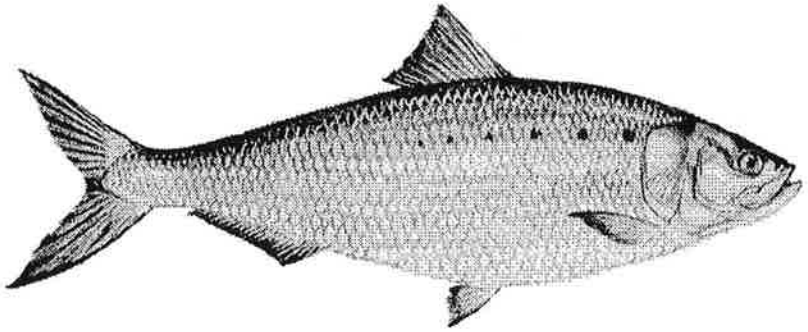
Fisheries Target Setting Task Force Report to the Living Resources Subcommittee on

PROPOSED STOCK RESTORATION TARGETS FOR CHESAPEAKE BAY AMERICAN SHAD

DRAFT



April 1995

Chesapeake Bay Program

DRAFT

PROPOSED STOCK RESTORATION TARGETS FOR CHESAPEAKE BAY AMERICAN SHAD

Prepared by

Fisheries Target Setting Task Force

Prepared for

Living Resources Subcommittee
Chesapeake Bay Program

April 1995

FOREWORD

The 1991 Action Agenda for the multi-jurisdictional Chesapeake Bay Program charged the Living Resources Subcommittee (LRSC) to "establish measurable living resources and habitat restoration targets", including fish stocks of commercial and recreational importance. A 1993 report to the LRSC by the Fisheries Management Plan Re-Assessment Task Force recommended that criteria or "triggers" based on biological attributes such as stock abundance, spawning stock biomass, and age structure be developed to guide management initiatives and regulatory decisions. Substantial progress is being made in establishing targets for non-exploited living resources such as submerged aquatic vegetation and benthic invertebrate communities. By comparison, target development for selected fish species has just begun.

This document develops and discusses the advantages and disadvantages of several quantitative and measurable stock restoration targets for American shad (Alosa sapidissima), a fish species that historically supported substantial recreational and commercial fisheries in the Chesapeake Bay and its major tributaries. American shad stocks are currently so depressed that harvest moratoria exist throughout the Maryland (since 1980) and Virginia (since 1994) portions of the Bay (Butowski et al. 1994) and within the Susquehanna River basin in Pennsylvania.

The stock restoration targets that are proposed and described in this document were developed by the LRSC's Fisheries Target Setting Task Force, chaired by Ron Klauda (Director of the Chesapeake Bay Research and Monitoring Division, Maryland Department of Natural Resources), based on technical input from Bill Richkus, Randall Hochberg and Jon Volstad of Versar, Inc. and suggestions from several individuals acknowledged below. Other Task Force members who contributed to this document are:

Herb Austin (Virginia Institute of Marine Sciences)
Chris Bonzek (Virginia Institute of Marine Sciences)
Nancy Butowski (Maryland Department of Natural Resources)
Bill Goldsborough (Chesapeake Bay Foundation)
Ed Houde (University of Maryland, Chesapeake Biological Laboratory)
Phil Jones (Maryland Department of Natural Resources)
Anne Lange (NOAA Chesapeake Bay Office)
Rob O'Reilly (Virginia Marine Resources Commission)
Ann Swanson (Chesapeake Bay Commission)
Jim Uphoff (Maryland Department of Natural Resources)

The Task Force acknowledges the support and encouragement of Verna Harrison, Chair of the Living Resources Subcommittee, without whose urgings this document would likely have not been prepared. The Task Force also acknowledges the valuable input of Rick Hoopes

(Pennsylvania Fish and Boat Commission), Tom Gunter (Virginia Department of Game and Inland Fisheries), Dave Dowling (Virginia Department of Game and Inland Fisheries), Dale Weinrich (Maryland Department of Natural Resources), Joe Loesch (Virginia Institute of Marine Sciences), Dick St. Pierre (U.S. Fish and Wildlife Service) and Gene Cronin (Coastal Consultant) to the development of these shad restoration targets.

The Fisheries Target Setting Task Force is working to develop stock restoration and protection targets for several Chesapeake Bay fish species. American shad is the first species the Task Force decided to address. Striped bass (Morone saxatilis) and blue crab (Callinectes sapidus) will be addressed next.

The stock restoration targets for American shad proposed by the Task Force are described in the Executive Summary section that follows this Foreword. For background information, detailed descriptions of data sources and target calculations, and a discussion of the advantages and disadvantages of several targeting approaches, the reader is referred to the Technical Memorandum prepared by Richkus et al. and titled **Evaluation of Potential Chesapeake Bay American Shad Stock Restoration Targets** that follows the Executive Summary. Funding for preparation of this Technical Memorandum was provided by the Maryland Power Plant Research Program.

EXECUTIVE SUMMARY

The establishment of stock restoration targets for Chesapeake Bay American shad and implementation of monitoring efforts aimed at tracking progress toward achievement of these targets provide a basis for evaluating the success of fishery management plans, water quality improvement efforts and habitat restoration/enhancement programs on this key anadromous fish species. Development of comparable targets for other important living resource species will collectively yield a valuable "yardstick" for measuring overall progress in the restoration of Chesapeake Bay and its living resources. The Fisheries Target Setting Task Force recommends that the tributary-specific stock restoration targets for American shad proposed below be considered for incorporation into Bay Program-related fisheries management plans for this species, and also used to stimulate stock assessment activities with American shad by the Chesapeake Bay Stock Assessment Committee (CBSAC).

Estimates of adult shad abundance during recent time periods when commercial landings records suggest that Bay stocks were relatively "healthy" (at least compared to the currently depressed status of all Bay shad stocks) were calculated to establish restoration targets in each of eight major spawning/nursery areas: Upper Bay/Susquehanna River, Patuxent River, Potomac River, Choptank River, Nanticoke River, Rappahannock River, York River and James River. These time periods were influenced by data availability and occurred from 1955 to 1970 in Maryland and from 1977 to 1985 in Virginia.

The selection of tiered targets is described in the Technical Memorandum that follows this Executive Summary. For the purpose of this target setting exercise, we defined the adult abundance estimates calculated for the time periods described above as Tier 2 targets, representative of "mostly restored" stocks that could probably sustain moderate levels of exploitation. The Task Force recommends that the appropriate level of exploitation, if any, on a given shad stock be determined later and included as an action item when the 1989 Chesapeake Bay Alosid Management Plan is reviewed and presumably updated, with input from CBSAC and others, and appropriate stock assessments are completed. Tier 1 targets, also proposed below, are defined as 50% of the Tier 2 targets and should be representative of "partially restored" stocks that may be able to sustain low levels of exploitation (also to be determined later). The Task Force decided not to propose Tier 3 or "fully restored" stock abundance targets at this time. In our view, the current understanding of American shad stock dynamics in Chesapeake Bay is not sufficient to quantitatively determine what adult abundance represents a fully restored stock status in each of the eight spawning/nursery areas.

The Task Force recommends that if these proposed stock restoration targets are adopted by the Bay Program, then CBSAC, LRSC and the state management agency participants in the Bay Program should act to ensure that one or more fishery-independent monitoring programs are conducted by the appropriate fisheries management agency responsible for each tributary to track progress toward the proposed targets. The Technical Memorandum attached to this Executive Summary describes how the annual seine surveys being conducted in several Maryland and Virginia rivers to measure juvenile striped bass abundance could be used to track the occurrence of juvenile American shad. These seine data could also be used to determine when a particular shad stock has increased sufficiently to justify the addition of a pound net survey or a tag and recapture study in that tributary aimed at a measure of adult abundance.

Tracking progress toward the adopted targets should be viewed by the Bay Program as an essential element in this and any other target setting activity, but one that will require a long-term commitment to a focused monitoring plan. An example of a stock status tracking scheme that will require the continued support of a relatively expensive, annual tag and recapture study to monitor adult abundance, but an approach that yields findings that are easily communicated to the public, is shown in the enclosed graph for the Upper Bay/Susquehanna River shad stock that is being monitored by Maryland's Department of Natural Resources (MDNR). Once the shad stocks recover to abundance levels that allow some amount of fishing pressure, we will be better able to monitor the stocks based on both fishery-dependent and independent statistics.

The stock restoration targets proposed by the Task Force and related ancillary information for American shad in each of the eight major spawning/nursery areas are presented below and summarized in the enclosed table.

Upper Bay/Susquehanna River

Current Stock Status

In two independent exercises, Richkus et al. (1990) and Klauda et al. (1991) presented qualitative assessments of American shad spawning stock status in each of the major rivers in Chesapeake Bay. They reported that the Upper Bay/Susquehanna River stock is at a very low level of abundance, but appeared to increase about 28 fold between 1980 and 1989. This is the only Bay shad stock that is being monitored annually with an intensive tag and recapture study conducted by MDNR. By 1994, the population size had increased to an estimated 129,500 adults (personal communication with Dale Weinrich, MDNR). Rulifson (1994) also reported that the American shad stock in the Susquehanna River in 1992 was increasing but still should be viewed as threatened.

Tier 1 Target

The proposed Tier 1 (partially restored) target is 1,615,000 adults. This stock size represents 50% of the Upper Bay population estimate in Table 10 (see attached Technical Memorandum), plus 50% of the 2 million adult shad goal established by the Susquehanna River anadromous fish restoration program (personal communication with Dick St. Pierre, USFWS) in an agreement that was signed in June 1993 by the governors of Pennsylvania and Maryland, several utilities and other fisheries agencies (Butowski et al. 1994). The 1994 adult abundance estimate of 129,500 adults represents 8% of the proposed Tier 1 target.

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 3,230,000 adults and represents 100% of the Upper Bay population estimate in Table 10, plus 100% of the 2 million adult shad target established by the Susquehanna River anadromous fish restoration program. The 1994 adult abundance estimate represents 4% of the proposed Tier 2 target.

Current Stock Status Monitoring Efforts

MDNR has conducted an annual monitoring program in the Upper Bay and lower Susquehanna River (below Conowingo Dam) since 1980 to estimate the size of the adult shad population (via a tag and recapture study) and also characterize key biological characteristics of the stock (Markham and Weinrich 1994). Gill nets, pound nets, hook and line, and the two fish lifts in operation at the Conowingo Dam are used to collect adult shad from mid-March through mid-June. All shad collected at the fish lifts are counted as part of the Susquehanna River anadromous fish restoration program. MDNR samples several shore sites in the Upper Bay with seines during July, August and September each year, and also monitors juvenile shad abundance with electrofishing surveys.

Patuxent River

Current Stock Status

The American shad population in the Patuxent River is currently only a remnant stock at a very low level of abundance that may still be declining (Richkus et al. 1990; Klauda et al. 1991). In 1993, MDNR and Potomac Electric Power Company initiated a pilot study aimed at stocking the Patuxent River with hatchery-reared American shad larvae and juveniles (personal communication with Ben Florence, MDNR). The stocking program continued in 1994 and 104,400 fall juveniles were stocked into the river.

Tier 1 Target

The proposed Tier 1 (partially restored) target is 7,500 adults.

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 15,000 adults.

Current Stock Status Monitoring Efforts

The adult shad population in the Patuxent River is not being monitored. MDNR samples several shore sites with seines during July, August and September each year, and also monitors juvenile alosid abundance with a mid-water trawl.

Potomac River

Current Stock Status

The American shad population in the Potomac River is currently at a low level of abundance according to Richkus et al. (1990) and Klauda et al. (1991). Rulifson (1994) reported that the population status in 1992 was not accurately known but appeared to be declining.

Tier 1 Target

The proposed Tier 1 (partially restored) target is 310,000 adults.

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 621,000 adults.

Current Stock Status Monitoring Efforts

The adult shad population in the Potomac River is not being monitored. MDNR samples several shore sites with seines during July, August and September of each year.

Choptank River

Current Stock Status

Richkus et al. (1990) and Klauda et al. (1991) reported that only a remnant shad population exists in the Choptank River that is at a very low level of abundance. Rulifson (1994) concluded that the shad population in 1992 was declining and threatened.

Tier 1 Target

The proposed Tier 1 (partially restored) target is 69,500 adults.

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 139,000 adults.

Current Stock Status Monitoring Efforts

The adult shad population in the Choptank River is not being monitored. MDNR samples several shore sites with seines during July, August and September of each year, and also monitors juvenile alosid abundance with a mid-water trawl.

Nanticoke River

Current Stock Status

The current shad population in the Nanticoke River is at a low level of abundance, but appears to be stable according to Richkus et al. (1990) and Klauda et al. (1991). Rulifson (1994) also reported that the population was stable in 1992 but threatened. The Nanticoke River is the only shad spawning/nursery area included in this targeting exercise that is not entirely closed to shad fishing. A small commercial fishery still exists in the Delaware portion of the river near Woodland Ferry. Annual reported landings between 1976 and 1991 averaged 1984 pounds (Krantz et al. 1992). Peak landings during this period occurred in 1981 (3800 pounds).

Tier 1 Target

The proposed Tier 1 (partially restored) target is 148,000 adults.

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 296,000 adults.

Current Stock Status Monitoring Efforts

A fishery-independent monitoring program focused on adults is being conducted by MDNR, but does not include adult abundance estimates. Stock characterization data could also be gleaned by sampling that portion of the Nanticoke River shad stock that is being exploited by the small commercial fishery operating in the upper river in Delaware. MDNR samples several shore sites in the Nanticoke River with seines during July, August and September of

each year, and also monitors juvenile alosid abundance with a mid-water trawl.

Rappahannock River

Current Stock Status

The current shad population in the Rappahannock River is at a very low level of abundance and appears to be declining (Richkus et al. 1990; Klauda et al. 1991; Rulifson 1994).

Tier 1 Target

The proposed Tier 1 (partially restored) target is 91,500 adults.

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 183,000 adults.

Current Stock Status Monitoring Efforts

The adult shad population in the Rappahannock River is monitored by VMRC and VIMS, but adult abundance estimates are not calculated. VIMS also samples several shore sites in the Rappahannock River with seines and push nets during the summer months each year that yield information on juvenile alosid abundance.

York River

Current Stock Status

The current shad population in the York River is at a low level of abundance but appears to be stable according to Richkus et al. (1991) and Klauda et al. (1990). Rulifson (1994) reported that the population was declining in 1992.

Tier 1 Target

The proposed Tier 1 (partially restored) target is 500,000 adults.

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 1,000,000 adults.

Current Stock Status Monitoring Efforts

The adult shad population is being monitored by VMRC and VIMS,

but the surveys do not provide adult abundance estimates. VIMS also samples several shore sites in the York River with seines and push nets during the summer months each year that yield information on juvenile alosid abundance.

James River

Current Stock Status

The current shad population in the James River is at a low level of abundance and appears to be declining (Richkus et al. 1990; Klauda et al. 1991; Rulifson 1994).

Tier 1 Target

The proposed Tier 1 (partially restored) target is 570,000 adults. This stock size represents 50% of the James River population estimate in Table 10 (for that portion of the river downstream from Richmond, see attached Technical Memorandum), plus 50% of the 568,200 adult shad goal established by the Virginia Department of Game and Inland Fisheries for the portion of the river between Richmond and Lynchburg when all blockages to upstream migration have been removed (personal communication with Price Smith, VDGIF).

Tier 2 Target

The proposed Tier 2 (mostly restored) target is 1,160,000 adults and represents 100% of the James River population downstream from Richmond (Table 10), plus 100% of the 568,200 adult shad goal established by VDGIF for the river between Richmond and Lynchburg.

Current Stock Status Monitoring Efforts

The adult shad population is being monitored by VMRC and VIMS, but the surveys do not provide adult abundance estimates. VIMS also samples several shore sites in the James River with seines during the summer months each year. Recently, a stocking effort was begun by the Virginia Department of Game and Inland Fisheries as part of a fish passage plan to restore anadromous alosids (including American shad) to historical spawning areas.

Conclusions

Achieving any of these proposed adult shad abundance targets will require diligent enforcement of the current moratoria on harvests in Bay waters, evaluation of more stringent harvest controls on the coastal intercept fisheries (probably critical to successful restoration of Bay shad stocks), commitment to a long-term monitoring program and considerable patience. ASMFC is in the process of rewriting the Shad and Herring FMP, and assessments of

the status of the Chesapeake Bay shad stocks will be a part of this activity.

Tier 1 target achievement should logically lead to an assessment of the target's relevance given the condition of the shad stocks at that time. Tier 1 target achievement could also trigger the appropriate management actions that would allow the fishing moratorium to be lifted on a given stock and some conservative level of harvest to begin. Tier 2 target achievement could lead to even greater harvest opportunities if a rigorous stock assessment supports such actions.

Recommendations for specific management actions are beyond the scope of the Fisheries Target Setting Task Force. Rather, we suggest that if these stock restoration targets are adopted, they should be added to the next version of the Fisheries Management Plan for Alosids in Chesapeake Bay. The appropriate resource management agencies should then decide, with input from CBSAC and ASMFC, what annual exploitation rates, if any, each stock can handle when the Tier 1 and Tier 2 restoration targets are reached. As additional stock assessment data are compiled during the next decade, Tier 3 or "fully restored" stock targets for Chesapeake Bay American shad should also be developed and adopted.

References

Butowski, N., B. Sauls, M. Whilden and E. Smoller. 1994. Annual progress report, fishery management plans 1993. Maryland Department of Natural Resources and Virginia Marine Resources Commission. Prepared for the Chesapeake Bay Program, Annapolis, MD.

Klauda, R.J., S.A. Fischer, L.W. Hall Jr. and J.A. Sullivan. 1991. American shad and hickory shad Alosa sapidissima and Alosa mediocris, pp. 9-1 to 9-27. In: S.L. Funderburk, J.A. Mihursky, S.J. Jordan and D. Riley (editors). Habitat Requirements for Chesapeake Bay Living Resources, second edition. Chesapeake Bay Program, Annapolis, MD.

Krantz, C.A., J.P. Mowrer, A.A. Jarzynski, R.V. Jesien, C.H. Hocutt and D.R. Weinrich. 1992. Investigation of anadromous alosids in Chesapeake Bay. Maryland Department of Natural Resources, Annapolis.

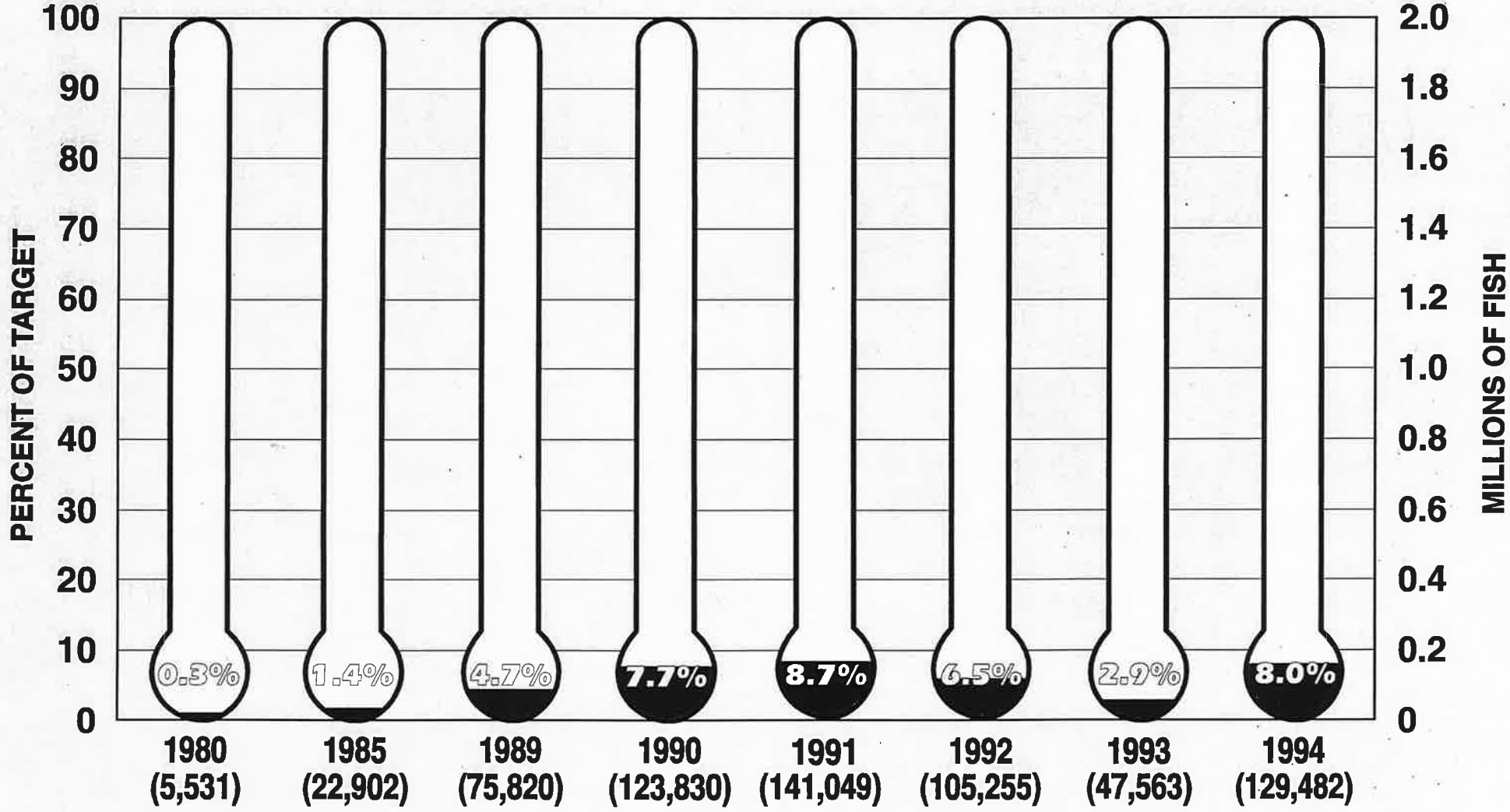
Markham, C.A. and D.R. Weinrich. 1994. Maryland's upper Chesapeake Bay American shad survey: an overview, pp. 97-107. In: J.E. Cooper, R.T. Eades, R.J. Klauda, and J.G. Loesch (editors). Anadromous Alosa Symposium. Tidewater Chapter, American Fisheries Society, Bethesda, MD.

Richkus, W.P., P. Jacobson, A. Ranasinghe, A. Shaughnessy, J. Chaillou, P. Kazyak, C. DeLisle, R. Batiuk and D. Packer. 1990 (draft). Characterization of the current status of key resource species in the basins of Chesapeake Bay. Versar, Inc. Prepared for the USEPA Chesapeake Bay Program, Annapolis, MD.

Rulifson, R.A. 1994. Status of anadromous *Alosa* along the east coast of North American, pp. 134-158. In: J.E. Cooper, R.T. Eades, R.J. Klauda, and J.G. Loesch (editor). Anadromous Alosa Symposium. Tidewater Chapter, American Fisheries Society, Bethesda, MD.

U.S. Environmental Protection Agency. 1993. Fisheries management plan re-assessment task force report. Report to the Living Resources Subcommittee.

AMERICAN SHAD STOCK - UPPER BAY/SUSQUEHANNA RIVER
PROGRESS TOWARD PROPOSED TIER 1 RESTORATION TARGET OF 1,615,000 ADULTS



Proposed Stock Restoration
Targets (Numbers of Adults) for Chesapeake Bay
American Shad

Spawning/Nursery Area	Tier 1 Target	Tier 2 Target
Upper Bay/Susquehanna River	1,615,000	3,230,000
Patuxent River	7,500	15,000
Potomac River	310,000	621,000
Choptank River	69,500	139,000
Nanticoke River	148,000	296,000
Rappahannock River	91,500	183,000
York River	500,000	1,000,000
James River	570,000	1,160,000

Technical Memorandum

EVALUATION OF POTENTIAL CHESAPEAKE BAY AMERICAN SHAD STOCK RESTORATION TARGETS

Prepared by:

William A. Richkus, Randall J. Hochberg, and Jon H. Volstad
Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045

Prepared for:

Ronald J. Klauda
Chesapeake Bay Research and Monitoring Division
Maryland Department of Natural Resources
Tawes State Office Building
Annapolis, MD 21401

April 1995

TABLE OF CONTENTS

INTRODUCTION

The 1991 Action Agenda for the Chesapeake Bay Program requires the Living Resources Subcommittee (LRSC) to "establish measurable living resources and habitat restoration targets," including those for exploited resources. Although substantial progress has been made in establishing targets for unexploited living resources, such as submerged aquatic vegetation (SAV) and benthic communities, comparable progress has not been made with regard to exploited species. This memorandum presents a summary of Versar's preliminary efforts, in support of the Chesapeake Bay Research and Monitoring Division (CBRM) of the Maryland Department of Natural Resources (MDNR), to develop measurable stock restoration targets for American shad, a species that historically supported substantial recreational and commercial fisheries in the Bay and now exhibits depressed abundance levels. Dr. Ronald J. Klauda is Director of CBRM and Chairman of the LRSC's Fisheries Target Setting Task Force. This group is working to establish stock restoration and protection targets for several Chesapeake Bay fish species. American shad is the first species the Task Force decided to address.

SOURCES OF DATA AND INFORMATION

The initial step in this effort was to review all available data and information that could contribute to assessing the historical status of shad stocks in all major bay tributaries. Versar identified these sources during preparation of a document characterizing the status of living resources in each of the major bay segments for the Chesapeake Bay Program (Richkus et al. 1990). The data sources employed included:

- Annual commercial landings data - This database collected by the National Marine Fisheries Service (NMFS) provides landings data for the Chesapeake Bay and its major tributaries dating back to the early 1900s.

- Maryland Estuarine Juvenile Fish Survey - MDNR has conducted a juvenile fish seine survey, targeting striped bass, since 1954. Stations were located mainly in the Potomac, Nanticoke, and Choptank Rivers, in addition to several locations in the Upper Bay. Because all species were identified and enumerated, this data set provides long-term abundance information for a number of key species, including American shad.

- Virginia Institute of Marine Sciences (VIMS) Juvenile Fish Survey - This database contains seine and trawl data collected since the early 1960s; the survey targets

striped bass and, as in the case of Maryland's survey, identifies and enumerates all species. Stations were located primarily in the James, York, and Rappahannock Rivers.

- Publications and Reports - additional landings data for American shad in Virginia rivers were obtained from annual alosid reports prepared by VIMS (e.g., Blumberg et al. 1991). Several other reports and publications were used to identify and estimate shad spawning habitat (e.g., Cronin 1971; Lippson 1973; Lippson et al. 1979).

- Consultations - Biologists from MDNR and VIMS who have been involved with shad research were contacted for information concerning juvenile fish survey data, shad spawning habitat, and adult population estimates (e.g., Herb Austin, Doug Dixon - VIMS; Harry Hornick, Dale Weinrich, Don Cosden, Jim Mowrer, Jim Uphoff - MDNR).

REVIEW OF FISHERY MANAGEMENT PLANS

To ensure that this target setting effort benefitted from state, interstate, and federal management planning efforts, we reviewed several fishery management plans (FMPs) to describe the targets or biological reference points delineated in those plans. The examined FMPs included those developed by Atlantic States Marine Fisheries Commission (ASMFC), Mid-Atlantic Fisheries Management Council (MAFMC), and MDNR. In some of the FMPs (e.g., striped bass, weakfish), fishing mortality rates were used as quantitative targets or biological reference points. We view these kinds of metrics as representing means for achieving the ultimate stock restoration targets, rather than population targets themselves. For example, a severely depressed stock can experience a relatively low fishing rate of F = 0.2 while still being well below the population level considered desirable or indicative of a restored status. Many of the FMPs contained qualitative goals, such as "to improve yield from the fishery" or "to prevent overfishing and maintain the spawning stock," which are of limited value for this project. The only quantitative restoration target was identified in the American Shad portion of the Alosid Management Plan prepared for the Chesapeake Bay Program in 1989, where a target of 500,000 adult shad, based on historic commercial landings, was set for the Upper Bay stock.

Appendix A summarizes the targets in those FMPs. Of those reviewed, only the adult population estimate for Upper Bay shad in Maryland, developed using commercial harvest and various assumptions concerning exploitation rates, sex ratios, and mean weights appeared to be a viable candidate for use on other portions of the Bay and potentially with other species.

SELECTION OF METHODS FOR DEVELOPING TARGETS

Several factors must be considered in developing status indicators or restoration targets for fish stocks:

- Ultimate Goal – In the cases of SAV and benthos, questions were raised about whether the goal was to restore "pristine" communities or simply to re-established the status of some past time that is deemed to represent an acceptable ecosystem. In the case of American shad, substantial and consistent commercial and recreational harvests were being taken from most spawning/nursery areas during the 1960s, and adult shad abundances for that time period might represent reasonable targets for restoration.[1] Although American shad populations in Chesapeake Bay during the 1960s were almost certainly much less abundant than historical peaks achieved during the 1800s (or earlier), they were clearly much more abundant 30 to 40 years ago than they are today.

- Data Availability – Although many specific theoretical targets might be envisioned for measuring stock status and monitoring progress toward achieving the selected restoration targets, the ability to develop targets depends on the availability of historical data and information. Ideally one would want to know the size of the spawning population of American shad in each major tributary each year for an extended period of time, particularly when the stocks were perceived to be at relatively "healthy" levels. Yet, absolute population estimates are available only for the Upper Bay and only over about the last decade. Also, because of interannual variability in spawning success, several years of data are essential during any particular period of years to ensure that natural variability can accounted for in some way in establishing a target.

- Representativeness of the Measured Parameter – Given that the Chesapeake Bay Program's objective is to restore the living resources of the Bay, the simplest population status index that could be used to track progress in this effort would be the abundance of the species of interest. As noted above, virtually no population estimates exist

[1] Goals established on this basis would be appropriate only for waters that supported shad stocks in recent decades. Such goals would not include increases in shad abundance that may result from providing passage into bay tributary waters, which, until recently, have not been accessible to upstream migrant adults (e.g., Susquehanna River). Restoration goals for such waters generally have been established based on the projected production capacity of the waters to which access has been provided.

absence of absolute abundance data, alternatives might include population parameters (e.g., growth rates, condition factor, mortality rates, fecundity) or indices of relative abundance (CPUE of adults and juveniles, or densities of eggs and larvae). Population parameters such as fishing mortality rates have been established as "biological reference points" in many management programs, as discussed above; however, in most cases, the quantitative relationship between such parameters and population size either does not exist (e.g., fishing mortality rate) is variable, (e.g., growth rates may be low when populations are high due to food limitation, but may also be low when populations low if food supplied are limited) or is unknown. Given these limitations, various indices of abundance would appear to offer the greatest potential for establishing some kind of stock restoration target for exploited fish species like American shad.

- Feasibility of Measuring Progress Toward the Target - A very precise index that would permit managers to reliably track changes in status of a focal fish species would not be useful if the cost of acquiring the data necessary for precise estimation of the index is prohibitive. Population estimation is an example of a desirable but costly index. Tag and recapture programs of the intensity necessary to develop precise population estimates for American shad or other fish species would have to be conducted on a regular basis for each stock being tracked. The cost of such efforts would be high. Indices that could be developed either from existing data collection programs or from programs requiring only limited field data collection would be less costly and presumably more feasible candidates for tracking progress toward a restoration target for any fish species.

Considering these four factors, we identified three potential means of developing American shad restoration targets: adult abundance estimates developed from commercial landings data; occurrence of juveniles in juvenile striped bass seine surveys; and probability of occurrence of eggs in ichthyoplankton surveys. Each of these potential abundance metrics is discussed in detail below. In addition, we briefly discuss the merits of monitoring shad stock status using pound nets as a sampling gear, a methodology that has been proposed by several Chesapeake Bay fisheries scientists as being potentially desirable for this purpose. We also present a method for combining pound net monitoring with tag and recapture studies.

Adult Abundance Estimates

The rationale for this approach is that the amount of commercial harvest in any given year is often related to the abundance of the fish population being exploited at that time. Based on such a premise, this approach involved defining average harvest levels over a time period during which complete records of commercial landings data were available for most of the Bay tributaries supporting shad, and then estimating adult abundance based on assumptions regarding exploitation rate and catch composition. The main appeal of this approach relates to data availability: an estimate can be developed using the large historical fisheries data base available from commercial landings records. The quantitative reliability of commercial landings data, however, is certainly questionable, as are the underlying assumptions that effort, exploitation rate, and catch composition remained constant over the period selected for estimation.

Some of the major factors that might affect the extent to which the magnitude of commercial landings is related to stock abundance are:

- harvest is a function of population size, fishing effort (related, in turn, to market value of the catch), and catch efficiency of that effort; for Chesapeake Bay, we have no reliable estimates of effort[2] or catch efficiency and no indication of how these variables may have changed over time, and

- traditionally, commercial fishermen have underreported their harvests; the degree of under-reporting and whether its magnitude has changed over time are not known.

Despite these limitations, commercial harvest records represent the sole long-term source of quantitative data that may be related to the abundance of the adult shad spawning stock in the past. As such, these data, when manipulated based on various assumptions, as described below, provide the only basis for estimating adult abundance in past decades that could serve as candidates for stock restoration targets. Estimating current adult shad abundance annually using this same approach as a means of tracking whether the restoration target has been attained clearly is not possible because American shad fisheries are closed in Chesapeake Bay waters of both Maryland (in 1980) and Virginia (in 1994). If restoration targets for American shad developed using

[2]Although numerous records of "effort" exist in various publications, these records document the amount of gear licensed in any year, not the amount of gear fished or the time period over which it was fished. The effort data, therefore, generally has been considered to be unusable for stock assessments.

commercial landings data are adopted by the Bay Program, other methods of estimating adult abundance, such as tag and recapture techniques, could be used to track progress until the fisheries were re-opened. If the shad fisheries in the Bay are re-opened, improved monitoring of effort, catch composition, and catch efficiency could allow for tracking spawning stock abundance using fishery-dependent data.

The approach we applied to develop restoration targets from commercial landings data is a two-step process first developed for the Upper Bay/Susquehanna River American shad stock by MDNR (1986), as described in the Draft Management Plan for American and Hickory Shad Stocks. First, for Maryland waters, we averaged water body-specific landings data for American shad for the period 1955 to 1970 to provide a mean annual harvest level. We selected that time "window" because substantial shad harvests were reported for all Maryland tributaries and because it was sufficiently recent that stock levels at that time might still be attainable. We wanted to use a substantial span of years to deemphasize the effects of variation in annual effort, catch efficiency, and underreporting in the average of annual landings. Landings records for Maryland tributaries and the time period selected for target development are indicated in Figures 1 through 5 (data are presented in Tables 1 through 5[3]). Landings data from Virginia rivers were not available for the same time period as Maryland data. For Virginia waters, we used commercial landings data from annual alosid stock assessment reports produced by VIMS for the period 1977 to 1985 (Figures 6 through 8 and Tables 6 through 8). We used 1985 as a cut-off year because landings declined precipitously after that year in most of the Virginia tributaries.

The second step was to estimate the abundance of the adult shad population in specific water bodies during the selected time periods. The steps in the estimation process and the basis for applying them to Maryland landings data are as follows:

- Generally adult shad average about 4.0 lbs each (ASMFC 1985); therefore, we divided the commercial landings (lbs) for each year during the selected time period by 4.0 to estimate the number of shad harvested.

[3]These tributary-specific landings data were compiled by aggregating harvest reported by gear for each of the reporting zones within each tributary for the years specified; numerous discrepancies in these landings data sets exist, and complete data sets were not available for all years (e.g., harvest for certain gears were not in the data sets for some years). The source of the data was Richkus et al. 1990.

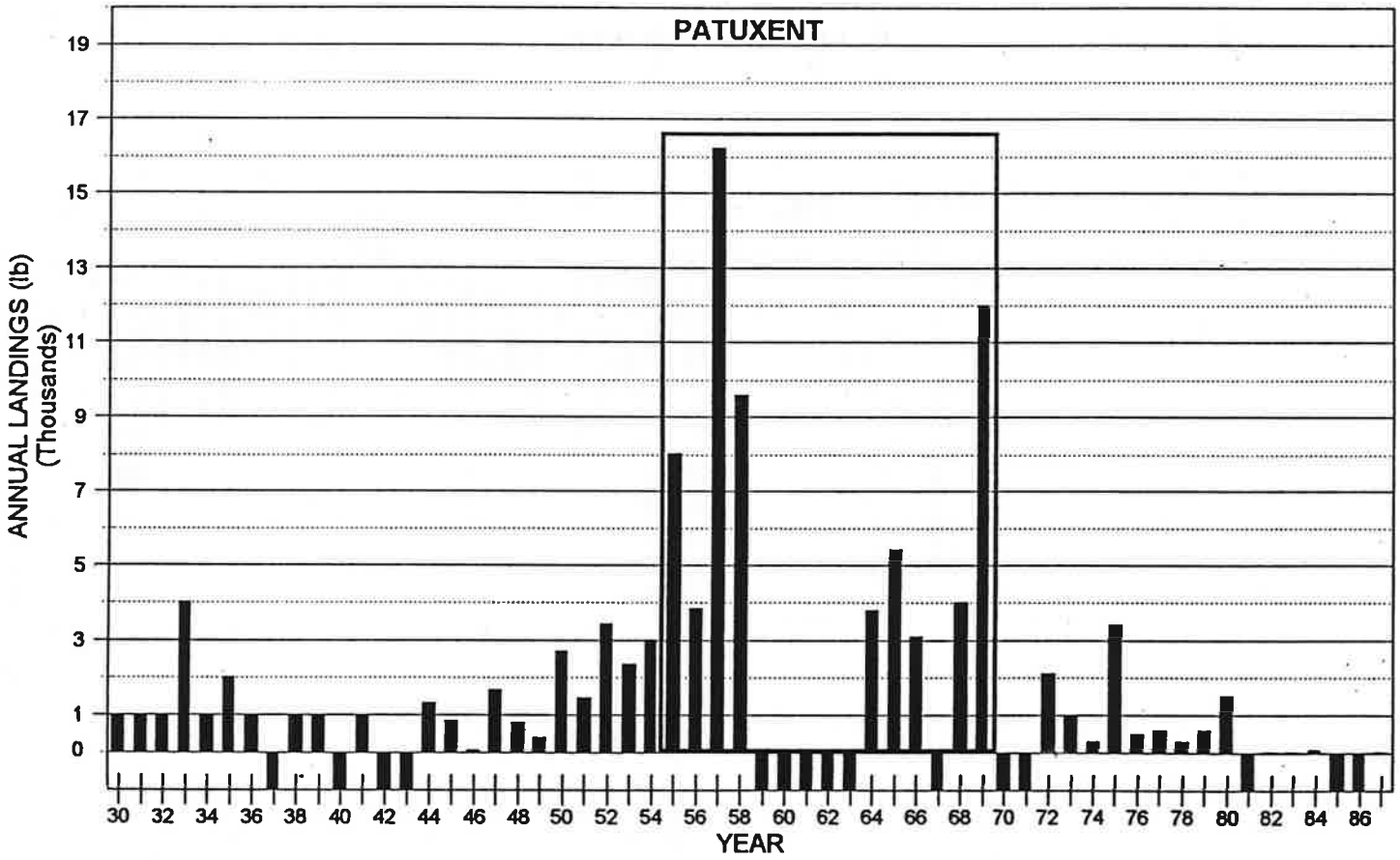


Figure 1. Commercial landing of American shad for the Patuxent River. Solid box = years selected for population estimate. Bars extending below zero represent missing or incomplete data which are not utilized in calculations.

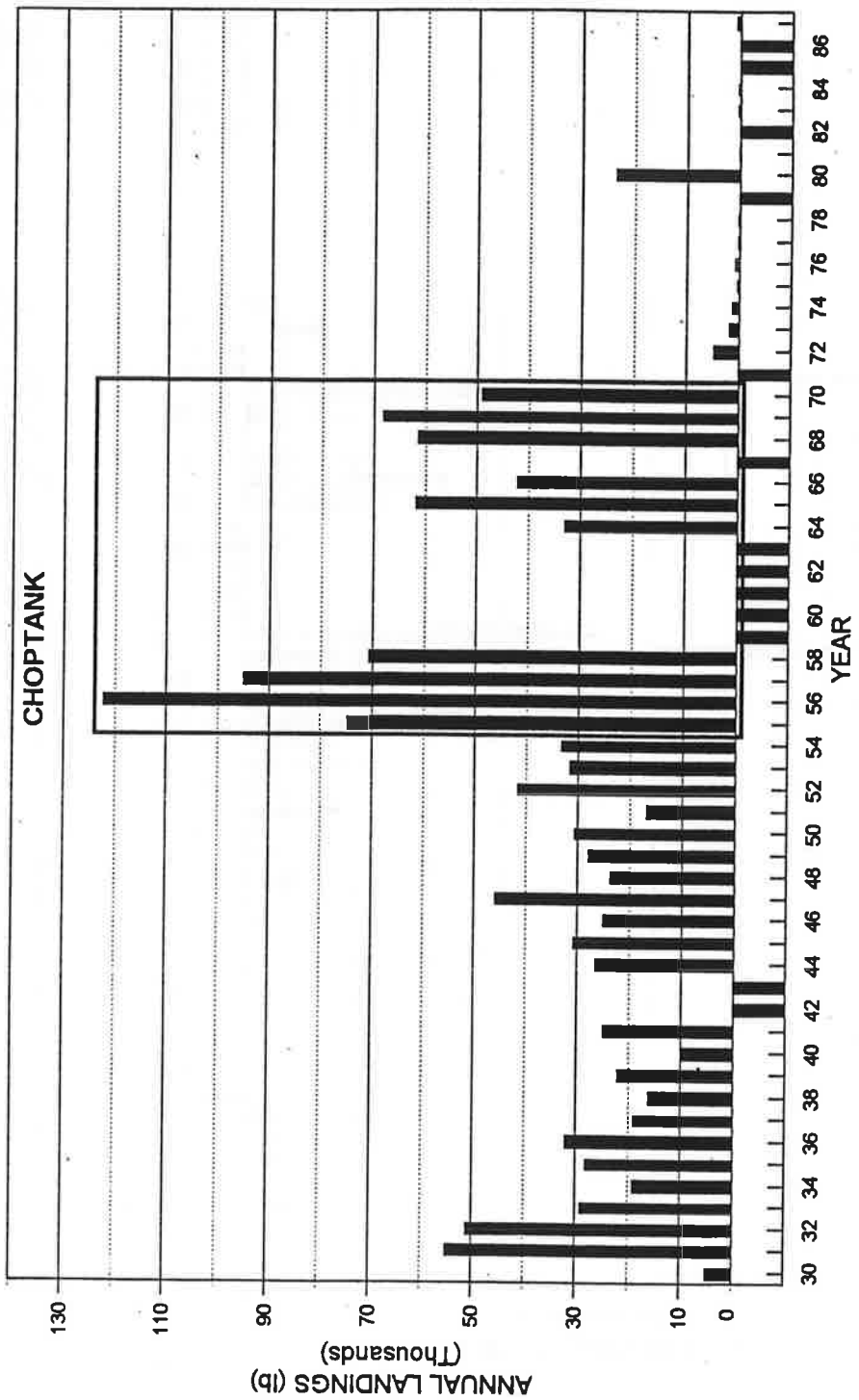


Figure 2. Commercial landing of American shad for the Choptank River. Solid box = years selected for population estimate. Bars extending below zero represent missing or incomplete data which are not utilized in calculations.

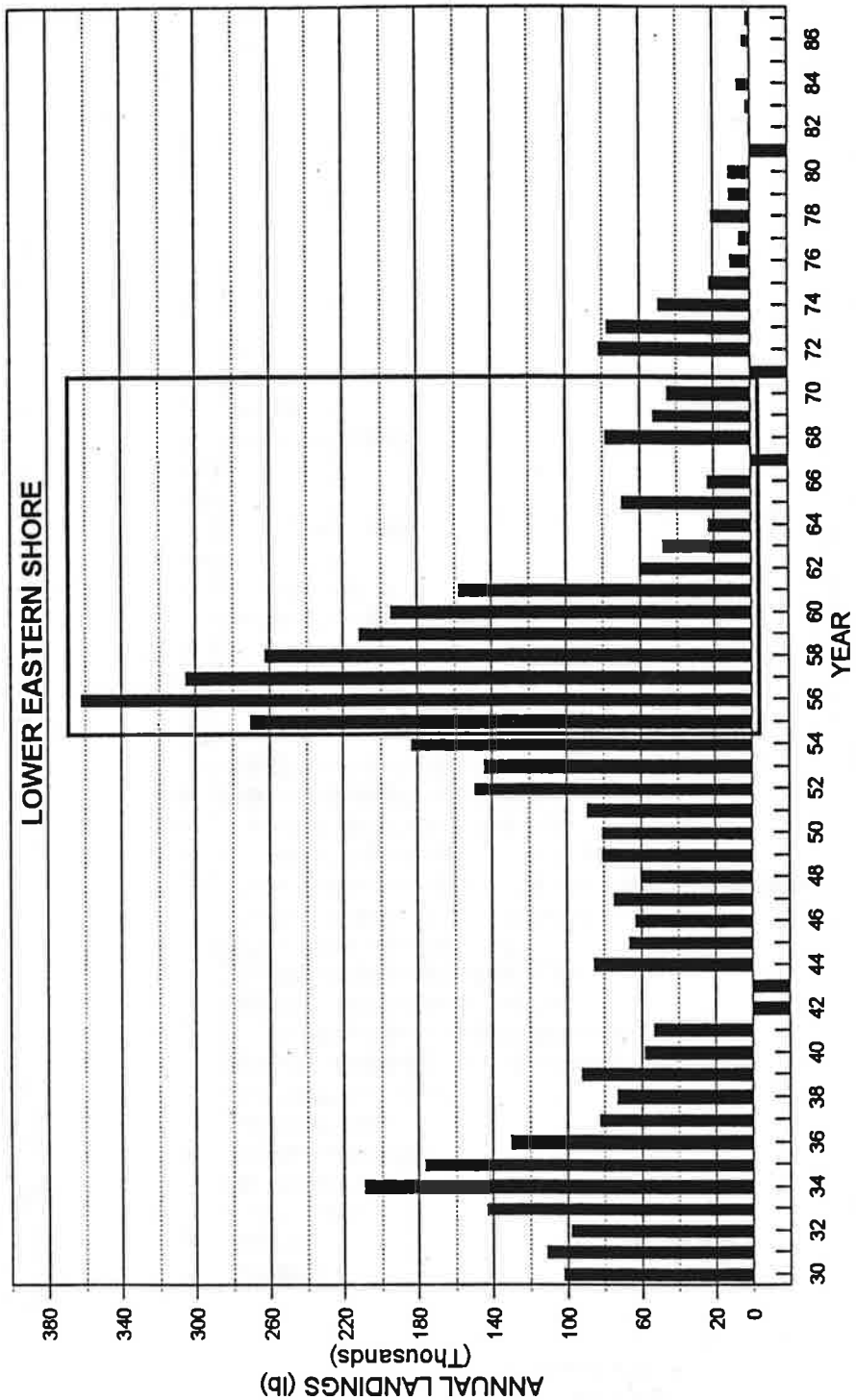


Figure 3. Commercial landing of American shad for the Lower Eastern Shore. Solid box = years selected for population estimate. Bars extending below zero represent missing or incomplete data which are not utilized in calculations.

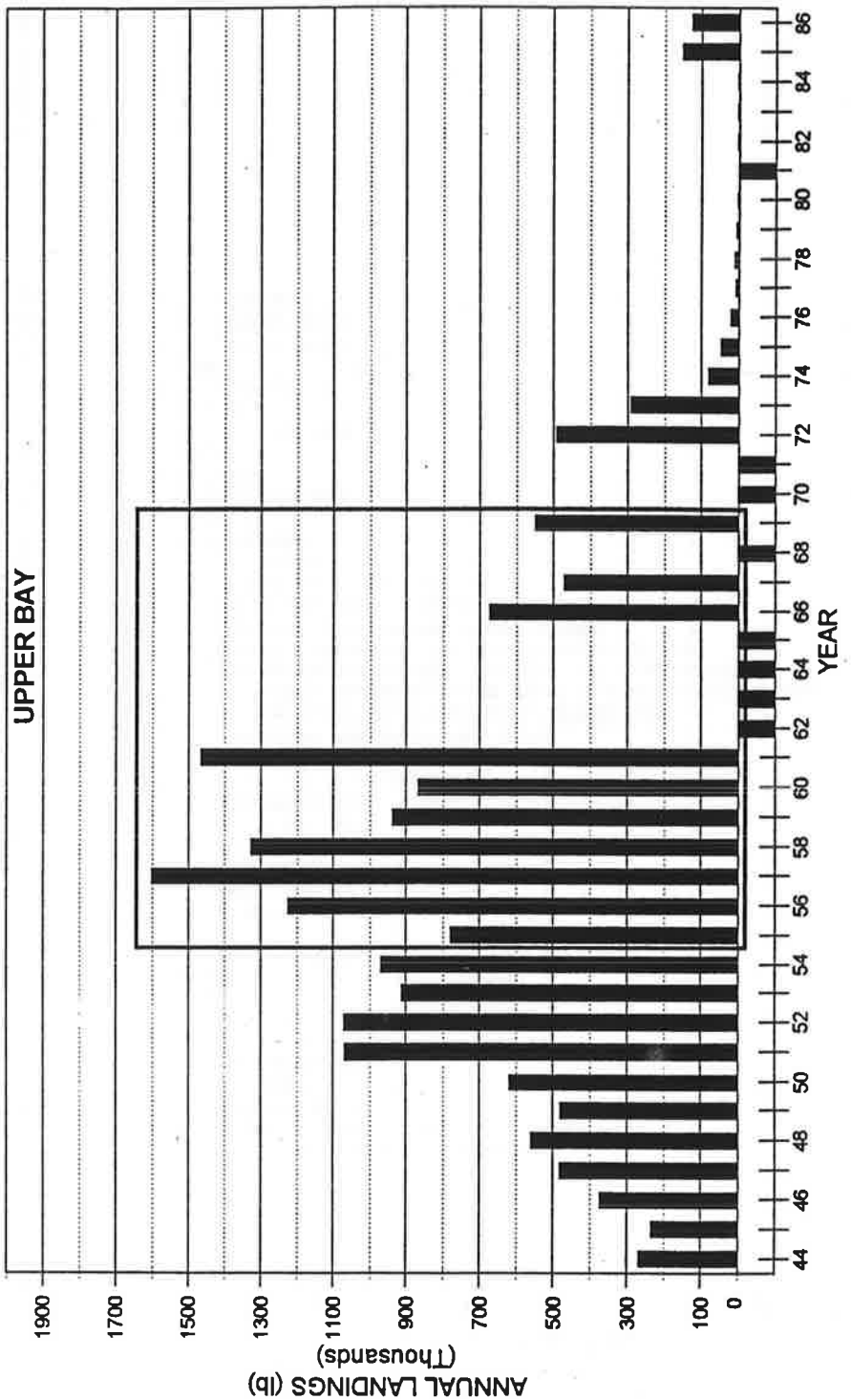


Figure 4. Commercial landing of American shad for the Upper Bay. Solid box = years selected for population estimate. Bars extending below zero represent missing or incomplete data which are not utilized in calculations.

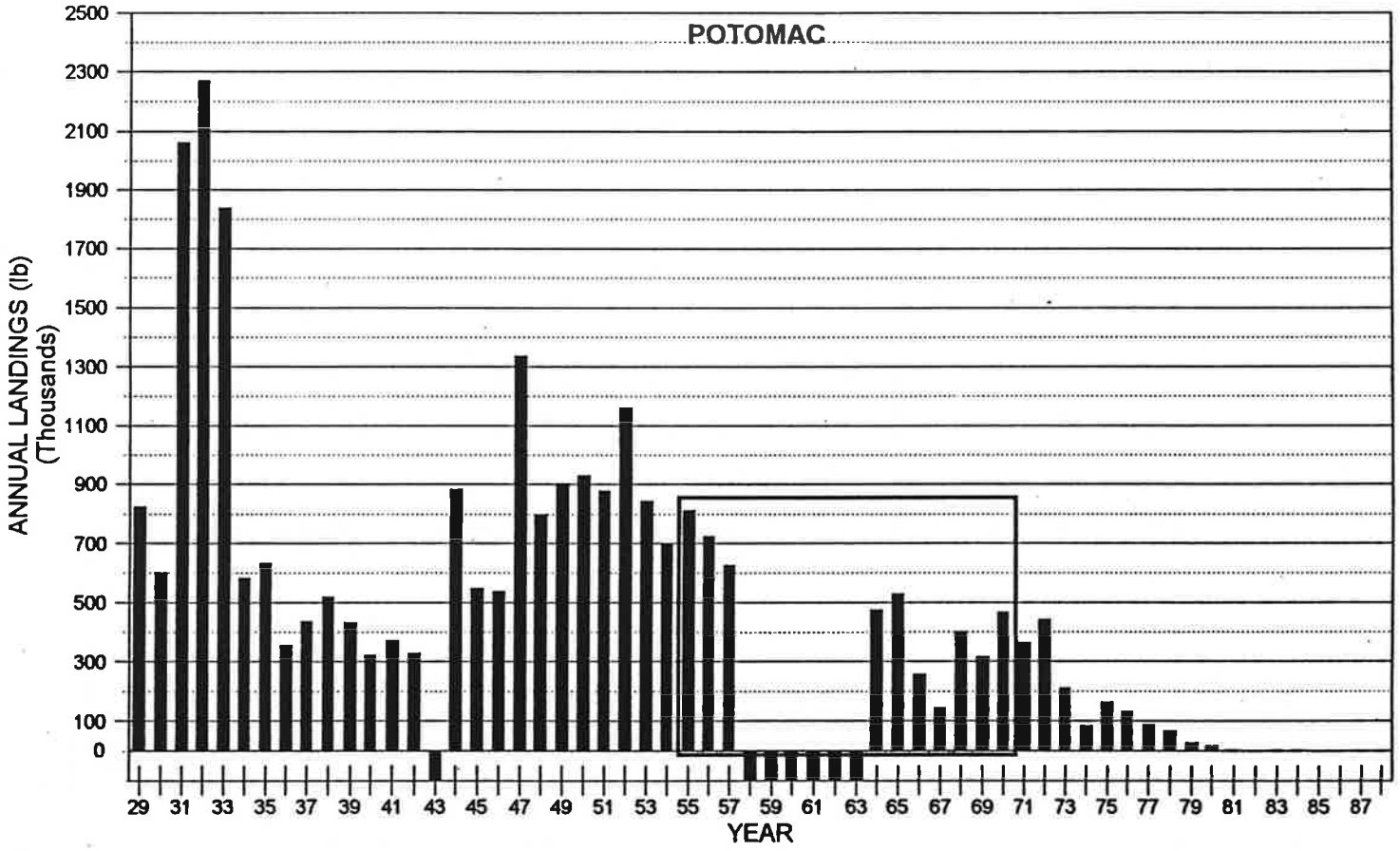


Figure 5. Commercial landing of American shad for the Potomac River. Solid box = years selected for population estimate. Bars extending below zero represent missing or incomplete data which are not utilized in calculations.

Table 1. Estimated annual landings (lbs) of American shad in the Patuxent River, 1930-1987

Year	Annual Landings	Year	Annual Landings
1930	1000	1959	--
1931	1000	1960	--
1932	1000	1961	--
1933	4000	1962	--
1934	1000	1963	--
1935	2000	1964*	3800
1936	1000	1965*	5400
1937	--	1966*	3100
1938	1000	1967	--
1939	1000	1968*	4000
1940	--	1969*	12000
1941	1000	1970	--
1942	--	1971	--
1943	--	1972	2100
1944	1312	1973	1000
1945	849	1974	300
1946	70	1975	3400
1947	1668	1976	500
1948	806	1977	600
1949	409	1978	300
1950	2700	1979	600
1951	1441	1980	1501
1952	3427	1981	--
1953	2359	1982	13
1954	3005	1983	10
1955*	8035	1984	75
1956*	3840	1985	--
1957*	16230	1986	--
1958*	9594	1987	10

* Years selected for population estimate

Table 2. Estimated annual landings (lbs) of American shad in the Choptank River, 1930-1987

Year	Annual Landings	Year	Annual Landings
1930	5000	1959	---
1931	55000	1960	---
1932	51000	1961	---
1933	29000	1962	---
1934	19000	1963	---
1935	28000	1964*	33000
1936	32000	1965*	61800
1937	19000	1966*	42100
1938	16000	1967	---
1939	22000	1968*	61400
1940	10000	1969*	68300
1941	25000	1970*	49100
1942	---	1971	---
1943	---	1972	4700
1944	26465	1973	1800
1945	30618	1974	1200
1946	25159	1975	300
1947	45755	1976	800
1948	23719	1977	200
1949	27933	1978	100
1950	30533	1979	---
1951	16750	1980	23576
1952	41462	1981	75
1953	31529	1982	---
1954	33190	1983	243
1955*	74628	1984	254
1956*	122236	1985	---
1957*	94982	1986	---
1958*	70796	1987	700

* Years selected for population estimate

Table 3. Estimated annual landings (lbs) of American shad in the Lower Eastern Shore, 1930-1987

Year	Annual Landings	Year	Annual Landings
1930	102000	1959*	211103
1931	111000	1960*	194252
1932	98000	1961*	157008
1933	143000	1962*	60000
1934	209000	1963*	47900
1935	176000	1964*	23100
1936	130000	1965*	69500
1937	82000	1966*	23300
1938	73000	1967*	---
1939	92000	1968*	78400
1940	58000	1969*	52400
1941	53000	1970*	44700
1942	---	1971	---
1943	---	1972	81400
1944	85133	1973	77200
1945	65898	1974	49600
1946	63045	1975	21800
1947	74573	1976	10600
1948	58429	1977	5800
1949	80459	1978	20900
1950	80256	1979	10900
1951	88458	1980	11141
1952	148410	1981	---
1953	143844	1982	240
1954	183006	1983	1922
1955*	269999	1984	6648
1956*	361958	1985	36
1957*	305266	1986	3488
1958*	262145	1987	1485

* Years selected for population estimate

Table 4. Estimated annual landings (lbs) of American shad in the Upper Bay, 1944-1986

Year	Annual Landings	Year	Annual Landings
1944	267976	1966*	675000
1945	233852	1967*	470000
1946	372146	1968	---
1947	479831	1969*	550000
1948	560292	1970	---
1949	478926	1971	---
1950	617689	1972	491600
1951	1070752	1973	291100
1952	1071938	1974	79900
1953	912067	1975	46800
1954	968337	1976	19200
1955*	779120	1977	6200
1956*	1226568	1978	10200
1957*	1600080	1979	4100
1958*	1326142	1980	1361
1959*	937977	1981	---
1960*	867429	1982	319
1961*	1464816	1983	705
1962	---	1984	355
1963	---	1985	150030
1964	---	1986	126233
1965	---		

* Years selected for population estimate

Table 5. Estimated annual landings (lbs) of American shad in the Potomac River, 1929-1988

Year	Annual Landings	Year	Annual Landings
1929	824487	1959	--
1930	600848	1960	--
1931	2061518	1961	--
1932	2269110	1962	--
1933	1837658	1963	--
1934	582400	1964*	475700
1935	631000	1965*	527000
1936	354800	1966*	258200
1937	435400	1967*	144700
1938	517600	1968*	399500
1939	430000	1969*	315800
1940	322400	1970*	465200
1941	371500	1971	361400
1942	328600	1972	441800
1943	---	1973	209388
1944	882065	1974	85018
1945	546918	1975	163376
1946	536216	1976	131811
1947	1336173	1977	89182
1948	796141	1978	67915
1949	904010	1979	27806
1950	931614	1980	16828
1951	877018	1981	4281
1952	1159991	1982	1868
1953	843944	1983	4860
1954	697205	1984	3800
1955*	812499	1985	307
1956*	721959	1986	400
1957*	624455	1987	832
1958	---	1988	1898

* Years selected for population estimate

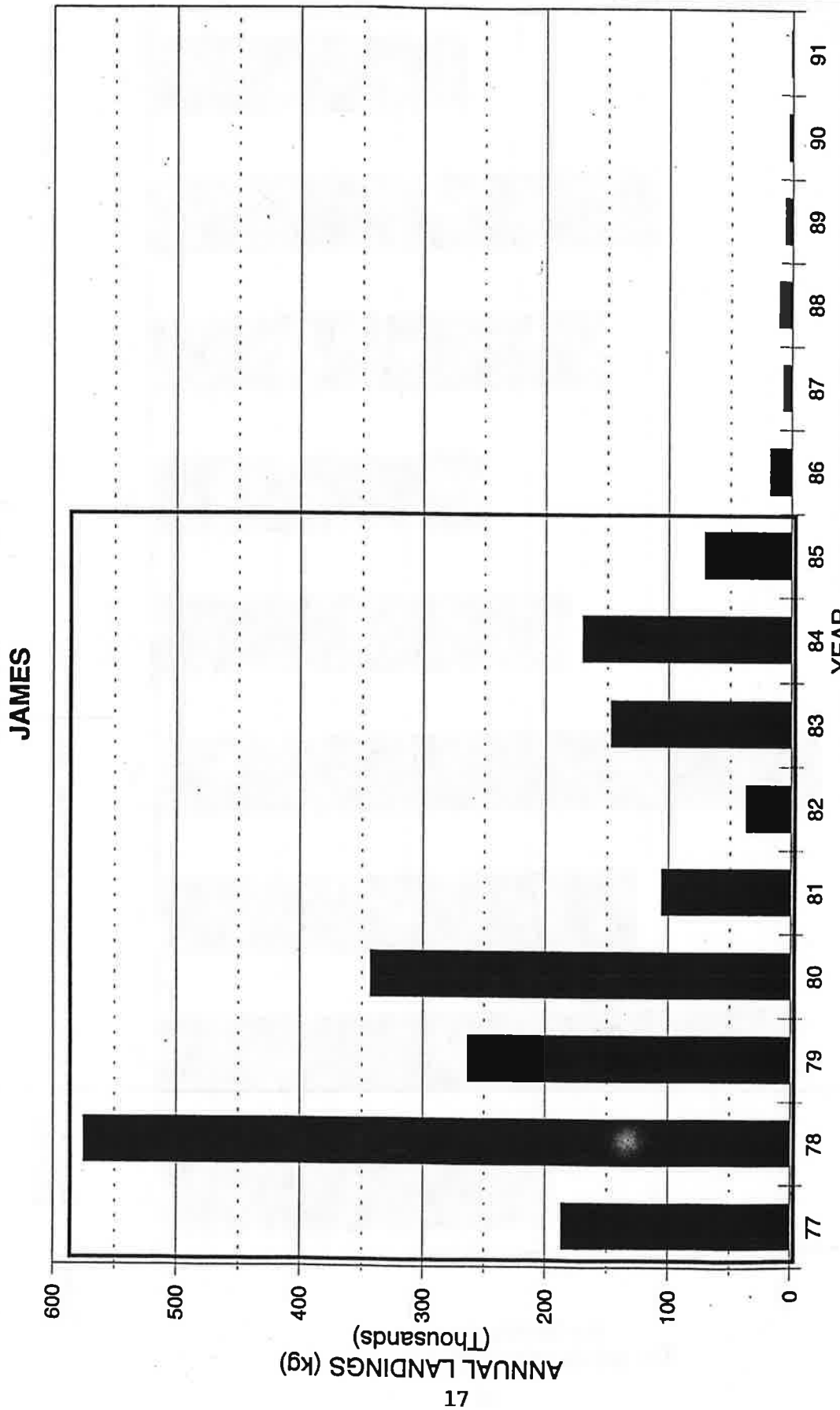


Figure 6. Commercial landing of female American shad for the James River. Solid box = years selected for population estimate.