Observations on the Biology of the Spinycheek Crayfish *Orconectes limosus* Associated with Water Chestnut in the Tidal Hudson River

A Final Report of the Tibor T. Polgar Fellowship Program

by

Michael Bednarski
SUNY ESF
Syracuse, NY 13210

Karin Limburg
SUNY ESF

and

Robert E. Schmidt
Simon's Rock College of Bard
Great Barrington, MA 01230

Bednarski, M., K.E. Limburg, and R.E. Schmidt. 2005. Observations on the biology of the spinycheek crayfish *Orconectes limosus* associated with water chestnut in the tidal Hudson River. Section III: 19 pp. *In* J.R. Waldman & W.C. Nieder, editors. Final Reports of the Tibor T. Polgar Fellowship Program, 2004. Hudson River Foundation, New York, New York.

Abstract

The spinycheek crayfish *Orconectes limosus*, is the only species of crayfish regularly encountered in the tidal Hudson River, but rarely in large numbers. However, it has been found in high abundance in conjunction with water chestnut *Trapa natans*, in Tivoli South Bay of the Hudson River. No study has been conducted in the past on a tidal population of crayfish-this was the first of its kind. Crayfish were surveyed using 10 plastic minnow traps of 42-cm in length and entry holes enlarged to 10 cm. These traps were baited and placed in various locations in Tivoli South Bay and checked on intervals of 1-8 days over the time period June 6 to August 18, 2004. Crayfish carapace length was measured in millimeters with Vernier calipers and gender was determined. Crayfish were marked by clipping a small piece from the telson. Forty-nine crayfish were captured. Two size classes were identified and differential growth was observed between males and females, with females averaging larger in size. Seasonality was shown during the capture period for both the young-of-year size class and the older size class. Low capture of crayfish overall was explained by predation by basses *Micropterus* spp. and American eel *Anguilla rostrata*. American eel potentially had the greatest predatory impact on the spinycheek crayfish in Tivoli South Bay.

Table of Contents

List of Figures

INTRODUCTION

Water chestnut *Trapa natans*, an exotic Eurasian macrophyte, was introduced into the Hudson River drainage basin in 1879 (Caraco and Cole 2002) and now occupies 2% of the surface area of the tidal Hudson River and 6% of the habitable shallows (Nieder et al. *in press*). Water chestnut forms large mats, which have dramatic effects on the aquatic environment. The main transpiration structures of water chestnut float on the surface, and the water under these mats of floating leaves can become anoxic at times of ebb tide (Caraco and Cole 2002). Water chestnut also provides excellent cover for aquatic organisms, a potential food source for herbivorous animals, and is habitat for a variety of invertebrates (Strayer et al. 2003) that could be food resources for carnivores.

The spinycheek crayfish *Orconectes limosus*, occurs from the James River, Virginia to southern New England along the coastal plain and piedmont (Ortmann 1906, Smith 1981). It inhabits a wide variety of habitats as long as the water body is permanent (Ortmann 1906). It feeds omnivorously, and a congener *O. virilis* has been shown to grow most rapidly on a diet of fish, but was able to maintain itself on a strictly vegetative diet (Jones and Momot 1981). It has been widely introduced into Europe to help compensate for the loss of the noble crayfish *Astacus astacus* which was decimated by the fungal crayfish plague *Aphanomyces astaci*. *Orconectes limosus* has been shown to harbor a form of the plague not lethal to itself (Vey et al. 1981). In many areas of Europe, *O. limosus* is now considered a pest (Laurent 1988).

In New England, this species lays eggs from the period of April until early June (Smith 1981). It can live a maximum of three years, but generally lives to two years of age (Smith 1981). It prefers quiet water, with cover in the forms of stones and vegetation such as water celery, *Vallisineria americana* (Ortmann 1906). Its preference for calm, vegetated water with stones make Tivoli South Bay good habitat for this species, with vegetation such as water chestnut providing cover and a current barrier for this crayfish. Rock cover is also present in many areas of Tivoli South Bay, especially in the areas of the shoreline and the railroad causeway.

The spinycheek crayfish is the only crayfish species regularly found in the tidal Hudson River (R. Daniels, New York State Museum, *pers. comm.*). Naturalists have found it frequently, but rarely in large numbers. However, Frenzel and Limburg (2003) in doing work on waterscaping water chestnut in Tivoli South Bay, reported catching large numbers of this species while pop-netting for fish. These observations provided the impetus for this study.

The objective of this study was to learn about the basic biology of the spinycheek crayfish associated with the water chestnut beds present in Tivoli South Bay. To do so, size classes of *O. limosus*, as well as gender differences, seasonality, catch per unit effort, and possible sources of predation were investigated in Tivoli South Bay between June 6 and August 19, 2004.

METHODS

Study site

Tivoli South Bay is located on the east side of the Hudson River between Catskill and Kingston at River Kilometer 159 (RKm where RKm 0 is the Battery in Manhattan). It is separated from the main river by a railroad causeway which allows for tidal exchange through bridges with depths of approximately 3.5 m and widths of approximately 10 m. The largest unvegetated areas are located immediately adjacent to these bridges. These openings are fringed with a mixture of water chestnut, water celery, and Eurasian water-milfoil. Beyond these areas are large mudflats covered dominated by water chestnut. Channels run through these areas, and aside from these channels, the bay is extremely shallow, with only centimeters of water covering much of the bay at low tide. The bay is fed by the Saw Kill at the eastern end.

Field and Lab Procedure

The equipment used to capture crayfish for this study consisted of 10 plastic minnow traps 42-cm long with entrance holes enlarged to approximately 10 cm diameter to allow easy entry into the traps. Before July 11 traps were baited with chicken hearts, chicken gizzards, or fish before July 11. After July 11, wet dog food was used, and dog food in chunks was the most effective at staying in minnow traps. The traps were weighted with a brick and marked by the use of a float.

Traps had to be placed in locations that were not dewatered at low tide, thus substantially limiting our choices. Various locations were tried, and trap locations varied until June 30, when location was kept constant throughout the remainder of the study. Trap location was based on several factors: vegetative cover, depth, water movement and structure. The traps were based in the southernmost opening of the water chestnut in Tivoli South Bay and the middle opening in the chestnut (Figure 1). After June 30, one trap (1) was placed in an area near the railroad bridge separating Tivoli South Bay from

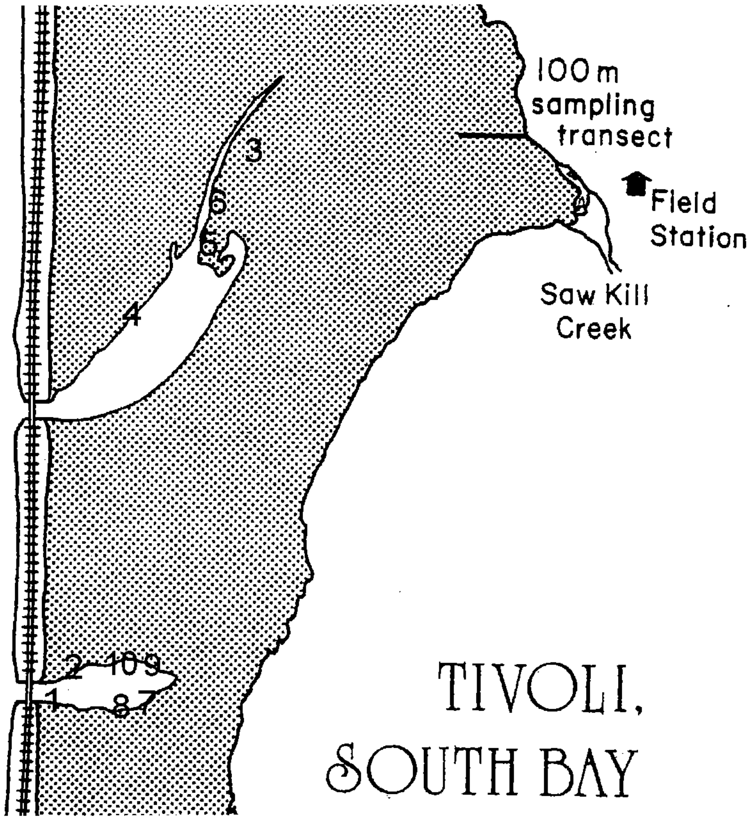

Figure 1. Map of study site (numbers denote trap, as mentioned in text).

main river, in close proximity to flowing water, with heavy water chestnut coverage and rip rap cover. Three traps (2, 4 and 5) were placed in similar areas in the south and middle openings of the bay consisting of strong tidal flow and a mixture of water chestnut, water celery, and Eurasian water-milfoil growth. Two traps (7 and 8) were placed in the southernmost opening in a similar plant that was connected to the main water chestnut bed by this vegetation. Two traps (9 and 10) were placed in similar conditions, with the submerged aquatic vegetation bed separated from the main water chestnut bed by openings in vegetation. A single trap (#3) was placed in an area of soft bottom, heavy water chestnut growth and weak tidal flow.

Traps were checked whenever possible, and rebaited every time they were retrieved. Intervals between trap checks varied between 1-8 days through the study.

Crayfish carapace length was measured using Vernier calipers and gender was determined by examining the first pleopods (Hobbs 2001).

Age-size classes were determined during the period of July 3 to August 3, in which 76% of the crayfish were captured. The crayfish were separated by gender and then graphed on a length frequency curve. The crayfish within the curve were used to calculate an average size for that particular size class.

A population estimate was extrapolated from the data by the use of the Schnabel multiple-recapture-algorithm, which relies on using permanent marks and then recording the numbers of organisms captured and marked at each sample period. Crayfish were marked by clipping a small piece of the telson off using scissors. This method of marking remains through several molts and poses little harm to the crayfish itself.

Seasonal trends were examined by looking at the capture rate compared to time. Crayfish were plotted on a catch-per-unit-effort (CPUE) basis. Two size classes (over 40 mm, under 20 mm carapace length) were graphed in this manner.

The use of *Orconectes limosus* as forage was examined during the course of the study by doing posthumous gut content analysis on 12 smallmouth bass *Micropterus dolomeiu* ranging in total length from 307 mm to 489 mm and one largemouth bass *Micropterus salmoides* of 406mm. The bass were obtained from the Northern Invitational Tournament conducted by the Bass Angler's Sportsmen Society out of Catskill, New York during August 12-13.

Data collected by Leonard Machut (SUNY ESF) in his study of the American eel in the tidal Hudson was used to determine the role of this predator. The data examined recorded the gut contents of 156 eels ranging in length from 63 to 699 mm collected from various tributaries of the Hudson River.

RESULTS

Capture rates of *Orconectes limosus* varied over time, with most (75.5%) individuals captured from July 3 to August 3. Over this period of time, we captured 38 out of the 49 total crayfish collected in this study. Nine crayfish were captured between June 6 and July 2, and four between period August 2 and August 18. Catch-per-unit-effort was defined as number of crayfish caught per day out of all 10 traps (crayfish/10 trap days). CPUE varied throughout the summer, with the highest values between July 11-17 and over July 25-Aug 1 (Figure 2).

Catch rate between July3-August 3 varied by habitat type. The trap set in heavy chestnut growth and on a soft bottom caught no crayfish. The average catch rate for the traps along the channels in water chestnuts and water celery mixes was 0.12 crayfish per day. The average catch rate for the trap in the rip rap area was 0.14 per day. The traps placed in submerged aquatic vegetation beds of slower flow with mixes of water chestnut, water celery and Eurasian water milfoil had catch rates of 0.06 crayfish per day (for the connected submerged aquatic vegetation bed) and 0.14 crayfish per day (for the unconnected submerged aquatic vegetation bed). Therefore, the lowest catches occurred in areas with the densest vegetation.

The Schnabel mark recapture algorithm (Schnabel 1938) gives a total population estimate of the crayfish to be 244.5 for the areas surveyed, with a 95% confidence interval of 102.5 to 386.5 crayfish for the areas of Tivoli South Bay surveyed.

In the size class analysis (Figure 3) crayfish <21 mm carapace length were considered to be young of year (YOY). Female YOY had a median carapace length of 14 mm and a mean of 13.6 mm. Another size class is apparent from the graphed data (Figure 3) with a median of 51 mm and a mean of 51.25 mm for females. Male crayfish YOY from the same capture period have a median of 12 mm and a mean of 12.9 mm. The older size class present has a median of 44.5 mm and a mean of 44.4 mm for males.

The differences in size present between the two sexes of crayfish shows that female crayfish grow faster than male crayfish. This is indicated by the larger size of the female crayfish in both YOY and the larger size class observed.

Small crayfish (those under 21 mm carapace length) were captured over the course of the study only during the period from July 3-July 30. The greatest capture numbers, of 6 and 7 individuals, occurred on July 10 and July 17, respectively. No

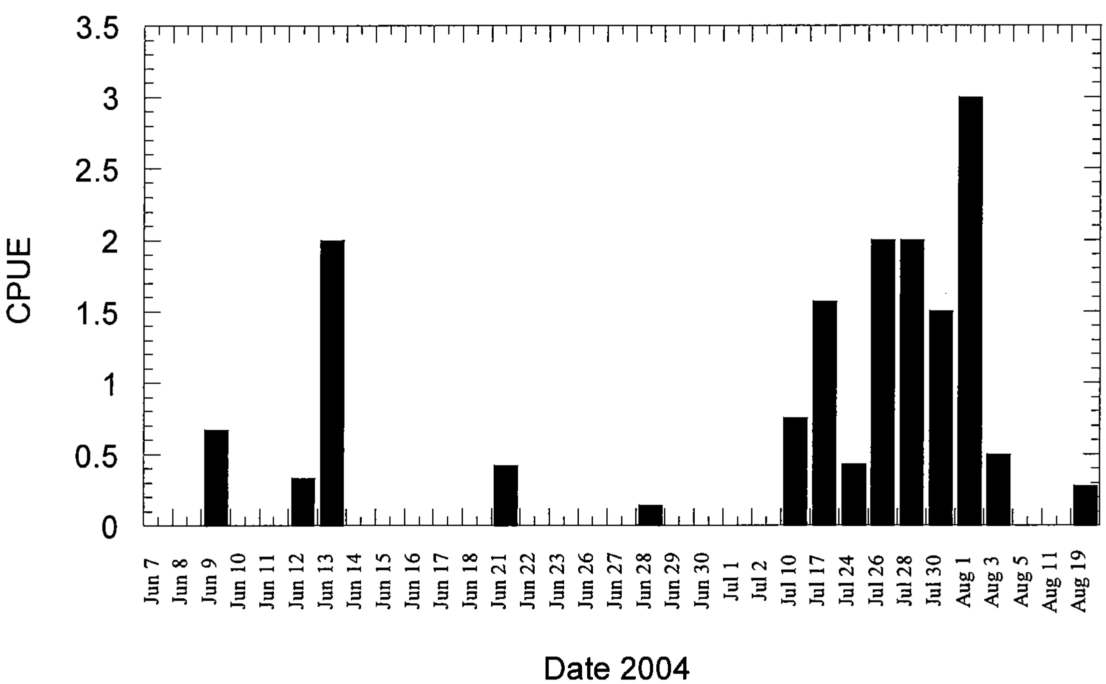

Figure 2. Catch per unit effort (crayfish/10 trap days) of spinycheek crayfish in Tivoli South Bay.

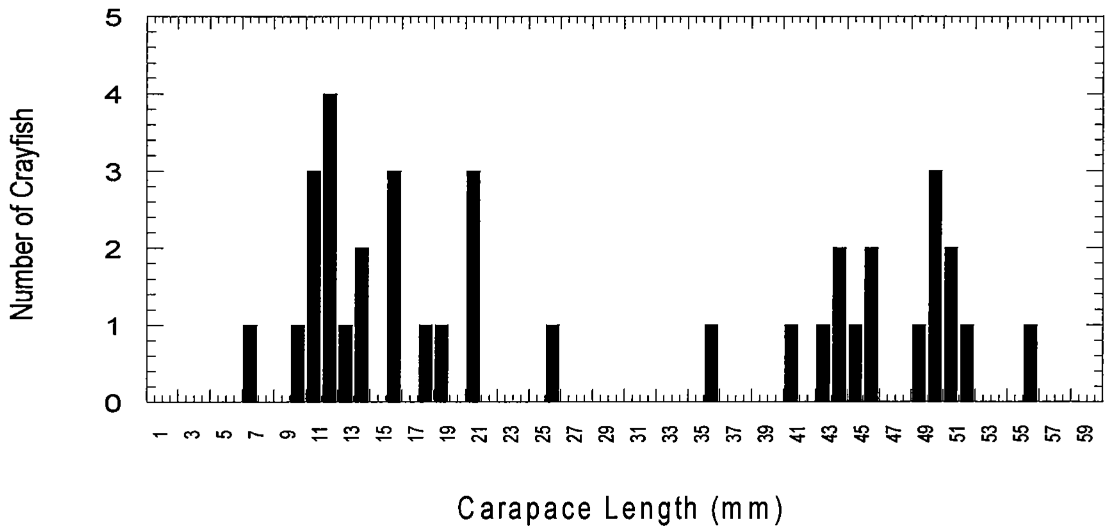

Figure 3. Carapace length frequency of spinycheek crayfish from Tivoli South Bay.

large crayfish (>40 mm carapace length) were captured June 29-July 24. The peak in captures came between August 1-3, when 6 large crayfish were taken in the traps. Only two size classes were shown by the data, but it appears that there is a missing year class. Crayfish outside if the two size classes shown were present in low numbers. This shows that those size crayfish may not spend as much time on the edge of the water chestnut beds, or are present in lower numbers. We believe there is an underrepresented year class in our sample. Crayfish >20 mm in carapace length were captured on June 9th (21 and 27 mm carapace length) and these crayfish are larger than what would be considered YOY. A few crayfish between 30-40 mm carapace length were also captured.

Crayfish were found to be a food source for smallmouth bass on the tidal Hudson River. Out of the gut contents examined, one fish was found to have crayfish present, three had fish remains present, one had insects, and the other seven smallmouth bass surveyed had empty stomachs. The one largemouth bass also had crayfish present in its gut.

DISCUSSION

Many facets of the basic biology of *Orconectes limosus* were explored and built upon in the study conducted. No egg or young bearing crayfish were captured during the course of our study in Tivoli South Bay. Earlier studies have shown that young bearing *O. limosus* have been found into July in southern New England (Smith 1981). Egg bearing females of the species *Astacus astacus* were seen to be much less active (Lindqvist and Lahti 1981). This inactivity, if present in *O. limosus,* could account for the lack of captures during the early part of the study.

There were seasonal differences present in our capture of crayfish in the water chestnut. We captured a total of 49 crayfish during the course of the study and of those, 37 were captured between July 3rd and August 3rd. These crayfish were graphed on a length frequency curve, and from this length frequency curve, we found two distinct size classes. Separating the crayfish by gender showed clearer curves. Sexual dimorphism has been observed in many species of crayfish in weight-per-length ratios (Lindqvist and Lahti 1981) with males weighing more per length than females. In this population, females have longer lengths for a given size class. This is important because many species in nature demonstrate this same property, with females growing faster and larger than do males, due perhaps to the need to carry eggs. Larger females would be more successful, being harder for predators to consume and more able to fend off predators targeting the slower moving egg carrying individual.

CPUE varied depending on the habitat type. The one area that did not have any crayfish captured from July 3rd to August 3rd, had one capture before July 3rd, but no others throughout the season. This trap was subject to heavy movement of silt and debris, as dozens of chestnut seeds would make their way into the trap. This area may be rather inhospitable for the spinycheek crayfish. The only difference among areas with mixed vegetation was whether the plant bed was connected to the main vegetative mats. The connected plant bed had an average capture rate of 0.06 crayfish per day, and the unconnected plant bed had a capture rate of 0.139 crayfish per day. This difference could be due to increased water exchange in an area surrounded on all sides by water versus one with reduced water exchange. In the areas surveyed with mixed vegetation and strong tidal movement, a capture rate of 0.12 crayfish per day was observed.

Reduced dissolved oxygen concentrations in water chestnut beds with reduced water exchange has been demonstrated (Caraco and Cole 2002) and low dissolved oxygen concentrations were reported from Tivoli South Bay at low tides (Frenzel and Limburg 2004, C. Nieder, HRNERR unpublished data.) the summer distribution of these crayfish could be due to avoidance of low dissolved oxygen levels forcing them to the edges of the water chestnut beds. During this study we easily captured crayfish lying on their sides on top of the water chestnut in Tivoli South Bay. These crayfish appeared to be fine and swam rapidly away when released. We think they were breathing from the surface film when the underlying water approached anoxia.

A population estimate of 245 crayfish was calculated for the area studied. The 95% confidence interval for the population ranges from 102.5 to 386.5. The large range here reflects the potential inaccuracy of this estimate. The upper limit was calculated by finding the difference between the lower limit and the population estimate and adding it to the population estimate. We only recaptured 2 out of 32 marked crayfish. Larger sample sizes would likely result in better estimations of the population size. Our system was also not closed. A major assumption for the Schnabel mark-recapture method is that the system remains closed, and migration into and out of the bay decreases the accuracy of the estimation. Migration of the crayfish is demonstrated by the seasonal differences in crayfish captures over the course of the season. We believe the crayfish were migrating out of the bay, as conditions at the end of summer would approach anoxia at low tidal stages.

The young-of-the-year first appeared in the sampling period July 3rd through July 10th, and were completely absent from previous samples. There is a definite seasonal effect present in the numbers of crayfish in the bay. The young of the year make use of the water chestnut bed for at least some portion of their life. Water chestnut provides excellent cover for small organisms, as well as a potential source of food for the crayfish. An interesting aspect of water chestnut is the tendency for large beds to go anoxic. Small crayfish of the species *O. virilis* were shown to consume more oxygen per gram of body weight than larger crayfish (Jones and Momot 1981). The juvenile crayfish we captured were captured entirely between July 3-August 3. They may be leaving the chestnut beds due to oxygen restrictions at this time of year, when chestnut growth is at its peak. Crayfish catches dropped for all size classes after August 3rd. We believe that young crayfish leave the bay in order to escape the unfavorable oxygen concentrations present in late summer.

The peak in captures of juveniles is consistent with earlier research done on this species in southern New England. Hatchlings have been observed attached to their mothers as early as June 14th until early July (Smith 1981). Smith (1981) found juvenile crayfish >10mm carapace length to beginning in early July, similar to our findings. Based on these observations, crayfish in Tivoli South Bay were hatched at approximately the same time.

Seasonal usage of the area by the larger crayfish occurs. A one week sampling period showed high use of the sampling area by the crayfish compared to the season as a whole. The sampling period of July 25th to August 1st had the most captures of larger crayfish, with the peak occurring on the sampling date August 1st. Captures of large individuals dropped markedly after this period, and were spotty before this period. The data shows that crayfish abundance in this size class is not consistent in number in this location. Density of water chestnut could be a factor affecting crayfish density. Water chestnut density was at its peak in mid August, and this high density could have forced crayfish out of the water chestnut due to anoxic conditions.

O. limosus appears to make up some portion of the diet of *Micropterus* spp. in the tidal Hudson River. Crayfish were found in the guts of two *Micropterus* surveyed, and crayfish are known to make up a large portion of the diet of various members of *Micropterus*. Work done in Tivoli South Bay has shown *Micropterus* to be present in low abundance, and a spring survey of predatory fishes in the bay showed crayfish not to be used as a major food source (R. Schmidt, unpublished data).

Low captures of *O. limosus* could be attributed to the high abundance of the American eel *Anguilla rostrata* in Tivoli South Bay. The Saw Kill, the creek feeding

Tivoli South Bay, was estimated to contain a population of 2234 eels (Petersson and Schmidt 2004). Out of the eels that had been surveyed, it was found that overall, 7.7% of eels had crayfish present in their stomachs (L. Machut unpublished data). Of eels over 300 mm total length, 17.9% contained crayfish. Crayfish make up a substantial portion of the diet of the American eel, and with densities of eels as high as they are, the eel may have the most profound effect on the population of the spinycheek crayfish. Predation of the eels may account for the size classes missing from the bay.

ACKNOWLEDGEMENTS

I would like to thank Karin Limburg for all her help, guidance and for always listening to my newest discovery, whether it is an undiscovered location of the rudd *Scardinius erythrophthlmus* or an explanation of a gizzard shad die off. I'd also like to thank Karin for introducing me to the Hudson Valley area. I'd like to thank Robert Schmidt for helping me with editing, putting graphs together, and for ensuring me that low crayfish captures were not necessarily a bad thing. The Polgar Fellowship committee definitely deserves a thanks, for allowing me to spend the summer in water chestnut and giving me my first chance to conduct actual field research. I'd like to thank my friends and family, especially Courtney Palermo for listening to the crayfish report every day and my parents Stanley and Marsha Bednarski for encouraging my summer adventures wherever they lead me.

REFERENCES

Caraco, N.F., and J.J. Cole. 2002. Contrasting impacts of a native and alien macrophyte on dissolved oxygen in a large river. Ecological Applications 12:1469-1509.

Hobbs, H.H. III. 2001. Decapoda. Pages 955-1002 *in* Thorp, J.H. and A.P. Covich. (Eds.) Ecology and classification of North American freshwater invertebrates. 2nd ed. Academic Press. New York, 1056 pp.

Jones, P.D., and W.T. Momot. 1981. The bioenergetics of *O. virilis* in two pothole lakes. Pages 192-209 *in* C.R. Goldman, editor. Freshwater crayfish V. AVI Publishing, Westport, Connecticut.

Laurent, P.J. 1988. *Austropotamobius pallipes* and *A. torrentium*, with observations on their interaction with other species in Europe. Pages 341-364 *in* D.M. Holdrich and R.S. Lawry, editors. Freshwater Crayfish: Biology, Management and Exploitation. Chambers and Hall, London.

Lindqvist, D., and E. Lahti. 1981. On the sexual dimorphism and condition index in the crayfish *Astacus astacus* L. in Finland. Pages 3-11 *in* C.R. Goldman, editor. Freshwater crayfish V. AVI Publishing, Westport, Connecticut.

MacCrimmon, H.R. and Robbins, W.H. 1974. The black bass in America and overseas. Publications Division Biomanagement and Research Enterprises. Sault Ste. Marie, Ontario Canada.

Nieder, W.C., E. Barnaba, S. Findlay, S. Hoskins, N. Holochuck, and E. Blair. 2004. Distribution and abundance of submerged aquatic vegetation in the Hudson River Estuary. Journal of Coastal Research 45:150-161.

Ortmann, A.E. 1906. The crayfishes of the State of Pennsylvania. Memoirs of the

Carnegie Museum 2:503-521.

Petersson, R., and R.E. Schmidt. 2004. Movements of American eel (*Anguilla rostrata*) in the Saw Kill, a Hudson River tributary. Pages VII-1-14 *in* W.C. Nieder and J.R. Waldman (Ed.). Final Reports of the Tibor T. Polgar Fellowship Program, 2003. Hudson River Foundation, New York, New York.

Schnabel, Z.E. 1938. The estimation of the total fish population of a lake. American Mathematical Monthly 45: 348-52.

Smith, D.G. 1981. Life history parameters of the crayfish *Orconectes limosus* in southern New England. Ohio Journal of Science 81:169-172.

Strayer, D.L., C. Lutz, H.M. Munger, and W.H. Shaw. 2003. Invertebrate communities associated with a native (*Vallisneria americana*) and an alien (*Trapa natans*) macrophyte in a large river. Freshwater Biology 48:1938-1949.

Vey, A., K. Söderhäll, and R. Ajaxon. 1981. Susceptibility of *Orconectes limosus* Raff. to the crayfish plague *Aphanomyces astaci* Schikora. Pages 284-291 *in* C.R. Goldman, editor. Freshwater crayfish V. AVI Publishing, Westport, Connecticut.