ASPECTS OF CARP BIOLOGY IN TIVOLI SOUTH BAY, A HUDSON RIVER TIDAL FRESHWATER MARSH

A report of the 1992 Tibor T. Polgar Fellowship Program

Charles Montgomery
Polgar Fellow
Simon's Rock College of Bard
Great Barrington, Massachusetts 01230

and

Robert E. Schmidt
Supervisor

ABSTRACT

This study investigated the life history and feeding biology of adult carp (*Cyprinus carpio*) in Tivoli South Bay, a portion of the Hudson River National Estuarine Research Reserve, during the spawning season. It became difficult to catch carp in gill nets when water-chestnut (*Trapa natans*) was dense. When compared with other data from North America, Hudson River carp were intermediate in weight when small, but heavier when large. Determination of age by counting scale annuli was not possible in this population. Carp were primarily benthic omnivores, although some food items were surface organisms. They consumed detritus, plant material, and benthic invertebrates. The amount of food consumed by individual carp was insufficient to maintain body weight which suggests that carp do not feed during spawning and/or they feed elsewhere in the estuary. The impact of feeding behavior of adult carp on Tivoli South Bay appears to be minimal although the larvae and juveniles feed extensively on organisms in the water-chestnut beds.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Carp (*Cyprinus carpio*) are large European minnows that are very abundant in the Hudson estuary. Few studies have been done on the biology of carp in North America despite efforts by the American Fisheries Society to stimulate interest in this species (Cooper, 1987). Almost no information on carp is available for the Hudson, although Hankin and Schmidt (1992) contend that carp populations may be increasing in the estuary.

Larval and juvenile carp have been studied in Tivoli South Bay. Pelczarski and Schmidt (1991) showed that juvenile carp were one of the two most abundant species in the European water-chestnut (*Trapa natans*) beds. Other studies documented the abundance of carp larvae in Tivoli South Bay (Schmidt and Kiviat, 1988; Anderson and Schmidt, 1989). Schmidt et al. (1992) calculated that 10^8 carp larvae left South Bay on each ebb tide for three weeks. Therefore about 10^9 carp larvae were exported from Tivoli South Bay in a season. Anyone observing the *Trapa* beds in early summer has seen large numbers of carp spawning in South Bay. A large female carp can produce 10^6 eggs (Panek, 1987) therefore 1,000 females could produce enough eggs to account for the number of carp larvae observed, probably a larger number of females than could be expected in South Bay despite their apparent abundance.

Feeding habits of larval carp were documented from the South Bay *Trapa* beds (Sidari and Schmidt, 1990). Foods of juveniles were investigated within the *Trapa* beds (Pelczarski and Schmidt, 1991). Analysis of the feeding biology of the adult

carp in South Bay could allow us to document the ontogenetic changes in feeding ofthis species in the Hudson.

Adult carp are omnivores, consuming many benthic invertebrates (Scott and Crossman, 1973). It has been suggested that carp can severely reduce macroinvertebrate standing crops by predation and mechanical disturbance of the bottom during feeding (Wilcox and Hornbach, 1991; Cahn, 1929). The purpose of this study was to document the significance of adult carp feeding to the Tivoli South Bay ecosystem.

METHODS

Study Area

This study concentrates on the Tivoli Bays component of the Hudson River National Estuarine Research Reserve, in particular Tivoli South Bay - a low (submerged at high tide) tidal freshwater wetland dominated by the floating macrophyte, *Trapa natans*. South Bay is located about 99 miles (River Mile 99) north of the Battery in Manhattan, well above the influence of salt water. South Bay is partially isolated from the main Hudson estuary by the Metro-North railroad and tidal exchange occurs through three openings in the railroad bed (Fig. 1). The marsh is 155 ha and tidal exchange was calculated at 10^6 m^3 per tidal cycle (Goldhammer and Findlay, 1988). Upland drainage from the Saw Kill (55 km^2) and spring flows (up to 5.9 m^3/sec - Schmidt and Limburg, 1989) add some water to the marsh. In the summer, water-chestnut density reaches 0.3 kg dry wt/m^2 (Schmidt and Kiviat, 1988).

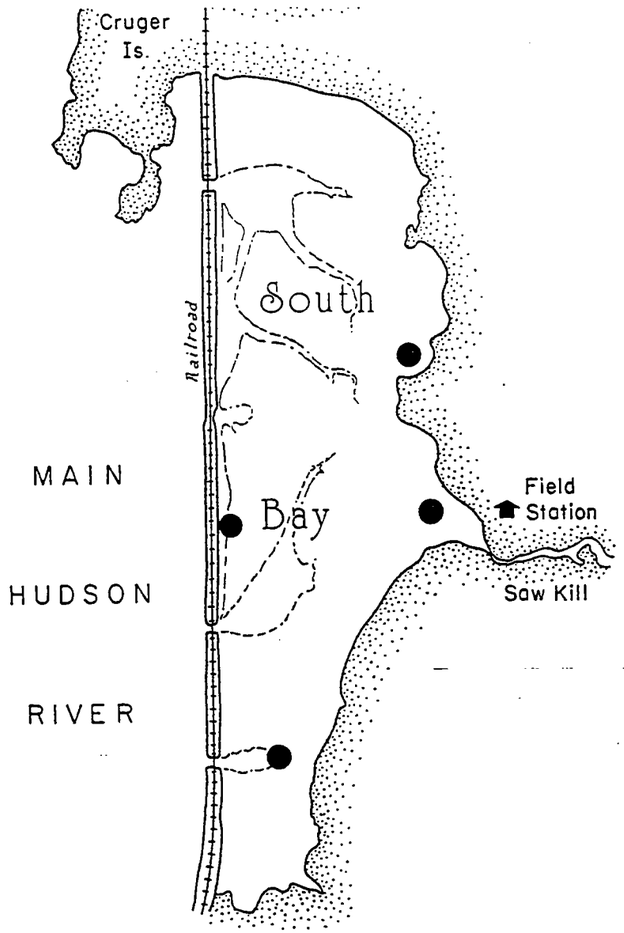

Figure 1. Sampling area in Tivoli South Bay, Hudson River, New York. Locations where gill nets were set are indicated by black circles.

Field Sampling and Laboratory Analysis

Fish were caught using two experimental gill nets: one 100-foot and one 150-foot net, each composed of three panels of monofilament with 2, 2.5, and 3 inch bar mesh, respectively. The nets were set from canoes at high tide for varying lengths of time (between 1-8 hr) in four different locations on the bay (Fig. 1). Usually we only set the larger gill net, but we set both nets on several occasions. Nets were set in open water and we recorded the amount of time that the nets were set. Early in the season, before water-chestnut was dense, nets were set near the mouth of the Saw Kill. As water-chestnut grew, we were restricted to areas near shore or in the pools by the culverts under the Metro-North railroad. In July the only area readily accessible was the pool by the southernmost culvert, and nets were anchored on each end with 10 lb weights in this area.

Once captured and removed from the nets, fish were brought to the lab at Simon's Rock College. Fish were either processed immediately or refrigerated and processed the following day. Fish were weighed with a Normark digital scale to the nearest ounce, measured (total length) to the nearest millimeter, and scales were removed from the left side anterior to the dorsal fin origin and dorsal to the lateral line. Scales were washed to remove mucus, pressed between glass slides, and slides were labelled with the date and a sequential number assigned to each fish.

The portion of the intestine anterior to the first loop was removed, split open, and contents were removed. Most of the mucus was removed from the stomach contents which were then placed in a pre-weighed plastic weighing dish and weighed

on a Mettler top loading electronic balance to the nearest 0.1 g. Stomach contents were then preserved in 50% isopropanol and labelled with the date and the number previously assigned to each fish. Gender was determined by gross visual examination of the gonads.

Preserved stomach contents were sorted by food item, identified to the lowest taxon practical with a Bausch and Lomb stereo dissecting microscope, and counted. All stomach contents not identifiable under the dissecting microscope were considered "detritus". Stomach contents were then air-dried and weighed to the nearest 0.01 g on the Mettler balance; each food item was weighed separately when adequate amounts were available. Occasionally when food items were very abundant, subsamples were taken, food items counted, air dried, and weighed and the remaining unsampled material was also air dried and weighed. A sample of detritus was examined under higher power to determine what kinds of material were present.

Catch per unit effort (CPUE) was calculated each time we sampled. One unit of effort was defined as an hour of fishing with 150 feet of gill net. Use of the 100 foot net for one hour was considered 0.67 units of effort. Total number of carp caught was divided by effort units and CPUE was plotted against sample date.

We derived a length-weight relationship by first converting fish weights to kilograms and then calculating a linear regression of total lengths (cm) against $\log_{10}$ weight (kg). Comparisons were made to length-weight relationships of carp in other parts of the United States by calculating the weight in grams at total lengths of 40-, 60-, and 80-cm from our regression line and other published regressions.

Determination of age was done by examining scales with a video camera mounted on a dissecting microscope. Annuli were counted and recorded for each specimen examined.

Wet weights of stomach contents were divided by total weight of the fish. Percentages of total weight were compared to literature values for normal ration size.

Food items were lumped into five major categories (detritus, snails, *Lemna*, midges, and other). The sum of dry weights for each food category for all carp was divided by the total dry weight for all food categories and expressed as a percentage of the total diet. The food items in the "other" category were those items that were not present in sufficient quantities to weigh. Percent of food items in this category was calculated by dividing the total number of a particular food item by the total number of "other" food items.

RESULTS

We sampled carp in Tivoli South Bay nine times between June 5 and July 27, 1992, inclusive. We collected a total of 64 carp measuring 30.6-81.7 cm total length (TL) and weighing 0.4-11.2 kg. We caught 43 males, 11 females, and 10 juveniles whose gender we could not determine. Although the three largest specimens we caught were females, the average lengths of the individuals in each gender were almost the same (60.2 cm TL for females and 60.4 cm TL for males).

Cpue varied from zero to 21.3 carp per net-hr. The first two samples (June 5 and 10) had high CPUE values but subsequent catches were all less than 0.94 carp per

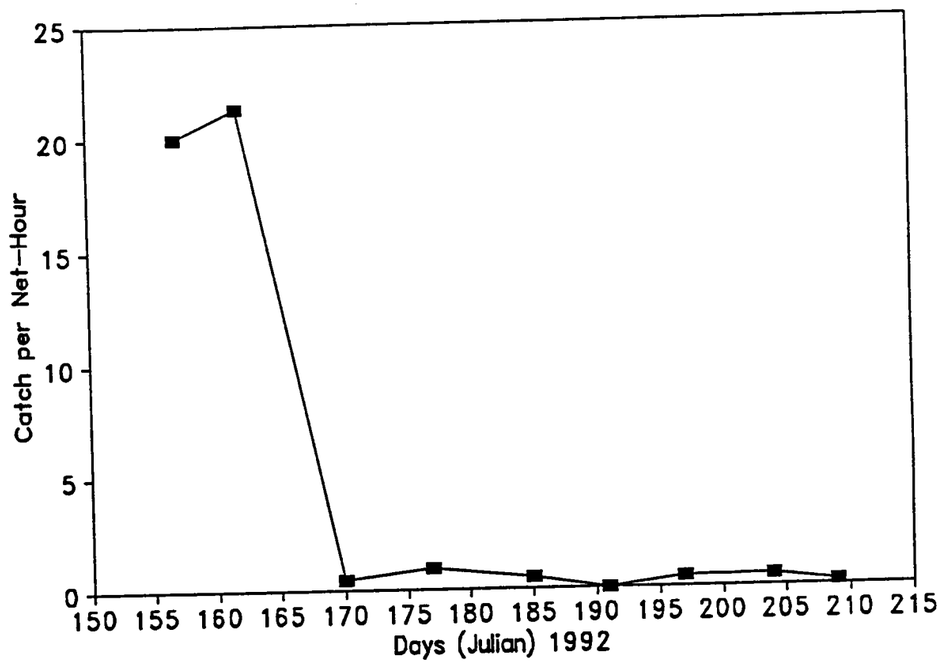

Figure 2. Catch per unit effort of carp in gill nets, Tivoli South Bay, Hudson River. The first sample date is June 5, 1992.

net-hr (Fig. 2). We attribute this large decline in catch to our reduced ability to deploy the nets due to rapid growth of water-chestnut, at least in the beginning of the season. We still observed large numbers of carp in June and July in the middle of the water-chestnut beds, but were unable to sample there. The number of carp in South Bay may in fact have declined towards the end of our sampling period, but our catches are not reliable evidence of this. On July 27, our CPUE fell to 0.17 carp per net-hr, a

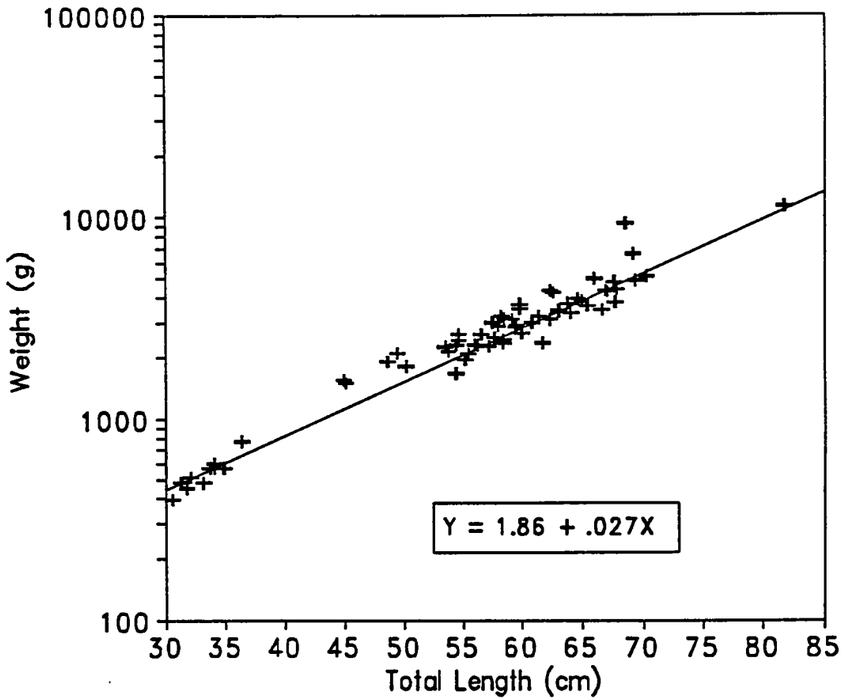

Figure 3. Length-weight relationship of adult carp from Tivoli South Bay, Hudson River, New York.

return that was not worth the effort, so we ceased sampling.

The total length vs weight relationship was (Fig. 3):

$$\text{Log}_{10} \text{ (weight in kg)} = 1.86 + .027(\text{TL in cm}).$$

Based on calculated weights at 40-, 60-, and 80-cm TL, the Hudson River carp are

Table 1. Comparison of weights of carp at given lengths among Hudson River fish and carp from fast and slow growing populations in North America.

	Calculated Weights (kg)		
Length (cm)	This Study	English, 1952a	Youn, 1962
40	0.87	0.92	0.66
60	3.02	2.80	2.48
80	10.47	6.16	7.38

intermediate in weight when small (Table 1) but heavier when larger compared to the highest and lowest calculated values for carp populations in North America (Carlander, 1969).

Determining age by counting scale annuli was ineffective. Difficulty in reading scale annuli accurately was evident because fish with similar total lengths showed estimated age differences of up to three years in smaller individuals. In larger fish, annuli near the center of the scale were obscured making estimation of age impossible. Panek (1987) said that estimating age in wild carp by using scale annuli was unreliable. Carp have been aged using pectoral spine sections (English, 1952b) and opercular bones (Youn, 1962) but we did not attempt to use those methods.

Out of the 64 carp we collected, only 15 contained food in their anterior intestine. Wet weights of intestine contents measured ranged between 0.1-4.7 g, and constituted 0.01-0.5% of body weight. Kevern (1966) calculated that a maintenance ration of wild carp was 2.9% of body weight per day and Chiba (1961) said that it

required 13.0% of body weight per day of daphniids or 3.0% of body weight per day of *Tubifex* worms to maintain body weight in small carp in culture. Since we only weighed the contents of the anterior third of the intestine, it is possible that we underrepresented the wet weight of the food the fish actually ate. However our impression is that the remainder of the food in the gut was at most about 5 g, which, if added to any of our samples, would still not raise the daily ration to 3% of body weight. Also, since we collected our fish in gill nets and some individuals spent hours in the nets, it is possible that a significant amount of food had been eliminated prior to our examination. However, in our first two samples, fishes were caught within 45 minutes of setting the net and these individuals had little food in their intestines. Kevern (1966) reported retention time for food in carp was 22-50 hr at 12.5 C and 16-25 hr at 20 C. Temperatures during our study probably ranged between 20-25 C, but retention times likely exceeded the time fish were entangled in the net. Therefore, because few carp had food in their intestines and those that did had much less than was necessary for daily maintenance, we conclude that carp in South Bay are feeding minimally if at all.

Those carp that did have food in their intestines were primarily feeding on detritus with considerably lower amounts of snails, *Lemna* sp., midges, and other organisms (Fig. 4) based on dry weights. Carp have been classified as detritivorous and secondarily herbivorous (Kevern, 1966; Eder and Carlson, 1977) and our data supported this. Examination of a sample of detritus under a light microscope revealed the presence of filamentous cyanophytes, vascular plant material, small particles of

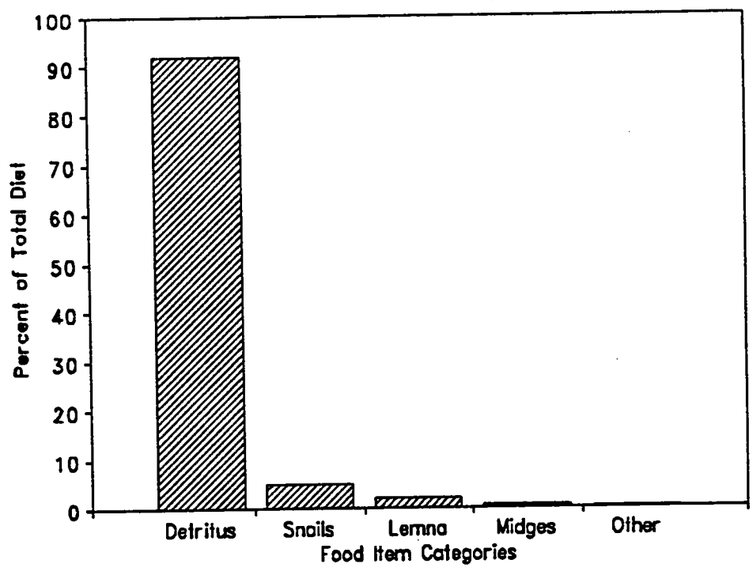

Figure 4. Food habits for carp collected in Tivoli South Bay, 1992. The percent of total diet is from all fish with food in their stomachs based on dry weights.

sediment, oligochaetes, diatoms, and filamentous chlorophytes. We did not attempt to quantify this microscopic material. Chironomid midges have been shown to be significant in carp diets (Rehder, 1959; Rose and Moen, 1951) and despite the small dry weight of this food category, they were numerous (419 in one 3.8 kg fish) in some of our carp.

The food items that were too scarce to weigh (the "other" category) consisted of a variety of common aquatic organisms (Fig. 5). Although it is possible that we

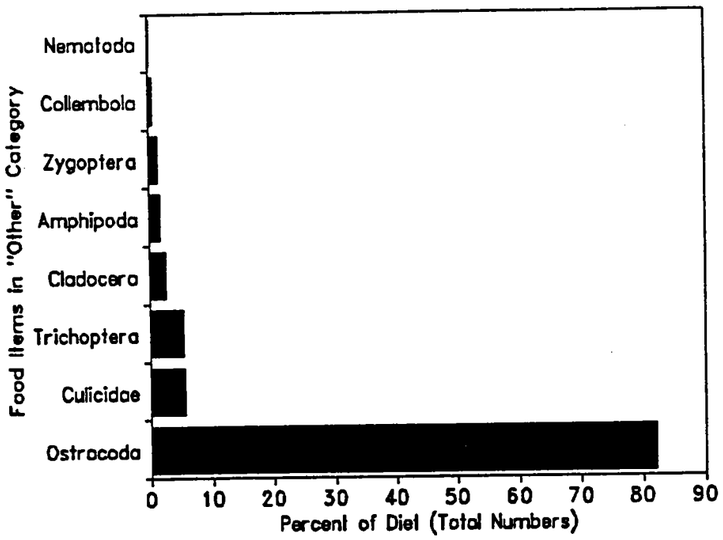

Figure 5. Food habits of carp collected in Tivoli South Bay, 1992. These are miscellaneous organisms that were too scarce to weigh. Percentages are based on a total of 515 organisms.

---

could have found literature values for weights of these organisms, they were seen in such small numbers that their contribution to the diet of the fish we examined was irrelevant. The ostracods were the most numerically abundant organism with a total of 423 from all fish, but 396 were from one individual carp. We counted a total of 29 of the next most abundant food item in the "Other" category (culicid larvae).

DISCUSSION

Our data on the quantity of food suggest that adult carp feed little, if at all, while inhabiting Tivoli South Bay. The obvious reason for the presence of these carp in South Bay is reproduction. Perhaps carp quit feeding while mating. It may also be the case that male carp remain in the spawning area longer than females, thus explaining why we caught a predominance of males. We could not find any literature to support these observations for carp, although both phenomena are well documented in other fishes in the same family.

The composition of the food that we did find is similar to the assemblage of detritus and invertebrates reported from Hudson River sediments (Simpson et al., 1984). The presence of *Lemna* and collembolans suggest that some food may be taken from the surface. Both food items are common among *Trapa* plants (Schmidt and Kiviat, 1988; Schoeberl and Findlay, 1988) but are also present elsewhere in the estuary. In any case, the adult carp don't seem to take advantage of the food resources in the *Trapa* beds although the larvae (Sidari and Schmidt, 1990) and juveniles (Pelczarski and Schmidt, 1991) clearly depend on these resources.

We have observed carp at the surface in the *Trapa* beds moving their mouths and making "popping" noises. Since we found very few surface organisms in carp, we suggest that the surface behavior may be due to the carp gasping for oxygen. Very low dissolved oxygen values (<3 mg/l) have been reported for the South Bay *Trapa* beds (Schmidt and Kiviat, 1988; Anderson and Schmidt, 1989).

Fernández-Delgado (1990) stated, "... estuarine habitats are not the best for carp

...". He was primarily referring to the negative affect of salinity on growth rates (Soller, 1965; Crivelli, 1981), although Fernández-Delgado (1990) did not report the salinity regime in his study area. From our observations on size and abundance of these fish, the Hudson estuary does seem to be a good habitat for carp. It may be that carp in the southern end of the estuary are being stressed by salinity, but in the freshwater areas that we sampled carp seem to be doing well.

RECOMMENDATIONS

We made some progress in documenting the biology of carp in the Hudson. Obviously, there is a huge amount of information that still needs to be gathered about this species. This is a common species that can be collected with relative ease. Its size and apparent abundance indicate that it could be a significant species in the Hudson estuary, particularly if it is directly converting plant detritus into fish biomass.

ACKNOWLEDGEMENTS

This research was funded by the Hudson River Foundation. Thanks to all who assisted in the completion of this project, especially everyone at Hudsonia Ltd. and Kathy Anne Schmidt. Facilities were generously supplied by Hudsonia Ltd., Bard College, and Simon's Rock College. Kathleen Andrea Schmidt drew Figure 1. This is Bard College Field Station-Hudsonia Contribution #62.

REFERENCES

Anderson, A.B. and R.E. Schmidt. 1989. A survey of larval and juvenile fish populations in water-chestnut (*Trapa natans*) in Tivoli South Bay, a Hudson River tidal marsh. Pages VI- 1-34 *in* E.A. Blair and J.R. Waldman, editors. Polgar Fellowship Reports of the Hudson River National Estuarine Research Reserve Program, 1988. Hudson River Foundation, New York, New York.

Cahn, A.R. 1929. The effect of carp on a small lake: Carp as dominant. Ecology 10: 271-274.

Carlander, K.D. 1969. Handbook of freshwater fishery biology. Volume One. Iowa State University Press, Ames, Iowa.

Chiba, K. 1961. The basic study on the production of fish seedling under possible control. I. The effect of food in quality and quantity on survival and growth of common carp fry. Bull. Freshwater Fish. Res. Lab. (Tokyo) 11: 105-128. (Japanese with English summary)

Cooper, E.L. (Ed.). 1987. Carp in North America. American Fisheries Society, Bethesda, Maryland.

Crivelli, A.J. 1981. The biology of the common carp, *Cyprinus carpio* L. in the Camargue, Southern France. J. Fish Biol. 18: 271-290.

Eder, S. and C.A. Carlson. 1977. Food habits of carp and white suckers in the South Platte and St. Vrain Rivers and Goosequill Pond, Weld County, Colorado. Trans. Am. Fish. Soc. 106: 339-346.

English, T.S. 1952a. Growth studies of the carp, *Cyprinus carpio* Linnaeus, in Clear Lake, Iowa. Iowa St. J. Sci. 24: 527-540.

English, T.S. 1952b. Method of sectioning carp spines for growth studies. Prog. Fish Cult. 14: 36.

Fernández-Delgado, C. 1990. Life history patterns of the common carp, *Cyprinus carpio*, in the estuary of the Guadalquivir river in south-west Spain. Hydrobiologia 206: 19-28.

Goldhammer, A. and S. Findlay. 1988. Estimation of suspended material flux between a *Trapa natans* stand and the Hudson River estuary. Pages VIII- 1-46 *in* J.R. Waldman and E.A. Blair, editors. Polgar Fellowship

Reports of the Hudson River National Estuarine Research Reserve Program, 1987. Hudson River Foundation, New York, New York.

Hankin, N. and R.E. Schmidt. 1992. Standing crop of fishes in water celery beds in the tidal Hudson River. Pages VIII- 1-23 *in* J.R. Waldman and E.A. Blair, editors. Final reports of the Tibor T. Polgar Fellowship Program, 1991. Hudson River Foundation, New York, New York.

Kevern, N.R. 1966. Feeding rate of carp estimated by a radioisotopic method. Trans. Am. Fish. Soc. 95: 363-371.

Panek, F.M. 1987. Biology and ecology of carp. Pages 1-15 *in* E.L. Cooper, editor. Carp in North America. American Fisheries Society, Bethesda, Maryland.

Pelczarski, K. and R.E. Schmidt. 1991. Evaluation of a pop net for sampling fishes from water-chestnut beds in the tidal Hudson River. Pages V- 1-33 *in* E.A. Blair and J.R. Waldman, editors. Final reports of the Tibor T. Polgar Fellowship Program, 1990. Hudson River Foundation, New York, New York.

Rehder, D.D. 1959. Some aspects of the life history of the carp, *Cyprinus carpio* in the Des Moines River, Boone County, Iowa. Iowa St. J. Sci. 34: 11-26.

Rose, E.T. and T.E. Moen. 1951. Results of increased fish harvest in Lost Island Lake. Trans. Am. Fish. Soc. 80: 50-55.

Schmidt, R.E., A.B. Anderson, and K. Limburg. 1992. Dynamics of larval fish populations in a Hudson River tidal marsh. Pages 458-475 *in* C.L. Smith, editor. Estuarine Research in the 1980s. SUNY Press, Albany, New York.

Schmidt, R.E. and E. Kiviat. 1988. Communities of larval and juvenile fishes associated with water-chestnut, watermilfoil, and water-celery in the Tivoli Bays of the Hudson River. Final Report to the Hudson River Foundation, New York, New York.

Schmidt, R.E. and K. Limburg. 1989. Fishes spawning in non-tidal portions of Hudson River tributaries. Final Report to the Hudson River Foundation, New York, New York.

Schoeberl, K.L. and S. Findlay. 1988. Composition, abundance, and dynamics of macroinvertebrates in Tivoli South Bay, with emphasis on the

Chironomidae (Diptera). Pages V- 1-35 *in* J.R. Waldman and E.A. Blair, editors. Polgar Fellowship Reports of the Hudson River National Estuarine Research Reserve Program, 1987. Hudson River Foundation, New York, New York.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bulletin 184.

Sidari, M. and R.E. Schmidt. 1990. Larval fish foods in water-chestnut beds. Pages VI- 1-23 *in* J.R. Waldman and E.A. Blair, editors. Polgar Fellowship Reports of the Hudson River National Estuarine Research Reserve Program, 1989. Hudson River Foundation, New York, New York.

Simpson, K.W., R.W. Bode, J.P. Fagnani and D.M. DeNicola. 1984. The freshwater macrobenthos of the main channel, Hudson River. Part B. Biology, taxonomy and distribution of resident macrobenthic species. Final Report to the Hudson River Foundation, New York, New York.

Soller, M. 1965. Carp growth in brackish water. Bamidgeh 17: 16-23.

Wilcox, T.P. and D.J. Hornbach. 1991. Macrobenthic community response to carp (*Cyprinus carpio* L.) foraging. J. Freshwater Ecology 6: 171-183.

Youn, P.M.D. 1962. Comparisons of some carp populations. Master's thesis. Iowa State University, Ames, Iowa.