DIET OF AMERICAN EEL (*ANGUILLA ROSTRATA*) ELVERS IN A HUDSON RIVER TRIBUTARY

A Final Report of the Tibor T. Polgar Fellowship Program

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ABSTRACT

Elvers of American eel (*Anguilla rostrata*) were collected from the tidal mouth of the Roeliff Jansen Kill, a Hudson River tributary. A total of 180 elvers collected from June through early August 2011 were examined for gut contents. Five kinds of aquatic insects comprised 94.9% of the total food items: four groups of chironomid midges (*Ablabesmyia* sp., *Pseudochironomus* sp., *Thienemanniella* sp., and unidentified adult midges) and an ephemeropteran (*Caenis* sp.).

The majority of the elvers were <9.0 cm TL and inhabited shallow (<10 cm deep) gravel to cobble river margins. Comparison of gut contents to macroinvertebrates collected by Surber sampling demonstrated that the elvers were non-selective, essentially feeding at random on the most abundant benthic insects. Elvers were classified as secondary or tertiary consumers in the detritus food web.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

INTRODUCTION

The American eel is an important economic resource on the East Coast of the United States. Recent evidence has indicated that the population of this species is declining partially due to overfishing and habitat degradation (Haro et al. 2000); therefore, it may be important to understand as much of the biology of American eel as possible.

There have been several studies on the diet of the juvenile (yellow eel) stage of American eel (e.g. Denoncourt and Stauffer 1993; Lookabaugh and Angermeir 1992; Machut 2006; Wenner and Musick 1975). These studies uniformly concluded that small yellow eels feed on benthic invertebrates (mostly insects) and larger (>35 cm) yellow eels eat fishes and crayfishes. None of these studies looked at very small (<9 cm) eels.

Every spring thousands or tens of thousands of glass eels (4.5-7.0 cm) enter the mouths of Hudson River tributaries (Schmidt and Lake, 2003, 2004, and unpublished data). When reaching tributary mouths, they settle to the bottom, develop pigmentation (at which point they are called "elvers"), and apparently stay in the shallow tidal habitat for their first summer. Upstream migration is very slow (Haro and Krueger 1988). Schmidt et al. (2009) reported very few of these elvers in an eel ladder 120 m upstream of the tidal habitat (and up a waterfall) in the Saw Kill, Dutchess County.

The growth and survival of these small elvers determines the magnitude of the upstream migration of yellow eels one to several years later. No studies have been done on the diet of the newly settled elvers. Tesch (1977) said that glass eels don't feed but newly settled European eels (*A. anguilla*) fed on anything small enough to be ingested.

The purpose of this study was to document the diet of American eel elvers in the tidal mouth of a Hudson River tributary.

METHODS

Study Area

This study was done in the tidal mouth of the Roeliff Jansen Kill, a Hudson River tributary. The mouth of the Roeliff Jansen Kill is located in the town of Linlithgo, Columbia County, NY. Specifically, samples were collected downstream (west) of the Rt. 9G bridge (Figure 1). This study area was selected because previous experience showed that elvers were numerous, the site is relatively easy to access, and few studies on fishes have been done in the Roeliff Jansen Kill.

Field Procedures

Elvers were collected with a Smith-Root backpack electroshocker. Sampling was conducted along the shoreline (usually north shore of the main channel) at or near low tide until 20 individuals had been collected in any given trip. Elvers were over-anaesthetized in clove oil and then transported to the laboratory.

Macroinvertebrates were sampled with a Surber sampler (330 µm mesh). Surber sampling was done in the habitat where elvers were collected and triplicate samples were taken on any one trip. Contents of the Surber sampler were preserved in 50% isopropanol in the field and transported to the laboratory.

Figure 1. Oblique aerial view looking west at the tidal mouth of the Roeliff Jansen Kill, Columbia County, New York. The road is Rt. 9G. Most of the elver samples were taken from the shallow river margin indicated by the arrow and line. Figure is modified from a Google Earth photograph.

Laboratory Procedures

Elvers were measured (total length in cm) and then weighed on an electronic balance (nearest 0.001 g). Specimens were then preserved in 70% ethanol. To determine food habits, stomachs of elvers were removed and the contents were examined under a dissecting microscope, identified initially to broad categories, and counted. Chironomid midges were divided into “species” based on overall appearance (body color, size and color of head, shape of head, size of prolegs, and size of antennae). Tentative identification of chironomid midges to genus was done following Simpson and Bode (1980) and Epler (2001). Other macroinvertebrates were identified using Wiggins (1977) and Merritt and Cummins (1984).

Macroinvertebrates were sorted from the Surber samples under a dissecting microscope. Specimens were sorted into the same categories established for the organisms found in the elver guts.

Comparisons between the organisms in the elver guts and those collected with the Surber sampler were done using Strauss’ (1979) linear index of food selection. This index is expressed as: $L = r_i – p_i$, where L is the linear index, r_i is the proportion of food item “i” in the eels’ gut and p_i is the proportion of food item “i” in the Surber samples. The Index can have values between 1.0 and -1.0, the former indicating that eels are eating only that food and it was not collected in the Surber samples and the latter indicating that eels are not eating the only food item collected in the Surber samples. A score of “0” would indicate that the proportion of food item “i” in the eels’ gut was the same as that in the Surber samples– (i.e. no selectivity). Positive values (between 0-1) would indicate that food item “i” was overrepresented in the eels’ guts compared to the Surber samples, and thus purposefully selected. Negative values would indicate the opposite. Indices were calculated by comparing each sampling trip to each Surber collection.

RESULTS

Nine sampling trips were made in this study from June 3 to August 5, 2011. Due to some logistical problems, sampling events were not evenly spaced. The average size of elvers collected was 58.3 mm total length (TL). Average size of elvers was expected to increase over the summer, but there was little apparent change in average size per collection (Figure 2). The median length category was 56-60 mm TL and the majority of elvers were between 51-70 mm TL (Figure 3).

Out of 180 elvers examined, 26 of them contained no food (14.4%). A total of 631 food items were retrieved from elver stomachs, an average of 4.1 food items per elver (that contained food) with a range of 1-17 items/elver. The food items were divided into six categories: 1) *Ablabesmyia* sp., a Chironomidae (40.0% of the total food items, average of 1.6/elver); 2) *Pseudochironomus* sp., a Chironomidae (7.9% of the total food items, average of 0.4/elver); 3) *Thienemanniella* sp., a Chironomidae (31.2% of the total food items, average of 1.4 items/elver); 4) unidentified adult Chironomidae (6.5% of the total food items, average of 0.2/elver); 5) Ephemeroptera larva-*Caenis* sp. (8.9% of the total food items, average of 0.4/elver); and 6) "other" (4.9% of the total food items, average of 0.2 items/eel). The latter category included 12 chironomid pupae (in one elver), 16 Trichoptera (14 *Polycentropus* sp. and 2 unidentified), 2 unidentified Ephemeroptera, 1 Amphipoda, and 2 Gastropoda (*Ferrissia* sp.).

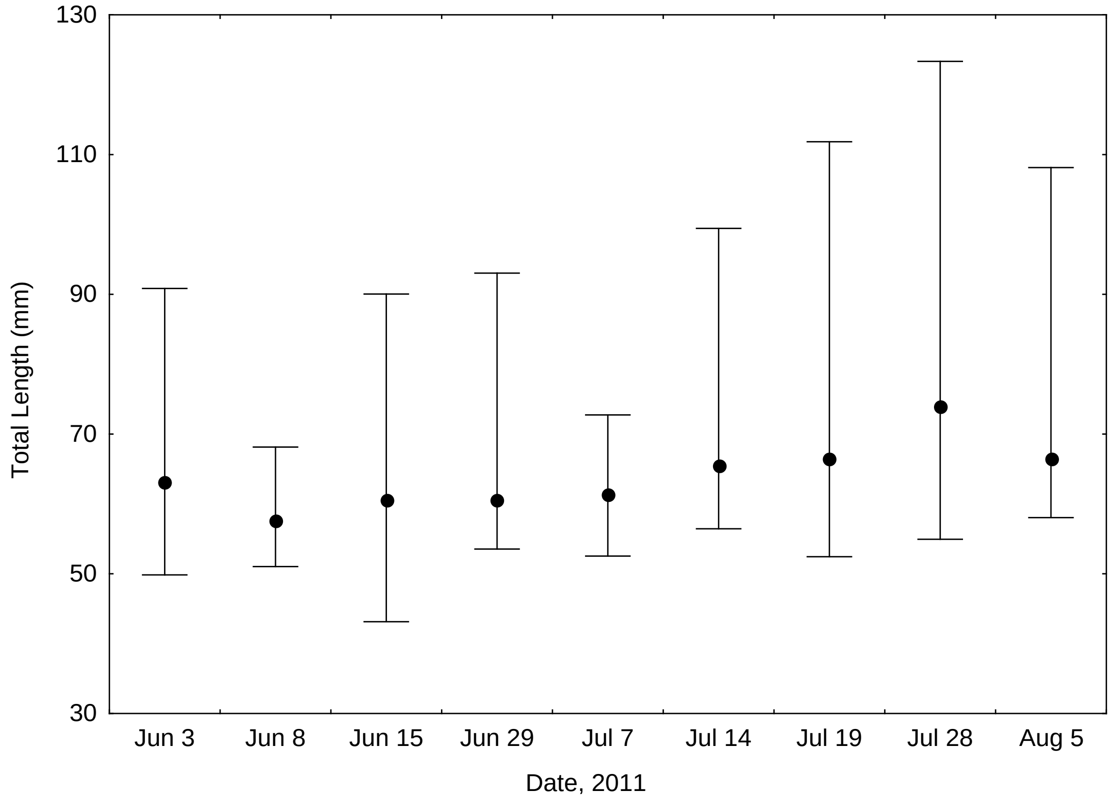

Figure 2. Mean (solid circle) and range (capped lines) of total lengths of elvers collected in the Roeliff Jansen Kill, summer 2011.

The range of elver sizes collected was 43-122 mm TL. Elvers were collected from as wide a range as possible, but it is likely that some individuals were erroneously included that were over a year old (and thus technically should be called "yellow eels"). Individuals that were 90 mm or larger are very likely to be yellow eels (Machut 2006). There was no evidence that these larger yellow eels consumed more prey items (Figure 4) or different prey items (Figure 5) than the smaller elvers and therefore including them in the analyses did not introduce a bias.

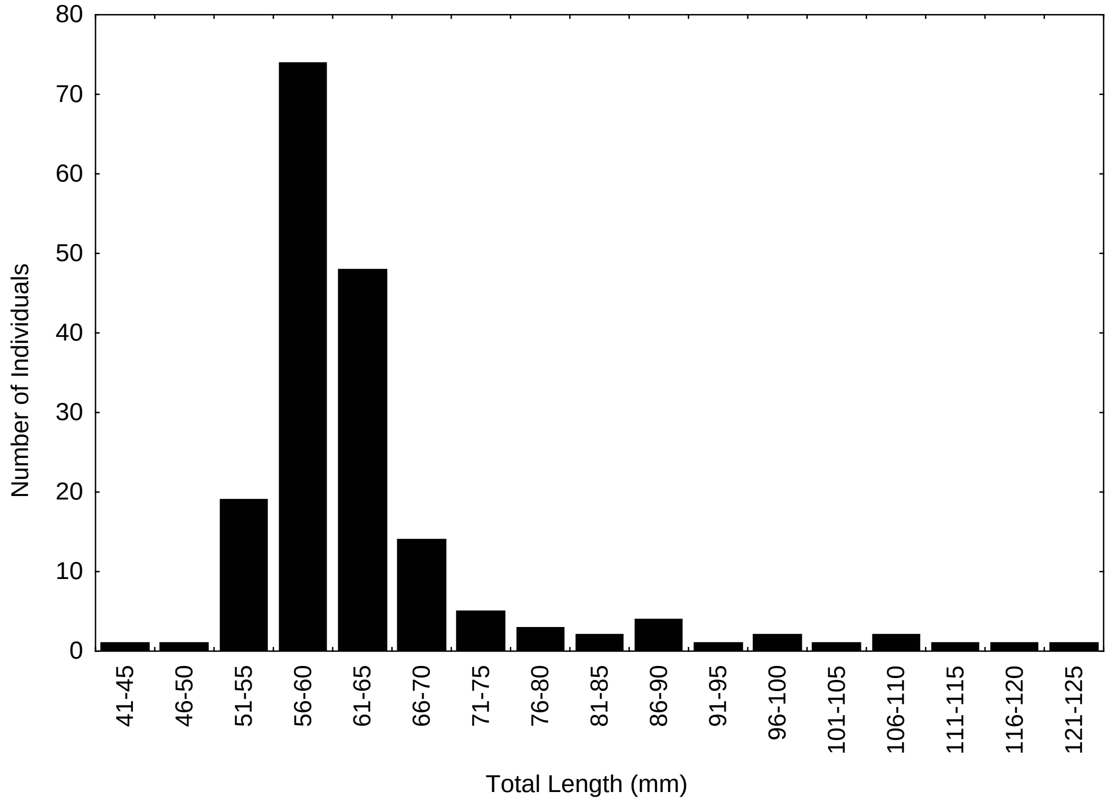

Figure 3. Length frequency of American eel elvers collected in the Roeliff Jansen Kill, summer 2011.

The five food items that made up the majority of the diet were not necessarily uniformly represented in each collection (Fig. 5). For instance, the larvae of the chironomid, *Thienemanniella* sp., were bimodally distributed being most abundant in mid-June and late July (Fig. 5). Larval *Caenis* sp., a small Ephemeroptera, was most abundant in stomachs in mid-July, but were relatively rare in earlier and later samples. It was presumed that these patterns reflect the life history of the insects in question.

The Surber sampler collections were done on June 9 and July 19, 2011. In the June sample, 894 individuals were sorted (total of three replicates) that were classified

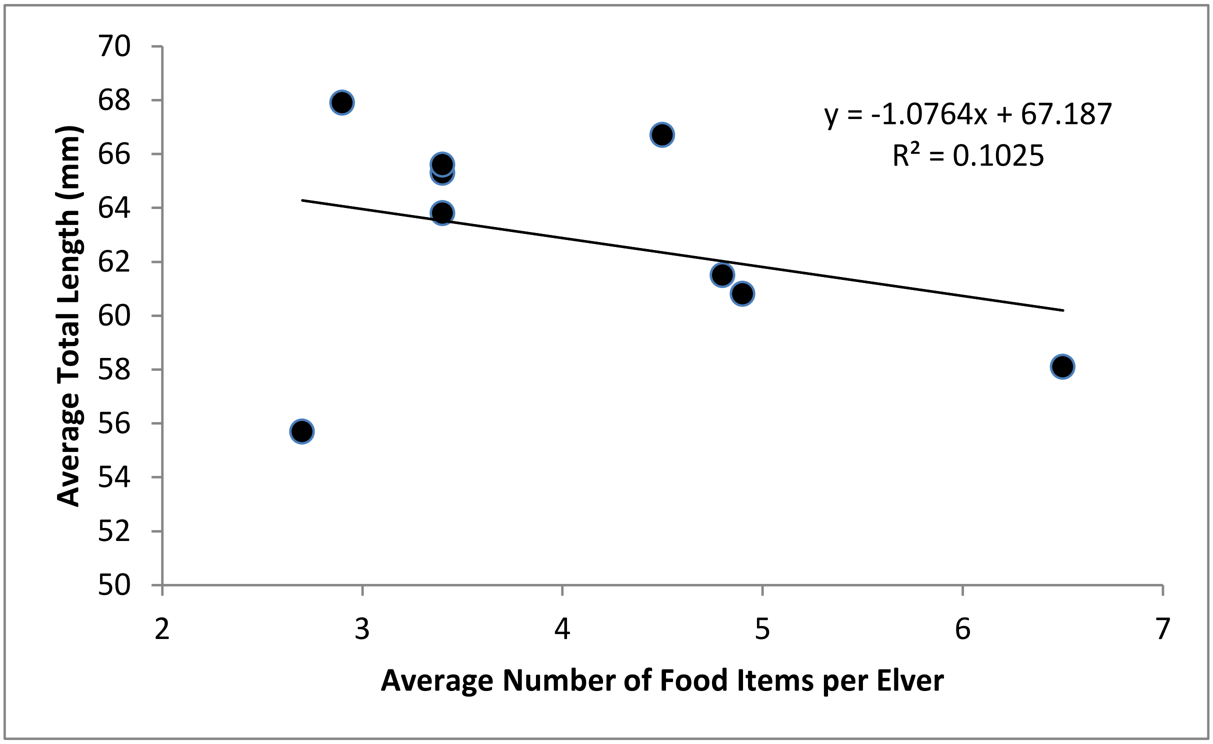

Figure 4. Average number of food items per elver or yellow eel plotted against average size of elver or yellow eel for each collection. The regression line indicates a slightly negative relationship (i.e.- larger eels eat fewer prey items) but the correlation coefficient is very low and the relationship is probably spurious.

into 15 groups (Table 1). The July collections contained many fewer individuals (total of 335) and were classified into 15 groups (Table 1). Strauss' (1979) Linear Index of Food Selection was calculated by comparing the proportion of each food item found in the elvers' stomachs (compared to the total number of all elvers) to the proportion of organisms (out of the total) of each set of Surber samples (Table 1). There were seven groups of organisms found in both the elver stomachs and the Surber samples. Although some of the Index values were positive and some negative, all but one value was close to zero (indicating no selection for or against each food item). The one exception was *Ablabesmyia* sp. compared to the June Surber samples, which indicated a moderate

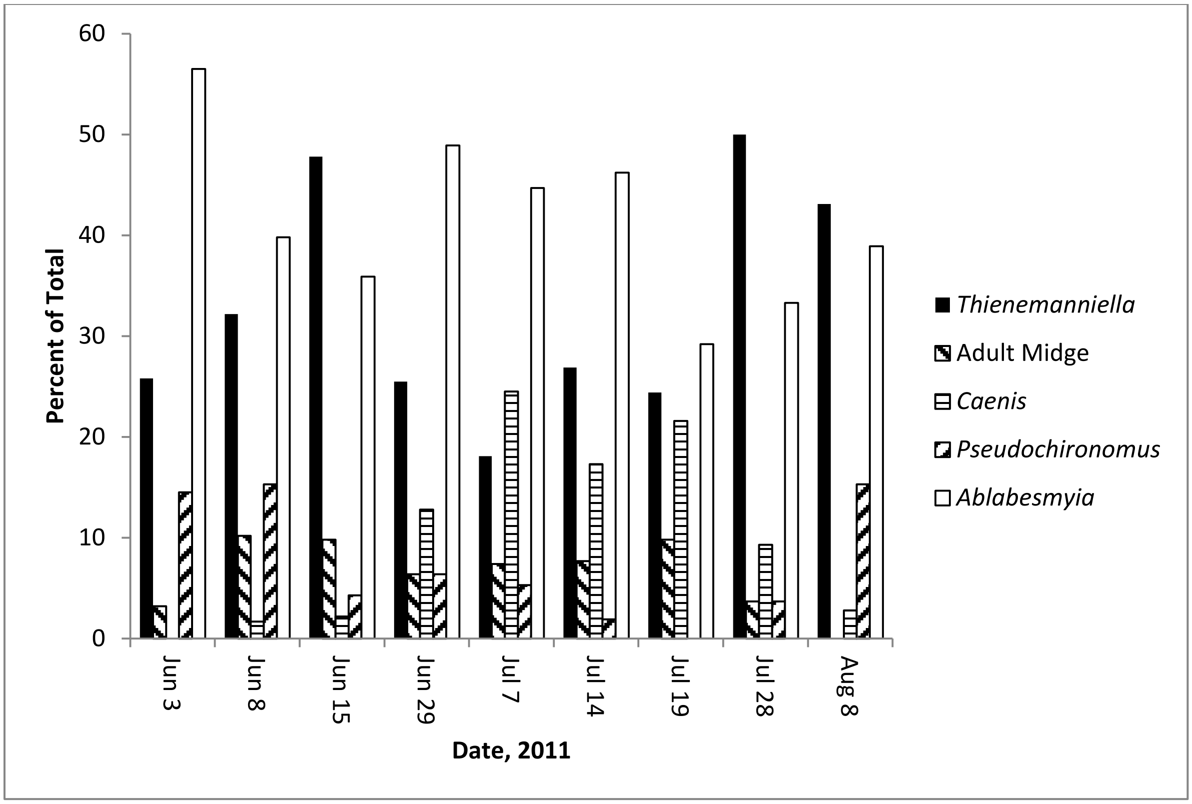

Figure 5. Plot of the five food items that comprised 95% of the total food items in American eel elvers by collection date.

selection for this taxon (L = 20.1) in the eel's diet. All of the invertebrate groups that were represented in the Surber samples but not isolated from the eels were rare in the Surber samples, and thus also had an Index value close to zero. It was concluded, therefore, that American eel elvers are not feeding selectively, but rather taking food at random. The proportions of food items in their stomachs closely reflects the abundance of the food items in the environment.

DISCUSSION

The lack of food selectivity demonstrated in this study was similar to Tesch's (1977) statement that European eel (*Anguilla anguilla*) elvers consumed anything that they could fit in their mouths. Since elvers are feeding non-selectively, the growth and survival of individual elvers is determined solely by the quantity and quality of the resources available.

The elvers should be considered as secondary or tertiary consumers in the detritus food web. Both *Pseudochironomus* and *Thienemanniella* feed on detritus (McShaffrey and Olive 1985), *Ablabesmyia* are obligate predators often feeding on other chironomids (Roback 1985), and *Caenis* are widely considered omnivorous (Edmunds et al. 1976).

Growth of the elvers was expected over the study period. Instead (Fig. 2) little, if any, change in size was seen over time. In fact, the elvers collected are essentially the same size as the glass eels captured in Hudson River tributary mouths in April and May (Schmidt and Lake 2003, 2004). If the elvers are not growing, or are growing so slowly that it could not be detected, it raises the question of whether or not the food items documented are adequate in quantity or quality. The possibility that the samples were biased towards collecting only the smallest elvers was not eliminated. Elvers can be aged by examining daily growth rings on otoliths (Martin 1995) but this was well outside the scope of this study. The specimens were preserved in ethanol and are now catalogued in the New York State Museum. These specimens could be aged and growth rates calculated.

Table 1. Comparison of the proportion of food items in elver stomachs with the proportion of organisms from Surber samples. "L" is Strauss' (1979) Linear Index of Food Selection where p_i is the proportion of that food category in the Surber sample and r_i is the proportion in the elver stomachs.

	June Surber			July Surber		
Food Category	p_i	r_i	L	p_i	r_i	L
Ablabesmyia	.20	.40	**.20**	.32	.40	**.08**
Pseudochironomus	.14	.09	**-.05**	.05	.09	**.04**
Thienemanniella	.35	.33	**-.02**	.24	.33	**.09**
Caenis	.08	.10	**-.02**	.15	.10	**-.05**
Adult Midge	.14	.05	**-.09**	.02	.05	**.03**
Amphipoda	.03	<.01	**-.03**	.04	.02	**-.02**
Ferrissia	.01	<.01	**-.01**	.06	.03	**-.03**
Larval Elmidae	.04	0	**-.04**	.06	0	**-.06**
Baetidae	.03	0	**-.03**	.01	0	**-.01**
Caddisflies				.02	0	**-.02**
Megaloptera	.01	0	**-.01**	<.01	0	**<-.01**
Psephenidae	.01	0	**-.01**	.01	0	**-.01**
Mite				.01	0	**-.01**
Atherix				.01	0	**-.01**
Midge pupa				.01	0	**-.01**
Empedid fly				<.01	0	**<-.01**
Adult Elmidae	<.01	0	**<-.01**			
Gerridae	<.01	0	**<-.01**			
Collembola	<.01	0	**<-.01**			
Isopoda	<.01	0	**<-.01**			

Elvers were collected from the very shallow (<10 cm deep) margins of the Roeliff Jansen Kill at or near low tide. In the instances when sampling took place in deeper water, very few elvers were caught and a substantial numbers of larger yellow eels were observed. Size segregation among habitats is known for American eel (Anderson and Schmidt 2006) probably due to avoidance of aggressive and/or cannibalistic interactions with larger eels (McCord 1977). Access to the sampling area is much more difficult at high tides, and therefore sampling did not take place at those times. Elvers might in fact be intertidal in this tributary, and therefore may spend much of their time burrowed into dewatered sediments.

The Roeliff Jansen Kill is one of the larger tributaries to the Hudson River estuary. The other 60+ tributaries vary considerably in size and physiography and few have been examined to determine the distribution and habitat of American eel elvers. The observations documented here are probably typical of most of the other Hudson River estuary tributaries, but that is an untested hypothesis.

The elver stage of the American eel is one of several critical developmental stages probably with a high mortality rate. Survivors are upstream migrant yellow eels whose success determines the distribution and density of the population in a given tributary and ultimately the abundance of downstream migrant silver eels. This study has documented some aspects believed to be critical to the elvers in tidal water (foods and habitat) but there needs to be much more work done on the tidal tributary habitat in the Hudson River estuary.

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