FISHES CONSUMING ZEBRA MUSSELS IN THE TIDAL HUDSON RIVER

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Schmidt, R.E., W.E. Chandler, and D. Strayer. 1995. Fishes consuming zebra mussels in the tidal Hudson River. Section IV: 20 pp. *In* E.A. Blair and J.R. Waldman (eds.), Final Reports of the Tibor T. Polgar Fellowship Program, 1994. Hudson River Foundation, NY.

Abstract

One hundred specimens of eight species of fish were collected for stomach content analysis in the vicinity of Tivoli North Bay, Hudson River, New York. Collections were made in May through early July and late August through mid-October, 1994. Zebra mussels (*Dreissena polymorpha*) were consumed by pumpkinseeds (*Lepomis gibbosus*) and redbreast sunfish (*L. auritus*) but not by any other species examined. Zebra mussels found in these fishes in the fall correlated with recruitment of the 1994 year class of the mussels to the benthos. Estimated sizes of consumed mussels showed that fishes were selecting the new year class of mussels.

The diets of white suckers (*Catostomus commersoni*), white perch (*Morone americana*), pumpkinseeds, and redbreast sunfish may have changed since the zebra mussel invasion in the Hudson. Comparisons of specimens of these four species from 1985 showed that, in 1994, these species all have added a substantial gastropod component to their diet. Zebra mussel colonization and deposition of feces and pseudofeces may be increasing the gastropod population or making them more available to fishes.

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Introduction

The zebra mussel (*Dreissena polymorpha*) was first observed in North American waters in Lake St. Clair in 1988 (Griffiths et al. 1991). This bivalve has spread rapidly from the Great Lakes and is firmly established in the tidal Hudson River. In 1994, there was an estimated 3 X 10^{11} individuals in the Hudson with densities reaching 30,000 mussels/m^2 (L. Weaver and T. Lynch, Marist College, pers. comm.).

Such an abundant source of animal protein should stimulate some Hudson River organisms to feed on zebra mussels. Fishes are the most abundant large carnivores in the Hudson estuary and the purpose of this study was to determine if any fishes are feeding on zebra mussels.

Several researchers (French 1993, McMahon et al. 1994) have developed lists of potential North American fish predators on zebra mussels based on morphology of the fish, known molluscivory, and a few reported instances of mussel predation. Ricciardi (1993) reported minimal predation on zebra mussels by St. Lawrence River benthivorous fishes.

Methods

Study Area- This study was done in the vicinity of Tivoli North Bay, a tidal freshwater marsh located at River Mile (RM) 99 of the Hudson River, New York. We chose this site because of ease of access and the documented presence of a dense zebra mussel population. Fish sampling was done primarily on the east shore of

Magdalen Island and the east end of the large tidal pool inside the railroad bed (Fig. 1).

Procedures- Using French (1993) as a guide, we targeted the following fish taxa for examination:

1. Sunfishes (*Lepomis* spp.), particularly pumpkinseeds (*L. gibbosus*).
2. Catostomids, which are represented by the white sucker (*Catostomus commersoni*) in the Hudson estuary.
3. Eurasian cyprinids like carp (*Cyprinus carpio*).
4. Miscellaneous large predators like ictalurids (*Ameiurus catus* and *A. nebulosus*), white perch (*Morone americana*), and American eels (*Anguilla rostrata*).

French (1993) listed sturgeons as potentially feeding on zebra mussels and shortnose sturgeon (*Acipenser brevirostrum*) have been observed feeding on zebra mussels in the Hudson (J. Waldman, HRF, pers. comm.). Shortnose sturgeon are listed as federally endangered and examining them was outside the scope of this project.

Fishes were collected in two sampling seasons. We collected fishes in May through the first part of July, 1994, which is prior to recruitment of zebra mussels. We then stopped sampling until the 1994 year class of zebra mussels settled. Our second sampling season was late August through mid-October, 1994.

The sunfishes and other incidental species were collected with a 50 ft seine (Ace 3/16" knotless nylon mesh) with a 4X4X4 ft bag. Seining was primarily done days and evenings on the east shore of Magdalen Island and on the east end of the

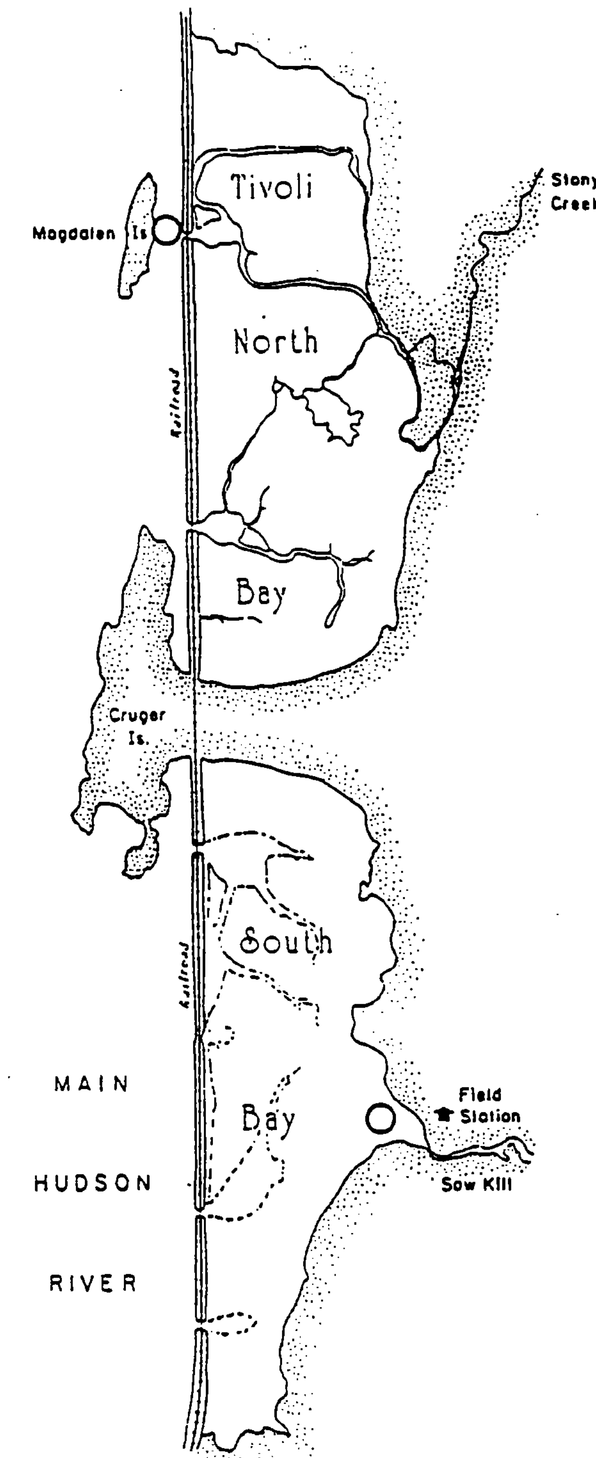

Figure 1. Study site at Tivoli North Bay, Hudson River, New York. This location is about 99 miles north of the Battery, Manhattan Island.

pool inside the railroad bed (Fig. 1) due to relatively unobstructed bottoms in these areas. Both areas had dense subtidal zebra mussel concentrations.

One or two experimental gill nets were used to capture larger fishes. The nets were 125 ft long and 6 ft deep each with five panels of different monofilament mesh: 0.5", 0.75", 1", 1.25", and 1.5" bar mesh. These nets were set in the day or evening in deeper areas around Magdalen Island or within 0.25 mi north of the island. Eel pots baited with fresh fish were set after dark.

Fishes of the appropriate species that we subjectively determined were large enough to ingest zebra mussels were placed on ice in the field. All other specimens were released. Specimens were examined after being frozen and then thawed.

Each specimen was identified, measured for total length (TL), and dissected. The stomach or anterior gut was removed and contents were teased out of the gut. Gut contents were examined for presence of zebra mussel shells and then preserved in 70% ethanol. Any zebra mussel shells were removed and stored separately.

Sizes of ingested zebra mussels were determined by measuring the umbo length with a calibrated ocular micrometer on a Wild M-8 microscope. The shell lengths were estimated using regression formulae reported by Hamilton (1992). Hamilton (1992) urged that regressions of umbo versus shell length should be developed for each zebra mussel population, but since we had so few specimens to measure, we simply used her regression data.

In order to detect any other changes in fish food habits that may have occurred after zebra mussel invasion, we compared the fishes caught in this study with

specimens collected in Tivoli North Bay in 1985 (Schmidt 1986). There were alcohol preserved specimens of four fishes from the 1985 survey that were comparable in size to those we collected in 1994; pumpkinseed, redbreast sunfish, white perch, and white sucker. All available specimens of these species from 1985 were dissected and gut contents processed as described above.

Food items from the 1985 fishes and the same four species from 1994 were identified and counted. Food habits were expressed as Significance (S) values (Windell 1971):

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

where % Occurrence is the percent of individuals in a given species of fish that has the particular food item and % Composition is the percent of a particular food item out of the total food items for that species of fish.

Results

We examined a total of 100 individuals of 8 species of fishes from the Tivoli North Bay vicinity (Table 1). The spring and early summer collections yielded one fish, a 65 cm TL carp, with a single fragment of zebra mussel in the gut. The shell was found far back in the intestine with a large amount of detritus. We doubt that this fish actually consumed a zebra mussel, but rather probably picked up a shell along with ingested sediments. Carp are known to ingest considerable sediment while feeding on benthos (Wilcox and Hornbach, 1991). We noticed that the sediments in the area are full of broken zebra mussel shells.

Table 1. Fishes examined for zebra mussels, 1994. Fishes were collected in vicinity of Tivoli North Bay, Hudson River, New York.

Species	Number	TL (cm)
Carp (*Cyprinus carpio*)	2	62-65
White sucker (*Catostomus commersoni*)	7	23-41
White catfish (*Ameiurus catus*)	5	23-46
Brown bullhead (*Ameiurus nebulosus*)	5	22-29
Redbreast sunfish (*Lepomis auritus*)	36	12-18
Pumpkinseed (*Lepomis gibbosus*)	13	10-18
Yellow perch (*Perca flavescens*)	3	18-23
White perch (*Morone americana*)	29	12-20

During June, the zebra mussel population consisted of two size classes (year classes) and it may be that they were too large (Fig. 2) for fishes to consume. In our late summer/early fall samples we found five fish that had eaten zebra mussels. Two pumpkinseeds (10.0 and 16.0 cm TL, 40% of the pumpkinseeds examined) and three redbreast sunfish (11.5, 15.0, and 16.0 cm TL, 17.6% of the redbreasts examined) contained crushed zebra mussel shells. We recovered three umbones from these fish and calculated the mussel sizes at (conservatively) 4.3, 5.6, and 8.2 mm shell length. When compared with mussel size distribution in September (Fig. 3), these fish were clearly feeding on the newly settled mussels.

Comparison of food habits of four fishes before and after zebra mussel invasion showed an interesting pattern. White suckers (Table 2) sampled in 1994 had a greater diversity of food items in their stomachs compared to 1985 and had included Pelecypoda (sphaeriid clams) and Gastropoda which were not seen in 1985.

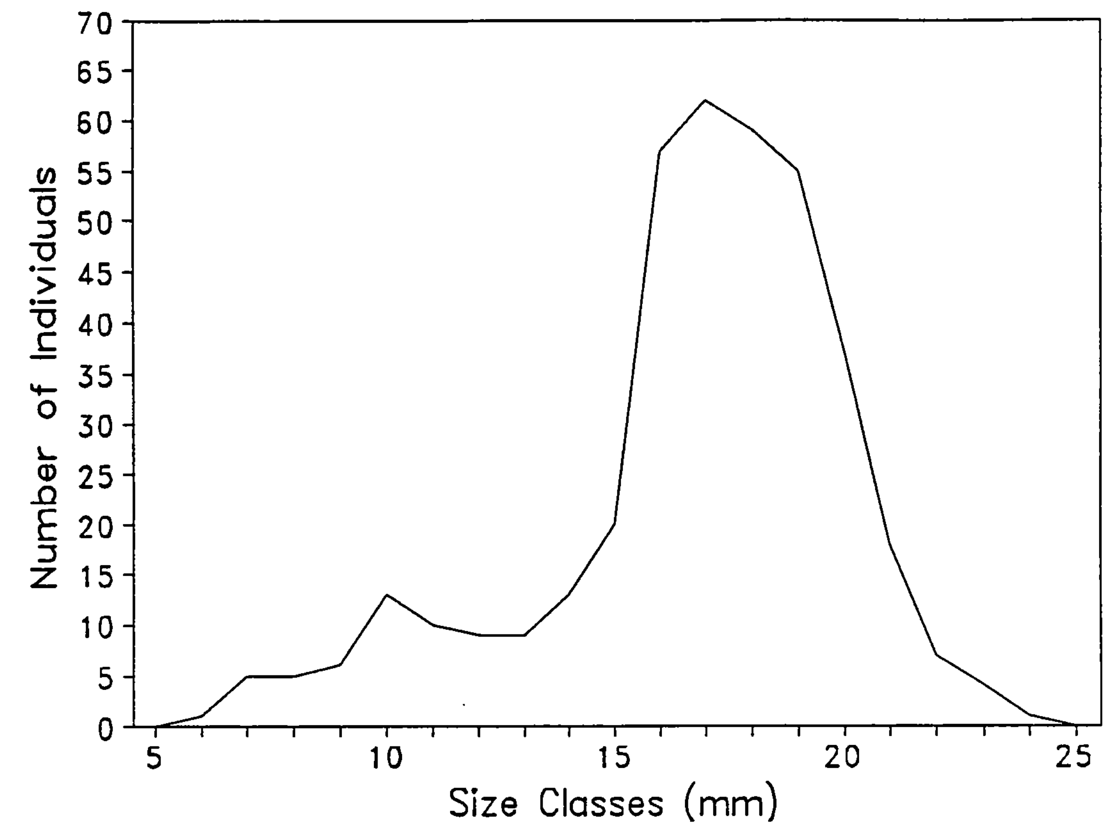

Figure 2. Size frequency distribution of zebra mussels from the Hudson River, June 1994. Mussel sizes are unpublished data from D. Strayer.

Pumpkinseeds (Table 3) had reduced their food diversity in 1994, concentrating to a great degree on Gastropoda, both in the spring and the fall. Redbreast sunfish (Table 4) fed heavily on Gastropoda in 1994 which were not seen in 1985 samples, although many of the gastropods were *Ferrissia* sp., probably eaten from the surface of *Vallisneria* leaves. Terrestrial insects were eaten heavily in the spring with gastropods of lower significance but the reverse was true in the fall, possibly due to reduced insect availability and increased *Vallisneria* biomass. White perch (Table 5) included

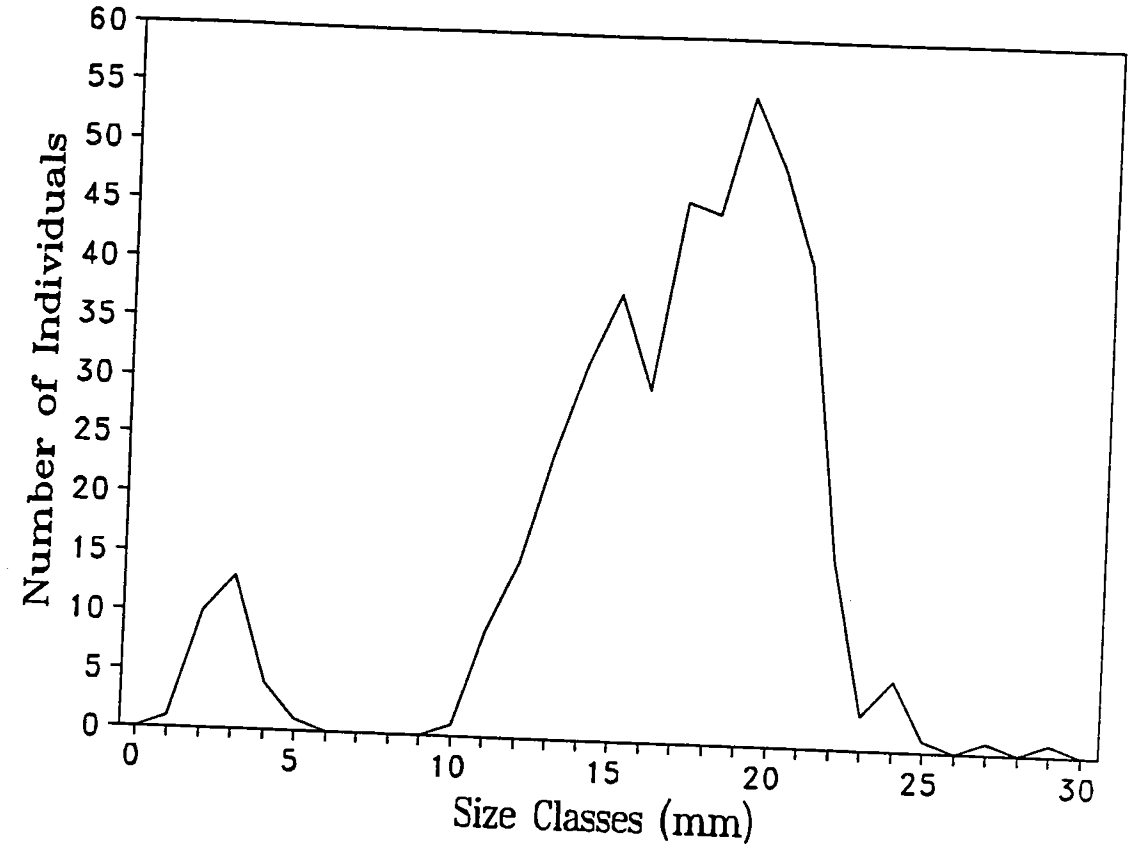

Figure 3. Size frequency distribution of zebra mussels from the Hudson River, September 1994. Mussel sizes are unpublished data from D. Strayer.

Gastropoda in their diet, which was not seen in 1985.

Although the numbers of fishes we were able to examine was small prior to zebra mussel invasion, this consistent pattern of increased gastropod ingestion may be a real change correlated with zebra mussel invasion. Stewart and Haynes (1994) reported significant population increases in several gastropod species following colonization by *Dreissena* spp. in Lake Ontario. Increased gastropod abundance in the Hudson may have stimulated increased consumption by fishes.

Table 2. Significance (Windell 1971) values for food items from white suckers in the vicinity of Tivoli North Bay, Hudson River, New York.

Food Item	Before Zebra Mussels (N=4)	After Zebra Mussels (N=6)
Chironomidae	85.6	99.1
Ostracoda	32.9	5.9
Amphipoda	6.5	5.9
Pelecypoda	-	4.7
Gastropoda	-	2.9
Trichoptera	6.5	-
Ephemeroptera	6.5	-
Acarinida	-	1.2
Coleoptera	-	1.2
Odonata	-	1.2
Porifera	-	1.2

Table 3. Significance (Windell 1971) values for food items from pumpkinseeds in the vicinity of Tivoli North Bay, Hudson River, New York.

Food Item	Before Zebra Mussel (N=5)	After Zebra Mussel Spring (N=6)	After Zebra Mussel Fall (N=5)
Gastropoda	36.3	88.9	97.3
Amphipoda	41.8	-	5.3
Trichoptera	33.2	4.3	-
Chironomidae	31.5	25.3	4.9
Ceratopogonidae	17.7	-	-
Isopoda	14.0	-	3.5
Oligochaeta	4.5	-	-
Millipede	4.5	-	-
Ephemeroptera	4.5	2.5	-
Hymenoptera	4.5	-	-
Psephenidae	-	2.5	-
Zebra mussel	-	-	4.9

Table 4. Significance (Windell 1971) values for food items from redbreast sunfish in the vicinity of Tivoli North Bay, Hudson River, New York.

Food Item	Before Zebra Mussel (N=5)	After Zebra Mussel Spring (N=6)	After Zebra Mussel Fall (N=5)
Terrestrial insects	26.4	78.9	25.9
Gastropoda	-	29.7	75.6
Trichoptera	40.8	5.0	3.0
Chironomidae	24.4	10.5	2.2
Arachnida	8.9	1.7	-
Odonata	8.9	1.7	-
Ceratopogonidae	6.3	-	-
Amphipoda	4.5	8.6	-
Oligochaeta	4.5	-	-
Pelecypoda	4.5	1.7	-
Hemiptera (aquatic)	4.5	1.7	8.6
Diptera (aquatic)	4.5	1.7	-
Millipede	-	1.7	-
Pisces	-	1.7	-
Elmidae	-	6.6	3.0
Isopoda	-	-	3.7
Zebra mussel	-	-	4.6

During sampling we also noted a seasonal change in fish species composition. In the spring, white perch dominated our catches and adult pumpkinseeds were only found in Tivoli North Bay. In the fall, adult individuals of our target species became scarce and pumpkinseed adults were found only around Magdalen Island. Both areas were dominated by young of the year sunfishes. An offshore fall movement by white perch has been documented (Klauda et al. 1988). The above observations suggest that other species may make a late fall offshore migration also.

Table 4. Significance (Windell 1971) values for food items from white perch in the vicinity of Tivoli North Bay, Hudson River, New York.

Food Item	Before Zebra Mussels (N=13)	After Zebra Mussels (N=27)
Chironomidae	74.9	50.8
Ostracoda	-	45.0
Amphipoda	18.3	1.3
Ceratopogonidae	14.5	-
Trichoptera	13.8	5.5
Gastropoda	-	10.0
Isopoda	7.6	7.3
Ephemeroptera	6.4	-
Fish eggs	2.8	3.7
Odonata	2.8	-
Chaoborus	2.8	-
Elmidae	-	3.0
Acarinida	-	0.7
Pelecypoda	-	0.7

Discussion

Although it is interesting to find that two species of native North American fishes will feed on zebra mussels, we cannot suggest that feeding by these sunfishes will significantly affect zebra mussel populations. The population size of both sunfishes appears large in the Hudson estuary, although no attempt has been made to estimate the magnitude of the populations. Redbreast sunfish are much more abundant in our study area than pumpkinseeds based on catch/effort observations.

Our observations that the sunfishes are only feeding on newly settled mussels and that the large sunfishes leave the study area in the fall suggest that there is a short window of opportunity from late August until mid-October when zebra mussels are vulnerable to fish predation. Even if 17-40% of the sunfishes are consuming zebra mussels, we think that sunfish densities are too low to affect the very dense zebra mussel populations.

If no effect can be seen on zebra mussels from sunfish feeding, feeding on zebra mussels may affect the sunfishes. Wainwright et al. (1991) found that pumpkinseeds feeding on snails had larger muscles associated with the pharyngeal crushing apparatus and that the pharyngeal bones were both larger and had a different shape than in pumpkinseeds that did not feed heavily on snails. Assuming that crushing zebra mussels requires more, or at least different, effort than crushing snails, pumpkinseeds that are feeding heavily on zebra mussels could be identified by their internal morphology. Wainwright et al. (1991) showed that this different morphology was an ontogenetic response to feeding behavior. We assume that similar modifications would occur in redbreast sunfish as well. Comparisons of the appropriate morphologies in sunfishes before and after zebra mussel invasion would be interesting and might be a way to detect the magnitude of zebra mussel use without examining stomach contents.

Apparently, only a few fishes (chiefly specialized molluscivores like sturgeons and pumpkinseeds) are eating zebra mussels in the Hudson. Our results, together with Ricciardi's (1993) findings that none of the fishes in the St. Lawrence River were taking many zebra mussels, suggest that few generalist fishes will shift their diets to include zebra mussels, despite high densities of zebra mussels. Potentially, of more

importance to these generalists than the zebra mussels themselves are changing availability of prey living in zebra mussel beds. Some studies (e.g., Griffiths, 1993; Stewart and Haynes, 1994) have shown that zebra mussels have greatly increased the populations of animals such as amphipods and gastropods, which probably rely on zebra mussel beds for shelter and food (feces and pseudofeces- see Rodite and Strayer, this volume). Our findings of increased importance of gastropods in the diets of several fishes after the zebra mussel invasion of the Hudson may be an example of this effect.

Recommendations

Further studies on the interaction between fishes and zebra mussels should concentrate on the time during and immediately after mussel settlement. Our data were collected in the shallows of the Hudson estuary. Sunfishes may be in contact with mussels small enough to eat for a longer period in deep, offshore waters. Examination of food habits from these deeper areas may give us a very different picture of this phenomenon.

Acknowledgements

This study was funded by the Hudson River Foundation and we are grateful. We thank Chris Hull and James Mann for helping with sampling. Lane Smith kindly shared his zebra mussel data with us.

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