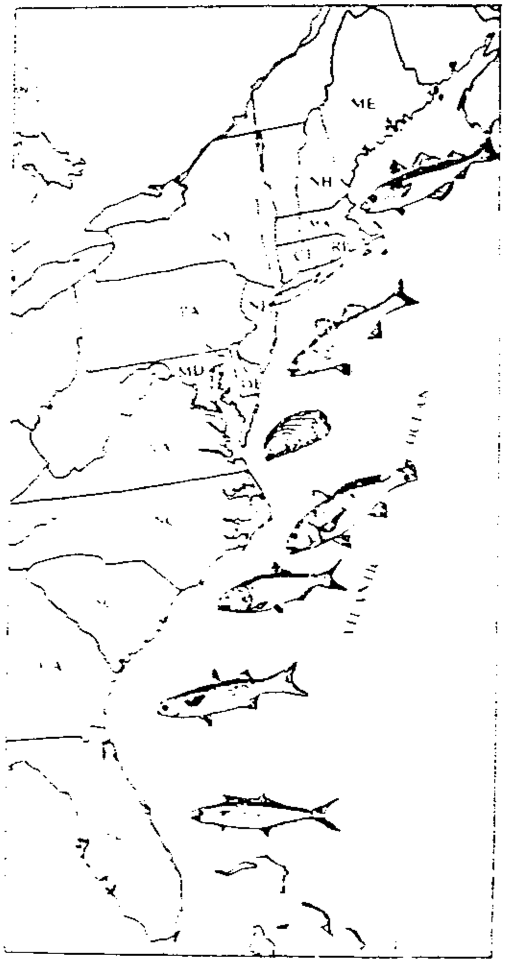
Fisheries Management Report No. 6

of the

ATLANTIC STATES MARINE FISHERIES COMMISSION



FISHERY MANAGEMENT PLAN FOR AMERICAN SHAD AND RIVER HERRINGS

October 1985

FISHERY MANAGEMENT PLAN FOR THE ANADROMOUS ALOSID STOCKS OF THE EASTERN UNITED STATES: AMERICAN SHAD, HICKORY SHAD, ALEWIFE, AND BLUEBACK HERRING

Phase II in Interstate Management
Planning for Migratory Alosids
of the Atlantic Coast

Atlantic States Marine Fisheries Commission
1717 Massachusetts Avenue, NW
Washington, D.C. 20036

October, 1985

FOREWORD

This management plan has been prepared by Martin Marietta Environmental Systems under Contract #84-3 and by ASMFC's Shad and River Herring Scientific and Statistical Committee as part of the Interstate Fisheries Management Program administered by the Atlantic States Marine Fisheries Commission. This plan has been reviewed and endorsed by the Interstate Fisheries Management Program's Shad and River Herring Management Board and Shad and River Herring Scientific and Statistical Committee. Funds were provided by Northeast Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA) under an 89-304 anadromous grant. For bibliographic purposes, this document should be cited as follows:

> Atlantic States Marine Fisheries Commission. 1985. Fishery Management Plan for the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring: Phase II in Interstate Management Planning for Migratory Alosids of the Atlantic Coast. Washington, DC. XVIII + 347 pp.

EXECUTIVE SUMMARY

Preparation of a Fishery Management Plan for the anadromous alosids (American and hickory shad, alewife, blueback herring) of the East Coast of the United States was recommended by the Advisory Committee of the Atlantic States Marine Fisheries Commission (ASMFC) and adopted by the Commission in 1981, in response to the very low current levels of commercial landings of all four species.

As part of the process of developing a Fishery Management Plan for these species, ASMFC established a Shad and River Herring Management Board, with representatives from each of the east coast states in which runs of the species occur and from two federal agencies--the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The Board subsequently appointed a Scientific and Statistical Committee to direct the development of the management plan. The committee is made up of one representative from each of the coastal states and one representative each from the USFWS and the NMFS. An Action Plan was developed at a Shad and River Herring Management Workshop in Philadelphia, Pennsylvania, 2-3 February 1982, that called for subsequent activity to occur in two phases:

- Phase I - compile available data on the current status and biology of each of the four species and define potential options for management action
- Phase II - develop a management plan, with specification of management actions where appropriate, and identify research needs.

The Phase I report was completed in July 1984. This management plan is based on information compiled in that document and additional data acquired since its publication.

The statement of the goal of this management plan developed by the Board is as follows:

> The goal of this Fisheries Management Plan (FMP) shall be to promote, in a coordinated coastwide manner, the protection and enhancement (including restoration) of shad and river herring stocks occurring on the Atlantic seaboard. This plan was developed because of depletion of stocks from overfishing, loss of habitat (resulting from construction and operation of dams and from pollution), inconsistencies in management actions, and lack of adequate data.

The objectives of the plan are to:

Objective 1 - Regulate exploitation to achieve fishing mortality rates sufficiently low to ensure survival and enhancement of depressed stocks and the continued well-being of stocks exhibiting no perceived decline. A corollary to this objective is minimization of exploitation of a given state's stocks by other states or nations.

Objective 2 - Improve habitat accessibility and quality in a manner consistent with appropriate management actions for nonanadromous fisheries. This objective can be addressed by the following types of management actions:

-- Improve or install passage facilities at dams and other obstacles preventing fish from reaching potential spawning areas

-- Improve water quality in areas where water quality degradation may have affected alosid stocks

-- Ensure that decisions on river flow allocation (e.g., irrigation evaporative loss, out of basin water transport, hydroelectric operations) take into account flow needs for alosid migration, spawning, and nursery usage

-- Ensure that water withdrawal (e.g., cooling flow, drinking water) effects (e.g., impingement and entrainment mortalities, turbine mortalities) do not affect alosid stocks to the extent that they result in stock declines.

Objective 3 - Initiate programs to introduce alosid stocks into waters that historically supported but do not presently support natural spawning migrations, expand existing stock restoration programs, and initiate new programs to enhance depressed stocks.

Objective 4 - Recommend and support research programs that will produce data needed for 1) the development of scientifically rigorous management recommendations relating to sustainable and acceptable yields, 2) the preservation of acceptable stock levels, and 3) optimal utilization of those stocks.

Lack of much needed information resulted in the development of many recommendations dealing with data needs. For this reason, the plan is viewed as a dynamic document. Monitoring of implementation and revision of the recommendations in response to new data will be essential for the plan to be successful. Recommendations of this management plan are as follows:

Regulation of Offshore Harvests

Recommendation 1.1

ASMFC will review, annually, Fishery Management Council decisions and NOAA regulations based on those decisions that relate to the anadromous alosids. Based on any new information or changes in existing status of the stocks, directed fisheries, or fisheries having a potential impact on the alosids, ASMFC shall develop and submit recommendations to the Fishery Management Councils. ASMFC shall retain their position as a voting member on council committees that address anadromous alosid issues (e.g., the Mid-Atlantic Council's Coastal Migratory Species Committee).

Recommendation 1.2

ASMFC will closely monitor the establishment and growth of joint venture and domestic mackerel fisheries in order to evaluate the consequences to river herring stocks of their capture as bycatch. ASMFC will join in the request of the Mid-Atlantic Fishery Management Council for implementation of a data collection plan by NMFS pursuant to Section 303(e) of the MFCMA. Data to be collected pursuant to such a plan should conform to the recommendations set forth in Appendix C of this plan. These data will be evaluated and analyzed to arrive at the recommendations mentioned above.

Regulation of Territorial Sea Harvests

Recommendation 2.1

Each state, in cooperation with NMFS, will monitor and document existing and new FCZ and territorial sea fisheries for anadromous alosids. The extent of participation, amount of harvest, and timing and location of each fishery will be documented; this information will be forwarded to ASMFC for its annual review of fisheries and stock status and for consideration of revision of existing recommendations in this plan. An interstate cooperative coastal shad tagging program will be conducted to determine which stocks are being exploited (see Recommendation 8.3).

Recommendation 2.2

All east coast states will recognize the priority rights of traditional fisheries in internal waters that target resident stocks, while not encouraging new intercept fisheries in territorial sea waters. Of greatest concern are fisheries taking shad along the coast very early in the year, including those occurring in South Carolina, North Carolina, Virginia, Maryland, and Delaware Bay. What appears to be an expanding summer-fall gill net fishery in the Gulf of Maine should also be closely monitored by the New England states. Such fisheries should not be encouraged and, if evidence suggests they pose a threat to any single stock of shad, steps should be taken to prohibit them.

Regulation of Harvests in Internal Water

Recommendation 3.1

Individual states will consider implementing fisheries management actions that would ensure that total exploitation rates for female American shad, hickory shad, and river herring (commercial and recreational) do not exceed levels that threaten the stability of stocks currently at acceptable levels or the enhancement of depressed or newly established stocks. Guidelines for maximum exploitation rates are presented in Table V-1.

Recommendation 3.2

Individual states will initiate studies to document existing fishing mortality rates of all four alosid species and to establish if density dependent catchability exists. Recommended guidelines for design of an acceptable study are presented in Table V-2. States shall obtain at least preliminary data within 2 years of adoption of this plan and provide these data to ASMFC for integration and distribution to interested parties.

Recommendation 3.3

Individual states shall improve records of catch and effort in general, and shall make a special effort to establish the amount of harvest reported as American shad and/or river herring that is actually hickory shad. Examples of steps that could be taken include education of fishermen, modification of reporting forms or mechanisms, and creel/harvest census during critical time periods.

Water Quality

Recommendation 4.1

Resource management agencies in each state shall evaluate their respective state water quality standards and criteria to ensure that those standards and criteria account for the special needs of anadromous alosids. This action should be taken within the normal cyclical process of criteria review that occurs in most states. Steps should be taken within 1 year of implementation of this plan to create a new class of waters (or redefine an existing class) to acknowledge status or potential status as anadromous alosid spawning and nursery areas (analogous to "trout waters"). Primary emphasis should be on locations where sensitive egg and larval stages are found. For those agencies without water quality regulatory authority, protocols and schedules for providing input on water quality regulations to the responsible agency should be identified or created. Waters of existing or potential value as alosid spawning/nursery areas should be identified for the appropriate water quality agency. Agencies in each state shall initiate actions to establish water quality criteria protective of anadromous alosid habitat requirements, but consistent with the management objectives for other species. Suggested values for key parameters are presented in Table V-3.

Recommendation 4.2

Results of ongoing studies dealing with the effects of acid deposition on anadromous alosids will be reviewed by all appropriate agencies and ASMFC as they become available. ASMFC will summarize those findings in a position document on an annual basis. Should those findings support the contention that acid deposition is having a deleterious impact on anadromous alosids, ASMFC shall offer that document as supporting evidence to all organizations and individuals pursuing acid rain controls and/or mitigation measures.

Flow Requirements

Recommendation 5.1

State resource management agencies shall identify or establish protocols that ensure that they have the opportunity to evaluate projects that may affect the flow of streams and rivers supporting or having the potential for supporting runs of anadromous alosids. State resource management agencies shall determine which state agency serves as the primary contact with the Federal Energy Regulatory Commission (FERC), since all applications relating to hydroelectric development are processed by the FERC.

Recommendation 5.2

In reviewing proposed projects that will affect flow regimes, agencies shall ensure that continuous minimum flows and the manner in which the operation of any facility alters flows will not adversely affect anadromous alosids. Guidelines for desirable instream flow variables are presented in Table V-4. State agencies should, if necessary, solicit the advice of the USFWS Instream Flow Group in developing flow recommendations.

Other Habitat Factors

Recommendation 6.1

All state and federal agencies responsible for reviewing impact statements for projects proposed for anadromous alosid spawning and nursery areas shall ensure that those projects will have no impact or only minimal impact on those stocks. Of special concern are natal rivers of newly established stocks or stocks considered depressed or severely depressed (Table V-1).

Recommendation 6.2

ASMFC and federal fisheries agencies shall continue to monitor progress in the development of Bay of Fundy hydroelectric projects. Communications with the Department of State and all interested members of Congress shall be renewed on an annual basis to reiterate opposition to the projects unless it can be demonstrated that no significant mortality to alosids will occur. Continued environmental studies shall be encouraged. Annual status reports based on information obtained from the Canadian government and project developers will be prepared and distributed to Board and Scientific and Statistical Committee members. ASMFC will request from the U.S. Department of State the right to review all environmental impact predictions prepared as part of project development. Factors that influence U.S. purchase of power from these projects should be monitored to determine if actions can be taken to discourage their development.

Restoration of Anadromous Alosids

Recommendation 7.1

All agency personnel participating in anadromous alosid restoration programs should be alert for indications of disease or parasites. At present, no information exists to suggest that transfer of disease or parasites is a problem. However, should a potentially serious problem arise, ASMFC shall develop a disease control and screening program for alosids. Such a program could follow the form of the existing New England Atlantic Salmon Disease Control Program.

Recommendation 7.2

Each state that has not already done so shall evaluate the potential for anadromous alosid restoration within their internal waters. Such an evaluation should include, at a minimum, a listing of waters that currently do not support anadromous alosid stocks but that might if water quality and access were improved or created. Within one year from the date of adoption of this plan, and annually thereafter, each state shall provide to ASMFC this evaluation, a summary description of ongoing restoration efforts, and a statement of anticipated restoration activities for the next five years. ASMFC shall use material from these submittals to prepare an annual summary of coastwide restoration efforts for distribution to agencies, legislators, and all other interested parties.

Recommendation 7.3

ASMFC and all state and federal resource agencies shall support, in every way possible, the preservation and enhancement of federal programs providing funds for the restoration of anadromous fish. Such programs include the Anadromous Fish Act and Wallop-Breaux programs and other federal grant programs that support studies of anadromous alosids, such as Sea Grant and Coastal Zone. It is obvious that most of the very successful anadromous alosid programs that currently exist would not have been initiated if these federal programs were not in place. Implementation of a coastwide alosid restoration plan will not be feasible in the absence of these federal programs. States should also develop additional state funding sources for restoration of anadromous alosids; possibilities include special licenses or stamps.

Recommendation 7.4

All state and federal agencies shall cooperate to further all current or planned anadromous alosid restoration efforts. Because the acquisition of gravid adults for transplanting is essential for most restoration efforts, those agencies having regulatory control over existing healthy runs of all species should be particularly sensitive to the needs of agencies implementing restoration efforts and should provide the maximum cooperation possible. ASMFC's Shad and River Herring Board will serve as a coordinator to resolve any major disputes.

Recommendation 7.5

Because of the important role of turbine mortality in determining the success or failure of many restoration programs, all agencies participating in restoration programs involving hydroelectric projects shall include in those programs plans for turbine mortality and downstream passage studies. The term "fish passage" should consistently be interpreted to include downstream passage in any discussion of restoration activity. Results of ongoing and new studies shall be provided on an annual basis to ASMFC for compilation and for dissemination of data to all appropriate state and federal agencies. A continuous exchange of information on turbine mortality and methods for passing anadromous alosides downstream may lead to new and successful methods for alleviating this problem.

Recommendation 7.6

All resource agencies shall oppose any new hydroelectric projects proposed for drainage systems currently supporting or with potential for supporting anadromous alosid runs unless the developer can demonstrate to the agencies' satisfaction that the project, as proposed, will not have an unacceptable adverse impact on alosid runs. Of particular concern here are small-scale hydroelectric projects existing or proposed for smaller drainage systems supporting river herring runs. Cumulative impacts of several facilities on the same drainage system must also be considered. Major issues are upstream passage of spawning adults and successful downstream passage (i.e., avoidance of turbine mortality) of outmigrating, spawned-out adults and juveniles.

Research Needs

Recommendation 8.1

ASMFC shall serve as a coordinator of research conducted along the east coast dealing with anadromous alosids. ASMFC will prepare a summary compendium of ongoing studies annually. Grant applications and/or proposals for anadromous alosid research programs submitted to federal and/or state agencies should be provided to ASMFC for comment to ensure that the focus of new studies is consistent with management needs identified in this plan.

Recommendation 8.2

In assigning priority for research funding under PL89-43 (Anadromous Fish Conservation Act), NOAA/NMFS and USFWS shall assign high priority to applications for state projects that satisfy data needs identified as having a high priority in this plan (see Table V-12 and V-13).

Recommendation 8.3

ASMFC shall design and coordinate the implementation of an interstate coastal shad tagging research program (see Recommendation 2.1). A tentative study design is presented in Table V-14. The initial interstate effort will focus on participation by South Carolina and North Carolina, or other states where the nature of the fishery makes the study more feasible. ASMFC will be responsible for coordination of the activities of individual states and integration and interpretation of results. Studies that lead to the development of techniques to identify the river of origin of fish taken in mixed stock fisheries (e.g., ocean tagging, extensive within river tagging, innate indicators) should be encouraged in order to enhance the interpretation of findings of this tagging program.

Recommendation 8.4

In establishing new anadromous alosid research programs, state and federal agencies will proceed according to the priorities presented in Table V-13.

Recommendation 8.5

ASMFC shall undertake the compilation and analysis of all data on offshore river herring distribution and harvest available from NOAA (e.g., NMFS research trawl data, observer data, experimental Polish trawl program data). This information should be updated annually, and should be used to develop or revise recommendations to the Fishery Management Councils on regulations needed to protect traditional domestic river herring fisheries.

Citizen Participation

Recommendation 9.1

Individual states are encouraged to establish programs that involve citizens in implementation of this plan. Such involvement would be appropriate as individual state plans are being developed. Participation by user groups and interested citizens may result in the public support required to implement the plan.

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I. INTRODUCTION

Preparation of a Fishery Management Plan for the anadromous alosids of the East Coast of the United States (American and hickory shad, alewife, blueback herring) was recommended to the Atlantic States Marine Fisheries Commission (ASMFC) by its advisory committee, with the recommendation being adopted by the commission in 1981. This action was prompted by the very low current commercial landings of all four species, which was perceived as an indication that management action would be required to restore stocks to their former levels of abundance. The basis for action by the commission was that the four species met five criteria for inclusion in the ASMFC Interstate Fisheries Management Program (ISFMP)(ASMFC 1982):

- The species are valuable to the states and to the nation.
- They are perceived to be in need of management for attainment of optimum yield.
- They are not currently scheduled for management under the Magnuson Fishery Conservation and Management Act (PL 94-265).
- There is reasonable expectation that the plan can be implemented.
- The species are amenable to cost-effective management.

As part of the process of developing a Fishery Management Plan for these species, ASMFC established a Shad and River Herring Management Board which includes representatives from each of the east coast states in which runs of the species currently or formerly occurred: Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, and Virgnia. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) are also represented.

The Board subsequently appointed a Scientific and Statistical Committee to direct the development of the management plan. The committee is made up of technical representatives from each of the previously mentioned states and the two federal agencies. An action plan was developed at a shad and river herring management workshop in Philadelphia, Pennsylvania, 2-3 February 1982, which called for subsequent activity to occur in two phases:

- Phase I - compile available data on the current status and biology of each of the four species and define potential management options

- Phase II - develop a management plan with specific management actions, where appropriate, and define research needs.

Martin Marietta Environmental Systems was contracted by ASMFC to develop the management plan. Phase I of the program was completed in July 1984 with the publication of a document entitled, "Current Status and Biological Characteristics of the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring; Phase I in Interstate Management Planning for Migratory Alosids of the Atlantic Coast." This document, which was made available to the public through the National Technical Information Service (NTIS), is included here as Appendix A, and presents the background information upon which the management plan is based. It is important to note that the status of these four species was evaluated primarily by examining landings data.

The present document constitutes the ASMFC management plan for the four anadromous alosids and, to the extent possible, it conforms to the standards for fishery management plans set by the Magnuson Fisheries Conservation and Management Act of 1976. However, because of the unique nature of these fisheries, this plan differs from the Magnuson Act standards in the following ways:

- Stocks of all four species are at very low levels over portions of their range. Thus, the major short term goal of this plan is to restore or enhance the species rather than to attain an optimum or maximum sustained yield.

- Most exploitation of anadromous alosids occurs in the state of their origin, and interjurisdictional and international conflicts are currently minimal. As a result, the plan focuses on offering biological and economic information of value to individual states in protection and enhancement of their own stocks and promotes coordination among states in all activities dealing with the anadromous alosids.

- Because this plan focuses mainly on restoration, economic issues are not addressed. While the integral role of economics in all fisheries is acknowledged, the depressed state of stocks in many states requires that all efforts currently be directed at biological aspects of management. At a later time, when stocks have been restored to stable and self-supportable levels, management recommendations may be revised to account for economic factors.

- This plan addresses the four species as a group. This approach is possible and desirable because of many similarities in their life history characteristics and current status. Some management objectives included here are applicable to all four species while others are specific to individual species.

- The absence of critical population biology data for all species limits the number of specific quantitative management objectives that could be incorporated into this plan. For this reason, many of the management objectives deal with information needs and acquisition. Thus, this plan is intended to be dynamic in nature; as information gaps are filled management recommendations will be revised and become more specific.

The remainder of this document is presented in four segments:

- The status of the stocks is summarized, based on material presented in detail in Appendix A
- Management problems are identified
- Management goals and objectives are presented
- Recommendations of actions necessary for achievement of management objectives are presented.

All references cited in the text of this plan are listed in the bibliography of Appendix A.

II. CURRENT STATUS OF THE EAST COAST ANADROMOUS ALOSID STOCKS

A. INTRODUCTION

As noted earlier, the Phase I document prepared as part of this management program and appearing here as Appendix A presents a compilation of available data on the current status and biology of the four anadromous alosids of the eastern United States. In this section, the Phase I report is summarized, and in some instances (e.g., catch records) data are updated.

B. SPECIES AND FISHERIES OVERVIEW

The four anadromous alosid species addressed in this plan are the American shad (Alosa sapidissima), hickory shad, (Alosa mediocris), alewife (Alosa pseudoharengus), and blueback herring (Alosa aestivalis). Alewife and blueback herring are addressed jointly as river herring because commercial fishermen do not distinguish between them. Thus, all landings data include only a single category for both species, labeled river herring. Figure I-1 in Appendix A illustrates the four species. Figures I-2 through I-5 in the appendix characterize the general life history of each of the species.

Of the four species, American shad and blueback herring are the two most ubiquitous, spawning from Nova Scotia to Florida. Hickory shad are more southern in distribution, while alewives are more northern. All are anadromous, with their spawning runs occurring from late winter to early summer, depending on species and latitude. Existing data suggest that the river herrings and American shad exhibit extensive seasonal coastal migrations, thus creating possibilities for interstate conflicts in fisheries. Nothing is known of the migratory behavior of hickory shad at sea.

Fisheries for all four species have changed dramatically during the 20th century. In the late 1800s and early 1900s, large, annual catches of all four species were made along the entire coast each spring, with most of the harvest being used for human consumption (Mansueti and Kolb 1953).

Coastwide harvests of all four species have declined markedly since the early 1900s, with the most recent decline occurring during the early 1970s. Tables II-2 and IV-1 of Appendix A present coastwide harvests of American shad and river herring from 1930 to 1984. Landings data for hickory shad (presented in Ch. III of Appendix A) are of questionable value for documenting stock trends. While changes in effort may have contributed to the observed declines in landings, the recent major harvest declines are believed to reflect major declines in stock size. River herring declines are attributable in part to large offshore river herring harvests by foreign fisheries in the late 1960s and early 1970s (Table IV-15 in Appendix A). Causes of declines in American shad and hickory shad are less well defined, as is discussed at length in Appendix A.

In addition to harvest levels changing over the last 50 years, the nature of fisheries, the use of harvest, and the economic value of the species have also changed:

- Shad runs, where abundant, now support extensive sport fisheries that may be of much greater economic value than commercial harvests (e.g., on the Connecticut and Delaware rivers).
- Extensive recreational fisheries which formerly existed in certain locations have essentially disappeared as stocks declined (e.g., American and hickory shad in Maryland).
- Use of commercially harvested river herring has changed from primarily human consumption to primarily pet food, fish meal, and bait.
- Modes of harvest have changed dramatically for American shad (from pound nets and haul seines to gill nets).
- The rate of increase in dollar value for all commercially harvested alosids has consistently been less than the inflation rate (Tables II-8 and II-19 in Appendix A).

Regional contributions to the coastwide stock declines of all species have differed markedly. Greatest harvest declines of both shad and river herring have occurred in the southeastern states and Chesapeake Bay region. Hickory shad stocks, which are more southern in distribution, may have also declined markedly. However, because only landings data are being considered here in evaluating stock status, it is possible that effort and not stock size may have declined in some areas. These observations must also be tempered somewhat by acknowledging the regional differences in fisheries that occur. Very little commercial exploitation of river herring occurs in Delaware, New Jersey, New York, and Connecticut. For this reason, landings data for the mid-Atlantic region do not serve as credible indicators of stock size.

In the case of American shad, the Delaware, Hudson, and Connecticut rivers support the only major shad runs north of the Chesapeake Bay, in contrast to the large number of rivers supporting runs in the Chesapeake and southeast regions. Another factor that confounds trend comparisons between stocks in northern and southern rivers is that the three major northern rivers have each been the focus of some special activity (i.e., restoration, pollution abatement, or fishery closure). Such factors prevent clear rigorous conclusions from being drawn regarding geographical differences in stock trends.

All of the above topics are treated in greater detail in Appendix A. Tables II-2 and IV-1 in Appendix A include American shad and river herring landings data not included in the original version of the Phase I report. Maine river herring landings for 1982 and 1983 declined markedly from earlier years. However, this is attributed to very high spring runnoff in those years (T. Squires, pers. comm.), and the landings decline is not viewed as an indicator of stock decline. In North Carolina, and Virginia, river herring landings in 1982 and 1983 appear to have rebounded substantially from the extremely low harvest taken in 1981. Whether this rebound reflects increased effort or increased stock is not known at this time. Increases in shad landings are also evident in North Carolina and Virginia. Without detailed effort data, no inferences about stock fluctuations can be drawn from these new harvest figures.

C. SOCIOECONOMIC CONTEXT

The nature of existing fisheries may help define management actions that would contribute to stock enhancement. Because all four alosids are anadromous, adult stocks concentrate in inshore areas during the spawning season and are then most vulnerable to exploitation. As a result, fisheries for these species have traditionally been concentrated in the spring and in areas adjacent to or within spawning locations.

Two major exceptions to these generalizations have occurred in the past. Late in the 1950s purse seine fisheries in Massachusetts took substantial amounts of shad and river herring when menhaden stocks declined (p. II-9 of Appendix A). In the late 1960s and early 1970s foreign fisheries began to exploit river herring in coastal waters, with offshore annual harvest eventually exceeding the domestic inshore harvest (p. IV-34 of Appendix A).

In response to the declines in stock abundance that have occurred over the past two decades, fisheries have changed drastically. Thus, the current socioeconomic context for management differs significantly from circumstances in the past. This background can be summarized by category: 1) fisheries conservation zone (FCZ), territorial sea, and Canadian fisheries and 2) internal waters fisheries.

Fisheries Conservation Zone, Territorial Sea, and Canadian Fisheries

- Currently, no domestic fisheries directed at river herring occur in the fisheries conservation zone (FCZ) or in territorial sea waters. Proposals for joint-venture fisheries for mackerel, to be conducted with foreign fleets, may alter this circumstance since such fisheries may take river herring as bycatch.
- Current total allowable landings for foreign fisheries (TALFF) is very low and permits limited bycatch of river herring. No foreign fisheries directed at river herrings exist.
- No foreign offshore fisheries for American shad exist (shad are categorized as a prohibited species within the FCZ). Domestic fisheries exist in offshore areas (>3 miles from shore) and in territorial seas (within 3 miles of shore). Southern territorial sea fisheries for shad yield the highest price per pound for shad along the east coast because they occur early in the season before more northernly runs begin. There are indications that there is increasing coastal/offshore harvest of shad by gillnetters operating along the coast from Maine to South Carolina, although total magnitude of harvest remains low relative to inshore harvests.
- A limited Canadian fishery for American shad occurs in the Bay of Fundy. While not of major significance at present, expansion of this fishery could pose a threat to east coast stocks.
- Additional expansion of FCZ and territorial sea fisheries may depend on market factors.

Internal Waters Fisheries

American Shad

- Most internal waters fisheries occur in or near natal streams.
- Fisheries in natal rivers tend to be traditional in nature with long-time participants, known markets, well defined seasons impacted by timing of the run, and fairly rigid timing of market demand. Primary income for most shad fishermen is from other sources.

- In southern states very substantial "sport" gillnetting occurs; thus harvests are difficult to document.
- Sport fisheries have become prominent in the northeastern and mid-Atlantic regions, to the extent that their economic value exceeds that of concomitant commercial fisheries in those areas. Conversely, in regions where stocks have declined substantially sport fisheries have virtually disappeared (e.g., Maryland runs).

Hickory Shad

- Limited commercial fisheries directed at hickory shad occur in the south, preceding the American shad runs. Most hickory shad harvest, however, is taken as bycatch in the American shad fisheries.
- Hickory shad formerly supported major sport fisheries. However, as stocks decline, these fisheries have also declined.
- Dollar value of hickory shad often differs markedly by state, based on public perception of the desirability of the species (p. III-6 of Appendix A).

River Herring

- Major river herring fisheries in Maine and Massachusetts are operated by local municipalities. Weirs are in place on the home streams, are operated seasonally, and yield harvests that go to traditional markets.
- Very limited river herring fisheries occur in the mid-Atlantic region.
- Fisheries in the Chesapeake Bay and North Carolina are dominated by pound nets. For such fisheries that are specific to river herring to be profitable, large amounts of fish must be harvested. In a sense, the fisheries are self-regulating, since when stocks are low, the fisheries become unprofitable and are not pursued.
- River herring are used primarily as commercial or recreational fishing or crabbing bait, for processing to fish meal, or as pet food. Some markets exist for canned roe, but a minor percentage of total harvest is used for human consumption.

- Substantial sport fisheries exist for river herring (hook and line as well as dip netting). These fisheries are poorly documented but are extensive and of great social importance.

D. SCIENTIFIC CONTEXT

Management actions should ideally be based on detailed knowledge of a species' life history, its population dynamics, and the type, pattern, and magnitude of its exploitation. In the case of the four alosid species addressed here, the depth of knowledge of these factors varies markedly, particularly in the areas of life history and population biology. These limitations will substantially constrain the types of management recommendations that can be developed at this time, which in turn suggests that this plan will have to be regularly reviewed and modified as new information becomes available. The following represents aspects of our knowledge of the species biology of greatest relevance to management recommendations.

Hickory Shad

- Detailed hickory shad studies have been conducted in very few locations, and all have focused on spawning stock age structure and behavior.
- Juveniles are difficult to capture, and little is known of their behavior during emigration.
- Virtually nothing is known about migratory patterns of subadults and nonspawning adults.
- While precise homing to natal streams is assumed, no evidence of homing exists.
- Very little is known of the population dynamics of the species, except that spawning runs are dominated by old repeat spawners to a much greater degree than for the other three alosid species.

River Herring

- Extensive studies of individual runs of alewife and blueback herring have been conducted in states where major fisheries exist, particularly in New England and Virginia.

- In New England states, where major spawning and nursery grounds consist of lakes and ponds, long-term average run size appears to be a function of the amount of spawning/nursery acreage (Gibson 1984, unpublished manuscript).

- In New England runs, fishing mortalities of 80 to 95% do not appear to have a significant impact on spawning success (p. IV-62 of Appendix A).

- In runs occurring in the southeast, some evidence of the dominant year class phenomenon is seen in river herring stocks. (See discussion of Virginia runs on p. IV-22 of Appendix A.) The nature of nursery areas in Virginia differs from that of spawning areas in New England waters, and acreage available for spawning appears to have a lesser impact on stock size than is the case in New England.

- Limited information suggests that river herring stocks undertake extensive coastal migrations, summering in the Gulf of Maine and Bay of Fundy, and wintering in the mid-Atlantic area. Whether regional stocks differ in their extent of migration and whether all stocks intermingle are not known (see pp. IV-37 to IV-46 of Appendix A).

- Patterns of immigration and emmigration of adults and juveniles from spawning areas are well documented.

- The deleterious impact of offshore foreign harvests of Chesapeake Bay and southeastern region river herring stocks suggests that excessive fishing mortality (perhaps of subadult fish) can drastically reduce future recruitment. This observation is not consistent with findings in the New England area.

- Homing of New England stocks is well documented; degree of precision of homing in stocks occurring in tributaries of large estuaries has not been well documented.

American Shad

- Most of the detailed knowledge available concerning American shad population dynamics is for the Connecticut River. Less detailed data are available for other rivers, including the Altamaha, Susquehanna, Delaware, and Hudson.

- In the Connecticut River, with present stock levels, environmental variables (temperature and river flow) appear to exert dominant control on spawning success each year. For shad stocks at very low levels (e.g., Pawcatuck River in Rhode Island) numbers of spawning adults may be the major factor controlling spawning success (Gibson 1984, unpublished manuscript).
- Coastal migration patterns of shad are relatively well documented. All east coast stocks intermingle at sea; they summer in the Gulf of Maine-Bay of Fundy area and overwinter in the mid-Atlantic region. Combined stocks move inshore to the south at the beginning of their spawning migration; individual stocks split from the northerly moving aggregation as they encounter their natal rivers.
- Patterns of immigration and emmigration of adults and juveniles from the spawning areas are well documented.
- Amount of escapement from the fishery is believed to play a major role in assuring the continued stability of a stock. Modeling runs have suggested that for the Connecticut River, harvest rates exceeding 40% of females may endanger stock survival (Crecco 1985, unpublished data).

E. MANAGEMENT CONTEXT

The distinctive characteristics of the fisheries for the anadromous alosids and their life histories define and/or constrain the types of management actions that are feasible and that are likely to lead toward achievement of management objectives. The following topics comprise the context within which management recommendations must be developed. Each is supported by the technical material just discussed and elaborated on in Appendix A.

Homing and Inshore Fisheries

As a generalization, most fisheries for shad and river herring occur in or at the mouths of the spawning streams or rivers. (Individual exceptions occur such as the coastal shad fishery in South Carolina.) It is likely that these fisheries account for the major proportion of adult mortality. The significance to management of the occurrence of homing and the nature of these fisheries is that:

- Drainage systems in general support unique stocks of anadromous alosids.
- Fisheries on these individual drainages constitute a major source of adult mortality.

Offshore and Coastal Migrations and Fisheries

The significance of migration patterns is that:

- Offshore fisheries (foreign or domestic) have potential for affecting runs of all species along the entire east coast.
- Proposed tidal hydroelectric facilities in the Bay of Fundy area pose a serious threat to all east coast river herring and American shad stocks (there is no evidence of hickory shad occurring in the Bay of Fundy).
- Nearshore coastal shad fisheries may affect nonresident shad stocks undertaking their regular seasonal migration.

Population Dynamics

The significance of population dynamics characteristics is that:

- Any management recommendations regarding hickory shad will have virtually no rigorous scientific basis.
- Management recommendations for all runs of American shad may have to draw on information available in very limited geographic areas.
- Habitat management (e.g., improving water quality and access) may have greater impacts on stocks than would harvest restrictions where runs are stable and near maximum carrying capacity.
- Fishing mortalities could have very deleterious effects on stocks that are at low levels, and harvest restrictions may offer the greatest possibility for enhancing recruitment.

Geographic Differences in Stock Status

As was discussed earlier, alosid stocks in the Chesapeake and southeast regions appear to have suffered declines, while those of the mid-Atlantic and New England regions have not. Opportunities for restoration of anadromous runs exist along the entire coast, particularly in areas with large numbers of existing dams. The significance of these points is that:

- Management recommendations should be focused on southern and Chesapeake Bay stocks.
- Restoration could play a major role in enhancing existing stock levels in most regions.

Applicability of Management Options

The life histories of these species and their fisheries determine the potential effectiveness of various management actions.

- Harvest of river herring in the FCZ by U.S. fishermen, either in directed fisheries or as bycatch, is currently unregulated and cannot be regulated unless a management plan is developed by the regional Fishery Management Councils (FMCs).
- Because of the nature of the species' life history, very few year classes make up the segments of American shad and river herring stocks being exploited in coastal and riverine fisheries. Thus, regulations relating to size limits or mesh sizes and designed to prevent growth overfishing will have no impact on these stocks. Stocks where repeat spawning is very substantial may benefit from size or mesh restrictions (e.g., hickory shad).
- Types of regulations that affect the exploitation rate of females will be most effective for controlling recruitment of alosid stocks. Examples of such regulations include lift days, seasons, area restrictions, and gear-type restrictions.

F. REGULATORY FRAMEWORKS

Implementation of any management recommendations included in this plan must be accomplished within existing regulatory frameworks. In the case of the anadromous alosids, the applicable regulatory frameworks are numerous and complex.

Fisheries in the Fisheries Conservation Zone

During periods of ocean residence, all alosid species are vulnerable to fisheries operating in the Fisheries Conservation Zone (3 to 200 nautical miles offshore). Such fisheries fall under the broad management purview of the regional Fishery Management Councils (New England, Mid-Atlantic, and South Atlantic) under authority of the Magnuson Fishery Conservation and Management Act. The councils receive technical/administrative support and advice from the National Oceanic and Atmospheric Administration.

American shad are currently classed as a prohibited species for foreign fisheries within the FCZ. By this classification, none can be legally landed though incidental harvest and overboard disposal are not regulated against. Hickory shad, alewife, and blueback herring are collectively termed "river herring." No fishery management plan (FMP) for anadromous alosids in the FCZ currently exists. The species are mentioned in a Preliminary Management Plan for other species under jurisdiction of the Secretary of Commerce. A total allowable level of foreign fishing (TALFF) for river herring is established as part of the Preliminary Management Plan (PMP) for finfish caught incidentally to foreign trawl fisheries of the Northwest Atlantic. The TALFF is then allocated annually to specific countries by the Department of State based on recommendations from NOAA. Total allocations cannot exceed the TALFF, and for river herring the total landings have generally been well below the TALFF (100 metric tons (mt)) in recent years (1981-1984). No directed fisheries are permitted and all of the TALFF is applied to bycatch. In the absence of an FMP, there exists no regulatory basis for controlling river herring harvests by United States fishermen within the FCZ. Joint-venture fisheries, in which U.S. ships harvest fish which are sold to foreign processing ships, thus fall outside the constraints of the TALFF. Joint venture fisheries must still receive approval of the Councils, however, and receive a permit from NOAA.

State-Managed Fisheries

Fisheries within 3 miles of the coastline and in estuarine and fresh waters fall under the regulatory authority of the individual states. In many drainage systems, interstate management plans have been developed for American shad, as will be discussed below. However, implementation of recommendations in those plans is the responsibility of the individual states, which are not legally bound by those plans.

Regulatory procedures differ substantially among the states. In some the resource management agencies have full regulatory authority, while in others state legislatures retain that authority. Details of regulatory procedures by state are presented in Appendix B. Differing procedures for implementing regulations result in differing amounts of time required for implementation. Time constraints may impact on the feasibility of proposed management actions.

Interstate Agreements

A large number of rivers supporting anadromous alosid runs occur along or cross state boundaries, and interstate compacts or agreements exist for many: Potomac River (Maryland and Virginia); Delaware River (Delaware, New Jersey, Pennsylvania, New York, NMFS, FWS); Connecticut River (Connecticut, Massachusetts, Vermont, New Hampshire, NMFS, FWS), Merrimack River (Massachusetts, New Hampshire, NMFS, FWS); Hudson River (New York, New Jersey, USFWS, NMFS); and the St. Croix River (Maine, Canada).

Fisheries in the Potomac River are regulated by the Potomac River Fisheries Commission (PRFC). The Commission is made up of representatives from Virginia and Maryland and is supported by a technical staff responsible for drafting regulations and monitoring the fisheries. The Commission has to date developed no formal species management plans. Coordination of PRFC regulations with those of Maryland and Virginia is informal, by virtue of the lead resource management personnel from each state being on the Commission. The District of Columbia has recently established a fisheries management program and coordinates their management activities with the PRFC.

Management of Connecticut River anadromous fisheries was initially guided by the Connecticut River Fisheries Policy Committee. The Connecticut River Atlantic Salmon Commission, created by Public Law 98-138 in 1983, has since assumed responsibility for all restoration efforts on the Connecticut River. The commission includes members from Connecticut, Massachusetts, New Hampshire, Vermont, U.S. Fish and Wildlife Service, and National Marine Fisheries Service. The focus of management activity has been restoration of American shad and Atlantic salmon. Individual states retain autonomous regulatory authority, except on Atlantic salmon. However, the Commission serves as a forum for coordinating management activities of the individual states.

In the Delaware River drainage, the Delaware Basin Fish and Wildlife Management Cooperative was created to manage the interstate fisheries resources of the basin. Consisting of representatives from New Jersey, Delaware, New York, Pennsylvania, NMFS, and USFWS, the Cooperative developed a comprehensive fishery management plan for American shad in the Delaware. As with the other cooperatives, implementation of the recommendations is the responsibility of the individual states.

The Susquehanna River Anadromous Fish Restoration Committee (SRAFRC) was created to guide efforts to restore anadromous fish, particularly American shad, to the Susquehanna River drainage system. The committee includes representatives from Maryland, Pennsylvania, New York, USFWS, the Susquehanna River Basin Commission, and the utilities that operate hydroelectric facilities on the Susquehanna. Because restoration is in its initial phases, all committee activities have dealt with technical matters in contrast to management or regulatory matters. Pennsylvania and Maryland have agreed to keep Susquehanna River shad fisheries closed while a restoration program is proceeding.

A Technical Committee for Fisheries Management of the Merrimack River was formally established on 29 September 1969. This committee was formed to design and implement needed research programs as well as to recommend sound fishery management procedures for the restoration and utilization of anadromous fish species in the Merrimack River basin. The committee consists of representatives from the Massachusetts Division of Fish & Wildlife, the Massachusetts Division of Marine Fisheries, the New Hampshire Fish & Game Department, the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the U.S. Forest Service.

Planning for development of a fisheries management plan for the St. Croix River is currently underway. Tentatively the management committee will include representatives from Canada's Department of Fisheries and Oceans, and from Maine's Atlantic Sea Run Salmon Commission, Department of Inland Fisheries and Wildlife, and Department of Marine Resources. A draft plan is expected to be completed in 1985.

A cooperative agreement between Rhode Island and Connecticut for the management of anadromous fish in the Pawcatuck River is also currently being developed.

III. STATEMENT OF THE PROBLEM

As was described in the introduction, stocks of all four anadromous alosids, considered in aggregate along the entire east coast, have been perceived to have declined substantially over the past two decades. Earlier, even more drastic declines, such as those of the early 1900s (Mansueti and Kolb 1953), were readily attributable to such factors as:

- Construction of large dams across the mainstems of major spawning rivers that prevented access to large portions of historical spawning areas
- Pollution of spawning and nursery areas
- Overfishing due to the methods then allowed, including extending nets across entire rivers, no stream closures, and unlimited harvest.

The more recent declines have been perplexing and frustrating to fisheries managers for a number of reasons:

- No major new dam construction activity has occurred over the past two decades.
- At least modest restrictions on fishing methods and total effort have been in place for many years, both before and after the recent decline (at least for the inshore fisheries).
- While degradation of water quality concomitant with increased development of watersheds has certainly occurred in the last 20 to 30 years, the decline has been gradual, while the major decline in alosid stocks occurred in a relatively brief period in the late 1960s and early 1970s.
- Major declines appear to have occurred in stocks of the southeastern and Cheasapeake Bay regions, while stocks in the mid-Atlantic and New England regions appear to have remained at "acceptable" levels or to have actually increased.
- Concerns about declines in stocks have been based on documented declines in commercial and recreational harvests. While documented declines and relatively anecdotal observations all support inferences of stock declines, little hard data are available to rigorously quantify the declining trends and establish statistical relationships to potential causative factors.

In order to develop management recommendations for these species in the face of such uncertainties, specific problem areas must be defined to the extent that existing information permits. Based on the review and discussion of material presented in the Phase I document (Appendix A), the Scientific and Statistical Committee and Management Board have identified four problem areas relevant to all four of the alosid species addressed here. These problem areas provide the framework within which management recommendations were developed:

- Recruitment overfishing may have occurred for all species, and excessive mortality due to fishing may currently be keeping stocks at depressed levels. Evidence of this is strongest for river herring stocks, for which extremely large offshore harvests of adult and subadult fish were followed immediately by drastic declines in southeastern and Cheasapeake Bay stocks. Relatively high exploitation rates for American shad have been documented in recent years for a number of spawning rivers; excessive exploitation rates could cause major stock declines. At low stock levels, recruitment may be strongly affected by stock size. Thus, high rates of exploitation on stocks at low levels will severely depress recruitment.

- Habitat quality has declined. This generalization is best supported by recent documentation of the decline in water quality of the Chesapeake Bay (EPA 1984), but is confirmed by findings of numerous other studies of river systems along the east coast. The Delaware River situation provides some confirmation of the validity of this problem but from an opposite perspective. Improvements in water quality in the Philadelphia-Camden area of the Delaware River were accompanied by gradual increases in shad stock; however, in some systems (e.g., Ogechee River, Georgia) shad stocks declined drastically with no observed changes in water quality. No substantial decreases in quantity of available habitat can be documented to have occurred in the past two decades. However, changes in river flows due to hydroelectric development and water use may have had impacts on specific stocks.

- American shad stocks from a large number of different river systems may be exposed to intercept fisheries during residence in ocean waters. Rapid expansion of the South Carolina coastal fishery in the last 5 or 6 years may have been supported by exploitation of mixed stocks of fish moving northward as part of their spawning migration pattern. However, no hard evidence of the effect of this fishery on exploitation rates of nonresident stocks is available. Restrictions on stationary gear (the major type used in this fishery) went into effect within the last two years, but apparently had only a limited impact on shad harvest (W. McCord, South Carolina Wildlife and Marine Resources Department, personal communication). Evidence of increased harvests of shad in territorical seas and the FCZ exists for many states along the coast (including Delaware Bay), and all such fisheries are exploiting multiple stocks. These types of fisheries pose potential interstate management problems. The lack of knowledge of the contribution which these fisheries make to total mortality of various stocks, the lack of knowledge as to which stocks are being most affected and the vulnerability of newly restored or depressed stocks to any additional sources of mortality all point to the potential importance of these intercept fisheries.

- <u>Major data deficiencies limit the development of scientifically rigorous management decisions</u>. As has already been discussed, many elements of population biology and life history are poorly documented for the anadromous alosids, especially hickory shad. This lack of knowledge will prevent the development of scientifically rigorous management recommendations. For example, recommendations on sustainable yields will not be possible. The almost total absence of useful data on hickory shad will allow development of only general recommendations for that species. However, the review of existing information does allow us to set research priorities.

IV. STATEMENT OF MANAGEMENT GOAL AND OBJECTIVES

A. MANAGEMENT GOAL

The goal of this management plan is as follows:

> The goal of this Fisheries Management Plan (FMP) shall be to promote, in a coordinated coastwide manner, the protection and enhancement (including restoration) of shad and river herring stocks occurring on the Atlantic seaboard. This plan was developed because of depletion of stocks from overfishing, loss of habitat (resulting from construction and operation of dams and from pollution), inconsistencies in management actions, and lack of adequate data.

This management goal was established at a joint meeting of the Scientific and Statistical Committee and the Management Board, held in Windsor Locks, Connecticut, 18-19 July 1984. The debate leading to establishment of this goal was long and often heated. Two major points of contention were:

- The need or lack of need for numerical goals. This argument centered on the basis for assessing whether the goal was being approached or met. One school of thought was that some numerical goal, such as commercial harvest levels experienced in the early 1960s, should be set as a basis for tracking the success of whatever management actions were implemented. The counter school of thought was that landings were heavily influenced by effort and market factors, thus placing into question the comparability of past and future harvest totals. The consensus was that the primary problem at present was that stocks were extremely low, and that it was premature to set specific numerical goals, especially since the focus of this plan is relatively short term. A number of existing state and interstate restoration plans do have numerical goals.

- Time limits for attainment of goals. This argument was similar to that concerning numerical goals, that is, some benchmark was necessary against which to measure progress. The consensus was that time limits for some objectives should be set, but that a time limit for the attainment of the overall goal was inappropriate.

B. OBJECTIVES

Objectives consistent with the management goal were developed at the July 1984 meeting mentioned above. Draft versions of those objectives were further refined at a meeting of the Shad and River Herring Management Board in Savannah, Georgia, on 1 October 1984. The objectives focus on the statement of the problem in Section III above, and they provide the rationale for the recommended management actions, which follow in Section V.

- <u>Objective 1</u>

  Regulate exploitation to achieve fishing mortality rates sufficiently low to ensure survival and enhancement of depressed stocks and the continued well-being of stocks exhibiting no perceived decline. A corollary to this objective is minimization of exploitation of a given state's stocks by other states or nations.

- <u>Objective 2</u>

  Improve habitat accessibility and quality in a manner consistent with appropriate management actions for nonanadromous fisheries. This objective can be addressed by the following types of management actions:

  -- Improve or install passage facilities at dams and other obstacles preventing fish from reaching potential spawning areas.

  -- Improve water quality in areas where water quality degradation may have affected alosid stocks.

  -- Ensure that decisions on river flow allocation (e.g., irrigation evaporative loss, out of basin water transport, hydroelectric operations) take into account flow needs for alosid migration, spawning, and nursery usage.

  -- Ensure that water withdrawal (e.g., cooling flow, drinking water) effects (e.g., impingement and entrainment mortalities, turbine mortalities) do not affect alosid stocks to the extent that they result in stock declines.

- <u>Objective 3</u>

  Initiate programs to introduce alosid stocks into waters that historically supported but do not presently support natural spawning migrations, expand existing stock restoration programs, and initiate new programs to enhance depressed stocks.

- Objective 4

  Recommend and support research programs that will produce data needed for 1) the development of scientifically rigorous management recommendations relating to sustainable and acceptable yields, 2) the preservation of acceptable stock levels, and 3) optimal utilization of those stocks.

V. MANAGEMENT RECOMMENDATIONS

The management recommendations presented here consist of actions that the Scientific and Statistical Committee and Board feel are necessary to achieve the objectives presented in Section IV. As was stated in earlier portions of this plan, many of these action items will generate data useful for development of additional recommendations. Thus, this plan must be modified on a regular basis if the management goal is to be ultimately met. Most of the following recommendations relate specifically to the objectives presented in Section IV.

A. REGULATION OF EXPLOITATION RATES

Concerns about exploitation fall into three basic categories, as presented in Section III, "Statement of the Problem":

- Exploitation of river herring, specifically, and American shad (if such harvest occurs) in the Fisheries Conservation Zone to the extent that inshore harvests and stock levels are affected
- Establishment or expansion of territorial sea fisheries for American shad (within 3 miles of shore) that exploit nonresident stocks
- Excessive exploitation of all of the alosids within traditional fishing grounds (i.e., internal waters) to the extent that recruitment overfishing is possible or stocks are prevented from increasing to levels supportable by existing habitat.

Specific management recommendations are presented for each of these three categories, following some elaboration of the basis for the concern and for the recommendation.

Exploitation in the Fisheries Conservation Zone

The potential problem of excessive harvest of river herring in the Atlantic Ocean from 3 to 200 miles offshore has very recently become a critical issue. Relevant events of the first several months of 1985 are documented in Appendix C. Applications to the Mid-Atlantic Fisheries Management Council for joint venture fisheries for mackerel prompted the recent activity. River herring are taken as bycatch in mackerel fisheries, and mackerel harvests of the magnitude projected for these fisheries would have resulted in river herring bycatches exceeding the current TALFF of 100 metric tons (mt). ASMFC was invited by the council to provide testimony concerning anticipated recommendations on TALFF at a January 1985 council meeting. Protracted discussion of the issue without its resolution led the council to assign the issue to its Coastal Migratory Species Committee for resolution. ASMFC was again invited to send representatives to the committee meeting to act in an advisory capacity. Minutes of this 5 March 1985 meeting are presented in Appendix C. The major actions resulting from this meeting were:

- Foreign mackerel fisheries were excluded from areas within 20 miles of shore and from a zone south of a line extending east from just north of the mouth of the Chesapeake Bay. TALFF was specified to be less than 1% of mackerel harvest, with no total limit. The intent of these modifications was to exclude foreign fisheries from areas where river herring bycatch was expected to be high, and where the stocks being affected were believed to be those from the Chesapeake and southeastern regions where populations are currently low.

- The committee concluded that they could not impose restrictions on mackerel fisheries prosecuted by American fishermen, whether operating on their own or as joint-venture partners. Thus, no action was recommended by the committee that would decrease the likelihood of large amounts of river herring being taken as bycatch by American fishermen.

- The committee requested ASMFC assistance in developing a list of data that could be recorded by NOAA observers working on offshore vessels and that would contribute to assessing the potential significance of river herring harvests in these expanding fisheries. Data needs were forwarded to the council.

Offshore harvests represent an uncalculated threat to inshore domestic fisheries. The possibility of dramatic changes in the offshore fisheries, with concomitant changes in river herring harvests, confirms the need to monitor this situation and initiate new actions to protect and enhance the river herring stocks as circumstances change. Recent events demonstrate that cooperation among ASMFC, the councils, and NOAA is feasible even in the absence of any formal cooperative agreement. However, under this arrangement, ASMFC remains in only an advisory role and has no formal vote on any managment action. The recommendations that follow are based on the above discussion and material presented in Appendix C.

- Recommendation 1.1

  ASMFC will review, annually, Fishery Management Council decisions and NOAA regulations based on those decisions that relate to the anadromous alosids. Based on any new information or changes in existing status of the stocks, directed fisheries, or fisheries having a potential impact on the alosids, ASMFC shall develop and submit recommendations to the Fishery Management Councils. ASMFC shall retain their position as a voting member on council committees that address anadromous alosid issues (e.g., the Mid-Atlantic Council's Coastal Migratory Species Committee).

- Recommendation 1.2

  ASMFC will closely monitor the establishment and growth of joint venture and domestic mackerel fisheries in order to evaluate the consequences to river herring stocks of their capture as bycatch. ASMFC will join in the request of the Mid-Atlantic Fishery Management Council for implementation of a data collection plan by NMFS pursuant to Section 303(e) of the MFCMA. Data to be collected pursuant to such a plan should conform to the recommendations set forth in Appendix C of this plan. These data will be evaluated and analyzed to arrive at the recommendations mentioned above.

Territorial Sea Fisheries

The issue of territorial sea fisheries relates primarily to American shad at present. While no similar problems appear to exist currently for either hickory shad or river herring, the recommendations below would apply to those species should similar problems arise some time in the future.

During preparation of this plan, potential problems with expanding shad fisheries in the ocean along the Atlantic coast were identified in Maryland, New York, New Jersey, South Carolina, and the Gulf of Maine. The nature of this potential problem is that these fisheries take shad originating in many different river systems along the east coast, as documented by a number of tagging studies (see Appendix A). Fisheries in the Delaware Bay also exploit stocks from many other georgraphic areas. These fisheries are potentially disruptive of traditional fisheries in internal waters.

At this time, these fisheries are rather limited in scope. Should the market situation change, however, expansion could occur and they could impact on some stocks. South Carolina coastal fisheries are also believed to be very wasteful. Weather conditions frequently prevent prompt tending of nets resulting in loss of harvest and often resulting in loss of gear which kills additional fish. Potential problems with these fisheries are exacerbated by the fact that at present it is not possible to distinguish the origin of fish taken in the catch. For this reason, it is not possible to determine which stocks are being most impacted by any of these fisheries.

In 1984, South Carolina promulgated regulations which prohibited the use of stationary gill nets in coastal areas. It was anticipated that these restrictions would effectively eliminate this fishery since stationary gill nets were the primary gear used. However, fishermen have apparently been able to use drift gill nets to continue this fishery. Because of the high market value of shad caught early in the season (when the South Carolina fishery was occurring), it is likely that elimination of that fishery would stimulate establishment of new fisheries, either outside the 3 mile limit or in other states. In addition, numerous anecdotal accounts of increasing offshore (beyond the 3 mile limit) shad gillnetting in many states up and down the coast have been received by Shad and River Herring Scientific and Statistical Committee members. Thus, the status of these fisheries has changed markedly, particularly over the past 18 months, and they remain a serious concern, especially to states initiating restoration programs. Very small, newly established stocks, such as those in the Susquehanna River (Pennsylvania, Maryland) and the Pawcatuck River (Rhode Island) could be seriously impacted if they were to suffer significant non-natal stream fishing mortality.

Based on this and earlier discussion, the following recommendations are presented:

- Recommendation 2.1

  Each state, in cooperation with NMFS, will monitor and document existing and new FCZ and territorial sea fisheries for anadromous alosids. The extent of participation, amount of harvest, and timing and location of each fishery will be documented; this information will be forwarded to ASMFC for its annual review of fisheries and stock status and for consideration of revision of existing recommendations in this plan. An interstate cooperative coastal shad tagging program will be conducted to determine which stocks are being exploited (see Recommendation 8.3).

- Recommendation 2.2

  All east coast states will recognize the priority rights of traditional fisheries in internal waters that target resident stocks, while not encouraging new intercept fisheries in territorial sea waters. Of greatest concern are fisheries taking shad along the coast very early in the year, including those occurring in South Carolina, North Carolina, Virginia, Maryland, and the Delaware Bay. What appears to be an expanding summer-fall gill net fishery in the Gulf of Maine should also be closely monitored by the New England states. Such fisheries should not be encouraged and, if evidence suggests they pose a threat to any single stock of shad, steps should be taken to prohibit them.

Controlling Exploitation Rates in Internal Waters

At the current time, and in the future should the above recommendations be implemented, most alosid stocks will experience most of their fishing mortality within waters under regulatory control of the state of their origin. Recommendations presented here represent advice to individual states on how to enhance the status of their own stocks, based on information documented in Appendix A, and in additional data compiled since publication of that report, which will now be discussed.

Appendix D summarizes information from studies in which fishing mortality rates of American shad were measured. Leggett (1976) and Crecco et al. (1985) have established that exploitation rates measured using disc tags have severe biases due to the manner in which the tag increases probability of capture by gill net. Using information presented in Leggett (1976) and included in Appendix D, mortality rates arrived at using disc tags were adjusted. These mortality rates were discussed by the full Scientific and Statistical committee on a number of occasions, and by a Chesapeake Bay-southeastern subcommittee meeting 20-21 February 1985, in Norfolk, Virginia. Examination of these data suggests that at least some shad stocks were experiencing very high exploitation levels prior to their recent declines. However, equally evident are many systems where high rates were recorded while stocks were doing rather well (e.g., James River in 1952). In general, however, adjustment of mortality rates measured using disc tags reveals that what had previously been considered to be very high exploitation rates during periods of stock stability were in reality substantially lower (e.g., Hudson River: reported rate, 65.7%; adjusted rate, 38.7%). In general, exploitation rates during periods when shad stocks were stable were less than 40%.

Additional evidence suggesting that natal river fishing rates have influenced the status of shad stocks includes the following:

- Analysis of historical data for the Connecticut River (Leggett 1976) revealed close relationships between high fishing pressure (50-60% exploitation rate) and subsequent stock declines during the period immediately after World War II. This confirms the role that excessive fishing mortality may play in shad declines and is the strongest case history supporting a 40% natal river fishing rate limit.

- Shad are fast-growing, short-lived fish. The exploited stock consists of only two or three year classes; thus, the species is vulnerable to recruitment overfishing, particularly since spawning success is strongly influenced by environmental conditions. The same type of life history is exhibited by the river herrings. (Northern stocks, however, exhibit extensive repeat spawning, as do hickory shad.) This life history strategy is consistent with those of many marine clupeids for which recruitment failure due to excessive exploitation rates has been documented.

- Gibson (1985, unpublished manuscript) analyzed data from the Pawcatuck River; his regression analyses revealed that 95% of the variation in Pawcatuck River year class strength thus far in that restoration effort can be attributed to the size of the spawning stock; this finding is in strong contrast to results on the Connecticut River, where Crecco (1984) found that parental stock size had only a small effect on year class size. Stock sizes of the Pawcatuck and Connecticut rivers differ from each other by several orders of magnitude. Gibson interprets his results as support for the contention that year class size is most dependent on environmental conditions when spawning stocks are large, and is most dependent on spawning stock size when spawning stocks are low. Restricting harvest when the number of spawners is depleted may enhance recruitment.

Recent population modeling work by Crecco (1985, personal communication) has suggested that the Connecticut River stock of shad could collapse if exploitation rates exceed 40% of the females. These modeling results are consistent with the case history of the Connecticut River stock discussed above (Leggett 1976). The model results are based on multiple runs of the model, each covering a 100-year time period, starting out with populations at their current levels, and incorporating functions reflecting documented relationships between environmental variables and spawning success (Crecco and Savoy 1985, in press) and relationships between fishing mortality and stock size. One key element in the model is that the potential for capture by the commercial fishery increases as stock size decreases with the result that catch per unit effort (CPUE) and total harvests remain steady or decrease only slightly while the stock is actually declining substantially. It will be very important in effecting future modifications of this plan that the existence of such a relationship in other shad and river herring fisheries along the coast be confirmed and quantified.

Integration of all of the above information led the Scientific and Statistical Committee to conclude that restrictions on exploitation rates can contribute to enhancing the status of newly established or currently depressed stocks and help prevent the collapse of stocks currently at acceptable levels. However, the degree of restriction needed will vary with the current status of the stocks.

For the purposes of this document, the committee has defined exploitation rate as the percentage of female fish in the spawning run that are captured in recreational or commercial fisheries during their spawning run in a single year. Implicit in these recommendations is the assumption that nonnatal stream exploitation rates remain constant [<15%, as was found for Connecticut River shad by Leggett (1976)]. Any increase in offshore or coastal exploitation rates would cause the recommended maximum harvest levels to be too high and would call for more restrictive limits. Three levels of maximum exploitation rate within natal rivers were assigned to the various alosid stocks (Table V-1), based on the following definitions of stock status:

	Status	Definition
I	Severely Depleted	Stocks currently at very low levels relative to their status during the 1950s and 1960s.
II	Depleted or Newly Established	Stocks currently substantially below levels which the habitat is known to be able to support. Also applies to newly restored stocks.
III	No Perceived Decline	Stocks which have remained relatively stable over the last 20 years.

The absence of reliable indicators of stock size for most years in most drainage systems for all four species discussed

Table V-1. Recommended maximum exploitation rates for shad and river herring. These recommended values will be modified as new data become available.

Stock and Status	Maximum Exploitation Rate (%)	Specific River or State (for all rivers within a state)
<u>American Shad</u>		
Severly depleted	0	Maryland
Depleted or newly established	25	Virginia, Florida, North Carolina, Rhode Island, Delaware River
No perceived decline	40	Connecticut and Hudson rivers, South Carolina, Georgia[a]
<u>Blueback Herring/Alewife</u>[b]		
Severly depleted	0	Maryland
Depleted or newly established	25	North Carolina, South Carolina, Florida, Virginia

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(a) See text on page V-9 concerning Georgia.
(b) Alewife outside of New England.
(c) No information on Georgia or Delaware bluebacks.

Table V-1. Continued

Stock and Status	Maximum Exploitation Rate (%)	Specific River or State (for all rivers within a state)
<u>Blueback Herring/Alewife</u> (Cont'd)		
No perceived decline[c]	40	Connecticut River, Hudson River
<u>New England Alewife</u>		
No perceived decline	Not to exceed current levels	Rhode Island, Connecticut, Massachusetts, New Hampshire, Maine
<u>Hickory Shad</u>		
Severely depleted	0	Maryland
Depleted	25	North Carolina, South Carolina, Georgia, Florida, Virginia

here prevented these categories from being defined quantitatively. Placement of individual stocks into categories was done using trends in landings over the past 20 years and all information available to fisheries biologists working in the respective states. The recommended exploitation values given in Table V-1 will be modified as new data become available.

The recommended exploitation rates for blueback herring presented in Table V-1 are the same as those for American shad because they have similar life history characteristics. Most hickory shad stocks were treated as "depleted," and it is recommended that natal exploitation rates not exceed 25%. The alewife stocks outside New England were pooled with the blueback herring because they often co-occur in the landings. The New England alewife was placed in the "No perceived decline" group, mainly because these are traditional fisheries that have persisted despite high levels of exploitation (60-90%), which is probably a function of the habitats used by those stocks.

While the rationale for a 40% rate for American shad is supported by a large amount of information, the scientific basis for the other specific recommendations is relatively arbitrary. The intention of the committee was to identify rates which by consensus were deemed to be conservative (i.e., that might be more restrictive than necessary.) As additional information is gathered on mortality rates of all these species, particularly in the Chesapeake Bay and southeastern regions, the recommendations will be reassessed.

Exploitation rate data collected in ongoing studies of shad in the Altamaha River, Georgia (Michaels 1984), raise several questions about the appropriateness of 40% as a generally applicable maximum exploitation rate. Data from three years of study revealed female exploitation rates of 47% to 64% (see Appendix D), yet stock abundance has appeared to remain stable. Whether southern stocks may be capable of sustaining higher exploitation rates than more northern stocks (such as those in the Connecticut River) will not be confirmed until longer-term studies are completed. In the absence of proof of such a contention, however, the committee felt that a conservative recommendation was appropriate.

The recommendations on exploitation in internal waters assumes that exploitation in territorial seas and the FCZ remains relatively insignificant. Any substantial change in those fisheries would have an impact on the efficacy of these recommendations. The percentage figures presented in Table V-1 are intended to be acceptable maxima, and are not to be construed as exploitation goals.

The recommendations arising from the above discussion are:

- Recommendation 3.1

  Individual states will consider implementing fisheries management actions that would ensure that total exploitation rates for female American shad, hickory shad, and river herring (commercial and recreational) do not exceed levels that threaten the stability of stocks currently at acceptable levels or the enhancement of depressed or newly established stocks. Guidelines for exploitation rates are presented in Table V-1.

- Recommendation 3.2

  Individual states will initiate studies to document existing fishing mortality rates of all four alosid species and to establish if density dependent catchability exists. Recommended guidelines for design of an acceptable study are presented in Table V-2. States shall obtain at least preliminary data within 2 years of adoption of this plan and provide these data to ASMFC for integration and distribution to interested parties.

- Recommendation 3.3

  Individual states shall improve records of catch and effort in general, and make a special effort to establish the amount of harvest reported as American shad and/or river herring that is actually hickory shad. Examples of steps that could be taken include education of fishermen, modification of reporting forms or mechanisms, and creel/harvest census during critical time periods.

B. IMPROVEMENT OF HABITAT QUALITY

Water Quality

The contribution of degradation in water quality to the observed declines in anadromous alosid stocks has been alluded to in past evaluation of these stocks (Mansuetii and Kolb 1953; Walburg and Nichols 1967) and is discussed in the Phase I report and this document. However, it has never been possible to rigorously quantify the magnitude of this contribution. Only

Table V-2. Suggested guidelines for studies to assess exploitation rates of anadromous alosids[a]

Basic study type	• Tag and recapture
Timing	• Tagging to start near the beginning of the spawning run, and continue through the run; tagging should stop before water temperatures reach levels at which handling mortality becomes significant • Reaction of fish to tagging should be determined (i.e., do most fish move downstream and, if so, how far)
Location	• Ideally, fish for tagging should be captured downstream of the major areas of exploitation
Target sex	• Focus on females if funding constrains the scope of the program
Tag type and tag return program	• Anchor streamer tags (as used by Crecco (Conn) and Michaels (Ga)) • Multilevel reward ($5, $10, $25) plus incentives (e.g., lottery) • Occasional canvass of fishermen, fish houses, and wholesalers

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[a] These guidelines are to some extent based on studies currently being done on Connecticut River and Altamaha River American shad. However, they should be equally appropriate for all studies of anadromous alosids, with modifications for the specific location, type, and timing of fisheries in individual drainage systems.

Table V-2. Continued

Number of fish to be tagged	● As many as funding permits (larger numbers of tag returns provide more precise estimates of exploitation) but distributed over the major portion of the run
Capture method	● Hook and line, pound nets (where possible), or drift gill nets. (Mesh sizes used should include those used by commercial fishermen as well as somewhat larger and small meshes to ensure adequate sampling of all age groups.)

on the Delaware River, where water quality problems were dramatically manifested in a "pollution block" in the Philadelphia/Camden area, has pollution abatement resulted in a measurable and large enhancement of an alosid stock, in this case American shad. In most anadromous alosid spawning and nursery areas, water quality declines have been gradual and poorly defined, and it has not been possible to link those declines to changes in alosid stock size. Conversely, in cases where there have been drastic declines in alosid stocks, such as in the Susquehanna River and upper Chesapeake Bay in Maryland, water quality problems have been implicated but not conclusively demonstrated to have been the single or major causative factor.

While cause and effect have not been rigorously demonstrated between water quality changes and alosid stock status, many water quality variables are known to affect the health and well being of all aquatic biota. Documentation of these effects, specifically for the four anadromous alosids, contributes to defining water quality criteria sufficient to protect alosid stocks.

Certain basic water quality parameters have been monitored throughout the east coast in a variety of water types. Such parameters include temperature, dissolved oxygen, conductivity/salinity, pH, and turbidity. The effects of many of these variables on various life stages of the four alosid species have also been studied, although to different degrees depending on species and variable. Available information on these effects is presented in Appendix E with individual tables included for three of the four species. Sources of these data are also included in the Appendix. No information on hickory shad responses to these water quality variables was found.

Some of the information presented in Appendix E was drawn from "A Management Plan for the American Shad (*Alosa sapidissima*) in the Delaware River Basin," prepared by the Delaware Basin Fish and Wildlife Management Cooperative in 1981. Additional guidance on acceptable levels of dissolved oxygen (DO) for shad appears in a document entitled, "Dissolved Oxygen Requirements of a 'Fishable' Delaware River Estuary," prepared for the Delaware River Basin Commission by an ad hoc task force in 1979 and since adopted by resolution of the Cooperative as an official recommendation concerning DO standards. Of all water quality parameters addressed in those documents, acceptable standards were specified only for dissolved oxygen. Additional studies to determine tolerance levels were recommended for the remaining parameters. The Delaware DO guidelines were accepted for this plan as being the desirable levels for protecting and enhancing anadromous alosid stocks.

The Instream Flow and Aquatic Systems Group of the USFWS is presently completing a Delphi assessment to provide information on American shad habitat requirements for use in decision making on instream flow needs. Alosid flow requirements are addressed in detail below. However, a portion of the Delphi process dealt with temperature requirements of all life stages of American shad. Temperature data from that Delphi process provide the basis for temperature criteria presented here.

Other substances that occur in anadromous alosid spawning and nursery areas and are believed to be potentially harmful to aquatic life have been very poorly monitored. These substances include toxic materials such as heavy metals and various organic chemicals (e.g., insecticides, solvents, herbicides). In the literature searches performed to construct the tables in Appendix E, no data were found indicating the concentrations of these substances that cause deleterious effects on any of the alosids. The Delaware Management Plan also provides no specific data on tolerance levels. The absence of such data precludes the development of acceptable water quality criteria for these substances.

The possiblity that acid rain may be a major factor in the decline of many anadromous fishes along the east coast has recently arisen as a major water quality issue. The existing information on tolerance of alosids to low pH is very limited (Appendix E) and insufficient to draw conclusions about the importance of acid rain in alosid declines. However, many studies are currently underway to investigate pH effects (including work sponsored by the Joint NMFS/USFWS Emergency Striped Bass Research Program, and by the Tidewater Fisheries and Power Plant Siting Program divisions of the Maryland Department of Natural Resources). The importance of these studies must be recognized in the recommendations presented in this segment of the plan.

While water quality may have drastic effects on fisheries, in most states the responsibility for water quality regulations and criteria is assigned to an agency different from the one responsible for fisheries management. The following recommendations deal with acceptable water quality criteria and actions necessary to ensure their being addressed in state water quality regulations. Because data on indivdual species are sometimes limited, the specific criteria suggested here are drawn from data for all species and are considered suitable for anadromous alosids in general.

- Recommendation 4.1

  Resource management agencies in each state shall evaluate their respective state water quality standards and criteria to ensure that those standards and criteria account for the special needs of anadromous alosids.

This action should be taken within the normal cyclical process of criteria review that occurs in most states. Steps should be taken within 1 year of implementation of this plan to create a new class of waters (or redefine an existing class) to acknowledge status or potential status as anadromous alosid spawning and nursery areas (analogous to "trout waters"). Primary emphasis should be on locations where sensitive egg and larval stages are found. For those agencies without water quality regulatory authority, protocols and schedules for providing input on water quality regulations to the responsible agency should be identified or created. Waters of existing or potential value as alosid spawning/nursery areas should be identified for the appropriate water quality agency. Agencies in each state shall initiate actions to establish water quality criteria protective of anadromous alosid habitat requirements, but consistent with the management objectives for other species. Suggested values for key parameters are presented in Table V-3.

- Recommendation 4.2

Results of ongoing studies dealing with the effects of acid deposition on anadromous alosids will be reviewed by all appropriate agencies and ASMFC as they become available. ASMFC will summarize those findings in a position document on an annual basis. Should those findings support the contention that acid deposition is having a deleterious impact on anadromous alosids, ASMFC shall offer that document as supporting evidence to all organizations and individuals pursuing acid rain controls and/or mitigation measures.

Flow Requirements

Riverine habitats serve as routes for migration and as spawning and nursery areas for most stocks of the four anadromous alosids. While these species have evolved such that stocks are able to survive natural deviations in river or stream flow (e.g., storm freshets, draughts), regular, unnatural alterations of flow caused by human water use activities can have serious effects on populations. Major problems arise with the creation or refurbishing of hydroelectric facilities. Such projects may deny access to spawning areas (a topic addressed below) but also may alter habitat characteristics such as flow (due to peaking operation and imposition of low flows) and water quality (due to impoundment effects such as decreases in DO and temperature).

Table V-3. Suggested water quality criteria suitable for anadromous alosid spawning and nursery areas

Variable	Time Period and Biological Activity	Value or Range	Goal of Criterion	Source of Information
Dissolved oxygen	Spring and fall (adult and juvenile migration)	Seasonal average not less than 6.5 mg/l; instantaneous minimum 4.0 mg/l	Permit successful movement of fish to and from spawning nursery areas	Delaware River Basin Fish and Wildlife Cooperative (1981)
	Summer (nursery for juveniles)	Not less than 5.0 mg/l at any time	Permit successful growth and survival of juveniles	Delaware River Basin Fish and Wildlife Cooperative (1981)
Suspended sediments	Spring through fall (migration, spawning, nursery activity)	Seasonal average <25 mg/l	Prevent adverse effects of suspended solids on the fish and their habitat	Delaware River Basin Fish and Wildlife Cooperative (1981)
Temperature	Spring (adult migration)	Water body cross-sectional average not to exceed 75°F; ΔT not to exceed 10°F	Ensure that heated water discharges will not block migration	USFWS Delphi (1985)
	Spring (spawning)	Mean daily temperature between 50° and 75°F; ΔT not to exceed 10°F	Ensure that heated or cooled (e.g., dam outflows) discharges will not impair spawning success	USFWS Delphi (1985)

Table V-3. Continued

Variable	Time Period and Biological Activity	Value or Range	Goal of Criterion	Source of Information
Temperature (continued)	Summer (nursery)	Mean daily temperature between 55° and 80°F; ΔT not to exceed 10°F	Ensure that heated or cooled discharges will not impair juvenile growth and survival	USFWS Delphi (1985)
	Fall (juvenile migration)	Water body cross-sectional average not to exceed 70°F (river herring) or 75°F (shad); ΔT not to exceed ± 10°F	Ensure that heated water discharges will not block migration	USFWS Delphi (1985)
pH	Spring (spawning and larval growth)	Instantaneous minimum 6.0 (concomitant aluminum levels must also be considered)	Allow survival and normal development of eggs and larvae	Preliminary laboratory results, MD Department of Natural Resources
Chlorine	Spring (eggs and larvae and juvenile survival)	<0.20 ppm	Allow survival and normal development of eggs and larvae	Morgan and Prince (1977); PSEG (1980)
Toxic compounds (metals, organics)		No available data	Permit successful completion of freshwater segment of life cycle	

Most resource agencies participate in the review of proposed hydroelectric and other water use projects. One frequent element of such reviews is an evaluation of the adequacy of proposed instream flows for protecting aquatic resources. Existing state regulations and/or guidelines regarding hydroelectric projects and stream flows are summarized in Appendix F.

The USFWS participates in the review of nearly all projects that affect stream flows. To facilitate their review of such projects and to provide an objective basis for instream flow decisions, an Instream Flow and Aquatic Systems Group was established within the Division of Biological Services. The function of this group is to develop objective methodologies for defining acceptable flow levels, and to provide assistance to USFWS, state agency personnel, and any other individuals or organizations involved in project reviews. In carrying out this function, this group has established a library of suitability index (SI) curves for various aquatic species for major habitat parameters. Curves for only one of the four anadromous alosids (American shad) have thus far been incorporated into this library. (SI curves are now being completed and will be added to the library in 1985.) Shad SI curves were developed using a Delphi process employing from 10 to 13 shad experts. Habitat characteristics included in this process were current velocity, water depth, substrate, cover, and temperature. Results of this effort offer guidance for selecting acceptable flows at projects where shad may be impacted.

Additional guidance for selecting minimum flows is provided by the requirements of individual states (Appendix F) or other agency divisions. The New England Regional USFWS office has developed guidelines for acceptable minimum flows at projects in the New England States. Their aquatic base flow (ABF) is calculated as the median daily average flow in the low flow month (generally August) for all years of record. The ABF represents the USFWS's minimum flow recommendation unless evidence is provided by the project applicant demonstrating that a lower flow is sufficient to protect aquatic resources.

Decisions on minimum flows are necessarily site specific. The intent of this segment of the plan is to provide general information that can be used by individual agencies to establish flows sufficient to protect anadromous alosid stocks, taking into account site specific factors. Substantial data relating to the flow needed for survival of American shad are available; such data are not available for the other three species. Loesch and Lund (1977) have suggested that blueback spawning sites are characterized by currents stronger than those preferred by alewives. However, no specific required velocities have been established. Recommended flow parameters for those three species are necessarily vague.

The importance of flow to alewife stock success has been reinforced by recent findings in Rhode Island (M. Gibson 1985, personal communication). Draught conditions prevailed during the summer of 1981, and current runs reveal that the contribution of the 1981 year class to 1984 runs is only about half of what would be expected from existing data (i.e., 22% of the run instead of 44%). While flow regulations cannot compensate for such draught conditions in many small waterways, they may prove very beneficial where augmentation of flows is feasible.

- Recommendation 5.1

  State resource management agencies shall identify or establish protocols that ensure that they have the opportunity to evaluate projects that may affect the flow of streams and rivers supporting or having the potential for supporting runs of anadromous alosids. State resource management agencies shall determine which state agency serves as the primary contact with the Federal Energy Regulatory Commission (FERC), since all applications relating to hydroelectric development are processed by the FERC.

- Recommendation 5.2

  In reviewing proposed projects that will affect flow regimes, agencies shall ensure that continuous minimum flows and the manner in which the operation of any facility alters flows will not adversely affect anadromous alosids. Guidelines for desirable instream flow variables are presented in Table V-4. State agencies should, if necessary, solicit the advice of the USFWS Instream Flow Group in developing flow recommendations.

Other Habitat Factors

Most human activities that affect alosid stocks do so indirectly by changing water quality or flows. However, several types of facilities and operations cause mortality directly. Prominent in this category are facilities using water for cooling purposes (e.g., power plants) or large volume water withdrawals (e.g., drinking water, pumped storage hydroelectric projects, irrigation). Fish mortality is caused by entrainment (i.e., intake and passage through the cooling or water withdrawal system) or impingement (i.e, entrapment on screens used to

Table V-4. General guidelines for selection of instream flows suitable for anadromous alosids; more specific details can be obtained from the indicated sources, particularly the SI curves from the FWS Delphi process.

Specific Guidelines

Species	Activity	Variable	Level	Source
American shad	Spawning/ incubation	Velocity	0.5-3.0 ft/sec	FWS Delphi, 1985
		Depth	2 to 40 ft	
		Substrate	Sand, gravel, cobble	
	Nursery	Velocity	0.2 to 3.0 ft/sec	
		Depth	3 to 40 ft	
	Migration	Velocity	0.5 to 3.0 ft/sec	
		Depth	< 1 ft	
Hickory shad, river herrings		NO DATA AVAILABLE		

General Guidelines

Loar, J.M. and M. J. Sale. 1981. Analysis of Environmental Issues Related to Small-Scale Hydroelectric Development: V. Instream Flow Needs for Fishery Resources. Oak Ridge National Laboratory, Environmental Sciences Division, Publication No. 1829. ORNL/TM-7861 ORNL, Oak Ridge, Tennessee 37830.

prevent debris from entering water intake structures). These types of effects are very site specific, and at present no one category poses a significant threat to east coast anadromous stocks. State and federal resource agencies already review environmental impact statements for proposed projects of the type being discussed here. Thus, other than suggesting that such reviews focus on the potential impacts on anadromous alosids, no recommendations relating to this category of habitat factors are necessary.

The single exception to this conclusion is in regard to proposed tidal hydroelectric facilities in the Bay of Fundy (p. 11-66 of Appendix A). All east coast stocks of American shad, and possibly river herring, use the Bay of Fundy as a summer foraging area. As they forage, fish appear to repeatedly move in and out the basins proposed for hydroprojects. Even if mortality due to single passage through a turbine is low, repeated passage will cause high total mortality. Because these projects pose such a great threat to east coast alosid stocks, progress on their development must be closely monitored.

- Recommendation 6.1

All state and federal agencies responsible for reviewing impact statements for projects proposed for anadromous alosid spawning and nursery areas shall ensure that those projects will have no impact or only minimal impact on those stocks. Of special concern are natal rivers of newly established stocks or stocks considered depressed or severely depressed (Table V-1).

- Recommendation 6.2

ASMFC and federal fisheries agencies shall continue to monitor progress in the development of Bay of Fundy hydroelectric projects. Communications with the Department of State and all interested members of Congress shall be renewed on an annual basis to reiterate opposition to the projects unless it can be demonstrated that no significant mortality to alosids will occur. Continued environmental studies shall be encouraged. Annual status reports based on information obtained from the Canadian government and project developers will be prepared and distributed to Board and Scientific and Statistical Committee members. ASMFC will request from the U.S. Department of State the right to review all environmental impact predictions prepared as part of project development. Factors that influence U.S. purchase of power from these projects should be monitored to determine if actions can be taken to discourage their development.

C. RESTORATION OF ANADROMOUS ALOSID STOCKS

For the purposes of this management plan, restoration activities are considered to fall into two categories: restoration of anadromous alosids to habitats that formerly supported stocks but currently do not, and the restoration to former levels of abundance runs currently at very low levels. Recommendations expected to contribute to the restoration of currently depressed stocks include those suggesting restrictions on exploitation rates (recommendations 3.1 and 3.2), those aimed at improving water quality (recommendations 4.1 and 4.2) and those dealing with stream flows (recommendation 5.2).

Most of the information presented in this section of the plan relates to restoration of stocks to currently unoccupied habitats. Opportunities exist for significant increases in total east coast populations of all four alosids should new runs be established in all available waters. Table V-5 presents restoration targets of 28 planned American shad restoration programs, most of which are in various stages of implementation. These programs alone, if successful, would add over 8 million shad to the east coast population (at an average weight of 4 lb, a total of 32 million lb). Current river herring restoration efforts are summarized in Table V-6. Potential numerical increases in river herring stocks are much greater than those for shad. Opportunities for hickory shad restoration are difficult to ascertain because of lack of knowledge of their life history and habitat requirements.

Methods

A number of methods have been used in past or current alosid restoration programs. The major methods are:

- Using hatcheries and stocking larvae and/or juveniles. This approach was used prior to the early 1900s in an attempt to enhance depleted stocks of American shad but was unsuccessful (Mansueti and Kolb 1953). More recent programs (e.g., Pawcatuck, Susquehanna) have employed stocking of shad fry and larvae, but the magnitude of contribution of these fish to future runs has not been well documented; on the Pawcatuck, no significant contribution of stocked fry to subsequent

Table V-5. Current and planned American shad restoration programs in Eastern North America (R. St. Pierre, USFWS).

River and Tributary	State(s) Involved	No. of Dams that Need Passage	Restoration Target (number of fish)
Androscoggin River,	ME	2(a)	135,250
Little Androscoggin	ME	7	89,750
Kennebec River	ME	5	470,000
Sebasticook River	ME	2	155,000
Sandy River	ME	1	100,000
Mainstem-tidal	ME	(Water quality)	750,000
Penobscot River	ME	11	1,500,000
Cocheco River	NH	1	25,000
Lamprey River	NH	2	26,000
Exeter River	NH	1	10,300
Merrimak River(b)	NH/MA	4	1,000,000
Concord River	MA	2	-
Nashua River	NH/MA	4	-
Souhegan River	NH	1	-
Pistcataquog River	NH	1	-
Contoocook River	NH	4	-
Charles River	MA	3	30-40,000
Taunton River	MA	-	25-35,000

(a) One fishway under construction, one to be initiated in 1986.
(b) Direct Fish & Wildlife Service coordination.

Table V-5. Continued

River and Tributary	State(s) Involved	No. of Dams that Need Passage	Restoration Target (number of fish)
Pawcatuck River	RI	-	25-30,000
Wood River	RI	5	-
Hunts River	RI	-	7,000
Thames River	CT	3	350,000
Connecticut River(b)	CT/MA/NH/VT	-	2,000,000
Westfield River	MA	1	-
Raritan River	NJ	9	100,000
Delaware River(b)	DE/NJ/PA/NY	-	-
Schuylkill River	PA	7	300-850,000
Lehigh River	PA	2	165-465,000
Susquehanna River(b)	MD/PA/NY	4	2-3,000,000
James River	VA	5	600,000

Table V-6. Compilation of information on river herring restoration programs (current and planned) along the East Coast

State	Number of Locations or River Systems	Alosid Species	Target Population Level
Maine	3 current 4 in planning	Alewife	46 million (For current and planned programs combined)
New Hampshire	6	Alewife Blueback	.3-.6 million .25-.5 million
Rhode Island	8	Alewife	≈ 2.5 million
Massachusetts	20	Alewife Blueback	? ?
New Jersey	1 Back Creek	Alewife	?
North Carolina	1 Lake Phelps	Blueback	?
Pennsylvania	Susquehanna River	Alewife Blueback	10 million
South Carolina	1 Santee-Cooper (Locks and rediversion canal)	Blueback	6.4 million
Virginia	James River	Alewife Blueback	?

runs was detectable (M. Gibson 1985, personal communication). No restoration programs for river herring or hickory shad have ever utilized hatcheries.

- Transplanting Eggs. This approach has also been commonly used, probably because of its low cost. However, no instance of egg transplants resulting in successful restoration of an anadromous alosid stock has ever been documented. On the Pawcatuck River, some fish were produced from egg transplants, but their numbers were insignificant and insufficient to support restoration.

- Transplanting Adults. This method has proved to be the most successful means of establishing new runs of American shad and river herring. Throughout the New England states, stocking of gravid adult alewife and blueback has resulted in runs returning to the streams receiving the stocked adults. Stocking of adult American shad in various rivers targeted for restoration has resulted in the production of juveniles (which were observed to migrate downstream in the fall) and the return of native adults in 4 or 5 years. The major problems encountered in adult transplant activity are that sources of fish must be found (e.g., a river with a run of substantial size, an agency that will allow fish to be taken, a location at which suitable gear can be used). In addition, transportation and handling difficulties must be overcome (e.g., travel distances cannot be too great, handling stress must be minimized, proper trucks and tanks must be used).

- Recovering Habitat. Anadromous alosids are usually excluded from potentially suitable habitat because of either physical blockage (i.e., dams) or because water quality is such that migration, spawning, and/or normal growth of juveniles is prevented by poor water quality. Steps taken in habitat recovery include the construction of fish passage facilities and/or improvement of water quality (e.g., control of acid mine drainage, elimination of pollutant discharges). In cases where healthy alosid runs already occur in the drainage system, habitat recovery activities provide the opportunity for the existing stocks to exploit new habitat (an example is the Connecticut River, where establishment of fish lifts at Holyoke Dam gave fish access to new segments of the river). Where healthy stocks do not exist, habitat recovery methods must be accompanied by one or more of the three methods already discussed.

Problems

Numerous problems have been encountered in the various restoration programs that have been attempted or are underway. A review of these problems provides a basis for developing recommendations that may improve prospects for successful restoration efforts.

- Most major dams causing migration blockage are owned by public utilities. Because restoration programs are quite expensive, the dam owners usually resist the establishment of such programs.
- FERC authority supercedes that of the states and other agencies with regard to dams on rivers and streams. The only means of forcing recalcitrant utilities to support restoration efforts is through FERC licensing procedures. FERC proceedings are notoriously slow. Thus, efforts to establish many restoration programs have dragged on for many years (e.g., for Susquehanna River restoration, proceedings were initiated in 1978 and are still ongoing).
- State legislation generally does not exist that establishes restoration as a state goal and that provides regulatory backing for many of the steps needed to accomplish restoration.
- Lack of access to habitats may prevent implementation of restoration programs; this problem arises primarily in areas where pond or lake spawning/nursery areas for alewife and blueback are involved.
- Interagency disagreements, and disputes among agencies from the same state, agencies from different states, different federal agencies, and federal and state agencies have frequently arisen in major restoration programs. Often the disputes arise because programs involve the restoration of more than one species and the priorities of the various agencies differ. The disputes often result in inefficiencies and delays in restoration efforts.
- Exploitation of newly established stocks is often difficult to restrict. This problem is particularly accute when dealing with the alosids. Large numbers of fish may be concentrated at a dam during a spawning run, giving the appearance of being very abundant. However, these runs may in fact represent the initial return of native fish extremely important for future growth of the stock; such runs may be only a small

fraction of the size of future runs. Regulatory agencies often face political pressure to open fisheries prematurely for the latter reason. Exploitation of these first-generation fish during the early stages of restoration may lead to failure of the effort.

- Turbine mortality of juvenile alosids may represent the biggest unresolved issue for many of the large restoration efforts. Measurement of turbine mortality rates of juvenile alosids is extremely difficult. If turbine mortality rates are high, any restoration effort that does not provide a means for juveniles to successfully bypass turbines during downstream migration will fail. Bypassing of turbines is generally very expensive because of either lost generation (i.e., using spills to get fish over the dam) or the need for installation of screening devices which are very expensive. Utilities are generally very resistant to accommodating downstream passage needs. Mortality of spawned-out adults due to passage through turbines also hinders restoration because it decreases the amount of repeat spawning that may occur. Repeat spawning is particularly important in northern runs.

- Introduction of diseases or parasites has been raised as a potential problem in restoration. These issues have been very prominent in salmonid restoration. However, no known examples of disease or parasite transport have yet been documented in any of the alosid restoration efforts carried out.

Costs and Funding Mechanisms

Major restoration programs are expensive. Installation of passage facilities at dams generally requires extensive construction activity. Biological work, including transplanting adults, monitoring restoration success, and performing related activities add to overall expenses. The Susquehanna River shad restoration program and Rhode Island's alewife and shad restoration activities provide examples of differing program costs.

The Susquehanna shad restoration program will ultimately entail the construction of fish passage facilities at four large dams (one over 100 ft in height). These dams are owned and operated as hydroelectric facilities by electric generation public utilities. Restoration of stocks is being carried out through egg collection, release of hatchery reared larvae and fry, and by adult transplants. Cost estimates for the restoration were developed during FERC proceedings (Docket EL/80-38) and have been summarized by R. St. Pierre, USFWS Susquehanna River Fisheries Coordinator. The costs below are rough estimates for a 10-year demonstration program:

Egg collection, adult transplants, hatchery operations	$ 5 million
Downstream migration and mortality studies (4 dams)	2 million
Downstream bypass and/or screening	2 million
Research, project management, etc.	1 million
Total	$10 million

If the demonstration program is successful and the utilities are ordered to construct permanent fish passage facilities, costs are estimated to be $58 million to $77 million in 1981 dollars. Assuming construction would not be initiated until at least 1995, costs would likely rise to about $100 million, plus additional funds for operating the facilities. The total cost of this program may be on the order of $125 million dollars, nearly all of it borne by the utilities. The projected size of the shad run is 2 million fish annually. In addition to American shad, the program is also designed to provide for the restoration of 10-20 million river herring, some hickory shad, and unestimated numbers of American eel (potentially millions). Benefits of this program would accrue to three states (Maryland, Pennsylvania, New York). The economic value of the recreational and commercial shad fishery alone has been estimated to be between 69 million and 268 million dollars (median of $111.3 million) by K.E. McConnel and I.E. Stran (Direct Testimony, FERC Docket EL80-38; May 1981).

Rhode Island's restoration programs are of a totally different nature. None of the dams involved serve as hydroelectric projects and most are publicly owned. Cost estimates for these programs were provided by M. Gibson, Rhode Island Division of Fish and Wildlife. Since 1968, Denil fishways have been constructed at 9 dams, at a total cost of $410,440. This construction was financed by Anadromous Fisheries Act funds (a 50:50 match with state funds) with anticipated production of between 2 million and 3 million alewives annually. Biological work related to the alewife programs and the shad restoration work on the Pawcatuck River and other coastal rivers has cost about $310,000, supported by Dingell-Johnson funds with a 25:75 state-federal match. Maintenance and field support has cost $85,000, also supported by Dingell-Johnson funds, with a 25:75 state-federal match. Total Rhode Island expenditures to date have been approximately $804,400, with an expectation of an additional 2 million to 3 million alewives and

25 thousand to 30 thousand American shad annually. Alosids have also benefitted from salmon restoration activities and water quality improvement programs.

The Susquehanna River and Rhode Island programs illustrate both the magnitude of costs which will be incurred in expanding existing restoration efforts, and the variety of funding sources which have been employed:

- Utilities. As owners and operators of dams that block migratory passage, utilities may be required to pay all costs involved in restoring anadromous fish to upstream watersheds. However, if the utility does not agree with the resource agencies and commit to implementing restoration efforts, the issue must be resolved by FERC. In FERC proceedings, the feasibility of restoration, its probability of success, and the ultimate benefits to be gained all arise as issues; the resolution of such issues is very difficult. The Electric Power Research Institute (EPRI), which is supported by utilities across the country, has funded a program to review problems with downstream passage of anadromous fish at hydroelectric facilities. Results of this program may be applicable to many restoration programs currently underway.

- Federal Funds. As illustrated in the Rhode Island example, federal funds from various sources have contributed to many successful restoration efforts. Anadromous Fish Act funds have been used for the construction of large numbers of fish passage facilities along the entire east coast. Dingell-Johnson funds have contributed to the biological and support work essential to these programs. It is likely that without these federal funding sources, very few of the restoration efforts would have been initiated. In addition to direct funding, USFWS provides technical assistance in the planning or design of restoration efforts. USFWS staff expertise in the engineering and design of fish passage facilities has contributed to the success of all the major restoration programs.

- State Funds. Sources of funds for fisheries work and the manner in which they are allocated differ markedly among the states. In general, federal programs that offer funds if they are matched by state monies certainly influence allocation of available funds. It is likely that without the impetus provided by Anadromous Fish Act funds, only limited amounts of state funds would have been spent for restoration purposes. Amount of funds allocated to anadromous alosid programs will also vary among states according to the perceived importance of the species (e.g., Maine will spend significantly more on alewife programs than will New Jersey or New York).

Species-Specific Restoration Information

Hickory Shad

There have been no known attempts at restoration of hickory shad. In the absence of any other information, procedures employed for American shad would probably provide the best guidelines for hickory shad restoration efforts.

American Shad

As noted earlier, current American shad restoration programs could add as many as 8 million additional shad to total east coast stocks. This number is based on estimates of the amount of habitat suitable for supporting American shad that will be made accessible. Many estimates of potential run size have used production figures developed for the Connecticut River (2.3 adult spawners per 100 yd^2 of spawning habitat). Parameters used to define potential "spawning habitat" in most cases were site specific; generally, knowledge of historical spawning ranges contributed to making the estimate. Production figures are essential for designing fish passage facilities since capacity is an important design criterion. The following two case studies of American shad restoration programs illustrates many of the points important to consider in undertaking such programs.

The Connecticut River shad restoration program represents a case of "enhancement" of a run in a major drainage basin. A strong run of shad occurred upriver to the base of Holyoke Dam before a fish lift was installed in 1955. The restoration program has allowed this stock to expand into previously unoccupied habitat. The entire history of this restoration effort is presented in detail in an article by Moffitt et al. (1982). Tables V-7 and V-8, from data from that article, document the passage facilities required for this program as well as the annual fish passage totals at the Holyoke fish lift from 1955 to 1984. While the numbers alone suggest that the program has been extremely successful, some of the increase in Holyoke passage may be due to more effective passage facilities, improved water quality, and other factors mentioned by Moffitt et al.

Table V-7. Existing and proposed fish passage facilities in the Connecticut River watershed

Dams				Fishways			
					Run size design capacity		
Location	River km	Year constructed	Present height (m)	Existing fishway type	salmon	shad	Operation date
	Mainstem						
Enfield	110	1880	2	ramp	—	—	1933
Holyoke[a]	139	1849	9	2 lifts with flume	40,000	1,000,000	1955
Turners Falls[b]	198	1798	12	3 ladders, 2 modified Ice Harbor and 1 vertical slot	40,000	850,000	1980
Vernon	228	1909	11	modified Ice Harbor w/ vertical slot ladder	40,000	750,000	1981
Bellows Falls	280	1907	10	vertical slot ladder	40,000	—	1983
Wilder	350	1950	19	split Ice Harbor	20,000	—	1986[c]
	Tributaries						
Leesville (Salmon River)		1918	6	Denil ladder	—	—	1980
Rainbow (Farmington River)		1925	16	vertical slot ladder	5,000	20,000	1976

[a] Three other fishways were built previously at Holyoke in 1873, 1940, 1952 of Brackett design, pool type ladder, and pressure lock, respectively. Shad passed none of these

[b] A previous pool-type ladder was built in 1942, but shad did not pass it

Tentative

Source: Moffit et al. (1982).

Table V-8. Anadromous fish passage recorded at the Holyoke Dam lift since 1955 .

Year	American Shad	River Herring	Atlantic Salmon	Striped Bass
1955	4,900	0	0	0
1956	7,700	0	0	0
1957	8,800	16	1	0
1958	5,700	29	1	0
1959[a]	15,000	20	0	0
1960	15,000	796	2	0
1961	23,000	1,200	0	0
1962	21,000	191	0	0
1963	30,000	32	0	0
1964	35,000	13	0	0
1965	34,000	53	0	0
1966	16,000	54	0	0
1967	19,000	356	0	0
1968	25,000	(b)	0	0
1969	45,000	10,000[c]	0	0
1970	66,000	1,900	0	0
1971	53,000	302	0	0
1972	26,000	188	0	0
1973	25,000	302	0	0
1974	53,000	504	0	0
1975	110,000	1,600	1	0
1976	350,000	4,700	1	0
1977	200,000	33,000	2	0
1978	140,000	38,000	23	0
1979	260,000	40,000	19	103[d]
1980	380,000	198,000	118	139[d]
1981	380,000	420,000	319	510[c]
1982	290,000	590,000	11	231[d]
1983	528,000	454,000	25	346[d]
1984	497,000	483,000	66	110[d]

[a] Passage facility modified.
[b] Not counted.
[c] Estimated.
[d] All immature.

Source: Modified from Moffitt (1982).

(1982). Limited stock augmentation activities relating to anadromous alosids have been conducted as part of this program. Between 1979 and 1983, 800 to 3,300 prespawn shad were transported from Holyoke to above Turner Falls and Vernon Dam to generate runs through new passage facilities at those dams.

The majority of funding for the Connecticut River program has come from the utilities, both for construction of passage facilities and in support of biological programs. However, federal and state funds have also contributed substantially, with sources including Anadromous Fish Act funds, Dingell-Johnson fish restoration funds, USFWS expenditures (directly and via research performed by the Massachusetts Cooperative Fishery Research Unit), and the state resource agencies of Connecticut, Massachusetts, New Hampshire, and Vermont. Total expenditures in the program have been very large, and it is nearly impossible to partition them into funds for alosids versus funds for salmon.

The Pawcatuck River shad program in Rhode Island represents an effort to reestablish shad in a system where they had not occurred in more than 50 years. Two fish passage facilities have been built on the lowermost dams. Denil fishways were constructed at Potter Hill and Bradford Dams in 1968 and 1979, permitting access to 28 river miles of habitat. An average of 1,500 prespawned American shad from the Connecticut River have been transplanted annually to the Pawcatuck River and its tributaries since 1975 (Table V-9). Evidence of successful spawning has been obtained (O'Brien 1977) and first returns of adults were witnessed in 1979. Since then, annual runs of shad have been monitored at a Potter Hill fish trap. Data on sex ratio, age structure, and growth rates have been collected. It cannot be shown from the data collected in this program that cultured juveniles contributed significantly to subsequent adult returns. It also appears that four transplanted females will yield the same number of future recruits as one native female (M. Gibson 1985, unpublished manuscript). These findings support the earlier statements that adult transfer is the best method for stock restoration. It also emphasizes the need to get as many native fish as possible into the spawning grounds even though numbers of first generation fish returning may be very small. Connecticut will soon prohibit capture of shad from it portion of the Pawcatuck to enhance restoration efforts. Costs of the Pawcatuck program were discussed earlier; all were covered by state and federal funds.

River Herring

River herring restoration programs are numerous in the New England states and less common in the mid-Atlantic states

Table V-9. Shad returns, stockings, and environmental data, Pawcatuck River, Rhode Island, 1975-1985

Year	No. of Transplanted Females	No. of Juveniles Cultured	No. of Returning Adults	No. of Females	No. of Age III	No. of Age IV	June Discharge[a]	June Temp.[a]
1975	96	12,500	-	-	-	-	530	19.8
1976	870	40,000	-	-	-	-	233	21.4
1977	734	75,000	-	-	-	-	366	20.0
1978	567	94,000	0	0	0	-	517	20.5
1979	1261	97,000	5	0	0	4	654	19.5
1980	1559	50,000	165	7	9[b]	125	315	20.0
1981	1058	0	882	249	5	101[b]	230	21.0
1982	880	0	645	224	12	41	800	18.0
1983	950	0	491	170	26	173	756	19.1
1984	275	0	1,265	314	74	629	992	20.3
1985[c]	200	0	4,100	1,522	158	1,246	-	-

[a] 1975-1982 U.S. Geological Survey; 1983-1984 Rhode Island Fish and Wildlife data.

[b] These values were adjusted to 12 and 132, respectively, to account for underutilization of juvenile habitat that occurred only in 1977 due to distribution of spawners (Wood River not stocked).

[c] Source: M. Gibson (May 1985, personal communication).

Source: M. Gibson (1985, unpublished manuscript).

and southward (see Table V-6). The majority of the New England programs deal with alewives, since most efforts involve providing access to ponds and lakes, which are preferred spawning/nursery areas for that species.

The Royal River program in Maine is an example of a very successful alewife restoration effort typical of many other New England programs. Table V-10 presents a summary of alewife escapement and stocking in the Royal River system. Fish passage facilities were constructed at two dams, and restoration was initiated by transplanting gravid adults from other systems. Funding has been with state and federal monies. Studies of this run suggest that most recruitment is generated by the small number of fish stocked in Sabbathday Lake (340 acres). Very preliminary calculations suggest that the ratio of returning progeny to number of adults stocked in the lake has been between 87 and 118. A stocking rate of 1.25 fish per acre of lake habitat produced a return of 147 adults per acre (T. Squiers 1985, Maine Department of Marine Resources, personal communication). These figures illustrate why the very high exploitation rates discussed earlier in this plan can be sustained in these New England river herring runs: productivity per spawning adult is very high.

Figure V-1 illustrates the progress of the alewife restoration progam being carried out on the Lamprey River in New Hampshire. The major elements of the program are similar to those of the Royal River program: construction of a fishway at the lowermost dam and a 5-year program of transplanting fish from below the dam to upstream areas. Once substantial numbers of fish began passing through the fishway, trucking of fish was discontinued. Funding for this program came from state and federal sources. Existing data do not permit specific calculations. However, Figure V-1 shows a high number of recruits generated per spawning adult during the initial phase of the program.

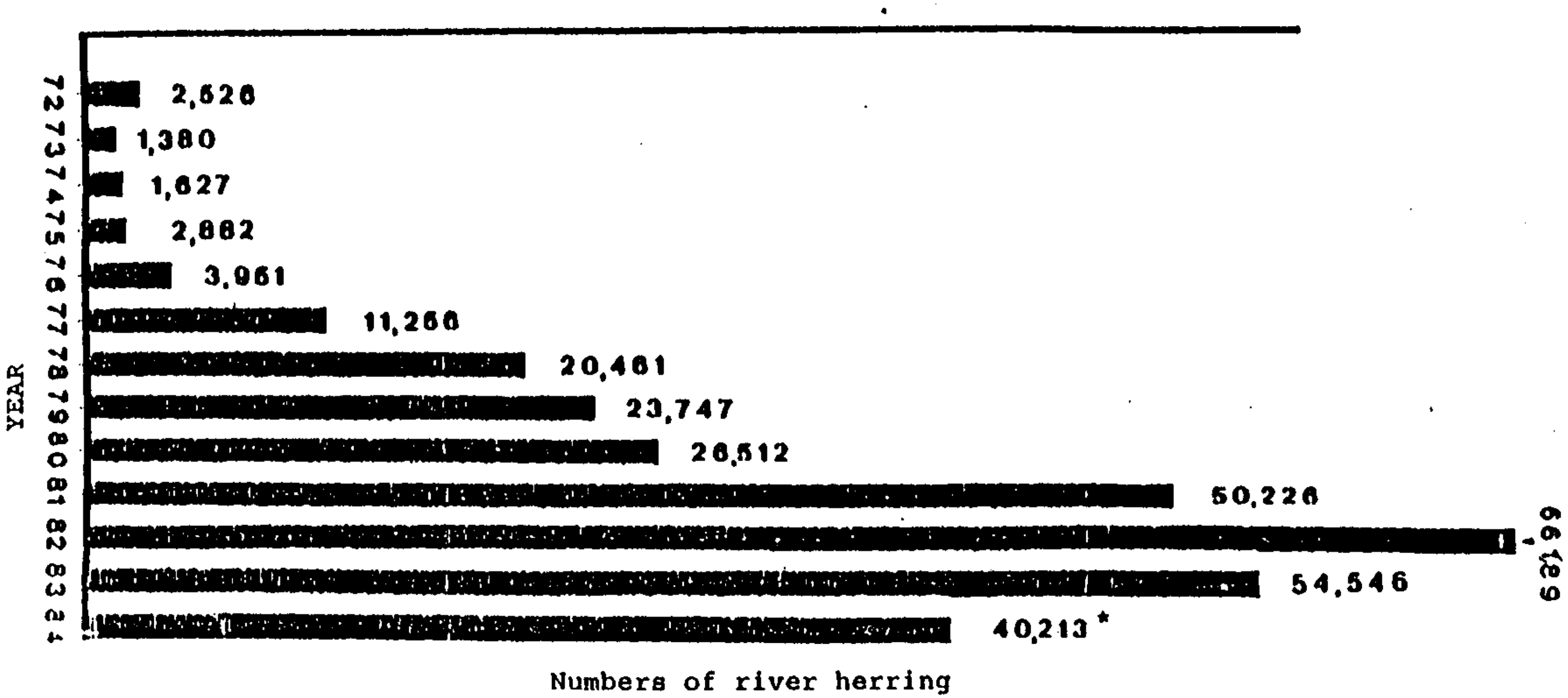
Connecticut River data (see Table V-8) show the magnitude of enhancement of blueback herring stock that resulted from passage of fish over Holyoke dam. The blueback herring is not a primary target species of this program and yet it appears to have benefited markedly from it. Interpretation of these data must, however, be tempered with caveats included in the discussion of the shad program: the increase in numbers can be due in part to improved efficiency of the lifts, redistribution of stock in the river, improved water quality, and other factors.

Table V-10. Alewife run size and stocking in Sabbathday Lake on the Royal River

Year	Total Run at Bridge St. Fishway	Total No. Stocked in Sabbathday Lake
1975	362	
1976	263	
1977	10	425
1978	119	
1979	19	262
1980	2	533
1981	50,000 (est.)	1,280
1982	24,160	582
1983	10,029	493
1984	46,485	527

NOTE: Sabbathday Lake is considered to be the primary spawning and nursery area for this run.

Source: T. Squiers (1985, personal communication).



*Approximately 11,600 river herring were removed from the 1984 run for stocking Lake Winnisquam on the Merrimack River system.

Figure V-1. Annual river herring passage at the Lamprey River fishway in New Hampshire (from J. Greenwood 1984, personal communication)

- Recommendation 7.1

All agency personnel participating in anadromous alosid restoration programs should be alert for indications of disease or parasites. At present, no information exists to suggest that transfer of disease or parasites is a problem. However, should a potentially serious problem arise, ASMFC shall develop a disease control and screening program for alosids. Such a program could follow the form of the existing New England Atlantic Salmon Disease Control Program.

- Recommendation 7.2

Each state that has not already done so shall evaluate the potential which exists for anadromous alosids restoration within their internal waters. Such an evaluation should include, at a minimum, a listing of waters that currently do not support anadromous alosid stocks but that might if water quality and access were improved or created. Within one year from the date of adoption of this plan, and annually thereafter, each state shall provide to ASMFC this evaluation, a summary description of ongoing restoration efforts, and a statement of anticipated restoration activities for the next five years. ASMFC shall use material from these submittals to prepare an annual summary of coastwide restoration efforts for distribution to agencies, legislators, and all other interested parties.

- Recommendation 7.3

ASMFC and all state and federal resource agencies shall support, in every way possible, the preservation and enhancement of federal programs providing funds for the restoration of anadromous fish. Such programs include the Anadromous Fish Act and Wallop-Breaux programs and other federal grant programs that support studies of anadromous alosids, such as Sea Grant and Coastal Zone. It is obvious that most of the very successful anadromous alosid programs that currently exist would not have been initiated if these federal programs were not in place. Implementation of a coastwide alosid restoration plan will not be feasible in the absence of these federal programs. States should also develop additional state funding sources for restoration of anadromous alosids; possiblities include special licenses or stamps.

- Recommendation 7.4

All state and federal agencies shall cooperate to further all current or planned anadromous alosid restoration efforts. Because the acquisition of gravid adults for transplanting is essential for most restoration efforts, those agencies having regulatory control over existing healthy runs of all species should be particularly sensitive to the needs of agencies implementing restoration efforts and should provide the maximum cooperation possible. ASMFC's Shad and River Herring Board will serve as a coordinator to resolve any major disputes.

- Recommendation 7.5

Because of the important role of turbine mortality in determining the success or failure of many restoration programs, all agencies participating in restoration programs involving hydroelectric projects shall include in those programs plans for turbine mortality and downstream passage studies. The term "fish passage" should consistently be interpreted to include downstream passage in any discussion of restoration activity. Results of ongoing and new studies shall be provided on an annual basis to ASMFC for compilation and for dissemination of data to all appropriate state and federal agencies. A continuous exchange of information on turbine mortality and methods for passing anadromous alosids downstream may lead to new and successful methods for alleviating this problem.

- Recommendation 7.6

All resource agencies shall oppose any new hydroelectric projects proposed for drainage systems currently supporting or with potential for supporting anadromous alosid runs unless the developer can demonstrate to the agencies' satisfaction that the project, as proposed, will not have an unacceptable adverse impact on alosid runs. Of particular concern here are small-scale hydroelectric projects existing or proposed for smaller drainage systems supporting river herring runs. Cumulative impacts of several facilities on the same drainage system must also be considered. Major issues are upstream passage of spawning adults and successful downstream passage (i.e., avoidance of turbine mortality) of outmigrating, spawned-out adults and juveniles.

D. RESEARCH AND DATA NEEDS

As has been repeatedly stated throughout this document and the Phase I report, the development of very specific management recommendations for the anadromous alosids has not been possible because of a lack of information on critical aspects of the biology of and fisheries for these four species. During development of this plan, the S&S Committee has identified both data needs (i.e., categories of information that are known to be needed and for which data can be acquired) and research needs (i.e., important areas of interest which are so poorly understood that research is necessary to determine which data are important).

A workshop sponsored by the Hudson River Foundation (HRF), in coordination with the Shad and River Herring Scientific and Statistical Committee, was held in February 1984 to discuss critical data needs for shad research on the Atlantic coast. Participants in that workshop included the S&S committee and outside experts on the American shad from the United States and Canada. Proceedings of the workshop were published by HRF and included a description of shad research projects listed according to priority established by the workshop participants. This list is presented here as Table V-11. As a result of further work of the S&S committee, the priorities of the listed projects were reassessed and a new ranking was developed (Table V-12), reflecting a more narrow focus on topics of particular relevance to this management plan. A Board review of those recommendations resulted in the final priority listing of research needs presented in Table V-13.

The lists presented in Tables V-11, V-12, and V-13 include many types of data needs, each of which can be given a high priority for different but justifiable reasons. Population dynamics of a fish stock control the manner in which that stock will respond to various levels of exploitation, yet little is known of many of such characteristics for all four of the anadromous alosid species. Thus, many of the data needs listed deal with population dynamics characteristics such as stock-recruitment relationships and factors influencing larval survival and spawning success (e.g., Table V-12, items 2 and 3). The relationships among those data needs are illustrated in Figure V-2. The quandry that arises, however, is that while such information is essential for proper management of these species, acquisition of sufficient information to fulfill those data needs will take a substantial number of years. As an example, work serving as the basis for most of what is known about American shad population dynamics was conducted on the Connecticut River for more than 15 years.

While the Scientific and Statistical Committee and Board agreed upon the vital need for population dynamics information,

Table V-11. The priority and title for research projects to identify critical data needs for shad. The approximate cost of each project is presented in parentheses. (From Proceedings of a Workshop on Critical Data Needs for Shad Research on Atlantic Coast of North America, 1984, J. Cooper, ed. Hudson River Foundation, New York, NY. 70 pp.)

PRIORITY	
1	**Intensified Ocean Tagging Program. (200K/yr) (600K)**
2	**Determine Fishing Mortality in Selected Regional Streams. (50K-100K/river) (250K)**
3.1	**Biotic and Abiotic Mechanisms Affecting the Stock/Recruitment Relationship. (50K-100K/river)**
3.2	**Studies of Egg and Larval Survival and Development.**
4.1	**Discrimination of American Shad Populations by Mitochondrial DNA Analysis. (250K/yr) (750K)**
4.2	**Parasites of Juvenile American Shad, Blueback Herring, and Alewife, as Biological Tags for Alosid Stock Discriminations. (26K/yr) (65K)**
5	**Historical Characterization of Socio-economic Development (i.e., Potential Pollutant Sources and Habitat Modification) of Selected Shad Rivers Along the East Coast. (150K-175K)**
6	**Turbine Mortality Studies. (150K-300K)**
7	**Energetics of Feeding and Spawning Migrations of Shad on the Atlantic Coast. (100K+)**
8	**Analyses of American Shad Growth: Circa 1970 versus Circa 1980. (25K/50K)**
9	**Identification and Quantification of Potential American Shad Spawning and Rearing Habitat Not Presently Utilized and an Analysis of Cost of Recovery. (150K-500K)**
10	**Development of Standardized Procedures for Developing Juvenile Abundance Indices.** (50K/river)

Table V-11. Continued

11	Examination of Early Juvenile Stages of Anadromous Clupeids.
12	An Analysis of Optimum Habitat Utilization of American Shad. (150K-300K)
13	Development of a Long-term Mark or Tag for Juvenile American Shad. (100K-300K)
14	Other proposals

Table V-12. Revised priority listing of shad research projects reflecting Scientific and Statistical Committee views

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1. Determination of Fishing Mortality in Selected Regional Streams
2. Studies of Egg and Larval Survival and Development
3. Determination of Biotic and Abiotic Mechanisms Affecting the Stock/Recruitment Relationship
4. Intensified Ocean Tagging Program
5. Turbine Mortality Studies
6. Identification and Quantification of Potential American Shad Spawning and Rearing Habitat Not Presently Utilized and Analysis of Cost of Recovery
7. Discrimination of American Shad Populations by Mitochondrial DNA Analysis
8. Development of a Long-term Mark or Tag for Juvenile American Shad
9. Historical Characterization of Socioeconomic Development (i.e., Potential Pollutant Sources and Habitat Modification) of Selected Shad Rivers Along the East Coast
10. Development of Standardized Procedures for Developing Juvenile Abundance Indices
11. Energetics of Feeding and Spawning Migrations of Shad on the Atlantic Coast
12. An Analysis of Optimum Habitat Utilization of American Shad
13. Analyses of American Shad Growth: Circa 1970 Versus Circa 1980
14. Parasites of Juvenile American Shad, Blueback Herring, and Alewife, as Biological Tags for Alosid Stock Discriminations
15. Examination of Early Juvenile Stages of Anadromous Clupeids

Table V-13. Priority listing of data and information needs for management of the anadromous alosids as established by the Shad and River Management Board (June 1985), focusing only on the research areas of greatest immediate need. Priorities of other research areas are as indicated in Table V-12.

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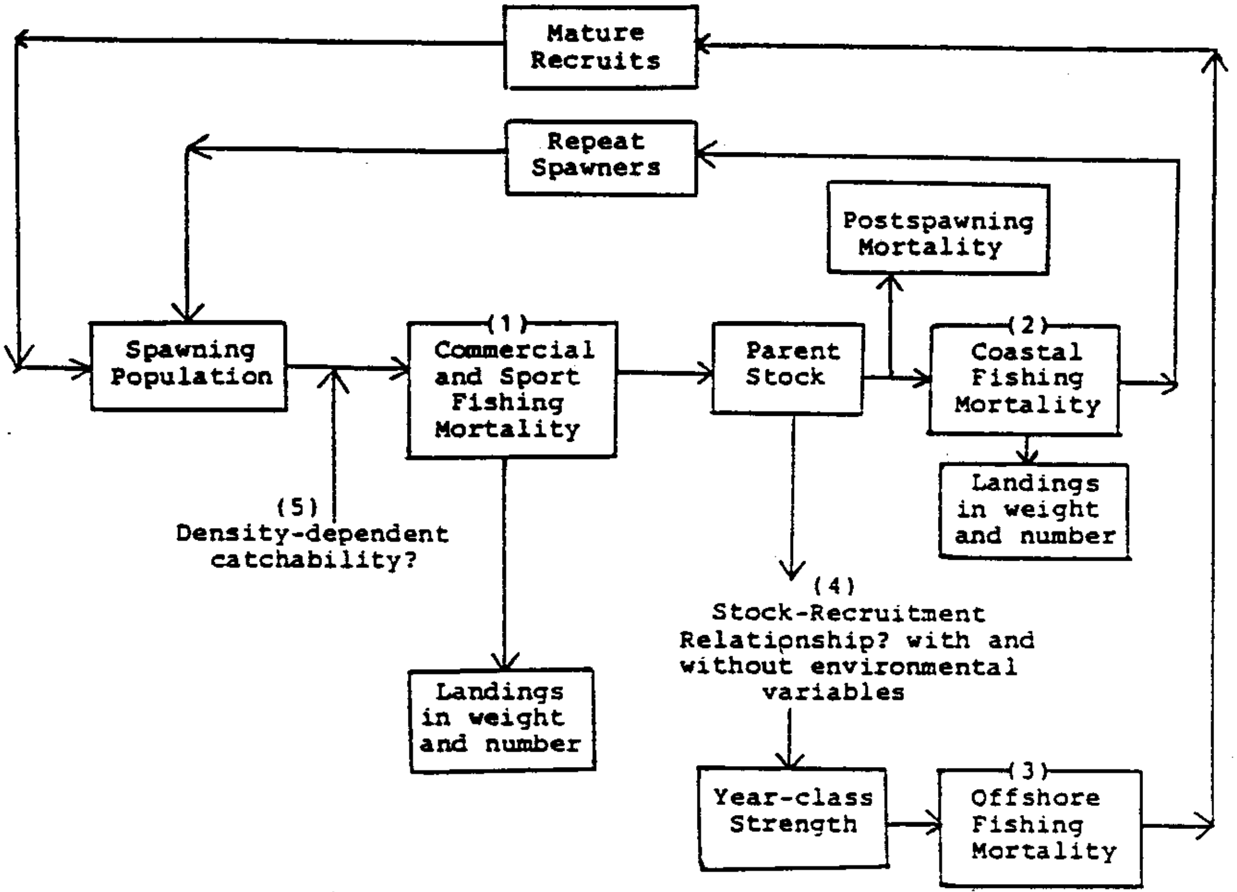
1. Determine the origins of shad being captured in fisheries operating in territorial sea waters of South Carolina, North Carolina, Virgnia, Maryland, Delaware, and New Jersey during winter and early spring (see Table V-14). This information is necessary to determine if these fisheries pose a threat to any East Coast stocks.
2. Determine annual exploitation rates of all anadromous alosids in each state. These data are needed to determine acceptable rates of exploitation consistent with stock stability and enhancement.
3. Develop a long-term mark or tag for juvenile alosids and/or a method for distinguishing among fish originating in different drainage systems. Such methods would contribute to determining which alosid stocks are being exploited in different fisheries and which are threatened by man's activities in certain areas (e.g., Bay of Fundy tidal hydroelectric facility construction).
4. Evaluate the magnitude of mortality to juvenile alosids caused by passage through hydroelectric turbines and determine optimal techniques for minimizing turbine-related mortality. This information is very important to ensure the success of restoration programs.
5. Develop basic life history information (e.g., population dynamics, migratory behavior, catch and effort data) on hickory shad in states where they are or have been abundant (South Carolina, North Carolina, Virginia, Maryland). These data are necessary for the development of even the most basic management recommendations.
6. Develop and implement programs to establish indices of juvenile alosid abundance in different drainage systems along the East Coast. A juvenile index, if properly calculated and validated, permits regulations to be altered as stock status changes, and can be used in evaluating factors that influence year class success.



DATA NEEDS:

1) Natal Fishing Mortality rate

2) Coastal Fishing Mortality rate

3) Offshore Fishing Mortality rate

4) Stock-recruitment Relationship

5) Density-dependent catchability

Figure V-2. Data needs for anadromous alosids within a population dynamics context it was also evident that certain types of information are needed immediately merely to determine if potential management problems exist and should be addressed. Examples of such information are: a determination of which stocks are being exploited in territorial sea fisheries for American shad in South Carolina; and, a determination of the actual exploitation rates of all of the alosids throughout their range. In many cases, data needed to answer these immediate questions may not contribute substantially to an understanding of the species' population dynamics, but are essential as a basis for making management decisions.

The types of conflicting demands just described led to the changes in priority reflected in the three tables included here. It is evident that as new data are acquired and more knowledge is gained about the species' population dynamics and their fisheries that priorities will be further revised.

Research Needs

- Recommendation 8.1

  ASMFC shall serve as a coordinator of research conducted along the east coast dealing with anadromous alosids. ASMFC will prepare a summary compendium of ongoing studies annually. Grant applications and/or proposals for anadromous alosid research programs submitted to federal and/or state agencies should be provided to ASMFC for comment to ensure that the focus of new studies is consistent with management needs identified in this plan.

- Recommendation 8.2

  In assigning priority for research funding under PL89-43 (Anadromous Fish Conservation Act), NOAA/NMFS and USFWS shall assign high priority to applications for state projects that satisfy data needs identified as having a high priority in this plan (see Tables V-12 and V-13).

- Recommendation 8.3

  ASMFC will design and coordinate the implementation of an interstate coastal shad tagging research program (see Recommendation 2.1). A tentative study design is presented in Table V-14. The initial interstate effort will focus on participation by South Carolina, and North Carolina, or other states where the nature of the fishery makes the study more feasible. ASMFC will be responsible for coordination of the activities of individual states and integration and interpretation of results. Studies that lead to the development of techniques to identify the river of origin of fish taken in mixed stock fisheries (e.g., ocean tagging, extensive within river tagging, innate indicators) should be encouraged in order to enhance the interpretation of findings of this tagging program.

- Recommendation 8.4

In establishing new anadromous alosid research programs, state and federal agencies will proceed according to the priorities presented in Table V-13.

- Recommendation 8.5

ASMFC shall undertake the compilation and analysis of all data on offshore river herring distribution and harvest available from NOAA (e.g., NMFS research trawl data, observer data, experimental Polish trawl program data). This information should be updated annually, and should be used to develop or revise recommendations to the Fishery Management Councils on regulations needed to protect traditional domestic river herring fisheries.

E. CITIZEN INVOLVEMENT

Development of management plans generally includes citizen participation to ensure that user groups are aware of and support recommendations of the plan. For the shad and river herring Fishery Management Plan, no formal citizens committee was established under the auspices of the ASMFC program. The states are encouraged to establish citizen programs of their own.

- Recommendation 9.1

Individual states are encouraged to establish programs that involve citizens in implementation of this plan.

Table V-14. Proposed guidelines for the design of a tagging study to determine which American shad stocks are being exploited in territorial and offshore sea fisheries

Basic Study Type	• Tag and Recapture
Objective	• To determine the home stream origin of shad stocks being exploited in territorial sea and Delaware Bay fisheries
General Methods:	
Timing	• January through April; focus within each state on the time period in which landings are greatest
Tag Type	• Floy streamer or internal anchor tag
Tag Return System	• Multilevel reward ($5, $10, $25) plus incentives (e.g., lottery)
Capture Methods	• Use drift gill nets, use mesh sizes identical to those used in commercial fisheries, fish the same locations as those fisheries
Number of fish to be tagged	• As many as possible within financial constraints

Such involvement would be appropriate as individual state plans are being developed. Participation by user groups and interested citizens may result in public support required to implement the plan.

VI. PLAN IMPLEMENTATION

A number of specific future needs will arise on initial implementation of this plan:

- Most of the recommendations presented here will serve as guidelines for the individual states, and in some aspects this plan serves as a coastwide strategic plan. Implementation would be enhanced if individual states develop state management plans that would essentially serve as the operational plans for implementation.

- A mechanism must be created to allow representatives from all interested state and federal agencies to participate in the monitoring of plan implementation, to assess the impact of this implementation on the stocks and the fisheries, and to initiate corrective action or alternative actions to ensure that there is continued progress in the protection and enhancement of anadromous alosid stocks. Because of the dynamic nature of this plan, the lack of such a mechanism is almost certain to result in eventual failure of the plan.

- No formal structure exists for linking recommendations presented in ASMFC management plans and decisions made concerning harvest of the species of interest in the FCZ. Such a structure would be helpful for coordinating the management activities of the states, the relevant federal agencies, and the Fisheries Management Councils.

- While a number of multistate management groups currently exist (e.g., Delaware Basin, Connecticut Basin) that oversee management of anadromous alosids in their respective areas of jurisdiction, there is no existing institutional structure for integrating and coordinating the ongoing activities of these groups. Thus, actions taken by one could be counterproductive to the efforts of another.

- A number of international issues have been encountered during the development of this plan, and some recommendations presented here specifically address those issues. It is likely that these issues will remain pertinent to the management of the anadromous alosids for an extended period of time. Some mechanism is needed to ensure that resolution of these and other international issues accounts for the interests of all appropriate states and of federal agencies.

The following institutional structures should be maintained to meet the needs just described:

- The Shad and River Herring Board should remain in existence.

- The existing management structure (ASMFC-Scientific and Statistical Committee-Program Manager) should remain in existence to maintain and modify the plan. Their functions would include, for example,

  - -- The exchange of new data and information developed in ongoing programs within each state and federal agency

  - -- The continued development of standardized data collection and processing procedures (e.g., scale reading, juvenile indices) to enhance the compatability of data being collected along the entire coastal range of each species

  - -- Evaluation and analysis of new information, review of existing management recommendations; and the development of annually revised management recommendations to Regional Fishery Management Councils, NOAA, and individual state and interstate consortia, as necessary. This activity would ensure consistency of all management actions directed at the four anadromous alosids throughout their range and over all life stages

  - -- Annual reexamination of data needs and priorities to reflect new data and information; the new priority list could then be distributed to all parties conducting research to help ensure that the greatest data needs continue to be met

  - -- Serving as a tag program clearinghouse to provide an information center for all alosid tagging studies being conducted on the East Coast.

LIST OF APPENDICES

A. Current Status and Biological Characteristics of the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring. Phase I in Interstate Management Planning for Migratory Alosids of the Atlantic Coast (Phase I Report; Initially Published July 1984). [Some material presented here is updated from the original report.]

B. Summary of Individual State's Fisheries Regulation Development Process

C. Documentation of Recent Activity Relating to Regulation of Offshore River Herring Harvest

D. Summary of Shad Fishing Mortality Data From the Literature

E. Summary of Information and Literature Sources on Responses of Anadromous Alosids to Specified Water Quality Variables

F. Summary of State Regulations Relating to Instream Flows and Fish Passage

APPENDIX A

PHASE I REPORT

(Tables II-2, III-1, IV-1, and Figures II-1, II-3, II-4, II-5, II-6, IV-1, IV-2, IV-3, IV-4, and IV-5 were updated September 1985.)

CURRENT STATUS AND BIOLOGICAL CHARACTERISTICS OF THE ANADROMOUS ALOSID STOCKS OF THE EASTERN UNITED STATES: AMERICAN SHAD, HICKORY SHAD, ALEWIFE, AND BLUEBACK HERRING

Phase I in Interstate Management Planning for Migratory Alosids of the Atlantic Coast

Prepared for

Interstate Fisheries Management
  Program
Atlantic States Marine Fisheries
  Commission
1717 Massachusetts Avenue, N.W.
Washington, D.C. 20036

July 1984

FOREWORD

This report has been prepared by Martin Marietta Environmental Systems under Contract #83-3 as part of the Interstate Fisheries Management Program administered by the Atlantic States Marine Fisheries Commission. This report was reviewed and endorsed by the Interstate Fisheries Management Program's Shad and River Herring Management Board and Shad and River Herring Scientific and Statistical Committee. Members of the Scientific and Statistical Committee made major contributions to the report's contents and format. Membership rosters are included as Appendix A to this report. Funds were provided by Northeast Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration under Cooperative Agreement Number NA-80-FA-H-000-17. For bibliographic purposes, this report should be cited as follows:

> Richkus, W.A. and G. DiNardo. 1984. Current status and biological characteristics of the anadromous alosid stocks of the eastern United States: American shad, hickory shad, alewife, and blueback herring. Atlantic States Marine Fisheries Commission, Fisheries Management Report 4, Washington, DC. xix + 225 pp.

EXECUTIVE SUMMARY

Preparation of a Fishery Management Plan for the anadromous alosids (American and hickory shad, alewife, blueback herring) of the East Coast of the United States was recommended by the Advisory Committee of the Atlantic States Marine Fisheries Commission (ASMFC) and adopted by the Commission in 1981, in response to the very low current levels of commercial landings of all four species.

As part of the process of developing a Fishery Management Plan for these species, ASMFC established a Shad and River Herring Management Board, with representatives from each of the east coast states in which runs of the species occur. The Board subsequently appointed a Scientific and Statistical (S&S) Committee to direct the development of the management plan. The committee is made up of one technical representative from each of the coastal states. An Action Plan was developed at a Shad and River Herring Management Workshop in Philadelphia, Pennsylvania, February 2-3, 1982, which called for subsequent activity to occur in two phases:

- Phase I - compile available data on the current status and biology of each of the four species and define potential options for management action
- Phase II - develop a management plan, with specification of management actions where appropriate, and identify research needs.

The present report represents completion of Phase I. American shad, hickory shad, and river herring (alewife and blueback herring) are treated in separate segments of this report. Each segment covers, as appropriate:

- Historical review of the fisheries for the species
- Recent trends in commercial and sport landings - regional basis
- Recent trends in fisheries - state-by-state
- Coastal migration patterns
- Selected life history aspects relevant to management

- Restoration efforts
- Environmental factors influencing stocks
- Management options.

For American shad, pertinent findings are as follows:

- All runs in the Chesapeake Bay and to the south have declined
- The Delaware River run has increased dramatically over the past decade, while Hudson and Connecticut River runs have remained stable
- The predominant gear types for commercial harvesting of American shad are gill nets (stake, anchor, and drift)
- Minimal or no repeat spawning occurs in southern stocks (North Carolina and south), with the percentage of repeat spawners increasing to the north
- All east coast stocks appear to mix at sea, during coastal prespawning migrations, and during foraging periods in the summer in the Gulf of Maine and the Bay of Fundy
- Yearclass size appears to be is set by the time larvae reach the juvenile stage.
- Current studies on the Connecticut River suggest that the numbers of juveniles produced is independent of spawning stock size.
- Restoration efforts that increase spawning habitat may add substantially to the total east coast stock of American shad

For hickory shad, pertinent finding are as follows:

- Landings have decreased in all runs along the east coast
- Spawning runs occur somewhat earlier than those of American shad
- Larger female hickory shad probably suffer the greatest fishing mortality of all segments of the hickory shad population

- Repeat spawners make up the majority of most hickory shad runs.
- Virturally no comprehensive information is available on the life history of hickory shad over a complete life cycle.

For the river herrings (alewife and blueback herring), pertinent findings are as follows:

- Both domestic and offshore landings (foreign) have declined dramatically in the recent decade, with the exception of the state of Maine, where landings have been stable.
- Offshore harvests by foreign fisheries in the late 1960's and early 1970's are strongly implicated in the decline in southern stocks.
- Offshore migrations are not well defined, but appear to be similar to those of American shad
- Spawning habitats appear to differ regionally, with ponds and lakes being used more frequently in New England states by alewives while bluebacks spawn in rivers and streams; to the south, bluebacks use both lakes and rivers as spawning areas.
- Substantial repeat spawning occurs in most runs, yet some runs experiencing extremely high fishing mortalities (80-90%) have remained very stable over extended periods of time.
- Restoration efforts, including the stocking of gravid adults and/or improved access to spawning habitats, have increased stocks dramatically in many drainage systems.

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I. INTRODUCTION

Preparation of a Fishery Management Plan for the anadromous alosids of the East Coast of the United States (American and hickory shad, alewife, blueback herring) was recommended by the Advisory Committee of the Atlantic States Marine Fisheries Commission (ASMFC) and adopted by the Commission in 1981. This action was in response to the very low current levels of commercial landings of all four species, which was perceived as an indication that management action would be required in order to restore stocks to their former levels of abundance. The basis for action by the Commission was that the four species met five criteria for inclusion in the ASMFC Interstate Fisheries Management Program (ISFMP)(ASMFC, 1982):

- Valuable to the states and to the nation
- Perceived to be in need of management for attainment of optimum yield
- Not currently scheduled for management under the Magnuson Fishery Conservation and Management Act (PL 94-265)
- Reasonable expectation of plan implementation
- Cost effective management.

As part of the process of developing a Fishery Management Plan for these species, ASMFC established a Shad and River Herring Management Board. Included on the Board are representatives from each of the east coast states in which runs of the species currently or fomerly occurred: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia and Florida. Both the National Marine Fisheries Service and the U.S. Fish and Wildlife Service also have representatives on the Board. A Board membership list is presented in Appendix A.

The Board subsequently appointed a Scientific and Statistical (S&S) Committee to direct the development of the management plan. The committee is made up of technical representatives from each of the previously mentioned states and the two Federal agencies. A S&S membership list is presented in Appendix A. An Action Plan was developed at a Shad and River Herring Management Workshop in Philadelphia, Pennsylvania, February 2-3, 1982, which called for subsequent activity to occur in two phases:

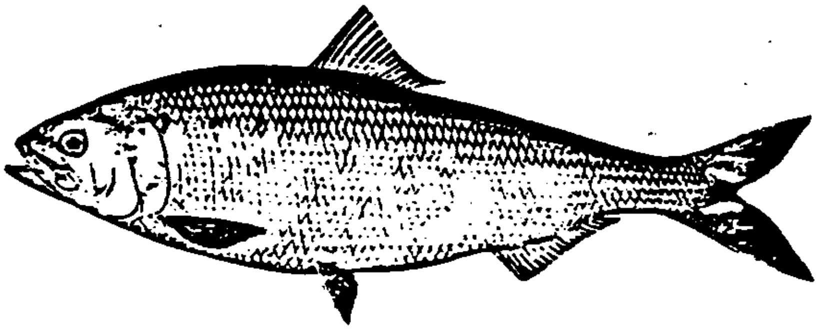
- Phase I - compile available data on the current status and biology of each of the four species and define potential options for management action
- Phase II - develop a management plan with specification of management actions where appropriate, and define research needs.

Martin Marietta Environmental Center (EC) was contracted by ASMFC in 1982 to carry out Phase I of the Action Plan. The primary sources of material for this report were overview documents prepared for each state by the individual members of the S&S Committee. This material was augmented with information taken from the literature. The present report represents completion of Phase I. It is not intended to be a detailed all-encompassing review of literature on the biology of all four species, since a number of other review documents exist that serve that specific purpose (e.g., Mansuetti and Kolb, 1953; Walburg and Nichols, 1967; Rulifson et al., 1982; Public Service Electric and Gas Company, 1982a, b, c). Instead this report focuses on current fisheries (both commercial and recreational) for each species, recent trends in landings and stock size, and those life history aspects considered most relevant to management action. To a certain extent, sources of data have been "screened", and those of questionable validity or lacking in general applicability have not been included.

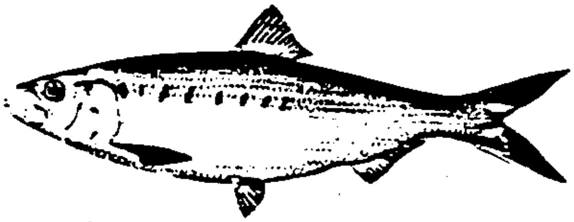
American shad, hickory shad, and river herring (alewife and blueback herring) will each be treated in a separate segment of this report. Each segment will have the same organization (where appropriate) as follows:

- Historical review of the fisheries for the species
- Recent trends in commercial and sport landings - regional basis
- Recent trends in fisheries - state-by-state
- Coastal migration patterns
- Selected life history aspects relevant to management
- Restoration efforts
- Environmental factors influencing stocks
- Management options.

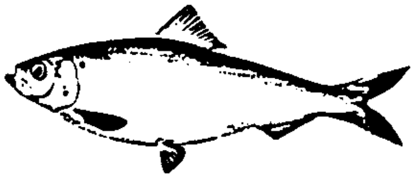
A bibliography of data and information sources is included at the end of the report, organized by state. The four species are illustrated in Fig. I-1. General characterizations of the life histories of each species are diagramed in Figs. I-2 to I-5.



American shad, *Alosa sapidissima*



Hickory shad, *Alosa mediocris*



Alewife, *Alosa pseudoharengus*

Blueback herring, *Alosa aestivalis*

Figure I-1. Illustrations of adults of the four species of east coast anadromous alosids. Drawings are to scale (adapted from Jones, Martin, and Hardy, 1978)

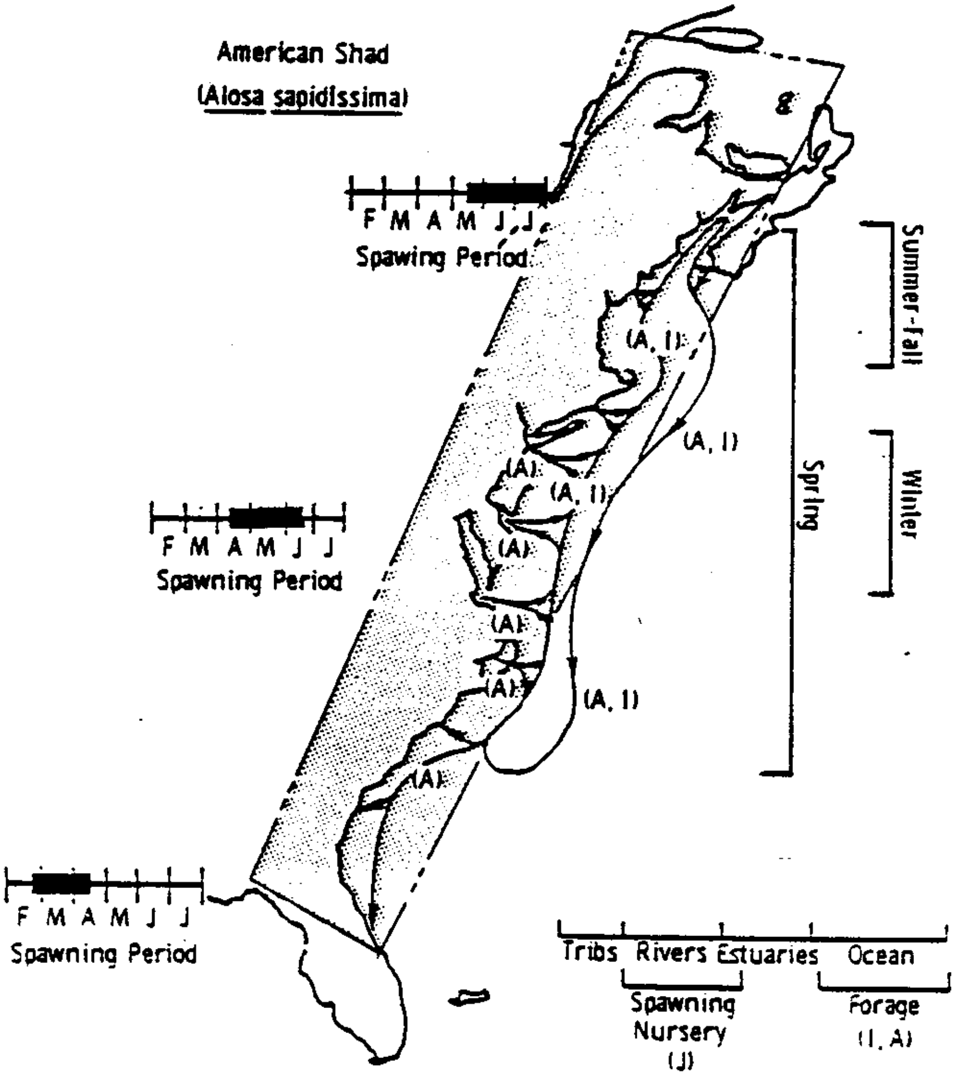


Figure I-2. Diagramatic characterization of the life history of the American shad; A = adult, I = immature, J = juvenile, shaded area represents range of spawning occurrence; bars indicate general seasonal or habitat distribution by life stage. Detailed discussion appears in the text.

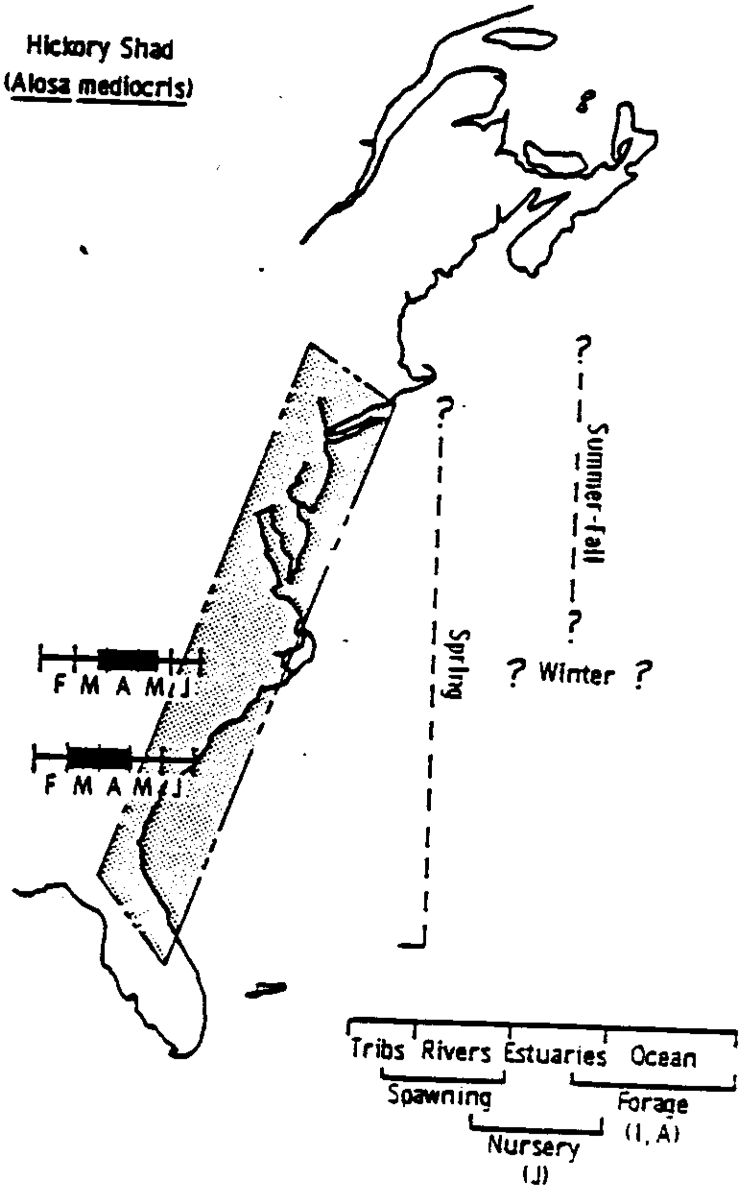


Figure I-3. Diagramatic characterization of the life history of the hickory shad; A = adult, I = immature, J = juvenile, shaded area represents possible range of spawning occurrence; bars indicate general seasonal and habitat distribution by life stage. Detailed discussion appears in the text; dashed lines represent speculation.

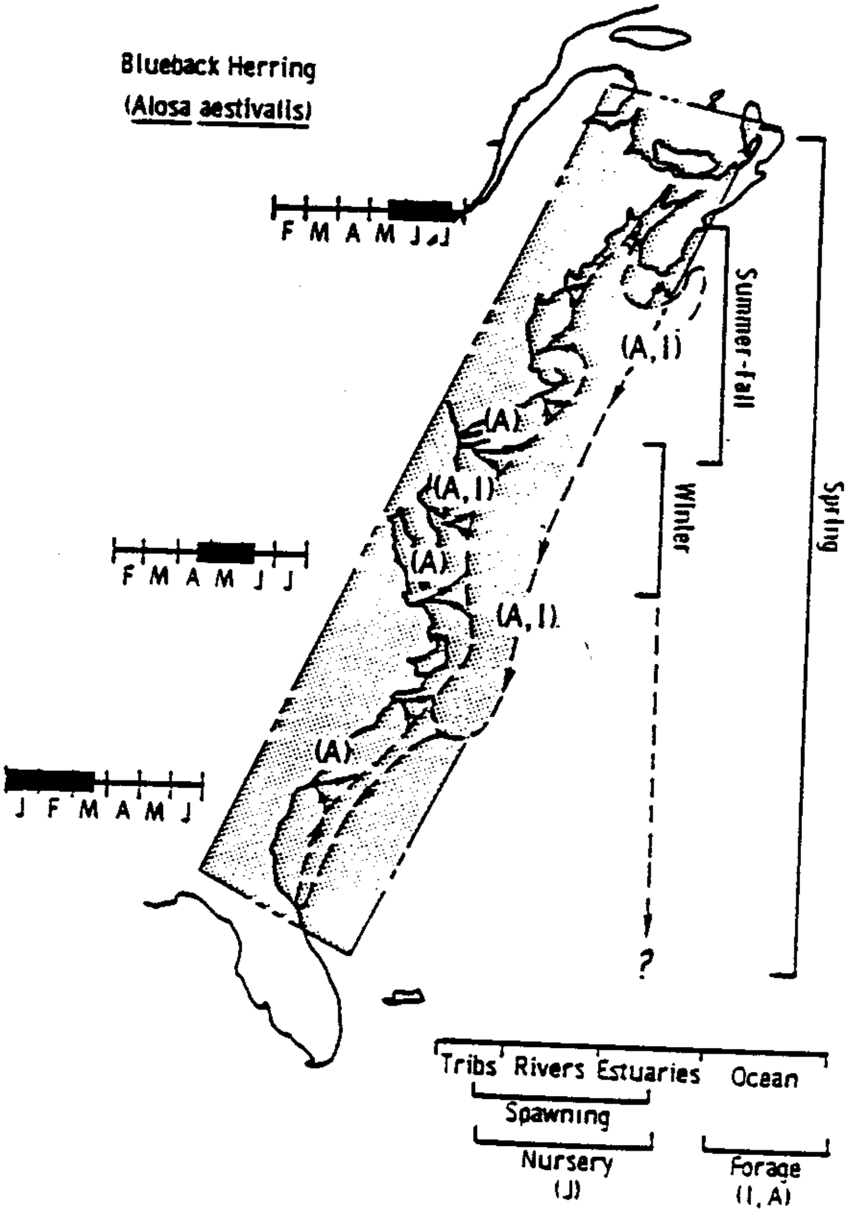


Figure I-4. Diagramatic characterization of the life history of the blueback herring; A = adult, I = immature, J = juvenile; dashed lines represent speculation; shaded area represents range of spawning occurrence; bars indicate general seasonal or habitat distribution of life stage. Detailed discussion appears in the text.

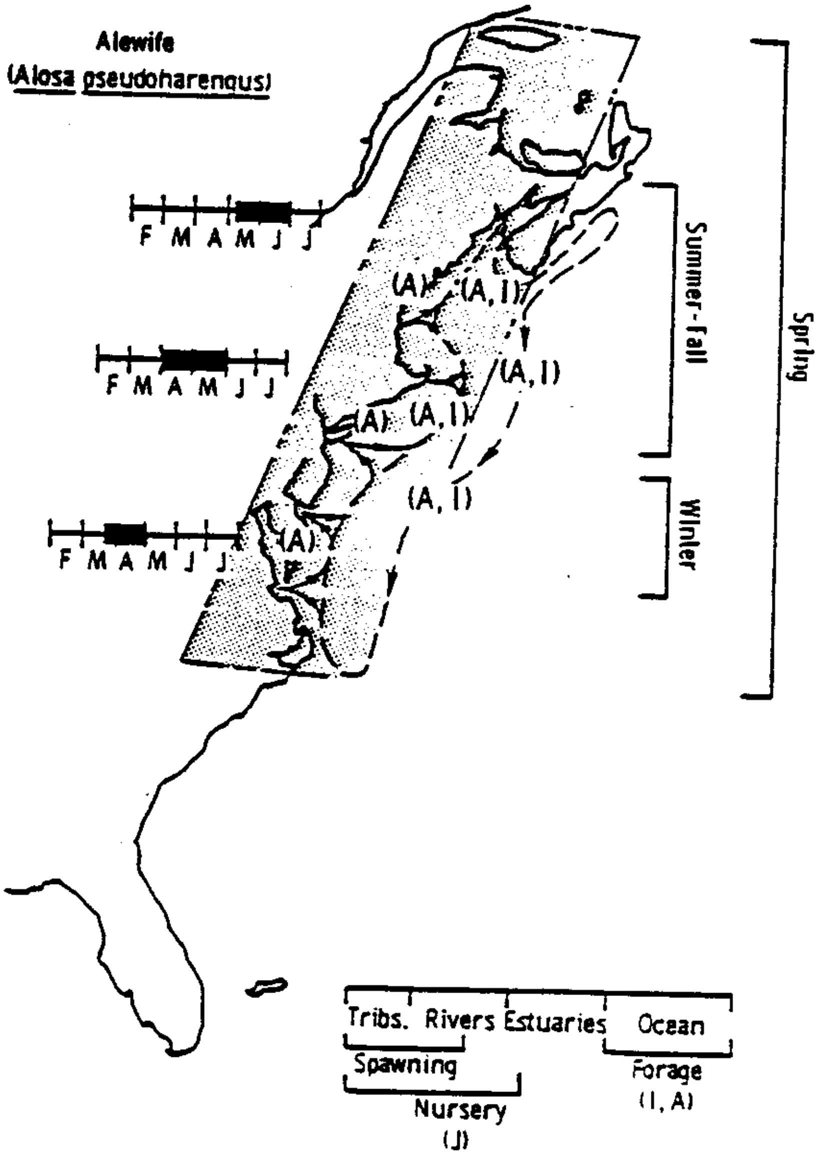


Figure I-5. Diagramatic characterization of the life history of the alewife; A = adult, I = immature, J = juvenile; shaded area represents range of spawning occurrence; bars indicate general seasonal or habitat distribution. Dashed lines represent speculation; detailed discussion appears in the text.

II. American Shad (*Alosa sapidissima*)

A. BACKGROUND AND HISTORICAL TRENDS

Background

American shad spawning runs occur along the east coast of the United States and Canada, from the St. Johns River in Florida to the St. Lawrence River in Canada. Major spawning rivers are listed in Table II-1 (from Walburg and Nichols, 1967).

Historically, the American shad was an extremely important resource species along the east coast of both the United States and Canada, supporting very large commercial fisheries. However, landings of American shad in commercial fisheries have shown long-term declines (Fig. II-1). These historical declines in landings, which have been interpreted as indicators of stock declines, sparked concerns and studies on numerous occasions in the past.

In a very thorough review of information on American shad fisheries, Mansuetti and Kolb (1953) noted that from 1897 to the 1940's, annual harvest of shad declined from 50 million pounds to approximately 11 million pounds. Their assessment of causes of the decline identified several potential major factors, including:

- Pollution of spawning rivers
- Siltation of spawning areas
- Overharvesting
- Dams, by preventing access to spawning areas.

However, they noted that these factors, singly or collectively, could not be made to account completely for the general decline of shad along the Atlantic coast. Mansuetti and Kolb also suggested the existence of some type of natural biological cycle in shad population size, but no evidence was presented to substantiate this view. They also indicated that the prognosis for American shad was poor and envisioned no known means of restoring stocks to their former magnitude.

Table II-1. The original and current limits of shad range in 23 major rivers of the Atlantic coast of the United States (adapted from Walburg and Nichols, 1967).

State	Original limit of shad run		1983 limit of shad run	
	River	Distance of source from coastline	Locality	Distance of source from coastline
		Miles		Miles
Florida	St. Johns	375	Lake Washington	250
Georgia	Altamaha	450	Hawkinsville	300
Georgia	Ogeechee	350	Midville	125
Georgia	Savannah	425	Savannah Lock and Dam	180
South Carolina	Edisto	300	Norway	120
South Carolina	Santee: Wateree	350	Santee Dam	65
	Congaree	410	Santee Dam	65
South Carolina	Pee Dee	497	Blewett Falls Dam	242
North Carolina	Cape Fear	290	Lock No. 1	65
North Carolina	Neuse	340	Milburnie	165
North Carolina	Pamlico-Tar	252	Rocky Mount	157
North Carolina	Roanoke	457	Spring Hill	215
Virginia	James	420	Boshers Dam	140
Virginia	Rappahannock	248	Falmouth Falls	155
Maryland	Potomac	400	Little Falls Dam	180
Maryland	Susquehanna	617	Conowingo Dam	205
New York - New Jersey	Delaware East Branch	388	Downsville, N.Y.	360
	West Branch	350	Deposit, N.Y.	350
New York	Hudson	314	Troy, N.Y.	130
Connecticut	Housatonic	202		No shad
Connecticut	Connecticut	174	Bellows Falls	174
Massachusetts	Merrimac	140	Eastman Falls	110
Maine	Kennebec	155		No shad
Maine	Penobscot	255		No shad

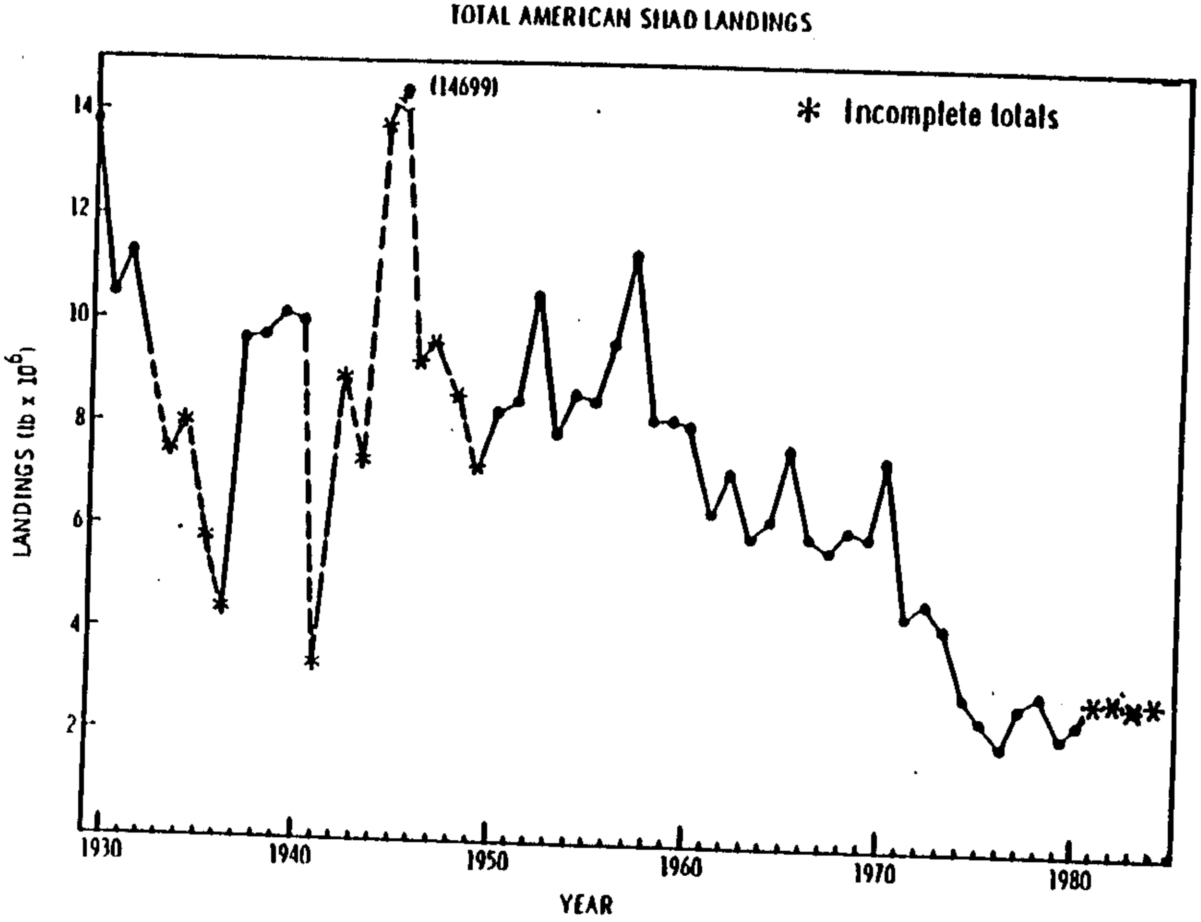


Figure II-1. Reported commercial landings of American shad along the east coast of the United States, 1930 to 1984. Sources of data are listed in Table II-2.

ASMFC recommendations to the United States Fish and Wildlife Service (USFWS) resulted in American shad studies being conducted by USFWS during the 1950's (e.g., Talbot and Sykes, 1957). These efforts were prompted by concern for the status of shad runs at that time, with the goal of establishing the reasons for declines and developing recommendations to reverse declining trends in American shad fisheries. Results of these studies were summarized by Walburg and Nichols (1967). They concluded that many factors had influenced the status of the American shad, but their list of major factors was essentially identical to that of the Mansuetti and Kolb study 14 years earlier:

- Pollution of spawning rivers
- Siltation of spawning areas
- Dams, by preventing access to spawning areas
- Overharvesting.

While Walburg and Nichols presented a more updated view of stock status than Mansuetti and Kolb (1953) they provided no new major insights into the causes of decline. In many respects, the present document represents an updating of the information compiled by Walburg and Nichols in 1967. This updating will begin by examining trends in shad commercial fisheries over the last 20 years on a regional basis; these regional trends will then be examined in more detail on a state-by-state basis.

B. RELEVANCE OF COMMERCIAL LANDINGS DATA TO STOCK ASSESSMENT

Because commercial landings data represent the only long-term records available relating to fish abundance, they serve as the primary basis for discussion of trends in stocks. However, as is widely known and acknowledged by fisheries experts, many factors influence the magnitude of landings beside the basic abundance of the fish being harvested. These include:

- Amount of fishing effort (e.g., number of fishermen, amount of gear used)
- Effects of demand for the species on fishing effort (market factors)

- Environmental conditions, as they may affect fishing effort and/or catchability of the fish (e.g., ice destroying pound nets during a cold winter; high river flow decreasing the efficiency of drift gill nets)
- Market value of roe (female) shad being higher than the market value of buck (male) shad, resulting in discard and non-reporting of buck shad harvest
- Unreliability of catch reporting by fishermen, often to the extent of 100 to 200%, with no constant bias from year-to-year (e.g., Maryland Watermens Association, 1980).

Catch per unit effort (CPUE) is assumed to be proportional to changes in fish stock size. However, a recent Connecticut study (Crecco 1983 in prep) has shown that commercial shad CPUE did not accurately reflect shad stock size. This lack of colinearity between CPUE and stock size was attributed to an inverse relationship between catachability (q) and population size (see Fig. II-2). The catchability coefficient is defined as the percentage of the fish stock removed by a single unit of fishing effort. Such a phenomena could be a market affect, with higher prices at times of low abundance causing fishermen to be more diligent. This phenomenon implies that shad runs can fall to low levels without this being demonstrated in the catch statistics. This is a promising hypothesis to explain how overfishing can cause recruitment failure. The inadequacies of CPUE as an indicator of stock abundance has previously been demonstrated for other fisheries (e.g., Bannerot and Austin, 1983). However, it has been pointed out that the shad fishery in the Connecticut River occurs in relatively confined areas. In an open system, such as the Delaware Bay, fishermen may not have the luxury of modifying the amount or nature of their effort in response to their perception of the size of the run (R. Miller, pers. comm.). Virginia fishermen do tend to be opportunistic in their exploitation of shad (J. Loesch, pers. comm.)

An even more limiting factor in using catch per unit effort as the indicator of American shad stock abundance is that there is essentially an absence of meaningful long-term records of effort along nearly the entire east coast. This absence of effort data currently precludes the use of catch per unit effort as a useful index of stock abundance for examining long-term trends in shad stocks.

Thus, the commercial landings data are the sole means of characterizing stock trends even though it is acknowledged that they only serve as a rough index of stock abundance. For this reason, only severe changes in landings can be considered meaningful in terms of stock changes. Reliable records of recreational harvest are too incomplete and sparse over time to be of use as stock abundance indices.

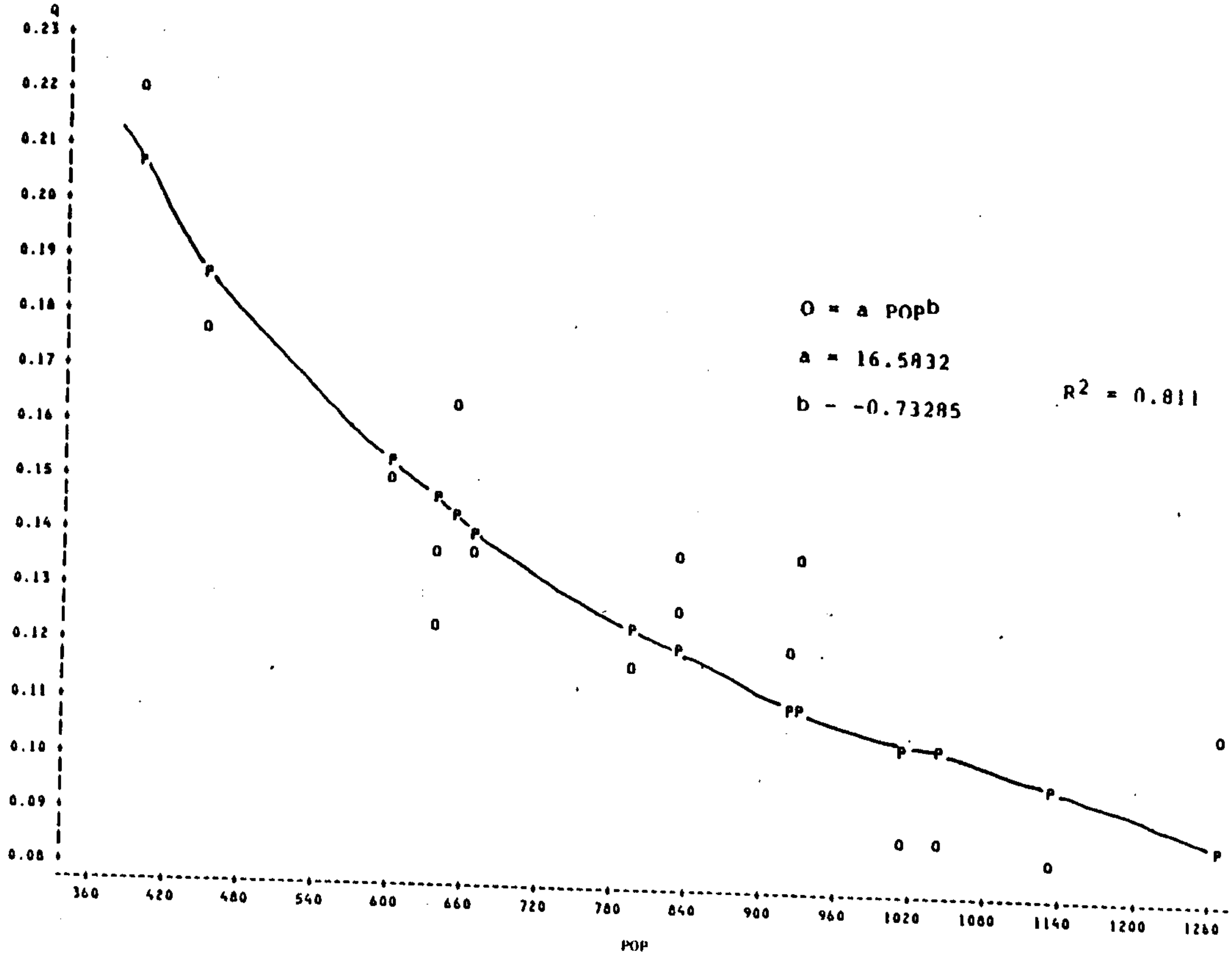


Figure II-2. Relationship between stock size (POP) and catchability (q) for Connecticut River shad (from Crecco 1983 in [illegible]

Table II-2. American shad catch (in thousands of pounds) per state and total Atlantic coast for years of available data. Data for 1880-1960 from Walburg & Nichols (1967); 1961-1979 from U.S. Dept. of Commerce Fishery Statistics of the United States (from PSE&G, 1982a); 1980 to present from Boreman (1982) and/or state fisheries agencies; where no number appears information was lacking.

Year	FL	GA	SC	NC	VA	MD	DE	PA	NJ	NY	CT	RI	MA	NH	ME	Total Atlantic Coast
1880		252	208	3,221	3,172	3,774	1,050	559	750	2,734						18,068
1887		255	366	4,783	3,815	4,041	1,270	1,424	6,495	3,586	337	17	133			29,630
1888		263	433	5,725	7,057	4,860	1,389	1,387	6,523		282	17	260		1,096	33,397
1889		356	577	5,403			1,498	2,753	10,424	4,332	196	17	234		839	
1890		400	563	5,815	7,266	7,128	1,797	2,898	10,623	3,777	120					
1896	1,299	537	672	8,843	11,171	5,541	1,993	2,501	13,910	2,201	261	53	114		1,404	50,499
1897	1,011	788	506	8,963	11,529	5,800	1,621	2,007	13,001	1,884	256					
1901					6,972	3,111	1,368	2,983	14,031	3,432	434				731	
1902	1,819	1,029	414	6,567							480	31	21		849	
1904				3,230	7,420	2,912	951	836	4,338	498	603				1,259	
1908	2,833	1,133	464	3,942	7,314	3,937	870	593	3,004	360	122	4	389		770	25,935
1909					6,030	3,253					122				980	
1915					4,714	1,455					140					
1918	964	101	167	1,657							241					
1920					7,294	1,867					176					
1921					6,909	1,807	87	19	168	116	72					
1923	503	134	184	2,370							46					
1925					6,104	1,260					146					
1927	348	187	182	2,387							120					
1928	691	317	320	3,118							199	6	31	0	110	
1929	701	472	260	1,913	7,977	1,549	94	22	342	364	318	15	92	0	36	13,955
1930	880	275	214	1,172	6,183	998	54	5	224	167	54	4	54	0	89	10,373
1931	621	112	152	883	7,291	1,196	39	7	257	357	75	18	150	0	158	11,336
1932	546	288	123	925	4,848	1,667	16	2	224	401	70	8	46	0	108	9,272
1933					4,817	1,374	22	2	458	352	133	11	63	0	179	
1934	782	232	209	1,274	4,105	885					525					
1935					2,883	800	25	10	818	476	403	6	106	0	13	
1936	282	236	177	1,095	1,615	570					385					
1937	288	193	138	698	3,086	405	20	13	3,340	1,021	383	5	48	0	9	9,647
1938	229	98	59	1,032	3,607	600	14	14	2,492	1,072	427	10	54	0	12	9,720
1939	254	75	42	859	3,559	624	44	11	2,699	1,378	409	28	85	0	8	10,075
1940	344	150	50	801	2,811	446	31	10	3,365	1,382	360	54	95	0	65	9,964
1941	256				2,126	514					438			0	48	
1942	321				2,430	725	14	7	4,826		373	1	33	0	161	
1943	666						24	0	3,348	2,245	553	2	114	0	272	
1944	811				4,665	711	41	0	4,314	2,130	747	4	20	0	441	
1945	842	222	89	912	5,299	617	133	0	2,917	2,850	772	2	29	0	15	14,699
1946	837				3,599	719		0		1,744	1,146	3	10	0	1,107	
1947	625				4,086	868	68	0	1,547	1,267	793	2	52	0	304	
1948	515				3,206	1,004	53	0	1,853	1,393	622	2	34	0	3	
1949	284				2,801	1,083	57	0	1,407	900	471	3	11	0	5	
1950	298	180	73	1,100	3,031	1,443	102	0	1,072	628	264	2	28	0	2	8,223
1951	336	206	96	1,244	3,295	1,554	110	0	682	462	338	6	72	0	76	8,477
1952	203	243	136	1,479	4,007	1,636	65	0	1,402	773	474	5	48	0	50	10,521
1953		214	110	1,188	3,054	1,448	60	0	679	491	360	4	40	0	27	7,799
1954		180	196	1,445	3,169	1,501	55	0	826	707	295	2	9	0	2	8,668
1955	508	158	88	649	3,500	1,464	12	0	1,326	615	210	5	37	0	7	8,599

Table II-2 (Continued)

Year	FL	GA	SC	NC	VA	MD	DE	PA	NJ	NY	CT	RI	MA	NH	ME	Total Atlantic Coast
1956	376	168	116	773	3,191	2,092	12	0	1,316	704	197	1	724	0	2	9,672
1957	361	247	80	837	2,918	2,356	3	0	1,384	627	329	5	2,214	0	8	11,369
1958	589	319	71	493	2,254	1,900	59	0	964	644	456	2	425	0	10	8,186
1959	540	391	80	419	1,774	1,481	28	0	1,026	672	401	3	1,303	0	2	8,200
1960	511	534	162	702	1,386	1,336	42	0	694	472	421	3	650	0	(1)	8,134
1961	425	404	110	673	1,329	1,815	90	0	633	303	463	4	80	0	0	6,329
1962	760	527	115	765	2,220	1,575	118	0	480	243	456	7	7	0	(1)	7,274
1963	590	331	120	693	2,312	827	100	0	442	202	301	2	22	0	8	5,942
1964	613	134	120	640	2,651	890	150	0	430	141	278	3	39	0	0	6,269
1965	758	376	176	1,069	2,955	1,343	110	0	392	133	352	4	24	0	0	7,692
1966	530	386	119	701	2,431	1,133	56	0	242	81	242	23	12	0	2	5,959
1967	319	334	132	777	2,138	867	26	0	248	113	240	5	509	0	(1)	5,709
1968	531	569	110	842	2,550	958	12	0	241	126	212	2	2	0	2	6,157
1969	390	618	177	719	2,248	1,292	18	0	180	136	190	6	5	0	0	5,987
1970	218	532	148	953	4,112	1,039	13	0	195	106	173	12	1	0	0	7,502
1971	253	420	99	680	1,520	953	8	0	141	73	243	42	0	0	0	4,430
1972	120	344	159	468	2,057	957	9	0	263	103	249	14	1	0	0	4,744
1973	99	239	26	321	2,436	597	8	0	143	157	258	2	1	0	0	4,287
1974	100	162	24	369	1,569	220	8	0	122	164	247	7	3	0	(1)	2,996
1975	33	182	62	241	1,137	184	19	0	122	196	165	6	2	0	35	2,384
1976	28	93	32	167	896	110	36	0	100	186	393	3	0	2	15	2,058
1977	97*	118	80	121	1,469	78		0	198	217	302	1	(1)	3	22	2,706
1978	131	238	105	402	1,235	93	70	0	242	309	266	1	(1)	3	25	3,261
1979	95*	268	197	278	993	18	95	0	149	438*	207	1	3	2	18	2,895
1980	141*	188	271	199	973	23	94	0	293	1,249*	312	2	2	0	28	3,618
1981	170*	196	317	352	499	-	191	0	264	541*	439	33			91	2,625
1982	145*	198	398	412	585	-	350	0	391	383*	373	79			26	3,076
1983	78*	210	331*	444	564	-	233	0	233	448*	447	21			41	2,773
1984	214		492		991	-		0	291	601	199	16			33	
1985	220															

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(1)denotes less than 500 lbs

*from A. Kahle, NYSDEC, November 1984.

Table II-2 presents annual landings of American shad by state for the period 1880 through 1983. Sources of the data are primarily NOAA catch records as reported in Fishery Statistics of the United States. Figures II-3 through II-6 represent annual landings aggregated by east coast region, including the New England region (Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut), Middle Atlantic region (New York, New Jersey, Pennsylvania, Delaware), the Chesapeake Bay region (Maryland and Virginia), and the South Atlantic region (North Carolina, South Carolina, Georgia, and Florida).

C. REGIONAL CHARACTERIZATION OF STOCK TRENDS BASED ON COMMERCIAL HARVESTS

The primary focus of these characterizations will be on a period since the last shad stock assessment was made by Walburg and Nichols (1967); i.e., from 1960 to the present. New England landings (Fig. II-3) have remained very stable for the last 20 years. The exception to this fairly stable pattern of landings occurred in the late 1950's and was caused by large reported landings of shad in Massachusetts. These large annual landings have been attributed by Walburg and Nichols to purse seine fisheries being directed at alternative species when Atlantic menhaden stocks declined dramatically. During the remainder of the last 20 years, the stability of New England landings around relatively low levels is almost entirely a function of the Connecticut River landings. The Connecticut River supports the sole major American shad fishery in New England.

Middle Atlantic landings (Fig. II-4) showed a fairly steep decline from the late 1950's to the mid 1960's, followed by a period of relative stability, but with levels remaining low. The current stable level of landings is a function of landings from both the Hudson and the Delaware Rivers, with the Hudson landings dominating.

Chesapeake landings (Fig. II-5) showed relatively large fluctuations in the early 1960's, but no abrupt decline until the early 1970's. That decline was most dramatic in Virginia in terms of total numbers of fish. Maryland landings essentially went to zero, with the subsequent closure of the fishery in 1981.

South Atlantic landings (Fig. II-6) showed a decline in the early 1970's comparable to that exhibited in the Chesapeake region landings. The decline was seen in landings from all the states in the region. There has been some evidence of an increase in the landings beginning in 1978 (Table II-1), although the increase is not dramatic.

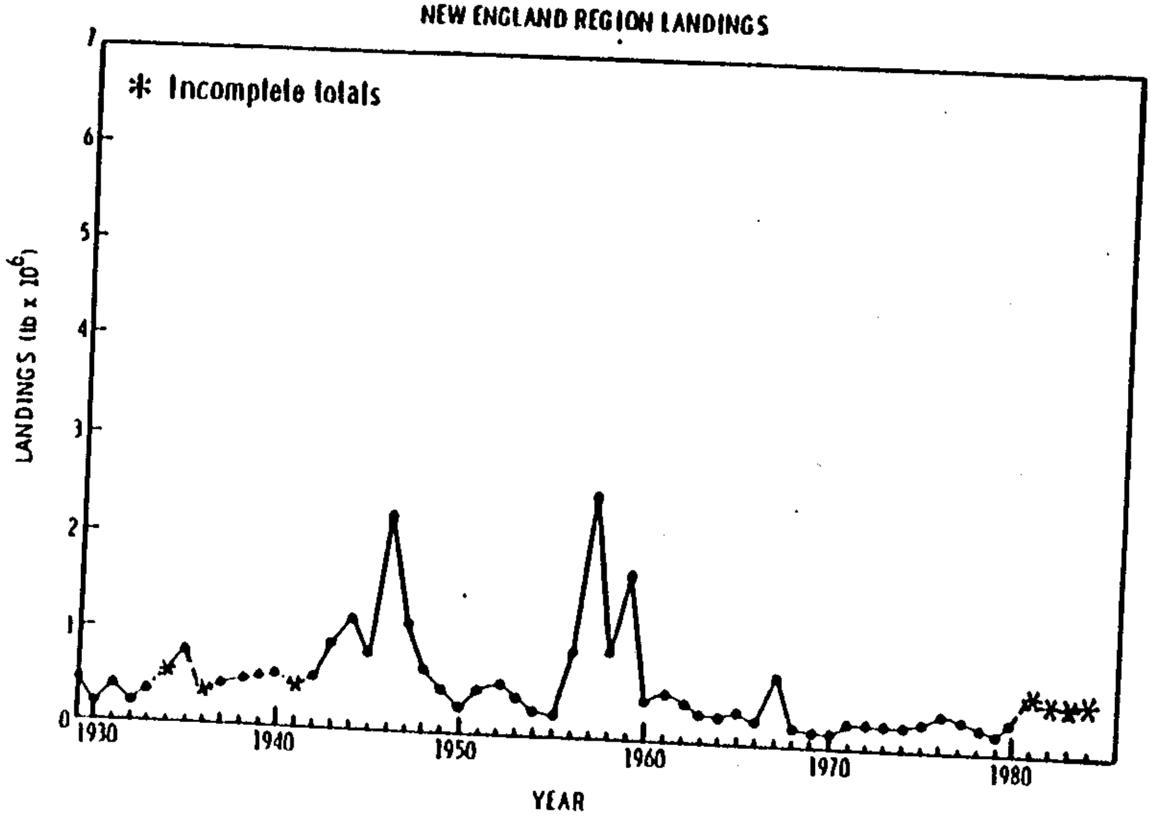


Figure II-3. Reported commercial landings of American shad in the New England region, 1930 to 1984; data sources are listed in Table II-2

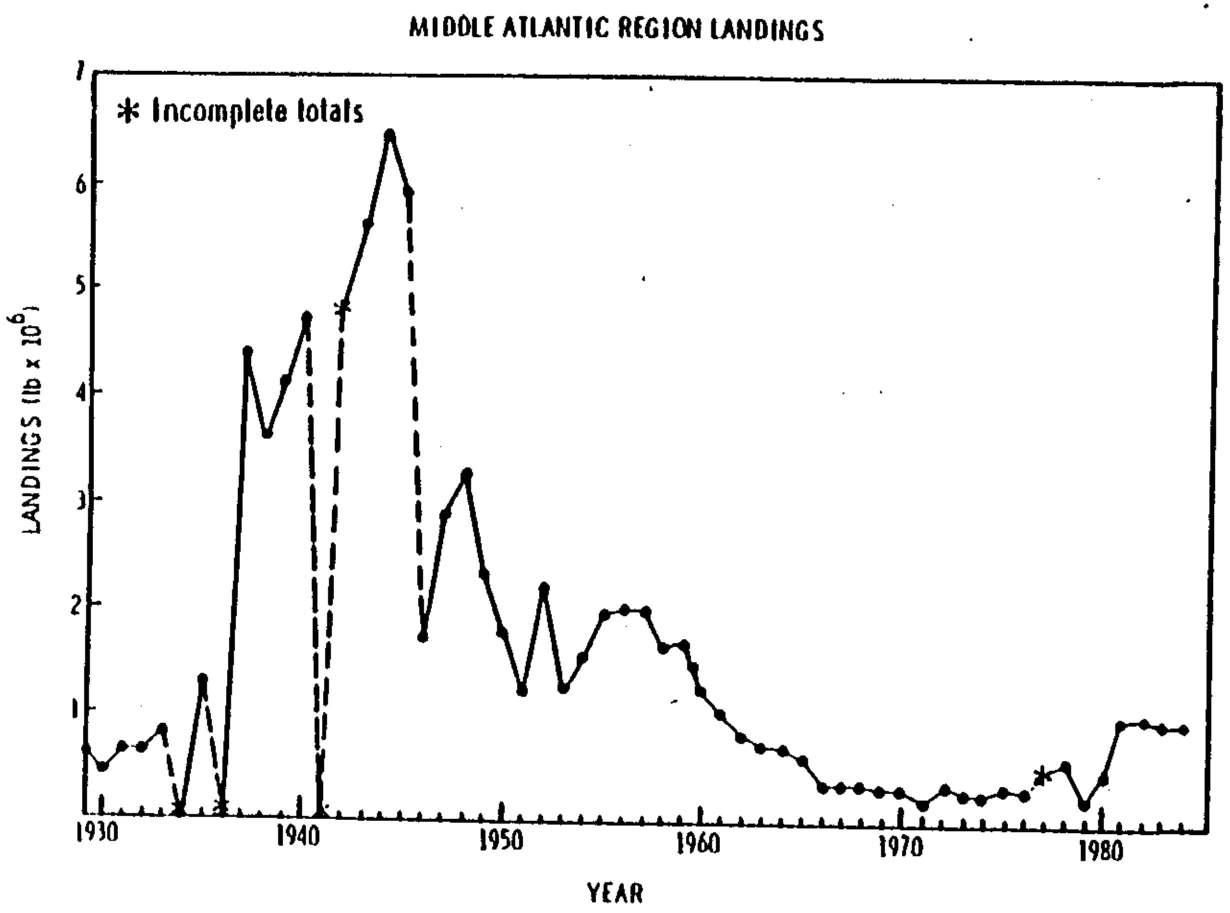


Figure II-4. Reported commercial landings of American shad in the Middle Atlantic region, 1930 to 1984; data sources are listed in Table II-2

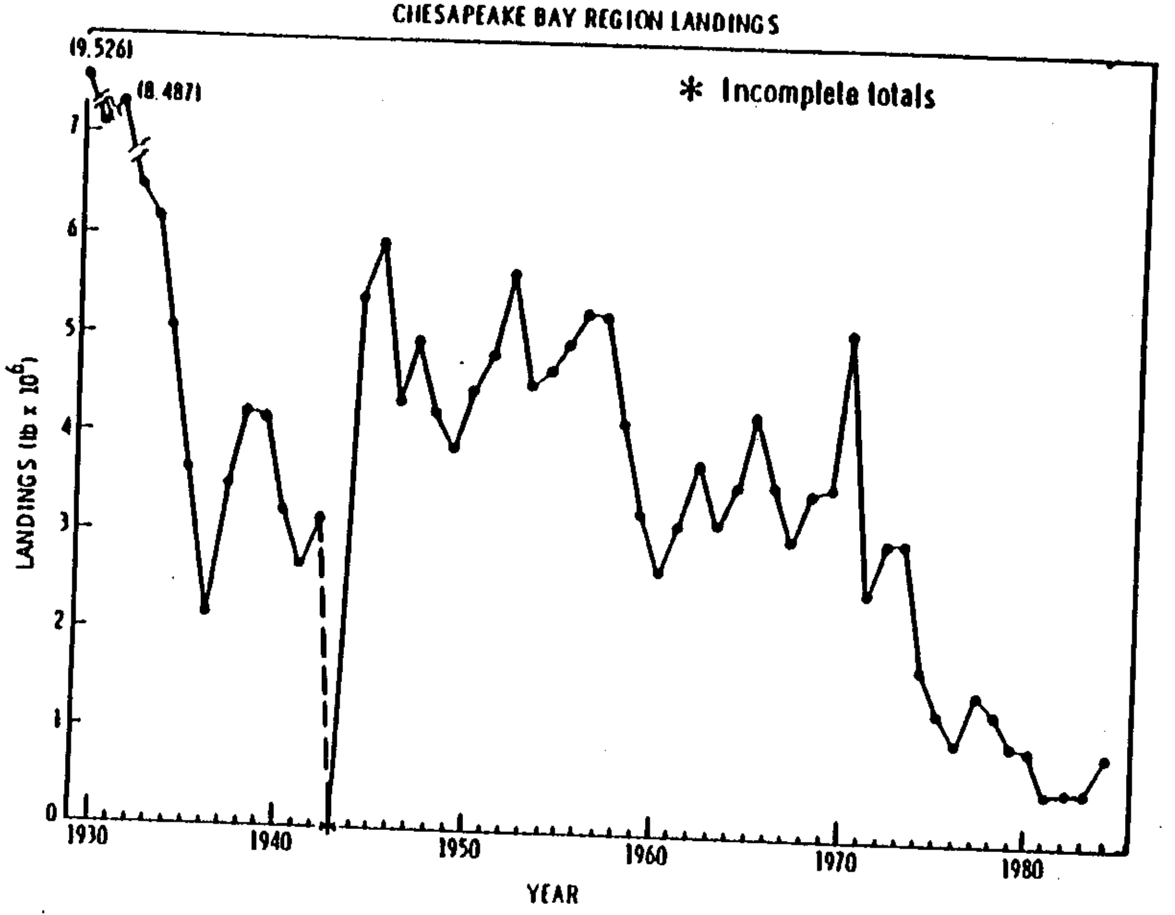


Figure II-5. Reported commercial landings of American shad in the Chesapeake region, 1930 to 1984; data sources are listed in Table II-2

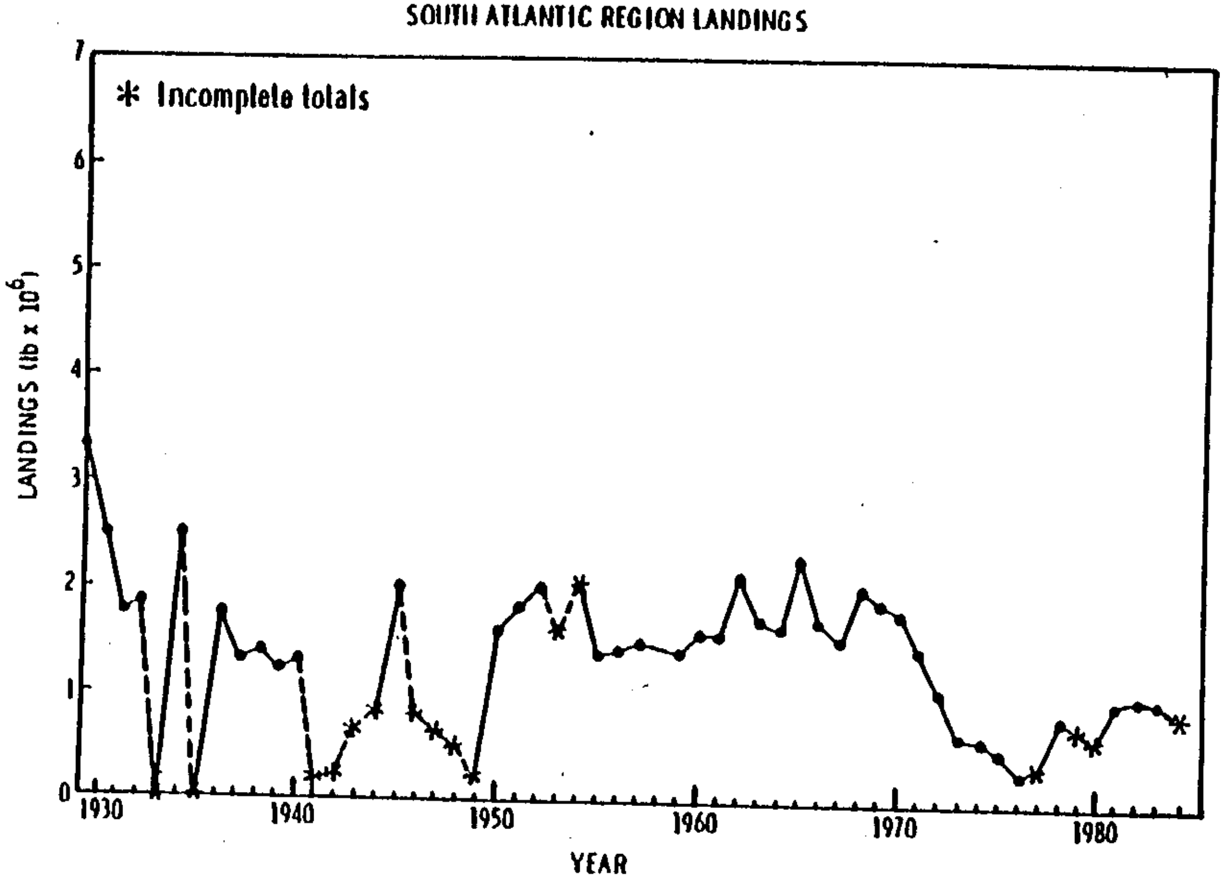


Figure II-6. Reported commercial landings of American shad in the South Atlantic Region, 1930 to 1984; sources of data are listed in Table II-2

Overall, the steep decline in total east coast landings that began in the 1970's (Fig. II-1) is primarily a function of the declines in landings in the Chesapeake and South Atlantic regions. These two regions have in the past contributed the majority of total east coast landings and thus have a disproportionate impact on total landings. The fisheries in different regions differ to a considerable degree, and the quality and quantity of data available differ in similar manners. A more detailed interpretation of the patterns of regional landings just discussed require examination of these fisheries by state and by river system within the state, where appropriate.

D. RECENT TRENDS IN AMERICAN SHAD FISHERIES - STATE-BY-STATE BASIS

Characterization of State Fisheries

Shad fisheries in the New England states of Rhode Island, Massachusetts, New Hampshire, and Maine are primarily undirected. While restoration efforts on a number of New England drainage systems presently are underway, none of these drainages currently supports an active commerical shad fishery. Commercial landings of American shad reported for these states represent fish taken as by-catch in coastal fisheries. Since these are fisheries directed at other species, and because the catch values are relatively small, New England catch data contribute little to an understanding of trends in stocks in this region.

In the state of Connecticut, the Connecticut River fishery comprises nearly all shad landings in the state. As noted in the regional characterizations above, landings have remained relatively stable over the past 20 years. Fishing effort has also remained relatively stable over the same period (V. Crecco, pers. comm.). On the Connecticut River, however, a major restoration program has been under way for a substantial period of time. The major activity in this restoration program has occurred at the Holyoke Dam, and began with the construction of the fish lift at that dam in 1955. This restoration program is discussed in more detail later in this report.

In the mid-Atlantic area, the Hudson and Delaware Rivers have generated nearly all recent shad landings. The Hudson River is the source of nearly all landings in New York state, and contributes a limited amount to landings reported for New Jersey. Klauda et al. (1976) described the declining trend in Hudson River American shad fisheries from the 1940's to 1975. However, landings since the early 1960's have remained relatively stable, though those in the 1970's may have been influenced by a decrease in fishing effort which accompanied publicized concerns about PCB pollution in the Hudson River drainage. PCB concerns may also have influenced marketability. Despite the absence of stock abundance information, the Hudson River stock appears to be relatively healthy, possibly having increased in recent years (Brandt, 1983).

In New Jersey and Delaware, the Delaware River supports the entire commercial fishery. This fishery is located primarily in the tidal waters of the Delaware Bay. As will be discussed later in the report, there is evidence to suggest that the shad fishery at Delaware Bay also takes fish from other river systems. Studies of the Delaware River American shad stock have shown that the stock has increased in size dramatically in recent years, from between 100,000 - 200,000 in the 1970's, to over 500,000 in 1981 (Lupine, 1982). The enhancement of the Delaware River American shad stock is due to the reduction of the duration of the pollution block that has occurred historically in the lower portion of the Delaware River in the Camden-Philadelphia area. In the past, this pollution block has created low dissolved oxygen conditions (<3ppm), which have caused either massive fish kills or prevented fish from moving through the area on their upstream or downstream migrations.

In Maryland waters, which constitute the upper Chesapeake Bay drainage, American shad runs in all major rivers have declined drastically in recent years. These rivers include the Susquehanna, Potomac, and the Nanticoke. These rivers differ considerably in the nature of their drainage systems, both geologically, as well as in terms of pattern and type of human development. The shad runs in all of the drainage systems declined in a pattern consistent with each other beginning in about 1972 (although the decline appeared to begin somewhat earlier in the Nanticoke River)(Carter and Weinrich, 1982). No specific cause for these abrupt declines has been established. All shad fisheries in the state were closed in 1980 and remain closed.

In the state of Virginia, tributaries of the Chesapeake Bay along the western shore support the major American shad runs. Commercial landings in Virginia show a general recent decline (e.g., Kriete and Loesch, 1976), but the characterization of changes in stock sizes based on these data may be compromised to some degree by unknown changes in effort (Atran, Loesch, and Kriete, 1982). Changes in effort, however, are not of sufficient magnitude to serve as the explanation for the precipitous decline in landings over the past decade. The subjective view of researchers in the state of Virginia is that Virginia American shad stocks are now relatively stable at a very low level relative to levels existing in earlier years.

In North Carolina, American shad runs occur in all major coastal drainage systems. A decline in annual landings of about 75% has occurred in the last decade; the causes for this decline are unexplained (Sholar, 1976; Johnson, 1982). The percentage decline in North Carolina landings has been more dramatic than that in Virginia or South Carolina, but has not resulted in stocks reaching the low levels observed in Maryland.

Landings in South Carolina declined to an all-time low in the mid 1970's. However, Crochet et al. (1976) did not observe a significant decline in experimental catch per unit effort of shad between 1974 and 1976. Recent increases of landings (400,000 pounds in 1982) are largely attributable to an increase in the ocean fishery, which currently contributes as much as 75% of total landings. There are indications that this fishery may be exploiting American shad stocks not resident to South Carolina (Ulrich, 1982). Thus, South Carolina shad stocks actually could have declined to the extent observed in other South Atlantic states, without the fisheries landings data showing evidence of the decline.

The shad fishery in Georgia is supported by several river systems. Landings have fluctuated widely over the last decade, but currently tend to be about 50% of the level of landings recorded in the late 1960's and early 1970's. Catch rates in terms of catch per unit effort declined strikingly in the early 1970's (Michaels, 1982). Georgia stocks appear to be relatively stable at low levels, similar to the case in Virginia and South Carolina.

Florida currently supports a very limited shad fishery, possibly because of low stock levels (R. Williams, pers. comm.). Because of the lack of fishing effort, catch data are insufficient to document current status of the stock. Local fisheries personnel believe that Florida stocks may be in a condition similar to that for the majority of the other South Atlantic states - stable at very low levels.

As a general overview of these individual state characterizations, landings data provide evidence to suggest that there has been a broad regional decline in American shad stocks south of the Delaware River, with the greatest declines appearing in the early 1970's. The disparate nature of the rivers supporting runs that have evidenced declines provides no clue as to a potential explanation for the declines. No systematic declines, and in fact some increases, have been observed in shad stocks of the Delaware, Hudson, and Connecticut Rivers. The health of runs in these three major river systems is suggested by all existing information.

The descriptive and relatively subjective characterizations just presented cannot be confirmed on a rigorous analytical basis because of the lack of the adequate population abundance data, the poor quality of most of the landings data, and the quantitiatively undefined market influence on fishing effort. Thus, there are insufficient data available currently to investigate potential hypotheses posed as explanations of the causes of stock declines.

Trends in Gear Usage

Detailed quantitative data on fishing effort directed at American shad are not available. Those "effort" data available, such as are presented in NOAA Fishery Statistics of the United States publications, are generally compilations of information on licensed fishermen or licensed gear. They do not represent the amount and frequency of fishing by the licensees, and thus are not true measures of fishing effort.

Characterizations of the distribution of catch by gear type do, however, provide some indication of how shad fisheries have changed over periods of years. Data on commercial landings as well as gear types used in commercial fisheries compiled in NOAA Fishery Statistics of the United States can be used to characterize trends in gear usage. These records were examined to establish landings of American shad by gear type for each of the states of the east coast (in Delaware, there is no licensing of gear; thus, effort data for that state since 1979 are estimates provided to NOAA by Delaware Division of Fish and Wildlife; R. Miller, pers. comm.).

Walburg and Nichols (1967) provided comparable information for the period prior to 1960. Thus, as a starting point for comparison here, data from Walburg and Nichols are presented in Table II-3. In 1960, various types of gill nets accounted for 63% of the total catch of American shad, with pound nets accounting for 16%. A number of other gear types accounted for the remaining 21% of total landings. In 1965 (Table II-4), gill nets accounted for 66% of landings, pound nets for 26.8%, and other gears for less than 10%. Gill nets continued to account for 66% of landings in 1970 (Table II-5), pound nets for 26.5%, and other gears for the remaining percentage. By 1976 (Table II-6) (the most current data available), gill nets accounted for 80% of total landings, pound nets for 19%, and other gears for approximately 1%.

The trend evident in these data is that gill nets have accounted for an increasingly large percentage of the total harvest of American shad, with gears other than pound nets being used much less frequently. Thus, gill nets have gradually become the gear of preference along the entire east coast, probably because of their ease of use, mobility and catch efficiency. In Virginia, pound net harvest drops to zero when shad stocks are low (J. Loesch, pers. comm.).

Current Status of Fisheries

The current status of state fisheries is summarized in Table II-7. The intent of this table is to provide a generalized characterization of the types and locations of current

Table II-3. American shad catch by state and gear (rounded to lbs x 10^3), Atlantic coast of the United States, 1960 (from Walburg and Nichols, 1967); dashed lines denote no catch reported.

State	Drift gill net	Stake and anchor gill net	Seine	Pound Net	Pyke net	Bow Net	Rod and Reel	Miscel- laneous	Total
Maine	(1)	—	—	—	—	—	—	—	(1)
New Hampshire	—	—	—	—	—	—	—	—	0
Massachusetts	—	8	—	20	—	—	—	631	658
Rhode Island	—	—	—	—	—	—	—	3	3
Connecticut	416	—	4	—	—	—	77	(1)	498
New York	143	127	3	144	—	—	—	—	417
New Jersey	8	567	1	116	—	—	—	1	694
Delaware	2	40	—	—	—	—	—	—	42
Maryland	323	678	10	325	—	—	13	60	1,409
Virginia	308	467	—	598	13	—	—	—	1,386
North Carolina	410	430	36	127	(1)	255	(1)	7	1,266
South Carolina	99	146	(1)	—	—	26	5	6	283
Georgia	513	223	—	—	—	24	8	—	768
Florida	50	163	299	—	—	—	198	—	709
TOTAL	2,274	2,848	354	1,330	13	304	302	709	8,134
% of Total	62.9%		4.4%	16.3%	<1%	3.7%	3.7%	8.7%	

(1) = less than 1,000 lbs.

Table II-4. American shad catch distribution by gear type (rounded to lbs x 10^3), 1965; dashed lines denote no catch reported (from NOAA Fishery Statistics of the United States).

Gear State	Drift Gill Net	Anchor, set or stake gill net	Haul Seine	Pound Net	Fyke and Hoop Net	Floating Traps	Otter Trawl	Other
Maine	---	---	---	---	---	---	---	---
New Hampshire	---	---	---	---	---	---	---	---
Massachusetts	---	---	---	---	---	---	(1)	---
Rhode Island	---	---	---	---	---	3	1	---
Connecticut	345	5	3	---	---	---	---	---
New York	58	63	2	10	---	---	1	---
New Jersey	51	284	17	25	---	---	11	---
Delaware	9	101	---	---	---	---	---	---
Maryland	282	996	(1)	65	---	---	5	---
Virginia	430	766	28	1625	106	---	---	---
North Carolina	52	620	64	332	---	---	---	---
South Carolina	141	35	---	---	---	---	---	---
Georgia	376	---	---	---	---	---	---	---
Florida	239	202	316	---	---	---	---	---
Total	1,984	3,071	429,200	2,053	106	3	15	4,900
Percent of Total	25.9%	40.0%	5.6%	26.8%	1.4%	<1.0%	<1.0%	<1.0%

(1) = less than 1,000 lbs.

Table II-5. American shad catch distribution by gear type (rounded to lbs x 10^3), 1970; dashed lines denote no catch reported (from NOAA Fishery Statistics of the United States).

State / Gear	Shad Drift Gill Net	Anchor, set or stake gill net	Haul Seine	Pound Net	Fyke and Hoop Net	Floating Traps	Otter Trawl	Other
Maine	---	---	---	---	---	---	---	---
New Hampshire	---	---	---	---	---	---	---	---
Massachusetts	---	---	---	(1)	---	---	(1)	---
Rhode Island	---	---	---	---	---	2	10	---
Connecticut	171	2	---	---	---	---	---	---
New York	47	49	(1)	9	---	---	---	---
New Jersey	8	144	3	19	---	---	21	---
Delaware	---	13	---	---	---	---	---	---
Maryland	168	818	(1)	52	---	---	(1)	(1)
Virginia	851	1399	150	1404	308	---	---	---
North Carolina	47	404	---	502	(1)	---	---	---
South Carolina	83	65	---	---	---	---	---	---
Georgia	532	---	---	---	---	---	---	---
Florida	27	65	127	---	---	---	---	---
Total	1,932	29,600	280	1,988	308	2	32	(1)
Percent of Total	25.8%	39.5%	3.7%	26.5%	4.1%	<1.0%	<1.0%	<1.0%

(1) = less than 1,000 lbs

Table II-6. American shad of catch distribution by gear type (rounded to lbs x 10^3), 1976; dashed lines denote no catch reported (from NOAA Fishery Statistics of the United States).

Gear State	Drift Gill Net	Anchor, set or stake gill net	Haul Seine	Pound Net	Fyke and Hoop Net	Floating Traps	Otter Trawl	Other
Maine	---	14	---	---	---	---	(1)	---
New Hampshire	---	1	---	---	---	---	---	---
Massachusetts	---	---	---	---	---	---	---	---
Rhode Island	---	---	---	---	---	3	---	---
Connecticut	40	---	---	---	---	---	---	---
New York	12	173	(1)	---	---	---	1	---
New Jersey	22	69	(1)	5	---	---	1	1
Delaware	2	33	---	---	---	---	---	---
Maryland	67	99	---	4	(1)	---	---	---
Virginia	78	546	1	271	---	---	---	---
North Carolina	7	109	6	44	---	---	---	---
South Carolina	9	23	---	---	---	---	---	---
Georgia	16	77	---	---	---	---	---	---
Florida	5	23	---	---	---	---	---	---
Total	193	1167	8	325	(1)	3	2	1
Percent of Total	11.3%	60.5%	<1.0%	19.0%	<1.0%	<1.0%	<1.0%	<1.0%

(1) = less than 1,000 lbs

Table II-7. Characterization of current (1980's) American shad fisheries, by state, developed from material provided by state fisheries agencies in overview documents; quantitative data on recreational fisheries was generally unavailable.

State	Gear type	Type of water fished	Percent of total harvest	Information Source
Rhode Island Massachusetts New Hampshire Maine	multiple gears (by-catch fishery)	coastal waters	100%	Maine Dept. of Marine Resources (1982) New Hampshire Fish and Game Dept. (1982) Massachusetts Div. of Marine Fisheries (1982) Rhode Island Div. of Fish and Wildlife (1982)
Connecticut	drift gill nets	within river (Connecticut River)	100%	Connecticut Dept. of Environmental Protection, Marine Fisheries Office (1982)
	recreational	within rivers	14% (of escapement)	
New York	stake gill nets	lower Hudson River (below RM 45)	100% combined	New York State Dept. of Environmental Conservation (1982)
	drift gill nets	upper Hudson River		
New Jersey	staked, anchored and drift gill nets	coastal waters (Delaware Bay, Raritan and Sandy Hook Bays, lower Hudson River, and coastal areas)	80%	New Jersey Div. of Fish, Game, and Wildlife (1982)
	pound nets	coastal waters	20%	
	recreational	within rivers (Delaware)	10.7% of run	

Table II-7. Continued

State	Gear type	Type of water fished	Percent of total harvest	Information Source
Delaware	anchored and drift gill nets	coastal waters	97%	Delaware Div. of Fish and Wildlife (1982)
	drift gill nets	within rivers (Nanticoke River)	3%	
Maryland	stake and drift gill nets	all waters	100% (when fishery is open)	MD. Dept. of Natural Resources (1982)
Virginia	pound nets	Chesapeake Bay and tributaries	1-4%	Atran, Loesch and Kriete, 1982
	stake and drift gill nets	within rivers	96-99%	
North Carolina	pound nets	coastal waters (Albemarle Sound)	66%	N.C. Dept. of Natural Resources (1982)
	drift gill nets	riverine	10%	
	anchor gill nets	coastal and riverine	20%	
	beach seine	Atlantic Ocean	4%	
South Carolina	drift and set gill nets	inland waters	25%	S.C. Dept. of Wildlife and Marine Resources (1982)
	set gill nets	lower rivers and coastal waters	75%	
	recreational	inland waters	not known	

Table II-7. Continued

State	Gear type	Type of water fished	Percent of total harvest	Information Source
Georgia	drift and set gill nets	inland waters	45% (in Altamaha River)	GA. Dept. of Natural Resources (1982)
	drift and set gill nets	coastal waters	55% (in Altamaha River)	
	recreational		5%	
Florida	anchored gill nets	lower St. Johns River	100%	R. Williams, personal communication
	recreational	Monroe and Harney lakes	8-44% of commercial	Williams and Bruger, 1972

shad fisheries in the individual states and the gear types used. States in which substantial coastal fisheries occur are of particular interest with the prime example being South Carolina. Coastal fisheries and fisheries such as those occurring in the Delaware Bay, have a high probability of harvesting of non-resident stocks.

Recreational fisheries are mentioned on Table II-7, despite the fact that they are poorly documented in most states. Comparisons of recreational harvest to commercial harvest in terms of percentage of total harvest, do not, of course, take into account the relative economic contribution of the respective fisheries. It is well documented that recreational fisheries contribute substantially to the economies of the regions in which shad runs occur (e.g., 1980 National Survey of Fishing, Hunting and Wildlife Associated Recreation, 1982). The magnitudes of recreational harvest in two states, however, are probably suggestive of the impact of fairly intensive recreational fisheries on shad stocks. The two fisheries of interest are those occurring in the Delaware River (New Jersey, New York and Pennsylvania) and in the Connecticut River. As indicated in Table II-7, recreational harvest in the Delaware River accounts for approximately 11% of the run, while the recreational fishery in the Connecticut River takes approximately 14% of the fish escaping the commercial fishery in the lower portion of the river.

Market Factors Influencing Shad Commerical Fisheries

As noted by Mansuetti and Kolb (1953), American shad has historically been considered a highly valuable food fish, particularly in the late 1800's and early 1900's. However, changes in dockside value of commercially harvested American shad over recent decades (i.e. approximately a doubling in value over 30 years, Table II-8), suggest that demand for American shad has declined substantially. The increase in value of shad of about 2 percent per year has been much less than that which would have been anticipated based on the rate of inflation. Many factors may contribute to the relatively low current value of shad, but the major significance of this fact is that the relatively low prices may result in a low commercial effort. As noted previously, fluctuations in effort can influence landings totals, and thus compromise the value of landings data as an indicator of stock abundance.

The relatively low dollar value of American shad may also have significance in terms of the tractability of management of the species. In drainage systems having very traditional fisheries (e.g., the Connecticut River), fishing effort may be relatively insensitive to market fluctuations and value. That is,

Table II-8. Annual average dockside value of American shad (dollars/lb) (From Fishery Statistics of the United States, 1950-1980); dashed lines denote no catch reported.

Year	ME	NH	MA	RI	CT	NY	NJ	PA	DE	MD	VA	NC	SC	GA	FL
1950	0.03	---	0.06	0.04	0.18	0.17	0.21	---	0.22	0.16	0.16	0.03	0.31	0.31	0.61
1951	0.42	---	0.56	0.03	0.18	0.15	0.23	---	0.22	0.17	0.18	0.24	0.45	0.35	0.16
1952	0.06	---	0.06	0.04	0.14	0.14	0.21	---	0.26	0.14	0.15	0.26	0.30	0.34	0.17
1953	0.04	---	0.02	0.04	0.02	0.14	0.19	---	0.28	0.15	0.17	0.25	0.29	0.36	0.20
1954	0.06	---	0.02	0.06	0.15	0.12	0.15	---	0.13	0.12	0.18	0.18	0.33	0.35	0.15
1955	0.05	---	0.03	0.14	0.14	0.13	0.15	---	0.22	0.14	0.17	0.25	0.31	0.30	0.12
1956	0.06	---	0.01	---	0.14	0.09	0.11	---	0.33	0.12	0.14	0.25	0.35	0.30	0.12
1957	0.06	---	0.01	0.05	0.14	0.10	0.11	---	0.25	0.13	0.17	0.25	0.31	0.30	0.13
1958	0.05	---	0.02	0.03	0.13	0.12	0.45	---	0.10	0.16	0.18	0.25	0.32	0.30	0.11
1959	0.06	---	0.02	0.07	0.13	0.12	0.12	---	0.14	0.12	0.17	0.25	0.32	0.31	0.12
1960	0.07	---	0.17	0.07	0.17	0.16	0.16	---	0.16	0.16	0.17	0.25	0.32	0.33	0.13
1961	---	---	0.01	0.06	0.17	0.15	0.17	---	0.14	0.16	0.17	0.25	0.32	0.23	0.16
1962	0.93	---	0.14	0.14	0.18	0.14	0.15	---	0.13	0.13	0.14	0.25	0.28	0.25	0.10
1963	---	---	0.04	0.06	0.21	0.19	0.20	---	0.13	0.16	0.15	0.24	0.28	0.27	0.11
1964	---	---	0.08	0.05	0.21	0.16	0.13	---	0.13	0.13	0.12	0.20	0.23	0.32	0.10
1965	---	---	0.08	0.10	0.21	0.16	0.10	---	0.15	0.11	0.10	0.20	0.35	0.38	0.11
1966	0.04	---	0.08	0.09	0.21	0.17	0.09	---	0.16	0.12	0.09	0.24	0.28	0.26	---
1967	0.09	---	0.01	0.07	0.19	0.16	0.13	---	0.19	0.15	0.08	---	---	---	0.16
1968	0.02	---	0.09	0.05	0.29	0.18	0.14	---	0.17	0.1	0.06	0.15	0.19	0.24	0.18
1969	---	---	0.08	0.06	0.31	0.15	0.12	---	0.11	0.10	0.07	0.19	0.33	0.30	0.16
1970	---	---	0.09	0.04	0.32	0.12	0.14	---	0.08	0.10	0.08	0.20	0.26	0.26	0.20
1971	---	---	---	0.02	0.28	0.22	0.16	---	0.62	0.13	0.09	0.17	0.40	0.32	0.20
1972	---	---	0.15	0.07	0.30	0.18	0.13	---	0.11	0.12	0.11	0.23	0.28	0.33	0.22
1973	---	---	0.14	0.05	0.28	0.32	0.19	---	0.12	0.18	0.15	0.26	0.46	0.38	0.27
1974	0.14	---	0.10	0.14	0.32	0.27	0.21	---	0.12	0.21	0.15	0.33	0.50	0.39	0.22
1975	0.11	0.10	0.10	0.17	0.35	0.40	0.24	---	0.21	0.24	0.27	0.34	0.60	0.54	0.26
1976	0.07	0.09	---	0.33	0.42	0.32	0.23	---	0.22	0.38	0.32	0.39	0.62	0.61	---
1977							0.27	---	0.21			0.46	0.68	0.71	
1978							0.28		0.28			0.36	0.69	0.66	
1979							0.18		0.16			0.44	0.79		
1980							0.19		0.33			0.44	0.79		
1981							0.25		0.46						
1982							0.30		0.39						
1983							0.33								

fishermen may continue fishing even though economically the return for their investment of time may be limited. In contrast, opportunistic fisheries, such as may occur in waters in the southern states (i.e., South Carolina), may be strongly influenced by market prices. This may be particularly true in the case of fisheries dominated by part-time fishermen interested in obtaining substantial returns for their investment of time.

American shad fisheries may also be substantially influenced by regionally varying, seasonal changes in market value. In order to determine if such a phenomenon occurs, dockside value by month and state for two recent years (1978 and 1979) was compiled from NOAA records (Tables II-9 and II-10). Tables II-11 and II-12 show the monthly shad catch for each state in 1978 and 1979. Value must be placed in perspective to the amount of harvest for the given month. As is evidenced by the data presented in these tables, the value of early southern harvests of shad was consistently higher than the value of shad landed in more northern fisheries. These data support the view that early southern shad are by far the most valuable of all shad landed along the east coast. For example, Table II-10 clearly shows high values for South Carolina and Georgia shad during the period January to March. The high value of these early harvests is due to the market demand existing in the northern states prior to the initiation of the northern runs. These southern fisheries generate fish that are exported to more northern states such as New York (Walburg and Nichols, 1967; Brandt, 1982).

Another aspect of the seasonal nature of the shad fishery is that price fluctuations toward the end of the season due to the lack of market demand may result in curtailment of fishing effort even during periods when harvests and harvest rate could be potentially quite high. Brandt (1983) suggests that the Hudson River fishery, for example, is strongly market limited. He notes that stake and anchor gill net fishermen are highly dependent on purchase of their catch by the Fulton Fish Market. When prices offered by the market drop substantially in the later part of the run, fishermen frequently pull their nets before the run is over. The decline in price may be totally independent of the abundance of the fish. That is, it appears to be a purely seasonal reaction of the market, independent of high or low level of supply. Brandt has also noted that the drift net fishery in the Hudson is one in which effort is frequently a function of immediate demand. That is, a fishermen knowing that he has a specific order for a certain amount of shad will apply the effort necessary to satisfy that specific order.

These market data have a number of implications for the management of commercial American shad fisheries. The relatively low commercial value of shad in the northern areas suggests that an expansion of the shad fisheries in those regions is unlikely. However, this neglects the possibility of new markets

Table II-9. Monthly dockside price per pound for American shad, by state, in 1978; dashed lines denote no catch reported. Blanks denote no data acquired; "shad" represents landings not identified as buck or roe (from NOAA Fishery Statistics of the United States).

State	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Maine	0.10	0.10	0.11	0.1	0.11	0.08	0.09	0.08	0.09	0.05	0.07	0.07
New Hampshire												
Massachusetts	---	---	---	---	---	0.11	---	---	---	---	---	---
Rhode Island	---	---	---	0.26	0.25	---	---	---	0.26	0.25	0.25	---
Connecticut												
New York	---	---	---	0.25	0.21	0.34	0.34	---	---	---	0.10	---
New Jersey	0.25	0.24	0.18	Buck = 0.07 Shad = 0.22	Buck = 0.34 Shad = 0.54	0.66	---	---	---	---	0.17	Buck = 0.31 Shad = 0.31
Delaware												
Maryland	---	---	0.33	0.25	0.28	0.25	---	---	---	---	---	---
Virginia	---	---	0.26	0.12	0.19	0.08	0.25	---	---	---	0.08	0.17
North Carolina	0.45	0.60	0.41	0.27	0.11	0.08	---	---	---	---	0.25	0.25
South Carolina	---	Buck = 0.60 Roe = 0.90 Shad = 0.80	Buck= 0.50 Roe = 0.80 Shad= 0.74	Buck = 0.35 Roe = 0.55 Shad = 0.51	---	---	---	---	---	---	---	---
Georgia	0.62	0.67	0.66	0.35	---	---	---	---	---	---	---	---
Florida												

Table II-10. Monthly dockside price per pound for American shad, by state, in 1979; dashed lines denote no catch reported. Blanks denote no data acquired; "shad" represents landings not identified as buck or roe (from NOAA Fishery Statistics of the United States).

State	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Maine	0.14	0.10	---	0.10	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.11
New Hampshire												
Massachusetts	---	---	---	0.07	---	---	---	---	---	0.11	---	---
Rhode Island	---	---	---	0.30	0.15	0.25	---	---	---	---	---	---
Connecticut												
New York	---	---	---	0.40	0.45	0.14	0.18	0.18	---	---	0.22	0.18
New Jersey	0.22	0.32	0.23	0.18	0.18	0.13	0.18	---	---	0.20	0.20	0.22
Delaware												
Maryland	---	---	0.17	0.24	0.34	0.39	---	---	---	---	---	---
Virginia	0.54	0.31	0.25	0.21	0.22	0.12	---	--	0.11	---	0.20	0.22
North Carolina	0.54	0.68	0.43	0.41	0.15	0.16	---	---	---	---	---	0.47
South Carolina	Buck= 0.39 Roe = 0.67	Buck= 0.65 Roe = 0.96 Shad = 0.73	Buck= 0.42 Roe = 0.80	Buck = 0.33 Roe = 0.62	---	---	---	---	---	---	---	---
Georgia	0.91	0.93	0.79	0.48	---	---	---	---	---	---	---	---
Florida												

Table II-11. Monthly American shad catch (lbs) by state - 1978. Dashed lines denote no catch reported, blanks denote no data acquired; "shad" represents landings not identified as buck or roe (from NOAA Fishery Statistics of the United States.

State	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Maine	684	100	45	566	2076	2176	1081	471	275	3135	7215	6687
New Hampshire												
Massachusetts	---	---	---	---	---	76	---	---	---	---	---	---
Rhode Island	---	---	---	133	177	---	---	---	55	620	250	---
Connecticut												
New York	---	---	---	306543	73	1332	398	---	---	---	99	---
New Jersey	183	25	8513	Buck = 4850 Shad = 162697	Buck= 48844 Shad= 8459	Buck= 4697 Shad= 3457	Buck= 74 Shad= 6	---	---	---	Shad= 12	Buck= 95 Shad= 100
Delaware												
Maryland	---	---	5669	38174	19640	820	---	---	---	---	---	---
Virginia	---	---	430708	758068	40340	5066	4	---	---	---	155	700
North Carolina	413	2076	266437	119820	12669	254	---	---	---	---	105	243
South Carolina	---	Buck= 9671 Roe= 14986 Shad= 11455	Buck= 15524 Roe= 44574 Shad= 131534	Buck= 3460 Roe= 10209 Shad= 63302	---	---	---	---	---	---	---	---
Georgia	12032	46449	172868	6601	---	---	---	---	---	---	---	---
Florida	91591	24804	---	---	---	---	---	1054	---	---	---	13591

Table II-12. Monthly American shad catch (lbs) by state - 1979. Dashed lines denote no catch reported; blanks denote no data acquired; "shad" represents landings not identified as buck or roe (from NOAA Fishery Statistics of the United States).

State	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Maine	1470	755	---	2395	2332	780	335	325	970	932	3281	4934
New Hampshire												
Massachusetts	---	---	---	2600	---	---	---	---	---	105	---	---
Rhode Island	---	---	---	340	396	670	---	---	---	---	---	---
Connecticut												
New York	---	---	---	330	288	1321	509	4900	---	---	74	640
New Jersey	Buck= 33 Shad= 6310	40	Buck= 11 Shad= 7240	109058	16874	1341	22	---	---	25	50	7704
Delaware												
Maryland	3	---	8988	31988	5962	47	---	---	---	---	---	---
Virginia	922	88	573789	390067	23607	1434	---	---	4000	---	59	129
North Carolina	2136	19744	198965	51238	4887	454	---	---	---	---	---	646
South Carolina	Buck= 361 Roe= 384	Buck= 11165 Roe= 67354 Shad= 55	Buck= 13060 Roe= 82267	Buck= 2489 Roe= 20061	---	---	---	---	---	---	---	---
Georgia	20489	105428	135447	6514	---	---	---	---	---	---	---	---
Florida												

for American shad coming into existence (e.g., use as pet food). In contrast, the relatively high price for early southern harvests of American shad suggests that the expansion of that fishery could occur. Recent increases in the South Carolina coastal harvests are an indicator of this type of a trend. Increases in these fisheries could also occur as a result of the creation of local early-season markets for the harvests.

If, in fact, the American shad fishery along the east coast of the United States is more in the nature of a traditional fishery than opportunistic fishery for most of the major runs, commercial effort may be relatively unresponsive to changes in stock abundance and price. This would suggest that implementation of any type of radical changes in the commercial fisheries may be resisted by the fishermen. State fisheries personnel have suggested that shad harvests tend to decline whenever a fishery for a more desirable, more valuable species is developed, as is the case with other relatively low value species.

Alternatives to the Use of Commercial Landings Data to Establish Trends in Stock Abundance

As was noted above, commercial landings data represent the primary source of long-term information on stock abundance for American shad. However in a limited number of locations, an alternative indicator of stock abundance is available: an index of juvenile abundance. The advantages of using data of this sort is that they are not influenced by annual changes in effort, inaccurate catch report, market factors, etc. There are, of course, numerous disadvantages to the use of the juvenile abundance index. The primary difficulty with the use of the indices developed for different drainage systems is that standardization of survey designs is unlikely. A standardized design would have to take into account the location of nursery areas and the shift in those areas within drainage system between seasons and in response to numerous environmental variables such as rainfall and temperature. Sampling design would also have to be of sufficient intensity in both time and space to provide a precise and accurate index. Additionally, a sufficient time record of juvenile abundance is needed to verify through correlation with subsequent estimates of adult stock size that the index is an accurate indicator of abundance.

The verification of an index's validity is an extremely difficult procedure, and as a consequence, has only been established in one river system, the Connecticut River. Table II-13 summarizes all of the juvenile index data available for river systems along the east coast. The data set collected in the Connecticut River is the only set satisfying the needs discussed above. Longterm data sets (i.e., greater than 4 years) are also available for rivers in Maryland, Virginia, New Jersey, and New York (for the Hudson River). Less extensive juvenile

Table II-13. Summary of "long-term" (>4 years) juvenile shad survey data currently available on a state-by-state basis

State	Time Period	Drainage System(s)	Comments	Data Sources
Connecticut	1966 to 1972; 1978 to present	Connecticut River	Survey designed to sample American shad; sampling locations and methods consistent; index of juvenile abundance was developed	Connecticut River Shad Study Reports, Connecticut Dept. of Marine Fisheries Office
New York	1973 to 1983	Hudson River	Survey directed primarily at striped bass; sampling locations and methods consistent; no integrated annual index has been developed	Yearclass reports for the multiplant impact study, Hudson River Estuary, Texas Instruments Inc. for Consolidated Edison Company of New York (1974 to 1983)
New Jersey Pennsylvania Delaware New York	1971 to 1975 1979 to present	Delaware River	Survey directed at American shad; sampling locations and methods changed between survey periods; index of juvenile abundance was developed	Delaware River Basin Fish and Wildlife Cooperative (1982) NJ Div. Fish Game and Wildlife (1983)
Maryland	1962 to present	Upper Chesapeake Bay Nanticoke River Choptank River Potomac River	Survey directed primarily at striped bass; sampling locations and methods consistent; all samples averaged for annual index	Maryland Dept. of Natural Resources (1982)
Virginia	1969 to 1975; 1976 to present	James River York River Rappahannock River Potomac River	Survey designs differed before 1975 and after 1976; locations and methods changed; different methods of developing index used.	Virginia Institute of Marine Science (1982)
North Carolina	1971 to present	Albemarle Sound	Consistent sampling design; no integrated index developed	North Carolina Dept. of Natural Resources (1982)

index data are also available for other states, particularly North Carolina.

Figure II-7 illustrates the relative magnitude of juvenile index values from several different drainages in different states. The intent of plotting these index values is to examine if any pattern amongst year-class success (as characterized by juvenile abundance) appears among the regional drainage systems. It is difficult to discern any comparable patterns among river systems from the data presented in that figure. This is primarily due to the lack of synoptic, credible data of sufficient time length. One subjective observation which can be made from the data presented in Figure II-6 is that both the Connecticut and Delaware rivers appear to have had exceptionally good year-classes in 1971.

The basic conclusion from examination of the available juvenile index data is that they are insufficient to rigorously (analytically) contrast trends among populations in the different drainage systems.

E. COASTAL MIGRATION PATTERNS

A knowledge of the coastal migration patterns of the American shad is important in examining various hypotheses proposed to explain the fluctuations in population abundance of East coast shad stocks. Such knowledge permits assessment of factors that may influence shad mortality rates during the portion of their life cycle that they spend at sea. An understanding of coastal migration patterns is also important in deliniating geographical areas in which potential interjurisdictional management problems may occur (that is, identifying locations where non-resident shad stocks are being fished in local fisheries, such as coastal South Carolina).

Coastal migrations must be examined in the context of the general life history pattern of the American shad, which was presented diagramatically in Fig. I-2. American shad are an anadromous species, spawning in freshwater rivers along the east coast in early spring. Juveniles resulting from the spring spawning emigrate from the freshwater nursery areas to the ocean in the fall. The immature shad remain in the ocean in general from 3 to 6 years. Evidence for homing in the American shad is very strong. Older studies supporting homing are summarized by Walburg and Nichols (1967). Of fish tagged in the Connecticut River in recent years, 97% of those recaptured were recaptured in the Connecticut (Crecco, pers. comm.). However, there is evidence of substantial straying of American shad, with the best example being the case of shad stocks on the west coast of the United States. The former U.S. Fish Commission (now NMFS) reported that shad fry were stocked in the Sacramento River system from 1871 through 1880 and subsequently spread

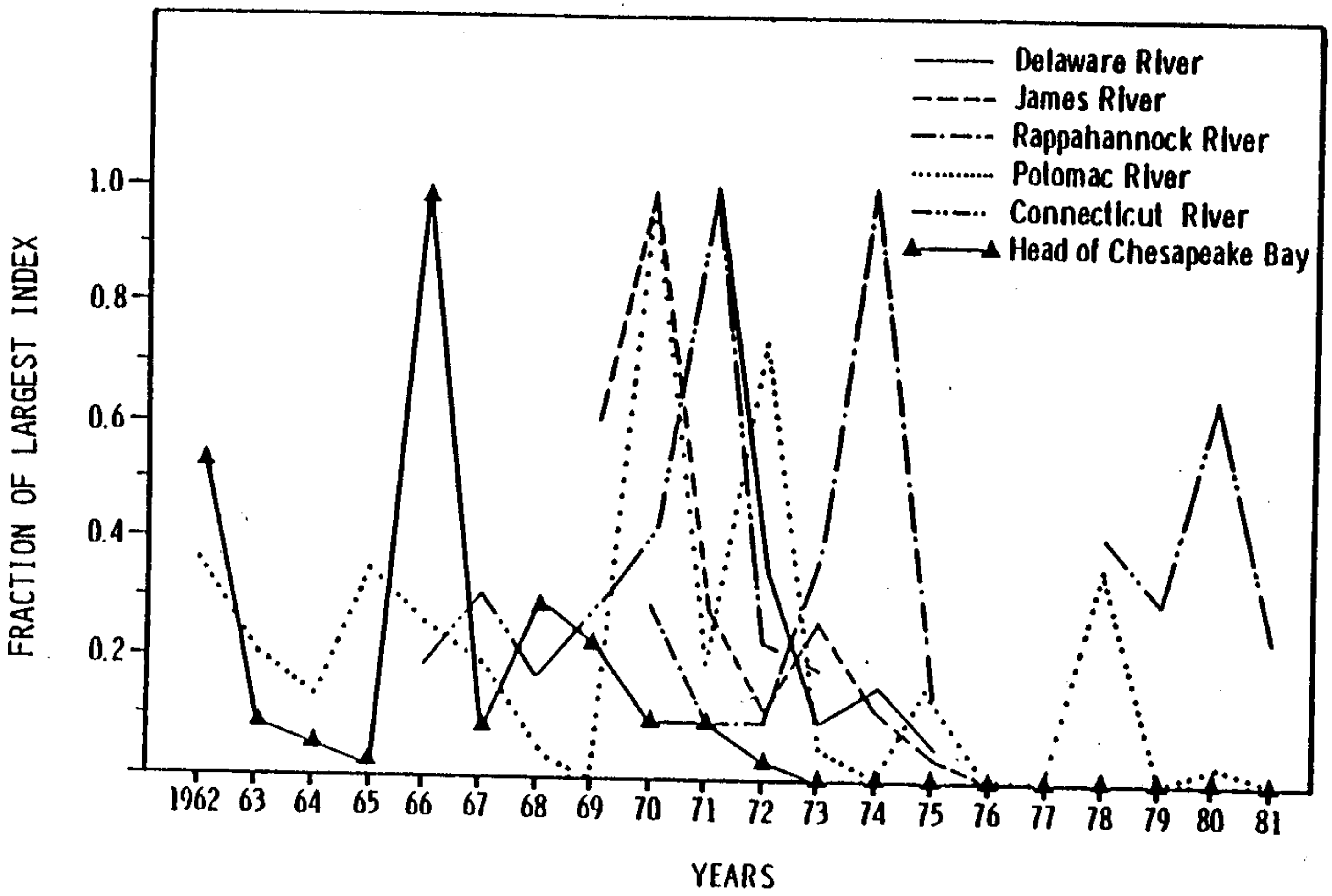


Figure II-7. Comparison of annual American shad juvenile abundance indices for different east coast drainage systems; data for each system are expressed as a percentage of the largest annual index; data sources are listed in Table II-13.

along nearly the entire northwest coast of the United States within 55 years. However, additional stockings in the Columbia River, the Williamette River in Oregon, the Skagit River in Washington and several other Northwest rivers do raise some doubts that all west coast stocks can be attributed to the Sacramento stockings.

It has been suggested (J. Loesch, pers. comm.) that the degree of shad homing may differ depending on the nature of the drainage system. Considerable mixing must occur among shad stocks that utilize the various tributaries in the Chesapeake Bay which could contribute to straying. In contrast, relatively precise homing might be expected in systems such as the Hudson or the Connecticut, where single large rivers exist.

Summary of Findings of Migration Studies

Talbot and Sykes (1958) reported the results of tagging studies conducted from 1938 to 1956. They concluded that, after spawning, adult fish from streams from as far south as Virginia migrate to the Gulf of Maine and remain in that vicinity throughout the summer into fall. In mid-fall, a migration southward begins, with overwintering occurring in the mid-Atlantic area. They concluded that immature fish overwinter in the mid-Atlantic and migrate northward to the Gulf of Maine with the spent adults in the late spring, returning to the mid-Atlantic area in the late fall. Other tagging studies were described by Walburg and Nichols (1967), providing additional support for the concept that the east coast shad stocks overwinter in the mid-Atlantic area.

Leggett and Whitney (1972) refined the description of the migratory pattern of American shad. They suggested that ocean migration patterns were related to water temperatures, and that fish occupied locations where temperatures ranged from 13 to 18°C. Their interpretations of offshore migration patterns was consistent with that of Talbot and Sykes (1958), but augmented with an understanding of the factors influencing that pattern. They also noted the occurrence of fish originating in the Connecticut River (and presumably fish from other central and northern coast stocks) off the North Carolina and Virginia coasts in February and March. In April, the more northern stocks are found in the vicinity of Chesapeake and Delaware Bays. In May and June, fish in prespawning condition from the more northern runs are present in New England and Canadian waters.

Neves and Depres (1979) documented the patterns of American shad catch in National Marine Fisheries Service research vessel bottom trawl surveys. They used these data to refine the description of shad migration patterns presented by Leggett and Whitney. Seasonal distribution of catch are shown in Figs.

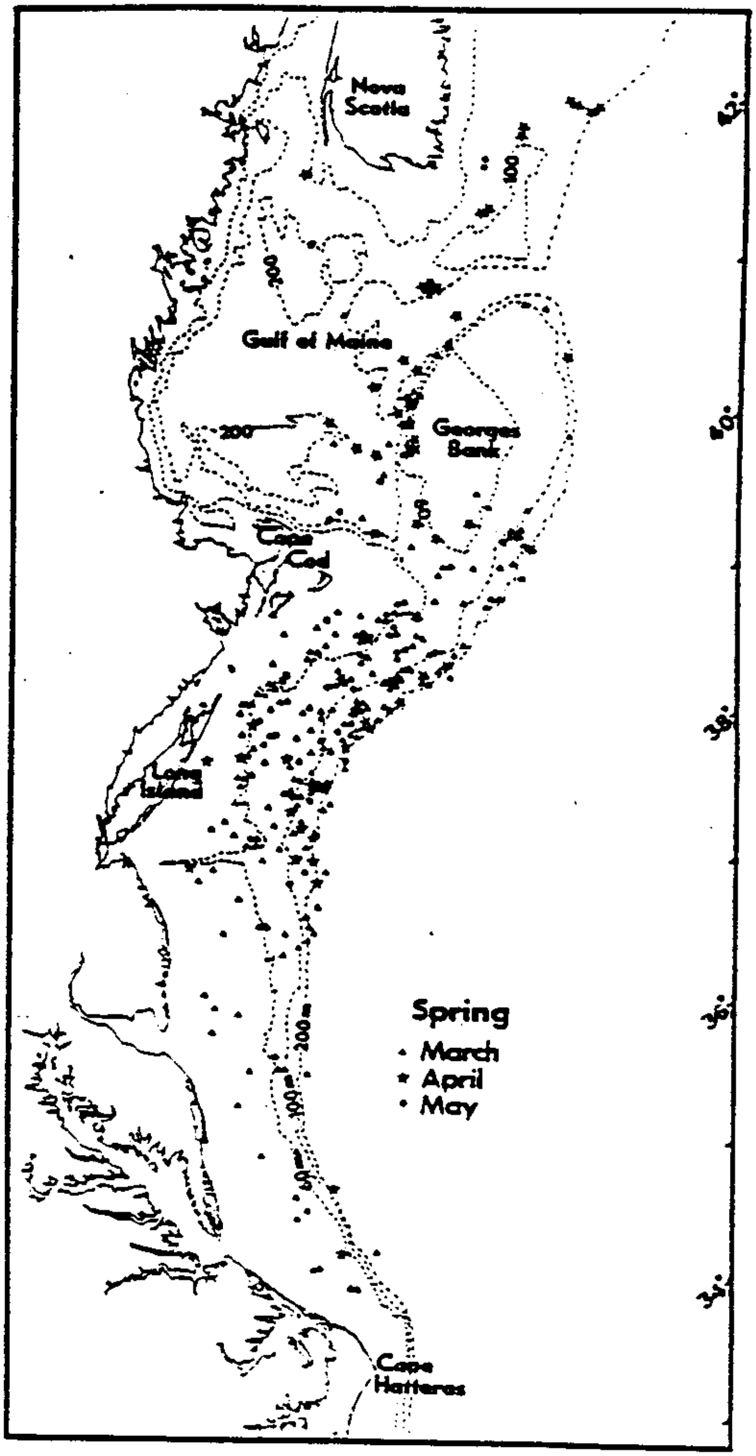


Figure II-8. Location of all American shad catches during spring bottom trawl surveys, 1968-76, Cape Hatteras, N.C., to Nova Scotia (from Neves and Depres, 1979).

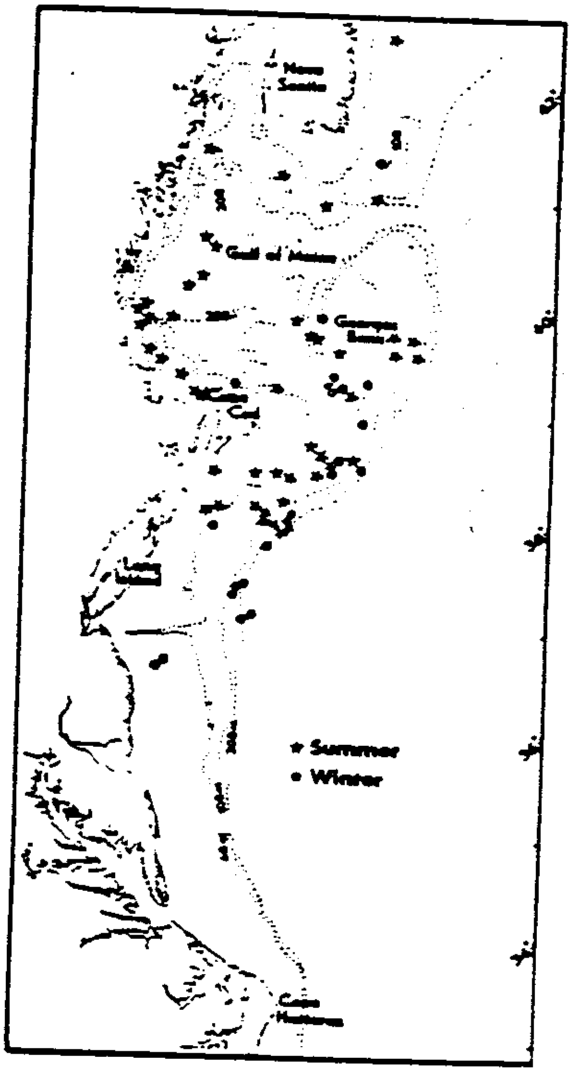


Figure II-9. Location of all American shad catches during summer and winter bottom trawl surveys, 1963-76, Cape Hatteras, N.C., to Nova Scotia (from Neves and Depres, 1979).

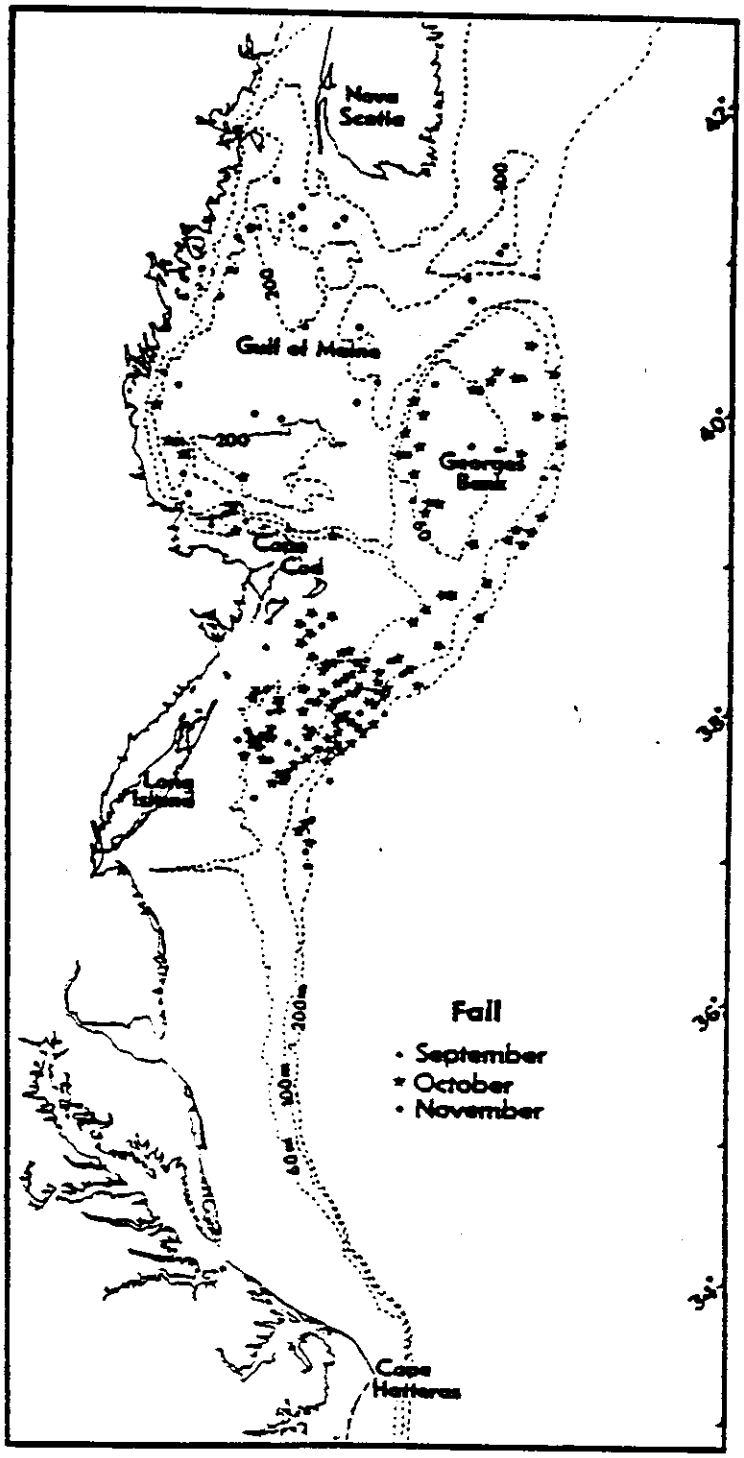


Figure II-10. Location of all American shad catches during autumn bottom trawl surveys, 1963-76, Cape Hatteras, N.C., to Nova Scotia (from Neves and Depres, 1979).

II-8 to II-10. Spring catch data (Fig. II-8) show that shad are widely distributed in the spring, in contrast to the pattern of migration described by Leggett and Whitney. However, Neeves and Depres did not discriminate between sexually mature and immature fish in their paper. Since trawl catches obviously would include both immature and mature fish, the wide spring distribution may reflect some separation of prespawning adults from immatures at this time of year. Neves and Depres also could not determine from the catch data itself whether stocks from all the river systems complelty intermingle at all times of the year. However, they did note that adults from all river systems along the east coast are found entering coastal waters as far south as North Carolina in the winter and spring. The authors cite other studies to conclude that a mix of various stocks from the east coast rivers do enter many of the estuaries along the coast in early spring during their northward migration, and that their timing and duration of stay are unknown.

Extensive summer tagging of American shad has been carried out recently in the Bay of Fundy, Canada. Figure II-11 shows locations of recaptures of fish tagged (from Scarratt and Dadswell, 1983). The widespread distribution of recaptures demonstrates that shad from all river systems along the east coast occur in the Bay of Fundy. The data conclusively confirm the seasonal movement patterns hypothesized by Leggett and Whitney and Talbot and Sykes. One other relevant aspect of these data is that, of fish tagged which had a known Canadian home river (i.e., fish which were tagged on their spawning run), five of 52 returns (approximately 10%) came from U.S. coastal waters. This information suggests that Canadian fish contribute to U.S. coastal harvest of American shad. Dadswell also notes the existence of a fall fishery for American shad in the Bay of Fundy which takes adults as well as sexually immature fish. However, this fishery is currently rather limited in extent.

Offshore Harvests

Documentation of offshore American shad harvests is in the form of catch reporting data tabulated by the International Commission for Northwest Atlantic Fisheries (ICNAF) and presented in its annual reports (ICNAF was abolished in 1979 and replaced by the Northwest Atlantic Fisheries Organization (NAFO) which continues to compile fisheries harvest data).

Reported offshore landings of American shad for the recent decade are presented in Table II-14 (from Boreman, 1982). The offshore data are reported by ICNAF reporting zone as well as by country. Data reported by country are a more precise documentation of the harvest actually taken in offshore waters. The data illustrate that reported offshore harvests of American shad are very limited. However, it is known that American shad are frequently misidentified as river herring by foreign as well as

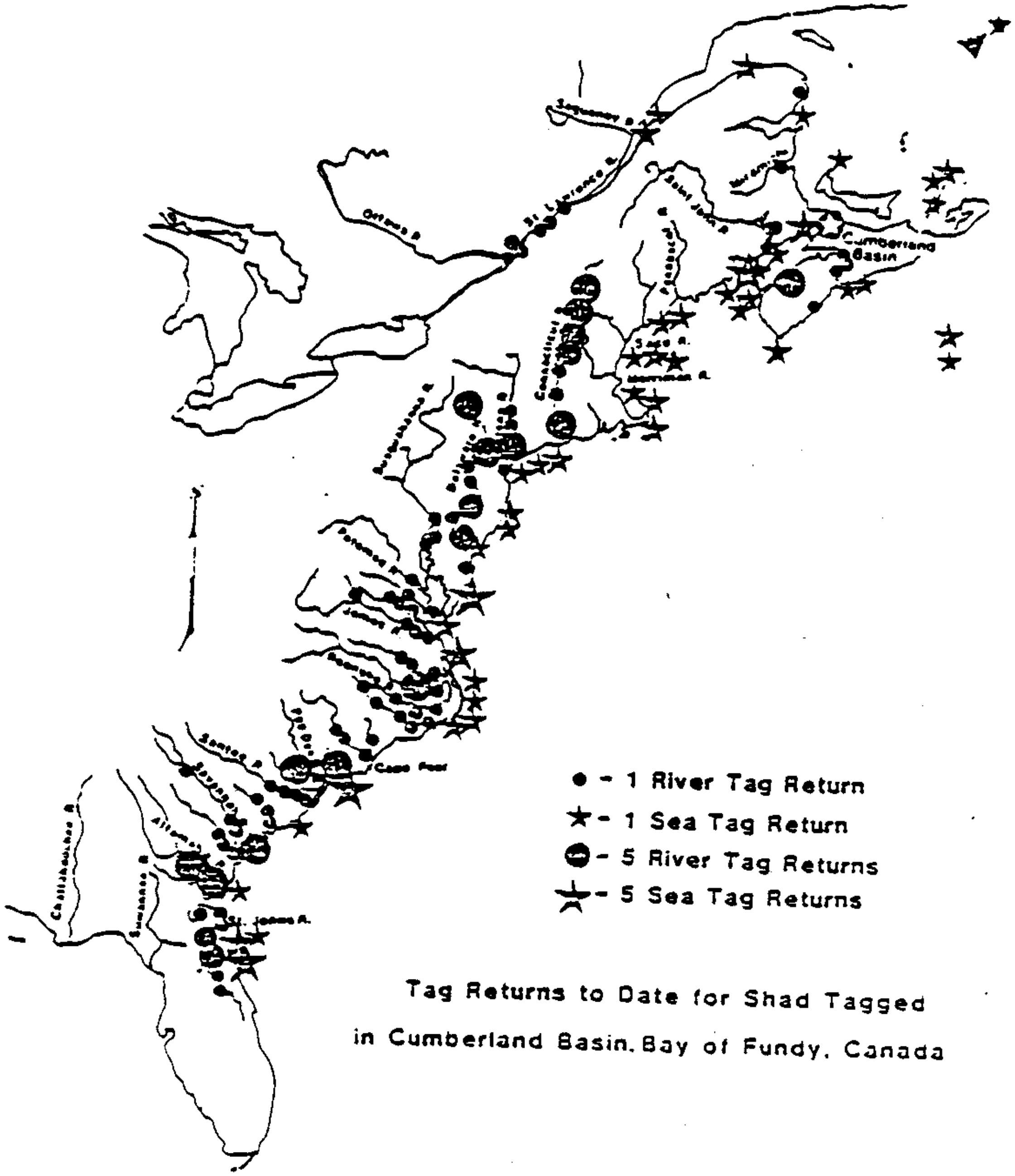


Figure II-11. Locality map for recaptures of shad tagged in Cumberland Basin (from Scarratt and Dadswell, 1983).

Table II-14. Landings of American shad (in thousands of pounds) in ICNAF/NAFO Areas 5 and 6 by Foreign Vessels (from Boreman, 1982)

Year	Nation				Total
	Bulgaria	E. Germany	Ireland	Japan	
1970	0	0	0	0	0
1971	0	0	0	0	0
1972	5	0	0	0	5
1973	0	308	0	0	308
1974	0	0	0	0	0
1975	0	0	1	0	1
1976	0	0	0	5	5
1977	0	0	0	0	0
1978	0	0	0	0	0
1979	0	0	0	0	0
1980	0	0	0	0	0

domestic fishing vessels. Species identification is particularly likely to be poor in the case of immature fish. However, the extent of possibly misidentified harvests is considered by NMFS staff to be minimal. The placement of U.S. observers onboard foreign fishing vessels operating in the U.S. Fishery Conservation Zone in recent years may have decreased the potential for identification errors.

Areas of Potential Interjurisdictional Management Problems

In earlier American shad work initiated by ASMFC (e.g., Talbot and Sykes, 1957, and others), the fisheries for American shad in the 1940's and 50's were characterized as a basis for examining the types of interjurisdictional problems which existed at that time. During those decades, substantial landings of shad were taken in coastal pound nets, particularly in the area of New Jersey and New York (Fischler, 1958; Nichols, 1957). These fisheries took substantial amounts of shad from stocks that were not native to the state in which they were harvested. As an example, 11% of the New York/New Jersey coastal catch was identified as originating in river systems other than the Connecticut and the Hudson. Of the remainder, 76% were Hudson River fish, and 13% were Connecticut River fish (Nichols, 1957). However, there was no detectable relationship between the magnitude of pound net catches in this coastal fishery and the size of shad runs on both the Hudson and the Connecticut Rivers. Whitney (1957) reported the results of a tagging study conducted in the Chesapeake Bay, which suggested that only approximately 3% of Maryland shad stocks were being harvested in pound nets in Virginia waters of the lower Chesapeake Bay. White et al. (1969) reported that 63% of the total harvest in the Delaware Bay is made up of fish from other drainage systems, as far north as Canada. Zarbock (1969) noted that 70% of the recaptures of fish tagged in the Delaware Bay were also taken in other waters. Chittenden (1974) characterized the segments of the Delaware Bay fishery dominated by non-Delaware stocks. Offshore foreign fisheries undoubtedly have the potential to take fish from all east coast coast drainage systems.

These findings are useful for identifying potential interjurisdictional problem areas. However, the reported findings can be influenced by numerous factors, such as the following:

- The composition of the catch in any given area may be a function of the time of the year during which effort is employed (relative to the timing of fish migration) as well as the nature of the gear (e.g., mesh size of gill nets relative to the difference in mean size of different stocks).

- The offshore fisheries (ICNAF/NAFO) use nonselective gear (e.g., large midwater trawls) which probably harvest all size (i.e., age) groups of fish. Thus, such fisheries could influence the at-sea mortality rates for both adults and immature life stages if substantial amounts of American shad were harvested.
- The late summer/early fall fishery for American shad in Canadian waters also takes both immature and mature fish; however, since these efforts are relatively low, it is unlikely that they will have significant effects.

Since all east coast stocks begin their prespawning migrations in southern coastal waters, northern stocks may be exposed to exploitation during much of their northward movement along the coastal United States. This would suggest the potential for higher fishing mortality of more northern stocks than of southern stocks. While immature fish may move with the spawning adults into inshore waters, fisheries are primarily directed at the large, preferably roe shad. This means that selective gear may be used (i.e., large mesh gill nets), with the result that immature fish cannot be detected or harvested.

Implications of Coastal Migration Patterns for Management

Coastal fisheries occurring to the south of South Carolina are unlikely to exploit any of the more northern stocks of American shad, based on the coastal migration pattern data discussed above. In contrast, the spring coastal fisheries from South Carolina northward, the fall fishery in Canadian waters, and the offshore fisheries all may exploit many different stocks of American shad.

The decline in the use of pound nets in coastal waters in the last two decades, particularly in the mid-Atlantic area (New Jersey-New York), reduces the exploitation of non-native stocks in those states. From the information presented above, it would appear that the fisheries in coastal waters of southern states (e.g., North and South Carolina) and in the Delaware Bay have greatest potential for creating interjurisdictional management problems in the case of American shad. The evolution of the southern coastal fisheries in response to high market demand in the early spring could accelerate such problems in the future.

F. SELECTED LIFE HISTORY ASPECTS RELEVANT TO MANAGEMENT

Latitudinal differences in age of maturity

Age of maturity is the age at which a fish first becomes sexually mature. For anadromous alosids, age of maturity differs between sexes. Table II-15 presents data for shad from runs from Florida to Canada. Leggett and Carscadden (1978) concluded that although males from the St. Johns River had a statistically significant lower mean age of maturity than males from all other runs examined (not evident in Table II-15), there was no latitudinal gradient in age of maturity, as is evident in the data presented in Table II-15. However, some degree of variability among river systems is also clear.

The significance of these data on age of maturity to the management of American shad stocks hinges primarily on the fact that all stocks remain at sea for similar periods of time before first returning to spawn. Since the stocks appear to mingle during the major portion of their stay at sea, any ocean or coastal fishery that significantly increases mortality of shad during the coastal migrations may impact on all stocks to a similar degree.

Size at Age

Tables II-16 and II-17 present data on size at age, by sex, for shad taken from five different river systems. All of these data are empirical, determined from actual measurements and scale reading of fish taken in samples, thus avoiding the potential problem of Lee's phenomenon.

Similar data are presented in Figure II-12, from Leggett and Carscaddan (1978). This graph shows the substantial difference in size at age between the more southern stocks and the more northern stocks. The authors attribute difference in growth to the length of juvenile stay in freshwater. However, an examination of other literature suggests that juveniles in the south (i.e., Georgia) leave nursery areas in October and November, as is the case in more northern rivers (Adams, 1970). Thus, the time of initiation of their ocean stay would appear to be similar to that of the juveniles for the more north rivers, suggesting that Leggett and Carscaddan's explanation may not be correct.

Coastal migration data discussed earlier suggests that all east coast stocks utilize the same summer feeding grounds (i.e., Gulf of Maine and Bay of Fundy). If this is the case, all stocks utilized the same resources as forage. Thus, the only

Table II-15. Maximum age and mean age at maturity of American shad from five Atlantic coast populations (from PSEG, 1982a)

River	Maximum Age		Mean Age at Maturity	
	Male	Female	Male	Female
Miramichi, NB[1]	7	7	4.2	4.6
St. John, NB[1]	10	10	4.2	4.5
Connecticut, CT[1]	8	8	4.1	4.8
Delaware, DE[2]				
1963	6	6	4.1	4.9
1964	6	6	4.3	5.2
1965	5	7	4.2	5.2
York, VA[1,2]	6	8	4.2	4.7
St. Johns, FL[1]	5	6	4.1	4.9

[1] From Leggett and Carscadden, 1978

[2] From Chittenden, 1969

Table II-16. Mean fork length (mm) of female American shad (from PSEG, 1982a)

	Age Group							
	1	2	3	4	5	6	7	8
St. John R., NB[1]								
$\bar{X}$				430.0	445.4	452.3	464.6	471.0
SD				11.1	17.6	16.2	18.8	29.7
Minimum				410.0	400.0	420.0	420.0	430.0
Maximum				450.0	470.0	480.0	500.0	510.0
n				7	12	20	11	5
Connecticut R., CT[1]								
$\bar{X}$				458.4	474.9	501.1	507.0	524.2
SD				18.2	17.1	21.1	22.5	22.1
Minimum				410.0	410.0	425.0	460.0	475.0
Maximum				495.0	510.0	530.0	540.0	565.0
n				36	176	23	30	24
Delaware R., NJ*[2]								
$\bar{X}$	209.2	321.9	404.4	464.1	511.1	537.8	553.0	558.0
SD	-	-	-	-	-	-	-	
Minimum	-	-	-	-	-	-	-	
Maximum	-	-	-	-	-	-	-	
n	87	87	87	87	59	18	4	
York R., VA[1]								
X				410.6	431.7	444.8	494.0	458.0
SD				14.7	18.7	39.3	36.9	20.8
Minimum				375.0	390.0	370.0	430.0	440.0
Maximum				440.0	520.0	505.0	567.5	475.0
n				34	101	33	9	2
St. Johns R., FL[1]								
$\bar{X}$			403.0	415.0	441.9	458.2		
SD			19.2	19.1	15.5	8.7		
Minimum			370.0	380.0	410.0	445.0		
Maximum			440.0	475.0	475.0	470.0		
n			13	126	58	6		

*Based on back calculation from scales.

[1] Leggett, 1969.

[2] DBFWMC, 1980.

Table II-17. Mean fork length (mm) of male American shad (from PSEG, 1982a)

	Age Group 1	2	3	4	5	6	7	8
St. John R., NB[1]								
$\bar{X}$				406.3	428.0	436.4	439.4	
SD				16.9	24.9	15.7	15.1	
Minimum				380.0	370.0	400.0	420.0	
Maximum				435.0	460.0	470.0	470.0	
n				8	15	29	18	
Connecticut R., CT[1]								
$\bar{X}$			397.3	432.5	453.0	469.0	480.0	482.8
SD			16.7	21.1	28.0	18.4	23.2	10.4
Minimum			365.0	390.0	345.0	440.0	420.0	460.0
Maximum			450.0	485.0	510.0	525.0	520.0	505.0
n			56	62	54	26	30	23
Delaware R., NJ*[2]								
$\bar{X}$	192.6	306.6	380.3	435.2	466.0	482.0	491.0	
SD	-	-	-	-	-			
Minimum	-	-	-	-	-			
Maximum	-	-	-	-	-			
n	186	186	135	170	26			
York R., VA[1]								
$\bar{X}$			335.0	379.1	398.0	407.2		
SD			-	22.3	19.6	22.4		
Minimum			-	345.0	350.0	375.0		
Maximum			-	435.0	430.0	440.0		
n			1	29	21	5		
St. Johns R., FL[1]								
$\bar{X}$			366.7	385.8	409.0			
SD			19.0	13.8	12.6			
Minimum			295.0	345.0	387.5			
Maximum			395.0	430.0	430.0			
n			56	130	10			

*Based on back calculation from scales.

[1] Leggett, 1969.

[2] DBFWMC, 1980.

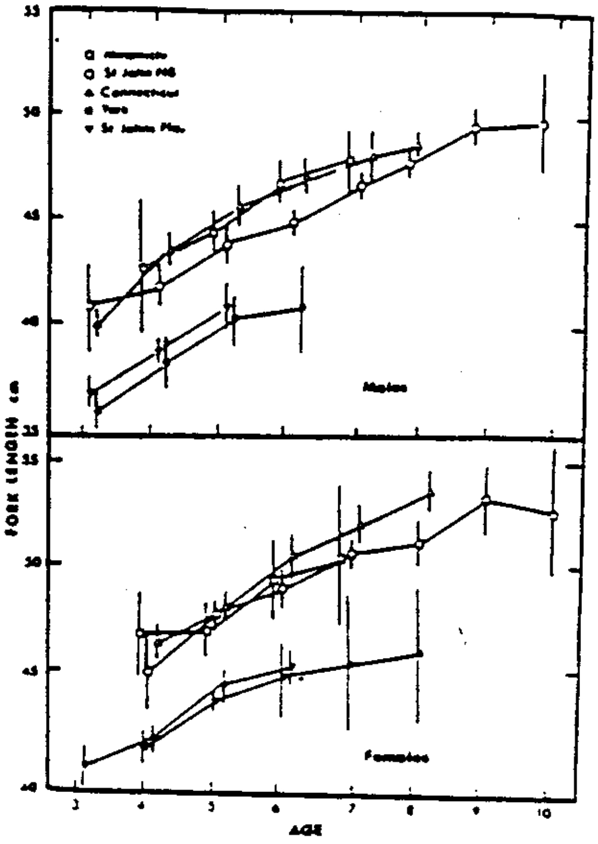


Figure II-12. Size by age of male and female American shad in populations spawning in five Atlantic coast rivers. Vertical bars represent 99% confidence intervals for means (from Leggett and Carscadden, 1978).

apparent explanation for differences in growth between northern and southern stocks is genetic factors relating to evolutionary adaptations of the stocks, as has been discussed by Leggett and Carscaddan (1978).

The significance of size of age data for management purposes is primarily that it may serve as a stock identifier in non-local waters.

Frequency of Repeat Spawning

Data in Table II-18 (from Walburg and Nichols, 1967) reveal the absence of repeat spawning in rivers south of North Carolina, and an increasing occurrence of repeat spawning to the north. Frequency of repeat spawning is strongly influenced by the occurrence of individual large year-classes. During the first year of return of large year-classes the frequency of repeat spawners may be very small primarily because of the large numbers returning from the dominant year-class. Similarly, the return of repeat spawners from a large class in subsequent years may inflate the relative percentage of repeat spawners in a given year. Thus the data summaries presented in Table II-18 must be considered generalizations.

Leggett and Carscaddan (1978) reconfirmed the pattern of frequency of repeat spawning shown in Table II-18 with more recent data. The same pattern is further corroborated by data collected in numerous state studies.

At a scale reading workshop carried out in 1982 in conjunction with a meeting of the Shad and River Herring S&S Committee, questions were raised about individual investigator's discrimination of spawning checks on scales of southern fish. While there is conclusive evidence of the occurrence of very small amounts of repeat spawning in North Carolina, there remains no evidence of repeat spawning from South Carolina to Florida. Existing literature (e.g., Walburg and Nichols, 1967) overwhelmingly supports the view that there is no repeat spawning in the most southern stocks.

The absence of repeat spawners in southern stocks of American shad has considerable significance for the feasibility of various management options in those regions. Similarly, even in runs in the Carolinas, Virginia, and Maryland, where the frequency of repeat spawning is relatively low, limits on the efficacy of harvest on management actions may exist. In cases where the percentage of repeat spawning is minimal, the size of the run in any given year is essentially a function of the spawning success in prior years. In contrast, runs having high percentages of repeat spawners can be enhanced by limiting exploitation in a given year to permit more fish to return as

Table II-18. Age distribution at capture, and number of previous spawnings, for American shad from certain rivers, Atlantic coast of the United States[1] (from Walburg and Nichols, 1967).

[In percent]

Age and spawning group	River									
	St. Johns	Ogeechee	Edisto	Neuse	James	York	Potomac	Delaware	Hudson	Connecticut
Total age (years) at capture:										
2	([2])	---	---	---	---	([2])	---	---	---	---
3	4	2	5	9	12	7	5	1	2	1
4	72	41	16	43	61	55	62	16	23	17
5	22	48	56	34	20	30	28	41	29	42
6	2	9	23	12	7	6	5	30	22	30
7	([2])	---	---	2	([2])	1	([2])	10	14	7
8	---	---	---	---	---	([2])	---	2	6	2
>8	---	---	---	---	---	---	---	---	4	1
Number of times spawned previously[3]:										
0	100	100	100	97	73	76	83	98	49	51
1	---	---	---	3	22	15	15	2	19	31
2	---	---	---	---	5	7	1	---	18	13
3	---	---	---	---	([2])	1	([2])	---	10	4
4	---	---	---	---	---	1	---	---	2	1
5	---	---	---	---	---	---	---	---	2	([1])
>5	---	---	---	---	---	---	---	---	([2])	---

[1] Data for: St. Johns, 1958--Walburg (1960a); Ogeechee, 1954--Sykes (1956); Edisto, 1955--Walburg (1956); Neuse, 1953--Walburg (1957a); James, 1952--Walburg and Sykes (1957); York, 1959--Nichols and Massmann (1963); Potomac, 1952--Walburg and Sykes (1957); Delaware, 1944-45-47-52--Sykes and Lehman (1957); Hudson, 1950-51--Talbot (1954); Connecticut, 1956-59--Walburg (1961).

[2] Less than 0.5 percent.

[3] Determined by counting the number of spawning marks on scales.

repeat spawners in the next year. Harvest restrictions in these circumstances can have a short-term, direct, nonrecruitment-related positive impact on runs in subsequent years. In contrast, size of runs without substantial repeat spawning depends completely on the year-class success of individual runs in the past, and can only be impacted to the extent that increases in run fecundity due to harvest restrictions in any given year result in greater production of progeny.

Mortality Rates

Mortality rates may be partitioned according to life stage:

- Ichthyoplankton
- Juvenile (in freshwater)
- Immature (at sea)
- Adults - fishing mortality; nonfishing spawning run mortality; post-spawning at-sea mortality.

Ichthyoplankton mortality rates tend to be extremely high. Leggett (1977) reported that, on the average, only 0.00083% of American shad eggs produce sexually mature adults. The majority of the mortality occurs from the time of deposition of the egg to the time of juvenile stage. Crecco et al. (1983a) have demonstrated that yearclass size is set at the point in time where larvae reach the juvenile stage, and that larval mortality rates are quite variable from year to year. Survival of larvae (after egg hatch) through juvenile stage may be on the order from 1 to 2% (Public Service Gas and Electric, 1982a).

Juvenile mortality rates have been reviewed in PSEG (1982), and a number of different observed mortality rates for the Connecticut and Delaware rivers are presented in Table II-19. Monthly survival rates of juveniles on the nursery grounds were in the range from 60 to 75%. Crecco et al. (1983a) reported more recent findings of daily mortality rates of juveniles of 1.8 to 2.0% per day. If one assumes an average river residence time for juveniles of three months, the survival of juveniles until outmigration would be on the order of 30% (e.g., 70% of juveniles are lost before reaching the ocean). Longer residence time would reduce this percentage figure even further. Residence times in the Delaware have been reported to be as high as 4-5 months, depending on water temperature (M. Miller, 1982).

Mortality of sexually immature fish at sea has not been documented. Analysis of tagging data collected by Dadswell

Table II-19. Total (= natural) mortality rates for juvenile American shad (from PSEG, 1982)

	Daily Growth Rate	Z_d	Z_m	Monthly Survival (%)	Monthly Mortality (%)
Delaware River (present study)					
100 mm FL	0.0970	0.00964	0.28906	74.9	25.1
150 mm FL	0.1315	0.01306	0.39187	67.8	32.4
200 mm FL	0.1660	0.01649	0.49468	61.0	39.0
Connecticut River (Hints et al., unpubl.)					
1966	-	0.01567	0.470	62.5	37.5
1967	-	0.01613	0.484	61.6	38.4
1968	-	0.00793	0.238	78.8	21.2
1969	-	0.01493	0.448	63.9	36.1
1970	-	0.01173	0.352	70.3	29.7
1971	-	0.01527	0.458	63.3	36.7
1972	-	0.00700	0.210	81.1	18.9
1978	-	0.01493	0.448	63.9	36.1
1979	-	0.01800	0.540	58.3	41.7
Mean:	-	0.01351	0.405	66.7	33.3

Z_d = Daily instuntaneous total mortality rate.

Z_m = Monthly instantaneous total mortality rate.

FL = Fork length.

et al 1983) will provide a strong basis for estimating such mortality rates. Based on normal biological processes in fish populations, mortality rates of sexually immature post-juvenile fish would be considerably lower than the mortality rates for the younger life stages.

Adult mortality rates have been estimated a number of different ways, including extensive tagging-recapture studies conducted over periods of years, as well as documentation of passage of individual yearclasses through a fishery by age composition studies over a period of years. All methods of estimation of mortality are subject to alternative interpretations of the data, and thus some older interpretations (e.g., Fredin, 1954) have been reassessed and considered to be in error (e.g., Leggett, 1976; Crecco, 1978). For this reason, compilations of figures from the literature, as are included here, should be considered to be general overviews of mortality rates as opposed to rigid documentation of true mortalities.

Table II-20 presents estimates of fishing mortality rates for a number of different river systems along the east coast. In general, rates may not be as high as presented here. As was already pointed out, some of these values may be suspect because of the manner in which they were derived (e.g., Fredin, 1954). Most recent data (Leggett, 1976; Crecco, 1978) suggest that current commercial fishing mortality rates are generally on the order of 20 to 30%. Fishing mortality rates differ, of course, by sex, since the fishery is directed primarily at larger female (roe) shad, which are more marketable than buck (male) shad. Roe shad fishing mortality rates tend to be approximately double those of buck shad (e.g., Crecco et al, 1982). This figure would of course vary with the amount of effort and specific conditions in any given year. Crecco (1980) has reported a recreational fishing mortality rate of 4 to 10% of the escapement past the commercial fishery on the Connecticut River. Comparable figures for the Delaware River are of 8 to 11% (Table II-21). Table II-22 provides estimates of weight of American shad by age and sex for the Connecticut River. These data permit comparison of numerical harvests reported for recreational fisheries and poundage harvests reported in commercial fisheries.

In addition to fishing mortality, natural mortality adds to the total mortality rate for adult shad. In river systems in which no repeat spawning occurs, of course, total mortality rates are 100%. Thus, it is evident that natural mortality rates are lower in more northern runs with repeat spawning than in southern runs, assuming no major difference in fishing mortality rates. Leggett (1976) assessed annual total mortality rates for Connecticut River shad. He reported annual rates for males and females of 70% and 71%, respectively. Mortality rates were estimated by PSEG (1982) for shad occurring in the Delaware River, and determined to be a 70-80%. However, these values are suspect given the very low percent repeat spawning in that system.

Table II-20. Fishing mortality rates of American shad populations in river systems along the Atlantic coast (adapted from Rulifson et al., 1982)

RIVER SYSTEM	YEAR	MORTALITY(%)	SOURCE(S)
Connecticut River	1941	32.8	Fredin (1954)
	1946	81.9	Fredin (1954)
	1965-1973	22.7	Leggett (1976)
Hudson River	1916	19.8	G.E. Talbot (1954)
	1947	79.0	G.E. Talbot (1954)
Potomac River	1944	41.9	Walburg and Sykes (1957)
	1949	76.0	Walburg and Sykes (1957)
James River	1957	73.0	Walburg and Sykes (1957)
York River	1953	58.3	Nichols and Massmann (1962)
	1958	44.4	Nichols and Massmann (1962)
	1959	55.2	Nichols and Massmann (1962)
Neuse River	1957	65.0	Walburg (1957)
Waccamaw-Pee Dee system	1974	33.9	Crochet et al. (1976)
	1975	29.0	Crochet et al. (1976)
	1976	18.5	Crochet et al. (1976)
Edisto River	1955	20.0	Walburg (1956)
Ogeechee River	1954	66.0	Sykes (1956)
Altamaha River	1967	48.6	Godwin (1968)
	1968	43.3	Godwin (1968)
	1982	52.1	Michaels (pers. comm.) Ga. DNR
	1983	32.3	Michaels (pers. comm.) Ga. DNR
St. Johns River	1960	15.0	Walburg (1960b)

Table II-21. Summary of American shad population estimates and exploitation rate by the sport fishery for the Delaware River, 1979 - 1982.*

Year	Population estimate	Exploitation rate (%)	Estimated number of shad harvested
1979	111,839 ± 32,191	8.0	8,947
1980	181,880 ± 55,058	8.0	14,550
1981	546,215 ± 133,590	8.1	44,243
1982	506,102 ± 176,680	10.7	54,153
1983	249,578 ± 87,342	8.0	19,966

*Prepared by A.J. Lupine, N.J. Division of Fish, Game and Wildlife

Table II-22. Average weight (kg) of American shad by age and sex calculated using von Bertalanffy growth model and observed values (from Crecco, 1978).

Males			Females		
(1) Age	(2) Obs. average weight	(3) Calc. average weight	(4) Age	(5) Obs. average weight	(6) Calc. average weight
II	-	0.572	II	-	0.764
III	0.941	0.902	III	-	1.175
IV	1.269	1.227	IV	1.632	1.606
V	1.534	1.522	V	2.035	2.032
VI	1.793	1.778	VI	2.404	2.435
VII	1.957	1.992	VII	2.926	2.805
VIII	-	2.167	VIII	3.064	3.137
IX	-	2.308	IX	-	3.429
X	-	2.420	X	-	3.683
XI	-	2.508	XI	-	3.901

Annual total mortality rates would appear to be on the order of 70-90% in the northern river systems where repeat spawning occurs.

Mortality rate data just discussed have significant impact on the feasibility of various management actions. The data demonstrate that the major mortality between egg and adult stages occurs during the prejuvenile life stages. In cases where these mortalities are controlled by environmental conditions, as is suggested by Crecco et al. (1983b), management actions aimed at modifying these factors may be infeasible. Restrictions on harvests have the capability solely for altering the portion of total mortality accounted for by fishing. As was noted above, fishing mortality rates due to either commercial fishing alone or in combination with recreational fishing, may account for on the order of 25%-50% of mortality to the spawning stock in a given year. In cases such as the southern runs, where total mortality will be 100%, restrictions on fishing may have limited impact on subsequent run sizes. This topic is discussed in detail under the heading of population dynamics, since the degree of independence between recruitment and spawning size is the determining factor.

Fecundity

Fecundity data had been collected from shad in many of the runs occurring along the east coast. Fecundity, expressed in terms of amount of eggs per female, varies according to the size of the fish but in general ranges between 200,000 and 300,000. Figure II-13 presents data summarized by Leggett and Carscadden (1978). The figure shows that the larger fish (which in northern runs may represent repeat spawners) yield significantly more eggs than the smaller fish. If repeat spawners make up a substantial portion of a run in any given year, they may contribute significantly to total run fecundity. Also, fish in the southern runs have a higher fecundity per unit body weight than do fish in the northern runs. Leggett and Carscaddan interpret this as an evolutionary adaptation of the southern runs; that is, because the fish have the opportunity to spawn only once (because of 100% total mortality), their fecundity per unit body weight is maximized.

The significance of these fecundity data for management is that manipulation of fishing rates may have some effect on the total fecundity of a run in any given year through resultant changes in percentage of repeat spawners. However, whether increasing total run fecundity has a concomitant effect on number of juveniles produced (i.e., on year-class size) is an open question. Data analyzed by Crecco et al. (1983b) suggest that, in fact, yearclass size is almost entirely controlled by environmental factors as opposed to run fecundity at "normal"

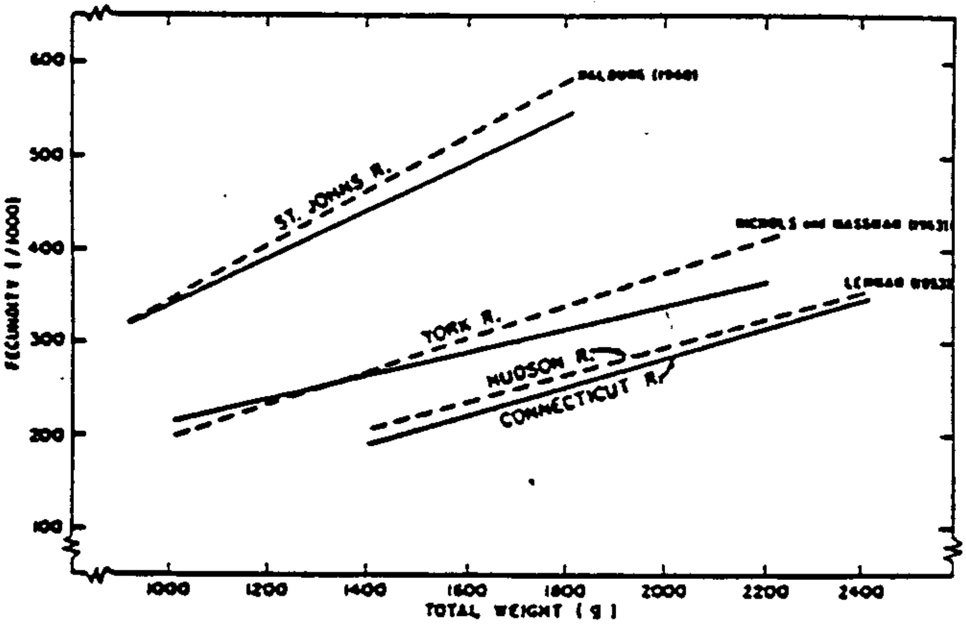


Figure II-13. Relative fecundity of American shad as determined in the referenced study (solid line) and by earlier investigators (dashed line) (from Leggett and Carscadden, 1978).

levels of spawning stock size. This topic is discussed in more detail under the heading of shad population dynamics. Fecundity may become important when run sizes have been depressed to some very low level, termed a threshold level.

Shad Population Dynamics

An understanding of the population dynamics of a species is the most important aspect of fisheries management. Population dynamics represents the integration of many of the individual life history aspects discussed above. Because of the complexity of the factors that control population dynamics, this aspect of any given species life history is in general poorly defined.

Studies reported in the literature in previous years (Talbot, 1954; Walburg, 1963) involved the use of regression analyses to investigate factors that influenced shad stock abundance. Talbot (1954) concluded that escapement (i.e., number of adults escaping the fishery and reaching the spawning grounds) five, four, and one year prior to the year in which stock size was estimated had a significant impact on subsequent year-class size, explaining 85% of the variation in landings in the Hudson River. Walburg (1963) also suggested that adult escapement has a substantial effect on subsequent run size in the Connecticut River. Both these studies suggested that shad exhibit stock-dependent recruitment, i.e., the number of juveniles produced was significantly related to the numbers of adults spawning.

More recent assessments of similar data and reexamination of the premises of the analyses done by both Talbot and Walburg have suggested that there are serious deficiencies in those analyses. Included in these deficiencies are the fact that data were autocorrelated, that the tags used in conducting the studies resulted in biased catch rates for tagged fish, and that there was selectivity in the gears used in documenting the run size. Leggett (1976) and Crecco (1978) both document numerous limitations in the analyses. In the case of the work done by Talbot, the role of run size one year earlier in determining the run size in a given year is of course strongly dependent on escapement simply because at that time, repeat spawners made up 50% of each run. Increased escapement resulted in more repeat spawners the following year, thus generating high correlation.

More recent analyses (e.g., Leggett, 1976, 1977; Crecco et al, 1983b) addressed the same issue of influence of stock stock size on subsequent recruitment to the fisheries in the Connecticut River. Leggett (1976) concluded that at the current time, Connecticut River shad stocks were far below the level of the stock capable of producing maximum yield. He concluded that year-class strength is in part dependent on spawning stock size, but that spawning stock size has much more limited influence than have environmental variables. Crecco (1978) and Crecco et al (1983b) expanded and refined the analyses of Leggett. These results showed that in recent years, stock size has had virtually no influence on the number of recruits returning to the river in subsequent years, and that environmentally-controlled mortality rates in the prejuvenile stage are the dominant factors determining the spawning success of the run in any given year. In essence, the data suggest no significant correlation between parent and progeny numbers.

No other east coast shad runs have been studied to the level of detail of the Connecticut River run. While numerous short-term, life-stage-specific studies have been done in some systems, only recently have relatively complete life history studies been initiated in certain systems (e.g., the Delaware River, the Altamaha River in Georgia). Thus the Connecticut River results must stand as the most detailed examination of population dynamics of American shad. Applicability of the Connecticut River findings to shad runs along the entire east coast must be assessed if those results are to be used as the basis for management decisions for east coast runs.

The significance of these population dynamics findings to the feasibility of management options (at least in the sense of harvest restrictions) is clear. If in fact adult run size has virtually no statistically significant effect on recruitment in subsequent years, restrictions on commercial or recreational harvests will do little to influence subsequent recruitment. The data demonstrate that manipulation of run size will not result in a predictable response in terms of numbers of progeny produced. However, all current researchers acknowledge that at some low population level, the total run fecundity and the total spawning stock size will play an increasingly greater role in determining the number of progeny subsequently produced. Information is not currently available to suggest what this low threshold level will be. Definition of the critical threshold spawning stock size would appear to be one of the major research goals for the future. Management actions involving water quality improvement and increases in habitat availability would, of course, have beneficial impact on stocks, independent of their population dynamics characteristics.

G. RESTORATION PROGRAMS

While restoration of fishery stocks may mean the rehabilitation of existing stocks that are currently at low levels, restoration efforts discussed here will focus on those aimed at establishing new runs to waters which formerly supported runs which were eliminated through either denial of access or through destruction of required habitat. Restoration programs are presently underway along much of the east coast. Existing programs are described in summary in Table II-23. Efforts on major river systems, either in progress or at the startup stage, are being conducted on the Connecticut River and the Susquehanna River. In addition, numerous efforts are being made on much smaller drainage systems listed in Table II-23.

In the majority of these programs, insufficient time has passed to assess success. Returns have been seen in the Pawcatuck River in Rhode Island, but numbers are not up to expectations. Because of the period of time during which the program has been ongoing, the Connecticut River may serve as the best case study of restoration of American shad on the east coast. A detailed discussion of the background and current status of this program is presented by Moffitt et al. (1982). Dam construction on the Connecticut River beginning in the 1700's was responsible for denying American shad access to the majority of the Connecticut River drainage. The lowermost of these dams is the Holyoke facility at South Hadley Falls in Massachusetts. This dam restricted anadromous fish to the lower 140 kilometers of the river. Numerous efforts were made in the early 1900's at reestablishing American shad above both Holyoke and other dams, but all were unsuccessful.

The first facility constructed at the Holyoke Dam for passage of American shad and other anadromous species began operation in 1955. Major improvements were made to the lift in 1976. Numbers of shad passed over the dam have increased from approximately 5,000 in 1955 to over 500,000 in 1983. The facility is designed to accommodate an American shad run of approximately 1 million. The passage data would suggest that the program has been very successful in reestablishing shad to the portion of the Connecticut River above Holyoke Dam. However, recent analyses (Crecco et al, 1983d) have been unable to document a relationship between number of adult shad passed above the Holyoke Dam and sizes of runs 4 and 5 years later. The alternative explanation for increased passage of fish would be increased attractiveness and improved efficiency of the lift facilities and their operations. One possible explanation for lack of demonstrated effectiveness of the restoration effort is high juvenile mortality during downstream passage through the dam turbines (Knapp et al, 1982). All relevant factors are currently under investigation.

Restoration programs serve as extremely valuable management tools because they essentially create new fish for the fishery with no restrictions on current users. However, the success of the restoration has yet to be conclusively demonstrated, and most cost-effective methods of implementation of this type of management approach must be evaluated.

Table II-23. Summary descriptions of current or proposed east coast American shad restoration programs other than the Connecticut River (adapted from material in Atran et al., 1983, and state overview documents).

State	Drainage system	Potential run size	Nature of restoration effort
Maine	Royal, Kennebec, Penobscot, Androscoggin, St. Croix Rivers	Annual harvest of 1.15 million pounds	Improvement in water quality and improved passage facilities
New Hampshire	Lamprey, Exeter and Cocheco Rivers	60,000 adults	Construction of fish passage facility and stocking of gravid adults in 1980-82
Massachusetts	Merrimack, Nemasket, Taunton, and Charles	1,000,000 adults	Construction of fish passage facilities and stocking of gravid adults
Rhode Island	Pawcatuck	Not established	Construction of fish passage facilities and stocking of gravid adults beginning in 1976
New Jersey	Raritan River	Not established	Pollution abatement and stocking of gravid adults.

Table II-23 (continued)

State	Drainage system	Potential run size	Nature of restoration effort
Pennsylvania	Schuylkill River	340,000 to 960,000 fish	Construction of fish passage facilities.
Maryland - Pennsylvania	Susquehanna River	2,000,000 fish	In FERC proceedings. Construction of fish passage at 4 dams requested. Stocking of gravid adults, planting of eggs, and release of hatchery juveniles since 1978.
Virginia	James River	60,000 fish	Construction of fish passage facilities; stocking of gravid adults anticipated.

H. ANTHROPOGENIC EFFECTS - RECENT OR POTENTIAL

The effects of pollution, dam construction, and other man-related environmental alterations on American shad have been documented in several of the earlier review documents (e.g., Walburg and Nichols, 1967; Mansuetti and Kolb, 1953). While these factors may have contributed to historical declines in landings, their role in declines seen in the last 20 years has generally not been clearly delineated. However, in several specific cases, the effects of man-related environmental alterations are known. These cases will be documented here.

Delaware River Pollution Block

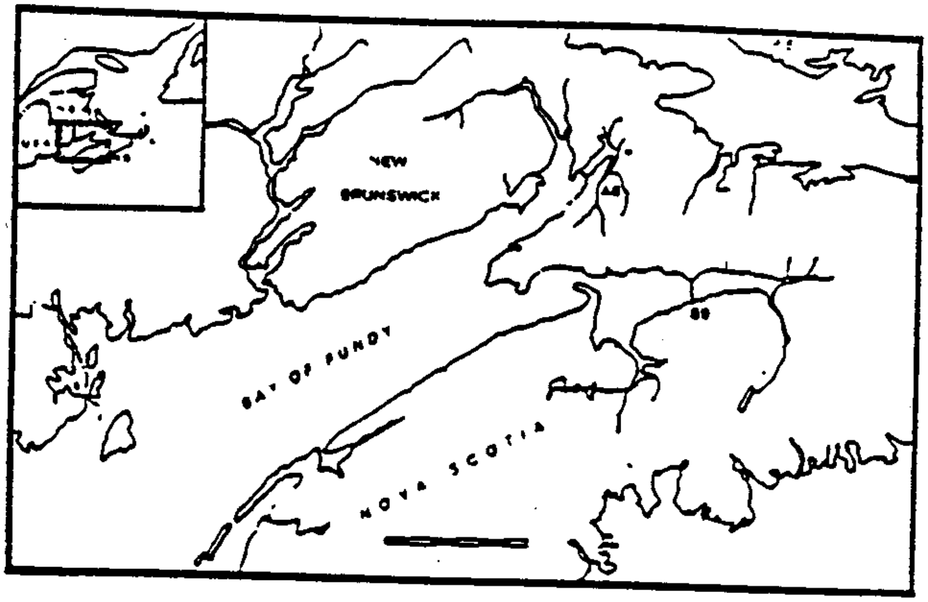
The area of the Delaware River in the vicinity of the cities of Camden, New Jersey, and Philadelphia, Pennsylvania, has a history of pollution problems. This problem is addressed in great detail in a Management Plan for the American Shad in the Delaware River Basin (DBFWMC, 1981). Pollution of the river results in depressed oxygen levels beginning in the spring and extending through the fall. The presence of extremely low dissolved oxygen, frequently reaching anoxia, during periods of spring spawning migration by adults or outmigration by juveniles has in the past served as a constraint on the success of the Delaware River American shad run. Pollution abatement programs over the last 20 years have decreased the organic loading in the Delaware River and contributed to a reduction in the magnitude and the duration of the oxygen block in the Delaware. This has provided an opportunity for more successful spawning runs and downstream emigration of juveniles, resulting in a dramatic increase in the Delaware River shad stock. Despite the success in reducing the duration of the oxygen block, detrimental oxygen levels still occur. Because this oxygen problem occurs in a location which can completely constrain the run (i.e., the pollution block extends across the entire river), any unusual condition, such as extremely low river flow that could aggravate the oxygen block, can have a dramatic impact on individual year-classes. Thus, the Delaware River shad run, despite being very successful within the recent decade, is extremely vulnerable to pollution conditions in one limited segment of the entire drainage system despite the fact that water quality is good upstream as well as downstream of the problem area.

Other Pollution Areas

Water quality conditions have also been considered to have impacted on alosids stocks in North Carolina in the Albemarle Sound area. However, the impact is not as clearly defined as in the case of the Delaware River. Changes in phytoplankton composition have been noted, with the occurrence of blue-green algal blooms and their presence in juvenile alosid guts noted (Johnson, 1982). While these indirect findings suggest a potential pollution effect on alosid stocks, the relationship has not been established rigorously. Similarly, pollution of nearly all estuarine waters along the east coast has certainly increased over the last 20 years, due to industrial, residential, and agricultural development on the watersheds. The general degradation of water quality is a coast-wide problem, although actions to decrease sewage discharges through the construction of sewage plants has actually decreased the levels of sewage nutrients discharged into coastal waters during the past 20 years. This decrease in organic enrichment would benefit the water quality conditions; however, it would not result in a reduction of other types of pollutant discharges into these waters, such as heavy metals, organic compounds, etc. The construction of the Blue Plains sewage treatment plant near Washington, DC, on the Potomac River, had an obvious effect in reducing nuisance algal blooms. The fact that American shad stocks in the Potomac declined during the same period that Blue Plains was reducing nutrient loading poses unresolved questions as to the effect of sewage chlorination and concurrent watershed development on shad stocks.

Bay of Fundy Hydroelectric Projects

Large tidal hydroelectric projects are currently being considered for construction in basins of the Bay of Fundy, Canada (Fig. II-14). These projects have been described in detail by Dadswell et al. (1983) and Gordon and Longhurst (1979). The two individual basins proposed as sites for hydrodevelopment are the Minas and Cumberland Basins. The very large tidal range in these areas, approaching 16 m in specific locations, provides a great potential for generation of electric power through control of water movement in these basins. However, Dadswell et al. (1983) have found that these particular basins are used extensively by American shad as foraging areas during summer months. The extensive tagging studies conducted by Dadswell and his co-workers have shown that fish from all runs along the east coast of the United States enter those specific basins. Dadswell has hypothesized that, in fact, these areas are critical to the success of all east coast shad stocks. Dadswell has also projected that construction of the proposed hydro projects with subsequent passage for American shad through turbines would cause major mortalities to all of the stocks. As described by Scarratt and Dadswell (1983) the situation in these basins is distinct from a circumstance in which the hydroelectric project is on a riverine system. In a river, fish would move through generating turbines only once, while in a tidal project fish may move into and out of



CHARACTERISTICS AND COSTS OF TIDAL POWER SCHEMES

	SITE B9		SITE A8
	1981 New Method	1981 New Method	
1. Total number of powerhouse units	106	128	37
2a Number of Sluices (Shallow)	6	70	—
2b Number of Deep Sluices	44	22	—
3. Number of Spare Units	6	8	2
4. Rated unit output MW	38	38	31
5. Installed Capacity MW	4028	4864	1147
6. Net Plant Capacity MW	3800	4560	1085
7. Net annual energy GWh	11766	14004	3183
8. Capacity Factor (%)	35.4	35.1	33.5
9. Cost Estimate ($\$\times10^6$)			
(a) Total Direct Cost	3524	4011	1153.2
(b) Indirect and interest plus contingency	2493	3019	726.1
(c) Total Capital Cost	6017	7030	1879.3
10. Annual Charge (9c) x .05531	332.8	388.8	103.9
11. Cost of Energy mills/KWh	28.3	27.8	32.6

Figure II-14. Characteristics of tidal hydroelectric facilities proposed for Bay of Fundy estuaries (from Fundy Tidal Power Project Description, 1982).

basin with each tidal cycle. Thus, where turbines cause a relatively small percentage mortality with one passage, the cumulative mortality resulting from repeated passage into and out of the basin would result in substantial mortalities. Also of concern are the potential changes in the basin ecosystem structure. Scarratt and Dadswell (1983) raised the possibility that a reduction of exchange and mixing in these upper basins may reduce biological productivity, resulting in a decline in the forage value of planktonic communities.

Extensive work has been conducted and is continuing in Canada to document the patterns of movement of shad in the basins of the Bay of Fundy and the stock composition of the fish utilizing those areas. A portion of the tag return information was presented earlier in Fig. II-11. As of spring of 1983, nearly 10,000 shad have been tagged and released in the two basins. These tagging studies will not only provide information on the migratory patterns and origin of the stocks using the basins, but will also provide detailed information on mortality rates for all ages of shad. The studies have already shown that the Bay of Fundy is used by all age groups of shad, including both sexually mature and immature fish.

While neither of the proposed major tidal projects is currently in development stage, a prototype, small-scale project will begin operation in 1984 on the Annapolis River estuary in Nova Scotia. Considerable concern has been expressed by American fisheries agencies about the potential for the proposed projects to impact American shad stocks. This concern was conveyed in a letter sent from the Atlantic States Marine Fisheries Commission to all state and federal agencies having responsiblity for fisheries management (see Appendix C). This letter, distributed during the summer of 1983, elicited responses from a number of federal agencies and legislators, as well as a response from the U.S. Department of State. The State Department contacted the Canadian government to express concerns with the project. The Canadian government responded that they were aware of the concerns and that when and if additional development and planning occurred for these projects, fisheries impacts would be one of the major areas investigated. At the current time there is no ongoing development work on the projects. However, considerable predevelopment design and planning have been done and are continuing. Should economic circumstances become more favorable, development could procede rather rapidly. Thus, these projects must be monitored rather closely in order to ensure that the fate of the American shad is fully considered in any development.

I. RELEVANCE AND POTENTIAL VALUE OF ALTERNATIVE MANAGEMENT ACTIONS

Summary of Important Population Biology Aspects

The efficacy of any management action is a function of the life history characteristics of the species being managed. Thus the critical aspects of American shad population biology must be taken into account when considering the potential value of any management action. This summary of these critical aspects is drawn from the material already presented:

- River and coastal fisheries are directed at a very limited number of age classes; ages 4 and 5 make up the majority of American shad harvests along the entire east coast of the United States, with older age classes contributing somewhat more to harvest in northern states.
- Offshore fisheries, and Canadian fisheries in the Bay of Fundy during summer and fall, may take all year-classes, including sexually immature fish.
- All east coast stocks appear to mix at sea during coastal prespawning migrations, and during foraging periods in the summer in the Gulf of Maine and the Bay of Fundy.
- American shad are relatively short-lived, and vary latitudinally from being iteroparous (spawning only once in their lifetime) to semilparous (spawning more than once in their lifetime).
- Certain population characteristics (e.g., size at age, percent repeat spawning) vary latitudinally suggesting that management actions may have to be regionally specific.
- Current data suggest that, for the most part, recruitment may be independent of spawning stock size.
- Restoration efforts opening up new areas of spawning habitat appear to have the potential for adding substantially to the total east coast stock of American shad.

Assessment of the Potential Impact of Various Management Options

Different categories of fishing regulations differ in their ultimate effect on a given population. For example, size limits may influence the fishing mortality rate of specific age classes of fish, whereas gear restrictions may affect all age groups. Thus, in examining the various types of regulatory actions that may be used to manage American shad, it is necessary first to examine the effect on a given stock that certain types of management actions would have.

One broad category of management action is the implementation of catch restrictions (i.e., the reduction in total harvest of a species). Catch restrictions would have different impacts on American shad stocks depending on which fishery is being restricted. In cases where a fishery is in place near the mouth of the spawning drainage system, the restriction on total harvest will increase the escapement of fish. In more northern areas, such an increase in escapement will not only increase the number of fish allowed to spawn in that year but may increase the probability of repeat spawning by those same fish in subsequent years. The net effect of catch restrictions on river fisheries is to increase the number of fish spawning. However, as discussed in the population dynamics section presented earlier in this report, increasing the number of spawning adults will have an unpredictable impact on subsequent recruitment.

Restriction of offshore harvests and harvests of shad in the summer and fall fisheries in Canadian waters may have its greatest impact in reducing total mortality rates for sexually immature fish, which would make up the majority the impacted populations. However, as was discussed earlier, these fisheries are presently very limited in magnitude. Control of these harvests may represent more of a preventative action than a restorative one.

Restriction of harvest in coastal waters during spawning migrations may impact on the fishing mortality rate for fish of different drainage systems. Based on the migration patterns already described, more northern stocks may be exposed to greater fishing pressure than more southern stocks as they migrate northward along the coast. Restrictions on fishing effort in southern waters have the potential for influencing run size of northern stocks.

The magnitude of potential benefits of water quality improvements may vary considerably by drainage system along the east coast. As was noted earlier in this report, the Delaware River run is vulnerable to seasonal declines in water quality in one specific segment of the entire drainage system. Improvements of water quality in that localized area have been extremely effective in enhancing the run in the Delaware. In other areas, such as Albemarle Sound, the more generic nature of water quality problems, with less specific direct linkage to stock condition, makes the efficacy of water quality improvement less clear. Similar circumstances occur in most of the drainage systems along the coast, except where localized conditions in specific spawning areas or in restricted migratory paths may serve as total constraints on the success of individual runs.

Restoration programs intuitively would appear to be an attractive management strategy in any portion of the range of American shad on the east coast, since they provide the opportunity to add fish to existing stocks with no detrimental impacts. However, the potential of restoration for contributing significantly has, to date, not been conclusively demonstrated. Success requires the existence of valuable habitat that is currently inaccessible to or unusable by fish, and a high potential for reestablishing runs through normal management actions (e.g., stocking of gravid adults in the spring, hatchery releases of juveniles, water quality improvements).

J. POTENTIAL EFFICACY OF REGULATORY CHANGES

The type of regulatory action that can have an influence on stock dynamics for American shad is, of course, dependent on its population biology characteristics. In contrast to fisheries for such species as cod, very few yearclasses of American shad are exploited (i.e., ages 4 and 5), and the individual fish are not long-lived. In such stocks, unrestricted harvest could result in stock overfishing as opposed to growth overfishing (i.e., instead of reducing the potential biomass harvest by harvesting fish too early in their period of growth, as could be the case for longlived species such as codfish and haddock, overharvesting may reveal itself in subsequent precipitous declines of the spawning stock). These particular aspects of the biology of American shad must be considered in developing a management strategy for the species. Specific regulatory actions must then be selected as the basis for carrying out that management strategy. For example, if it were to be determined that certain sizes, ages, or sexes must be protected, that strategy could be implemented by a number of different types of regulatory action, including the following:

<u>Gear Types</u> - The type of gear employed in a fishery very strongly influences the composition of the harvest taken from a given stock. Certain gears (i.e., gill nets) may be very selective for certain sizes of fish in contrast to other gears (i.e., pound nets), which have equal probability of capture for a broad range of sizes and ages of fish in the vicinity of the gear. Thus, limitations on the type of gear to be employed can be an effective means of altering the exploitation rates for given age, sex, or size category of the species.

<u>Gill Net Mesh Size</u> - Gill nets are an extremely selective gear type. Changes in the legal size of mesh of gill nets have a strong impact on the size frequency of fish captured by those nets. Proper selection of mesh size can result in differential harvest of different

age, size, or sex categories within any given species. In the case of American shad, harvest of mature females could be decreased by requiring smaller mesh size regulations. In addition, the composition of net material (i.e., monofilament vs twine) may have a substantial impact on the overall efficiency of the net; Leggett (1976) has shown that monofilament gill nets are much more efficient than twine gill nets for the capture of American shad. Thus, controls on composition of the nets may be a means of implementing regulated inefficiency in harvest.

Lift Or Closed Periods - Lift periods are those designated times during which fishermen are required to lift their gear (e.g., gill nets, pound nets) from the water to permit increased escapement of fish past the area of fishing. Since the major American shad fisheries occur near the mouth of the spawning rivers, fish that get past this primary location for fishing are almost certain to contribute to total fecundity of the run during that season. In general, lift periods and/or closing of fisheries permit additional escapement in direct proportion to the length of the lift. That is, a lift period of two days per week should, on the average, increase escapement by two-sevenths. However, the relative efficiency of lift periods may vary according to the pattern of the spawning run in a given year and the location of the major gears being used, in relationship to the major migratory routes of the species. In addition, lift periods for fisheries that are situated well into the major spawning areas for the species will not have the same potential value as the lift periods of fisheries situated at the mouths of rivers or along major migratory routes. The precise impact of lift periods on a given run in any given year may be relatively unpredictable.

Seasons - The period of spawning migration of American shad in any given drainage system appears to be strongly controlled by water temperature (Leggett and Whitney, 1972). While seasonal temperature patterns are relatively consistent on a long-term average, the specific temperature conditions in any one year may vary from that average considerably. Regulating the fishing season would help ensure a certain percentage of escapement of a given stock. However, as in the case of lift periods, the actual result of the given season in any given year may be rather unpredictable. Also, in a strongly seasonal fishery such as that for American shad, the use of seasons as a management approach may be inappropriate, since the species are only exploited for a brief period of time.

Locations of Fishing - Restrictions on the areas where fishing is allowed may have a substantial impact on the percentage escapement for a given run. Permitting fishing only near the entrance to a given drainage system ensures that fish passing the fishery will be available for spawning. In contrast, where fishing is permitted on the spawning grounds, the percentage of available stock that may escape the fishery will be much less predictable. Location of fishing may be the type of regulatory action that would make the effects of other types of regulations (such as lift periods) more predictable in total impact on the stock. Thus it may be important as one element of a multi-faceted management action.

Ouotas - Ouotas are defined as the optimal allowable harvest for a given stock to ensure acceptable subsequent recruitment in the stock. The implementation of the quota system for any given species is dependent on knowledge of the population biology of the species and the existence of a strong quantitative data base for all life stages of the species. In the case of American shad, the data bases necessary for establishing quotas are not available, and the population biology of the species suggests that recruitment, at least under normal conditions, is independent of stock size. In such a case, quotas may be an inappropriate means of manipulating stocks so as to influence subsequent stock size. However, quotas may play a role in allocation of the harvest among user groups where reduction of fishing mortality from all sources is desired.

Recreational Fishing Restrictions - The most common types of limitations placed on recreational fishermen are creel limits and size limits. Size limits in the case of American shad are an inappropriate management action, since they are generally implemented to prevent growth overfishing (i.e., to protect those size classes having the greatest potential for rapid growth before harvest). Size limits would only have an impact in terms of mortality by sex, since buck shad tend to be much smaller than roe shad. Creel limits would serve primarily as a means of allocating harvest among more fishermen, since unless the total number of recreational fishermen were limited, the total recreational harvest would not be controlled. The importance of recreational harvest control may be that in most cases recreational fisheries occur near the actual spawning grounds, in contrast to commercial fisheries which tend to occur near the entrances to the drainage systems.

Innovative Management Strategies

Certain aspects of American shad life history suggest that the optimal approach to management may be one which is flexible and permits alteration of regulations on a year-by-year basis in response to documented changes in spawning success from year-to-year. Crecco's extensive work on the Connecticut River (Crecco et al, 1983a,b) has suggested that the majority of mortality of American shad occurs between the egg and juvenile stage, and that year-class success is set by the time the juvenile stage is reached. Based on this premise, the spawning success of a run in any given year can be established by a detailed juvenile index survey. Fisheries for American shad are known to take mostly virgin fish of ages 4 and 5. Age of maturity by sex is reasonably well documented, as was noted earlier in the report. With a sound data base on relative juvenile abundance from year-to-year and the knowledge of the normal composition of the catch, fisheries management approaches may be outlined which would establish the allowable harvest in any given year based upon the juvenile index 4 and 5 years previously. While the success of such a management approach in terms of subsequent recruitment would not be predictable, it would permit implementation of restrictive regulations in cases where extremely poor spawning success has been documented. This would be a conservative, flexible management approach. It would ensure that fishing mortality would not be an additional source of mortality and stress to a stock already reduced to possibly dangerously low levels.

K. DATA DEFICIENCIES

Relatively little detailed information is available spanning long periods of time on the majority of shad stocks, as is the case with the majority of fisheries along the east coast of the United States. The single exception to this general pattern is the Connecticut River, where long-term data bases are available for almost all aspects of both life history and the fishery for the species. It is evident from the literature generated by the Connecticut River shad programs that the nature of the data being collected on the Connecticut would be the ideal type to be collected in all other major shad runs. Thus, the Connecticut River data base may serve as a benchmark against which to compare data available from the other systems. This comparison points out the major data deficiencies for American shad:

- Accurate catch and effort data - the need for accurate catch and effort data has been frequently stated in the past (Mansuetti and Kolb, 1953; Walburg and Nichols, 1967). This data was viewed as being of value because catch-per-unit effort indices may serve as an index of relative stock size. While accurate total catch data are essential for many different reasons (e.g., establishing economic value of the fishery), the value of accurate effort data has been placed in question by recent studies (e.g., V. Crecco, pers. comm.; Bannerot and Austin, 1983). In addition, the varied nature of the gear types used in fisheries for the species (e.g., stake gill nets, drift gill nets, run-around gill nets, pound nets) increases the complexity of definition of effort units. Thus, improvements in records of effort may be a fruitless activity.

- Long-term juvenile index data - The value of long-term records of relative juvenile abundance in establishing population dynamics characteristics of shad stocks has been demonstrated conclusively in the case of the Connecticut River. In addition, the Maryland juvenile index definitely foretold the decline of stocks in that state. Thus long-term juvenile index data may serve as an extremely valuable tool for establishing flexible management actions in response to the relative spawning success of the stock, as was discussed earlier. However, as was also discussed above, proper juvenile index surveys must take into account the nature of the nursery area of the species, changes in nursery area between years, the representativeness of sampling stations, the efficiency of the sampling gear being used, and all other relevant factors that may influence catch-per-unit sampling effort. If not adequately designed, juvenile surveys may yield misleading data.

- Stock discrimination data - Of particular concern with respect to stock discrimination are those fisheries where multiple stocks may be harvested. This would include fisheries in coastal waters (i.e., South Carolina), in offshore waters, and in Canadian waters. Identification of stocks that are being harvested would permit a clearer definition of total fishing mortality rates for individual stocks. Such data would also provide an objective means of implementing regulations in areas where interjurisdictional problems may arise because of harvest of nonresident stocks.

- Recreational catch data - In many of the major shad runs along the east coast, recreational fisheries are extremely important, both in terms of economic value as well as in potential impact on the stock on the spawning grounds. In general, recreational fisheries are poorly defined. Information on total recreational harvest may permit a clearer definition of management goals, and also may provide a basis for selection of proper regulatory approaches in managing stocks.

- Documentation of offshore harvest - Improved identification of offshore harvests of alosids would contribute to the general documentation of total fishing mortality of stocks of all species. Such information could also be augmented by stock discrimination information developed from samples of offshore harvests.

- Early life stage biological data - Work being conducted on the Connecticut River has strongly suggested that mortality rates from the egg to the juvenile stage are the dominant factors controlling year-class success and recruitment to harvests in future years. Because of the importance of mortality of these life stages for determining the subsequent success of the fishery, additional information should be developed to examine factors influencing these mortality rates. The potential for other factors, such as pollution, to act synergistically or antagonistically to already existing natural factors controlling year-class success should also be assessed.

III. HICKORY SHAD (*Alosa mediocris*)

A. BACKGROUND

The hickory shad is a more southern species than the cosmopolitan American shad, with spawning populations occurring from Florida northward, probably as far as New York. Older documents (e.g., Hildebrand and Schroeder, 1928; Bigelow and Schroeder, 1953) describe harvests of hickory shad in southern New England. However, they also note frequent misidentification of the species. Overview documents prepared by state fisheries personnel along the east coast report no current hickory shad spawning north of Maryland. In New York state, hickory shad are taken along the eastern shore of Long Island in May and June, but not in the Hudson River American shad fishery; however, this is viewed as an artifact of the fishing gear used in the Hudson being selective for the larger American shad (Brandt, pers. comm.). Hickory shad are smaller than American shad but larger than river herring (Fig. I-1).

As in the case of American shad, landings data represent the only potential long-term record of hickory shad abundance. However, there are a number of factors that make hickory shad commerical landings data of much poorer quality than American shad data. The close similarity in appearance of hickory and American shad frequently results in hickory shad being lumped with American shad in many landings reports. However, in some locations where directed fisheries exist for hickory shad, landings data are species specific. The accuracy of identification of hickory shad may also change with season. Since hickory shad runs begin somewhat earlier than those of American shad, all fish taken early may be identified as hickory shad. Overall, the value of recorded commercial landings of hickory shad as documentation of stock abundance is very questionable.

Reported commercial landings of hickory shad are presented in Table III-1. The data suggest a declining trend in abundance. However, the data limitations just discussed make conclusions about the magnitude and rate of decline difficult to establish. In addition, hickory shad frequently support rather extensive recreational fisheries; however, dependable recreational harvest data do not exist.

Subsequent sections of this chapter of the report are generally organized in the same manner as for the American shad, focusing on the nature of hickory shad fisheries by state, life history aspects relevant to management, and assessment of the efficacy of various management options. However, this report

Table III-1. Reported commercial landings of hickory shad on the east coast of the U.S. (pounds) (NOAA Fishery Statistics of the United States); dashed lines denote no catch reported; blanks denote no data acquired.

DATE	MD	VA	NC	SC	GA	FL	TOTAL
1950					8,000	14,874	22,874
1951					6,000	-	6,000
1952					9,000	-	9,000
1953					6,000	5,725	11,725
1954					0	1,189	1,189
1955					5,000	3,170	8,170
1956			268,082		8,873	21,626	298,581
1957			247,782	6,550	3,330	23,004	280,666
1958			83,985	560	3,119	19,217	106,881
1959	11,300	19,100	99,495	100	4,367	-	134,362
1960	1,874	10,300	180,703	2,586	3,844	-	199,307
1961	15,738	54,000	276,437	923	2,882	-	349,980
1962	6,864	42,100	171,650	791	1,699	-	223,104
1962	4,555	25,600	292,657	750	1,201	-	324,763
1964	14,697	49,542	232,892	1,962	1,030	-	300,123
1965	12,753	34,900	202,000	-	877	-	250,530
1966	8,454	41,265	196,596	-	1,913	-	248,228
1967	7,134	28,400	130,574	-	1,222	-	167,330
1968	6,825	13,830	141,305	-	11,308	-	173,268
1969	19,798	99,765	100,716	1,950	12,295	-	234,524

Table III-1. Continued

DATE	MD	VA	NC	SC	GA	FL	TOTAL
1970	40,132	23,909	61,424	2,600	4,491	-	132,556
1971	11,160	10,490	62,053	-	1,730	-	85,433
1972	22,288	26,803	69,190	3,399	2,515	-	124,195
1973	61,271	55,395	65,973	-	3,456	-	186,095
1974	12,957	41,189	41,725	-	343	-	96,214
1975	15,147	30,908	29,202	2,004	1,294	-	78,555
1976	4,680	3,620	18,716	-	555	-	27,571
1977	984	1,386	22,109	-	1,123	-	25,602
1978	1,394	1,622	20,507	-	2,079	-	25,602
1979	1,895	1,055	31,716	-	445		35,111
1980	2,101		91,501	720	410		94,732
1981	0		81,312	557	377		82,246
1982	0		24,742	676	867		26,285
1983	0		64,669	1,315	2,696		68,680
1984				888	2,862		3,750

segment will differ somewhat from both the American shad and river herring portions for two reasons: 1) the southern range of the hickory shad obviates the need for regional treatment of the fisheries, and 2) the absence of substantial information on many aspects of the life history of the hickory shad limit the depth of treatment.

B. INDIVIDUAL STATE FISHERIES

No commercial landings of hickory shad were reported in Florida after 1959. The occurrence of large harvests in 1956 through 1958, prior to absence of reports, is unexplained (Table III-1). Whether the absence of landings after 1959 was due completely to a decline of the stock or was attributable in part to the lack of landings being reported separately from those of American shad is not known. A very active sport fishery for shad formerly occured on the St. Johns River in Florida, but only about 2.4% of the catch were hickory shad (Walburg, 1960, cited in Rulifson et al., 1982). In recent years, commercially harvested hickory shad have been used primarily as bait in fish and crab traps (Williams et al., 1975).

In Georgia, hickory shad made up approximately 6% of the total shad harvest in 1968, while in 1979 the percentage declined to 0.3% (Michaels, 1982). Higher prices paid for female American shad caused the fishermen to select gill net mesh sizes that are inefficient for hickory shad; therefore, the decline in hickory shad harvest may be incidental to a shift in the direction of effort. For this reason, the fluctuations and/or trends in reported landings cannot be considered to reflect the status of hickory shad stocks. In the absence of specific survey data related to this species, the status of hickory shad in Georgia must be considered to be undefined. Fisheries for hickory shad in Georgia are almost entirely inland. Data collected in 1982 revealed that 90.4% of the hickory shad landed in the Altamaha River were taken in riverine waters, as opposed to the majority of American shad being taken in coastal waters (i.e., sounds and ocean) (Michaels, 1982).

A directed fishery for hickory shad does not exist in South Carolina; reported landings are taken as by-catch in American shad fisheries. Because of the large mesh sizes used in those fisheries, and because the fishery is timed to coincide with the peak of American shad migration, major portions of hickory shad runs may suffer no significant exploitation (Ulrich, 1982).

In North Carolina, there is an early directed fishery for hickory shad, which employs nets of smaller mesh size than those used for American shad and thus of greater efficiency for harvest of hickory shad. However, hickory shad are also harvested in the fishery directed at American shad in most of the major drainage systems in the state. In the American shad fishery, large females make up the majority of hickory shad landings. Most of the harvest is taken in pound and gill nets, but the species has also supported an extensive sport fishery. The North Carolina sport fishery for hickory shad was characterized by Marshall (1976) who reported very low stock levels at that time. Landings of formerly extensive sports fisheries have declined significantly in recent years (Johnson, 1982). Reported commercial landings of hickory shad in North Carolina have been low but stable for the past several years.

As in North Carolina, a limited early fishery directed at hickory shad occurs in Virginia. The emphasis on hickory shad is in effect until American shad runs begin, at which time there is a shift in direction of fishermen's effort. Gill nets account for the majority of hickory shad taken in Virginia (Atran et al., 1982). Active sport fisheries occur in most of the drainage systems having runs, generally in the freshwater tidal areas. Harvests of hickory shad in Virginia declined drastically in 1976 (Table III-1), and are currently stable at a very low level.

Virtually nothing is known of hickory shad stocks in Maryland. Reported commercial landings have declined in recent years, but reporting was probably erratic in the earlier years. For this reason, the magnitude and true extent of a stock decline cannot be assessed from the data. A major sport fishery had occurred in the Upper Chesapeake Bay on Octorraro Creek, a tributary of the Susquehanna River. This fishery declined precipitously in the mid-1970s and has never recovered. The evidence that exists points to a very dramatic decline of hickory shad in Maryland. The hickory shad fishery was closed in 1980 and remains closed.

C. MARKET FACTORS AFFECTING HARVEST

Dockside value of hickory shad (price per pound) by year by state is presented in Table III-2. The accuracy of the data are placed in question, in part, as a result of the mixing of hickory and American shad landings. The prices presented in the table are those specifically for hickory shad; other prices may be in effect when hickory shad are mixed with American shad. The perceived value of hickory shad differs markedly from state to state. In South Carolina and Georgia in recent years, for instance, roe hickory shad command nearly the same price as roe American shad, while in North Carolina the value differs by a factor of four. These types of price differentials would appear to be due to differences in the public and commercial perception of the species, as opposed to any specific difference in the quality of the fish. In addition, the smaller size of hickory shad may contribute to a lower value. Indications

Table III-2. Hickory shad dockside value, by state (rounded to dollars per pound); dashed lines denote no catch reported; blanks denote no data acquired (from NOAA Fishery Statistics of the United States).

YEAR	MD	VA	NC	SC	GA	FL
1950	0.07	0.05	0.05	0.10	0.14	0.04
1951	0.07	0.05	0.07	0.18	0.15	0.04
1952	0.06	0.05	0.04	0.16	0.15	
1953	0.10	0.05	0.04	0.12	0.17	0.03
1954	0.07	0.05	0.05	-	-	0.03
1955	0.08	0.04	0.05	-	0.20	0.03
1956	0.06	0.06	0.06	0.15	0.11	0.04
1957	0.04	0.04	0.06	0.06	0.08	0.05
1958	0.02	0.04	0.06	0.04	0.08	0.03
1959	0.05	0.05	0.06	0.02	0.08	-
1960	0.02	0.03	0.05	0.01	0.08	-
1961	0.06	0.06	0.05	0.06	0.02	-
1962	0.14	0.04	0.05	0.04	0.02	-
1963	0.06	0.04	0.03	0.03	0.04	-
1964	0.07	0.05	0.04	0.03	0.21	-
1965	0.08	0.03	0.04	-	0.09	-
1966	0.05	0.05	0.03	-	0.14	-
1967	0.14	0.07	0.06	-	0.03	-
1968	0.03	0.07	0.04	-	0.09	-
1969	0.10	0.03	0.05	0.15	0.17	-
1970	0.09	0.08	0.05	0.33	0.20	-
1971	0.09	0.09	0.05	-	0.28	-
1972	0.07	0.08	0.06	0.33	0.50	-
1973	0.12	0.13	0.04	-	0.25	-

Table III-2 (continued)

YEAR	MD	VA	NC	SC	GA	FL
1974	0.11	0.11	0.07	-	0.37	-
1975	0.13	0.26	0.06	0.35	0.36	-
1976	0.25	0.30	0.11	-	0.42	-
1977		0.32	0.08	-	0.56	-
1978	0.24	0.44	0.18	-	0.64	-
1979	0.31	0.12	0.16	-	0.70	-
1980						
1981		0.37				

from state fisheries personnel from all of the southern states suggest that there is no directed market for hickory shad, which are sold to the same customers who purchase American shad. A market exists primarily because hickory shad runs precede those of American shad. For this reason, the market factors discussed as influencing American shad landings would have a similar impact on landings of hickory shad.

D. LIFE HISTORY ASPECTS RELEVANT TO MANAGEMENT

General Life History Characterization

Very little is known of the general life history of the hickory shad. The limited amount of detailed information which is available has been developed through studies done in North Carolina (e.g., Mansuetti, 1962; Pate, 1972; Street, 1970; Street, 1969; Street et al., 1975). Older reviews are presented in Hildebrand and Schroeder (1928) and Bigelow and Schroeder (1953). Rulifson et al., (1982) reviewed much existing literature, including much that is anecdotal.

The time of spawning for hickory shad is from March to May in all the southern states, with runs beginning somewhat earlier in the more southern states (Rulifson et al., 1982). Specific locations of spawning areas are generally unknown, except in North Carolina (Marshall, 1976). Spawning occurs in freshwater in extensive segments of the river reach. Juvenile hickory shad are seldom caught, and there is some suggestion that they move downstream at an earlier age than other anadromous alosids. It has been suggested that hickory shad juveniles use estuarine waters as major nursery areas, as opposed to the other alosids that use freshwater nurseries (Pate, 1972; Sholar, 1977).

Oceanic distribution and movement patterns are almost entirely unknown. Lack of sufficient identification of hickory shad in offshore harvests results in no hickory shad being reported in the offshore fisheries. In North Carolina, hickory shad were taken from November to March in a year-round survey program in coastal waters, but they were not taken at other times of the year (Holland and Yelverton, 1973). These data suggest the possibility that hickory shad may move out of the North Carolina area from the beginning of the spawning run through the fall. Bigelow and Shroeder (1953) report occasional large harvests of hickory shad in southern New England in summer and fall. The occurrence of hickory shad in more northern states despite the absence of spawning runs in those states also suggests that hickory shad may undertake the same types of migration as American shad. However, no concrete data are available to document if this is in fact the case.

Age of Maturity and Repeat Spawning

Table III-3 presents age distribution data for samples of hickory shad taken from Florida to North Carolina. A wide age-distribution is evident in all of the runs, with no distinct differences in age of maturity between the sexes. Street et al. (1975) reported that repeat spawners made up approximately 50% of the total run of hickory shad in Albemarle Sound, while in the Neuse River, Pate (1972) found as high as 76% repeat spawning females. The only drainage system in which low repeat-spawning of hickory shad has been reported is the Northeast Cape Fear River, in which only 19% of the males and 9% of the females were found to be repeat spawners (Sholar, 1977). Similarly low values (15%) were found by Fischer (1980) in the same river. In contrast, Street and Adams (1969) reported 70 to 80% repeat spawners in the Altamaha River. In general, repeat spawning is very prominent in runs of hickory shad, as is also suggested by the common occurrence of fish between the ages of 6 and 8.

One caveat that must be considered in examining all hickory shad age and repeat-spawning data is that hickory shad scales are acknowledged by fisheries workers to be among the most difficult alosid scales to read. This difficulty suggests that some available age data may be of questionable accuracy, although the distinction between which data are questionable and which are not cannot be made. Another factor that must be considered in examining age distribution data is that percentage of individual year-classes in samples collected in any one year is strongly influenced by the relative magnitude of that year-class included in the sample. Thus, the most meaningful data are those which aggregate data collected from runs occurring over a period of years.

Size at Age

Table III-4 presents size-at-age data for fish from Florida, South Carolina, and North Carolina. As in the case of other anadromous alosids, females tend to be larger than males. The largest size groups (e.g., fish greater than 350 mm) are about the size of the smallest American shad. This size group, which is composed primarily of older female hickory shad, would be the group most susceptible to harvest as by-catch in American shad fisheries.

Mortality

Very limited data are available on mortality rates for hickory shad. Two values reported in the literature were 82%

Table III-3. Age composition (%) of hickory shad populations in river systems.
M = males; F = females; C = sexes combined
(From Rulifson et al., 1982)

RIVER SYSTEM AND YEAR	SEX	AGE CLASS I II	III	IV	V	VI	VII	VIII	SOURCE(S)
Neuse River									
1977	M	9	39	31	10	6	4	1	Marshall (1977).
	F	1	33	36	19	6	5	1	
1978	M		9	66	22	3	0		Hawkins (1979)
	F		9	64	20	6	1		
Northeast Cape Fear River									
1976	M		29	65	0	6			Sholar (1977b)
	F			45	55				
1978-79	M		52	33	15				Fischer (1980)
	F		10	40	50				
Santee River									
1974	C		21	31	48				Curtis (1974)
St. Johns River									
1971-74	M	12	62	12	12	2			Williams et al. (1975)
	F	2	73	10	13	2			

Table III-4. Size composition (mean fork length in mm) of hickory shad populations in river systems.
M = males; F = females; C = sexes combined
(From Rulifson et al., 1982)

RIVER SYSTEM AND YEAR	SEX	I	II	III	IV	V	VI	VII	VIII	SOURCE(S)
Albemarle Sound										
1975	M		289	325	350	371	360	365		Street et al. (1975)
	F		341	341	355	387	384	390		
Pamlico Sound & River										
1976	M		286	297	341	355	395	-		Marshall (1976)
	F		290	324	354	376	413	427		
Neuse River										
1972	M		294	332	346	356	357	369		Page (1972)
	F		311	354	376	395	409	420		
1977	M		294	336	344	356	381	384	397	Marshall (1977)
	F		307	343	357	367	386	415	411	
1978	M			325	343	352	361	-		Hawkins (1979)
	F			338	362	369	403	403		
White Oak River										
1974	M			345	-					Sholar (1975)
	F			-	318					
Northeast Cape Fear River										
1976	M			291	331	-	433			Sholar (1977b)
	F			-	326	349	-			
1978-79	M			300	316	354				Fischer (1980)
	F			308	338	370				
Santee River										
1974	C			411	467	487				Curtis (1974)
St. Johns River										
1971-74	M	-	315	340	358	376	384			Williams et al. (1975)
	F	216	326	352	370	400	420			

total annual mortality in 1977 (Loesch et al., 1977) and 47% in 1978 (Johnson, et al., 1978). These high values would appear to be inconsistent with the high percentage of repeat spawners reported in most hickory shad studies. The overwhelming evidence that repeat spawners make up the majority of hickory shad runs suggest that these mortality values are of questionable validity.

In addition, escapement data also suggest relatively low fishing mortalities. Godwin (1968) reported hickory shad escapement rates in the Altamaha River of 70.2% for females and 87.1% for males.

Other Life History Aspects

All other aspects of the life history of hickory shad are more poorly documented than those aspects just discussed. Any management actions proposed for this species will therefore have to be taken with a very limited biological foundation.

E. MANAGEMENT AND RESTORATION

Because of the lack of detailed information on both fisheries and life history of the species, no actions have been taken by any state directed specifically at hickory shad, except in the case of Maryland, which has closed the hickory shad fisheries. While there have been apparent drastic declines in runs of hickory shad in a number of drainage systems in the southern states, no restoration efforts have been initiated.

F. RELEVANCE AND POTENTIAL VALUE OF VARIOUS MANAGEMENT ACTIONS

Relevant Aspects of Life History and Fisheries

Three major aspects of hickory shad life history are of particular relevance for management of the species:

- Spawning runs are phased somewhat earlier than those of American shad
- Larger roe hickory shad probably suffer the greatest fishing mortality of all segments of the hickory shad population

- A high percentage of repeat spawning of the species suggests that the populations may be dependent on relatively low annual mortalities to remain viable; if this were the case, excessive annual mortality could be detrimental to population stability.

Assessment of the Potential Impact of Various Management Options

Management actions that result in a reduced harvest of hickory shad would have greatest influence on the mortality rates of large, older females. Because fecundity is directly related to body size in most species, restrictions on commercial harvests of hickory shad could substantially increase the total fecundity of a run in any given year, if the run had been exposed to significant fishing mortality in the past. However, the result of increased run fecundity on subsequent recruitment and run size is not known.

Water quality improvements, as was discussed in the case of American shad, might improve the quality of spawning and nursery habitat and/or provide additional suitable habitat for the species. However, no dramatic water quality changes have been documented in any of the systems in which drastic declines in hickory shad appear to have occurred (e.g., comparable to the circumstances in the lower Delaware River). Thus, the role of water quality in influencing the dynamics of hickory shad in the past two decades is undefined.

Restoration of hickory shad runs to drainage systems where access had historically been restricted, would, as in the case of American shad, contribute new fish to existing stocks. However, so little is known about hickory shad that it is difficult to determine areas in which runs may have previously occurred and where they are now absent. Rulifson and Huish (1982) list many streams in the South which are thought to have hickory shad runs but their status is not known. Another factor that may limit the feasibility of restoration may be the lack of available stock for transplanting and a lack of knowledge of proper handling procedures.

G. POTENTIAL EFFICACY OF REGULATORY CHANGES

Seasons

Because hickory shad runs precede those of American shad, regulating seasons for shad fisheries may be an effective means of minimizing fishing mortality rates of large hickory roe shad. However, as was discussed above, the consequence of enhancing run fecundity by minimizing harvest of this particular population segment is unclear.

Gill Net Mesh Sizes

Since hickory shad are taken primarily as by-catch in American shad fisheries, mesh size regulations may have a substantial effect on the fishing mortality rates for the species. Restrictions on the mesh size that would eliminate the use of smaller mesh nets would be certain to decrease fishing mortality rates for hickory shad.

Gear Types

Except for restrictions on gill net mesh sizes, discussed above, little could be done that would differentially affect the harvest of hickory shad as opposed to American shad. This is especially true since so little is known about hickory shad migration patterns and habitat usage. If in fact it were known that hickory shad follow different migratory paths within the drainage systems, limitations on specific types of gear, which selectively fished different types of water, might be a means of controlling the hickory shad harvest.

Lift or Closed Periods

The influence of lift or closed periods during hickory shad runs would have the same impact on hickory shad as was discussed for American shad. That is, the length of a lift within any given period of time (i.e., days per week) would result, on the average, in additional escapement proportional to the relative length of the lift period. Additional escapement would increase total run fecundity.

Catch Quotas and/or Restricted Entry

The almost total lack of information on hickory shad population dynamics, abundance, and general life history essentially eliminates these management approaches as viable options. The data and information bases needed to establish such restrictions do not exist. In addition, the mixing of hickory shad with American shad landings, and the probable misidentification of substantial portions of the total harvest make such a regulatory approach impractical and unenforceable.

H. DATA DEFICIENCIES

Very little is known of hickory shad runs throughout most of their range. Hickory shad are taken incidental to fisheries directed at other species, and even in the case of directed fisheries, only portions of the run are fished intensively. The limited knowledge of life history, in particular the estuarine and coastal migration patterns, suggest that a first step in alleviating data deficiencies should be to undertake life history studies throughout the range of the species. Such information would be vital for the design of studies which would be directed at developing more management-specific data bases, such as:

- Juvenile abundance indices
- Population dynamics characteristics (i.e., mortality rates by life stage)
- Characteristics of spawning, nursery, and foraging habitat.

In addition, the mixing of hickory shad with American shad harvests suggests that although valid catch and effort data might be desirable, acquisition of such information is impractical. The complexity of the fisheries capturing hickory shad suggests that use of catch-per-unit effort-type indices for tracking stock abundance may be impossible. This, in turn, suggests that stocks would have to be monitored using some type of scientific survey approach.

IV. RIVER HERRING: ALEWIFE (Alosa pseudoharengus) AND BLUEBACK HERRING (Alosa aestivalis)

A. BACKGROUND

The term "river herring," which is applied to both alewife and blueback herring throughout their range along the east coast of the United States, is based on the anadromous nature of both species. It is used generically because in commercial harvest no distinction is made between the two species. As a consequence, all available fisheries data consists of combined harvests of the two species. Thus the use of commercial landings data in assessing trends in abundance of both species requires that they be considered together. In this report, trends in stocks will be discussed in reference to both species together. However, where information is available and appropriate, species-specific material will be presented.

Range

The alewife is the more northern species of the two, being found from Nova Scotia to South Carolina, with the center of distribution skewed towards the northern states (Hildebrand and Schroeder, 1928; Leim and Scott, 1966). Blueback herring have a relatively cosmopolitan distribution along the east coast, occurring from Nova Scotia in the north to Florida in the south (Hildebrand and Schroeder, 1928; Leim and Scott, 1966). However, their center of distribution along the coast is definitely to the south, and they represent the anadromous river herring that occurs in the most southern states.

Historical Trends in Fisheries

Fisheries for river herring have changed dramatically over the last hundred years. In the 1800's and early 1900's, river herring were harvested and salted as food fish, and extremely large harvests were made (Bigelow and Schroeder, 1953). Since that time, both the markets and the nature of gear used in these fisheries have changed drastically. In recent years, the major use of river herring has been for bait (for crab, lobster, and fish), pet food, and reduction to fish meal. Such use varies by geographical region. For example, in Maryland nearly all river herring harvests have been used for crab bait, in Rhode Island nearly all is used for lobster bait, and in Virginia substantial amounts are used for pet food.

Historical records of domestic landings of river herring are presented in Fig. IV-1 and Table IV-1. In addition to domestic landings, substantial offshore landings of river herring were reported by foreign fisheries operating in coastal waters during the late 1960's and early 1970's. The pattern of offshore landings is indicated in Fig. IV-1. Offshore harvests of river herring declined in the mid-1970s concomitant with a decline in the level of foreign fishing effort off the U.S. coast, when the new 200-mile Fishery Conservation Zone was created in the United States.

River herring landings declined abruptly in the beginning of the 1970's. Recent total landings for the entire east coast are the lowest in history. Subsequent portions of this section of the report will follow the format of the American shad segment.

B. RECENT TRENDS IN LANDINGS ON A REGIONAL BASIS

Relevance of Landings Data to Stock Assessment

Factors influencing the relationship of American shad commercial landings to stock size were discussed in section II of this report. Many of those same factors, as well as several others, influence that relationship in the case of river herrings.

- Abundance of the stock
- Amount of fishing effort (e.g., number of nets fished, number of days fished)
- Influence of market factors on the fishing effort (e.g., price per pound at any given time)
- Influence of environmental conditions on effectiveness of effort (e.g., weather conditions, river flow, bottom topography through their effect on the catchability of fish by particular gears)
- Unreliability of catch reports, particularly where harvests per individual may be relatively small; in some states, substantial river herring harvests are made by individual unlicensed fishermen fishing with dip nets, who have no reporting requirement; in cases where fish are harvested for use as bait by the fishermen actually

Table IV-1. River herring catch (in thousands of pounds) per state and total Atlantic coast for years of available data. Data are from U.S. Dept. of Commerce Fishery Statistics of the United States (from PSEG, 1982b), and other sources as noted. Dashed lines denote no catch reported; blanks denote no data acquired.

Year	FL[2]	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	Total Atlantic Coast
1887	-	25	(1)	23,747	4,402	11,062	*	4,085[1]	*	18	1,430	4,130	100	2,526	
1888	-	24	(1)	20,451	6,453	11,512	*	3,881[1]	*	25	1,589	6,292	147	2,836	
1889	-	36	37	19,316	-	-	-	-	-	53	1,307	3.911	140	4,022	
1892	-	-	-	-	-	-	-	-	-	681	1,190	3,651	50	2,276	
1896	-	-	-	-	12,198	17,667	-	-	-	1,001	2,077	5,356	294	3,388	
1897	-	25	2	-	13,690	17,139	-	-	-	-	-	4,779	239	1,249	
1898	-	-	-	-	-	-	-	-	-	868	1,012	2,900	325	3,619	
1902	-	22	-	15,173	-	-	-	-	-	1,663	705	4,517	475	3,341	
1905	-	-	-	-	-	-	-	-	-	1,232	599	4,861	122	3,082	
1908	-	32	-	12,530	37,885	28,805	-	-	-	1,025	288	4,062	121	2,085	
1919	-	-	-	-	-	-	-	-	-	177	270	3,064	0	1,296	
1920	-	-	-	-	16,665	7,072	-	-	-	-	-	-	-	-	
1921	-	-	-	-	18,834	6,505	-	-	-	-	-	-	-	-	
1922	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
1923	-	-	0	8,989	-	-	-	-	-	-	-	-	-	-	
1924	-	-	-	-	-	-	-	-	-	116	391	2,593	0	1,583	
1925	-	-	-	-	17,910	7,701	-	-	-	-	-	-	-	-	
1926	-	-	-	-	-	-	*	2,490[1]	*	-	-	-	-	-	
1927	-	-	2	11,911	-	-	-	-	-	-	-	-	-	-	
1928	-	-	2	7,808	-	-	-	-	-	16	161	2,248	0	2,132	
1929	408	-	0	10,768	12,570	5,924	*	1,223[1]	*	9	119	1,386	58	2,821	
1930	366	-	2	9,839	15,387	5,741	*	3,856[1]	*	1	186	1,790	0	2,129	35,286
1931	321	-	0	7,994	17,239	7,827	*	3,615[1]	*	27	127	2,212	0	2,796	39,297
1932	80	-	0	6,584	13,852	7,553	*	2,191[1]	*	19	73	1,164	20	2,296	42,158
1933	148	-	-	-	19,177	6,550	*	1,381[1]	*	15	176	923	0	1,703	33,832
1934	315	-	0	14,897	5,846	5,234	*	-	-	-	-	-	-	-	40,410

Table IV-1. Continued

Year	FL$_2$	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	Total Atlantic Coast
1935	224	–	–	–	10,974	4,229	*	555[2]	*	18	55	959	0	3,374	31,652
1936	232	–	0	11,929	8,,689	3,369	–	–	–	–	–	–	–	–	
1937	400	–	0	5,818	15,064	3,819	*	3,819[2]	*	85	218	1,086	0	2,818	33,127
1938	392	–	0	11,219	17,691	5,397	*	5,397[2]	*	28	181	958	0	3,140	44,403
1939	320	–	0	7,714	14,831	4,398	147	35	60	14	23	946	0	2,954	31,442
1940	408	–	0	8,708	11,433	4,679	124	35	62	34	20	879	0	2,260	28,642
1941	412	–	0	–	11,951	5,061	–	–	–	–	–	–	–	–	
1942	416	–	–	–	9,258	3,422	11	58	399	6	200	984	207	2,368	
1943	420	–	–	–	–	–	–	–	–	–	–	–	–	–	
1944	424	–	–	–	17,841	3,504	33	40	10	12	175	2,266	218	2,526	
1945	428	0	0	8,022	14,619	2,584	90	14	261	20	0	988	163	1,358	28,533
1946	419	0	–	–	12,029	3,497	–	–	123	3	217	1,249	–	1,225	
1947	400	0	–	–	22,173	2,746	12	324	89	4	751	633	74	1,499	37,567
1948	386	0	–	–	19,365	3,720	6	171	132	675	317	468	80	1,868	36,474
1949	372	0	–	–	22,003	4,965	26	20	99	1,146	134	502	4	3,281	41,582
1950	358	0	0	6,422	28,702	5,926	47	29	104	1,948	312	270	0	3,166	17,284
1951	514	0	0	12,534	32,604	6,752	37	7	75	490	905	276	0	3,479	57,673
1952	278	0	0	6,511	28,841	4,494	122	1	90	1,061	181	1,905	0	2,783	46,267
1953	0	0	0	13,842	23,976	4,653	104	9	57	340	216	5,535	0	2,443	51,175
1954	51	0	0	12,758	27,930	3,981	76	0	84	973	17	3,020	0	3,296	52,186
1955	57	0	0	12,648	21,843	5,145	1	23	102	890	46	2,621	0	3,779	47,155
1956	77	0	0	12,554	22,107	5,026	1	22	68	79	55	8,922	0	4,588	53,499
1957	30	0	0	11,773	18,758	3,410	8	8	56	63	29	19,027	75	3,969	57,206
1958	127	0	0	14,914	18,361	4,391	0	1	66	10	12	33,815	60	3,095	74,852
1959	16	0	0	14,154	17,447	4,484	0	2	46	8	341	11,618	80	1,631	49,827
1960	26	0	0	12,815	15,464	3,525	3	3	38	20	0	17,651	95	1,412	51,052
1961	2	0	0	11,951	15,526	2,444	(1)	17	34	6	0	20,838	100	1,667	52,585

Table IV-1. Continued

Year	FL[2]	GA	SC	NC	VA	MD	DE	NJ	NY	CT	RI	MA	NH	ME	Total Atlantic Coast
1962	0	0	0	14,302	25,300	2,378	0	20	38	19	0	8,276	125	1,682	52,140
1963	23	0	0	15,100	26,085	1,466	0	3	32	3	129	11,735	150	1,480	56,206
1964	2	0	0	7,561	26,640	1,314	0	14	37	15	140	5,529	75	1,480	42,807
1965	21	0	2,760	12,826	36,200	2,092	0	22	24	24	210	6,935	125	3,106	64,345
1966	0	0	2,817	12,519	28,535	1,433	0	12	4,188	7	192	6,633	75	1,786	58,197
1967	0	0	2,802	18,486	28,107	2,337	0	9	4	23	186	5,432	65	1,617	59,068
1968	0	0	2,820	15,525	32,319	3,963	0	8	7	33	203	117	41	2,249	57,285
1969	0	0	1,975	19,762	30,446	3,458	0	5	9	11	215	100	38	1,768	57,787
1970	0	0	100	11,521	19,046	2,065	0	8	11	122	144	1,156	31	1,623	35,827
1971	0	0	718	12,722	10,285	2,811	0	10	0	25	53	222	25	1,954	28,825
1972	0	0	297	11,237	10,451	1,690	0	15	(1)	23	34	1,907	24	2,216	27,894
1973	0	0	433	7,926	9,269	2,031	(1)	7	22	14	15	695	22	2,691	23,126
1974	0	0	87	6,210	13,342	1,388	(1)	11	15	17	36	229	0	3,310	24,645
1975	2	0	18	5,952	11,360	718	(1)	9	15	36	41	1,717	0	3,768	23,637
1976	1	0	67	6,402	4,238	126	(1)	11	1	67	34	45	0	3,395	14,387
1977	1	-	282	8,523	1,390	102	(1)	11	0	64	3	30	12	3,374	13,756
1978	-	-	196	6,608	2,127	201	(1)	2	0	61	2	40	11	2,781	12,076
1979	-	-	334	5,119	1,688	1,150	6	7	0	42	6	38	10	2,305	9,690
1980	-	-	661	6,219	1,184	738	(1)	19	1	63	2	5	0	2,645	10,978
1981	-	-	-	4,754	520	151	0	14	65	53	-	5	-	2,327	7,889
1982	-	-	>309	9,438	1,307	590	0	14	229	42	5	25	114	1,390	13,463
1983	-	-	636	5,864	1,838	119	1	2	124	37	6	50	107	1,187	9,871
1984	-	-	625	11,700	972[3]	113		3	4	32	1	90	43	817	
1985	-	-												900	

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(1) Denotes less than 500 lbs

[1] Regional total from Joseph and Davis, 1965

[2] From Moreman, 1982

* Landings aggregated under New Jersey

[3] Preliminary

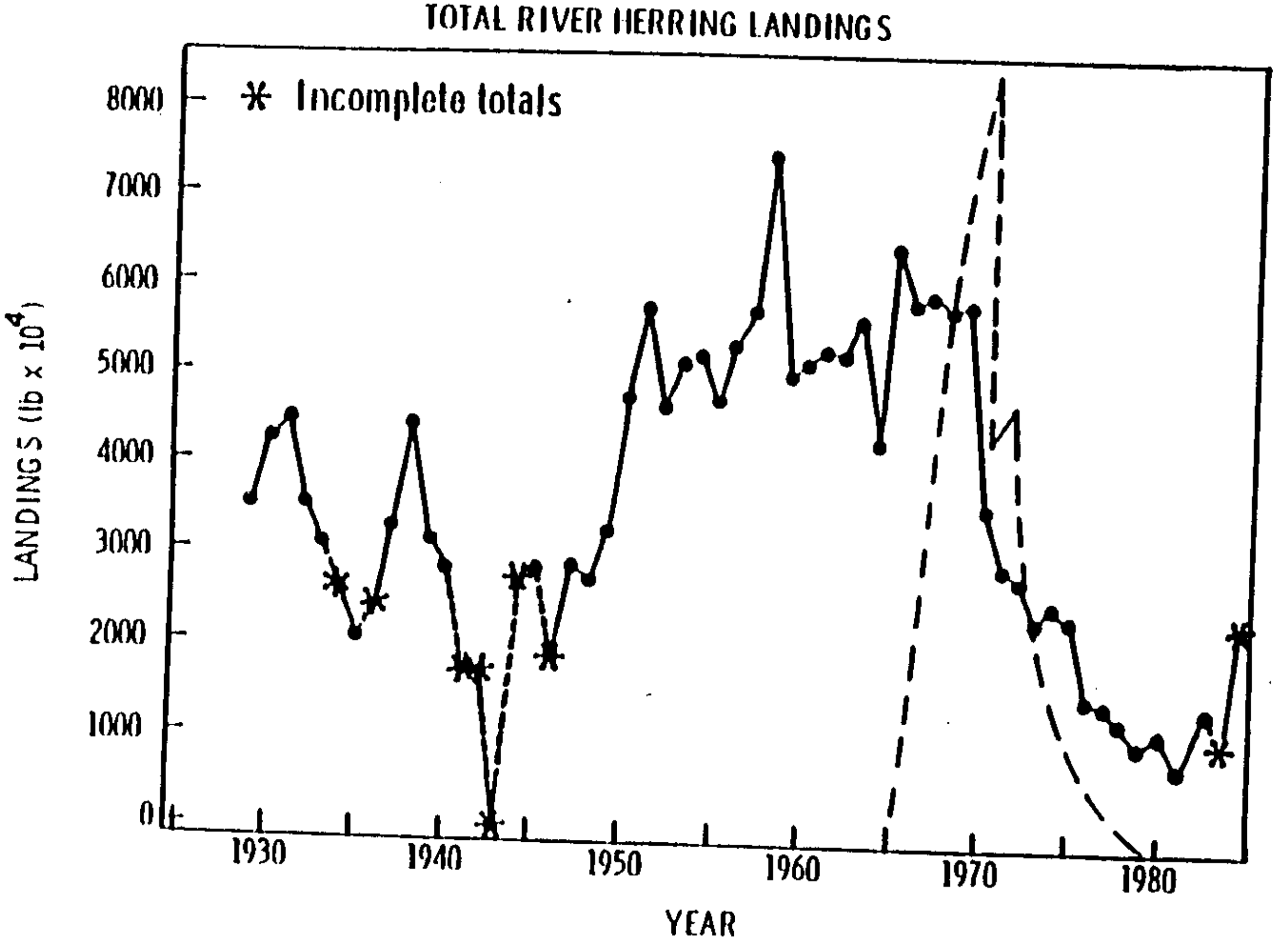

Figure IV-1. Reported commercial landings of river herring (sometimes recorded as "alewife" in landings records) along the east coast of the United States, 1929 to 1984; data are from NOAA Fishery Satistics of the United States and ICNAF. Dashed line represents offshore harvest by foreign fishing vessels.

using the bait (i.e., not involving established dealers or middlemen), harvest reporting may be poor; in Virginia, logbook records recorded for personnel at the Virginia Institute of Marine Science frequently exceeded the totals that eventually were recorded as harvest by the Virginia Marine Resources Commission (J. Loesch, personal communication).

- Unexplained reporting inconsistency up to 1950's; many states having active river herring fisheries reported no harvest during that period of time; thus for many years in the long-term record, total east coast harvest of river herring is not known.

River herring fisheries employ a wide variety of gear types. Quantification of effort for many of these gear types is extremely difficult (e.g., dip net, nondirected gill net). Furthermore, the normalization of the effort of units across all gears is essentially impossible. For these reasons, the use of catch-per-unit-effort (CPUE) as an index for stock abundance along the entire east coast is not possible. Even within individual regions or states, the same factors may make use of CPUE of questionable value.

The nature of the river herring fisheries has changed dramatically over the last 50 years. Whereas in the early 1900's most river herrings were landed for human consumption, only a very small proportion of current landings is used for that purpose. Currently, the amount of fishing effort exerted in river herring fisheries may be strongly influenced by logistics and other factors independent of stock abundance. For example, in fisheries where harvest is sold to dealers for reduction to fish meal, the existence of a single major dealer may determine the existence of the fishery.

There are extensive recreational fisheries for river herring in many areas along the east coast. While some are of the hook and line type (i.e., in the Delaware River), many permit various types of dip nets and seines. The total quantities of fish landed by these recreational netters for personal use may be quite large. All of these landings are unreported, and thus represent a large potential error in recorded river herring harvests.

In Florida, official NOAA landings records record "alewives" as being taken along the west (Gulf) coast in recent years (i.e., since 1972). No river herring runs exist on the west coast of Florida, and the landings recorded as alewives are undoubtedly misidentified.

Overall, river herring landings data may not represent stock abundance very accurately. The data probably are less reliable than American shad data but more reliable than hickory shad data. The many factors influencing river herring reported commercial landings may explain the large degree of variability observed in data on a state-by-state basis (Table IV-1).

Regional Characterization of Fisheries Based on Landings Data

River herring landings in New England are illustrated in Fig. IV-2. The most distinctive characteristic of landings in this region is the series of large landings occurring from the mid-50s to the mid-60's, which can mostly be accounted for by large reported landings in the state of Massachusetts. These may be explained as being a response of menhaden purse seiners switching to river herring as an alternative species when menhaden stocks declined. Purse seine harvests in Massachusetts are discussed later in the report. Landings in the state of Maine, which are the major component of New England landings at other times, have remained relatively stable at a high level for the last two decades. Landings in the remaining states have either declined dramatically (i.e., Rhode Island, New Hampshire) or have remained stable at low levels (Connecticut).

In the middle Atlantic region, landings have been consistently low over the last 40 years (Fig. IV-3). A single anomalous harvest of over 4 million pounds was reported by the State of New York in 1966. This particular record appears to be another case of menhaden fisheries exploiting river herring as an alternative source, based on NOAA records of harvest by gear. Although river herring appear to be abundant in the middle Atlantic region, as will be discussed under individual state discussions below, only limited fisheries exist for them.

River herring landings in the Chesapeake region (Fig. IV-4) have fluctuated as much as 100% over the last 40 to 50 years. However, in the 1970s, they declined to historically low levels and never rebounded. The decline was somewhat more marked in Maryland than in Virginia, with respect to current magnitudes of harvest. However, when viewed from the perspective of the percentage decline from historical levels, Virginia stocks have declined more. Recent harvests are the lowest ever reported for either state, and are the primary reason that total current, east coast landings are extremely low.

Landings in the south Atlantic region have fluctuated widely in the past, and are strongly influenced by changes in effort in different years. Although recent landings are the lowest ever reported, past landings also have been quite low (Figure IV-5).

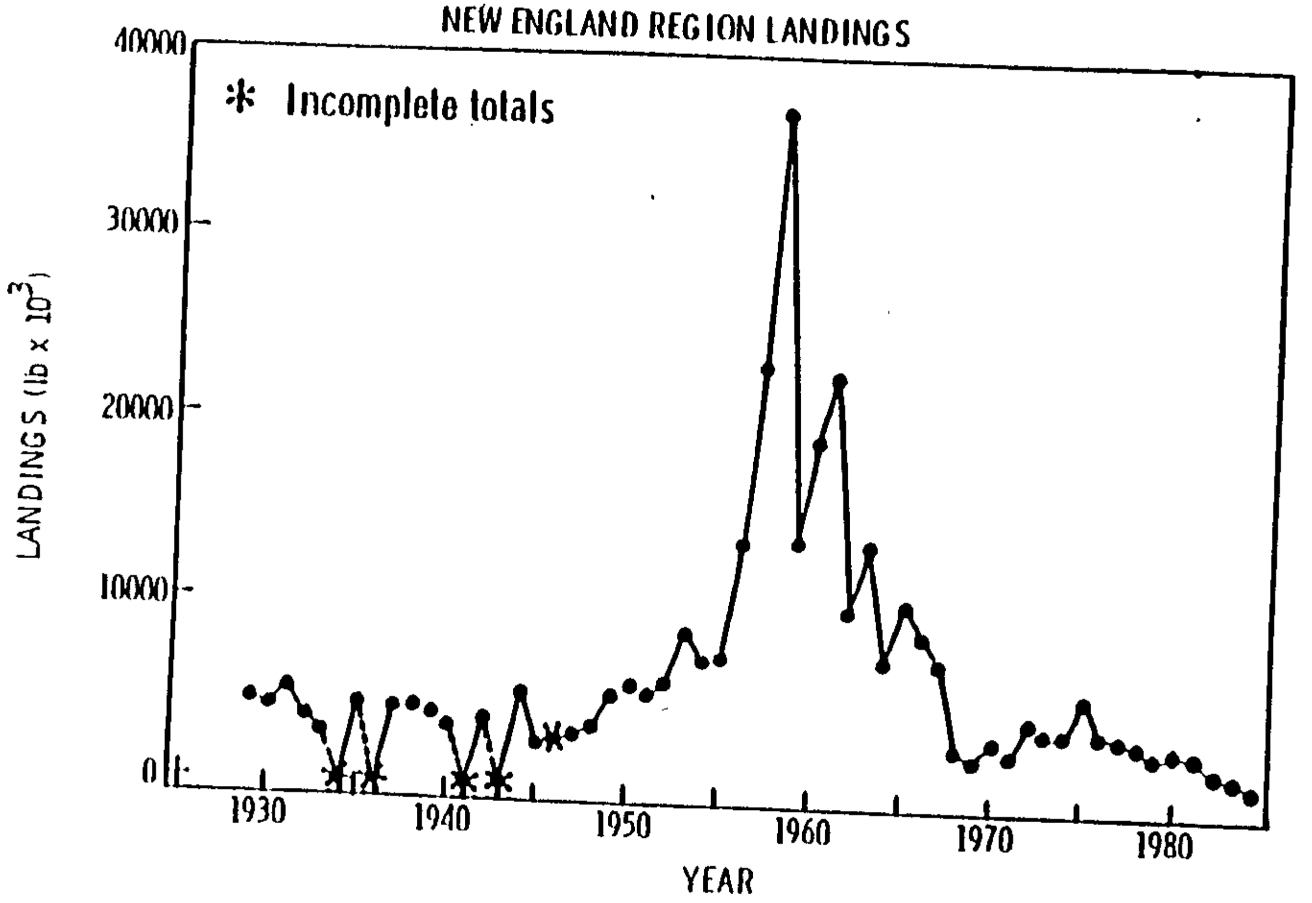

Figure IV-2. Reported commercial harvest of river herring ("alewife") in the New England region, 1929 to 1984; sources of data are noted on Table II-1

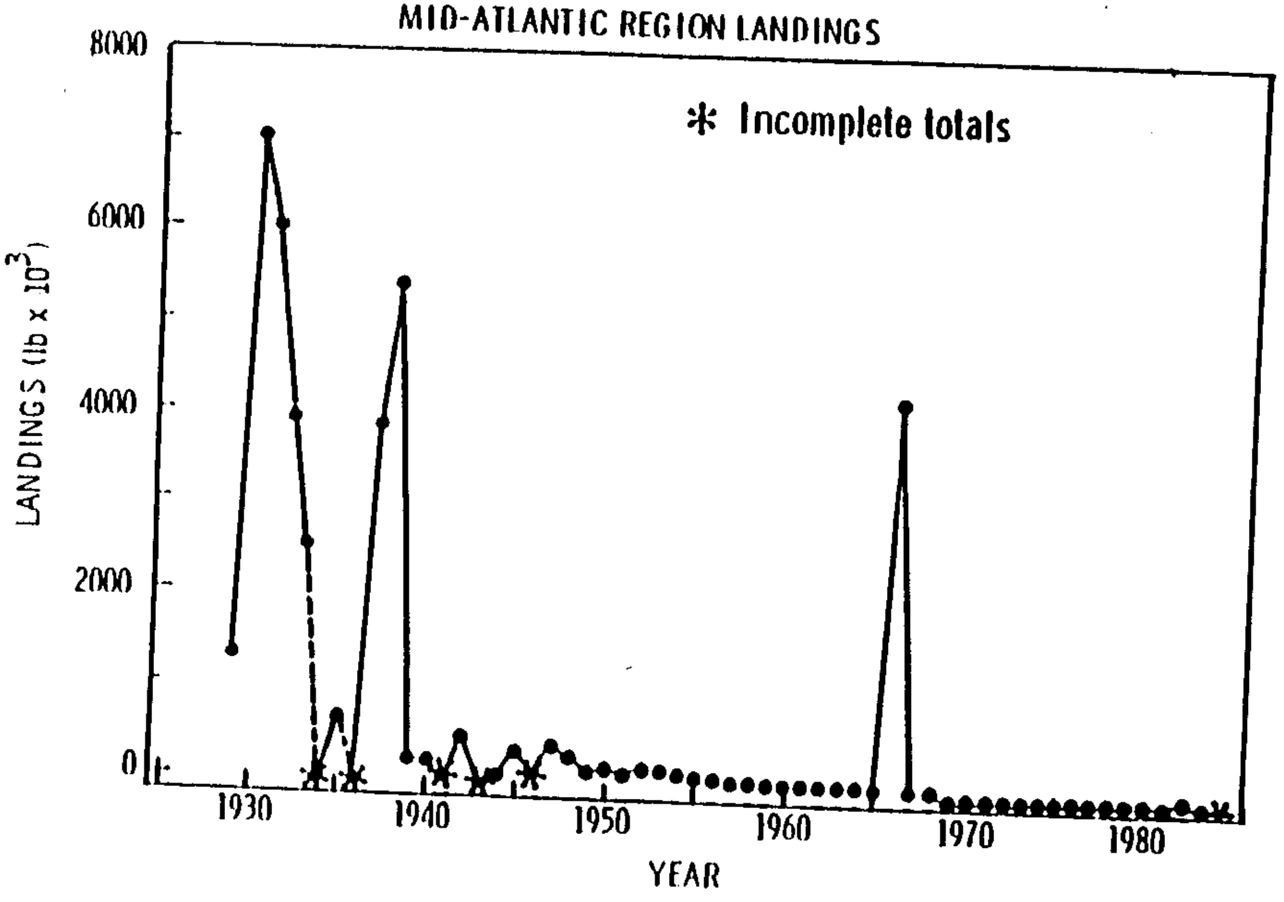

Figure IV-3. Reported commercial harvest of river herring ("alewife") in the Mid-Atlantic Region, 1929 to 1984 (data sources are noted on Table IV-1)

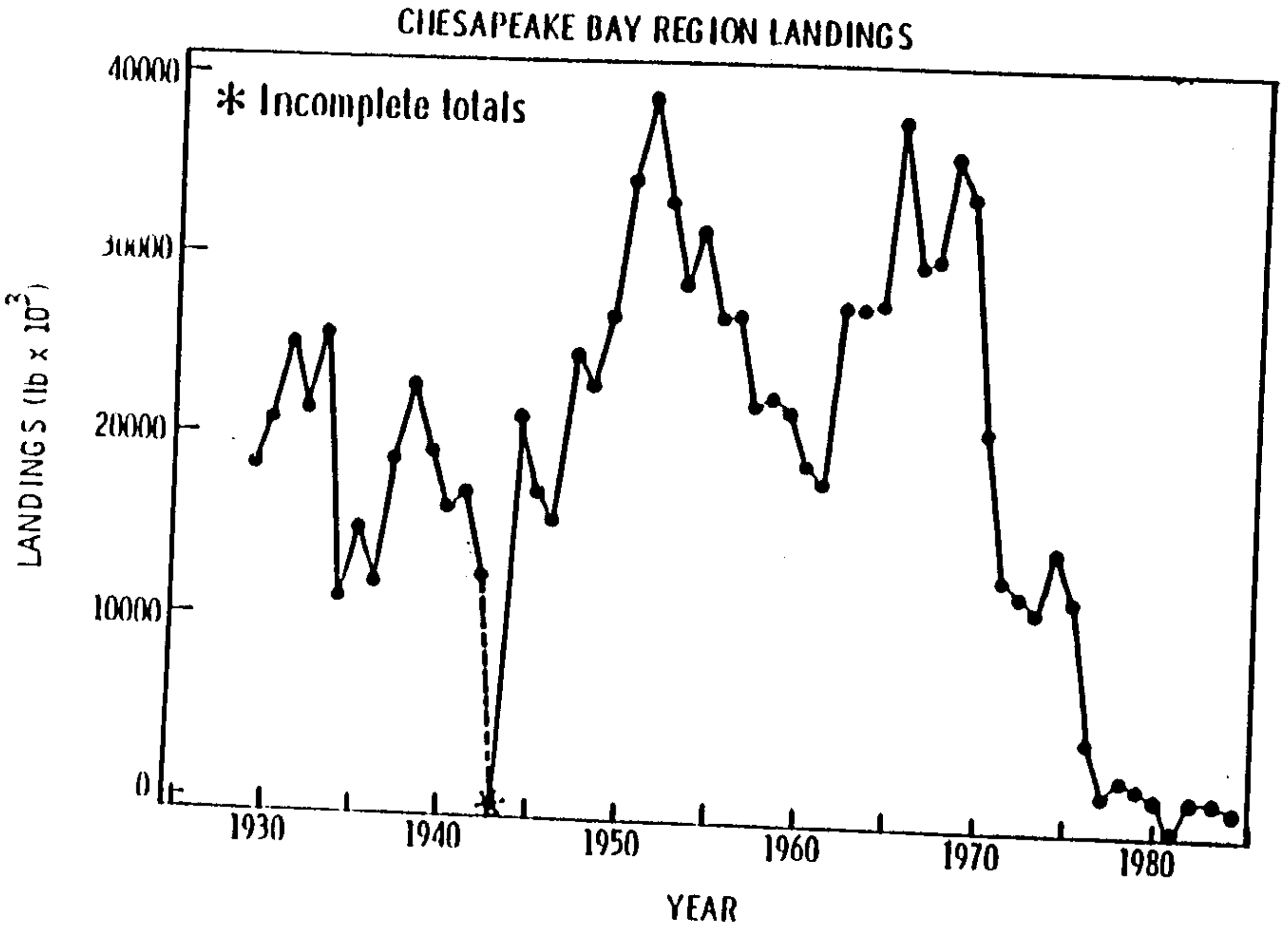

Figure IV-4. Reported commercial harvest of river herring ("alewife") in the Chesapeake Region, 1929 to 1984 (data sources are noted on Table IV-1)

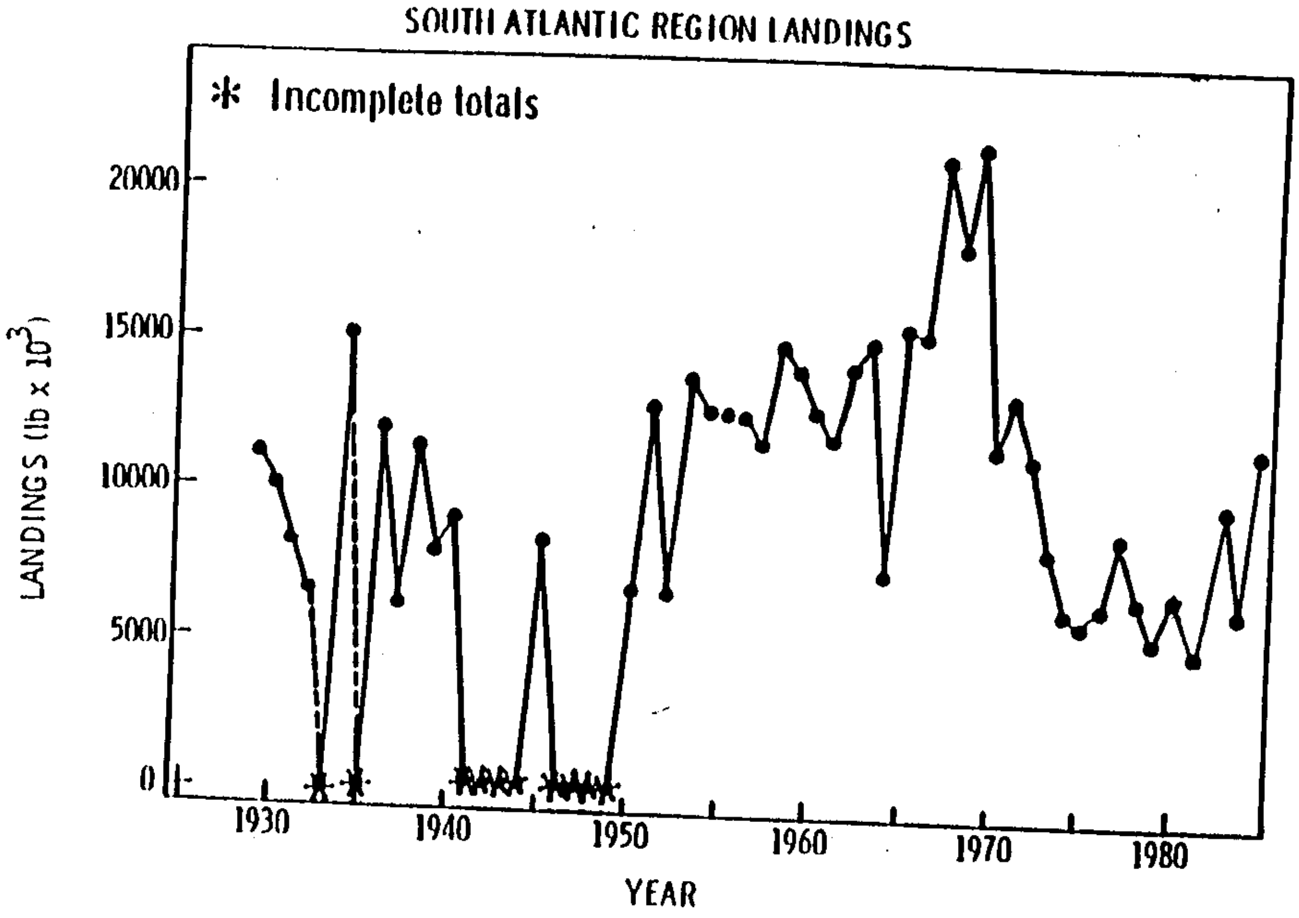

Figure IV-5. Reported commercial harvest of river herring ("alewife") in the South Atlantic region, 1929 to 1984; sources of data are noted on Table IV-1

C. CHARACTERIZATION OF FISHERIES ON A STATE-BY-STATE BASIS

Trend and Gear Usage and Fisheries Characteristics

In order to assess trends in the nature of river herring fisheries on a state-by-state basis, NOAA data were compiled for 1965, 1970, and 1976. The percentage of harvest by various gear types by state over time are illustrated in Tables IV-2, 3, and 4. The types of gear used in river herring fisheries differ substantially by region. Haul seines, dip nets, and weirs predominate in New England, while gill nets, pound nets, haul seines, and fyke nets predominate in the south.

Pound nets have been responsible for the majority of river herring landings in all years, accounting for as high as 86% of east coast landings in 1970. Weirs, used especially in Maine, took a large percentage (24%) of the total catch in 1976. The contribution of gear types other than pound nets and weirs to overall landings has declined substantially over the last decade. In effect, the nature of the fishery has become much less diverse. Note the decreasing contribution of purse seine fisheries in Massachusetts in 1965 and 1970 and their absence in 1976.

Current river herring fisheries on a state-by-state basis are characterized in Table IV-5. As with the species already discussed, these characterizations are meant only as generalized descriptions and were developed from state overview documents.

Characterizations of Fisheries Trends by State

River herring fisheries in Florida are located only on the St. Johns River. In the 1960's, blueback herring were harvested by numerous haul seiners; at present, none are active (R. Williams, pers. comm.). NOAA records indicate that most of the recent harvest has been taken by gill net, but whether the fish are taken as by-catch or in a directed fishery for river herring is not clear. Because of the strong effect of market factors on river herring fisheries, the data do not reveal whether the decline in Florida landings is representative only of stock declines or is affected to a major extent by market factors. No additional data are available to provide further insight to this question. River herring landed in Florida in recent decades have been used primarily as crab and catfish bait.

Georgia has never had a fishery for blueback herring because the types of gears normally used for this species (e.g., pound nets, small mesh gill nets) are not legal in the drainage systems

Table IV-2. Domestic river herring landings (lb x 10^3) by gear type by state, 1965, as reported in NOAA Fishery Statistics of the United States; dashed lines denote no catch reported. *Maine landings, although listed as taken by dip net in NOAA records, are almost entirely taken in river weirs. **Massachusetts landings by purse seine reported in NOAA records cannot be corroborated as being river herring.

Gear State	Otter Trawl	Floating Traps	Haul Seine	Gill Net	Pound Net	Fyke and Hoop Net	Weirs or Stop Net	Dip Net	Purse Seine	Other
Maine	---	---	---	---	---	---	881.	2226*	---	---
New Hampshire	---	---	---	---	---	---	125	---	---	---
Massachusetts	---	---	533	---	4	---	---	66	** 6332	---
Rhode Island	---	---	210	---	---	---	---	---	---	---
Connecticut	---	---	17	---	---	---	---	2	---	---
New York	---	---	2	---	---	21	---	---	---	---
New Jersey	---	---	9	---	---	12	---	---	---	---
Delaware	---	---	---	---	---	---	---	---	---	---
Maryland	---	---	6	163	1919	3	---	---	---	---
Virginia	---	---	2660	104	28089	5268	---	---	---	---
North Carolina	---	---	514	3235	---	---	---	---	---	---
South Carolina	---	---	---	---	---	---	---	2760	---	---
Georgia	---	---	---	---	---	---	---	---	---	---
Florida	---	---	3	19	---	---	---	---	---	---
Total	---	---	3953	7025	39090	5304	1006	5054	6332	---
% of Total	---	---	5.8%	10.5%	57.7%	7.5%	1.5%	7.5%	9.3%	---

Table IV-3. Domestic river herring landings (lb x 10^3) by gear type by state, 1970, as reported in NOAA Fishery Statistics of the United States; dashed lines denote no catch reported. *Maine landings, although listed as taken by dip net in NOAA records, are almost entirely taken in river weirs. **Massachusetts landings by purse seine reported in NOAA records cannot be corroborated as being river herring.

State / Gear	Otter Trawl	Floating Traps	Haul Seine	Gill Net	Pound Net	Fyke and Hoop Net	Weirs or Stop Net	Dip Net	Purse Seine	Other
Maine	---	---	---	---	---	---	---	*1623	---	---
New Hampshire	---	---	---	---	---	---	25	6	---	---
Massachusetts	243	---	100	---	---	---	---	---	**814	---
Rhode Island	18	24	102	---	---	---	---	---	---	---
Connecticut	93	---	14	(1)	---	---	---	15	---	---
New York	2	---	2	5	---	3	---	---	---	---
New Jersey	---	---	4	2	---	(1)	1	---	---	---
Delaware	---	---	---	---	---	---	---	---	---	---
Maryland	---	---	3	213	1046	(1)	---	---	---	2
Virginia	(1)	---	349	29	10069	598	---	---	---	---
North Carolina	---	---	552	32	10073	(1)	---	34	---	---
South Carolina	---	---	---	---	---	---	---	---	---	---
Georgia	---	---	---	---	---	---	---	---	---	---
Florida	---	---	---	---	---	---	---	---	---	---
Total	355	24	1126	280	30788	603	26	1678	814	2
% of Total	1.0%	< 1.0%	3.2%	1.0%	86.3%	1.7%	< 1.0%	4.7%	2.3%	< 1.0%

(1) = less than 1000 lbs

Table IV-4. Domestic river herring landing (lb x 10^3) by gear type by state, 1976 as reported in NOAA Fishery Statistics of the United States; dashed lines denote no catch reported. *Maine landings, although listed as being taken by dip net in NOAA records, are almost entirely taken in river weirs.

State \ Gear	Otter Trawl	Floating Traps	Haul Seine	Gill Net	Pound Net	Fyke and Hoop Net	Weirs or Stop Net	Dip Net	Purse Seine	Other
Maine	---	---	---	---	---	---	---	3395*	---	---
New Hampshire	---	---	---	---	---	---	---	---	---	---
Massachusetts	---	---	38	---	---	---	---	6	---	---
Rhode Island	---	3	31	---	---	---	---	---	---	---
Connecticut	---	---	61	4	---	---	---	2	---	1
New York	---	---	---	---	---	---	---	2	---	---
New Jersey	---	---	10	---	---	2	---	---	---	---
Delaware	---	---	---	(1)	---	---	---	---	---	---
Maryland	---	---	3	18	104	(1)	---	---	---	---
Virginia	---	---	(1)	15	4222	---	---	---	---	---
North Carolina	---	---	61	235	6106	---	---	---	---	---
South Carolina	---	---	---	---	---	---	---	67	---	---
Georgia	---	---	---	---	---	---	---	---	---	---
Florida	---	---	(1)	---	---	---	---	---	---	---
Total	---	3	204	273	10433	2	---	3471	---	(1)
Percent of Total	---	< 1%	1.4%	2.0%	72.5%	< 1%	---	24%	---	< 1%

(1) = less than 1000 lbs

Table IV-5. Characterization of current (1980's) river herring fisheries, by state, based on information provided in state overview documents

State	Gear Type	Type of Water Fished	Percent of Harvest	Probable Species Composition	Use of Harvest	Source of Information
Florida	Haul seine Gill net	Inshore Riverine	12% (1976) 88% (1976)	Blueback 100%	Crab and catfish bait	Williams and Grey, 1975; Williams, pers. comm. FL Dept. Nat. Res.
Georgia	No fishery - appropriate gear illegal	——	——	Blueback 100%	——	Michaels, 1982 Georgia Dept. of Nat. Res.
South Carolina	Dip and hoop nets Haul seine Hook and line	Riverine (Cooper River) Riverine (Santee River) Riverine	65% 35% Not reported	Blueback ~ 100% Alewife - trace	Bait Bait Roe consumption	Ulrich, 1982 South Carolina Wildlife & Marine Res. Dept.
North Carolina	Pound nets Gill nets Dip net (recreational)	Estuarine Riverine Riverine	95% ~ 5% Unknown	Blueback 51-95% Alewife 5-49%	Crab bait Crab bait Consumption	Johnson, 1982 Johnson et al. 1980 NC Dept. Nat. Res.
Virginia	Pound nets Dip nets (recreational)	Estuarine Riverine	99% (1976) Unknown	Blueback < 27% Alewife < 30%	Pet food Bait (eel and crab)	Atran, Loesch and Kriete, 1982 Kriete, pers. comm. VIMS.
Maryland	Pound nets Gill nets	Estuarine Estuarine	< 90% < 10%	Blueback - dominant in Susquehanna Alewife - minor	Crab bait - Pet food, roe for human consumption minor	Carter et al., 1982 MD Tidewater Administration
Delaware	Gill nets Hook and line (recreational)	Estuarine Riverine	100% Unknown	Unknown	Crab bait - (80-90%) Human consumption (10-20%)	Miller, 1982 DE Div. of Fish & Wildlife
Pennsylvania	Hook and line	Riverine	Unknown	Unknown	Unknown	R. Hesser, pers. comm.

Table IV-5. Continued

State	Gear Type	Type of Water Fished	Percent of Harvest	Probable Species Composition	Use of Harvest	Source of Information
New Jersey	Haul seine Dip net Hook and line (recreational)	Unknown Riverine (Delaware River)	Unknown (84,000 fish)	Alewife (majority) Blueback (minority)	Unknown Consumption	Lupine, 1982 Zich, 1978 NJ Div. Fish, Game, & Wildlife
New York	Gill nets Haul seines Dip and scap nets (recreational)	Estuarine Estuarine Riverine	Minor Minor Major	Blueback (minority) Alewife (majority)	Consumption	Brandt, 1983 NY Dept. Envir. Con.
Connecticut	Gill nets Dip nets Haul seine	Estuarine Riverine Riverine	Unknown	Blueback (majority) Alewife (minority)	Lobster bait; consumption	Crecco, 1982 CT Dept. Environ. Protection. Marine Fisheries Off.
Rhode Island	Haul seine Bow nets	Estuarine Riverine	Minor Major	Alewife > 90% Blueback < 10%	Lobster bait	Gibson, 1982 RI Fish & Wildlife
Massachusetts	Dip net Haul seine	Riverine	Unknown	Alewife (majority) Blueback (minority)	Lobster bait, human consumption (minor)	DiCarlo, 1982 MA Div. Mar. Fish.
New Hampshire	Weirs Dip net Gill net	Riverine Riverine Riverine	10% 65% 25%	Alewife (majority)	Lobster bait	Greenwood, 1982 NH Fish & Game Dept.
Maine	River weirs	Riverine	100%	Alewife – 100%	Lobster bait >90% Processing consumption <10%	Flagg and Squiers, 1982 ME Dept. Mar. Res.

inhabited by river herring (Ulrich et al., 1982). Although a number of studies of population biology of river herring in Georgia have been done (e.g., Street, 1969; Godwin and Adams, 1969), the data are insufficient for assessing stock abundance or trends in stock abundance. The current status or recent trends in abundance of Georgia's river herring stocks also cannot be assessed.

South Carolina had no modern fishery for river herring until 1965, when a haul seine fishery was established in the Santee River. Its appearance resulted in a large increase in reported river herring landings in the late 1960's (Table IV-1). However, the magnitude of the landings declined rather rapidly in the 5 to 10 years thereafter. Whether this decline reflected a stock decline or a market effect is not established. A sequence of poor year-classes may have contributed to the decline. Recent landings (late 1970's) appear on the rise. However, substantial data are not available to establish the current status of stocks in most drainage systems.

North Carolina river herring landings declined substantially (approximately 50%) in the early 1970's, then remained stable until an upswing in 1982 (Johnson, 1982). While effort decreased in 1978 and 1979 due to ice removing some pound nets (Johnson et al., 1980), effort between 1972 and 1978 appears to have remained relatively constant. For this reason, the decline in North Carolina landings probably reflects a considerable decline in stocks in the early 70's. This premise is also supported by CPUE data (Table IV-6). The current fishery is dominated by pound nets, and most landings are used as bait.

Although Virginia has consistently had the highest annual landings of river herring of states along the east coast, they began to decline dramatically in the late 1960's, reached a temporary plateau in the early 1970's, and then crashed to very low levels in the late 1970's. Loesch et al., (1979) showed that during this decline, the proportion of blueback herring to alewife increased. These data suggest that the rate of decline in alewife stocks exceeded the rate of decline in blueback herring. The decline in total harvests in the late 1960's has been attributed to offshore overexploitation of river herring stocks by foreign fishing fleets (see Fig. IV-1). Hurricane Agnes, which passed through the region in 1972, is also believed to have affected spawning success in that year as a result of high flows preventing spawning in normal locations and causing displacement of larvae and juveniles from optimal nursey areas. The apparent stock declines suggested by landings data are also reflected in declines in CPUE (Table IV-7). Virginia stocks have not rebounded from these major impacts to date. Current landings in Virginia may also be influenced by market changes. The last fish processing plant which handled river herring in Virginia closed in 1981 (Kriete, pers. comm.), which may have

Table IV-6. River herring catch-and-effort, Albemarle Sound, North Carolina 1971-75. Data are in pounds (lb) and metric tons (mt)(from Street and Davis, 1976).

Season	Total catch (lb)	Total catch (mt)	Pound net catch (lb)	Pound net catch (mt)	Percent of total	Pound net effort	Catch/effort (lb)	Catch/effort (mt)	Other gear (lb)	Other gear (mt)
1971	12,711,200	5,766	12,005,975	5,446	95	645	18,614	8.44	705,225	320
1972	11,237,033	5,097	11,020,023	4,999	98	727	15,158	6.88	217,010	98
1973	7,931,600	3,598	7,613,900	3,454	96	625	12,182	5.53	317,700	144
1974	6,277,671	2,848	5,876,357	2,665	95	653	8,985	4.08	401,314	182
1975	5,903,957	2,678	5,427,072	2,462	92	675	8,040	3.65	476,885	216

Table IV-7. Estimates of the landings of river herring in the Potomac and Rappahannock rivers combined, by spawning check history. Units are thousands of fish and c/f is catch/net/season, by spawning class (from Street and Davis, 1976).

Year, total number, c/f	0	1	2	3	4	5	6	Total & yearly c/f[1]	No. of Pound Nets[2]
1965	17,890	5,573	2,018	973	333	0	0	25,472	146
CPE	122.5	20.6	13.8	6.6	2.3	0	0	174.5	
1966	11,826	7,915	4,258	1,277	495	0	0	27,086	139
CPE	85.1	56.9	29.2	9.2	3.6	0	0	194.9	
1967	15,603	3,964	2,574	594	321	34	23	23,113	127
CPE	122.9	31.2	20.3	4.7	2.5		0.2	182.0	
1968	12,238	3,927	2,759	951	204	65	3	20,147	133
CPE	92.0	29.5	20.7	7.2	1.5	0.5		151.5	
1969	7,336	2,243	886	455	38	4	0	10,962	119
CPE	61.6	18.9	7.5	3.8	0.4		0	92.1	
1970	10,655	2,754	1,593	613	362	14	0	15,991	97
CPE	109.8	28.4	16.4	6.3	3.7	0.2	0	164.9	
1971	2,998	1,470	506	72	22	0	0	5,068	99
	30.3	14.8	5.1	0.7	0.2	0	0	51.2	
1972	3,885	472	502	131	50	5		5,045	105
CPE	36.6	4.5	4.7	1.2	0.5	0.1		47.6	
1973	2,681	817	444	140	33	0	0	4,115	
CPE	27.6	8.4	4.6	1.4	0.4	0	0	42.4	97

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[1] Catch per net per season, all ages combined.
[2] In the last half of April, only nets above river mile 10 used.

an impact on harvests in the future. The data in Tables IV-8 to IV-11 indicate contributions of individual alewife and blueback year-classes to total river herring harvests for the period 1968 to 1980 in the Rappahannock and Potomac Rivers. These data illustrate the dominance of a single year-class (1966) of blueback in the Potomac River in contributing to the fishery, and show that year-class success may be extremely variable from year-to-year, independent of the decline over this period of time.

The decline in Maryland river herring landings is of a similar magnitude to that observed in Virginia throughout the 1970's; i.e., essentially one order of magnitude. The decline in Maryland landings is evident in all statistical reporting areas (i.e., drainage systems) in the state (Carter et al., 1982), suggesting that the factors causing the decline are not specific to a particular river system. Although landings in some years may have been influenced by declines in the number of pound nets being fished, the change in effort is not sufficient to explain the declines. As in Virginia, alewife may have declined to a greater extent than blueback herring (Environmental Resources Management, 1980). Maryland stocks may have been affected substantially by both Hurricane Agnes (in 1972) and offshore harvests in the late 1960's and early 1970's.

In Delaware, river herring are taken as by-catch in fisheries directed at other species (e.g., white perch)(Miller, 1982). Landings have been low and variable for a number of years, and probably are not indicative of stock abundance. Both blueback herring and alewife may occur in nearly all accessible freshwater streams in the state. However, no data are available to assess their status or recent trends in stock size.

A similar situation exists in New Jersey, where no directed fisheries occur. All New Jersey landings are by-catch and do not reflect actual abundance of stocks. There is a substantial recreational hook and line fishery for river herring on the Delaware River near Trenton, New Jersey. River herring appear to be very abundant in the Delaware River, and 133 river herring runs in 63 different drainage systems of the state have been documented (Zich, 1978). However, no specific quantitative data are available to address current stock abundance or to define recent trends in abundance.

Historically, river herring have supported a minor commercial fishery in the Hudson River in New York. Commercial sale of river herrings was prohibited from 1976 through 1981 due to PCB pollution, but was permitted again in 1982, thus impacting on the value of commercial landings as stock abundance index. Observations by NYDEC suggest that river herring have increased in abundance in the "Albany Pool" region of the Hudson River in recent years in response to significant improvements in water

Table IV-8. Annual and total year-class contributions (mt) to the Rappahannock River alewife fishery, 1968-1980 (from Atran et al., 1982).

	Year Class												
Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1968	49.79												
1969	44.49	13.21											
1970	47.31	73.36	7.75										
1971	30.62	94.20	57.73	4.48									
1972	18.04	51.10	60.52	54.51	8.82								
1973	1.96	8.00	18.87	39.84	81.20	0.90							
1974		5.40	1.08	18.78	55.90	134.04	0.65						
1975			0.07	0.43	1.16	9.68	59.66	1.23					
1976					0.13	1.71	14.43	25.39	2.15				
1977					0.34	0.17	4.32	41.24	36.16	2.46			
1978							1.83	11.38	54.67	57.03	5.89		
1979								0.28	2.41	14.84	19.89	18.60	
1980										2.49	7.03	12.87	0.88
Yearclass TOTAL	192.21	245.27	146.02	118.04	147.55	146.50	80.89	79.52	95.39	76.82	32.81	31.47	0.88

Table IV-9. Annual and total yearclass contributions (mt) to the Rappahannock River blueback fishery, 1968-1980 (from Atran et al., 1982).

	Year Class												
Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1968	10.68												
1969	90.10	11.39											
1970	14.76	25.48	0.97										
1971	18.19	107.12	72.15	1.01									
1972	8.56	33.17	52.83	37.58									
1973	1.69	8.94	37.34	74.14	118.34	0.97							
1974		1.56	6.00	20.48	46.19	55.97	0.26						
1975				0.52	3.44	19.94	146.82	1.03					
1976					0.07	2.44	26.88	36.05	2.38	0.07			
1977							8.58	107.09	88.06	5.23			
1978						0.38	1.91	78.25	211.10	84.74	4.96		
1979								7.62	42.36	127.51	229.18	16.94	
1980								1.17	6.25	20.32	140.46	26.57	0.59
Yearclass TOTAL	143.98	187.66	169.29	133.73	168.04	79.70	184.45	231.21	350.15	237.87	374.60	43.51	0.59

Table IV-10. Annual and total year-class contributions (mt) to the Potomac River alewife fishery, 1968-1980 (from Atran et al., 1982).

	Year Class												
Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1968	10.93												
1969	97.51	124.05											
1970	38.69	136.99	16.01										
1971	37.55	190.93	115.21										
1972	61.26	169.34	180.59	210.70									
1973	5.44	13.84	21.22	58.88	144.51	6.10							
1974			5.29	8.04	26.51	254.45							
1975				13.44	6.81	62.34	298.17	1.86					
1976					1.47	15.26	72.96	49.97	1.98				
1977						0.04	2.16	16.66	12.56	3.04			
1978								8.41	17.31	20.51	2.16		
1979									1.26	1.39	7.11	1.73	
1980										0.56	14.86	18.15	
TOTAL	251.38	635.15	338.32	291.06	179.30	338.19	373.29	76.90	33.11	25.50	24.13	19.88	

Table IV-11. Annual and total yearclass contributions (mt) to the Potomac River blueback fishery, 1968-1980 (from Atran et al., 1982).

	Year Class												
Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1968	20.03												
1969	646.78	99.65											
1970	492.09	1671.00	23.95										
1971	203.66	1053.98	1000.96	16.24									
1972	74.38	294.52	439.86	576.54	2.56								
1973	2.11	20.61	67.21	151.59	135.26	1.95							
1974		7.06	18.85	51.80	157.71	1068.90							
1975			0.81	37.13	116.23	335.23	1560.10	0.83					
1976				3.54	4.70	98.72	233.70	87.33	4.20				
1977						1.02	31.79	108.67	36.25	1.43			
1978							26.27	157.82	318.41	106.39	1.54		
1979									37.10	79.67	285.31	34.16	
1980									4.22	28.79	213.49	23.72	1.67
Yearclass TOTAL	1439.05	3146.82	1551.64	836.84	416.46	1505.82	1851.86	354.65	400.18	216.28	500.34	57.88	1.67

quality (Brandt, 1983). The observed increase in spawning range and abundance of river herrings suggest that New York stocks are increasing although hard supportive data are not available.

In Connecticut, river herring landings have remained relatively stable over the last 20 years. Distribution of catch among river systems is not known, but the major contributor to the blueback herring harvest probably is the Connecticut River. Alewife runs occur in the majority of the small streams along the coast, but no data are available to assess current status or recent trends in abundance. The view of the state fisheries agency is that stocks are relatively stable (Crecco, 1982).

A large decline in reported river herring harvests in Rhode Island in 1970 resulted from closing a major haul seine fishery at Gilbert Stuart Brook to accomodate the state's need for fish to transplant to other drainage systems for restoration purposes (Gibson, 1982). The substantial decline in harvest that appears in the records after 1976 may have resulted from a reduction in the state's transplanting program, together with a reduction in efforts to provide access to currently inaccessible habitats (Gibson, 1982). Many of the new runs established in the early 1970's declined as a result of these reduced efforts. Current data suggest that stocks in Rhode Island are at very low levels but remain fairly stable. The run at Gilbert Stuart Brook, which has been monitored for the last four years, nearly doubled between 1980 and 1982 to over 80,000 fish, but then declined to 68,000 in 1983.

River herring fisheries in Massachusetts are distinct from fisheries in all the more southern states in that local towns control the fisheries on most of the major drainage systems. Landings in the past 20 years have fluctuated widely from year-to-year (Table IV-1), with 1980 harvests being the lowest ever reported. Recordkeeping by the towns or their designated agents is very poor, and the meaning of the recorded landings data is questionable (DiCarlo, 1982). While the NOAA data suggest a substantial decline in the fishery in recent years, state biologists believe that the stocks have remained relatively stable based on field observations of runs. Recreational harvests by dip netters may be substantial and are also unreported.

New Hampshire implemented new landings records procedures in 1982. A 114,000-pound harvest was recorded for that year, which is dramatically higher than previous years. The very low NOAA values for the previous years probably are extreme underestimates and are not indicative of stock abundance. Recent restoration efforts have been very successful in New Hampshire, with creation of a run of over 50,000 river herring on the Lamprey River. Thus, although data are not available for rigorous documentation, New Hampshire stocks would appear to be increasing (Greenwood, 1982).

River herring landings in Maine have remained remarkably stable when contrasted to landings of other states. For the past 30 years, harvests have fluctuated year-to-year by at most a factor of 2. Although there was a great amount of fishway construction in the 1970's, the new runs were not believed to have substantially contributed to landings through 1976 (Walton, Smith and Sampson, 1976). These authors also noted that landings, in most cases, were a function of what the market will buy rather than the available supply. However, the harvests on the major runs supporting Maine's river herring fisheries have been extremely high (as will be discussed later in the report), and at least for the last 10 years, market factors have probably not had a major impact on reported landings. The absence of substantial declines in Maine river herring harvests in the 1960's, when offshore foreign harvests were greatest, suggests that Maine stocks were not being exploited in those fisheries.

Juvenile Indices as Indicators of Abundance Trends

Extensive scientific studies of river herring have been done in states where the species have supported important fisheries, i.e., North Carolina, Virginia, Maine, Rhode Island, and Maryland. In the remaining states, individual studies have been done, but they tend to be of limited duration or extent and thus of limited value for documenting status or trends in stock abundance.

Juvenile indices are available for several of the states. Maryland's juvenile index data extend back to 1962. These data, categorized by segment of the Chesapeake Bay, are presented in Table IV-12. The data were collected in a consistent manner at the same locations in the fall of each year. Since environmental conditions such as river discharge may vary year-to-year, resulting in shifts in the location of nursery areas and possibly in the time patterns of migration, the value of these juvenile indices as indicators of year-class abundance is probably questionable except in cases of extreme values. With these qualifications, the data can be used to examine some aspects of fluctuations in populations of river herring.

Table IV-13 presents the results of a correlation analysis of alewife and blueback herring juvenile index data within river system as well as between river systems. The data were also analyzed to determine if they supported the conclusion that there were declining trends in year-class abundance over the period of data collection. There was a positive correlation between alewife and blueback herring juvenile indices in the Nanticoke and the Potomac Rivers, but no correlation with data from the Choptank and the head of the Chesapeake Bay. These results are not definitive in establishing whether both

Table IV-12. Alewife and blueback herring juvenile index data for four segments of the Maryland Chesapeake Bay (adapted from Carter, 1982)

	Nanticoke River		Choptank River		Potomac River		Head of Bay	
Year	Alosa aestivalis	Alosa pseudoharengus	Alosa aestivalis	Alosa pseudoharengus	Alosa aestivalis	Alosa pseudeharengus	Alosa aestivalis	Alosa pseudoharengus
1962	6.6	0.5	5.3	2.67	76.8	1.0	56.2	20.4
1963	10.2	2.3	0.4	0.7	0.4	0.4	51.6	6.3
1964	10.2	5.3	0.6	0.3	18.5	19.6	27.2	0.6
1965	20.4	0.5	0.1	0.1	37.3	1.1	10.8	2.7
1966	39.5	0.5	0.8	4.3	23.0	19.6	27.5	15.7
1967	65.7	2.3	22.0	9.8	5.3	0.1	85.1	4.8
1968	19.2	4.5	1.8	4.8	4.5	0.1	79.1	0.3
1969	202.8	0.9	0.8	3.8	2.0	1.1	743.0	10.1
1970	1.8	1.9	15.0	1.4	25.2	5.6	27.3	100.9
1971	3.3	0.5	1.0	1.6	39.6	6.6	16.3	13.7
1972	5.0	3.9	1.5	0.1	13.9	3.6	5.5	1.7
1973	4.3	0.4	0.2	1.2	0.1	0.6	11.8	2.5
1974	8.0	3.4	0.2	0.3	0.1	0.3	0.0	1.1
1975	2.6	0.4	0.7	0.0	107.0	20.7	0.5	13.2
1976	0.2	0.1	0.0	0.5	1.6	0.2	0.4	2.3
1977	0.2	0.1	0.2	0.2	40.5	11.2	0.3	7.3
1978	8.1	0.2	5.0	0.7	100.9	10.0	36.7	3.7
1979	24.6	0.3	18.9	0.6	17.7	2.7	1.0	2.7
1980	3.2	1.0	0.0	0.1	92.2	7.6	0.1	3.2
1981	0.0	0.0	0.1	0.2	0.2	0.4	0.0	3.9
1982	3.0	0.2	0.7	0.4	19.5	1.1	0.1	0.3
20-yr mean	21.8	1.5	3.7	1.7	30.3	5.6	59.03	10.9

Table IV-13. Results of analyses of Maryland river herring juvenile index data; data are presented in Table IV-12.

A. Similarity in pattern of annual relative abundance of each species in the four river systems.

Blueback herring (Friedman's test) $p < 0.005$
(significant similarity among rivers)

Alewife (Friedman's test) $p < 0.25$
(no significant relationship)

B. Similarity in pattern of annual relative abundance of both species within each river system (Spearman Rank Correlation)

Nanticoke River $p < 0.05$
(significant correlation)

Choptank River $p > 0.05$
(no correlation)

Potomac River $p < 0.05$
(significant correlation)

Head of Bay $p > 0.05$
(no correlation)

C. Evidence of time trend in data

Nanticoke River
  Blueback herring $p < 0.01$
  Alewife $p < 0.01$

Choptank River
  Blueback herring $p > 0.25$
  Alewife $p < 0.05$

Potomac River
  Blueback herring $p > 0.50$
  Alewife $p > 0.50$

Head of Bay
  Blueback herring $p < 0.001$
  Alewife $p > 0.25$

species are responding in a similar manner to whatever factors may be determining year-class success. The second set of analyses addressed the question of whether the relative year-class success of each species was similar among four river systems. For the blueback herring, there was a consistent pattern of juvenile index abundance among the four river systems for the time period of data collection. A similar consistent pattern could not be statistically established with alewife. However, as shown in Table IV-12, alewife were much less abundant and the rather sparse data available may contribute to the absence of statistical significance. In the final analyses, the question of whether declining trends could be detected with the juvenile index was addressed. Declining trends in the index for blueback herring were found in the Nanticoke and the head of the bay, while declining trends for alewife were found in the Nanticoke and the Choptank. For the other species-river system combinations, no declining trend could be statistically determined.

The failure of the juvenile index to demonstrate stock declines in view of the dramatic decline in landings suggests inaccuracies in the data. However, the consistency in abundance patterns for blueback herring among the four river systems suggests that factors influencing yearclass success may be operating on broad regional areas as opposed to localized drainage systems.

Juvenile index data have been collected in Virginia for a number of years (Table IV-14). However, the procedures used in early surveys (1972-1977) may have yielded unrepresentative estimates of juvenile abundance based on more recent assessments of survey techniques (J. Loesch, pers. comm.). Sampling was done on a very limited number of dates and in only a few locations and may have yielded inaccurate data. In addition, all sampling was done during daytime, and day-night differences in catch efficiency have been found (Loesch et al, 1982). With these caveats, some assessment can be made of the utility of these data for examining fluctuations in stock abundance.

The data suggest a tendency for both species to respond in a similar manner in terms of annual abundance (e.g., 1973 and 1975 produced large indices in most cases). The relative magnitude of indices for the Potomac River match reasonably well with Maryland's data (Table IV-12). The large 1975 and 1977 year-classes appear in both state's data, as does the poor 1976 year-class. These similarities suggest that both sets may be representative of juvenile abundance. However, as with Maryland's data, no declining trends are evident and thus they do not correspond well to landings data.

Juvenile index data are also available for river herring in Albemarle Sound in North Carolina (Fig. IV-6). These data also do not demonstrate declines. However, since these year-

Table IV-14. Adjusted juvenile alosid catch-per-unit of effort (CPUE) for the indicated rivers, 1972-1978 (from Loesch et al., 1979); * = nighttime samples.

Species	Year	Potomac	Rappahannock	Mattaponi	Pamonkey	James
Alewife	1972	3.52	91.60	31.49	10.27	23.85
	1973	3.65	223.41	117.58	32.78	36.67
	1974	6.29	5.30	1.49	8.92	14.69
	1975	4.31	45.16	7.28	48.49	38.42
	1976	1.85	1.24	0	3.50	1.62
	1977	10.66	11.58	0.34	1.63	0.91
	1978*	7.42	14.49	10.03	3.02	3.42
Blueback	1972	193.16	1049.55	174.79	100.37	3936.98
	1973	22.91	3221.82	52.71	626.46	5663.88
	1974	19.46	414.65	60.97	49.75	566.05
	1975	1881.44	4252.23	211.88	1406.09	16238.98
	1976	5.07	140.10	23.80	2.00	79.33
	1977	529.15	894.72	39.10	167.75	241.98
	1978*	284.62	302.78	52.42	187.67	613.84

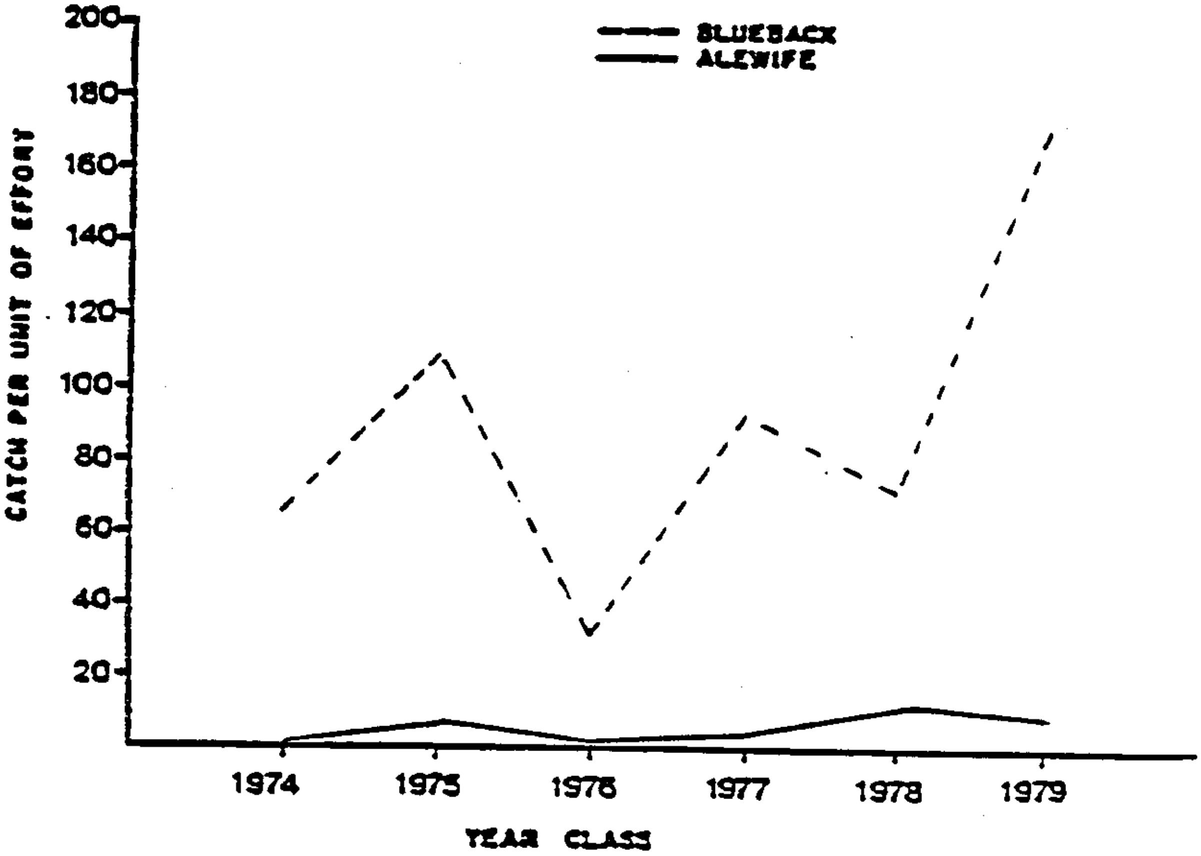

Figure IV-6. Catch-per-unit of effort for blueback herring and alewife year-classes 1974 through 1979 by seine in Albemarle Sound, North Carolina (11 monthly stations)(from Johnson et al., 1980) classes would have entered the fishery from 1978 through 1984, they may accurately predict the current low-level stability of stocks.

Juvenile river herring data were collected in the Hudson River between 1968 and 1982 (Texas Instruments, Inc., 1977-1980). However, integration of the data from different stations and dates to develop annual indices has not been done to date, and thus the data cannot currently be used to examine stock trends.

None of the juvenile index data sets described above have been rigorously verified through correlation with year-class contribution to fisheries in subsequent years. Havey (1973) did report a relationship between numbers of juveniles produced and run size 4 years later for a run in Maine, but this was based on a census of juveniles leaving a pond and not a statistical sampling of that population. Positive correlations between indices and landings four years later of blueback herring were reported for the Rappahannock and Potomac Rivers by Loesch et al. (1979), but there is some question of the validity of those data (Loesch, pers. comm.). The correlation results and descriptive contrasts presented here suggest that the indices may be of value for representing high and low year-class extremes, while having limited utility for representing more average year-classes.

D. COASTAL AND OFFSHORE HARVESTS

Foreign fishing fleets began to exploit offshore river herring stocks in the late 1960's. Peak catch was in 1969, at approximately 80 million pounds (Table IV-15). Catches declined significantly after that date. Street and Davis (1976) concluded that these offshore harvests contributed to overharvest and caused stock declines, particularly in the Chesapeake Bay and South Atlantic stocks. Street and Davis reported that the offshore harvests were composed primarily of fish less than 190 mm in length, which would suggest that they were primarily sexually immature individuals.

Since 1977, the foreign fishery for river herring in the Fishery Conservation Zone (FCZ) of the United States has been managed by the Preliminary Fishery Management Plan (PMP) for the foreign trawl fisheries of the Northwest Atlantic (Boreman, 1982). Allocation of river herring between 1977 and 1980 was 1.1 million pounds annually with some additional allowable by-catch. Since 1981, the allocation has been limited to 100 metric tons, and by-catch regulations have been changed. Current allocations are presented in Table IV-16. When a country's annual allocation for any one species is reached, fishing by that nation's vessels in that part of the FCZ in the northwest Atlantic Ocean must cease and the fishing vessels must leave the

Table IV-15. Reported landings of river herring (lbs x 10^3) in ICNAF/NAFO Areas 5 and 6 by foreign vessels (from Boreman, 1982)

YEAR	BUL	GDR	POL	ROM	SPA	USSR	TOTAL
1964	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0
1967	0	0	0	0	0	14356	14356
1968	0	0	0	0	0	49184	49184
1969	1133	249	0	0	0	78322	79704
1970	1481	419	0	0	0	42083	43983
1971	2291	18538	3101	2015	0	22029	47974
1972	1129	7674	4162	0	0	14756	27721
1973	972	3593	7167	0	0	2348	14080
1974	1704	5862	2399	556	0	1042	11563
1975	1219	4676	137	0	0	1433	7465
1976	564	2778	31	0	0	539	3912
1977	0	152	0	0	0	264	416
1978	0	0	0	0	23	25	48
1979	0	0	4	0	0	24	28
1980	0	0	0	0	4	0	4

Table IV-16. Allocations of river herring by country for foreign fishing within the U.S. Fishery Conservation Zone, 1978-1983

(in metric tons)

	1978	1979	1980	1981	1982	1983
TALFF	500	500	500	100	100	100
ALLOCATIONS						
Bulgaria	—	—	—	5	20	5
Cuba	—	—	25	5	—	—
FRG	—	12	50	—	—	—
GDR	—	10	25	—	—	25
Ireland	—	10	—	—	—	—
Italy	12	13	50	10	10	10
Japan	23	46	50	10	10	10
Mexico	44	40	50	—	—	—
Poland	—	14	50	18	—	—
Portugal	—	—	—	5	5	5
Romania	7	10	10	—	—	—
Spain	52	57	75	10	10	10
USSR	279	197	—	—	—	—
UNALLOCATED	83	91	115	37	45	35

NOTES: River herring for purposes of foreign fishing is defined as alewife, blueback herring, and hickory shad.

TALFF is total allowable level of foreign fishing.

SOURCE: Fisheries of the United States, 1978-1983. USDOC/NOAA/NMFS.

fishing area (G. Mahoney, pers. comm.). Reported offshore landings since 1978 have been consistently low (Table IV-15).

As was discussed in the case of American shad and hickory shad, numerous problems may exist with the ICNAF/NAFO data which serve to document offshore landings. Key among them is the problem with species identification. An additional problem with total ICNAF landings results from inclusion of potentially inaccurate NOAA inshore landings data. This problem can be avoided by examining the ICNAF/NAFO data on a country-by-country basis, since foreign fleets operate only in offshore waters.

Coastal fisheries for river herring are currently minimal in magnitude. Nearly all major river herring harvests are made within individual river systems or at the mouths of those drainage systems.

The totals of current offshore and coastal harvests of river herring are relatively insignificant. Even if current foreign fishery allocations of river herring were taken each year, those landings would comprise less than 2% of total harvest in any given year. However, these fisheries do focus on immature, smaller fish, and a low percentage in terms of total poundage can represent a larger percentage in terms of numbers of individuals. Although the potential for problems with offshore fisheries exists, the problem appears minimal at present.

E. COASTAL MIGRATIONS

A knowledge of coastal migration patterns of river herring is relevant to examination of hypotheses relating to factors influencing mortality and stock trends. Such information is also needed to assess the potential for interjurisdictional conflicts in harvesting the species. Coastal migration must be placed in perspective to the general life history patterns of the two river herring species, summarized in Figs. I-4 and I-5.

Juvenile river herring generally emigrate from freshwater to the ocean in the fall. However, in some instances, it appears that high abundance of juveniles may trigger very early (e.g., summer) emigration of large numbers of small juveniles from the nursery area (e.g., Richkus, 1975). Length of stay of immature fish in the ocean is generally four or five years, dependent on sex. There is some indication that alewives in northern states may remain in inshore waters for one or two years (e.g., Walton, 1981). Spawning runs begin earliest in southern states (December to January in Florida) and latest in the North (May to June in Maine) (Tables IV-17 and IV-18). Homing of fish to their stream of origin is a generally accepted premise, particularly based on numerous successes in creating new runs through stocking of

Table IV-17. Location, month, and water temperature of spawning run of anadromous alewife populations (from PSEG 1982b)

Location	Months of Spawning Runs	Peak Spawning Period	Temperature (°C)	Reference
Tar River, NC	mid-May to mid-April	-	ca. 10-20°C	Frankensteen, 1976
Chowan River, NC	starts early March	by end March	-	Holland and Yelverton, 1973
Lake Mattamuskeet, NC	February through May	March to early April	peak at 12.9-13.1°C	Tyus, 1971, 1974
Maryland streams	late March through April	-	-	Mansueti and Hardy, 1967
Chesapeake Bay tributaries	arrive late March	-	-	Hildebrand and Schroeder, 1928
Chesapeake Bay tributaries	late March through April	-	-	O'Dell, 1975, 1976
Delaware Bay tributaries	early April to mid-May	last half April	-	Smith, 1971
Delaware River, NJ	April through late June	-	-	Anselmini, 1974a,b, IA 1979a,b
New Jersey streams	April, May, June	-	present 10-21.5°C	Zich, 1977
New York streams	early April to early June	-	-	Decker et al., undated
Pausacaco Pond, RI	mid-March to end May	-	run starts 6.7°C; to 21.1°C	Cooper, 1961
Connecticut and Thames rivers, CT	early March to early June	-	-	Marcy, 1969
Bride Lake, CT	early March to June	-	run starts 4-5°C, ends 15-19°C	Kissil, 1974
Bride Lake, CT	early April to early June	mid-May	run starts 5°C	Cianci, 1969
Bride Lake, CT	starts late March or early April	early May to June	-	Kissil, 1969
Parker River, MA	mid-April through end May	early May	peak run ca. 10°C	Mayo, 1974
Massachusetts Bay tributaries	early April to as late as August 20	-	-	Bigelow and Schroeder, 1953
Long Pond, Love Lake, ME	early May to mid-June	-	runs start 10-16.5°C	Havey, 1961, 1968
Maine streams	few until late April or early May	-	-	Bigelow and Schroeder, 1953
Damariscotta Lake, ME	early May to late June	-	-	Libby, 1981

Table IV-17. Continued

Location	Months of Spawning Runs	Peak Spawning Period	Temperature (°C)	Reference
Bay of Fundy tributaries, NB	April through June	-	-	McKenzie, 1932
Margaree River, NS	starts early May, lasts 4-6 weeks	-	-	Scott and Crossman, 1973
Saint John River, NB	early May through late June	-	-	Messieh, 1977
Saint John River, NB	starts March or April	-	-	McKenzie, 1932
Saint John River, NB	earliest good runs in April	-	-	Bigelow and Schroeder, 1953
Maritime Prov. Canada	May through late June	-	-	Gillespie, 1967

Table IV-18. Location, month, and water temperature of spawning runs of blueback herring populations (from PSEG, 1982)

Location	Months of Spawning Runs	Peak Spawning Period	Temperature(°C)	Reference
		Anadromous Blueback Herring		
St. Johns River FL	December, January, February	-	-	McLane, 1955
Georgia Rivers	February, March, April	-	-	Street and Adams, 1969
Santee River SC	Late February through late April	End March to mid-April	13.3-18.5°C	Mather, 1979
Cooper River SC	Early March to early May	Mid-March through early April	6-17°C	Christie, 1978
Tar River NC	Early March to mid-May	-	ca. 10-20°C	Frankensteen, 1976
Chowan River NC	On going in early May	-	-	Holland and Yelverton, 1973
Rappahannock R. VA	March through June	-	-	[illegible], 1966
Potomac River VA	Starts last half April to first half May	-	-	Hildebrand, 1963
Susquehanna R. PA	Mid-April to early June	Early May to mid-May	-	[illegible] et al., 1980
Chesapeake Bay Tributaries	Lower bay-early April, upper bay-late April	-	-	Hildebrand and Schroeder, 1928
Chesapeake Bay Tributaries	Last half April through first half May	-	-	Odell, 1974, 1976
Delaware Estuary	Late April through mid-June	Last half May	13-24°C	Smith, 1971; Wang and Kernehan, 1979
Delaware River	Late April through June	Late May and early June	-	Anselmini, 1974a,b,c; IA, 1979a,b
New Jersey Streams	April, May, June	-	Present 12.3-24°C	Zich, 1977
[illegible] Brook CT	Late April through mid-September	Mid-May through mid-July	Run starts 4.3-9.5°C First spawn at 14°C	Loesch, 1969; Loesch and Lund, 1977
Saint John R. NB	Mid-May to late June	-	-	Messieh, 1977
Canadian Streams	June	-	-	Leim and Scott, 1966

gravid adults in currently unoccupied sites. However, some Bay, with a large estuarine area and numerous tributaries in close proximity, considerable exchange of stocks among river systems may occur (Loesch, pers. comm.).

Coastal Movement Patterns

Very little tagging study data are available for the two species of river herring. There are several explanations for this:

- Most fisheries for the species take large volumes of fish, making detection of small tags unlikely
- These species are not of great economic value in many states, limiting the amount of effort applied in studies.

As a result, tag return information is relatively anecdotal. Brian Jessup (Fisheries and Oceans Canada, pers. comm.) conducted tagging studies in the Bay of Fundy area of Canada and had two tags returned from North Carolina. There have been two tag returns from a small experimental tagging of spent adult river herring on the Orland River in the state of Maine conducted in 1981 and 1982. Of 400 tagged in 1981 and 350 in 1982, one return came from Massachusetts and one from Virginia, both from the 1982 tagging (T. Squiers, pers. comm.). Street (1975) reported that several river herring tagged in North Carolina were taken in the foreign fishery offshore of that state during the summer. These data, while extremely limited, indicate that river herring undertake extensive oceanic migrations, and may in fact carry out the same pattern of migration shown by the American shad.

Neves (1981) described the offshore distribution of alewife and blueback herring based on 10 years of NMFS research vessel trawl survey data. In the spring (Figure IV-7), alewife distributions extend further north than those of blueback herring (Fig. IV-8), which is consistent with the more northern distribution of that species. Summer distributions (Fig. IV-9) also suggest a somewhat more northern center of distribution of alewife. Data for winter and fall are more sparse and less definitive (Figs. IV-9 and IV-10). Alewives appear more widely distributed than blueback herring (Figs. IV-7 and IV-8). Neves hypothesizes that river herring follow a coastal migration pattern similar to that of American shad.

Milstein (1981) reported the occurrence of 1+ aged river herring off of the coast of southern New Jersey in the winter. In Maine, Walton et al. (1976) reported that 1+ fish use inshore than in the case of American shad for extended coastal movement.

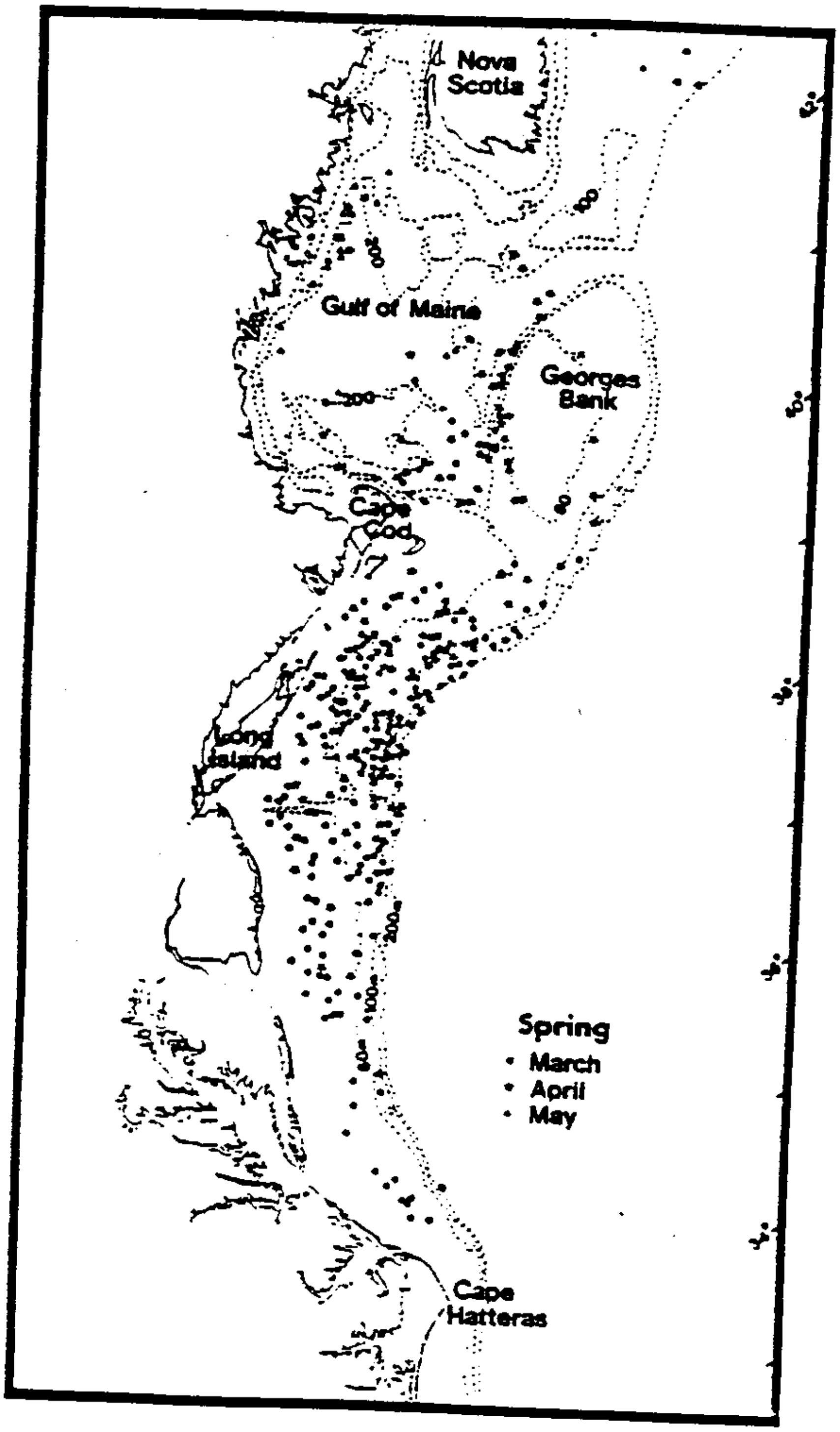

Figure IV-7. Location of alewife catches during spring bottom trawl surveys, 1968-78, Cape Hatteras NC, to Nova Scotia (from Neves, 1981)

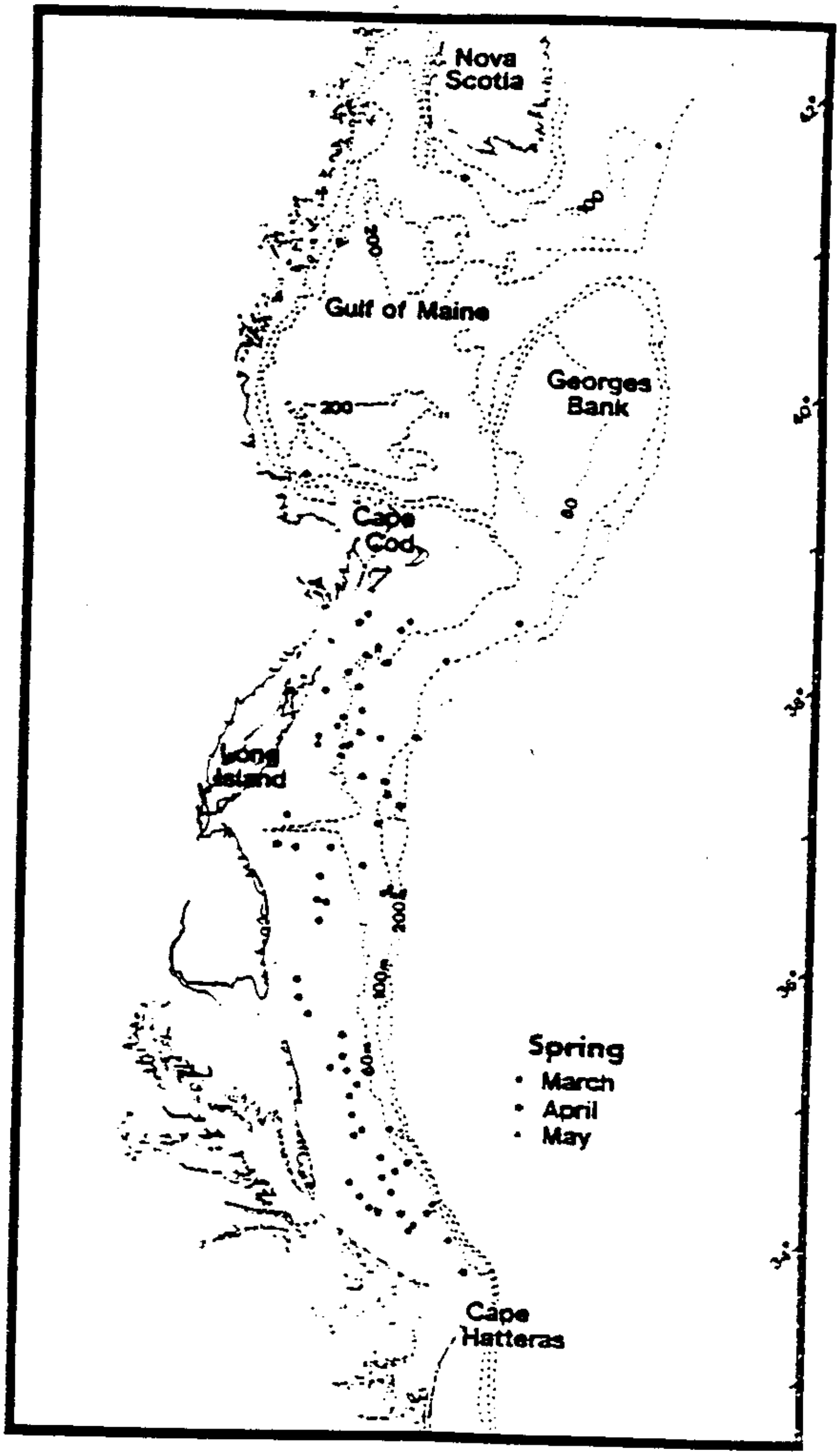

Figure IV-8. Location of blueback herring catches during spring bottom trawl surveys, 1968-78, Cape Hatteras, NC, to Nova Scotia (from Neves, 1981)

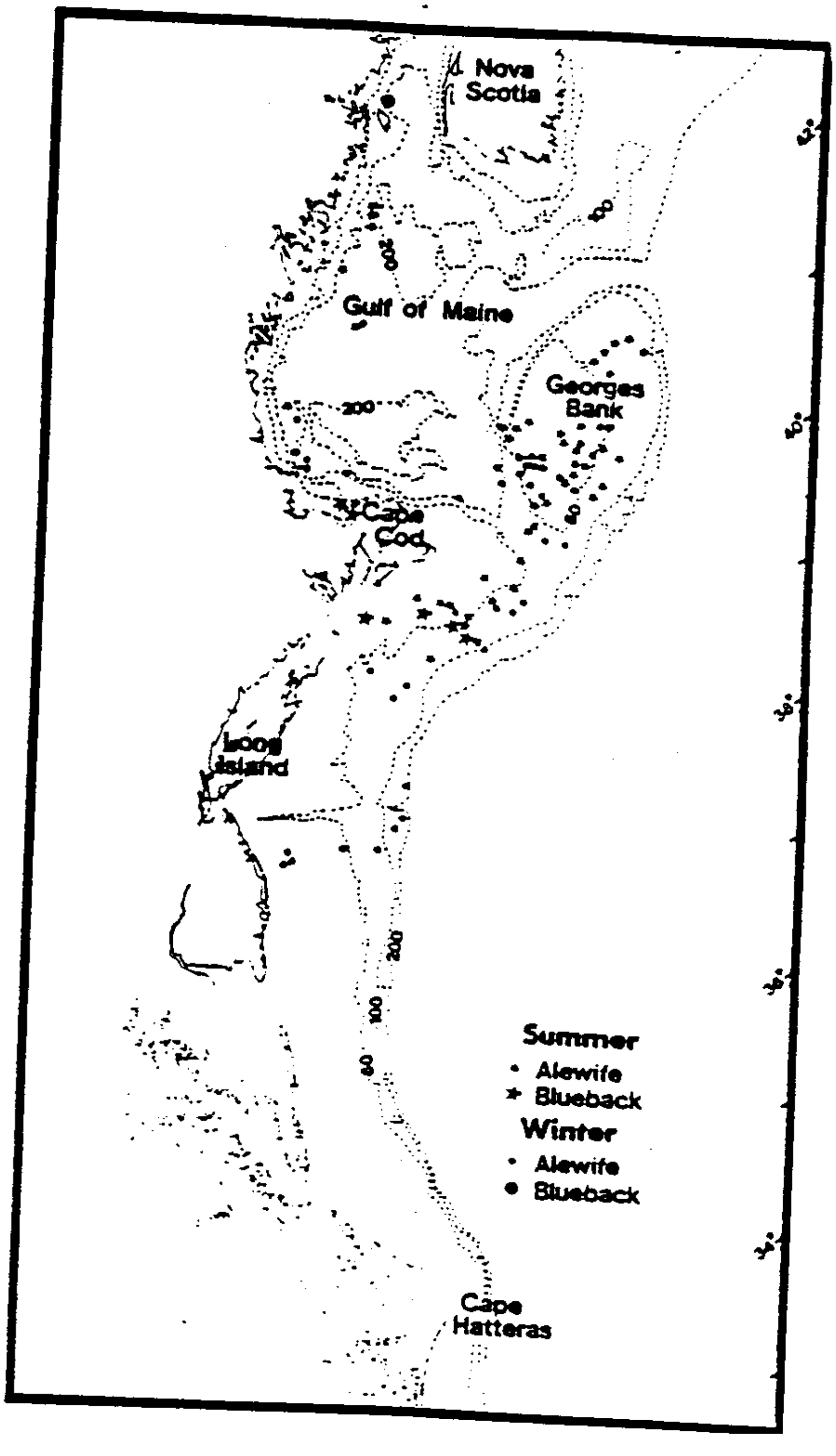

Figure IV-9. Location of catches of alewife and blueback herring during summer and winter bottom trawl surveys, 1963-78, Cape Hatteras, NC, to Nova Scotia (from Neves, 1981)

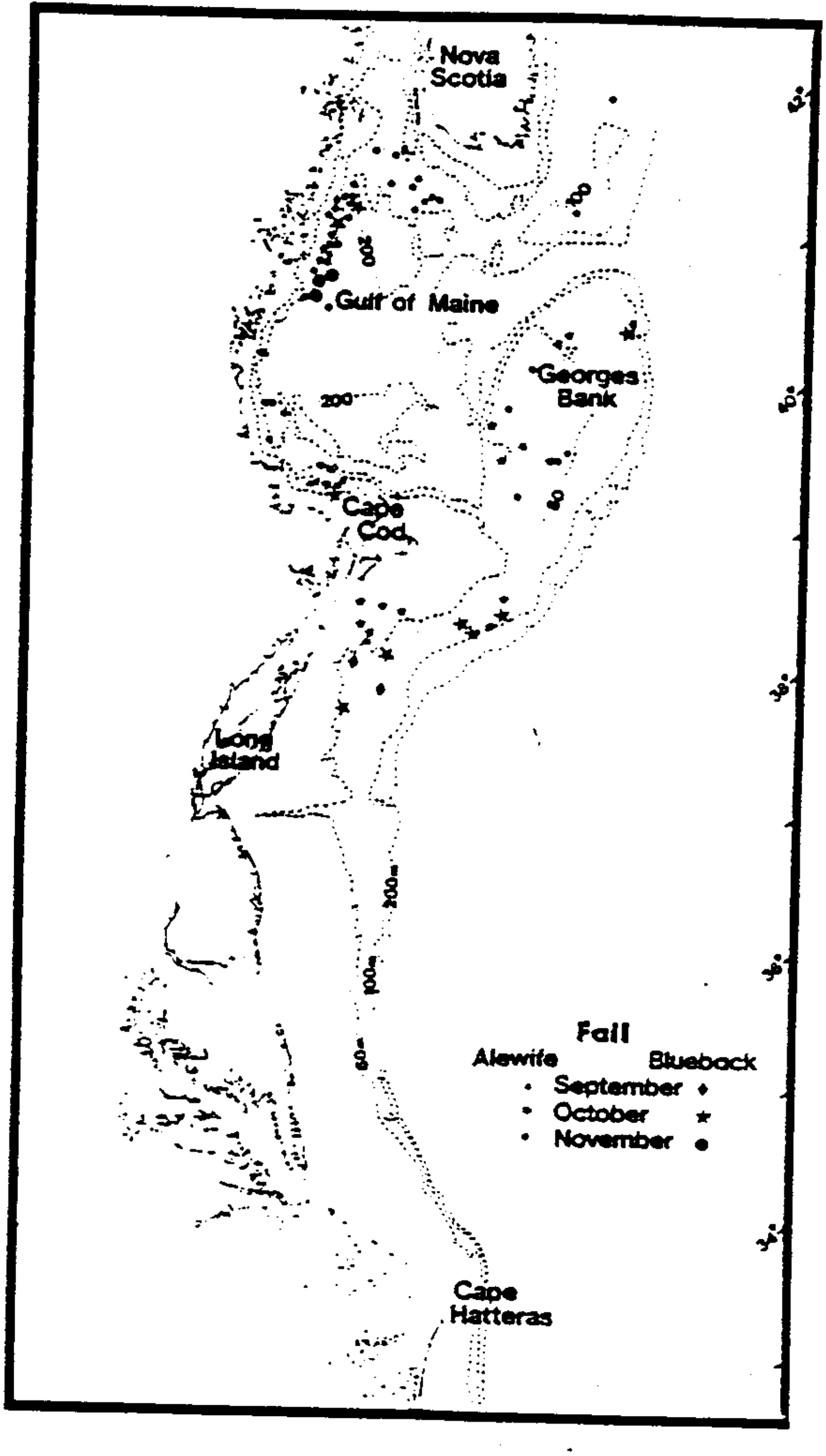

Figure IV-10. Location of catches of alewife and blueback herring during fall bottom trawl surveys, 1963-78, Cape Hatteras, NC, to Nova Scotia (from Neves, 1981)

The offshore harvests by foreign fleets in the late 1960's appeared to impact southern blueback herring stocks while having little apparent effect on northern alewife stocks (see Virginia and Maine discussions above). These findings suggest that coastal river herring stocks do not mingle to the extent that American shad stocks apparently do, at least during the seasons during which foreign harvests were being made. Seasonal changes in location of the foreign fleet during the period when large offshore harvests were being made also suggest a general northward movement of the stocks in summer. The fleet would begin operations off the North Carolina-Virginia coasts in spring and move northward to the Georges Banks area in late summer (H. Johnson, pers. comm.).

In summary, while no data are available to assess the specific coastal migration patterns of individual stocks of river herring from along the east coast of the U.S., the limited data are consistent with an assumption that river herring exhibit a migratory pattern similar to that of American shad. Potential for interjurisdictional conflicts exist where there are active fisheries in coastal waters and the lower portions of major estuaries.

F. MARKET FACTORS INFLUENCING FISHERIES

In the early 1900's, river herring were prized as food fish, primarily because they were amenable to salting for shipment to major urban markets (Williams et al. 1972). With the advent of refrigeration, their use as food fish declined. In more recent years, river herring have been used primarily for bait, pet food, and reduction to fish meal. All these uses have relatively low dollar value and high volume.

Increases in dockside value of landings over the past 30 years appear to reflect the relative low desirability of river herring. Price per pound has risen by only a factor of five over this period, and current value remains very low (3 to 6 cents per pound)(Table IV-19).

Seasonal changes in price do occur, but not with a regional pattern as shown with American shad. NOAA data suggest that early values are high in both Maine and North Carolina. However, the accuracy of the short-term (i.e., monthly) NOAA data is poor. Maine landings are reported for the months of June through October, despite the fact that virtually all harvests are taken in May (Squiers, pers. comm.). Seasonal changes in price per pound would not be expected, since river herring landings are not shipped any extensive distance, but are used locally.

Because of the large-volume nature of commercial river herring fisheries, landings may be significantly influenced by the existence of a small number of major buyers or processing

Table IV-19. Annual average dockside value of river herring (dollars)(from NOAA Fishery Statistics of the United States). Dashed lines denote no catch reported, blanks denote no data acquired.

Year	ME	NH	MA	RI	CO	NY	NJ	PA	DE	MD	VA	NC*	SC	GA	FL
1950	0.01	----	0.12	0.01	0.01	0.03	0.05		0.03	0.02	0.02	0.02	----	----	0.03
1951	0.01	----	0.11	0.01	0.01	0.02	0.04		0.04	0.02	0.01	0.01	----	----	0.02
1952	0.01	----	0.12	0.01	0.01	0.01	0.01		0.06	0.02	0.02	0.01	----	----	0.05
1953	0.01	----	0.02	0.01	0.01	0.04	0.02		0.03	0.02	0.02	0.01	----	----	----
1954	0.01	----	0.01	0.02	0.01	0.04			0.01	0.02	0.01	0.01	----	----	0.04
1955	0.01	----	0.01	0.02	0.01	0.02	0.04		0.05	0.02	0.01	0.01	----	----	0.18
1956	0.01	----	0.01	0.02	0.01	0.03	0.04		0.03	0.02	0.01	0.11	----	----	0.26
1957	0.01	0.01	0.01	0.01	0.02	0.02	0.04		0.04	0.02	0.02	0.01	----	----	0.03
1958	0.01	0.02	0.01	0.01	0.02	0.02	0.04		----	0.02	0.01	0.01	----	----	0.03
1959	0.01	0.01	0.01	0.01	0.01	0.22	0.04		----	0.02	0.01	0.01	----	----	0.03
1960	0.01	0.01	0.01	----	0.01	0.05	0.03		0.02	0.02	0.02	0.01	----	----	0.04
1961	0.02	0.01	0.01	----	0.01	0.93	0.06		0.05	0.01	0.02	0.01	----	----	0.03
1962	0.01	0.01	0.01	----	0.02	0.03	0.05		----	0.01	0.02	0.01	----	----	----
1963	0.02	0.01	0.01	0.02	0.02	0.03	0.04		----	0.02	0.02	0.01	----	----	0.04
1964	0.02	0.01	0.01	0.01	0.01	0.03	0.07		----	0.02	0.02	0.01	----	----	0.02
1965	0.01	0.07	0.12	0.01	0.01	0.04	0.04		----	0.02	0.01	0.10	0.02	----	0.05

Table IV-19. Continued

Year	ME	NH	MA	RI	CD	NY	NJ	PA	DE	MD	VA	NC	SC	GA	FL
1966	0.02	0.01	0.01	0.02	0.02	0.02	0.04		----	0.02	0.02	0.01	0.02	----	0.03
1967	0.03	0.03	0.01	0.02	0.02	0.05	0.42		----	0.02	0.02	0.02	0.02	----	----
1968	0.02	0.02	0.02	0.02	0.03	0.06	0.04		----	0.02	0.02	0.02	0.02	----	----
1969	0.02	0.03	0.02	0.02	0.03	0.11	0.03		----	0.02	0.02	0.02	0.02	----	----
1970	0.02	0.03	0.01	0.02	0.02	0.09	0.03		----	0.02	0.02	0.02	0.02	----	----
1971	0.02	0.04	0.02	0.04	0.04		0.04		----	0.02	0.02	0.02	0.03	----	----
1972	0.02	0.04	0.02	0.04	0.04	0.06	0.07		----	0.02	0.03	0.02	0.02	----	----
1973	0.03	0.04	0.02	0.07	0.07	0.04	0.04		0.02	0.02	0.03	0.03	0.03	----	----
1974	0.03	----	0.04	0.06	0.06	0.07	0.04		0.03	0.02	0.03	0.04	0.03	----	----
1975	0.04	----	0.01	0.05	0.06	0.07	0.04		0.04	0.02	0.04	0.04	0.06	----	0.15
1976	0.03	----	0.04	0.06	0.04	0.10	0.09		0.04	0.04	0.04	0.05	0.04	----	0.23
1977															

houses. In Virginia, the last processing plant handling river herring closed in 1982 (W. Kriete, pers. comm.), suggesting that landings may decline substantially in the future due to lack of a market.

Several implications of market factors for management of river herring can be drawn from these data. The very low dollar value of these species suggests that fisheries will only persist if large volumes can be harvested. Large relative changes in low prices (i.e., going from 3 to 4 cents per pound), may serve as limited incentive for increases in fishing effort. Existence of a market may be a more important controlling factor on the magnitude of landings than price.

G. SELECTED LIFE HISTORY ASPECTS RELEVANT TO MANAGEMENT

Age of Maturity

Data on age of maturity for male and female blueback herring from several drainage systems along the east coast are presented in Tables IV-20 and IV-21. No latitudinal gradient in age at maturity is evident, although some large differences between river systems are evident. As a generalization, about 80% of females return to spawn by age IV, while data for males are so variable that generalizations cannot be made. The literature frequently allude to males returning at age III (e.g., Hildebrand and Schroeder, 1928).

Comparable data for alewife are presented in Tables IV-22 and IV-23. These data suggest a somewhat higher age of maturity for female alewife than for blueback herring. Male alewife data are more consistent with data for male blueback herring in showing a higher percentage of fish returning at age III than is the case for females. Data from Rhode Island and Maine indicate that mean age and length for males is consistently lower than for females (R.I. Div. of Fish and Wildlife, 1983; Maine Department of Marine Resources, 1983).

These age-of-maturity data suggest no significant difference between the two species: more males return at a somewhat (although not substantially) earlier age than females, and most fish are recruited to spawning runs at least once by age V. Depth of interpretation of such compilations of data is limited because of possible differences in scale-reading procedures followed by different investigators. Such differences were evident during a scale reading workshop held by the Shad and River Herring S and S Committee. However, such age distribution data are sufficient to provide a general overview of the species life history characteristics.

Table IV-20. Cumulative proportion virgin female of blueback herring maturing by age in several Atlantic coast river systems (from PSEG, 1982a)

Reference Location	Street and Adams, 1969 Altamaha, Ogeechee, and Savannah Rivers, GA		Pate, 1973 Albemarle Sound and tributaries, NC		Johnson et al., 1977 Albemarle Sound NC		Johnson et al., 1977 Scuppernong River NC	
Age	n	Proportion	n	Proportion	n	Proportion	n	Proportion
II	4	0.070	-	-	-	-	-	-
III	26	0.510	76	0.284	17	0.037	12	0.080
IV	28	0.980	104	0.672	306	0.695	109	0.807
V	1	1.000	68	0.925	118	0.949	26	0.980
VI	-	-	16	0.985	24	1.000	3	1.000
VII	-	-	4	1.000	-	-	-	-

Reference Location	Johnson et al., 1977 Meherrin River NC		Johnson et al., 1977 Chowan River NC		Johnson et al., 1977 Alligator River NC		Johnson et al., 1977 Edenton Bay NC	
Age	n	Proportion	n	Proportion	n	Proportion	n	Proportion
III	-	-	3	0.021	2	0.067	-	-
IV	63	0.441	111	0.803	23	0.834	-	-
V	59	0.834	28	1.000	5	1.000	1	1.000
VI	21	1.000	-	-	-	-	-	-
VII	-	-	-	-	-	-	-	-

Reference Location	Patrinoulz et al, 1980 Susquehanna River PA		Present Study Delaware River NJ		Loesch, 1969 Poquetanuck and Trading Coves, CT		Marcy, 1969 Connecticut River and Bride Brook, CT	
Age	n	Proportion	n	Proportion	n	Proportion	n	Proportion
III	-	-	-	-	4	0.235	17	0.090
IV	49	0.412	2	0.182	5	0.529	141	0.836
V	66	0.967	6	0.727	8	1.000	31	1.000
VI	4	1.000	1	0.818	-	-	-	-
VII	-	-	2	1.000	-	-	-	-

Reference Location	Scherer, 1972 Connecticut River MA	
Age	n	Proportion
III	7	0.125
IV	40	0.849
V	9	1.000

Table IV-21. Cumulative proportion of virgin male blueback herring maturing by age in several Atlantic coast river systems (from PSEG, 1981a)

Reference Location	Street and Adams, 1969 Altamaha, Ogeechee, and Savannah Rivers, GA		Pate, 1973 Albemarle Sound and tributaries, NC		Johnson et al., 1977 Albemarle Sound NC		Johnson et al., 1977 Scuppernong River NC	
Age	n	Proportion	n	Proportion	n	Proportion	n	Proportion
II	12	0.200	-	-	-	-	-	-
III	41	0.870	112	0.333	50	0.078	33	0.125
IV	7	0.990	154	0.791	453	0.787	192	0.855
V	1	1.000	66	0.987	128	0.987	38	1.000
VI	-	-	4	1.000	8	1.000	-	-

Reference Location	Johnson et al., 1977 Meherrin River NC		Johnson et al., 1977 Chowan River NC		Johnson et al., 1977 Alligator River NC		Johnson et al., 1977 Edenton Bay NC	
Age	n	Proportion	n	Proportion	n	Proportion	n	Proportion
III	4	0.029	12	0.065	1	0.024	-	-
IV	69	0.536	142	0.837	36	0.881	-	-
V	55	0.940	30	1.000	5	1.000	3	0.333
VI	8	1.000	-	-	-	-	5	0.888
VII	-	-	-	-	-	-	1	1.000

Reference Location	Patrimoulx et al, 1980 Susquehanna River PA		Present Study Delaware River NJ		Loesch, 1969 Poquetanuck and Trading Coves, CT		Marcy, 1969 Connecticut River and Bride Brook, CT	
Age	n	Proportion	n	Proportion	n	Proportion	n	Proportion
III	3	0.031	4	0.333	15	0.500	93	0.469
IV	57	0.613	3	0.583	12	0.900	99	0.967
V	38	1.000	3	0.833	3	1.000	7	1.000
VI	-	-	1	0.916	-	-	-	-
VII	-	-	1	1.000	-	-	-	-

Reference Location	Scherer, 1972 Connecticut River MA	
Age	n	Proportion
III	62	0.559
IV	48	0.991
V	1	1.000

Table IV-22. Cumulative proportion of virgin female alewife maturing by age in several Atlantic coast river system (from PSEG, 1982b)

Reference Location	Pate, 1973 Albemarle Sound and tributaries, NC		Johnson et al., 1977 Albemarle Sound, NC		Johnson et al., 1977 Scuppernong River, NC	
Age	n	Proportion	n	Proportion	n	Proportion
III	26	0.132	17	0.046	13	0.104
IV	128	0.782	272	0.787	86	0.792
V	38	0.975	62	0.956	20	0.952
VI	5	1.000	16	1.000	6	1.000

Reference Location	Johnson et al., 1977 Meherrin River, NC		Johnson et al., 1977 Chowan River, NC		Johnson et al., 1977 Alligator River, NC	
Age	n	Proportion	n	Proportion	n	Proportion
IV	27	0.600	58	0.734	4	0.032
V	16	0.956	16	0.937	101	0.840
VI	2	1.000	5	1.000	10	1.000

Reference Location	Johnson et al., 1977 Edenton Bay, NC		Tsimenides, 1970 Rappahannock River, VA		Tsimenides, 1970 Potomac River, VA	
Age	n	Proportion	n	Proportion	n	Proportion
III	-	-	34	0.176	15	0.259
IV	-	-	146	0.933	40	0.948
V	-	-	13	1.000	3	1.000
VI	1	1.000	-	-	-	-

Reference Location	Present study Delaware River, NJ	
Age	n	Proportion
III	4	0.114
IV	17	0.600
V	6	0.771
VI	7	0.971
VII	1	1.000

Table IV-23. Cumulative proportion of virgin male alewife maturing by age in several Atlantic coast river systems (from PSEG, 1982b)

Reference Location	Pate, 1973 Albemarle Sound and tributaries, NC		Johnson et al., 1977 Albemarle Sound, NC		Johnson et al., 1977 Scuppernong River, NC	
Age	n	Proportion	n	Proportion	n	Proportion
II	-	-	2	0.003	-	-
III	81	0.319	97	0.171	59	0.303
IV	136	0.854	387	0.843	111	0.872
V	36	0.995	65	0.956	22	0.985
VI.	1	1.000	5	1.000	3	1.000

Reference Location	Johnson et al., 1977 Meherrin River, NC		Johnson et al., 1977 Chowan River, NC		Johnson et al., 1977 Alligator River, NC	
Age	n	Proportion	n	Proportion	n	Proportion
II	-	-	2	0.015	-	-
III	7	0.084	12	0.105	19	0.133
IV	65	0.867	101	0.859	109	0.895
V	11	1.000	18	0.993	14	0.993
VI	-	-	1	1.000	1	1.000

Reference Location	Johnson et al., 1977 Edenton Bay, NC		Tsimenides, 1970 Rappahannock River, VA		Tsimenides, 1970 Potomac River, VA	
Age	n	Proportion	n	Proportion	n	Proportion
III	-	-	62	0.259	31	0.526
IV	-	-	170	0.971	28	1.000
V	3	0.333	7	1.000	-	-
VI	5	0.889	-	-	-	-
VII	1	1.000	-	-	-	-

Reference Location	Present study Delaware River, NJ	
Age	n	Proportion
III	3	0.176
IV	11	0.823
V	3	1.000

Size at Age

Tables IV-24 and IV-25 present length-at-age data for male and female alewife and blueback herring. Two major points are revealed by these data: females of both species are larger than males, and there is a latitudinal trend in size, with northern fish being of greater size than southern fish. The majority of data presented here are actual measurements of fish at age as opposed to back-calculated lengths at age, thus avoiding the problems of Lee's phenomenon and scale edge resorption.

Juvenile Growth Rates

A compilation of juvenile growth rates for both species is presented in Table IV-26. A regional trend in growth rates is suggested by these data, with substantially higher rates for northern stocks. However, as is discussed below, growth rate may be strongly affected by juvenile density.

Frequency of Repeat Spawning

Spawning history data for blueback herring and alewife are presented in Tables IV-27 and IV-28. As a broad generalization, repeat spawners comprise 30 to 40 percent of all runs. No distinctive latitudinal gradient in percentage repeat spawning is shown in the data presented here, in contrast to the case with American shad. Bulak et al. (1977), reporting only 8% repeat spawners in the Santee-Cooper system in South Carolina, has suggested that a latitudinal gradient does exist. These types of data are heavily influenced by previous fishing mortality, the occurrence of individual dominant year-classes, and the existence of consistent scale-reading biases between individual investigators and geographical regions which cannot be identified. The majority of existing data suggest no latitudinal trend in repeat spawning percentage.

Fecundity

Fecundity estimates for both blueback herring and alewife vary with fish size, with size in turn varying by age and latitude. Data have been collected for fish from many different latitudes along the east coast (e.g., Street, 1969; Frankensten, 1976; Loesch, 1979; Scherer, 1972; Kissil, 1969; Mayo, 1974). In general, fecundity ranges from 100,000 to 200,000 eggs per female for blueback herring, and from 100,000 to 300,000 for alewife. Different methods of estimating fecundity introduce

Table IV-24. Length at age of blueback herring (from PSEG, 1982b)

Data Source	Location	Measurement		AGE III	IV	V	VI	VII	VIII	IX	X	XI
							FEMALES					
Street and Adams,[a] 1969	GA	FL (mm)	$\bar{X}$	244	255	265	276	273	-	-	-	-
			R	-	-	-	-	-	-	-	-	-
Pate, 1973	NC	FL (mm)	$\bar{X}$	245	253	258	264	268	280	307	-	-
			R	226-275	235-272	236-281	251-281	250-290	280	307	-	-
Frankensteen, 1976	NC	FL (mm)	$\bar{X}$	-	246.2	254.7	265.0	265.4	-	-	-	-
			R	-	-	-	-	-	-	-	-	-
Beal, 1968[b]	VA	FL (mm)	$\bar{X}$	-	191	222	230	252	259	262	266	270
			R	-	180-203	217-228	228-245	249-254	256-260	261-262	266-267	270
Petrimoulx et al. 1980	PA	TL (mm)	$\bar{X}$	-	283	287	307	321	312	-	-	-
			R	-	269-305	250-315	293-328	313-328	312	-	-	-
Marcy, 1969	CT	TL (mm)	$\bar{X}$	261.3	276.4	291.3	300.9	310.9	-	-	-	-
			R	258-265	255-291	259-321	255-320	289-330	-	-	-	-
Scherer, 1972	MA	TL (mm)	$\bar{X}$	-	275.7	285.1	304.1	320.1	-	-	-	-
			R	-	266-291	263-325	280-325	312-331	-	-	-	-
							MALES					
Street and Adams,[a] 1969	GA	FL (mm)	$\bar{X}$	234	242	252	264	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-
Pate, 1973	NC	FL (mm)	$\bar{X}$	231	241	245	251	258	270	-	-	-
			R	210-247	212-264	221-269	230-283	243-270	270	-	-	-
Frankensteen, 1976	NC	FL (mm)	$\bar{X}$	-	237.9	244.1	250.5	260.1	-	-	-	-
			R	-	-	-	-	-	-	-	-	-
Beal, 1968[b]	VA	FL (mm)	$\bar{X}$	-	187	218	232	241	250	256	-	-
			R	-	184-200	218-220	232-240	240-246	250	256	-	-
Petrimoulx et al. 1980	PA	TL (mm)	$\bar{X}$	254	272	277	301	291	-	-	-	-
			R	236-281	262-296	265-301	283-318	291	-	-	-	-
Marcy, 1969	CT	TL (mm)	$\bar{X}$	258.0	266.5	279.5	285.8	298.1	-	-	-	-
			R	244-271	248-287	243-297	271-303	275-312	-	-	-	-
Scherer, 1972	MA	TL (mm)	$\bar{X}$	268.5	267.9	277.0	290.8	306.5	-	-	-	-
			R	244-284	249-292	255-312	273-305	300-313	-	-	-	-

[a] Titles of length-frequency figures in Street and Adams (1969) appear to be in error. Figure 4: hickory shad is actually blueback herring. Lengths herein were derived from this figure.

[b] Beal (1968) apparently counted the freshwater mark as an annulus.

Table IV-25. Length at age of alewife (from PSEG, 1982b)

Reference	Location	Measurement		III	IV	V	VI	VII	VIII	IX
							Males			
Pate, 1973	NC	FL (mm)	$\bar{x}$	236	249	256	259	258	279	-
			R	220-263	226-275	230-279	240-280	255-276	264-281	-
Rideout, 1974	MA	TL (mm)	$\bar{x}$	274.7	298.7	309.4	313.9	319.3	321.2	320.0
			R	250-296	280-316	288-327	297-332	305-335	308-338	320-320
Marcy, 1969	CT	TL (mm)	$\bar{x}$	-	264.6	277.9	289.9	300.7	-	-
			R	-	200-290	257-299	266-306	286-315	-	-
Graham, 1956	Canada	SL (mm)	$\bar{x}$	174.4	175.1	188.6	-	-	-	-
			R	-	-	-	-	-	-	-
							Females			
Pate, 1973	NC	FL (mm)	$\bar{x}$	254	261	270	277	283	287	-
			R	238-276	230-290	239-292	251-298	255-311	264-296	-
Rideout, 1974	MA	TL (mm)	$\bar{x}$	280.4	306.8	318.0	316.8	331.3	333.5	335.2
			R	260-299	282-321	303-332	302-324	315-353	321-352	317-347
Marcy, 1969	CT	TL (mm)	$\bar{x}$	-	283.7	284.0	299.0	307.8	324.8	-
			R	-	266-299	261-302	271-317	287-325	313-339	-
Graham, 1956	Canada	SL (mm)	$\bar{x}$	-	167.3	202.5	248.0	-	-	-
			R	-	-	-	-	-	-	-

Table IV-26.. Growth rates of juvenile blueback herring and alewife.

Species	Data Source	Location	Growth per day
Blueback herring	Loesch (1969)	Connecticut	0.452 mm 0.569 mm 0.657 mm
	Burbidge (1974)	Virginia	0.209 mm
	Michaels (1982)	Georgia	0.208 mm
Alewife	PSE&G (1982)	New Jersey	0.625 mm
	Jimenez (1978)	Massachusetts	0.820-0.996 mm

Table IV-27. Spawning history of anadromous alewife; percentage by age and times spawned (from PSEG, 1982b)

Location (Year)	Reference	Age	Times Spawned															
			Males								Females							
			0	1	2	3	4	5	6	n	0	1	2	3	4	5	6	n
Albemarle Sound and Tributaries, NC (1972)	Pate, 1973	III	100.0							81	100.0							26
		IV	79.5	20.5						171	87.7	12.3						146
		V	37.9	43.5	18.6					93	33.6	46.0	20.4					113
		VI	3.7	22.2	51.9	22.2				27	6.7	17.3	61.3	14.7				75
		VII				87.5	12.5			8		5.7	20.0	60.0	14.3			35
		VIII				50.0		50.0		2				50.0	37.5	12.5		8
		Total	66.1	21.9	7.8	3.6	0.3	0.3		384	48.9	21.1	18.9	8.9	2.0	0.2		403
Albemarle Sound, NC (1975-76)	Johnson et al., 1977	II	100.0							2								0
		III	100.0							87	100.0							17
		IV	93.0	7.0						416	96.8	3.2						281
		V	32.0	63.5	4.4					203	33.5	64.3	2.2					103
		VI	11.6	20.9	67.4					43	13.9	49.4	36.7					67
		VII		100.0		100.0				2		8.3	41.7	41.7	8.3			12
		VIII								0			100.0					1
		IX								0			100.0					1
		Total	72.5	22.3	5.0	0.1				753	65.6	33.1	1.0	0.1	0.2			363
Scuppernong River, NC (1975-76)	Johnson et al., 1977	III	100.0							59	100.0							13
		IV	91.0	9.0						122	97.7	2.3						88
		V	61.1	36.1	2.8					36	70.0	30.0						29
		VI	50.0	33.3	16.7					6	60.0	30.0	10.0					10
		VII								0			100.0					1
		Total	87.4	11.6	0.9					223	88.6	9.9	1.4					141
Meherrin River, NC (1975-76)	Johnson et al., 1977	III	100.0							7								0
		IV	98.5	1.5						66	100.0							27
		V	31.6	68.4						51	38.1	59.5	2.4					42
		VI		15.4	84.6					13	20.0	25.0	55.0					20
		VII				100.0				1			33.3	66.7				3
		VIII								0				100.0				2
		IX								0				100.0				1
		Total	60.1	31.2	8.0	0.7				138	49.5	31.6	13.7	5.3				95
Chowan River, NC (1975-76)	Johnson et al., 1977	II	100.0							2								0
		III	100.0							12								0
		IV	95.3	4.7						107	96.7	3.3						60
		V	23.1	71.8	5.1					78	21.3	77.3	1.3					75
		VI	4.8	23.8	71.4					21	17.9	10.7	71.4					28
		VII		100.0						1		14.3	42.9	42.9				7
		Total	61.1	30.3	8.6					221	46.5	37.6	14.1	1.8				170
Alligator River, NC (1975-76)	Johnson et al., 1977	III	100.0							19	100.0							4
		IV	90.1	9.9						111	95.3	4.7						106
		V	36.8	52.6	10.5					38	25.6	69.2	5.1					39
		VI	33.3		66.7					3	11.1	22.2	66.7					9
		Total	78.4	18.1	3.5					171	73.4	21.5	5.1					158
Edenton Bay, NC (1975-76)	Johnson et al., 1977	V	100.0							3								0
		VI	25.0	60.0	15.0					20		100.0						1
		VII	5.3	63.2	26.3	5.3				19			50.0	50.0				4
		VIII								0				100.0				1
		IX								0				50.0	50.0			2
		Total	21.4	57.1	19.0	2.4				42	0.0	12.5	25.0	50.0	12.5			8

Table IV-27. Continued

			Times Spawned															
			Males								Females							
Location (Year)	Reference	Age	0	1	2	3	4	5	6	N	0	1	2	3	4	5	6	N
Rappahannock River, VA (1963-69)	Tsimenides, 1970	III	25.0			up to four				339	17.6			up to six				193
		IV	71.1			spawns				339	75.7			spawns				193
		V	3.9							339	6.7							193
		Total								1017								579
Potomac River, VA (1963-69)	Tsimenides, 1970	III	52.6			up to four				59	23.9			up to six				58
		IV	47.4			spawns				59	70.9			spawns				58
		V								0	5.2							58
		Total								118								174
Delaware River, NJ (1981)	Present Study	III	100.0							3	100.0							4
		IV	84.6	15.4						13	89.5	10.5						19
		V	60.0	40.0						5	60.0	30.0	10.0					10
		VI		33.3	33.3	33.3				3	77.8	11.1		11.1				9
		VII				100.0				1	50.0			50.0				2
		VIII								0				100.0				1
		Total	68.0	20.0	4.0	8.0				25	77.8	13.3	2.2	6.7				45
Connecticut River and Bride Brook, CT (1966-67)	Marcy, 1969	III	100.0							-								-
		IV	100.0							-	100.0							-
		V	24.1	75.9						-	57.7	42.3						-
		VI		38.7	61.3					-		74.2	25.8					-
		VII			69.6	30.4				-			82.3	17.7				-
		VIII								-				100.0				-
		Total	(Males + Females = 844 total)															

Table IV-28. Spawning history of blueback herring; percentage by age and times spawned (from PSEG, 1982a)

Times Spawned

Location (Year)	Reference	Age	Males								Females							
			0	1	2	3	4	5	6	n	0	1	2	3	4	5	6	n
Altamaha, Ogeechee and Savannah Rivers, GA (1968-69)	Street and Adams, 1969	II	30.0	-	-	-					7.0	-	-	-				
		III	47.0	-	-	-					44.0	-	-	-				
		IV	22.0	-	-	-					47.0	-	-	-				
		V	1.0	-	-	-					2.0	-	-	-				
		Total	32.0	41.0	19.0	8.0					17.0	51.0	27.0	5.0				—
Albemarle Sound and Tributaries, NC (1972)	Pate, 1973	III	100.0							112	100.0							76
		IV	61.4	38.6						143	74.3	25.7						140
		V	32.8	36.3	30.8					201	31.3	36.4	32.3					217
		VI	4.7	14.1	62.4	18.8				85	16.5	17.5	47.4	18.6				97
		VII		5.6	5.6	83.3	5.6			18	18.2		22.7	40.9	18.2			22
		VIII					100.0			1					100.0			4
		IX														100.0		1
		Total	50.9	26.5	17.6	4.7	0.3			560	48.1	23.7	21.7	4.8	1.4	0.2		557
Albemarle Sound NC (1975-76)	Johnson et al., 1977	III	100.0							50	96.4	3.6						28
		IV	99.7	0.3						434	97.5	2.5						316
		V	54.3	44.3	1.3					333	45.4	53.1	1.5					260
		VI	11.8	42.6	44.1	1.5				68	10.5	49.2	40.3					124
		VII		20.0	60.0	20.0				10		15.6	46.7	35.6	2.2			45
		VIII			100.0					1			100.0					1
		IX				100.0				2				100.0				4
		Total	76.2	18.3	4.9	0.6				898	80.1	16.2	3.0	1.0	0.1			778
Scuppernong River, NC (1975-76)	Johnson et al., 1977	III	100.0							33	92.3	7.7						13
		IV	97.5	2.5						197	94.8	5.2						115
		V	65.5	31.0	3.4					58	51.0	49.0						51
		VI									60.0	40.0						5
		VII												100.0				1
		Total	91.3	8.0	0.7					288	81.1	18.4		0.5				185
Meherrin River, NC (1975-76)	Johnson et al., 1977	III	100.0							4								
		IV	95.8	4.2						72	100.0							63
		V	59.1	40.9						91	54.1	43.1	2.8					109
		VI	13.3	43.3	41.7	1.7				60	20.4	32.4	37.2					101
		VII		22.2	55.6	22.2				9		17.9	43.6	35.9	2.6			39
		VIII			100.0					1			25.0	25.0	50.0			4
		IX				100.0				2				85.7	14.3			7
		Total	56.4	28.6	13.0	2.1				239	44.8	31.2	15.1	6.5	2.2			323
Chowan River, NC (1975-76)	Johnson et al., 1977	III	100.0							33	100.0							3
		IV	96.6	3.4						147	99.1	0.9						112
		V	43.5	55.1	1.4					69	31.1	55.6	13.3					90
		VI		42.9	57.1					7		54.5	36.4	9.1				11
		VII			100.0					1								
		Total	79.8	17.9	2.3					257	65.7	26.4	7.4	0.5				216
Alligator River NC (1975-76)	Johnson et al., 1977	III	100.0							1	100.0							3
		IV	94.7	5.3						38	95.8	4.2						24
		V	33.3	66.7						15	22.7	72.7	4.5					22
		VI			100.0					1		100.0						1
		Total	76.4	21.8	1.8					55	62.0	36.0	2.0					50

Table IV-28. Continued

Location (Year)	Reference	Age	Times Spawned															
			Males								Females							
			0	1	2	3	4	5	6	n	0	1	2	3	4	5	6	n
Edenton Bay (1975-76)	Johnson et al., 1977	V	100.0							3								0
		VI	25.0	60.0	15.0					20		100.0						1
		VII	5.3	63.2	26.3	5.3				19			50.0	50.0				4
		VIII								0				100.0				1
		IX								0				5.0	50.0			2
		Total	21.4	57.1	19.0	2.4				42	0	12.5	25.0	50.0	12.5			8
Susquehanna River, PA (1980)	Petrimoulx et al., 1980	III	100.0							3								0
		IV	96.6	3.4						39	98.0	2.0						50
		V	69.1	23.5	5.9					35	82.5	16.3	1.3					80
		VI	19.0	47.6	33.3					21	10.0	65.0	25.0					40
		VII			100.0					1		40.0	20.0	40.0				5
		VIII								0					100.0			1
		Total	73.6	18.7	7.9					119	67.6	23.9	6.8	1.1	0.6			176
Delaware River, NJ (1981)	Present Study	III	100.0							4								0
		IV	100.0							3	66.7	33.3						3
		V	42.9	42.9	14.3					7	46.2	38.5	15.4					13
		VI	10.0	30.0	30.0	30.0				10	11.1	33.3	44.4	11.1				9
		VII	20.0	20.0	40.0	20.0				5	40.0		20.0	40.0				5
		VIII								0				100.0				2
		IX								0					50.0	50.0		2
		Total	41.4	24.1	20.7	13.8				29	32.4	26.5	20.6	14.7	2.9	2.9		34
Connecticut River and Bride Brook, CT (1966-67)	Marcy, 1969	III	100.0								100.0							
		IV	55.6	44.4							83.3	16.7						
		V		53.4	46.6						2.9	83.8	13.3					
		VI		2.7	56.8	40.5						10.9	82.8	6.3				
		VII			21.4	42.9	35.7						42.6	35.3	2.1			
		Total									(Males and Females = 335 Total)							
Poquetanuck and Trading Coves, CT (1966)	Leach, 1969	III	100.0							13	100.0							4
		IV	53.1		46.9					23	100.0							5
		V	3.3		96.7					87	16.4		83.6					50
		VI			100.0					23			100.0					29
		VII			100.0					2			100.0					17
		Total	20.0		80.0					150	16.2		83.8					105

unknown biases into the data, and thus various estimates of fecundity in the literature may not be directly comparable. The data demonstrate that both species of river herring have relatively high fecundity, at levels comparable to that for American shad.

Mortality Rates

Mortality and survival rates presented in PSEG (1982b,c) were estimated by using age frequency data presented in the literature (Tables IV-29 and IV-30). Annual mortality rates appear to vary significantly among river systems, ranging from 30 to 90%. No latitudinal gradient is evident, and rates for blueback and alewife appear relatively similar. However, values such as those calculated by PSEG can be strongly influenced by the representativeness of the samples yielding the age data, and by scale-reading procedures.

Despite the great variability in the data, several generalizations can be made. Annual survival rates appear to be highest for ages 4 to 5, and lower but fairly constant for older age groups. As noted above, there is no latitudinal gradient in mortality rates. However, mortality rates can be strongly influenced by fishing pressure, since the fisheries in the different regions of the country vary markedly. Thus, the comparability of mortality estimates for the purpose of drawing conclusions about population biology of the species is inappropriate unless all related factors are accounted for.

Some limited but very precise data are available concerning fishing mortalities of some runs of river herring. Walton (1980) studied several alewife runs in Maine that have supported stable fisheries for many years. He found that fishing mortalities for individual runs ranged from 80 to 95% each year, which exceed nearly all the reported mortality data in literature. However, they are a result of complete monitoring of run size and harvest, and are thus very accurate. DiCarlo (1982) reported exploitation rates of 73 and 80% in 1980 and 81, respectively, in the Herring River in Massachusetts. Both studies were conducted in streams in which the entire alewife run could be diverted into catch facilities. These data demonstrate that fishing mortalities in relatively stable runs in northern states can be extremely high without causing stock declines. In Rhode Island, draught conditions often result in a lack of sufficient outflow from certain drainage systems with dams to permit emmigration by juveniles or spawned-out adults. In such cases, mortalities of 100% occur (M. Gibson, pers. comm.).

Some limited data on juvenile mortality rates are available. Richkus (1974b) reported mortality rates of 75% of juveniles over a 6-week period prior to emigration from a pond in Rhode Island.

Table IV-29. Mean survival and instantaneous mortality of adult male and female alewife (from PSEG, 1982b)

Location	Reference	Males					Females				
		IV-V	V-VI	VI-VII	VII-VIII	VIII-IX	IV-V	V-VI	VI-VII	VII-VIII	VIII-IX
Albemarle Sound and Tributaries, NC	Pate, 1973	0.55	0.28	0.30	0.25	-	0.77	0.66	0.46	0.22	-
Albemarle Sound, NC	Johnson et al, 1977	0.48	0.21	0.04	-	-	0.65	0.36	0.17	0.16	0.50
Scuppernong River, NC	Johnson et al., 1977	0.29	0.16	-	-	-	0.32	0.34	0.10	-	-
Meherrin River, NC	Johnson et al., 1977	0.77	0.25	0.07	-	-	-	0.47	0.15	0.66	0.50
Alligator River, NC	Johnson et al., 1977	0.31	0.07	-	-	-	0.36	0.23	-	-	-
Chowan River, NC	Johnson et al., 1977	0.72	0.26	0.04	-	-	-	0.37	0.25	-	-
Chown River, NC	Holland and Yelverton, 1973	-	0.16	0.66	0.50	-	-	-	-	-	-
Rappahannock River, VA	Tsimenides, 1970	0.76	0.35	0.26	0.08	-	0.77	0.48	0.63	0.18	-
Potomac River, VA	Tsimenides, 1970	0.96	0.65	0.34	-	-	0.67	0.90	0.38	0.31	-
Delaware River, NJ	Present Study	0.41	0.60	0.33	-	-	0.52	0.40	0.25	0.50	-
Parker River, MA	Mayo, 1974	-	-	-	0.27	0.20	-	-	-	-	-
Connecticut River, Ct	Marcy, 1969	-	0.75	0.31	-	-	-	-	0.61	0.10	-
Long Pond, ME	Havey, 1961[a]	0.39	0.19	-	-	-	0.39	0.17	-	-	-
Mean Survival (S)		0.56	0.32	0.26	0.27	-	0.55	0.43	0.33	0.30	-
Instantaneous Total Mortality (Z)		0.5798	1.1394	1.3471	1.3093		0.5978	0.8440	1.1087	1.2040	

[a] Marcy (1969) indicated that Havey counted the freshwater mark as an annulus.

Table IV-30. Estimated mean survival rates of adult male and female blueback herring (from PSEG, 1982a)

Location	Data source	MALES					FEMALES					
		IV-V	V-VI	VI-VII	VII-VIII	VIII-IX	IV-V	V-VI	VI-VII	VII-VIII	VIII-IX	IX-X
Albemarle Sound and Tributaries, NC	Pate, 1973	0.83	0.42	0.21	0.05	-	-	0.44	0.33	0.05	-	-
Albemarle Sound, NC	Johnson et al., 1977	0.53	0.29	0.15	0.10	-	0.83	0.35	0.22	-	-	-
Scuppernong River, NC	Johnson et al., 1977	0.29	-	-	-	-	0.44	0.10	-	-	-	
Meherrin River, NC	Johnson et al., 1977	-	0.45	0.15	0.11	-	-	0.94	0.30	0.10	-	-
Tar River, NC	Frankensteen, 1976	-	0.34	0.30	-	-	-	0.52	0.16	-	-	-
Alligator River, NC	Johnson et al., 1977	0.39	0.07	-	-	-	0.92	0.09	-	-	-	-
Chowan River, NC	Johnson et al., 1977	0.47	0.10	0.14	-	-	0.70	0.23	0.20	-	-	-
Chowan River, NC	Holland and Yelverton, 1973	-	0.91	0.45	-	-	-	0.33	-	-	-	-
Rappahannock River VA	Beal, 1968[a]	-	-	0.42	0.22	0.17	-	-	0.66	0.21	0.57	0.25
Susquehanna River, PA	Petrimoulx et al., 1980	0.93	0.30	0.05	-	-	-	0.31	0.13	0.20	-	-
Delaware River, NJ	Present Study 1981	-	-	0.50	-	-	-	0.46	0.56	0.40	-	-
Connecticut River, MA	Scherer, 1972	0.40	0.36	0.14	-	-	-	0.28	0.06	-	-	-
Connecticut River, CT	Marcy, 1969	-	0.31	0.37	-	-	-	-	0.74	-	-	-
Thames River, CT	Loesch and Lund, 1977	-	0.26	0.09	-	-	-	0.30	0.39	-	-	-

[a] Beal counted the freshwater mark as an annulus.

As estimated by Loesch and Kreite (1980), daily juvenile mortality rates in Virginia have a mean of 0.03.

The various mortality data just discussed have many different implications for management. The most dramatic data are the fishing mortality rates for runs in Maine and Massachusetts. Those studies reveal that stable and sustained yields can be generated from runs that encounter extremely high fishing mortality rates. The species must have very high reproductive potential for runs to remain viable under those conditions, which in turn suggests that fishing mortality may have a limited impact on subsequent year-class strength. The summary of North Carolina CPUE data presented earlier (Table IV-6) suggests that overharvest and perhaps, more significantly, harvest of sub-adults in offshore waters can reduce stocks to a level at which ready recovery is not possible. In these circumstances, high fishing mortality exerted on the nonreproductive segment of the popuation may, in fact, have had a significant impact on run stability.

Spawning Habitat Characteristics

The nature of habitats used for spawning along the east coast by river herring appears to differ in a regionally distinct way. In the New England states, where alewife make up the majority of river herring stocks, the majority of production comes from spawning in ponds that are accessible to spawning adults. In the mid Atlantic and more southern states, the majority of spawning appears to take place in rivers, small streams, or tidal waters. In North Carolina, swamps appear to be a dominant spawning area. One exception to this general pattern is in the Santee-Cooper system, where blueback utilize impoundments as spawning and nursery grounds. It has been suggested that blueback do not utilize ponds as spawning areas in the north due to competition with alewife (J. Loesch, pers. comm.); however, this observation is not documented in the literature.

Population Dynamics

Havey (1973) reported a strong correlation between the number of juvenile alewives produced and the numbers of adults returning four years later. This suggests that year-class size is set by the time larvae reach the juvenile stage.

The most precise information on the reproductive potential of river herring stocks comes from the results of restoration programs, which will be discussed in the next section of the report. These restoration programs demonstrate the capability for stocks of both blueback herring and alewife in individual drainage systems to increase dramatically when access to previously unexploited spawning and nursery habitats is opened (e.g., Richkus, 1974a), and thus exhibit a high intrinsic rate of increase. Some data from Maine (Walton, 1981) suggest that there is a saturation of such habitats under conditions of high adult spawning stock; that is, at these higher abundances, larger numbers of spawning adults produce fewer juveniles per adult. Such a response might be the case where limited acreage areas are the major nurseries for the stock. However, observations such as those reported by Walton (1981), may not have accounted for the unobserved early migration of large numbers of small juveniles which has been reported to occur under circumstances of very high juvenile density (Richkus, 1974b). The hypothesis posed in this case was that high densities of juveniles cropped zooplankton to very low levels. A lack of forage resulted in early migration of large numbers of juveniles which could then utilize estuarine areas as nursery. Such a phenomenon would yield population dynamics behavior contrary to that hypothesized by Walton. M. Gibson (R.I. Div. of Fish and Wildlife, pers. comm.) has detected a 4.5 year cycle in some alewife runs in Rhode Island, which is consistent with the age of maturity of Rhode Island stocks and a pattern of stock-dependent recruitment, and supports the hypothesis described by Richkus (1974b). A weak relationship between spawning stock size and juvenile production was reported by Havey (1973) for an alewife run in Maine.

In non-pond types of spawning habitats, such as open estuarine tidal freshwater, habitat limits may not be the major controlling factor on river herrings stocks. In such cases, environmental variation may in fact play a major role, as is suggested for American shad. Insufficient data are available for runs of either species of river herring to document the nature of long-term fluctuations in stock abundance or to investigate the factors that would influence those fluctuations.

Ecological Importance

In most drainage systems along the east coast, juvenile river herring represent the major planktivorous species present in the nursery areas during spring and summer. Juvenile alosids have been shown to have a large impact on zooplankton abundance and species composition through predation (Brooks, 1968; Wells, 1970).

Juvenile alosids may also serve as a major forage species for many important game species. As an example, the work being done on blueback herring by Bulak (1977) in the Santee-Cooper River system in South Carolina is, in part, a function of their perceived importance as forage for striped bass. In many New England states (e.g., Rhode Island), gravid adult alewife are planted in ponds inaccessible to spawning runs, to provide juveniles as forage for resident game species, such as large mouth and small mouth bass, and enhanced growth rates of those species have been observed (M. Gibson, pers. comm.).

H. RESTORATION PROGRAMS

Extensive restoration activities have occurred in the New England states in recent decades. These efforts, which are directed primarily at alewives, have involved construction of fish passage facilities at numerous mill dams on small streams as the primary management activity. Gravid spawning adults taken from existing runs are then stocked in the newly accessible ponds, and their progeny serve as the initial spawning run 3 to 5 years later. Less extensive efforts at restoration have been made in the middle and southern mid-Atlantic and southern states. In some cases (i.e., Virginia) the nature of the major spawning in nursery areas (the large riverine and estuarine freshwaters) rule out active restoration efforts such as those occurring in New England. In other states, where restoration in the ponds through establishing fish passage facilities and stocking of adults might be feasible, the species has not been considered of sufficient importance or need to initiate such activities.

Restoration projects initiated in Maine involved the installation of fishways and the stocking of gravid adults. These projects are listed in Table IV-31. Limited data are currently available on the quantitative success of these restoration efforts on the Royal River. An estimated 50,000 fish returned to the Royal River in 1981 four years after the initial stocking of Sabbathday Lake with subsequent runs of 24,160 in 1982 and 10,029 in 1983 (T. Squiers, pers. comm.).

In New Hampshire, restoration efforts have been made on six coastal streams. The most successful of these efforts has been on the Lamprey River, where after nine years a run of over 50,000 fish has been established (Fig. IV-11). A substantial run may have also been established on the Exeter River, with a 1981 run size of over 15,000 fish but a dramatic decline to less than one thousand in 1982 and 1983.

At least 20 streams in Massachusetts are currently being stocked with gravid adult alewives, with a total of 36,000 fish transported in 1981. The intent of this effort is to establish new runs or augment declining runs. From 1971 to 1979, eight new fish passage facilities were constructed. While no data are available to determine quantitative success of these restoration efforts, the first fish passage facility on the Merrimack River at Essex Dam in Lawrence successfully passed alewife and shad in 1983 (DiCarlo, 1982). At the Holyoke Dam fishlift on the Connecticut River, the number of blueback

Table IV-31. Fishway and stream improvement projects in Maine (adapted from Flagg, 1981)

PROJECT NAME	COMPLETION DATE	WATERSHED	LOCATION TOWN	MILES OF STREAMS MADE ACCESSIBLE	ACRES OF LAKES MADE ACCESSIBLE	SPECIES UTILIZING FISHWAYS
Flanders Stream	1969	Flanders Stream	Sullivan	5.1	537	Alewives, brook trout
Winnegance Lake	1970	Kennebec River	Phippsburg	1.3	137	Alewives
Bristol Mills	1971	Pemaquid River	Bristol	7.9	2449	Alewives, brown trout
Chemo Pond	1971	Penobscot River	Bradley	15.0	1146	Alewives, brook trout
Boyden Lake	1972	Little River	Perry	9.3	1702	Alewives
Coleman Pond*	1972	Ducktrap River	Lincolnville	0.2	198	Alewives, brook trout
Bridge Street Dam	1974	Royal River	Yarmouth	0.7	13	Alewives, brook trout, brown trout
Elm Street Dam	1981	Royal River	Yarmouth	--	340	
Pitcher Pond	1974	Ducktrap River	Lincolnville	3.8	473	Alewives, brook trout
West Bay Pond	1974	West Bay Stream	Gouldsboro	4.6	249	Alewives, brook trout
Gardner Lake	1976	East Machias River	East Machias	6.0	5536	Alewives, land-locked salmon, Atlantic salmon
Blackman Stream	1978	Penobscot River	Bradley	Fish passage improvement below Chemo Pond Fishway		
TOTALS				53.7	12,440	

*Indicates removal of old dam. All other projects were Denil fishways constructed over dams.

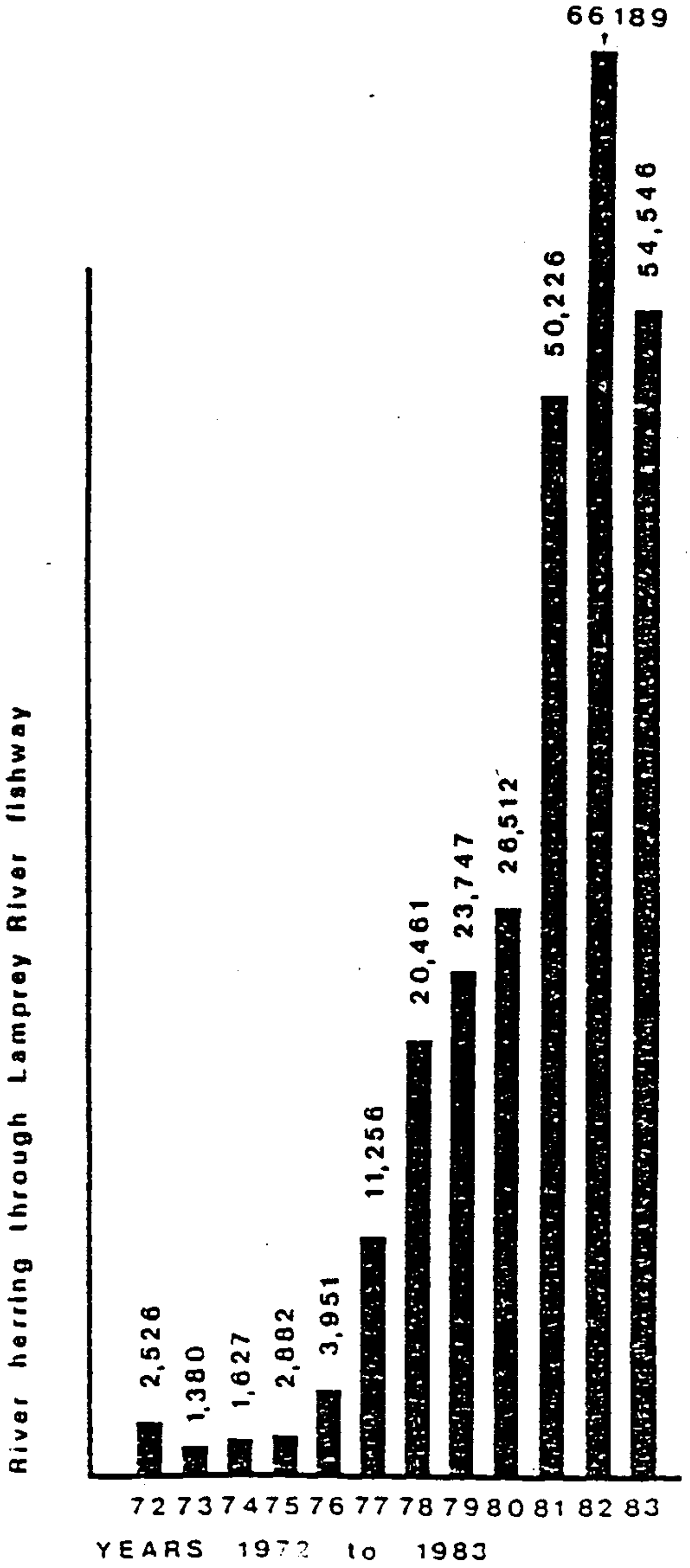

Figure IV-11. Lamprey River alewife run size, 1972 to 1983 (from Greenwood, 1983) herring lifted over the dam increased dramatically between 1974 and 1981 (Table IV-32). These data suggest that restoration has been highly successful in increasing the run size. However, the increase in lift numbers can also have been influenced by the increased efficiency of operation of the fishlift, or by a shift in the distribution of spawning blueback herring in the Connecticut River. Crecco (pers. comm.) found an apparent upstream shift in the center of distribution of larval blueback herring in recent years, which corresponds to the higher numbers of fish being lifted over the dam.

Numerous fishways were constructed in Rhode Island in the late 1960's and early 1970's. Runs were established by stocking gravid adults; the accomplishments of several of those projects are presented in Table IV-33. Several of these runs had become quite extensive in size in the past decade. However, due to a subsequent decrease in restoration efforts and a lack of completion of developing access to major portions of some of the drainage systems, runs have declined in more recent years.

In South Carolina, work is currently underway to preserve the existing blueback herring run in the Santee-Cooper system from any impact caused by the Santee-Cooper Rediversion Project (e.g., Bulak, 1981). Rediversion of substantial flow from one river to the other as a result of this project may alter the distribution of blueback herring stocks in those drainage systems. While not specifically a restoration program, this work involves investigation of fish utilization of the river systems and upstream reservoirs.

In Maryland, surveys of streams supporting anadromous fish runs have been made, and obstructions to migratory passage noted (e.g., Odell et al., 1975). While no current activity relating to removing these obstructions is underway, some future action is anticipated. No explicit river herring restoration efforts are known to exist in the remainder of the states. Potential for restoration has been examined for the Susquehanna (Maryland, Pennsylvania, New York) and James (Virginia) Rivers (e.g., Atran et al., 1983). In many of the east coast states, fish appear to be sufficiently abundant or fisheries are of such a limited extent that extensive restoration efforts are not considered justifiable.

I. ENVIRONMENTAL AND WATER QUALITY EFFECTS ON STOCKS

Major kills of river herring have occurred in various locations along the east coast, some explained and some unexplained. Commonly, large kills have occurred in circumstances of high densities in restricted areas during spawning runs, resulting in excessive oxygen consumption and subsequent asphyxiation.

Table IV-32. Anadromous fish passage recorded at the Holyoke Dam lift since 1955

Year	American shad	Blueback herring	Atlantic salmon	Striped bass
1955	4,900	0	0	0
1956	7,700	0	0	0
1957	8,800	16	1	0
1958	5,700	29	1	0
1959	15,000	20	0	0
1960	15,000	796	2	0
1961	23,000	1,200	0	0
1962	21,000	191	0	0
1963	30,000	32	0	0
1964	35,000	13	0	0
1965	34,000	53	0	0
1966	16,000	54	0	0
1967	19,000	356	0	0
1968	25,000	a	0	0
1969	45,000	10,000b	0	0
1970	66,000	1,900	0	0
1971	53,000	302	0	0
1972	26,000	188	0	0
1973	25,000	302	0	0
1974	53,000	504	0	0
1975	110,000	1,600	1	0
1976	350,000	4,700	1	0
1977	200,000	33,000	2	0
1978	140,000	38,000	23	0
1979	260,000	40,000	19	103c
1980	380,000	198,000	118	139c
1981	380,000	420,000	319	510
1982	290,000	590,000	11	231
1983	528,000	454,000	25	346

a not counted
b estimated
c all immature

Source: Modified from Moffitt, C.M., B. Kynard, and S.G. Rideout. 1982. Fisheries 7(6):2-10.

Table IV-33. Summary of some anadromous fish projects in Rhode Island, 1968-1975 (from data provided by R.I. Division of Fish and Wildlife).

Location	Date	Cost	Information (as of 1983)
Hamilton ladder	1968	$34,000	Alewife run established - 10,000
Peacedale ladder	1969	52,730	Alewife run established - 10,000
Wakefield ladder	1970	38,000	Same as Peacedale.
Bellville ladder	1971	41,000	Same as Peacedale.
Nonquit ladder	1972	26,710	Alewife run 300,000 established; 1,000,000 potential.
Forge Road ladder	1975	39,000	Alewife run of 10,000 established; 150,000 potential.
Bradford ladder	1980	42,000	Alewife run of 50,000 established; 1,000,000 potential.
Potowonut ladder	1982	67,000	Alewife run of 10,000 established; 150,000 potential.

In Maryland, kills of river herring occurred in the Susquehanna River below Conowingo Dam in the 1960's. These kills occurred during the spring spawning run, when turbine output from the dam was shut off in the evening, and fish were trapped at high densities in isolated pools below the dam. Oxygen was reduced to lethal levels and kills occurred (Carter, 1981). In subsequent years, the utility operating the dam has continuously released 5,000 cfs water during the spawning period for anadromous species, and kills have not recurred at those times.

In the Connecticut River, several large kills of blueback herring occurred in the estuarine portion of the river in 1960's and 1970's (Moss et al, 1976). Analyses suggest a number of causative factors (e.g., temperature fluctuations, low dissolved oxygen) though definitive explanations were never arrived at. However, the authors concluded that further deterioration of water quality in the Connecticut River could threaten blueback herring stocks. Occasional kills of river herring have occurred in the Delaware River, associated with the pollution block in the Philadelphia and Camden area. No relationship between these kills and subsequent stock levels has been established. Algal blooms and subsequent oxygen depletion on the tidal Potomac River in Maryland resulted in numerous fish kills in the early 1960's. A number of species, including river herring were involved in those kills (Md. DNR). After construction of the Blue Plains Sewage Treatment Plant, discharge of nutrients in the Potomac was significantly reduced, and algal blooms and related oxygen depletion was decreased. Fish kills have not occurred in recent years. In Virginia, Loesch (1981) documented the elimination of Alosa runs in the Pohick Creek which may have been related to high chlorine levels in sewage discharges into the creek.

On a number of estuarine systems along the east coast, impingement of juvenile alosids at power plant intakes has been recorded. In some cases, impingement rates are quite high for example, Indian Point, on the Hudson River (Texas Instruments, 19771981); and power plants on the Delaware River estuary (DBFWMC, 1981). Total magnitude of impingement mortality along the entire east coast has never been assessed. Individual large kills have occurred at numerous power plant sites, but in general, they represent isolated incidents. Regular impingement rates tend to be relatively low; however, the totals impinged over an entire migratory season might be substantial.

An additional environmental threat that appears to be increasing is the construction of small-scale hydroelectric (SSH) projects on numerous small streams along the northeast coast. SSH projects have been proposed for a variety of locations, such as roadway culverts, existing partially broken dams, old decommissioned projects, etc. Extensive reestablishment of hydroelectric sites on such streams without construction of fish passage facilities could reduce the total availability of river herring spawning habitat. While various documents have been prepared cataloging potential SSH sites in the eastern United States (e.g., USACOE, 1979), no assessment of cumulative effect on anadromous species has been made.

Because river herring runs historically occurred in virtually all small as well as large coastal tributaries, and since pollution of any tributary will have affected the single stock native to that tributary, the current absence of runs where they historically occurred (e.g., Zich, 1977) a posteriori demonstrates adverse effects of water quality degradation. However, the fact that runs occur in many widely dispersed tributaries provides evidence that the total stock of the region can respond to adverse environmental modifications.

Potential development of hydroelectric facilities in the Bay of Fundy was discussed in the American shad segment of this report. Such facilities pose a threat to many river herring stocks, should it be demonstrated that those stocks use the basins of the Bay of Fundy to the same extent as do American shad.

J. POTENTIAL MANAGEMENT OPTIONS

Aspects of River Herring Biology Pertinent to Management

Several aspects of the life history of alewife and blueback herring are particularly relevant to the potential value of different management actions. These include:

- Individual stocks return to their home streams to spawn, but under some circumstances (e.g., possibly in the Chesapeake Bay) there may be some mixing of stocks from tributaries in close proximity.
- Offshore migrations are not well defined; whether a nearshore northward migration of all east coast stocks occurs prior to spawning, as in the case of American shad, is not known.
- Most stocks along the coast exhibit capability for substantial repeat spawning, on the order of 40% of any given run; heavy exploitation of runs can prevent this capability from being expressed (e.g., in some Maine runs where exploitation is 90 to 95% of the run in any given year).

- Latitudinal gradients occur in size and age, but gradients are not strongly evident in other life history characteristics; therefore, no differences in specific management actions by region appear necessary. One latitudinal life history difference is the use of ponds as major spawning nursery habitats in the more northern states by alewives, as opposed to the use of swampy areas and rivers and streams as the predominant spawning area by southern stocks of both alewife and blueback herring.
- Runs of river herring are readily restored through the stocking of gravid adults and the provision of passage facilities over migratory obstacles.

Assessment of Impact on Populations of Various Management Options

Any regulations that would result in a reduction in harvest of river herring will increase the size of the spawning stock in any given year, and similarly will increase the number of fish appearing as repeat spawners in following years. An increase in spawning stock for a given year, however, may not result in increases in year-class strength in that year. The work done in Maine and Massachusetts, showing very high fishing mortalities, suggests that the number of spawners allowed access to the spawning and nursery area may under the existing circumstances have little effect on the number of juveniles produced. Thus catch reductions may not be related directly to subsequent recruitment to future runs.

Excessive exploitation of sexually immature fish while at sea, as occurred in the foreign harvests of river herring in the late 60's and early 70's, appears to have caused declines in the southern and mid-Atlantic river herring stocks. The effects may have been due primarily to the extremely high fishing mortality rate. In such circumstances, catch reductions may have a significant effect on future run sizes.

The limited nature of existing coastal fisheries would suggest that there may be little exploitation of nonresident river herring stocks in any of the east coast states. Because of the locations of pound nets at the mouths of major rivers supporting river herring runs, it is likely that nearly all harvests in that gear are of resident fish. Restrictions on individual state harvests would appear to have primary impact on runs occurring in those states.

On a tributary basis, water quality improvements would appear to be a means of establishing new river herring stocks or enhancing existing low-level stocks. Improvements on small tributary streams along the major drainage systems of the east coast may be a more tractable problem than water quality improvements on the large drainages such as the Delaware or

Hudson Rivers. While improvement of small tributaries may be more tractable, because of their size and the small size of runs using such streams, the net effect on total east coast stock size would be very limited unless a large number of streams were improved.

The comparative ease of restoring river herring populations, which has been demonstrated particularly well in the New England states, suggests that total abundance of river herring could be substantially enhanced if all suitable waters were made available for spawning.

Efficacy of Specific Regulatory Changes

- Gill net mesh sizes - Since most river herring fisheries are not sex-specific, the sex-related size differences would not enter into selection of mesh size by fishermen. In addition, in most fisheries, two year-classes (ages 4 and 5) make up most of the landings, and the size differences between these two age groups is minimal. For those fisheries in which gill nets are a prime gear, mesh size limitations are unlikely to have major impact on stock dynamics, since the degree to which discrimination occurs among sexes and age groups is very limited. Gill net mesh sizes would have greatest impact on limiting total harvest of river herring in mixed species fisheries as opposed to differentially affecting fishing mortality rates for different segments of river herring stock.

- Seasons - Runs of river herring occur within a certain time window during the year, but individual "waves" within that time period are triggered by fluctuations in water temperatures (e.g., Richkus, et al. 1976). Specifying fishing seasons within the spawning period window will have an unpredictable influence on fishing mortality in any given year because climatological conditions will trigger waves in unpredictable patterns. Therefore, it would not appear that setting of seasons for river herrings represents a useful regulatory approach for managing the fisheries, except for altering fishing pressure on one of the two species (since alewife run earlier than blueback herring).

- Gear type - The influence of gear type on river herring harvest is overwhelming. For example, no fishery exists in the state of Georgia because appropriate gears are illegal. Because of the low dollar value of river herring, large volumes must be harvested to establish a viable commercial fishery, and certain gear types are most appropriate for such large volume harvesting (e.g., pound nets, haul seines, and weirs). Restrictions on use of those types of gears would have a substantial effect on the total harvest of river herring.

- Locations of fishing - River herring are most susceptible to exploitation in restricted portions of their migratory routes or at migration barriers (e.g., below dams and fish passage facilities). Fishing mortality can be altered drastically by permitting or restricting exploitation in those areas where potential for harvest is highest. Such regulatory activity, when combined with gear restrictions, has the greatest potential for altering harvest of these species.

- Lift or closed periods - Lift or closed periods would be most appropriate as a regulatory action in locations where the fisheries are located on the restricted portions of migratory routes or on the spawning stream itself. The "wave" nature of the migratory pattern may produce some uncertainty in the total effect of closures from week-to-week or year-to-year. For example, should a two-day per week closure period occur during a "wave," escapement will be extremely high, whereas if the closure occurred during a relatively low migration period, escapement will not be enhanced substantially. On the average, however, it is reasonable to assume that escapement would approximate the same proportion of the run as closure does, for a given time period. Lift periods have been used in the management of river herring since the 1800's in many areas along the east coast.

- Catch quota - Quotas would only be a reasonable regulatory approach if the size of the spawning stock in a given year was predictable, and if the magnitude of desirable escapement was defined. Both of these factors are unlikely to be well defined for river herring fisheries. For this reason, the use of quotas in management would only be valuable as a means of allocation of harvests, in contrast to providing a means for manipulation of subsequent recruitment.

- Restricted entry - In cases where the fisheries are dominated by large-volume harvest gear (e.g., pound nets, haul seines) in a restricted waterway, limiting the number of licensed fishermen may control the total harvest. However, the consequence of restricted entry is dependent on how it impacts on other aspects of the fisheries, such as the amount of gear used and the total effort expended by the individual fishermen. In the majority of river herring fisheries, restricted entry could have substantial impact on total harvests.

K. DATA DEFICIENCIES

While acquisition of accurate catch-and-effort data may be desirable, it may only be feasible to obtain such information for the major components of the fisheries, such as the pound netters, haul seiners and the weir fisheries, where a fairly small number of fishermen are harvesting a major portion of catch. Catch-and-effort data for these fisheries may be useful for establishing an index of stock abundance. However, it is unlikely that accurate harvest data could be acquired for the other users of these individual species, including the sport fishermen, dip netters, and the segment of the user groups taking small amounts on a continuous basis. It would be desirable to establish the magnitude of harvest of these multiple small users. Another factor making acquisition of the latter type of data difficult is the widespread nature of the runs and the occurrence of runs on many small streams.

Long-term juvenile index data would be desirable as an index of stock abundance if it could be demonstrated that the indices collected were acquired in an appropriately designed study program, and if the validity of the indices as representing spawning success was demonstrated by a subsequent correlation with harvests. Difficulties may arise in establishing meaningful juvenile indices due to the widespread nature of river herring runs in many drainage systems. Because fish tend to spawn in large rivers as well as in small tributaries of those rivers, the design of a survey which would provide representative data must be considered carefully. The absence of catch composition data for most runs in prior years has limited the capability for demonstrating correlation between the juvenile index and subsequent harvests.

Information on the coastal migration patterns of river herring and development of techniques that discriminate between different stocks would provide a means of determining where regional stocks may be vulnerable to exploitation when off the spawning grounds. Such information would also provide an indication of the magnitude of fishing mortality experienced by different regional stocks.

Information on the population dynamics of river herring stocks throughout their distribution along the east coast would contribute to an understanding of the influence of spawning stock size on year-class successs. This information is needed to establish desirable escapement rates and thus establish allowable harvest levels. Differences in population biology by latitude or by the nature of spawning habitat (e.g., pond spawners vs tributary spawners) would permit establishment of stock-specific management actions.

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APPENDIX A

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APPENDIX B

Summary of shad fishing laws and regulations

Year	Season	Closed days and areas	Net regulations	Recreational
Georgia				
1983	Jan. 1 through April 31	Two or three day closures, differing by river.	4 1/2 inch stretch mesh. Set nets only in main channel, no longer than 100 feet and not extending over more than half the stream width. Drift nets not longer than 10000 ft.	Must have fresh-water fishing license. Limit is 8 shad/day each fisherman limited to two poles and lines each. Bow nets allowed with minimum mesh.
Rhode Island				
1983	unknown	Pawcatuck and Wood Rivers	Unlawful to net.	Hook and line only, limit is 6 shad/day.
New Jersey				
	November 1 to April 30		AREA 1 Delaware Bay and the Marine portions of its tributaries:	Hook and line and bows. License required.

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
	March 15 to December 15		Haul seine, minimum mesh 2-3/4" stretched; no longer than 70 fathoms. Fyke net, minimum 3" stretched (net and leaders); no longer than 30 fathoms (including leaders).	
	February 1 to May 15		Run around net, minimum mesh 2-3/4" stretched; no longer than 200 fathoms.	
	February 15 to May 15		Shad gill net, (drift, stake, or anchor) minimum mesh 5" stretched.	
	March 1 to December 31		Pound net, minimum mesh 2" stretched.	
	March 1 to December 31		Wire pound net, not to exceed into Delaware Bay more than 300' from MLW mark, or 300' from outside of the flats, which fall bare of MLW.	
	September 1 to May 31		Parallel net, minimum 3-1/2" stretched, may be set only along low tide line parralel to shore.	

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
		2 p.m. Saturday until midnight Sunday	AREA 2 Delaware River between Penn. and New Jersey below Trenton Falls.	Rod and lines or hand lines must have three or less hooks. All bows acceptable
	Open		seine - none	
	Open		gill net - none	
	July 1 to June 1		eel pot or fyke net, without wings, max. entrance diameter 6" max. outside diameter 30".	
	September 1 to May 31		parallel net or stake net at edge of low water, min. mesh 3-1/2" stretched.	
			Delaware River between Penn. and New Jersey above Trenton Falls.	Maximum of three lines fished at once. All bows acceptable
	Open		seine	

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
	July 1 to June 1		eel pot or fyke net, without wings, max. entrance diameter 6", max. outside diameter 30".	
		2 p.m. Sat. to midnight Sun.	AREA 3 Fresh tidal (portions of tributaries to the Delaware Bay between New Jersey and Delaware.	
	February 1 to June 15		drifting gill net min. mesh 5-1/4" stretched.	
	April 1 to November 30		haul seine min. mesh 2-3/4" stretched, max. length 70' fathoms.	
		2 p.m. Sat. to midnight Sun.	AREA 4 Fresh tidal tributaries to the Delaware River between Penn. and New Jersey.	Hook and line and bows. Licence required.
	March to June 10		seine min. mesh 2-1/2" stretched; drifting gill net min. mesh 5-1/4" stretched.	

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
Delaware				
1982	Feb. 1 to June 10	No fishing from 12:00 noon Sat. to 12:00 midnight Sun. in any Delaware Bay tributary from Blackbird Creek to one-mile south of Mispillion River; Broadkill River - no shad fishing from noon Sat. to sunrise Mon.	Delaware River and Bay: Minimum mesh size 5 1/4 inches stretch Other waters including tributaries of Delaware Bay: Haul seine, fykes, pound nets - minimum mesh 2-inches stretch; gill nets - minimum mesh 3-inches stretch; Maximum length 300-yards in Indian River & Bay, Rehoboth Bay or their tributaries	Tidal waters: Hook and line and spearguns Nontidal waters: Hook and line only; one hook per line
Maryland				
Prior to 1982	Jan. 1 to June 5		None	
1980	Unknown	All Maryland waters except the Potomac River.	None	Closed in all Maryland waters except the Potomac River.
1982	Closed	All Maryland waters	None	Closed

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
Virginia				
1982	Unknown (only on James River)	None	Pound net: minimum mesh 51 mm. Haul seine: maximum length 914 meters; longer than 183 meters minimum mesh 76 mm. Maximum length of fishing structure in Chesapeake Bay 366 meters with minimum of 61 metes between successive structures and 274 meters between adjoining rows of structures. No net set across any river, bay, estuary, creek or inlet longer than one forth the width of the body of water and net shall not be fished more than 1/2 the distance across the channel of water.	Unknown
South Carolina				
1978	Below 40-mile limits: Feb. 1-March 25 Horry County, above 40-mile limit: Feb. 1-May 4	Days - Savannah River: upstream of Interstate 95, Sunday, Monday, and Tuesday closed; downstream of Interstate 95, closed Saturday, Sunday, and Monday	Savannah River: set issuing procedure changed to allow renewal of previously held sets the first 15 days of new licensing year; only 2 sets per household	No creel limit Hook and line season Feb. 1 to May 1. skimbow season Feb. 1 to May 1.

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
	Edisto River, above 40-mile limit: Feb. 1-April 20 Savannah River: Jan. 15-April 15 All other areas, above 40-mile limit: Feb. 1-April 30	Game Zone 5 and 8: 1 hour after official sunset Sunday to Wednesday noon Game Zone 7, Berkeley, and Williamsburg counties: Saturday noon-Monday noon All other areas: Saturday noon-Tuesday noon Areas - Savannah River: fishing prohibited in North Channel of Savannah River downstream from New Savannah Cut and in Back River Cooper River: gill net fishing prohibited in either branch of river or its tributaries from upper "T's" inland Combahee River: closed from US Hwy. 17 seaward Area within the 3 mile limit seaward of Winyah Bay closed to stake and anchor nets	Savannah River: minimum mesh size increased to 4 1/2 inches; maximum mesh size set at 5 1/2 inches stretched mesh Georgetown County: no drift net to exceed 1/2 width of stream between mouth of Waccamaw River and Butler Island Black and Waccamaw Rivers: net length limited to 200 yds. from mouth of either river to 40-mile limit Edisto River: registered sets issued to licensed fishermen with option to renew each licensing year (15 day grace period); no more than two sets per household All streams minimum mesh 5 1/2 inches stretched One half of stream must remain open Minimum of 200 yds. between nets Unlawful for net to remain on bank of stream for more than 3 days after close of season	

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
New York				
1983	March 15 to June 15 in Delaware and Hudson Rivers	"The Flats" in the Hudson River. Others to be established by the Dept. of Environmental Conservation.	Drift gill nets not to exceed 2,000 ft. in length. Other nets not to exceed 1200 ft. in length. Minimum mesh 2-1/2" stretched.	Unknown
		In river estuary no net shall be fixed within 1500 feet of any other licensees net.	Operation of nets is permitted in tidal portions of the Hudson River and tributaries up to the first impassable barrier. Dip nets are also permitted in the Mohawk River upstream of the City of Rome, New York.	
North Carolina				
	None	None (Limited in one small area)	None	None
Connecticut				
1983	April 1 to June 15	Friday sundown to Sunday sundown Thames River: gill net fishing prohibited	Gill net: minimum mesh size 5 inches stretched mesh.	Hook and line 6 fish only daily limit.

Summary of shad fishing laws and regulations (Continued)

Year	Season	Closed days and areas	Net regulations	Recreational
Rhode Island				
1983	None	No shad may be taken from the Pawcatuck and Wood Rivers.	No harvest allowed except by hook and line.	Hook and line only; six fish daily limit
New Hampshire				
1982	None	Fishing permitted upstream (north) of Memorial Bridge in Portsmouth.	Unlawful to net	Hook and line only.

APPENDIX C

ASMFC Letter on Bay of Fundy Hydroproject Concerns

Atlantic States Marine Fisheries Commission
1717 Massachusetts Avenue, N.W.
Washington, D. C. 20036

July 13, 1983

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Vice Chairman
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New Hampshire
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Executive Director
IRWIN M. ALPERIN
(202) 387-5330

Hon. Robert A. Jones, Chief
Fisheries Unit - Room 255
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State Office Bldg.
Hartford, CT 06106

Dear Bob:

I have been asked to bring to your attention a matter of grave concern to the members of the Atlantic States Marine Fisheries Commission's Interstate Fisheries Management Policy Board. This Board is comprised of administrators of the Atlantic Coast states fisheries agencies and the National Marine Fisheries Service and is dedicated to the management of interjurisdictional marine and anadromous fisheries. Recognizing the value of stocks of American shad and river herring, this organization recently authorized the development of a plan for the interstate management of these species and created a management board and scientific and statistical committee for this purpose.

Recent evidence presented to these bodies of administrators and scientists indicates the potential for a very serious problem that could impact all of the coastal stocks of American shad from Canada to Florida. This evidence, presented at the 1983 Northeast Fish and Wildlife Conference in May of this year by Dr. Michael Dadswell and associates of the Canadian Department of Fisheries and Oceans, shows that American shad from nearly every river system in eastern North America utilize the Bay of Fundy, and in particular the areas known as Minas and Cumberland Basins, as summer feeding grounds. Proposals for the development of tidal power projects within these basins are being considered by Canadian power companies and associated regulatory agencies. It is clear that these projects, when operational, will cause appreciable mortalities among these shad stocks. It has been estimated that repeated passage through turbines at these installations could cause the mutilation of as high as 90% of the shad present. Since it has been demonstrated that up to one third of the total Atlantic Coast shad stocks can be found in these areas during the summer feeding period, severe adverse impact can be expected from the operation of the planned facilities.

In recognition of the importance of these feeding grounds within the Bay of Fundy and the potential hazard that tidal electric generation barriers can represent to shad stocks (and other fishes such as river herring, sturgeon, and striped bass utilizing this area), I wish to express the concerns of the Interstate Fisheries Management Policy Board with these projects. We urge that full consideration be given to the extremely serious ecological damage that such projects could cause. Due consideration must be given to the anticipated economic losses to Atlantic Coast commercial fishermen, and to the full economic ramifications of these projects on the burgeoning sport fisheries these stocks now support. Other issues which should be explored fully by appropriate agencies include the effects of these tidal power projects on migratory waterfowl, and coastal impacts as far south as Boston, Massachusetts caused by permanent changes in normal tidal amplitudes.

We bring this matter to your attention in the hope that you will use whatever influence or authority you may have to assure that adequate consideration is given to this grave situation.

Sincerely

Irwin M. Alperin
Executive Director

/s

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APPENDIX B

SUMMARY OF INDIVIDUAL STATE'S FISHERIES REGULATION DEVELOPMENT PROCESS

State	Regulatory authority	Regulatory process (route)	Office responsibility	Regulatory time constraints	Anticipated problems
Maine	Dept. of Marine Resources	Dept. of Mar. Res.→public hearing→Advisory Council→ Commissioner of Mar. Res.→ promulgated	Dept. of Mar. Res.: Collects information and drafts proposed regulation. Advisory Council: Composed of 8 members of the commercial fishing industry and 1 member representing recreational fisheries, all appointed by the Governor. Reviews pertinent comments discussed at the public hearing and if acceptable, incorporates them into the proposed regulation. Council advises the Commissioner of Mar. Res. on the nature of the regulation. The advice of the Council is binding on the Commissioner. Commissioner of Mar. Res.: Through advise from the Advisory Council, the Commissioner either approves or disapproves the proposed regulation.	The only mandated time constraint deals with the public hearing process. Announcements for the public hearing (in local newspapers), must be made 30 days prior to the hearing date.	No anticipated problems; the process is very streamlined. After the public hearing, the tasks involving the Advisory Council and the Commissioner of Mar. Res. are completed quickly.
New Hampshire	Fish and Game Dept.	Fisheries Dept.→Director of the Fisheries Dept.→Fish and Game Commission→Public hearing→ Joint Legislative Committee on Administrative Rules→promulgated.	Fisheries Dept.: Drafts proposed regulation and submits it to the Director. Director of Fisheries: Reviews proposed regulation; if approved the proposed rule is put on the agenda of the next Fish and Game Commission meeting (at least 2 weeks before scheduled meeting). Fish and Game Commission: Reviews proposed regulation. If approved the proposed regulation is published in the Register and open for public comment. A public hearing can be scheduled 20 days after the proposed regulation appears in the register, however, it is not necessary to have a public hearing. Joint Leg. Comm. on Admin. Rules: Approves or disapproves proposed regulation. If approved, the committee has 20 days to file the regulation. If disapproved, the Fish Dept. has 44 days to respond to the committee's decision. The Fish Dept. can either change the regulation or adopt it over the committee's disapproval (in which case the burden of proof would fall on the Fish Dept. to justify the regulation).	Announcement for the public hearing must be made 20 days prior to the hearing date. If Joint Leg. Comm. on Admin. Rules approves regulation the maximum time to submit the regulation for adoption is 30 days. If disapproved, the committee has 44 days maximum to present a final ruling. With no problems encountered a proposed regulation can go through the entire system in 3.5 months.	No anticipated problems.

State	Regulatory authority	Regulatory process (route)	Office responsibility	Regulatory time constraints	Anticipated* problems
Massachusetts	River Herring: Div. of Marine Fish./Local Gov.	Public meetings→Marine Fish. Advisory Commission→Local Gov.→Promulgated	Public Meeting: Local gov. gets together and petitions the Marine Fish. Advisory Comm. to allow them to institute regulations and manage the local fishery. Marine Fish Advis. Comm.: Reviews local government proposed management plan (regulations included), confers with Div. of Mar. Fish. biologists and approves or disapproves petition (they usually agree). Local Government: Manages local fishery, setting all regulations. Local governments are allowed to change regulations and are not required to inform the Div. of Mar. Fish.	There are no time constraints.	Any new regulations have to be approved by the governing body (typically the local gov.). They would then have to be persuaded to follow the wishes of the Div. of Mar. Fish. If at anytime they do not agree with the proposed or existing regulations they (the regulations) can be dropped.
	American Shad	Inland Fisheries→Public hearing/Bd. of directors→Secretary of State→promulgated	Inland Fish: drafts proposed regulation. Bd. of Directors: Governor appointed; they review, approve or disapprove the proposed regulation and participate in the public hearing. If accepted, the proposed regulation is submitted to the Secretary of State for promulgation. Sec. of State: Enacts the regulation.	Announcement of the public hearing must occur 30 days prior to the hearing date.	No anticipated problems.
Rhode Island	Div. of Fish & Wildlife	Div. of Fish & Wildlife→Mar. Fish. Coun.→Public hearing→Mar. Fish. Council→Promulgated	Div. of Fish & Wildlife: Collects pertinent information and drafts proposed regulation. Marine Fish. Coun.: Comprised of citizens appointed by the Governor. Members include representatives of special interest groups (i.e., Comm. and Sport Fisherman, scientists, etc.). Council is a subgroup of the R.I. Coastal Mgt. Council. Council has authority to approve, disapprove, or require modifications to proposed regulation. After the public hearing, the proposed regulation is returned to the Council at which time the public's comments are discussed, and any modifications resulting from the hearing incorporated. If major modifications are required as a result of the public hearing the modified version must again go out for public hearing. If no modifications are made the proposed regulation must be filed within 20 days.	The only mandated time constraints deal with the public hearing process and the pre-promulgation period. Announcements for the public hearing must be made 30 days prior to the hearing date. Filing of the proposed regulation, after final approval must occur within 20 days after acceptance.	No anticipated problems, the process is very streamlined. After the public hearing, the tasks involving the Marine Fish. Council must be completed within 20 days.

State	Regulatory authority	Regulatory process (route)	Office responsibility	Regulatory time constraints	Anticipated problems
Connecticut	State Legislature	Bureau of Fish. → Comm. of Env. Prot. → Public Hearing → Bureau of Fish. → Comm. of Env. Prot. → Attorney General → General Assembly Regulations Review Committee → Secretary of State	Bureau of Fish.: Proposes regs; conducts public hearing(s); compiles and addresses public comments; prepares final proposed regs; submits to Comm. Env. Prot. for certification; prepares, and mails to interested parties, notice of availability of final proposed regs; submit to Attorney General, 30 days after mailing of notice; modifies proposed regs based on comments by Attorney General and submits to General Assembly Regulations Review Committee. Commissioner of Environmental Protection: Reviews proposed regs (Dep. Commissioner) issues statement of intent re: proposed regs and schedule of public hearings. Notice must be published in Law Journal 30 days prior to public hearing and in local newspaper not more than 30 nor less than 10 days prior to hearing. Certifies final proposed regulations. Attorney General: Reviews final proposed regs as to form and legal sufficiency. Must comment within 30 days. Regulations Review Committee: Approves final proposed regs. Must act within 60 days or approval automatic. May return regs for cause in which case agency may modify and resubmit or may reject outright in which case agency has recourse to the full General Assembly. Secretary of State: Files final approved regs.	Notice of public hearing must be published in Law Journal 30 days in advance of hearing date. Final proposed regs can not be submitted to Attorney General or Regs Review Committees for at least 30 days after notice of availability of final proposed regs is mailed to interested parties. Attorney General has 30 days for review. Regs Review Committee has 60 days to act or approval is automatic. Regs effective upon filing with Secretary of State or on a later date as may be indicated. Total maximum time 160 days.	No problems anticipated.
New York	Bureau of Fish.	Regional Fishery Managers → Bureau of Fisheries for review → Division Director for review and approval → Regional Fishery Managers for modification and public review → Bureau of Fisheries → Promulgated	Regional Fishery Managers: Draft proposed regulation and submit it to the Bureau of Fish. Upon approval by the Div. Director, incorporate changes into the proposed regulation and discuss the proposed regulation with the public (approximately 3 months). Submit the public's comments, if pertinent, to the Bureau of Fish. for review. Bureau of Fisheries: Contacts Regional Fishery Managers for suggested modifications to existing regulations or for the proposal of new ones. (This usually occurs in Nov.) Reviews the initial draft proposal submitted by the Regional Fish. Man. Reviews the proposed regulation after the public comment period and suggests modifications. Division Director: Reviews proposed regulation. If approved, it is sent back to the Regional Fish. Man. for incorporation of modifications (if needed) and public review. Reviews proposed regulation if public opposition is great.	Regional Fish. Managers: Submit proposed regulations in Nov. Div. Director: Makes 1st review and approval or disapproval by late Dec. Regional Fishery Managers: Contacts public and special interest groups from Jan.-March. Bureau of Fish: Makes final decision by April. Regulation is promulgated in April or May.	No problems are anticipated.

State	Regulatory authority	Regulatory process (route)	Office responsibility	Regulatory time constraints	Anticipated problems
New Jersey	Div. of Fish, Game and Wildlife	Fisheries Dept.→Fish and Game Council→Public hearing→promulgated.	__Fisheries Dept.__: Drafts proposed regulation and submits it to the Fish and Game Council. When needed, incorporates modifications into the proposed regulation. __Fish and Game Council__: Appointed by the Commissioner or elected to the Council. Reviews proposed regulation, suggests modifications, and if approved passes it on to the public hearing process. If modifications are needed the proposed regulation is sent back to the Fisheries Dept.	Public hearing must be announced 30 days in advance.	No anticipated problems.
Pennsyl-vania	Penn. Fish Commission	Fish. Dept.→Proposed regulation published in agenda of next commission meeting→Public Commission Meeting→Announced in Penn. Bull. as proposed regulations→Public Commission meeting for final adoption→promulgated	__Fish Dept.__: Submit proposed regulations to Public Commission at their request. __Public Commission__: Made up of 10 individuals appointed by the governor. Meet four times annually. Meeting are open to the public. Review and suggest modifications to the proposed regulation. If approved, the regulation is published in the Penn. Bull. for public review. The Commission will accept written comments from the public up until their next meeting (usually 3 months), at which time a final decision is rendered. If approved the proposed regulation is promulgated.	Time constraints are governed by the public commission's meeting dates (every 3 months).	No anticipated problems.
Delaware	Div. of Fish and Wildlife	Div. of Fish and Wildlife→Public hearing→Tidal Fish Advisory Council→Promulgated	__Div. Fish and Wildlife__: Draft proposed regulation. __Tidal Fish, Advisory Council__: Nominated by Governor and confirmed by Senate according to specifications in state statute. Appointees are usually members of special interest groups (i.e., recreational fishermen, commercial netters, etc.). Review proposed regulation and advise. However, if recommendation is to disapprove the proposed regulation it can still be promulgated.	Announcement of the public hearing must occur 20 days prior to the hearing date in one newspaper with general circulation.	No anticipated problems.

State	Regulatory authority	Regulatory process (route)	Office responsibility	Regulatory time constraints	Anticipated* problems
Maryland	Dept. of Natural Resources	Fish. Dept.→Secretary of Natural Resources→Published in MD Register→Public hearing and comment period (45 days after appearing in MD Register)→Published in MD Register for adoption→Enacted as law.	Fish. Dept.: Drafts proposed regulation and submits it to the Secretary of Nat. Res. Secretary of Nat. Res.: Reviews proposed regulation. If approved, it is published in the MD Register at which time the public has 45 days to comment. A public hearing may also held during the 45 day comment period. After the comment period (45 days) the proposed regulation is again published in the MD Register for adoption. However, if modifications to the proposed regulation after the public comment period are great, the modified proposed regulation goes through the public comment period again. The regulation is enacted 10 days after it appears in the MD Register for the second time.	The public comment period must last for 45 days. Total time for a proposed regulation to go through the system is approximately 90 days.	No anticipated problems.
Virginia	Div. of Mar. Res.	Div. of Mar. Res.→Mar. Res. Commission→Div. of Mar. Res. (for drafting of proposed regulation)→promulgated.	Div. of Mar. Res.: Approaches Mar. Res. Comm. about proposed regulation. If approved by the Mar. Res. Comm., the Div. of Mar. Res. must draft the proposed regulation and initiate the public hearing process. Marine Res. Comm.: A 7-man-board which reviews the proposed regulation for approval or disapproval. Two or three public hearings are held, the last being in front of the Mar. Res. Comm. at which time they give their final decision. If approved the Commission sets the date at which time the regulation will be enacted. The Mar. Res. Comm. can never adopt an amended form of the regulation that is more stringent than that proposed. Public Hearing Process: Can take 10 to 60 days depending on the immediacy of the matter. If regulation is to have a state wide effect 3 public hearings all held throughout the state the last in front of the Mar. Res. Comm. If the regulation is specific in nature, only 2 hearings are required, the last in front of the Mar. Res. Comm.	The public comment period can last between 10 and 60 days.	No anticipated problems.

State	Regulatory authority	Regulatory process (route)	Office responsibility	Regulatory time constraints	Anticipated* problems
North Carolina	Fisheries Dept.	Public→ Fisheries Commission→ Fish Dept.→ Public hearing→promulgated	A proposed regulation can be drafted by either the Fisheries Dept. or the public. Fisheries Commission: a 15 member Commission appointed by the Governor. Selection criteria states that one member must be a scientist, one must represent recreational fishermen, one must represent commercial fishermen, and one must represent dealers. This Commission makes the initial decision on whether or not to approve the proposed regulation and pass it on to a public hearing.	Announcement for the public hearing must be made 30 days prior to the hearing date.	If existing regulations are thought to be discriminatory special interest groups may propose modifications.
South Carolina	Legislative Action	Two possible routes: A. Dept. of Mar. Fish.→Mar. Adv. Bd.→S.C. Wild. & Mar. Res. Comm.→ Public notice→General Assembly for vote→Promulgated. B. County legislators draft regulations→House or Senate→S.C. Wild. & Mar. Res. Comm.→ Dept. of Mar. Fish.→S.C. Wild. & Mar. Res. Comm.→Public notice→ General Assembly for vote→ Promulgated.	Dept. of Mar. Fish.: Draft proposed regulation and submit it to the Mar. Advisory Bd. Review proposed regulation submitted to the S.C. Wild. & Mar. Res. Comm. by the House or Senate. Mar. Advisory Bd.: Reviews proposed regulation, makes changes, and if approved submits it to the S.C. Wild. and Mar. Res. Comm. S.C. Wild. & Mar. Res. Comm.: Composed of nine members, two of whom are the chairman of the Agricultural and Nat. Res. Committee of the State House of Representatives and the Fish, Game, and Forestry Committee of the Senate. Review proposed regulation and decide whether to release the proposed regulation for voting in the General Assembly. General Assembly: Votes on the proposed regulation. County Legislatures: Draft proposed regulations and submit it to the House or Senate, depending on which one he is a member of. House or Senate: Refers proposed regulation to the S.C. Wild. & Mar. Res. Comm.	There is a 45-day period between the time the public notice is given and the time it can be filed with the General Assembly. The General Assembly is given 90 days within which time it must act. If General Assembly approval or disapproval is not forthcoming during that period (90 days), the regulation goes into effect regardless.	Through pressure for special interest groups, County legislators may attempt to block proposed regulations, or propose modifications to existing regulations.

State	Regulatory authority	Regulatory process (route)	Office responsibility	Regulatory time constraints	Anticipated* problems
Georgia	Dept. of Nat. Res.	Coastal Res. Div.→Commissioner→Public hearing→Commissioner→Bd. of Nat. Res.→Secretary of State→Promulgated.	Coastal Res. Div.: Drafts proposed regulation and submits it to the Commissioner. Commissioner: Reviews proposed regulation, makes modifications, and disapproves or approves the proposed regulation for public hearing. After public hearing all comments and modifications are reviewed by the Commissioner, and if approved sent to the Bd. of Nat. Res. Bd. of Natural Resources: Votes on whether or not to accept proposed regulation. If accepted it is sent to the Secretary of State. Sec. of State: Holds for a filing period of 20 days at which time it is promulgated.	Announcement of the public hearing must occur 30 days prior to the hearing date. Sec. of State holds proposed regulation for a 20-day filing period before it is promulgated.	No anticipated problems.
Florida	Mar. Fish. Comm.	Mar. Fish. Comm.→Public hearing→Mar. Fish. Comm.→Governor's cabinet→promulgated.	Marine Fish. Comm.: Draft proposed regulation. Hold a public hearing on the proposed regulation and incorporate public comments (if pertinent) into the regulation. Pass the proposed regulation to the Governor's cabinet for approval. Governor's Cabinet: Review proposed regulation, make changes, and approve or disapprove the regulation. If disapproved it is sent back to the Mar. Fish. Comm. for modifications. If approved its promulgated	Announcement of the public hearing must occur 30 days prior to the hearing date.	No anticipated problems.

APPENDIX C

DOCUMENTATION OF RECENT ACTIVITY RELATING TO REGULATION OF OFFSHORE RIVER HERRING HARVEST

1. Memorandum dated 10 January 1985 from Jim McCallum, ASMFC, to S&S Committee members on joint venture applications to the Mid-Atlantic Council.
2. Position paper by W. Richkus submitted to the Mid-Atlantic Council.
3. Letter from Emory Anderson, NMFS, to John Bryson, Mid-Atlantic Council, dated 8 February 1985, presenting information on the magnitude, timing, and location of river herring bycatch.
4. Letter from John Boreman, NMFS, dated 7 March 1985, presenting information on offshore river herring harvest, 1971-1980.
5. Letter from W. Richkus to Paul Perra, ASMFC, on river herring data which should be acquired by NMFS.

Memorandum • ATLANTIC STATES MARINE FISHERIES COMMISSION

TO : Shad and River Herring Board and S&S Committee DATE 1/10/85

FROM : Jim McCallum, Council Liaison

SUBJECT: Mid-Atlantic Fishery Management Council Request Regarding River Herring Bycatch in the Atlantic Mackerel TALFF NUMBER M 85-3

The Scientific and Statistical Committee of the Mid-Atlantic Fishery Management Council on November 19, 1984 urged the Council to request an ASMFC recommendation on bycatch of river herring in relation to development of Amendment #2 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan (summary attached). At its December 5-6 meeting, the Council agreed to make this request.

The draft FMP amendment reads, in part, "...The foreign river herring fishery is managed through the Trawl Fisheries of the Northwest Atlantic FMP. The Total Allowable Level of Foreign Fishing(TALFF) is 100 mt and is allocated for bycatch in other fisheries, primarily the mackerel fishery... The average river herring bycatch in (the mackerel) fishery for the last three years has been 3% of the mackerel catch. There is some indication that the river herring bycatch increases as the fishery moves closer to shore...

"The river herring TALFF is low because of the condition of the resource...

:...The most likely case is that the (mackerel) fishery will develop initially through joint ventures, probably with related directed foreign fisheries. If the latter situation prevails, if the river herring TALFF remains 100 mt, and if the 3% bycatch relationship continues, there is clearly a problem relative to foreign catches in the development of the U.S. fishery.

"If the only river herring catch by foreign vessels is bycatch in the mackerel fishery, if the foreign catch amounts to 3 mt of river herring for every 100 mt of mackerel, and if the river herring TALFF is 100 mt, then the total allowed foreign mackerel catch cannot exceed 3,333 mt. While this might represent a worst case situation and additional analyses are needed, there is a problem that, if it cannot be solved, at least it must be recognized in the development of the mackerel fishery."

Joint venture applications for the coming fishing year will probably be in the range of 38,000 - 78,000 metric tons. Several possible applications have not been received. Joint venture policy for this and other fisheries has been under discussion for several years in a highly politicized atmosphere. Interest in pursuing large joint ventures in mackerel this year is very high.

The Council and the NMFS will need to make decisions on foreign joint ventures and directed fishing requests in the mackerel fishery early in 1985, and the Council would like to hear from the Commission at its January 16-17 meeting in Easton, Maryland. There will be no opportunity for the Shad and River Herring Board or the SSC to discuss the request as a group before then, so we will not be able to present the Council with a formal recommendation.

M 85-3
1/10/85

After conversations with Bob Jones (Chairman, Shad and River Herring Board), Harrel Johnson (Chairman, Shad and River Herring Scientific and Statistical Committee), and Bill Richkus (Manager, Shad and River Herring Management Program, Martin Marietta) we decided that Bill and Harrel would put together some basic summary information provided by the ASMFC Phase I of the Management Plan for Migratory Alosids of the Atlantic Coast prepared under contract by Martin Marietta Environmental Systems, other draft documents, and any other recent biological information, for distribution to the Council. We will present the information verbally at the Mid-Atlantic Council meeting in Easton, Maryland at 8:00 am, January 17. Several members of the Board and SSC will be present at the Council meeting and the following Striped Bass Stocking Subcommittee, and can be available to answer questions from the Council. Following the Commission presentation, the Council will consider that information during their decision process on the joint venture applications.

A draft of the information to be presented is attached.

Please call me before noon January 15 if you have any questions or additional suggestions.

Thank you.

Enclosure

cc: Ralph W. Abele

SUMMARY MINUTES

SCIENTIFIC & STATISTICAL COMMITTEE (SSC) MEETING

19 November 1984

Philadelphia, PA

There was an SSC Meeting held on 19 November 1984 at the Best Western Airport Inn in Philadelphia, PA. Chairman Hargis convened the meeting at approximately 10:05 a. m. Other Committee members present were Drs. Emory Anderson, Lee Anderson, Austin, Haskin, Holliday, Mr. Surdi, Mr. Wilk and Mr. Hamer. Other attendeees included Mr. Kelfer and Ms. Stevenson, Mid-Atlantic staff, Mr. Marchessault, New England Council staff, Mr. Dave Wallace (United Shellfishermen's Association) and Mr. Steve Devore (American Original).

ATLANTIC MACKEREL, SQUID, AND BUTTERFISH FMP AMENDMENT #2

Mr. Keifer stated that the current Atlantic Mackerel, Squid, and Butterfish FMP lapses in March 1986 and that is was time for the Committee to evaluate the objectives and agree on what problems are to be addressed by Amendment #2. The Committee reviewed a Memo dated 25 September 1984 to the Council's Squid, Mackeral and Butterfish Committee (See Attachment 1) which stated staff's opinions for objectives and problems to be solved by Amendment #2. The Committee offered no changes or additions to the objectives ~~and one addition and minor changes to some of the problems outlined in the Memo.~~ In reference to Problem 2 (C) and due to the apparent problem with the river herring bycatch in the foreign mackerel fishery, particularly when carried out nearshore in conjunction with joint ventures, the Committee urges the Council to ask the Atlantic States Marine Fisheries Commission for its recommendation of bycatch on river herring in relationship to the development of the FMP amendment.

Currently there is a permit requirement for US fishermen (Problem 4 (D)) in the Plan and the staff's question was whether to remove that requirement since it currently yielded no valuable information. The Committee's opinion was not to remove the permit requirement but rather change the word from "Remove" to "Evaluate" to try to obtain better data from the permit. Dr. Holliday felt that the SSC's Data Needs Report needed to be added to the preliminary outline of problems for Squid/Mackerel/Butterfish Amendment #2 and offered the following motion which was seconded by Dr. Lee Anderson and carried unanimously:

> EVALUATE EXISTING PERMITTING AND DATA COLLECTION SYSTEMS RELATIVE TO THE SQUID/MACKEREL/BUTTERFISH DATA NEEDS SPECIFIED IN THE SSC REPORT, EXAMINE HOW THE FMP SHOULD BE CHANGED WHERE NECESSARY TO ATTAIN THESE DATA.

Mr. Keifer stated that there was an opinion expresssed by Council member Stevenson at the Squid, Mackerel, Butterfish Committee Meeting on 23 October 1984 that silver and red hake should possibly be added into Amendment #2 since they are also undeveloped species and have a potential for becoming a target for a directed fishery in the near future. The Committee discussed at great length whether to include the hakes into Amendment #2 and decided that there was no biological facts to support their inclusion at the present time. They unanimously passed the following motion made by Dr. Austin and seconded by Mr. Hamer:

(from Draft Amendment 2 to Mackerel, Squid and Butterfish FMP)

4.2.3. River Herring Bycatch in Foreign Mackerel Fishery.

The foreign river herring fishery is managed through the Trawl Fisheries of the Northwest Atlantic FMP. The TALFF is 100 mt and is allocated for bycatch in other fisheries, primarily the mackerel fishery.

The Council has the preparation of a River Herring FMP on its long range schedule. The Atlantic States Marine Fisheries Commission (ASMFC) is preparing a river herring management plan which may serve as the basis of the Council's FMP.

The most significant (in terms of size of catch) mackerel fishery in the recent past has been the Polish fishery carried out primarily for research purposes. The average river herring bycatch in that fishery for the last three years has been 3% of the mackerel catch. There is some indication that the river herring bycatch increases as the fishery moves closer to shore, although a complete analysis of this in currently under way.

The river herring fishery was an inshore US fishery until the late 1960s when foreign fleets entered the fishery. The US catch averaged 24,800 mt between 1963 and 1969. A downward trend began in 1969, with the 1983 catch 4,100 mt. Data from the NEFC spring and autumn bottom trawl surveys from the Gulf of Maine to northern New Jersey indicate that stock levels have been relatively stable since 1968. Data from the spring botto trawl surveys between northern New Jersey and Cape Hatteras indicate an increase in river herring biomass since 1975 (USDC, 1984).

The river herring TALFF is low because of the condition of the resource.

While the intent is not to regulate river herring as part of this FMP, the river herring situation poses a significant problem, particularly with regard to the development of the mackerel fishery. If the mackerel fishery develops only with US vessels, the river herring catch will likely increase but it will have no regulatory significance since the FMP does not manage the US fishery. However, the most likely case is that the fishery will develop initially through joint ventures, probably with related directed foreign fisheries. If the latter situation prevails, if the river herring TALFF remains 100 mt, and if the 3% bycatch relationship continues, there is clearly a problem relative to foreign catches in the development of the US fishery.

If the only river herring catch by foreign vessels is bycatch in the mackerel fishery, if the foreign catch amounts to 3 mt of river herring for every 100 mt of mackerel, and if the river herring TALFF is 100 mt, then the total allowed foreign mackerel catch cannot exceed 3,333 mt. While this might represent a worst case situation and additional analyses are needed, there is a problem that, if it cannot be solved, at least it must be recognized in the development of the mackerel fishery.

ASMFC SHAD AND RIVER HERRING SCIENTIFIC AND STATISTICAL COMMITTEE POSITIONS ON RIVER HERRING HARVESTS IN THE U.S. FISHERY CONSERVATION ZONE

Prepared by:

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and

Manager, Shad and River Herring
Management Program
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Atlantic States Marine Fisheries Commission

January 17, 1985

INTRODUCTION

This document summarizes current opinions and views of the Atlantic States Marine Fisheries Commission's Shad and River Herring Scientific and Statistical Committee on the issue of acceptable levels of offshore river herring* harvests by both foreign and joint-venture fisheries. These views are documented in minutes of committee meetings and in draft documents produced as part of the management program. While they do not constitute final recommendations of the committee, they are strongly indicative of the likely nature of recommendations to be included in the final Interstate Fisheries Management Plan scheduled for completion in October, 1985.

This document was prepared at the request of Jim McCallum, of the Atlantic States Marine Fisheries Commission, and after consultation with Mr. Robert Jones, Chairman of ASMFC's Shad and River Herring Management Board, and Mr. Harrel Johnson, Chairman of ASMFC's Shad and River Herring Scientific and Statistical Committee.

BACKGROUND

Appendix A presents excerpts on offshore river herring harvests from the first document produced in the shad and river herring management program, entitled "Current status and biological characteristics of the anadromous alosid stocks of the eastern United States: American shad, hickory shad, alewife and blueback herring."(a full citation appears in the appendix). Existing information suggests that very large offshore river herring harvests in the late 1960's and early 1970's were in large part responsible for the precipitous declines later observed in river herring stocks in the Chesapeake Bay and southeastern coastal states. River herring stocks in the northeastern and New England states were not similarly affected, suggesting that they were not being over exploited by those same foreign fisheries. Annual river herring landings along the east coast are currently at the lowest level recorded, primarily attributable to extremely low harvests in the Chesapeake Bay and southeastern United States.

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*For purposes of the foreign fishing regulations, the term 'river herring' is considered to include alewife, blueback herring, and hickory shad; American shad is considered a prohibited species (50 CFR 611.50()(4)).

COMMITTEE VIEWS AND OPINIONS

Topics to be addressed in the anadromous alosids Interstate Fisheries Management Plan were discussed at Committee meetings which took place July 18-19 and September 17-18, 1984. A draft outline for the management plan was prepared and revised as a result of those meetings. That outline currently is being used in developing a draft management plan (first draft scheduled to be completed in January 1985). In a proposed section of the plan entitled, "Actions necessary for achievement of management objectives," the Committee has included actions aimed at "minimizing to the extent necessary the offshore harvest of alosids." The three specific actions proposed are:

--Provide technical input on a periodic basis for establishing acceptable harvest levels by the Regional Fishery Management Councils and NOAA.

--Recommend to NOAA and the Councils modifications to seasons and/or areas for those fisheries taking alosids as bycatch so as to reduce the bycatch.

--Monitor the establishment and development of joint-venture fisheries which have the potential for or are targeting harvest of alosids; discourage establishment of such fisheries.

These proposed steps make it clear that the Committee has serious concerns about the potential impact of offshore harvests on river herring stocks. In particular, the current depressed state of Chesapeake Bay and southeastern United States stocks may make those stocks particularly sensitive to any increase in fishing mortality, whether inshore or offshore. Information available to the Committee suggested that recent foreign offshore harvests were well below the allowable quotas.* The Committee's intentions are to suggest, at a minimum, that the TALFF remain the same, or, at best, be reduced substantially. Formulation of a specific recommendation on appropriate quotas (TALFF plus joint-venture harvests) is constrained by the paucity of information on population dynamics characteristics of the depressed river herring stocks (in particular, total and fishing mortality rates) and on the geographical origin of stocks

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*While the TALFF for river herring was 100 mt annually for 1983 and 1984, amounts allocated to foreign nationals by the Department of State have been less--65 mt for 1983 and 85 mt for 1984. Reported foreign harvests were considerably lower than the amounts allocated, approximately 6 mt in 1983 and 16 mt in 1984; the Northeast Region recommended no change in the level of TALFF for 1985 (G. Mahoney, NMFS, pers. comm.).

being harvested in offshore waters. Acquisition of these data will be a high priority of the Management Plan. In the absence of evidence to the contrary, any reduction in offshore harvest of river herring would appear to be beneficial to the currently depressed stocks.

In addition, it should be noted that incidental harvests of American shad by offshore fisheries are also of great concern to the Committee. Since they are a "prophibited species", harvest is not legal. However, because of sensitivity to handling, any shad caught will be lost even though released. Thus, establishment of any new fisheries should take into account probability of accidental capture of American shad.

APPENDIX A

(Selected excerpts relating to offshore harvests of river herring taken from the document cited below)

CURRENT STATUS AND BIOLOGICAL CHARACTERISTICS OF THE ANADROMOUS ALOSID STOCKS OF THE EASTERN UNITED STATES: AMERICAN SHAD, HICKORY SHAD, ALEWIFE, AND BLUEBACK HERRING

Phase I in Interstate Management Planning for Migratory Alosids of the Atlantic Coast

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July 1984

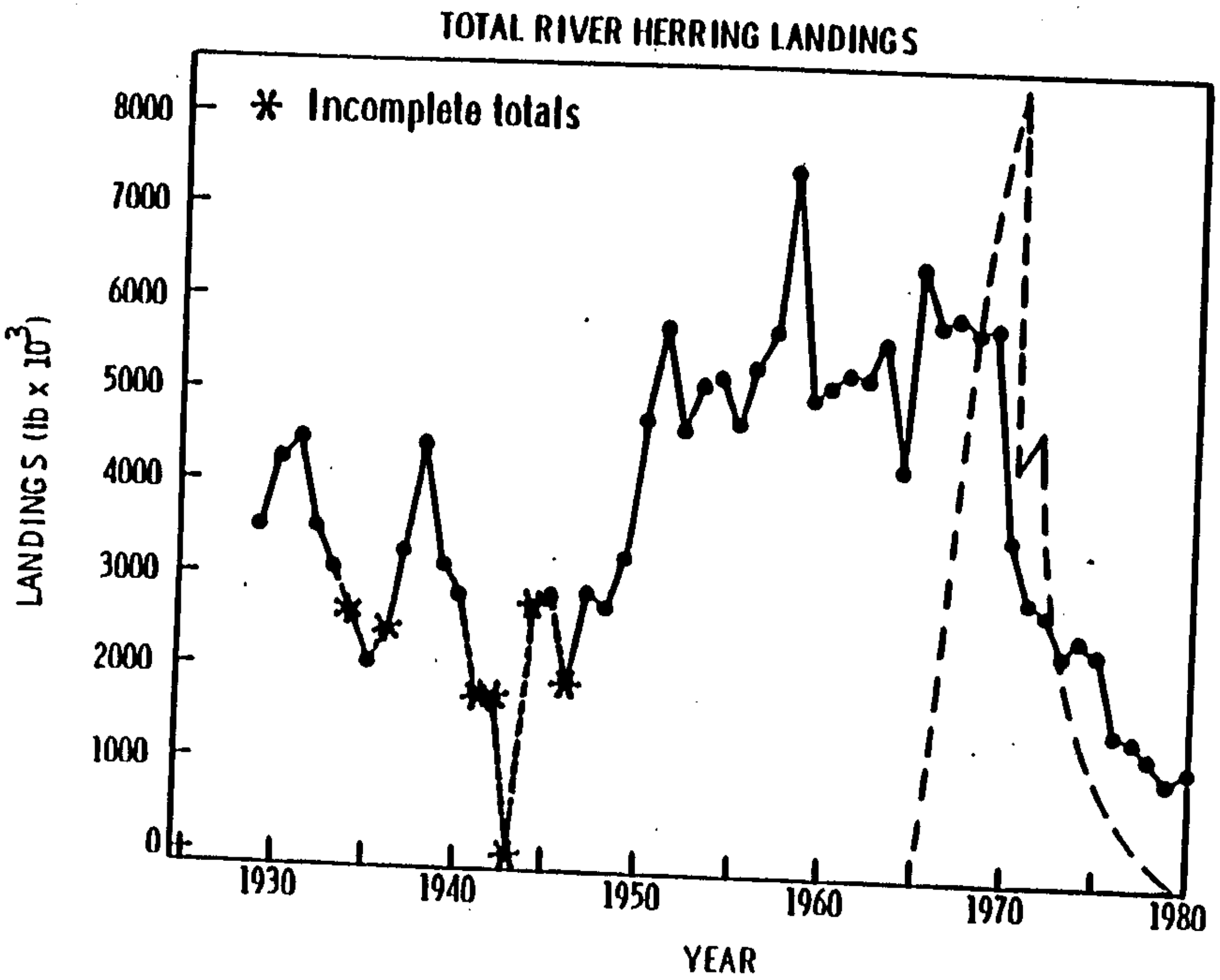

Figure IV-1. Reported commercial landings of river herring (sometimes recorded as "alewife" in landings records) along the east coast of the United States, 1929 to 1980; data are from NOAA Fishery Statistics of the United States and ICNAF. Dashed line represents offshore harvest by foreign fishing vessels.

classes would have entered the fishery from 1978 through 1984, they may accurately predict the current low-level stability of stocks.

Juvenile river herring data were collected in the Hudson River between 1968 and 1982 (Texas Instruments, Inc., 1977-1980). However, integration of the data from different stations and dates to develop annual indices has not been done to date, and thus the data cannot currently be used to examine stock trends.

None of the juvenile index data sets described above have been rigorously verified through correlation with year-class contribution to fisheries in subsequent years. Havey (1973) did report a relationship between numbers of juveniles produced and run size 4 years later for a run in Maine, but this was based on a census of juveniles leaving a pond and not a statistical sampling of that population. Positive correlations between indices and landings four years later of blueback herring were reported for the Rappahannock and Potomac Rivers by Loesch et al. (1979), but there is some question of the validity of those data (Loesch, pers. comm.). The correlation results and descriptive contrasts presented here suggest that the indices may be of value for representing high and low year-class extremes, while having limited utility for representing more average year-classes.

D. COASTAL AND OFFSHORE HARVESTS

Foreign fishing fleets began to exploit offshore river herring stocks in the late 1960's. Peak catch was in 1969, at approximately 80 million pounds (Table IV-15). Catches declined significantly after that date. Street and Davis (1976) concluded that these offshore harvests contributed to overharvest and caused stock declines, particularly in the Chesapeake Bay and South Atlantic stocks. Street and Davis reported that the offshore harvests were composed primarily of fish less than 190 mm in length, which would suggest that they were primarily sexually immature individuals.

Since 1977, the foreign fishery for river herring in the Fishery Conservation Zone (FCZ) of the United States has been managed by the Preliminary Fishery Management Plan (PMP) for the foreign trawl fisheries of the Northwest Atlantic (Boreman, 1982). Allocation of river herring between 1977 and 1980 was 1.1 million pounds annually with some additional allowable by-catch. Since 1981, the allocation has been limited to 100 metric tons, and by-catch regulations have been changed. Current allocations are presented in Table IV-16. When a country's annual allocation for any one species is reached, fishing by that nation's vessels in that part of the FCZ in the northwest Atlantic Ocean must cease and the fishing vessels must leave the

Table IV-15. Reported landings of river herring (lbs x 10^3) in ICNAF/NAFO Areas 5 and 6 by foreign vessels (from Boreman, 1982)

YEAR	BUL	GDR	POL	ROM	SPA	USSR	TOTAL
1964	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0
1967	0	0	0	0	0	14356	14356
1968	0	0	0	0	0	49184	49184
1969	1133	249	0	0	0	78322	79704
1970	1481	419	0	0	0	42083	43983
1971	2291	18538	3101	2015	0	22029	47974
1972	1129	7674	4162	0	0	14756	27721
1973	972	3593	7167	0	0	2348	14080
1974	1704	5862	2399	556	0	1042	11563
1975	1219	4676	137	0	0	1433	7465
1976	564	2778	31	0	0	539	3912
1977	0	152	0	0	0	264	416
1978	0	0	0	0	23	25	48
1979	0	0	4	0	0	24	28
1980	0	0	0	0	4	0	4

Table IV-16. Allocations of river herring by country for foreign fishing within the U.S. Fishery Conservation Zone, 1978-1983

(in metric tons)

	1978	1979	1980	1981	1982	1983
TALFF	500	500	500	100	100	100
ALLOCATIONS						
Bulgaria	—	—	—	5	20	5
Cuba	—	—	25	5	—	—
FRG	—	12	50	—	—	—
GDR	—	10	25	—	—	25
Ireland	—	10	—	—	—	—
Italy	12	13	50	10	10	10
Japan	23	46	50	10	10	10
Mexico	44	40	50	—	—	—
Poland	—	14	50	18	—	—
Portugal	—	—	—	5	5	5
Romania	7	10	10	—	—	—
Spain	52	57	75	10	10	10
USSR	279	197	—	—	—	—
UNALLOCATED	83	91	115	37	45	35

NOTES: River herring for purposes of foreign fishing is defined as alewife, blueback herring, and hickory shad.

TALFF is total allowable level of foreign fishing.

SOURCE: Fisheries of the United States, 1978-1983. USDOC/NOAA/NMFS.

fishing area (G. Mahoney, pers. comm.). Reported offshore landings since 1978 have been consistently low (Table IV-15).

As was discussed in the case of American shad and hickory shad, numerous problems may exist with the ICNAF/NAFO data which serve to document offshore landings. Key among them is the problem with species identification. An additional problem with total ICNAF landings results from inclusion of potentially inaccurate NOAA inshore landings data. This problem can be avoided by examining the ICNAF/NAFO data on a country-by-country basis, since foreign fleets operate only in offshore waters.

Coastal fisheries for river herring are currently minimal in magnitude. Nearly all major river herring harvests are made within individual river systems or at the mouths of those drainage systems.

The totals of current offshore and coastal harvests of river herring are relatively insignificant. Even if current foreign fishery allocations of river herring were taken each year, those landings would comprise less than 2% of total harvest in any given year. However, these fisheries do focus on immature, smaller fish, and a low percentage in terms of total poundage can represent a larger percentage in terms of numbers of individuals. Although the potential for problems with offshore fisheries exists, the problem appears minimal at present.

E. COASTAL MIGRATIONS

A knowledge of coastal migration patterns of river herring is relevant to examination of hypotheses relating to factors influencing mortality and stock trends. Such information is also needed to assess the potential for interjurisdictional conflicts in harvesting the species. Coastal migration must be placed in perspective to the general life history patterns of the two river herring species, summarized in Figs. I-4 and I-5.

Juvenile river herring generally emigrate from freshwater to the ocean in the fall. However, in some instances, it appears that high abundance of juveniles may trigger very early (e.g., summer) emigration of large numbers of small juveniles from the nursery area (e.g., Richkus, 1975). Length of stay of immature fish in the ocean is generally four or five years, dependent on sex. There is some indication that alewives in northern states may remain in inshore waters for one or two years (e.g., Walton, 1981). Spawning runs begin earliest in southern states (December to January in Florida) and latest in the North (May to June in Maine) (Tables IV-17 and IV-18). Homing of fish to their stream of origin is a generally accepted premise, particularly based on numerous successes in creating new runs through stocking of

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Fisheries Center
Woods Hole Laboratory
Woods Hole, Massachusetts 02543

February 8, 1985 F/NEC1:EDA

Mr. John C. Bryson
Executive Director
Mid-Atlantic Fishery Management Council
Room 2115, Federal Building
300 South New Street
Dover, DE 19901-6790

Dear John:

I have taken a look at the data from the US-Polish research fishery for mackerel in an attempt to get some helpful information concerning the by-catch problem in the foreign mackerel fishery. This issue will apparently be considered at the March 5 meeting of the Council's Coastal Migratory Species Committee. Since I will be unable to attend that meeting, I have assembled as much information as possible in this letter and its attachments. Ed Bowman will attend the meeting on behalf of the Center.

River herring, as well as other species, have been taken as by-catch in the directed fisheries for mackerel by Poland beginning in 1981. (Note: Their fishery in 1981 was as a result of an allocation from TALFF; the 1982-84 fisheries were research activities conducted cooperatively with the NEFC.) The text table below summarizes the relevant catch data from each year:

Year	Catch (mt)				River herring / mackerel
	All species	Mackerel	River herring	Other species	
1981	4,078	3,979	11	88	.003
1982	4,887	4,364	206	317	.047
1983	4,638	4,341	93	204	.021
1984	5,838	5,531	222	85	.040

During these four years, the by-catch of river herring has varied from 0.3% to 4.7% of the mackerel catch and has averaged 2.8%.

In an attempt to get some idea as to possible area/time differences in the river herring by-catch, the results from 1984 were examined in detail. (Note: The 1981-83 data were not examined in detail because of the time involved in the analysis. None of the 1981-84 data have been stored on computer files yet, although work has just begun on this in order to facilitate extensive analysis of the entire data base this summer.) For each of the 439 trawl hauls made in 1984 the distance from shore was plotted. Distance from shore varied from 3 to about 80 miles and averaged about 28 miles.

-more-

Catches of both river herring and mackerel were tallied according to where caught (3-19 miles, ≥20 miles, and total), month, and vessel (Table 1). Within the 3-19 mile zone, the average distance from shore for the 161 hauls made there was about 15 miles. Total catches of river herring were much greater in waters less than 20 miles from shore (71%) than in waters 20 miles or greater from shore (29%). The by-catch percentage of river herring for all months and for both vessels was 6.8 in the 3-19 mile zone and 2.0 in the ≥20 mile zone; the overall percentage was 4.0. By-catch percentages varied on a monthly basis, with the highest percentages occurring in March in all areas.

The location of trawl hauls made by the Polish vessels in 1984 is provided in Figures 1 and 2. As indicated, the bulk of the hauls made in the 3-19 mile zone occurred in waters off Delmarva and south, with some off northern New Jersey. River herring by-catch occurred in all areas, however, even in southern New England waters. Of the 58 hauls which caught greater than 1 mt of river herring, 69% were south of the mouth of Chesapeake Bay (37° N).

Of the 5,531 mt of mackerel caught by the Polish fishery in 1984, 42% was from 3-19 miles and 58% was from ≥20 miles (Table 1). The greater portion of the mackerel catch was taken in waters 20 miles or more from shore primarily because 63% of the hauls occurred there. Catch rates for both mackerel and river herring were higher in the 3-19 mile zone (26% higher for mackerel, 326% higher for river herring) (Table 2). On a monthly basis, mackerel as well as river herring catches (Table 1) and catch rates (Table 2) were greatest in March.

In 1984, the total river herring by-catch in the Polish fishery consisted of 83% blueback herring and 17% alewife. Recognizing the likelihood for some incorrect identification of these two species, these percentages must be viewed as only approximate.

The length frequency of river herring measured aboard the Polish vessels in 1984 is as follows:

Fork length (cm)	Number
18	4
19	-
20	-
21	5
22	35
23	129
24	190
25	172
26	157
27	104

-more-

Fork length (cm) (cont'd)	Number
28	57
29	14
30	10
31	3
32	1
33	-
34	-
35	1
Total	882

This length frequency represents adult fish which would be on the verge of moving inshore to spawn.

Even though the greatest river herring by-catch in a directed mackerel fishery is likely to occur inside 20 miles, some will also occur outside 20 miles. Actual levels of by-catch will obviously vary by area and month and also depending on the skill of the individual vessel captains involved in a mackerel fishery. However, regardless of the by-catch percentages one assumes (4%, 2%, 7%), the amount caught is certainly going to exceed the 100-mt level presently on record. Therefore, if a significant increase in the mackerel catch is planned (up to 50,000 mt, for example), whether by US or foreign trawlers, you will have to plan on a significant increase in river herring by-catch (1,000 mt if you assumed a 2% by-catch on 50,000 mt of mackerel).

I hope the above information will be of help. Please contact Ed if you have questions, as I will be away from the office February 18-March 8.

Sincerely,

Emory

Emory D. Anderson
Chief, Offshore Fishery
Resources Investigation

Attachments (4)

cc: D. Marshall, NEFMC
S. Testaverde, F/NER72
E. Bowman, F/NEC

Table 1. Catch (kg) of mackerel and river herring in the US-Polish research fishery for mackerel during January-April 1984. Catches and the ratio between river herring and mackerel catches are given by month, vessel, and distance from shore.

	3-19 miles			≥ 20 miles			Total		
Month	Mackerel	River herring	Ratio	Mackerel	River herring	Ratio	Mackerel	River herring	Ratio
				ADMIRAL ARCISZEWSKI					
Jan	337,600	27,830	.082	755,900	5,445	.007	1,093,500	33,275	.030
Feb	128,880	1,830	.014	290,370	2,810	.010	419,250	4,640	.011
Mar	888,050	46,300	.052	416,980	7,960	.019	1,305,030	54,260	.042
Apr	88,840	1,730	.019	611,540	12,360	.020	700,380	14,090	.020
Total	1,443,370	77,690	.054	2,074,790	28,575	.014	3,518,160	106,265	.030
				KNIAZIK					
Jan	242,720	14,415	.059	461,610	240	.001	704,330	14,655	.021
Feb	93,708	-	-	373,251	2,576	.007	466,959	2,576	.006
Mar	554,278	65,639	.118	279,493	32,225	.115	833,771	97,864	.117
Apr	-	-	-	8,200	412	.050	8,200	412	.050
Total	890,706	80,054	.090	1,122,554	35,453	.032	2,013,260	115,507	.057
				TOTAL					
Jan	580,320	42,245	.073	1,217,510	5,685	.005	1,797,830	47,930	.027
Feb	222,588	1,830	.008	663,621	5,386	.008	886,209	7,216	.008
Mar	1,442,328	111,939	.078	696,473	40,185	.058	2,138,801	152,124	.071
Apr	88,840	1,730	.019	619,740	12,772	.021	708,580	14,502	.020
Total	2,334,076	157,744	.068	3,197,344	64,028	.020	5,531,420	221,772	.040

Table 2. Catch per trawl tow (kg) of mackerel and river herring in the US-Polish research fishery for mackerel during January-April 1984. Catch rates and number of tows are given by month, vessel, and distance from shore.

	3-19 miles			≥ 20 miles			Total		
Month	No. tows	Mackerel	River herring	No. tows	Mackerel	River herring	No. tows	Mackerel	River herring
					ADMIRAL ARCISZEWSKI				
Jan	20	16,880	1,392	40	18,898	136	60	18,225	555
Feb	10	12,888	183	19	15,283	148	29	14,457	160
Mar	45	19,734	1,029	27	15,444	295	72	18,125	754
Apr	6	14,807	288	59	10,365	209	65	10,775	217
Total	81	17,819	959	145	14,309	197	226	15,567	470
					KNIAZIK				
Jan	20	12,136	721	49	9,421	5	69	10,208	212
Feb	12	7,809	-	44	8,483	59	56	8,339	46
Mar	48	11,547	1,367	38	7,355	848	86	9,695	1,138
Apr	0	-	-	2	4,100	206	2	4,100	206
Total	80	11,134	1,001	133	8,440	267	213	9,452	542
					TOTAL				
Jan	40	14,508	1,056	89	13,680	64	129	13,937	172
Feb	22	10,118	83	63	10,534	85	85	10,426	85
Mar	93	15,509	1,204	65	10,715	618	158	13,538	963
Apr	6	14,807	288	61	10,160	209	67	10,576	216
Total	161	14,497	980	278	11,501	230	439	12,600	505

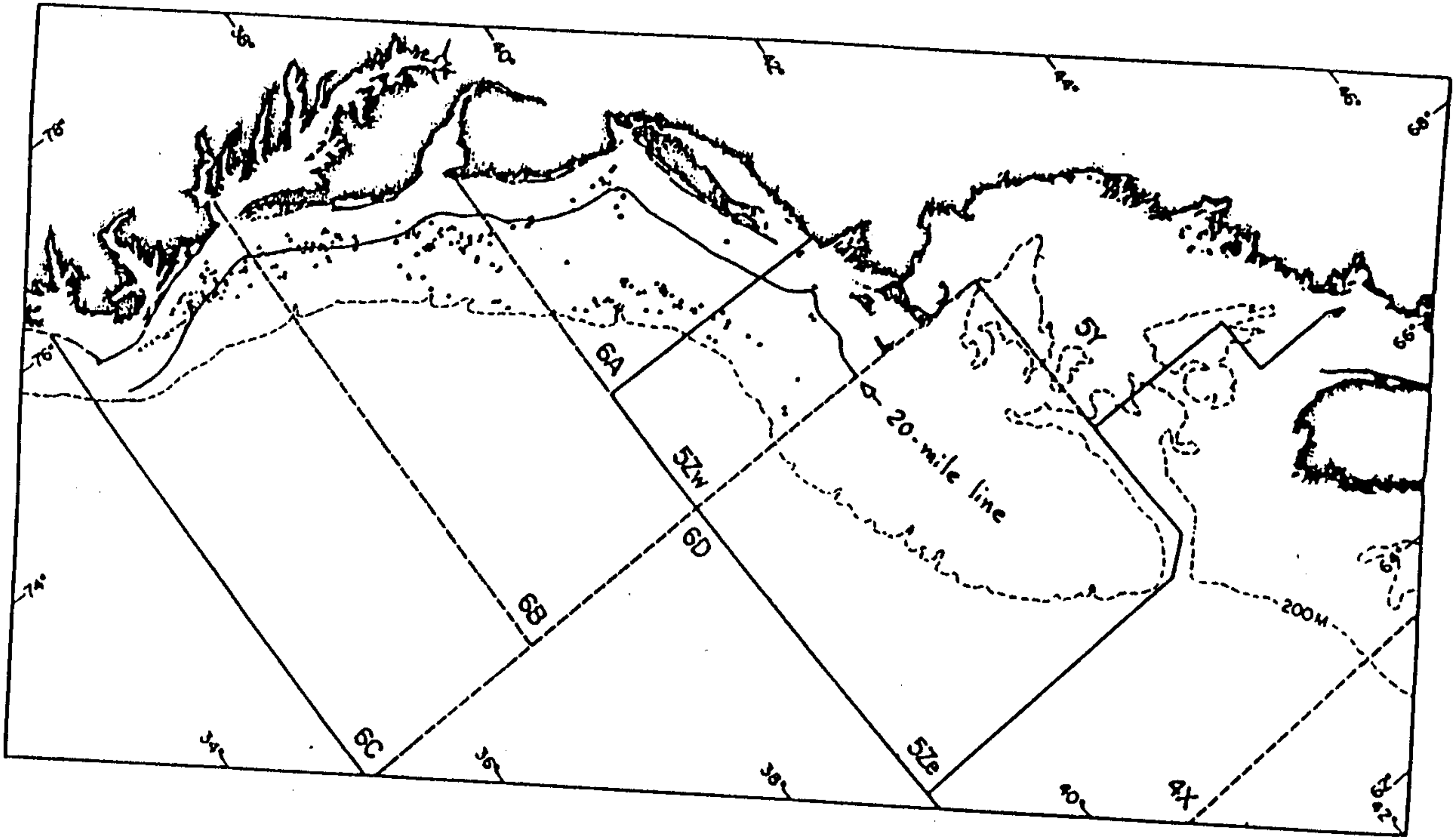

Figure 1. Area of work for the Polish M/T ADMIRAL ARCISZEWSKI Cruise 84-01(I-V) Atlantic Mackerel Research Fishery during 6 January - 30 April 1984. Dots depict location of trawl tows.

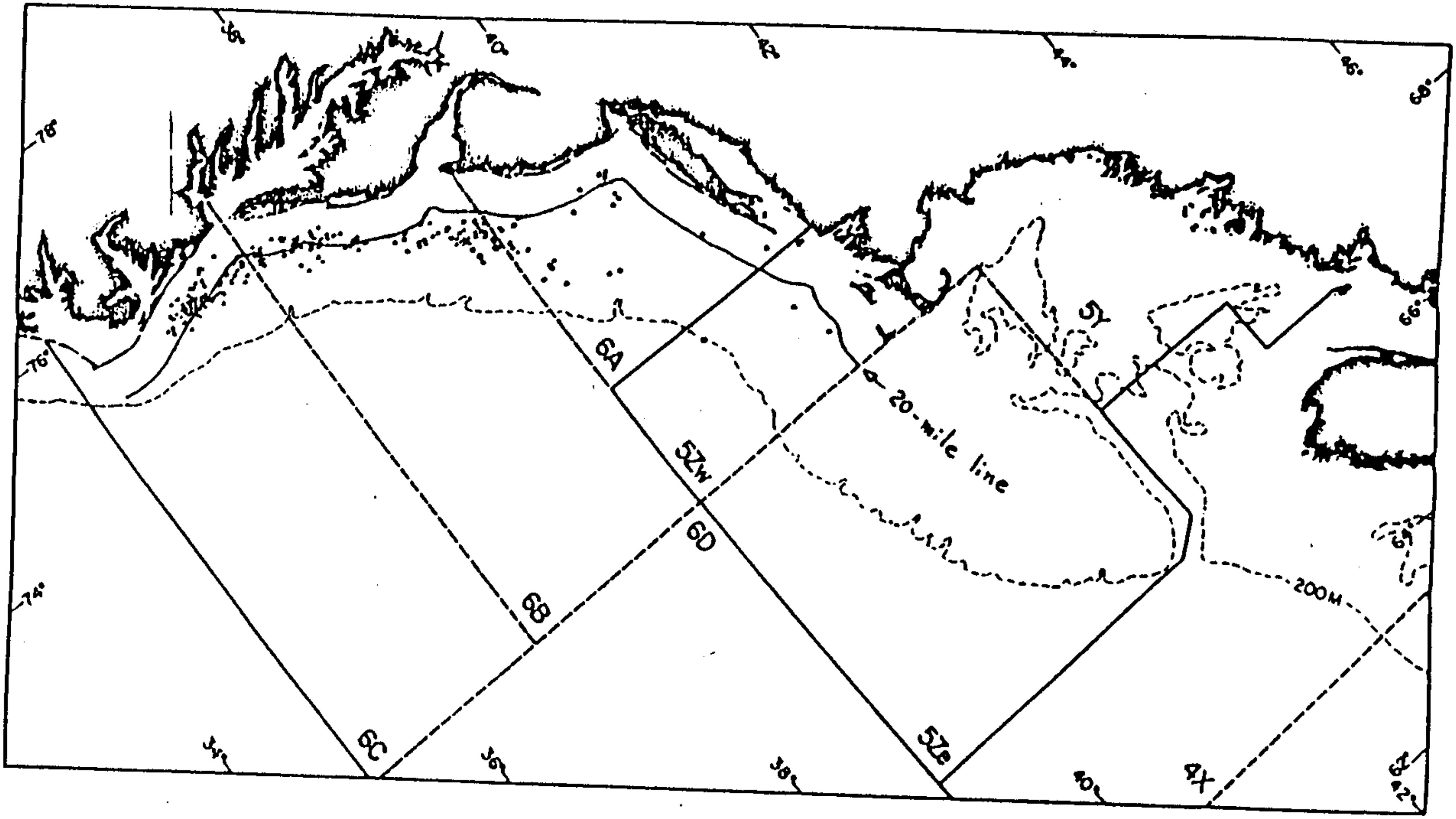

Figure 2. Area of work for the Polish M/T KNIAZIK Cruise 84-01(I-IV) Atlantic Mackerel Research Fishery during 6 January - 4 April 1984. Dots depict location of trawl tows.

NATIONAL MARINE [illegible]
Northeast Fisheries Center
Woods Hole Laboratory
Woods Hole, Massachusetts 02543

March 7, 1985 F/NEC1:JB

William A. Richkus, Ph.D.
Martin-Marietta Environmental Systems
9200 Rumsey Road
Columbia, Maryland 21045-1934

Dear Bill,

I received your phone message the other day regarding distribution of foreign vessel catch of river herring off the United States during the 1970's. I have been unable to reach you by phone so I have gone ahead and prepared a table of the data that I have regarding the catch by foreign vessels in NAFO Subareas 5 and 6 from 1971 to 1980. This data differs slightly than the data presented in my laboratory reference document because I have found some additional landings that were listed as blueback herring for the years 1973 and 1974. Specifically, in 1973 Bulgaria reported 816,000 lbs of blueback herring landings in addition to 972,000 lbs of river herring landings (which, I presume, are alewife landings), and in 1974 Rumania reported 556,000 lbs of blueback herring landings. I have added the blueback herring landings to the river herring landings. Please let me know if you need additional information.

Sincerely,

John

John Boreman
Chief, Coastal Fisheries
Resources Investigation

MARTIN MARIETTA ENVIRONMENTAL SYSTEMS

9200 RUMSEY ROAD
COLUMBIA, MARYLAND 21045-1934
(301) 964-9200
FAX #(301) 964-9200, EXT. 350

March 15, 1985

Mr. Paul Perra
Atlantic States Marine Fisheries Commission
1717 Massachusetts Avenue, N.W.
Washington, D.C. 20036

Dear Paul::

As you requested, I have assessed river herring and shad data needs with regard to the offshore fisheries. Below is a list of specific types of data which are needed to determine the potential impact of these offshore fisheries on coastal stocks of those species. I have attempted to provide a series of alternative levels of data for each category, going from those data most desirable but labor intensive to those requiring least effort but still being of some value.

1. Recording the presence of adult and/or subadult American shad and hickory shad in the mackerel bycatch (with some indication of relative magnitude of catch).

2. Size frequency distribution of river herring in the bycatch (minimum sample size of about 30 fish of each species - alewife, blueback); second order data - size frequency distribution without speciation; third order data - subjective evaluation of nature of the catch, whether it is mostly adults or subadults or both. These data would not be necessary for each haul, but should be taken from trawls in defined geographical/time segments (perhaps using the NAFO subareas and two week time periods).

3. Collections of scales from fish used for size frequency distributions; these scales could be used by researchers to contribute to stock discrimination.

4. Estimates of magnitude of bycatch of river herring, by haul, including tows taking none or very little

REPORTED COMMERCIAL LANDINGS (000 POUNDS) OF RIVER HERRING BY FOREIGN VESSELS

YEAR	COUNTRY	NAFO SUBAREA 5Y	5Ze	5Zw	6A	6B	6C	TOTAL
1971	POLAND	0	2567	534	0	0	0	3101
	ROMANIA	0	44	165	1129	633	44	2015
	USSR	0	858	16154	2309	926	1782	22029
	TOTAL	0	3469	16853	3438	1559	1826	27145
1972	BULGARIA	0	589	218	322	0	0	1129
	GDR	73	1521	847	710	3682	842	7675
	POLAND	2	3201	62	635	225	37	4162
	USSR	93	5185	4963	3772	478	265	14756
	TOTAL	168	10496	6090	5439	4385	1144	27722
1973	BULGARIA	0	509	664	553	62	0	1788
	GDR	0	525	785	930	1270	84	3594
	POLAND	84	2110	4228	602	60	84	7168
	USSR	0	403	181	1484	132	148	2348
	TOTAL	84	3547	5858	3569	1524	316	14898
1974	BULGARIA	0	179	260	1164	101	0	1704
	GDR	0	1446	902	955	2524	35	5862
	POLAND	0	595	895	844	64	0	2398
	ROMANIA	0	0	0	117	342	97	556
	USSR	0	454	64	522	2	0	1042
	TOTAL	0	2674	2121	3602	3033	132	11562
1975	BULGARIA	0	278	238	703	0	0	1219
	GDR	0	2513	298	1049	467	348	4675
	POLAND	0	0	0	82	55	0	137
	USSR	0	1179	0	254	0	0	1433
	TOTAL	0	3970	536	2088	522	348	7464
1976	BULGARIA	0	0	13	317	234	0	564
	GDR	0	37	4	1219	1387	130	2777
	POLAND	0	31	0	0	0	0	31
	USSR	0	340	60	139	0	0	539
	TOTAL	0	408	77	1675	1621	130	3911
1977	GDR	0	0	0	73	57	22	152
	USSR	0	35	154	75	0	0	264
	TOTAL	0	35	154	148	57	22	416
1978	SPAIN	0	4	2	15	2	0	23
	USSR	0	0	18	7	0	0	25
	TOTAL	0	4	20	22	2	0	48
1979	USSR	0	0	9	15	0	0	24
1980	SPAIN	0	2	2	0	0	0	4
	USSR	0	0	0	2	0	0	2
	TOTAL	0	2	2	2	0	0	6
1971-1980		252	24605	31720	19998	12703	3918	93196

(this information contributes to defining areas where bycatch may be minimal); second order data- presence or absence of substantial amounts of river herring in each mackerel tow.

5. It would be nice to obtain tissue samples or otoliths from herring bycatch which could be used in research into stock discrimination studies; however, because no such studies are underway, at least to my knowledge, I would consider this data category to be very low priority.

Those represent the major data needs as far as I can tell. If you have any questions, please give me a call.

Sincerely,

Bill

William A. Richkus, Ph.D.
Manager
Shad and River Herring
Management Program

jvg