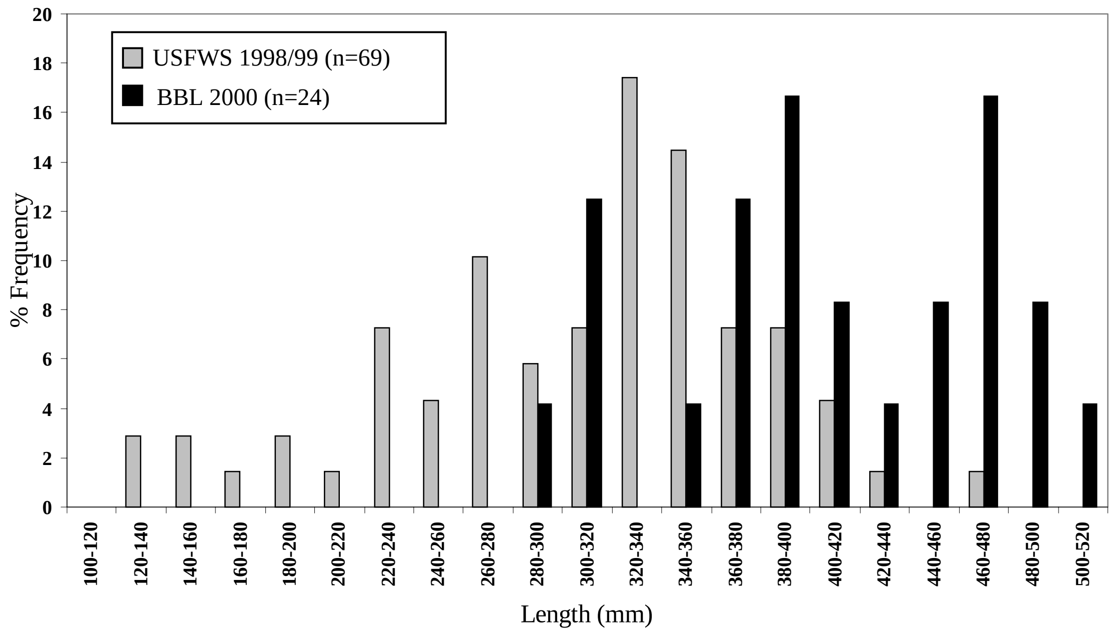


Figure 5-3. Relationship between total length and number of annuli (scales and otoliths) from largemouth bass collected in the Housatonic River in 1998/1999, 2000, and 2001.



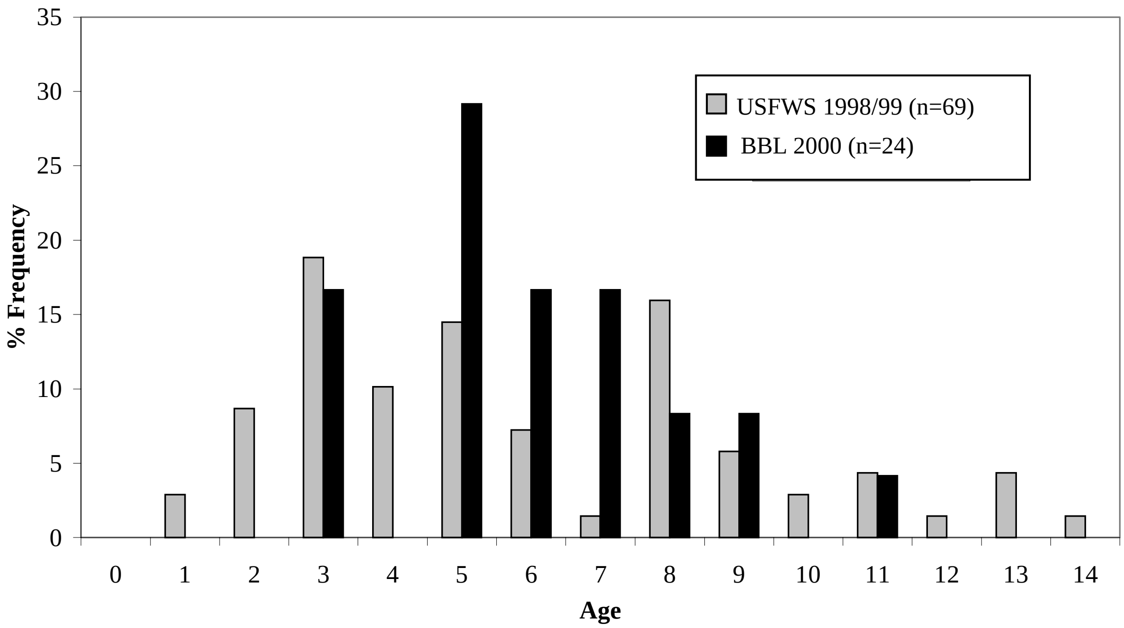


Figure 5-4. Length-frequency (top figure) and age class-frequency (bottom figure) of largemouth bass in the Housatonic River as defined from USFWS data set (Smithwood 1999) and fish collected by BBL in 2000. Age determinations for both data sets were made via otoliths.

The top graph in Figure 5-4 shows the sample size structure presented as a length-frequency histogram; the bottom graph shows the same fish presented as an age-frequency histogram. Of the 69 largemouth bass collected by the USFWS, 60.9% were at least 300 mm total length. The age-class structure suggests the sampled population was primarily composed of individuals ranging from 3 to 8 years old; relatively few old fish (> 9 year old) were collected, and the frequency of fish in the 100-120 mm size class (≤ 1 year old) is not shown, since Smithwood (1999) provided only composite length and weight data for fish < 120 mm. The largemouth bass collected in 2000 by BBL (n=24) were all larger than 280 mm total length (top graph in Figure 5-4) with these fish ranging in age from 3 to 11 years (bottom graph Figure 5-4).

5.2.2.3 Proportional Stock Density

The calculated PSD of the largemouth bass population (≥ 200 mm) sampled in October 2001 was 91. This relatively high value reflects the overall low number of fish collected that were in the 200 to 300 mm size range (Figure 5-2). The 2000 data yielded a PSD of 82, which, although not as high as the PSD calculated for 2001, is still reflective of an adult population dominated by large-sized fish.

5.2.2.4 Relative Weight

The length-weight relationship for largemouth bass larger than 100 mm collected in 2001 was similar to that for fish collected in 2000 (Figure 5-5). Analysis of individual largemouth bass (> 150 mm) plotted as relative weight versus total length, indicates that the majority of fish captured during 2000 (69%) and 2001 (91%) had W_r values greater than the 105, which is the upper value of the acceptable range (95 to 105) proposed by Anderson (1980, as cited in Blackwell et al. 2000) for managed largemouth bass populations (Figure 5-6). As would be expected, the mean W_r values for Housatonic River largemouth bass population were high in both years. The mean W_r was 109 in 2000 and 117 in 2001. Exceedance of the standard mean W_r of 100 proposed by Anderson and Neumann (1996) and the acceptable range of mean W_r values (95 to 105) suggests that the Housatonic River largemouth bass are “robust” and in good condition.

5.2.2.5 Young-of-Year Catch-Per-Unit-Effort

Catch-per-unit-effort estimates of young-of-year largemouth bass were computed for seven main channel, six transition, and seven backwater habitats within the Study Reach of the Housatonic River during the October 2001 surveys (Table 5-2 and Figure 4-5). CPUE estimates were based

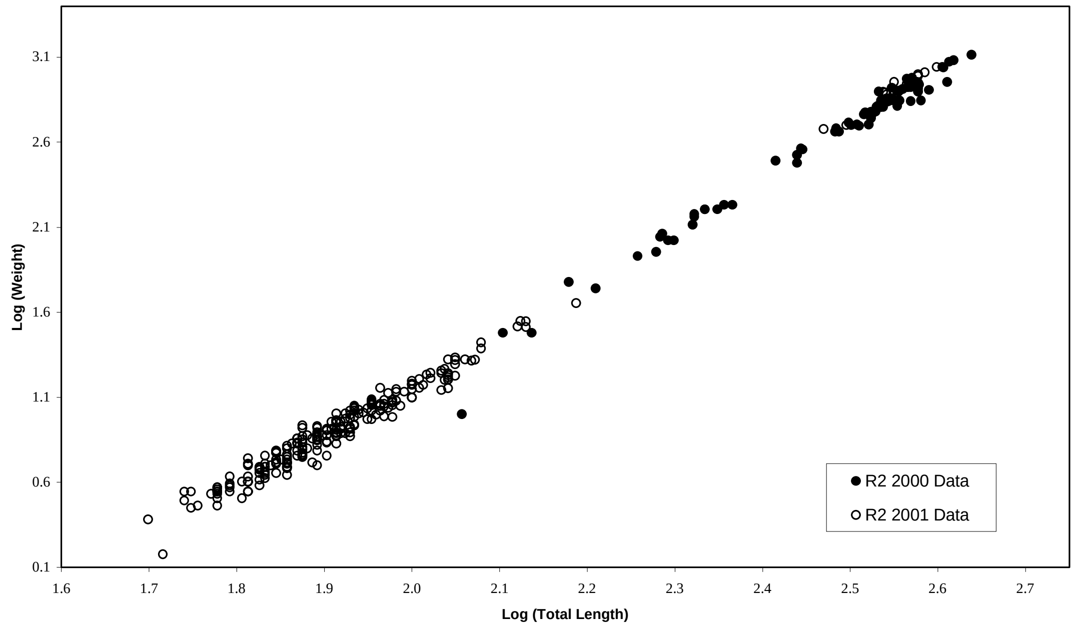


Figure 5-5. Scatter plot of log weight regressed on log total length for largemouth bass collected in 2000 and 2001within the Study Reach of the Housatonic River.

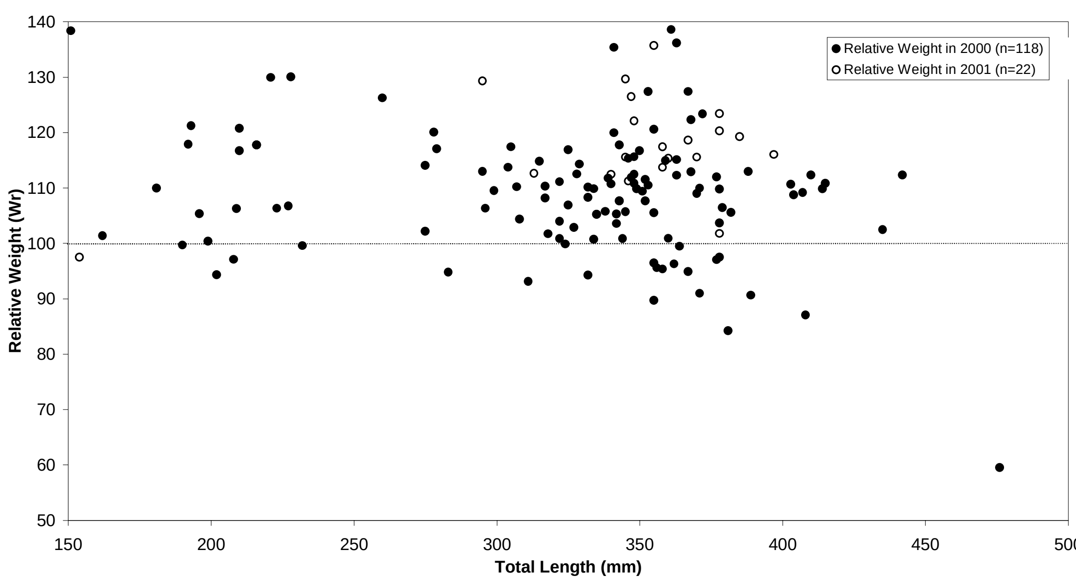


Figure 5-6. Relationship between total length (mm) and relative weight (W_r) for largemouth bass (> 150 mm) collected by electrofishing in the Housatonic River in October 2001 and June, July, and August 2000. Dashed reference line is the W_r standard for largemouth bass.

Table 5-2. Catch-per-unit-effort (CPUE) of young-of-year largemouth bass (< 100 mm) in the fall of 2000 and 2001 in the Housatonic River.

		October 2001 Electrofishing				**September 2000 Electrofishing**			
			Transect Time				**Transect Time**		
Habitat Type	**Site**	**Number of YOY**	**seconds**	**minutes**	**CPUE fish/min**	**Number of YOY**	**seconds**	**minutes**	**CPUE fish/min**
Main Channel	UWPMC2	NS	NS	NS	NS	0	501	8.4	0.00
Main Channel	HR2TR2	0	1,647	27.5	0.00	0	576	9.6	0.00
Main Channel	HR2TR1	1	1,148	19.1	0.05	1	997	16.6	0.06
Main Channel	HR2TR3	3	1,648	27.5	0.11	0	607	10.1	0.00
Main Channel	YBMC1	2	884	14.7	0.14	NS	NS	NS	NS
Main Channel	UNLMC	3	1,131	18.9	0.16	NS	NS	NS	NS
Main Channel	UWPMC1	7	1,317	22.0	0.32	1	579	9.7	0.10
Main Channel	LWPTR3	7	1,021	17.0	0.41	NS	NS	NS	NS
Transition	NLBWTR1	NS	NS	NS	NS	3	600	10.0	0.30
Transition	NLBWTR2	NS	NS	NS	NS	3	329	5.5	0.55
Transition	LWPMC2	7	874	14.6	0.48	NS	NS	NS	NS
Transition	YBSC1	6	739	12.3	0.49	11	449	7.5	1.47
Transition	LWP-Island	9	956	15.9	0.56	1	353	5.9	0.17
Transition	UWP3TR2	18	1,600	26.7	0.68	1	669	11.2	0.09
Transition	LWPMC1	15	1,179	19.7	0.76	NS	NS	NS	NS
Transition	OM8MC	15	925	15.4	0.97	NS	NS	NS	NS
Backwater	LWPBW1	3	1,067	17.8	0.17	8	1,271	21.2	0.38
Backwater	LWPBW3	7	1,065	17.8	0.39	5	510	8.5	0.59
Backwater	YBBW1	3	396	6.6	0.45	NS	NS	NS	NS
Backwater	UWPI	7	623	10.4	0.67	NS	NS	NS	NS
Backwater	UWPSW	19	721	12.0	1.58	9	623	10.4	0.87
Backwater	NLBW3TR1	25	876	14.6	1.71	2	923	15.4	0.13
Backwater	NLBW3TR2	24	460	7.7	3.13	3	727	12.1	0.25
Main Channel Subtotal		23	8,796	146.6	0.16	2	3,260	54.3	0.04
Transition Subtotal		70	6,273	104.6	0.67	19	2,400	40.0	0.48
Backwater Subtotal		88	5,208	86.8	1.01	27	4,054	67.6	0.40
Total		181	20,277	338.0	0.54	48	9,714	161.9	0.30

NS = Not sampled

on largemouth bass less than 100 mm total length. As discussed in Section 5.2.4.2, scale analysis indicated all largemouth bass less than 90 mm were young-of-year and approximately 32% of fish between 90 and 110 mm were young-of-year. Therefore, a length of 100 mm was selected as a reasonable approximation to represent young-of-year largemouth bass. Effort varied by transect and ranged from 6.6 minutes (min) at YBBW1 (backwater) to 27.5 min at HR2TR2 (main channel). Total effort applied per main channel, transition, and backwater areas was 146.6, 104.6, and 86.8 min, respectively. The numbers of young-of-year bass collected ranged from 0 fish at HR2TR2 (main channel) to 25 fish at NLBW3TR1 (backwater). The numbers of young-of-year bass collected by habitat type were 23 fish in main channel habitats, 70 fish in transition habitats, and 88 fish in backwater habitats.

Overall, CPUE of young-of-year largemouth bass in backwater habitats was greater than 6 times the CPUE in main channel habitats. In transition habitats, the average CPUE was over 4 times the CPUE in main channel habitats. CPUE estimates within the main channel habitat types ranged from 0 fish/min at HR2TR2 to 0.41 fish/min at LWPTR3. For the transition areas, CPUE estimates ranged from 0.48 fish/min (LWPMC2) to 0.97 fish/min (OM8MC), and for backwater areas from 0.17 fish/min (LWPBW1) to 3.13 (NLBW3TR2). Young-of-year largemouth bass were especially abundant in three backwater areas (UWPSW, NLBW3TR1, NLBW3TR2), where the total number collected (n=68) represented 38% of all fish captured. CPUEs averaged for each habitat type indicated that young-of-year bass were most commonly found within backwater areas (CPUE = 1.01 fish/min), followed by transition habitats (CPUE = 0.67 fish/min). Comparatively few fish were collected in the main channel areas (CPUE = 0.16 fish/min). Overall, CPUEs in the Housatonic River were significantly more abundant ($p< 0.05$; ANOVA) in backwater and transition areas than in main channel habitats at the end of the growing season (Table 5-2).

Average young-of-year largemouth bass CPUEs in the Housatonic River for 2000 by habitat type were significantly lower than in 2001 (Table 5-2). Habitat-based CPUEs for main channel, transition, and backwater areas were 0.04, 0.48, and 0.40 fish/min, respectively. Thus, CPUEs in 2001 were 4 times higher in main channel habitats, 1.4 times higher in transition habitats, and 2.5 times higher in backwater habitats than in 2000. The highest CPUEs in 2000 occurred at YBSC1 with 1.47 fish/min (transition habitat) and UWPSW with 0.87 fish/min (backwater habitat). The average CPUEs across all sampled habitats in the Housatonic River were 1.8 times higher in 2001 (0.54 fish/min) compared to 2000 (0.30 fish/min).

5.2.3 Largemouth Bass Reproduction

Studies focused on evaluating largemouth bass reproduction were initiated in 2000, with a more detailed and comprehensive study completed in 2001.

5.2.3.1 Year 2000 Spawning and Larval Fish Surveys

The reproductive studies completed in 2000 consisted of largely opportunistic observations made of nesting and spawning behavior of largemouth bass at selected locations within the Study Reach, coupled with "spot" sampling of larval fish using a variety of sampling techniques. The focus of the 2000 studies was to document the timing (periodicity) and duration of spawning and to identify locations for more intensive study in 2001.

From May 7 through July 2, 2000, numerous adult largemouth bass were observed hovering over cleared-out nests along various survey sites on the Housatonic River. A single observation of largemouth bass spawning activity was made on May 11, 2000 at UNLBW (Figure 4-1), and on two occasions (May 16 and June 11, 2000) nests with eggs were observed within the Study Reach. Larval and young-of-year largemouth bass were observed at several locations throughout the Study Reach from July 1 through August 1, 2000. Efforts to capture these larval and young-of-year bass included deployment of modified minnow traps suitable for capturing small fish, and the use of dip-nets. The dip-net sampling effort captured several largemouth bass ranging in size from 7 to 30 mm, while the baited minnow traps captured only non-target species. Young-of-year largemouth bass were also collected from the Study Reach using a beach seine. In addition, an underwater camera and digital camcorder were used to record a brood of 7 to 15 mm long larval bass within the Study Reach.

5.2.3.2 Year 2001 Spawning and Larval Fish Surveys

Surveys of index sites for largemouth bass nesting activities were initiated on May 10 and continued through July 3, 2001. Photos of each index site are provided in Appendix F (Figures F-1 through F-16). The density of active largemouth bass nests found on each day of observation is listed in Table 5-3. An active nest with an adult and eggs was found on the first survey date, May 10, at index site OM2. Active nests were found at five other index sites (OM8W, UWP2, UWP3SW, UWP4E, and UWPIE) during the initial seven days of observations (Table 5-3), and active nests with eggs were found in four (OM2, UWP2, UWP3SW, and UWP4E) of these six sites on the first survey dates.

Table 5-3. The density (number of nests/100 m) of active largemouth bass nests at Housatonic River index sites in 2001 are calculated for each survey date at each index site and across all sites on each survey date.

	Nest Density per 100 Meter by Index Site															Average
Date	**NLBW3E**	**NLBW3N**	**NLBW3W**	**OM2**	**OM7**	**OM8W**	**OM9**	**UWP2**	**UWP3E**	**UWP3SW**	**UWP4**	**UWP5**	**UWPIE**	**UWPIW**	**UWPW**	**Density**
5/10/01				1.08												1.08
5/11/01				1.08				1.33		0.74	0.66					0.95
5/14/01									0.00	1.11						0.56
5/15/01								0.00					0.70		0.00	0.23
5/16/01	0.00	0.00	0.00	1.08	0.00	0.48	0.00			0.37						0.24
5/21/01								0.89	2.40	0.37	0.33		2.80	0.67	1.24	1.24
5/22/01	0.00	0.87	1.37													0.75
5/23/01						0.48	0.00									0.24
5/24/01								0.89	0.00	0.37	0.98	0.47				0.54
5/29/01								0.44					0.70			0.57
5/30/01	0.00	0.00	0.00	1.08		0.48										0.31
5/31/01					0.96		1.22	0.44		0.37	0.00	0.47	0.70	0.00	0.00	0.46
6/1/01	0.75	1.74	0.00	0.00		0.96										0.69
6/6/01	0.00	0.00	0.00					0.00								0.00
6/7/01				2.15	2.88	0.00	0.00						0.00	0.00	0.00	0.72
6/8/01	0.00	0.87	1.37						0.00	0.37	0.00	1.87				0.64
6/11/01				0.00	0.96	0.00										0.32
6/12/01	2.99	1.74	0.00		0.00								0.70	0.67	0.00	0.87
6/13/01				0.00		0.48		0.44				0.00				0.23
6/14/01	1.49	0.87	0.00		0.00		0.00						0.70	0.67		0.53
6/15/01						0.00		0.44							0.62	0.36
6/18/01								0.44	0.00	0.37	0.00	0.00				0.16
6/19/01				0.00	0.00											0.00
6/20/01	0.00	0.00	0.00				0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00
6/22/01												0.00	0.00	0.00		0.00
6/25/01	0.00	0.00	0.00	0.00		0.00		0.00				0.00				0.00
6/26/01							0.00									0.00
6/27/01	0.00	0.00	0.00	0.00												0.00
7/3/01								0.00					0.00	0.00		0.00

Active nests were found over a 39-day period, beginning with index site OM2 on May 10 and ending with site UWP2 on June 18 (Figure 5-7). No nests were observed on June 6 due to a rainstorm on the 3rd that resulted in increased water levels and decreased visibility. Adult largemouth bass were observed in close proximity to nests in all index sites during the majority of the surveys.

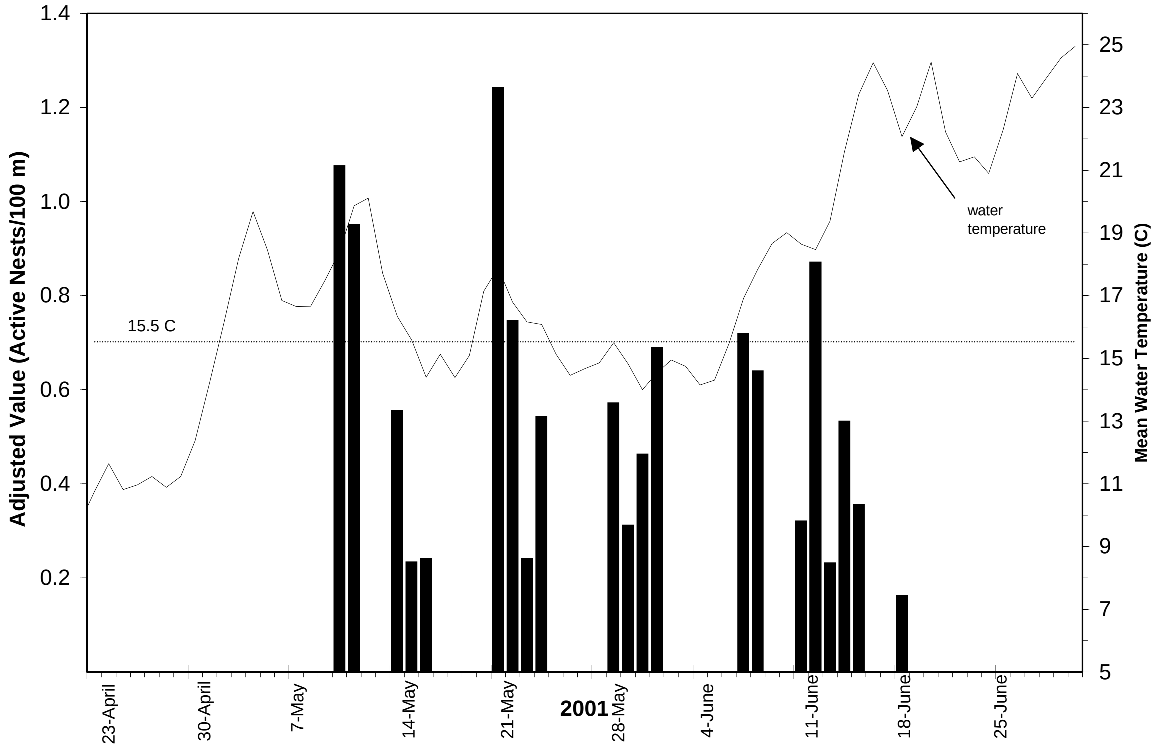


Figure 5-7. Average density of largemouth bass nests across all index sites in the Housatonic River, Massachusetts, May – June 2001. The black bars represent the average density of active largemouth bass nests per 100 meters across all of the index sites in the Housatonic River during May and June 2001. The mean daily water temperature recorded in Woods Pond is also shown. The horizontal line at 15.5°C is the threshold temperature for largemouth bass spawning. Surveys were also conducted on June 6, 19, 20, 22, 25-27, and July 3, but no nests were found.

Active largemouth bass nests were found in water with an average depth of 17 inches, although water depths ranged from 3 to 27 inches over observed nests. Most nests were located within 13 feet from the shoreline, and they ranged from 0 to 40 feet away from shore. The size of each nest ranged from 1.2 to 15.3 square feet and the average nest size was 6.7 square feet. The majority of observed nests were shallow pits where the mud had been cleared away to expose the roots of aquatic vegetation, such as arrow arum (*Peltandra* sp.) or yellow water lily (*Nuphar* sp.). The fertilized eggs were often found adhered to exposed roots in the nest pit. Some nests were primarily mud, and in these nests the eggs would typically be adhered to small sticks on the bottom of the nest.

The peak average density of largemouth bass nests across all sites observed on one day was 1.24 nests per 100 meters (Table 5-3). This density was observed on May 21 when mean water temperature was 17.9°C after rapidly rising above 15.5°C for the second time that spring. Although active nests were found throughout the spawning period, the other two highest densities (1.08 on May 10 and 0.95 on May 12) also were observed following rapid water temperature increases from below the published 15.5°C threshold for spawning activities (Figure 5-7).

We identified 77 individual largemouth bass nests within the 15 index sites during the observations conducted between May 10 and June 18 (Table 5-4). Only 20 of these nests were located a second time, and of these, 13 were active on more than one date. Nests were difficult to relocate because of dense and continuously growing vegetation and decreasing water levels, which precluded boat access in some cases. Because so few nests were relocated a second time, we were unable to assess the success of individual nests. In total, considering nests found more than once, we tallied 94 observations of active largemouth bass nests (i.e., nests guarded by an adult bass or containing eggs, sacfry, or swim-up larvae) (Table 5-4).

Of the 94 observations of active nests, 51 observations revealed nests with eggs. In the remaining nests (without eggs), either 1) spawning had not yet occurred, 2) spawning had occurred earlier and the nest contained sacfry or swim-up larvae, 3) spawning had occurred earlier and the offspring already moved off of the nest, or 4) spawning had occurred but failed and eggs had been consumed by predators. Of the 51 observations of nests with eggs, 18 had fungus on some or all of the eggs. Seven additional observations were made of nests with eggs that did not have any fungus, but in which at least 10% of the eggs in the nest were white. Because the fungus, *Saprolegnia*, initially colonizes dead eggs, the presence of at least 10% white eggs might indicate a nest that will subsequently be consumed by fungus. In total, 51% (n=26) of observed nests with eggs contained fungused eggs or eggs in which 10% or more were white (n=26). Nests with eggs were observed in 13 of the 15 index sites and incidences of fungus or 10% or more white eggs were observed from all but one of these sites. Figures 5-8 and 5-9 show the incidence of fungus on nests in relation to water

Table 5-4. Largemouth bass nest observations by index site and date in the Housatonic River, Massachusetts in 2001. The locations of each index site are shown on Figure 4-6.

Index Site	Nest No.	Site/Date	Adult	Eggs	Egg Condition	Sacfry	Swim-up Larvae	Active Nest
NLBW3E	1	6/1/01	No	Yes	fungus-100%	No	No	Yes
	2	6/12/01	Yes	Yes	white-75%	No	No	Yes
		6/14/01	No	Yes	fungus-100%	No	No	Yes
	3	6/12/01	Yes	Yes	fungus-100%	No	No	Yes
		6/14/01	No	No	NA	No	No	No
	4	6/12/01	Yes	No	NA	No	No	Yes
	5	6/12/01	Yes	Yes	fungus-100%	Yes	No	Yes
	6	6/14/01	Yes	Yes	unknown	Yes	No	Yes
NLBW3N	7	5/22/01	Yes	Yes	unknown	No	No	Yes
	8	6/1/01	No	Yes	good	No	No	Yes
	9	6/1/01	No	Yes	good	No	No	Yes
	10	6/8/01	Yes	Yes	good	No	No	Yes
		6/12/01	No	Yes	fungus-100%	No	No	Yes
	11	6/8/01	Yes	Yes	good	No	No	Yes
	12	6/12/01	Yes	No	NA	Yes	No	Yes
		6/14/01	No	Yes	good	No	No	Yes
NLBW3W	13	5/22/01	No	Yes	fungus-50%	No	No	Yes
		5/30/01	No	No	NA	No	No	No
	14	5/22/01	Yes	Yes	unknown	No	No	Yes
	15	6/8/01	Yes	No	NA	No	No	Yes
	16	6/8/01	Yes	No	NA	No	No	Yes
OM2	17	5/10/01	Yes	Yes	fungus-10%	No	No	Yes
		5/11/01	No	Yes	fungus-75%	No	No	Yes
		5/16/01	Yes	No	NA	No	No	Yes
	18	5/30/01	Yes	No	NA	No	No	Yes
	19	6/7/01	Yes	No	NA	No	Yes	Yes
	20	6/7/01	Yes	No	NA	Yes	No	Yes
OM7	21	5/31/01	Yes	No	NA	No	Yes	Yes
	22	6/7/01	Yes	No	NA	Yes	No	Yes
		6/11/01	No	No	NA	No	No	No
	23	6/7/01	Yes	Yes	good	No	No	Yes
		6/11/01	No	Yes	fungus-75%	No	No	Yes
	24	6/7/01	Yes	Yes	good	No	Yes	Yes
OM8W	25	5/16/01	Yes	No	NA	No	No	Yes
	26	5/23/01	Yes	No	NA	No	No	Yes
		5/30/01	No	No	NA	No	Yes	Yes
		6/1/01	No	No	NA	No	Yes	Yes

Table 5-4. Largemouth bass nest observations by index site and date in the Housatonic River, Massachusetts in 2001. The locations of each index site are shown on Figure 4-6.

Index Site	Nest No.	Site/Date	Adult	Eggs	Egg Condition	Sacfry	Swim-up Larvae	Active Nest
	27	6/1/01	No	No	NA	Yes	No	Yes
	28	6/13/01	Yes	No	NA	No	No	Yes
OM9	29	5/31/01	Yes	No	NA	No	No	Yes
	30	5/31/01	Yes	Yes	white-< 5%	No	No	Yes
UWP2	31	5/11/01	Yes	Yes	white-< 5%	No	No	Yes
	32	5/11/01	Yes	No	NA	No	No	Yes
	33	5/11/01	No	Yes	unknown	No	No	Yes
	34	5/21/01	Yes	No	NA	No	Yes	Yes
		5/29/01	No	Yes	good	No	No	Yes
	35	5/21/01	Yes	Yes	fungus-50%	No	No	Yes
		5/24/01	No	Yes	white-25% fungus-25%	No	No	Yes
	36	5/24/01	Yes	No	NA	No	No	Yes
	37	5/31/01	No	Yes	fungus-100%	No	No	Yes
	38	6/13/01	Yes	No	NA	Yes	No	Yes
	39	6/15/01	Yes	No	NA	Yes	No	Yes
		6/18/01	No	No	NA	No	Yes	No
UWP3E	40	5/21/01	Yes	No	NA	No	No	Yes
		5/24/01	No	No	NA	No	No	No
	41	5/21/01	No	No	NA	No	Yes	Yes
	42	5/21/01	Yes	No	NA	No	Yes	Yes
	43	5/21/01	Yes	No	NA	No	No	Yes
		5/24/01	No	No	NA	No	No	No
UWP3SW	44	5/11/01	No	Yes	white-10%	No	No	Yes
		5/14/01	Yes	Yes	good	No	No	Yes
		5/16/01	No	Yes	good	No	No	Yes
		5/21/01	No	No	NA	No	No	No
		5/24/01	No	No	NA	No	No	No
	45	5/11/01	Yes	No	NA	No	No	Yes
	46	5/14/01	No	Yes	good	No	No	Yes
	47	5/14/01	No	Yes	fungus-75%	No	No	Yes
	48	5/21/01	Yes	Yes	good	No	No	Yes
		5/24/01	No	Yes	fungus-75%	No	No	Yes
	49	5/31/01	No	Yes	good	No	No	Yes
	50	6/8/01	Yes	No	NA	Yes	No	Yes
		6/18/01	Yes	No	NA	No	No	Yes
UWP4E	51	5/11/01	Yes	Yes	unknown	No	No	Yes

Table 5-4. Largemouth bass nest observations by index site and date in the Housatonic River, Massachusetts in 2001. The locations of each index site are shown on Figure 4-6.

Index Site	Nest No.	Site/Date	Adult	Eggs	Egg Condition	Sacfry	Swim-up Larvae	Active Nest
	52	5/11/01	Yes	No	NA	No	No	Yes
	53	5/21/01	Yes	Yes	good	No	No	Yes
		5/24/01	No	Yes	fungus-100%	No	No	Yes
UWP4W	54	5/24/01	Yes	No	NA	No	No	Yes
	55	5/24/01	Yes	Yes	white-10%	No	No	Yes
UWP5	56	5/24/01	Yes	Yes	white-100%	No	No	Yes
		5/31/01	No	Yes	good	No	No	Yes
	57	6/8/01	Yes	Yes	white-10%	No	No	Yes
	58	6/8/01	Yes	Yes	good	No	No	Yes
	59	6/8/01	Yes	Yes	fungus-75%	No	No	Yes
	60	6/8/01	Yes	Yes	white-25%	No	No	Yes
UWPIE	61	5/15/01	Yes	No	NA	No	No	Yes
	62	5/21/01	Yes	No	NA	No	No	Yes
	63	5/21/01	Yes	No	NA	No	No	Yes
	64	5/21/01	Yes	No	NA	No	No	Yes
	65	5/21/01	Yes	No	NA	No	No	Yes
	66	5/29/01	Yes	No	NA	No	No	Yes
	67	5/31/01	No	Yes	fungus-100%	No	No	Yes
	68	6/12/01	Yes	No	NA	No	No	Yes
	69	6/14/01	Yes	No	NA	No	No	Yes
UWPIW	70	5/21/01	Yes	Yes	good	No	No	Yes
	71	6/12/01	Yes	Yes	white-100%	No	No	Yes
		6/14/01	No	Yes	few eggs, fungus-100%	No	No	Yes
	72	5/21/01	Yes	No	NA	No	No	Yes
	73	5/21/01	Yes	No	NA	No	No	Yes
	74	6/15/01	Yes	Yes	good	No	No	Yes
UWPW	75	5/21/01	Yes	No	NA	No	No	Yes
	76	5/21/01	Yes	No	NA	No	No	Yes
	77	6/15/01	Yes	Yes	good	No	No	Yes
Total No. of Observations	77	102	67	51		9	9	94

NA= Not applicable

temperature and flow. No obvious correlation was found between the incidence of fungused or dead eggs and fluctuations in water temperature or flow.

Of the 94 observations of active nests, nine nests contained sacfry and eight nests contained larvae which had just recently swum-up from the nest. Sacfry were observed in nests from seven index sites, and larvae were observed in nests from five index sites. In general, sacfry were difficult to observe, as during this stage the larval fish are colorless and on the bottom of the nest. Although a glass-bottom tube was used to aid observations, it is likely that the number of nests with sacfry was underestimated. In total, 16 nests were observed to contain sacfry or swim-up larvae.

Observations of five nests indicated that some nests may have been used repeatedly for spawning or contained embryos from more than one fertilization. For example, nest #5 contained sacfry, but it also contained eggs covered in fungus (Table 5-4). It is possible that the sacfry emerged from a set of eggs that were fertilized prior to the set of eggs that had become covered in fungus. Similarly, nest #44 had eggs with approximately 10% that were white (dead), but three days later a clutch of eggs without white or fungused eggs was observed in the rest. This pattern was even more dramatic in nest #56, in which all eggs appeared to be white on May 24, yet seven days later the same nest contained a clutch of healthy-looking eggs. Another observation of potential repeat spawning within the same nest was seen on June 8 in nest #59, in which two adults were seen over a nest that contained fungused eggs.

5.2.4 Young-of-Year Growth Rates

5.2.4.1 Year 2000 Young-of-Year Growth Rates

In 2000, largemouth bass young-of-year were primarily collected near the end of the growing season during the September electrofishing event. A few young-of-year were also collected and measured for total length during the summer. During the June 2000 electrofishing surveys, four young-of-year were collected with an average size of 87.5 mm. These fish had likely over-wintered, and were thus 11 to 12 months old. During early July, young-of-year bass captured were much smaller, ranging in size from 27 to 41 mm. Young-of-year collected in late-July/early-August ranged in size from 30.9 to 67 mm, whereas young-of-year collected in September ranged from 50 to 91 mm total length.

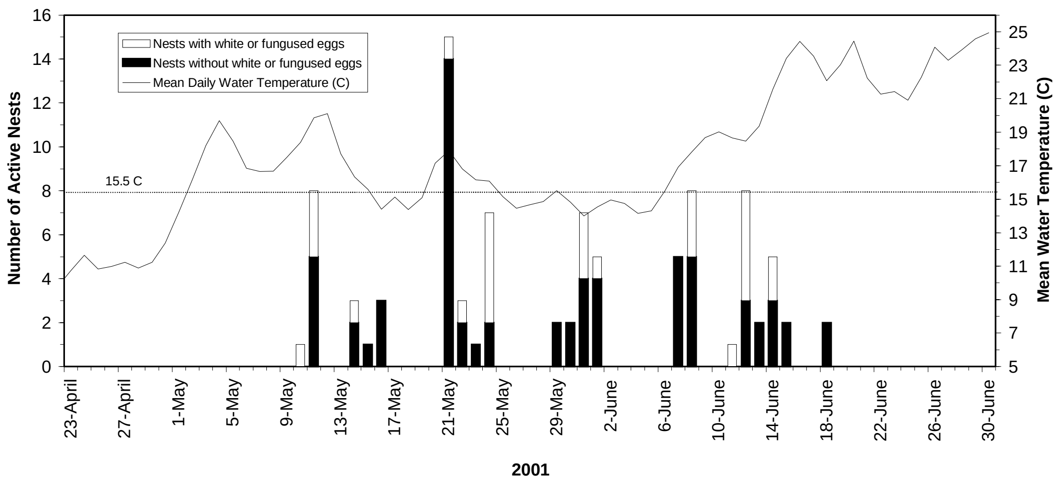


Figure 5-8. Temporal distribution of the number of active largemouth bass nests and nests with white or fungused eggs observed in index sites in the Housatonic River, Massachusetts, 2001, and the mean water temperatures in Woods Ponds.

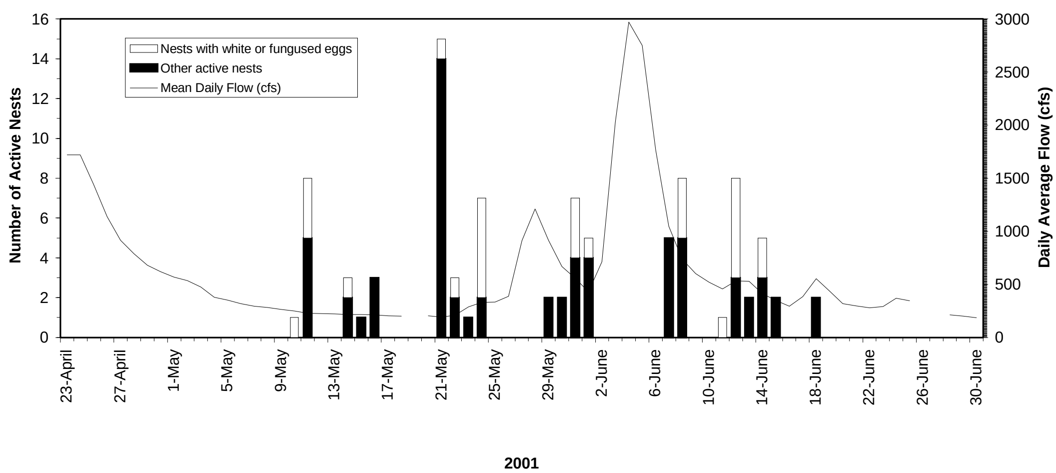


Figure 5-9. Temporal distribution of the number of active largemouth bass nests and nests with white or fungused eggs observed in index sites in the Housatonic River, Massachusetts, 2001, and mean daily discharge (cubic feet per second) as measured at the USGS gaging station at Great Barrington; flow data are provisional.

The growth rates for young-of-year largemouth bass captured in 2000 were calculated for two time-intervals and were based on fish collected in the Woods Pond area. From July 2 to August 1, 2000, fish grew from 32.9 mm to 52.1 mm for an average daily rate of 0.64 mm/day. From August 1 to September 27, 2000, the fish grew from 52.1 mm to 70.7 mm equating to a daily rate of 0.28 mm/day. The mean estimated daily growth rate for the entire period (July through September 2000) was 0.42 mm/day.

5.2.4.2 Year 2001 Young-of-Year Growth Rates

In 2001, individual length measurements from 302 young-of-year largemouth bass collected from the index sites ranged from 4 to 65 mm for fish collected during the period from May 21 to July 11 (Figures 5-10 and 5-11 and Table 5-5). Fish as small as 4 and 5 mm were observed as late in the spawning season as June 18. These fish, which were collected as swim-up larvae on a nest in index site UWP2 (Table 5-4), were collected at the end of the largemouth bass spawning period. The size range of young-of-year fish captured during each survey increased over the growing season. The difference in young-of-year total length measurements ranged from 3 mm on May 30 to 27 mm on June 27. For sampling events in which relatively large differences in fish sizes (i.e., differences > 15-20 mm) were collected, the young-of-year fish likely represented progeny from multiple spawnings (early and late).

Early life stage growth has been shown to be significantly dependent on water temperature (Coutant and DeAngelis 1983). This is illustrated in Figures 5-10 and 5-11, where the period of increased growth commenced around June 6, the time when mean water temperatures increased sharply. This relationship is most dramatic prior to brood dispersal at a total length of approximately 30 mm, around the size when fingerling bass typically switch to a piscivorous diet. At this point, growth becomes more dependent on food availability than on water temperature. During the summer of 2001 in the Housatonic River, the majority of largemouth bass fry were at least 30 mm by around June 30.

The total number of largemouth brood observations (congregations of over 1000 to less than 100 fish) in each index site ranged from 27 observations (site NLBW3E) to one observed brood (sites UWP3SW, UWP4W, and UWP5) (Figure 5-12). A total of 145 brood observations were made during the index site surveys (Appendix D, Table D-7). Since observations were made repeatedly in 15 index sites, it is likely that many of the observations were of the same brood. In general, fish less than 20 mm were found in broods visually estimated to contain at least 1000 larval fish. Fish between 20 and 30 mm tended to be

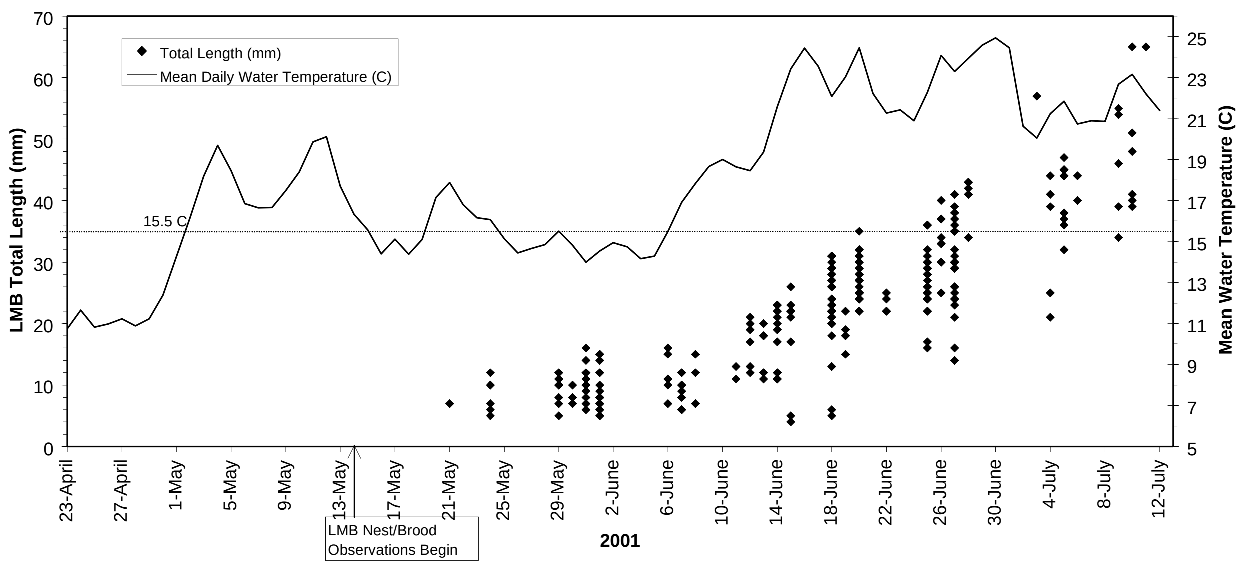


Figure 5-10. Total lengths of young-of-year largemouth bass as a function of date of collection from index sites in the Housatonic River, Massachusetts, and mean daily water temperature in lower Woods Pond for the period May 21 through July 11, 2001; n = 302.

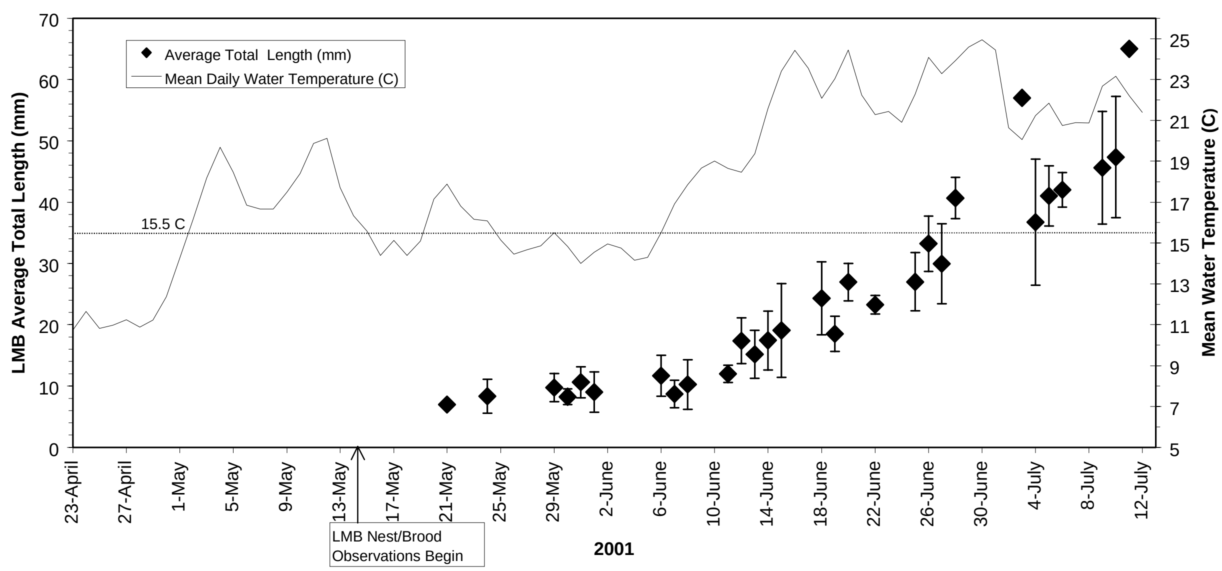


Figure 5-11. Average total length measurements and standard deviations of young-of-year largemouth bass as a function of date of collection from index sites in the Housatonic River, Massachusetts, and mean daily water temperature in lower Woods Pond for the period May 21 through July 11, 2001.

Table 5-5. The daily number of fish collected, the minimum, maximum, and average total length; and the standard deviation are shown for young-of-year largemouth bass collected from June 7 through September 27, 2000, and May 11 through July 11, 2001 at sites within the Housatonic River Study Area.

Date	Number of Fish	Total Length (mm) Minimum	Maximum	Range	Average	Standard Deviation
6/7/00	3	88	99	11	93	5.73
6/10/00	1	82	82	--	82	--
7/2/00	40	27	41	14	32.9	3.11
7/30/00	1	45	45	--	45	--
7/31/00	6	31	52	21	38.6	10.28
8/2/00	2	59	67	8	63	5.66
9/26/00	24	50	85	35	64	7.94
9/27/00	25	51	91	40	70.7	12.77
Total	102					
5/21/01	1	7	7	--	7.0	-
5/24/01	6	5	12	7	8.3	2.73
5/29/01	10	5	12	7	9.8	2.27
5/30/01	4	7	10	3	8.3	1.26
5/31/01	15	6	16	10	10.6	2.53
6/1/01	18	5	15	10	9.0	3.27
6/6/01	6	7	16	9	11.7	3.33
6/7/01	9	6	12	6	8.7	2.24
6/8/01	3	7	15	8	10.3	4.04
6/11/01	2	11	13	2	12.0	1.41
6/12/01	6	12	21	9	17.4	3.74
6/13/01	6	11	20	9	15.2	3.92
6/14/01	14	11	23	12	17.4	4.80
6/15/01	10	4	26	22	19.1	7.65
6/18/01	40	5	31	26	24.3	5.95
6/19/01	4	15	22	7	18.5	2.89
6/20/01	43	22	32	10	27.0	3.03
6/22/01	4	22	25	3	23.3	1.50
6/25/01	25	16	36	20	27.0	4.76
6/26/01	9	25	40	15	33.2	4.52
6/27/01	30	14	41	27	30.0	6.53
6/28/01	6	34	43	9	40.7	3.39
7/3/01	1	57	57	--	57.0	-
7/4/01	5	21	44	23	36.8	10.30
7/5/01	11	32	47	15	41.0	4.92
7/6/01	2	40	44	4	42.0	2.83
7/9/01	5	34	55	21	45.6	9.18
7/10/01	6	39	65	26	47.3	9.89
7/11/01	1	65	65	--	65.0	-
Total	302					

observed in broods containing approximately 100 fish, and young-of-year fish larger than 30 mm were typically not associated with a brood, although they were still found in the same areas where nests and broods had been observed.

Minnow traps were placed in 11 index sites and in one main channel site. The main channel site was near the UWP-MC Stevens/Greenspan DO probe. Minnow traps were set between June 18 and July 10, and a total of 31 young-of-year largemouth bass were collected in the traps. Total lengths of largemouth bass captured in the minnow traps were combined on a daily basis with all other observations from each index site (Table 5-5).

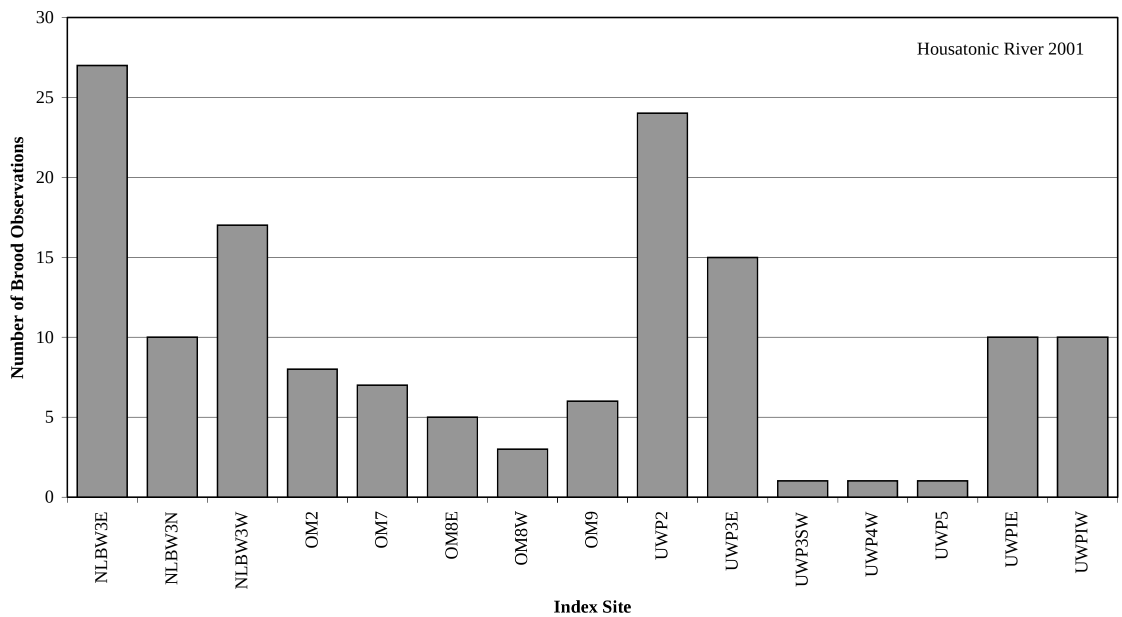


Figure 5-12. The number of largemouth bass young-of-year broods observed at each index site in the Housatonic River, Massachusetts in 2001.

Because young-of-year fish were collected from many different broods across all index sites (as well as from dispersed broods and from minnow traps), growth rates were estimated by using the average total length measured on each day to calculate an average size for each two-week period (Table 5-6). Growth rates were then calculated as the difference between the average starting and ending lengths during each two-week period. For this calculation, we assumed an average fry size of 6 mm at swim-up (Carr 1942; Meyer 1970; Goodgame and Miranda 1993). Daily growth rates during each two-week period were then estimated by dividing by 14 days.

Table 5-6. Average length on sampling dates, cumulative degree days, and estimated two-week and daily growth rates for largemouth bass fry captured in the Housatonic River Index Reach, May – July 2001. Degree days are defined as a running total of mean daily water temperatures > 10ºC. Growth rates for the first period are based on an initial size of 6 mm at swim-up.

Date	Number of Fish	Average Total Length (mm)		Degree Days Over 10°C	Growth Rate	
		Daily	2-Week		mm/2-week	mm/day
5/21/01	1	7.0		113.73		
5/24/01	6	8.3		131.21		
5/29/01	10	9.8		152.92		
5/30/01	4	8.3		157.01		
5/31/01	15	10.6		160.18		
6/1/01	18	9.0	8.82	163.20	2.82	0.20
6/6/01	6	11.7		183.83		
6/7/01	9	8.7		189.18		
6/8/01	3	10.3		195.48		
6/11/01	2	12.0		218.67		
6/12/01	6	17.4		226.56		
6/13/01	6	15.2		234.61		
6/14/01	14	17.4		244.76		
6/15/01	10	19.1	13.96	256.39	5.13	0.37
6/18/01	40	24.3		292.94		
6/19/01	4	18.5		304.07		
6/20/01	43	27.0		316.53		
6/22/01	4	23.3		337.65		
6/25/01	25	27.0		368.76		
6/26/01	9	33.2		380.22		
6/27/01	30	30.0		392.35		
6/28/01	6	40.7	27.98	402.99	14.02	1.00
7/3/01	1	57.0		460.41		
7/4/01	5	36.8		470.08		
7/5/01	11	41.0		481.05		
7/6/01	2	42.0		491.04		
7/9/01	5	45.6		520.84		
7/10/01	6	47.3		532.63		
7/11/01	1	65.0	47.8	543.92	19.83	1.42

Growth rates increased during each consecutive two-week interval, from an initial rate of 2.82 mm/2-weeks between May 21 and June 3; 5.13 mm/2-weeks between June 4 and June 17; 14.02 mm/2-weeks between June 18 and July 1; and 19.83 mm/2-weeks between July 2 and the final survey date on July 11. The observed growth rates were likely influenced by prevailing water temperatures. The period of greatest growth corresponded to a time when mean water temperatures were > 22ºC (Figure 5-11). A strong relationship (r^2=0.99) was detected between two-week interval growth rates and accumulated degree days over 10ºC (Figure 5-13). Daily growth rates calculated from the bi-weekly growth rates are also shown on Table 5-6. For the period from May 21 through July 11 young-of-year fish grew an average of 0.85 mm/day.

The estimated average growth rate of largemouth bass following brood dispersal (estimated as occurring on July 1 at 28 mm) through October 11 (103 days) was 0.47 mm/day; the growth rate estimated for the entire period of study (May 21 through October 11; 141 days) was 0.49 mm/day. Estimates of young-of-year largemouth bass growth rates at the end of the 2001 growing season were dependent on our ability to distinguish large young-of-year fish from similarly sized age 1 fish. A length-frequency histogram of fish smaller than 200 mm indicated a potential overlap in age classes for the size range 95 to 105 mm (Figure 5-14). Although scale analysis was not useful for determining the overall population structure in the Housatonic River from our 2000 and 2001 collections, scales were collected from 35 fish between 82 and 200 mm total length in the fall of 2001 to estimate end-of-season growth rates. Scale analysis indicated that all fish less than 90 mm were young-of-year, and approximately 32% of fish between 90 and 110 mm were young-of-year (Appendix D, Table D-5). One young-of-year fish collected in October 2001 was as large as 120 mm. Based on these determinations, young-of-year fish averaged 76.2 mm in October 2001 (calculated as the average length of 151 fish less than 90 mm, plus 32% of 54 fish between 90 and 110 mm) (Appendix D, Table D-5).

5.3 FISH COMMUNITY STUDIES

Results of surveys completed in 2000 and 2001 indicated that the Study Reach of the Housatonic River supported a diverse assemblage of fish species that is dominated by centrarchids.

During the two-year study, a total of 26 species were collected from locations within the study area, including the Housatonic River upstream of Woods Pond Dam, the East and West

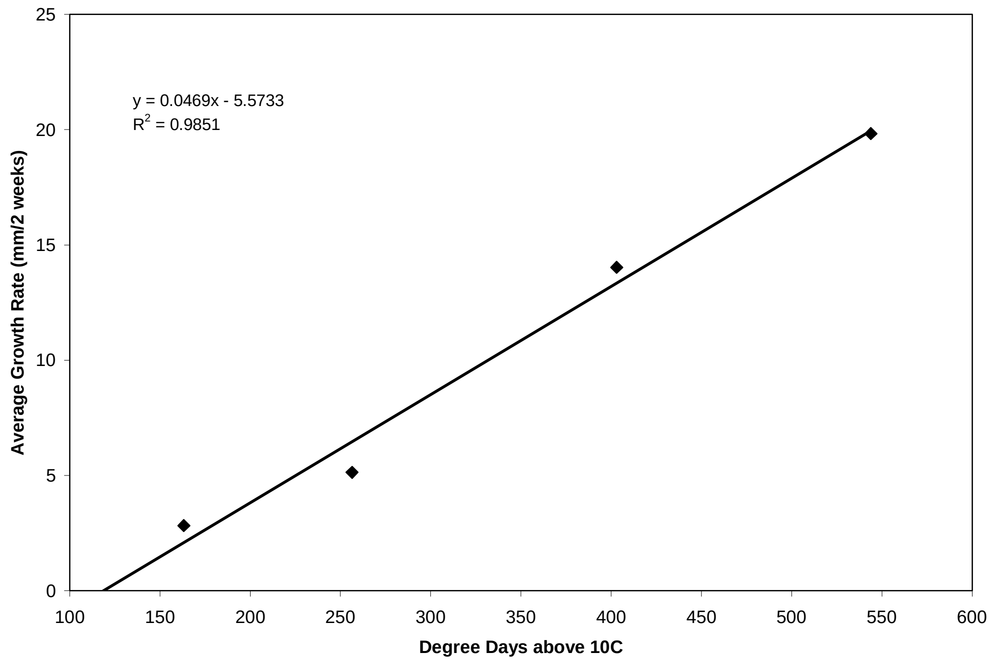


Figure 5-13. Graph of average young-of-year growth rates (mm/2-week) over accumulated degree days over 10°C for Housatonic River largemouth bass between May 14 and July 11. The r^2 of 0.99 indicates that 99% of the variability in early growth can be explained by water temperature.

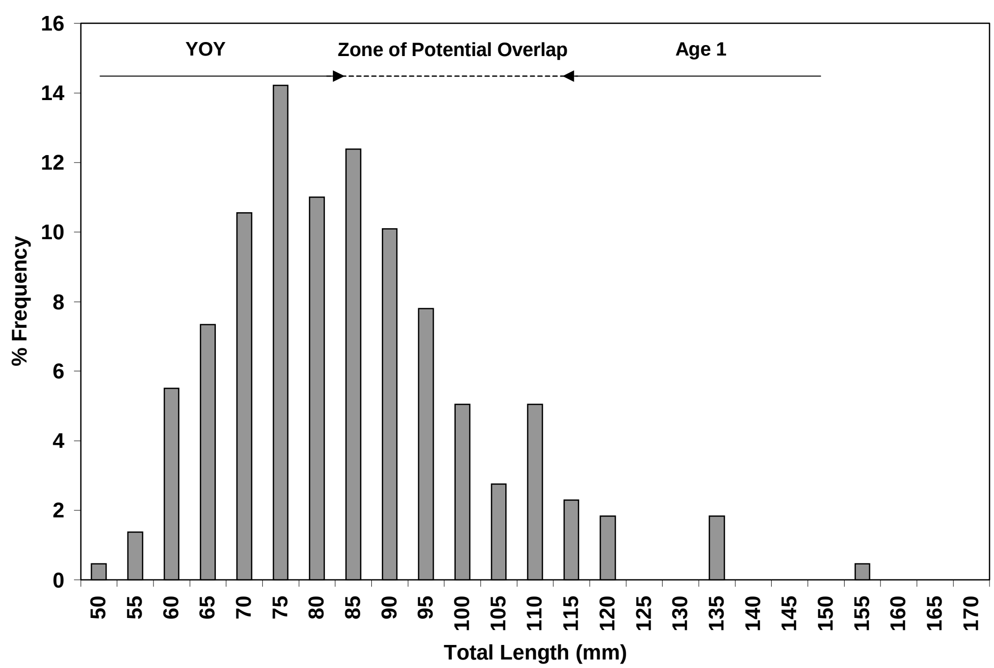


Figure 5-14. Length-frequency histogram for largemouth bass (n=219) less than 200 mm collected from the Housatonic River between October 9 and October 11, 2001.

branches, and four tributaries upstream of Woods Pond Dam. Table 5-7 lists all of the fish species collected by R2 in 2000 and 2001 and also includes specimens collected from the Housatonic River by other researchers. Photos of some specimens collected by R2 during the two-year study are provided in Appendix F (Figures F-17 through F-32)

The following sections present fish community data results for the 2000 electrofishing surveys on the two branches, the six tributary sites, and the mainstem, and for the 2001 surveys conducted on the mainstem Housatonic River.

5.3.1 Mainstem Surveys

In 2000, the fish community in the Study Reach was dominated by bluegill and pumpkinseed (Figure 5-15). As shown in Table 5-7, we collected 20 fish species in 2000 from the Study Reach of the Housatonic River. These included a single specimen of redhorse sucker, which had not been previously documented in the Housatonic River and is not published as occurring in the state (Hartel and Halliwell 1996). A single tiger muskie was also captured during the 2000 survey. Tiger muskies are sterile hybrids between a northern pike and muskellunge, and they are stocked in several of the lakes that drain to the Housatonic River.

A total of 1,414 fish and 16 species were collected during the October 2001 electrofishing effort on the Housatonic River (Table 5-8, Figure 5-16). The most abundant fish species collected was yellow perch, and the most abundant family was the centrarchids, which included largemouth bass, bluegill, pumpkinseed, and black crappie. Young-of-year fish dominated the numbers of collected yellow perch, largemouth bass, black crappie, and sunfish. During the October 2001 electrofishing survey, numerous young-of-year yellow perch and sunfish were not collected or enumerated due to difficulties in capturing such small-bodied fish from the boat. The 16 species collected primarily represented the trophic categories of generalist feeder and top carnivore. Few species considered to be insectivores were collected and no benthic feeding species were collected.

Many fish species collected in the Housatonic River during October 2001 were observed to exhibit diverse size structures, which included juvenile as well as adult size classes. Appendix D, Figures D-1 through D-5 show the length-frequency histograms for bluegill and pumpkinseed, rock bass, black crappie, yellow perch, and white sucker collected during the October 2001 electrofishing effort.

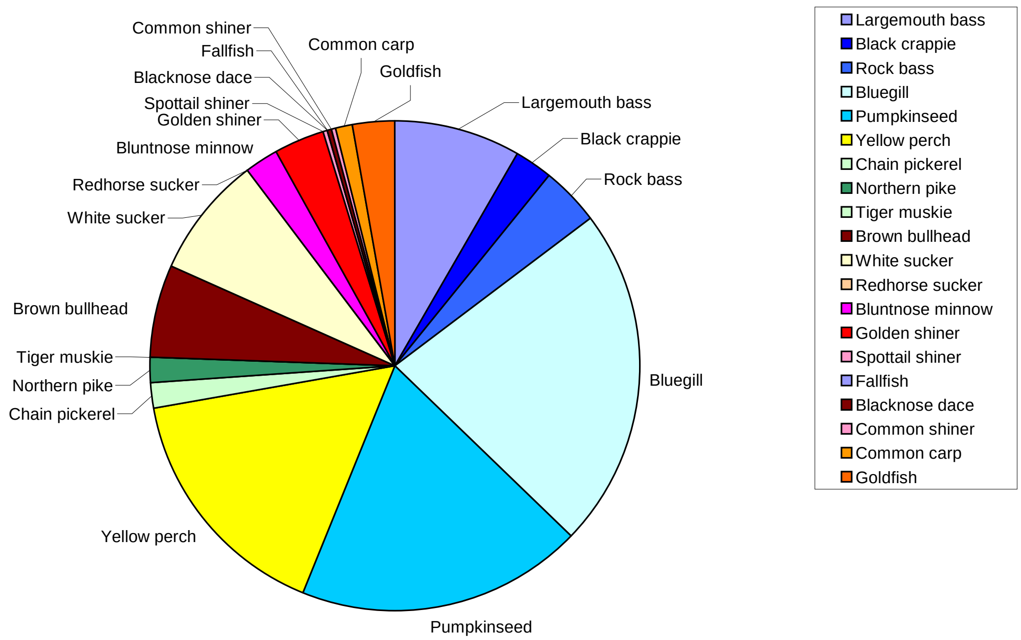


Figure 5-15. Relative abundance of fish species collected in the Housatonic River in 2000.

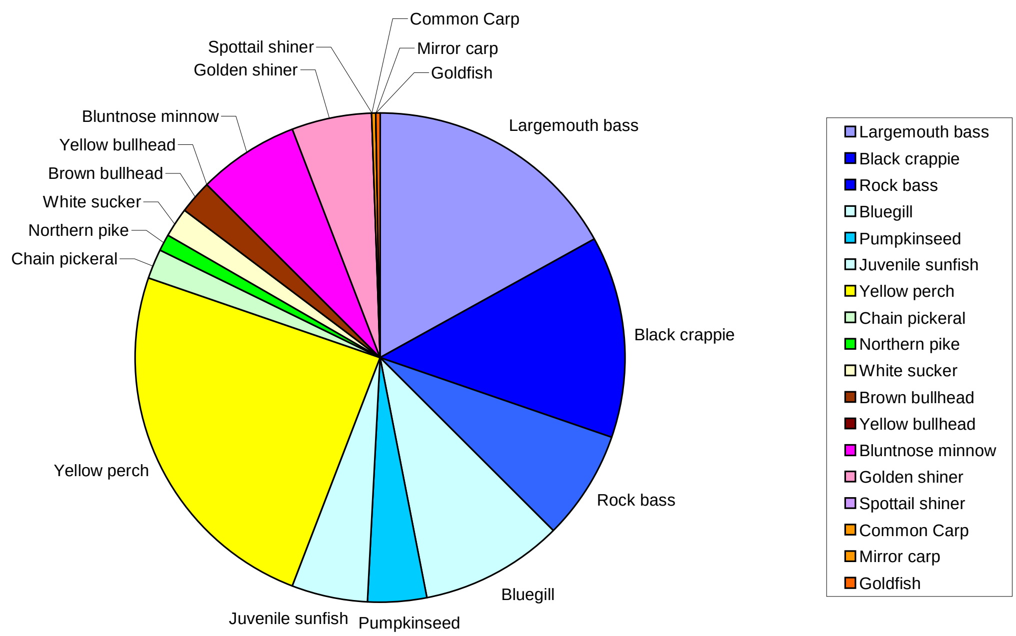


Figure 5-16. Relative abundance of fish species collected in the Housatonic River during October 2001.

Table 5-7. List of fish species collected from the Housatonic River system, Massachusetts by R2 Resource Consultants (R2) and by other researchers (Mc = McCabe 1943; M= Bergin 1971; S=Stewart Laboratories 1982; B = BB 1991; C = Chadwick & Associates 1994)[1]. Fish collected by R2 are from 2000 and 2001 main channel (MC) surveys, and 2000 East Branch and West Branch (WB/EB) surveys, and 2000 tributary (TR) surveys. The locations of the fish collected during the other studies are not specified in this table.

Family Common Name	Species Name	R2 Collections 2001 MC	R2 Collections 2000 MC	2000 WB/EB	2000 TR	Other Studies
Ictaluridae						
Brown bullhead	*Ameiurus nebulosus*	R2	R2		R2	Mc, C, M, S
Yellow bullhead	*Ameiurus natalis*	R2				C
Castomidae						
White sucker	*Catostomus commersoni*	R2	R2	R2	R2	Mc, C, M
Redhorse sucker	*Moxostoma* sp.		R2			
Longnose sucker	*Catostomus catostomus*					Mc, C, M
Creek chubsucker	*Erimyzon oblongus*					Mc
Cyprinidae						
Common Carp	*Cyprinus carpio*	R2	R2			C
Goldfish	*Carassius auratus*	R2	R2			C, M
Bluntnose minnow	*Pimephales notatus*	R2	R2	R2	R2	C
Spottail shiner	*Notropis hudsonius*	R2	R2	R2		C, M
Golden shiner	*Notemigonus crysoleucas*	R2	R2		R2	Mc, C, M
Common shiner	*Luxilus cornutus*		R2	R2		Mc, C, M
Bridle shiner	*Notropis bifrenatus*					Mc
Creek chub	*Semotilus atromaculatus*				R2	Mc, C, M
Fallfish	*Semotilus corporalis*		R2	R2	R2	Mc, C, M
Blacknose dace	*Rhinchthys atratulus*		R2	R2	R2	Mc, C, M
Longnose dace	*Rhinchthys cataractae*			R2		Mc, C, M
Fathead minnow	*Pimephales promelas*					C
Cyprinodontidae						
Banded killifish	*Fundulus diaphanous*				R2[2]	M, C
Esocidae						
Chain pickerel	*Esox niger*	R2	R2	R2	R2	Mc, C, M, S
Northern pike	*Esox lucius*	R2	R2	R2		C
Grass pickerel	*Esox americanus vermiculatus*					Mc
Tiger muskie	*E. masquinongy* x *E. lucius*		R2[2]			S

Table 5-7. List of fish species collected from the Housatonic River system, Massachusetts by R2 Resource Consultants (R2) and by other researchers (Mc = McCabe 1943; M= Bergin 1971; S=Stewart Laboratories 1982; B = BB 1991; C = Chadwick & Associates 1994)[1]. Fish collected by R2 are from 2000 and 2001 main channel (MC) surveys, and 2000 East Branch and West Branch (WB/EB) surveys, and 2000 tributary (TR) surveys. The locations of the fish collected during the other studies are not specified in this table.

Family Common Name	Species Name	R2 Collections 2001 MC	R2 Collections 2000 MC	2000 WB/EB	2000 TR	Other Studies
Centrarchidae						
Largemouth bass	*Micropterus salmoides*	R2	R2	R2	R2	Mc, B, C, M, S
Smallmouth bass	*Micropterus dolomieu*					Mc, C
Black crappie	*Pomoxis nigromaculatus*	R2	R2	R2		C, S
White crappie	*Pomoxis annularis*					C
Rock bass	*Ambloplites rupestris*	R2	R2	R2	R2	Mc, C, M, S
Bluegill	*Lepomis macrochirus*	R2	R2	R2	R2	Mc, C, M, S
Pumpkinseed	*Lepomis gibbosus*	R2	R2	R2	R2	Mc, C, M, S
Green sunfish	*Lepomis cyanellus*					S
Redbreasted sunfish	*Lepomis auritus*					Mc
Redear sunfish	*Lepomis microlophus*					S
Percidae						
Yellow perch	*Perca flavescens*	R2	R2	R2		Mc, B, C, M, S
Tessellated darter	*Etheostoma olmstedi*					C
Percopsidae						
Trout perch	*Percopsis omiscomaycus*					Mc
Cottidae						
Slimy sculpin	*Cottus cognatus*				R2	Mc
Salmonidae						
Eastern brook trout	*Salvelinus fontinalis*				R2	Mc, S
Brown trout	*Salmo trutta*				R2	Mc, B, C, M, S
Rainbow trout	*Oncorhynchus mykiss*			R2		Mc, M, S
Total Species Richness		16	20	16	16	39

[1] = as reported in Chadwick & Associates 1994.

[2] = Tiger muskie stunned during electrofishing, but not collected. Banded killifish collected in Felton Pond.

Table 5-8. Abundance, length, weights, and trophic category of fish collected in October 2001 on the Housatonic River, Massachusetts..

Species	Trophic Category	Total	Total Length (mm)			Min. and Max. Weight (g) / Total Length (mm)	
			Average	Minimum	Maximum	Minimum	Maximum
Brown bullhead (*Ictalurus nebulosus*)	G[a,b]	31	249	70	322	20.0/118	460/318
Yellow bullhead (*Ictalurus natalis*)	G[a,b]	1	250	250	250	225/250	225/250
White sucker (*Catostomus commersoni*)	G[a,b]	27	249	60	495	2.2/60	1,250/460
Common Carp (*Cyprinus carpio*)	G[b]	2	347	94	600	14.1/94	2,700/600
Mirror Carp (*Cyprinus carpio*)	G	1	115	115	115	21.4/115	21.4/115
Goldfish (*Carassius auratus*)	G	3	334	325	343	850/325	930/335
Bluntnose minnow (*Pimephales notatus*)	G[a]	92	55	30	100	NA	NA
Spottail shiner (*Notropis hudsonius*)	IN[a,b]	1	58	58	58	NA	NA
Golden shiner (*Notemigonus crysoleucas*)	G[b]	76	71	30	172	17.5/120	54.0/172
Chain pickerel (*Esox niger*)	TC[a,b]	25	215	76	308	6.9/76	190/308
Northern Pike (*Esox lucius*)	TC[a,b]	18	310	205	570	43.8/205	850/570
Largemouth bass (*Micropterus salmoides*)	TC[a]	239	106	50	397	1.5/50	1,100/397
Black crappie (*Pomoxis nigromaculatus*)	TC[a]	191	74	40	355	4.1/65	275/355
Rock bass (*Ambloplites rupestris*)	TC[a]	100	155	30	273	1.8/48	445/273
Bluegill (*Lepomis macrochirus*)	G[a,b]	135	90	40	203	1.4/40	170/203
Pumpkinseed (*Lepomis gibbosus*)	G[a], IN[b]	55	129	52	193	2.0/52	150/180
Juvenile sunfish (*Lepomis* spp.)		70	30	10	38	1.1/37	1.4/38
Yellow perch (*Perca flavescens*)	TC[a], IN[b]	347	112	60	325	3.6/71	460/325
Total		1,414					

For trophic categories, G = Generalist, IN = Insectivore, and TC = Top Carnivore;
a = Halliwell et al. 1999 and b = Whittier 1999.

5.3.2 East and West Branch and Tributary Surveys

During 2000, a total of 16 species were collected from the East and West branches of the Housatonic River just upstream of their confluence. In these main branches of the Housatonic River, bluegill were numerically dominant. Although this was similar to the community observed in the Housatonic River, the fish community in these two branches contained more dace and other small cyprinids than were found in the main river (Figure 5-17). One stocked adult rainbow trout was captured in the East Branch study site.

Sixteen species were collected in the six tributary study sites (Sackett, upper and lower Mill, Roaring, Moorewood, and Felton brooks). The fish community in the tributaries was different from those in the major branches and mainstem of the Housatonic River (Figure 5-18). The tributary fish community was dominated by eastern brook trout, a species that was not collected in the other sites. In addition, brown trout and slimy sculpin were relatively abundant in the tributaries.

5.4 ENVIRONMENTAL CONDITIONS MONITORING

In 2000, the monitoring of environmental conditions influencing largemouth bass reproduction was limited to water temperature, which was recorded continuously at the 13 study site locations, and flow data obtained from the USGS. In 2001, continuous water temperature recorders were used again, and were supplemented with continuous recording dissolved oxygen monitors placed in locations within three of the largemouth bass reproduction index sites. The temperature and DO recorders were removed during the October 2001 electrofishing surveys. Spot observations of water temperature, DO, pH, and conductivity were also collected during the summer with a hand-held datasonde; measurements are provided in Appendix E.

5.4.1 Water Temperature

In 2000, water temperatures were downloaded from 12 of the 13 recorders placed at the study sites. The recorder placed at the Upper New Lenox main channel (UNLMC) site (Figure 4-1 and Figure 4-15) was lost. In 2001, water temperatures were recorded at 12 locations within the Housatonic River and the East and West branches (Figure 4-14). Appendix E contains graphs depicting daily average water temperatures (C) for each study site. A horizontal line at 15.5°C is shown on each graph to represent the lower limit of water temperature suitable for largemouth bass to initiate spawning and for embryos to successfully develop.

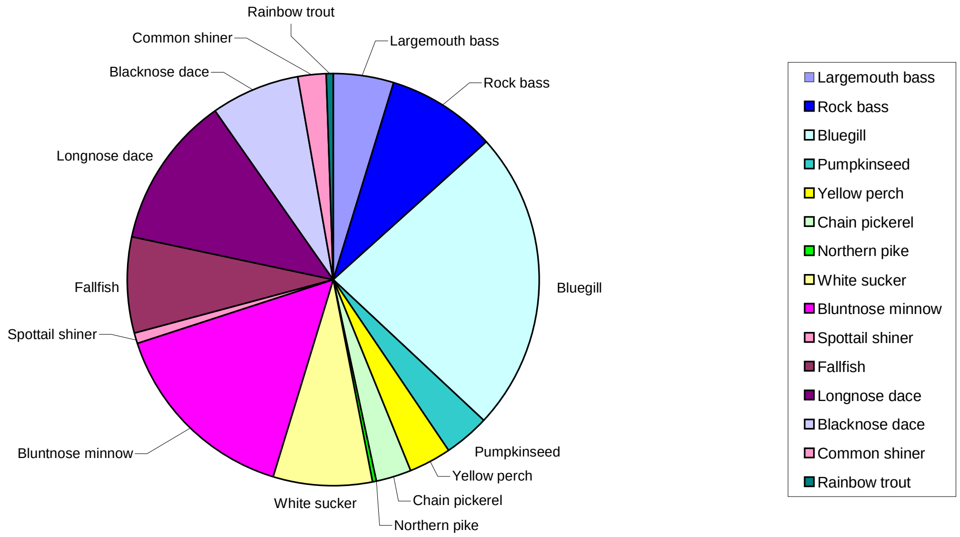


Figure 5-17. Relative abundance of fish species collected in the East and West branches of the Housatonic River in 2000.

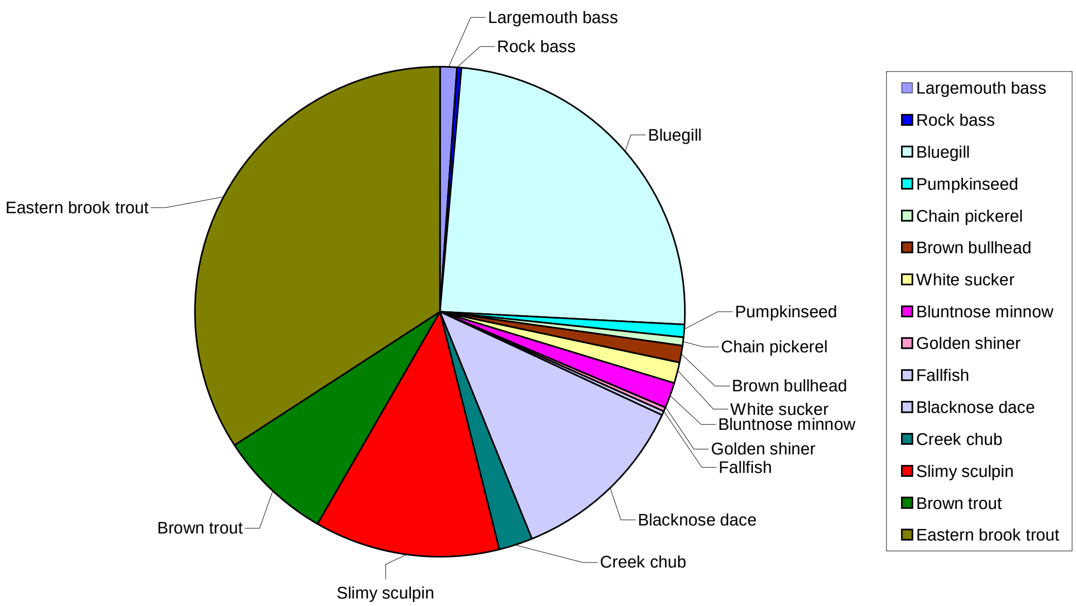


Figure 5-18. Relative abundance of fish species collected in tributaries to the Housatonic River in 2000.

In 2001, water temperatures in the Housatonic River began to warm around April 10, as indicated by the Woods Pond temperature recorder (Figure 5-19). Water temperatures then increased substantially over the next month and remained at or close to 15.5°C through early June. Water temperatures increased to over 20°C in July and then gradually decreased through early August and September to levels below 15ºC. Water temperatures approached 10°C by the second week of October, marking the end of the largemouth bass growing season. These data indicate that largemouth bass spawning could have been initiated as early as May 2, when temperatures first warmed to 15.5°C (Figure 5-19 and Appendix E). In general, temperatures remained above this threshold after May 2. Water temperatures rarely approached the optimal temperature of 25°C for largemouth bass growth (Coutant and DeAngelis 1983) in the main channel, while backwater areas experienced optimal temperatures through most of July and August.

Throughout the Study Reach, maximum water temperatures and patterns of diurnal fluctuations were different between the main channel and backwater areas. Temperatures in the main channel were generally cooler than in the backwater areas and exhibited typical diurnal fluctuations from less than 2 to 3ºC. In contrast, wider diurnal fluctuations (generally from about 6 to 7ºC) occurred in the backwater locations, including in Woods Pond. Daily fluctuations in water temperatures greater than 10ºC were noted in July at the Yokun Brook outlet to the Housatonic River (Appendix E, Figure E-7).

The Stevens/Greenspan probes provided a finer-scale resolution of the variability in water temperatures within and among habitat types in the Study Reach. Within the three backwater areas (OM8, UWP, UWP2) monitored by the Stevens/Greenspan probes (Figure 4-6), the widest diurnal fluctuations in water temperature consistently occurred in the nearshore (NS) locations, which were also the shallowest locations (Appendix E). The widest diurnal fluctuations occurred in OM8-NS (6 to 7ºC), followed by UWP-NS (4 to 5ºC), and UWP2-NS (2 to 3ºC). Water temperature maxima exceeded 30ºC on at least two occasions in OM8-NS, and for a period of several days in UWP-NS. Water temperatures monitored in the middle (M) locations were always lower than in the nearshore areas. The temperatures measured in the three main channel (MC) locations generally averaged less than 25ºC. Of the three main channel locations monitored with Stevens/Greenspan probes, UWP-MC displayed the widest diurnal fluctuations in water temperatures (2 to 3ºC). Since water temperatures affect largemouth bass growth rates and the dissolved oxygen content in the water, it is likely that spawning and rearing largemouth bass react to site-specific differences in water temperatures within the Study Reach. The observed differences in water temperature patterns

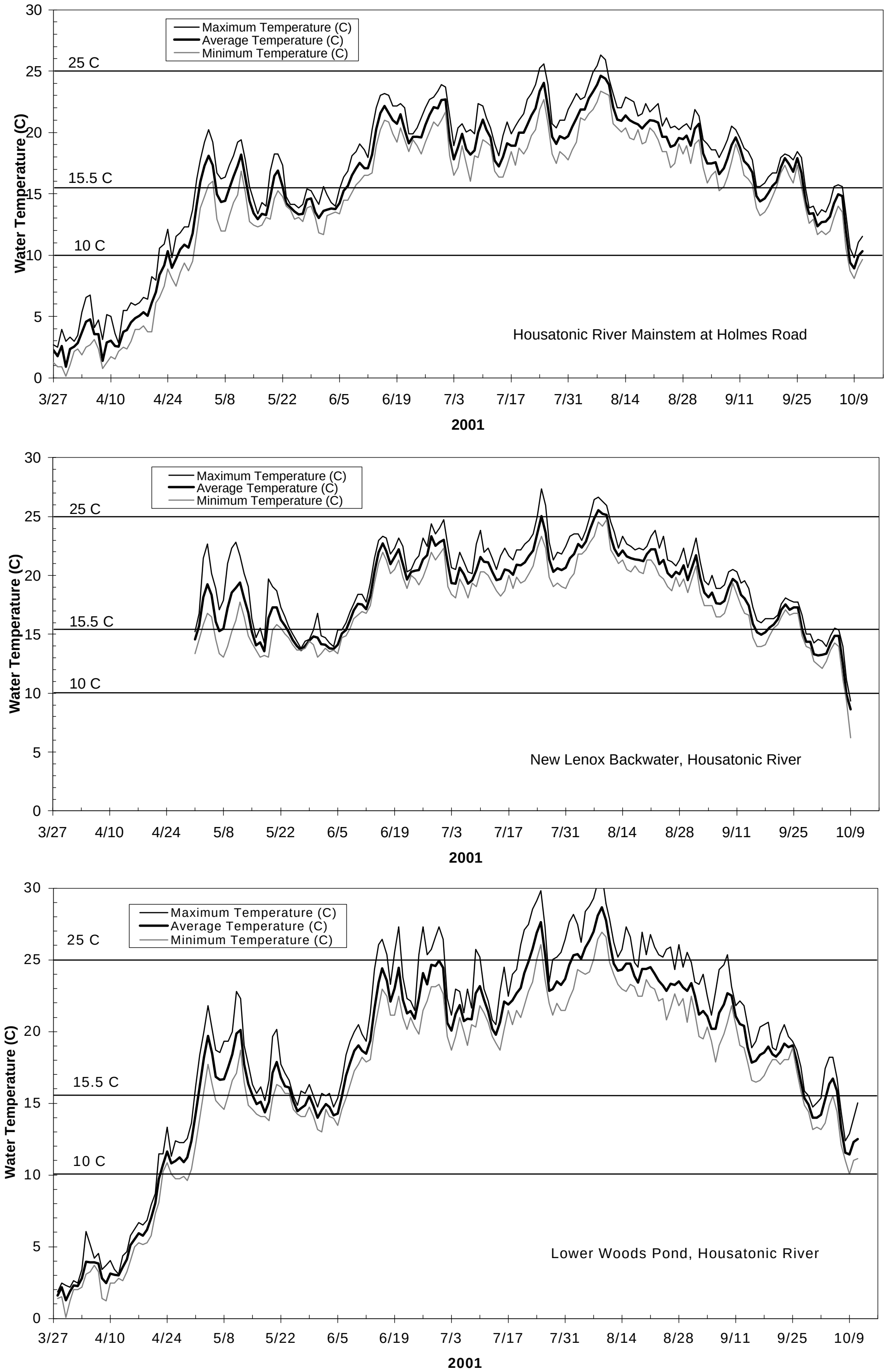


Figure 5-19. Daily water temperatures in the main channel, a backwater, and the Woods Pond area of the Housatonic River, Massachusetts, 2001. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C – initiation of spawning; and 25°C – optimal growth.

between mainstem and backwater habitats and within backwater areas describes one way in which floodplain rivers, such as the Housatonic, contain a mosaic of interconnected habitats.

Differences in water temperatures between years were also evident. A comparison of water temperatures recorded in 2000 and in 2001 indicates that water temperatures were cooler during 2000 (Appendix E). Although water temperature recorders were placed in the river too late in year 2000 to capture the first date in May that temperatures increased above the spawning threshold of 15.5ºC, water temperatures in Upper Woods Pond and Lower Woods Pond were observed to decrease below 15.5ºC three times after the middle of May. During June 2001, there were 58 more degree days over 10°C at the lower Woods Pond site than in 2000. The main channel site at Holmes Road had 24 more degree days over 10ºC in 2001 than in 2000. In addition, Woods Pond water temperatures in 2000 never reached the optimal temperature of 25ºC for largemouth bass growth.

5.4.2 Dissolved Oxygen

Daily differences in DO concentrations during 2001 were apparent between the monitored main channel and backwater sites, with the three main channel sites consistently showing less diurnal fluctuation than the three backwater sites (Figures 5-20 through 5-22). In addition, with the exception of an abrupt and severe reduction in DO beginning on August 26, DO concentrations in the main channel sites were generally above 5 mg/L. The August 26 event resulted in DO concentrations of 0 mg/L at the two lower main channel sites (UWP2-MC and UWP-MC). This extremely low concentration persisted for about a 7-day period at UWP2-MC and for one day at UWP-MC (Figures 5-21 and 5-22).

The largest diurnal fluctuations in DO concentrations were associated with the nearshore sites. In particular, OM8-NS consistently exhibited daily fluctuations in excess of 11 to 12 mg/L (Figure 5-20). Daily fluctuations in DO concentrations also occurred at the other two nearshore sites, although not with the same magnitude. Although DO levels decreased as low as 0 mg/L in the nearshore sites, DO concentrations consistently reached the lowest values at the middle locations within the backwater areas. Extended periods of anoxia were notable in all three backwaters, with UWP2-M exhibiting the single longest period (late August through mid-September) when DO concentrations were at or close to 0 mg/L (Figure 5-22).

The data depicted in Figures 5-20 through 5-22 were subsequently filtered to remove the potential effects of fouling (see Appendix C). The filtered data used only those

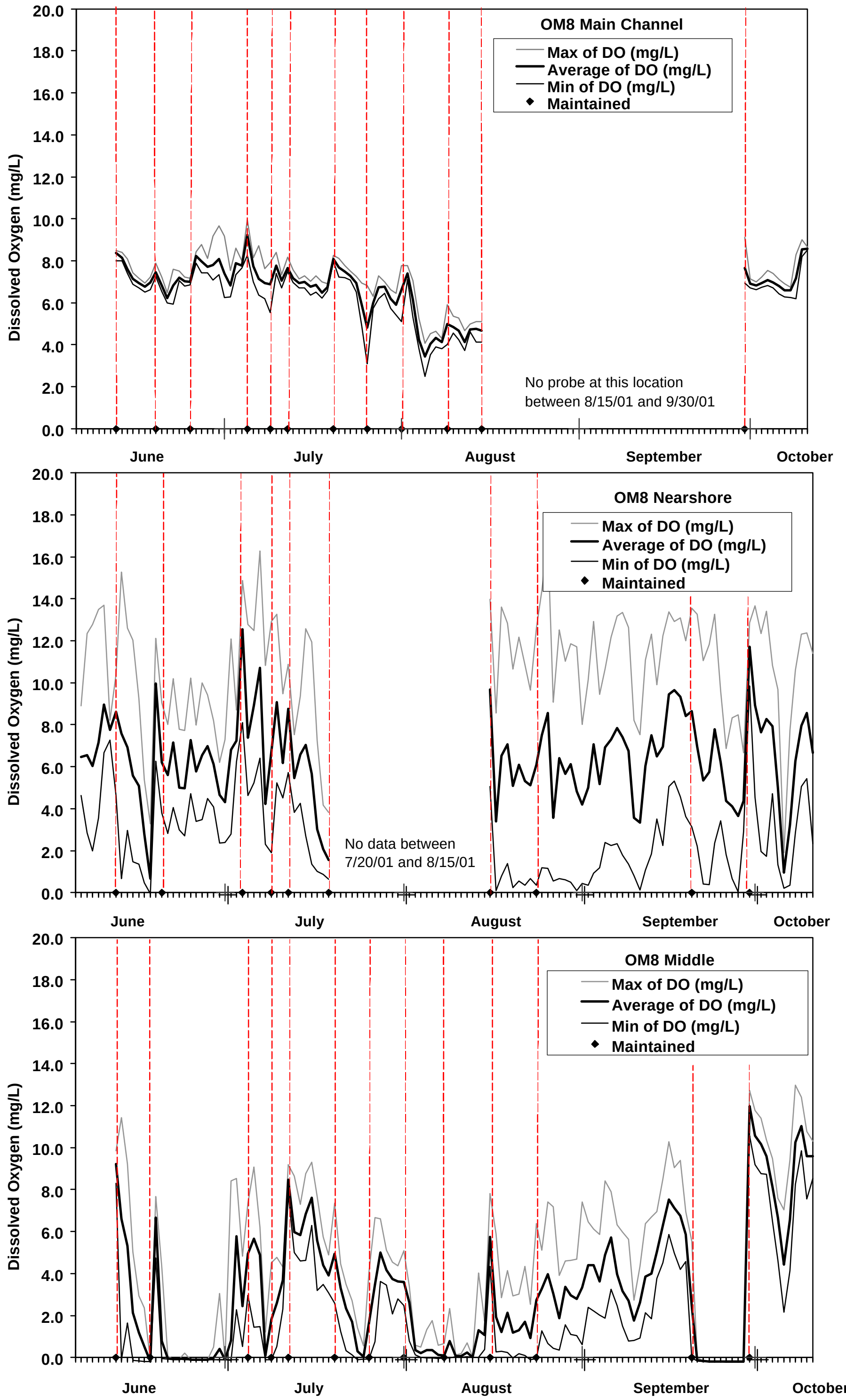


Figure 5-20. Daily maximum, minimum, and average DO concentrations measured in the main channel and in two locations in OM8, Housatonic River between June and October 2001. Vertical dashed lines indicate maintenance events.

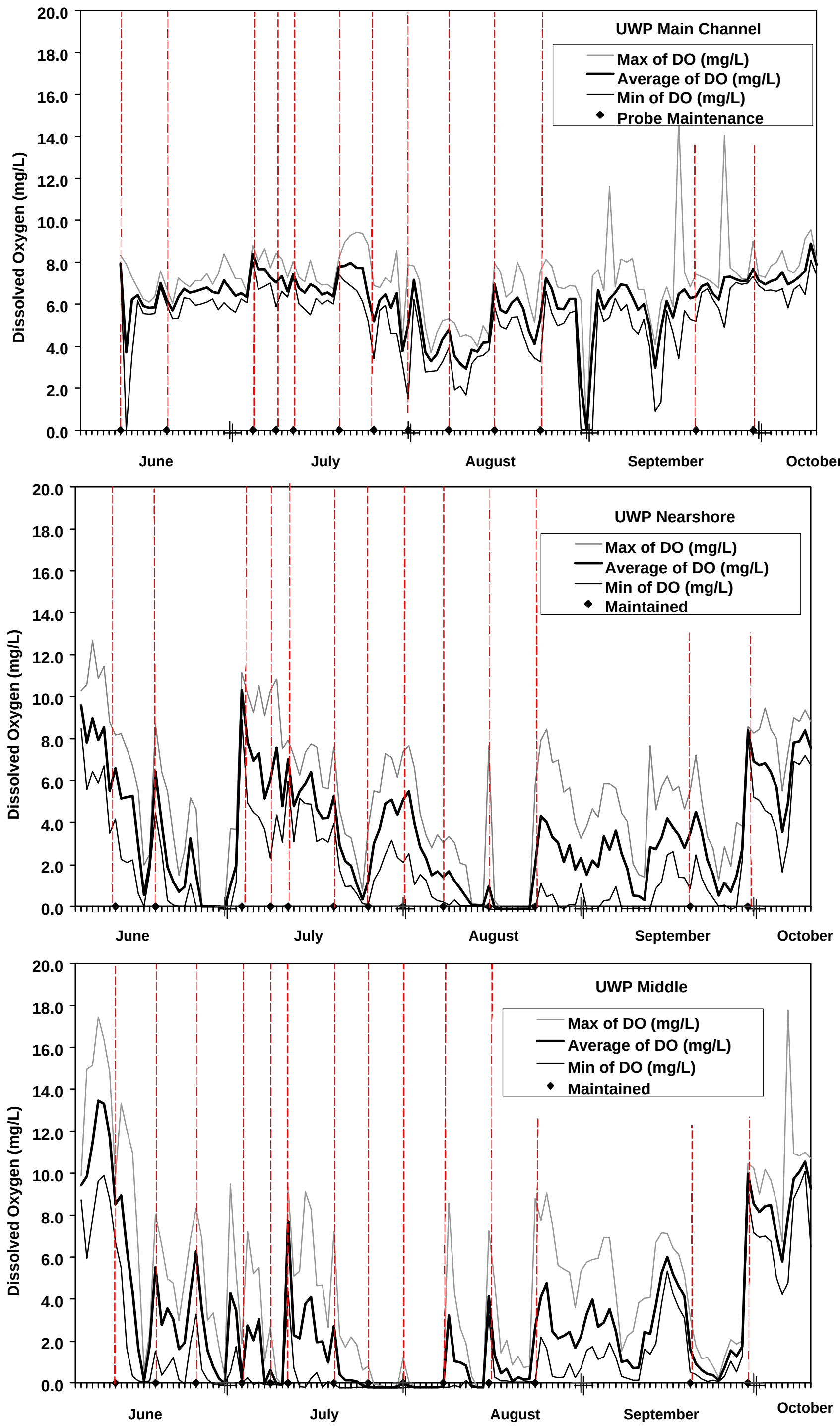


Figure 5-21. Daily maximum, minimum, and average DO concentrations measured in the main channel and in two locations in UWP, Housatonic River between June and October 2001. Vertical dashed lines indicate maintenance events.

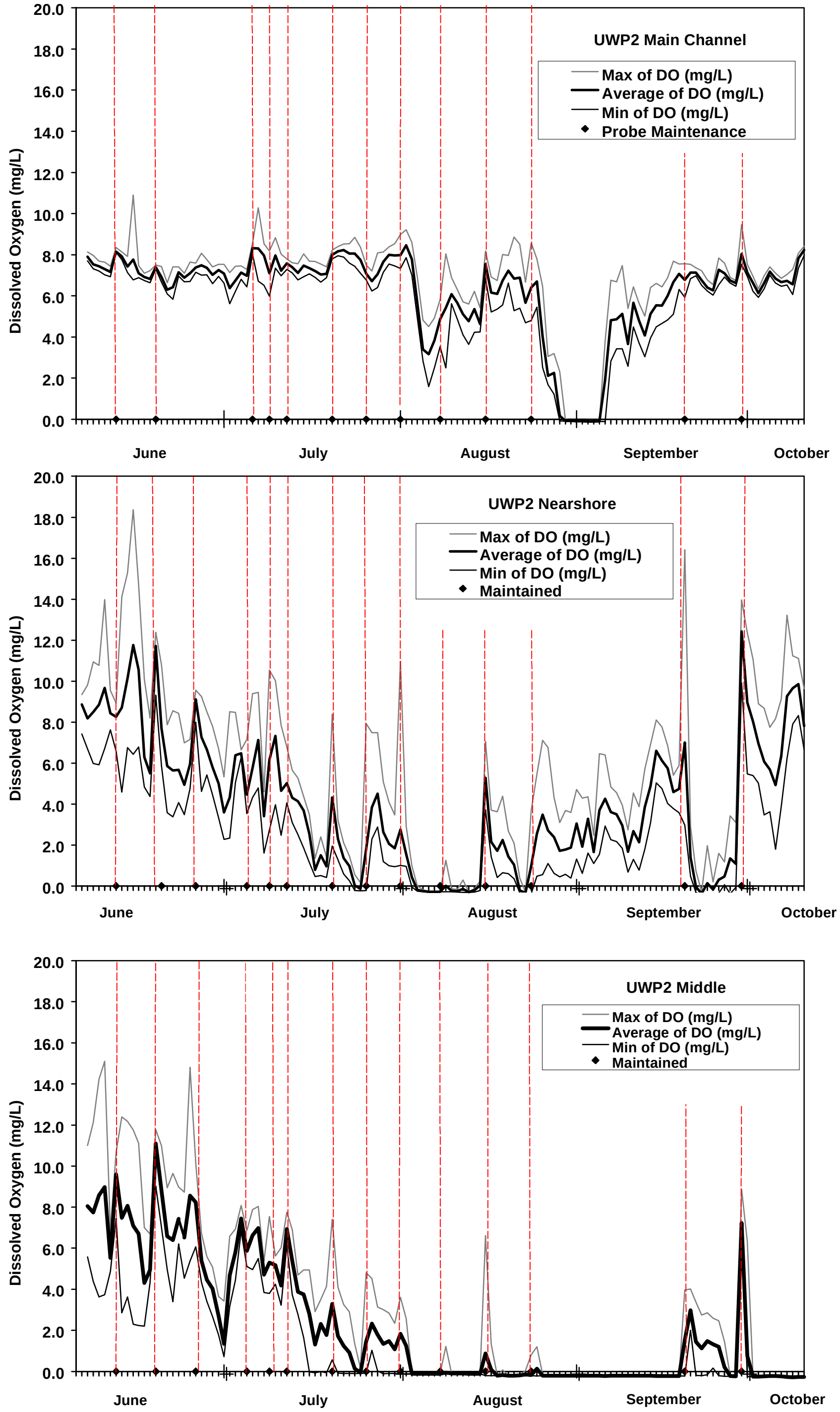


Figure 5-22. Daily maximum, minimum, and average DO concentrations measured in the main channel and in two locations in UWP2, Housatonic River between June and October 2001. Vertical dashed lines indicate maintenance event.

measurements from each 24-hour period following deployment or cleaning of the probes, and with this data set the same trends in DO fluctuations and anoxic conditions are apparent (Appendix E, Table E-1). A frequency analysis of the filtered data sets was completed for DO concentrations ≤ 5 mg/L (DO concentration at which largemouth bass growth is reduced), ≤ 3 mg/L (largemouth bass avoidance), and ≤ 1 mg/L (lethal), separated into main channel, nearshore, and middle locations. Results confirmed that the main channel sites experienced relatively few excursions below the DO thresholds for largemouth bass growth and survival. In the main channel, DO depressions below 1 mg/L were limited to the UWP site (1.7%) (Appendix E, Table E-2). The frequency of potentially stressful or lethal DO concentrations was greatest in the middle areas of the backwater habitats. Of the three backwater locations, UWP-M exhibited the highest occurrence for each of the three threshold DO levels; 68.2% for ≤ 5 mg/L; 58.5% for ≤ 3 mg/L, and 39.2% for ≤ 1 mg/L. UWP2-M contained the second highest occurrences of measurements ≤ 3 mg/L and ≤ 1 mg/L, 41.7% and 25.5%, respectively. OM8-M had the second highest occurrence of DO concentrations ≤ 5 mg/L (62.8%).

Separation of frequency data by month suggests that DO sags were most frequent in late summer (Appendix E, Table E-3). The percentage of DO values ≤ 1 mg/L increased substantially for UWP-M from June (8.7%) to July (60%), and then decreased in August (48.5%) and September (29.6%). In UWP2, the occurrence of DO concentrations ≤ 1 mg/L was zero in June and July, and then sharply increased in August (71.4%), with a subsequent decrease in September (18.4%). The pattern of DO concentrations less than or equal to 1 mg/L in the nearshore sites indicated that the frequency was highest in August at UWP-NS (33.2%) and UWP2-NS (33.3%) and in September at OM8-NS (8%).

5.4.3 Flow

The annual hydrograph for the Housatonic River in 2001 suggests that flows were below average during most of the year, and in particular during July through September (Figure 5-23). Two high flow events occurred, the first and largest (peak flows about 4,000 cfs) occurred in mid-April, and the second (peak flow around 3,000 cfs) occurred in early June. Flows declined sharply following the snowmelt event in April and remained well below average (approximately 200-250 cfs) until a heavy rainfall in June. By mid-June flows had declined below average and remained low through late September. The low flow conditions during this period were a function of low precipitation during those months. A comparable graph for the year 2000 is shown in Figure 5-24.

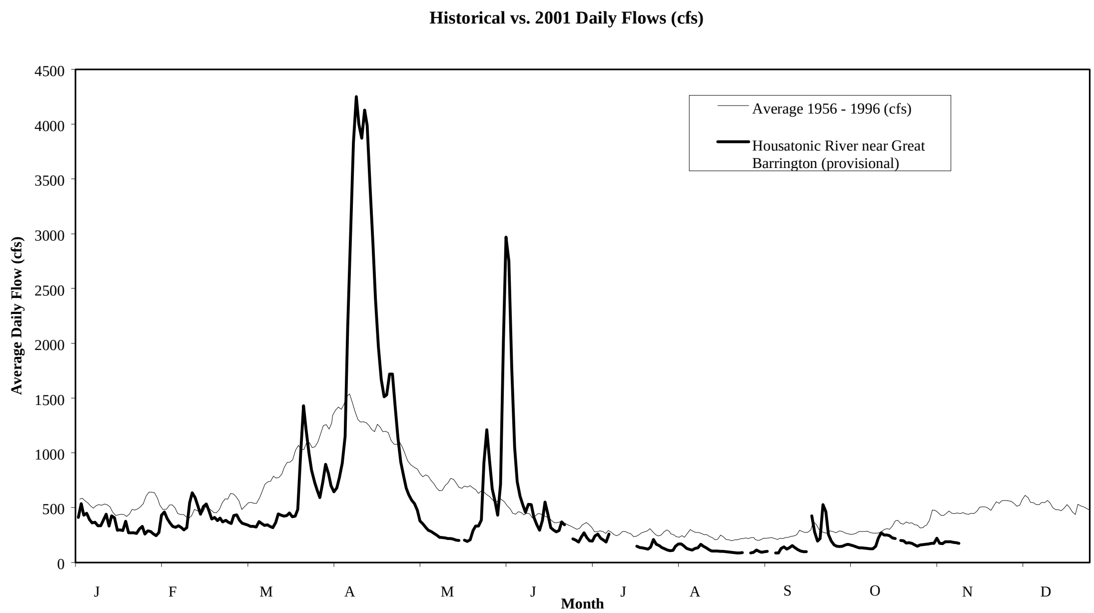


Figure 5-23. Flow (cfs) conditions during 2001 (provisional data) and the average historical flow conditions in the Housatonic River at the Great Barrington USGS station.

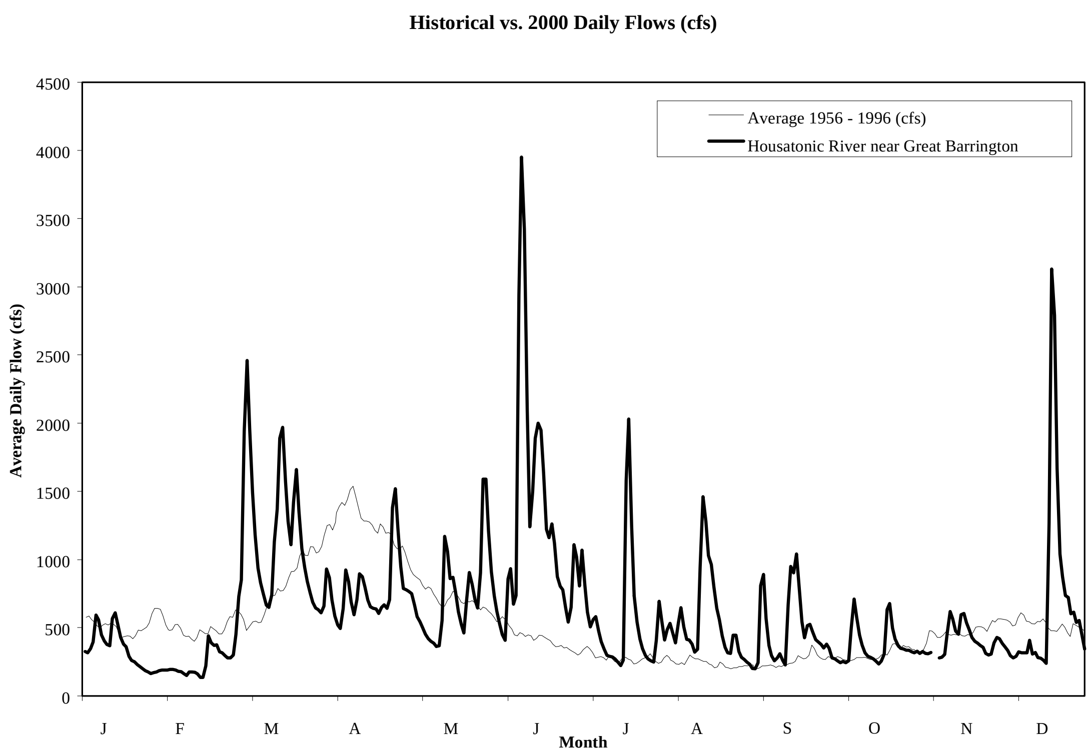


Figure 5-24. Flow (cfs) conditions during 2000 (October through December are provisional data) and the average historical flow conditions in the Housatonic River at the Great Barrington USGS station.

We observed a dramatic change in water levels at a number of the index sites in conjunction with the 2nd high flow event in June (Figure 5-25). Over this period, water levels in some locations fluctuated by more than 1 foot, resulting in shoreline and largemouth bass nesting areas that were inundated and then dewatered as flow levels decreased. For example, in one two-day period between June 12 and 14, water levels dropped by 5 inches (from 18 inches to 13 inches) over one of the nests observed in the NLBW3N index site.

In contrast and as illustrated in Figure 5-24 and Table 5-9, flow conditions during 2000 were generally higher than normal, and notably less stable during the July through September period. There were several flow events during this period in which flows more than doubled within a relatively short time frame. These included events in mid-July, in which the flow change was > 1,500 cfs, one in mid-August when flows increased > 900 cfs, and two events in mid-September when flows increased around 500 cfs. Overall, the flow conditions in 2000 were higher and much more variable than the flows in 2001.

Table 5-9. Flow statistics for the Housatonic River near Great Barrington (USGS station # 1197500) for the years 2000, 2001, and 1956-1996.

	Year 2000			**Year 2001**			**Historical (1956-1996)**		
Month	**Mean**	**20% excd**	**80% excd**	**Mean**	**20% excd**	**80% excd**	**Mean**	**20% excd**	**80% excd**
May	734	905	460	389	540	216	702	939	337
June	1325	1902	723	715	728	296	410	503	173
July	539	614	272	186	230	136	269	315	123
August	532	647	315	116	138	94	239	271	107
September	479	697	277	175	213	98	234	275	109

Note: The year 2001 data set is provisional and there are several missing flows in each month. These missing data were ignored when computing the mean and exceedance flows. For example: There are 3 missing flows in September 2001, and therefore the mean and exceedance flows were calculated based on 27 flows.

5.4.4 Cloud Cover

During the 2001 study period, the highest percentages of overcast days (as recorded at the Pittsfield, Massachusetts Airport atmospheric station) occurred during June and July, although there were relatively few days (5 maximum) when the percentages were greater than 50%. When superimposed along with DO concentrations for the nearshore and middle locations within the backwater areas, there was some indication of an inverse relationship between cloud cover and DO concentrations (Appendix E, Figures E-18 through E-20). For example, during the period June 7 through June 25 at the UWP-NS site, daily minimum DO concentrations were relatively high (> 6 mg/L) during cloudless days (June 7-10), and then

Figure 5-25. Photographs of index site NLBW3N before (June 1, 2001 – upper photo), during (middle photo), and after (June 25 – bottom photo) the June 4 high flow event.

concentrations began to decrease during June 10-12 as the percent overcast conditions approached 50%, with a further decrease in DO concentrations during June 13-17 (reaching 0 mg/L on the 17th) as overcast conditions increased to around 40% (Appendix E, Figure E-19). On the same figure, DO concentrations are seen to increase to over 4 mg/L on June 19 when overcast conditions are low, with a subsequent decrease in DO to 0 mg/L during a five day period when overcast levels were greater than 50%. Similar trends were noted at times for the nearshore and middle probe locations at the other backwater locations (Appendix E, Figures E-18 through E-20).

A comparison of overcast conditions in 2000 with 2001 (based on summarized data from the National Climatic Data Center) indicates a much higher incidence of overcast, cooler, and wetter conditions in 2000 (Table 5-10). Average air temperatures and precipitation amounts during July and August 2000 (17.5ºC and 3.72 inches, and 17.7ºC and 4.58 inches) were likewise cooler and higher than in 2001 (17.7ºC and 2.97 inches, and 20.8ºC and 2.37 inches).

Table 5-10. Comparison of overcast conditions in 2000 and 2001 in Pittsfield, Massachusetts (National Climatic Data Center).

	Percent of Days with > 50% Overcast Conditions	
Month	**2000**	**2001**
June	33	37
July	35	23
August	39	13
September	43	33

6. DISCUSSION

The results of this study indicate that a viable, self-sustaining largemouth bass population exists within the reach of the Housatonic River extending from the confluence of the East and West branches of the Housatonic River downstream to Woods Pond Dam. Largemouth bass adults and juveniles were found in locations throughout the reach, but were concentrated in areas characteristic of bass habitats, as mapped during the 2000 surveys, such as low velocity backwater areas (Figure 5-1). Habitat surveys in six tributaries to the upper Housatonic River identified limited largemouth bass habitat. In contrast, the habitat surveys of the mainstem Housatonic River (including connected backwaters and embayments) indicated that the area of potential bass habitat increased in a downstream direction as impounded and backwater habitats become more abundant near Woods Pond Dam. The highest densities of adult and juvenile largemouth bass were found in shallow embayments and the adjacent areas. Monitoring of 15 index sites located in backwater habitats during the period May through July 2001 indicated these areas are used by largemouth bass for nesting and spawning. Larval fish were documented at each index site. As will be discussed below, juvenile growth rates and catch (CPUE) rates of young-of-year largemouth bass in the fall of 2001 were comparable to populations in other systems. The age class structure of the population appears to be dominated by large, relatively old (4+ and older) individuals, a likely consequence of the population being unexploited due to lack of fishing pressure. Observations of reproduction, young-of-year growth and relative density, and population structure indicate that the largemouth bass population is successfully reproducing within this reach of the Housatonic River, and that year class strength is likely determined by a mosaic of interrelated factors, specifically, air and water temperature, flow, and dissolved oxygen concentrations.

6.1 HABITAT CHARACTERISTICS AND SUITABILITY FOR LARGEMOUTH BASS POPULATIONS

The Housatonic River within the Study Reach is, in general, a flat, meandering floodplain river with abundant areas of slack water habitat. Two types of tributaries drain to the Study Reach, including coldwater tributaries that originate on October Mountain and warmer water tributaries that originate in ponds and wetlands. Habitats most suitable for largemouth bass production are lakes with shallow vegetated areas for spawning and deep holes for overwintering, or large, slow moving rivers or pools of streams with soft bottoms (Stuber et al. 1982). Suitable largemouth bass habitat is abundant in the impounded Woods Pond area of the Housatonic River; in connected backwater areas, which are most abundant downstream of New Lenox Road; and in the ponds and wetlands that drain to the river. Within the Study Reach the greatest amount of largemouth bass habitat that can support spawning and overwintering populations (Figure 5-19) occurs in the reach closest to Woods Pond Dam.

Results of surveys in the Study Reach and major tributaries of the Housatonic River indicated that the majority of largemouth bass spawning habitat was contained in backwater areas and embayments within or directly connected to the mainstem river. The majority of tributaries that drain to the Study Reach (Felton Brook, Roaring Brook, Mill Brook, and Sackett Brook) were unsuitable for bass spawning because they were dominated by lotic-type habitats. Two tributary exceptions contained large areas of ponded water habitat, which contain potential largemouth bass spawning habitat. These were the lower section of Yokun Brook and Moorewood Pond and their outlets to the mainstem river.

6.2 LARGEMOUTH BASS POPULATION CHARACTERISTICS

6.2.1 Distribution

Fish sampling supported our delineation of suitable largemouth bass habitat. Largemouth bass were collected in the mainstem river, the East and West branches, backwaters, and the tributaries draining ponds or wetlands. In general, largemouth bass were most abundant in shallow backwater areas connected to the main channel. Largemouth bass were typically captured at locations containing abundant cover and structure, for example, within root wads, snags, aquatic macrophytes, and overhanging vegetation. Largemouth bass were not collected from the coldwater tributaries draining October Mountain with the exception of one fish collected in a lower section of Mill Brook. No largemouth bass were observed in Felton Brook Reservoir, which drains to Felton Brook. Two other large ponds that drain directly to the Study Reach, which do have largemouth bass, are Moorewood Pond and the Yokun Brook wetland between East Street and the railroad tracks that parallel the Housatonic River. Although these ponded areas were not sampled directly, largemouth bass were seen in these waters from the shoreline and largemouth bass were collected from the outlet tributaries. It is not known if the largemouth bass in these ponds overwinter in the river or in the ponds.

6.2.2 Population Structure

The sampled population in summer 2000 contained a high proportion (69%) of large-size fish, while the majority of the fish (78%) collected in fall 2001 were young-of-year less than 100 mm in total length. This difference was partly due to differences in timing of the sampling between years and also likely due to a stronger year class in 2001, as discussed below.

The size class structure for the adult largemouth bass population was assessed through the calculation of PSD values. The PSD values calculated for the Housatonic River in 2000 and 2001 incorporated minimum stock (200 mm) and quality (300 mm) lengths. PSD is calculated by dividing the number of quality fish by the total number of fish that are at least stock size and then multiplying by 100. Of the largemouth bass captured during 2000 and 2001, few fell into the 200 to 300 mm length category. With relatively few fish representing this size range (200 to 300 mm), the computed PSD values were comparatively large: PSD of 82 in 2000 and PSD of 91 in 2001. These high values exceed the commonly accepted range of 40 to 70 for a managed largemouth bass population (Gabelhouse 1984) and indicate a high proportion of large-size (older) fish.

Information on largemouth bass PSD values of unharvested populations in flowing systems like the Housatonic River is lacking in the literature. However, a review of PSD values from lakes and reservoirs (see Table 3-1) indicated that most of these populations had PSD values lower than those calculated for this study, although some were comparable to the values calculated for the Housatonic River. For example, Green et al. (1986), in a study of New York bass populations, reported a wide range of PSD values in 11 different lakes. The PSD values varied seasonally and by capture method (i.e., angling and electrofishing). For collections made by electrofishing, four of the eleven systems had PSD values ≥ 70 during one or more periods, and two of the eleven had PSD values ≥ 90 during one of the sampling periods. Hartley (unpublished data) surveyed 25 ponds in Massachusetts during 1992-94 and calculated largemouth PSD values ranging from 3 to 79. Of the 25 ponds surveyed, 14 of them had PSD values within the accepted range of 40-70 (Gabelhouse 1984) and three ponds had PSDs of ≥ 70.

The largemouth bass population in the Housatonic River is largely unfished and unexploited. In unfished systems, large-sized fish are not removed by anglers and PSD values for the population can be greater than in fished populations (Goedde and Coble 1981). The lack of fishing pressure on other large predatory species (e.g., northern pike) can also reduce the number of mid-sized bass through predation, further increasing PSD values. PSD values can also be affected by population abundance or capture efficiency during sampling (Willis et al. 1993). Although our study did not sample abundance directly, the numbers and diversity of fish collected during our electrofishing efforts indicate that the abundance of fish, in general, in the Housatonic River is quite high. Additionally, our observations of spawning success, as determined by observations of nests, broods, and relatively high CPUE estimates for young-of-year bass at the end of the growing season, indicate that recruitment is not limiting the largemouth bass population in the Study Reach.

Thus, it is likely that the high proportion of large-sized adult bass and the resultant high PSD values are primarily a result of a lack of fishing pressure. However, it is also possible that the size-class structure (and PSD values) are a reflection of recent past environmental conditions, which resulted in weak year class strengths for fish in the 200 to 300 mm size classes. Extreme fluctuations in largemouth bass populations are common. For example, in the Illinois River, electrofishing collections of young-of-year largemouth bass varied from 2.5 to 58.3% of the total population over a six-year study (Raibley et al. 1997). The frequency and abundance of young-of-year largemouth bass in the Housatonic River was substantially greater in 2001 than 2000, suggesting development of a strong year class. As discussed below, we believe that environmental conditions in 2001 were conducive to largemouth bass reproduction and young-of-year survival.

Because largemouth bass, similar to many other fish, grow slower as they age, age determinations indicated considerable overlap in size classes for a given age, especially in the larger fish. Largemouth bass in the Housatonic River with lengths between 300 and 400 mm were determined to have ages that ranged from 5 to 13 years. Otolith and scale analysis also showed that even fish as young as age 3 ranged in size from 190 to 296 mm. The oldest fish aged during this study (fish collected by R2 and BBL) was 11 years; the USFWS study (Smithwood 1999) identified a fish as old as 14 years. These fish were aged using otolith analysis. Because we released all fish that were captured for our assessment of the largemouth bass population structure, we did not collect otoliths from our electrofishing events. In our study, scale analysis accurately aged fish younger than 6 years, but accuracy diminished for older fish. Because we were unable to accurately age older largemouth bass using scales, we could not determine an age structure for the population.

6.2.3 Relative Weight

The measured weight and length relationship of the largemouth bass collected in 2000 and 2001 indicated that the fish were relatively fit (had a high relative weight) compared to established standards used to manage largemouth bass as a sport fishery. Although the W_r index is typically employed by fisheries personnel for the purpose of attaining angling management goals, its use as an ecological condition factor can describe unexploited populations as well (as is the case with the Housatonic River). A mean W_r of 100 for a broad range of size groups describes fish in good condition and may indicate ecological and physiological optimality, or be used as a benchmark for comparing populations (Anderson and Neumann 1996).

Relative weight is often presented as a mean value for specified length categories (i.e., stock and quality). Although not as common, mean W_r values can be calculated for entire samples or as separate values for each fish plotted against total length. We plotted W_r for each fish and calculated the mean W_r values for the population as a whole. By examining individual values on a graph, it is possible to detect any abnormal length-related trends (e.g., intermediate-length fish might be in poorer condition than small or large fish) (Blackwell et al. 2000). Nearly all the W_r values for each Housatonic River largemouth bass were above the acceptable range of 95 to 105 for managed largemouth bass populations (Anderson 1980, as cited in Blackwell et al. 2000), and the mean W_r value by year across all size classes ($\geq$ 150 mm) exceeded 100, which is the benchmark suggested by Anderson and Neumann (1996) as representing a healthy bass population. Specifically, the mean W_r value for 2000 was 109 and for 2001 the mean W_r value was 117. Moreover, the mean W_r values for the Housatonic River bass were similar to or higher than values reported by Green et al. (1986) for largemouth bass from 12 systems in New York and for values from several ponds in Massachusetts (Hartley unpublished data). Thus, the individual and population mean W_r values indicate that Housatonic River largemouth bass are robust and in good conditions.

6.3 REPRODUCTION AND GROWTH

Observations in 2001 indicated that Housatonic River largemouth bass nested in shallow backwater habitats. Sites containing active nests subsequently supported broods of larval bass, which exhibited growth rates and relative abundances typical of other systems. Overall, nesting and spawning success was likely affected by fluctuating water temperatures and water levels, although no obvious correlation was found.

6.3.1 Spawning Duration and Localized Densities

Largemouth bass spawning activities in the index sites on the Housatonic River occurred over a 39-day period during the spring of 2001. The period of time used for spawning has been noted to exhibit a latitudinal gradient, likely due to the length of growing season (Goodgame and Miranda 1993). In other locations, spawning durations, based on population hatch dates estimated from daily otolith growth rings, were calculated to range from 26 days in one New York lake (Schmidt and Fabrizio 1980), 36 to 51 days in Illinois (Miller and Storck 1982; Kohler et al. 1993), and 60 to 71 days in Mississippi (Goodgame and Miranda 1993). In a four-year study in a Minnesota lake, largemouth bass fertilization extended over 44 days (Kramer and Smith 1960). In two Idaho lakes, nesting activity extended between 45 and 47 days (Bennett and Bowles 1985). The 39-day period when active nests were observed in the Housatonic River is within the spawning duration range reported for other northern latitudes.

The strategy of extended spawning periods is likely an adaptation that helps ensure reproductive success at the population level where the spawning environment is frequently subjected to random disturbances, such as temperature and water level fluctuations. During the spring of 2001, water temperature in Woods Pond increased to above 15.5°C near the beginning of May. Following this initial warming, water temperatures fluctuated above and below 15.5°C during the last half of the month, although water temperatures remained relatively close to 15.5°C throughout this period. Active nests were observed continuously during this period of temperature fluctuation. Kramer and Smith (1962) noted that a sharp drop in water temperature followed by increasing temperatures triggered renewed spawning activities.

It is likely that spawning occurred prior to the first survey date on May 10, 2001. An analysis of mean daily water temperature in the Housatonic River indicated that water temperatures dramatically increased over a four-day period, from approximately 11°C on April 29 to over 15.5°C (temperature threshold for largemouth bass spawning) on May 2. Because largemouth bass can take from one to five days between nest building and spawning (Carr 1942), it is possible that nest building and spawning had occurred in the first several days following the increase in water temperature and before our first survey.

Largemouth bass in the Housatonic River were observed to spawn in relatively shallow water near the shoreline of calm backwater areas. As noted in Section 5.4.3, we observed a dramatic change in water levels at a number of the spawning sites in conjunction with a high flow event in early June 2001. Over this period, water levels in some locations fluctuated by more than 1 ft, resulting in shoreline areas that were inundated and then dewatered as flow levels decreased. Water level fluctuations in the spring are common and are likely a typical abiotic factor that affects largemouth bass year class strength on the Housatonic River. Depending on the magnitude, water level fluctuations during the spawning period can result in nest abandonment or nest dewatering. Nest abandonment has been speculated to be more directly influenced by wave action and temperature fluctuations, which result from fluctuating water levels (Summerfelt 1975).

The highest density of nests observed at one index site on the Housatonic River was approximately 3.0 nests/100 meter of shoreline, although average densities across all index sites during the spawning period ranged from 0 to 1.24 nests/100 meter. Based on a maximum of 30 nests counted on one day by Kramer and Smith (1962) in an approximately 535-acre Minnesota lake, we estimated a nest density of 0.57 nests/100 m for that lake. However, this estimate assumes an even distribution of nests around the perimeter of the lake, which could be an underestimate of localized densities, since largemouth bass tend to congregate their nests in preferred areas (Carr 1942). Our observations indicated, similarly, that largemouth bass in the Housatonic River built their nests in localized areas within larger areas of potentially suitable habitat.

6.3.2 Hatching Success and Brood Observations

Quantitative estimates of egg-to-fry or nesting success could not be made for individual nests, due to difficulties in relocating individual nests on subsequent survey dates. However, the combination of nest and brood observations, growth rates, and young-of-year CPUE provides evidence of successful spawning for the Housatonic River largemouth bass population. In fact, our collection of a diverse assemblage of young-of-year species in combination with observations of nesting and brooding centrarchids species indicates that several species are successfully reproducing in the Housatonic River.

In total, 94 observations identified largemouth bass nests that we classified as active (i.e., nests guarded by an adult bass or containing eggs, sacfry, or swim-up larvae). Of these, eggs were identified in 51 nests. In the remaining nests, either: 1) spawning had not yet occurred; 2) spawning had occurred earlier and the nest contained sacfry or swim-up larvae; 3) spawning had occurred but failed and eggs had been consumed by predators; or 4) spawning had occurred earlier and the offspring had already moved off the nest. Approximately one-half of nests with eggs contained some or all embryos that were either white and opaque (dead) or covered in fungus, presumed to be *Saprolegnia*, which is ubiquitous in freshwater systems and a common problem with bass populations (Knotek 1995; Kramer and Smith 1992). Our results showed no obvious correlation between the incidence of fungused or dead eggs and fluctuation in water temperature or flow, although other researchers noted that sharp decreases in water temperature were associated with unsuccessful nests and the presence of fungus (Kramer and Smith 1962). Interestingly, two studies noted that nests that were heavily infested with fungus sometimes also produced live sacfry (Christie and Regier 1973; Knotek 1995). We also observed one nest during our study that contained both live sacfry and eggs covered in fungus. Although we presented the incidence of nests without eggs and nests with fungus on eggs, these numbers should not be construed as measures of nesting success or failure, since we were rarely able to follow individual nests over time. Fluctuations in water level, macrophyte growth, and water clarity made it difficult to relocate nests, even when they were marked with flagging.

In addition to the nests with eggs, we observed sacfry or swim-up larval fish in 16 nests within the index sites. these included 9 nests with sacfry and 8 with swim-up larvae. Again, these numbers do not allow a quantitative determination of hatching success because we could not follow individual nests over time. Rather, we were attempting to assess whether the index sites contain evidence of successful largemouth bass reproduction.

Broods of larval largemouth bass were observed within each index site that contained active nests. We made observations of 145 broods, and collected total length measurements of separate fish from these broods. The first brood was found on May 21, 19 days after mean water temperatures increased above 15.5°C. Fish as small as 4 mm were observed in one nest in the Housatonic River, but, in general, the smallest brooding fish ranged from 5 to 7 mm. Broods containing fish in this size range were observed within the index sites until June 18. On this same date, the largest young-of-year fish collected were 31 mm, probably from broods that hatched one month earlier. The presence of broods within all index sites that contained active nests provides evidence of successful largemouth bass reproduction.

During the surveys, we also observed hundreds of other active centrarchid nests within the index sites. Broods of sunfish and yellow perch were observed in many of the backwater areas confirming successful reproduction of those species.

6.3.3 Growth Rates of Young-of-Year Largemouth Bass

Growth rates of larval and fingerling largemouth bass are influenced by hatch date, with early-hatching fish exhibiting a higher growth rate compared to late-hatch fish sampled at the same age (Phillips et al. 1995). Because largemouth bass in the Housatonic River spawn over an extended period, variable growth rates between early and late-hatch fish may have resulted in the observed large range of young-of-year sizes (50 to 120 mm, average of 76.2 mm) at the end of the growing season. Average growth rates during 2001 were estimated to be 0.20 mm/day during the first two weeks following swim-up (May 21 through June 3), 0.37 mm/day in the next two weeks (June 4 through June 17), 1.00 mm/day during June 18 through July 1, and 1.42 mm/day during the period July 2 through July 11. The growth rate averaged over the first 8-weeks was 0.85 mm/day. These growth rates were strongly correlated with river water temperatures. Early-stage growth rates under laboratory conditions range from 0.19 to 0.99 mm/day at constant water temperatures from 15.2 to 24.9°C (Coutant and DeAngelis 1983). In 2000, measurements of young-of-year largemouth bass in the Housatonic River indicated an average growth rate of 0.64 mm/day between July 2 and August 1.

Few estimates have been made of early life-stage growth rates for largemouth bass outside of the laboratory. However, the calculated growth rates in the Housatonic River fall within the estimated growth rates of 0.5 to 1.04 mm/day for largemouth bass in North Carolina (Phillips et al. 1995) and 0.71 to 0.84 mm/day for largemouth bass in Minnesota (Kramer and Smith 1960).

Kramer and Smith (1960) calculated approximate growth rates for fish in Minnesota after brood dispersal until the end of the growing season as ranging from 0.22 to 0.44 mm/day. Using the average size of young-of-year fish collected in October 2001 in the Housatonic River (76.2 mm), the average growth rate of largemouth bass in the Housatonic River following brood dispersal (estimated as 28 mm on July 1) was 0.47 mm/day, with a range from 0.21 to 0.89 mm/day for fish that were 50 or 120 mm on October 11.

More estimates are available for comparing the total length calculated for young-of-year largemouth in the Housatonic River at the end of the growing season. In October 2001, the average size of Housatonic River young-of-year largemouth bass was 76.2 mm, with some at least as large as 120 mm (range of 50 to 120 mm). The average size is similar to, although somewhat less than, the average 78.7 mm total length attained by young-of-year largemouth bass in Micajah Pond, Massachusetts (Grice 1959), and the average 85 mm total length calculated for populations across Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and

Pennsylvania (Carlander 1977). The average length of 76.2 mm is also less than the average of 93 mm for young-of-year fish in Dryden Lake, New York (Green 1982) or the 97 and the average of 102 mm for young-of-year largemouth bass observed in Quabbin Reservoir, Massachusetts (McCaig and Mullan 1960). Because growth rates appear comparable to other systems, the smaller total length achieved in the Housatonic River in the fall may reflect a shorter growing season than for most other largemouth bass systems (as the Study Reach is near the northern limits of largemouth bass distributions), in combination with differences in physical habitat characteristics and differences in local climate and topography.

Scale analysis indicated that there was a wide range of total lengths for young-of-year fish, with some fish more than twice as large as the smallest fish. The presence of a bimodal size range of in the young-of-year population is likely related to differences in growth rates between early- and late-hatch fish (Miller and Storck 1984; Phillips et al. 1995). Interestingly, scale analysis indicated that one 2-year old fish in the Housatonic River was only 100 mm total length. Although this is an apparent anomaly, 2-year old fish as small as 130 mm have also been collected from Threemile Pond in Sheffield, Massachusetts (Smithwood 1999).

6.3.4 Catch-Per-Unit-Effort

The observed patterns of young-of-year CPUE among three different habitat types (backwater, transition, and main channel) were consistent between 2000 and 2001. Largemouth bass and other fish in the Housatonic River are expected to exhibit habitat partitioning. For example, the calculated CPUE rates support the common assumption that largemouth bass are typically found near structural cover, such as downed wood or within dense beds of aquatic macrophytes. Young-of-year bass were collected in the highest numbers from or adjacent to the areas in which spawning occurred. These were backwater or transition areas contiguous with the main channel and which contained abundant aquatic vegetation.

Electrofishing-based CPUE estimates have been used to generate effective measures of habitat use by largemouth bass (Sammons and Bettoli 1999), and are used as a common index of largemouth bass population densities (Coble 1992; McInerny and Degan 1993). CPUEs calculated for young-of-year bass in the Study Reach at the end of each growing season were higher in 2001 (overall average of 0.54 fish/min) than in 2000 (overall average of 0.30 fish/min). In both years, CPUEs were higher in backwater and transition areas than in the main channel. For example, habitat-specific averages in 2001 ranged from 0.16 fish/min in main channel areas to 1.01 fish/min in backwater areas. These variations in CPUE estimates indicate that young-of-year were most abundant in nursery habitats (backwaters), and also indicate differences in year class strength between years. These sorts of variations in population abundance between habitat types and year classes are typical of many freshwater fish species. Although published estimates of young-of-year largemouth bass CPUE estimates are limited, the range of average CPUE estimates for the Housatonic River falls within the ranges reported for other systems (Kohler et al. 1993, 0.13 to 1.34 fish/min; Jackson and Noble 1995, 0.2 to 2.2 fish/min). Our calculated CPUEs for young-of-year bass in the Housatonic River suggest that conditions during the 2001 spawning, incubation and larval and fry rearing periods afforded a higher survival than in 2000, resulting in the potential development of a stronger year class.

6.4 FACTORS INFLUENCING YEAR CLASS STRENGTH

The results of the environmental conditions monitoring suggest that largemouth bass production in the Study Reach of the Housatonic River is influenced by a suite of interrelated, largely climatic, density-independent factors other than PCBs. These include streamflow and associated water levels within backwater areas, and water temperature. In addition, it is likely that cloud cover and dissolved oxygen concentrations influence distribution and year class strength.

6.4.1 Streamflow

Streamflow conditions can influence the success of largemouth bass spawning, egg incubation, and fry survival. In 2000, highly variable flow conditions occurred throughout the spring and summer (Figure 5-24). These included flood conditions during early spring (early June) shortly after the first evidence of spawning activity, as well as storm-related high flows occurring in July and August when largemouth bass larval fish and fry would have been present. We believe the early spring high-flow event may have temporarily deterred spawning activities for a period of time, perhaps as a result of the combination of physical disturbance (high velocities) and perhaps more importantly, reductions in water temperature below the 15.5ºC threshold. Kramer and Smith (1962) noted a cessation in largemouth bass spawning activity in response to sharp reductions in water temperature, and Raibley et al. (1997) reported that weak year classes were produced in years when water levels fluctuated during the spawning period. Although overbank flows in a river with a wide floodplain, such as the Housatonic River, may provide increased forage and cover for juvenile fish (Raibley et al. 1997; Kohler et al. 1993; Bayley 1995), the timing of a flood pulse may be critical to determining whether it results in beneficial (increased growth and survival of fingerlings) or adverse (disrupted nesting and survival of embryos and larval fish) effects to that year class.

Flow conditions in 2001 were more stable than in 2000, and were substantially lower during the nesting, egg incubation, and larval and fry rearing periods (Figures 5-23 and 5-24). The one exception occurred in June 2001 when a short duration high-flow event resulted in fluctuating water levels and subsequent dewatering of shoreline areas in backwater habitats. Water depths over a number of nests we had identified during earlier surveys were severely reduced (some nests were essentially dewatered), presumably resulting in nest abandonment. However, the overall flow conditions in 2001 were more stable and we believe more conducive to successful nest construction, larval hatching, and fry survival. The increased abundance in young-of-year largemouth bass in 2001 supports this contention.

6.4.2 Water Temperature

Water temperature has been shown to be an important environmental condition associated with the initiation and success of largemouth bass spawning. Water temperatures are most importantly influenced by ambient air temperature, cloud cover, and streamflow conditions. Water temperatures were generally cooler during 2000 than in 2001 and never attained 25ºC, the optimal temperature for largemouth bass growth (Coutant and DeAngelis 1983). In contrast, water temperatures in 2001 were much warmer and periodically exceeded 25ºC in a number of locations from June through August (Appendix E). The higher young-of-year growth rates of largemouth bass in 2001 versus 2000 is likely attributable to these differences in measured water temperatures.

6.4.3 Dissolved Oxygen

Dissolved oxygen is critical for embryo and larval development and for growth and survival of largemouth bass once they leave the nest. Largemouth bass reproductive success depends on parental care provided by the adult male. While the male guards the nest, fin movements create water currents over the developing embryos, which refreshes the local oxygen concentration. Free swimming largemouth bass have been observed to avoid waters with dissolved oxygen concentrations lower than 3 mg/L (Spoor 1977), although fry can apparently temporarily withstand oxygen concentrations as low as 1 mg/L during the morning hours in mid-summer with no apparent mortality (Kramer and Smith 1962). On the other hand, oxygen concentrations as low as 4 mg/L can impair the growth rate of juvenile largemouth bass (Stewart et al. 1967).

In the backwater areas of floodplain rivers, bacterial and plant respiration can exceed primary production, resulting in reduced levels of dissolved oxygen (Fontenot et al. 2001) particularly in the absence of light (at night or during overcast days). In addition, when these plants senesce at the end of summer, bacterial decomposition could result in anoxia (no dissolved oxygen) in backwater areas. Backwater areas and embayments in the Housatonic River (including Woods Pond) typically become covered with thick mats of algae as the summer progresses and so are susceptible to low DO conditions.

Wide diurnal fluctuations in DO were documented in 2001 within three backwater areas (OM8, UWP and UWP2) used for spawning by largemouth bass (Figure 4-6). Such extreme fluctuations are a natural consequence of primary production, respiration, and decomposition. The largest diurnal fluctuations in DO were associated with the nearshore sites, where fluctuations in excess of 11-12 mg/L were common. Dissolved oxygen concentrations consistently reached the lowest values in the middle areas of the backwater sites, with extended periods of anoxia noted at all three locations. Of the three locations, UWP-M exhibited the highest percentages of values ≤ 5 mg/L (68.2%), ≤ 3 mg/L (58.5%), and ≤ 1 mg/L (39.2%). The occurrence of DO levels below the threshold levels for largemouth bass growth and survival occurred most frequently in July and August. Monitoring results confirm that the main channel sites experienced relatively few DO depressions below 1 mg/L and these were limited to the UWP site. Relatively constant DO concentrations in the main channel were expected, since the mainstem sites are flowing water and hence generally less sensitive to diurnal cycles of photosynthesis and respiration that occurs in ponded water areas.

July through September is a biologically sensitive period for bass reproduction and early-life stage survival. Thus, despite evidence of a strong 2001-year class, it is likely that brooding fish experienced localized and/or temporarily stressful and potentially lethal DO concentrations. Diurnal cycles of DO concentrations in monitored backwater nursery areas frequently fluctuated between supersaturation to lethal levels. During overnight minnow trap sets in June and July 2001, dead young-of-year largemouth bass were found on 3 occasions (6/26/01 in NLBW3; 6/26/01 in OM8; and 6/27/01 OM2). Each of these fish exhibited a gaped mouth, which is a typical symptom of low DO (Carlson and Siefert 1974). A recent study on larval fish abundance in backwater areas indicated that although there were few fish in areas with low DO levels, abundant fish were found immediately following a return to high DO (Fontenot et al. 2001). These researchers concluded that fish moved into refugia areas of higher DO concentrations. The magnitude of a given year class is, therefore, likely influenced by both the ability of fish to sense and avoid areas of low DO (hypoxia), and the availability and areal extent of suitable habitat refugia. Whitmore et al. (1960) determined that largemouth bass exhibited a strong avoidance response to DO concentrations ≤ 1.5 mg/L. Locations of DO refugia in the Housatonic River are most likely proximal to or within transitional areas to the main channel flow. These areas represent prime habitat for a variety of adult predatory fish, including largemouth bass, rock bass, northern pike, chain pickerel and yellow perch. Hence, in addition to directly impacting the survival of larvae and fry, extended periods of hypoxia may force young fish into areas where the risk of predation is much higher.

6.4.4 Cloud Cover

Cloud cover or overcast conditions influence air and water temperatures, as well as the level of photosynthesis, which in turn affects the magnitude and duration of diurnal shifts in dissolved oxygen. The percent cloud cover was greater in 2000 than in 2001 during July, August, and September. These months represent a biologically sensitive period for largemouth bass early-life stage survival. We believe that the greater cloud cover in 2000 likely resulted in diurnal DO sags in the backwater nursery areas, which were greater in magnitude, duration, and areal extent than those measured during 2001. Such conditions may have resulted in a weaker 2000-year class as evidenced by the smaller CPUEs of young-of-year largemouth bass in the fall of 2000 than in 2001.

6.4.5 Overwinter Conditions

The size and structure of largemouth bass populations are also be influenced by conditions experienced beyond their first growing season. For example, several studies have focused on variable overwinter survival of young-of-year, or recruitment to age 1. The studies have indicated that overwinter mortality mostly affected smaller-sized YOY fish, and hence afforded an overwinter survival advantage to YOY largemouth bass that had hatched early in the year and grew larger (Aggus and Elliot 1975; Bennett and Bowles 1985; Fullerton et al. 2000). A similar relationship to body size and overwinter mortality in Alabama ponds was found to be directly related to lipid reserves accumulated during the fall (Ludsin and DeVries 1997). In contrast, other studies have not observed size-related overwinter mortality (Kohler et al. 1993). Typically, in the northern part of their range, lakes with considerable areas too deep for aquatic vegetation are capable of supporting an overwintering population of largemouth bass (Carlander 1975).

Overwintering patterns of young-of-year and juvenile and adult largemouth bass in the Housatonic River are unknown. We suspect that overwintering conditions of young-of-year bass represent another important potential regulator of year class strength. Overwintering conditions and availability of refugia may also be important to the survival of adult and juvenile largemouth bass (and other species), as has been shown by Carlson (1992) in the Hudson River.

6.5 FISH COMMUNITY

The fish community in the Housatonic River Study Reach is more representative of a Massachusetts lake than a Massachusetts river. The large number of species associated with lakes and ponds that were found in the Study Reach was not unexpected, considering that the upper 10-mile reach of the Housatonic River is relatively flat, and contains numerous backwater areas, and that approximately 5 miles of river are impounded behind Woods Pond Dam. In New England, lakes are typically dominated numerically by bluegill in the south and yellow perch in the north (Whittier 1999). The Housatonic River in the Study Reach was dominated numerically in 2001 by yellow perch, many of which were young-of-year. Electrofishing in 2000 indicated a community dominated by bluegill and pumpkinseed. Yellow perch, bluegill, and pumpkinseed are typically considered to be "pond" fishes (McCabe 1943).

A compilation of species found in the river and its tributaries during several separate studies (Chadwick & Associates 1994) listed 39 species, 25 of which were observed by R2 in 2000 and 2001. In general, species that were collected in the major branches and tributaries, but which were not collected the Study Reach during our surveys, were fish species closely associated with gravel-bottomed reaches, such as minnows, dace, and the tessellated darter, or fish that require cooler water temperatures, such as the trout species.

The Study Reach of the Housatonic River contained a large proportion of piscivorous, or top carnivore species, such as northern pike, chain pickerel, yellow perch, and largemouth bass. The presence of abundant top carnivores means that abundant prey fish are also present, which was the case in both the 2000 and 2001 surveys. Large numbers of predaceous species have been used to indicate a healthy and trophically diverse fish assemblage in streams (Karr et al. 1986). A study of 55 lakes in southern New England indicated also that it was not uncommon for piscivores to be dominant in most lakes (Whittier 1999). Although efforts have been made to use community attributes to rank New England streams and lakes in comparison to minimally impacted regional reference sites (Halliwell et al. 1999; Whittier 1999; Bain and Meixler 2000), no standard method has been proposed and validated. Because the Study Reach of the

Housatonic River has many lake-like characteristics, caution would be needed if the fish community in this reach were compared with target or reference fish communities from other regional rivers, which may be more representative of rivers without extensive backwaters and impoundments.

6.6 CONCLUSIONS

The results of this study provide information concerning the largemouth bass population (and other fish communities) within the Study Reach of the Housatonic River. The major findings and conclusions of this study are:

1. The largemouth bass population in the Study Reach of the Housatonic River is self-sustaining.

    - Largemouth bass spawning habitat was abundant in backwater areas and embayments within or directly connected to the mainstem river.
    - Largemouth bass spawning was documented in 15 index sites extending from New Lenox Road to Woods Pond.
    - Broods of larval largemouth bass were observed in all index sites that contained active nests. The first brood in 2001 was found on May 21, 19 days after mean water temperatures increased above 15.5°C. A total of 145 broods were observed within the index sites between May 21 and July 4, 2001.
    - Free-swimming fry as small as 4 mm were observed in one nest in the Housatonic River, but, in general, the smallest brooding fish ranged from 5 to 7 mm. Fish less than 20 mm were found in broods containing at least 1000 larval fish. Fish between 20 and 30 mm were typically found in broods containing approximately 100 fish.
    - At the end of the growing season in 2000 and 2001, young-of-year largemouth bass were most abundant in backwater (nursery) habitats and in transitional habitats located between the backwaters and the main channel.

2. The largemouth bass population in the Study Reach of the Housatonic River is not dependent on tributary recruitment.

    - The majority of tributaries (Felton Brook, Roaring Brook, Mill Brook, and Sackett Brook) contained lotic-type habitat unsuitable for bass spawning or rearing and are not considered as possible sources of recruitment to the largemouth bass population in the river.

3. Attributes of reproduction, growth, and population structure of the largemouth bass population in the Study Reach of the Housatonic River are similar to largemouth bass populations in other systems.

    - Average growth rates of young-of-year bass during 2001 were estimated to be 0.20 mm/day during the first two weeks following swim-up (May 21 through June 3), 0.37 mm/day in the next two weeks (June 4 through June 17), 1.00 mm/day during June 18 through July 1, and 1.42 mm/day during the period July 2 through July 11. The growth rate averaged over the first 8 weeks was 0.85 mm/day. Growth rates were strongly correlated with river water temperatures. This range of early life-stage growth rates falls within the ranges documented for largemouth bass in other systems
    - Young-of-year largemouth bass catch-per-unit-effort (CPUE) estimates in the Housatonic River were higher in 2001 than in 2000 and were also significantly higher in backwater and transition areas than in main channel areas. The between-year differences suggest that conditions during the 2001 season afforded a higher survival and thus a stronger year class in 2001, while the between-habitat differences confirm the greater abundance of young-of-year fish in the habitats in which they were spawned and reared. The range of average CPUE estimates for the Housatonic River is within the range of reported CPUEs for other systems.
    - Proportional Stock Density (PSD) estimates for both 2000 (82) and 2001 (91) were relatively high compared to the range for managed largemouth bass populations and compared to other systems, and indicate an adult population with a high proportion of large (> 300 mm), older fish. These high values are indicative of a largely unfished and unexploited largemouth bass population in the Housatonic River.
    - The relative weight (W_r) values for Housatonic River largemouth bass were consistently within or above the acceptable range of 95-105 for managed largemouth bass populations and similar to those reported for other systems. Moreover, the mean W_r value for each year across all size classes was above the standard of 100 (as a mean) for a healthy largemouth bass populations.

4. The fish community in the Study Reach of the Housatonic River is similar to fish communities that are typical of Massachusetts lakes.

    - The fish community contained a large proportion of piscivorous, or top carnivore species, such as northern pike, chain pickerel, yellow perch, and largemouth bass. Numerically, the fish community was dominated by sunfish and yellow perch. This assemblage of predator and prey species was similar to typical fish communities in New England lakes.

- During the surveys, hundreds of active centrarchid nests were observed within the index sites. Broods of sunfish and yellow perch were observed in many of the backwater areas, confirming successful reproduction of those species.
- The warm water temperatures in the summer and paucity of gravel substrate indicate that the Study Reach is not capable of supporting a self-sustaining trout population.

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APPENDIX A

Assessment of Candidate Reference Streams

CONTENTS

1. INTRODUCTION

The Housatonic River, Massachusetts has been subjected to a number of anthropogenic impacts in addition to the release of PCBs, including those that relate to other industries, urbanization, channelization, agricultural activities, and dams and impoundments. Such activities have and continue to influence the aquatic biota within the river, including important fish species. Whether and the degree to which each of the different activities (including PCBs) are affecting fish populations is difficult to determine.

In general, there are three avenues of inquiry that can be applied to assess whether a particular activity or condition (e.g., a particular contaminant) is negatively affecting a fish population or fish community within a given stream. These are: 1) the use of "control" segments within the "target" stream itself that are upstream of the zone of impact of the contaminant but are morphologically similar to the "test" stream segment; 2) the use of "reference" streams that share similar physical, hydrological, and geomorphological characteristics to the "test" stream, as well as similar anthropogenic impacts except for the contaminant(s) under evaluation; or 3) the use of existing and historical data and information obtained from a wide range of streams from which to compare fish population metrics with those in the "test" stream. The selection of a specific approach is largely dependent on the extent of available data, and the existence of suitable control segments or reference streams.

In this case, the use of an upstream control site for making comparisons of fish population characteristics was rejected due to significant differences in channel size and morphology of the upstream river segments that were not affected by releases for the GE facility. We thus undertook an evaluation of the suitability of candidate reference streams to determine whether any could be identified that could serve as reference streams for an evaluation of largemouth bass and other fish population characteristics in the upper mainstem Housatonic River. We were interested in and evaluated the reach of the river extending from Pittsfield, Massachusetts to Ashley Falls, and in particular the river reach between the confluence of the East and West branches of the Housatonic River in Pittsfield and Woods Pond Dam (the "Study Reach").

This appendix presents the results of a review and assessment of several candidate reference streams to determine whether they have sufficiently similar attributes for comparison with the upper Housatonic River. The focus of this work was the identification of one or more stream(s) whose attributes closely resembled the physical, hydrological, geomorphological, chemical, and biological characteristics of the upper Housatonic River and that was subjected to the same types and relative magnitudes of anthropogenic impacts, except for the presence of PCBs.

This assessment was conducted over a three and a half week period (March 8 through 3l, 2000), and included; 1) an initial data compilation and screening of sites; 2) a field reconnaissance and aerial flyover and videotaping of candidate sites; and 3) data analysis and reporting.

2. METHODS

2.1 Data Acquisition and Screening of Candidate Sites

Prior to conducting the field reconnaissance, R2 compiled information and data specific to the upper Housatonic River and other basins that were within the same or similar ecoregions (Omernik 1987). Specific information that was reviewed included: drainage area, mean annual flow, average summer water temperature, land use activities, basin elevation, and fish community composition. For the purposes of this assessment, the upper Housatonic River was delineated as the river and its watershed upstream of the USGS gaging station at Great Barrington, Massachusetts. The data sources used in compiling the information are listed in the references (Section 5). Both published and unpublished information were used. Much of the information were available from web sites for the U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), Massachusetts Geographical Information Systems (MASSGIS), and a report on the upper Housatonic River by Chadwick & Associates (1994).

The initial data compilation and screening consisted of identifying 10 river basins that were within the same or similar ecoregion as the upper Housatonic River (Figure 1). The Housatonic River is located within the Northeastern Highlands ecoregion (Omernik 1987). Ecoregions are generally considered to be regions of relative homogeneity in ecological systems or in relationships between organisms and their environment (Omernik 1987). Although we focused our effort on identifying potential reference streams that were within the same Northeastern Highlands ecoregion as the Housatonic River, we also considered rivers that flowed through the adjacent ecoregion to the west, the Northern Appalachian Plateau and Uplands ecoregion and the Northeastern Coastal Zone ecoregion to the east. The identified candidate systems were:

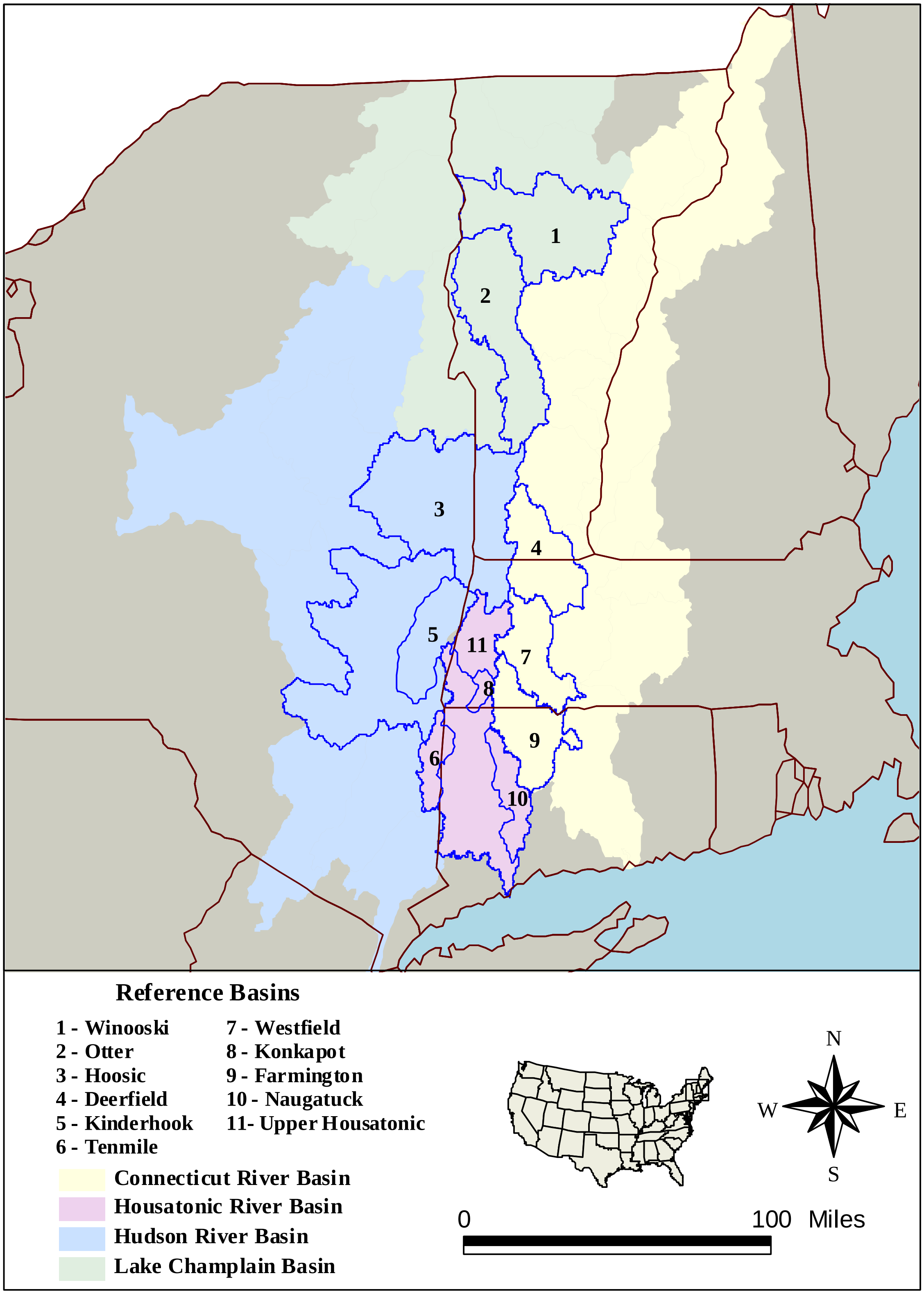

Figure 1. Locations of the upper Housatonic River and Candidate Reference Basins.

- Naugatuck River - Connecticut
- Tenmile River – New York/Connecticut
- Konkapot River - Massachusetts
- Deerfield River - Massachusetts
- Westfield River - Massachusetts
- Hoosic River – Massachusetts/New York
- Farmington River - Connecticut
- Kinderhook Creek – New York
- Winooski River - Vermont
- Otter Creek – Vermont

2.2 Field Reconnaissance and Aerial Videotaping

Each of the candidate streams was visited via a vehicle survey and/or surveyed via an aerial flyover (helicopter) during which the streams were videotaped (using a digital video camera). The aerial surveys provided a landscape perspective of each stream relative to specific habitat and channel characteristics and anthropogenic factors, such as extent of channelization, impoundments, urbanization, and industrial development, that influence each system. These surveys were completed over a 2-day period (March 21-22) in 2000.

Three of the streams listed above, Deerfield River, Westfield River, and Winooski River, were eliminated from further consideration based solely on the vehicle surveys. The channel shape of these rivers was visually deemed to be so dramatically different from the upper Housatonic River that aerial surveys were considered unnecessary.

Aerial surveys and videotaping were conducted on the upper Housatonic River, Tenmile River, Naugatuck River, Farmington River, Hoosic River, and Kinderhook Creek. An aerial survey without videotaping was completed on the lower Housatonic River downstream of Great Barrington. The aerial surveys provided a landscape perspective of each of the streams relative to specific habitat and channel characteristics, and anthropogenic factors (e.g., extent of channelization, impoundments, urbanization, and industrial development) that are influencing each system. The remaining two river systems, Otter Creek and the Konkapot River, were investigated via vehicle surveys.

3. REVIEW OF CANDIDATE REFERENCE STREAMS

A summary of attributes and characteristics compiled for each of the candidate reference streams and for the upper Housatonic River is presented in Table A-1. Addendum A-1 contains a series of templates that provide a location map, photographs (ground and aerial views), and a brief description of each of the candidate streams.

4. CONCLUSIONS

The results of our analysis indicated that it would be difficult to find a suitable reference stream that shared enough similarity with the upper Housatonic River for a comparison of fish population characteristics. The upper Housatonic River originates in the city of Pittsfield and although some sections have been confined or channelized, its predominant form is a low-gradient, meandering river with an extensive floodplain. The river contains numerous backwaters and a large section of impounded water upstream of Woods Pond Dam. In contrast, several high-gradient, coldwater tributaries drain to the river from October Mountain. The Housatonic River system and its watershed upstream of Great Barrington were determined to be unique among other candidate reference streams primarily because:

- the system is headwatered in an urban environment and is subjected to a variety of anthropogenic impacts (e.g., channelization, stormwater runoff, waste water discharge, and industrial discharge);
- the system has a number of small dams that both affect the aquatic habitats and potentially isolate populations of fish;
- the system contains both coldwater and warmwater tributary habitats combined with warmwater mainstem habitats; and
- the system incorporates a unique combination of complex palustrine-riverine habitats.

As shown in Table A-1, each of the candidate reference streams shares some similarity with the upper Housatonic River system. For example, the relative size of the drainage area of each reference stream was similar to the upper Housatonic River (282 square miles), with the exception of the Konkapot River (61 square miles) and the Hoosic River (510 square miles). The Hoosic River was further determined to not be a suitable reference stream because of concerns about PCB contamination in that river. The Konkapot River was determined to be an

Table A-1. Summary of attributes and characteristics of the Housatonic River and candidate reference streams (See notes for data source and explanations).

River	**Upper Housatonic**	**Naugatuck**	**Tenmile**	**Konkapot**	**Deerfield**	**Westfield**	**Hoosic**	**Farmington**	**Kinderhook**	**Winooski**	**Otter**
USGS Station Number	01197500	01208500	01200000	01198200	01168500	01183500	01334500	01188090	01361000	04286000	04282000
USGS Station Name	Housatonic River near Great Barrington, MA	Naugatuck River at Beacon Falls, CT	Tenmile River near Gaylordsville, CT	Konkapot River at Ashley Falls, MA	Deerfield River at Charlemont, MA	Westfield River near Westfield, MA	Hoosic River near Eagles Bridge, NY	Farmington River at Unionville, CT	Kinderhook Creek at Rossman, NY	Winooski River at Montpelier, VT	Otter Creek at Center Rutland, VT
USGS Hydrologic Unit Code: Basin	01100005	01100005	01100005	01100005	01080203	01080206	0202003	01080207	02020006	02010003	02010002
Drainage Area (sq. mi.)	282	260	203	61	361	497	510	378	329	397	307
Station Elevation (feet)	683	117	304	670	517	98	355	190	25	500	475
Slope (ft/mi)	16.5	NA	NA	NA	37.4	28.8	NA	NA	NA	NA	NA
Mean Annual Flow (cfs)	526	521	309	76	900	938	951	678	440	596	554
Baseflow (cfs)	125	105	36	25	186	160	NA	216	NA	119	135
Baseflow as Percentage of mean Annual Flow (%)	24	20	12	33	21	17	NA	32	NA	20	24
Average Summer Water Temperature (C)	21.8	22.8	NA	16.9	18.6	20.6	21.3	19.1	22.6	20.9	19.4
PCB Concerns	Y	?	N	N	N	N	Y	N	N	N	N
Ecoregion	58	59	58-60	58	58	58	58-60	58	60	58	58
Game Fish Communities	Largemouth bass, smallmouth bass, carp, chain pickerel, northern pike, trout	Smallmouth bass, trout, salmon broodstock	NA	NA	Smallmouth bass, trout	Smallmouth bass, trout	Largemouth bass, smallmouth bass, northern pike	Largemouth bass, smallmouth bass, carp, American eel, chain pickerel, northern pike	Trout	Smallmouth bass, largemouth bass, bullhead, yellow perch, carp, landlock salmon, trout, walleye	Smallmouth bass, largemouth bass, bullhead, yellow perch, carp, landlock salmon, trout, walleye

Table A-1. Summary of attributes and characteristics of the Housatonic River and candidate reference streams (See notes for data source and explanations).

River	Upper Housatonic	Naugatuck	Tenmile	Konkapot	Deerfield	Westfield	Hoosic	Farmington	Kinderhook	Winooski	Otter
Land Use	City near headwaters; mixed/city	15% residential 3% commercial 3% urban 10.5% cropland and pasture	42% agriculture 3% urban	13% agriculture 3% urban	Small town below headwaters; mixed/small towns near gaging station; no cities	No city at headwaters; larger cities near gaging station	Small industrial towns near headwaters	7.7% residential 1.2% commercial 1.6% urban 12.5% cropland and pasture	No cities, primarily forest	City near headwaters; mixed/ forested	City near headwaters; mixed/ agriculture
Percent of Drainages Area as Lake (%)	2.07	2.5	2	2.8	NA	NA	NA	2.5	NA	NA	NA
Percent of Drainage Area as Forest (%)	65	65	53	80	82	78	NA	75	NA	NA	NA

Notes:

Ecoregions - as reported in "Ecoregions of the Conterminous United States", Omernik (1987).

Slope - As defined and reported by USGS: "Main-channel slope, in feet per mile, from the gaging station to the basin divide, as measured with dividers set to 0.1 mile or with a map measurer."

Elevation - Elevation of USGS gaging station with respect to NGVD.

Percent of Drainage Area as Lake - As defined by USGS: "Area of lakes, ponds, and marshes, in percent of total drainage area, measured by planimetering or by using a transparent grid. The marsh area includes the area of wooded marshes and marshes as defined by the appropriate topographic quadrangle map symbol."

Percent of Drainage Area as Forest - As defined by USGS: "Area of forest, in percentage of the drainage area, determined from the forest cover as shown on the topographic map with the green woodland overprint using the grid method."

Mean annual flow - For period of record for each USGS station/ As reported by USGS, 50% exceedance flow used for Konkapot Station.

Baseflow - Estimated as 90% exceedance flow for each USGS station for period of record, as reported by USGS.

Average summer water temperature (C) - Average of June, July, and August measurements from USGS water quality database:QWDATA.

NA - Not assessed.

unsuitable reference stream because of its significantly smaller watershed and because the watershed is predominantly forested and lacks an urban center at its headwaters. Several of the candidate reference streams exhibited dramatically different channel shapes than the Housatonic River, such as the predominantly channelized Naugatuck River and the confined and steeper gradient channels of the Deerfield, Westfield, Farmington, and Winooski rivers. The lack of extensive backwaters and impounded areas made it unlikely that these rivers would support a fish community comparable to the Housatonic River. The Farmington River was further deemed to be an unsuitable reference stream due to the management of dams on the river to provide cooler water temperatures in the summer. Four rivers that exhibited a channel shape more similar to the meandering upper Housatonic River were Tenmile River, Kinderhook Creek, Konkapot River, and Otter Creek. However, Tenmile and Konkapot rivers and Kinderhook Creek do not have urban centers in their watersheds similar to the upper Housatonic River watershed. Otter Creek is likely influenced by the city of Rutland near its headwaters. Investigations into the fish community of Otter Creek revealed that this system is known for its salmonid and smallmouth bass populations rather than largemouth bass.

The major reasons that each candidate reference stream was considered unsuitable for comparison with the upper Housatonic River are listed below:

- Naugatuck River – Channelized stream channel
- Tenmile River – Anthropogenic impacts do not include urban center at the headwaters
- Konkapot River – Smaller drainage area and anthropogenic impacts do not include urban center at the headwaters
- Deerfield River – Confined channel and steeper gradient
- Westfield River – Confined channel and steeper gradient
- Hoosic River – Channelized stream channel and PCB concerns
- Farmington River – Confined channel shape and cooler water temperatures
- Kinderhook Creek – Anthropogenic impacts do not include urban center at the headwaters
- Winooski River – Confined channel and steeper gradient
- Otter Creek – Fish population dominated by salmonids and smallmouth bass

None of the candidate streams shared enough similarity with the upper Housatonic River system to warrant further consideration of their use as a reference stream from which to make comparisons with the upper Housatonic fish populations or fish communities.

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U.S. Geological Survey 7.5 X 15 Minute Quadrangle Map: Pittsfield East, Massachusetts: 42073-Dl-TM-025.

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ADDENDUM A-1

Location Maps, Representative Photos, and General Descriptions of the Housatonic River and Candidate Reference Streams

Upper Housatonic River Basin

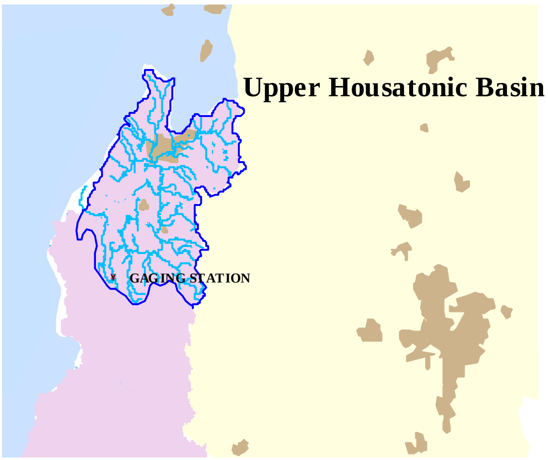

Figure A-1. Map of the upper Housatonic River Basin.

Figure A-3. Aerial photo of the upper Housatonic River Basin.

Figure A-2. Aerial photo of the upper Housatonic River Basin.

The upper Housatonic River Basin was delineated at the USGS gaging station at Great Barrington, MA (01197500). The mainstem river at this point drains 282 square miles. This basin is located within the Northeastern Highlands (58) ecoregion, as described by Omernik (1987). The largest urban center in the watershed is the city of Pittsfield located near the headwaters. The upper reaches of the river are characterized by extensive wetlands and ponded water.

Naugatuck River Basin

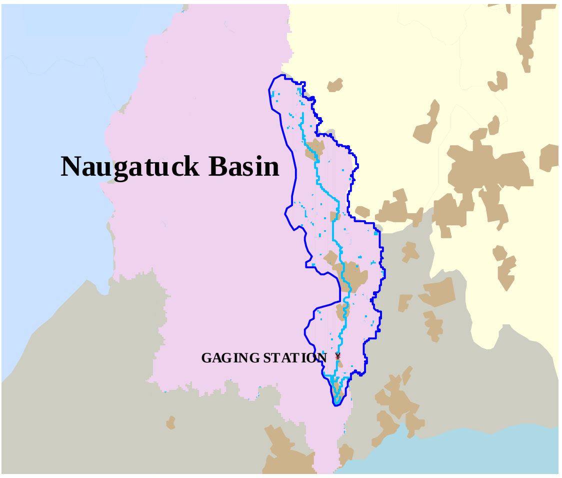

Figure A-4. Map of the Naugatuck River Basin.

Figure A-6. Aerial photo of the Naugatuck River Basin.

Figure A-5. Ground photo of the Naugatuck River Basin.

The Naugatuck River Basin was delineated at the USGS gaging station at Beacons Falls, CT (01208500). This watershed is a subbasin of the Housatonic River, located to the southeast of the Upper Housatonic Basin. This subbasin is located in the Northeastern Coastal Zone (59) ecoregion as described by Omernik (1987). The Naugatuck River drains 260 square miles, which is approximately 92 percent of the size of the upper Housatonic River Basin. The Naugatuck River is characterized by extensive industrial development along most of its length. The river has been channelized and contained within concrete banks along many sections.

Tenmile River Basin

Figure A-7. Map of the Tenmile River Basin.

Figure A-9. Aerial photo of the Tenmile River Basin.

Figure A-8. Aerial photo of the Tenmile River Basin.

The Tenmile River Basin was delineated at the USGS gaging station near Gaylordsville, CT (01200000). This watershed is a subbasin of the Housatonic River, southwest of the upper Housatonic River Basin. This subbasin is located on the edge of the Northeastern Highlands ecoregion (58), which is the same ecoregion as the Upper Housatonic River Basin. The Tenmile River drains 203 square miles, which is approximately 72 percent of the size of the upper Housatonic River Basin. There are no large urban centers in the watershed.

Konkapot River Basin

Figure A-10. Map of the Konkapot River Basin.

Figure A-12. Aerial photo of the Konkapot River Basin.

Figure A-11. Aerial photo of the Konkapot River Basin.

The Konkapot River Basin was delineated at the USGS gaging station at Ashley Falls, MA (01198200). This watershed is a subbasin of the Housatonic River, located to the southeast of the Upper Housatonic Basin. This subbasin is located within the Northeastern Highlands (58), which is the same ecoregion as the Upper Housatonic River Basin. The Konkapot River drains 61 square miles, which is approximately 22 percent of the size of the upper Housatonic River Basin. There are no large urban centers in the watershed. The upper reaches of the river are characterized by extensive wetlands and ponded water.

Deerfield River Basin

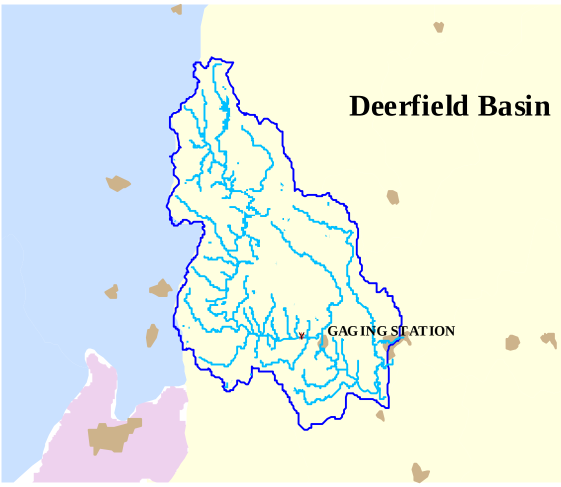

Figure A-13. Map of the Deerfield River Basin.

Figure A-14. Ground photo of the Deerfield River Basin.

Figure A-15. Aerial photo of the Deerfield River Basin.

The Deerfield River Basin was delineated at the USGS gaging station at Charlemont, MA (01168500). The Deerfield River at this location drains 361 square miles, which is approximately 28 percent larger than the size of the upper Housatonic River Basin. This basin is located within the Northeastern Highlands (58), which is the same ecoregion as the Upper Housatonic River Basin. The Deerfield River is confined within a relatively narrow valley, characterized by regulated flows, and has a relatively steep gradient.

Westfield River Basin

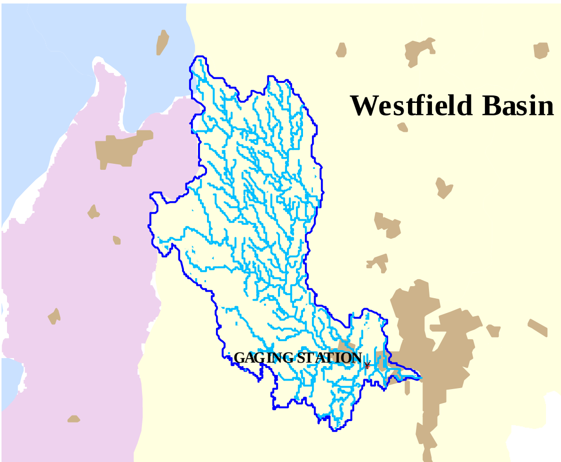

Figure A-16. Map of the Westfield River Basin.

Figure A-17. Ground photo of the Westfield River Basin.

Figure A-18. Aerial photo of the Westfield River Basin.

The Westfield River Basin was delineated at the USGS gaging station near Westfield, MA (01183500). The Westfield River at this location drains 497 square miles, which is approximately 76 percent larger than the size of the upper Housatonic River Basin. This basin is located within the Northeastern Highlands (58), which is the same ecoregion as the Upper Housatonic River Basin. The Westfield River is confined within a relatively narrow valley, characterized by regulated flows, and has a relatively steep gradient.

Hoosic River Basin

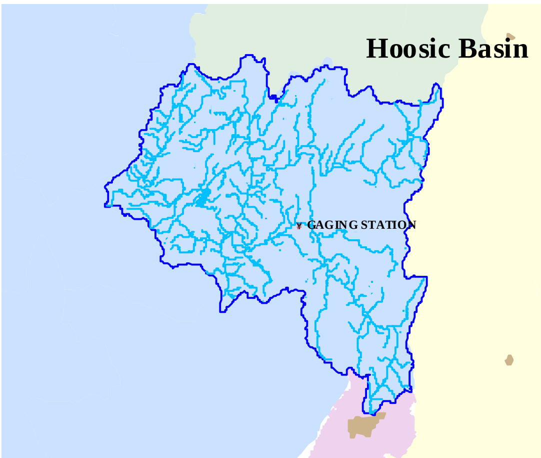

Figure A-19. Map of the Hoosic River Basin.


Figure A-20. Ground photo of the Hoosic River Basin.


Figure A-21. Aerial photo of the Hoosic River Basin.

The Hoosic River Basin was delineated at the USGS gaging station near Eagle Bridge, NY (01334500). The Hoosic River at this location drains 510 square miles, which is approximately 80 percent larger than the size of the upper Housatonic River Basin. This basin is located within both the Northeastern Highlands (58), which is the same ecoregion as the Upper Housatonic River Basin, and the Northern Appalachian Plateau and Uplands (60) ecoregion. The Hoosic River is characterized by extensively altered channel morphology through the towns of Adams and North Adams. At these locations the flow has been placed in concrete flood-control chutes. The river is reportedly contaminated with PCB from a location near the town of North Adams.

Farmington River Basin

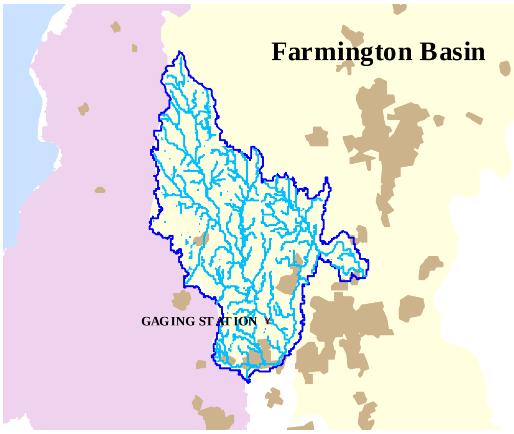

Figure A-22. Map of the Farmington River Basin.

Figure A-24. Aerial photo of the Farmington River Basin.

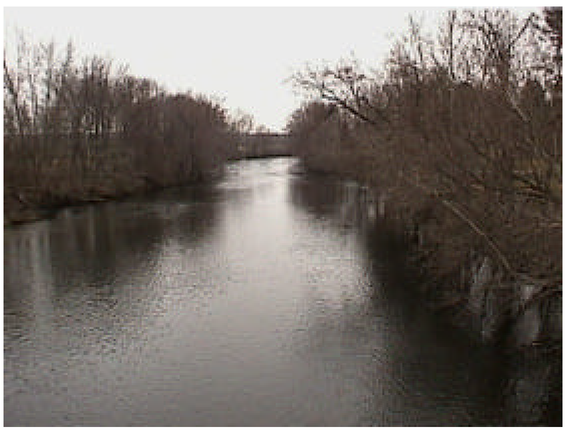

Figure A-23. Ground photo of the Farmington River Basin.

The Farmington River Basin was delineated at the USGS gaging station at Unionville, CT (01188090). The Farmington River at this location drains 378 square miles, which is approximately 34 percent larger than the size of the upper Housatonic River Basin. This basin is located within the Northeastern Highlands (58), which is the same ecoregion as the Upper Housatonic River Basin. The Farmington River is relative confined and is regulated by a series of reservoirs at its headwaters, one of which serves to maintain cool summertime water temperatures.

Kinderhook Creek Basin

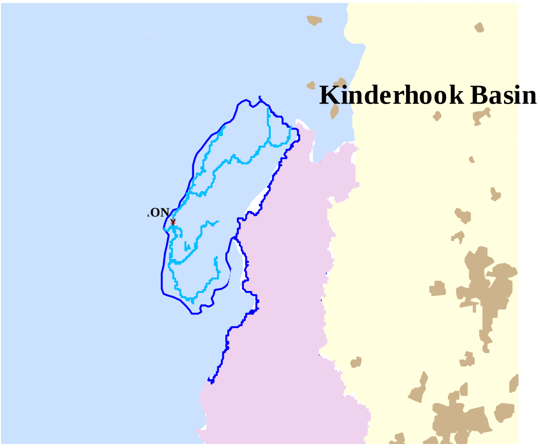

Figure A-25. Map of the Kinderhook Creek Basin.

Figure A-27. Aerial photo of the Kinderhook Creek Basin.

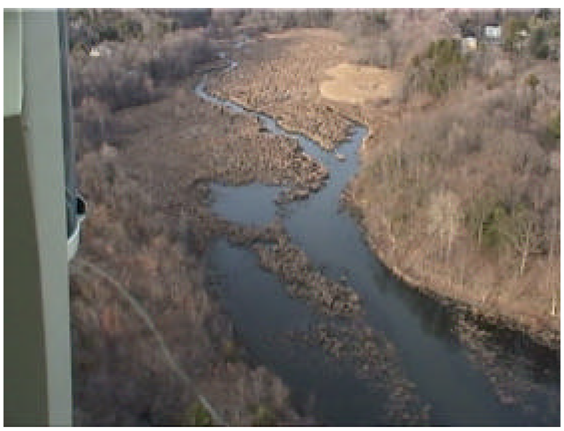

Figure A-26. Aerial photo of the Kinderhook Creek Basin.

The Kinderhook Creek Basin was delineated at the USGS gaging station at Rossman, NY (01361000). Kinderhook Creek at this location drains 329 square miles, which is approximately 17 percent larger than the size of the upper Housatonic River Basin. This basin is located within the Northern Appalachian Plateau and Uplands (60) ecoregion. Kinderhook Creek is characterized by relatively little urban development, much of the stream flows through heavily forested watershed.

Winooski River Basin

Figure A-28. Map of the Winooski River Basin.

Figure A-29. Ground photo of the Winooski River Basin.

Figure A-30. Aerial photo of the Winooski River Basin.

The Winooski River Basin was delineated at the USGS gaging station at Montpelier, VT (04286000). The Winooski River at this location drains 397 square miles, which is approximately 37 percent larger than the size of the upper Housatonic River Basin. This basin is located within the Northeastern Highlands (58), which is the same ecoregion as the Upper Housatonic River Basin. The Winooski River is characterized by a relatively mountainous watershed and a narrow floodplain near the city of Montpelier

Otter Creek Basin

Figure A-31. Map of the Otter Creek Basin.

Figure A-32. Ground photo of the Otter Creek Basin.

Figure A-33. Aerial photo of the Otter Creek Basin.

The Otter Creek Basin was delineated at the USGS gaging station at Center Rutland, VT (04282000). The Otter Creek at this location drains 307 square miles, which is approximately 8 percent larger than the size of the upper Housatonic River Basin. This basin is located within the Northeastern Highlands (58), which is the same ecoregion as the Upper Housatonic River Basin. The Otter Creek is characterized by extensive meanders and wetlands; the city of Rutland is relatively near its headwaters.

APPENDIX B

Trout Habitat Suitability Analysis for the Upper Housatonic River

CONTENTS

1. INTRODUCTION

An investigation of the suitability of the upper Housatonic River system in Massachusetts to support resident or fluvial trout populations was completed by R2 Resource Consultants (R2) in conjunction with a study on largemouth bass habitat, reproduction, and population structure. This appendix describes the study methods and results of the investigations and includes a summary of trout life histories and habitat requirements.

The purpose of this study was to: 1) complete a preliminary investigation into the suitability of the Housatonic River watershed upstream of the town of Ashley Falls to support trout; and 2) complete a more thorough investigation of trout distribution and habitat in the Housatonic River and tributaries upstream of Woods Pond Dam. The ultimate goal of these investigations was to assess if the mainstem Housatonic River from the GE facility in Pittsfield downstream to Woods Pond Dam contains suitable habitat to support self-sustaining populations of trout.

2. METHODS

In the spring of 2000, R2 conducted a preliminary evaluation of potential trout habitat available in the Housatonic River watershed upstream of the town of Ashley Falls. This evaluation included: 1) conversations with fish biologists familiar with the Housatonic River regarding fish distributions and trout management; 2) compilation of flow and water temperature data collected by the U.S. Geological Survey (USGS) and other sources; 3) identification of tributaries within the study area; and 4) observations and photographs taken during a field reconnaissance (between 20-23 March 2000) of tributaries near their mouths. The investigation focused on assessing if flow, water temperatures, and substrate in this reach of the Housatonic River was suitable to support trout. Consideration was given to the possibility that trout may move among or within distinct habitat segments, such as the mainstem, tributaries, or lakes.

During the summer of 2000, overall fish habitat conditions and fish distributions were determined as part of a study focused on largemouth bass in a section of the Housatonic River, extending approximately 10 miles from the confluence of the East Branch and West Branch of the Housatonic River in Pittsfield to Woods Pond Dam in Lenox Station, Massachusetts. The areas assessed also included the lower East, West, and Southwest branches of the Housatonic River and the tributaries that drain to the Housatonic River upstream of Woods Pond Dam. Additional measurements of habitat condition parameters (e.g., water temperature) and fish communities were completed in the lower approximately 5-mile mainstem reach from New

Lenox Road to Woods Pond Dam during the summer of 2001. The methods used for describing the habitat conditions and assessing fish distributions during 2000 and 2001 are discussed in Chapter 4 of the main document. The observations of habitat conditions and fish distributions completed during these studies were combined with the results of the preliminary investigation in the spring of 2000 to describe the habitat suitability of the upper Housatonic River to support self-sustaining trout populations. Additional information on habitat conditions and fish distributions is contained in Chapter 5 and in Appendices D, E, and F of the main document.

3. TROUT LIFE HISTORIES AND HABITAT REQUIREMENTS

The following section describes the trout species known to occur in the Housatonic River watershed and the habitat requirements that limit their distribution and production.

3.1 RANGE

Trout in western Massachusetts, including tributaries to the upper Housatonic River, are largely managed by the Massachusetts Division of Fisheries and Wildlife (MDFW) as a put-and-take fishery. In the Housatonic River basin, adult hatchery fish are released to tributaries and lakes that drain to the river. Three trout species are stocked in Housatonic waters: rainbow trout (*Oncorhynchus mykiss*), eastern brook trout (*Salvelinus fontinalis*), and brown trout (*Salmo trutta*). Technically, eastern brook trout is a char, as opposed to a trout, although all three species are in the same family, Salmonidae. For the purposes of this report, eastern brook trout are discussed as “trout.” Tiger trout are a sterile hybrid cross between brown and brook trout, which are occasionally stocked in Massachusetts.

Rainbow trout and brown trout are not native to Massachusetts. The rainbow trout is native to the Pacific Coast from Alaska to Mexico, and is raised and stocked regularly in many Massachusetts waters. The brown trout is native to northern Europe and the British Isles, and was introduced widely into many parts of the United States, beginning as early as 1883 (Pflieger 1975; Wydoski and Whitney 1979, Smith 1985). Of these three trout, the brook trout is the only native species, with an original range from Labrador south to Pennsylvania and along the Appalachian Mountains to Georgia, west to Wisconsin and Minnesota, and north to Hudson Bay (Smith 1985). Brook trout have also been widely introduced throughout the United States.

3.2 RESIDENT, FLUVIAL, AND ADFLUVIAL LIFE HISTORIES

Self-sustaining populations of rainbow, brown, or brook trout found in rivers are capable of exhibiting four different life history strategies or forms. These life history forms are classified as resident, fluvial, adfluvial, and anadromous. Because a series of impassable dams exist on the Housatonic River downstream of the study area, the anadromous (ocean-going) form is not discussed in this report. The resident, fluvial, adfluvial life histories are defined below:

- **Resident –** populations that typically reside in smaller tributaries in which they are able to complete their entire life cycle, including spawning and rearing.
- **Fluvial –** migratory populations that use different habitats and sections of rivers in order to complete their life cycle. Typically, the adult component of the population resides in larger river systems. Adults migrate upstream into smaller tributaries in which to spawn, and fry and juveniles may rear within the smaller tributaries for two to three years prior to maturation, at which time they migrate downstream and assume residency in the larger rivers. If self-sustaining trout exist in the mainstem Housatonic, it is likely that they would use a fluvial life history strategy.
- **Adfluvial –** migratory populations that use different habitats in order to complete their life cycle. Typically, the adult component of the population resides in a lake or reservoir system. Adults migrate into rivers and tributaries in which to spawn, and fry and juveniles may rear within the tributaries for several years prior to maturation, at which time they assume residency in the lake. Alternatively or in combination, the fry and/or juveniles may outmigrate directly to the lake and rear within.

There is a strong connection between fish populations and habitat diversity, both temporally and spatially. In the case of fluvial populations, although the adult phase may reside in a large river, there is a connection to smaller tributaries during migrations and spawning, and subsequent rearing of fry and juveniles.

Rieman and McIntyre (1993) noted that for some trout species, both resident and migratory forms can coexist and give rise to one another. They cited the work of Berg (1985), Foote et al. (1992), and Schmitz (1992), who demonstrated that resident-type populations of trout can retain migratory phenotypes that can express themselves under differing conditions. Rieman and McIntyre (1993) indicated that a diversity of life history strategies is important for ensuring population stability and persistence, especially given the year-to-year variability in climatic conditions, which may favor or disfavor various species and life stages.

3.3 REPRODUCTION

Rainbow, eastern brook, and brown trout are typically stream spawners although some individuals can spawn on gravel beaches where groundwater upwelling keeps the embryos oxygenated. Trout lay their eggs in nests that the females construct in gravel substrates, which are often in areas of swiftly flowing water. Rainbow trout are spring spawners; spawning occurs from March-June, and following egg incubation, the fry emerge from May to early August. Brown trout spawning occurs in the fall from October to December. Brown trout fry emerge from late November to early March, depending on the timing of spawning and water temperature. Brook trout spawning also occurs in the fall and the timing of emergence is similar to brown trout. In streams where the water temperature is near freezing in the winter, incubation for both species typically lasts most of the winter (Werner 1980). In most cases, mature adults move into headwater streams to spawn. Each of these species digs a nest, called a redd, in a gravel area relatively free of fine sediments. Eggs are fertilized in the nest externally, and then the fertilized eggs are buried and the embryos incubate in the substrate until hatching. Most trout are at least 3 years old before spawning, but some individuals can spawn as early as 1 year old (Wydoski and Whitney 1979).

3.4 Habitat Requirements

The habitat requirements for each of the three species of trout have been reviewed in separate reports prepared by the U.S. Department of Fish and Wildlife Service as part of their development of habitat suitability index (HSI) models, which use a habitat-based approach to impact assessment (Raleigh 1982; Raleigh et al. 1984, 1986). Although the HSI models assess a suite of habitat parameters, such as water quality and flow, water temperature, substrate composition, instream cover, and stream bank vegetation and canopy cover, to judge whether habitat is unsuitable or optimum, unsuitable habitat can often be determined by one limiting factor. In general, warm water temperature is likely the most important factor limiting trout distribution and production (Raleigh 1982; Raleigh et al. 1984, 1986). In this section we have summarized the most important limiting factors for trout identified in these three reports, including water temperature, dissolved oxygen, streamflow, and spawning substrates.

3.4.1 Water Temperature and Dissolved Oxygen

Trout are poikilotherms (cold blooded), and their metabolism and life history functions are closely linked to water temperatures. All trout prefer cool water throughout their life cycle. Although some trout can survive at relatively high water temperatures, most cannot survive temperatures that exceed approximately 73 to 77°F (23 to 25°C) (Bjornn and Reiser 1991). Of the three species, brown trout are the most tolerant of warm water and brook trout are the least tolerant, although all three trout species avoid water temperatures greater than 66°F (19°C) (Raleigh 1982; Raleigh et al. 1984, 1986). If possible, trout try to avoid such temperatures by moving to other areas. Optimal temperature requirements for good growth and survival of brown trout are 12 to 19°C (Raleigh et al. 1986), 11 to 16°C for eastern brook trout (Raleigh 1982), and 12 to 18°C for rainbow trout (Raleigh et al. 1984). Typical factors that can lead to altered thermal regimes in streams include removal of riparian vegetation and forest canopy, reduced water flows, and increased surface area in impoundments.

Trout require plenty of dissolved oxygen (DO) throughout their life cycle from rearing to migration to egg incubation. One result of this requirement is that trout are more likely to be found in cold flowing water, or in relatively clear, cool lakes – both of which typically contain saturated DO concentrations. Dissolved oxygen concentrations in water are directly influenced by the temperature of water (warmer water can hold less DO than coldwater). The concentrations of DO in river waters are influenced by surface agitation and resulting re-aeration that typically occurs in riffles and cascades. Reduced streamflow or low gradient glides can decrease the degree of re-aeration. Eutrophic lakes and associated cycles of photosynthesis and respiration can also result in DO concentrations lower than are typically found in less productive lakes. Dissolved oxygen in substrates where trout eggs are deposited can become reduced by an increase in fine-grained sediments that can impair intergravel flow and oxygen exchange.

3.4.2 Spawning Substrate

Suitable substrate for embryo development is composed of gravels that are small enough for the adult fish to dig a nest, but not so small that intergravel velocities and dissolved oxygen concentrations are reduced to levels that result in smothering of the embryos and developing larvae. In general, suitable gravels are between 1 and 10 cm in diameter with less than 5 percent fine sediment (Raleigh 1982; Raleigh et al. 1984, 1986). The size of the spawning female determines the optimum gravel size, with larger fish using larger gravels.

3.4.3 Streamflow

In streams, the amount of flow plays a direct role in determining the areal extent of habitats that can be used by adult fish for spawning. The magnitude and timing of streamflow also has an influence on the quality of the spawning gravels and on maintaining suitable conditions for the incubating embryos and larval fish.

The amount of flow in a river has a direct influence on the distribution and quantity of water depths and associated velocities that are most often utilized by fry and juvenile trout. Chapman (1966) considered velocity to be perhaps the more important of the two factors, noting that without suitable velocities, no fish will be present. Studies have shown that trout fry typically use velocities less than 0.3 ft/sec (Chapman and Bjornn 1969; Everest and Chapman 1972; Griffith 1972). As fish grow, they become stronger and are often associated with higher water velocities (Smith and Li 1983). Shifts in velocity usage by fish have been observed seasonally, presumably in response to water temperature changes. The shifts are generally from higher velocities in the summer feeding periods to lower velocities during the winter holding periods (Chisholm et al. 1987; Tschaplinski and Hartman 1983).

Water depths used by trout fry and juveniles can be quite variable depending on the factors associated with such depths, e.g., substrates, cover, food, velocity, and predator density. Newly hatched fry often utilize the extreme edge habitats of a stream where velocities are low and there are few predators. As fish grow, they are capable of using deeper waters with limits of use generally related to some other interrelated parameter such as water velocity.

Without sufficient streamflow in a stream or river, adult fish cannot successfully migrate upstream to spawning areas. The quantity of such flows necessary for passage has been evaluated by a number of investigators who have assessed passage requirements based on the percentage of the average annual flow (Baxter 1961) and on specific water depths and water velocities through which adult fish are capable of migrating (Thompson 1972). For trout, these were defined in terms of minimum water depths and maximum water velocities and ranged from 0.4 to 0.8 ft, and 4.0 to 8.0 ft/sec respectively (Thompson 1972). These represent minimum depth and maximum velocity criteria and must be evaluated in the context of applying such to stream reaches that pose as potential migration barriers, such as shallow riffles.

In general, the degree to which streamflow conditions may become problematic to upstream migrating adults relates directly to their migration period. Thus, species that migrate during the spring under high streamflow conditions (e.g., rainbow trout) would be less likely to encounter flow related impediments, than species that migrate later in the year, such as brown and brook trout.

4. OBSERVATIONS OF TROUT IN THE HOUSATONIC RIVER AND TRIBUTARIES

Trout are stocked annually or biannually in several of the lakes and tributaries that drain to the Housatonic River, including the Southwest and East branches. Although rainbow trout are stocked most heavily, brown and brook trout are also stocked. The stocked fish are hatchery raised, and are released as catchable fish for the angling population. In the lower reaches of the Housatonic River, the Connecticut Department of Environmental Protection stocks the Housatonic River with brown trout in a designated "trout management area." In this part of the river, water temperatures and flows are manipulated by the upstream dam operators for the benefit of catch and release anglers. Table B-1 lists the lakes and tributaries that drain to the upper reaches of the Housatonic River that are stocked with trout (MDFW 2000).

A draft compilation of published and unpublished data indicates that no wild populations of rainbow trout are known to be present in the Housatonic River basin (pers. comm. with K. Hartel). In the spring and summer of 2000, R2 collected only one rainbow trout, an adult hatchery fish in the East Branch of the Housatonic River. Eroded or worn fins are typical identifying marks on hatchery fish. No juvenile or wild-spawned rainbow trout were observed in the mainstem river or the East or West branches. Wild-spawned adult and juvenile eastern brook trout were collected in several of the tributaries upstream of Woods Pond Dam including Felton Brook, Roaring Brook, and Mill Brook. Wild-spawned brown trout were observed in Mill Brook. No trout were collected in the fall of 2000 or 2001 in the mainstem and backwaters of the Housatonic River.

5. OBSERVATIONS OF TROUT HABITAT IN THE HOUSATONIC RIVER AND TRIBUTARIES

During the spring and summer of 2000, R2 conducted aquatic habitat surveys of the mainstem Housatonic River and several of its tributaries upstream of Woods Pond Dam. Results of these surveys indicated that the mainstem river would not likely support self-sustaining populations of any trout species due to elevated summer water temperatures and lack of spawning habitat. Areas with suitable water temperatures and gravels to support trout populations included Mill, Roaring, and Felton brooks, which each flowed from October Mountain to the Housatonic River.

Sustained high water temperatures in the mainstem Housatonic River are unsuitable to support trout during the summer. Continuous water temperature recorders (Onset Optic Stowaway®

Table B-1. Lakes and tributaries in the upper Housatonic River basin that are regularly stocked with trout (MDFW 2000).

Lake	**Tributary**
Onota Lake	Southwest Branch of the Housatonic River
Lake Pontoosuc	Smith Brook
Plunkett Reservoir	Lulu Cascade Brook
Goose Pond	East Branch of the Housatonic River
Laurel Lake	Sackett Brook
Mansfield Lake	Wahconah Falls Brook
Stockbridge Bowl	Bennett Brook
Lake Buel	Goose Pond Brook
Lake Garfield	Hop Brook
York Pond	Greenwater Brook
	Beartwon Brook
	Washington Mountain Brook
	Williams River
	Cone Brook
	Green River
	West Brook
	Yokun Brook
	Larrywaug Brook
	Konkapot River
	Hubbard Brook
	Iron Works Brook
	Umpachenne Brook

Temp) were used to measure water temperatures (ºC) at 12 locations in the Housatonic River system upstream of Woods Pond Dam, including four in the mainstem river, one in the East Branch, one in the West Branch, and separate recorders in six small tributaries. These recorders measured water temperature every 30 minutes during May through September 2000. In 2001, water temperature recorders were used in the East and West branches and in 10 locations within the mainstem and backwaters of the mainstem Housatonic River.

Monitoring results indicated that daily average water temperatures in the mainstem and East and West branches exceeded 19ºC for sustained periods of time during the summers of 2000 and 2001, as shown in Appendix E, Figures E-1 through E-8. In contrast, water temperatures were much cooler in the tributaries draining October Mountain (Felton, Mill, and Roaring brooks) (Appendix E, Figures E-3 and E-4).

In addition to unsuitable summertime water temperatures, substrates in the mainstem Housatonic River are dominated by sand and other fine-grained materials. Trout spawn in gravel substrates that are generally free of fine-grained sediments (Raleigh 1982; Raleigh et al. 1984, 1986). The sandy-bottomed mainstem river upstream of Woods Pond Dam provides little suitable habitat for successful trout spawning and incubation.

6. CONCLUSIONS

The investigations of the suitability of the upper Housatonic River system (above Woods Pond Dam) to support self-sustaining trout populations resulted in several key observations:

1. Three species of trout (rainbow, brown, and brook) are stocked regularly in lakes and tributaries, which drain to the Housatonic River.
2. Naturally spawned eastern brook trout were collected by R2 in Felton Brook, Roaring Brook, and Mill Brook. Naturally spawned brown trout were observed in Mill Brook. No naturally spawned or hatchery-raised trout were collected by R2 from the mainstem Housatonic River.
3. Habitat conditions of the mainstem Housatonic River are not suitable to support adult or juvenile trout during the summer due to elevated water temperatures.
4. The mainstem Housatonic River does not contain suitable trout spawning habitat.

For these reasons, we conclude that the upper mainstem Housatonic River above Woods Pond Dam does not likely support a viable self-sustaining trout population.

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APPENDIX C

Stevens/Greenspan DO Probe Reliability Assessment

APPENDIX C

Investigation of the Reliability of Stevens/Greenspan Units

The Steven/Greenspan DO sensor is based on new, improved diffusion cell and electrode technology that enables more reliable readings than conventional, polarographic/membrane oxygen electrodes. The Stevens/Greenspan DO sensor, however, has a much greater response time to changes in ambient DO than does alternative membrane/electrode based equipment. The manufacturer quotes that a 45- to 60-minute response time is needed to reach from 90 to 98% of a new level when large, rapid changes in DO occur. Therefore, although spot measurements of dissolved oxygen, pH, and temperature were also collected with a portable hand-held datasonde Hydrolab® Quanta® System, the DO readings obtained by each system were are not used for calibration checks. In addition, to prevent fouling the Hydrolab membrane in the soft substrates, all Hydrolab readings were taken at approximately 10 inches below the water surface, which on occasion may have measured stratified water column concentrations in comparison with readings obtained at the deeper portion of the water column with the Stevens/Greenspan DO probes.

The Stevens/Greenspan DO probe is designed to be less susceptible to fouling during prolonged periods of deployment. However, because the Stevens/Greenspan DO probe technology is relatively new, two analyses were completed to assess the reliability of the DO concentrations recorded by these units during relatively long-term deployments in the Housatonic River. The schedule of probe deployment, retrieval, and *in situ* cleaning is shown in Table C-1.

Graphical analysis indicated that measurements of DO one-half hour prior to and approximately one hour following *in situ* cleaning (on July 26, August 1, and August 8) tended upwards and were significantly different (paired t-test, $p=0.003$, $df=23$), whereas a comparison of measurements collected at the same times on each day prior to the cleaning events showed no trend and were not significantly different (paired t-test, $p=0.5$, $df=23$) (Figure C-1).

The possibility exists that the action of rowing up to the probes, removing the probes from their position to clean them, and then replacing the probes disturbed a stratified water column. If this were the situation, then DO concentrations and temperature concentrations would be expected to both increase due to water column mixing regardless of the influence of cleaning. To test this possibility, relative changes in water temperatures before and after cleaning the probes were graphed in the same way that relative changes in DO concentrations were graphed (Figure C-1).

Table C-1. Schedule listing the dates and times that the Stevens/Greenspan probes were deployed, pulled, and cleaned by location during 2001 in the Index Reach of the Housatonic River, Massachusetts.

Location	Serial No.	Probe[1] No.	Date	Time	Action	Location	Serial No.	Probe No.	Date	Time	Action
OM-8 Main Channel	12406	8	6/12/01	14:00	Deployed	OM-8 Middle	12404	3	6/12/01	13:30	Deployed
			6/18/01	11:30	Pulled				6/18/01	11:30	Pulled
	12404	3	6/19/01	13:00	Deployed		12403	2	6/19/01	13:30	Deployed
			6/25/01	12:00	Pulled				.		
			6/26/01	15:00	Deployed				.		
			7/4/01	10:00	Pulled				7/4/01	10:30	Pulled
	12404	3	7/5/01	10:00	Deployed		12403	2	7/5/01	10:30	Deployed
			7/9/01	9:30	Cleaned				7/9/01	10:00	Cleaned
			7/11/01	11:00	Pulled				7/11/01	11:30	Pulled
	12405	4	7/12/01	11:10	Deployed		12401	5	7/12/01	11:18	Deployed
			7/19/01	11:30	Pulled				7/19/01	11:38	Pulled
		4	7/20/01	11:42	Deployed		12401	5	7/20/01	11:57	Deployed
			7/26/01	13:43	Cleaned				7/26/01	13:49	Cleaned
			8/1/01	9:14	Cleaned				8/1/01	9:23	Cleaned
			8/8/01	9:07	Cleaned				8/8/01	9:14	Cleaned
			8/15/01	9:38	Pulled				8/15/01	9:48	Pulled
			.				12405	4	8/16/01	8:02	Deployed
			.						8/24/01	11:24	Cleaned
			.						9/20/01	10:25	Cleaned
			.						9/29/01	10:56	Pulled
	12405	4	9/30/01	10:59	Deployed		12407	6	9/30/01	11:05	Deployed
			10/11/01	12:00	Pulled				10/11/01	12:00	Pulled

Table C-1. Schedule listing the dates and times that the Stevens/Greenspan probes were deployed, pulled, and cleaned by location during 2001 in the Index Reach of the Housatonic River, Massachusetts.

Location	Serial No.	Probe[1] No.	Date	Time	Action	Location	Serial No.	Probe No.	Date	Time	Action
OM-8 Nearshore	12408	9	6/6/01	11:00	Deployed	UWP2 Main Channel	12407	6	6/6/01	15:00	Deployed
			6/11/01	10:30	Pulled				6/11/01	12:00	Pulled
	12401	5	6/12/01	13:00	Deployed		12407	6	6/12/01	17:30	Deployed
			6/18/01	11:00	Pulled				6/18/01	12:30	Pulled
	12402	1	6/19/01	13:30	Deployed		12405	4	6/19/01	15:30	Deployed
			7/3/01	10:30	Pulled				7/5/01	11:00	Pulled
	12402	1	7/4/01	11:00	Deployed		12405	4	7/6/01	8:30	Deployed
			7/9/01	10:00	Cleaned				7/9/01	11:30	Cleaned
			7/11/01	11:00	Pulled				7/11/01	14:00	Pulled
	12400	7	7/12/01	11:34	Deployed		12408	9	7/12/01	12:21	Deployed
			7/19/01	11:44	Pulled				7/19/01	12:55	Pulled
	12400	7	7/20/01	probe failed to record				9	7/20/01	12:23	Deployed
			.						7/26/01	15:08	Cleaned
			.						8/1/01	10:28	Cleaned
			.						8/8/01	10:04	Cleaned
			.						8/15/01	11:18	Pulled
	12401	5	8/16/01	8:07	Deployed		12403	2	8/16/01	8:52	Deployed
			8/24/01	11:28	Cleaned				8/24/01	12:37	Cleaned
			9/20/01	10:31	Cleaned				9/20/01	11:55	Cleaned
			9/29/01	11:03	Pulled				9/29/01	10:31	Pulled
	12403	2	9/30/01	11:11	Deployed		14316	New7	9/30/01	12:28	Deployed
			10/11/01	12:00	Pulled				10/11/01	12:00	Pulled

Table C-1. Schedule listing the dates and times that the Stevens/Greenspan probes were deployed, pulled, and cleaned by location during 2001 in the Index Reach of the Housatonic River, Massachusetts.

Location	Serial No.	Probe[1] No.	Date	Time	Action	Location	Serial No.	Probe No.	Date	Time	Action
UWP2 Middle	12406	8	6/6/01	14:30	Deployed	UWP2 Nearshore	12405	4	6/6/01	14:30	Deployed
			6/11/01	12:00	Pulled				6/11/01	12:00	Pulled
	12402	1	6/12/01	18:00	Deployed		12403	2	6/12/01	17:30	Deployed
			6/18/01	12:30	Pulled				6/18/01	12:30	Pulled
	12407	6	6/19/01	15:30	Deployed		12406	8	6/19/01	15:30	Deployed
			.						6/25/01	14:30	Pulled
			.				12406	8	6/26/01	16:30	Deployed
			7/3/01	12:30	Pulled				7/4/01	12:00	Pulled
	12407	6	7/4/01	13:00	Deployed		12406	8	7/5/01	12:00	Deployed
			7/9/01	12:00	Cleaned				7/9/01	12:00	Cleaned
			7/11/01	14:00	Pulled				7/11/01	14:00	Pulled
	12406	8	7/12/01	12:29	Deployed		12407	6	7/12/01	12:34	Deployed
			7/19/01	13:10	Pulled				7/19/01	13:04	Pulled
			7/20/01	12:31	Deployed		12407	6	7/20/01	12:36	Deployed
			7/26/01	15:12	Cleaned				7/26/01	15:17	Cleaned
			8/1/01	10:33	Cleaned				8/1/01	10:39	Cleaned
			8/8/01	10:13	Cleaned				8/8/01	10:18	Cleaned
			8/15/01	11:24	Pulled				8/15/01	11:26	Pulled
	12404	3	8/16/01	8:57	Deployed		12407	6	8/16/01	9:02	Deployed
			8/24/01	12:44	Cleaned				8/24/01	12:50	Cleaned
			9/20/01	10:58	Cleaned				9/20/01	11:02	Cleaned
			9/29/01	12:00	Pulled				9/29/01	12:04	Pulled
	12404	3	9/30/01	12:35	Deployed		12406	8	9/30/01	10:16	Deployed
			10/11/01	12:00	Pulled				10/11/01	12:00	Pulled

Table C-1. Schedule listing the dates and times that the Stevens/Greenspan probes were deployed, pulled, and cleaned by location during 2001 in the Index Reach of the Housatonic River, Massachusetts.

Location	Serial No.	Probe[1] No.	Date	Time	Action	Location	Serial No.	Probe No.	Date	Time	Action
UWP Main Channel						UWP Middle	12401	5	6/6/01	13:00	Deployed
									6/11/01	11:48	Pulled
	12400	7	6/12/01	17:00	Deployed		12408	9	6/12/01	15:30	Deployed
			6/18/01	12:00	Pulled				6/18/01	12:00	Pulled
	12408	9	6/19/01	14:30	Deployed		12400	7	6/19/01	15:00	Deployed
			.						6/25/01	13:30	Pulled
			.				12400	7	6/26/01	16:30	Deployed
			7/4/01	10:59	Pulled				7/4/01	11:30	Pulled
	12408	9	7/5/01	11:00	Deployed		12400	7	7/5/01	11:30	Deployed
			7/9/01	10:30	Cleaned				7/9/01	11:00	Cleaned
			7/11/01	12:30	Pulled				7/11/01	13:30	Pulled
	12403	2	7/12/01	11:54	Deployed		12404	3	7/12/01	12:03	Deployed
			7/19/01	12:06	Pulled				7/19/01	12:23	Pulled
	12403	2	7/20/01	13:32	Deployed		12404	3	7/20/01	12:56	Deployed
			7/26/01	14:25	Cleaned				7/26/01	14:41	Cleaned
			8/1/01	9:46	Cleaned				8/1/01	9:53	Cleaned
			8/8/01	9:39	Cleaned				8/8/01	9:51	Cleaned
			8/15/01	10:22	Pulled				8/15/01	10:40	Pulled
	12402	1	8/16/01	8:26	Deployed		12408	9	8/16/01	8:34	Deployed
			8/24/01	12:00	Cleaned				8/24/01	12:09	Cleaned
			9/20/01	10:39	Cleaned				9/20/01	12:44	Cleaned
			9/29/01	11:24	Pulled				9/29/01	11:38	Pulled
	12408	9	9/30/01	11:45	Deployed		12402	1	9/30/01	11:56	Deployed
			10/11/01	12:00	Pulled				10/11/01	12:00	Pulled

Table C-1. Schedule listing the dates and times that the Stevens/Greenspan probes were deployed, pulled, and cleaned by location during 2001 in the Index Reach of the Housatonic River, Massachusetts.

Location	Serial No.	Probe[1] No.	Date	Time	Action	Location	Serial No.	Probe No.	Date	Time	Action
UWP Near Shore	12404	3	6/6/01	13:00	Deployed	UWP Near Shore (cont)	12402	1	7/20/01	13:01	Deployed
			6/11/01	11:30	Pulled				7/26/01	14:37	Cleaned
	12405	4	6/12/01	15:00	Deployed				8/1/01	9:57	Cleaned
			6/18/01	12:00	Pulled				8/8/01	9:47	Cleaned
	12401	5	6/19/01	10:00	Deployed				8/15/01	10:48	Pulled
			7/3/01	12:00	Pulled		12406	8	8/16/01	8:39	Deployed
	12401	5	7/4/01	12:00	Deployed				8/24/01	12:15	Cleaned
			7/9/01	11:00	Cleaned				9/20/01	10:50	Cleaned
			7/11/01	13:00	Pulled				9/29/01	9:30	Pulled
	12402	1	7/12/01	12:10	Deployed		12401	5	9/30/01	12:15	Deployed
			7/19/01	12:25	Pulled				10/11/01	12:00	Pulled

[1] Probes were assigned randomly at each redeployment.

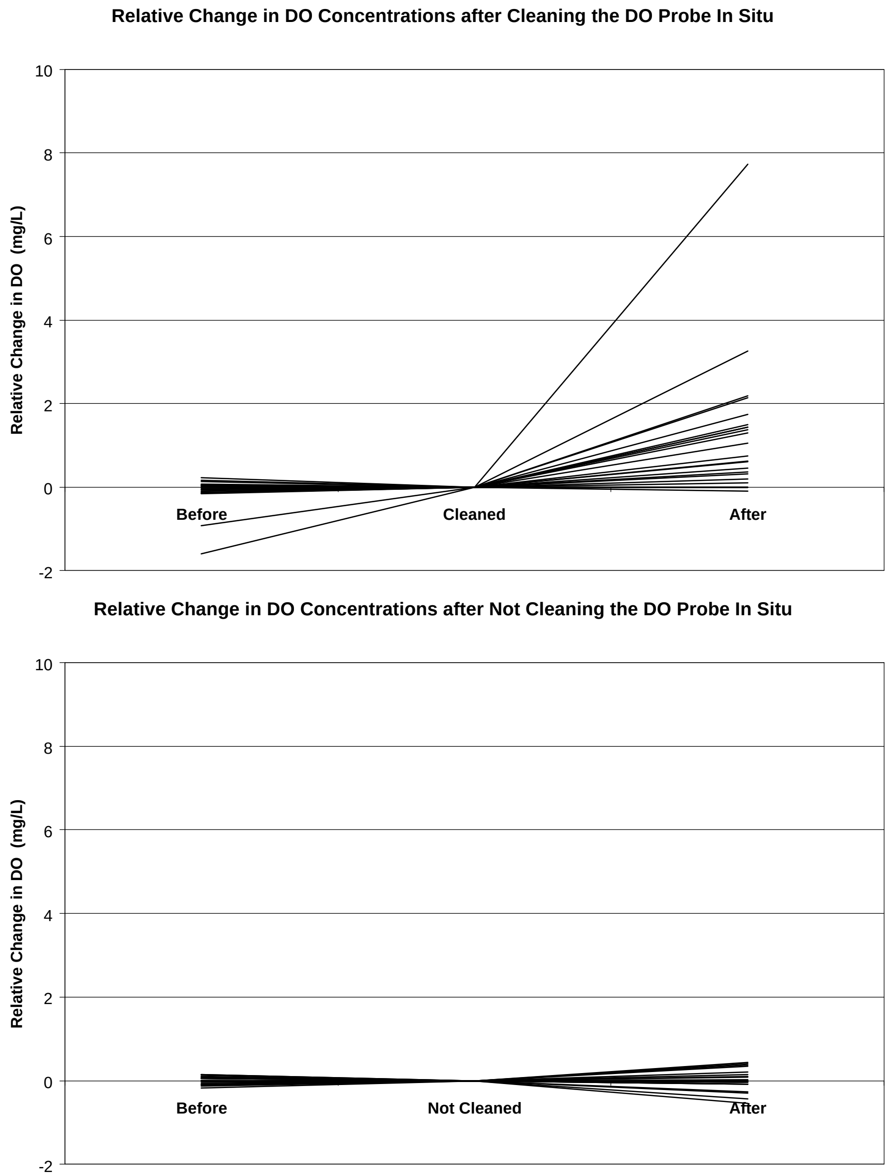

Figure C-1. Relative changes in concentrations of DO (mg/L) just prior to *in situ* cleaning and approximately one hour following cleaning (on July 26, August 1, and August 8) were significantly different (p=0.003, df=23) in comparison to relative changes in DO concentrations at the same times on days prior to *in situ* cleaning (p=0.5; df=23).

Although temperatures did appear to increase following maintenance of the probes, a t-test between the relative differences after probe maintenance and the relative differences at the same times on the days prior to maintenance indicated that differences were not significant (t=0.10, df=46). The slight increase one hour after maintenance was similar to the increase seen on the days previous to cleaning and was likely a result of diurnal temperature fluctuations. These calibration analyses indicate that the DO probes were often fouled by biological activity (e.g., algal attachment) or fine sediment deposition at some point following deployment and prior to cleaning.

In addition to estimating the relatively immediate effect of cleaning the DO probes, a post-retrieval calibration check procedure was used for each unit and retrieval event. The probes were removed from the water periodically and brought back to the lab where the data were downloaded and the probes cleaned, recalibrated, and redeployed. Prior to cleaning the probes, post-retrieval readings to air-saturation values were investigated after the probes were allowed to equilibrate in the air environment for more than 1 hour. The instrument DO readings obtained at this time were compared to the temperature-compensated air-saturation values. The ratio of the post-retrieval reading to the air-saturation was used to verify that the individual probes were responding to actual environmental variations in DO levels with minimal perturbations (false readings) that might be associated with *in situ* fouling of the sensor. If the post-retrieval DO reading in air reached 90% or greater of the expected air-saturation value, the data recorded during deployment were considered acceptable and representative of the deployment location. High post-retrieval ratios (>0.9) were used as affirmative evidence that the probes were functioning within reasonable limits of accuracy and representativeness. Ratios below 0.9 suggested that some degree of fouling developed between deployment and retrieval that would likely cause the recorded DO values to be below the actual ambient concentrations. During the study, there were 68 post-retrieval calibration checks. Only three of these validation checks failed to reach the 90% or greater air-calibration acceptance criteria.

The results of the two calibration checks are seemingly contradictory. DO concentrations following *in situ* cleaning showed fouling, whereas post-retrieval calibration checks showed that fouling was relatively rare. It is presumed that these results indicate that the major cause of probe fouling was due to biological activity as opposed to deposition of fine particulates, although no direct evidence exists to indicate that this is the case. However, the three times when the probes did not re-equilibrate following removal from the river could indicate fouling caused by fine sediments, which would hinder oxygen exchange in the air as well as under water. In the other cases when the probes did re-equilibrate to air-saturation values, the probes were either not fouled or were potentially temporarily fouled by aquatic epiphytes, which ceased to affect oxygen concentrations once the probes were allowed to dry.

APPENDIX D

Fish Data

(tabular listing of fish collected during the surveys by site)

CONTENTS

FIGURES

TABLES

APPENDIX D

Fish Data

(tabular listing of fish collected during the surveys by site)

INTRODUCTION

This appendix contains several graphs and tables of fish data collected from the Housatonic River study area by R2 Resource Consultants, Inc. during 2000 and 2001. The graphs contained in this appendix are length-frequency histograms of fish species other than largemouth bass that were collected in the Housatonic Study Reach during 2001. These graphs support the description of the observed fish community as presented in Section 5.3 of the main report. Data tables are also included in this appendix describing the numbers of fish collected on the Housatonic River system (including tributaries within the study area) by species and location during the 2000 and 2001 sampling events. Other data tables are specific to largemouth bass, and present the dates, locations, and length and weight data for each largemouth bass collected during the study. A listing of each graph and table can be found in the preceding table of contents.

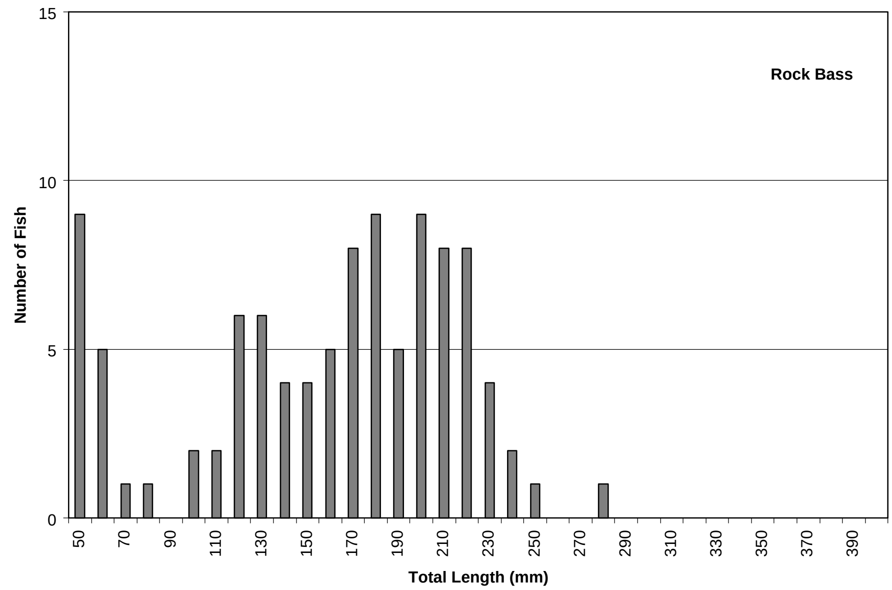

Figure D-1. Length-frequency histogram of rock bass size-classes collected on the Housatonic River during October 2001.

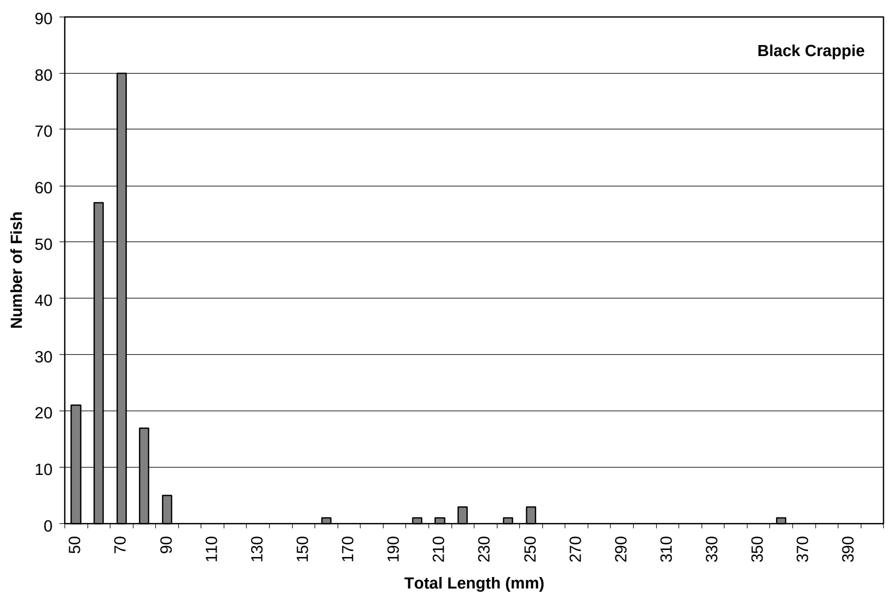

Figure D-2. Length-frequency histogram of black crappie size-classes collected on the Housatonic River during October 2001.

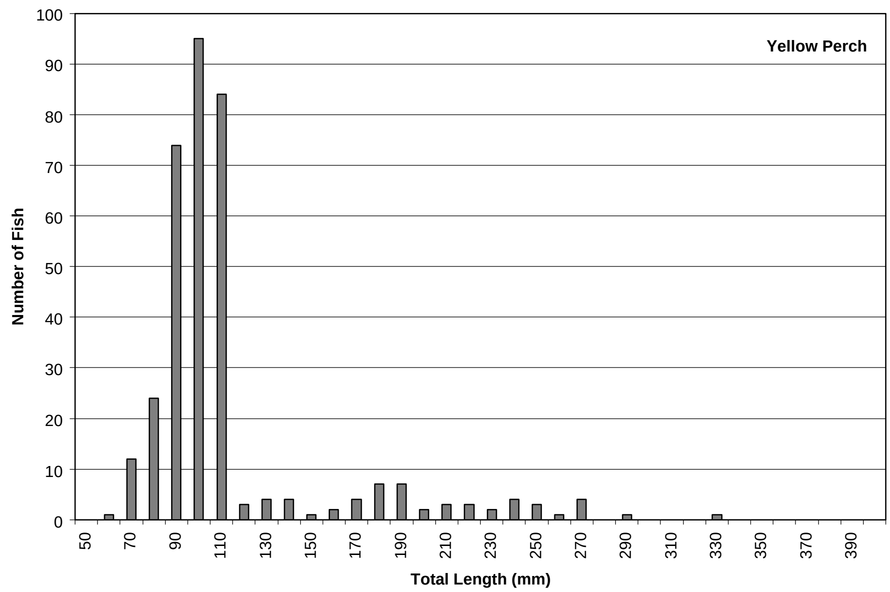

Figure D-3. Length-frequency histogram of yellow perch size-classes collected on the Housatonic River during October 2001.

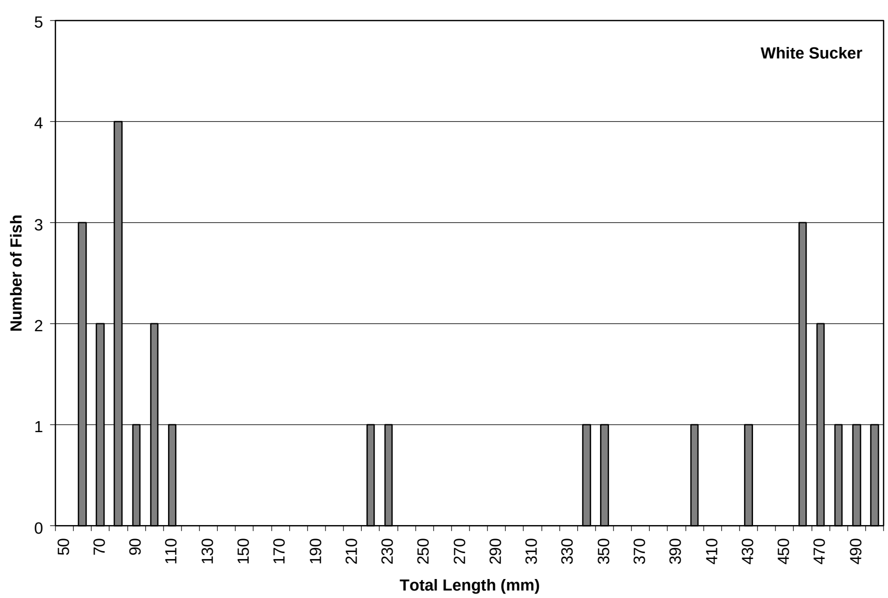

Figure D-4. Length-frequency histogram of white sucker size-classes collected on the Housatonic River during October 2001.

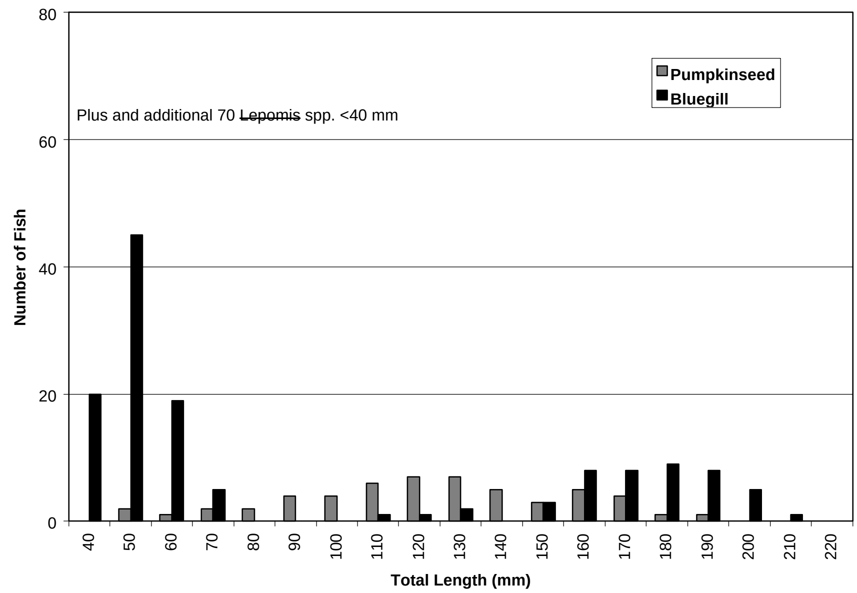

Figure D-5. Length-frequency histogram of bluegill and pumpkinseed size-classes collected on the Housatonic River during October 2001.

Table D-1. Year 2000 electrofishing schedule on the Housatonic River system.

Date	Location	Code	Electrofishing Gear
June 7, 8, July 31	Lower Woods Pond	LWP	Boat
June 7, 8	Upper Woods Pond	UWP	Boat
June 8	Upper Woods Pond Backwater 3	UWP3	Boat
June 8	Upper Woods Pond Backwater 4	UWP4	Boat
June 8, July 31	October Mountain Backwater 8	OM8	Boat
June 8	October Mountain Backwater 9	OM9	Boat
June 9	New Lenox Backwater 3	NLBW3	Boat
June 9, July 30	Upper New Lenox Backwater	UNLBW	Boat
June 9, July 30	Upper New Lenox Main Channel	UNLMC	Boat
June 9	Upper New Lenox Backwater 5	UNLBW5	Boat
June 9	Upper New Lenox Backwater 4	UNLBW4	Boat
June 10	Mill Brook – Upper	MBU	Backpack
June 10	Mill Brook – Lower	MBL	Backpack
June 10	Roaring Brook	RB	Backpack
June 10	Felton Brook	FB	Backpack
June 11	Moorewood Brook	MRB	Backpack
July 30	New Lenox Main Channel	HR2	Boat
July 30	Sykes Brook Main Channel	SYBMC	Boat
July 31	Yokun Brook Backwater	YBBW	Boat
July 31	Yokun Brook Side Channel	YBSC	Boat
July 31	Yokun Brook Main Channel	YBMC	Boat
July 31	Lower Woods Pond Right Bank	LWPRB	Boat
August 1	Lower Woods Pond Main Channel	LWPMC	Boat
August 1	Lower Woods Pond Side Channel	LWPSC	Boat
August 1	Upper Woods Pond Main Channel	UWPMC	Boat
August 1	Sackett Brook	SB	Backpack
August 2	East Branch	EB	Raft
August 2	West Branch	WB	Raft

Table D-2. Numbers of fish captured on the Housatonic River system by species and location during the June and late-July/August 2000 electrofishing surveys. The electrofishing sites are shown in Figure 4-4.

	Fish Species[1]																													
Site	**BB**	**BNM**	**CC**	**GF**	**GS**	**STS**	**CS**	**FF**	**BND**	**LND**	**CH**	**UCYP**	**CP**	**NP**	**TM**	**LMB**	**JSF**	**BG**	**PS**	**RB**	**BC**	**USF**	**YP**	**SC**	**WS**	**RH**	**BRT**	**EBT**	**RBT**	**Total**
HR2	4	1					1	1					5		1	11		20	20	1	3		17							85
UNLMC	1												3	1		4		13	3	1			4		2					32
UNLBW	8	1	2		7	3							9	2		14		26	20		5		17		12					126
UNLBW4	1											1						1					2							5
UNLBW5	2	1																					1		3					7
NLBW3	19	19	1		7	1							3	2		5		12	17	2	3		20		5					116
SYBMC		11						1	1					1		10		11	2	4			9		26	1				77
YBMC	1				5	1	4									9		16	15	3	1		9		5					69
YBSC	3		1		1								1	4		13		22	8	13			20		26					112
YBBW	1				15								2	3		5		1					6							33
OM8	8		1	1	1								3	2		9		17	17		2		4							65
OM9	4				1											1		3	1		1				4					15
UWPMC	1												1			6		22	8	8	1		4		2					53
UWP	11		3	25	1								3	3		14		76	59	6	5		22		8					237
UWP3	5			1												5		4	49	2	3		3							71
LWPMC	5		1											1		2		5	3	2	2		9		6					36
LWP	8		3	16	10									2		5	2	56	27	2	5	6	59		13					214
LWPSC	5		1		3									2		3		15	6	3	2		13		4					57
LWPRB		1		1	2		2							1		8		8	4	11			17		7					62
UWP4	8		2	1												9		27	38	1	6		18		4					114

Table D-2. Numbers of fish captured on the Housatonic River system by species and location during the June and late-July/August 2000 electrofishing surveys. The electrofishing sites are shown in Figure 4-4.

	Fish Species[1]																													
Site	**BB**	**BNM**	**CC**	**GF**	**GS**	**STS**	**CS**	**FF**	**BND**	**LND**	**CH**	**UCYP**	**CP**	**NP**	**TM**	**LMB**	**JSF**	**BG**	**PS**	**RB**	**BC**	**USF**	**YP**	**SC**	**WS**	**RH**	**BRT**	**EBT**	**RBT**	**Total**
EB		19				2	1	16	15	26			2			8		16	4	12					14				1	136
WB		14					4						4	1		2		35	4	7			7		3					81
MRB		4			1			1					1			2		62	1	1										73
SB									33		6		1											7	2		17	12		78
MBU																		2						17	2		1	11		33
MBL																1		3						10			3	20		37
RB																												14		14
FB	3																	1	1									38		43
Total	98	71	15	45	54	7	12	19	49	26	6	1	38	25	1	146	2	474	307	79	39	6	261	34	148	1	21	95	1	2081

[1] Species Key:

BB=brown bullhead
BNM=bluntnose minnow
CC=common carp
GF=goldfish
GS=golden shiner
STS=spottail shiner
CS=common shiner
FF=fallfish
BND=blacknose dace
LND=longnose dace
CH=creek chub
UCYP=unidentified cyprinid
CP=chain pickerel
NP=northern pike
TM=tiger muskie
LMB=largemouth bass
JSF=juvenile sunfish
BG=bluegill
PS=pumpkinseed
RB=rock bass
BC=black crappie
USF=unidentified sunfish
YP=yellow perch
SC=slimy sculpin
WS=white sucker
RH=redhorse sucker
BRT=brown trout
EBT=eastern brook trout
RBT=rainbow trout

Table D-3. Length, weight, and age determinations for largemouth bass captured during the June and late-July/August 2000 electrofishing on the Housatonic River.

Date	Location	Surveys Site[1]	Total Length (mm)	Weight (g)	Age
6/7/00	Housatonic River	LWP	362	680	5
6/7/00	Housatonic River	LWP	377	780	6
6/7/00	Housatonic River	LWP	414	1190	6
7/31/00	Housatonic River	LWP	2 stunned but not netted		
6/8/00	Housatonic River	UWP4	322	540	2
6/8/00	Housatonic River	UWP4	296	395	3
6/8/00	Housatonic River	UWP4	317	510	4
6/8/00	Housatonic River	UWP4	367	700	4
6/8/00	Housatonic River	UWP4	311	405	5
6/8/00	Housatonic River	UWP4	352	695	5
6/8/00	Housatonic River	UWP4	344	605	6
6/8/00	Housatonic River	UWP4	364	715	6
6/8/00	Housatonic River	UWP4	382	885	6
8/1/00	Housatonic River	LWPMC	190	90	3
8/1/00	Housatonic River	LWPMC	1 stunned but not netted		
7/31/00	Housatonic River	LWPRB	307	460	5
7/31/00	Housatonic River	LWPRB	332	505	5
7/31/00	Housatonic River	LWPRB	322	505	6
7/31/00	Housatonic River	LWPRB	332	590	8
7/31/00	Housatonic River	LWPRB	371	840	9
7/31/00	Housatonic River	LWPRB	408	900	9
7/31/00	Housatonic River	LWPRB	51.8	nd	nd
7/31/00	Housatonic River	LWPRB	324	495	nd
8/1/00	Housatonic River	LWPSC	353	830	nd
8/1/00	Housatonic River	LWPSC	358	650	nd
8/1/00	Housatonic River	LWPSC	367	940	nd
7/31/00	Housatonic River	OM8	193	115	2
6/8/00	Housatonic River	OM8	325	535	5
6/8/00	Housatonic River	OM8	442	1500	5
6/8/00	Housatonic River	OM8	318	475	6
6/8/00	Housatonic River	OM8	341	700	6
6/8/00	Housatonic River	OM8	370	825	6
7/31/00	Housatonic River	OM8	30.9	nd	nd
7/31/00	Housatonic River	OM8	51.9	nd	nd
6/8/00	Housatonic River	OM8	407	1120	nd
6/8/00	Housatonic River	OM9	335	580	5
7/30/00	Housatonic River	SYBMC	199	105	2
7/30/00	Housatonic River	SYBMC	275	300	3
7/30/00	Housatonic River	SYBMC	377	900	7
7/30/00	Housatonic River	SYBMC	341	790	nd

Table D-3. Length, weight, and age determinations for largemouth bass captured during the June and late-July/August 2000 electrofishing on the Housatonic River.

Date	Location	Surveys Site[1]	Total Length (mm)	Weight (g)	Age
7/30/00	Housatonic River	SYBMC	343	640	nd
7/30/00	Housatonic River	SYBMC	346	705	nd
7/30/00	Housatonic River	SYBMC	349	690	nd
7/30/00	Housatonic River	SYBMC	352	720	nd
7/30/00	Housatonic River	SYBMC	363	820	nd
7/30/00	Housatonic River	SYBMC	372	950	nd
6/9/00	Housatonic River	NLBW3	228	210	2
6/9/00	Housatonic River	NLBW3	221	190	3
6/9/00	Housatonic River	NLBW3	361	970	5
6/9/00	Housatonic River	NLBW3	355	640	6
6/9/00	Housatonic River	NLBW3	325	585	8
6/9/00	Housatonic River	UNLBW	308	440	4
6/9/00	Housatonic River	UNLBW	355	800	4
6/9/00	Housatonic River	UNLBW	348	700	5
6/9/00	Housatonic River	UNLBW	363	970	5
6/9/00	Housatonic River	UNLBW	388	995	5
6/9/00	Housatonic River	UNLBW	340	640	6
7/30/00	Housatonic River	UNLBW	127	30	1
7/30/00	Housatonic River	UNLBW	435	1300	10
7/30/00	Housatonic River	UNLBW	45	nd	nd
7/30/00	Housatonic River	UNLBW	315	520	nd
7/30/00	Housatonic River	UNLBW	338	600	nd
7/30/00	Housatonic River	UNLBW	347	690	nd
7/30/00	Housatonic River	UNLBW	371	695	nd
7/30/00	Housatonic River	UNLBW	389	805	nd
7/30/00	Housatonic River	HR2	151	60	2
7/30/00	Housatonic River	HR2	210	145	3
7/30/00	Housatonic River	HR2	304	460	6
7/30/00	Housatonic River	HR2	181	85	nd
7/30/00	Housatonic River	HR2	192	110	nd
7/30/00	Housatonic River	HR2	209	130	nd
7/30/00	Housatonic River	HR2	227	170	nd
7/30/00	Housatonic River	HR2	329	595	nd
7/30/00	Housatonic River	HR2	351	700	nd
7/30/00	Housatonic River	HR2	355	700	nd
7/30/00	Housatonic River	HR2	368	910	nd
7/30/00	Housatonic River	UNLMC	339	640	nd
7/30/00	Housatonic River	UNLMC	3 stunned but not netted		
6/7/00	Housatonic River	UWP	91.6	9.6	0
6/7/00	Housatonic River	UWP	99.3	12.9	0
6/7/00	Housatonic River	UWP	132.5	29.3	1

Table D-3. Length, weight, and age determinations for largemouth bass captured during the June and late-July/August 2000 electrofishing on the Housatonic River.

Date	Location	Surveys Site[1]	Total Length (mm)	Weight (g)	Age
6/7/00	Housatonic River	UWP	208	117	1
6/7/00	Housatonic River	UWP	202	103.5	2
6/7/00	Housatonic River	UWP	283	305	3
6/7/00	Housatonic River	UWP	355	595	4
6/7/00	Housatonic River	UWP	322	490	6
6/7/00	Housatonic River	UWP	342	610	6
6/7/00	Housatonic River	UWP	356	640	6
6/7/00	Housatonic River	UWP	476	1007	10
6/8/00	Housatonic River	UWP	332	580	5
6/8/00	Housatonic River	UWP	350	740	6
6/8/00	Housatonic River	UWP	363	800	6
6/8/00	Housatonic River	UWP3	88.1	8.2	0
6/8/00	Housatonic River	UWP3	299	420	4
6/8/00	Housatonic River	UWP3	327	525	4
6/8/00	Housatonic River	UWP3	342	620	nd
6/8/00	Housatonic River	UWP3	378	840	nd
8/1/00	Housatonic River	UWPMC	223	160	3
8/1/00	Housatonic River	UWPMC	59	nd	nd
8/1/00	Housatonic River	UWPMC	67	nd	nd
8/1/00	Housatonic River	UWPMC	210	150	nd
8/1/00	Housatonic River	UWPMC	279	360	nd
8/1/00	Housatonic River	UWPMC	378	890	nd
7/31/00	Housatonic River	YBBW	381	700	4
7/31/00	Housatonic River	YBBW	359	790	6
7/31/00	Housatonic River	YBBW	32	nd	nd
7/31/00	Housatonic River	YBBW	32.2	nd	nd
7/31/00	Housatonic River	YBBW	32.8	nd	nd
7/31/00	Housatonic River	YBMC	328	580	4
7/31/00	Housatonic River	YBMC	345	640	4
7/31/00	Housatonic River	YBMC	305	480	nd
7/31/00	Housatonic River	YBMC	334	550	nd
7/31/00	Housatonic River	YBMC	415	1210	nd
7/31/00	Housatonic River	YBMC		1 stunned but not netted	
7/31/00	Housatonic River	YBMC		3 stunned but not netted	
7/31/00	Housatonic River	YBSC	260	310	4
7/31/00	Housatonic River	YBSC	278	365	5
7/31/00	Housatonic River	YBSC	334	600	6
7/31/00	Housatonic River	YBSC	343	700	6
7/31/00	Housatonic River	YBSC	348	720	6
7/31/00	Housatonic River	YBSC	378	790	6
7/31/00	Housatonic River	YBSC	403	1100	7

Table D-3. Length, weight, and age determinations for largemouth bass captured during the June and late-July/August 2000 electrofishing on the Housatonic River.

Date	**Location**	**Surveys Site**[1]	**Total Length (mm)**	**Weight (g)**	**Age**
7/31/00	Housatonic River	YBSC	404	1090	7
7/31/00	Housatonic River	YBSC	335	580	8
7/31/00	Housatonic River	YBSC	348	690	8
7/31/00	Housatonic River	YBSC	275	335	nd
7/31/00	Housatonic River	YBSC	360	700	nd
7/31/00	Housatonic River	YBSC	379	870	nd
8/2/00	Branch	WB	137	30	1
8/2/00	Branch	WB	368	840	nd
8/2/00	Branch	EB	114	10	1
8/2/00	Branch	EB	162	55	1
8/2/00	Branch	EB	196	105	2
8/2/00	Branch	EB	216	160	nd
8/2/00	Branch	EB	232	170	nd
8/2/00	Branch	EB	317	500	nd
8/2/00	Branch	EB	353	720	nd
8/2/00	Branch	EB	410	1180	nd
6/10/00	Tributary	MBL	82	6.5	0
6/11/00	Tributary	MRB	125	28.8	1
6/11/00	Tributary	MRB	295	415	nd

nd = not determined
[1] = The locations of each sampling site are indicated on Figure 4-4.

Table D-4. Numbers of fish collected on the Housatonic River by species and location during the October 2001 electrofishing survey. The electrofishing sites are shown on Figure 4-5.

		Fish Species[1]																		
Location	**Site**	**BB**	**YB**	**BNM**	**CC**	**GF**	**GS**	**MC**	**STS**	**CP**	**NP**	**LMB**	**JSF**	**BG**	**PS**	**RB**	**BC**	**YP**	**WS**	**Total**
Main Channel	HR2	1		50			5		1	2	7	6		4	2	9	4	29	7	127
	UNLMC			23								3		2		1	3	18	7	57
	LWPTR3	2			1						2	18	7	12	1	5	18	107		173
	UWPMC1									2		11		7	1	5		5		31
	YBMC1						2			3		2		12	32	43	2	3	2	101
Transition	LWPMC1	2		1			15			1	2	20	14	3		8	15	34		115
	LWPMC2										2	15	8	6	4	7	13	38	2	95
	OM8MC			1								22		4		4	2	3		36
	LWPIsland	4								1	3	12	5	10	2	3	21	41	2	104
	UWP3TR2		1				18	1		1	1	26	3	5		4	13	7	1	81
	YBSC1	1		16			23			1	1	6				4	12	16	6	86
Backwater	LWPBW1											5	13	13	5	1	11			48
	LWPBW3											12	16	26	2	3	5	13		77
	YBBW1						12			14		4								30
	UWPI	6			1	3	1					7	1	10	1		7	3		40
	UWPSW			1								20	1	12		2	29	8		73
	NLBW3	15										50	2	9	5	1	36	22		140
	Total	31	1	92	2	3	76	1	1	25	18	239	70	135	55	100	191	347	27	**1414**

[1]Species Key:

BB=brown bullhead
YB=yellow bullhead
BNM=bluntnose minnow
CC=common carp
GF=goldfish
GS=golden shiner
MC=mirror carp
STS=spottail shiner
CP=chain pickerel
NP=northern pike
LMB=largemouth bass
JSF=juvenile sunfish (bluegill or pumpkinseed)
BG=bluegill
PS=pumpkinseed
RB=rock bass
BC=black crappie
YP=yellow perch
WS=white sucker

Table D-5. Length, weight, and age determinations for largemouth bass captured during the October 2001 electrofishing surveys on the Housatonic River.

Date	Habitat Type	Site[1]	Total Length (mm)	Weight (g)	Age
10/10/01	Main Channel	HR2	90	11.8	1
10/10/01	Main Channel	HR2	347	780.0	nd
10/10/01	Main Channel	HR2	60	3.5	nd
10/10/01	Main Channel	HR2	65	4.3	nd
10/10/01	Main Channel	HR2	78	7.1	nd
10/10/01	Main Channel	HR2	378	1000.0	nd
10/12/01	Main Channel	LWPTR3	86	10.8	0
10/12/01	Main Channel	LWPTR3	102	16.1	0
10/12/01	Main Channel	LWPTR3	109	15.9	0
10/12/01	Main Channel	LWPTR3	110	16.0	1
10/12/01	Main Channel	LWPTR3	112	20.8	1
10/12/01	Main Channel	LWPTR3	112	21.5	1
10/12/01	Main Channel	LWPTR3	115	21.0	1
10/12/01	Main Channel	LWPTR3	117	20.6	1
10/12/01	Main Channel	LWPTR3	120	26.4	1
10/12/01	Main Channel	LWPTR3	346	680.0	6
10/12/01	Main Channel	LWPTR3	74	6.8	nd
10/12/01	Main Channel	LWPTR3	92	11.5	nd
10/12/01	Main Channel	LWPTR3	93	9.7	nd
10/12/01	Main Channel	LWPTR3	93	12.1	nd
10/12/01	Main Channel	LWPTR3	96	13.5	nd
10/12/01	Main Channel	LWPTR3	98	13.5	nd
10/12/01	Main Channel	LWPTR3	102	14.3	nd
10/12/01	Main Channel	LWPTR3	108	17.4	nd
10/10/01	Main Channel	UNLMC	55	3.5	nd
10/10/01	Main Channel	UNLMC	56	2.8	nd
10/10/01	Main Channel	UNLMC	86	8.6	nd
10/11/01	Main Channel	UWPMC1	100	12.5	1
10/11/01	Main Channel	UWPMC1	370	875.0	7
10/11/01	Main Channel	UWPMC1	345	700.0	8
10/11/01	Main Channel	UWPMC1	397	1100.0	8
10/11/01	Main Channel	UWPMC1	79	7.5	nd
10/11/01	Main Channel	UWPMC1	80	8.1	nd
10/11/01	Main Channel	UWPMC1	82	9.1	nd
10/11/01	Main Channel	UWPMC1	82	10.1	nd
10/11/01	Main Channel	UWPMC1	86	8.7	nd
10/11/01	Main Channel	UWPMC1	87	10.1	nd
10/11/01	Main Channel	UWPMC1	90	11.7	nd
10/11/01	Main Channel	YBMC1	56	3.5	nd
10/11/01	Main Channel	YBMC1	92	14.3	nd

Table D-5. Length, weight, and age determinations for largemouth bass captured during the October 2001 electrofishing surveys on the Housatonic River.

Date	Habitat Type	Site[1]	Total Length (mm)	Weight (g)	Age
10/12/01	Transition	LWPIsland	108	18.0	0
10/12/01	Transition	LWPIsland	75	7.4	nd
10/12/01	Transition	LWPIsland	75	8.6	nd
10/12/01	Transition	LWPIsland	80	6.9	nd
10/12/01	Transition	LWPIsland	85	9.5	nd
10/12/01	Transition	LWPIsland	85	10.5	nd
10/12/01	Transition	LWPIsland	86	10.5	nd
10/12/01	Transition	LWPIsland	86	11.2	nd
10/12/01	Transition	LWPIsland	90	11.3	nd
10/12/01	Transition	LWPIsland	95	9.6	nd
10/12/01	Transition	LWPIsland	100	12.5	nd
10/12/01	Transition	LWPIsland	108	13.8	nd
10/12/01	Transition	LWPMC1	110	17.4	1
10/12/01	Transition	LWPMC1	358	800	6
10/12/01	Transition	LWPMC1	378	825	6
10/12/01	Transition	LWPMC1	358	775.0	8
10/12/01	Transition	LWPMC1	68	4.5	nd
10/12/01	Transition	LWPMC1	68	4.9	nd
10/12/01	Transition	LWPMC1	75	5.7	nd
10/12/01	Transition	LWPMC1	82	8.1	nd
10/12/01	Transition	LWPMC1	82	9.2	nd
10/12/01	Transition	LWPMC1	84	7.7	nd
10/12/01	Transition	LWPMC1	85	8.2	nd
10/12/01	Transition	LWPMC1	85	8.4	nd
10/12/01	Transition	LWPMC1	86	nd	nd
10/12/01	Transition	LWPMC1	91	9.9	nd
10/12/01	Transition	LWPMC1	92	11.2	nd
10/12/01	Transition	LWPMC1	94	10.9	nd
10/12/01	Transition	LWPMC1	95	11.3	nd
10/12/01	Transition	LWPMC1	95	11.7	nd
10/12/01	Transition	LWPMC1	95	12.1	nd
10/12/01	Transition	LWPMC1	100	14.0	nd
10/12/01	Transition	LWPMC2	96	12.0	0
10/12/01	Transition	LWPMC2	110	17.0	0
10/12/01	Transition	LWPMC2	120	24.3	0
10/12/01	Transition	LWPMC2	105	17.5	1
10/12/01	Transition	LWPMC2	109	18.4	1
10/12/01	Transition	LWPMC2	118	20.9	1
10/12/01	Transition	LWPMC2	132	32.8	1
10/12/01	Transition	LWPMC2	355	900	8
10/12/01	Transition	LWPMC2	68	5.7	nd

Table D-5. Length, weight, and age determinations for largemouth bass captured during the October 2001 electrofishing surveys on the Housatonic River.

Date	Habitat Type	Site[1]	Total Length (mm)	Weight (g)	Age
10/12/01	Transition	LWPMC2	72	4.9	nd
10/12/01	Transition	LWPMC2	78	7.0	nd
10/12/01	Transition	LWPMC2	81	9.0	nd
10/12/01	Transition	LWPMC2	82	7.7	nd
10/12/01	Transition	LWPMC2	94	13.3	nd
10/12/01	Transition	LWPMC2	103	14.8	nd
10/11/01	Transition	OM8MC	95	11.8	0
10/11/01	Transition	OM8MC	110	14.2	1
10/11/01	Transition	OM8MC	100	15.1	2
10/11/01	Transition	OM8MC	313	500	4
10/11/01	Transition	OM8MC	340	650	6
10/11/01	Transition	OM8MC	360	800	6
10/11/01	Transition	OM8MC	343	640	7
10/11/01	Transition	OM8MC	348	760	8
10/11/01	Transition	OM8MC	64	4.0	nd
10/11/01	Transition	OM8MC	65	5.1	nd
10/11/01	Transition	OM8MC	68	4.9	nd
10/11/01	Transition	OM8MC	72	4.9	nd
10/11/01	Transition	OM8MC	72	5.1	nd
10/11/01	Transition	OM8MC	72	5.6	nd
10/11/01	Transition	OM8MC	72	6.5	nd
10/11/01	Transition	OM8MC	74	6.1	nd
10/11/01	Transition	OM8MC	78	8.3	nd
10/11/01	Transition	OM8MC	82	8.9	nd
10/11/01	Transition	OM8MC	83	8.2	nd
10/11/01	Transition	OM8MC	83	9.0	nd
10/11/01	Transition	OM8MC	90	9.3	nd
10/11/01	Transition	OM8MC	92	10.5	nd
10/12/01	Transition	UWP3TR2	112	19.7	0
10/12/01	Transition	UWP3TR2	96	14.0	1
10/12/01	Transition	UWP3TR2	104	17.1	1
10/12/01	Transition	UWP3TR2	105	16.2	1
10/12/01	Transition	UWP3TR2	295	475	5
10/12/01	Transition	UWP3TR2	367	875	6
10/12/01	Transition	UWP3TR2	378	975	7
10/12/01	Transition	UWP3TR2	385	1025	8
10/12/01	Transition	UWP3TR2	73	6.7	nd
10/12/01	Transition	UWP3TR2	74	6.7	nd
10/12/01	Transition	UWP3TR2	74	7.2	nd
10/12/01	Transition	UWP3TR2	76	7.5	nd
10/12/01	Transition	UWP3TR2	78	7.3	nd

Table D-5. Length, weight, and age determinations for largemouth bass captured during the October 2001 electrofishing surveys on the Housatonic River.

Date	Habitat Type	Site[1]	Total Length (mm)	Weight (g)	Age
10/12/01	Transition	UWP3TR2	78	7.4	nd
10/12/01	Transition	UWP3TR2	78	8.5	nd
10/12/01	Transition	UWP3TR2	80	8.0	nd
10/12/01	Transition	UWP3TR2	80	8.2	nd
10/12/01	Transition	UWP3TR2	82	7.5	nd
10/12/01	Transition	UWP3TR2	82	7.8	nd
10/12/01	Transition	UWP3TR2	84	9.4	nd
10/12/01	Transition	UWP3TR2	84	10.1	nd
10/12/01	Transition	UWP3TR2	86	11.0	nd
10/12/01	Transition	UWP3TR2	87	10.6	nd
10/12/01	Transition	UWP3TR2	90	12.2	nd
10/12/01	Transition	UWP3TR2	93	11.5	nd
10/12/01	Transition	UWP3TR2	100	14.8	nd
10/11/01	Transition	YBSC1	62	3.8	nd
10/11/01	Transition	YBSC1	68	4.2	nd
10/11/01	Transition	YBSC1	74	7.2	nd
10/11/01	Transition	YBSC1	75	6.8	nd
10/11/01	Transition	YBSC1	76	6.3	nd
10/11/01	Transition	YBSC1	88	10.2	nd
10/12/01	Backwater	LWPBW1	110	21.0	0
10/12/01	Backwater	LWPBW1	135	32.5	1
10/12/01	Backwater	LWPBW1	68	5.1	nd
10/12/01	Backwater	LWPBW1	78	7.8	nd
10/12/01	Backwater	LWPBW1	93	11.1	nd
10/12/01	Backwater	LWPBW3	110	16.5	1
10/12/01	Backwater	LWPBW3	133	35.3	1
10/12/01	Backwater	LWPBW3	154	45.0	1
10/12/01	Backwater	LWPBW3	345	785	6
10/12/01	Backwater	LWPBW3	72	4.4	nd
10/12/01	Backwater	LWPBW3	75	7.1	nd
10/12/01	Backwater	LWPBW3	80	6.8	nd
10/12/01	Backwater	LWPBW3	86	8.6	nd
10/12/01	Backwater	LWPBW3	90	10.5	nd
10/12/01	Backwater	LWPBW3	90	11.5	nd
10/12/01	Backwater	LWPBW3	97	11.2	nd
10/12/01	Backwater	LWPBW3	112	16.8	nd
10/10/01	Backwater	NLBW3	216	160	2
10/10/01	Backwater	NLBW3	50	2.4	nd
10/10/01	Backwater	NLBW3	52	1.5	nd
10/10/01	Backwater	NLBW3	55	3.1	nd
10/10/01	Backwater	NLBW3	57	2.9	nd

Table D-5. Length, weight, and age determinations for largemouth bass captured during the October 2001 electrofishing surveys on the Housatonic River.

Date	Habitat Type	Site[1]	Total Length (mm)	Weight (g)	Age
10/10/01	Backwater	NLBW3	59	3.4	nd
10/10/01	Backwater	NLBW3	60	2.9	nd
10/10/01	Backwater	NLBW3	60	3.2	nd
10/10/01	Backwater	NLBW3	60	3.5	nd
10/10/01	Backwater	NLBW3	60	3.6	nd
10/10/01	Backwater	NLBW3	60	3.7	nd
10/10/01	Backwater	NLBW3	60	3.7	nd
10/10/01	Backwater	NLBW3	62	3.5	nd
10/10/01	Backwater	NLBW3	62	3.7	nd
10/10/01	Backwater	NLBW3	62	3.9	nd
10/10/01	Backwater	NLBW3	62	4.3	nd
10/10/01	Backwater	NLBW3	64	3.2	nd
10/10/01	Backwater	NLBW3	65	4.0	nd
10/10/01	Backwater	NLBW3	65	4.0	nd
10/10/01	Backwater	NLBW3	65	5.0	nd
10/10/01	Backwater	NLBW3	67	4.5	nd
10/10/01	Backwater	NLBW3	67	4.7	nd
10/10/01	Backwater	NLBW3	67	4.8	nd
10/10/01	Backwater	NLBW3	67	4.9	nd
10/10/01	Backwater	NLBW3	68	4.6	nd
10/10/01	Backwater	NLBW3	69	5.0	nd
10/10/01	Backwater	NLBW3	70	5.1	nd
10/10/01	Backwater	NLBW3	70	5.2	nd
10/10/01	Backwater	NLBW3	70	5.4	nd
10/10/01	Backwater	NLBW3	70	5.9	nd
10/10/01	Backwater	NLBW3	70	6.0	nd
10/10/01	Backwater	NLBW3	70	6.1	nd
10/10/01	Backwater	NLBW3	71	5.4	nd
10/10/01	Backwater	NLBW3	72	6.3	nd
10/10/01	Backwater	NLBW3	75	5.6	nd
10/10/01	Backwater	NLBW3	75	6.4	nd
10/10/01	Backwater	NLBW3	75	8.3	nd
10/10/01	Backwater	NLBW3	77	5.2	nd
10/10/01	Backwater	NLBW3	77	7.2	nd
10/10/01	Backwater	NLBW3	78	5.0	nd
10/10/01	Backwater	NLBW3	78	7.3	nd
10/10/01	Backwater	NLBW3	80	5.7	nd
10/10/01	Backwater	NLBW3	80	7.5	nd
10/10/01	Backwater	NLBW3	81	8.2	nd
10/10/01	Backwater	NLBW3	82	9.0	nd
10/10/01	Backwater	NLBW3	83	7.7	nd

Table D-5. Length, weight, and age determinations for largemouth bass captured during the October 2001 electrofishing surveys on the Housatonic River.

Date	Habitat Type	Site[1]	Total Length (mm)	Weight (g)	Age
10/10/01	Backwater	NLBW3	85	9.9	nd
10/10/01	Backwater	NLBW3	86	9.6	nd
10/10/01	Backwater	NLBW3	89	10.8	nd
10/10/01	Backwater	NLBW3	92	11.2	nd
10/11/01	Backwater	UWPSW	82	7.4	0
10/11/01	Backwater	UWPSW	65	5.5	nd
10/11/01	Backwater	UWPSW	67	3.8	nd
10/11/01	Backwater	UWPSW	67	4.1	nd
10/11/01	Backwater	UWPSW	68	4.4	nd
10/11/01	Backwater	UWPSW	70	5.2	nd
10/11/01	Backwater	UWPSW	72	4.8	nd
10/11/01	Backwater	UWPSW	72	5.2	nd
10/11/01	Backwater	UWPSW	72	5.2	nd
10/11/01	Backwater	UWPSW	72	5.4	nd
10/11/01	Backwater	UWPSW	74	5.7	nd
10/11/01	Backwater	UWPSW	75	5.9	nd
10/11/01	Backwater	UWPSW	75	6.2	nd
10/11/01	Backwater	UWPSW	78	6.6	nd
10/11/01	Backwater	UWPSW	78	7.6	nd
10/11/01	Backwater	UWPSW	82	6.7	nd
10/11/01	Backwater	UWPSW	83	8.4	nd
10/11/01	Backwater	UWPSW	85	7.8	nd
10/11/01	Backwater	UWPSW	90	12.0	nd
10/11/01	Backwater	UWPSW	135	35.1	nd
10/11/01	Backwater	UWPI	65	3.5	nd
10/11/01	Backwater	UWPI	65	3.5	nd
10/11/01	Backwater	UWPI	65	4.0	nd
10/11/01	Backwater	UWPI	70	4.5	nd
10/11/01	Backwater	UWPI	72	5.8	nd
10/11/01	Backwater	UWPI	75	5.8	nd
10/11/01	Backwater	UWPI	78	6.1	nd
10/11/01	Backwater	YBBW1	85	7.4	0
10/11/01	Backwater	YBBW1	100	15.7	1
10/11/01	Backwater	YBBW1	60	3.4	nd
10/11/01	Backwater	YBBW1	89	9.3	nd

nd = not determined
[1] = The locations of each sampling site are indicated on Figure 4-5.

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/10/01	Main Channel	HR2	BB	118	20.0
10/10/01	Main Channel	HR2	BC	50	nr
10/10/01	Main Channel	HR2	BC	70	nr
10/10/01	Main Channel	HR2	BC	73	6.2
10/10/01	Main Channel	HR2	BC	75	4.4
10/10/01	Main Channel	HR2	BG	55	3.0
10/10/01	Main Channel	HR2	BG	58	4.9
10/10/01	Main Channel	HR2	BG	70	7.0
10/10/01	Main Channel	HR2	BG	58	3.7
10/10/01	Main Channel	HR2	BNM	68	nr
10/10/01	Main Channel	HR2	BNM	70	nr
10/10/01	Main Channel	HR2	BNM	72	nr
10/10/01	Main Channel	HR2	BNM	72	nr
10/10/01	Main Channel	HR2	BNM	85	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	50	nr
10/10/01	Main Channel	HR2	BNM	50	nr
10/10/01	Main Channel	HR2	BNM	50	nr
10/10/01	Main Channel	HR2	BNM	50	nr
10/10/01	Main Channel	HR2	BNM	50	nr
10/10/01	Main Channel	HR2	BNM	60	nr
10/10/01	Main Channel	HR2	BNM	60	nr
10/10/01	Main Channel	HR2	BNM	60	nr
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	75	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	75	nr
10/10/01	Main Channel	HR2	BNM	80	nr
10/10/01	Main Channel	HR2	BNM	80	nr
10/10/01	Main Channel	HR2	BNM	80	nr
10/10/01	Main Channel	HR2	BNM	80	nr
10/10/01	Main Channel	HR2	BNM	80	nr
10/10/01	Main Channel	HR2	BNM	80	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	30	nr
10/10/01	Main Channel	HR2	BNM	40	nr
10/10/01	Main Channel	HR2	BNM	50	nr
10/10/01	Main Channel	HR2	CP	255	110
10/10/01	Main Channel	HR2	CP	308	190
10/10/01	Main Channel	HR2	GS	67	nr
10/10/01	Main Channel	HR2	GS	67	nr
10/10/01	Main Channel	HR2	GS	75	nr
10/10/01	Main Channel	HR2	GS	77	nr
10/10/01	Main Channel	HR2	GS	85	nr
10/10/01	Main Channel	HR2	LMB	90	11.8
10/10/01	Main Channel	HR2	LMB	347	780
10/10/01	Main Channel	HR2	LMB	60	3.5
10/10/01	Main Channel	HR2	LMB	65	4.3
10/10/01	Main Channel	HR2	LMB	78	7.1
10/10/01	Main Channel	HR2	LMB	378	1000
10/10/01	Main Channel	HR2	NP	220	55.0
10/10/01	Main Channel	HR2	NP	235	70.0
10/10/01	Main Channel	HR2	NP	240	70.0
10/10/01	Main Channel	HR2	NP	278	120
10/10/01	Main Channel	HR2	NP	408	350
10/10/01	Main Channel	HR2	NP	231	75.0
10/10/01	Main Channel	HR2	NP	504	650
10/10/01	Main Channel	HR2	PS	60	nr
10/10/01	Main Channel	HR2	PS	110	25.3
10/10/01	Main Channel	HR2	RB	111	28.2
10/10/01	Main Channel	HR2	RB	115	30.6
10/10/01	Main Channel	HR2	RB	121	230.0
10/10/01	Main Channel	HR2	RB	198	180
10/10/01	Main Channel	HR2	RB	225	245
10/10/01	Main Channel	HR2	RB	227	260
10/10/01	Main Channel	HR2	RB	154	75.0
10/10/01	Main Channel	HR2	RB	205	195
10/10/01	Main Channel	HR2	RB	220	235
10/10/01	Main Channel	HR2	SPT	58	nr
10/10/01	Main Channel	HR2	WS	75	3.2
10/10/01	Main Channel	HR2	WS	60	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/10/01	Main Channel	HR2	WS	70	nr
10/10/01	Main Channel	HR2	WS	70	nr
10/10/01	Main Channel	HR2	WS	80	nr
10/10/01	Main Channel	HR2	WS	230	130
10/10/01	Main Channel	HR2	WS	105	nr
10/10/01	Main Channel	HR2	YP	75	40.0
10/10/01	Main Channel	HR2	YP	85	5.2
10/10/01	Main Channel	HR2	YP	87	6.2
10/10/01	Main Channel	HR2	YP	95	10.6
10/10/01	Main Channel	HR2	YP	100	13.0
10/10/01	Main Channel	HR2	YP	100	11.0
10/10/01	Main Channel	HR2	YP	175	63.9
10/10/01	Main Channel	HR2	YP	175	63.0
10/10/01	Main Channel	HR2	YP	210	98.6
10/10/01	Main Channel	HR2	YP	70	6.4
10/10/01	Main Channel	HR2	YP	82	8.7
10/10/01	Main Channel	HR2	YP	95	8.5
10/10/01	Main Channel	HR2	YP	95	9.1
10/10/01	Main Channel	HR2	YP	107	12.0
10/10/01	Main Channel	HR2	YP	108	11.3
10/10/01	Main Channel	HR2	YP	110	20.0
10/10/01	Main Channel	HR2	YP	140	35.0
10/10/01	Main Channel	HR2	YP	140	30.0
10/10/01	Main Channel	HR2	YP	145	30.0
10/10/01	Main Channel	HR2	YP	164	60.0
10/10/01	Main Channel	HR2	YP	178	60.0
10/10/01	Main Channel	HR2	YP	178	57.0
10/10/01	Main Channel	HR2	YP	185	84.0
10/10/01	Main Channel	HR2	YP	203	105
10/10/01	Main Channel	HR2	YP	213	120
10/10/01	Main Channel	HR2	YP	238	180
10/10/01	Main Channel	HR2	YP	264	230
10/10/01	Main Channel	HR2	YP	85	6.0
10/10/01	Main Channel	HR2	YP	92	7.9
10/10/01	Main Channel	UNLMC	BC	65	4.3
10/10/01	Main Channel	UNLMC	BC	72	5.1
10/10/01	Main Channel	UNLMC	BC	78	5.7
10/10/01	Main Channel	UNLMC	BG	162	86.1
10/10/01	Main Channel	UNLMC	BG	175	130
10/10/01	Main Channel	UNLMC	BNM	30	nr
10/10/01	Main Channel	UNLMC	BNM	40	nr
10/10/01	Main Channel	UNLMC	BNM	40	nr
10/10/01	Main Channel	UNLMC	BNM	45	nr
10/10/01	Main Channel	UNLMC	BNM	47	nr
10/10/01	Main Channel	UNLMC	BNM	47	nr
10/10/01	Main Channel	UNLMC	BNM	48	nr
10/10/01	Main Channel	UNLMC	BNM	48	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/10/01	Main Channel	UNLMC	BNM	49	nr
10/10/01	Main Channel	UNLMC	BNM	51	nr
10/10/01	Main Channel	UNLMC	BNM	51	nr
10/10/01	Main Channel	UNLMC	BNM	52	nr
10/10/01	Main Channel	UNLMC	BNM	52	nr
10/10/01	Main Channel	UNLMC	BNM	54	nr
10/10/01	Main Channel	UNLMC	BNM	55	nr
10/10/01	Main Channel	UNLMC	BNM	60	nr
10/10/01	Main Channel	UNLMC	BNM	60	nr
10/10/01	Main Channel	UNLMC	BNM	60	nr
10/10/01	Main Channel	UNLMC	BNM	60	nr
10/10/01	Main Channel	UNLMC	BNM	60	nr
10/10/01	Main Channel	UNLMC	BNM	60	nr
10/10/01	Main Channel	UNLMC	BNM	70	nr
10/10/01	Main Channel	UNLMC	BNM	71	nr
10/10/01	Main Channel	UNLMC	LMB	55	3.5
10/10/01	Main Channel	UNLMC	LMB	56	2.8
10/10/01	Main Channel	UNLMC	LMB	86	8.6
10/10/01	Main Channel	UNLMC	RB	213	200
10/10/01	Main Channel	UNLMC	WS	60	2.2
10/10/01	Main Channel	UNLMC	WS	60	2.7
10/10/01	Main Channel	UNLMC	WS	72	4.0
10/10/01	Main Channel	UNLMC	WS	75	4.7
10/10/01	Main Channel	UNLMC	WS	85	4.5
10/10/01	Main Channel	UNLMC	WS	92	7.5
10/10/01	Main Channel	UNLMC	WS	100	8.9
10/10/01	Main Channel	UNLMC	YP	71	3.6
10/10/01	Main Channel	UNLMC	YP	78	5.2
10/10/01	Main Channel	UNLMC	YP	78	5.3
10/10/01	Main Channel	UNLMC	YP	80	6.1
10/10/01	Main Channel	UNLMC	YP	80	5.2
10/10/01	Main Channel	UNLMC	YP	83	5.6
10/10/01	Main Channel	UNLMC	YP	85	5.6
10/10/01	Main Channel	UNLMC	YP	85	7.0
10/10/01	Main Channel	UNLMC	YP	86	7.3
10/10/01	Main Channel	UNLMC	YP	97	9.9
10/10/01	Main Channel	UNLMC	YP	130	24.3
10/10/01	Main Channel	UNLMC	YP	155	43.5
10/10/01	Main Channel	UNLMC	YP	163	50.0
10/10/01	Main Channel	UNLMC	YP	165	45.6
10/10/01	Main Channel	UNLMC	YP	173	60.0
10/10/01	Main Channel	UNLMC	YP	174	61.3
10/10/01	Main Channel	UNLMC	YP	186	74.0
10/10/01	Main Channel	UNLMC	YP	268	280
10/12/01	Main Channel	LWPTR3	BB	268	nr
10/12/01	Main Channel	LWPTR3	BB	318	460
10/12/01	Main Channel	LWPTR3	BC	60	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Main Channel	LWPTR3	BC	60	nr
10/12/01	Main Channel	LWPTR3	BC	60	nr
10/12/01	Main Channel	LWPTR3	BC	60	nr
10/12/01	Main Channel	LWPTR3	BC	60	nr
10/12/01	Main Channel	LWPTR3	BC	60	nr
10/12/01	Main Channel	LWPTR3	BC	60	nr
10/12/01	Main Channel	LWPTR3	BC	60	nr
10/12/01	Main Channel	LWPTR3	BC	70	nr
10/12/01	Main Channel	LWPTR3	BC	70	nr
10/12/01	Main Channel	LWPTR3	BC	70	nr
10/12/01	Main Channel	LWPTR3	BC	70	nr
10/12/01	Main Channel	LWPTR3	BC	70	nr
10/12/01	Main Channel	LWPTR3	BC	70	nr
10/12/01	Main Channel	LWPTR3	BC	80	nr
10/12/01	Main Channel	LWPTR3	BC	90	nr
10/12/01	Main Channel	LWPTR3	BC	242	215
10/12/01	Main Channel	LWPTR3	BC	245	200
10/12/01	Main Channel	LWPTR3	BG	40	nr
10/12/01	Main Channel	LWPTR3	BG	40	nr
10/12/01	Main Channel	LWPTR3	BG	40	nr
10/12/01	Main Channel	LWPTR3	BG	70	nr
10/12/01	Main Channel	LWPTR3	BG	110	nr
10/12/01	Main Channel	LWPTR3	BG	158	nr
10/12/01	Main Channel	LWPTR3	BG	175	nr
10/12/01	Main Channel	LWPTR3	BG	175	nr
10/12/01	Main Channel	LWPTR3	BG	175	nr
10/12/01	Main Channel	LWPTR3	BG	185	nr
10/12/01	Main Channel	LWPTR3	BG	190	nr
10/12/01	Main Channel	LWPTR3	BG	190	nr
10/12/01	Main Channel	LWPTR3	CC	94	14.1
10/12/01	Main Channel	LWPTR3	JSF	30	nr
10/12/01	Main Channel	LWPTR3	JSF	30	nr
10/12/01	Main Channel	LWPTR3	JSF	30	nr
10/12/01	Main Channel	LWPTR3	JSF	30	nr
10/12/01	Main Channel	LWPTR3	JSF	30	nr
10/12/01	Main Channel	LWPTR3	JSF	30	nr
10/12/01	Main Channel	LWPTR3	JSF	30	nr
10/12/01	Main Channel	LWPTR3	LMB	74	6.8
10/12/01	Main Channel	LWPTR3	LMB	86	10.8
10/12/01	Main Channel	LWPTR3	LMB	92	11.5
10/12/01	Main Channel	LWPTR3	LMB	93	9.7
10/12/01	Main Channel	LWPTR3	LMB	93	12.1
10/12/01	Main Channel	LWPTR3	LMB	96	13.5
10/12/01	Main Channel	LWPTR3	LMB	98	13.5
10/12/01	Main Channel	LWPTR3	LMB	102	14.3
10/12/01	Main Channel	LWPTR3	LMB	102	16.1
10/12/01	Main Channel	LWPTR3	LMB	108	17.4

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Main Channel	LWPTR3	LMB	109	15.9
10/12/01	Main Channel	LWPTR3	LMB	110	16.0
10/12/01	Main Channel	LWPTR3	LMB	112	20.8
10/12/01	Main Channel	LWPTR3	LMB	112	21.5
10/12/01	Main Channel	LWPTR3	LMB	115	21.0
10/12/01	Main Channel	LWPTR3	LMB	117	20.6
10/12/01	Main Channel	LWPTR3	LMB	120	26.4
10/12/01	Main Channel	LWPTR3	LMB	346	680.0
10/12/01	Main Channel	LWPTR3	NP	254	95.0
10/12/01	Main Channel	LWPTR3	NP	262	105
10/12/01	Main Channel	LWPTR3	PS	80	nr
10/12/01	Main Channel	LWPTR3	RB	116	34.5
10/12/01	Main Channel	LWPTR3	RB	120	35.5
10/12/01	Main Channel	LWPTR3	RB	126	42.8
10/12/01	Main Channel	LWPTR3	RB	172	98.7
10/12/01	Main Channel	LWPTR3	RB	218	210
10/12/01	Main Channel	LWPTR3	YP	60	nr
10/12/01	Main Channel	LWPTR3	YP	70	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	80	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	90	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Main Channel	LWPTR3	YP	90	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	100	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	110	nr
10/12/01	Main Channel	LWPTR3	YP	138	nr
10/12/01	Main Channel	LWPTR3	YP	140	nr
10/12/01	Main Channel	LWPTR3	YP	287	300
10/12/01	Main Channel	LWPTR3	YP	325	460
10/11/01	Main Channel	UWPMC1	BG	45	nr
10/11/01	Main Channel	UWPMC1	BG	45	nr
10/11/01	Main Channel	UWPMC1	BG	48	nr
10/11/01	Main Channel	UWPMC1	BG	52	nr
10/11/01	Main Channel	UWPMC1	BG	52	nr
10/11/01	Main Channel	UWPMC1	BG	55	nr
10/11/01	Main Channel	UWPMC1	BG	55	nr
10/11/01	Main Channel	UWPMC1	CP	190	35.0
10/11/01	Main Channel	UWPMC1	CP	253	95.0
10/11/01	Main Channel	UWPMC1	LMB	79	7.5
10/11/01	Main Channel	UWPMC1	LMB	80	8.1
10/11/01	Main Channel	UWPMC1	LMB	82	9.1
10/11/01	Main Channel	UWPMC1	LMB	82	10.1
10/11/01	Main Channel	UWPMC1	LMB	86	8.7
10/11/01	Main Channel	UWPMC1	LMB	87	10.1
10/11/01	Main Channel	UWPMC1	LMB	90	11.7
10/11/01	Main Channel	UWPMC1	LMB	100	12.5
10/11/01	Main Channel	UWPMC1	LMB	345	700

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Main Channel	UWPMC1	LMB	370	875
10/11/01	Main Channel	UWPMC1	LMB	397	1100
10/11/01	Main Channel	UWPMC1	PS	133	nr
10/11/01	Main Channel	UWPMC1	RB	48	1.9
10/11/01	Main Channel	UWPMC1	RB	55	2.7
10/11/01	Main Channel	UWPMC1	RB	110	272
10/11/01	Main Channel	UWPMC1	RB	145	65.0
10/11/01	Main Channel	UWPMC1	RB	273	445
10/11/01	Main Channel	UWPMC1	YP	97	9.2
10/11/01	Main Channel	UWPMC1	YP	102	14.8
10/11/01	Main Channel	UWPMC1	YP	130	23.8
10/11/01	Main Channel	UWPMC1	YP	195	85.0
10/11/01	Main Channel	UWPMC1	YP	232	165.0
10/11/01	Main Channel	YBMC1	BC	72	nr
10/11/01	Main Channel	YBMC1	BC	155	55.6
10/11/01	Main Channel	YBMC1	BG	67	nr
10/11/01	Main Channel	YBMC1	BG	127	nr
10/11/01	Main Channel	YBMC1	BG	148	70.0
10/11/01	Main Channel	YBMC1	BG	149	nr
10/11/01	Main Channel	YBMC1	BG	152	nr
10/11/01	Main Channel	YBMC1	BG	158	nr
10/11/01	Main Channel	YBMC1	BG	165	85.0
10/11/01	Main Channel	YBMC1	BG	165	105
10/11/01	Main Channel	YBMC1	BG	165	nr
10/11/01	Main Channel	YBMC1	BG	175	nr
10/11/01	Main Channel	YBMC1	BG	178	nr
10/11/01	Main Channel	YBMC1	BG	185	160
10/11/01	Main Channel	YBMC1	CP	232	69.2
10/11/01	Main Channel	YBMC1	CP	250	100
10/11/01	Main Channel	YBMC1	CP	252	105
10/11/01	Main Channel	YBMC1	GS	50	nr
10/11/01	Main Channel	YBMC1	GS	140	26.0
10/11/01	Main Channel	YBMC1	LMB	56	3.5
10/11/01	Main Channel	YBMC1	LMB	92	14.3
10/11/01	Main Channel	YBMC1	PS	72	nr
10/11/01	Main Channel	YBMC1	PS	84	nr
10/11/01	Main Channel	YBMC1	PS	97	nr
10/11/01	Main Channel	YBMC1	PS	100	nr
10/11/01	Main Channel	YBMC1	PS	105	28.0
10/11/01	Main Channel	YBMC1	PS	109	nr
10/11/01	Main Channel	YBMC1	PS	110	nr
10/11/01	Main Channel	YBMC1	PS	111	nr
10/11/01	Main Channel	YBMC1	PS	112	nr
10/11/01	Main Channel	YBMC1	PS	113	nr
10/11/01	Main Channel	YBMC1	PS	115	nr
10/11/01	Main Channel	YBMC1	PS	117	nr
10/11/01	Main Channel	YBMC1	PS	120	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Main Channel	YBMC1	PS	122	40.0
10/11/01	Main Channel	YBMC1	PS	122	45.0
10/11/01	Main Channel	YBMC1	PS	122	nr
10/11/01	Main Channel	YBMC1	PS	125	nr
10/11/01	Main Channel	YBMC1	PS	125	nr
10/11/01	Main Channel	YBMC1	PS	130	nr
10/11/01	Main Channel	YBMC1	PS	132	50.0
10/11/01	Main Channel	YBMC1	PS	135	nr
10/11/01	Main Channel	YBMC1	PS	140	nr
10/11/01	Main Channel	YBMC1	PS	140	nr
10/11/01	Main Channel	YBMC1	PS	147	80.0
10/11/01	Main Channel	YBMC1	PS	150	nr
10/11/01	Main Channel	YBMC1	PS	150	nr
10/11/01	Main Channel	YBMC1	PS	160	nr
10/11/01	Main Channel	YBMC1	PS	165	nr
10/11/01	Main Channel	YBMC1	PS	170	nr
10/11/01	Main Channel	YBMC1	PS	172	nr
10/11/01	Main Channel	YBMC1	PS	180	150
10/11/01	Main Channel	YBMC1	PS	nr	23.8
10/11/01	Main Channel	YBMC1	RB	55	60.0
10/11/01	Main Channel	YBMC1	RB	93	16.5
10/11/01	Main Channel	YBMC1	RB	100	20.0
10/11/01	Main Channel	YBMC1	RB	118	34.4
10/11/01	Main Channel	YBMC1	RB	120	34.3
10/11/01	Main Channel	YBMC1	RB	130	50.0
10/11/01	Main Channel	YBMC1	RB	140	60.0
10/11/01	Main Channel	YBMC1	RB	144	65.0
10/11/01	Main Channel	YBMC1	RB	145	65.5
10/11/01	Main Channel	YBMC1	RB	152	67.0
10/11/01	Main Channel	YBMC1	RB	160	92.0
10/11/01	Main Channel	YBMC1	RB	160	83.7
10/11/01	Main Channel	YBMC1	RB	162	78.0
10/11/01	Main Channel	YBMC1	RB	163	85.0
10/11/01	Main Channel	YBMC1	RB	164	95.0
10/11/01	Main Channel	YBMC1	RB	165	nr
10/11/01	Main Channel	YBMC1	RB	170	100
10/11/01	Main Channel	YBMC1	RB	170	100
10/11/01	Main Channel	YBMC1	RB	173	130
10/11/01	Main Channel	YBMC1	RB	173	110
10/11/01	Main Channel	YBMC1	RB	175	100
10/11/01	Main Channel	YBMC1	RB	175	105
10/11/01	Main Channel	YBMC1	RB	178	110
10/11/01	Main Channel	YBMC1	RB	180	110
10/11/01	Main Channel	YBMC1	RB	180	125
10/11/01	Main Channel	YBMC1	RB	184	135
10/11/01	Main Channel	YBMC1	RB	185	130
10/11/01	Main Channel	YBMC1	RB	185	140

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Main Channel	YBMC1	RB	185	140
10/11/01	Main Channel	YBMC1	RB	187	145
10/11/01	Main Channel	YBMC1	RB	193	140
10/11/01	Main Channel	YBMC1	RB	193	170
10/11/01	Main Channel	YBMC1	RB	195	130
10/11/01	Main Channel	YBMC1	RB	196	145
10/11/01	Main Channel	YBMC1	RB	200	165
10/11/01	Main Channel	YBMC1	RB	200	175
10/11/01	Main Channel	YBMC1	RB	210	210
10/11/01	Main Channel	YBMC1	RB	215	205
10/11/01	Main Channel	YBMC1	RB	220	185
10/11/01	Main Channel	YBMC1	RB	230	265
10/11/01	Main Channel	YBMC1	RB	235	325
10/11/01	Main Channel	YBMC1	RB	237	300
10/11/01	Main Channel	YBMC1	RB	245	325
10/11/01	Main Channel	YBMC1	WS	215	nr
10/11/01	Main Channel	YBMC1	WS	347	nr
10/11/01	Main Channel	YBMC1	YP	100	12.6
10/11/01	Main Channel	YBMC1	YP	183	73.4
10/11/01	Main Channel	YBMC1	YP	230	150
10/12/01	Transition	LWPMC1	BB	180	nr
10/12/01	Transition	LWPMC1	BB	290	nr
10/12/01	Transition	LWPMC1	BC	50	nr
10/12/01	Transition	LWPMC1	BC	50	nr
10/12/01	Transition	LWPMC1	BC	60	nr
10/12/01	Transition	LWPMC1	BC	60	nr
10/12/01	Transition	LWPMC1	BC	60	nr
10/12/01	Transition	LWPMC1	BC	60	nr
10/12/01	Transition	LWPMC1	BC	70	nr
10/12/01	Transition	LWPMC1	BC	70	nr
10/12/01	Transition	LWPMC1	BC	70	nr
10/12/01	Transition	LWPMC1	BC	70	nr
10/12/01	Transition	LWPMC1	BC	70	nr
10/12/01	Transition	LWPMC1	BC	70	nr
10/12/01	Transition	LWPMC1	BC	80	nr
10/12/01	Transition	LWPMC1	BC	80	nr
10/12/01	Transition	LWPMC1	BC	90	nr
10/12/01	Transition	LWPMC1	BG	50	nr
10/12/01	Transition	LWPMC1	BG	50	nr
10/12/01	Transition	LWPMC1	BG	143	nr
10/12/01	Transition	LWPMC1	BNM	60	nr
10/12/01	Transition	LWPMC1	CP	217	59.5
10/12/01	Transition	LWPMC1	GS	40	nr
10/12/01	Transition	LWPMC1	GS	40	nr
10/12/01	Transition	LWPMC1	GS	50	nr
10/12/01	Transition	LWPMC1	GS	50	nr
10/12/01	Transition	LWPMC1	GS	50	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	LWPMC1	GS	50	nr
10/12/01	Transition	LWPMC1	GS	60	nr
10/12/01	Transition	LWPMC1	GS	60	nr
10/12/01	Transition	LWPMC1	GS	60	nr
10/12/01	Transition	LWPMC1	GS	60	nr
10/12/01	Transition	LWPMC1	GS	70	nr
10/12/01	Transition	LWPMC1	GS	70	nr
10/12/01	Transition	LWPMC1	GS	70	nr
10/12/01	Transition	LWPMC1	GS	70	nr
10/12/01	Transition	LWPMC1	GS	70	nr
10/12/01	Transition	LWPMC1	JSF	10	nr
10/12/01	Transition	LWPMC1	JSF	20	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	JSF	30	nr
10/12/01	Transition	LWPMC1	LMB	68	4.9
10/12/01	Transition	LWPMC1	LMB	68	4.5
10/12/01	Transition	LWPMC1	LMB	75	5.7
10/12/01	Transition	LWPMC1	LMB	82	8.1
10/12/01	Transition	LWPMC1	LMB	82	9.2
10/12/01	Transition	LWPMC1	LMB	84	7.7
10/12/01	Transition	LWPMC1	LMB	85	8.2
10/12/01	Transition	LWPMC1	LMB	85	8.4
10/12/01	Transition	LWPMC1	LMB	86	nr
10/12/01	Transition	LWPMC1	LMB	91	9.9
10/12/01	Transition	LWPMC1	LMB	92	11.2
10/12/01	Transition	LWPMC1	LMB	94	10.9
10/12/01	Transition	LWPMC1	LMB	95	11.7
10/12/01	Transition	LWPMC1	LMB	95	12.1
10/12/01	Transition	LWPMC1	LMB	95	11.3
10/12/01	Transition	LWPMC1	LMB	100	14.0
10/12/01	Transition	LWPMC1	LMB	110	17.4
10/12/01	Transition	LWPMC1	LMB	358	775
10/12/01	Transition	LWPMC1	LMB	358	800
10/12/01	Transition	LWPMC1	LMB	378	825
10/12/01	Transition	LWPMC1	NP	485	625
10/12/01	Transition	LWPMC1	NP	570	850
10/12/01	Transition	LWPMC1	RB	30	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	LWPMC1	RB	40	nr
10/12/01	Transition	LWPMC1	RB	80	nr
10/12/01	Transition	LWPMC1	RB	125	nr
10/12/01	Transition	LWPMC1	RB	135	nr
10/12/01	Transition	LWPMC1	RB	145	nr
10/12/01	Transition	LWPMC1	RB	156	nr
10/12/01	Transition	LWPMC1	RB	202	nr
10/12/01	Transition	LWPMC1	YP	70	nr
10/12/01	Transition	LWPMC1	YP	70	nr
10/12/01	Transition	LWPMC1	YP	80	nr
10/12/01	Transition	LWPMC1	YP	80	nr
10/12/01	Transition	LWPMC1	YP	90	nr
10/12/01	Transition	LWPMC1	YP	90	nr
10/12/01	Transition	LWPMC1	YP	90	nr
10/12/01	Transition	LWPMC1	YP	90	nr
10/12/01	Transition	LWPMC1	YP	90	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	100	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC1	YP	110	nr
10/12/01	Transition	LWPMC2	BC	50	nr
10/12/01	Transition	LWPMC2	BC	50	nr
10/12/01	Transition	LWPMC2	BC	60	nr
10/12/01	Transition	LWPMC2	BC	60	nr
10/12/01	Transition	LWPMC2	BC	70	nr
10/12/01	Transition	LWPMC2	BC	70	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	LWPMC2	BC	70	nr
10/12/01	Transition	LWPMC2	BC	70	nr
10/12/01	Transition	LWPMC2	BC	70	nr
10/12/01	Transition	LWPMC2	BC	85	nr
10/12/01	Transition	LWPMC2	BC	85	nr
10/12/01	Transition	LWPMC2	BC	215	170
10/12/01	Transition	LWPMC2	BC	220	235
10/12/01	Transition	LWPMC2	BG	40	nr
10/12/01	Transition	LWPMC2	BG	40	nr
10/12/01	Transition	LWPMC2	BG	50	nr
10/12/01	Transition	LWPMC2	BG	158	nr
10/12/01	Transition	LWPMC2	BG	168	nr
10/12/01	Transition	LWPMC2	BG	195	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	JSF	30	nr
10/12/01	Transition	LWPMC2	LMB	68	5.7
10/12/01	Transition	LWPMC2	LMB	72	4.9
10/12/01	Transition	LWPMC2	LMB	78	7.0
10/12/01	Transition	LWPMC2	LMB	81	9.0
10/12/01	Transition	LWPMC2	LMB	82	7.7
10/12/01	Transition	LWPMC2	LMB	94	13.3
10/12/01	Transition	LWPMC2	LMB	96	12.0
10/12/01	Transition	LWPMC2	LMB	103	14.8
10/12/01	Transition	LWPMC2	LMB	105	17.5
10/12/01	Transition	LWPMC2	LMB	109	18.4
10/12/01	Transition	LWPMC2	LMB	110	17.0
10/12/01	Transition	LWPMC2	LMB	118	20.9
10/12/01	Transition	LWPMC2	LMB	120	24.3
10/12/01	Transition	LWPMC2	LMB	132	32.8
10/12/01	Transition	LWPMC2	LMB	355	900
10/12/01	Transition	LWPMC2	NP	245	nr
10/12/01	Transition	LWPMC2	NP	485	650
10/12/01	Transition	LWPMC2	PS	85	nr
10/12/01	Transition	LWPMC2	PS	148	nr
10/12/01	Transition	LWPMC2	PS	155	nr
10/12/01	Transition	LWPMC2	PS	185	nr
10/12/01	Transition	LWPMC2	RB	55	nr
10/12/01	Transition	LWPMC2	RB	55	nr
10/12/01	Transition	LWPMC2	RB	55	nr
10/12/01	Transition	LWPMC2	RB	124	nr
10/12/01	Transition	LWPMC2	RB	140	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	LWPMC2	RB	200	185
10/12/01	Transition	LWPMC2	RB	215	170
10/12/01	Transition	LWPMC2	WS	400	nr
10/12/01	Transition	LWPMC2	WS	470	nr
10/12/01	Transition	LWPMC2	YP	80	nr
10/12/01	Transition	LWPMC2	YP	80	nr
10/12/01	Transition	LWPMC2	YP	80	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	90	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	100	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	110	nr
10/12/01	Transition	LWPMC2	YP	183	nr
10/12/01	Transition	LWPMC2	YP	230	185
10/12/01	Transition	LWPMC2	YP	235	nr
10/12/01	Transition	LWPMC2	YP	267	250
10/11/01	Transition	OM8MC	BC	65	nr
10/11/01	Transition	OM8MC	BC	75	5.6
10/11/01	Transition	OM8MC	BG	45	nr
10/11/01	Transition	OM8MC	BG	52	nr
10/11/01	Transition	OM8MC	BG	53	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Transition	OM8MC	BG	55	nr
10/11/01	Transition	OM8MC	BNM	50	nr
10/11/01	Transition	OM8MC	LMB	64	4.0
10/11/01	Transition	OM8MC	LMB	65	5.1
10/11/01	Transition	OM8MC	LMB	68	4.9
10/11/01	Transition	OM8MC	LMB	72	6.5
10/11/01	Transition	OM8MC	LMB	72	4.9
10/11/01	Transition	OM8MC	LMB	72	5.1
10/11/01	Transition	OM8MC	LMB	72	5.6
10/11/01	Transition	OM8MC	LMB	74	6.1
10/11/01	Transition	OM8MC	LMB	78	8.3
10/11/01	Transition	OM8MC	LMB	82	8.9
10/11/01	Transition	OM8MC	LMB	83	8.2
10/11/01	Transition	OM8MC	LMB	83	9.0
10/11/01	Transition	OM8MC	LMB	90	9.3
10/11/01	Transition	OM8MC	LMB	92	10.5
10/11/01	Transition	OM8MC	LMB	95	11.8
10/11/01	Transition	OM8MC	LMB	100	15.1
10/11/01	Transition	OM8MC	LMB	110	14.2
10/11/01	Transition	OM8MC	LMB	313	500
10/11/01	Transition	OM8MC	LMB	340	650
10/11/01	Transition	OM8MC	LMB	343	640
10/11/01	Transition	OM8MC	LMB	348	760
10/11/01	Transition	OM8MC	LMB	360	800
10/11/01	Transition	OM8MC	RB	167	85.0
10/11/01	Transition	OM8MC	RB	193	150
10/11/01	Transition	OM8MC	RB	204	180
10/11/01	Transition	OM8MC	RB	210	215
10/11/01	Transition	OM8MC	YP	83	5.5
10/11/01	Transition	OM8MC	YP	84	8.0
10/11/01	Transition	OM8MC	YP	270	250
10/12/01	Transition	LWPIsland	BB	70	nr
10/12/01	Transition	LWPIsland	BB	195	nr
10/12/01	Transition	LWPIsland	BB	220	nr
10/12/01	Transition	LWPIsland	BB	268	nr
10/12/01	Transition	LWPIsland	BC	40	nr
10/12/01	Transition	LWPIsland	BC	50	nr
10/12/01	Transition	LWPIsland	BC	50	nr
10/12/01	Transition	LWPIsland	BC	50	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	60	nr
10/12/01	Transition	LWPIsland	BC	70	nr
10/12/01	Transition	LWPIsland	BC	70	nr
10/12/01	Transition	LWPIsland	BC	70	nr
10/12/01	Transition	LWPIsland	BC	80	nr
10/12/01	Transition	LWPIsland	BC	90	nr
10/12/01	Transition	LWPIsland	BC	203	120
10/12/01	Transition	LWPIsland	BC	241	225
10/12/01	Transition	LWPIsland	BG	40	nr
10/12/01	Transition	LWPIsland	BG	40	nr
10/12/01	Transition	LWPIsland	BG	40	nr
10/12/01	Transition	LWPIsland	BG	50	nr
10/12/01	Transition	LWPIsland	BG	50	nr
10/12/01	Transition	LWPIsland	BG	50	nr
10/12/01	Transition	LWPIsland	BG	50	nr
10/12/01	Transition	LWPIsland	BG	60	nr
10/12/01	Transition	LWPIsland	BG	60	nr
10/12/01	Transition	LWPIsland	BG	60	nr
10/12/01	Transition	LWPIsland	CP	235	77.0
10/12/01	Transition	LWPIsland	JSF	30	nr
10/12/01	Transition	LWPIsland	JSF	30	nr
10/12/01	Transition	LWPIsland	JSF	30	nr
10/12/01	Transition	LWPIsland	JSF	30	nr
10/12/01	Transition	LWPIsland	JSF	30	nr
10/12/01	Transition	LWPIsland	LMB	75	8.6
10/12/01	Transition	LWPIsland	LMB	75	7.4
10/12/01	Transition	LWPIsland	LMB	80	6.9
10/12/01	Transition	LWPIsland	LMB	85	10.5
10/12/01	Transition	LWPIsland	LMB	85	9.5
10/12/01	Transition	LWPIsland	LMB	86	11.2
10/12/01	Transition	LWPIsland	LMB	86	10.5
10/12/01	Transition	LWPIsland	LMB	90	11.3
10/12/01	Transition	LWPIsland	LMB	95	9.6
10/12/01	Transition	LWPIsland	LMB	100	12.5
10/12/01	Transition	LWPIsland	LMB	108	13.8
10/12/01	Transition	LWPIsland	LMB	108	18.0
10/12/01	Transition	LWPIsland	NP	205	43.8
10/12/01	Transition	LWPIsland	NP	210	44.0
10/12/01	Transition	LWPIsland	NP	225	57.0
10/12/01	Transition	LWPIsland	PS	135	nr
10/12/01	Transition	LWPIsland	PS	193	nr
10/12/01	Transition	LWPIsland	RB	50	nr
10/12/01	Transition	LWPIsland	RB	50	nr
10/12/01	Transition	LWPIsland	RB	50	nr
10/12/01	Transition	LWPIsland	WS	485	nr
10/12/01	Transition	LWPIsland	WS	495	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	LWPIsland	YP	70	nr
10/12/01	Transition	LWPIsland	YP	70	nr
10/12/01	Transition	LWPIsland	YP	70	nr
10/12/01	Transition	LWPIsland	YP	70	nr
10/12/01	Transition	LWPIsland	YP	70	nr
10/12/01	Transition	LWPIsland	YP	70	nr
10/12/01	Transition	LWPIsland	YP	70	nr
10/12/01	Transition	LWPIsland	YP	80	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	90	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	100	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	110	nr
10/12/01	Transition	LWPIsland	YP	120	nr
10/12/01	Transition	LWPIsland	YP	220	nr
10/12/01	Transition	UWP3TR2	BC	50	nr
10/12/01	Transition	UWP3TR2	BC	50	nr
10/12/01	Transition	UWP3TR2	BC	50	nr
10/12/01	Transition	UWP3TR2	BC	50	nr
10/12/01	Transition	UWP3TR2	BC	50	nr
10/12/01	Transition	UWP3TR2	BC	60	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	UWP3TR2	BC	60	nr
10/12/01	Transition	UWP3TR2	BC	60	nr
10/12/01	Transition	UWP3TR2	BC	60	nr
10/12/01	Transition	UWP3TR2	BC	60	nr
10/12/01	Transition	UWP3TR2	BC	70	nr
10/12/01	Transition	UWP3TR2	BC	70	nr
10/12/01	Transition	UWP3TR2	BC	70	nr
10/12/01	Transition	UWP3TR2	BG	40	nr
10/12/01	Transition	UWP3TR2	BG	50	nr
10/12/01	Transition	UWP3TR2	BG	160	nr
10/12/01	Transition	UWP3TR2	BG	163	nr
10/12/01	Transition	UWP3TR2	BG	195	nr
10/12/01	Transition	UWP3TR2	CP	205	46.4
10/12/01	Transition	UWP3TR2	GS	40	nr
10/12/01	Transition	UWP3TR2	GS	50	nr
10/12/01	Transition	UWP3TR2	GS	50	nr
10/12/01	Transition	UWP3TR2	GS	60	nr
10/12/01	Transition	UWP3TR2	GS	60	nr
10/12/01	Transition	UWP3TR2	GS	60	nr
10/12/01	Transition	UWP3TR2	GS	60	nr
10/12/01	Transition	UWP3TR2	GS	70	nr
10/12/01	Transition	UWP3TR2	GS	70	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	GS	80	nr
10/12/01	Transition	UWP3TR2	JSF	30	nr
10/12/01	Transition	UWP3TR2	JSF	30	nr
10/12/01	Transition	UWP3TR2	JSF	30	nr
10/12/01	Transition	UWP3TR2	LMB	73	6.7
10/12/01	Transition	UWP3TR2	LMB	74	7.2
10/12/01	Transition	UWP3TR2	LMB	74	6.7
10/12/01	Transition	UWP3TR2	LMB	76	7.5
10/12/01	Transition	UWP3TR2	LMB	78	8.5
10/12/01	Transition	UWP3TR2	LMB	78	7.3
10/12/01	Transition	UWP3TR2	LMB	78	7.4
10/12/01	Transition	UWP3TR2	LMB	80	8.2
10/12/01	Transition	UWP3TR2	LMB	80	8.0
10/12/01	Transition	UWP3TR2	LMB	82	7.8
10/12/01	Transition	UWP3TR2	LMB	82	7.5
10/12/01	Transition	UWP3TR2	LMB	84	10.1
10/12/01	Transition	UWP3TR2	LMB	84	9.4

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Transition	UWP3TR2	LMB	86	11.0
10/12/01	Transition	UWP3TR2	LMB	87	10.6
10/12/01	Transition	UWP3TR2	LMB	90	12.2
10/12/01	Transition	UWP3TR2	LMB	93	11.5
10/12/01	Transition	UWP3TR2	LMB	96	14.0
10/12/01	Transition	UWP3TR2	LMB	100	14.8
10/12/01	Transition	UWP3TR2	LMB	104	17.1
10/12/01	Transition	UWP3TR2	LMB	105	16.2
10/12/01	Transition	UWP3TR2	LMB	112	19.7
10/12/01	Transition	UWP3TR2	LMB	295	475
10/12/01	Transition	UWP3TR2	LMB	367	875
10/12/01	Transition	UWP3TR2	LMB	378	975
10/12/01	Transition	UWP3TR2	LMB	385	1025
10/12/01	Transition	UWP3TR2	MC	115	21.4
10/12/01	Transition	UWP3TR2	NP	245	85.0
10/12/01	Transition	UWP3TR2	RB	30	nr
10/12/01	Transition	UWP3TR2	RB	40	nr
10/12/01	Transition	UWP3TR2	RB	165	nr
10/12/01	Transition	UWP3TR2	RB	175	nr
10/12/01	Transition	UWP3TR2	WS	452	nr
10/12/01	Transition	UWP3TR2	YB	250	225
10/12/01	Transition	UWP3TR2	YP	70	nr
10/12/01	Transition	UWP3TR2	YP	90	nr
10/12/01	Transition	UWP3TR2	YP	90	nr
10/12/01	Transition	UWP3TR2	YP	90	nr
10/12/01	Transition	UWP3TR2	YP	90	nr
10/12/01	Transition	UWP3TR2	YP	90	nr
10/12/01	Transition	UWP3TR2	YP	247	nr
10/11/01	Transition	YBSC1	BB	265	280
10/11/01	Transition	YBSC1	BC	60	nr
10/11/01	Transition	YBSC1	BC	60	nr
10/11/01	Transition	YBSC1	BC	60	nr
10/11/01	Transition	YBSC1	BC	62	nr
10/11/01	Transition	YBSC1	BC	63	nr
10/11/01	Transition	YBSC1	BC	64	nr
10/11/01	Transition	YBSC1	BC	64	nr
10/11/01	Transition	YBSC1	BC	65	nr
10/11/01	Transition	YBSC1	BC	65	4.1
10/11/01	Transition	YBSC1	BC	65	nr
10/11/01	Transition	YBSC1	BC	65	nr
10/11/01	Transition	YBSC1	BC	68	nr
10/11/01	Transition	YBSC1	BNM	40	nr
10/11/01	Transition	YBSC1	BNM	40	nr
10/11/01	Transition	YBSC1	BNM	40	nr
10/11/01	Transition	YBSC1	BNM	40	nr
10/11/01	Transition	YBSC1	BNM	40	nr
10/11/01	Transition	YBSC1	BNM	50	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Transition	YBSC1	BNM	50	nr
10/11/01	Transition	YBSC1	BNM	50	nr
10/11/01	Transition	YBSC1	BNM	50	nr
10/11/01	Transition	YBSC1	BNM	50	nr
10/11/01	Transition	YBSC1	BNM	60	nr
10/11/01	Transition	YBSC1	BNM	74	nr
10/11/01	Transition	YBSC1	BNM	80	nr
10/11/01	Transition	YBSC1	BNM	85	nr
10/11/01	Transition	YBSC1	BNM	94	nr
10/11/01	Transition	YBSC1	BNM	100	nr
10/11/01	Transition	YBSC1	CP	285	165
10/11/01	Transition	YBSC1	GS	60	nr
10/11/01	Transition	YBSC1	GS	70	nr
10/11/01	Transition	YBSC1	GS	70	nr
10/11/01	Transition	YBSC1	GS	75	nr
10/11/01	Transition	YBSC1	GS	75	nr
10/11/01	Transition	YBSC1	GS	75	nr
10/11/01	Transition	YBSC1	GS	78	nr
10/11/01	Transition	YBSC1	GS	80	nr
10/11/01	Transition	YBSC1	GS	80	nr
10/11/01	Transition	YBSC1	GS	80	nr
10/11/01	Transition	YBSC1	GS	80	nr
10/11/01	Transition	YBSC1	GS	80	nr
10/11/01	Transition	YBSC1	GS	80	nr
10/11/01	Transition	YBSC1	GS	80	nr
10/11/01	Transition	YBSC1	GS	82	nr
10/11/01	Transition	YBSC1	GS	95	nr
10/11/01	Transition	YBSC1	GS	98	
10/11/01	Transition	YBSC1	GS	115	nr
10/11/01	Transition	YBSC1	GS	120	17.5
10/11/01	Transition	YBSC1	GS	120	nr
10/11/01	Transition	YBSC1	GS	127	nr
10/11/01	Transition	YBSC1	GS	142	28.3
10/11/01	Transition	YBSC1	GS	172	54.0
10/11/01	Transition	YBSC1	LMB	62	3.8
10/11/01	Transition	YBSC1	LMB	68	4.2
10/11/01	Transition	YBSC1	LMB	74	7.2
10/11/01	Transition	YBSC1	LMB	75	6.8
10/11/01	Transition	YBSC1	LMB	76	6.3
10/11/01	Transition	YBSC1	LMB	88	10.2
10/11/01	Transition	YBSC1	NP	285	130
10/11/01	Transition	YBSC1	RB	202	175
10/11/01	Transition	YBSC1	RB	210	190
10/11/01	Transition	YBSC1	RB	215	230
10/11/01	Transition	YBSC1	RB	222	215
10/11/01	Transition	YBSC1	WS	335	425
10/11/01	Transition	YBSC1	WS	425	870

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Transition	YBSC1	WS	460	1160
10/11/01	Transition	YBSC1	WS	460	1250
10/11/01	Transition	YBSC1	WS	463	1050
10/11/01	Transition	YBSC1	WS	475	1075
10/11/01	Transition	YBSC1	YP	75	6.2
10/11/01	Transition	YBSC1	YP	80	6.4
10/11/01	Transition	YBSC1	YP	83	5.8
10/11/01	Transition	YBSC1	YP	85	7.0
10/11/01	Transition	YBSC1	YP	85	7.0
10/11/01	Transition	YBSC1	YP	85	6.4
10/11/01	Transition	YBSC1	YP	94	8.5
10/11/01	Transition	YBSC1	YP	96	10.6
10/11/01	Transition	YBSC1	YP	100	13.4
10/11/01	Transition	YBSC1	YP	115	11.0
10/11/01	Transition	YBSC1	YP	155	47.2
10/11/01	Transition	YBSC1	YP	190	95.0
10/11/01	Transition	YBSC1	YP	231	150
10/11/01	Transition	YBSC1	YP	242	175
10/11/01	Transition	YBSC1	YP	260	220
10/11/01	Transition	YBSC1	YP	nr	10.8
10/12/01	Backwater	LWPBW1	BC	60	nr
10/12/01	Backwater	LWPBW1	BC	60	nr
10/12/01	Backwater	LWPBW1	BC	60	nr
10/12/01	Backwater	LWPBW1	BC	70	nr
10/12/01	Backwater	LWPBW1	BC	70	nr
10/12/01	Backwater	LWPBW1	BC	70	nr
10/12/01	Backwater	LWPBW1	BC	70	nr
10/12/01	Backwater	LWPBW1	BC	70	nr
10/12/01	Backwater	LWPBW1	BC	70	nr
10/12/01	Backwater	LWPBW1	BC	80	nr
10/12/01	Backwater	LWPBW1	BC	80	nr
10/12/01	Backwater	LWPBW1	BG	40	nr
10/12/01	Backwater	LWPBW1	BG	40	nr
10/12/01	Backwater	LWPBW1	BG	40	nr
10/12/01	Backwater	LWPBW1	BG	40	nr
10/12/01	Backwater	LWPBW1	BG	40	nr
10/12/01	Backwater	LWPBW1	BG	50	nr
10/12/01	Backwater	LWPBW1	BG	50	nr
10/12/01	Backwater	LWPBW1	BG	50	nr
10/12/01	Backwater	LWPBW1	BG	50	nr
10/12/01	Backwater	LWPBW1	BG	158	nr
10/12/01	Backwater	LWPBW1	BG	168	nr
10/12/01	Backwater	LWPBW1	BG	175	nr
10/12/01	Backwater	LWPBW1	BG	175	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	JSF	30	nr
10/12/01	Backwater	LWPBW1	LMB	68	5.1
10/12/01	Backwater	LWPBW1	LMB	78	7.8
10/12/01	Backwater	LWPBW1	LMB	93	11.1
10/12/01	Backwater	LWPBW1	LMB	110	21.0
10/12/01	Backwater	LWPBW1	LMB	135	32.5
10/12/01	Backwater	LWPBW1	PS	98	nr
10/12/01	Backwater	LWPBW1	PS	158	nr
10/12/01	Backwater	LWPBW1	PS	165	nr
10/12/01	Backwater	LWPBW1	PS	168	nr
10/12/01	Backwater	LWPBW1	PS	175	nr
10/12/01	Backwater	LWPBW1	RB	135	nr
10/12/01	Backwater	LWPBW3	BC	70	4.8
10/12/01	Backwater	LWPBW3	BC	70	nr
10/12/01	Backwater	LWPBW3	BC	70	nr
10/12/01	Backwater	LWPBW3	BC	70	nr
10/12/01	Backwater	LWPBW3	BC	240	235
10/12/01	Backwater	LWPBW3	BG	40	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	45	nr
10/12/01	Backwater	LWPBW3	BG	70	nr
10/12/01	Backwater	LWPBW3	BG	125	nr
10/12/01	Backwater	LWPBW3	BG	168	107

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Backwater	LWPBW3	BG	183	nr
10/12/01	Backwater	LWPBW3	BG	185	149
10/12/01	Backwater	LWPBW3	BG	185	nr
10/12/01	Backwater	LWPBW3	BG	190	nr
10/12/01	Backwater	LWPBW3	BG	195	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	JSF	30	nr
10/12/01	Backwater	LWPBW3	LMB	72	4.4
10/12/01	Backwater	LWPBW3	LMB	75	7.1
10/12/01	Backwater	LWPBW3	LMB	80	6.8
10/12/01	Backwater	LWPBW3	LMB	86	8.6
10/12/01	Backwater	LWPBW3	LMB	90	10.5
10/12/01	Backwater	LWPBW3	LMB	90	11.5
10/12/01	Backwater	LWPBW3	LMB	97	11.2
10/12/01	Backwater	LWPBW3	LMB	110	16.5
10/12/01	Backwater	LWPBW3	LMB	112	16.8
10/12/01	Backwater	LWPBW3	LMB	133	35.3
10/12/01	Backwater	LWPBW3	LMB	154	45.0
10/12/01	Backwater	LWPBW3	LMB	345	785
10/12/01	Backwater	LWPBW3	PS	95	16.0
10/12/01	Backwater	LWPBW3	PS	138	58.0
10/12/01	Backwater	LWPBW3	RB	105	24.1
10/12/01	Backwater	LWPBW3	RB	125	43.7
10/12/01	Backwater	LWPBW3	RB	214	220
10/12/01	Backwater	LWPBW3	YP	88	nr
10/12/01	Backwater	LWPBW3	YP	97	10.3
10/12/01	Backwater	LWPBW3	YP	100	nr
10/12/01	Backwater	LWPBW3	YP	102	nr
10/12/01	Backwater	LWPBW3	YP	103	nr
10/12/01	Backwater	LWPBW3	YP	105	nr
10/12/01	Backwater	LWPBW3	YP	105	nr
10/12/01	Backwater	LWPBW3	YP	105	nr
10/12/01	Backwater	LWPBW3	YP	107	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/12/01	Backwater	LWPBW3	YP	109	nr
10/12/01	Backwater	LWPBW3	YP	190	85.0
10/12/01	Backwater	LWPBW3	YP	214	nr
10/12/01	Backwater	LWPBW3	YP	245	170
10/11/01	Backwater	YBBW1	CP	76	6.9
10/11/01	Backwater	YBBW1	CP	152	25.0
10/11/01	Backwater	YBBW1	CP	165	23.4
10/11/01	Backwater	YBBW1	CP	190	36.8
10/11/01	Backwater	YBBW1	CP	190	55.0
10/11/01	Backwater	YBBW1	CP	194	40.0
10/11/01	Backwater	YBBW1	CP	194	49.0
10/11/01	Backwater	YBBW1	CP	195	35.0
10/11/01	Backwater	YBBW1	CP	201	40.0
10/11/01	Backwater	YBBW1	CP	203	50.0
10/11/01	Backwater	YBBW1	CP	205	60.0
10/11/01	Backwater	YBBW1	CP	211	70.0
10/11/01	Backwater	YBBW1	CP	240	85.0
10/11/01	Backwater	YBBW1	CP	278	115
10/11/01	Backwater	YBBW1	GS	30	nr
10/11/01	Backwater	YBBW1	GS	30	nr
10/11/01	Backwater	YBBW1	GS	40	nr
10/11/01	Backwater	YBBW1	GS	40	nr
10/11/01	Backwater	YBBW1	GS	40	nr
10/11/01	Backwater	YBBW1	GS	50	nr
10/11/01	Backwater	YBBW1	GS	50	nr
10/11/01	Backwater	YBBW1	GS	50	nr
10/11/01	Backwater	YBBW1	GS	50	nr
10/11/01	Backwater	YBBW1	GS	50	nr
10/11/01	Backwater	YBBW1	GS	50	nr
10/11/01	Backwater	YBBW1	GS	53	nr
10/11/01	Backwater	YBBW1	LMB	60	3.4
10/11/01	Backwater	YBBW1	LMB	85	7.4
10/11/01	Backwater	YBBW1	LMB	89	9.3
10/11/01	Backwater	YBBW1	LMB	100	15.7
10/11/01	Backwater	UWPI	BB	252	nr
10/11/01	Backwater	UWPI	BB	270	nr
10/11/01	Backwater	UWPI	BB	278	285
10/11/01	Backwater	UWPI	BB	282	300
10/11/01	Backwater	UWPI	BB	290	340
10/11/01	Backwater	UWPI	BB	290	nr
10/11/01	Backwater	UWPI	BC	55	nr
10/11/01	Backwater	UWPI	BC	60	nr
10/11/01	Backwater	UWPI	BC	60	nr
10/11/01	Backwater	UWPI	BC	60	nr
10/11/01	Backwater	UWPI	BC	65	nr
10/11/01	Backwater	UWPI	BC	70	nr
10/11/01	Backwater	UWPI	BC	218	170

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Backwater	UWPI	BG	40	nr
10/11/01	Backwater	UWPI	BG	50	nr
10/11/01	Backwater	UWPI	BG	50	nr
10/11/01	Backwater	UWPI	BG	50	nr
10/11/01	Backwater	UWPI	BG	60	nr
10/11/01	Backwater	UWPI	BG	60	nr
10/11/01	Backwater	UWPI	BG	60	nr
10/11/01	Backwater	UWPI	BG	70	nr
10/11/01	Backwater	UWPI	BG	118	30.0
10/11/01	Backwater	UWPI	BG	194	170
10/11/01	Backwater	UWPI	CC	600	2700
10/11/01	Backwater	UWPI	GF	325	850
10/11/01	Backwater	UWPI	GF	335	930
10/11/01	Backwater	UWPI	GF	343	nr
10/11/01	Backwater	UWPI	GS	70	nr
10/11/01	Backwater	UWPI	JSF	30	nr
10/11/01	Backwater	UWPI	LMB	65	4.0
10/11/01	Backwater	UWPI	LMB	65	3.5
10/11/01	Backwater	UWPI	LMB	65	3.5
10/11/01	Backwater	UWPI	LMB	70	4.5
10/11/01	Backwater	UWPI	LMB	72	5.8
10/11/01	Backwater	UWPI	LMB	75	5.8
10/11/01	Backwater	UWPI	LMB	78	6.1
10/11/01	Backwater	UWPI	PS	64	nr
10/11/01	Backwater	UWPI	YP	85	5.5
10/11/01	Backwater	UWPI	YP	96	9.0
10/11/01	Backwater	UWPI	YP	115	18.2
10/11/01	Backwater	UWPSW	BC	50	nr
10/11/01	Backwater	UWPSW	BC	50	nr
10/11/01	Backwater	UWPSW	BC	50	nr
10/11/01	Backwater	UWPSW	BC	50	nr
10/11/01	Backwater	UWPSW	BC	50	nr
10/11/01	Backwater	UWPSW	BC	50	nr
10/11/01	Backwater	UWPSW	BC	50	nr
10/11/01	Backwater	UWPSW	BC	52	nr
10/11/01	Backwater	UWPSW	BC	58	nr
10/11/01	Backwater	UWPSW	BC	60	nr
10/11/01	Backwater	UWPSW	BC	60	nr
10/11/01	Backwater	UWPSW	BC	60	nr
10/11/01	Backwater	UWPSW	BC	60	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	65	nr
10/11/01	Backwater	UWPSW	BC	75	nr
10/11/01	Backwater	UWPSW	BG	40	nr
10/11/01	Backwater	UWPSW	BG	40	nr
10/11/01	Backwater	UWPSW	BG	40	nr
10/11/01	Backwater	UWPSW	BG	50	nr
10/11/01	Backwater	UWPSW	BG	50	nr
10/11/01	Backwater	UWPSW	BG	50	nr
10/11/01	Backwater	UWPSW	BG	50	nr
10/11/01	Backwater	UWPSW	BG	50	nr
10/11/01	Backwater	UWPSW	BG	50	nr
10/11/01	Backwater	UWPSW	BG	50	nr
10/11/01	Backwater	UWPSW	BG	56	nr
10/11/01	Backwater	UWPSW	BG	203	170
10/11/01	Backwater	UWPSW	BNM	50	nr
10/11/01	Backwater	UWPSW	JSF	30	nr
10/11/01	Backwater	UWPSW	LMB	65	5.5
10/11/01	Backwater	UWPSW	LMB	67	3.8
10/11/01	Backwater	UWPSW	LMB	67	4.1
10/11/01	Backwater	UWPSW	LMB	68	4.4
10/11/01	Backwater	UWPSW	LMB	70	5.2
10/11/01	Backwater	UWPSW	LMB	72	4.8
10/11/01	Backwater	UWPSW	LMB	72	5.4
10/11/01	Backwater	UWPSW	LMB	72	5.2
10/11/01	Backwater	UWPSW	LMB	72	5.2
10/11/01	Backwater	UWPSW	LMB	74	5.7
10/11/01	Backwater	UWPSW	LMB	75	6.2
10/11/01	Backwater	UWPSW	LMB	75	5.9
10/11/01	Backwater	UWPSW	LMB	78	6.6
10/11/01	Backwater	UWPSW	LMB	78	7.6
10/11/01	Backwater	UWPSW	LMB	82	6.7
10/11/01	Backwater	UWPSW	LMB	82	7.4
10/11/01	Backwater	UWPSW	LMB	83	8.4
10/11/01	Backwater	UWPSW	LMB	85	7.8
10/11/01	Backwater	UWPSW	LMB	90	12.0
10/11/01	Backwater	UWPSW	LMB	135	35.1
10/11/01	Backwater	UWPSW	RB	48	1.8
10/11/01	Backwater	UWPSW	RB	68	4.8
10/11/01	Backwater	UWPSW	YP	85	6.2
10/11/01	Backwater	UWPSW	YP	91	7.9

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/11/01	Backwater	UWPSW	YP	95	8.6
10/11/01	Backwater	UWPSW	YP	103	11.2
10/11/01	Backwater	UWPSW	YP	108	15.9
10/11/01	Backwater	UWPSW	YP	110	14.3
10/11/01	Backwater	UWPSW	YP	110	17.5
10/11/01	Backwater	UWPSW	YP	125	21.9
10/10/01	Backwater	NLBW3	BB	222	nr
10/10/01	Backwater	NLBW3	BB	229	nr
10/10/01	Backwater	NLBW3	BB	229	nr
10/10/01	Backwater	NLBW3	BB	230	nr
10/10/01	Backwater	NLBW3	BB	230	nr
10/10/01	Backwater	NLBW3	BB	235	nr
10/10/01	Backwater	NLBW3	BB	258	200
10/10/01	Backwater	NLBW3	BB	267	260
10/10/01	Backwater	NLBW3	BB	275	nr
10/10/01	Backwater	NLBW3	BB	280	290
10/10/01	Backwater	NLBW3	BB	295	340
10/10/01	Backwater	NLBW3	BB	223	nr
10/10/01	Backwater	NLBW3	BB	265	nr
10/10/01	Backwater	NLBW3	BB	322	nr
10/10/01	Backwater	NLBW3	BB	300	nr
10/10/01	Backwater	NLBW3	BC	70	4.2
10/10/01	Backwater	NLBW3	BC	72	5.5
10/10/01	Backwater	NLBW3	BC	195	145
10/10/01	Backwater	NLBW3	BC	355	275
10/10/01	Backwater	NLBW3	BC	55	nr
10/10/01	Backwater	NLBW3	BC	55	nr
10/10/01	Backwater	NLBW3	BC	55	nr
10/10/01	Backwater	NLBW3	BC	55	nr
10/10/01	Backwater	NLBW3	BC	57	nr
10/10/01	Backwater	NLBW3	BC	58	nr
10/10/01	Backwater	NLBW3	BC	60	nr
10/10/01	Backwater	NLBW3	BC	60	nr
10/10/01	Backwater	NLBW3	BC	60	nr
10/10/01	Backwater	NLBW3	BC	60	nr
10/10/01	Backwater	NLBW3	BC	60	nr
10/10/01	Backwater	NLBW3	BC	60	nr
10/10/01	Backwater	NLBW3	BC	62	nr
10/10/01	Backwater	NLBW3	BC	62	nr
10/10/01	Backwater	NLBW3	BC	62	nr
10/10/01	Backwater	NLBW3	BC	62	nr
10/10/01	Backwater	NLBW3	BC	63	nr
10/10/01	Backwater	NLBW3	BC	63	nr
10/10/01	Backwater	NLBW3	BC	65	nr
10/10/01	Backwater	NLBW3	BC	65	nr
10/10/01	Backwater	NLBW3	BC	65	nr
10/10/01	Backwater	NLBW3	BC	65	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/10/01	Backwater	NLBW3	BC	65	nr
10/10/01	Backwater	NLBW3	BC	65	nr
10/10/01	Backwater	NLBW3	BC	65	nr
10/10/01	Backwater	NLBW3	BC	65	nr
10/10/01	Backwater	NLBW3	BC	69	nr
10/10/01	Backwater	NLBW3	BC	69	4.3
10/10/01	Backwater	NLBW3	BC	70	nr
10/10/01	Backwater	NLBW3	BC	73	nr
10/10/01	Backwater	NLBW3	BC	75	nr
10/10/01	Backwater	NLBW3	BC	75	nr
10/10/01	Backwater	NLBW3	BG	40	1.4
10/10/01	Backwater	NLBW3	BG	43	1.8
10/10/01	Backwater	NLBW3	BG	48	2.7
10/10/01	Backwater	NLBW3	BG	55	3.9
10/10/01	Backwater	NLBW3	BG	55	3.9
10/10/01	Backwater	NLBW3	BG	153	75.0
10/10/01	Backwater	NLBW3	BG	155	90.0
10/10/01	Backwater	NLBW3	BG	180	130
10/10/01	Backwater	NLBW3	BG	192	160
10/10/01	Backwater	NLBW3	JSF	37	1.1
10/10/01	Backwater	NLBW3	JSF	38	1.4
10/10/01	Backwater	NLBW3	LMB	52	1.5
10/10/01	Backwater	NLBW3	LMB	55	3.1
10/10/01	Backwater	NLBW3	LMB	59	3.4
10/10/01	Backwater	NLBW3	LMB	60	2.9
10/10/01	Backwater	NLBW3	LMB	60	3.6
10/10/01	Backwater	NLBW3	LMB	62	3.5
10/10/01	Backwater	NLBW3	LMB	62	4.3
10/10/01	Backwater	NLBW3	LMB	62	3.7
10/10/01	Backwater	NLBW3	LMB	62	3.9
10/10/01	Backwater	NLBW3	LMB	65	5.0
10/10/01	Backwater	NLBW3	LMB	65	4.0
10/10/01	Backwater	NLBW3	LMB	67	4.8
10/10/01	Backwater	NLBW3	LMB	67	4.9
10/10/01	Backwater	NLBW3	LMB	67	4.5
10/10/01	Backwater	NLBW3	LMB	70	5.1
10/10/01	Backwater	NLBW3	LMB	70	5.4
10/10/01	Backwater	NLBW3	LMB	70	5.2
10/10/01	Backwater	NLBW3	LMB	72	6.3
10/10/01	Backwater	NLBW3	LMB	75	5.6
10/10/01	Backwater	NLBW3	LMB	75	6.4
10/10/01	Backwater	NLBW3	LMB	77	7.2
10/10/01	Backwater	NLBW3	LMB	77	5.2
10/10/01	Backwater	NLBW3	LMB	78	7.3
10/10/01	Backwater	NLBW3	LMB	80	7.5
10/10/01	Backwater	NLBW3	LMB	83	7.7
10/10/01	Backwater	NLBW3	LMB	216	160

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/10/01	Backwater	NLBW3	LMB	50	2.4
10/10/01	Backwater	NLBW3	LMB	57	2.9
10/10/01	Backwater	NLBW3	LMB	60	3.2
10/10/01	Backwater	NLBW3	LMB	60	3.5
10/10/01	Backwater	NLBW3	LMB	60	3.7
10/10/01	Backwater	NLBW3	LMB	60	3.7
10/10/01	Backwater	NLBW3	LMB	64	3.2
10/10/01	Backwater	NLBW3	LMB	65	4.0
10/10/01	Backwater	NLBW3	LMB	67	4.7
10/10/01	Backwater	NLBW3	LMB	68	4.6
10/10/01	Backwater	NLBW3	LMB	69	5.0
10/10/01	Backwater	NLBW3	LMB	70	5.9
10/10/01	Backwater	NLBW3	LMB	70	6.1
10/10/01	Backwater	NLBW3	LMB	70	6.0
10/10/01	Backwater	NLBW3	LMB	71	5.4
10/10/01	Backwater	NLBW3	LMB	75	8.3
10/10/01	Backwater	NLBW3	LMB	78	5.0
10/10/01	Backwater	NLBW3	LMB	80	5.7
10/10/01	Backwater	NLBW3	LMB	81	8.2
10/10/01	Backwater	NLBW3	LMB	82	9.0
10/10/01	Backwater	NLBW3	LMB	85	9.9
10/10/01	Backwater	NLBW3	LMB	86	9.6
10/10/01	Backwater	NLBW3	LMB	89	10.8
10/10/01	Backwater	NLBW3	LMB	92	11.2
10/10/01	Backwater	NLBW3	PS	52	2.0
10/10/01	Backwater	NLBW3	PS	145	80.0
10/10/01	Backwater	NLBW3	PS	180	150
10/10/01	Backwater	NLBW3	PS	125	41.9
10/10/01	Backwater	NLBW3	PS	165	120
10/10/01	Backwater	NLBW3	RB	203	180
10/10/01	Backwater	NLBW3	YP	95	9.9
10/10/01	Backwater	NLBW3	YP	95	10.5
10/10/01	Backwater	NLBW3	YP	96	10.6
10/10/01	Backwater	NLBW3	YP	167	50.0
10/10/01	Backwater	NLBW3	YP	185	70.0
10/10/01	Backwater	NLBW3	YP	195	85.0
10/10/01	Backwater	NLBW3	YP	203	95.0
10/10/01	Backwater	NLBW3	YP	87	nr
10/10/01	Backwater	NLBW3	YP	90	7.5
10/10/01	Backwater	NLBW3	YP	90	7.2
10/10/01	Backwater	NLBW3	YP	90	nr
10/10/01	Backwater	NLBW3	YP	92	7.9
10/10/01	Backwater	NLBW3	YP	92	nr
10/10/01	Backwater	NLBW3	YP	92	nr
10/10/01	Backwater	NLBW3	YP	95	nr
10/10/01	Backwater	NLBW3	YP	95	nr
10/10/01	Backwater	NLBW3	YP	102	nr

Table D-6. Lengths and weights for all fish captured during the October 2001 Housatonic River electrofishing surveys. The species key is shown in Table D-4.

Date	Habitat Type	Site[1]	Species	Total Length (mm)	Weight (g)
10/10/01	Backwater	NLBW3	YP	102	nr
10/10/01	Backwater	NLBW3	YP	107	14.2
10/10/01	Backwater	NLBW3	YP	110	nr
10/10/01	Backwater	NLBW3	YP	130	nr
10/10/01	Backwater	NLBW3	YP	173	61.0

nr = not recorded

[1] = The locations of each sampling site are indicated on Figure 4-5.

Table D-7. The number of largemouth bass young-of-year broods observed at each index site in the Housatonic River in 2001.

	Index Site															
Date	**NLBW3E**	**NLBW3N**	**NLBW3W**	**OM2**	**OM7**	**OM8E**	**OM8W**	**OM9**	**UWP2**	**UWP3E**	**UWP3SW**	**UWP4W**	**UWP5**	**UWPIE**	**UWPIW**	**Total**
5/21/01	nd	nd	nd	nd	nd	nd	nd	nd	1	2	nd	nd	nd	nd	nd	3
5/24/01	nd	nd	nd	nd	nd	nd	nd	nd	3	nd	nd	nd	nd	nd	nd	3
5/29/01	nd	nd	nd	nd	nd	nd	nd	nd	4	nd	nd	nd	nd	2	nd	6
5/30/01	1	nd	nd	nd	nd	nd	1	nd	nd	nd	nd	nd	nd	nd	nd	2
5/31/01	nd	nd	nd	nd	1	nd	nd	1	4	nd	nd	1	nd	1	1	9
6/1/01	3	nd	2	nd	nd	nd	1	nd	nd	nd	nd	nd	nd	nd	nd	6
6/6/01	1	nd	nd	nd	nd	nd	nd	nd	2	nd	nd	nd	nd	nd	nd	3
6/7/01	nd	nd	nd	1	2	nd	1	nd	nd	nd	nd	nd	nd	nd	nd	4
6/8/01	nd	nd	nd	nd	nd	nd	nd	nd	nd	1	nd	nd	1	nd	nd	2
6/11/01	nd	nd	nd	nd	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1
6/12/01	nd	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	2	nd	3
6/13/01	nd	nd	nd	1	nd	nd	nd	nd	3	nd	nd	nd	nd	nd	nd	4
6/14/01	2	1	1	nd	2	nd	nd	nd	nd	nd	nd	nd	nd	1	nd	7
6/15/01	nd	nd	nd	nd	nd	nd	nd	nd	5	nd	nd	nd	nd	nd	nd	5
6/18/01	3	3	4	nd	nd	2	nd	nd	1	9	nd	nd	nd	nd	nd	22
6/19/01	nd	nd	nd	1	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	2
6/20/01	5	1	5	nd	nd	nd	nd	3	1	3	1	nd	nd	2	7	28
6/22/01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	2	2	4
6/25/01	7	4	3	2	nd	2	nd	nd	nd	nd	nd	nd	nd	nd	nd	18
6/26/01	nd	nd	nd	nd	nd	nd	nd	2	nd	nd	nd	nd	nd	nd	nd	2
6/27/01	5	nd	2	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	10
7/4/01	nd	nd	nd	nd	nd	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	1
Total	27	10	17	8	7	5	3	6	24	15	1	1	1	10	10	145

nd = none detected

APPENDIX E

Environmental Conditions Data

(graphs and tables of water temperature, dissolved oxygen, and pH data collected by site)

CONTENTS

FIGURES

TABLES

APPENDIX E

Environmental Conditions Data

(graphs and tables of water temperature,
dissolved oxygen, and pH data collected by site)

INTRODUCTION

This appendix contains several graphs and tables of water temperature, dissolved oxygen (DO) concentrations, and pH that were collected from the Housatonic River study area by R2 Resource Consultants, Inc. during 2000 and 2001. Two sets of graphs are included in this appendix: 2000 and 2001 water temperature data collected with Onset Optic Stowaway® Temp continuous recorders; and water temperature, DO, and pH data collected with Stevens/Greenspan probes. A series of graphs are also presented which show daily percent cloud cover and maximum and minimum DO concentrations in the Housatonic River. Several tables are included in this appendix that summarize the DO concentrations measured with the Stevens/Greenspan units. Two other tables are presented which detail water temperature, DO, conductivity, and pH measurements collected during 2001 with the hand-held Hydrolab Quanta unit.

The graphs and tables in this appendix support several of the descriptions of environmental conditions that can influence the largemouth bass population as presented in Section 5.4 of the main report and which are supported by Appendix C. A listing of each graph and table can be found in the preceding table of contents.

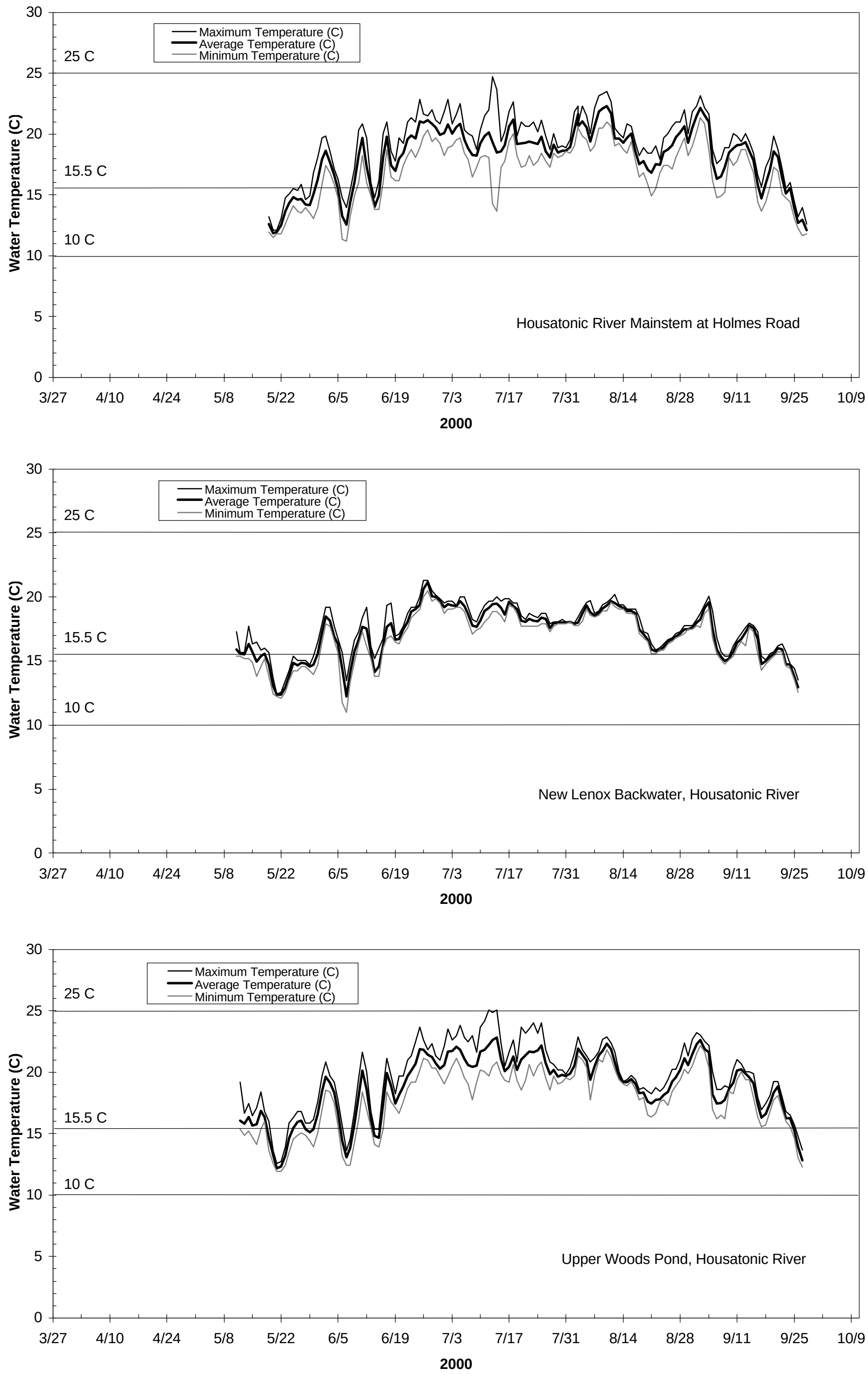

Figure E-1. Daily water temperatures in the main channel, a backwater, and the Woods Pond area of the Housatonic River, Massachusetts, 2000. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C initiation of spawning; and 25°C – optimal growth.

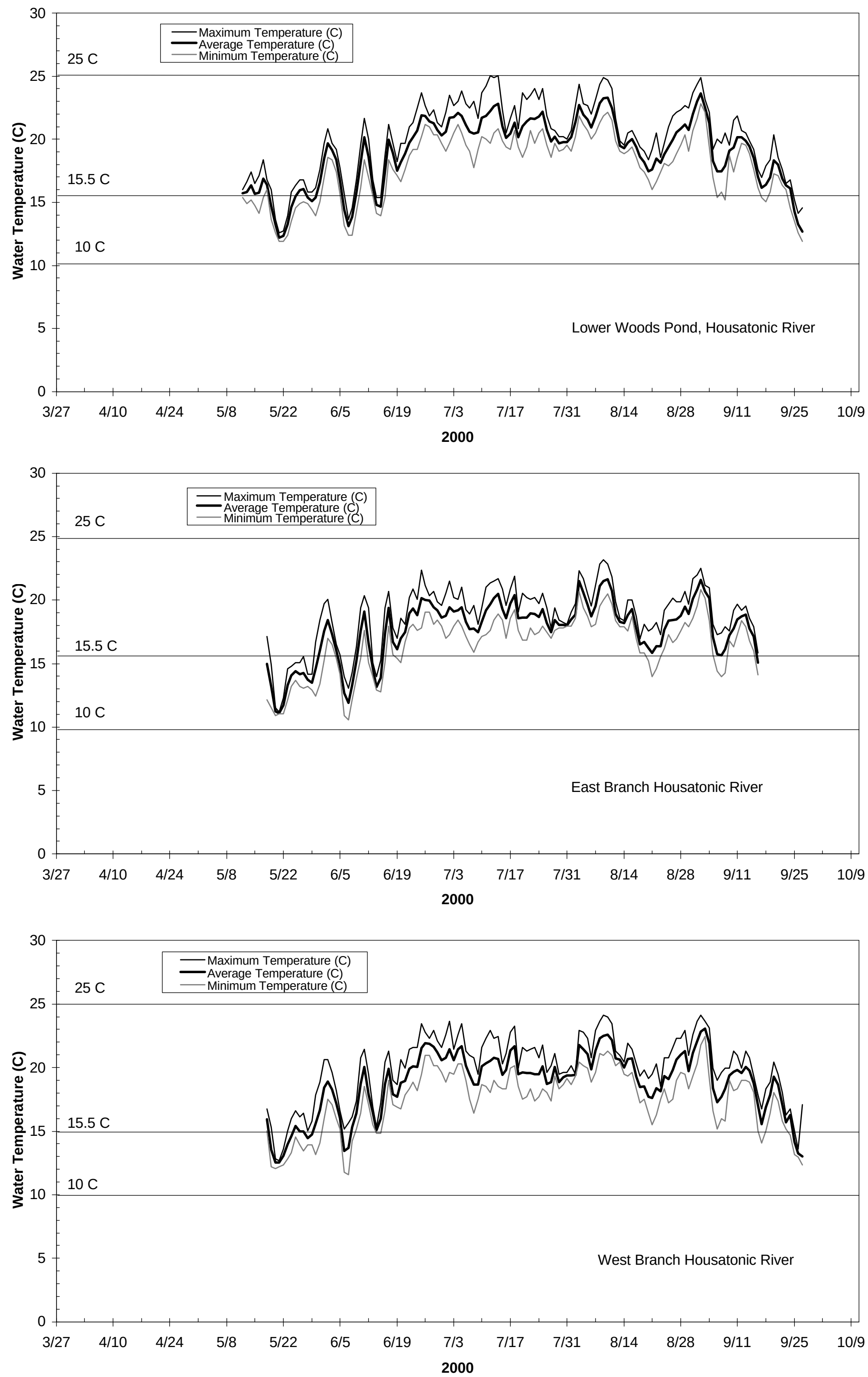

Figure E-2. Daily water temperatures in the Woods Pond area and two branches of the Housatonic River, Massachusetts, 2000. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C initiation of spawning; and 25°C – optimal growth.

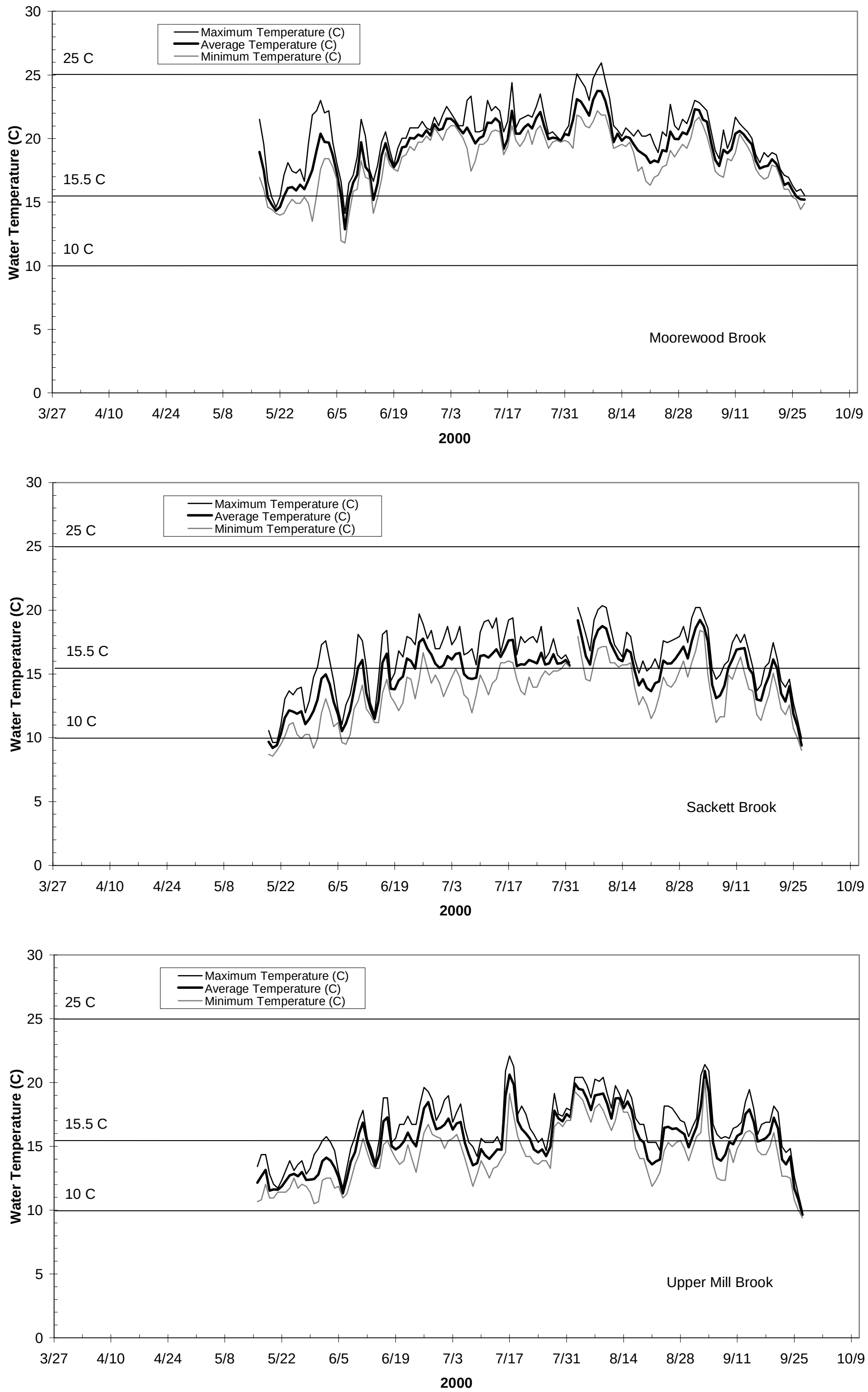

Figure E-3. Daily water temperatures in three tributaries of the Housatonic River, Massachusetts, 2000. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C – initiation of spawning; and 25°C – optimal growth.

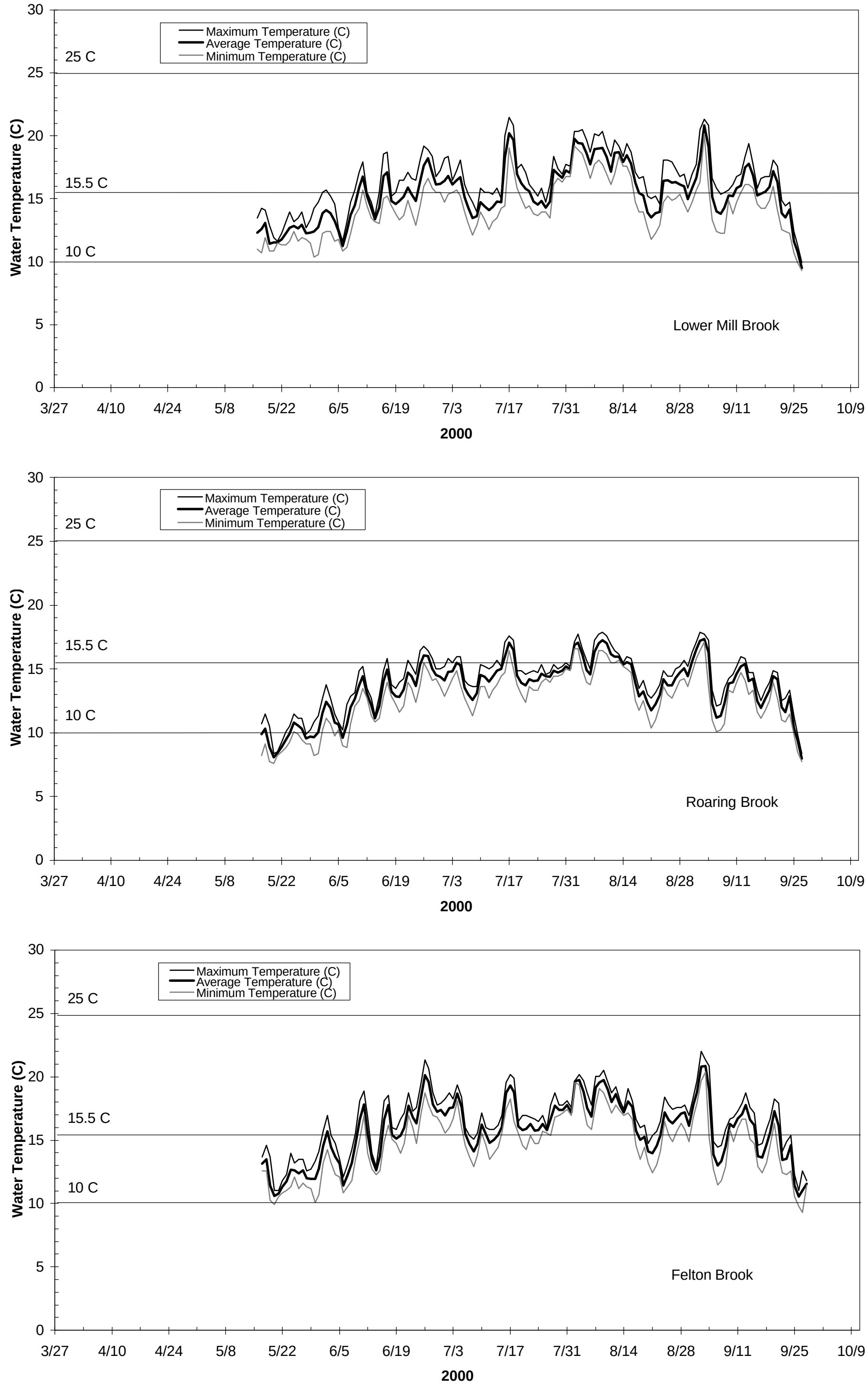

Figure E-4. Daily water temperatures in three tributaries of the Housatonic River, Massachusetts, 2000. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C – initiation of spawning; and 25°C optimal growth.

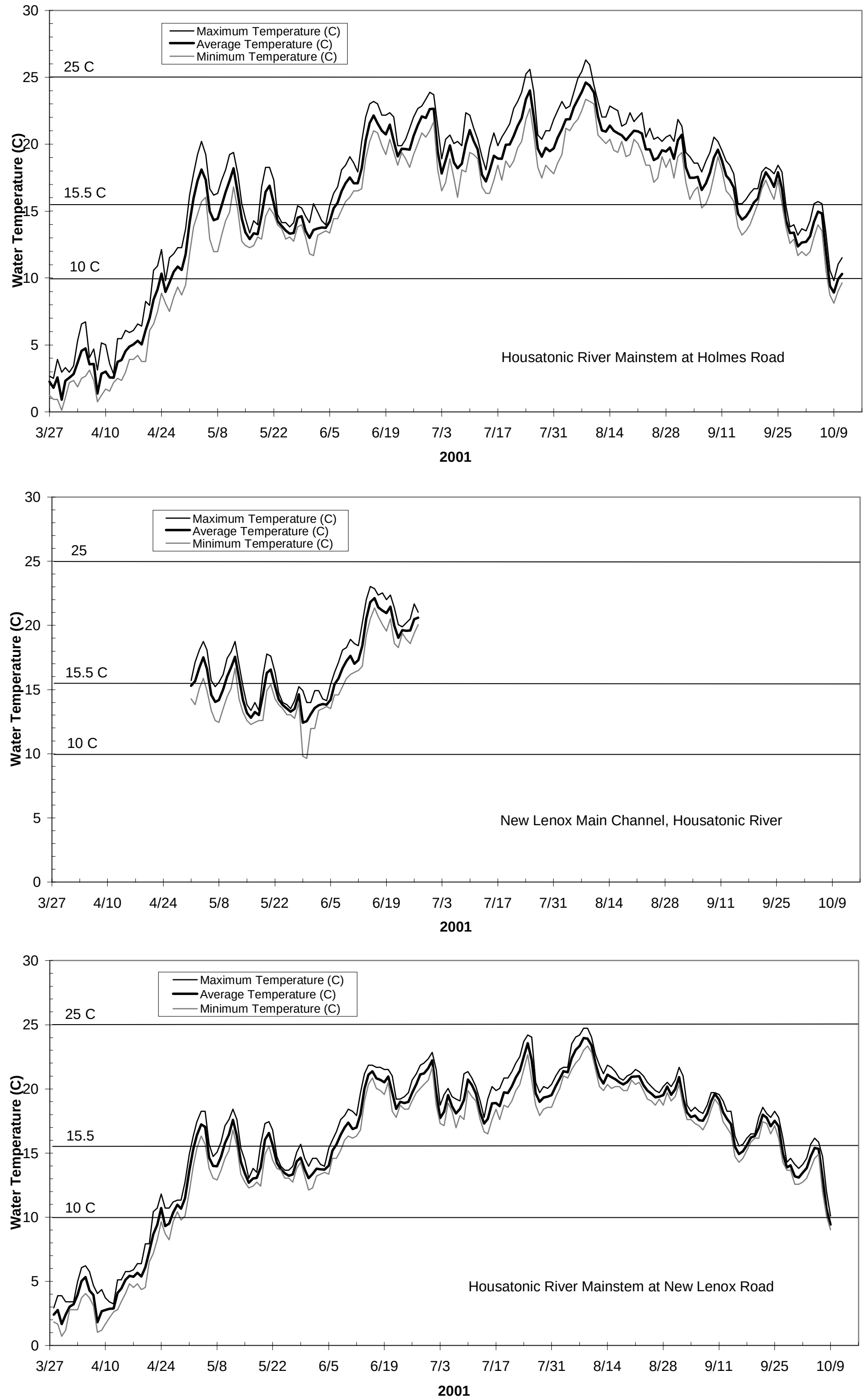

Figure E-5. Daily water temperatures in three main channel sites of the Housatonic River, Massachusetts, 2001. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C – initiation of spawning; and 25°C – optimal growth.

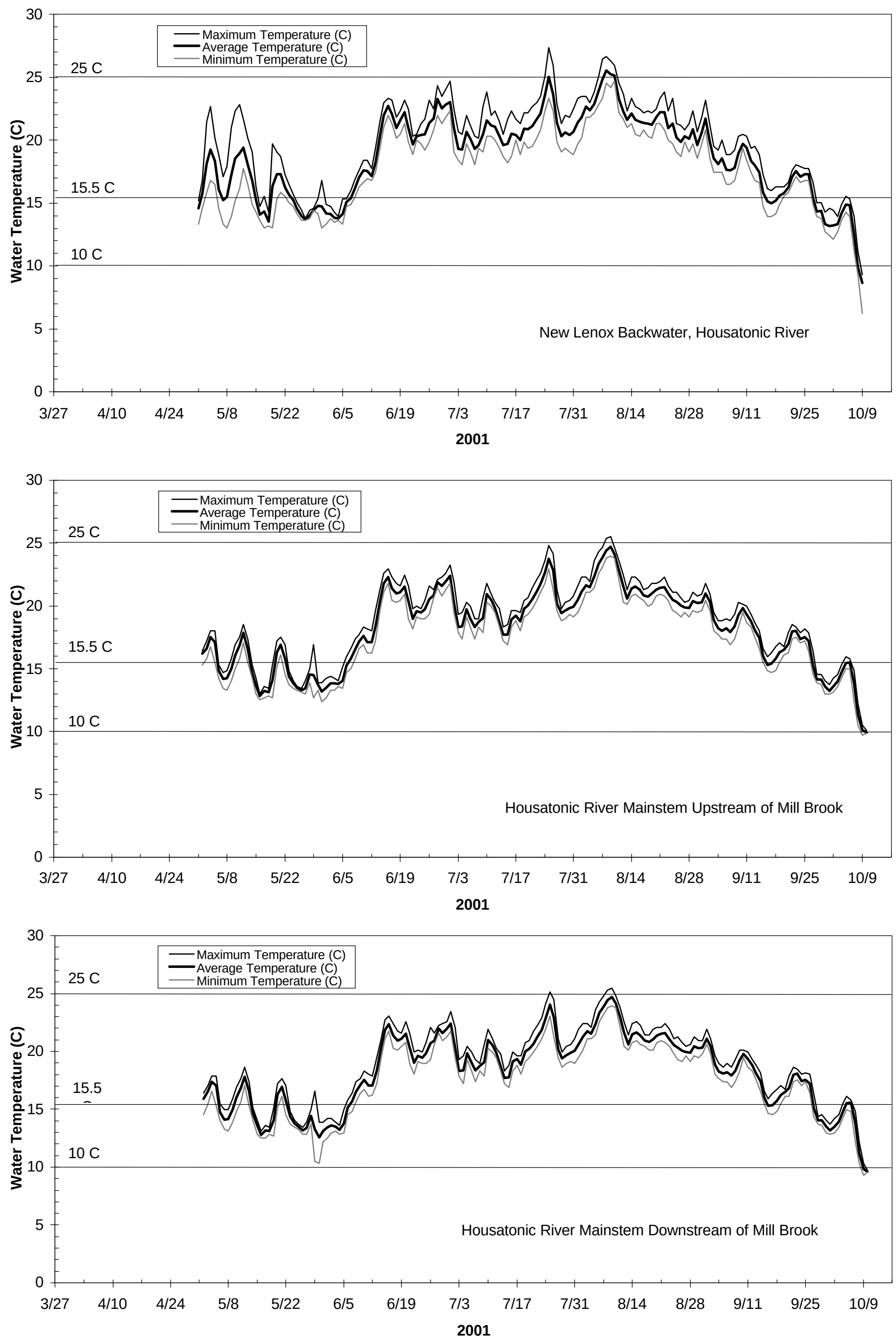

Figure E-6. Daily water temperatures in one backwater and two main channel sites of the Housatonic River, Massachusetts, 2001. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C initiation of spawning; and 25°C – optimal growth.

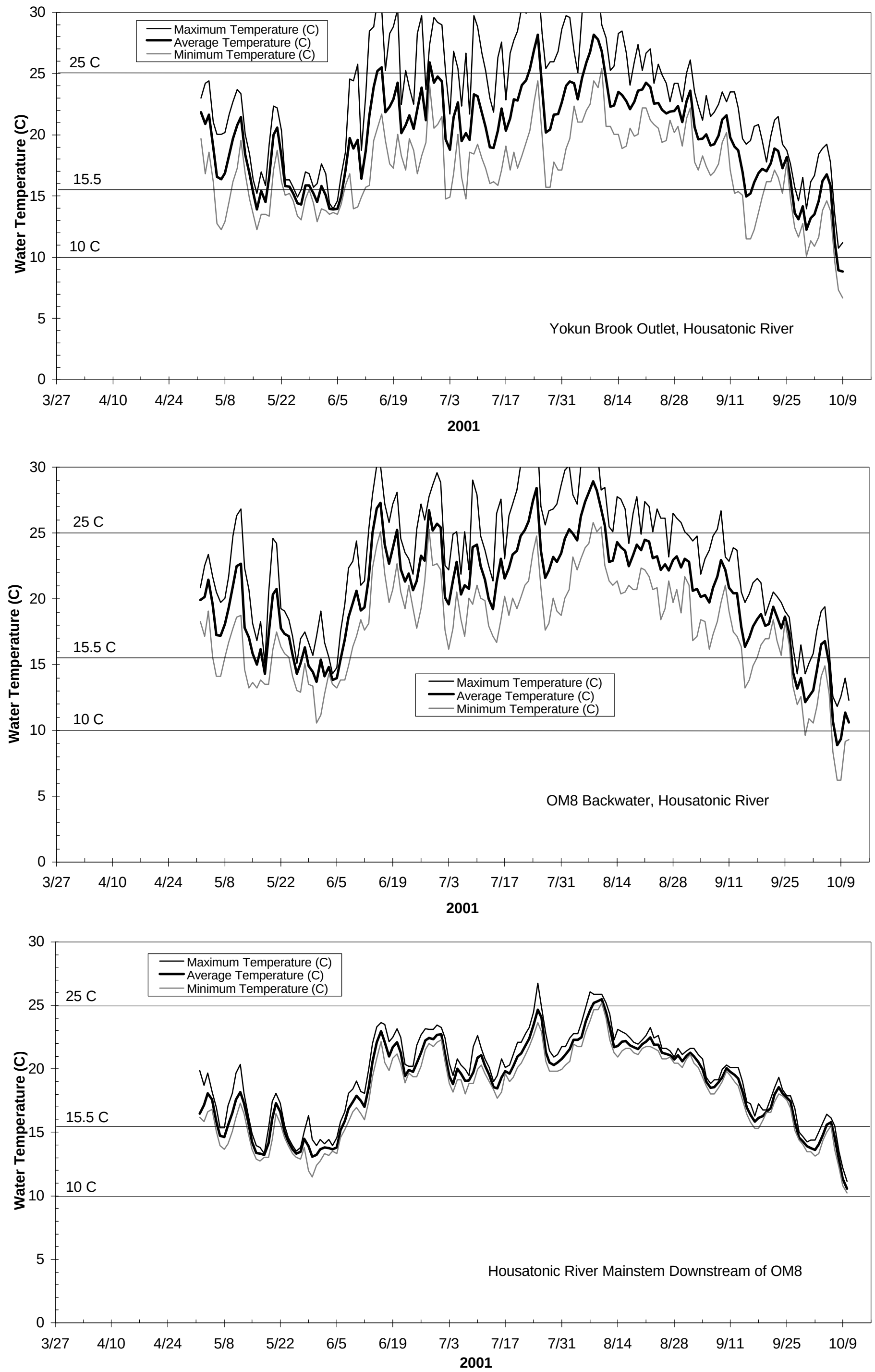

Figure E-7. Daily water temperatures in two backwater and one main channel site of the Housatonic River, Massachusetts, 2001. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C initiation of spawning; and 25°C – optimal growth.

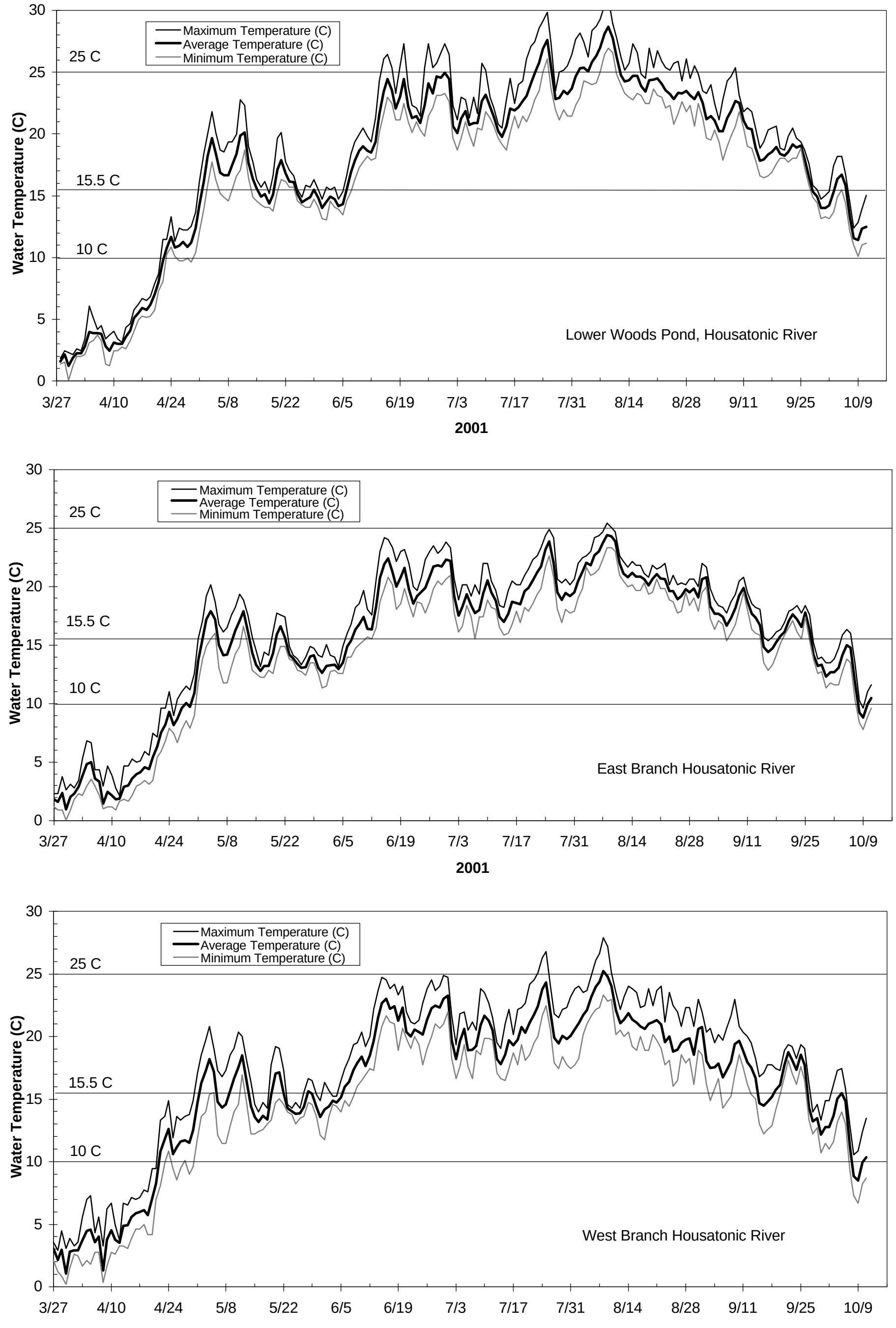

Figure E-8. Daily water temperatures in the Woods Pond area and two branches of the Housatonic River, Massachusetts, 2001. Horizontal lines indicate: 10°C - the extent of the growing season; 15.5°C initiation of spawning; and 25°C – optimal growth.

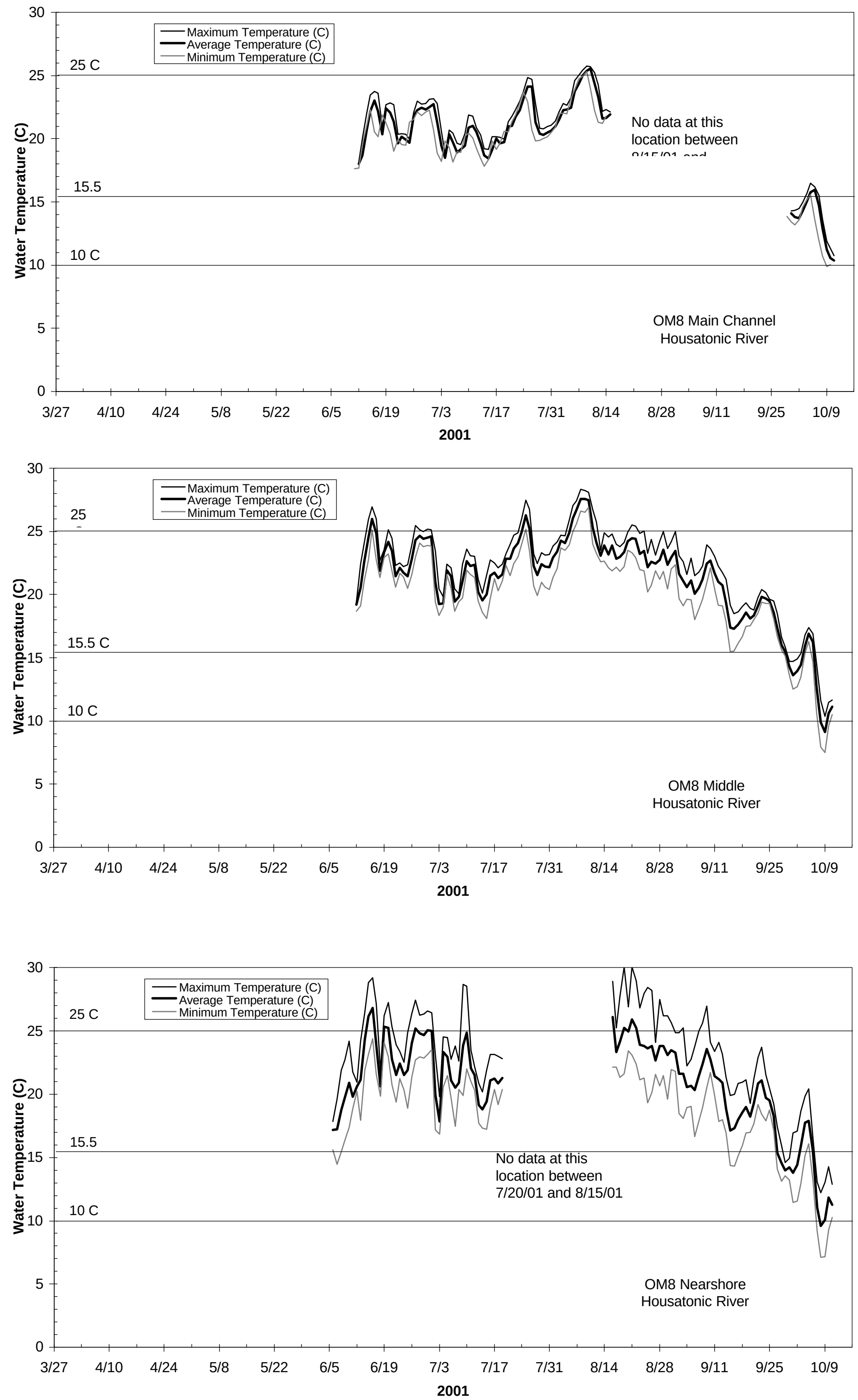

Figure E-9. Daily water temperatures in the main channel and two locations in OM8, Housatonic River, Massachusetts measured with the Stevens/Greenspan probes during 2001.

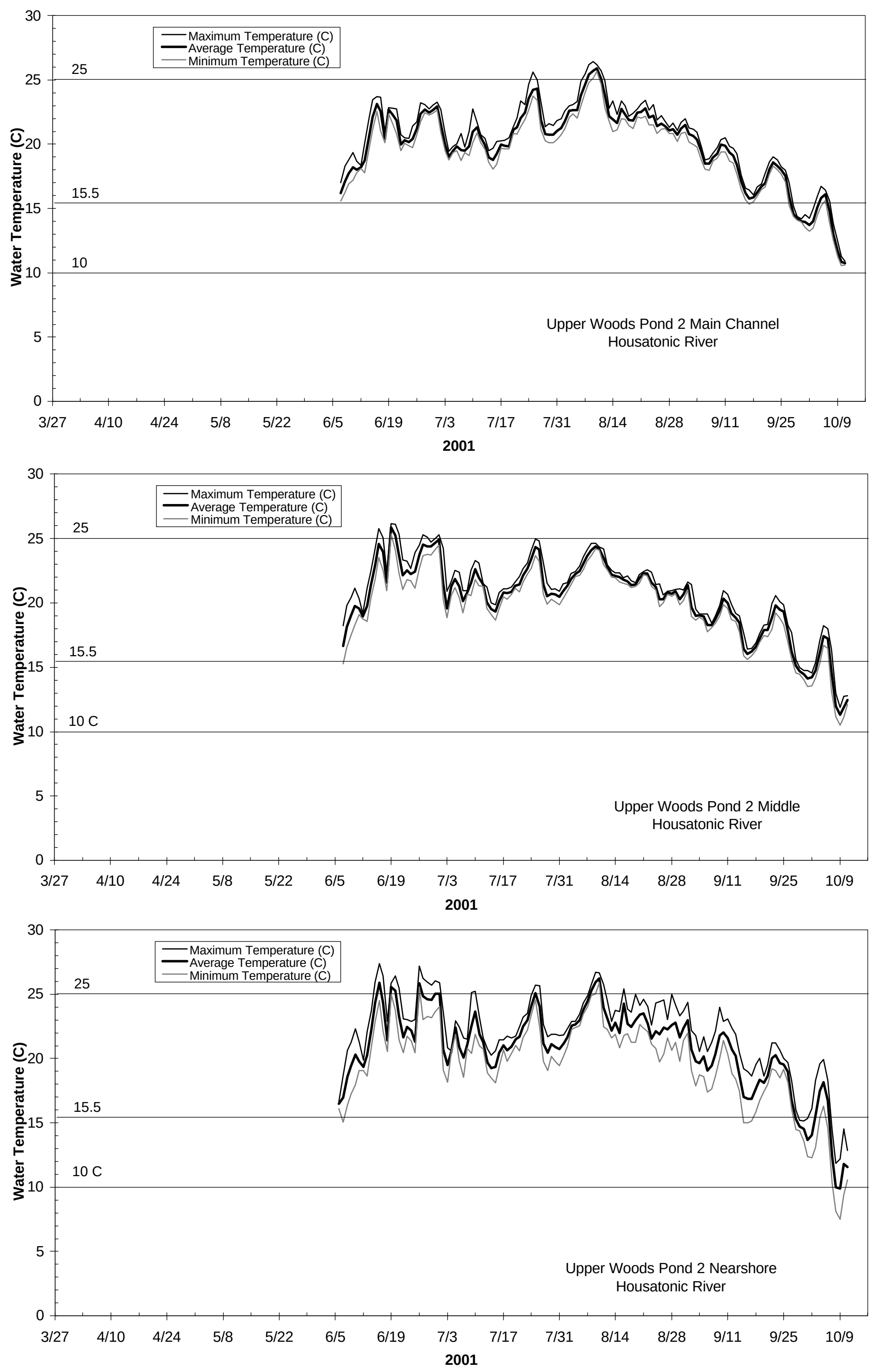

Figure E-10. Daily water temperatures in the main channel and two locations in UWP2, Housatonic River, Massachusetts measured with the Stevens/Greenspan probes during 2001.

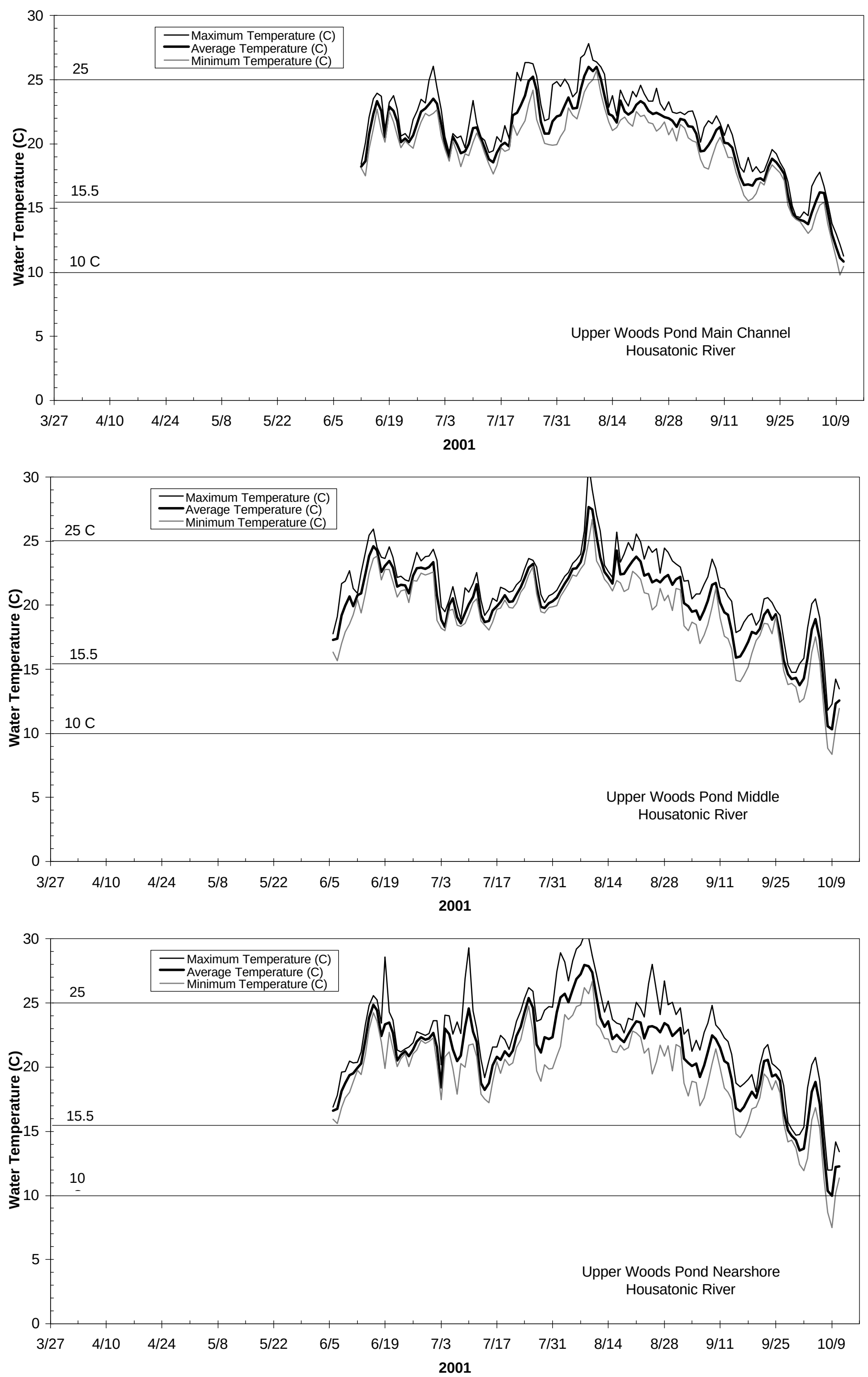

Figure E-11. Daily water temperatures in the main channel and two locations in UWP, Housatonic River, Massachusetts measured with the Stevens/Greenspan probes during 2001.

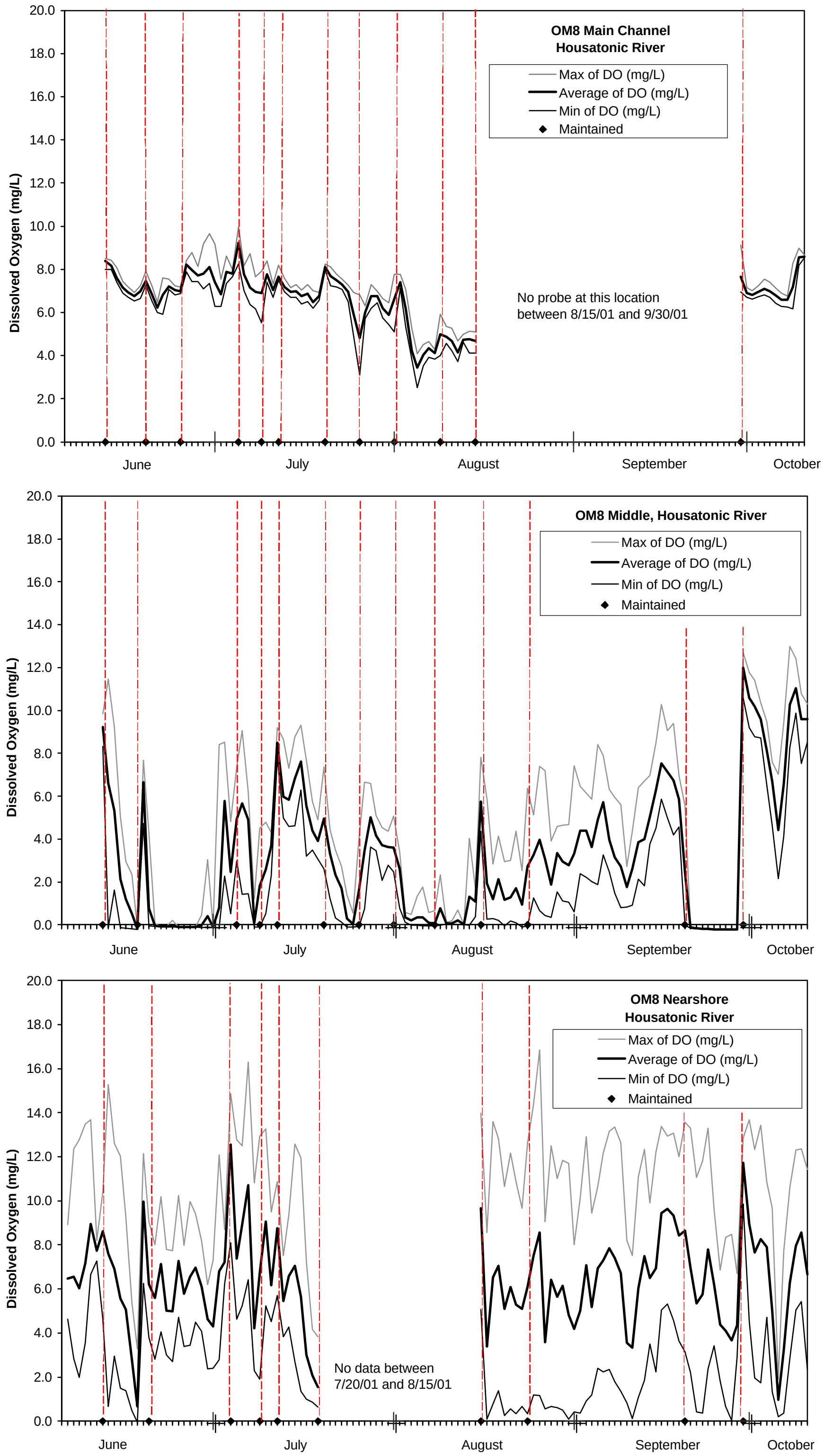

Figure E-12. Daily maximum, minimum, and average DO concentrations measured in the main channel and two locations in OM8, Housatonic River, Massachusetts between June and October 2001. Vertical dashed lines indicate maintenance events.

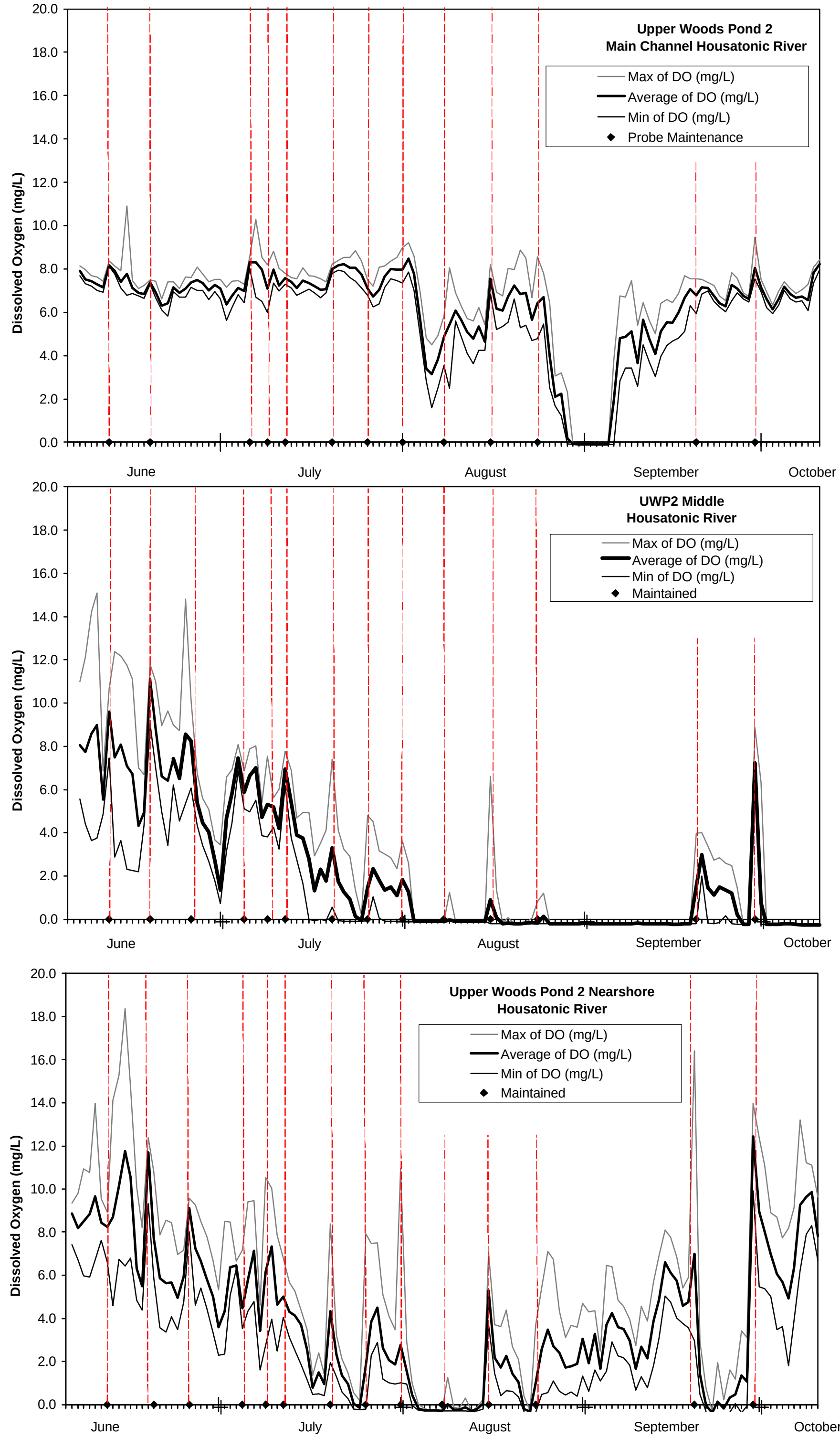

Figure E-13. Daily maximum, minimum, and average DO concentrations measured in the main channel and two locations in UWP2, Housatonic River, Massachusetts between June and October 2001. Vertical dashed lines indicate maintenance events.

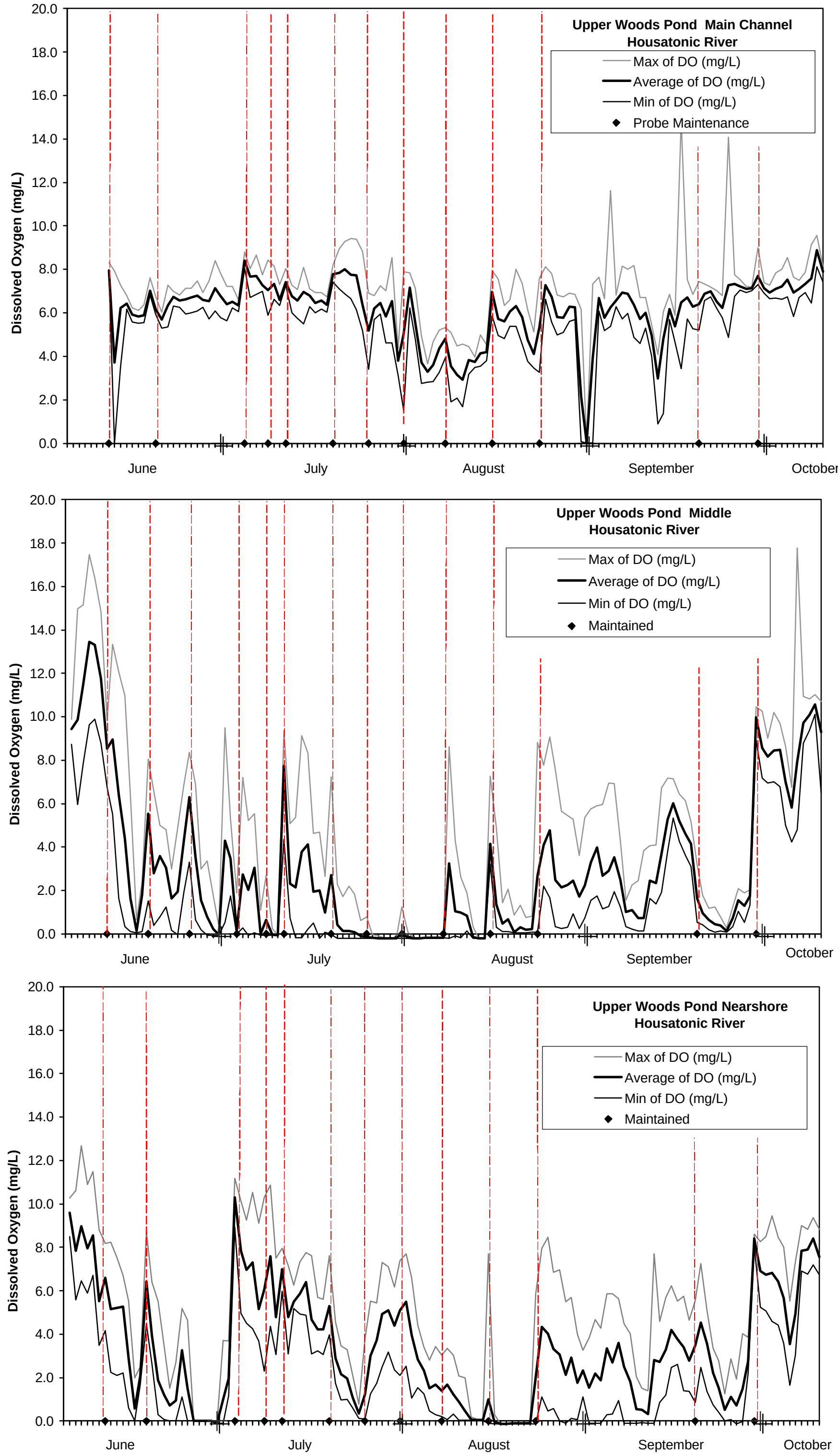

Figure E-14. Daily maximum, minimum, and average DO concentrations measured in the main channel and two locations in UWP, Housatonic River, Massachusetts between June and October 2001. Vertical dashed lines indicate maintenance events.

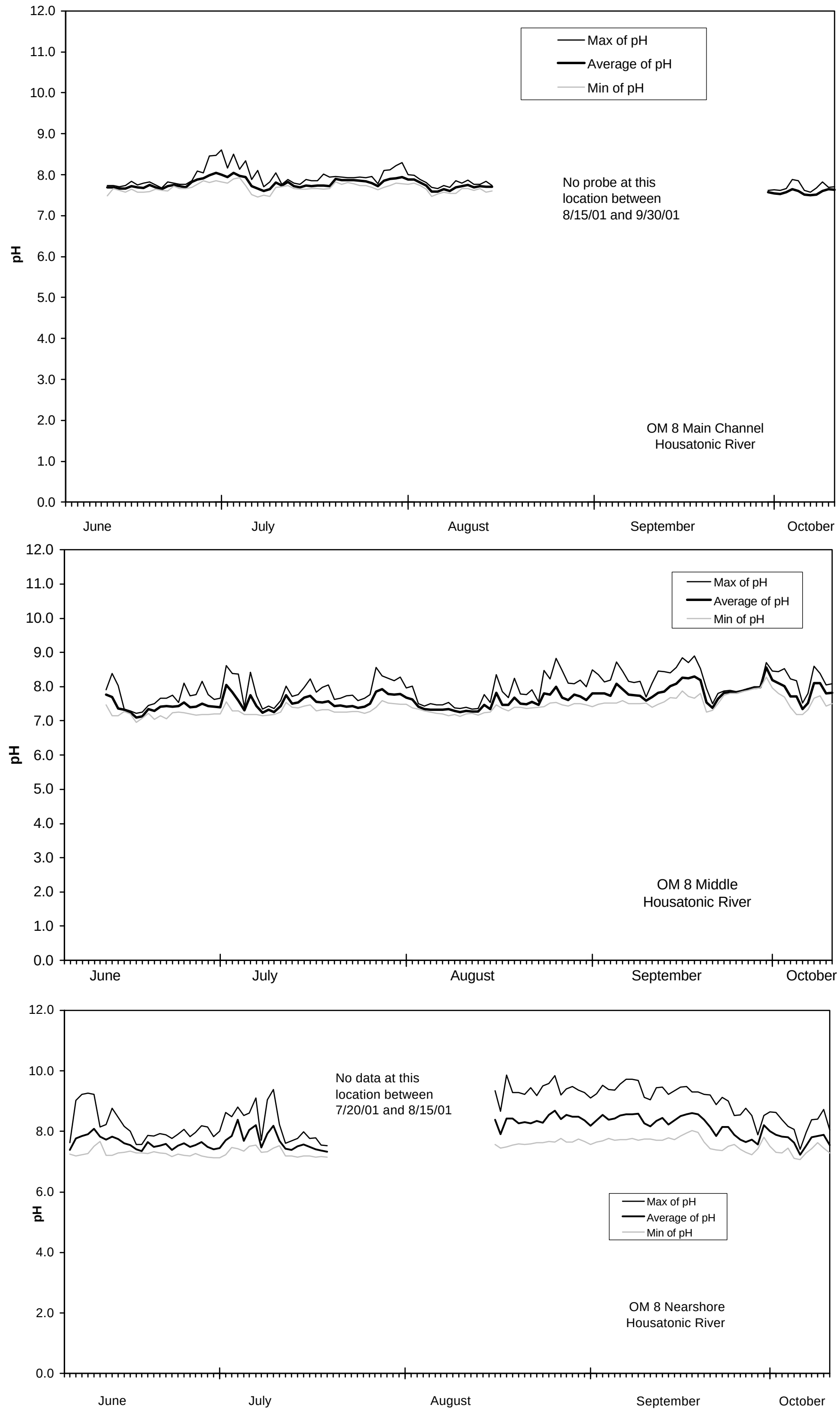

Figure E-15. Daily maximum, minimum, and average pH measured in the main channel and two locations of OM8, Housatonic River, Massachusetts between June and October 2001.

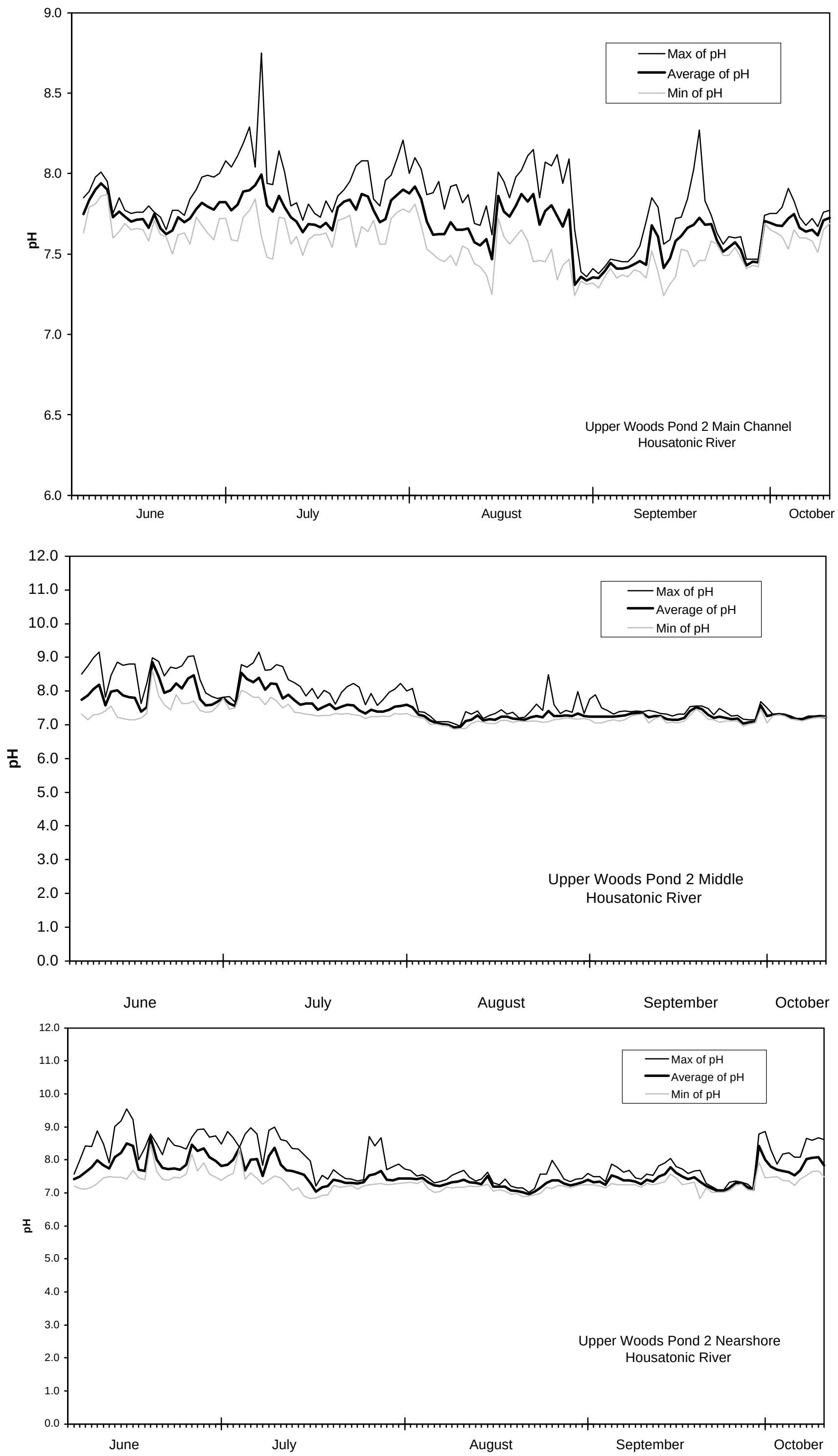

Figure E-16. Daily maximum, minimum, and average pH measured in the main channel and two locations in UWP2, Housatonic River, Massachusetts between June and October 2001.

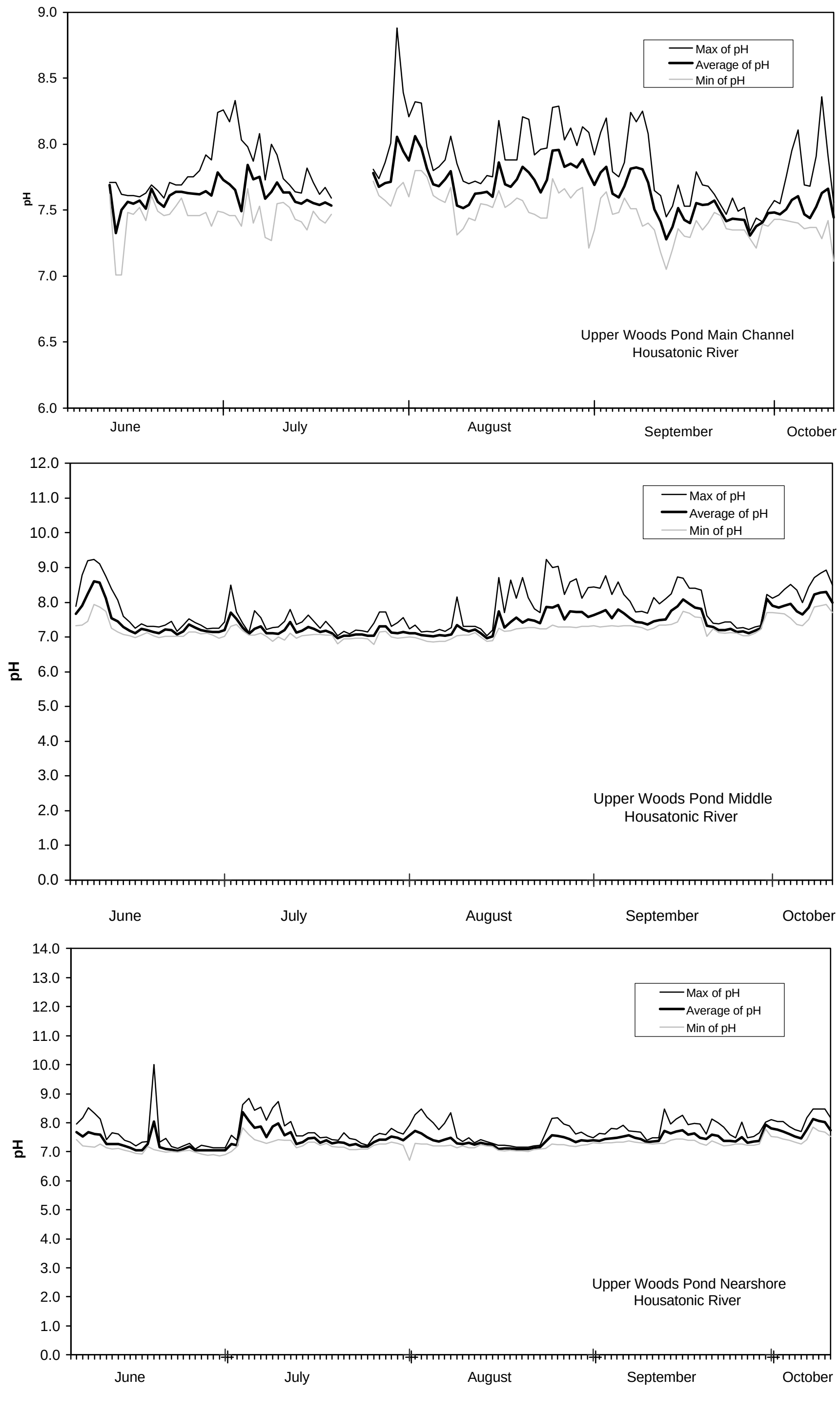

Figure E-17. Daily maximum, minimum, and average pH measured in the main channel and two locations in UWP, Housatonic River, Massachusetts between June and October 2001.

OM8 Nearshore

OM8 Middle

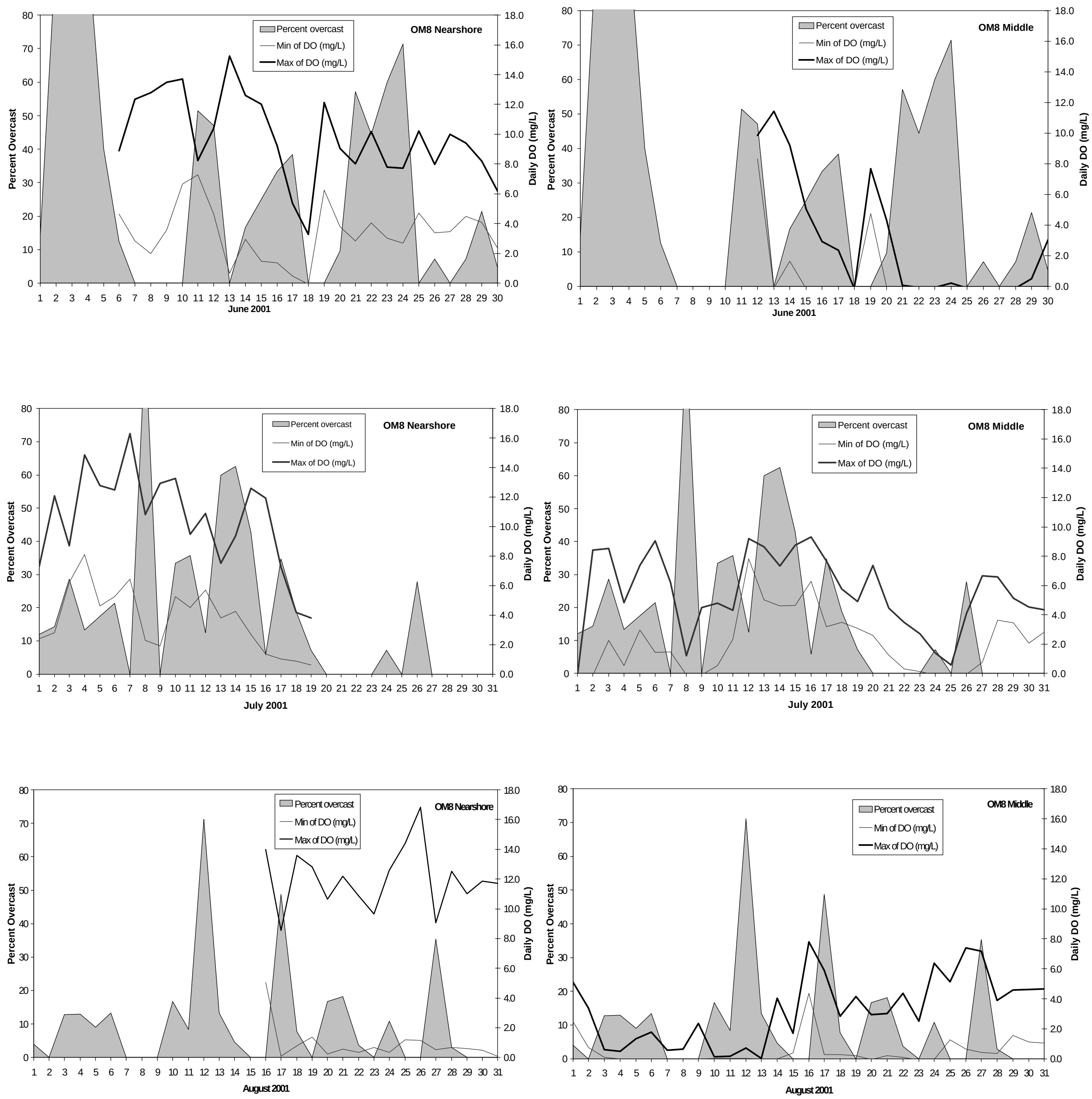

Figure E-18. Daily percent cloud cover and maximum and minimum dissolved oxygen concentrations in the October Mountain 8 (OM8) Nearshore and Middle sites, Housatonic River during June, July, and August 2001.

UWP Nearshore

UWP Middle

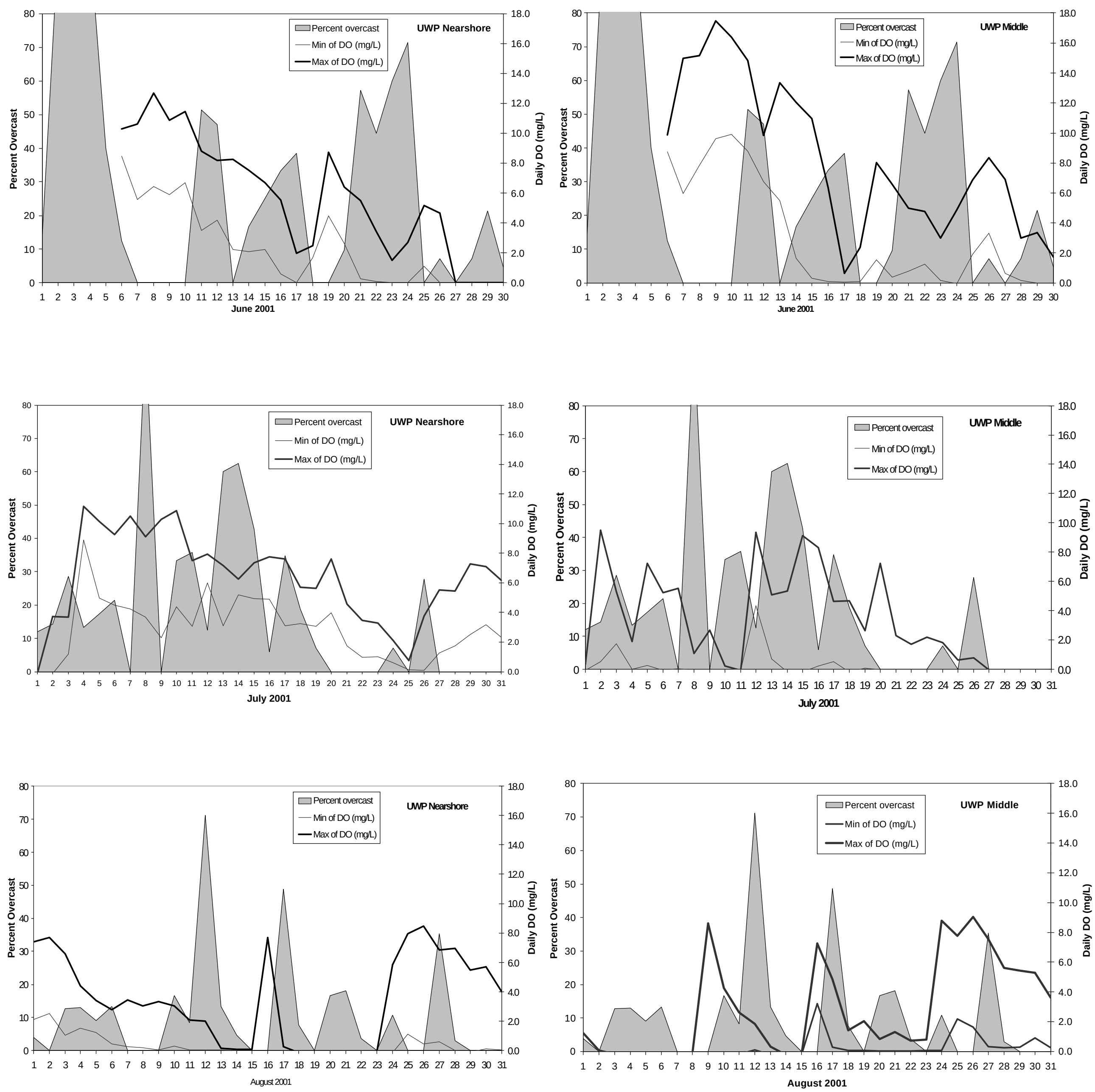

Figure E-19. Daily percent cloud cover and maximum and minimum dissolved oxygen concentrations in the Upper Woods Pond (UWP) Nearshore and Middle sites, Housatonic River during June, July, and August 2001.

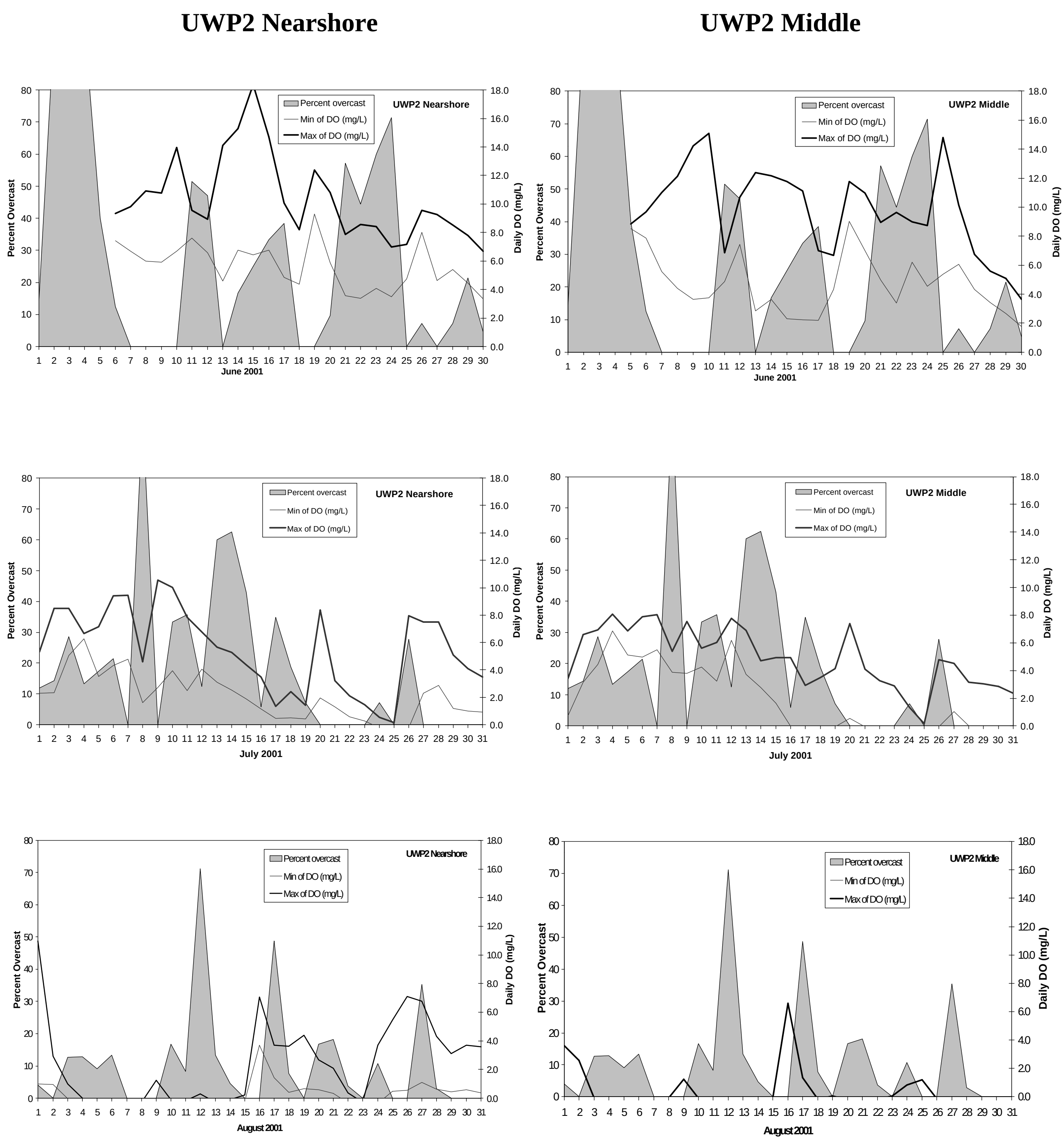

Figure E-20. Daily percent cloud cover and maximum and minimum dissolved oxygen concentrations in the Upper Woods Pond 2 (UWP2) Nearshore and Middle sites, Housatonic River during June, July, and August 2001.

Table E-1. Maximum, minimum and average DO concentrations (mg/L) in backwater and main channel Housatonic River sites for each 24-hour period following deployment or cleaning of the Stevens/Greenspan probes, within three backwater areas in the Housatonic River, Massachusetts, June – September 2001.

	Dissolved Oxygen (mg/L)								
Date	**Max.**	**Ave.**	**Min.**	**Max.**	**Ave.**	**Min.**	**Max.**	**Ave.**	**Min.**
	OM8 Main Channel			**OM8 Nearshore**			**OM8 Middle**		
6/6/01	ND	ND	ND	8.91	5.08	2.85	ND	ND	ND
6/12/01	8.49	8.24	8.00	10.51	5.77	0.66	9.84	6.49	0.00
6/19/01	7.90	7.14	6.64	12.13	7.20	3.80	7.66	3.49	0.00
6/26/01	8.56	7.93	7.43	ND	ND	ND	ND	ND	ND
7/4 or 7/5/01	9.95	8.56	7.29	14.87	10.47	4.62	7.35	4.51	1.44
7/9/01	7.92	7.53	6.45	12.93	8.70	4.88	4.51	2.40	0.51
7/12/01	8.19	7.48	7.06	10.88	6.66	3.82	9.20	7.38	5.11
7/20/01	8.25	7.83	7.24	ND	ND	ND	7.35	3.86	1.23
7/26/01	6.81	6.14	4.80	ND	ND	ND	4.08	2.59	0.74
8/1/01	7.77	7.41	6.55	ND	ND	ND	5.08	3.59	2.30
8/8/01	5.19	4.19	3.83	ND	ND	ND	1.87	0.18	0.00
8/16/01	ND	ND	ND	13.99	6.91	0.23	7.81	5.03	1.55
8/24/01	ND	ND	ND	12.60	6.58	1.18	6.37	3.95	1.62
9/20/01	ND	ND	ND	13.57	7.72	2.20	2.68	0.18	0.00
9/30/01	9.13	7.22	6.70	12.85	9.06	4.55	12.71	11.02	9.19
Summary	9.95	7.25	3.83	14.87	7.41	0.23	12.71	4.21	0.00
	UWP Main Channel			**UWP Nearshore**			**UWP Middle**		
6/6/01	ND	ND	ND	10.28	7.86	5.58	9.88	8.21	5.96
6/12/01	8.33	4.75	0.00	8.18	4.78	2.24	11.37	7.72	5.5
6/19/01	7.60	6.55	6.02	8.72	5.10	2.63	8.04	3.40	0.37
6/26/01	ND	ND	ND	ND	ND	ND	8.35	3.80	0.65
7/4 or 7/5/01	8.80	7.94	6.70	11.17	8.38	4.96	7.21	1.87	0.00
7/9/01	8.44	7.32	6.61	10.29	7.45	4.37	2.67	0.56	0.00
7/12/01	8.04	7.01	6.01	7.95	5.83	3.10	9.34	4.45	0.71
7/20/01	8.21	7.62	7.11	7.62	3.61	1.74	7.23	1.20	0.00
7/26/01	6.90	6.34	5.70	4.06	2.41	1.27	0.02	0.00	0.00
8/1/01	7.89	7.10	5.03	7.38	5.36	2.54	0.53	0.00	0.00
8/8/01	5.32	4.72	3.49	3.04	1.36	0.06	2.07	0.00	0.00
8/16/01	7.96	6.65	4.96	7.69	0.63	0.00	7.25	3.48	1.02
8/24/01	7.59	7.03	6.51	5.84	3.74	1.10	8.80	4.60	1.44
9/20/01	7.43	6.82	6.55	5.54	4.10	2.46	1.76	0.98	0.41
9/30/01	9.01	7.37	6.90	8.60	7.22	5.23	10.45	9.19	7.17

Table E-1. Maximum, minimum and average DO concentrations (mg/L) in backwater and main channel Housatonic River sites for each 24-hour period following deployment or cleaning of the Stevens/Greenspan probes, within three backwater areas in the Housatonic River, Massachusetts, June – September 2001.

	Dissolved Oxygen (mg/L)								
Date	**Max.**	**Ave.**	**Min.**	**Max.**	**Ave.**	**Min.**	**Max.**	**Ave.**	**Min.**
Summary	9.01	6.71	0.00	11.17	4.84	0.00	11.37	3.28	0.00
	UWP2 Main Channel			**UWP2 Nearshore**			**UWP2 Middle**		
6/6/01	9.16	8.10	7.7	9.66	8.21	6.70	9.25	7.6286	5.57
6/12/01	8.35	7.97	7.76	14.12	7.99	4.59	12.20	7.0412	2.86
6/19/01	7.50	7.12	6.67	12.38	9.04	5.87	11.78	9.4186	7.01
6/26/01	ND	ND	ND	9.56	7.40	4.62	ND	ND	ND
7/4,7/5, or 7/6/01	8.57	7.95	6.71	7.16	4.87	3.53	8.08	6.618	5.55
7/9/01	8.18	7.68	7.27	10.54	7.58	3.96	6.56	5.48	4.25
7/12/01	7.79	7.43	7.12	6.79	4.82	3.66	7.76	6.23	4.30
7/20/01	8.36	8.07	7.79	8.39	3.17	1.31	7.39	2.25	0.00
7/26/01	7.32	6.84	6.24	7.94	4.29	2.33	4.80	2.83	1.17
8/1/01	8.98	8.35	7.86	7.05	2.33	1.31	3.49	1.98	0.08
8/8/01	5.82	4.65	2.50	1.26	0.00	0.00	1.22	0.00	0.00
8/16/01	8.18	7.02	5.45	7.05	4.17	1.64	6.61	0.71	0.00
8/24/01	8.56	6.89	5.45	3.97	1.80	0.48	1.20	0.13	0.00
9/20/01	7.56	7.17	6.83	13.20	4.27	0.48	4.01	3.24	2.00
9/30/01	9.46	7.59	6.95	13.96	9.80	5.47	8.87	4.095	0.00
Summary	9.46	7.34	2.50	14.12	5.30	0.00	12.20	4.11	0.00

ND=No data

Table E-2. Summary table of the percentage of dissolved oxygen concentrations during each 24-hour period, which were less than or equal to 5.0, 3.0, or 1.0 mg/L at each location in the Housatonic River, in 2001 following deployment or cleaning of the Stevens/Greenspan probes.

DO (mg/L)	**Percent of readings equal to or less than specified DO concentrations**								
	Main Channel			**Nearshore**			**Middle**		
	OM8	**UWP**	**UWP2**	**OM8**	**UWP**	**UWP2**	**OM8**	**UWP**	**UWP2**
<=5.0	0.0	8.0	3.2	28.6	51.2	48.8	62.8	68.2	57.6
<=3.0	0.0	3.0	1.0	11.8	29.1	29.8	39.6	58.5	41.7
<=1.0	0.0	1.7	0.0	2.5	9.5	11.2	19.6	39.2	25.5

Table E-3. Summary table by month of the percentage of dissolved oxygen concentrations during each 24-hour period (d), which were less than or equal to 5.0, 3.0, or 1.0 mg/L at each location in the Housatonic River, in 2001 following deployment or cleaning of the Stevens/Greenspan probes.

DO (mg/L)	Percent of Readings Equal to or Less Than Specified DO Concentrations								
	Main Channel			**Nearshore**			**Middle**		
	OM8	**UWP**	**UWP2**	**OM8**	**UWP**	**UWP2**	**OM8**	**UWP**	**UWP2**
June	d=3	d=2	d=3	d=3	d=3	d=4	d=2	d=4	d=3
<=5.0	0.0	23.5	0.0	40.1	36.1	6.6	44.0	34.2	11.6
<=3.0	0.0	19.4	0.0	17.0	10.2	0.0	36.0	26.5	4.8
<=1.0	0.0	11.2	0.0	3.4	0.0	0.0	20.0	8.7	0.0
July	d=5	d=5	d=5	d=3	d=5	d=5	d=5	d=5	d=5
<=5.0	0.0	0.0	0.0	15.7	45.5	57.1	65.8	88.2	53.1
<=3.0	0.0	0.0	0.0	0.0	23.3	18.8	33.7	80.8	18.4
<=1.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	60.0	0.0
August	d=2	d=4	d=4	d=2	d=4	d=4	d=4	d=4	d=4
<=5.0	0.0	3.0	5.0	36.7	75.0	89.2	75.0	86.2	99.0
<=3.0	0.0	0.0	1.6	25.5	59.2	74.9	43.4	66.8	92.3
<=1.0	0.0	0.0	0.0	7.1	33.2	33.3	23.5	48.5	71.4
September	d=1	d=2	d=2	d=2	d=2	d=2	d=2	d=2	d=2
<=5.0	0.0	0.0	0.0	22.5	40.1	31.6	50.0	50.0	71.4
<=3.0	0.0	0.0	0.0	8.2	11.2	27.6	50.0	50.0	39.8
<=1.0	0.0	0.0	0.0	8.0	0.0	17.3	45.9	29.6	18.4

Table E-4. Water quality data measured with the Hydrolab Quanta at Housatonic River index sites during 2001 largemouth bass reproduction surveys.

Date	Index Site	Time	Temp (C)	DO (mg/L)	Cond. (mS)	pH
5/30/01	NLBW3E	11:33 AM	15.38	6.86	0.385	8.30
6/1/01	NLBW3E	9:35 AM	14.90	10.51	0.436	8.70
6/6/01	NLBW3E	8:56 AM	15.04	6.94	0.231	8.01
6/8/01	NLBW3E	10:04 AM	18.78	8.86	0.295	8.01
6/12/01	NLBW3E	11:35 AM	20.83	8.87	0.416	8.01
6/14/01	NLBW3E	9:51 AM	23.36	8.17	0.438	8.02
6/18/01	NLBW3E	9:07 AM	21.72	5.61	0.453	8.38
6/20/01	NLBW3E	9:00 AM	23.15	8.70	0.489	7.71
6/25/01	NLBW3E	9:36 AM	20.94	6.05	0.475	8.53
6/27/01	NLBW3E	10:45 AM	23.80	9.09	0.485	8.17
5/22/01	NLBW3N	9:51 AM	17.74	7.43	0.442	8.36
6/1/01	NLBW3N	9:02 AM	14.70	11.04	0.362	8.64
6/8/01	NLBW3N	9:45 AM	18.33	9.16	0.249	7.84
6/12/01	NLBW3N	11:07 AM	18.86	9.02	0.314	7.75
6/14/01	NLBW3N	9:12 AM	22.20	8.51	0.381	7.92
6/18/01	NLBW3N	8:48 AM	20.80	6.96	0.332	8.31
6/20/01	NLBW3N	8:30 AM	22.49	6.86	0.405	7.48
6/25/01	NLBW3N	9:05 AM	20.88	6.60	0.376	8.43
6/27/01	NLBW3N	11:11 AM	23.43	8.56	0.395	8.09
5/22/01	NLBW3W	10:38 AM	17.00	nr	nr	nr
5/30/01	NLBW3W	12:18 PM	16.00	nr	nr	nr
6/1/01	NLBW3W	9:35 AM	14.90	10.51	0.436	8.70
6/8/01	NLBW3W	10:26 AM	18.88	7.51	0.240	7.72
6/12/01	NLBW3W	11:50 AM	19.88	8.80	0.302	8.12
6/14/01	NLBW3W	10:19 AM	23.63	8.00	0.412	7.93
6/18/01	NLBW3W	9:57 AM	22.15	7.52	0.340	8.57
6/20/01	NLBW3W	9:25 AM	22.97	6.47	0.487	7.56
6/25/01	NLBW3W	9:57 AM	21.46	7.12	0.509	8.57
6/27/01	NLBW3W	10:26 AM	23.27	7.22	0.461	7.86
5/10/01	OM2	12:05 PM	21.32	9.55	0.362	7.95
5/11/01	OM2	10:11 AM	18.17	8.54	0.386	7.91
5/16/01	OM2	11:30 AM	14.98	11.61	0.392	8.62
5/30/01	OM2	1:45 PM	16.02	6.20	0.283	8.07
6/1/01	OM2	11:03 AM	14.01	6.24	0.289	7.95
6/7/01	OM2	9:07 AM	13.84	5.93	0.235	7.09
6/11/01	OM2	9:26 AM	18.12	4.90	0.303	8.04
6/13/01	OM2	10:58 AM	20.89	5.72	0.301	7.55
6/19/01	OM2	11:54 AM	24.46	10.43	0.304	8.02
6/25/01	OM2	11:08 AM	21.15	4.36	0.280	8.27
6/27/01	OM2	12:22 PM	25.62	9.76	0.302	8.58

Table E-4. Water quality data measured with the Hydrolab Quanta at Housatonic River index sites during 2001 largemouth bass reproduction surveys.

Date	Index Site	Time	Temp (C)	DO (mg/L)	Cond. (mS)	pH
5/31/01	OM7	9:28 AM	11.69	8.82	0.253	7.33
6/7/01	OM7	10:23 AM	16.38	8.43	0.251	7.77
6/11/01	OM7	10:02 AM	17.44	9.08	0.314	8.34
6/12/01	OM7	2:04 PM	20.56	8.72	0.287	7.72
6/14/01	OM7	11:33 AM	23.10	8.04	0.249	7.66
6/19/01	OM7	12:20 PM	23.52	12.80	0.300	8.68
6/18/01	OM8E	10:58 AM	23.06	7.13	0.400	8.28
6/20/01	OM8E	11:12 AM	27.25	7.81	0.522	7.65
6/25/01	OM8E	12:28 PM	25.25	10.16	0.504	8.85
5/16/01	OM8W	1:41 PM	15.50	nr	nr	nr
5/23/01	OM8W	2:21 PM	18.45	9.28	0.468	8.53
5/30/01	OM8W	2:14 PM	16.09	5.31	0.729	8.60
6/1/01	OM8W	12:14 PM	18.77	10.48	0.725	8.16
6/7/01	OM8W	11:07 AM	17.16	6.81	0.238	7.57
6/11/01	OM8W	10:42 AM	19.33	9.02	0.326	8.55
6/13/01	OM8W	12:12 PM	22.85	11.21	0.368	8.60
6/15/01	OM8W	9:21 AM	25.03	7.25	0.438	8.51
6/25/01	OM8W	12:49 PM	25.56	12.30	0.562	9.07
5/16/01	OM9	2:16 PM	15.51	10.25	0.363	8.51
5/23/01	OM9	3:06 PM	18.68	6.96	0.348	8.12
5/31/01	OM9	10:05 AM	11.41	8.05	0.166	7.80
6/7/01	OM9	12:06 PM	18.24	7.79	0.218	7.72
6/14/01	OM9	1:15 PM	24.01	8.51	0.264	7.73
6/20/01	OM9	11:42 AM	25.89	6.37	0.286	7.39
6/26/01	OM9	3:15 PM	28.47	11.27	0.269	8.37
5/15/01	UWP2	11:17 AM	16.90	10.55	0.362	8.83
5/21/01	UWP2	12:20 PM	21.96	9.82	0.370	8.94
5/24/01	UWP2	11:20 AM	17.67	9.30	0.171	8.59
5/29/01	UWP2	2:30 PM	17.88	8.86	0.253	8.69
5/31/01	UWP2	12:32 PM	15.01	9.70	0.233	8.30
6/6/01	UWP2	3:16 PM	18.85	8.11	0.213	7.57
6/13/01	UWP2	2:40 PM	26.50	14.10	0.241	9.72
6/15/01	UWP2	11:35 AM	27.67	8.19	0.218	9.59
6/18/01	UWP2	1:01 PM	nr	nr	nr	nr
6/20/01	UWP2	2:17 PM	26.87	9.06	0.250	9.52
6/25/01	UWP2	12:33 PM	25.08	11.80	0.270	9.77
6/8/01	UWP3	1:39 PM	20.25	6.37	0.325	7.54
6/18/01	UWP3	1:40 PM	24.15	5.73	0.372	8.11

Table E-4. Water quality data measured with the Hydrolab Quanta at Housatonic River index sites during 2001 largemouth bass reproduction surveys.

Date	Index Site	Time	Temp (C)	DO (mg/L)	Cond. (mS)	pH
5/21/01	UWP3E	1:09 PM	22.89	8.40	0.445	8.64
5/24/01	UWP3E	11:57 AM	17.99	7.92	0.483	8.21
5/21/01	UWP3E	11:18 AM	15.59	8.39	0.432	8.20
6/8/01	UWP3E	1:39 PM	20.25	6.37	0.325	7.54
6/20/01	UWP3E	2:48 PM	29.20	6.56	0.331	8.37
5/11/01	UWP3SW	1:33 PM	23.00	7.40	0.406	8.35
5/14/01	UWP3SW	1:52 PM	20.56	11.90	0.419	9.36
5/14/01	UWP3SW	1:26 PM	19.41	10.22	0.432	8.80
5/21/01	UWP3SW	2:00 PM	24.50	nr	nr	nr
5/24/01	UWP3SW	12:12 PM	16.00	nr	nr	nr
5/31/01	UWP3SW	1:43 PM	16.00	11.64	0.279	9.08
6/8/01	UWP3SW	2:04 PM	21.10	10.99	0.263	8.72
6/18/01	UWP3SW	2:06 PM	25.55	13.08	0.297	9.77
6/20/01	UWP3SW	3:00 PM	30.63	10.81	0.325	9.43
5/11/01	UWP4E	2:21 AM	21.97	9.33	0.397	8.73
5/21/01	UWP4E	2:45 PM	23.80	11.18	0.347	9.20
5/24/01	UWP4E	1:20 PM	13.22	9.76	0.045	8.05
5/31/01	UWP4E	2:02 PM	15.50	11.61	0.186	9.20
5/24/01	UWP4W	1:41 PM	17.00	nr	nr	nr
5/31/01	UWP4W	2:02 PM	15.50	11.61	0.186	9.20
6/8/01	UWP4W	2:32 PM	21.87	10.53	0.260	9.22
6/18/01	UWP4W	2:32 PM	22.90	8.55	0.133	8.64
5/24/01	UWP5	2:16 PM	17.04	9.98	0.403	8.93
5/31/01	UWP5	2:35 PM	16.00	nr	nr	nr
6/8/01	UWP5	3:13 PM	20.19	10.29	0.279	9.08
6/13/01	UWP5	4:11 PM	21.32	11.08	0.297	8.45
6/18/01	UWP5	2:50 PM	25.27	11.69	0.320	9.51
6/25/01	UWP5	3:22 PM	25.59	10.53	0.340	9.43
5/15/01	UWPIE	9:01 AM	14.79	8.94	0.425	8.72
5/21/01	UWPIE	10:52 AM	19.47	9.41	0.447	8.39
5/29/01	UWPIE	1:19 PM	17.96	7.54	0.486	8.19
5/31/01	UWPIE	11:20 AM	14.52	9.71	0.688	8.32
6/7/01	UWPIE	1:15 PM	18.61	9.22	0.249	7.90
6/12/01	UWPIE	3:26 PM	21.94	10.61	0.311	8.61
6/14/01	UWPIE	2:51 PM	23.02	8.18	0.317	7.65
6/20/01	UWPIE	12:38 PM	25.48	9.48	0.369	7.61
6/22/01	UWPIE	9:58 AM	21.15	6.35	0.370	8.35
7/3/01	UWPIE	11:53 AM	19.22	11.60	0.434	9.22

Table E-4. Water quality data measured with the Hydrolab Quanta at Housatonic River index sites during 2001 largemouth bass reproduction surveys.

Date	Index Site	Time	Temp (C)	DO (mg/L)	Cond. (mS)	pH
5/21/01	UWPIW	9:34 AM	18.65	nr	nr	nr
5/31/01	UWPIW	10:32 AM	13.53	7.11	0.726	7.76
6/7/01	UWPIW	1:00 PM	19.30	8.96	0.229	7.98
6/12/01	UWPIW	3:51 PM	22.30	9.69	0.351	8.18
6/14/01	UWPIW	2:26 PM	25.50	11.52	0.313	8.80
6/20/01	UWPIW	1:06 PM	26.89	10.47	0.362	8.26
6/22/01	UWPIW	9:35 AM	20.11	6.23	0.462	8.39
7/3/01	UWPIW	11:37 AM	20.39	10.22	0.423	9.12
5/15/01	UWPW	10:04 AM	15.45	8.38	0.433	8.45
5/21/01	UWPW	11:21 AM	20.94	9.96	0.424	8.81
5/31/01	UWPW	11:46 AM	14.59	10.42	0.685	8.57
6/7/01	UWPW	1:40 PM	19.17	8.21	0.292	7.84
6/12/01	UWPW	4:14 PM	22.67	7.72	0.334	8.30
6/15/01	UWPW	10:22 AM	24.80	5.32	0.406	8.19
6/20/01	UWPW	1:48 PM	28.57	10.95	0.345	9.32

nr = no reading

Table E-5. Water quality data measured with the Hydrolab Quanta at various locations throughout the Housatonic River Study Reach; May through July 2001.

Date	Location	Time	Temp (C)	DO (mg/L)	Cond. (mS)	pH	Depth (m)
5/10/01	NLBW 3	9:07	17.66	11.67	0.42	8.7	0
5/10/01	NLBW 3	9:07	16.44	11.62	0.417	8.59	1
5/10/01	NLBW 3	9:07	15.84	10.40	0.410	8.25	2
5/10/01	NLBW3 main channel	9:51	15.22	9.88	0.437	8.04	0
5/10/01	NLBW3 main channel	9:51	15.19	9.67	0.439	8.03	1
5/10/01	NLBW3 main channel	9:51	15.16	9.72	0.438	8.02	2
5/10/01	OM2	12:26	21.32	9.55	0.362	7.95	0
5/10/01	UWP	14:29	21.2	12.11	0.393	8.57	0
5/10/01	LWP	15:30	21.3	14.50	0.357	9.00	0
5/10/01	LWP	15:30	21.24	13.92	0.360	9.05	1
5/11/01	OM6	8:39	18.17	8.54	0.386	7.91	0
5/11/01	UWP-nearshore	11:18	20.62	11.43	0.402	8.72	0
5/11/01	UWP-middle	11:31	21.02	9.13	0.410	8.25	0
5/11/01	UWP2-nearshore	12:46	25.08	8.93	0.325	8.41	0
5/11/01	UWP2-middle	12:51	23.92	8.62	0.366	8.72	0
5/11/01	UWP3-nearshore	13:28	24.28	9.73	0.431	8.32	0
5/11/01	UWP3-middle	13:33	23.00	7.40	0.406	8.35	0
5/11/01	UWP4	14:21	21.97	9.33	0.397	8.73	0
5/11/01	UWP4	14:21	16.92	9.45	0.432	8.49	2
5/15/01	UWP	nr	14.18	7.72	0.445	8.36	0
5/16/01	NLBW3 main channel	9:42	12.57	8.61	0.449	8.33	0
5/16/01	NLBW3 main channel	9:42	12.57	8.54	0.449	8.36	1
5/21/01	UWPIW	9:26	18.64	8.35	0.437	8.53	0
5/29/01	UNLBW	10:06	15.09	7.66	0.198	8.08	nr
5/29/01	UNLMC	10:23	14.21	9.27	0.228	8.15	nr
5/29/01	US Mill Brook	11:03	14.63	8.23	0.237	8.38	0
5/29/01	DS Mill Brook	11:13	14.61	8.13	0.215	8.35	nr
5/29/01	Yokun Brook Outlet	11:33	16.33	6.72	0.340	8.25	nr
5/29/01	OM8 main channel	13:01	15.01	7.63	0.227	8.31	nr
6/11/01	OM7 main channel	10:05	17.67	7.90	0.332	8.05	0
6/11/01	OM7 main channel	10:05	17.66	6.99	0.332	8.04	1
7/6/01	OM7	6:38	19.11	5.96	0.385	7.78	nr
7/6/01	OM7	6:42	19.23	3.77	0.182	7.78	nr
5/11/01	LWP-deep hole	15:21	22.02	11.49	0.402	9.17	0
5/11/01	LWP-deep hole	15:21	17.61	11.74	0.408	9.01	1
5/11/01	LWP-deep hole	15:21	14.61	14.33	0.355	9.25	2
5/11/01	LWP-deep hole	15:21	11.64	13.11	0.281	8.84	3

Table E-5. Water quality data measured with the Hydrolab Quanta at various locations throughout the Housatonic River Study Reach; May through July 2001.

Date	Location	Time	Temp (C)	DO (mg/L)	Cond. (mS)	pH	Depth (m)
5/14/01	LWP-deep hole	11:11	16.57	12.08	0.399	9.33	0
5/14/01	LWP-deep hole	11:11	16.60	12.15	0.398	9.38	1
5/14/01	LWP-deep hole	11:11	15.65	12.04	0.396	9.44	2
5/14/01	LWP-deep hole	11:11	12.04	9.33	0.305	8.50	3
5/24/01	LWP-deep hole	~14:00	16.50	9.06	0.416	8.77	0
5/24/01	LWP-deep hole	~14:00	15.90	8.70	0.400	8.65	1
5/24/01	LWP-deep hole	~14:00	14.89	6.83	0.405	8.34	2
5/24/01	LWP-deep hole	~14:00	13.15	5.04	0.410	8.19	3
5/24/01	LWP-deep hole	~14:00	11.30	1.41	0.365	7.97	4
5/31/01	LWP-deep hole	14:45	14.13	8.68	0.279	8.40	0
5/31/01	LWP-deep hole	14:45	14.05	8.53	0.281	8.43	1
5/31/01	LWP-deep hole	14:45	13.97	8.51	0.282	8.46	2
5/31/01	LWP-deep hole	14:45	12.65	6.24	0.301	8.19	3
5/31/01	LWP-deep hole	14:45	12.01	2.36	0.373	7.99	4
6/19/01	LWP-deep hole	15:50	24.85	8.79	0.321	8.13	0
6/19/01	LWP-deep hole	15:50	21.59	7.88	0.324	7.80	1
6/19/01	LWP-deep hole	15:50	19.18	11.97	0.316	8.63	2
6/19/01	LWP-deep hole	15:50	16.04	8.97	0.281	7.83	2.6
7/10/01	LWP-deep hole	11:59	24.30	12.91	0.329	9.85	0
7/10/01	LWP-deep hole	11:59	20.35	4.08	0.357	8.69	1
7/10/01	LWP-deep hole	11:59	19.03	3.94	0.360	8.53	2
7/10/01	LWP-deep hole	11:59	17.12	1.88	0.344	8.41	3
7/11/01	LWP-deep hole	16:11	22.94	12.20	0.357	8.80	0
7/11/01	LWP-deep hole	16:11	22.98	12.07	0.357	8.82	0.3
7/11/01	LWP-deep hole	16:11	22.96	12.09	0.357	8.82	0.6
7/11/01	LWP-deep hole	16:11	22.90	12.04	0.356	8.81	0.9
7/11/01	LWP-deep hole	16:11	21.45	11.41	0.361	8.49	1.2
7/11/01	LWP-deep hole	16:11	21.00	10.94	0.359	8.43	1.5
7/11/01	LWP-deep hole	16:11	19.49	5.38	0.357	7.81	1.8
7/11/01	LWP-deep hole	16:11	19.12	3.43	0.358	7.60	2.1
7/11/01	LWP-deep hole	16:11	18.76	2.34	0.357	7.48	2.4
7/11/01	LWP-deep hole	16:11	17.80	1.08	0.350	7.41	3

nr = not recorded

APPENDIX F

Photographs

(photographs of largemouth bass reproduction index sites, and fish species collected during electrofishing)

Figure F-1. Index Site NLBW3E Housatonic River, Massachusetts, June 4, 2001.

Figure F-2. Index Site NLBW3W Housatonic River, Massachusetts, June 4, 2001.

Figure F-3. Index Site NLBW3N Housatonic River, Massachusetts, June 1, 2001.

Figure F-4. Index Site OM2 Housatonic River, Massachusetts, June 4, 2001.

Figure F-5. Index Site OM7 Housatonic River, Massachusetts, June 27, 2001.

Figure F-6. Index Site OM9 Housatonic River, Massachusetts, June 15, 2001.

Figure F-7. Index Site OM8E Housatonic River, Massachusetts, July 4, 2001.

Figure F-8. Index Site OM8W Housatonic River, Massachusetts, June 25, 2001.

Figure F-9. Index Site UWPIE Housatonic River, Massachusetts, June 4, 2001.

Figure F-10. Index Site UWPIW Housatonic River, Massachusetts, June 4, 2001.

Figure F-11. Index Site UWPW Housatonic River, Massachusetts, June 16, 2001.


Figure F-12. Index Site UWP2 Housatonic River, Massachusetts, June 4, 2001.

Figure F-13. Index Site UWP3E Housatonic River, Massachusetts, May 17, 2001.

Figure F-14. Index Site UWP3SW Housatonic River, Massachusetts, June 4, 2001.

Figure F-15. Index Site UWP4 Housatonic River, Massachusetts, May 17, 2001.

Figure F-16. Index Site UWP5 Housatonic River, Massachusetts, June 25, 2001.

Figure F-17.
Brown bullhead captured during electrofishing surveys on the Housatonic River, Massachusetts, 2000.

Figure F-18.
Yellow bullhead captured during electrofishing surveys on the Housatonic River, Massachusetts, October 11, 2001.

Figure F-19.
Common carp captured during electrofishing surveys on the Housatonic River, Massachusetts, 2000.

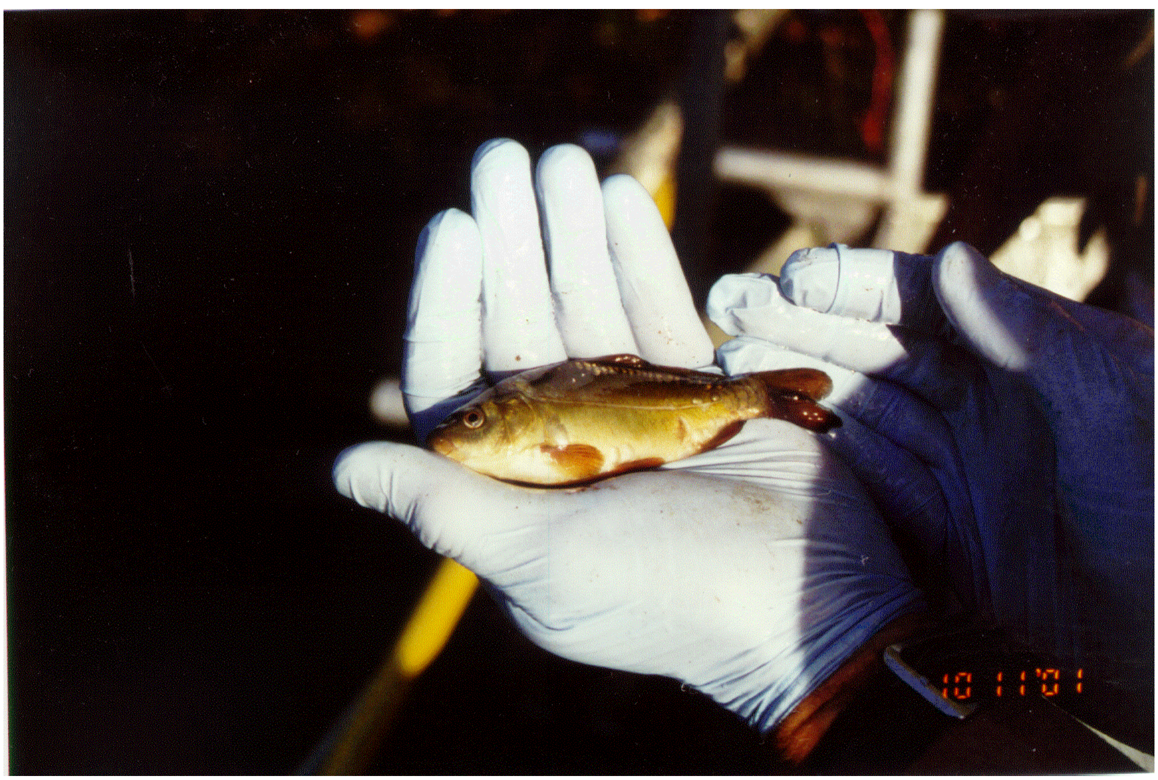

Figure F-20. Mirror carp captured during electrofishing surveys on the Housatonic River, Massachusetts, October 11, 2001.

Figure F-21.
Goldfish captured during electrofishing surveys on the Housatonic River, Massachusetts, 2000.

Figure F-22.
Common shiners captured during electrofishing surveys on the Housatonic River, Massachusetts, 2000.

Figure F-23.
Fallfish captured during electrofishing surveys on the Housatonic River, Massachusetts, 2000.

Figure F-24.
Chain pickerel captured in a minnow trap on the Housatonic River, Massachusetts, June 28, 2001.

Figure F-25.
Northern pike captured during
electrofishing surveys on the
Housatonic River, Massachusetts,

Figure F-26.
Yellow perch captured during
electrofishing surveys on the
Housatonic River, Massachusetts, 2000.

Figure F-27.
Largemouth bass captured during
electrofishing surveys on the
Housatonic River, Massachusetts, 2000.

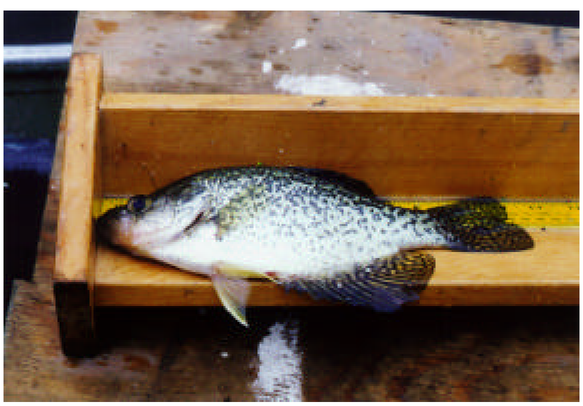

Figure F-28.
Black crappie captured during
electrofishing surveys on the
Housatonic River, Massachusetts, 2000.

Figure F-29.
Rock bass captured during electrofishing surveys on the Housatonic River, Massachusetts, 2000.

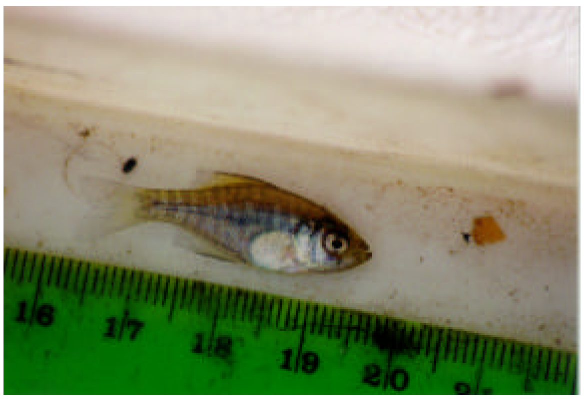

Figure F-30.
Juvenile sunfish captured in a minnow trap on the Housatonic River, Massachusetts, June 28, 2001.

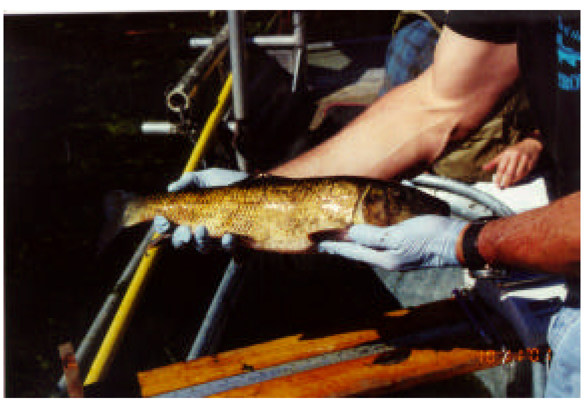

Figure F-31.
White sucker captured during electrofishing surveys on the Housatonic River, Massachusetts, October 11, 2001.

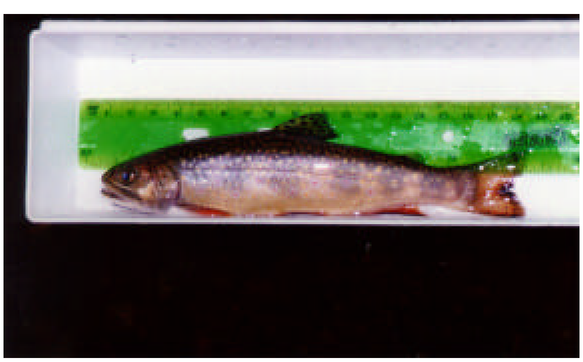

Figure F-32.
Eastern brook trout captured during electrofishing surveys on Mill Brook, Massachusetts, 2000.

APPENDIX G

Results of the Aquatic Habitat Assessment of the Upper Housatonic River and the Major Tributaries to the Study Reach

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

This appendix describes the results of aquatic habitat assessments conducted in the upper Housatonic River system (Massachusetts) in 2000 by R2 Resource Consultants, Inc. The aquatic habitat conditions in the Housatonic River were assessed from the confluence of the East and West branches of the Housatonic River downstream to Woods Pond Dam. Additional assessments were completed in the lower reaches of the East Branch, West Branch, and Southwest Branch, and in the tributaries of Sackett, Moorewood, Mill, Roaring, Yokun, and Felton brooks. The survey methods are described in detail in Chapter 4 of the main report and the site location is shown in Figure 1-1 of the main report.

In general, the surveys were conducted at two geographical scales. Landscape-scale surveys were used to describe the overall reach characteristics, such as the channel width, gradient, substrate, and the percent of channel comprised of the major habitat unit types (i.e., pool, riffle, and glide). Site-specific habitat assessments were completed at thirteen locations that were subsequently assessed for fish use (Figure 4-2 in the main report).

2. HOUSATONIC RIVER MAINSTEM CHANNEL AND BACKWATERS

The mainstem Housatonic River was assessed from the confluence of the East and West branches of the Housatonic River in the city of Pittsfield downstream to Woods Pond Dam near the town of Lenox Station. This section of the mainstem was divided into four reaches for the habitat-mapping survey, the results of which are described below.

2.1 HABITAT MAPPING

The **Housatonic River upstream of Holmes Road** was surveyed on May 7, 2000. This reach was just over one mile long (5,391 feet) and on the survey date had a water temperature of 17ºC. The river within this reach was low gradient (< 1%), and composed primarily of glide habitat (87%), only five pools (13%) were observed. The pools were generally corner pools formed at the outside of meander bends. Only one embayment comprised of a relatively small backwater area of shallow, zero-velocity water, was observed along the reach. The river substrate was dominated by sand and the banks were composed of clay (Figure G-1). Although the average water depth was 3.3 feet, bottom undulations occasionally created shallower areas. These dune-like undulations were comprised mostly of sand, but also contained small amounts of fine gravel.

Bankfull width ranged from 55 feet in the upper fifth of the reach to 75 feet at the downstream end. Aquatic cover averaged 24% and was primarily provided by undercut banks, deep water, and accumulations of small woody debris. Land use adjacent to both banks was typically forest, except for the downstream area near the Holmes Road bridge where residential buildings and lawns encroached on the left bank (facing downstream).

Figure G-1. Housatonic River upstream of the Holmes Road crossing, May 2000.

The **Housatonic River from Holmes Road to New Lenox Road**, a reach approximately five miles long, was surveyed on May 8 and July 31, 2000 (Table G-1). The May 8th survey was conducted on the lower half of the reach, while the upper half was surveyed on July 28. The July survey of the upper reach also included a site just downstream of the confluence of Sykes Brook that was assessed in 1992 and 1993 as Site HR-1 by Chadwick & Associates (1994). The bankfull width was consistently 75 feet and the gradient was less than 1% along much of this five-mile reach (Figure G-2). The reach was predominantly a continuous glide with numerous

Figure G-2. Housatonic River upstream of New Lenox Road crossing, July 2000. A beaver dam is visible on the right hand side of the photo (right bank facing downstream) at the mouth of an unnamed tributary just downstream of the sewage treatment plant.

Table G-1. Landscape-scale aquatic habitat characteristics of the reaches surveyed on the Housatonic River system, 2000.

Reach	Surveyed Length (ft)	Average Bankfull Width (ft)	% Gradient	Major Habitat Units	Substrate (Dom./Subdom.)	Aquatic Cover
Housatonic River – upstream of Holmes Road	5,391 (~ 1 mile)	67	< 1	glide: 87% pool: 13%	sand/small gravel	undercut banks, deep water, small wood: 24%
Housatonic River – Holmes Road to New Lenox Road	26,876 (~ 5 miles)	75	< 1	predominantly glide	sand/small gravel	small wood, deep water: 30%
Housatonic River – New Lenox Road to Woods Pond	21,717 (~ 4 miles)	85	< 1	glide: 50% embayment: 50%	sand	aquatic vegetation, small wood, deep water: 30%
Housatonic River – Woods Pond	4,514	1,335	< 1	impounded: 100%	sand/small gravel	aquatic vegetation, deep water: 50%
East Branch, Housatonic River	10,229 (~ 2 miles)	50	< 1	glide: 88% riffle: 11%	sand/small gravel	vegetation, small wood: 5%
West Branch, Housatonic River – Mill St. to Southwest Branch	4,139	40	1	riffle: 63% glide: 32%	cobble/sand	small wood: 10-30%
West Branch, Housatonic River – Southwest Branch to East Branch	5,474 (~ 1 mile)	48	< 1	glide: 84% pool: 14%	sand/sm gravel	small wood: 10%
Southwest Branch, Housatonic River – Hungerford St. to Barker Road	15,079 (2.8 miles)	30	< 1	glide: 79% riffle: 10% debris complex: 8% pool: 3%	sand/sm gravel	small wood, deep water: 30%
Southwest Branch, Housatonic River – Barker Road to Clapp Park	1,481	34	< 1	glide: 94% riffle: 6%	sand	vegetation, deep water: 30%
Southwest Branch, Housatonic River – Clapp Park to West Branch	2,495	28	< 1	glide: 100%	sand/sm gravel	vegetation: 30%

Table G-1. Landscape-scale aquatic habitat characteristics of the reaches surveyed on the Housatonic River system, 2000.

Reach	Surveyed Length (ft)	Average Bankfull Width (ft)	% Gradient	Major Habitat Units	Substrate (Dom./Subdom.)	Aquatic Cover
Moorewood Brook	505	10	< 1	glide: 70% pool: 30%	sand/small gravel	vegetation, small wood: 10%
Sackett Brook upstream of dam	1,700	29	1-2	riffle: 42% glide: 34% pool: 21%	large gravel/small gravel	small wood, rocks, vegetation: 5-10%
Sackett Brook downstream of dam	1,900	24	1	glide: 54% pool: 24% riffle: 15%	sand/small gravel	small wood, vegetation, undercut banks: 5-60%
Upper Mill Brook	1,445	19	1.5-6	riffle: 89% pool: 10%	large gravel/sand and boulder/cobble	wood, rock, vegetation: 20-40%
Lower Mill Brook	2,207	17	< 1	riffle: 27% pool: 23% glide: 17%	small gravel	undercut banks: 30%
Roaring Brook	1,924	23	1-4	riffle: 79% chute: 16% pool/glide: 5%	boulder	vegetation, rocks: 50-60%
Yokun Brook	1,920	26	1.5	riffle: 75% pool: 22%	cobble/sand	rocks, deep water: 10%
Felton Brook	694	14	< 1-4	riffle: 65% pool: 27% glide: 8%	cobble/small gravel and sand/small gravel	small wood, vegetation: 50-80%

meanders. Because the reach was assessed during two different flows, percent glide compared to other habitat units was not calculated. It was noted, however, that backwater areas in old meander bends and log jams occurred more frequently than in the upper one mile of river. These areas and deep water in the main channel provided the majority of available aquatic cover. Substrates were dominated by sand with occasional "dunes" of sand and small gravel. Residential and commercial land use was infrequent, and most of the adjacent banks were forested.

The **Housatonic River from New Lenox Road to Woods Pond** was surveyed on May 12, 2000, which was a reach approximately four miles long. This reach encompassed one of the main river sites (HR-2) used by Chadwick & Associates (1994) during their 1992-93 studies. The upper extent of the reach was located along abandoned pastureland where the banks were steep and eroded. Where the old pastures ended, the river entered forested bottom-land, and the low banks allowed the main channel to overtop more frequently into floodplain ponds (Figure G-3). In several areas, the main channel seemingly disappeared, where the water spread out into old meanders, beaver impoundments, and tributary deltas. Where the main channel was more constrained, it averaged approximately 85 feet across; water depth averaged 10 feet. Submerged vegetation provided abundant aquatic cover in the shallow backwater and impoundment areas. Cover in the main channel was relatively sparse except for deep water and accumulations of woody debris along the stream edges.

Figure G-3. Housatonic River downstream of New Lenox Road crossing, May 2000.

The **Housatonic River at Woods Pond** was surveyed on May 5, 2000, and encompassed a reach 4,514 feet long. The downstream boundary of this reach is located at Woods Pond Dam, which serves to impound the river creating Woods Pond. Although a meandering thalweg existed within this reach, the reach was more characteristic of lentic than lotic habitats (Figure G-4). The land use surrounding Woods Pond was primarily wetland and forest. Aquatic cover in the main channel area was primarily in the form of deep water (6 to 10 feet deep), although observations through a remote underwater video camera (Aqua-Vu) indicated that submerged aquatic vegetation covered 50% of the substrate. The substrate was sand and small gravel. In both 2000 and 2001, extensive mats of surface algae developed and covered large sections of Woods Pond during the summer and early fall periods. The embayment areas within this reach were characterized by water depths that averaged around 2.5 feet coupled with areas of dense aquatic vegetation that provided 70 to 80% of the available cover. Lower Woods Pond contained a deep-water area; the deepest location identified during the survey was 15 feet. This deep hole and the main channel area were the only areas of Woods Pond where aquatic vegetation was not dominant.

Figure G-4. Woods Pond on the Housatonic River, July 2000.

2.2 SITE-SPECIFIC SURVEYS

The habitat mapping of the mainstem river resulted in the selection of five site-specific study sites (Figure 4-2 in the main report), including two main channel sites (Holmes Road [HR] and upstream of New Lenox Road [UNLMC]), one backwater site (Upper New Lenox Road backwater [UNLBW]), and two impounded sites (Upper Woods Pond [UWP] and Lower Woods Pond [LWP]).

The two study sites established on Woods Pond were characterized as impounded areas located off of the main channel. The UNLBW was located in an old meander bend that was cut off from the mainstem channel at the upstream end. Measured water velocities at each of these three sites were zero. Average water depth at UWP and LWP were approximately 3 feet aquatic vegetation covered about 50% of each study site. The water depths at site UNLBW were more variable; the upstream end was relatively shallow, but became progressively deeper in a downstream direction.

A corner pool existed at the outer bend where the historical thalweg was located. Average water velocities in the two main channel sites ranged from 1.4 to 1.5 feet per second. Site-specific habitat parameters are provided in Table G-2.

Table G-2. Average velocity, water quality, and physical attributes measured at the 13 study sites on the Housatonic River system in May 2000.

Study Site	Survey Date	Water Temp. (C)	DO (mg/L)	pH	Cond. (µs/L)	Average Depth (ft)	Average Width (ft)	Average Velocity (f/s)
Upper Woods Pond site (UWP)	5/12/00	16.0	10.3	6.22	0.378	3.2	540	0.0
Lower Woods Pond site (LWP)	5/12/00	16.5	11.0	6.8	0.298	3.0	600	0.0
Upper New Lenox Backwater (UNLBW)	5/11/00	15.6	4.5	6.1	0.400	2.2	70	0.0
Upper New Lenox Main Channel (UNLMC)	5/11/00	15.0	9.4	5.69	0.298	5.0	90	1.50
Holmes Road (HR)	5/19/00	13.5	8.9	ND	0.278	2.7	70	1.43
East Branch (EB)	5/18/00	14.5	ND	ND	0.309	1.6	45	0.85
West Branch (WB)	5/18/00	15.0	ND	ND	0.309	2.1	40	0.79
Moorewood Brook (MRB)	5/17/00	22.0	10.2	ND	0.508	0.5	8	0.51
Sackett Brook (SB)	5/19/00	10.5	10.2	ND	0.202	2.3	20	0.21
Upper Mill Brook (MBU)	5/16/00	10.5	10.8	ND	0.061	0.5	13	0.96
Lower Mill Brook (MBL)	5/16/00	10.0	10.8	ND	0.061	0.6	14	1.54
Roaring Brook (RB)	5/16/00	9.0	11.2	ND	0.039	0.7	10	1.70
Felton Brook (FB)	5/17/00	11.0	10.8	ND	0.045	0.5	4	0.45

ND = Not determined due to equipment failure.

3. MAJOR BRANCHES TO THE HOUSATONIC RIVER

3.1 HABITAT MAPPING

There are three major tributary rivers upstream of Woods Pond Dam. These include the East Branch of the Housatonic River, the West Branch of the Housatonic River, and the Southwest Branch of the Housatonic River. The Southwest Branch flows into the West Branch, which flows south until it joins the East Branch of the Housatonic River. The mainstem Housatonic River begins at the confluence of the East and West branches of the Housatonic River. All three tributaries were surveyed by raft in May 2000.

The East and West branches of the Housatonic River, within the surveyed sections, were channelized, had relatively low gradients (although the West Branch was slightly steeper than the East Branch), and flowed through urbanized areas of the City of Pittsfield (Table G-1). The upper reach of the **West Branch** of the Housatonic River was surveyed on May 5, 2000, beginning at a high dam near Mill Street and extending downstream for 4,139 feet to the confluence with the Southwest Branch. The dam at Mill Street effectively impedes upstream movement of fish. The upper reach of the West Branch had an average bankfull width of approximately 40 feet; stream gradient was approximately 1% along most of the surveyed section (Figure G-5). The average water depth along this reach was 1.5 feet and the predominant habitat units were riffle (63%) and glide (32%); no pools were observed in the surveyed reach. A 100-foot length of channel downstream of the Mill Street Dam was classified as its own habitat unit type. The substrates were comprised primarily of cobble and sand and small gravel. The lower 300 feet of the West Branch, just upstream of its confluence with the Southwest Branch contained depositional islands composed of small gravel and sand. Although the banks were steep and prevented the river from overtopping onto a floodplain,

Figure G-5. West Branch of the Housatonic River downstream of Mill Street road crossing, May 2000.

relatively mature box elder trees (*Acer negundo*), including blown-down trees existed along most banks. This downed wood provided the majority of available cover for aquatic organisms, which covered between 10 to 30% of the wetted channel. The stream channel also contained substantial amounts of urban flotsam and litter including shopping carts, tires, and metal and plastic debris.

Figure G-6. Lower reach of the West Branch of the Housatonic River, May 2000.

The lower reach of the West Branch was surveyed from the confluence of the Southwest Branch to its mouth on May 7, 2000. This lower reach had an average bankfull width of 48 feet (Figure G-6). The river continued to be dominated by glide habitat (84%) that was interspersed with alternating sequences of pool habitat (14%). The remaining habitat areas were small debris dams. Substrates were predominantly sand with small gravel subdominant. Although beaver activity was noted in this reach, most obstacles to travel via raft had recently been removed. Aquatic cover in this reach was minimal and averaged 10% in most areas (wood cover), although in some areas deep water associated with scour at the outer bends of meanders provided approximately 40% cover within the glide habitat.

Figure G-7. Low dam and impoundment on the upper reach of the Southwest Branch of the Housatonic River, just upstream of the Barker Road crossing, May 2000.

The survey of the **Southwest Branch** of the Housatonic River extended from a 4-ft high dam near the Hungerford Street bridge downstream for approximately 3.6 miles to the confluence with the West Branch. The only other human-made dam on the river downstream of the survey starting point was located just over 2.7 miles downstream from the Hungerford Street bridge (approximately 250 feet upstream of the Barker Road bridge). This low dam is unlikely to impede upstream fish movement at high flows (Figure G-7).

The Southwest Branch was divided into three reaches for habitat mapping, all of which were surveyed on either May 5 or 8, 2000. The upper reach, from Hungerford Street downstream to Barker Road, encompassed a distance of 15,080 feet (~2.8 miles). This segment had a stream gradient < 1%, and an average bankfull width of 30 feet; water depths averaged 1.8 feet (Table G-1). Habitat types were, dominated by glides (79%) with some scour pools located along the outer edges of meander bends; riffle habitat was uncommon (10%). Aquatic cover averaged between 20 and 50% of the wetted channel area and was provided by small woody debris, overhanging vegetation, and deep water in the outer meander bend pools; substrate was dominated by sand.

The middle reach, from Barker Road downstream to Clapp Park, was 1,481 feet long and was channelized (Figure G-8). This reach contained primarily glide habitat (94%) and had an average bankfull width of 33 feet. Although this section had been heavily modified, the river had an extensive floodplain that contained standing water during the survey

Figure G-8. Southwest Branch of the Housatonic River downstream of the Barker Road crossing, May 2000.

Within the lower reach, approximately 2,495 feet downstream from Clapp Park to the confluence with the West Branch, the river returned to its meandering pattern and contained up to 70% aquatic cover, primarily from overhanging vegetation. Substrates throughout were dominated by sand and water depth that averaged around 2 feet. Along the section from the Cadwell Street bridge downstream to the mouth of the Southwest Branch, numerous beaver dams were found. Although many of these beaver dams were difficult to portage around, they would not likely impede fish movement. The surveyed channel appeared to regularly overtop into its floodplain upstream of the confluence with the West Branch.

The **East Branch** of the Housatonic River was surveyed on May 6, 2000 from the Newell Road bridge crossing upstream of the GE facility, downstream for approximately two miles to the mouth of the river at the confluence with the West Branch Housatonic River. The East Branch bankfull width averaged approximately 50 feet and the gradient was less than 1% along most of the surveyed section (Table G-1 and Figure G-9). Water depth varied along the surveyed reach but averaged 2.5 feet deep in the glide habitat units and just over 1-foot deep in the riffle units. The predominant habitat units were glide (88%) and riffle (11%) with only two pools in the surveyed reach. Upstream of the Elm Street bridge crossing the river was predominantly a series of glides; downstream the river exhibited a more sinusoidal channel bottom and glides were typically separated by short riffle segments. Only two pools were observed in the reach. Substrates were dominated by sand, although a few areas contained patches of gravel and cobble. Adjacent to the GE facility, the substrate had been modified and was primarily composed of cobble and gravel. Overall, the surveyed channel was of uniform structure and generally lacked instream complexity. Most of the available aquatic cover was provided by overhanging vegetation along the channel edges, which on average covered only 5% of the wetted channel. An exception was the reach just upstream of the Elm Street bridge crossing, which had relatively abundant downed wood and covered 40 to 50% of the wetted channel. A complete barrier to fish passage is located upstream of the surveyed site at a relatively high dam just downstream of the Route 9 bridge crossing in Dalton.

Figure G-9. East Branch of the Housatonic River downstream of the General Electric facility, May 2000.

3.2 SITE-SPECIFIC SURVEYS

The habitat mapping of the three major tributary rivers resulted in the selection of two site-specific study sites. One of these, located on the East Branch of the Housatonic River (EB), was representative of a channelized tributary. The second, a site on the lower West Branch of the Housatonic River (WB), represented a large, more naturally meandering tributary. Both sites were located just upstream of their confluence and the origin of the mainstem Housatonic River. Measured site-specific habitat attributes measured at each site are presented in Table G-2.

4. TRIBUTARIES

4.1 HABITAT MAPPING

Six small tributaries were investigated during the habitat mapping surveys. These streams were Sackett, Moorewood, Mill, Roaring, Yokun, and Felton brooks.

Moorewood Brook enters the Housatonic River on the right bank (facing downstream) approximately 10 river miles upstream from Woods Pond Dam. During the habitat mapping survey on May 7, 2000 the water temperature was 19°C. This small, short stream averaged 10 feet wide and flowed for approximately 500 feet from the outlet of Moorewood Lake to the Housatonic River (Figures G-10 and G-11). This sandy-bottomed stream was comprised of 70% glide and 30% pool. One deep (approximately 6-feet deep) pool existed at the outlet of a culvert that passed the stream underneath a railroad crossing. This stone culvert had a flat grade and natural bottom and did not appear to be a barrier to fish migration. The stream surveyed started at the outlet pool of this culvert. Cover was

Figure G-10. Facing upstream towards the railroad crossing on Moorewood Brook, May 2000.

Figure G-11. Moorewood Lake just upstream of the railroad crossing at the lake outlet, May 2000.

sparse and in the form of small wood and overhanging vegetation. Although flows were low during the May survey (water depths averaged 0.5 ft) observations made of this stream during flood conditions (June 11, 2000) indicated the Housatonic River backflushes through the culvert and into Moorewood Lake.

Sackett Brook was surveyed from East New Lenox Road downstream to the floodplain of the Housatonic River. Sackett Brook enters the Housatonic River approximately 9.4 river miles upstream from Woods Pond Dam. During the habitat mapping survey on May 4, 2000 the water temperature was 11.5°C. A dam approximately 15- ft high was located just over 1,700 feet downstream of the survey starting point. This location was approximately 1,900 feet upstream of the mouth of the stream channel. The dam was identified as the upstream limit of fish movement in Sackett Brook. Upstream of the dam, the channel gradient ranged from 1 to 2%. For approximately 1,000 feet from the road crossing downstream, the channel exhibited a riffle-pool sequence, while the lower section just upstream of the dam was comprised of glide habitats. Overall, the reach upstream of the dam was composed of 42% riffle, 34% glide, and 21% pool. The remaining habitat was an island complex upstream of the impoundment at the dam. Channel width averaged 29 feet and substrates were primarily large and small gravel. Although two habitat units had 50% aquatic cover from small wood and boulders, most of the reach was relatively devoid of aquatic cover. The adjacent land use was predominately residential lawn or immature forest.

The reach of Sackett Brook, downstream of the dam, was slightly narrower and averaged 24 feet wide (Figure G-12). Habitat types were 54% glide, 24% pool, and 15% riffle, and 7% island complex. The channel gradient flattened as it approached the Housatonic River, and substrates transitioned from predominately gravel to sand. The surrounding land use along this reach was agricultural and

Figure G-12. Sackett Brook upstream of its confluence with the Housatonic River, May 2000.

immature forest. Aquatic cover was relatively high with small woody debris, overhanging vegetation, and undercut banks providing cover from 5 to 60% of the wetted channel. The lower reach also had several split channels, one of which flowed to a shallow pond within the Canoe Meadows property. This channel and pond were not surveyed.

Mill Brook was surveyed in two sections, the reach upstream of the road crossing (Roaring Brook Road), and the reach downstream of the road crossing to the confluence with Roaring Brook. The stream flowed through a culvert underneath Roaring Brook Road; the culvert did not appear to be a barrier to fish migration. During the habitat mapping surveys on May 4 and 6, 2000 the water temperatures were 13 and 14.5°C, respectively.

Figure G-13. Upper Mill Brook in the Housatonic River system, May 2000.

Upper Mill Brook upstream of the road crossing was comprised of 89% riffle and 10% pool, and had an average bankfull width of 19 feet (Table G-1 and Figure G-13). The channel gradient was 1.5 to 2% in the lowest 200 feet becoming steeper in its upper reaches higher up on October Mountain (4.5 to 6%). A 4-ft high crib dam was located approximately 1,500 feet upstream of the road crossing. The substrates in the lower section were large gravel and sand; substrates in the steeper sections were dominated by boulders and cobbles. Aquatic cover varied from 20 to 40% and was in the form of small woody debris and vegetation in the lower section and large rock in the upper section. Surrounding land use was predominantly immature forest.

Lower Mill Brook, downstream of the Roaring Brook Road crossing, had a much flatter gradient than Upper Mill Brook and it was bordered on one side by abandoned pastureland (Figure G-14). Lower Mill Brook joins Roaring Brook on the floodplain of the Housatonic River before entering the Housatonic River on the left bank (facing downstream) approximately 4 river miles upstream of Woods Pond Dam. Average bankfull width was 17 feet, and the substrates were dominated by small gravel. Aquatic cover varied from zero to 75% and averaged 30%, primarily in the form of undercut banks. The channel was composed of 27% riffle, 23% pool, and 17% glide. The lower 340 feet of channel upstream of the confluence with Roaring Brook was impounded a likely result of beaver activity.

Figure G-14. Lower Mill Brook in the Housatonic River system, May 2000.

Roaring Brook was similar to Mill Brook in that it originates in October Mountain, and flows east towards the Housatonic River. As mentioned above, both streams join before entering the Housatonic River approximately 4 river miles upstream of Woods Pond Dam. Roaring Brook was comprised of low-gradient riffle (1% gradient) habitat from the confluence upstream for approximately 1,100 feet, high-gradient riffle (4% gradient) for the next 700 feet upstream (Figure G-15) and then a steep cascade at the upper 120 feet of the surveyed reach. Overall, riffle habitat occupied 79% of the channel length, cascade habitat 16%, and pool and glide habitats 2 and 3%, respectively. However, in the high-gradient section, small pools associated with the boulder substrate existed within the riffle units. Aquatic cover was abundant throughout the reach and was estimated at 50% in the low-gradient section (comprised of overhanging vegetation) and 60% in the high-gradient section (comprised of large

Figure G-15. Roaring Brook in the Housatonic River system, May 2000.

rocks). During the habitat mapping survey on May 4, 2000 the water temperature was 10.5°C.

Yokun Brook flows west and enters the right bank (facing downstream) of the Housatonic River approximately 3 river miles upstream of Woods Pond Dam. The stream was surveyed from the road crossing at Edgewood Road (Figure G-16) downstream for approximately 1,900 feet. The survey ended just downstream of the East Street road crossing. The stream downstream of this point was impounded by beaver dams and was impossible to survey on foot (Figure G-17). Upstream of East Street, the stream channel had a gradient of approximately 1.5% and exhibited a pool-riffle sequence. Riffle habitat was 75% of the surveyed channel length, and pool habitat was 22%. Some of the stream banks have been armored to protect residential lawns. Although residential lawns were present along some of the surveyed length, most of the adjacent land was forested. Substrates were dominated by cobble, and the average bankfull width was 26 feet. Aquatic cover was relatively sparse (averaged 10%) and was provided primarily by rocks and deep water. On May 8, 2000 the water temperature was 21°C, which was the highest water temperature recorded during the aquatic habitat mapping surveys.

Figure G-16. Yokun Brook upstream of East Street, Housatonic River system, May 2000.

Figure G-17. Impounded waters of Yokun Brook between East Street and the railroad tracks that parallel the Housatonic River. The photograph was taken from the railroad facing upstream, Mav 2001.

Felton Brook flows east from October Mountain, and enters the left bank of the Housatonic River approximately 0.75 river miles upstream of Woods Pond Dam. This is the downstream-most tributary to Woods Pond.

During the habitat mapping survey on May 17, 2000 the water temperature was 11°C. This stream was surveyed from the Roaring Brook Road (also Woodland Road) crossing downstream to the floodplain of the Housatonic River. We could not locate the mouth of Felton Brook since its lower floodplain within which the channel becomes undefined. The section just downstream of the road crossing had a relatively steep gradient (3 to 4%) for approximately 450 feet (Table G-1). In this section, the substrate was dominated by cobbles; channel width averaged 14 feet. The gradient flattened as the stream entered a forested wetland (Figure G-18), the substrate changed to one dominated by sand and small gravel, and the channel narrowed to 8 feet. Aquatic cover throughout the surveyed reach was relatively high and averaged between 50 and 80%, primarily from small wood and overhanging vegetation. Land use adjacent to the surveyed section was immature forest.

Figure G-18. Felton Brook in the Housatonic River system, June 2000.

4.2 SITE-SPECIFIC SURVEYS

Six study sites were established on the tributaries to the Housatonic River within the study area (Figure 4-2 in the main report): Moorewood Brook (MRB); Sackett Brook (SB); Upper Mill Brook (MB-U); Lower Mill Brook (MB-L); Roaring Brook (RB); and Felton Brook (FB). These study sites include both high and low-gradient tributaries to the Housatonic River upstream of Woods Pond Dam. Measured site-specific habitat parameters are provided in Table G-2.

5. SUMMARY

The results of the habitat surveys indicated that there are two types of tributaries draining to the Study Reach, coldwater tributaries that originate on October Mountain and warmer water tributaries that originate in ponds and wetlands. In general, tributaries can support largemouth bass only if they contain impounded areas or deep, slackwater pools. Within the Study Reach, only the impounded areas on Moorewood and Yokun Brooks, upstream of the railroad crossing, contained habitats that were suitable for largemouth bass. Within the upper Housatonic River, suitable largemouth bass habitat is abundant in Woods Pond, in shallow backwater areas, and in the ponds and wetlands that drain to the river (Figure 5-1 in the main report). Additional largemouth bass habitat that occurs at the mouths of tributaries was considered to be part of the floodplain and available habitat of the mainstem Housatonic River.