Trophic Status of the Spottail Shiner, (*Notropis hudsonius*) in Tivoli North Bay, a Hudson River Fresh-tidal Marsh

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ABSTRACT

Spottail shiners (Notropis hudsonius) collected in the tidal fresh-water Tivoli North Bay marsh fed primarily on Cladocera, Ostracoda, and Chironomidae. Size of the shiners was correlated with differences in feeding. Larger (>6 cm) individuals fed more on chironomids and less upon cladocerans than the small (<6 cm) individuals. Little change was seen over the summer except that large spottail shiners fed less heavily on Chironomidae later in the season.

The role of spottail shiners in the trophic dynamics of the marsh is to convert benthic and epiphytic invertebrates into forage fish biomass.

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INTRODUCTION

As part of a study on the Tivoli North Bay component of the Hudson River National Estuarine Research Reserve, Schmidt (1986) identified three species of fishes that he considered dominant in the summer community: banded killifish (Fundulus diaphanus), tessellated darter (Etheostoma olmstedi) and spottail shiner (Notropis hudsonius). Subsequently, trophic relationship studies were done on the first two species (Richard and Schmidt, 1987; Duryea and Schmidt, 1987). The purpose of this study was to delineate the feeding relationships of spottail shiners in Tivoli North Bay.

The role of tidal freshwater marshes in the Hudson estuary is considered important (Limburg, et al., 1986) but the specifics of mechanisms that couple high marsh productivity (Odum and Smith, 1981) to the open estuary are generally not known. Spottail shiners are a conspicuous presence in the Hudson estuary and were thus considered a significant species in power plant impact studies (Texas Instruments, 1981). Their small size (adults are between 8-10 cm total length- Schmidt, 1986) and apparent abundance suggest that they are important as a forage species for larger Hudson River fishes.

Odum, et al. (1978) described the fish nursery role of tidal freshwater marshes as one of the most significant ecological functions of the marsh. Spottails inhabit the

marshes from early larval stages (Schmidt - work in progress) through their first fall as juveniles (Schmidt, 1986; Rod and Sramek, 1986). Therefore, over an annual cycle, spottails can be seen as an exporter of marsh productivity in the form of forage fish biomass. A significant part of understanding this relationship, then, is the trophic status of spottail shiners in the marsh.

Life histories and general feeding habits for spottails have been published (Anderson and Brazo, 1978; Smith and Kramer, 1964; Wells and House, 1974; McCann, 1959; Griswold, 1963) but these studies, without exception, looked at midwestern lake populations. It is ironic that so little data exist for the Hudson population, the type locality of the species.

METHODS

Study Area

This study was done in Tivoli North Bay, a tidal freshwater marsh on the Hudson River estuary (river mile 99), New York. Tivoli North Bay is part of the Hudson River National Estuarine Research Reserve and has been designated as an Experimental Ecological Reserve.

Tivoli North Bay is a high marsh dominated by narrowleaf cattail (Typha angustifolia). Stable winding channels are found throughout the marsh which, with a tidal range of about 1.2 m, vary in depth from about 1.3 m

at low tide to about 2.5 m.

The sites chosen for this study were the wide channels that flow into large pools in the middle of the marsh. Sites most frequently sampled were the channel west of Redcedar Bluff (Figure 1- A) and the large pool east of Magdalen Island (Figure 1- B). The channels and pool are very shallow at low tide. The substrate is soft muck on the channel and pool margins and is composed of firmer clay in the center. Typical emergent vegetation in the vicinity of the sample sites was arrow arum (Peltandra virginica), arrowhead (Saggitaria sp.), pickerelweed (Pontedaria cordata), burrmarigold (Bidens sp.), dotted smartweed (Polygonum sp.) and narrowleaf cattail. The dominant submergent vegetation was water celery (Vallisneria americana) and Eurasian water milfoil (Myriophyllum spicatum).

Procedure

Sampling was done at or near low tide during the day. Fishes were collected with a 3/16-inch Ace knotless nylon mesh 17.5 m bag seine. We collected approximately once a week from June 15 through August 16, 1987. On each date, we collected until 10-15 adult specimens and 15 juvenile specimens were captured, if possible. Spottail shiners were narcotized in carbonated water in the field to reduce possible regurgitation of stomach contents (K. Limburg, pers. comm.) and then preserved in 10% formalin.

In the laboratory, shiners were measured (total length

to the nearest mm) and digestive tracts were dissected out. Since Notropis have no morphological stomach, we arbitrarily designated the anterior loop of the digestive tract as the stomach. The contents of the stomachs were removed, identified (Pennak, 1953), and counted under a stereo dissecting microscope. After dissection, the shiners and stomach contents were stored in 50% isopropanol.

The importance of various food items in the diet was calculated 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 to 100; % Occurrence is the percentage of fish that contain a particular item out of the total number of fish examined; and % Composition is the average percentage that an item contributes to the total of all food items in the sample. All calculations were made only on those shiners containing food.

The shiners collected were arbitrarily divided into 5 mm size categories. Significance for each food item was then calculated for spottail shiners pooled into each size group. The significance data were plotted against size categories and a linear regression was calculated from the data. A t-test was done on the regression line to determine if the slope was significantly different from zero

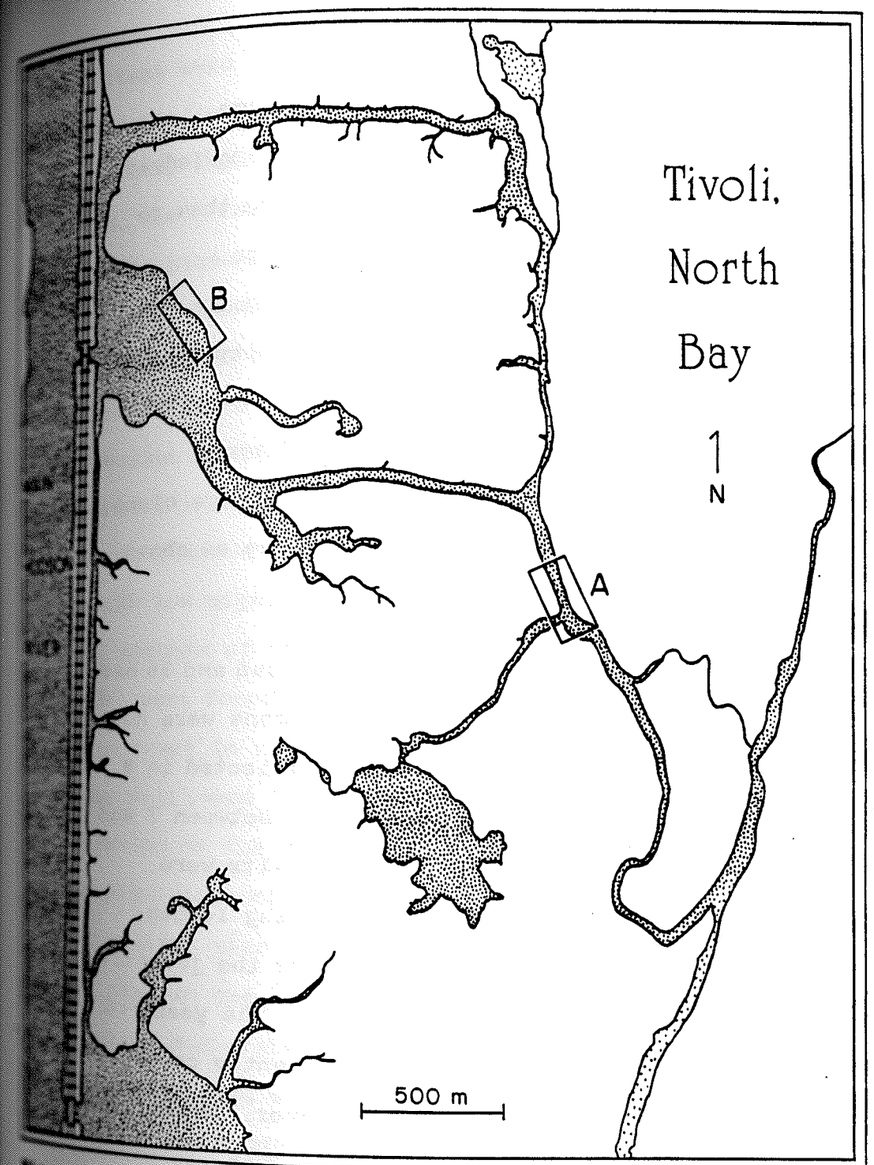

Figure 1. Study area in Tivoli North Bay, Hudson River, New York. Spottail shiners were collected at the sites marked A and B.

(Chatterjee and Price, 1977).

Spottail shiners were also divided into two age classes, young of the year (juvenile) and yearling (adult) by constructing length frequencies and comparing them to Schmidt (1986). In that study (Schmidt, 1986) age classes of spottail shiners were determined by scale annuli and length frequency from the same locality as our study. Significance for each food item was then calculated for each collection for each age class. Significances were plotted against time for each age class and regression lines were drawn and t-tests done as above.

RESULTS

A total of 139 spottail shiners was dissected and 36 had no food in their stomachs. These latter specimens were not included in the analysis. The shiners were collected in 8 samples from June 15 through August 16, 1987. Between 7 and 15 juvenile specimens and between 0 and 15 adults were examined from each sample. Schmidt (1986), using length frequency and scale annuli data indicated that the juvenile age class described in this study is young of the year (<6.7 mm total length). We were not able to consistently capture adult spottails (>7.8 mm total length), however, contrary to Schmidt (1986), the adults did not disappear from the marsh in July and August but were collected through August 16. The range of sizes in this study was 1.1-9.9 mm total length.

Food items were lumped into 10 descriptive categories: Ostracoda, Cladocera, Chironomidae, unidentified, Amphipoda, aquatic mites, Copepoda, Diptera, Notonectidae, and flatworms. The first three taxa in this list were consistently present in shiners from all samples and generally had relatively high significance values. Therefore, we concentrated on analyzing these taxa.

The unidentified category was also common but adds little to information on feeding relationships. Amphipods and aquatic mites occasionally had high significance values (>30) and all the rest of the taxa were seen very infrequently and always with low significance values.

Small amounts of plant material (filamentous green algae and seeds) were found, undigested, throughout the entire digestive tract in a few stomachs examined. We believe that algae was swallowed incidentally and did not contribute to the nutrition of the fish.

When significances of the three major food items were plotted against size of spottail shiners (Figures 2, 3 and 4), the fish in the three smallest size classes (1.1-2.5 mm) seemed to be disparate data points, especially in Figure 2. We eliminated these size classes from further analysis but these data suggest that the small spottail shiners have very different behavior patterns than older fish.

A regression (Figure 2) of cladoceran significance versus size groups had a significant ($p > .95$) negative slope (Y =

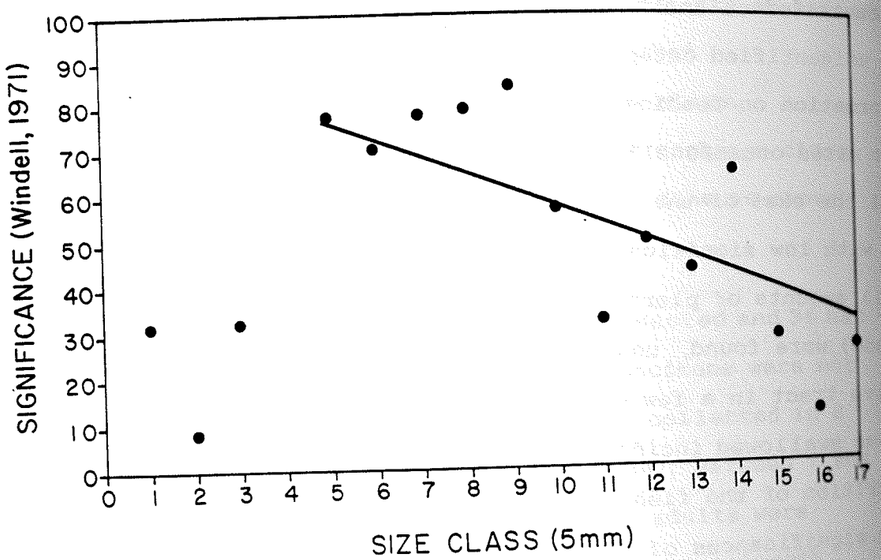

Figure 2. Significance of Cladocera in the diet of spottail shiners by size class. Data points for size classes 1, 2 and 3 were not included in the regression analysis.

.1.8X + 95.5; R = .75) while a similar regression for chironomid significance (Figure 3) had a significant positive slope (Y = 3.8X - 8.6; R = .68). These data suggest that larger spottail shiners select more chironomids and less cladocerans than smaller fish. Ostracod significance did not change with fish size since the slope of the fitted regression line (Figure 4) was not statistically different from zero (Y = 0.68X + 15.4, R = .14).

Within the first age class, young of the year shiners tended to have higher significance values for Cladocera than ostracods or chironomids although the scatter in a plot of significance versus time is large. Diet did not change with time during the study period; none of the regressions in Figure 5 had slopes statistically different from zero (Cladocera: Y = 0.42X + 43.3, R = .37; Ostracoda: Y = -0.27X + 37.3, R = .20; Chironomidae: Y = -0.24X + 28.4, R = .23).

The adult shiners showed a decrease in ostracod significance over time (Figure 6). The regression had a statistically significant negative slope (Y = -0.86X + 55.6, R = .72). The other two regressions indicated no change in significance values over time (Cladocera: Y = -0.25X + 33.2, R = .31; Chironomidae: Y = -0.26X + 39.7, R = .28). Adult shiners did have relatively high significance values for aquatic mites and amphipods especially later in the summer.

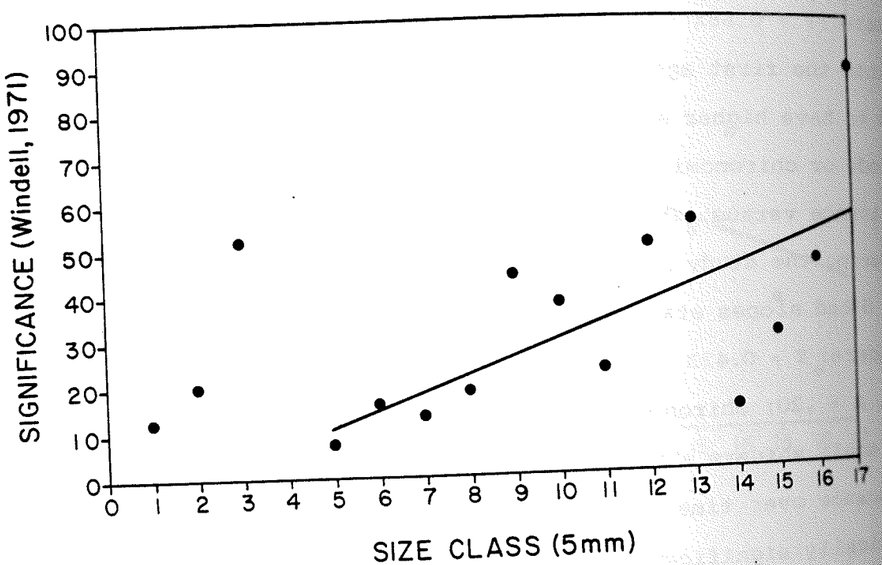

Figure 3. Significance of Chironomidae in the diet of spottail shiners by size class. Data points for size classes 1, 2 and 3 were not included in the regression analysis.

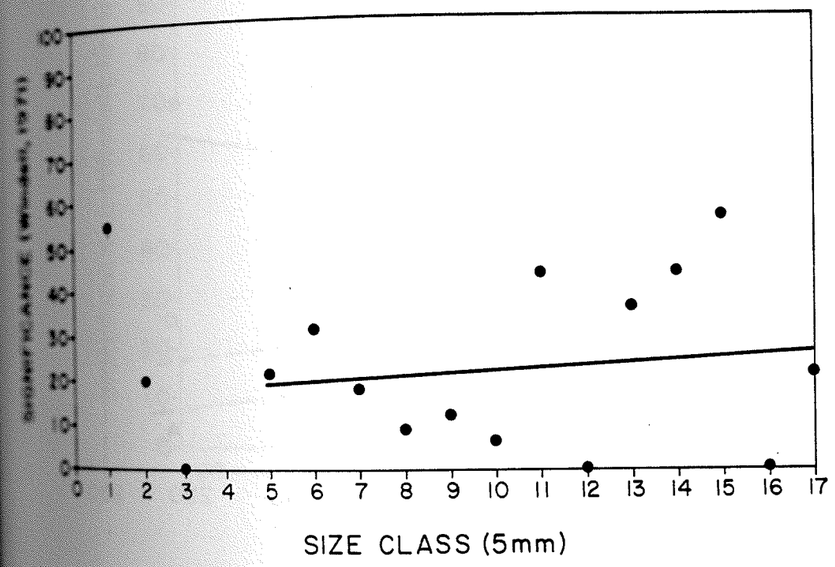

Figure 4. Significance of Ostracoda in the diet of spottail shiners by size class. Data points for size classes 1, 2 and 3 were not included in the regression analysis.

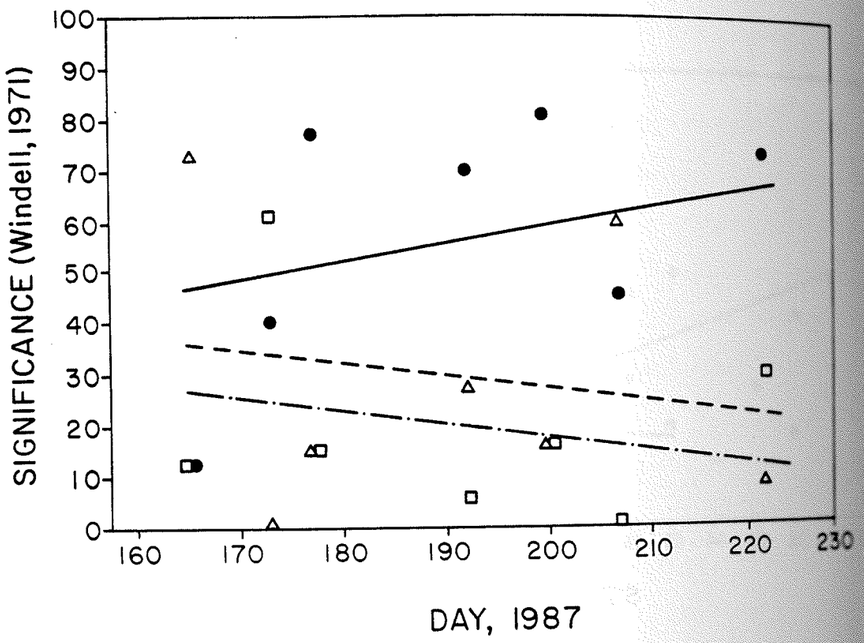

Figure 5. Significance of Cladocera (●,——), Ostracoda (△,---), and Chironomidae (□,—·—) over time for juvenile (<6.7 mm) spottail shiners.

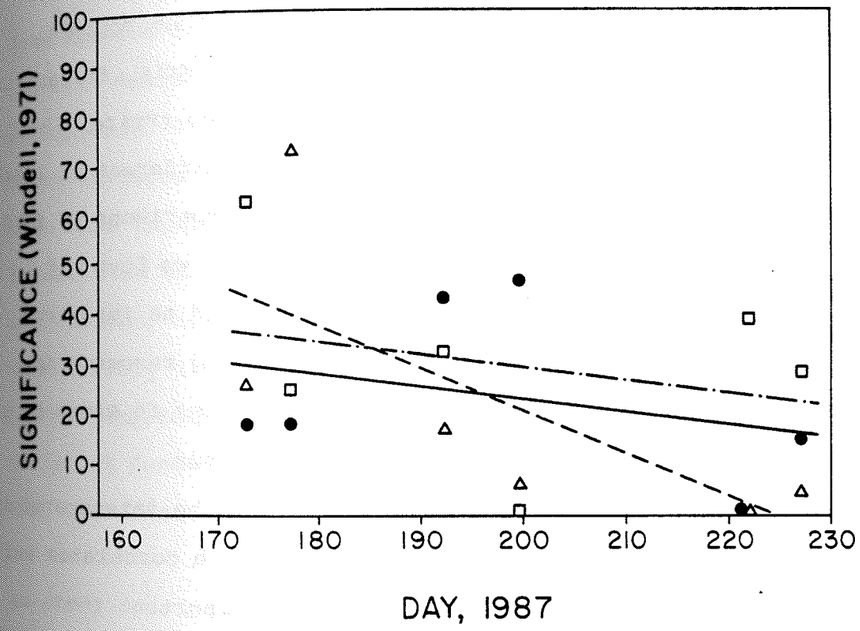

Figure 6. Significance of Cladocera (●,——), Ostracoda (△,---), and Chironomidae (□,—·—) over time for adult (>7.8 mm) spottail shiners.

DISCUSSION

Spottail shiners in Clear Lake, Iowa fed on insect larvae, Cladocera, algae and aquatic mites (McCann, 1959; Griswold, 1963) but there was no indication of differences among age classes. In Red Lake, Minnesota (Smith and Kramer, 1964), spottails less than 10 mm ate rotifers and algae, 10-70 mm fish fed on Cladocera, and larger fish ate Ephemeroptera nymphs, molluscs, and other shiners. In Lake Erie, fingernail clams (Sphaeriidae) were very important foods (Price, 1961). Since the resource bases are probably very different in lakes compared to Hudson River marshes, direct comparisons of food items with the above are not too useful, but we found it interesting that aquatic mites were mentioned as important foods. This seems to us to be an unusual food resource for fishes and we did see them with some frequency in stomachs of larger spottails towards the end of the summer.

In general, the published literature can be interpreted to say that spottails are benthic feeders, which correlates well with its subterminal mouth. Of the three important foods we found in spottail stomachs, at least two of them are benthic or epiphytic resources: Chironomidae and Ostracoda. The ostracods were mostly Cypria cf palustera, a primarily epiphytic organism (Yozzo, pers. comm.). The Cladocera could be epiphytic as well.

We found most of our specimens in shallow to moderately deep channel margins usually in association with dense

vegetation (water chestnut, Eurasian water milfoil, water celery). Coupled with the observations above, this suggests that the trophic role of spottail shiners in the marsh is to convert benthic and epiphytic invertebrates to forage fish biomass.

The general food items taken by the other two important fish species studied in the marsh were similar to spottail shiners. Banded killifish (Fundulus diaphanus) also fed on chironomids, cladocerans, and ostracods but do so on the marsh surfaces (Richard and Schmidt, 1987). Banded killifish also take copepods, which were rare in spottail stomachs. Tessellated darters (Etheostoma olmstedi) fed on chironomids, cladocerans, copepods and ostracods with the latter considerably less significant that the other three categories (Duryea and Schmidt, 1987). Spottails seem to have a somewhat different feeding pattern than tessellated darters although they are often found in the same habitat.

CONCLUSIONS AND RECOMMENDATIONS

Feeding habits of spottail shiners change with size; larger individuals concentrating more on Chironomidae and less on Cladocera than smaller individuals. Ostracods are also important foods for all sizes. Within age classes, there was little change over the summer in foods consumed. The use of chironomids did decline in adults over the season.

Spottails are converting epiphytic and benthic

invertebrates into forage fish biomass. Further studies should be directed at determining the role of spottail shiners as a forage base in and out of the marsh.

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