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COUNTY OF ONONDAGA
DEPARTMENT OF DRAINAGE
AND SANITATION

April 2000

Oxygen Consumption, Ammonia Excretion and Filtration Rates of Three Size Classes of Zebra Mussels Collected in the Seneca River, New York

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Oxygen Consumption, Ammonia Excretion and Filtration Rates of Three Size Classes of Zebra Mussels Collected in the Seneca River, New York

1.0 INTRODUCTION

In August 1999, the County of Onondaga Department of Drainage and Sanitation (County) retained Beak Consultants Incorporated (Beak) to perform an assessment of the dreissenid mussel population in the Seneca River system as a part of the County's Ambient Monitoring Program (AMP). The primary goal of this program was to provide data required to update a mathematical model that will assist the County in making future management decisions concerning the discharge of treated wastewater into Onondaga Lake and the Seneca River system. The existing model was developed prior to the establishment of a large population of zebra mussels in the river. To update the kinetic framework of the model to include the effects of zebra mussels, an accurate assessment of the bioactivity of the mussels in the Seneca River is required.

Zebra mussels (*Dreissena polymorpha*) have the capacity to affect the oxygen, nitrogen and phosphorus dynamics of a water body. Reported oxygen consumption rates for zebra mussels can exceed 0.6 ppm of oxygen per hour per gram (dry weight) of mussel soft body tissue for mussels held at 17.1°C (Sprung and Borcherding 1991). Large densities of mussels can, therefore, be expected to depress oxygen levels in a water body. Various investigators have documented changes to the nitrogen and phosphorus budgets in lakes and rivers after zebra mussel invasions that can directly be attributed to filtration by zebra mussels (Anott and Vanni 1996, James et al. 1997, Johengen et al. 1995, Heath et al. 1995, Effler et al. 1997).

Aldridge et al. (1995) investigated the effects of temperatures between 20° and 32°C on the oxygen consumption, ammonia excretion and filtration rates of zebra mussels. They conducted

these laboratory based studies on 13 mm to 17 mm mussels that were collected from the U.S. Army Corps of Engineers (ACOE) Black Rock Lock Facility on the Niagara River in Buffalo, New York. Separate groups of mussels were acclimated to 20°, 24°, 28° and 32°C prior to the tests.

The County requested that Beak conduct a study comparable to Aldridge et al. (1995) using mussels collected from the Seneca River to address any site-specific differences in the oxygen consumption, ammonia excretion or filtration rates of Seneca River mussels. To better satisfy the requirements of the Seneca River mathematical model, three size groups of mussels were tested: mussels approximately 10 mm or less (total length along the longest axis), mussels greater than 10 mm and less than approximately 20 mm, and mussels greater than 20 mm. To better represent the expected water temperatures in the Seneca River during the mussels' active period, the 32°C test was replaced with a test on mussels acclimated to 15°C. Except as noted in Section 2.0 of this report, the methods used in this study followed Aldridge et al.

This report provides the results of the laboratory study on oxygen consumption, ammonia excretion and filtration rates of Seneca River zebra mussels conducted by Beak in 1999-2000. The results of these laboratory studies are also used in conjunction with the results of a previous study conducted by Beak to determine the population characteristics of zebra mussels in the Seneca River. Information from the population study on the distribution, density and size frequency of mussels along the Seneca River are used to estimate the oxygen consumption, nitrogenous excretion and total filtration caused by the existing mussel population.

2.0 METHODS

Zebra mussels for all tests were collected at a number of locations along the Seneca River in early November 1999. At each location, mussels were scraped from the hard substrate with a drywall seamer, being careful to sever the byssal threads from the substrate and not the body. These mussels were wrapped in wetted newspaper, placed in coolers on ice and transported to Beak's Lancaster, New York laboratory. At the lab the mussels from all locations were composited and held at approximately 15 to 20°C in 380-l plastic tubs in dechlorinated, aerated tap water. Prior to the acclimation period, the mussels were separated into the three size ranges to be tested: approximately 10 mm and less (total shell length along the axis), greater than 10 mm and less than approximately 20 mm, and greater than 20 mm. As a convention for this report, these size classes of mussels will be referred to as small, medium and large. For each of the three size groups, approximately 50 individuals were placed into each of four separate 10-cm x 12-cm x 12-cm cages fitted with 1-mm mesh.

On November 19, 1999, one cage of each size group of mussels was placed into one of four 25-l glass aquaria containing 15°C dechlorinated tap water. Acclimation temperatures were established by increasing the temperature by approximately 1°C per day until the test temperature was reached. The 15°C test tank was held at the initial temperature. The 20°C tank was at temperature on November 30, the 24°C tank was at temperature on December 1, and the 28°C tank was at temperature on December 3. Chillers with mixers (Frigid Unit D116 1/6 hp unit) were used in conjunction with aquarium heaters (Aquatic System Visi-Therm VTN 200 watts) to maintain temperatures in the 15°C tanks, while aquarium heaters alone were used to maintain the warmer temperatures. The mussels were fed dried *Chlorella* every other day throughout the experiment, except when tests were conducted. The photoperiod cycle was maintained at 14 hours of light and 10 hours of darkness. Once the desired test temperatures were met, the mussels were held for at least 30 days prior to testing. An Onset Optic Stowaway Temperature Sensor (Model 1462-A) was placed in each acclimation tank to provide a record of the temperatures in the tanks. Every other day, approximately 20 percent of the water in each acclimation tank was removed and replaced with dechlorinated tap water that was at the tank temperature.

2.1 Oxygen Consumption Study Methods

Prior to the onset of the test program, 10 pairs of randomly selected mussels were taken for each size class and test temperature and placed into individually numbered mesh bags, which were constructed with bridal veil fabric and closed with a cable tie. This was done so individual mussels could be tracked through all of the tests. Pairs of mussels were used instead of single mussels as in Aldridge et al. (1995). From discussions with these investigators, it was decided that results using single mussels could be near or below the detection limit of the oxygen and ammonia meters within the time frame that would not stress the test mussels. The mussels were not fed after 48 hours prior to the oxygen consumption tests.

Tests were conducted on the 28°C acclimated mussels on January 12, 2000, on the 20°C mussels on January 17, the 24°C mussels on January 18, and the 15°C mussels on January 19. To conduct the oxygen consumption test, the mussels were removed from the mesh bags, examined for viability and placed into labeled 300-ml BOD bottles that contained fully oxygenated, dechlorinated tap water at the test temperature. Three water-filled BOD bottles that had no mussels were used as controls. All samples were capped and placed in a water bath to maintain temperature. Mussels were allowed to respire (consume DO) in the bottles. This period was selected based on oxygen consumption rates determined previously so that a maximum difference of 2 ppm was achieved. A greater than 2 ppm drop in DO could stress the mussels in the test bottles. DO measurements were taken with an Orion pH/ISE Meter (Model 290A) with an Orion Model No. 97-0-99 DO Probe. DO was measured in the control samples at the beginning and end of each test run. After the oxygen determinations were made, the mussels were placed back into the mesh bags, returned to the acclimation tanks and returned to feeding conditions prior to being used for the ammonia excretion tests.

2.2 Ammonia Excretion Study Methods

Mussels were not fed after 48 hours prior to the ammonia excretion tests. Ammonia excretion tests on the mussels acclimated to 28°C and 24°C were conducted on January 24, 2000, and tests on the 15°C and 20°C acclimated mussels were conducted on January 25. Mussel pairs were removed from the mesh bags, examined for viability, and placed into individual glass vials that

contained 10 ml of dechlorinated tap water held at the test temperature. All mussels held at the same acclimation temperature were tested concurrently. Three vials filled with 10 ml of test water were used as controls. All vials were placed into a water bath to maintain test temperatures. Mussels were held in the vials at least 1.5 hours prior to measuring ammonia concentrations. The mussels were then removed from the vials, put into their mesh bags and returned to the acclimation tanks, where feeding was resumed. Ammonia concentrations were measured with an Orion pH/ISE Meter (Model 290A) with an Orion Model #95-12 Ammonia Probe.

2.3 Filtration Study Methods

The filtration tests were performed on February 21-22, 2000 on mussels held at 15°C, 20°C, and 24°C. Tests were not conducted on mussels held at 28°C due to excessive mortality, which had been expected based on reported mortality of mussels held at temperatures greater than 24°C for prolonged periods. To conduct the filtration test, mussel pairs were removed from the mesh bags and the shells were washed in dechlorinated tap water to remove any debris. Mussels were placed into test chambers that consisted of a 1-inch long, 1-inch diameter PVC pipe with 1-mm mesh fabric screening over each open end. The chambers containing mussels were placed in aerated dechlorinated water for 15 minutes to remove any debris (e.g., pseudofeces) that would interfere with the results. The chambers then were rinsed thoroughly.

For the filtration tests, the mussel chambers were suspended in 250-ml beakers containing 210 ml of *Chlorella* at the concentration of 67.3 ppm. Two samples that contained 210 ml of 67.3 ppm *Chlorella* with no mussels and two samples with only dechlorinated tap water served as controls. The beakers were set in a water bath and gently stirred. After 45 minutes, a 10-ml sample was collected from each bottle and were refrigerated. Mussels were allowed to filter for a total of 1.5 hours and then removed. The contents of each beaker were poured into an individually labeled 160-ml reagent bottle and were refrigerated until spectrophotometric analysis was conducted.

Spectrophotometric analyses were conducted using a Beckman Model DB Prism Spectrophotometer. A standard curve was developed using six solutions of *Chlorella*

concentrations ranging from 13.5 ppm to 80.1 ppm. Reductions in *Chlorella* concentrations were converted to filtration rates using the standard curves.

After tests were completed, all mussels were measured along the longest axis. Mussels then were placed into 10 percent HNO_3 to decalcify the shells. The decalcified mussels were placed in separately labeled plastic bags and frozen for possible additional analysis.

3.0 RESULTS

Appreciable mortality occurred for the mussels held in the 28°C acclimation tanks. This mortality was expected, since mussels held at temperatures of 24°C or greater generally are stressed because their energy expenditure exceeds their rate of assimilation (Aldridge et al. 1995). Too few small mussels survived in the 28°C acclimation tanks to perform the ammonia, oxygen or filtration tests. Mortality occurring during the interval between the oxygen and ammonia tests also precluded collection of ammonia data on large mussels held at 28°C. Further mortality occurred during the intervals between the ammonia and filtration tests, thus precluding analysis of all mussels acclimated to 28°C and small and medium mussels acclimated to 24°C.

The mean lengths of the small mussels from the 15°, 20°, 24°, and 28°C acclimation groups were 9.97± 0.261 mm (mean ± standard error, n = 19), 9.47± 0.208 mm (n = 19), 9.95± 0.223 mm (n = 20) and 10.50± 0.500 mm (n = 2), respectively. The mean lengths for the medium mussels for the 15°, 20°, 24°, and 28°C acclimation groups were 15.15± 0.340 mm (n = 20), 16.53± 0.370 mm (n = 19), 16.45± 0.312 mm (n = 20) and 16.47± 0.319 mm, respectively. The mean lengths for the large mussels from the 15°, 20°, 24°, and 28°C acclimation groups were 22.35± 1.55 mm (n = 20), 23.29± 1.251 mm (n = 20) and 22.20± 1.039 mm (n = 20), respectively. The mean lengths of individual mussels were not significantly different (ANOVA, $p \leq 0.05$) among the acclimation temperatures for either the small or large size groups. There was a significant difference in the mean lengths of mussels among the acclimation temperature in the middle size group (ANOVA, $p = 0.010$); mussels acclimated to 15°C on average were significantly smaller (15.15± 0.340 mm) than the 20°C (16.53± 0.370 mm), 24°C (16.45± 0.312 mm) or 28°C (16.47± 0.319 mm) acclimation groups. Although differences were statistically significant, all of the means for the medium mussels fell well within the desired range (i.e., greater than 10 mm and less than 20 mm). The mean length of the small mussels held at 28°C was greater than 10 mm, which could indicate growth during the acclimation period.

3.1 Oxygen Consumption Results

The mean rate of oxygen consumption (ppm of oxygen/mussel/hr) ranged from 0.00199± 0.000169 ppm for the small mussels acclimated to 15°C to 0.04695± 0.009449 ppm for the large mussels acclimated to 28°C (Table 1).

At each temperature, there was a significant difference (ANOVA, $p < 0.005$) in the rate of oxygen consumption among the size groups (Figure 1). The mean oxygen consumption rate at each temperature was least for small mussels and greatest for large mussels. A post-hoc Least Significant Difference Pairwise Multiple Comparison test (LSD PMS) was conducted to determine where the significant differences resided. For each temperature, all size groups of mussels were significantly different from each other.

There was also a significant difference (ANOVA, $p < 0.05$) in the oxygen consumption rates for each size group of mussels across acclimation temperatures. A post-hoc LSD PMC test was conducted to determine where the significant differences resided. For large mussels, the oxygen consumption rates were significantly lower ($p < 0.05$) at 15°C than at all other temperatures and were significantly lower at 24°C than at 28°C. For medium mussels, the oxygen consumption rate at 15°C was significantly lower ($p < 0.05$) than at 20°, 24°, and 28°C. For small mussels, the oxygen consumption rate at 15°C was significantly lower ($p < 0.05$) than at 24°C. There were no other significant differences in the rate of oxygen consumption across temperatures.

3.2 Ammonia Excretion Results

The mean rate of ammonia excretion (ppm ammonia/mussel/hour) ranged from 0.0000485± 0.00000445 for small mussels held at 20°C to 0.000916± 0.000266 for the medium mussels held at 24°C (Table 1). No ammonia tests were conducted on the small or medium mussels acclimated to 28°C due to extensive mortality during the acclimation phase.

At 15°, 20° and 24°C, there was a significant difference (Kruskal Wallis Test, $p < 0.05$) in the ammonia excretion rates among size groups. The non-parametric Kruskal Wallis test was used because of a violation of the assumption of homogeneity of variance required for the parametric

ANOVA, which could not be resolved using data transformations. At 15° and 20°C, the ammonia excretion rate was least for the small mussels and greatest for large mussels (Figure 2). Post-hoc testing (LSD PMC test, $p < 0.05$) indicated that there were significant differences among all size groups of mussels at 15° and 20°C. At 24°C, the ammonia excretion rate of the small mussels was significantly lower than the medium or large size groups. There was not, however, a significant difference in the excretion rate between the medium and large mussels acclimated to 24°C.

There was a significant difference (ANOVA, $p< 0.005$) in the excretion rates for each size group of mussels acclimated to different temperatures, but the relationship between excretion rate and temperature among the size groups was not consistent (Figure 2).

Fitration is units of $\frac{mg}{L \cdot mussel \cdot hr}$

see Fig 2

3.3 Filtration Study Results

The mean filtration rates (measured as reduction of *Chlorella* concentrat 1.96 mg/mussel/hour for small mussels at 15°C to 23.553 ± 2.288 n mussels at 24°C. A single small mussel acclimated to 20°C had a mear mg/hour. This result was not used in further analyses because it was based on a single individual.

There was a significant effect of acclimation temperature on the filtration rate of large mussels (ANOVA, $p<0.0001$) and medium mussels (ANOVA, $p<0.0001$). Large mussels at 15°C had significantly lower filtration rates than at 20°C or 24°C. Filtration rates for large mussels at 20°C and 24°C were not significantly different. Medium mussels at 15°C had significantly lower filtration rates than at 20°C.

Mussel size had a significant effect on filtration rates at 15°C (ANOVA, $p<0.05$). The filtration rate for large mussels was significantly greater than for medium or small mussels. There was no significant effect of size on filtration rates for mussels acclimated to 20°C.

4.0 DISCUSSION

4.1 Comparison of Results to Previous Study

In general, the results pertaining to oxygen consumption and ammonia excretion generally were comparable to those found by Aldridge et al. (1995) (Table 23). Filtration results in the present study, however, were higher than in the previous study. Aldridge et al. (1995) performed tests on mussels approximately 13 mm to 17 mm in size, corresponding to the medium size category in this study. Aldridge et al. tested mussels acclimated to 20°, 24°, 28° and 32°C, so data overlapped the present study only at 20°, 24° and 28°C.

of see Table 23

The oxygen consumption rates of the present study were about one third ~~less than~~ those found by Aldridge et al. Given the standard errors calculated for each study, the ammonia excretion results were not different. The filtration results were more than an order of magnitude greater in the present study than in the Aldridge study (Table 23).

Differences in these parameters between the two studies are likely due to population-specific differences of the zebra mussels rather than laboratory protocol. In general, methodologies used in the present investigation were identical to those used by Aldridge et al. There were minor changes in protocol, such as using two mussels per test, but it is unlikely that these changes affected the results.

Holding mussels for long periods at the higher acclimation temperatures could have produced stresses not found in the natural environment of the Seneca River, where high temperatures are not sustained for as prolonged a period. Extensive mortality of mussels held at the higher temperatures indicated a very stressful condition. Aldridge et al. (1995) estimated that between 24°C and 28°C, the energy expenditure of the 15-mm mussels exceeds their assimulative capacity, resulting in negative growth which, if sustained, would result in death. They postulated that smaller mussels would be more adversely affected than larger mussels, as occurred in the

present study. The impact of these temperature-related stresses on the study results cannot be determined.

4.2 Relationship to Population Distribution Study

The primary objective of this study was to determine the consumption of dissolved oxygen, excretion of ammonia and filtration rate by the zebra mussel population that exists in the project reach in the Seneca River. This information will ultimately be used in the mathematical model of the Seneca River developed by the County.

In fall 1999, Beak and County personnel conducted a study to determine the distribution and abundance of zebra mussels along an approximately 30-mile reach of the Seneca and Oneida Rivers, from just east of Cross Lake eastward to near Schroeppel Island, about 4 miles east of the confluence of the Seneca, Oswego and Oneida Rivers. In that study, reaches of the river containing comparable contiguous habitat (water quality, flow and substrate) were mapped. Based on this assessment, 19 habitat zones were used to describe the study area (Figure 4). Within each habitat zone, standardized techniques using SCUBA were employed to collect samples of the substrate and resident zebra mussels. Subsequent analyses were performed to determine the density (number of mussels per square meter), size distribution, and biomass of zebra mussels in each of the 19 habitat zones. Detailed methods and results can be found in the County Report entitled "1999 Seneca River Dreissenid Mussel Assessment Program Distribution of Zebra Mussels Along a Selected Reach of the Seneca River."

For each habitat zone, the density of zebra mussels was determined for each of the following mussel size categories: 10 mm and less (measured along the longest axis), greater than 10 mm and less than 20 mm, and greater than 20 mm (Table 3). These size categories were also used for the laboratory tests. Oxygen consumption, ammonia excretion and filtration rates of the zebra mussels per square meter present in each habitat zone were estimated by multiplying the mean rate of the parameter for individual mussels by the mean density of the mussels within each size category (Tables 4-23). Standard errors were also calculated.

Overall, the greatest oxygen consumption by zebra mussels per square meter was estimated for Habitat Zones III and XVII - XVIII (Figures 5-7). Relatively high oxygen consumption also was estimated for Zones V, VII and VIII. Since the number of mussels controls the total oxygen consumption, this trend would be consistent over all temperatures. The greatest overall rate of oxygen consumption (70.84 ppm/m^2/hour) would be in Habitat Zone XVII at 20°C (Table 24 and Figure 6). At 15°C, the greatest rate of oxygen consumption (30.46 ppm/m^2 x hour) would be in Habitat Zone III (Table 24 and Figure 5). At 24°C, the greatest rate of oxygen consumption would be in Zone XVII (45 ppm/m^2 x hour) (Table 24 and Figure 7). Except in Zones II, III and XIV, the density of large mussels would contribute heavily to the oxygen consumption for each zone. In Zones II, III and XIV, the relatively high densities of small mussels in these zones increased their contribution to the overall oxygen consumption, although small mussels consume significantly less oxygen than larger mussels.

Mussel density also influences the amount of ammonia excreted per square meter per hour. Therefore, the ammonia excretion rates across habitat zones generally would parallel oxygen consumption rates (Figures 8-10). At 15°C, the greatest ammonia excretion rate would be in Zone VII (1.10 ppm/m^2/hour) (Table 24 and Figure 8). High excretion rates also would occur in Habitat Zones III, V, VIII and XVIII. At 20°C, the greatest ammonia excretion rate would be in Habitat Zone XVII (1.04 ppm/m^2/hour). Ammonia excretion rates also would be high in those habitat zones at 15°C. At 24°C, ammonia excretion rates would be highest in Zone III (2.86 ppm/m^2/hour) (Table 24 and Figure 10), followed by Zone V (1.74 ppm/m^2/hour) and by Zone VIII (1.47 ppm/m^2/hour). Zones XVII and XVIII, which would have the greatest ammonia excretion rates at 15°C and 20°C, would have rates of only 1.41 ppm/m^2/hour and 1.28 ppm/m^2/hour, respectively at 24°C. This may be attributed to increases in individual excretion rates of small and medium mussels as temperatures increase to 24°C, whereas there would be virtually no increase for large mussels at 24°C (Figure 2), possibly because of their differing reaction to stresses from higher water temperatures.

The filtration rate for zebra mussels would be much greater in Zone III than in any other zone (Figures 11 and 12). At 15°C, the filtration rate in Zone III would be 88,397.62 mg/m^2/hour

(Table 24). At 20°C, it would increase to 335,134.30 mg/m^2/hour. At both temperatures, the next greatest filtration rate would occur in Zone XIV. At 15°C and 20°C, the filtration rate of small mussels would be comparable to medium and large mussels (Table 2), so filtration rates were controlled by the total density of mussels in a zone rather than a particular size of mussels.

5.0 CONCLUSIONS

This study provides information on the rate of oxygen consumption, ammonia excretion and filtration by zebra mussels along a reach of the Seneca and Oneida Rivers. Based on this information, any point in the study reach can be assigned a consumption, excretion or filtration rate expressed in parts per million per square meter of substrate per hour, based on the ambient water temperature. This information can be used to update the kinetic framework of the mathematical model to include the effects of the zebra mussel on these parameters.

The values developed are based on the population as it existed in the fall of 1999. Significant changes to the population structure have been reported in the project reach (see "1999 Seneca River Dreissenid Mussel Assessment Program - Distribution of Zebra Mussels Along a Selected Reach of the Seneca River"). These changes could profoundly impact the effect that the mussels have on the water body. The unpredictability of the extent of these changes from year to year suggests that periodic checks of the status of zebra mussel population in the study reach be made to ensure the accuracy of the mathematical model.

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Sprung, M. and J. Borcheeding. 1991. Physiological and morphometric changes *Dreissena polymorpha* in (Mollusca: Bivalvia) during a starvation period. Malacologia 33:179-191.

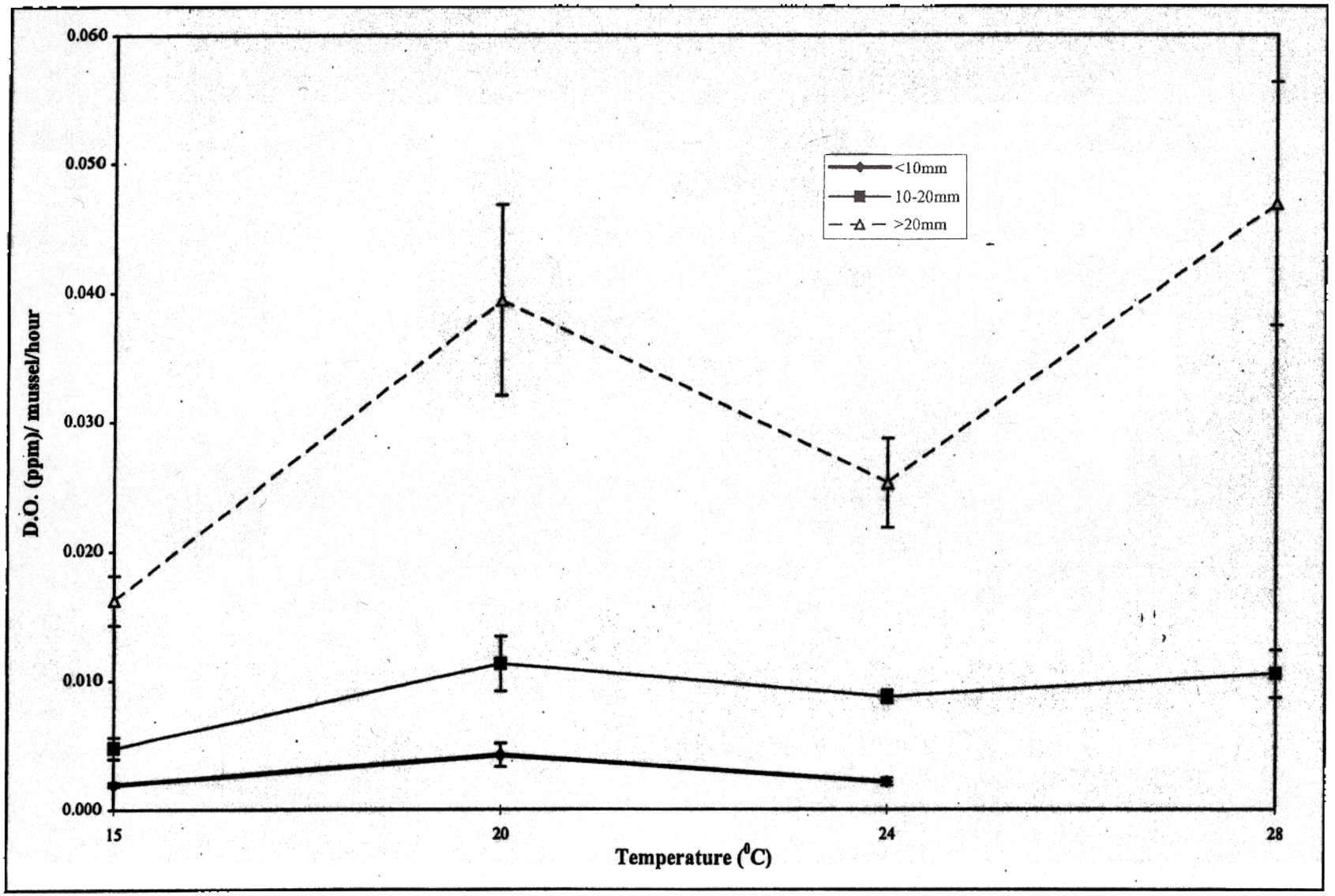


Figure 1. Mean oxygen consumption rates (with standard error bars) of zebra mussels collected in the Seneca River and acclimated to 15°, 20°, 24°, and 28°C by size range.

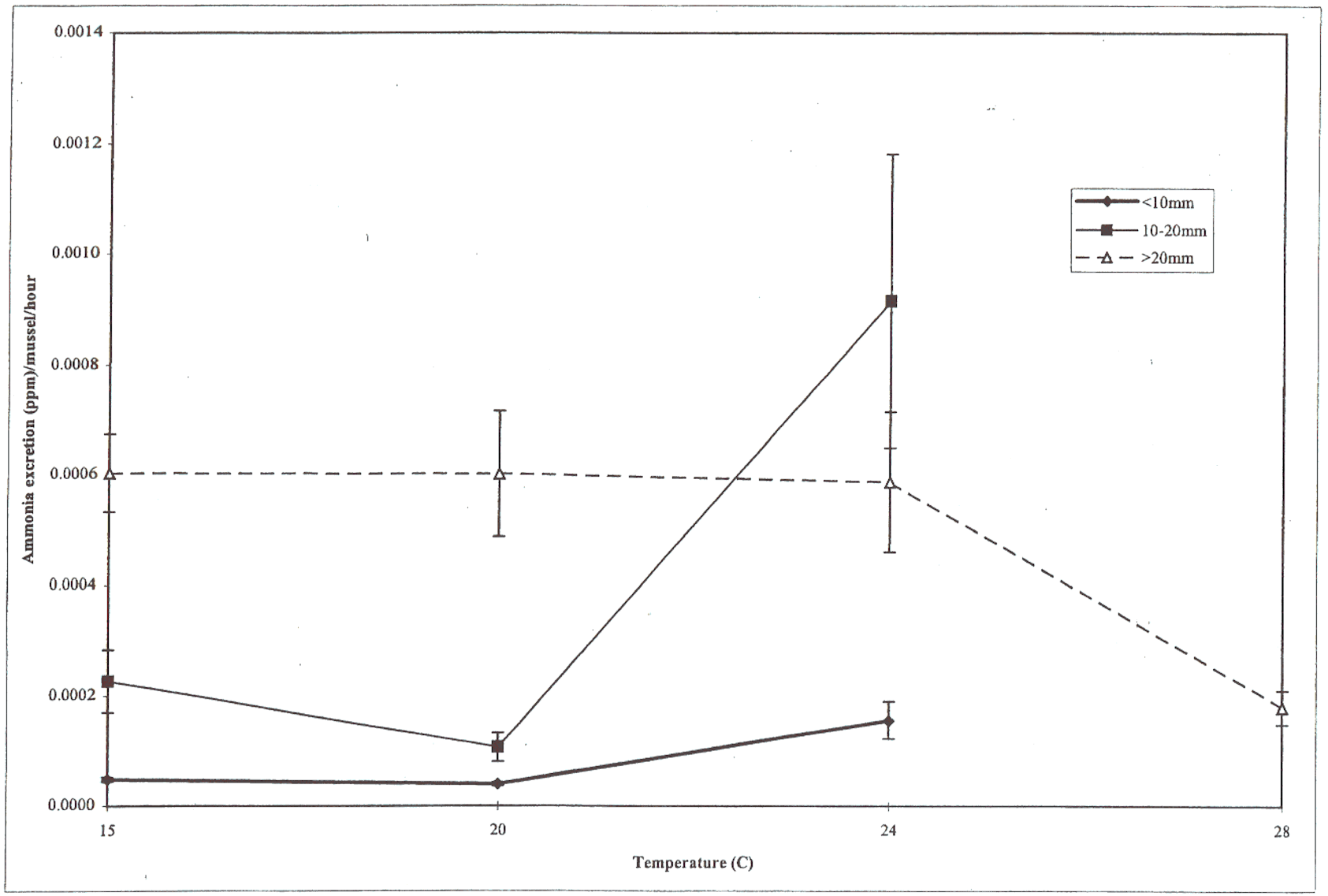


Figure 2. Mean ammonia excretion rate (with standard error bars) of zebra mussels collected in the Seneca River and acclimated to 15^0, 20^0, 24^0, and 28^0 C by size range.

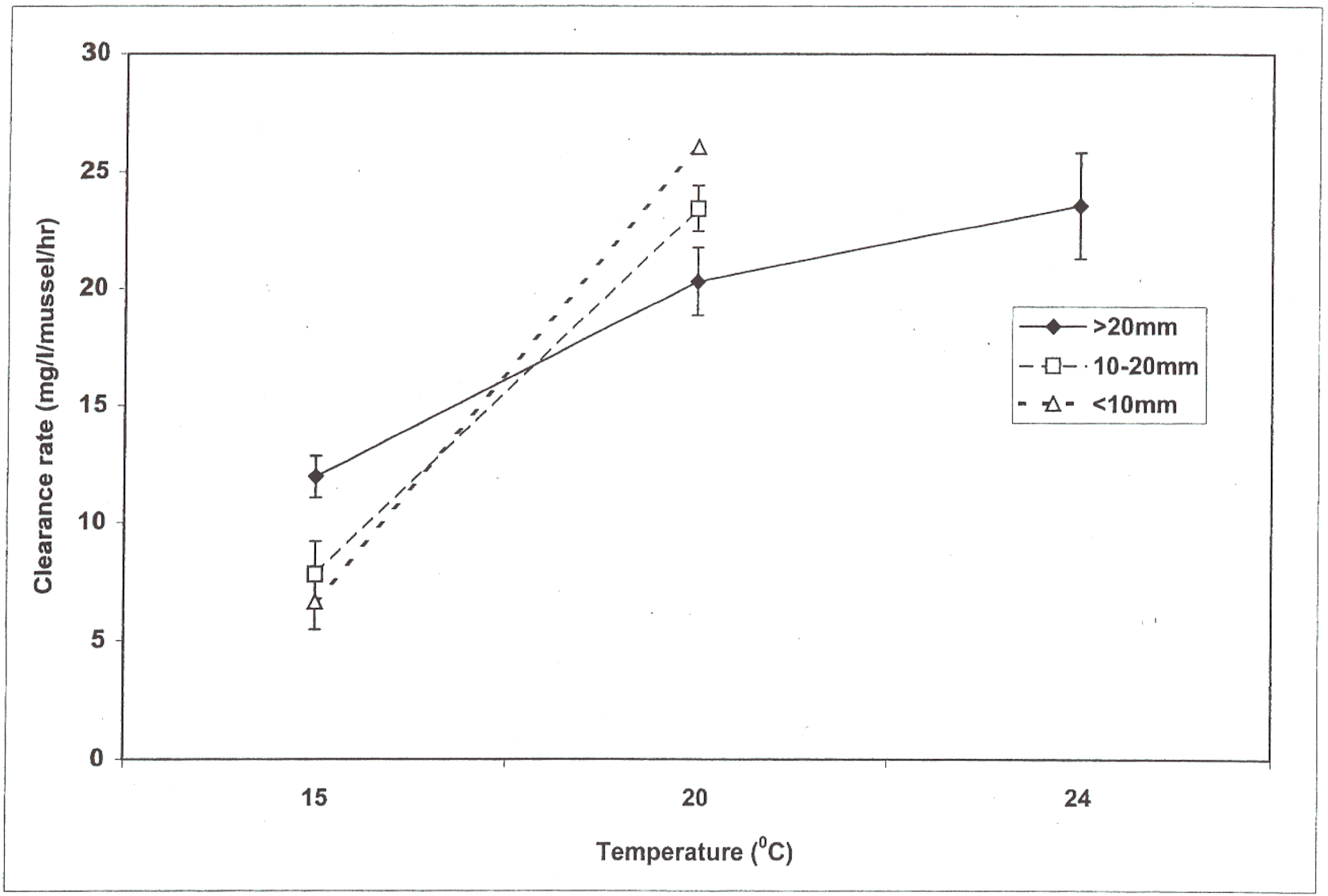


Figure 3. Freeze-dried *Chlorella* clearance rate by three size classes of Seneca River zebra mussels (Dreissena polymorpha) held at three temperatures

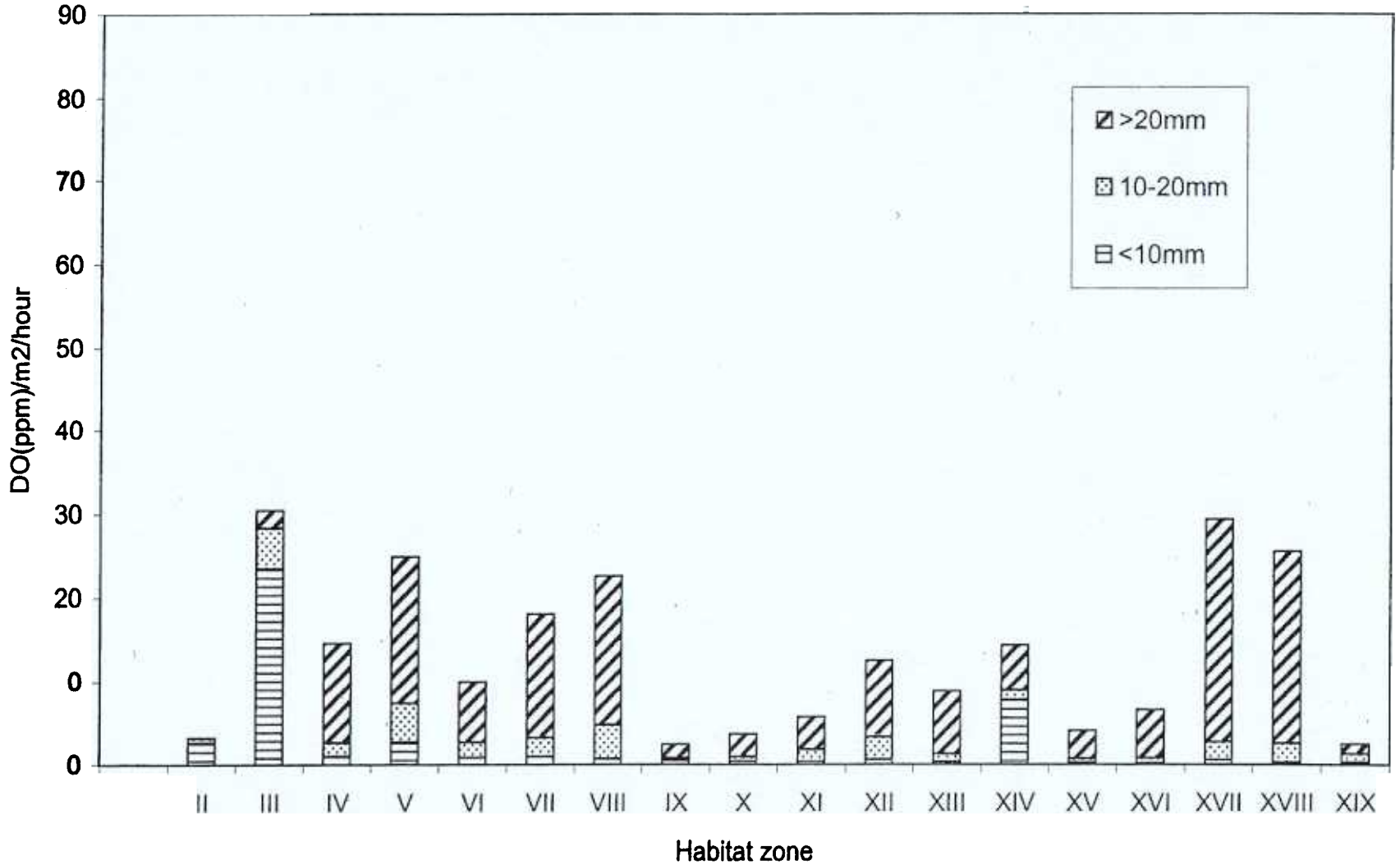
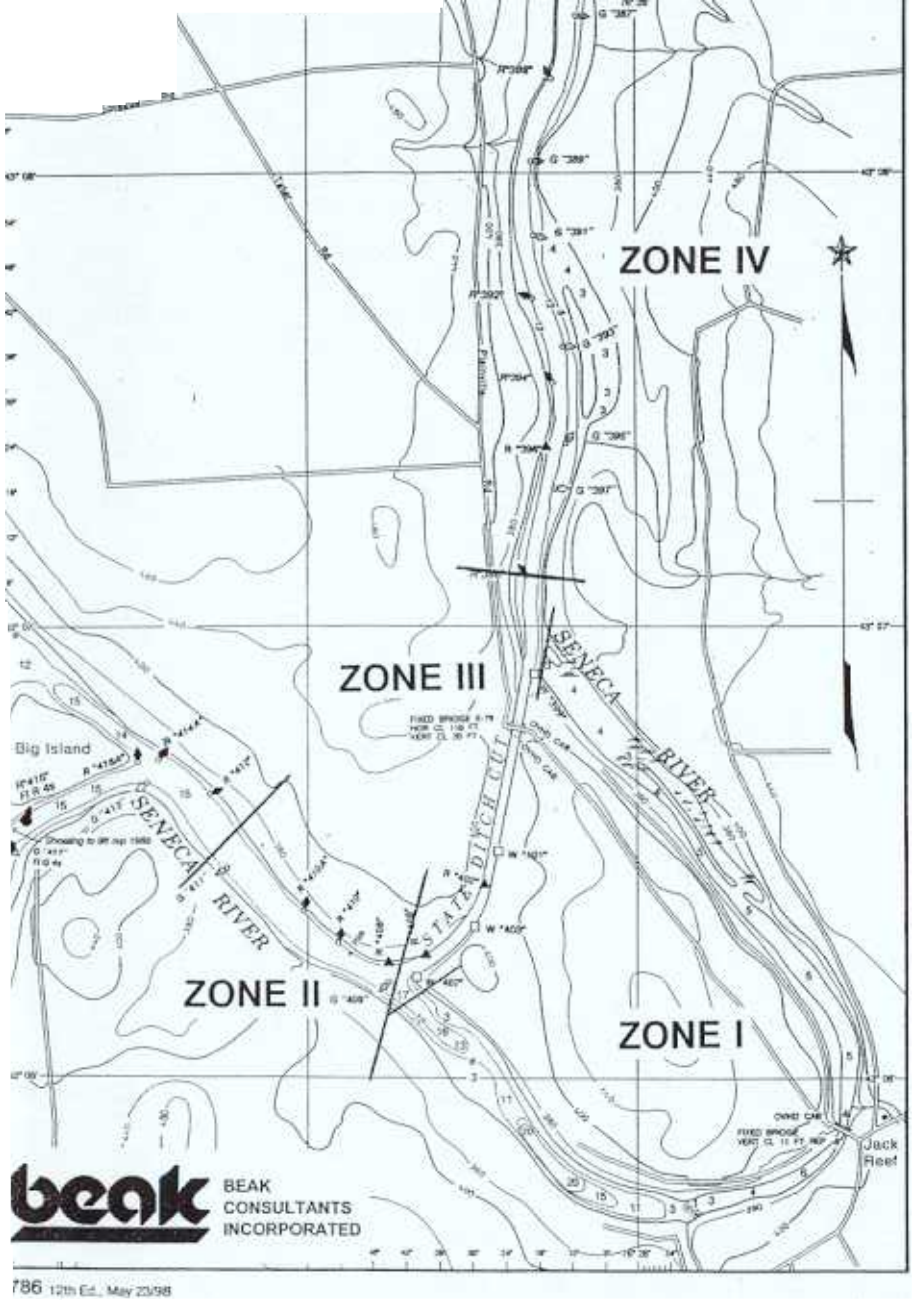


Figure 5. Dissolved oxygen consumption of zebra mussels acclimated at 15^0 C per m^2 of substrate in the Seneca River by habitat zone and size group.



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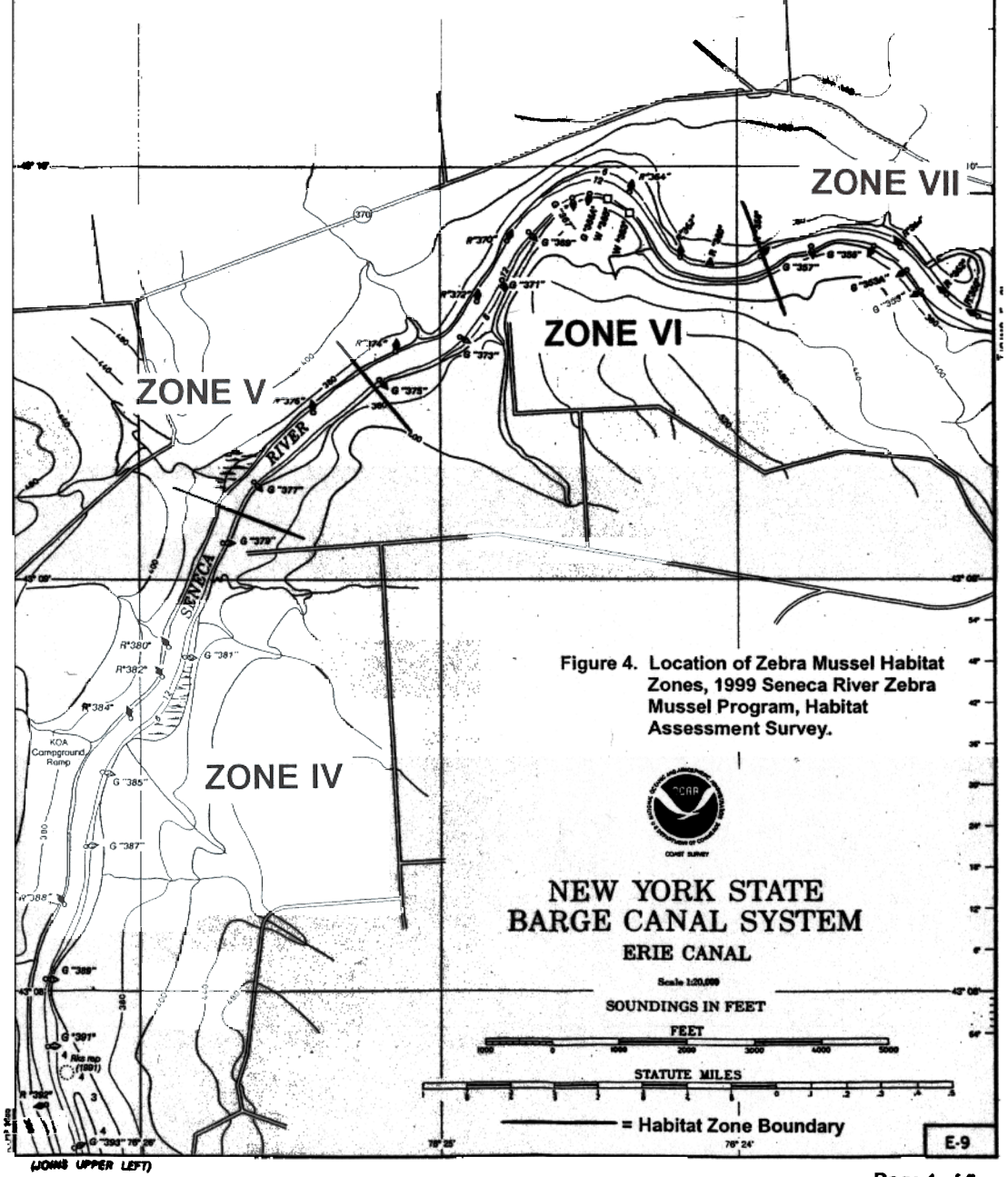
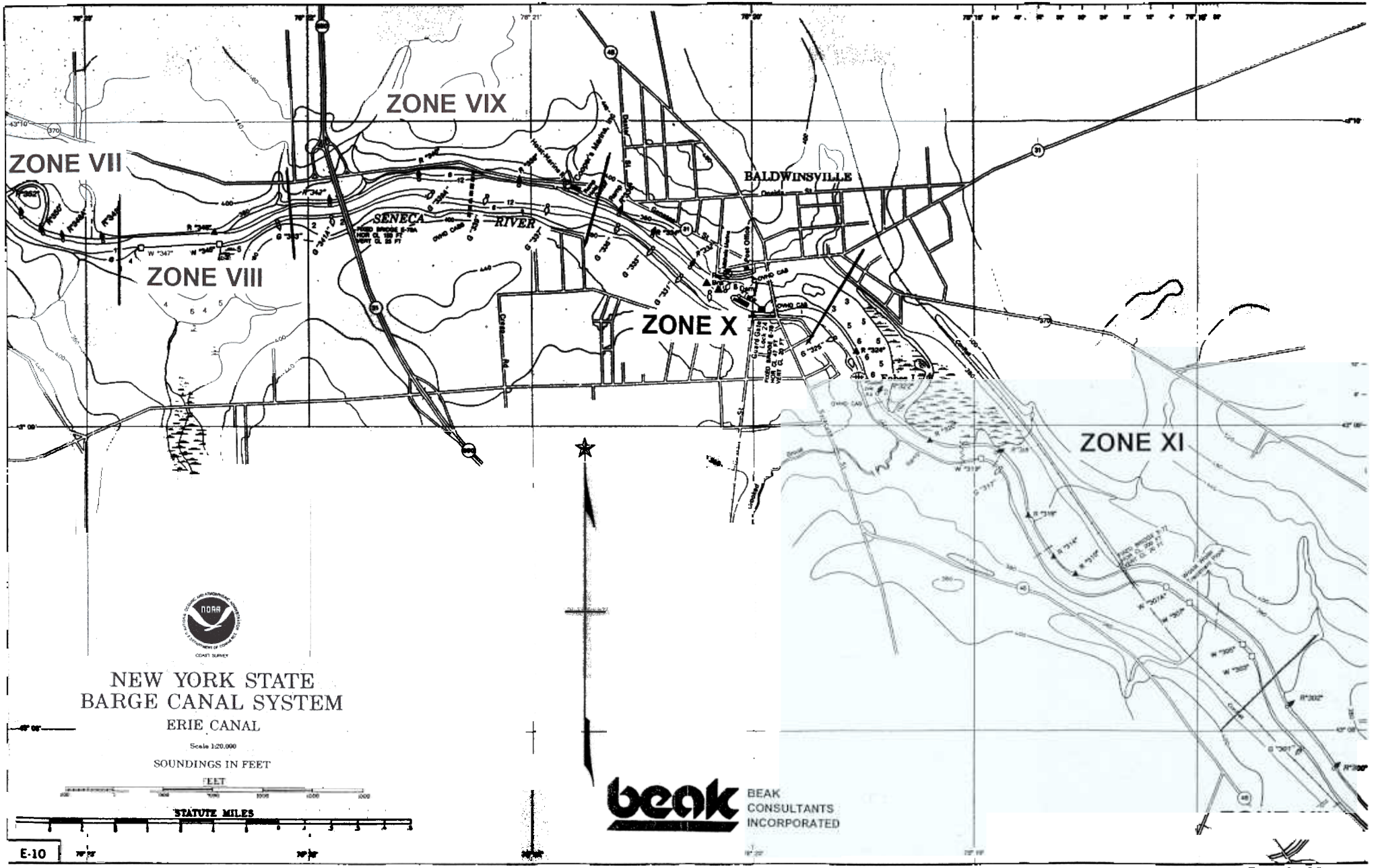
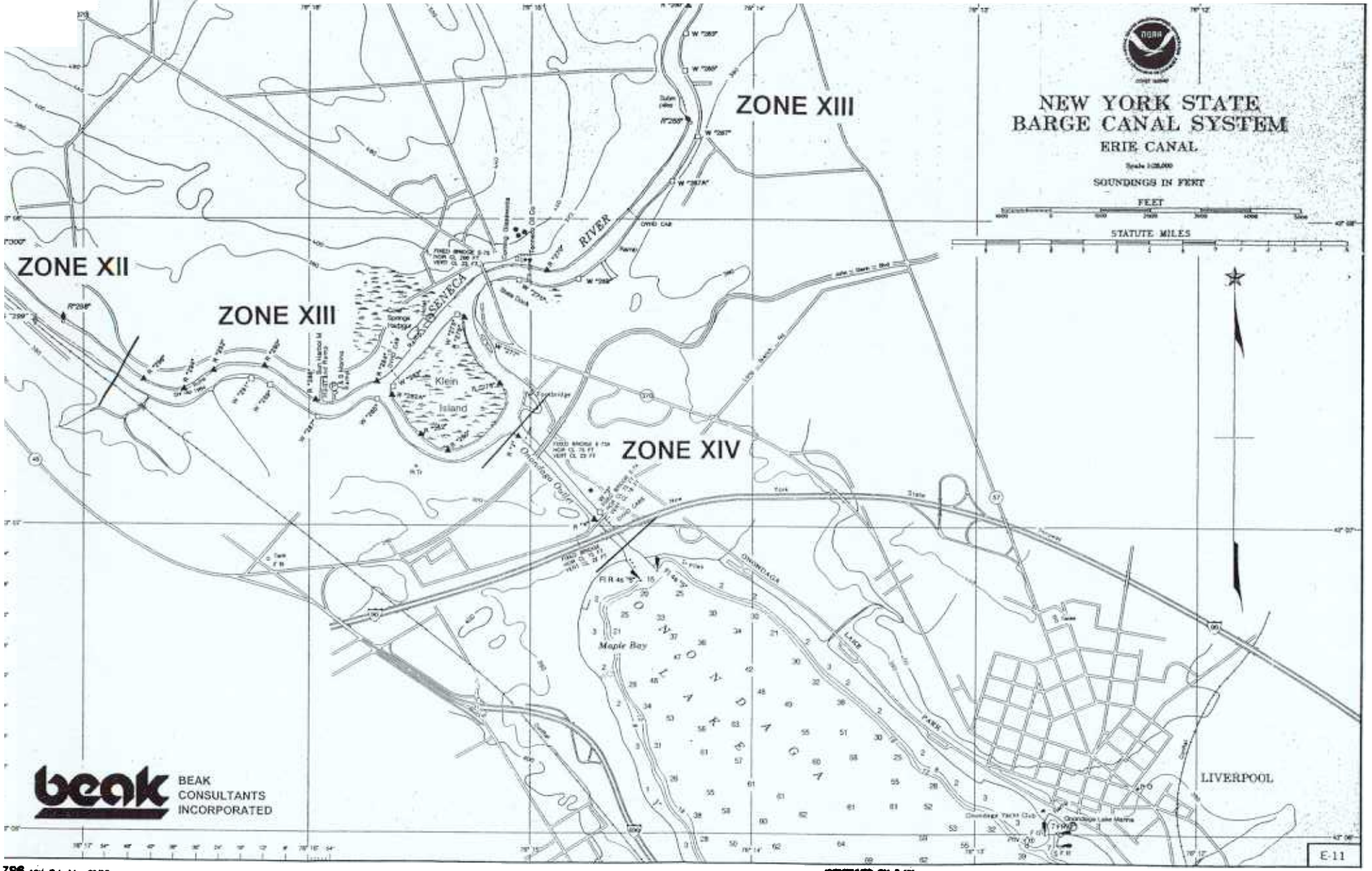
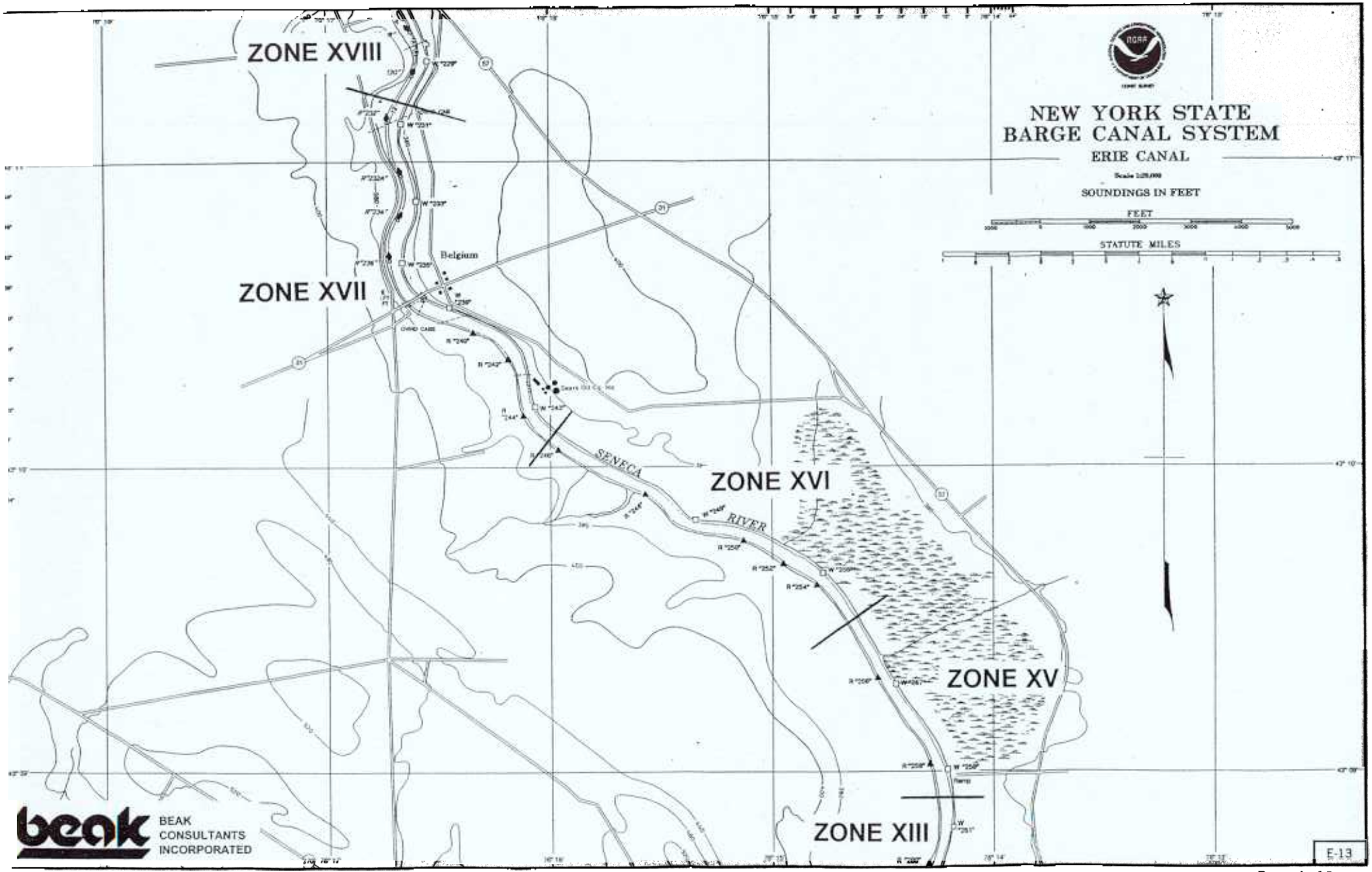


Figure 4. Location of Zebra Mussel Habitat Zones, 1999 Seneca River Zebra Mussel Program, Habitat Assessment Survey.

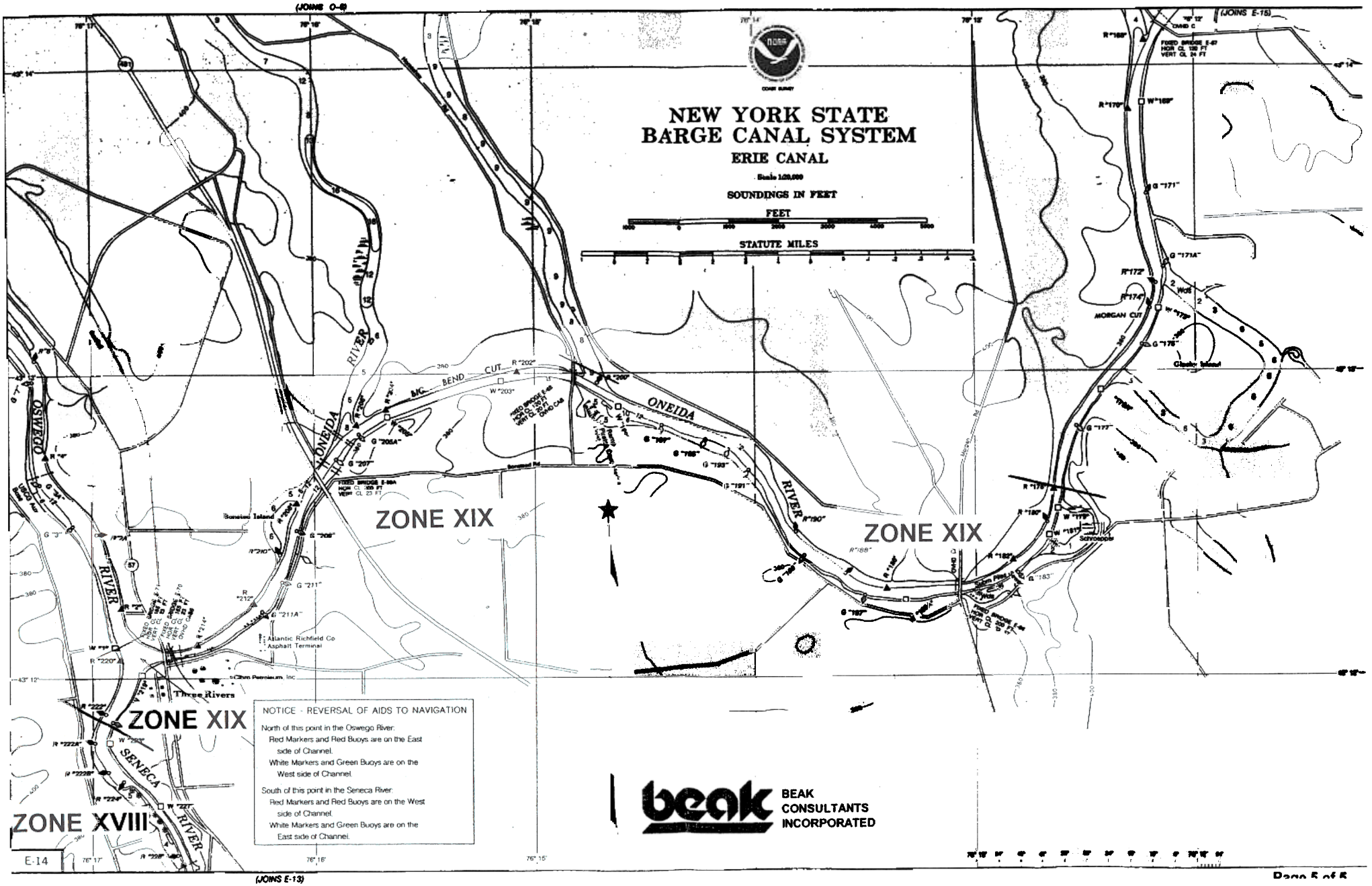

ZONE VIX
ZONE VII
ZONE VIII
ZONE X
ZONE XI
BALDWINSVILLE
SENECA
RIVER
NEW YORK STATE
BARGE CANAL SYSTEM
ERIE CANAL
Scale 1:20,000
SOUNDINGS IN FEET
FEET
STATUTE MILES
BEAK
CONSULTANTS
INCORPORATED



(CONTINUED ON E-12)


NEW YORK STATE
BARGE CANAL SYSTEM
ERIE CANAL
SOUNDINGS IN FEET
FEET
STATUTE MILES
ZONE XVIII
ZONE XVII
ZONE XVI
ZONE XV
ZONE XIII
Belgium
SENECA
RIVER
BEAK
CONSULTANTS
INCORPORATED
E-13

(JOINS E-11)


(JOINS O-8)
(JOINS E-15)
(JOINS E-13)
NEW YORK STATE
BARGE CANAL SYSTEM
ERIE CANAL
Scale 1:20,000
SOUNDINGS IN FEET
FEET
STATUTE MILES
ZONE XIX
ZONE XIX
ZONE XIX
ZONE XVIII
OSWEGO RIVER
ONEIDA RIVER
SENECA RIVER
BIG BEND CUT
MORGAN CUT
Three Rivers
Schroeder
Atlantic Richfield Co Asphalt Terminal
NOTICE - REVERSAL OF AIDS TO NAVIGATION
North of this point in the Oswego River:
Red Markers and Red Buoys are on the East side of Channel.
White Markers and Green Buoys are on the West side of Channel.
South of this point in the Seneca River:
Red Markers and Red Buoys are on the West side of Channel.
White Markers and Green Buoys are on the East side of Channel.
BEAK CONSULTANTS INCORPORATED

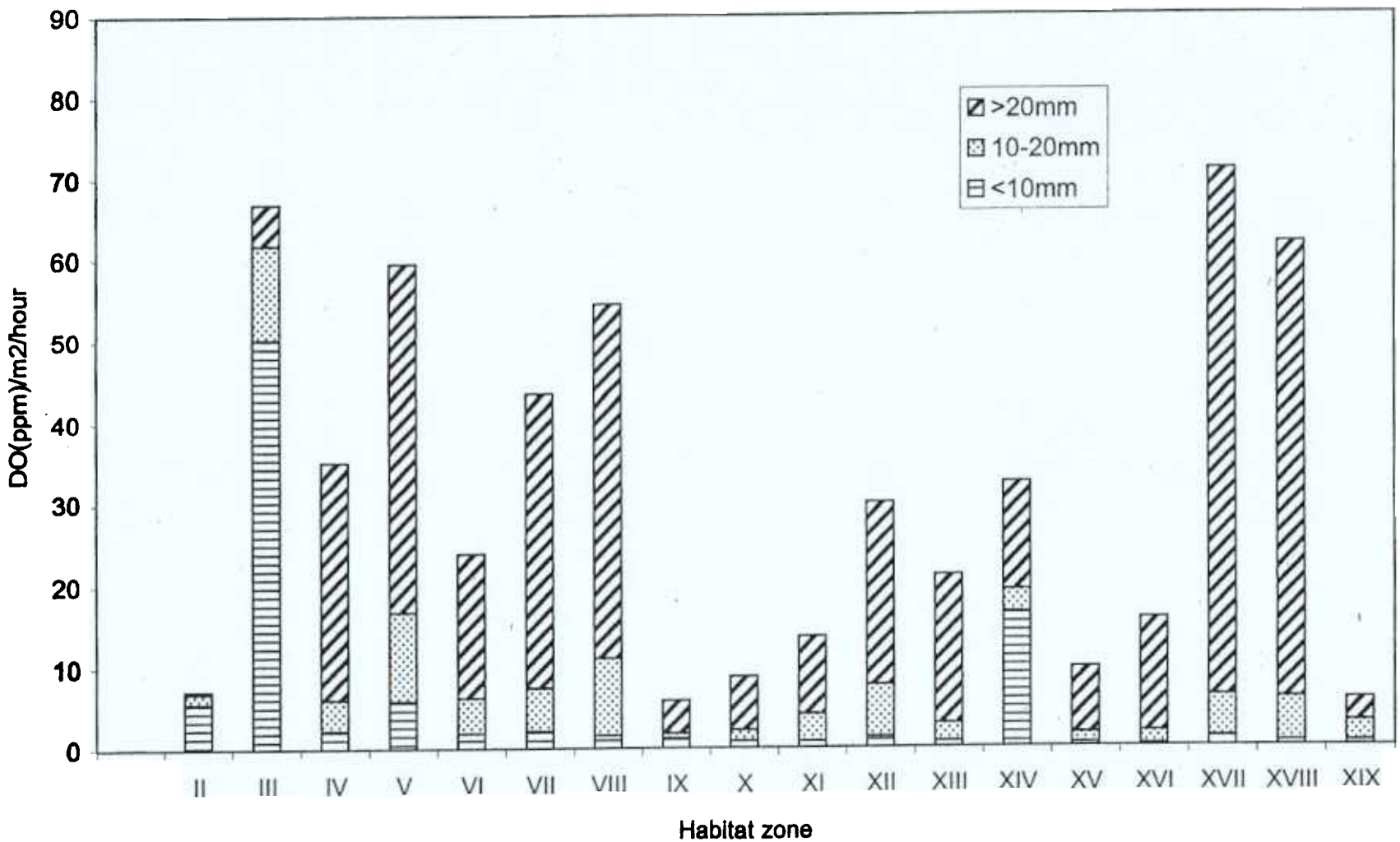


Figure 6. Dissolved oxygen consumption of zebra mussels acclimated at 20^0 C per m^2 of substrate in the Seneca River by habitat zone and size group.

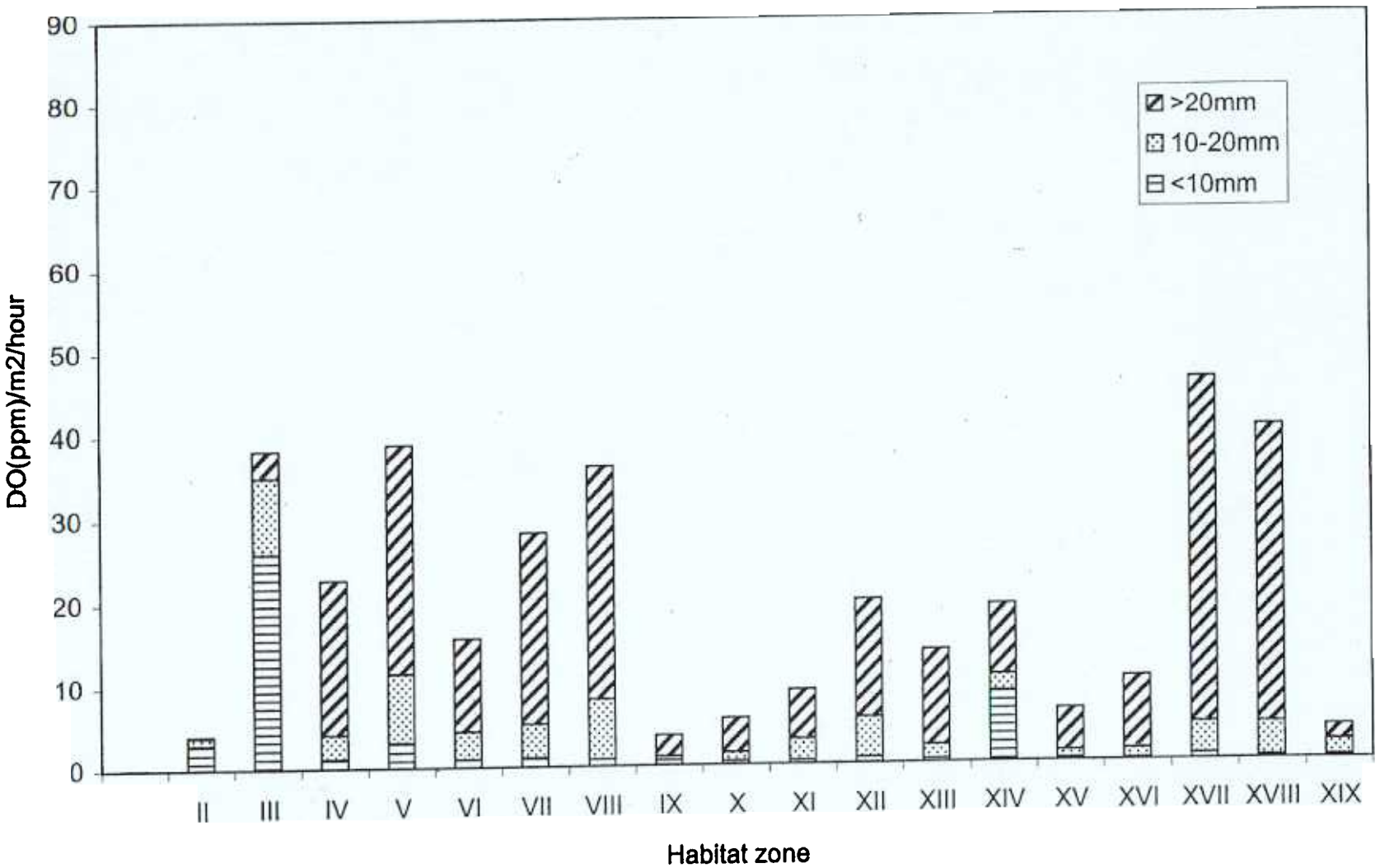


Figure 7. Dissolved oxygen consumption of zebra mussels acclimated at 24^0 C per m^2 of substrate in the Seneca River by habitat zone and size group

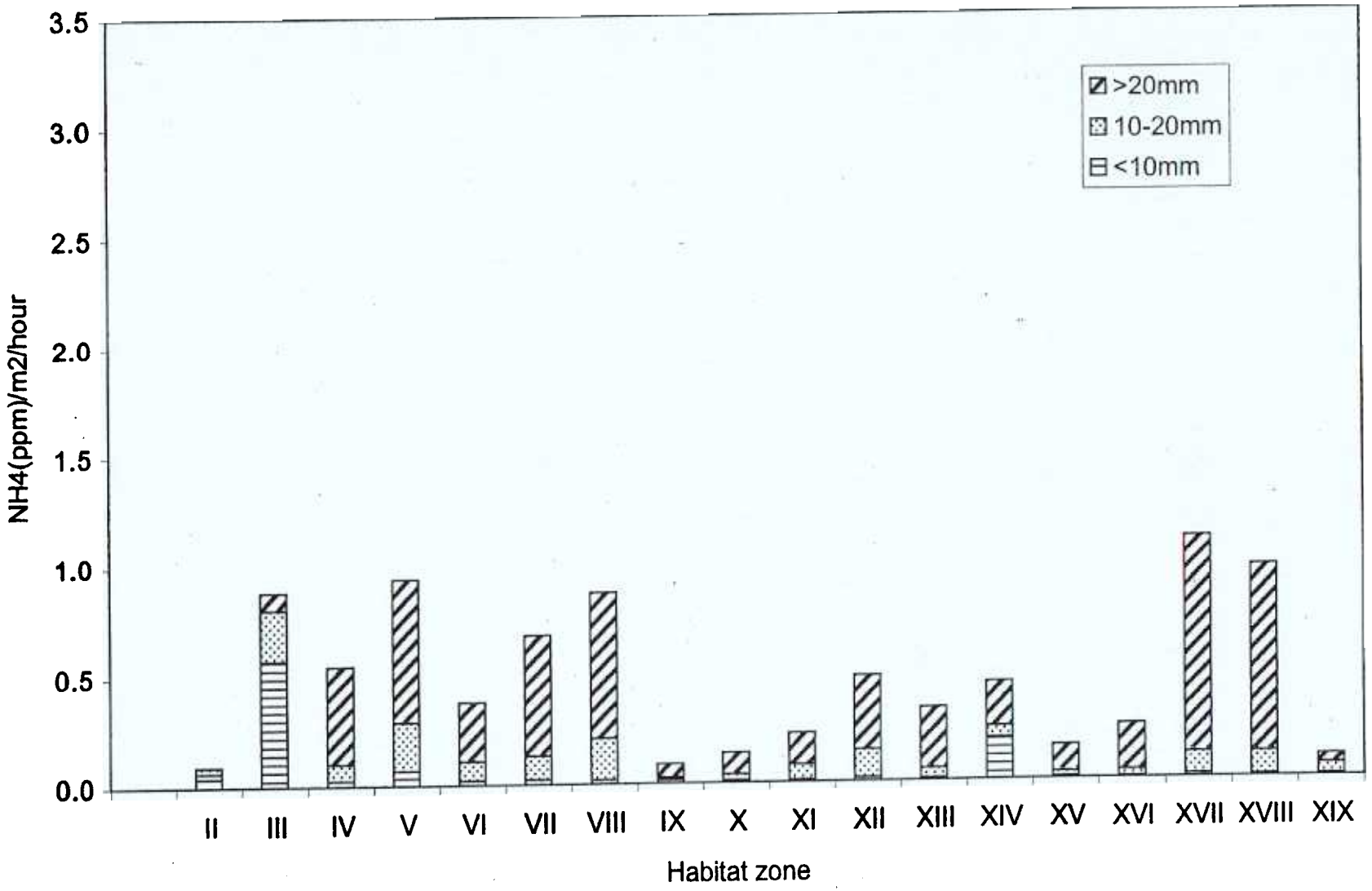


Figure 8. Ammonia excretion of zebra mussels acclimated at 15^0 C per m^2 of substrate in the Seneca River by habitat zone and size group

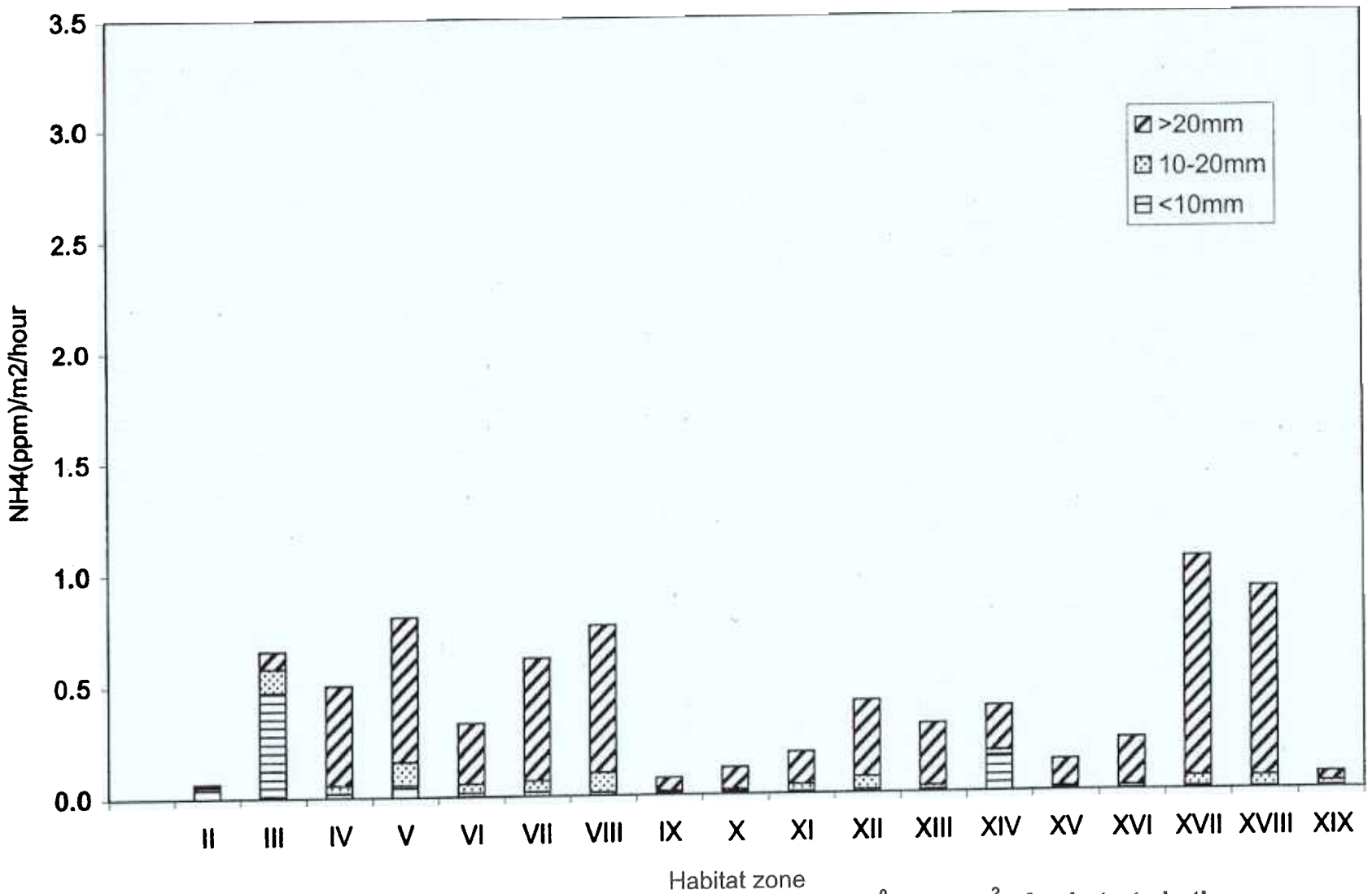


Figure 9. Ammonia excretion of zebra mussels acclimated at 20^0 C per m^2 of substrate in the Seneca River by habitat zone and size group

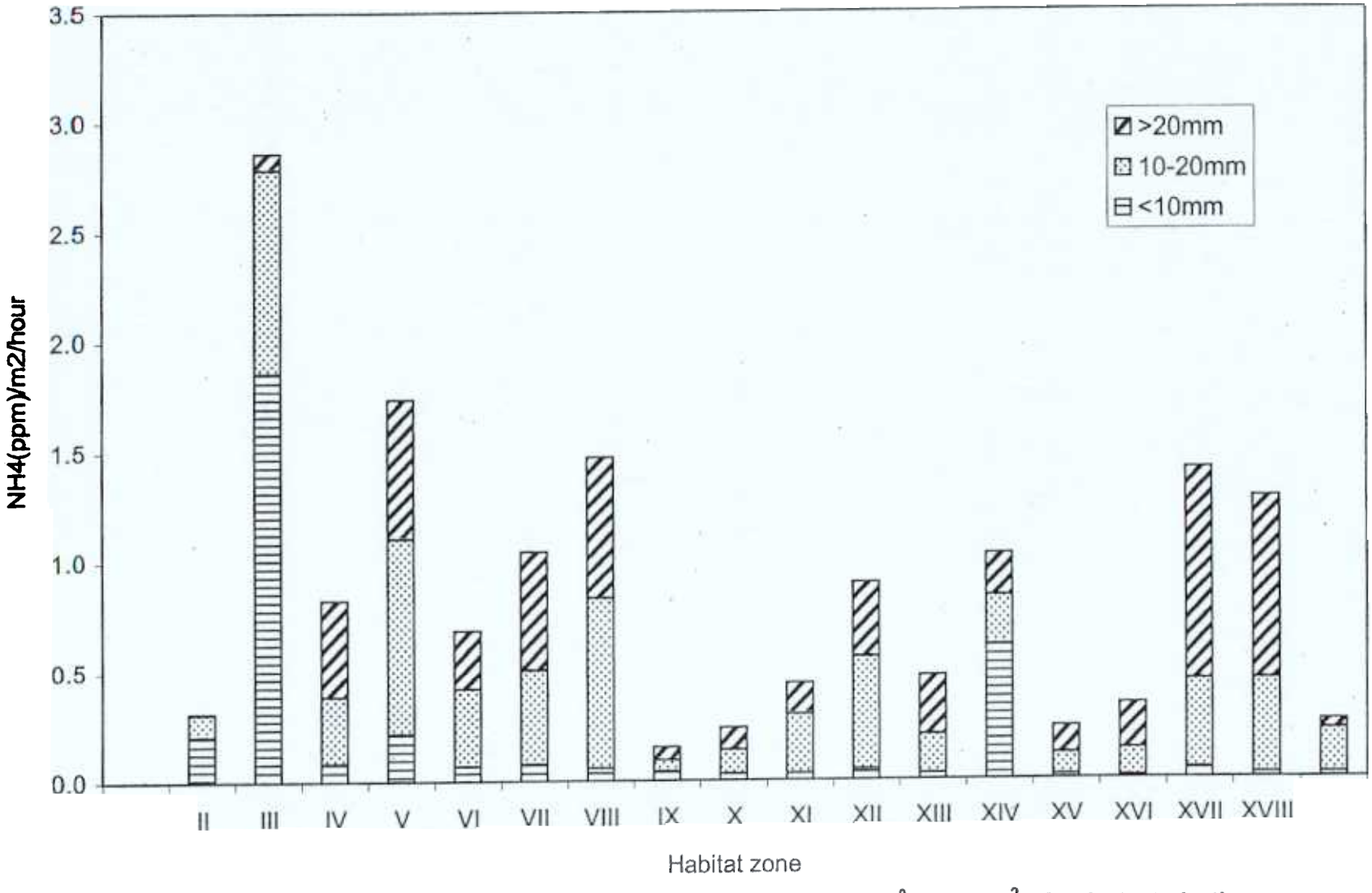


Figure 10. Ammonia excretion of zebra mussels acclimated at 24^0 C per m^2 of substrate in the Seneca River by habitat zone and size group

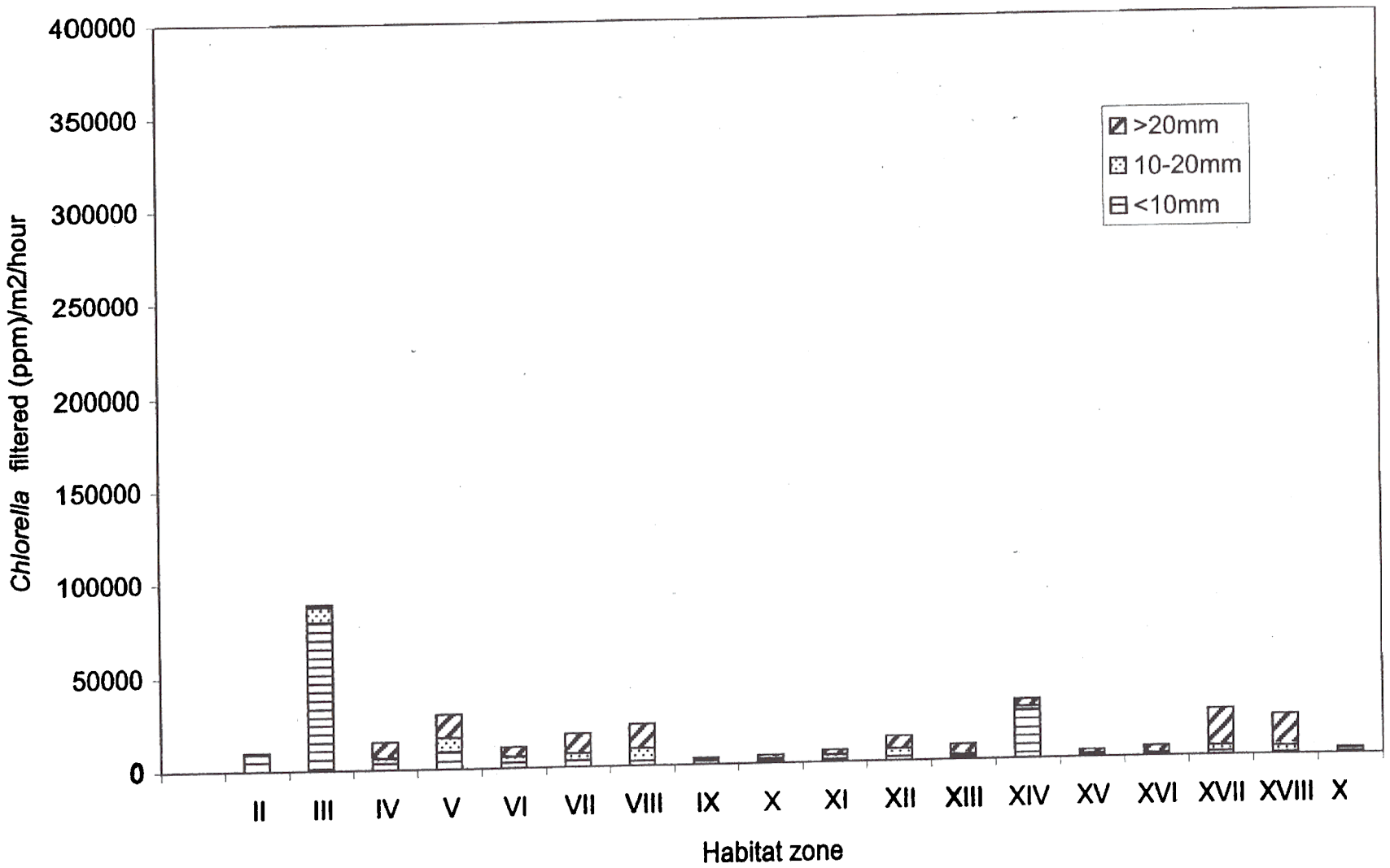


Figure 11. Filtration rate (clearance of *Chlorella*) of zebra mussels acclimated at 15^0 C per m^2 of substrate in the Seneca River by habitat zone and size group

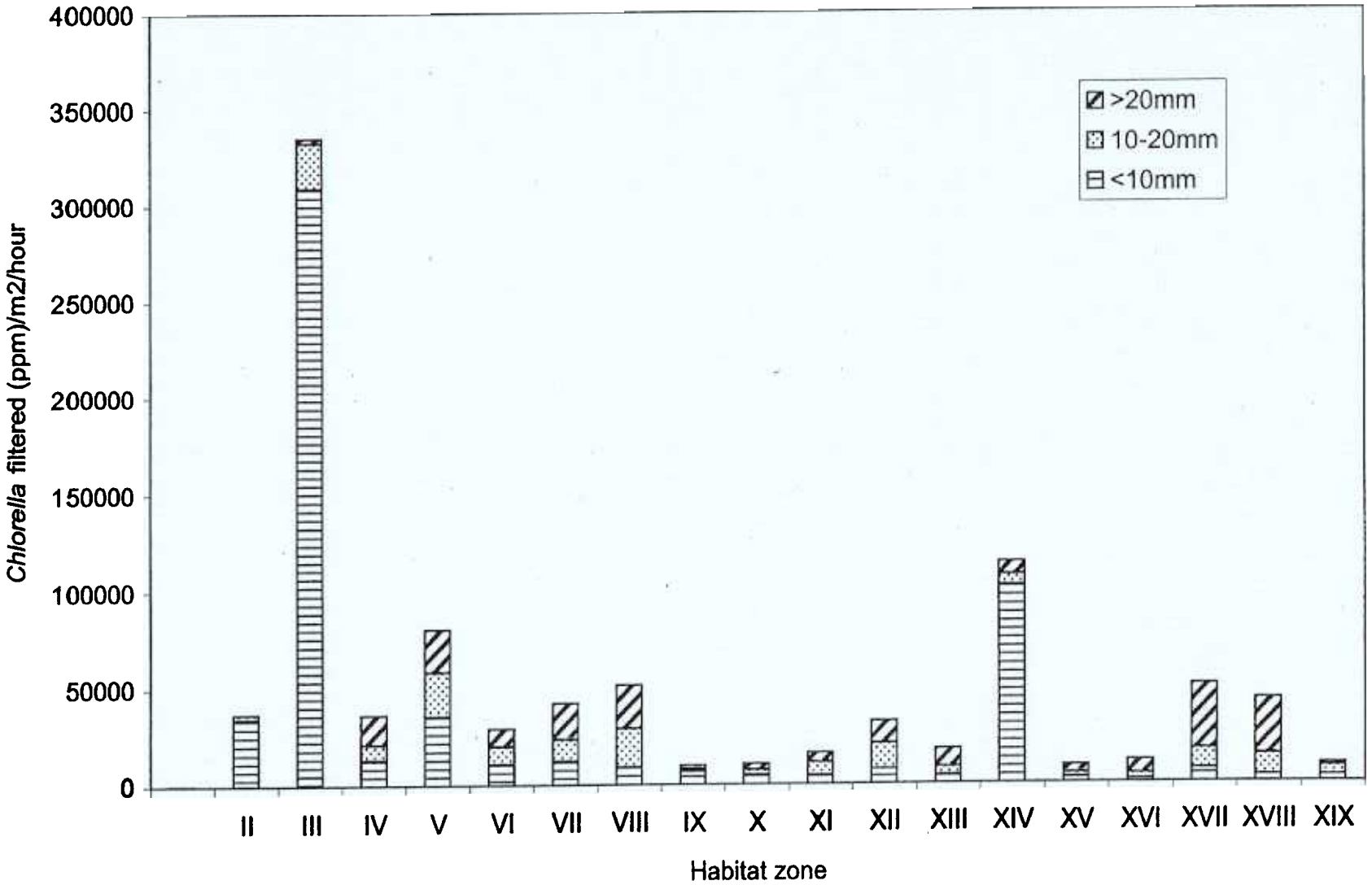


Figure 12. Filtration rate (clearance of *Chlorella*) of zebra mussels acclimated at 20^0 C per m^2 of substrate in the Seneca River by habitat zone and size group

Table 1. Mean dissolved oxygen consumption and ammonia excretion rates of Seneca River zebra mussels by acclimation temperature and mussel size group

Dissolved Oxygen consumption rate (~~ppm~~ mg D.O./mussel/hour)

Mean			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	0.001985	0.004778	0.01626
20	0.004244	0.011318	0.039451
24	0.0022	0.008757	0.025304
28		0.010532	0.046953

Standard error			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	0.000169	0.000817	0.001937
20	0.000898	0.00214	0.007411
24	0.000301	0.000496	0.003452
28		0.00184	0.009449

Number of mussels tested			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	10	10	10
20	10	10	10
24	4	8	10
28		8	10

Nitrogen excretion rate (~~ppm~~ mg NH4/mussel/hour)

Mean			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	4.85E-05	0.000227	0.000603
20	3.98E-05	0.000107	0.000602
24	0.000157	0.000916	0.000588
28			0.000181

Standard error			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	4.45E-06	5.65E-05	7.08E-05
20	3.69E-06	2.62E-05	0.000114
24	3.4E-05	0.000266	0.000127
28			3.04E-05

Number of mussels tested			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	10	10	10
20	8	10	10
24	2	7	10
28			4

Table 2. Mean freeze-dried *Chlorella* clearance rate by Seneca River zebra mussels, by acclimation temperature and mussel size group

$\frac{mg}{L \cdot mussel \cdot hr}$

Mean			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	6.668	7.820	11.967
20	26.091	23.426	20.295
24			23.553

Standard error			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	1.196	1.379	0.892
20	---	0.980	1.435
24			2.288

Number of mussels tested			
	Size group		
Temperature (C)	<10mm	10-20mm	>20mm
15	16	19	19
20	1	4	11
24			3

Table 3. Relative frequency and mean density of zebra mussels by length category for 19 habitat zones in the Seneca River

ZONE I				ZONE II				ZONE III			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	12	100.0%	9	<10	195	91.5%	1,308	<10	724	91.2%	11,833
10-20	0	0.0%	0	10-20	17	8.0%	114	10-20	62	7.8%	1,013
>20	0	0.0%	0	>20	1	0.5%	7	>20	8	1.0%	131
TOTALS	12	100.0%	9	TOTALS	213	100.0%	1,428	TOTALS	794	100.0%	12,977

ZONE IV				ZONE V				ZONE VI			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	176	32.7%	520	<10	124	40.0%	1,368	<10	153	34.1%	431
10-20	113	21.0%	334	10-20	88	28.4%	971	10-20	137	30.5%	386
>20	250	46.4%	739	>20	98	31.6%	1,081	>20	159	35.4%	448
TOTALS	539	100.0%	1,593	TOTALS	310	100.0%	3,420	TOTALS	449	100.0%	1,266

ZONE VII				ZONE VIII				ZONE IX			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	149	26.0%	485.6	<10	64	15.8%	364	<10	103	62.4%	263
10-20	145	25.3%	472.6	10-20	148	36.5%	843	10-20	22	13.3%	56
>20	280	48.8%	912.6	>20	193	47.7%	1,099	>20	40	24.2%	102
TOTALS	574	100.0%	1,870.8	TOTALS	405	100.0%	2,306	TOTALS	165	100.0%	422

ZONE X				ZONE XI				ZONE XII			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²	Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	68	39.5%	188	<10	55	25.1%	181	<10	82	21.1%	302
10-20	43	25.0%	119	10-20	90	41.1%	296	10-20	153	39.3%	563
>20	61	35.5%	168	>20	74	33.8%	243	>20	154	39.6%	567
TOTALS	172	100.0%	474	TOTALS	219	100.0%	720	TOTALS	389	100.0%	1,432

Table 3. Continued.

ZONE XIII			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	43	20.2%	166
10-20	50	23.5%	193
>20	120	56.3%	463
TOTALS	213	100.0%	821

ZONE XIV			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	439	87.1%	3,895
10-20	27	5.4%	240
>20	38	7.5%	337
TOTALS	504	100.0%	4,471

ZONE XV			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	26	23.6%	98
10-20	29	26.4%	109
>20	55	50.0%	206
TOTALS	110	100.0%	413

ZONE XVI			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	26	10.2%	56
10-20	64	25.1%	138
>20	165	64.7%	355
TOTALS	255	100.0%	549

ZONE XVII			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	75	11.6%	273
10-20	122	18.9%	444
>20	450	69.6%	1,639
TOTALS	647	100.0%	2,357

ZONE XVIII			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	40	6.6%	134
10-20	141	23.3%	471
>20	423	70.0%	1,413
TOTALS	604	100.0%	2,017

ZONE XIX			
Length (mm)	Frequency	Relative Frq.	Mean Number #/M²
<10	95	29.6%	121.6
10-20	170	53.0%	217.7
>20	56	17.4%	71.7
TOTALS	321	100.0%	411.0

Table 4. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone I

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.017432579	0.001481	15°C	0.000425684	3.91E-05	15°C	58.56301392	10.5014
20°C	0.037268402	0.007885	20°C	0.000349617	3.243E-05	20°C	229.135791	----
24°C	0.019320351	0.002646	24°C	0.001379019	0.0002987	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0	0	15°C	0	0	15°C	0	0
20°C	0	0	20°C	0	0	20°C	0	0
24°C	0	0	24°C	0	0	24°C	----	----
28°C	0	0	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0	0	15°C	0	0	15°C	0	0
20°C	0	0	20°C	0	0	20°C	0	0
24°C	0	0	24°C	0	0	24°C	0	0
28°C	0	0	28°C	0	0			

Table 5. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone II

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.595617815	0.220549	15°C	0.06338208	0.0058221	15°C	8719.719559	1563.6
20°C	5.549065696	1.174019	20°C	0.052056135	0.0048281	20°C	34117.09379	----
24°C	2.876696927	0.393991	24°C	0.205328507	0.0444757	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.544658278	0.093175	15°C	0.025924186	0.0064406	15°C	891.4343579	157.236
20°C	1.290182762	0.243955	20°C	0.012180438	0.0029873	20°C	2670.570218	111.725
24°C	0.998320265	0.056574	24°C	0.104390917	0.0302705	24°C	----	----
28°C	1.200585883	0.209786	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.109038178	0.012989	15°C	0.004045093	0.0004745	15°C	80.24488369	5.98363
20°C	0.264549456	0.049695	20°C	0.004035982	0.0007642	20°C	136.0926745	9.62316
24°C	0.169682694	0.023151	24°C	0.003941663	0.0008538	24°C	157.9431796	15.3461
28°C	0.31485892	0.063365	28°C	0.001213001	0.0002041			

Table 6. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone III

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	23.48895769	1.995852	15°C	0.573574043	0.0526868	15°C	78908.81415	14149.7
20°C	50.21608674	10.62424	20°C	0.471080273	0.0436921	20°C	308741.5134	----
24°C	26.03257383	3.565411	24°C	1.858113545	0.402481	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	4.841566719	0.828254	15°C	0.230444814	0.0572515	15°C	7924.122512	1397.7
20°C	11.46866976	2.168564	20°C	0.10827413	0.0265543	20°C	23739.1855	993.142
24°C	8.874250825	0.502896	24°C	0.927949896	0.26908	24°C	----	----
28°C	10.67222678	1.864825	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.12611923	0.253264	15°C	0.078874666	0.0092515	15°C	1564.68307	116.674
20°C	5.158410549	0.968989	20°C	0.078697009	0.0149002	20°C	2653.650848	187.641
24°C	3.308617649	0.451413	24°C	0.076857908	0.0166476	24°C	3079.710602	299.232
28°C	6.139387318	1.235541	28°C	0.023652124	0.0039794			

Table 7. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone IV

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	1.03258816	0.087739	15°C	0.025214647	0.0023161	15°C	3468.877093	622.031
20°C	2.207528206	0.467048	20°C	0.020708961	0.0019207	20°C	13572.45543	----
24°C	1.144406997	0.156738	24°C	0.081683746	0.0176933	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	1.595739403	0.272985	15°C	0.07595266	0.0188696	15°C	2611.723696	460.671
20°C	3.779976463	0.71474	20°C	0.035686237	0.0087521	20°C	7824.23457	327.331
24°C	2.924877944	0.16575	24°C	0.30584443	0.0886865	24°C	----	----
28°C	3.517475597	0.614631	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	12.01508731	1.43124	15°C	0.445735117	0.0522818	15°C	8842.309234	659.346
20°C	29.15111828	5.475931	20°C	0.444731144	0.084204	20°C	14996.26465	1060.39
24°C	18.69760143	2.551017	24°C	0.434338047	0.0940787	24°C	17404.00598	1691.01
28°C	34.69479681	6.982265	28°C	0.133662465	0.0224885			

Table 8. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone V

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.715226731	0.230712	15°C	0.066302796	0.0060904	15°C	9121.533801	1635.65
20°C	5.804772729	1.228119	20°C	0.054454939	0.0050506	20°C	35689.24689	----
24°C	3.009258277	0.412147	24°C	0.21479027	0.0465251	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	4.638057619	0.793439	15°C	0.22075836	0.054845	15°C	7591.0421	1338.95
20°C	10.98659882	2.077411	20°C	0.103722965	0.0254381	20°C	22741.33903	951.396
24°C	8.501232978	0.481758	24°C	0.888944702	0.2577695	24°C	----	----
28°C	10.2236333	1.78644	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	17.57854561	2.093961	15°C	0.652128019	0.0764904	15°C	12936.64641	964.649
20°C	42.64923333	8.011503	20°C	0.650659166	0.1231938	20°C	21940.12538	1551.39
24°C	27.35532676	3.732239	24°C	0.635453657	0.1376408	24°C	25462.7457	2474.02
28°C	50.7598532	10.21533	28°C	0.195553446	0.0329016			

Table 9. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone VI

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.856189853	0.07275	15°C	0.020907197	0.0019205	15°C	2876.284544	515.769
20°C	1.830413442	0.387261	20°C	0.017171224	0.0015926	20°C	11253.85615	----
24°C	0.948906539	0.129962	24°C	0.067729611	0.0146707	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	10-20mm	ppm NH4/hour	SE	10-20mm	mg *Chlorella*/hour	SE
15°C	1.845305452	0.315679	15°C	0.087831294	0.0218207	15°C	3020.184853	532.717
20°C	4.371146794	0.826522	20°C	0.041267394	0.0101209	20°C	9047.907624	378.524
24°C	3.382314936	0.191673	24°C	0.353677043	0.1025566	24°C	----	----
28°C	4.067592042	0.710756	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	7.288668847	0.868228	15°C	0.270394678	0.0317155	15°C	5363.977986	399.976
20°C	17.68383717	3.321844	20°C	0.269785641	0.0510804	20°C	9097.129643	643.261
24°C	11.34245815	1.547514	24°C	0.263480914	0.0570706	24°C	10557.72903	1025.81
28°C	21.04677878	4.235626	28°C	0.081083176	0.0136421			

Table 10. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone VII

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.963981142	0.081909	15°C	0.02353934	0.0021623	15°C	3238.398646	580.702
20°C	2.060856053	0.436016	20°C	0.01933302	0.0017931	20°C	12670.67703	----
24°C	1.068370533	0.146324	24°C	0.07625653	0.0165177	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.257976012	0.386275	15°C	0.10747324	0.0267005	15°C	3695.596816	651.85
20°C	5.348677964	1.01136	20°C	0.050496131	0.0123842	20°C	11071.31524	463.174
24°C	4.138711011	0.234537	24°C	0.43277078	0.1254916	24°C	----	----
28°C	4.977238456	0.869704	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	14.83927728	1.767658	15°C	0.550506778	0.0645709	15°C	10920.72618	814.327
20°C	36.00319465	6.763069	20°C	0.549266816	0.1039965	20°C	18521.19119	1309.64
24°C	23.09254064	3.150643	24°C	0.536430784	0.1161922	24°C	21494.88087	2088.49
28°C	42.84993498	8.623472	28°C	0.165080313	0.0277746			

Table 11. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone VIII

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.723282565	0.061457	15°C	0.01766175	0.0016224	15°C	2429.795749	435.705
20°C	1.546276362	0.327146	20°C	0.014505716	0.0013454	20°C	9506.907748	----
24°C	0.801606739	0.109788	24°C	0.057215869	0.0123934	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	4.025861131	0.68871	15°C	0.191619547	0.0476058	15°C	6589.068925	1162.22
20°C	9.536432008	0.779764	20°C	0.09003214	0.0220805	20°C	19739.61524	825.817
24°C	7.379119929	0.18083	24°C	0.771609199	0.2237455	24°C	----	----
28°C	8.874173477	0.670547	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	17.86725274	2.128352	15°C	0.662838462	0.0777467	15°C	13149.11576	980.492
20°C	43.3496973	8.143082	20°C	0.661345485	0.1252171	20°C	22300.46638	1576.87
24°C	27.80460613	3.793537	24°C	0.645890243	0.1399014	24°C	25880.94163	2514.65
28°C	51.59352465	10.3831	28°C	0.198765184	0.033442			

Table 12. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone IX

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.522843352	0.044426	15°C	0.012767249	0.0011728	15°C	1756.440174	314.961
20°C	1.117765526	0.236486	20°C	0.010485829	0.0009725	20°C	6872.31209	----
24°C	0.57946199	0.079363	24°C	0.041359958	0.0089589	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.268798041	0.045984	15°C	0.012794023	0.0031785	15°C	439.9378816	77.5987
20°C	0.63672694	0.120396	20°C	0.006011251	0.0014743	20°C	1317.971418	55.138
24°C	0.492687878	0.02792	24°C	0.051518677	0.014939	24°C	----	----
28°C	0.59250937	0.103533	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	1.663285519	0.198131	15°C	0.061704484	0.0072375	15°C	1224.068084	91.2752
20°C	4.03547903	0.75805	20°C	0.061565501	0.0116566	20°C	2075.979073	146.793
24°C	2.588366516	0.353145	24°C	0.060126753	0.0130236	24°C	2409.290116	234.092
28°C	4.802907512	0.966576	28°C	0.018503306	0.0031132			

Table 13. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone X

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.372189761	0.031625	15°C	0.009088457	0.0008348	15°C	1250.334436	224.207
20°C	0.795689343	0.168344	20°C	0.007464412	0.0006923	20°C	4892.104262	----
24°C	0.412494141	0.056495	24°C	0.029442381	0.0063774	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.566491002	0.09691	15°C	0.026963362	0.0066987	15°C	927.1676637	163.539
20°C	1.341899969	0.253734	20°C	0.012668693	0.003107	20°C	2777.620503	116.203
24°C	1.038338112	0.058842	24°C	0.108575446	0.0314839	24°C	----	----
28°C	1.248711583	0.218195	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.735002909	0.325794	15°C	0.101463003	0.011901	15°C	2012.781168	150.087
20°C	6.635689881	1.24649	20°C	0.101234468	0.0191674	20°C	3413.610436	241.378
24°C	4.256148371	0.58069	24°C	0.09886868	0.0214152	24°C	3961.686314	384.927
28°C	7.897601386	1.589378	28°C	0.030425682	0.0051191			

Table 14. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XI

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.358756467	0.030483	15°C	0.008760431	0.0008047	15°C	1205.206622	216.115
20°C	0.76697085	0.162268	20°C	0.007195002	0.0006673	20°C	4715.535526	----
24°C	0.397606157	0.054456	24°C	0.028379729	0.0061473	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella/hour***	**SE**
15°C	1.41302098	0.241727	15°C	0.067255782	0.016709	15°C	2312.671085	407.922
20°C	3.347154326	0.6329	20°C	0.031600023	0.0077499	20°C	6928.329011	289.85
24°C	2.589967943	0.146771	24°C	0.270824042	0.0785315	24°C	----	----
28°C	3.114710839	0.544253	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	3.954041447	0.471006	15°C	0.146686835	0.0172054	15°C	2909.912869	216.984
20°C	9.593332691	1.802073	20°C	0.146356437	0.0277107	20°C	4935.116193	348.964
24°C	6.153187994	0.839514	24°C	0.142936176	0.0309603	24°C	5727.479058	556.495
28°C	11.41770018	2.297791	28°C	0.04398694	0.0074007			

Table 15. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XII

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.599258377	0.050919	15°C	0.014633219	0.0013442	15°C	2013.14884	360.993
20°C	1.281130097	0.271049	20°C	0.012018362	0.0011147	20°C	7876.719809	----
24°C	0.664151988	0.090962	24°C	0.047404833	0.0102682	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.691291529	0.460403	15°C	0.128097827	0.0318245	15°C	4404.798081	776.943
20°C	6.375112765	1.205444	20°C	0.060186561	0.0147608	20°C	13195.94928	552.06
24°C	4.932947838	0.279546	24°C	0.515821394	0.149574	24°C	----	----
28°C	5.932392384	1.036604	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	9.219204138	1.098194	15°C	0.342013581	0.040116	15°C	6784.724219	505.917
20°C	22.36772012	4.201695	20°C	0.34124323	0.0646099	20°C	11506.66836	813.641
24°C	14.34671259	1.957402	24°C	0.333268583	0.0721868	24°C	13354.13383	1297.52
28°C	26.62139742	5.357508	28°C	0.102559517	0.0172555			

Table 16. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XIII

l Oxygen			*Ammonia excretion*			*Chlorella clearance*		
mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
°C	0.329112511	0.027965	15°C	0.008036559	0.0007382	15°C	1105.620707	198.257
°C	0.703596245	0.14886	20°C	0.006600481	0.0006122	20°C	4325.892031	----
°C	0.364752062	0.049956	24°C	0.026034719	0.0056393	24°C	----	----
°C	----	----	28°C	----	----			
)mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
°C	0.921117415	0.157577	15°C	0.043842571	0.0108922	15°C	1507.579606	265.915
°C	2.181936564	0.412573	20°C	0.020599362	0.005052	20°C	4516.425873	188.947
°C	1.688343352	0.095677	24°C	0.176544259	0.051193	24°C	----	----
°C	2.030411748	0.354787	28°C	----	----			
mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
°C	7.52366816	0.896221	15°C	0.279112671	0.0327381	15°C	5536.921931	412.872
°C	18.25399473	3.428946	20°C	0.278483997	0.0527273	20°C	9390.436865	664.001
°C	11.70815866	1.597409	24°C	0.271975996	0.0589107	24°C	10898.12851	1058.89
°C	21.7253634	4.37219	28°C	0.083697438	0.014082			

Table 18. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XV

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.1935616	0.016447	15°C	0.004726558	0.0004342	15°C	650.2509194	116.602
20°C	0.413807468	0.087549	20°C	0.003881954	0.00036	20°C	2544.195539	----
24°C	0.21452236	0.029381	24°C	0.015311851	0.0033167	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.519652362	0.088898	15°C	0.024733975	0.0061449	15°C	850.507536	150.017
20°C	1.230948922	0.232755	20°C	0.011621219	0.0028501	20°C	2547.961133	106.595
24°C	0.952486183	0.053977	24°C	0.099598205	0.0288807	24°C	----	----
28°C	1.145465544	0.200154	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	3.35413852	0.399546	15°C	0.124431666	0.014595	15°C	2468.424011	184.063
20°C	8.137842547	1.528664	20°C	0.124151396	0.0235064	20°C	4186.365659	296.019
24°C	5.219632912	0.712143	24°C	0.121250053	0.0262631	24°C	4858.51208	472.064
28°C	9.685418959	1.949173	28°C	0.037313289	0.0062779			

Table 19. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XVI

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.111089966	0.009439	15°C	0.002712693	0.0002492	15°C	373.1956769	66.9206
20°C	0.237494717	0.050247	20°C	0.002227953	0.0002066	20°C	1460.17906	----
24°C	0.123119884	0.016862	24°C	0.008787864	0.0019035	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.658188835	0.112597	15°C	0.031327918	0.0077831	15°C	1077.248186	190.011
20°C	1.559113161	0.294806	20°C	0.014719372	0.0036099	20°C	3227.233613	135.013
24°C	1.206413782	0.068366	24°C	0.126150541	0.0365802	24°C	----	----
28°C	1.450840383	0.253514	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	5.77507832	0.687929	15°C	0.214243571	0.0251294	15°C	4250.075511	316.916
20°C	14.01154955	2.632018	20°C	0.213761009	0.0404728	20°C	7207.987806	509.679
24°C	8.987043524	1.226152	24°C	0.208765544	0.0452191	24°C	8365.274006	812.79
28°C	16.67613091	3.356041	28°C	0.06424516	0.0108092			

Table 20. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XVII

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.542238997	0.046074	15°C	0.013240869	0.0012163	15°C	1821.59791	326.645
20°C	1.159230684	0.245259	20°C	0.010874816	0.0010086	20°C	7127.25063	----
24°C	0.600957986	0.082307	24°C	0.042894267	0.0092912	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.123040932	0.363192	15°C	0.101050714	0.0251049	15°C	3474.750513	612.896
20°C	5.029044679	0.950922	20°C	0.047478517	0.0116441	20°C	10409.70112	435.495
24°C	3.891384512	0.220521	24°C	0.406908698	0.1179923	24°C	----	----
28°C	4.679802138	0.817731	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	26.65105757	3.174681	15°C	0.988699621	0.1159681	15°C	19613.4149	1462.52
20°C	64.66104751	12.14634	20°C	0.986472674	0.1867757	20°C	33263.70438	2352.09
24°C	41.47376037	5.658495	24°C	0.963419407	0.208679	24°C	38604.39406	3750.89
28°C	76.95766192	15.48759	28°C	0.296481078	0.0498826			

Table 21. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XVIII

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.265185803	0.022533	15°C	0.00647554	0.0005948	15°C	890.8652967	159.748
20°C	0.566929937	0.119946	20°C	0.005318405	0.0004933	20°C	3485.632155	----
24°C	0.293902739	0.040253	24°C	0.020977744	0.0045439	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	2.249978891	0.384907	15°C	0.1070926	0.026606	15°C	3682.508043	649.542
20°C	5.329734439	1.007778	20°C	0.050317288	0.0123404	20°C	11032.10373	461.534
24°C	4.124052852	0.233707	24°C	0.431238027	0.1250472	24°C	----	----
28°C	4.959610467	0.866624	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	22.9722268	2.736457	15°C	0.852222538	0.0999602	15°C	16906.03888	1260.63
20°C	55.73543357	10.4697	20°C	0.850302993	0.1609937	20°C	28672.084	2027.41
24°C	35.74884888	4.877414	24°C	0.830431928	0.1798736	24°C	33275.56115	3233.13
28°C	66.3346608	13.34973	28°C	0.255555734	0.0429969			

Table 22. Estimated dissolved oxygen consumption, ammonia excretion, and *Chlorella* clearance rates for zebra mussels by length category per square meter of Seneca River substrate in Zone XIX

Dissolved Oxygen			*Ammonia excretion*			*Chlorella clearance*		
<10mm	**ppm D.O./hour**	**SE**	**<10mm**	**ppm NH4/hour**	**SE**	**<10mm**	**mg *Chlorella*/hour**	**SE**
15°C	0.241449369	0.020516	15°C	0.005895923	0.0005416	15°C	811.1251086	145.449
20°C	0.516184779	0.109209	20°C	0.004842362	0.0004491	20°C	3173.637778	----
24°C	0.267595889	0.03665	24°C	0.019100053	0.0041372	24°C	----	----
28°C	----	----	28°C	----	----			
10-20mm	**ppm D.O./hour**	**SE**	**10-20mm**	**ppm NH4/hour**	**SE**	**10-20mm**	**mg *Chlorella*/hour**	**SE**
15°C	1.039969116	0.177909	15°C	0.049499574	0.0122976	15°C	1702.102473	300.226
20°C	2.463471651	0.465808	20°C	0.023257296	0.0057039	20°C	5099.179914	213.327
24°C	1.906190149	0.108022	24°C	0.19932375	0.0577984	24°C	----	----
28°C	2.292395601	0.400565	28°C	----	----			
>20mm	**ppm D.O./hour**	**SE**	**>20mm**	**ppm NH4/hour**	**SE**	**>20mm**	**mg *Chlorella*/hour**	**SE**
15°C	1.16590441	0.138883	15°C	0.043252664	0.0050733	15°C	858.0284987	63.9807
20°C	2.828728287	0.531366	20°C	0.043155242	0.0081709	20°C	1455.188017	102.897
24°C	1.81435352	0.247542	24°C	0.04214673	0.0091291	24°C	1688.827287	164.09
28°C	3.366668551	0.677536	28°C	0.012970164	0.0021822			

Table 23. Comparison of oxygen consumption and ammonia excretion rates for mussels 10mm to 20mm, Aldridge et al. (1995) and present study

TEMPERATURE(C)	OXYGEN CONSUMPTION (~~PPB~~ ug O/MUSSEL/HOUR)		TEMPERATURE(C)	AMMONIA EXCRETION (PPB/MUSSEL/HOUR)	
	ALDRIDGE ET AL	BEAK		ALDRIDGE ET AL	BEAK
15	---	4.78(0.82)	15	---	0.227(0.057)
20	16.7(4.1)	11.32(2.14)	20	0.40(0.26)	0.107(0.026)
24	25.2(4.9)	8.75(0.05)	24	0.46(0.19)	0.916(0.27)
28	43.2(14.3)	10.53(0.18)	28	1.39(0.42)	---
32	61.0(23.3)	---	32	1.97(0.58)	---

TEMPERATURE(C)	FILTRATION RATE (PPM/MUSSEL/HOUR)	
	ALDRIDGE ET AL	BEAK
15	---	7.802(1.379)
20	1.666(1.187)	23.426(0.980)
24	2.085(1.088)	---
28	0.893(0.621)	---
32	0.446(0.446)	---

← This shows Beak >> Aldridge, but DG's comparison using $\frac{ugC}{hr \cdot mussel}$ is much closer, so someone is wrong

able 24. **Dissolved oxygen consumption (DO), ammonia excretion (NH4) and filtration rate (*Chlorella*) of zebra mussels per square meter substrate per hour by temperature and habitat zone in the Seneca River**

DO (mg/l)																			
15C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	0.017433	2.595618	23.48896	1.032588	2.715227	0.85619	0.963981	0.723283	0.522843	0.37219	0.358756	0.599258	0.329113	7.730558	0.193562	0.11109	0.542239	0.265186	0.241449
10-20mm	0	0.544658	4.841567	1.595739	4.638058	1.845305	2.257976	4.025861	0.268798	0.566491	1.413021	2.691292	0.921117	1.144403	0.519652	0.658189	2.123041	2.249979	1.039969
>20mm	0	0.109038	2.126119	12.01509	17.57855	7.288669	14.83928	17.86725	1.663286	2.735003	3.954041	9.219204	7.523668	5.481537	3.354139	5.775078	26.65106	22.97223	1.165904
Total	0.017433	3.249314	30.45664	14.64341	24.93183	9.990164	18.06123	22.6164	2.454927	3.673684	5.725819	12.50975	8.773898	14.3565	4.067352	6.544357	29.31634	25.48739	2.447323
20C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	0.037268	5.549066	50.21609	2.207528	5.804773	1.830413	2.060856	1.546276	1.117766	0.795689	0.766971	1.28113	0.703596	16.52685	0.413807	0.237495	1.159231	0.56693	0.516185
10-20mm	0	1.290183	11.46867	3.779976	10.9866	4.371147	5.348678	9.536432	0.636727	1.3419	3.347154	6.375113	2.181937	2.710855	1.230949	1.559113	5.029045	5.329734	2.463472
>20mm	0	0.264549	5.158411	29.15112	42.64923	17.68384	36.00319	43.3497	4.035479	6.63569	9.593333	22.36772	18.25399	13.29936	8.137843	14.01155	64.66105	55.73543	2.828728
Total	0.037268	7.103798	66.84317	35.13862	59.4406	23.8854	43.41273	54.43241	5.789971	8.773279	13.70746	30.02396	21.13953	32.53706	9.782599	15.80816	70.84932	61.6321	5.808385
24C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	0.01932	2.876697	26.03257	1.144407	3.009258	0.948907	1.068371	0.801607	0.579462	0.412494	0.397606	0.664152	0.364752	8.567699	0.214522	0.12312	0.600958	0.293903	0.267596
10-20mm	0	0.99832	8.874251	2.924878	8.501233	3.382315	4.138711	7.37912	0.492688	1.038338	2.589968	4.932948	1.688343	2.097611	0.952486	1.206414	3.891385	4.124053	1.90619
>20mm	0	0.169683	3.308618	18.6976	27.35533	11.34246	23.09254	27.80461	2.588367	4.256148	6.153188	14.34671	11.70816	8.530242	5.219633	8.987044	41.47376	35.74885	1.814354
Total	0.01932	4.0447	38.21544	22.76689	38.86582	15.67368	28.29962	35.98533	3.660516	5.706981	9.140762	19.94381	13.76125	19.19555	6.386641	10.31658	45.9661	40.1668	3.98814
NH4 (mg/l)																			
15C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	0.000426	0.063382	0.573574	0.025215	0.066303	0.020907	0.023539	0.017662	0.012767	0.009088	0.00876	0.014633	0.008037	0.188772	0.004727	0.002713	0.013241	0.006476	0.005896
10-20mm	0	0.025924	0.230445	0.075953	0.220758	0.087831	0.107473	0.19162	0.012794	0.026963	0.067256	0.128098	0.043843	0.05447	0.024734	0.031328	0.101051	0.107093	0.0495
>20mm	0	0.004045	0.078875	0.445735	0.652128	0.270395	0.550507	0.662838	0.061704	0.101463	0.146687	0.342014	0.279113	0.203354	0.124432	0.214244	0.9887	0.852223	0.043253
Total	0.000426	0.093351	0.882894	0.546902	0.939189	0.379133	0.681519	0.87212	0.087266	0.137515	0.222703	0.484745	0.330992	0.446596	0.153892	0.248284	1.102991	0.965791	0.098648
20C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	0.00035	0.052056	0.47108	0.020709	0.054455	0.017171	0.019333	0.014506	0.010486	0.007464	0.007195	0.012018	0.0066	0.155039	0.003882	0.002228	0.010875	0.005318	0.004842
10-20mm	0	0.01218	0.108274	0.035686	0.103723	0.041267	0.050496	0.090032	0.006011	0.012669	0.0316	0.060187	0.020599	0.025593	0.011621	0.014719	0.047479	0.050317	0.023257
>20mm	0	0.004036	0.078697	0.444731	0.650659	0.269786	0.549267	0.661345	0.061566	0.101234	0.146356	0.341243	0.278484	0.202896	0.124151	0.213761	0.986473	0.850303	0.043155
Total	0.00035	0.068273	0.658051	0.501126	0.808837	0.328224	0.619096	0.765883	0.078063	0.121368	0.185151	0.413448	0.305684	0.383528	0.139655	0.230708	1.044826	0.905939	0.071255
24C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	0.001379	0.205329	1.858114	0.081684	0.21479	0.06773	0.076257	0.057216	0.04136	0.029442	0.02838	0.047405	0.026035	0.611532	0.015312	0.008788	0.042894	0.020978	0.0191
10-20mm	0	0.104391	0.92795	0.305844	0.888945	0.353677	0.432771	0.771609	0.051519	0.108575	0.270824	0.515821	0.176544	0.21934	0.099598	0.126151	0.406909	0.431238	0.199324
>20mm	0	0.003942	0.076858	0.434338	0.635454	0.263481	0.536431	0.64589	0.060127	0.098869	0.142936	0.333269	0.271976	0.198154	0.12125	0.208766	0.963419	0.830432	0.042147
Total	0.001379	0.313661	2.862921	0.821866	1.739189	0.684888	1.045458	1.474715	0.153005	0.236887	0.44214	0.896495	0.474555	1.029026	0.23616	0.343704	1.413222	1.282648	0.260571
***Chlorella* (ppm)**																			
15C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	58.56301	8719.72	78908.81	3468.877	9121.534	2876.285	3238.399	2429.796	1756.44	1250.334	1205.207	2013.149	1105.621	25970.04	650.2509	373.1957	1821.598	890.8653	811.1251
10-20mm	0	891.4344	7924.123	2611.724	7591.042	3020.185	3695.597	6589.069	439.9379	927.1677	2312.671	4404.798	1507.58	1873.029	850.5075	1077.248	3474.751	3682.508	1702.102
>20mm	0	80.24488	1564.683	8842.309	12936.65	5363.978	10920.73	13149.12	1224.068	2012.781	2909.913	6784.724	5536.922	4034.049	2468.424	4250.076	19613.41	16906.04	858.0285
Total	58.56301	9691.399	88397.62	14922.91	29649.22	11260.45	17854.72	22167.98	3420.446	4190.283	6427.791	13202.67	8150.122	31877.12	3969.182	5700.519	24909.76	21479.41	3371.256
20C	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
<10mm	229.1358	34117.09	308741.5	13572.46	35689.25	11253.86	12670.68	9506.908	6872.312	4892.104	4715.536	7876.72	4325.892	101611.3	2544.196	1460.179	7127.251	3485.632	3173.638
10-20mm	0	2670.57	23739.19	7824.235	22741.34	9047.908	11071.32	19739.62	1317.971	2777.621	6928.329	13195.95	4516.426	5611.243	2547.961	3227.234	10409.7	11032.1	5099.18
>20mm	0	136.0927	2653.651	14996.26	21940.13	9097.13	18521.19	22300.47	2075.979	3413.61	4935.116	11506.67	9390.437	6841.614	4186.366	7207.988	33263.7	28672.08	1455.188
Total	229.1358	36923.76	335134.3	36392.95	80370.71	29398.89	42263.18	51546.99	10266.26	11083.34	16578.98	32579.34	18232.75	114064.2	9278.522	11895.4	50800.66	43189.82	9728.006

APPENDIX A

Raw data for Onondaga zebra mussel dissolved oxygen consumption study

Raw data for Onondaga zebra mussel ammonia excretion study

Raw data for Onondaga zebra mussel *Chlorella* clearance rate study

Appendix A-1. Raw data for Onondaga zebra mussel dissolved oxygen consumption study

MUSSEL	TEST TEMP	MUSSEL SIZE	DO BLANK START	DO BANK END	TIME TESTED(HRS)	MUSSEL DO	BLANK DO DEMAND	MUSSEL DEMAND/HR	# MUSSELS	DEMAND/MUSSEL Original	DEMAND/MUSSEL DOppm/mussel*hr
1	28	20+	8.05	7.707	15.5	6.21	0.343	0.096580645	1	0.096580645	0.029003197
2	28	20+	8.05	7.707	15.5	6.158	0.343	0.099935484	1	0.099935484	0.030010656
3	28	20+	8.05	7.707	15.5	6.483	0.343	0.078967742	1	0.078967742	0.023714037
4	28	20+	8.05	7.707	15.5	2.615	0.343	0.328516129	1	0.328516129	0.098653492
5	28	20+	8.05	7.707	15.5	2.598	0.343	0.329612903	1	0.329612903	0.098982854
6	28	20+	8.05	7.707	15.5	2.96	0.343	0.306258065	2	0.153129032	0.045984694
7	28	20+	8.05	7.707	15.5	4.862	0.343	0.183548387	1	0.183548387	0.055119636
8	28	20+	8.05	7.707	15.5	3.871	0.343	0.247483871	2	0.123741935	0.03715974
9	28	20+	8.05	7.707	15.5	7.14	0.343	0.036580645	1	0.036580645	0.010985179
10	28	20+	8.05	7.707	15.5	3.586	0.343	0.265870968	2	0.132935484	0.039920586
1	28	10 TO 20	8.05	7.707	16	7.103	0.343	0.03775	1	0.03775	0.011336336
3	28	10 TO 20	8.05	7.707	16	6.801	0.343	0.069125	1	0.069125	0.020758258
4	28	10 TO 20	8.05	7.707	16	6.405	0.343	0.081375	2	0.0406875	0.012218468
5	28	10 TO 20	8.05	7.707	16	7.499	0.343	0.013	1	0.013	0.003903904
6	28	10 TO 20	8.05	7.707	16	7.357	0.343	0.021875	1	0.021875	0.006569069
7	28	10 TO 20	8.05	7.707	16	7.23	0.343	0.0298125	1	0.0298125	0.008952703
8	28	10 TO 20	8.05	7.707	16	6.995	0.343	0.0445	1	0.0445	0.013363363
10	28	10 TO 20	8.05	7.707	16	7.328	0.343	0.0238125	1	0.0238125	0.007150901

↑ ÷ ↑ ≈3.33

Appendix A-1. Continued

MUSSEL	TEST TEMP	MUSSEL SIZE	DO BLANK START	DO BANK END	TIME TESTED(HRS)	MUSSEL DO	BLANK DO DEMAND	MUSSEL DEMAND/HR	# MUSSELS	DEMAND/MUSSEL Original	DEMAND/MUSSEL DOppm/mussel*hr
1	24	20+	8.622	8.309	20.67	6.091	0.313	0.107305273	2	0.053652637	0.016111903
2	24	20+	8.622	8.309	20.67	4.636	0.313	0.167924528	2	0.083962264	0.025213893
3	24	20+	8.622	8.309	20.67	4.672	0.313	0.175955491	1	0.175955491	0.052839487
4	24	20+	8.622	8.309	20.67	6.176	0.313	0.103193033	1	0.103193033	0.030988899
5	24	20+	8.622	8.309	20.67	5.737	0.313	0.124431543	2	0.062215772	0.018683415
6	24	20+	8.622	8.309	20.67	5.349	0.313	0.143202709	2	0.071601355	0.021501908
7	24	20+	8.622	8.309	20.67	4.887	0.313	0.165553943	2	0.082776971	0.024857949
8	24	20+	8.622	8.309	20.67	5.788	0.313	0.121964199	2	0.0609821	0.018312943
9	24	20+	8.622	8.309	20.67	6.069	0.313	0.108369618	2	0.054184809	0.016271714
10	24	20+	8.622	8.309	20.67	4.419	0.313	0.188195452	2	0.094097726	0.028257575
1	24	10 TO 20	8.622	8.309	22	7.715	0.313	0.027	1	0.027	0.008108108
3	24	10 TO 20	8.622	8.309	22	7.426	0.313	0.040136364	2	0.020068182	0.006026481
4	24	10 TO 20	8.622	8.309	22	7.68	0.313	0.028590909	1	0.028590909	0.008585859
5	24	10 TO 20	8.622	8.309	22	7.527	0.313	0.035545455	1	0.035545455	0.010674311
6	24	10 TO 20	8.622	8.309	22	7.103	0.313	0.054818182	2	0.027409091	0.008230958
7	24	10 TO 20	8.622	8.309	22	7.644	0.313	0.030227273	1	0.030227273	0.009077259
8	24	10 TO 20	8.622	8.309	22	7.581	0.313	0.033090909	1	0.033090909	0.00993721
10	24	10 TO 20	8.622	8.309	22	6.929	0.313	0.062727273	2	0.031363636	0.009418509
	24	10-	8.622	8.309	21.67	8.104	0.313	0.009460083		0.009460083	0.002840866
	24	10-	8.622	8.309	21.67	8.127	0.313	0.008396708		0.008396708	0.002522135
	24	10-	8.622	8.309	21.67	8.202	0.313	0.004937702		0.004937702	0.001482793
	24	10-	8.622	8.309	21.67	8.168	0.313	0.006506691		0.006506691	0.001953981

Appendix A-1. Continued

MUSSEL	TEST TEMP	MUSSEL SIZE	DO BLANK START	DO BANK END	TIME TESTED(HRS)	MUSSEL DO	BLANK DO DEMAND	MUSSEL DEMAND/HR	# MUSSELS	DEMAND/MUSSEL Original	DEMAND/MUSSEL DOppm/mussel*hr
1	20	20+	9.168	9.015	6.67	6.733	0.153	0.342128936	1	0.342128936	0.102741422
2	20	20+	9.168	9.015	6.67	7.979	0.153	0.155322339	2	0.077661169	0.023321672
3	20	20+	9.168	9.015	6.67	7.221	0.153	0.268965517	2	0.134482759	0.040385213
4	20	20+	9.168	9.015	6.67	7.48	0.153	0.230134933	2	0.115067466	0.034554795
5	20	20+	9.168	9.015	6.67	7.017	0.153	0.299550225	2	0.149775112	0.044977511
6	20	20+	9.168	9.015	6.67	7.749	0.153	0.189805097	2	0.094902549	0.028499264
7	20	20+	9.168	9.015	6.67	7.566	0.153	0.217241379	2	0.10862069	0.032618826
8	20	20+	9.168	9.015	6.67	7.473	0.153	0.231184406	2	0.115592204	0.034712374
9	20	20+	9.168	9.015	6.67	8.141	0.153	0.131034483	2	0.065517241	0.019674847
10	20	20+	9.168	9.015	6.67	7.548	0.153	0.21994003	2	0.109970015	0.033024029
1	20	10 TO 20	9.168	8.862	23.33	7.522	0.306	0.057436777	2	0.028718388	0.008624141
2	20	10 TO 20	9.168	8.862	23.33	8.584	0.306	0.09764252	1	0.09764252	0.029322078
3	20	10 TO 20	9.168	8.862	23.33	7.553	0.306	0.056108015	2	0.028054008	0.008424627
4	20	10 TO 20	9.168	8.862	23.33	7.1	0.306	0.075525075	2	0.037762538	0.011340101
5	20	10 TO 20	9.168	8.862	23.33	7.066	0.306	0.076982426	2	0.038491213	0.011558923
6	20	10 TO 20	9.168	8.862	23.33	7.609	0.306	0.053707673	2	0.026853836	0.008064215
7	20	10 TO 20	9.168	8.862	23.33	7.335	0.306	0.065452207	2	0.032726104	0.009827859
8	20	10 TO 20	9.168	8.862	23.33	7.816	0.306	0.04474925	1	0.04474925	0.013436213
9	20	10 TO 20	9.168	8.862	23.33	7.654	0.306	0.051778826	2	0.025889413	0.007774598
10	20	10 TO 20	9.168	8.862	23.33	8.116	0.306	0.031975997	2	0.015987998	0.004801201
1	20	10-	9.168	8.862	24	8.337	0.306	0.021875		0.0109375	0.003284535
2	20	10-	9.168	8.862	24	8.31	0.306	0.023		0.0115	0.003453453
3	20	10-	9.168	8.862	24	8.459	0.306	0.016791667		0.008395833	0.002521271
4	20	10-	9.168	8.862	24	8.457	0.306	0.016875		0.0084375	0.002533784
5	20	10-	9.168	8.862	24	8.569	0.306	0.012208333		0.012208333	0.003666166
6	20	10-	9.168	8.862	24	8.515	0.306	0.014458333		0.007229167	0.002170921
7	20	10-	9.168	8.862	24	8.119	0.306	0.030958333		0.030958333	0.009296797
8	20	10-	9.168	8.862	24	8.601	0.306	0.010875		0.0054375	0.001632883
9	20	10-	9.168	8.862	24	8.099	0.306	0.031791667		0.031791667	0.009547047
10	20	10-	9.168	8.862	24	8.17	0.306	0.028833333		0.014416667	0.004329329

Appendix A-1. Continued

MUSSEL	TEST TEMP	MUSSEL SIZE	DO BLANK START	DO BANK END	TIME TESTED(HRS)	MUSSEL DO	BLANK DO DEMAND	MUSSEL DEMAND/HR	# MUSSELS	DEMAND/MUSSEL Original	DEMAND/MUSSEL DOppm/mussel*hr
1	15	20+	9.709	9.453	24.5	6.584	0.256	0.117102041	2	0.05855102	0.017582889
2	15	20+	9.709	9.453	24.5	8.166	0.256	0.052530612	2	0.026265306	0.007887479
3	15	20+	9.709	9.453	24.5	7.39	0.256	0.084204082	2	0.042102041	0.012643256
4	15	20+	9.709	9.453	24.5	6.349	0.256	0.126693878	2	0.063346939	0.019023105
5	15	20+	9.709	9.453	24.5	7.465	0.256	0.081142857	2	0.040571429	0.012183612
6	15	20+	9.709	9.453	24.5	5.599	0.256	0.157306122	2	0.078653061	0.023619538
7	15	20+	9.709	9.453	24.5	7.649	0.256	0.073632653	2	0.036816327	0.011055954
8	15	20+	9.709	9.453	24.5	5.156	0.256	0.175387755	2	0.087693878	0.026334498
9	15	20+	9.709	9.453	24.5	6.04	0.256	0.139306122	2	0.069653061	0.020916835
10	15	20+	9.709	9.453	24.5	7.6	0.256	0.075632653	2	0.037816327	0.011356254
1	15	10 TO 20	9.709	9.453	24.67	8.895	0.256	0.022618565	2	0.011309283	0.003396181
2	15	10 TO 20	9.709	9.453	24.67	7.62	0.256	0.07430077	2	0.037150385	0.011156272
3	15	10 TO 20	9.709	9.453	24.67	8.971	0.256	0.0195379	2	0.00976895	0.002933619
4	15	10 TO 20	9.709	9.453	24.67	9.011	0.256	0.017916498	2	0.008958249	0.002690165
5	15	10 TO 20	9.709	9.453	24.67	9.03	0.256	0.017146332	2	0.008573166	0.002574524
6	15	10 TO 20	9.709	9.453	24.67	8.812	0.256	0.025982975	2	0.012991488	0.003901348
7	15	10 TO 20	9.709	9.453	24.67	8.4	0.256	0.042683421	2	0.021341711	0.006408922
8	15	10 TO 20	9.709	9.453	24.67	8.582	0.256	0.03530604	2	0.01765302	0.005301207
9	15	10 TO 20	9.709	9.453	24.67	8.552	0.256	0.036522092	2	0.018261046	0.005483798
10	15	10 TO 20	9.709	9.453	24.67	8.807	0.256	0.026185651	2	0.013092825	0.003931779
1	15	10-	9.709	9.453	25	9.206	0.256	0.00988		0.00494	0.001483483
2	15	10-	9.709	9.453	25	9.03	0.256	0.01692		0.00846	0.002540541
3	15	10-	9.709	9.453	25	9.072	0.256	0.01524		0.00762	0.002288288
4	15	10-	9.709	9.453	25	9.194	0.256	0.01036		0.00518	0.001555556
5	15	10-	9.709	9.453	25	9.179	0.256	0.01096		0.00548	0.001645646
6	15	10-	9.709	9.453	25	9.272	0.256	0.00724		0.00362	0.001087087
7	15	10-	9.709	9.453	25	9.054	0.256	0.01596		0.00798	0.002396396
8	15	10-	9.709	9.453	25	9.25	0.256	0.00812		0.00812	0.002438438
9	15	10-	9.709	9.453	25	9.153	0.256	0.012		0.006	0.001801802
10	15	10-	9.709	9.453	25	9.018	0.256	0.0174		0.0087	0.002612613

Appendix A-2. Raw data for Onondaga zebra mussel ammonia excretion study

MUSSEL	TEMP.	SIZE RANGE	MEAN NH4 BLANK	NH4 MUSSEL	START TIME	END TIME	HOURS TESTED	# MUSSELS	NH4 /HOUR Original	NH4ppm/mussel*hr
1	15	10MM-	0.015	0.13	712	1516	8.03	2		
2	15	10MM-	0.015	0.11	712	1518	8.1	2		
3	15	10MM-	0.015	0.0966	712	1519	8.1	2		
4	15	10MM-	0.015	0.1	712	1520	8.1	2		
5	15	10MM-	0.015	0.0901	712	1525	8.17	2		
6	15	10MM-	0.015	0.0863	712	1527	8.25	2		
7	15	10MM-	0.015	0.0815	712	1529	8.28	2		
8	15	10MM-	0.015	0.0685	712	1532	8.33	1		
9	15	10MM-	0.015	0.0685	712	1533	8.33	2		
10	15	10MM-	0.015	0.0585	712	1535	8.38	2		
1	15	10MM+ TO 20MM	0.015	0.268	717	1539	8.37	2	0.015113501	0.000151135
2	15	10MM+ TO 20MM	0.015	1.09	717	1541	8.4	2	0.063988095	0.000639881
3	15	10MM+ TO 20MM	0.015	0.721	717	1543	8.43	2	0.041874259	0.000418743
4	15	10MM+ TO 20MM	0.015	0.263	717	1545	8.47	2	0.014639906	0.000146399
5	15	10MM+ TO 20MM	0.015	0.478	717	1548	8.52	2	0.027171362	0.000271714
6	15	10MM+ TO 20MM	0.015	0.107	717	1549	8.53	2	0.005392732	5.39273E-05
7	15	10MM+ TO 20MM	0.015	0.204	717	1551	8.57	2	0.011026838	0.000110268
8	15	10MM+ TO 20MM	0.015	0.375	717	1554	8.62	2	0.020881671	0.000208817
9	15	10MM+ TO 20MM	0.015	0.162	717	1602	8.75	2	0.0084	0.000084
10	15	10MM+ TO 20MM	0.015	0.348	717	1605	8.8	2	0.018920455	0.000189205
1	15	20MM+	0.015	0.771	708	1452	7.73	2	0.048900388	0.000489004
2	15	20MM+	0.015	0.967	708	1454	7.76	2	0.061340206	0.000613402
3	15	20MM+	0.015	0.868	708	1456	7.8	2	0.054679487	0.000546795
4	15	20MM+	0.015	0.535	708	1458	7.83	2	0.033205619	0.000332056
5	15	20MM+	0.015	0.793	708	1501	7.88	2	0.049365482	0.000493655
6	15	20MM+	0.015	1.24	708	1503	7.92	2	0.077335859	0.000773359
7	15	20MM+	0.015	0.789	708	1505	7.95	2	0.048679245	0.000486792
8	15	20MM+	0.015	1.83	708	1508	8	2	0.1134375	0.001134375
9	15	20MM+	0.015	1.12	708	1509	8.02	2	0.068890274	0.000688903
10	15	20MM+	0.015	0.778	708	1511	8.05	2	0.047391304	0.000473913

↑

$\frac{mg\ NH_4}{mussel \cdot hr}$

cause corrected for 10ml vial

Appendix A-2. Continued

MUSSEL	TEMP.	SIZE RANGE	MEAN NH4 BLANK	NH4 MUSSEL	START TIME	END TIME	HOURS TESTED	# MUSSELS	NH4 /HOUR	NH4ppm/mussel*hr
	20	10MM-	0.016	0.0465	903	1211	3.13	2	0.004872204	4.8722E-05
2	20	10MM-	0.016	0.0464	903	1215	3.2	2	0.00475	0.0000475
3	20	10MM-	0.016	0.0292	903	1217	3.24		0.004074074	4.07407E-05
4	20	10MM-	0.016	0.0345	903	1221	3.3	2	0.00280303	2.80303E-05
5	20	10MM-	0.016	0.0322	903	1225	3.36	1	0.004821429	4.82143E-05
7	20	10MM-	0.016	0.0242	903	1230	3.45	1	0.002376812	2.37681E-05
8	20	10MM-	0.016	0.0505	903	1232	3.48	2	0.004956897	4.9569E-05
9	20	10MM-	0.016	0.0274	903	1237	3.57	1	0.003193277	3.19328E-05
1	20	10MM+ TO 20MM	0.016	0.0476	858	1248	3.83		0.008250653	8.25065E-05
2	20	10MM+ TO 20MM	0.016	0.0324	858	1250	3.87		0.004237726	4.23773E-05
3	20	10MM+ TO 20MM	0.016	0.154	858	1251	3.88	2	0.017783505	0.000177835
4	20	10MM+ TO 20MM	0.016	0.0877	858	1254	3.93	2	0.009122137	9.12214E-05
5	20	10MM+ TO 20MM	0.016	0.16	858	1257	3.98	2	0.018090452	0.000180905
6	20	10MM+ TO 20MM	0.016	0.248	858	1300	4.03	2	0.028784119	0.000287841
7	20	10MM+ TO 20MM	0.016	0.0627	858	1304	4.1	2	0.005695122	5.69512E-05
8	20	10MM+ TO 20MM	0.016	0.0396	858	1310	4.2	1	0.005619048	5.61905E-05
9	20	10MM+ TO 20MM	0.016	0.0757	858	1313	4.25	2	0.007023529	7.02353E-05
10	20	10MM+ TO 20MM	0.016	0.0355	858	1319	4.35	2	0.002241379	2.24138E-05
1	20	20MM+	0.016	0.168	853	1139	2.77	1	0.054873646	0.000548736
2	20	20MM+	0.016	0.279	853	1144	2.85	2	0.046140351	0.000461404
3	20	20MM+	0.016	0.442	853	1146	2.88	2	0.073958333	0.000739583
4	20	20MM+	0.016	0.166	853	1150	2.95	1	0.050847458	0.000508475
5	20	20MM+	0.016	0.483	853	1152	2.98	1	0.156711409	0.001567114
6	20	20MM+	0.016	0.192	853	1155	3.03	2	0.029042904	0.000290429
7	20	20MM+	0.016	0.244	853	1200	3.12	2	0.036538462	0.000365385
8	20	20MM+	0.016	0.38	853	1202	3.15	2	0.057777778	0.000577778
9	20	20MM+	0.016	0.35	853	1205	3.2	2	0.0521875	0.000521875
10	20	20MM+	0.016	0.298	853	1206	3.22	2	0.04378882	0.000437888

Appendix A-2. Continued

MUSSEL	TEMP.	SIZE RANGE	MEAN NH4 BLANK	NH4 MUSSEL	START TIME	END TIME	HOURS TESTED	# MUSSELS	NH4 /HOUR Original	NH4ppm/mussel*hr
2	24	10MM-	0.0147	0.058	1028	1359	3.52	1	0.012301136	0.000123011
7	24	10MM-	0.0147	0.0829	1028	1402	3.57	1	0.019103641	0.000191036
2	24	10MM+ TO 20MM	0.0147	0.212	1032	1321	2.82		0.069964539	0.000699645
3	24	10MM+ TO 20MM	0.0147	3.15	1032	1331	2.98	1	1.052114094	0.010521141
4	24	10MM+ TO 20MM	0.0147	0.278	1032	1334	3.03	1	0.08689769	0.000868977
5	24	10MM+ TO 20MM	0.0147	0.125	1032	1337	3.08		0.035811688	0.000358117
6	24	10MM+ TO 20MM	0.0147	0.284	1032	1340	3.13	1	0.086038339	0.000860383
7	24	10MM+ TO 20MM	0.0147	0.241	1032	1343	3.18	1	0.071163522	0.000711635
8	24	10MM+ TO 20MM	0.0147	0.164	1032	1346	3.23	1	0.04622291	0.000462229
10	24	10MM+ TO 20MM	0.0147	0.818	1032	1349	3.28		0.244908537	0.002449085
1	24	20MM+	0.0147	0.444	1036	1406	3.5	1	0.122657143	0.001226571
2	24	20MM+	0.0147	0.477	1036	1409	3.55	1	0.130225352	0.001302254
3	24	20MM+	0.0147	0.304	1036	1411	3.58	1	0.080810056	0.000808101
4	24	20MM+	0.0147	0.208	1036	1415	3.65	1	0.052958904	0.000529589
5	24	20MM+	0.0147	0.175	1036	1417	3.68	2	0.021779891	0.000217799
6	24	20MM+	0.0147	0.304	1036	1420	3.73	2	0.038780161	0.000387802
7	24	20MM+	0.0147	0.223	1036	1423	3.78	2	0.02755291	0.000275529
8	24	20MM+	0.0147	0.386	1036	1426	3.83	2	0.048472585	0.000484726
9	24	20MM+	0.0147	0.402	1036	1428	3.87	2	0.05003876	0.000500388
10	24	20MM+	0.0147	0.128	1036	1430	3.9	2	0.014525641	0.000145256

Appendix A-2. Continued

MUSSEL	TEMP.	SIZE RANGE	MEAN NH4 BLANK	NH4 MUSSEL	START TIME	END TIME	HOURS TESTED	# MUSSELS	NH4 /HOUR Original	NH4ppm/mussel*hr
2	28	20MM+	0.0094	0.1	905	1151	2.77	2	0.016353791	0.000163538
4	28	20MM+	0.0094	0.163	905	1158	2.88	2	0.026666667	0.000266667
5	28	20MM+	0.0094	0.116	905	1213	3.13	2	0.017028754	0.000170288
7	28	20MM+	0.0094	0.0825	905	1203	2.97	2	0.012306397	0.000123064

Appendix A-3. Raw data for Onondaga zebra mussel *Chlorella* clearance rate study

<=10mm@15C	%abs@1.5 hrs	mg/l	mg/l consumed	mg/l consmd/mussel		%abs@45min	mg/l	mg/l consumed	mg/l consmd/mussel	mg/l cleared/hr/mussel
S-1*	0.1525	54.53103615	12.79396385	6.396981926	4.264654618	0.13	46.48383	20.84117415	10.42058708	6.947058051
S-2a	0.13	46.48382585	20.84117415	20.84117415	13.8941161	0.1425	50.9545	16.37050176	16.37050176	10.91366784
S-2b	0.135	48.2720948	19.0529052	19.0529052	12.7019368	0.15	53.6369	13.68809833	13.68809833	9.125398887
S-3										
S-4	0.1725	61.68411197	5.64088803	5.64088803	3.76059202					
S-5	0.165	59.00170854	8.323291464	8.323291464	5.548860976					
S-6	0.1675	59.89584301	7.429156986	7.429156986	4.952771324					
S-7*	0.165	59.00170854	8.323291464	4.161645732	2.774430488					
S-8a	0.18	64.3665154	2.958484597	2.958484597	1.972323064					
S-8b	0.1775	63.47238093	3.852619074	3.852619074	2.568412716					
S-9a	0.14	50.06036376	17.26463624	17.26463624	11.50975749	0.1225	43.80142	23.52357759	23.52357759	15.68238506
S-9b	0.1525	54.53103615	12.79396385	12.79396385	8.529309235	0.17	60.78998	6.535022508	6.535022508	4.356681672
S-10*	0.125	44.69555689	22.62944311	11.31472155	7.543147703	0.135	48.27209	19.0529052	9.526452599	6.350968399
>10<=20mm@15C										
M1a	0.16	57.21343958	10.11156042	10.11156042	6.741040279					
M1b	0.14	50.06036376	17.26463624	17.26463624	11.50975749	0.17	60.78998	6.535022508	6.535022508	4.356681672
M2a	0.145	51.84863271	15.47636729	15.47636729	10.31757819	0.14	50.06036	17.26463624	17.26463624	11.50975749
M2b	0.14	50.06036376	17.26463624	17.26463624	11.50975749	0.1275	45.58969	21.73530863	21.73530863	14.49020575
M3a	0.14	50.06036376	17.26463624	17.26463624	11.50975749	0.1475	52.74277	14.58223281	14.58223281	9.721488539
M3b	0.15	53.63690167	13.68809833	13.68809833	9.125398887	0.125	44.69556	22.62944311	22.62944311	15.08629541
M4a	0.15	53.63690167	13.68809833	13.68809833	9.125398887	0.14	50.06036	17.26463624	17.26463624	11.50975749
M4b	0.145	51.84863271	15.47636729	15.47636729	10.31757819	0.15	53.6369	13.68809833	13.68809833	9.125398887
M5a	0.18	64.3665154	2.958484597	2.958484597	1.972323064					
M5b	0.1475	52.74276719	14.58223281	14.58223281	9.721488539	0.125	44.69556	22.62944311	22.62944311	15.08629541
M6	0.185	66.15478436	1.170215641	1.170215641	0.780143761					
M7a	0.19	67.94305331	-0.618053315	-0.618053315	-0.412035543					
M7b	0.19	67.94305331	-0.618053315	-0.618053315	-0.412035543					
M8a	0.075	26.81266733	40.51213267	40.51213267	27.00808844	0.1375	49.16623	18.15877072	18.15877072	12.10584715
M8b	0.16	57.21343958	10.11156042	10.11156042	6.741040279					
M9a	0.185	66.15478436	1.170215641	1.170215641	0.780143761					
M9b	0.16	57.21343958	10.11156042	10.11156042	6.741040279					
M10a	0.175	62.57824645	4.746753552	4.746753552	3.164502368					
M10b	0.14	50.06036376	17.26463624	17.26463624	11.50975749	0.1375	49.16623	18.15877072	18.15877072	12.10584715

* = measurements including two mussels

Appendix A-3. Continued

>20mm@15C	%abs@1.5 hrs	mg/l	mg/l consumed	mg/l consmd/mussel	mg/cleared/hr/mussel	%abs@45min	mg/l	mg/l consumed	mg/l consmd/mussel	mg/cleared/hr/mussel
L1*	0.1275	45.58969137	21.73530863	10.86765432	7.245102877	0.1325	47.37796	19.94703968	9.973519838	6.649013225
L2a	0.1175	42.01315346	25.31184654	25.31184654	16.87456436	0.105	37.54248	29.78251893	29.78251893	19.85501262
L2b	0.1275	45.58969137	21.73530863	21.73530863	14.49020575	0.11	39.33075	27.99424998	27.99424998	18.66283332
L3*	0.135	48.2720948	19.0529052	9.526452599	6.350968399	0.125	44.69556	22.62944311	11.31472155	7.543147703
L4a	0.135	48.2720948	19.0529052	19.0529052	12.7019368	0.14	50.06036	17.26463624	17.26463624	11.50975749
L4b	0.1225	43.80142241	23.52357759	23.52357759	15.68238506	0.135	48.27209	19.0529052	19.0529052	12.7019368
L5*	0.1125	40.2248845	27.1001155	13.55005775	9.033371833	0.1175	42.01315	25.31184654	12.65592327	8.437282181
L6a	0.135	48.2720948	19.0529052	19.0529052	12.7019368	0.1175	42.01315	25.31184654	25.31184654	16.87456436
L6b	0.135	48.2720948	19.0529052	19.0529052	12.7019368	0.125	44.69556	22.62944311	22.62944311	15.08629541
L7a	0.1275	45.58969137	21.73530863	21.73530863	14.49020575	0.1225	43.80142	23.52357759	23.52357759	15.68238506
L7b	0.125	44.69555689	22.62944311	22.62944311	15.08629541	0.1125	40.22488	27.1001155	27.1001155	18.06674367
L8*	0.125	44.69555689	22.62944311	11.31472155	7.543147703	0.1225	43.80142	23.52357759	11.76178879	7.841192529
L9*	0.095	33.96594316	33.35905684	16.67952842	11.11968561	0.125	44.69556	22.62944311	11.31472155	7.543147703
L10	0.14	50.06036376	17.26463624	17.26463624	11.50975749	0.12	42.90729	24.41771206	24.41771206	16.27847471
<=10mm@20C										
S9	0.0925	28.18869967	39.13630033	39.13630033	26.09086689		50.06036	17.26463624	17.26463624	11.50975749
>10<=20mm@20C										
M1	0.105	31.99503341	35.32996659	35.32996659	23.55331106	0.135	48.27209	19.0529052	19.0529052	12.7019368
M5	0.11	33.51756691	33.80743309	33.80743309	22.53828873	0.12	42.90729	24.41771206	24.41771206	16.27847471
M7a	0.0925	28.18869967	39.13630033	39.13630033	26.09086689	0.125	44.69556	22.62944311	22.62944311	15.08629541
M7b	0.115	35.0401004	32.2848996	32.2848996	21.5232664	0.1525	54.53104	12.79396385	12.79396385	8.529309235
>20mm@20C										
L2a	0.12	36.5626339	30.7623661	30.7623661	20.50824407	0.135	48.27209	19.0529052	19.0529052	12.7019368
L2b	0.11	33.51756691	33.80743309	33.80743309	22.53828873	0.1475	52.74277	14.58223281	14.58223281	9.721488539
L3*	0.085	25.90489943	41.42010057	20.71005029	13.80670019	0.12	42.90729	24.41771206	12.20885603	8.139237355
L5a	0.1375	41.89150113	25.43349887	25.43349887	16.95566591	0.15	53.6369	13.68809833	13.68809833	9.125398887
L5b	0.135	41.13023438	26.19476562	26.19476562	17.46317708	0.15	53.6369	13.68809833	13.68809833	9.125398887
L6	0.0975	29.71123317	37.61376683	37.61376683	25.07584456	0.14	50.06036	17.26463624	17.26463624	11.50975749
L7	0.125	38.08516739	29.23983261	29.23983261	19.49322174	0.155	55.42517	11.89982937	11.89982937	7.933219583
L8	0.0825	25.14363268	42.18136732	42.18136732	28.12091155	0.1375	49.16623	18.15877072	18.15877072	12.10584715
L9	0.145	44.17530138	23.14969862	23.14969862	15.43313242	0.14	50.06036	17.26463624	17.26463624	11.50975749
L10	0.105	31.99503341	35.32996659	35.32996659	23.55331106	0.145	51.84863	15.47636729	15.47636729	10.31757819
>20mm@24C										
L3	0.1275	38.84643414	28.47856586	28.47856586	18.98571057			13.68809833	13.68809833	9.125398887
L5	0.0925	28.18869967	39.13630033	39.13630033	26.09086689			20.84117415	20.84117415	13.8941161
L10	0.095	28.94996642	36.37503358	36.37503358	25.58335572			17.26463624	17.26463624	11.50975749

* = measurements including two mussels