Estimating relative abundance of young of the year American eel, *Anguilla rostrata*, in the Virginia tributaries of Chesapeake Bay

by

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Table of Contents

OBJECTIVES

1. To monitor the glass eel migration, or run, into the Virginia Chesapeake Bay tributaries, to determine spatial and temporal components of recruitment.

2. Evaluate various gears and methods of collecting glass eels to determine the most effective and efficient method to maximize resources.

3. Examine the diel, tidal, lunar, and water property (temperature, salinity, pH, etc) factors which may influence young of the year eel recruitment.

4. Collect basic biological information on glass eels. To include but not limited to; length, weight, and pigment stage.

INTRODUCTION

Measures of juvenile recruitment success have long been recognized as a valuable fisheries management tool. In the Chesapeake Bay, these measures have provided reliable indicators for future year class strength for blue crabs (Lipcius and van Engel, 1990), striped bass (Goodyear, 1985), and several other recreationally important fishes (Geer and Austin, 1999).

The American eel, *Anguilla rostrata*, is a valuable commercial species along the entire Atlantic coast from New Brunswick to Florida. Landings along the U.S. Atlantic coast have varied from 290 MT in 1962 to a high of 1600 MT in 1975 (NMFS, 1999). In recent years there seems to be declining harvest, with similar patterns seen in the Canadian maritime providences. The Mid-Atlantic states (New York, New Jersey, Delaware, Maryland, and Virginia) have comprised the largest portion of the East Coast catch (88% of the reported landings) since 1988 (NMFS 1999). The Chesapeake Bay jurisdictions of Virginia, Maryland, and Potomac River Fisheries Commission (PRFC) alone represent 30, 15, and 18% respectively, of the annual United States (Gulf and Atlantic coast states) commercial harvest for the years 1987-1996 (ASMFC, 1999). Some fishery-independent indices have shown a decline in abundance in recent years as well (Richkus and Whalens 1999; Geer *in review*). Hypotheses for the decline include shifts in the Gulf Stream, pollution, over-fishing, parasites, habitat loss, and barriers to passage (Castonguay et al. 1994).

Many fisheries management techniques have not been applied to American eels because

little basic biological information is known. Variation in growth rates, length at age, and other biological parameters has complicated stock assessment methodologies and management efforts. Additionally, few studies have addressed the recruitment of glass eels to the estuaries from the spawning grounds in the Sargasso Sea.

The Atlantic States Marine Fisheries Commission (ASMFC) adopted the Interstate Fishery Management Plan for American Eel (FMP) in November 1999. The Plan focuses on increasing the states' efforts to collect data on the resource and the fishery it supports through fishery dependent and independent studies. To this end, member jurisdictions (including Virginia) agreed to implement an annual abundance survey of young-of-year American eel (YOY). The survey is intended to "...characterize trends in annual recruitment of the young of the year eel over time [to produce a] qualitative appraisal of the annual recruitment of American eel to the U.S. Atlantic coast (ASMFC 1999)".

The agencies included as member jurisdictions in the Chesapeake Bay (Virginia Marine Resource Commission - VMRC, Potomac River Fisheries Commission -PRFC, and Maryland Department of Natural Resources –MDDNR) have recognized the importance of assessing eel recruitment to the Chesapeake Bay to better understand the dynamics of American eel populations and fisheries. Managers at these agencies have consulted with other scientists to establish common protocols and strategies for capturing YOY eels to achieve the goals of the management Plan. In spring 2000, the Virginia Institute of Marine Science (VIMS) and Maryland Department of Natural Resources evaluated methodologies and sampling locations for surveying YOY recruitment to Maryland and Virginia tributaries of the Chesapeake Bay, the result being a Bay-wide monitoring program with common sampling methods and goals.

The 1999 ASMFC FMP monitoring requirement must be established and implemented by all East coast states by the year 2001 (ASMFC 1999). The results of these surveys will provide much needed data on coastal recruitment success, and further the understanding of American eel population dynamics.

Life History

The American eel is a catadromous species which ranges from Greenland to Central America along the Atlantic coasts and inland to the Mississippi and Great Lakes drainages. The species is panmictic, supported throughout its range by a single spawning population. Spawning takes place during winter to early spring in the Sargasso Sea after which the adults die. The eggs hatch into leaf-shaped larvae called, leptocephali, which are transported by the ocean currents in a northwesterly direction. Within a year, metamorphosis into the next stage (glass eel) occurs near the western Atlantic coast. Coastal currents and active migration transport the glass eels into rivers and estuaries of Chesapeake Bay from February to June. As growth continues, the eel becomes pigmented and is called an elver. Some eels migrate upriver into freshwater ponds and lakes, while others remain in estuaries. Most of the eel's life is spent in these habitats as a yellow eel. Age at maturity varies greatly with location and latitude. In Chesapeake Bay, it may range from 8 to 24 years, with most being less than 10 years old (Owens and Geer, *in review*). Upon maturity, eels migrate back to the Sargasso Sea to spawn and die. A metamorphosis into the 'silver eel' stage occurs during the seaward migration, which occurs from late summer through autumn.

METHODS

Minimum criteria for YOY American eel sampling has been established by the ASMFC American eel FMP. Sampling gear must be from the Technical Committee approved list. The timing and placement of these gear must coincide with those periods of peak onshore migration. At a minimum, the gear must be in operation during periods of flood tides during the 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), occurring at least at one site per jurisdiction. The entire catch of YOY eels is to be counted from each sampling event, with a minimum of 60 specimens taken for length/weight and pigment stage on a weekly basis.

Due to the importance of the eel fishery in Virginia and the Chesapeake Bay, additional methods have been implemented to insure proper temporal and spatial coverage, and to provide reliable estimates of recruitment success. To provide the necessary spatial coverage and to assess suitable locations, numerous sites in both Virginia (funded by VIMS, VMRC, and PRFC) and

and Maryland (funded by PRFC) were evaluated in 2000 (Geer et al., 2000). Final site selection was based on known areas of glass eel recruitment, accessibility, and specific physical criteria which are demonstrated causes of glass eel concentration. Maryland discontinued sampling of the Potomac River in 2001, due in part to the low catch rates observed the previous year (Geer et al., 2000). Funding from VMRC and PRFC allowed VIMS to establish a fairly comprehensive sampling design for Virginia waters during the 2001 sampling season. For convenience, sampling was divided into two routes. The Potomac-Rappahannock route was sampling four days a week in 2001 from March 12th to May 12th. Because of the close proximity to VIMS, the York-James route was sampling daily from February 23rd to May 18th, then three to five days a week on select sites until June 29th.

The Irish eel ramps were used to collect eels at all sites (Figure 1). This gear is approved in the FMP (ASMFC 1999). The configuration of these ramps as described below proved successful for attracting and capturing small eels in tidal waters of Chesapeake Bay. Ramp operation required the continuous flow of water over the climbing substrate and through the collection device. The passive supply of water to the traps through gravity feed required that the water level be considerably higher above the trap than below it, or that water traveling at high velocity be available nearby (Figure 1). Hoses were attached to the ramp and collection buckets with adapters were used to allow for quick removal for collecting. Enkamat^{TM} erosion control material on the floor of the ramp 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. Submersion of the ramp entrance was considered undesirable, and as such was placed in shallow water (< 25 cm). These angles, in combination with the 4° angle of the substrate inside the ramp, resulted in sufficient slope to create attractant flow. A hinged lid provided access for cleaning and for flow adjustments. Flow over the textured climbing surface was adjusted to maintain a depth of 5-10 mm.

Traps were checked four days per week on the Potomac-Rappahannock route (Monday-Wednesday-Friday, and alternating weekend days), and daily on the York-James route. Only eels found in the ramp's collection bucket (not on the climbing surface) were recorded. Trap performance was rated on a scale of 1 to 4 (1=good, 4=not functioning), with water temperature and level, salinity, pH, air temperature, wind direction and speed, and precipitation recorded

during most site visits. All eels were enumerated and placed above the impediment, with any subsample information appropriately recorded. Specimens less than or equal to ~85 mm were classified as 'young-of-the-year', while those greater than ~85 mm were considered 'elvers'. This corresponded to the observation of two distinct modes in the 2000 length frequencies, which likely reflects differing year classes. Lengths, weights, and pigment stage (according to Haro and Krugo 1988) were collected from at least sixty eels on a weekly basis.

In addition to the ramps, dip nets (45x21cm 800 *u*m mesh) were used to provide information on the presence and abundance of eels. Dip nets were deployed by sweeping either a set distance (culverts and other concrete substrates) or a set time of 30 seconds (gravel, mud, and sand bottoms) (Figure 2). Dip net use was intense in 2000, since it quickly allowed for assessment of sites and potential recruitment success. Their use was much more limited once the survey sites and methods became established in 2001.

In 2000, another static gear was also assessed. The Virginia fyke net was designed after gear confiscated by marine patrol officers (Figure 2). The design is simple and includes a 30 cm length of 17 cm diameter pvc piping with wings spreading to 40 cm. The wings are made of 9.5 mm diameter metal bars wrapped with window screen mesh. Similar mesh runs beneath the wings and extends out beyond them in a 20 cm semi circle. A 9.5 mm link chain in attached to each wing and sewn into the end of this semi-circle. The principle is similar to any fyke net, with a mesh bag attached at the end to collect the samples. The gear was fished at two sites in 2000 in shallow waters adjacent to the shore.

A total of 48 sites were considered for sampling, of which 39 were visited/accessed, and 17 were sampled at least once (Table 1, Figure 3). Sites on the Potomac River are discussed in Geer et al. (2000) and Geer (2001) and will not be discussed further.

In 2000, effort was concentrated on establishing methodology, evaluation gears, and assessing potential sites. Of the Rappahannock River sites assessed, three were sampled. Barricks Millpond was sampled by dip net on April 19th, 2000 with 43 glass eels collected in five dip net samples in Mill Creek below the spillway (Table 2). The Irish eel ramp would be difficult to fish at this site due to limited access to the spillway. Garlands Millpond (Richmond County) drains to Totuskey Creek and was sampled ineffectively with dip netting on April 5th, 2000 (Table 2). Kamps Millpond (Lancaster County) drains into the Eastern Branch of the

Corrotoman River and provided an ideal site with easy access (Figure 4). This was selected as the Rappahannock site and fished regularly since. Catches of both glass eels and elvers occurred both with dip nets and Irish eel ramp (Table 2).

Seven sites were accessed or sampled on the York River, many of which occurred off Queens Creek (York County). Waller's Millpond Reservoir was assessed and sampled with dip nets on April 19th, 2000. The site appeared favorable for sampling with at least one of the static gears (Table 2). Queens Lake was assessed in 2000 and eels were observed climbing the spillway. Superficial dip netting was conducted in 2001 with success. Cheatham Pond and other ponds on the Cheatham Annex military base were assessed in 2001, but obtaining access on a regular basis seemed problematic, and as such, this site was eliminated from consideration. Jones Millpond is located on the Colonial Parkway and the site provided a spillway for the Irish ramp, and a shallow stream for both dip netting and the Virginia fyke net (Figure 5). This site was sampled regularly in 2000, with a series of 30 second dip nets, the fyke net, and a ramp placed at the top of the spillway. However, the site was eliminated in 2001 due to very low catch rates in the ramp (Table 2). The best site assessed in 2000 was Brackens Pond (Figure 6). It is located along the Colonial Parkway at the base of the Naval Weapon Station Pier. Its proximity to the York River is less than 100 m with the tide often reaching the spillway. This site was chosen at the primary site in 2000 with gear comparisons performed throughout the sampling season. In 2001, Wormley Pond was selected to replace Jones Millpond. The site is located on the Yorktown Battle field grounds and provides very easy access (Figure 7). It drains into Wormley Creek which has a tidal range that routine reaches a depth of 50 cm at the spillway. This site could not be sampled in 2000 because the road crossing over the spillway was destroyed by Hurricane Floyd and repairs were not completed until the fall of 2000.

A total of 11 sites were evaluated on the James River (Figure 3). However, most of these sites, (especially those on the Southside – Suffolk and Isle of Wight Co.) were completely destroyed by Hurricane Floyd, making sampling with a static gear very difficult. Lake Maury (Newport News) provided an ideal location immediately adjacent to the James River (Figure 8). Sampling with an Irish ramp was attempted in 2001 (Table 3). However, the lake level was dropped nearly two meters by the Virginia Department of Transportation to conduct road repairs which made it difficult to obtain the proper flow for the Irish ramp. Sampling occurred between

February 24th and March 13th 2001, but was discontinued because of the ramp's ineffectiveness due to low flow rates. Numerous eels were often observed in the spillway during sampling, providing support for future sampling when water levels are returned to normal.

Sampling at each site was more involved in 2000 than in 2001. During the 2000 season, intense dip netting was conducted at each site regularly fished. Dip netting either occurred over a set distance (in concrete culvert), or for 30 seconds (in stream beds) with several replicates. Irish eels ramps were placed at those sites sampled regularly (Kamps, Jones, Brackens Ponds), with Virginia fyke nets placed at Jones and Brackens. An additional ramp was placed at Brackens at the beaver dam upstream of the first spillway to further evaluate the gears (Figure 6). In 2001, the ramp was the primary fishing gear, with dip nets used only to assess the presence of eels.

For analysis purposes, a daily and annual catch per unit effort (CPUE) was established for each site and individual gear. CPUE for the static gears was catch per 24 hours of soak time, while that of the dip nets was merely the mean catch for that day by type of dip (time or distance).

At least once per week a sample from each river system of approximately sixty eels was collected, which were measured to the nearest millimeter, weighed to the nearest 0.01g, and pigment stage recorded as described in (Haro and Krugo, 1988). Specimens less than or equal to ~85 mm were classified as 'glass eels', while those greater than ~85 mm were considered 'elvers'. This corresponded to our observation of two obvious modal lengths in the catch which likely reflect differing year classes. At each site temperature, salinity, tidal stage, stream flow, time, condition of the gear, and substrate type were recorded.

RESULTS

The 2000 sampling season was considered exploratory but was able to provide some very important information. Site selection became clear through the assessment and sampling of a variety of locations. Sampling occurred between March 15th and May 17th at three sites (Brackens Pond and Jones Millpond on the York River, and Kamps Millpond on the Rappahannock), with two additional sites on the Potomac River (Gardys Millpond and Clarks Millpond). Several other sites were sampling during the assessment on a very limited basis.

A major goal of the 2000 sampling season was to determine the most appropriate gear for this survey. Bracken Pond served as the sight for all gear comparisons and results show that the Irish eel ramp was superior the Virginia fyke net, as well as both types of active dip netting methods (Table 4). The ramps (mean = 502.2 $\pm$ 252.1) captured significantly more YOY eels than either the Virginia fyke net (38.2 $\pm$ 21.2) (Table 4), or dip nets sampled over a set distance (30.6 $\pm$ 15.0) or time (8.6 $\pm$ 11.4)($p \leq 0.05$) (Table 4). Both passive gears fished better than the active dip nets, most probably due to the fact that the active gears were fished only for a small moment of the day, during daylight hours when eels are less active.

Brackens Pond was the most productive site in 2000. Daily catches of over 8,000 eels were common in late March and again in mid-April (Figure 9, Table 2). Dip netting in the culvert produced a mean catch rate of 30.65 glass eels per sample, and the fyke net captured and average of 38.20 per day (Table 2). The ramp at Jones Millpond was unsuccessful at capturing glass eels but began catching elvers near the end of the survey (Figure 10). The culvert's grade and long distance (45^{O} and 30 m), accompanied by strong flow early in the season may have restricted eel migration up into the pond. However, the fyke net and dip netting performed approximately 40 m downstream proved to be fairly successful (Figure 10, Table 2). The shallow fast moving water of the culvert at Kamps Millpond presented some difficulties in maintaining flow over the ramp. However, a modification to the intake hose solved this problem and resulted in a mean catch rate of 10.35 for the season (Figure 11, Table 2). Dip netting at this site was conducted primarily over course sand producing a mean of 8.57 glass eels per sample (Figure 11, Table 2) .

With methods and sampling design firmly established, the 2001 sampling season produced even better results. The Irish eel ramp was selected as the primary gear with dip netting performed only as a method of confirming presence. Jones Millpond was dropped from sampling since the eel ramp proved unsuccessful the prior year. Wormley Creek was selected as an alternative site. This new site proved very successful producing as many as 19,205 glass eels in a single day (Table 3). Catches at this site peaked during the third week of March and again in the second week of April (Figure 12). Catches of glass eels remained near zero from April 15^{th} until the end of sampling on May 17^{th} (Figure 12). Brackens Pond catches were comparable but not as high as in 2000 (Table 3). Unlike Wormley, where thousands of eels were observed

were observed “staging” just prior to migrating over the dam, then periods of low catch, Brackens provided several clear and distinct pulses that continued throughout the season (Figure 13). Sampling was continued on Brackens Pond in an attempt to determine the end of the “run”. However, after each rain event, another pulse of glass eels would be captured, with each new pulse slightly smaller than the last (Figure 13). Sampling was finally discontinued on June 29th. Kamps showed only a single pulse of glass eels between April 8 and 10th, but elvers pulses were seen throughout the sampling period (Figure 14). The CPUE of the ramp was over ten times greater in 2001 (Table 3). This may be because the ramp was not used until April 12th in 2000, possibly missing the major run. There was some suspicion that the ramp was being tampered with during this period. Law enforcement officers were notified to patrol the area and no subsequent episodes were noted.

Again, as in 2000, the eel ramp was superior to other sampling methods. The ramp comprised over 89% of the glass eels captured in 2000, and 92% of the larger elvers. Since the fyke net was not used in 2001, the percentage was even higher (> 99%) (Table 5). The ease of use, inexpensive construction cost, and ability to be modified to suit a particular site, makes it an ideal sampling gear. The fyke net was designed by poachers to be small, transportable, and inconspicuous. However, as a fishing gear it proved cumbersome since each time it was fished the stones and sediment around the gear would need to be re-adjusted. In comparison, the eel ramp never moved during the entire sampling season. The sampling bucket makes removing the catch quick and simple. Dip nets have some potential uses, such as determining migration rates up a stream. However, the ASMFC FMP states that any active gear must be fished at night during a high tide. This has proven logistically difficult. In addition to these gears, a Sheldon eel trap was evaluated on the Potomac by MDDNR in 2000 and shown to unsuccessful when compared to the Irish eel ramp (Geer et al. 2000).

Environmental parameters were not clearly correlated with catch in either year (Figures 15 and 16). Both air and water temperatures were warmer in 2000 as compared to 2001 (Figures 15 and 16). During 2000 sampling, Brackens Pond water temperatures ranged from 10.5 C^o to 27.4 C^o (mean = 18.3 C^o). In 2001, when sampling continued until June 29th, temperatures ranged from 5.0 C^o to 33.8 C^o , with a mean of 18.6 C^o . Air temperatures varied greatly with a range of 1.3 C^o to 33.4 C^o observed in 2001, with slightly less variation in 2000 (6.0 C^o to 32.4

C^{o}). Similar observations were seen at other sites with lower temperatures observed on the Rappahannock (Figures 15 and 16). Measures of pH were consistently recorded in 2001, ranging from 6.5 to 8.8 (Figure 16). A sharp decline was observed in pond pH in both Wormley and Brackens on April 3rd, continuing until May 1st (Figure 16). This same decline was not observed on the Rappahannock site (Kamps). The decline could be due to large rain events observed on the York on March 21st, or algal blooms which could lower pH. However, the Kamps site showed similar levels of precipitation at that time with no noticeable decline in pH. It could be a result of calibration or instrument error. However, the long period of lower pH values refutes this possibility since instruments were checked and calibrated on a regular basis.

In 2000, stream flow was estimated as water velocity (m/sec) during a given sampling event, and did not take into account the water depth or width of the stream. This sample year, attempts to estimate flow based on stream height and width were only moderately successful at Brackens. With continued data collection, this method will prove much more useful, providing a daily rate of discharge in m^3/sec. Parameters such as lunar phase and water temperature which have anecdotally been shown to correlate with glass eel runs, were not consistently observed between the sites. A more detailed investigation of all physical parameters using multivariate statistical methods is necessary if further explanation is wanted.

Average lengths for YOY on the York River revealed a significant downward trend through the sampling season in both years, with 2001 being much more noticeable (Figure 17). The same trend was seen in Rappahannock samples in 2001, but was not evident in 2000 (Figure 18). Mean lengths appear to be larger for the Rappahannock River as compared to the York. Mean lengths by sampling period indicate values as high as 62.5 mm on the Rappahannock as compared to 57.7 mm on the York (Figures 17 and 18).

An overall estimate of recruitment can only be considered preliminary at this time. Two years of data most likely have not recorded all the variability associated with recruitment. Questions remain as to the exact timing of the run, and the potential influence the physical parameters of a site have to overall recruitment. However, the 2001 "index" appears much higher in 2001 for both glass eels and elvers as compared to results observed in 2000 (Tables 2 and 3). The replacement of Jones Millpond with Wormley Creek clearly accounts for most of

this difference. These estimates will undergo further revision as the survey become better established.

DISCUSSION

The success seen at such sites as Brackens Pond and Wormley Creek the past two years indicates that the criteria for YOY sampling sites, which were derived by VIMS and MDNR personnel based on ASMFC guidelines, were valid. Unfortunately, finding such suitable sites often proved difficult - especially after Hurricane Floyd had destroyed many of the existing sites in September 1999. Many of the sites visited in 2000 and 2001 may have historically provided good eel runs, but destruction of habitat in and around these millponds may have restricted recruitment. With some ingenuity, sites that appear to be marginal for the Irish eel ramp may proved successful. If the run is highly variable from year to year (as is suspected), a very productive site one year may be unproductive in future years. Conversely, poor sites in one year may be very productive in others. The survey overcame many of the obstacles facing sampling its first season (2000). Successful sites and gears have been identified, and with consistent funding, the ASMFC sampling requirements should be easily achieved in future years.

CONCLUSIONS AND RECOMMENDATIONS

- Irish eel ramps continue to be an effective gear in coastal Virginia. This passive gear appears to be cost- and time-effective sampling gear for Virginia waters, once suitable sampling sites are established.

  Drainages with high densities of eels (perhaps identified from other surveys) could be targeted for YOY sampling. Sites in these drainages may have as yet unquantified characteristics which make them particularly attractive to immigrating YOY.
- Sampling should continue at the primary sites (Wormley, Brackens, and Kamps), with the goal of adding at least one site on the James River as well.
- Sampling should start on or around February 15th, and continue through June 30th if necessary. Given the great variability associated with spring temperatures in the Chesapeake region, sampling must be over a wide range of water temperatures to ensure that sampling

occurs at optimal temperatures. Sampling at Brackens Pond continued until nearly July and glass eels were still be captured regularly.

- Dip netting may be an expedient way to determine the presence and relative abundance of eels and act as a barometer indicating when passive gear should be deployed. However, once methods and seasonal timing are identified, its usefulness as a sampling gear will diminish.
- The ultimate goal of this survey is to provide estimates of recruitment for YOY and elver eels. 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 sampling site. Parameters such as pond drainage area, distance from the ocean, discharge, and other physical parameters should be evaluated in an attempt to provide a relative value for each site. This value can then be used to weigh the catch rates at each site, to provide and overall estimate of recruitment.

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TABLES

Attachment B:

Table 1. Potential sites for YOY American eel sampling. Sites in bold are those regularly sampled. See Figure 1 for locations.

SiteCode	Site	Acres	Location	County	Tributary	Sample
James River						
LM	Lake Maury	149.27	Riverside Dr	Newport News	James River	Y
LN	Lake Normandy	2.77	Normandy Ln	Newport News	Deep Creek	N
LP	Lake Powell	64.30	SR 618	James City	Mill Creek	N
JP	Jolly Pond	45.44	SR 618	James City	Gordan Cr	N
HL	Harrison's Lake	28.12	US 5, USFWS	Charles City	Herring Creek	N
WM	Waller's Millpond Resevoir	330.39	Rt 60	York	Queens Creek	Y
SL	Sleepy Lake	53.15	Route 17	Suffolk	Chuckatuck Cr	Y
TL	Tormentors Lake	96.71	Rt 673	Isle of Wight	Tormentor Cr	Y
MH	Mt. Holly Creek	31.53	Rt 709 off Rt 258	Isle of Wight	Mt. Holly Cr	N
LL	Lonestar Lakes	95.06	Rt 628 off Rt 10	Suffolk	Cedar Creek	N
GW	Godwins/Crumps Millpond	24.25	Rt 10	Suffolk	Nansemond R.	N
WB	Western Branch Resevoir	1299.75	Rt 10	Suffolk	W Br. Nansemond R.	N
York River						
BP	**Bracken's Pond**	**1.12**	**Colonial Pkwy**	**York**	**York River**	**Y**
JM	**Jones Mill Pond**	**56.83**	**Colonial Pkwy**	**York**	**Queens Creek**	**Y**
QL	Queens Lake	75.66	Queens Dr	York	Queens Creek	Y
HM	Haynes Millpond	52.29	SR 614	Gloucester	Carters Cr	Y
WC	**Wormley Pond**	**?**	**Yorktown Battlefield**	**York**	**Wormley Cr**	**Y**
CT	Cheatham Pond	103.64	Cheatham Annex	York	Queens Creek	N
GO	Goddins Pond		SR 600	James City	Philbates Creek	N
DP	Davis Pond		SR 273	New Kent	Pamunkey R.	N
OP	Olsons Pond		Off Rt 30	King Williams	Pamunkey R.	N
Piankatank River						
CD	Conrad's Pond	25.71	Route 33	Middlesex	Piankatank	N
Chesapeake Bay						
HW	Harwood Mill Reservoir	330.22	Route 17	York	Poquoson River	N
BB	Big Bethel Reservoir	210.43	Rt 600 Big Bethel Rd	Hampton	Back River	N

Table 1 (continued).

SiteCode	Site	Acres	Location	County	Tributary	Sample
Rappahannock River						
BL	Blakemore Millpond	28.74	SR 718 off Rt 201	Lancaster	W. Br. Corrotoman R.	N
BM	Barricks Mill Pond	25.42	SR 625	Middlesex	Mill Creek	Y
DM	Davis Mill Pond	19.22	SR 616	Lancaster	W. Br. Corrotoman R.	N
EM	Essex Millpond	53.37	SR 609	Essex	Piscataway Creek	N
GM	Garlands Millpond	55.30	SR 620	Richmond	Totuskey Creek	Y
HP	Hillard Pond	60.57	SR 602	Middlesex	Lagrange Creek	N
KM	**Kamps Millpond**	**74.34**	**Rt 3 to SR 790**	**Lancaster**	**E. Br Corrotoman R.**	**Y**
CH	Chinns Pond	47.73	Route 3	Richmond	Lancaster Cr	N
BA	Balls Pond	20.30	SR 354		Urbanna Cr	N
RL	Rosegil Lake	41.13	Off SR 639	Middlesex	Rappahannock	N
Potomac River						
BC	Bridges Creek	41.59	RT 3 west of SR204	Westmoreland	Bridge Creek	N
BE	Beales Millpond	38.37	SR 612	Northumberland	Nomini Creek	N
CM	**Clarks Millpond**	**14.23**	**SR 634**	**Northumberland**	**Coan River**	**Y**
CP	Courtney Millpond	21.39	SR 620	Northumberland	Yeocomico River	Y
DW	Downings Millpond	9.34	SR 629	Northumberland	Presley Creek	N
GA	**Gardy's Millpond**	**46.52**	**SR 617**	**Northumberland**	**Yeocomico River**	**Y**
MC	Machodoc Creek Pond	8.40	SR 613	Westmoreland	Machodoc Creek	N
MP	Mill Creek Pond	1.01	Route 360	Northumberland	Coan River	Y
PC	Pope Creek Pond Potomac Mills Pond	22.44	Rt 3 behind VDOT	Westmoreland	Pope Creek	N
SH	Lake Independence	109.84	SR639	Westmoreland	Currioman Bay	N
SM	Sydnors Millpond	28.75	SR 604	Northumberland	Hull Creek	Y
HE	Headley's Millpond	9.62	Rt 360	Northumberland	Coan River	N
FL	Fallins Millpond	20.55	Rt 360	Northumberland	Coan River	N
CR	Corbin Pond	29.45		Northumberland	Potomac	N
GK	Gaskin Pond	73.79	SSR 657	Northumberland	Chesapeake Bay	N

Table 2. Catch statistics from the 2000 sampling season. CPUE is shown as catch per 24 hours of soak time for the static gears, and mean per dip for the active gears.

						Young of Year				Elvers				
River	Site Name	Site Code	First Date	Last Date	Gear	Total	CPUE	S.E.	Max.	Total	CPUE	S.E.	Max.	Sampling Events
York														
	Brackens Pond	BP	16-Mar	17-May	Irish Eel Ramp # 2	56,134	938.17	222.79	8,025	530	8.82	2.57	99	60
					Irish Eel Ramp # 3	956	17.76	3.71	103	0	0.00	0.00	0	54
					Summary for Gear	57,090	502.19	126.03	8,025	530	4.64	1.41	99	114
					Virginia Fyke Net	2,234	38.20	10.58	392	0	0.00	0.00	0	58
					Dip Net - Time	43	8.60	5.68	31	1	0.20	0.20	1	5
					Dip Net Distance	2,513	30.65	7.52	314	0	0.00	0.00	0	82
					Summary for Site	61,880	222.00	53.46	8,025	531	1.90	0.60	99	259
	Jones Millpond	JM	15-Mar	17-May	Irish Eel Ramp	0	0.00	0.00	0	113	3.18	2.74	86	61
					Virginia Fyke Net	541	10.84	2.89	111	15	0.33	0.11	3	44
					Dip Net - Time	1,123	6.07	0.65	61	26	0.14	0.03	2	185
					Summary for Site	1,664	5.65	0.66	111	154	0.52	0.29	86	290
	Waller's Millpond	WM	19-Apr	19-Apr	Dip Net - Time	2	0.67	0.33	1	0	0.00	0.00	0	3
	Haynes Millpond	HM	16-Apr	16-Apr	Dip Net - Time	24	12.00	6.00	18	0	0.00	0.00	0	2
					Summary for System	63,570	109.55	26.04	8,025	685	1.18	0.32	99	554
Rapp.														
	Kamps Millpond	KM	30-Mar	17-May	Irish Eel Ramp	163	10.35	6.97	79	5	0.14	0.07	2	11
					Dip Net – Time	420	8.57	2.08	61	11	0.22	0.08	2	49
					Summary for Site	583	9.72	2.13	79	16	0.27	0.07	2	60
	Barricks Millpond		19-Apr	19-Apr	Dip Net – Time	43	8.60	5.68	31	1	0.20	0.20	1	5
	Garlands Millpond		5-Apr	5-Apr	Dip Net – Time	0	0.00	0.00	0	0	0.00	0.00	0	4
					Summary for System	626	9.07	1.91	79	17	0.25	0.07	2	69
2000 Overall Summary						64,196	98.92	23.32	8,025	702	1.08	0.29	99	623

Table 3. Catch statistics from the 2001 sampling season. CPUE is shown as catch per 24 hours of soak time for the static gears, and mean per dip for the active gears.

						Young of Year				Elvers				
River	Site Name	Site Code	First Date	Last Date	Gear	Total	CPUE	S.E.	Max.	Total	CPUE	S.E.	Max.	Sampling Events
York														
	Brackens Pond	BP	23-Feb	29-Jun	Irish Eel Ramp	52,850	480.45	71.45	3,519	335	3.05	0.74	70	110
					Dip Net Distance	700	6.36	1.85	172	1	0.01	0.01	1	110
				Summary for Site		53,550	243.41	39.09	3,519	336	1.53	0.38	70	220
	Wormley Pond	WC	27-Feb	17-May	Irish Eel Ramp	82,260	1,041.27	318.32	19,205	175	2.22	0.48	28	79
					Dip Net Distance	442	5.59	1.69	82	2	0.03	0.03	2	79
				Summary for Site		82,702	523.43	163.95	19,205	177	1.12	0.26	28	158
Summary for System						136,252	360.46	72.43	19,205	513	1.36	0.25	70	378
Rapp.														
	Kamps Millpond	KM	12-Mar	12-May	Irish Eel Ramp	4,006	121.39	69.75	2,184	222	6.73	1.56	36	33
					Dip Net - Time	174	5.61	1.50	31	7	0.23	0.10	2	31
Summary for Site/System						4,180	65.31	36.44	2,184	229	3.58	0.90	36	64
James														
	Lake Maury	LM	24-Feb	13-Mar	Irish Eel Ramp	0	0	0	0	0	0	0	0	3
					Dip Net Time	0	0	0	0	0	0	0	0	3
Summary for Site/System						0	0	0	0	0	0	0	0	6
2001 Overall Summary						140,432	317.72	62.35	19,205	742	1.68	0.25	70	448

Table 4. Gear comparisons between the Irish eel ramp (two ramps), Virginia fyke net, and two types of dip net methods performed at Brackens Pond (York River) in Year 2000. CPUE represents catch per 24 hours soak time for the static gears (ramp and fyke net), and mean per sampling event for active fishing gears (dip nets).

	Glass Eels				Elvers				
Gear	Total	CPUE	95% Confidence Interval (+/-)	Max.	Total	CPUE	95% Confidence Interval (+/-)	Max.	Sampling Events
Irish Eel Ramp(2)	57,090	502.19	252.05	8,025	530	4.64	2.82	99	114
Virginia Fyke Net	2,234	38.20	21.15	392	0	0.00	0.00	0	58
Dip Net – Time	43	8.60	11.36	31	1	0.20	0.40	1	5
Dip Net Distance	2,513	30.65	15.04	314	0	0.00	0.00	0	82

Table 5. Catch statistics by gear type for the 2000 and 2001 sampling season. CPUE is shown as catch per 24 hours of soak time for the static gears, and mean per dip for the active gears.

		Young of Year				Elvers				
	Gear	Total	CPUE	S.E.	Max.	Total	CPUE	S.E.	Max.	Sampling Events
	Irish Eel Ramp	57,253	308.40	79.17	8,025	648	3.89	1.25	99	186
	Virginia Fyke Net	2,795	26.40	6.26	392	15	0.14	0.05	3	102
	Dip Net – Time	1,935	7.11	0.07	67	39	0.14	0.03	2	272
	Dip Net –Distance	2,513	30.65	7.52	314	0	0.00	0.00	0	82
2000 Overall Summary		64,196	98.92	23.32	8,025	702	1.08	0.29	99	623

		Young of Year				Elvers				
	Gear	Total	CPUE	S.E.	Max.	Total	CPUE	S.E.	Max.	Sampling Events
	Irish Eel Ramp	139,116	621.23	126.07	19,205	732	2.91	0.43	70	221
	Dip Net–All types	1,316	5.98	1.12	172	10	0.05	0.02	2	220
2001 Overall Summary		140,432	317.72	62.35	19,205	742	1.68	0.25	70	442

FIGURES