EVALUATION OF A POP NET FOR SAMPLING FISHES FROM WATER-CHESTNUT BEDS IN THE TIDAL HUDSON RIVER

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ABSTRACT

Quantitative samples of juvenile and adult fishes were obtained from water-chestnut (*Trapa natans*) beds in the freshwater tidal Hudson River with a pop net. The pop net used was smaller and heavier than those described in the literature but the standing crop of fishes (g wet weight/m^2) and the density (#/m^2) was comparable to other pop net studies.

Two categories of fishes were observed. Two species, fourspine stickleback (*Apeltes quadracus*) and carp (*Cyprinus carpio*), were collected consistently and in substantial numbers and they were considered residents in the water-chestnut. Other species were seen rarely and were categorized as non-residents. Much of the variance in standing crop was due to the non-resident species. Standing crop estimates of fishes in water-chestnut were generally low compared to estimates of standing crops in other types of submerged aquatic vegetation.

The fishes in the water-chestnut beds were feeding primarily on Cladocera and chironomid midge larvae.

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INTRODUCTION

During recent years, primarily through the Polgar Fellowship Program, considerable effort has been directed at studying the Tivoli South Bay ecosystem. As a summary of these studies, Findlay et al. (1988) modelled carbon flux in Tivoli South Bay. Several components of this model were estimates taken from other marshes because data from Tivoli South Bay were lacking. Secondary consumers (fishes) were identified as one important component of the model that was poorly understood. Odum et al. (1978) described the highly significant role of tidal freshwater marshes as a nursery for small fishes, yet we know little about this aspect of Tivoli South Bay because the dense water-chestnut (Trapa natans) growth makes standard fish sampling techniques ineffective.

Recently, a net has been developed that potentially could work in water-chestnut beds. Larson et al. (1986) devised a "pop net" for sampling fishes around artificial structures. This sampling device was a net with a sealed PVC collar around the top for floatation and a heavy bottom line. When the net was set, the floatation collar was shackled to the bottom line so that the net was collapsed to a few centimeters high. The net was put in place and left unattended for a predetermined amount of time (several hours). Then the shackles were released simultaneously (Larson et al., 1986 used solenoids to release the shackles from a distance) and the floatation collar "popped" to the surface, thus isolating a column of water and associated fishes.

Killgore et al. (1989) and Serafy et al. (1988) both used pop nets to estimate standing crop of fishes in Myriophyllum and Hydrilla beds in Chesapeake Bay tributaries. Dewey et al. (1989) used a similar net to sample vegetated areas in the Mississippi River. The pop net designs in these studies were simpler than that used by Larson et al. (1986) and were successful in capturing fishes in environments similar to Tivoli South Bay. Hydrilla, like Trapa, is an exotic plant that produces dense floating mats. Fishes collected from the Hydrilla beds were similar to species we would expect to find in Tivoli South Bay (carp, golden shiners, spottail shiners, brown bullheads, banded killifish, common sunfish, and tessellated darters- Killgore et al., 1989 and Serafy et al., 1988).

In the past few years, several studies were performed that provided data on the larval fish communities in Tivoli South Bay. Schmidt and Kiviat (1988) found that water-chestnut beds had a greater

diversity and catch per unit effort of fish larvae than other submerged aquatic plant communities. Water-chestnut plants support an abundance of microcrustacea and other invertebrates that fish larvae could consume (Schoeberl and Findlay, 1988) and also provide protection from larger fish and avian predators. Anderson and Schmidt (1988) and Bohne and Schmidt (1988) estimated standing crop of fish larvae in the Trapa beds and flux of larvae between the marsh and the estuary, respectively. Schmidt et al. (In press) summarized the above information and included estimates of larval fish transport into Tivoli South Bay from the Saw Kill (Schmidt and Limburg, 1989). Most recently, Sidari and Schmidt (1990) described the larval fish food web in Tivoli South Bay.

During the studies cited above, larger fishes were observed in the Trapa beds. Also, some of the larvae collected in the water-chestnut are not transported out of the marsh as larvae, but probably remain in the water-chestnut through part or all of their first summer (Bohne and Schmidt, 1988). Therefore, we have evidence that juvenile and adult fishes may be using Trapa beds. Determining what species are found in water-chestnut and their standing crop will provide data on how water-chestnut may be influencing Hudson River fish communities and provide data on a potentially significant Hudson River estuarine habitat for fishes. The purposes of this study were to document species composition of the juvenile and adult fish community in a water-chestnut bed, estimate the standing crop of fishes in the water-chestnut, and determine the relationship of fishes to the invertebrate community.

MATERIALS AND METHODS

Study area

The Tivoli Bays area comprises >300 hectares of freshwater tidal shallows and wetlands on the east shore of the Hudson River, 160 km north of the Battery, located at the southern tip of Manhattan. The Tivoli Bays are one of four geographic components of the Hudson River National Estuarine Research Reserve. Tivoli South Bay (Fig. 1) is separated from the main river by a railroad bed built on fill in 1850. Three small bridges allow the 1.2 meter tide to exchange through the causeway. South Bay is 1-2 m deep at high tide and extremely shallow with exposed mudflats at low tide. The Saw Kill, a perennial stream with a watershed of 68 km^2, is the main tributary to South Bay. At the north end is a 15-ha stand of wooded tidal swamp separating South and North Bays. Water-chestnut covers South Bay

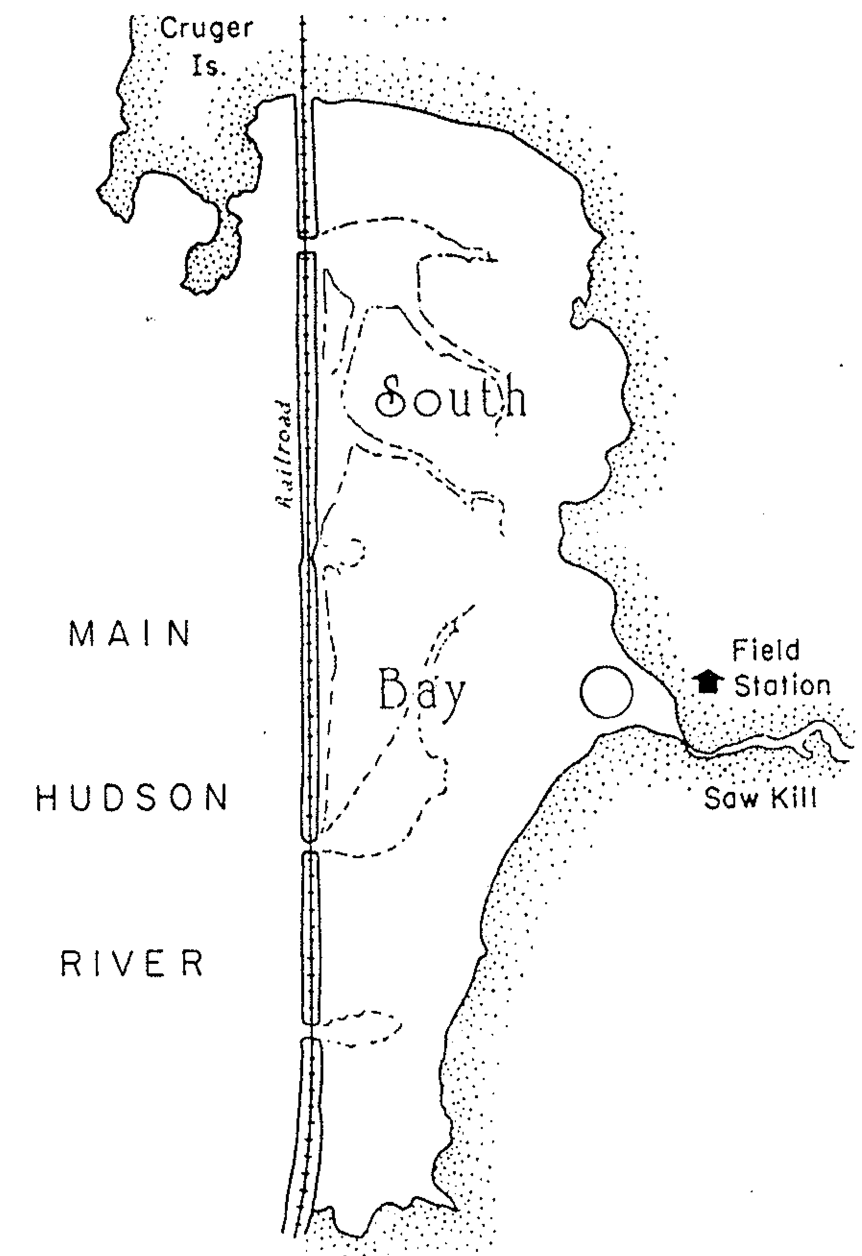


Figure 1. Map of Tivoli South Bay, Hudson River, New York showing area sampled with pop nets, 1990.

in the summer. Before water-chestnut became abundant in the tidal Hudson, the widespread plant communities in sheltered shallows like South Bay were probably dominated by water-celery, pondweeds, and a variety of other submerged aquatic vascular plants (Muenscher, 1937). Floating leaved species were rare or absent.

Procedure

The pop net used was modified from the designs of Larson et al. (1986), Serafy et al. (1988), Dewey et al. (1989), and Killgore et al. (1989). The sampling area of the pop net was smaller (5.23 m^2) because of the difficulty of transporting large nets through the water-chestnut beds. Since water-chestnut mats are denser than the plant communities sampled by the above researchers, we increased the buoyancy of the float frame by using 1.5 inch PVC pipe. The weight of the bottom frame was also increased to compensate for the increased buoyancy by using 1 inch plastic water pipe filled with two 3/8 inch concrete reinforcement rods. Elbows were placed on the four corners of both frames and sealed with all-purpose PVC cement. The netting used was 3/16 inch Ace knotless nylon, 6 feet deep. Once the netting was sewed onto the frame, it effectively fished about 5.5 feet, which is a foot

deeper than most of Tivoli South Bay. Four square 3.5 inch U-bolts were used to shackle the top and bottom frames together.

We chose an area of Tivoli South Bay within a quarter mile of the Bard College field station for sampling. Within this area, we chose netting locations arbitrarily.

A sampling trip consisted of carrying the net out into the water-chestnut, shackling the top and bottom frames together using the U-bolts, and then sinking the net. Sinking the net became difficult later in the season, when water-chestnut was particularly dense. Perhaps this calls for an even heavier bottom frame. One pair of U-bolts was used to shackle each of two opposite sides of the net. A line was tied to each U-bolt, and these lines were tied to two buoys, one on each side of the net. The lines were stretched such that the buoys were approximately 6 m from the net. The net was left submerged in place for at least one full tidal cycle.

The net was popped within two hours of high tide. In order to pop the net, we walked into the water-chestnut, approaching the net from opposite directions in order to avoid disturbing any fishes that might be present. The lines to the shackles were pulled simultaneously, and the top frame rose to the surface.

We removed all water-chestnut rosettes (by hand) off the top of the frame and then removed the rosettes from within the net. Fishes were collected by placing a 3 m long, 3/16 inch mesh Ace knotless nylon seine within the pop net and pulling the seine across the cleared area. We seined until five consecutive hauls produced no fishes. We often observed small fishes falling through the mesh of the seine. We made no special effort to capture or retain these individuals. We made efforts to return the fishes to the laboratory alive, but sometimes it was not reasonable to do so, and in those cases the fishes were preserved in 10% formalin.

Fishes were measured to the nearest millimeter and were weighed to the nearest 0.05 g on a triple beam balance. All fishes were then preserved in 10% formalin. Since some collections were preserved before weighing, we needed to convert preserved weights to wet weights. We calculated a linear regression between the mean wet weight and mean preserved weight for each one millimeter length class of fourspine sticklebacks (Apeltes quadracus). We used fourspine stickleback data because they were the most abundant species and there was a wide range of length classes. We used the regression line to calculate the wet weight of other

species, making the assumption that all species will change weight in the same way.

Standing crop was calculated by summing wet weights of all individuals per collection and dividing by the area of the pop net. This was then converted to standing crop for Tivoli South Bay by multiplying by 155 ha. Similar calculations of standing crop were done for each species in each collection.

In order to determine the food habits of the captured species, a maximum of five individuals per species per collection were selected for gut analysis. Individuals were chosen to represent the range of sizes captured. The guts of these fishes were dissected out and the contents were identified to the lowest taxon practicable and counted. These data were then used to calculate the importance of various food items following Windell (1971). He defined the significance of a food item in the diet as:

$$S = \sqrt{(\%\ \text{Occurrence})(\%\ \text{Composition})}$$

where S is the significance value which can theoretically range from 0-100; % Occurrence is the percentage of fish that contain a particular food item out of the total fish examined; and % Composition is the average percentage that an item contributes to the total number of all food items in the sample. All calculations were made only on those fishes containing food.

RESULTS

A total of nine samples were taken on the following dates, 1990: July 3, 4, 11, 13, 16, 20, 25, 27, and August 6. A total of 275 fishes, representing seven species were captured (Table 1). Fourspine sticklebacks were the most abundant species followed by carp. Because these two species were captured in every pop net sample and together they made up 94% of the fishes collected, they were considered residents in the water-chestnut beds. All other species collected were considered non-residents. We believe that these fishes spend only a small part of their time in the water-chestnut beds, staying mainly on the edges of the beds.

Resident standing crops fluctuated between 0.431 g/m^2 on July 4 and 4.981 g/m^2 on July 27 (Fig. 2). Total standing crops (resident plus non-resident) ranged from 0.565 g/m^2 on July 25 to 10.431 g/m^2 on July 11. Total standing crop for Tivoli South Bay ranged between 670 kg and 7720 kg for the resident species and between 868 kg and 16,167 kg for all species combined.

The variation in standing crop (Fig. 2) that we observed probably has several components. Recruitment

Table 1. List of fishes and sizes collected by pop nets in Tivoli South Bay, summer 1990.

Species	Total Number	Range Total Length (mm)
Fourspine stickleback (*Apeltes quadracus*)	207	20-46
Carp (*Cyprinus carpio*)	51	17-55
Banded killifish (*Fundulus diaphanus*)	7	26-86
Tessellated darter (*Etheostoma olmstedi*)	6	21-41
Spottail shiner (*Notropis hudsonius*)	2	17-109
American eel (*Anguilla rostrata*)	1	122
White perch (*Morone americana*)	1	157

of individuals to the gear was occurring particularly among young-of-the-year fourspine sticklebacks. Mean wet weights of the resident species dropped on July 16 (Fig. 3) which indicates the retention of very small sticklebacks in our 3/16 inch mesh. The variation in resident species standing crop after July 16 (Fig. 2) is mostly due to variations in number of young-of-the-year sticklebacks.

A second major source major source of variation is

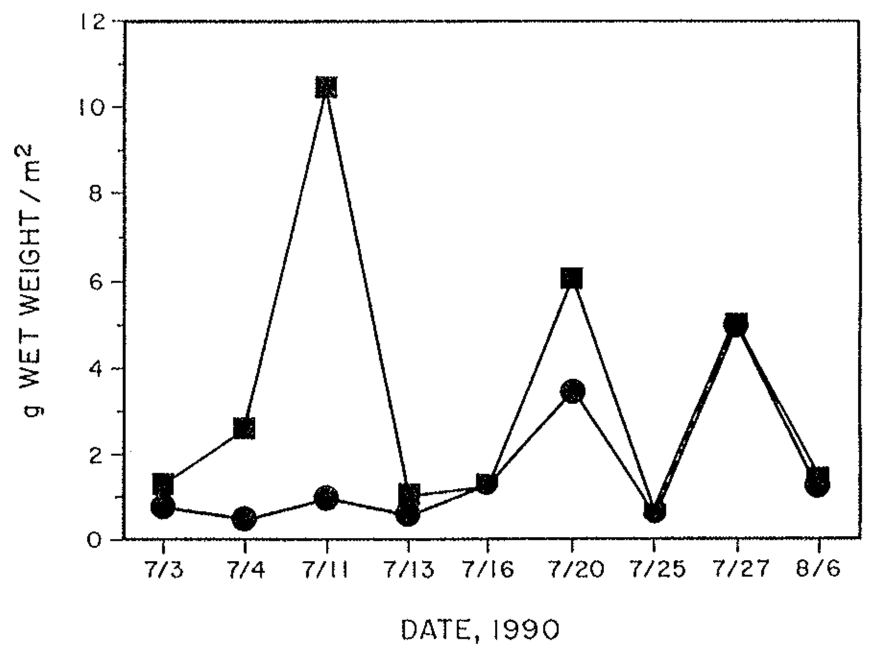


Figure 2. Standing crop (g/m^2 based on wet weights) of fishes in the Tivoli South Bay water-chestnut beds, summer 1990. Circles are resident species and squares are total of all fishes.

the movement of non-resident species through the study area. The non-residents had a much higher average wet weight prior to July 16 than afterwards (Fig. 3). Therefore much of the variation observed in the first half of the study was due to a very few large individuals (white perch and spottail shiners) passing through the water-chestnut.

Finally, there is patchiness in the distribution of resident species in the water-chestnut bed. The difference in magnitude of standing crop between July 20

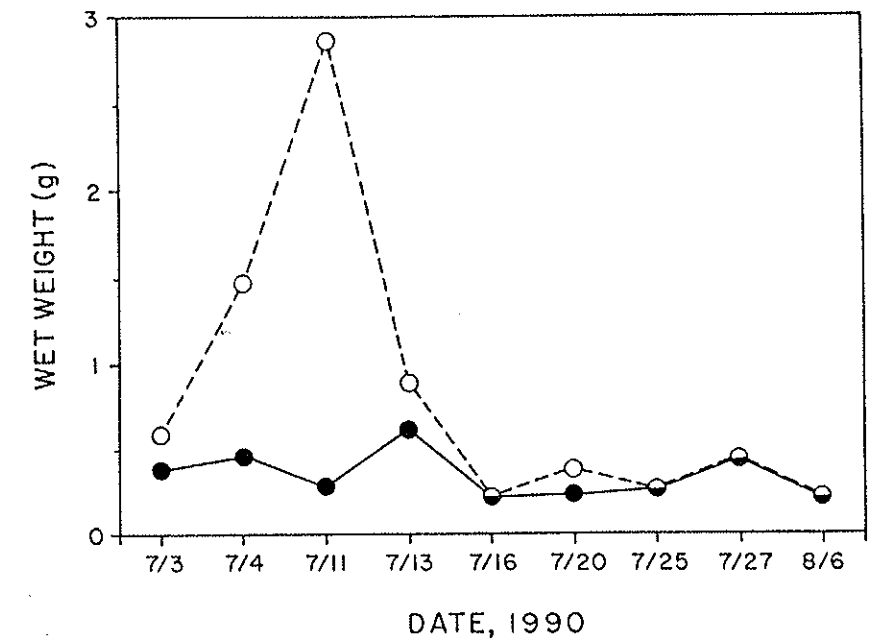


Figure 3. Average wet weights (grams) of fishes collected in the Tivoli South Bay water-chestnut beds. Solid lines are the resident species and dashed lines represent all species collected.

and 25 (Fig. 2) may reflect the patchiness of the resident species.

Our data are comparable to fish densities and standing crops from the other pop net studies. Serafy et al. (1988) reported standing crops of 5-8.5 g wet weight/m^2 (converted from dry weight by the method they described) from Hydrilla and Vallisneria beds, roughly the midrange of our standing crop values. Killgore et al. (1989) collected an average of 16.7-91.3 fish per pop net in Hydrilla which converts to 4.4-51.3 fish per our smaller pop net. Our average sample was 30.6 fish per pop net. Dewey et al. (1989) reported an average of 3.5-34.3 individuals per collection in a larger pop net with slightly larger mesh. This is an average of 14.1 fish per our pop net, lower than our collections.

Although we did not do a thorough literature survey, our impression is that standing crop values for fishes in aquatic vegetation are few and far between. Average values for three studies were between 10-13 g/m^2 from a variety of habitats (Table 2). Those averages are equivalent to our highest standing crop estimate and most of our values range from 50% to an order of magnitude lower than the average values reported in Table 2.

Findlay et al. (1987) in their estimate of the carbon flux in Tivoli South Bay used a value of 180 g wet weight/m^2 for standing crop of fishes. This number was derived from Rozas and Odum (1987) and was considered a high value. They also chose an arbitrary value of 1.0 g C/m^2 (20 g wet weight/m^2) as a low estimate of fish standing crop. According to our data, the low estimate used by Findlay et al. (1987) is still an order of magnitude too high.

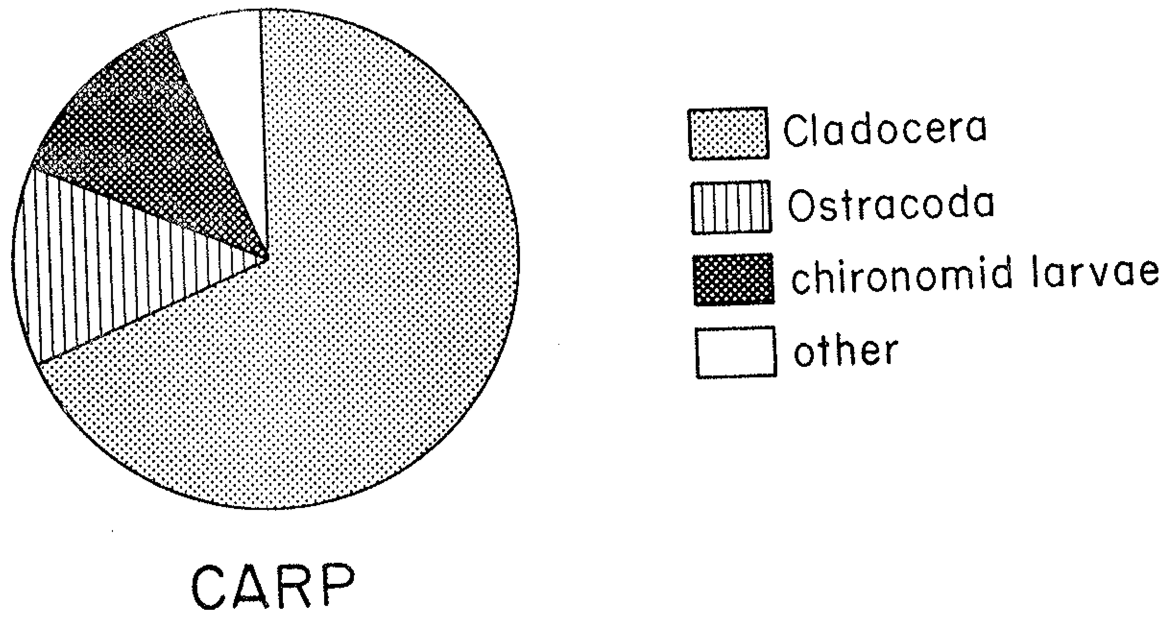
Findlay et al. (1987) suggested that consumption by fishes might exceed the secondary production and that

Table 2. Standing crops of fish communities from vegetated habitats. None of the collection methods are comparable to each other or to our study.

Standing Crop (g/m^2) Average	Range	Habitat	Citation
10	0.1-66	tropical mangrove	Flores-Verdugo et al. 1990
10.1	8.4-11.7	subtropical lake	Wegener et al. 1973
12.6	7.6-15.7	temperate brackish sound	Borawa et al. 1978

fishes in water-chestnut may be feeding on previously unknown food items or feeding outside of the plant beds. The latter may be happening in the non-resident species. Our estimates of standing crop suggest that the low biomass of fishes can be comfortably supported by the epiphytic invertebrate production.

The three main foods of resident (Fig. 4) and non-resident (Table 3) species were Cladocera, Ostracoda, and larval Chironomidae. Chironomids comprised a higher percentage of the fourspine stickleback than the diet of juvenile carp (Fig. 4). Cladocerans had consistently high significance values in all species (Table 3). Significance values for ostracods and chironomids were



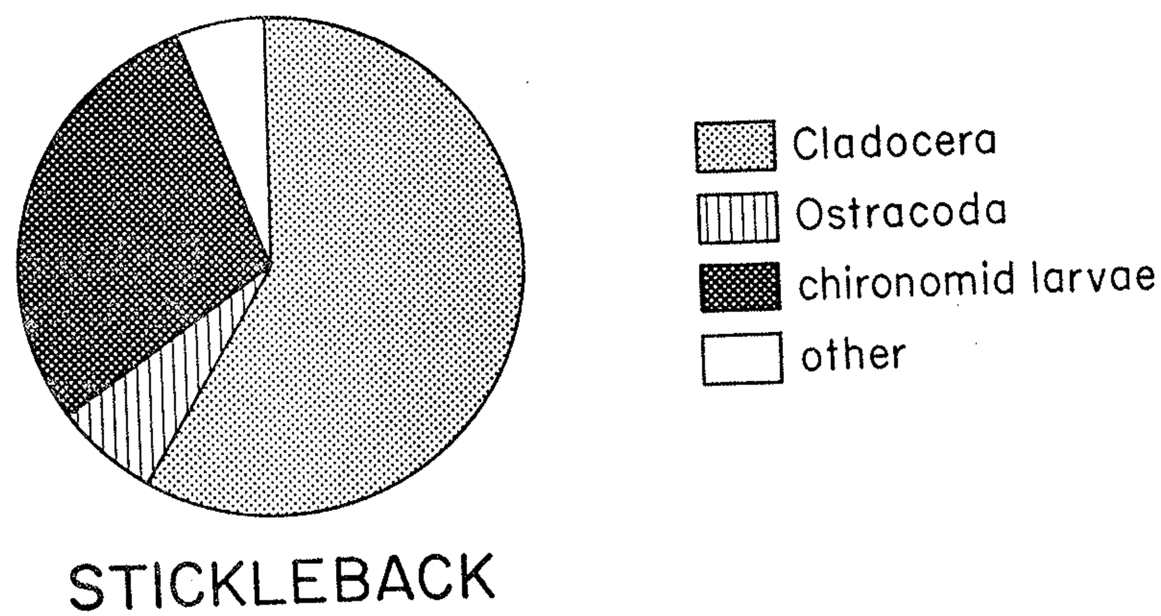


Figure 4. Percentages of food organisms based on total numbers from carp and fourspine sticklebacks in water-chestnut beds, Tivoli South Bay, 1990.

Table 3. Windell Significance values of the three major foods of fishes collected in water-chestnut beds, Tivoli South Bay, 1990.

Species	N	Significance Values		
		Cladocera	Ostracoda	Chironomidae
Fourspine stickleback	36	58.5	16.0	44.6
Carp	28	72.5	17.5	25.0
Banded killifish	4	57.4	42.1	23.0
Tessellated darter	4	47.1	-	64.6
Spottail shiner	2	68.2	-	-

more variable.

It is difficult to compare our diet analysis to other studies (Table 4) since there are several confounding variables that were not addressed consistently in all the studies. There are ontogenetic changes in diet, seasonal changes in the availability of prey, and habitat differences among the various studies done. Ostracods had a much lower significance in our study in all species than Yozzo and Odum (1990) reported from fishes collected on the edge of the water-chestnut beds. Likewise Yozzo and Odum (1990) reported a lower significance for cladocerans in all fishes they examined

Table 4. Comparison of Windell significance values for fishes in Tivoli South and North Bays. Food items are abbreviated: Clad = Cladocera, Ostr = Ostracoda, and Chir = Chironomidae larvae.

Species	Food	Study* 1	2	3	4	5	6
Fourspine stickleback	Clad	59	28-52				
	Ostr	16	41-44				
	Chir	45	60-65				
Carp	Clad	72		71+			
	Ostr	18		-			
	Chir	25		4			
Banded killifish	Clad	57	26-43	51+	32-81		
	Ostr	42	60-72	-	1-55		
	Chir	23	34-47	50	8-39		
Tessellated darter	Clad	47	18-54			6-35	
	Ostr	-	16-19			4-19	
	Chir	65	38-62			50-91	
Spottail shiner	Clad	68	11-42	84+			9-90
	Ostr	-	4-58	-			0-55
	Chir	-	27-75	-			8-90

*1 = this study; 2 = Yozzo and Odum, 1990; 3 = Sidari and Schmidt, 1990; 4 = Richard and Schmidt, 1987; 5 = Duryea and Schmidt, 1987; 6 = Smith and Schmidt, 1988

compared to ours. Ostracods were not seen in larval fish guts (Sidari and Schmidt, 1990) from the water-chestnut beds. Ostracods are abundant as epiphytes of <u>Trapa</u> (Yozzo and Odum, 1990) which suggests that there

is a difference in the perceived (by the fishes) availability of this prey in the water-chestnut beds as compared to the edge habitat.

When comparing banded killifish, tessellated darters, and spottail shiners from this study and Yozzo and Odum (1990) to the previous studies in Tivoli North Bay (Table 4), there is no pattern apparent in the data. The numbers of specimens of these species were very low in our study, however, and may not be an accurate representation of the water-chestnut food web.

DISCUSSION

The pop net used in this study successfully collected quantitative samples of fishes from an environment that has resisted sampling efforts in the past. This method would be useful in any submerged or emergent aquatic vegetation.

Because it was not possible to set pop nets from boats or with SCUBA divers, as reported in the previous studies (cited above), we used a smaller net and walked into the water-chestnut beds to set and retrieve the net.

Further design modifications might be useful. A heavier bottom frame would make setting the net in very dense (late summer) water-chestnut easier but would make carrying the net more difficult. Construction of the bottom frame should be done so that the outside of the bottom frame precisely lines up with the outside of the top frame (recall that the diameters of the pipe used for the top and bottom frame were different). This will facilitate placing the U-bolts without having them slip off. A rubber band placed over the ends of the U-bolts once they are in place might also help prevent the U-bolts from slipping off.

The preliminary data we collected on standing crop of fishes suggests that water-chestnut has a low density of juvenile and adult fishes compared to other submerged aquatic vegetation. This observation is in line with the food web described by Findlay et al. (1987) and correlates with the low dissolved oxygen values measured in South Bay water-chestnut beds in previous studies (Schmidt and Kiviat, 1988; Anderson and Schmidt, 1988).

These data also document part of the relationship between the water-chestnut beds and the fish populations in the main estuary. Carp are certainly an abundant species in the estuary and the substantial numbers of carp collected in this study and by Sidari and Schmidt (1990) suggest that water-chestnut beds are a significant nursery for this species. The role that carp have in the estuary has not been documented,

however.

The most abundant fish, fourspine sticklebacks, do not have an immediate and obvious connection to the fish community in the main estuary. Our subjective opinion is that sticklebacks are not commonly encountered in the open waters of the Hudson. We are not aware of any fishes (or other organisms) that prey heavily on sticklebacks either. This part of the water-chestnut food web may be mostly isolated from the rest of the Hudson ecosystem.

Given the small sample sizes of the non-resident species, we cannot address what significance the water-chestnut beds may have on species moving through the habitat. A much more intense sampling effort would be necessary to document any patterns in the appearance of these species.

RECOMMENDATIONS

Pop nets are potentially very useful, albeit labor intensive, for sampling fishes from dense aquatic vegetation. Any studies planned in the Hudson estuary that require quantitative esitmates of fish populations should consider the use of these sampling devices.

Any further studies done in water-chestnut beds should concentrate on estimating the variance in fish standing crop due to space, time of year, and diurnal changes. Replication of nets and a short sampling frequency would provide these estimates as well as providing better information on the non-resident species.

Studies on the life history of fourspine sticklebacks, especially including the seasons when water-chestnut is not present, would be especially important in understanding the dynamics of the fish populations in this habitat. Likewise, an understanding of the niche of carp in the Hudson estuary would be of value.

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