White Perch (*Morone americana*): Diet and Food Web Support in the Hackensack Meadowlands

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Introduction:

The New Jersey Meadowlands Commission (NJMC) through MERI conducted a fisheries resource inventory of the lower Hackensack River and its major tributaries. This study replicated the work that was done during a similar fisheries study between February 1987 and December 1988. The primary purpose of the new study was to inventory the fishery resources of the lower Hackensack River, with an emphasis on determining if the fish community has responded to perceived improvements in water quality over the past 13 years.

The study inventoried the fisheries resources of the lower Hackensack River and its major tributaries (Sawmill Creek, Berry's Creek, Mill Creek, and Cromakill Creek) using four different gear types; otter trawls, trap nets, gillnets and seines. A total of nine trawling locations, six trap net locations, three gillnet locations and three seine locations were fished on a monthly basis during the first year of the study. Fishes collected during the study were identified, counted, measured and weighed. Most were returned to the water. Some were retained for tissue analysis for contaminants, while others were kept for further identification or as voucher specimens.

Additional Studies

We performed two additional studies that supplement the work conducted by MERI. This section describes the additional studies on diet and food web.

Food Habits Study

We used some of the specimens of white perch, *Morone americana*, collected for tissue analysis of contaminants, to perform a food habits study. A close relative of the striped bass (*M. saxatilis*), it is an important food fish in the Chesapeake Bay and elsewhere, and is caught both commercially and for sport. It is an abundant species in the brackish water of the Hackensack estuary, and was one of the most commonly caught fish species in both the current survey and the previous survey a decade ago. This study was performed in order to: 1) identify the prey

organisms consumed by examining stomach contents of captured fish, and 2) analyze tissue samples for stable isotopes to determine the origin of primary production. It is of interest to know which plants form the base of the food web supporting them. Organic matter from terrestrial sources carried by rivers, phytoplankton, benthic microalgae, and detritus from marsh plants can all play a role, but in order to ascertain the relative importance of each, stable isotopes of carbon, nitrogen and sulfur can be examined. The use of stable isotopes to determine food web structure involves the comparison of stable isotope ratios between consumers and their food resources. The distribution of the rarer, heavier stable isotope of an element varies in the biosphere due to variations in the rate at which it participates in reactions. For example, the RUBISCO enzyme in photosynthesis discriminates against the heavier ^{13}C atoms, so that all plant material is depleted in ^{13}C relative to atmospheric CO_2. There is also a fractionation of isotopes when animals assimilate their food so that the isotopic composition of primary producers at the base of an animal's food chain can be deduced from the isotopic composition of the animal. In estuaries, the C stable isotopes are most useful in discriminating between phytoplankton, benthic microalgae, and marsh plants at the base of the food web (Sullivan and Currin, 2000).

The invasion of the common reed, *Phragmites australis* into Atlantic coast brackish marshes has been of considerable concern (Chambers et al. 1999), especially since it has traditionally been considered to be of little value as food or habitat to fishery resources (Weinstein and Balletto 1999). In the Hackensack Meadowlands and elsewhere many marsh restoration projects involve the removal of this species and replacement with *Spartina alterniflora*. However, the stable isotope technique was used by Stribling and Cornwell (1997) to demonstrate that in lower salinity wetlands of Chesapeake Bay, C3 plants (*Juncus roemerianus* and *Phragmites australis*) contributed to the food web, along with the C4 plant *Spartina alterniflora*, and benthic microalgae. In southern New Jersey, Wainright et al (2000) determined that for killifish (*Fundulus heteroclitus*), the mixture of

primary producers depends on the relative abundance of different plants. In *Spartina*-dominated sites, isotope ratios indicated that the killifish were supported by *Spartina* production, and in *Phragmites*-dominated marshes, the killifish were supported by that plant. Benthic microalgae (primarily diatoms) also were important, but phytoplankton were relatively unimportant. Weinstein et al. (2000) similarly showed the incorporation of *P. australis* production into the food web supporting white perch and bay anchovy (*Anchoa mitchelli*) in Delaware Bay. Since *P. australis* is the dominant wetland plant in the Meadowlands and is viewed as an undesirable invader, it is frequently removed and replaced with *S. alterniflora* in wetland restoration projects in the area. It was therefore of interest to examine whether it contributes to the food web of the white perch.

Methods:

Stomach Contents:

During the dissection of white perch for chemical analysis, the fish stomachs were preserved in 10% formalin while on the collecting boat. In the laboratory, the stomachs were opened, and the contents placed in a petri dish. The stomach contents were examined under a stereo dissecting microscope, and separated by taxonomic category (e.g., forage fish, grass shrimp, other crustaceans, insect larvae, worms, mollusks and detritus). Taxonomic identification proceeded as far as is possible given the condition of the stomach contents. Weights (dried) of each component were determined for each category.

Stable Isotope Analysis

Samples of *Spartina* and *Phragmites* (the main macrophyte primary producers) from the Meadowlands (Saw Mill Creek), as well as a samples of fish muscle tissue from individual white perch were set aside, oven-dried to constant weight, and sent to the laboratory of Dr. Robert Michener at Boston University for stable isotope analysis. Four samples of each plant, and 12 samples of the fish (three from each season of the year) were analyzed. Analysis was performed with a continuous flow elemental analyzer (ANCA-GSL)/mass spectrometer stable

isotope ratio analysis system. Standards from N.I.S.T. for animal and plant material as well as methods blanks were routinely analyzed for quality control/assurance. For peptone, the expected $\delta\ ^{13}C$ was –14.7, and three standards were –14.78, -14.78 and –14.62. The expected $\delta\ ^{15}N$ was 7.4 and three standards were 7.04, 7.04, and 7.21. For glycene, the expected $\delta\ ^{13}C$ was –34, and three standards were –33.92, -33.92, and –34. The expected $\delta\ ^{15}N$ was 10.7, and three standards were 10.78, 10.78, and 10.86.

Carbon stable isotope ratios provide information about the base of the food web, and nitrogen stable isotope ratios provide indication about how high on the food web the fish are feeding.

Results and Discussion:

Food Habits:

Many of the fish were collected in trap nets that were set one day and retrieved the following day. Therefore, many of the captured fish had empty stomachs by the time they were collected. In comparing the proportion of fish with and without food in their stomachs, differences were seen among the different months. We also compared the lengths (L) and condition factors (K) of fish with and without food in their stomachs. The data are seen in Table 1.

Table 1

Month	% w food	L with food	L w/o food	K with food	K w/o food
July	23%	243 ± 18.3	241 ± 31.0	1.40 ± 0.18	1.46 ± 0.10
Aug	0		253.1 ± 34.6		1.45 ± 0.12
Sept	100%	215 ±15.6		1.45 ± 0.13	
Oct	75%	214.8 ± 49.5	171 ± 10.1	1.43 ± 0.22	1.42 ± 0.19
Nov	25%	233.2 ± 23.1	212.9 ± 39.7	1.54 ± 0.09	1.43 ± 0.17
Dec	85%	182.9 ± 16.0	177.7 ± 18.1	1.46 ± 0.14	1.47 ± 0.06
Mar	63%	172.4 ± 20.1	180 ± 20.2	1.28 ± 0.16	1.13 ± 0.30
Apr.	72%	228.5 ± 25.3	226.7 ± 20.2	1.71 ± 0.14	1.57 ± 0.12
May	47%	233.3 ± 12.7	241.3 ± 10.2	1.50 ± 0.18	1.49 ± 0.09
June	20%	231.8 ± 17.7	232.4 ± 33.1	1.38 ± 0.09	1.49 ± 0.14

There appears to be a somewhat greater percentage of fish with empty guts in the warmer months. This may be due to more rapid digestion during those months. (The high proportion of fish in September with food in their guts is due to their having been captured in a seine net and processed quickly, rather than having the long delay after capture in trap nets.) The winter collections (December and March) had somewhat smaller fish than the collections at other times of the year. However, at any given month, there is no difference in the total lengths of the fish that had vs. those that did not have food in their stomachs. An ANOVA for K factor for all months, with and without food was significant ($F = 4.45$, $p < 0.0001$), but Bonferroni pairwise comparisons revealed no groups that were significantly different from other groups. The overall mean K for all fish was 1.47 + 0.15. The K for all fish with food in their guts was 1.50 + 0.16, while that for fish without food was 1.45 + 0.14. There was only one month, April, in which there was a significant difference between the K of fish with vs without food by t-test ($t = 2.18$, $p = 0.04$). This difference may be due to the contribution of the gut contents themselves to the weight of the fish, thus appearing to increase the K factor.

The major prey items noted in the stomachs were shrimp, gammarid amphipods, plant material, and fish. In most of the stomachs, varying amounts of

unidentifiable material were seen, due to its advanced state of digestion. Other prey items that appeared infrequently in the stomachs were insects and isopods.

Table 2 indicates for each month of collection, the actual number of fish with food in their stomachs, the total dry weight of the stomach contents and percent of the dry weight due to shrimp, amphipods, plant material, fish, and unknown material. It can be seen that the weight of the stomach contents was greatest in the fish caught in April. This supports the idea, mentioned earlier, that the different (higher) condition factor for fish that month compared to fish without food in their guts was due to the contribution of the weight of the stomach contents to the weight of the fish.

Table 2

Month	N	Dry wt.	% shrimp	% amphip	% plant mat.	% fish	% unknown
July	6	0.318	10	25	4	0	61
Sept.	4	0.116	0	0	3	0	97
Oct	12	1.56	49	1	0	26	24
Nov	5	0.056	0	2	0	0	98
Dec	17	1.441	24	15	0	0	61
March	5	0.667	0	89	0	0	11
April	18	2.21	1	31	0	17	51
May	7	0.456	0	2	1	79	18
June	4	0.074	0	0	0	0	100
Whole Year		6.90	17	23	<1	17	43

The weight of the gut contents appears to be somewhat less in the summer months than the rest of the year. This parallels the percentage of fish with food in their stomachs at different times of the year, and, as mentioned before, may be an artifact due to more rapid digestion in the warmer weather.

The overall diet is dominated by gammarid amphipods, with smaller amounts of shrimp and fish prey. The fish as prey appear to be equivalent to shrimp (17%) in terms of their contribution to the diet by weight. However, this percentage

represents far fewer individual prey fish because of their larger size and greater proportional contribution to the weight of the gut contents. In point of fact, among all the fish examined, only three individual white perch had fish in their stomachs. Amphipods, by virtue of being small in size, contributed far more in terms of numbers of individuals to the diet. There was only one month (September) in which recognizable gut contents were found in some of the white perch collected that amphipods did not contribute to the gut contents.

Table 3 shows the number of amphipods in the stomachs of white perch for each month.

Table 3

Month	**Amphipod count ± SD**
July	22.5 ± 31.9
September	0
Oct	1.58 ± 3.22
Nov	1.2 ± 2.4
Dec	7.88 ± 7.11
Mar	14.8 ± 7.6
Apr	10.05 ± 17.3
May	1.75 ± 2.16
June	0.5 ± 0.86

The importance of gammarid amphipods in the diet reinforces results of Weisberg and Jannicki (1990) who studied which perch diets in the freshwater portion of the Susquehanna River, Maryland. They found that *Gammarus fasciatus* accounted for over 40% of the diet. Since they captured fish by electroshocking, there was not such a delay in obtaining the gut contents as there was in the trap net sampling utilized in the present study. The delay in our study accounts for the large percentage of fish with empty guts as well as the large amount of unidentifiable (digested) material in the guts. Weisberg and Jannicki (1990) found that the gammarid amphipods accounted for a greater percentage of the white perch diet in the early fall than in the summer, which is different from our results, but they did not sample in the spring, the time when our fish had the greatest

proportion of amphipods. In their fish, gammarids were more important in the diet for fish that were under 200 mm long than for larger individuals. Similarly, in the Hudson River estuary, Gammarid amphipods were the single most important component of white perch diets, comprising almost 40% of the diet of both juvenile (<110 mm) and adult individuals, as seen by Bath and O'Connor (1985). In our fish, for all the collections, the number of amphipods averaged 6.36 + 7.38 in white perch smaller than 200 mm, and 7.2 + 16.8 in individuals larger than 200 mm, so there was no significant difference between the numbers of amphipods in the stomachs of smaller vs larger fish.

Stable Isotope Analysis:

The C and N isotopes of white perch caught during different seasons, as well as the isotope signature for live and dead *Spartina alterniflora* and *Phragmites australis* are shown in Figure 1. The $\delta\ ^{13}C$ isotope composition of the fish reflects the primary producer at the bottom of the food web. It can be seen that the $\delta\ ^{13}C$ values for white perch are closer to those of *P. australis* than to *S. alterniflora*. The marshes around the Hackensack River are heavily dominated by the former species. Also, benthic microalgae, which were not measured in this study, tend to have stable C isotope values in the same general area (around –17 to –24), so they are likely to be significant contributors to the stable isotope composition of the white perch. Amphipods, the major prey item of white perch, probably consume benthic microalgae as well as macrophyte detritus. Numerous studies have indicated that amphipods obtain a significant portion of their C from benthic microalgae (Sullivan and Currin 2000). There appear to be some differences in the isotope composition of fish collected at different seasons of the year, but they are variable and there are no statistically significant differences among them. It is also interesting to note the rather large difference in $\delta\ ^{13}C$ between live and dead *Phragmites* samples. Such a large difference in C isotope value for live and dead *Phragmites* has not been reported before. The lower $\delta\ ^{15}N$ values for dead relative to live plant material has been reported before (Currin et al 1995). The levels in the dead, rather than live, plant samples are closer to the levels in most of the fish samples. This is consistent

with the food web contribution of the plant material after it has died and become detritus. Since the Meadowlands are dominated by *Phragmites australis*, it is not surprising that the isotopic signature is consistent with the incorporation of *Phragmites* production into the food web for white perch. In a feeding study with invertebrates (Weis et al. 2001) it was found that *Spartina* detritus and *Phragmites* detritus supported survival and growth of fiddler crabs (*Uca pugnax* and *U. pugilator*) and grass shrimp (*Palaemonetes pugio*) equivalently. Detritus from both species was able to support limb regeneration and molting of *U. pugilator*, and survival but not regeneration and molting of *U. pugnax*. Neither detritus diet was sufficient to support survival of grass shrimp, however.

The δ ^{15}N isotope levels reflect the level on the food web at which the fish have been feeding. It is interesting to see that the largest fish in the collection had the highest δ ^{15}N, and small fish tended to be low, reflecting that the largest fish fed higher up on the food web. However, there was no overall significant correlation of fish size with δ ^{15}N. A number of the fish had lower δ ^{15}N levels than the two plants, although there is supposed to be an increase going up the food chain. The δ ^{15}N levels for benthic microalgae are 7-10 (Sullivan and Currin, 2000), so this is strong evidence for their being a major contributor to the food web of the white perch. It appears that both ontogenetic changes in diet and seasonal changes in food web structure appear to be affecting the fish's N values.

Currin et al. (2003) studied the stable isotope levels in primary producers and killifish (*Fundulus heteroclitus*) at *Spartina*, *Phragmites*, and restored *Spartina* sites in southern NJ. At their Alloway Creek sites, the δ ^{13}C values corresponded to values for benthic microalgae, and were midway between the values for *Spartina* and *Phragmites*. They concluded that both macrophytes and the benthic microalage contributed to the food web for *Fundulus*. The mean value for fish

inhabiting the restored marshes was intermediate between fish from the natural *Spartina* and from the *Phragmites* marshes. In contrast, our white perch were much closer to the *Phragmites* values. It is difficult to discriminate between benthic microalgae and *Phragmites* contributions using C isotopes, however.

The δ ^{15}N isotope levels are useful for determining the trophic position of consumers, and those of the killifish suggested ontogenetic changes in the trophic position of the fish as they matured (Currin et al. 2003). The average enrichment in consumer δ ^{15}N is 3.4 per mil per trophic level and it appeared that the fish were feeding about two levels above primary producers. The δ ^{15}N for the 20-40 mm fish were 12-14, while the larger fishes (60-80 mm) tended to be 16-18. At their Hog Island site, however, the δ ^{15}N values tended to be 7-10, considerably lower, but so were the primary producers (at 3-6). This was attributed to lower anthropogenic N inputs at Hog Island. The δ ^{13}C values were consistent with a diet derived 75% from *Phragmites* and 25% from *Spartina*, while the δ ^{15}N values suggested greater input from benthic microalgae.

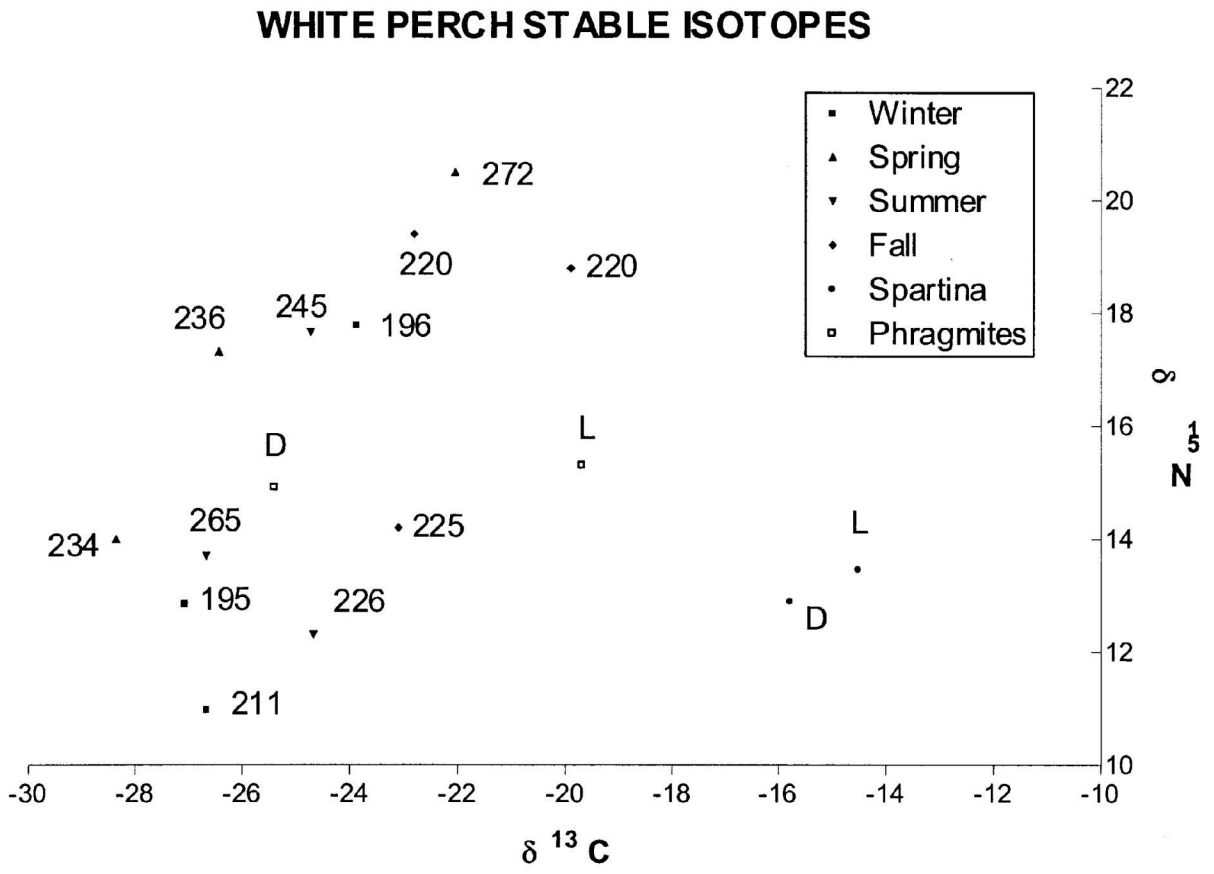
Litvin and Weinstein (2003) studied stable isotopes of white perch in Delaware Bay creeks and found δ ^{13}C values of -23-24, similar to ours, and δ ^{15}N levels of 13-14, similar to some of ours.

Given the average change in consumer δ ^{15}N of 3.4 per mil per trophic level, it appears that our white perch are from two different trophic levels, one group of 6 fish with 10-14, and the other group of 6 fish at about 18-20. However, both groups include fish from all seasons and include both small and large individuals. Of our white perch, only the largest individual caught (272 mm) had a δ ^{15}N value over 20. The values for our white perch suggest that while half of them were feeding at the same trophic level as juvenile *Fundulus,* others were feeding at levels comparable to or slightly higher than the larger killifish.

Conclusion:

Stable isotope data suggest that white perch, despite their greater size, do not appear in general to feed higher on the food chain than killifish, and that microalgae are the major contributor to their food web, followed by detritus of *Phragmites australis*. Their gut contents, dominated by amphipods, support this conclusion.

Figure 1. Stable isotopes of N and C for white perch collected during different seasons of the year, and of plant samples. The number by each white perch represents the length of the fish. "L" and "D" by the plant samples indicates whether they were live or dead leaves.



Literature Cited

Bath, D.W. and J.M. O'Connor 1985. Food preferences of white perch in the Hudson River estuary. N.Y. Fish and Game J. 32: 63-70.

Chambers, R.M., L.A. Meyerson and K. Saltoonstall 1999. Expansion of *Phragmites australis* into tidal wetlands of North America. Aquat. Bot. 64: 261-273.

Currin, C.A., S.Y. Newell, and H.W. Paerl 1995. The role of benthic microalgae and standing dead *Spartina alterniflora* in salt marsh food webs: Considerations based on multiple stable isotope analysis. Mar. Ecol. Prog. Ser. 121: 99-116.

Currin, C.A., S.C. Wainright, K.W. Able, M.P. Weinstein and C.M. Fuller 2003. Determination of food web support and trophic position of the mummichog, *Fundulus heteroclitus*, in New Jersey smooth cordgrass (*Spartina alterniflora*), common reed (*Phragmites australis*) and restored salt marshes. Estuaries 26: 495-510.

Stribling, J.M. and J.C. Cornwell 1997. Identification of important primary producers in theChesapeake Bay tidal creek system using stable isotopes of carbon and sulfur. Estuaries 20: 77-85.

Sullivan, M.J. and C.A. Currin 2000. Community structure and functional dynamics of benthic microalgae in salt marshes. In: Concepts and Controversies in Tidal Marsh Ecology, ed. M.P. Weinstein and D. Kreeger. Kluwer Acad. Publ., Dordrecht. Pp 81-106.

Summers, K. Folmar, L. and Rodon-Naveira, M. 1997. Development and testing of bioindicators for monitoring the condition of estuarine ecosystems. Environ. Monit. Assess. 47: 275-301.

Wainright, S.C., M.P. Weinstein, K.W. Able and C.A. Currin 2000. Relative importance of benthic microalgae, phytoplankton and the detritus of smooth *cordgrass Spartina alterniflora* and the common reed *Phragmites australis* to brackish-marsh food webs. Mar. Ecol. Prog. Ser. 200: 77-91.

Weinstein, M.P. and J.H. Balletto 1999. Does the common reed *Phragmites australis,* affect essential fish habitat? Estuaries 22: 793-802.

Weinstein, M.P., S.Y. Litvin, K.L. Bosley, C.M. Fuller and S.C. Wainright 2000. The role of tidal salt marsh for marine transient and resident finfishes: A stable isotope approach. Trans. Amer. Fish. Soc. 129: 797-810.

Weis, J.S., L. Windham & P. Weis. 2002. Growth, survival and metal content in marsh invertebrates fed diets of detritus from *Spartina alterniflora* and *Phragmites*

australis from metal-polluted and clean sites. Wetlands Ecology and Management, 10: 71-84.

Weisberg, S. B. and A. J. Janicki 1990. Summer feeding patterns of white perch, channel catfish, and yellow perch in the Susquehanna River, Maryland. J. Freshwater Ecol. 5: 391- 405.