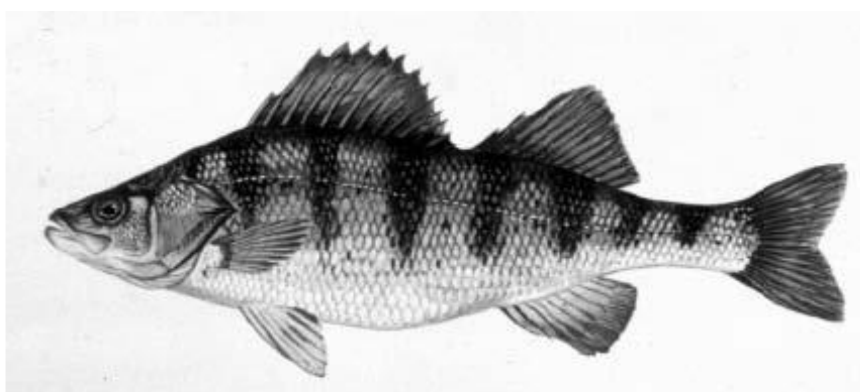
Maryland Tidewater Yellow Perch Fishery Management Plan

Prepared by Fisheries Service Yellow Perch Workgroup Maryland Department of Natural Resources Annapolis, Maryland

November 2002



FOR MORE INFORMATION PLEASE CONTACT

Maryland Department of Natural Resources Fisheries Service Tawes State Office Building 580 Taylor Avenue
Annapolis, Maryland 21401 1-800-688-FINS 410-260-8272

DNR GENERAL INFORMATON 1-877-620-8DNR

www.dnr.state.md.us
Fisheries Service Ext. -8272

Parris N. Glendening, Governor Kathleen Kennedy Townsend, Lt. Governor J. Charles Fox, Secretary, DNR
Karen M. White, Deputy Secretary, DNR

Adoption Statement

We, the undersigned, adopt the Maryland Tidewater Yellow Perch Fishery Management Plan as a guide to managing the tidewater yellow perch stocks in the Maryland portion of the Chesapeake Bay and its tributaries. The Tidewater Yellow Perch Fishery Management Plan provides a framework for restoring and conserving the yellow perch resource. It adopts management strategies that focus on ecosystem-based components and sets forth biological reference points (benchmarks) and pre-defined decision rules (i.e., what actions follow when the stock is or is not at an optimal level) to guide harvest strategies. The development of this plan was a joint effort between the Fisheries Service and the Resource Assessment Service of the Maryland Department of Natural Resources.

The Maryland Department of Natural resources will periodically review and update the plan and report on progress made in achieving the management plan's goals and objectives.

Date ________________________________

Secretary of MD Dept. of Natural Resources

Assistant Secretary of MD Dept of Natural Resources

Director of Maryland Fisheries Service

Acknowledgments

The Maryland Tidewater Yellow Perch Fishery Management Plan was developed and written by the Yellow Perch Fishery Management Planning Team over a two year period between 2000 and 2002. Maryland DNR Fisheries Service staff who were part of the Yellow Perch Fishery Management Planning Team included Nancy Butowski and Bennie Williams of Fishery Management Plans; Harley Speir, Jim Uphoff, Dale Weinrich, Paul Piavis, Bruce Pyle, Tony Jarzynski, Jim Mowrer, Bob Sadzinski, Edward Webb and Erik Zlokivitz of Biological Monitoring & Analysis; and Steve Minkkinen of Restoration and Enhancement. Staff biologists from the Maryland DNR Fisheries Service and the Maryland DNR Resource Assessment Service worked collaboratively to develop an ecosystem-based fishery management plan. Margaret McGinty and Drew Koslow of the Tidewater Ecosystem Assessment Division of the Maryland Resource Assessment Service provided important tributary water quality data and expertise in the mapping of tidewater yellow perch habitat. Jill Stevenson, Deputy Director of the Maryland DNR Fisheries Service, Phil Jones, Director of Resource Management and Howard King, Manager of Policy, Planning and Outreach helped to review the document and provided professional oversight and guidance throughout the writing and development of the fishery management plan. We would also like to express our gratitude to the Yellow Perch Advisory Panel, the Maryland Sportfisheries Advisory Commission, the Tidewater Fisheries Commission, the Coastal Conservation Association and yellow perch stakeholders for reviewing and contributing to Maryland's Tidewater Yellow Perch Fishery Management Plan.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

The Yellow Perch Fishery Management Plan (FMP) provides a framework for restoring, conserving, and wisely using the yellow perch resource throughout Maryland tributaries and the Chesapeake Bay. The goal of the plan is to restore and protect the reproductive capability and ecological value of yellow perch stocks while allowing sustainable recreational and commercial utilization wherever possible.

The Yellow Perch FMP adopts an ecological perspective for protecting, enhancing and restoring yellow perch stocks, and managing the fisheries. Traditionally, FMPs have focused on managing harvest and addressing allocation issues. In many cases, fishery regulations alone cannot lead to recovery of stocks that are depressed as a result of other ecological considerations. Water quality concerns and habitat degradation are theorized to contribute to depressed yellow perch stocks in many tributaries. A key focus of this plan is to first identify limiting factors that hinder yellow perch restoration; then develop effective ecosystem action plans to address these factors. Fishery ecosystem management, therefore, requires an integrative and collaborative strategy throughout the Department of Natural Resources. Fisheries Service will take a leadership role with the Resource Assessment Service, Watershed Planning and Assessment Service, and the Chesapeake Bay Program to incorporate yellow perch considerations into appropriate water quality monitoring and watershed planning activities. As other activities are identified, appropriate DNR units and/or other agencies will also be included in yellow perch management efforts. Since the implementation of ecosystem management is in its beginning phase, additional steps will need to be defined.

The Severn River has been targeted as a test system for implementing ecosystem-based management. Efforts will be focused on delineating essential fish habitat; identifying current habitat-limiting conditions; and establishing aquatic health guidelines that will benefit yellow perch stocks. Enhancement efforts will include a five-year stocking plan to assess population levels and determine constraints on survival of early life history stages. Other tributary basins will be assessed for restoration, maintenance or enhancement projects.

While the ecological management approach is being developed, traditional fishery management regimes will be used to ensure existing stocks are not over-exploited. Biological reference points (benchmarks) and predefined decision rules (i.e., what actions follow when the stock is or is not at an optimal level) have been developed to guide harvest strategies. Actions to control fishing effort include minimum size limits, seasonal and area restrictions. As the status of yellow perch stocks change with time, management strategies will be adjusted as necessary. Monitoring projects that assess the abundance and harvest of yellow perch will be continued and annually evaluated to ensure that these activities provide the best data for stock assessment and ecosystem implementation. Stewardship of the yellow perch resource will be promoted through outreach efforts. The Yellow Perch FMP will be biannually reviewed and updated.

Section I. Fishery Management

Fishery Management Background

The goal of a fishery management plan (FMP) is to protect the reproductive capability of a resource while allowing optimal utilization over time. An FMP endeavors to quantify biologically appropriate levels of harvest; identify habitat requirements and recommend protection and restoration measures; monitor the status of the resource, including fishery-dependent and independent surveys; and define and enforce management recommendations. The ecological, economic and sociological factors affecting a resource are considered during the development of a plan. Once a FMP is adopted, the process does not end. Progress towards the implementation of the strategies and actions are tracked on a regular basis. As the status of a stock changes over time, management strategies and actions may need to be changed, and amendments and revisions are then necessary.

For the yellow perch FMP, an ad hoc Yellow Perch Workgroup was formed with representatives from DNR, sport fishermen groups, commercial fishermen and local watershed conservation organizations. The DNR team drafted the biological background and fishery information sections and the ad hoc workgroup participated in management discussions. When the management section was drafted, additional input was provided by Maryland's Sport Fish Advisory Committee and Tidal Fish Advisory Committee. Comments were compiled in a public tracking table and changes were made to the draft as appropriate. Upon adoption, the Plan will be incorporated by reference into the Annotated Code of Maryland. Under Natural Resources Article, Section 4-215, a fishery management plan gives the Department authority to implement necessary regulations.

Introduction

The harvest of yellow perch reached low levels in the late 1970s and early 1980s. After the dramatic decline in harvest, regulations were implemented in 1989 that limited the commercial and recreational fisheries. By the mid-1990s, commercial harvest had increased and was the highest since 1967. Factors that contributed to the increase in landings were increased recruitment, a change in market, and increased fishing effort. During 1999, there was concern over the increased effort on a rebuilding yellow perch resource, especially in the upper Bay. Since then, stock status and exploitation patterns have been identified for designated yellow perch areas using the results of directed surveys and analyses of the stock data. Yellow perch regulations were based on limited, river-specific data, and made it difficult for user-groups to be aware of open and closed areas. It was also difficult to keep up with changes in regulations. Management strategies for controlling fishing mortality were strengthened and simplified in 2000 and are currently being evaluated for their effectiveness. Biological reference points have been developed to direct management of the resource

Goals and Objectives

The goal of the Maryland Yellow Perch Fishery Management Plan is to:

Restore and maintain a viable spawning population that supports the ecological role of yellow perch in the Chesapeake Bay while generating optimum long-term social and economic benefits from their recreational and commercial utilization over time.

In order to achieve this goal, the following objectives must be met:
1. Develop an ecosystem-based framework for assessing, protecting, enhancing and restoring the yellow perch resource throughout the Maryland tributaries and upper Chesapeake Bay.

2. Develop institutional pathways that ensure yellow perch are considered in Chesapeake Bay restoration efforts such as nutrient reductions, best agricultural management practices, restoration of stream buffers, restoration of submerged aquatic vegetation (SAV), and initiatives to reduce the impact of development in watersheds that contain yellow perch spawning and nursery areas.

3. Determine habitat requirements for yellow perch and work with institutions, associations, communities, and individual landowners to restore riverine habitat for yellow perch.

4. Develop criteria for implementing yellow perch restoration efforts and restore/enhance yellow perch stocks in selected areas.

5. Define the role of stocking in the yellow perch restoration effort and develop a 5 year plan to implement it.

6. Establish biological reference points for the yellow perch resource and determine appropriate targets and thresholds. Use the thresholds and targets to guide fishery management decisions.

7. Categorize areas of the Chesapeake Bay according to stock status and fishing effort, and implement management strategies to meet the target fishing rate objective.

8. Increase access to the yellow perch resource for fishermen and non-consumptive users within the boundaries established by the target fishing rate objective.

9. Determine stakeholder preferences for yellow perch management.

10. Coordinate the development of tidal and freshwater yellow perch regulations to insure compatibility and enforcement.

11. Monitor stock status and develop additional indicators of stock status

Development of an Ecosystem Management Approach

Although the concept of ecosystem management is widely accepted, defining it and developing practical implementation strategies are not straightforward endeavors. For the purposes of the Yellow Perch FMP, ecosystem management is defined as a philosophy that emphasizes the following principles:

1 *the integration of physical, chemical, biological and social components;*
2 *the interaction of these components, and*
3 *how these components relate to a system's productivity and yellow perch population dynamics.*

Fisheries ecosystem management includes the protection and enhancement of habitat features that contribute to fish production. It also considers how the harvest of one species might impact other species in the ecosystem and incorporates that relationship into management decisions or in other words, multispecies management.

Ecosystem-based management is not a new idea and there are several efforts underway to implement an ecosystem approach. A report to Congress by the Ecosystems Principles Advisory Panel, <u>Ecosystem-Based Fishery Management,</u> recommended that Regional Management Councils develop Fishery Ecosystem Plans that recognize the interrelationships between species and the habitat needs of the managed species. With the help of the Chesapeake Bay Program and Bay jurisdictions, the National Oceanographic and Atmospheric Administration (NOAA) is leading an effort to develop a Fisheries Ecosystem Plan (FEP) for the Chesapeake Bay. The Atlantic States Marine Fisheries Commission (ASMFC) is also investigating options for incorporating multispecies management decisions and ecological considerations into its interstate management plans. These regional efforts will provide additional guidance on ecosystem planning and implementation.

In 1996, recommendations for guiding ecosystem-based management efforts were presented by the MDNR Ecosystem Council. The Council suggested a number of outcomes which would require a collaborative effort and move the MDNR towards managing on an ecosystem basis. This approach requires the integration of the Department's compartmentalized management and planning activities into a framework that focuses on whole, ecologically functioning systems, not just the system's parts. Most of the Action Initiatives have been set into place. Fisheries Service will integrate its Yellow Perch FMP activities to support the following outcomes:

1 *A shared understanding of ecosystem management principles among DNR staff.*
2 *The Maryland Department of Natural Resources as a leader in scientifically-based ecosystem management.*
3 *A continuous flow, compilation, analysis, interpretation and dissemination of pertinent ecological data.*
4 *An accessible database shared among resource professionals and partners*
5 *A core protected lands network representative of Maryland's native biological diversity.*
6 *Incorporation of ecosystem management principles into local government policies and initiatives.*
7 *Marylanders living in harmony with their environment.*

Within the State of Maryland, the Departments of Natural Resources, Environment and Health and Mental Hygiene have the primary responsibilities for programs that protect, promote and enhance environmental quality for state residents. Federal agencies such as the Environmental Protection Agency, Department of Commerce, Department of Interior and the Army Corps of Engineers have important permitting, research and advisory roles in environmental protection. Many of the restoration and enhancement roles have been coordinated through the Chesapeake Bay Program (Refer to Appendix 1-1. Chesapeake Bay Program Efforts). It is the sum of the actions of these agencies which seek to maintain a quality environment, with healthy land, water and air components, that one can define broadly as ecosystem management.

Strategy: Implement Ecosystem Considerations

A. Maryland DNR Fisheries Service will coordinate with the various programs established within DNR and the Chesapeake Bay Program to develop integrated, comprehensive habitat assessment, restoration and protection actions necessary for yellow perch recovery and maintenance.

B. Ecosystem guidelines will continue to be refined for all phases of the yellow perch FMP including habitat and restoration activities, formulating biological reference points, controlling fishing mortality, collecting monitoring data, and implementing outreach projects.

Action 1.

Adopt the following Fisheries ecosystem guidelines:

1 Participate in relevant forums that develop federal or state water quality criteria.

2 Cooperate with the DNR's Chesapeake and Coastal Watershed Services in the development of watershed assessment surveys, watershed restoration plans, and in the implementation of restoration and enhancement projects. a.) As a result of the 1998 Clean Water Action Plan, 58 watersheds in Maryland were designated in need of restoration. Grants and technical assistance are available to counties to help develop watershed restoration action strategies (WRASs). Each year, DNR in partnership with local government, will coordinate the development of five new plans.

i. The first five WRAS areas were initiated in June 2000 and include: Georges Creek (Allegany County); Isle of Wight Bay (Worcester County); Little Patuxent River (Howard County); Manokin River (Somerset County); and Middle Chester River (Kent County).

ii. During 2001, WRAS areas were initiated in: Breton Bay (St. Mary's County); Bush River (Baltimore County); Liberty Reservoir (Baltimore County); Upper Choptank River and Upper Patuxent River.

iii. During 2002, WRAS areas were accepted for Island Creek (Patuxent River); Corsica (Choptank); Worcester (Chincoteague Bay); Western Branch (Patuxent River); and lower Monocacy River (Potomac River).

b.) Fisheries Service will review county proposals and make appropriate recommendations.

c.) Fisheries Service will coordinate with the watershed planning group to ensure that yellow perch and other finfish/shellfish habitat requirements are considered and implemented in the WRAS areas.

3. Participate in the review of permits for projects that have the potential for significant impact on fishery resources. The process used by the Environmental Review Unit (ERU) has been reviewed by Fisheries Service and the following process will be implemented: a.) ERU receives internal and external reviews such as permit applications and any activity that has the potential to adversely impact aquatic habitat. b.) ERU distributes project information to appropriate DNR units including Fisheries Service. c.) Fisheries Service provides appropriate monitoring data to identify fish and shellfish distribution, assess potential impacts, and review regulatory requirements. Fisheries Service also provides recommendations for avoiding, minimizing or mitigating project impacts on fisheries resources.

d.) ERU prepares a DNR response and coordinates any follow-up between DNR and other agencies.

1 Cooperate with the Chesapeake Bay Program and the Atlantic States Marine Fisheries Commission to develop models, collect and exchange data, and support research projects that explore multispecies management.

2 Develop funding sources for habitat restoration.

3 Develop research proposals to examine habitat-fish linkages. **Implementation**: Began in 2001 and continuing.

Action 2.

Initiate a Severn River Ecosystem study that focuses on life history stage analysis to assess the effects of degraded habitat on stock abundance (Appendix 1-2. Application of Ecosystem Principles in the Severn River).

Implementation: Began in 2001.

Action 3.

Use the Yellow Perch FMP as a model for the application of ecosystem-based fishery management principles and develop new methods of application/implementation. **Implementation**: On-going

Yellow Perch Restoration and Enhancement

Habitat conservation is a key component in sustaining fish populations. Habitat encompasses all the physical, chemical and biological aspects of the environment that influence fish populations. Fish are an integral part of the aquatic community and watershed. To consider enhancing fish populations through stocking initiatives without considering the habitat is counter-productive. Habitat features that generally influence fish distribution and abundance include: temperature; salinity; water flow; nutrients; turbidity; channel depth; substrate type; and stream cover.

Since the late 1800s and the early 1900s, hatchery operations have been used to periodically supplement yellow perch natural reproduction. When the relationship between the number of fry released and subsequent stock size could not be established, hatchery operations were discontinued (Muncy 1959). Restoration efforts in the 1950's involved transporting adults to rivers with low populations. During this time, there was a high rate of straying. Transplanted fish left the area where they were moved. Consequently, this effort was discontinued as a viable method of stock restoration. From 1988 through 1991, MDNR undertook another effort to determine the feasibility of enhancing yellow perch populations through hatchery production and stocking. Following the release of cultured fish, sampling surveys were conducted to recapture stocked yellow perch and look for marked fish. Researchers found that the irregular structure of the otoliths made it difficult to determine if individuals were hatchery-raised. Marks were observed on otoliths soon after marking hatchery fish but were not readily distinguishable on juveniles collected from the rivers.

During 2001, a pilot project was conducted for raising and stocking yellow perch as part of a stock enhancement program. Development of reliable production and marking techniques for stocking and the assessment of stocking impacts were the primary project goals. The results of different marking trials yielded a reliable OTC mark. Over 300,000 larvae and juveniles were successfully stocked in the St. Mary’s and Miles Rivers during 2001. These techniques were utilized to develop a five-year stocking plan (see Appendix 1-3 for details and current update). The plan proposes to enhance the yellow perch population, determine the status of the resource, evaluate survival, and assess habitat quality.

Strategy: Restore Yellow Perch Habitat and Enhance Yellow Perch Populations

A Develop a watershed-based approach for restoring yellow perch stocks. Evaluate the use of yellow perch as an indicator species for habitat and water quality restoration efforts.

1) An Anadromous Fish Index has been developed as a watershed indicator. Yellow perch is one of eight species identified as part of the index. This indicator is used to help identify watersheds that are candidates for conservation and protection. Conservation organizations can use this indicator to help target areas (i.e., watersheds with high fish index) for conservation.

B Evaluate hatchery production of yellow perch as a population assessment and restoration tool (Appendix 1-3. Five-Year Stocking Plan for Yellow Perch).

Action 4.

Use the table on Stock Status and Exploitation (Table 1) and the watershed planning process, to designate yellow perch areas for restoration, maintenance or enhancement and develop specific habitat strategies for each area.

Implementation: 2002-2003

Action 5.

Designate the currently closed rivers as yellow perch areas of particular concern so if resources and

funding become available they can be directed to these areas. The following watersheds have been designated as yellow perch spawning areas and harvest is prohibited: Magothy, Nanticoke, Patapsco, Severn, South, and West Rivers.
Implementation: 2002

Action 6.
Form a Maryland DNR intra- and inter-departmental team to implement habitat restoration strategies for yellow perch in prioritized tributaries of the Bay. Coordinate with the Watershed Restoration Action Plans and evaluate five watersheds annually
Implementation: Began in 2002 and continuing.

Action 7.

a presence-absence distribution data (Refer to yellow perch maps Figures 1a-e);
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area,	**Stock status**

Identify essential fish habitat (EFH) for yellow perch utilizing progressively more detailed information:

Implementation: On-going effort

Action 8.
Facilitate the implementation of habitat management and restoration practices identified as important to yellow perch, such as:
a Reduce nutrient inputs from all sources to improve dissolved oxygen conditions.
b Reduce sediment input.
c Restore riparian forests.
d Develop stream use classification criteria.
Implementation: As appropriate when restoring yellow perch habitat

Fishing Mortality

The commercial harvest of yellow perch reached low levels in the late 1970s and early 1980s. After the dramatic decline in harvest, regulations were implemented in 1989 that limited the commercial and recreational fisheries (refer to Section II. Table 14. Summary of yellow perch regulations). By the mid-1990s, commercial harvest had increased and was the highest since 1967. The yellow perch commercial harvest has continued to increase. Factors that contribute to increased landings include increased recruitment, a change in market, and increased fishing effort. During 1999, there was concern by MDNR and the general public about the increased effort on a rebuilding yellow perch resource, especially in the upper Bay.

Most fishing for yellow perch occurs during the spawning season when the fish are aggregated in upstream reaches of spawning tributaries. Maryland DNR has managed its tidal recreational yellow perch fishery through minimum size limits, creel limits and area closures. The yellow perch commercial fishery has also been managed through minimum size limits. Beginning in 2000, a maximum size limit was added (also known as a slot length limit) to the commercial regulations. Commercial fishing effort is also managed by seasonal and areal closures. Determining appropriate harvest levels for each tributary would require accurate stock size estimates from all areas and data is currently not available. Quota-based management is possible, but has several drawbacks. A new commercial reporting system, specific to yellow perch, would be needed to track and enforce an intense, short-lived fishery on a daily basis and over a broad geographic area. The monetary and manpower requirements for such a system would be high. Under the present reporting system, there is a lag time between harvest and reporting which would make it difficult to monitor a commercial quota. After consideration of these factors, DNR has rejected quota-based management at this time. However, this option may be considered in the future if resource assessment data indicate a need for more restrictive measures.

More than 95% of yellow perch harvested by commercial fishermen in Maryland are caught by fyke nets. Maryland has some restrictions on the distance between fyke nets in Harford County and fyke nets are prohibited in Talbot County and in a few other areas of the state, but there are no restrictions on the number of nets. In the past, there has been some confusion over which areas are closed to commercial harvest and enforcement of the closed areas. Additional methods for controlling and/or reducing effort in the commercial fishery include restrictions on the number of nets, their location, daily harvest limits and daily time restrictions. If additional restrictions on the fishery are necessary, implementation would require increased enforcement, including additional manpower and funding.

The recreational fishery is an important and intensive early spring fishery. Estimates of annual recreational harvest in pounds during 1982-2000 from Maryland's portion of Chesapeake Bay were obtained from the Marine Recreational Fishery Statistical Survey (MRFSS). Eight estimates had sufficient precision (proportional standard error or PSE below 40%) to be considered useable**.** Their PSE's varied between 27% and 37%. These recreational estimates were paired with their respective commercial landings. Recreational harvest was estimated as a percentage of total harvest for each year by [recreational pounds / (recreational + commercial pounds)]. Annual estimates indicated that recreational harvest varied between 7% and 36% of annual harvest. The average percentage, 18%, was estimated by taking the sum of the useable MRFSS harvest estimates and dividing this number by the sum of the respective commercial and recreational harvests. Data from the DNR spring creel survey indicated that recreational fishermen preferred harvesting a greater quantity of fish rather than fish of a larger size. Creel reports also indicated some harvested fish were undersized. Better data on recreational fishing effort are needed, especially, tributary-specific.

Establishing threshold and target fishing mortality rates to manage the yellow perch resource is a risk-averse strategy that will protect yellow perch and provide a standard by which to manage the resource. If a stock is harvested at a rate exceeding the threshold, it will not be able to sustain itself. A target is set at a lower level of exploitation to minimize the chance of overshooting the threshold and collapsing the stock. Spawning stock biomass per recruit (SSBR) characterizes the reproductive potential of a stock in terms of spawning stock biomass (or weight) produced by a year-class over its lifetime under conditions of constant growth, mortality, and recruitment (Goodyear 1993). An unfished population is at its maximum spawning potential (100% MSP) and added mortality from fishing decreases spawning potential by removing spawners. Compensation for increased removal of spawners by increased egg to pre-recruit survival has some upper limit and consistently poor recruitment in exploited fish populations has been noted once SSBR becomes less than 20% of MSP (Goodyear 1993). Based on the best available data and analysis, % MSP is the preferred biological reference point for the Maryland Yellow Perch Fishery Management Plan.

Strategy: Control Fishing Mortality

Establish biological reference points (BRP) that describe the targets and thresholds (limits) for yellow perch stocks. Manage the fishery using the percent maximum spawning potential (% MSP) target-limits based on the perceived resilience (productivity) of the stock.

Action 9.

Adopt biological reference points of $F_{35\%}$ as a target and $F_{25\%}$ as a threshold for the yellow perch resource. As more data becomes available, the biological reference points may be changed to reflect the most current status of the resource.

Implementation: 2002

Action 10.

Adopt the following decision rules for managing the yellow perch resource based on the target and threshold mortality rates.

A Target Decision Rule 1) Fish at or above the target F and maintain reproduction above the target. 2) If the target conditions are not met in a year, but the estimate of F is within 20% of the target, no action will be taken. 3) If the target conditions are not met in a second consecutive year (estimate of F is still within 20% of the target), immediate action will be taken to reach the target. 4) If in any year the target conditions are violated by more than 20%, immediate action will be taken to reach the target.

B Threshold Decision Rule 1) If the threshold is exceeded in a given year, immediately reduce F to the target F. 2) If the threshold is exceeded in a second consecutive year, management actions will range from reducing F to the target F, to closure of the fishery. The decision to close the fishery and the duration of the closure will be based on an analysis of other biological parameters of the stock (such as stock structure and juvenile abundance).

3) After a fishery is closed, a reopened fishery will occur at an interim rate that is one-half of the target F for at least two years. When the threshold is no longer violated, the target F is applied.

C Utilize the decision rules to make recommendations regarding the yellow perch systems currently under assessment (Upper Bay, Nanticoke, Choptank and Patuxent Rivers).

Implementation: 2002

Action 11.

Use Table 1 to guide the development of management strategies and actions for selected river systems within the Maryland portion of the Chesapeake Bay. Management actions may include but are not limited to size limits, creel limits, closed seasons, area closures, and/or net restrictions. The parameters used to manage the fisheries may change annually with new data analysis, changing stock conditions, and changing commercial markets. As the stock changes over time, management strategies and actions may change and additional management measures may be required.

Implementation: On-going. Evaluated/updated periodically.

a presence-absence distribution data (Refer to yellow perch maps Figures 1
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium, length distributio favorable, age truncated
Patuxent, 1999 (10 inch)	Moderate, CPUE up
Potomac tributaries	
Chester	Moderate, CPUE down
Wye and Miles	Presumed moder
Choptank, 2001	High
Nanticoke, 2001	Presumed high, l favorable
Lower Eastern Shore	
Water Body	**Water Quali**
Upper Bay	CBP Nutrients[1]
Susquehanna Flats	
Northeast River	
Elk River	
Bohemia River	TEA Hydrolab[2]

Table 1. Description of stock and exploitation status.

[1] Upper Bay is north of the mouth of the Patapsco and Chester Rivers; western shore tributaries are the rivers from the Patapsco south to the Patuxent; and lower Eastern Shore rivers are rivers south of the Choptank River and excluding the Nanticoke River. [2] Exploitation status: over-exploited, stock size low and F exceeds overfishing limit; fully exploited, stock size is moderate or high, or F meets or exceeds target, but is

below limit; less-exploited, stock level is moderate or high, F is below the target with no chance of exceeding the limit.

[3] Recent recruitment is over the past five years; JI indicates a juvenile index time-series exists and RSD indicates relative stock density of 5.5-8.8 inch yellow perch was used to judge recruitment. [4] Blank indicates unknown

Action 12.
Continue the 8.5 - 11.0 inch slot limit for the commercial fishery in all open areas which will provide for the target SSBR. Adjust fishing mortality (F) depending on the status of the stock determined from fishery-independent and dependent monitoring surveys. Size limits may change based on the assessments.

Implementation: Current size limits implemented in 2000 and will be assessed annually

Action 13.
Continue the uniform recreational minimum size limit of 9.0 inches in all open areas. Adjust size limits and/or creel limits depending on the status of the stock determined from fishery-independent and dependent monitoring surveys and in relationship to the established targets.

Implementation: Current size limits implemented in 2000 and will be assessed annually

User Conflicts

More than 95% of yellow perch harvested by commercial fishermen in Maryland are caught by fyke nets. Maryland has some restrictions on the distance between fyke nets in Harford County and fyke nets are prohibited in Talbot County and in a few other areas of the state, but there are no restrictions on the number of nets. In the past, there has been some confusion over which areas are closed to commercial harvest and enforcement of the closed areas. Additional methods for controlling and/or reducing effort in the commercial fishery include restrictions on the number of nets, their location, daily harvest limits and daily time restrictions. If additional restrictions on the fishery are necessary, implementation would require increased enforcement, including additional manpower and funding. Recreational fishermen are concerned that the commercial fishery harvests too many yellow perch before they have a chance to spawn. There is also concern about fyke nets as navigational hazards.

Strategy: User Conflicts
Examine the conflict between commercial and recreational uses of yellow perch. Identify any problems, and recommend solutions.

Action 14.
Establish an *ad hoc* yellow perch committee comprising appropriate stakeholders to provide input into the yellow perch management process.

Implementation: Began in 2001 and will meet as necessary.

Action 15.
Evaluate the utility of a web-based volunteer angler survey to collect data on the recreational fishery and implement the survey if feasible. Evaluate the utility of using the data to address allocation issues for the yellow perch resource.

Implementation: Evaluate the feasibility of a web survey in 2002; if feasible implement in 2003; Evaluate after one year (2004) and make a decision to continue or discontinue. Evaluate the utility of the survey bi-annually. Determine when the survey will end.

Action 16.

MDNR has implemented a system to track the use of pound nets in the Bay. Evaluate the pound net system for tracking fyke nets and make recommendations for their use.

Implementation: 2003

Action 17.

If fishing mortality is too high in relation to the adopted targets, strategies to reduce fishing effort will be explored. Topics to be considered include but are not limited to: capping the number of fyke nets per fishermen; the placement of fyke nets in river systems (i.e., total number per river system; distance between nets); daily harvest limits; seasonal; daily time restrictions; and seasonal quotas.

Implementation: Evaluated when targets have been exceeded

Action 18.

Evaluate the need for increased enforcement of yellow perch regulations, develop strategies to meet the needs and implement actions accordingly.

Implementation: To be determined.

Stock Status

Based on the limited number of areas regularly monitored, the status of the yellow perch resource varies from area to area. Yellow perch populations are river specific except in areas without a salinity barrier. There could be as many as 25 tributary-specific populations in Maryland. The ability of MDNR Fisheries Service to sample the wide geographic range of the spring yellow perch fishery is limited by time and manpower. Yellow perch biological data have been collected by the Multifish Survey in the spring of various years from the Nanticoke, Choptank and Patuxent rivers and the upper Bay. Length-at-age, age-at-maturity, CPUE, spawning history, mortality, and catch composition are determined from the surveys. A limited amount of recreational fishing data has been collected through creel surveys on the Choptank and Chester rivers such as catch per angler, length frequencies and sex ratios. In addition, the Natural Resources Police have also collected some recreational fishing data (2000-2001). Juvenile yellow perch indices have been calculated for the upper Chesapeake Bay and Potomac River using the data from the Maryland Juvenile Finfish Survey. Juvenile production in the upper Bay was at baseline levels from 1979-1992 before a shift to higher recruitment levels after 1992. The higher juvenile indices (JI) correspond to the subsequent higher estimated stock size. The JI is one indicator of stock health in the upper Bay and can be used as an indicator of reproductive success in other areas. The data collected by these projects are essential for yellow perch stock assessment analysis.

Stock status in unsampled areas has been defined by using population data from nearby systems and applying the life history characteristics to the stock assessment model. Increasing the number of sampled areas would provide a better understanding of the status of yellow perch stocks in these areas. Additional stock status indicators would be helpful, especially in the upper Bay. In February 2000, MDNR began a winter trawl survey in the upper Bay to provide more data on the status of the stock. The survey collected length and age frequency data and will be used to estimate relative abundance. Yellow perch sampling was expanded into the Severn River in the spring of 2001.

The Patapsco, Magothy, Severn, South,West, Wye, Miles, and Nanticoke Rivers have been closed to harvest since 1989. The status of the stocks in these rivers is poorly known and the resources needed to conduct fishery independent surveys to determine stock status in these areas are limited. The Severn and the South Rivers have been selected as pilot areas for a yellow perch population enhancement plan. Angler catch and release is currently permitted in these areas.

Strategy: Monitor Stock Status

Maryland DNR will monitor yellow perch stocks in representative areas of the Chesapeake Bay in order to assess yellow perch stock status. Assessment and additional management efforts will be focused on areas already under special management measures, i.e., closed areas.

Action 19.

Continue to sample commercial and recreational harvest of yellow perch and collect basic biological data. Additional biological data may indicate changes in the status of the stocks and require additional management measures.

Implementation: On-going

Action 20.

Develop a method for evaluating yellow perch recruitment and utilize it as one of the parameters for assessing stock status and consequent management actions.

Implementation: 2003 **Action 21.** Yellow perch egg strands are easy to collect and important for hatchery and/or aquaculture endeavors. Maryland will prohibit the removal and selling of egg chains, including egg chains that have been stripped by artificial methods, unless a scientific collection permit has been issued.

Implementation: 2002

Action 22.

Evaluate additional fishery-independent indicators of stock status such as the trawl survey in the upper Bay.

Implementation: Dependent on manpower and funding.

Action 23.

Review and evaluate yellow perch monitoring efforts biannually. Recommend changes in monitoring protocol as necessary to implement the Yellow Perch FMP.

Implementation: 2002 and even number years thereafter.

Yellow Perch Outreach

One of the confounding components of assessing yellow perch stock status is the wide fluctuations in recruitment and the region-specific nature of yellow perch. It is logistically difficult to describe the characteristics of each stock in all systems. There have been several efforts to implement a working relationship between state and federal governments, business, the agricultural community and citizens to improve water quality and enhance habitat for living resources. Maryland's Tributary Teams system is a good example of one of these efforts. Through the Team system there are community watershed organizations that participate in stream monitoring. There are also recreational fishing organizations participating in tagging and data collection. Community organizations could be utilized to collect information on yellow perch, habitat and watershed problems.

Yellow perch have been used in aquatic education programs. To date, the Yellow Perch Hatch, Raise and Release Project has involved 16 teachers and 660 students. Fisheries Service personnel support the "Aquatic Ecosystems of the Chesapeake Bay Aquaculture Demonstration Center. Currently, the center has three different yellow perch age-classes on display. Over the years, yellow perch have been released into the Patuxent River and the Upper Magothy. Students have also participated in water testing as part of the fish rearing curriculum. Education programs provide a "hands-on" opportunity for promoting environmental awareness.

Strategy : Implement Yellow Perch Outreach

MDNR will continue outreach efforts to engage the fishing and non-fishing communities in stewardship of the yellow perch resource in tributary basins.

Action 24.

Utilize volunteers from the recreational fishing sector, such as CCA or watershed community associations, to obtain recreational fishing data in areas not sampled by the MDNR Multifish Survey. Explore the use of a volunteer recreational survey using the web similar to the recreational survey implemented for striped bass (see Action 15).

Implementation: Dependent on volunteer recruitment.

Action 25

Add yellow perch egg strand sampling in the early spring to river basins with volunteer monitoring programs to obtain data on yellow perch spawning locations.

Implementation: Dependent on volunteer recruitment

Action 26.

MDNR will continue to partner with the Yellow Perch Hatch, Raise and Release Project by providing assistance and advice in the collecting, raising, releasing and stocking of yellow perch in all facets of the project.

Implementation: On-going

Action 27.

MDNR Fisheries Outreach will explore new avenues to involve the public in yellow perch projects, such as a new exhibit on identifying yellow perch egg strands and collecting information on their occurrence and distribution; cooperative efforts with the TEAM Program; and volunteer monitoring opportunities.

Implementation: Open

Appendix 1-1

Chesapeake Bay Program Efforts

The Chesapeake Bay Program has set forth a goal for vital habitat protection and restoration. It is: ***to preserve, protect and restore those habitats and natural areas that are vital to the survival and diversity of the living resources of the Bay and its rivers***. A key component to an ecosystem approach for yellow perch is to successfully integrate the objectives of yellow perch management into watershed management planning. Guidelines to ensure the aquatic health of stream corridors (2.2.2) have been developed. Integrating yellow perch habitat and water quality considerations into the aquatic health of streams is an important step. There are many habitat protection and restoration activities already occurring in the Bay and tributaries that will affect yellow perch stocks. Some of these activities are noted below, not as actions MDNR Fisheries Service is directing, but activities that MDNR is actively involved. The commitments also demonstrate how regional ecosystem considerations are occurring. The following C2K commitments are important for yellow perch.

Watersheds

2.2.1 Work with local governments, community groups and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the Bay watershed covered by this Agreement. These plans would address the protection, conservation and restoration of stream corridors, riparian forest buffers and wetlands for the purposes of improving habitat and water quality, with collateral benefits for optimizing stream flow and water supply.

Implementation: 2010

2.2.2. Each jurisdiction will develop guidelines to ensure the aquatic health of stream corridors. Guidelines should consider optimal surface and groundwater flows.

Implementation: 2001

2.2.3 Each jurisdiction will work with local governments and communities that have watershed management plans to select pilot projects that promote stream corridor protection and restoration.

Implementation: 2002

2.2.5 Each jurisdiction, working with local governments, community groups and watershed organizations, will develop stream corridor restoration goals based on local watershed management planning.

Implementation: 2004

Wetlands

2.3.3.1 Achieve a net resource gain by restoring 25,000 acres of tidal and non-tidal wetlands.

Implementation: 2010

Forests

2.4.1.1 Ensure that measures are in place to meet our riparian forest buffer restoration goal of 2,010 miles **Implementation:** 2010

2.4.1.2 Conserve existing forests along all streams and shorelines.
Implementation: on-going

There are additional C2K commitments " to define the water quality conditions necessary to protect aquatic living resources." As part of the renewed effort to restore water quality criteria as state standards, tidal water designated uses criteria are being developed. There are five habitats defined for the Chesapeake Bay Tidal Water Designated Uses. Yellow perch spawning and nursery habitats have been considered when defining the migratory spawning and nursery designated use areas.

Appendix 1-2

Application of Ecosystem Management to the Severn River

The Severn River’s 70 square mile watershed is now less than 50% forested and over 40% has been developed. Some 120,000 people live in the watershed . The key stressors to the freshwater portion of the river are identified as nutrient enrichment, acid rain, inadequate riparian buffer, unstable banks and poor overall physical habitat (Boward, *et al*. 1999). With the exception of acid rain, these stressors all arise from development in the watershed. When the amount of impervious land cover exceeds 15% of a watershed, the impacts of urbanization become pronounced as the number of fish species declines, rare species disappear and benthic food organisms decline (Boward *et al.* 1999)

Urbanization generated problems in the freshwater portion of the river are transmitted to the tidewater portion in the form of nutrient and pollutant input, which diminishes water quality, and sediment which covers fish spawning habitat, smothers clams and oysters, shades submerged grasses and kills fish eggs and larvae. Increased impervious surface causes rainwater to be quickly whisked downstream and high flows of freshwater can reduce salinity below the minimum required for survival of estuarine shellfish. Higher spring flows can push eggs and larvae of spring migrant fish, which spawn in freshwater, into less suitable hatching and nursery areas. Quicker removal of rainwater allows less to soak into the ground where it can seep into streams late in the summer to maintain stream flow and cooler water temperatures. Habitat for fresh tidal species of fish may be squeezed in the fall as freshwater flows decline and saltwater intrudes from the Bay. High nutrient loads can cause overproduction of algae which can lead to dissolved oxygen problems.

In the spring of 2001, Fisheries Service (FS) sampled a range of sizes and ages in the Severn River yellow perch spawning population. Eggs and larvae were present in the spring and juvenile perch were present in the summer. Limited sampling of dissolved oxygen found low readings. On September 19, 2001, a fish kill was investigated in Valentine Creek and dissolved oxygen measurements were made at all sites that had been sampled in the spring and summer. Bottom dissolved oxygen and many measurements of dissolved oxygen at the surface were inadequate to support fish life over a large portion of the River above Round Bay. This low oxygen situation persisted through September.

It is unknown if this low oxygen situation occurs to the same degree every year but the number of fish kill calls from the Severn is usually high. Analysis of the adult fish data from the spring of 2001 produced an estimate of an annual rate of fishing mortality of 25%. However, the river is closed to harvest of yellow perch. Some fish could be removed illegally but it is most likely that this rate of mortality reflects fish kills from low dissolved oxygen in previous years. Rates of natural mortality in unfished populations are usually from 15 to 18%. Even in the Choptank River which has only a modest sport fishery on yellow perch, the annual fishing mortality is approximately 17%.

In order to address problems in the watershed which are producing hypoxia in the Severn River tidewater, the Ecosystem Management Planning Project will make the Severn River a priority for habitat improvement activities over the next several years. Anne Arundel County submitted the Severn as a priority watershed for funding under the DNR Watershed Restoration Action Strategy Initiative but was turned down as other watersheds of higher priority were selected. The County is, however, continuing with their Severn River Master Plan. They have finished with Phase I, developing analytical tools, and are starting with Phase II, measuring field conditions.

The FS will join the process and assist Anne Arundel County. A full discussion of the needs has not been completed; however, we anticipate dedicating approximately $175,000 which include funding for four positions to FS activities in ecosystem management. The core project will network with other FS projects, DNR programs, other State agencies and Anne Arundel County on definition and correction of the problems affecting yellow perch in the Severn.

Severn River (SVR)
Strategy 1:

A) Define the problems affecting yellow perch in the Severn River and develop specific actions to correct the problems.

B) Evaluate the use of early life history stage analysis to assess effects of degraded habitat on stock abundance.

Action SVR 1.
FS coordinated the following actions during 2001:

1 In cooperation with RAS, deploy continuous oxygen monitors to determine daily patterns of dissolved oxygen.
2 Continue broad scale monitoring of channel dissolved oxygen.
3 Sample fish populations in the fluvial and fresh tidal areas.
4 Review Maryland Biological Stream Survey data on the Severn watershed.
5 Extend the Fisheries Service Winter Trawl Survey into the Severn in November and December.

Action SVR 2.
FS coordinated the following actions during 2002:

1 Sample spawning populations of yellow perch in the Severn.
2 Determine egg strand distribution.
3 Determine spring water quality.
4 Sample perch larval distribution.
5 Sample perch juvenile distribution.
6 Set up a comprehensive water quality sampling network.
7 Begin experimental stocking of yellow perch

The FS is in the early stages of identifying problems and directing habitat enhancement activities to directly benefit yellow perch. As the pilot program progresses, it will become clearer what direction can or will be taken to correct and/or restore the watershed. The problems are clearly widespread and priorities must be assigned to those actions which have the most value or the best chance of succeeding. The planning, zoning and permitting powers of the County will be of great value in addressing problems. The Severn River Association and the Severn River Tributary Team will be asked to participate. Fishermen's organizations will be enlisted to provide constituent input into planning. The Severn will serve as a model and testing ground for moving large scale, active habitat protection and restoration activities clearly into the activities of the Fisheries Service. New relationships will be established and new activities will begin with the objective of providing fishermen with increased opportunity to harvest fish.

Appendix 1-3

Yellow Perch Culture and Stocking: A Five Year Plan

Maryland Fisheries Service Mariculture, Estuarine and Marine Hatcheries (DNR) program conducted a pilot project for yellow perch restoration during the Spring of 2001. Development of reliable production and marking techniques for stocking and the assessment of stocking impacts were the primary project goals. Techniques included induced spawning of adult yellow perch using hormonal stimulation, OTC marking trials to determine optimal doses for effective marking, culture of several ages/sizes of perch for stocking and development of methods to uniquely mark fish stocked at different sizes. Intensive culture of fingerlings to a size large enough to employ other marks such as coded wire tags (CWT's) was also evaluated. CWT's contain more specific information and large fish may survive better than small ones. These techniques have been very successful in assessing the impacts of stocking striped bass, American shad and hickory shad larvae and juveniles.

Stocking can be used to enhance or reestablish fish populations. Selecting tributaries that could benefit from stocking is critical for a successful program. An assessment of available habitat and historic and/or current population data should be important considerations. Stocking marked fish can also be used to collect valuable stock assessment information from the population. Many mark recapture strategies employed in fisheries management lend themselves to this type of assessment. Stocking multiple sizes/ages of marked fish (larval, juvenile) allows for the evaluation of survival for these life stages. Stocking can also be used to assess aquatic habitat. Impacts that diminish watershed water quality can reduce survival during critical early life history stages and thus reduce abundance. Evaluation of egg, larval, juvenile, sub-adult and adult survival can be used to determine factors that limit stock abundance. Evaluation of growth rates could be used to indicate habitat quality. Learning how anthropogenic-induced changes affect population recruitment can focus attention to adverse impact mitigation and habitat improvement.

Action ST.1 In order to enhance/ restore yellow perch populations and evaluate riverine ecosystems in Maryland, DNR Fisheries Service initiated a five-year yellow perch stocking program starting in 2002.

Stocking Procedures and Considerations

1. Collect pre-spawned adults from predetermined stocking area (see protocol for selection below). If adults are not available from stocking area, use adults from the closet geographic area for restocking efforts.
2. Culture and release between 500,000 and 1,000,000 OTC marked larvae and juveniles.
3. Implement a sampling schedule to monitor the hatchery-produced fish through the season. -21

4. Analyze yellow perch captured during the monitoring efforts to determine if the fish are hatchery or wild born.
5. For years 1 and 2, determine survival and abundance using mark-recapture data. a.) If survival is below "x", discontinue stocking and select another area. If habitat/water quality problems have been identified, make recommendations for improvements. b.) If survival is above "x", continue stocking
6. For years 3 through 5, analyze adult and juveniles for hatchery marks to assess the contribution of the stocking efforts on the spawning stock. a.) If ratio of hatchery to wild fish is "x", continue stocking. b.) If ratio of hatchery to wild fish is "x", discontinue stocking

7. After year 5, develop a monitoring strategy to periodically measure abundance and track success in stocked areas.

Action ST.2 Develop criteria for evaluating the overall success of the stocking program.

Action ST.3 Adapt to new developments in science and restoration technology.

Action ST.4 Develop a Protocol for Selecting Tributaries for Population Enhancement (Directly related to Action 11)

Topics to be considered:

1 Initially, focus efforts in areas directly under FMP strategies [Table 15 - Western Shore (Severn and South Rivers)]. Prioritize areas based on the likelihood of success.

2 Determine if suitable habitat is available for yellow perch population enhancement efforts a.) utilize historic and current population data b.) examine water quality parameters to ensure the minimum requirements have been met

3 Evaluate restoration efforts within the watershed and coordinate activities to optimize efforts.

Appendix 1-4

MDNR Monitoring Efforts

Fishery dependent and independent monitoring provide the data to assess the status of yellow perch stocks. Since yellow perch populations can be tributary-specific, monitoring all systems would be the ideal. However, monitoring is restrained due to manpower and funding.

Strategy MP.1 Develop and implement a yellow perch monitoring strategy which incorporates fish population data, harvest data, water quality data and habitat parameters.

Action MP.1

Sample adult and juvenile yellow perch in selected areas. Nine areas of the Chesapeake Bay have been described according to stock status, exploitation, recruitment and fishing activity (Table 1). Monitoring efforts will be focused in these regions. Table 2 summarizes yellow perch sampling effort.

Action MP.2

A. Track commercial yellow perch harvest using mandatory reporting.
B. Evaluate adding yellow perch to the striped bass pilot project using electronic cards for reporting commercial harvest.

Action MP.3

Coordinate with RAS to link water quality data with yellow perch population data.

A. Utilize the data obtained from the dataflow instrument which includes continuous monitoring of DO, temperature and salinity.
B. Select tributaries to be monitored based on yellow perch considerations.

Table 2. Yellow Perch Sampling Efforts Maryland Department of Natural Resources

-23

a presence-absence distribution data (Refer to yellow perch maps Figures 1a
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium, length distribution favorable, age truncated
Patuxent, 1999	Moderate,

-24

a presence-absence distribution data (Refer to yellow perch maps Figures 1a
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

[1]

CBP

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium, length distribution favorable, age truncated
Patuxent, 1999 (10 inch)	Moderate, CPUE up
Potomac tributaries	
Chester	Moderate, CPUE down
Wye and Miles	Presumed moderat
Choptank, 2001	High
Nanticoke, 2001	Presumed high, len favorable
Lower Eastern Shore	
Water Body	**Water Quality**
Upper Bay	CBP Nutrients[1]
Susquehanna Flats	
Northeast River	
Elk River	
Bohemia River	TEA Hydrolab[2]
Water Body	**Water Quality**
Sassafras River	
Worton Creek	
Chester River	CBP Nutrients[1] TE
Lower Eastern Shore	
Wye River	CBP Nutrients[1] TE
Choptank River	CBP Nutrients[1] TE
Fishing Bay	CBP Nutrients[1] TE
Nanticoke River	CBP Nutrients[1] TE
Big Annemessex River	CBP Nutrients[1] TE
Western Shore	

Nutrients: collected on a monthly basis from Oct-Mar and a bimonthly basis from Apr-Sept. Water quality parameters include temperature, conductivity, dissolved oxygen, salinity, pH, secchi depth, total nitrogen, total phosphorous, dissolved inorganic nitrogen, dissolved inorganic phosphorous, dissolved organic nitrogen, dissolved organic phosphorous, total organic nitrogen, total organic carbon, particulate phosphorous, particulate nitrogen, particulate carbon, nitrate, nitrite, and chlorophyll a. [2]**TEA Hydrolab**: water quality information collected with fish data. Parameters measured include temperature, conductivity, dissolved oxygen, salinity, pH, and secchi depth. [3]**Data Flow**: parameters collected monthly; collected continuously over a defined spatial scale and include temperature, turbidity, salinity, depth, chlorophyll a, and dissolved oxygen. For the river systems noted, the sampling area includes much of the shallow areas of the main stem. [4]**Continuous Monitoring**: from buoys deployed in several areas of the Chesapeake Bay. Parameters include temperature, conductivity, dissolved oxygen, salinity, and pH on a continuous basis at a specific station. [5]**MDJFS (Maryland Juvenile Finfish Survey**): Seine survey annually samples 22 fixed locations throughout the MD portion of the Chesapeake Bay during July through September. Auxiliary stations sampled at the head of the Bay and Patuxent River. Water quality parameters collected includes: surface water temperature, surface salinity. Dissolved oxygen, pH, and turbidity (secchi disk) were added in 1997. Upper Bay sampling sites are the main data source for the development of the MD juvenile yellow perch index.

Section II. Biological Background

Introduction

Yellow perch (*Perca flavescens)* are members of the family Percidae. They have been found throughout most of the freshwater areas in Maryland and have adapted to estuarine habitats within the Chesapeake Bay. Adult yellow perch have developed a “semi-anadromous” life history strategy. Adults migrate into tidal and non-tidal freshwater to spawn, then move downstream into estuarine waters to complete all other phases of their life cycle. Although tagging results suggest that yellow perch rarely leave their river of origin (Mansueti 1960), salinity does not appear to be a barrier to movement between river systems. Yellow perch are known to occur in salinities as high as 13 ppt. (Richkus and Stroup 1987). Yellow perch stocks have been important to both the commercial and recreational fisheries in Maryland. The late winter/early spring spawning runs of yellow perch offer Maryland sport fishermen their first angling opportunity of the season. Prior to the mid-1980's, this fishery was an important tradition for many Maryland anglers. The widespread distribution of the species, their accessability during the spring spawning runs, the minimal expense involved (no fancy equipment needed), catchability, and their excellent culinary qualities, make them a popular recreational species. The yellow perch commercial fishery is short in duration but regionally important. Mature yellow perch congregate in upstream stretches of small spawning streams during a brief period and feed vigorously, making them vulnerable to overharvest.

Yellow perch stocks significantly declined in abundance during the 1970s. Regulations implemented in the late1980s increased minimum size limits and closed some river systems to harvest. As local yellow perch stocks gradually increased during the 1990s, regulations were relaxed. Currently, biological reference points are proposed to direct management of the resource.

Life History

Adult yellow perch migrate upstream to areas of low salinity (0-2.5 ppt) to spawn between late January and early April. Large numbers of yellow perch usually congregate in discrete areas. Males arrive on the spawning grounds first and stay longer than the females. Spawning begins within a week after the males arrive, when water temperatures rise above 4.5°C (40°F) (Casey et al. 1988). Yellow perch spawning locations in the Maryland portion of the Chesapeake Bay were documented in the 1950's (Muncy 1962) and in the late 1970's (O’Dell 1987) (Figures 1a-e.) During spawning, chains or ribbons of yellow perch eggs are extruded and may snag on submerged litter. Females aid fertilization by dragging the partially extruded egg clusters through areas of concentrated milt (Piavis 1991). Hatching is influenced by both salinity and siltation (Muncy 1962). In general, yellow perch egg chains or clusters are most common in clear water and deposition of egg clusters decreases with increasing turbidity (Scott and Crossman 1973; Nelson and Walburg 1977 as cited in Krieger et al. 1983).

Yellow perch eggs hatch in approximately three to four weeks in water temperatures between 8° and 11° C (Uphoff 1991). Newly hatched yellow perch are classified as prolarvae (6mm total length) until the yolk sac has completely reabsorbed (Piavis 1991). Larvae commonly feed on copepods and cladocerans then enter a postlarval stage (8-20mm total length) until bone ossification is complete. Postlarval yellow perch continue to feed on zooplankton (Kelso and Ward 1977 as cited in Krieger et al. 1983). The juvenile stage is reached when bone ossification is complete and the finfolds are developed, usually between 20 and 40mm total length (Piavis 1991). Juvenile yellow perch consume ostracods (mussel or seed shrimp), amphipods and chironomids (midges). During the juvenile stage, yellow perch will migrate toward the littoral zone to take advantage of a larger selection of prey. Yellow perch larger than 120 mm feed on fish, such as anchovies, killifish, silversides, minnows and small mud crabs and blue crabs. Prey selection is primarily based on size and availability (Piavis 1991).

Estuarine yellow perch grow faster than freshwater yellow perch (Muncy 1962). Tsai and Gibson (1971) attribute the increase in growth rate to abundant and diverse foraging opportunities in the estuarine habitat. Growth rates of yellow perch can be influenced by many factors including diet, physical factors (water temperature and pH), and ecological factors (eg. feeding or trophic interactions with other species). Age structure within a stock can vary due to different rates of recruitment, growth and maturity (Richkus and Stroup 1987). In the 1950's, yellow perch age structure in the Severn River was equally distributed between ages two through ten (Muncy 1962). Yellow perch age distribution from the Severn River during 2001 ranged between three and seven. Studies from the 1970's and 1980's in tributaries of the Chesapeake Bay, indicated that spawning populations were dominated by only a few age classes of older fish. More recently (1999), age structure in some tributaries has expanded with ages two through fourteen observed (Table 3). Comparing length at age from the Choptank, Nanticoke and Patuxent Rivers, only small differences were observed among river systems.

Adult yellow perch are multiple spawners and were thought to live as long as 12 years (Muncy 1962). During 1999, an age 14 fish was collected from the Choptank River. This was the oldest yellow perch collected since the sampling program began in 1989. Female yellow perch are generally larger than their male counterparts of the same age class. Young male yellow perch may reach maturity at the end of their first year, but more frequently at lengths greater than 130 mm TL (5.1 inches). Female yellow perch usually reach maturity during their second or third year, at lengths greater than 170 mm TL (6.7 inches) and 100% are mature by age four (between 9" and 11"). Female fecundity varies depending on length, weight, geographic location and genetic stock. For example, female fecundity in the Patuxent River varied between 5,300-75,700 eggs per female (Smith et al 1978 as cited in Piavis 1991) while female fecundity in the Severn River varied between 5,900-109,000 eggs per female (Muncy 1962).

Spawning success as a whole is dependent on a combination of factors including the quality and availability of habitat, suitable environmental conditions for both spawning and larval development, and adult stock size (Eaton et al 1993). In fish population dynamics, when there is a strong stock recruitment relationship, the number of older, mature fish is positively correlated with year class strength. The stock recruitment relationship has not been defined for yellow perch. However, yellow perch are long-lived and, therefore, have a greater probability of occasionally producing strong year classes (Rago and Goodyear 1987 as cited in Piavis et al. 1993). Year class strength has been correlated with the rate of warming during incubation and hatching (Hartman 1972; Escchenroder 1977 as cited in Krieger et al. 1983), as well as habitat availability. Strong year classes during 1984 played a major role in stabilizing yellow perch stocks in the Chesapeake Bay. Year class strength during this time may have been related to an increase in rainfall which created more freshwater spawning habitat (Richkus et al 1987). Large year-classes were also noted in 1993 and 1996.

Table 3. Total length at age by sex for Maryland yellow perch, 1999.

The Fisheries

<u>*Recreational*</u>

Recreational fishery statistics for yellow perch are limited, especially before 1979. Examining the number of trophy citations from 1964 to 1982, can provide some insight into the recreational fishery. Records from

a presence-absence distribution data (Refer to yellow perch maps Figures 1a

b habitat-related density data;

c growth, reproduction, and survival rate within habitats;

d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium, length distribution favorable, age truncated
Patuxent, 1999 (10 inch)	Moderate, CPUE up
Potomac tributaries	
Chester	Moderate, CPUE down
Wye and Miles	Presumed moderat
Choptank, 2001	High
Nanticoke, 2001	Presumed high, ler favorable

Fishing in Maryland magazine indicate that citations awarded for yellow perch 14 inches or longer averaged 53 per year and were recorded from at least 15 different systems throughout the state. From 1985 through 1999, the number of citations averaged only 8 per season, with no more than 6 systems represented in any one year. Although the number of citations indicate a decline in yellow perch availability, without an estimate of fishing effort, the true scale of change is unknown.

Williams et al. (1982; 1983) used telephone and intercept surveys to estimate the statewide tidewater harvest in 1979 and 1980. They estimated that 125,851 yellow perch (52,896 pounds) were harvested by sport fishermen in Maryland waters during May-December of 1979, and 116,518 yellow perch (57,402 pounds) were harvested during May-December of 1980. These estimates did not account for the yellow perch catch during the late winter/early spring spawning season when most yellow perch were probably caught. Survey results indicated a low percentage of anglers targeted yellow perch during the months of May-October. In November and December, the number of anglers targeting yellow perch and the overall percent of trips catching yellow perch increased. The number of fish caught per hour or catch-per-angler-hour (CPAH) ranged from 0.00 to 5.45 for each sampling wave during May-December 1979 and 1980. The mean CPAH was 0.32 fish per hour (Williams et al. 1982; 1983).

The Marine Recreational Fisheries Statistics Survey (MRFSS) conducted by the National Marine Fisheries Service (NMFS) monitors saltwater and tidal recreational fishing along the Atlantic Coast and provides harvest and release estimates for Maryland. However, this survey does not provide a clear picture of current effort or catch of yellow perch. Yellow perch are grouped into the category “other fish” which includes largemouth bass, smallmouth bass, crappie, pumpkinseed, white marlin, and “unidentified bottom fish.” In 1998, 1.2 million fish from this category were harvested and released, of which an unknown fraction were yellow perch (personal communication, NMFS, Fisheries Statistics and Economics Division).

Roving Creel survey

Maryland DNR Fishery Service conducted an access point, spring creel survey (Hayne, 1991) on the Choptank and Chester rivers from1995 to1999. Over the years, creel agents intercepted hundreds of anglers from late winter to early spring. The survey found that anglers kept between 6% and 21% of their total catch (Appendix #2-1). Some percentage of fish were probably released because they were below the minimum size limit. Most anglers thought the number of fish caught was the primary reason fishing was good or bad and size was less important in terms of quality fishing (Sadzinski et. al, 1997) (Table 4). In addition, fishing access was more important to anglers than size or number of fish (Zlokovitz and Webb 2000). Mean CPAH on the Choptank River varied between 2.0 and 3.2 (1995-1999) with no trend in mean length of harvested fish (Table 5). Mean CPAH during the spawning seasons (1995-1999) was higher than the mean catch rate of 0.32 reported during the non-spawning seasons (Williams et al.1982, 1983). Anecdotal information suggests that catch-rates during the yellow perch spawning season in Maryland were higher 15-30 years ago.

The relative stock density (RSD) or the proportion of fish in a length category, was used to characterize length distribution of harvested fish and quality of the fishery during the spring creel survey (Gablehouse 1984). Harvested fish were grouped into five size categories each with an associated minimum length: stock (RSD_{Stock}); quality ($RSD_{Quality}$); preferred ($RSD_{Preferred}$); memorable ($RSD_{Memorable}$); and, trophy (RSD_{Trophy}) (Table 6). Length categories were based on world-record lengths from the International Game Fish Association. During the period 1995-1999, anglers harvested mainly $RSD_{Quality}$ and $RSD_{Preferred}$ fish from the Chester and Choptank rivers. Relative stock density shifted towards slightly larger fish between 1998 and 1999 (Tables 7 and 8). All RSD_{stock} category fish were below the 9" minimum size limit, indicating that a small proportion (4% total)of sublegal fish were harvested from both rivers (Zlokovitz and Webb 2000). Sampling sites on the Chester and Choptank rivers were limited and sampling the wide geographic range of the spring yellow perch fishery is problematic. In an effort to increase the amount of information available from the recreational fishery, MDNR Fisheries Service initiated a volunteer creel survey in 1999, but no data was returned.

The value of the recreational fishery is relatively unknown. Richkus and Stroup (1987) reported the economic value of the recreational yellow perch fishery as the marginal willingness to pay, or the amount of money that a fisherman would spend to catch one yellow perch. In 1983, that amount was calculated as $0.50 in Maryland. Multiplying this value by the estimated sportfishing harvest during the non-spawning season, the yearly value of Maryland yellow perch sportfishing was $120,000. This estimate did not account for catch during the heavily fished spawning period, which represents a large fraction of the total annual catch. In 1999, yellow perch anglers interviewed on the Chester and Choptank Rivers during a creel survey, spent an average of $19.00 per trip on bait, tackle, and gasoline, not including a fishing license (E. Zlokovitz, Maryland DNR, Pers. comm.). However, no current data is available on the total number of yellow perch fishing trips statewide.

Table 4. Percentage of interviewed anglers ranking yellow perch fishing as good or excellent on the Choptank and Chester Rivers.

Table 5. Mean catch-per-angler-hour (CPAH) for anglers targeting yellow perch and mean length of harvested yellow perch, 1995-99.*Williston was not sampled in 1998 and 1999.

a presence-absence distri
b habitat-related density c
c growth, reproduction, a
d production rates by hab

Area, year assessed
Head-of-Bay, 2001[1]

a presence-absence distribution data (Refer to yellow perch ma
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**St**
Head-of-Bay, 2001[1]	M
Western shore (Severn, 2001)	M le fa tr
[illegible]	[illegible]

Table 6. Minimum lengths (mm)* for relative stock density categories of yellow perch.

a presence-absence di
b habitat-related dens
c growth, reproductio
d production rates by

Area, year assessed
Head-of-Bay, 2001[1]

*Based on world-record lengths from the International Game Fish Association

Table 7. Percentage of harvested yellow perch in each RSD category. Choptank River, 1995-1999*.

* Creel survey ended in 1999.

Table 8. Percentage of harvested yellow perch in each RSD category. Chester River, 19971999*.

a presence-absence distribution data (Refer to yellow
b habitat-related density data;
c growth, reproduction, and survival rate within habit
d production rates by habitat.

Area, year assessed
Head-of-Bay, 2001[1]

* Creel survey ended in 1999.

Commercial Yellow Perch Fishery

Over 95% of the yellow perch harvested in the Maryland portion of the Chesapeake Bay and its tributaries are caught in fyke nets. The remaining 5% of the reported harvest have been from pound nets, drift gill nets, anchored gill nets, fish pots, haul seines, and hook and line (Table 9). Traditionally, commercial fishermen began to set fyke nets in Chesapeake Bay tributaries in early February to catch yellow perch during their spawning runs.

a presence-absence distribution data (Refer to ye
b habitat-related density data;
c growth, reproduction, and survival rate within h
d production rates by habitat.

Area, year assessed
Head-of-Bay,

At the turn of the century, the Maryland yellow perch commercial fishery harvested approximately 1.0 million pounds per year (Casey et al. 1987). By the mid to late 1960s, the yellow perch commercial harvest averaged 183,000 pounds annually. Harvest continued to decrease during the1970's to approximately 53,000 pounds, and reached an all time low of 15,000 pounds (1981). By the late 1980s, catches had improved but were still below harvest levels of the early 1970s (Figure 2). Regulations were implemented to allow populations to recover while maintaining a limited commercial fishery. Since landings during the month of February were approximately 24% (1964-1987 combined) of the total, commercial fishing was closed in February. Areas perceived to have low levels of yellow perch were closed year- round. Commercial fishermen continued to report yellow perch harvest during February and landings during this month remained the second highest (Figures 3 and 4). Tributaries closed to both commercial and recreational fishing but reporting commercial landings include the Choptank, Patapsco, and Nanticoke rivers. An examination of the fishery records indicates that some of the reported landings may have been incorrectly coded for yellow perch. During the mid-1990s, commercial harvest of yellow perch averaged 67,000 pounds annually. Commercial harvest began exceeding 100,000 pounds in 1997 (Figure 2) and reached 203,000 pounds in 1999. Increased commercial landings during these years can be partly attributed to the reopening of the Chester and Patuxent rivers. These areas were closed to commercial fishing in 1987 and opened in 1993 with a 10 inch minimum size limit. Other factors that may have contributed to the increased landings include increased recruitment, a change in the yellow perch market, and increased fishing effort (Piavis and Uphoff,1999). Reported commercial landings were 105,000 pounds and 127,000 for the years 2000 and 2001, respectively. Preliminary landings for 2002 are 166,000 pounds. Yellow perch harvested in the upper Bay have comprised 76-88% of the harvest since 1997. Higher landings and effort in the upper Bay have been under scrutiny because the stock is considered fully exploited (Piavis and Uphoff 1999).

The majority of yellow perch harvested in Maryland have been sent to states in the midwest as live fish for stocking in fee fishing ponds with a smaller proportion processed for food. Yellow perch harvest from the Great Lakes declined in the mid 1990s and the majority of yellow perch harvested in Maryland were sold as table-fare for this market. The live market paid fishermen $0.25 to $0.60 per pound, while the Great Lakes market provided $0.75 to $2.00 per pound. The increase in price per pound has most likely influenced the increase in fishing effort (Figure 5).

History of yellow perch hatchery production

In response to the decline in commercial and recreational harvests and stock abundance in the late 1800's and the early 1900's, yellow perch hatchery operations were initiated to supplement natural reproduction. These hatcheries operated from about 1890 to 1955 on various Maryland tributaries of the Chesapeake Bay (Muncy 1959). Eggs and sperm from commercially harvested yellow perch were collected and hatched. During this time period, as many as 767 million fry were produced annually (Muncy, 1959). Yellow perch fry were stocked in numerous tributaries throughout the Chesapeake Bay (Table 10). No relationship could be established between the number of fry released and the subsequent stock size. All hatchery operations were discontinued in 1955 (Muncy 1959).

In 1988, MDNR began hatchery production to supplement natural populations in various tributaries. The methods of production employed by Muncy in the early 1950s were utilized in 1988 (Eaton et. al.1993). Egg strands were taken from female yellow perch harvested in commercial fyke nets on the Sassafras River. The egg strands were transported to hatchery ponds, placed in hatching boxes, and monitored for predation and fungal infestations. After hatching, growth was tracked and feeding requirements were monitored. When the fry reached a suitable length, the ponds were drained, the fry were captured and transported to designated tributaries for release (Table 11). During transport, oxytetracycline was added to the tank to mark the young fish. Later in the season, juvenile yellow perch were captured using beach seines and otoliths were extracted and examined for oxytetracycline (OTC) marks. Project personnel were not able to identify any OTC marks. Blood samples were also collected and tested for specific antibodies produced as a result of the OTC exposure but test results were inconclusive (Eaton et. al., 1993). Since the 1988 stocking project did not verify the OTC marks on their hatchery-raised yellow perch fry before they were released, it is uncertain whether or not they were successfully marked. There was a notable increase in the number of age 1+ yellow perch on the Wye River which might have been attributed to the survival of stocked juveniles, but other stocked tributaries showed no clear signs that stocking had affected restoration. Hatchery operations were terminated in 1992 (Eaton et al. 1992). Yellow perch have been successfully marked using OTC in other yellow perch stocking efforts outside of the Chesapeake Bay (Unkenholz et al. 1997).

a presence-absence distribution data (Refer to yellow perch maps Figures 1a-e);
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium

Maryland Fisheries Service Mariculture, Estuarine and Marine Hatcheries program conducted a pilot project for yellow perch restoration during the spring of 2001. Development of reliable production and marking techniques for stocking and the assessment of stocking impacts were the primary project goals. Techniques included using hormonal stimulation to induce spawning, OTC marking trials to determine optimal doses for effective marking, culture of several ages/sizes of yellow perch for stocking, and development of methods to uniquely mark fish stocked at different sizes. The hatchery staff developed a process to reliably mark yellow perch. Fish of different ages/sizes were uniquely marked by varying the number and pattern of OTC marks. Intensive culture of fingerlings to a size large enough to employ other marks such as coded wire tags (CWT's), was also evaluated. Coded wire tags contain more specific information and growing the fish to a larger size increases survival. These techniques have been very successful in assessing the impacts of stocking striped bass, American shad, and hickory shad larvae and juveniles. As a result of the hatchery effort, over 90,000 juveniles were stocked in the St. Mary's River, and 125,000 juveniles and 98,000 larvae were stocked in the Miles River during 2001.

Table 9. Yellow perch landings (pounds) by gear 1993-2000

( )- indicate number of fishermen (licenses) reporting landings from a particular gear.

Adult yellow perch relocation

In February 1989, 1990 and 1991, MDNR purchased adult yellow perch from commercial fishermen and transported them to river systems with depleted populations to enhance fish spawning and reproduction. The

a presence-absence distribution data (Refer to yellow perch maps Figures 1a-e);
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium, length distribution favorable, age truncated
Patuxent, 1999	Moderate,

majority of fish transported were in peak or near peak spawning condition. The Patuxent River and the two

a presence-absence distribution data (Refer to yellow perch maps Figures 1a
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**

major tributaries to the South River, North Branch and Bacon Ridge Branch, were the Western Shore stocking locations. The Choptank River and Marshyhope Creek, which feeds into the Nanticoke River, were the systems stocked on the Eastern shore. Not all systems were stocked each year (Table 10).

Table 10. Number of yellow perch fry stocked in Maryland river systems, 1940-1955 (from Muncy 1959)

a presence-absence distribution data (Refer to yellow perch maps Figures 1a-
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium, length distribution favorable, age truncated
Patuxent, 1999 (10 inch)	Moderate, CPUE up
Potomac tributaries	
Chester	Moderate, CPUE down
Wye and Miles	Presumed moderate
Choptank, 2001	High
Nanticoke, 2001	Presumed high, len favorable
Lower Eastern Shore	
Water Body	**Water Quality**
Upper Bay	CBP Nutrients[1]

Table 12. Number of adult Yellow perch relocated to selected tributaries, 1989-1991

Table 11. Number of juvenile yellow perch stocked in Maryland, 1988-1992

a presence-absence distribution data (Refer to yellow perch maps Fi
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock st**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium length d

Prior to release, a number of perch were tagged with Floy t-bar tags which were inserted posterior to the second spiny dorsal. Tagging allowed tracking of the fish both within and out of the systems in which they were

a presence-absence distribution data (Refer to yellow perch maps Figures
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium

stocked. Relocated yellow perch dispersed and often left the system in which they were stocked in order to return to their natal waters (Mansuetti 1960). Since the relocated fish were close to spawning, there was the possibility that they had spawned prior to leaving the stocked system. Tag returns received from recreational and commercial fishermen indicated that many of the perch did not remain in the systems beyond a couple days of stocking and in some cases, a day. Tags were recovered a tenth of mile from the stocking point the following day to 19.5 miles downstream in a week. All tag returns occurred downstream of the stocking sites indicating movement out of the system.

Since beach seine samples on the Patuxent and Choptank Rivers and electro-fishing samples in Marshyhope Creek did not indicate an increase in juvenile perch, adult stocking was terminated in 1991.

Precautionary Management

A precautionary management approach reflects the desire to develop fishery policies that minimize the risk (chance or probability) that something undesirable will happen (Francis and Shotten 1997). In the case of fishery science, the "something undesirable" is the collapse of a fish stock. Risk arises from uncertainty and uncertainty in fishery science arises from incomplete knowledge of population dynamics, inadequate data, simplified models used for assessments, deficient implementation of policies, and a lack of clear management objectives (Francis and Shotten 1997). The precautionary approach categorizes biological reference points (BRPs) as targets and thresholds (Caddy and McGarvey 1996). First, an overfishing threshold is defined. If a stock is harvested at a rate exceeding the threshold, it will not be able to sustain itself. Next, a target is set at a lower level of exploitation to minimize the chance of overshooting the threshold and collapsing the stock. The fishery is managed for the target, a level of fishing mortality (F), and for the overfishing threshold. The range of possible estimates of current F determines the risk (probability) of exceeding the threshold. A distribution (range) of F's must be used rather than a point estimate because F is derived from a sample and not the population itself. The probability of overfishing is quantified from the portion of the distribution of current F exceeding the threshold. The target F is a level of "safe" fishing that is below the overfishing threshold to provide a margin of error (Caddy and McGarvey 1996). Fishing mortality rates (F's) may be distributed below, at, or in excess of the target F as long as the risk of exceeding the overfishing threshold is low enough. If the probability of exceeding the overfishing threshold exceeds some pre-agreed upon level, action should be taken to reduce harvest. Exceeding the overfishing threshold does not mean the stock will collapse, only that the chance of collapse is thought to be significant (Francis and Shotten 1997).

Spawning stock biomass per recruit (SSBR) represents the spawning potential of yellow perch in the Bay (Piavis and Uphoff 1999). It characterizes the reproductive potential of the stock in terms of spawning stock biomass (or weight) produced by a year-class over its lifetime under conditions of constant growth, mortality, and recruitment (Goodyear 1993). An unfished population is at its maximum spawning potential (100% MSP) and added mortality from fishing decreases spawning potential by removing spawners. Fishing mortality lowers lifetime spawning biomass by shortening average lifespan. The basic concept stems from the observation that significant rises in survival of young fish must occur to compensate for removal of spawners by fishing for the population to survive. Compensation for increased removal of spawners by increased egg to pre-recruit survival has some upper limit and consistently poor recruitment in exploited fish populations has been noted once SSBR becomes less than 20% of MSP (Goodyear 1993). Management based on SSBR links a harvest strategy to robustness of the stock to recruitment overfishing based on a measured or assumed stock-recruitment relationship. If a description of a stock-recruitment relationship is lacking, a 30% MSP is recommended as a reasonable first choice (Goodyear 1993, Mace and Sissenwine 1993, and Mace 1994). Percent MSP is just one of many biological reference points that can be used in managing a fishery.

Stock Assessment

The 1998 yellow perch stock assessment utilized data collected from the Choptank, Patuxent, and Chester Rivers, and the upper Chesapeake Bay (Piavis and Uphoff 1999). Updates to the stock assessment have occurred every year since the initial assessment. Otoliths (ear bones) were used to determine age. Population length structure and relative stock densities (RSDs) were determined using a length-categorization system (Gablehouse 1984). Total mortality (Z) was estimated using length-based catch curves. Natural mortality (M) was determined as 0.25, using the oldest age in the population (12 years). Fishing mortality (F) was determined from the equation Z-M=F. Relative abundance was determined using commercial catch and effort data.

A Thompson-Bell SSBR analysis was used to determine the percentage of SSBR of an unfished yellow perch stock. This method uses recruitment vectors and fishery selection patterns to scale fishing mortality (F) and the number of mature fish at age to define SSBR. Using biological reference points (BRPs) which preserved 20% ($F_{20\%}$) and 30% ($F_{30\%}$) of the virgin stock size, and estimated replacement of the spawning stock (F_{rep}), the SSBR without fishing (F=0) was computed. The biomass corresponding to the various reference points was identified and F's which produced 20%, 30%, and replacement SSBR were determined. Two additional BRPs were determined, $F_{0.1}$ and F_{max}. The $F_{0.1}$ reference point is one of the most risk-averse or conservative parameters. The F_{max} is one of the most risk prone harvest strategies, especially in non-equilibrium situations (Piavis and Uphoff 1999). Table 13 defines the calculated levels of F for three Maryland rivers and potential BRPs.

Table 13. Fishing mortality (F), maximum spawning potential (MSP), and biological reference points (BRPs) for yellow perch from the upper Chesapeake Bay, Patuxent River and Choptank River.

a presence-absence distribution data (Refer to yellow perch maps Figu
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock statu**
Head-of-Bay, 2001[1]	Medium

Stock Status

Although yellow perch stocks were depressed in the mid-1980s, recent data indicate that several major river systems have expanding or healthy yellow perch populations. One of the confounding components of assessing yellow perch stock status is its region-specific nature. There could be as many as 25 tributary-specific populations in Maryland making it logistically difficult to describe the characteristics of each stock in all systems. The MDNR Multifish Survey monitors the status of yellow perch stocks in selected areas within the Maryland portion of the Chesapeake Bay. Over the years, commercial fyke nets have been sampled in the upper Chesapeake Bay, the Chester and the Nanticoke rivers. Experimental fyke nets have also been utilized on the Choptank, Patuxent and Severn rivers. Creel surveys have been conducted on the Chester and Choptank Rivers. The Natural Resources Police (NRP) conducted a yellow perch survey during 2000 and 2001. Yellow perch juvenile abundance can be estimated for the Potomac River, Patuxent River, upper Chesapeake Bay and the Nanticoke River, however, the upper Bay estimate is the only reliable estimate of abundance.

To the extent possible, management strategies have been developed for river-specific stock conditions (Piavis, 1991, Piavis 1996). The 1998 stock assessment and subsequent updates, have focused on three areas. Up until 1999, the Choptank River was managed under a low exploitation strategy (9" recreational size limit, no commercial fishery); the Patuxent River under a medium exploitation strategy (9" recreational and 10" commercial size limit); and the upper Bay under a high exploitation strategy (8 ½" recreational and commercial size limit). Based on the biological reference points (BRPs) determined from the spawning stock biomass per recruit (SSBR) analysis and indices of relative abundance and recruitment, the stock status of each of the three areas was assessed. The upper Bay yellow perch stock was considered fully exploited. The spawning potential ratio (SPR) increased from 26% of the maximum spawning potential to 46% from 1998 to 2000. Fishing mortality rates were below F_{20} (the overfishing threshold) and F_{max} (the most risk prone target) during 1998 and 2000. Fishing rates exceeded F_{30} (the target fishing rate) and $F_{0.1}$ (the most risk averse target) in all three years. The estimates of F in the Patuxent and Choptank rivers were safely below all the reference points produced by the different stock assessment analyses (Table 14). Inferences on stock status in unsampled areas were formulated by using population data from nearby systems and applying the life history characteristics to model simulations (Table1). Uphoff (1999) examined the risk of fishing yellow perch stocks in the upper Bay and in the Patuxent River below 20% MSP, at F_{1998} and at 25% higher than F_{1998}. This analysis included uncertainty in several Thompson-Bell model parameters. In 1998, the risk of being below 20% MSP was about 11% in the upper Bay and less than 0.5% in the Patuxent.River. An increase in F by 25%, raised the risk to nearly 55% in the upper Bay and 3% in the Patuxent River (Piavis and Uphoff 1999).

In addition to the stock assessment results, yellow perch juvenile indices (JI) were available for the Potomac River and the upper Bay from the Maryland Juvenile Finfish Survey (Cosden et al.1998). Juvenile indices in the upper Bay increased dramatically in 1993 and in 1994 produced the highest index since the survey began (1979) (Figure 6). The yellow perch JI provides additional evidence that the yellow perch stock is expanding in the upper Bay. Catches of yellow perch have increased in western shore tributaries (Patapsco River to South River) since 1993 (M.McGinty, MDNR, personal communication). Some of these tributaries do not have viable spawning populations and the increased catches may be the result of yellow perch movement from the upper Bay. Unpublished data from Mattawoman Creek (Potomac River tributary) revealed that the highest catches occurred in 1993, and 1995 through 1998. The Wicomico River (another Potomac River tributary) also had the highest juvenile catches during 1994 and 1995 since 1989. Although the number of juvenile yellow perch caught in the

Potomac River is variable from year to year and does not produce a reliable index, the data suggest that yellow perch stocks were at levels that produced above average recruitment during the mid-1990s.

Laws and Regulations

Prior to 1988, very few regulations existed for yellow perch. A minimum size limit of 8 inches was required for the commercial harvest of yellow perch by any gear type except hook and line. In addition, there were some area closures and gear restrictions but these did not reflect any biological management of yellow perch stocks (Richkus & Stroup 1987). Many of these regulations were believed to have been established to minimize trespassing on private property (O'Dell, pers.comm) and were implemented in the 1960's. By the late 1970s, the decline of yellow perch became obvious, especially in the lower western shore river systems. Available data indicated that yellow perch in 11 rivers or watersheds were severely depressed. By the late 1980s, MDNR proposed new regulations. In 1989, the Chester, Choptank, Magothy, Miles, Nanticoke, Patapsco, Patuxent, Severn, South, West and Wye river watersheds were closed to commercial and recreational yellow perch fishing. In other watersheds, available information indicated that yellow perch populations were low but stable. To avoid increasing fishing pressure caused by the watershed closures, actions to control fishing especially during the pre-spawning period, were implemented. The sale of yellow perch during February was prohibited, a daily catch limit was established (5 fish creel limit for the recreational fishery), and the minimum size was increased from 8 to 8 ½ inches. Barbless hooks were required for the recreational fishery between February 1st and March 15th.

In order to adequately protect river populations from over-exploitation, MDNR proposed a strategy to incrementally increase the minimum size to10 inches as a means to increase the reproductive capacity of the spawning stock. Increasing the size limit in a stepwise fashion would allow a review of the impacts for each size increment and a review of the growth and availability of legal size fish to the recreational and commercial fisheries. Following the 1989 regulations, river systems were reopened depending on the status of the population in a particular river system. In 1991, the Tuckahoe Creek (on the Choptank), Patuxent, and Wye rivers were reopened at a 9 inch minimum size for the recreational fishery. In 1992, the Choptank River was reopened at a 9 inch minimum size for the recreational fishery. In late 1993, the Patuxent River was reopened at a 10 inch minimum size for the commercial fishery. In 1994, the Chester and the Miles rivers were reopened at a 9 inch minimum size for the recreational fishery and the Chester was reopened at a 10 inch minimum size limit for the commercial fishery. The changes in regulations were difficult to remember and confusing to anglers (Table 14).

a presence-absence distribution data (Refer to yellow perch maps Figures 1a-e
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	**Stock status**
Head-of-Bay, 2001[1]	Medium
Western shore (Severn, 2001)	Medium, length distribution favorable, age truncated
Patuxent, 1999 (10 inch)	Moderate, CPUE up
Potomac tributaries	
Chester	Moderate, CPUE down

For the 2000 fishing season, MDNR implemented more consistent yellow perch regulations. The minimum size limit for the commercial fishery was a slot limit of 8.5"- 11" in all open areas and the recreational fishery had a 9" limit in all open areas. The commercial slot limit was determined by modeling SBR. The 8.5-11" slot limit preserved the characteristics associated with successful reproduction without a radical increase in the minimum size limit (Uphoff & Piavis 1999). The closed areas remained the same for both fisheries and the commercial closed season during February continued. The commercial hook and line were required to follow the recreational limits of 9" minimum size and a 5 fish/person/day creel. All other regulations remained the same.

Description of Habitat

Yellow perch have been reported from all tributaries in the Chesapeake Bay and are most numerous in the upper Bay. Adults migrate from estuarine waters to less saline areas in late January through March and spawning generally takes place in March. Spawning is influenced by water temperature and optimal spawning temperatures have been reported between 8- 12 ^{o}C (46-54^{o}F) (Piavis 1991). Preferred water velocity for spawning is 0.5 to 2.5 ft/sec; preferred depth is 1.5 to 3 ft. and preferred substrate is mud/soft clay or silt (Jesien et al. 1991). Other habitats used for spawning include areas of submerged brush or vegetation and shallow areas (<15 m) where the bottom is uneven (Richkus and Stroup, 1987). Eggs and larvae are sensitive to pH and aluminum interactions, and sedimentation. Water temperature influences hatching time. At lower temperatures, fish embryos take longer time to develop. Water temperature during hatching in the Chesapeake Bay is typically around18^{o}C (64^{o}F) with hatching 8-11 days after spawning. Larval yellow perch move offshore after hatching. This behavior is believed to reduce the risks of predation from littoral species. Larvae have a temperature range between 10 and 30^{o}C (50-86^{o}F). Juveniles (20-40 mm TL) generally migrate back to the littoral zone to feed on nearshore food sources. Juveniles have a temperature range similar to larvae. Young of the year yellow perch exhibit optimal growth at temperatures between 26-30°C (7986°F) (Piavis 1991). Optimal temperature for adult yellow perch is around 25°C. Lake studies indicate that adults tolerate a temperature range of 12-16°C (54-61°F) during the winter and a range of 16-22°C (61-72°F) during the summer. Behavioral responses to water temperature are probably very important in determining habitat utilization by yellow perch. Water temperature also affects growth and feeding.

Yellow perch spawn in areas between 0-2.5 ppt salinity. There is a decrease in hatching rates with increasing salinity. Larger areas of suitable spawning habitat probably occur in years with high rainfall. Optimum salinity for developing fish is between 0-2.0 ppt. The influence of salinity on growth patterns has not been determined. Juveniles and adults can tolerate a salinity range of 0-13 ppt but are most abundant in 5-7 ppt.

Dissolved oxygen (DO) is an important ecological factor and required for fish respiration. Unpolluted waters are normally saturated with oxygen at a given temperature. For all life history stages of yellow perch, the minimum DO concentration is 5 mgL^{-1} (Piavis 1991). DO lower than the optimum may influence fish to leave a particular area, it could impede their growth, and also affect survival.

Suspended sediments in the water column may affect yellow perch reproduction. Eggs and larvae are negatively affected when sediment particles are >500 mgL^{-1} Oxygen uptake during the egg stage is impeded by sediment. Turbidity may lower visibility of prey and affect feeding rates, especially during the larval stage when yellow perch are dependent on zooplankton (Richkus & Stroup 1987). Sediments may also damage gills and gill membranes. A summary of water quality parameters for different life stages of yellow perch can be found in Table 15.

Acidic waters, represented by low pH, can have a detrimental affect on aquatic systems and have been known to cause reproductive failure in some fish populations. In the Chesapeake Bay, acid rain is the largest source of acidic input to freshwater streams. Newly hatched yellow perch are the most sensitive to acid conditions and adults are the most tolerant (Klauda et al. 1988). Critical acidic conditions for egg and larval yellow perch occur at a pH between 4.5 and 5.5. Harmful effects of acidity on larval and juvenile yellow perch are enhanced when associated with dissolved aluminum.

Observations from stream surveys in the 1980's have resulted in some generalities regarding stream habitat. Streams which did not support anadromous and semi-anadromous fish species were channelized or had minimal to no buffers in agricultural areas. Streams in the upper watershed require good riparian buffers to protect from impacts due to agriculture, especially siltation. Streams with 25 to 50 ft. buffers had significantly higher water quality than streams without buffers (Jesien et al, 1991).

Table 15. Water Quality Parameters for different life stages of yellow perch (from Piavis 1991)

(NA =

a presence-absence distribution data (Refer to yellow perch maps Figures 1a-e);
b habitat-related density data;
c growth, reproduction, and survival rate within habitats;
d production rates by habitat.

Area, year assessed	Stock status
Head-of-Bay, 2001[1]	Medium

data not available)

There is little information on feeding habits of yellow perch in estuarine areas especially for larval fish. In freshwater lakes, larvae consume zooplankton, primarily copepods and cladocerans. Yellow perch larvae collected from the Choptank River in 1990 fed primarily on cladocerans and copepods (J. Uphoff, MDNR, pers. comm.) In the Chesapeake Bay, juvenile yellow perch feed primarily on small crustaceans, insects, worms and mollusks (Hildebrand & Schroeder 1928). Juveniles first feed on zooplankton but as they change their life style to a bottom-dwelling existence, they switch food items to benthic invertebrates. Cannibalism has been documented in hatchery ponds especially during early life history stages. Adult yellow perch in the Chesapeake Bay feed on anchovies, killifish, silversides, scud, caddisfly larvae, midge larvae, mud crabs and blue crabs. Differences in stomach contents from area to area probably reflect the availability of different forage bases rather than differences in behavior (Richkus & Stroup 1987). Predation on yellow perch has not been thoroughly documented in Chesapeake Bay. Yellow perch are often found in the same areas as largemouth bass, chain pickerel, catfish, white perch, striped bass, and bluefish. Piscivorous birds such as ospreys, bald eagles, gulls, terns, herons, and egrets have also been present in areas where yellow perch are found.

Threats to Habitat

The most common threats to fish habitat can be categorized as 1) physical habitat destruction, alteration, blockage, and fragmentation; 2) inadequate water quality and quantity; 3) eutrophication and hypoxia (a particular aspect of water quality); 4) introduction of exotic species; and 5) toxic contaminants (Schmitten 1999). Habitat quality and quantity must be maintained in order to support healthy yellow perch stocks. Threats to yellow perch habitat include nutrient enrichment, degradation of stream buffers, and human development. Land use decisions that consider effects on the aquatic habitat would be the most beneficial for yellow perch populations. Areas with bank erosion increase sedimentation and is detrimental to yellow perch eggs and larvae.

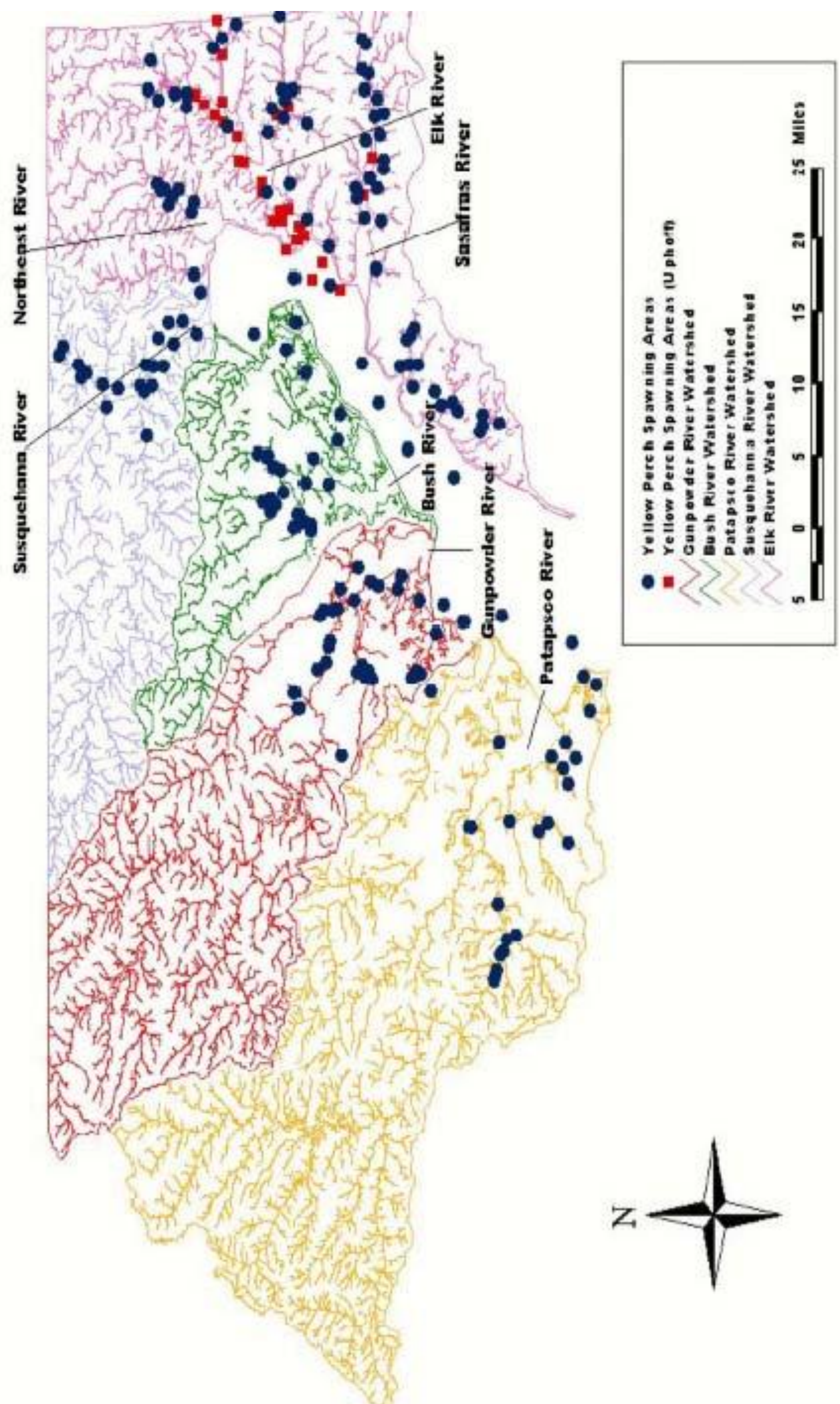


Figure 1a. Upper Bay yellow perch spawning areas

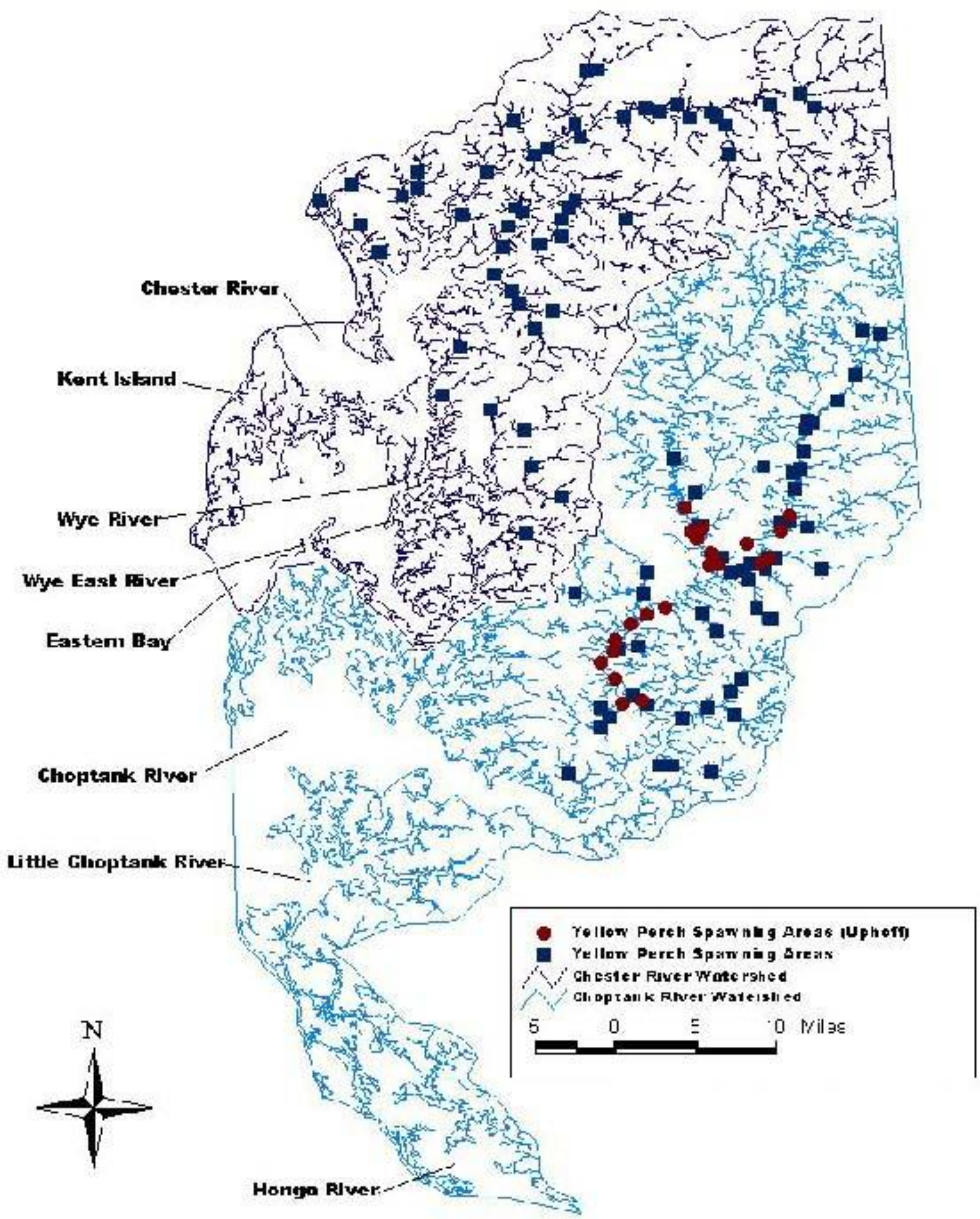


Figure 1b. Chester and Choptank Rivers yellow perch spawning areas.

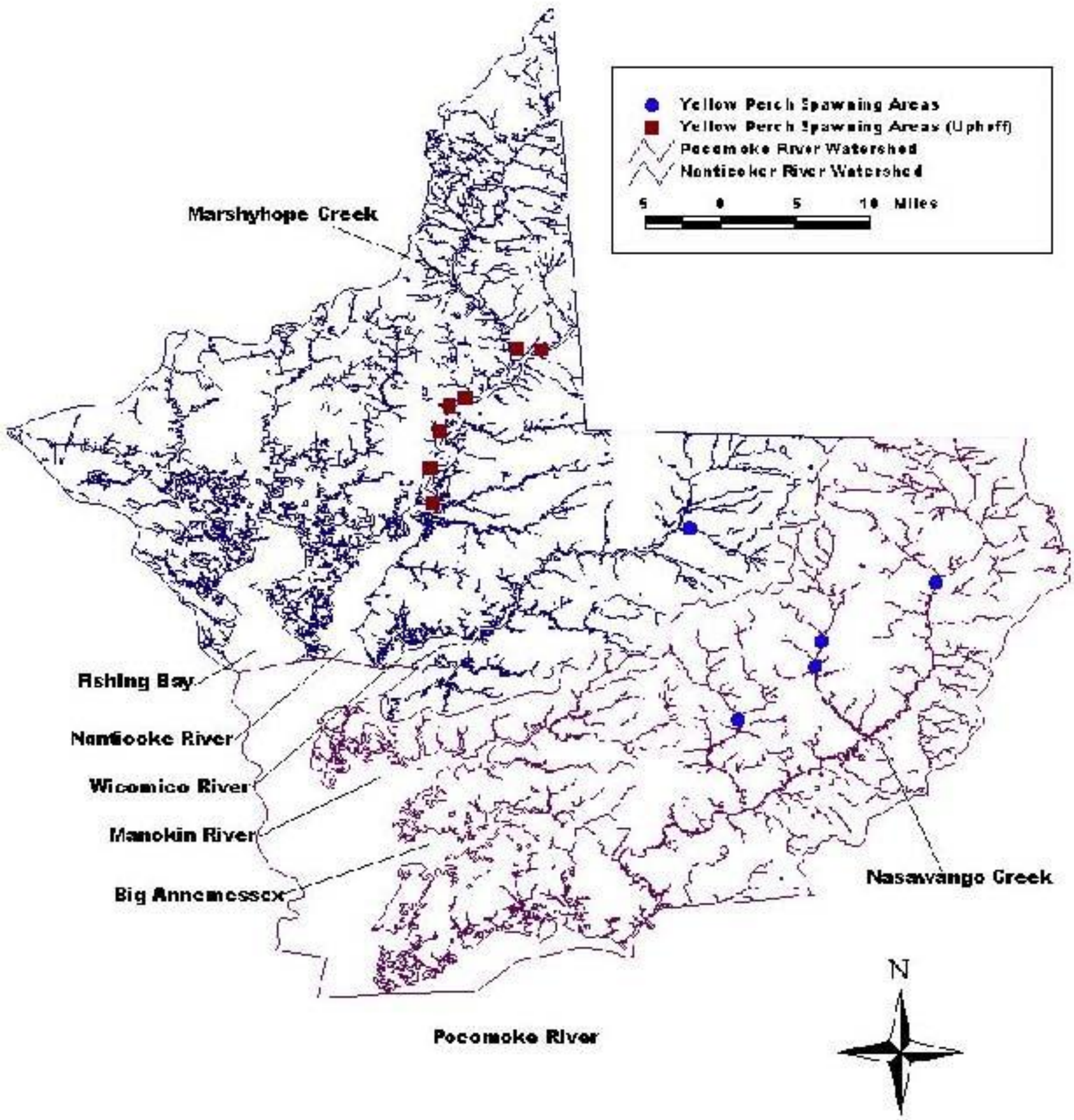


Figure 1c. Lower Eastern Shore yellow perch spawning areas.

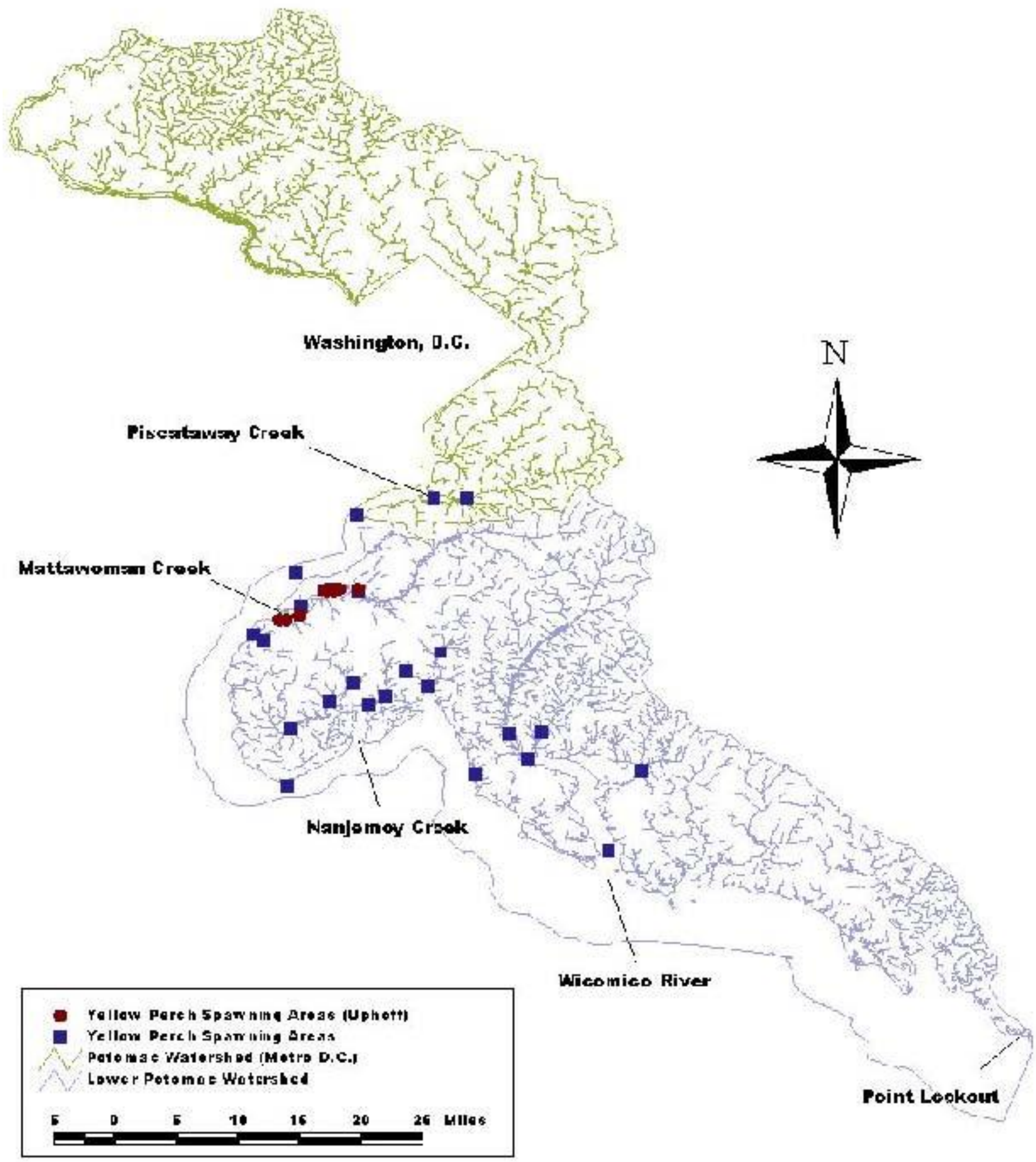


Figure 1d. Potomac River yellow perch spawning areas.

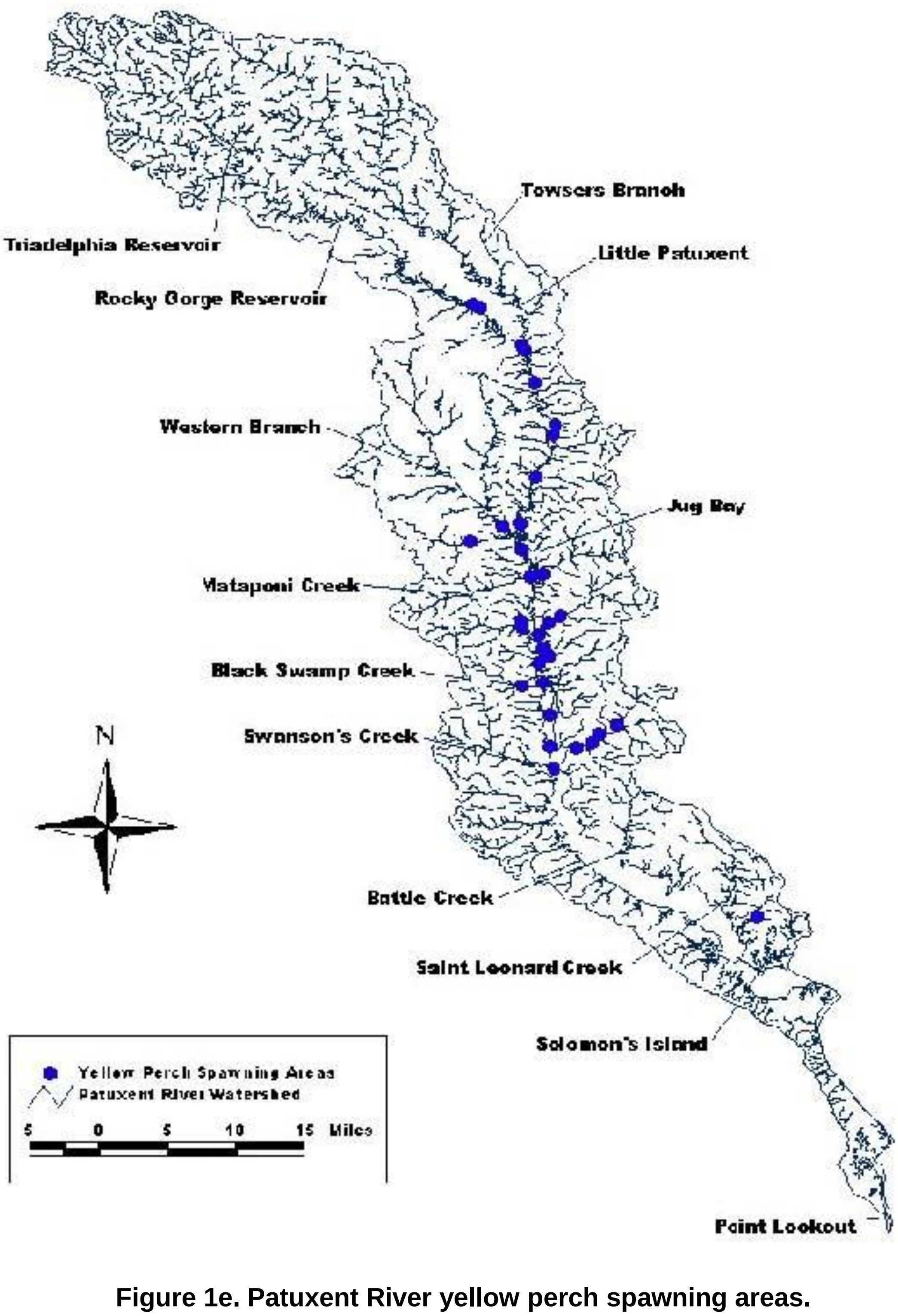


Figure 1e. Patuxent River yellow perch spawning areas.

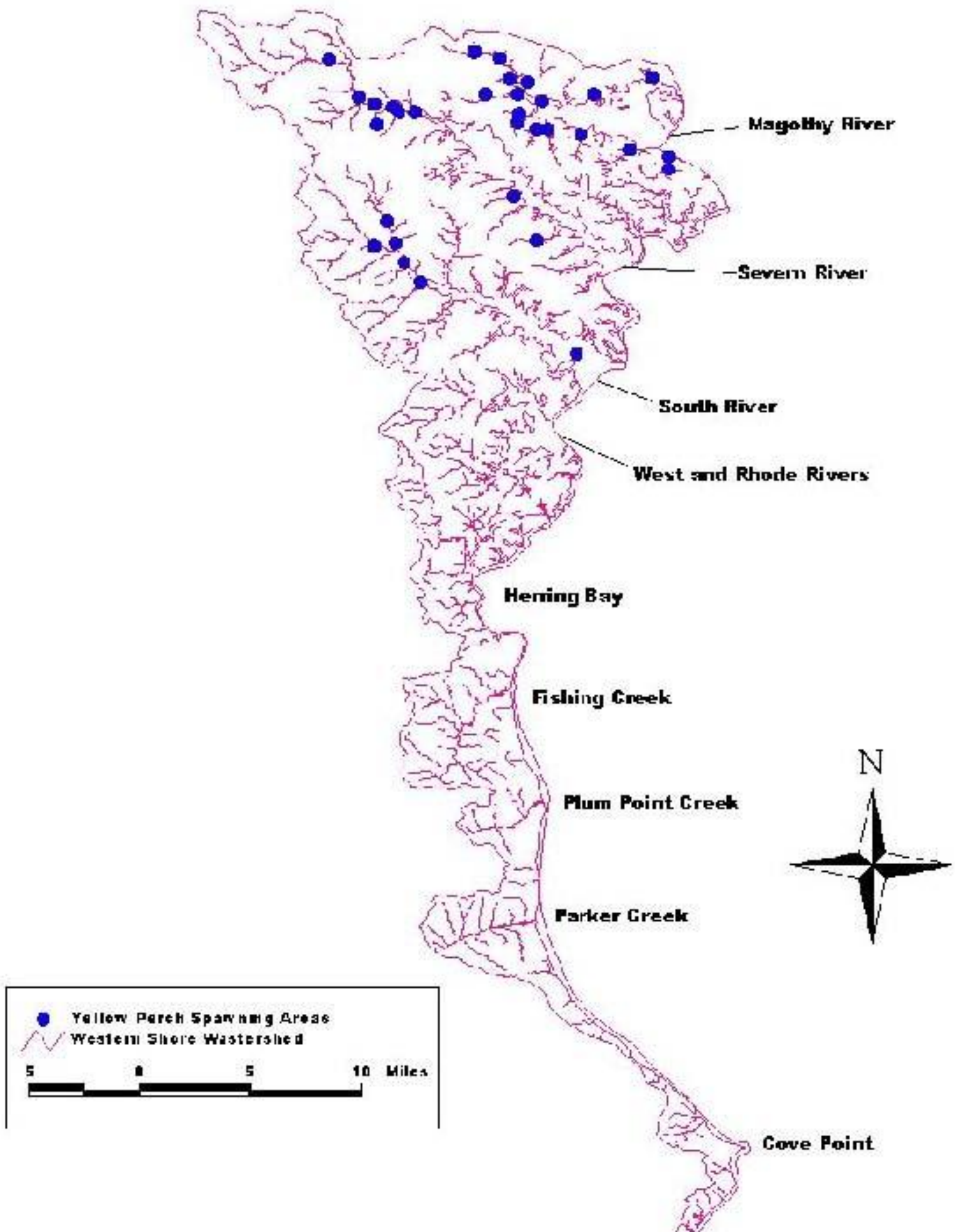
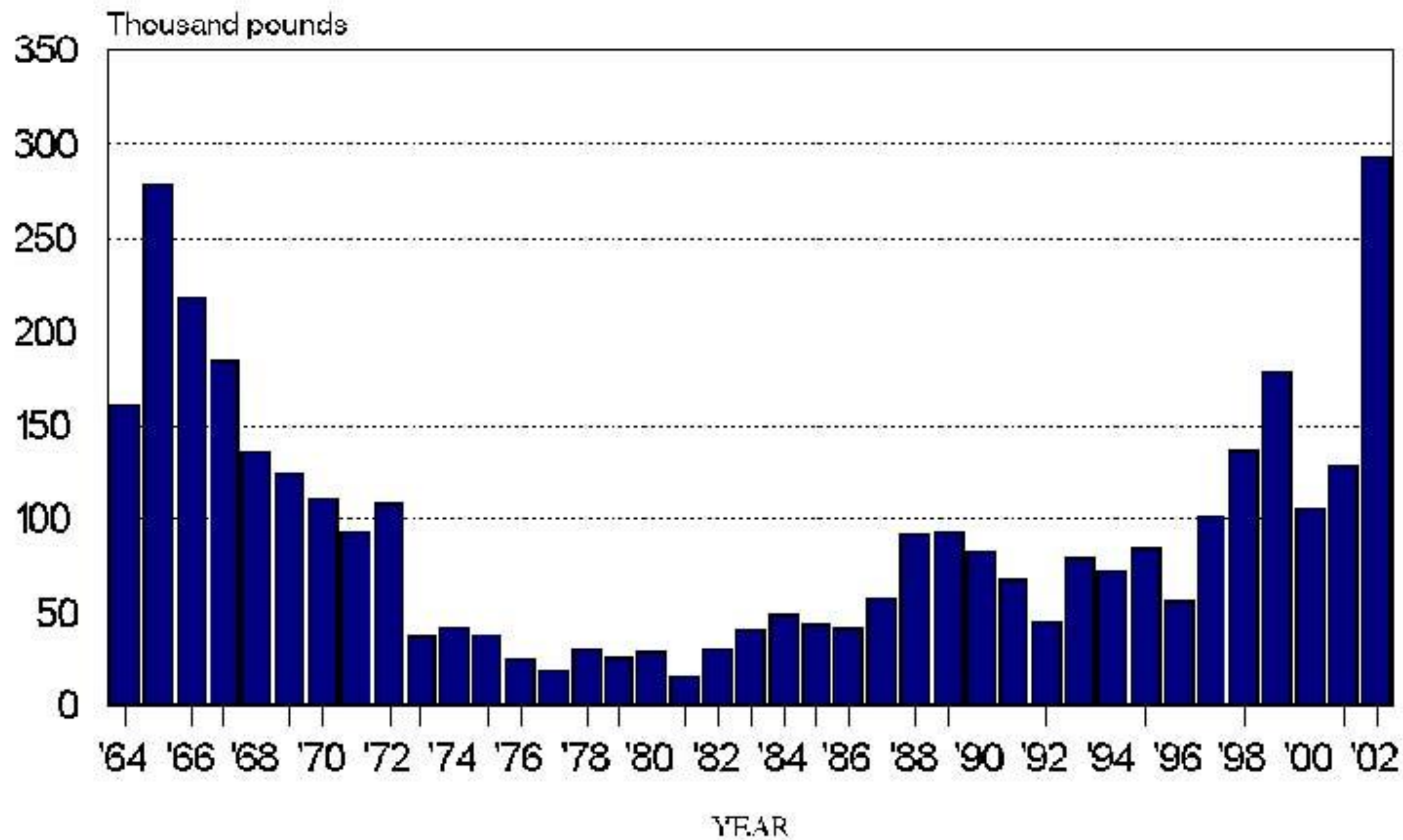


Figure 1f. Western Shore yellow perch spawning areas.

Figure 2: Commercial yellow perch landings, 1964-2002*



*2002 Preliminary landings

FIGURE 3: Yellow Perch Percent of Landings by Month, 1980-1988 (pre-closure)

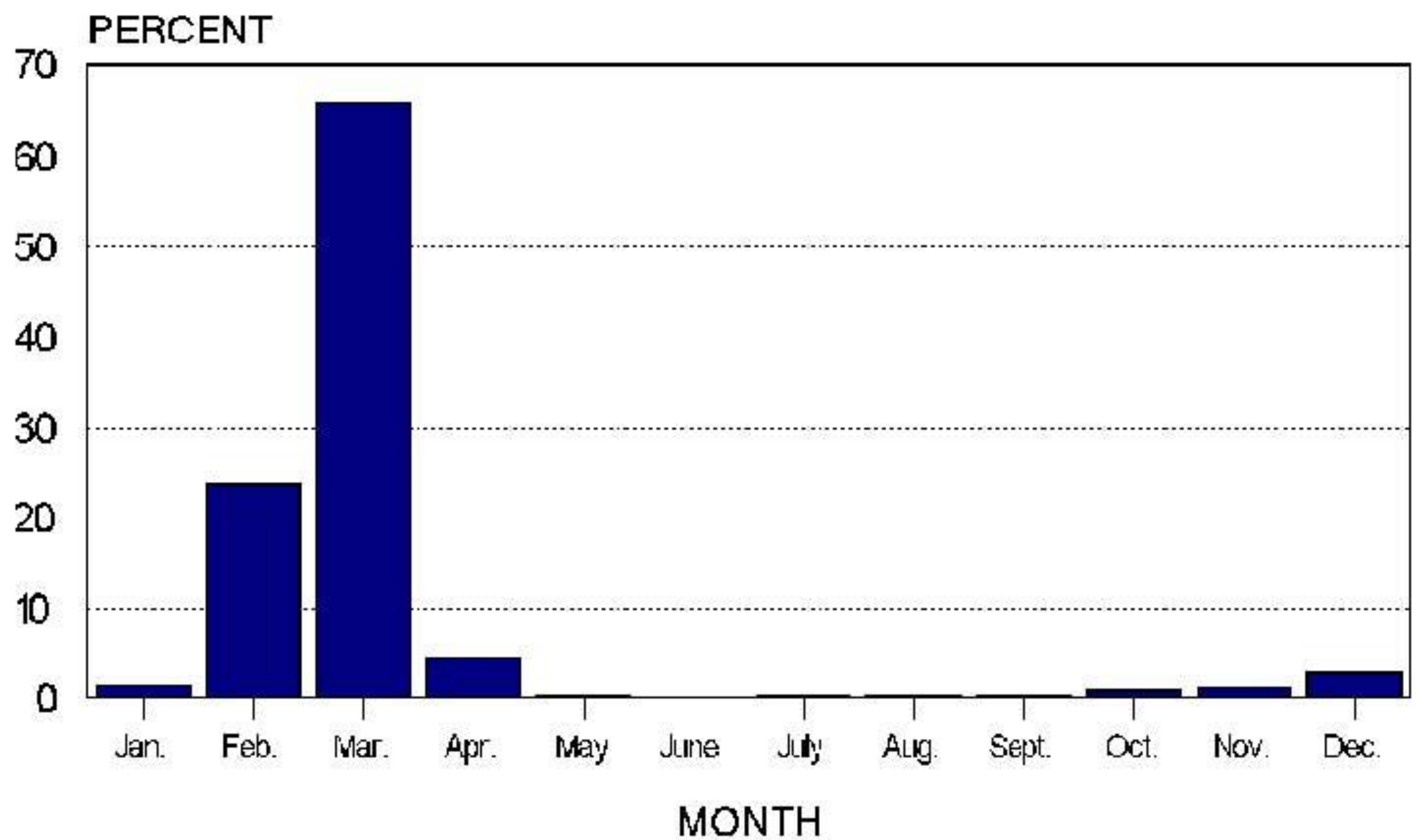


Figure 4: Yellow perch percent of landings by month, 1989-1999, 2000, and 2001 (post-closure)

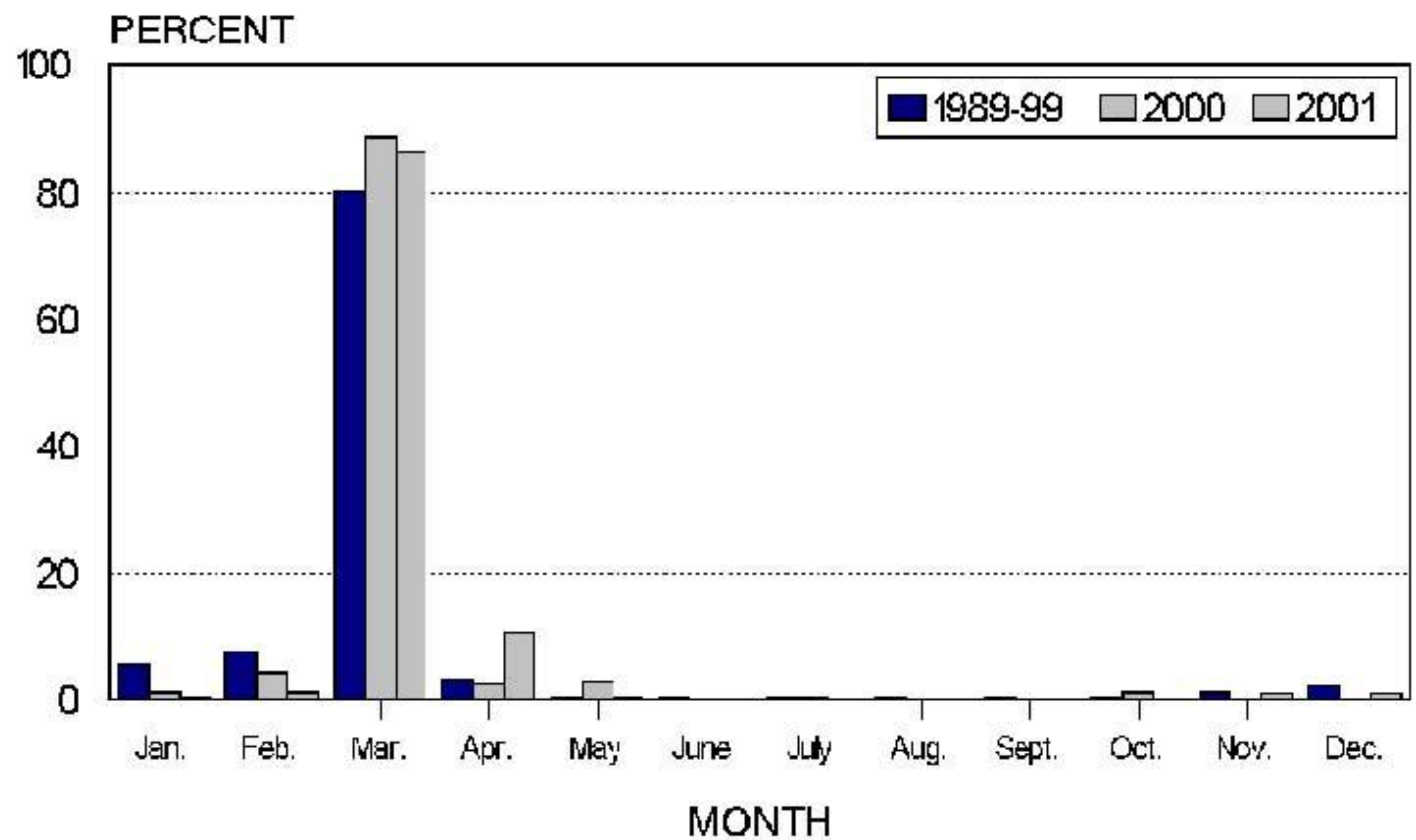
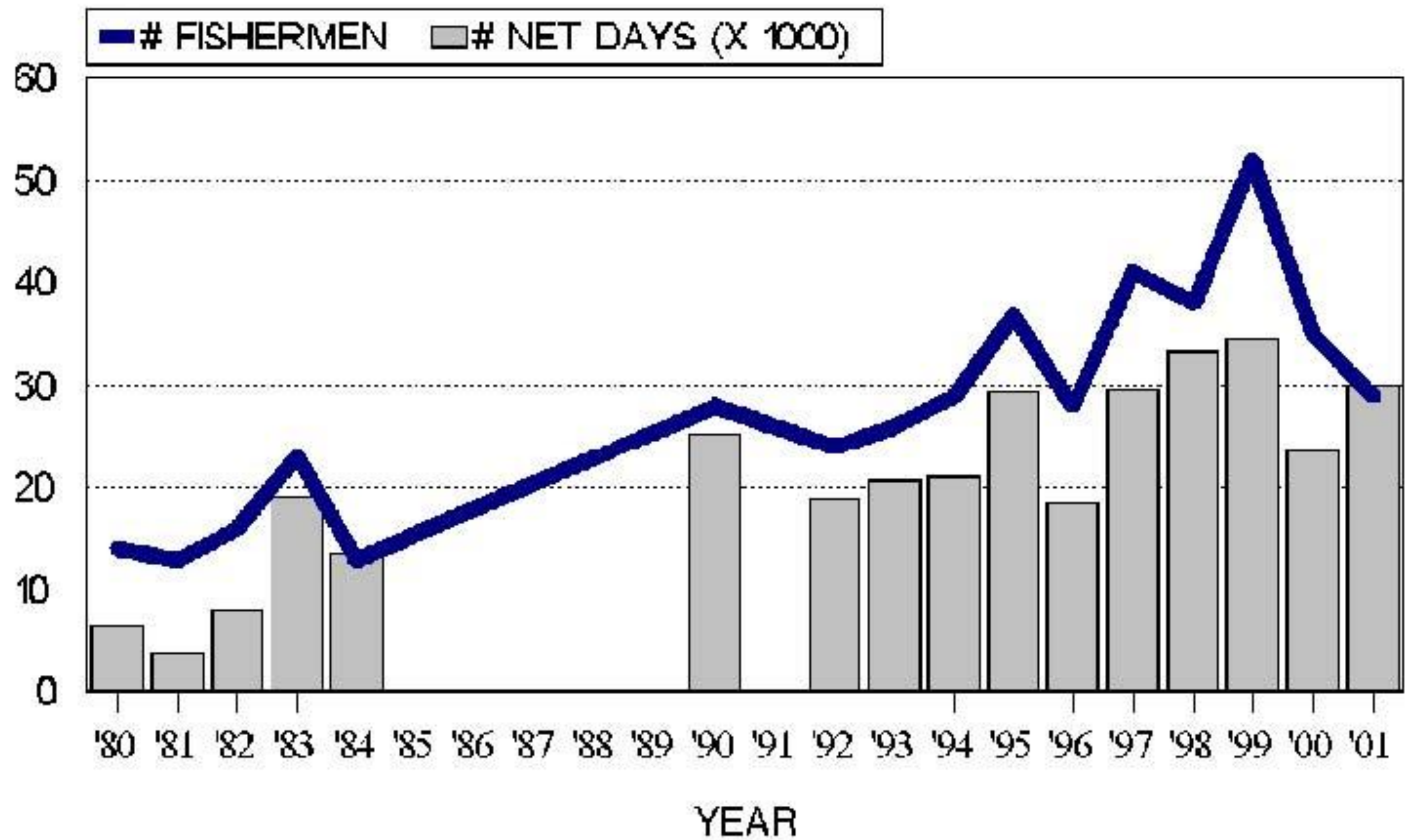
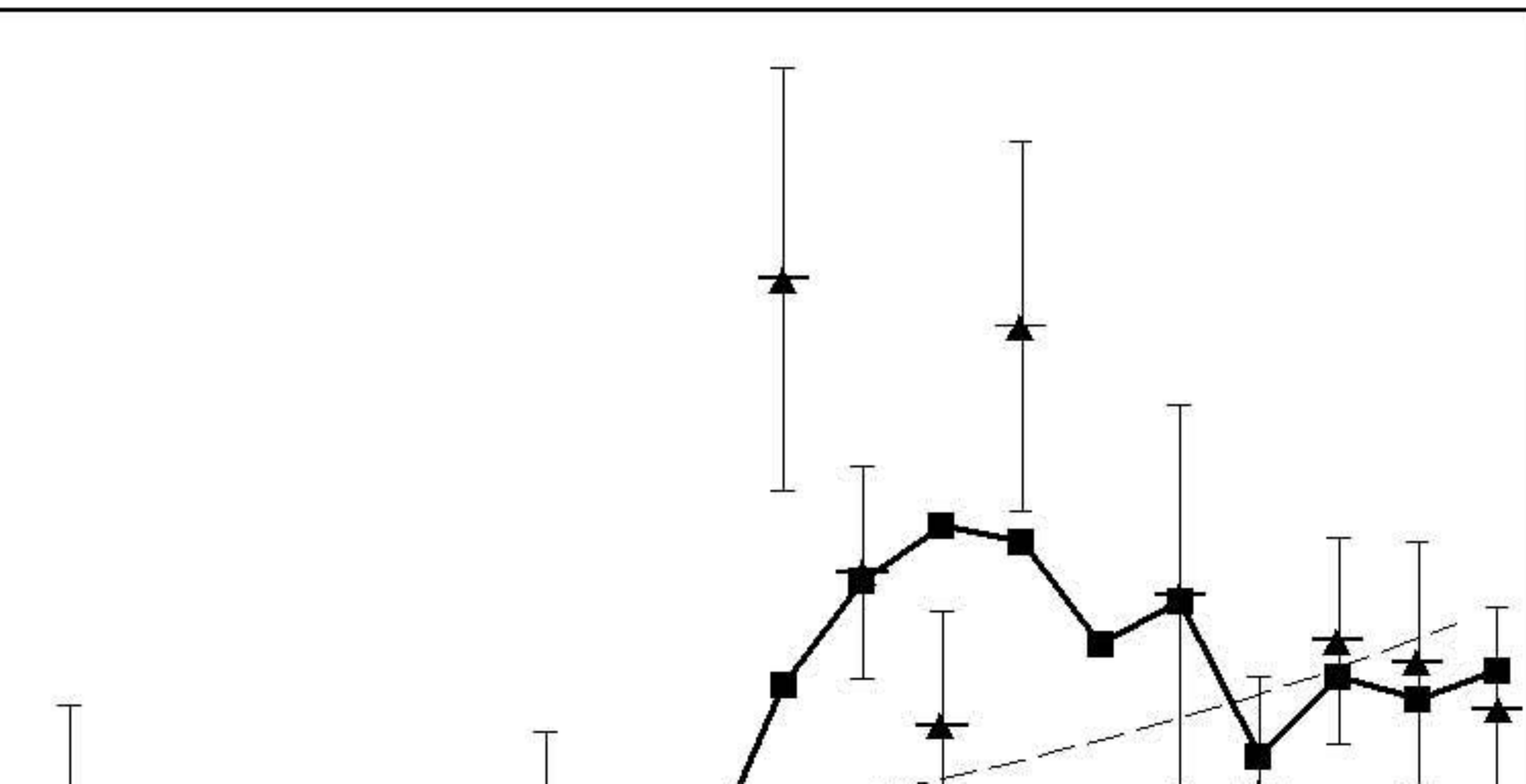


FIGURE 5: Effort levels for yellow perch commercial fyke net fishery

(January-April and December of each year)



low perch upper ChesapeakeBay indices from the Esturarine
fish Survey (EJFS) (mean LN-transformed CPUE+1) from
manent and auxilary stations with 95% CI and exponential
ash line) and data smoothed trend line (solid line) collected,



References

Auld, A.H. and Schubel. 1974. Effects of suspended sediment on fish eggs and larvae. Chesapeake Bay Inst. Spec. Rept. 40

Caddy, J. F., and R. McGarvey. 1996. Targets or limits for management of fisheries? North American Journal of Fisheries Management 16:479-487.

Casey, J.F., Minkkinen, S.P., Soldo, J.B.. 1988. Characterization of Choptank River Populations of White (*Morone americana*) and Yellow (*Perca flavescens*) Perch. Final report FY 1986. Maryland Department of Natural Resources, Tidewater Administration, Fisheries Division. 102 pp.

Eaton, W.R., Piavis, P.G., Pyle, B.H., Webb, E.J. 1990. Investigation of Yellow Perch (*Perca flavescens*) Stocks in Maryland. Maryland Department of Natural Resources, Tidewater Administration, Fisheries Division. Project Number F-46-R. 87 pp.

Eaton, W.R., P. Piavis, B. Pyle and E. Webb. 1992. Investigation of yellow perch stocks in Maryland. MD Dept. Nat. Res. Tidewater Admin.. Report F-46.

Eaton, W.R., P. Piavis, B. Pyle and E. Webb. 1993. Investigation of yellow perch stocks in Maryland. MD Dept. Nat. Res. Tidewater Admin.. Report F-46.

Eschenroder, R.L. 1977. Effects of intensified fishing, species change, and spring water temperatures on yellow perch, *Perca flavescens,* in Saginaw Bay. J. Fish. Res. Board Can. 34(10:1830-1838.

Fishing in Maryland Magazine. [ed.] B. Burton and L. Tims. Annual Publication, FIM Publishing, Inc, P.O. Box 201, Phoenix, MD

Francis, R.I.C.C., and R. Shotten. 1997. "Risk" in fisheries management: a review. Canadian Journal of Fisheries and Aquatic Sciences 54:1699-1715.

Gablehouse, D.W. 1984. A length-categorization system to assess fish stocks. N. Amer. J. Fish Management 4:273-285.

Goodyear, C. P. 1993. Spawning stock biomass per recruit in fisheries management: Foundation and current use. Pages 67-81 *in* S. J. Smith, J. J. Hunt and D. Rivard, editors. Canadian Special Publication Fisheries and Aquatic Sciences 120.

Hartman, W.L. 1972. Lake Erie: Effects of exploitation, environmental changes and new species on the fishery resources. J. Fish. Res. Board Can. 29(6): 899-912.

Hayne, D.W. 1991. The access point creel survey: procedures and comparison with the roving-clerk creel survey. Amer. Fish. Soc. Sympo. 12:123-138.

Janicki, A. 1990. Yellow Perch Spawning Streams. Technical Memorandum CBRM-AD-91-2. Maryland Department of Natural Resources, Chesapeake Bay Research and Monitoring Division. 46 pp.

Jesien, R.V., T.S. Hopkins, C.L. Counts, and R. L. Takacs. 1991. Anadromous fish Survey of Somerset County Streams, Final Report. Commissioners for Somerset County, Princess Anne, MD. 42pp.

Kelso, J.R.M., and Ward, F.J., 1977. Unexploited percid populations of West Blue Lake, Manitoba, and their interactions. J. Fish. Res. Board Can, 34(10):1936-1940.

Klauda, R.J. 1989. Definitions of critical environmental conditions for selected Chesapeake Bay finfishes exposed to acidic episodes in spawning and nursery habitats. Maryland Department of Natural Resources, CBRM AD-89-6, Annapolis, Maryland.

Klauda, R.J., D. Baudler, D. Levin, and R. Palmer. 1988. Sensitivity of yellow perch larvae and juveniles to short term acidic pulses in the laboratory. Unpublished ms.

Krieger, D. A., Nelson, P. C., and Terrell, W. 1983. Habitat Suitability Information: Yellow Perch. U.S. Fish and Wildlife Service, FWS/OBS-83/10.55. 37 pp.

Mace, P. M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Canadian Journal of Fisheries and Aquatic Sciences 51:110-122.

Mace, P.M. 1999. Current status and prognosis for marine capture fisheries. Fisheries 24:30.

Mace, P. M., and M. P. Sissenwine. 1993. How much spawning per recruit is enough? Pages 101118 *in* S. J. Smith, J. J. Hunt and D. Rivard, editors. Canadian Special Publication Fisheries and Aquatic Sciences 120

Mansueti, R.J. 1960. Comparison of the movements of stocked and resident yellow perch, *Perca flavescens*, in tributaries of Chesapeake Bay, Maryland. Chesapeake Sci. 1:21-35.

Muncy, R.J. 1959. Evaluation of the yellow perch hatchery program in Maryland. MD Dept. Res. And Educ., Resource Study Rept. 15

Muncy, R. J. 1962. Life History of the Yellow Perch, *Perca flavescens,* in Estuarine Waters of the Severn River, a Tributary of Chesapeake Bay, Maryland. Chesapeake Science Vol. 3., 143-159 pp.

Nelson, W.R., and C.H. Walburg. 1977. Population dynamics of yellow perch, (*Perca favescens*), sauger (*Stizostedion canadense*) and walleye (*S. vitreum vitreum*) in four main stems of the Missouri River reservoirs. J. Fish. Res. Board Can. 34(10): 1748-1763

O'Dell, J.C., 1987. Status of Yellow Perch (*Perca flavescens*) in Maryland. A Situation Paper on the Biology, Distribution, Stocks, and Fisheries of Yellow Perch with Suggested Study Needs and Management Actions. Maryland Department of Natural Resources, Tidewater Administration, Fisheries Division, Special Initiatives Section, 100 pp.

Piavis, P.G. 1991. Habitat Requirements for Chesapeake Bay Living Resources: Yellow Perch. Maryland Department of Natural Resources, Fisheries Division. Pp 14.1-14.15.

Piavis, P. G., and J. H. Uphoff. 1999. Status of yellow perch in Maryland's portion of Chesapeake Bay during 1998. Fisheries Technical Report Series Number 25, Maryland Department of Natural Resources, Annapolis.

Piavis, P.G., E.J. Webb III, J.H. Uphoff Jr., B.H. Pyle and W.R. Eaton. 1993. Investigation of Yellow Perch (*Perca flavescens*) Stocks in Maryland.. Maryland Department of Natural Resources, Fisheries Division. Project NumberF-46. 66 pp.

Piavis, P.G., E. Webb III, J.H. Uphoff, B. Pyle and W. Eaton. 1995. Investigation of yellow perch stocks in Maryland. Department of Natural Resources, Annapolis.

Rago, P.J. and C.P. Goodyear. 1987. Recruitment mechanisms of striped bass and Atlantic salmon: comparative liabilities of alternative life histories. American Fisheries Society Syposium 1:402-416.

Richkus, W.A. and F. Stroup. 1987. Source Document: Characterization of the biology of and fisheries for Maryland stocks of yellow perch. Maryland Dept. Nat. Res. Tidewater Admin., Annapolis. Contract No. F40-85-008. Versar, Inc. Columbia, MD

Sadzinski, R.A.. 1997. Assessment of the spring recreational finfish harvest in the Choptank River. *In* Markham, C.A., J.P. Mowrer, A.A. Jarzynski, P.G. Piavis, B.H. Pyle, R.A. Sadzinski, E.J. Webb and D.R. Weinrich. Stock assessment of selected resident and migratory recreational finfish species within Maryland's Chesapeake Bay. Federal Aid Project F-37-R. Annual Report, Department of the Interior, Fish and Wildlife Service.

Schmitten, R. A. 1999. Essential Fish Habitat: Opportunities and challenges for the next millennium. Amer. Fish. Sym. 22:3-10.

Scott, W.B., and E.J. Crossman. 1973 Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184.

966 pages

Sissenwine, M. P., and J. G. Shepherd. 1987. An alternative perspective on recruitment overfishing and biological reference points. Canadian Journal of Fisheries and Aquatic Sciences 44:913
918.

Smith, L.L., S.J. Broderius, D.M. Oseid, G.L. Kimball and W.M. Koenst. 1978. Acute toxicity of hydrogen cyanide to freshwater fishes. Arch. Environm. Contami. Toxicol. 7:325-337

Tsai, C. and Gibson. 1971 Fecundity of the yellow perch, *Perca flavescens* (Mitchell), in the Patuxent River, Maryland Chesapeake Sci. 12:270-284

Unkenholz, E., M. Brown, and K. Pope. 1997. Oxytetracycline marking efficacy for yellow perch fingerlings and temporal assays of tissue residues. The Progressive Fish-Culturist 59:280-284

Uphoff, J. H. Jr. 1991. Early Life History Dynamics and Recruitment of Yellow Perch in the Choptank River, Maryland 1980-1985. Technical Memorandum CBRM-HI-91-1.Maryland Department of Natural Resources, Chesapeake Bay Research and Monitoring Division. 36 pp.

Webb III, E., and E.R. Zlokovitz. 1999. Assessment of the 1998 recreational finfish harvests in the Choptank and Chester Rivers and summer head boat surveys. *In* J.P. Mowrer, A.A. Jarzynski, P.G. Piavis, B.H. Pyle, R.A.Sadzinski, E.R. Zlokovitz, E.J. Webb and D.R. Weinrich. Stock assessment of selected resident and migratory recreational finfish species within Maryland's Chesapeake Bay. Federal Aid Project F-37-R. Annual Report, Department of the Interior, Fish and Wildlife Service.

Williams, J.B., H.S. Speir, S.Early, and T.P. Smith. 1982. 1979 Maryland saltwater sport fishing survey. Maryland Department of Natural Resources, Tidewater Administration, Annapolis, Maryland. Report No. TA-CRD-82-1.

Williams, J.B.,T.P. Smith, H.S. Speir, and S. Early. 1983. 1980 Maryland saltwater sport fishing survey. Maryland Department of Natural Resources, Tidewater Administration, Annapolis, Maryland. Report No. TA-CRD-83-1

Zlokovitz,.E.R and E. Webb III, 2000. Assessment of spring tributary and summer headboat recreational finfish harvest in 1999. *In* J.P. Mowrer, A.A. Jarzynski, P.G. Piavis, B.H. Pyle, R.A.Sadzinski, E.R. Zlokovitz, E.J. Webb and D.R. Weinrich. Stock assessment of selected resident and migratory recreational finfish species within Maryland's Chesapeake Bay. Federal Aid Project F54-R. Annual Report, Department of the Interior, Fish and Wildlife Service.

APPENDIX 2-1.

Summary of Yellow Perch Data from Creel Surveys on the Choptank (1995-1999) and Chester (1997-1999) Rivers.For all anglers targeting all species.

Angler obs.= number of anglers observed;Angler int.= number of anglers interviewed;YP harv.= number of yellow perch caught by interviewed anglers;YP rel.= number of yellow perch released by interviewed anglers;Total catch = YP harv. +YP rel.

a presence-absence distribution data
b habitat-related density data;
c growth, reproduction, and survival
d production rates by habitat.

Area, year assessed
Head-of-Bay, 2001[1]
Western shore (Severn, 2001)
Patuxent, 1999 (10 inch)
Potomac tributaries
Chester
Wye and Miles
Choptank, 2001
Nanticoke, 2001
Lower Eastern Shore
Water Body
Upper Bay
Susquehanna Flats
Northeast River
Elk River
Bohemia River
Water Body
Sassafras River
Worton Creek
Chester River
Lower Eastern Shore
Wye River
Choptank River
Fishing Bay
Nanticoke River

Appendix 2-2

2000 Fisheries Service - Natural Resources Police Yellow Perch Fishing Survey Yellow perch spring spawning run s

***Please fill out separate form for each fishing access site which you routinely patrol.**

NRP Officers Name:_______________

Major Watershed:___________ ______County:________ _______Stream or River Name:____________Road crossing or access point:_____________

Approximate number of fishermen observed at this site in during spring of 2000:__________1. Would you characterize this site as high use______ moderate use ____or low use____.2.

Number of fishermen observed here compared to previous years:3. Average______ Above Average__

_	e	v	_	N	ye	caught	ru
_	l	e	_	u	llo	at this	n:
_	o	r	_	m	w	site	4.
_	w	a	_	be	pe	during	
		g	_	r	rc	2000	
B	A	e	_	of	h	spring	

Hi	__	Below	here
gh	Number	Average________	compared
:_	s of	Sizes of yellow	to
__	yellow	perch you	previous
_	perch	observed in	years:___
M	caught	catch at this	_7.Avera
od	at this	site:6.4 - 7.9	ge____
er	site	inches ____	Larger
at	compar	% of catch8 -	than
e:	ed to	11.9 inches	average_
__	previous	____ % of	____
__	years:5.	catch12	Smaller
_	Average	inches and	than
Lo	_____	larger _____	average_
w:	Above	% of catch	____Com
__	Average	Sizes of yellow	ments:
__	_____	perch caught	

2000 Maryland Department of Natural R

esourcesFisheries Service/ Natural Re

sources PoliceYellow Perch Spring Fis

hing Survey

a presence-absence distribution data (Refer to yell
b habitat-related density data;
c growth, reproduction, and survival rate within ha
d production rates by habitat.

[illegible]tions, please contact Erik Zlokovitz, Fisheries Biologist, Matapeake Field Office, (410)-643-6801 e-ma

Officers name:_ ______________________________

Region: _____________________

Rank Fishing as Poor, Fair,Good , or Excellent based on observations of fish being caught and opinions ofanglers at site.

Area, year assessed
Head-of-Bay, 2001[1]
Western shore (Severn, 2001)
Patuxent, 1999 (10 inch)
Potomac tributaries
Chester
Wye and Miles
Choptank, 2001
Nanticoke, 2001
Lower Eastern Shore
Water Body
Upper Bay
Susquehanna Flats
Northeast River
Elk River
Bohemia River
Water Body
Sassafras River
Worton Creek
Chester River
Lower Eastern Shore
Wye River
Choptank River
Fishing Bay
Nanticoke River
Big Annemessex River

*Any

il:mata-fish-1@dnr.state.md.us