ANNUAL (2013) PERFORMANCE REPORT

SURVEY AND MANAGEMENT OF MARYLAND'S FISHERY RESOURCES

Maryland Department of Natural Resources
Fisheries Service
Inland Fisheries Division
Tawes State Office Building B-2
580 Taylor Avenue
Annapolis, Maryland 21401

U.S. Fish & Wildlife Service
Federal Aid Grant: F-48-R-23

This grant was supported by funds from the Federal Aid in Fish Restoration Acts
(Dingell-Johnson & Wallop-Breaux)
and the State of Maryland Fisheries Management and Protection Fund

Compiled by
Susan Rivers, Planning Project Manager

Approved by
Don Cosden, Director, Inland Fisheries

TABLE OF CONTENTS

Fisheries Information Resources A1
Technical Guidance and Environmental Review
Creel Surveys
Database Management
Supplemental Information

Freshwater Impoundments B1
Survey and Inventory
Monitor Trends in Fish Populations

Coldwater Streams C1
Survey and Inventory of Fish Species and Habitat

Major Rivers and Streams D1
Monitor Trends in Fish Population Dynamics

Tidal Freshwater Rivers E1
Adult Population Assessment
Juvenile Recruitment Surveys
Hatchery Contribution
Population Genetics Assessment
Tournament Creel Surveys

Literature Cited F1

ANNUAL PERFORMANCE REPORT
2013

Maryland Department of Natural Resources
Fisheries Service
Inland Fisheries Division

SURVEY AND MANAGEMENT OF FRESHWATER FISHERIES RESOURCES

USFWS Federal Aid Grant F-48-R-23

Study I

Management of Fisheries Information Resources

By:

Brett Coakley
Don Cosden
Letha Grimes
Charles Gougeon
Mary Groves
Todd Heerd
Alan Klotz
Joseph Love
John Mullican
Susan Rivers
Mark Staley
Mark Toms
Ross Williams

Table of Contents
Management of Fisheries Information Resources

Job 1: Technical Guidance and Environmental Review A3

Job 2: Creel Surveys A25

Job 3: Database Management A31

Additional information on regulations for 2014 .... A35

State: Maryland

Project Number: F-48-R-23
Study No.: I
Job No.: 1

Project Title: Survey and Management of Freshwater Fisheries Resources

Study Title: Management of Fisheries Information Resources

Job Title: Technical Guidance and Environmental Review

Introduction

The objectives of this job are to conduct environmental reviews and provide technical guidance for any projects that may impact fish populations and their habitat.

Methods

The Inland Fisheries Division is involved both directly and indirectly with technical guidance and environmental review activities. Staff gathers information and then provides comment and guidance to regulating agencies, technical committees, advisory boards, private industry and the general public an activities that can include waterway construction, timbering, stormwater management, road construction, mining, water discharges, , and environmental catastrophe mitigation.

Within the Department of Natural Resources (DNR), Inland Fisheries personnel provide input and guidance to members of the DNR Integrated Policy and Review Unit (IPR), (former Environmental Review Unit (ERU)) on construction and waterway activities that require permitting by DNR or the Department of the Environment. Inland Fisheries has an Environmental Review Coordinator (ERC) who provides guidance to the IPR through permit and project review. Resource managers in the field assist the ERC when needed. Staff reviews each project, checks historical data on the area in question, and conducts site visits as needed to determine potential impacts on fish populations and other living things in their associated habitats. Work on projects can include site visits that can include on-site sampling of fish populations and the surrounding ecosystem. Monitoring studies are developed for key projects to show the condition of a fishery before, during and after a project. This information not only helps with a current project but will also provide information on similar projects in the future. If required, staff uses this information to develop a Fisheries position statement. In cases where no relevant data have been collected, staff members conduct a literature search of similar projects to develop a best course of action statement. If a project cannot be avoided, mitigation alternatives are developed to minimize the impact and replace the impacted resource.

Reviews and guidance are provided to other groups including: Bureau of Mines on mine drainage issues and mine development; Army Corps of Engineers on water discharges from dams and waterway blockage or realignment; State Highway Administration on road construction, bridges and stormwater management; and local jurisdictions for sediment and erosion control around construction projects.

Mining projects and activities are governed by MDE/Bureau of Mines (BOM). BOM has maintained a near autonomous role managing mining activities. Recently, the expansion of the IPR staff has allowed DNR and Fisheries Service to become more involved with mining permit review. The ERC and the Regional Fishery Manager play crucial roles in evaluating mine permit applications.

Fisheries staff provides direction and input into the planning and construction process of road and highway projects when requested by the IPR. Many of the projects are site-specific and unique and each presents a wide range of issues to address. Many road projects span extended periods of time and require close monitoring and frequent consultation with staff. Smaller, short-term projects may require less time but must still be monitored to prevent major impacts on local waters. Staff works closely with highway engineers and consultants to provide input concerning roadway and stream restoration design. Standards established by MDE for stream classifications are used to protect fish, associated aquatic species, and water quality during construction projects. They also prohibit construction during critical life stages to prevent loss of fish.

Concerns over the extraction of natural gas from Marcellus Shale formations in western Maryland continued in 2013. Executive Order 01.01.2011.11 established the Marcellus Shale Safe Drilling Initiative in 2011. The Advisory Commission established by Fisheries Service continued to assist State policymakers and regulators to determine whether gas production from gas extraction from Marcellus Shale can be accomplished without the risks of adverse impacts on the aquatic community. The continuing task of MDE, DNR and the Marcellus Shale Advisory group is to conduct a three-part study and to report findings and recommendations. The studies appointed tasks will cover:

- findings and related recommendations regarding sources of revenue and standards of liability for damages caused by gas exploration and production
- recommendations for best management practices (BMPs) for all aspects of natural gas exploration and production in the Marcellus Shale in Maryland
- findings and recommendations regarding the potential impact of Marcellus Shale drilling in Maryland

Fisheries and volunteer groups initiated baseline sampling of streams targeted as potential Marcellus Shale drilling sites.

Results and Discussion

The following section describes the environmental review and technical guidance activities conducted by staff in 2013. A summary of all environmental review and technical guidance activities for the year is found in Table 1. Reporting this year shows activities combined for each category since staff cooperated across units for many reviews. Also, the Environmental Review Coordinator assigned reviews and worked with field staff to evaluate projects.

2013 Environmental Review Activities

Land acquisition

Sawmill Branch, Baltimore County
Central Region Staff considered to properties for state acquisition in Baltimore County. One would enhance protection of the brook trout population in the Sawmill Branch watershed. The second would protect an important coldwater tributary to the S. Branch Patapsco.

Unicorn Branch, Queen Anne's County
Fisheries provided comments on the potential acquisition of a small 1-acre property located on Unicorn Branch directly downstream of the Unicorn Lake and Fish Hatchery. Acquisition of the property will protect it from development, and will expand fishing opportunities for anglers who fish in Unicorn Branch. Unicorn Branch itself contains important spawning habitat for many tidal fish species.

Savage River Watershed, Garrett County
West Region I provided comments to the Land Stewardship Committee regarding potential state acquisition of land within the Savage River Watershed. The purchase of this property is consistent with Maryland Department of Natural Resources' ***2006 Brook Trout Fisheries Management Plan*** strategies designed to conserve and protect critical brook trout habitat in this watershed. The main goal of the plan is to *"restore and maintain healthy brook trout populations in Maryland's freshwater streams and provide long-term social and economic benefits from a recreational fishery."* To achieve this goal, Maryland Department of Natural Resources set forth objectives pertaining to increasing public ownership of lands bordering streams supporting brook trout populations, with emphasis in the Savage River Watershed. By increasing public land ownership within this popular Brook trout stream drainage basin, the stream buffer zone is protected from further development impacts.

Timber sales and harvest

Chesapeake/Pocomoke Work Plan
Eastern Region participated in the annual Chesapeake/Pocomoke State Forest Annual Work Plan Meeting. They conducted site visits to proposed work areas when more information was needed. None of the proposed activities were predicted to negatively impact fisheries resources or water quality.

Green Ridge State Forest, Allegany County
West I provided comments to the Green Ridge State Forest Manager regarding a proposed a salvage harvest on Oldtown Orleans Rd to utilize dead timber before further value was lost. All water resources (1^{st} order streams) will be protected by the no-cut 50' foot buffer zone and avoiding several springs in the harvest area.

Forests, Garrett County
Inland Fisheries Biologists attended the annual work plans field reviews for the Savage River, Potomac-Garrett, and Green Ridge State Forests. The no-cut stream buffers protect the water resources on several of the timber harvest proposals. One proposal was within the buffer zone of Elk Lick, a tributary to the upper Savage River. County Roads officials wanted to remove the dead and dying trees surrounding the stream, but Fisheries asked that they drop the trees into the stream to provide large woody debris in-stream habitat.

Invasive species

Northern Snakehead
Fisheries staff continues to deal with Northern Snakehead (*Channa argus*). Central Region staff assisted Maryland National Capital Parks and Planning Commission to remove snakehead from Northwest Branch in Montgomery County. Other regional staff across the state dealt with reported snakehead sightings. Fortunately, other reports were fish species other than the Northern Snakehead. To date, the species has been established in the tidal Potomac River and some of its tributaries, and has been found in some isolated locations in Eastern Shore waters.

Hydrilla
Fisheries staff provided equipment, potential collection sites and assistance with collection to the United States Geological Survey (USGS) with their genetics study of *Hydrilla.* As the plant species expands to other waters across the State, staff continues to cooperate with other agencies to attempt to control *Hydrilla*.

Didymosphenia geminata
Western Region I staff performed wader wash station maintenance along the Savage River, North Branch Potomac River, Casselman River, and Youghiogheny River locations. A dense bloom of *Didymosphenia geminata* (didymo) occurred in the North Branch Potomac River downstream of Jennings Randolph Lake. Western Region staff collected benthic macroinvertebrate samples from the North Branch Potomac River from the tailrace area downstream to the lower Catch-and-Return Trout Fishing Area to document any effect didymo may be having on the benthic community.

Nontidal wetlands alteration

Potomac River, National Airport
West II Regional Staff participated in several meetings regarding the expansion of National Airport in Washington, D.C. The expansion would have some impacts on the nontidal Potomac and several mitigation projects were discussed to lessen the impacts on Smallmouth Bass and Channel Catfish in that portion of the river.

Stream Restoration - Little Antietam Creek, Washington County
A stream restoration project on Little Antietam Creek in Washington County had the potential to impact native trout species in the watershed. West II Staff reviewed the

proposals and time-of-year restrictions in order to protect the trout during spawning and shortly after the hatched fry emerged from redds.

Whitings Neck Project, Potomac River
West II Staff provided comments on pier construction near Whitings Neck on the upper Potomac to minimize impacts on Smallmouth Bass populations.

Culler Lake Restoration, Frederick County
The City of Frederick is planning to restore Culler Lake. West II Staff provided input on plans and gave recommendations to provide enhanced habitat and improved water quality for fish species in the lake.

Stream and Habitat Restoration

Piney Run Tailwater Restoration, Carroll County
There was a combine effort between Carroll County Government, Trout Unlimited, and MD DNR to develop a stream restoration plan for the Piney Run Tailwater area. The features of the plan include the following:

- Stream restoration of over 6 miles of a severely degraded stream channel
- Removal of 2 fish migration blockages (6-foot dam and 2-foot incased utility crossing)
- Reforestation of the floodplain (stream presently does not have a forested buffer)
- Possible additional reforestation of uplands areas
- Plugging of agricultural ditches and wetland creations
- Possible cold water release from upstream reservoir
- Establishment of bike and walking trails along stream
- Funding by Chesapeake and Coastal Bays Trust Fund
- Restoration design by staff of U.S. Fish and Wildlife Service
- Total cost estimated to be between 6 and 8 million dollars

Staff presented a poster on this restoration at the Maryland Water Monitoring Council meeting in December.

Savage River Restoration Project, Garrett County
Staff participated in the Savage River Watershed Association meeting to discuss the Savage River Restoration Project on a privately owned property (Garrett County). A stream design engineer with the Canaan Valley Institute prepared the project proposal. The property suffered severe bank erosion, loss of riparian zone trees, and emergency road repairs due to recent flood events. The plan will improve in-stream fish habitat, restore the original flood plain, reduce the width of the river, and bio-engineer the stream banks for stability. Work is scheduled to begin this spring, and Fisheries Service has committed to pre- and post-project biological monitoring as part of the project agreement.

Impoundment Habitat, Queen Anne's and Cecil Counties
Eastern Region Staff received over 1000 pounds of recycled Christmas Trees from Kent County Waste Management Division. The recycled trees were attached concrete blocks to sink them, and then were deployed into public freshwater fishing areas on the Eastern

Shore to provide additional fish habitat. This annual program is a great example of how State and Local agencies can work together to the benefit of fish and fishermen. This year, fish habitat structures were placed in Wye Mills Lake and Unicorn Lake (Queen Anne's County), and Stemmers Run Reservoir (Cecil County).

Perryville Reservoir Restoration Project, Cecil County
Eastern Regional Staff provided comments to the Town of Perryville on the partial drawdown of Perryville Reservoir, a now unused 2-acre impoundment located adjacent to Mill Creek in Cecil County. Although not currently classified as "Use III: Nontidal Cold Water Aquatic Life Waters" Mill Creek contains a reproducing population of Brown Trout. Built over 60 years ago, Perryville Reservoir was designed to pull water out of Mill Creek, as well as runoff from its own watershed to keep it filled. Excess leakage at the water control structure and erosion of the berm that separates it from Mill Creek was causing concern for town officials. Options for the partially drained, unused impoundment are being discussed. Comments stressed that future plans will focus on retention of accumulated sediments and a reduction of potential thermal pollution from the impounded, warmer water during the summer months to protect Mill Creek.

Susquehanna River Habitat Improvement
Eastern Regional Staff reviewed proposed habitat improvement projects for the Susquehanna River below Conowingo Reservoir. The projects focused on improving downstream habitat for American Shad and Shortnose Sturgeon reproduction. These projects are part of the ongoing re-licensing agreement for the reservoir. Comments were restricted to the feasibility of completing and maintaining the projects in the long term. Additionally, these projects could arouse dissention among the dedicated anglers who fish that section of river.

Private Property Improvements - Washington and Frederick Counties
West II Staff provided technical guidance to private landowners regarding instream woody debris and trout habitat. They emphasized that some instream debris is necessary as long as it doesn't present a safety hazard.

Reservoirs/water allocation

Patuxent River Tailwater, Howard and Montgomery Counties
Central Region Staff attended meetings regarding the Patuxent Tailwater section downstream of Brighton Dam Howard and Montgomery Co. They discussed potential coldwater release strategies, developed a draft Memorandum of Understanding between MD DNR and Washington Suburban Sanitary Commission (WSSC), and exchanged multiple phone calls and e-mails with Trout Unlimited, WSSC, and DNR staff. The tailwater area is being managed as a Catch-and-Return Trout Fishing area.

Piney Run Reservoir, Carroll County
Central Region Staff worked with Trout Unlimited, Carroll County government, other MD DNR agencies and MDE regarding a potential coldwater release from Piney Run Reservoir in Carroll County. The area downstream of the reservoir has provided a

seasonal, recreational trout fishery in the past, but a coldwater release would allow a year-round fishery and more stable trout populations.

Gunpowder Falls, Baltimore County
Central Region Staff worked with Baltimore City Watershed staff to regulate water flows and temperatures in the Gunpowder Falls tailwater trout fishery below Prettyboy Reservoir in Baltimore County. The river maintains a healthy Brown Trout population supported by cold temperatures and year round low levels. Releases from the reservoir also appear to be exerting a control on an outbreak of didymo first found in the river in 2008.

Koontz Run, Allegany County
Fisheries staff provided comments to the Environmental Review Unit regarding a dam removal and a water appropriations permit on Koontz Run, a tributary to Georges Creek in Allegany County. The water appropriation permit is for municipal water supply for the Town of Lonaconing and is currently withdrawn from Koontz Reservoir. Koontz Run supports a naturally reproducing Brook Trout population (514 brook trout per mile) and other coldwater fish species including Blacknose Dace and Blue Ridge Sculpin upstream of the impoundment. The dam and reservoir will be removed and replaced with an in-stream inlet to a water storage tank. The dam removal should eliminate thermal issues in the stream until riparian shade is restored. The construction of a series of step pools through the former reservoir site will allow fish passage and the expansion of the Brook Trout population. The water appropriation permit should provide adequate flow protection downstream of the inlet during the critical summer months. Inland Fisheries will conduct fish population monitoring prior to and after the dam removal/stream habitat improvement projects have been completed.

Rocky Gap Lake, Allegany County
West II staff provided comments on potential impacts of the expansion of Rocky Gap Lodge in Allegany County. Impacts on water quality could negatively impact fish populations in Rocky Gap Lake.

Road, highway, Bridge and Pipeline projects

Bridge Replacement - Big Hunting Creek, Catoctin Mountain Park, Frederick County
A National Park Service bridge replacement project on a tributary to Big Hunting Creek (Frederick County) attracted the attention of West II Staff. The existing bridge on Distillery Run provided a barrier that separated a Brook Trout population from Brown Trout incursion from Big Hunting Creek. Staff recommended that the stream barrier be maintained to protect the Brook Trout resource.

Camp Spring Run, Washington County
West II Staff placed time of year restrictions on a bridge replacement on Camp Spring Run (Washington County) to protect its wild Brown Trout population.

Bear Creek Road Project, Garrett County
West I Staff provided wild trout information to the Environmental Review Unit regarding road culvert replacements in Bear Creek tributary streams in Garrett County. Both wild Brook Trout and Brown Trout are found at the seven culvert replacement sites, so staff recommended time of year restrictions as well as Best Management Practices (BMP's) for sediment control.

Fishing Creek Road Project, Frederick County
West II Staff consulted with Frederick County Roads and Office of Sustainability to recommend road/ford improvements at Delauter Rd and Fishing Creek to protect Brook Trout habitat.

Comprehensive plans

Ten Mile Creek Watershed Comprehensive Plan, Montgomery County
The Comprehensive Plan for the Ten Mile Creek watershed in Montgomery County includes major development and land disturbance in the area. Central Region Staff provided data on fish species and stream quality. This watershed drains into Little Seneca Lake and excessive sedimentation could have a negative impact on bass and sunfish populations in the lake.

Super Storm Sandy Clean-up Plan on Youghiogheny River, Garrett County
West I Regional Staff provided comments to the Deep Creek Lake Natural Resource Management Area group regarding their emergency response plan for removal of fallen trees (from Super Storm Sandy) from the whitewater section of the Youghiogheny River. This section of river is a Class V rapids section for whitewater rafting and kayaks. The fallen trees and limbs in this section presented additional hazards to paddlers. Staff recommended that trees still firmly attached to the bank in flat water or low hazard areas should be left in place to minimize stream bank damage and erosion. The hazard removal volunteers will be instructed that this large woody debris should remain to provide excellent habitat for both fish and aquatic macroinvertebrates.

Wildlands Plan Review, Garrett and Allegany Counties
West I Staff prepared comments regarding 14 proposed Wildlands designations within the Green Ridge, Potomac-Garrett, and Savage River State Forests, and the Youghiogheny River Natural Resource Management Area in Garrett and Allegany Counties. Fisheries Service generally supports Wildland designations to provide long-term watershed protection. Staff provided comments on issues that could impact fishery management activities, water quality improvement projects, and the economic importance of the fisheries.

Deep Creek Lake Watershed Management Plan, Garrett County
A multi-jurisdictional group is working on a management plan for Deep Creek Lake in Garrett County. The group includes Maryland Departments of Natural Resources (MDDNR) and the Environment (MDE), fishing groups, recreational groups, and local stakeholders. Staff prepared the fisheries resource section of the *Deep Creek Lake*

Watershed Management Plan. This report will also include sections land use, geology, hydrology, lake and stream water quality, forest resources, wetlands, rare species, and storm water management. It will provide guidance and recommendations to the Deep Creek Lake Watershed Steering Committee to ensure the future well-being of the lake.

ORV Trail Plans, Washington County
Staff reviewed plans for ORV trails for Sideling Hill and Woodmont in Washington County. These trails can contribute significant sediment and erosion to local streams, so Fisheries comments addressed these concerns to protect local fish populations.

Abandoned Mine Land Projects

Savage River, Garrett County
West I Staff provided comments to the Savage River State Forest ID Team regarding potential deep mining application under the state forest. Concerns included mineral rights, potential hydrologic and water quality affects, pre- and post-monitoring, and concerns of setting a precedent of allowing deep mining under public land.

Jennings Run, Allegany County
West I Staff provided comments to the Environmental Review Unit regarding a strip mine permit application in the Jennings Run Watershed (Allegany County). The applicant is adding 5 acres to their existing 70-acre permit. There was no plan for a new sediment control pond, so the applicant planned to use existing structures. There are Brook Trout populations throughout the Jennings Watershed so the strict enforcement of BMP's and water quality monitoring of site run-off should be done by the MDE Bureau of Mines (BOM) inspectors.

Land Reclamation Projects - Garrett and Allegany Counties
West I Staff participated in the MDE Lands Reclamation Committee's monthly meetings. The committee discussed the option of allowing sediment control ponds to remain on reclaimed strip mines after the final restoration efforts in order to provide more diverse wildlife habitat on these sites. Attendees developed a list of criteria which includes that these ponds would be very shallow and would not influence the thermal regime of the nearest stream. By allowing shallow ponds to remain, this would provide habitat for amphibians, waterfowl, and other wetland dependant wildlife. Through the year, field site visits occurred to determine whether each reclamation passed or failed the revegetation standard. Staff participated in field reviews of 18 strip mine reclamation projects in Garrett and Allegany Counties (total of 314 acres) for the Phase II bond release. They evaluated herbaceous cover, erosion sites, permanent legumes, tree survival, and necessary repairs on each of these sites.

Large Woody Debris Removal Review

Large Woody Debris Review - Cecil, Montgomery and Baltimore Counties
Central Region Staff reviewed large woody debris (LWD) removal proposals for Susquehanna State Park, Seneca State Park, and Gunpowder State Park. Staff carefully considered each proposed removal. LWD can provide habitat and food sources for fish

and other aquatic species. Removal was favored when public safety and safe passage of recreational watercraft were issues.

Handicapped Accessible Trail Project

Patuxent River Handicapped Access – Howard and Montgomery Counties

Central Region Staff reviewed proposed handicapped access on the Patuxent River Tailwater Fly Fishing Area (Howard/Montgomery Co.). Plans are under way to make the area accessible to handicapped fly anglers. An accessible trail and fishing platform are being incorporated into the trail design.

Hazardous waste spills

Laurel Run, Garrett County

West I Staff investigated a fertilizer/hydrated lime spill into Laurel Run, a naturally reproducing Brook Trout tributary stream to the Youghiogheny River. Hydrated lime causes dramatic pH increases that can cause a fish kill. About ½ mile of the stream was walked downstream of the spill site and no dead fish were observed. The stream flow was higher than normal during the event which may have had a dilution effect on the lime.

Time of year in-stream construction waivers

Staff conducted reviews of numerous projects across the state that required time of year waivers for in-stream construction. They provided comments to the Environmental Review Unit. Some of the projects were reviewed by each local Soil Conservation District as well, and these projects were required to meet Best Management Practices for each. The Department of Natural Resources does not object to MDE granting the requested waiver of the restriction period for projects as long as every attempt is made to complete each project as quickly as possible to minimize impact.

Wastewater Treatment Plant Discharge

Wastewater Treatment Plant Discharges, Washington and Frederick Counties

West II staff reviewed applications for wastewater treatment plants for areas in Washington and Frederick Counties. The Greenbrier Lake (Washington County) plant discharges into native Brown Trout waters. The Frederick permit involved a discharge into the Carroll Creek watershed, where the stream is managed for a Youth and Blind Fishing area.

2013 Technical Guidance Activities

Pond assessment

Bloomfield Park Pond, Queen Anne's County

Eastern Regional Staff planned seining surveys of Bloomfield Park Pond. Bloomfield Park Pond was experiencing an intense blue-green algal bloom with an appearance that was characteristic of the species *Microcystis*. Planned fish sampling was postponed, and MDE was contacted to collect and analyze water samples since *Microcystis* and related species can have significant human and animal health impacts. Their preliminary tests suggested high counts of several potential toxic species, and *Microcystin* toxin levels were above acceptable limits. They suggested water contact advisories to be posted by Queen Anne's County Health Department at the pond.

Sassafras Natural Resource Management

Eastern Regional Staff completed a seining survey of Sassafras Natural Resource Management Area (NRMA) Pond. Surveys in 2011 suggested a shortage of Largemouth Bass with no reproduction and an overabundant forage base. As a result, the pond was stocked with advanced fingerling Largemouth Bass that fall. It appears that the stocking was successful; many YOY bass were collected in the 2013 survey and forage species were less abundant.

Southgate Pond, Ocean Pines

Eastern Region provided the Ocean Pines Community Association and Public Works Department with the results of a fish survey completed in their largest impoundment. The "South Gate" pond experienced an extensive fish kill in 2011 due to low dissolved oxygen, and fishermen have reported poor success since then. Overall, very few adult fish of any species were collected, but young Largemouth Bass and Bluegill Sunfish were quite abundant. Fishermen will simply need to be patient as they grow to larger sizes. Fishing should be excellent in just 1-2 years. Recommendations were made suggesting they increase the amount of physical habitat within the pond, and reduce nutrient runoff within the watershed.

Handicapped Pier, Blair's Valley Lake – Washington County

West II staff provided recommendations for a handicap accessible fishing pier at Blair's Valley Lake in Washington County.

Water Quality

Basin Run, Cecil County

Eastern Region Staff completed an investigation into a complaint of excess sediment runoff from an active construction site into a tributary of Basin Run, a Use III watershed. Given the topography, existing sediment control measures were inadequate to handle sediment movement during intense rainfall events. Staff attended a follow-up meeting at a local planned development in Cecil County to inspect new work completed by the developer to reduce sediment movement and transport within and from the site. Several new super-silt fences had been installed along with dozens of staked straw bales and installation of more curlex erosion control blankets. An electrofishing survey to document fish species present in the impacted adjacent tributary to Basin Run was completed. No trout were collected during the survey. Temperature recording loggers were deployed in the stream above and below the site to monitor any thermal pollution from the site and the effluent from its huge stormwater management pond.

Hunting Creek Gauging Station, Frederick County

West II Staff consulted on flow weir and WQ monitoring options for the Hunting Creek gauging station for Cunningham Falls State Park. The Park is required to maintain water temperature, flow and quality below Cunningham Falls Lake to support Brook, Brown and Rainbow Trout that reside below the dam.

Potomac River Watershed USGS Contaminant Survey
West II worked with USGS on a contaminant study in the Potomac River watershed. They cooperated with USGS and Penn State for sediment and POCIS sampler studies in the Potomac. Staff collected Smallmouth Bass from the Monocacy River and the Potomac to study tissue contaminants. Staff made collections of Smallmouth Bass and Golden Redhorse from the Potomac River near Cumberland for a USGS algal toxin study.

Groundwater Withdrawals

Wells in Savage River Watershed, Garrett County
West I staff provided comments to the Savage River State Forest (SRSF) ID Team regarding water monitoring wells. Maryland Geological Service (MGS) will be drilling a pair of observation wells located in SRSF near where Mt. Aetna Rd crosses the Savage River. These wells will be near a USGS stream gage that will be installed at the same site on the Savage River. Once the wells are finished, MGS will be measuring water levels in the wells on an ongoing basis. In conjunction with the stream-gage data, this information will help us better understand the relations between surface and ground water. Fisheries Service supports this proposal to obtain baseline data on the groundwater resources in the Savage River watershed

Population Assessment

EPA Large River Assessment, Potomac River
West I provided access and sampling assistance to the Watershed Assessment Service in conducting survey for EPA Large River Assessment on the Potomac River at Williamsport.

Environmental Review Coordinator Activities

2013 Environmental Review Coordinator Activities

Issue: **Reservoir and water allocation permits, review and management.**

Inland Fisheries Concern: Finite supplies of water present fish managers and water supply managers with unique and very specific challenges. Growing competition for a limited supply of water and specific objectives of water supply managers often result in situations that prevent all or some from attaining their intended objectives. Water allocation must be meticulously coordinated to insure that it meets and conforms to all of water delivery objectives while attempting to meet the recreational needs of individual user groups.

Wild trout managers require adequate water supplies in order to support minimum flow requirements and sufficient cold water reserves for temperature management of sensitive trout species. In addition, trade offs over the protection of fish species in the impoundments and those in the tailwaters below the dams often make striking a balance among all users a difficult and continual process.

Actions Taken: Fisheries Service staff communicated and engaged water supply managers and regulators from MDE to work out solutions to enable all water users to achieve their water needs and conform to the laws of the State. Fisheries Service continued input through the DNR Integrated Policy and Review Unit (IPR), (former Environmental Review Unit (ERU)). Additional IPR comments were handled by an internal review process for State Lands by all DNR units to help guide the protection of potentially affected natural resources and users. In 2013 Fisheries Service provided review input on the following water supply activities:

1.) Deep Creek Lake - concerning water allocations for hydroelectric operations; water temperature maintenance, monitoring, analysis and flow manipulation to support trout management and releases for white water boating events in the Youghiogheny River; seasonal pool level management in Deep Creek Lake to address the recreational needs of lakeside property owners/boaters
2.) Active communication with the Army Corps of Engineers (ACOE) regarding water supply, desired discharge volumes, minimum flow, and maintenance of reservoir pool elevation, time of year water temperature control and water quality management for the Savage River Reservoir and tailwater, Jennings Randolph Reservoir and the North Branch Potomac River tailwater
3.) Ongoing exchange and communication with Brighton Dam water supply managers, Trout Unlimited and hydroelectric power providers on the Patuxent River regarding water temperature monitoring, water supply, power generation and trout management concerns below the dam.
4.) Provided comments and construction design input on the construction of a water appropriation structure and new permit for Koontz Run (Alleghany County).

Outcome/Expected Result: Staff continued to monitor trout populations and water temperatures in the Youghiogheny River below the tailrace of the Deep Creek Lake hydroelectric station. Data were shared with water managers and MDE in order to assess and monitor the success of all water release guidelines and permit conditions. Staff used these data to adapt, protect and enhance fish habitat through continued participation in the water appropriation permit review and approval process. The data were used to re-evaluate/develop permit revisions and to monitor a constantly changing formula of water supply, allocation and stakeholder interests.

Staff provided final review and project design input the permit for a new water appropriation system located on Koontz Run (Allegany County). The project will remove a small public water supply reservoir on Koontz Run that is impounded by an old and dilapidated dam. The reservoir has provided municipal water to the town of Lonaconing for many years and other local water systems. Reservoir water supply will be replaced with a stream diversion weir and equivalent underground storage tank capacity. Demolition and removal of the old dam and reservoir will eliminate warm surface water discharges into Koontz Run. The project will restore the stream channel following dam removal. Design plans will target riparian shade, fish passage and habitat restoration. The project will improve downstream water temperatures for brook trout and will reconnect the natural stream channel to restore free movement of Brook Trout and other resident fish species above and below the old dam site. Several key permit design conditions are included below:

1. Establish a minimum flow-by and water intake design at the weir that will minimize fish entrapment.
2. Add a pilot channel above and below the weir to provide fish passage.
3. Replace reservoir capacity with underground storage tanks to eliminate warm surface spillover from the old reservoir to restore and enhance critical brook trout habitat in Koontz Run.
4. Eliminate a barrier to fish movement.
5. Permit conditions that include Fisheries Service consultation and approval prior to initiation of the new water withdrawal. Fisheries Service added a permit condition that ensured that the reservoir not be drained prior to project completion and water testing of the storage tanks. Notice from the permit holder to Fisheries Service must also occur prior to reservoir draining and dam removal to ensure that seasonally adequate stream flow-by will result when the tank system is filled and the new water appropriation system is initialized.
6. Stream flow diversion into the large storage tanks will be monitored with permanent flow meters to record water appropriated from Koontz Run.
7. Three water wells on the site that formerly discharged into the reservoir will now be metered and will only be directed into the storage tanks.

Ongoing water temperature data collection, fish monitoring and analysis of variable test discharges from Jennings Randolph Lake (JRL) continued in order to model available trout habitat limitations and needs. Staff continued to cooperate with water managers to make the necessary assessments to meet these and other recreational stakeholder needs in JRL and in the North Branch Potomac River immediately downstream of the lake.

Fisheries managers continued trout management activities and monitoring in the tailwater of the Patuxent River below Brighton Dam to further assess and develop the trout fishery. Discussions continued between Fisheries Service, Trout Unlimited, water managers and hydroelectric power managers to investigate and improve existing cold water release solutions or options. The participating parties discovered a functional water release gate on the bottom of the reservoir that was formerly described as non-functional and welded shut. Further investigations conducted by the dam operators identified discharge limitations due to badly rusted intake grates at all water levels. Divers cleaned the intake grates in December 2013 using high pressure water guns. Now all gates are fully operational. The dam operators are planning to replace all of the intake grates sometime next year.

The Maryland Fisheries Service shared funding in 2013 to install and monitor a real time USGS gage to monitor flow and water temperature immediately below the Brighton Dam. Dam operators at WSSC also requested and paid for an additional backup temperature gage that was installed at the USGS gage weir. They required an instantaneous temperature and flow gage to interface directly with their dam operations center as a back up to the USGS gage. Otherwise, instant discharge and temperature information would not be available since USGS protocol must be verified which results in an information delay. These major improvements will greatly enhance the ability to regulate and monitor discharge temperature and flow in the tailwater using real time data. Improvements in the tailwater are expected to improve assuming there is adequate cold water supply in the reservoir and if reliable real time temperature monitoring is continually funded and successfully maintained.

Issue: Developing interest in Natural Gas extraction in Garrett County and in westernmost Allegany County, Maryland.

Technological advances in natural gas extraction from Marcellus Shale deposits located in neighboring states such as Ohio, West Virginia, Pennsylvania and New York have generated increased activity in those states. The potential use of horizontal drilling and hydraulic fracturing or “fracking” techniques in Western Maryland counties has raised significant environmental concerns from State government officials and Inland Fisheries staff. Several natural gas extraction permit applications have appeared on Maryland’s doorstep over the last several years. These initial permit requests were received when Maryland had no existing state policies or guidelines to govern this specific activity.

The State has not determined whether gas extraction activities can be accomplished without incurring adverse impacts on public health, safety, the environment, and natural resources. In response to those concerns, Executive Order 01.01.2011.11 established the "Marcellus Shale Safe Drilling Initiative". The order established an Advisory Commission to assist State policymakers and regulators in determining whether gas production from the Marcellus Shale in Maryland can be accomplished without the risks mentioned above.

The Executive Order directs the Maryland Department of the Environment (MDE) and the DNR, in consultation with the Advisory Commission, to conduct a three-part study and report findings and recommendations. The completed study will provide:

i. findings and related recommendations regarding sources of revenue and standards of liability for damages caused by gas exploration and production;
ii. recommendations for best practices for all aspects of natural gas exploration and production in the Marcellus Shale in Maryland; and
iii. findings and recommendations regarding the potential impact of Marcellus Shale drilling in Maryland.

Inland Fisheries Concern:
The fracking process uses millions of gallons of water per well. Very high water pressure makes the drill cut through the earth. Although portions of the wells are lined, there is a huge risk to underground aquifers that provide vital drinking water. Groundwater withdrawals for fracking present another concern. Studies have shown that baseflow in streams can be significantly reduced when appropriated groundwater is withdrawn and not released back into the watershed basin. In addition to wells, the major water resources are associated with water supply, wetlands, lakes, rivers, streams, spring seeps, vernal pools, and floodplains. These all support high quality, sensitive stream and aquatic habitats. Water withdrawals taken from local Maryland water sources, as well as the importation of water from surrounding states raise serious concerns about impacts upon living terrestrial and aquatic communities.

The potential for impaired ground water supply is high in this area. Waste water from the fracking process would be trucked off site to treatment plants for processing, or stored on-site in tanks or shallow holding ponds. The ponds pose serious maintenance issues and raise many more environmental concerns should the ponds overflow or leak. Some of the materials added to the water used in the fracking process are proprietary and not fully disclosed for evaluation. Additionally, the soil and rock cuttings generated during the well drilling process may contain some level of radioactivity.

The movement of hundreds of thousands of gallons of water and waste water into and out of each fracking site poses a number of other issues including: increased heavy truck activity; subsequent impacts upon local roadways due to significant increases in heavy truck use; increased noise; impacts from air pollution; potential for hazardous driving conditions to all drivers; and, increased risk of accidents involving trucks transporting contaminated water to treatment facilities.

Actions Taken: The first of the three-part study and Executive Order 01.01.2011.11 was completed regarding funding and liability in December 2011. A Memorandum of Understanding (MOU) between MDE and University of Maryland Center for Environmental Science – Appalachian Laboratory (UMCES-AL) was signed February 2012 to survey and recommend a set of best management practices (BMP). A draft report was presented to MDE and DNR in early September 2012. The final UMCES-Al report titled "Recommended Best Management Practices for Marcellus Shale Gas Development in Maryland" authored by Dr. Keith Eshleman and Dr. Andrew Elmore was completed in 2013 and has been under review and comment since its release. Active review and comment on the content of the BMP document has continued through 2013 by MDE, DNR, the Advisory Commission and the general public. Comments on the Final BMP Report are expected to be completed in early 2014. Fisheries Service has provided fish resource data, comments and concerns through the MDDNR Marcellus Shale Technical Team and IPR unit. Select staffs from the DNR resource units, including Fisheries Service participate in the Marcellus Shale Tech Team. The group continues to review, edit and report on the documents generated by the Executive Order and on behalf of all potentially affected natural resources that may be open to impacts should Marcellus Shale Gas development occur in Maryland.

DNR continued data collections to establish pre-drilling baseline conditions in areas underlain by Marcellus Shale in western MD by expanding and modifying monitoring programs and expanding the use of trained volunteer monitors. The Governor provided $1,500,000 in funding to supplement the FY13 budget for studies designed to continue and expand baseline monitoring of surface and ground water, air quality, public health, greenhouse gas emissions, economic impact, waste handling, traffic safety, road and bridge impacts, local land use impact and proper scope of the applicant's environmental assessment.

Areas of special importance that could be impacted by gas development have been identified and mapped by cooperating DNR units. Inland Fisheries staff attended a one day workshop held at Garrett College to participate in a mapping and information gathering exercise designed for stakeholders to identify the many ways state lands and waters are used by the public for fishing, hunting, recreation and wildlife habitat. Information and mapping acquired by this process will be made available to the public and will be used by MDDNR planners to ensure that the most comprehensive recreational use information is considered as Marcellus Shale Gas planning efforts go forward.

DNR will continue to participate in its interagency coordination process in order to review and provide comments on draft regulations. MDE has agreed to notify DNR if any modifications resulted from DNR or other agency comments before final revisions are submitted for processing through the Administrative, Executive and Legislative Review (AELR) regulation process.

Outcome/Expected Result: Inland Fisheries is hopeful that the Executive Order and inputs from the Marcellus Work Group, Advisory Commission and interagency coordination will provide the necessary tools and information as part of the three-part study mandated by the Executive Order that will enable the State policymakers and regulators to make the best informed decision without unacceptable risks of adverse impacts to public health, safety, the environment and natural resources.

Issue: Roadway, housing development and infrastructure construction projects and natural resource concerns.

Inland Fisheries conducts reviews of road, housing development and infrastructure projects in order to ensure that sediment and erosion control, adequate fish passage consideration, stream restoration/stabilization, mitigation and/or environmental stewardship, and storm water management ensure aquatic resource protection. There is a constant need and demand for review, assessment, update and/or retrofits to new and or existing storm water management design, facilities, ponds and impoundments. In other cases, unique infrastructure construction projects pose precedent setting circumstances that require new and untried approaches. Under such a scenario review, comment and assessment make the environmental review process very time consuming and often require change or adoption to existing State policy.

Inland Fisheries Concern: Trout streams are highly sensitive to the effects of increasing impervious surface in watersheds. Sedimentation and water temperature increases due to the loss of tree canopy and riparian vegetation during expansions or initial utility construction or maintenance, housing development construction, road and highway construction and other such land disturbances can adversely impact cold, cool and warm water aquatic communities. Time-of-year restrictions for MDE-defined stream classifications establish seasonal closures for in-channel stream work to protect fish and associated aquatic species during critical life stages such as spawning, egg incubation and hatching. In some cases, affected waterways may also harbor rare, threatened or endangered species (RTE). RTE species require additional conditions to ensure protection from anticipated impacts generated by construction activities. Highway, road and infrastructure (gas line, sewer line, power lines etc.) construction projects also promote environmental impacts following construction, including initial sedimentation, increased watershed imperviousness and storm water runoff from development, road-induced pollution and air quality impairment.

Actions Taken: Fisheries staff provided direction and input into the planning and construction process of road and highway projects as needed and as directed or requested by the Integrated Policy and Review Unit (IPR). Staff continued to work closely with highway engineers, utilities and consultants to provide input concerning roadway, stream restoration and unique infrastructure needs and resource protection design.

Outcome/Expected Result:

Inter County Connector

One such project included the ongoing and expansive multilane Inter County Connector (ICC) toll road project, an 18.5 mile project in Montgomery and Prince Georges Counties. The road opened to traffic in late November of 2011. Multitudes of sediment and erosion control issues, storm water retrofits, stream restorations, and newly applied storm water design facilities required continued follow-up and occasional oversight throughout the process which is not yet completed. Considerable resource benefits to Inland Fisheries were acquired from this ongoing process. Fisheries Service continues to work with ICC contractors and provides input for remaining construction activity for the final build portion of the ICC at Route 95. MDE approved many storm water facilities along the ICC and has converted most of them from temporary sediment and erosion facilities to their final design functions. A few notable benefits included the following:

1. Participation and input was provided through the permit process as required to conduct biological collections in waters of the state. Permit details provided by Fisheries secured species specific collection protocols and time of year protections for all fish species. Trout and the Comely Shiner (RTE species) required time of year restrictions and adjustments to sampling protocols and times.
2. Active Fisheries involvement in the steering, planning, monitoring and design process. All stream mitigation, environmental stewardship, and compensatory mitigation projects required for the ICC gave Fisheries the opportunity to insert the necessary resource information needs into design and development for each. Since many design engineers and consultants were in competition for mitigation projects associated with the ICC, participation by DNR IPR, Fisheries Service and other resource agencies, prevented excessive and unnecessary in-stream construction proposals that could have promoted unstable or ineffective restoration objectives or results. Fisheries Service was able to effectively influence the direction and outcomes that should maximize mitigation benefits and protect viable fish habitats.
3. Early design input by the IPR secured the implementation of long span, multi-million dollar bridges that now connect from ridge to ridge over Good Hope Tributary, Gum Spring Tributary and the main stem of Paint Branch. SHA is obligated to provide widespread monitoring along the entire length of the ICC and other off-site mitigation projects affiliated with this project. Valuable data and assessment will follow this effort that will form the building blocks for future road construction projects.

Columbia Gas Pipeline

Inland Fisheries staff coordinated meetings and field site visits with IPR, FERC and pipeline representatives and consultants to identify and provide comment for all sensitive resources along the proposed Columbia Natural Gas pipeline project. The project required many hours of field visits, meetings and environmental reiterations to date. The project referenced as the Line MB Extension Project is located in Baltimore and Harford Counties. The project proposes to install a 21.4 mile extension of 26-inch natural gas pipeline (Line MB) from Owings Mills to Rutledge Compressor Station. The pipeline will generally parallel Columbia's existing 26-inch Line MA and will conform to the existing right-of-way (ROW) to the greatest extent practicable. The pipeline proposes to cut through the headwater reaches of the highest quality wild trout streams located in central Maryland. Approximately 65 stream crossings will occur. Of these, 43 are classified as perennial, 14 intermittent and 8 ephemeral. MDE identified all but one stream as highly sensitive Use III, Nontidal Cold Water (wild trout) Aquatic Life waters. Big Gunpowder Falls is the only Use III designated trout water proposed to be crossed by the project that is known to have an invasive microscopic alga, *Didymosphenia geminata*, also known as "rock snot" or "Didymo". The alga (a diatom) is easily transported from one stream or waterway to another and can be easily spread by fishing gear, felt bottom boots, waders or transfer of a single drop of contaminated water. Cells can survive and can remain viable in wet, cool, damp conditions for a month or more if not properly dried or disinfected. Once established in a stream or river, the alga forms dense mats that can cover the bottom and has the potential to impact aquatic life and fish species life cycles. Given the number and close proximity of such high quality streams to be crossed by the pipeline, MDDNR is very concerned that construction activities associated with this project will present a high risk of Didymo introduction to uncontaminated waterways as construction staff and equipment move from one stream crossing to the next. Preventative measures were taken to address this issue that resulted with the development of an "Invasive Species Control Plan for *Didymosphenia geminata* at Big Gunpowder Falls". The Columbia Gas Transmission, LLC staff engaged their consultant (CH2M Hill Engineers) and used disinfection information methods provided by MDDNR on how to disinfect and control against the spread of Didymo and produced the Invasive Species Control Plan referenced above. Other details of protecting against the inadvertent spread of Didymo were also addressed and even included the sediment and erosion control plans at the proposed Big Gunpowder Falls crossing location.

A single unnamed tributary to Winters Run in Harford County is classified as a Use IV, Recreational Trout Water.

A federally and state-listed RTE species (Bog Turtle *Glyptemys muhlenbergii*) is known to occur in some of the project-impacted watersheds. Surveys to determine its status were continued in 2013. Little Gunpowder Falls is classified as a Tier II catchment by MDE and contains populations of a "Watch List" species, the Shield Darter.

A project modification proposal on the northeast end of the project could shorten the pipeline by 0.4 miles and if approved, may avoid a portion of the Gunpowder Falls State Park and avoid a known Brook Trout population found in a tributary to the Little Gunpowder Falls. Proposed pipeline crossings and construction activities on the main stem and tributaries to the Little Gunpowder Falls pose potential downstream impacts to a Tier II designated catchment on the Little Gunpowder Falls. DNR has approached Columbia Gas with a monitoring proposal designed to monitor and collect data in and above the Tier II stream section during the construction process. As of December 2013, Columbia Gas had agreed to do so but details of the agreed upon monitoring have yet to be qualified or finalized.

This major infrastructure project will require close and continued coordination and input until the project is completed. Construction and tree removal were planned as early as March 2013 but have been delayed while the review continues. Staffs have continued to review literature and are speaking to industry experts in order to assess which stream crossing methods will be most environmentally friendly. Horizontal Directional Drilling (HDD) is being considered for some select stream crossings to minimize sediment and erosion impacts as compared to the more typical and proposed method of cut and trench that can produce greater sediment and erosion concerns. Each site was visited and evaluated in 2013 in order to assess each for the presence of wild trout and the pros and cons of each stream crossing method. To date, many meetings have taken place with the Columbia Gas to develop and identify a recommended list of HDD stream crossings. DNR and other regulatory and review agencies continue to lobby and negotiate with the gas company to finalize a list of HDD crossing candidate streams; however, Columbia Gas continues to provide push back on the formerly agreed to list of highly sensitive stream and wetland complexes that would benefit most from using HDD versus conventional cut and trench construction protocols.

HDD applications minimize the permanent loss of ROW and riparian vegetation and forest cover verses the standard cut and trench protocol. HDD pipeline crossings are expected to minimize the threat of sediment inputs into affected aquatic habitats. Since pipelines are typically situated much deeper beneath streams and wetlands when crossed with HDD, there will be a much smaller threat of having the pipeline exposed from stream erosion. Cut and trench installations observed along this very ROW during field visits have shown where pipeline exposure has promoted significant in-stream sedimentation issues and have caused fish barriers to develop. Placement of cut and trench pipelines through sensitive wetland and critical spring seep locations may also adversely affect their important contributions and function when transected by a shallow placed barrier such as a pipeline. Fisheries Service plans to continue work on this very important project and will continue to be an active participant in the review and construction process until it is completed.

Table 1. Summary of Environmental Review and Technical Guidance activities in 2013.

Environmental Review	Number of Reviews
Collection permit	141
Stocking Permits	48
Land acquisition	35
Strip mining reclamation	29
Nontidal wetlands alteration	24
Stream and habitat restoration	21
Invasive species	15
Timber sales	11
Bridge projects	11
Instream construction – time of year waivers	11
Reservoirs/water allocation	9
Comprehensive plans	9
Road projects	7
Internal Environmental Review of Fisheries Management Areas	6
State Lands Projects	5
Strip mining	5
Large Woody Debris in Stream Review	5
Aquaculture permit	4
Housing Developments	4
Wastewater Treatment Plant discharge	4
Groundwater withdrawals	4
Tidal water/wetlands alteration	3
Deep mine	2
Dams – removal/relicensing	2
Handicap Accessible Trail Development	2
Hazardous waste spills	1
Gas Pipeline Construction	1
Dredging	1
Utility Work	1
Gas wells	1
Technical Guidance	
Pond assessment	27
Population assessment	9
Water quality consultation	7
General Guidance to Landowners	2

State: <u>Maryland</u>

Project Number: <u>F-48-R-23</u>
Study No.: <u>I</u>
Job No.: <u>2</u>

Project Title: Survey and Management of Freshwater Fisheries Resources

Study Title: Management of Fisheries Information Resources

Job Title: Creel Surveys

In 2013, the Creel Survey for Potomac River Smallmouth Bass Angling continued.

2012 Potomac River Smallmouth Bass Angling Catch Rate Survey

Introduction

Inland Fisheries currently monitors the relative abundance of the Potomac River Smallmouth Bass (*Micropterus dolomieu*) population by electrofishing $CPUE_{60}$ and by tournament catch rates (5 bass per boat creel, 2 anglers and 8 hour day). A creel survey of general Smallmouth Bass anglers was undertaken to complement these metrics as a measure of relative abundance with the following objectives:

- Measure the overall catch rate of Smallmouth Bass to determine fishing success and monitor trends
- Measure the catch rate of Smallmouth Bass ≥ 305 mm (12" – minimum length limit)
- Determine the percent of legal sized bass in the catch and the percent harvest
- Compare the angling catch rates between statewide regulation area (5 bass per day creel, 305 mm minimum size) and the Catch-and-Return Bass Fishing Area.

Methods

The nontidal Potomac River poses a number of creel sampling challenges. The river from Cumberland, MD to the District of Columbia spans a distance of nearly 290 km (180 miles) making coverage by a typical roving creel survey difficult and very expensive. While the Potomac River is within and managed by the State of Maryland, access from the Potomac's southern bank is from either Virginia or West Virginia. Further complicating study design was the nearly unlimited access to the river provided by the Chesapeake and Ohio Canal National Park and canal towpath that closely parallels the river from Cumberland, MD to Georgetown. Additionally, wading becomes popular during the summer in some of the shallow stretches; these anglers are more difficult to contact than boaters that must use a designated access.

In 2012 the pilot survey selected a more manageable 56 km (35 mile) section from Harpers Ferry, WV (confluence with Shenandoah R.) downstream to Seneca, MD

(Seneca Breaks). (Surveys on this section continued in 2013.) This section includes two regulation schemes, a 32-km (20-mile) section under catch-and-release regulations and a 24-km (15 mile) section under Statewide regulations (12 " minimum size, 5 bass per day creel). All Maryland nontidal waters are subject to a black bass closed season (catch and release permitted) from March 1 through June 15. There are four boat ramps/access areas from the MD side used to access the catch-and-release area and one from the VA side. There are five boat ramps/access points from the MD side and one from the VA side used to access the State-wide regulation area.

Since angling catch rates were believed to be more important for management than the total angling effort, the survey design was simplified to reduce costs and staff time. Anglers were contacted at boating access areas as well as on the water and, if they were willing to participate, were provided with a postage-paid survey card (Figure 1). At the conclusion of their fishing day, anglers were only required to answer a few brief questions about their day's catch and drop the card in the mail. Each card was individually numbered. To improve participation, each returned card made the angler eligible for a chance to win $50 in cash or prizes from a random drawing at the conclusion of the survey. Because the survey determined the angling catch rate and not the total effort, it was not necessary to stratify survey times or locations. However, to ensure that cards were distributed during a variety of fishing conditions, cards were distributed at least once each week from June 1 through October 31 by Fisheries staff during both weekends and weekdays. Members of two local fishing organizations (PSBC – Potomac Smallmouth Bass Club, MDBF – Maryland Bass Federation) were also provided with survey cards. These members recorded their own trips and distributed cards to other anglers they encountered on the water. A suggested script was provided to present a consistent message to the general public.

In 2013, an on-line version of the angler's card was added to the online Angler Survey to a larger user group.

Results

Information provided by anglers is cost effective and an important part of managing fisheries. Creel surveys provide insight into angler success, harvest attitudes, and the effectiveness of regulations. Potomac River bass anglers were surveyed using two methods, on the water distribution of postage pre-paid creel cards and through an on-line volunteer angler survey page. A total of 212 usable creel cards were returned by anglers participating in the 2013 Potomac River Smallmouth Bass Catch Rate Survey. Due to the variability of wading opportunities in the study area and the low number of cards returned by wading anglers, only the information from boat anglers was summarized.

A total of 55 usable entries were made by boat anglers through the on-line volunteer angler survey; only 19 entries were received by wading anglers. Only three on-line boat entries were received from the upper river and they were not included in the analysis.

There was no difference ($\alpha = 0.05$) in the catch rate of Smallmouth Bass ≥ 305 mm (12") by boat anglers using creel cards (1.1/hr), boat anglers using the on-line survey (1.2/hr), or by wading anglers using the on-line survey (1.2/hr)(ANOVA single factor $F = 0.23$, $P = 0.79$). However, there was a significant difference in catch rates for sub-legal Smallmouth Bass (< 305 mm) reported by boat anglers using creel cards (2.6/hr) and by boat anglers using the on-line survey (1.4)(two tailed t-test, $P = 3.5E\text{-}05$). Moreover, there was no difference in catch rate between wading anglers and boat anglers reporting sublegal size bass through the on-line survey. It is speculated that anglers may keep track of "keepers" more accurately than the number of sub-legal fish they catch. Additionally, cards distributed to anglers just prior to their trip and filled out during or at the conclusion of the trip may reflect a more accurate recording of the catch than if the catch had to be recalled from memory at a later date for the on-line survey.

ANOVA tests showed significant differences in the total catch rate of Smallmouth Bass ($F = 6.47$, $P = 0.002$) and the catch rate for legal-size bass (≥ 305 mm) among the lower, middle, and upper river segments ($F = 4.32$, $P = 0.014$). A summary of the catch data, by river segment and collected using the postage pre-paid creel cards is presented in Table 1.

The percentage of the total angler catch consisting of legal size (305 mm) Smallmouth Bass reported from creel cards from the upper and middle river segments was 18% and 24%, respectively. Using 127 mm (5") as an approximate length that smallmouth are recruited to hook and line gear, the percentage of legal size bass caught by electrofishing from the collection of bass ≥ 127 mm was 14% and 25% for the upper and middle river, respectively. This suggests that size distributions determined from electrofishing can be reasonably compared to size distributions reported by anglers. Too few electrofishing surveys were conducted in the lower river segment during 2013 to allow a comparison.

Angling catch rates for Smallmouth Bass recorded in 2013 were higher than values reported from a creel diary program during 1979 – 1985 (MD DNR, 1986) (Table 2). Although the surveys used different methodologies to obtain angling catch rates, the results were thought to be analogous enough to make general comparisons. The anglers that participated in the diary program were skilled, avid anglers and members of a local fishing organization. These fishermen could be expected to have a higher catch rate than more casual anglers. By design, the creel card survey (2013) captured a broader range of angler experience, though enthusiastic anglers did take an interest in and repeatedly participated in the 2013 survey. Nevertheless, the two surveys allow a comparison of current and past fishing success and an additional tool to evaluate the quality of the Potomac River Smallmouth Bass fishery.

Discussion

Information provided by fishermen is cost effective and an important part of managing fisheries. Creel surveys provide insight into angler success, harvest attitudes, and the effectiveness of regulations. This survey targeted anglers fishing for Smallmouth Bass and like all surveys, had some inherent bias. Although it was stressed to report all trips whether bass were caught or not, some anglers may not have reported trips when no fish were caught. Additionally, more ardent, and possibly skilled, anglers returned multiple cards potentially biasing towards higher catch rates. However, these results could be expected to be similar to the results of the previous MD DNR 1986 survey that incorporated fishing diaries of avid river anglers.

The results of this survey demonstrate that the catch and release ethic among bass anglers has become so prevalent that fishing mortality is predominantly related to hooking/handling mortality and estimated to be less than 5%. With very little exploitation, the catch rate of quality size bass has significantly increased. Based on the results of this survey and the current harvest attitudes of anglers, restrictive fishing regulations would not be effective at improving the relative abundance, size distribution, or fishing success for Smallmouth Bass in the Potomac River.

Recommendations

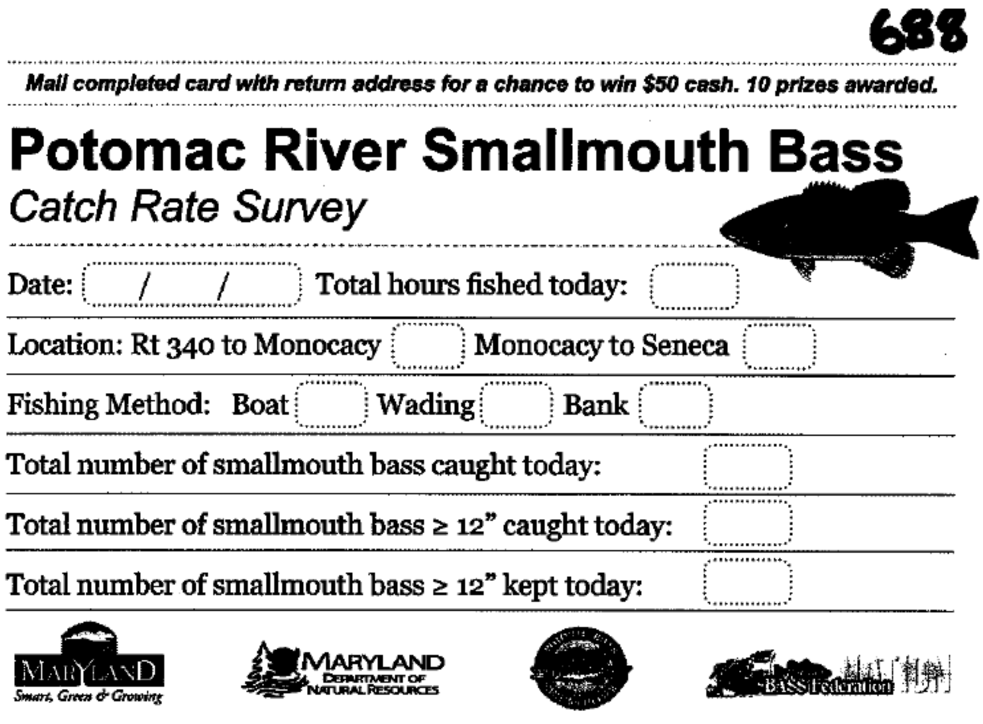
- Conduct angler catch rate survey of the lower, middle, and upper sections of the Potomac River at least once during 5 yr grant to assess angling quality and supplement existing population trend data.

Table 1. Summary of 2013 Potomac River Smallmouth Bass angler catch data, by river segment, obtained from postage pre-paid creel cards. Cards were distributed to anglers between March 1 and October 31. Catch rate is bass/hr.

	Lower	**Middle**	**Upper**	**Total**
total catch rate	**3.0**	**3.8**	**3.0**	**3.3**
mean total catch	3.0	4.3	3.0	3.5
≥ 12" catch rate	**1.1**	**0.9**	**0.5**	**0.9**
survey card N	86	82	44	212
% ≥ 12" in catch	**36**	**24**	**18**	**27**
mean catch/outing	16.9	20.0	16.4	18.0
mean ≥12"/outing	6.1	4.8	2.9	4.9
mean hrs per outing	5.6	5.2	5.5	5.4

Table 2. Comparison of 2013 angler Smallmouth Bass catch rate data with historical (1979 – 1985) creel diary data from the nontidal Potomac River (MD DNR, 1986). Minimum size = 305 mm. * creel cards from individual trips. ** values are total number/total hours, means are from individual trip data.

Year	**# creel diaries**	**Total SMB caught per Hr**	**# SMB < 305 mm caught per Hr**	**# SMB ≥ 305 mm caught per Hr**	**Percent of SMB ≥ 305 mm in total catch**
1979	3	2.35	1.59	0.76	32
1980	5	3.27	2.96	0.31	10
1981	5	2.37	1.95	0.42	18
1982	4	2.43	1.97	0.47	19
1983	5	1.72	1.33	0.40	23
1984	4	1.81	1.30	0.52	28
1985	6	1.81	1.20	0.62	36
Median		2.35	1.59	0.47	23
Mean		2.25	1.76	0.50	24
95% CI		(1.8 – 2.8)	(1.2 – 2.3)	(0.4 – 0.6)	(15 – 30)
2013	**212***	**3.3****	**2.6**	**0.9**	**27**
Mean		**3.5**	**2.6**	**1.0**	**29**



688

Mail completed card with return address for a chance to win $50 cash. 10 prizes awarded.

Potomac River Smallmouth Bass

Catch Rate Survey

Date: / / Total hours fished today:

Location: Rt 340 to Monocacy Monocacy to Seneca

Fishing Method: Boat Wading Bank

Total number of smallmouth bass caught today:

Total number of smallmouth bass ≥ 12" caught today:

Total number of smallmouth bass ≥ 12" kept today:

MARYLAND Smart, Green & Growing

MARYLAND DEPARTMENT OF NATURAL RESOURCES

BASS Federation

Figure 1. Postage-paid creel card distributed to anglers during the 2013 catch rate survey.

State: Maryland

Project No.: F-48-R-23
Study: I
Job No.: 3

Project Title: Survey and Management of Freshwater Fisheries Resources

Study Title: Management of Fisheries Information Resources

Job Title: Database Management

Introduction

In order to fulfill its responsibility to manage, restore and enhance Maryland's freshwater resources, the Inland Fisheries Division is improving its data and information management system. A number of goals were defined as necessary to achieve a better system: improve the efficiency and accuracy of data entry, provide utility for summary and reporting; provide methods of geographically projecting and querying data; and data summaries.

Methods

Maryland Department of Natural Resources Inland Fisheries and the Information Technology (IT) staff developed a data management system referred to as the Geographic Inland Fisheries Survey (GIFS) system. This system was built on Microsoft Structured (MS) Query Language (MS SQL) and provided for query and macro functions through an integrated MS Access module. A third module (MapObjects) was incorporated to identify tabular data geographically.

The GIFS system was designed to incorporate nearly all standardized aquatic surveys performed by the Inland Fisheries staff. This included streams, inland and tidal rivers, and freshwater impoundments. Finfish, invertebrate, water quality and physical habitat fields were all included. In addition, the GIFS system provided a way to export a "snapshot" of the data on the SQL Server to an Access database for querying on local PC's.

Results / Discussion

Work continued in 2013 on routine data entry/editing and improving the quality of existing data. A summary of new records entered for 2013 included 112 Site table records, 1,155 Pass records, 1,404 Invertebrate records, and 17,458 Individual Fish records. Many of the records were collected in past years but entered in 2013. For instance, 8,591 new Individual Fish records were from data collected in prior years. Table 1 illustrates the progress made with data entry and validation of existing data.

At a meeting in February 2013 between several persons involved with database work, a new version of GIFS was planned. A programmer from Maryland DNR's IT team suggested the current GIFS was becoming outdated and improvements could be made by switching to a web browser type interface and greatly improving the GIS component. Another potential benefit would be to allow data collected in the field to be directly recorded into GIFS on a tablet or similar internet enabled device. The programmers created a development version of the web-based GIFS and testing progressed through the end of 2013. The new version will be ready in 2014 and will initially run in parallel with the old version.

One focus of work has been to add location coordinates for each Site or a related Pass where they were missing. Coordinates were added to approximately 30 Sites during the year. Estimated location points were placed on either Google Earth or USGS National Map and the resulting images sent to the field crews to be verified. There remains about 991 Sites with no related coordinates.

A major update to the Invertebrate Species lookup table was completed. The update incorporated changes in taxonomic classification since the table was created as well as to better align the invertebrate list in GIFS with Maryland Biological Stream Survey, a sister agency. The update involved updating or adding many species to the table as well as their tolerance values. The table increased from 287 records to 591 records. A work order to add a new field called the "Functional Feeding Group" is still pending.

Staff attended a meeting of the Multistate Aquatic Resource Information System (MARIS) in Washington, D.C. on August 8 and 9, 2013. The two-day meeting had discussions on both technical and policy issues. A deadline was determined for states to contribute new data to MARIS by October 2013. A set of queries were designed and updated to summarize data in GIFS for MARIS. A new snapshot of the data (dated July 31, 2013) was uploaded in October. The previous copy was dated February 2011. Data within MARIS are available at the web site (http://www.marisdata.org/). Data should be updated annually.

Working with the MARIS project brought attention to some data problems within GIFS and also limited what was shared with MARIS. One of the most challenging problems was that fish data are represented in two different tables, one for individual fish and the other for summary counts or observations of fish. In many instances the fish are in one table but not the other and thus presents a problem for getting an accurate count of fish from both sources. Another problem was that the methodology field was blank for many of the Passes. The protocol for MARIS was to include the first pass only from multiple pass electrofishing surveys. The field necessary to determine multiple pass surveys was Methodology and in many cases only the first pass of a multiple pass survey had the methodology selected, not the additional passes. Therefore it was not possible to separate by Methodology. In other instances the summary catch data for species other than the target species were totaled in the first pass but were actually for all the passes at the location. Therefore analysis could be misleading for some locations.

A new query for the Tidal Bass project was created to eliminate an error in analysis. The original query output had all species although the data had the appearance of being filtered for Largemouth Bass. The error was difficult to detect since nearly all individual fish were Largemouth Bass and only a handful of other species. The new query is able to filter for Largemouth Bass and show all Sites sampled regardless of whether a Largemouth was found. Another task for the Tidal Bass project was to eliminate all tournament entries from GIFS. An independent web access database was created to handle tournament information and therefore no longer needed to be stored in GIFS. Approximately 885 Passes of Tidal Bass tournaments were deleted. Non-tidal tournaments remain intact with 33 Passes.

GIFS database system attempts to fill the needs of multiple survey types and users. Updates and refinements is a continuous process. Work orders to add or remove fields, improve labels, or append table data that have been received recently should be completed after the new GIFS is in production.

Table 1. MD DNR Geographic Inland Fisheries Survey (GIFS) data entry progress 2013.

Regions	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Western Region –D1													
Lakes													
Streams (Coldwater)													
Rivers (Warmwater)													
Invertebrates													
Tournaments													
Western Region – D2													
Lakes													
Streams (Coldwater)													
Rivers (Warmwater)													
Invertebrates													
Tournaments													
Central Region													
Lakes													
Streams (Coldwater)													
Rivers (Warmwater)													
Invertebrates													
Tournaments													
Southern Region													
Lakes													
Streams (Coldwater)													
Tidal Rivers													
Invertebrates													
Tournaments												**	
Eastern Region													
Lakes													
Streams (Coldwater)													
Tidal Rivers													
Invertebrates													
Tournaments													

No Data Entered		Partial Data with Validation		Complete Data with Validation	
Partial Data without Validation		Complete Data without Validation		No Data Collected	

**Tidal Bass tournament data is no longer entered into GIFS. A new database was created that can be accessed by tournament directors over the internet.

State: Maryland **Project Number:** F-48-R-23

Project Title: Survey and Management of Freshwater Fisheries Resources

Supplemental Information

The following information covers work not charged to any federal aid project, but describes outcomes resulting from data and research collected in this and other projects.

Introduction

Each year the Maryland Inland Fisheries Service uses information gathered on fish populations and related resources across the State to develop management strategies to insure the perpetuation of fish species, and to provide maximum fishing opportunities and quality of the experience. The development of regulations helps meet these strategies by guiding anglers to help maintain the fishery.

Methods

In the winter of 2013, the Inland Fisheries submitted regulation changes that were needed to meet the management needs of freshwater fish species. Staff considered species and waterway characteristics, current population data and fishing pressure information to develop regulations for a given body of water or for statewide application. The potential regulation was posted on the Fisheries website for review and comment by the public. Potentially affected individuals (PAIs) were notified of the posting. Comments were accepted until the end of May. In June staff compiled the formal regulations and forwarded them to the Maryland Register for additional comments from the public. A final request for comments was sent to the PAIs in August. After receiving all comments and following a public hearing in October, staff completed final regulations and submitted to Maryland Register, for regulations to take effect by January 1 2013.

Results and Discussion

The following regulations were enacted for 2013:

- Change the upper boundary of the Put-and-Take/Delayed Harvest area on Owens Creek from Raven Rock to Buck Lantz Rd. The regulation was proposed because the name of the boundary road was easily confused with another location.

Recommendations

Fisheries will continue to use survey data to continually update and modify regulations to preserve and protect fish populations and their associated habitat, while striving to meet the needs of the angling public.

ANNUAL (2013) PERFORMANCE REPORT

Maryland Department of Natural Resources
Fisheries Service
Inland Fisheries Division

SURVEY AND MANAGEMENT OF FRESHWATER FISHERIES RESOURCES

Management of Freshwater Impoundments

USFWS Federal Aid Grant F-48-R-23

Study II

By:

Adam Eshleman
Brett Coakley
Don Cosden
Charles Gougeon
Mary Groves
Tim Groves
Todd Heerd
Jody Johnson
Alan Klotz
Joseph Love
John Mullican
Mark Staley
Jerry Stivers
Mark Toms
Branson Williams
Ross Williams

Table of Contents
Management of Freshwater Impoundments

Survey and Inventory B3

Monitor Trends in Fish Population B4
- Deep Creek Lake B7
- Johnsons Pond B24
- Loch Raven Reservoir B29
- Savage River Reservoir B37
- Smithville Lake B48
- Triadelphia Reservoir B52
- Urieville Lake B60

State: Maryland

Project Number: F-48-R-23
Study No.: II
Job No.: 1

Project Title: Survey and Management of Freshwater Fisheries Resources

Study Title: Management of Maryland's Freshwater Impoundments

Job Title: Survey and Inventory

Introduction

Maryland’s public impoundments, which exceed 100 in number and 10,000 hectares in surface area, provide a wide diversity of recreational fishing opportunities. Most of the bodies of water larger than 4 hectares also afford the option of boating to supplement shoreline fishing. The physical diversity of habitats and fish species variety, combined with wide distribution and easy access make these impoundments valuable resources promoting healthy and enjoyable outdoor recreation for citizens in Maryland and neighboring states. Surveys of fish habitat and inventory of fish populations guarantee the continued maintenance, protection and enhancement of State fishery resources

Objectives

The objective of this job is to obtain baseline physical, chemical, and fish species information to describe a new or existing impoundment with limited or no survey history. This includes: identifying and describing new fisheries resources and management opportunities; monitoring and evaluating the impact of increasing white perch populations in reservoirs; and documenting and evaluating the effects of changing aquatic habitat, fishing pressure, and management programs.

Results/Discussion

The wide diversity of lake size and morphology across geographical regions required the development and adaptation of several different strategies for electrofishing surveys. Reservoir drawdown and periodic or seasonal aquatic vegetation impacts have presented recurring sampling challenges. In small impoundments the entire accessible shoreline is sampled; smaller impoundments having heavy infestations of vegetation and/or lack adequate depth present sampling limitations. The combination of shoreline seining and fall electrofishing surveys has been effective in documenting natural reproduction of sportfish and newly introduced fish species. Each kind of assessment has been accurate enough to monitor and track large-scale trends and the general health of these populations. The large impoundment survey methodology has improved data reliability by establishing sampling protocol that has provided coverage across all habitat types and has lowered the chance of bias in site selection. The precision of length category (PSD) and condition indices has been found to be adequate for describing targeted fish populations in impoundments.

There were no “Initial Survey and Inventory” studies conducted in 2013.

State: Maryland

Project Number: F-48-R-23
Study No.: II
Job No.: 2

Project Title: Survey and Management of Freshwater Fisheries Resources

Study Title: Management of Maryland's Freshwater Impoundments

Job Title: Monitor Trends in Fish Populations

Objectives

The objective of this job is to obtain fish population information on previously surveyed impoundments to monitor for changes that may require immediate or future corrective fish management action; and collect aquatic habitat information for evaluation relative to changes in fish populations.

Methods

Procedures followed are cited in each impoundment report if different from those described in this Methods section. Monitoring studies were conducted on Deep Creek Lake, Johnson's Pond, Loch Raven Reservoir, Savage River Reservoir, Smithville Lake, Triadelphia Reservoir and Urieville Lake.

A. Impoundment Methods

The wide range of target species and impoundment morphology across Maryland required a variety of gears and methods to achieve project goals. In addition, new electrofishing methods, introduced in 2002, were employed and evaluated in some but not all impoundments. Within Study II, these new methods are referred to as 'Random Site Electrofishing'; all others are referred to as 'Single Sample Electrofishing'. Individual reports cite which of these methods were used and describe variations or additional protocols in detail.

B. General Electrofishing Procedures

Field Procedures

These procedures were common to both electrofishing methods described below. Sampling was conducted with 16- or 18-foot Smith-Root electrofishing boats equipped with 5.0 kilowatt (kw) gasoline generators. Crews consisted of one driver and two netters. Target species were netted and held in a live-well until a site was completed or the live-well reached capacity. Fish were measured for total length (TL) by pressing the mouth shut against the end of the measuring board or cradle and depressing the tail to determine the greatest possible length. Weights were measured and reported in grams. Fish scales were collected for aging from the left side after the tip of the pectoral fin and below the lateral line.

Analytical Procedures

Catch rate (catch per unit effort or CPUE), standardized to fish per hour ($CPUE_{Hr}$), and was calculated as an index of relative abundance. $CPUE_{Hr}$ was further calculated for various length categories as proposed by Gablehouse (1984). Proportional and relative stock densities (PSD and RSD), the percentages of fish sampled within each of these length categories, were used to describe population size structure in terms of species balance and angling quality.

Relative weights (Wr) were estimated for various species and size groups. Relative weight was developed by Wege and Anderson (1978) as a method to determine fish condition. This index of relative weight is:

$$Wr = W/Ws \times 100$$

Where:

Wr = Relative weight of a fish
W = Actual weight of a fish
Ws = Standard weight for a fish of same length (from table)

C. Random Site Electrofishing

Field Procedures

The shoreline was divided into 400-meter sites. This was done with maps or with Global Positioning System (GPS) units prior to the start of sampling. When an impoundment was too large to sample every site, a sub-set of sites was randomly chosen. Unless otherwise noted, site selections were based upon the systematic method of allocation (Nielsen and Johnson, 1983; Snedecor and Cochran, 1968; Miranda et al., 1996). The sample size was determined and then sites were numbered to provide consecutively numbered groups equal to the desired number of samples. A random choice was made from the range of consecutive numbers and that site was sampled. Electrofishing started at the first station coordinate reached and continued for 600 seconds. Actual start/stop waypoints were entered and uploaded to a PC to accurately determine linear sample distance. All size groups of largemouth bass and other game species of moderate or low density were targeted for collection during the 600-second samples (see reports for target species list).

A subset of these stations was randomly chosen for full species community sampling. All species and sizes were collected during the first 100 seconds of electrofishing at these stations.

Analytical Procedures

Relative abundance indices were estimated as the mean of $CPUE_{Hr}$ across all sites. Both arithmetic and geometric mean estimates were made. Geometric means were based on the natural log of CPUE +1. Log-transformation served to stabilize the variance and provide more precise indices.

D. Composite Site Electrofishing

Field Procedures

Sampling was conducted around the perimeter of the lake, but did not include the entire shoreline. Instead it focused on areas of habitat suitable for black bass. When the live-well was full, sampling stopped, individual fish data were recorded and the fish were released. Sampling then resumed until the lake had been circumnavigated or the sample size was determined to be sufficient. In small impoundments a high percentage of the shoreline was actually sampled but on larger bodies as little as 5% may have been sampled. The location of samples, although not specifically predetermined, generally remained constant unless changes in habitat or water levels required a change in location. This most closely resembled a fixed site strategy.

Analytical Procedures

Analyses were as described under 'Random Site Electrofishing' except that all parameters were estimated from the pooled samples. This did not allow for the calculation of variance, confidence intervals or tests for significant differences.

Seining

Shoreline sites were sampled for young-of-year (YOY) black bass species using a 9.1 m x 1.2 m, 3.2 mm mesh beach seine. Site locations were generally fixed but varied with changes in shoreline, bottom habitats or from water level variation. Initial selections were made to facilitate gear effectiveness and to sample representative habitat. A seining index was used to quantify YOY abundance based on the number of YOY collected from 30.5m of shoreline (three hauls):

Number of YOY per 30.5m of shoreline	**Seining Index**
0 - .50	Poor
0.51 - 2.50	Fair
2.51 - 5.50	Good
5.51 +	Excellent

Deep Creek Lake

Introduction

Deep Creek Lake (DCL), located in Garrett County, is Maryland's largest freshwater impoundment with a surface area of 1579 hectare, an average depth of 9 m, a maximum depth of 22.8 m, and a surface elevation of 445 m at full pool. The MD DNR Resource Assessment Service (MD DNR RAS 2010) reports that DCL exhibits patterns of a typical deep, temperate zone reservoir with two mixed seasons and two stratified seasons, pH levels > 6.5 and < 7.3, and low turbidity levels (< 100 NTU) which do not exceed Maryland Department of the Environment water quality criteria for its Use III-P designated use. The lake stratifies in the summer when dissolved oxygen concentrations approach zero ppm at depth > 10 m; however, a zone of cold and oxygenated water sufficient to support two-story fishery management exists in all seasons. DCL supports at least nineteen fish species providing coldwater, coolwater, and warmwater fisheries (MD DNR 2011). Largemouth Bass *Micropterus salmoides*, Smallmouth Bass *Micropterus dolomieu*, and Walleye *Sander vitreus* are the most popular sportfish. Annual stocking of adult Brown Trout *Salmo trutta* and Rainbow Trout *Oncorhynchus mykiss* provide put and take trout fishing opportunity. Warmwater gamefish and panfish, except Walleye and Yellow Perch *Perca flavescens*, are managed under Maryland's statewide regulations (MD DNR 2013). Walleye and Yellow Perch are managed in DCL by special regulations. Walleye regulations include a closed season from 1 March through 15 April, a five fish daily creel limit, and a 381 mm minimum size limit the remainder of the year. Yellow Perch regulations include a 10 fish daily creel limit, 20 fish possession limit, no closed season, and no minimum size restriction. Trout fishing is managed under Put and Take regulations as described in the 2013 Maryland Fishing Guide (MD DNR 2013).

Objective

The purpose of this study was to:

- Determine fish species composition, proportional stock density (PSD), relative stock density (RSD), relative weight (Wr), length frequency distribution, and relative abundance of important gamefish and panfish species.
- Determine black bass, Walleye, and Yellow Perch reproductive success.

Methods

Fish community survey

A Smith-Root SR-16H, 5.0 kw, pulsed DC electrofishing boat was used to sample twenty established sites after dark on 5 and 6 June 2013 for fish species composition and relative abundance. Each station was sampled for 600 seconds of electrofishing effort. Fish were identified to species, measured for total length (TL) in mm, and weighed to the nearest gram. Relative abundance of fish species was recorded as catch per unit of electrofishing effort ($CPUE_{60}$). Observed abundance estimates were derived from sample size and fish were rated as abundant (>100 individuals), common (5-100 individuals), or scarce (< 5 individuals). Proportional stock density (PSD) and relative stock density (RSD) were calculated using methods described by Anderson (1980). Confidence intervals for proportional stock density and relative stock density were calculated using the formula described by Gustafson (1988). Relative weight (Wr), a measure of fish condition, was calculated using methods described by Anderson (1980). Otoliths for age determination were obtained from Largemouth Bass and Walleye that were sacrificed for virology testing.

Walleye surveys
A Smith-Root SR-16H, 5.0 kw, pulsed DC electrofishing boat was used to sample for Walleye after dark on 15 April 2013 along the dam breast and the Deep Creek State Park shoreline. Additional adult Walleye data were obtained at an open tournament held on 20 April 2013. Walleye captured in open tournaments were held in a modified 300-gallon stock tank during tournament weigh-ins. The holding tank was supplied with oxygen at 20 psi and water was re-circulated at a rate of 18 gallons per minute using a gasoline powered water pump. Non-iodized salt was added to aid in restoring ionic balance in stressed fish. Walleye were held up to two hours and released back into DCL at the weigh-in site. Night-time electrofishing was conducted on 21 October 2013 to measure Walleye young-of-year (YOY) abundance. Relative abundance of adult and YOY Walleye was recorded as catch per unit of electrofishing effort ($CPUE_{60}$).

Juvenile fish survey
A 15-meter seine net was used to collect YOY black bass and Yellow Perch at twenty established stations on 29 and 30 July 2013. Abundance indices were reported as the number of YOY per 30.5 m of shoreline. A qualitative value for black bass was assigned based on the shoreline-seining index described by MD DNR (2000). Associated fish species collected in the seine hauls were also recorded.

Results

Fish community
The list of common names, scientific names, observed abundance estimates, and pooled CPUE abundance of sixteen fish species collected in DCL during 2013 is contained in Table 1. The sixteen species representing six families are indicative of a coldwater, coolwater, warmwater fishery. The panfish species, Bluegill, Pumpkinseed, and Yellow Perch were regarded as common to abundant. Smallmouth Bass and Walleye were the most abundant gamefish species. Fish species composition in DCL was largely unchanged from that observed during the last five-year study period (MD DNR 2011).

Walleye
Summaries of electrofished and tournament-captured Walleye population data for 2013 are contained in Table 2. The PSD_{38} value for electrofished Walleye was greater than the suggested range of 30 to 60% (Anderson and Weithman 1978). The Wr of the combined walleye population was less than the suggested range for good condition of 95 to 100% (Wege and Anderson 1978). Walleye length frequency distribution (Figure 1) showed

diverse size classes from YOY to trophy-size fish (547 mm) and a large proportion of the population within the 376 mm to 425 mm size class. The $CPUE_{60}$ value showed Walleye were the second most abundant gamefish species in the 2013 sample. Based on the YOY $CPUE_{60}$ value, a strong 2013 year-class was produced (Table 2). Walleye reached legal size (381 mm) by Age 3+, however otolith sample size was low (Table 3). Walleye tested negative for viral hemorrhagic septicemia (VHS) in 2013.

Yellow Perch
Yellow Perch were the most abundant fish species collected in DCL in 2013 (Table 1). Summaries of Yellow Perch population data are contained in Table 4. The PSD_{20} value for Yellow Perch was greater than the range of 30 to 50% suggested by Anderson and Weithman (1978). The RSD_{25} value shows a high percentage of the population is of preferred (250 mm) size or larger. Yellow Perch Wrs were less than the 95 to 100% expected range for good condition (Wege and Anderson 1978), although the fish did not appear to be in poor condition. The length frequency distribution (Figure 2) shows a population characterized by a diverse size structure from YOY size to memorable size (350 mm). Seining surveys for YOY Yellow Perch (Table 4) showed a similar abundance level in DCL since the first survey was conducted in 2007.

Smallmouth Bass
Summaries of Smallmouth Bass population data are contained in Table 5. The PSD_{28} value for Smallmouth Bass was within the expected range of 30 to 60% for a balanced population, while the RSD_{35} was below the suggested range of 10 – 25% (Anderson and Weithman 1978). The Wrs for Smallmouth Bass in all size categories were below the 95 to 100% expected range for good condition (Wege and Anderson 1978). Smallmouth Bass show a diverse length frequency distribution from YOY sized fish to fish > 400 mm (Figure 3). Reproductive success was considered “poor” in 2013.

Largemouth Bass
Summaries of Largemouth Bass population data are contained in Table 6. The PSD_{30} and RSD_{38} values were greater than the optimal range of 40 to 60% for a balanced population. The Wrs in all size categories were within or slightly less than the 95 to 100% range suggested by Wege and Anderson (1978). The length frequency distribution (Figure 4) shows a diverse size structure with an abundance of fish in the 326 to 350 mm size. Reproductive success was considered “good”. Largemouth Bass reach legal size (305 mm) by Age 3+ (Table 7). Largemouth Bass tested negative for viral hemorrhagic septicemia (VHS) and Largemouth Bass Virus (LMBV) in 2013.

Bluegill
Bluegill population data are contained in Table 8. The PSD_{15} and RSD_{20} values were greater than the suggested ranges described by Anderson and Weithman (1978) indicating a population comprised of an abundance of quality and preferred size fish. Length frequency distribution (Figure 5) further shows a diverse size structure from YOY to memorable size (255mm) fish in the population. The Wrs of Bluegill in all size

categories were within the expected 95 to 100% range for a balanced population. YOY Bluegills were abundant in the seining surveys in 2013.

Pumpkinseed
Pumpkinseed population data are contained in Table 9. The PSD15 and RSD20 values were greater than the suggested ranges described by Anderson and Weithman (1978). Length frequency distribution (Figure 6) and high PSD and RSD values indicate a population with a large portion of fish > 200 mm. The Wrs for all size categories were within the expected range of 95 to 100% as described by Wege and Anderson (1978).

Chain Pickerel
Chain Pickerel population data are contained in Table 10. The PSD_{38} and RSD_{51} values are indicative of a balanced population. Length frequency distribution shows a diverse age and size population structure with trophy-sized fish > 500 mm (Figure 7).

Trout Species
A combined total of 4,800 Brown Trout, Rainbow Trout, and Golden Trout were stocked in DCL in 2013. However, only one Rainbow Trout was collected during electrofishing sampling efforts primarily due to their pelagic, deeper water habitat preferences.

Discussion

Deep Creek Lake supports a popular Walleye fishery. Regulation modifications first implemented in 1993 (increased the minimum size limit from 355 mm to 381 mm) and 1995 (established a closed season from March 1 through April 15) have resulted in improved age and size structures as well as improved annual reproduction. The natural reproduction level in 2013 was the highest level recorded since 2004. The electrofishing and tournament capture samples both indicate that the majority of legal-size Walleye are between 381 and 425 mm TL, with occasional opportunities to catch trophy size fish. Walleye tested negative for VHS in 2013.

The Yellow Perch population in DCL is well balanced with stock (≥ 130 mm), quality (≥ 200 mm), preferred (≥ 250 mm), and memorable (≥ 300 mm) sized fish represented in the population. Reproductive success in 2013, described as the YOY seining index was similar to the mean value for years 2007 through 2012, indicating consistent annual reproduction rates. A 10 fish daily creel limit and 20 fish possession limit was implemented for DCL effective 1 January 2010. The regulation change was based on electrofishing sampling and creel census data gathered from angler interviews. It is expected to maintain and enhance the Yellow Perch population in DCL.

Smallmouth Bass are one of the most sought after gamefish species in DCL. Smallmouth Bass continue to maintain sustainable harvest and recruitment levels into older year-classes as evidenced by the diverse age and size structure observed in the electrofishing data. Smallmouth Bass was the third most abundant gamefish in DCL in 2013, however reproductive success was considered “poor”.

Largemouth Bass abundance in the 2013 electrofishing sample (N = 40) increased from 2012 (N = 12). In July 2010, the Maryland Department of the Environment determined that abnormal high water temperatures aided the bacterium *Aeromonas hydrophila* and a protozoan gill parasite to cause a large fish kill in DCL. Most DCL fish species were affected and an estimated 10,000 fish died. The observed lower abundance of Largemouth Bass in 2012 suggested that the 2010 fish kill may have had an adverse effect on the population size. In response, a corrective stocking of 10,000 Largemouth Bass fingerlings (source – Manning Hatchery) was conducted in 2012. The combination of stocking effort and two observed years of “good” reproduction are expected to improve Largemouth Bass abundance in DCL. Largemouth Bass tested negative for both VHS and LMBV in 2013.

Bluegills and Pumpkinseeds are common to abundant in DCL and the populations are characterized by having adequate quality size fish to provide angler interest. Chain Pickerel are very abundant; however angler interest in this species is relatively low in DCL. Golden Shiners were found to be the most abundant forage fish species in DCL. Common Carp are also abundant and attain very large sizes in DCL and there is growing angler interest in this species. Brown Trout, Rainbow Trout, and Golden Trout are stocked annually in DCL. Trout are adequately supported by well oxygenated coldwater in the hypolimnion during summer which allows for year-round survival and angling opportunities in all seasons.

Management recommendations

All project work objectives were accomplished during this study period; however further monitoring studies will be required to further assess and monitor the development of fish populations in DCL. Recommended studies for 2014 include:

- Conduct a comprehensive fish population survey to monitor the status of resident game and non-gamefish species including relative abundance, age and size structures, and reproductive indices.
- Obtain tournament capture data on Largemouth Bass, Smallmouth Bass, and Walleye.
- Continue annual adult Brown Trout and Rainbow Trout stocking, and consider increasing annual allocation if State trout production increases.

Table 1. A list of common names, scientific names, observed abundance estimate and relative abundance of sixteen fish species collected in Deep Creek Lake, 2013 (Robins *et al* 1991).

Common name	**Scientific name**	**Observed abundance Estimate or Pooled $CPUE_{60}$**
Common Carp	*Cyprinus carpio*	Common
Golden Shiner	*Notemigonus crysoleucas*	62
Yellow Bullhead	*Ameiurus natalis*	< 1
Brown Bullhead	*Ameiurus nebulosus*	< 1
Chain Pickerel	*Esox niger*	18
Rainbow Trout	*Oncorhynchus mykiss*	< 1
Brown Trout	*Salmo trutta*	Stocked, not collected
Rock Bass	*Ambloplites rupestris*	20
Pumpkinseed	*Lepomis gibbosus*	18
Bluegill	*Lepomis macrochirus*	56
Smallmouth Bass	*Micropterus dolomieu*	57
Largemouth Bass	*Micropterus salmoides*	12
Black Crappie	*Pomoxis nigromaculatus*	< 1
Johnny Darter	*Etheostoma nigrum*	Common*
Yellow Perch	*Perca flavescens*	88
Walleye	*Sander vitreus*	51
Total species = 16		

* collected in seine hauls only

Table 2. Summary of Walleye population indices in Deep Creek Lake, 2013.

<table>
<tr><th colspan="6">Pooled spring and fall electrofishing and tournament-capture data</th></tr>
<tr><td colspan="2">Indices</td><td>Overall</td><td>Stock$_{25}$</td><td>Quality$_{38}$</td><td>Preferred$_{51}$</td></tr>
<tr><td colspan="2">Wr (%)</td><td>80</td><td>80</td><td>78</td><td>72</td></tr>
<tr><td colspan="2">N</td><td>337</td><td>51</td><td>230</td><td>2</td></tr>
<tr><th colspan="6">Pooled spring and summer electrofishing data</th></tr>
<tr><td colspan="3">PSD$_{38}$ (%) with 95% CI</td><td colspan="2">RSD$_{51}$ with 95 % CI (%)</td><td>N</td></tr>
<tr><td colspan="3">66 $\pm$ 8</td><td colspan="2">0.6 $\pm$ 5</td><td>151</td></tr>
<tr><th colspan="6">Individual data sets</th></tr>
<tr><td>Sample</td><td>Mean TL mm (range)</td><td>Mean W g (range)</td><td>CPUE$_{60}$</td><td colspan="2">N</td></tr>
<tr><td>Spring Nighttime</td><td>397 (275-534)</td><td>525 (166-1188)</td><td>192</td><td colspan="2">144</td></tr>
<tr><td>Summer Nighttime</td><td>353 (190-500)</td><td>420 (56-1068)</td><td>2.4</td><td colspan="2">8</td></tr>
<tr><td>Fall YOY</td><td>153 (135-180)</td><td>27 (18-42)</td><td>168</td><td colspan="2">84</td></tr>
<tr><td>Spring Tournament</td><td>433 (384-547)</td><td>683 (436-1298)</td><td>4 fish per boat</td><td colspan="2">132</td></tr>
</table>

Table 3. Walleye age by otolith method, Deep Creek Lake, 2013.

Age	Mean TL (mm) (range)	Mean W (g) (range)	N
2+	354 (345-370)	352 (334-386)	5
3+	395	516	1
4+	393	544	1
5+	443 (425-460)	741 (622-860)	2
6+	443 (430-455)	748 (700-796)	2
7+	463 (430-496)	858 (668-1048)	2

Table 4. Summary of Yellow Perch population indices in Deep Creek Lake, 2013.

Indices	Value	N
Wr, overall (%)	89	141
Wr, stock (%)	92	55
Wr, quality (%)	92	35
Wr, preferred (%)	85	31
Wr, memorable (%)	81	19
PSD_{20} (%)	58 $\pm$ 9	147
RSD_{25} (%)	34 $\pm$ 9	147
Mean TL (mm) (range)	221 (92-350)	151
Mean W (g) (range)	176 (22-564)	141
$CPUE_{60}$	88	294
Seining index	20/30.5m	368

Table 5. Summary of Smallmouth Bass population indices in Deep Creek Lake, 2013.

Indices	Value	N
Wr, overall (%)	88	188
Wr, stock (%)	91	110
Wr, quality (%)	83	57
Wr, preferred (%)	81	11
PSD_{28} (%)	38 $\pm$ 8	178
RSD_{35} (%)	6.2 $\pm$ 4	178
Mean TL (mm) of fish $\geq$ 305 mm (range)	336 (305-412)	53
Mean W (g) of fish $\geq$ 305 mm (range)	453 (294-898)	53
$CPUE_{60}$	57	189
Seining index	0.4/30.5 m	8

Table 6. Summary of Largemouth Bass population indices in Deep Creek Lake, 2013.

Indices	**Value**	**N**
Wr, overall (%)	93	40
Wr, stock (%)	98	10
Wr, quality (%)	89	19
Wr, preferred (%)	93	10
Wr, memorable (%)	92	1
PSD_{30}	75 $\pm$ 16	40
RSD_{38}	28 $\pm$ 17	40
Mean TL (mm) of fish $\geq$ 305 mm (range)	375 (310-560)	29
Mean W (g) of fish $\geq$ 305 mm (range)	782 (366-2608)	29
$CPUE_{60}$	12	40
YOY index	3.1/30.5m	56

Table 7. Largemouth Bass age by otolith method, Deep Creek Lake, 2013.

Age	**Mean TL (mm) (range)**	**Mean W (g) (range)**	**N**
2+	250	198	1
3+	354 (330-372)	627 (484-738)	8
4+	370 (355-385)	724 (678-774)	3
5+	395	802	1

Table 8. Summary of Bluegill population indices in Deep Creek Lake, 2013.

Indices	**Value**	**N**
Wr, overall (%)	99	187
Wr, stock (%)	99	30
Wr, quality (%)	98	117
Wr, preferred (%)	101	34
Wr, memorable (%)	100	6
PSD_{15}	84 $\pm$ 6	187
RSD_{20}	21 $\pm$ 7	187
Mean TL (mm) (range)	175 (113-255)	187
Mean W (g) (range)	132 (24-424)	187
$CPUE_{60}$	56	187

Table 9. Summary of Pumpkinseed population indices in Deep Creek Lake, 2013.

Indices	**Value**	**N**
Wr, overall (%)	109	59
Wr, stock (%)	107	11
Wr, quality (%)	110	33
Wr, preferred (%)	109	15
PSD_{15}	82 $\pm$ 12	60
RSD_{20}	27 $\pm$ 13	60
Mean TL (mm) (range)	177 (110-225)	60
Mean W (g) (range)	144 (30-306)	59
$CPUE_{60}$	18	60

Table 10. Summary of Chain Pickerel population indices in Deep Creek Lake, 2013.

Indices	**Value**	**N**
PSD_{38}	55 $\pm$ 16	49
RSD_{51}	12 $\pm$ 11	49
Mean TL (mm) (range)	394 (230-640)	50
Mean W (g) (range)	372 (62-1598)	50
$CPUE_{60}$	18	60

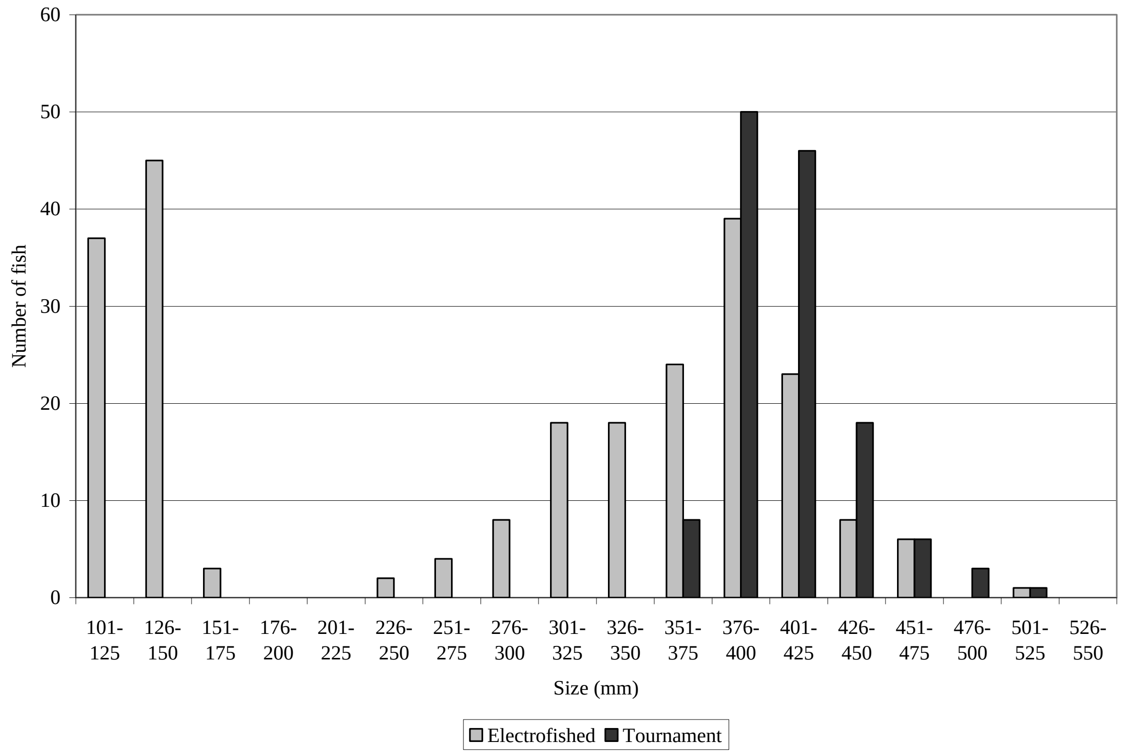


Figure 1. Length frequency distribution of Walleye collected by electrofishing (N=236) and tournament (N=132) in Deep Creek Lake, 2013.

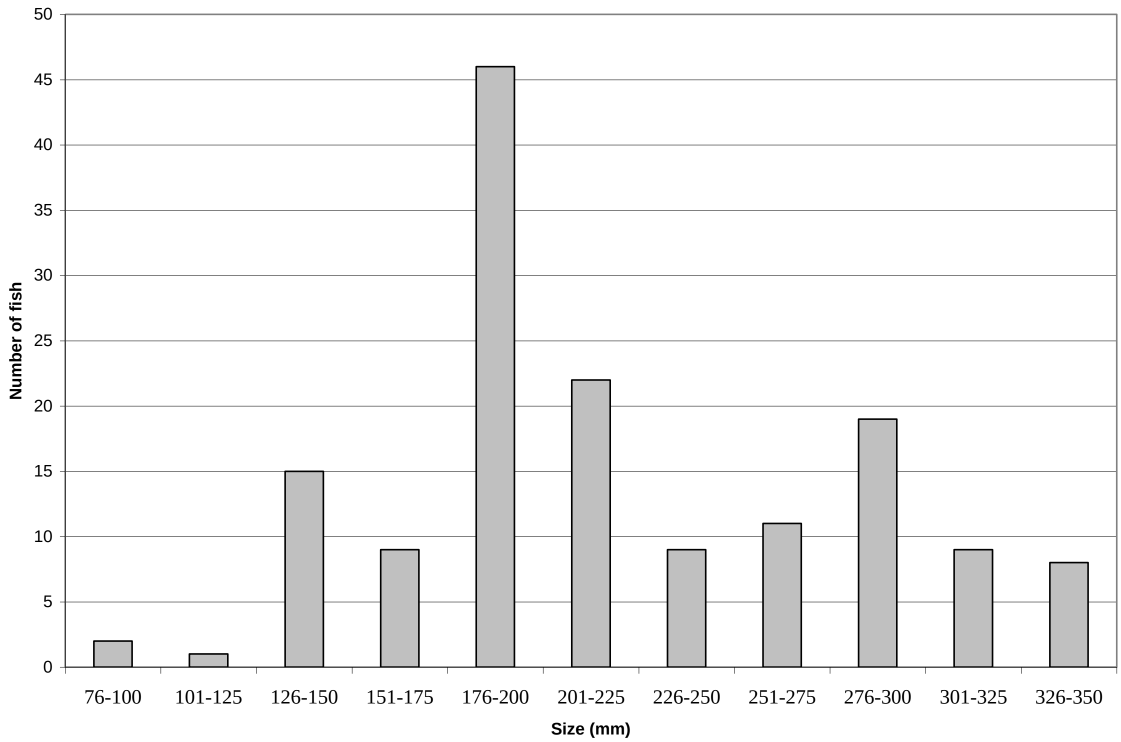


Figure 2. Length frequency distribution of Yellow Perch collected by electrofishing (N=151) in Deep Creek Lake, 2013.

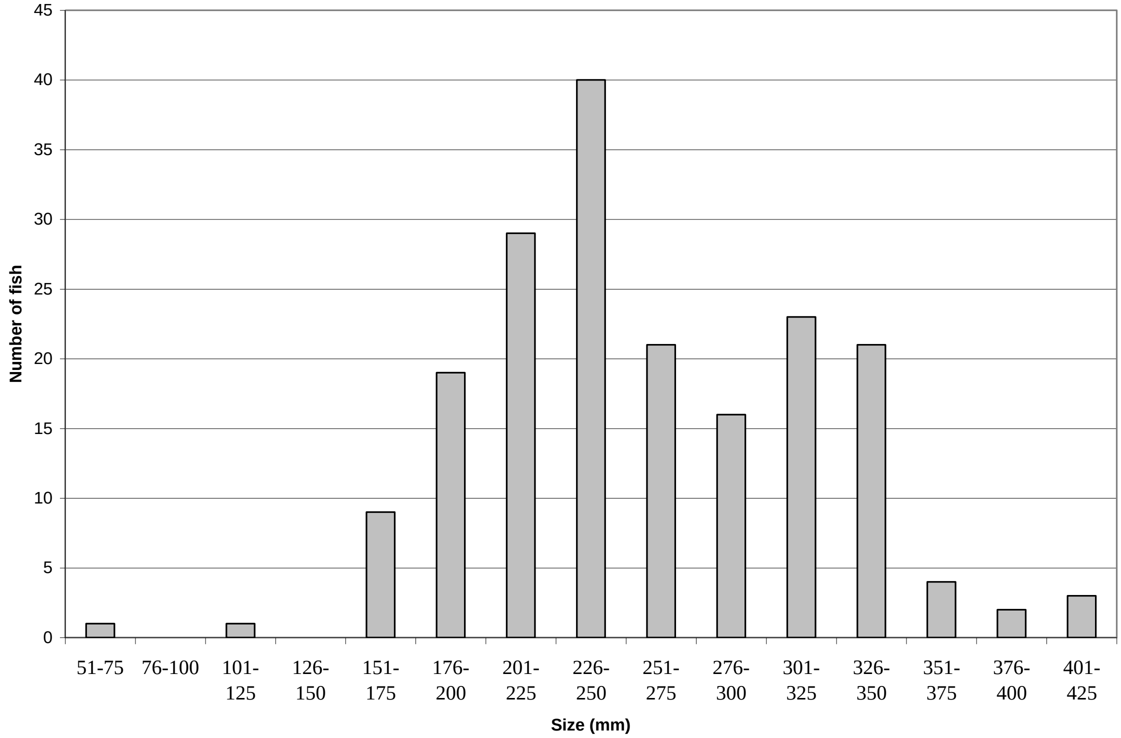


Figure 3. Length frequency distribution of Smallmouth Bass collected by electrofishing (N=189) in Deep Creek Lake, 2013.

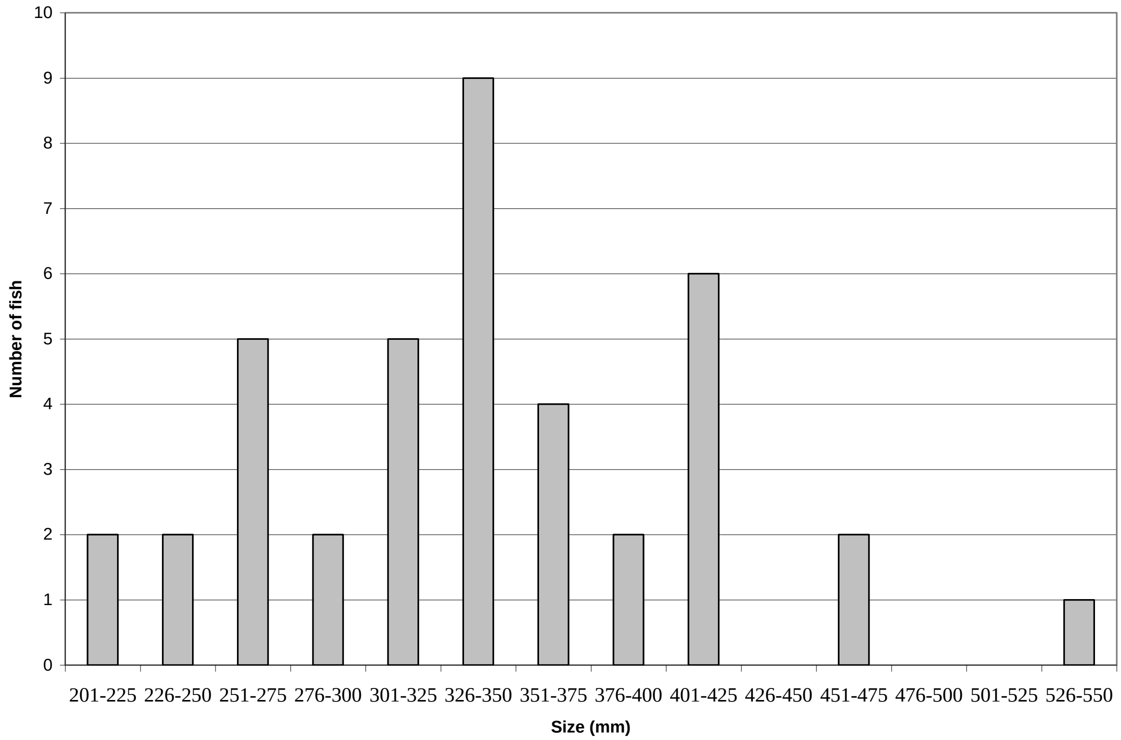


Figure 4. Length frequency distribution of Largemouth Bass collected by electrofishing (N=40) in Deep Creek Lake, 2013.

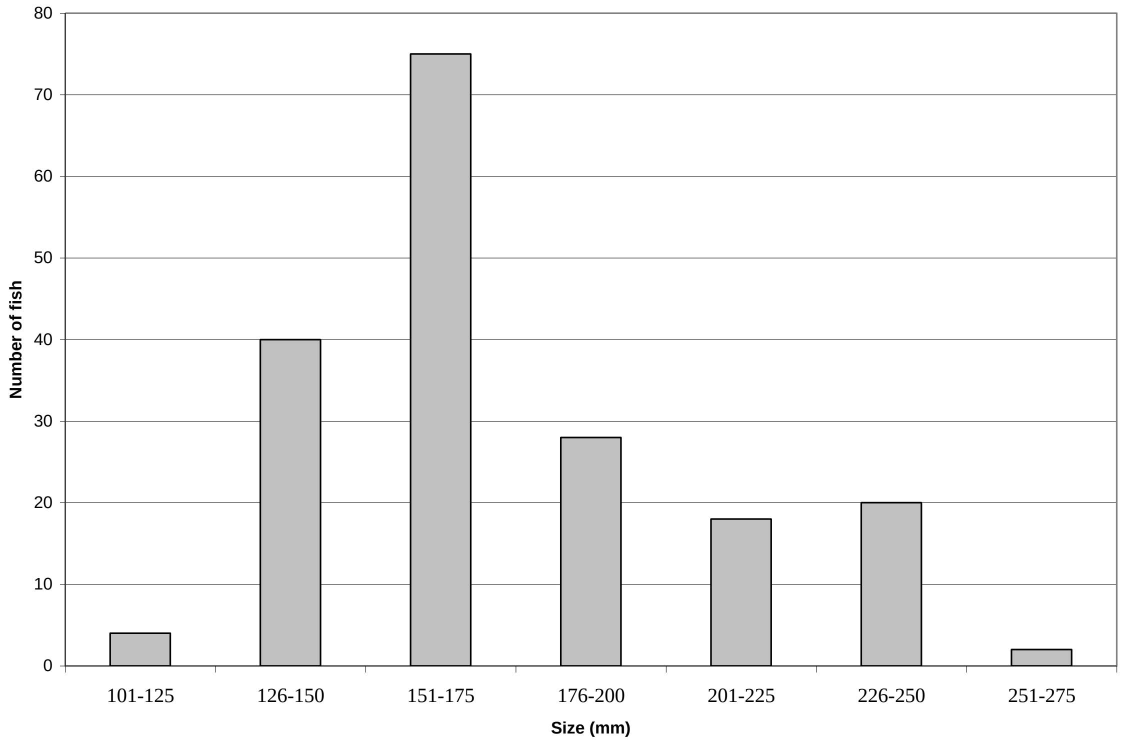


Figure 5. Length frequency distribution of Bluegill collected by electrofishing (N=187) in Deep Creek Lake, 2013.

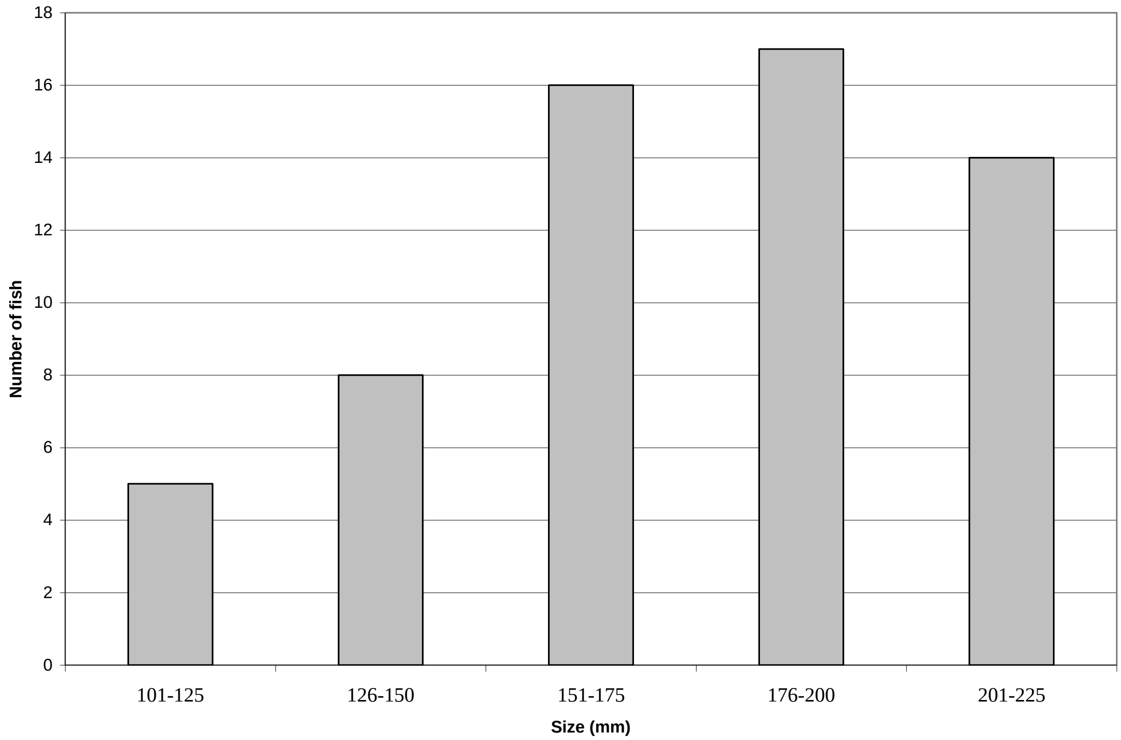


Figure 6. Length frequency distribution of Pumpkinseed collected by electrofishing (N=60) in Deep Creek Lake, 2013.

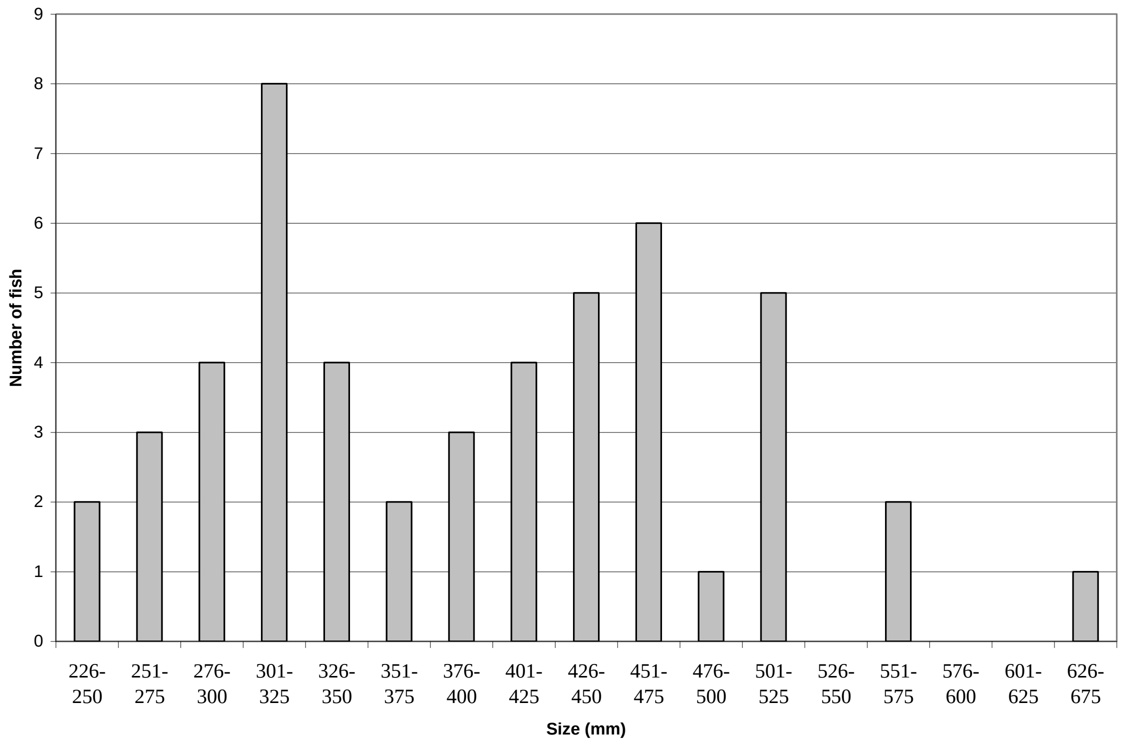


Figure 7. Length frequency distribution of Chain Pickerel collected by electrofishing (N=50) in Deep Creek Lake, 2013.

Johnsons Pond
(Wicomico County)

Introduction

Johnsons Pond at 43.7 hectares is one of the largest impoundments on Maryland's eastern shore. Maximum depth of the pond is approximately three meters. Johnsons Pond is fed by multiple tributaries; the two principle tributaries form the lake's north and east forks. These forks form a lower "main pool" which embodies the balance of the lake. The east fork is relatively shallow and featureless with the exception of rooted aquatic vegetation and a small amount of submerged timber. The north fork has better depth and quality habitat including trees, stumps, docks and rooted aquatic vegetation. The eastern shoreline of the main pool has steep banks with many trees in the water however; most of the habitat in the lower third of the pond exists on the western shoreline and consists of trees, brush and limbs. There are numerous private docks located throughout the pond that provide excellent fish habitat.

Historically Johnsons Pond has been one of the most productive Largemouth Bass fisheries on the Eastern Shore. It was characterized by high catch rates resulting from dependable annual recruitment. Johnsons Pond has been managed under "Trophy Bass Regulations" since 1990. The regulation allows for harvest of smaller bass, while preventing harvest of fish within a protected 11-15 inch slot. One bass per angler larger than 15 inches can be harvested per day.

Objective

The purpose of this study was to:

- Determine fish species composition, proportional stock density (PSD), relative weight (Wr), length frequency distribution, and relative abundance of important gamefish and panfish species.

Methods

Assessments of the fisheries resources within Johnsons Pond were conducted on October 8, 2013 using an 18 foot Smith-Root 5kw electrofishing boat. Five 600 second samples were conducted that encompassed a major portion of the lower lake perimeter. More detailed descriptions of methods can be found under the Study II, Job 2 Methods section of this report. Upper areas of the lake cannot be sampled with traditional gear due to the shallow depth, abundance of woody debris and rooted vegetation. All Largemouth Bass were collected, measured to total length (mm TL), and weighed (g). Mean lengths and weights were calculated using only adult fish >150 mm (Reynolds and Babb 1978).

All Bluegill Sunfish encountered during the first 100 seconds of each sample were collected and measured for total length (mm TL). Any Chain Pickerel and Black Crappie encountered were also collected and measured. Population specific data were recorded for analysis of bass and bluegill stocks as described in the Study II, Job 2 Methods section referenced above. Population or community parameters that were addressed included: total length (mm TL), weight (g), growth, relative abundance and size and age structure. Condition of the stock was determined by examining relative weight (Wr) (Wege and Anderson 1978). Stock structure was addressed by computing the index of proportional stock density (PSD) and relative stock density (RSD) (Weithman et al. 1979). Relative abundance was determined by calculating the catch per unit of effort statistic (CPUE) and reported as fish per hour.

Results

Largemouth Bass data collected during the 2013 survey were quite different from the 2010 survey in both abundance and size structure (Figure 1). CPUE for stock size bass (>200mm) dropped significantly from 118+46 in 2010 to 47±6 in 2013. Largemouth Bass PSD was 69%±18 and was above the recommended range of 40-60% (Reynolds and Babb 1978). This was likely attributed to poor reproduction in recent years. The data suggest that reproduction was again poor in 2013, as young-of-year (YOY) bass comprised only 7% of the total catch (N=3). Mean relative weights for some 25mm length intervals were below the optimal range 95-100% (Figure 2) (Wege and Anderson 1978).

The desirable range of PSD for prey is 20 to 50% where the management objective is good bass fishing from waters comprised mainly of Largemouth Bass and Bluegill Sunfish (Weithman et al. 1979). Bluegill Sunfish PSD was 15%±10 in 2013. This was below the recommended range but higher than survey results observed in 2007 or 2010. No bluegills of “preferred” length (> 200 mm) were collected in 2013 (Figure 3).

Chain Pickerel and Black Crappie were not frequently encountered in the 2013 survey. Some Chain Pickerel were quite large and ranged in size from 213-530mm. Relative abundance estimates for all fish species encountered appear in Table 1.

Discussion

Overall, the Largemouth Bass population appears to have shifted from one dominated by smaller, younger individuals to one dominated by older, larger individuals. Poor reproduction observed in 2013 is not expected to change this trend. Although there appears to be suitable forage within the pond, low relative weights of bass are concerning since Golden Shiners and Gizzard Shad should compensate for any prey deficiencies in the bluegill population.

Recommendations

Given the poor reproduction of Largemouth Bass in 2013 staff will plan to stock bass into Johnsons Pond in 2014. Bluegill Sunfish will also be stocked if available. Maryland’s “Trophy Bass Regulations” are designed to be used where surplus numbers of smaller bass cause density dependant problems within the population. If Johnsons Pond can no longer support consistent reproduction, perhaps a regulation change should be considered.

Table 1. Common and scientific names, and observed abundance estimates for fish species sampled from Johnsons Pond, Fall 2013.

Common Name	**Scientific Name**	**General Occurrence**
Largemouth Bass	*Micropterus salmoides*	Common
Bluegill Sunfish	*Lepomis macrochirus*	Common
Gizzard Shad	*Dorosoma cepedianum*	Abundant
Creek Chubsucker	*Erimyzon oblongus*	Common
Brown Bullhead	*Ameiurus nebulosus*	Rare
Golden Shiner	*Notemigonus crysoleucas*	Common
White Perch	*Morone americana*	Common
Yellow Perch	*Perca flavescens*	Rare
Common Carp	*Cyprinus carpio*	Common
Redear Sunfish	*Lepomis microlophus*	Rare
Black Crappie	*Pomoxis nigromaculatus*	Common
Chain Pickerel	*Esox niger*	Common

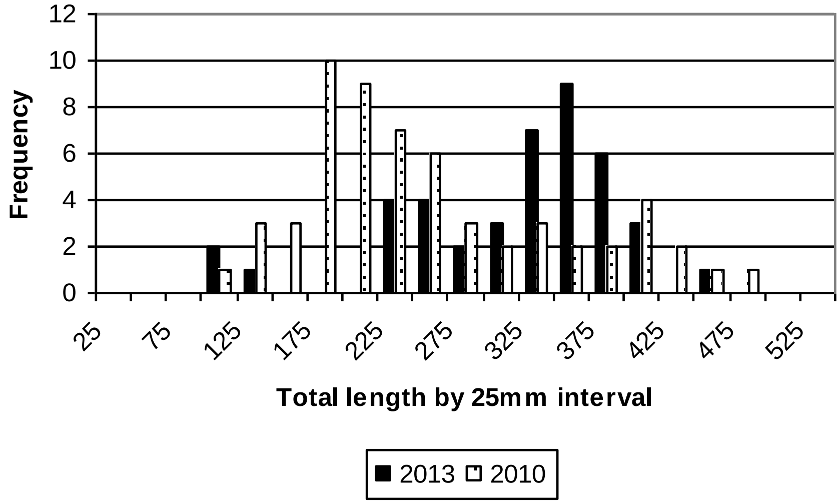


Figure 1. Length-frequency distribution of Largemouth Bass collected from Johnsons Pond, Fall 2010 and 2013.

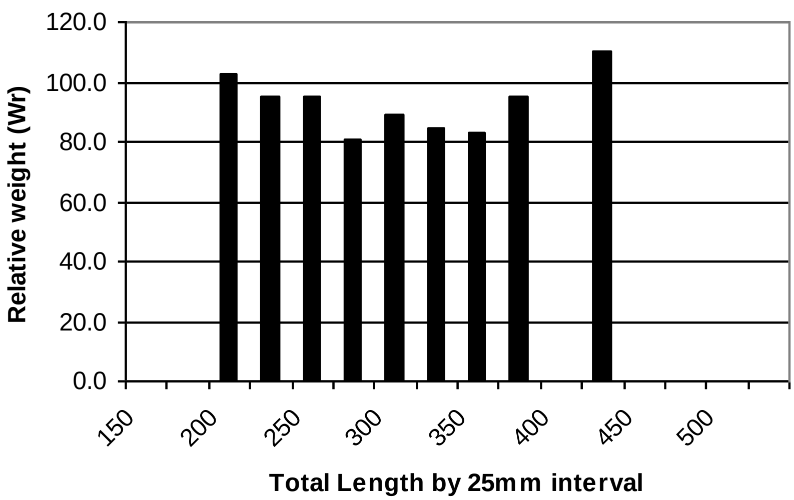


Figure 2. Relative weights for Largemouth Bass collected from Johnsons Pond, Fall 2010 and 2013.

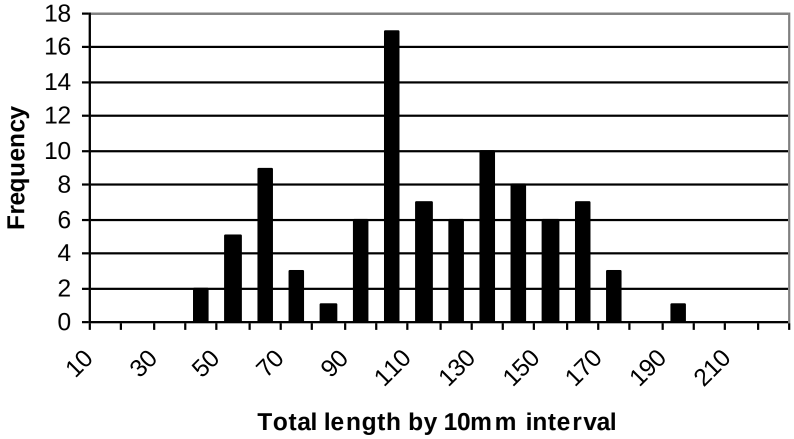


Figure 3. Length-frequency distribution of Bluegill Sunfish collected from Johnsons Pond, Fall 2013.

Loch Raven Reservoir
(Baltimore County)

Introduction

Loch Raven Reservoir, a 971 hectare (2400 acre) impoundment, is located in the Piedmont region of central Maryland. The reservoir is owned and maintained by the City of Baltimore Department of Public Works. A variety of sportfish species provide fishing opportunities. Fishing is permitted from the shoreline and for boats that possess a seasonal Baltimore City Reservoir boat permit. Boat propulsion is limited to rowing, paddling, or battery powered motors. The reservoir has one boat ramp/rental facility operated by Baltimore County Recreation Department located on Dulaney Valley Road. Additional watershed usage regulations may be found in an annual publication by the City of Baltimore Department of Public Works entitled "Pocket Guide to Boating and Fishing: Reservoirs."

Objectives

The black bass population is the primary focus of sampling efforts and management. Electrofishing surveys are conducted to assess the population structure of black bass and other gamefish. The objective of this survey was to obtain fish population information on a previously surveyed impoundment to monitor for changes that may require immediate or future corrective fish management action.

Methods

A 5.5 m (18 ft) Smith-Root electrofishing boat equipped with a 5 kW electrical generator was used for the electrofishing sampling. The electrical output was generally set between 8 and 12 amps, with a frequency of 60 pulses /second direct current. Electrofishing Catch-per-unit-effort ($CPUE_{60}$) rates were based upon actual shocking time. Survey sampling and data analysis methods follow those described in the Study II Job 3 Methods section under Composite Site Electrofishing.

Results

The fall electrofishing survey was conducted over three nights: 15, 16 and 17 October 2013. The shoreline was divided into 153 potential electrofishing stations (400m). Fifteen electrofishing stations (comprising 10% of all potential stations) were completed totaling 152 minutes. Three 600 second fish community samples were taken within the fifteen samples. The Largemouth and Smallmouth Bass populations were the focus of the survey. The water temperature during the 2013 sample was between 15.8 and 19.3° C (60.5 – 67.75° F) which was barely outside the recommended range of 16-22° C (Betross and Willis, 1988).

The Largemouth Bass length frequency histogram (Figure 1) shows a population with a strong year class corresponding with age 1, followed by a large proportion of the population in the 300 to 450 mm range. The Proportional Stock Density (PSD) value of 86 (95% C.I. 63-109) (Table 1) well exceeds the recommended range of 40-60 for bass in a balanced population (Reynolds and Babb, 1978). The Relative Stock Density (RSD) value of 61 (95% C.I. 39-83) well exceeded the suggested 10-25 percent range for bass in a balanced population (Anderson, 1980). Relative weights for Largemouth Bass were in and above the optimal range (95-100) for bass (Figure 3) (Wege and Anderson, 1978). Population indices for Largemouth Bass appear in Table 1.

Only four Smallmouth Bass were collected during the study. This sample size is too small to draw any valid conclusions. In the history of Loch Raven Reservoir, Smallmouth Bass numbers have never been as high as Largemouth Bass numbers. The habitat is much better suited for a recreational Largemouth Bass fishery.

The Chain Pickerel length frequency histogram (Figure 2) shows a population with a strong year class corresponding with age 1 and is followed by a large proportion of the population in the 325 to 475 mm range. The Proportional Stock Density (PSD) for Chain Pickerel was 74 (95% C.I. 58-90) (Table 2). Population indices for Chain Pickerel appear in Table 2.

The Bluegill PSD of 35 (31-39) (95% C.I.) is within the range of 20 to 50% recommended for a prey species (Weithman et al., 1979). The 2013 Bluegill PSD shows a significant increase over the Bluegill PSD observed in the 2008 survey. The 2008 survey showed a PSD of 22 (16-28) (95% C.I.) (MD DNR, 2008). The relative abundance of other species is described in Table 4. The Gizzard Shad CPUE was based on three 600 second electrofishing runs where every Gizzard Shad was collected. The Gizzard Shad CPUE for 2013 was 60; this value is significantly less than the CPUE of 84 that was observed in the 2008 survey (MD DNR, 2008). Redear Sunfish had a PSD of 58 (41-75) (95% C.I.) in Loch Raven Reservoir in 2013. White Perch, Yellow Perch, Black Crappie, and White Crappie are other recreationally important panfish in Loch Raven Reservoir. Qualitative panfish data (Table 4) was calculated based on the 15 electrofishing runs.

Discussion

Largemouth Bass are significantly more abundant than Smallmouth Bass in Loch Raven Reservoir; the Largemouth Bass total CPUE is 31 times as large as the Smallmouth Bass total CPUE of 1.58. The PSD of Largemouth Bass is higher than the recommended 40-60 range (Reynolds and Babb, 1978). The Largemouth Bass relative stock density (RSD) value of 61 (95% C.I. 39-83) indicates an excellent fishery for large bass in Loch Raven Reservoir. The length frequency histogram for Largemouth Bass (Figure 1) displays diverse year classes and good recruitment of YOY fish for 2013.

Relative weights for Largemouth Bass (Figure 3) are higher than those obtained from Prettyboy Reservoir in 2011 and very similar to those obtained from Liberty Reservoir in

2012 (MD DNR, 2011, 2012). Mean CPUE values for substock and quality size Largemouth Bass in Loch Raven Reservoir are very similar to those observed in the 2008 survey of Loch Raven Reservoir. The Mean CPUE for stock size fish in 2013 was 8; this value is much lower than the mean CPUE value of 46 in 2008 (MD DNR, 2008). Smallmouth Bass CPUE values in Loch Raven were much lower than the values from Prettyboy and Liberty Reservoirs (MD DNR, 2011, 2012). Chain Pickerel were sampled extensively during the 2013 survey of Loch Raven Reservoir. Although there was a limited sample size of Chain Pickerel collected in the 2008 survey, it appears that numbers have increased since then. The Chain Pickerel total mean CPUE value was 70 during the 2013 survey. This number is much higher than the total mean CPUE value of 39 which was observed in the 2008 Loch Raven Reservoir survey (MD DNR, 2008). The Chain Pickerel PSD was 75 in the 2008 survey and 74 in the 2013 survey (Table 2) (MD DNR, 2008). *Hydrilla* growth in Loch Raven will help to provide great spawning habitat and juvenile habitat for Chain Pickerel in the reservoir. Chain Pickerel will continue to be sampled extensively in the future in order to further assess what their impact might be on the Largemouth Bass fishery.

Overall, Loch Raven should continue to provide an excellent recreational fishery for Largemouth Bass. Smallmouth bass will be an infrequent bonus fish for anglers.
The panfish community is dominated by Bluegill in Loch Raven Reservoir. Yellow Perch and Redbreast Sunfish population data (Table 4) indicate a good fishery for these species. Chain Pickerel are present in most of the reservoir and are providing a good opportunity for anglers to catch quality-size Pickerel. White Perch are an important panfish found in the reservoir but their population was not quantified in this survey. Electrofishing during the spring spawning season for White Perch is the preferred time to sample large numbers of this species.

Gizzard Shad were first documented in Loch Raven in 2006 during a spring electrofishing survey. They are now found throughout the reservoir and in 2008 it was documented that they ranged upstream in the Gunpowder Falls to at least the confluence with Little Falls. The three fish community samples documented Gizzard Shad abundance during the 2013 survey. The abundance of Gizzard Shad during the 2013 survey was 67 fish per hour. This number is lower than the 84 fish per hour that was documented in 2008 (MD DNR, 2008). After the 2008 survey, there was concern that an expanding Gizzard Shad population could become a nuisance in Loch Raven Reservoir. The 2013 Loch Raven Reservoir survey indicates that the Gizzard Shad population has not yet become a nuisance and has perhaps been limited by the abundant population of predatory fish.

Recommendations

- Conduct electrofishing surveys to assess population structure of Largemouth Bass, Smallmouth Bass and panfish.
- Continue to monitor the Chain Pickerel and Gizzard Shad populations in Loch Raven Reservoir.

Table 1. Largemouth Bass Pooled Population Parameters collected by MD DNR Fifteen 600-second electrofishing runs, Loch Raven Reservoir, Fall 2013.

	Number	**PSD (95% C.I.)**	**RSD (35/38)**	**Total Substock $CPUE_{Hr}$**	**Total Stock $CPUE_{Hr}$**	**Total Quality $CPUE_{Hr}$**	**Total $CPUE_{Hr}$**
Largemouth Bass	124	86 (63-109)	61 (39-83)				
Mean (95% C.I.)				16 (9-23)	5 (3-7)	28 (20-36)	49 (37-61)
Geometric Mean				15	8	23	44

Table 2. Chain Pickerel Pooled Population Parameters collected by MD DNR – Fifteen 600-second electrofishing runs, Loch Raven Reservoir, Fall 2013.

	Number	**PSD (95% C.I.)**	**RSD (35/38)**	**Total Substock $CPUE_{Hr}$**	**Total Stock $CPUE_{Hr}$**	**Total Quality $CPUE_{Hr}$**	**Total $CPUE_{Hr}$**
Chain Pickerel	197	74 (58-90)	7 (0-23)				
Mean (95% C.I.)				24 (12-36)	14 (8-20)	40 (22-58)	78 (51-105)
Geometric Mean				20	12	35	70

Table 3. Redear Sunfish Pooled Population Parameters collected by MD DNR – Three 600-second electrofishing runs, Loch Raven Reservoir, Fall 2013.

	Number	**PSD (95% C.I.)**	**RSD (35/38)**	**Total Substock $CPUE_{Hr}$**	**Total Stock $CPUE_{Hr}$**	**Total Quality $CPUE_{Hr}$**	**Total $CPUE_{Hr}$**
Redear Sunfish	19	58 (41-75)	11 (0-27)				
Mean (95% C.I.)				0	14 (4-24)	22 (1-43)	36 (24-48)
Geometric Mean				0	12	16	35

Table 4. Common and scientific names and relative abundance of species collected by MD DNR electrofishing surveys, Loch Raven Reservoir 2013.

Common	**Scientific Name**	**Abundance[1]**
Common Carp	*Cyprinus carpio*	Scarce
Gizzard Shad	*Dorosoma cepedianum*	Abundant
Golden Shiner	*Notemigonus crysoleucas*	Scarce
White Sucker	*Catostomus commersonii*	Common
Yellow Bullhead	*Ameiurus natalis*	Rare
White Perch	*Morone americana*	Scarce
Redear Sunfish	*Lepomis microlophus*	Rare
Green Sunfish	*Lepomis cyanellus*	Rare
Bluegill	*Lepomis macrochirus*	Abundant
American Eel	*Anguilla rostrata*	Rare
Smallmouth Bass	*Micropterus dolomieu*	Rare
Largemouth Bass	*Micropterus salmoides*	Abundant
Black Crappie	*Pomoxis nigromaculatus*	Rare
White Crappie	*Pomoxis annularis*	Rare
Yellow Perch	*Perca flavescens*	Common
Chain Pickerel	*Esox Niger*	Abundant
Pumpkinseed	*Lepomis gibbosus*	Rare

[1]Abundance key: rare 1-5 individuals, scarce 6-25 individuals, common 26-100 individuals, abundant >100 individuals

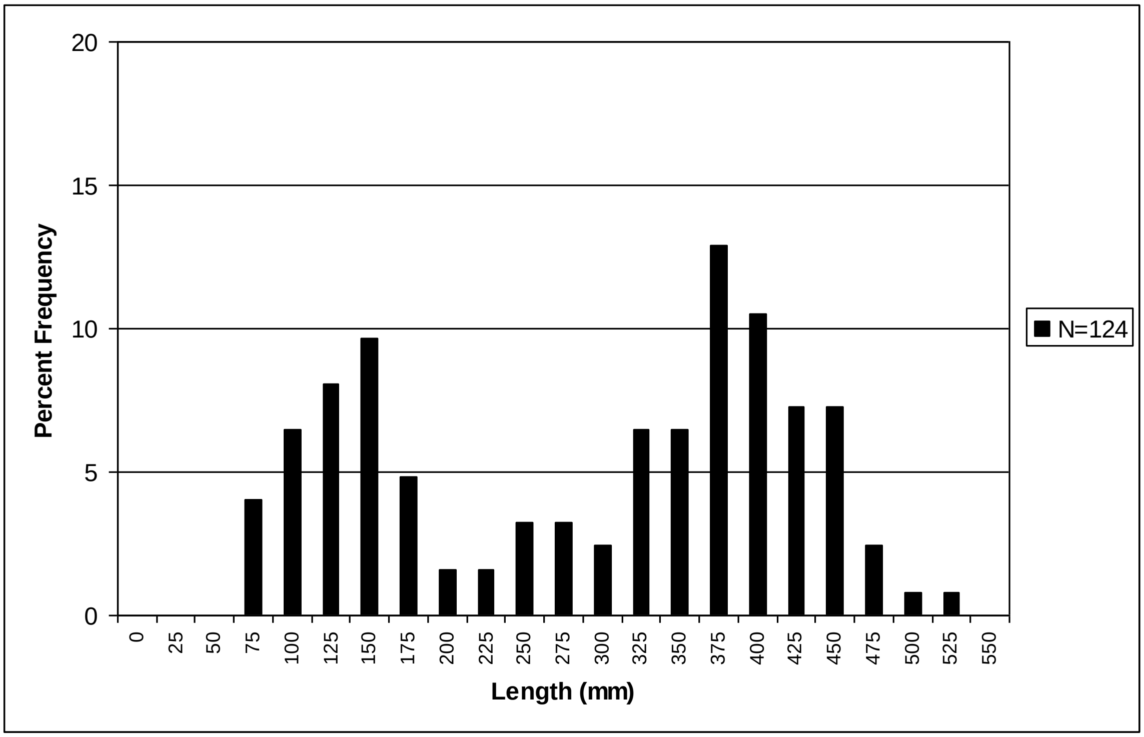


Figure 1. Length Frequency Distribution of Largemouth Bass in Loch Raven Reservoir, Fall 2013.

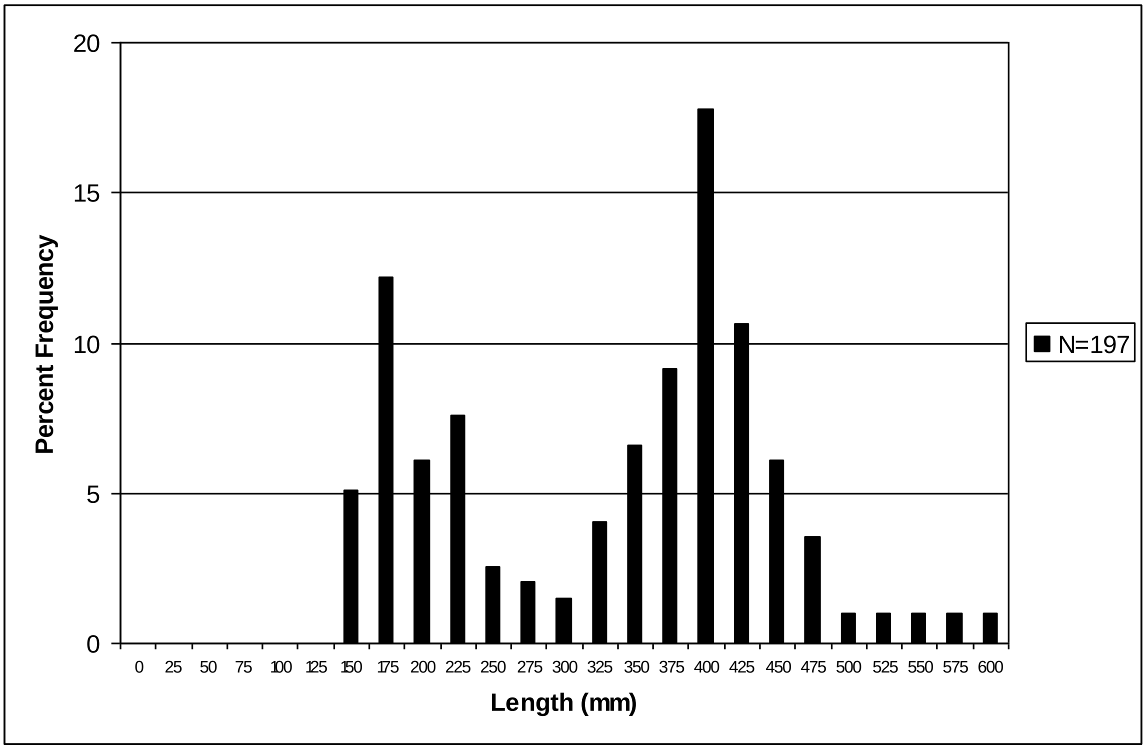


Figure 2. Length Frequency Distribution of Chain Pickerel in Loch Raven Reservoir, Fall 2013.

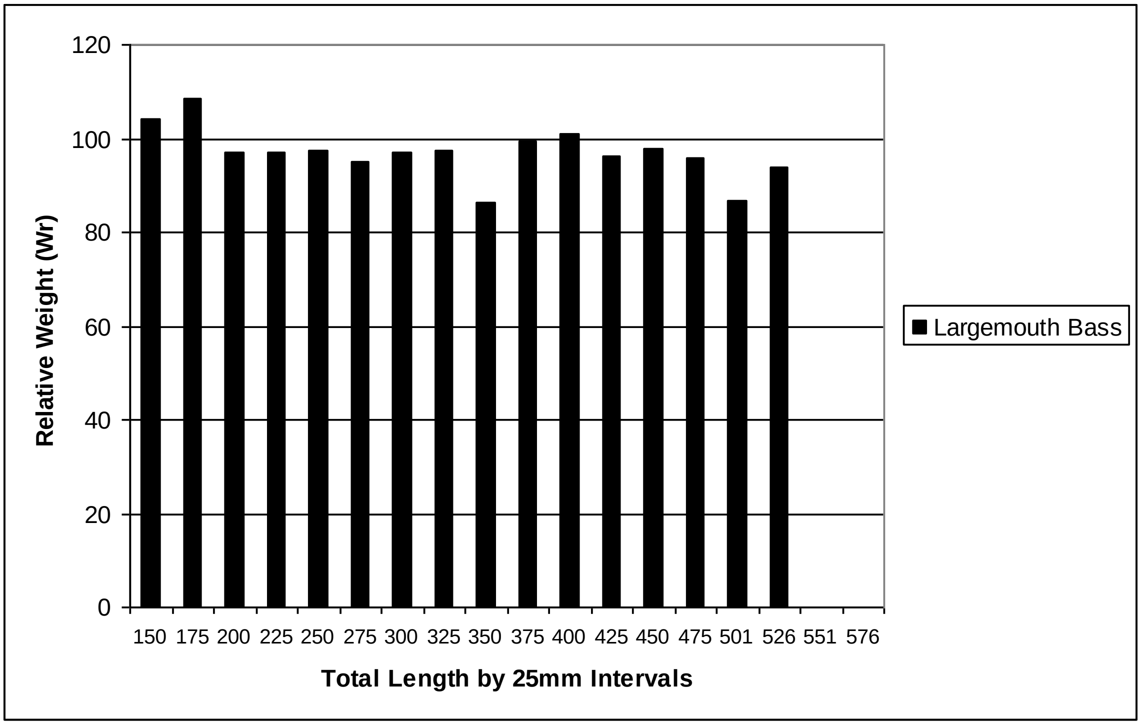


Figure 3. Relative Weights for Largemouth Bass collected by MD DNR in Loch Raven Reservoir, Fall 2013.

Savage River Reservoir
(Garrett County)

Introduction

The Savage River Reservoir is an oligotrophic 142-hectare (350 acre), maximum depth of 46 meters (150 ft) impoundment on the Savage River located in Garrett County, Maryland. The watershed upstream of the dam is about 105 square miles, mostly within the Savage River State Forest. The Savage River Reservoir, operated by the Upper Potomac River Commission, was completed in 1952 for flood control and domestic water supply. The Savage River Reservoir is a popular fishing destination and public access is allowed around the entire shoreline. Public boat launches are located at Big Run State Park, Dry Run, and near the dam breast. Boats are limited to electric motors. The Savage River Reservoir currently supports at least 13 fish species including diverse warmwater, coolwater, and coldwater fish species. Warmwater gamefish and panfish are managed under Maryland's statewide regulations and trout are managed under Put and Take regulations as described in the 2013 Maryland Freshwater Sportfishing Guide (MD DNR 2013).

In 2009 the Savage River Reservoir was drained to replace two intake gates which were not operational. The inoperative gates presented a serious problem with flood control for the downstream communities. Salvage and recovery of the reservoir fish population in 2009 was deemed unfeasible due to several reasons. Lack of a holding area for the fish during the drawdown period was the major reason. It is not a good practice to transfer adult fish from one waterbody to another waterbody that already contains an established fish community. Any introduction may upset the population balance as well as fish health concerns were factors in this decision. The reservoir's fish population was expected to cease to exist once the reservoir was completely drained. A description of an emergency draining of the Savage River Reservoir during January 1963 indicated that there were few if any pools remaining that could support fish life. Observations in 2009 also showed very little areas in the drained reservoir that contained adequate water depth to support significant fish numbers. In 2010 the Savage River Reservoir intake gates were repaired and the dam was operating at full pool by March. Re-stocking efforts in the Savage River Reservoir have been completed as of 2013. Totals are as follows; Largemouth Bass (38,600), Walleye (895,000), Bluegill (183,780), Black Crappie (49,500), and Redear Sunfish (9,120).

Objective

The purpose of this study was to:

- Determine fish species composition, observed abundance estimates, and relative abundance.
- Determine proportional stock density (PSD), relative stock density (RSD) and relative weight (Wr), and size distribution of gamefish and panfish species.
- Determine reproductive success of the reservoir's resident fish species.

Methods

Fish community survey
A Smith-Root SR-16H 5.0 kw, pulsed DC electrofishing boat was used to sample six randomly chosen sites on 5 May 2013 for fish species composition and relative abundance. Eight stations were sampled in 2009. Each station was sampled for 600 seconds of electrofishing effort. Fish were identified to species, measured for total length (TL) in mm, and weighed to the nearest gram. Relative abundance of fish species was recorded as catch per unit of electrofishing effort ($CPUE_{60}$/fish per hour). Observed abundance estimates were derived from sample size and fish were rated as abundant (>100 individuals), common (5-100 individuals), or scarce (< 5 individuals). Proportional stock density (PSD) and relative stock density (RSD) were calculated using methods described by Anderson (1980). Confidence intervals for proportional stock density and relative stock density were calculated using the formula described by Gustafson (1988). Relative weight (Wr), a measure of fish condition, was calculated using methods described by Anderson (1980).

Juvenile fish survey
A 15-meter seine net was used to collect YOY black bass at seven randomly chosen stations on 31 July 2013. Abundance indices were reported as the number of young of year (YOY) per 30.5 m of shoreline. A qualitative value for black bass was assigned based on the shoreline-seining index described by MD DNR (2000). Other fish species collected in the seine hauls were also recorded.

Results

Fish community
The list of common names, scientific names, observed abundance estimates, and pooled $CPUE_{60}$ abundance of fish species collected in Savage River Reservoir for years 2009 and 2013 is contained in Table 1. Thirteen fish species were collected during 2013 compared to the seventeen species collected in 2009. Of the fish absent from the 2013 sample, most were riverine species that are common in the Savage River upstream of the reservoir. Maintenance stocking for the Savage River Reservoir for years 2010 through 2013 are contained in Table 2.

Largemouth Bass
Summaries of Largemouth Bass population data for 2009 and 2013 are contained in Table 3. The relative abundance was lower in 2013 compared to 2009 (Table 1). The Wrs in all size categories for both years were less than 95 to 100% range of a balanced population suggested by Wege and Anderson (1978). The PSD_{30} and RSD_{38} were above the 40 to 60% optimal range in both years (Anderson and Weithman 1978). The length

frequency distribution for years 2009 and 2013 are presented in Figure 1. Sample size in 2009 (N = 110) was greater than the 2013 sample size (N = 14), however the 2013 length frequency distribution shows multiple year classes with fish measuring up to 473 mm TL. A total of 38,600 fingerling Largemouth Bass were stocked in the reservoir in 2010 – 2012 in order to re-establish the Largemouth Bass fishery (Table 2). The YOY index for 2013 indicated "excellent" reproduction, indicating a self-sustaining population has been established.

Smallmouth Bass

Summaries of Smallmouth Bass population data for years 2009 and 2013 are contained in Table 4. Smallmouth Bass abundance increased from 2009 to 2013 without any reintroduction efforts (Table 1). The overall Wr in 2009 was within the 95 to 100% expected range, however the overall Wr dropped below the values for a balanced population described by Wege and Anderson (1978) during 2013. The PSD_{28} value in 2009 was higher than the suggested 30 to 60% range, however the value was less than the suggested rang in 2013 (Anderson and Weithman 1978). The RSD_{35} was in the expected range for both years, an indication that the 2013 population contained a higher proportion of larger fish as shown in Figure 2. Smallmouth Bass sizes from 201 to 250 mm dominated the 2013 sample, and fish measuring between 400 mm and 500 mm were also collected. Reproductive success in 2013 was considered "excellent", indicating a self-sustaining population has been established.

Bluegill and Sunfish species

Bluegills were the second most abundant fish in 2013 sample and just slightly below the value observed in 2009 (Table 1). Summaries of Bluegill population data for years 2009 and 2013 are contained in Table 5. Relative weights were within the expected range of 95 to 100% suggested by Wege and Anderson (1978) for both years. The PSD_{15} values for both years were well above the suggested range for a balanced population described by Anderson and Weithman (1978). The RSD_{20} value was greater in 2009 as larger fish were in the population (Figure 3). Bluegills in the 151 to 175 mm range were abundant in the 2013 sample compared with 2009 when fish 176 to 250 mm range dominated the population. Table 2 shows that 183,780 Bluegill fingerlings were stocked in the reservoir from 2010 – 2012. YOY Bluegills were common in the seining surveys in 2013, indicating a self-sustaining population has been established. Rock Bass, Redbreast Sunfish, Black Crappies, and Pumpkinseeds were also collected during the 2013 electrofishing survey, but in relatively low abundance (Table 1). Black Crappie fingerlings were stocked in the reservoir to re-establish the population (Table 2).

Yellow Perch and Walleye

Yellow Perch were the most abundant fish species collected in 2013 (Table 1), showing an increase in number from 2009 (Table 6). Summaries of Yellow Perch population data for years 2009 and 2013 are contained in Table 6. The Wrs for both years were below the 95 to 100% suggested range described by Wege and Anderson (1978). The PSD_{20} values were within the 30 to 50% suggested range for both years (Anderson and Weithman 1978). However, the RSD_{25} for both years was less than the suggested range (Anderson and Weithman 1978). A large proportion of the 2013 population were within the 176 to 200 mm size class (Figure 4). Despite stocking large numbers of Walleye fry and fingerlings in 2010 – 2013 (Table 2), only one adult Walleye (445 mm, 712 g) was collected during the 2013 sampling effort.

Trout Species
A combined total of 3,850 Rainbow Trout and Golden Trout were stocked in the Savage River Reservoir in 2013. The reservoir stratifies in mid-summer, providing coldwater habitat for year-round trout survival. Angler's reports indicate that trout are caught throughout the year.

Forage Fish and Non-gamefish Species
The Swallowtail Shiner was the most abundant forage fish species found in 2009, however none were found during the 2013 sampling efforts. Other minnow species, Golden Shiners and Bluntnose Minnows, were found in low abundance in 2009 and were absent in 2013. White Suckers, Brown Bullheads, and Yellow Bullheads were also found in low abundance during 2013.

Discussion

Based on the 2013 fish community survey in the Savage River Reservoir, the fishery is recovering from the draining event that occurred during 2010. The warmwater, coolwater, and coldwater fishery is now adequate to support a recreational fishery; however abundance and size distributions are still not equivalent to that prior to the draining of the reservoir.

The re-introduction of Largemouth Bass and Bluegills has been successful as both species have established self-sustaining populations. Black Crappie re-introductions appear to have been successful based on angler reports; however the sample size was low during 2013. Walleye fingerling and fry stocking success has not been realized as only one adult Walleye was collected in 2013.

Smallmouth Bass re-colonized the reservoir without the aid of stocking. The Smallmouth Bass abundance level in 2013 was greater than that observed in 2009. YOY Smallmouth Bass were abundant in 2013, and memorable sized (> 400 mm) Smallmouth Bass were present in the population during 2013.

Yellow Perch re-colonized the reservoir without the aid of stocking, and they were the most abundant fish species collected in the 2013 survey. The population size structure indicates a large proportion of the population is less than 200 mm TL, an indication that growth rates may be slow in the absence of an adequate food base and lack of top level piscivorous fish species. In order to reduce the abundance of Yellow Perch, a stocking of 200 adult Walleye from Deep Creek Lake will occur in spring 2014. An attempt to collect pre-spawn Walleye will be made to improve natural reproduction potential in the Savage Reservoir in 2014. The Deep Creek Lake Walleye were tested for viral hemorrhagic septicemia (VHS) by the US Fish and Wildlife Service in 2013, and results were negative.

Recommendations

Recommended activities for the next five-year study period include:

- Conduct a comprehensive fish population surveys to monitor the status of resident game and non-game fish species including relative abundance, age and size structures, and reproductive indices.
- Continue annual adult Rainbow Trout stockings.
- Stock 200 adult Walleye from Deep Creek Lake in spring of 2014 in order to establish a self-sustaining population and to provide a predatory fish species for control of the abundant Yellow Perch population.

Table 1. A list of common names, scientific names, observed abundance estimates and relative abundance of fish species collected in Savage River Reservoir, 2009, 2010, and 2013 (Robbins *et al* 1991).

Common name	**Scientific name**	**$CPUE_{60}$ or observed abundance estimate in 2009**	**$CPUE_{60}$ or observed abundance estimate in 2013**
Golden Shiner	*Notemigonus crysoleucas*	Scarce	0
Swallowtail Shiner	*Notropis procne*	Abundant	0
Bluntnose Minnow	*Pimephales notatus*	<1	0
White Sucker	*Catostomus commersonii*	23	8
Yellow Bullhead	*Ameiurus natalis*	10	2
Brown Bullhead	*Ameiurus nebulosus*	0	1
Rainbow Trout	*Oncorhynchus mykiss*	2	2
Brook Trout	*Salvelinus fontinalis*	<1	0
Rock Bass	*Ambloplites rupestris*	63	18
Redbreast Sunfish	*Lepomis auritus*	2	5
Green Sunfish	*Lepomis cyanellus*	2	0
Pumpkinseed	*Lepomis gibbosus*	9	12
Bluegill	*Lepomis macrochirus*	54	40
Smallmouth Bass	*Micropterus dolomieu*	12	28
Largemouth Bass	*Micropterus salmoides*	83	14
Black Crappie	*Pomoxis nigromaculatus*	7	3
Yellow Perch	*Perca flavescens*	21	149
Walleye	*Sander vitreus*	<1	1
Total species=	**18**	**17**	**13**

Table 2. Maintenance fish stocking for Savage River Reservoir, 2010 - 2013.

Date	Species	Number	Size/lb	Source
4/6/2010	Bluegill	25,080	Fingerlings	Manning Hatchery
4/6/2010	Redear Sunfish	9,120	Fingerlings	Manning Hatchery
4/15/2010	Walleye	800,000	Fry	Manning Hatchery
5/13/2010	Walleye	25,000	Fingerlings	Manning Hatchery
6/9/2010	Black Crappie	18,000	Fingerlings	Manning Hatchery
6/9/2010	Largemouth Bass	12,000	Fingerlings	Manning Hatchery
9/22/2010	Bluegill	83,700	1,200/lb	Manning Hatchery
5/12/2011	Walleye	20,000	Fingerlings	Manning Hatchery
6/8/2011	Largemouth Bass	26,600	1900/lb	Manning Hatchery
7/6/2011	Bluegill	75,000	Fingerlings	Manning Hatchery
7/6/2011	Black Crappie	8,500	Fingerlings	Manning Hatchery
4/18/2012	Walleye	25,000	Fingerlings	Manning Hatchery
5/29/2012	Black Crappie	23,000	Fingerlings	Manning Hatchery
5/2/2013	Walleye	25,000	Fingerlings	Manning Hatchery
Totals: Bluegill (183,780); Redear Sunfish (9,120); Walleye (895,000); Black Crappie (49,500); Largemouth Bass (38,600).				

Table 3. Summary of Largemouth Bass population indices in Savage River Reservoir, 2009 and 2013.

Indices	2009 Values	2009 N	2013 Values	2013 N
Wr, overall (%)	84	103	79	14
Wr, stock (%)	94	10	73	8
Wr, quality (%)	83	82	81	2
Wr, preferred (%)	83	11	81	4
PSD_{30} (%)	91 ± 7	102	43 ± 35	14
RSD_{38} (%)	11 ± 8	102	29 ± 32	14
Mean TL mm (range)	323 (75-455)	110	296 (202-473)	14
Mean W g (range)	500 (33-1248)	103	402 (88-1120)	14
$CPUE_{60}$	83	110	14	14
Seining Index	16/30.5 m	113	7/30.5 m	47

Table 4. Summary of Smallmouth Bass population indices in Savage River Reservoir, 2009 and 2013.

Indices	**2009 Value**	**2009 N**	**2013 Value**	**2013 N**
Wr, overall (%)	95	12	83	27
Wr, stock (%)	116	2	82	20
Wr, quality (%)	90	8	78	2
Wr, preferred (%)	91	2	109	1
Wr, memorable (%)	NA	0	88	3
PSD_{28} (%)	83 $\pm$ 31	12	23 $\pm$ 21	26
RSD_{35} (%)	17 $\pm$ 31	12	15 $\pm$ 18	26
Mean TL mm (range)	261 (95-372)	15	260 (95-490)	28
Mean W g (range)	381 (129-672)	12	324 (52-1534)	27
$CPUE_{60}$	12	15	28	28
Seining Index	1/30.5 m	7	6/30.5 m	44

Table 5. Summary of Bluegill population indices in Savage River Reservoir, 2009 and 2013.

Indices	**2009 Value**	**2009 N**	**2013 Value**	**2013 N**
Wr, overall (%)	99	70	95	40
Wr, stock (%)	88	8	86	4
Wr, quality (%)	97	20	97	27
Wr, preferred (%)	103	41	95	9
Wr, memorable (%)	83	1	NA	0
PSD_{15} (%)	89 $\pm$ 9	70	86 $\pm$ 13	43
RSD_{20} (%)	60 $\pm$ 13	70	21 $\pm$ 15	43
Mean TL mm (range)	194 (50-250)	72	174 (100-215)	43
Mean W (g) (range)	191 (15-338)	70	125 (20-234)	40
$CPUE_{60}$	54	72	43	43

Table 6. Summary of Yellow Perch population indices in Savage River Reservoir, 2009 and 2013.

Indices	**2009 Value**	**2009 N**	**2013 Value**	**2013 N**
Wr, overall (%)	90	21	78	149
Wr, stock (%)	91	9	81	86
Wr, quality (%)	90	11	76	55
Wr, preferred (%)	83	1	71	7
PSD_{20} (%)	57 $\pm$ 27	21	40 $\pm$ 9	154
RSD_{25} (%)	5 $\pm$ 15	21	4.5 $\pm$ 4	154
Mean TL mm (range)	191 (88-250)	23	190 (125-295)	156
Mean W (g) (range)	106 (25-190)	21	84 (22-266)	149
$CPUE_{60}$	21	28	156	156

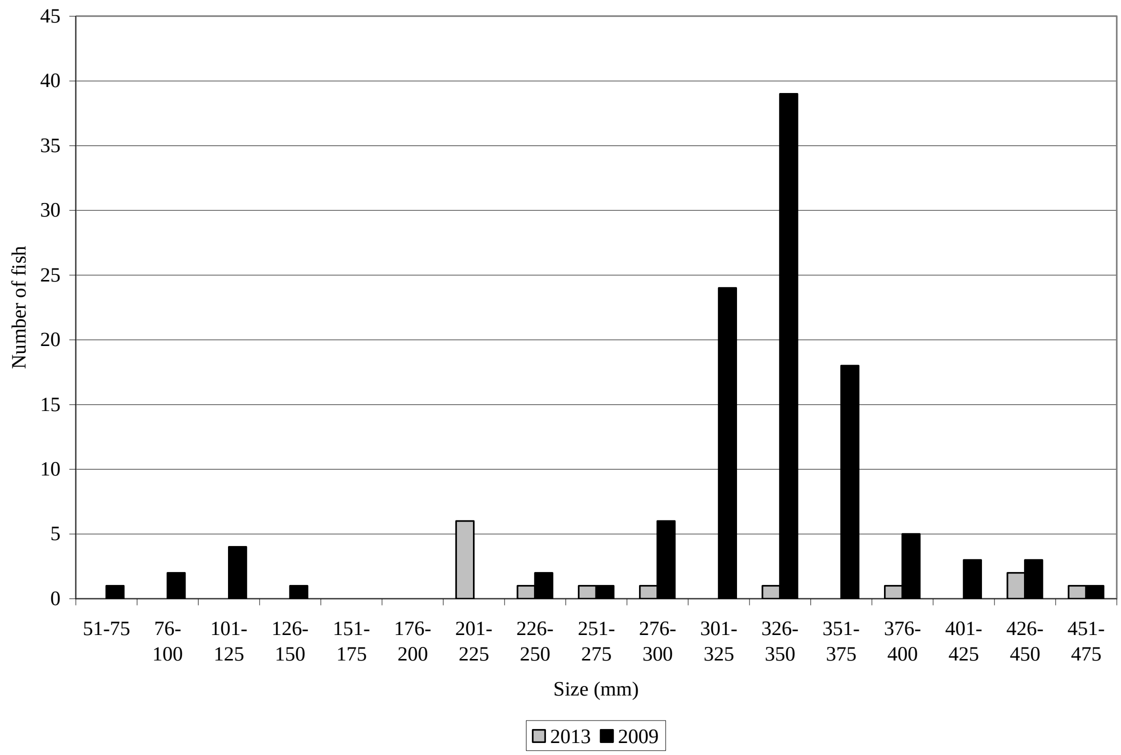


Figure 1. Length frequency distribution for Largemouth Bass in the Savage River Reservoir for years 2009 (N=110) and 2013 (N=14).

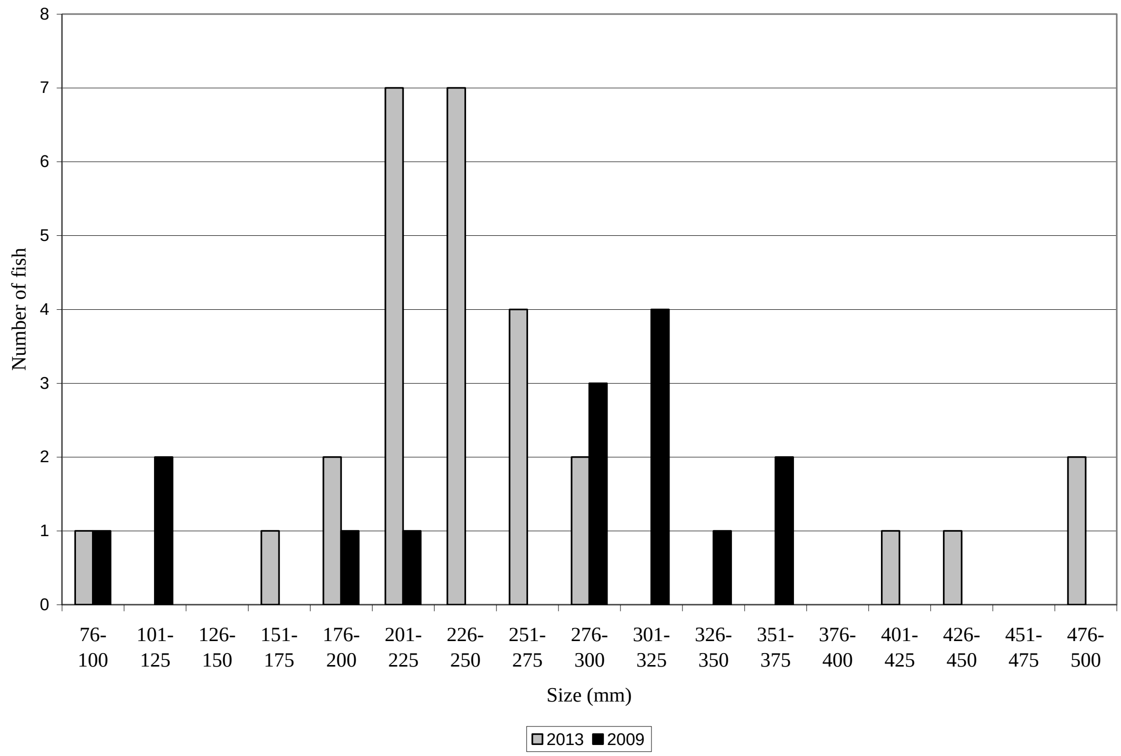


Figure 2. Length frequency distribution for Smallmouth Bass in the Savage River Reservoir for years 2009 (N=15) and 2013 (N=28).

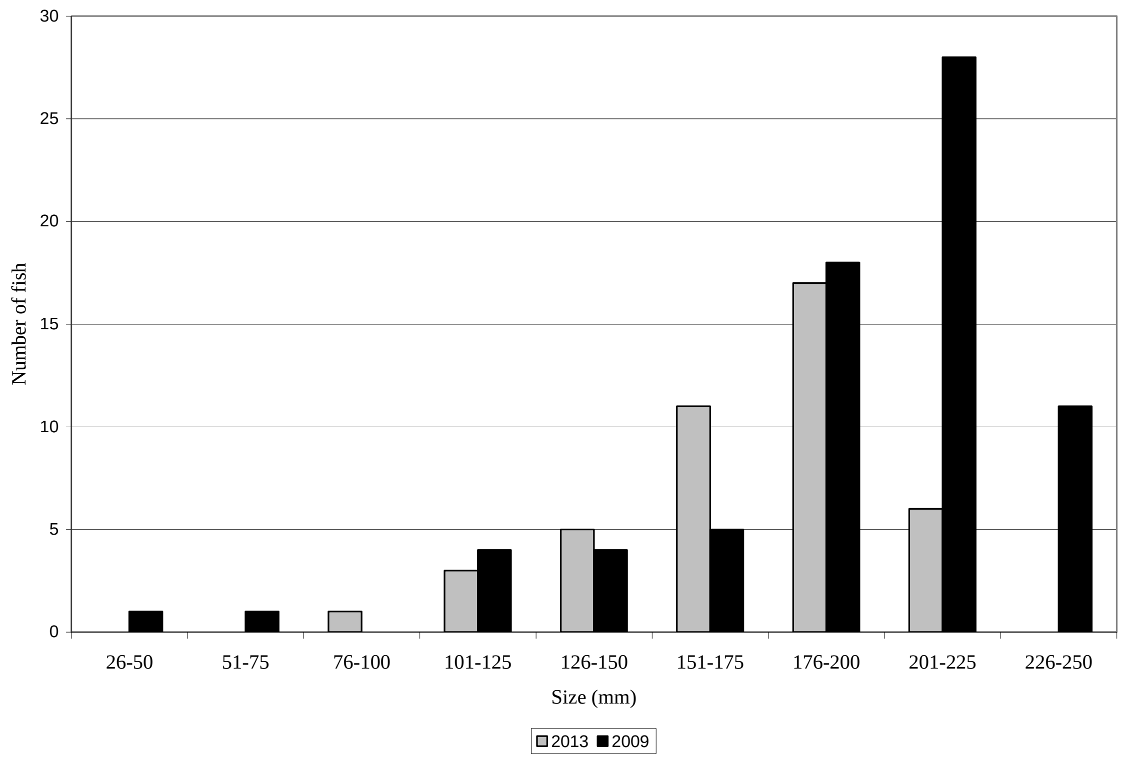


Figure 3. Length frequency distribution for Bluegill in the Savage River Reservoir for years 2009 (N=72) and 2013 (N=43).

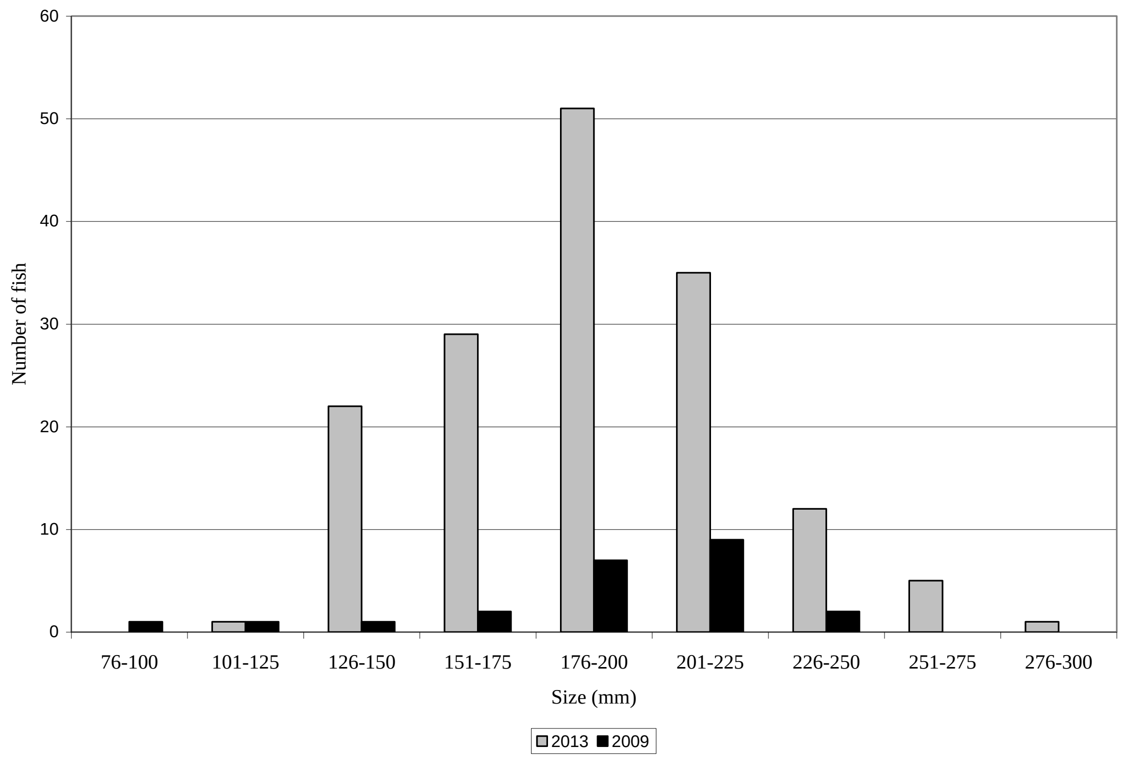


Figure 4. Length frequency distribution for Yellow Perch in the Savage River Reservoir for years 2009 (N=23) and 2013 (N=156).

Smithville Lake
(Caroline County)

Introduction

Smithville Lake is a 16.2 hectare Fishery Management Area (FMA) located in southeastern Caroline County, Maryland. As an FMA, there is the opportunity to manage the impoundment exclusively for fishing, thus eliminating conflicts that often occur in multi-use situations. Purchased in 1955 from the Smithville Farm Machinery Company, the lake was created by impounding the water of a tributary to Marshyhope Creek. The Maryland Department of Natural Resources (DNR), Fisheries Service, Inland Fisheries Division owns and manages the lake to provide a public angling resource. Maximum depth in Smithville Lake is 3 m and the average depth is roughly 1 m. The upper third of the lake is very shallow with gradual drop-offs while the lower portion of the lake consists of steeper banks with sharp drop-offs. The lower two-thirds of Smithville Lake is the best fish habitat. In recent years poor water quality has been suspect in the Lake in times of drought. Smithville Lake was issued a water contact advisory in 2010 due to a bloom of the harmful algal species *Microcyctis*. Although control of the lake water quality is often difficult to manage, it can affect the quality of the fishery resources.

Objective

The purpose of this study was to:

- Determine fish species composition, proportional stock density (PSD), length frequency distribution, and relative abundance of important gamefish and panfish species.

Methods

Assessments of the fisheries resources in Smithville Lake were conducted on September 9, 2013 using an 18 foot Smith-Root 5kw electrofishing boat. Three 600 second samples were conducted and encompassed a major portion of the lower lake. More detailed descriptions of methods can be found under the Study II, Job 2 Methods section of this report. Upper areas of the lake are not sampled with traditional gear due to the shallow depth, abundance of woody debris and rooted vegetation. All Largemouth Bass were collected, measured to total length (mm TL), and weighed (g). Mean lengths and weights were calculated using only adult fish >150 mm (Reynolds and Babb, 1978).

All Bluegill Sunfish encountered during the first 100 seconds of each sample were collected and measured for total length (mm TL). All Chain Pickerel and Black Crappie encountered also were collected and measured. Population specific data were recorded for analysis of bass and bluegill stocks as described in the Study II, Job 2 Methods section referenced above. Population or community parameters that were addressed included: total length (mm TL), weight (g), growth, relative abundance and size and age structure. Condition of the stock was determined by examining relative weight (Wr)

(Wege and Anderson, 1978). Stock structure was addressed by computing the index of proportional stock density (PSD) and relative stock density (RSD) (Weithman et al., 1979). Relative abundance was determined by calculating the catch per unit of effort statistic (CPUE) and reported as fish per hour.

Results

A total of 39 Largemouth Bass were collected during the electrofishing effort, 11 of which were young-of-year (YOY) (Figure 1). Stock size bass CPUE was 25±7, which is significantly lower than the previous surveys conducted in 2011 and 2006 and calculated as 40±8 and 52±17 bass/hour, respectively. Mean relative weights for 25 mm length groups were generally above 95% with a few exceptions (Figure 1) (Wege and Anderson, 1978). Largemouth Bass PSD was 48%±23 in 2013, and lower than the 70%±20 reported in 2011. Both fell within the desired PSD range of 40-60% (Reynolds and Babb, 1978). Generally smaller bass were more abundant in the 2013 survey.

Bluegill Sunfish of all sizes were abundant in Smithville Lake (Figure 2). The desirable range of PSD for prey is 20 to 50% where the management objective is good bass fishing from waters containing mainly bass and bluegills (Weithman et al., 1979). Bluegill PSD was 28%±15 in 2013 and fell within the recommended range. Chain Pickerel were rarely encountered (N=4) in the 2013 Smithville Lake survey, and ranged in size from 340-480 mm TL. Black Crappie and Redear Sunfish were observed to be common overall but did not appear as common in the 100 second panfish samples. Redear Sunfish were stocked to provide additional angling opportunities and to bolster forage fish populations. Redear Sunfish numbers were lower than bluegill, but many have reached impressive size. Table 1 presents all other fish species encountered and their observed abundance estimates. Gizzard Shad were listed as “abundant” in 2013 which contrasted with previous years.

Discussion

For many years Smithville Lake has supported a high quality fishery for Largemouth Bass, Bluegill Sunfish, Black Crappie, Chain Pickerel and Redear Sunfish. It continues to be a very popular destination for both boating and shoreline anglers. Although the 2013 data suggest that the bass fishery has deteriorated since it was last surveyed, variations in bass abundance are not uncommon in small impoundments. The 2011 survey identified several years of poor reproduction. The 2013 survey results showed improved numbers of juvenile bass in the fishery. There continue to be some quality sized bass available to anglers; however, general bass abundance was lower than anticipated. Advanced fingerling bass were stocked in Smithville Lake in 2013 in order to improve the otherwise poor or inconsistent bass recruitment. Forage does not appear to be a limiting factor for bass as Bluegill Sunfish and Golden Shiners are abundant.

Recommendations

Current statewide non-tidal regulations for Largemouth Bass and panfish species appear to be suitable for Smithville Lake.

Table 1. Common and scientific names, and observed abundance estimates of species sampled from Smithville Lake, Fall 2013.

Common Name	**Scientific Name**	**General Occurrence**
Largemouth Bass	*Micropterus salmoides*	Common
Bluegill Sunfish	*Lepomis macrochirus*	Abundant
Gizzard Shad	*Dorosoma cepedianum*	Abundant
Creek Chubsucker	*Erimyzon oblongus*	Common
Brown Bullhead	*Ameiurus nebulosus*	Rare
Golden Shiner	*Notemigonus crysoleucas*	Common
American Eel	*Anguilla rostrata*	Common
Redear Sunfish	*Lepomis microlophus*	Common
Black Crappie	*Pomoxis nigromaculatus*	Common
Chain Pickerel	*Esox niger*	Common

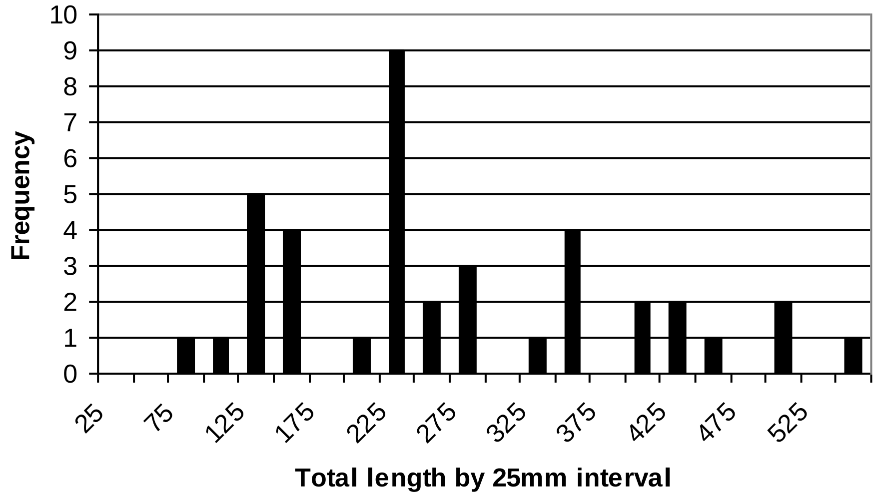


Figure 1. Length-frequency distribution of Largemouth Bass collected from Smithville Lake, 2013.

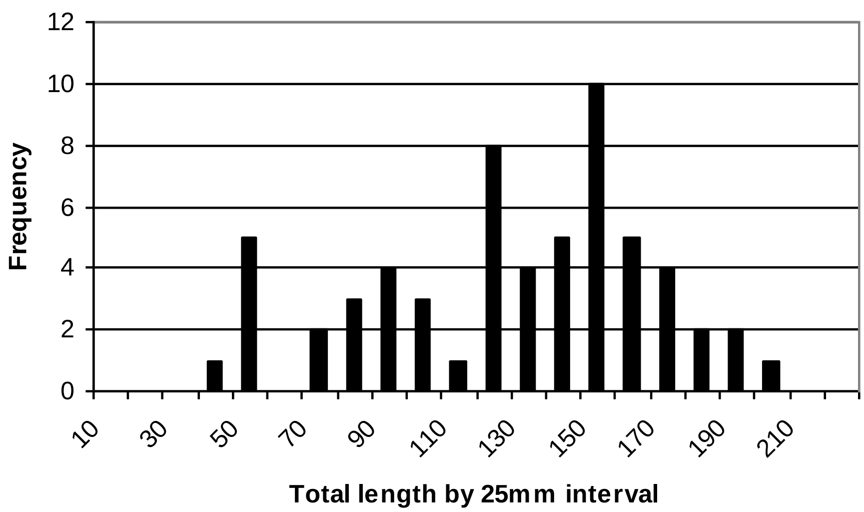


Figure 2. Length-frequency distribution of Bluegill Sunfish collected from Smithville Lake, 2013.

Triadelphia Reservoir
(Montgomery and Howard Counties)

Introduction

Triadelphia Reservoir is a 324 hectare (800 acre) impoundment located 15 miles northeast of Washington, D.C. The Washington Suburban Sanitary Commission (WSSC) manages the reservoir as a water supply for the Washington D.C./Maryland metropolitan area. Fishing and other activities are open to the public from March 1 through November by permit obtained from WSSC. Reservoir staff plays an active role in managing the fishery through enforcement of regulations, habitat improvement, and supplemental stocking. They also operate a "grow out" pond adjacent to the reservoir which is used to raise fish to the fingerling stage for stocking.

Fisheries data on Triadelphia reservoir has been collected since the mid 1980s in order to characterize gamefish populations. Sampling techniques, however, have varied which presents a problem when trying to compare indices. New sampling procedures, described by Bonar (2000), were implemented in 2002 to provide continuity in sampling procedures and allow for more accurate statistical analysis.

Methods

Supplemental stocking of Largemouth Bass (*Micropterus salmoides*) and Striped Bass (*Morone saxatilis*) fingerlings was performed in 2013. Additionally, Smallmouth Bass (*Micropterus dolomieu*) were stocked from an on-site source. Adult Smallmouth Bass brood were collected in spring 2013 and placed in a 0.6 hectare (1.5 acre) "grow out" pond adjacent to the reservoir. The pond was monitored periodically by WSSC personnel for Smallmouth Bass reproduction. Adult fish were removed and returned to the reservoir when fry were old enough to be self sufficient. Maryland DNR Inland fisheries and WSSC personnel periodically sampled the fingerling bass with a 9.14 m (30 foot) haul seine to monitor fish abundance, condition, and food availability. Upon depletion of the food supply, the pond and fingerlings was drained directly into a cove of the reservoir. This method of fish rearing is not labor intensive and it is relatively inexpensive. In addition, it removes much of the stress to the fish associated with handling.

Random Site Selection using Electrofishing gear was chosen for sampling at Triadelphia Reservoir. The details of all the methods used are outlined in *"General Electrofishing Procedures"* and *"Random Site Electrofishing"* at the beginning of the study titled "Management of Maryland's Freshwater Impoundments". Catch per unit effort ($CPUE_{hr}$), Proportional Stock Density (PSD), length frequency distribution, and Relative Weight (W_r) were estimated for gamefishes and several non-gamefishes. Relative abundance was determined for all species collected (Table 1). Water quality parameters were measured and recorded, and included secchi depth (cm), pH, temperature (°C), conductivity (µmhos), and dissolved oxygen (DO, ppm). Sample sites were chosen based upon a systematic method of site allocation (Nielsen and Johnson, 1983; Snedecor and Cochran, 1968; Miranda, *et al*., 1996). Simple Random Sampling as described by Bonar (2000) was first implemented in 2002 and has been followed in all subsequent surveys.

Twenty sites were sampled for gamefishes in 2013. Four of these sites were selected for total community samples where all fish were collected. Normal site length was 400 m and electrofishing duration was approximately 600 seconds per site. Four sites deviated from its original coordinates due to low water. A handheld Global Positioning System (GPS) was used to record coordinates and site start and stop times in order to keep sample length to about 400 m.

Results

Fish that were stocked since 2005 are listed in Table 2. Most stocked fish species were reared at Manning Hatchery, a warm water facility located in Southern Maryland. A total of 14 adult Smallmouth Bass were placed in the "grow out" pond in April 2013. The number of fingerling Smallmouth Bass produced is unknown, but the mean number of fingerling collected in four haul seine tows before the pond was drained was 116 per haul. Fish ranged in size from 36—90 mm total length (TL).

Fall electrofishing surveys were conducted on the nights of November 4 and 5, 2013. A list of species collected and their relative abundance is listed in Table 1. Surface water temperature averaged 14° C. The surface DO averaged 9 ppm and conductivity ranged from 123—178 µmhos.

Arithmetic mean (AM) $CPUE_{hr}$ for Largemouth Bass in 2013 were higher than those in 2010 but stock to quality size Largemouth Bass $CPUE_{hr}$ showed a slight decrease (Table 3). The most abundant length group present was 150 to 200mm TL and there was a notable increase in the abundance of fish from 325 to 475mm. (Figure 1). Proportional stock density (PSD) for Largemouth Bass was on the upper end of the 30-70% guideline proposed by Weithman, *et al*. (1979) (Table 3). The mean relative weight (W_r) for Largemouth Bass of all sizes was 97, above what Kohler and Hubert (1993) used to describe underweight fish.

Smallmouth Bass $CPUE_{hr}$ showed a slight increase in stock and quality fish. Sub-stock fish $CPUE_{hr}$ dropped from 2 to 1 per hour in 2013 from the 2010 survey but numbers remain lower than in 2007. Only 16 Smallmouth Bass were collected in 2013, two of which were considered young of year fish. PSD was also on the upper end of the desired range of 30 – 70% for predators (Weithman, et al., 1979). Mean relative weight for all fish was 91. Fish in the ≤ 200mm length group were in excellent condition and have a weighted mean relative weight of 105.

Northern Pike (*Esox lucius*) $CPUE_{hr}$ was similar to previous years. Too few pike were collected in 2013 to accurately characterize the population, but relative weight was calculated and showed fish in very good condition (W_r = 96). PSD for Northern Pike was 86% indicating an abundance of large fish, but very few small to intermediate fish.

White Crappie (*Pomoxis annularis*) indices for PSD and CPUE have changed little over the years. However, CPUE of sub-stock size fish increased from 0 to 17/hour since 2010 and indicate improved reproduction. Stock and quality size fish were slightly less abundant since 2010. PSD increased to 86% and relative weight was 78, indicative of underweight fish.

$CPUE_{hr}$ of stock size Black Crappie (*Pomoxis nigromaculatus*) has increased to 14. Sub-stock and quality sizes Black Crappie have similar values to those seen in 2010. PSD values dropped to 19% from 27% in 2010. Fish were in good condition with a mean relative weight of 94.

Other gamefishes that were observed but poorly represented in Triadelphia included Walleye (*Sander vitreus*), Channel Catfish (*Ictalurus punctatus*), and Striped Bass. Electrofishing catches have been consistently low for these species and may indicate that alternate gears or a change in sampling seasons are necessary to collect an adequate number of specimens for evaluation.

$CPUE_{hr}$ for non-gamefishes was generally greater than those for gamefishes (Table 4). Bluegill (*Lepomis macrochirus*) catch rates increased from 2010, sub-stock and stock to quality $CPUE_{hr}$ were much greater than in 2010 but similar to values seen in 2007. Quality size Bluegill (>180mm) more than doubled their numbers but stock size fish increased by more than 62% since 2010. Thus, PSD was well below the desired range of 20-50% (Weithman, et al. 1979). Relative weight for Bluegill less than 100 mm and greater than 175mm were at or near the minimum value of 85, indicative of underweight fish. Fish from 100 to 175 mm were firmly underweight (Figure 2).

White Perch (*Morone americana*) catch rates increased significantly since 2010 while the PSD dropped to 7. Yellow Perch (*Perca flavescens*) catch rates were the lowest since before 2007, while the PSD increased to 14%. White Sucker (*Catostomus commersonii*), Common Carp (*Cyprinus carpio*), and Gizzard Shad (*Dorosoma cepedianum*) were frequently observed during electrofishing but data on these species were not collected.

Discussion

Triadelphia Reservoir water levels in 2013 were near full pool, which tends to distribute fish throughout the available habitat and decrease electrofishing catches. However, even though the lake was close to full pool, our catch rates were better than normal for some fishes.

The relative abundance of stock size Largemouth Bass, as indicated by $CPUE_{hr,}$ showed a slight decrease in 2013 over previous years. There is an abundance of fish moving through the quality size range creating a high PSD. Smallmouth Bass CPUE also showed a slight increase in stock size fish compared to 2010 but remain less than in 2007.

Northern Pike were present but not abundant in 2013. Northern Pike experience better reproduction in Triadelphia Reservoir in years following a prolonged period of draw down. Draw down allows the terrestrial vegetation to flourish and provide vital spawning habitat when later re-watered to full pool. There is very minimal natural spawning habitat in the reservoir during years that do not have at least a partial draw down. In 2013, the reservoir water level was not conducive to high reproductive output of Northern Pike.

Crappie species are doing well in the reservoir, with an increase in stock size Black Crappie and similar numbers of quality fish since 2010. Numbers of sub-stock White Crappie were high and indicate the most successful reproduction since before 2007.

Bluegills continue to be the most abundant species found in Triadelphia, but juvenile White Perch and Yellow Perch were also common throughout the survey. Although higher numbers of quality gamefishes and non-gamefishes were found in 2013, forage fish such as Gizzard Shad, White Sucker, Spottail Shiners, Common Carp, and various minnows were abundant at all sites.

The records of catches by fishermen that were reported to WSSC's Brighton Dam Office continue to indicate some excellent fishing in Triadelphia. Anglers have caught trophy size Largemouth and Smallmouth Bass, Striped Bass, Northern Pike, Walleye, and Black and White Crappie. Some of the Striped Bass catches weighed in excess of 20 pounds.

Recommendations

Current sampling methods have provided useful information about the fishery in Triadelphia reservoir although some species are consistently under-represented. This is most likely due to choice of sampling gear and the timing of surveys which may bias catches. Alternate sampling procedures and techniques such as sampling in the spring or using nets and traps may be more effective in collecting species such as Walleye, Striped Bass, or Smallmouth Bass.

Management of the "grow out" pond for producing Smallmouth Bass should be continued to supplement the population. Periodic surveys should continue to determine if stocking has increased the population.

The sunfishes, bass and perch have been well represented in fall surveys and sampling for them in this manner should continue. Variances in mean CPUEs could be improved by stratifying the shoreline according to habitat type and sampling evenly within each strata. A random stratified design will help reduce the variance in data for some species, but it can ultimately increase variance in others when the distribution of target species is not similar. If this is the case, several sampling methods or sampling efforts within different seasons will be needed to accurately characterize the fish population.

Table 1. 2013 fish species, number collected and CPUE in Triadelphia Reservoir.

Species	Common name	Number Collected	CPUE
Pomoxis nigromaculatus	Black Crappie	55	20.4
Lepomis macrochirus	Bluegill	528	800
Ameirus nebulosus	Brown Bullhead	1	0.4
Ictalurus punctatus	Channel Catfish	3	1.1
Cyprinus carpio	Common Carp	Observed	
Dorosoma cepedianum	Gizzard Shad	46	207
Micropterus salmoides	Largemouth Bass	203	75.5
Esox lucius	Northern Pike	7	2.6
Lepomis cyanellus	Green Sunfish	12	54
Morone americana	White Perch	117	527
Catostomus commersonii	White Sucker	22	99.1
Perca flavescens	Yellow Perch	174	64.7
Pomoxis annularis	White Crappie	34	12.6
Micropterus dolomieu	Smallmouth Bass	16	5.9
Notropis hudsonius	Spottail Shiner	9	40.5
Morone saxatilis	Striped Bass	3	1.1
Notemigonus crysoleucas	Golden Shiner	Observed	
Sander vitreus	Walleye	9	3.3
Ameirus natalis	Yellow Bullhead	3	1.1

Table 2. Species stocked in Triadelphia Reservoir, 2005 - 2010.

Species	Number of Fish	Size	Date
Largemouth Bass	200	fingerling	6/5/2013
Striped Bass	8,000	fingerling	6/5/2013
Smallmouth Bass[1]	14	adult	4/17/2013
Striped Bass	4,500	fingerling	8/16/10
Striped Bass[1]	3,000	fry	5/26/10
Striped Bass	17,000	fry	5/26/10
Walleye	2,000	fry	5/1/09
Striped Bass	130,000	fry	4/24/09
Striped Bass	150,000	fingerling	6/18/08
Walleye	20,000	fry	4/30/08
Walleye	7,000	fingerling	5/23/07
Walleye	250,000	fry	4/18/05
Walleye	45,000	fingerling	5/12/05
Fathead minnow[1]	3,000	adult	4/8/05
Smallmouth Bass[1]	1,000	fingerling	6/15/05
Striped Bass	500	fingerling	6/8/05

[1]Stocked in Triadelphia “grow out” pond.

Table 3. CPUE (#fish/hour) of sub-stock, stock and quality size groups with arithmetic mean confidence intervals (CI) in parenthesis, and PSD with CI of predator species in electrofishing samples at Triadelphia Reservoir.

Species	**Year**	**Substock[a] (CI)**	**Stock-to-Quality[b] (CI)**	**≥Quality[c] (CI)**	**All [c]**	**PSD (CI)**
Largemouth	2007	48 (+/-42)	68 (+/-35)	19 (+/- 12)	135 (+/-79)	23 (+/-9)
	2010	20 (+/-9)	18 (+/-9)	4 (+/-3)	42 (+/-16)	16 (+/-11)
	2013	30 (+/-17)	14 (+/-6)	25 (+/-11)	68 (+/-24)	66 (+/-9)
Smallmouth	2007	27 (+/-43)	10 (+/-13)	4 (+/-6)	41 (+/-59)	35 (+/-28)
	2010	1 (+/-2)	4 (+/-3)	1 (+/-2)	4 (+/-3)	38 (+/-58)
	2013	1 (+/-2)	5 (+/-3)	2 (+/-2)	5 (+/-3)	69 (+/-37)
Northern Pike	2007	3 (+/-3)	2 (+/-2)	2 (+/-2)	7 (+/-6)	57 (+/-67)
	2010	1 (+/-1)	1 (+/-1)	2 (+/-1)	3 (+/-2)	67 (+-76)
	2013	0	0.3	2 (+/-1)	2 (+/-2)	86 (+/-52)
Black Crappie	2007	0	20 (+/-36)	4 (+/-7)	19 (+/-36)	36 (+/-44)
	2010	16 (+/-20)	8 (+/-7)	3 (+/-2)	27 (+/-25)	27 (+/-19)
	2013	12 (+/-14)	14 (+/-10)	2 (+/-2)	28 (+/-23)	19 (+/-16)
White Crappie	2007	0	0.5 (+/-1)	11 (+/-10)	11 (+/-10)	94 (+/-19)
	2010	0	2 (+/-2)	9 (+/-5)	11 (+/-7)	81 (+/-18)
	2013	17 (+/-25)	1 (+/-2)	5 (+/-5)	23 (+/-29)	86 (+/-29)

[a] Substock = less than minimum stock size.
[b] Stock = Largemouth 200-299mm, Smallmouth 180-279mm, Northern Pike350-529mm, Crappie species 130-199mm
[c] ≥Quality = Largemouth ≥300mm, Smallmouth ≥280mm, Northern Pike ≥530mm, Crappie species ≥200mm

Table 4. CPUE (number of fish per hour) of sub-stock, stock and quality size groups with arithmetic mean confidence intervals (CI) in parenthesis, and PSD with CI of species collected during 200-second electrofishing samples at Triadelphia Reservoir.

Species	Year	Substock (CI)	Stock-to-Quality[a] (CI)	≥Quality[b] (CI)	All [c] (CI)	PSD
Bluegill	2007	408 (+/-511)	1644 (+/-1058)	408 (+/-511)	1644 (+/-1058)	15 (+/-5)
	2010	Not Collected	612 (+/-531)	31 (+/-24)	802 (+/-725)	5 (+/-2)
	2013	662 (+/-675)	1647 (+/-1173)	68 (+/-82)	2376 (+/-1844)	4 (+/-2)
White Perch	2007	12 (+/-31)	294 (+/-259)	30 (+/-44)	336 (+/306)	9 (+/-10)
	2010	229 (+/-253)	108 (+/-119)	6 (+/-7)	342 (+/-377)	5 (+/-5)
	2013	342 (+/-465)	171 (+/-116)	13.5 (+/-27)	527 (+/-384)	7 (+/-11)
Yellow Perch	2007	102 (+/-262)	156 (+/-199)	6 (+/-15)	264 (+/-458)	4 (+/-11)
	2010	185 (+/-135)	64 (+/-35)	3 (+/-6)	252 (+/-133)	5 (+/-7)
	2013	84 (+/-65)	12 (+/-7)	2 (+/-1)	97 (+/-66)	14 (+/-14)

[a] Substock = less than minimum stock size.
[b] Stock = Bluegill 80-149mm, Perch species 130-199mm
[c] Quality = Bluegill ≥150mm, Perch species ≥200mm

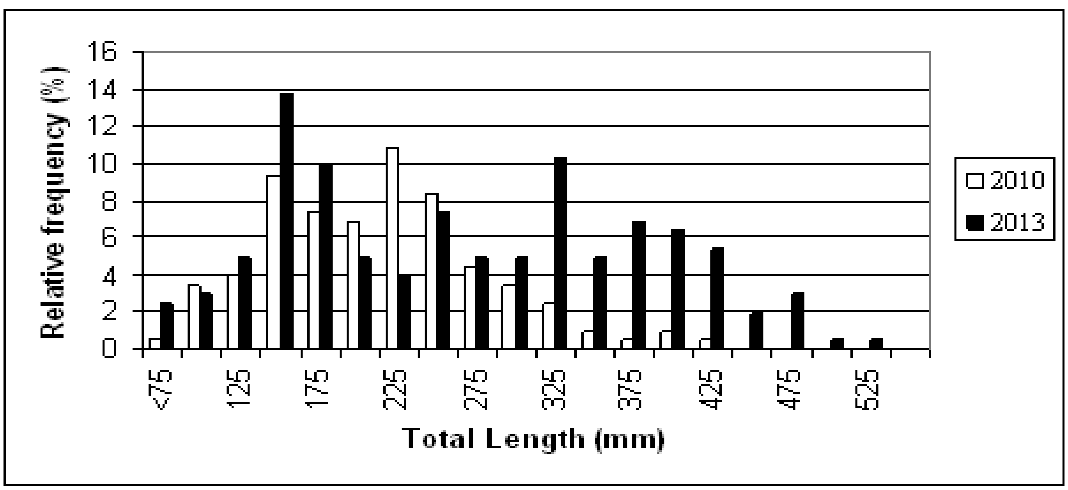


Figure 1. Length-frequency distribution of Largemouth Bass in Triadelphia Reservoir for 2010 and 2013. Total Lengths were grouped in 25 mm intervals.

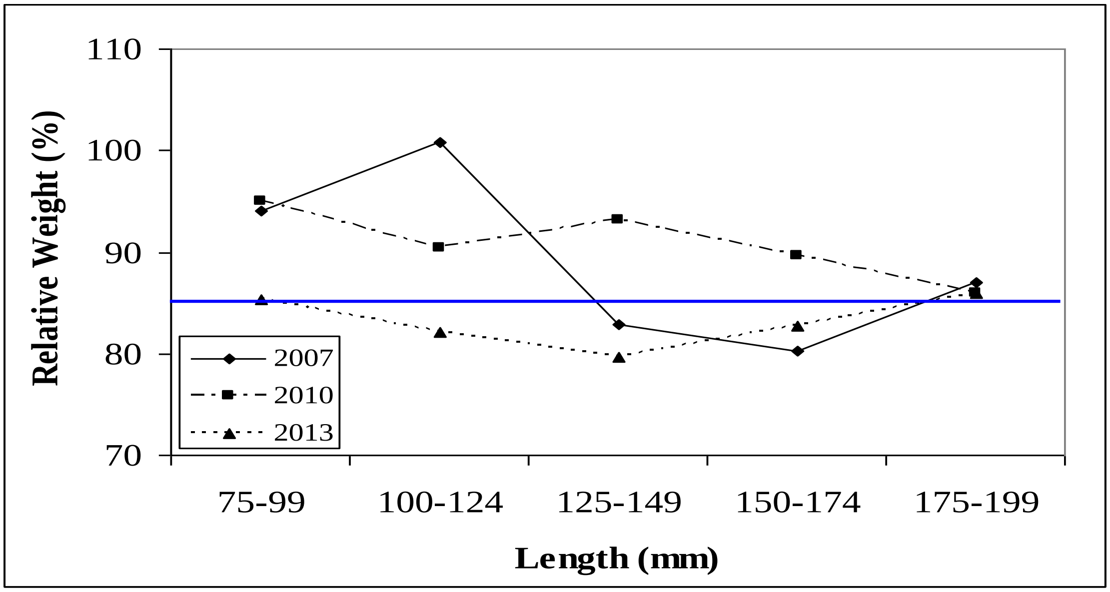


Figure 2. (Weighted) Relative weight of Bluegill caught in Triadelphia Reservoir 2007, 2010 and 2013. The dark blue line marks the 85% threshold. Fish that have relative weights below 85% are considered underweight by Kohler and Hubert (1993).

Urieville Lake
(Kent County)

Introduction

Urieville Lake is a shallow, eutrophic, 14.2 hectare impoundment located in Kent County. The lake was initially built in colonial times when two tributaries to Morgan Creek were impounded. When first created, Urieville Lake had fairly steep bottom topography, with two distinct, flooded creek channels that were 2-3 m deep in some places. Over time, intense agricultural practices, deforestation, and development in its watershed have caused excess sediment and nutrient loading into the lake. Consequently, the lake has silted in so badly that the channels are virtually non-existent and most of the lake has become extremely shallow. Excess nitrogen and phosphorus inputs into the shallow lake have promoted excellent conditions for aquatic plant growth. By June heavy aquatic vegetation impacts most of the lake. Heavy vegetative coverage significantly impairs angling and fish management activities. Mechanical harvesting and herbicide applications were performed in the early 1990's with limited benefits, so it was decided that a new approach was needed to restore the lake.

In 1996 a comprehensive "Urieville Lake Diagnostic Study" was completed to evaluate current lake resource problems and to present possible restoration alternatives. The study concluded that nutrient and sediment loading of the lake comprised the major factors limiting fish management potential. The study also identified alternatives to help address the sediment, nutrient and aquatic plant issues. The alternatives covered a broad spectrum of possible control methods that included the use of mechanical plant harvesters, chemical herbicides and bottom dredging. A combination of all the methods was recommended as the preferred course of action; however, budget limitations prohibited any recommended actions. The final consensus from many agencies was to choose the most cost effective option which was to drain the lake.

In the fall of 1998 there was an attempt by management to drain Urieville Lake and improve conditions for fish. Once drained, the plan was to allow the bottom sediments to freeze, dry out and be planted with rye in the spring. The objective was to allow for natural compaction of the sediments that would retard new aquatic plant growth when refilled. The process of draining the lake was halted when it was discovered that over 2000 cubic yards of sediment had discharged into the stream below the impoundment. Subsequently, management staff was forced into corrective action and were ordered to pump the sediment back over the spillway and back into the lake. No other rehabilitative actions have occurred since and the lake remains in a degraded state. Fish kills caused by low dissolved oxygen levels have sporadically occurred in the past. Since the 1998 reclamation attempt, Urieville Lake was re-stocked with Largemouth Bass, Bluegill Sunfish and Redear Sunfish to augment the remaining populations.

Objective

The purpose of this study was to:

- Determine fish species composition, proportional stock density (PSD), length frequency distribution, and relative abundance of important gamefish and panfish species.

Methods

Assessment of the fisheries resources within Urieville Lake were conducted on May 9, 2013 using an 18 foot Smith-Root 5kw electrofishing boat. Traditional fall sampling is not feasible due to the abundant aquatic vegetation. Three 600 second samples were taken which encompassed the majority of the lower lake perimeter. Upper areas of the lake were not sampled due to shallow depth and abundant vegetation. More detailed descriptions of methods can be found under the Study II Job 2 Methods section of this report. All Largemouth Bass were collected, measured (mm TL), and weighed (g). Mean lengths and weights were calculated using only adult fish >150 mm (Reynolds and Babb, 1978). All Bluegill Sunfish and other panfish encountered during the first 100 seconds of each sample were collected and measured. Population specific data were recorded for fundamental analysis of Largemouth Bass and Bluegill Sunfish stocks.

Population or community parameters that were addressed included: length (mm TL), weight (g), growth, relative abundance and size structure. Condition of the stock was determined by examining relative weight (Wr) (Wege and Anderson, 1978). Stock structure was addressed by computing the index of proportional stock density (PSD) and relative stock density (RSD) (Weithman et al., 1979). Relative abundance was determined by calculating the catch per unit of effort statistic (CPUE) and reported as fish per hour.

Results

Only 14 Largemouth Bass were collected during the 2013 electrofishing effort. Overall, low numbers of Largemouth Bass in all size classes were collected (Figure 1). CPUE of bass was 35±10 bass/hr and was similar to CPUE values from 2009 and 2002 which were 43 and 38 respectively. Mean relative weights for 25 mm length groups were all above acceptable levels of 95% (Wege and Anderson, 1978). Bass PSD was 50%±35, however this statistic is not significant due to the small sample size (Reynolds and Babb, 1978).

Very few Bluegill Sunfish were collected (N=14). The desirable range of PSD for prey is 20 to 50% where the management objective is for good bass fishing in water containing mainly Largemouth Bass and Bluegill Sunfish (Weithman et al., 1979). Bluegill PSD was 33%±37, lower than the targeted range. This statistic is not significant due to a small sample size. A table showing other fish species found and their observed abundance estimates are included in Table 1. The bluegills ranged in size from 50-168mm.

Discussion

Urieville Lake continues to support a fair fishery for Largemouth Bass and Bluegill. There are small numbers of quality sized bass (>300 mm) and bluegill (>150 mm) available to anglers willing to fish in the tough, weedy conditions (Figures 1 and 2). Although few Bluegill Sunfish were collected during the (3)100 second fish community surveys, many other individuals were encountered. Larger individuals were observed on spawning beds in a very small portion of the lake that was outside our chosen fish community sampling stations. Several large Redear Sunfish were also collected. Past stocking has helped to improve and re-establish fishable bass and bluegill populations. Urieville Lake water quality and habitat issues are expected to continue to limit future fish abundance and angling quality. Until the nutrient and sediment problems are resolved this impoundment will continue to produce limited fishing opportunities.

Recommendations

Current statewide regulations concerning Largemouth Bass and panfish are sufficient at this time. Fish populations within Urieville Lake are largely limited by water quality and there is no indication that over harvest is taking place.

Table 1. Common and scientific names and observed abundance estimates of fish species sampled from Urieville Lake, Spring 2013.

Common Name	**Scientific Name**	**General Occurrence**
Largemouth Bass	*Micropterus salmoides*	Common
Bluegill Sunfish	*Lepomis macrochirus*	Common
Creek Chubsucker	*Erimyzon oblongus*	Common
Pumpkinseed Sunfish	*Lepomis gibbosus*	Common
Golden Shiner	*Notemigonus crysoleucas*	Scarce
Common Carp	*Cyprinus Carpio*	Rare
American Eel	*Anguilla rostrata*	Scarce
Redear Sunfish	*Lepomis microlophus*	Scarce
Brown Bullhead	*Ameiurus nebulosus*	Common

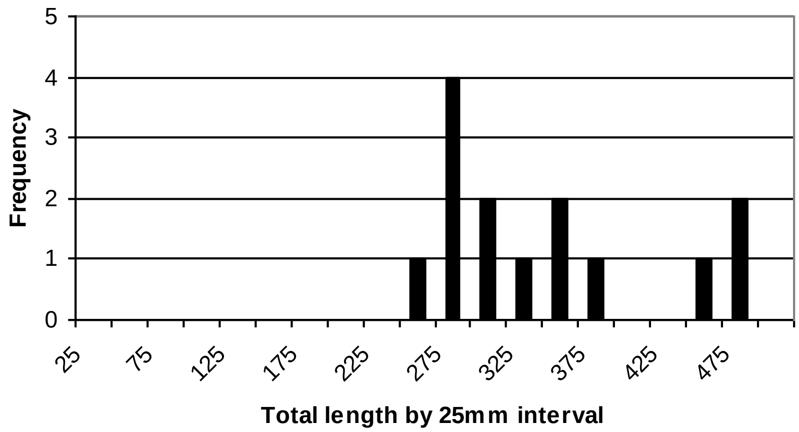


Figure 1. Length-frequency distribution of Largemouth Bass collected from Urieville Lake, Spring 2013.

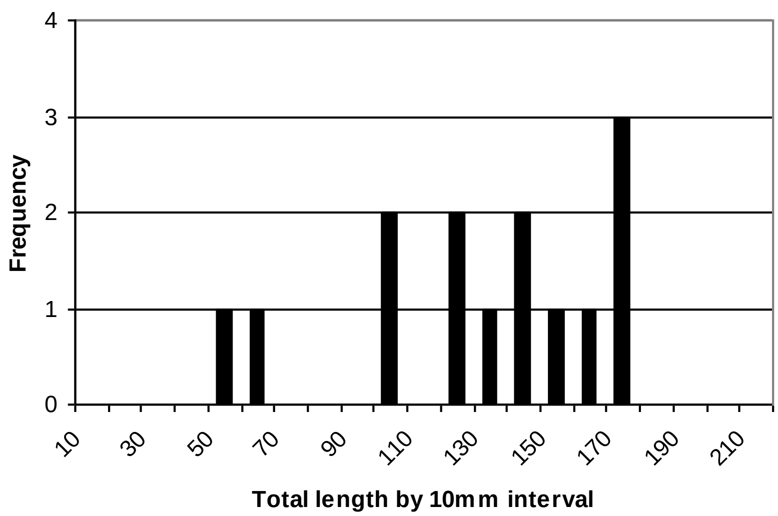


Figure 2. Length-frequency distribution of Bluegill Sunfish collected from Urieville Lake, Spring 2013.

ANNUAL PERFORMANCE REPORT
2013

Maryland Department of Natural Resources
Fisheries Service
Inland Fisheries Division

SURVEY AND MANAGEMENT OF FRESHWATER FISHERIES RESOURCES

Management of Maryland's Coldwater Streams

USFWS Federal Aid Grant F-48-R-23

Study III
Jobs 1 and 2

By:
Brett Coakley
Todd Heerd
Joshua Henesy
Alan Klotz
John Mullican
Susan Rivers
Mark Toms
Kenneth Wampler

Table of Contents
Management of Maryland's Coldwater Streams

Trout Population Statistics C3
Individual Stream Studies
- Savage River Tailwater C12
- Youghiogheny River C30
- Antietam Creek C42
- Beaver Creek C50
- Black Rock Creek C57
- Fishing Creek C62
- Hunting Creek C66
- Little Hunting Creek C72
- Bee Tree Run C77
- Gunpowder Falls Tailwater C80
- Paint Branch C88
- Basin Run C94
- Mill Creek and Rock Run C97

SUMMARY OF TROUT POPULATION STATISTICS – 2013

State: Maryland

Project No.: F-48-R-23
Study No.: III
Job No.: 1

Project Title: Survey and Management of Maryland's Fishery Resources

Study Title: Management of Maryland's Coldwater Streams

Job Title: Trout Population Statistics

Objectives:

The objectives of this study are:

- To determine the distribution and abundance of trout, and to identify physical, chemical and biological parameters affecting densities of trout for those waters of the state which are known to support natural trout populations, may have the potential to support natural trout populations, or may be utilized to provide public recreational trout fishing.
- To monitor environmental conditions in order to detect changes in environmental quality to prevent or reduce environmental degradation as well as to document any improvement in environmental quality.
- To provide data for the development of effective management plans.

Methods

The methods described here are those used in all sample areas. In the event that the methodology had to be modified in an individual area, it is noted in the methods section for that area.

Sampling stations are selected to include all the habitat types present in the stream reach to be surveyed (pool, riffle, run, etc.). The total length and width of the station are then measured to the nearest tenth of a meter. Stream surface area is computed and expressed in hectares. Fish populations are estimated using the three pass regression technique ($P \leq 0.05$) outlined by Zippin (1958). Fish are collected using dip nets and a Smith-Root backpack electrofishing unit (LR-24, Model 12-A POW) or a Smith-Root barge/bank mounted electrofishing unit (1.5KW or 2.5 GPP). The survey begins at the downstream end of the station and three electrofishing passes are made through the entire station. During each pass all the sportfish are collected and placed in a separate float box. The relative abundances of non-game species are observed and recorded. Observed abundance estimate is expressed as scarce (< 5 individuals), common (5-100 individuals) or abundant (> 100 individuals). All sportfish are anesthetized with a 1:10 solution of clove oil and ethanol alcohol, identified to the species level, measured for total length to the nearest millimeter, weighed to the nearest gram, and returned alive to the stream at the end of the survey. Population estimates for each species collected are made using the MICROFISH 2.2 software package (VanDeventer and Platts 1985). The coefficient of condition factor (K) was used to assess physical condition for trout species (Lagler 1952). Statistical analyses of population means were interpreted as described in Motulsky (2003).

Results & Discussion

Table 1 summarizes the results of all trout population studies funded within Federal Aid Project F-48-R-23 during 2013. An individual description of results for each sampling area follows, however in order to provide a quick reference of coldwater fishery resources of the State, Fisheries Service staff prepared the following table summarizing the results of all trout population studies funded with Federal Aid Project F-48-R-20 during 2013. Population studies were conducted by Inland Fisheries personnel and the results are grouped by watersheds. Agencies of Federal, State, and local government with resource management, land-use planning, and environmental protection responsibilities are encouraged to use this information to provide the maximum degree of protection for those streams that are within their jurisdiction.

Table 1. Results of trout population surveys in Maryland during 2013. Key: Bk = Brook Trout; Bn = Brown Trout; R = Rainbow Trout; Ct = Cutthroat Trout; n = naturally reproduced; a = stocked as adults; f = stocked as fingerlings.

North Branch Potomac River Watershed								
Stream/Station	**Species/ Origin**	**Adult Kg/ha**	**Adult Trout/ha**	**Adult Trout/km**	**95% CI**	**YOY/ ha**	**YOY/ km**	**95% CI**
North Branch Potomac River								
Upper C&R	Bn-n,f	3	19	38	33.13	0	0	0
	Rn-n,f	12	22	44	11.69	0	0	0
	Total	15	42	82	13.11	0	0	0
Trout Run								
Lower	Bk-n	0	0	0	0	244	147	11.7
Jennings Run								
Brick Plant	Bk-n	37	158	40	0	0	0	0
Ashley Run								
Lower	Bk-n	15	286	53	0	3357	627	3.5
Cash Valley Run								
Lower	Bk-n	57	737	187	1.01	5895	1493	2.4
Upper	Bk-n	4	91	19	0	227	46	29.4
Koontz Run								
Lower	Bk-n	30	731	253	0	0	0	0
Upper	Bk-n	6	237	120	0	0	0	0
Sand Spring Run								
Armory	No Trout Collected In Sample							
Staub Run								
Oil Spillway	Bk-n	40	931	360	6.07	793	307	8.3
Winebrenner Run								
Below Dam	Bk-n	3	87	27	0	0	0	0
Savage River Tailwater								
Fly Only	Bk-n	7	93	159	2.32	214	368	8.8
	Bn-n	62	419	720	4.34	61	104	6.9
	Rn-a	2	10	16	0	0	0	0
	Ct-f	1	3	5	0	0	0	0
	Total	71	521	896	2.94	278	478	7.1
Aarons Run	Bk-n	3	37	60	20.65	57	93	24.9
	Bn-n	64	433	714	5.32	63	104	10.3
	Rn-a	2	10	16	98.33	0	0	0
	Ct-f	1	3	5	0	0	0	0
	Total	73	493	813	6.02	123	203	13.4
Upper Savage River								
Frostburg Pond Lower	No Trout Collected In Sample							
Frostburg Pond Upper	No Trout Collected In Sample							

Table 1 (continued). Results of trout population surveys in Maryland during 2013. Key: Bk = Brook Trout; Bn = Brown Trout; R = Rainbow Trout; Ct = Cutthroat Trout; n = naturally reproduced; a = stocked as adults; f = stocked as fingerlings.

Stream/Station	**Species/ Origin**	**Adult Kg/ha**	**Adult Trout/ha**	**Adult Trout/km**	**95% CI**	**YOY/ ha**	**YOY/ km**	**95% CI**
Upper	Bk-n	38	1172	453	2.73	103	40	101.7
Middle	Bk-n	25	245	160	13.4	61	40	101.7
	Rn-a	5	20	13	0	0	0	0
	Total	30	265	173	0	61	40	101.7
Lower	Bk-n	17	509	360	71.47	57	40	101.7
	Rn-a	9	38	27	0	0	0	0
	Total	27	509	360	71.47	57	40	101.7
Broadwater's Chapel	Bk-n	1	19	13	0	0	0	0
	Rn-a	7	38	27	0	0	0	0
	Total	6	57	40	0	0	0	0
Big Run								
Upper	Bk-n	33	1220	667	3.42	732	400	25.9
Middle	Bk-n	30	1030	453	5.45	1394	613	4.8
Lower	Bk-n	41	541	267	6.2	622	307	3.6
Monroe Run								
Upper	Bk-n	64	2900	773	1.6	450	120	11.8
Middle	Bk-n	74	1636	720	1.39	2636	1160	11.1
Lower	Bk-n	27	737	373	1.82	474	240	-5.9
Monroe Run								
Upper	Bk-n	114	2433	973	4.45	900	360	14.4
Middle	Bk-n	63	1167	747	11387	646	413	3.9
Lower	Bk-n	8	150	40	93.1	0	0	0
	Rn-a	6	50	13	0	0	0	0
	Total	14	200	53	48.73	0	0	0
Poplar lick								
Upper	Bk-n	39	1375	440	4.11	2083	667	9.1
Middle	Bk-n	55	1281	547	3.58	1375	587	30.6
Lower	Bk-n	94	2000	747	5.31	429	160	17.3
Blue Lick								
Upper	Bk-n	39	1417	453	2.9	542	173	7.7
Middle	Bk-n	28	484	200	10.99	1161	480	144.2
Lower	Bk-n	9	345	133	0	138	53	0
Little Savage River								
Upper	Bk-n	26	365	427	21.9	378	187	21.4
Middle	Bk-n	127	1741	627	7.02	0	0	0
Lower	Bk-n	52	1586	613	17.43	759	293	91.8
Crabtree Creek								
Upper	Bk-n	50	579	293	5.14	1105	560	2.6
Middle	Bk-n	28	286	213	3.66	1036	773	10.1

Table 1 (continued). Results of trout population surveys in Maryland during 2013. Key: Bk = Brook Trout; Bn = Brown Trout; R = Rainbow Trout; Ct = Cutthroat Trout; n = naturally reproduced; a = stocked as adults; f = stocked as fingerlings.

Stream/Station	Species/ Origin	Adult Kg/ha	Adult Trout/ha	Adult Trout/km	95% CI	YOY/ ha	YOY/ km	95% CI
Black Lick								
Lower	Bk-n	12	382	173	1.18	0	0	0
Elk Lick								
Lower	Bk-n	35	967	387	4.48	33	13	0
Mud Lick								
Lower	Bk-n	11	321	120	0	71	27	0
Bear Pen								
Lower	Bk-n	71	1500	640	16.7	19.06	813	98.4
Dry Run								
Lower	Bk-n	50	1071	200	4.16	1286	240	7.6
Spring Lick								
Lower	Bk-n	20	600	160	- 84.68	1300	347	5.4
Youghiogheny River Watershed								
Buffalo Run								
Lower	No Trout Collected In Sample							
Chub Run								
Lower	Bk-n	0	0	0	0	26	13	0
Cove Run								
Hickory	Bk-n	10	103	40	106.9	241	93	15
Hoyes Run								
Hunters Camp	Bk-n	5	154	53	43.25	500	173	8.3
	Bn-n	10	192	67	9.32	115	40	182.3
	Rn-n	17	346	120	21.5	692	240	0
	Total	31	692	240	2.94	1308	453	2.7
Youghiogheny River								
Hoyes Run	Bn-f,n	14	162	720	15.06	0	0	0
	Rn-f,a	43	262	1165	5.22	0	0	0
	Total	58	423	1879	5.71	0	0	0
Sang Run	Bn-f	4	10	38	41.77	0	0	0
	Rn-f,a	8	19	71	39.09	0	0	0
	Total	13	33	121	40.27	0	0	0
Upper And Middle Potomac Watershed								
Hunting Creek								
Elbow Pool	Bn-n	80	973	518	2.74	813	433	4.9
	Rn-a	24	147	78	0	0	0	0
	Total	104	1120	596	2.38	813	433	4.9
Bear Ranch	Bn-n	77	778	368	4.76	926	439	6.0
	Rn-a	4	19	9	0	0	0	0
	Total	81	796	377	4.65	926	439	6.0

Table 1 (continued). Results of trout population surveys in Maryland during 2013. Key: Bk = Brook Trout; Bn = Brown Trout; R = Rainbow Trout; Ct = Cutthroat Trout; n = naturally reproduced; a = stocked as adults; f = stocked as fingerlings.

Stream/Station	**Species/ Origin**	**Adult Kg/ha**	**Adult Trout/ha**	**Adult Trout/km**	**95% CI**	**YOY/ ha**	**YOY/ km**	**95% CI**
Little Hunting Creek								
Catoctin Hollow	Bn-n	140	1444	470	2.56	1333	434	5.6
Manor Area	Bn-n Rn-f Total	49 1 50	1167 24 1190	474 10 484	2.04 0 2.0	833 0 833	339 0 339	17.1 0 17.1
Catoctin Furnace	Bk-n Bn-n Total	0 183 183	0 2056 2056	0 742 742	0 1.35 1.35	56 972 1028	20 351 371	0 5.7 5.4
Fishing Creek								
Upper Right Fork	Bk-n	52	1810	529	2.63	1857	542	12.8
Lower Right Fork	Bk-n	17	786	289	3.03	1381	509	3.4
Upper Left Fork	Bk-n Rb-a Total	40 14 56	2842 79 2921	1200 33 1233	3.7 0 3.6	921 0 921	389 0 389	60.0 0 60.0
Lower Left Fork	Bk-n Rb-a Total	22 7 28	1174 43 1217	404 15 419	3.7 0 3.57	261 0 261	90 0 90	0 0 0
Above Ford Left Fork	Bk-n	106	5579	1472	2.83	1895	500	8.3
Below Ford Left Fork	Bk-n	44	2733	605	7.23	1333	295	5.0
Beaver Creek								
Lower Jackson	Bn-n	74	752	505	5.15	473	318	4.9
Upper Jackson	Bn-n Rb-a,f,n Total	193 5 199	1466 17 1483	939 11 950	2.94 250 2.91	552 9 560	354 6 359	10.9 0 10.8
Put and Take	Bn-n Rb-a,f,n Total	359 2 360	3014 14 3027	1812 8 1820	4.04 0 4.02	2635 14 2649	1584 8 1592	4.1 0 4.1
Zimmerman	Bn-n Rb-a,f,n Total	90 2 93	521 8 537	390 6 402	20.63 0 21.54	322 8 314	241 6 235	64.1 0 52.6
Black Rock								
Rt. 66	Bn-n	162	1316	316	4.0	316	76	0

Table 1 (continued). Results of trout population surveys in Maryland during 2013. Key: Bk = Brook trout; Bn = Brown Trout; R = Rainbow Trout; Ct = Cutthroat Trout; n = naturally reproduced; a = stocked as adults; f = stocked as fingerlings.

Stream/Station	Species/ Origin	Adult Kg/ha	Adult Trout/ha	Adult Trout/km	95% CI	YOY/ ha	YOY/ km	95% CI
Patapsco River Watershed								
Piney Run								
Above Route 97	Bn-n	0	0	0	0	105	41	112.5
Gunpowder Falls Watershed								
Springhouse Run								
Near Confluence With Prettyboy Reservoir	Bk-n	41	800	320	5.9	633	253	76.2
Clipper Mill tributary								
Along Clipper Mill Road	Bk-n	11	125	27	100	625	133	27.1
Frog Hollow								
Spooks Hill And Parsonage Roads	Bk-n Bn-n Total	6 4 10	70 47 116	20 14 34	106.9 100 29.4	47 0 47	14 0 14	635.3 0 635.3
Piney Creek								
Above I-83	Bn-n	80	940	376	2.8	280	112	12.6
Panther Branch								
Near Confluence With Gunpowder Tailwater	Bn-n	26	571	213	3.5	3036	1133	27
Mingo Branch								
USGS Station Upstream	Bn-n	49	1000	200	100	4267	853	37.6
Bush Cabin Run								
Below Evna Road	Bk-n Bn-n Total	11 19 29	233 200 433	59 51 110	14.99 45.2 16.9	33 300 400	8 76 102	100 33.1 82.3
Sawmill Branch								
5 Green Glade Road	Bk-n	7	89	30	100	133	45	20.2

Table 1 (continued). Results of trout population surveys in Maryland during 2013. Key: Bk = Brook Trout; Bn = Brown Trout; R = Rainbow Trout; Ct = Cutthroat Trout; n = naturally reproduced; a = stocked as adults; f = stocked as fingerlings.

Stream/Station	Species/ Origin	Adult Kg/ha	Adult Trout/ha	Adult Trout/km	95% CI	YOY/ ha	YOY/ Km	95% CI
Unnamed tributary to Sawmill Branch								
5 Green Glade Road	Bk-n	7	467	76	33.1	2467	403	36.8
Unnamed tributary to Sawmill Branch								
Gunpowder Falls State Park	Bk-n	17	320	100	11.7	1440	451	39
Tributary to unnamed tributary to Sawmill Branch								
Gunpowder Falls State Park	Bk-n	0	0	0	0	818	120	100
Bunker Hill tributary								
Above Confluence With Gunpowder Falls	Bk-n Bn-n Total	0 11 11	0 203 203	0 99 99	0 16.9 16.9	16 688 688	8 335 335	100 42.9 37.8
Walker Run								
Horse Trail Crossing	Bk-n	11	179	53	100	71	21	100
Silver Run								
Slab Bridge Rd Below Old Mill Dam	Bk-n	43	586	227	100	207	80	20.2
Bee Tree Run								
Middle	Bn-n	81	1161	545	5.9	1403	659	8.6
Gunpowder Falls Tailwater								
Dam/Falls	Bn-n Rb-s Total	114 1 116	1094 6 1101	1757 10 1767	1.8 100 1.8	19 88 107	30 141 172	100 15.7 10.6
Masemore Road	Bn-n Bk-n Rb-s Total	61 0 0 60	515 2 0 517	661 3 0 664	1.1 100 1.1	235 0 7 240	303 0 9 309	32.5 0 38.1 29.6
Below Blue Mount Road	Bn-n	49	349	722	1.5	156	323	8.9
Long Green Creek								
Downstream of Long Green Pike	Bn-n	3	16	11	100	11	7	100

Table 1 (continued). Results of trout population surveys in Maryland during 2013. Key: Bk = Brook Trout; Bn = Brown Trout; R = Rainbow Trout; Ct = Cutthroat Trout; n = naturally reproduced; a = stocked as adults; f = stocked as fingerlings.

Stream/Station	Species/ Origin	Adult Kg/ha	Adult Trout/ha	Adult Trout/km	95% CI	YOY/ ha	YOY/ km	95% CI
Potomac-Washington Watershed								
Good Hope Tributary								
Hobbs Drive	Bn-n	1	38	9	100	0	0	0
Gum Springs Tributary								
Mouth	Bn-n	3	27	6	100	0	0	0
Lower Susquehanna Watershed								
Gladden Branch								
Rocks Station Road	Bk-n	29	432	121	7.4	270	75	27.1
Kellogg Branch								
Knopp Road	Bk-n Bn-n Total	2 12 15	43 43 87	13 13 27	100 100 100	0 130 130	0 40 40	0 253 253
Patuxent River Watershed								
Patuxent River Tailwater								
Below Brighton Dam	Bn-s Rb-s Total	4 0 4	16 0 16	25 0 25	66.6 0 66.6	16 83 99	25 128 153	100 16.6 12.1
Haviland Mill Road	Bn-s Rb-s Total	6 1 7	33 4 37	51 6 57	100 100 100	0 4 4	0 6 6	0 100 100
Lower Susquehanna Watershed								
Basin Run Unnamed Tributary								
Russell Road	Bn-n	0	0	0	0	650	130	0

State: Maryland

Project No.: F-48-R-23
Study No.: III
Job No.: 2

Project Title: Survey and Management of Maryland's Fishery Resources

Study Title: Management of Maryland's Coldwater Streams

Job Title: Individual stream studies

Western Region District I – Garrett and Allegany Counties
Savage River Tailwater Trout Population Studies
(Garrett County)

Introduction

The Savage River Tailwater (SRT) is a 7.9 km stream reach of the Savage River between the Savage River Reservoir Dam and its confluence with the North Branch Potomac River (NBPR) in Garrett County, MD. The SRT was managed entirely as a Put and Take trout fishery prior to 1987. After the completion of Jennings Randolph Reservoir on the NBPR upstream of the mouth of the Savage River in 1982, The United States Army Corps of Engineers (USACE), operators of both reservoirs, coordinated flow management from the Savage River Reservoir closely with that of Jennings Randolph Reservoir. The result was more flexibility in the management of the Savage River Reservoir, and increased potential for wild trout management downstream. By 1986, the USACE had begun to implement flow and lake level management recommendations from the MD DNR Inland Fisheries Service designed to enhance coldwater fisheries management downstream of the Savage River Reservoir. The SRT is regulated under Trophy Trout regulations implemented in January 1987 and further modified in 1991. The current regulation strategy includes a Fly-fishing Only Trophy Trout Management Area located in the section of the river from the Savage River Reservoir downstream approximately 2.1 km to the Allegany Bridge. A Trophy Trout Management Area, restricted to the use of single hook artificial lures or flies, is located between the Allegany Bridge and the mouth of the river, a distance of about 4.4 km. Regulations for both Trophy Trout Management Areas include a year-round open season, a 305 mm minimum size limit for Brook Trout *Salvelinus fontinalis*, a 457 mm minimum size limit for Brown Trout *Salmo trutta*, and a two-trout daily creel limit. There is no minimum size limit on Rainbow Trout *Oncorhynchus mykiss* in either area. The stocking of hatchery trout in the SRT was discontinued after 1990.

Objectives

The purpose of this study is to monitor trout population parameters of the wild Brook Trout and Brown Trout fishery that has developed in the SRT since 1987. The objectives are:

- Estimate adult and young of year trout population densities annually in two established sampling stations.
- Estimate adult trout standing crops annually.
- Calculate indices of physical condition of adult trout.
- Monitor the aquatic macroinvertebrate community.

Methods

Fish population survey
Methodology follows that described in the Study III Job 1 Methods section. Only variations from that methodology are described here. Trout populations were estimated at two stations in the SRT during 2013. Station 1 was located in the 2.1 km Fly Fishing Only section, while Station 2 was located in the 4.4 km Artificial Lures/Flies section.

Benthic Macroinvertebrates
Benthic macroinvertebrate surveys in two sample stations were conducted in August 2013. Benthic macroinvertebrates were collected using a kick net (six 30 second kicks) at each sample station. The samples were collected from a variety of stream habitats, including riffle areas and pools within each station. The samples were placed in a labeled sample bottle and preserved with 70% isopropyl alcohol. In the lab, the samples were poured into a white tray and all macroinvertebrates were picked from the detritus and placed in a sample bottle containing 70% isopropyl alcohol. The macroinvertebrates were identified to the lowest practical taxon (Merritt and Cummins 1996; Pennak 1978; Stewart and Stark 1988; Wiggins 1977) and population indices were calculated using the methods utilized by the Maryland Department of Natural Resource's Inland Fisheries Division described by MD DNR (2004) and from the Maryland Biological Stream Survey (Southerland et al. 2005). Results are shown in the Appendix of this report section.

Results

A list of fish species collected in the SRT during 2013 is contained in Table 1. This fish species assemblage, consisting mainly of salmonids, cottids, and cyprinids, is indicative of a coldwater community (Steiner 2000).

Estimates of adult trout species standing crops (kg/ha) in the SRT from 2009 to 2013 are presented in Figure 1. Combined trout species standing crops showed an increase for the first time since the reservoir draining event during 2010. Brook Trout standing crops in the SRT have decreased significantly since 1988, and have remained relatively low (< 5 kg/ha) during the last five-year period (Figure 1). Brown Trout standing crops have increased for the first time since the February 2010 reservoir draining event (Figure 1). Table 2 shows that Brown Trout continue to make up the majority of the combined species standing crop, comprising about 87.5% of the total during 2013, with Brook Trout comprising 7%, and Rainbow Trout/Cutthroat Trout the remainder.

Figure 2 shows the adult trout species densities (trout per km) for the years 2009 through 2013. The combined adult trout densities did not meet our management objective of 621 adult trout per km during 2010 through 2012. However, the strong 2012 year-class provided for an increase in adult trout densities, exceeding our management goals in 2013. Adult Brown Trout continue to be the dominant salmonid species in the SRT comprising about 84% of the estimated adult density (Table 3). Adult Brook Trout estimated densities continue to be low, accounting for only 13% of the estimated combined adult trout densities in 2013. Rainbow Trout are generally found in low densities in the SRT (N = 6), and are emigrants from the North Branch Potomac River or from the Savage River Reservoir, where they are stocked as part of the Put and Take trout stocking program. Two adult Cutthroat Trout were also collected (one in each station) and were most likely stocked as fingerlings in the North Branch Potomac River in 2011.

Young-of-year (YOY) trout densities for 2009 through 2013 are shown in Figure 3. Weak year classes for both Brook and Brown Trout were observed in 2009 through 2011 when the estimated YOY densities were less than 200/km. A strong year-class for both Brook and Brown Trout was documented in 2012 when both species exceeded 500 YOY per km. The 2013 year-class for both Brook Trout and Brown Trout were less than 250 YOY/km; however Brook Trout YOY densities were about 2 times greater than Brown Trout YOY densities (Table 5).

During the critical trout egg/fry stage (October 2012 –May 2013), flows in the SRT exceeded 800 cfs on at least four events, with maximum flows reaching 3,000 cfs in early May (Figure 4). These high flow events during this time period generally have negative impacts on YOY densities.

The densities of quality-sized trout in the SRT for 2009 - 2013 are presented in Figure 5. The quality-size trout (QST) estimate is a useful descriptor of the population's age and size structure. The mean number of quality sized Brown Trout (> 305 mm) per km showed a slight decrease since 2009 as older, larger fish exit the population and there has been poor recruitment up until 2013. The mean number of quality-size Brook Trout (> 229 mm) per km continued to be relatively low in 2013, as numbers ranged from 8 to 20 QST/km during this five year period.

Average size and condition of adult trout in the SRT for 2013 are contained in Table 4. Condition factors (K) were in the optimal range (0.90-1.10) for all trout species. This is an indication that habitat and forage availability is sufficient to support current trout numbers. Average size of both adult Brook Trout and Brown Trout decreased since 2012, indicating the recruitment of the Age 1+ fish from the 2012 year-class into the adult population (Figures 6 and 7). The maximum size Brook Trout was 300 mm, close to the Trophy Trout minimum size of 305 mm; while the maximum size Brown Trout was 410 mm, less than the Trophy Trout size of 457 mm.

Discussion

Trophy trout regulations were first implemented on a limited basis in 1987, and then extended throughout the SRT in 1991. The stocking of hatchery Rainbow Trout was discontinued after 1990. The minimum size requirements for harvestable Brook and Brown Trout in the SRT protect a high proportion of the wild trout population and the termination of stocking eliminated competition for space and forage between wild and hatchery trout. Initially, wild Brook Trout numbers increased quickly, exceeding the Brown Trout population in 1988. Since 1988, the wild trout population of the SRT has reflected the gradual domination of Brown Trout in terms of standing crop and density. Other investigators have reported comparable findings in streams where Brook Trout and Brown Trout coexist (Waters 1983, Faush and White 1981, Kaeding 1980). Barnhart and Engstrom Heg (1984) reported that a similar pattern of Brook Trout and Brown Trout standing crops developed in the Batten Kill River subsequent to the implementation of restrictive harvest regulations. Various reasons are offered. Brown Trout, often larger in size, displace Brook Trout to marginal habitat (Faush and White 1981, Dewald 1990). Brown Trout are more aggressive than Brook Trout and compete more successfully for limited space (Waters 1983). Brown Trout prey effectively on young-of-the-year Brook Trout while consuming few YOY Brown Trout (Alexander 1977).

Conditions due to dam release operations during winter 2009 and the draining of the reservoir during February 2010, and high spring flows in 2011 led to poor or absent year-classes of wild trout during these years. Adult trout densities and standing crops declined in 2012 due to lack of recruitment stock. Flows from the Savage River Reservoir did not exceed 800 cfs during the critical trout spawning, egg, and fry period from October 2011 through May 2012. As a result, a strong year-class was produced for both Brook and Brown Trout in the SRT in 2012. A moderate year-class for both Brook Trout and Brown Trout was documented in 2013, and flows exceeded 800 cfs during four events during the critical life stage in 2013.

The overall quality of the SRT trout fishery is truly extraordinary, with adult trout densities exceeding the management goal of 621 trout/km in 2013. Although comprising a relatively small proportion of all trout in the SRT, wild Brook Trout dominate the remainder of the watershed upstream of the Savage River Reservoir. Wild Brown Trout are present in less than 10% of streams supporting self-sustaining trout populations in the upper North Branch Potomac River watershed. The SRT, characterized by an abundance of wild Brown Trout including many quality-sized fish, offers a unique opportunity for anglers. However, the continued presence of a viable wild Brook Trout component in the SRT trout fishery is desirable from a management perspective. The continued maintenance of a significant wild Brook Trout component in the SRT is considered a key element of overall wild trout management in the SRT. Brook Trout strike flies and lures aggressively and are relatively easier for anglers to catch than Brown Trout, thus contributing to the overall perception of fishing quality. Although Brook Trout were only 13 % of the estimated adult trout density in the SRT during 2013, contacts with anglers indicated that Brook Trout were routinely caught. At this point in the history of the SRT fishery, successful reproduction by Brook Trout is imperative to maintain their current levels. Measures for maintenance of flows during the critical egg and fry stage are necessary to ensure optimal condition for year-class success.

Recommendations

All project work objectives for this study period were accomplished. However, further study will be required in order to continue to monitor the status of wild Brook Trout and Brown Trout in response to trophy trout management in the SRT. It is recommended that this study be continued in 2014.

Table 1. A list of common and scientific names and observed abundance estimate of fish species collected in the Savage River Tailwater, 2013.

Common Name	**Scientific Name**	**General Occurrence**
Blacknose Dace	*Rhinichthys atratulus*	Scarce
Longnose Dace	*Rhinichthys cataractae*	Common
White Sucker	*Catostomus commersonii*	Common
Cutthroat Trout	*Oncorhynchus clarki*	Scarce
Rainbow Trout	*Oncorhynchus mykiss*	Common
Brown Trout	*Salmo trutta*	Abundant
Brook Trout	*Salvelinus fontinalis*	Abundant
Blue Ridge Sculpin	*Cottus caeruleomentum*	Abundant
Yellow Perch	*Perca flavescens*	Scarce

Table 2. Adult trout standing crops (Kg/ha with 95% CI) in the Savage River Tailwater, 2013.

Station	Combined species	Brook Trout	Brown Trout	Rainbow Trout	Cutthroat Trout
1	71 $\pm$ 2	7 $\pm$ 0	62 $\pm$ 3	2 $\pm$ 0	1 $\pm$ 0
2	73 $\pm$ 3	3 $\pm$ 1	64 $\pm$ 3	2 $\pm$ 3	1 $\pm$ 0
Mean =	72 $\pm$ 3	5 $\pm$ 1	63 $\pm$ 3	2 $\pm$ 1	1 $\pm$ 0

Table 3. Adult trout densities (Trout/km with 95 % CI) in the Savage River Tailwater, 2013.

Station	Combined species	Brook Trout	Brown Trout	Rainbow Trout	Cutthroat Trout
1	896 ± 26	159 ± 3	720 ± 31	16 ± 0	5 ± 0
2	813 ± 49	60 ± 13	714 ± 38	16 ± 16	5 ± 0
Mean =	855 ± 38	110 ± 8	717 ± 35	16 ± 8	5 ± 0

Table 4. Mean size and condition with ranges in parenthesis of adult Brook Trout, Brown Trout, and Rainbow Trout in the Savage River Tailwater, 2013.

Species	N	Mean TL (mm)	Mean W (g)	Mean K factor
Brook Trout	40	193 (145-300)	77 (33-222)	0.98 (0.82-1.19)
Brown Trout	252	227 (137-410)	148 (26-720)	0.99 (0.69-1.31)
Rainbow Trout	6	321 (285-380)	313 (210-506)	0.91 (0.79-1.00)
Cutthroat Trout	2	275 (260-290)	193 (160-226)	0.92 (0.91-0.93)

Table 5. Young of year trout densities (YOY/km with 95% CI) in the Savage River Tailwater, 2013.

Station	Combined species	Brook Trout	Brown Trout
1	478 ± 34	368 ± 26	104 ± 7
2	203 ± 27	93 ± 23	104 ± 10
Mean =	341 ± 31	231 ± 25	104± 9

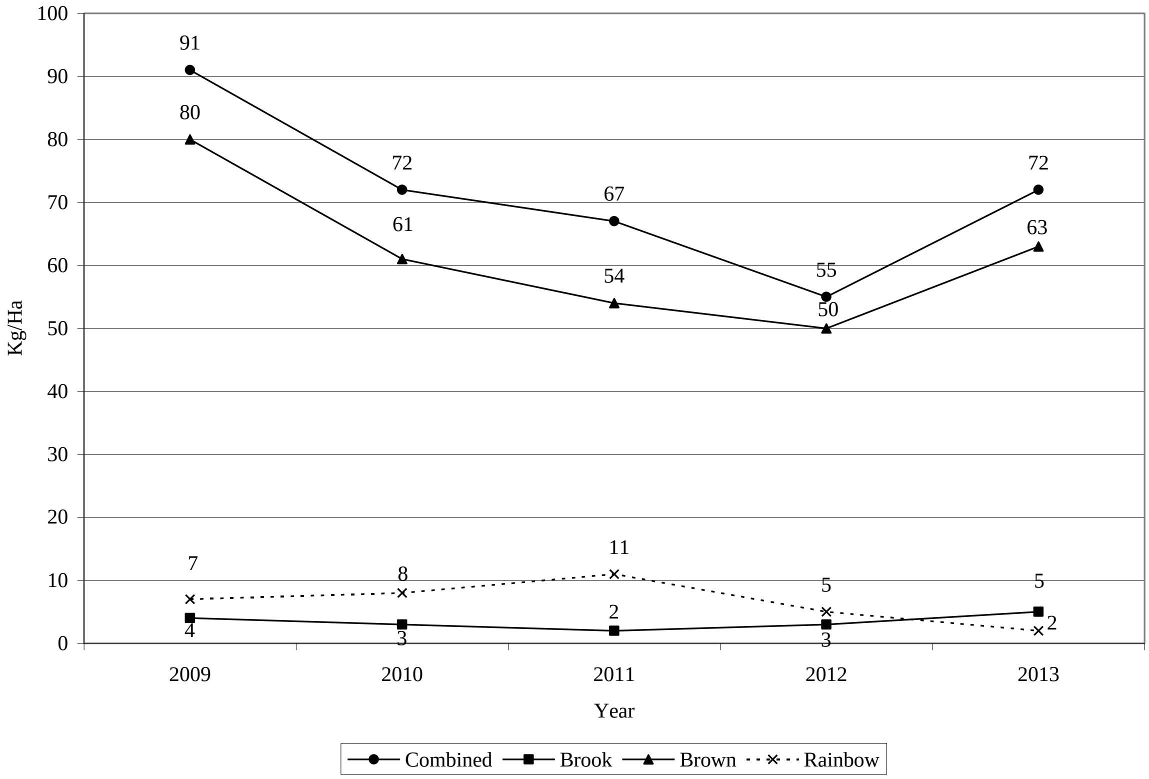


Figure 1. Adult trout standing crops (Kg/ha) in the Savage River Tailwater, 2009 - 2013.

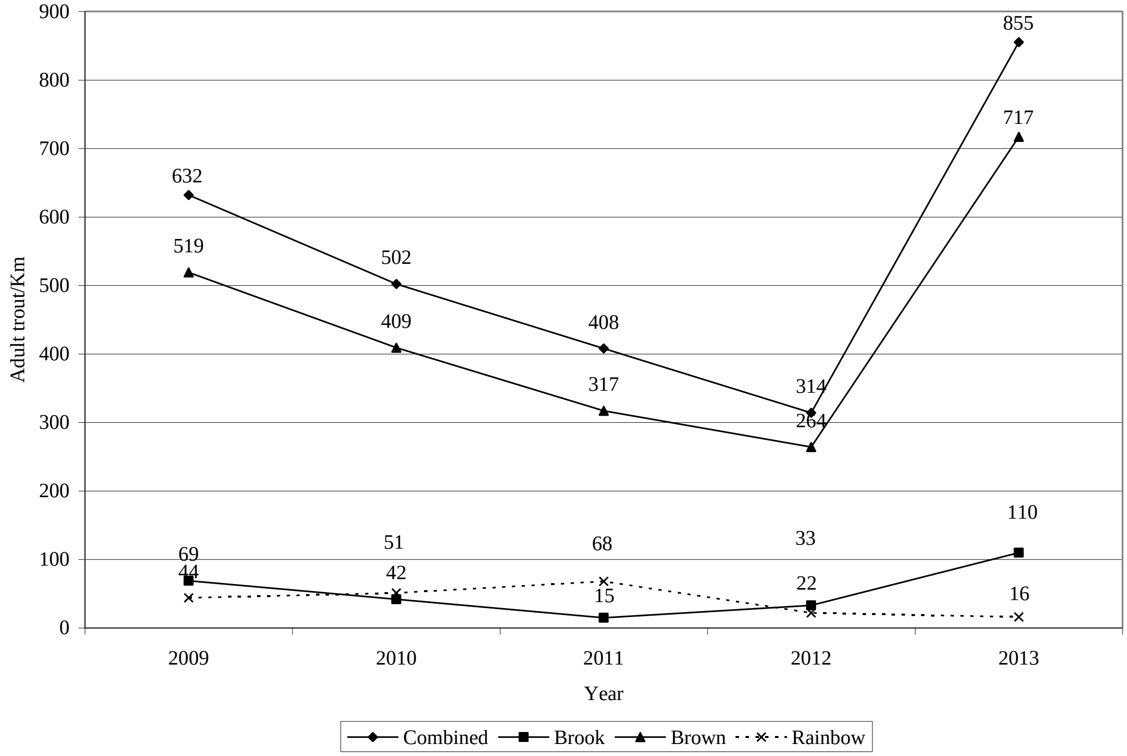


Figure 2. Adult trout densities (trout per kilometer) in the Savage River Tailwater, 2009 –2013.

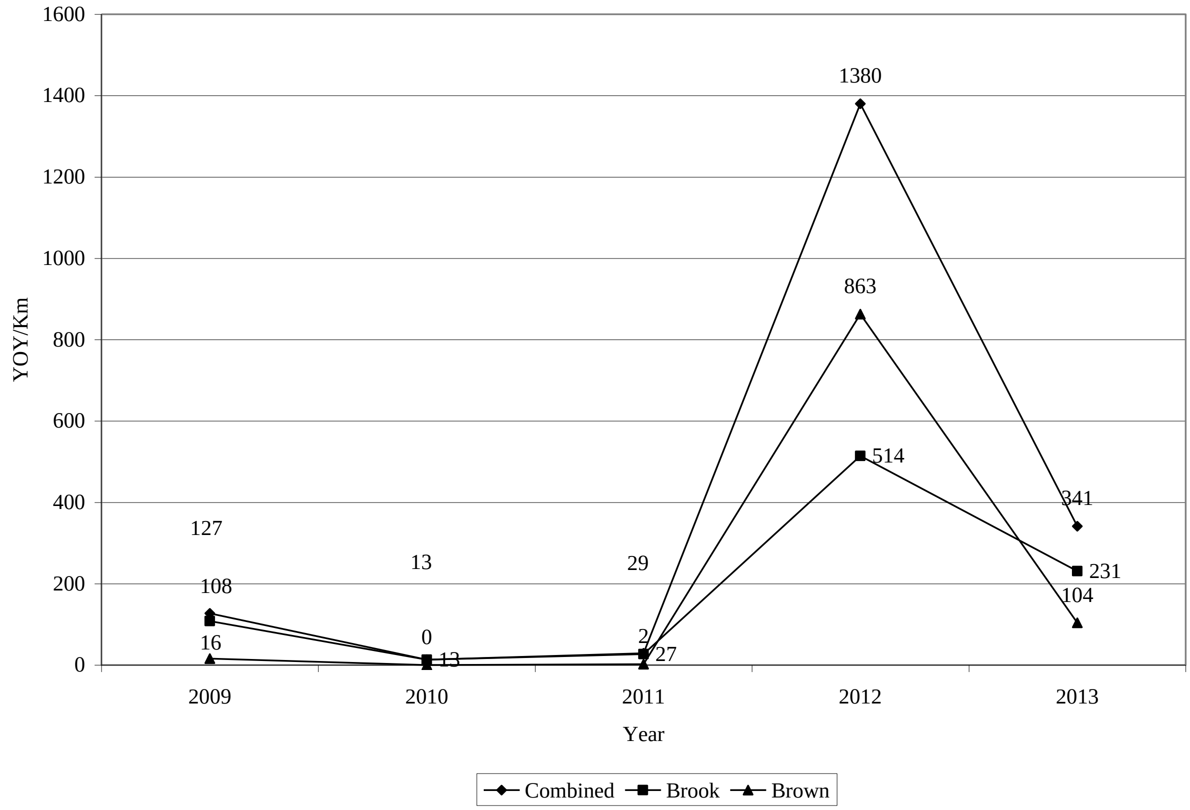


Figure 3. Young of year trout densities in the Savage River Tailwater, 2009 - 2013.

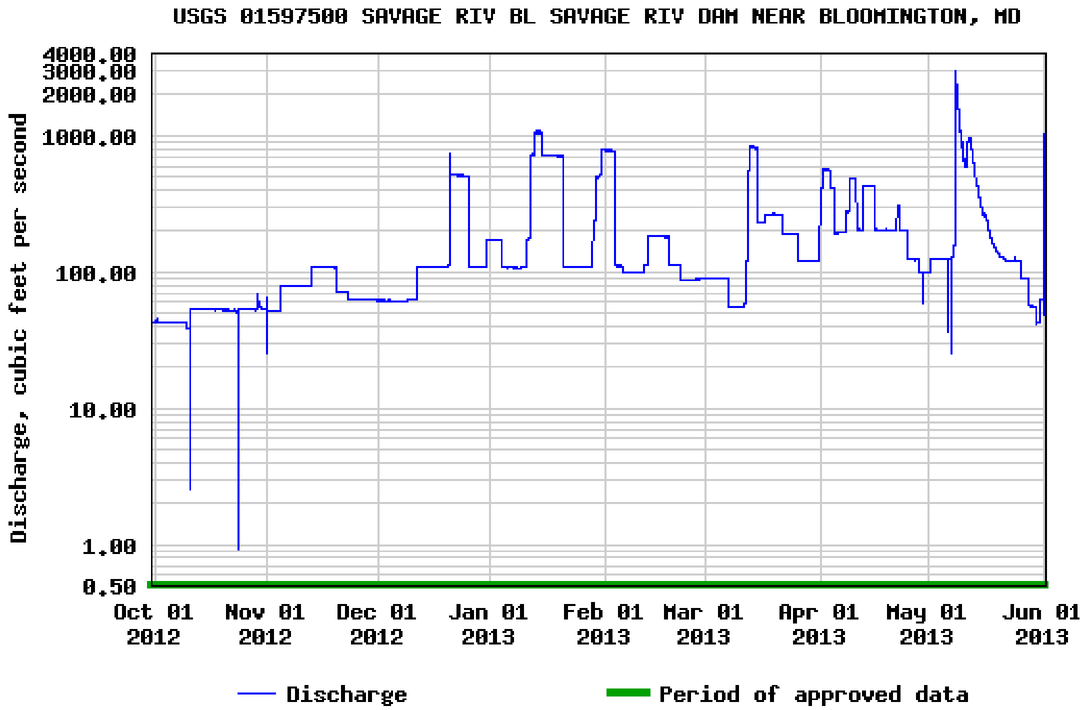


Figure 4. Discharge (cubic foot per second) in the Savage River Tailwater during the critical trout egg/fry stage, 1 October 2012 through 1 June 2013.

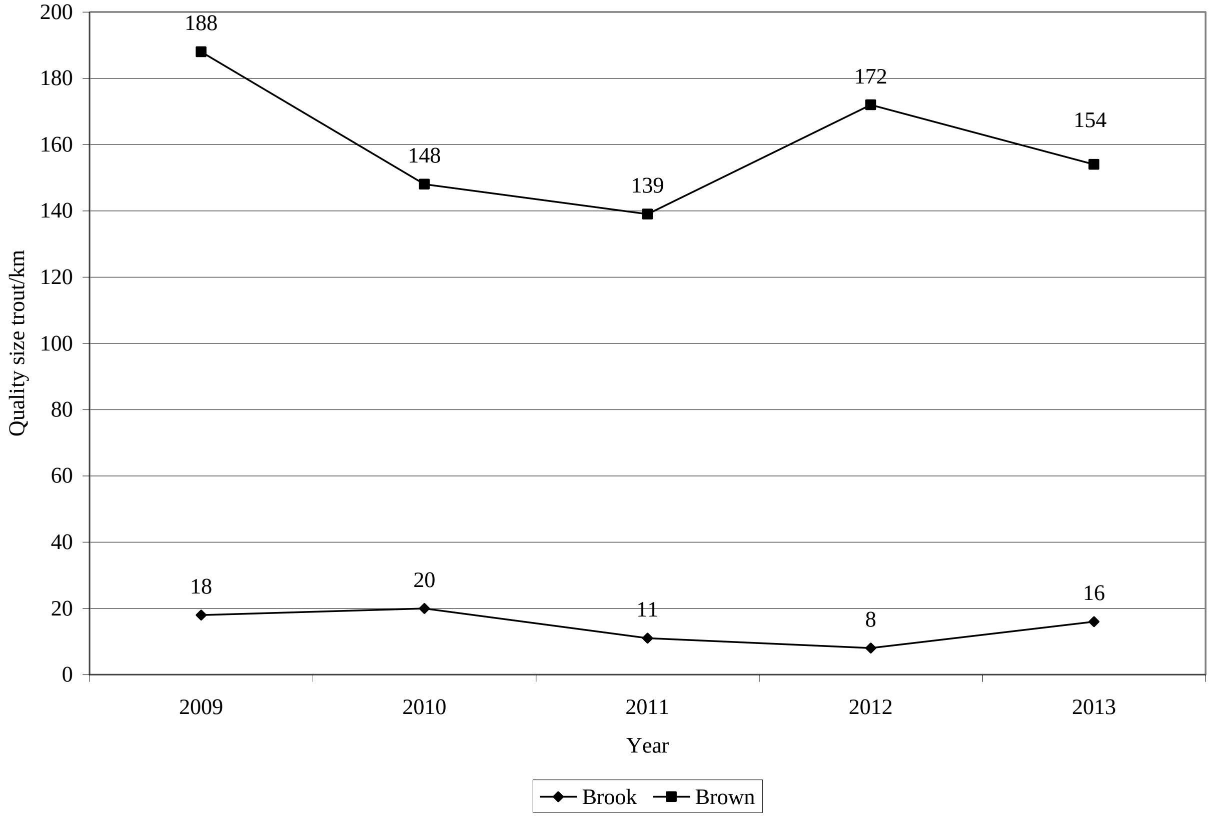


Figure 5. Quality size trout (≥ 229 mm Brook Trout and ≥ 305 mm Brown Trout) densities in the Savage River Tailwater, 2009 – 2013.

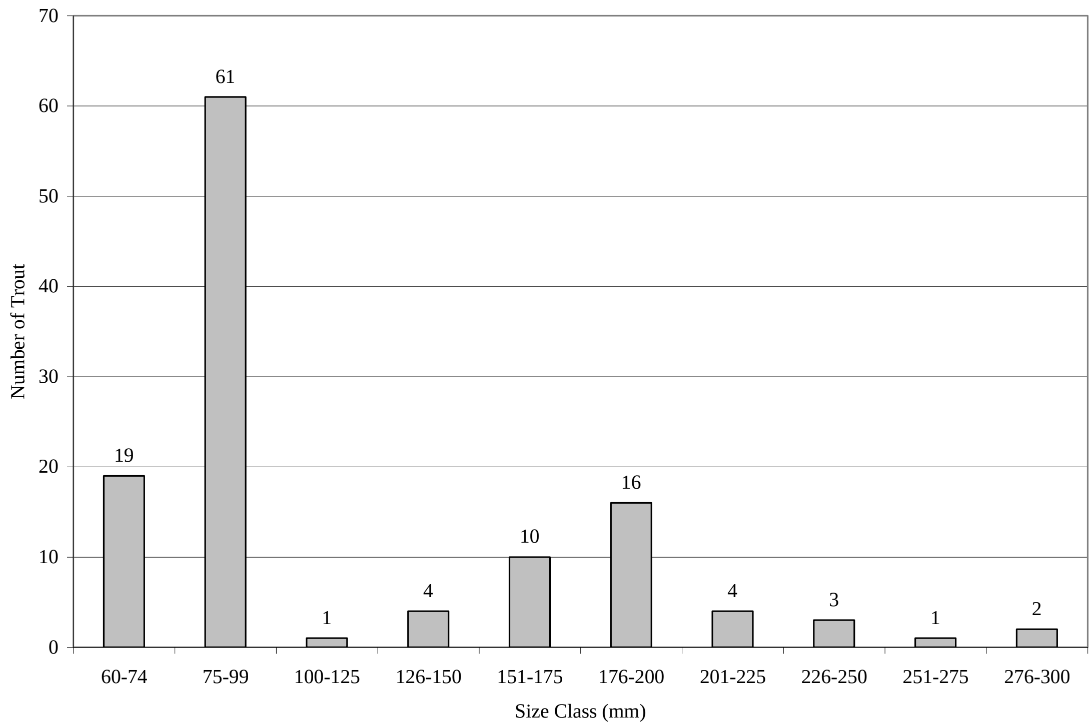


Figure 6. Brook Trout length frequency distribution (N = 121) in the Savage River Tailwater, 2013.

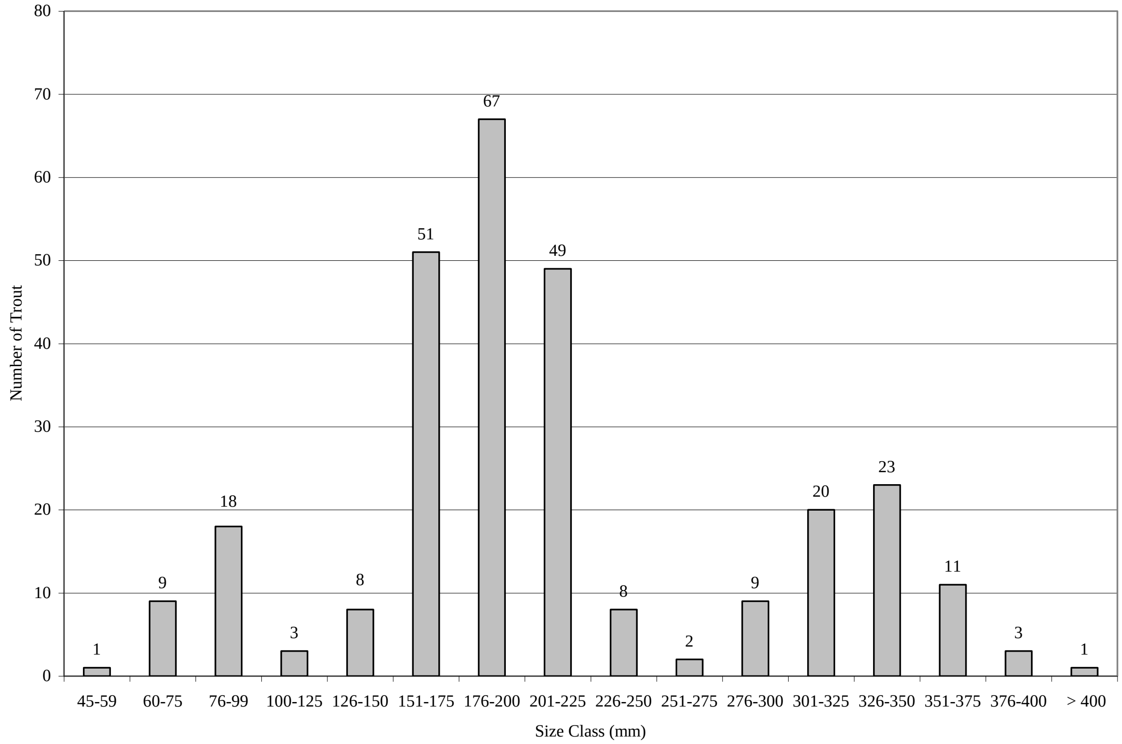


Figure 7. Brown Trout length frequency distribution (N = 283) in the Savage River Tailwater, 2013.

Appendix

SAVAGE RIVER MACROINVERTEBRATE SAMPLES AUGUST 2013

The following macroinvertebrate samples were collected in August of 2013. In 2013, this was the first time Porifera (freshwater sponges) were collected at both stations, but they were much more abundant at the lower, Aaron Run station.

Savage River Allegany Bridge August 9, 2013					
Order	Family/genus	Count	Tolerance	Feeding	Life habit
Ephemeroptera	Baetis sp	55	3.9	Collector	sw, cb, cn
	Heptagenia sp	5	2.6	Scraper	cn, sw
	Paraleptophlebia sp.	13	2	Collector	sw, cn, sp
	Pseudocloeon sp. (=Acentrella sp.)	4	4.9	Collector	sw, cn
	Stenonema sp.	6	4.6	Scraper	cn
Plecoptera	Leuctra sp.	95	0.4	Shredder	cn
Trichoptera	Hydropsyche sp.	8	7.5	Filterer	cn
	Hydroptila sp.	4	6	Scraper	cn
	Potamyia sp.	6	5.7	Filterer	cn
Diptera	Chironomidae - SF Chironominae	64	6.6	Collector	
	SF Orthocladiinae	67	7.6	Collector	
	SF Tanypodinae	17	7.5	Predator	
	TR Tanytarsini	111	3.5	Collector	
	Unid Empididae	1	7.5	Predator	sp, bu
	Tipulidae - Antocha sp.	2	8	Collector	cn
	Hexatoma sp	2	1.5	Predator	bu, sp
Hydracarina		4	6	Predator	sw
Isopoda	Asellus sp. (=Caecidotea)	29	2.6	Collector	sp
Amphipoda	Gammarus sp.	354	6.7	Shredder	sp
Coleoptera	Elmidae - Dubiraphia sp	3	5.7	Scraper	cn, cb
Decapoda	Unid Cambaridae	1	2.8	Shredder	sp
Annelida	Unid Oligochaeta	18	10	Collector	bu
	Porifera in samples				
		S = 22 N = 869			

Fisheries Data	MBSS Data – Combined Highlands
Richness = 22	Number of Taxa = 22 (3)
HBI = 5.3	Number of EPT taxa = 9 (3)
Scraper filterer ratio = 1.28	Number of Ephemeroptera taxa = 5 (5)
EPT = #196 Taxa 9	% intolerant urban = 16.7 (1)
EPT/C = 0.76	% Tanytarsini = 12.8 (5)
Dominant family = 40.7% Gammaridae	% Scrapers = 2.1 (1)
CPOM = 0.51	% Swimmers = 8.7 (3)
Diversity = 2.95	% Diptera = 28.4 (3)
Equitability = 0.49	IBI = 3 fair

Savage River Macroinvertebrate Sampling – Aaron Run Station August 9, 2013					
Order	Family/genus	Count	Tolerance	Feeding	Life habit
Ephemeroptera	Acentrella sp	43	4.9	Collector	sw, cn
	Baetis sp	209	3.9	Collector	sw, cb, cn
	Drunella sp	20	1.9	Scraper	cn, sp
	Epeorus sp	25	1.7	Scraper	cn
	Ephemerella sp	3	2.3	Collector	cn, sw
	Eurylophella sp	6	4.5	Scraper	cn, sp
	Heptagenia sp	9	2.6	Scraper	cn, sw
	Leucrocuta sp	23	1.8	Scraper	cn
	Paraleptophlebia sp	46	2	Collector	sw, cn, sp
	Stenonema sp	57	4.6	Scraper	cn
Plecoptera	Allocapnia sp	1	4.2	Shredder	cn
	Acroneuria sp	8	2.5	Predator	cn
	Agnetina sp (= Phasganophora sp)	1	2.2	Predator	cn
	Isoperla sp	3	2.4	Predator	cn, sp
	Leuctra sp	769	0.4	Shredder	cn
Trichoptera	Cheumatopsyche sp	10	6.5	Filterer	cn
	Dolophilodes sp	22	1.7	Filterer	cn
	Hydropsyche sp	37	7.5	Filterer	cn
	Polycentropus sp	7	1.1	Filterer	cn
	Potamyia sp	3	5.7	Filterer	cn
	Rhyacophila sp	8	2.1	Predator	cn
Diptera	Blephariceridae - Blephoricera sp	3	4	Scraper	cn
	Chironomidae - Chironominae	10	6.6	Collector	
	Chironomidae - Orthocladiinae	16	7.6	Collector	
	Chironomidae - Tanypodinae	55	7.5	Predator	
	Chironomidae - Tanytarsini	83	3.5	Collector	
	Simuliidae - Simulium sp	8	5.7	Filterer	cn
	Tipulidae – Antocha sp	9	8	Collector	cn
	Hexatoma sp	16	1.5	Predator	bu, sp
	Unid Empididae	4	7.5	Predator	sp, bu
Isopoda	Asellus sp	11	2.6	Collector	sp
Amphipoda	Gammarus sp	38	6.7	Shredder	sp
Nematomorpha	Gordidae	4	6.8	Predator	
Acariformes	Hydracarina	5	6	Predator	sw
Megaloptera	Nigronia sp	1	1.4	Predator	cn, cb
Coleoptera	Elmidae – Stenelmis sp	20	7.1	Scraper	cn
	Unidentified	28	4.8	Collector	cn
Oligochaeta	Unid oligochaeta	48	10	Collector	bu
Turbellaria	Unidentified	5	4	Predator	sp
Lepidoptera	Pyraulidae	1	6.7	Shredder	cb
	Numerous Porifera in samples				
		S = 40 N = 1675			

Fisheries Data	MBSS Data – Combined Highlands
Richness = 40	Number of Taxa = 40 (5)
HBI = 2.7	Number of EPT taxa = 21 (5)
Scraper filterer ratio = 1.87	Number of Ephemeroptera taxa = 10 (5)
EPT = #1310 Taxa 21	% intolerant urban = 58 (3)
EPT/C = 7.99	% Tanytarsini = 4.9 (5)
Dominant family = 45.9% Leuctridae	% Scrapers = 9.7 (3)
CPOM = 0.48	% Swimmers = 18.1 (5)
Diversity = 3.31	% Diptera = 12.2 (5)
Equitability = 0.43	IBI = 4.5 good

Data Analysis

To compare these data to past samples, two criteria were chosen –the Index of Biotic Integrity (IBI) from the Maryland Biological Stream Survey (MBSS) data evaluation, and the Hilsenhoff Biotic Index modified (HBI) used by Inland Fisheries. Trendlines were inserted for both sets of data and both showed that macroinvertebrate populations have been improving gradually over the accumulated sampling results. Figure 1 shows the IBI data for the Allegany Bridge station; Figure 2 shows the HBI. Figure 3 shows the IBI data for the Aaron Run bridge station; Figure 4 shows the HBI.

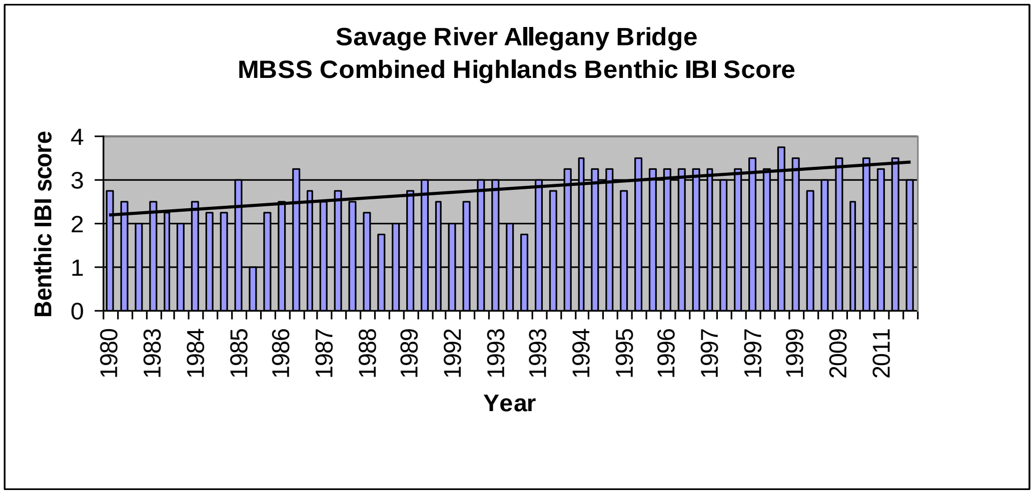


Figure 1. Savage River Allegany Bridge station IBI data 1980 – 2013. (Scores: very poor: 1 – 1.9; poor: 2 – 2.9; fair: 3 – 3.9; good: 4 – 5.)

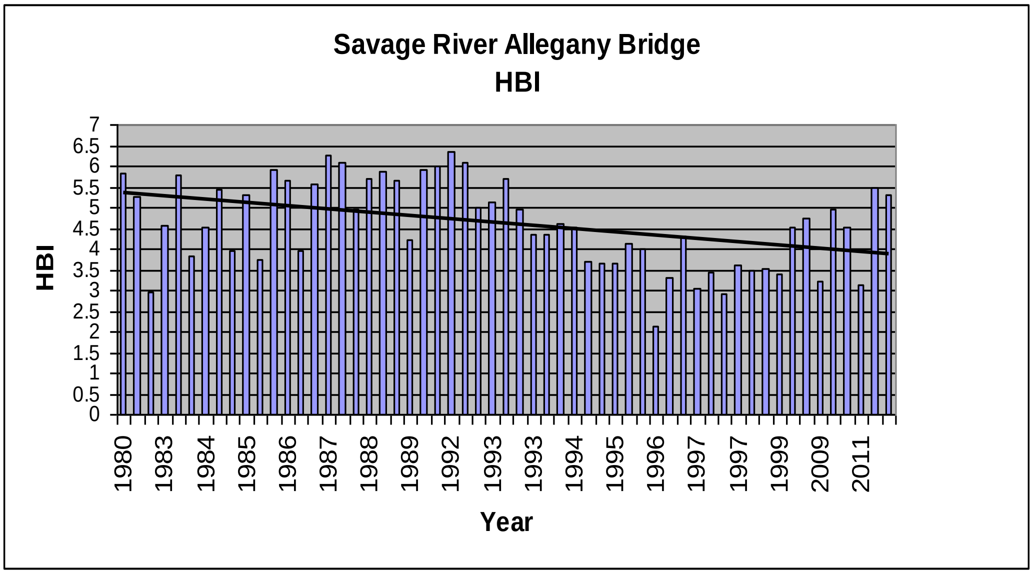


Figure 2. Savage River Allegany Bridge station HBI data 1980 – 2013. (Score – excellent: 0 – 3.5; very good: 3.51 – 4.5; good: 4.51 – 5.5; fair: 5.51 – 6.5; fairly poor: 6.51 – 7.5; poor: 7.51 – 8.5; very poor: 8.51 – 10.)

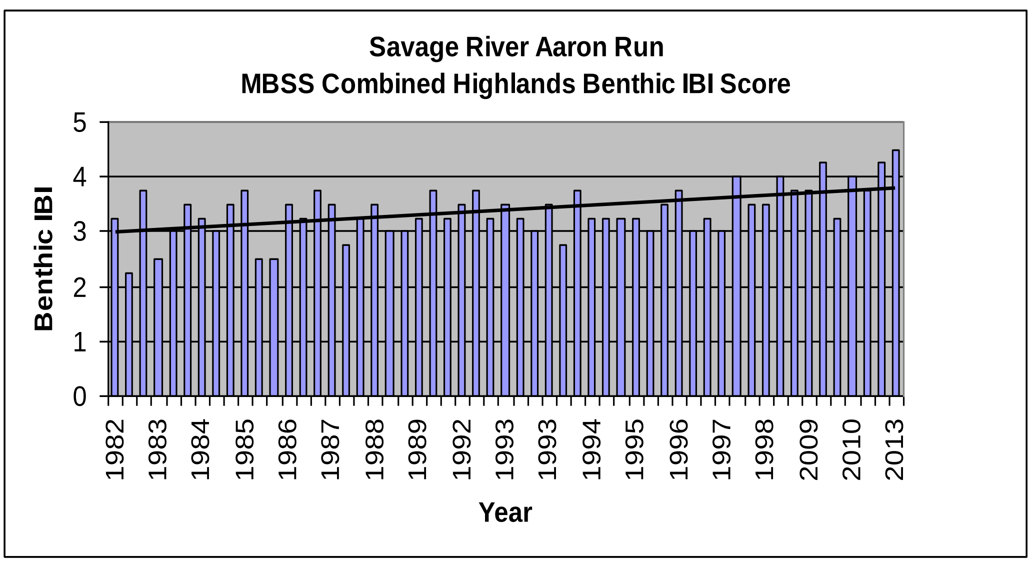


Figure 3. Savage River Aaron Run station IBI data 1980 – 2013. (Scores: very poor: 1 – 1.9; poor: 2 – 2.9; fair: 3 – 3.9; good: 4 – 5.)

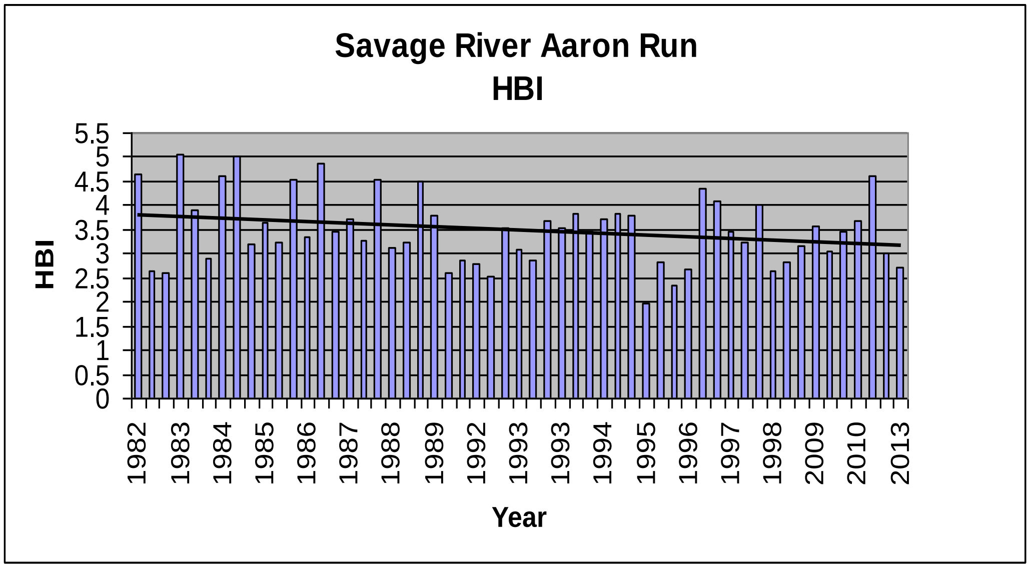


Figure 4. Savage River Allegany Bridge station HBI data 1980 – 2013. (Scores: excellent: 0 – 3.5; very good: 3.51 – 4.5; good: 4.51 – 5.5; fair: 5.51 – 6.5; fairly poor: 6.51 – 7.5; poor: 7.51 – 8.5; very poor: 8.51 – 10.)

Youghiogheny River Trout Population Studies
(Garrett County)

Introduction

The portion of the Youghiogheny River (Garrett County, MD) from the Deep Creek Hydro Station (DCHS) tailrace downstream approximately 6.4 km to the Sang Run bridge was designated a Catch and Release Trout Fishing Area (C&R TFA) in 1993. Regulations limit terminal tackle to artificial lures and flies. Fishing is permitted year-round. Prior to 1993, this portion of the river was managed under Maryland's Designated Trout Stream regulations, which specified a two-fish daily creel limit with no minimum size, bait, or tackle restrictions. The fishery in the C&R TFA is maintained through put-and-grow stockings of fingerling Brown Trout Salmo trutta and Rainbow Trout Oncorhynchus mykiss. Staff strives to maintain a trout population density of 621 trout/ km and standing crop of 25 kg/ha as measured during fall sampling efforts. Two sampling stations within the C&R TFA, the Hoyes Station located near the upper boundary and the Sang Run Station located near the lower boundary, have been surveyed for trout populations annually since 1988. Trout populations were sampled at a third location, known as the Deadman's Station, about midway in the C&R TFA beginning in 1999, however this station was dropped in 2009 due to inaccessibility.

The current operating license for the DCHS requires temperature control (maintenance of < 25° C in the Youghiogheny River measured at Sang Run during June, July, and August), minimum flow maintenance (40 cfs in the Youghiogheny River measured at the DCHS tailrace outflow), and dissolved oxygen augmentation to meet State standards (> 6 ppm average, 5 ppm minimum in the DCHS discharge) for downstream coldwater fisheries enhancement. These combined measures were implemented beginning in 1995 as part of an operating license renewal agreement with the Maryland Department of the Environment (1994), Water Resource Administration -Deep Creek Lake Project - Water Appropriation Permit No. GA92S009(01) and re-issued in 2007 with Water Appropriation Permit No. GA1992S009(07) (MDE 2007).

Objectives

The purpose of this study is to monitor trout population parameters in the Youghiogheny River C&R TFA in response to catch and release regulations and coldwater enhancement measures working in concert since 1995. The objectives are to:

- Document fish species composition and abundance.
- Estimate trout population densities and standing crops annually in two established sampling stations.
- Calculate indices of physical condition for trout species.

Methods

Fish populations
Methodology follows that described in the Study III Job 1 Methods section. Only variations from that methodology are described here. Fish sampling locations at Hoyes and Sang Run are presented in Table 1.

Temperature Enhancement
Onset StowAway® temperature loggers were deployed in the river at nine sites from Swallow Falls to Sang Run between June and September to assess the effectiveness of water temperature control by the DCHS. The temperature monitors were programmed to record at thirty-minute intervals. One temperature logger was deployed at the DCHS to record ambient air temperatures. Temperature data were forwarded to Versar, Inc., a MD DNR consultant, for analysis. Temperature enhancement and flow augmentation protocols for the DCLHS are described in the licensing agreement (MDE 2007).

Results

Fish populations
A list of the common and scientific names of the twelve fish species collected in the Youghiogheny River within the C&R TFA during 2013 is contained in Table 2. The fish species assemblage is indicative of a coldwater/coolwater fish community (Steiner 2000).

Trout densities and standing crops reached the management objective of 621 trout/km and 25 kg/ha (Tables 3 and 4). However, the majority of the trout densities and biomass resulted from summer stockings of both Brown Trout (< 200 mm TL) and Rainbow Trout (< 275 mm TL) as shown in Figures 1 and 2. The long-term trout densities and standing crops since 1988 to 2013 are presented in Figures 3 and 4, and show a positive trend line since the adoption of catch and return regulations and temperature enhancement protocols.

Average total length, weight, and condition factors for trout in the Youghiogheny River are contained in Table 5. Condition factors were within the optimal range (0.90 - 1.10) for both species. Species composition of trout in the Youghiogheny River C&R TFA was 36 % Brown Trout and 64% Rainbow Trout in 2013. Length frequency distribution of Brown and Rainbow Trout collected in the river during 2013 show quality-size (> 305 mm) and trophy-size Brown and Rainbow Trout (> 457 mm) were present in the population (Figures 1 and 2). Earlier age-class trout were well represented from the spring and summer fingerling stockings in 2013 (Figures 1 and 2).

The estimated number of quality-size trout (> 305 mm) per kilometer is presented in Table 6. The quality-size trout (QST) estimate is a useful descriptor of the population's age and size structure. Generally, fingerling-stocked trout attain 305 mm by Age 3 in the

Youghiogheny River C&R TFA. We have observed a significant increase in the number of quality-size trout (QST) since catch and release and coldwater enhancement measures were implemented (t-test $P = <0.0001$). Despite significant decreases in trout densities during 2011 and 2012, (exceedances were 18 and 17 days, maximum temperatures 28.0 °C and 26.1 °C respectively) the number of QST has remained stable as shown in Figure 5.

A record of fingerling trout stocking for 2013 is presented in Table 8. The annual management objective number is a minimum of 20,000 fall fingerlings (10,000 Brown Trout and 10,000 warmwater Rainbow Trout). This annual stocking rate generally achieves the management objective of 621 trout/km within the management area during the fall survey. Surplus Kamloops and Shasta strain Rainbow Trout fingerlings were stocked in the spring and appeared to have poor survival. Larger surplus Kamloops strain Rainbow Trout from the Freshwater Institute were stocked just prior to the sampling time period. Despite equal numbers stocked at Hoyes and Sang Run, few were collected at the Sang Run station, while they were abundant at the Hoyes station. Brown Trout fingerlings stocked during May and August were well represented in the fall sample. The number of fingerling Brown Trout and Warmwater-strain Rainbow Trout met the management objective in 2013. Three hundred adult Kamloops Rainbow Trout were stocked in the fall in order to improve fishing conditions especially in the Sang Run area.

Temperature Enhancement
All temperature data were forward to Versar, Inc for analysis. Report will be delivered upon completion.

Discussion

Prior to 1995, Youghiogheny River temperature often exceeded 25° C in mid-summer and reached as high as 29° C in the C&R TFA, reducing available trout habitat to cool water refugia created by tributaries, spring seeps, groundwater flow interface, and shade (MD DNR 1991). Trout standing crops, adult trout densities, and numbers of quality size trout in the Youghiogheny River C&R TFA have increased since catch and release regulations as well as minimum flow, dissolved oxygen augmentation, and coldwater temperature enhancement releases implemented at the DCHS beginning in 1995. Maintenance of water temperature and flow volume within a range which Brown and Rainbow Trout can tolerate has increased available habitat in the Youghiogheny River C&R TFA during critical mid-summer periods, increasing survival and supporting a larger population as well as a high quality fishery. We strive to produce an adult trout population of 621/km (1,000/mile) throughout the Youghiogheny River C&R TFA to maintain a high-quality trout fishery. The 2005, 2011, and 2012 estimated trout population decreased significantly from previous post-temperature enhancement years. During these years, the trout population densities and standing crops were reduced to levels observed prior to the temperature enhancement plan mainly due to the number and duration of temperature exceedances. The loss of trout densities in 2011 and 2012 was the greatest reduction (6.2 and 6.4-fold decrease respectively from 2010) since the temperature enhancement plan was instituted in 1995.

The current put-and-grow fingerling stocking management objective of 20,000 fall fingerlings annually (10,000 Brown Trout, 10,000 warmwater Rainbow Trout) is intended to achieve the desired adult trout densities. The stocking objective level for both Warmwater Rainbow Trout and Brown Trout was met in 2013. The stocking of spring Kamloops and Shasta strain Rainbow Trout appear to have had low survival rates by the fall stocking period. Temperature exceedances most likely caused of poor over-summer survival of these fish. However, Brown Trout fingerlings stocked during the summer showed good survival by the fall sample. Warmwater Rainbow Trout and Brown Trout stocked as fall fingerlings recruit to age 1+ at similar rates (MD DNR 2002). Condition factors for adult trout were within the optimal range for both Brown Trout and Rainbow Trout, indicating that food availability did not limit survival. Abundance of other fish species in the river has remained stable throughout this study period indicating that trout stocking is having little effect on their populations. Barnhart and Engstrom-Heg (1984) concluded that put-and-grow management in larger rivers where recruitment is stable or controlled supported the best catch and release trout fisheries.

Recommendations

All project work objectives for this study period were accomplished. However, further study will be required in order to continue to monitor the status of the trout population within the Youghiogheny River C&R TFA. It is recommended that this study be continued in 2015.

Table 1. Youghiogheny River trout sampling stations 2013.

Station Name	**Start location**	**End location**
Hoyes Run	N39°31.681 W79°24.684	N39°31.584 W79°24.619
Sang Run	N39°33.918 W79°25.643	N39°33.888 W79°25.519

Table 2. List of common and scientific names and relative abundance of fish species collected in the Youghiogheny River Catch and Release Trout Fishing Area, 2013.

Common Name	**Scientific Name**	**General occurrence**
River Chub	*Nocomis micropogon*	Abundant
Longnose Dace	*Rhinichthys cataractae*	Common
White Sucker	*Catostomus commersonii*	Scarce
Northern Hog Sucker	*Hypentelium nigricans*	Abundant
Margined Madtom	*Noturus insignis*	Common
Brown Bullhead	*Ameiurus nebulosus*	Scarce
Rainbow Trout	*Oncorhynchus mykiss*	Abundant
Brown Trout	*Salmo trutta*	Abundant
Mottled Sculpin	*Cottus bairdi*	Abundant
Pumpkinseed	*Lepomis gibbosus*	Scarce
Rock Bass	*Ambloplites rupestris*	Common
Smallmouth Bass	*Micropterus dolomieu*	Common
Total species = 12		

Table 3. Trout densities (trout/km 95% CI) in the Youghiogheny River Catch and Release Trout Fishing Area, 2013.

Station	**Combined species**	**Brown Trout**	**Rainbow Trout**
Hoyes	1879 + 107	720 +109	1165 + 61
Sang Run	121 + 49	38 + 16	71 + 28
Mean =	1000 + 78	379 + 63	618 + 45

Table 4. Trout standing crops (kg/ha 95% CI) in the Youghiogheny River Catch and Release Trout Fishing Area, 2013.

Station	Combined species	Brown Trout	Rainbow Trout
Hoyes	58 + 3	14 + 3	43 + 2
Sang Run	13 + 5	4 + 2	8 + 3
Mean =	36 + 4	9 + 3	26 + 3

Table 5. Average length, weight, and condition factors of trout collected in the Youghiogheny River Catch and Return Trout Fishing Area, 2013. Means with ranges in parenthesis.

Species	N	Total Length (mm)	Weight (g)	Condition Factor (K)
Brown Trout	119	196 (155 – 585)	108 (36 – 1924)	1.01 (0.68 – 1.34)
Rainbow Trout	212	253 (121 – 460)	177 (12 – 1130)	0.96 (0.68 – 1.25)

Table 6. Estimated quality-size trout (> 305 mm) in the Youghiogheny River Catch and Return Trout Fishing Area, 2013.

Station	Combined species	Brown Trout	Rainbow Trout
Hoyes	71	27	44
Sang Run	44	16	27
Mean =	58	22	36

Table 7. Stocking record for the Youghiogheny River Catch and Return Trout Fishing Area, 2013.

Date	**Species/strain**	**Number**	**Size**	**Source**
5-17-13	Rainbow Trout/Kamloops	23,000	59/lb	APH
5-20-13	Brown Trout	10,750	43/lb	Cushwa
7-26-13	Rainbow / Shasta	10,700	49/lb	APH
7-26-13	Rainbow / Shasta	5,775	33/lb	APH
8-9-13	Brown Trout	5,000	8.4/lb	Cushwa
9-3-13	Rainbow Trout/Kamloops	1,000	2.4/lb	Freshwater Inst.
10-4-13	WW Rainbow	10,000	23/lb	Laurel Hill
10-22-13	Rainbow Trout/Kamloops	300	2.2/lb	Bear Creek
Total = 24,000 Fingerling Kamloops Rainbow Trout; 300 Adult Kamloops Rainbow Trout Fingerlings; 16,475 Fingerling Shasta Rainbow Trout; 10,000 Fingerling Warmwater Rainbow Trout; 15,750 Fingerling Brown Trout.				

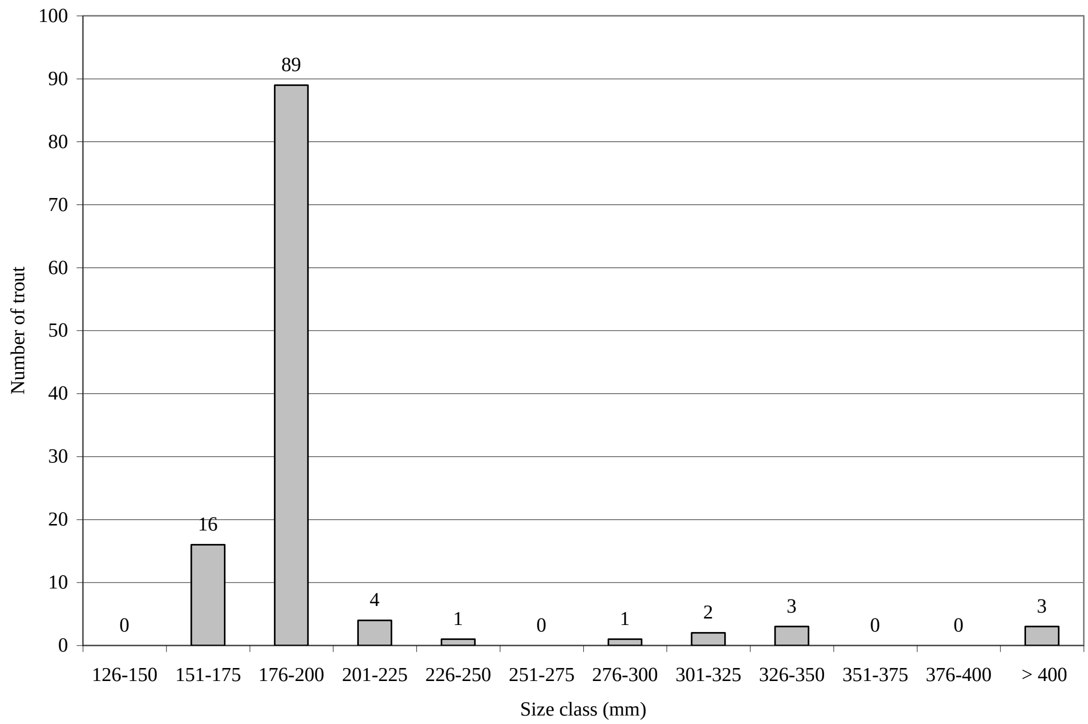


Figure 1. Length frequency distribution of Brown Trout (N = 119) in the Youghiogheny River Catch and Release Trout Fishing Area, 2013.

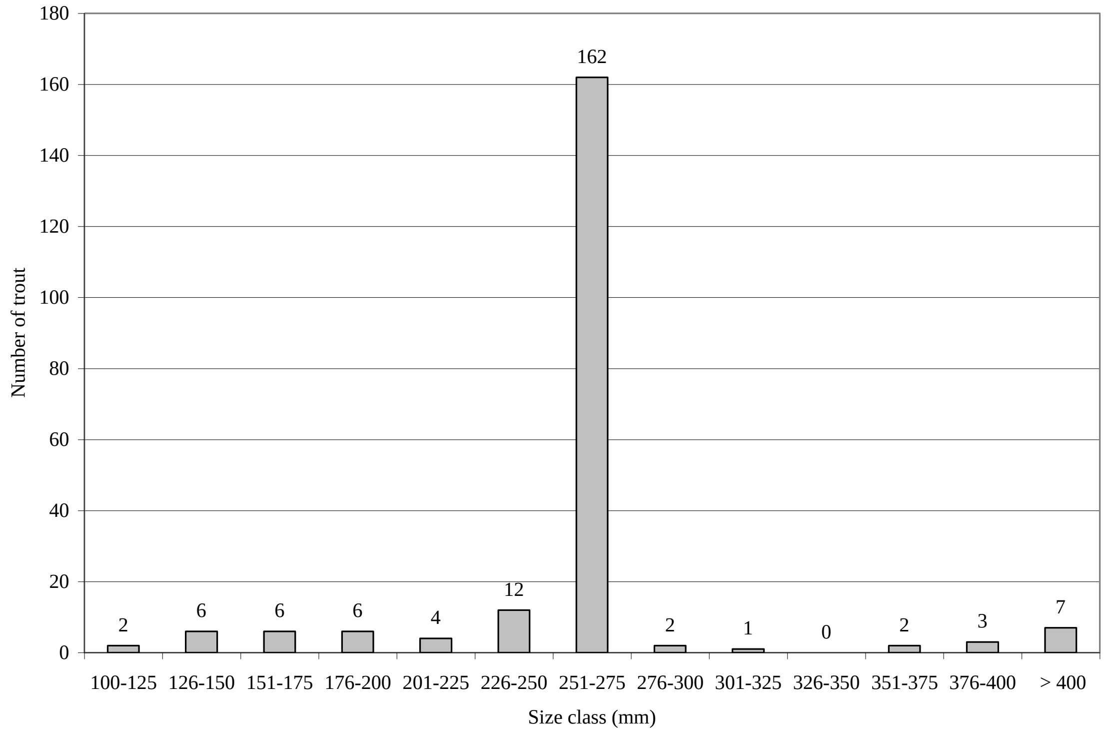


Figure 2. Length frequency distribution of Rainbow Trout (N = 212) in the Youghiogheny River Catch and Release Trout Fishing Area, 2013.

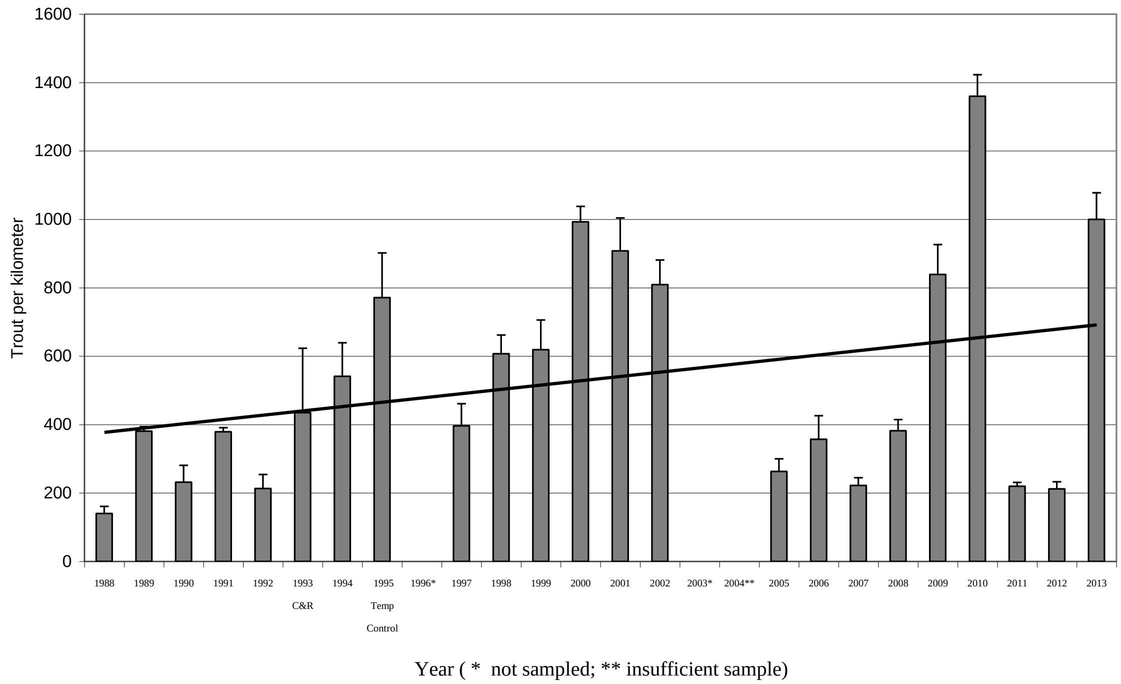


Figure 3. Mean trout densities (trout/km) in the Youghiogheny River Catch and Return Trout Fishing Area, 1988 – 2013.

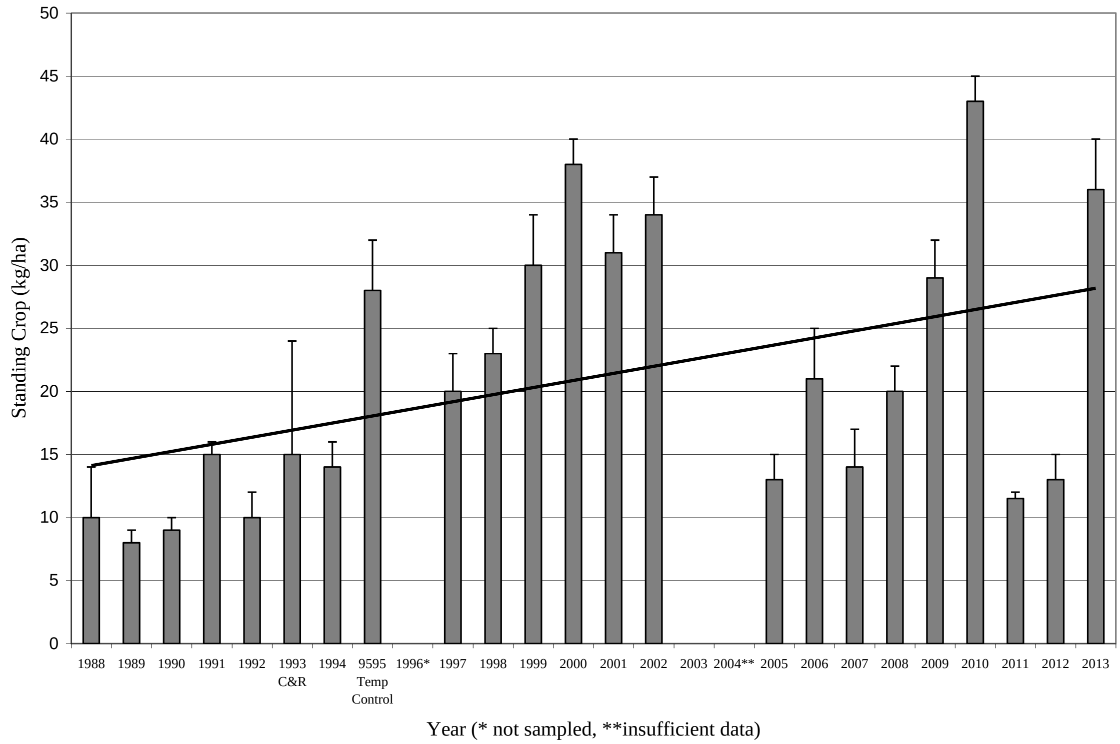


Figure 4. Mean trout standing crops (kg/ha) in the Youghiogheny River Catch and Return Trout Fishing Area, 1988 – 2013.

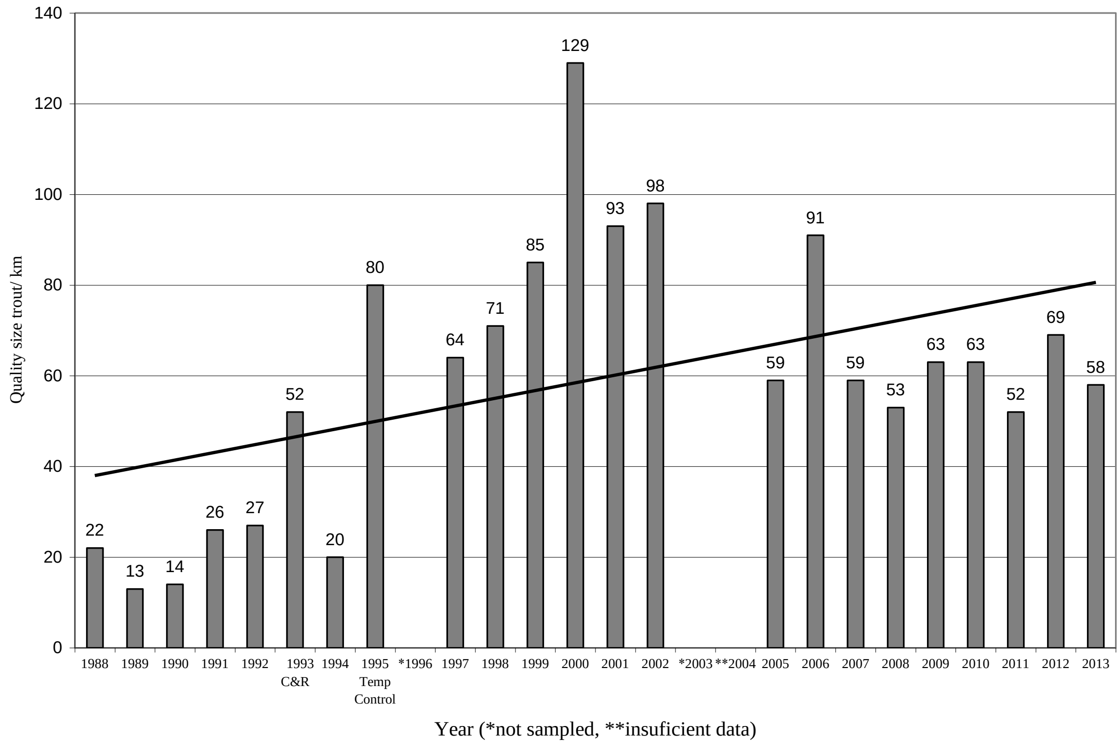


Figure 5. Mean quality sized trout ($\geq$ 305 mm) per km in the Youghiogheny River Catch and Return Trout Fishing Area, 1988 – 2013.

Western Region II
(Washington and Frederick Counties)

Antietam Creek
(Washington County)

Introduction

Antietam Creek originates in southern Pennsylvania and flows south through Washington County, Maryland for approximately 68 km to become a direct tributary to the Potomac River within the Upper Potomac Drainage. A 3m dam within Devils Backbone County Park located approximately 22 km upstream of the Potomac River juncture prevents upstream movement of fish species. The majority of Antietam Creek is managed as a Put-and-Grow trout fishery maintained by annual stockings of Rainbow and Brown Trout fingerlings. Put-and-Take trout fishing regulations are in effect from the upper boundary of Devils Backbone Park downstream to the mouth of Beaver Creek where stockings of approximately 5000 adult Brown and Rainbow Trout occur annually during the Spring and Fall. Although Smallmouth Bass are collected throughout the mainstem, the strongest population exists below the Devils Backbone Dam.

Stream temperatures were monitored and recorded in 2012. The most recent electrofishing survey conducted on Antietam Creek was in 2007.

Objectives

Efforts during 2013 focused on determining the current status of the gamefish populations and update fish species information with the following objectives:

- Obtain abundance and length-weight data for trout species and evaluate fingerling trout stockings.
- Obtain abundance and length-weight data for Smallmouth Bass downstream of Devils Backbone Dam.
- Record basic water quality

Methods

Methodology for sampling fish populations follow that described in the Study III Job 1 Methods section. Stream temperatures were monitored using StowAway TidBit thermographs manufactured by Onset Corp. and Boxcar Pro 4 software. Basic water quality was measured using an YSI Model EXO1 Sonde and multi meter.

Results

Antietam Creek has historically been a successful put-and-grow fishery that provides anglers with the chance to catch trophy-size trout. Fingerling stockings of Rainbow and

Brown Trout occur annually at various locations and rates dependent upon supply. A summary of the fingerling trout stockings that have taken place 2010-2013 are presented in Table 1. Adipose fin clipping has been used to mark various stockings, primarily of the warmwater tolerant strain of Rainbow Trout. The majority of fingerlings are distributed within the upper reaches (above Backbone Dam) where stream temperatures are generally cooler throughout the summer months (Figure 1).

Four single pass electrofishing surveys using barge equipment were completed during 2013, two sites above the city of Hagerstown (Millers Church and Leiter's Mill) and two sites below (Poffenberger and Devil's Backbone) (Table 2). Results were compared with those recorded during the 2007 survey and are shown in Table 3. Rainbow and Brown Trout collected at the Backbone station were all a result of recent adult stockings and not included in fingerling trout evaluation. Higher catch rates of both Rainbow and Brown Trout were observed at all three sites upstream of Backbone Dam. A length frequency graph shows that multiple year classes of both trout species were collected and several large Brown Trout were available to anglers (Figure 2).

Despite stocking above Backbone Dam that favored Rainbow Trout nearly 2:1, Brown Trout CPUE was 47% higher. The largest Rainbow and Brown Trout were both collected at the Millers Church site and measured 353 mm and 522 mm respectively. A total of 12 clipped warmwater Rainbow Trout were collected ranging in size from 225 mm-353 mm, representing 25% of the total Rainbow catch. One clipped Brown Trout was collected at the Millers Church station, attributed to the 2010 fall stocking, measuring 494 mm in its 4th year. Antietam Creek trout generally exhibit excellent physical condition due to ample forage. The condition factor K for Brown Trout was 0.91 $\pm$ .02 and 0.94 $\pm$ 0.03 for Rainbow Trout within the optimal range (.9 – 1.1) described by Lagler (1952). Both species have historically grown quickly and produced trophy-size individuals.

Antietam Creek continues to provide a quality fishery for Smallmouth Bass downstream of Devils Backbone Dam. Even with catch rates nearly tripling since the 2007 survey, size structure has remained relatively unchanged (Table 4). A length frequency graph shows multiple year-classes of Smallmouth Bass are present (Figure 3). These population indices are indicative of a healthy Smallmouth Bass population with a desirable size structure for recreational anglers. The largest Smallmouth Bass collected measured 504 mm in total length and weighed 1.77 kg.

Water quality data indicates that Antietam Creek is a slightly basic, and suitable for cold and coolwater fish species (Table 5). These characteristics are the result of the limestone geology in the Hagerstown Valley and the many springs that contribute to Antietam Creek and its tributaries.

Management Recommendations

- Manage Antietam Creek as a Put-and-Grow trout fishery upstream of the Devils Backbone Dam with annual fingerling stockings of Brown and Rainbow Trout. Brown Trout and warmwater Rainbow Trout should be used when available.
- Manage Antietam Creek downstream of Devils Backbone Dam primarily for Smallmouth Bass.

Table 1. Summary of fingerling Rainbow and Brown Trout stocking in Antietam Creek 2010-2013. Clipped – adipose fin.

Date	**Species**	**Number**	**Size**	**Location**	**Source**
6/10/2010	Brown	5,000	42/lb.	Millers Church-Trovinger	Stickleys
6/17/2010	Rainbow	8,000	75/lb.	Poffenberger-Rt.34	APH
6/17/2010	Brown	4,700	32/lb.	Poffenberger-Rt.34	Cushwa
10/12/2010	Warmwater Rainbow	2,239 Clipped	16/lb.	Poffenberger-Roxbury	Stickleys
10/13/2010	Brown	2,000 Clipped	8/lb.	Millers Church-Old Forge	Fountain Rock
10/27/2010	Rainbow	1,700	10/lb.	Poffenberger-Roxbury	Freshwater Institute
6/2/2011	Rainbow	9,500	93/lb.	Millers Church-Roxbury	APH
6/14/2011	Brown	1,400	63/lb.	Millers Church-Clopper	Cushwa
9/1/2011	Warmwater Rainbow	5,000 Clipped	40/lb.	Millers Church-Funkstown	Stickleys
9/29/2011	Brown	2,500	8/lb.	Millers Church-Rt.34	Fountain Rock
8/2/2012	Rainbow	19,500	160/lb.	Millers Church-Burnside Bridge	Cushwa
10/17/2012	Warmwater Rainbow	2,500	21/lb.	Millers Church-Trovinger	Laurel Hill
10/17/2012	Warmwater Rainbow	2,500 Clipped	21/lb.	Funkstown-Burnside Bridge	Laurel Hill
11/28/2012	Brown	2,000	8/lb.	Millers Church-Burnside Bridge	Fountain Rock
5/14/2013	Rainbow	9,900	62/lb.	Millers Church-Rt.34	APH
5/22/2013	Brown	10,000	43/lb.	Millers Church-Keedysville	Cushwa
9/17/2013	Brown	2,500	6/lb.	Millers Church-Burnside Bridge	Cushwa
10/8/2013	Warmwater Rainbow	10,000	23/lb.	Millers Church-Roxbury	Laurel Hill

Table 2. 2013 GPS coordinates of Antietam Creek electrofishing stations.

Station	**Description**	**GPS Start**	**GPS Stop**
1	Millers Church Rd	N39°42.931 W77°36.655	N39°42.990 W77°36.452
2	Leiters Mill Rd	N39°42.054 W77°37.624	N39°42.152 W77°37.495
3	Poffenberger Rd	N39°35.756 W77°42.800	N39°35.701 W77°42.590
4	Devils Backbone	N39°32.086 W77°42.600	N39°32.229 W77°42.648

Table 3. Rainbow and Brown Trout CPUE, by station, collected by electrofishing in Antietam Creek during 2007 and 2013.

Millers Church		**Leiters Mill**		**Poffenberger**		**Backbone**	
Rainbow CPUE		Rainbow CPUE		Rainbow CPUE		Rainbow CPUE	
2007	2013	2007	2013	2007	2013	2007	2013
39	63	5	19	8	12	65	2
Brown CPUE		Brown CPUE		Brown CPUE		Brown CPUE	
2007	2013	2007	2013	2007	2013	2007	2013
41	74	32	53	0	11	0	6

Table 4. Smallmouth Bass population data collected by electrofishing at Devils Backbone, Antietam Creek during 2007 and 2013.

Parameters	2007	2013
N (≥180 mm)	27	107
CPUE60	42	122
PSD (CL 80%)	30 ± 14	28 ± 6
RSD350	11	16
mean Wr	97	87

Table 5. Basic water quality data recorded from Antietam Creek at the upper and lower electrofishing sites during 2013.

Site	**Date**	**Dissolved Oxygen (mg/l)**	**pH**	**Temp. (°C)**	**Cond. (µ/cm)**
Miller Church	9/9/2013	9.6	8.5	17.1	434
Backbone	9/10/2013	9.8	8.5	20.3	435

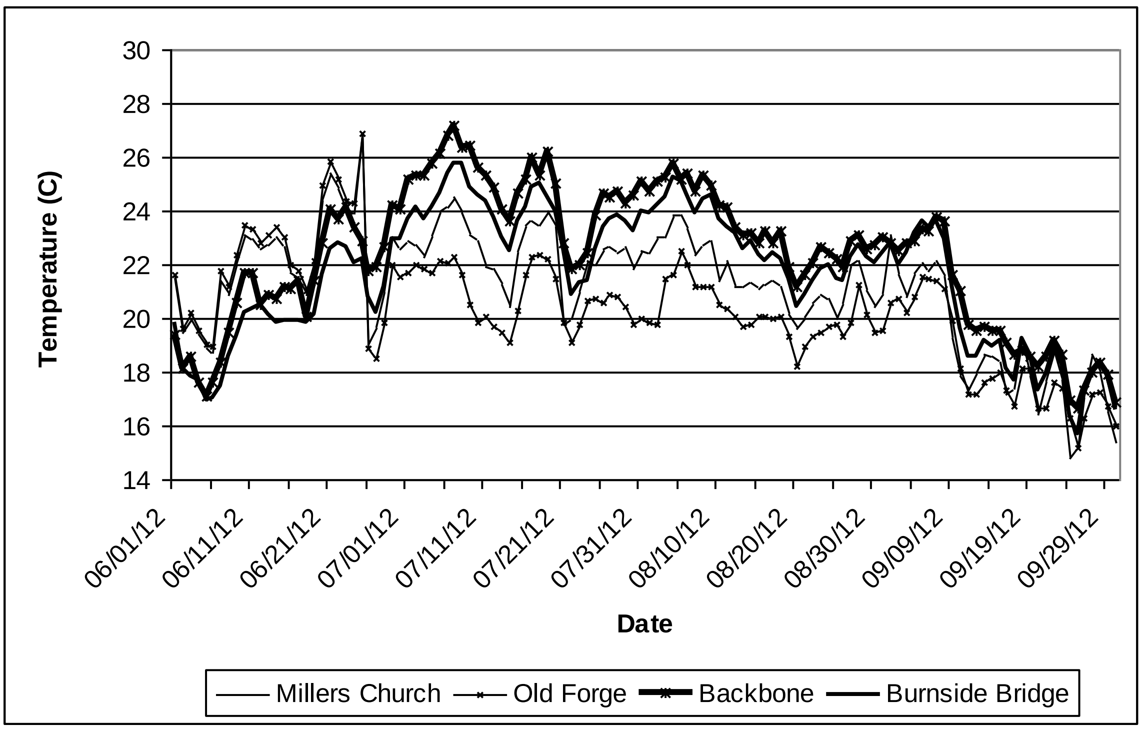


Figure 1. Maximum daily stream temperatures recorded in Antietam Creek above (Millers Church, Old Forge) and below (Backbone, Burnside Bridge) Backbone Dam during 2012.

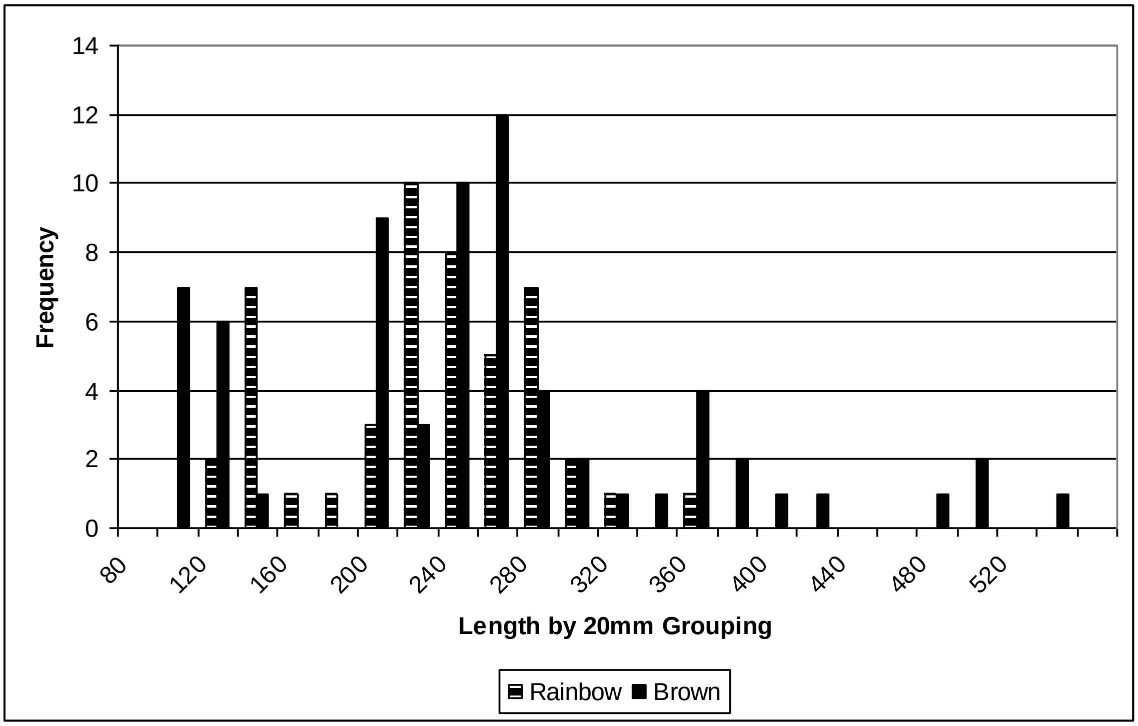


Figure 2. Length frequency of Rainbow Trout (N = 48) and Brown Trout (N = 68) collected by electrofishing during 2013 from Antietam Creek above Backbone Dam (Millers Church, Leiters Mill, Poffenberger).

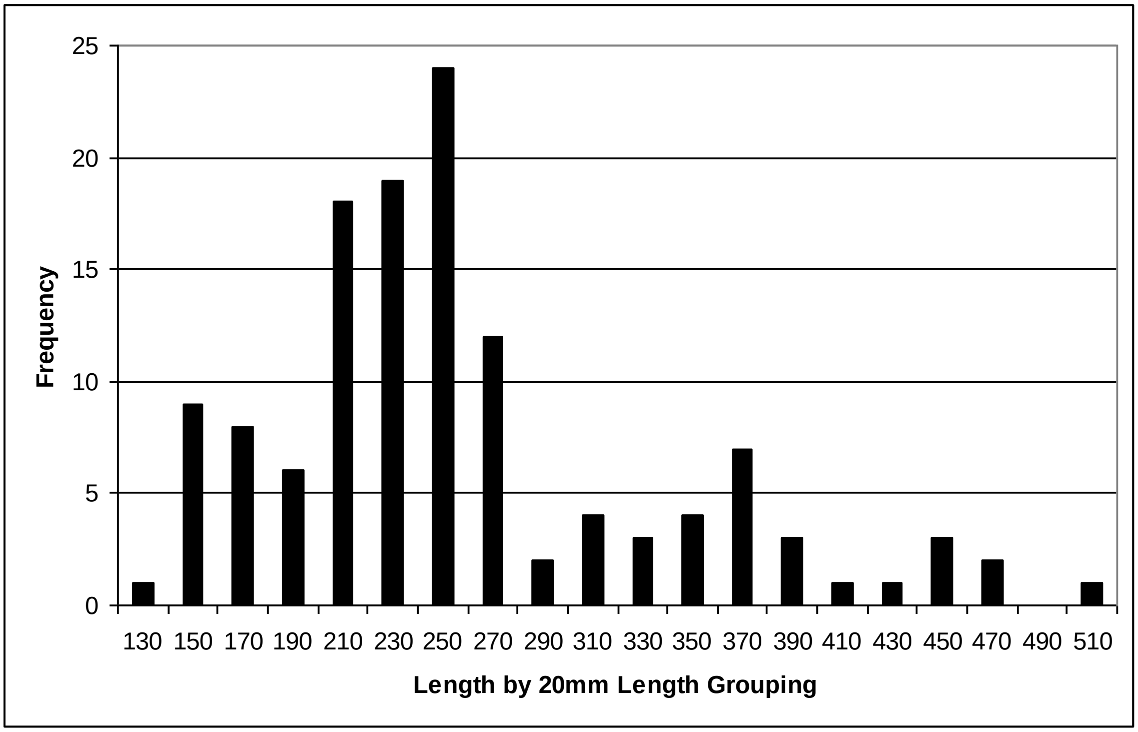


Figure 3. Length frequency of Smallmouth Bass (N = 128) collected during 2013 electrofishing effort in Antietam Creek at the Devils Backbone station.

Beaver Creek
(Washington County)

Introduction

Beaver Creek is one of the largest limestone streams in Maryland. Originating as a freestone stream on the west slope of South Mountain, the majority of the flow during the summer months is influenced by the numerous springs in the Hagerstown Valley. The largest spring (~11,356 l/min) influencing Beaver Creek is used as the water supply for the Albert Powell State Trout Hatchery, which rears adult and YOY Rainbow Trout (Oncorhynchus mykiss) for stocking into Maryland streams. Upstream of the spring's influence, Beaver Creek is considered a warm-water stream and flows underground much of the year due to local Karst geology. Intensive agricultural operations (dairy and row crop) within the Hagerstown Valley have severely impacted Beaver Creek throughout its length. Various stream improvement projects have been completed on the mainstem and its tributaries to correct harmful effects of improper land management practices.

Beaver Creek has historically been managed as a Put-and-Take trout (P&T) fishery with a five trout per day creel limit. Effective 1 January 2004, approximately one mile of Beaver Creek formerly under the management of the Antietam Fly Anglers was established as a catch-and-return/fly-fishing-only area (C&R) open to the public. This area extends from the mouth of Black Rock Creek downstream to the upper boundary of the Perini property, approximately 161 m above Beaver Creek Road. The special regulation area is entirely on private property. Wild YOY Brown Trout (Salmo trutta) were transplanted from the Gunpowder River tailwater from 2002 to 2005 to address inadequate natural reproduction from hatchery stock. Due to favorable year-round water temperatures and excellent spawning substrate, a self sustaining Brown Trout population has developed and this area is now managed for wild trout. Trout populations have been monitored annually since 2004 at two established stations within the C&R area (upper and lower Jackson) and one within the P&T area since 2005. In 2009 an additional station was established, located within an extensive stream restoration project completed during the summer of 2010 (Zimmerman property). Trout population data is collected to document the response of trout populations to habitat alterations at the lower extent of the C&R section.

Objectives

Fisheries management activities were conducted in 2013 to evaluate the coldwater fishery within the Catch-and-Release and Put-and Take areas with the following objectives:

- Obtain estimates of standing crop and abundance for adult and YOY trout within the four established stations.
- Obtain basic water quality data.
- Record summer stream temperatures.

Methods

Methodology for monitoring fish populations follow that described in the Study III Job 1 Methods section.

Basic water quality was measured using a HACH Model FF-1A Fish Farming test kit and YSI EXO1 sonde and multi meter. Stream temperatures were monitored using HOBO Water Temp Pro data loggers manufactured by Onset Corp.

Results

Adult and YOY Brown Trout population data by survey station is presented in Table 1. Standing crop (kg/ha) and density (trout/ha) of yearling and older Brown Trout has steadily increased reaching record highs at all stations with the exception of Zimmerman station. The upper and lower Jackson and Zimmerman survey sites were combined to determine trout population estimates for the Catch and Return Area of Beaver Creek (Figures 1 & 2). Despite the high density, mean condition factor K for Brown Trout remains within the optimal range of 0.9 – 1.1 suggested by Lagler (1952) indicating excellent physical condition. Brown Trout reproduction was considered excellent in Beaver Creek reaching record highs at all stations within the Catch and Release Area. This strong year-class is expected to further increase Brown Trout densities in 2014.

In spite of the annual stocking of adult Rainbow Trout within the Put and Take area, few are collected at any sample site (Table 2). The constant potential of fingerling Rainbow Trout escapees from the Albert Powell Hatchery makes identifying natural reproduction difficult. Only four Rainbow Trout YOY were collected during 2013.

Basic water quality was measured at the uppermost (Put and Take) and lowermost (Zimmerman property) stations during the time of survey and recorded in Table 3. Water quality parameters remained favorable for survival and growth of trout at both sites. Beaver Creek has high conductivity and hardness, characteristic of limestone influenced streams in the Hagerstown Valley.

Thermographs were placed above and below the Catch-and-Release area at Rt. 70 and Rt. 40, respectively. Water temperatures were excellent for the survival and growth of trout (Figure 3). Maximum daily stream temperature rarely exceeded 19°C (66°F) within the Catch-and-Release area. The excellent natural reproduction combined with favorable stream temperatures suggest that there is potential for the wild brown trout population to expand further downstream, below the current C&R Area.

Recommendations

Monitor adult and YOY trout populations annually within the C&R and P&T Areas to monitor natural reproduction, standing crop, and abundance.
Conduct additional electrofishing surveys to document the status of wild trout populations in Beaver Creek from the C&R Area to its confluence with Antietam Creek.
Expand efforts to monitor Beaver Creek summer stream temperatures with additional thermographs downstream of Rt. 40.

Table 1. Beaver Creek adult and YOY Brown Trout population data collected by electrofishing by station 2009 - 2013. (95% CI). ** - insufficient depletion produced high confidence interval.

STATION	**2009**	**2010**	**2011**	**2012**	**2013**
Put and Take					
Standing Crop (kg/ha)	60 ± 2	150 ± 4	139 ± 8	151 ± 7	359 ± 14
Density – (trout/ha)	321 ± 13	1026 ± 26	711 ± 39	836 ± 41	3014± 121
YOY/ha	885 ± 77	182 ± 38	1053 ± 147	2904 ± 136	2635± 108
Mean K Factor	1.09±0.04	1.03±0.03	1.09± 0.02	1.07± 0.02	1.02± 0.01
Upper Jackson					
Standing Crop (kg/ha)	42 ± 3	105 ± 56	105 ± 23	111 ± 8	193 ± 6
Density – (trout/ha)	138 ± 9	483 ± 256	655 ± 14	603 ± 43	1466 ± 43
YOY/ha	69 ± 362	121 ± 69	95 ± 17	276 ± 17	552 ± 60
Mean K Factor	1.01±0.08	0.99± 0.03	0.96± 0.02	0.99± 0.01	0.96± 0.01
Lower Jackson					
Standing Crop (kg/ha)	21 ± 2	26 ± 1	30 ± 4	66 ± 1	74 ± 4
Density – (trout/ha)	93 ± 8	163 ± 8	256 ± 31	434 ± 8	752 ± 39
YOY/ha	0	116 ± 38	0	419 ± 15	473 ± 23
Mean K Factor	1.03±0.05	1.07± 0.05	1.00± 0.02	1.02± 0.02	0.97± 0.02
Zimmerman Property					
Standing Crop (kg/ha)	29 ± 24	11 ± 2	148**	76 ± 3	90 ± 19
Density – (trout/ha)	120 ± 99	98 ± 16	785**	372 ± 16	521 ± 107
YOY/ha	10	33 ± 16	124 ± 8	107 ± 41	322 ± 206
Mean K Factor	1.07±0.06	0.91± .07	1.01± 0.02	1.01± 0.03	0.98± 0.03

Table 2. Beaver Creek adult and YOY Rainbow Trout population data (95% CI) collected by electrofishing by station during 2009 – 2013.

STATION	**2009**	**2010**	**2011**	**2012**	**2013**
Put and Take					
Standing Crop (kg/ha)	0	0	25*	0	2*
Density – (trout/ha)	0	0	79*	0	14*
YOY/ha	38 ± 38	91 ± 19	26**	0	14*
Upper Jackson					
Standing Crop (kg/ha)	7 ± 3	7**	9**	5**	5**
Density – (trout/ha)	34 ± 17	26**	26**	17**	17**
YOY/ha	2 ± 5	17 ± 43	0	9**	9*
Lower Jackson					
Standing Crop (kg/ha)	8*	0	0	0	0
Density – (trout/ha)	23*	0	0	0	0
YOY/ha	0	0	0	8**	8*
Zimmerman Property					
Standing Crop (kg/ha)	0	8*	41 ± 7	11**	2**
Density – (trout/ha)	0	24*	99 ± 17	17**	8**
YOY/ha	10*	122 ± 16	8*	8*	8*

* all trout collected on first pass.
** insufficient depletion.

Table 3. Water quality measured at the uppermost (Put and Take) and lowermost (Zimmerman property) stations in Beaver Creek, July 2013.

Parameter	**Put and Take**	**Zimmerman**
Temperature (ºC)	16.8	16.3
pH	7.9	7.6
Alkalinity (mg/l)	25.65	17.1
Hardness (mg/l)	290.7	325
Conductivity (µS/cm)	439	467
Dissolved Oxygen (mg/l)	9.6	8.8

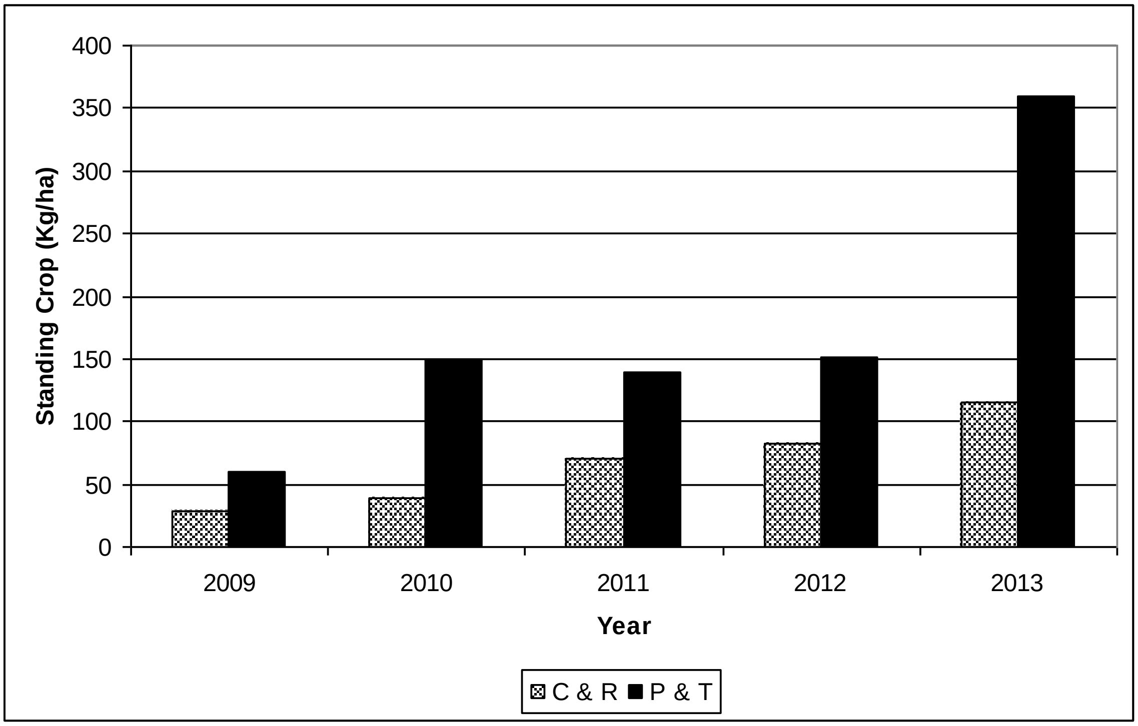


Figure 1. Adult Brown Trout Standing Crop (Kg/ha) estimates from Beaver Creek Catch and Return Area and Put and Take Area, 2009 – 2013.

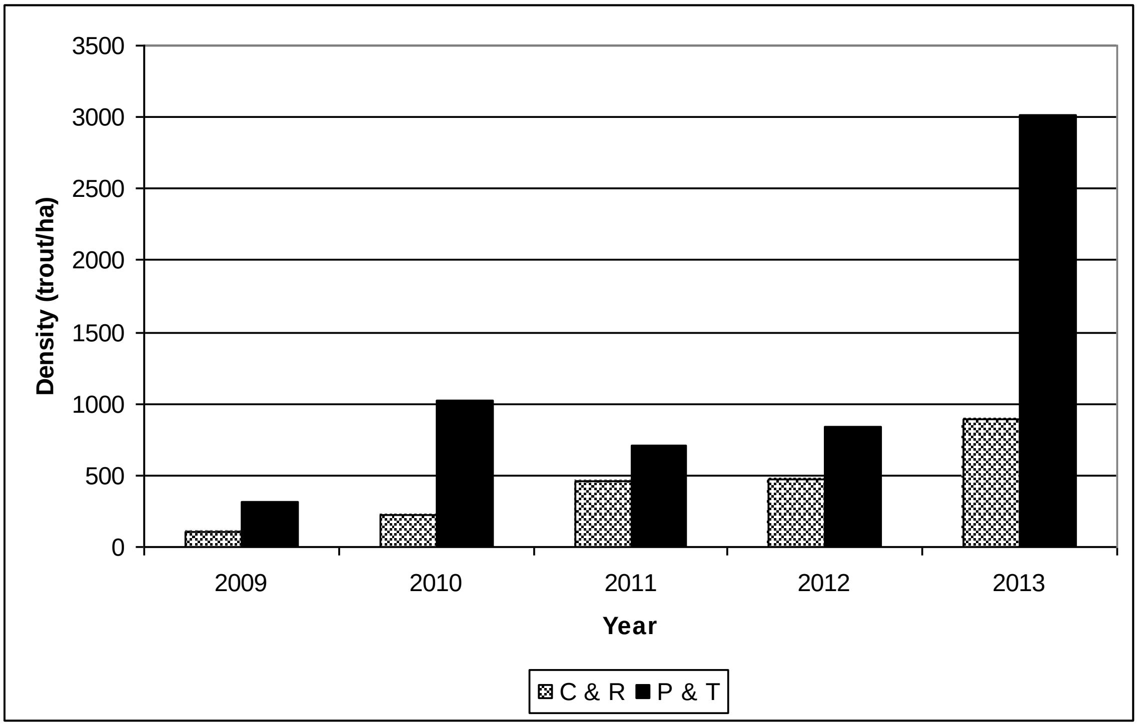


Figure 2. Adult Brown Trout density (trout/ha) estimates from Beaver Creek Catch and Return Area and Put and Take Area, 2009 – 2013.

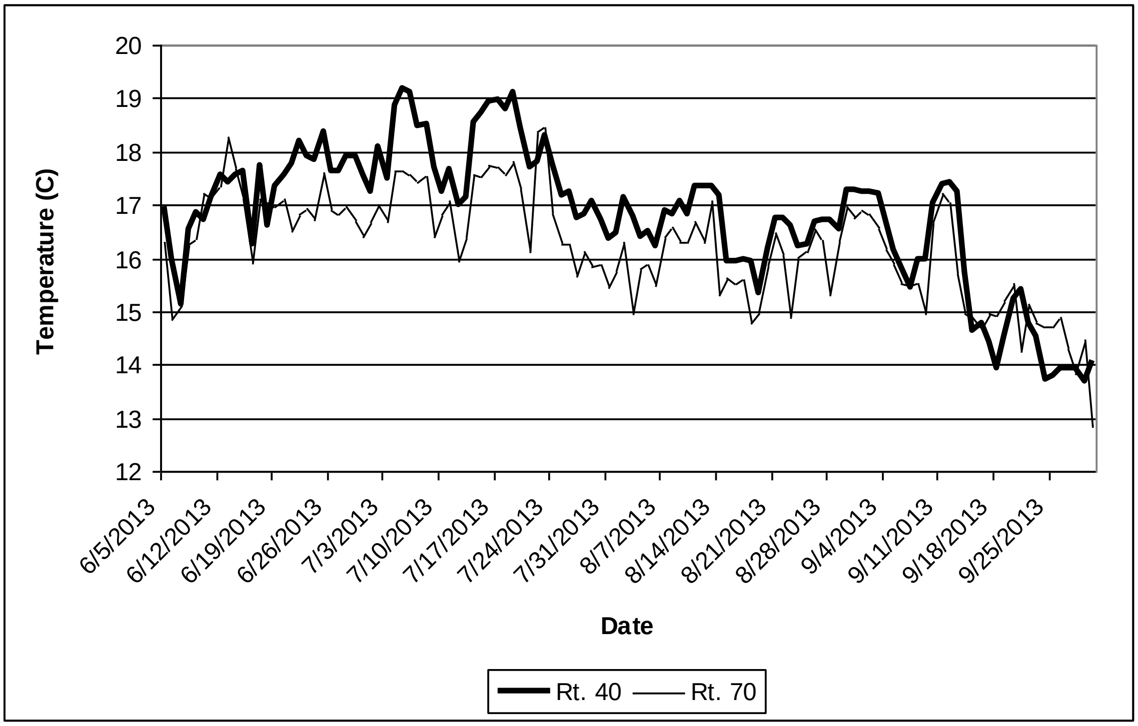


Figure 3. Maximum daily temperatures recorded in Beaver Creek Rt. 70 and Rt. 40 during June – September, 2013.

Black Rock Creek
(Washington County)

Introduction

Black Rock Creek is a small (< 3m wide) tributary to Beaver Creek in Washington County. Although originating as a freestone stream on the west slope of South Mountain, limestone springs influence the flow and water chemistry in the lower reaches. This influence begins just north of Route 70 and continues downstream to the confluence with Beaver Creek.

The abundance of trout in Black Rock Creek had been limited by degraded habitat resulting from over-grazing in the watershed. During 2002 and 2003, many of the landowners enrolled in the Conservation Reserve Enhancement Program (CREP), fencing cattle from the stream and allowing riparian areas to regenerate. An in-stream irrigation pond supplying water to the Beaver Creek Country Club golf course had dramatically increased stream temperatures downstream. A stream restoration project to remove the irrigation pond was completed in 2008. The dam was breached and the pond was allowed to slowly drain, limiting the amount of sediment loss downstream. Eliminating the pond from the stream channel reduced stream temperatures significantly. A newly formed stream channel was constructed with vegetated riparian areas during 2010. In 2009 a smaller scale in stream restoration project was completed involving the removal of a small concrete and stone dam, upstream of the electrofishing site on the Heaton‘s property. Bank stabilization and stream improvement devices were incorporated to allow unimpeded upstream migration of fish species. In addition, another stream improvement project was completed in 2009 by the Maryland State Highway Administration. Prior to 2009, runoff from Route 70 flowed into Black Rock Creek via concrete drainage channels. The M.S.H.A. replaced the concrete drainage system with a vegetated channel allowing greater infiltration.

Brown Trout (Salmo trutta) are not stocked into Black Rock Creek and most likely migrated upstream from Beaver Creek. Rainbow Trout (Oncorhynchus mykiss), once naturally reproducing from stocked fingerlings, have not been collected since 2006. Historically, electrofishing surveys had been completed at various locations on Black Rock Creek. Beginning in 2003 electrofishing efforts were concentrated to one established station upstream of Black Rock Road on the Heaton’s property. As populations increased, an additional station was established in 2012 within the stream reclamation area upstream of Rt. 66.

Objectives

Management efforts conducted during 2013 consisted of electrofishing to assess the trout populations following the establishment of conservation programs and restoration efforts with the following objectives:

- Obtain estimates of standing crop and abundance for adult and YOY trout
- Record abundance estimate of non-game fish species.
- Record basic water quality.
- Record summer stream temperatures upstream and downstream of the reclamation area.

Methods

Methodology for sampling fish populations follow that described in the Study III Job 1 Methods section. Basic water quality was measured using a Model FF-1A Fish Farming test kit and YSI EXO1 sonde and multi meter.

Stream temperatures were recorded using HOBO Water Temp Pro data loggers manufactured by Onset Corp. and Boxcar Pro 4 software. Devices were placed at the Heaton property and downstream of the reclamation area.

Results

The completion of multiple stream improvement projects has demonstrated substantial benefits for trout populations. A single, newly established station within the stream reclamation area upstream of Rt. 66 (drained irrigation pond) was surveyed by electrofishing during 2013. Trout abundance was sufficient to conduct a three pass depletion survey for both adult and YOY Brown Trout (Table 1). Population estimates have currently surpassed those determined for adult Brown Trout populations within the Catch and Release area of Beaver Creek during 2013. The collection of numerous Brown Trout YOY coupled with observations of spawning adults suggest spawning is now successful within Black Rock Creek. However, upstream migration from Beaver Creek is now much easier. No Rainbow Trout were collected in Black Rock Creek.

Brown Trout and four non-game fish species were observed during electrofishing efforts (Table 2). Blacknose Dace *(Rhinichthys atratulus*) and Checkered Sculpin (*Cottus sp*.) were the most abundant fish species observed.

Water quality was recorded at the Rt. 66 station at time of survey and recorded in Table 3. Black Rock Creek is a relatively hard, high conductivity stream, indicative of karst geology and limestone influence.

Stream temperatures remain excellent for the survival and growth of trout both upstream and downstream of the reclamation site in Black Rock Creek (Figure 1). During 2013 maximum daily stream temperatures averaged only 2.4ºC warmer at the downstream location rarely exceeding 20ºC (68ºF) during the summer months.

Management Recommendations

- Monitor the status of the adult and YOY Brown Trout populations annually.
- Monitor summer stream temperatures upstream and downstream of the stream reclamation area.

Table 1. Adult and YOY Brown Trout population data collected (95% CI) by electrofishing in Black Rock Creek and the Beaver Creek C&R Area (upper Jackson, lower Jackson and Zimmerman stations) during 2012 and 2013.

Black Rock Creek	**2012**	**2013**
Standing Crop (kg/ha)	69 ± 60	162 ± 6
Density (trout/ha)	533 ± 466	1316 ± 53
YOY/ha	400	316
Condition Factor K	1.06 ± 0.07	1.04 ± 0.03
Beaver Creek C&R Area		
Standing Crop (kg/ha)	87 ± 3	115 ± 4
Density (trout/ha)	516 ± 16	894 ± 30
YOY/ha	357 ± 12	431 ± 30
Condition Factor K	1.01 ± 0.01	0.97 ± 0.01

Table 2. Abundance estimate of non-game fish species observed while electrofishing in Black Rock Creek, 2013.

Common	**Scientific**	**Abundance Estimate**
Blacknose Dace	*Rhinichthys atratulus*	Abundant
Checkered Sculpin	*Cottus sp.*	Abundant
Longnose Dace	*Rhinichthys cataractae*	Common
White Sucker	*Catostomus commersonii*	Common

Table 3. Water quality measured at the stream reclamation area (Rt. 66) in Black Rock Creek, 2 July 2013.

Parameter	**Rt. 66**
Temperature (ºC)	17.8
pH	8.1
Alkalinity (mg/l)	17.1
Hardness (mg/l)	256
Conductivity (µS/cm)	374
Dissolved Oxygen (mg/l)	8.7

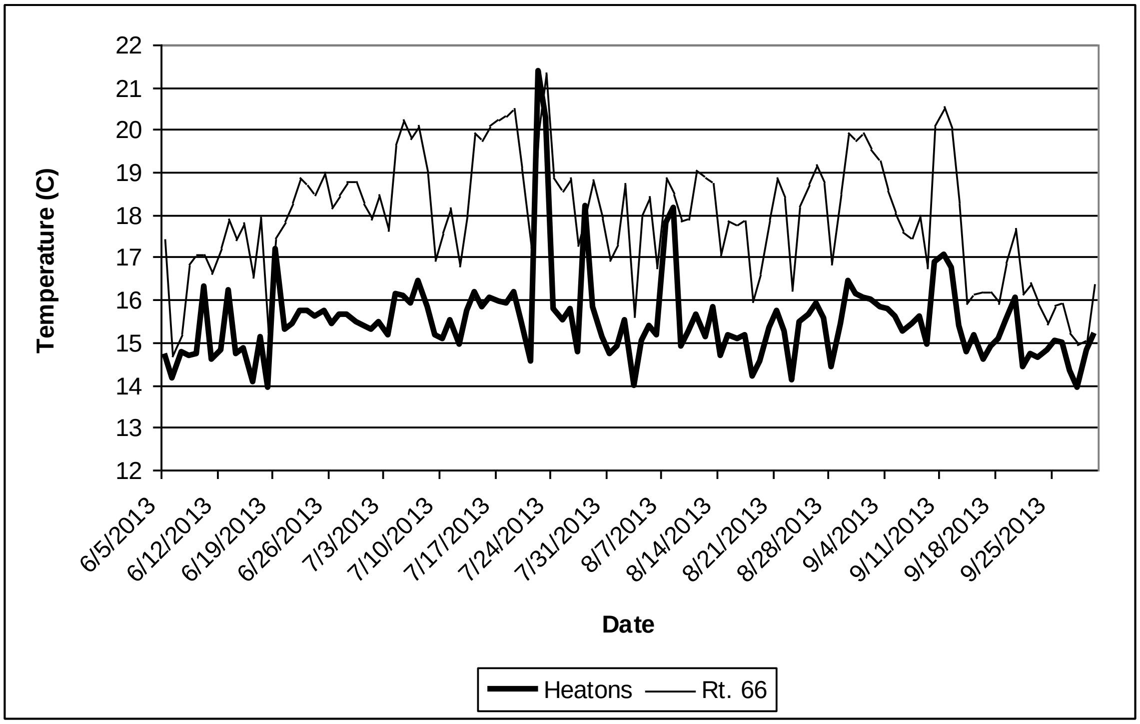


Figure 1. Maximum daily stream temperatures recorded in Black Rock Creek upstream (Heaton's) and downstream of the stream reclamation (Rt. 66) during 2013.

Fishing Creek
(Frederick County)

Introduction

Originating on the east slope of Catoctin Mountain in Frederick County, Fishing Creek flows east until becoming a direct tributary of the Monocacy River. The headwaters of Fishing Creek are split between two forks, both of which flow through Frederick City watershed property. Native Brook Trout inhabit both the Right and the Left Forks of Fishing Creek upstream of the Frederick City water supply reservoir. To protect the native Brook Trout population and because of the streams small size (mean width 3.6 m), stocking of Rainbow Trout in the Right Fork as part of the Put-and-Take program ceased in 1990. The Left Fork continues to be included in the Spring Put-and-Take program; a total of 2,700 adult Rainbow Trout were stocked in 2013. A five trout per day creel limit applies to the Left Fork while a two trout per day creel is in effect on the Right Fork. The Brook Trout population is surveyed on a biennial basis at two established stations in both forks. The upper Right Fork station was moved in 2005 due to in-stream obstructions. The new station begins at the upstream end of the original station. The most recent survey was conducted in 2011.

Objectives

Fish management activities in 2013 consisted of electrofishing surveys to monitor the status of the Brook Trout populations with the following objectives:

- Obtain population estimates for adult and young-of-year Brook Trout.
- Obtain physical condition data for adult Brook Trout.
- Record basic water quality data.
- Determine baseline population estimates for adult and young-of-year Brook Trout upstream and downstream of Delauter Road ford.

Methods

Methodology for sampling fish populations follow that described in the Study III Job 1 Methods section. Basic water quality was measured using a HACH Model FF-1A Fish Farming test kit and YSI EXO1 sonde and multi meter.

Results

Adult Brook Trout in both Forks of Fishing Creek experienced significant declines in standing crop and densities in 2011. Significant improvement, however, was documented in 2013(Table 1). Standing crop increased by 53% in Right Fork and 73% in Left Fork in addition to densities increasing 174% and 303%, respectively. Population indices have generally been lowest at the Lower Left Fork station. This area receives the majority of the Put-and-Take stocking and angling pressure leading to harvest, hooking injury, and stress on Brook Trout. Nonetheless, recent surveys found both standing crop and density values to be lowest in Lower Right Fork where no stocking takes place.

Adult Brook Trout exhibit good physical condition at the lower stations of both forks, within the optimal range of 0.9 – 1.1 suggested by Lagler (1952) (Table 1). The poor physical condition observed at the upper stations may be density dependant.

Basic water quality was collected at the lower site from each fork and expressed in Table 2. Water quality in both forks is very similar, nearly neutral, and soft, with low conductivity.

Currently, the greatest threat to Brook Trout habitat within the Frederick City Watershed is the influx of sediment from gravel roads and trails carried by stormwater runoff. The Maryland Forest Service, the City of Frederick, the Frederick County Roads Department, and Inland Fisheries are working to address key stormwater issues in the watershed to reduce sedimentation. In October of 2013, the “rainmaker” (a device constructed to test the amount of sediment contributed from a roadway during a typical 1 inch per hour rain event) was used to determine the amount of sediment mobilized by the standardized rain event. The device was set up on the sloped approach to the Delauter Road ford, a problem area known to generate sediment transport into the left fork of Fishing Creek. Water samples were collected and flow was recorded at a catch point downhill from the testing section. Information recorded will provide baseline data for sediment and nutrient contributions of Delauter Road to Left Fork of Fishing Creek. Population estimates for adult and YOY Brook Trout were derived from additional electrofishing surveys conducted upstream and directly downstream of the Delauter Road ford (Table 3). All Brook Trout population indices were significantly lower downstream of the ford. Future surveys (“rainmaker”, trout population estimates, and physical habitat) will be used to evaluate the success of modifications to the ford and roadway approach in reducing sedimentation into Fishing Creek and its effect on the aquatic community.

Recommendations

- Monitor the status of the Fishing Creek Brook Trout populations by electrofishing on a biennial basis at the four established stations.
- Conduct additional electrofishing surveys at the two sites upstream and downstream of the Delauter Road ford during 2014 to obtain population estimates of adult and YOY Brook Trout. Results of these surveys will be used to evaluate the response of the trout population to modifications of the Delauter Road ford and the sloped approach.

Table 1. Fishing Creek adult and YOY Brook Trout population data (95% CI) collected by electrofishing station for 2009, 2011, and 2013. Long-term geometric mean since 1988.

Station	**2009**	**2011**	**2013**	**long term G-mean**
Right Fork Upper				
Standing Crop (kg/ha)	61 ± 25	32 ± 2	52 ± 1	36
Density (trout/ha)	1833 ± 751	762 ± 48	1810 ± 48	1107
YOY/ha	1333	476 ± 48	1857 ± 238	532
Condition Factor K	0.87 ± 0.05	1.01 ± 0.04	0.86 ± 0.03	-
Right Fork Lower				
Standing Crop (kg/ha)	21	11 ± 1	17 ± 0.5	34
Density (trout/ha)	968	225 ± 25	786 ± 24	1194
YOY/ha	2323 ± 906	475 ± 47	1381 ± 47	1060
Condition Factor K	0.91 ± 0.03	1.04 ± 0.06	0.97 ± 0.02	-
Left Fork Upper				
Standing Crop (kg/ha)	52 ± 2	23 ± 1	40 ± 1.5	30
Density (trout/ha)	2714 ± 107	762 ± 48	2842 ± 105	1264
YOY/ha	2214 ± 215	1286 ± 190	921 ± 553	939
Condition Factor K	0.77 ± 0.04	0.85 ± 0.10	0.64 ± 0.03	-
Left Fork Lower				
Standing Crop (kg/ha)	15 ± 1	16 ± 4	22 ± 0.8	14
Density (trout/ha)	577 ± 38	348 ± 87	1174 ± 43	557
YOY/ha	692 ± 77	130*	261	303
Condition Factor K	1.05 ± 0.05	1.04 ± 0.07	1.02 ± 0.04	-

* all trout collected on first pass.

Table 2. Water quality data measured from lower stations of Right and Left Forks of Fishing Creek, July 2013.

Parameter	**Left Fork**	**Right Fork**
Temperature (°C)	19.7	18.8
Conductivity (µS/cm)	39	26
pH	7.1	7.2
Alkalinity(mg/l)	17.1	<17.1
Hardness(mg/l)	34.2	17.1
Dissolved Oxygen (mg/l)	8.1	8.8

Table 3. Fishing Creek Brook Trout population data (95% CI) collected by electrofishing of Left Fork upstream and downstream of Delauter Road ford. September 25, 2013.

Station	**2013**
Left Fork upstream of ford	
Standing Crop (kg/ha)	106 ± 3
Density (trout/ha)	5579 ± 158
YOY/ha	1895 ± 157
Condition Factor K	0.73 ± 0.02
Left Fork downstream of ford	
Standing Crop (kg/ha)	44 ± 3
Density (trout/ha)	2733 ± 200
YOY/ha	1333 ± 89
Condition Factor K	0.68 ± 0.05

Hunting Creek
(Frederick County)

Introduction

Hunting Creek is one of Maryland's most popular and historic trout resources, enjoyed by a wide range of user groups including Presidents, wild trout anglers, fly-fishing enthusiasts and park visitors who come to see trout in a scenic natural setting. Originating on Catoctin Mountain, Hunting Creek flows easterly into Cunningham Falls Reservoir, a 17-hectare impoundment completed in 1972. A tailwater fishery exists downstream of Cunningham Falls Dam. Tailwater release guidelines established in 1984 have provided more flexibility to optimize water quality for trout. Hunting Creek was the first Maryland trout stream under special management regulations; catch-and-return, fly-fishing-only regulations currently apply within the boundaries of Catoctin Mountain Park and Cunningham Falls State Park. An excellent population of wild Brown Trout (*Salmo trutta*) is found throughout the mainstem downstream to the town of Thurmont while native Brook Trout (*Salvelinus fontinalis*) are limited to the headwaters upstream of Cunningham Falls Reservoir. Adult Rainbow Trout (*Oncorhynchus mykiss*) are stocked annually within the tailwater. A comprehensive management plan was formulated in 1993, which limits the annual stocking to a maximum of 1000 hatchery trout. In May of 2012 the presence of Didymo (*Didymosphenia geminata*), an invasive algae, was confirmed within the tailwater of Hunting Creek.

Traditionally, sampling is conducted at four fixed stations annually. The Hemlock Bridge station is located upstream of the reservoir; the Elbow Pool and Bear Branch stations are located within the tailwater; the Route 15 station is located downstream of Frank Bentz Pond, a 0.8-hectare in-stream impoundment.

Objectives

Electrofishing surveys were conducted to monitor adult and YOY trout populations in Hunting Creek with the following objectives:

- Obtain standing crop and abundance estimates for adult and young-of-year(YOY) trout populations.
- Obtain basic water quality.
- Monitor seasonal water temperatures within the tailwater and upstream of Cunningham Falls Reservoir.
- Obtain a current flow rating curve at gauging station.

Methods

Methodology for sampling fish populations follow that described in the Study III Job 1 Methods section. Basic water quality was measured using a HACH Model FF-1A Fish Farming test kit and YSI EXO1 sonde and multi meter.

Stream temperatures were monitored using HOBO Water Temp Pro data loggers manufactured by Onset Corp. Loggers were placed in the headwaters above Cunningham Falls, below Cunningham Falls Reservoir at the Gauging Station, and below Frank Bentz Pond to monitor summer stream temperatures.

Results

Electrofishing surveys during 2013 on Hunting Creek were restricted to the Elbow Pool and Bear Branch stations. Surveys were not completed within the Hemlock Bridge and Rt. 15 stations to reduce additional stress on trout populations due to warm stream temperatures (>20 C Hemlock Bridge and >23 C Rt. 15). Consecutive years of poor recruitment have led to declining wild Brown Trout abundance throughout Hunting Creek, upstream of Cunningham Falls Reservoir as well as in the tailwater. Adult standing crop and density values had generally declined at all stations reaching record lows during 2011, with only slight improvement in 2012 (Table 1). Strong Brown Trout recruitment and survival in 2012 helped to dramatically increase adult Brown Trout standing crop and density 67% and 191%, respectively in 2013. However, the majority of the adult population consisted of the 2012 year class (Figure 1). Brown Trout reproduction in 2013 was excellent, well above the long term geometric mean at both stations. Brown Trout physical condition (mean K) remains within the optimal range of 0.9 – 1.1 suggested by Lagler (1952) at all stations (Table 2).

Adult Rainbow Trout hatched and reared at Albert Powell State Trout Hatchery were stocked within the tailwater of Hunting Creek to supplement the existing fishing opportunities for wild brown trout. A spring stocking of approximately 450 adult Rainbow Trout along with an additional 300 in the fall were distributed throughout 2.6 km of stream within the Catch and Return/ Fly Fishing Only section during 2013. A total of eleven adult Rainbow Trout were collected during electrofishing surveys suggesting poor survival of hatchery fish.

Basic water quality parameters were measured at the Elbow Pool station on Hunting Creek at the time of the electrofishing surveys (Table 3). Values remain consistent with previous years, and indicate that water quality remains suitable for trout.

Maximum daily summer stream temperatures recorded during 2013 in Hunting Creek above Cunningham Falls (Hemlock Bridge station), at the gauging station, and near Rt. 15 below Frank Bentz pond are presented in Figure 2. Stream temperatures remained below 22°C (71.6°F) at the gauging station, including spillover events. However, stream temperatures in the headwaters and below Frank Bentz Pond reach levels considered stressful for trout populations. Maximum daily stream temperatures recorded at Hemlock Bridge were above 20°C (68.0°F) 46 days (28 consecutive days) between June 27th and September 30th, reaching a high temperature of 24.8°C (76.6°F) on July 19. Brook Trout mortality may occur when water temperatures exceed 24°C (Raleigh 1982). Maximum daily stream temperatures recorded at Rt. 15 were above 22°C (71.6°F) 57 days (35 consecutive days) between June 5th and September 30th, reaching a high temperature of 27.1°C (81.0°F) on July 17. Literature suggests that optimum water temperatures for Brown Trout are between 12–19°C (53.6-66.2°F), and mortality may occur when temperatures reach 27°C (80.6°F) (Raleigh 1982).

Flow measurements were recorded at the gauging station below Cunningham Falls reservoir during a range of manipulated discharges from the dam on May 7th. Measurements were used to determine the present flow rating curve to ensure MDE dam release guidelines for minimum flow are met. It was determined the present discharge released during periods of minimum flow was actually twice as high as the actual required minimum flow (1.5 cfs). Higher minimum flows have caused no negative affects, so the recommendation was made that park staff continue to manipulate the flows as they have been in recent years. The slightly higher flows will better help the aquatic life in the tailwater cope with a warming climate.

In May of 2012 the presence of Didymo, an invasive alga, was confirmed within the tailwater of Hunting Creek. The heaviest bloom was observed at the Joe Brooks Memorial with lighter growth observed as far downstream as the lower boundary of Catoctin Mountain National Park. No Didymo blooms were observed within Hunting Creek during 2013.

Recommendations

Monitor the wild and stocked trout populations by annual electrofishing surveys at established stations to remain up-to-date on their current status and determine long-term trends. Schedule the Hemlock Bridge station when morning stream temperatures are below 18ºC (65ºF).

- Continue to monitor summer water temperatures above and below Cunningham Falls, at the gauging station, and at Route 15.
- Monitor effects of Didymo on aquatic life within Hunting Creek tailwater. Compare recent and historical macro-invertebrate data to document any potential impact Didymo may be having on these populations.

Table 1. Summary of Hunting Creek adult and YOY Brown Trout population data (95% CI) collected by electrofishing. 2009 - 2013. Long-term G-mean = geometric mean since 1988.

STATION	**2009**	**2010**	**2011**	**2012**	**2013**	**long term G-mean**
Elbow Pool						
Standing Crop (kg/ha)	66±2	79	59±8	58±4	80±2	65
Density – (trout/ha)	682±26	600	427±60	360±27	973±27	611
YOY/ha	381±26	373±384	147±13	960±106	813±40	345
Bear Branch						
Standing Crop (kg/ha)	44±2	53±2	28±2	36±5	77±4	58
Density – (trout/ha)	464±19	519±18	204±18	241±37	778±37	530
YOY/ha	204±19	74±55	111±18	537±37	926±56	181

Table 2. Mean size and condition (95% CI) of adult Brown Trout collected by electrofishing in Hunting Creek, 2013.

Station	**N**	**Mean TL (mm)**	**Mean W (g)**	**Mean K Factor**
Elbow Pool	73	197 ± 10	82 ± 15	0.92 ± 0.02
Bear Branch	42	207 ± 13	99 ± 23	0.98 ± 0.05

Table 3. Basic water quality measured within Hunting Creek at Elbow Pool station on September 12, 2013.

Parameter	**Result**
Temperature (ºC)	21.2
Dissolved Oxygen (mg/l)	7.2
pH	8.5
Alkalinity (mg/l)	17.1
Hardness (mg/l)	68.4
Conductivity (µS/cm)	149

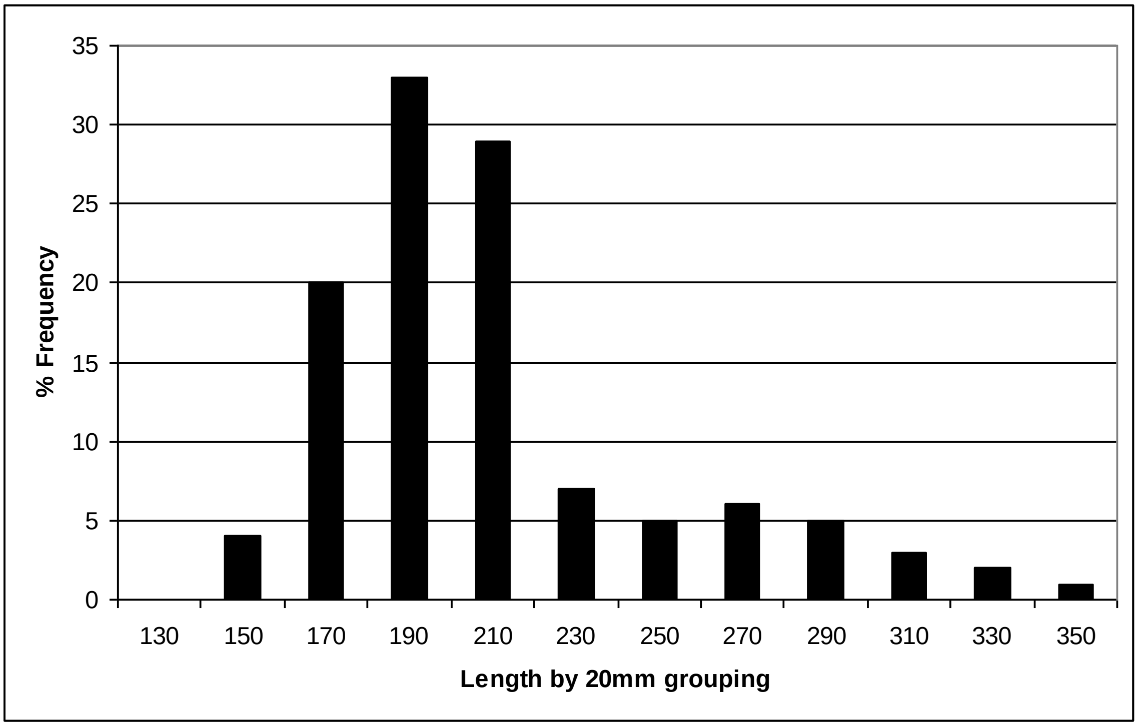


Figure 1. Length frequency of adult Brown Trout collected during electrofishing surveys at Elbow Pool and Bear Branch stations in Hunting Creek, 2013.

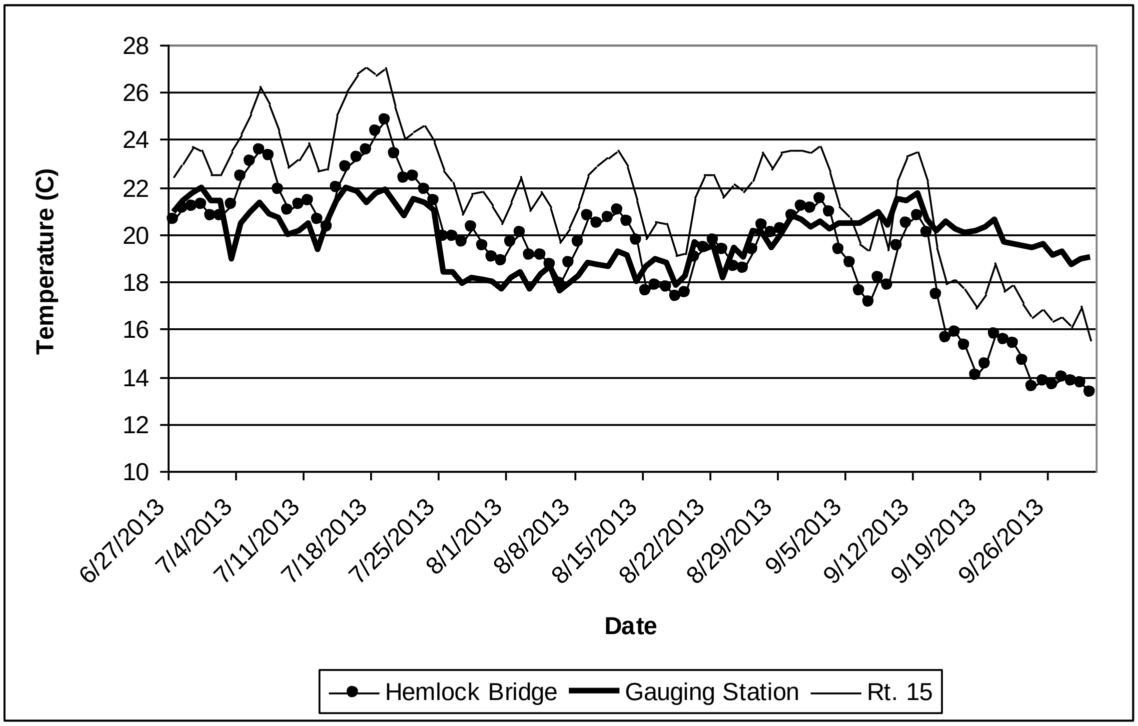


Figure 2. Maximum daily stream temperatures recorded at Hemlock Bridge, Gauging Station, and Rt. 15 in Hunting Creek, June- September 2012.

Little Hunting Creek
(Frederick County)

Introduction

Little Hunting Creek begins as one of several headwater streams located within the Catoctin Mountains in northern Frederick County, meandering through both private property and Cunningham State Park before eventually flowing into Big Hunting Creek. Little Hunting Creek has been managed for wild trout since 1994. Since that time, no hatchery trout have been stocked and anglers within the Cunningham Falls State Park Manor Area have been subject to catch-and-return regulations limited to artificial lures. Initially, two electrofishing stations were established to monitor trout populations. The uppermost Catoctin Hollow Road station is located within private property with tightly controlled access and serves as a “control” site. This station was moved slightly downstream and shortened in 2011 due too in stream obstructions caused by recent storm events. This section of property is currently undergoing new ownership which may affect future trout populations and access. The Manor Area station, located entirely within Cunningham Falls State Park is the most easily accessed area and highly impacted by human influence due too its proximity to parking and picnicking areas. Based on the positive response of the wild trout to catch-and-return regulations, the Maryland Fisheries Service extended the special regulation area (Catch and Return, Artificial Lures Only) approximately 0.8 km downstream effective January 1, 2002. An additional survey station (Catoctin Furnace) was established within this new area to evaluate if the positive response shown by the wild trout in the Manor Area could be extended further downstream. Biennial surveys at each station are conducted to remain up-to-date on the current status of this important natural resource and to document population trends. The most recent survey was completed in 2011.

Objectives

Fish management activities in 2013 consisted of electrofishing at three sites with the following objectives:

- Obtain population estimates for adult and young-of-year trout.
- Obtain physical condition data for adult trout.
- Obtain basic water quality.

Methods

Methodology for sampling fish populations follow that described in the Study III Job 1 Methods section. Basic water quality was measured using a HACH Model FF-1A Fish Farming test kit and YSI EXO1 sonde and multi meter.

Results

Recent renovations and instream alterations to a historical stream withdrawal valve limited stream flow within the uppermost electrofishing station (Catoctin Hollow) in 2013. Brook Trout populations have diminished in Little Hunting Creek (Table 1). Poor recruitment and limited survival since 2007 have significantly reduced Brook Trout populations to where no adult Brook Trout were collected during 2013 at any station. However, two YOY Brook Trout were collected at the lowermost station (Catoctin Furnace) verifying reproductive success, albeit limited.

Both standing crop and density values for adult Brown Trout increased significantly at all stations since 2009, reaching record highs at the Catoctin Hollow and Catoctin Furnace stations (Table 2). However the population is dominated by smaller individuals suggesting excellent recruitment and survival of 2012 year class (Figure 1). The middle station (Manor Area) continues to provide the lowest population values for adult Brown Trout. In the past, substantial alteration of the stream channel by anthropogenic activity within this entire section has resulted in degraded habitat for adult trout causing populations to suffer. Efforts have been made by Cunningham Falls Park staff to reduce alterations within and adjacent to Little Hunting Creek. Natural reproduction of Brown Trout was considered excellent throughout the sample area in 2013.

The mean total length, weight, and condition factor (K) of Brown Trout collected from Little Hunting Creek during 2013 is shown in Table 3. Brown Trout physical condition fell well below the optimal range of 0.9 – 1.1 suggested by Lagler (1952). Poor physical condition may be related to significantly higher densities.

Basic water quality was recorded at the upper and lowermost stations (Table 4). Water chemistry was similar at both locations; nearly neutral, soft, with low conductivity providing desirable conditions for trout survival.

Recommendations

- Continue biennial electrofishing surveys at the three established stations to document the status of the wild Brook and Brown Trout populations.
- Establish station in headwaters to determine Brook Trout populations.
- Establish lower distribution of Brown Trout populations.

Table 1. Little Hunting Creek adult and YOY Brook Trout population data (95% CI) collected by electrofishing in 2007, 2009, 2011, and 2013. Long term G-mean = geometric mean since 1989 for Catoctin Hollow Rd. and Manor Area, since 2001 for Catoctin Furnace.

STATION	**2007**	**2009**	**2011**	**2013**	**long term G-mean**
Catoctin Hollow Rd					
Standing Crop (kg/ha)	9 ± 2	9 ± 1	3*	0	8
Density (trout/ha)	186 ± 48	164	53*	0	135
YOY/ha	372 ± 43	73*	26*	0	107
Manor Area					
Standing Crop (kg/ha)	1*	1*	0	0	3
Density (trout/ha)	23*	21*	0	0	24
YOY/ha	227 ± 18	21*	0	0	41
Catoctin Furnace					
Standing Crop (kg/ha)	0	0	1*	0	2
Density (trout/ha)	0	0	25*	0	11
YOY/ha	161 ± 47	32*	0	56*	34

* all trout collected in first pass.

Table 2. Little Hunting Creek adult and YOY Brown Trout population data (95% CI) collected by electrofishing in 2009, 2011, and 2013. Long-term G-mean = geometric mean since 1989 for Catoctin Hollow Rd and Manor Area, since 2001 for Catoctin Furnace.

STATION	**2009**	**2011**	**2013**	**long term G-mean**
Catoctin Hollow Rd				
Standing Crop (kg/ha)	91 ± 4	107*	140 ± 4	54
Density (trout/ha)	455 ± 18	342*	1444 ± 37	388
YOY/ha	836 ± 18	0	1333 ± 75	187
Manor Area				
Standing Crop (kg/ha)	16 ± 1	17 ± 2	49 ± 1	28
Density (trout/ha)	250 ± 21	178 ± 21	1167 ± 24	352
YOY/ha	667 ± 83	0	833 ± 142	134
Catoctin Furnace				
Standing Crop (kg/ha)	71 ± 4	83*	183 ± 2	48
Density (trout/ha)	581 ± 32	325*	2056 ± 28	428
YOY/ha	548 ± 65	100 ± 50	972 ± 55	34

* all trout collected in first pass

Table 3. Mean size and condition (95% CI) of Little Hunting Creek adult Brown Trout collected by electrofishing, 2013.

Species	**N**	**Mean TL (mm)**	**Mean W (g)**	**Mean K Factor**
Brown Trout	162	183 ± 9	77 ± 23	0.79 ± 0.02

Table 4. Basic water quality recorded in Little Hunting Creek at Catoctin Hollow Rd. and Catoctin Furnace stations on September 26, 2013.

Parameter	**Catoctin Hollow**	**Catoctin Furnace**
Temperature (ºC)	11.9	14.2
pH	7.0	6.9
Alkalinity (mg/l)	<17.1	<17.1
Hardness (mg/l)	34.2	34.2
Conductivity (µS/cm)	56	74
Dissolved Oxygen (mg/l)	10.3	9.9

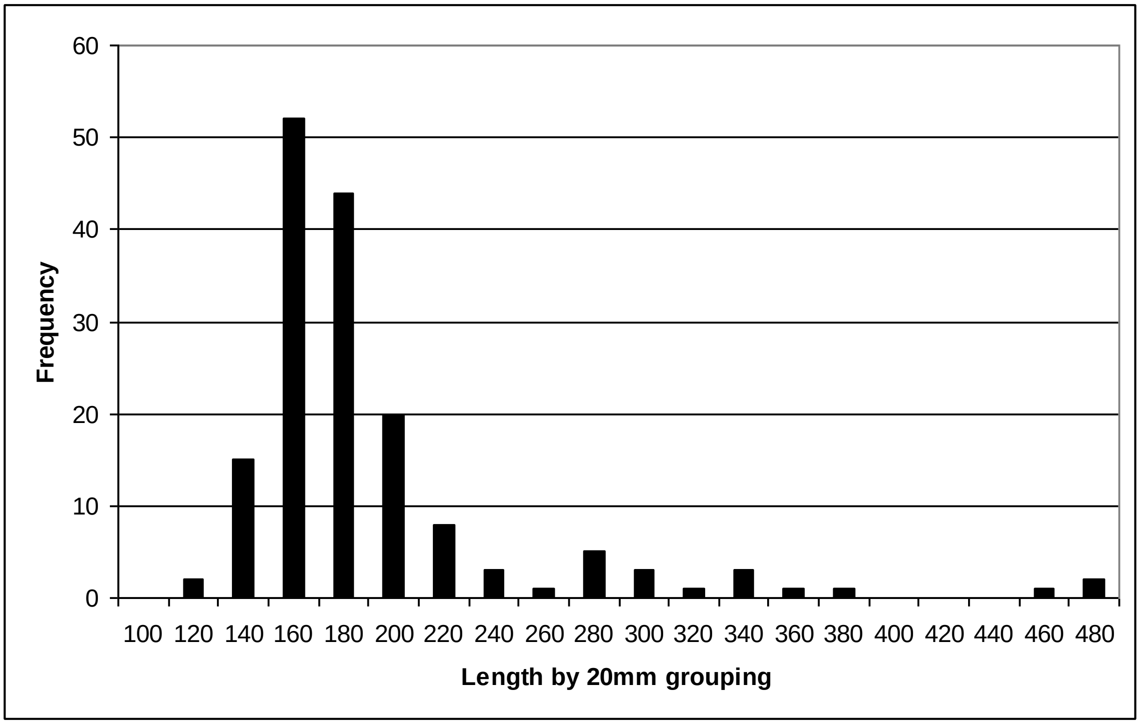


Figure 1. Length distribution of adult Brown Trout (N = 162) collected by electrofishing on Little Hunting Creek during 2013.

Central Region
(Montgomery, Howard, Carroll, Baltimore, Harford, and Cecil Counties)

Bee Tree Run
(Baltimore County)

Introduction

Bee Tree Run is a small to medium size freestone stream located in the northeast corner of Baltimore County. Bee Tree Run supports a self-sustaining Brown Trout population. Prior to January 1, 1989, Bee Tree Run was stocked annually with adult Rainbow Trout from Bee Tree Road downstream to the confluence with Little Falls and managed as put-and-take with a five trout per day limit and no bait restrictions. Stocking of hatchery trout was discontinued as of January 1, 1989 and Bee Tree Run has since been managed as a wild trout stream with a two trout per day limit and no size restrictions. The use of artificial flies, lures and bait are permitted in Bee Tree Run. Three stations had been surveyed annually from 1988 through 1993. The three stations are located between Bentley Springs and Freeland, Maryland and are referred to as the lower, middle and upper stations. The upper and lower stations are approximately 2.4 kilometers apart and the middle station is 1.9 kilometers below the upper station. Beginning in 1994, the decision was made to rotate the three survey stations, sampling one of the three annually as stream conditions or scheduling permit. The fisheries activity conducted in Bee Tree Run in 2013 was a multiple-pass electrofishing survey in the middle station. The middle station was last surveyed in 2009.

Objectives

The objectives of the fisheries activities in Bee Tree Run were to monitor the distribution and population characteristics of wild Brown Trout in the stream to evaluate management strategies aimed at maximizing recreational fishing opportunities and to monitor habitat and environmental conditions affecting the trout population dynamics in Bee Tree Run for the purpose of preventing or reducing environmental degradation and documenting any improvement in environmental quality.

Methods

Methodology follows that described in the Study III Job 1 Method section. Only variations from the methodology are described here.

Results

Electrofishing Surveys
The July 25, 2013 electrofishing survey in the middle station resulted in a 98 percent increase in adult Brown Trout standing crop (kg/ha) and a 242 percent increase in adult density (trout/ha) since the last electrofishing survey in 2009 (Table 1). The 2013

standing crop was the highest of the twelve surveys since multiple-pass regression surveys were first conducted in the middle station in 1988. The density of young-of-the-year (YOY) Brown Trout in 2013 was 49 percent lower than the 2009 survey, however; only 1997 and 2009 had a greater density of YOY in the middle station (Table 2). Recruitment in Bee Tree Run is the most consistent of any freestone Brown Trout stream in the Central Region. The condition factor (K) of the adult Brown Trout collected during the survey was 0.93 ± .02, within the optimal range of 0.90 – 1.10. A list of all fish species observed during the electrofishing survey can be found in Table 3.

Recommendations

It is recommended that this study be continued in 2014. An electrofishing survey in the upper station should be conducted in 2014 to monitor standing crop and density of the wild Brown Trout population. Monitoring of the stream will continue to ensure that the population dynamics of Brown Trout in Bee Tree Run are available if necessary for environmental review and to local governmental agencies requiring biological assessment data.

Table 1. Standing crops and densities (95% CI) of adult Brown Trout collected by MD DNR during multiple-pass electrofishing surveys in the middle station of Bee Tree Run, 1988-1994, 1997, 2000, 2003, 2009 and 2013.

Year	**kg/hectare**	**trout/hectare**	**trout/km**
2013	81±5	1161±68	545±32
2009	41±2	339±19	159±9
2003	17*	187	85
2000	41±1	413±13	188±6
1997	57±2	484±14	241±7
1994	80±1	798±13	396±6
1993	37±2	482±21	257±11
1992	40±3	447±30	214±14
1991	63±1	536±8	258±4
1990	54±1	598±11	287±5
1989	25±1	247±13	119±6
1988	13±1	178±1	86±1
Mean	46±14	489±175	236±84
Range	68	983	460

* No confidence intervals as all adult trout were collected on the first pass

Table 2. Densities (95% CI) of young-of-the-year (YOY) Brown Trout collected by MD DNR during multiple-pass electrofishing surveys in the middle station of Bee Tree Run, 1988-1994, 1997, 2000, 2003, 2009 and 2013.

Year	**YOY/hectare**	**YOY/km**
2013	1403±120	659±57
2009	2742±364	1288±171
2003	373±221	169±100
2000	200±12	91±6
1997	1845±166	918±83
1994	963±39	479±20
1993	837±77	403±38
1992	1188±102	571±49
1991	1188±69	571±33
1990	240±22	116±11
1989	818±52	393±25
1988	659±92	317±44
Mean	1038±459	498±219
Range	2542	1197

Table 3. Species name and relative abundance of fishes observed during an electrofishing survey by MD DNR in the middle station of Bee Tree Run in 2013.

Common Name	**Scientific Name**	**Relative Abundance**
Brown Trout	*Salmo trutta*	A
Central Stoneroller	*Campostoma anomalum*	S
Common Shiner	*Luxilus cornutus*	S
Blacknose Dace	*Rhinichthys atratulus*	A
Longnose Dace	*Rhinichthys cataractae*	S
Cutlips Minnow	*Exoglossum maxillingua*	S
Rosyside Dace	*Clinostomus funduloides*	S
Creek Chub	*Semotilus atromaculatus*	S
River Chub	*Nocomis micropogon*	S
White Sucker	*Catostomus commersonii*	C
Northern Hog Sucker	*Hypentelium nigricans*	S
Tessellated Darter	*Etheostoma olmstedi*	S

Relative Abundance: A= Abundant; C= Common; S= Scarce

Gunpowder Falls Tailwater
(Baltimore County)

Introduction

Since a coldwater agreement between Trout Unlimited (TU) and Baltimore City went into effect on November 5, 1986, a thriving self-sustaining Brown Trout fishery has developed and dominated the fish species composition of the Gunpowder Falls tailwater for twenty-seven years. The agreement obligates Baltimore City to provide a minimum discharge of 11.5 cubic feet per second, however; Baltimore City reserves the right to notify TU if the minimum cannot be delivered due to municipal water supply constraints or water shortage.

The Gunpowder Falls tailwater is managed under three different regulation strategies along its 28.2 km length. The upper 11.6 km of river is managed as a catch-and-return (C&R) area, restricted to the use of artificial lures and flies only. The first C&R area was established January 1, 1989 between Prettyboy dam and Falls Road. The second C&R portion was added January 1, 1991 from York Road downstream to Blue Mount Road. The third and final addition included the section from Falls Road to York Road on January 1, 1993. Two established electrofishing stations within the C&R area, dam/Falls and Masemore Road stations, were surveyed in 2013. The middle 6.8 km portion of tailwater was established as a two trout/day harvest area for wild trout on January 1, 1997. This section is not stocked with hatchery trout and allows the use of bait. A single electrofishing station established within this managed area, the Blue Mount station, was surveyed in 2013. This management area was extended another 2.5 km to 9.3 km in January 2006. The change was made to reduce the harvest of wild Brown Trout in a section of put-and-take (P&T) water that was not being stocked and was determined not to be suitable for conventional P&T stocking. The remaining 7.3 km of tailwater has been managed as a P&T area since 1989. The P&T portion is stocked annually in the spring and fall with hatchery reared adult Rainbow Trout. A creel limit of five trout/day applies in the P&T area and there are no restrictions on terminal tackle.

Objectives

The objectives of the fisheries activities conducted in the Gunpowder Falls tailwater in 2013 were to monitor population and recruitment trends of the wild trout fishery within 28.2 km of the Gunpowder Falls tailwater managed under various fishing regulation strategies, monitor response and success of Rainbow Trout fingerling stockings between Falls Road and Prettyboy dam and monitor tailwater temperatures in response to water release strategies employed since 2004.

Methods

Methodology follows that described in the Study III Job 1 Methods section. Only variations from that methodology are described here.

Water regulation from Prettyboy Reservoir is required in order for the fall electrofishing survey to be completed at a discharge of approximately 30 cubic feet per second (cfs).

Tailwater temperatures are monitored hourly using continuous recording data loggers manufactured by Onset Computer Corporation. Temperature data are downloaded and graphed using the HOBOware software package. Devices are located approximately 1.9 and 12.5 km below Prettyboy dam in the Falls Road and Blue Mount Road electrofishing stations, respectively. The information is collected annually and is used to monitor and evaluate thermal conditions from water release protocol activities first implemented in 2004.

Results

Electrofishing Surveys

Electrofishing surveys were conducted at three established sites in 2013 that included dam/Falls, Masemore and Blue Mount stations.

Adult Brown Trout standing crop (kg/ha) increased 11% and density (trout/ha) increased 41% in the dam/Falls station in 2013 compared to the 2012 results (Tables 1 and 2). The Masemore station had a 15% increase in standing crop (kg/ha) and a 48% increase in density (trout/ha) of adult Brown Trout in 2013 when compared to 2012 estimates (Tables 1 and 2). One adult Brook Trout was collected during the Masemore Road survey. The Blue Mount station had a 44% increase in standing crop (kg/ha) and a 26% increase in density (trout/ha) of Brown Trout adults in 2013 when compared to 2012 results (Tables 1 and 2). Mean lengths, weights and condition factors (K) of yearling and older Brown Trout at dam/Falls, Masemore and Blue Mount stations for 2013 can be found in Table 3.

Young-of-the-year (YOY) Brown Trout density (YOY/ha) decreased 64% in the dam/Falls station, decreased 53% in the Masemore station and increased 19% in the Blue Mount station in 2013 compared to 2012 estimates (Table 4).

Water Temperature Monitoring

HOBO Water Temp Pro loggers were deployed above Falls Road and below Blue Mount Road within the Blue Mount electrofishing station between May 3 and October 29, 2013. Stream temperatures were monitored and evaluated between May 4 and October 28, 2013. The maximum water temperature in the Blue Mount station was 21.10° C (69.98° F) on September 2 and the maximum water temperature above Falls Road was 18.89° C (66.00° F) on October 11 (Figures 1 and 2). Stream temperatures did not exceed 20° C

(68° F) on any of the 178 monitored days above Falls Road. The Blue Mount site experienced stream temperatures in excess of 20° C eleven of the 178 monitored days, however; no days had a mean stream temperature over 20° C. Water temperatures were excellent during the monitoring period for the growth and survival of wild trout.

Rainbow Trout Fingerlings
Five thousand Rainbow Trout fingerlings (60/lb) were stocked into the Gunpowder Falls tailwater on May 22, 2013. Thirty-eight thousand Kamloops Rainbow Trout fingerlings have been stocked into a 2.1 km reach of tailwater between Prettyboy dam and Falls Road since 2002 as part of put-and-grow management to provide another catchable species of trout. One Rainbow Trout adult and 14 Rainbow Trout fingerlings were collected in the dam/Falls station and three Rainbow Trout fingerlings were collected in the Masemore Road station during the population surveys in 2013. Rainbow Trout fingerling stocking efforts to date have failed to improve standing crops above those previously sustained by limited natural reproduction (Table 1, 2).

Recommendations

All project work objectives were accomplished in 2013. Fall electrofishing surveys should be continued at a minimum of three established survey sites in 2014. A Rainbow Trout fingerling stocking should be considered as in previous years with a target number of 5,000 in order to attain the desired management objective of establishing and maintaining a quality Rainbow Trout fishery between Falls Road and Prettyboy dam. Water temperature monitoring should continue above Falls Road and in the Blue Mount station using Onset Water Temp Pro recorders in 2014.

Table 1. A comparison of adult trout standing crops (kg/ha ± 95% CI) collected during electrofishing surveys by MD DNR in Gumpowder Falls tailwater at dam/Falls, Masemore and Blue Mount stations from 2011 to 2013.

Station	**Combined kg/ha**	**Brown kg/ha**	**Rainbow kg/ha**
dam/Falls			
2013	116 ± 2	114 ± 2	*1 f
2012	103 ± 1	103 ± 1	0
2011	126 ± 3	124 ± 3	*3 f
Masemore			
2013	60 ± 1	61 ± 1	0
2012	53 ± .5	53 ± .5	0
2011	78 ± 1	76 ± 1	1 ± 1 f
Blue Mount			
2013	49 ± 1	49 ± 1	0
2012	34 ± .4	34 ± .4	0
2011	40 ± 1	40 ± 1	0

f- Fingerling Rainbow Trout origin
*No confidence interval since all fish were collected in one pass

Table 2. A comparison of adult trout densities (trout/hectare ± 95% CI) collected during electrofishing surveys by MD DNR in Gunpowder Falls tailwater at dam/Falls, Masemore and Blue Mount stations from 2011 to 2013.

Station	**Combined Trout/ha**	**Brown Trout/ha**	**Rainbow Trout/ha**
dam/Falls			
2013	1101 ± 19	1094 ± 19	*6 f
2012	774 ± 8	774 ± 8	0
2011	1170 ± 30	1157 ± 29	*13 f
Masemore			
2013	517 ± 6	515 ± 6	0
2012	347 ± 3	347 ± 3	0
2011	646 ± 6	636 ± 6	7 ± 3 f
Blue Mount			
2013	349 ± 5	349 ± 5	0
2012	278 ± 4	278 ± 4	0
2011	299 ± 6	299 ± 6	0

f- fingerling Rainbow Trout origin
*No confidence interval since all fish were collected in first pass

Table 3. Mean size, condition and confidence intervals (± 95% CI) of yearling and older Brown Trout collected during electrofishing surveys by MD DNR in Gunpowder Falls tailwater at dam/Falls, Masemore and Blue Mount stations between 2006 and 2013.

Station	**N**	**Mean TL (mm)**	**Mean W (g)**	**Mean K Factor**
dam/Falls				
2013	173	213 ± 6	105 ± 8	0.96 ± 0.01
2012	123	236 ± 5	133 ± 7	0.98 ± 0.01
2011	181	220 ± 5	107 ± 7	0.95 ± 0.01
2010	245	215 ± 3	99 ± 5	0.96 ± 0.01
2009	266	209 ± 4	89 ± 6	0.90 ± 0.01
2008	251	220 ± 4	109 ± 6	0.97 ± 0.01
2007	305	223 ± 4	109 ± 6	0.91 ± 0.01
2006	280	233 ± 12	125 ± 10	0.91 ± 0.01
Masemore				
2013	211	225 ± 5	118 ± 9	0.94 ± 0.01
2012	143	246 ± 6	152 ± 11	0.96 ± 0.02
2011	261	225 ± 5	120 ± 9	0.94 ± 0.01
2010	282	222 ± 4	114 ± 7	0.97 ± 0.01
2009	250	210 ± 5	98 ± 8	0.93 ± 0.01
2008	189	215 ± 6	107 ±9	0.97 ± 0.01
2007	218	214 ± 5	103± 7	0.96 ± 0.01
2006	385	212 ± 8	96 ± 6	0.89 ± 0.01
Blue Mount				
2013	262	235 ± 6	139 ± 12	0.94 ± 0.01
2012	209	230 ±6	124 ± 12	0.90 ± 0.01
2011	223	227 ± 6	135 ± 15	0.98 ± 0.01
2010	228	214 ± 6	107 ± 12	0.93 ± 0.01
2009	145	235 ± 9	147 ± 21	0.94 ± 0.01
2008	176	237 ± 7	151 ± 17	0.98 ± 0.01
2007	200	213 ± 7	100 ± 13	0.87 ± 0.02
2006	323	204 ± 5	91 ± 9	0.87 ± 0.01

Table 4. A comparison of young-of-year densities (YOY/hectare ± 95% CI) of wild Brown Trout collected during electrofishing surveys by MD DNR in Gunpowder Falls tailwater at dam/Falls, Masemore and Blue Mount stations in 2011, 2012 and 2013.

Station	**N**	**YOY/ha**
dam/Falls		
2013	3	*19
2012	38	245 ± 20
2011	0	0
Masemore		
2013	73	235 ± 76
2012	204	502 ± 11
2011	30	75 ± 8
Blue Mount		
2013	109	156 ± 14
2012	92	131 ± 12
2011	50	77 ± 17

*No confidence interval since the trout was collected in one pass

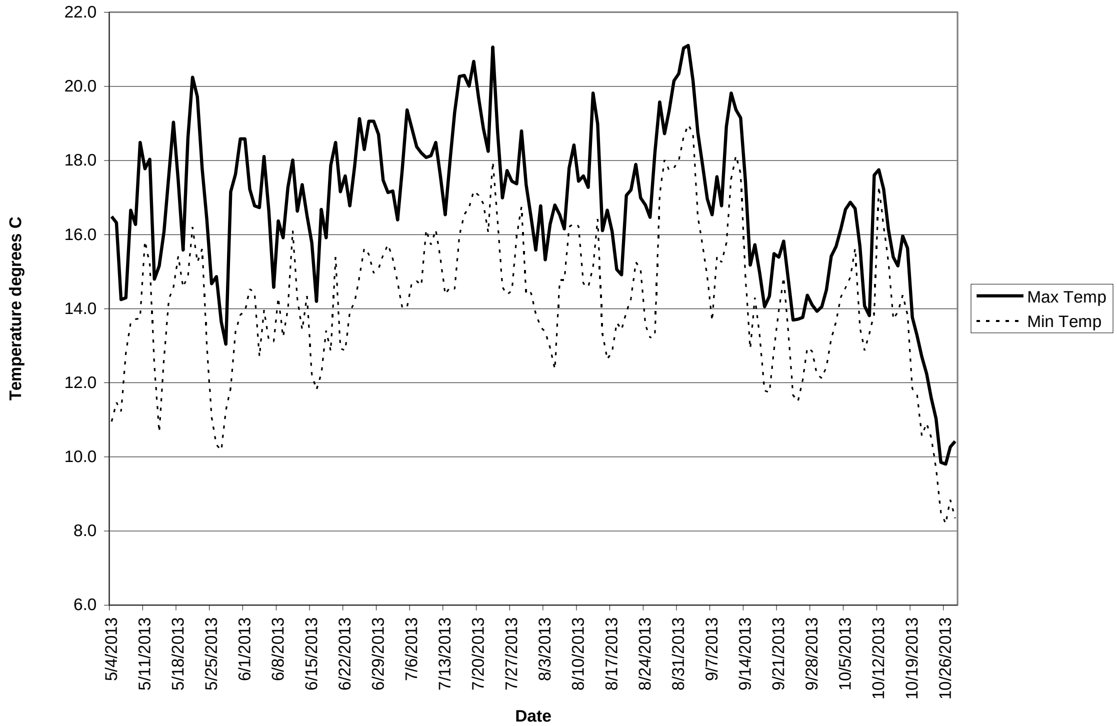


Figure 1. Minimum and maximum daily water temperatures (°C) recorded hourly with an Onset Water Temp Pro logger by MD DNR from May 4, 2013 to October 28, 2013 in the Blue Mount station in the Gunpowder Falls tailwater.

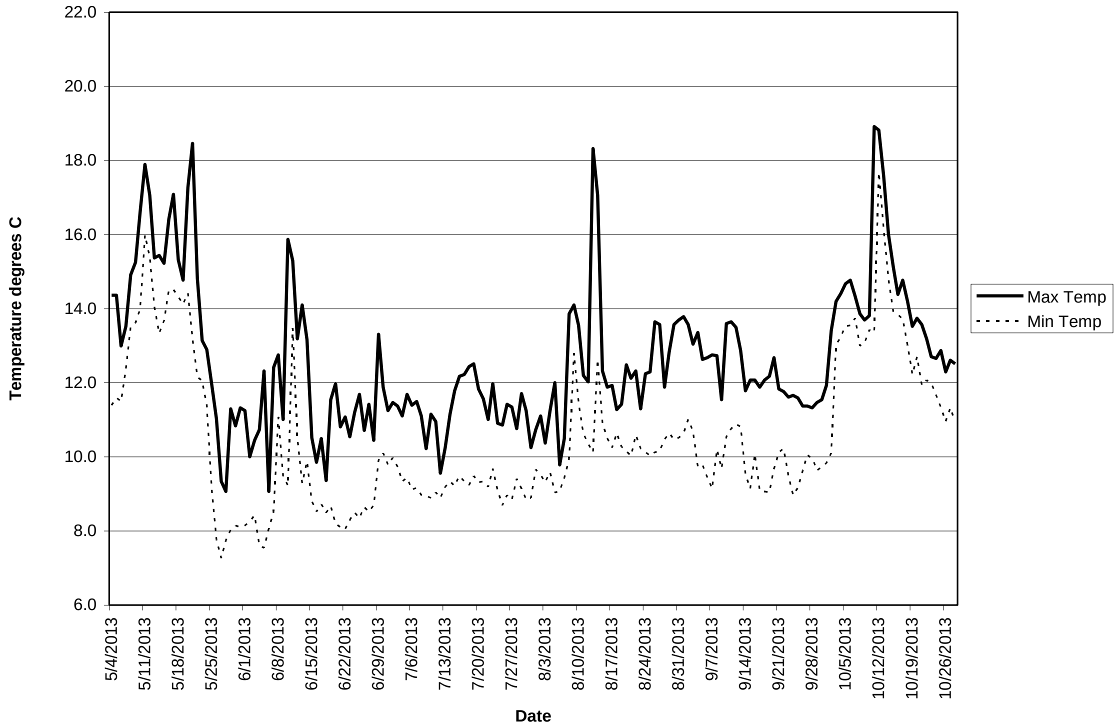


Figure 2. Minimum and maximum daily water temperatures (°C) recorded hourly with an Onset Water Temp Pro logger by MD DNR from May 4, 2013 to October 28, 2013 above Falls Road station in the Gunpowder Falls tailwater.

Paint Branch
(Montgomery County)

Introduction

Paint Branch was the first stream in the State of Maryland to be managed as a Special Wild Trout Management Area on January 1, 1980. The use of bait was prohibited and only single hook flies and lures were permitted. All trout caught were to be returned to the water. The area subject to this provision included the mainstem and all tributaries above Fairland Road. On January 1, 1989, regulations were changed statewide to allow multiple hooked lures and flies in all catch-and-return trout waters to include the Paint Branch from Fairland Road upstream. The catch-and-return management strategy is aimed at providing maximum protection to Maryland's longest surviving urban trout population. The fisheries activities conducted in the Good Hope tributary to Paint Branch in 2013 included one multiple-pass electrofishing survey, a swim-up fry count, redd counts and water temperature monitoring. A multiple-pass electrofishing survey was also conducted in the Gum Springs tributary to Paint Branch.

Objectives

The objectives of the fisheries activities were to monitor the distribution and population characteristics of Brown Trout in the Paint Branch and monitor habitat and environmental conditions affecting the Brown Trout population dynamics in the Paint Branch for the purpose of preventing or reducing environmental degradation and documenting any improvement in environmental quality.

Methods

Methodology followed that described in the Study III Methods section. Only variations from that methodology are described here.

Swim-up Fry Survey and Redd Count
Brown Trout fry counts are conducted in March and/or April in the Good Hope tributary to Paint Branch from the confluence of the Paint Branch upstream to the Montgomery County Highway Depot tributary, a distance of 1.45 kilometers. Swim-up Brown Trout fry counts are conducted by walking along the stream or wading up through the stream and counting the identifiable fry. The number of observed Brown Trout fry is recorded to determine the success of the annual hatch. Redd counts are conducted by walking along the Good Hope tributary from the confluence of the Paint Branch mainstem upstream to the Montgomery County Highway Depot tributary, and counting all easily identifiable redds. Disturbance in the stream substrate that gives the appearance of moved gravel by spawning trout are not counted unless classic redd characteristics of an obvious down cut and pit with a raised gravel spit are observed. The counts are conducted a minimum of two times during November.

Water Temperature Monitoring
An Onset WaterTemp Pro logger monitored water temperatures. The logger was wired under a stream bank and was covered with boulders to prevent loss due to a potential high stream flow event. Stream temperatures (°C) were recorded hourly. Temperature data were downloaded and graphed using the HOBOware software package.

Results

Swim-up fry survey
Central Region staff conducted a swim-up Brown Trout fry survey in the Good Hope tributary on April 11, 2013. No fry were found which was not surprising considering no redds were counted in the fall of 2012 for the first time since redd counts were first conducted in 1978, a period of 35 years. Fry counts are conducted to determine if there is a successful hatch of Brown Trout in the spring.

Water Temperature Monitoring
Stream temperatures were monitored in the Good Hope tributary at Hobbs Drive. A single Onset WaterTemp Pro logger monitored water temperatures in the Good Hope tributary for 159 days from May 17 to October 22, 2013 (Figure 1). The highest temperature recorded at Hobbs Drive was 22.87° C (73.17° F) on July 19 and 20. Twenty-nine of the 159 (18%) monitored days had mean water temperatures over 20°C (68° F) that ranged from 20.10° C to 22.00° C (68.18° F – 71.6° F). Water temperatures were considered fair to stressful for the survival of Brown Trout during the summer of 2013 in the Good Hope tributary.

Electrofishing Surveys
A multiple pass electrofishing survey was conducted on September 18 in the Hobbs Drive station of the Good Hope tributary for the 35th consecutive year. Only one yearling Brown Trout was collected during the electrofishing survey (Table 1). There was no Brown Trout young-of-the-year (YOY) recruitment in the Hobbs Drive station in 2013. This was only the fourth time in the 35 years of multiple pass surveys that no YOY were collected in the Hobbs Drive station, however; 2013 was the third consecutive year without recruitment (Table 1). The Good Hope tributary historically provided the most consistent and reliable Brown Trout recruitment in the Paint Branch watershed. The decline of Brown Trout in the Good Hope tributary can be attributed to the lack of significant recruitment in the Good Hope tributary over the last eleven years due to unstable and declining spawning substrate and adult habitat as a result of an increase in frequency of high stream flow storm events and stressful summer water temperatures. Mean size, condition and 95 percent confidence intervals for adult Brown Trout collected in the Good Hope tributary from 2007 through 2013 can be found in Table 2. The condition factor of the yearling Brown Trout collected during the survey was 0.96, within the optimal range of 0.90-1.10.

The 157.9-meter lower Gum Springs tributary station was surveyed on September 18. One Brown Trout adult was collected during the survey (Table 3). The adult Brown Trout had a condition factor (0.93) within the optimal range of 0.90-1.10. No Brown Trout YOY were collected in the lower Gum Springs station in 2013 for the third consecutive year. The lower section of the Gum Springs tributary continues to support limited but inconsistent recruitment as 18 of the past 23 electrofishing surveys have resulted in single digit or failed Brown Trout recruitment. The species name of fishes collected during the 2013 electrofishing surveys in the Paint Branch tributaries are listed in Table 4.

Redd Count

The Good Hope tributary is surveyed annually to provide some insight into the annual Brown Trout spawning effort and to identify important stream reaches utilized by spawning trout in the Good Hope tributary. Brown Trout begin spawning in the Paint Branch watershed by early November. The first of two redd counts was conducted on November 6, 2013. No redds were observed during the first count. A second redd count was conducted on November 21 with one redd observed during the second count. The lack of good quality spawning gravel has become common in the Good Hope tributary and was observed throughout the Good Hope tributary in 2013 with sand, large cobble and boulders dominating the composition of the stream bottom substrate. Multiple surveys are conducted in the Good Hope to get the most accurate count possible. No redds were observed in 2012 for the first time since the count began in 1978. The mean redd count is 16 ± 4 (95% CI) for the years 1978 through 2013 but only 3 ± 3 (95% CI) for the last five counts (2009-2013).

Recommendations

The management strategy proposed for the Paint Branch in 2014 is to conduct a swim-up fry count in the Good Hope tributary to assess whether trout reproduction occurred and electrofish one or more established stations in the Good Hope tributary to Paint Branch. A redd count will be conducted in November to assess spawning effort and spatial distribution of the Brown Trout in the Good Hope tributary. Additional electrofishing surveys may be conducted in Gum Springs at the confluence with Paint Branch to continue monitoring Brown Trout population trends. Additional fish sampling efforts conducted by cooperating agencies and local governments will be coordinated through Maryland Department of Natural Resources (MD DNR) Inland Fisheries as necessary. It is imperative that MD DNR Inland Fisheries continues to monitor the Paint Branch Brown Trout population in order to assess trends and status of the only self-sustaining population of Brown Trout in Montgomery County.

Table 1. Population data (95% CI) for wild Brown Trout collected by MD DNR during multiple-pass electrofishing surveys in the Hobbs Drive station of the Good Hope tributary to Paint Branch, 2007-2013.

Year	Adult N	Adult kg/ha	Adult Trout/ha	Adult trout/km	YOY N	YOY/ha	YOY/km
2013	1	1*	38	9	0	0	0
2012	1	13*	53	9	0	0	0
2011	1	2*	53	9	0	0	0
2010	0	0	0	0	3	158±169	28±30
2009	1	11*	53	9	1	53*	9
2008	2	9*	105	19	2	105±667	19±121
2007	1	5*	53	9	9	474±45	84±8

* No 95% confidence interval as all trout were collected during one pass

Table 2. Mean size, condition and confidence intervals (95%) for yearling and older Brown Trout collected during electrofishing surveys by MD DNR in the Hobbs Drive station of the Good Hope tributary to Paint Branch from 2007-2013.

Date	N	Mean TL (mm)	Mean W (g)	Mean K Factor
09/18/13	1	146	30	.96
09/20/12	1	290	254	1.04
09/15/11	1	155	35	.94
09/22/10	0	-	-	-
09/24/09	1	270	218	1.11
09/11/08	2	199±381	87±496	1.02±0.3
09/10/07	1	222	104	.95

Table 3. Population estimates (95% CI) for Brown Trout electrofished by MD DNR in the lower Gum Springs tributary to Paint Branch, 2007-2013.

Year	Adult N	Adult kg/ha	Adult trout/ha	Adult trout/km	YOY N	YOY/ ha	YOY/ Km
2013	1*	3	27	6	0	0	0
2012	1*	1	27	6	0	0	0
2011	2	1±6	54±343	12±76	0	0	0
2010	0	0	0	0	14	378±56	81±12
2009	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0
2007	3	2±2	81±81	17±17	3*	81	17

* No 95% confidence intervals as all trout were collected on the first pass

Table 4. Fish species observed during electrofishing surveys by MD DNR in the lower Gum Springs tributary (1) and Good Hope tributary at Hobbs Drive (2) in 2013.

Common Name	Scientific Name	Station
Brown Trout	*Salmo trutta*	1,2
Blacknose Dace	*Rhinichthys atratulus*	1,2
Longnose Dace	*Rhinichthys cataractae*	2
Cutlips Minnow	*Exoglossum maxillingua*	1,2
Rosyside Dace	*Clinostomus funduloides*	1,2
Creek Chub	*Semotilus atromaculatus*	1,2
Fallfish	*Semotilus corporalis*	1,2
Common Shiner	*Luxilus cornutus*	1
White Sucker	*Catostomus commersonii*	1,2
Blue Ridge Sculpin	*Cottus caeruleomentum*	1,2
Tessellated Darter	*Etheostoma olmstedi*	1
Green Sunfish	*Lepomis cyanellus*	1
American Eel	*Anguilla rostrata*	1,2
Sea Lamprey	*Petromyzon marinus*	2

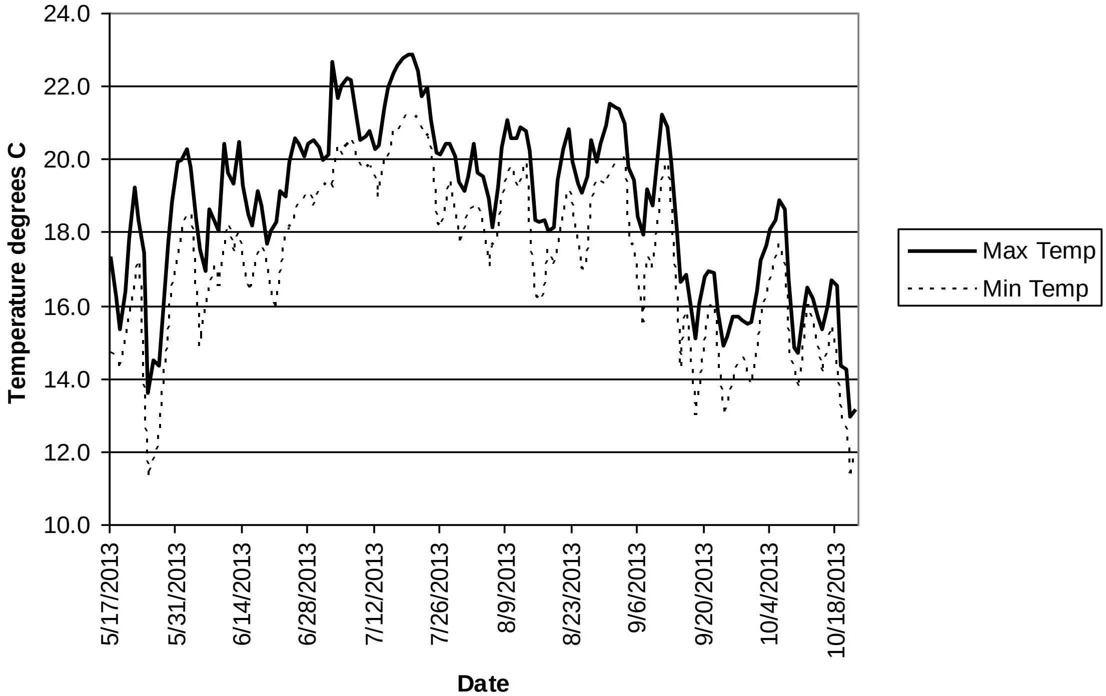


Figure 1. Maximum and minimum daily water temperatures (°C) recorded hourly with an Onset Water Temp Pro logger by MD DNR from May 17, 2013 to October 22, 2013 in Good Hope tributary to Paint Branch at Hobbs Drive.

Basin Run
(Cecil County)

Introduction

Basin Run is a small-to medium-sized stream located in western Cecil County. It supports a naturally reproducing population of Brown Trout and is considered unique and rare in this portion of the state. Until stocking was discontinued in 1997, Basin Run was managed as a put-and-take (P&T) hatchery-supported fishery, regulated with a five trout creel/angler. State policy, which discourages stocking wild trout waters, prompted the move to stop stocking Basin Run and to pursue wild trout management. Monitoring of the Brown Trout fishery in Basin Run by Maryland Department of Natural Resources (MD DNR) has been conducted since 1990. In 1999, Basin Run was placed under a two-fish/day creel limit in an effort to assess the wild trout potential of Basin Run. A significant tributary referenced as the "unnamed tributary" originates near the town of Woodlawn in Cecil County and has been found to be a major spawning and nursery site for Brown Trout. This tributary has been sampled routinely by MD DNR since 1992. On December 19 2000, the embankment of two small ponds failed during a heavy storm event, causing sediment from an EPA Superfund site, located in the town of Woodlawn, to spill into the unnamed tributary. The sediment entered the unnamed tributary immediately below Waibel Road, impacting approximately one mile of stream habitat. The combined impact of an extended drought (1998–2002), and a slow response time to remove accumulated sediments in the summer of 2001, further disrupted the ecology of the unnamed tributary and Basin Run mainstem. Since that time, the watershed has been affected by many flood events, including one 500-year and two 100-year events. New housing developments continue to threaten its water quality. One such project was investigated in July 2013. A summary of the investigation can be found in Job 1: Environmental Review.

Methods

Methodology follows that described in the Study III Job 1 Methods section. Only variations from that methodology are described here.

In 2013, one two-pass electrofishing survey was completed on the unnamed tributary to Basin Run near the Russell Road crossing. The station is 200m in length.

Results

Only two adult Brown Trout were encountered in the survey. However, young-of-year (YOY) Brown Trout were abundant (Tables 1 and 2). This is not unexpected since the unnamed tributary is clearly functioning predominantly as a spawning and nursery area and habitat for larger adults is very limited. A species list of fish encountered while sampling the unnamed tributary can be found in Table 3.

Recommendations

High quality tributaries to Basin Run, such as this unnamed tributary, supply Basin Run with cool, high quality inflow, and hold a ready supply of Brown Trout adults and YOY accessible to Basin Run. Although previously stocked, Basin Run mainstem is now a very poor candidate as a put-and-take hatchery supported trout fishery due to its small size and limited public access. Allowing the stream to persist as a wild trout stream, managed under the statewide creel limit of two trout/angler/day and the use of bait is an appropriate use at this time. Continued monitoring of the wild trout population will allow periodic assessment of the wild trout population trend and provide opportunity for input to future management needs.

Additional monitoring of fish and or water temperatures may be required in response to the needs of Maryland DNR’s Environmental Review Unit.

Table 1. Total numbers of Brown Trout collected from the Russell Road station of the unnamed tributary, 2011 and 2013.

Unnamed Tributary at Russell Road	**2011**	**2013**
Adults	8	2
YOY	17	26

Table 2. Population estimates (Zippin depletion method) for adult and young-of-year (YOY) Brown Trout from the Russell Road station of the unnamed tributary, September 2013.

Unnamed Tributary at Russell Road	**2011**	**2013**
YOY/ha	825±1644	650±59
YOY//km	165±	130±12

Table 3. Species name and relative abundance of fish observed in from the Russell Road station of the unnamed tributary, September 2013.

Common Name	**Scientific Name**	**Relative Abundance**
Tessellated Darter	*Etheostoma olmstedi*	C
Blacknose Dace	*Rhinichthys atratulus*	A
Rosyside Dace	*Clinostomus funduloides*	C
White Sucker	*Catostomus commersonii*	S
American eel	*Anguilla rostrata*	C
Blue Ridge Sculpin	*Cottus caeruleomentum*	A
Creek Chub	*Semotilus atromaculatus*	S
Longnose Dace	*Rhinichthys cataractae*	C

Relative abundance: A=Abundant; C=Common; S=Scarce

Mill Creek and Rock Run
(Cecil County)

Introduction

Cecil County Maryland is home to several wild trout streams, and two stocked (put-and-take) trout streams. All have weathered repeated environmental insults in recent years, including a sediment pond embankment failure on a federally funded supersite, several 100-year floods, a 500-year flood, and the worst recorded drought in Maryland's history. Despite these events, the wild trout populations continue to sustain themselves.

Prior to 2002, only Basin Run and Love Run were classified as use III streams by the Maryland Department of the Environment (MDE). This classification recognizes the self-sustaining trout populations, and protects the stream's water quality by prohibiting any detrimental activities in the watershed. Eastern Regional Staff were able to successfully reclassify Rock Run to Class III in 2002, based on trout population surveys and in-situ stream temperature data. Attempts are being made to re-class Mill Creek, which supports a healthy, but small, wild trout population. Both Mill Creek and Rock Run were sampled in 2013 to verify their wild trout populations.

Methods

Methodology follows that described in the Study III Job 1 Methods section. Only variations from that methodology are described here.

Single-pass electrofishing surveys were conducted in Mill Creek within a 170m station located upstream from Jackson Station Road, and Rock Run within a 200m station located upstream of MD Rt. 222. A two-pass electrofishing survey was attempted in Rock Run, but an equipment malfunction prohibited the second pass from being completed. Therefore, data are presented from pass one only.

Results

Catch results for the two single-pass surveys are included in Table 1. Mill Creek and Rock Run continue to support reproducing populations of Brown Trout. Both streams produced adult and sub-adult trout. Young-of-year (YOY) were collected in Rock Run, but none were collected from Mill Creek in 2013. The presence of multiple cohorts present both streams indicate multiple years of successful reproduction. A fish species list for Mill Creek and Rock Run can be found in Table 2. Species encountered from both streams were very similar.

Recommendations

Wild, reproducing populations of Brown Trout continue to persist in both Mill Creek and Rock Run. Although Rock Run is currently classified as a Use III stream, more efforts should be undertaken to re-classify Mill Creek as well. Intense development pressures are being felt in the watershed and its water quality needs protection now. Both streams are currently managed under "Statewide Regulations" which are 2 trout/angler/day with no gear or bait/lure restrictions. These data suggest that the regulations are sufficient to allow the population to sustain itself.

Table 1. Number of Brown Trout collected during single pass electrofishing surveys from Mill Creek upstream of Jackson Station Road crossing and from Rock Run upstream of Rt. 222 Crossing, 2007-2013. Rock Run was not sampled (NS) in 2009. Neither stream was sampled in 2010 or 2012.

	2007		**2008**		**2009**		**2011**		**2013**	
	Adult	**YOY**	**Adult**	**YOY**	**Adult**	**YOY**	**Adult**	**YOY**	**Adult**	**YOY**
Mill	4	0	3	3	2	0	9	3	3	0
Rock	2	5	10	2	NS	NS	10	0	10	1

Table 2. Species name and relative abundance of fish observed from Mill Creek upstream of Jackson Station Road crossing and from Rock Run upstream of Rt. 222 Crossing, September 2013.

Common	**Scientific**	**Relative Abundance***	
		Mill Creek	**Rock Run**
Northern Hogsucker	*Hypentelium nigricans*		A
Green Sunfish	*Lepomis cyanellus*		S
Tessellated Darter	*Etheostoma olmstedi*	S	C
Blacknose Dace	*Rhinichthys atratulus*	A	A
Rosyside Dace	*Clinostomus funduloides*	A	C
American Eel	*Anguilla rostrata*	S	A
Common Shiner	*Luxilus cornutus*		C
Smallmouth Bass	*Micropterus dolomieu*		S
Creek Chub	*Semotilus atromaculatus*	C	C

Relative abundance: A=Abundant; C=Common; S=Scarce.

ANNUAL PERFORMANCE REPORT
2013

Maryland Department of Natural Resources
Fisheries Service
Inland Fisheries Division

SURVEY AND MANAGEMENT OF FRESHWATER FISHERIES RESOURCES

Management of Maryland's Major Rivers

USFWS Federal Aid Grant F-48-R-23

Study IV

By:

Joshua Henesy
Jody Johnson
Alan Klotz
John Mullican
Susan Rivers
Mark Toms
Kenneth Wampler

Table of Contents
Major Rivers and Streams

North Branch Potomac River D8
    Appendix: North Branch Macroinvertebrate samples D28
Potomac River D32
    Appendix: Potomac River Mainstem Macro Algae Study Methods and Macroinvertebrate Data D53
Monocacy River D61

State: Maryland

Project No.: F-48-R-23
Study No.: IV

Project Title: Survey and Management of Freshwater Fisheries Resources

Study Title: Management of Major Rivers and Streams

Introduction

Timely and accurate assessments of the status of riverine fish populations and their habitat are essential to the development of appropriate management policy and strategies. Scientific information must be continuously updated in order to maintain and enhance existing river fisheries, and develop new angling opportunities. This project provides key information to support the fishery management process for Maryland's major rivers and streams.

These are highly dynamic systems with large annual variations in flow, temperatures and other conditions within a given season. Species responses to these conditions include; variability in yearclass strength of up to several orders of magnitude, annual differences in rates of growth particularly in juveniles, changes in condition and other factors which affect populations and fishing success over multiple years. In recent years fish health and water quality have become a concern, with neighboring states within the Potomac River basin experiencing significant fish kill events. Annual monitoring is required to quickly identify and respond to these changes or trends in populations.

General Methods

Fish Surveys

Black Bass YOY Relative Abundance

The relative abundance of YOY black bass is determined by seining or backpack electrofishing. Electrofishing is generally used when the physical habitat does not permit seining or surveys are specific for black bass species.

Seining

Young-of-year (YOY) fish species were collected using a 9.1 m x 1.2 m, 3.2 mm mesh haul seine. Three locations (general, pool, and riffle) within a station were sampled to account for variable habitats. Smallmouth YOY relative abundance is expressed as the geometric mean YOY per haul. One YOY was added to each haul to compensate for zero values.

Electrofishing

A Smith-Root Model LR-24 backpack electrofisher is used to collect YOY black bass from three 50 m shoreline segments at each sample site. Segments are selected to include all the habitat types present in the river reach to be surveyed (pool, riffle, run, etc.). Sampling begins at the downstream point and proceeds upstream along the shoreline. Electrofishing is most effective using pulsed (120pps) DC current; voltage is adjusted for maximum shocking efficiency; shocking time is automatically recorded. Black bass YOY are held in a bucket until the 50 m segment is completed, measured to the nearest mm, and released. Relative abundance is expressed as the geometric mean number of YOY per 50 m of shoreline sampled and by CPUE60. One YOY is added to each run to account for zero values when computing the geometric mean.

Adult Fish Stocks

Adult fish are collected by electrofishing. On navigable rivers, a commercially-built electrofishing boat manufactured by Smith-Root Inc. equipped with a 7.5 GPP (gas powered pulsator) and outboard jet is used to collect fish during a single-pass at fixed stations. Sample stations are selected to include all the habitat types present in the river reach to be surveyed (pool, riffle, run, etc.) that have a reasonable probability of annual access under low flows. Sampling is conducted during daylight hours during the fall once water temperatures fall below 18.3° C (65° F). Electrofishing is accomplished using pulsed DC current (60 pulses per second or pps); voltage is adjusted for maximum shocking efficiency; shocking time is automatically recorded. Timed runs between 1200 and 1700 seconds are conducted to obtain relative abundance data. Electrofishing begins at the upstream limit of the run and proceeds downstream. Sampling is conducted bank to bank to account for mid-river habitat where depth is generally less than 2.1 m. When depths generally exceed 2.1 m, sampling follows the shoreline. Fish are collected using two netters; fish are held in an on-board, aerated live well, measured to the nearest millimeter, weighed to the nearest gram, and released. GPS coordinates are recorded at both the upstream and downstream limits of each run.

Catch-per-unit-effort ($CPUE_{Hr}$) is used as a measure of relative abundance expressed as the number of fish collected per hour of actual electrofishing time. Evaluation of size structure is made using the concept of proportional stock density (PSD) as proposed by Gablehouse (1984). Lengths and weights of collected fish are used to obtain relative weight (Wr), as described by Wege and Anderson (1978). FAST (Fishery Analysis and Simulation Tools) software (FAST 2005) is used to calculate population parameters.

Benthic Macroinvertebrate Sampling Methods

Benthic macroinvertebrates were collected at each sampling site using 3 – 30 second kicks from riffle areas in depths no greater than 1 m. Sampling began at the downstream end of the reach and proceeds upstream. Using a 600-micron mesh D-net, three kicks were sampled in a riffle or series of riffles of various velocities. (A kick is a stationary sample accomplished by positioning the net and disturbing the bottom directly upstream of the net, using a kicking and stomping motion of the foot, dislodging the upper layer of cobble or gravel and scraping the underlying bed.) The net contents were then placed into a 5 gallon bucket of water. The kicks collected from different locations within the same sample site were combined to form a single aggregate sample. Bucket contents were sieved through a three sieve sorting system, stacked from largest mesh to smallest. U.S. Standard Sieve's were used. Sizes from largest to smallest were: 0.525, 0.0394, and 0.0234 inch mesh. Invertebrates were handpicked in the field from each sieve and preserved in vials containing 70% Isopropyl alcohol. The samples were taken back to lab for identification using Olympus 10x/22 dissecting microscope. Specimens were identified to the lowest taxa possible, based on physical condition and lab equipment available. In areas with little to no riffle habitat, samples were taken where maximum current and cobble substrate existed.

In the past, each site was treated as an individual sample and then grouped according to river section; upper, middle, and lower. The procedures changed in 2012 to analyzing each station individually.

A number of calculations were used to evaluate sample data. The majority of measurements measured tolerance to organic pollution. Diversity and equitability are the exceptions; they measure the stability of the macroinvertebrate population.
The following statistical analyses were used:

Richness = number of species or taxa in sample
Formula s = richness = total number of taxa or species
The following scale is used to rate richness:
greater than 26 – non impacted
19 to 26 – slightly impacted
11 to 18 – moderately impacted
less than 11 – severely impacted

HBI = Hilsenhoff Biotic Index, formula as modified in Bode (1988). Tolerance values were taken from Maryland Biological Stream Survey, 2005. This assigns tolerance values to each species, and the HBI formula calculates a rating value for the whole sample.

Formula: $\sum^{s} (n_t * T_t) / N$
Where s = taxa in sample; N = total number of individuals in sample, or sample size; n_t = number of specimens in each taxa; T_t = tolerance value for this specific taxa

HBI values =	0.00 to 3.50 excellent	No apparent organic pollution
	3.51 to 4.50 very good	Possible slight organic pollution
	4.51 to 5.50 good	Some organic pollution
	5.51 to 6.50 fair	Fairly significant organic pollution
	6.51 to 7.50 fairly poor	Significant organic pollution
	7.51 to 8.50 poor	Very significant organic pollution
	8.51 to 10.00 very poor	Severe organic pollution

Diversity = the dispersion of the specimens among species in the sample. Analysis derived using the Shannon Weiner and Shannon Weaver (USEPA, 1973) formulas for Diversity of individual species.

Formulas:

Shannon Weiner = H' = $\sum$ pi (ln (pi))

Where pi = relative abundance of each group of organisms

Shannon Weaver = d = 3.321928/N (NlogN - $\sum$ (n_i logn_i)

Where N = total number of organisms, n_i = organisms in each taxa. (The Shannon Weaver formula uses base 10 logarithms)

Values above 3.00 indicate undisturbed waters, while those less than 1.00 are severely degraded

Equitability = equitability or evenness indices are calculated using two methods:

1) Results derived from Shannon Weiner (H'), are used as the numerator in the following equation to obtain a comparative analysis amongst the samples (species evenness).

Shannon Weiner Based Equitability Formula: J = H' / H' max

Where H' max = ln S (S = # of species) = the maximum number of species theoretically expected with that diversity

2) There is an established table based on the Mac Arthur broken stick model that establishes a number of species that should be maximal for each given diversity measure (USEPA, 1973) . That number of species, derived using the diversity value from Shannon Weaver (d) is used as the numerator in the following equation to obtain a comparative analysis among the samples (species evenness).

Shannon Weaver Based Equitability Formula: s' / s, where s' is the theoretical richness of species expected with a given diversity; and, s is the actual richness of the sample.

These formulas compare the theoretical number of species associated with each diversity measure to the actual value. Equitability is measured on a scale of 0 to 1. The closer to 1, the closer the sample comes to the theoretical maximum. In general, the higher the equitability value, the healthier the population. However, for samples that contain less than 100 specimens, the equitability values tend to skew too high, so these data should be viewed with caution.

CPOM = those organisms commonly referred to as shredders, processors of coarse particulate organic matter. Measurement is sample count compared to the whole sample. Since shredders tend to be more sensitive organisms, the higher the number, the better.

Formula: Number of shredders / N, where N is the total number of specimens in the sample.

Scraper filterer ratio = is useful in measuring trends from headwaters to mouth in aquatic systems. Scrapers consume unicellular algae by scraping from substrate, while filterers eat filamentous algae by filtering it out of the water column. Unicellular algae are found in more pure, clean water, whereas filamentous algae are typical of nutrient enriched water. This ratio should be a large number in the headwaters and decrease with downstream movement.

Formula: Sc/Fi , where Sc = number of scrapers in sample and Fi = number of filterers

EPT Index Number = number of specimens in orders Ephemeroptera, Plecoptera, and Trichoptera in sample. These specific taxa are indicative of more pristine ecosystems, so the larger the whole number, the healthier the system.
EPT Taxa Rating:

More than 10 - non impacted
6 to 10 – slightly impacted
2 to 5 – moderately impacted
0 to 1 – severely impacted

Dominant Family = percent contribution of the dominant family of the sample. The higher the percentage of dominance, the more disturbed and unbalanced the population.

Abundance of key groups may be provided. The groups used are Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), and Coleoptera (beetles).

Other data provided can include the composition of functional feeding groups.
Feeding groups used are:

Scrapers – herbivores that ingest algae and other materials on the surface of rocks

Collectors – gather particulate and organic matter from surfaces, (these may include detritivores), process fine particulate organic matter

Filterers – filter material from the water column, which can include filamentous algae and detritus

Shredders – shred living dead plant material, herbivores, or detritivores, process coarse particulate organic matter

Predators – prey on living animals

These provide a picture of the function of the food web. All of these groups interact in a healthy system. When one is missing or diminished, the system is impaired.

2013 Federal Aid Annual Report F-48-R-23
Study IV Job 2
North Branch Potomac River
From Jennings Randolph Lake Dam Downstream to Cumberland, MD

Prepared by: Alan Klotz, Western Region 1 Fisheries Manager
Susan Rivers, Aquatic Macroinvertebrate Specialist

Introduction
Water quality in the North Branch Potomac River (NBPR) from Jennings Randolph Lake (JRL) downstream to Cumberland, MD (about 60 km), has been historically impacted by acid mine drainage from abandoned coal mines and industrial pollution. Pollution mitigation efforts by MD DNR Fisheries Service, Maryland Department of the Environment, industry, and the public have been underway for at least three decades. Substantial progress towards improved physical habitat and water quality, enhanced aquatic communities, and sport fishery development in the NBPR has been achieved. However, much work remains in order to develop the full recreational potential of the river.

As part of an ongoing statewide project to establish baseline data characterizing the freshwater fisheries resources of Maryland, Inland Fisheries Service staff initiated a fishery survey in the NBPR from the JRL Dam downstream to Cumberland, MD. The purpose of the work is to describe and monitor the important developing sport fisheries for trout and black bass in order to maintain and enhance recreational fishing opportunities.

Objectives

- Identify and estimate relative abundance of all fish species in the NBPR study area.
- Monitor reproductive success, and estimate population numbers and standing crop for all trout species when practical, or as an alternative, determine relative abundance in areas where habitat and flow conditions prevent conducting depletion-based population estimates.
- Develop indices of size and physical condition of trout.
- Determine relative abundance, and describe the age and size structure, proportional stock density (PSD), relative weight (Wr), reproductive success, and general distribution of black bass in the Catch and Return Black Bass Fishing Area.
- Monitor river temperatures and flows during the critical summer period.
- Monitor the benthic macroinvertebrate communities in the river.

Methods

Fish Population Surveys

Fish populations were surveyed at nine stations in the NBPR during 2013. Sampling station location descriptions are contained in Table 1. Sampling stations were selected to include all the habitat types present in the stream reach to be surveyed (pool, riffle, run, etc.). Fish were collected in Station 2 using a Smith/Root 2.5 GPP, pulsed DC, barge-mounted electro-fishing unit equipped with three anodes. The trout population was estimated using the three pass regression technique described by Zippin (1958). Estimates were calculated using the MICROFISH 2.2 software package (Van Deventer and Platts 1985). A Model LR-24 Smith-Root backpack electro-fisher was used to sample shallow riffle areas for black bass reproductive success indices and fish species relative abundance at Stations 6, 6B, 7, 8, and 9. A 16-foot Cataraft inflatable boat equipped with a Smith/Root 2.5 kilowatt, pulsed DC electro-fishing unit was used to collect fish in Stations 5A, 6A, and 7A where the physical size of the NBPR precludes depletion derived population estimates. The Cataraft was operated using five personnel: an individual at the oars, a worker operating the anode petal, and three persons with dip nets collecting fish. Electro-fishing effort (seconds) was recorded to obtain a measure of relative abundance (catch per unit effort) for all fish species. General abundance occurrence was derived from sample size and fish were rated as abundant (>100 individuals), common (5-100 individuals), or scarce (< 5 individuals). Smallmouth Bass reproductive indices were reported as the number of young of year (YOY) per 50 m of shoreline.

At all sampling stations, trout and black bass were anesthetized, identified to the species level, measured for total length to the nearest millimeter, weighed to the nearest gram, and returned alive to the stream. The coefficient of condition (K) described by Lagler (1956) was used as a measure of fish condition for trout. Growth histories were determined by length frequency distribution or otolith reading. Proportional stock density (PSD) and relative stock density (RSD) for black bass were calculated using methods described by Anderson (1980). Confidence intervals for PSD and RSD values were calculated using the formula described by Gustafson (1988). Relative weight (Wr), a measure of fish condition, was calculated using the methods described by Wege and Anderson (1978) for Smallmouth Bass.

Temperature

NBPR water temperatures were monitored in the area of the river from Westernport downstream to Pinto, MD to evaluate coldwater fisheries potential. Temperatures were recorded using Onset StowAway® temperature loggers at one hour intervals.

Benthic Macroinvertebrates

Benthic macroinvertebrate surveys in the NBPR sample stations (1, 2, 4, and 6) were conducted in August and October 2013. Benthic macroinvertebrates were collected using a kick net (six 30 second kicks) at each sample station. The samples were collected from a variety of stream habitats, including riffle areas and pools within each station. The samples were placed in a labeled sample bottle and preserved with 70% isopropyl alcohol. In the lab, the samples were poured into a white tray and all macroinvertebrates were picked from the detritus and placed in a sample bottle containing 70% isopropyl alcohol. The macroinvertebrates were identified to the lowest practical taxon (Merritt and Cummins 1996; Pennak 1978; Stewart and Stark 1988; Wiggins 1977) and population indices were calculated using the methods utilized by the Maryland Department of Natural Resource's Inland Fisheries Division described by MD DNR (2004) and from the Maryland Biological Stream Survey (Southerland et al. 2005). Results are shown in the Appendix of this report.

Results

Fish Population Community
A list of common and scientific names of the 25 fish species collected in the NBPR during 2013 is contained in Table 2. Relative abundance or general occurrence for each fish species by station is presented in Table 3. The fish assemblage within the study area of the river is representative of a coldwater community beginning at Station 2, and transitions into a coolwater/warmwater community by Station 9 (Steiner 2000).

Catch and Return Trout Fishing Area
Station 2 is located within the upper C&R TFA of the NBPR. Two trout species were collected in relatively low abundance within this station during 2013 (Table 3). The mean condition factor for Rainbow Trout *Oncorhynchus mykiss* (n = 8) and Brown Trout *Salmo trutta* (n = 7) was within the optimal range (Table 4). Rainbow trout comprised about 54% of the density and 80% of the combined species standing crop (Table 5). Brown trout accounted for 46% of the density and 20% of the standing crop. The length frequency distribution of Rainbow Trout showed older, larger fish comprising the low density population. Brown Trout within this station shows that the size structure is characterized by multiple age classes from YOY to quality sized trout > 300 mm (Figure 1). The NBPR supports natural reproduction of Brook Trout, Brown Trout, and Rainbow Trout, but supplemental adult and fingerling stockings are essential to support an adequate population to sustain a high angler-use recreational fishery. Adult Rainbow Trout (1,640) and fingerling Brown Trout (5,000) were stocked within the upper C&R TFA during 2013 (Table 6). No hatchery trout were stocked in the lower C&R TFA because the fishery is supported by natural reproduction. The Put and Take Trout Fishing Areas at Barnum and Westernport received more than 12,000 adult trout to provide recreational trout fishing opportunities (Table 6). During the 2013 fall sampling date, a heavy bloom of the invasive diatom *Didymosphenia geminata* (aka Didymo) was observed covering the river's substrate.

The adult combined trout species densities and standing crops from 2001 to 2013 have been variable in the upper C&R TFA; however long-term data suggests a declining trout population as shown in Figures 2 and 3. The 2013 estimated combined trout species densities and standing crops are at the lowest levels observed during the last 13 years.

Zero Creel Limit Trout Fishing Area (ZCL TFA)
The NBPR's Zero Creel Limit Trout Fishing Area (ZCL TFA) was surveyed throughout its 29 km management length (Westernport to Pinto) during 2013. The Westernport to McCoole section (Station 5A) contained the highest trout abundance for both Rainbow Trout and Brown Trout with catch per unit effort (CPUE) of 73 Rainbow Trout per hour and 22 Brown Trout per hour (Table 3). Both Rainbow Trout and Brown Trout abundance decreased in the NBPR ZCL downstream of McCoole in 2013. Table 3 shows the CPUE of Rainbow Trout in the McCoole/Black Oak section (Station 6A) was 16/hr and 2/hr for Brown Trout. Station 7A – the Black Oak to Pinto section of the river generally has low trout abundance, with Rainbow Trout abundance at 5/hr and Brown Trout abundance at 1/hr in 2013.

Both trout species exhibited optimal body condition (Table 6). Length frequency distributions of trout collected in all ZCL stations are presented in Figures 4 and 5. The Rainbow Trout population is characterized by having good numbers of intermediate sized fish < 300 mm, abundant quality sized fish > 300 mm, with few trophy fish > 400 mm (Figure 4). The Brown Trout population however is dominated by larger fish > 400 mm (Figure 5).

Fingerling Brown Trout and Rainbow Trout were stocked in the ZCL TFA during 2013 to support the fishery (Table 6). A total of 114,852 fingerling Rainbow Trout and 18,200 fingerling Brown Trout were stocked in the ZCL TFA during 2013.

Temperature Monitoring
Temperatures recorded in the NBPR from Westernport downstream to Pinto during summer 2013 are presented in Figures 6 – 9. Temperatures were low enough to support trout in the entire ZCL TFA throughout the critical summer period. Temperatures within the ZCL TFA stations did not exceed the management recommendation of 25° C during the critical summer period when flows were generally greater than 250 cfs measured in the NBPR at Luke, MD. The daily mean flow was 494 cfs during this time period (Figure 10).

Catch and Return Black Bass Fishing Area (C&R BFA)
The 40 km river stretch between Keyser, WV and Cumberland, MD is managed as a Catch and Return Bass Fishing Area (C&R BFA). This special management area supports a Smallmouth Bass population characterized by a diverse size structure, with size classes within the 150 mm – 250 mm dominating the population in 2013 (Figure 11). The PSD_{28} and RSD_{35} values for Smallmouth Bass during 2013 (Table 8) were less than the values indicative of a balanced population (Anderson and Weithman 1978). Quality ($\geq$ 280 mm) and preferred size ($\geq$ 350 mm) Smallmouth Bass were represented in the population in low numbers. Relative weights (Wrs) for stock were within the 95 to 100% range of good condition while quality and preferred size less than that range described by Wege and Anderson (1978). Smallmouth Bass reproduction was documented within the entire C&R BFA, with an average of 2.5 YOY per 50 m of shoreline.

Discussion

Natural reproduction and multiple year-classes of Brook Trout, Brown Trout, and Rainbow Trout have been documented within the NBPR since trout population surveys began in the early 1990's. Whirling disease (*Myxobolus cerebralis*) was diagnosed in free ranging Rainbow Trout in the NBPR upper C&R TFA in 2006. Subsequent use of caged Rainbow Trout fry in the river during 2012 showed that the fry became infected with the parasite in the upper C&R TFA. Tests for sentinel Rainbow Trout fry placed in the river within the lower C&R TFA, P&T TFA at Westernport, and the ZCL TFA at the McCoole FMA tested negative in 2012. The presence of *Myxobolus cerebralis* in the NBPR may limit trout survival, especially in newly hatched fry and spring fingerling stocked trout. In order to continue to provide fishing opportunities in the upper C&R TFA, MD DNR will focus on stocking the whirling disease resistant Brown Trout fingerlings as well as adult Rainbow Trout and Brown Trout to supplement the fishery. The lower C&R TFA, however, seems to be supporting a quality wild Rainbow Trout, Brown Trout and Brook Trout fishery, so no hatchery introductions were made during 2013 in this management area.

Currently, annual trout survival is variable within Zero Creel Limit Trout Management Area due to increased water temperatures during periods of low flow (< 300 cfs) and high ambient air temperatures. Water temperature monitoring results from 2007-2013 suggest that when releases from the Savage River Reservoir and JRL total ≥ 250 cubic feet/second, water temperature at Pinto, the downstream extent of the ZCL TFA, will remain within a thermal range that will support trout management. The economic value of the NBPR's fisheries was recently estimated at nearly $2 million per year (Hanson et al 2010). The wild and put and grow naturalized trout fishery is the major contributor. Therefore, MD DNR will continue to hold discussions with the USACE and other user groups within the North Branch Advisory Group to pursue a flow regime which will protect this fishery. A flow and temperature model for the critical summer period may be necessary to achieve this objective. MD DNR Fisheries Service currently is conducting temperature modeling which will provide guidance in protecting the tailwater trout fishery. This is in accordance with the recent letter from The Greater Cumberland Commission asking that the USACE recognize the importance of this fishery and give it greater protection from high water temperatures by adjusting discharge from Jennings Randolph Reservoir.

In response to water quality improvements in the NBPR, MD DNR Inland Fisheries Service initiated a fingerling black bass stocking program in the NBPR from 1993 through 1997 with the objective of establishing naturally reproducing black bass population in the NBPR. MD DNR Inland Fisheries Service designated the 40.2 km portion of the NBPR between Keyser and Cumberland as a Catch and Return Bass Fishing Area effective January 2001. This black bass fishery is now well established, with the 2013 YOY survey results showing the sixteenth year of successful reproduction by Smallmouth Bass.

Management Recommendations

Recommended studies for 2014 include:

- Continue to monitor for the presence of whirling disease throughout the NBPR trout management areas.
- Trout population surveys in the upper C&R TFA should continue in order to monitor the effects of special fishing regulations and water quality enhancements. Coordination of sampling efforts with the USACE will be necessary to arrange for reduced flow levels from JRL Dam. Discharge rates of about 100 cfs during stream surveys will ensure safe wading conditions and efficient sampling during early fall 2014.
- Trout population surveys should continue in the ZCL TFA to evaluate the status of trout populations. Surveys should take place in late spring when river flows are adequate (> 300 cfs) to allow the use of the Cataraft electrofishing unit.
- Fingerling trout stockings should continue in NBPR C&R TFAs (7.3 km) at a suggested rate of 22,500 Brown Trout fingerlings and 2,000 adult Rainbow Trout annually. About 10,000 adult Brown Trout and Rainbow Trout should continue to be stocked in the Put and Take Trout Fishing Areas. A commitment of at least 45,000 Brown Trout and 45,000 Rainbow Trout fingerlings annually should be dedicated for the 29 km ZCL TFA of the NBPR.
- Monitoring efforts in the C&R BFA should be continued to describe age and size structure, physical condition, reproductive success, and distribution of Smallmouth Bass.
- Continue temperature monitoring in order to develop a temperature and flow model that would assist resource manager in protection and enhancement of the NBPR’s recreational trout fisheries.

Table 1. North Branch Potomac River sample station locations, 2013*.

Station	Description	Km downstream of JRL Dam
1 – Tailrace – Natural Propagation Area*	Beginning at a point 123 m downstream from the confluence of the Tailrace and the old river channel and ending 60 m upstream of that confluence	0
2 - Upper Catch and Return Trout Fishing Area	Beginning at a point .4 km upstream of the first power line and ending 183 m upstream.	1.3
3 – Barnum, Put and Take Trout Fishing Area*	Beginning at the second bridge abutments in Barnum, WV, and ending 183 m upstream.	1.9
4 - Lower Catch and Return Trout Fishing Area*	Beginning at the whitewater take-out downstream of Warnicks, and ending 183 m upstream.	8.1
5 – Piedmont, Put and Take Trout Fishing Area*	Beginning 60 m upstream of the UPRCWTP and ending 183 m upstream. Within the plume of Georges Creek.	15.3
5A Piedmont/McCoole	Beginning at the mouth of Georges Creek downstream to the McCoole boat launch	15.3 – 24.4
6 –McCoole, Zero Creel Limit Trout Fishing Area	Beginning at the boating access area on the former Landis property and ending about 183 meters upstream.	24.4
6A – McCoole/Black Oak	Beginning at the McCoole boat launch downstream to the Black Oak boat launch	24.4 – 33.0
6B – Keyser	Beginning 183 meters downstream of the Rt. 220 Bridge and ending at the bridge.	27.0
7 – Black Oak, 0 Creel Trout; Catch and Return Bass	Beginning at the MD DNR boating access and ending about 183 meters upstream	33.0
7A – Black Oak to Pinto	Beginning at the MD DNR Boating access and ending at the Twigg Property in Pinto	33.0 – 50.3
8 – Pinto, Catch and Return Bass Fishing Area	Beginning at the Western MD Railroad bridge on the Charles Twigg property near Pinto, MD, and ending about 300 m upstream.	50.3
8A – Pinto to Cumberland*	Beginning on the Twigg property downstream to the Cumberland Fairgrounds boat launch	50.3 – 60.0
9 – Cumberland Fairgrounds	Beginning at the Cumberland Fairground boat ramp and ending about 300 m upstream	60.0

* Not sampled during 2013.

Table 2. List of common and scientific names of fish collected in the North Branch Potomac River from Jennings Randolph Lake Dam downstream to Cumberland, MD, 2013.

Common name	**Scientific name**
Central Stoneroller	*Campostoma anomalum*
Cutlips Minnow	*Exoglossum maxillingua*
Common Shiner	*Luxilus cornutus*
Spottail Shiner	*Notropis hudsonius*
Bluntnose Minnow	*Pimephales notatus*
Blacknose Dace	*Rhinichthys atratulus*
Longnose Dace	*Rhinichthys cataractae*
Creek Chub	*Semotilus atromaculatus*
Fallfish	*Semotilus corporalis*
White Sucker	*Catostomus commersonii*
Northern Hogsucker	*Hypentelium nigricans*
Yellow Bullhead	*Ameiurus natalis*
Rainbow Trout	*Oncorhynchus mykiss*
Brown Trout	*Salmo trutta*
Brook Trout	*Salvelinus fontinalis*
Blue Ridge Sculpin	*Cottus caeruleomentum*
Rock Bass	*Ambloplites rupestris*
Redbreast Sunfish	*Lepomis auritus*
Green Sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth Bass	*Micropterus dolomieu*
Fantail Darter	*Etheostoma flabellare*
Tessellated Darter	*Etheostoma olmstedi*
Walleye	*Sander vitreus*
Total species = 25	

Table 3. Fish species relative abundance (CPUE fish/hr or general occurrence*) in North Branch Potomac River sampling stations, 2013.

Common name	**2**	**5A**	**6**	**6A**	**6B**	**7**	**7A**	**8**	**9**
Central Stoneroller		C							
Cutlips Minnow			45		50	12		4	
Common Shiner							C		4
Spottail Shiner						4		4	
Bluntnose Minnow			78		50			134	155
Blacknose Dace			22			8		4	
Longnose Dace	C	C	745	C	100	4	C	7	4
Creek Chub									
Fallfish		C		A			A		
White Sucker		A	7	A	4		A		
Northern Hogsucker		A		A			A		
Yellow Bullhead				S	8	8		4	
Rainbow Trout	11	73		16			5		
Brown Trout	10	22		2	4		1		
Brook Trout				< 1					
Blue Ridge Sculpin		C		C					
Rock Bass		C		C	4	33	C	83	50
Redbreast Sunfish				C	4		4	72	8
Green Sunfish						17			
Pumpkinseed									4
Bluegill					17				4
Smallmouth Bass		29	26	30	4	12	55	43	66
Fantail Darter			67		29	8		29	
Tessellated Darter			15		8	4		4	8
Walleye				< 1					
Species Richness =	**3**	**10**	**8**	**13**	**12**	**10**	**10**	**11**	**9**

* A = abundant (>100 individuals); C =common (5-100 individuals); S = scarce (< 5 individuals).

Table 4. Mean total length, weight, and condition factor (K) with ranges for Rainbow Trout and Brown Trout in North Branch Potomac River upper Catch and Return Trout Fishing Area, 2013.

Species	n	TL (mm)	W(g)	K
Rainbow Trout	8	367 (294-510)	536 (236-1116)	0.98 (0.77-1.14)
Brown Trout	7	228 (135-330)	158 (24-354)	1.03 (0.94-1.17)

Table 5. Trout population densities and standing crops (with 95% CI) in the North Branch Potomac River upper Catch and Return Trout Fishing Area, 2013.

Species	Trout/Km	Kg/Ha
Combined species	82 $\pm$ 10	15 $\pm$ 2
Rainbow Trout	44 $\pm$ 5	12 $\pm$ 1
Brown Trout	38 $\pm$ 12	3 $\pm$ 1

Table 6. Mean total length, weight, and condition factor (K) with ranges for Rainbow trout and Brown trout in the North Branch Potomac River Zero Creel Limit Trout Fishing Area, 2013.

Species	n	TL (mm)	W(g)	K
Rainbow Trout	127	268 (106-410)	244(10-566)	1.08(0.75-1.39)
Brown Trout	27	370 (185-570)	644(72-1390)	1.02(0.69-1.25)

Table 7. Fish stocking record for the North Branch Potomac River downstream of Jennings Randolph Lake, 2013.

Date	Species	Number	Size	Area stocked	Source
2/12	Rainbow Trout	58,307	110/lb	NBPR ZCL	Spring Run Hatchery. Petersburg, WV
4/16	Brown Trout	15,000	67/lb	NBPR ZCL	Cushwa
4/16	Brown Trout	5,000	67/lb	NBPR Upper C&R	Cushwa
5/14	Rainbow Trout	28,500	62/lb	NBPR ZCL	APH
6/14	Rainbow Trout	14,185	11.85/lb	NBPR ZCL	Petersburg, WV
7/24	Rainbow Trout Shasta	13,860	55/lb	NBPR ZCL	APH
8/7	Rainbow / Golden Trout	140	3 lb each	NBPR Upper C&R	Petersburg, WV
9/3	Rainbow Trout	1,000	2.4/lb	NBPR Upper C&R	Freshwater Inst.
10/8	Rainbow Trout	500	2/lb	NBPR Upper C&R	Freshwater Inst.
11/19	Brown Trout	3,200	4/lb	NBPR ZCL	Cushwa
Spring	Rainbow Trout	10,600	2/lb	P&T Areas	APH, Bear Creek, Freshwater Inst.
Fall	Rainbow Trout	1,600	2/lb	P&T Areas	Freshwater Inst.

Table 8. Summary of Smallmouth Bass size, condition, and reproductive indices in the North Branch Potomac River Catch and Return Bass Fishing Area, 2013.

Indices	Value	n
Wr Overall (> 180 mm)	91.3 %	172
Wr Stock (180 – 279 mm)	91.8 %	156
Wr Quality (280 - 349 mm)	88.2 %	12
Wr Preferred (350 - 429 mm)	82.8%	4
PSD_{28}	8 $\pm$ 5%	172
RSD_{35}	2 $\pm$ 3%	172
YOY/50 m	2.5	38

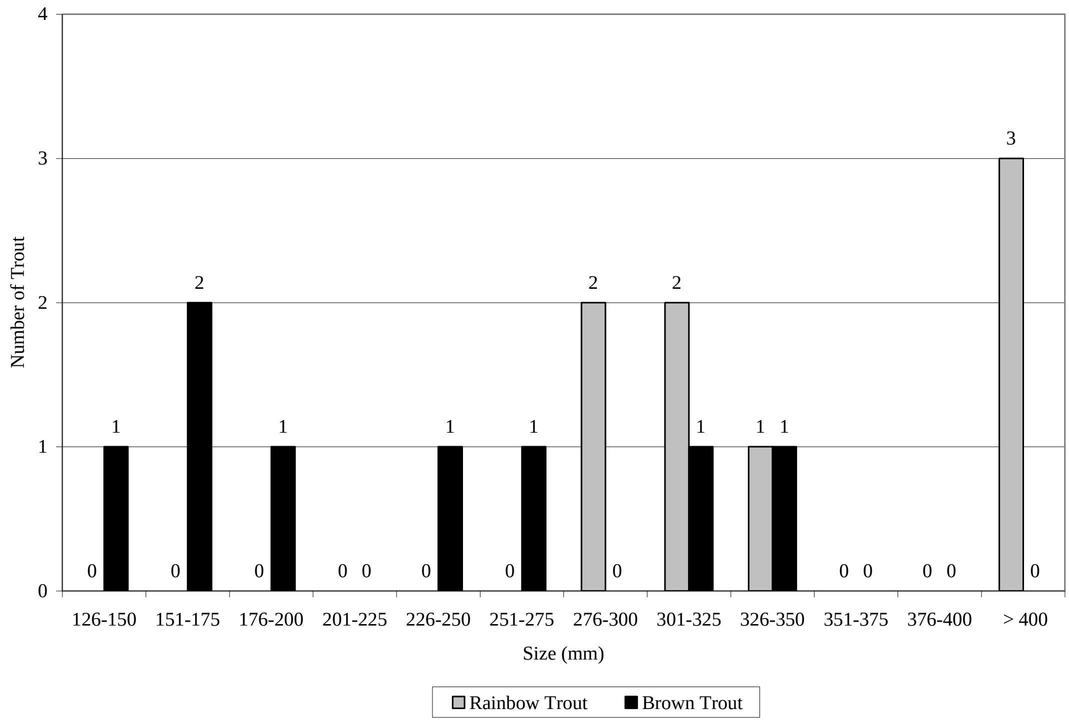


Figure 1. Length frequency distribution of Rainbow Trout (n=8) and Brown Trout (n=7) in the upper Catch and Return Trout Fishing Area of the North Branch Potomac River, September 2013.

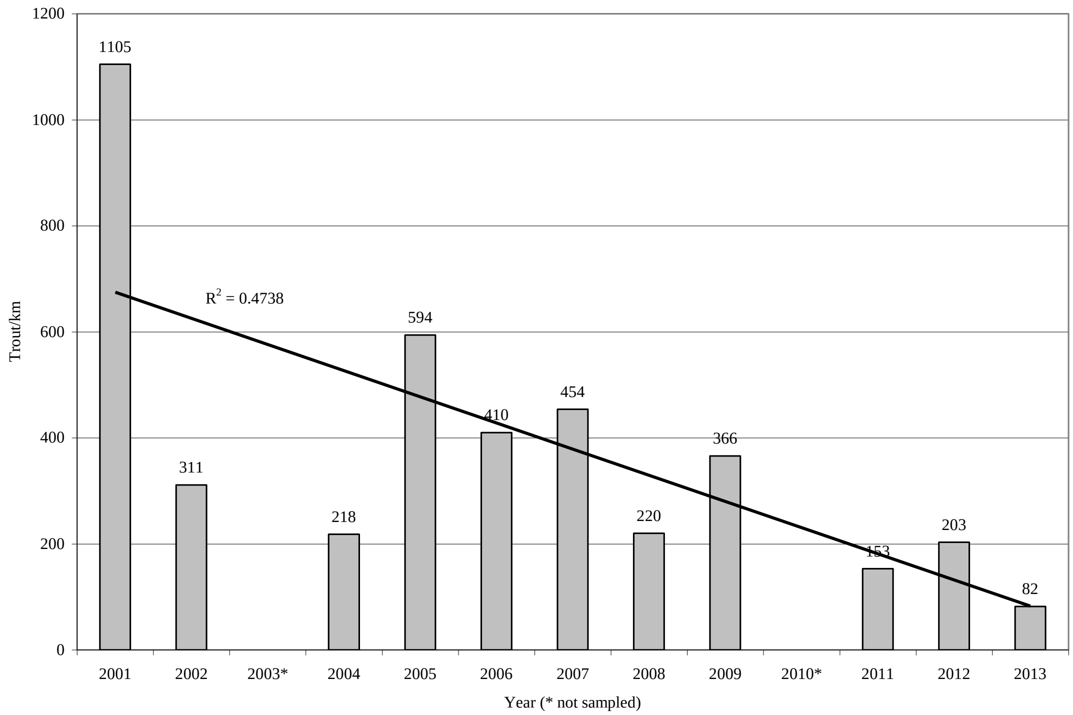


Figure 2. Adult combined trout species density (Trout/km) in the North Branch Potomac River upper Catch and Return Trout Fishing Area, 2001 – 2013.

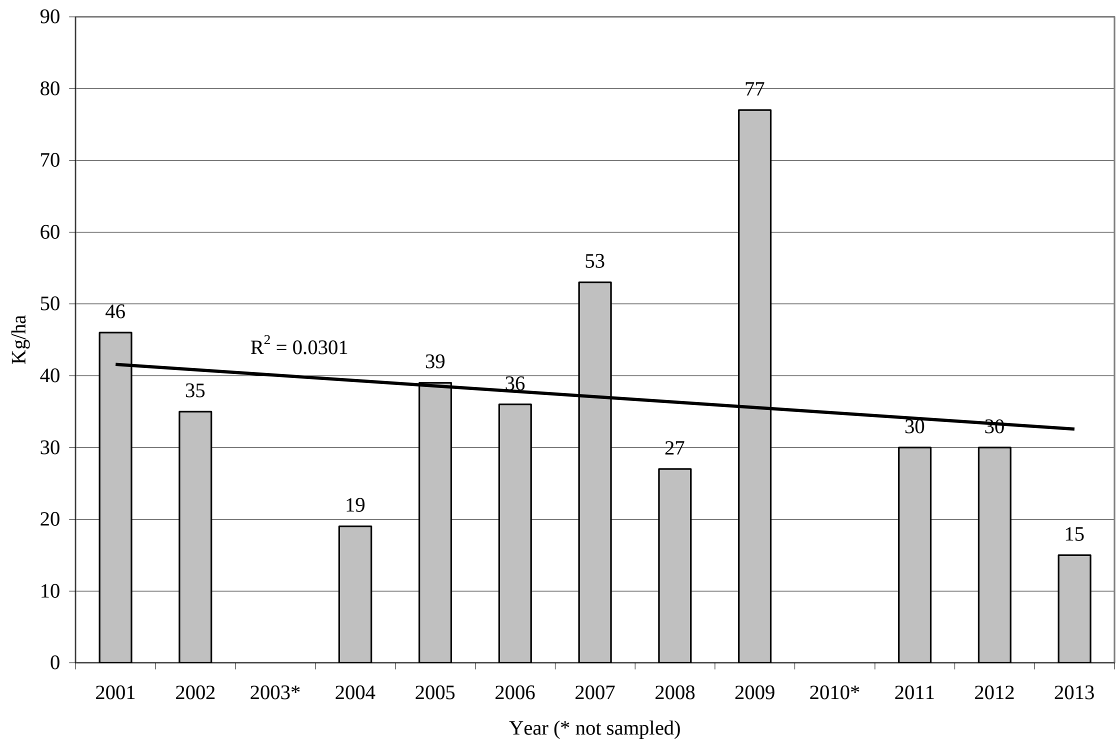


Figure 3. Adult combined trout species standing crop (kg/ha) in the North Branch Potomac River upper Catch and Return Trout Fishing Area, 2001 – 2013.

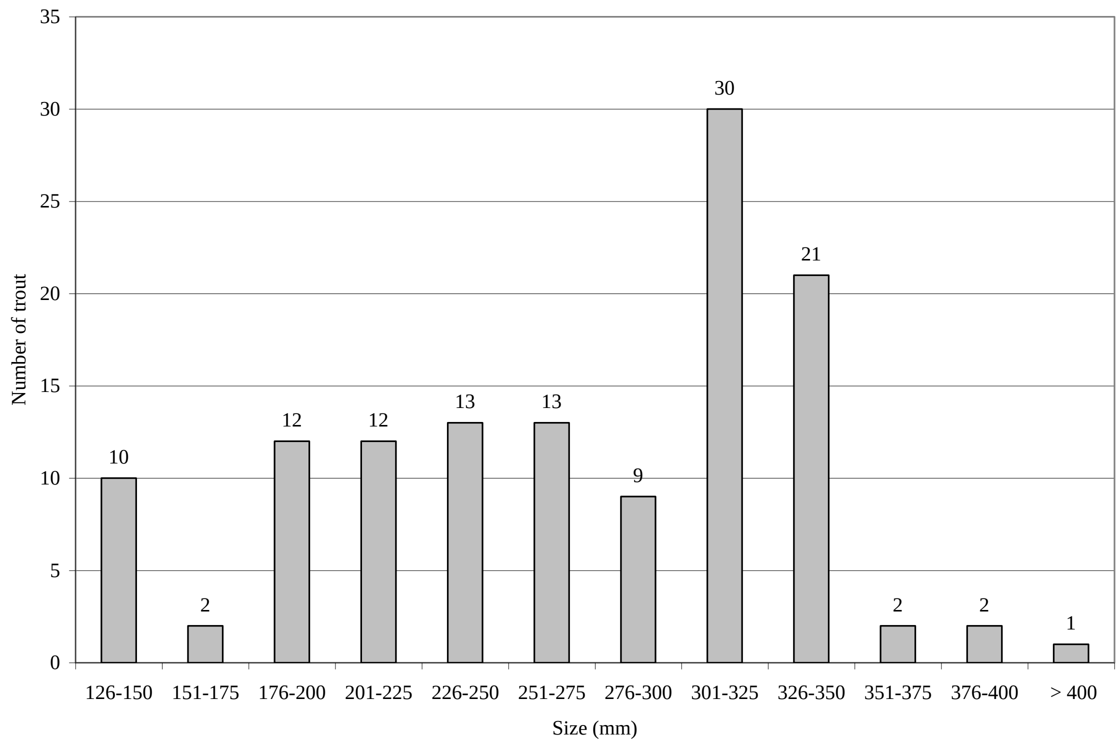


Figure 4. Length frequency distribution of Rainbow Trout (n = 127) in the North Branch Potomac River Zero Creel Limit Trout Fishing Area, June 2013.

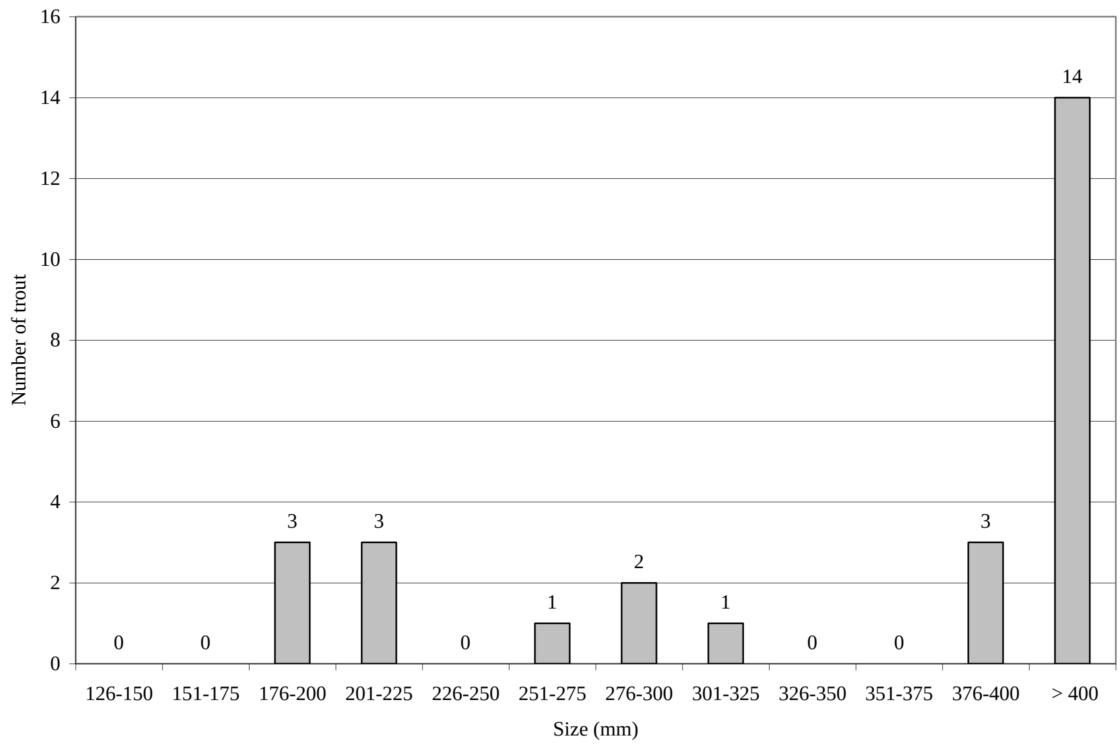


Figure 5. Length frequency distribution of Brown Trout (n = 27) in the North Branch Potomac River Zero Creel Limit Trout Fishing Area, June 2013.

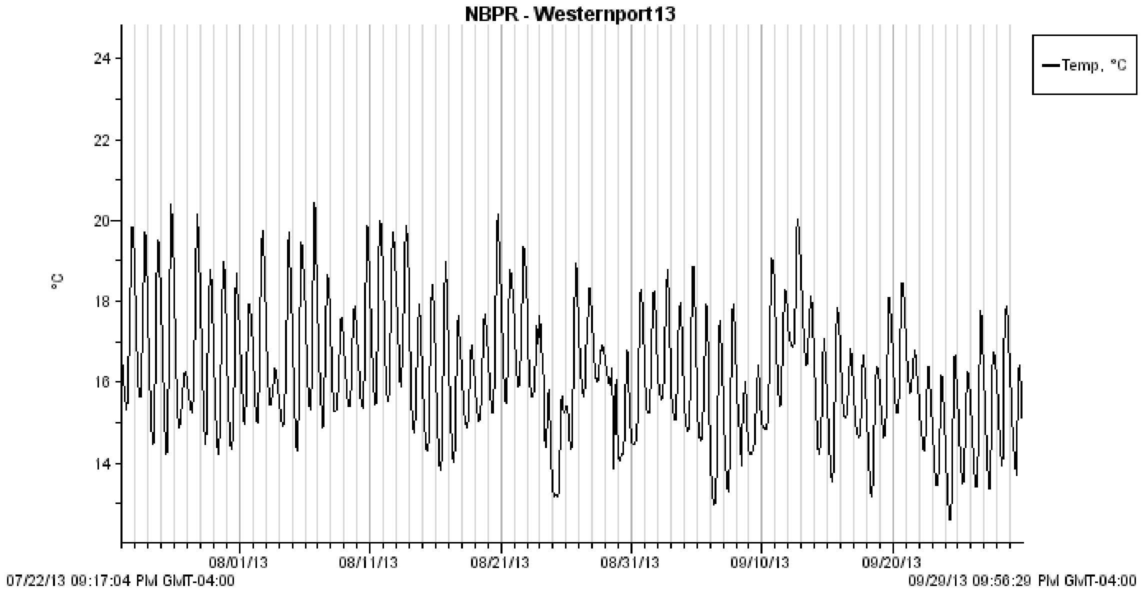


Figure 6. Temperatures recorded in the North Branch Potomac River at Westernport Put and Take Trout Fishing Area, 2013.

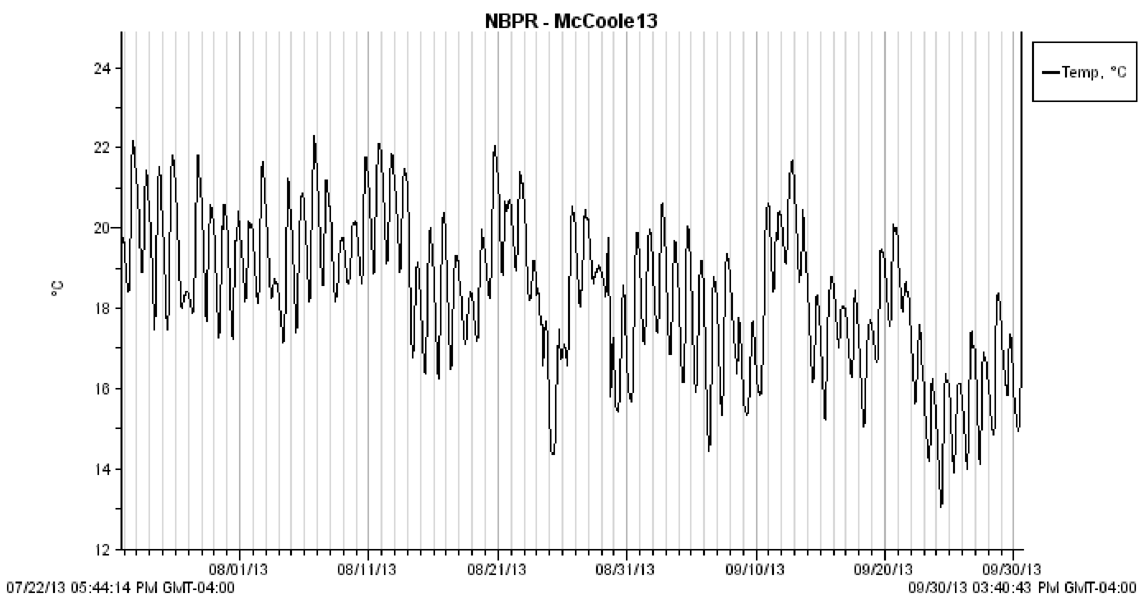


Figure 7. Temperatures recorded in the North Branch Potomac River within the Zero Creel Limit Trout Fishing Area at McCoole Fisheries Management Area, 2013.

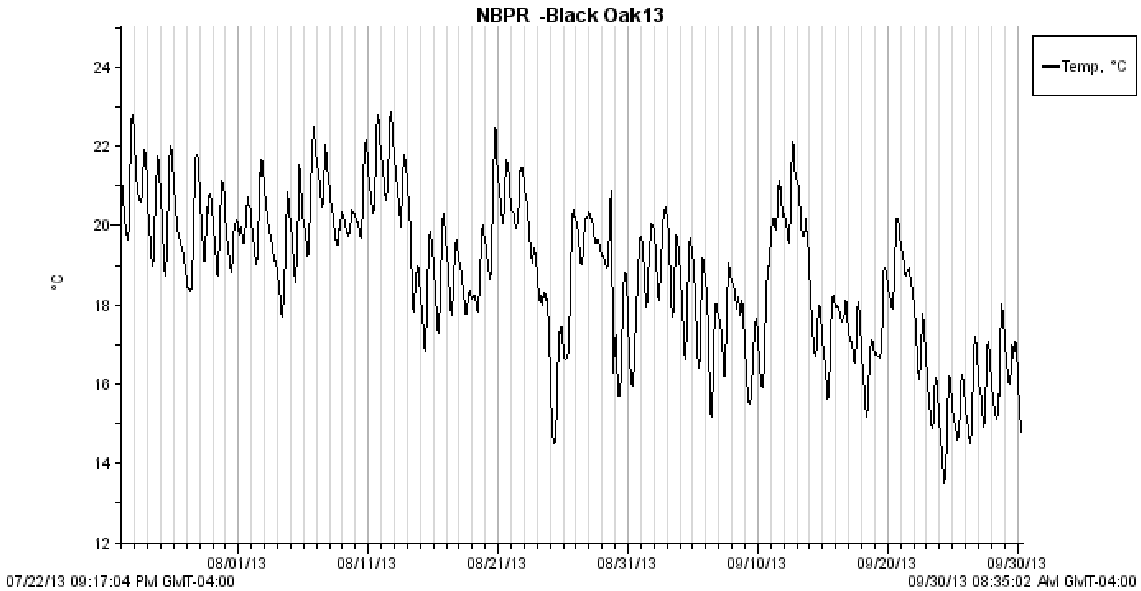


Figure 8. Temperatures recorded in the North Branch Potomac River within the Zero Creel Limit Trout Fishing Area at the Gary Yoder Fisheries Management Area, 2013.

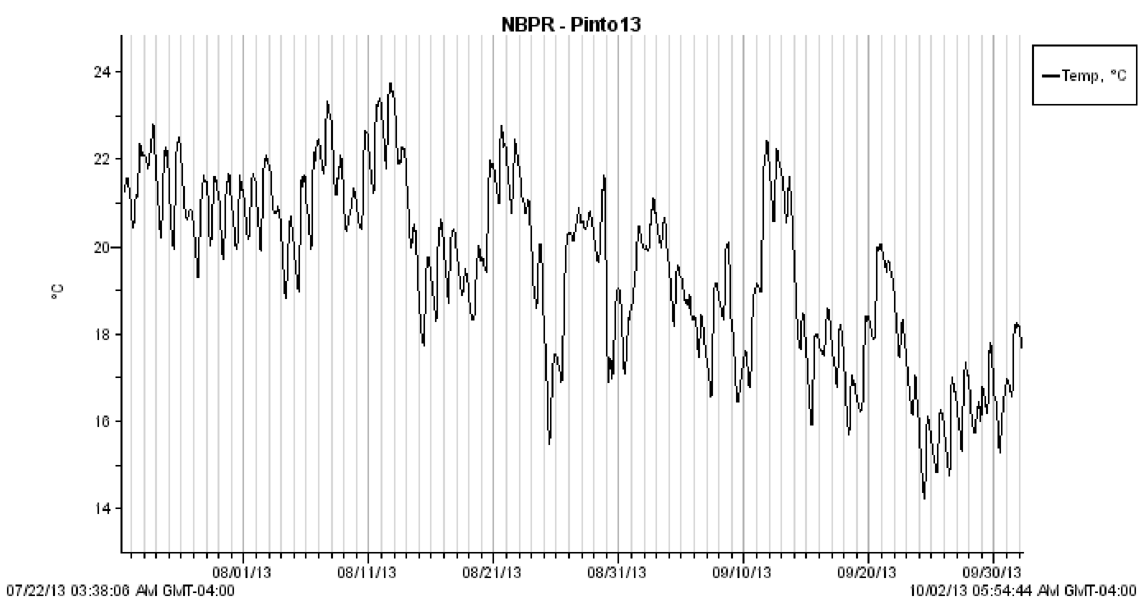


Figure 9. Temperatures recorded in the North Branch Potomac River at the lower boundary of the Zero Creel Limit Trout Fishing Area (Pinto), 2013.

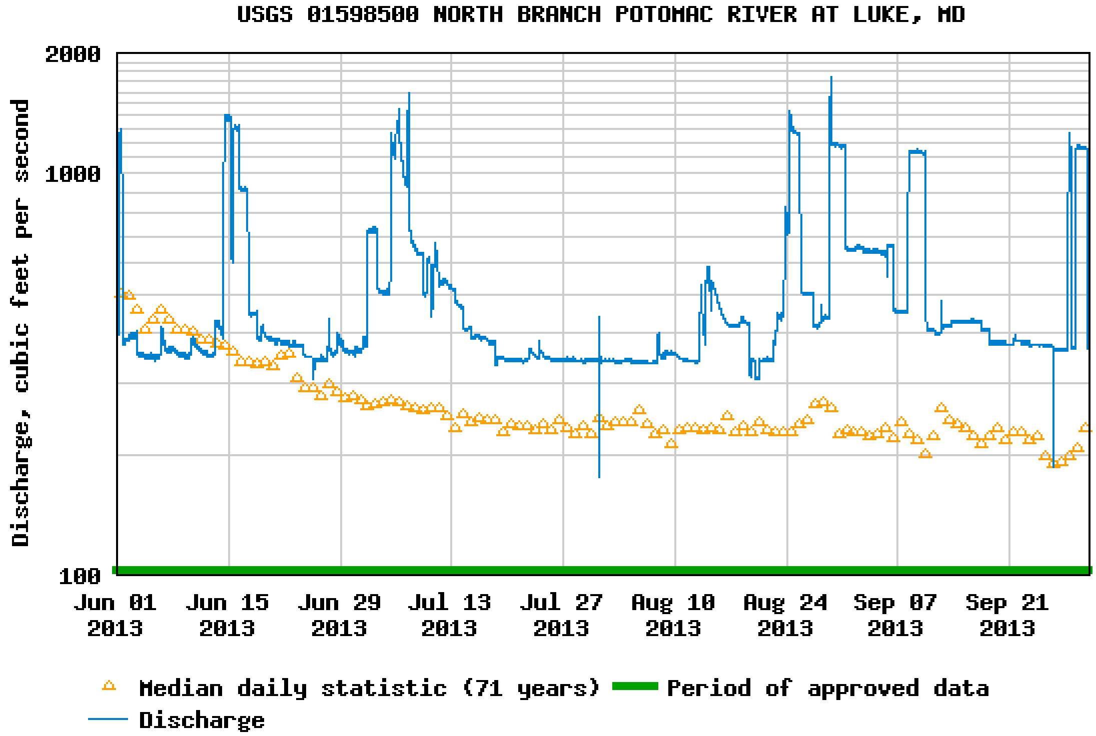


Figure 10. Flows recorded in the North Branch Potomac River at Luke, MD, June through September 2013.

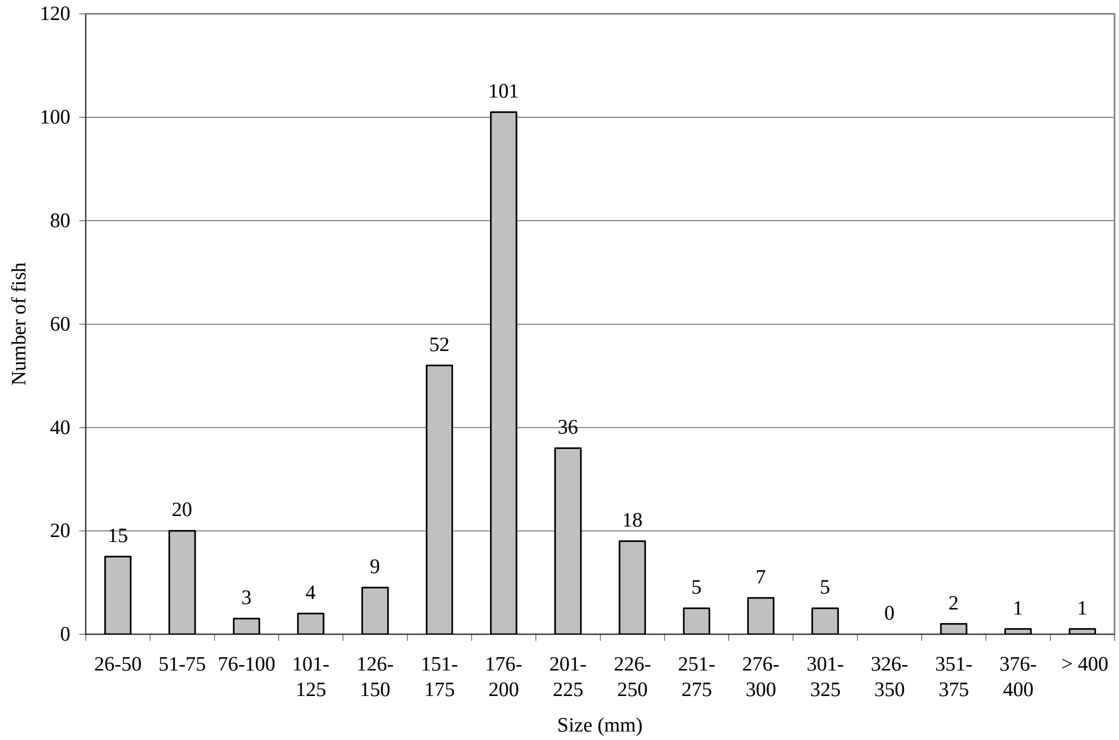


Figure 11. Length frequency distribution of Smallmouth Bass (n = 279) in the North Branch Potomac River Catch and Return Bass Fishing Area, 2013.

Appendix: NORTH BRANCH POTOMAC RIVER MACROINVERTEBRATE SAMPLES - 2013

Sampling was conducted at these stations on the North Branch of the Potomac River in order to rate the impacts of the invasive diatom *Didymosphenia geminata* on the macroinvertebrate populations in the river. Data from these samples were compared with historical data.

The comparisons showed that data from the Station 1 (Tailrace), Station 2 (Upper Catch and Return Trout Fishing Area), and Station 4 (Lower Catch and Return Trout Fishing Area) stations had higher IBI scores than those readings from previous years. Other data measures were comparable with historical data. The McCoole station (Station 6) was new, so there were no historical data to rate the impacts on this station.

The "Didymo" infestation in the river is still relatively new, so the macroinvertebrate populations will be monitored to determine whether impacts occur in the future.

Station 1 - NBPR Tailrace 6-30 sec kicks August 27, 2013					
Order	**Family/genus**	**Count**	**Tolerance**	**Feeding**	**Life habit**
Ephemeroptera	Baetis sp	10	3.9	Collector	Sw
	Paraleptophlebia sp.	1	2	Collector	Sw
	Pseudocloeon sp. (=Acentrella sp.)	14	4.9	Collector	Sw
Plecoptera	Leuctra sp.	5	0.4	Shredder	Cn
Trichoptera	Cheumatopsyche sp	28	6.5	Filterer	Cn
	Diplectrona sp	13	2.7	Filterer	Cn
	Hydropsyche sp.	58	7.5	Filterer	Cn
	Rhyacophila sp	1	2.1	Predator	Cn
	Unidentified Hydropsychidae.	46	5.7	Filterer	Cn
Diptera	Chironomidae - SF Chironominae	195	6.6	Collector	
	SF Tanypodinae	2	7.5	Predator	
	TR Tanytarsini	4	3.5	Collector	
	Empididae - unidentified	3	7.5	Predator	Sp
	Simuliidae – Simulium sp	1	5.7	Filterer	Cn
	Tipulidae - Hexatoma sp	1	1.5	Predator	Bu
Isopoda	Asellus sp. (=Caecidotea)	10	2.6	Collector	Sp
Amphipoda	Gammarus sp.	128	6.7	Shredder	Sp
		S = 17 N = 520			

Fisheries Data	**MBSS Data – Combined Highlands**
Richness = 17	Number of Taxa = 17 (3)
HBI = 6.26	Number of EPT taxa = 9 (3)
Scraper filterer ratio = 0	Number of Ephemeroptera taxa = 3 (3)
EPT = # 176 Taxa 9	% intolerant urban = 6 (1)
EPT/C = 0.88	% Tanytarsini = 0.7 (3)
Dominant family = 38.6% Chironomidae	% Scrapers = 0 (1)
CPOM = 0.26	% Swimmers = 4.8 (3)
Diversity = 2.67	% Diptera = 39.6 (3)
Equitability = 0.52	IBI = 2.5 poor

Station 2 - NBPR Upper Catch and Return Trout Fishing Area 6-30 sec kicks Aug 27, 2013					
Order	**Family/genus**	**Count**	**Tolerance**	**Feeding**	**Life habit**
Ephemeroptera	Baetis sp	10	3.9	Collector	Sw
	Paraleptophlebia sp.	5	2	Collector	Sw
	Pseudocloeon sp. (=Acentrella sp.)	14	4.9	Collector	Sw
	Stenacron sp	2	2	Collector	Cn
	Stenonema sp.	4	4.6	Scraper	Cn
Plecoptera	Leuctra sp.	10	0.4	Shredder	Cn
Trichoptera	Cheumatopsyche sp	5	6.5	Filterer	Cn
	Dibusa sp (Unid Hydroptilidae)	1	4	Scraper	Cn
	Diplectrona sp	3	2.7	Filterer	Cn
	Hydropsyche sp.	8	7.5	Filterer	Cn
	Unidentified Hydropsychidae	3	5.7	Filterer	Cn
	Rhyacophila sp	9	2.1	Predator	Cn
Diptera	Chironomidae - SF Chironominae	110	6.6	Collector	
	SF Orthocladiinae	2	7.6	Collector	
	SF Tanypodinae	18	7.5	Predator	
	TR Tanytarsini	43	3.5	Collector	
	Unidentified	1	6.6		
	Empididae Unid	12	7.5	Predator	Sp
	Ephydridae - unidentified	1	6	Collector	Bu
	Tipulidae - Antocha sp.	1	8	Collector	Cn
	Dicranota sp	1	1.1	Predator	Sp
Isopoda	Asellus sp. (=Caecidotea)	3	2.6	Collector	Sp
Amphipoda	Gammarus sp.	49	6.7	Shredder	Sp
Hemiptera	Veliidae – Rhagovelia sp	1	6	Predator	Sk
Annelida	Unid Oligochaeta	5	10	Collector	Bu
Hirudinea	Unidentified	1	6	Predator	Sp
		S = 26 N = 322			

Fisheries Data	**MBSS Data – Combined Highlands**
Richness = 26	Number of Taxa = 26 (5)
HBI = 5.66	Number of EPT taxa = 12 (3)
Scraper filterer ratio = 0.26	Number of Ephemeroptera taxa = 5 (5)
EPT = # 74 Taxa 12	% intolerant urban = 10.2 (1)
EPT/C = 0.42	% Tanytarsini = 13.3 (5)
Dominant family = 42.5% Chironomidae	% Scrapers = 1.5 (1)
CPOM = 0.18	% Swimmers = 9 (3)
Diversity = 3.34	% Diptera = 58.7 (1)
Equitability = 0.56	IBI = 3 fair

Station 4 - NBPR Lower Catch and Return Trout Fishing Area at Warnick Cemetery 6-30 sec kicks August 27, 2013					
Order	**Family/genus**	**Count**	**Tolerance**	**Feeding**	**Life habit**
Ephemeroptera	Baetis sp	29	3.9	Collector	Sw
	Heptagenia sp	7	2.6	Scraper	Cn
	Isonychia sp	9	2.5	Filterer	Sw
	Leucrocuta sp	22	1.8	Scraper	Cn
	Paraleptophlebia sp.	11	2	Collector	Sw
	Pseudocloeon sp. (=Acentrella sp.)	14	4.9	Collector	Sw
	Stenacron sp	1	2	Collector	Cn
	Stenonema sp.	17	4.6	Scraper	Cn
Plecoptera	Acroneuria sp	2	2.5	Predator	Cn
	Allocapnia sp	2	4.2	Shredder	Cn
	Leuctra sp.	42	0.4	Shredder	Cn
	Yugus sp	1	0	Predator	Cn
Trichoptera	Cheumatopsyche sp	23	6.5	Filterer	Cn
	Diplectrona sp	1	2.7	Filterer	Cn
	Hydropsyche sp.	12	7.5	Filterer	Cn
	Hydropsychidae - unidentified	5	5.7	Filterer	Cn
	Rhyacophila sp	7	2.1	Predator	Cn
Diptera	Chironomidae - SF Chironominae	6	6.6	Collector	
	SF Orthocladiinae	3	7.6	Collector	
	SF Tanypodinae	1	7.5	Predator	
	TR Tanytarsini	2	3.5	Collector	
	Unidentified	1	6.6		
	Simuliidae – Simulium sp	5	5.7	Filterer	Cn
	Tipulidae - Hexatoma sp	8	1.5	Predator	Bu
	Unid Empididae	2	7.5	Predator	Sp
Megaloptera	Nigronia sp	1	1.4	Predator	Cn
Isopoda	Asellus sp. (=Caecidotea)	4	2.6	Collector	Sp
Amphipoda	Gammarus sp.	56	6.7	Shredder	Sp
Coleoptera	Elmidae - Stenelmis sp	1	5.7	Scraper	Cn
Decapoda	Unid Cambaridae	3	2.8	Shredder	Sp
Annelida	Unid Oligochaeta	1	10	Collector	Bu
		S = 31 N = 299			

Fisheries Data	**MBSS Data – Combined Highlands**
Richness = 31	Number of Taxa = 31 (5)
HBI = 4.09	Number of EPT taxa = 17 (5)
Scraper filterer ratio = 0.85	Number of Ephemeroptera taxa = 8 (5)
EPT = # 205 Taxa 17	% intolerant urban = 39.8 (3)
EPT/C = 15.8	% Tanytarsini = 0.7 (3)
Dominant family = 18.7% Gammaridae	% Scrapers = 15.7 (5)
CPOM = 0.34	% Swimmers = 21.1 (5)
Diversity = 4.02	% Diptera = 9.4 (5)
Equitability = 0.76	IBI = 4.5 good

Station 6 - NBPR Zero Creel Limit for Trout Species at McCoole 6-30 sec kicks October 24, 2013					
Order	**Family/genus**	**Count**	**Tolerance**	**Feeding**	**Life habit**
Ephemeroptera	Baetis sp	1	3.9	Collector	Sw
	Stenacron sp	24	2	Collector	Cn
	Stenonema sp.	52	4.6	Scraper	Cn
Trichoptera	Brachycentrus sp	7	2.3	Filterer	Cn
	Cheumatopsyche sp	27	6.5	Filterer	Cn
	Diplectrona sp	2	2.7	Filterer	Cn
	Hydropsyche sp.	88	7.5	Filterer	Cn
	Leucotrichia sp	3	5	Scraper	Cn
	Neureclipsis sp	4	0.2	Filterer	Cn
Diptera	Chironomidae - SF Chironominae	5	6.6	Collector	
	SF Tanypodinae	2	7.5	Predator	
	Unidentified	1	6.6		
	Unid Empididae	1	7.5	Predator	Sp
	Tipulidae - Antocha sp.	57	8	Collector	Cn
Coleoptera	Dryopidae – Helichus sp	1	6.4	Scraper	Cn
	Elmidae - Stenelmis sp	2	7.1	Scraper	Cn
Megaloptera	Nigronia sp	8	1.4	Predator	Cn
	Sialis sp	1	1.9	Predator	Bu
Gastropoda	Ferrisia sp	7	7	Scraper	Cb
		S = 19 N = 293			

Fisheries Data	**MBSS Data – Combined Highlands**
Richness = 19	Number of Taxa = 19 (3)
HBI = 6.0	Number of EPT taxa = 9 (3)
Scraper filterer ratio = 0.45	Number of Ephemeroptera taxa = 3 (3)
EPT = # 208 Taxa 9	% intolerant urban = 15.7 (1)
EPT/C = 26	% Tanytarsini = 0 (1)
Dominant family = 40% Hydropsychidae	% Scrapers = 22.2 (5)
CPOM = 0	% Swimmers = 0.3 (1)
Diversity = 2.97	% Diptera = 22.5 (5)
Equitability = 0.58	IBI = 2.75 poor

Potomac River
Cumberland, MD downstream to District of Columbia
(Allegany, Washington, Frederick and Montgomery Counties)

Introduction

The non-tidal Potomac River, or upper Potomac as it is usually called, provides outstanding angling opportunities for several popular gamefish species. Forming Maryland's southern boundary for over 320 km, the river is readily accessible to residents of Maryland's western-shore counties as well as nonresidents from Virginia and West Virginia. It is no surprise then, that the Potomac River is Maryland's "most fished" and favorite freshwater fishing destination (Rivers, 2004).

Two special regulation areas have been established on the Potomac River with the goal of improving black bass size structure and the catch rates of quality-size and larger bass. A catch and release area was established in 1995 on a 32-km stretch between the mouth of the Monocacy River and Seneca Breaks in Montgomery County. Another catch and release area for black bass was enacted on a 40-km stretch of the NBPR between Keyser, WV and Cumberland, MD effective January 1, 2001. Black bass in the remainder of the Potomac River are subject to a 305-mm minimum size limit and a five fish per day creel (statewide regulations).

Objectives

Surveys were conducted to assemble the fish population data necessary to make appropriate management decisions with the goal of protecting and enhancing the popular Potomac River sport fisheries. Fishery management activities conducted on the Potomac River during 2013 included haul seining to assess natural reproduction of fish species and electrofishing to assess adult fish stocks with the following objectives:

- Assess Walleye (*Sander vitreum*) size structure, yearclass strength, growth and mortality rates, and relative abundance.
- Determine Muskellunge (*Esox masquinongy*) exploitation, angling catch rates, growth, mortality, and assess size structure.
- Monitor Smallmouth Bass (*Micropterus dolomieu*) yearclass strength, relative abundance, growth, mortality, size distribution, physical condition, and general angling catch rates.
- Record basic water quality parameters.
- Collect macroinvertebrate data to assess river conditions using a variety of metrics.

Methods
Young-of-year (YOY) black bass were collected using the seining methods outlined in the Study IV general methods section. Adult fish were collected by electrofishing according to the methods outlined in the Study IV general methods section. Population indices for Walleye, Muskellunge, Smallmouth Bass were calculated using the methods described in the Study IV general methods section.

To obtain length at age data, five fish from each 2-cm length group were sacrificed to obtain sagittal otoliths. A sample of otoliths from larger Smallmouth Bass was obtained during previous collections and/or from tournament mortalities. Otoliths were prepared and ages estimated using the method described by Heidinger and Clodfelter, 1987. Length at age was predicted using the von Bertalanffy growth equation. Total annual and instantaneous mortality was estimated using the FAST program by catch-curve regressions and using the formula presented by Gulland (1976) based on the von Bertalanffy growth function and length frequency data.

To obtain angling catch rates for smallmouth bass, a pilot creel survey was initiated in 2012. The survey began in June and continued through October. The survey area extended from the Route 340 Bridge near Harpers Ferry, WV downstream to the lower end of the Seneca pool at Seneca Breaks, a distance of 63 km. The survey area was divided into two sections, Rt 340 downstream to the Monocacy (305 mm min. size, 5 fish per day creel, March 1 thru June 15 catch –and-release season) and from the Monocacy downstream to Seneca Breaks (year-round catch-and-release for black bass). Roving creel clerks provided boat, wading, and bank fishermen with a postage pre-paid survey card. Anglers were instructed to answer a few brief questions about their days catch and drop the card in the mail at the conclusion of their fishing day. To improve participation, each returned card entered anglers in a random drawing for a chance to win prizes. Since there was no difference ($\alpha = 0.05$) in catch rates between the two regulation sections (MD DNR, 2012), the data were combined. The angler creel survey was expanded in 2013 to include the entire river separated into three segments (upper, middle, and lower river) using the same methodology used during 2012 as well as an on-line volunteer anglers survey on the MD DNR Fisheries Service web site.

Lower river sites included Edwards Ferry, Whites Ferry, Point of Rocks and Brunswick; middle river sites included Dargan, Shepherdstown, Taylors Landing, and Williamsport; upper river sites included McCoys Ferry, Hancock, Little Orleans, and PawPaw and the NBPR sites include Oldtown, Spring Gap, and Cumberland.

Basic water quality was measured using a HACH Model FF-1A Fish Farming test kit and a YSI EXO1 sonde/handheld unit outfitted with four sensors to record temperature, conductivity, dissolved oxygen, pH, and total algae (chlorophyll-a and phycocyanin conc.). An investigation to better understand the spatial and temporal distribution of macro algae blooms in the Potomac River and how these blooms may be initiated by and alter water quality parameters and macroinvertebrate populations was initiated in 2013.

The algae and macroinvertebrate investigative methods and preliminary results are presented in the Appendix.

Results/Discussion

Walleye

The Potomac River Walleye population is monitored by spring electrofishing collections below Dams 4 and 5 to obtain length at age and length frequency distributions and during annual fall electrofishing collections at sites throughout the river to obtain measures of adult and YOY relative abundance and proportional size distribution. The primary objective of the daytime fall electrofishing surveys is to assess the smallmouth bass population; however, all walleye observed during the surveys are collected, measured, and weighed.

Daytime electrofishing was conducted at Taylors Landing downstream of Dam 4 on 3/4/2013 and 3/20/2013 and at Williamsport downstream of Dam 5 on 3/11/2013. A comparison of Walleye length frequency from the 2012 and 2013 spring collections shows the growth of the 2010 yearclass further into the harvestable portion of the population and the poor recruitment in 2011 and 2012 (Table 1),(Figure 1). The poor 2012 yearclass is reflected in the very small percentage of fish in the stock – quality increment (Table 1) in 2013 suggesting poor survival of both stocked and naturally produced fingerlings. The largest Walleye collected by electrofishing from the Potomac River during an electrofishing survey was collected during the spring of 2013; the pre-spawn female measured 753 mm (29.7") in total length with an otolith estimated age of 13 years.

A total of 25 mature Walleye (15 male, 10 female) collected during the spring surveys were retained and transported to the Manning Warmwater Hatchery for brood stock. Approximately 25,000 Walleye fingerlings produced from these fish were stocked between Dam 3 and 4 on May 2 to supplement natural reproduction. An additional stocking of approximately 8,000 fingerlings was made at Williamsport on May 9. Unfortunately, the May 9th stocking occurred under poor conditions of high flows and high turbidity. Mion, et al. (1998) documented a significant, inverse relationship between larval survival and river discharge in the Sandusky and Muamee Rivers in Ohio. All Walleye fingerlings stocked in the Potomac during 2013 were marked with OTC to differentiate them from wild fish during future surveys.

Walleye yearclass strength is assessed based on the CPUE of young-of-year (< 330 mm) collected during the fall electrofishing surveys between Dams 3 and 4. A total length of 330 mm was used to designate yearling and older Walleye because using stock length (250 mm) would include young-of-year (MD DNR, 2009). During the fall of 2011 a single young Walleye (306 mm) was collected during 2.2 hours of electrofishing for a CPUE of 0.45 YOY/hour. Similar to 2011, a single YOY Walleye (255 mm) was collected during 2.3 hours of electrofishing in 2012 for a CPUE of 0.43 YOY/hour. During 2013, a single YOY Walleye was collected at the Williamsport site outside of the

Dam 3 to Dam 4 reach and was not included in the CPUE calculation; no young Walleye were collected during daylight electrofishing surveys between Dams 3 and 4 in 2013. However, daytime electrofishing is known to be a poor estimator of young Walleye abundance. A night electrofishing survey was conducted at Dargan between Dams 3 and 4 on October 30 to better determine yearclass strength. A total of six young Walleye were collected during 0.76 hours of electrofishing for a CPUE of 7.9 fish per hour. Of the seven total young Walleye collected during 2013, four (57%) were determined to be of hatchery origin verifying that hatchery fingerlings are contributing to the fishery.

Highly variable yearclass strength has made it necessary to collect otoliths over multiple years so that most age classes were represented. The mean total length at age based on otolith age estimates were run through the FAST von Bertalanffy solver. The results suggest a close age – length relationship for both male ($R^2 = 0.94$, $P > F = 0.0001$) and female ($R^2 = 0.95$, $P > F = 0.0001$) Walleye. Estimates of length at infinity for male (566 mm - 22.3 inches) and female Walleye (744 mm - 29.3 inches) are very close to the maximum known lengths for male (574 mm - 22.6") and female (753 mm – 29.7") Potomac River Walleye. Female Walleye grow at a much faster rate than males with growth rates diverging at age 3 (Figure 2.). Based on the von Bertalanffy growth function using otolith estimated ages, male Walleye will reach the 381 mm (15") minimum length limit in 1.9 years whereas females will reach the minimum size in 1.7 years. Female Walleye will reach the 508 mm (20") protected size (January 1 through April 15) in just 3.6 years; male Walleye will take 5.9 years to reach the protected size limit.

Using the formula presented by Gulland (1976), the instantaneous rate of total annual mortality (Z) was estimated to be -0.25 (S = 78%) and -0.31 (S = 73%) for female and male Walleye, respectively.

The CPUE of Walleye collected during annual fall electrofishing surveys has been used as a measure of relative abundance for Potomac River Walleye. However, Maryland has no other major river Walleye populations for comparison. Recently, the Pennsylvania Fish and Boat Commission set their electrofishing catch rate objective for major rivers known to have quality Walleye fisheries at ten Age 1+ Walleye and 2 legal-length (375 mm - 15") Walleye per hour based on the historic mean catch rate of 2.84 legal-length Walleye per hour from quality fisheries (PFBC, 2011). The CPUE for legal length (381 mm – 15") Potomac River Walleye has been consistently above that threshold since 2004 (Table 2) with a mean of 9.1 (5.4 – 12.8) suggesting that the Potomac River is providing anglers with a quality Walleye fishery comparable to other riverine fisheries in the Mid-Atlantic region.

Muskellunge

Length and weight data were collected from Muskellunge captured during routine electrofishing surveys as well as angled fish. Relatively few YOY or adult Muskellunge are captured during the fall electrofishing surveys. Data from angled Muskellunge is proving to be a much more efficient means of obtaining population data. An on-going tagging project to gain insight on exploitation, movement and growth was initiated in 1997. Dart tags (Hallprint Pty Ltd) are applied using an applicator needle on the fish's left side hooking into the interneural bones. An angler diary program was established in 2009 to monitor angler effort, catch, harvest, and obtain a larger size distribution data set.

To date, a total of 641 Potomac River Muskellunge have been tagged with 223 recaptures for an overall recapture rate of 35%. Five-hundred-fifty-eight of the tagged Muskellunge were captured by two experienced anglers and 83 were collected by electrofishing during the 16 years of the project. The overall recapture rate for Potomac River Muskellunge is higher than most rates reported in the literature. No attempt was made to determine the tag reporting rate. Undoubtedly, there were some unreported recaptures and the true recapture rate is higher than 35%. A compilation of data from six separate Muskellunge Inc. chapter tagging projects conducted on over 100 bodies of water revealed an overall average recapture rate of 17% (Richards & Ramsell, 1984). However, recapture rates for 578 Muskellunge caught, tagged, and released by the 16 most experienced anglers ranged from 22% to 44%, and averaged 28%. The large number of tagged Muskellunge, the experience of the Muskellunge anglers, combined with the popularity and relatively small size of the Potomac certainly contributed to the high rate of recaptures. Of the 168 muskellunge recorded in the angler creel diaries during 2013, 7.1% were tagged.

Estimates of Muskellunge growth were derived from the mark – recapture tagging data and the von Bertalanffy growth equation (scale analysis). Gulland-Holt plots (Gulland & Holt, 1959) of female (Figure 3) and male (Figure 4) Muskellunge were produced from multi-year recapture data. Using this method, the growth parameter K for female and male Muskellunge was 0.119 and 0.174, respectively. Length at infinity ($L\infty$) was estimated to be 1300 mm (51.2") for female and 1133 mm (44.6") for male Muskellunge by the intercept on the X –axis where the growth rate is zero. The Gulland-Holt plots overestimate the ultimate length of both female and male muskellunge; the largest known female measured 1219 mm (48") and the largest known male measured 1054 mm (41.5").

Scales were removed from a total of 119 Muskellunge (62 female, 57 male) captured between October and March (2008 - 2013) for age and growth analysis. The von Bertalanffy predicted length at age for Muskellunge is presented in Figure 5. Female and male Muskellunge reach the 914 mm (36") minimum size in 5.3 years and 5.7 years, respectively. To reach 1016 mm (40"), however, takes 7.2 years for female and 10.2 years for male Muskellunge. The FAST program using the von Bertalanffy growth function estimated the $L\infty$ of female Muskellunge at 1244 mm (49.0") with a K value of 0.189 ($P = 0.0001$, $R^2 = .99$) and the $L\infty$ of male Muskellunge at 1054 mm (41.5") with a K value of .289 ($P = 0.0001$, $R^2 = .98$).

To date, the oldest Muskellunge collected was a 1168 mm (46") female aged by scale analysis to be 13 years old. The largest known female Muskellunge measured 1219 mm (48") in total length and was estimated to be 12 years old, whereas the largest known male Muskellunge measured 1054 mm (41.5") and was estimated to be 9 years old. The oldest male Muskellunge was estimated to be 11 years old and measured 1016 mm (40").

The close relationship of the growth function estimates derived from the scale age data and the tagging study recapture data, as well as the accuracy of the scale $L\infty$ estimates to the size of the largest known individuals of each sex, imply that ages based on scale analysis are providing an accurate estimate of Muskellunge growth in the Potomac River.

Based on the sample of scale-aged fish, the FAST program was used to assign ages to the 2013 angler caught Muskellunge. The FAST program, using catch-curve regression, estimated annual mortality of age five and older Muskellunge (age Muskellunge recruit to harvestable population) in 2013 at 28% with an instantaneous mortality rate (Z) of -0.32 and a predicted maximum age of 15.8 years (R^2 = 0.87, P = 0.0002). Using the formula presented by Gulland (1976) based on the von Bertalanffy growth function, the 2013 size distribution data, and the minimum harvestable length (914 mm – 36"), the instantaneous mortality was estimated to be -0.43 and annual mortality was 35%. This is a length-based model, which are generally not as accurate as age-based models because of the assumptions that must be met: constant recruitment during the period covered by the length distribution and that Z remains constant over the ages. Even so, the mortality estimates derived by both methods are in comparative agreement.

Annual Muskellunge size structure parameters were determined from the lengths of angled Muskellunge reported from angler diaries. The size distribution combined with the angler catch rates suggests that the Potomac River is supporting an excellent sport fishery for Muskellunge (Figure 6). Poor reproduction during 2008 and 2009 reduced the percentage of S – Q Muskellunge in 2010. The percentage of S – Q Muskellunge increased in 2011, 2012 and 2013 as a result of increased reproduction in 2010, 2011, and 2012. The percentage of S-Q Muskellunge in the catch may be useful in providing a qualitative measure of yearclass strength 2 and 3 years prior (Figure 6). The percentage of Muskellunge within the S-Q increment in 2013 fell below the long-term (2000 – 2013) median value of 11%. A Kolmogorov-Smirnov comparison of the Muskellunge size distributions reported from the angling creel diaries in 2012 and 2013 found no difference (α = 0.05) in the distributions (D = 0.089, P = 0.408).

A total of 16 anglers participated in the diary program in 2013. The Muskellunge angling catch rate decreased significantly (α = 0.05) from 2011 to 2012 and 2013 (Table 3). It is unclear if the decline in catch rate reflects a decrease in muskellunge abundance, difficult fishing conditions, or fish becoming more difficult to catch with increasing fishing pressure. Nevertheless, the 2013 catch rate (0.064; 15.7 hrs/fish) remained similar to or higher than catch rates reported from other angler diary programs. Based on consolidated effort and catches during a 26 year period for the Canadian province of Ontario, the angler CPUE was 0.069, meaning it took anglers 14.5 hours to catch a Muskellunge (Kerr, 2007). Angler diary programs in North Carolina (Borawa, 1990) and Minnesota (Younk and Cook, 1992) reported catch rates of 0.038 and 0.027, respectively. There was no difference in the mean annual angling catch rates from the upper (0.09 ± 0.09, CV = 41) or middle (0.10 ± 0.12, CV = 50) river segments 2011 – 2013. Efforts are continuing to improve diary participation. All Muskellunge reported in the diaries were released.

Angling catch rates were highest during the cool and coldwater months and lowest during the summer months, with the exception of July (Figure 7). July catch rates reflect greater angling success by anglers targeting Muskellunge concentrated in thermal refuges as river temperatures exceed 26°C (80°F). The greatest numbers of trips were reported during May and June. Exceptional fishing conditions existed in the Potomac throughout the winter of 2012 resulting in catch rates that were probably much above "normal" during January and February. In spite of an open season during spawning (April), angler success was relatively poor at that time.

Smallmouth Bass Yearclass Strength

Smallmouth Bass yearclass strength has been monitored annually since 1975. Since PawPaw has historically been the upstream limit of the seining survey, this limit was used for long-term comparison. Smallmouth Bass yearclass strength has been highly variable with a long-term median value of 1.7 YOY/haul. The relative abundance of YOY Smallmouth Bass recorded 2008 through 2010, and in 2013 (1.2 YOY/haul), fell below the long-term median value of 1.7 while the 2011 and 2012 values were slightly above the long-term median (Figure 8). The strongest yearclass produced during the 38 years of the survey was produced in 2007. Although the long-term data suggests that there has been no significant ($\alpha = 0.05$) change in Smallmouth reproduction (linear regression 0.011, 95% CI –0.017 – 0.039, P = 0.42), dominant yearclasses appear to have become less frequent since 1997 (Figure 8).

Smallmouth Bass Population Data

A total of 686 Smallmouth Bass were collected during 14 electrofishing runs at 7 sites during October, 2013 with a total electrofishing time of 5.2 hours. The mean duration of each run was 0.37 hr (95% CI 0.31 – 0.44, CV = 30). Sites at Little Orleans, Hancock, Point of Rocks and Brunswick were not sampled because low flows prevented navigation; Whites Ferry was not sampled due to excessive SAV growth. Using the formula discussed in Bonar et al. (2000) based on the number of samples (14) and the sample variance, the mean $CPUE_{60}$ for quality size Smallmouth Bass was within 23% of the true mean at the 95% CL. The $CPUE_{60}$ for stock size and greater Smallmouth was highly variable among runs and ranged from 23 stock bass/hour (Edwards Ferry) to 207 stock bass/hour (Dargan). There was no difference in the $CPUE_{60}$ for Smallmouth bass ≥ stock size (two tailed t-test, P = 0.71, $\alpha = 0.05$) or ≥ quality size (two tailed t-test, P = 0.27, $\alpha = 0.05$) between the upper and middle river sections; Edwards Ferry was the only lower river site surveyed in 2013 so the lower river wasn't included in the comparison. The overall $CPUE_{60}$ for stock size and greater Smallmouth in 2013 was higher than the 2006 – 2012 mean $CPUE_{60}$ (Table 4), though not significantly.

Ages were estimated from a total of 369 Smallmouth Bass collected during the 2009 – 2013 electrofishing surveys and from tournament catches/mortalities (232 otoliths, 137 scales) to determine growth parameters. Although length at age generally increased with downstream progression, the differences between the upper, middle, and lower river sections were not significant (ANOVA F = 2.38, P = 0.11, $\alpha = 0.05$) so they were combined for analysis. Length at age data based on otolith/scale age estimates were run through the FAST von Bertalanffy solver. The results suggest a close age – length relationship ($R^2 = 0.99$, $P > F = 0.0001$). $L\infty$ was estimated at 570 mm (22.4”), close to the length of the largest Smallmouth collected from the Potomac during the last 25 years (559 mm – 22”, collected in 2011). K was estimated to be 0.165. Smallmouth Bass reach the 305mm (12”) minimum size in 4.2 years (Figure 9). Bass in the lower stretches are expected to reach the minimum size slightly quicker whereas bass in the far western stretches will take longer. The age to reach quality size (Aq, quality = 280 mm) was 3.6 years. The median growth coefficient (K) value for North American Smallmouth Bass populations was 0.16 and the median age at quality size (Aq) was 3.9 (Beamesderfer and North, 1995), similar to the values obtained for the Potomac. To improve the precision of the growth parameter estimates, age data based on otoliths from a greater number of bass approaching $L\infty$ needs to be collected (Table 5), particularly within the middle river segment.

Smallmouth mortality rates based on ages assigned to the 2013 electrofishing catch were estimated using weighted catch curve analysis (FAST). The weighted catch curve regression ($P > F = 0.0017$, $R^2 = 0.68$) for age 4 and older bass estimated total annual mortality at 40% with an instantaneous mortality (Z) of -0.51 and a theoretical maximum age of 12 years. The median instantaneous natural mortality rate based on 409 North American Smallmouth bass populations was reported by Beamesderfer and North (1995) to be -0.39 with a corresponding annual natural mortality rate of 32%. Based on these values, exploitation (u) of Potomac River Smallmouth bass was estimated to be 9%.

The 2013 Smallmouth Bass size distribution was very similar to the 2006 – 2012 mean PSD, RSD_{350}, and RSD_{430} values (Tables 4 and 6). The current size distribution is indicative of a balanced population (Anderson and Weithman, 1978) and similar to the mean size distributions reported for riverine populations in Tennessee (Fiss et al., 2001). The current size distribution is providing good fishing opportunities.

The relative weight (Wr) for stock, quality, preferred, and memorable sized Smallmouth Bass in 2013 was 88, 85, 85, and 87, respectively. Relative weights have remained consistent from year to year, but are only slightly above the 25th percentile observed for other North American populations (Wr = 86; Beamesderfer and North, 1995).

Smallmouth Bass Angler Creel Survey

Information provided by fishermen is cost effective and an important part of managing fisheries. Creel surveys provide insight into angler success, harvest attitudes, and the effectiveness of regulations. Potomac River bass anglers were surveyed using two methods, on the water distribution of postage pre-paid creel cards and through an on-line volunteer angler survey page. A total of 212 usable creel cards were returned by anglers participating in the 2013 Potomac River Smallmouth Bass Catch Rate Survey. Due to the variability of wading opportunities in the study area and the low number of cards returned by wading anglers, only the information from boat anglers was summarized.

A total of 55 usable entries were made by boat anglers through the on-line volunteer angler survey; only 19 entries were received by wading anglers. Only three on-line boat entries were received from the upper river and they were not included in the analysis.

There was no difference ($\alpha = 0.05$) in the catch rate of Smallmouth Bass ≥ 305 mm (12") by boat anglers using creel cards (1.1/hr), boat anglers using the on-line survey (1.2/hr), or by wading anglers using the on-line survey (1.2/hr)(ANOVA single factor $F = 0.23$, $P = 0.79$). However, there was a significant difference in catch rates for sub-legal Smallmouth Bass (< 305 mm) reported by boat anglers using creel cards (2.6/hr) and by boat anglers using the on-line survey (1.4)(two tailed t-test, $P = 3.5E-05$). Moreover, there was no difference in catch rate between wading anglers and boat anglers reporting sublegal size bass through the on-line survey. It is speculated that fishermen may keep track of "keepers" more accurately than the number of sub-legal fish they catch. Additionally, cards distributed to anglers just prior to their trip and filled out during or at the conclusion of the trip may reflect a more accurate recording of the catch than if the catch had to be recalled from memory at a later date for the on-line survey. Only one percent of the legal-size bass caught were reported as harvested

ANOVA tests showed significant differences in the total catch rate of Smallmouth Bass ($F = 6.47, P = 0.002$) and the catch rate for legal-size bass (≥ 305 mm) among the lower, middle, and upper river segments ($F = 4.32$, $P = 0.014$). A summary of the catch data, by river segment and collected using the postage pre-paid creel cards is presented in Table 7.

The percentage of the total angler catch consisting of legal size (305 mm) Smallmouth Bass reported from creel cards from the upper and middle river segments was 18% and 24%, respectively. Using 127 mm (5") as an approximate length that smallmouth are recruited to hook and line gear, the percentage of legal size bass caught by electrofishing from the collection of bass ≥ 127 mm was 14% and 25% for the upper and middle river, respectively. This suggests that size distributions determined from electrofishing can be reasonably compared to size distributions reported by anglers. Too few electrofishing surveys were conducted in the lower river segment during 2013 to allow a comparison.

Angling catch rates for Smallmouth Bass recorded in 2013 were higher than values reported from a creel diary program during 1979 – 1985 (MD DNR, 1986)(Table 8). Although the surveys used different methodologies to obtain angling catch rates, the results were thought to be analogous enough to make general comparisons. The anglers that participated in the diary program were skilled, avid anglers and members of a local fishing organization. These fishermen could be expected to have a higher catch rate than more casual anglers. By design, the creel card survey (2013) captured a broader range of angler experience, though enthusiastic anglers did take an interest in and repeatedly participated in the 2013 survey. Nevertheless, the two surveys allow a comparison of current and past fishing success and an additional tool to evaluate the quality of the Potomac River Smallmouth Bass fishery.

Invasive Species

For the first time since 2002, flathead catfish (*Pylodictis olivaris*) were collected from the Potomac River in 2012. On June 10, 2012 an angler caught a large adult flathead near Williamsport. This fish was verified by a DNR biologist and measured 923 mm (37.5") in total length and weighed 10.98 kg (24.2 lbs) and was subsequently aged at 24 years old by examining the sectioned lapillus otolith. Two additional flathead catfish were collected during the 2012, fall electrofishing survey, also at Williamsport. These fish measured 404 mm and 490 mm in total length and weighed 660 g and 1335 g, respectively and were estimated to be 4 years old based on the sectioned otolith. No flathead catfish were collected during the routine 2013 Potomac River electrofishing surveys.

Water Quality

Basic water quality parameters (hardness, conductivity, temperature, pH, dissolved oxygen, chlorophyll-a, PC - phycocyanin) were recorded at each site (Cumberland to Great Falls) during the July seining survey (Table 9). Values were similar to those reported during the last five year grant period (MD DNR, 2012). Two additional parameters were measured in 2013: chlorophyll-a (µg/L) and phycocyanin (µg/L). Values of chlorophyll-a (0.13 – 4.19µg/L) during 2013 remained within the reference range of 0.05 - 5.74 for rivers and streams within EPA ecoregion 9 (EPA, 2000). Analysis of water quality and algal pigment concentration is presented in the Appendix under macroinvertebrate investigations.

Management Recommendations

The Potomac River mainstem continues to provide excellent fishing opportunities and the following management actions are recommended:

Walleye

- Continue the spring electrofishing surveys below Dams 4, 5, to expand on current Walleye length at age data, monitor size structure, and assess the previous years reproductive success.
- Monitor adult and YOY (Young-of-year) Walleye relative abundance using the CPUE of night electrofishing surveys conducted during October. Surveys should be conducted at Dargan, Shepherdstown, and Taylors Landing (2 samples per site).
- Continue spring brood collections.
- To achieve the highest quality walleye fishery from the limited resources available, fingerling walleye stocking efforts should be limited to the 1129 ha stretch between Dam 5 and Dam 3 (Washington County) at a target stocking rate of approximately 35 fingerlings per hectare. The annual stocking of 40,000 fingerlings in this river segment should be adequate to supplement existing natural reproduction. All fingerlings should be marked with OTC to evaluate the contribution of hatchery fish during future surveys.

Muskellunge

- Continue to collect length, age, growth, and exploitation data for male and female Muskellunge through the current tagging project to improve data set for length at age and catch curve analysis.
- Continue to collect angler effort, catch rate, and length frequency data through the angler diary program and work to expand angler participation.

Smallmouth Bass

- Continue annual assessment of yearclass strength using current methodology at all fixed stations Cumberland downstream to Seneca.
- Assess adult Smallmouth Bass annually by boat electrofishing during the fall at established, fixed stations.
- conduct two to three 1200 second or longer runs at each site to adequately sample all habitat types and reduce variability among runs.
- conduct electrofishing surveys at water temperatures below 21°C (70°F) and above 5.0°C (41°F).
- Collect otoliths, particularly older ages near length at affinity, to obtain more accurate length at age and catch curve data taking advantage of natural and tournament mortality and fish collected during fish health investigations.
- Conduct angler catch rate survey of the lower, middle, and upper sections of the Potomac River at least once during 5 yr grant to assess angling quality and supplement existing population trend data.

Flathead Catfish

- Conduct a summer, night electrofishing survey at Williamsport to evaluate the expansion of the flathead catfish introduction.
- Increase length-at-age data by estimating age using sectioned otoliths.
- Educate anglers on the ecological dangers of introducing new species through Department media and by posting informational signs at fishing access areas.

Table 1. Summary of size distribution data for Potomac River Walleye collected by spring electrofishing 2011 - 2013. 95% CI.

Year	PSD	RSD_{510}	RSD_{630}	ISD_{S-Q}	ISD_{Q-P}	ISD_{P-M}	ISD_{M-T}
2011	78 (68-88)	66 (55-77)	7.4 (1-14)	**22**	12	59	7
2012	91 (86-96)	39 (31-48)	5.2 (1-9)	**9**	52	34	5
2013	99 (98 – 101)	45 (36 – 53)	10 (5 – 15)	**1**	55	35	10

Table 2. Young-of-year Walleye (YOY < 330 mm) $CPUE_{60}$ and the geometric mean $CPUE_{60}$ of legal length (381 mm) Walleye collected by daytime electrofishing during the fall from the Potomac River, Dam 3 to Dam 4, 2001 – 2013. 95% CI.

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
YOY CPUE	28.5	0.39	0	4.7	2.4	5.5	0.35	0	0	1.5	0.45	0.43	0
Gmean CPUE legal length	**3.3**	**4.2**	**25.6**	**4.9**	**5.2**	**5.2**	**8.2**	**11.9**	**18.8**	**6.0**	**12.7**	**6.7**	**10.4**

Table 3. Summary of Potomac River Muskellunge angler catch data obtained from voluntary diary program 2011 - 2013. 95% CI.

	2011	**2012**	**2013**
Muskie N	205	226	168
mean length	35.4	36.0	36.8
participant N	10	15	16
Angler Hrs	1413	2988	2633
Total Catch/Hr	**0.15**	**0.08**	**0.06**
hr/fish	**6.7**	**12.5**	**15.7**
trips	172	295	321
Mean Catch/Hr	0.23	0.10	0.08
	(.17 - .29)	(.08 - .12)	(.06-.10)
variance	0.161	0.041	0.026
standard deviation	0.40	0.20	0.16
CV	177	201	204
% annual recaptures	9.3	6.6	7.1

Table 4. Comparison of annual river-wide population data for Smallmouth Bass collected by electrofishing from the Potomac River during October, November 2006 - 2013. Annual $CPUE_{60}$ is expressed as the geometric mean of all fall runs. All confidence intervals are 95%.

Year	**PSD**	**RSD_{350}**	**RSD_{430}**	**$CPUE_S$**	**$CPUE_Q$**	**$CPUE_P$**	**Wr**	**N**
2006	35 (31 – 39)	13 (10 – 15)	2 (1 – 4)	56 (43 – 73)	20 (17 – 22)	7	88	662
2007	35 (31 – 39)	13 (10 – 15)	2 (1 – 4)	74 (53 – 103)	27 (20 – 37)	12	88	1212
2008	38 (34 – 42)	13 (10 – 16)	5 (3 – 7)	81 (65 – 102)	30 (23 – 39)	12	87	691
2009	30 (27 – 33)	11 (9 – 13)	2 (1 – 3)	83 (62 – 110)	27 (21 – 34)	12	89	1192
2010	32 (28 – 36)	8 (6 – 10)	1 (.3 – 2)	68 (49 – 94)	16 (10 – 25)	11	91	715
2011	53 (50-56)	18 (16-21)	3 (2-4)	105 (82– 135)	59 (46–76)	21 (17-26)	91	1125
2012	51 (47 – 55)	16 (13 – 19)	3 (2 – 4)	72 (53 – 97)	35 (26 – 47)	12 (8 – 17)	93	564
Mean	**39**	**13**	**3**	**77**	**31**	**12**	**90**	**880**
	(31-48)	(10-16)	(1-4)	(63-91)	(18-44)	(9-16)	(88-92)	
2013	**40**	**12**	**3**	**97**	**39**	**10**	**88**	**686**

Table 5. von Bertalanffy predicted length (mm) at age for Potomac River Smallmouth Bass based on otolith and scale estimated ages (N = 369; 232 otolith, 137 scale).

Age	**Predicted Length (mm)**	**N**
2	191	28
3	248	80
4	297	33
5	338	52
6	373	38
7	403	50
8	428	44
9	450	24
10	468	5
11	483	3
12	497	9
13	508	2
14	517	1

Table 6. Annual incremental size distribution (percent) of Smallmouth Bass collected by electrofishing from the Potomac River 2006 – 2013.

Year	**Stock – Qual.**	**Qual. – Pref.**	**Pref. – Mem.**	**Mem. - Trophy**
2006	65	22	10	2
2007	64	24	9	3
2008	62	25	8	5
2009	70	19	9	2
2010	68	24	7	1
2011	47	35	15	3
2012	49	35	13	3
Mean	61	26	10	3
	(52 - 69)	(20 - 30)	(8 - 13)	(2 - 4)
2013	**60**	**28**	**9**	**3**

Table 7. Summary of 2013 Potomac River Smallmouth Bass angler catch data, by river segment, obtained from postage pre-paid creel cards. Cards were distributed to anglers between March 1 and October 31. Catch rate is bass/hr.

	Lower	Middle	Upper	Total
total catch rate	**3.0**	**3.8**	**3.0**	**3.3**
mean total catch	3.0	4.3	3.0	3.5
≥ 12" catch rate	**1.1**	**0.9**	**0.5**	**0.9**
survey card N	86	82	44	212
% ≥ 12" in catch	**36**	**24**	**18**	**27**
mean catch/outing	16.9	20.0	16.4	18.0
mean ≥12"/outing	6.1	4.8	2.9	4.9
mean hrs per outing	5.6	5.2	5.5	5.4

Table 8. Comparison of 2013 angler Smallmouth Bass catch rate data with historical (1979 – 1985) creel diary data from the nontidal Potomac River (Enamait and Davis, 1986). Minimum size = 305 mm. * creel cards from individual trips.
** values are total number/total hours, means are from individual trip data.

Year	# creel diaries	Total SMB caught per Hr	# SMB < 305 mm caught per Hr	# SMB ≥ 305 mm caught per Hr	Percent of SMB ≥ 305 mm in total catch
1979	3	2.35	1.59	0.76	32
1980	5	3.27	2.96	0.31	10
1981	5	2.37	1.95	0.42	18
1982	4	2.43	1.97	0.47	19
1983	5	1.72	1.33	0.40	23
1984	4	1.81	1.30	0.52	28
1985	6	1.81	1.20	0.62	36
Median		2.35	1.59	0.47	23
Mean		2.25	1.76	0.50	24
95% CI		(1.8 – 2.8)	(1.2 – 2.3)	(0.4 – 0.6)	(15 – 30)
2013	**212***	**3.3****	**2.6**	**0.9**	**27**
Mean		**3.5**	**2.6**	**1.0**	**29**

Table 9. Basic Potomac River water quality parameters collected during annual young-of year seining survey during July, 2013.

Site	Date	Water Temp (°C)	Hard. (mg/L $CaCO_3$)	Cond. (µohms/cm)	D.O. (ppm)	pH	Chl.-a (µg/L)	PC (µg/L)	River Mile
Great Falls	8/15/2013	23.1	205	392	9.6	8.3	0.47	-0.05	0
Seneca1	7/23/2013	28.3	103	288	10	8.2	3.07	0.15	16
Seneca2	7/23/2013	27.8	137	330	12.4	8.4	2.02	0.08	16
Seneca3	7/23/2013	29.3	154	335	9	8.4	2.54	0.08	16
Whites Ferry MD	7/23/2013	30.4		414	7.1	7.9	0.79	-0.03	36
Whites Ferry RC	7/23/2013	29.1		332	8	8.4	1.7	0.07	36
Whites Ferry VA	7/23/2013	28.9		321	8.9	8.3	4.19	0.09	36
Brunswick1	7/10/2013	27.2	171	397	7.1	7.8	1.31	0.15	67
Brunswick2&3	7/10/2013	27	188	372	6.9	7.9	1.32	0.12	67
Dargan1	8/1/2013	23.9	188	350	7.6	7.8	1.05	-0.04	83
Dargan2	8/1/2013	24.4	154	320	7.8	7.7	1.14	-0.05	83
Dargan3	8/1/2013	24.4	171	343	8.2	7.8	1.01	-0.06	83
Taylors1	8/1/2013	25.6	171	341	10.4	8.2	0.61	-0.06	108
Taylors2	8/1/2013	24.2	154	293	10.2	7.9	1.37	0.01	108
Taylors3	8/1/2013	25.4	154	340	9.7	8.1	0.63	-0.02	108
Williamsport2	7/31/2013	24	137	291	7.7	7.4	0.43	-0.09	141
Williamsport ramp	7/31/2013	23.8	188	398	7.9	7.7	0.78	-0.08	141
McCoys riffle	7/31/2013	24	154	343	9	8.2	0.15	-0.08	141
McCoys pool	7/31/2013	24.3	137	298	9.9	8.4	0.41	-0.1	160
Hancock pool	8/6/2013	23	171	351	9.7	8.2	0.51	-0.06	183
Hancock riffle	8/6/2013	23.1	154	357	8.8	8.3	0.19	-0.07	183
Hancock general	8/6/2013	23.1	154	354	9.2	8.2	0.28	-0.08	183
L. Orleans general	7/31/2013	24.9	171	393	10.8	8.5	0.22	-0.1	210
L. Orleans riffle	7/31/2013	24.3	188	390	9.9	8.5	0.13	-0.08	210
PawPaw riffle	8/6/2013	22.6	188	406	8.3	7.8	0.45	-0.07	245
PawPaw general2	8/6/2013	22.6	188	404	8	7.8	0.34	-0.06	245
PawPaw general3	8/6/2013	22.2	205	432	8.4	7.7	0.31	-0.06	245
Oldtown	7/18/2013	29.4	205	507	8.3	7.5	0.34	-0.11	263
Spring Gap	7/17/2013	24.8	222	462	7	7.2	0.69	-0.07	273
Cumberland	7/17/2013	27.3	239	510	8.6	7.6	0.33	-0.11	290
Mean		**25.4**	**172**	**369**	**8.8**	**8.0**	**1.0**	**0.0**	

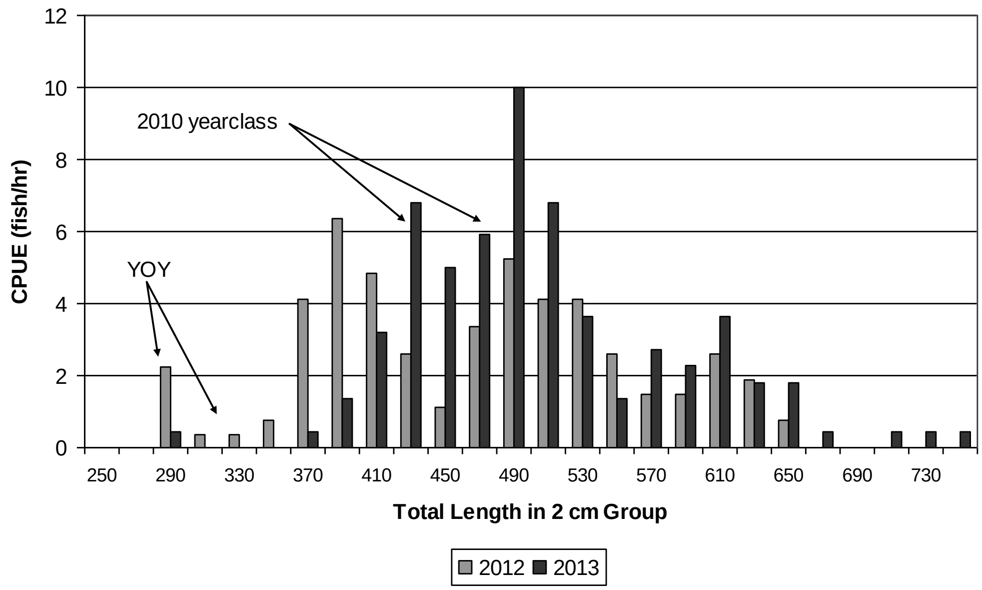


Figure 1. Length frequency distribution of Potomac River Walleye collected by daytime electrofishing during the spring, 2012 and 2013. 2012 N = 135, 2013 N = 130.

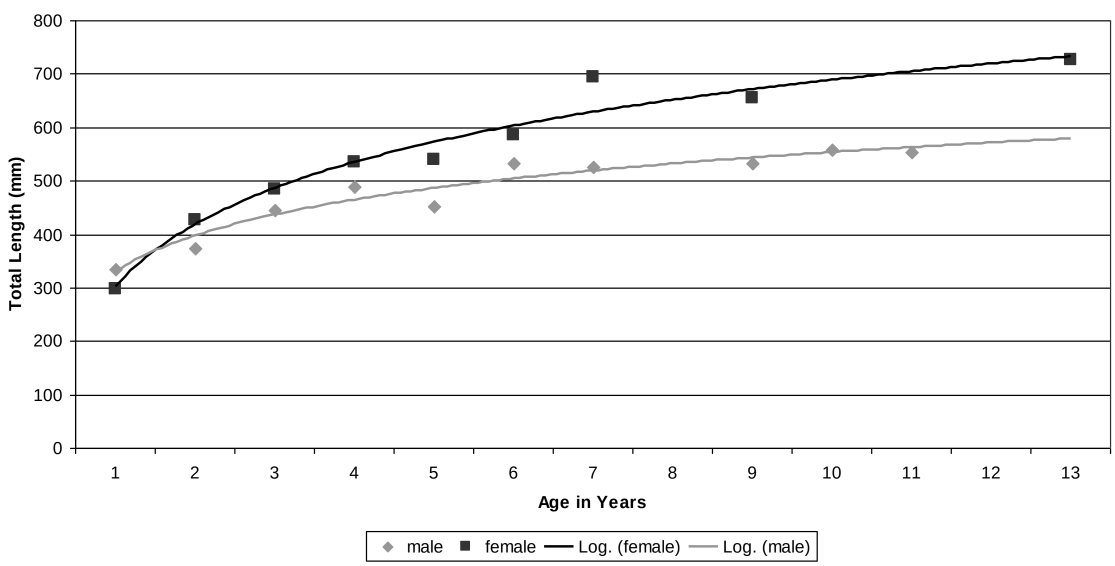


Figure 2. von Bertallanfy predicted length at age data for male and female Potomac River Walleye based on age estimates derived from otoliths. Males N = 63, female N = 59.

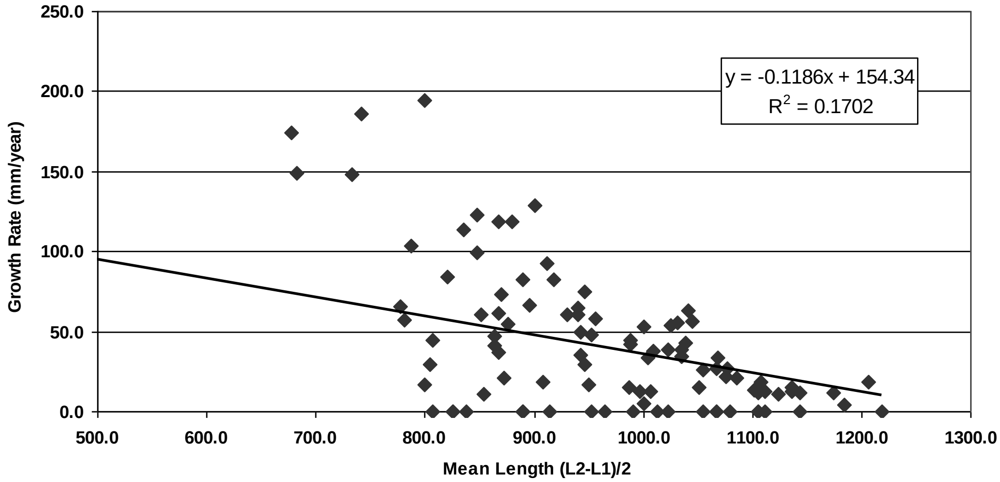


Figure 3. Gulland-Holt plot for female Potomac River Muskellunge based on multi-year recapture data (2003 – 2013). L∞ = 1300 mm (51.2”), K = 0.119. Female recaptures N = 102.

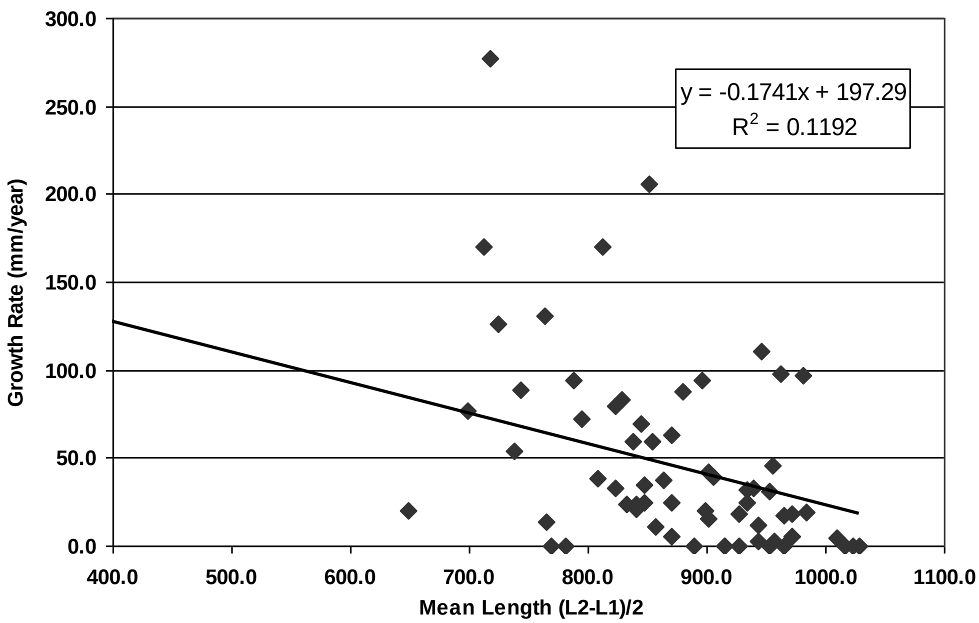


Figure 4. Gulland-Holt plot for male Potomac River Muskellunge based on multi-year recapture data (2003 – 2013). L∞ = 1133 mm (44.6”), K = 0.174. Male recapture N = 68.

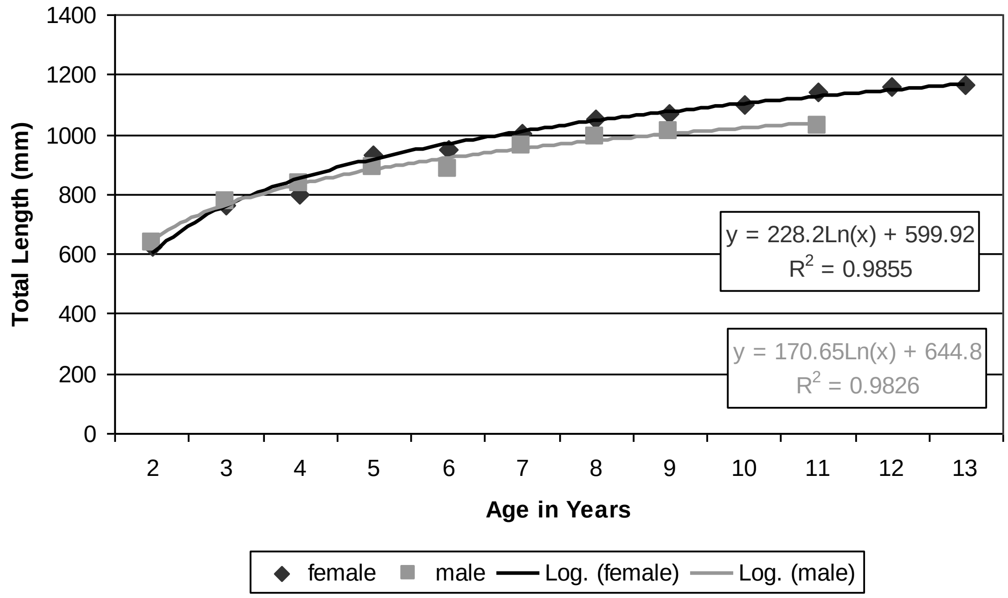


Figure 5. Predicted length at age of male and female Potomac River Muskellunge determined by the von Bertalanffy growth equation based on scale estimated ages. Female L∞ = 1244 mm (49.0”), K = 0.189; Male L∞ = 1054 mm (41.5”), K = 0.289. Female N = 62, Male N = 57.

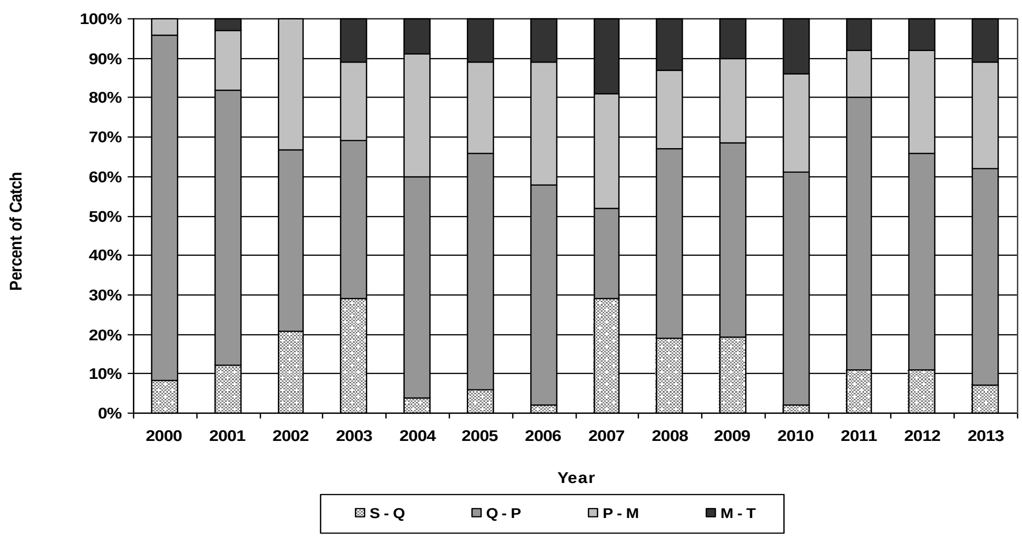


Figure 6. Yearly incremental size distribution of Potomac River Muskellunge captured by angling and electrofishing 2000 – 2013.

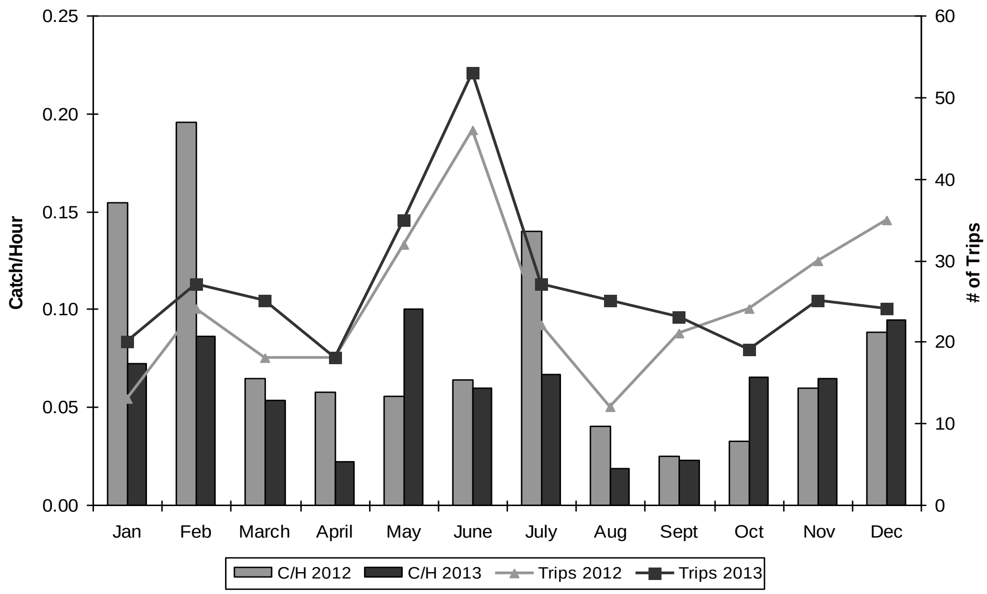


Figure 7. Monthly angling catch rates of Potomac River Muskellunge reported by angler creel diaries in 2012 and 2013 with angling trips per month. 2012 diaries = 15, 2013 diaries = 16.

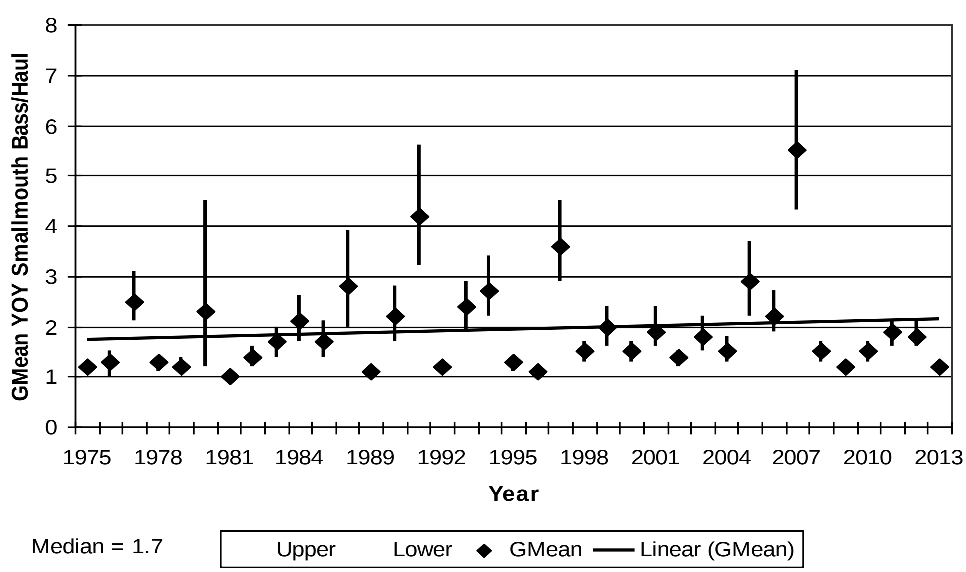


Figure 8. 1975 – 2013 annual geometric mean number of young-of-year Smallmouth Bass captured per seine haul from the Potomac River (PawPaw to Seneca). Linear regression 0.011 (96% CI -0.017 – 0.039, P = 0.423).

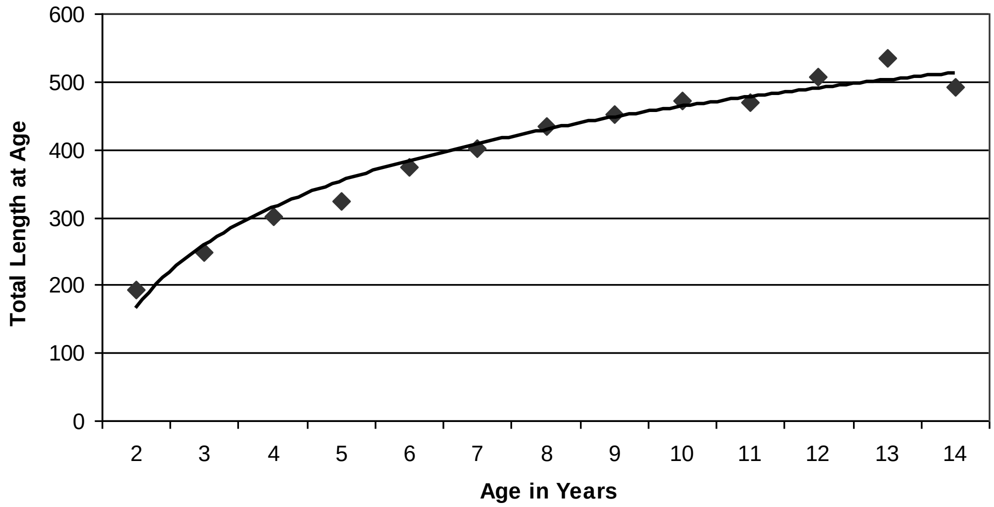


Figure 9. Predicted length at age of Potomac River Smallmouth Bass determined by the von Bertalanffy growth equation using ages based on otoliths and scales. $L\infty$ = 570 mm (22.4”), K = 0.165. N= 369 (232 otolith, 137 scale samples).

Appendix: POTOMAC RIVER MAINSTEM MACRO ALGAE STUDY METHODS AND MACROINVERTEBRATE DATA

Rationale – The nontidal Potomac River is Maryland's most popular fishing destination for freshwater anglers and is also a popular destination for recreational boaters and tubers. Nuisance blooms of algae, particularly the blue-green algae *Planktothrix rubescens*, *Oscillatoria*, have resulted in unsightly and odorous mats of algae that discourage recreational use and may be having negative impacts on aquatic life. Of particular concern is the affect these blooms may be having on benthic macro-invertebrate populations, water quality, and the deleterious effects that cyanobacteria toxins may pose to aquatic invertebrates and fish. The survey is designed to collect baseline data on the species of algae present, the spatial and temporal growth of algae, how algae blooms respond to and affect water quality, and document the presence of algal toxins.

Study Site – Algal blooms have been most prolific in the Potomac River downstream of the confluence with the Shenandoah River near Harpers Ferry, WV. This survey will focus on the 60 km of the river between the Shenandoah confluence and the confluence of Seneca Creek. Significant tributaries within this river reach include the Shenandoah River (contributes flow from the south) while Catoctin Creek and the Monocacy River (largest MD trib) contribute flow from the north.

Survey Locations – Three survey locations (Whites Ferry, Point of Rocks, and Brunswick) have been indentified within the study site that will incorporate the water quality influences of the major tributaries. Transverse bank to bank transect locations have been identified that have a shallow profile most likely to foster algae growth and give the greatest chance to make visual observations of the river substrate across the width of the river.

Brunswick:	N39 18' 52.47" W77 39' 14.42" 359 m in width (center 180m = 197 yds)
Point of Rocks	N39 16' 16.80" W77 32' 31.21" 300 m in width (center 150m = 164 yds)
Whites Ferry	N39 09' 00.35" W77 31' 22.61" 348 m in width (option 1) (center 174m = 190 yds)
	N39 11' 14.57" W77 28' 42.22" 322 m in width (option 2) (center 161m = 176 yds)

At each transect location (Brunswick, Point of Rocks, Whites Ferry) three sample points are taken, one at river center and one approximately 20 m from each shoreline to account for potential influence from tributaries.

Survey Protocol - Algae surveys will begin during the month of May and continue through October. Surveys will be conducted twice a month until bloom begins and conducted once per week during the bloom. After the bloom, surveys will once again be conducted twice a month. At the transect locations, a 4' x 4' square (rebar painted white) will be placed on the river bottom at river center and 20 m from each bank and the percent algae coverage estimated visually. To aid assessment, observations will be made using a five gallon bucket with a plexiglass bottom to reduce surface glare. If water clarity/flow is suitable, underwater photographs should be taken at each plot during each survey. If algal growth is observed to be significant outside of transect, two additional plots should be evaluated at those locations and the coordinates of these plots recorded. Locations of algae and SAV growth will be recorded on Site Maps. Once per month a sample of algae will be collected from each plot to identify the species of algae present. Algal samples will be stored in zip-lock bags, labeled and identified by WAS.

At each plot location the following spot water quality parameters will be recorded using a YSI EXO1 sonde at the substrate: water temperature, conductivity, dissolved oxygen, pH, chlorophyll, and phycocyanin. View WQ parameters on the dashboard screen and hit "capture data" to record readings when they stabilize (40 seconds). Go to data files and scroll down list to the most recent (time is recorded in file name) to view captured readings. **Record these numbers on data sheet.** All sensors will be calibrated at the beginning of each month and checked on Monday morning of each week (QC under settings) to ensure that unit is within calibration specs. The water depth will be recorded to the tenth of a meter (EXO Sonde). Surveys should be conducted as close to dawn as possible and the order of sample sites rotated each time.
SPAT samplers should be deployed near each bank at each sampling location (Brunswick, Point of Rocks, and Whites Ferry) to document the presence of algal toxins if/when a bloom develops.

This study will continue for at least three years and the data will be summarized at the conclusion of the study. Methods and anaylsis of macroinvertebrate/water quality data is presented below. Samples will be identified and metrics calculated for individual plots to account for differences that may result from tributary influence.

Macro-Invertebrate Data

Introduction

Benthic macroinvertebrate populations are currently, and have historically, been utilized to assess water quality (Barbour, et al. 1999). Individual adaptations of aquatic macroinvertebrate life cycles and a species tolerance of organic pollutants can reflect the health of the environments they live in (Barbour, et al. 1999).

This benthic study was initiated as a basic measure of environmental quality and the relationship both spatial and temporal changes may have on water chemistry and the invertebrate community compositions. The objective of this year's invertebrate sampling was to establish a monitoring program for the Potomac River to better assess the decline of important species and determine potential ecosystem stressors.

Methods

Macroinvertebrate samples were collected and analyzed using the procedures outlined in the Study IV general methods section.

Due to habitat restrictions, standard sampling methodology (3 – 30 second kick samples) was changed for one survey point. White's Ferry Virginia shoreline was sampled using jab collection techniques; therefore, it was excluded from these analyses.
20, 1 foot jabs were conducted. Jab technique varied depending on the specific and available habitat. Submerged vegetation was sampled using a 1 foot upward thrust of the 600-micron mesh D-net. This was repeated until 20 thrusts were accomplished. Woody debris was sampled by placing the D-net downstream of the wood. A 1 square foot swipe with a gloved hand was performed ensuring that the dislodged objects and invertebrates were collected into the D-net. Frequently, combinations of both methods were utilized to attain 20 jab samples. Hereafter, all sample contents were processed identically to the methods previously described.

2-WAY ANOVA – Two-way analysis of variance was conducted to determine if habitat conditions differed among months (June/July vs. August/September) and locations (VA shore, MD shore, and the river center). Habitat conditions were summarized with a score produced using principal components analysis (PCA) of the environmental data recorded during this study. Two sets of scores were produced, each set representing the first 2 principal components (or axes). The first 2 principal components were used because these components accounted for the majority of variance of the original dataset.

ANOVA: Single Factor – Single factor analysis of variance tests were performed to determine if there were significant differences for each water quality variable and macroinvertebrate index (see above) among locations (VA shore, MD shore, and the river center).

tTest: Two-Sample Assuming Unequal Variances – A t-test was used to determine whether water quality variables and macroinvertebrate indices differed between early summer (June/July) and late summer (August/September).

Confidence Intervals - All reported means are accompanied with confidence intervals. These intervals were computed at a 95% confidence level.

Principal Component Analysis (PCA) - A principal component analysis was performed on the water quality data in order to best determine the most important and/or significant gradients based on the entire data set (see also, Two-Way Analysis of Variance, above).

Nonmetric Multidimensional Scaling Analysis (NMDS) – A nonmetric multidimensional scaling analysis was performed on macroinvertebrate collection data to identify patterns of community association within the dataset.

PAST statistical software was used to compute PCA, NMDS, and 2-WAY ANOVA analyses (Hammer et al. 2001).

Results/Discussion

A total of 36 samples were taken from June through September among the three different locations. A total of 9 samples were collected each month; one 20 m from each bank and one at river center, for a total of 3 samples per location per month. Sixty-two taxa comprised of 6452 individuals were collected, processed, and identified for this analysis.

Principal component analysis summarized the original environmental dataset to 2 unrelated axes that accounted for 61.6% of the variance of the original dataset. Of those, the first principal component (PC1) accounted for 39.3% of the variance in the original dataset and was highly associated with Chlorophyll *a*, phycocyanin, pH, and Dissolved Oxygen (Table 1). These variables illustrated a significant temporal change with different habitat conditions between early summer (June & July) and late summer (August & September)(Table 2). The second principal component (PC2) accounted for 22.3% of the variance in the original dataset. The PC2 was correlated with water temperature and conductivity (Table 1). Habitat conditions did not differ significantly among locations ($F = 2.298$, $P = 0.105$)(Table 3). However, additional analyses revealed a statistical difference in conductivity among survey points (ANOVA: Single Factor, $F = 8.395$, $P = 0.0004$).

Nonmetric Multidimensional Scaling Analysis (NMDS) of the macroinvertebrate community assemblage also indicated an important temporal change with strong seasonal relationships (55.7% of variance in the original community matrix). A very distinct separation was observed between the community composition of June and July versus August and September (Figure 2). Samples were first categorized as June and July or August and September, and the means of community diversity indices and HBI were compared for statistical significance using paired t-tests.

HBI values were significantly higher in June and July compared to August September, (Mean values = 5.23 (+/- 0.27) and 4.24 (+/- 0.32), respectively). This suggests greater concentrations of organic pollution in June and July. By proportion, fewer taxa of the EPT were collected in June and July, as well. Percent abundance of EPT taxa was greater in August and September than in June and July (t-test, $P = 0.0004$). Mean values for June and July were 49% (+/- 0.09) and 72% (+/- 0.09) in August and September. No statistical significance was detected for species diversity and taxa richness values.

Additional investigations were performed on relative abundances of functional feeding groups. No significant correlations were discovered for filtering macroinvertebrates; however, scraping invertebrates and phycocyanin concentration showed a positive relationship (correlation = 0.57). Scraper numbers were significantly higher in June and July (30% +/- 0.1) than August and September (10% +/- 0.05)(t-test, t-stat = 5.09, $P = 0.00007$). Phycocyanin concentrations followed a similar temporal pattern to the relative abundance of scrapers. There was a significant difference in phycocyanin concentration June/July (0.45 +/- 0.02) and August/September (0.37 +/- 0.03)(t Test, tstat = 4.74, $P = 0.00003$). These findings suggest a significant and potentially dependent relationship between the relative abundance of scrapers and phycocyanin concentrations. Scrapers consume unicellular algae on the substrate.

The survey design is sufficient for detecting trends in macroinvertebrate communities and trends that likely relate to changes in nutrient loading (i.e., chlorophyll *a*, phycocyannin). Results this year will serve as a baseline reference for future data collections and analyses. Environmental conditions did not result in nuisance blue-green algae blooms. The 2013 data will be used for comparison in subsequent years should algal blooms occur. Data comparisons will then be made to determine the possible ramifications of nuisance algae blooms in the nontidal Potomac River. Future surveys and analyses should enable more specific conclusions from water chemistry and macroinvertebrate communities on both a spatial and temporal scale. It is speculated that during intense or prolonged benthic algal blooms, scraper taxa should dominate the macroinvertebrate assemblages and the proportion of EPT will be depressed to at least levels noted in June and July of this study.

Table 1. Principal Component Analysis Axes Loadings. Chlorophyll A and phycocyanin data were linearly transformed prior to analyses in order to obtain a normal distribution.

	Principal Component 1	Principal Component 2
Temperature	-0.10149	0.62169
Conductivity	0.28631	0.51061
Dissolved Oxygen	0.45831	-0.32153
pH	0.46327	-0.18034
Depth	-0.13231	-0.40458
Chlorophyll A	-0.48614	0.03113
Phycocyanin	0.47877	-0.22853

Table 2. 2-WAY ANOVA, PC1 (Nutrient Loadings Axis).

	Sum of sqrs	df	Mean square	F	P
Transect:	0.81261	2	0.406307	0.1988	0.82
Time:	83.2066	1	83.2066	40.71	< 0.0001
Interaction:	2.22775	2	1.11388	0.545	0.5815
Within:	208.46	102	2.04372		
Total:	294.707	107			

Table 3. 2-WAY ANOVA, PC2 (Conductivity/Temperature Axis).

	Sum of sqrs	df	Mean square	F	P
Transect:	7.17003	2	3.58501	2.298	0.1056
Time:	0.1412	1	0.141202	0.09053	0.7641
Interaction:	0.40483	2	0.202413	0.1298	0.8784
Within:	159.096	102	1.55976		
Total:	166.812	107			

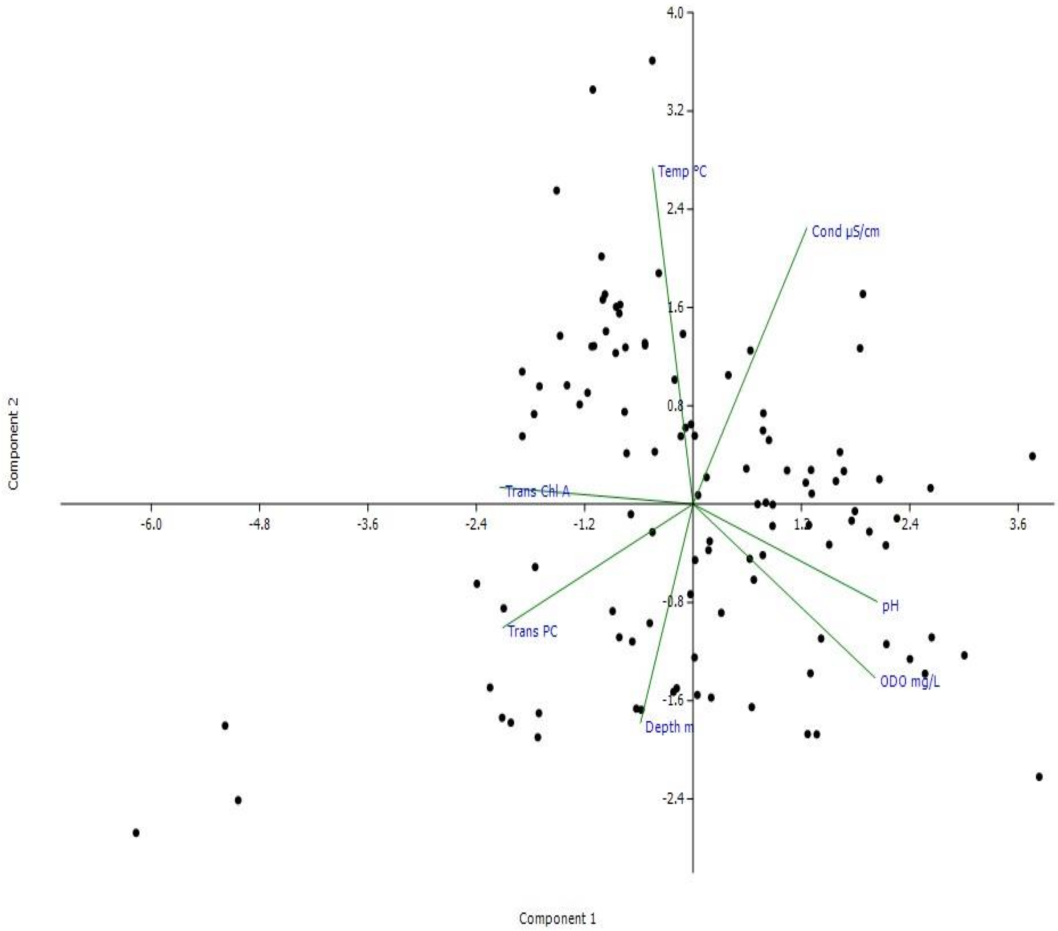


Figure 1. Scatter Plot of Principal Component Analysis (PCA) for water chemistry variables. Component 1 (X axis) is represented by dissolved oxygen, pH, chlorophyll-*a* and phycocyannin. Component 2 (Y axis) is represented by conductivity and temperature. Water chemistry data was collected from three cross-sectional sampling points at three separate geographic locations within the Potomac River from June – September. Each point illustrated on the PCA represents a single collection. Chlorophyll *a* and phycocyanin data were linearly transformed to achieve a normal distribution; therefore, TransPC and TransChl A indicate these respective values on the scatter plot.

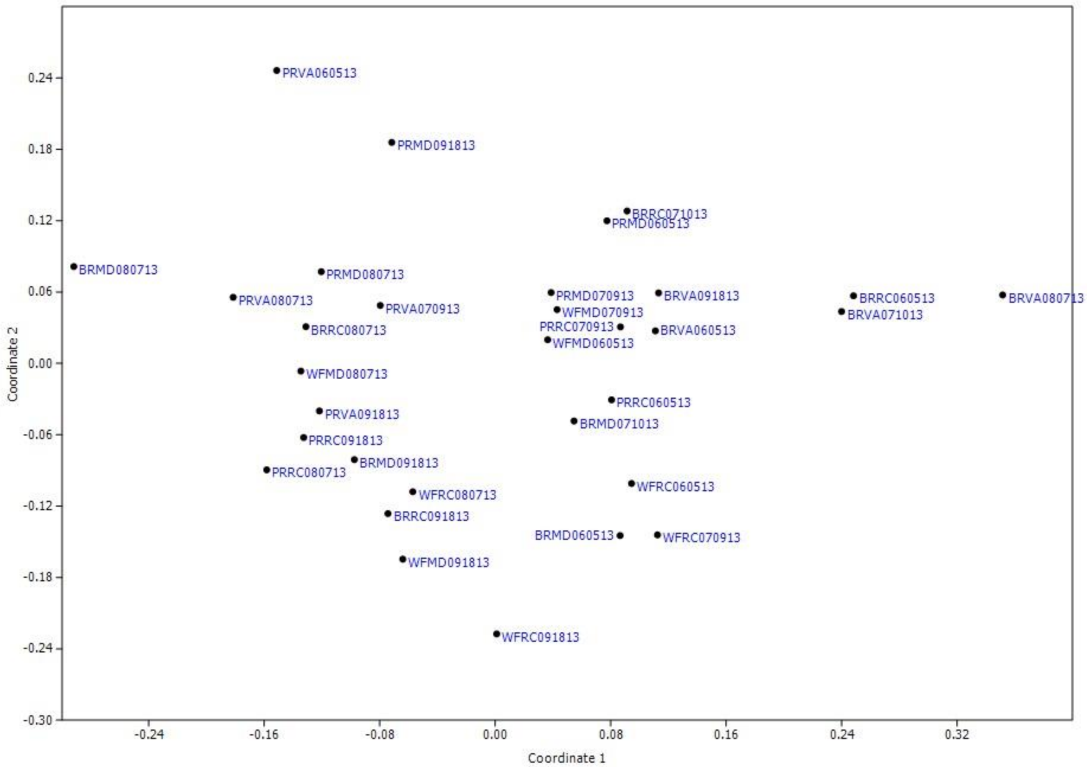


Figure 2. Nonmetric Multidimensional Scaling Analysis (NMDS) of macroinvertebrate community composition. Each point represents one composite sample of 3-30second kicks for the respective date and location. WF = White's Ferry, PR = Point of Rocks, BR = Brunswick; MD = Maryland shoreline, RC = River center, VA = Virginia shoreline. Numerals correspond with dates (MMDDYY).

Monocacy River – Progress Report

Introduction

The Monocacy River is the largest Maryland tributary to the Potomac River with a watershed that encompasses nearly 251,230 hectares. Originating near the Pennsylvania line and formed by the junction of Marsh and Rock Creeks, the Monocacy flows south 93 km to its confluence with the Potomac River near Dickerson, MD. Varying in width from 12 m (40') to 114 m (375'), the Monocacy flows gently with an average gradient of 3 percent. During runoff events turbidity becomes very high.

A significant fish kill involving mostly adult Smallmouth Bass and sucker species occurred throughout the Monocacy during late May, 2009. The characteristics of this fish kill were similar to other fish kills that have occurred throughout the Potomac watershed in recent years (Blazer, et al., 2010).

Electrofishing surveys to assess adult Smallmouth Bass were last conducted on the Monocacy in 2012. Management activities conducted during 2013 included seining to assess reproduction of fish species, electrofishing to assess adult Smallmouth Bass, and recording basic water quality parameters with the following objectives:

- determine the relative abundance of young-of-year Smallmouth Bass as a means of evaluating yearclass strength
- estimate Smallmouth Bass and Redbreast Sunfish density, standing crop, and size structure at two sites, one within the Catch-and-Release area and one in the Statewide regulation area to evaluate the recovery of the Smallmouth fishery to the spring 2009 fish kill.
- record basic water quality parameters

Methods

The relative abundance of YOY black bass was determined by seining and electrofishing following the methods outlined in Study IV. To evaluate adult fish stocks, a population estimate for stock, quality, and preferred-length Smallmouth Bass was obtained using the method described by Zippin (1958) following the procedures outlined in Study III. Two sites were sampled, Criss Ford Road in the lower river (catch-and-release bass fishing area) and at Route 77 in the upper river (statewide bass fishing regulation). Three inflatable pontoon barges equipped with Smith-Root 2.5 GPP units using two anodes each were used in wadeable areas to fully cover the width (Route 77 mean width 41 m, Criss Ford Road mean width 53 m) of a larger, warmwater river. Electrofishing was found to be most effective using pulsed (60pps) DC current; voltage was adjusted for maximum shocking efficiency; shocking time was automatically recorded. Population indices for Smallmouth Bass were obtained using the methods described in the Study IV general methods section. Water quality data was recorded at each sample site using an EXO1 Sonde/handheld unit manufactured by YSI Incorporated. The four port sonde was outfitted with sensors for conductivity, temperature, pH, dissolved oxygen, and total algae. The total algae sensor measured both chlorophyll A and phycocyanin in µg/L.

Results and Discussion

Smallmouth Bass Reproduction

Maryland Inland Fisheries has utilized haul seine surveys conducted during July to measure the relative abundance of Potomac River YOY Smallmouth Bass and yearclass strength since 1975 (MD DNR 1980). Seining has also been used to measure YOY abundance on the Monocacy since 1997. The relative abundance of YOY Smallmouth Bass has been highly variable ranging from a geometric mean of 1.1 (1.0 – 1.4) YOY/haul in 2009 to a record high 8.4 (4.3 – 16.4) YOY/haul in 2007. The long-term median (1997 – 2013) was 1.9 YOY/haul; the geometric mean number of YOY/haul recorded in 2013 (1.2 YOY/haul) fell well below the long-term median value (Figure 1). High water levels and turbidity are believed to have resulted in poor fry survival. A linear regression of the data suggests a positive trend during the last 16 years, however, the trend was not significant ($P = 0.658$, lower 95% = -0.158, upper 95% = 0.242). Smallmouth Bass reproduction has been sufficient to maintain a desirable fishery.

Adult Smallmouth Bass Population

A substantial fish kill occurred in the upper Monocacy River during May, 2009 following a high water event. The kill primarily affected adult Smallmouth Bass and sucker species. To date, no single, specific biological or chemical "cause" for the mortality has been identified, despite much research by state, federal and other investigators. Population estimates determined during the fall of 2008 and 2009 using barge-mounted electrofishing equipment documented declines in adult Smallmouth Bass biomass and density near 60% (Maryland DNR, 2011). Depletion surveys using barge equipment to obtain population estimates were scheduled for the fall of 2012, but high flows prevented this method of sampling. Conditions were favorable for conducting depletion surveys in 2013 and three-pass depletion surveys were completed during September at the two established sites.

Results of the 2013 depletion surveys suggest that the Monocacy River Smallmouth Bass population has recovered from the 2009 fish kill (Table 1). Further, the 2013 survey documented biomass and density values that were significantly ($\alpha = 0.05$) higher than pre-fish kill values recorded in 2008 for bass ≥ quality size (Table1). Smallmouth bass biomass estimates averaged 31.7 kg/ha in an Iowa river (Paragamian 1984) and 28.1 kg/ha in a Minnesota stream (Waters et al. 1993). Smallmouth bass total biomass estimates (adult + YOY) averaged 8.6 and 9.3 kg/ha in the Rappahannock and James Rivers (Odenkirk, Smith, 2005). Standing crop values reported in 2005 and 2010 from depletion surveys conducted at three sites on the lower and upper New River, Virginia ranged from 5.3 kg/ha to 48.7 kg/ha with a mean of 14.1 kg/ha (John Copeland, Virginia Dept. of Game and Inland Fish, personal communication). Smallmouth Bass biomass estimates from the Monocacy River compare favorably with other mid-Atlantic rivers.

Relative weight values remained relatively unchanged and are similar to values recorded from other Maryland populations within the Potomac watershed.

Even though the biomass and density of Smallmouth Bass showed significant declines following the fish kill, the size distribution of stock size and greater Smallmouth did not (Table 2) (Figure 2). A Kolmogorov-Smirnov test of the 2008 and 2009 distributions showed no significant difference at the 95% confidence level ($D = 0.1002$, $P = 0.315$). This suggests that the stock and quality segments were affected equally by the fish kill. However, the larger percentage of Smallmouth ≥ quality size in the 2013 survey (Figure 2) resulted in a slightly significant difference between the 2009 post-fish kill distribution and the 2013 distribution ($D = 0.1817$, $P = 0.005$). The PSD value is within the range recommended by Anderson and Weithman, (1978) for a balanced population. PSD and RSD_{350} values for the Monocacy were similar to mean values reported for 20 riverine populations in Tennessee (Fiss et al., 2001) and should be providing a size distribution attractive to anglers.

Redbreast Sunfish

Little population data has been collected for lotic Redbreast Sunfish populations in Maryland. To obtain baseline population data for Redbreast Sunfish in the Monocacy River, this species was also collected during the depletion surveys and population parameters determined.

With no prior population data available for Monocacy River Redbreast Sunfish, the 2013 Monocacy data was compared with Redbreast Sunfish population data collected from depletion surveys conducted in Conococheague Creek during 2010 (Table 3). The area sampled during depletion surveys was similar in both rivers. However, standing crop and density values were several orders of magnitude greater in the Monocacy. Standing crop values reported in 2005 and 2010 from depletion surveys conducted at three sites on the lower New River, Virginia ranged from 0.3 kg/ha to 16 kg/ha (John Copeland, Virginia Dept. of Game and Inland Fish, personal communication).

The size distribution of the Redbreast Sunfish in the Monocacy River (2013) was significantly ($\alpha = 0.05$) different than the size distribution found in Conococheague Creek during 2010 (Kolmogorov-Smirnov test $D = 0.1341$, $P = 0.005$),(two tailed t-test, $t = 4.48$, $P = 9.7E\text{-}06$). This difference was due to a greater proportion of fish in the stock – quality increment and fewer fish in the quality – preferred increment (Figure 3) for the Monocacy distribution. Only one individual ≥ preferred length was collected from the Conococheague and none were collected from the Monocacy. Depletion surveys conducted by the Virginia DGIF at three locations on the lower New River in 2005 and 2010 as well as four sites on the James River in 2002 and 2007 did not collect any Redbreast Sunfish ≥ preferred length (John Copeland and Dan Goetz, Virginia Dept. of Game and Inland Fish, personal communication). Personal communication with Steve Reeser (VDGIF) revealed that the RSD_{200} for Redbreast Sunfish collected during 2007 depletion surveys at the Compton, Newport, and Island Ford sites in the Shenandoah watershed were 0, 0.6, and 0.8, respectively. The combined results in Maryland and

Virginia suggest that sunfish ≥ preferred length are not common in mid-Atlantic warmwater rivers.

Basic water quality parameters were recorded at each site during the summer YOY surveys. Values were consistent among sites and similar to values recorded during previous years. Values of chlorophyll-a (0.63 – 1.86 µg/L) during 2013 remained within the reference range of 0.05 - 5.74 for rivers and streams within EPA ecoregion 9 (EPA, 2000).

Management Recommendations

- Continue annual seining surveys to determine Smallmouth Bass yearclass strength and monitor abundance of forage species.

- Conduct a depletion survey at two sites during 2015 to obtain population estimates for Smallmouth Bass and Redbreast Sunfish. Conduct surveys during the late summer or early fall (water temperature > 15.5 °C) in the upper and lower river to monitor the adult Smallmouth Bass and Redbreast Sunfish size structure (PSD, RSDP), abundance (biomass, density), and physical condition (Wr).

- Collect scale samples from Smallmouth Bass and Redbreast Sunfish to obtain age and growth data and determine mortality rates. At least five samples should be collected from each 2 cm length group less than quality size and from all fish ≥ quality size.

Table 1. Comparison of standing crop and density of Monocacy River Smallmouth Bass collected at two sites (combined) pre and post fish kill by multiple-pass electrofishing during 2008, 2009, and 2013 at the 95% CL. Total is all Smallmouth Bass age 1+ and older.

Site	**Pre Fish Kill**	**Post Fish Kill**	**Post Fish Kill**
Year	**2008**	**2009**	**2013**
Hectares	2.7	3.3	3.0
Mean Weight (kg)			
Total	0.14	0.15	0.15
Stock +	0.22	0.20	0.26
Quality +	0.46	0.41	0.48
Preferred +		0.69	0.75
Standing Crop (kg/ha)			
Total	**27** (25 – 30)	12 (10 – 13)	**26** (24 – 29)
Stock +	**22** (21 – 24)	11 (9 – 14)	**22** (20 – 24)
Quality +	**10** (9 – 10)	3 (2 – 4)	**14** (12 – 15)
Preferred +	**3** (3 – 4)	0	**5** (4 – 7)
Density (bass/ha)			
Total	**193** (178 – 209)	80 (69 – 90)	**179** (163 – 195)
Stock +	**99** (92 – 106)	56 (45 – 68)	**86** (80 – 92)
Quality +	**21** (20 – 23)	8 (6 – 10)	**29** (25 – 32**)**
Preferred +	**5** (4 – 5)	0	**7** (5 – 9)
Wr			
Substock	97	89	92
Stock	91	89	88
Quality	88	90	87
Preferred	81	88	89

Table 2. Comparison of Monocacy River Smallmouth Bass size distribution data collected by barge electrofishing pre and post fish kill by multiple-pass electrofishing during 2008, 2009, and 2013 at the 95% CL.

Year	2008	2009	2013
PSD	24 (18 – 29)	16 (10 – 22)	34 (28 – 40)
RSD_{35}	5 (3 – 8)	1 (-1 – 2)	8(5 – 12)
RSD_{43}	< 1	0	< 1
$ISD_{S\text{-}Q}$	76%	84%	66%
$ISD_{Q\text{-}P}$	18%	15%	26%
$ISD_{P\text{-}M}$	5%	1%	8 %

Table 3. Comparison standing crop and density of Redbreast Sunfish collected from Conococheague Creek and the Monocacy River at two sites (combined) by multiple-pass electrofishing at the 95% CL.

Site	Conococheague	Monocacy
Year	**2010**	**2013**
Hectares	3.1	3.0
N	188	1190
Mean Weight (kg)		
Stock +	0.052	0.039
Quality +	0.093	0.079
Preferred +	0.175	-
Standing Crop (kg/ha)		
Stock +	4 (3 – 4)	17 (17 – 18)
Quality +	2 (1-2)	7 (6-7)
Preferred +	-	0
Density (sunfish/ha)		
Stock +	69 (62 – 76)	441 (427-455)
Quality +	18 (16 – 20)	85 (81-89)
Preferred +	< 1	0
Wr		
Stock	99	92
Quality	95	85
Preferred	92	-

Table 4. Monocacy River water quality data collected during the 2013 summer seining surveys by site. 95% CL.

Date	Site	Temp °C	Cond. μhms/cm	D.O. mg/L	pH	Hard. mg/L	chloroA μg/L	PC μg/L
7/15	Mon. Blvd	27.9	393	8.3	7.6	188	0.78	0.03
7/15	Pinecliff	26.4	397	7.8	7.7	171	1.86	0.08
7/15	Buckeys.	26.7	467	7.5	7.6	188	1.07	0.03
7/15	Criss Ford	27.3	468	7.8	7.6	188	0.63	0.03
7/15	Rt 28	25.4	394	7	7.5	171	1.08	0.06
7/16	Rt 77	27.6	388	8.8	7.9	171	1.12	0.13
7/16	Rt 550	28.6	369	7.7	7.8	154	0.97	0.08
7/16	Devilbiss	28.4	362	8	7.8	154	1.02	0.06
Mean		**27.3**	**405**	**7.9**	**7.7**	**173**	**1.1**	**0.1**

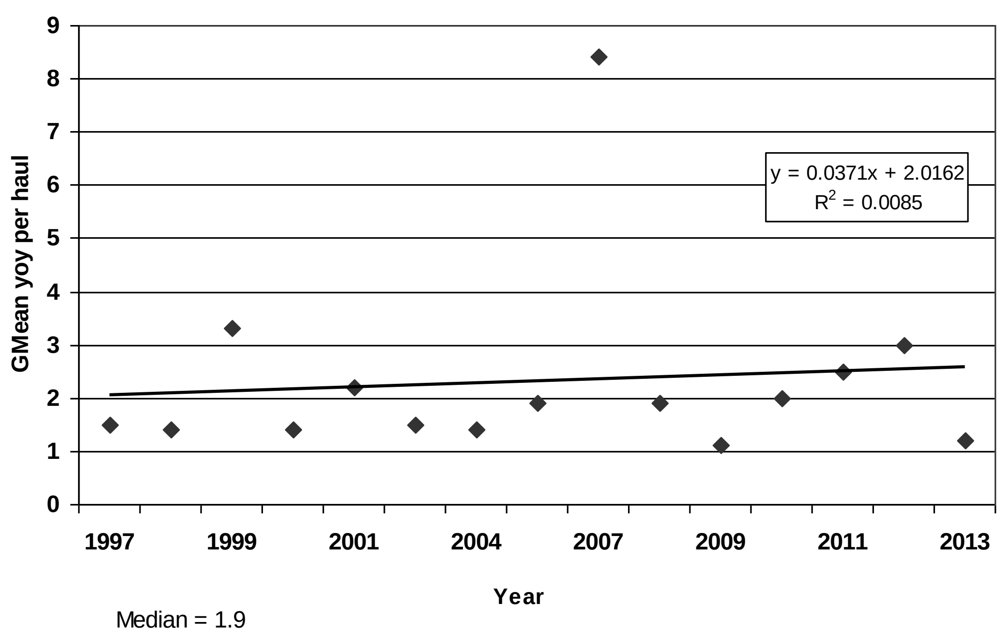


Figure 1. Relative abundance expressed as the geometric mean number of Smallmouth Bass YOY per seine haul from the Monocacy River 1997 – 2013. Linear regression P = 0.658, lower 95% = -0.158, upper 95% = 0.242.

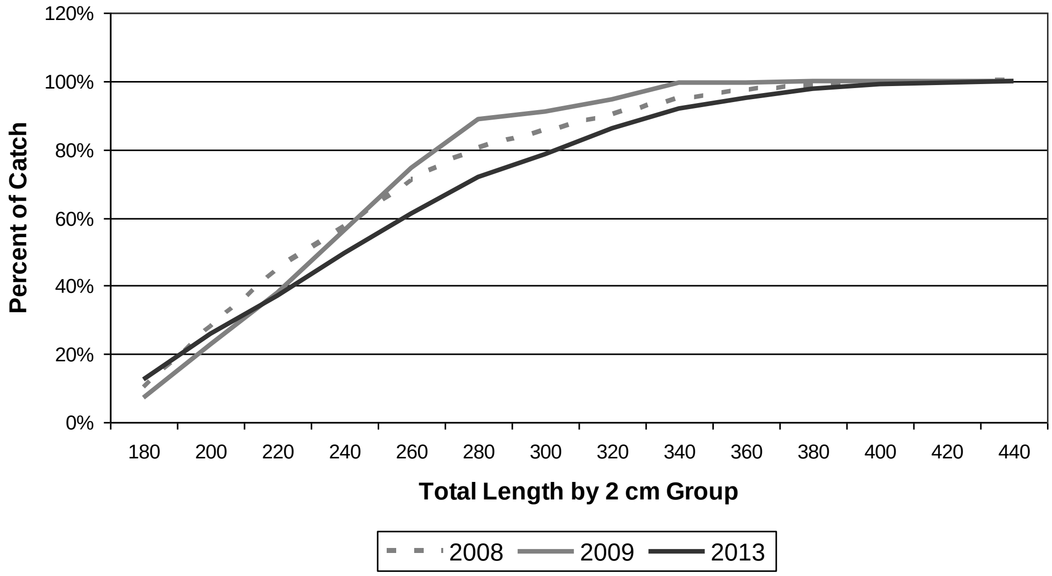


Figure 2. Cumulative percent of Smallmouth Bass ≥ stock size in catch by 2 cm length group collected by barge electrofishing from the Monocacy River during depletion surveys in 2008, 2009 and 2013. 2008 N = 241, 2009 N = 142, 2013 N = 234.

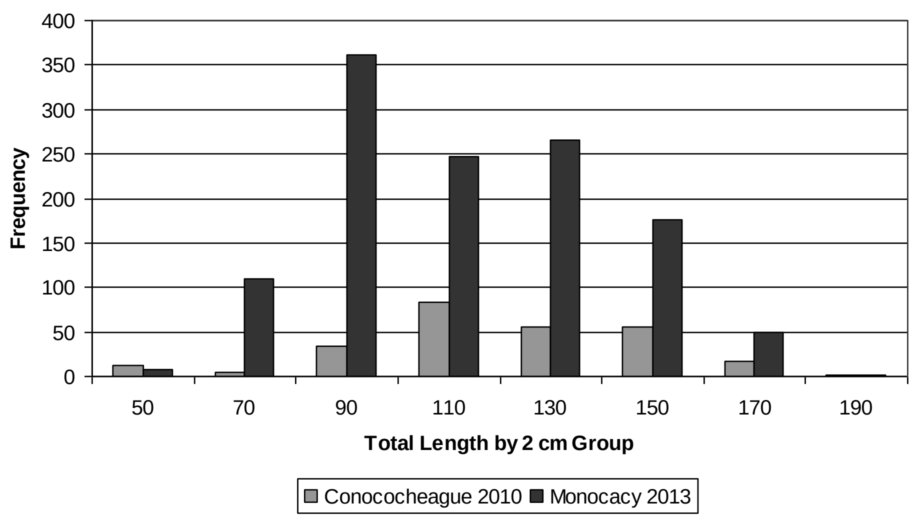


Figure 3. Length frequency of Redbreast Sunfish collected by electrofishing during 3-pass depletion surveys from Conococheague Creek (2010) and the Monocacy River (2013). Conococheague Creek N = 264, Monocacy River N = 1217.

ANNUAL PERFORMANCE REPORT

2013

Maryland Department of Natural Resources
Fisheries Service
Inland Fisheries Division

SURVEY AND MANAGEMENT OF FRESHWATER FISHERIES RESOURCES

Management of Maryland's Tidal Freshwater Streams

Study V

USFWS Federal Aid Grant F-48-R-23

by

Joseph Love
Brett Coakley
Mary Groves
Tim Groves
Richard Schaefer
Jerry Stivers
Branson Williams
Ross Williams

Table of Contents

Management of Maryland's Tidal Freshwater Streams

Adult Population Assessment E3

Juvenile Abundance Surveys E35

Hatchery Contribution E43

Tournament Creel Surveys E46

Population Genetics Assessment E57

State: Maryland

Project Number: F-48-R-17
Study No.: V
Job No.: 1

Project title: Survey and Management of Freshwater Fisheries Resources
Study Title: Management of Maryland's Tidal Freshwater Streams
Job Title: Population Assessment

Introduction

Largemouth Bass (*Micropterus salmoides* (Lacepède 1802)) is arguably the most popular sportfish of inland waters. While originally restricted to the southeastern United States, the species has been widely introduced throughout the United States and worldwide since the 1800's. Interest in competitive fishing for largemouth (and other *Micropterus* spp.) has been invigorated over the past 40 years by large tournament sportfishing organizations. As a result of its popularity, researchers across the nation have instituted programs to monitor and stock Largemouth Bass throughout waterways. Because of the popularity and widespread introduction of Largemouth Bass, the scientific literature is replete with information on life history and ecology, evolution, and fishery management for the species (Philipp and Ridgway 2002).

In the Chesapeake Bay watershed, several tidal drainages have been stocked repeatedly with Largemouth Bass and each tidewater population is currently considered a separate management unit. The tidewater drainages assessed in 2013 included: Potomac River, Patuxent River; upper Chesapeake Bay; Choptank River; Marshyhope Creek (Nanticoke River); Wicomico River; and Pocomoke River (Fig. 1).

The metrics used to assess the populations have been described in a Fishery Management Plan for Tidal Black Bass. Traditionally, relative abundance has been used to monitor populations for problems. Average relative weight of individuals was also measured and reflects the fattiness or robustness of fish in a population. While relative weight is often touted as an easy means to simply quantify the fattiness of a fish, relative weight is also related to fish health, reproductive condition, and survivorship. Lower survivorship of many individuals leads to a decline in population size. It follows that anglers cannot catch fish as frequently, which threatens fisheries for sport fish. Additional measures have been developed to help forecast changes in populations before a decline becomes chronic. For instance, changes in the size or age structure of populations might indicate future changes in reproduction or survivorship. The proportional size distribution (PSD) is a common index that quantifies size structure for Largemouth Bass (Guy et al. 2007; Quist et al. 2009). The PSD that is commonly measured includes the relative proportion of 305 mm (12 inches) total length (TL) and 381 mm (15 inches) TL. The PSD_{381} measures the relative abundance of older, larger and more fecund fish in the population.

Population assessments were conducted along with an assessment of habitats. In addition, work was preformed to address the spread and/or impact of invasive Northern

Snakehead (*Channa argus*) and Blue Catfish (*Ictalurus furcatus*) in tidewater areas. Maryland Department of Natural Resources (MDDNR), Inland Fisheries has received reports of Blue Catfish occupying the tidal portion of the Potomac River for many years. However, Northern Snakehead is a recent invader to the Potomac River and may pose a threat to Largemouth Bass populations (Love and Newhard 2012).

Objectives

1. Within the framework of the Fishery Management Plan, compare indices for catch, PSD, body condition, and growth rates to assess the status of Largemouth Bass populations from targeted tidal drainages of the Chesapeake Bay watershed;
2. Summarize habitat conditions among targeted drainages.
3. Calculate and identify trends of relative abundance of Northern Snakehead and Blue Catfish.

Methods

Tidal Bass Survey. Largemouth Bass was sampled in targeted drainages using a stratified, random design (Markham et al. 2002; Love 2011). Sampling occurred during fall (September – November). The sampling data were used to develop drainage-specific indices that reflect the population status of Largemouth Bass.

At each site, approximately 250 m was sampled for Largemouth Bass using boat electrofishing. In most cases, the amount of time that electricity was applied to water at each site was at least 250 seconds. When stunned, Largemouth Bass was removed from the electric field and allowed to recover in a live well with well-aerated and re-circulating water. Once the site had been sampled thoroughly, Largemouth Bass was counted, measured to total length (in mm), and weighed (in grams). Largemouth Bass was then released to their site of capture.

Habitat conditions just prior to time of sampling were recorded by measuring the variables: water temperature (°C), specific conductivity (µS), dissolved oxygen (mg/L), water clarity (as a Secchi depth in meters), and minimum and maximum depth (in meters). Some of these variables affected the ability to catch Largemouth Bass and were used in models to remove their influence on catch statistics (see below).

Population Indices. Drainage-specific indices that described the demography of Largemouth Bass populations included: 1) catch per electrofishing hour (CPUE) and CPUE corrected for sampling conditions (see below); 2) proportional size distribution (PSD; Guy et al. 2007) for legally harvested or “quality” fish (305 mm) and “preferred” fish (381 mm); 3) instantaneous mortality (Z); 4) growth rates (GR) computed from the von Bertalanffy growth function (VBGF) and an exponential rise model fitting length data to age; 5) the slope of the relationship of mass to length (L-W slope); and 6) relative weight (W_r) and relative condition (K_n).

The number of fish caught at a site may depend on effort as well as habitat conditions. The CPUE was standardized for effort and environmental factors that affect estimates of catch (Stefánsson 1996; Campana et al. 2006). These environmental factors included: specific conductivity, water clarity, and water temperature. The value is the product of: 1) the probability of encountering the species given the effort and environmental conditions; and 2) the number of fish expected to be caught given the environmental conditions.

The PSD_{305} and PSD_{381} are fishery important indices that represent the proportion of the sample that is legally catchable. The PSD_{305} and PSD_{381} were calculated by dividing the number of fish greater than or equal to 305 and 381 mm TL, respectively, by the total number of fish that were not juveniles (> 200 mm TL).

Instantaneous mortality (Z) is computed using catch-curve analysis, which is the regression of the number of each age cohort (transformed by the natural log) against older age cohorts (2+ years). The slope of the regression is Z. Age was estimated from a length-at-age key that was developed by aging Largemouth Bass from tidal drainages of the Chesapeake Bay (Isermann and Knight 2005). Annual mortality (A), or the proportion of individuals that die annually, was computed from Z as: $1 - e^{-Z}$.

Growth rate was computed from von Bertalanffy growth functions (VBGF) fitting length-at-age data with a least-squares approach. Because growth is seasonal and periodic, the von Bertalanffy growth function was modified following Cloern and Nichols (1978). The form of the model where x = age (in years), is: total length =

$$L_\infty - (L_\infty - L_o) * \exp((-k * (x - t_o)) - (((180 * k) / \pi) * (\cos((\pi * (t_o)) / 180) - \cos((\pi * (x)) / 180))))$$

Growth rate was also computed from an exponential rise (EXPrise) model fit to length-at-age data. The form of the model is $y = \text{intercept} + a*(1-B^x)$, where x = age and y = length. Because changes in length-at-age greatly diminish after age 4, growth rates (i.e., difference in length between ages) were computed and averaged between successive ages for ages 1 – 3.

To determine and compare the rate at which mass increased with length, length data were fit to mass using a linear regression model. The slope of the regression was the slope of the length-weight relationship (L-W slope).

The relative weight at length was computed relative to that weight expected from national models developed for populations throughout the United States (Wege and Anderson 1978; Henson 1991). Relative weight (W_r) of an individual measures its robustness or girth and may be indicative of fish health. If a fish's robustness was exactly that expected nationally, then $W_r = 1$. Values greater than 1 indicate that the fish exceeds that expected from national standards. As stressed by Cone (1989), W_r assumes isometric growth that is not appropriate for widely distributed species. The W_r may be biased because they assume that the slope of the length-weight relationship is 3.0. Therefore, a second index that is directly related to the parameters of the length-weight relationship may be more accurate (Cone 1989). It is condition relative to the population within the targeted river drainage.

Reference Points. Reference points for the aforementioned indices have been developed for Potomac River, Chester River, Choptank River, and upper Chesapeake Bay because a suitable, 10-year reference database existed. The reference points were the 25th and 75th percentiles. If a 2012 index estimate was less than the 25th percentile, then it was considered below average. In contrast, if the estimate was greater than the 75th percentile, then it was considered above average. If the index was between the two reference points, then no change (nc) was noted. Other, more general reference point-estimates were also obtained from the literature (Calder 1996; Ridgway 2002; Bonar et al. 2009; see Tidal Bass Fishery Management Plan).

Invasive Species Assessment. **Northern Snakehead**.—During the survey, Northern Snakehead was captured, measured, and killed. The number of Northern Snakehead per electrofishing hour was computed as a CPUE (as above). This CPUE served as an index of relative abundance and was compared to earlier years. The first Northern Snakehead was captured during the survey in 2006. In addition to CPUE, the relative proportion of sites with Northern Snakehead was calculated. This value was also compared with estimates from earlier years.

In Nanjemoy Creek, the population size and habitat preferences of Northern Snakehead were assessed by marking and recapturing fish every 2 weeks from March until October. This work was conducted in collaboration with other agencies (U.S. Fish and Wildlife Service Maryland Fishery Resources Office, D.C. Fisheries, and Virginia Department of Game and Inland Fishes). While several methods were attempted to estimate population size, two were used to provide estimates: a constant capture and recapture probability model and a Schnabel model.

Blue Catfish.—From October 2008 through August 2013, a Smith-Root SR 18 electrofishing boat equipped with a 9,000 Watt generator was used to collect Blue Catfish from the tidal Potomac River to examine gut contents. During the colder months of 2012 and 2013 fish were collected by hook-and-line because some studies indicate electrofishing efficiency decreases when water temperatures dip below 18° C (Morris and Novak, 1968, Quinn, 1986, Justus, 1996). Jug lines with double hooks were also used in 2013 to determine their effectiveness in shallow water. All samples were collected between the Woodrow Wilson Bridge and Chicamuxen Creek (approximately 40.2 km or 25 miles south of Washington DC). Sampling areas were known locations that attract Blue Catfish or were selected by the presence of fish indicated by a boat mounted Humminbird 798ci HD si Shiner. Water depths ranged from 0.9—20 m (3—65 ft) and varied with collection method. In 2008 and 2009 stomach contents were extracted using a gastric lavage method adapted from a technique used on Largemouth Bass in St. Mary's Lake (California, MD) (MDDNR, 2003). Later samples were collected from euthanized fish. Fish were kept on ice once captured to slow digestion. Fish length (total and forked length, mm), weight (g or kg), sex, maturity, and stomach contents were determined at the end of each sampling day. A portion of unknown gut contents were frozen and delivered to biologists at the Smithsonian Environmental Research Center (SERC) for identification via DNA bar coding (2012 & 2013).

Gut contents were recorded and separated into fish and non-fish prey items. Blue Catfish were categorized by season (Spring, Summer, Winter, Fall) and size groups suggested by Schloesser et al. (2011) based on preferred prey types: <306 mm (primarily invertebrates and some fish), 306-610mm (transition into primarily fish), and >610 mm (primarily piscivorous). Previous DNR Inland Fisheries reports analyzed all prey items found in Blue Catfish (MDDNR 2012). Data in 2013 focused primarily on Blue Catfish piscivory from 2009 – 2013; so fish less than 306 mm were excluded from final diet analysis.

Results and Discussion

General. There were 514 Largemouth Bass were collected from targeted drainages of the Chesapeake Bay watershed. Fish ranged in size from 42 mm – 555 mm TL (4 g – 3160 g) and averaged 303 mm TL (628 g)(Fig. 2). The slope of the length-weight relationship for all fish was 2.89 (Fig. 3), which is similar to a reference point of 3.0.

Notable catches during the tidal bass survey included Northern Snakehead (*Channa argus*). Unlike 2012, Red Drum (*Scienops ocellatus*) was not common; in fact, it was not collected.

Habitats in 2013 tended to be oligohaline and had fairly neutral pH levels, except Pocomoke River (Table 1). The acidic and somewhat hypoxic water of Pocomoke River has been common for many years. Water clarity was fairly similar among all tidewater areas, but highest for Potomac River and lowest for Gunpowder River, which was surveyed during spring.

Current Assessments. **Upper Chesapeake Bay—**There were 135 Largemouth Bass collected from the upper Chesapeake Bay. These fish ranged from 103 mm to 555 mm in total length (TL). Catch was lower than average. The CPUE and Cor-CPUE of the upper Chesapeake Bay were below average in 2013 (Figs. 4 and 5; Table 2). Size structure was similar to earlier years, but PSD_{381} was above average relative to reference points (Figs. 6 and 7; Table 2). An instantaneous mortality rate could not be determined because a linear model could not be fit to the dataset. Somatic growth and body condition for Largemouth Bass was not different from previous years (Table 2).

The catch estimates for 2013 were lower than expected, possibly because of fewer juveniles collected as well as survey conditions. The acreage of submerged aquatic vegetation (SAV) in 2012 was approximately half of that measured from 2010 data (VIMS 2012). Data for SAV coverage for 2013 is not yet available; if current levels are low as they were in 2012, then it could lead to either greater mortality of young-of-year or affect the distribution (and hence, catch) of Largemouth Bass in the survey. Very few

Largemouth Bass exhibited signs of disease, though hooking injuries were not uncommon for fish collected in Northeast River. While most Largemouth Bass appeared to be in good health and condition, additional testing of LMBV and monitoring of survivorship is warranted because of the increased attention toward the upper Bay fishery by competitive sportfish anglers.

Potomac River—There were 110 fish sampled from tidal freshwater reaches of the Maryland's Potomac River. The fish ranged in total length from 42 –465 mm TL. The CPUE estimate was lower than reference points (Figs. 4 and 5; Table 2). The PSD_{305} and PSD_{381} were above average (Table 2; Figs. 6 and 7), indicating that few subadults (< 305 mm) were collected. The change in catch does not appear to be related to lower survivorship. Instantaneous mortality rate was below average (Fig. 8; Table 2). Growth rates were lower for ages 1 – 3 than normal (Table 2) and body condition was likewise lower (Table 2).

The Potomac River population in 2013 exhibited some signs of stress whereby catch levels were low, the catch of subadults was low, the growth rates of subadults was low, and body condition tended to be lower than reference points. There has been a decline in catch for recent years (Fig. 4), which may be related to reduced levels of recruitment (see Job 2) or changes in sampling conditions. The acreage of submerged aquatic vegetation has been reduced by half between 2010 and 2012 and average density has increased (VIMS 2012). The distributional change in grasses may have affected the ability to catch fish or possibly reproduction. We cannot eliminate the hypothesis that the recent expansion of Northern Snakehead population has negatively affected recruitment and catch of subadults. Interestingly, the catch of Northern Snakehead (see below) in the survey has decreased for the first time in relative abundance and distribution, possibly a result of increased fishing pressure for the species.

Patuxent River— There were 87 fish sampled from tidal freshwater reaches of the Patuxent River. They ranged in total length from 86 – 485 mm TL. Catch estimates have not changed appreciably since 1999, but were greater in 2013 than the previous two years (Figs. 3 and 4). Size structure for the population is typical of that for reference populations (Table 2; Figs. 6 and 7). The instantaneous mortality rate ($Z = -0.64$) indicated lower survivorship than that for the reference ($Z = -0.57$). The greatest proportion of diseased Largemouth Bass collected during the survey was collected from Patuxent River (see below). Growth rates and condition factors were typical for the population and general reference point-estimates (Table 2; Figs. 9-10).

The Patuxent River population has benefitted from a fairly consistent stocking program. Catch estimates have not changed appreciably. Because size structure has been fairly stable and catch estimates have not remarkably increased despite intensive stocking, it's possible that the population has reached its carrying capacity. This population represents a small, but reasonably stable population for Largemouth Bass in the Chesapeake Bay watershed. It is currently being used to assess the contribution of hatchery stocking by releasing marked fish; a full evaluation should be completed by 2015.

Wicomico River—There were 39 fish sampled from tidal freshwater reaches of the Wicomico River. They ranged in total length from 82 – 505 mm TL. The catch from Wicomico River was typical of other years. The CPUE and cor-CPUE was slightly greater than that for 2012, but within the range expected from earlier surveys (Figs. 4-5). The PSD_{305} and $PSD_{381}$was greater than general reference point-estimates (Table 2; Figs. 6-7), indicating few age 1 or age 2 fish. While PSD_{305} declined relative to 2012, the PSD_{381} increased. More, older Largemouth Bass were collected in 2013 relative to 2012. The instantaneous mortality rate could not be determined because the data could not be fit to a linear model. Growth and condition were similar to reference points (Table 2; Figs. 9-10).

The population from Wicomico River may suffer from harvest or removal of older fish; however, several older Largemouth Bass were collected during this survey. The low catch level is also related to the inability to collect young fish (age 0 – age 2). resources appear reasonable to support growth and robust bodies (MDDNR 2011), the paucity of younger age classes may not be related to insufficient prey. Stocking conducted in 2012 may help bolster young age classes in this population, thereby contributing to a more sustainable population. It is anticipated that older Largemouth Bass collected during this survey will spawn and contribute to natural reproduction.

The suitable habitat for Largemouth Bass tends to be restricted to Salisbury on Wicomico River. The survey design was modified in 2013 to eliminate sites that were spread far downstream. This modification did not appear to influence the results of the survey. It did, however, allow for more efficient use of time.

Marshyhope Creek (Nanticoke River)—There were 95 fish collected from Marshyhope Creek. These fish ranged in total length from 70 mm to 486 mm TL. Catch was similar to earlier surveys (Figs. 4-5). Size structure differed and fewer larger fish were collected in 2013 than 2012. The PSD_{305} and PSD_{381} were lower than those expected from reference points (Table 2; see also Figs. 6 and 7, respectively). The instantaneous mortality rate was greater than the general reference point and is slightly greater than earlier years with estimates (Table 2; Fig. 8). Growth rates and body condition were not different than reference points (Table 2; Figs. 14-15).

The population in Marshyhope Creek had properties observed in recent history. This suggests that the population has not changed substantially since survey work had begun. While not as frequent or large as those on the Upper Bay or Potomac River, tournaments originating within the Nanticoke watershed are popular. Many of the tournaments originate in Delaware in Broad Creek. These tournaments typically do not use release boats so there had been concern that tournaments from Seaford would contribute to low population sizes in Marshyhope Creek. However, this does not appear to be the case. In general, indices reflect a good population with natural and effective reproduction.

Pocomoke River—There were 28 Largemouth Bass collected from Pocomoke River. They ranged in total length from 170 – 462 mm. Catch estimates tended to be lower than expected from earlier surveys (Figs. 4-5). The PSD_{305} and PSD_{381} values were similar to the general reference points (Table 2; Figs. 6-7). Growth rates were lower than general reference points (Table 2). The robustness of Largemouth Bass was not different from general reference points (Table 2).

As expressed by anglers and biologists in the past, the Pocomoke River population tends to have few older Largemouth Bass. Fewer Largemouth Bass were collected in 2013 than earlier years for unknown reasons. As expected, growth rates were lower than reference points, but relative conditions indices suggested normal fattiness. The rate of growth may be low because of habitat conditions, which tend to be hypoxic (average = 2.77 mg/L, unpubl. data collected using Sondes between May and September, 2004 and 2005) and slightly acidic (Table 1). Conditions that lower the oxygen capacity of hemoglobin (i.e., hypoxia and hypercapnia) may ultimately lower growth rates and metabolism.

Gunpowder River—There were 7 Largemouth Bass collected from Gunpowder River. They ranged in total length from 206 – 487 mm. Because only 7 fish were collected, some indices were not computed because they lack a robust sample size. The CPUE was the lowest among tidewater areas surveyed (Table 1), possibly because an effective sampling strategy is on-going and has not yet been developed.

Choptank River—There were 36 Largemouth Bass collected from Choptank River. They ranged in total length from 54 to 540 mm. Catch for Choptank River was lower than reference points (Figs. 4-5; Table 2). While CPUE is lower for 2006-2013 surveys than 1999-2002 surveys, the cor-CPUE tends to indicate that there was little change in relative abundance except for a lower value in 2013. The cor-CPUE helps reduce effects of specific conductivity and water clarity on the catch estimate. The CPUE reported in 2013 is only slightly lower than that reported by Fewlass in 1994 for Choptank River (CPUE = 9.67; MDDNR 1995). Size structure was similar to earlier surveys. The PSD305 was greater than the reference point (Fig. 6), but PSD381 index was not (Fig. 7; Table 2). The instantaneous mortality rate was not different than earlier estimates. Largemouth Bass grew well, indicating suitable conditions and resources. Growth rates and body condition were greater than reference points (Table 2).

The Choptank River population has been the subject of intensive stocking that has been staggered across the past few years. The utility of this stocking is not readily apparent, though two hatchery released, advanced fingerling (4 – 6 inches at release) were recaptured (see Job 3). The natural carrying capacity of Choptank River may be less than anglers had hoped. Thus, stocking juveniles may not provide a substantial, sustainable fishery. The stocking of adults would provide a fishery, but that impact on other resources is likely to be significant.

Invasive Species Assessment. **Northern Snakehead—**Northern Snakehead has successfully established itself in the Potomac River, but has since expanded to Patuxent River. Northern Snakehead has also been collected in relatively small numbers from Rappahannock River, Rohde River, Wicomico River, Blackwater River, and Nanticoke River. Of these, an established population (i.e., one with reproduction) exists within Wicomico River (near Salisbury) and the upper Nanticoke River. It is likely that Northern Snakehead can move among Wicomico River, Blackwater River, and Nanticoke River by moving about Fishing Bay (a confluence of the mouths of these rivers). Several Northern Snakehead adults were caught at the footbridge of upper Blackwater River in summer 2013. In addition, a young Northern Snakehead was caught in a small trap in a ditched area that connects upper Blackwater River to Little Choptank River. It is expected that this mechanism of dispersal could lead to of the Choptank River. To date, no individuals have been verified as collected from tidal freshwater habitats of Choptank River.

The population size of a small region of Nanjemoy Creek (Potomac River) was determined to be 315 (SE = 26) using a constant capture probability model. The Schnabel estimate was greater (N = 2576), but was likely biased by two large collections (hence, greater capture probabilities) during spring. While this estimate may not be indicative of the entire Nanjemoy Creek, it was used to help determine carrying capacity of the system using habitat preference information. The habitat preferences are currently analyzed in collaboration with U.S. Fish and Wildlife Service Maryland Fishery Resources Office.

The relative abundance and distribution of Northern Snakehead decreased since 2012 in Potomac River (Figs. 11 and 12). This is the first reported decrease in either of these indices since the species was first discovered in Potomac River. It is not clear whether the cause of the decline is increased angling effort. However, angling effort for the past 2 – 3 years has increased considerably and has been supported by initiatives by both MD DNR Fisheries Service and the U.S. Fish and Wildlife Service.

For the first time in the history of the survey, two Northern Snakehead adults were captured during a survey of Wicomico River. Though the species was captured by anglers since 2011, it had not been collected by electrofishing survey gear until 2013. Adults were also collected from Patuxent River, similar to last year. It appears that it takes 2 years between angler reporting and collection by electrofishing gear during Tidal Bass surveys (Fig. 11).

Blue Catfish—A total of 1,637 Blue Catfish were examined for gut contents between 2008 and 2013. An effort was made to collect fish year-round but success was limited, particularly during winter. Diet data from small Blue Catfish (TL <306mm) were not included in the 2013 analysis since much of the data included invertebrates and non-fish prey items; diet data compiled for 2009 – 2013 included prey items for Blue Catfish greater than 306 mm only. Fish were collected in water from 0.9 – 20 m (3—65 ft) in depth.

Almost 70% of stomachs examined during spring were empty or contained unidentifiable fish remains (Fig. 13). Fewer empty stomachs were observed during Summer and Fall samples but more than 50% of fish captured during winter had empty stomachs. Most fish were captured using electrofishing gear. In 2013, standard hook-and-line fishing and jug lines were employed to supplement electrofishing catches. While neither angling method produced large numbers of fish, jug lines were most effective. Blue Catfish collected with this method were often caught on the upper hook which was approximately 0.6 m (2 ft) above the substrate.

Unidentified fish remains (UFR), submerged aquatic vegetation (SAV), and empty stomachs represented over 75% of samples for all seasons. Unidentified fish remains, mollusks, Gizzard Shad (*Dorosoma cepedianum*), and White Perch (*Morone americana*) were found to be the most common items in Blue Catfish stomachs for much of the year. However, a variety of fishes and other organisms have also been found and support the theory that Blue Catfish are opportunistic feeders and utilize many available food sources (Table 3). Filamentous algae were frequently found in both the stomachs and intestines of fish of all sizes, even those weighing in excess of 40 lbs. As expected, these algae contained small mollusks and a variety of other invertebrates. Parasites of the class Cestoda (tapeworms) were also found in a small number of samples.

Often, stomach contents could not be identified because the items were in the advanced stages of digestion. This was true for fish of all size groups. A subset of stomach contents (N= 54) was sent to SERC biologists to identify fish remains using DNA bar-coding (Fig. 14). Gizzard Shad, White Perch, and Bluegill (*Lepomis macrochirus*) comprise 50% of the fishes identified through DNA testing (Fig. 14). Although Gizzard Shad and White Perch were identified in Blue Catfish stomachs in the field, few Bluegill were intact and recognizable. Tessellated Darter (*Etheostoma olmstedi*) and Spottail Shiner (*Notropis hudsonius*) were also common in the DNA samples but few were found during field examinations. Although not included in Figure 14, the DNA of a Double Crested Cormorant was also detected in the samples tested by SERC biologists.

The length of Blue Catfish collected during the five year diet study ranged between 71mm and 1235 mm (Fig. 15). Fish between 500 to 700 mm in length were more abundant in our samples but this distribution may not be reflective of the true length profile of Blue Catfish in the Potomac River since larger fish were often specifically targeted.

Average relative weights for fish across all years exceeded 100% (Fig. 16). Relative weights above 100% shows that Blue Catfish are able to efficiently utilize available food resources on the Potomac River and that they are healthy and robust (Muoneke and Pope, 1999). Even so, a slight trend downward in relative weights over the last few years may indicate increased intraspecific competition.

Initially, the principal concern of Inland Fisheries biologists regarding Blue Catfish on the Potomac River was predation on anadromous fishes, especially shad and herring species. Although data do not indicate that alosines are a primary food source for Blue Catfish in the tidal freshwater portion of the river, it is possible that current gears do not capture feeding Blue Catfish, particularly in Spring when alosines and Blue Catfish are more likely to occupy the same habitat.

Gizzard Shad, White Perch, mollusks and catfish are commonly found when examining the stomach contents of Blue Catfish greater than 306mm in length. DNA bar-coding indicates we are likely underestimating the importance of sunfishes and other small fishes in Blue Catfish diets. The traditional perception that Blue Catfish are is merely an opportunistic, deep river species may be overly simplistic. Our diet study shows that Blue Catfish often venture into very shallow waters (< 1 m) and utilize small, shallow water species such as Tessellated Darter and Spottail Shiner.

The population of Blue Catfish in the tidal freshwater portion of the Potomac River should continue to be monitored to document growth, shifts in distribution, and structure but not on a yearly basis. Additional samples to determine age and size structure of the population will continue in 2014, but these samples will shift to springtime data collections and may employ alternative gears.

Attention will shift to the Patuxent River were a growing Blue Catfish population has been reported. Diet surveys, as well as general life history data will be collected on Blue catfish in the Patuxent River. Hoop nets, as well as electrofishing gear have been successful at capturing other catfish species on the Patuxent River. It is hoped that these methods will prove effective for Blue Catfish as well. Due to physiological features of the Patuxent River the introduction of a large top-predator like Blue Catfish could be detrimental to native species, including those that have been targeted for restoration such as Striped Bass (*Morone saxatilis*) and shad and herring.

Blue Catfish are an undesirable species in Maryland's tidal waters but are established in several river systems. A balance needs to be made between protecting our aquatic resources from invasive species and recognizing the important economic and recreational role these species already play in Maryland. Data indicate that Blue Catfish can be harvested at a large enough size that would appeal to anglers wishing to take a meal home, yet are young enough that they have not reached reproductive maturity. This size group is also recognized by the Maryland Department of Environment (MDE) as fish that have lower levels of PCBs and Mercury, meaning that people can take advantage of including them in their diet with greater frequency without an increase in contaminants.

Diseases and Viruses. No tissues of Largemouth Bass were tested for Largemouth Bass Virus (LMBV) in 2013. A discussion with biologists within the Tidal Bass Program of MD DNR led to consensus to focus testing at Potomac River and upper Chesapeake Bay and staggered every 3 years. In addition, an ArcGIS layer depicting occurrences of disease is developed and will be made available on-line by Spring 2013. It will be an updateable map that provides constituents information regarding testing for LMBV, as well as other pathogens.

During the fall survey, 2.7% of surveyed fish had signs of infection. Disease was most often encountered on tidewater of Patuxent River where 8% of the individuals had signs of infection. Other tidewater areas had a lower frequency of disease among individuals: Choptank River (7.7%), Marshyhope Creek (1%), Pocomoke River (7.1%), Potomac River (1%), upper Chesapeake Bay (< 1%), Gunpowder River (0%), and Wicomico River (0%). Infections were generally minor and caused by bacteria or fungus.

Recommendations

Response to 2012 Recommendations.—As suggested in 2012, it was determined that the grasses of upper Bay were about 50% of that in 2008 and 2010. A similar pattern was observed for Potomac River. Thus, diminished grasses might explain lower than normal catch indices and/or annual differences in survivorship or reproduction. It was also recommended to assess resource availability for Pocomoke River; however, that assessment was not considered a priority by the Eastern Region Manager. To determine if harvest is occurring at a higher level for Pocomoke River or other eastern shore rivers, an on-line creel survey was developed in 2013. It will be coupled with minimal roving surveys in 2014 or 2015 to address harvest. Data from the on-line 2013 survey indicate very low harvest; however, effort was not well represented from eastern shore drainages (see Job 4). As noted in this assessment, data have surfaced to support naturally lower oxygen levels in Pocomoke River, which could retard growth rates.

In 2012, it was recommended to re-assess prime and marginal designations in Wicomico River in order to improve efficiency of the survey. The designations were re-evaluated using ArcGIS and sites were sampled in a more efficient manner in 2012.

It was recommended to generate mechanisms to keep fish in their home rivers. Closed areas were not a popular idea among anglers when the idea was expressed during the Black Bass Roundtable in February 2012. None-the-less, signs were posted on Choptank River to encourage anglers to release their catch. Additionally, tournaments were encouraged to avoid the Choptank River during the spawning season. Despite these efforts, at least one "scatterpoint" tournament whereby anglers launch from multiple rivers on eastern shore of Maryland, and weigh-in and release at a single river, occurred in 2013. While the number of anglers participating in this scatterpoint tournament was low, if these tournaments gain in popularity then they will pose a threat to small fisheries such as Wicomico River.

It was recommended to continue studying Blue Catfish and Northern Snakehead. Such studies are continuing. Finally, it was recommended to monitor the incidence of disease and make that available via social media and networking websites. The incidence of disease is being better catalogued by the Tidal Bass Survey via a new datasheet and protocol that was contributed to by Oxford Fish Health Laboratory and the Striped Bass Seine Survey. Additionally, that information is supplied to a GIS layer that will be available on-line beginning in 2014. Continued testing for LMBV will occur for popular fisheries of upper Bay and Potomac River.

2013 Recommendations.—The fisheries of the Potomac River and upper Chesapeake Bay watersheds require additional creel census of black bass tournaments, testing for LMBV and other pathogens, and monitoring of both recruitment and habitat (or submerged vegetation) changes. The Potomac River fishery may be experiencing problems with recruitment. Some indices indicating lower catches and poor growth, as well as high PSD's indicate that habitat is changing in Potomac River in a way that restricts population growth for Largemouth Bass (see also Job 2). To eliminate the hypothesis that a decline in gear effectiveness is causing observed patterns of declining relative abundance, it is recommended that the power applied to the water by electrofishing vessels be checked and compared with published standards for effectively surveying fishes. It is also suggested to conduct targeted studies to determine: 1) if young fish truly prefer grasses or emergent vegetation in the river; and 2) if survivorship of young fish may be affected by predation of newly emerging predators, such as Northern Snakehead. It is also recommended to continue working with anglers to improve handling of Largemouth Bass during tournaments and improve survivorship of released fish, particularly in times of high angling effort and high catch rates (see Job 4).

An efficient survey program for Gunpowder River should continue to be developed. The fisheries for Choptank River, Wicomico River, and Pocomoke River should continue to monitored, particularly Pocomoke River where very few fish were collected this year. The Patuxent River fishery is a small, but encouraging fishery that could provide anglers a good alternative to Potomac River fishery.

Table 1. Environmental variables (VAR) measured for targeted waterways of the Chesapeake Bay watershed (2013). The average, coefficient of variation, and number (N) of observations are given for: water temperature (TE; °C), specific conductivity (SC; microSiemens), dissolved oxygen (DO; mg/L), pH, salinity (SA), and water clarity (WC; cm of visibility).

RIVER	VAR	TE	DO	SC	SA	pH	WC
UBAY	N of Cases	28.00	28.00	28.00	28.00	28.00	27.00
UBAY	Average	21.28	7.86	295.9	0.15	7.85	66.07
UBAY	CV	0.03	0.18	0.34	0.42	0.05	0.42
POTOMAC	N of Cases	40.00	40.00	41.00	40.00	39.00	41.00
POTOMAC	Average	20.53	8.54	1948.4	1.14	7.80	98.34
POTOMAC	CV	0.11	0.32	1.52	1.55	0.05	0.45
PATUXENT	N of Cases	25.00	25.00	22.00	22.00	25.00	25.00
PATUXENT	Average	15.00	7.88	270.9	0.15	7.44	61.60
PATUXENT	CV	0.07	0.13	0.22	0.22	0.04	0.46
GUNPOWDER	N of Cases	17.00	17.00	17.00	11.00	17.00	17.00
GUNPOWDER	Average	21.28	8.20	1608.4	1.14	8.01	30.06
GUNPOWDER	CV	0.08	0.12	0.92	0.76	0.05	0.38
CHOPTANK	N of Cases	25.00	25.00	25.00	25.00	25.00	25.00
CHOPTANK	Average	20.05	7.43	487.7	0.23	7.28	60.68
CHOPTANK	CV	0.07	0.16	0.95	1.19	0.04	0.41
WICOMICO	N of Cases	23.00	23.00	23.00	23.00	23.00	23.00
WICOMICO	Average	20.99	9.14	262.6	0.11	7.69	59.48
WICOMICO	CV	0.04	0.11	0.33	0.75	0.04	0.14
MARSHYHOPE	N of Cases	25.00	25.00	25.00	25.00	25.00	25.00
MARSHYHOPE	Average	19.66	8.14	464.2	0.22	7.20	54.20
MARSHYHOPE	CV	0.05	0.12	1.41	1.81	0.02	0.40
POCOMOKE	N of Cases	25.00	25.00	25.00	25.00	25.00	25.00
POCOMOKE	Average	18.74	3.23	107.1	0.07	6.74	57.44
POCOMOKE	CV	0.03	0.24	0.07	1.19	0.03	0.09

Table 2. Stock assessment of Largemouth Bass populations in 2012 for targeted drainages of the Chesapeake Bay watershed using indices and metrics reflecting changes in population biology. When a metric falls below the 25th percentile computed for available data for that river, the ▼ symbol is given. When a metric falls above the 75th percentile computed for available data for that river, then the ▲ symbol is given. nc = value falls within the 25th and 75th percentiles. For tidal rivers where 25th and 75th percentiles for populations were not available, values were compared to general, reference point-estimates established for non-Maryland populations; 👍 = values similar to reference point-estimate and 👎 = values much different than reference point. Abbreviations for indices are in text.

River	N	CPUE	Cor-CPUE	PSD_{305}	PSD_{381}	Z	GR-EXPrise	GR-VBGF	LW-Slope	W_r	K_n
Upper Bay	28	38.71 ▼	3.52 ▼	0.84 n.c.	0.71 ▲		64.58 n.c.	64.87 n.c.	3.28 n.c.	1.00 n.c.	1.00 n.c.
Potomac	41	19.03 ▼	1.86 ▼	0.86 ▲	0.43 ▲	-0.57 ▼	60.61 ▼	60.95 ▼	3.01 ▼	1.00 n.c.	0.95 ▼
Patuxent	25	28.36	3.52	0.60 👍	0.28	-0.64 👍	66.50	66.76	3.23 👍	1.00	0.99
Choptank	25	7.77	1.09	0.83 👍	0.35 👍	-0.54	69.91	75.24	3.26 👍	1.00	1.01
Wicomico	23	10.53	1.54	0.77 👍	0.54 👍		65.77	66.10	3.24 👍	0.99	1.01
Marshyhope	24	28.20	3.69	0.51 👎	0.13 👎	-0.89 👍	69.39	69.71	3.19 👍	0.99	1.02
Pocomoke	25	7.18	0.80	0.58	0.27	-0.82 👍	59.52 👎	59.60 👎	3.27 👍	0.99	1.01
Gunpowder	18	0.78	ND[1]	0.57	0.28	ND[1]	ND[1]	ND[1]	2.81 👍	0.97	ND[1]

[1]ND = Not Determined; Because only 7 Largemouth Bass were collected from Gunpowder River, some indices were not calculated.

Table 3. Identifiable fishes found in the stomachs of Blue Catfish collected in the Potomac River, 2009 – 2013.

Common Name	**Scientific Name**
Tesselated Darter	*Etheostoma olmstedi*
Bluegill	*Lepomis macrochirus auratus*
Largemouth Bass	*Micropterus salmoides*
Yellow Perch	*Perca flavescens*
American Eel	*Anguilla rostrata*
Pumpkinseed	*Lepomis gibbosus*
Northern Snakehead	*Channa argus*
Atlantic Menhaden	*Brevoortia tyrannus*
Goldfish	*Carassius auratus*
Bay Anchovy	*Anchoa mitchilli*
Spot	*Leiostomus xanthurus*
Longnose Gar	*Lepisosteus osseus*
Spottail Shiner	*Notropis hudsonius*
Atlantic Needlefish	*Strongylura marina*
Catfish (spp.)	*Ictalurus* spp.

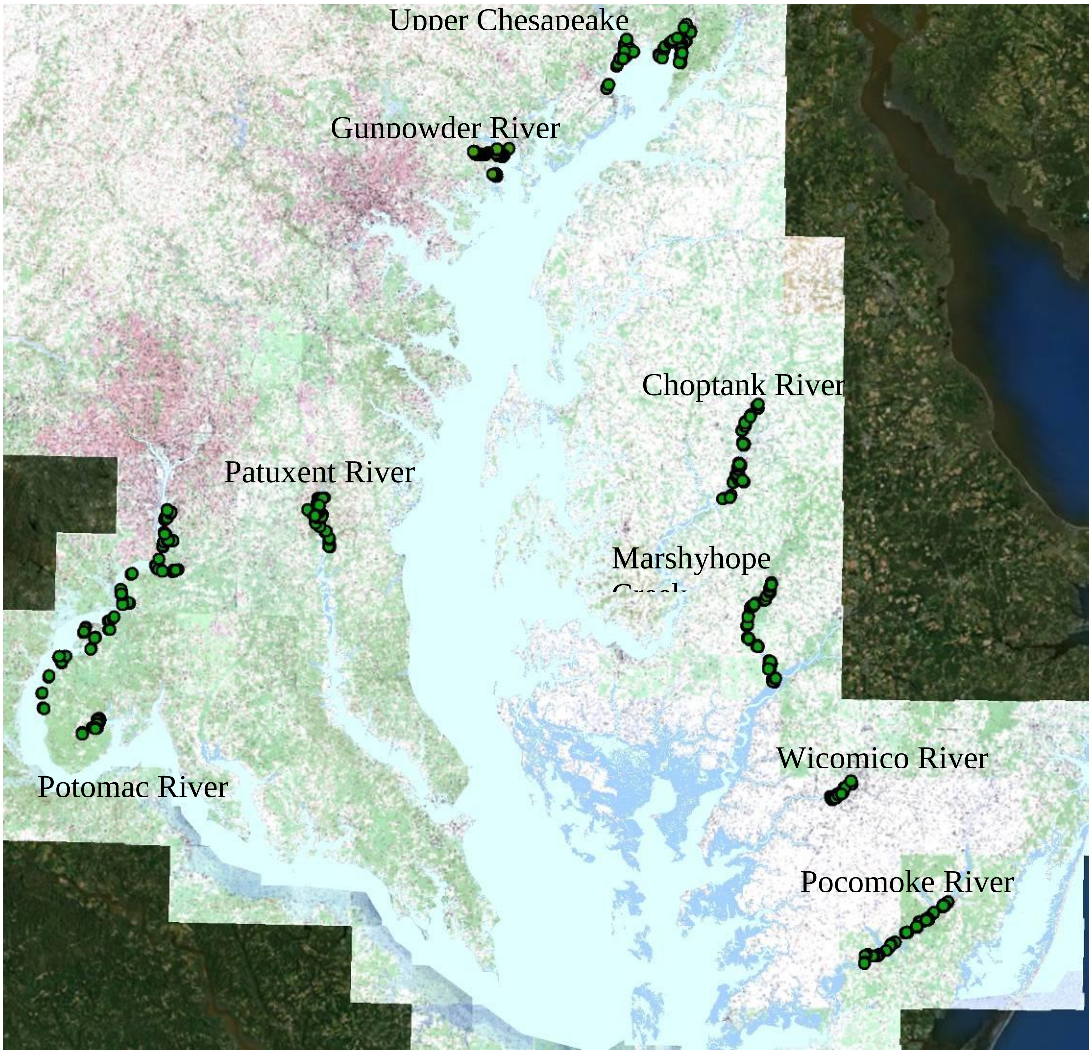


Figure 1. Map of survey sites for Largemouth Bass (*Micropterus salmoides*) in Chesapeake Bay watershed during the tidal bass survey (2013).

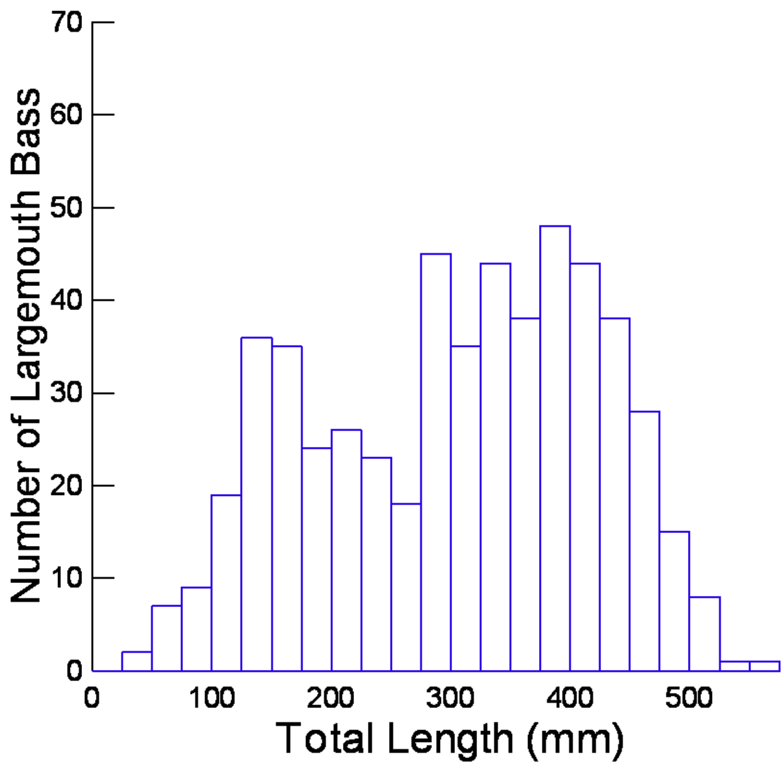


Figure 2. Length frequency distribution of Largemouth Bass (*Micropterus salmoides*) collected during the tidal bass survey of targeted drainages of the Chesapeake Bay watershed (2013).

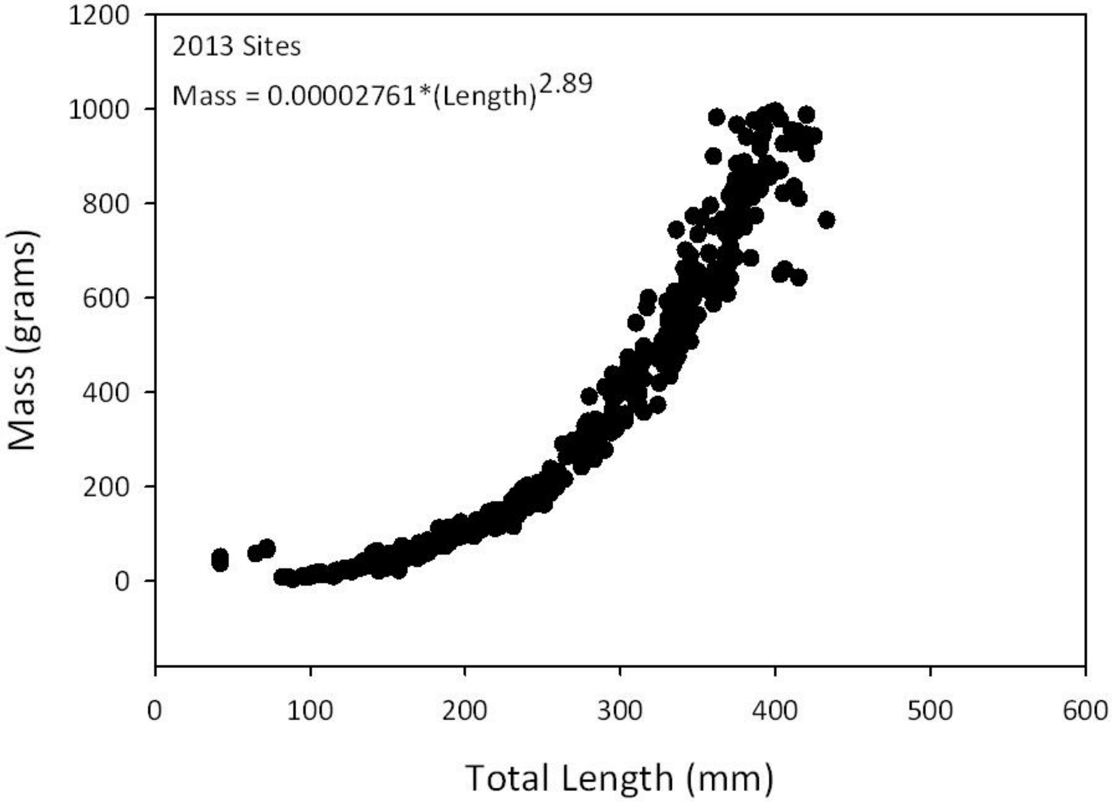


Figure 3. Length-weight relationship for Largemouth Bass (*Micropterus salmoides*) populations from targeted drainages of the Chesapeake Bay watershed (2013).

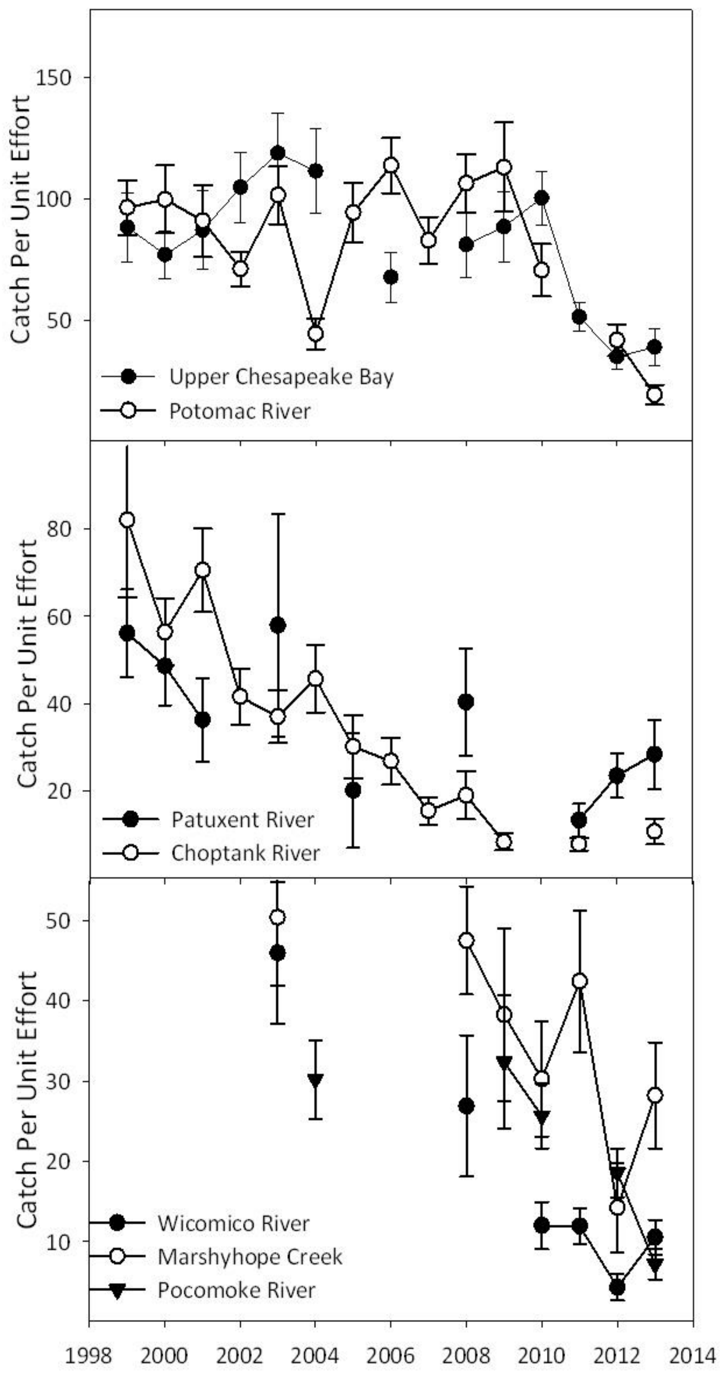


Figure 4. Catch per unit effort (CPUE) of Largemouth Bass (*Micropterus salmoides*) calculated using arithmetic, stratified means for all available years and targeted drainages of the Chesapeake Bay watershed during the Tidal Bass Survey.

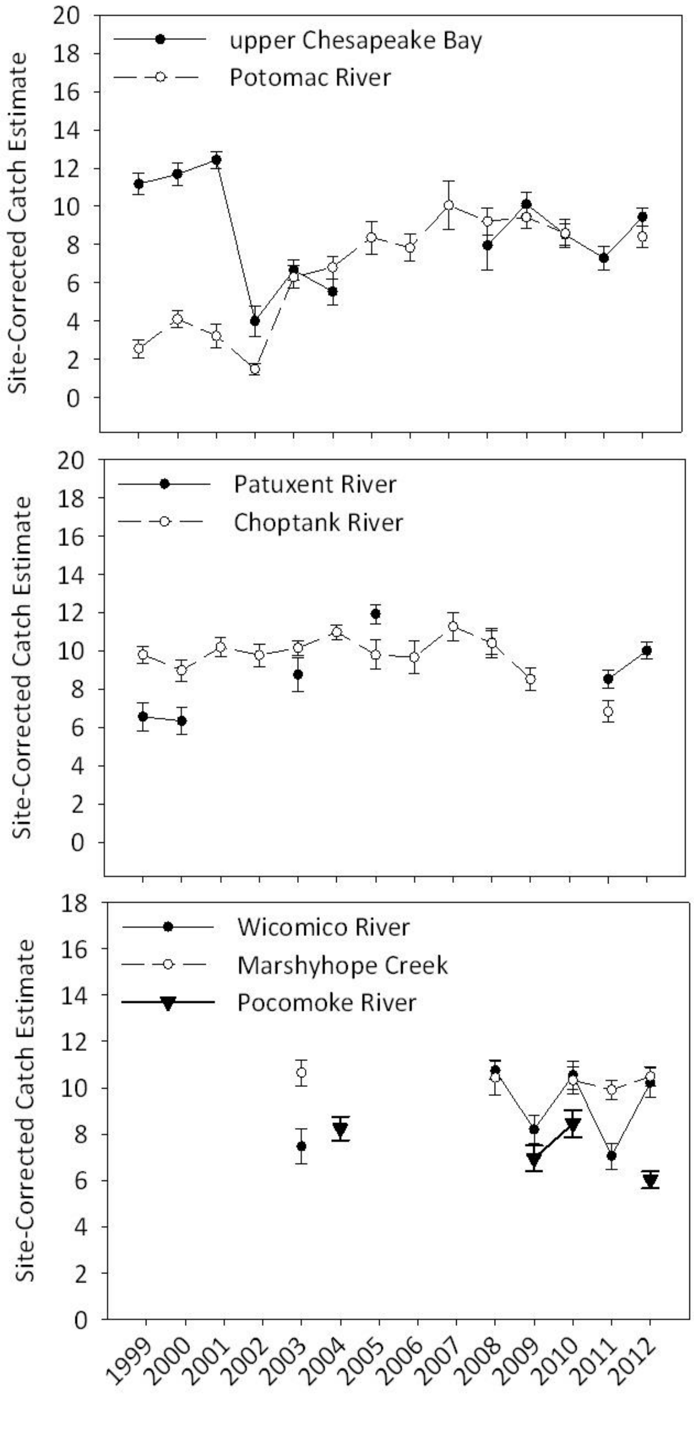


Figure 5. Corrected mean catch per unit effort (CPUE; ± SE) of Largemouth Bass (*Micropterus salmoides*) for targeted drainages of the Chesapeake Bay watershed during the tidal bass survey. Catch was corrected for site-specific differences in: effort, specific conductivity, water temperature, and water clarity.

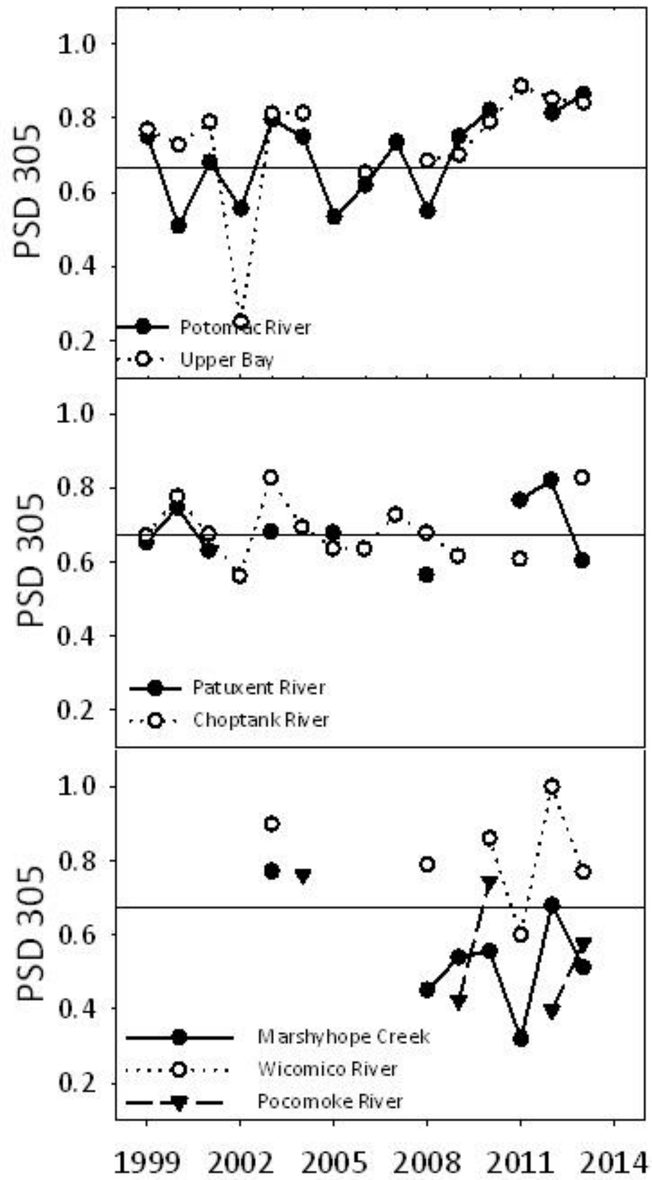


Figure 6. The proportional size distribution (PSD) of 305 mm total length Largemouth Bass (*Micropterus salmoides*) collected from 1999 – 2011 for targeted drainages of the Chesapeake Bay watershed. The solid line is the expected PSD_{305} for lentic populations of Largemouth Bass inhabiting similar ecoregions (Bonar et al. 2009).

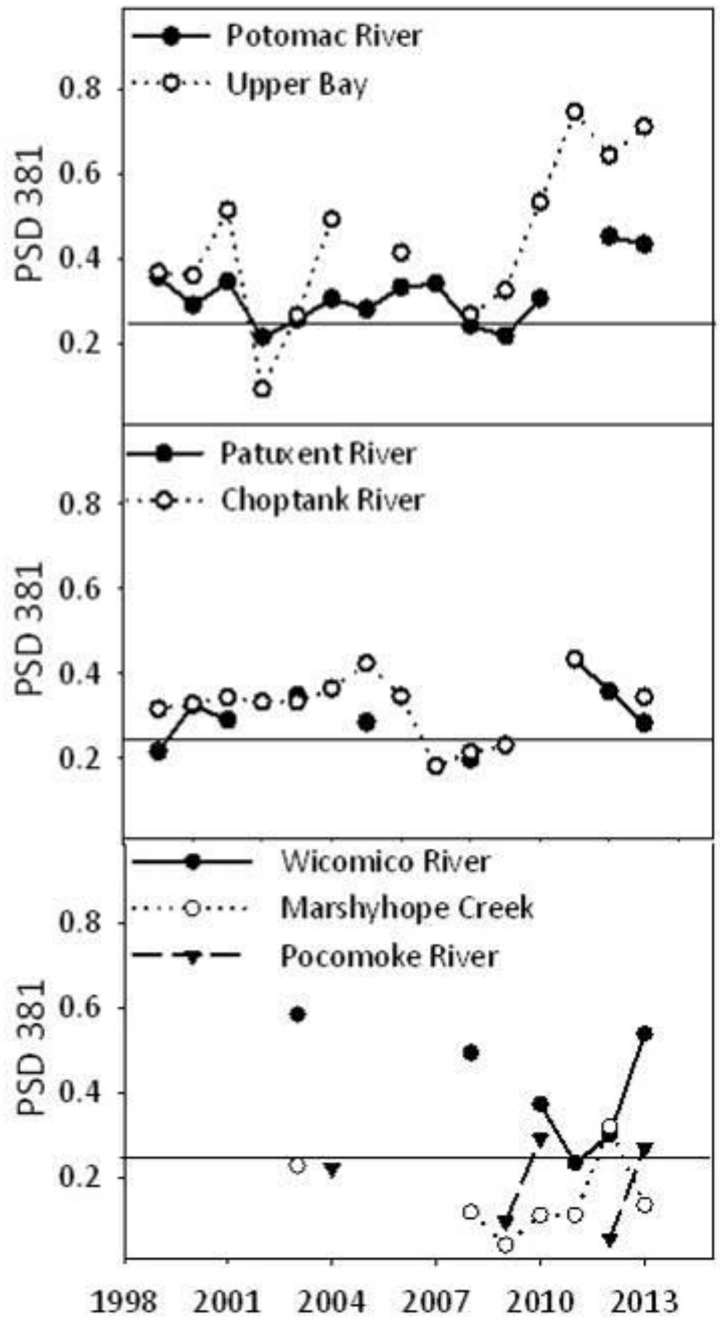


Figure 7. The proportional size distribution (PSD) of 381 mm total length Largemouth Bass (*Micropterus salmoides*) collected from 1999 – 2011 for targeted drainages of the Chesapeake Bay watershed. The solid line is the expected PSD_{381} for lentic populations of Largemouth Bass inhabiting similar ecoregions (Bonar et al. 2009).

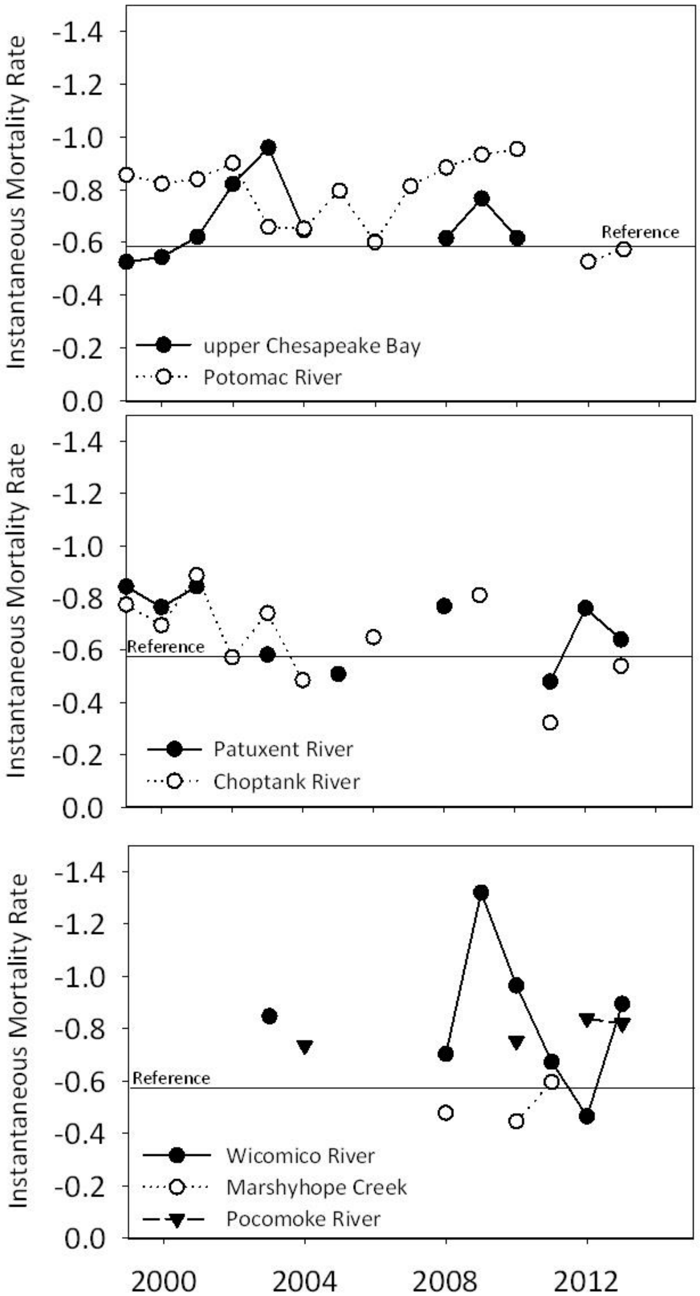


Figure 8. Annual instantaneous mortality (Z) of Largemouth Bass (*Micropterus salmoides*) averaged among years for waterways of the Chesapeake Bay watershed. A drawn line for reference is given and reflects Z from other studies.

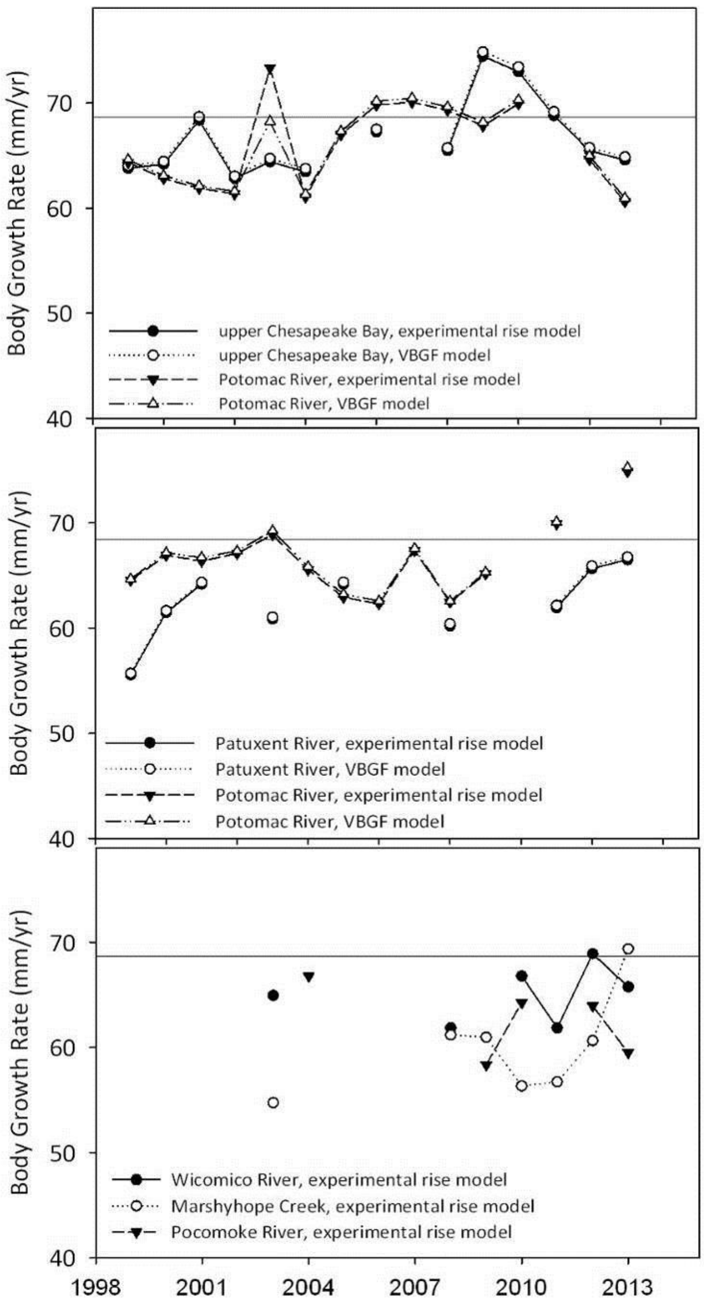


Figure 9. Annual and spatial variation in the growth rates of ages 0 - 3 Largemouth Bass (*Micropterus salmoides*) averaged among individuals collected from targeted drainages of the Chesapeake Bay watershed (1999 – 2012). Growth rates were calculated from length-at-age data fit to exponential rise and von Bertalanffy growth functions (VBGF). Solid line is a reference line reported for growth of Largemouth Bass in the Chesapeake Bay (Elser 1962).

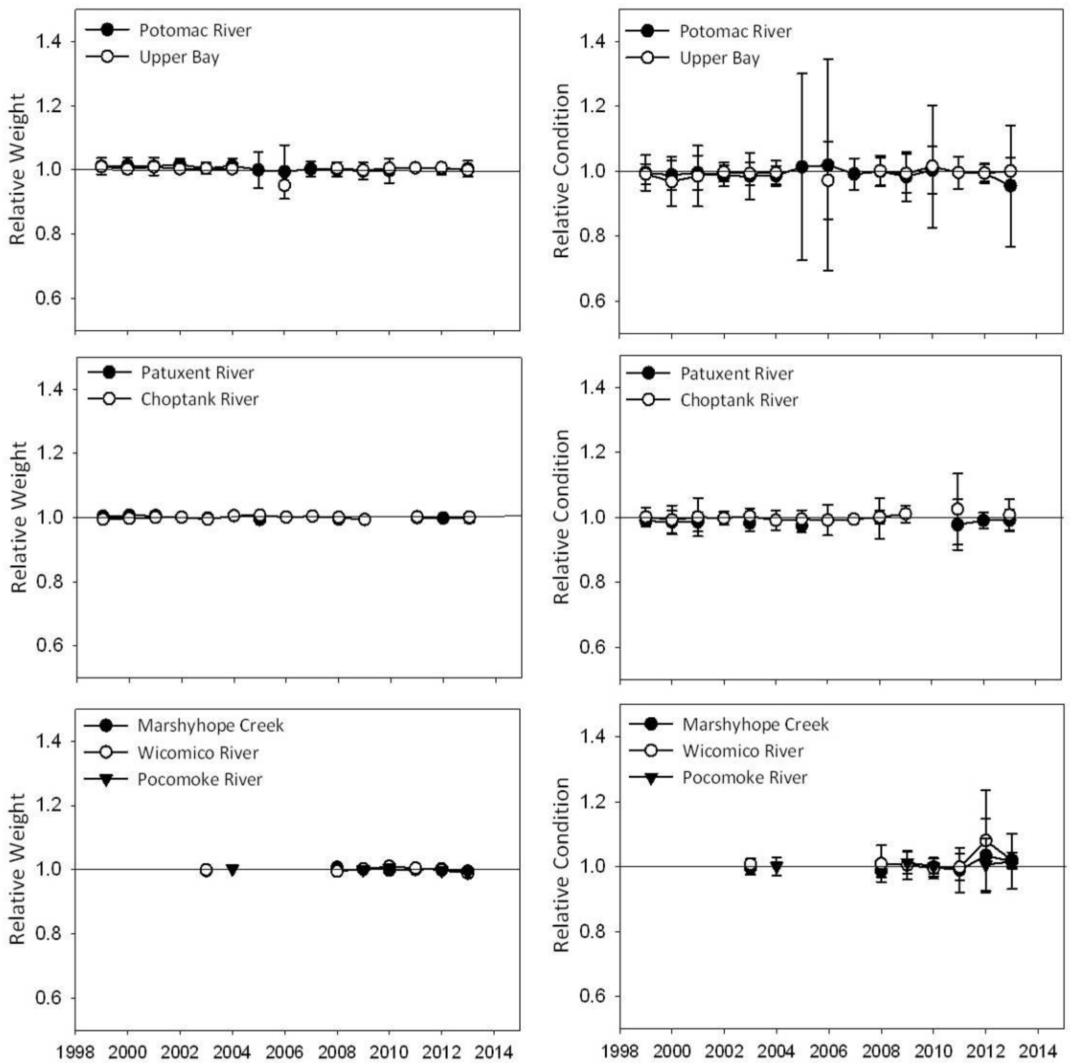


Figure 10. Body condition of Largemouth Bass (*Micropterus salmoides*) from targeted tidal freshwater portions of drainages of the Chesapeake Bay. Left Panels: Relative Weights are ratios of observed weight to predicted weight from a nationally accepted length-weight relationship. Error bars are standard errors of the mean. The solid line is the expected ratio for a fish meeting the national standard (Wege and Anderson 1978). Right Panel: Relative Condition is ratio of observed weight to expected weight based on length-weight relationships for the drainage. The solid line is the expected ratio for a fish meeting the rivers' standard.

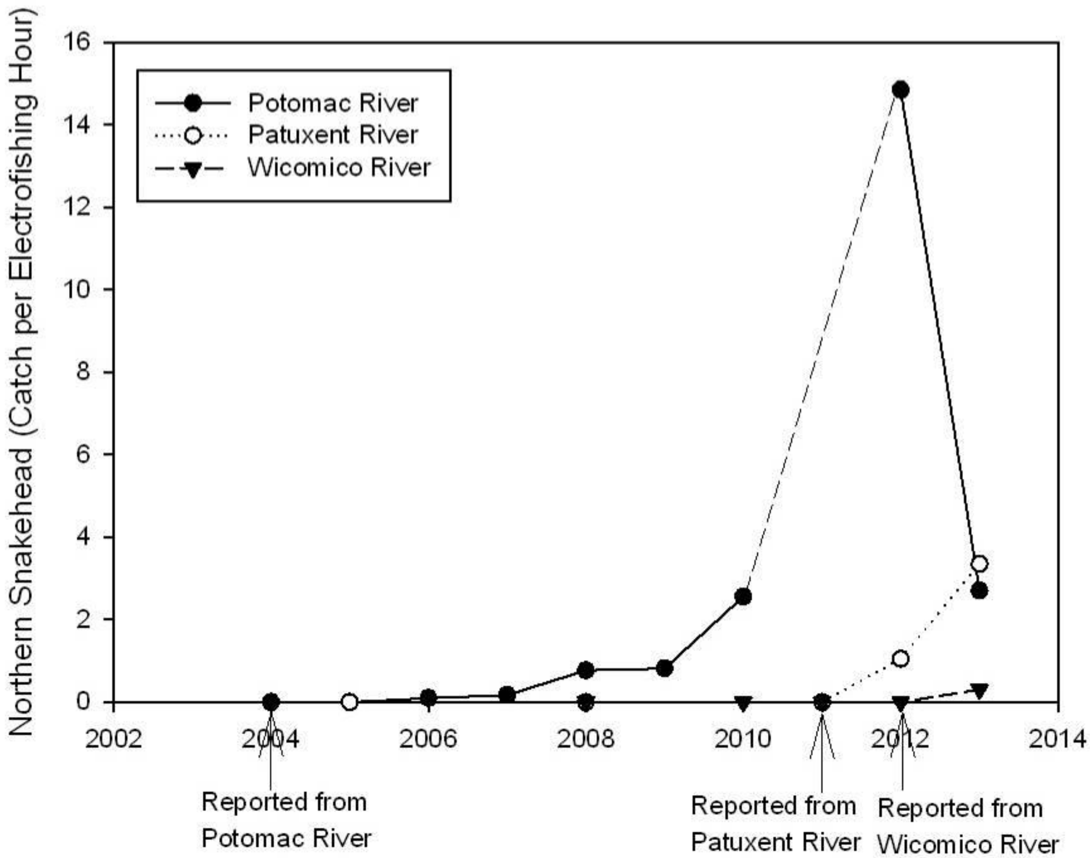


Figure 11. The Catch-per-Hour of Northern Snakehead (*Channa argus*) in Potomac River, Patuxent River, and Wicomico River. Arrows indicate the initial report of finding a Northern Snakehead by anglers or other members of the public (unpublished data, USGS; http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=2265). Dashed line for Potomac River is drawn to connect two annual surveys that are separated by a missing year of data collection (2011).

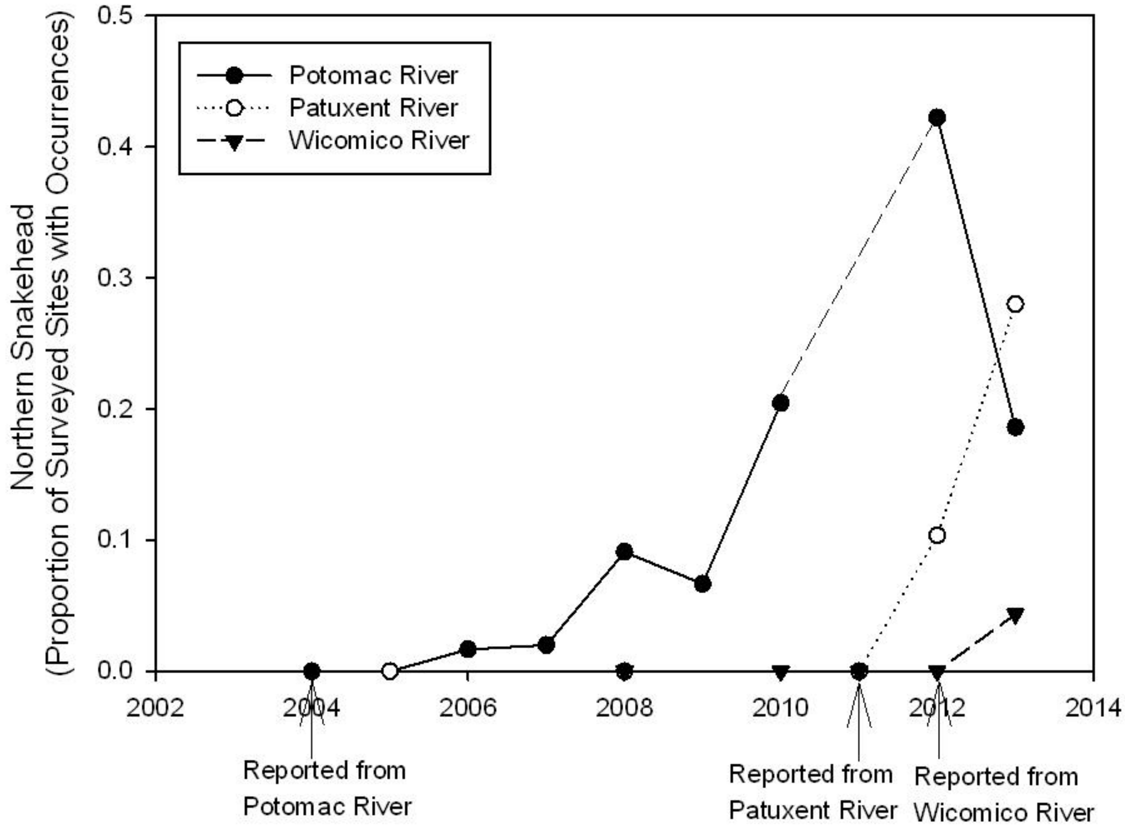


Figure 12. The proportion of surveyed sites where Northern Snakehead (*Channa argus*) occurred in Potomac River, Patuxent River, and Wicomico River. Arrows indicate the initial report of finding a Northern Snakehead by anglers or other members of the public (unpublished data, USGS; http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=2265). Dashed line for Potomac River is drawn to connect two annual surveys that are separated by a missing year of data collection (2011).

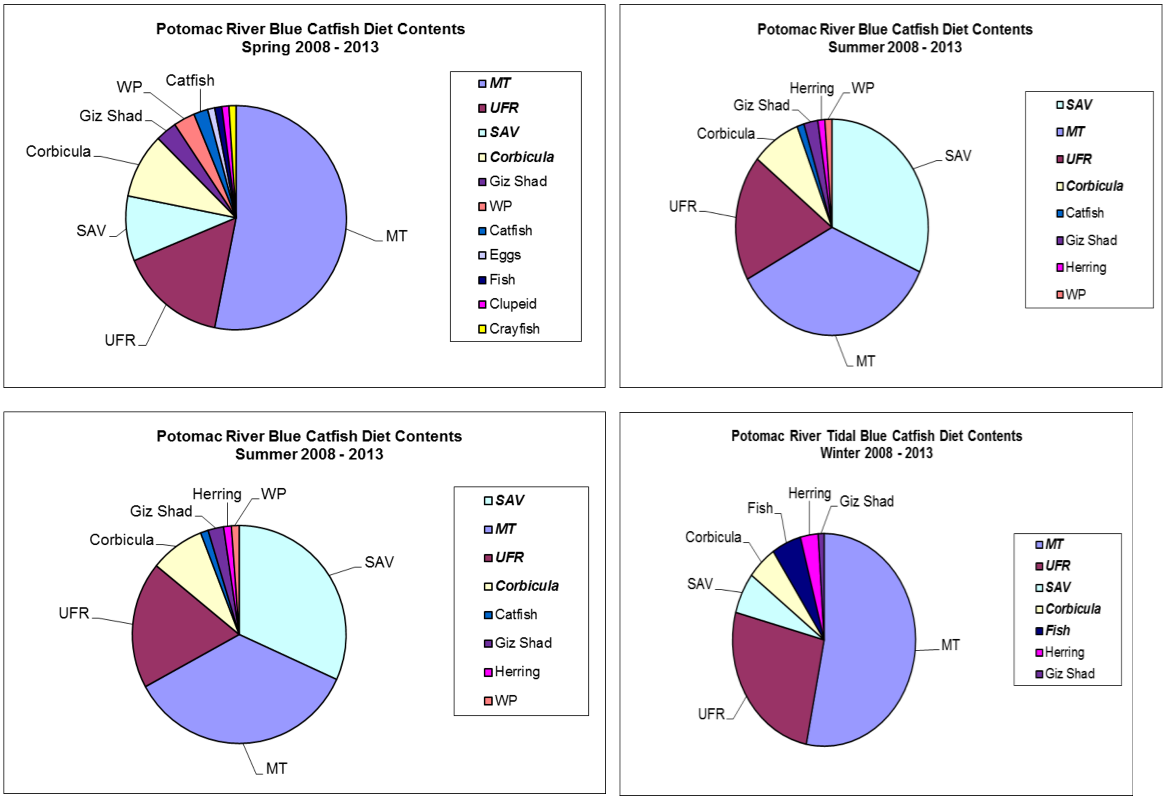


Figure 13. Potomac River Tidal Blue Catfish Diet Data 2008-2013. All fish except those collected in 2012 and 2013 were captured using a SR18 electrofishing boat. In 2012 and 2013 fish collection methods included hook and line and jug lining, particularly when water temperatures fell below 18C.

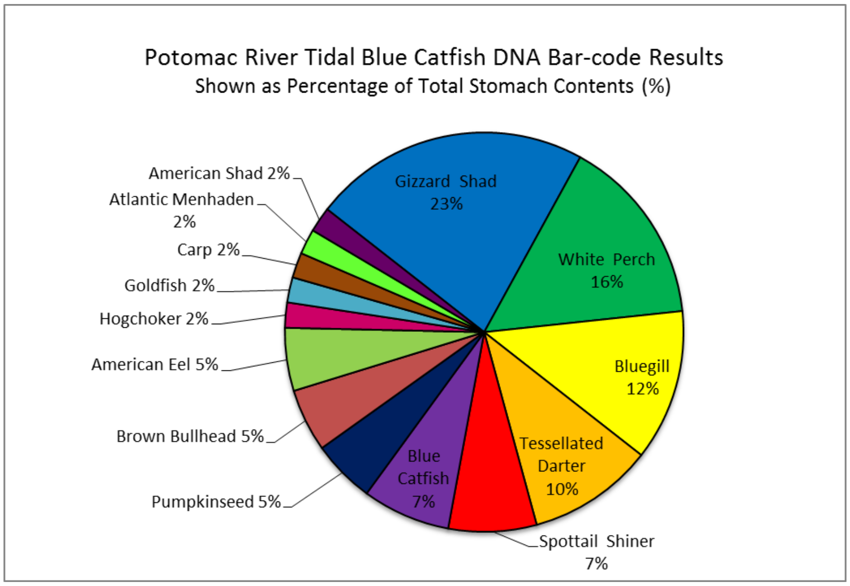


Figure 14. Results of DNA bar-coding performed by the Smithsonian Environmental Research Center (SERC). Samples (N=54) were from the tidal Potomac River, provided by MDNR 2012 and 2013.

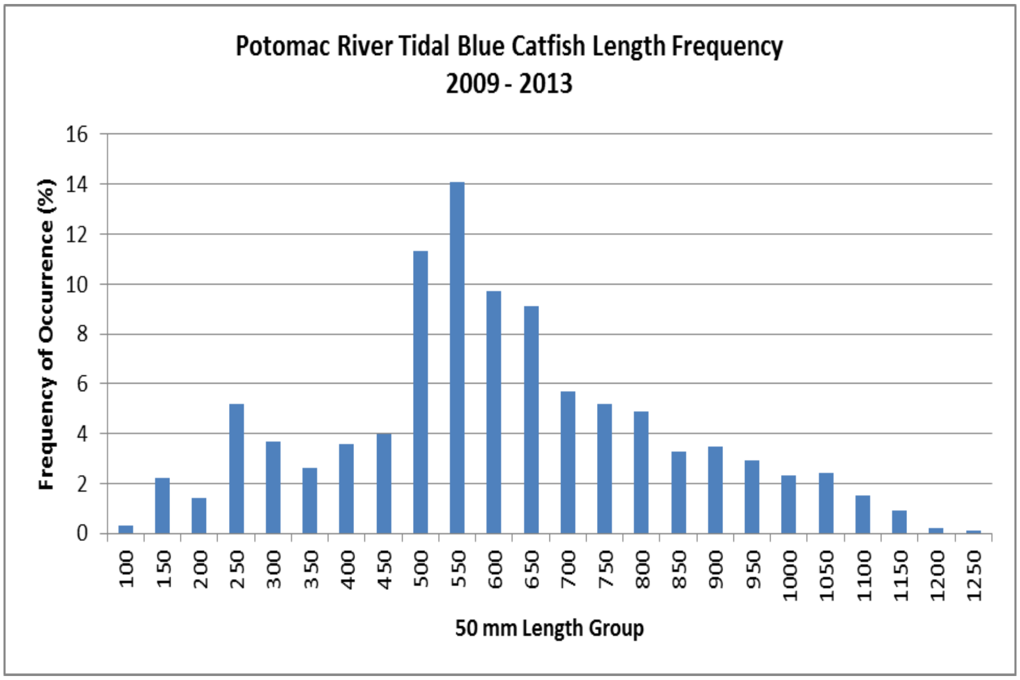


Figure 15. Length Frequency of Blue Catfish captured on the tidal Potomac River 2009-2013. Capture methods included electrofishing, hook and line and jug line.

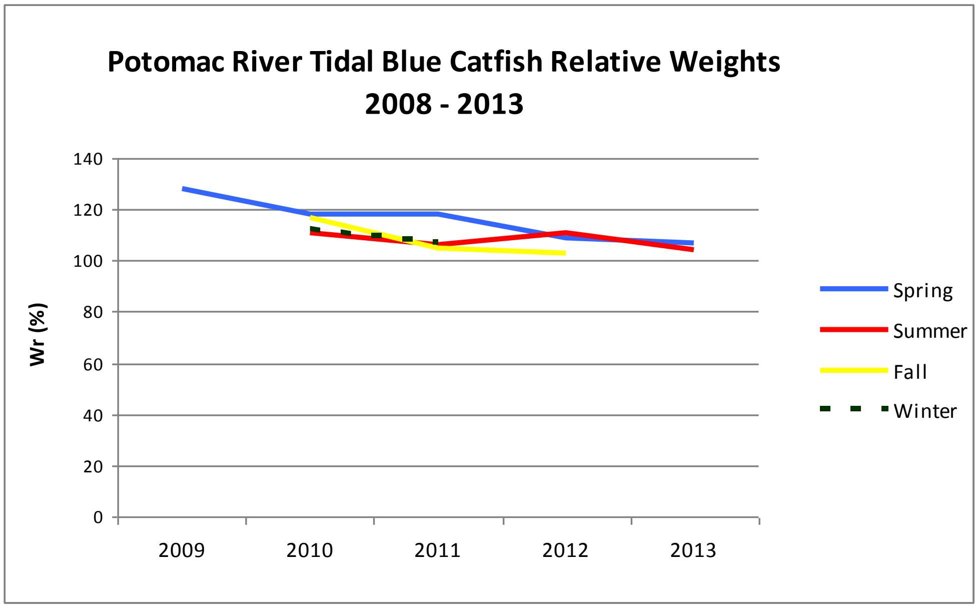


Figure 16. Potomac River tidal Blue Catfish Relative Weights 2008-2013. Relative Weights 100% and above are desired. Fish with Relative Weights below 85% are considered underweight.

State: Maryland

Project Number: F-48-R-17
Study No.: V
Job No.: 2

Project title: Survey and Management of Freshwater Fisheries Resources
Study Title: Management of Maryland's Tidal Freshwater Streams
Job Title: Juvenile Abundance Survey

Introduction

An important measure of sustainability and productivity of a fish population is recruitment. Recruitment is the number of offspring entering into the adult, spawning stock. For the purpose of this study, a juvenile is defined as an individual less than or equal to 200 mm total length (TL). A Largemouth Bass subadult ranges in size from 201 mm TL to approximately 300 mm TL, when it becomes sexually mature. Recruitment of subadults into the adult, spawning stock is variable and leads to greater variation in parameters describing population dynamics (Allen and Pine 2000). Therefore, recruitment variability can influence age and size structure and the quality of fish harvested by anglers. Because Largemouth Bass is a relatively short-lived species (< 15 years), 3 or 4 weak year classes may cause declines in population size. The effects of such events may be exacerbated by death or translocation of large adults. While most of the fishing effort in the Chesapeake Bay watershed is catch-and-release, the translocation of large adults is common, especially in tournament-fished drainages. Monitoring the annual trends in the number of juveniles within a population may be useful for identifying successively weak year-classes and identify populations that may require corrective stocking for maintaining the fishery. The purpose of this job was to utilize an efficient sampling program to generate and monitor indices of juvenile recruitment for Largemouth Bass.

Objectives

1. To calculate juvenile indices that reflect the status of juveniles for targeted tidal fresh portions of drainages of the Chesapeake Bay watershed;
2. To evaluate the indices relative to previous years for each drainage.

Methods

Juvenile Survey. Targeted rivers of the Chesapeake Bay watershed were surveyed for Largemouth Bass (Fig. 1) to generate juvenile indices. Data used to generate juvenile indices were obtained from the Tidal Bass Survey described in Job 1. Additional surveys during summer were deemed unnecessary because they produced redundant indices to those from methods in Job 1 (unpubl. data, J. Love).

Juvenile Indices. The indices were: juvenile CPUE (JUV_{CPUE}) within prime habitats, percent occurrence of juveniles among prime habitat sites ($JUV_{\%OCC}$), and proportion of juveniles within the sample of Largemouth Bass (JUV_{PSD}). The JUV_{CPUE} was computed as the number of juveniles collected at a prime habitat site, divided by electrofishing time. The geometric mean of JUV_{CPUE} among prime sites was calculated for a drainage and year. This geometric mean did not include sites where abundance was 0; hence, patterns of mean JUV_{CPUE} do not implicitly include variation due to absences and overestimates the relative abundance of juveniles collected throughout the entire survey as a result. The $JUV_{\%OCC}$ was calculated as the quotient of the number of prime sites where juveniles occurred by the total number of prime sites. This measure accounts for catch variation that is attributable to absences of juveniles among sites. The JUV_{PSD} was the proportion of juveniles in a sample of all Largemouth Bass collected at a site during the survey. This measure can be biased by the relative proportions of other age classes and is only useful as reflection of age structure within the sample. The proportion may increase when reproduction was high or when catch of other age classes was low. Assuming gear is equally efficient among years, the JUV_{PSD} should reflect changes in reproduction if the proportions of older age classes are stable (i.e., a stable age structure).

Reference Points. Reference points for the aforementioned indices were developed for watersheds with available data and provided in the Fishery Management Plan (FMP). Following guidelines of the FMP, estimates for the current year (2013) were compared with the percentiles to determine if the estimate was above average (greater than 75^{th} percentile) or below average (less than 25^{th} percentile). No additional general reference point-estimates were available.

Results and Discussion

General. There were 133 juvenile Largemouth Bass caught during the survey. The Potomac River yielded the most juveniles (36) and the Pocomoke River, the least (2).

Current Assessments. **Upper Chesapeake Bay—**There were 28 juveniles caught in the upper Chesapeake Bay. Similar to 2012, all three juvenile indices were below average, indicating a drop in relative abundance and distribution (Figs. 1-3; Table 1). Only 20.7% of the sample of Largemouth Bass was comprised of juveniles. Juveniles were collected from 38.9% of the prime habitat sites, which is much lower than normal (Fig. 3).

Reproduction in the upper Chesapeake Bay was poor in 2012 and 2013. This may be related to poor grass growth as a result of poor water clarity during spring 2012 (pers. obs. Mary Groves, Southern Regional Manager) and less grass coverage (VIMS 2012). Poor reproduction in the upper Chesapeake Bay may lead to poor recruitment and smaller size classes in the fishery in the near future.

Potomac River—All three juvenile indices were below average (Figs. 1-3; Table 1). Juveniles were collected from 34.6% of prime habitat sites (Table 1).

In 2012, reproduction in the Potomac River was average to above average relative to the reference dataset. However, there has been a steady and progressive decline in relative abundance since 2010, and in distribution since 2006. These changes may indicate a recent and progressive problem with recruitment and may currently explain expressed concerns of the fishery by recreational anglers.

Patuxent River—There were 34 juveniles caught in Patuxent River. The indices have not appreciably changed relative to the time series (Figs. 1-3). The JUV_{PSD} was slightly greater than 2012. Juveniles were collected from 47.1% of prime habitat sites (Table 1), slightly greater than that in 2012 (Fig. 3).

Of the 34 juveniles caught in Patuxent River, none were marked suggesting that natural reproduction is occurring Patuxent River. No juvenile Largemouth Bass were stocked from hatcheries to Patuxent River prior to the fall surveys. The contribution of earlier stocking may have provided a minimal biomass that is capable of sustaining the population with natural reproduction. A full assessment of the influence of hatchery stocking for Patuxent River population will be finished in 2015.

Reproduction for Patuxent River is steady, supporting a small population of Largemouth Bass, and may be buffered by consistent stocking efforts.

Gunpowder River—No juveniles were collected on Gunpowder River. Survey efforts will be improved for spring 2014 to include more habitats that can be efficiently sampled using boat electrofishing.

Choptank River—There were 7 juveniles collected in Choptank River. The JUV_{CPUE} and $JUV_{\%OCC}$ indices were below average (Table 1). The JUV_{CPUE} index was similar to values measured since 2010 and some years prior (Fig. 1). The JUV_{PSD} was not different than reference points.

Natural reproduction seems to be limited by available habitat and across a select group of prime sites. Despite stocking over 10,000 marked juveniles (> 50 mm) in 2013, there were no recovered marked juveniles.

Wicomico River—There were 13 juveniles were caught in Wicomico River. The JUV_{CPUE} was not different than earlier years (Fig. 1). Interestingly, JUV_{PSD} has increased steadily (Fig. 2). Because neither overall relative abundance nor PSD 305 has markedly declined, it's likely that the increase in JUV_{PSD} reflects better reproduction. Juveniles were also collected at more sites (only 43.7% of prime sites)(Table 1) than in 2012.

Reproduction in Wicomico River may be naturally restricted to the most upstream areas. Stocking efforts in 2012 may have helped bolster recruitment to age 1 and 2, though those age classes will not be represented in survey data until 2015 or 2016 because of gear bias. The protection of adults in this river from harvest or other factors seems necessary to improve population size.

Marshyhope Creek (Nanticoke River)—There were 13 juveniles collected from Marshyhope Creek. Indices were generally less than observed for most of the time series (Figs. 1-3). Approximately 13.7% of the overall sample of Largemouth Bass was comprised of juveniles and juveniles were collected at 35.3% of the prime habitat sites (Table 1).

Reproduction in Marshyhope Creek appears steady, though relative abundance tended to be low in 2013 relative to earlier years. This creek may serve as a source population for others that are fished in the upper Nanticoke River mainstem.

Pocomoke River—Unlike 2012, only 2 juveniles were collected from Pocomoke River. These were collected at one site. As a result, all indices are at their lowest levels observed for the time series (Fig. 1). Approximately 7.1% of the sample of Largemouth Bass was comprised of juveniles (Table 1; Fig. 2). Juveniles were collected at 5.5% of prime habitat sites (Fig. 3).

Very few juveniles were collected in the survey of the Pocomoke River. The poor collection may be an artifact of sampling bias or indicate poor reproduction and juvenile survivorship in 2013.

Recommendations

1. Determine if mitigating poor reproduction with hatchery contributions ameliorates problems with recruitment.
2. Continue generating a reference dataset for Wicomico River, Pocomoke River, Marshyhope Creek, Patuxent River, and Gunpowder River.
3. Refine a GIS layer that illustrates important reproduction areas in tidal rivers, provide that information to Blue Infrastructure
    a. determine if there are ways of enhancing such habitat in targeted drainages
    b. determine factors that may impair the reproduction areas by evaluating neighboring land use and sources of point and non-point pollution

Table 1. Juvenile production for Largemouth Bass populations in 2013 for targeted drainages of the Chesapeake Bay watershed. When an index fell below the 25th percentile computed for available data for that river, the ▼ symbol is given. When a metric fell above the 75th percentile computed for available data for that river, then the ▲ symbol is given. n.c. = value falls within the 25th and 75th percentiles. Abbreviations for indices are in text.

River	Juv_{CPUE}	Juv_{PSD}	$Juv_{\%OCC}$
Potomac	11.37 ▼	0.327 ▼	0.346 ▼
Upper Bay	20.52 ▼	0.207 ▼	0.389 ▼
Patuxent	16.36	0.391	0.471
Gunpowder	0.00	0.00	0.00
Choptank	9.47 ▼	0.194 n.c.	0.118 ▼
Wicomico	9.15	0.333	0.437
Marshyhope	10.73	0.137	0.353
Pocomoke	13.21	0.071	0.055

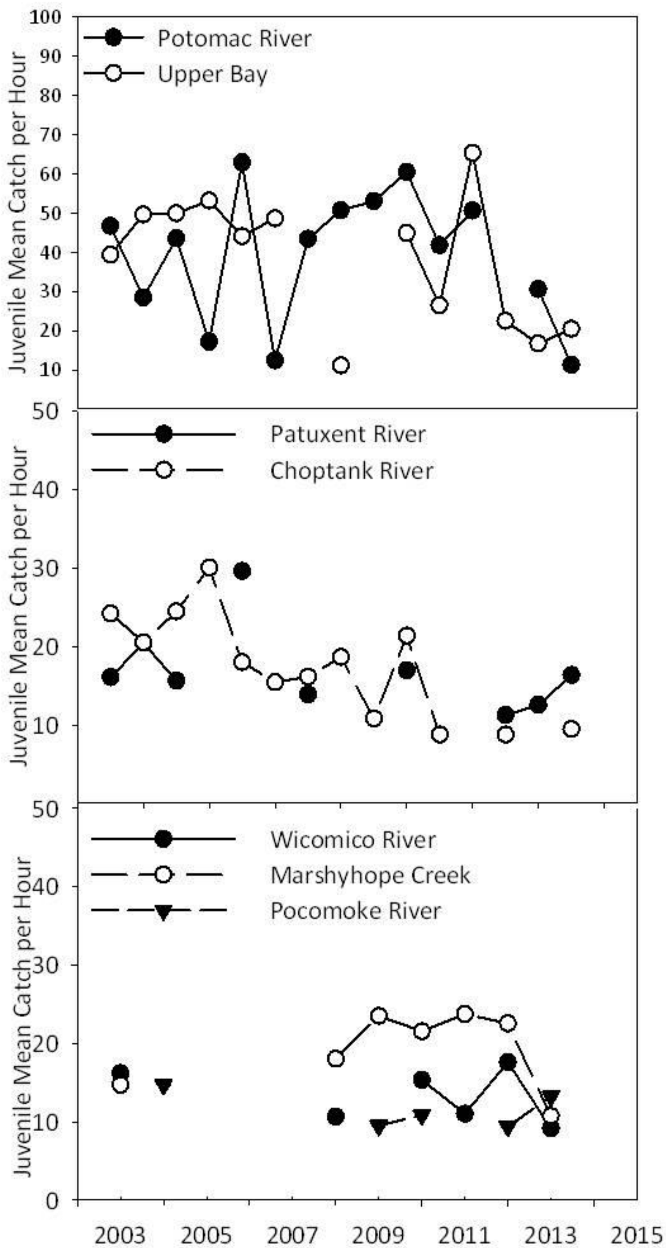


Figure 1. The catch per unit effort (JUV_{CPUE}; geometric mean ± SE) of juvenile (≤ 200 mm TL) Largemouth Bass (*Micropterus salmoides*) estimated for prime habitat sites where they were collected (1999 – 2013, available years).

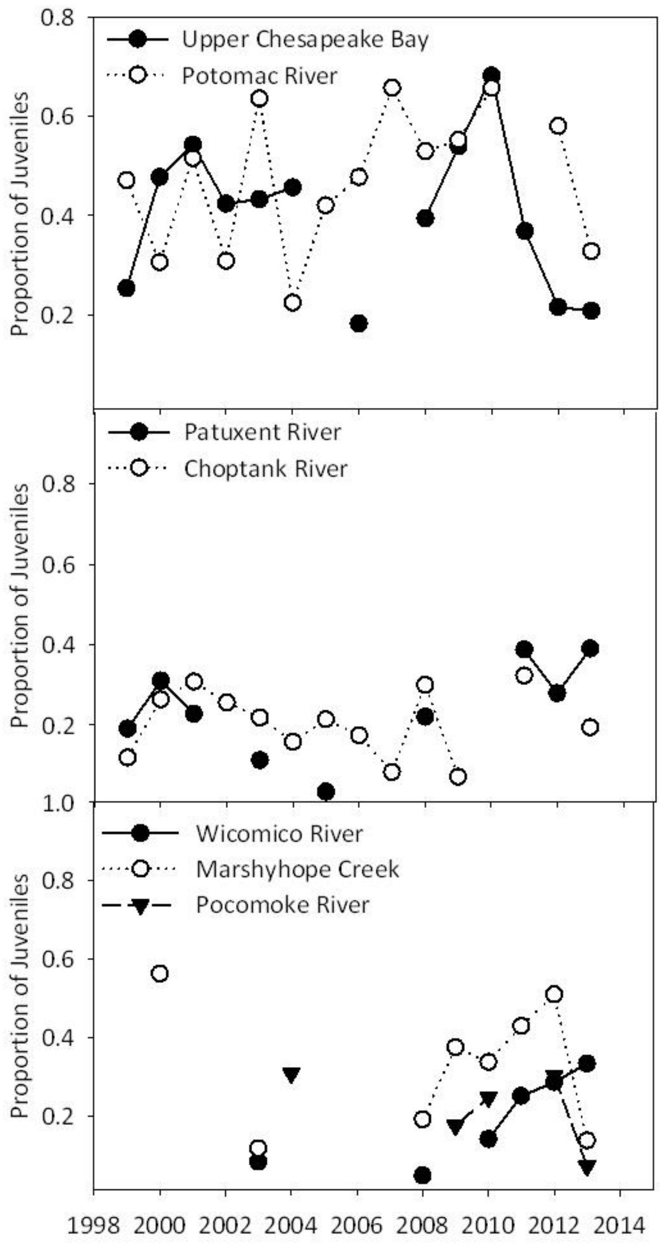


Figure 2. Proportion of juvenile Largemouth Bass (*Micropterus salmoides*)(JUV_{PSD}) in an annual sample of Largemouth Bass surveyed in targeted drainages of the Chesapeake Bay watershed (1999 – 2013, available years).

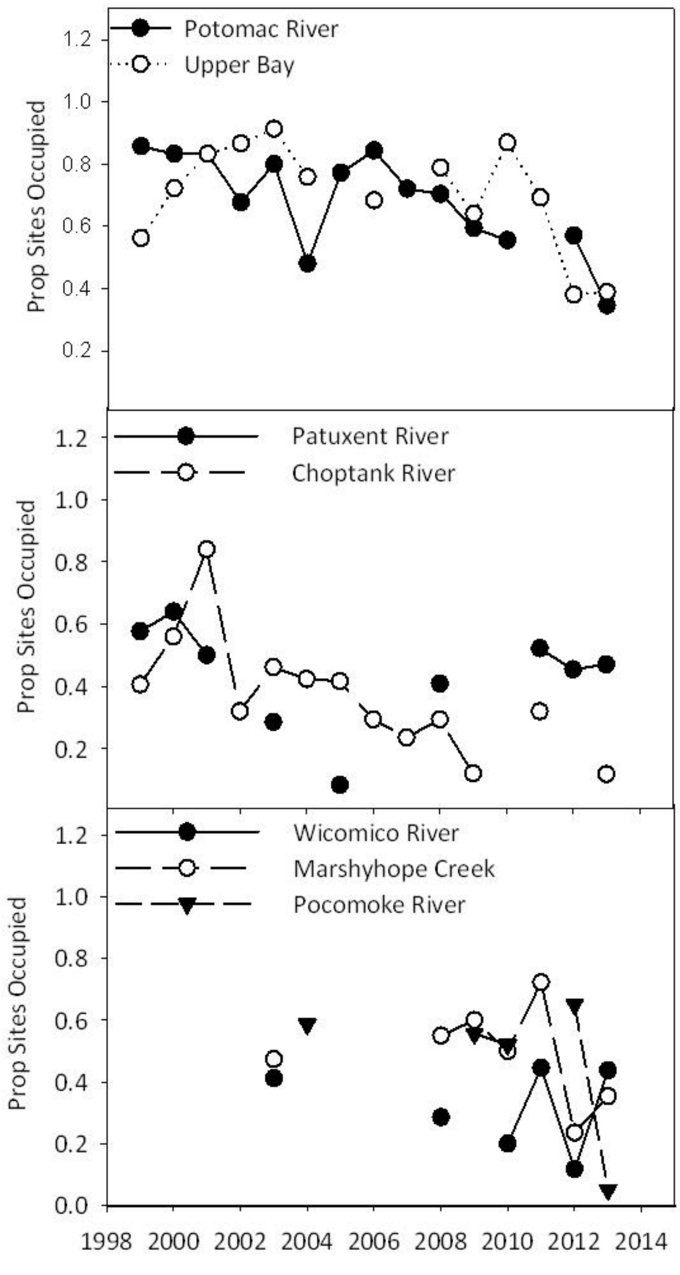


Figure 3. Proportion of prime sites ($JUV_{\%OCC}$) occupied by juvenile Largemouth Bass (*Micropterus salmoides*) for targeted drainages of the Chesapeake Bay (1999 – 2013, available years).

State: Maryland

Project Number: F-48-R-17
Study No.: V
Job No.: 3

Project title: Survey and Management of Freshwater Fisheries Resources
Study Title: Management of Maryland's Tidal Freshwater Streams
Job Title: Hatchery Contribution

Introduction

Success of a sustainable fishery depends on the number of juveniles that reach sexual maturity. Habitat conditions in some drainages of the Chesapeake Bay are potentially harrowing for reproducing adults, which can limit reproduction. Reproduction for Largemouth Bass depends on habitat conditions and the ability of males to defend their nests effectively. High stream discharge from rainstorm events, lack of habitat structure (e.g., grass or snag), and strong fishing pressure may contribute to greater mortality of juveniles and lower percentages of recruits to older age classes. Infrequent stochastic events (e.g., hurricanes and colder than normal winters) also reduce juvenile survivorship. As a result of reduced recruitment, catch levels decline over time and overfishing occurs. To offset increased natural mortality of juveniles, juvenile Largemouth Bass that were grown in farm ponds were selectively released to targeted tidally freshwater streams.

Objectives

1. Release Largemouth Bass to waterways of the Chesapeake Bay watershed;
2. Document recaptures of hatchery reared fish.

Methods

Since 1982, Maryland DNR has recorded the number of Largemouth Bass young-of-year released to various drainages of the Chesapeake Bay watershed. Fish were released mainly during late fall (September – October; i.e., as advanced fingerlings)(Table 1).

The majority of juveniles were released to Choptank River. Early stage fry (~25 mm) were released in large quantities without marks. Older fish released in June were tagged with coded wire tags (CWT). In late fall, advanced fingerlings were marked using passive integrated transponder tags (PIT). The fish were marked with staggered marking types in order to determine whether a particular size class contributed to the spawning stock. A full analysis of whether hatchery fish are contributing to the spawning stock, and a review of the best sizes, will be available in the 2015 Federal Aid Report.

Once Largemouth Bass was collected in Choptank River during the fall survey (see Job 1), each one was scanned using a CWT and PIT detectors. Because there is a history of stocking marked fish in the Patuxent River, all Largemouth Bass collected during that survey were scanned for both PIT tags and coded wire tags (CWT).

Results and Discussion

Hatchery Contribution. In 2013, 214,340 juveniles were raised and released from spawning of adults that were captured from the Potomac River and upper Chesapeake Bay. These adults were released to their home drainages in June. Of the young-of-year raised, most were released to Choptank River (Table 1).

Recruitment to Subsequent Age Classes. In 2013 in Choptank River, there were 2 recaptures of advanced fingerlings that were likely released in 2011. These were 367 and 368 mm TL. At a stocking size of 200 mm, the growth rate is approximately 84 mm/yr, which is slightly higher than that (70 mm/yr) typically exhibited for similarly aged Largemouth Bass in tidal rivers (see Job 1). These recaptured fish had been marked with PIT tags to follow individual growth profiles over time. Despite over 10,000 fingerlings and advanced fingerlings being released to Choptank River, none of the 7 juveniles collected had been spawned in the hatchery. This is likely because of low capture probabilities and presumably high mortality of juveniles. Fry released to Choptank River were not suitably marked; thus it is impossible to know whether the juveniles collected in fall had been hatchery releases earlier in the spring. However, the massive stocking of Largemouth Bass fry in 2009 and 2011 has not led to strong age 3 classes or greater catches, indicating that there is very minimal contribution of fry stocking to the spawning stock. Further analysis of these data is pending.

In Patuxent River, only 3 captured Largemouth Bass had tags. The tags were CWT tags, indicating that the fish were stocked at a size of approximately 50 mm. The sizes of the fish were 207 mm, 371 mm, and 393 mm. The 207 mm fish must have been stocked in 2010 as that is the latest date that CWT marked fish were stocked to the Patuxent River. If true, then that indicates the fish had a growth rate of 50 mm/yr (since June 2010), which is pretty low. The other two fish were likely stocked in 2009, yielding growth rates of approximately 71 mm/yr, which is typical of similarly aged Largemouth Bass in tidal rivers.

Recommendations

1. Stock Largemouth Bass to Choptank River as part of the long-term strategy to determine if stocking has an impact to the fish population
    a. stock a combination of fry, fingerling, and advanced fingerling
    b. complete a partial assessment in 2015, with stockings scheduled for 2015 and 2017
2. Stock Largemouth Bass to Patuxent River as part of a short-term strategy to determine if stocking has an impact to the fish population
    a. complete assessment in 2015
    b. determine whether fingerlings or advanced fingerlings recruit into the fishery

Table 1. Disposition of hatchery reared Largemouth Bass by stage and release area.

DATE	RIVER	NUMBER	STAGE (tag type)	NOTES
5/21-5/30	Choptank	202,677	Fry (none)	Denton, 313 Bridge
7/9,7/16	Choptank	10,565	Fingerling (CWT)	Denton, 313 Bridge
9/11	Gunpowder	93	Adv. Fingerling (none)	Gunpowder SP
10/9	Choptank	125	Adv. Fingerling (PIT)	Denton
10/9	Choptank	300	Fingerling (PIT)	Denton, 83 marked
11/14	Patuxent	580	Adv. Fingerling (PIT)	Western Branch,
Total		214,340		

State: Maryland

Project Number: F48-R-17
Study No.: V
Job No.: 4

Project title: Survey and Management of Freshwater Fisheries Resources
Study Title: Management of Maryland's Tidal Freshwater Streams
Job Title: Creel Surveys

Introduction

The sport of tournament fishing for black bass provides useful data for black bass management. The catch of tournament anglers, while biased for larger and older fish, may be used to support trends observed from fishery independent studies. The mortality of fish during and following tournaments also provides critical insight into fishing mortality.

In addition to a vast audience and participants in tournament sportfishing, large tournaments may generate over 2 million dollars during a week-long event. Baker (2002) reported that large tournaments can generate 2.4 million dollars in a single event at Lake Champlain, largely because the participating anglers spend more than tourists. The impact to local revenue may be modest, however, stemming partially from poor information on the actual economic impact of a large tournament (pers. comm., D. Dudley, Chief of Tourism, Charles County Economic Development and Tourism). In addition to revenue, tournament fishing promotes a sport both locally and nationally. Television programs that promote Largemouth Bass fishing are regularly aired on local networks and cable networks. Arguably, no other fishery receives as much national attention as that for black bass.

While competitive sportfishing accounts for a large fraction of participation in the Largemouth Bass fishery, recreational fishing is also highly valued. In some cases, Largemouth Bass also provides for a subsistence fishery as it is a meaty fish that provides a mild, white fillet. The participation by recreational anglers in the black bass fishery has been assessed with creel surveys in the past. To compliment those surveys, a free and on-line creel census was developed for inland tidal and non-tidal waters (i.e., the Volunteer Angler Survey).

Objectives

1. Determine the number of tournaments and angler participation;
2. Assess angling effort on the stock of Largemouth Bass during the spawning (15 inch) and non-spawning season (12 inch);
3. Quantify and evaluate annual trends in mortality during tournaments;
4. Assess angling effort directed at Largemouth Bass by recreational anglers using a Volunteer Angler Survey.

Methods

Survey Effort. Tournament schedules were searched using the World Wide Web during winter and early spring. Some anglers registered their own tournaments on-line. Beginning in late Fall 2012, it became a requirement for all black bass tournament directors to register their tournaments on-line and get a permit. This registration will significantly cut costs of biologists and provide a much more inclusive dataset in 2013.

Tournament directors were contacted directly or on site for the creel survey. During large tournaments ($\geq$ 50 boats or 100 anglers), a MDDNR Fisheries biologist attended the event, particularly if there was a release boat. The creel survey began in March 2011 and ended in November 2011. Creel survey reports were conducted on site or on-line (http://dnrweb.dnr.state.md.us/fish/bass/basstournament.asp). As part of the permitting procedure mentioned above, directors are required to submit survey reports on-line within 30 days of their tournament day. This requirement will significantly reduce costs of Inland Fisheries to travel to tournaments.

CPAH. Catch per angler hour (CPAH) was determined from tournaments that utilize a rule of 5 bass per angler. The CPAH was calculated as the number of fish caught during a tournament, divided by the product of the number of anglers and the number of hours the tournament allowed anglers to fish. The CPAH was the number of fish caught per angler-hour. These CPAH estimates were averaged for each river for the spawning season (i.e., 1 March – 15 June; the 15" minimum harvest size season) and non-spawning season (the 12" minimum harvest size season). Average CPAH was plotted for each year and for each season to evaluate pattern trends. Averages were also compared with 25th and 75th percentiles generated from data collected from 2004 – 2010.

Survivorship. For the purpose of this study, initial mortality (IM) of an individual was defined as the death of an individual during the weigh-in procedure. In some cases, a fish died after its being weighed. When a fish died after the weigh-in procedure and prior to its being released to the habitat, it was also tallied for IM. A MDDNR fishery biologist was present at all large-tournament events and death of fish prior to their release to the river was noted. Estimates of IM were computed as a proportion that was the number of dead fish divided by the total number of weighed-in fish. Initial Mortality was determined for tournaments held during the spawning and non-spawning season.

Volunteer Angler Survey. A VAS was developed for inland tidal and non-tidal fisheries (Fig. 1). It was posted on-line (http://dnr.maryland.gov/fisheries/survey/index.asp) and advertised, along with others, in the spring using press releases. It was also advertised with the Angler's Log whereby anglers who submitted information immediately received a "thank you" and follow-up email encouraging their participation in the VAS. The survey was incentivized with a random drawing of entries from Bass Pro Shops.

Results

General. Data were collected for 140 tournaments in Potomac River and upper Chesapeake Bay, during which 5,483 anglers fished approximately 8 hours a day from March – November on Potomac River and the upper Chesapeake Bay (Table 1). The number of tournament activity reports from the Potomac River was 56, which is lower than the 84 from the upper Chesapeake Bay. This is the first year in the time series when the number of tournaments in the upper Bay exceeded those of the Potomac River. The number of tournaments in the upper Chesapeake Bay was higher than previous years (Table 1). The mandatory permitting system may now be representing upper Bay tournaments that were not originally represented; however, a recent swelling among anglers of an extraordinary upper Bay fishery has likely navigated interest from the Potomac River to the upper Bay.

Data were also collected for a small number tournaments held in other tidal waters of the state (Gunpowder River, Choptank River, Nanticoke River, Pocomoke River, Wicomico River). In total, anglers reported data for 47,026 lbs and 20,521 fish.

Angling Effort. The CPAH for the Potomac River during the non-spawning season (0.39 bass/ang-hr) was not different than reference points (Table 2) and higher than that reported for the upper Chesapeake Bay (0.28 bass/ang-hr)(Table 2). In general, CPAH for both Potomac River and the upper Chesapeake Bay has increased over time during both the non-spawning and spawning seasons (Fig. 2). The CPAH for other drainage populations is less well-reported and was similar to that for the upper Chesapeake Bay and Potomac River (Table 2).

Survivorship. For both Potomac River and upper Chesapeake Bay, initial mortality (IM) at the weigh-in scale was generally lower than 0.05 (Table 2), which is the reference point cited in the FMP. Thus, survivorship tended to be greater than 95% of all released fish (Fig. 3). Alternatively, it may be a result of greater catch rates leading to greater handling, greater catches, and greater mortality. Survivorship following Largemouth Bass tournaments ranged, on average, between 97.9% and 100%.

Volunteer Angler Survey. There were 301 volunteer angler surveys submitted and they represented at least 534 anglers. The average number of anglers per angler survey was 1.77. The average number of hours per trip was 4.4, with a total of 1355 reported. Of these anglers, 37.9% reported targeting Largemouth Bass.

There were 3528 fishes caught and reported. Of those, 638 were Largemouth Bass. Thus, 18.1% of the catch by anglers was Largemouth Bass. As expected from previous creel census, a very small proportion of reported Largemouth Bass was harvested (13 of 638, or 2.0%).

The average spent by anglers targeting Largemouth Bass ($35.00/day) was slightly more than that spent by anglers who did not target Largemouth Bass ($31.00/day).

Of anglers targeting bass, most reports were submitted from anglers who fished impoundments (40.4%; Figure 4). The Potomac River was the second well-reported location (24.6% of reports); the upper Chesapeake Bay was third (4.4%). Similar to that observed with tournament angler reports, the Potomac River and upper Chesapeake Bay appear to be the two most highly targeted tidewater areas by anglers. Other systems reported as targeted by anglers included: Gunpowder River and Middle River (1.8%), Pocomoke River (0.9%), and Nanticoke River (0.9%).

Discussion

Catch per angler hour has increased for Potomac River and the upper Chesapeake Bay over time. Angler participation has remarkably increased in the upper Chesapeake Bay. The Potomac River and upper Chesapeake Bay remain the two most important tidewater fisheries for Largemouth Bass, which is also supported by data from the Volunteer Angler Survey. The CPAH estimates are underestimates because they do not account for discards or culled Largemouth Bass.

Reported survivorship levels have not changed noticeably in the Potomac River and upper Chesapeake Bay since 2005. Similar to initial mortality in the Potomac River, initial mortality for the upper Bay was less than 5%, on average. Initial mortality occurs because of hooking injury (Wilde and Pope 2008), handling stress and live well conditions (Gilliand 2002; Suski et al. 2006; Siepker et al. 2007). Mortality is also expected to be higher during summer months when water temperatures are relatively high (Wilde 1998). None-the-less, many anglers have adopted good handling practices; there remain several observed problems at tournaments, though. These problems include: dry bags, improper holding of fish (from lip, without support of caudal region), and poor live well maintenance. Awareness may help solve these problems, particularly through the on-line permitting and requirements. Additional on-the-ground work is still encouraged.

Recommendations

1. Improve data collection from popular tournament sites of eastern shore rivers;
2. Sync a targeted, on-the-ground creel survey with the Volunteer Angler Survey that incentivizes anglers to provide information on their fishing and harvest of Largemouth Bass
3. Continue to improve the communication network among directors, anglers, and the Tidal Bass Program
4. Provide legitimate and informative information related to live well maintenance and improving survivorship to anglers
5. Use established channels to facilitate exchange of relevant and important information related to the fishery and handling of Largemouth Bass

Table 1. History of tournament activity in the upper Chesapeake Bay (UBAY) and Potomac River (POTM). The number of tournaments (#TOURNS) and the sum of participating anglers across days (#ANGLERS) are given for each year (1989, 1994 – 2013). Surveys were not routinely conducted until 1994 and less effort was directed toward the upper Chesapeake Bay until 2005. Numbers in parentheses are catch per angler hour (CPAH) during the 12 inch, non-spawning season. The CPAH reflects only weighed-in, legally harvestable fish and not those culled.

YEAR	# $TOURNS_{UBAY}$	# $TOURNS_{POTM}$	# $ANGLERS_{UBAY}$	# $ANGLERS_{POTM}$
1989	NA	8[*]		1056 (0.28)
1994	18[1]	125[1]	906 (0.20)	5538 (0.28)
1995	5[1]	178[1]	403 (0.34)	6958 (0.31)
1996	5[1]	168[1]	412 (0.22)	4919 (0.33)
1997	20[1]	221[1]	1420 (0.32)	5062 (0.31)
1998	7[1]	272[1]	610 (0.32)	5568 (0.28)
1999	12[2]	72[2]	(0.21)	(0.24)[4]
2000	3[3]	77[3]	(0.24)[4]	(0.24)[4]
2001	4	75	318 (0.18)[4]	3750 (0.21)[4]
2002	16	145	(0.34)[4]	(0.26)[4]
2003	12	82	511 (0.22)	3523 (0.35)[4]
2004	3	107	82 (0.31)[4]	4042 (0.23)[4]
2005	30	98	508 (0.23)[4]	5299 (0.29)[4]
2006	14	103	1062 (0.27)[4]	5730 (0.35)[4]
2007	30	102	719 (0.30)[4]	6397 (0.34)[4]
2008	25	103	764 (0.24)[4]	4802 (0.42)[4]
2009	26	85	1500 (0.30)	3594 (0.44)
2010	41	81	2512 (0.29)	3962 (0.36)
2011	51	64	1308 (0.29)	2938 (0.42)
2012	55	73	1254 (0.36)	3043 (0.37)
2013	84	56	1952 (0.28)	3531 (0.39)

[*]incomplete dataset obtained prior to dedicated creel survey efforts (pers. comm., M. Groves, Southern Region Manager, MDDNR)
[1]From MDDNR (1999)
[2]From MDDNR (2000)
[3]From MDDNR (2001)
[4]From MDDNR (2009)

Table 2. Black bass tournaments provided estimates of mortality throughout the weigh-in process (M) and catch per angler-hour (CPAH) of Largemouth Bass in 2012 for targeted drainages of the Chesapeake Bay watershed. Estimates of Mortality are given for Large (L, ≥ 100 anglers) and Small (S, < 100 anglers) tournaments. The CPAH estimates were calculated for the spawning (SP; March 1 – June 15) and non-spawning (NS) seasons. When a metric falls below the 25th percentile computed for available data for that river, the ▼ symbol is given. When a metric falls above the 75th percentile computed for available data for that river, then the ▲ symbol is given. nc = no change in the value. Abbreviations for indices are in text. na = not available.

River	M LNS	M LSP	CPAH SP	M SNS	M SSP	CPAH NS
Potomac	0.021 n.c.	0.013 n.c.	0.293 ▲	0.017 n.c.	0.009 ▼	0.386 n.c.
Upper Bay	0.003 ▼	0.000 n.c.	0.222 ▼	0.009 n.c.	0.016 n.c.	0.281 ▲
Choptank						
Pocomoke						0.530
Wicomico						0.304
Gunpowder			0.236			0.396
Marshyhope						0.342
Sassafras			0.186			

Freshwater (Tidal & Nontidal) Multispecies Survey (Includes Snakehead)

Welcome JOSEPH

1. When was your most recent fishing trip (MM/DD/YYYY)?	-- Month -- -- Date -- (yyyy)
2. For your most recent fishing trip, how many hours did you fish? (for example, 1.5)	
3. For your most recent fishing trip, how many other anglers were in your party?	
4. For your most recent fishing trip, where did you fish?	-- If Other,
5. For your most recent fishing trip, were you fishing from a boat or the bank?	--
6. For your most recent fishing trip, were you fishing a bass tournament?	○ Yes ○ No
7. For your most recent fishing trip, how many fish of each did you CATCH, if any? *(this information helps fishery managers understand the value of the habitat for the fish and the success of the anglers on the water)*	
Largemouth Bass:	0
Catfish:	0
Crappie:	0
Yellow Perch:	0
Bluegill (or other sunfish):	0
White Perch:	0
Pickerel:	0
Northern Snakehead:	0
Other: Type in Species	0
8. For your most recent fishing trip, check the fish you were TRYING to catch, if any?	
Largemouth Bass:	0
Catfish:	0
Crappie:	0
Yellow Perch:	0
Bluegill (or other sunfish):	0
White Perch:	0
Pickerel:	0

Figure 1. Volunteer Angler Survey developed for Inland Freshwater Tidal and Non-tidal Ecosystems.

Northern Snakehead:	0
Other: Type in Species	0
9. For your most recent fishing trip, how many fish of each did you KEEP, if any? *(this answer helps fishery managers understand how valuable fish is to our diets)*	
Largemouth Bass:	0
Catfish:	0
Crappie:	0
Yellow Perch:	0
Bluegill (or other sunfish):	0
White Perch:	0
Pickerel:	0
Northern Snakehead:	0
Other: Type in Species	0
10. For your most recent fishing trip, what bait did you use?	
11. Check if you think northern snakeheads are a threat to:	☐ Largemouth Bass ☐ Aquatic Communities ☐ Native Species ☐ Uncertain
12. Have you ever fished specifically for northern snakehead?	○ Yes ○ No
13. Do you plan to fish again for northern snakehead?	○ Yes ○ No
14. For your most recent fishing trip, roughly how much money did you spend? *(this answer helps provide information on the value of fishing in Maryland)*	--

Submit Reset

Figure 1 (*cont.*). Volunteer Angler Survey developed for Inland Freshwater Tidal and Non-tidal Ecosystems.

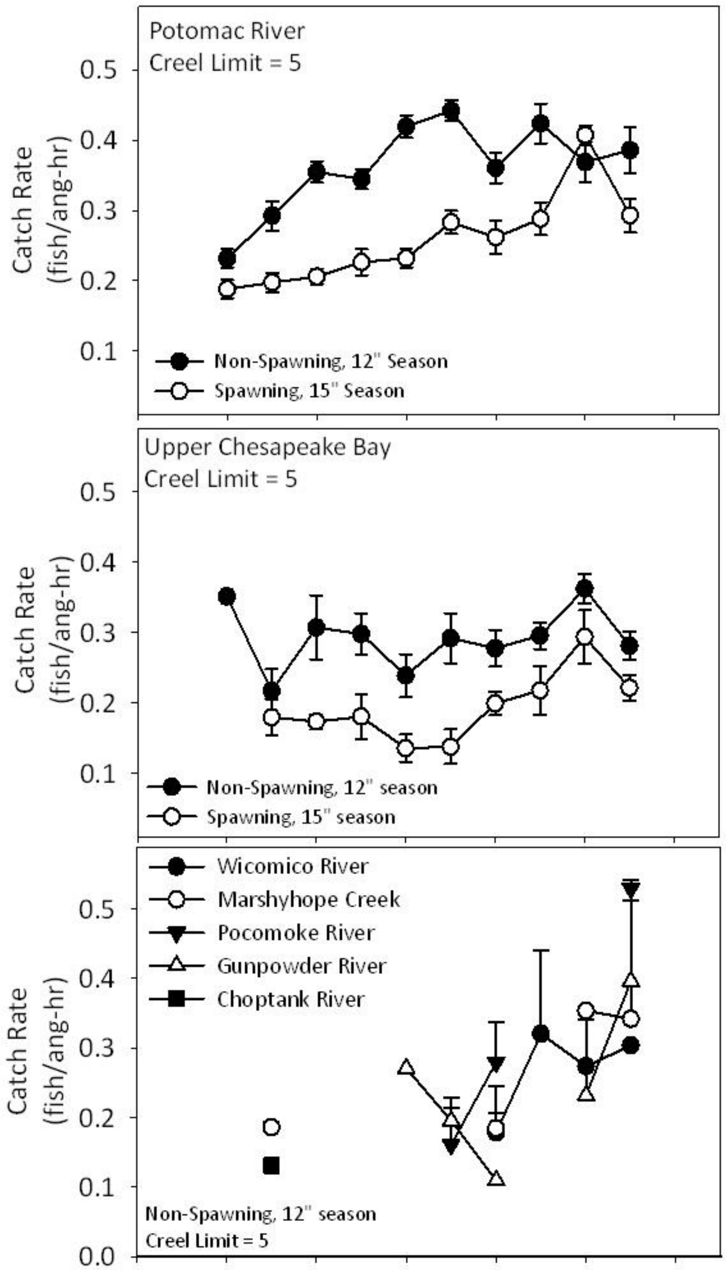


Figure 2. Catch per angler hour (± SE) and biomass of Largemouth Bass (*Micropterus salmoides*) reported from tournament anglers during the spawning season (1 March – 15 June) and non-spawning season since 2004 in targeted drainages of the Chesapeake Bay watershed.

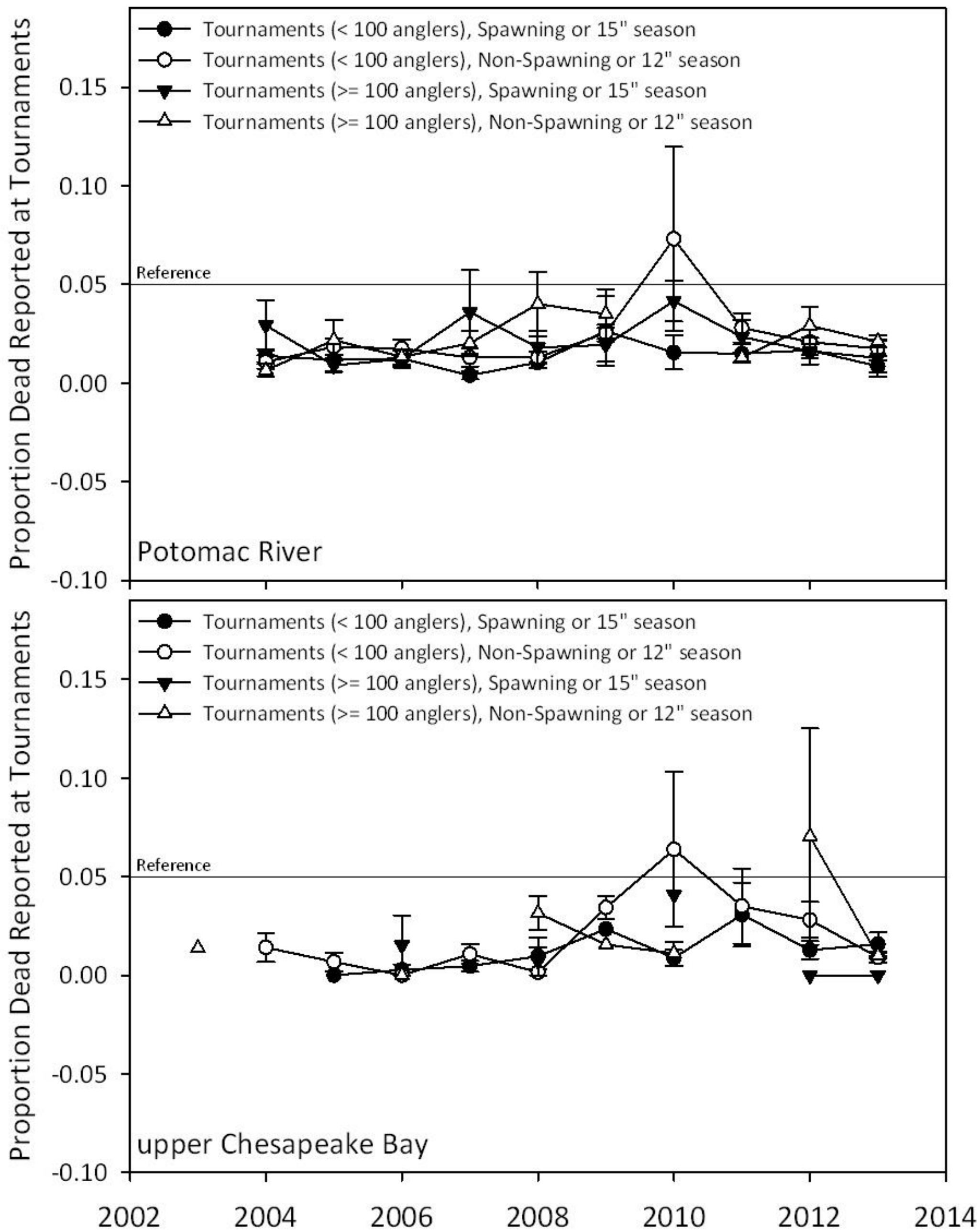


Figure 3. Reported survivorship of Largemouth Bass (*Micropterus salmoides*) averaged for tournaments held during the spawning season (Sp; 1 March – 15 June) and non-spawning season (NS) since 2003 in the Potomac River and the upper Chesapeake Bay.

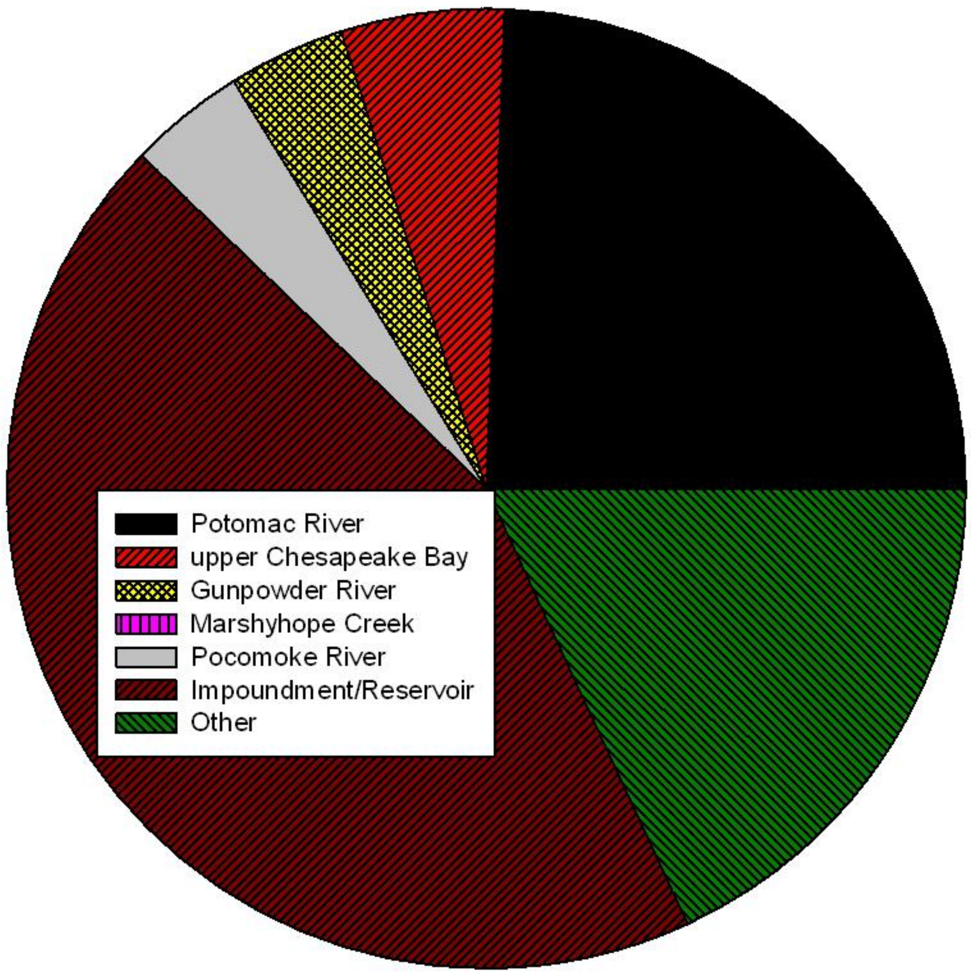


Figure 4. Relative proportion of angler reports from various waterways where anglers caught Largemouth Bass (*Micropterus salmoides*). The other category includes, Anacostia River, Bush River, Patapsco River, and small streams and ponds.

State: Maryland

Project Number: F48-R-17
Study No.: V
Job No.: 5

Project title: Survey and Management of Freshwater Fisheries Resources
Study Title: Management of Maryland’s Tidal Freshwater Streams
Job Title: Population Genetic Assessment

No work has been done with this assessment.

Literature Cited 2013

Alexander, G.R. 1977. Consumption of small trout by large predatory brown trout in the North Branch of the Ausable River, Michigan. Michigan DNR Fisheries Rep. No. 1855. Federal Aid in Sportfish Restoration Proj. F-35-R. Final Report. Lansing.

Allen, M.S. and W.E. Pine III. 2000. Detecting fish population responses to a minimum length limit: effects of variable recruitment and duration of evaluation. North American Journal of Fisheries Management 20: 672-682.

Anderson, R.O. 1980. Proportional Stock Density (PSD) and Relative Weight (Wr): interpretive indices for fish populations and communities. Pages 27-33 in S. Gloss and B. Shupp, editors. Practical fisheries Management: more with less in the 1980's. Proceedings of the 1st Annual Workshop of the New York Chapter American Fisheries Society. New York Cooperative Fishery Research Unit, Ithaca, New York, USA.

Anderson, R.O. and A.S. Weithman. 1978. The concept of balance for coolwater fish populations. Pages 371-381 *in* R.L. Kendall, editor. Selected coolwater fishes of North America, Special Publication 11, North American Fisheries Society Bethesda, Maryland.

Baker, P. 2002. FLW Outdoors leaves $10,000 'thank you' note at Lake Champlain. www.FLWoutdoors.com. [internet posting]

Barbour, M.T., J. Gerritsen, B.D. Snyder, J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Barnhart, G. A. and R. Engstrom-Heg. 1984. A synopsis of some New York Experiences with catch and release management of wild salmonids. Pages 91 – 101 *in* F. Richardson and R.H. Hamre, technical editors. Wild Trout III – Proceedings of the Symposium, Yellowstone National Park.

Beamesderfer, R.C.P., and J.A. North. 1995. Growth, natural mortality, and predicted response to fishing for largemouth bass and smallmouth bass populations in North America. North American Journal of Fisheries Management 15: 688 – 704.

Betross, E.A. and D.W. Willis. 1988. Seasonal patterns in sampling data for largemouth bass and bluegills in a northern Great Plains impoundment. Prairie Naturalist 20: 193-202.

Blazer, V.S., L.R. Iwanowicz, C.E. Starliper, D.D. Iwanowicz, P. Barbash, J. D. Hedrick, S.J. Reeser, J.E. Mullican, S.D. Zaugg, M.R. Burkhardt, and J. Kelble. "Mortality of Centrarchid Fishes in the Potomac Drainage: Survey Results and Overview of Potential Contributing Factors." Journal of Aquatic Animal Health 22: 190 – 218. 2010

Bode, R.W. 1988. Quality assurance work plan for biological stream monitoring in New York State. New York State Department of Environmental Conservation. Albany, New York.

Bonar, S.A., B.D. Bolding, M. Divens. 2000. Standard Fish Sampling Guidelines for Washington State Ponds and Lakes. Washington Department of Fish and Wildlife, Fish Program. Olympia.

Borawa, J.C. 1990. Muskellunge fishery angler diary program. Federal Aid in Fish Restoration Project F-24-15. North Carolina Wildlife Resources Commission. Raleigh.

Calder, W.A. III. 1996. Size, Function, and Life History. Dover Publications, Inc. Mineola, NY

Campana, S.E., L. Marks, W. Joyce, and N.E. Kohler. 2006. Effects of recreational and commercial fishing on blue sharks (*Prionace glauca*) in Atlantic Canada, with inferences on the North Atlantic population. Canadian Journal of Fisheries and Aquatic Sciences 63: 670-682.

Cone, R.S. 1989. The need to reconsider the use of condition index in fishery science. Transactions of the American Fisheries Society 118:510-514.

Copeland, John. personal communication, Virginia Dept. of Game and Inland Fish

Dewald, L.C. 1990. Growth, habitat use, and foraging behavior of wild brook char and hatchery brown trout in the presence and absence of each other. M.S. thesis. Frostburg State University, Frostburg, MD.

Enamait, E.C. and R.M. Davis. 1986. Monitoring of Smallmouth Bass in the Potomac River 1980 – 1985. *In* Federal Aid in Sportfish Restoration Project F-29-R-9. Annual Report. Maryland Department of Natural Resources, Tidewater Administration. Annapolis.

FAST. 2005. Fishery Analysis and Simulation Tools (FAST 2.0) software developed by J.W. Slipke and M.J. Maceina, Department of Fisheries and Allied Aquacultures, Auburn University, Alabama.

Faush, K.D., and R.J. White. 1981. Competition between brook trout and brown trout for positions in a Michigan stream. Canadian Journal of Fisheries and Aquatic Sciences 38:1220-1227.

Fiss, F. C., T. A. Cleveland, B. D. Carter, R. D. Bivens, and J. M. Swearengin. 2001. Population characteristics of riverine smallmouth bass in Tennessee, simulated effects of length limits, and management recommendations. Tennessee Wildlife Resources Agency, Fisheries Report 01 - 19.

Gablehouse, D.W. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Gilliand, E.R. 2002. Livewell operating procedures to reduce mortality of black bass during summer tournaments. *In* D.P. Philipp and M.S. Ridgway, eds. Black Bass 2000: ecology, conservation, and management. American Fisheries Society Symposium 31:477-488, Bethesda, Maryland.

Gulland, J.A. 1976. Production and catches of fish in the sea. p. 283-316 in D.H. Cushing and J.J. Walsh (eds.) The ecology of the seas. Blackwell Scientific Publications, Oxford.

Gulland, J.A. and Holt, S.J. 1959. Estimation of growth parameters for data at unequal time intervals. Journal du Conseil, Conseil International pour L'Exploration de la Mer, 25 (1): 9 – 47.

Gustafson, K.A. 1988. Approximating confidence intervals for indices of fish population size structure. North American Journal of Fisheries Management 8: pages 139-141.

Guy, C.S., R. M. Neumann, D.W. Willis, and R.O. Anderson. 2007. Proportional size distribution (PSD): a further refinement of population size structure index terminology. Fisheries 32(7):348.

Hammer, Ø., Harper, D.A.T., and P. D. Ryan, 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4(1): 9pp

Hanson, E., A. Collins, S. Zegre, and A. Hereford. 2010. The benefits of acid mine drainage remediation on the North Branch Potomac River. Downstream Strategies, Morgantown, WV 26505.

Heidinger, R. C., and K. Clodfelter. 1987. Validity of the otolith for determining age and growth of walleye, striped bass, and smallmouth bass in power cooling plant ponds. Pages 241-251 *in* R. C. Summerfelt and G. E. Hall, editors. Age and growth of fish. Iowa State University Press, Ames.

Henson, J.C. 1991. Quantitative description and development of a species-specific standard growth from for largemouth bass, with application to the relative weight index. Master's thesis. Texas A&M University, College Station.

http://dnrweb.dnr.state.md.us/fish/bass/basstournament.asp

http://dnr.maryland.gov/fisheries/survey/index.asp

http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=2265)

http://www.marisdata.org/

Isermann, D.A. and C.T. Knight. 2005. A computer program for age-length keys incorporating age assignment to individual fish. North American Journal of Fisheries Management 25:1153-1160.

Justus, B. 1994. Observations on electrofishing techniques for three catfish species in Mississippi. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 48:524-532.

Kaeding. L.R. 1980. Observations on communities of brook and brown trout separated by an upstream-movement barrier on the Firehole River. The Progressive Fish Culturist Vol. 42(3):174-176.

Kerr, S.J. 2007. Characteristics of Ontario muskellunge (Esox masquinongy) fisheries based on volunteer angler diary information. Environmental Biology of Fisheries 79:61 – 69.

Lagler, K.F. 1952. Freshwater fishery biology. First edition, Wm. C. Brown Co., Dubuque, Iowa.

Love, J.W. 2011. Habitat suitability index for largemouth bass *Micropterus salmoides* in tidal rivers of Chesapeake Bay watershed. Transactions of the American Fisheries Society 140:1049-1059.

Love, J.W. and J.J. Newhard. 2012. Will the expansion of northern snakehead negatively affect the fishery for largemouth bass in the Potomac River (Chesapeake Bay)? North American Journal of Fisheries Management 32:859-868.

Markham, J.L., D.T. Cosden, and R.K. Schaefer. 2002. Use of GIS generated habitat maps for sampling largemouth bass in Maryland's tidal rivers. Pages 693-602 *in* D.P. Philipp and M.S. Ridgway, editors. Black Bass: Ecology, Conservation, and Management. American Fisheries society, Symposium 31, Bethesda, Maryland.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Coldwater Fisheries Program). 1986. Federal Aid in Sportfish Restoration Project F-36-R 1985. Final Report. Maryland Tidewater Administration. Annapolis.

MD DNR (Maryland Department of Natural Resources). 1991. Trout studies in the Youghiogheny River catch and release trout fishing area- final performance report 1987 - 1990, Project F-48-R, Study B, Job 2. Maryland Department of Natural Resources, Annapolis, MD 21401.

MD DNR Maryland (Department of Natural Resources, Freshwater Fisheries Division). 1991. Survey, Inventory, and Management of Maryland's Coldwater Fishery Resources. Federal Aid in Sportfish Restoration Project F-36-R, Study B, Job 2 1985 - 1990. Final Report. Annapolis.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Freshwater Fisheries Division). 1995. Survey and management of Maryland's fishery resources: performance report 1994. Federal Aid in Sportfish Restoration Project F-48-R-9. Annual Report Maryland Department of Natural Resources, Annapolis, Maryland.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Freshwater Fisheries Division). 1999. Survey and management of Maryland's fishery resources: performance report 1998. Federal Aid in Sportfish Restoration Project F-48-R-9. Annual Report Maryland Department of Natural Resources, Annapolis, Maryland.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Inland Fisheries Division). 2000. Survey and management of Maryland's fishery resources: performance report 1999. Federal Aid in Sportfish Restoration Project F-48-R-9. Annual Report. Annapolis.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Inland Fisheries Division). 2001. Survey and management of Maryland's fishery resources: final performance report 1996 -2000. Federal Aid in Sportfish Restoration Project F-48-R-10. Final Report. Annapolis.

MD DNR (Maryland Dept. of Natural Resources Fisheries Service, Inland Fisheries Division). 2002. Survey and management of Maryland's fisheries resources; performance report 2001. Federal Aid in Sportfish Restoration Project F-48-R-11. Annual Report. Annapolis.

MD DNR (Maryland Department of Natural Resources, Fisheries Service, Inland Fisheries Division). 2003. Survey and management of Maryland's fishery resources: performance report 2003. Federal Aid in Sportfish Restoration Project F-48-R-18). Annual Report. Annapolis, Maryland.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Inland Fisheries Division). 2004. Survey and management of Maryland's fisheries resources; performance report 2003. Federal Aid in Sportfish Restoration Project F-48-R-13. Annual Report. Annapolis.

Maryland Department of Natural Resources Fisheries Service, Inland Fisheries Division **(**MD DNR). 2009. Survey and management of Maryland's fisheries resources: performance report 2008. Federal Aid in Sportfish Project F-48-R-18. Annual Report. Annapolis.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Inland Fisheries Division). 2011. Survey and management of Maryland's fishery resources: annual performance report 2010. Federal Aid in Sportfish Restoration Project F-48-R-20). Annapolis.

MD DNR (Maryland Department of Natural Resources Fisheries Service, Inland Fisheries Division). 2012. Survey and management of Maryland's fishery resources: annual performance report 2011. Federal Aid in Sportfish Restoration Project F-48-R-20). Annapolis.

MD DNR 2013. Maryland Fishing Guide . Annapolis MD

MD DNR RSA (Maryland Department of Natural Resources, Resource Assessment Service). 2010. 2009 Deep Creek Lake Water Quality Monitoring Program Volume I. Annapolis.

MDE (Maryland Department of the Environment). 1994. Deep Creek Lake hydroelectric station water appropriation permit no. GA92S009(01). MDE - Water Rights Division. Baltimore.

MDE (Maryland Department of the Environment). 2007. Deep Creek Lake hydroelectric station water appropriation and use permit no. GA1992S009(07). MDE – Water Rights Division, Baltimore, MD.

Merritt, R.W. and K. W. Cummins. 1984. An introduction to the aquatic insects of North America, second edition. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Mion, Joseph B, Roy A. Stein, and Elizabeth A. Marschall. 1998. River Discharge Drives Survival of Larval Walleye. Ecological Applications, 1998, v.8, iss.1, p.88-103

Miranda, L.E., W.D. Hubbard, S.Sangara, T. Holman. 1996. Optimizing Electrofishing sample duration for estimating relative abundance of largemouth bass in reservoirs. North American Journal of Fisheries Management 16:324-331.

Morris, L.A. and P.F. Novak. 1968. The telephone generator as an electrofishing tool. Progressive Fish Culturist 30:110-112.

Motulsky, H.J. 2003. Prism 4 Statistics Guide – statistical analyses for laboratory and clinical researchers. Graphpad Software, Inc., San Diego CA.

Muoneke, M.I. and K.L. Pope. 1999. Development and evaluation of a standard weight equation for Blue Catfish. North American Journal of Fisheries Management 19:878-879.

Nielsen L.A., and D.L. Johnson. 1983. Sampling Considerations. Pages 1-21 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques, 1st edition. American Fisheries Society, Bethesda, Maryland

Odenkirk, John and Scott Smith. 2005. Single Versus Multiple-Pass Boat Electrofishing for Assessing Smallmouth Bass Populations in Virginia Rivers. North American Journal of Fisheries Management, Volume 25, Issue 2. pp 717 – 724.

Paragamian, V. L. 1984. Population characteristics of smallmouth bass in five Iowa streams and management recommendations. North American Journal of Fisheries Management 4:497–506.

Philipp, D.P. and M.S. Ridgway, eds. 2002. Black Bass 2000: ecology, conservation, and management. American Fisheries Society, Symposium 31. American Fisheries Society. Bethesda, Maryland.

Pennak, R. W. 1978. Freshwater invertebrates of the United States. Ronald Press, NY.

Quinn, S.P. 1986. Effectiveness of an electrofishing system for collecting Flathead Catfish. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 40:85-91.

Quist, M.C., K.I. Bonvechio, and M.S. Allen. 2009. Statistical analysis and data management. Pages 171 – 194 *in* Bonar, S.A., W.A. Hubert, and D.W. Willis (eds.). Standard Methods for Sampling North American Freshwater Fishes, American Fisheries Society. Bethesda, Maryland.

Raleigh, R.F. 1982. Habitat suitability index models: brook trout. U.S. Department of Interior. Fish and Wildlife Service, FWS/OBS-82/10.24.

Reeser, Steve. personal communication, Virginia Dept. of Game and Inland Fish

Reynolds, J.B., and L.R. Babb. 1978. Structure and dynamics of largemouth bass populations. Pages 50-61 *in* G.D. Novinger and J.D. Dillard, editors. New Approaches to the Management of Small Impoundments. North Central Division, American Fisheries Society, Special Publication 5. Bethesda, Maryland.

Richards, K. and Ramsell, R. 1986. Quantifying the success of muskellunge catch and release programs: A summary of cooperative angler-tagging studies. Pages 309 – 315 *in* Managing Muskies. American Fisheries Society Special Publication 15. Bethesda, Maryland.

Ridgway, M.S. 2002. Movements, home range, and survival estimation of largemouth bass following displacement. American Fisheries Society Symposium 31: 525-533, Bethesda, Maryland.

Rivers, S.E. 2004. Angler's preference survey. Study I, Job 2. *In* Survey and management of Maryland's fishery resources: annual performance report 2004. Federal Aid in Sportfish Restoration Project F-48-R-14). Maryland Department of Natural Resources Fisheries Service, Inland Fisheries Division. Annual Report. Annapolis.

Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. Common and scientific names of fishes from the United States and Canada, fifth edition. American Fisheries Society - Special Publication 20. Bethesda, Maryland.

Schloesser, R.W., M.C. Fabrizio, R.J. Latour, G.C. Garman, B. Greenlee, M. Groves, and J. Gartland. 2011. Ecological Role of Blue Catfish in Chesapeake Bay Communities and Implications for Management *in* Conservation, Ecology and Management of Catfish, The Second International Symposium. Pages 369-382, P.H. Michaletz and V.H. Travnichek, editors. American Fisheries Society. Symposium 77, Bethesda, MD.

Siepker, M.J., K.G. Ostrand, S.J. Cooke, D.P. Phillipp, and D.H. Wahl. 2007. A review of the effects of catch-and-release angling on black bass, *Micropterus* spp.: implications for conservation and management of populations. Fisheries Management and Ecology 14: 91-101.

Snedecor, G.W., and W. G. Cochran. 1968. Statistical Methods. 6th edition. Iowa State University Press, Ames.

Southerland, M.T., M.J. Kline, D.M. Boward, G.M. Rogers, R.P. Morgan, P.F. Kazyak, R.J. Klauda, and S.A. Stranko. 2005. New biological indicators to better assess the condition of Maryland streams. Maryland Department of Natural Resources Publication # DNR-12-0305-0100.

Stefánsson, G. 1996. Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES Journal of Marine Science 53:577-588.

Steiner, L. 2000. Pennsylvania Fishes. Pennsylvania Fish and Boat Commission, Harrisburg.

Stewart, K.W. and B.P. Stark. 1988. Nymphs of the North American stonefly genera (Plecoptera). Entomological Society of America, Washington, D.C.

Suski, C.D., S.S. Killen, J.D. Kieffer, and B.L. Tufts. 2006. The influence of environmental temperature and oxygen concentration on the recovery of largemouth bass from exercise: implications for live-release angling tournaments. Journal of Fish Biology 68: 120-136.

U.S. EPA. 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. United States Environmental Protection Agency. EPA-670/4-73-001. July 1973. Environmental Monitoring Series. National Environmental Research Center, Cincinnati.

U.S. EPA. 2000. Ambient Water Quality Criteria Recommendations, Rivers and Streams in EcoRegion IX. U.S. Environmental Protection Agency, Washington, DC. EPA-822-B-00-019.

Van Deventer, J.S. and W.S. Platts. 1985. MicroFish 2.2 microfish interactive program. Microsoft Corporation.

Waters, T.F. 1983. Replacement of brook trout by brown trout over 15 years in a Minnesota stream: production and abundance. Transactions of the American Fisheries Society 112: 137-146.

Waters, T.F., J.P. Kaehler, T.J. Polomis, and T.J. Kwak. 1993. Production dynamics of Smallmouth Bass in a small Minnesota stream. Transactions of the American Fisheries Society 122:588 – 598.

Wege, G. J. and R. O. Anderson. 1978. Relative Weight (Wr): a new index of condition for largemouth bass. Pages 79-133 *in* G. D. Novinger and J. D. Dillard, editors. New approaches to the Management of Small Impoundments. American Fisheries Society Special Publication No. 5, North Central Division, American Fisheries Society. Bethesda, MD.

Weithman, S. A., J. B. Reynold, and D. E. Simpson. 1979. Assessment of structure of

Largemouth Bass stocks by sequential sampling. 33rd Proceeding Annual Conference Southeast Association Fish and Wildlife Agencies 33, pages 415-424.

Wiggins, G.B. 1977. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press, Toronto, Canada.

Wilde, G.R. 1998. Tournament-associated mortality in black bass. Fisheries 23(10):12 22.

Wilde, G.R. and K.L. Pope. 2008. A simple model for predicting survival of angler-caught and released largemouth bass. Transactions of the American Fisheries Society 137:834-840.

Willis, D.W., B.R. Murphy, and C.S. Guy. 1993. Stock density indices: development, use, and limitations. Reviews in Fisheries Science 1: 203-222.

Younk, J.A. and Cook, M.F. (1992) Applications of an angler diary for muskellunge, *Esox masquinongy*. Fisheries Investigational Report 420. Minnesota Dept. of Natural Resources. St Paul, Minnesota.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.