LAKE CHAMPLAIN 2000
ZEBRA MUSSEL MONITORING PROGRAM

Final Report
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A Report Prepared For the
Lake Champlain Basin Program

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF TABLES:

LIST OF FIGURES:

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INTRODUCTION

The Vermont Department of Environmental Conservation (VTDEC), in cooperation with the Lake Champlain Basin Program, initiated the Lake Champlain Zebra Mussel Monitoring Program in 1994 to track zebra mussel distribution in the lake. Annual reports have been provided each year (Kamman 1994, Stickney 1996, Eliopoulos and Stangel 1997, 1998, 1999, and 2000a). This report presents veliger, juvenile, and adult zebra mussel distributions during 2000 compared with previous years of monitoring.

Goals and objectives

Zebra mussel monitoring included veliger (larvae), settled juvenile, and adult life stages at open-water and nearshore lake stations, lake tributaries, and inland lakes. Greater emphasis was placed on veliger monitoring, as it is in their pelagic stage that zebra mussels are most easily spread and sampled in Lake Champlain. The goals of the Lake Champlain Zebra Mussel Monitoring Program include the following monitoring and technical assistance aspects:

(1) Monitor the distribution and abundance of zebra mussel larvae, juveniles, and adults in Lake Champlain.

(2) Determine the occurrence of new zebra mussel colonization in Lake Champlain, its tributaries, and inland lakes with high boating activity and/or close proximity to Lake Champlain and incorporate this information into a database.

(3) Use the data to help determine the appropriate management response and assess the effectiveness of spread prevention or control measures.

(4) Inform the public, members of the Lake Champlain Basin Aquatic Nuisance Species and Zebra Mussel Task Force, related water treatment facility operators, and marina managers of the presence of zebra mussels so that they may take appropriate spread prevention and control measures.

(5) Provide technical assistance to the groups listed above regarding the design and operation of zebra mussel monitoring programs.

(6) Document selected water quality parameters pertinent to zebra mussel survival at open-water sampling sites in Lake Champlain and its tributaries.

(7) Produce a yearly report documenting the findings of the Lake Champlain Zebra Mussel Monitoring Program.

(8) Maintain the Lake Champlain Zebra Mussel Monitoring Program website.

FIELD SAMPLING METHODS

Open-water veligers

Twelve open-water lake stations, shown in Figure 1, were sampled for occurrence and density of veligers. These stations were co-located with stations of the Lake Champlain Long-Term Water Quality and Biological Monitoring Project (New York State Department of Environmental Conservation and Vermont Department of Environmental Conservation 2000). Co-location of these stations allowed for relating zebra mussel monitoring results with other water quality and biological data in previous reports, and for improved overall sampling efficiency.

Open-water veliger samples were collected twice monthly starting in late-April using vertical plankton net tows as described in the Vermont Department of Environmental Conservation Field Methods Manual (1989, method 4.2.1). A 13 cm aperture size Wisconsin style plankton net with a 63 μm (micron) net mesh size was towed vertically to the lake surface from a depth of ten meters, or one meter from the lake bottom in areas where the bottom depth was less than ten meters, at a 0.5 m/sec retrieval rate for optimal veliger entrapment (Marsden, 1992, method 3.5). To calculate veliger densities, a net efficiency of 95% was assumed and the volume of water filtered was estimated based on the length of tow and net aperture. Veliger samples consisted of five composited net tows of equal length. Volume of water filtered for each sample ranged from 0.13 m^3 to 0.66 m^3 depending on depth of station sampled. Length of net tow, surface water temperature, and Secchi disk transparency were recorded for each sample. Once out of the water, the net contents were concentrated and transferred to a 50 ml plastic container and preserved with a 95% ethanol solution in a 1:1 ratio of sample to ethanol solution. After sampling, the net was rinsed vigorously three times in the lake. Sampling was discontinued in October.

As described in Eliopoulos and Stangel (2000a) plankton net efficiency is highly variable. Results obtained from plankton net sampling should be compared only within Lake Champlain and not with data from other monitoring programs using other techniques.

Nearshore veligers

Occurrence and density of veligers were determined at 11 nearshore lake stations (Figure 1) located in shallow water near marinas or in bays. The nearshore stations were located on both the Vermont and New York sides of the lake.

Nearshore veliger samples were collected using horizontal plankton net tows twice a month beginning in late-April. The net was thrown from shore and slowly towed horizontally below the surface at a rate of 0.5 m/sec (Vermont Department of Environmental Conservation, 1989, method 4.2.2). Net tow samples and field duplicates were composites of five tows of equal length. Length of tow, surface water temperature, and Secchi disk transparency were recorded for each sample. Estimated volume of water filtered, net cleaning protocol, sample preservation, and storage were the same as for openwater veliger samples. Sampling was discontinued in October.

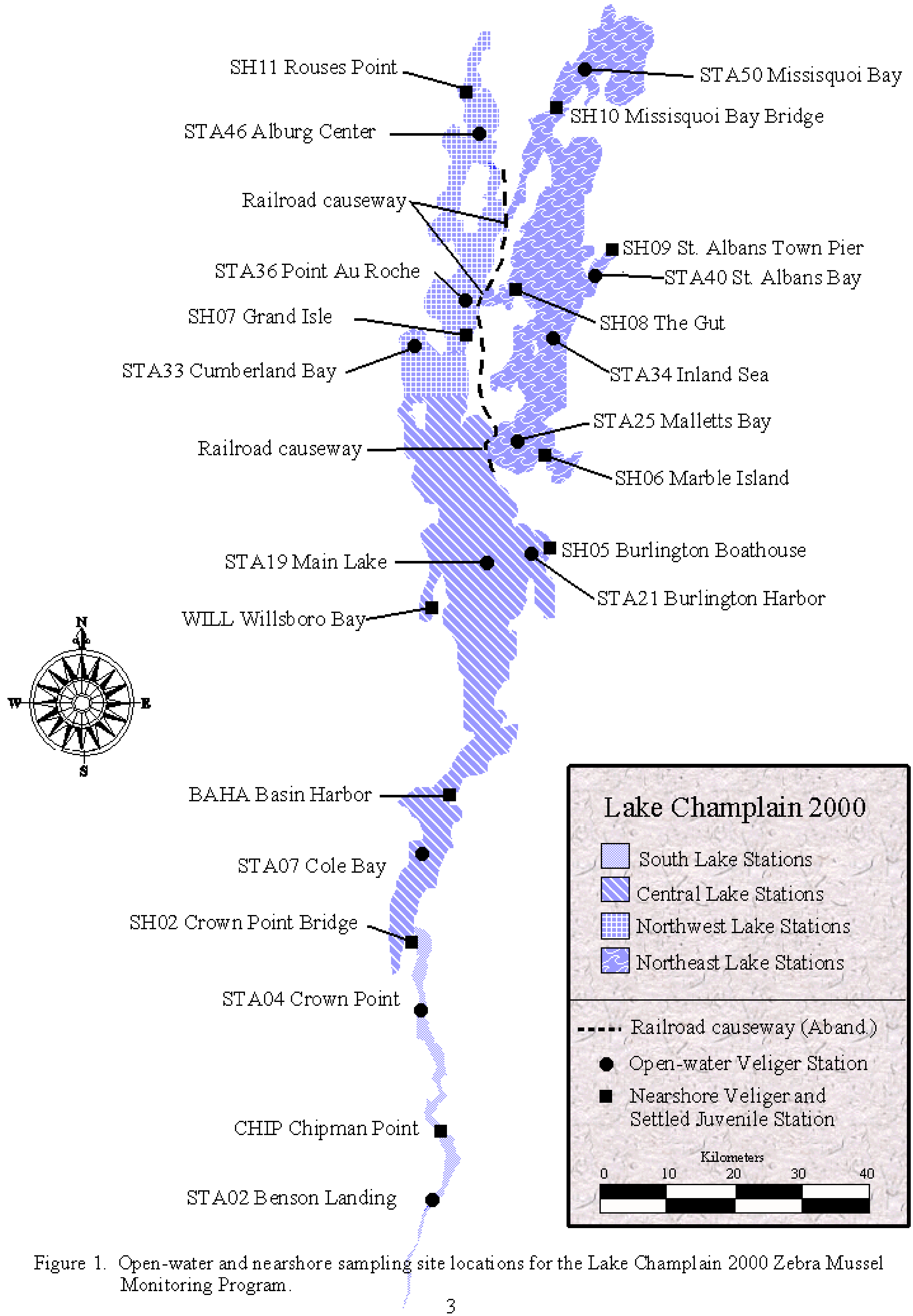


Figure 1. Open-water and nearshore sampling site locations for the Lake Champlain 2000 Zebra Mussel Monitoring Program.

Nearshore settled juveniles

Occurrence and density of settled juveniles were determined at the 11 nearshore stations, shown in Figure 1, beginning in late-April by deploying an array of three 15X15 cm gray colored polyvinyl chloride (PVC) settling plates. The plates were arranged horizontally (Figure 2), along a stainless steel threaded eyebolt and separated with nuts and washers by approximately 3 cm. The plate array was suspended in the water column by attaching a rope to the eyebolt and to a dock, bridge abutment, or float. The plate array was submerged so that the top plate was 2-3 m below the lake surface. The bottom of the plate array was attached to a rope with a weight resting on the lake bottom. The top plate remained in the water for the entire sampling season to estimate seasonal accumulation. The middle and bottom plates were collected and replaced alternately every two weeks. This allowed plates to be available for settled juveniles for a total of four weeks.

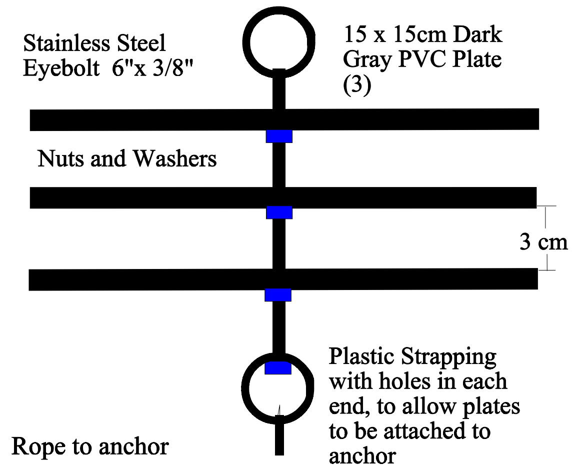


Figure 2. Settling plate array.

Each retrieved settling plate was stored in an air-tight plastic container and treated with a minimal amount of 95% ethanol. Drenching the plates with ethanol could cause the mussels to detach, and was avoided. The plates were transported to the laboratory where they were stored in a refrigerator at 4 ºC. Since newly settled zebra mussel shells are fragile, plates were handled carefully to avoid damage.

Adult distribution

Information on the distribution of adult zebra mussels in Lake Champlain was compiled from a variety of sources including observations by VTDEC staff biologists working on this and other related projects, researchers from the University of Vermont, and confirmed citizens' sightings. Adult mussel densities have been characterized by relative abundance at selected areas during snorkel survey in 1997, 1998, 1999 and 2000. Snorkel surveys were conducted by two people for approximately fifteen minutes at each site. This information was used to track the extension of the adult zebra mussel distribution in Lake Champlain.

Tributary sampling

Six Lake Champlain tributaries (Figure 3) were selected for sampling in 2000, including the Missisquoi River, Lamoille River, Winooski River, Dead Creek, Putnam Creek, and the Poultney River. Plankton net samples were collected from each river and analyzed for veligers. The net used for river sampling was not used in Lake Champlain. When traveling between sampling sites, the plankton net was stored in a 95% ethanol solution to kill any veligers

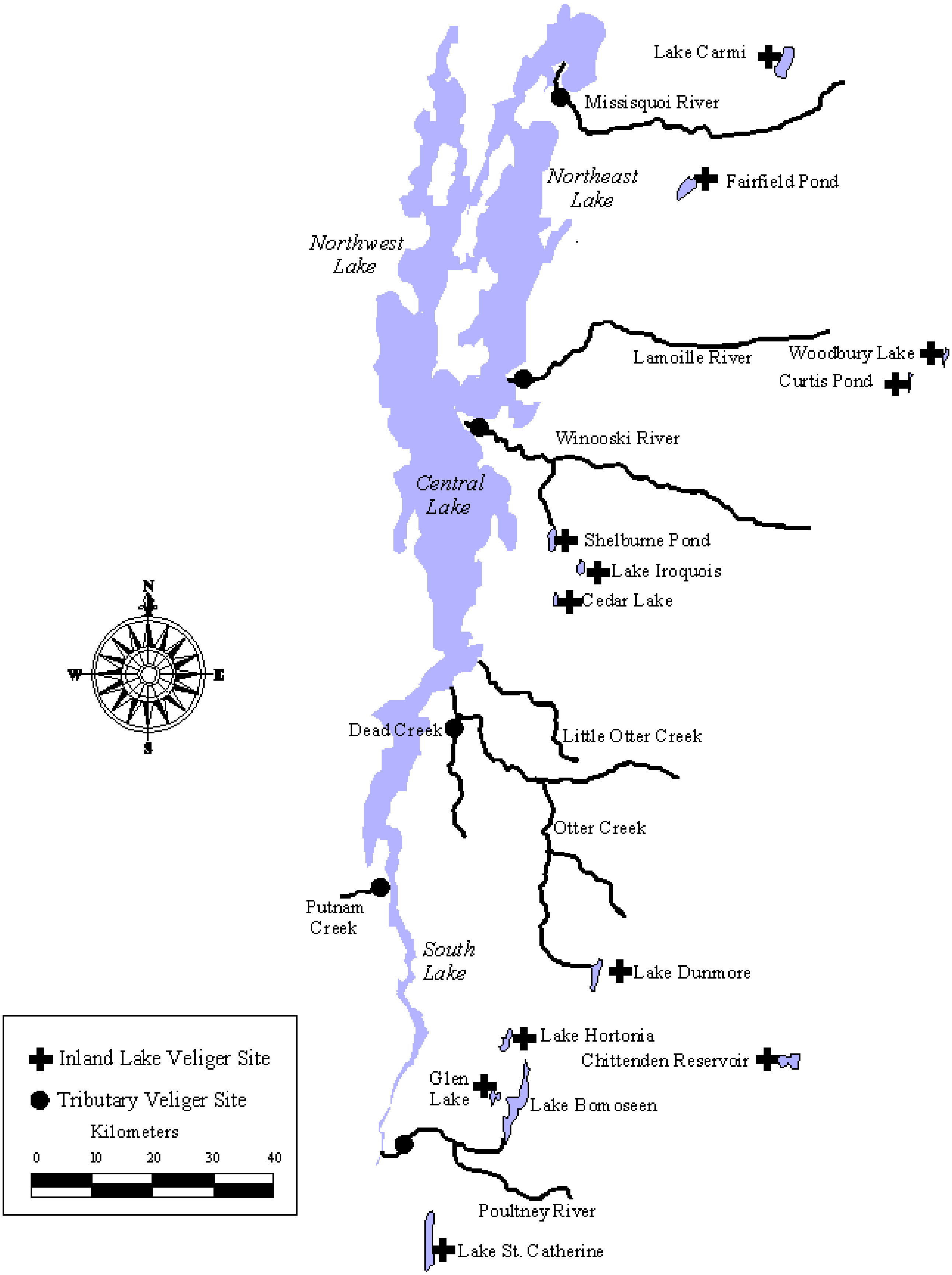


Figure 3. Inland lake and tributary sampling sites for the Lake Champlain 2000 Zebra Mussel Monitoring Program.

remaining in the net. Net cleaning protocol and sample preservation were the same as for open-water veliger sampling.

Inland lake sampling

Twelve Vermont inland lakes with high boating activity or close proximity to Lake Champlain were selected for sampling. These lakes included Lake Carmi, Cedar Lake, Chittenden Reservoir, Curtis Pond, Lake Dunmore, Fairfield Pond, Glen Lake, Lake Hortonia, Lake Iroquois, Shelburne Pond, Lake St. Catherine, and Woodbury Lake (Figure 2). Horizontal plankton net tows were taken from the shore at public access areas or lake outlets during July and August. The net used in Lake Champlain was not used in inland lakes and was stored in 95% ethanol between sampling sites.

In addition, researchers from Castleton State College conducted a zebra mussel monitoring program in Lake Bomoseen with assistance from VTDEC. A plankton net was used to determine the presence of veligers, and snorkels surveys were conducted for adult zebra mussels throughout the summer.

LABORATORY ANALYTICAL METHODS

Veligers

Analytical procedures and calibration followed methods detailed in Marsden (1992). A dissecting stereo-microscope at 30X magnification was used with a cross-polarization light technique (Johnson, 1995) to enhance veliger detection for counting purposes. Veliger identification was verified under a compound microscope with assistance of VTDEC Biomonitoring and Aquatic Studies Section taxonomists. For samples containing relatively few veligers (approximately 100 per sample), all veligers were counted. If veligers were too abundant to count in full (approximately >100 per sample), the sample was diluted quantitatively as necessary and three 1.0 ml subsamples were extracted into 1.0 ml Sedgewick-Rafter cells, counted, and used to estimate the density of the entire sample. Densities were reported as number of veligers/m^3.

Settled juveniles

The 15X15 cm (225 cm^2) settling plate was placed under a dissecting stereo-microscope at 30X magnification and all juveniles on the underside of the plate were counted. If settled juvenile densities were too abundant to count accurately, five 1.0 cm^2 replicates were counted using a 1.0 cm^2 counting cell randomly placed on the plate. Juveniles were counted in each 1.0 cm^2 block, and plate density was estimated as number of juveniles/m^2 (method modified from Marsden, 1992). On plates with extremely dense encrustations and uniform distribution of individuals, ¼ of the plate area was counted.

Quality assurance procedures

A complete description of project quality assurance procedures is provided in the Lake Champlain Zebra Mussel Monitoring Program Work/QA plan (Eliopoulos and Stangel 2000b). Data precision was determined through field duplication of 11% of the veliger samples and 22% of juvenile settling plate samples during 2000. In addition, 9% of all veliger samples and juvenile sampling plates were reanalyzed as laboratory duplicates. The relative percent difference (RPD) for both field and laboratory duplicates was calculated.

$$RPD = (\text{count a} - \text{count b}) / (\text{count a} + \text{count b}) / 2 \quad \times 100$$

Accuracy of veliger and settled juvenile identifications was accomplished by comparison with reference samples and through consultation with taxonomists in the Biomonitoring and Aquatic Studies Section of VTDEC. Data comparability was achieved by using standardized methods as defined in the Vermont Department of Environmental Conservation Field Methods Manual (1989) and in Marsden (1992).

RESULTS AND DISCUSSION

Zebra mussels in Lake Champlain continued to reproduce and settle successfully during 2000. Figure 4 shows the annual changes in zebra mussel distribution since 1993, the year of their discovery in Lake Champlain.

Comparisons of veliger and settled juvenile densities between lake stations and/or between years were based on seasonal time-weighted mean density estimates. Simpson's integral was used to calculate the area under the density vs. time plots and the areas were divided by the duration of the sampling season. Seasonal weighted mean estimates were based on equal sampling season lengths of 150 days starting and ending with zero density values at the beginning and end of the sampling seasons.

Seasonal weighted mean densities were considered more appropriate than geometric means, arithmetic means, or single peaks because of the extreme within-season variation in veliger and settled juvenile densities. Veliger production and juvenile settlement occur during discrete time periods, causing densities to increase from zero upwards over several orders of magnitude within a short time interval during a season at some stations. Mean values would therefore be too strongly biased by the number of samples obtained during non-reproductive periods. Seasonal time-weighted mean density values provide a better index of the overall larval and juvenile production at each site.

Veligers

Variations in veliger densities during the 2000 sampling season are described for all regions of the lake in Figures 5-10. Veliger densities with temperature and Secchi depths for 2000 are available in Appendix A. The 1994-2000 data are available on the Lake Champlain Basin Program website at http://www.anr.state.vt.us/champ/zmmonitoring.htm. Veligers were

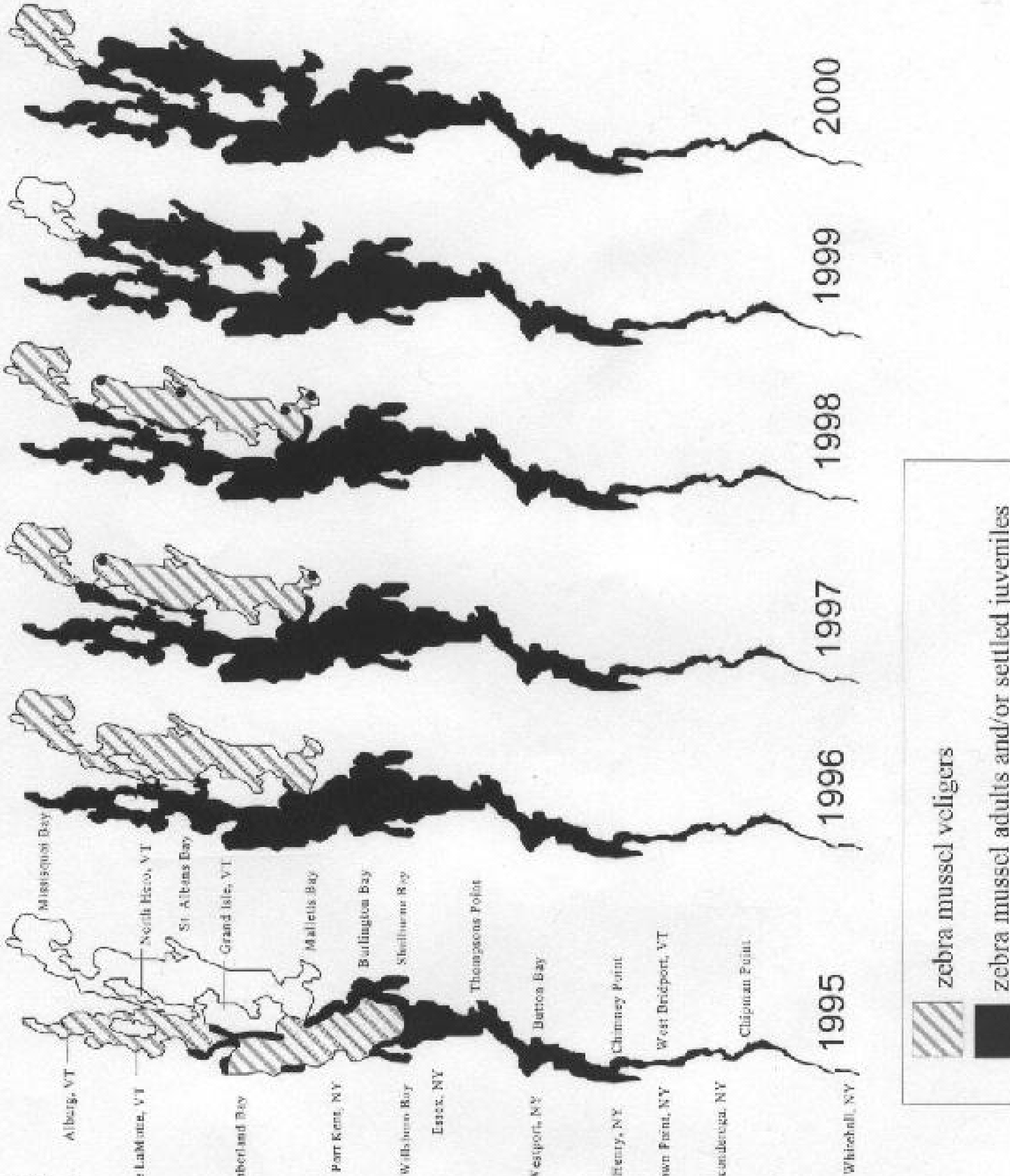


Figure 4. Annual changes in Lake Champlain zebra mussel distribution since 1993.

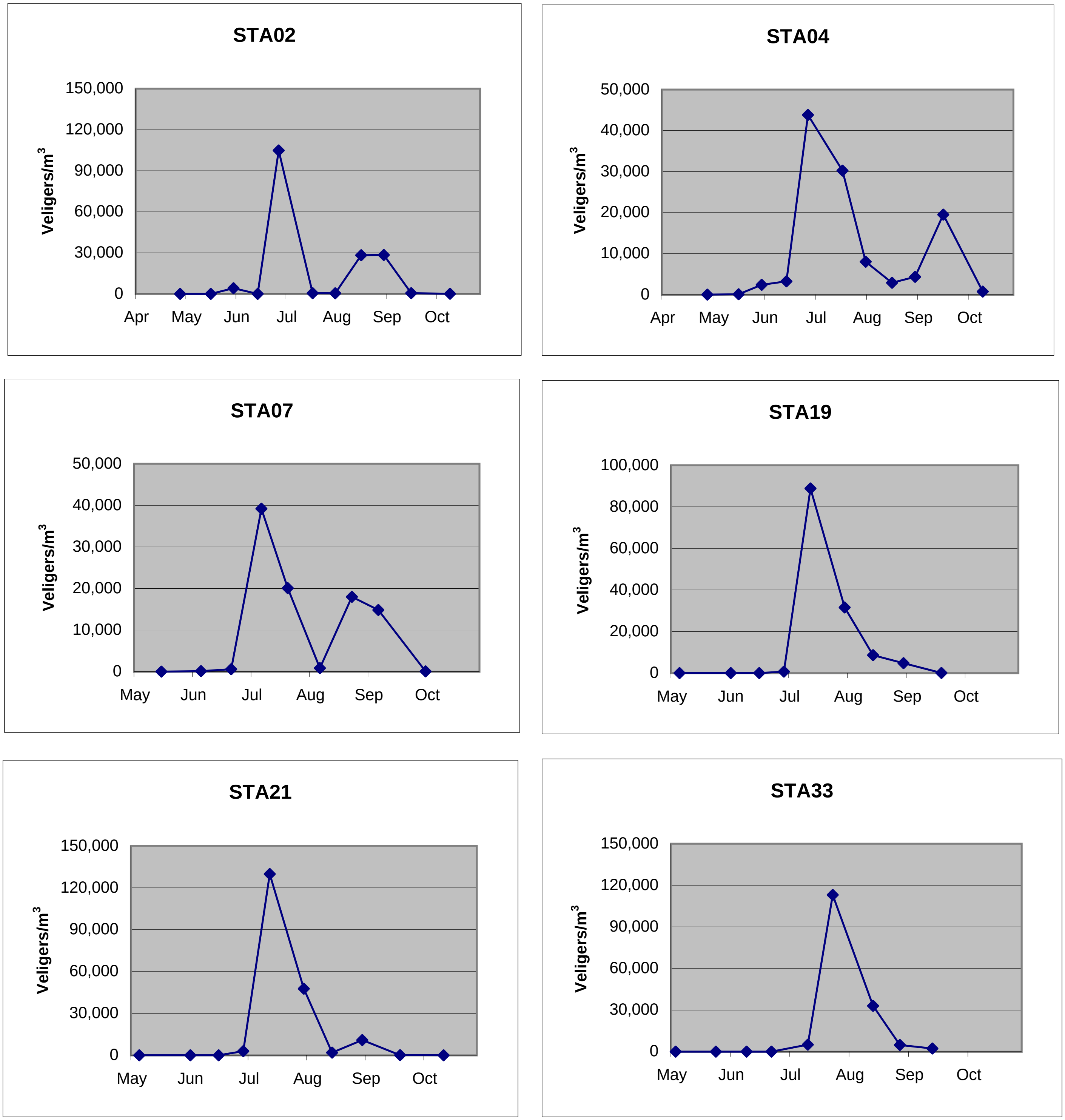


Figure 5. Veliger densities at open-water stations during 2000.

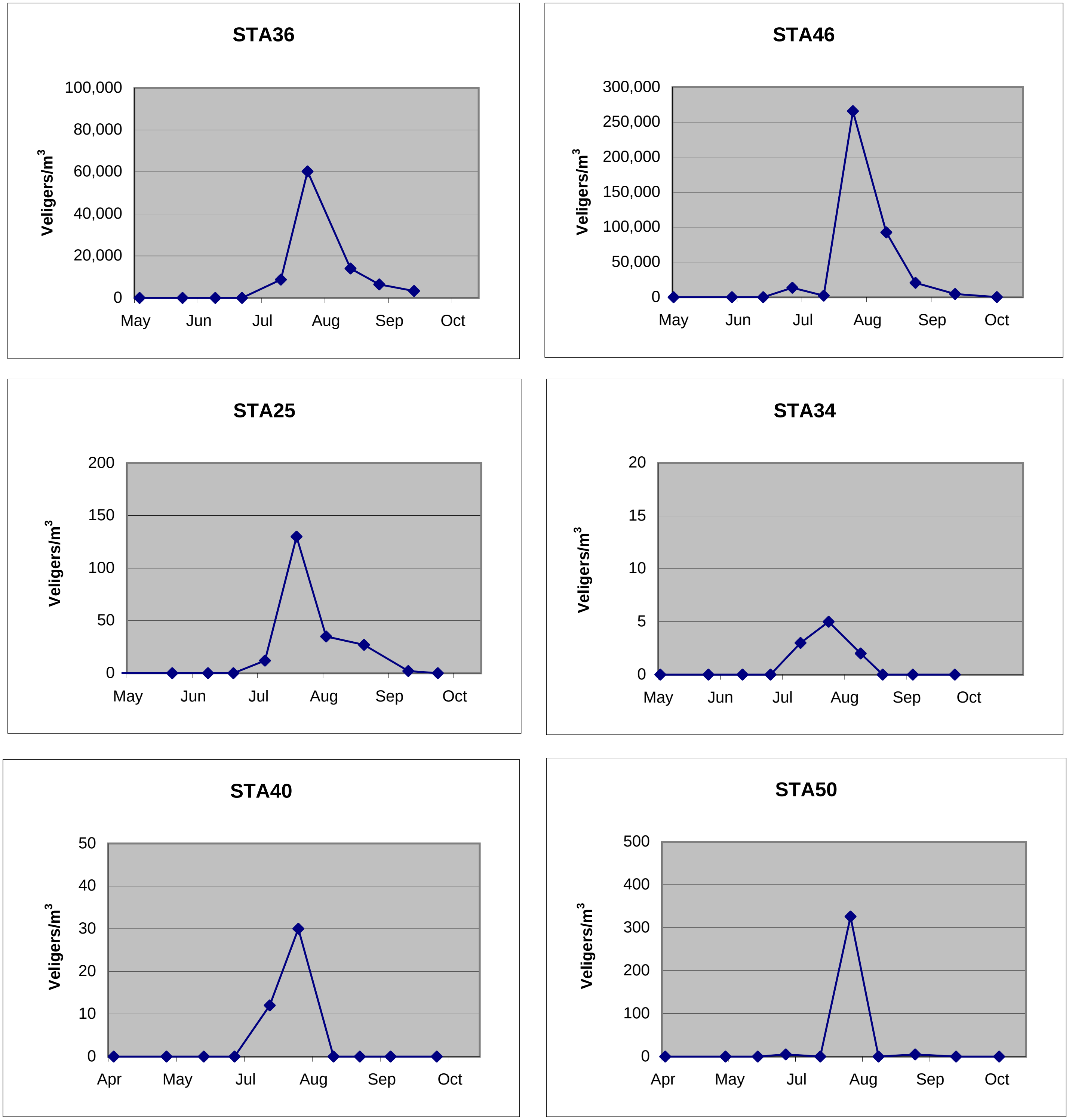


Figure 6. Veliger densities at open-water stations during 2000.

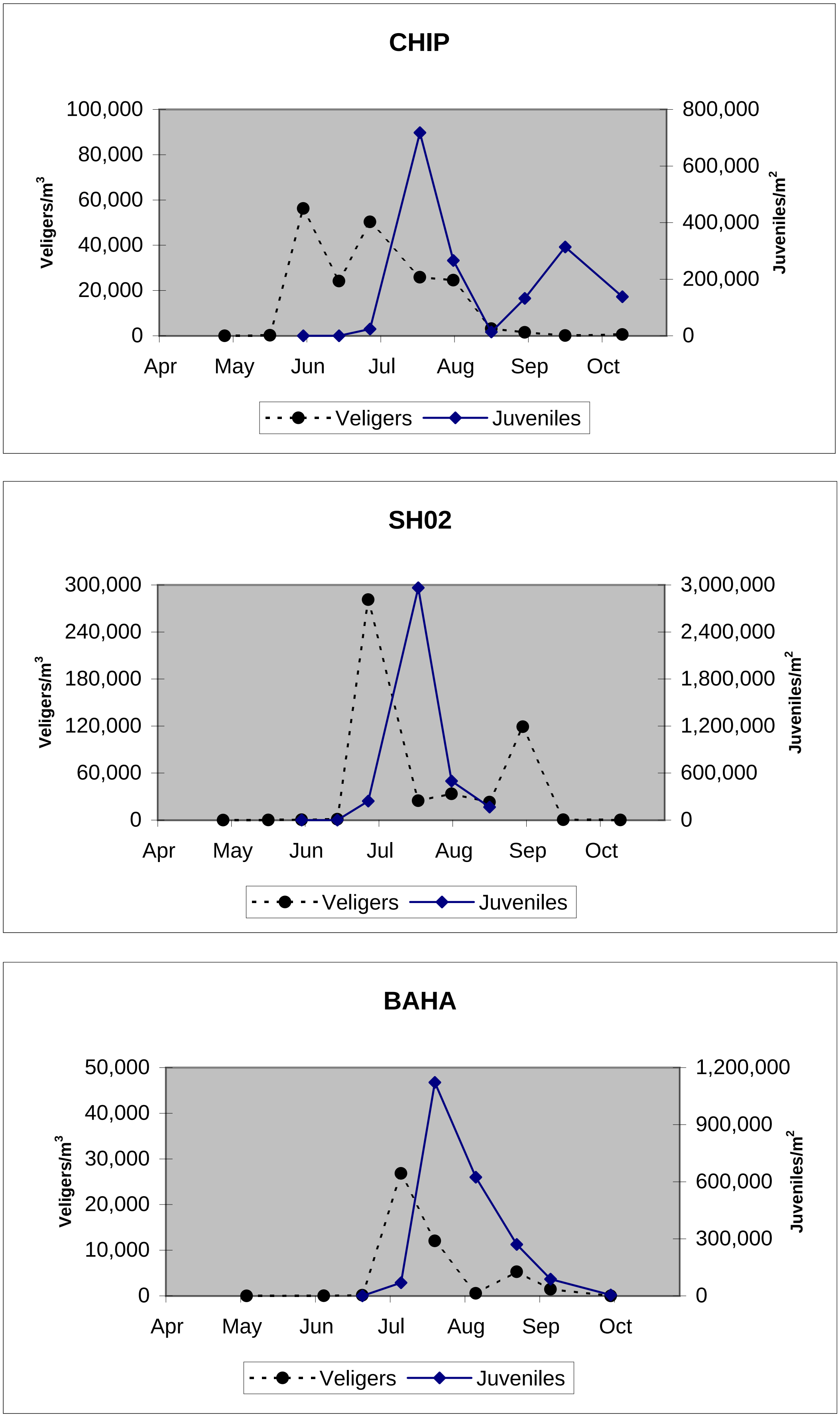


Figure 7. Veliger and settled juvenile densities at nearshore stations during 2000.

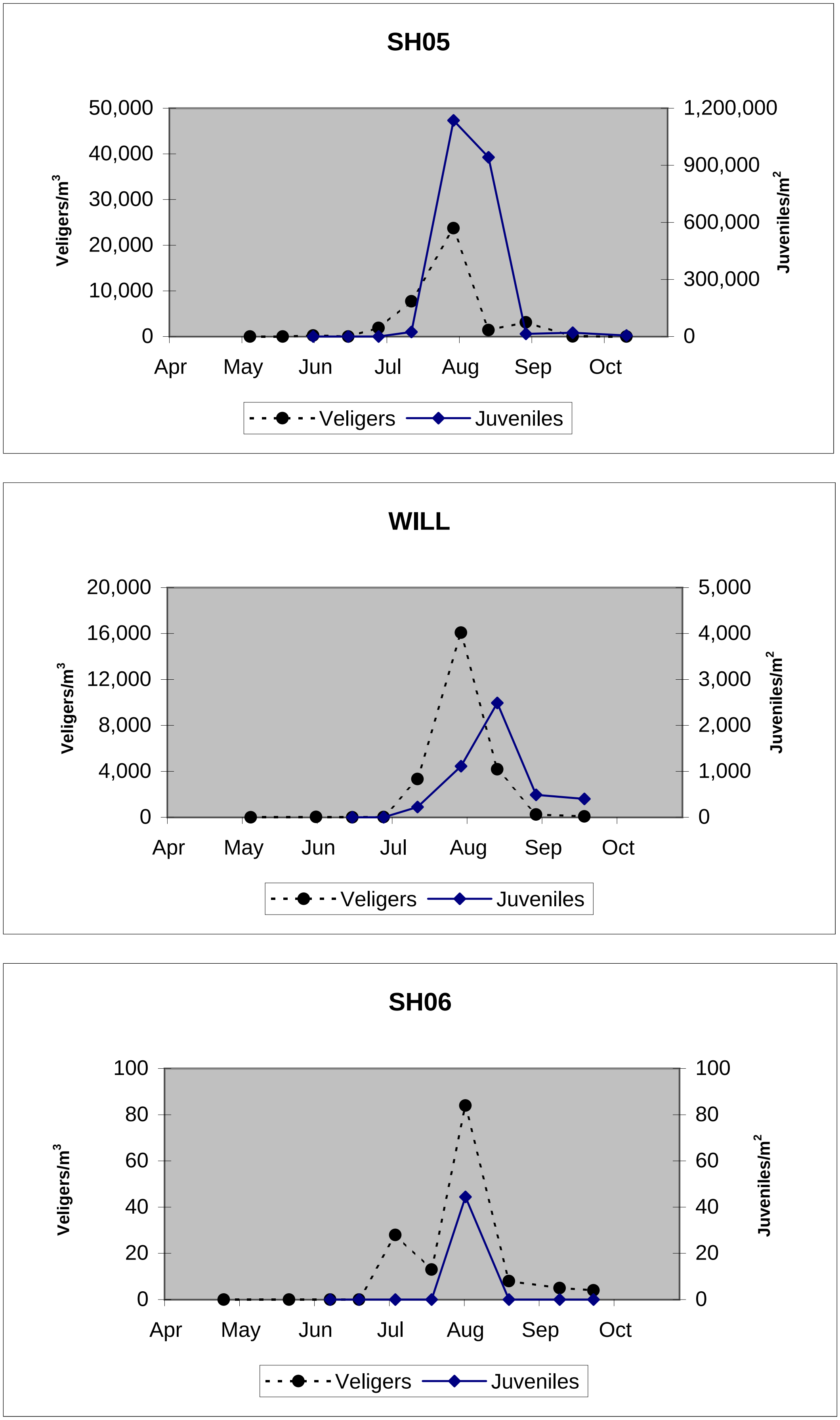


Figure 8. Veliger and settled juvenile densities at nearshore stations during 2000.

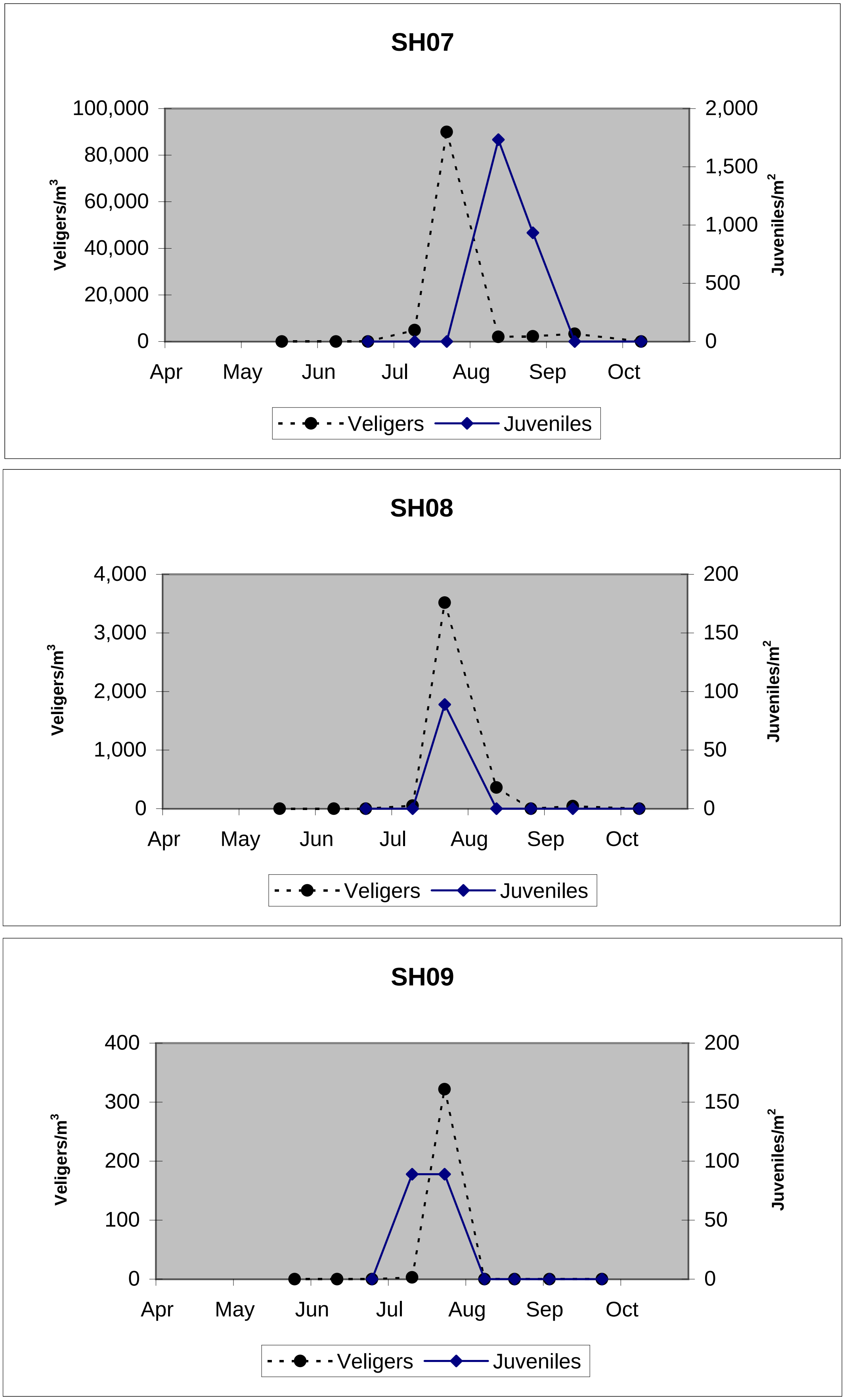
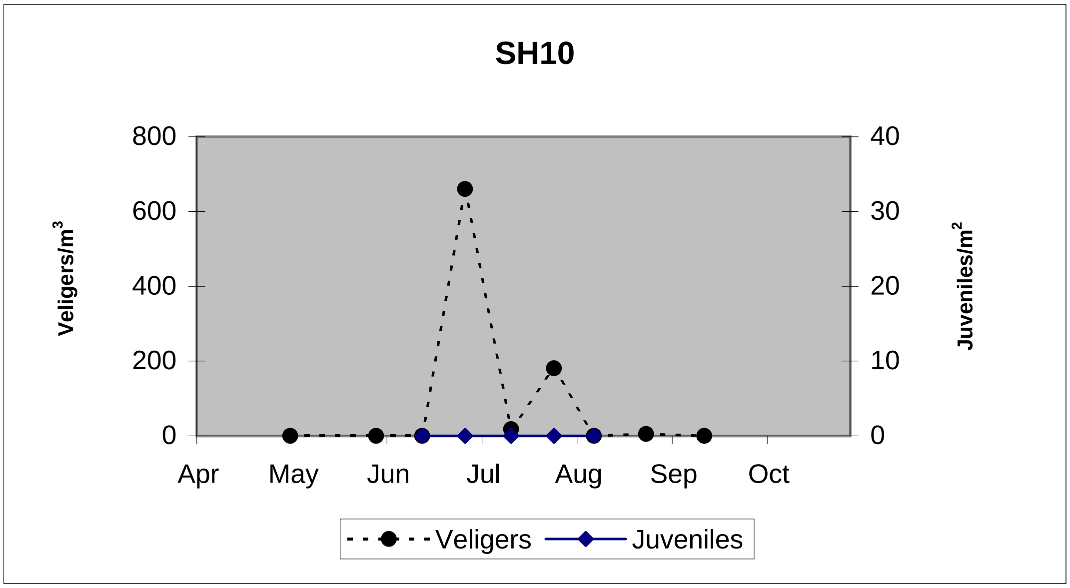


Figure 9. Veliger and settled juvenile densities at nearshore stations during 2000.



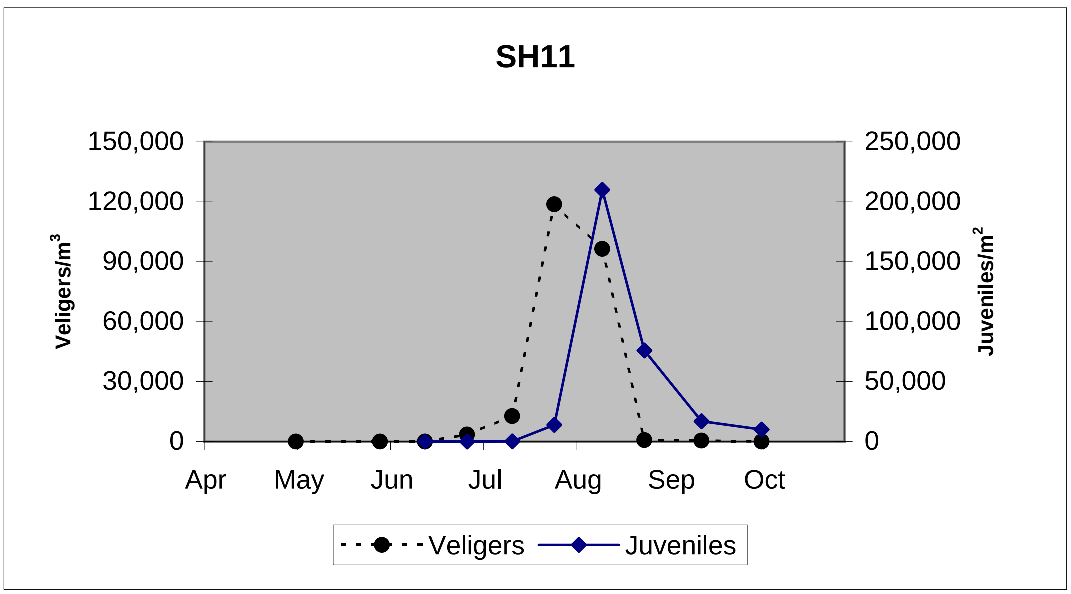


Figure 10. Veliger and settled juvenile densities at nearshore stations during 2000.

first detected in 2000 in the South Lake on May 17 as water temperatures reached 14º C. Veligers were found one to two weeks later in the Central, Northeast, and Northwest lake regions. Timing of peak densities varied throughout the lake regions, ranging from May 31 to September 1, with the earliest peak at the South Lake station Chipman Point (CHIP). Veligers were reduced to very low densities throughout the lake by early October.

In 2000, the highest observed peak density in the lake was 281,268 veligers/m^3 at the South Lake station Crown Point Pier (SH02). Nine of the twelve highest veliger densities occurred in the Central and Northwest Lake. The highest recorded veliger density exclusive of the South Lake was found at Point Au Fer (STA46) with a density of 265,597 veligers/m^3. Peak densities in the Northeast Lake continued to be about two or three orders of magnitude lower in comparison to all other lake regions, although at least some veligers were recorded at all lake stations. The highest veliger density recorded in the Northeast Lake was at The Gut (SH08), with a density of 3,516 veligers/m^3 on July 24.

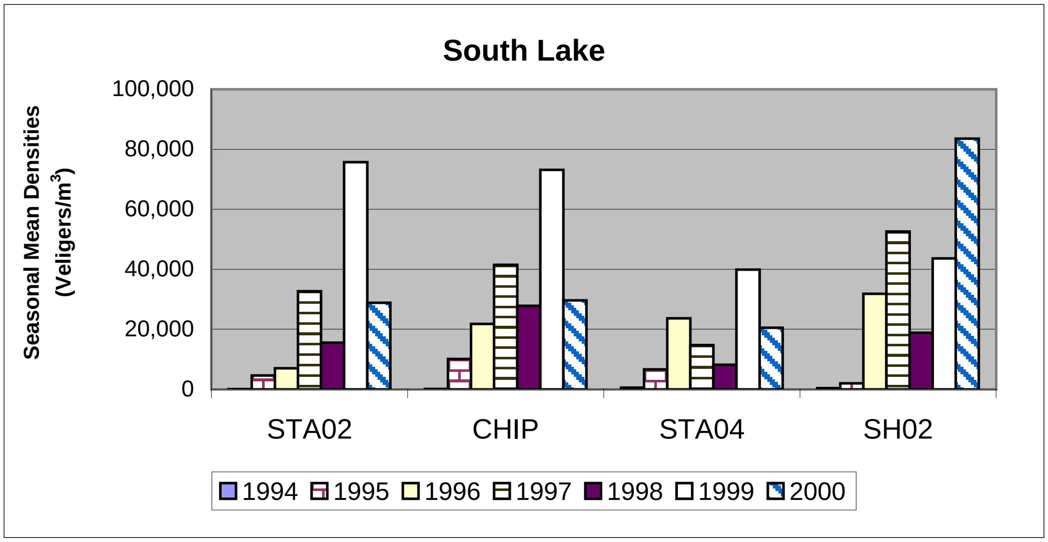
Changes in seasonal weighted mean veliger densities at each lake station during the period of 1994-2000 are shown in Figures 11 and 12. In 2000, seasonal weighted mean veliger densities exceeded those found in 1999 at 14 of 23 stations. The greatest increases were found in the Northwest and Northeast Lake sections, while decreases occurred at three of the four South Lake stations.

Settled juveniles

Variations in juvenile densities during the 2000 sampling season at all nearshore stations are described in Figures 7-10. Settled juvenile densities with number of days plates were in the lake for 2000 are available in Appendix B. The 1994-2000 data are available on the Lake Champlain Basin Program website at http://www.anr.state.vt.us/champ/zmmonitoring.htm. Settled juveniles were first detected in the South Lake on June 28, the Central Lake on July 7, and in both the Northwest and Northeast Lake on July 12. The 2000 peak settled juvenile density was 2,964,000 juveniles/m^2 collected in mid-July in the South Lake at SH02. The peak density in the Central Lake was 1,136,000 juveniles/m^2 at Burlington Boathouse (SH05) on July 31. Peak densities in the Northwest Lake were found at Rouses Point (SH11) on August 11 with a density of 210,000 juveniles/m^2. Peak densities in the Northeast Lake were found at SH08 and St. Albans Bay (SH09) in July with densities of 89 juveniles/m^2.

The settling plate array from SH02 was vandalized in late August. The settling plate array at Missisquoi Bay Bridge (SH10) was lost during the same time period.

Differences among seasonal weighted mean juvenile densities from 1998-2000 for selected nearshore stations are shown in Figure 13. Data from only these years were used due to a lack of reliable data from some stations during previous years because of loss or vandalism of sampling plates. SH02 had the highest seasonal weighted mean juvenile densities during 2000. Only three of 11 stations had an increase in seasonal weighted mean settled juvenile densities in 2000 compared to 1999. No juvenile settlement was recorded at SH10 in 2000.



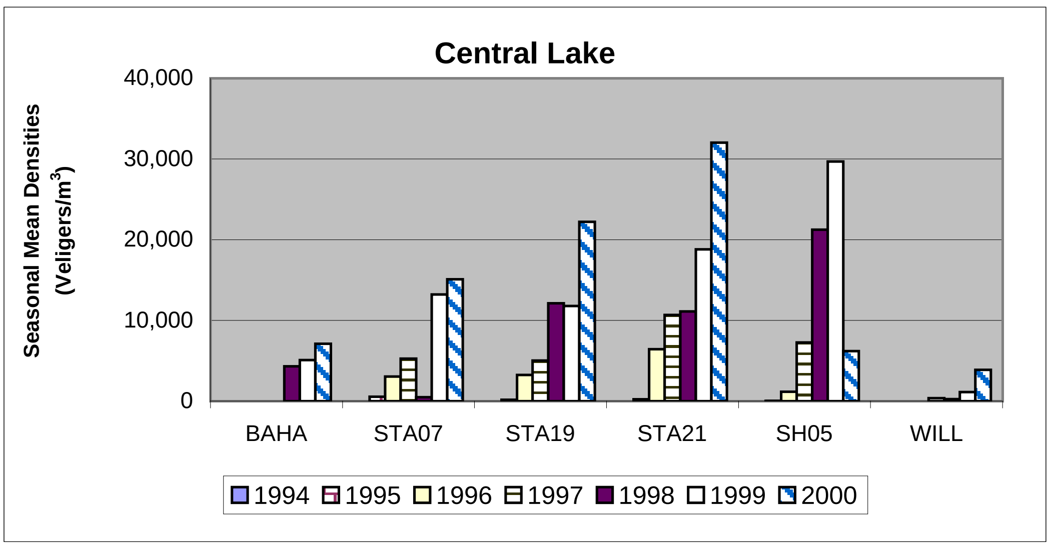
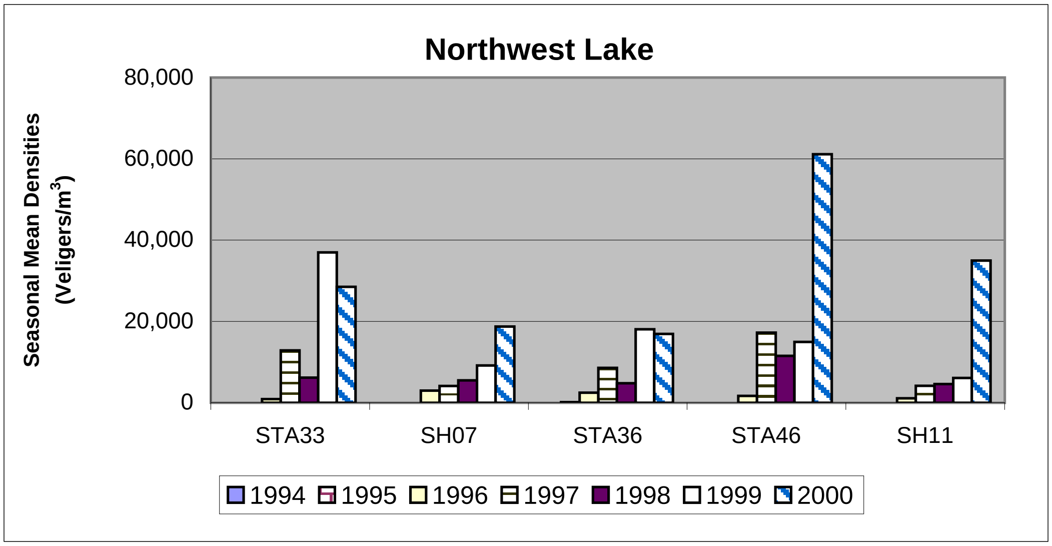


Figure 11. Seasonal weighted mean veliger densities for selected stations from 1994-2000.



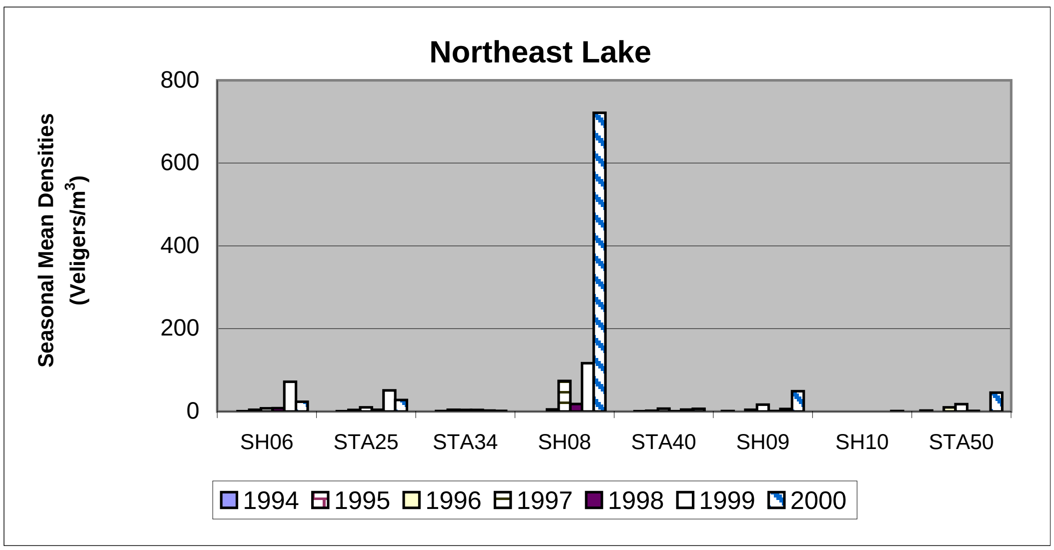


Figure 12. Seasonal weighted mean veliger densities for selected stations from 1994-2000.

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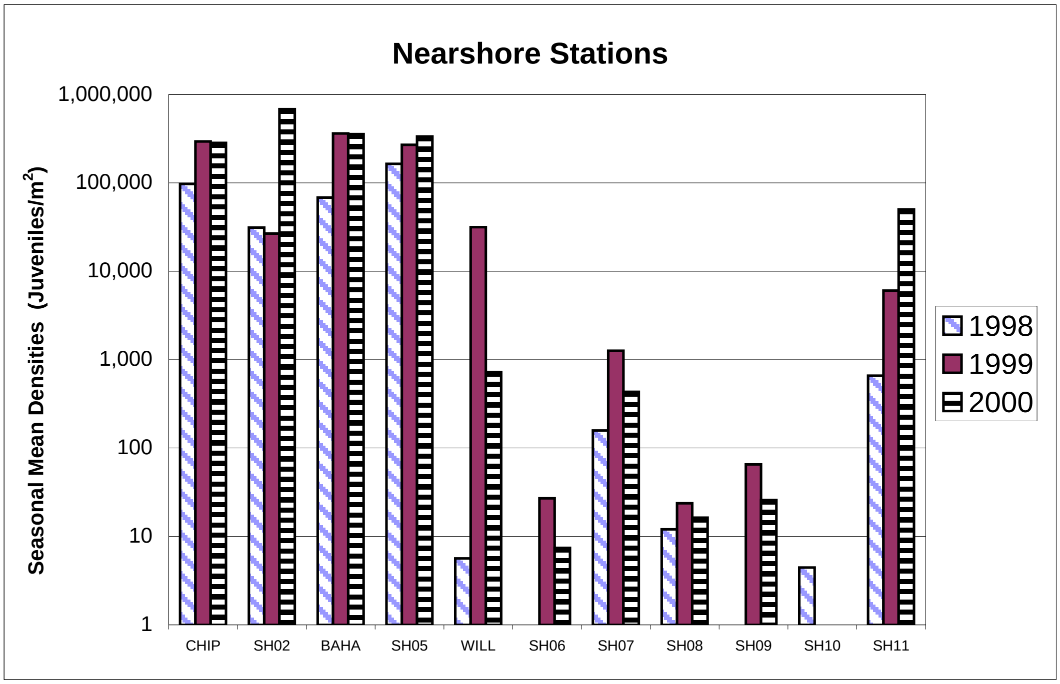

Figure 13. Seasonal weighted mean juvenile densities for selected nearshore stations in Lake Champlain from 1998-2000.

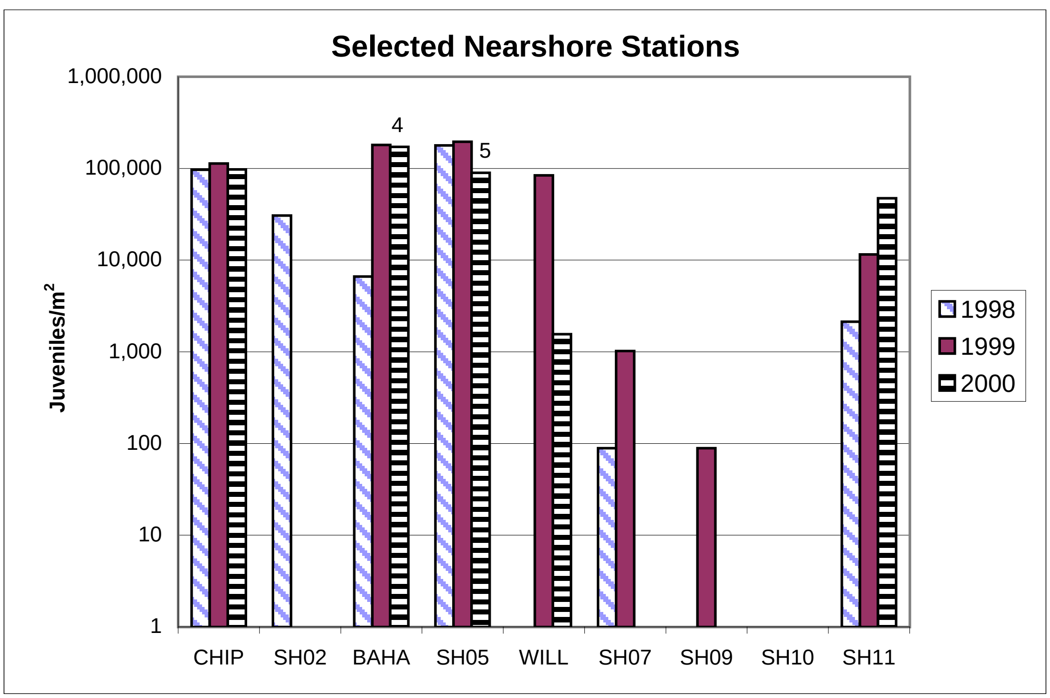

Figure 14. Season plate densities from 1998-2000. The 2000 average juvenile size (mm) is noted above the bars for selected nearshore stations in Lake Champlain.

Season juvenile settling plate densities and average juvenile size for selected nearshore stations from 1998-2000 are shown in Figure 14. The greatest season plate density during the 2000 season was recorded at Basin Harbor (BAHA), with 171,556 juveniles/m^2. Early settlers at CHIP grew to approximately 6 mm in October compared to 14.5 mm in 1999. There was no second cohort on the CHIP plate this year as reported in the past three years. Before being vandalized in August, it was noted that juveniles on the season plate at SH02 were of similar size to juvenile zebra mussels at CHIP. The average size of settled juveniles on season plates in all other nearshore stations was 4-6 mm.

The settling plates at Grand Isle Ferry Dock (SH07) were again infested with the exotic snail mud bythinia , *Bythinia tentaculata*, which feed by grazing and filtering. The season plate at SH07 had no settlement, even though veliger densities had increased this year and settlement had occurred on the 4-week plates.

Tributaries and inland lakes

No veligers were found in any of the samples collected during 2000 in Lake Carmi, Cedar Lake, Chittenden Reservoir, Curtis Pond, Lake Dunmore, Fairfield Pond, Glen Lake, Lake Hortonia, Lake Iroquois, Shelburne Pond, Lake St. Catherine, or Woodbury Lake (Figure 2). Veligers had been detected in Lake Hortonia and Lake Dunmore in 1999. Veliger detection in these lakes does not necessarily mean that there are adult zebra mussels in the lake or that they are reproducing. Veligers found could be the result of contamination from a variety of sources including recreational equipment or wildlife.

No veligers were found in samples taken during 2000 from the Missisquoi River, Lamoille River, Winooski River, Dead Creek, Putnam Creek, or the Poultney River (Figure 2). Adult zebra mussels had been found in the LaPlatte River in 1997 and in Lewis Creek and Otter Creek in 1998. No sampling was performed in these rivers or in Little Otter Creek during 2000. Veligers were found in Little Otter Creek and the Winooski River in 1999.

Snorkel surveys conducted by researchers from Castleton State College confirmed the presence of adult zebra mussels at numerous locations in Lake Bomoseen. One site off Mason Point has produced almost three hundred adult zebra mussels attached to various substrate (Hampton, personal comm. 2000). No veligers were found in Lake Bomoseen samples collected and analyzed by either Castleton State College or VTDEC researchers.

Adult distribution

Adult zebra mussels continue to be common to very abundant on most firm substrates in the South, Central, and Northwest regions of Lake Champlain. In contrast, comparatively few adults were found in the Northeast Lake (Malletts Bay, north to Missisquoi Bay). The Northeast Lake is open to water exchange with the Central Lake only through openings in the railroad causeway as shown in Figure 1. These restrictions may slow the drift of veligers into the Northeast region of the lake. However, observations made during 1999 and 2000 indicated that zebra mussel adults are slowly expanding their range into some areas of the Northeast Lake.

Quality assurance results

Mean relative percent differences (RPD) of field and laboratory duplicates were calculated for open-water and nearshore veliger and settled juvenile samples for 2000 (Table 1). The RPD of field duplicates represents the combined field and analytical variability, while the RPD of laboratory duplicates measures the variability within the analytical procedure. The mean RPD values for all veliger and settled juvenile laboratory and field duplicate samples were within the acceptable data quality objective limits (Eliopoulos and Stangel 2000b).

Table 1. Mean relative percent differences for 2000 laboratory and field zebra mussel veliger and juvenile duplicate samples.

	Sample Type	Number Counted	Mean RPD	Number of Duplicate Pairs
Laboratory RPD's	Veligers	0 - 100	12.3	12
		>100	8.3	9
	Juveniles	0 -100	-	0
		>100	9.3	8
Field RPD's	Veligers	0 -100	22.1	13
		>100	15.1	11
	Juveniles	0 - 100	8.5	6
		>100	27.1	14

SUMMARY AND CONCLUSIONS

The results of the 2000 Zebra Mussel Monitoring Program indicated that veliger densities in Lake Champlain continued to increase at 14 of 23 stations. Juvenile settlement decreased at 7 of 11 stations. The Northeast Lake continued to have very little veliger and settled juvenile production compared to the rest of the lake, although most station densities did increase above 1999 levels.

Zebra mussel adults have been well established in the South, Central, and Northwest Lake since 1996. However, the range expansion in the Northeast Lake has been relatively slow. As of 2000, known adult zebra mussel distribution in the Northeast lake includes only Malletts Bay and the Inland Sea. The slower range expansion and the lack of large zebra mussel populations in the Northeast Lake may be due to the restricted water exchange or the lower calcium levels found in this section of the lake. As previously reported (Eliopoulos and Stangel 1998, 1999, 2000a), calcium is critical to zebra mussel growth, reproduction and survival.

Adult zebra mussels continue to be found in Lake Bomoseen in 2000. No other lakes were found to have zebra mussels.

RECOMMENDATIONS

The efficient combination of the Zebra Mussel Monitoring Program with the Long-Term Water Quality and Biological Monitoring Program provides a nationally unique lake database. Information on veliger and juvenile densities monitored consistently since the initial colonization is obtained concurrently with comprehensive water quality data. This information is critical for determining the effects of zebra mussels on the Lake Champlain ecosystem and for assessing the risk and impact of zebra mussel colonization of other water bodies.

Future documentation of changes in phosphorus, chlorophyll, transparency, zooplankton, and phytoplankton using data obtained by the Long-Term Water Quality and Biological Monitoring Program will be valuable in assessing ecological effects of zebra mussels in Lake Champlain. It is therefore important that the Zebra Mussel Monitoring Program continue at least until zebra mussel populations stabilize in Lake Champlain. The following recommendations address ways in which the program can be improved to more effectively meet the overall goals and objectives.

Veliger sampling

Zebra mussel colonization of other Vermont lakes should continue to be documented by collecting plankton samples and analyzing them for veligers. If time allows, an effort should be made to survey for adult zebra mussels in lakes where veligers are found.

Juvenile sampling

The project should continue to monitor juvenile settlement in Lake Champlain to document the establishment of zebra mussels in the Northeast lake.

Adult sampling

The project should continue to track the distribution and abundance of adult zebra mussels in Lake Champlain with the greatest effort employed in the Northeast lake where range expansion is still occurring.

Water quality comparisons

The project will periodically update the comparison of water quality monitoring results before and after zebra mussel infestation as done in Table 5 of the 1998 report.

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Appendix A: Zebra mussel veliger density data 2000

Station	Date	Temp (C)	Secchi (m)	Secchi to bottom?	Density (n/m3)
BAHA	5/4/2000	4		Yes	0
BAHA	6/5/2000	13.1	3.9	No	19
BAHA	6/21/2000	15.9	3.9	No	134
BAHA	7/7/2000	18	2.1	No	26,840
BAHA	7/21/2000	19.2	3.1	No	12,054
BAHA	8/7/2000	20.2	4.1	No	562
BAHA	8/24/2000	20.8	5	No	5,282
BAHA	9/7/2000	20		Yes	1,451
BAHA	10/2/2000	15		Yes	12
CHIP	4/28/2000	9	1	No	0
CHIP	5/17/2000	17	1.1	No	223
CHIP	5/31/2000	18.7	0.8	No	56,254
CHIP	6/15/2000	16.6	1.3	No	24,193
CHIP	6/28/2000	24.8	1.2	No	50,321
CHIP	7/19/2000	22.8	0.6	No	25,867
CHIP	8/2/2000	23	0.5	No	24,561
CHIP	8/18/2000	23	0.9	No	3,157
CHIP	9/1/2000	24.5	1.1	No	1,507
CHIP	9/18/2000	19	0.8	No	90
CHIP	10/12/2000	11	1.1	No	540
SH02	4/28/2000	7	1.1	No	0
SH02	5/17/2000	13.8	1.6	No	139
SH02	5/31/2000	15.5	1.3	No	425
SH02	6/15/2000	15.7	1.2	No	1,153
SH02	6/28/2000	21.4	1.6	No	281,268
SH02	7/19/2000	21.8	2	No	24,810
SH02	8/2/2000	21	1.2	No	33,526
SH02	8/18/2000	22	1.5	No	22,884
SH02	9/1/2000	23	1.6	No	119,187
SH02	9/18/2000	17	2.6	No	450
SH02	10/12/2000	11.5		Yes	201
SH05	5/5/2000	7	6	No	0
SH05	5/19/2000	8	3.4	No	0
SH05	6/1/2000	11	3.8	No	223
SH05	6/16/2000	14	4.3	No	0
SH05	6/29/2000	18.5		Yes	1,875
SH05	7/13/2000	19.8	4.7	No	7,711
SH05	7/31/2000	23	4.5	No	23,732
SH05	8/15/2000	24		Yes	1,408
SH05	8/31/2000	21		Yes	3,119
SH05	9/20/2000	18.8		Yes	24
SH05	10/13/2000	12.5		Yes	0
SH06	4/25/2000	4	1.8	No	0
SH06	5/22/2000	10.8	2.3	No	0
SH06	6/8/2000	14	4.1	No	0
SH06	6/20/2000	20	4.2	No	0
SH06	7/5/2000	21.8	5	No	28
SH06	7/20/2000	21	5.1	No	13
SH06	8/3/2000	22.3	5.6	No	84
SH06	8/21/2000	22	6.5	No	8
SH06	9/11/2000	19.9	4.8	No	5
SH06	9/25/2000	17.2	4.5	No	4
SH07	5/18/2000	8		No	0
SH07	6/9/2000	10.5		Yes	0
SH07	6/22/2000	14.1		Yes	3
SH07	7/11/2000	17	2.3	No	4,925
SH07	7/24/2000	20.1		Yes	89,989
SH07	8/14/2000	21.3		Yes	1,991
SH07	8/28/2000	20		Yes	2,238
SH07	9/14/2000	18.5		Yes	3,305
SH07	10/11/2000	14		Yes	0
SH08	5/18/2000	8.9	3.9	No	0
SH08	6/9/2000	10.7		Yes	0
SH08	6/22/2000	12.8		Yes	0
SH08	7/11/2000	19.5		Yes	52
SH08	7/24/2000	20.2		Yes	3,516
SH08	8/14/2000	23.2		Yes	362
SH08	8/28/2000	21		Yes	0
SH08	9/14/2000	19.8		Yes	43
SH08	10/11/2000	14		Yes	0
SH09	5/26/2000	14	2	No	0
SH09	6/12/2000	16	2.1	No	0
SH09	6/26/2000	22	1.6	No	0
SH09	7/12/2000	23.8	2	No	3
SH09	7/25/2000	24	2.7	No	322
SH09	8/10/2000	25	0.6	No	0
SH09	8/22/2000	21.5	0.9	No	0
SH09	9/5/2000	20.9	1.6	No	0
SH09	9/26/2000	17.5	1.7	No	0
SH10	5/1/2000	8.5	1.2	No	0

Appendix A: Zebra mussel veliger density data 2000

Station	Date	Temp (C)	Secchi (m)	Secchi to bottom?	Density (n/m3)
SH10	5/29/2000	14.8	1.8	No	0
SH10	6/13/2000	16.9	2	No	0
SH10	6/27/2000	23.1	2.1	No	660
SH10	7/12/2000	23.5	2.9	No	18
SH10	7/26/2000	25.5	2.7	No	181
SH10	8/8/2000	23.5	1.4	No	0
SH10	8/25/2000	22.5	2.5	No	5
SH10	9/13/2000	19.8	2.7	No	0
SH11	5/1/2000	5.2		Yes	0
SH11	5/29/2000	11.8		Yes	15
SH11	6/13/2000	12.4		Yes	40
SH11	6/27/2000	19.1		Yes	3,538
SH11	7/12/2000	15.9		Yes	12,699
SH11	7/26/2000	21.5		Yes	118,758
SH11	8/11/2000	23		Yes	96,435
SH11	8/25/2000	21		Yes	732
SH11	9/13/2000	19.2		Yes	520
SH11	10/3/2000	14.5		Yes	33
STA02	4/28/2000	8.2	0.9	No	0
STA02	5/17/2000	17.1	0.4	No	8
STA02	5/31/2000	17.9	0.9	No	4,114
STA02	6/15/2000	15.6	0.7	No	30
STA02	6/28/2000	24.8	1.2	No	104,848
STA02	7/19/2000	21.2	0.4	No	522
STA02	8/2/2000	20.3	0.2	No	452
STA02	8/18/2000	21.2	0.6	No	28,252
STA02	9/1/2000	23	1.6	No	28,448
STA02	9/18/2000	19	0.7	No	6,750
STA02	10/12/2000	11.1	0.9	No	95
STA04	4/28/2000	7.8	0.8	No	0
STA04	5/17/2000	14.8	1.1	No	102
STA04	5/31/2000	17	1.7	No	2,380
STA04	6/15/2000	16	1.5	No	3,255
STA04	6/28/2000	23.8	1.9	No	43,823
STA04	7/19/2000	22.8	1.3	No	30,236
STA04	8/2/2000	23	1.6	No	8,016
STA04	8/18/2000	23	1.7	No	2,873
STA04	9/1/2000	23.2	1.2	No	4,319
STA04	9/18/2000	18.2	2.2	No	19,513
STA04	10/12/2000	11.3	2.6	No	723
STA07	5/15/2000	11.2	3.4	No	0
STA07	6/5/2000	12	2.9	No	118
STA07	6/21/2000	14.9	3	No	570
STA07	7/7/2000	18	3.8	No	39,177
STA07	7/21/2000	20.4	3	No	20,091
STA07	8/7/2000	18.2	4.9	No	842
STA07	8/24/2000	20.2	5	No	18,006
STA07	9/7/2000	19.5	4.6	No	14,817
STA07	10/2/2000	14	4.5	No	47
STA19	5/5/2000	3.4	6	No	0
STA19	6/1/2000	11.2	3.6	No	0
STA19	6/16/2000	11.2	5.7	No	21
STA19	6/29/2000	19	6.9	No	723
STA19	7/13/2000	19.5	5.9	No	88,858
STA19	7/31/2000	21.7	4.7	No	31,542
STA19	8/15/2000	22.2	6	No	8,589
STA19	8/31/2000	20.5	5.6	No	4,764
STA19	9/20/2000	17.8	6.2	No	45
STA21	5/5/2000	5.2	5.6	No	0
STA21	6/1/2000	11.8	3	No	2
STA21	6/16/2000	14	4.5	No	0
STA21	6/29/2000	19.8	5.6	No	2,983
STA21	7/13/2000	20	4.6	No	129,835
STA21	7/31/2000	22.7	3.8	No	47,715
STA21	8/15/2000	24	5	No	1,890
STA21	8/31/2000	22	4.9	No	10,882
STA21	9/20/2000	18.3	5.3	No	63
STA21	10/13/2000	12.8	6.8	No	6
STA25	4/25/2000	4	2.8	No	0
STA25	5/22/2000	10.1	2	No	0
STA25	6/8/2000	14.2	3.9	No	0
STA25	6/20/2000	17	4.1	No	0
STA25	7/5/2000	21	7.8	No	12
STA25	7/20/2000	21	9.5	No	130
STA25	8/3/2000	23	6.7	No	35
STA25	8/21/2000	21.3	6.5	No	27
STA25	9/11/2000	19.2	5	No	2
STA25	9/25/2000	16.9	4.5	No	0
STA33	5/3/2000	5.5	5.2	No	0
STA33	5/24/2000	11.3	2	No	0

Appendix A: Zebra mussel veliger density data 2000

Station	Date	Temp (C)	Secchi (m)	Secchi to bottom?	Density (n/m3)
STA33	6/9/2000	12	4.1	No	0
STA33	6/22/2000	16.2	2.5	No	0
STA33	7/11/2000	17.3	5.9	No	5,063
STA33	7/24/2000	20.2	3.9	No	113,010
STA33	8/14/2000	23	5.1	No	32,999
STA33	8/28/2000	20.5	7.4	No	4,810
STA33	9/14/2000	19	4.4	No	2,296
STA34	5/2/2000	4.8	2	No	0
STA34	5/26/2000	9.8	3.8	No	0
STA34	6/12/2000	13	5.9	No	0
STA34	6/26/2000	16.4	8	No	0
STA34	7/11/2000	18.4	5	No	3
STA34	7/25/2000	23.2	6.2	No	5
STA34	8/10/2000	21.8	6.1	No	2
STA34	8/21/2000	20.5	3.6	No	0
STA34	9/5/2000	20.4	3.8	No	0
STA34	9/26/2000	17.5	4.3	No	0
STA36	5/3/2000	3.5	6.5	No	0
STA36	5/24/2000	8.9	3.1	No	0
STA36	6/9/2000	11.1	7.1	No	8
STA36	6/22/2000	13.2	4.2	No	0
STA36	7/11/2000	17.6	4.8	No	8,712
STA36	7/24/2000	21	6.8	No	60,272
STA36	8/14/2000	23.2	5.5	No	14,013
STA36	8/28/2000	21	7	No	6,442
STA36	9/14/2000	18.3	6.2	No	3,303
STA40	5/2/2000	6.2	1.5	No	0
STA40	5/26/2000	13	2.6	No	0
STA40	6/12/2000	15.2	3.2	No	0
STA40	6/26/2000	20.3	3.2	No	0
STA40	7/12/2000	23	3	No	12
STA40	7/25/2000	23.2	4.2	No	30
STA40	8/10/2000	24.8	1	No	0
STA40	8/22/2000	21.3	1.2	No	0
STA40	9/5/2000	20.4	1.9	No	0
STA40	9/26/2000	16.8	2	No	0
STA46	5/1/2000	4.8	4.8	No	0
STA46	5/29/2000	11	5	No	3
STA46	6/13/2000	12	6.2	No	83
STA46	6/27/2000	18.1	5.1	No	13,436

Station	Date	Temp (C)	Secchi (m)	Secchi to bottom?	Density (n/m3)
STA46	7/12/2000	17.5		Yes	2,285
STA46	7/26/2000	21.2	3.8	No	265,597
STA46	8/11/2000	23	5.7	No	92,517
STA46	8/25/2000	21.2	5.5	No	20,573
STA46	9/13/2000	18.8		Yes	4,646
STA46	10/3/2000	14.5		Yes	136
STA50	5/1/2000	8	1.1	No	0
STA50	5/29/2000	16	1.5	No	0
STA50	6/13/2000	16.2	2.5	No	0
STA50	6/26/2000	21.8	2.3	No	5
STA50	7/12/2000	22.1	3.2	No	0
STA50	7/26/2000	24.8	2.3	No	326
STA50	8/8/2000	22.8	1.9	No	0
STA50	8/25/2000	20.2	3.7	No	5
STA50	9/13/2000	21		Yes	0
STA50	10/3/2000	14.5	1.5	No	0
WILL	5/5/2000	7	5	No	0
WILL	6/1/2000	12	4.2	No	33
WILL	6/16/2000	7.2	7	No	0
WILL	6/29/2000	16.2	5.9	No	17
WILL	7/13/2000	20.2	5.5	No	3,336
WILL	7/31/2000	20.1	4.6	No	16,082
WILL	8/15/2000	23	9	No	4,181
WILL	8/31/2000	20.3	7	No	242
WILL	9/20/2000	18	7.6	No	77

Appendix B: Zebra mussel juvenile density data 2000

Station	Date	Days in Lake	Density (n/m2)
BAHA	6/21/2000	16	0
BAHA	7/7/2000	33	68,978
BAHA	7/21/2000	30	1,122,000
BAHA	8/7/2000	30	624,000
BAHA	8/24/2000	34	270,000
BAHA	9/7/2000	31	88,000
BAHA	10/2/2000	119	171,556
CHIP	5/31/2000	34	0
CHIP	6/15/2000	31	0
CHIP	6/28/2000	29	23,867
CHIP	7/19/2000	34	718,000
CHIP	8/2/2000	35	266,000
CHIP	8/18/2000	30	13,422
CHIP	9/1/2000	30	132,000
CHIP	9/18/2000	31	314,000
CHIP	10/12/2000	42	138,000
CHIP	10/12/2000	168	97,600
SH02	5/31/2000	34	0
SH02	6/15/2000	31	0
SH02	6/28/2000	29	242,000
SH02	7/19/2000	34	2,964,000
SH02	8/2/2000	35	498,000
SH02	8/18/2000	30	166,000
SH05	6/1/2000	26	0
SH05	6/16/2000	27	0
SH05	6/29/2000	28	0
SH05	7/13/2000	27	24,267
SH05	7/31/2000	32	1,136,000
SH05	8/15/2000	32	942,000
SH05	8/31/2000	31	13,778
SH05	9/20/2000	35	20,000
SH05	10/13/2000	43	5,156
SH05	10/13/2000	161	89,422
SH06	6/8/2000	43	0
SH06	6/20/2000	28	0
SH06	7/5/2000	28	0
SH06	7/20/2000	30	0
SH06	8/3/2000	28	44
SH06	8/21/2000	31	0
SH06	9/11/2000	38	0
SH06	9/25/2000	34	0
SH06	10/17/2000	175	0
SH07	6/21/2000	32	0
SH07	7/11/2000	32	0
SH07	7/24/2000	33	0
SH07	8/14/2000	33	1,733
SH07	8/28/2000	34	933
SH07	9/14/2000	30	0
SH07	10/11/2000	146	0
SH08	6/22/2000	33	0
SH08	7/11/2000	32	0
SH08	7/24/2000	32	89
SH08	8/14/2000	33	0
SH08	8/28/2000	34	0
SH08	9/14/2000	31	0
SH08	10/11/2000	146	0
SH09	6/26/2000	14	0
SH09	7/12/2000	30	89
SH09	7/25/2000	29	89
SH09	8/10/2000	29	0
SH09	8/22/2000	28	0
SH09	9/5/2000	25	0
SH09	9/26/2000	107	0
SH10	6/13/2000	43	0
SH10	6/27/2000	29	0
SH10	7/12/2000	30	0
SH10	7/26/2000	30	0
SH10	8/8/2000	27	0
SH11	6/13/2000	43	0
SH11	6/27/2000	28	0
SH11	7/12/2000	30	89
SH11	7/26/2000	30	13,867
SH11	8/11/2000	30	210,000
SH11	8/25/2000	30	76,000
SH11	9/13/2000	32	16,978
SH11	10/3/2000	156	47,244
WILL	6/16/2000	41	0
WILL	6/29/2000	28	0
WILL	7/13/2000	27	222
WILL	7/31/2000	32	1,111
WILL	8/15/2000	32	2,489
WILL	8/31/2000	31	489
WILL	9/20/2000	138	1,556
WILL	9/20/2000	35	400