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Evaluating Recruitment of American Eel, Anguilla rostrata, in the Potomac River (Spring 2015)

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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 60% of the annual United States commercial harvest (ASMFC 2012). American Eel is also important to the recreational fishery as it is often used live as bait for striped bass and cobia. In 2012, Chesapeake Bay commercial landings (771,536 lbs) were 72% of the U.S. landings (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division). Since the 1980s, harvest along the U.S. Atlantic Coast has declined, with similar patterns occurring in the Canadian Maritime Provinces (Meister and Flagg 1997). The American Eel Benchmark Stock Assessment report (ASMFC 2012) established that the American Eel is depleted in U.S. waters.

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. The recent American Eel Benchmark Stock Assessment report (ASMFC 2012) 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 facultative 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.

Two sites are sampled on the Potomac River (Clark's Millpond and Gardy's Millpond). 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.

Irish eel ramps were used to collect eels at both 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.

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 two 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 indices at each site were standardized to a 24-hour soak time.

Results and Discussion

Glass eels were sampled from the Potomac River at Gardy's Millpond and Clark's Millpond between 25 March and 30 June 2015; the study period encompassed 97 days. Glass eel sampling at Clark's Millpond in 2015 resulted in the collection of a single individual; the same number collected last year. Glass eel recruitment at Gardy's Millpond resulted in the collection of 113 glass eels in 2015 (Table 1). Glass eels first arrived in mid-April at Gardy's Millpond followed by several small pulses of glass eels during the survey period (Figure 2). Glass eel indices of abundance were below average at Gardy's Millpond (mean index = 194.5) and considerably below average at Clark's Millpond (mean index = 184.0) in 2015 (Figure 4).

The capture of elvers occurred as soon as traps were deployed in late March and early April (Figures 2 and 3). We captured only 11 elvers at Clark's Millpond compared with 591 elvers at Gardy's Millpond (Table 2). Elver index values remain stable with no clear trends in relative abundance (Figure 5). 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). We continue to observe a greater abundance of elvers at Gardy's Millpond compared with Clark's Millpond despite similar historical recruitments of glass eels to each system (not counting the past two years at Clark's).

It is unclear why so few elvers and glass eels were observed at Clark's Millpond in 2014 and again in 2015. The flow of water out of the millpond was steady, though the area below the spillway appears to have eroded away with some scouring as well. Exploratory dip-netting below the spillway in 2015 found hard-clay bottom with little to no detritus. We hypothesize that hard-clay bottom habitats offer glass eels no refuge from predation, and thus such habitats may not be attractive to glass eels. Because we did not want to disrupt the area and affect catches of glass eels, we had not assessed the area below the spillway in prior years. In the future, we plan to monitor downstream conditions to determine if eel catches are affected by changes in and around our sampling sites. It is also possible that the connection of the millpond stream with the Coan River may have been altered in some way (e.g., silting in, or change in flow) that affected recruitment to the area. Another possibility is poaching, however, most glass eels collected at Potomac River sites are pigmented and poachers typically target non-pigmented eels.

Pigmentation stages of Potomac River glass eels consisted of mostly stages 4 and 5 (17% and 22%, respectively; Figure 6). Glass eels captured on the Potomac River exhibit late-stage pigmentation patterns beginning with stage 3 and darker individuals (Figure 7). Average length (57.76 mm TL) and weight (0.16 g) of glass eels captured in 2015 were similar to lengths and weights observed in previous years (Figure 8). Glass eels from the Potomac River are more developed and are likely older than those at sites closer to the mouth of Chesapeake Bay. Total catch of glass eels at sites on the Potomac River are typically below those in other VA tributaries, which may be due to natural mortality or a dilution effect as glass eels migrate into the variety of habitats 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 other 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 other lower Chesapeake Bay systems.

Conclusions and Recommendations

1. Below-average recruitment of glass eels occurred at Gardy's and Clark's Millponds, with only a single individual observed at Clark's Millpond in 2015. The trap at Clark's Millpond was working properly and flow was consistent over the spillway indicating that conditions may have changed downstream from the trap area. Exploratory dip netting below the spillway found hard-clay bottom with little to no detritus for eels to bury in perhaps reducing the attractiveness of the area for recruitment. We are unsure what the conditions looked like in this area in prior years. However, in the future, we will monitor the area below the traps to determine if changes in habitat are associated with changes in eel catches.

2. Abundance of elvers at Gardy's Millpond remained above-average in 2015; this was the third consecutive year with an above-average index. Similar to what we observed in 2014, very few elvers were captured from Clark's Millpond suggesting a change to the local habitat.

3. We recommend continued sampling of glass eels from the Potomac River sites because recruitment estimates from Gardy's Millpond 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.

References

Able, K. W. and M. P. Fahay. 1998. The first year in the life of estuarine fishes in the Middle Atlantic Bight. Rutgers University Press, New Brunswick, NJ. 342 p.

Atlantic States Marine Fisheries Commission (ASMFC). 2000. Interstate Fishery Management Plan for American Eel. Fishery Managament report No. 36. Washington, D.C. 79p.

ASMFC 2012. American Eel Stock Assessment for peer review. ASMFC, Stock Assessment Report No. 12-01, Washington, D.C. 254 p.

Castonguay, M., P.V. Hodson, C.M. Couillard, M.J. Eckersley, J.D. Dutil and G. Verreault. 1994. Why is recruitment of American Eel, *Anguilla rostrata*, declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51:479-488.

Ciccotti, E, T. Ricci, M. Scardi, E. Fresi and S. Cataudella. 1995. Intraseasonal characterization of glass eel migration in the River Tiber: space and time dynamics. J. Fish Biol. 47:248-255.

Facey, D. E. and M. J. Van Den Avyle. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—American eel. U. S. Fish Wildl. Serv. Biol. Rep. 82(11.74). U. S. Army Corps of Engineers, TR EL-82-4. 28 p.

Geer, P.J. 2001. Evaluating recruitment of American eel, *Anguilla rostrata*, to the Potomac River -- Spring 2001. Final Report to the Potomac River Fisheries Commission. Virginia Institute of Marine Science, Gloucester Point, Virginia. 21 p.

Haro, A. J. and W. H. Kreuger. 1988. Pigmentation, size and migration of elvers, *Anguilla rostrata* (Lesuer), in a coastal Rhode Island stream. Can. J. Zool. 66:2528-2533.

Haro, A., W. Richkus, K. Whalen, W.-Dieter Busch, S. Lary, T. Brush, and D. Dixon. 2000. Population decline of the American eel: Implications for research and management. Fisheries 25(9): 7-16.

Hedgepeth, M. Y. 1983. Age, growth and reproduction of American eels, *Anguilla rostrata* (Lesueur), from the Chesapeake Bay area. Masters Thesis. College of William and Mary. 61 p.

Jenkins, R. E. and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society. Bethesda, MD. 1079 p.

Knights, B. 2003. A review of the possible impacts of long-term oceanic and climate changes and fishing mortality on recruitment of anguillid eels of the Northern Hemisphere. The Science of the Total Environment 310(1-3):237-244.

Meister, A. L. and L. N. Flagg. 1997. Recent developments in the American eel fisheries of North America. FOCUS 22(1):1-4.

Murdy, E.O., R.S. Birdsong and J.A. Musick. 1997. Fishes of Chesapeake Bay. Smithsonian Institution Press. 324 p.

Olney, J. E. and J. M. Hoenig. 2001. Managing a fishery under moratorium: Assessment opportunities for Virginia's stocks of American shad. Fisheries 26: 6-11.

Owens, S. J. and P. J. Geer. 2003. Size and age structure of American eels in tributaries of the Virginia portion of the Chesapeake Bay. Pages 117-124 *in* D. A. Dixon (Editor). Biology, Management and Protection of Catadromous Eels. American Fisheries Society, Symposium 33, Bethesda, MD, USA.

Richkus, W. and K. Whalen. 1999. American eel, *Anguilla rostrata*, scoping study. A literature review and data review of the life history, stock status, population dynamics, and hydroelectric impacts. Final Report, March 1999 by Versar, Inc., Prepared for EPRI.

Sorensen, P. W. and M. L. Bianchini. 1986. Environmental correlates of the freshwater migration of elvers of the American eel in a Rhode Island brook. Trans. Amer. Fish. Soc. 115:258-268.

Sullivan, M. C., K. W. Able, J. A. Hare, and H. J. Walsh. 2006. *Anguilla rostrata* glass eel ingress into two, U. S. east coast estuaries: patterns, processes and implications for adult abundance. Journal of Fish Biology 69:1081-1101.

Tuckey, T. D. and M. C. Fabrizio. 2010. Estimating relative abundance of young of year American eel, *Anguilla rostrata*, in the Virginia Tributaries of Chesapeake Bay (Spring 2009). Final Report to the Virginia Marine Resources Commission. Virginia Institute of Marine Science, Gloucester Point, VA. 27 p.

Table 1. Summary of glass eel collections in the Potomac River at Clark's Millpond and Gardy's Millpond (2000 – 2015). CPUE is calculated as the Area Under the Curve (AUC).

Source	Year	Start Date	End Date	Total Catch	AUC
Clark's	2000	1-Apr	16-May	15	23.74
	2001	16-Mar	12-May	4	4.05
	2002	8-Mar	2-May	115	115.79
	2003	11-Mar	16-May	24	40.21
	2004	8-Mar	30-May	447	468.93
	2005	10-Mar	27-May	223	295.78
	2006	28-Feb	25-May	80	90.53
	2007	27-Feb	5-Jul	435	470.33
	2008	19-Mar	20-Jun	22	31.98
	2009	25-Mar	18-Jun	42	42.68
	2010	19-Mar	21-Jul	421	389.06
	2011	16-Mar	28-Jun	46	104.51
	2012	23-Feb	16-Jul	419	495.38
	2013	21-Feb	7-Jun	196	208.07
	2014	10-Mar	13-Jun	1	1.00
	2015	25-Mar	30-Jun	1	1.00
Gardy's	2000	12-Apr	16-May	291	286.85
	2001	12-Mar	12-May	729	730.25
	2002	8-Mar	2-May	129	129.50
	2003	11-Mar	16-May	71	70.01
	2004	8-Mar	24-May	39	38.86
	2005	10-Mar	27-May	94	102.68
	2006	28-Feb	25-May	46	45.39
	2007	27-Feb	5-Jul	248	260.09
	2008	19-Mar	20-Jun	187	178.94
	2009	25-Mar	18-Jun	231	229.92
	2010	19-Mar	21-Jul	90	80.25
	2011	16-Mar	28-Jun	35	36.78
	2012	23-Feb	16-Jul	261	259.83
	2013	21-Feb	13-Jun	333	383.86
	2014	10-Mar	13-Jun	243	253.10
	2015	25-Mar	30-Jun	113	118.42

Table 2. Summary of elver collections in the Potomac River at Clark's Millpond and Gardy's Millpond (2000 – 2015). CPUE is calculated as the Area Under the Curve (AUC).

Source	Year	Start Date	End Date	Total Catch	AUC
Clark's	2000	1-Apr	16-May	5	10.69
	2001	16-Mar	12-May	205	253.67
	2002	8-Mar	2-May	90	90.95
	2003	11-Mar	16-May	225	237.72
	2004	8-Mar	30-May	314	316.36
	2005	10-Mar	27-May	62	62.33
	2006	28-Feb	25-May	153	195.68
	2007	27-Feb	5-Jul	90	90.31
	2008	19-Mar	20-Jun	276	289.16
	2009	25-Mar	18-Jun	90	90.46
	2010	19-Mar	21-Jul	208	209.59
	2011	16-Mar	28-Jun	84	114.09
	2012	23-Feb	16-Jul	268	256.69
	2013	21-Feb	7-Jun	148	158.23
	2014	10-Mar	13-Jun	13	14.63
	2015	25-Mar	30-Jun	11	11.09
Gardy's	2000	12-Apr	16-May	15	16.46
	2001	12-Mar	12-May	624	660.76
	2002	8-Mar	2-May	273	277.15
	2003	11-Mar	16-May	300	300.78
	2004	8-Mar	24-May	483	476.76
	2005	10-Mar	27-May	313	330.15
	2006	28-Feb	25-May	692	827.71
	2007	27-Feb	5-Jul	198	198.23
	2008	19-Mar	20-Jun	393	385.88
	2009	25-Mar	18-Jun	360	358.27
	2010	19-Mar	21-Jul	375	317.53
	2011	16-Mar	28-Jun	507	527.09
	2012	23-Feb	16-Jul	411	406.59
	2013	21-Feb	13-Jun	664	1564.73
	2014	10-Mar	13-Jun	967	982.11
	2015	25-Mar	30-Jun	591	656.03

Figure 1. Sampling sites in the Potomac River.

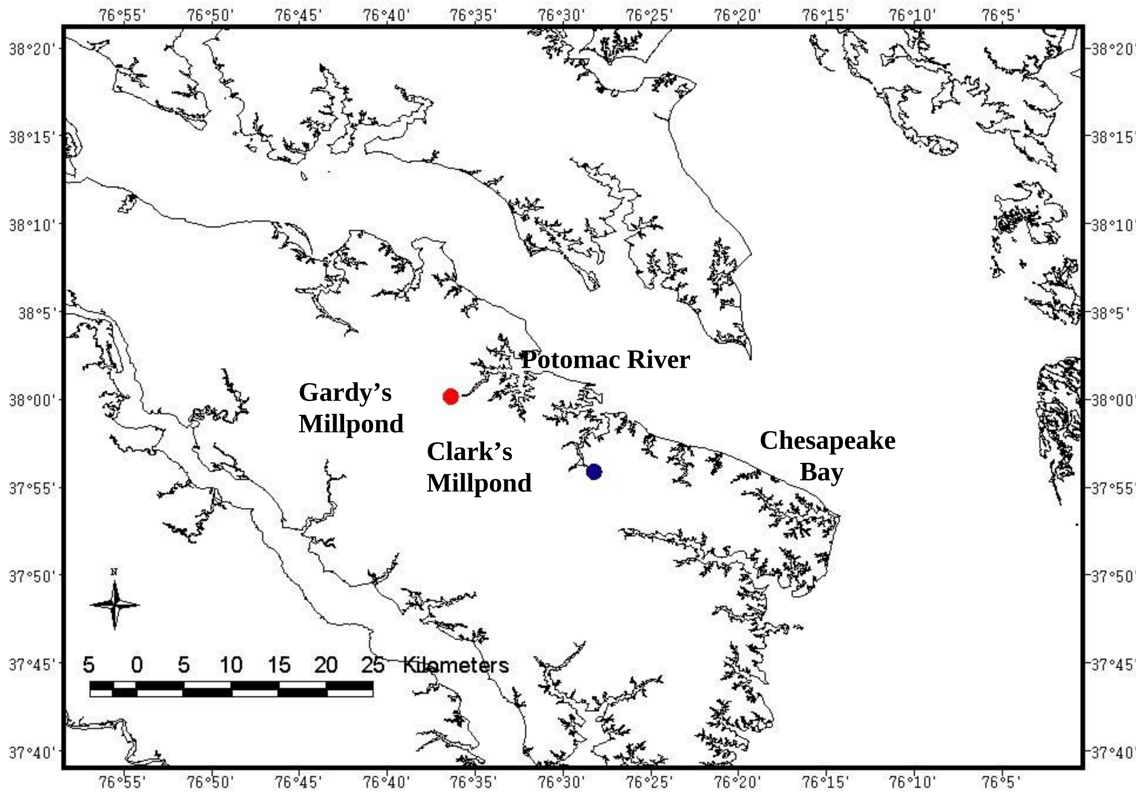

Figure 2. Number of glass eels and elvers captured during each sampling event and water temperature at Gardy's Millpond, 2015.

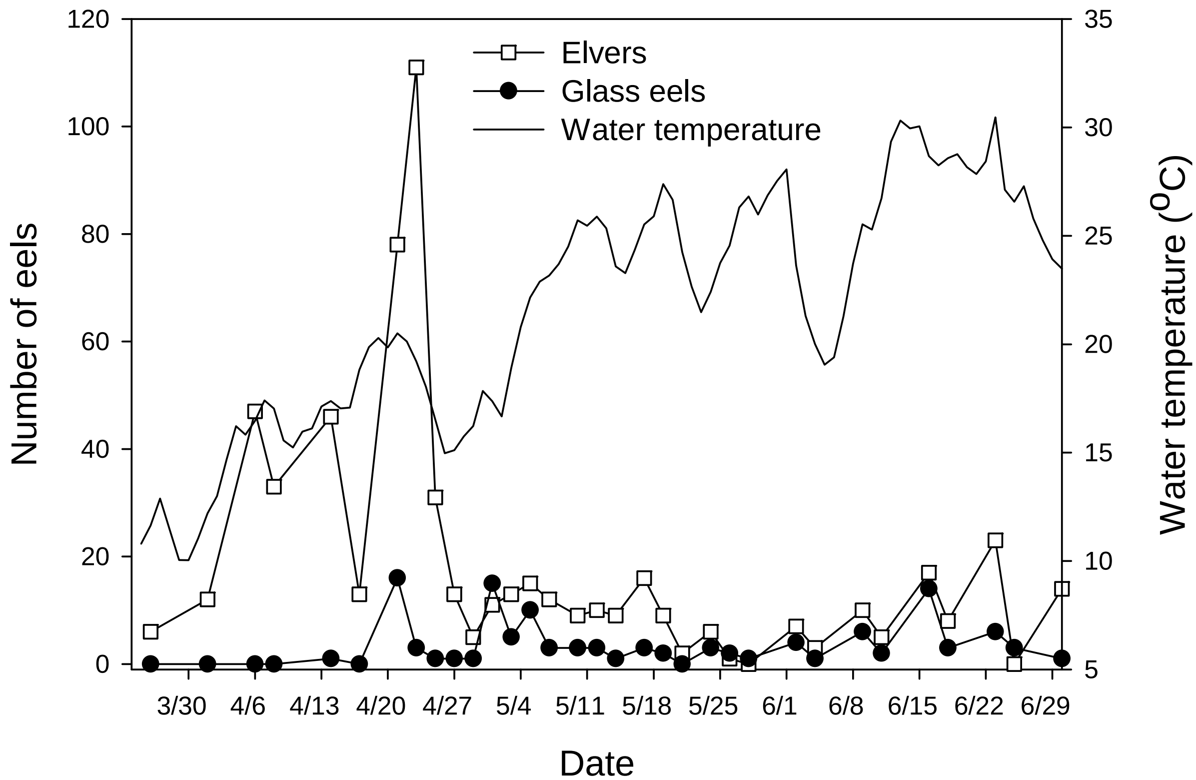

Figure 3. Number of glass eels and elvers captured during each sampling event and water temperature at Clark's Millpond, 2015.

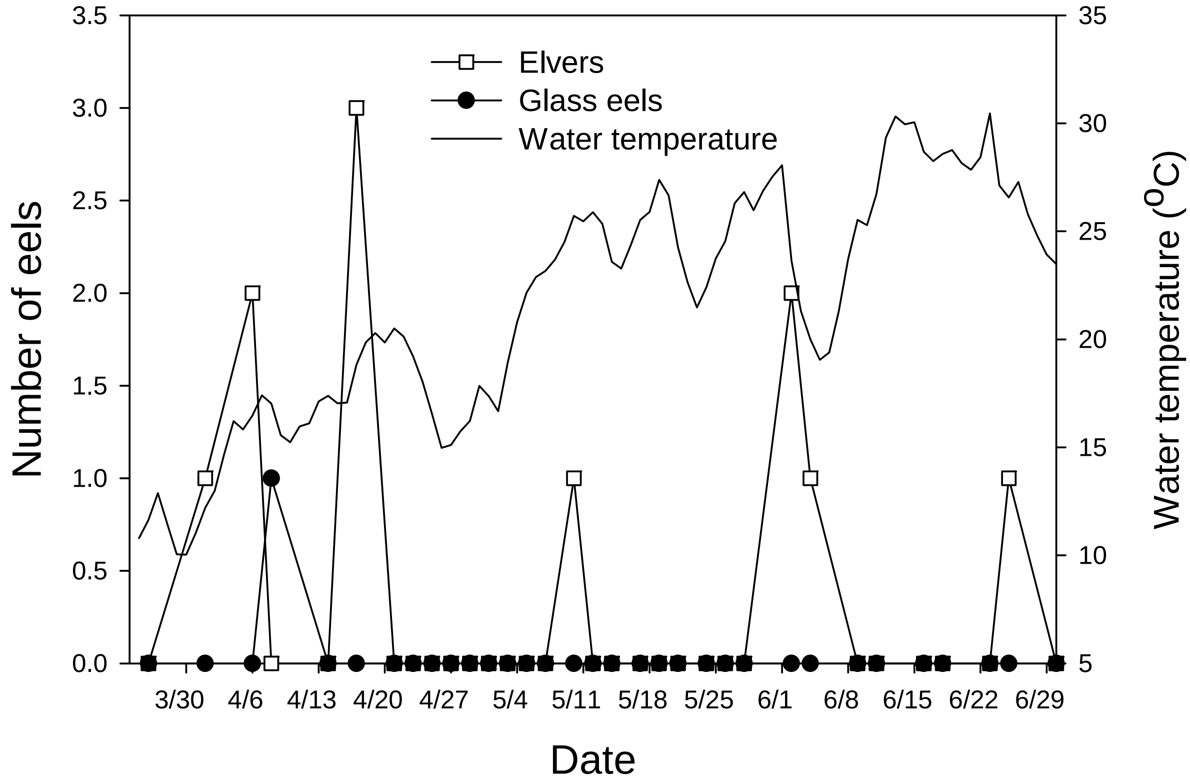

Figure 4. Glass eel index (area-under-the-curve method) from 2000 to 2015. Collections in 2000 followed different protocols and are not directly comparable to collections in later years. Time-series averages consist of data from 2001 to 2015.

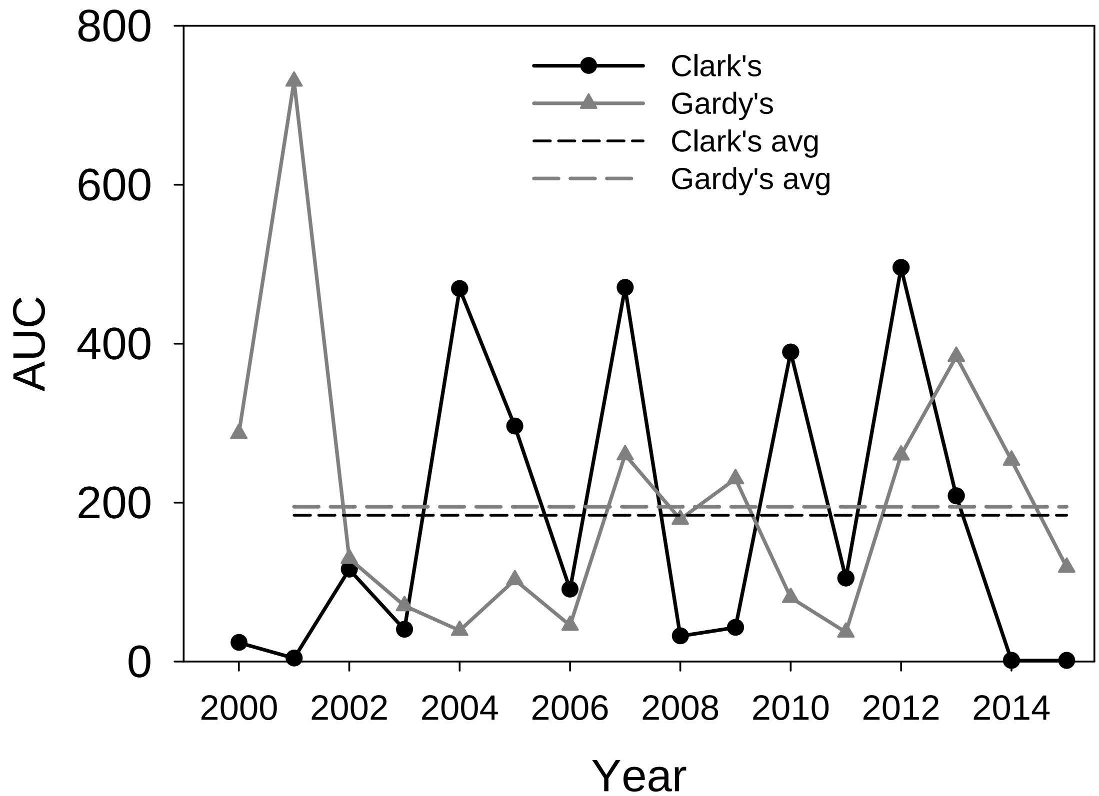

Figure 5. Elver eel index (area-under-the-curve method) from 2000 to 2015. Collections in 2000 followed different protocols and are not directly comparable to collections in later years. Time-series averages consist of data from 2001 to 2015.

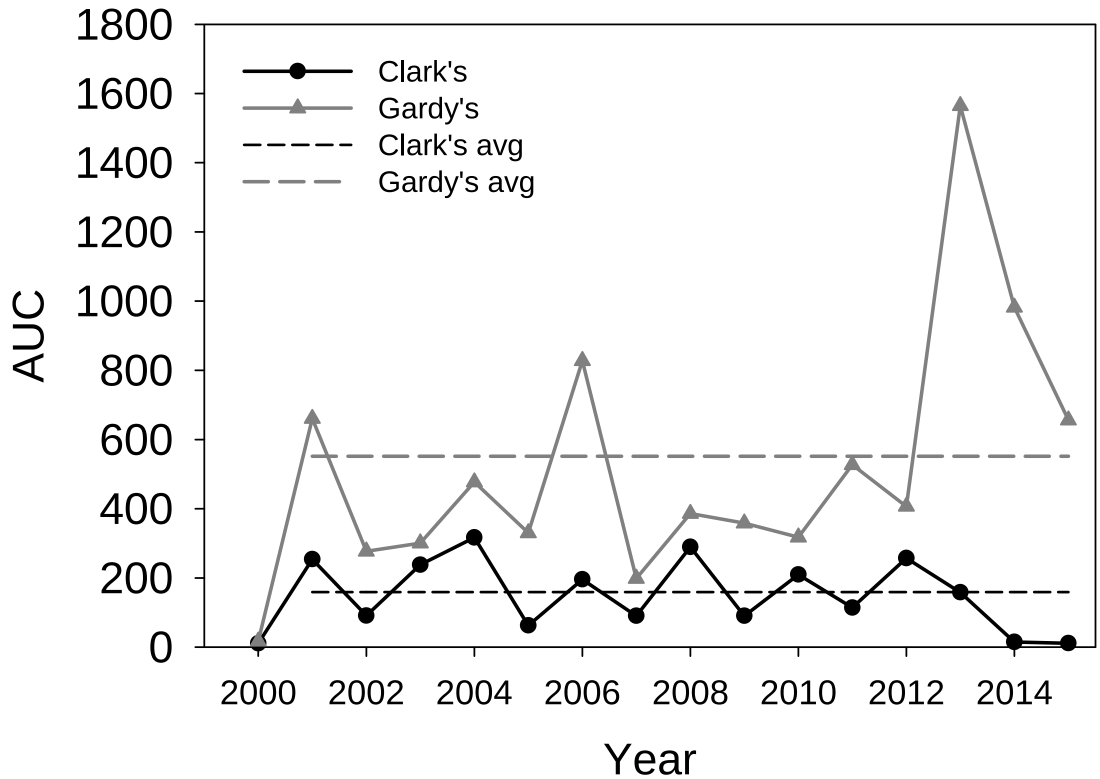

Figure 6. Glass eel pigment stage frequency distribution for the Potomac River, 2015 (N = 66).

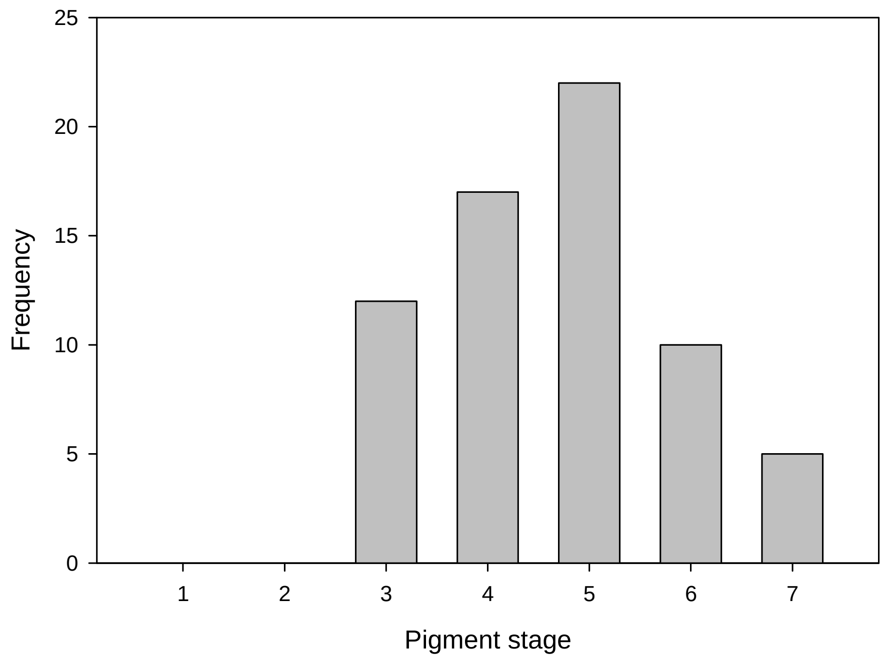

Figure 7. Glass eel pigment stage frequency distribution for the Potomac River, 2002 – 2015 (except 2003, which was not assessed that year).

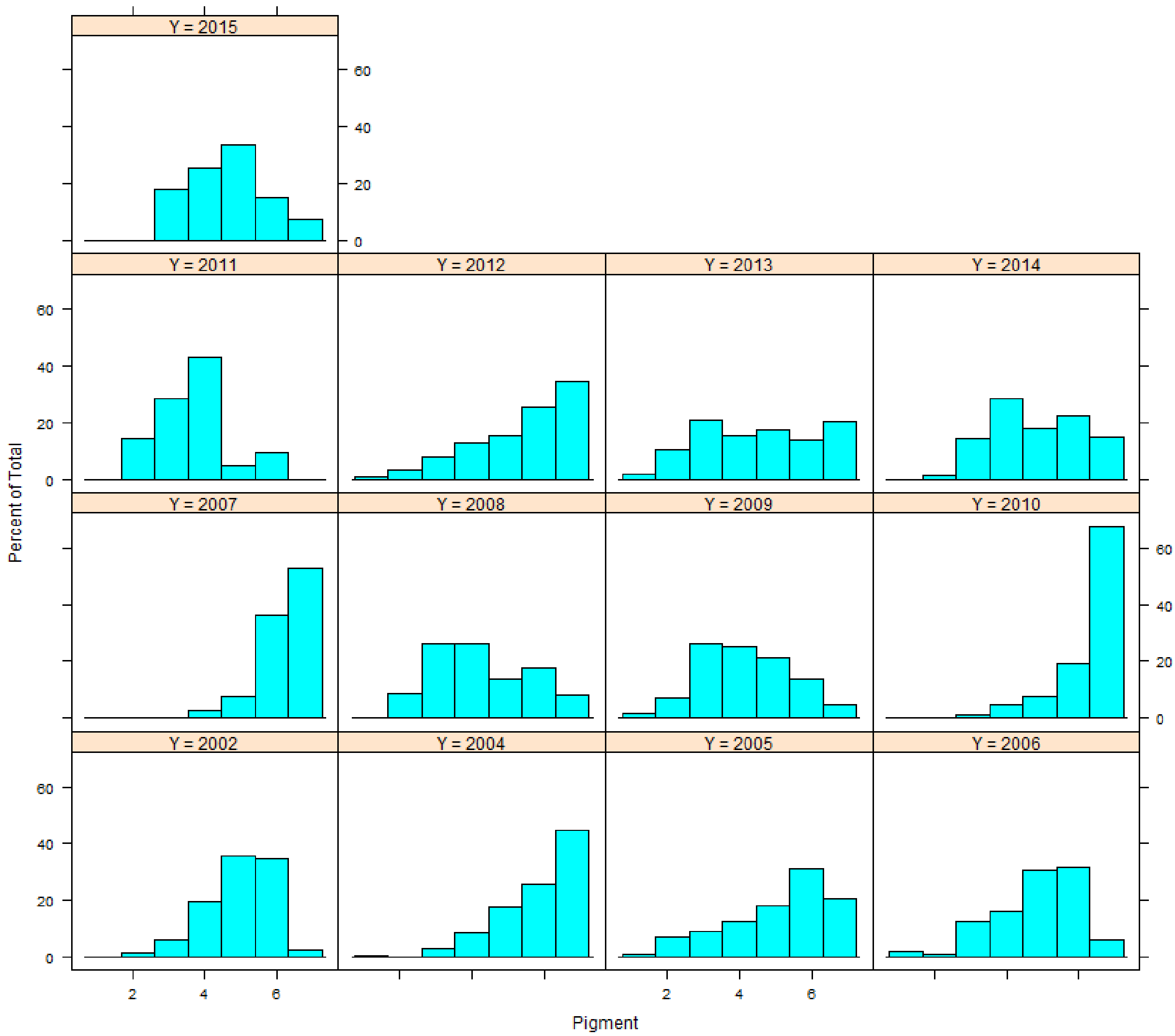

Figure 8. Total length and wet weight of glass eels captured at Gardy's Millpond, 2015. Average TL = 57.76 mm, average weight = 0.16 g, N = 66 eels.