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2012-2013 Data Supplement to the Merrimack Station Fisheries Survey Analysis of 1972-2011 Catch Data

Presented To:
Public Service of New Hampshire
780 North Commercial Street
Manchester, NH

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1.0 Introduction

The scope of this report was to supplement the "*Merrimack Station Fisheries Survey Analysis of 1972-2011 Catch Data*" (Normandeau 2011), referred herein as the "1972-2011 Fisheries Report", by updating the observations and results with two additional years (2012 and 2013) of standardized electrofishing data. This 2012-2013 data supplement used the same methodology and analyses as the 1972-2011 Fisheries Report, unless otherwise noted, and is organized into the following three major sections:

(1) results and analysis of fish community data collected in Garvins Pool (the thermally uninfluenced impoundment immediately upstream from Hooksett Pool and therefore the appropriate upstream reference), Hooksett Pool and Amoskeag Pool (the impoundment immediately downstream from Hooksett Pool) during 2012 and 2013 (Report Section 2.0),

(2) an updated RIS population trends analysis, for the 1972-2013 time period, that builds on the results first presented in 2007 (Normandeau 2007) and most recently updated in 2011 (Normandeau 2011) by adding more recent data collected from Hooksett Pool during the comparable time periods of August and September 2012 and 2013 (Report Section 3.0), and

(3) an assessment of biocharacteristics for RIS and other resident fish species during the 2012 and 2013 study periods that builds on the results first presented in Normandeau 2011 (Report Section 4.0).

2.0 2012-2013 Fish Community Assessment of Garvins, Hooksett and Amoskeag Pools

2.1 Overview

Electrofishing was conducted during August and September 2012 and 2013 at standardized sampling transects located within Garvins, Hooksett and Amoskeag Pools in continuation of the sampling program described in the 1972-2011 Fisheries Report (Figure 2-1; Normandeau 2011)).

2.2 Methodology

2.2.1 Field Methodology

A total of 24 electrofishing stations were sampled within Garvins, Hooksett (north and south) and Amoskeag Pools during August and September, 2012 and 2013 (Table 2-1). These were the same stations sampled in 2010 and 2011. Field and data collection methods for electrofishing during 2012 and 2013 followed the same field and data collection methods as described in the 2011 Report and described in field Standard Operating Procedures

(SOP's) that governed all sampling activities during 2012 (Normandeau 2012a) and 2013 (Normandeau 2013).

2.2.2 Analytical Methodology

Catch Per Unit of Effort Indices of Fish Species Abundance

Catch per unit effort ("CPUE"), a commonly used index of population density or stock size (Flotemersch et al. 2006), was standardized to the number of fish per 1,000 ft (300 m) for each sample and was used as a relative index of fish abundance for fish species in Garvins, Hooksett and Amoskeag Pools during August and September 2012 and 2013. As described in the 2011 Report, the same statistical comparisons were made for identifying significant[1] differences in CPUE for each species (total, young of the year [YOY], immature and mature) among Garvins, Hooksett and Amoskeag Pools for the 2012 and 2013 sampling season.

Comparison of Fish Community Structure

Five indices described and used to compare the fish community structure among pools in the 1972-2011 Fisheries Report (Normandeau 2011) was also used separately in the 2012 and 2013 catch data: (1) taxa richness, (2) Shannon Diversity Index, (3) percent generalist feeders, (4) percent tolerant individuals, and (5) the Bray-Curtis Percent Similarity Index. Fish species caught during 2012 and 2013 were classified by trophic guilds and pollution tolerance based on the same definitions used in the 2011 Report, with one exception. Sea Lamprey were considered "parasitic filterers" because they were collected as juveniles (ammocoetes) which are benthic filter feeders, but become parasitic piscivores after they migrate to the sea as adults.

Multivariate analyses were performed using PRIMER v6 (Plymouth Routines in Multivariate Ecological Research) software to examine spatial patterns in the overall similarity of fish assemblages sampled in Garvins, Hooksett and Amoskeag Pools during 2012 and 2013 (Clarke 1993, Warwick 1993, Clarke and Green 1988, Clarke and Warwick 2001). These analyses included ordination by non-metric multidimensional scaling (MDS) to plot the patterns of community-level similarity among the pools, "similarity percentages" (SIMPER) analysis to identify contributions from individual taxa to the overall dissimilarity among pools, and analysis of similarities (ANOSIM) to test for differences in community composition among the pools. These multivariate community analyses were performed individually by year using monthly mean CPUE per station and fish taxon and following the methods used in the 1972-2011 Fisheries Report (Normandeau 2011). In contrast to the 1972-2011 Fisheries Report, the cluster analysis and supporting information (dendrograms) were not presented for the 2012 and 2013 data because they were considered descriptive and least useful for interpreting differences in community structure among pools.

[1] Statistical significance is determined when a result has a probability (p) of occurring that is less than the probability of rejecting a true null hypothesis (α), where herein $\alpha = 0.05$—i.e., 1-in-20 chance of rejecting a true null hypothesis.

2.3 2012-2013 Garvins, Hooksett and Amoskeag Pool Electrofishing Results

2.3.1 2012 Sample Collections

A total of 240 electrofishing samples were collected from Garvins, Hooksett and Amoskeag Pools during August and September 2012 (Table 2-2). During August 2012, a total of 120 electrofishing samples were collected of which 116 (97%) were considered valid for analytical tasks (Use Code 1). Of the 120 electrofishing samples collected during September 2012, 98% (117 out of 120) were Use Code 1 samples. Classification of electrofishing samples as Use Code 2 during 2012 fisheries community sampling was primarily related to the inability to sample the entire 1,000 ft transect length due to ongoing recreational use over a portion of the transect.

2.3.2 2013 Sample Collections

A total of 240 electrofishing samples were collected from Garvins, Hooksett and Amoskeag Pools during August and September 2013 (Table 2-3). During August 2013, a total of 120 electrofishing samples were collected of which 117 (98%) were Use Code 1. Of the 120 electrofishing samples collected during September 2013, 100% (120 out of 120) were Use Code 1 samples. Classification of electrofishing samples as Use Code 2 during 2013 fisheries community sampling was primarily related to the inability to sample the entire 1,000 ft transect length due to ongoing recreational use over a portion of the transect.

2.3.3 2012 General Catch Characteristics

Table 2-4 presents the 2012 Merrimack River electrofishing survey results from Garvins Pool (Stations 1-6), Hooksett Pool (Stations 7-18) and Amoskeag Pool (Stations 19-24). A total of 5,781 fish representing 21 fish taxa and one taxonomic category (Sunfish family) were captured by electrofishing during August and September 2012 within the three combined Pools (Garvins, Hooksett and Amoskeag). The additional taxonomic category (Sunfish family) in Table 2-5 represented individual centrarchids which were too small for species-specific identification in the field.

When electrofishing catch from Garvins, Hooksett and Amoskeag Pools was combined, Spottail Shiner was the most abundant species representing 27.6% (1.597 individuals) of the total catch (Table 2-4). Largemouth Bass (1,113 individuals, 19.3% of total catch) and Alewife (651 individuals, 11.3% of total catch) were the second and third most frequently captured species, respectively. Those three species accounted for 58.2% of the total catch during 2012. With the exception of Redbreast Sunfish (525 individuals, 9.1% of total catch), Bluegill (498 individuals, 8.6% of total catch) and Fallfish (425 individuals, 7.4% of total catch) no other fish species comprised greater than 5% of the total catch among all three Merrimack River pools.

Total catch in Garvins Pool was dominated by Spottail Shiner (1,538 individuals; 46.0% of the total catch), Alewife (587 individuals; 17.6% of the total catch) and Largemouth Bass (319 individuals; 9.5% of the total catch). Largemouth Bass (721 individuals; 36.5% of the total catch), Redbreast Sunfish (278 individuals; 14.1% of the total catch), and Fallfish (253 individuals; 12.8% of the total catch) were the most abundant species in Hooksett Pool. In Amoskeag Pool, Redbreast Sunfish composed 41.8% of the total catch (194 individuals) followed by Largemouth Bass (73 individuals, 15.7% of total catch) and Bluegill (54 individuals; 11.6% of total catch).

2.3.4 2013 General Catch Characteristics

Table 2-5 presents the 2013 Merrimack River electrofishing survey results from Garvins Pool (Stations 1-6), Hooksett Pool (Stations 7-18) and Amoskeag Pool (Stations 19-24). A total of 4,257 fish representing 22 fish taxa and one taxonomic category (Sunfish family)were captured by electrofishing during August and September 2013 within the three combined Pools (Garvins, Hooksett and Amoskeag). The additional taxonomic category (Sunfish family) in Table 2-5 represented individual centrarchids which were too small for species-specific identification in the field.

When electrofishing catch from Garvins, Hooksett and Amoskeag Pools was combined, Bluegill was the most abundant species representing 26.7% (1,137 individuals) of the total catch (Table 2-5). Pumpkinseed (656 individuals, 15.4% of total catch) and Redbreast Sunfish (557 individuals, 13.1% of total catch) were the second and third most frequently captured species, respectively. Those three species accounted for 55.2% of the total catch during 2013. With the exception of Fallfish (393 individuals, 9.2% of total catch), Largemouth Bass (385 individuals, 9.0% of total catch), Yellow Perch (320 individuals, 7.5% of total catch) and Alewife (221 individuals, 5.2% of total catch), no other fish species comprised greater than 5% of the total catch among all three Merrimack River pools.

The three most abundant species captured in Garvins Pool included Bluegill (417 individuals; 31.7% of the total catch), Pumpkinseed (219 individuals; 16.7% of the total catch) and Yellow Perch (164 individuals; 12.5% of the total catch). Bluegill (571 individuals; 24.1% of the total catch), Fallfish (361 individuals; 15.3% of the total catch), and Redbreast Sunfish (360 individuals; 15.2% of the total catch) were the three most abundant species in Hooksett Pool. In Amoskeag Pool, sunfish species were numerically most abundant with Bluegill composing 25.9% of the total catch (149 individuals) followed by Redbreast Sunfish (145 individuals, 25.2% of total catch) and Pumpkinseed (125 individuals; 21.7% of total catch).

2.3.5 2012 Electrofishing Catch-Per-Unit-Effort

Table 2-6 presents the mean CPUE values (±95% confidence intervals) calculated for each fish species collected during 2012 within Garvins Pool, Hooksett Pool (north and south of Merrimack Station), Amoskeag Pool, and all stations combined. Results for an ANOVA and Tukey-Kramer multiple pairwise comparison tests on the log transformed mean CPUE values among Garvins, Hooksett, and Amoskeag Pools for each taxa collected by electrofishing during 2012 are presented in Table 2-7. Potential differences for mean CPUE values among Pools (Garvins, Hooksett and Amoskeag) for YOY, immature and mature fish were examined for the nine taxa from which scale samples were collected during 2012 (Table 2-8).

2.3.6 2013 Electrofishing Catch-Per-Unit-Effort

Table 2-9 presents the mean CPUE values (±95% confidence intervals) calculated for each fish species collected during 2013 within Garvins Pool, Hooksett Pool (north and south of Merrimack Station), Amoskeag Pool, and all stations combined. Results for an ANOVA and Tukey-Kramer multiple pairwise comparison tests on the log transformed mean CPUE values among Garvins, Hooksett, and Amoskeag Pools for each taxa collected by electrofishing during 2013 are presented in Table 2-10. Potential differences for mean CPUE values among Pools (Garvins, Hooksett and Amoskeag) for YOY, immature and mature fish were examined for the nine taxa from which scale samples were collected during 2013 (Table 2-11).

2.3.7 2012-2013 Community Indices

Taxa Richness

The number of fish species in the combined electrofishing catch from Garvins, Hooksett and Amoskeag Pools was 21 for 2012 and 22 for 2013. The taxa richness in the 2012 electrofishing catch from each pool was 19 fish species in Hooksett Pool, 18 fish species in Garvins Pool and 15 fish species in Amoskeag Pool (Table 2-12). The number of fish species caught by electrofishing in each pool during 2013 was 20 fish species in Hooksett Pool, 18 fish species in Garvins Pool and 17 fish species in Amoskeag Pool.

During 2012, five species (Black Crappie, Brown Bullhead, Common Shiner, Spottail Shiner and Yellow Perch) present in both Garvins and Hooksett Pools were not found in Amoskeag Pool (Table 2-4). Two species (American Eel and Margined Madtom) were unique to Hooksett and Amoskeag Pools in the 2012 electrofishing catch. During the August-September 2012 sampling, Golden Shiner were collected only in Garvins Pool and Sea Lamprey were collected only in Amoskeag Pool.

While the majority of species captured occurred in all Pools during 2013, three species (American Eel, Brown Bullhead and Yellow Bullhead) were present in both Garvins and Hooksett Pools but not found in Amoskeag Pool (Table 2-5). Two species (Common Shiner and Margined Madtom) were unique to Hooksett Pool while Sea Lamprey and Common Carp were only captured in Amoskeag Pool.

Shannon Diversity Index

The Shannon Diversity Index (H′) and evenness (E_H) were calculated for the fish communities sampled within Garvins, Hooksett and Amoskeag Pools during 2012 and 2013 (Table 2-13).

Percent Generalist Feeders

During 2012, there were 9 species of generalist feeders found in Garvins Pool, 8 in Hooksett Pool and 6 in Amoskeag Pool and the percentage of total catch represented by generalist feeders was highest in Amoskeag Pool and lowest in Garvins Pool (Table 2-14). Total catch of generalist feeders during 2012 was dominated by Bluegill, Fallfish and Pumpkinseed in

Garvins Pool; Redbreast Sunfish, Fallfish, and Bluegill in Hooksett Pool; and Redbreast Sunfish, Bluegill and Pumpkinseed in Amoskeag Pool.

During 2013, there were 8 species of generalist feeders found in Garvins Pool, 9 in Hooksett Pool and 6 in Amoskeag Pool (Table 2-14). Total catch of generalist feeders during 2013 in each Pool was dominated by three members of the Genus *Lepomis* (Bluegill, Pumpkinseed and Redbreast Sunfish). These three species accounted for 96.9% of the generalist feeders captured in Garvins Pool and 92.7% in Amoskeag Pool. In Hooksett Pool, the three *Lepomis* species and Fallfish accounted for 92.1% of the generalist feeders captured.

Percent Tolerant Individuals

Tolerances to environmental perturbations for fish species collected in Garvins, Hooksett and Amoskeag Pools are presented in Table 2-16. During 2012, there were 5 species tolerant of pollution found in Garvins and Hooksett Pools, and 4 in Amoskeag Pool (Table 2-14). The percentage of pollution-tolerant species was highest in Hooksett Pool and lowest in Garvins Pool (Table 2-14). Total catch of pollution tolerant fish species during 2012 was dominated by Bluegill in Garvins, Hooksett and Amoskeag Pools. Bluegill represented 92.4% of the total catch of pollution tolerant individuals in Garvins Pool, 80.6% in Hooksett Pool, and 93.1% in Amoskeag Pool.

During 2013, there were 6 species tolerant of pollution found in each Garvins and Hooksett Pools, and 3 in Amoskeag Pool (Table 2-14). The percentage of pollution-tolerant species was highest in Garvins Pool and lowest in Amoskeag Pool (Table 2-14). Total catch of pollution tolerant fish species during 2013 was dominated by Bluegill in Garvins, Hooksett and Amoskeag Pools. Bluegill represented 96.3% of the total catch of pollution tolerant individuals in Garvins Pool, 78.2% in Hooksett Pool, and 94.3% in Amoskeag Pool.

Bray-Curtis Percent Similarity Index—2012 Spatial Comparison

The fish community from the August-September 2012 electrofishing catch differed significantly among the pools (ANOSIM, Global R = 0.518, $P = 0.001$; Table 2-15). The MDS plot (Figure 2-2) shows relatively higher similarity in monthly fish assemblages among stations (replicates) within a pool and less similarity among pools with increasing separation from Garvins Pool to Amoskeag Pool. The stress level for the plot was relatively low at 0.17 indicating a good representation of the relationship among collections.
Table 2-16 presents a comparison of the fish community sampled by electrofishing within Garvins, Hooksett and Amoskeag Pools in August and September of 2012 as computed by the Bray-Curtis Percent Similarity Index. Comparing the 2012 fish communities, the Bray-Curtis similarity was greater between Garvins and Hooksett Pools (61.5%) than it was between Garvins and Amoskeag Pools (41.0%).

Hooksett and Garvins Pools were distinguished by higher abundance of Spottail Shiner and Alewife in Garvins Pool and higher abundance of Fallfish and Redbreast Sunfish in Hooksett Pool (Table 2-17). Hooksett and Amoskeag Pools were distinguished by higher abundance of Largemouth Bass, Fallfish, and Bluegill and lower abundance of Redbreast Sunfish in Hooksett Pool. Finally, in the comparison between Garvins and Amoskeag Pools, these pools were distinguished by a higher abundance of Spottail Shiner, Alewife, Largemouth Bass, and Bluegill in Garvins Pool.

Bray-Curtis Percent Similarity Index—2013 Spatial Comparison

The fish community from the August-September 2013 electrofishing catch differed significantly among the pools (ANOSIM, Global R = 0.352, $P = 0.001$; Table 2-18). The MDS plot (Figure 2-3) shows that, as in 2012, the samples collected in Hooksett Pool clustered intermediate between the clusters for Garvins Pool and Amoskeag Pool. Table 2-19 presents a comparison of the fish community sampled by electrofishing within Garvins, Hooksett and Amoskeag Pools in August and September of 2013 as computed by the Bray-Curtis Percent Similarity Index.

During 2013, Hooksett and Garvins Pools were distinguished by a greater abundance of Bluegill, Yellow Perch and Alewife in Garvins Pool and Fallfish and Redbreast Sunfish in Hooksett Pool (Table 2-20). Hooksett and Amoskeag Pools were distinguished by higher abundance of Fallfish, Bluegill, Largemouth Bass, Pumpkinseed and Redbreast Sunfish in Hooksett Pool. Garvins and Amoskeag Pools were distinguished by a greater abundance of Bluegill, Yellow Perch, Largemouth Bass, Chain Pickerel and Alewife in Garvins Pool and a greater abundance of Redbreast Sunfish in Amoskeag Pool.

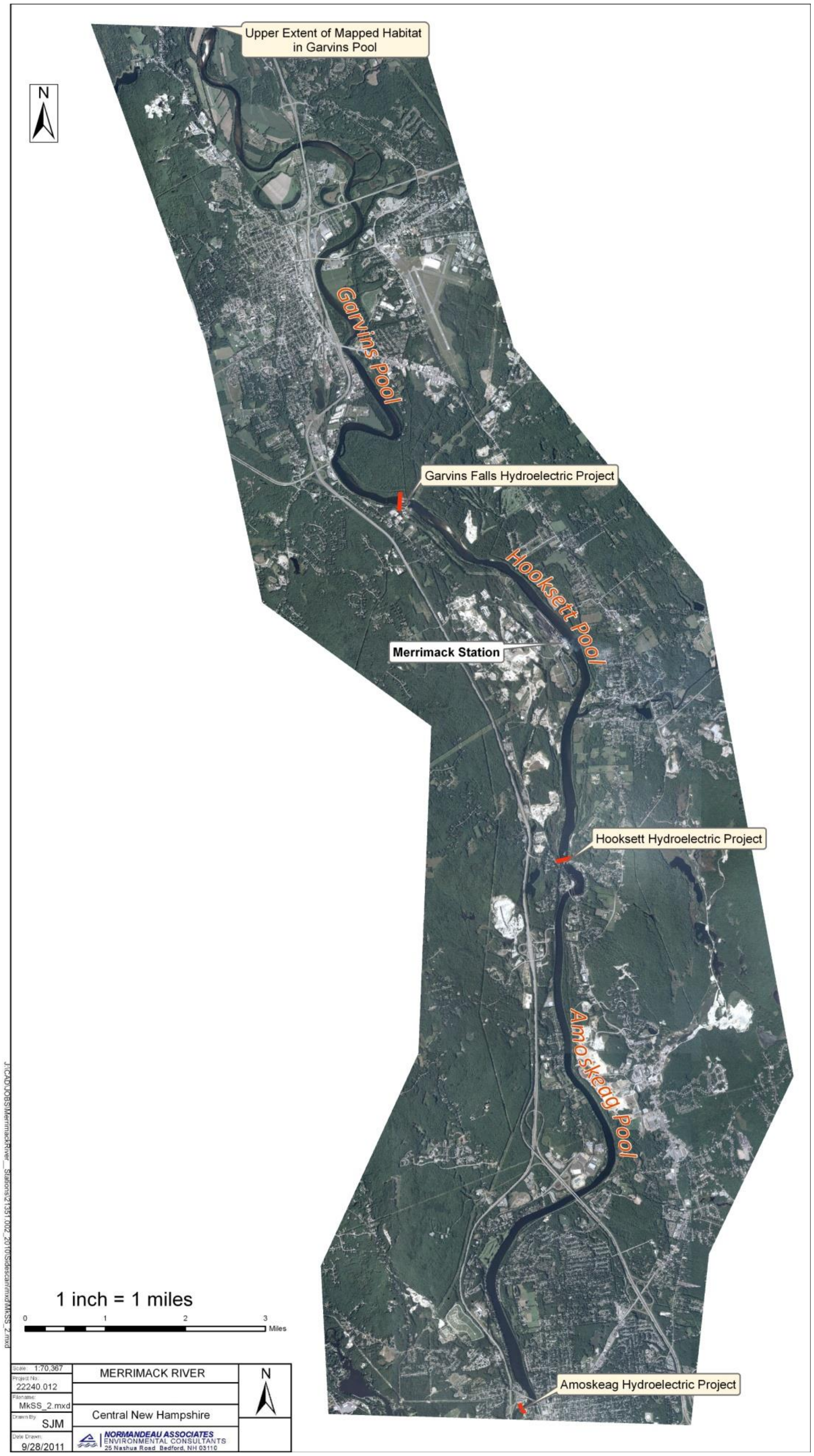

Figure 2-1. Study area on the Merrimack River showing the location of Merrimack Station relative to Garvins, Hooksett, and Amoskeag Pools.

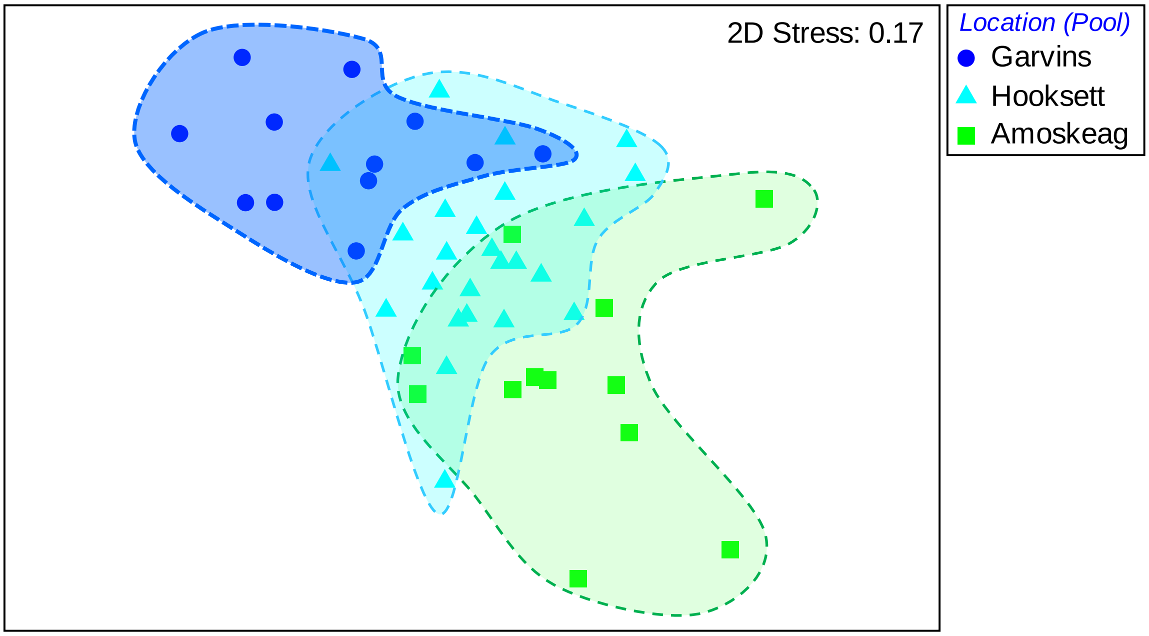

Figure 2-2. Results of MDS ordination based on Bray-Curtis similarities of square root transformed monthly catch per unit effort at electrofishing stations sampled during August and September 2012 within Garvins, Hooksett and Amoskeag Pools in the Merrimack River.

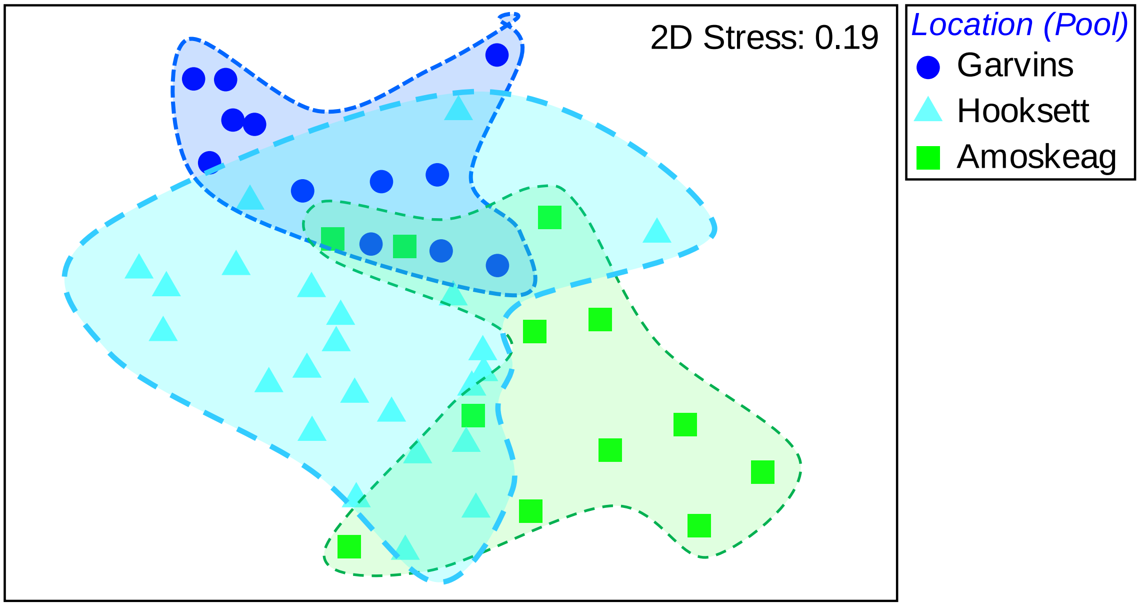

Figure 2-3. Results of MDS ordination based on Bray-Curtis similarities of square root transformed monthly catch per unit effort at electrofishing stations sampled during 2013 within Garvins, Hooksett and Amoskeag Pools in the Merrimack River.

Table 2-1. Station locations and descriptions for the 2012-2013 Merrimack River Electrofishing Survey. Latitudes and Longitudes in NH State Plane NAD82 ft.

	2012 Station Nomenclature		Historic Station Nomenclature*		Downstream Coordinates		Upstream Coordinates	
Sample Pool	Station ID	Bank	Station ID	Station ID	Latitude	Longitude	Latitude	Longitude
Garvins Pool	1	E	-	-	43.216456	-71.520455	43.219001	-71.521944
Garvins Pool	2	W	-	-	43.210400	-71.529254	43.211714	-71.525980
Garvins Pool	3	E	-	-	43.203980	-71.529447	43.206640	-71.530518
Garvins Pool	4	W	-	-	43.201155	-71.525902	43.202906	-71.528348
Garvins Pool	5	E	-	-	43.198036	-71.521088	43.200003	-71.523843
Garvins Pool	6	W	-	-	43.195446	-71.522625	43.197824	-71.523492
Hooksett North	7	E	-	-	43.152841	-71.479231	43.154316	-71.481726
Hooksett North	8	W	-	-	43.151892	-71.480329	43.153275	-71.483162
Hooksett North	9	E	11	N9-N10 E	43.148551	-71.473960	43.150595	-71.476427
Hooksett North	10	W	11	N9-N10 W	43.147791	-71.474940	43.149807	-71.477485
Hooksett North	11	E	12	N6-N7 E	43.144461	-71.467750	43.146312	-71.470606
Hooksett North	12	W	12	N6-N7 W	43.143651	-71.469370	43.145546	-71.472070
Hooksett South	13	E	13	S0-S1 E	43.133661	-71.461010	43.136421	-71.461850
Hooksett South	14	W	13	S0-S1 W	43.133271	-71.462970	43.136091	-71.463280
Hooksett South	15	E	14	S4-S5 E	43.129631	-71.463380	43.132171	-71.461990
Hooksett South	16	W	14	S4-S5 W	43.129766	-71.464874	43.132321	-71.463400
Hooksett South	17	E	15	S17-S18 E	43.111831	-71.463510	43.114421	-71.464380
Hooksett South	18	W	15	S17-S18 W	43.111345	-71.465901	43.114111	-71.466490
Amoskeag Pool	19	E	-	-	43.092070	-71.465914	43.094391	-71.464809
Amoskeag Pool	20	W	-	-	43.093372	-71.466968	43.095710	-71.465364
Amoskeag Pool	21	E	-	-	43.086912	-71.465751	43.089718	-71.466247
Amoskeag Pool	22	W	-	-	43.085515	-71.467300	43.088319	-71.467540
Amoskeag Pool	23	E	-	-	43.081936	-71.465777	43.084736	-71.465512
Amoskeag Pool	24	W	-	-	43.081728	-71.467561	43.084495	-71.467324

*As referenced in the report titled "*Merrimack Station Fisheries Survey Analysis of 1967 Through 2005 Catch and Habitat Data*" (Normandeau 2007)

Table 2-2. Achieved electrofishing sample design and designated Use Code for all samples collected within Garvins (Stations 1-6), Hooksett (Stations 7-18) and Amoskeag (Stations 19-24) Pools during August and September 2012.

Sample Date	Sample Use Code by Station																								Total Count
	Garvins Pool						Hooksett Pool												Amoskeag Pool						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
8/6/2012													1	1	1	1	1	1							**6**
8/7/2012																			2	1	1	1	1	1	**6**
8/8/2012	1	1	1	1	1	1	1	1	1	1	1	1													**12**
8/9/2012	1	1	1	1	1	1							1	1	1	1	1	1							**12**
8/10/2012							1	1	1	1	1	1	1	1	1	1	1	1							**12**
8/13/2012							2	1	1	1	1	1							1	1	1	1	1	1	**12**
8/14/2012	1	1	1	1	1	1	1	1	1	1	1	1													**12**
8/16/2012	1	1	1	1	1	1							1	1	1	2	1	1							**12**
8/17/2012							1	1	1	1	1	1							1	1	1	1	1	1	**12**
8/20/2012																			1	2	1	1	1	1	**6**
8/21/2012	1	1	1	1	1	1																			**6**
8/22/2012													1	1	1	1	1	1							**6**
8/23/2012																			1	1	1	1	1	1	**6**
9/6/2012																			1	1	1	1	1	1	**6**
9/10/2012	1	1	1	1	1	1							1	1	1	1	1	1							**12**
9/11/2012																			1	1	1	1	1	1	**6**
9/12/2012							1	1	1	1	1	1													**6**
9/13/2012																			1	1	1	1	1	1	**6**
9/14/2012	1	1	1	1	1	1																			**6**
9/17/2012							1	1	1	1	1	1	1	1	1	2	1	1							**12**
9/18/2012							1	1	1	1	1	1							1	1	1	1	1	1	**12**
9/19/2012	1	1	1	1	1	1							1	1	1	1	1	1							**12**
9/20/2012	1	1	1	1	1	1	1	1	1	1	1	1													**12**
9/21/2012							1	1	1	2	1	1	1	1	1	1	1	1							**12**
9/24/2012	1	1	1	1	1	1																			**6**
9/25/2012																			1	1	1	1	1	1	**6**
9/27/2012													1	1	1	1	1	2							**6**
Total Count	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**240**

Table 2-3. Achieved electrofishing sample design and designated Use Code for all samples collected within Garvins (Stations 1-6), Hooksett (Stations 7-18) and Amoskeag (Stations 19-24) Pools during August and September 2013.

Sample Date	Sample Use Code by Station																								Total Count
	Garvins Pool						Hooksett Pool												Amoskeag Pool						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
8/7/2013							1	1	1	1	1	1	1	1	1	2	1	1							12
8/12/2013																			1	1	1	1	1	1	6
8/13/2013													1	1	1	1	1	1							6
8/14/2013	1	1	1	1	1	1																			6
8/15/2013	1	1	1	1	1	1	1	1	1	1	1	2													12
8/16/2013							1	1	1	1	1	1							1	1	1	1	1	1	12
8/17/2013	1	1	1	1	1	1																			6
8/18/2013																			1	1	1	1	1	1	6
8/19/2013	1	1	1	1	1	1							1	1	1	1	1	1							12
8/20/2013							1	1	1	1	1	1	1	1	1	1	1	1							12
8/21/2013	1	1	1	1	1	1													1	1	1	1	1	1	12
8/22/2013							1	1	1	1	1	1	1	1	1	1	1	1							12
8/23/2013																			2	1	1	1	1	1	6
9/3/2013																			1	1	1	1	1	1	6
9/4/2013	1	1	1	1	1	1																			6
9/9/2013							1	1	1	1	1	1													6
9/10/2013	1	1	1	1	1	1																			6
9/11/2013							1	1	1	1	1	1	1	1	1	1	1	1							12
9/13/2013																			1	1	1	1	1	1	6
9/14/2013																			1	1	1	1	1	1	6
9/16/2013													1	1	1	1	1	1							6
9/17/2013													1	1	1	1	1	1							6
9/18/2013	1	1	1	1	1	1																			6
9/19/2013													1	1	1	1	1	1							6
9/20/2013																			1	1	1	1	1	1	6
9/21/2013													1	1	1	1	1	1							6
9/22/2013							1	1	1	1	1	1													6
9/23/2013	1	1	1	1	1	1																			6
9/24/2013							1	1	1	1	1	1													6
9/25/2013	1	1	1	1	1	1																			6
9/26/2013							1	1	1	1	1	1													6
9/27/2013																			1	1	1	1	1	1	6
Total Count	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**240**

Table 2-4. Total catch (N) and relative abundance (%) of fishes caught by electrofishing within Garvins Pool (Stations 1-6), Hooksett Pool (Stations 7-18) and Amoskeag Pool (Stations 19-24) during 2012.

Common Name	Garvins Pool (Stations 1-6)		Hooksett Pool (Stations 7-18)		Amoskeag Pool (Stations 19-24)		All Pools (Stations 1-24)	
	N	%	N	%	N	%	N	%
Alewife	587	17.6	48	2.4	16	3.4	651	11.3
American Eel			7	0.4	2	0.4	9	0.2
Black Crappie	5	0.1	10	0.5			15	0.3
Bluegill	232	6.9	212	10.7	54	11.6	498	8.6
Brown Bullhead	1	<0.1	1	0.1			2	<0.1
Chain Pickerel	88	2.6	18	0.9	3	0.6	109	1.9
Common Shiner	39	1.2	4	0.2			43	0.7
Fallfish	160	4.8	253	12.8	12	2.6	425	7.4
Golden Shiner	5	0.1					5	0.1
Largemouth Bass	319	9.5	721	36.5	73	15.7	1,113	19.3
Margined Madtom			13	0.7	3	0.6	16	0.3
Pumpkinseed	108	3.2	35	1.8	39	8.4	182	3.1
Redbreast Sunfish	53	1.6	278	14.1	194	41.8	525	9.1
Rock Bass	4	0.1	15	0.8	18	3.9	37	0.6
Sea Lamprey					2	0.4	2	<0.1
Smallmouth Bass	16	0.5	184	9.3	42	9.1	242	4.2
Spottail Shiner	1,538	46.0	59	3.0			1,597	27.6
Sunfish Family	79	2.4	48	2.4	3	0.6	130	2.2
Tessellated Darter	3	0.1	1	0.1	1	0.2	5	0.1
White Sucker	11	0.3	41	2.1	1	0.2	53	0.9
Yellow Bullhead	2	0.1	2	0.1	1	0.2	5	0.1
Yellow Perch	93	2.8	24	1.2			117	2.0
Total	**3,343**	**100.0**	**1,974**	**100.0**	**464**	**100.0**	**5,781**	**100.0**

Table 2-5. Total catch (N) and relative abundance (%) of fishes caught by electrofishing within Garvins Pool (Stations 1-6), Hooksett Pool (Stations 7-18) and Amoskeag Pool (Stations 19-24) during 2013.

	Garvins Pool (Stations 1-6)		Hooksett Pool (Stations 7-18)		Amoskeag Pool (Stations 19-24)		All Pools (Stations 1-24)	
Common Name	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Alewife	104	7.9	82	3.5	35	6.1	221	5.2
American Eel	2	0.2	23	1.0			25	0.6
Black Crappie	1	0.1	1	0.0	1	0.2	3	0.1
Bluegill	417	31.7	571	24.1	149	25.9	1,137	26.7
Brown Bullhead	2	0.2	1	0.0			3	0.1
Chain Pickerel	83	6.3	38	1.6	6	1.0	127	3.0
Common Carp					1	0.2	1	0.0
Common Shiner			1	0.0			1	0.0
Fallfish	8	0.6	361	15.3	24	4.2	393	9.2
Golden Shiner	1	0.1	37	1.6	3	0.5	41	1.0
Largemouth Bass	155	11.8	207	8.7	23	4.0	385	9.0
Margined Madtom			17	0.7			17	0.4
Pumpkinseed	219	16.7	312	13.2	125	21.7	656	15.4
Redbreast Sunfish	52	4.0	360	15.2	145	25.2	557	13.1
Rock Bass	4	0.3	25	1.1	11	1.9	40	0.9
Sea Lamprey					1	0.2	1	0.0
Smallmouth Bass	13	1.0	77	3.3	28	4.9	118	2.8
Spottail Shiner	74	5.6	8	0.3	1	0.2	83	1.9
Sunfish family	1	0.1	2	0.1			3	0.1
Tessellated Darter	4	0.3	5	0.2	1	0.2	10	0.2
White Sucker	10	0.8	97	4.1	6	1.0	113	2.7
Yellow Bullhead	1	0.1	1	0.0			2	0.0
Yellow Perch	164	12.5	140	5.9	16	2.8	320	7.5
Total	**1,315**	**100.0**	**2,366**	**100.0**	**576**	**100.0**	**4,257**	**100.0**

Table 2-6. Mean CPUE (fish per 1,000 ft) and 95% upper (UCL) and lower (LCL) confidence limits of fishes caught by electrofishing within Garvins Pool (Stations 1-6), Hooksett Pool North (Stations 7-12), Hooksett Pool South (Stations 13-18) and Amoskeag Pool (Stations 19-24) during 2012.

	Garvins Pool (Stations 1-6)			Hooksett Pool North (Stations 7-12)			Hooksett Pool South (Stations 13-18)			Amoskeag Pool (Stations 19-24)			All Pools (Stations 1-24)		
Common Name	**LCL**	**CPUE**	**UCL**	**LCL**	**CPUE**	**UCL**	**LCL**	**CPUE**	**UCL**	**LCL**	**CPUE**	**UCL**	**LCL**	**CPUE**	**UCL**
Alewife	0.0	9.8	20.5	0.0	0.3	0.8	0.0	0.5	1.1	0.0	0.3	0.8	0.0	2.8	5.5
American Eel		0.0		0.0	0.0	0.1	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.1
Black Crappie	0.0	0.1	0.2	0.0	0.1	0.2	0.0	0.1	0.1		0.0		0.0	0.1	0.1
Bluegill	2.9	3.9	4.9	1.6	2.3	2.9	0.8	1.2	1.5	0.4	0.9	1.4	1.7	2.1	2.4
Brown Bullhead	0.0	0.0	0.1	0.0	0.0	0.1		0.0			0.0		0.0	0.0	0.0
Chain Pickerel	1.0	1.5	2.0	0.0	0.2	0.3	0.0	0.2	0.3	0.0	0.1	0.1	0.3	0.5	0.6
Common Shiner	0.0	0.7	1.3		0.0		0.0	0.1	0.2		0.0		0.0	0.2	0.4
Fallfish	0.0	2.7	5.7	0.2	0.6	1.0	2.2	3.4	4.6	0.1	0.2	0.4	0.9	1.7	2.6
Golden Shiner	0.0	0.1	0.2		0.0			0.0			0.0		0.0	0.0	0.0
Largemouth Bass	4.3	5.3	6.3	5.7	7.2	8.7	3.1	4.7	6.2	0.8	1.3	1.7	4.0	4.6	5.3
Margined Madtom		0.0		0.0	0.0	0.1	0.1	0.2	0.3	0.0	0.1	0.1	0.0	0.1	0.1
Pumpkinseed	1.3	1.8	2.3	0.2	0.4	0.6	0.0	0.1	0.2	0.4	0.7	1.0	0.6	0.8	0.9
Redbreast Sunfish	0.4	0.9	1.4	2.0	3.0	4.0	1.0	1.8	2.6	2.3	3.2	4.0	1.8	2.2	2.6
Rock Bass	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.2	0.4	0.1	0.3	0.5	0.1	0.2	0.2
Sea Lamprey		0.0			0.0			0.0		0.0	0.0	0.1	0.0	0.0	0.0
Smallmouth Bass	0.1	0.3	0.5	0.7	1.1	1.6	1.4	2.0	2.6	0.5	0.7	1.0	0.8	1.0	1.2
Spottail Shiner	6.5	25.6	44.8		0.0		0.0	1.0	2.4		0.0		1.8	6.9	11.9
Sunfish Family	0.3	1.3	2.3	0.1	0.3	0.5	0.2	0.4	0.7	0.0	0.1	0.1	0.3	0.5	0.8
Tessellated Darter	0.0	0.1	0.1	0.0	0.0	0.1		0.0		0.0	0.0	0.1	0.0	0.0	0.0
White Sucker	0.0	0.2	0.4	0.0	0.1	0.3	0.2	0.6	1.0	0.0	0.0	0.1	0.1	0.2	0.3
Yellow Bullhead	0.0	0.0	0.1	0.0	0.0	0.1		0.0		0.0	0.0	0.1	0.0	0.0	0.0
Yellow Perch	1.1	1.6	2.0	0.0	0.1	0.2	0.1	0.3	0.5		0.0		0.4	0.5	0.7

Table 2-7. Summary of the analysis of variance and Tukey-Kramer multiple pairwise comparisons of the mean log10(x+1)-transformed catch per unit effort (CPUE) of selected freshwater fish species among Garvins (G, Stations 1-6), Hooksett (H, Stations 7-18), and Amoskeag (A, Stations 19-24) Pools based on electrofishing in the Merrimack River during 2012.

Common Name	*F*	*P*	Adjusted Tukey Pairwise Comparison
Alewife	15.53	<.0001	G H A
American Eel	1.31	0.2711	
Black Crappie	2.22	0.1106	
Bluegill	26.29	<.0001	G H A
Brown Bullhead	0.48	0.6211	
Chain Pickerel	51.85	<.0001	G H A
Common Shiner	6.08	0.0027	G H A
Fallfish	12.05	<.0001	H G A
Largemouth Bass	40.43	<.0001	G H A
Margined Madtom	4.18	0.0165	H A G
Pumpkinseed	36.10	<.0001	G A H
Redbreast Sunfish	13.22	<.0001	A H G
Rock Bass	2.53	0.0818	
Smallmouth Bass	20.29	<.0001	H A G
Spottail Shiner	58.51	<.0001	G H A
Tessellated Darter	1.64	0.197	
White Sucker	3.87	0.0223	H G A
Yellow Bullhead	0.70	0.4955	
Yellow Perch	71.51	<.0001	G H A

Note: If the F-value for the overall model was not significant (i.e. P <0.05), pairwise comparisons were not provided. Pools indicated by their initials are ordered from highest to lowest mean transformed CPUE; means that are not significantly different are underlined.

Table 2-8. Summary of the analysis of variance and Tukey-Kramer multiple pair-wise comparisons of the mean log10(x+1)-transformed catch per unit effort (CPUE) of young of year (YOY), immature and mature individuals for nine species of resident freshwater fish among Garvins (G), Hooksett (H), and Amoskeag (A) Pools based on electrofishing in the Merrimack River during 2012.

Common Name	Life stage	Mean CPUE			*F*	*P*	Tukey Pariwise Comparison
		Garvins	Hooksett	Amoskeag			
Black Crappie	YOY	0.0	0.0	0.0	-	-	
	Immature	0.1	0.0	0.0	5.80	0.0035	G H A
	Mature	0.0	0.1	0.0	4.79	0.0092	H G A
Bluegill	YOY	0.2	0.1	<0.1	1.79	0.1688	
	Immature	3.5	1.4	0.9	26.86	<.0001	G H A
	Mature	0.2	0.2	<0.1	22.27	<.0001	H G A
Fallfish	YOY	0.0	0.0	0.0	-	-	
	Immature	2.7	2.0	0.2	11.98	<.0001	H G A
	Mature	0.0	<0.1	0.0	18.58	-	H G A
Largemouth Bass	YOY	2.7	2.3	0.8	14.09	<.0001	G H A
	Immature	2.2	3.0	0.5	32.77	<.0001	H G A
	Mature	0.4	0.7	0.0	46.41	<.0001	H G A
Pumpkinseed	YOY	0.1	<0.1	0.0	5.80	0.0035	G H A
	Immature	1.0	0.2	0.4	31.01	<.0001	G A H
	Mature	0.7	0.1	0.3	37.14	<.0001	G A H
Rock Bass	YOY	0.0	0.0	0.0	-	-	
	Immature	<0.1	0.1	0.1	1.82	0.1645	
	Mature	<0.1	<0.1	0.2	4.08	0.0181	A H G
Smallmouth Bass	YOY	0.2	0.8	0.1	14.42	<.0001	H G A
	Immature	0.1	0.7	0.6	10.29	<.0001	H A G
	Mature	0.0	0.1	0.0	24.36	<.0001	H G A
White Sucker	YOY	0.0	0.0	0.0	-	-	
	Immature	0.1	0.2	<0.1	4.05	0.0187	H G A
	Mature	0.1	0.2	<0.1	3.12	0.0459	H G A
Yellow Perch	YOY	<0.1	0.0	0.0	1.45	0.2374	
	Immature	0.6	0.2	0.0	32.83	<.0001	G H A
	Mature	0.9	0.0	0.0	121.56	<.0001	G H A

Note: If the F-value for the overall model was not significant (i.e. P <0.05), pairwise comparisons were not provided. Pools indicated by their initials are ordered from highest to lowest mean transformed CPUE; means that are not significantly different are underlined.

Table 2-9. Mean CPUE (fish per 1,000 ft) and 95% upper (UCL) and lower (LCL) confidence limits of fishes caught by electrofishing within Garvins Pool (Stations 1-6), Hooksett Pool North (Stations 7-12), Hooksett Pool South (Stations 13-18) and Amoskeag Pool (Stations 19-24) during 2013.

	Garvins Pool (Stations 1-6)			Hooksett Pool North (Stations 7-12)			Hooksett Pool South (Stations 13-18)			Amoskeag Pool (Stations 19-24)			All Pools (Stations 1-24)		
Common Name	**95% LCL**	**CPUE**	**95% UCL**	**95% LCL**	**CPUE**	**95% UCL**	**95% LCL**	**CPUE**	**95% UCL**	**95% LCL**	**CPUE**	**95% UCL**	**95% LCL**	**CPUE**	**95% UCL**
Alewife	0.4	1.7	3.1	-0.1	0.5	1.1	0.1	0.9	1.6	0.1	0.6	1.1	0.5	0.9	1.4
American Eel	0.0	0.0	0.1	0.1	0.2	0.3	0.0	0.2	0.3		0.0		0.1	0.1	0.2
Black Crappie	0.0	0.0	0.1	0.0	0.0	0.1		0.0		0.0	0.0	0.1	0.0	0.0	0.0
Bluegill	5.5	7.0	8.4	5.5	7.1	8.7	1.7	2.3	2.9	1.2	2.5	3.8	4.0	4.7	5.4
Brown Bullhead	0.0	0.0	0.1	0.0	0.0	0.1		0.0			0.0		0.0	0.0	0.0
Chain Pickerel	1.0	1.4	1.8	0.2	0.3	0.4	0.1	0.3	0.4	0.0	0.1	0.2	0.4	0.5	0.6
Common Carp		0.0			0.0			0.0		0.0	0.0	0.1	0.0	0.0	0.0
Common Shiner		0.0			0.0		0.0	0.0	0.1		0.0		0.0	0.0	0.0
Fallfish	0.0	0.1	0.2	0.7	1.4	2.1	2.8	4.6	6.4	0.1	0.4	0.7	1.1	1.6	2.2
Golden Shiner	0.0	0.0	0.1	0.0	0.5	1.1	0.0	0.1	0.3	0.0	0.1	0.2	0.0	0.2	0.3
Largemouth Bass	2.1	2.6	3.1	1.5	2.2	2.8	0.8	1.2	1.7	0.2	0.4	0.6	1.3	1.6	1.9
Margined Madtom		0.0		0.0	0.1	0.2	0.0	0.2	0.3		0.0		0.0	0.1	0.1
Pumpkinseed	2.8	3.7	4.5	2.0	2.9	3.8	1.4	2.2	2.9	1.4	2.1	2.8	2.3	2.7	3.1
Redbreast Sunfish	0.5	0.9	1.2	2.3	3.5	4.8	1.7	2.6	3.4	1.7	2.5	3.2	1.9	2.4	2.8
Rock Bass	0.0	0.1	0.1	0.0	0.2	0.3	0.1	0.3	0.5	0.0	0.2	0.3	0.1	0.2	0.2
Sea Lamprey		0.0			0.0			0.0		0.0	0.0	0.1	0.0	0.0	0.0
Smallmouth Bass	0.1	0.2	0.3	0.2	0.5	0.7	0.6	0.8	1.1	0.3	0.5	0.7	0.4	0.5	0.6
Spottail Shiner	0.0	1.2	3.4		0.0		0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.3	0.9
Sunfish family	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1		0.0		0.0	0.0	0.0
Tessellated Darter	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1
White Sucker	0.1	0.2	0.3	0.2	0.8	1.4	0.4	0.8	1.1	0.0	0.1	0.2	0.3	0.5	0.6
Yellow Bullhead	0.0	0.0	0.1		0.0		0.0	0.0	0.1		0.0		0.0	0.0	0.0
Yellow Perch	1.9	2.7	3.5	0.6	1.3	2.0	0.5	0.9	1.4	0.0	0.3	0.6	1.0	1.3	1.6

Table 2-10. Summary of the analysis of variance and Tukey-Kramer multiple pairwise comparisons of the mean log10(x+1)-transformed catch per unit effort (CPUE) of selected freshwater fish species among Garvins (G, Stations 1-6), Hooksett (H, Stations 7-18), and Amoskeag (A, Stations 19-24) Pools based on electrofishing in the Merrimack River during 2013.

Common Name	*F*	*P*	Adjusted Tukey Pairwise Comparison
Alewife	2.45	0.0889	
American Eel	7.01	0.0011	H G A
Black Crappie	0.16	0.8499	
Bluegill	18.21	<0.0001	G H A
Brown Bullhead	1.49	0.2282	
Chain Pickerel	42.13	<0.0001	G H A
Common Carp	1.52	0.2219	
Common Shiner	0.5	0.6059	
Fallfish	38.09	<0.0001	H G A
Golden Shiner	1.49	0.2284	
Largemouth Bass	29.08	<0.0001	G H A
Margined Madtom	6.71	0.0015	H G A
Pumpkinseed	5.01	0.0074	G H A
Redbreast Sunfish	14.32	<0.0001	H A G
Rock Bass	1.72	0.1809	
Sea Lamprey	1.52	0.2219	
Smallmouth Bass	4.53	0.0117	H A G
Spottail Shiner	4.27	0.0151	G H A
Tessellated Darter	0.86	0.4233	
White Sucker	9.31	0.0001	H G A
Yellow Bullhead	0.49	0.6135	
Yellow Perch	26.94	<0.0001	G H A

Note: If the F-value for the overall model was not significant (i.e. P <0.05), pairwise comparisons were not provided. Pools indicated by their initials are ordered from highest to lowest mean transformed CPUE; means that are not significantly different are underlined.

Table 2-11. Summary of the analysis of variance and Tukey-Kramer multiple pair-wise comparisons of the mean log10(x+1)-transformed catch per unit effort (CPUE) of young of year (YOY), immature and mature individuals for nine species of resident freshwater fish among Garvins (G), Hooksett (H), and Amoskeag (A) Pools based on electrofishing in the Merrimack River during 2013.

Common Name	Life stage	Mean CPUE			*F*	*P*	Tukey Pairwise Comparison
		Garvins	Hooksett	Amoskeag			
Black Crappie	YOY	0.0	<0.1	0.0	0.5	0.6059	
	Immature	0.0	0.0	<0.1	1.52	0.2219	
	Mature	<0.1	0.0	0.0	1.48	0.2295	
Bluegill	YOY	<0.1	<0.1	0.0	1.55	0.2137	
	Immature	4.0	3.5	2.4	7.91	0.0005	G H A
	Mature	3.0	1.1	0.1	80.75	<.0001	G H A
Fallfish	YOY	0.0	0.0	0.0	-	-	
	Immature	0.1	2.7	0.4	36.17	<.0001	H A G
	Mature	0.0	0.3	0.0	32.06	<.0001	H A G
Largemouth Bass	YOY	1.9	1.4	0.3	21.36	<.0001	G H A
	Immature	0.5	0.2	0.1	15.03	<.0001	G H A
	Mature	0.2	0.1	0.0	12.66	<.0001	G H A
Pumpkinseed	YOY	0.0	<0.1	0.0	0.50	0.6059	
	Immature	2.4	2.3	1.5	3.24	0.0410	G H A
	Mature	1.3	0.2	0.6	43.18	<.0001	G A H
Rock Bass	YOY	0.0	0.0	0.0	-	-	
	Immature	<0.1	0.2	<0.1	4.39	0.0135	H A G
	Mature	<0.1	0.1	0.1	3.12	0.0459	A H G
Smallmouth Bass	YOY	0.1	0.1	0.1	0.68	0.5078	
	Immature	0.1	0.5	0.5	6.76	0.0014	H A G
	Mature	<0.1	<0.1	<0.1	5.33	0.0055	H A G
White Sucker	YOY	<0.1	0.0	0.0	1.48	0.2295	
	Immature	0.1	0.6	0.1	9.19	0.0001	H G A
	Mature	<0.1	0.2	0.0	11.19	<.0001	H G A
Yellow Perch	YOY	0.7	0.5	0.3	5.07	0.0070	G H A
	Immature	1.7	0.6	<0.1	24.42	<.0001	G H A
	Mature	0.3	<0.1	0.0	39.76	<.0001	G H A

Note: If the F-value for the overall model was not significant (i.e. P <0.05), pairwise comparisons were not provided. Pools indicated by their initials are ordered from highest to lowest mean transformed CPUE; means that are not significantly different are underlined.

Table 2-12. Taxa richness (number) of fish species captured by electrofishing in Garvins Pool, Hooksett Pool and Amoskeag Pool during 2012 and 2013.

Year	Hooksett Pool	Garvins Pool	Amoskeag Pool
2012	19	18	15
2013	20	18	17

Table 2-13. Shannon Diversity Index and evenness values for fish species captured by electrofishing in Garvins Pool, Hooksett Pool and Amoskeag Pool during 2012 and 2013.

Year	Hooksett Pool		Garvins Pool		Amoskeag Pool	
	Diversity	Evenness	Diversity	Evenness	Diversity	Evenness
2012	2.05	0.70	1.81	0.63	1.85	0.68
2013	2.17	0.72	2.02	0.70	1.81	0.64

Table 2-14. Number of species (percentage of total catch) classified as generalist feeders and pollution tolerant fish species and collected in Garvins, Hooksett and Amoskeag Pools during 2012 and 2013.

Pool	2012		2013	
	% Generalist Feeders	% Pollution Tolerant	% Generalist Feeders	% Pollution Tolerant
Garvins	9 (18.3%)	5 (7.5%)	8 (54.0%)	6 (32.9%)
Hooksett	8 (41.9%)	5 (13.3%)	9 (73.6%)	6 (30.9%)
Amoskeag	6 (64.9%)	4 (12.5%)	7 (78.7%)	3 (27.4%)

Table 2-15. Results of ANOSIM for testing differences in the fish communities from Garvins, Hooksett, and Amoskeag Pools during 2012.

Pool Comparison	2012	
	R-statistic	*P*
Garvins vs. Amoskeag	0.696	0.001
Garvins vs. Hooksett	0.543	0.001
Amoskeag vs. Hooksett	0.419	0.001

Table 2-16. Bray-Curtis Percent Similarity Index for the fish communities sampled by electrofishing during 2012 and 2013 within Garvins Pool (Stations 1-6), Hooksett Pool (Stations 7-18) and Amoskeag Pool (Stations 19-24).

2012	Garvins Pool	Hooksett Pool	Amoskeag Pool
Garvins Pool			
Hooksett Pool	61.5		
Amoskeag Pool	41.0	68.1	

Table 2-17. Average abundance and percent contribution to the dissimilarity in the fish communities as indicated by SIMPER analysis for Garvins, Hooksett, and Amoskeag Pools during 2012.

Common Name	Average Abundance (No./1,000 ft)			Percent Contribution to Dissimilarity		
	Garvins	Hooksett	Amoskeag	H:G	H:A	G:A
Spottail Shiner	3.5	0.3	0.0	19.0	3.3	18.3
Alewife	2.1	0.3	0.2	12.3	4.3	12.1
Fallfish	0.9	1.1	0.3	8.3	11.4	5.9
Redbreast Sunfish	0.7	1.3	1.6	7.0	11.8	7.9
Pumpkinseed	1.3	0.4	0.6	6.7	6.3	6.0
Largemouth Bass	2.3	2.3	1.0	5.4	17.8	8.9
Bluegill	1.9	1.2	0.7	5.8	9.4	8.4
Smallmouth Bass	0.3	1.1	0.8	6.3	7.0	4.3

Table 2-18. Results of ANOSIM for testing differences in the fish communities from Garvins, Hooksett, and Amoskeag Pools during 2013.

Pool Comparison	2013	
	R-statistic	*P*
Garvins vs. Amoskeag	0.481	0.001
Garvins vs. Hooksett	0.335	0.001
Amoskeag vs. Hooksett	0.311	0.002

Table 2-19. Bray-Curtis Percent Similarity Index for the fish communities sampled by electrofishing during 2012 and 2013 within Garvins Pool (Stations 1-6), Hooksett Pool (Stations 7-18) and Amoskeag Pool (Stations 19-24).

2013	Garvins Pool	Hooksett Pool	Amoskeag Pool
Garvins Pool			
Hooksett Pool	72.8		
Amoskeag Pool	65.8	75.5	

Table 2-20. Average abundance and percent contribution to the dissimilarity in the fish communities as indicated by SIMPER analysis for Garvins, Hooksett, and Amoskeag Pools during 2013.

Common Name	Average Abundance (No./1,000 ft)			Percent Contribution to Dissimilarity (90%)		
	Garvins	Hooksett	Amoskeag	H:G	H:A	G:A
Fallfish	0.2	1.5	0.4	12.4	14.1	4.5
Bluegill	2.5	2.0	1.4	11.1	11.8	14.3
Yellow Perch	1.4	0.7	0.2	10.4	8.0	13.4
Redbreast Sunfish	0.8	1.6	1.5	9.1	8.3	8.3
Alewife	1.1	0.5	0.6	8.8	7.4	9.0
Pumpkinseed	1.8	1.5	1.3	7.0	8.5	8.5
Chain Pickerel	1.1	0.4	0.2	6.8	4.4	9.4
Largemouth Bass	1.5	1.2	0.5	6.7	9.6	11.3
White Sucker	0.3	0.6	0.2	5.0	6.2	3.3
Smallmouth Bass	0.4	0.7	0.6	4.7	5.3	4.5
Spottail Shiner	0.5	0.1	0.0	4.6	-	4.9
Rock Bass	0.1	0.3	0.3	3.0	4.1	-
American Eel	0.1	0.3	0.0	2.7	3.0	-

3.0 Inter-annual Abundance Trends from the 1972-2013 Hooksett Pool Sampling Program

3.1 Overview

Population trend analysis was used to examine available Hooksett Pool fisheries data from electrofishing efforts conducted between 1972 and 2013, following the same sampling design (Table 3-1) and methodology used in previous population trend analyses (Normandeau 2007, Normandeau 2011).

3.2 Data Analysis

As in the 1972-2011 Fisheries Report (Normandeau 2011), the Kendall's tau-b correlation coefficient (PROC CORR, SAS Institute 2010) was used to test whether annual mean CPUE increased or decreased (monotonically) over time. This same data set, with the addition of 2012 and 2013 data, was analyzed to determine how the structure of the Hooksett Pool fish community may have changed by year or among the 1970s (1972, 1973, 1974, and 1976), 1995, and the 2000s (2004, 2005, 2010, 2011, 2012, and 2013) using five common community indices: (1) taxa richness, (2) Shannon Diversity Index, (3) percent generalist feeders, (4) percent tolerant individuals, and (5) the Bray-Curtis Percent Similarity Index. Temporal patterns in the similarity of fish assemblages sampled by electrofishing during August and September in Hookset Pool were examined by the same multivariate analyses used in the 1972-2011 Fisheries Report (Normandeau 2011): (1) ordination by non-metric multidimensional scaling (MDS) to plot the patterns of community-level similarity among the periods (1970s, 1995, and 2000s), (2) analysis of similarities (ANOSIM) to test for differences in community composition among the periods, and (3) "similarity percentages" (SIMPER) analysis to identify contributions from individual taxa to the overall dissimilarity among these periods.

3.3 Results of Hooksett Pool Electrofishing Trends Analysis

3.3.1 General Catch Characteristics

Table 3-2 presents the annual catch and relative abundance (%) of species captured by electrofishing in August and September with standardized sampling during the period from 1972 through 2013. A total of 24 species and two additional taxonomic categories (carp and minnow family, and sunfish family) were observed in Hooksett Pool electrofishing catches during the months of August and September of the 11 years included in this analysis. The total number of fish species observed among years varied, ranging from a high of 19 during the 2011 and 2012 sampling seasons to a low of 12 during 1972 and 1976. The total electrofishing catch of individuals in August and September of the selected years ranged from a low of 446 in 2005 to a high of 2,663 fish in 1995 (Table 3-2). Within the standardized sampling period of August and September, the species with the highest relative abundance during 1972, 1973, 1974 and 1976 was Pumpkinseed, during 1995 and 2004 was Spottail Shiner, during 2005, 2010 and 2012 was Largemouth Bass, during 2011 was Fallfish and during 2013 was Bluegill (Table 3-2).

Of the 24 fish species captured, Chain Pickerel, Largemouth Bass, Pumpkinseed, Redbreast Sunfish, Smallmouth Bass, White Sucker and Yellow Perch were present in Hooksett Pool during the August-September period of all 11 years of electrofishing. One species, White Perch, was present in the August-September electrofishing samples only during the 1970s. Although not observed within the standardized August and September samples during the 2000s, White Perch are still present in Hooksett Pool and have been observed in months/years not selected for standardized trend analysis (specifically, 2005 and 2009).

Bluegill and Rock Bass first appeared in the standardized August and September electrofishing catches in Hooksett Pool during 1995. However, Bluegill were a part of the Hooksett Pool fish community during the 1970s. The species were first detected during the June 1972 electrofishing (Normandeau 1972), and were also observed in Hooksett Pool during the June 1974 and 1975 electrofishing as well as the June 1976 and September 1978 seine survey sampling (Normandeau 1972, 1974, 1975, 1976, 1978). There are no records of Rock Bass from trap net, seine or electrofishing within Hooksett Pool during any year in the 1970s.

Likewise, there were no sampling records for Eastern Silvery Minnow, Black Crappie and Alewife during the 1970s or 1990s, and these three species first appeared in electrofishing catches during 2004. Alewife present in Hooksett Pool in August and September of 2004 and 2010 are likely the result of successful spawning of adults stocked by the New Hampshire Fish and Game Department ("NHFGD") in Northwood Lake. Alewife present in Hooksett Pool in August and September of 2012 and 2013 were all YOY and were likely the result of successful spawning of adults stocked by NHFGD in Winnisquam Lake.

American Eel, present in the standardized August-September sampling during the 1970s, were absent from standardized August-September sampling during 1995 but has been a component of all sampling years during the 2000s. American Eel were captured by the 1995 electrofishing during May and October and by trap net during August.

Spottail Shiner was first identified in the Hooksett Pool electrofishing catches during 1974. However, they did not show up in abundance within the standardized boat electrofishing effort during August-September until 1995. Spottail Shiner were present in high abundance within the seine surveys conducted in Hooksett Pool during 1974. Approximately 4,143 Spottail Shiner were captured in Hooksett Pool during 1974 seine sampling (Normandeau 1974). Although seine survey catch for *Notropis* shiner species during 1975 and 1976 were not identified to species, based on the percentage of *Notropis* catch (98.5%) identified as Spottail Shiner during 1974 it can be reasonably assumed that Spottail Shiner represented a large component of catch during those years as well (Normandeau 1974, 1975, 1976). Spottail Shiner were not present in the standardized August-September sampling during 2013.

American Shad present in Hooksett Pool during 2010 are likely the result of successful spawning or larval stocking of shad by USFWS in Garvins Pool. Adult and larval (aged 8-14 days post-fertilization) American Shad were stocked at the Boscawen boat ramp located approximately 23 river miles upstream of Garvins Falls Hydroelectric Project and the upper end of Hooksett Pool during 2010 and 2011 (US Fish and Wildlife Service, personal communication). There is a single record for American Shad collected from Hooksett Pool during 1978, with a single individual collected at Station S-0 during a September seine survey.

3.3.2 Catch-Per-Unit-Effort

Table 3-3 presents the CPUE for all individual taxa captured by electrofishing in Hooksett Pool in August and September of the years with standardized sampling during the period from 1972 through 2013. The presence of a trend in the temporal pattern of CPUE (Figure 3-1) was examined for the four resident RIS (Smallmouth Bass, Largemouth Bass, Pumpkinseed and Yellow Perch), along with Fallfish and White Sucker, and nine other fish species resident in Hooksett Pool (Black Crappie, Bluegill, Brown Bullhead, Chain Pickerel, Golden Shiner, Redbreast Sunfish, Rock Bass, Spottail Shiner and Yellow Bullhead). Table 3-4 presents results of the nonparametric Kendall's tau-b test used to test the null hypothesis that there is no statistically significant ($p<0.05$) monotonically increasing or decreasing inter-annual trend in abundance during the period analyzed. CPUE trends were not analyzed for anadromous RIS fish species. Alewife and American Shad spend a relatively short time in Hooksett Pool as they pass through on their outmigration during the fall. Due to the current lack of fish passage on the Merrimack River to allow these species access to Hooksett Pool and inconsistent stocking of the species over the full time series (1967-2013), trends analyses for these two species were not conducted because doing so would not provide useful information regarding potential thermal impacts to abundance. The remaining RIS, Atlantic Salmon, was not present during the August and September time period during any of the years sampled.

Of the fifteen species examined, the Kendall tau-b results indicated that there was a statistically significant increasing trend in annual mean CPUE in Hooksett Pool during the time series for two species (Black Crappie and Rock Bass), a statistically significant decreasing trend in annual mean CPUE in Hooksett Pool for one species (Pumpkinseed) and no detectable significant trend in annual mean CPUE in Hooksett Pool during the time series for the remaining twelve species (Table 3-4). There were five changes to the overall trends detected among these fifteen fish species following the addition of data collected during 2012 and 2013 to those trends observed for the standardized sampling collected prior to 2012 (Normandeau 2011). With the inclusion of the 2012 and 2013 catch data to the time series, four species (Brown Bullhead, Chain Pickerel, Redbreast Sunfish and Yellow Perch) with a decreasing species-specific trend for the period 1972-2011 no longer demonstrated a detectable trend in abundance. Rock Bass, previously showing no detectable trend in abundance for the period from 1972 through 2011, show an increasing species-specific trend with the addition of the 2012 and 2013 catch data.

Temperature guilds (i.e., coolwater/warmwater) for fish species, as previously defined in the 1972-2011 Fisheries Report, were assessed in the trends analysis for the years with standardized sampling from 1972 through 2013. Among the five members of the coolwater guild, CPUE increased for one species whereas there were no significant trends among the four other coolwater fish species (Table 3-4, Table 3-5). Among the ten members of the warmwater guild, CPUE decreased for one species, CPUE increased for one species, and there were no significant trends for eight species (Table 3-4, Table 3-5).

3.3.3 Community Indices

In addition to evaluating trends in species-specific CPUEs over the period from 1972 through 2013, changes in community trends were examined through five indices: (1) taxa richness, (2) Shannon Diversity Index, (3) percent generalist feeders, (4) percent tolerant individuals, and (5) the Bray-Curtis Percent Similarity Index.

Taxa Richness

Taxa richness for electrofishing at monitoring stations 9-18 in Hooksett Pool in August and September of the years with standardized sampling during the 1972-2013 time period is presented in Table 3-6. The number of taxa observed during 1972 and 1976 were the lowest overall of the eleven sample years considered (12 species) while the greatest number of taxa were observed during 2011 and 2012 (19 species). Within the Hooksett Pool time series, taxa richness increased from 12 species sampled during 1972 to 18 sampled in 2013 (with expected year-to-year variability). Of the 12 species observed during the August-September electrofishing effort in 1972, all were represented within the most recent (2013) August-September electrofishing effort (Table 3-2).

Shannon Diversity Index

Table 3-6 presents the Shannon Diversity Index of the fish communities in Hooksett Pool for each year within the period from 1972 through 2013 that was sampled by standardized electrofishing. Fish community diversity in Hooksett Pool was lowest during the 1995 sampling, due to that year’s high abundance of Bluegill in the electrofishing catch, and highest during 2013. Values for evenness of the Hooksett Pool fish assemblage have been closer to 1 during more recent years (2004, 2005, 2011, and 2013) than had been observed during the 1970s.

Percent Generalist Feeders

The percentage of generalist feeders (calculated using the number of individuals) in Hooksett Pool during August and September of the years with standardized sampling from 1972 through 2013 is presented in Table 3-6. Of the twelve fish species recorded in August and September of 1972 (the first year of available data with a consistent and documented sampling effort), seven were listed as generalist feeders and the remainder were listed as piscivores. Of the 18 fish species recorded in August and September of 2013 (the most recent year of available data with consistent and documented sampling effort), 8 were listed as generalist feeders.

Percent Tolerant Individuals

The percentage of pollution-tolerant species (calculated using the number of individuals) in Hooksett Pool in August and September of the years with standardized sampling during the period from 1972 through 2013 is presented in Table 3-6. Of the twelve fish species recorded in August and September of 1972 (the first year of available data with a consistent and documented sampling effort), five were listed as pollution-tolerant with the remainder listed as intermediate in their tolerance to pollution. Of the eighteen fish species recorded in August and September of 2013 (the most recent year of available data with a consistent and documented sampling effort), six were listed as pollution-tolerant with the remainder listed as intermediate in their tolerance to pollution

Bray-Curtis Percent Similarity Index

The fish community in Hooksett Pool differed significantly among the decades (1970s, 1995, 2000s) based on the August-September 1972-2013 electrofishing catch (ANOSIM, Global R = 0.871, $P = 0.001$; Table 3-7). These differences among periods spanning decades are shown graphically in the MDS plot (Figure 3-2), where relative distance between any two data points represent their ranked ordered similarities. Similar to previously reported observations (Normandeau 2011), the primary fish species driving the differences observed between decades were Bluegill, Pumpkinseed and Spottail Shiner (Table 3-8).

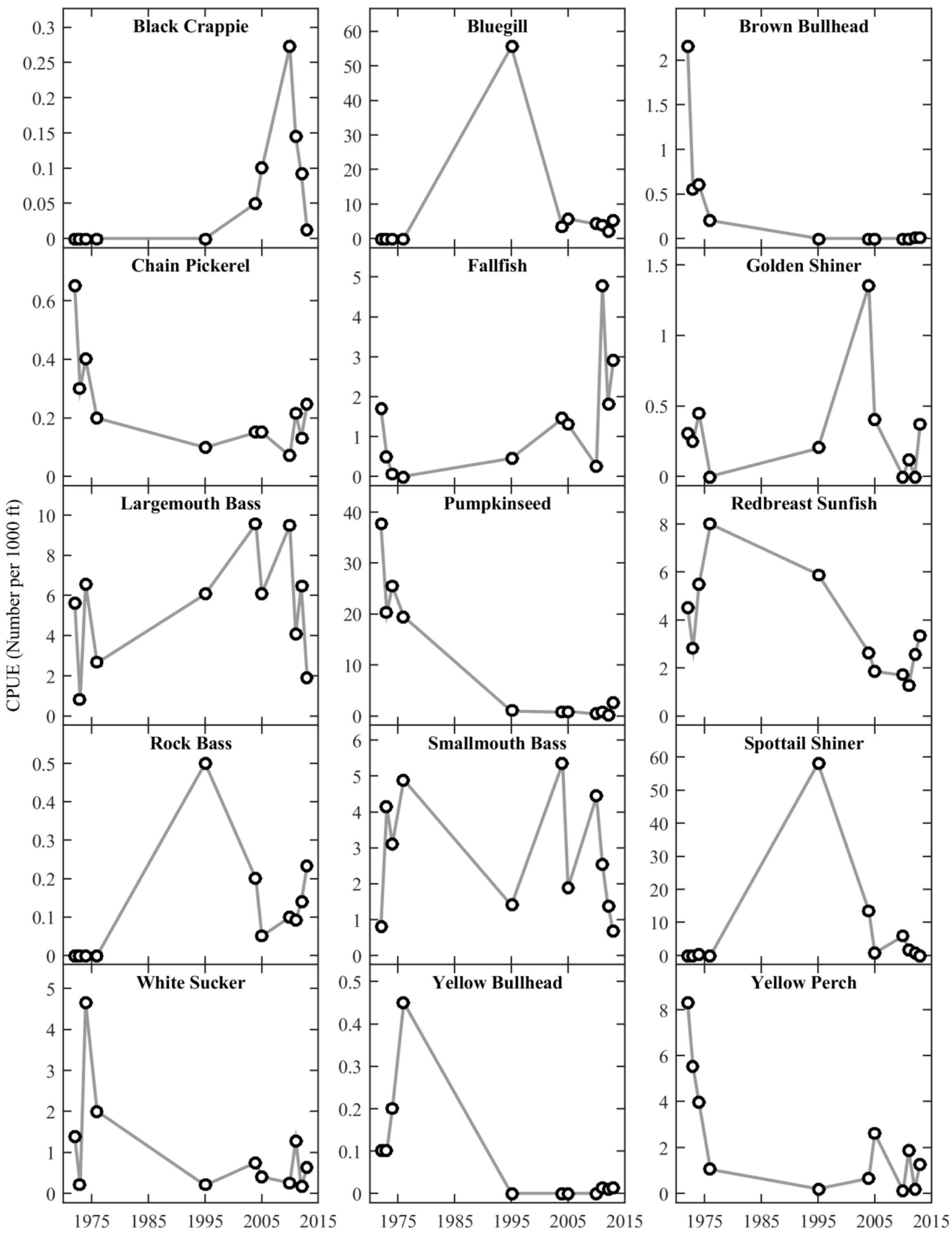

Figure 3-1. Mean catch per unit effort (CPUE) of fifteen fish species caught by electrofishing during August and September of all years with consistent sampling effort in Hooksett Pool (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, 2011, 2012 and 2013).

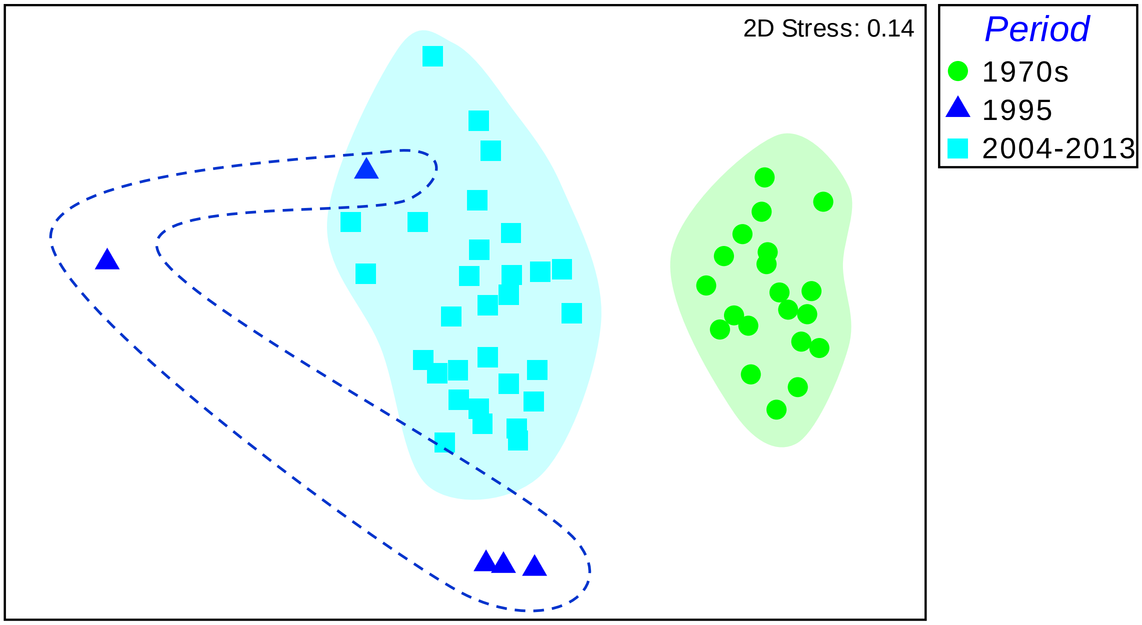

Figure 3-2. Results of MDS ordination based on Bray-Curtis similarities of square-root transformed abundances at Hooksett Pool electrofishing stations 9-18 during August and September in the 1970s (1972, 1973, 1974,and 1976), 1995, and 2000-2013 period (2004, 2005, 2010, 2011, 2012, and 2013). Each data point corresponds to the abundances averaged over months (August and September) and banks (East and West) matching historic stations 11-15 (Table 2-1).

Table 3-1. Sampling design comparison of the Merrimack Station electrofishing surveys conducted in Hooksett Pool of the Merrimack River near Bow, NH during 1967-2013. Shading denotes data selected for trends analysis.

		Year														
		1967	1968	1969	1972	1973	1974	1975	1976	1995	2004	2005	2010	2011	2012	2013
		NHFGD	NHFGD	NHFGD	NAI	NAI	NAI	NAI	NAI	NAI	NAI	NAI	NAI	NAI	NAI	NAI
Month	Unknown															
	March									x						
	April										x	x			x	
	May									x	x	x			x	
	June				x	x	x			x	x	x				
	July							x	x	x	x	x				
	August				x	x	x	x	x	x	x	x	x	x	x	x
	September	x	x	x	x	x	x		x	x	x	x	x	x	x	x
	October							x		x	x					
	November											x				
	December									x	x	x				
Station	North	x	x	x											x	
	South	x	x	x											x	
	N9-N10 E				x	x	x	x	x	x	x	x	x	x	x	x
	N9-N10 W				x	x	x	x	x	x	x	x	x	x	x	x
	N6-N7 E				x	x	x	x	x	x	x	x	x	x	x	x
	N6-N7 W				x	x	x	x	x	x	x	x	x	x	x	x
	Zero-S1 E				x	x	x	x	x	x	x	x	x	x	x	x
	Zero-S1 W				x	x	x	x	x	x	x	x	x	x	x	x
	S4-S5 E				x	x	x	x	x	x	x	x	x	x	x	x
	S4-S5 W				x	x	x	x	x	x	x	x	x	x	x	x
	S17-S18 E				x	x	x	x	x	x	x	x	x	x	x	x
	S17-S18 W				x	x	x	x	x	x	x	x	x	x	x	x
Transect Length	1,000'				x	x	x	x	x	x	x	x	x	x	x	x
	Variable														x	
	Unknown	x	x	x												

Table 3-2. **Total catch (N) and relative abundance (%) of fishes caught by electrofishing in Hooksett Pool (Stations 9-18) during August and September of select years (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, 2011, 2012, and 2013).**

Common Name	1972		1973		1974		1976		1995		2004		2005		2010		2011		2012		2013	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Alewife											80	8.4			20	0.8			44	2.7	72	3.6
American Eel	17	1.3	16	2.2	21	2.0	9	1.1			4	0.4	3	0.7	16	0.6	6	0.3	3	0.2	19	1.0
American Shad															69	2.7						
Black Crappie											1	0.1	2	0.4	23	0.9	13	0.5	9	0.6	1	0.1
Bluegill									1,111	41.7	64	6.7	112	25.1	366	14.1	356	15.0	185	11.3	503	25.2
Brown Bullhead	43	3.4	11	1.5	12	1.1	4	0.5											1	0.1	1	0.1
Carp and minnow family															3	0.1						
Chain Pickerel	13	1.0	6	0.8	8	0.8	4	0.5	2	0.1	3	0.3	3	0.7	6	0.2	20	0.8	13	0.8	24	1.2
Common Shiner					2	0.2			70	2.6	62	6.5					39	1.6	4	0.2		
Eastern Blacknose Dace																	1	<0.1				
Eastern Silvery Minnow											14	1.5										
Fallfish	34	2.7	10	1.4	1	0.1			9	0.3	29	3.0	26	5.8	27	1.0	493	20.8	179	11.0	286	14.3
Golden Shiner	6	0.5	5	0.7	9	0.9			4	0.2	27	2.8	8	1.8			13	0.5			30	1.5
Largemouth Bass	113	8.8	17	2.3	131	12.5	53	6.7	121	4.5	191	20.0	122	27.4	829	32.0	393	16.6	627	38.4	184	9.2
Margined Madtom							4	0.5							4	0.2	1	<0.1	8	0.5	17	0.9
Pumpkinseed	753	58.8	404	55.7	508	48.4	389	48.9	19	0.7	14	1.5	18	4.0	30	1.2	76	3.2	29	1.8	259	13.0
Redbreast Sunfish	90	7.0	56	7.7	110	10.5	160	20.1	118	4.4	53	5.5	37	8.3	146	5.6	116	4.9	252	15.4	324	16.2
Rock Bass									10	0.4	4	0.4	1	0.2	9	0.3	9	0.4	14	0.9	23	1.2
Smallmouth Bass	16	1.2	83	11.4	62	5.9	98	12.3	28	1.1	107	11.2	38	8.5	400	15.4	261	11.0	135	8.3	63	3.2
Spottail Shiner					6	0.6			1,161	43.6	271	28.3	16	3.6	585	22.6	197	8.3	54	3.3		
Sunfish family															12	0.5	35	1.5	36	2.2	2	0.1
Tessellated Darter					3	0.3	4	0.5	2	0.1	4	0.4			9	0.3	23	1.0	1	0.1	4	0.2
White Perch			1	0.1																		
White Sucker	28	2.2	4	0.6	93	8.9	40	5.0	4	0.2	15	1.6	8	1.8	25	1.0	131	5.5	16	1.0	61	3.1
Yellow Bullhead	2	0.2	2	0.3	4	0.4	9	1.1	0								1	<0.1	1	0.1	1	0.1
Yellow Perch	166	13.0	110	15.2	79	7.5	21	2.6	4	0.2	13	1.4	52	11.7	10	0.4	189	8.0	20	1.2	119	6.0
Total	**1,281**	**100.0**	**725**	**100.0**	**1,049**	**100.0**	**795**	**100.0**	**2,663**	**100.0**	**956**	**100.0**	**446**	**100.0**	**2,589**	**100.0**	**2,373**	**100.0**	**1,632**	**100.0**	**1,994**	**100.0**

Table 3-3. Mean CPUE (fish per 1,000 ft) of species captured by electrofishing in Hooksett Pool (Stations 9-18) during August and September of select years (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, 2011, 2012, and 2013).

Common Name	Year										
	1972	1973	1974	1976	1995	2004	2005	2010	2011	2012	2013
Alewife	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.21	0.00	0.44	0.73
American Eel	0.85	0.80	1.05	0.45	0.00	0.20	0.15	0.18	0.06	0.03	0.20
American Shad	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00
Black Crappie	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.27	0.15	0.09	0.01
Bluegill	0.00	0.00	0.00	0.00	55.55	3.20	5.60	4.28	3.89	1.89	5.19
Brown Bullhead	2.15	0.55	0.60	0.20	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Chain Pickerel	0.65	0.30	0.40	0.20	0.10	0.15	0.15	0.07	0.22	0.13	0.25
Common Shiner	0.00	0.00	0.10	0.00	3.50	3.10	0.00	0.00	0.38	0.04	0.00
Eastern Blacknose Dace	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Eastern Silvery Minnow	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00
Fallfish	1.70	0.50	0.05	0.00	0.45	1.45	1.30	0.27	4.78	1.83	2.90
Golden Shiner	0.30	0.25	0.45	0.00	0.20	1.35	0.40	0.00	0.12	0.00	0.37
Largemouth Bass	5.65	0.85	6.55	2.65	6.05	9.55	6.10	9.47	4.07	6.46	1.90
Margined Madtom	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.04	0.01	0.08	0.18
Pumpkinseed	37.65	20.20	25.40	19.45	0.95	0.70	0.90	0.35	0.74	0.30	2.65
Redbreast Sunfish	4.50	2.80	5.50	8.00	5.90	2.65	1.85	1.70	1.27	2.55	3.33
Rock Bass	0.00	0.00	0.00	0.00	0.50	0.20	0.05	0.10	0.09	0.14	0.24
Smallmouth Bass	0.80	4.15	3.10	4.90	1.40	5.35	1.90	4.43	2.54	1.39	0.66
Spottail Shiner	0.00	0.00	0.30	0.00	58.05	13.55	0.80	5.86	1.87	0.55	0.00
Tessellated Darter	0.00	0.00	0.15	0.20	0.10	0.20	0.00	0.09	0.20	0.01	0.04
White Perch	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Sucker	1.40	0.20	4.65	2.00	0.20	0.75	0.40	0.26	1.29	0.17	0.64
Yellow Bullhead	0.10	0.10	0.20	0.45	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Yellow Perch	8.30	5.50	3.95	1.05	0.20	0.65	2.60	0.11	1.84	0.21	1.25

Table 3-4. Kendall tau b results for detection of increasing or decreasing species-specific trends within Hooksett Pool (Stations 9-18) for fish captured by electrofishing in August and September of select years (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, 2011, 2012, and 2013).

Common Name	Type	Temperature Guild*	Kendall-Tau	p-value	Trend
Black Crappie	Resident	Coolwater	0.54272	0.0266	Increase
Bluegill	Resident	Warmwater	0.40452	0.0930	Unable to Detect Significant Trend
Brown Bullhead	Resident	Warmwater	-0.44721	0.0699	Unable to Detect Significant Trend
Chain Pickerel	Resident	Warmwater	-0.36699	0.1183	Unable to Detect Significant Trend
Fallfish	RIS	Coolwater	0.34545	0.1391	Unable to Detect Significant Trend
Golden Shiner	Resident	Warmwater	-0.18699	0.4311	Unable to Detect Significant Trend
Largemouth Bass	RIS	Warmwater	0.09091	0.6971	Unable to Detect Significant Trend
Pumpkinseed	RIS	Warmwater	-0.63636	0.0064	Decrease
Redbreast Sunfish	Resident	Warmwater	-0.38182	0.1021	Unable to Detect Significant Trend
Rock Bass	Resident	Warmwater	0.52010	0.0308	Increase
Smallmouth Bass	RIS	Warmwater	-0.20000	0.3918	Unable to Detect Significant Trend
Spottail Shiner	Resident	Warmwater	0.13484	0.5756	Unable to Detect Significant Trend
White Sucker	RIS	Coolwater	-0.25689	0.2743	Unable to Detect Significant Trend
Yellow Bullhead	Resident	Warmwater	-0.21635	0.3759	Unable to Detect Significant Trend
Yellow Perch	RIS	Coolwater	-0.45455	0.0516	Unable to Detect Significant Trend

RIS = Representative Important Species
* See Table 3-5 in the 1972-2011 Fisheries Report (Normandeau 2011) for temperature guild references

Table 3-5. Summary of results for resident Hooksett Pool fish species assessed during trend analysis from standardized electrofishing in August and September of select years (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, 2011, 2012, and 2013).

Trend	Coolwater Species	Warmwater Species
Increasing	1	1
Decreasing	0	1
No Significant Trend	4	8

Table 3-6. Taxa richness (number), Shannon Diversity Index, evenness, percentage generalist feeder and percentage pollution tolerant values for fish captured within Hooksett Pool (Stations 9-18) by electrofishing during August and September of select years (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, 2011, 2012 and 2013).

Year	Number of Taxa	Shannon Diversity Index	Shannon Evenness	% Generalist Feeders	% Pollution Tolerant/
1972	12	1.47	0.59	74.6	7.5
1973	13	1.48	0.58	67.9	5.2
1974	15	1.72	0.64	70.4	13.3
1976	12	1.57	0.63	75.7	7.8
1995	14	1.26	0.48	50.1	42.0
2004	18	2.20	0.76	27.6	11.5
2005	14	2.03	0.77	46.9	29.4
2010	17	1.86	0.66	22.9	15.7
2011	19	2.23	0.76	51.7	21.4
2012	19	1.91	0.65	40.9	12.6
2013	18	2.43	0.84	73.5	30.8

Table 3-7. **Results of ANOSIM for testing differences in the fish community in Hooksett Pool among the 1970s (1972, 1973, 1974, and 1976), 1995, and the 2000s (2004, 2005, 2010, 2011, 2012, and 2013).**

Decadal Comparison	R-statistic	*P*
1970s vs. 1995	0.974	0.001
1970s vs. 2000s	0.894	0.001
1995 vs. 2000s	0.700	0.001

Table 3-8. **Average abundance and percent contribution to the dissimilarity in the fish communities as indicated by SIMPER analyses for samples collected in Hooksett Pool during August and September of selected years (1972, 1973, 1974, 1976, 1995, 2004, 2005, 2010, 2011, 2012, and 2013.**

	Average Abundance (No./1,000 ft)			Percent Contribution to Dissimilarity		
Common Name	1970s	1995	2000s	1970s to 1995	1970s to 2000s	1995 to 2000s
Bluegill	0.0	6.7	0.9	26.7	23.2	28.1
Pumpkinseed	4.9	0.7	1.9	17.2	11.1	3.9
Yellow Perch	2.0	0.3	0.8	7.0	7.8	3.9
Largemouth Bass	1.8	2.4	2.4	4.1	6.3	4.7
Fallfish	0.4	0.4	1.2	2.3	6.1	5.5
Redbreast Sunfish	2.1	2.1	1.4	5.2	5.5	7.1
Smallmouth Bass	1.6	1.1	1.5	3.2	4.9	3.6
Spottail Shiner	0.1	3.8	1.0	12.3	4.9	18.4
White Sucker	1.0	0.3	0.6	3.7	4.8	3.0
Brown Bullhead	0.8	0.0	0.0	3.1	4.3	
American Eel	0.8	0.0	0.3	3.3	3.4	
Golden Shiner	0.3	0.2	0.3		2.4	2.1
Alewife	0.0	0.0	0.5		2.4	2.4
Chain Pickerel	0.5		0.3		2.3	
Yellow Bullhead	0.3		0.0		1.7	
Rock Bass		0.54	0.28			2.79
Common Shiner		1.06	0.26	3.59		5.32

4.0 Biocharacteristics of Selected Merrimack River Fish Species

4.1 Overview

Collection of biocharacteristics data was conducted during the spring and fall of 2012 and fall of 2013. Spring 2012 biocharacteristics sampling focused on the collection of length, weight, age, gender, sexual condition, fecundity and incidence of internal/external parasitism data for two coolwater RIS fish species (Yellow Perch and White Sucker). Fall 2012 and 2013 biocharacteristics sampling was conducted simultaneous to the standardized community electrofishing (Section 2.0) and focused on the length, weight, age and incidence of external parasitism of Merrimack River RIS and resident fish species. Biocharacteristics data were collected in Garvins, Hooksett and Amoskeag Pools of the Merrimack River.

4.2 Methods

4.2.1 Spring 2012 Biocharacteristics Field Collection

Merrimack River fisheries sampling during spring 2012 was designed to examine and compare biological characteristics of two RIS species (Yellow Perch and White Sucker) among Garvins, Hooksett and Amoskeag Pools. Yellow perch and White Sucker populations were sampled weekly during the spring and field sampling was directed to target the collection of both species for the laboratory assessment of fecundity and spawning condition. In addition to reproductive characteristics, biological characteristics including length, weight, age and incidence of disease or parasitism were also recorded. Sampling was conducted using the same equipment and procedures followed during spring 2008 and 2009, as documented in the 1972-2011 Fisheries Report (Normandeau 2011).

Within each sampling week and pool, a maximum target number of 180 Yellow Perch and 200 White Sucker was set to be taken to the laboratory in fresh condition for biocharacteristics analysis. Quotas for both species (Yellow Perch or White Sucker) in each week and pool were intended to be filled by tallying all fish caught in each complete sampling effort (i.e. each 10 minute electrofishing sample). Sample processing was conducted using the same procedures followed in spring 2008 and 2009. Additional details of the field collection methods for spring biocharacteristics sampling are described in the SOP that was prepared before sampling began and governed all sampling activities during 2012 (Normandeau 2012b).

4.2.2 Fall 2012 and 2013 Biocharacteristics Field Collection

The primary objective of the Merrimack River fisheries sampling during fall 2012 and 2013 was to continue the 2011 the sampling program by electrofishing during August and September 2012 and 2013 at standardized sampling transects located within Garvins, Hooksett and Amoskeag Pools, as described in the 1972-2011 Fisheries Report (Normandeau 2011). In short, each fish caught by electrofishing was counted, identified to species, weighed to the nearest gram, and measured to the nearest millimeter total length. Scale samples were collected from age-1 or older fish following the same methods and minimum length requirements used in the 2011 Report. Prior to release, each individual was examined for the presence of external parasites and a ranking was assigned based on abundance.

4.2.3 Laboratory Methodology

Yellow Perch and White Sucker collected during spring 2012 were returned to the laboratory where they were autopsied to gather biological information including length, weight, age, gender, sexual condition, fecundity and incidence of disease or parasitism, following the same methods described in the 1972-2011 Fisheries Report (Normandeau 2011). Additional details of the laboratory methods for spring biocharacteristics sampling are described in the SOP that was prepared before sampling began and governed all sampling activities during 2012 (Normandeau 2012b). Scale samples were processed for age determination for White Sucker and Yellow Perch collected during spring 2012 and Largemouth Bass, Smallmouth Bass, Pumpkinseed, White Sucker, Fallfish, Yellow Perch, Rock Bass, Black Crappie and Bluegill scale samples were collected during fall 2012 and 2013 in Garvins, Hooksett and Amoskeag Pools. Scale preparation and age determination was performed using the same methods described in the 2011 Report (Normandeau 2011).

4.2.4 Analytical Methodology

The same data management procedures and analytical methods with SAS software used in the 1972-2011 Fisheries Report were followed in analysis of the fish biocharacteristics from the 2012 and 2013 electrofishing catch. An analysis of covariance (ANCOVA) was used to test for significant differences in condition by comparing total length-total weight (L-W) relations of fish among pools or years within Hooksett Pool. Age and growth of selected fish were described by the mean total length at age and their differences among pools for each year were tested for statistical significance by a general linear model and Tukey's studentized range multiple pair-wise comparison tests. A *Z*-statistic for a binomial test of proportions was used to test whether the proportions of female and male Yellow Perch and White Sucker were equal. The proportions of female and mature Yellow Perch and White Sucker were also compared among pools and tested for equality using the Chi-square (χ^2) statistic for a 2x3 contingency table followed by Tukey-type multiple comparison tests of proportions. Length or age at 50% maturation (L_{50} and A_{50}, respectively) for Yellow Perch and White Sucker was estimated from logistic regression. A Gonadosomatic index (GSI, %) of gravid or milting (ripe) White Sucker and Yellow Perch was estimated for each gender and pool. ANCOVA was used to compare the differences in the length-fecundity relationships among Garvins, Hooksett and Amoskeag Pools. A frequency distribution describing the occurrence of parasites was calculated on a rank scale and tested for differences among pools using multi-contingency tables and the Pearsons Chi-square test statistic. Total instantaneous mortality (*Z*) rates for RIS with sufficient catch-at-age data were estimated from catch curve regressions and compared among pools by ANCOVA.

4.3 Species-Specific Catch Characteristics

Twenty-two fish species were captured by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August and September 2012 and 2013. In addition to the late-summer community sampling, quota-driven sampling was directed at two important coolwater fish species (Yellow Perch and White Sucker) during March and April 2012. Biocharacteristics data collected during both of those sampling periods are presented in this section.

4.3.1 Black Crappie

Biocharacteristics of the Black Crappie population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Black Crappie collected by electrofishing in Garvins and Hooksett Pools during August and September 2012 are presented in Table 4.3.1-1. There were no Black Crappie collected in Amoskeag Pool during August and September 2012.

2013—The total length and pool of the three Black Crappie individuals caught during August and September 2013 were 49 mm in Hooksett Pool, 114 mm in Amoskeag Pool, and 167 mm in Garvins Pool.

Condition

Sample sizes of Black Crappie collected during August and September 2012 (Table 4.3.1-1) and 2013 were insufficient for comparison of condition between pools.

Age-Length

2012—The mean total length at age (±95% C.I.) of Black Crappie collected by electrofishing in Garvins and Hooksett Pools during August and September 2012 is presented in Table 4.3.1-2. The age of Black Crappie ranged from age 0 to age 1 in Garvins Pool, and from age 2 to age 3 in Hooksett Pool. Insufficient sample size (n < 15) prevented the comparison of mean length-at-age among pools for all cohorts of Black Crappie collected during August and September 2012.

2013—The ages of the Black Crappie collected during August and September 2013 were age 0 for the 48-mm individual, age 1 for the 116-mm individual, and age 2 for the 168-mm individual.

Mortality

The catch at age of Black Crappie caught by electrofishing during August and September 2008-2013 was too low and variable in Garvins and Amoskeag Pools for estimating mortality from a catch curve. Figure 4.3.1-1 shows the age structure of the 12 Black Crappie caught in Garvins Pool and the three individuals caught in Amoskeag Pool during August and September 2008-2013. The catch-curve regression for age 2-5 Black Crappie caught in Hooksett Pool during August and September 2008-2013 was not statistically significant (Figure 4.3.1-2, Z = 1.15; F = 18.9, P = 0.144). There were no significant regressions for cohort-specific catch curves of Black Crappie based on electrofishing catch during August-September from 2008 through 2013 ($P > 0.05$).

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Black Crappie collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2012 is presented in Table 4.3.1-3. The prevalence of external parasites was significantly greater in Hooksett Pool than in Garvins Pool during 2012.

2013—No external parasites were found on the Black Crappie individuals collected by electrofishing during August-September 2013.

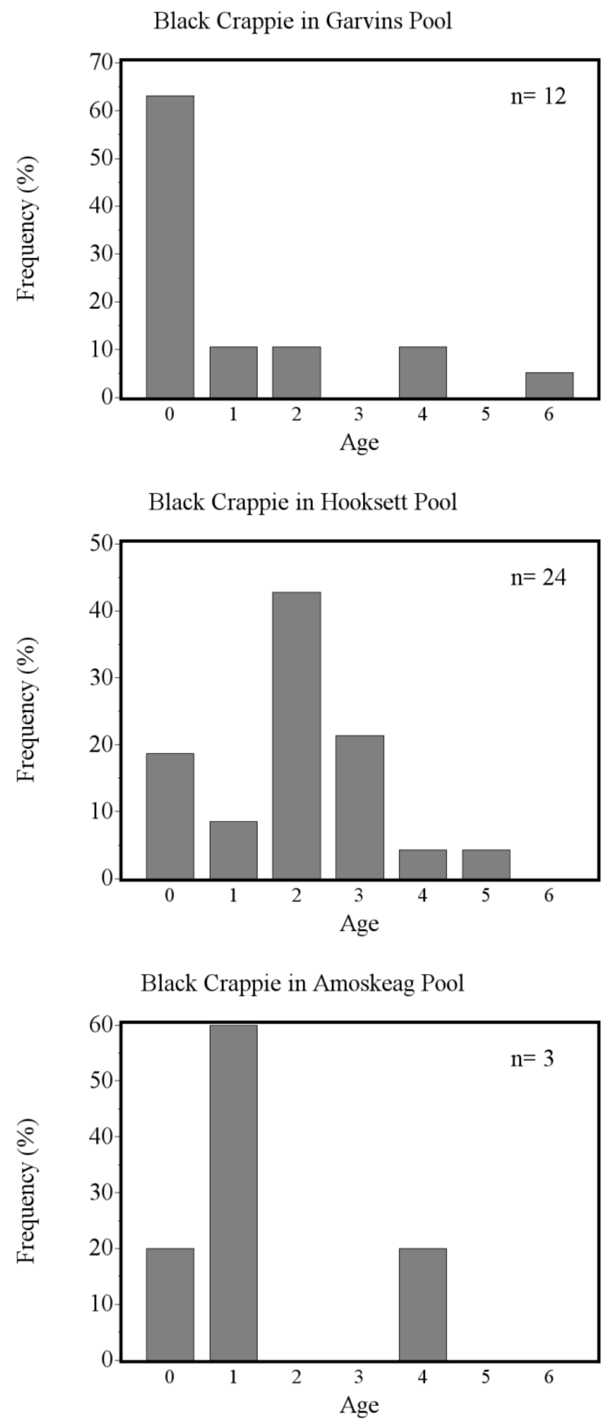

Figure 4.3.1-1. Catch at age of Black Crappie caught by electrofishing in Garvins, Hooksett, and Amoskeag Pools, Merrimack River, during August-September 2008- 2013.

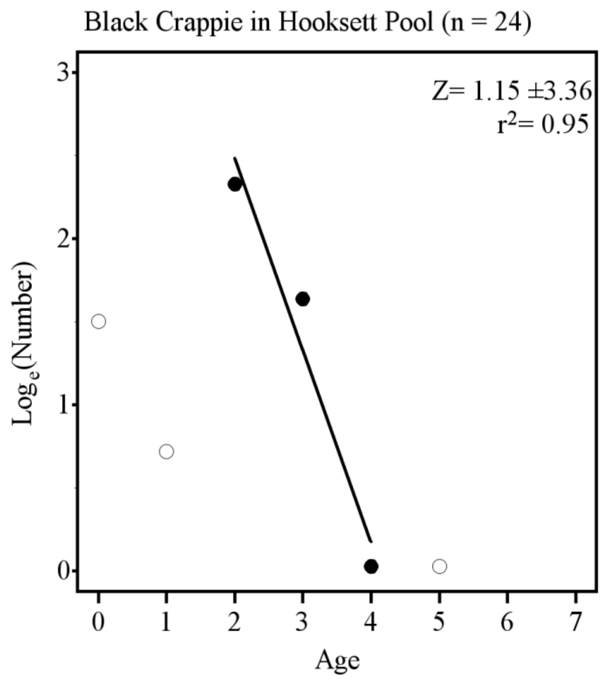

Figure 4.3.1-2. Catch curve estimate of instantaneous total mortality rate (Z ± 95% confidence intervals) for Black Crappie of fully recruited ages (solid circles) caught by electrofishing during August-September from 2008 through 2013 in Hooksett Pool, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: age 4 fish included to provide minimum catch-at-age data for best available estimate of instantaneous mortality.

Table 4.3.1-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for black crappie collected in Garvins and Hooksett Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	5	67	108	84	15	5	4	16	8	5
Hooksett	10	132	227	167	33	10	36	172	77	50
Total	**15**	**67**	**227**	**140**	**49**	**15**	**4**	**172**	**54**	**52**

Table 4.3.1-2. Mean length at age (± 95% C.I.) for black crappie captured by electrofishing from Garvins and Hooksett Pools during August-September 2012.

Age	Cohort	Pool	N	Mean	± 95% C.I.
0	2012	Garvins	4	80	9
1	2011	Garvins	1	108	
2	2010	Hooksett	7	148	12
3	2009	Hooksett	3	208	31

Table 4.3.1-3. Frequency distribution of external parasite loads for black crappie collected from Garvins and Hooksett Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	3	60	2	40	0	0
Hooksett [B]	3	30	6	60	1	10

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.2 Bluegill

Biocharacteristics of the Bluegill population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Bluegill collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2012 are presented in Table 4.3.2-1.

2013—The mean, minimum, maximum and standard deviation of total length and total wet weight of Bluegill collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2013 are presented in Table 4.4.2-2.

Condition

2012—Length-weight relationships for Bluegill based on August and September 2012 catches are presented in Table 4.3.2-3. The slope parameters for the length-weight relationships in Hooksett Pool and Amoskeag Pool were significantly different. There was no significant difference in slope parameters between Garvins Pool and Hooksett Pool or between Garvins Pool and Amoskeag Pool. The 2012 *y*-intercept parameter in the length-weight relationship was significantly higher for Bluegill in Amoskeag Pool than in Hooksett Pool. There was no significant difference between Bluegill *y*-intercept parameters in Garvins and Hooksett Pools during the August and September 2012 catches.

2013— Length-weight relationships for Bluegill based on August and September 2013 catches are presented in Table 4.3.2-4. The slope parameters for the length-weight relationships in Garvins Pool and Hooksett Pool were significantly different. There was no significant difference in slope parameters between Amoskeag Pool and Hooksett Pool or between Amoskeag Pool and Garvins Pool. The 2013 *y*-intercept parameter in the length-weight relationship was significantly higher for Bluegill in Hooksett Pool than in Garvins Pool. There was no significant difference between Bluegill *y*-intercept parameters in Amoskeag Pool and Hooksett or Garvins Pools during the August and September 2013 catches.

Comparison among years in Hooksett Pool—Length-weight relationships for Bluegill collected in Hooksett Pool during the available years from 1995 through 2013 are presented in Table 4.3.2-5. The slope parameters of the length-weight relationship for 2013 was significantly greater than for 1995, but significantly less than for 2004, 2011, and 2012. The *y*-intercept parameter from the 1995 length-weight relationship was significantly higher than the estimate from 2004, 2005, and 2010 through 2013.

Age-Length

2012—The mean total length at age (±95% C.I.) of Bluegill collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September, 2012 is presented in Table 4.3.2-6. The age of Bluegill ranged from age 0 to age 6 in Garvins and Hooksett Pools, and from age 0 to age 3 in Amoskeag Pool. The mean total length of age-0 Bluegill was significantly smaller in Garvins Pool than in Hooksett and Amoskeag Pools. There was no significant difference in mean length of age-1 Bluegill among pools, and no significant difference for age-2 Bluegill between Garvins and Hooksett Pools. Insufficient sample sizes (n < 15) prevented the comparison of mean lengths for age-2 Bluegill from Amoskeag Pool, and for age 3 through age 6 for all pools.

2013— The mean total length at age (±95% C.I.) of Bluegill collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September, 2013 is presented in Table 4.3.2-7. The age of Bluegill ranged from age 0 to age 9 in Garvins Pool, from age 0 to age 7 in Hooksett Pool and from age 0 to age 4 in Amoskeag Pool. There was no significant difference in the mean length of age-1 Bluegill among pools. Insufficient sample sizes (n < 15) prevented the pairwise comparison of mean length of age-0, age-2, and age-4 Bluegill among all pools and for age-3, age-5, age-6 and age-7 Bluegill between Garvins and Hooksett Pools.

Mortality

Catch curves used to estimate instantaneous mortality rate (Z) for Bluegill caught by electrofishing in each Merrimack River pool during August-September 2008-2013 are shown in Figure 4.3.2-1. Regression of the catch curve was statistically significant for ages 1-9 in Garvins Pool (Z = 0.63, P <0.001), ages 0-7 in Hooksett Pool (Z = 0.48, P = 0.001), and ages 1-5 in Amoskeag Pool (Z = 1.17, P = 0.006). These total instantaneous mortality rates for Bluegill were significantly different among Merrimack River pools (ANCOVA, F = 8.72, P = 0.003). The Z for ages 1-5 Bluegill from Amoskeag Pool was significantly higher than the Z for ages 1-9 in Garvins Pool (t = 3.36, P = 0.004) and Z for ages 0-7 in Hooksett Pool (t = 4.17, P = 0.001), but the Z estimates were not significantly different between catches in Garvins and Hooksett Pools (t = -1.59, P = 0.132). The annual mortality rates of Bluegill based on estimates of Z were 47% for ages 1-9 in Garvins Pool, 38% for ages 0-7 in Hooksett Pool, and 69% for ages 1-5 in Amoskeag Pool.

The catch-curve regression for the 2009 cohort of ages 1-3 Bluegill caught in Hooksett Pool was the only cohort-specific catch curve that was statistically significant (Figure 4.3.2-2, Z = 1.97; F = 569.9, P = 0.028). The annual mortality rate based on the Z estimate for the 2009 cohort of ages 1-3 Bluegill was 86% which was substantially higher than the annual mortality rates of the three pools based on the aggregate 2008-2013 catch, particularly Hooksett Pool.

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Bluegill collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2012 is presented in Table 4.3.2-8. The prevalence of external parasites was significantly greater in Garvins Pool than in either Hooksett or Amoskeag Pools during 2012.

2013— The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Bluegill collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 is presented in Table 4.3.2-9. The prevalence of external parasites was significantly greater in Garvins and Hooksett Pools than in Amoskeag Pool during 2013.

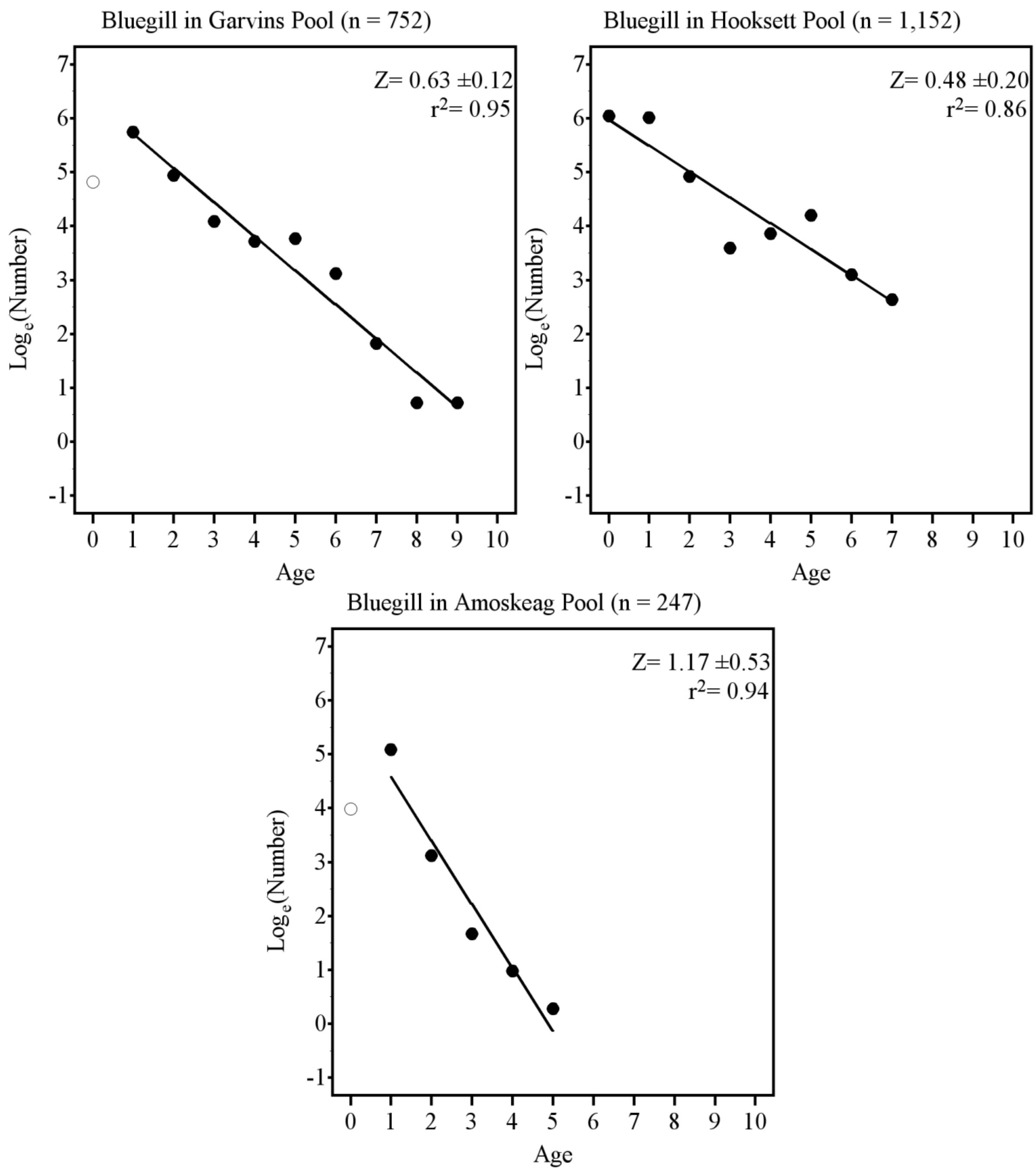

Figure 4.3.2-1. Catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Bluegill of fully recruited ages (solid circles) caught by electrofishing during August-September 2008-2013 in Garvins, Hooksett, and Amoskeag Pools, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: oldest ages in some cases were included to provide the minimum catch-at-age data needed for the best available instantaneous mortality estimate.

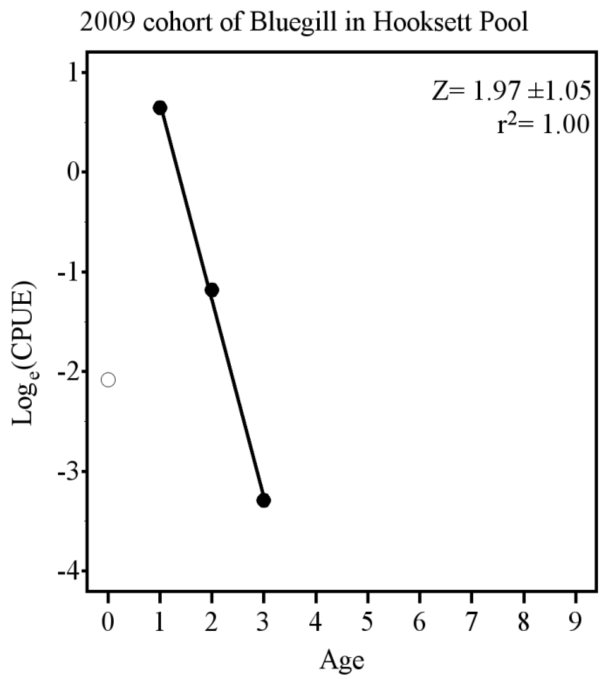

Figure 4.3.2-2. Catch curve estimate of instantaneous total mortality rate (Z ± 95% confidence intervals) for the 2009 cohort of Bluegill in Garvins Pool, Merrimack River, based on mean catch per unit effort (CPUE) at fully recruited ages (solid circles) from electrofishing samples collected during August-September of 2008-2013.

Table 4.3.2-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Bluegill collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

	Total Length (mm)					Weight (g)				
Pool	**N**	**Min.**	**Max.**	**Mean**	**SD**	**N**	**Min.**	**Max.**	**Mean**	**SD**
Garvins	232	40	245	124	40	215	2	355	56	52
Hooksett	212	41	248	104	49	198	2	380	45	69
Amoskeag	54	46	172	104	33	52	2	100	28	24
Total	**498**	**40**	**248**	**113**	**45**	**465**	**2**	**380**	**48**	**58**

Table 4.3.2-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Bluegill collected in Garvins and, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	417	27	221	101	33	387	3	226	28	38
Hooksett	571	35	250	89	35	521	2	295	22	45
Amoskeag	149	53	194	95	22	136	2	190	19	23
Total	**1,137**	**27**	**250**	**94**	**33**	**1,044**	**2**	**295**	**24**	**40**

Table 4.3.2-3. Regression statistics for total length (mm) vs. weight (g) for Bluegill from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations [a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	215	3.217	-5.163	0.99				
Hooksett	198	3.267	-5.244	0.99	NS		NS	
Amoskeag	52	3.119	-4.963	0.99	NS	*	NS	*

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.2-4. Regression statistics for total length (mm) vs. weight (g) for Bluegill from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	387	3.399	-5.562	0.98				
Hooksett	521	3.171	-5.116	0.97	*		*	
Amoskeag	136	3.31	-5.391	0.97	NS	NS	NS	NS

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.2-5. Regression statistics for total length (mm) vs. weight (g) for Bluegill sampled during August-September 1995, 2004, 2005, 2010, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]											
					Slope						Intercept					
					1995	2004	2005	2010	2011	2012	1995	2004	2005	2010	2011	2012
1995	306	2.912	-4.562	0.95												
2004	42	3.282	-5.274	0.98	*						*					
2005	95	3.152	-5.000	0.98	*	*					*	*				
2010	329	3.107	-4.926	0.98	*	*	NS				*	*	NS			
2011	306	3.310	-5.321	0.99	*	NS	*	*			*	NS	*	*		
2012	198	3.267	-5.244	0.99	*	NS	*	*	NS		*	NS	*	*	NS	
2013	521	3.171	-5.116	0.96	*	*	NS	NS	*	*	*	NS	NS	*	*	NS

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.2-6. Mean length at age (± 95% C.I.) for Bluegill captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2012	Garvins	B	28	52	3
		Hooksett	A	65	64	3
		Amoskeag	A	17	68	6
1	2011	Garvins	A	47	108	5
		Hooksett	A	39	112	6
		Amoskeag	A	26	112	6
2	2010	Garvins	A	45	148	5
		Hooksett	A	19	144	8
		Amoskeag		10	144	10
3	2009	Garvins		2	184	19
		Hooksett		3	180	19
		Amoskeag		1	168	
4	2008	Garvins		3	200	45
		Hooksett		7	208	10
5	2007	Garvins		1	216	
		Hooksett		9	220	10
6	2006	Garvins		1	208	
		Hooksett		1	208	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. ($\alpha = 0.05$). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.2-7. Mean length at age (± 95% C.I.) for Bluegill captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2013	Garvins		13	68	7
		Hooksett		31	56	3
		Amoskeag		14	72	5
1	2012	Garvins	A	51	92	4
		Hooksett	A	54	92	4
		Amoskeag	A	46	96	4
2	2011	Garvins		9	124	13
		Hooksett		16	132	11
		Amoskeag		1	140	
3	2010	Garvins		19	156	6
		Hooksett		6	160	27
4	2009	Garvins		13	160	8
		Hooksett		7	168	16
		Amoskeag		2	180	85
5	2008	Garvins		11	180	7
		Hooksett		9	204	9
6	2007	Garvins		7	184	9
		Hooksett		6	208	20
7	2006	Garvins		3	180	21
		Hooksett		3	232	22
9	2004	Garvins		1	220	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.2-8. Frequency distribution of external parasite loads for Bluegill collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	134	58.01	82	35.5	15	6.49
Hooksett [B]	172	81.13	38	17.92	2	0.94
Amoskeag [C]	51	94.44	3	5.56	0	0

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.2-9. Frequency distribution of external parasite loads for Bluegill collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	169	56.71	106	35.57	23	7.72
Hooksett [A]	334	61.28	184	33.76	27	4.95
Amoskeag [B]	107	78.1	25	18.25	5	3.65

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.3 Chain Pickerel

Biocharacteristics of the Chain Pickerel population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013. Biocharacteristics data available for Chain Pickerel captured during August-September 2012 and 2013 are limited to length, weight and external parasites. No scale samples were collected for age determination.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Chain Pickerel collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2012 are presented in Table 4.3.3-1.

2013— The mean, minimum, maximum and standard deviation of total length and total wet weight of Chain Pickerel collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2013 are presented in Table 4.3.3-2

Condition

2012—Length-weight relationships for Chain Pickerel in Garvins and Hooksett Pools based on the August-September 2012 catch are presented in Table 4.3.3-3. The slopes of the Garvins and Hooksett Pool length-weight curves derived from the August-September 2012 catch of Chain Pickerel did not differ significantly ($F = 0.94$, $P = 0.3340$, however, after assuming a common slope between the 2012 length-weight curves for Chain Pickerel collected in Garvins and Hooksett Pools, the y-intercept parameter from the Hooksett Pool length-weight relationship was significantly higher than the Garvins Pool estimate.

2013— Length-weight relationships for Chain Pickerel in Garvins and Hooksett Pools based on the August-September 2013 catch are presented in Table 4.3.3-4. The slopes of the Garvins and Hooksett Pool length-weight curves derived from the August-September catches of Chain Pickerel during 2013 did not differ significantly ($F = 0.12$, $P = 0.7286$). After assuming a common slope between the 2013 length-weight curves for Chain Pickerel collected in Garvins and Hooksett Pools, the y-intercept parameter from the Hooksett Pool length-weight relationship did not differ significantly from the Garvins Pool estimate.

Comparison among years in Hooksett Pool—Length-weight relationships for Chain Pickerel collected from Hooksett Pool during the years 2011 through 2013 are presented in Table 4.3.3-5. The slopes of the annual length-weight curves of Chain Pickerel caught in Hooksett Pool during August-September did not significantly differ among these three years ($F = 0.25$, $P = 0.7789$). After assuming a common slope among the three length-weight curves, the y-intercept parameter from the 2011 length-weight relationship was significantly higher than the 2013 estimate.

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Chain Pickerel collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2012 is presented in Table 4.3.3-6.

The prevalence of external parasites was significantly greater in Hooksett Pool than in either Garvins or Amoskeag Pools during 2012.

2013— The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Chain Pickerel collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 is presented in Table 4.3.3-7. There was no significant difference in the prevalence of external parasites in Hooksett Pool relative to the distribution observed in Garvins Pool during 2013.

Table 4.3.3-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Chain Pickerel collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

	Total Length (mm)					Weight (g)				
Pool	**N**	**Min.**	**Max.**	**Mean**	**SD**	**N**	**Min.**	**Max.**	**Mean**	**SD**
Garvins	88	66	478	200	86	86	3	660	74	123
Hooksett	18	121	532	263	111	17	10	1015	185	256
Amoskeag	3	146	208	174	31	3	16	45	28	15
Total	**109**	**66**	**532**	**209**	**92**	**106**	**3**	**1015**	**91**	**155**

Table 4.3.3-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Chain Pickerel collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

	Total Length (mm)					Weight (g)				
Pool	**N**	**Min.**	**Max.**	**Mean**	**SD**	**N**	**Min.**	**Max.**	**Mean**	**SD**
Garvins	83	58	509	172	103	69	2	740	80	149
Hooksett	38	82	508	164	78	36	3	800	50	135
Amoskeag	6	102	261	164	75	6	5	100	39	48
Total	**127**	**58**	**509**	**169**	**94**	**111**	**2**	**800**	**68**	**141**

Table 4.3.3-3. Regression statistics for total length (mm) vs. weight (g) for Chain Pickerel from Garvins and Hooksett Pools during August-September 2012.

Pool	N	Slope (b) [b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	81	3.114	-5.553	0.99		NS		*
Hooksett	17	3.114	-5.525	0.99	NS		*	

Notes: If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

[a]Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.3-4. Regression statistics for total length (mm) vs. weight (g) for Chain Pickerel from Garvins and Hooksett Pools during August-September 2013.

Pool	N	Slope (b)[b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	69	3.163	-5.661	0.99		NS		NS
Hooksett	36	3.163	-5.672	0.98	NS		NS	

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.3-5. Regression statistics for total length (mm) vs. weight (g) for Chain Pickerel sampled during August-September 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)[b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					2011	2012	2011	2012
2011	25	3.159	-5.628	0.99				
2012	17	3.159	-5.632	0.99	NS		NS	
2013	36	3.159	-5.663	0.99	NS	NS	*	NS

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.3-6. Frequency distribution of external parasite loads for Chain Pickerel collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	30	34.09	39	44.32	19	21.59
Hooksett [B]	5	27.78	11	61.11	2	11.11
Amoskeag [C]	2	66.67	1	33.33	0	0

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.3-7. Frequency distribution of external parasite loads for Chain Pickerel collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	38	56.72	20	29.85	9	13.43
Hooksett [A]	24	68.57	9	25.71	2	5.71
Amoskeag	3	60	1	20	1	20

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.4 Fallfish

Biocharacteristics of the Fallfish population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Fallfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2012 are presented in Table 4.3.4-1.

2013— The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Fallfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2013 are presented in Table 4.3.4-2.

Condition

2012—The length-weight relationships for Hooksett and Garvins Pools based on the 2012 catch are presented in Table 4.3.4-3. The slope parameter for Fallfish collected in Garvins Pool was significantly greater than for Hooksett Pool, however, the *y*-intercept parameter for Fallfish in Hooksett Pool was significantly greater than the 2012 Garvins Pool estimate.

2013— The length-weight relationships for Hooksett and Amoskeag Pools based on the 2013 catch are presented in Table 4.3.4-4. The slopes of the Hooksett and Amoskeag Pool length-weight curves did not differ significantly (F=2.99, P=0.0847). After assuming a common slope between the 2013 length-weight curves for Fallfish collected in Amoskeag and Hooksett Pools, the *y*-intercept parameter from the Amoskeag Pool length-weight curve was significantly higher than the Hooksett Pool estimate.

Comparison among years in Hooksett Pool—The length-weight relationships for Hooksett Pool for the available years between 2004 and 2013 are presented in Table 4.3.4-5. The slope and y-intercept parameters for 2013 differed significantly from those for 2010-2012, but were not significantly different from the parameters for 2004 and 2005, the two earliest years with adequate data for comparison.

Age-Length

2012—The mean total length at age (±95% C.I.) of Fallfish collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September, 2012 is presented in Table 4.3.4-6. The age of Fallfish ranged from age 0 to age 3 in Garvins Pool, age 0 to age 4 in Hooksett Pool, and age 1 to age 3 in Amoskeag Pool. The mean total length of age-0 Fallfish was not significantly different between Garvins and Hooksett Pools. Mean length of Fallfish was not compared among pools for other age groups because sample sizes were insufficient (n<15).

2013— The mean total length at age (±95% C.I.) of Fallfish collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September, 2013 is presented in Table 4.3.4-7. The age of Fallfish ranged from age-1 to age-2 in Garvins Pool, age-0 to age-4 in Hooksett Pool, and age-1 to age-3 in Amoskeag Pool. The mean total length of age-1 Fallfish was significantly larger in Amoskeag Pool than it was in Hooksett Pool. Insufficient sample sizes ($n<15$) prevented the pairwise comparison of mean length between pools age-2 Fallfish among Garvins, Hooksett, and Amoskeag Pools as well as age-3 Fallfish between Hooksett and Amoskeag Pools.

Mortality

Catch curves used to estimate instantaneous mortality rate (Z) for Fallfish caught by electrofishing in each Merrimack River pool during August-September 2008-2013 are shown in Figure 4.3.4-1. The catch-curve regression for Fallfish was statistically significant for ages 0-6 in Garvins Pool ($Z = 0.68$; $F = 76.3$, $P = 0.001$) and ages 2-6 in Hooksett Pool ($Z = 1.21$; $F = 1{,}593.4$, $P = 0.001$), but was not statistically significant for ages 1-3 in Amoskeag Pool ($Z = 0.80$; $F = 15.1$, $P = 0.160$). There was a significant difference in total instantaneous mortality of Fallfish among Merrimack River pools (ANCOVA, $F = 9.3$, $P = 0.011$). The Z for ages 2-6 Fallfish from Hooksett Pool was significantly higher than the Z for ages 0-6 in Garvins Pool ($t = 4.32$, $P = 0.004$), but was not significantly different from the Z for ages 1-3 in Amoskeag Pool ($t = -1.68$, $P = 0.138$). The Z estimates for Fallfish from Garvins and Amoskeag Pools were not significantly different ($t = 0.54$, $P = 0.606$). The annual mortality rates of Fallfish based on estimates of Z were 49% for ages 0-6 in Garvins Pool, 70% for ages 2-6 in Hooksett Pool, and 55% for ages 1-3 in Amoskeag Pool.

There were no significant regressions for cohort-specific catch curves of Fallfish based on electrofishing catch during August-September from 2008 through 2013 ($P > 0.05$).

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Fallfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2012 is presented in Table 4.3.4-8. The prevalence of external parasites was significantly greater in Hooksett Pool than in either Garvins or Amoskeag Pools during 2012.

2013— The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Fallfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2013 is presented in Table 4.3.4-9. The prevalence of external parasites was significantly greater in Hooksett and Garvins Pools than in Amoskeag Pools during 2013. The prevalence of external parasites did not differ significantly between Fallfish sampled in Garvins and Hooksett Pools during 2013.

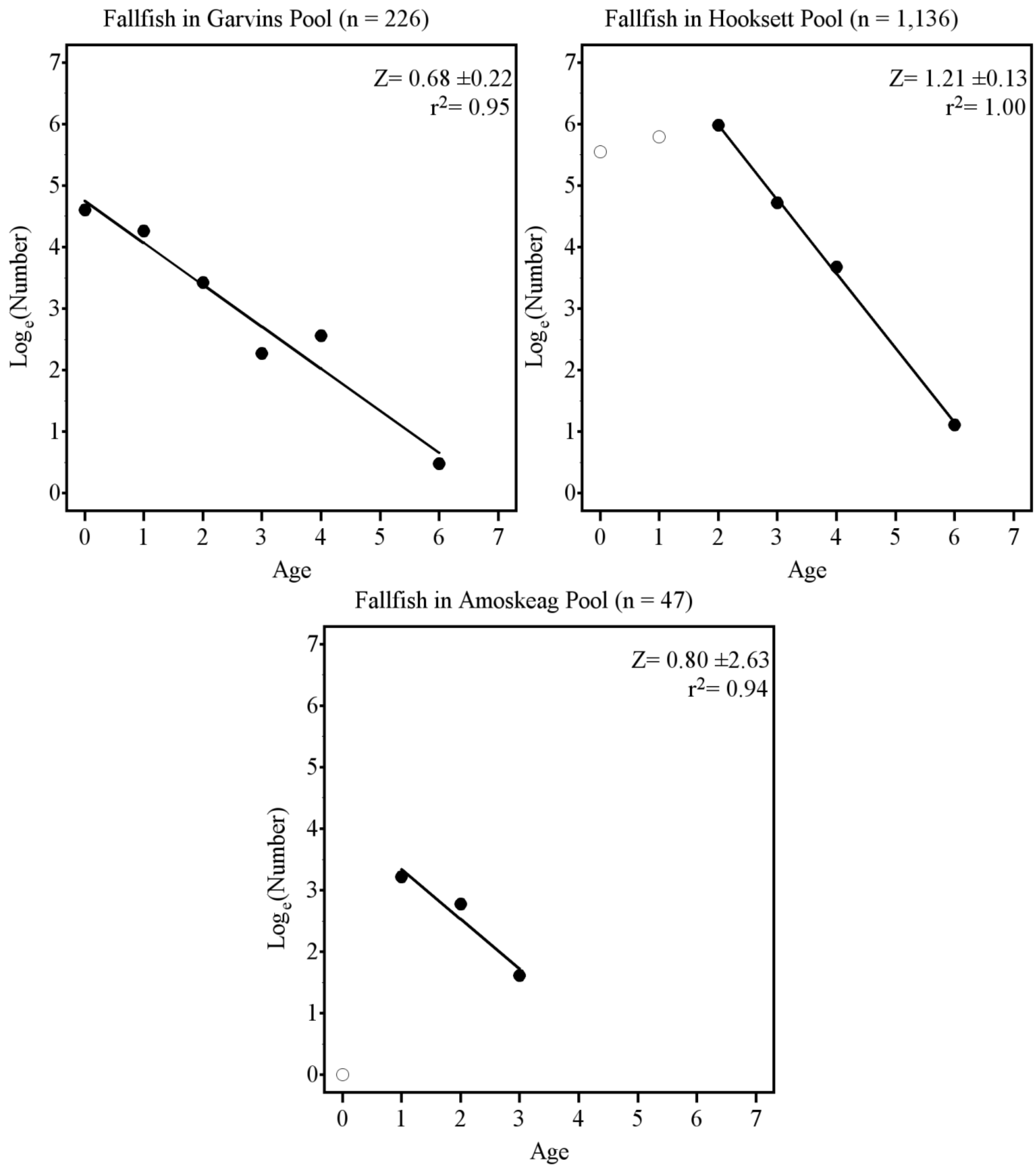

Figure 4.3.4-1. Catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Fallfish of fully recruited ages (solid circles) caught by electrofishing during August-September 2008-2013 in Garvins, Hooksett, and Amoskeag Pools, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: oldest ages in some cases were included to provide the minimum catch-at-age data needed for the best available instantaneous mortality estimate.

Table 4.3.4-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Fallfish collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	127	46	210	73	28	88	2	94	7	18
Hooksett	253	45	222	120	53	223	2	124	31	29
Amoskeag	12	107	237	158	47	12	12	136	51	42
Total	**392**	**45**	**237**	**106**	**52**	**323**	**2**	**136**	**25**	**29**

Table 4.3.4-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Fallfish collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	8	90	133	115	14	8	4	21	13	6
Hooksett	361	81	255	127	30	339	4	155	22	23
Amoskeag	24	106	242	131	26	22	13	140	26	26
Total	**393**	**81**	**255**	**127**	**29**	**369**	**4**	**155**	**22**	**23**

Table 4.3.4-3. Regression statistics for total length (mm) vs. weight (g) for Fallfish from Garvins and Hooksett Pools during August-September 2012.

Pool	N	Slope[b] (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	85	3.257	-5.620	0.97		*		*
Hooksett	223	3.098	-5.211	0.99	*		*	

Notes: If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slop did not differ significantly between pools, ANCOVA tested for difference in elevation.
[a]Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$
[b] Assumed common slope due to non-significant finding

Table 4.3.4-4. Regression statistics for total length (mm) vs. weight (g) for Fallfish from Garvins and Amoskeag Pools during August-September 2013.

Pool	N	Slope (b)[b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Hooksett	Amoskeag	Hooksett	Amoskeag
Hooksett	339	3.204	-5.504	0.97		NS		*
Amoskeag	22	3.204	-5.452	0.96	NS		*	

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slop did not differ significantly between pools, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$
[b] Assumed common slope due to non-significant finding

Table 4.3.4-5. Regression statistics for total length (mm) vs. weight (g) for fallfish sampled during August-September 2004, 2005, 2010, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]									
					Slope					Intercept				
					2004	2005	2010	2011	2012	2004	2005	2010	2011	2012
2004	26	3.172	-5.356	0.94										
2005	24	3.340	-5.771	0.92	NS					NS				
2010	37	3.050	-5.108	>0.99	NS	*				NS	*			
2011	493	3.128	-5.282	0.98	NS	NS	NS			NS	*	NS		
2012	223	3.098	-5.211	0.99	NS	*	NS	NS		NS	*	NS	NS	
2013	339	3.215	-5.527	0.97	NS	NS	*	*	*	NS	NS	*	*	*

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$

Table 4.3.4-6. Mean length at age (± 95% C.I.) for Fallfish captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August and September 2012.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2012	Garvins	A	48	64	2
		Hooksett	A	52	68	3
1	2011	Garvins		3	92	21
		Hooksett		32	120	4
		Amoskeag		7	124	12
2	2010	Garvins		3	172	42
		Hooksett		54	168	4
		Amoskeag		2	188	44
3	2009	Garvins		3	204	15
		Hooksett		13	200	8
		Amoskeag		2	220	101
4	2008	Hooksett		1	200	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.4-7. Mean length at age (± 95% C.I.) for Fallfish captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August and September 2013.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2013	Hooksett		2	84	9
1	2012	Garvins		6	108	9
		Hooksett	B	52	108	4
		Amoskeag	A	16	124	5
2	2011	Garvins		2	132	9
		Hooksett		33	152	5
		Amoskeag		5	136	11
3	2010	Hooksett		11	204	11
		Amoskeag		1	244	
4	2009	Hooksett		10	228	13

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.4-8. Frequency distribution of external parasite loads for Fallfish collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	122	96.06	5	3.94	0	0
Hooksett [B]	158	62.95	81	32.27	12	4.78
Amoskeag [C]	10	83.33	2	16.67	0	0

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.4-9. Frequency distribution of external parasite loads for Fallfish collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	5	83.3	1	16.7	0	0
Hooksett [A]	262	79.9	64	19.5	2	0.6
Amoskeag [B]	20	100.0	0	0	0	0

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.5 Largemouth Bass

Biocharacteristics of the Largemouth Bass population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Largemouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during 2012 are presented in Table 4.3.5-1.

2013— The mean, minimum, maximum and standard deviation of total length and total wet weight of Largemouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during 2013 are presented in Table 4.3.5-2.

Condition

2012—Length-weight relationships for Largemouth Bass in Garvins, Hooksett and Amoskeag Pools based on the August-September catch in 2012 are presented in Table 4.3.5-3. The slope parameters for the three pools were not significantly different ($F = 0.74$, $P = 0.4762$). After assuming a common slope among all 2012 Largemouth Bass length-weight curves, the *y*-intercept parameters from Garvins, Hooksett and Amoskeag Pools did not differ significantly from one another.

2013— Length-weight relationships for Largemouth Bass based in Garvins, Hooksett, and Amoskeag Pools based on the August-September 2013 catch are presented in Table 4.3.5-4. The slope and *y*-intercept parameters for Garvins Pool and Hooksett Pool were not significantly different from each other; however, the slope and *y*-intercept parameters for both of these pools were significantly different from the parameters for Amoskeag Pool.

Comparison among years in Hooksett Pool—Length-weight relationships for Largemouth Bass in Hooksett Pool based on the available years from 1995 through 2013 are presented in Table 4.3.5-5. The slope and y-intercept parameters for 1995 were significantly different from the corresponding parameters for all other years. However, the slope and *y*-intercept parameters for the three most recent years (2011 through 2013) were not significantly different from each other.

Age-Length

2012—The mean total length at age (±95% C.I.) of Largemouth Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September, 2012 is presented in Table 4.3.5-6. The age of Largemouth Bass ranged from age 0 to age 9 in Garvins Pool, from age 0 to age 11 in Hooksett Pool, and from age 0 to age 2 in Amoskeag Pool. The mean total length of age-0 Largemouth Bass was not significantly different among the three pools, but the mean length of age-1 Largemouth Bass was significantly lower in Amoskeag Pool than in Garvins and Hooksett Pools. There was no significant difference in mean length of age-2 Largemouth Bass between Garvins and Hooksett Pools.

Insufficient sample size (n<15) prevented all other pairwise comparisons of mean length-at-age between pools.

***2013*—** The mean total length at age of Largemouth Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September, 2013 is presented in Table 4.3.5-7. The age of Largemouth Bass ranged from age-0 to age-9 in Garvins Pool, from age-0 to age-10 in Hooksett Pool, and from age 0-to age-1 in Amoskeag Pool. The mean total length of age-0 Largemouth Bass did not differ significantly among the three pools. Insufficient sample sizes (n<15) prevented the pairwise comparison of mean length between age-1 Largemouth Bass among Garvins, Hooksett, and Amoskeag Pools as well as age-2, age-4, age-5, and age-9 Largemouth Bass between Hooksett and Amoskeag Pools.

Mortality

Catch curves used to estimate instantaneous mortality rate (Z) for Largemouth Bass caught by electrofishing in each Merrimack River pool during August-September 2008-2013 are shown in Figure 4.3.5-1. The catch-curve regression for Largemouth Bass was statistically significant for ages 0-9 in Garvins Pool ($Z = 0.52$; $F = 44.2$, $P < 0.001$), ages 0-11 in Hooksett Pool ($Z = 0.41$; $F = 74.8$, $P < 0.001$), and ages 0-3 in Amoskeag Pool ($Z = 1.17$; $F = 37.8$, $P = 0.026$). There was a significant difference in total instantaneous mortality of Largemouth Bass among Merrimack River pools (ANCOVA, $F = 4.12$, $P = 0.032$). The Z for ages 0-3 Largemouth Bass from Amoskeag Pool was significantly higher than the Z for ages 0-9 in Garvins Pool ($t = 2.29$, $P = 0.033$) and Hooksett Pool ($t = 2.71$, $P = 0.014$). The Z estimates for Largemouth Bass from Garvins and Hooksett Pools were not significantly different ($t = -1.26$, $P = 0.223$). The annual mortality rates of Largemouth Bass based on estimates of Z were 41% for ages 0-9 in Garvins Pool, 34% for ages 0-11 in Hooksett Pool, and 69% for ages 0-3 in Amoskeag Pool.

There were no significant regressions for cohort-specific catch curves of Largemouth Bass based on electrofishing catch during August-September from 2008 through 2013 ($P > 0.05$).

Parasitism

***2012*—**The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Largemouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2012 is presented in Table 4.3.5-8. The prevalence of external parasites was significantly greater in Amoskeag Pool than in either Garvins or Hooksett Pools during 2012. There were no significant differences in the prevalence of external parasites among Largemouth Bass sampled in Garvins and Hooksett Pools during 2012.

***2013*—** The frequency distribution of external parasite loads for Largemouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 is presented in Table 4.3.5-9. The prevalence of external parasites was significantly greater in Amoskeag Pool than in either Garvins or Hooksett Pools during 2013. There were no significant differences in the prevalence of external parasites among Largemouth Bass sampled in Garvins and Hooksett Pools during 2013.

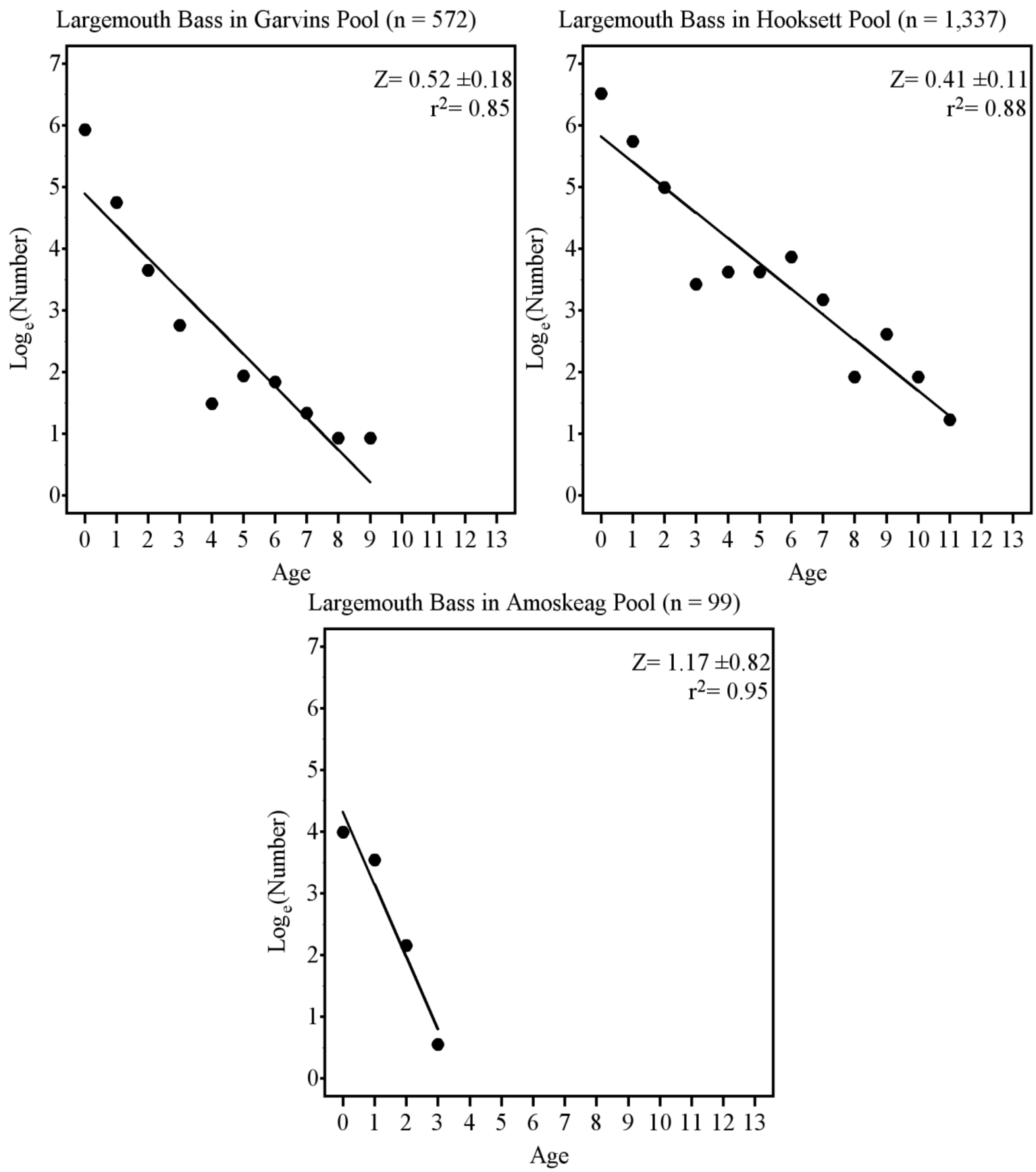

Figure 4.3.5-1. Catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Largemouth Bass of fully recruited ages (solid circles) caught by electrofishing during August-September 2008-2013 in Garvins, Hooksett, and Amoskeag Pools, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: oldest ages in some cases were included to provide the minimum catch-at-age data needed for the best available instantaneous mortality estimate.

Table 4.3.5-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Largemouth Bass collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	319	54	500	124	77	301	2	1825	72	235
Hooksett	721	41	578	126	72	689	2	3250	75	288
Amoskeag	73	72	224	98	23	70	4	123	14	17
Total	**1113**	**41**	**578**	**124**	**72**	**1060**	**2**	**3250**	**70**	**264**

Table 4.3.5-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Largemouth Bass collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	155	42	524	122	104	122	2	2,600	150	410
Hooksett	207	28	535	111	100	182	2	2,500	123	384
Amoskeag	23	44	161	96	35	20	3	51	16	16
Total	**385**	**28**	**535**	**115**	**99**	**324**	**2**	**2,600**	**127**	**383**

Table 4.3.5-3. Regression statistics for total length (mm) vs. weight (g) for Largemouth Bass from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Pool	N	Slope (b)[b]	Intercept ($\log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	301	3.125	-5.178	0.99				
Hooksett	689	3.125	-5.177	0.99	NS		NS	
Amoskeag	70	3.125	-5.179	0.94	NS	NS	NS	NS

Notes: If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

[a]Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.5-4. Regression statistics for total length (mm) vs. weight (g) for Largemouth Bass from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	122	3.105	-5.125	1				
Hooksett	182	3.108	-5.135	0.99	NS		NS	
Amoskeag	20	2.775	-4.464	0.99	*	*	*	*

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.5-5. Regression statistics for total length (mm) vs. weight (g) for Largemouth Bass sampled during August-September 1995, 2004, 2005, 2010, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]											
					Slope						Intercept					
					1995	2004	2005	2010	2011	2012	1995	2004	2005	2010	2011	2012
1995	111	3.456	-5.926	0.94												
2004	164	3.04	-4.962	0.97	*						*					
2005	115	3.019	-4.907	0.97	*	NS					*	NS				
2010	852	3.042	-4.985	0.99	*	NS	NS				*	NS	NS			
2011	383	3.094	-5.106	0.99	*	NS	*	*			*	*	*	*		
2012	689	3.125	-5163	0.99	*	*	*	*	NS		*	*	*	*	NS	
2013	182	3.108	-5.135	0.99	*	*	*	*	NS	NS	*	*	*	*	NS	NS

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.5-6. Mean length at age (± 95% C.I.) for Largemouth Bass captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
		Garvins	A	172	84	1
		Hooksett	A	276	84	1
0	2012	Amoskeag	A	46	88	2
		Garvins	A	46	132	7
		Hooksett	A	51	128	6
1	2011	Amoskeag	B	23	108	4
		Garvins	A	23	192	12
		Hooksett	A	27	200	13
2	2010	Amoskeag		3	188	58
		Garvins		4	192	22
3	2009	Hooksett		5	272	77
		Garvins		2	360	218
4	2008	Hooksett		6	332	41
		Garvins		3	408	98
5	2007	Hooksett		3	316	130
		Garvins		4	412	36
6	2006	Hooksett		3	452	137
		Garvins		2	468	158
7	2005	Hooksett		5	440	22
8	2004	Hooksett		2	408	123
		Garvins		2	480	133
9	2003	Hooksett		1	576	
10	2002	Hooksett		1	520	
11	2001	Hooksett		1	580	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.5-7. Mean length at age (± 95% C.I.) for Largemouth Bass captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2013	Garvins	A	116	72	2
		Hooksett	A	173	76	2
		Amoskeag	A	16	76	5
1	2012	Garvins		13	164	13
		Hooksett		10	160	14
		Amoskeag		7	144	11
2	2011	Garvins		8	240	17
		Hooksett		6	216	37
3	2010	Garvins		7	316	27
4	2009	Garvins		2	356	79
		Hooksett		2	368	19
5	2008	Garvins		2	368	164
		Hooksett		4	412	30
6	2007	Hooksett		5	396	18
8	2005	Garvins		3	504	39
9	2004	Garvins		2	472	13
		Hooksett		3	512	33
10	2003	Hooksett		1	512	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.5-8. Frequency distribution of external parasite loads for Largemouth Bass collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	67	21	132	41.38	120	37.62
Hooksett [A]	105	14.56	317	43.97	299	41.47
Amoskeag [B]	5	6.85	26	35.62	42	57.53

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.5-9. Frequency distribution of external parasite loads for Largemouth Bass collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	59	48.8	36	29.8	26	21.5
Hooksett [A]	101	50.8	69	34.7	29	14.6
Amoskeag [B]	7	30.4	14	60.9	2	8.7

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.6 Pumpkinseed

Biocharacteristics of the Pumpkinseed population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Pumpkinseed collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2012 are presented in Table 4.3.6-1

2013— The mean, minimum, maximum and standard deviation of total length and total wet weight of Pumpkinseed collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2013 are presented in Table 4.3.6-2.

Condition

2012—Length-weight relationships for Pumpkinseed caught in Garvins, Hooksett and Amoskeag Pools during August-September 2012 are presented in Table 4.3.6-3. The slope parameters for the three pools did not differ significantly ($F = 0.02$, $P = 0.9814$), However, after assuming a common slope among all 2012 Pumpkinseed length-weight curves, the *y*-intercept parameter from the Hooksett Pool length-weight relationship was significantly higher than either the Garvins and Amoskeag Pool estimates.

2013— Length-weight relationships for Pumpkinseed caught in Garvins, Hooksett, and Amoskeag Pools during August-September 2013 are presented in Table 4.3.6-4. The slopes of the length-weight curves for Pumpkinseed caught during August-September 2013 varied among pools. The slope and *y*-intercept parameters for Garvins and Hooksett Pools were significantly different from each other; however, there were no significant differences between the parameter values for these two pools and the parameter values for Amoskeag Pool.

Comparison among years in Hooksett Pool—Length-weight relationships for Pumpkinseed caught in Hooksett Pool during August-September of the available years from 1995 through 2013 are presented in Table 4.3.6-5. The slopes of the length-weight curves for Pumpkinseed caught in Hooksett Pool were not significantly different among years ($F = 1.17$, $P = 0.3241$). After assuming a common slope among all annual length-weight curves, the *y*-intercept parameter from the 2013 length-weight relationship was significantly lower than the estimates for 1995, 2005, 2010, and 2011.

Age-Length

2012—The mean total length at age (±95% C.I.) of Pumpkinseed collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September 2012 is presented in Table 4.3.6-6. The age of Pumpkinseed ranged from age 0 to age 4 in Garvins Pool, from age 0 to age 2 in Hooksett Pool, and from age 1 to age 3 in Amoskeag Pool. The mean total length of age-1 Pumpkinseed was not significantly different between Garvins and

Amoskeag Pools. Insufficient sample size (n<15) prevented all other pairwise comparisons of mean length-at-age between pools.

2013— The mean total length at age of Pumpkinseed collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September 2013 is presented in Table 4.3.6-7. Ages of collected Pumpkinseed ranged from age-0 to age-6 in Garvins Pool, from age-0 to age-3 in Hooksett Pool and from age-0 to age-3 in Amoskeag Pool. The mean total length of age-1 Pumpkinseed collected during 2013 was significantly higher in Garvins and Amoskeag Pools than that observed in Hooksett Pool. Insufficient sample sizes (n<15) prevented the pairwise comparison of mean length between age-0, age-2, and age-3 Pumpkinseed among Garvins, Hooksett, and Amoskeag Pools.

Mortality

Catch curves used to estimate instantaneous mortality rate (Z) for Pumpkinseed caught by electrofishing in each Merrimack River pool during August-September 2008-2013 are shown in Figure 4.3.6-1. The catch-curve regression for Pumpkinseed was statistically significant for ages 1-7 in Garvins Pool ($Z = 0.85$; $F = 129.2$, $P < 0.001$) and ages 1-4 in Amoskeag Pool ($Z = 1.12$; $F = 35.9$, $P = 0.027$), but not statistically significant for ages 1-3 in Hooksett Pool ($Z = 2.02$; $F = 55.8$, $P = 0.085$). There was no significant difference in total instantaneous mortality of Pumpkinseed between Garvins and Amoskeag Pools (ANCOVA, $F = 1.91$, $P = 0.210$). The annual mortality rates of Pumpkinseed based on estimates of Z were 57% for ages 1-7 in Garvins Pool, 87% for ages 1-3 in Hooksett Pool, and 67% for ages 1-4 in Amoskeag Pool.

The catch-curve regression for the 2007 cohort of ages 1-4 Pumpkinseed caught in Garvins Pool was the only cohort-specific catch curve that was statistically significant (Figure 4.3.6-2, $Z = 1.29$; $F = 31.1$, $P = 0.031$). The annual mortality rate based on the Z estimate for the 2007 cohort of ages 1-4 Pumpkinseed was 73%, which was within the range of annual mortality rates of the three pools based on the aggregate 2008-2013 catch.

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Pumpkinseed collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2012 is presented in Table 4.3.6-8. The prevalence of external parasites was significantly greater in Garvins Pool than in either Hooksett or Amoskeag Pools during 2012.

2013— The frequency distribution of external parasite loads for Pumpkinseed collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 is presented in Table 4.3.6-9. The prevalence of external parasites was significantly greater in Garvins Pool than in either Hooksett or Amoskeag Pools during 2013. There were no significant differences in the prevalence of external parasites among Pumpkinseed sampled in Amoskeag and Hooksett Pools during 2013.

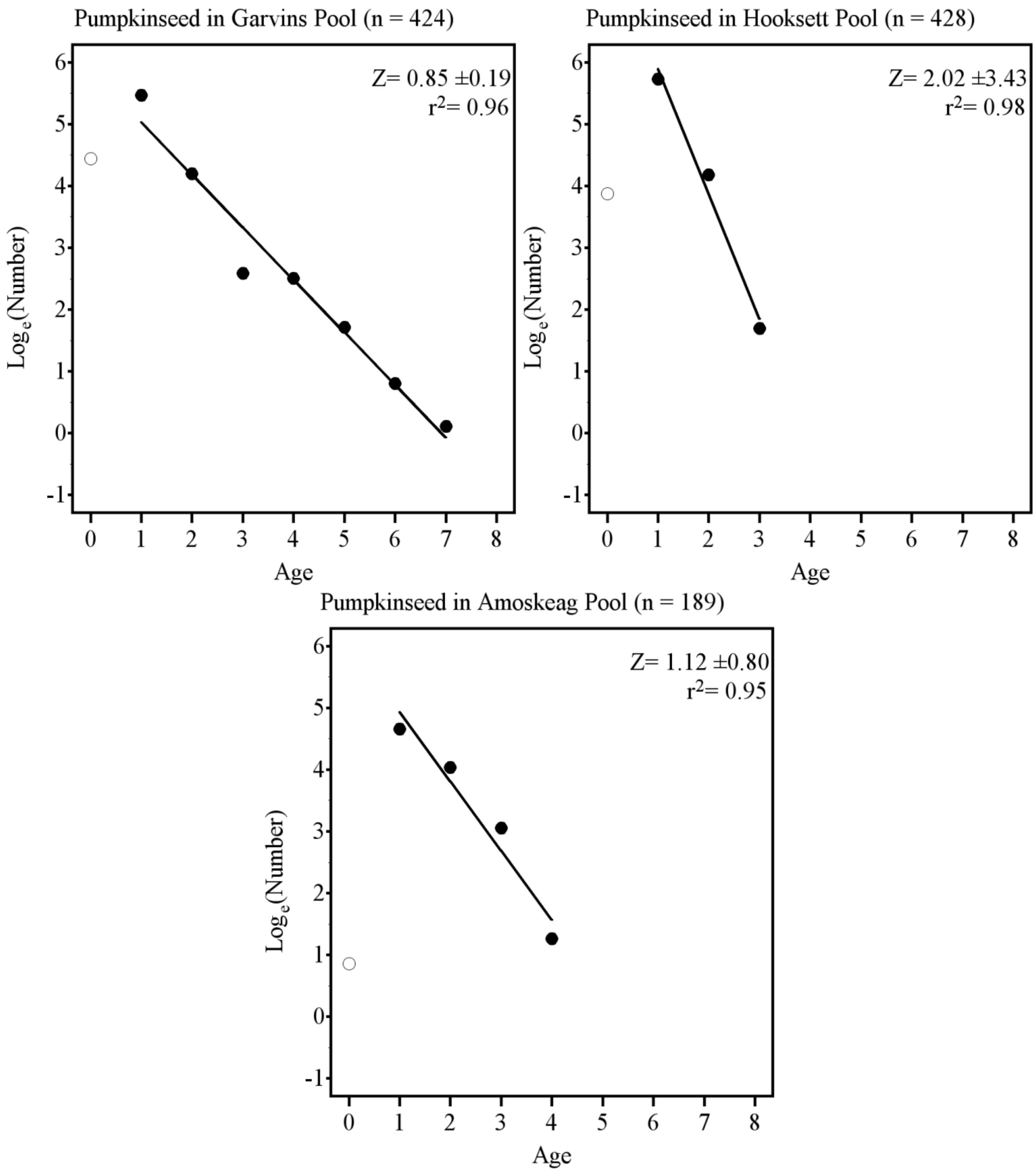

Figure 4.3.6-1. Catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Pumpkinseed of fully recruited ages (solid circles) caught by electrofishing during August-September 2008-2013 in Garvins, Hooksett, and Amoskeag Pools, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles).

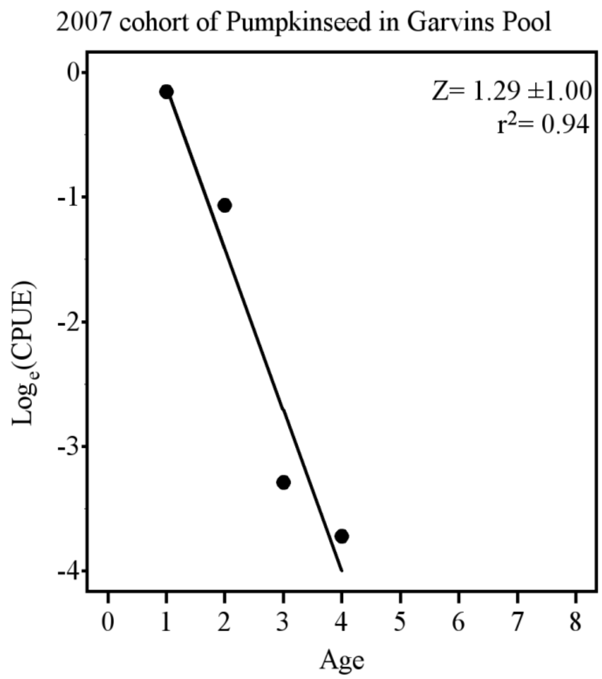

Figure 4.3.6-2. Catch curve estimate of instantaneous total mortality rate (Z ± 95% confidence intervals) for the 2007 cohort of Pumpkinseed in Garvins Pool, Merrimack River, based on mean catch per unit effort (CPUE) at fully recruited ages (solid circles) from electrofishing samples collected during August-September of 2008-2013.

Table 4.3.6-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Pumpkinseed collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	108	45	189	104	35	103	2	153	31	28
Hooksett	35	47	141	93	24	34	2	66	20	17
Amoskeag	39	79	154	111	18	37	7	67	28	16
Total	**182**	**45**	**189**	**103**	**31**	**174**	**2**	**153**	**28**	**24**

Table 4.3.6-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Pumpkinseed collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	219	55	192	84	24	188	2	154	16	24
Hooksett	312	48	118	74	11	292	2	24	7	4
Amoskeag	125	55	144	90	18	120	3	70	14	11
Total	**656**	**48**	**192**	**81**	**19**	**600**	**2**	**154**	**11**	**15**

Table 4.3.6-3. Regression statistics for total length (mm) vs. weight (g) for Pumpkinseed from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Pool	N	Slope[b] (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	103	3.299	-5.333	1				
Hooksett	34	3.299	-5.307	1	NS		*	
Amoskeag	37	3.299	-5.357	1	NS	NS	NS	*

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b]Assumed common slope due to non-significant finding

Table 4.3.6-4. Regression statistics for total length (mm) vs. weight (g) for Pumpkinseed from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	188	3.435	-5.627	0.96				
Hooksett	292	3.072	-4.933	0.87	*		*	
Amoskeag	120	3.261	-5.292	0.94	NS	NS	NS	NS

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.6-5. Regression statistics for total length (mm) vs. weight (g) for Pumpkinseed sampled during August-September 1995, 2005, 2010, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope[b] (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]									
					Slope					Intercept				
					1995	2005	2010	2011	2012	1995	2005	2010	2011	2012
1995	17	3.135	-4.954	0.95										
2005	17	3.135	-4.970	0.72	NS					NS				
2010	31	3.135	-4.971	0.99	NS	NS				NS	NS			
2011	77	3.135	-5.001	0.98	NS	NS	NS			*	NS	NS		
2012	34	3.135	-4.984	0.98	NS	NS	NS	NS		NS	NS	NS	NS	
2013	292	3.135	-5.049	0.87	NS	NS	NS	NS	NS	*	*	*	*	*

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.6-6. Mean length at age (± 95% C.I.) for Pumpkinseed captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2012	Garvins		22	64	9
		Hooksett		8	68	9
1	2011	Garvins	A	40	92	5
		Hooksett		14	88	6
		Amoskeag	A	20	100	5
2	2010	Garvins		35	132	4
		Hooksett		11	120	8
		Amoskeag		12	116	8
3	2009	Garvins		4	156	16
		Amoskeag		5	136	15
4	2008	Garvins		2	180	63

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.6-7. Mean length at age (± 95% C.I.) for Pumpkinseed captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2013	Garvins		4	60	6
		Hooksett		9	60	8
		Amoskeag		2	72	19
1	2012	Garvins	A	40	84	4
		Hooksett	B	57	76	3
		Amoskeag	A	46	88	4
2	2011	Garvins		14	104	3
		Hooksett		5	96	12
		Amoskeag		16	112	8
3	2010	Garvins		2	144	76
		Hooksett		1	120	
		Amoskeag		2	128	95
4	2009	Garvins		4	172	23
5	2008	Garvins		2	168	44
6	2007	Garvins		1	176	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.6-8. Frequency distribution of external parasite loads for Pumpkinseed collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	45	41.67	41	37.96	22	20.37
Hooksett [B]	21	60	10	28.57	4	11.43
Amoskeag [C]	34	87.18	5	12.82	0	0

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.6-9. Frequency distribution of external parasite loads for Pumpkinseed collected from Garvins, Hooksett and Amoskeag Pools during August-September, 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	66	44.3	55	36.91	28	18.79
Hooksett [B]	191	63.25	92	30.46	19	6.29
Amoskeag [B]	84	72.41	27	23.28	5	4.31

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.7 Redbreast Sunfish

Biocharacteristics of the Redbreast Sunfish population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013. Biocharacteristics data available for Redbreast Sunfish captured during August-September 2012 and 2013 are limited to length, weight and external parasites. No scale samples were collected for age determination.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Redbreast Sunfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2012 are presented in Table 4.3.7-1.

2013—The mean, minimum, maximum and standard deviation of total length and total wet weight of Redbreast Sunfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2013 are presented in Table 4.3.7-2.

Condition

2012—Length-weight relationships for Redbreast Sunfish based on the August-September 2012 catch in Garvins, Hooksett, and Amoskeag Pools are presented in Table 4.3.7-3. The slope and *y*-intercept parameters for Garvins Pool were both significantly different from the parameters for Hooksett Pool and Amoskeag Pool. The slope and *y*-intercept parameters for Hooksett Pool and Amoskeag Pool were not significantly different from each other.

2013— Length-weight relationships for Redbreast Sunfish based on the August-September 2013 catch in Garvins, Hooksett, and Amoskeag Pools are presented in Table 4.3.7-4. The slopes of the length-weight curves derived from the August-September 2013 catch data did not differ significantly (F=2.41, P=0.091). Assuming a common slope, the *y*-intercept parameters from the Garvins and Amoskeag Pool length-weight relationships were significantly different from the Hooksett Pool estimate.

Comparison among years in Hooksett Pool— Length-weight relationships for Redbreast Sunfish in Hooksett Pool based on the available years from 1995-2013 are presented in Table 4.3.7-5. The slope parameter for 1995 was higher than in any other year, and the *y*-intercept parameter for 1995 was lower than in any other year. The slope and *y*-intercept parameters for 1995 were significantly different from all other years except 2005. Otherwise, there were no particular patterns in the between-year comparisons for Hooksett Pool.

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Redbreast Sunfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2012 is presented in Table 4.3.7-6. There were no significant differences among the frequency distributions of external parasites among the three sampling locales during 2012.

2013— The frequency distribution of external parasite loads for Redbreast Sunfish collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 is presented in Table 4.3.7-7. The prevalence of external parasites was significantly greater in Garvins Pool than in Amoskeag Pool during 2013. There were no significant differences among the frequency distributions of external parasites in Redbreast Sunfish captured in Hooksett Pool when compared with those in Amoskeag or Garvins Pools during 2013.

Table 4.3.7-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Redbreast Sunfish collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	53	76	182	118	22	50	7	136	35	23
Hooksett	278	36	207	116	29	262	2	198	39	29
Amoskeag	194	22	177	120	25	192	2	115	37	22
Total	**525**	**22**	**207**	**118**	**27**	**504**	**2**	**198**	**38**	**26**

Table 4.3.7-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Redbreast Sunfish collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	52	48	172	112	33	48	3	114	34	26
Hooksett	360	47	180	94	30	340	2	128	21	24
Amoskeag	145	49	181	101	33	132	2	130	27	29
Total	**557**	**47**	**181**	**97**	**31**	**520**	**2**	**130**	**24**	**26**

Table 4.3.7-3. Regression statistics for total length (mm) vs. weight (g) for Redbreast Sunfish from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	50	3.047	-4.828	0.96				
Hooksett	262	3.235	-5.195	0.99	*		*	
Amoskeag	192	3.245	-5.241	0.98	*	NS	*	NS

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$

Table 4.3.7-4. Regression statistics for total length (mm) vs. weight (g) for Redbreast Sunfish from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Pool	N	Slope[b] (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	48	3.233	-5.237	0.99				
Hooksett	340	3.233	-5.243	0.97	NS		*	
Amoskeag	132	3.233	-5.222	0.98	NS	NS	NS	*

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$
[b] Assumed common slope due to non-significant finding

Table 4.3.7-5. Regression statistics for total length (mm) vs. weight (g) for Redbreast Sunfish sampled during August-September 1995, 2004, 2005, 2010, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]											
					Slope						Intercept					
					1995	2004	2005	2010	2011	2012	1995	2004	2005	2010	2011	2012
1995	105	3.410	-5.583	0.95												
2004	43	2.958	-4.572	0.97	*						*					
2005	34	3.359	-5.461	0.98	NS	*					NS	*				
2010	167	2.983	-4.675	0.99	*	NS	*				*	NS	*			
2011	160	3.180	-5.080	0.97	*	NS	NS	*			*	*	NS	*		
2012	262	3.235	-5.195	0.99	*	*	NS	*	NS		*	*	NS	*	NS	
2013	340	3.200	-5.157	0.97	*	*	NS	*	NS	NS	*	*	NS	*	NS	NS

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.7-6. Frequency distribution of external parasite loads for Redbreast Sunfish collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	32	60.38	20	37.74	1	1.89
Hooksett [A]	177	63.9	88	31.77	12	4.33
Amoskeag [A]	139	72.02	53	27.46	1	0.52

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.7-7. Frequency distribution of external parasite loads for Redbreast Sunfish collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	18	41.9	17	39.5	8	18.6
Hooksett [AB]	154	44.1	154	44.1	41	11.8
Amoskeag [B]	80	57.1	51	36.4	9	6.4

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.8 Rock Bass

Biocharacteristics of the Rock Bass population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Rock Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September, 2012 are presented in Table 4.3.8-1.

2013—The mean, minimum, maximum and standard deviation of total length and total wet weight of Rock Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2013 are presented in Table 4.3.8-2.

Condition

2012—Length-weight relationships for Rock Bass based on the August-September 2012 catch in Hooksett and Amoskeag Pools are presented in Table 4.3.8-3. The slope parameters for the two pools were not significantly different ($F = 0.95$, $P = 0.3378$). After assuming a common slope, the y-intercept parameters were also not significantly different ($F = 3.17$, $P = 0.085$).

2013—Sample sizes of Rock Bass collected during August and September 2013 in Garvins, Hooksett, and Amoskeag Pools were insufficient for comparison of condition among pools.

Comparison among years in Hooksett Pool— Length-weight relationships for Rock Bass collected in Hooksett Pool during August and September 2012-2013 are presented in Table 4.3.8-4. The slope parameters for these relationships did not differ significantly ($F = 1.39$, $P = 0.2472$). After assuming a common slope between both length-weight curves, the y-intercept parameters from the 2012 and 2013 length-weight relationships were not significantly different ($F = 0.56$, $P = 0.459$).

Age-Length

2012—The mean total length at age (±95% C.I.) of Rock Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September 2012 is presented in Table 4.3.8-5. The age of Rock Bass caught in 2012 ranged from age-0 to age-3 in Garvins Pool, from age 0 to age 5 in Hooksett Pool, and from age 2 to age 4 in Amoskeag Pool. Sample sizes (n<15) were insufficient for pairwise comparisons of mean length-at-age among pools.

2013—The mean total length at age of Rock Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September 2013 is presented in Table 4.3.8-6. The age of Rock Bass caught in 2013 ranged from age-0 to age-5 in Garvins Pool, from age 0-to age-7 in Hooksett Pool, and from age-2 to age-5 in Amoskeag Pool. Sample sizes (n<15) were insufficient for pairwise comparisons of mean length-at-age among pools.

Mortality

The catch at age of Rock Bass caught by electrofishing in Garvins and Hooksett Pools during August and September 2008-2013 was too low or variable for estimating mortality from a catch curve (Figure 4.3.8-1). The catch-curve regression for ages 3-5 Rock Bass caught in Amoskeag Pool during August and September 2008-2013 was not statistically significant (Figure 4.3.8-2, $Z = 1.55$; $F = 118.2$, $P = 0.058$), but annual mortality of 79% was based on this estimate. There were no significant regressions for cohort-specific catch curves of Rock Bass based on electrofishing catch during August-September from 2008 through 2013 ($P > 0.05$).

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Rock Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August-September 2012 is presented in Table 4.3.8-7. The prevalence of external parasites was significantly greater in Amoskeag Pool than in Hooksett Pool during 2012. There was not adequate data available for Garvins Pool to permit the use of pairwise comparisons among sample locations during 2012.

2013—The frequency distribution of external parasite loads for Rock Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August-September, 2013 is presented in Table 4.3.8-8. The prevalence of external parasites was significantly greater in Amoskeag Pool than in Hooksett Pool during 2013. There was not adequate data available for Garvins Pool to permit the use of pairwise comparisons among sample locations during 2013.

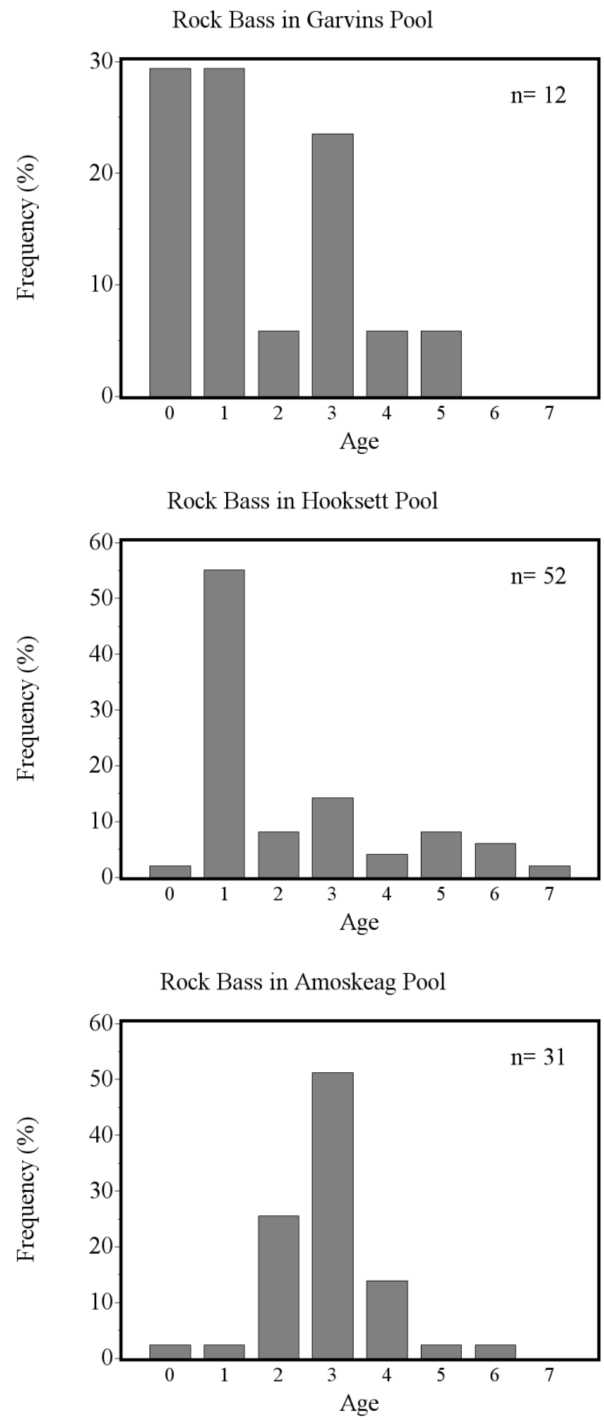

Figure 4.3.8-1. Catch at age of Rock Bass caught by electrofishing in Hooksett Pool, Merrimack River, during August-September 2008- 2013.

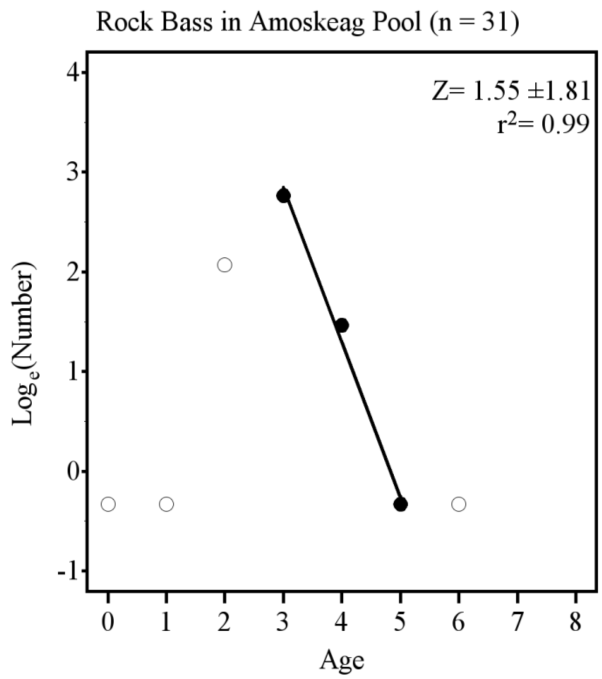

Figure 4.3.8-2. Catch curve estimate of instantaneous total mortality rate (Z ± 95% confidence intervals) for Rock Bass of fully recruited ages (solid circles) caught by electrofishing during August-September from 2008 through 2013 in Hooksett Pool, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: age-5 fish included to provide minimum catch-at-age data for best available estimate of instantaneous mortality.

Table 4.3.8-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Rock Bass collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

	Total Length (mm)					Weight (g)				
Pool	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	4	55	164	120	46	4	3	95	54	38
Hooksett	15	56	178	125	35	15	4	120	48	37
Amoskeag	18	136	187	162	15	17	47	115	82	20
Total	**37**	**55**	**187**	**142**	**34**	**36**	**3**	**120**	**64**	**33**

Table 4.3.8-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Rock Bass collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	4	60	187	114	55	4	5	116	42	51
Hooksett	25	62	237	126	48	24	5	290	63	79
Amoskeag	11	146	204	180	16	11	66	188	113	35
Total	**40**	**60**	**237**	**140**	**49**	**39**	**5**	**290**	**75**	**70**

Table 4.3.8-3. Regression statistics for total length (mm) vs. weight (g) for Rock Bass from Hooksett and Amoskeag Pools during August-September 2012.

					ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
Pool	N	Slope (b)[b]	Intercept ($\log_{10}a$)	R^2	Hooksett	Amoskeag	Hooksett	Amoskeag
Hooksett	15	2.933	-4.556	0.99		NS		NS
Amoskeag	17	2.933	-4.581	0.94	NS		NS	

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.8-4. Regression statistics for total length (mm) vs. weight (g) for Rock Bass sampled during August-September 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)[b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]	
					Slope	Intercept
					2012	2012
2012	15	3.042	-4.783	0.99		
2013	24	3.042	-4.795	0.99	NS	NS

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.8-5. Mean length at age (± 95% C.I.) for Rock Bass captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Age	Cohort	Pool	N	Mean	± 95% C.I.
		Garvins	1	56	
0	2012	Hooksett	1	56	
1	2011	Hooksett	8	108	11
		Garvins	1	132	
		Hooksett	1	124	
2	2010	Amoskeag	8	156	10
		Garvins	2	148	101
		Hooksett	3	164	22
3	2009	Amoskeag	8	168	9
		Hooksett	1	164	
4	2008	Amoskeag	1	168	
5	2007	Hooksett	1	172	

Table 4.3.8-6. Mean length at age (± 95% C.I.) for Rock Bass captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Age	Cohort	Pool	N	Mean	± 95% C.I.
0	2013	Garvins	1	60	
1	2012	Garvins	1	88	
		Hooksett	15	96	6
2	2011	Hooksett	3	120	55
		Amoskeag	2	172	155
3	2010	Garvins	1	120	
		Hooksett	3	176	55
		Amoskeag	4	176	7
4	2009	Amoskeag	3	184	30
5	2008	Garvins	1	188	
		Hooksett	2	208	174
		Amoskeag	1	196	
7	2006	Hooksett	1	216	

Table 4.3.8-7. Frequency distribution of external parasite loads for Rock Bass collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

	Absent		Light		Moderate/Heavy	
Pool	N	%	N	%	N	%
Garvins	1	25	2	50	1	25
Hooksett [A]	10	66.67	5	33.33	0	0
Amoskeag [B]	5	27.78	8	44.44	5	27.78

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.8-8. Frequency distribution of external parasite loads for Rock Bass collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins	2	50.0	1	25.0	1	25.0
Hooksett [A]	12	50.0	11	45.8	1	4.2
Amoskeag [B]	2	18.2	5	45.5	4	36.4

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.9 Smallmouth Bass

Biocharacteristics of the Smallmouth Bass population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Smallmouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2012 are presented in Table 4.3.9-1.

2013—The mean, minimum, maximum and standard deviation of total length and total wet weight of Smallmouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2013 are presented in Table 4.3.9-2.

Condition

2012—Length-weight relationships for Smallmouth Bass based on August-September 2012 catches in Garvins, Hooksett and Amoskeag Pools are presented Table 4.3.9-3. The slope parameters for these relationships did not differ significantly ($F = 0.71$, $P = 0.4921$). However, after assuming a common slope among all 2012 Smallmouth Bass length-weight curves, the y-intercept parameter from the Hooksett Pool length-weight relationship was significantly higher than the Amoskeag Pool estimate.

2013— Length-weight relationships for Smallmouth Bass based on August-September 2013 catches in Hooksett and Amoskeag Pools are presented in Table 4.3.9-4. The slopes of the length-weight curves derived from the August-September 2012 catches of Smallmouth Bass from Hooksett and Amoskeag Pool did not differ significantly ($F = 0.01$, $P = 0.9126$). Assuming a common slope among the 2013 length-weight curves of Smallmouth Bass, the y-intercept parameters for Hooksett and Amoskeag Pools were not significantly different ($F = 3.41$, $P = 0.0679$).

Comparison among years in Hooksett Pool— Length-weight relationships for Smallmouth Bass collected from Hooksett Pool during the available years from 1995 through 2013 are presented in Table 4.3.9-5. The slope parameter for 1995 was higher than in any other year, and the y-intercept parameter for 1995 was lower than in any other year. The slope and y-intercept parameters for 1995 were significantly different from all other years. Otherwise, there were no particular patterns in the between-year comparisons for Hooksett Pool.

Age-Length

2012—The mean total length at age (±95% C.I.) of Smallmouth Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September 2012 is presented in Table 4.3.9-6. The age of Smallmouth Bass ranged from age 0 to age 2 in Garvins and Amoskeag Poolsand from age 0 to age 5 in Hooksett Pool. The mean total length of age-1 Smallmouth Bass was not significantly different between Hooksett and Amoskeag Pools. Sample sizes (n < 15) were insufficient to make other pairwise comparisons of mean length-at-age among pools.

2013—The mean total length at age of Smallmouth Bass collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September 2013 is presented in Table 4.3.9-7. The age of Smallmouth Bass ranged from age-0 to age-8 in Garvins and from age-0 to age-5 in Hooksett and Amoskeag Pools. Insufficient sample sizes ($n<15$) prevented the pairwise comparison of mean length between age-0, age-1, and age-2 Smallmouth Bass among Garvins, Hooksett, and Amoskeag Pools as well as age-3 Smallmouth Bass between Garvins and Hooksett Pools and age-5 Smallmouth Bass between Hooksett and Amoskeag Pools.

Mortality

Catch curves used to estimate instantaneous mortality rate (Z) for Smallmouth Bass caught by electrofishing in each Merrimack River pool during August-September 2008-2013 are shown in Figure 4.3.9-1. The catch-curve regression for Smallmouth Bass was statistically significant for ages 0-5 in Garvins Pool ($Z = 0.65$; $F = 69.1$, $P = 0.001$), ages 0-6 in Hooksett Pool ($Z = 0.83$; $F = 83.2$, $P < 0.001$), and ages 0-6 in Amoskeag Pool ($Z = 0.81$; $F = 369.5$, $P < 0.001$). These total instantaneous mortality rates for Smallmouth Bass were not significantly different among the Merrimack River pools (ANCOVA, $F = 1.37$, $P = 0.287$). The annual mortality rates of Smallmouth Bass based on estimates of Z were 48% for ages 0-5 in Garvins Pool, and 56% for ages 0-6 in Hooksett Pool and ages 0-6 in Amoskeag Pool.

Catch curve estimates for Z based on significant regressions ($P < 0.05$) on log-transformed CPUE at age were found for several cohorts of Smallmouth Bass caught by electrofishing during August-September 2008-2013 in Hooksett Pool (Figure 4.3.9-2) and Amoskeag Pool (Figure 4.3.9-3). Annual mortality rates of Smallmouth Bass caught in Hooksett Pool based on these Z estimates were 76% for the 2006 cohort (ages 2-5), 82% for the 2008 cohort (ages 1-4), and 78% for the 2010 cohort (ages 0-2). Annual mortality rates of Smallmouth Bass caught in Amoskeag Pool based on these Z estimates were 59% for the 2007 cohort (ages 1-4) and 61% for the 2009 cohort (ages 0-2). There was insufficient data to compare Z of a specific cohort of Smallmouth Bass among pools. The Z estimates of Smallmouth Bass in Hooksett Pool were nearly double based on the cohort-specific catch curves compared to the aggregate 2008-2013 catch, whereas the Z estimates of Smallmouth Bass in Amoskeag Pool from the two cohort-specific catch curves were similar to the estimate from the catch curves based on the aggregate 2008-2013 catch.

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Smallmouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2012 is presented in Table 4.3.9-8. The prevalence of external parasites was significantly greater in Hooksett and Amoskeag Pools than in Garvins Pool during 2012.

2013—The frequency distribution of external parasite loads for Smallmouth Bass collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 is presented in Table 4.3.9-9. The prevalence of external parasites was significantly greater in

Hooksett and Amoskeag Pools than in Garvins Pool during 2013. There were no significant differences in the prevalence of external parasites among Smallmouth Bass sampled in Amoskeag and Hooksett Pools during 2013.

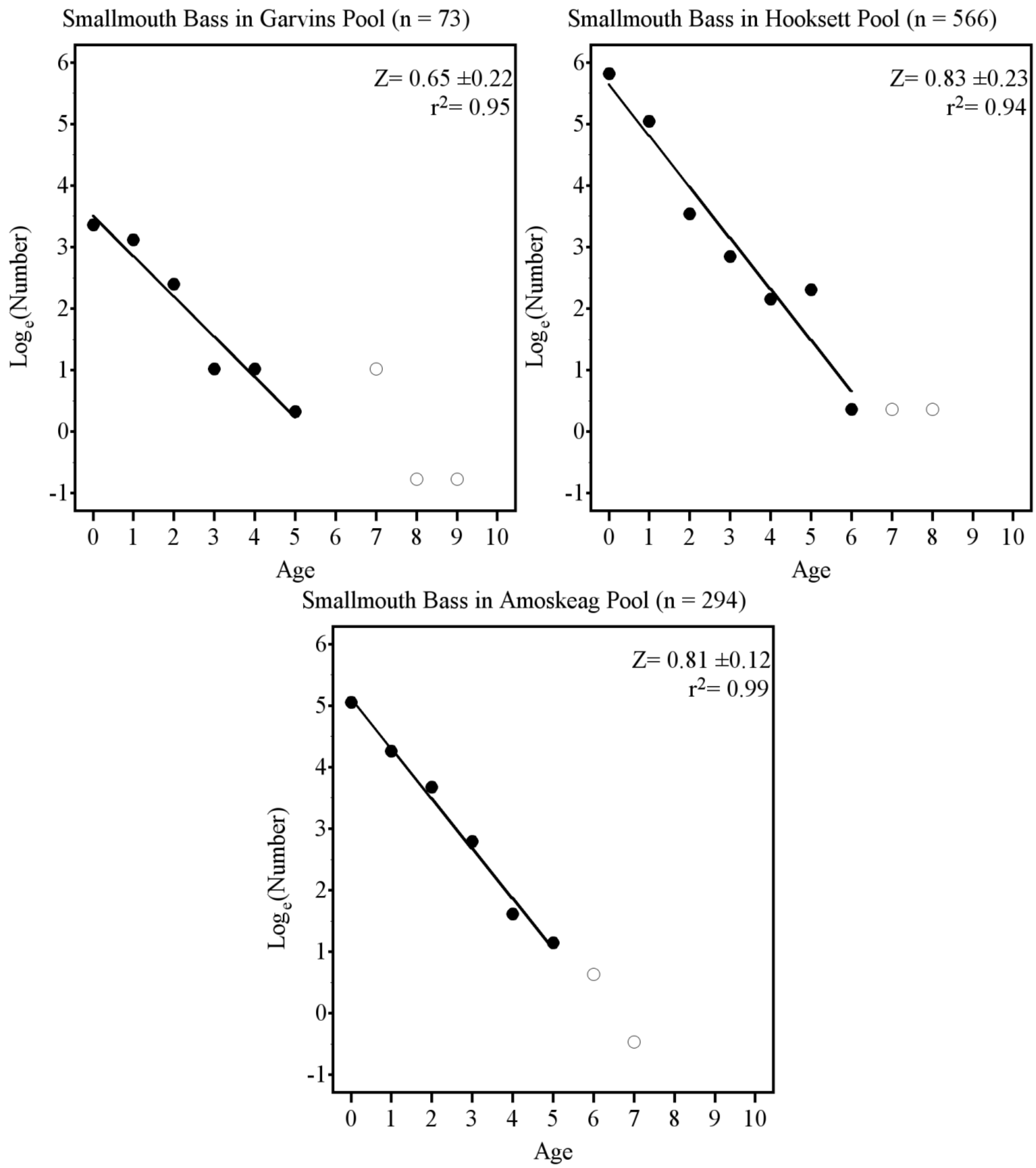

Figure 4.3.9-1. Catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Smallmouth Bass of fully recruited ages (solid circles) caught by electrofishing during August-September 2008-2013 in Garvins, Hooksett and Amoskeag Pools, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: oldest ages in some cases were included to provide the minimum catch-at-age data needed for the best available instantaneous mortality estimate.

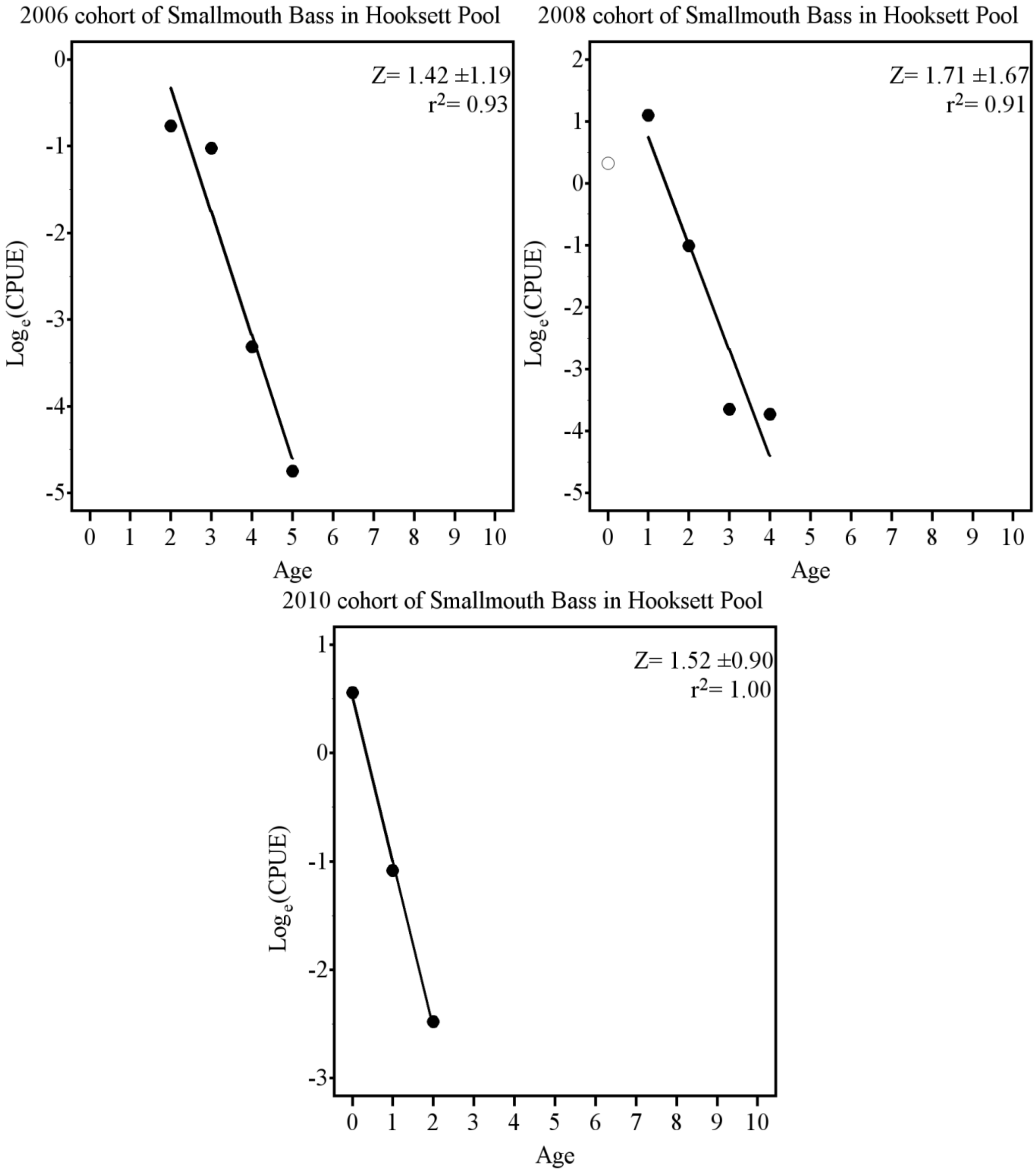

Figure 4.3.9-2. Cohort-specific catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Smallmouth Bass in Hooksett Pool, Merrimack River, based on mean catch per unit effort (CPUE) of fully recruited ages (solid circles) from electrofishing samples during August-September 2008-2012. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles).

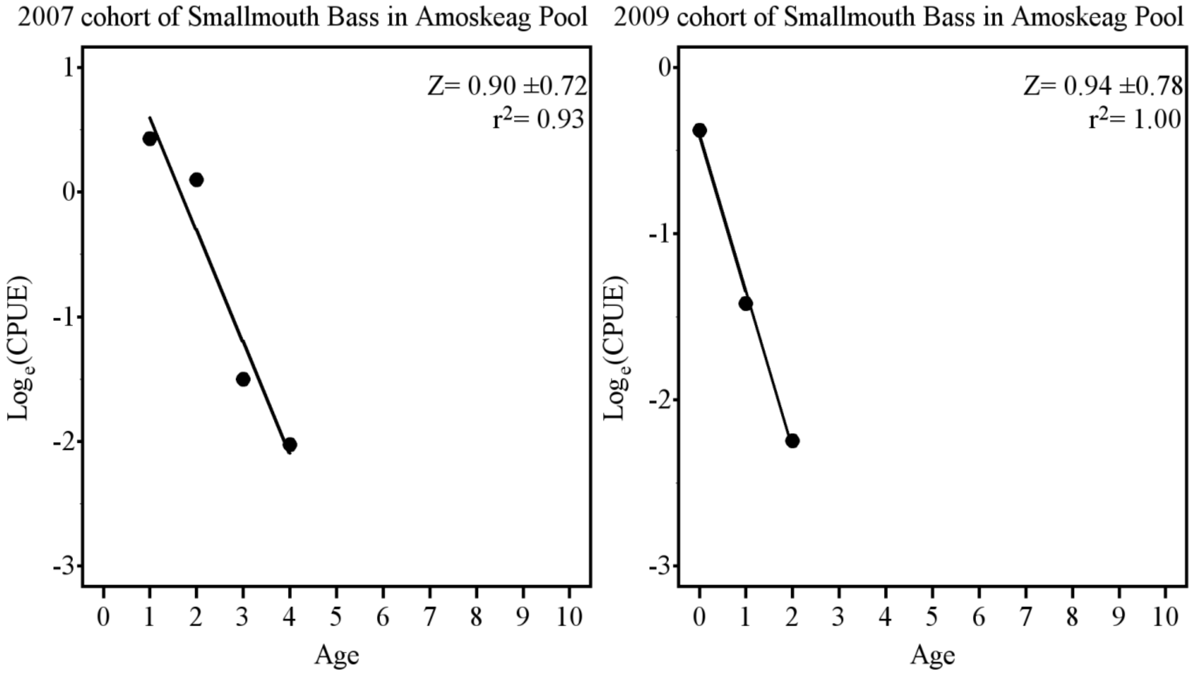

Figure 4.3.9-3. Cohort-specific catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Smallmouth Bass in Amoskeag Pool, Merrimack River, based on mean catch per unit effort (CPUE) of fully recruited ages (solid circles) from electrofishing samples during August-September 2008-2012. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles).

Table 4.3.9-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Smallmouth Bass collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	16	68	247	128	66	15	4	205	52	68
Hooksett	184	61	465	119	68	174	3	1400	54	167
Amoskeag	42	72	326	149	49	39	5	415	54	68
Total	**242**	**61**	**465**	**125**	**65**	**228**	**3**	**1400**	**54**	**150**

Table 4.3.9-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Smallmouth Bass collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	13	47	468	144	119	12	2	1,400	165	402
Hooksett	77	46	425	167	86	70	2	850	112	173
Amoskeag	28	51	315	157	59	25	3	263	60	57
Total	**118**	**46**	**468**	**162**	**84**	**107**	**2**	**1,400**	**105**	**194**

Table 4.3.9-3. Regression statistics for total length (mm) vs. weight (g) for Smallmouth Bass from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Pool	N	Slope (b)[b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	15	2.994	-4.893	0.99				
Hooksett	174	2.994	-4.882	0.99	NS		NS	
Amoskeag	39	2.994	-4.907	0.99	NS	NS	NS	*

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b]Assumed common slope due to non-significant finding

Table 4.3.9-4. Regression statistics for total length (mm) vs. weight (g) for Smallmouth Bass from Hooksett and Amoskeag Pools during August-September 2013.

Pool	N	Slope[b] (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Hooksett	Amoskeag	Hooksett	Amoskeag
Hooksett	70	3.107	-5.152	0.99		NS		NS
Amoskeag	25	3.107	-5.169	0.99	NS		NS	

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b]Assumed common slope due to non-significant finding

Table 4.3.9-5. Regression statistics for total length (mm) vs. weight (g) for Smallmouth Bass sampled during August-September 1995, 2004, 2005, 2010, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]											
					Slope						Intercept					
					1995	2004	2005	2010	2011	2012	1995	2004	2005	2010	2011	2012
1995	25	3.707	-6.435	0.98												
2004	96	2.807	-4.437	0.96	*						*					
2005	37	3.201	-5.328	0.98	*	*					*	*				
2010	441	2.974	-4.825	0.99	*	*	*				*	*	*			
2011	282	2.988	-4.879	0.99	*	*	*	NS			*	*	*	NS		
2012	174	2.993	-4.881	0.99	*	*	*	NS	NS		*	*	*	NS	NS	
2013	70	3.106	-5.150	>0.99	*	*	NS	*	*	*	*	*	NS	*	*	*

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.9-6. Mean length at age (± 95% C.I.) for Smallmouth Bass captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2012.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
		Garvins		9	76	5
		Hooksett		112	88	2
0	2012	Amoskeag		8	88	6
		Garvins		3	148	20
		Hooksett	A	32	148	9
1	2011	Amoskeag	A	18	136	5
		Garvins		4	228	19
		Hooksett		7	252	25
2	2010	Amoskeag		15	184	11
3	2009	Hooksett		1	272	
4	2008	Hooksett		2	460	22
5	2007	Hooksett		3	388	80

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.9-7. Mean length at age (± 95% C.I.) for Smallmouth Bass captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2013	Garvins		7	68	10
		Hooksett		16	68	6
		Amoskeag		3	60	13
1	2012	Garvins		3	148	27
		Hooksett		37	140	6
		Amoskeag		12	136	12
2	2011	Garvins		1	184	
		Hooksett		9	228	20
		Amoskeag		10	192	22
3	2010	Garvins		1	292	
		Hooksett		8	256	22
4	2009	Hooksett		2	332	73
5	2008	Hooksett		3	388	75
		Amoskeag		1	316	
8	2005	Garvins		1	468	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.9-8. Frequency distribution of external parasite loads for Smallmouth Bass collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	9	56.25	6	37.5	1	6.25
Hooksett [B]	65	35.52	87	47.54	31	16.94
Amoskeag [B]	14	33.33	24	57.14	4	9.52

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.9-9. Frequency distribution of external parasite loads for Smallmouth Bass collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	5	41.67	3	25	4	33.33
Hooksett [B]	17	23.61	25	34.72	30	41.67
Amoskeag [B]	7	25	10	35.71	11	39.29

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.10 Spottail Shiner

Biocharacteristics of the Spottail Shiner population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during August-September 2012 and 2013. Biocharacteristics data available for Spottail Shiner captured during August-September 2012 and 2013 are limited to length, weight and external parasites. No scale samples were collected for age determination.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and weight (g) of Spottail Shiner collected by electrofishing in Garvins and Hooksett Pools during August and September 2012 is presented in Table 4.3.10-1.

2013—The mean, minimum, maximum and standard deviation of total length and weight of Spottail Shiner collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August and September 2013 is presented in Table 4.3.10-2.

Condition

2012— Length-weight relationships for Spottail Shiner based on August-September 2012 catches in Garvins and Hooksett Pools are presented Table 4.3.10-3. There were no Spottail Shiners collected in Amoskeag Pool during August-September 2012. The slopes of the length-weight curves derived from the August-September 2012 catches of Spottail Shiner in Garvins and Hooksett Pool did not differ significantly ($F = 2.34$, $P = 0.1271$). After assuming a common slope between the length-weight curves of Spottail Shiner caught in Garvins and Hooksett Pools during 2012, the y-intercept parameter from the Garvins Pool length-weight relationship was significantly higher than the Hooksett Pool estimate.

2013— Sample sizes of Spottail Shiner (Table 4.3.10-2) collected during August and September 2013, in Garvins and Hooksett Pools were insufficient for comparison of condition between pools or across years.

Comparison among years in Hooksett Pool—Length-weight relationships for Spottail Shiner collected from Hooksett Pool during the available years between the 1995 and 2012 are presented in Table 4.3.10-4. The slope and y-intercept parameters for 1995 and 2004 were significantly different from each other and from all years. The slope and y-intercept parameters for 2010, 2011, and 2012 were not significantly different from each other.

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Spottail Shiner collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August-September 2012 is presented in Table 4.3.10-5. There were no significant differences in the prevalence of external parasites for Spottail Shiner collected in Garvins and Hooksett Pools during 2012.

2013—The frequency distribution of external parasite loads for Spottail Shiner collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August-September 2013 is presented in Table 4.3.10-6. The prevalence of external parasites for Spottail Shiner collected in Hooksett Pool was significantly higher than in Garvins Pool during 2013. There was not adequate data available for Amoskeag Pool to permit the use of pairwise comparisons among sample locations during 2013.

Table 4.3.10-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Spottail Shiner collected in Garvins and Hooksett Pools during August-September 2012.

	Total Length (mm)					Weight (g)				
Pool	**N**	**Min.**	**Max.**	**Mean**	**SD**	**N**	**Min.**	**Max.**	**Mean**	**SD**
Garvins	668	30	99	56	13	289	2	10	3	1.1
Hooksett	59	48	84	61	9	26	2	4	2	0.8
Total	**727**	**30**	**99**	**56**	**13**	**315**	**2**	**10**	**3**	**1.1**

Table 4.3.10-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Spottail Shiner collected in Garvins and Hooksett Pools during August-September 2013.

	Total Length (mm)					Weight (g)				
Pool	**N**	**Min.**	**Max.**	**Mean**	**SD**	**N**	**Min.**	**Max.**	**Mean**	**SD**
Garvins	58	53	106	85.07	12.05	53	2	10	5.47	2.11
Hooksett	8	83	105	92.5	8.38	8	3	10	6.13	2.36
Amoskeag	1	66	66	66		1	2	2	2	
Total	**67**	**53**	**106**	**85.67**	**12.03**	**62**	**2**	**10**	**5.5**	**2.16**

Table 4.3.10-3. Regression statistics for total length (mm) vs. weight (g) for Spottail Shiner from Garvins and Hooksett Pools during August-September 2012.

Pool	N	Slope (b)[b]	Intercept ($\log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations [a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	273	1.596	-2.486	0.4		NS		*
Hooksett	26	1.596	-2.548	0.9	NS		*	

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$
[b] Assumed common slope due to non-significant finding

Table 4.3.10-4. Regression statistics for total length (mm) vs. weight (g) for Spottail Shiner sampled during August-September 1995, 2004, 2010, 2011, and 2012 from Hooksett Pool.

Year	N	Slope (b)	Intercept ($\log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]							
					Slope				Intercept			
					1995	2004	2010	2011	1995	2004	2010	2011
1995	29	3.103	-5.244	0.94								
2004	21	4.219	-7.534	0.83	*				*			
2010	727	2.282	-3.709	0.66	*	*			*	*		
2011	121	2.257	-3.709	0.82	*	*	NS		*	*	NS	
2012	26	2.201	-3.653	0.85	*	*	NS	NS	*	*	NS	NS

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$

Table 4.3.10-5. Frequency distribution of external parasite loads for Spottail Shiner collected from Garvins and Hooksett Pools during August-September 2012.

Pool	Absent		Light	
	N	%	N	%
Garvins [A]	655	98.64	9	1.36
Hooksett [A]	55	93.22	4	6.78

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.10-6. Frequency distribution of external parasite loads for Spottail Shiner collected from Garvins and Hooksett Pools during August-September, 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	47	81.03	8	13.79	3	5.17
Hooksett [B]	5	62.5	1	12.5	2	25
Amoskeag	1	100	0	0	0	0

Notes: Different letters indicate significant within year differences between pools.

No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

4.3.11 White Sucker

Biocharacteristics of the White Sucker population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during March, April, August and September 2012 and August-September 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of White Sucker collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during March-April 2012 are presented in Table 4.3.11-1 and during August-September 2012 are presented in Table 4.3.11-2.

2013—The mean, minimum, maximum and standard deviation of total length and total wet weight of White Sucker collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 are presented in Table 4.3.11-3.

Condition

2012— Length-weight relationships for March -April of 2012 are presented in Table 4.3.11-4. The slope parameter was significantly higher for the Hooksett Pool estimate than the Garvins Pool estimate, and the *y*-intercept parameter for Hooksett Pool was significantly lower than the Garvins Pool estimate. Neither the Garvins nor the Hooksett Pool slope and *y*-intercept parameters were significantly different from the Amoskeag Pool parameters.

Sample sizes of White Sucker collected during August and September 2012 in Garvins and Amoskeag Pools were insufficient for comparison of condition among pools. However, a length-weight relation for White Sucker sampled during August and September 2012 in Hooksett Pool was developed and is presented in Table 4.3.11-5.

2013— Sample sizes of White Sucker collected during August and September 2013, in Garvins and Amoskeag Pools were insufficient ($n < 15$) for comparison of condition between pools. However, a length-weight relation for White Sucker sampled during August and September 2013 in Hooksett Pool was developed and is presented in Table 4.3.11-5.

Comparison among years in Hooksett Pool—Length-weight relationships for the years 2004 and 2010 through 2013 are presented in Table 4.3.11-5. The slope parameter for 2004 was significantly lower than the estimates for 2010, 2011, and 2012, but was not significantly different from the 2013 slope estimate. The *y*-intercept parameter for 2004 was significantly lower than the estimate from 2010, 2011, and 2012, but not 2013. The 2011 length-weight relationship had a significantly higher slope parameter and lower *y*-intercept parameter than estimates for 2004, 2010, and 2013.

Age-Length

2012—The mean total length at age (±95% C.I.) of White Sucker collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during March-April and August -September 2012 is presented in Table 4.3.11-6. The age of White Sucker ranged from age 1 to age 6 in Garvins and Amoskeag Pools, and from age 0 to age 7 in Hooksett Pool. The mean total length of age-1 White Sucker was significantly lower in Hooksett Pool than in Garvins Pool. For each White Sucker cohort from age 2 through age 5, there was no significant difference in mean length between Garvins and Hooksett Pools. Sample sizes ($n < 15$) were insufficient for other pairwise comparisons of mean length-at-age among pools.

2013— The mean total length at age of White Sucker collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September 2013 is presented in Table 4.3.11-7. The age of White Sucker ranged from age-0 to age-5 in Garvins Pool, age-1 to age-3 in Amoskeag Pools, and from age-1 to age-7 in Hooksett Pool. Sample sizes ($n<15$) were insufficient for pairwise comparisons of mean length-at-age among pools.

Mortality

Catch curves used to estimate instantaneous mortality rate (Z) for White Sucker caught by electrofishing in each Merrimack River pool during August-September 2008-2013 are shown in Figure 4.3.11-1. The catch-curve regression for White Sucker was statistically significant for ages 3-6 in Garvins Pool ($Z = 0.96$; $F = 11{,}681.8$, $P < 0.001$), ages 2-7 in Hooksett Pool ($Z = 0.52$; $F = 409.7$, $P < 0.001$), and ages 2-5 in Amoskeag Pool ($Z = 1.10$; $F = 72.8$, $P = 0.014$). These total instantaneous mortality rates for White Sucker were significantly different among Merrimack River pools (ANCOVA, $F = 31.8$, $P < 0.001$). The Z for age 2-7 White Sucker in Hooksett Pool was significantly less than the Z for ages 3-6 in Garvins Pool ($t = -5.27$, $P < 0.001$) and ages 2-5 in Amoskeag Pool ($t = 7.00$, $P < 0.001$). The Z estimates for White Sucker from Amoskeag and Garvins Pools were not significantly different ($t = 1.4$, $P = 0.203$). The annual mortality rates of White Sucker based on estimates of Z were 62% for ages 3-6 in Garvins Pool, 41% for ages 2-7 in Hooksett Pool, and 67% for ages 2-5 in Amoskeag Pool.

There were no significant regressions for cohort-specific catch curves of White Sucker based on electrofishing catch during August-September from 2008 through 2013 ($P > 0.05$).

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for White Sucker collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during March-April 2012 is presented in Table 4.3.11-8 and during August-September 2012 is presented in Table 4.3.11-9. The prevalence of external parasites was significantly greater in Hooksett Pool than was observed in Garvins Pool during March-April and greater in Garvins Pool than was observed in Hooksett Pool during August-September 2012. There was not adequate data available from Amoskeag Pool to permit the use of pairwise comparisons among sample locations during March-April 2012. The incidence of external parasites on White Sucker in Amoskeag Pool during August-September 2012 was lower than that observed in either Garvins or Hooksett Pools.

The frequency distribution of internal parasite loads, as assessed by presence/absence, for White Sucker collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during March-April 2012 are presented in Table 4.3.11-10. There was no significant difference in the prevalence of internal parasites among Garvins, Hooksett and Amoskeag Pools for White Sucker collected during 2012.

2013— The frequency distribution of external parasite loads for White Sucker collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August-September 2013 is presented in Table 4.3.11-11. The overall prevalence of external parasites on White Sucker collected in the three Pools of the Merrimack River during August and September 2013 was higher in Hooksett and Amoskeag Pools than in Garvins Pool.

Gender, Reproduction, and Fecundity

2012—The percentages of male and female White Sucker caught in Garvins, Hooksett and Amoskeag Pools collected by electrofishing during March and April, 2012 are shown in Table 4.3.11-12. The percentage of male and female White Sucker in the March-April 2012 catch was not significantly different in Garvins Pool (Z-statistic = -1.40, $P = 0.186$), Hooksett Pool (Z-statistic = -0.84, $P = 0.439$), and Amoskeag Pool (Z-statistic = -0.87, $P = 0.487$). The percentage of female White Sucker was not significantly different among pools (X^2-statistic = 0.34, $P = 0.844$). Likewise, the percentage of male White Sucker also didn't differ significantly among pools.

The frequency and percent composition of each stage of maturity for White Sucker in Garvins, Hooksett, and Amoskeag Pools is presented in Table 4.3.11-13. The percentage of mature (milting, ripe and running, partially spent, and spent) male White Sucker caught during March-April 2012 in Hooksett Pool was significantly lower than in Amoskeag Pool (q-statistic = 3.61, $P < 0.05$), but was similar between Hooksett and Garvins Pools (q-statistic = 0.97, $P > 0.05$), and between Garvins and Amoskeag Pools (q-statistic = 3.07, $P > 0.05$; Table 4.3.11-14). The proportion of mature female White Sucker did not differ significantly among Garvins, Hooksett and Amoskeag Pools (X^2-statistic = 0.60, $P = 0.742$; Table 4.3.11-14).

Table 4.3.11-15 presents the gonadosomatic index (GSI) values for gravid female and milting male White Sucker caught in Garvins, Hooksett and Amoskeag Pools during March-April 2012. The mean GSI for female White Sucker caught in Garvins Pool was substantially lower than in Hooksett and Amoskeag Pools based on non-overlapping 95% confidence intervals. However, the 95% confidence intervals overlapped for the mean GSI for male White Sucker in Garvins, Hooksett and Amoskeag Pools.

The age and length at 50% maturity for male and female White Sucker captured by electrofishing in Garvins, Hooksett and Amoskeag Pools during March-April 2012 are shown in Table 4.3.11-16. The age at 50% maturity of White Sucker ranged from 3.4 to 3.5 years for males and 3.7 to 4.6 years for females among the three pools. The mean total length at 50% maturity of White Sucker ranged from 273 to 398 mm for males and 408 to 422 mm for females among the pools.

A significant log-linear relation existed between length and fecundity for ripe female White Sucker within each pool (Table 4.3.11-17). The regression slopes for the length-fecundity relation did not significantly differ among pools (ANCOVA, $F = 0.2$, $P = 0.816$). Based on a common regression slope of 2.853, the fecundity for White Sucker was significantly different among all pools (ANCOVA, $F = 21.0$, $P < 0.001$); fecundity was highest in Amoskeag Pool (y-intercept = -3.091) followed by Hooksett Pool (y-intercept = -3.135) and Garvins Pool (y-intercept = -3.237). For example, the predicted fecundity for a 400-mm ripe female White Sucker was 21,503 eggs in Amoskeag Pool, 19,449 eggs in Hooksett Pool, and 15,353 eggs in Garvins Pool. Sample estimates of White Sucker fecundity from individuals collected during March-April, 2012 ranged from 5,204 to 40,579 eggs per ripe female in Garvins Pool, 13,592 to 46,002 eggs per ripe female in Hooksett Pool and 12,229 to 52,154 eggs per ripe female in Amoskeag Pool.

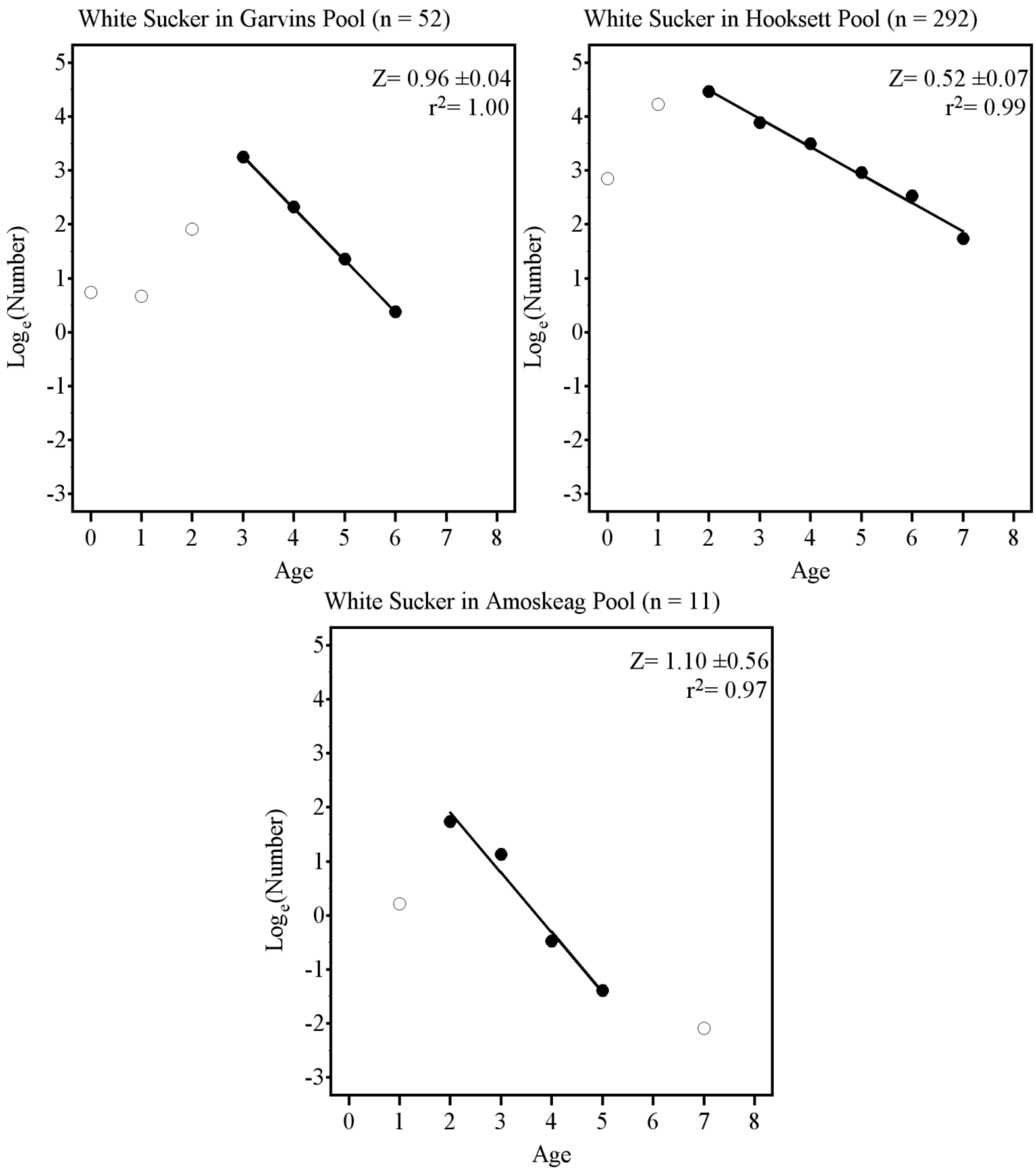

Figure 4.3.11-1. Catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for White Sucker of fully recruited ages (solid circles) caught by electrofishing during August-September 2008-2013 in Garvins, Hooksett and Amoskeag Pools, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: oldest ages in some cases were included to provide the minimum catch-at-age data needed for the best available instantaneous mortality estimate.

Table 4.3.11-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for White Sucker collected in Garvins, Hooksett and Amoskeag Pools during March-April 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	185	194	534	362	97	173	74	1800	597	398
Hooksett	208	101	563	341	128	208	10	1790	608	520
Amoskeag	34	146	534	396	92	30	32	1803	817	449
Total	**427**	**101**	**563**	**355**	**113**	**411**	**10**	**1803**	**619**	**470**

Table 4.3.11-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for White Sucker collected in Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	11	277	450	377	64	11	210	1010	629	311
Hooksett	41	173	523	364	122	39	50	1700	666	506
Amoskeag	1	263	263	263		1	141	141	141	
Total	**53**	**173**	**523**	**365**	**112**	**51**	**50**	**1700**	**648**	**469**

Table 4.3.11-3. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for White Sucker collected in Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	10	59	434	337	109	7	256	720	508	191
Hooksett	97	145	547	309	73	92	42	1,500	366	277
Amoskeag	6	225	353	301	44	6	140	530	331	133
Total	**113**	**59**	**547**	**311**	**75**	**105**	**42**	**1,500**	**373**	**268**

Table 4.3.11-4. Regression statistics for total length (mm) vs. weight (g) for White Sucker from Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	N	Slope (b)	Intercept ($\log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	172	3.004	-4.986	0.99				
Hooksett	208	3.098	-5.226	0.99	*		*	
Amoskeag	30	3.096	-5.189	0.99	NS	NS	NS	NS

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$

Table 4.3.11-5. Regression statistics for total length (mm) vs. weight (g) for White Sucker sampled during August-September 2004, 2010, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)	Intercept ($\log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]							
					Slope				Intercept			
					2004	2010	2011	2012	2004	2010	2011	2012
2004	15	2.819	-4.507	0.99								
2010	61	2.984	-4.939	>0.99	*				*			
2011	146	3.065	-5.131	>0.99	*	*			*	*		
2012	39	2.985	-4.926	0.99	*	NS	NS		*	NS	NS	
2013	92	2.934	-4.807	0.97	NS	NS	*	NS	NS	NS	*	NS

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.
Test results symbols for probability (p) levels of significance:
* = significant, $p \leq 0.05$
NS = not significant, $p > 0.05$

Table 4.3.11-6. Mean length at age (± 95% C.I.) for White Sucker captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during March-April and August-September 2012.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2012	Hooksett		5	116	14
		Garvins	A	31	232	7
		Hooksett	B	50	188	9
1	2011	Amoskeag		2	156	73
		Garvins	A	28	256	10
		Hooksett	A	44	244	11
2	2010	Amoskeag		2	236	253
		Garvins	A	38	368	18
		Hooksett	A	25	356	23
3	2009	Amoskeag		5	312	31
		Garvins	A	55	408	7
		Hooksett	A	43	416	10
4	2008	Amoskeag		13	412	15
		Garvins	A	31	468	11
		Hooksett	A	42	472	8
5	2007	Amoskeag		7	460	32
		Garvins		7	492	30
		Hooksett		17	512	12
6	2006	Amoskeag		6	464	31
7	2005	Hooksett		3	520	37

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.11-7. Mean length at age (± 95% C.I.) for White Sucker captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during August-September 2013.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2013	Garvins		1	60	
1	2012	Hooksett		3	216	68
		Amoskeag		1	224	
2	2011	Hooksett		26	268	8
3	2010	Garvins		6	352	44
		Hooksett		23	304	11
		Amoskeag		4	316	34
4	2009	Garvins		1	364	
		Hooksett		8	412	33
5	2008	Garvins		1	404	
		Hooksett		2	436	19
6	2007	Hooksett		3	496	82
7	2006	Hooksett		1	520	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.11-8. Frequency distribution of external parasite loads for White Sucker collected from Garvins, Hooksett and Amoskeag Pools during March-April 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	89	47.85	71	38.17	26	13.98
Hooksett [B]	81	39.13	57	27.54	69	33.33
Amoskeag [C]	19	55.88	6	17.65	9	26.47

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.11-9. Frequency distribution of external parasite loads for White Sucker collected from Garvins, Hooksett and Amoskeag Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	1	9.09	7	63.64	3	27.27
Hooksett [B]	13	31.71	15	36.59	13	31.71
Amoskeag	0	0	1	100	0	0

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.11-10. Frequency distribution of internal parasite loads for White Sucker collected from Garvins, Hooksett and Amoskeag Pools during March-April 2012.

Pool	Absent		Present	
	N	%	N	%
Garvins [A]	162	87	24	13
Hooksett [A]	192	92	16	8
Amoskeag [A]	30	88	4	12

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.11-11. Frequency distribution of external parasite loads for White Sucker collected from Garvins, Hooksett and Amoskeag Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	5	62.5	0	0	3	37.5
Hooksett [B]	35	37.2	36	38.3	23	24.5
Amoskeag [C]	2	33.3	4	66. 7	0	0

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.11-12. Frequency of male and female White Sucker collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	Gender	Frequency N	Frequency %
Garvins	Male A	83	44.9
	Female A	102	55.1
Hooksett	Male A	95	47.0
	Female A	107	53.0
Amoskeag	Male A	14	42.4
	Female A	19	57.6

Notes: Different letters indicate proportion of females and males within each pool were significantly different from 0.5 (1:1 female:male ratio).

Table 4.3.11-13. Frequency distribution of the reproductive condition of White Sucker (sexes combined) collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Reproductive condition	Garvins		Hooksett		Amoskeag		Total	
	N	%	N	%	N	%	N	%
Gravid or milting (ripe)	32	17.3	67	33.0	20	60.6	119	28.3
Ripe and running	1	0.5	3	1.5			4	1.0
Partially spent	5	2.7	5	2.5	2	6.1	12	2.9
Spent	37	20.0	16	7.9	2	6.1	55	13.1
Immature	73	39.5	92	45.3	9	27.3	174	41.3
Not gravid or not milting (resting)	4	2.2	2	1.0			6	1.4
Semi-gravid or semi-milting (developing)	33	17.8	18	8.9			51	12.1
Total	**185**	**100.0**	**203**	**100.0**	**33**	**100.0**	**421**	**100.0**

Table 4.3.11-14. Percent maturity of female and male White Sucker collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	Male	Female
Garvins	39.8 AB	77.5 A
Hooksett	34.7 A	72.9 A
Amoskeag	71.4 B	73.7 A

Different letters indicate proportion of mature females or males caught during spring 2012 were significantly different among pools.

Table 4.3.11-15. Gonadosomatic index (GSI, %) of gravid female and milting male White Sucker collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	Male				Female			
	N	95% LCL	Mean GSI	95% UCL	N	95% LCL	Mean GSI	95% UCL
Garvins	10	4.0	4.5	5.0	22	12.8	13.7	14.7
Hooksett	19	3.7	4.2	4.8	48	15.0	16.1	17.3
Amoskeag	6	3.5	4.6	5.6	14	16.6	18.3	20.1
Total	**35**	**4.0**	**4.4**	**4.7**	**84**	**15.1**	**15.9**	**16.7**

Table 4.3.11-16. Age and length at 50% maturity of male and female White Sucker collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	Age at 50% Maturity		Length (mm) at 50% Maturity	
	Male	Female	Male	Female
Garvins	3.5	3.7	314	408
Hooksett	3.5	4.4	273	422
Amoskeag	3.4	4.6	398	415

Table 4.3.11-17. Regression[a] statistics for log-linear relation($E = aL^b$) between total length (L, mm) and fecundity (E, eggs) of female White Sucker collected from Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	N	Slope (b)	Intercept ($\log_{10}a$)	F	R^2	P-value
Garvins	20	2.857	-3.248	156.7	0.90	<0.001
Hooksett	45	2.779	-2.938	127.8	0.75	<0.001
Amoskeag	12	3.132	-3.832	27.8	0.74	<0.001

[a] $\log_{10}(\text{fecundity}) = b \times \log_{10}(\text{length}) + \log_{10}a$

4.3.12 Yellow Perch

Biocharacteristics of the Yellow Perch population are described from samples collected by boat electrofishing from Garvins, Hooksett and Amoskeag Pools of the Merrimack River during March, April, August and September 2012 and August-September 2013.

Length and Weight

2012—The mean, minimum, maximum and standard deviation of total length (mm) and total wet weight (g) of Yellow Perch collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during March-April 2012 are presented in Table 4.3.12-1 and during August-September 2012 are presented in Table 4.3.12-2.

2013— The mean, minimum, maximum and standard deviation of total length and total wet weight of Yellow Perch collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during August-September 2013 are presented in Table 4.3.12-3.

Condition

2012—Length-weight relationships for Yellow Perch based on the March-April 2012 catch in Garvins, Hooksett, and Amoskeag Pools are presented in Table 4.3.12-4. The slope and *y*-intercept parameters for Garvins Pool was significantly higher than the parameters for Hooksett Pool, but none of the parameters for Garvins or Hooksett Pools were significantly different from the corresponding parameters for Amoskeag Pool.

Length-weight relationships for Yellow Perch based on the August-September catch in Garvins and Hooksett Pools are presented in Table 4.3.12-5. There were no Yellow Perch collected in Amoskeag Pool during August-September 2012. The slopes of the length-weight curves for Yellow Perch caught in Garvins and Hooksett Pools during August-September 2012 did not differ significantly ($F = 2.32$, $P = 0.2534$). When a common slope was assumed for the length-weight relationship of Yellow Perch from Garvins and Hooksett Pools, the *y*-intercept parameter from the Hooksett Pool length-weight relationship was significantly higher than the Garvins Pool estimate.

2013— Length-weight relationships for Yellow Perch based on the August-September 2013 catch in Garvins and Hooksett Pools are presented in Table 4.3.12-6. The length-weight relationship for Garvins Pool had a significantly higher slope parameter and a significantly lower *y*-intercept parameter than the length-weight relationship for Hooksett Pool.

Comparison among years in Hooksett Pool—Length-weight relationships for Yellow Perch collected in Hooksett Pool during the available years from 2005 through 2013 are presented in Table 4.3.12-7. The slopes of the length-weight curves of Yellow Perch from Hooksett Pool did not differ significantly among August-September catches during 2005, 2011, 2012 and 2013 ($F = 2.16$, $P = 0.0927$. Assuming a common slope, the *y*-intercept parameter of the length-weight relationship for the 2013 catch was significantly lower than the estimates for the 2005, 2011, and 2012 catches.

Age-Length

2012—The mean total length at age (±95% C.I.) of Yellow Perch collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during March-April and August-September 2012 is presented in Table 4.3.12-8. The age of Yellow Perch ranged from age 0 to age 8 in Garvins Pool, from age 0 to age 7 in Hooksett Pool, and age 1 to age 5 in Amoskeag Pool. The mean total length of both age-1 and age-4 Yellow Perch was significantly lower in Garvins Pool compared to Hooksett Pool. For age-2 and age-3 Yellow Perch, there was no significant difference in mean length between Garvins and Hooksett Pools. Sample sizes (n < 15) were insufficient for other pairwise comparisons of mean length-at-age among pools.

2013— The mean total length at age of Yellow Perch collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August and September, 2013 is presented in Table 4.3.12-9. The age of Yellow Perch ranged from age-0 to age-6 in Garvins Pool, from age-0 to age-4 in Hooksett Pool, and age-0 in Amoskeag Pool. The mean total length of age-0 Yellow Perch did not differ significantly among all three Merrimack River pools. Insufficient sample sizes (n<15) prevented the pairwise comparison of mean length between age-1, age-2, age-3, and age-4 Yellow Perch between Garvins and Hooksett Pools.

Mortality

Catch curves used to estimate instantaneous mortality rate (Z) for Yellow Perch caught by electrofishing in each Merrimack River pool during August-September 2008-2013 are shown in Figure 4.3.12-1. The catch-curve regression for Yellow Perch was statistically significant for ages 0-8 in Garvins Pool (Z = 0.59; F =199.2, P <0.001), ages 0-4 in Hooksett Pool (Z = 0.94; F = 112.6, P = 0.001), and ages 0-5 in Amoskeag Pool (Z = 0.68; F =79.5, P = 0.001). These total instantaneous mortality rates for Yellow Perch were significantly different among Merrimack River pools (ANCOVA, F = 5.41, P = 0.018). The Z for ages 0-4 Yellow Perch from Hooksett Pool was significantly higher than the Z for ages 0-8 in Garvins Pool (t = 3.26, P = 0.006), but was not significantly different from the Z for ages 0-5 in Amoskeag Pool (t = -2.09, P = 0.055). The Z estimates for Yellow Perch from Garvins and Amoskeag Pools were not significantly different (t = 1.04, P = 0.316). The annual mortality rates of Yellow Perch based on estimates of Z were 47% for ages 0-8 in Garvins Pool, 61% for ages 0-4 in Hooksett Pool, and 49% for ages 0-5 in Amoskeag Pool.

There were no significant regressions for cohort-specific catch curves of Yellow Perch based on electrofishing catch during August-September from 2008 through 2013 (P > 0.05).

Parasitism

2012—The frequency distribution of external parasite loads, as assessed on a rank scale from absent to moderate/heavy, for Yellow Perch collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during March-April 2012 is presented in Table 4.3.12-10 and during August-September 2012 is presented in Table 4.3.12-11. The prevalence of external parasites was significantly greater in Hooksett Pool than was observed in Garvins Pool during March-April and the prevalence of moderate to heavy loads of external parasites was greater in Garvins Pool than was observed in Hooksett Pool during August-September 2012.

There was not adequate data available from Amoskeag Pool to permit the use of pairwise comparisons among sample locations during August-September 2012 and the incidence of external parasites on Yellow Perch in Amoskeag Pool during March-April 2012 was greater than that observed in Garvins Pool. The frequency distribution of internal parasite loads, as assessed by presence/absence, for Yellow Perch collected by electrofishing in Garvins, Hooksett and Amoskeag Pools during March-April 2012 are presented in Table 4.3.12-12. The prevalence of internal parasites was significantly greater in Garvins Pool than in either Hooksett or Amoskeag Pools.

2013— The frequency distribution of external parasite loads for Yellow Perch collected by electrofishing in Garvins, Hooksett, and Amoskeag Pools during August-September 2013 is presented in Table 4.3.12-13. The prevalence of external parasites was significantly greater in Garvins Pool than was observed in Hooksett or Amoskeag Pools during August-September 2013. The incidence of external parasites on Yellow Perch in Hooksett Pool during August-September 2013 was greater than that observed in Amoskeag Pool.

Gender, Reproduction, and Fecundity

2012—The percentages of male and female Yellow Perch caught in Garvins, Hooksett and Amoskeag Pools by electrofishing during March and April 2012 are shown in Table 4.3.12-14. The percentage of male Yellow Perch caught by electrofishing was significantly higher than the percentage of females in Garvins Pool (Z-statistic = 7.16, $P < 0.001$) and the percentage of males was significantly lower than the percentage of females in Hooksett Pool (Z-statistic = -2.03, $P = 0.004$). The percentage of male and female Yellow Perch in Amoskeag Pool was not significantly different from a 1:1 male-to-female ratio (55%; Z-statistic = 0.426, $P = 0.832$). The percentage of male Yellow Perch was significantly greater in Garvins Pool than in Hooksett (q-statistic = 9.5, $P < 0.05$), but was not different between Garvins and Amoskeag Pools (q-statistic = 2.0, $P > 0.05$) and Hooksett and Amoskeag Pools (q-statistic = 1.24, $P > 0.05$). Conversely, the percentage of female Yellow Perch in Garvins Pool was significantly lower than in Hooksett Pool but was the same between Garvins and Amoskeag Pools and between Hooksett and Amoskeag Pools.

The frequency and percent composition of each stage of maturity for Yellow Perch is presented in Table 4.3.12-15. The percentage of mature male Yellow Perch was significantly lower in Hooksett Pool than in Garvins Pool (q-statistic = 15.1, $P < 0.05$) and Amoskeag Pool (q-statistic = 3.56, $P < 0.05$), but was not significantly different between Garvins and Amoskeag Pools (q-statistic = 1.6, $P > 0.05$; Table 4.3.12-16). The percentage of mature female Yellow Perch was significantly lower in Hooksett Pool than in Garvins Pool (q-statistic = 12.8, $P < 0.05$) or Amoskeag Pool (q-statistic = 7.2, $P < 0.05$), but was similar between Garvins and Amoskeag Pools (q-statistic = 2.3, $P > 0.05$; Table 4.3.12-16).

Table 4.3.12-17 presents the GSI for gravid female and milting male Yellow Perch caught in Garvins and Hooksett Pools during March-April 2012. The mean GSI for male Yellow Perch caught in Hooksett Pool was substantially higher than in Garvins Pool based on non-overlapping 95% confidence intervals, while the mean GSI for females was substantially lower in Hooksett Pool than in Garvins and Amoskeag Pools. The 95% confidence intervals for the mean GSI overlapped between female Yellow Perch caught in Garvins and Amoskeag Pools.

The age and length at 50% maturity for male and female Yellow Perch captured by electrofishing in Garvins, Hooksett, and Pools during March-April 2012 are shown in Table 4.3.12-18. The age at 50% maturity of Yellow Perch ranged from 1.9 to 3.7 years for males and 2.6 to 3.9 for females among the three pools. The mean total length at 50% maturity of Yellow Perch ranged from 159 to 214 mm for males and 154 to 210 mm for females among the three pools.

A significant log-linear relation existed between length and fecundity for ripe female Yellow Perch within each pool (Table 4.3.12-19). The regression slopes for the length-fecundity relation did not significantly differ among pools (ANCOVA, $F = 0.7$, $P = 0.397$). Based on a common regression slope of 3.454, the fecundity for Yellow Perch was significantly higher in Hooksett Pool (y-intercept = -3.847) than in Garvins Pool (y-intercept = -3.893; ANCOVA, $F = 4.54$, $P = 0.040$). For example, the predicted fecundity for a 200-mm ripe female Yellow Perch was 12,560 eggs in Hooksett Pool and 11,297 eggs in Garvins Pool. Sample estimates of Yellow Perch fecundity from individuals collected during March-April, 2012 ranged from 8,680 to 64,670 eggs per ripe female in Garvins Pool, 6,724 to 63,253 eggs per ripe female in Hooksett Pool and 22,390 to 32,241 eggs for the two ripe females caught in Amoskeag Pool.

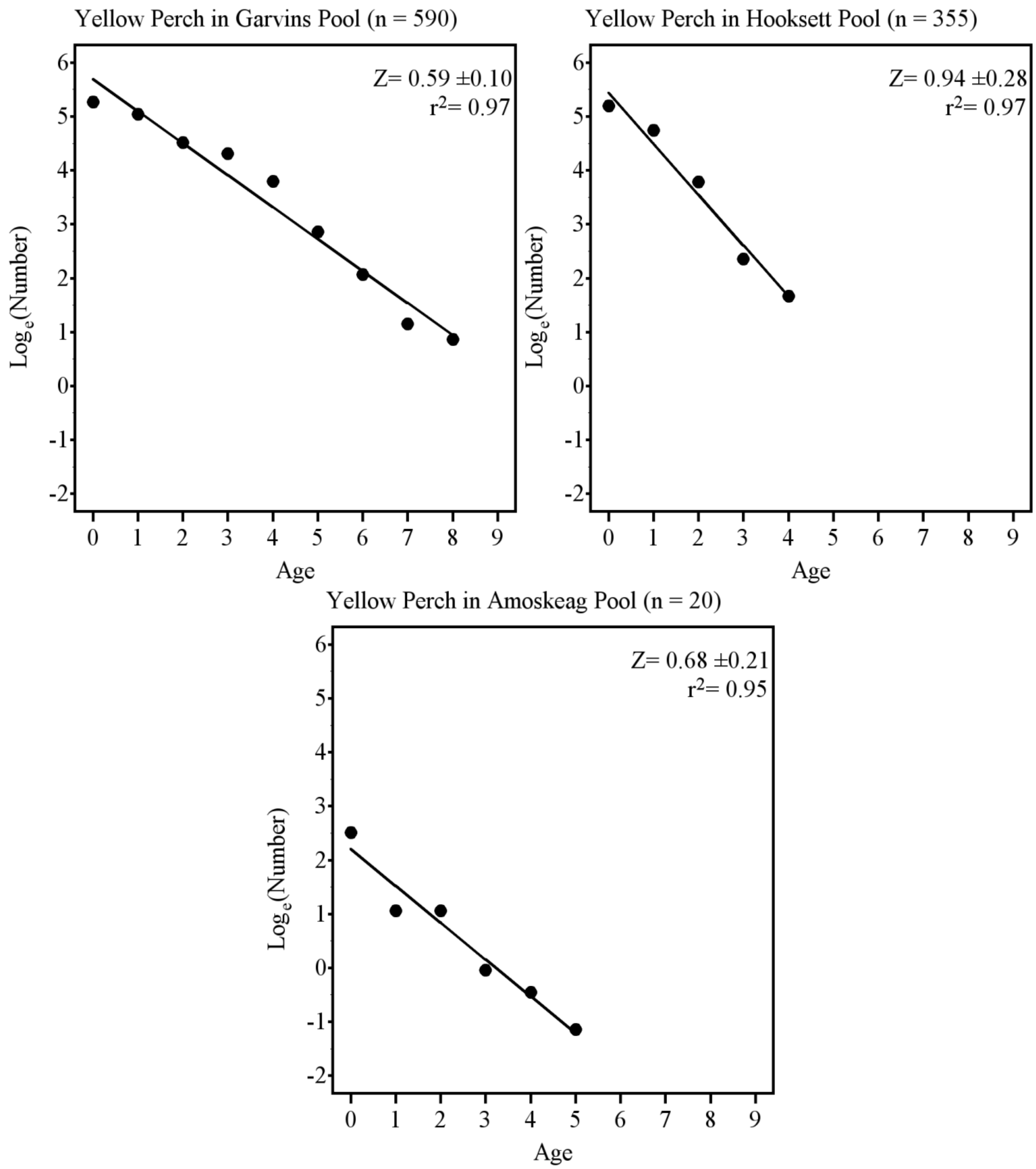

Figure 4.3.12-1. Catch curve estimates of instantaneous total mortality rate (Z ± 95% confidence intervals) for Yellow Perch of fully recruited ages (solid circles) caught by electrofishing during August-September 2008-2013 in Garvins, Hooksett and Amoskeag Pools, Merrimack River. Ages either not fully recruited to the gear or older ages not well represented were excluded (open circles). Note: oldest ages in some cases were included to provide the minimum catch-at-age data needed for the best available instantaneous mortality estimate.

Table 4.3.12-1. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Yellow Perch collected in Garvins, Hooksett and Amoskeag Pools during March-April 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	363	83	334	212	42	351	5	480	116	67
Hooksett	543	72	308	154	45	543	3	420	47	52
Amoskeag	22	114	273	201	35	20	13	289	100	59
Total	**928**	**72**	**334**	**178**	**52**	**914**	**3**	**480**	**75**	**67**

Table 4.3.12-2. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Yellow Perch collected in Garvins and Hooksett Pools during August-September 2012.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	93	71	290	163	39	93	4	265	61	49
Hooksett	24	89	203	149	30	23	9	107	49	28
Total	**117**	**71**	**290**	**160**	**38**	**116**	**4**	**265**	**59**	**46**

Table 4.3.12-3. Total number of fish (N), minimum (Min.), maximum (Max.), mean (Mean), and standard deviation (SD) of the mean total length (mm) and total weight (g) for Yellow Perch collected in Garvins and Hooksett Pools during August-September 2013.

Pool	Total Length (mm)					Weight (g)				
	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Garvins	164	51	249	106	51	133	2	170	28	40
Hooksett	140	54	250	88	35	120	2	118	12	22
Amoskeag	16	61	95	69	8	11	2	8	3	2
Total	**320**	**51**	**250**	**96**	**44**	**264**	**2**	**170**	**19**	**33**

Table 4.3.12-4. Regression statistics for total length (mm) vs. weight (g) for Yellow Perch from Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations [a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	351	3.084	-5.157	0.99				
Hooksett	543	2.848	-5.545	0.98	*		*	
Amoskeag	20	2.868	-5.542	0.98	NS	NS	NS	NS

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.12-5. Regression statistics for total length (mm) vs. weight (g) for Yellow Perch from Garvins and Hooksett Pools during August-September 2012.

Pool	N	Slope (b)[b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations [a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	87	3.054	-5.050	0.98		NS		*
Hooksett	23	3.054	-5.012	0.99	NS		*	

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.12-6. Regression statistics for total length (mm) vs. weight (g) for Yellow Perch from Garvins and Hooksett Pools during August-September, 2013.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]			
					Slope		Intercept	
					Garvins	Hooksett	Garvins	Hooksett
Garvins	133	3.036	-5.044	0.99		*		*
Hooksett	120	2.889	-4.766	0.95	*		*	

Notes: [a]If slope differed significantly between pools, ANCOVA tested for difference in intercept; if slope did not differ significantly between pools, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

Table 4.3.12-7. Regression statistics for total length (mm) vs. weight (g) for Yellow Perch sampled during August-September 2005, 2011, 2012 and 2013 from Hooksett Pool.

Year	N	Slope (b)[b]	Intercept ($log_{10}a$)	R^2	ANCOVA test for differences in length vs. weight equations[a]					
					Slope			Intercept		
					2005	2011	2012	2005	2011	2012
2005	49	2.974	-4.870	0.92						
2011	178	2.974	-4.894	0.97	NS			*		
2012	23	2.974	-4.836	0.99	NS	NS		NS	*	
2013	120	2.974	-4.930	0.95	NS	NS	NS	*	*	*

Notes: [a]If slope differed significantly between years, ANCOVA tested for difference in intercept; if slope did not differ significantly between years, ANCOVA tested for difference in elevation.

Test results symbols for probability (p) levels of significance:

* = significant, $p \leq 0.05$

NS = not significant, $p > 0.05$

[b] Assumed common slope due to non-significant finding

Table 4.3.12-8. Mean length at age (± 95% C.I.) for Yellow Perch captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during March-April and August-September 2012.

Age	Cohort	Pool	ANCOVA	N	Mean	± 95% C.I.
		Garvins		1	72	
0	2012	Hooksett		87	92	2
		Garvins	B	41	128	5
		Hooksett	A	220	140	3
1	2011	Amoskeag		5	160	28
		Garvins	A	54	160	4
		Hooksett	A	159	164	3
2	2010	Amoskeag		2	168	161
		Garvins	A	79	196	5
		Hooksett	A	56	200	7
3	2009	Amoskeag		7	216	8
		Garvins	B	123	216	4
		Hooksett	A	30	236	9
4	2008	Amoskeag		6	224	24
		Garvins		74	236	5
		Hooksett		7	260	23
5	2007	Amoskeag		2	224	9
		Garvins		38	256	7
6	2006	Hooksett		1	280	
		Garvins		11	264	16
7	2005	Hooksett		1	268	
8	2004	Garvins		2	292	120

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.12-9. Mean length at age (± 95% C.I.) for Yellow Perch captured by electrofishing from Garvins, Hooksett, and Amoskeag Pools during fall 2013.

Age	Cohort	Pool	ANOVA	N	Mean	± 95% C.I.
0	2013	Garvins	A	68	76	3
		Hooksett	A	95	76	2
		Amoskeag	A	16	68	4
1	2012	Garvins		7	120	22
		Hooksett		7	132	26
2	2011	Garvins		10	168	7
		Hooksett		1	200	
3	2010	Garvins		11	200	7
		Hooksett		3	204	18
4	2009	Garvins		4	208	30
		Hooksett		3	228	34
5	2008	Garvins		5	240	6
6	2007	Garvins		1	212	

Notes: Analysis of variance (ANOVA) was used to test for significant differences in mean total length at age among Merrimack River pools for a cohort. Unique letter combinations identify significantly different mean total lengths based on Tukey's pairwise comparison test. (α = 0.05). Minimum sample size in each pool included in the ANOVA was 15 individuals.

Table 4.3.12-10. Frequency distribution of external parasite loads for Yellow Perch collected from Garvins, Hooksett and Amoskeag Pools during March-April 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	70	19.28	149	41.05	144	39.67
Hooksett [B]	37	6.81	149	27.44	357	65.75
Amoskeag [C]	2	9.09	6	27.27	14	63.64

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.12-11. Frequency distribution of external parasite loads for Yellow Perch collected from Garvins and Hooksett Pools during August-September 2012.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	2	2.15	6	6.45	85	91.4
Hooksett [B]	0	0	4	16.67	20	83.33

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.12-12. Frequency distribution of internal parasite loads for Yellow Perch collected from Garvins, Hooksett and Amoskeag Pools during March-April 2012.

Pool	Absent		Present	
	N	%	N	%
Garvins [A]	216	62	131	38
Hooksett [B]	317	81	72	19
Amoskeag [B]	16	73	6	27

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e <5) for pairwise comparison.

Table 4.3.12-13. Frequency distribution of external parasite loads for Yellow Perch collected from Garvins and Hooksett Pools during August-September 2013.

Pool	Absent		Light		Moderate/Heavy	
	N	%	N	%	N	%
Garvins [A]	22	17.7	36	29.0	66	53.2
Hooksett [B]	54	41.2	64	48.9	13	9.9
Amoskeag [C]	10	83.3	2	16.7	0	0

Notes: Different letters indicate significant within year differences between pools.
No letter indicates insufficient sample size (i.e., <5) for pairwise comparison.

Table 4.3.12-14. Frequency of male and female Yellow Perch collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	Gender	Frequency	
		N	%
Garvins	Male [A]	239	69.3
	Female [B]	106	30.7
Hooksett	Male [A]	174	44.8
	Female [B]	214	55.2
Amoskeag	Male [A]	12	54.5
	Female [A]	10	45.5

Notes: Different letters indicate proportion of females and males within each pool were significantly different from 0.5 (1:1 female:male ratio).

Table 4.3.12-15. Frequency distribution of the reproductive condition of Yellow Perch (sexes combined) collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Reproductive condition	Garvins		Hooksett		Amoskeag		Total	
	N	%	N	%	N	%	N	%
Gravid or milting (ripe)	82	23.8	92	23.7	2	9.1	176	23.3
Ripe and running	30	8.7	17	4.4			47	6.2
Partially spent	72	20.9	5	1.3	4	18.2	81	10.7
Spent	103	29.9	3	0.8	4	18.2	110	14.6
Immature	44	12.8	256	66.0	2	9.1	302	40.0
Not gravid or not milting (resting)	12	3.5	7	1.8	10	45.5	29	3.8
Semi-gravid or semi-milting (developing)	2	0.6	8	2.1			10	1.3
Total	**345**	**100.0**	**388**	**100.0**	**22**	**100.0**	**755**	**100.0**

Table 4.3.12-16. Percent maturity of female and male Yellow Perch collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	Male	Female
Garvins	97.1^{A}	65.1^{A}
Hooksett	57.5^{B}	15.0^{B}
Amoskeag	91.7^{A}	90.0^{A}

Notes: Different letters indicate proportion of mature females or males caught during spring 2012 were significantly different among pools.

Table 4.3.12-17. Gonadosomatic index (GSI, %) of gravid female and milting male Yellow Perch collected by electrofishing within Garvins, Hooksett, and Amoskeag Pools during March-April 2012.

Pool	Male				Female			
	N	95% LCL	Mean GSI	95% UCL	N	95% LCL	Mean GSI	95% UCL
Garvins	57	3.4	3.8	4.1	25	29.9	33.0	36.1
Hooksett	75	4.7	5.1	5.4	17	24.6	27.0	29.4
Amoskeag					2	34.3	34.6	34.9
Total	**132**	**4.2**	**4.5**	**4.8**	**44**	**28.6**	**30.7**	**32.9**

Table 4.3.12-18. Age and length of male and female Yellow Perch collected by electrofishing within Garvins and Hooksett Pools during March-April 2012.

Pool	Age at 50% Maturity		Length (mm) at 50% Maturity	
	Male	Female	Male	Female
Garvins	3.7	3.9	214	210
Hooksett	1.9	2.6	159	154
Amoskeag	2.5	3.0	196	207

Table 4.3.12-19. Regression[a] statistics for log-linear relation($E = aL^b$) between total length (L, mm) and fecundity (E, eggs) of female Yellow Perch collected from Garvins and Hooksett Pools during March-April 2012.

Pool	N	Slope (b)	Intercept ($log_{10}a$)	F	R^2	P-value
Garvins	24	3.567	-4.164	313.2	0.93	<0.001
Hooksett	17	3.318	-3.526	265.4	0.95	<0.001

[a] $\log_{10}(\text{fecundity}) = b \times \log_{10}(\text{length}) + \log_{10}a$

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