

**Estimating Relative Abundance of Young of Year American Eel, *Anguilla rostrata*,  
in the Virginia Tributaries of Chesapeake Bay (Spring 2007)**

**Final Report**

**Submitted by**

**Troy Tuckey**

**Department of Fisheries Science  
Virginia Institute of Marine Science  
College of William and Mary  
Gloucester Point, Virginia 23062**

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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. In recent years, harvest along the U.S. Atlantic Coast has declined, with similar patterns occurring in the Canadian Maritime Provinces (Meister and Flagg 1997). Landings from the Chesapeake Bay typically represent 63% of the annual United States commercial harvest (ASMFC 2000). In 2005 Virginia commercial landings were one-third of the average annual landings since mandatory reporting began in 1993 (VMRC 2006).

A decline in abundance of American eel has been observed in recent years with conflicting evidence regarding spatial synchrony throughout their range (Richkus and Whalen 1999; Sullivan et al. 2006). Limited knowledge about fundamental biological characteristics of juvenile American eel has complicated interpretation of juvenile abundance trends (Sullivan et al. 2006). Hypotheses for the decline in abundance include locational shifts in the Gulf Stream, pollution, overfishing, parasites, and barriers to fish passage (Castonguay et al. 1994; Haro et al. 2000). 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).

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 (including Virginia) agreed to implement an annual survey for 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, 2006) emphasized the importance of the coast-wide survey as an index of sustained recruitment over the historical coastal range and an early warning of potential range

contraction of the species. The Virginia Institute of Marine Science continued its spring sampling to estimate relative abundance of young of year (YOY) American eels in Virginia tributaries of Chesapeake Bay. Funding was provided by the Marine Recreational Fishing Advisory and Commercial Fishing Advisory Boards, which ensured compliance with the 1999 ASMFC Interstate Fishery Management Plan for American Eels.

### **Life History**

The American eel is a catadromous species which 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 (over 9-12 months) in a generally northwesterly direction and can grow to 85 mm TL (Jenkins and Burkhead 1993). Within a 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). As growth continues, the glass eel becomes pigmented (elver stage) and within 12 to 14 months acquires 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 occurs from late summer through autumn. Age at maturity varies greatly with location and latitude, and in Chesapeake Bay may 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 back to the Sargasso Sea to spawn and die (Haro et al. 2000).

It has been suggested that glass eel migration consists of waves of invasion (Boetius and Boetius 1989 as reported by Ciccotti et al. 1995), and perhaps a fortnightly periodicity related to selective tidal stream transport (Ciccotti et al. 1995). Additionally, alterations in freshwater flow (timing and magnitude) to bays and estuaries may affect the size, timing and spatial patterns of upstream migration of glass eels and elvers (Facey and Van Den Avyle 1987). Eel YOY may use freshwater “signals” to enhance recruitment to local estuaries, thereby influencing year-class strength (Sullivan et al. 2006).

### **Objectives**

1. Monitor the glass eel migration, or run, into the Virginia Chesapeake Bay tributaries to determine the spatial and temporal components of recruitment.
2. Examine environmental parameters which may influence young of year eel recruitment.
3. Collect basic biological information on recruiting eels including length, weight, and pigment stage.

### **Methods**

Minimum criteria for YOY American eel sampling has been established in the ASMFC American Eel FMP, with the Technical Committee approving sampling gear. The timing and placement of gear must coincide with periods of peak YOY onshore migration. At a minimum, the gear must fish during flood tides during nighttime hours. 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 a minimum of 60 glass eels (if present per system) must be examined for length, weight, and pigmentation stage weekly.

Numerous study sites in Virginia were evaluated in 2000 (Geer 2001) and final site selection was based on known areas of glass eel occurrence, accessibility, and specific physical criteria (e.g. proper habitat) suitable for glass eel recruitment. Four sites were selected with two on the York River, and one each on the Rappahannock

and James rivers. Two sites on the York River are Brackens Pond and Wormley Pond (Figure 1). Brackens Pond is located along the Colonial Parkway at the base of the Yorktown Naval Weapon Station Pier and is less than 100 m from the York River with the tide often reaching the spillway. This site was chosen as a primary site in 2000 with gear comparisons performed throughout the sampling season. Wormley Pond is located on the Yorktown Battlefield and drains into Wormley Creek which has a tidal range that routinely reaches 50 cm depth at the spillway. This site was not sampled in Spring 2000. Kamp's Millpond drains into the Eastern Branch of the Corrotoman River, a tributary to the Rappahannock River (Figure 1). Kamp's Millpond covers approximately 80 acres and is located upstream of Route 790, just north of Kilmarnock. The final collection site on the James River is Wareham's Pond, which is located adjacent to Kingsmill in James City County. Wareham's Pond drains directly into the James River, which is about 100 m away, though a high tide may reach the end of the spillway (Figure 1).

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 a continuous flow of water over the climbing substrate and the collection device, which 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<sup>TM</sup> 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°), 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° incline of the substrate inside the ramp, provided sufficient slope to create attractant flow. A hinged lid provided access for cleaning and flow adjustments.

Once eel recruitment began, traps were checked daily on the York River (Wormley and Brackens Ponds) and four days per week (Monday-Wednesday-Friday and alternating weekend days) on the Rappahannock River (Kamp's Millpond) and James River (Wareham's Pond). 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, pH, air temperature, wind direction and speed, and precipitation were recorded during most site visits. All eels were enumerated 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). Length, weight, and pigmentation stage (see Haro and Krueger 1988) were collected from 60 eels from each system weekly. Daily catch (raw number of eels caught per day) and annual geometric mean catch per unit effort (CPUE) were calculated for each site. Annual CPUE at each site were standardized to a 24 hour soak time and geometric means were calculated using the time period in which 95% of the cumulative total catch was sampled (i.e., dates in which 0%-2.5% and 97.5%-100% of the cumulative total catch was collected were excluded), in an effort to account for the interannual variability in the period of maximum recruitment.

## **Results**

Sampling on the York River (Brackens Pond and Wormley Pond) was conducted from 14 February to 18 May 2007. Wareham's Pond on the James River was sampled from 15 February to 18 May 2007, while sampling at Kamp's Millpond on the Rappahannock River was conducted from 27 February through 5 July 2007.

Daily catches of juvenile eels increased when water temperatures approached 10 °C (Figures 2 - 5). On the York River, peak catches of glass eels and elvers occurred from mid to late March and again in late April in Wormley pond (Figure 2) and Brackens Pond (Figure 3). At Wareham's Pond on the James River, peak catches of glass eels occurred in early April, while elver catches reached a peak from mid to late April (Figure 4). Catches of juvenile American eel at Kamp's Millpond on the Rappahannock River reached a peak in May for glass eels and in late June for elvers (Figure 5).

Annual CPUE for glass eels and elvers have been variable at all sites over the time series. The 2007 glass eel CPUE decreased at both Brackens Pond and Wormley Pond compared to 2006 (Figure 6, top), while elver CPUE for 2007 was the highest

observed at both sites relative to previous years (Figure 6, bottom). Glass eel and elver CPUE at Kamp's Millpond remained low relative to the time series (Figure 3, top and bottom). Low CPUE of glass eels was also observed in Wareham's Pond in 2007, but an increase in elver CPUE was observed in 2007 (Figure 7, top and bottom).

Pigmentation stages of glass eels at Wormley pond on the York River were dominated by stages 1 and 2 during late February and early March with increasing abundance of stages 3 and 4 occurring during late March and early April with a few at stage 6 (Figure 8). The recruitment of glass eels in mid to late April consisted of stages 1 through 7. Juvenile American eel total lengths ranged from 47 to 68 mm with a mean at 57.0 mm (sd = 3.17; Figure 9).

## **Discussion**

Timing of glass eel and elver recruitment to rivers in Virginia follow a pattern related to the proximity of the sampling location to the mouth of Chesapeake Bay. Stations nearer to Chesapeake Bay showed recruitment peaks earlier in the year compared with those further away from the mouth of the bay. Variability in the occurrence of recruitment peaks was greater among rivers than within the two sites on the York River indicating that timing of recruitment can be monitored at a single station in each river.

Annual CPUE of juvenile eels varied greatly among sites and years with widely varying patterns in some instances (e.g. glass eel CPUE at Wormley Pond). The York River typically has greater relative abundance of glass eels compared with the James and Rappahannock rivers, but similar estimates of abundance for elvers. The short time-series of data limits detailed analysis and interpretation of recruitment patterns in Virginia.



## **Conclusions and Recommendations**

1. Irish eel ramps are an efficient passive gear for sampling YOY American eel in coastal Virginia.
2. Sampling should continue at the primary sites on the York, James and Rappahannock Rivers and should start at least as early as the previous year and continue later, if necessary. Given the great variability associated with spring temperatures in the Chesapeake Bay region, sampling must be over a wide water temperature range to ensure that sampling encompasses peak migration of YOY eels.
3. The ultimate goal of this survey is to provide annual estimates of recruitment for YOY eels and elvers. Considering the unique nature of each site, and the performance variability of the sampling gear at these sites, it may be necessary to develop an "index" for each site. Parameters such as pond drainage area, distance from the ocean, discharge, and other physical parameters should continue to be evaluated to provide a relative value for each site. This value may then be used to weigh the catch rates at each site to provide an overall estimate of juvenile eel recruitment.
4. Additional years of data are necessary to solve the American eel recruitment puzzle. Anomalies that occur offshore (e.g. Gulf Stream changes) should also be investigated.

Further information on past VIMS American Eel Recruitment research can be found at [http://www.vims.edu/fish/eels/eel\\_publications.html](http://www.vims.edu/fish/eels/eel_publications.html).

## Literature Cited

- 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 Jersey. 342 pp.
- ASMFC, 2000. Fishery Management Plan for American Eel, *Anguilla rostrata*.
- Castonquay, 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 pp.
- Geer, P.J. 2001. Evaluating recruitment of American eel, *Anguilla rostrata*, to the Potomac River ---Spring 2001. Report prepared for Potomac River Fisheries Commission. Virginia Institute of Marine Science Gloucester Point, Virginia 23062. 21 pp.
- Geer, P.J. 2003. Distribution, relative abundance, and habitat use of American eel *Anguilla rostrata* in the Virginia portion of the Chesapeake Bay. Pages 101-115 in D.A. Dixon (Editor). Biology, Management and Protection of Catadromous Eels. American Fisheries Society, Symposium 33, Bethesda, MD, USA.
- Haro, A.J. and W.H. Kreuger. 1988. Pigmentation, size and migration of elvers, *Anguilla rostrata* (Lesueur), 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 pp.
- Jenkins, R. E. and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society. Bethesda, MD. 1079 pp.
- 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 eastern North American. *Focus* 22(1): 25-26.
- Murdy, E.O., R.S. Birdsong and J.A. Musick. 1997. *Fishes of Chesapeake Bay*. Smithsonian Institution Press. 324 pp.
- 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*, scooping 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.
- Sorenson, 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. *J. Fish. Bio.* 69:1081-1101.
- VMRC, 2006. Commercial landings data. <http://www.mrc.state.va.us/>

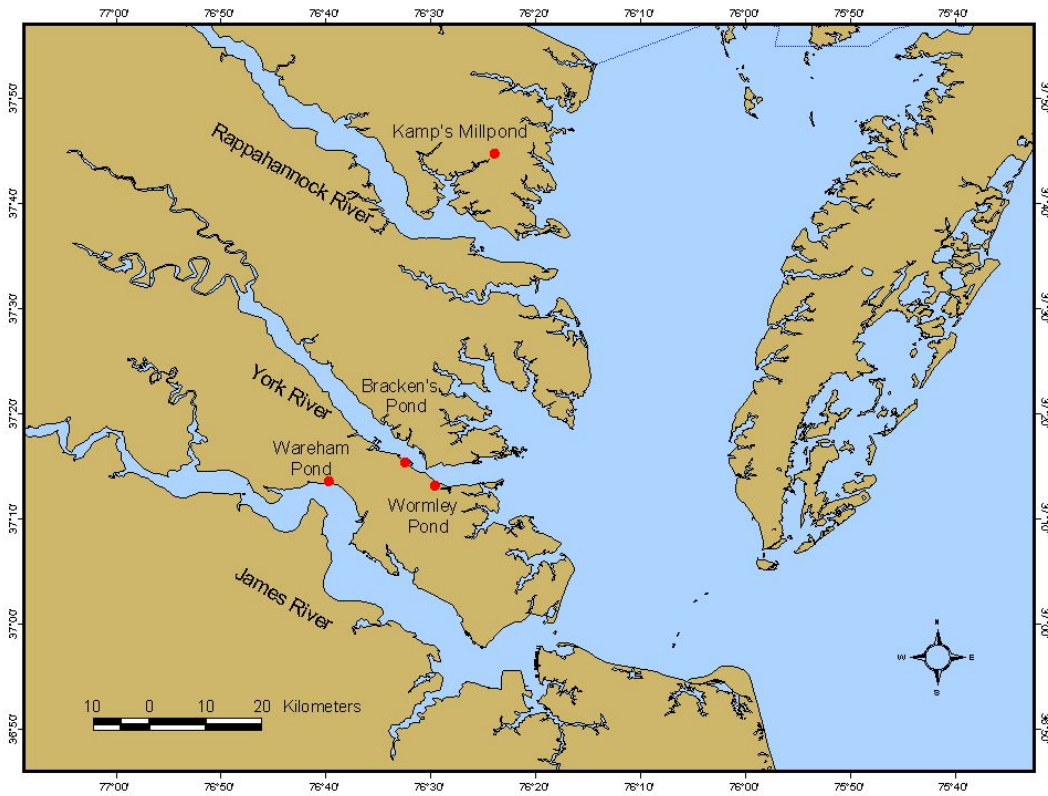


Figure 1. American eel sampling sites in the Rappahannock (Kamp's Millpond), York (Wormley Pond and Brackins Pond), and James (Wareham's Pond) rivers, Virginia, 2007.

### Wormley Pond

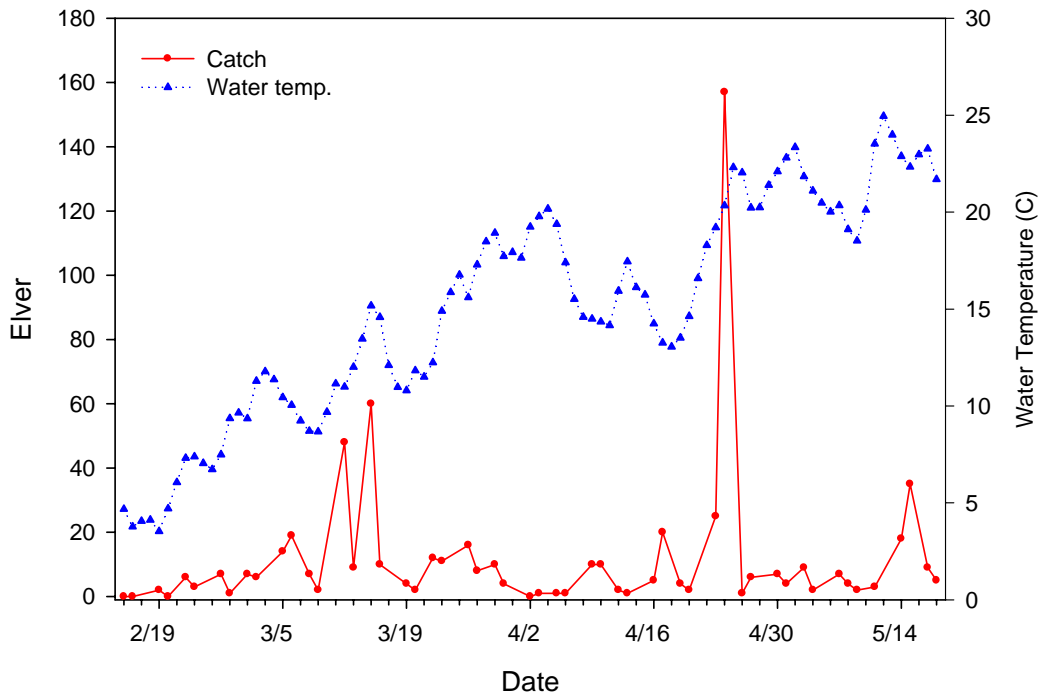
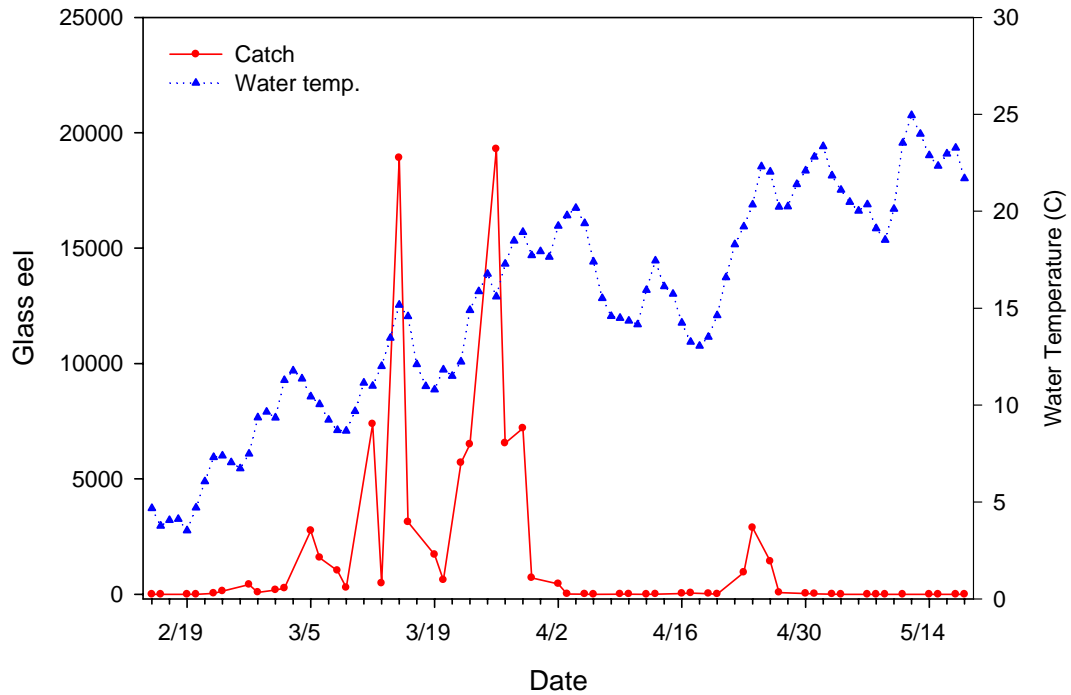


Figure 2. Daily catch (raw count) of glass eels and elvers and daily water temperature (°C) at Wormley Pond on the York River during 2007.

### Brackens Pond

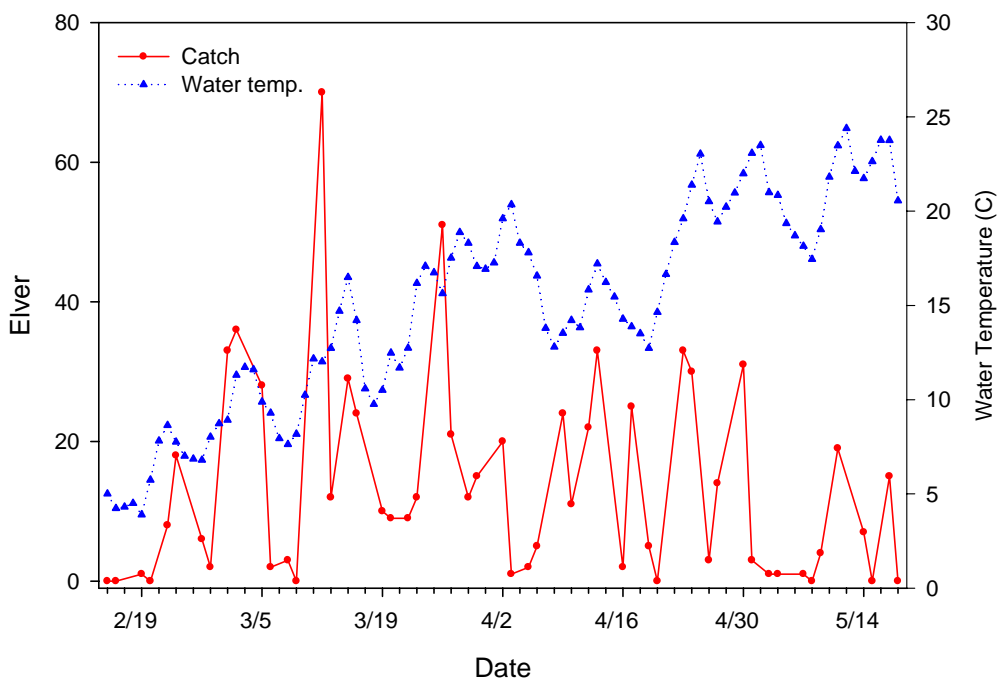
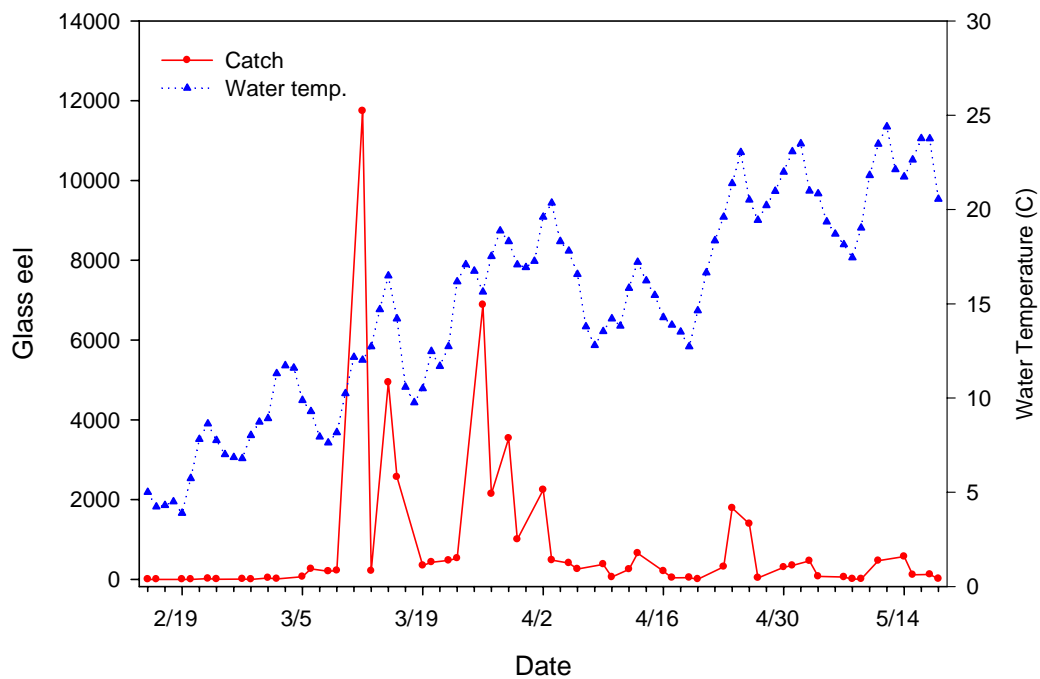


Figure 3. Daily catch (raw count) of glass eels and elvers and daily water temperature (°C) at Brackens Pond on the York River during 2007.

### Wareham's Pond

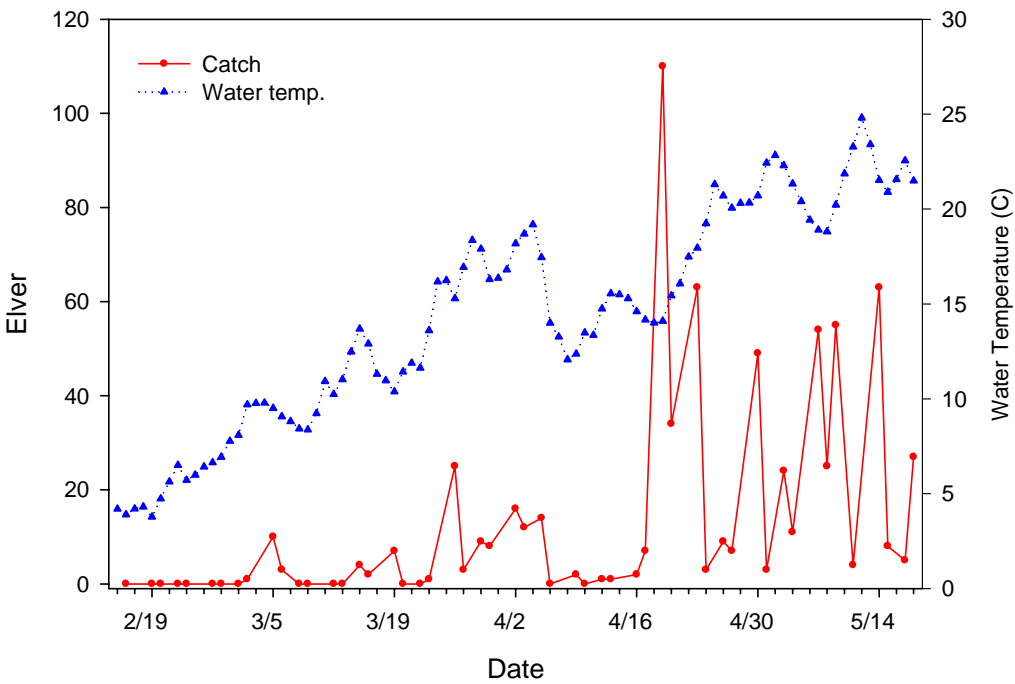
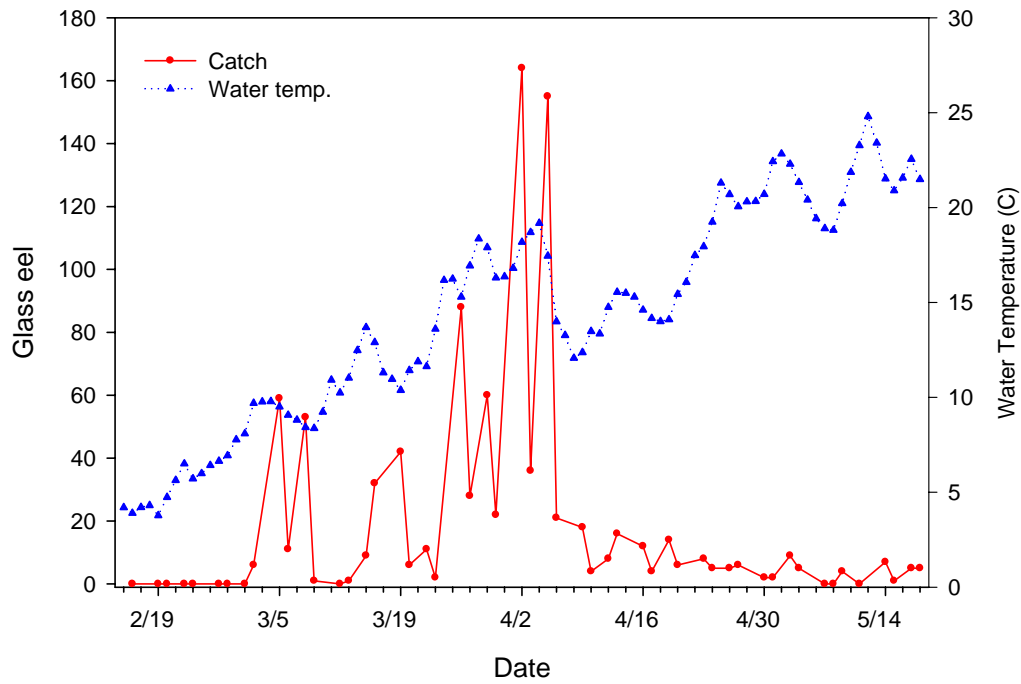


Figure 4. Daily catch (raw count) of glass eels and elvers and daily water temperature (°C) at Wareham's Pond on the James River during 2007.

### Kamp's Millpond

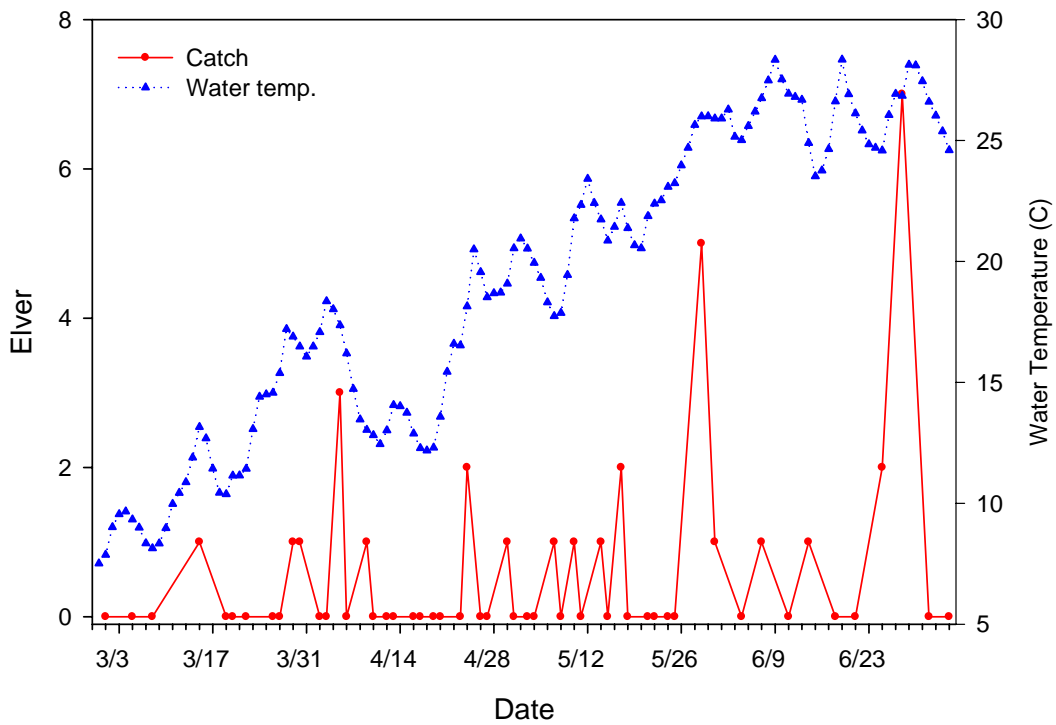
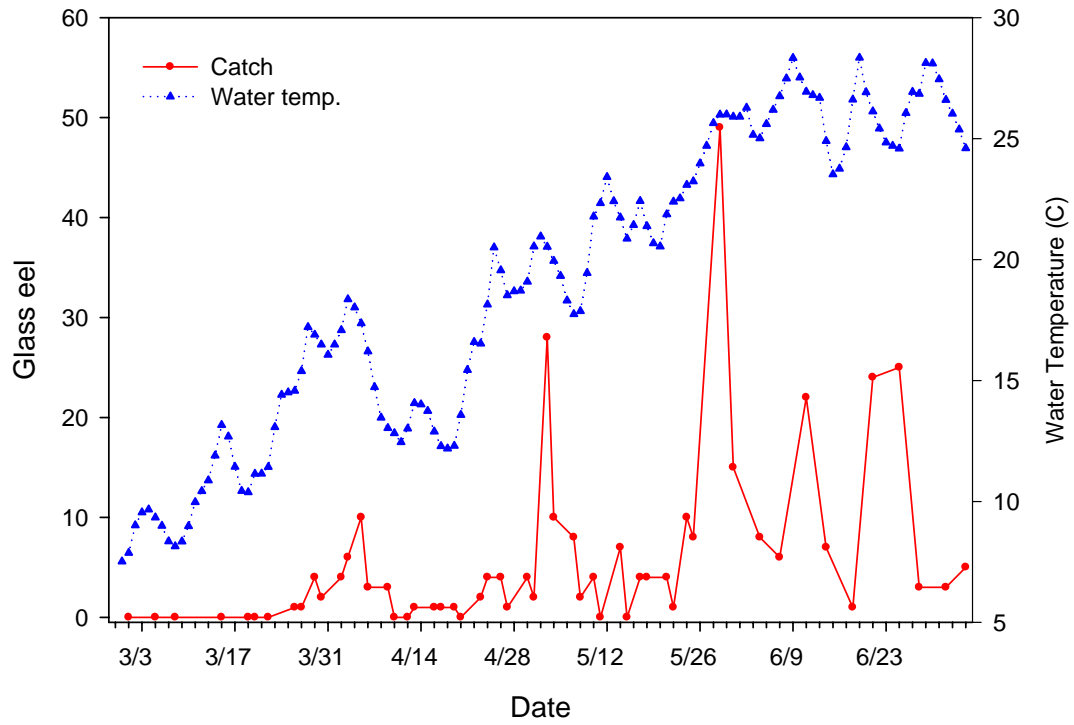


Figure 5. Daily catch (raw count) of glass eels and elvers and daily water temperature (°C) at Kamp's Millpond on the Rappahannock River during 2007.



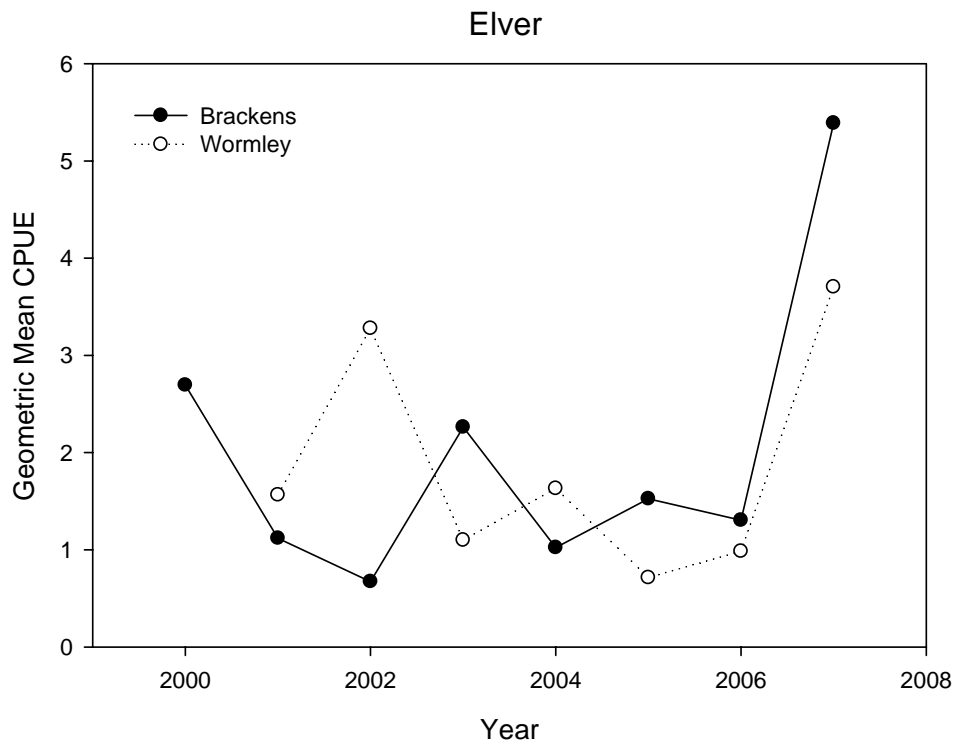
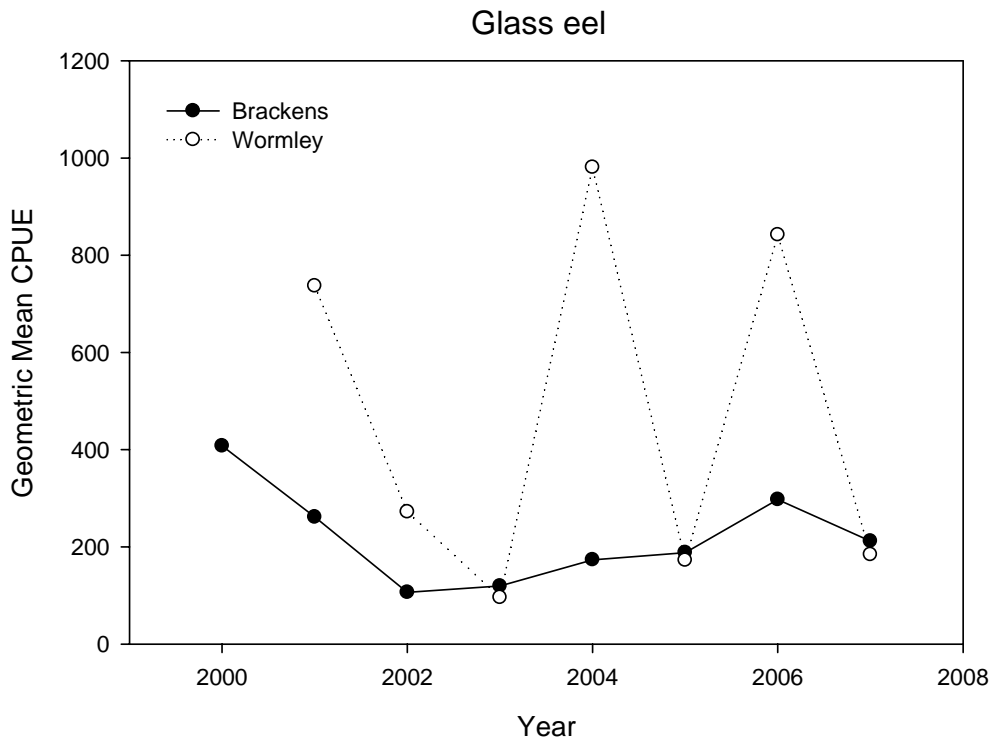


Figure 6. Glass eel (top) and elver (bottom) annual CPUE (daily geometric mean) for Brackens Pond (2000-2007) and Wormley Pond (2001-2007).

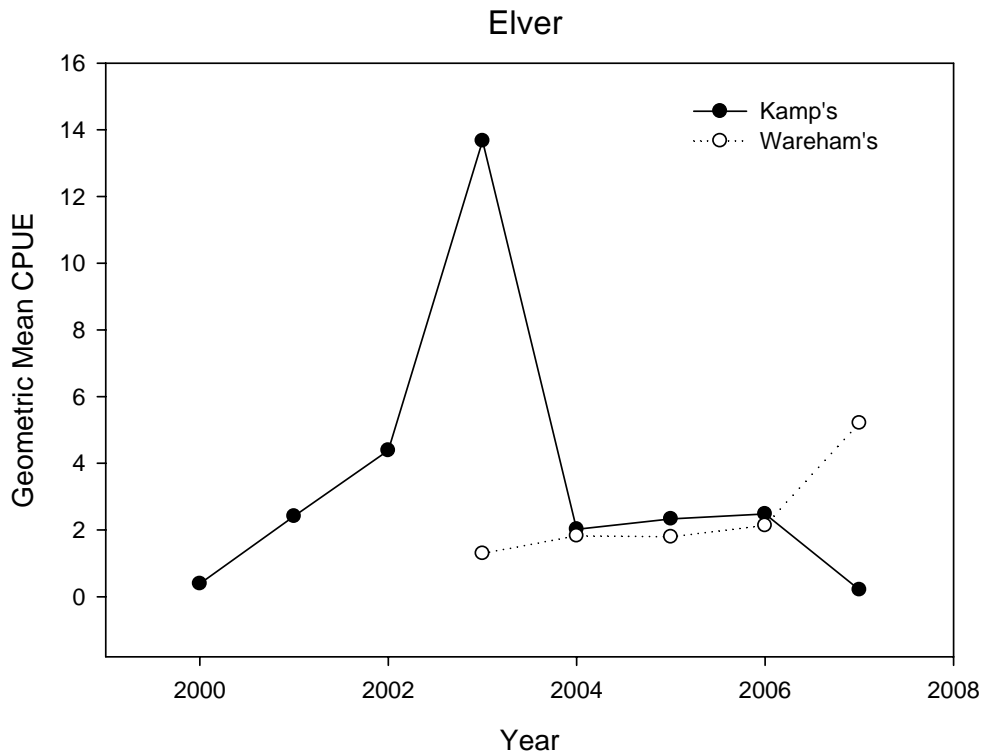
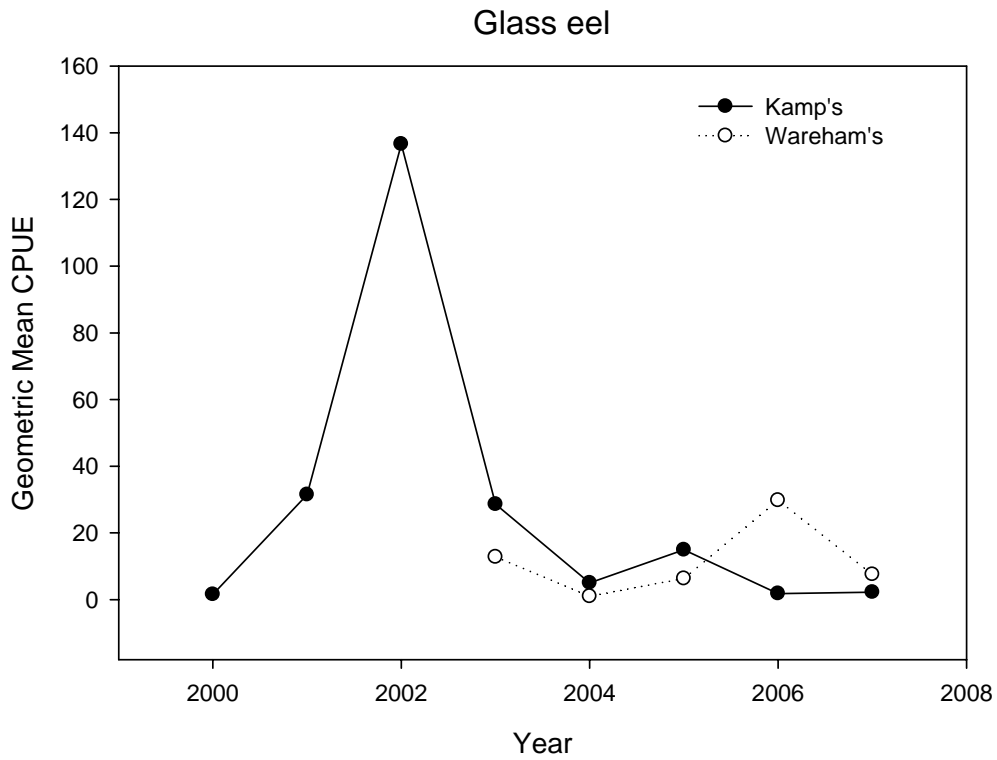


Figure 7. Glass eel (top) and elver (bottom) annual CPUE (daily geometric mean) for Kamp's Pond (2000-2007) and Wareham's Pond (2003-2007).

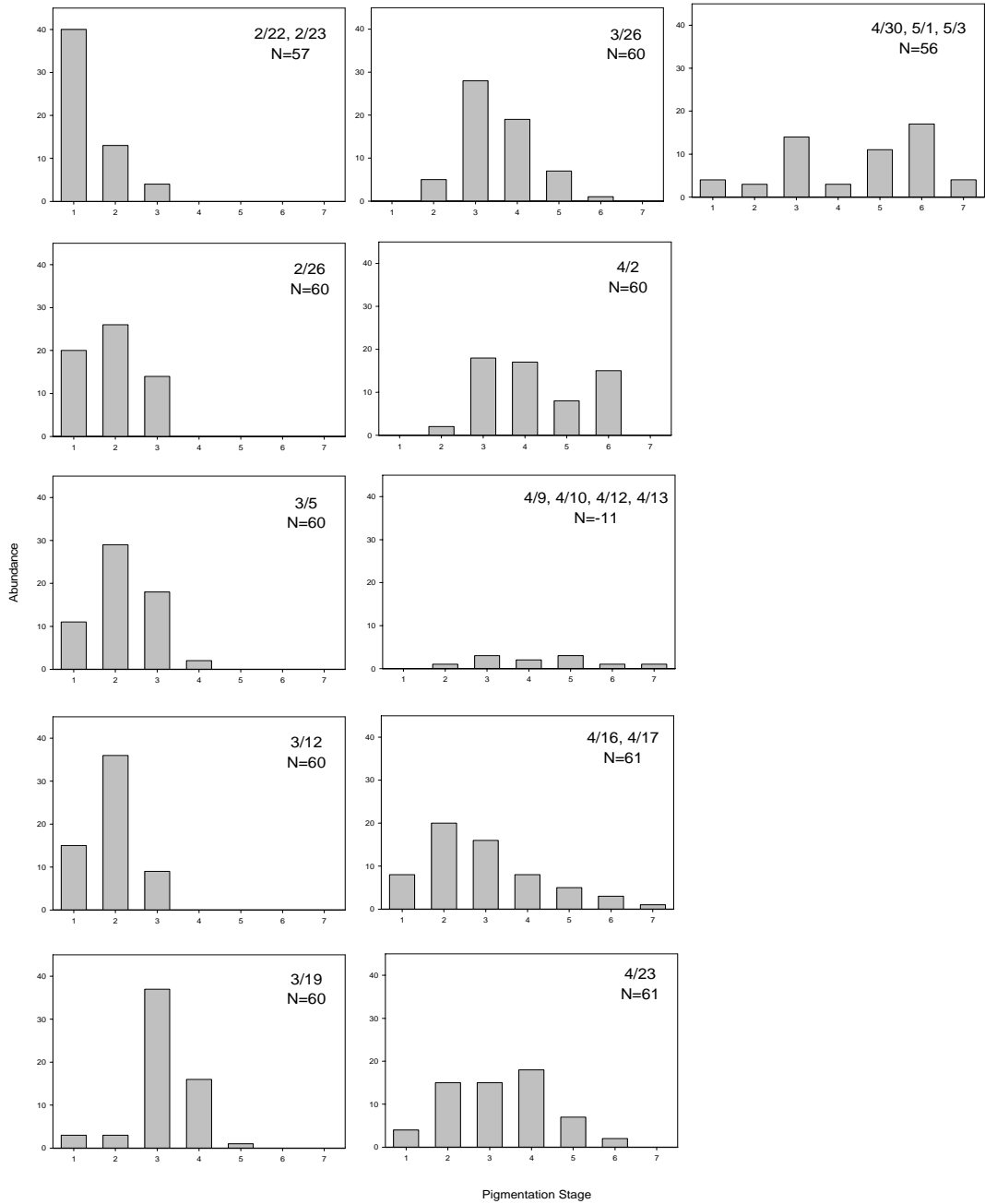


Figure 8. Weekly pigmentation stage at Wormely Pond on the York River during 2007.

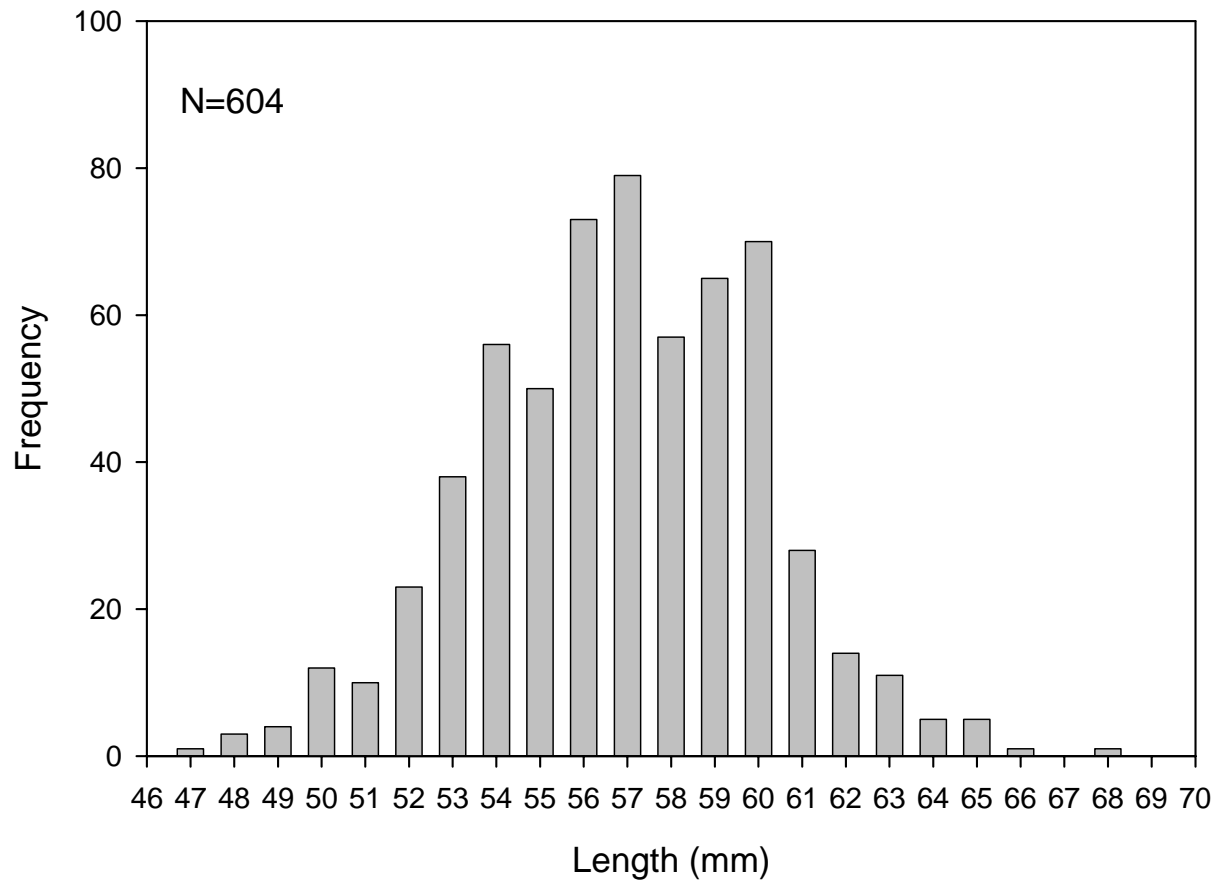


Figure 9. Glass eel length frequency at Wormley Pond on the York River, 2007.