Evaluating Recruitment of American Eel, *Anguilla rostrata*, in the Potomac River (Spring 2011)

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By

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Acknowledgments

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Introduction

American eel (*Anguilla rostrata*) is a valuable commercial species along the Atlantic coast of North America from New Brunswick to Florida. Landings from Chesapeake Bay typically represent 63% of the annual United States commercial harvest (ASMFC 2000). American eel is also important to the recreational fishery as it is often used live as bait for striped bass and cobia. In 2007, Virginia commercial landings (196,853 lbs) were 70% of the average annual landings in VA since mandatory reporting began (1993) and 23.6% of the US landings (ASMFC 2008; VMRC 2008). Since the 1980s, however, harvest along the U.S. Atlantic Coast has declined, with similar patterns occurring in the Canadian Maritime Provinces (Meister and Flagg 1997).

Hypotheses for the decline in abundance of American eel in recent years include locational shifts in the Gulf Stream, pollution, overfishing, parasites, and barriers to fish passage (Castonguay et al. 1994; Haro et al. 2000). The decline in abundance may or may not exhibit spatial synchrony (Richkus and Whalen 1999; Sullivan et al. 2006); additionally, factors such as unfavorable wind-driven currents may affect glass eel recruitment on the continental shelf and may have a greater impact than fishing mortality or continental climate change (Knights 2003). Limited knowledge about fundamental biological characteristics of juvenile American eel has complicated interpretation of juvenile abundance trends (Sullivan et al. 2006).

The Atlantic States Marine Fisheries Commission (ASMFC) adopted the Interstate Fishery Management Plan (FMP) for the American eel in November 1999. The FMP focuses on increasing coastal states' efforts to collect American eel data through both fishery-dependent and fishery-independent studies. Consequently, member jurisdictions agreed to implement an annual survey for young-of-year (YOY) American eels. The survey is intended to "…characterize trends in annual recruitment of the YOY eels over time [to produce a] qualitative appraisal of the annual recruitment of American eel to the U.S. Atlantic Coast" (ASMFC 2000). The development of these surveys began in 2000 with full implementation by 2001. Survey results should provide necessary data on coastal recruitment success and further understanding of American eel population dynamics. A recent American eel stock assessment report (ASMFC 2009) emphasized the importance of the coast-wide survey for providing data useful in calculating an index of recruitment over the historical coastal range and for serving as an early warning of potential range contraction of the species. Funding for the Virginia Institute of Marine Science's spring survey in the Potomac River was provided by the Potomac River Fisheries Commission, thereby ensuring compliance with the 1999 ASMFC Interstate Fishery Management Plan for American Eels.

Life History

The American eel is a catadromous species that occurs along the Atlantic and Gulf coasts of North America and inland in the St. Lawrence Seaway and Great Lakes (Murdy et al. 1997). The species is panmictic and supported throughout its range by a single spawning population (Haro et al. 2000; Meister and Flagg 1997). Spawning takes place during winter to early spring in the Sargasso Sea. Eggs hatch into leaf-shaped, transparent, ribbon-like larvae called leptocephali, which are transported by ocean currents (for 9-12 months) in a generally northwesterly direction and can grow to 85 mm TL (Jenkins and Burkhead 1993). Within one year, metamorphosis into the next life stage (glass eel) occurs in the western Atlantic near the east coast of North America. A reduction in length to about 50 mm TL occurs prior to reaching the continental shelf (Jenkins and Burkhead 1993). Coastal currents and active migration transport the glass eels (= YOY) into Maryland and Virginia rivers and estuaries from February to June (Able and Fahay 1998). Ciccotti et al. (1995) suggested that glass eel migration occurs as waves of invasion with perhaps a fortnightly periodicity related to tidal currents and stratification of the water column. Alterations in the timing and magnitude of freshwater flow to bays and estuaries may affect the magnitude, timing, and spatial patterns of upstream migration of glass eels (Facey and Van Den Avyle 1987). Young-of-year eels may use freshwater “signals” to enhance recruitment to local estuaries, thereby influencing year-class strength in a particular estuary (Sullivan et al. 2006).

As glass eels grow, they become pigmented (elver stage) and within 12 to14 months eels acquire a dark color with underlying yellow (yellow eel stage). Many eels migrate upriver into freshwater rivers, streams, lakes, and ponds, while others remain in estuaries. Most of the eel’s life is spent in these habitats as a yellow eel. Metamorphosis into the silver eel stage occurs during the seaward migration that takes place from late summer through autumn. Age at maturity varies greatly with location and latitude, and in Chesapeake Bay, mature eels range from 8 to 24 years, with most being less than 10 years old (Owens and Geer 2003). American eel from Chesapeake Bay mature and migrate at an earlier age than eels from northern areas (Hedgepeth 1983). Upon maturity, eels migrate to the Sargasso Sea to spawn and die (Haro et al. 2000).

Objectives

The objectives of our study in the Potomac River were to:

1. monitor the young-of-year (glass eel) migration into the Potomac River watershed to determine spatial and temporal components of American eel recruitment; and

2. collect basic biological information on recruiting glass eels, including length, weight, and pigment stage.

Methods

Minimum criteria for YOY American eel sampling were established in the ASMFC American Eel FMP and used in our survey. Specifically, the timing and placement of gear must coincide with periods of peak YOY onshore migration. At a minimum, the gear must be deployed during nighttime flood tides. The sampling season is designated as a minimum of four days per week for at least six weeks or for the duration of the run. At least one site must be sampled in each jurisdiction. The entire catch of YOY eels must be counted from each sampling event and at least 60 glass eels (if present per system) must be examined for length, weight, and pigmentation stage weekly.

Due to the importance of the eel fishery in Virginia and the Potomac River, the methods used must ensure proper temporal and spatial sampling coverage, and provide reliable recruitment estimates. To provide the necessary spatial coverage and to assess suitable locations, numerous sites in both Virginia and Maryland were evaluated previously (Geer 2001). Final site selection was based on known areas of glass eel concentrations, accessibility, and specific physical criteria (e.g., appropriate habitat) suitable for glass eel recruitment to the sampling gear. The Maryland sampling of the Potomac River (northern shore site) was discontinued in 2001, due in part to the low catch rates in 2000 (Geer 2001). At the request of PRFC, the Virginia Institute of Marine Science (VIMS) began sampling two sites on the southern shore of the Potomac River (Gardy's Millpond and Clark's Millpond; Figure 1) in 2000.

Irish eel ramps were used to collect eels at all sites. The ramp configuration successfully attracts and captures small eels in tidal waters of Chesapeake Bay. Ramp operation requires continuous flow of water over the climbing substrate and the collection device, and was accomplished through a gravity feed. Hoses were attached to the ramp and collection buckets with adapters to allow for quick removal for sampling. Enkamat™ erosion control material on the ramp floor provided a textured climbing surface and extended into the water below the trap. The ramps were placed on an incline (15-45^{o}), often on land, with the ramp entrance and textured mat extending into the water. The ramp entrance was placed in shallow water (< 25 cm) to prevent submersion. The inclined ramp and an additional 4^{o} incline of the substrate inside the ramp provided sufficient slope to create attractant flow. A hinged lid provided access for cleaning and flow adjustments.

Sampling on the Potomac River (Clark's Millpond and Gardy's Millpond) was conducted from 16 March to 21 June 2011. Clark's Millpond (Coan River – Northumberland County) spillway is situated approximately one meter above the creek with a steady stream flow that requires a modified ramp extension to allow the eels to access the spillway. Gardy’s Millpond (Yeocomico River – Northumberland County) contains a spillway that drains through four box culverts, across a riffle constructed of riprap and into a lotic area of the Yeocomico River.

Only eels in the ramp's collection bucket (not on the climbing surface) were recorded. Trap performance was rated on a scale of 0 to 3 (0 = new set; 1 = gear fishing; 2 = gear fishing, but not efficiently; 3 = gear not fishing). Water temperature, air temperature, wind direction and speed, and precipitation were recorded during site visits. All eels were counted and placed above the impediment, with any subsample information recorded, if applicable. Specimens less than or equal to ~ 85 mm total length (TL) were classified as YOY, while those greater than 85 mm TL were considered elvers. These lengths correspond to the two distinct length-frequency modes observed in the 2000 survey, which likely reflects differing year classes (Geer 2001). Individual length, weight, and pigmentation stage information (see Haro and Krueger 1988) were collected weekly. Daily catch (raw number of eels caught per day) and annual area-under-the-curve (AUC) indices are presented for each site (Olney and Hoenig 2001). Annual AUC at each site was standardized to a 24-hour soak time.

Results and Discussion

The collection of eels in 2011 was similar to previous years with the capture of elvers beginning earlier than glass eels. Elvers were captured in greatest numbers early in the sampling period at Gardy’s Millpond with a second peak in early May (Figure 2). At Clark’s Millpond, elver catches increased slowly to a single peak in early May (Figure 3). More elvers were observed at Gardy’s Millpond than at Clark’s Millpond with collections at Gardy’s Millpond above the historic average and those at Clark’s Millpond below average (Table 2; Figure 4). Initial arrival and migration of elvers may be correlated with increases in water temperature, however elver migration may be delayed at freshwater interfaces until certain behavioral and physiological changes have occurred (Sorensen and Bianchini 1986).

Recruitment of glass eels at Clark's Millpond and Gardy's Millpond were below time-series averages in 2011 (Table 1; Figure 5). There was no clear peak in recruitment at Gardy's Millpond with glass eels arriving at the site throughout the sampling period in low numbers (Figure 2). At Clark's Millpond, there was a peak in glass eels in late April and early May and another peak in late June (Figure 3). The strong peak in late June consisted of glass eels that were heavily pigmented (Stage 6 or 7) indicating that they were not recent arrivals from the continental shelf.

Pigmentation stages for glass eels from Potomac River sites were mostly stage 4 (Figure 6). Length and weight of glass eels captured in 2011 were similar to previous years with an average length of 59.36 mm TL and an average weight of 0.15 g (Figure 7).

Developmental stages of glass eels at sites on the Potomac River show that glass eels are more developed and are likely older than those at sites nearer the mouth of Chesapeake Bay. Total catch of glass eels at sites on the Potomac River are typically below those in VA, which may be due to natural mortality or a dilution effect as glass eels migrate into the variety of different habitats that are available in lower Chesapeake Bay. Although recruitment of glass eels is low at Potomac River sites, variation in recruitment levels is also lower than that found at sites in lower Chesapeake Bay (Tuckey and Fabrizio 2010). Smaller variation in recruitment indices in the Potomac River may allow for the earlier detection of change as there is less noise in the signal compared with widely varying recruitment pulses found in lower Chesapeake Bay.

Conclusions and Recommendations

1. Similar to 2010, recruitment of glass eels in 2011 occurred earlier at Gardy's Millpond, but at lower abundances than at Clark's Millpond.

2. Recruitment of elvers occurred early in the 2011 sampling season at Gardy's Millpond and decreased as sampling progressed. At Clark's Millpond, there was a single recruitment pulse in early May.

3. Recruitment of glass eels at these sites consists of more developed glass eels compared with stations located nearer the mouth of Chesapeake Bay.

4. We recommend continued sampling of glass eels from the Potomac River sites because recruitment estimates from Clark's and Gardy's Millponds display consistency (low variation) through time, a characteristic that will enhance detection of change. Time series of glass eel abundances from the James, York, and Rappahannock rivers are more variable (more 'noise' in the data) and are less likely to provide early and definitive signals of change.

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Table 1. Summary of glass eel collections on the Potomac River at Clark's Millpond, Gardy's Millpond, and for the combined sites (2000 – 2011). CPUE is calculated as the Area Under the Curve (AUC).

Source	YEAR	Start Date	End Date	Total Catch	AUC CPUE24h
Clark's	2000	28-Apr	15-May	15	23.74
	2001	9-Apr	22-Apr	4	4.05
	2002	1-Apr	27-Apr	115	115.79
	2003	25-Apr	15-May	24	40.21
	2004	21-Apr	27-May	447	468.93
	2005	13-Apr	26-May	223	295.78
	2006	6-Apr	22-May	80	90.53
	2007	26-Apr	1-Jul	435	470.33
	2008	14-Apr	19-Jun	22	31.98
	2009	6-Apr	11-Jun	42	42.68
	2010	19-Mar	21-Jul	421	389.06
	2011	16-Mar	21-Jun	46	104.51
Gardy's	2000	16-Apr	27-Apr	291	286.85
	2001	8-Apr	24-Apr	729	730.25
	2002	29-Mar	25-Apr	129	129.50
	2003	7-Apr	13-May	71	70.01
	2004	2-Apr	18-May	39	38.86
	2005	28-Mar	5-May	94	102.68
	2006	17-Mar	11-May	46	45.39
	2007	23-Apr	27-Jun	248	260.09
	2008	20-Mar	11-Jun	187	178.94
	2009	30-Mar	3-Jun	231	229.92
	2010	19-Mar	21-Jul	90	80.25
	2011	16-Mar	21-Jun	35	36.78

Table 2. Summary of elver collections on the Potomac River at Clark's Millpond, Gardy's Millpond, and for the combined sites (2000 – 2011). CPUE is calculated as the Area Under the Curve (AUC).

Source	YEAR	Start Date	End Date	Total Catch	AUC CPUE24h
Clark's	2000	5-Apr	15-May	5	10.69
	2001	19-Mar	10-May	205	253.67
	2002	13-Mar	21-Apr	90	90.95
	2003	17-Mar	8-May	225	237.72
	2004	2-Apr	23-May	314	316.36
	2005	28-Mar	24-May	62	62.33
	2006	15-Mar	24-May	153	195.68
	2007	15-Mar	27-Jun	90	90.31
	2008	24-Mar	15-Jun	276	289.16
	2009	30-Mar	31-May	90	90.46
	2010	19-Mar	21-Jul	208	209.59
	2011	16-Mar	21-Jun	84	114.09
Gardy's	2000	16-Apr	15-May	15	16.46
	2001	16-Mar	1-May	624	660.76
	2002	15-Mar	27-Apr	273	277.15
	2003	19-Mar	6-May	300	300.78
	2004	10-Mar	11-May	483	476.76
	2005	23-Mar	17-May	313	330.15
	2006	10-Mar	14-May	692	827.71
	2007	15-Mar	27-Jun	198	198.23
	2008	20-Mar	11-Jun	393	385.88
	2009	30-Mar	2-Jun	360	358.27
	2010	19-Mar	21-Jul	375	317.53
	2011	16-Mar	21-Jun	507	527.09

Figure 1. Sampling sites in the Potomac River.

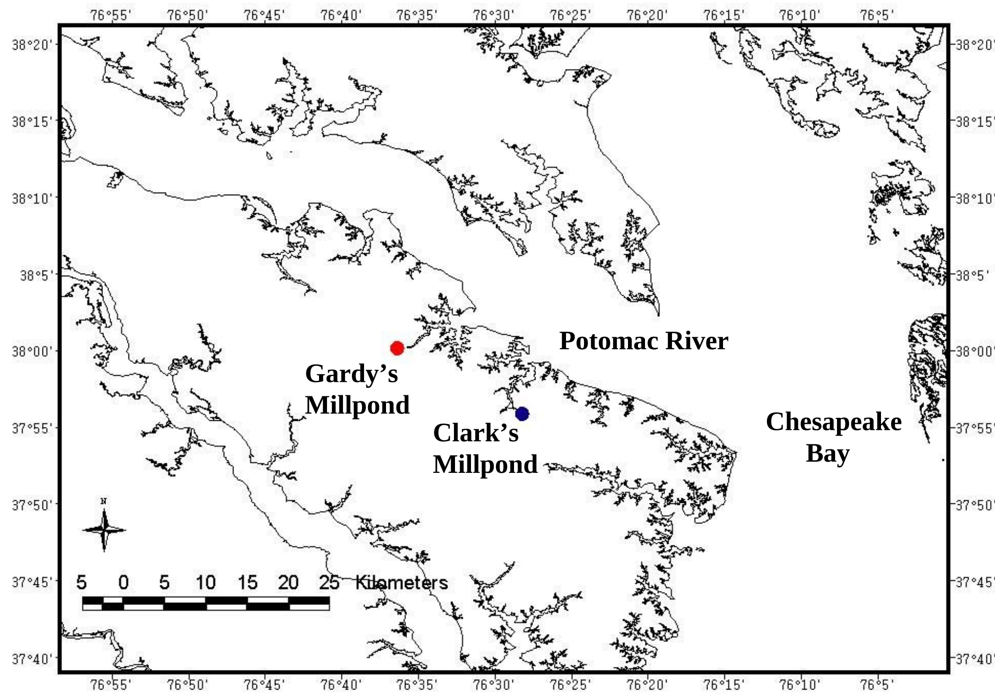

Figure 2. Number of glass eels and elvers captured during each sampling event and water temperature at Gardy's Millpond, 2011.

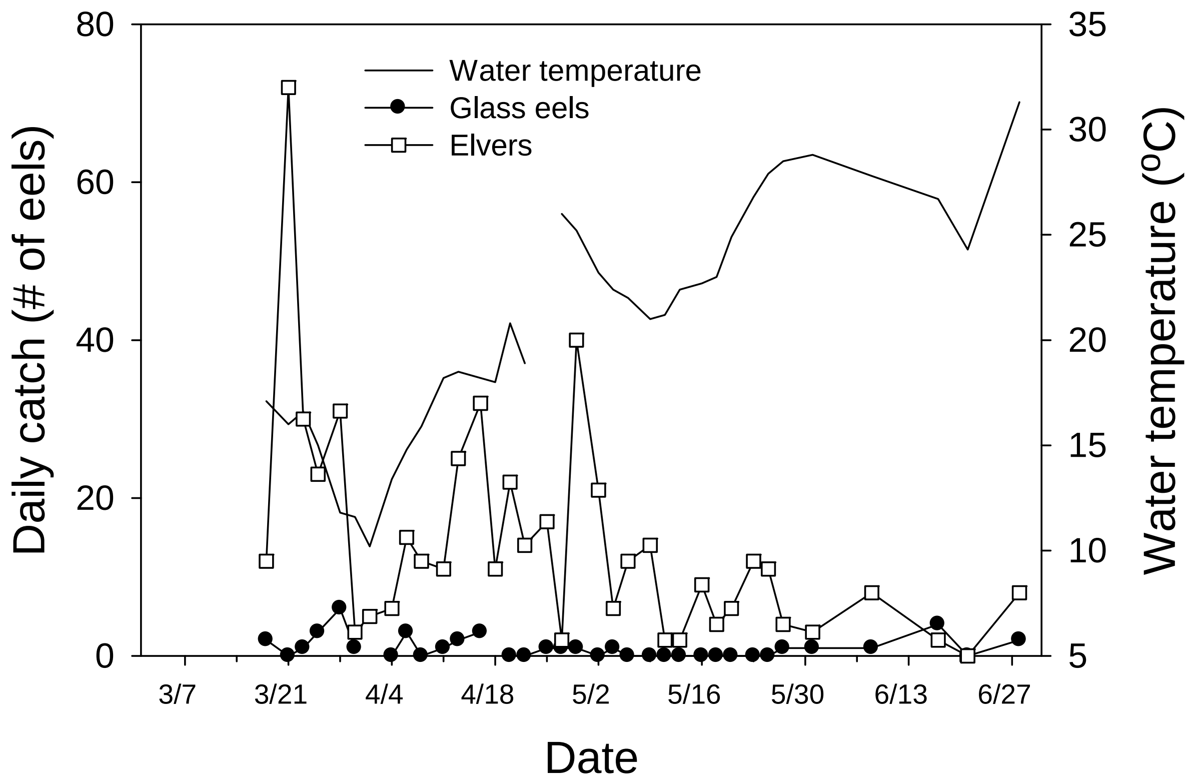

Figure 3. Number of glass eels and elvers captured during each sampling event and water temperature at Clark's Millpond, 2011.

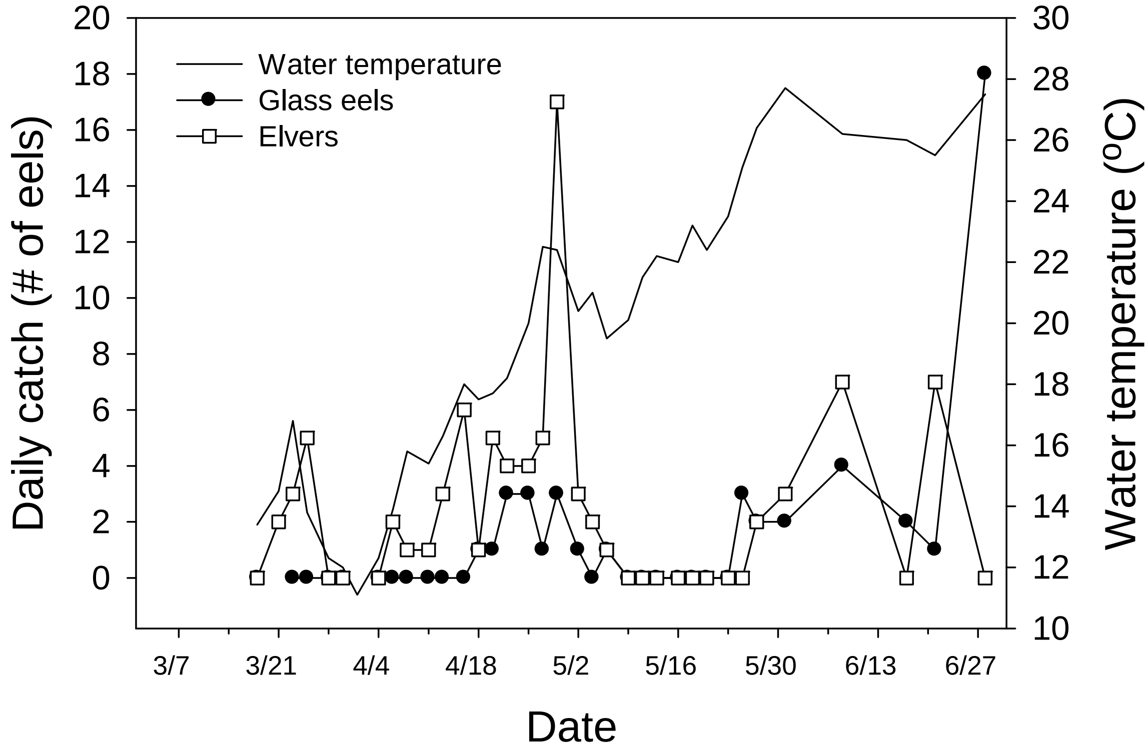

Figure 4. Elver eel index (area-under-the-curve method) from 2000 to 2011. Collections in 2000 followed different protocols and are not directly comparable to collections in later years. Time-series averages consist of data from 2001 to 2011

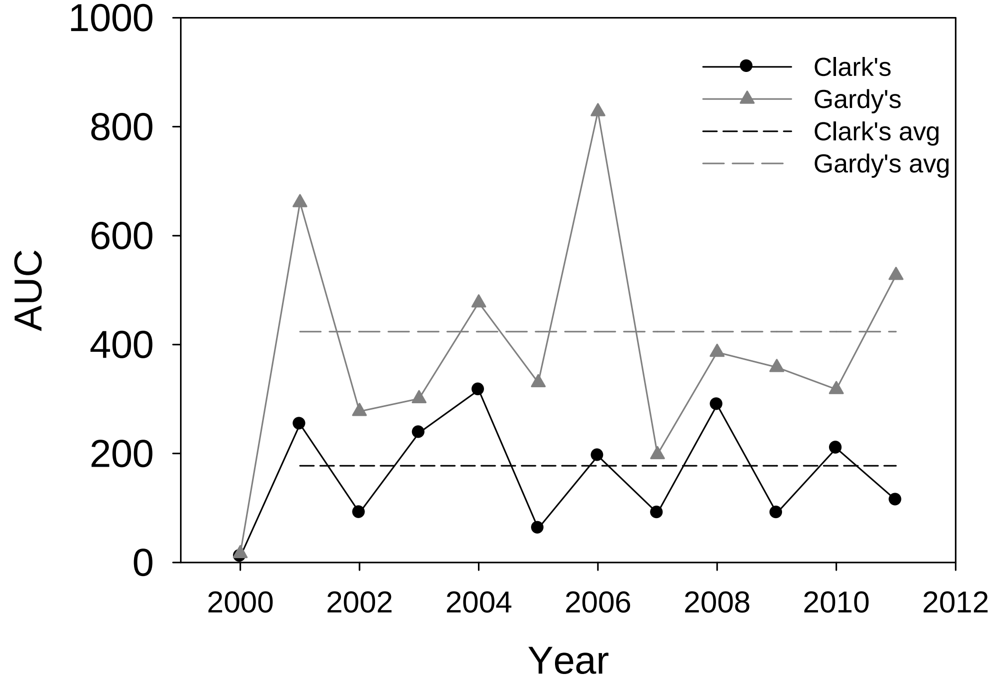

Figure 5. Glass eel index (area-under-the-curve method) from 2000 to 2011. Collections in 2000 followed different protocols and are not directly comparable to collections in later years. Time-series averages consist of data from 2001 to 2011.

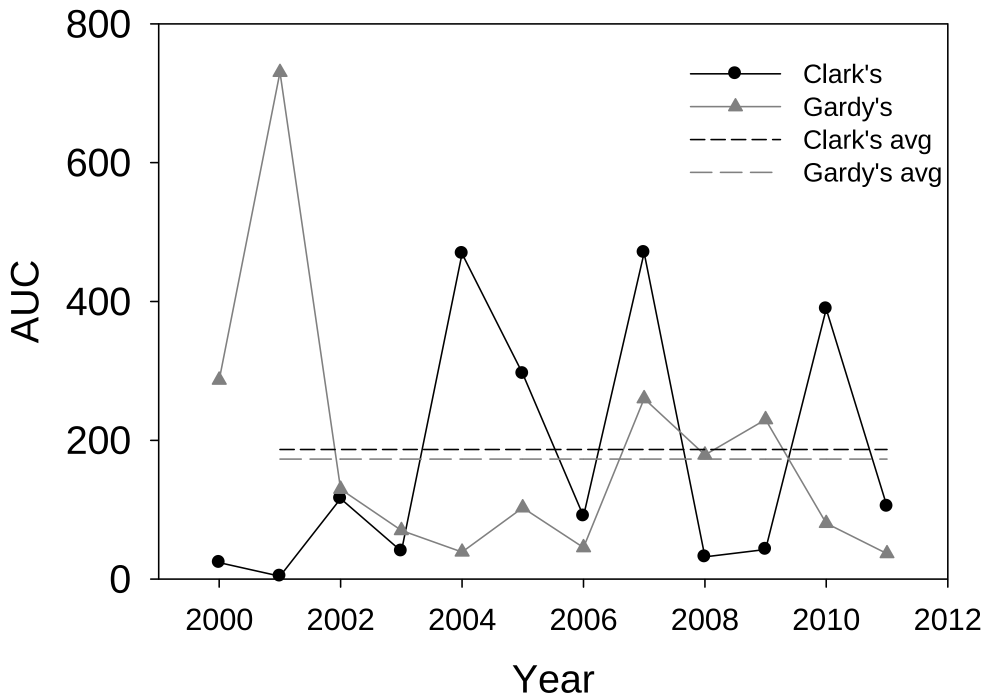

Figure 6. Glass eel pigment stage frequency distribution for the Potomac River, 2011.

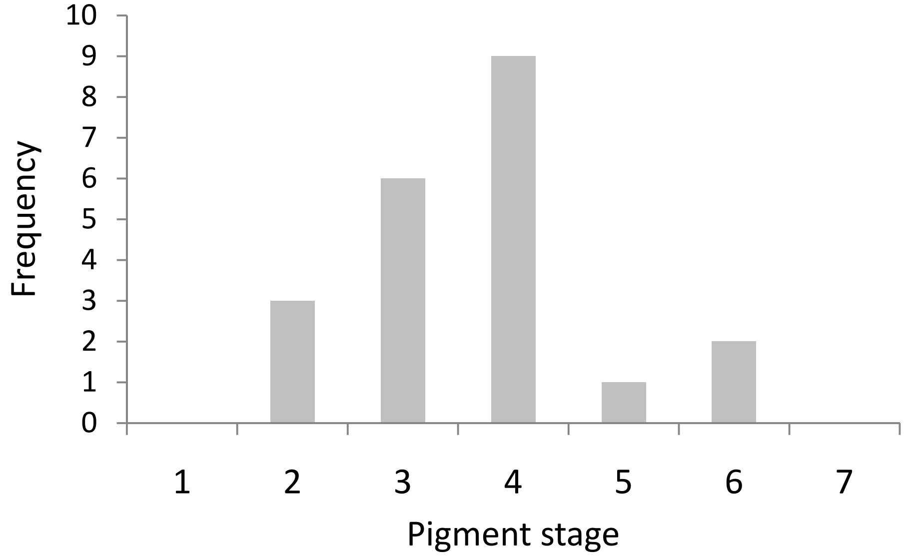

Figure 7. Total length and wet weight of glass eels captured at Clark's and Gardy's Millponds, 2011. Average TL = 59.36 mm, average weight = 0.15 g.