Results from the 2005-2008 Bush River Study

Final Report

Prepared for:

Chesapeake Bay National Estuarine Research Reserve

Grant #: NA04NOS4200070

Contract #: 14-05-CBR070

Submitted by

R.A. Sadzinski and A. Campo
June 2008

Executive Summary

After the successful completion of the Bush River pilot study in 2005, funding was secured and a long-term contractor was hired to coordinate the collection and analysis of egg and larval fish samples and coordinate, schedule, and analyze seine and trawl data at historical and present sites in the Bush River.

This study was composed of ichthyoplankton sampling, haul seining and bottom trawling. An average of 22 volunteers collected 630 ichthyoplankton samples over the four years of the study. This accounted for 82% of the scheduled samples and samples not collected were generally due to high water and/or hazardous conditions.

Biweekly haul seine sampling was conducted at four sites from July to October in the Bush River. Over the four years of the study, volunteers conducted 65 haul seines. During haul seining over 5,500 fish including 41 different fish species were captured annually resulting in a catch-per-seine of 5.4 fish.

Bottom trawling in the Bush River was conducted biweekly from July through October at three locations. During sampling, 4,500 fish were captured including 29 fish species by 77 trawls resulting in a catch-per-trawl of 5.8 fish.

The significant numbers of juvenile or adult fish captured during bottom trawling in the Bush River during 2005-2008, indicated a diverse fish community and when compared to other DNR sampled systems in 2008, ranked as the most diverse in species and most significant in catch-per-seine. This data indicated that the Bush River serves as a significant spawning area for river herring and a significant nursery area for many fish species in the Chesapeake Bay.

Nutrient loading, particularly nitrogen, appears to be a significant problem in the river basin, while water temperature, dissolved oxygen, conductivity and pH were all within normal levels and do not appear to be a limiting factor.

The fragility of the Bush River watershed was indicated by the high degree of impervious surface within it (12.8%) stressing its protection from further development. Land-use planning must be evaluated carefully in the Bush River watershed to minimize potential impacts to water quality and the fisheries.

Introduction

The Bush River is a tributary of the western Chesapeake Bay and feeder streams include Winter's Run, Bynum Run, Church Creek and Swan Creek (Figure 1). The Bush River basin encompasses 213 square miles, lies entirely in Harford County, Maryland and has a fair distribution of forest, urban, suburban and agricultural usage (Maryland DNR). Most of the poorly stabilized stream banks resulted from the switch from agricultural to primarily urbanized usage.

Nutrient loading, particularly nitrogen, appears to be a significant problem in the river basin. There also appears to be several sources of nitrogen including shallow ground water concentrations from point and non-point sources, surface flow from urbanized areas and agricultural runoff.

The Bush River watershed has been the focus of several intense water quality studies conducted by Maryland Department of Natural Resources (MD DNR; 2002) and many of the subwatersheds had elevated levels of nitrates/nitrites in 2002; including West Branch, Bynum Run and upper James Run/Broad Run.

Nitrogen levels are generally elevated but within acceptable limits for the biota, it appears the main factor affecting the Bush River appears to be sedimentation. Pasternack (1998) rebuilt historic sedimentation rates in the Bush River and noted that sediment deposition resulted after significant disturbances in the watershed. In addition, he noted that winter ice and marsh vegetation was primarily responsible for redistributing sediments while wind and tide were responsible for sediment transport in the subtidal and intertidal zones (Pasternack et al. 1997; McGinty [MD DNR; personal communication]).

Water quality including temperature, dissolved oxygen, conductivity and pH were all within normal levels (MD DNR 2002) and do not appear to be a limiting factor in the watershed.

Tidal freshwater wetlands depend on persistent sediment deposition to maintain surface elevation. Slight rises in water can have significant impacts on tidal freshwater wetlands. In the mid-Atlantic region, rising sea levels and anthropomorphic changes threaten tidal freshwater wetlands (Najjar et al. 2000). The Bush River may be particularly sensitive to changes in sea level because of the introduction of more brackish water into the watershed.

Aberdeen Proving Grounds (APG) located on the south shore of the Bush River has been a full scale manufacturer and testing facility for military weapons. In addition, this site also served as a weapons disposal site but since 1976, research has been directed at determining source pollution, its biological impact and minimizing migration of the pollution from its source. Environmental investigations of APG and remedial action have demonstrated no significant migration of chemicals from the APG site.

The Chesapeake and Atlantic Coastal Bays 2010 Trust Fund which provides finances for stormwater and comprehensive watershed restoration programs selected the Bush River has one of the eight recipients in 2010. In addition, by presidential order in 2009, the Chesapeake Bay has received the highest level of protection by "making restoration of the Chesapeake Bay a greater national priority and contains many provisions, which include establishing a Bay federal leadership committee, directing EPA to fully use its Clean Water Act authorities, reducing water pollution from federal property, developing a Chesapeake Bay climate change strategy, improving agricultural conservation practices and expanding public access to the Bay. Under the Executive Order, the EPA will also be developing strategies to ensure compliance and enforcement with pollution laws throughout the watershed."

Sedimentation rates are highly influenced by plant densities, sea level elevation, floods, and land-use. In the Bush River's tidal wetlands, Pasternack (et al. 2000) determined that sedimentation rates were dependent on elevation, plant distribution, and distance to the mouth of the river. In 2003, Pasternack (et al. 2003) also concluded that inriver discharge and Susquehanna River flow did not significantly influence water levels in the Bush River.

Methods

Introduction

This study was conducted by trained volunteers overseen by a contractor. The study was composed of two components; spring ichthyoplankton sampling and summer seining and trawling. In either case, trained volunteers were overseen by the watershed contractor and state fisheries scientist. Training for volunteers occurred annually and included equipment field training, fish identification, and an overview of the datasheets.

Ichthyoplankton sampling

Nineteen ichthyoplankton sites were sampled biweekly according to established protocol (Table 1; McGinty 2005). Samples were collected using stream nets made of 360-micron mesh. They were attached to a square frame with a 300 X 460 mm opening. The frame was connected to a wood handle so that the net could be held in place. A threaded collar was placed on the end of the net so that a mason jar could be connected to the net to collect the sample. Nets were placed in the stream for five minutes, with the opening facing upstream. The nets were then retrieved and rinsed in the stream, by repeatedly dipping the upper part of the net and splashing water on the outside of the net to avoid sample contamination, this ensured that the contents would be flushed into the mason jar. The mason jar was then removed from the net. A sample label describing the site, date, time, and collectors was placed in the jar. The jar was sealed and placed in a cooler for transport. After a team finished sampling for the day, they would turn their samples over to the coordinator, who would then fix them with 10% buffered formalin and 2 ml rose Bengal to stain the protein.

Water quality measures including, temperature, pH, conductivity and dissolved oxygen were recorded for each site. Water quality parameters were taken using a hand held YSI model 55. The meters were calibrated for dissolved oxygen according to the manual. pH was collected

using pHTester meters which were calibrated in the lab according to the manual prior to being used in the field. Calibrations were conducted using known pH buffer solutions of 4, 7 and 10.

Ichthyoplankton data were recorded on standard field data forms and verified at site and also by the volunteer coordinator. Samples were sorted in the laboratory by a fisheries biologist. All samples were rinsed with water to remove the formalin. Samples were then placed into a white sorting pan. The samples were sorted systematically (from one end of the pan to another) under a 10x bench magnifier. All larvae and eggs were removed from the sample and identified under a microscope. Eggs and larvae were retained in small vials and fixed with formaldehyde for verification. Ten percent of the samples were placed back into the jar after they were sorted in order to assess sorting efficiency.

Successful reproduction of fish species from the Bush River was indicated by the presence of eggs or larval fish. Annual number of sites sampled varied by year because of changes in stream morphology and safety concerns (Table 2). Data is presented by year for yellow perch, white perch and river herring (Tables 3-6). Summary data by year, species and station is presented in Table 7. Twenty-six stations were sampled over the four years but not all stations were sampled annually due to changes in stream morphology.

Adult and Juvenile Fish Sampling

Haul seine sampling was conducted biweekly at four sites from July to October in the Bush River using a 30.5m x1.2m x 6.4mm seine. The net was dragged perpendicular to the shore and upon reaching the end; the net was swept in a circular pattern and onto the shoreline. Fish were quickly removed, identified and counted. Those fish not quickly identified were

placed into water-filled, oxygen injected containers, sorted, speciated and counted as quickly as possible to minimize mortality.

Sites were chosen based on availability of seinable beaches and historical sites and consisted of four sites (Figure 2). All fish were counted by species but targeted fish were counted by life stage (striped bass, white perch and yellow perch). Catch-per-unit-effort (CPUE) was calculated for each species by dividing the total catch by the number of sites times the number of site visits resulting in catch-per-seine-per-day and was calculated annually.

Bottom trawling was conducted at three sites within the Bush River (Figure 3). This gear was composed of a 16 foot bottom trawl which consisted of 7.6 cm (3 inch) stretched mesh in the wings and body, 1.9 cm (0.75 inch) stretched mesh in the cod-end and a 1.3 cm (0.5 inch) stretched mesh liner. Trawl tows were 10 minutes in length. The trawl was retrieved into the boat by hand and the catch was emptied into a 50 gallon trough. All fish were identified to species and enumerated. Data was entered onto field datasheets and at a later date, entered into a spreadsheet for analysis. Water quality measures including, temperature, pH, conductivity and dissolved oxygen were recorded for each site. Water quality parameters were taken using a hand held YSI model 55. The meters were calibrated for dissolved oxygen according to the manual.

Results and Discussion

Ichthyoplankton sampling

An average of 22 volunteers collected 630 samples over the four years of the study (Table 2). This accounted for 82% of the scheduled samples and samples not collected were due to high water and/or hazardous conditions.

Table 8 summarizes the ichthyoplankton data by year, site and percent presence by target species (white perch, yellow perch and herring). River herring were the most abundant fish in the ichthyoplankton samples. White and yellow perch were found in significantly less frequency. This data indicates that river herring because of their semi-buoyant eggs may be better able to survive the conditions in the Bush River or adult stocks of river herring have increased while white perch and yellow perch stocks have decreased. Recent data on adult stocks in the upper Chesapeake Bay have indicated that river herring stocks are decreasing statewide (Sadzinski 2008) and this likely includes the Bush River.

Comparing ichthyoplankton sampling sites to Odell's 1972 data (Table 9; O'Dell 1972) indicated that present spawning of white and yellow perch occurred at sites much lower in the watershed and may be directly related to increased sedimentation in the streams where spawning was historically documented.

The ichthyoplankton sampling during 2005-2008 indicated stable river herring reproductive success while there was a concerning absence of white and yellow perch eggs or larval fish. This is especially noteworthy when compared to historical datasets within the watershed.

Adult and Juvenile Fish Sampling

Annual sampling using haul seines and bottom trawls has occurred since 2005 in the Bush River. Table 10 summarizes the annual catches by gear type, but the total number of fish species annually sampled (gears combined) was 45, 34, 45 and 50, respectively,

Annually, over ten thousand fish were caught either by haul seine or trawl and the average by gear type was over 5,500 fish by haul seining while approximately 4,500 fish were captured using the trawl (Table 10). It should be noted that the CPUE is a more appropriate metric to compare the two gears because of the differences in the number of sites sampled was significantly different biased higher for the haul seine. Overall 2005-2008 CPUE for haul seining equaled 5.4 fish per seine per day while for trawling equaled 5.8 fish per trawl per day, significantly more. Table 11 compares the total catch (gears combined) by species and year.

Comparison of CPUEs during the time series (Tables 12-15) was also investigated for select species (river herring, yellow perch and white perch). Figures 4 and 5 plot the alewife herring and blueback herring juvenile indices generated by haul seining and compared these to the geometric mean generated by Maryland DNR's striped bass seine survey (SBSS) in the upper Chesapeake Bay. The trends are very similar for alewife herring, highest in 2005 and again in 2007 while for blueback herring, these indices differ significantly in 2005 but trend well for the next three years, demonstrating the significant decline in juvenile production found throughout the Chesapeake Bay in 2008.

Atlantic menhaden indices for the Bush River are presented in Figure 6 and were compared to the SBSS dataset for the upper Chesapeake Bay. For the time series, the Bush River indices are increasing significantly and compare well to the SBSS trend. These data

demonstrate the increasing abundance of juvenile Atlantic menhaden in the upper Chesapeake Bay including the Bush River.

Juvenile yellow perch (Figure 7) have decreased during the last four years in the Bush River and compare very well to the SBSS trend. The 2008 index in conjunction with the very poor yellow perch larval and egg presence demonstrates the poor reproductive success of yellow perch in the Bush River streams and may be caused by reduced adult stock abundance or a shift in habitat use. McGinty (MD DNR personal communication) investigated yellow perch spawning in the Bush River in 2007 through visual observation of egg chains but did not observe egg chains in the areas near head of tide. Adult yellow perch seine CPUE decreased significantly ($r^2 = 0.91$ $P = 0.02$) while trawl CPUE had no trend (Figure 8; $r^2 = 0.13$ $P = 0.30$, respectively).

Surveys conducted in the tidal areas for presence of larval yellow perch indicated good production in the tidal reaches. For three consecutive years, larval presence has been above an established historical mean in the Bush River (McGinty, et al, 2009).

Juvenile white perch within the surveys (Figure 9) have not shown a trend, although each index declined to its lowest level in 2006 with slight increases after that year.

Gizzard shad (Figure 10) serve as an indicator species for poor water quality and also as a forage base. CPUEs in the Bush River were generally the highest for any fish species, averaging 62 fish per haul in the seine fishery. This may demonstrate the nursery habitat available in the Bush River and the very large numbers of gizzard shad reproducing in the upper Chesapeake Bay.

Another very important fish prey species that is generally not investigated within the Chesapeake Bay is inland silversides and spottail shiners. Both of these indices for the seine

survey by the Bush River volunteers were trending the same, peak in 2006 down to their lower levels in 2007 and 2008 (Figure 11). These fish serve as a forage base for many species and may also serve as an indicator species for water quality. The similar trend indicates that they may share and may be limited by the same habitat requirements.

These target species were also compared to Maryland DNR Fisheries Service Habitat Project's seine and trawl survey also in the Bush River (2006-2008; M. McGinty MD DNR, personal communication). Figures 12 compares alewife herring trends between the groups and are similar except for 2007, while the trend is similar for blueback herring (Figure 13). The long-term (1959-2008) upper Chesapeake Bay juvenile indices for alewife and blueback herring are presented in Figure 14 and demonstrate the variability of juvenile recruitment even at similar adult abundance levels and these indices are likely environmentally driven (Sadzinski et al 2009).

Atlantic menhaden juvenile indices from the Volunteer study were compared to DNR data and trends were very similar (Figure 15). In the upper Chesapeake Bay, Atlantic menhaden juvenile indices (Figure 16) have been very low for over fifteen years and the significant catches in the Bush River may indicate more favorable environment or avoidance of predators.

Juvenile yellow perch and white perch indices from the volunteer study on the Bush River were also compared to DNR data and trends were very similar (Figure 17 and 18, respectively). Juvenile white perch indices from the upper Chesapeake Bay (Figure 19) also show a similar trend with a significant increase in production in 2007 and fewer fish in 2008. White and yellow perch stocks have been examined in the upper Chesapeake Bay and indicated that populations are stable with low total mortality (Piavis et al 2008).

Inland silversides and spottail shiner indices were also compared to MD DNR trends within the river and the minor differences between them is likely due to their habitat preference, tidal state and time of day the area was sampled.

Maryland DNR has compared the Bush River system using their data to other systems in the Chesapeake Bay (Tables 15 and 16). Bush River was ranked number first out of the eight systems investigated for number of fish caught per seine haul (302) and for species diversity (N = 27). This comparison was also reinforced by the trawl data collected by MD DNR that ranked the Bush River second in number of fish caught per trawl (244) and for species diversity (N = 21), while being ranked with the highest amount of impervious surface (IS) in the watershed (12.8%).

IS is a key factor in developed watersheds because once the IS percentage equals 15% or more, significant negative fisheries effects are incurred (McGinty 2009). This habitat-based reference point for IS is being applied to estuarine watersheds and may serve as the basic framework to manage fish in urbanizing watersheds. This is a relatively easy metric that provides not only fisheries managers with a simple tool for fisheries impact measurement but also a tool for user-groups interested in resource protection and may serve communities attempting to limit development in sensitive watersheds, such as the Bush River. The percentage of IS is reaching the threshold in the Bush River and fish communities will likely be impacted significantly by continued watershed development. Land-use planning must be evaluated carefully in the Bush River watershed to minimize potential impacts to water quality and the fisheries.

Overall, the assessment indicates that stream spawning habitat has declined in the Bush River; however, the tidal areas still support important nursery functions for significant

recreational and commercial fish species and their prey. These nursery habitats are vital to supporting healthy bay fish populations. Losses in these habitats can translate into decreases in quality of life for local residents, particularly fisherman. Projected development in the watershed will result in increased sedimentation and further degradation of the streams and tidal reaches which will contribute to a decline in fish habitat in the Bush River.

Another important indicator is submerged aquatic vegetation (SAV) which may serve as an indicator of water quality. In the Bush River SAV has increased significantly in the past few years (Figure 20) and may be related to improvements in water quality in the river. This increased density of SAV in the Bush River may provide better habitat and survival for juvenile fish**.**

Recommendations:
(Not prioritized)

- Initiate a Forest Preservation Plan for the Bush River watershed
- Continue collecting field data including water quality, ichthyoplankton sample, bottom trawl and seining for adult and juvenile fish
- Initiate long-term sediment sampling
- Determine the reproductive limitations for white perch and yellow perch that may exist in the watershed
- Reduce nitrogen and phosphorus input into the river
- Consider fisheries resource needs in land planning
- Reduce sedimentation rates and determine its potential long-term impact on reproductive success of targeted fish species.
- Establish an online database from the biotic information collected during this study.

Literature Cited

Maryland Department of Natural Resources. 2002. Report on nutrient and biotic surveys in the Bush River watershed, Harford County, Maryland, March 2002 as part of the watershed restoration action strategy. Chesapeake and Coastal Watershed Services, Watershed Restoration Program; Watershed Evaluation Section. December 2002.

Maryland Department of Natural Resources. 1998. Bush River Basin Report. Maryland Biological Stream Survey. Web accessed March 2009.

McGinty, M., J. Uphoff, R. Lukacovic, J. Mowrer, and B. Pyle. 2009. Project 3: 2008 Fisheries and Habitat Interactions Project: Development of Habitat-based Reference Points for Chesapeake Bay Fishes of Special Concern: Impervious Surface as a Test Case *in* 2001 Stock assessment of selected resident and migratory recreational finfish species within Maryland's Chesapeake Bay. Maryland Department of Natural Resources, Federal Aid Annual Report F-54-R, Annapolis, Maryland

Najjar, R.G., H.A. Walker, P.J. Barron, and etc. 2000. Potential impacts of climate change on the mid-Atlantic coastal region. Climate Research 14, 219-233.

Pasternack, G.B. and L.A. Hinnov. 2003. Hydrometeorological controls on water level in a vegetated Chesapeake Bay tidal freshwater delta. Estuarine, Coastal and Shelf Science. Volume 58, Number 2 pages 367-387.

Pasternack, G.B., W. B. Hilgartner, and G. S. Grace. 2000. Biogeomorphology of an upper Chesapeake Bay river-mouth tidal freshwater marsh. Wetlands. Volume 2000: 20(3).

Piavis, P and E.W. Webb. 2008. Population assessment of yellow perch in Maryland with special emphasis on head-of-Bay stocks. Pages I-43 to I-66 *in* Chesapeake Bay finfish / habitat investigations, 2007. Maryland Department of Natural Resources, Federal Aid Annual Report F-61-R-1, Annapolis, Maryland.

Sadzinski, R., A. Jarzynski. 2009. Stock assessment of adult and juvenile anadromous species in the Chesapeake Bay. Pages II-1 to II-48 *in* Chesapeake Bay finfish / habitat investigations, 2008. Maryland Department of Natural Resources, Federal Aid Annual Report F-61-R-1, Annapolis, Maryland.

Table 1. Description of sites for ichthyoplankton sampling in the Bush River.

Site Number	Site Name	Defined Location	Comments
1	BHHT	Bush River – HaHa Branch tidal	on Route 40- across the road from the trailer park
2	BOP1	Bush River-Otter Point Creek	Bosley Conservancy- where road meets the water
3	BWRT	Bush River-Winter's Run tidal	Take a right at Burger King, go over little bridge next immediate right turn (USGS gauge site)
4	BWR1	Bush River-Winter's Run 1	old crab shack- small building with parking lot now owned by Harford county(corner of fashion way)
	BWR2	Bush River-Winter's Run 2	
5	BHH1	Bush River- HaHa Branch 1	walk toward tire pile, follow wide path, take 1st left in path and look for flagging near tree (Large billboard on property- across rte 7 from new development-was Erney Blades old pr
6	BBR1	Bush River- Bynum Run 1	park and enter near Harford county gate
	BBR2	Bush River- Bynum Run 2	
7	BJR1	Bush River- James Run 1	park just before bridge walk over bridge - to left, then head down stream
	BJR2	Bush River- James Run 2	
8	BCR1	Bush River- Cranberry Run 1	sample in stream near downed tree and bicycle tire in water

9	BSC1	Bush River Swan Creek 1	
10	BSC2	Bush River Swan Creek 2	USGS gauge is located
	BSC3	Bush River Swan Creek 3	
11	BSGRT	Bush River Grays Run Tidal	Park on the side of the road facing the Grays run sign (not the marshy side)
12	BUN1	Bush River Unnamed Tributary 1	Clubhouse Road Crossing
	BSR1	Bush River Sod Run 1	Chelsea Road Crossing

Table 2. Ichthyoplankton sampling specifics, 2005-2008.

	Year			
	2005	2006	2007	2008
Number of sites	15	23	18	19
Number of sampling dates	10	10	10	11
Number of samples proposed	150	230	180	209
Number of samples collected	124	186	180	140
Number of Volunteers	23	22	23	19

Table 2.1 Ichthyoplankton fish trap sites, Bush River Drainage Basin 2006-2007. (Historic lat and long's used from O'Dell study)

River/Stream	station	Location Description	Latitude	Longitude	Team assigned
Winter's Run	BWR1	Crab Shack	39.43193	-76.28931	
Bynum Run	BBR1	Route 7 Road Crossing	39.47001	-76.26532	
Grays Run	BGR1	Route 40 Road Crossing	39.47958	-76.2173	
Otter Point Creek	BOP1	Bosely Conservancy	39.4435	-76.28444	
Cranberry Run	BCR1**	Spesutia Road Crossing	39.47833	-76.21627	
Sod Run 1	BSR1	Chelsea Road Crossing	39.438	-76.21395	
Winter's Run	BWR1	Crab Shack	39.43193	-76.28931	
Bynum Run	BBR1	Route 7 Road Crossing	39.47001	-76.26532	
Grays Run	BGR1	Route 40 Road Crossing	39.47958	-76.2173	
Cranberry Run	BCR1**	Spesutia Road Crossing	39.47833	-76.21627	
Otter Point Creek	BOP1	Bosely Conservancy	39.4435	-76.28444	
HaHa Branch	BHB1*	Route 7 Road Crossing	39.45088	-76.28801	2
James Run	BJR1	Route 7 Road Crossing	39.47535	-76.25998	
Unnamed Tributary	BUN1	Clubhouse Road Crossing	39.44446	-76.23324	
Swan Creek *	BSC1*	Chelsea Road Crossing	Not available	Not available	

* stopped setting traps at swan creek as of April 27 , 2007 due to theft

Table 3. Number of ichthyoplankton samples with eggs or larval fish from the three targeted fish species in 2005.

2005 - Number of samples with yellow perch															
	BBR1	BBR2	BCR1	BGR1	BHH1	BJR1	BJR2	BOP1	BSC1	BSC2	BSC3	BSR1	BUN1	BWR1	BWR2
12-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Mar	0	0	0	0		0	0	0	0	0	0	0	0		
22-Mar	0	0	0	0	0	0	0		0	0	0			0	0
9-Apr	0	0	0	0	0	0	0	0				0	0	0	0
16-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Apr	0								0	0	0				
1-May	0	0	0	0	0	0	0	0						0	0
7-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#samples pres	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of samples with white perch															
	BBR1	BBR2	BCR1	BGR1	BHH1	BJR1	BJR2	BOP1	BSC1	BSC2	BSC3	BSR1	BUN1	BWR1	BWR2
12-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Mar	0	0	0	0		0	0	0	0	0	0	0	0		
22-Mar	0	0	0	0	0	0	0		0	0	0			0	0
9-Apr	0	0	0	0	0	0	0	0				0	0	0	0
16-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Apr	0								0	0	0				
1-May	0	0	0	0	0	0	0	0						0	0
7-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
# samples pres	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of samples with herring															
12-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 Continued															
19-Mar	0	0	0	0		0	0	0	0	0	0	0	0		
22-Mar	0	0	0	0	0	0	0		0	0	0			0	0
9-Apr	1	0	0	1	0	0	0	1				0	0	0	0
16-Apr	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0
23-Apr	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
29-Apr	1		0	0					0	1	0				
1-May	1	0			0	0	0	1						0	0
7-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-May	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
# samples pres	3	0	0	1	0	1	0	3	2	2	0	0	1	0	0
%presence	30	0	0	11.11	0	11.111	0	37.5	25	25	0	0	14.29	0	0

Table 4. Number of ichthyoplankton samples with eggs or larval fish from the four targeted fish species in 2006.

White perch

	BBR1	BBR2	BCR1	BGR1	BHH1	BJR1	BJR2	BOP1	BSC1	BSC2	BSC3	BSR1	BUN1	BWR1	BWR2	GPCA	GPSW	GPWA	GPWR	BACK	MOSC
15-Mar								0	0	0	0	0		0	0					0	
22-Mar	0	0	0	0	0	0	0	0		0	0	0	0	0	0					0	
29-Mar	0		0	0	0	0	0	0	0	0	0	0	0	0	0						
1-Apr	0	0	0	0	0	0		0	0	0	0	0	0	0	0					1	
8-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1		0	1	
15-Apr		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1		1	0	
22-Apr	0	0	0	0	0	0	0	0	0	0	0	0		0	0					0	
29-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
6-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
13-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1	1	2	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0	40.0	33.3	20.0	25.0	

Yellow perch

	BBR1	BBR2	BCR1	BGR1	BHH1	BJR1	BJR2	BOP1	BSC1	BSC2	BSC3	BSR1	BUN1	BWR1	BWR2	GPCA	GPSW	GPWA	GPWR	BACK	MO
15-Mar								0	0	0	0	0		0	0					0	
22-Mar	0	0	0	0	0	0	0	0		0	0	0	0	0	0					0	
29-Mar	0		0	0	0	0	0	0	0	0	0	0	0	0	0						
1-Apr	0	0	0	0	0	0		0	0	0	0	0	1	0	0					0	
8-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1		0	0	
15-Apr		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	
22-Apr	0	0	0	0	0	0	0	0	0	0	0	0		0	0					0	
29-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
6-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
13-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	
	0.0	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	20.0	40.0	0.0	0.0	0.0	

Herring

	BBR1	BBR2	BCR1	BGR1	BHH1	BJR1	BJR2	BOP1	BSC1	BSC2	BSC3	BSR1	BUN1	BWR1	BWR2	GPCA	GPSW	GPWA	GPWR	BACK	MO
15-Mar								0	0	0	0	0		0	0					0	
22-Mar	0	0	0	0	0	0	0	0		0	0	0	0	0	0					0	
29-Mar	0		0	0	0	0	0	0	0	0	0	0	0	0	0						
1-Apr	0	0	0	0	0	0		0	0	0	0	0	1	0	0					0	
8-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	
15-Apr		0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0		0	0	
22-Apr	0	0	0	0	0	0	0	0	0	0	0	0		0	0					0	
29-Apr	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0		
6-May	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
13-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	0	0	0	1	1	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	
	0.0	0.0	0.0	11.1	11.1	11.1	0.0	10.0	11.1	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table 5. Number of ichthyoplankton samples with eggs or larval fish from the four targeted fish species in 2007.

yellow perch																		
	BBR1	BCR1	BGR1	BGRT	BHH1	BHHT	BJR1	BOP1	BSC1	BSC2	BSC3	BUN1	BWR1	BWRT	GPCA	GPSW	GPWA	GPWR
21-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
14-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
21-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
6-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	1
Percent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	0	0.375	0.125
white perch																		
	BBR1	BCR1	BGR1	BGRT	BHH1	BHHT	BJR1	BOP1	BSC1	BSC2	BSC3	BUN1	BWR1	BWRT	GPCA	GPSW	GPWA	GPWR
21-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
21-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
28-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Percent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0
Herring/shad																		
	BBR1	BCR1	BGR1	BGRT	BHH1	BHHT	BJR1	BOP1	BSC1	BSC2	BSC3	BUN1	BWR1	BWRT	GPCA	GPSW	GPWA	GPWR

Table 5 Continued																		
21-Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Mar	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
31-Mar	0	0	1	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0
7-Apr	1	0	1	1	0	0	1	1	1	1	1	0	0	1	1	0	0	0
14-Apr	0	0	0	0	0	0	1	1	0	1	0	1	1	1	0	0	0	0
21-Apr	1	0	0	1	0	1	1	1	1	1	1	1	0	1	0	0	1	0
28-Apr	1	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	0	0
6-May	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
11-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	3	1	3	3	1	2	5	5	3	4	3	2	3	5	1	0	1	0
Percent	0.3	0.111	0.3	0.3	0.111	0.2	0.5	0.56	0.375	0.5	0.4	0.2	0.33	0.56	0.13	0	0.125	0

Table 6. Number of ichthyoplankton samples with eggs or larval fish from the four targeted fish species in 2008.

white perch																			
	BBR1	BCR1	BGRT	BHH1	BHHT	BJR1	BOP1	BSC1	BSC2	BWR1	BWRT	GPCA	GPSW	GPWA	GPWR	MOSQ	ROM	BACK	WOOD
8-Mar	0																		0
15-Mar	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Mar	0	0		0			0			0	0	0	0	0	0		0	0	0
29-Mar	0	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0
5-Apr		0		0			0	0	0	0	0	0	0	0	0	0	0	0	0
12-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
19-Apr		0		0			0	0	0	0	0	0	1	1	0		0		0
26-Apr	0	0	0	0	0	0	0	0	0	0	0					0	0	0	0
3-May	0			0	0	0	0			0	0					0	0	0	0
10-May	0	0	0	0	0	0	0		0	0	0					0	0	1	0
17-May		0																	
Sum	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	1	0
Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	33.3	0.0	0.0	0.0	12.5	0.0
yellow perch																			
	BBR1	BCR1	BGRT	BHH1	BHHT	BJR1	BOP1	BSC1	BSC2	BWR1	BWRT	GPCA	GPSW	GPWA	GPWR	MOSQ	ROM	BACK	WOOD
8-Mar	0																		1
15-Mar	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Mar	0	0		0			0			0	0	0	0	0	0		0	0	0
29-Mar	0	0	0	0	0	0	0	0	0	0	0	0		0		1	0	0	1
5-Apr		0		0			0	0	0	0	0	0	0	0	0	0	0	0	0
12-Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
19-Apr		0		0			0	0	0	0	0	0	0	0	0		0		0
26-Apr	0	0	0	0	0	0	1	0	0	0	1					0	0	0	0
3-May	0			0	0	0	0			0	0					0	0	0	0
10-May	0	0	0	0	0	0	0		0	0	0					0	0	0	0
17-May		0																	
Sum	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2	0	1	3

Percent	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	0.0	11.1	0.0	0.0	0.0	0.0	28.6	0.0	12.5	30.0
Table 6 continued																			
	herring																		
	BBR1	BCR1	BGRT	BHH1	BHHT	BJR1	BOP1	BSC1	BSC2	BWR1	BWRT	GPCA	GPSW	GPWA	GPWR	MOSQ	ROM	BACK	WOOD
8-Mar	0																		0
15-Mar	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
22-Mar	0	0		0			0			0	1	0	0	0	0		0	0	0
29-Mar	0	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0
5-Apr		0		0			1	0	0	0	1	0	1	0	0	1	1	0	0
12-Apr	2	0	0	0	0	0	1	0	0	0	1	0	1	0	1	0	0	1	1
19-Apr		0		0			0	0	1	0	1	0	1	1	1		1		0
26-Apr	1	0	0	1	0	0	0	0	0	0	0					1	0	1	0
3-May	0			0	0	0	1			0	1					1	1	0	1
10-May	0	0	0	0	0	0	1		0	0	1					1	1	1	1
17-May		0																	
Sum	3	0	0	1	0	0	4	0	1	0	6	0	3	1	2	4	5	3	3
Percent	33.3	0.0	0.0	11.1	0.0	0.0	44.4	0.0	14.3	0.0	66.7	0.0	60.0	16.7	40.0	57.1	55.6	37.5	30.0

Table 7. Bush River and Gunpowder River Ichthyoplankton percent presence by species, station and year

	2005				2006				2007				2008			
Station	# Samples	%her	% yp	% wp	# Samples	%her	% yp	% wp	# Samples	%her	% yp	% wp	# Samples	%her	% yp	% wp
BBR1	10	30.0	0.0	0.0	8	0.0	0.0	0.0	10	30.0	0.0	0.0	9	33.0	0.0	0.0
BBR2	9	0.0	0.0	0.0	8	0.0	0.0	0.0								
BCR1	9	0.0	0.0	0.0	9	0.0	0.0	0.0	9	11.1	0.0	0.0	8	0.0	0.0	0.0
BGR1	9	11.1	0.0	0.0	9	11.1	11.1	0.0	10	30.0	0.0	0.0				
BGRT									10	30.0	0.0	0.0	5	0.0	0.0	0.0
BHH1	8	0.0	0.0	0.0	9	11.1	0.0	0.0	9	11.1	0.0	0.0	9	11.1	0.0	0.0
BHHT									10	20.0	0.0	0.0	8	0.0	0.0	0.0
BJR1	9	11.1	0.0	0.0	9	11.1	0.0	0.0	10	50.0	0.0	0.0	9	0.0	0.0	0.0
BJR2	9	0.0	0.0	0.0	8	0.0	0.0	0.0								
BOP1	8	37.5	0.0	0.0	10	10.0	0.0	0.0	9	56.0	0.0	0.0	9	44.4	11.1	0.0
BSC1	8	25.0	0.0	0.0	9	11.1	0.0	0.0	8	37.5	0.0	0.0	6	0.0	0.0	0.0
BSC2	8	25.0	0.0	0.0	10	0.0	0.0	0.0	8	50.0	0.0	0.0	7	14.3	0.0	0.0
BSC3	8	0.0	0.0	0.0	10	0.0	0.0	0.0	8	38.0	0.0	0.0				
BSR1	7	0.0	0.0	0.0	10	0.0	0.0									
BUN1	7	14.3	0.0	0.0	8	12.5	12.5	0.0	10	20.0	0.0	0.0				
BWR1	8	0.0	0.0	0.0	10	0.0	0.0	0.0	9	33.0	0.0	0.0	9	0.0	0.0	0.0
BWR2	8	0.0	0.0	0.0	10	0.0	0.0	0.0								
BWRT									9	56.0	0.0	0.0	9	66.7	11.1	0.0
GPCA					5	0.0	20.0	60.0	8	13.0	13.0	0.0	6	0.0	0.0	0.0
GPSW					5	0.0	40.0	40.0	8	0.0	0.0	0.0	5	60.0		20.0
GPWA					3	0.0	0.0	33.3	8	12.5	37.5	25.0	6	16.7	0.0	33.3
GPWR					5	0.0	0.0	20.0	8	0.0	12.5	0.0	5	40.0	0.0	0.0
BACK					8	0.0	0.0	25.0					7	37.5	12.5	12.5
MOSQ					8	25.0	25.0	12.5					9	57.1	28.6	0.0
ROM					8	33.3	0.0	0.0					8	55.6	0.0	0.0
WOODREST					8	12.5	12.5	50.0					10	30.0	30.0	0.0

Table 8. The percent of positive (species present) ichthyoplankton samples collected by Bush River volunteers, 2005-2008.

Fish species	Year			
	2005	2006	2007	2008
White Perch	0	7.5	1.1	3.5
Yellow Perch	0	4.3	2.8	4.9
Herring	10.4	5.9	25	24.6

Table 9. Number of historic and present sites with species present in the ichthyoplankton samples

Species	Historical (1972)	Present
River Herring	8	7
White perch	7	0
Yellow perch	4	0

Table 10. Seine and Trawl data summarized by year from the Bush River, 2005-2008.

	2005		2006		2007		2008	
	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl
Annual Number of seines or trawls	20	13	24	18	13	19	20	15
Annual Number of species captured	41	28	34	25	41	23	36	21
Total Catch	6614	3071	5250	4410	4803	6579	5564	4209
Total CPUE	6.48	4.63	5.91	6.62	4.09	6.79	5.25	5.29

Table 11. Number of fish by select species and year captured from the Bush River seine and trawl survey, 2005-2008.

(Note – does not include all fish species)

Species	Year			
	2005	2006	2007	2008
Alewife herring	527	32	106	2
Atlantic menhaden	71	1345	115	423
Bay anchovy	6	381	324	5
Bluegill	42	116	13	4
Banded killifish	123	125	300	64
Carp	6	9	3	4
Channel catfish	38	22	3	3
Gizzard shad	1425	1616	2299	437
Golden shiner	34	62	1	4
Inland silverside	101	226	40	24
Largemouth bass	9	14	7	3
Pumpkinseed	764	776	418	373
Silvery minnow	174	48	70	22
Spot	241	33	72	69
Spottail shiner	323	915	327	90
Striped bass	22	58	23	34
Striped killifish	0	58	0	2
Tessellated darter	88	100	120	19
White perch (juvenile)	2708	832	4746	976
White perch (adult <200mm)	819	2295	1210	660
White perch (adult>200mm)	86	43	15	1
Yellow perch (juvenile)	119	33	51	2
Yellow perch +1	70	85	15	7
Sunfish (unknown)	0	0	52	4
Brown bullhead	132	344	220	76
White sucker	2	2	8	2
Blue crab (adult≤121mm)	3	2	14	6
Blue crab (adult≥121mm)	0	3	14	14
Total	7933	9575	10586	3316

Table 12. Number of fish sampled by trawl and seine in 2005 and the resulting CPUE by gear type.

	Total			CPUE	
Species	Seine	Trawl		Seine	Trawl
Alewife	503	24		25.15	1.846154
American eel	1	4		0.05	0.307692
American shad	2	0		0.1	0
Atlantic croaker	0	0		0	0
Atlantic menhaden	61	10		3.05	0.769231
Atlantic silverside	43	38		2.15	2.923077
Atlantic needlefish	1	0		0.05	0
Bay anchovy	1	5		0.05	0.384615
Bluefish	0	0		0	0
Bluegill	29	13		1.45	1
Blueback herring	1149	84		57.45	6.461538
Banded killifish	123	0		6.15	0
Carp	6	0		0.3	0
Channel catfish	9	29		0.45	2.230769
Gizzard shad	1276	149		63.8	11.46154
Golden shiner	26	8		1.3	0.615385
Hogchoker	0	0		0	0
Inland silverside	94	7		4.7	0.538462
Largemouth bass	9	0		0.45	0
Mummichog	11	0		0.55	0
Pumpkinseed	530	234		26.5	18
Rough silverside	4	0		0.2	0
Silvery minnow	174	0		8.7	0
Spot	137	104		6.85	8
Spottail shiner	284	39		14.2	3
Striped anchovy	0	0		0	0
Striped bass	17	5		0.85	0.384615
Striped killifish	0	0		0	0
Tessellated darter	54	34		2.7	2.615385
White perch (juvenile)	1058	1650		52.9	126.9231
White perch ((adult <200mm)	365	454		18.25	34.92308
White perch (adult>200mm)	54	32		2.7	2.461538
Yellow perch	91	28		4.55	2.153846
Yellow perch +1	56	14		2.8	1.076923
Blue spotted sunfish	12	0		0.6	0
Black crappie	2	0		0.1	0
Sunfish (unknown)	156	15		7.8	1.153846
Golden shiner	2	0		0.1	0
Table 12 continued					

Brown bullhead	23	79		1.15	6.076923
Green sunfish	0	6		0	0.461538
Small mouth bass	25	4		1.25	0.307692
Eastern silvery minnow	203	0		10.15	0
Sucker, white	0	0		0	0
Blue crab (61-120mm immature)	0	0		0	0
Blue crab (adult</=121mm)	2	1		0.1	0.076923
Blue crab (adult>/=121mm)	0	0		0	0
Hickory shad	14	1		0.7	0.076923
White sucker	2	0		0.1	0
Sucker, unknown	2	0		0.1	0
Smallmouth bass	0	0		0	0
Creek chub sucker	3	0		0.15	0
Total / Mean	6614	3071		6.484314	4.631976

Table 13. Number of fish sampled by trawl and seine in 2006 and the resulting CPUE.

Species	Total Catch		CPUE	
	Seine	Trawl	Seine	Trawl
Alewife	31	1	1.291667	0.055556
American eel	2	2	0.083333	0.111111
Atlantic menhaden	1342	3	55.91667	0.166667
Atlantic silverside	75		3.125	0
Banded killifish	125		5.208333	0
Bay anchovy	128	253	5.333333	14.05556
Blue crab (adult</=121mm)		2	0	0.111111
Blueback herring	25	1	1.041667	0.055556
Bluefish	11		0.458333	0
Bluegill	78	38	3.25	2.111111
Bluespotted sunfish	1		0.041667	0
Brown bullhead	3	341	0.125	18.94444
Carp	7	2	0.291667	0.111111
Channel catfish	1	21	0.041667	1.166667
Creek chub sucker	1		0.041667	0
Eastern silvery minnow	4		0.166667	0
Gizzard shad	1295	321	53.95833	17.83333
Golden shiner		62	0	3.444444
Hickory shad	1		0.041667	0
Inland silverside	226		9.416667	0
Largemouth bass	14		0.583333	0
Larval fish, unknown	4		0.166667	0
Pumpkinseed	318	458	13.25	25.44444
Rough silverside	2		0.083333	0
Silvery minnow	47	1	1.958333	0.055556
Spot	12	21	0.5	1.166667
Spottail shiner	671	244	27.95833	13.55556
Striped bass	56	2	2.333333	0.111111
Tessellated darter	31	69	1.291667	3.833333
White catfish	1	14	0.041667	0.777778
White perch (adult>200mm)	16	27	0.666667	1.5
White perch ((adult <200mm)	555	1740	23.125	96.66667
White perch (juvenile)	115	717	4.791667	39.83333
White sucker	2		0.083333	0
Yellow Bullhead		2	0	0.111111
Yellow perch	17	16	0.708333	0.888889
Yellow perch +1	33	52	1.375	2.888889
Total	5250	4410		

Table 14. Number of fish sampled by trawl and seine in 2007 and the resulting CPUE.

Species	Total			CPUE	
	Seine	Trawl		**Seine**	**Trawl**
Alewife	87	19		3.782609	1
American eel	1	4		0.043478	0.210526
American shad	31	1		1.347826	0.052632
Atlantic croaker	0	0		0	0
Atlantic menhaden	115	0		5	0
Atlantic silverside	1	0		0.043478	0
Atlantic needlefish	0	0		0	0
Bay anchovy	19	305		0.826087	16.05263
Bluefish	12	0		0.521739	0
Bluegill	13	0		0.565217	0
Blueback herring	711	7		30.91304	0.368421
Banded killifish	299	1		13	0.052632
Carp	3	0		0.130435	0
Channel catfish	2	1		0.086957	0.052632
Gizzard shad	1972	327		85.73913	17.21053
Golden shiner	1	0		0.043478	0
Hogchoker	1	1		0.043478	0.052632
Inland silverside	40	0		1.73913	0
Largemouth bass	7	0		0.304348	0
Mummichog	2	0		0.086957	0
Pumpkinseed	168	250		7.304348	13.15789
Rough silverside	0	0		0	0
Silvery minnow	70	0		3.043478	0
Spot	23	49		1	2.578947
Spottail shiner	196	131		8.521739	6.894737
Striped anchovy	0	0		0	0
Striped bass	16	7		0.695652	0.368421
Striped killifish	0	0		0	0
Tessellated darter	35	85		1.521739	4.473684
White perch (juvenile)	687	4059		29.86957	213.6316
White perch (adult <200mm)	138	1072		6	56.42105
White perch (adult>200mm)	0	15		0	0.789474
Yellow perch	45	6		1.956522	0.315789
Yellow perch +1	8	7		0.347826	0.368421
Blue spotted	1	0		0.043478	0

sunfish					
Black crappie	0	0		0	0
Sunfish (unknown)	52	0		2.26087	0
Golden shiner	0	0		0	0
Brown bullhead	4	216		0.173913	11.36842
Eastern silvery minnow	0	0		0	0
Hickory shad	3	0		0.130435	0
White sucker	8	0		0.347826	0
Blue crab (adult</=121mm)	3	11		0.130435	0.578947
Carp	0	0		0	0
Long eared sunfish	2	1		0.086957	0.052632
Smallmouth bass	1	0		0.043478	0
Goldfish	13	4		0.565217	0.210526
Juv. smallmouth bass	1	0		0.043478	0
Juv. blue crab	1	0		0.043478	0
Grass shrimp	1	0		0.043478	0
unknown herring	10	0		0.434783	0
Total	**4803**	**6579**	Mean	4.094629	6.789474

Table 15. 2008 Number of fish sampled by trawl and seine in 2008 and the resulting CPUE.

2008	Sum by Gear			CPUE	
Species	**Seine**	**Trawl**		**Seine**	**Trawl**
Alewife	2	0		0.1	0
American eel	0	1		0	0.066667
American shad	0	0		0	0
Atlantic croaker	0	2		0	0.133333
Atlantic menhaden	2053	90		102.65	6
Atlantic silverside	0	0		0	0
Atlantic needlefish	0	0		0	0
Bay anchovy	10	117		0.5	7.8
Bluefish	0	0		0	0
Bluegill	4	0		0.2	0
Blueback herring	2	1		0.1	0.066667
Banded killifish	88	0		4.4	0
Carp	8	3		0.4	0.2
Channel catfish	14	4		0.7	0.266667
Gizzard shad	903	356		45.15	23.73333
Golden shiner	5	0		0.25	0
Hogchoker	1	0		0.05	0
Inland silverside	45	0		2.25	0
Largemouth bass	3	0		0.15	0
Mummichog	0	0		0	0
Pumpkinseed	358	87		17.9	5.8
Rough silverside	0	0		0	0
Silvery minnow	34	0		1.7	0
Spot	69	227		3.45	15.13333
Spottail shiner	211	15		10.55	1
Striped anchovy	0	0		0	0
Striped bass	127	4		6.35	0.266667
Striped killifish	2	0		0.1	0
Tessellated darter	3	41		0.15	2.733333
White perch (juvenile)	830	1582		41.5	105.4667
White perch ((adult <200mm)	623	1245		31.15	83
White perch (adult>200mm)	117	108		5.85	7.2
Yellow perch	12	2		0.6	0.133333
Yellow perch +1	3	14		0.15	0.933333
Blue spotted sunfish	0	0		0	0
Black crappie	0	0		0	0
Sunfish (unknown)	4	0		0.2	0
Golden shiner	0	0		0	0

Table 15 continued					
Brown bullhead	12	293		0.6	19.53333
Eastern silvery minnow	0	0		0	0
Hickory shad	0	0		0	0
White sucker	5	0		0.25	0
Blue crab (adult</=121mm)	1	13		0.05	0.866667
Creek chub sucker	4	0		0.2	0
Longeared sunfish	0	0		0	0
Smallmouth bass	0	0		0	0
Goldfish	0	0		0	0
White catfish	1	4		0.05	0.266667
Clam	1	0		0.05	0
Croaker	6	0		0.3	0
unknown herring	1	0		0.05	0
Mud crab	1	0		0.05	0
Total	**5564**	**4209**	**0**	**5.151852**	**5.196296**

Table 16. Catch statistics and impervious cover in seines by river in 2008 (MD DNR 2009)

River	Number of Samples	Number of Species	Species Comprising 90% of Catch	Percent Impervious	Total Catch	Number of Fish per Seine
Langford	22	12	Atlantic menhaden White perch Striped killifish	0.9	4231	192
Corsica	17	14	Atlantic menhaden White perch Mummichog Striped killifish	4	3864	227
Mattawoman	0			8.5		
Bush	**24**	**27**	**Gizzard shad** **White perch adult** **White perch juvenile** **Atlantic menhaden** **Pumpkinseed** **Spottail shiner** **Banded killifish** **Spottail shiner**	**12.8**	**7252**	**302**
Nanjemoy	17	18	Atlantic menhaden White perch juvenile White perch adult Gizzard shad Mummichog Atlantic silverside Pumpkinseed	1.8	2379	140
Wye	21	7	Atlantic menhaden White perch adult Atlantic silverside Striped killifish	1.2	2986	142
Tred Avon	24	10	White perch adult Striped killifish Atlantic silverside Atlantic menhaden Spot Mummichog	5.6	1933	81
Northeast	24	15	Blueback herring White perch adult White perch juvenile Pumpkinseed Gizzard shad Bay anchovy Spottail shiner Yellow perch juvenile Bluegill Largemouth bass	6.1	2531	105

Table 17. Catch statistics and impervious cover in trawl by river in 2008 (MD DNR 2009).

River	Number of Samples	Number of Species	Species Comprising 90% of Catch	Percent Impervious	Total Catch	Number of Fish per Trawl
Langford	24	15	White perch adult Bay anchovy Spot	0.9	5143	214
Corsica	24	13	White perch adult Bay anchovy Spot	4	3549	148
Mattawoman	24	19	White perch adult White perch juvenile Bluegill Spottail shiner Pumpkinseed	8.5	989	41
Bush	**18**	**21**	**White perch adult White perch juvenile Gizzard shad Brown bullhead Bay anchovy**	**12.8**	**4385**	**244**
Nanjemoy	17	19	White perch juvenile Bay anchovy Brown bullhead White perch adult	1.8	4425	260
Wye	24	13	Bay anchovy Spot White perch adult	1.2	2964	124
Tred Avon	24	15	Bay anchovy Spot Hogchoker Weakfish	5.6	4065	169
Northeast	24	22	White perch juvenile White perch adult Gizzard shad Brown bullhead Bay anchovy	6.1	4060	169

Figure 1. Map of the Bush River watershed

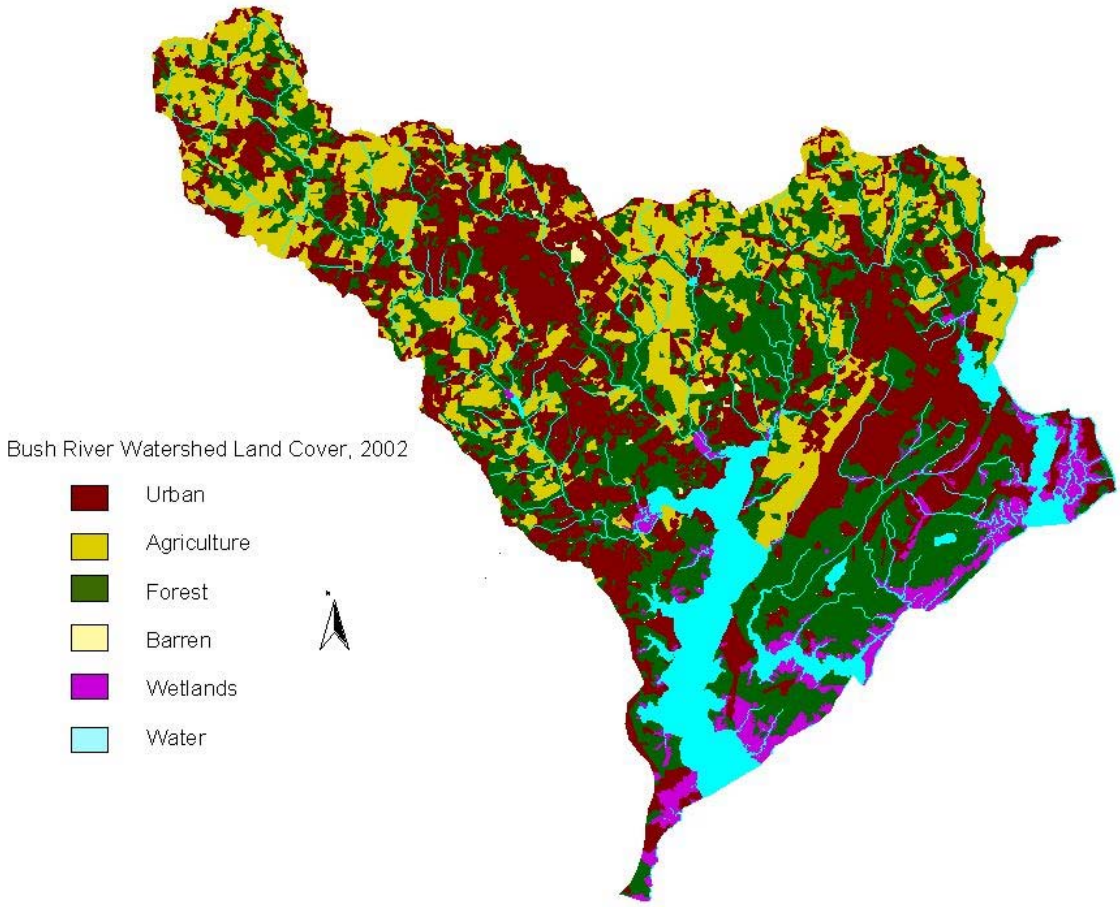


Figure 2. Historic and present ichthyoplankton sampling locations in the Bush River.

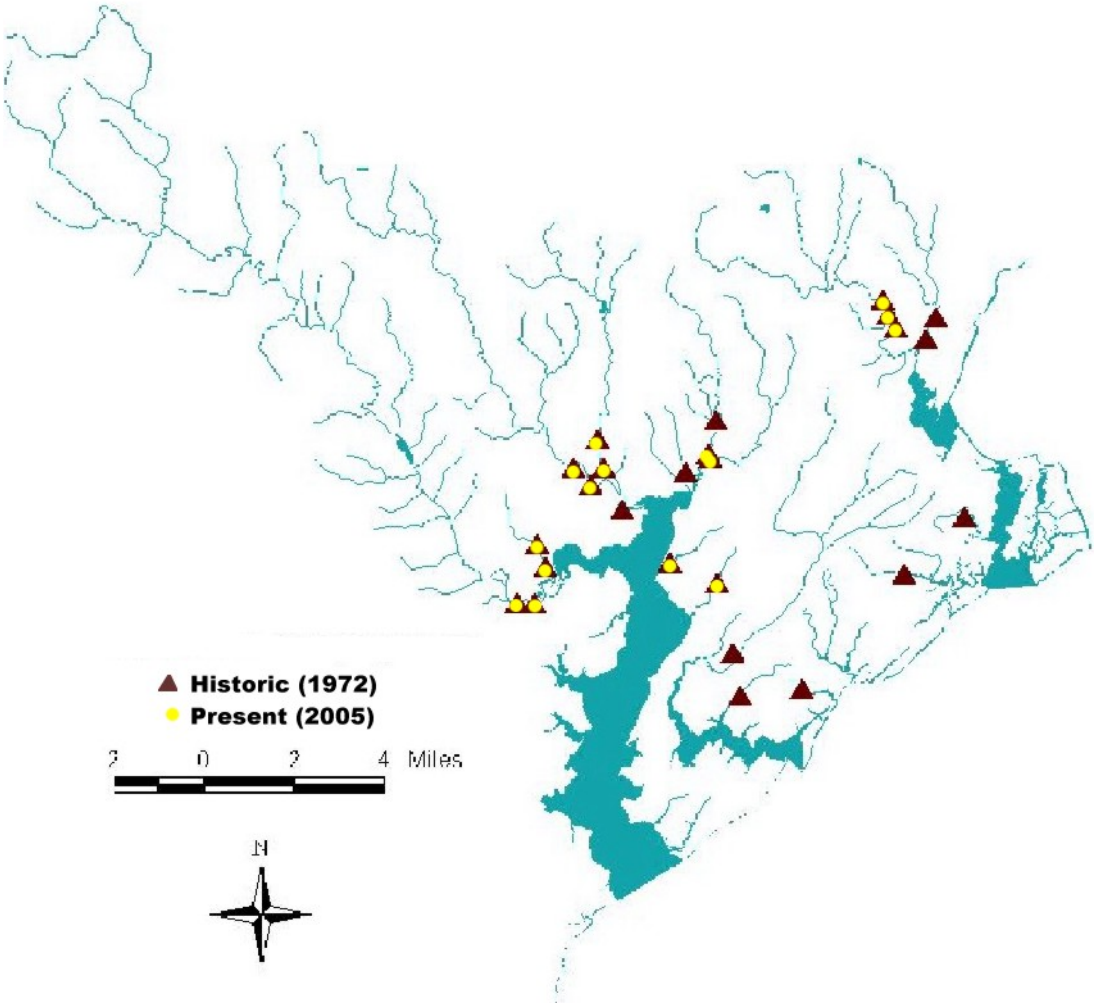


Figure 3. Haul seine and bottom trawl locations in the Bush River.

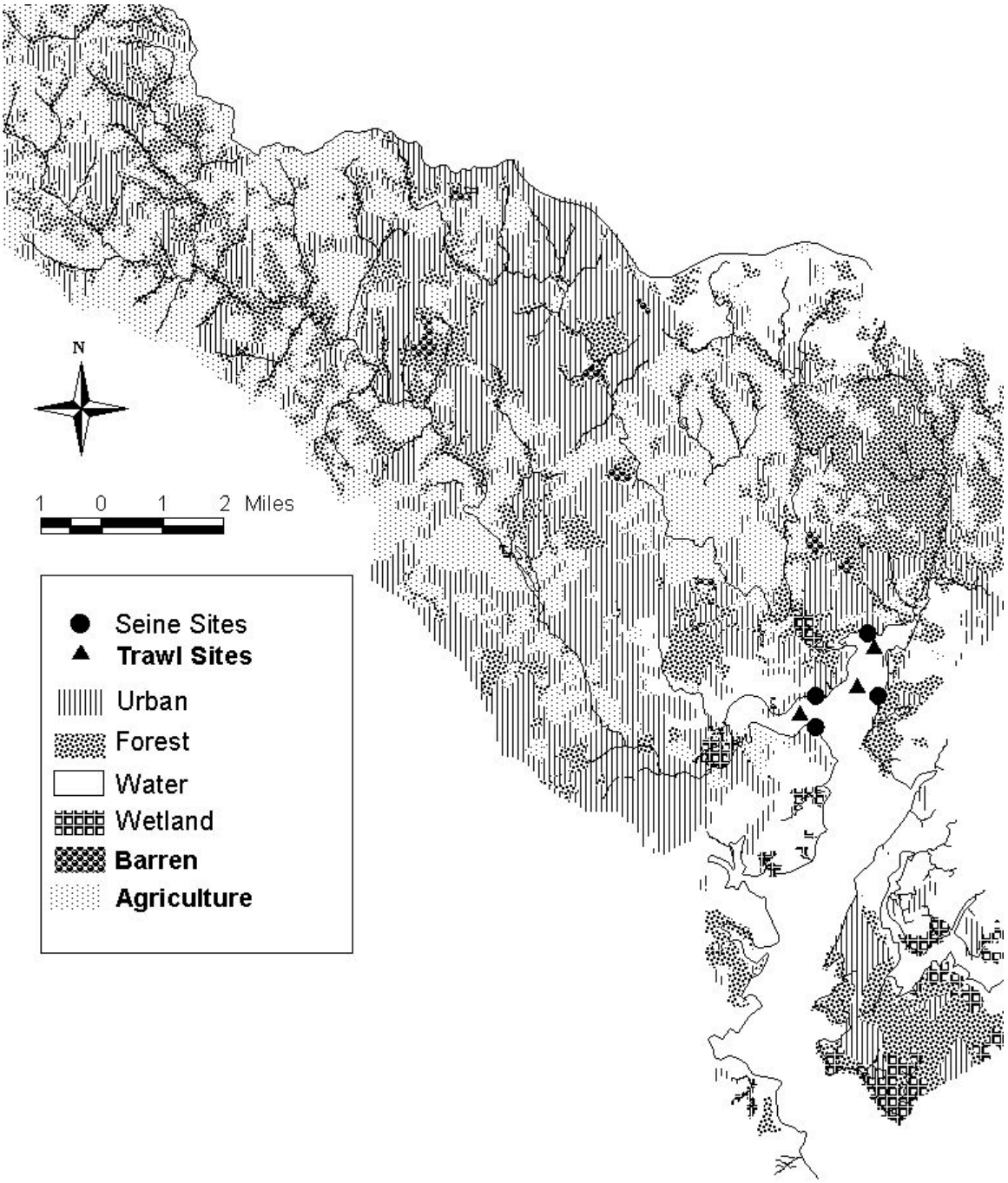


Figure 4. Catch per seine or trawl (bars) for juvenile alewife herring from the Bush River volunteer datasets and from the upper Chesapeake Bay striped bass seine survey (SBSS; (Source http://www.dnr.state.md.us/fisheries/juvindex/index.html), 2005-2008

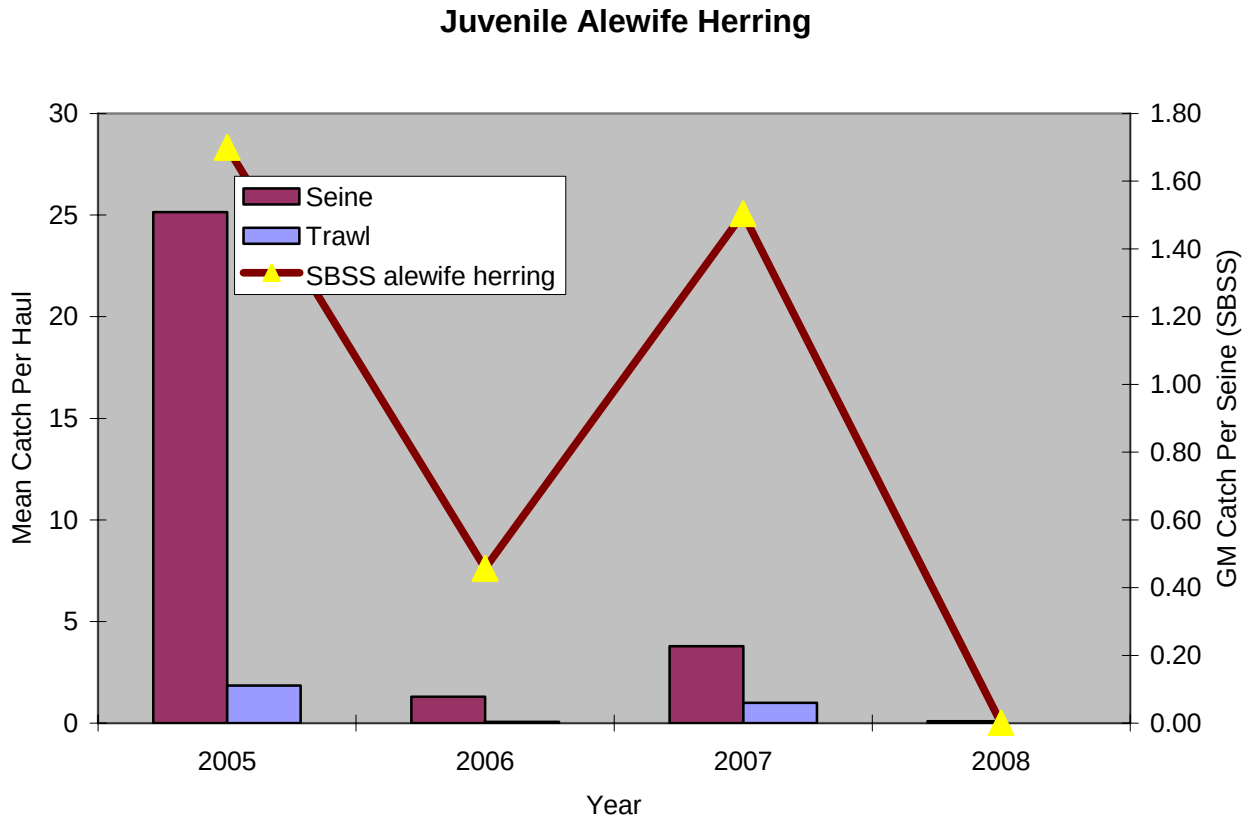


Figure 5. Catch per seine or trawl (bars) for juvenile blueback herring from the Bush River volunteer datasets and from the upper Chesapeake Bay striped bass seine survey (SBSS; (Source http://www.dnr.state.md.us/fisheries/juvindex/index.html), 2005-2008

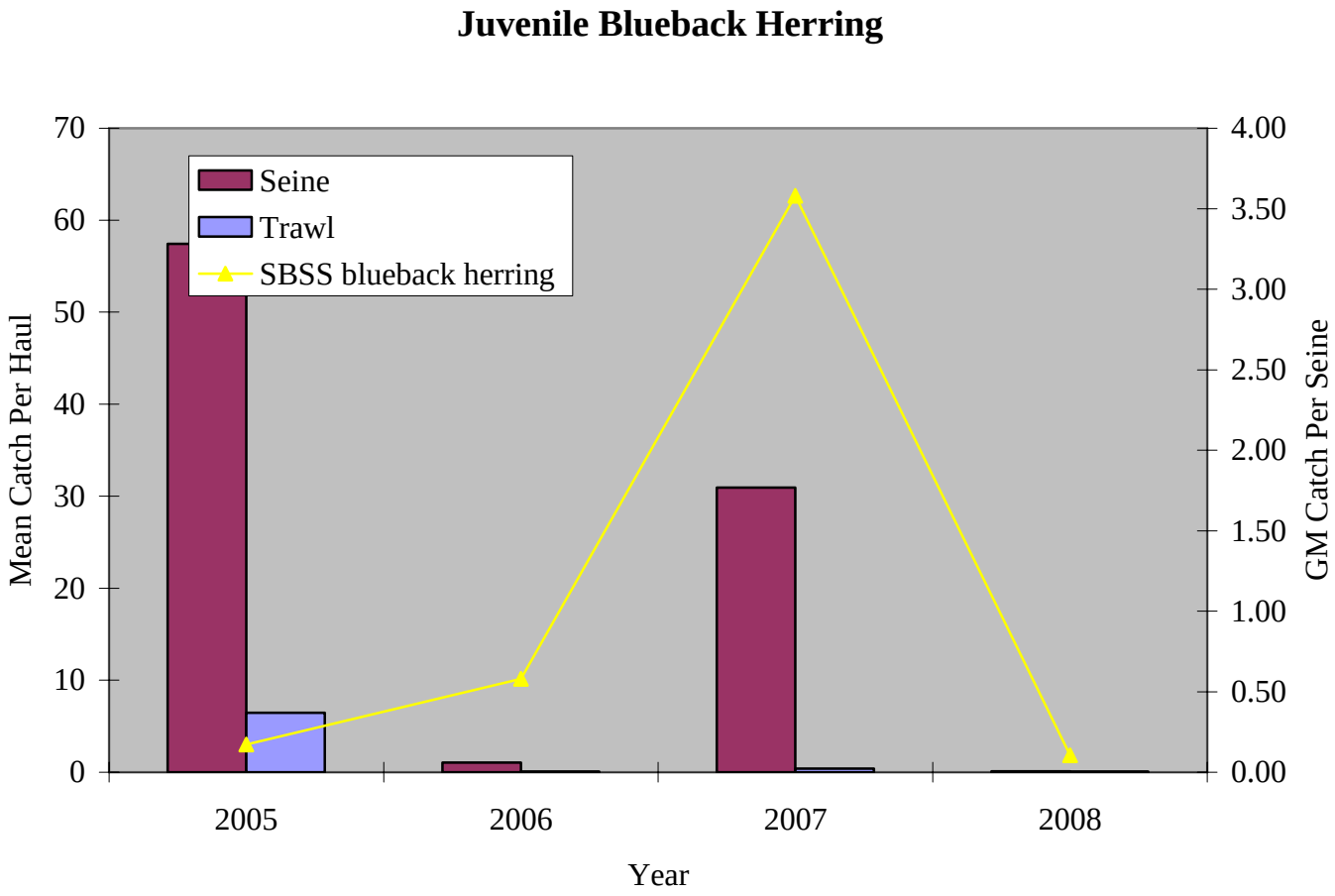


Figure 6. Catch per seine or trawl (bars) for Atlantic menhaden from the Bush River volunteer datasets and from the upper Chesapeake Bay striped bass seine survey (SBSS; (Source http://www.dnr.state.md.us/fisheries/juvindex/index.html), 2005-2008

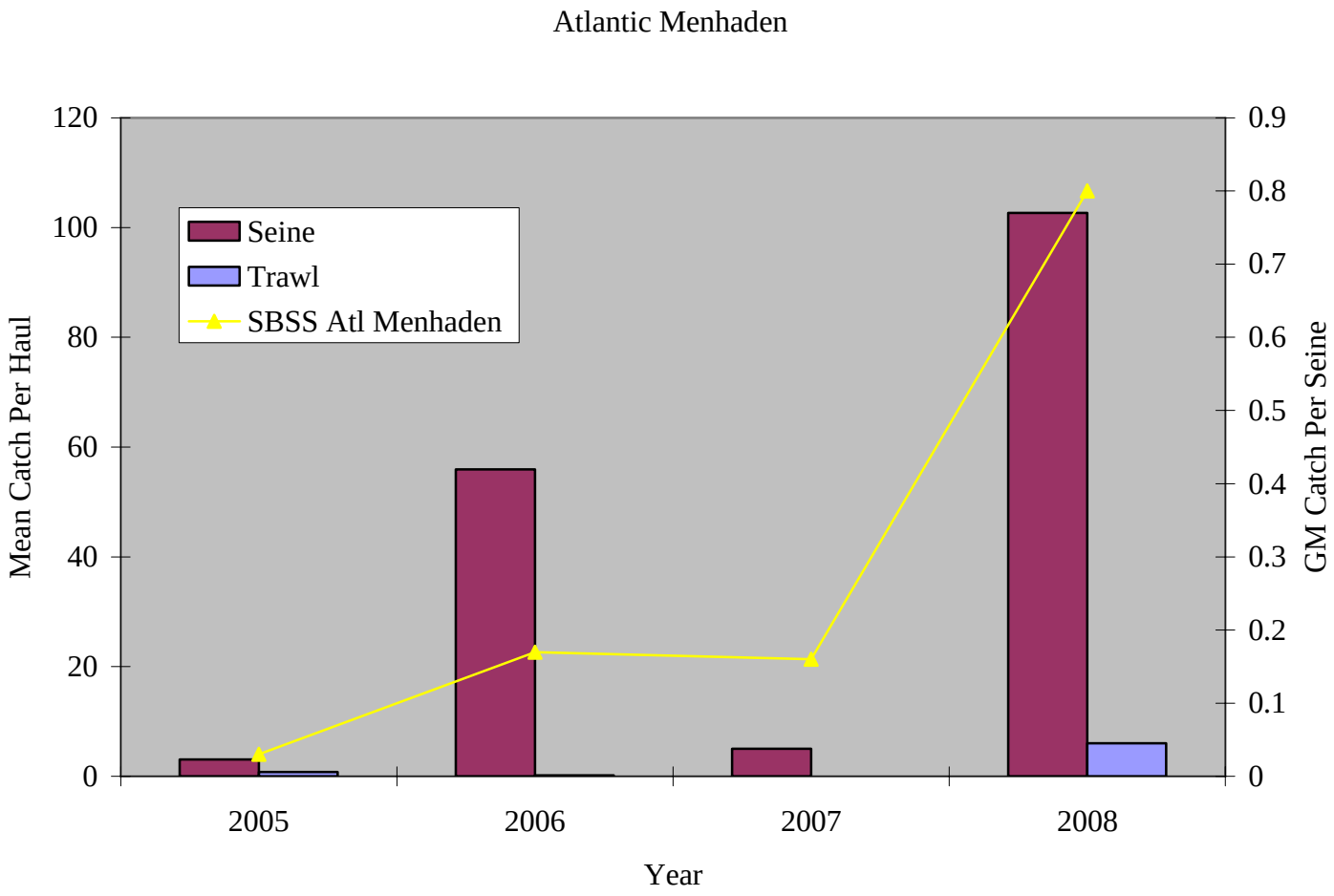


Figure 7. Catch per seine or trawl (bars) for juvenile yellow perch from the Bush River volunteer datasets and from the upper Chesapeake Bay striped bass seine survey (SBSS; (Source http://www.dnr.state.md.us/fisheries/juvindex/index.html), 2005-2008

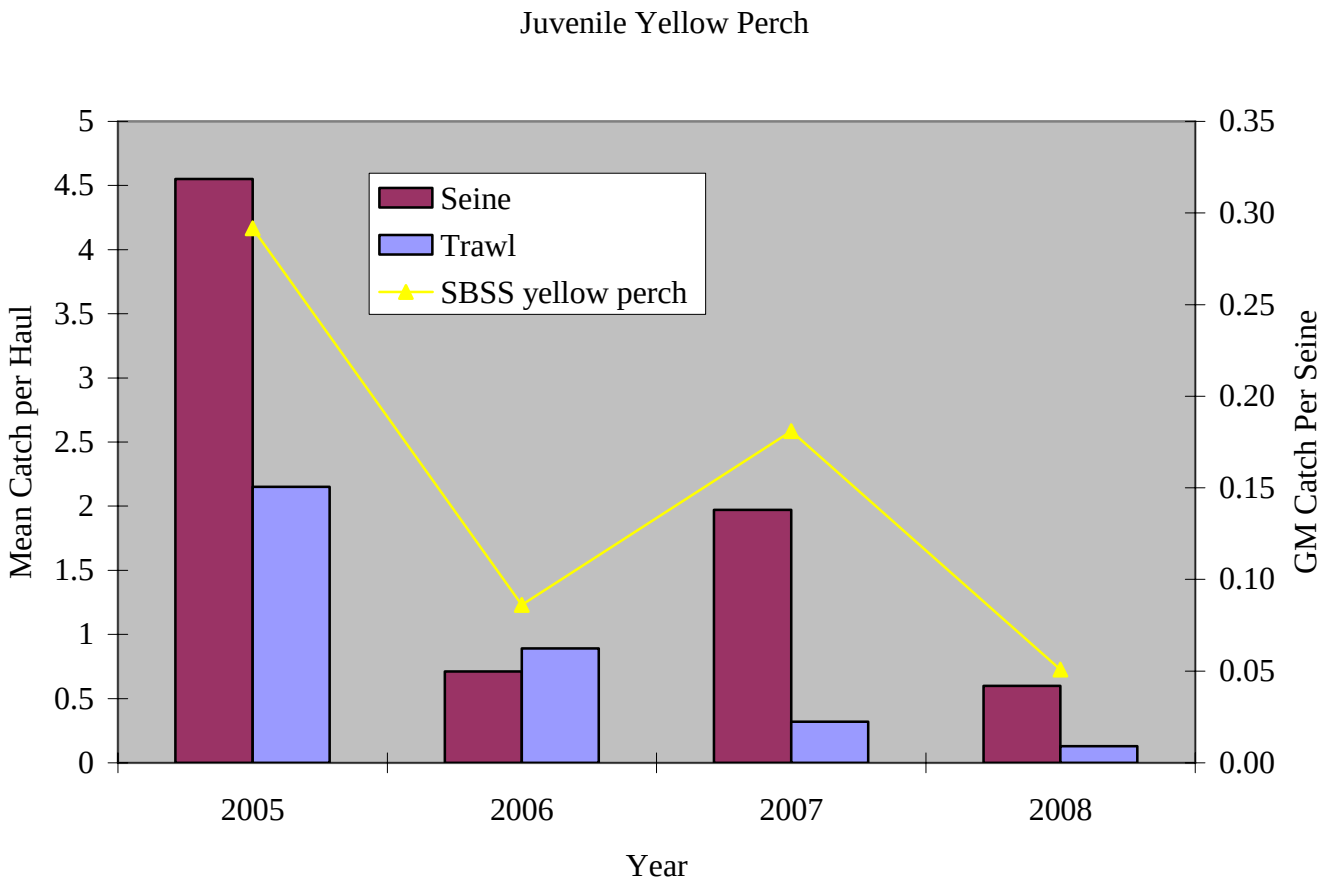


Figure 8. Catch per seine or trawl (bars) for adult yellow perch from the Bush River volunteer datasets, 2005-2008.

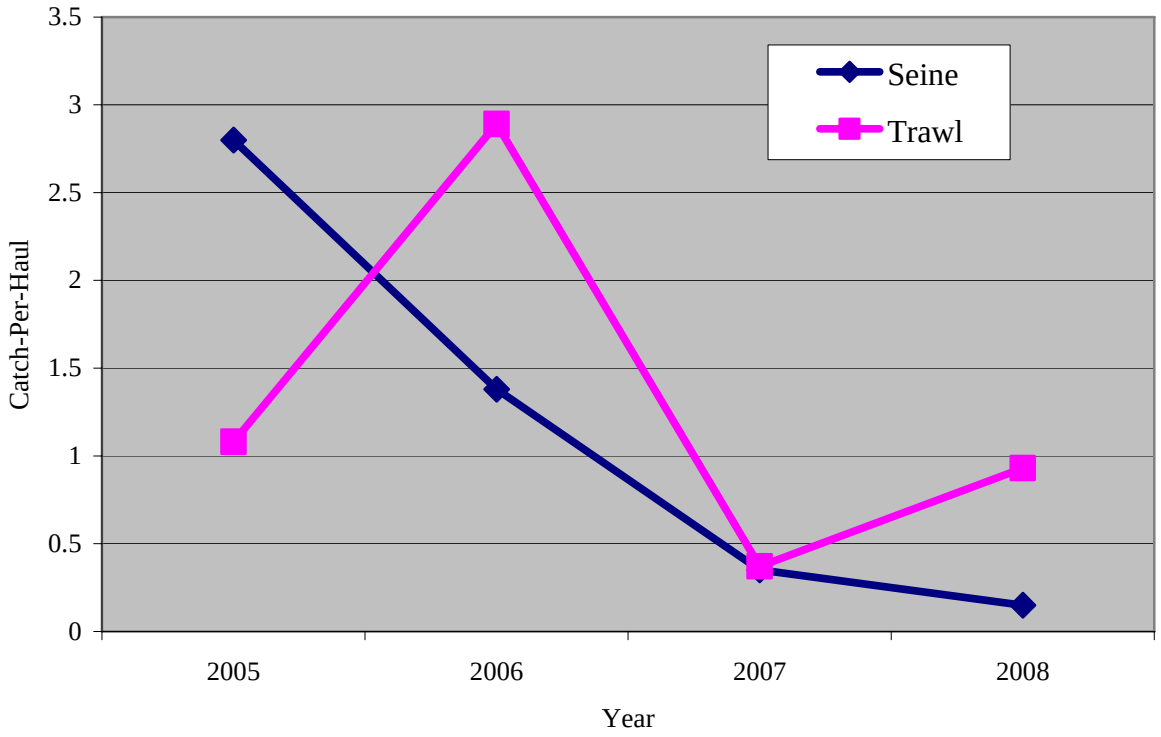


Figure 9. Catch per seine or trawl (bars) for juvenile white perch adults from the Bush River volunteer datasets and from the upper Chesapeake Bay striped bass seine survey (SBSS; (Source http://www.dnr.state.md.us/fisheries/juvindex/index.html), 2005-2008

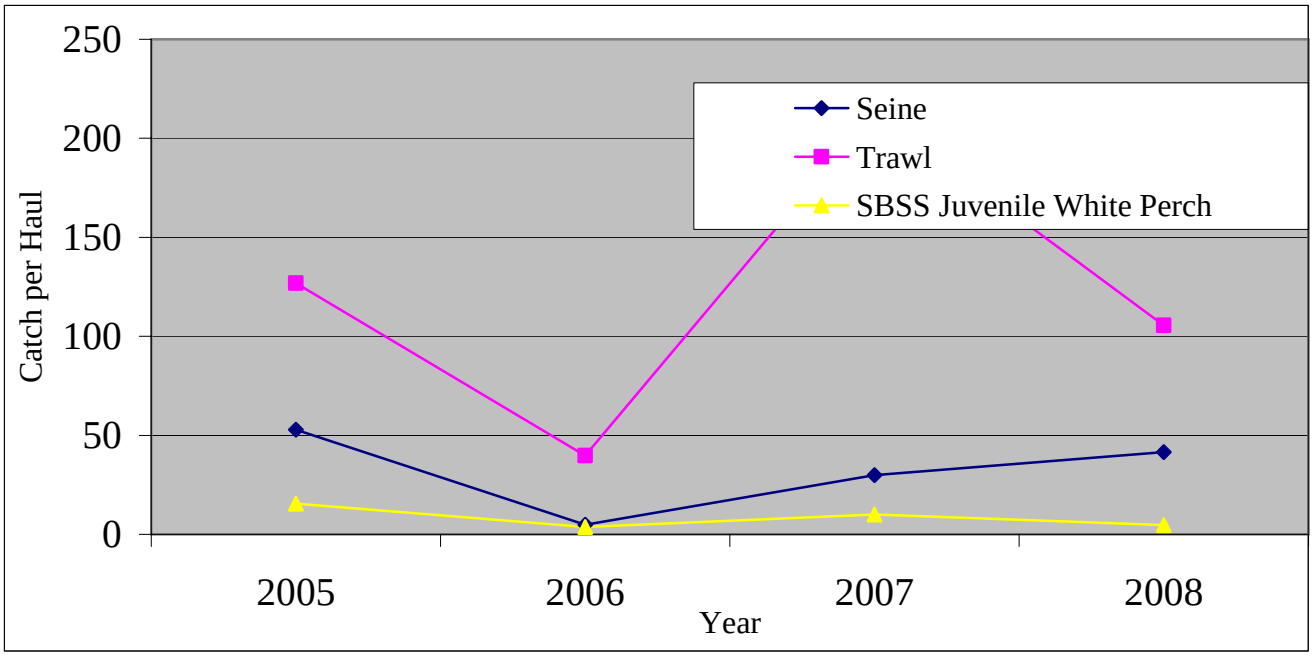


Figure 10. Catch per seine or trawl for gizzard shad from the Bush River volunteer datasets, 2005-2008

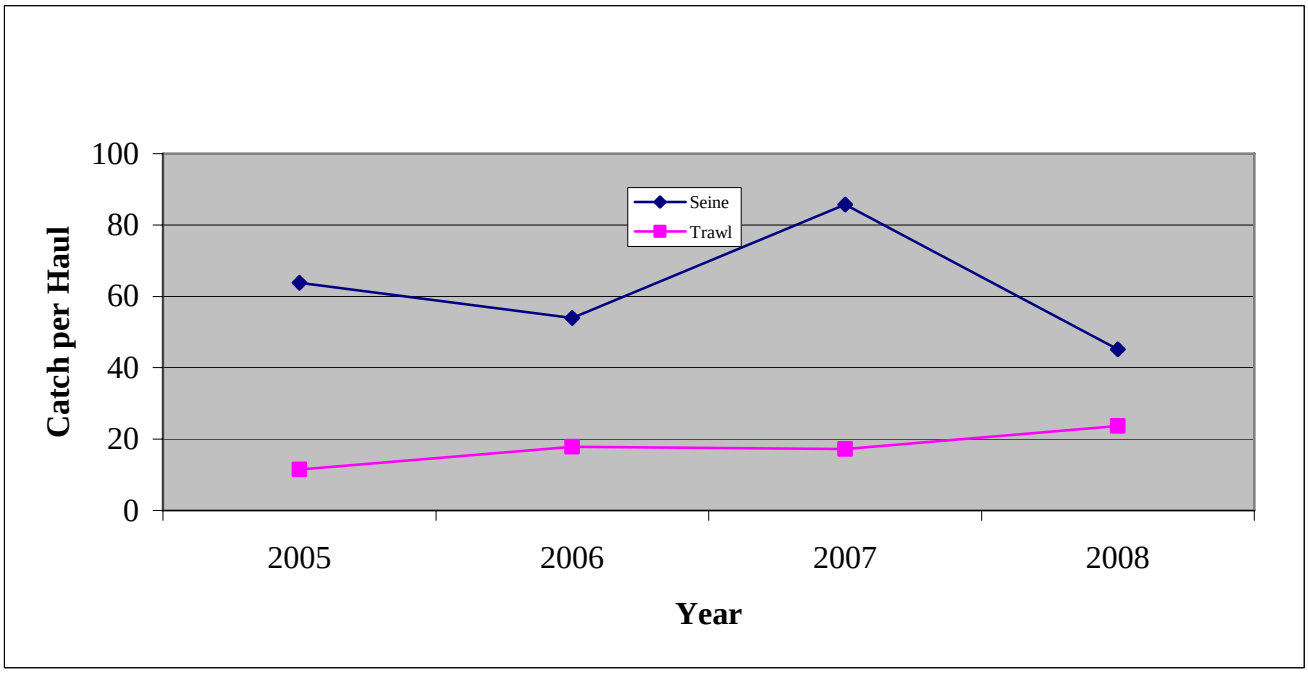


Figure 11. Catch per seine for inland silversides and spottail shiners from the Bush River volunteer datasets, 2005-2008.

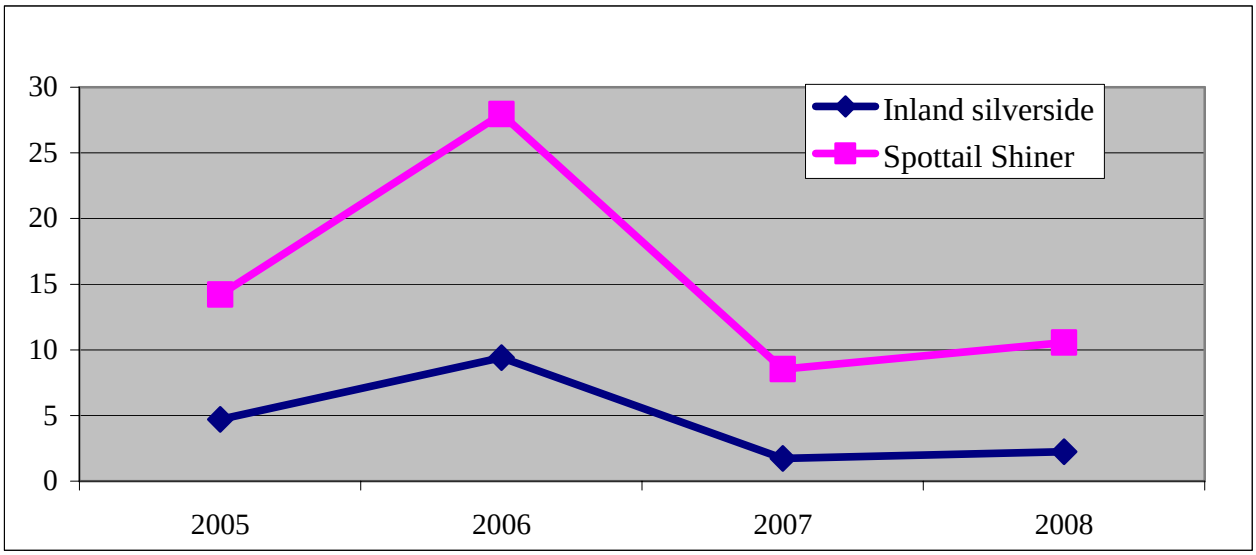


Figure 12. Catch per seine or trawl (bars) for alewife herring from the Bush River volunteer data set, 2005-2008 and from the Maryland DNR Fisheries Service Habitat Project's seine survey (M. McGinty MD DNR, personal communication), 2006-2008.

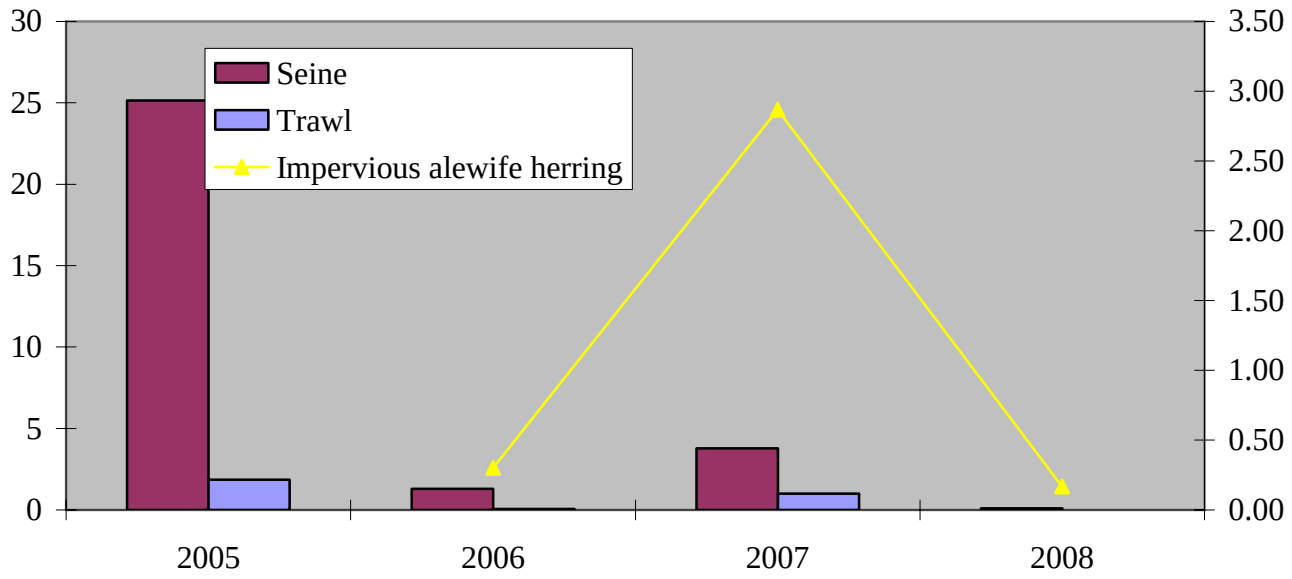


Figure 13. Catch per seine or trawl (bars) for juvenile blueback herring from the Bush River volunteer data set, 2005-2008 and from the Maryland DNR Fisheries Service Habitat Project's seine and trawl survey (M. McGinty MD DNR, personal communication), 2006-2008.

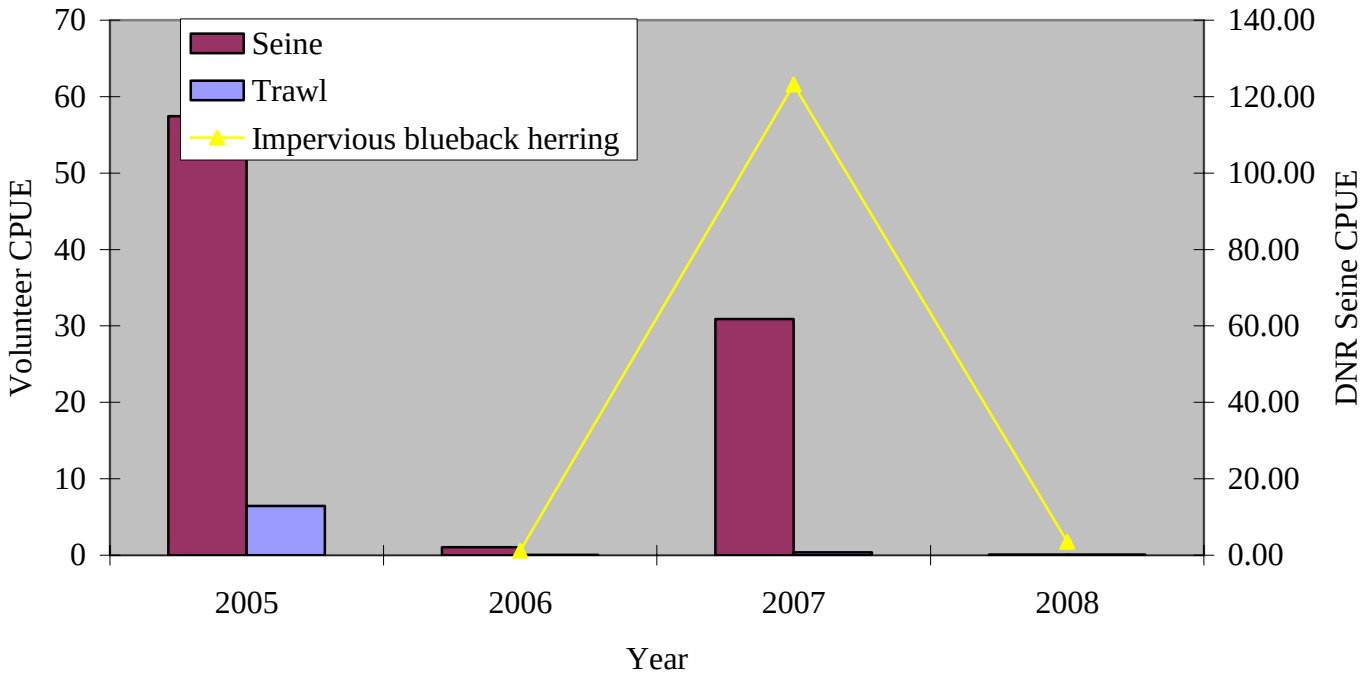


Figure 14. MD DNR's Upper Chesapeake Bay juvenile alewife and blueback herring geometric mean CPUEs, 1959-2008. (Source http://www.dnr.state.md.us/fisheries/juvindex/index.html)

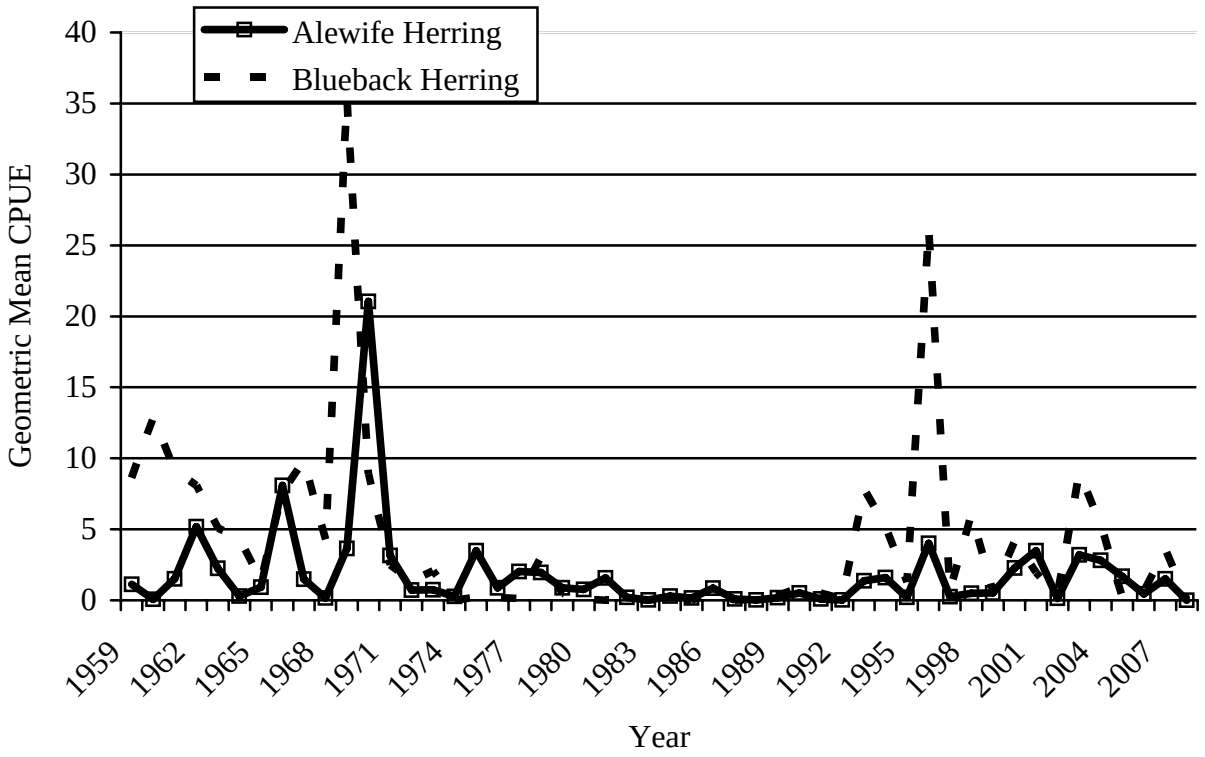


Figure 15. Catch per seine or trawl (bars) for Atlantic menhaden from the Bush River volunteer data set, 2005-2008 and from the Maryland DNR Fisheries Service Habitat Project's seine and trawl survey (M. McGinty MD DNR, personal communication), 2006-2008.

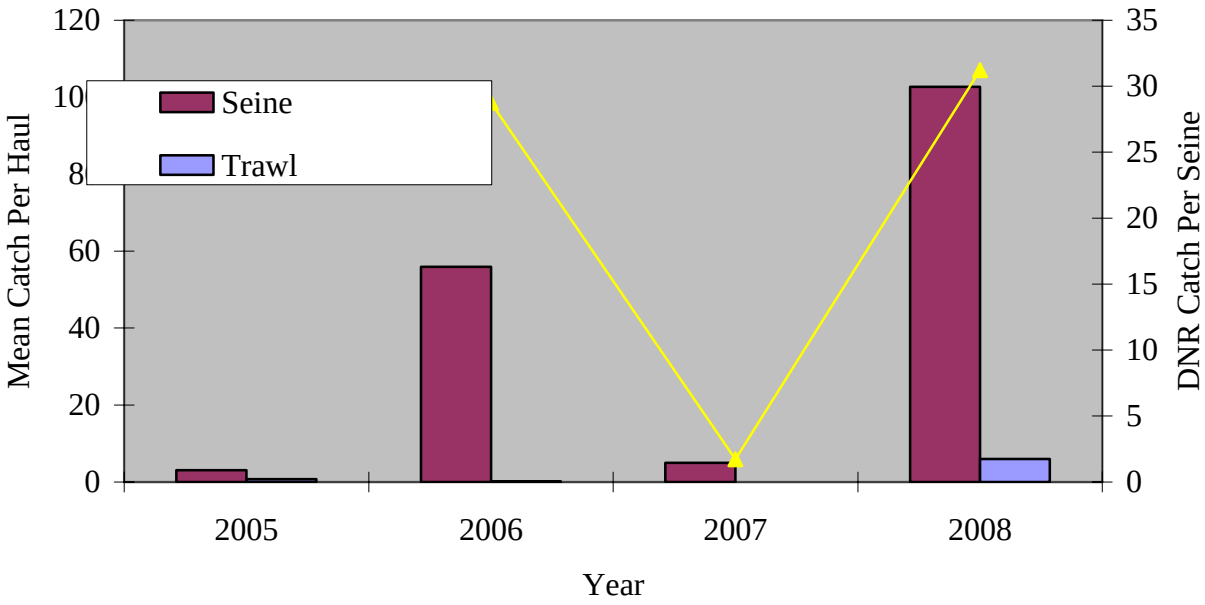


Figure 16. Upper Chesapeake Bay Atlantic menhaden and juvenile white perch geometric mean CPUEs, 1959-2008. (Source: http://www.dnr.state.md.us/fisheries/juvindex/index.html)

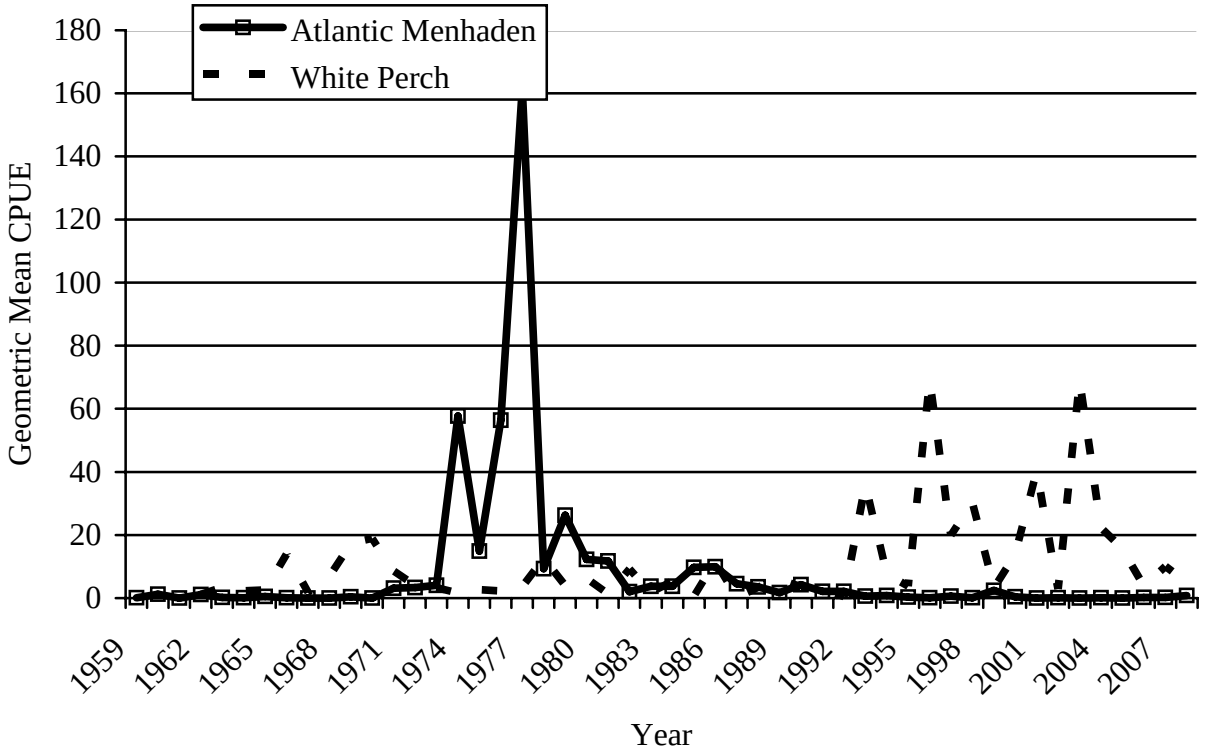


Figure 17. Catch per seine for juvenile yellow perch from the Bush River, 2005-2008 compared to the Maryland DNR Fisheries Service Habitat Project's seine and trawl survey (M. McGinty MD DNR, personal communication), 2006-2008.

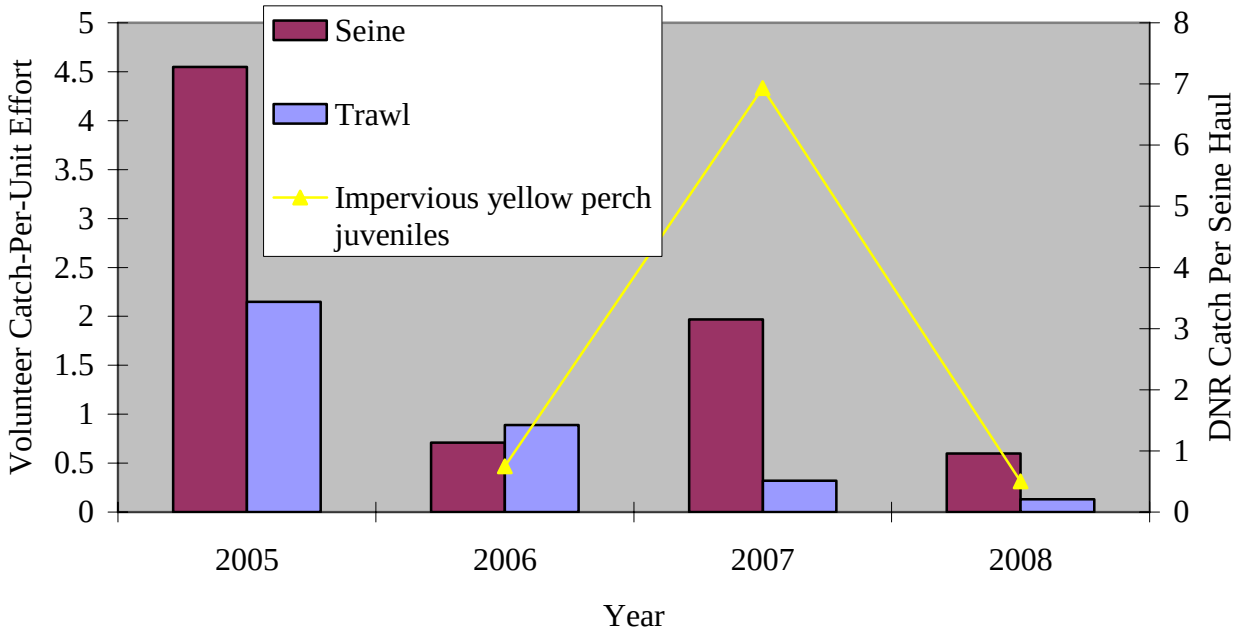


Figure 18. Catch per seine or trawl (bars) for juvenile white perch from the Bush River volunteer data set, 2005-2008 and from the Maryland DNR Fisheries Service Habitat Project's seine and trawl survey (M. McGinty MD DNR, personal communication), 2006-2008.

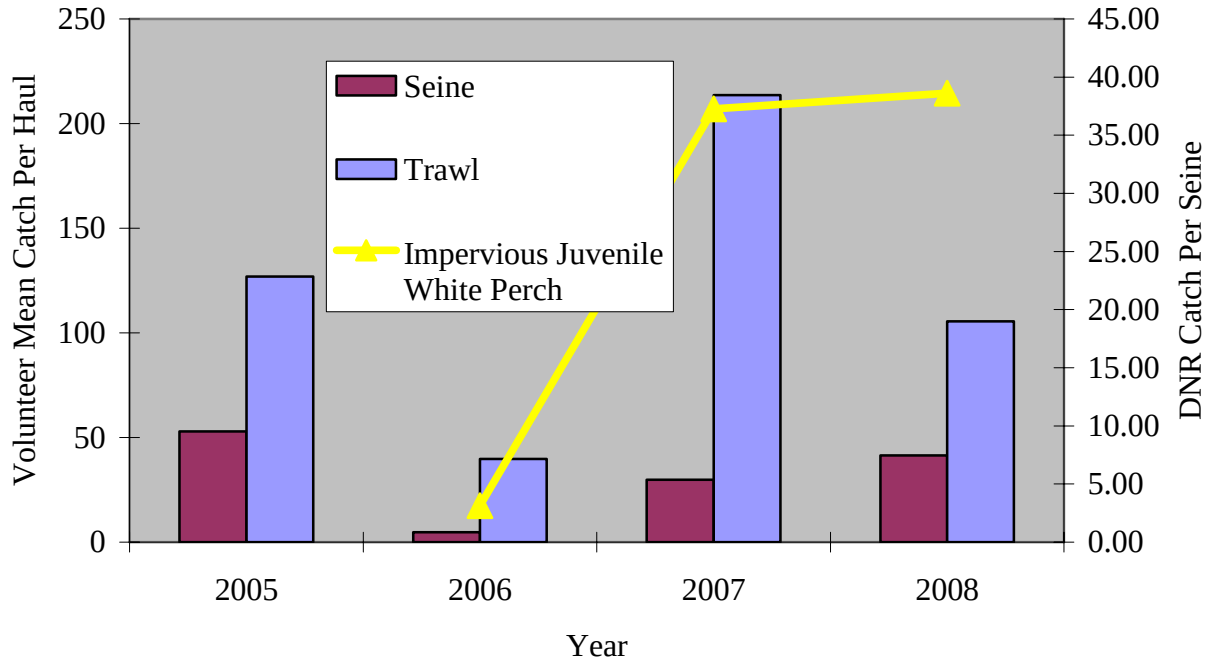


Figure 19. Catch per seine for two prey species from the Bush River volunteer data set, 2005-2008 compared to the Maryland DNR Fisheries Service Habitat Project's seine and trawl survey (M. McGinty MD DNR, personal communication), 2006-2008.

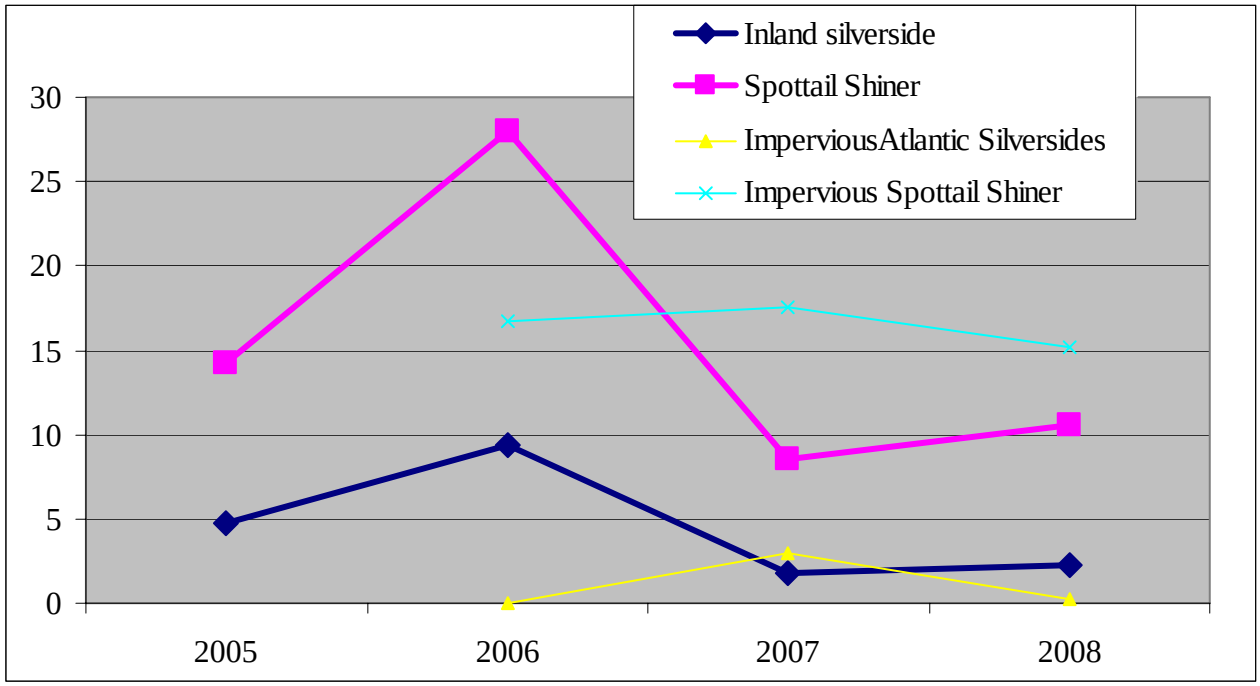
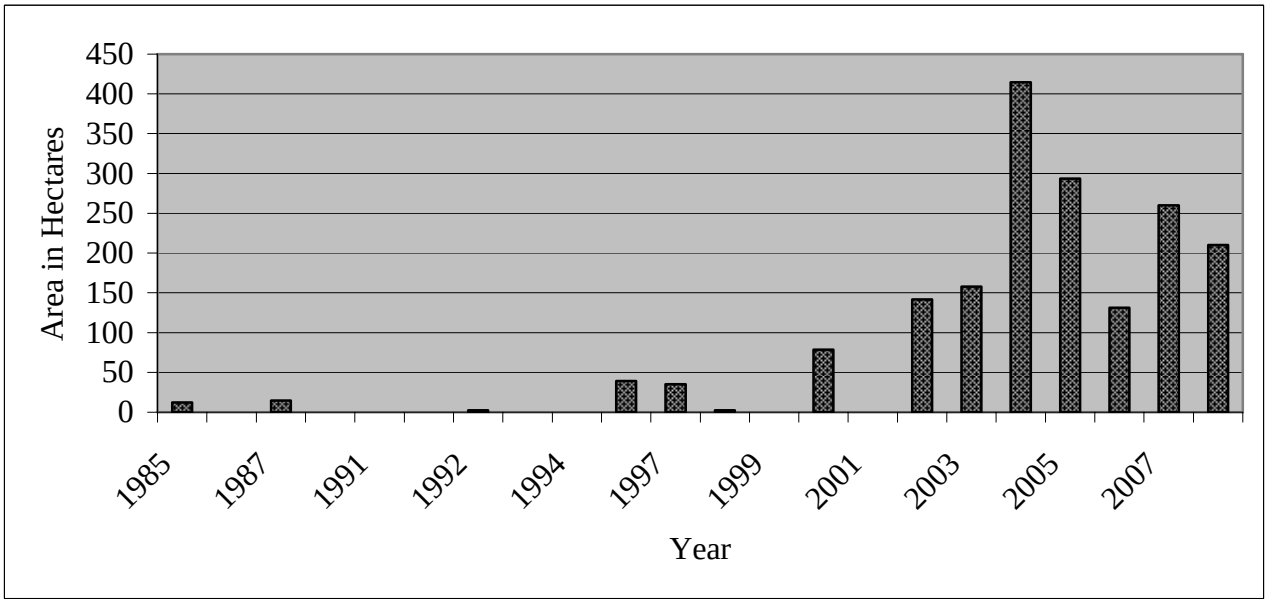


Figure 20. Submerged Aquatic Vegetation (SAV) in hectares within the Bush River watershed.



Appendix A Seining Sites

BUS[1]S01 Given Name: Beta Shoe Factory
GPS coordinates: N 39d27'55.9" W 076d14'05.7" Elevation: 11m

Driving Directions:
1. Turn **Left** out of Leight Parking lot onto **Otter pt. road**
2. Make **first Right** onto **Rt. 40 East** at the street light
3. Travel 1.9 miles
4. Turn **Right** onto **Bata Blvd**
5. You will drive through gates to get to the condos
6. In between the finished and the construction site you will find a gravel path[2]
7. Follow that gravel path to a wooden plank/boardwalk
8. The seine site is right in front of an overturned little white boat

BUSS[3]02 Given Name: Park Beach Drive
GPS coordinates: N 39d27'02.6" W 076d13'56.7" Elevation: -12m

Driving Directions:
1.Turn **Left** out of Leight Parking lot onto **Otter pt. road**
2.Make **first Right** onto **rt. 40East** at the street light Travel 3.6 miles
3.. Turn **Right** at **spesutia Road** travel 0.7miles
4.. **Bear Right** onto **Perryman Road** travel less than 0.1miles
5. Turn **Right** onto **Perryman Road** aka rt. 159
6. Travel 2.1 miles Turn **Right** onto **Forest Green Road**
7. Make **slight Left** to stay on **Forest Green Road**
8. Forest Green Road dead ends at Park Beach Dr.
9. The house a little to the Right is Mr. Roz house.
10. Park in the right side of the garage
11. Walk around the house towards a nice size tree and walk down stairs to the dock
12. Jump down on the Left side of the dock and walk about 20 paces to the seine site.

BUSS03 Given Name: Baker Avenue
GPS coordinates: N 39d27'01.9" W 076d15'21.2" Elevation: -3m

Driving Directions:
1.Turn **Left** out of Leight Parking lot onto **Otter pt. road**
2.Make **first Right** onto **rt. 40East** at the street light
3. Travel 0.5 miles Turn **Right** onto **Long Bar Harbor Rd.**
4. Travel 0.1 mile turn **Right** onto **Washington Ave.**
5. Washington Ave dead ends on Baker Ave.
6. Turn **Left** onto **Baker Ave** go all the way down
7. Park vehicle in the little parking area next to the drive way
8. To the right rear of the vehicle there is a path between bushes
9. Follow that path around the side of the house
10. Seine site is to the right of the large bush on the beach

BUSS04 Given Name: Flying Point Park
GPS coordinates: N 39d26'34.6" W 076d15'24.3" Elevation: 9m

Driving Directions:
1. Turn **Left** out of Leight Parking lot onto **Otter Pt. Road**.
2. Turn **LEFT** onto **rt. 40West** at the street light
3. Travel 2.5 miles Turn **Left** onto **Edgewood Road**
4. Travel 1.2 miles Turn **Left** onto **Willoughby Beach Rd**.
5. Travel 2.6 miles Turn **Left** onto **Flying Point Road**
6. Turn **Left** at the end of the road into the park.
7. Park vehicle in the space provided by the building.
8. Walk towards to beach to where it is not blocked off by rocks
9. Seine site is in front of the bench

[1] BUS=river system
[2] Italics indicates walking directions
[3] S- indicates Seine T indicates trawl