Fisheries Management Report No. 12
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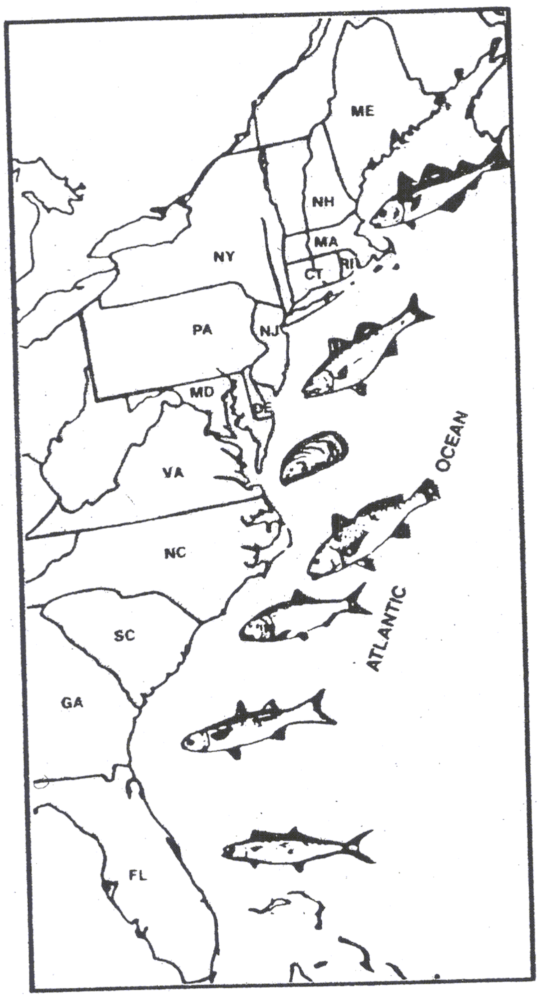
ATLANTIC STATES MARINE FISHERIES COMMISSION



1988 SUPPLEMENT TO AMERICAN SHAD AND RIVER HERRINGS FISHERY MANAGEMENT PLAN

October 1988

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I. INTRODUCTION

The Atlantic States Marine Fisheries Commission's Fishery Management Plan for American Shad and River Herrings was issued in October 1985. The plan (ASMFC 1985) specified four management objectives:

I. 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.

II. 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.

III. 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.

IV. 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, the preservation of acceptable stock levels, and optimal utilization of those stocks.

The plan presents 25 management recommendations, grouped into nine categories :

- Regulation of offshore harvests
- Regulation of territorial sea harvests
- Regulation of harvests in internal waters
- Water quality
- Flow requirements
- Other habitat factors
- Restoration of anadromous alosids
- Research needs
- Citizen participation.

Chapter VI of the plan discussed problems in implementation and actions which would have to be taken in order to achieve the plans objectives. Among those actions was an annual reexamination of status of stocks and fisheries and of state of knowledge about these species, so that new information and findings could be disseminated among fisheries managers, research and information needs could be reprioritized and recommendations could be modified to reflect the new information.

Since the plan was issued, a variety of research programs and studies dealing with anadromous alosids have been conducted. In addition, ASMFC has supported the activities of an anadromous alosid Stock Assessment Subcommittee, chaired by Dr. Victor Crecco, Connecticut Marine Fisheries. The subcommittee conducted analyses of historical data from many American shad spawning runs along the east coast in order to establish the magnitude of historical fishing mortality rates and to identify fishing mortality rates that would be allow for preservation of the stocks. In addition, the committee reviewed methodologies that are best suited for collection of the types of data needed for management of the alosid stocks.

In July 1987, an anadromous alosid research workshop was held in Annapolis, Maryland, in conjunction with a meeting of the ASMFC Shad and River Herring Scientific and Statistical Committee. The workshop encompassed presentations by a number of researchers working with anadromous alosids, and presentations by fisheries staff from each state on status of stocks and fisheries. Based on this information, management recommendations in the plan were reviewed, and several were modified. Research priorities were also reexamined and revised in accordance with new research findings.

This document is intended to summarize the presentations at the workshop and document changes to recommendations and research priorities. Because these changes represent a modification to an approved management plan, they must be approved by the Shad and River Herring Management Board and the Commission. This document will then be considered an amendment to the original plan.

II. RESEARCH FINDINGS

Research needs for anadromous alosids were examined at great length in the management plan. Three listings of needs were included, with the final and dominant listing being that established by the Management Board (Table II-1). A significant amount of research dealing with most of those priority needs has been done since 1985. Findings relating to each of these needs which were presented at the workshop are summarized below. In many cases, more detailed presentations of the findings and/or abstracts are included here as appendices, as noted in the summaries below.

A. ORIGINS OF SHAD CAPTURED IN COASTAL FISHERIES AND THE STATUS OF COASTAL FISHERIES

Concerns about origins of American shad being taken in coastal fisheries have increased since the late 1970's, when coastal harvests in South Carolina began to rise dramatically (Richkus and Dinardo 1984). Shad harvested early in the season have a high market value, so there is considerable economic advantage to pursuing fish in the coastal waters, before they enter traditional fishing grounds near spawning areas. Management agencies in more northern states were concerned that the fish being taken in these coastal fisheries might be from northern stocks. Further expansion of such fisheries could pose a danger to stocks which were in a severely depressed state (e.g., Maryland stocks) or were in initial stages of restoration (e.g., Pawacatuck River in Rhode Island).

The management plan recommended (Recommendation 2.1) that states closely monitor any coastal fisheries for American shad which exist or become established. At the workshop, state representatives were requested to give a report on the current status of their coastal shad fisheries.

Georgia reported that no shad harvest occurs in their coastal waters. South Carolina reported that shad taken in the ocean accounted for 48% of statewide shad harvest in 1986; the ocean fishery accounted for 50% of the roe shad harvest. North Carolina indicated that the ocean fishery in the vicinity of Cape Fear had increased, but the agency believes that those harvests are missed in the current landings recording procedures. The most dramatic increase in ocean shad fisheries has been in the state of Virginia. Ocean harvests accounted for 60% of the total state-wide landings in 1986, and 63% of state-wide landings in 1987. These landings are coming from the Rudy Inlet (Virginia Beach) area of the state.

Table II-1. 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 (from ASMFC 1985)

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.

Ocean landings in Maryland have remained fairly constant for 10 years. The number of ocean gillnetters was 8 in 1986 and 7 in 1987. Total landings by these fishermen were 127,000 pounds in 1986 and 116,000 pounds in 1987. The Delaware ocean harvest of 30,000 pounds in 1987 was about 10% of total state landings.

Ocean landings in New Jersey are difficult to distinguish from Delaware Bay landings. The nature of the market drives this fishery, which consists of directed drift gillnetting. New York has seen a sharp increase in its ocean fishery since 1980, with those landings being between 30,000 and 130,000 pounds for New York alone (Table II-2). Most of New Jersey's ocean landings are from the southern part of that state, while most of those from New York are taken along eastern Long Island.

Ocean shad landings in Connecticut have remained fairly constant at about 3% of total state landings, with the fishery not changing in recent years. Rhode Island has seen an increase in ocean landings since 1981, up to about 40,000 pounds per year. However, that increase may be in part due to better catch reporting. Most of the fish landed are sold for lobster bait. Massachusetts ocean landings during the 1980s have been about 30,000 pounds per year until 1986, when they increased to 60,000 pounds. There is a concern that some of these landings may be from the Merrimark River run, which is in the midst of a restoration effort; however, there is no means of determining if this concern is valid. Maine reported no directed ocean fishery, but ocean landings of shad taken as bycatch were 68,000 and 23,000 pounds in 1985 and 1986, respectively.

Through 1988, the only program conducted to investigate the origin of shad being taken in coastal fisheries has been the ocean tagging program conducted by the state of South Carolina. The program and findings from 1986 and 1987 are described in Appendix A. In 1986, 489 fish were captured and tagged in ocean waters near the mouth of Winyah Bay, South Carolina. Of those fish, 120 (24.5%) were recaptured. The majority of returns (68.3%) came from the river systems in close proximity to the tagging site. Georgia rivers accounted for another 10.9% of the returns, while only 2 fish (0.4%) were returned from northern states. In 1987, only 125 fish were tagged. Of the 38 returns (30%), 66% were from adjacent river systems and the rest were from other South Carolina or Georgia rivers. None came from more northern states.

The relatively small numbers of fish tagged thus far in this study reflects the logistical difficulties in conducting a program of this type. The results to date do suggest that the majority of fish being taken in South Carolina's coastal fisheries are from South Carolina and Georgia stocks and thus pose no threat to more northern stocks which are being restored or are currently at depressed levels. However, the expanding fisheries

Table II-2. Commerical landings of American shad in the Hudson River and Atlantic Ocean for New York and New Jersey (provided by R. Brandt, NYDEC)

Year	Hudson River			Atlantic Ocean			
	New York	New Jersey	Total	Long Island New York	New Jersey	Total	
1974	163690 $ 44,000.00 $0.27	67641 $19,610.00 $0.29	231331 $ 63,610.00 $0.27	0	23046 $ 3,505.00 $0.15	23046 $ 3,505.00 $0.15	lbs. $ $/lbs.
1975	196004 $ 79,000.00 $0.40	37097 $14,839.00 $0.40	233101 $ 93,839.00 $0.40	0	31181 $ 6,011.00 $0.19	31181 $ 6,011.00 $0.19	lbs. $ $/lbs.
1976	183157 $ 58,611.00 $0.32	29122 $ 9,258.00 $0.32	212279 $ 67,869.00 $0.32	2454 $ 682.00 $0.28	24680 $ 6,632.00 $0.27	27134 $ 7,314.00 $0.27	lbs. $ $/lbs.
1977	120300 $ 40,902.00 $0.34	63754 $20,894.00 $0.33	184054 $ 61,796.00 $0.34	1036 $ 357.00 $0.34	68811 $18,383.00 $0.27	69847 $18,740.00 $0.27	lbs. $ $/lbs.
1978	306543 $ 76,635.00 $0.25	110905 $39,697.00 $0.36	417448 $116,332.00 $0.28	1902 $ 612.00 $0.32	59101 $ 8,488.00 $0.14	61003 $ 9,100.00 $0.15	lbs. $ $/lbs.
1979	430338 $129,102.00 $0.30	59812 $12,093.00 $0.20	490150 $141,195.00 $0.29	8142 $ 1,566.00 $0.19	64442 $13,343.00 $0.21	72584 $14,909.00 $0.21	lbs. $ $/lbs.
1980	1135320 $272,476.00 $0.24	161650 $31,897.00 $0.20	1296970 $304,373.00 $0.23	113576 $20,475.00 $0.18	75930 $14,405.00 $0.19	189506 $34,880.00 $0.18	lbs. $ $/lbs.

Table II-2. Continued

Year	Hudson River			Atlantic Ocean			
	New York	New Jersey	Total	Long Island New York	New Jersey	Total	
1981	482736	100570	583306	58234	93287	151521	lbs.
	$125,511.00	$28,896.00	$154,407.00	$25,037.00	$21,201.00	$46,238.00	$
	$0.26	$0.29	$0.26	$0.43	$0.23	$0.31	$/lbs.
1982	309598	36195	345793	73489	135382	208871	lbs.
	$108,359.00	$31,370.00	$139,729.00	$24,781.00	$47,226.00	$72,007.00	$
	$0.35	$0.87	$0.40	$0.34	$0.35	$0.34	$/lbs.
1983	415462	72162	487624	33033	132214	165247	lbs.
	$112,174.00	$29,897.00	$142,071.00	$11,563.00	$40,883.00	$52,446.00	$
	$0.27	$0.41	$0.29	$0.33	$0.31	$0.32	$/lbs.
1984	567869	76775	644644	33540	187009	220549	lbs.
	$136,288.00	$18,762.00	$155,050.00	$11,739.00	$44,560.00	$56,299.00	$
	$0.24	$0.24	$0.24	$0.35	$0.24	$0.26	$/lbs.
1985	680064	53428	733492	93810	166047	259857	lbs.
	$163,216.00	$14,051.00	$177,267.00	$33,591.00	$41,578.00	$75,169.00	$
	$0.24	$0.26	$0.24	$0.36	$0.25	$0.29	$/lbs.
1986	615768	118998	734766	72809			lbs.
	$135,469.00	$18,467.00	$153,936.00	$14,084.00			$
	$0.22	$0.16	$0.21	$0.19			$/lbs.

in more northern states, such as North Carolina and Virginia, may well be exploiting stocks from Chesapeake Bay tributaries, and could thus pose a threat to restoration of stocks such as those in Maryland tributaries and in the Susquehanna River. For this reason, continued study of the origin of shad taken in coastal fisheries remains a high priority research area.

B. ESTIMATION OF ANNUAL EXPLOITATION RATES OF ANADROMOUS ALOSID STOCKS IN EACH STATE

During development of the management plan, it became evident that fishing mortality rates for most of the anadromous alosid stocks along the east coast were unknown. The absence of knowledge of exploitation rates made it difficult to investigate factors responsible for stock declines, the population dynamics characteristics of the stocks and desireable management regimes for all the species. It also became evident that most of the states did not have ongoing programs which would permit estimation of current exploitation rates. For these reasons, an anadromous alosid Stock Assessment Subcommittee was established to: prepare a summary of methodologies appropriate for estimation of fishing mortality rates; and, analyse historical data to determine historical exploitation rates and identify exploitation rates which could be sustained by a stock at historical abundance levels.

A report from the committee entitled, "Methods of Estimating Fishing Mortality Rates on American Shad Stocks," is incorporated here as Appendix B. This report identifies procedures which can be followed by individual state agencies in order to establish current exploitation rates of all their alosid stocks.

A second report from the committee entitled, "Historical Exploitation Rates of East Coast American Shad Stocks," is presented here as Appendix C. This report presents the results of analysis of data from eleven river systems along the east coast: Connecticut, Hudson, Delaware, Susquehanna, James, York, Rappahannock, Edisto, Savannah, Waccamaw, Altamaha, and St. Johns. Estimates of sustainable exploitation rates were on the order of 40-50% annual. Results from these analyses provided the basis for a reassessment of recommended exploitation rates presented in the management plan, as is discussed later in this report.

C. LONG-TERM MARKING AND/OR STOCK DESCRIMINATION

Participants in the workshop did not identify any recent programs intended to develop long term marks of alosids from specific stocks or to discriminate between fish from different stocks or geographical regions.

Short-term marking of hatchery reared juvenile shad through use of oxytetracycline, which leaves marks on otoliths which can be distinguished for a period of several months, is being used in the Susquehanna River shad restoration effort. However, it is not yet certain if these marks are retained during the period of time when immature fish remain at sea (R. St. Pierre, personal communication). Whether they will permit identification of hatchery fish at sea or when they return to the river to spawn will be examined in the near future.

No research into long-term marking or alosid stock descrimination is currently planned by any of the state or federal agencies.

D. HYDROELECTRIC TURBINE MORTALITY

A limited number of turbine mortality studies have been done in recent years. On the Susquehanna River, Safe Harbor Water Power Corporation, Conestoga, Pa., has funded juvenile shad turbine mortality studies each year since 1986. Logistical problems have to date precluded collection of sufficient data to estimate turbine mortality rates . However, the data have been sufficient to design new studies which it is hoped will generate the necessary data (R. St. Pierre, USFWS). Additional work is continuing on the effectiveness of spills to pass juvenile shad downstream without their passage through turbines.

Mortality of radio-tagged adult shad due to turbine passage has been assessed incidental to studies of movements of transplanted adult shad in the Susquehanna (SRAFRC, 1988). The estimate of mortality based on data collected in 1987 was 29%, but the data were very limited.

Extensive studies have been conducted for many years at Connecticut River hydroelectric facilities of mortality of both adult and juvenile shad due to turbine passage (e.g., Kynard et al., 1988). However, no new publications on this work have been produced in the past several years.

Turbine mortality is also of major concern with regard to tidal hydroelectric power generation facilities proposed for various portions of the Bay of Fundy in Canada. An abstract of the presentation made at the workshop by Dr. M. J. Dadswell concerning studies of mortality at a pilot tidal hydropower facility in Canada is presented in Appendix D. Such facilities are of concern because east coast stocks of anadromous alosids summer in the Bay of Fundy, and any significant mortality due to passage through turbines could have a drastic deleterious impact on all east coast stocks. Observed mortality rate of adult shad which passed through the tidal turbines was 46.3%, with wide variability. Clearly such turbine passage poses a threat to the well-being of United States shad stocks.

E. HICKORY SHAD LIFE HISTORY STUDIES

None of the states reported any specific programs initiated to gain more information about the life history of hickory shad stocks. It appears that hickory shad are a low priority species within all of the states in which it occurs. It is unlikely that any of the agencies will initiate needed studies in the near future. This finding serves as a basis for a new management recommendation, presented later in this document, that ASMFC and its member agencies encourage hickory shad research be undertaken by graduate students seeking advanced degrees and/or by university researchers.

F. ESTABLISH JUVENILE ALOSID ABUNDANCE SURVEYS

Juvenile shad abundance surveys are conducted annually in the Kennebec/Androscogin Rivers, Connecticut River, Hudson River, Delaware River, upper Chesapeake Bay, lower Chesapeake Bay, and Altamaha River, Georgia. Juvenile river herring are also taken in these surveys, and all the anadromous alosids are regularly taken in juvenile surveys for other species, such as striped bass.

While much data on juvenle alosid abundance in the various river systems exists and catch-per-unit-effort indices are regularly calculated, most of the time series of indices have not been validated against relative abundance of adults in subsequent spawning runs and none have been validated to the same extent as have been striped bass indices. On the Hudson River, in particular, a long term data set exists on juvenile abundance, but an accurate index of yearclass strength from these data has only recently been finalized (R. Brandt, NYDEC).

Since the ASMFC management plan was issued in 1985, Maryland has expanded their juvenile alosid survey to include seven spawning rivers in Maryland: Susquehanna, Northeast, Chester, Choptank, Nanticoke, Pocomoke, and Patuxent (D. Weinrich, Md. Tidewater Administration, pers. comm.). These surveys include the use of electroshocking and trawls. No other states have modified ongoing juvenile surveys or initiated new juvenile survey programs.

No states are currently using juvenile relative abundance indices as key elements of management programs. Such a step is unlikely to occur before indices can be validated and specific management objectives within a state specified.

III. ADDITIONAL ALOSID RESEARCH FINDINGS

Many research and monitoring programs dealing with anadromous alosids have been conducted and remain ongoing which do not deal with the six research priorities specified in the management plan. Presentations by a number of researchers were made at the July 1987 workshop covering several of these programs, and abstracts of those presentations are presented here in Appendix D. Also reviewed at the workshop were the programs being conducted by the state agencies. Reports from several of the state agencies on these activities are also included in Appendix D. Highlights of these presentations are presented here, with the specific relevant section of Appendix D indicated.

A. BAY OF FUNDY AMERICAN SHAD RESEARCH (APPENDIX D-1)

Dr. M.J. Dadswell carried out a shad tagging program in the Bay of Fundy from 1979 to 1985, during which time a total of 31,550 shad were marked. Of the 1,100 tags returned thusfar, 70% have been from all sections of the east coast of the United States. These studies have shown that all stocks of American shad summer in the Bay of Fundy, and Dadswell is currently analysing the data to establish mortality rates for immature and mature shad. Dadswell's tidal turbine mortality rates were addressed earlier.

B. RESTORATION OF AMERICAN SHAD TO THE SUSQUEHANNA RIVER (APPENDIX D-2)

Mr. Richard St. Pierre is USFWS Fisheries Coordinator for the Susquehanna River and oversees the ongoing shad restoration program for that river. The restoration effort includes upstream transplants of gravid adults, hatchery rearing of fry and juveniles, studies of upstream and downstream migration, and studies of turbine mortality. A total of 5,200 and 7,667 shad were captured at the Conowingo Dam in 1986 and 1987, respectively, up dramatically from the annual total catch of 127 fish per year in the 1970s.

C. HARVEST OF RIVER HERRING IN THE FCZ (APPENDICES D-3 AND D-4)

The declines in river herring stocks observed in the mid-1970s has been attributed in large part to excessive harvest by foreign fishing fleets operating in the FCZ (Richkus and DiNardo 1984).

Concerns remain that any harvest of river herring in fisheries taking place in the FCZ may hinder recovery of depressed stocks in the Chesapeake Bay and further south. Thus, offshore harvests are being closely monitored.

Mr. Gary Shepherd, NMFS, summarized river herring by-catch in mackerel fisheries from 1983 to 1986. The total river herring by-catch amounted to less than 0.5% of the total mackerel catch and the majority of fish taken were mature adults.

Mr. George LaPointe, ASMFC, subsequently provided more recent information on the FCZ mackerel fisheries and herring bycatch restrictions. Included in this material (Appendix D-4) is correspondence relating to an accidental large haul of river herring made by a Dutch vessel. The correspondence shows the sensitivity which the foreign fleets have to restrictions on river herring harvest and also the difficulties encountered in attempting to completely avoid harvest of river herring.

D. ACID DEPOSITION EFFECTS ON ANADROMOUS ALOSIDS (APPENDIX D-5)

Dr. Ronald Klauda, Johns Hopkins University, has been conducting research on the effects which acid deposition may have on the reproductive success of anadromous alosids, in particular blueback herring. He has found that blueback herring are very sensitive to low pH levels and elevated aluminum concentrations. Acid pulses of 5.5-5.6 resulted in 25 to 50% mortality, and 70 to 100% mortality when combined with aluminum concentrations of 60-100 ppm. Field studies were inconclusive due to the absence of rain events. It appears that acid deposition may have played a role in the decline of anadromous alosids in Maryland.

E. OCEAN MIGRATION OF ALEWIFE AND BLUEBACK HERRING (APPENDIX D-6)

Dr. Roger Rulifson, East Carolina University, has been conducting biological studies and tagging of alewife and blueback herring in the Bay of Fundy in conjunction with the work being done by Dr. Dadswell. He has found that the blueback

IV. REVISIONS OF RESEARCH PRIORITIES

The July workshop provided an opportunity for the Scientific and Statistical Committee to review progress which had been made in advancing the state of knowledge about anadromous alosid biology and fisheries. The presentations made at the meeting and the discussion which took place about other research projects permitted a reassessment of the research priorities identified in 1985 when the management plan was issued. This new listing of research priorities (Table IV-1) also reflects what the S&S Committee views as important information needs for management of anadromous alosid stocks at the present time.

A. ANNUAL EXPLOITATION RATES

A key ingredient in establishing effective management regimes for any fishery is a knowledge of the magnitude of current fishing mortality on the target species. Discussions at the workshop revealed that there remains a paucity of information on what the current exploitation rates are of most of the individual river stocks of American shad and almost all of the river herring stocks. Thus, the highest priority was assigned to this most critical information need.

B. STOCK IDENTIFICATION PROCEDURES

The expansion of ocean fisheries for American Shad (see Chapter II) in a number of the coastal states has continued to be of concern to those states in which stocks are currently depressed and might be adversely affected by these fisheries. Similar concerns exist with regard to harvest of river herring in the FCZ (see Appendices D-8d,e). The ability to identify the origin of fish being taken in these ocean fisheries would help determine if there really is cause for concern about these fisheries, and, if so, permit management strategies to be developed to alleviate those concerns.

C. LIFE CYCLE RESEARCH

The importance of life cycle research has been evidenced by the progress which has been made in understanding the biology of American shad in the Connecticut River (e.g., Crecco and Savoy, 1984) and in managing that shad stock. The modeling work

Table IV-1. Anadromous alosid research priorities (revised)

- Determine annual exploitation rates on a regular basis for all major exploited stocks
- Develop or employ stock identification procedures (e.g., tissue analyses, tagging) to permit detection of specific river stocks in mixed-stock, intercept fisheries
- Implement life-cycle process-oriented research to allow a determination of anthropogenic impacts on early life history survival
- Monitor basic stock status annually (e.g., age structure of spawning stock, juvenile production)
- Improve records of catch and effort
- Study the effects of introduction of anadromous river herring on pond ecosystems (phytoplankton, zooplankton, other fish species) (focus of controversy over river herring restoration in Maine)
- Encourage university thesis research on hickory shad (lack of importance of the species makes implementation of agency programs unlikely).

done on that stock was only possible with the detailed life history information developed over many years of intensive study. The Connecticut remains the only stock for which such complete information is available, and it is unclear as to how transferable that information is to stocks in other systems. It is unlikely that southern stocks, in particular, have identical life cycle parameters. A long-term committment to conducting life cycle research on anadromous alosids in key river systems along the East coast would contribute substantially to effective management of these resources.

D. STOCK STATUS MONITORING

Effective management of anadromous alosid stocks requires very basic information, such as reproductive success and relative abundance of spawning stocks. Such information is not being collected on most spawning rivers. Compilation of such information on a regular basis for key rivers in each state would contribute substantially to effective management.

E. IMPROVE CATCH AND EFFORT DATA

Accurate and timely information on catch and effort is important in controlling exploitation and carrying out various types of modeling in order to identify appropriate management strategies. Information on recreational catch and effort is extremely limited for most alosid stocks, and commercial catch and effort data remain suspect in many states due to possible underreporting, inaccurate record keeping and idiosyncracies in the fisheries or in the manner in which information is reported that make the data unusable (e.g., reporting the amount of gill net licensed rather than the amount fished; the sale of fish off of truck tailgates with no formal records of the sales). Improvement of such records remains an important management requirement.

F. EFFECTS OF RIVER HERRING ON POND ECOSYSTEMS

This research need was identified by the state of Maine as a result of public controversies which have arisen in response to andromous alosid restoration programs. The concerns are that when herring are introduced into a pond, they will crop zooplankton to the extent that phytoplankton blooms will occur, resulting in degradation in water quality. An additional concern is that the juvenile alosids will compete with resident species for forage, thus impacting those resident stocks. Little specific information exists at the present time which could be used to addresss these concerns.

G. RESEARCH ON HICKORY SHAD

As was discussed earlier, no state has initiated a program specifically targeting hickory shad since the management plan was issued in 1985. In discussions at the workshop, it was evident that the hickory shad remains a low priority species in the states in which it occurs. It was also apparent that none of the states would be initiating any new hickory shad programs in the near future. However, it was also clear that the hickory shad would be an excellent species for study by students seeking graduate degrees. Little is known about the species, and even very basic life-history studies would contribute substantially to the extent of our knowledge. It was concluded that all agencies should encourage university research on this species throughout its range.

Table V-1. Recommended maximum annual exploitation rates (revised)

Stock and Status	Rate	States or Rivers
American shad		
Severely depleted	0%	Maryland, Ogechee River (Georgia), Rhode Island
Depleted or newly established	25%	Virginia, Florida
Rebuilding, partially restored, at least minimal acceptable level	40-45%	Connecticut, Delaware and Hudson Rivers, Georgia (except Ogechee), South Carolina, North Carolina
Blueback herring/Alewife		
Severely depleted	0%	Maryland
Depleted or newly established	25%	Delaware River, Florida, Virginia, several rivers in Maine
Rebuilding, partially restored, at least minimal acceptable levels	60%	South Carolina, North Carolina, Connecticut River, Hudson River, Rhode Island, Massachusetts, New Hampshire, some rivers in Maine, New Jersey, Georgia
Hickory shad		
Severely depleted	0%	Maryland
Depleted	25%	North Carolina, South Carolina, Georgia, Florida, Virginia

Recommendation 3.2 - No change, but documentation of current fishing mortality rates can be facilitated by following methodology guidelines prepared by the Stock Assessment Subcommittee (Appendix B).

Recommendation 3.3 - no change

D. WATER QUALITY

Recommendation 4.1 - No change. Guidelines for water quality standards were presented in Table V-3 of the original plan. Maryland subsequently developed new water quality guidelines for the protection of anadromous fish, which are included in this document (Appendix D-8h), and which may serve as a model for use by other states.

Recommendation 4.2 - No change. Results of ongoing studies dealing with the effects of acid deposition on anadromous alosids were presented at the July workshop and are summarized in Appendix D-5. The existing information suggests that acid deposition may have a deleterious impact on the anadromous alosids.

E. FLOW REQUIREMENTS

Recommendation 5.1 - No change

Recommendation 5.2 - A sentence was added to the recommendation, so that it now reads, "In reviewing proposed projects that will affect flow regimes, EVERY EFFORT WILL BE MADE TO AVOID ANY DEWATERING OF RIVERINE HABITAT, AND CONTINUOUS FLOWS AND FACILITY OPERATIONS WILL BE SELECTED WHICH will not adversely affect anadromous fish. ....."

F. OTHER HABITAT FACTORS

Recommendations 6.1 and 6.2 - No change

G. RESTORATION OF ANADROMOUS ALOSIDS

Recommendation 7.1 - No change

Recommendation 7.2 - No change. States which have established restoration plans to date include New Hampshire, Massachusetts, New York, Pennsylvania, New Jersey, Delaware, Maine, Maryland and Virginia. Restoration of American shad into the upper portions of the Connecticut River is continuing. Several plans are described in state reports included in Appendix D.

Recommendation 7.3 - No change

Recommendation 7.4 - No change. However, several states appear to still have difficulty in obtaining shad from the Holyoke lift on the Connecticut River which are needed to support their own restoration activities. It appears that the agencies responsible for management of that facility should be more responsive to the needs of other states.

Recommendation 7.5 - A sentence was added to the end of the recommendation which reads, "THESE SAME CONCERNS SHOULD BE ADDRESSED FOR ANY WATER DIVERSION PROJECTS, SINCE SUCH PROJECTS COULD RESULT IN REMOVAL AND MORTALITY OF DOWNSTREAM MIGRATING ALOSIDS."

Recommendation 7.6 - The first sentence of the recommendation was changed to read, "All resource agencies shall oppose any new hydroelectric OR WATER DIVERSION projects proposed for drainage systems currently supporting or with potential for supporting anadromous alosid runs ...."

H. RESEARCH NEEDS

Recommendation 8.1 - No change

Recommendation 8.2 - A new priority listing of research needs was presented earlier in Table IV-1.

Recommendation 8.3 - No change

Recommendation 8.4 - A new priority listing of research needs was presented earlier in Table IV-1.

Recommendation 8.5 - The first sentence of the recommendation is changed to read, "NMFS WILL UNDERTAKE the compilation and analysis of all data on offshore river herring distribution and harvest ....."

I. CITIZEN PARTICIPATION

Recommendation 9.1 - No change

J. REVISED MANAGEMENT RECOMMENDATIONS

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).

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

J. REVISED MANAGEMENT RECOMMENDATIONS

Regulation of Offshore Harvests

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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

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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 will make every effort to avoid any dewatering of riverine habitat and to ensure that continuous flows and facility operations will be selected which 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 Interstate Fisheries Management Program Policy 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. These same concerns should be addressed for any water diversion projects, since such projects could result in removal and mortality of downstream migrating alosids.

Recommendation 7.6

All resource agencies shall oppose any new hydroelectric or water diversion 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 amended plan (see Table IV-1 of this document).

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

NMFS will 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.

Tables V2, V3, V4 and V14

Excerpted from

ASMFC's Fisheries Management Report No. 6

Fisheries Management Plan

for

American Shad and River Herrings

October, 1985

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

[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.)

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	

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.

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

APPENDIX A

Project Descriptions and Preliminary
Findings of South Carolina
Coastal Tagging Studies, 1986 and 1987

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ABSTRACT

A PILOT TAGGING PROJECT TO IDENTIFY STOCKS OF AMERICAN SHAD TAKEN IN NEAR SHORE OCEAN FISHERIES.

ULRICH, Glenn F., McCORD, John W., JENKINS, Nan C., S.C. Wildlife and Marine Resources Department, Charleston, South Carolina 29412.

Increased fishing effort on American shad outside their natal streams by coastal gill net fishermen has become a concern of scientists developing a regional shad management plan. Their concern was that these ocean fisheries were intercepting spawning stocks of American shad en route to rivers over a wide geographic range. The identification of the stocks taken by coastal fishermen is a necessity for assessing their impacts on regional in-stream management and restoration activities.

This project was initiated in January 1986 to develop approaches to answering the stock identity questions raised by ocean fisheries. Tagging operations were centered near the mouth of Winyah Bay, South Carolina, an important ocean fishing area in the Southeast region. Shad were caught with 5 1/2 inch stretched mesh gill nets in an area closed to commercial fishing to avoid immediate recaptures. Floy FT-1 dart tags were applied to the fish which were then moved approximately 1/2 mile from the tagging area and released. Pre-release mortality rates averaged 17.8 percent (105 of 590 fish) during the first year's study. Highest mortality was experienced when shad or incidental species catches were high, resulting in longer time elapsing before all shad could be removed from the net. Mortalities were also directly correlated to increasing seasonal water temperatures.

Tag returns documented the mixed composition of stocks taken by the ocean fishery with returns received from as far south as the Altamaha River in Georgia. The tag return rate was 24.5 percent (120 of 489 fish). The Winyah Bay-Waccamaw-Pee Dee River system in nearest proximity to the tagging area accounted for most of the tag returns (68.3%). Returns were received from all other South Carolina rivers except the Combahee River. Georgia returns accounted for 10.9 percent of the tagged shad with the Altamaha River contributing 9.2 percent of these recaptures. Only two fish were recaptured north of the tagging site.

The effect of capture location and seasonality on the stocks intercepted by ocean fisheries will be investigated in a continuation of this project scheduled to begin in early January 1987.

"Summary of a Presentation by Billy McCard, July 7, 1987"

Activities in South Carolina related to shad and river herring during the winter and spring of 1987 were similar to those of 1986. Funding for American shad investigations was through NMFS udner PL 89-304. Major topics of study were: 1) continued collection of CPUE from cooperating commercial gill-netters on selected rivers and coastal waters; 2) ocean shad tagging in the vicinity of South Carolina's ocean gill net fishery for shad to determine the riverine destination of stocks susceptible to this fishery; and 3) monitoring of the by-catch of Atlantic and short-nosed sturgeon in shad nets to determine the potential impact of the shad fishery on depleted stocks of these species. In addition, shad landings were also collected by project biologists in cooperation with the Marine Resources Division's Fisheries Statistics Section. Landings were recorded by water area, dealer type and county.

1) CPUE

A network of cooperative commercial shad fishermen has been established within the four major river systems in S. C. over the past eight years. Some information has also been collected from fishermen in the nearshore ocean fishery near Georgetown. Rivers for which CPUE data have been collected and monitored for changes in stock status are the Waccamaw-Pee Dee system, Santee River, Edisto River and Savannah River: CPUE data over all years indicate no obvious changes in stocks within the river systems evaluated under this program.

2) Ocean Shad Tagging

Tagging in 1987 was carried out in similar fashion with that in 1986. The tagging area was expanded to include the Murrells Inlet jetties, but sufficient numbers of shad were not encountered in this area. Accordingly, most sampling effort was again focused near the Winyah Bay north jetty.

Prevailing easterly winds during the tagging period (Jaunary 21 - April 13) resulted in a decline in tagging effort from 1986. Fifteen tagging trips were made but only nine were made to Winyah Bay. Considerable effort was expaned at the Murrells Inlet jetties with very low catch rates. Only 125 American shad were tagged during 1987. However, 38 tag returns were received by project biologists for a return rate of 30%. The distribution of tag returns by water area was similar to that of 1986. Most returns (25 or 66%) were from the Winyah Bay - Waccamaw-Pee Dee River systems. All other returns were from areas south of the tagging site as follows: five from the Atlantic Ocean off of S. C., one from the Edisto River, one from the Savannah River and six from the Altamaha River, Georgia.

Handling procedures were refined from those of 1986 with the use of a flow through holding tank and pre-tagging mortality was only 7.4%.

3) **Sturgeon By-catch**

Sturgeon catch rates were very low when compared to those of shad for both 1986 and 1987. However, biologists feel that significant numbers of juvenile Atlantic sturgeon are taken in shad nets, particularly in the Winyah Bay area. The commercial fishery for Atlantic sturgeon was closed statewide in 1985 because of severely depressed adult stocks. For this reason, the potential impact of the commercial shad net by-catch onjuvenile stocks needs to be closely monitored.

Also, the endangered short-nosed sturgeon is commonly caught in shad nets but generally in much lower numbers than are juvenile Atlantic sturgeon. However, relatively large numbers of adult and subadult short-nosed sturgeon are incidentally caught in shad gill nets in the Savannah River. Many of these fish have been collected from Savannah River shad fishermen over the past several springs to be used as brood-stock at the Orangeburg National Fish Hatchery in Orangeburg, S. C.

4) Shad landings were supplied for the 1986 season but have not been summarized to date for the 1987 season. The preliminary total for 1987 is approximately 484,000 pounds.

An independent and state funded study was undertaken by a member of the Marine Resources Division's staff from 1985 through 1987 to determine the extent of the developing recreational shad fishery in the tailrace of the Cooper River below Pinopolis Dam near Moncks Corner, S.C. This study was initiated primarily to determine the impact on this shad fishery from rediversion of water back into Santee River from the Santee-Cooper lakes instead of the Cooper River. This project was completed by the U. S. Army Corps of Engineers in March of 1985 and was undertaken to reduce siltation problems in Charleston Harbor. A copy of the report on this project is attached.

Another ongoing program deals with blueback herring on the Cooper and Santee Rivers and passage of these fish into the Santee Cooper Lakes through navigational locks on the tailrace of the Cooper River and a recently installed fish lift on the Rediversion Canal of the Santee River. As I mentioned at the S&S meeting, a substantial, but undetermined number of American shad, as well as some hickory shad are passed by both of these facilities into the Santee-Cooper Lakes. This project is conducted by the freshwater division of our department and exchange of information between the freshwater and marine divisions is alarmingly poor. A brief description of this project is enclosed. It might be in the best interest of the ASMFC to contact Dick Christy directly in order to receive more detailed information on his project and possibly to notify him of future ASMFC activities.

APPENDIX B

METHODS OF ESTIMATING FISHING MORTALITY RATES ON AMERICAN SHAD STOCKS

APPENDIX B

METHODS OF ESTIMATING FISHING MORTALITY RATES ON AMERICAN SHAD STOCKS

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A Report Prepared for the
Atlantic States Marine Fisheries Commission
Shad and River Herring Scientific and Statistical Committee

Introduction

The ability to assess the current status of American shad *Alosa sapidissima*, and other alosid stocks along the Atlantic coast requires a clearer understanding of the natural and man-made (pollution, fishing, dams) factors causing changes in stock abundance. Exploitation of the spawning stock within its natal river is of particular importance, since it is the only man-made factor over which state fishery managers have some direct control. Moreover, sport and commercial shad fisheries within most Atlantic coast rivers are located well downstream of the major spawning grounds (Walburg and Nichols 1967), so that intensive fishing can seriously reduce spawning stock escapement and the subsequent production of dominant year classes. Therefore, knowledge of how fishing mortality varies with fishing effort (hours or days fished) is needed before fishery managers can effectively control escapement through fishing effort regulations. In addition, if a long time series of fishing mortality rates are estimated for several Atlantic coast rivers, we can better evaluate to what extent overfishing is related to recent stock declines (ASMFC 1985).

The purpose of this paper is to describe several methods to estimate commercial and recreational fishing mortality rates for American shad in their natal rivers. An example of each technique is presented, as well as the assumptions on which each method is based. Although the methods are applied to American shad data, most can be modified slightly to estimate fishing rates on any anadromous stock. Most of the methods of estimating fishing mortality require that repeat spawning occurs and is discernible on the scales. Therefore, the methods can only be used for shad stocks from North Carolina to New Foundland, Canada. Where repeat spawning is virtually absent, such as in the rivers of Florida, Georgia, and South Carolina (Leggett 1969), the methods of estimating fishing mortality are limited to mark-recapture studies. Unless otherwise stated, all mortality rates derived here are instantaneous because annual natural and fishing mortality rates are not additive. The instantaneous fishing rates for all methods were computed under the assumption that exploitation on the spawning population is type I (Ricker 1975), indicating that the biological year starts when the spawning population enters the river , so that fishing mortality precedes natural mortality.

Direct Estimates of Fishing Mortality

The most straightforward way of estimating riverine fishing mortality is by tag-recapture experiments. If American shad are tagged (M_x) randomly during their upriver migration in year x and subsequently recaptured (R_x) by the commercial and sport fisheries in the same year, the exploitation rate (u_x) for each fishery is estimated by:

$$u_x = R_x/M_x \quad , \qquad (1)$$

and the instantaneous fishing rate (F_x) for a type I fishery is expressed by:

$$F_x = -\log_e(1-u_x) \quad . \qquad (2)$$

The reliability of u_x and F_x from tag-recapture studies depends on several assumptions that are familiar to most fishery biologists (Ricker 1975, pages 81-83). If fishing effort (f_x) data such as the number of nets or days fished annually are known in year x, the catchability coefficient (q) of each unit of fishing effort can be calculated:

$$q = F_x/f_x \quad . \qquad (3)$$

The instantaneous fishing rates for other years when fishing effort data are accessible can be estimated by:

$$F_x = q * f_x \quad . \qquad (4)$$

When landings data (C_x) are also included for the same time period, the annual population size, (N_x) can be estimated:

$$N_x = C_x/1-\exp(-\bar{q}*f_x) \quad , \qquad (5)$$

where the quantity $1-\exp(-\bar{q}*f_x)$ is equal to the rate of exploitation (R_x/M_x) of equation 1. The validity of eqs. 4 and 5 depend on the assumption that the catchability coefficient is constant. This assumption needs to be evaluated further since the commercial catchability coefficient for American shad in the Conneticut River was found to be inversely related to stock size (Crecco and Savoy 1985). Even if this assumption is violated, however, eq. 4 can still generate a relative trend in exploitation rates. For further details on eqs. 4 and 5, consult Fredin (1954) and Leggett (1976).

Example 1. A total of 4855 American shad were tagged in the Conneticut River in 1980, of which 721 were recaptured in the commercial gillnet fishery. The annual exploitation rate (u_x) in 1980 was estimated by eq. 1:

$$0.149 = 721/4855 \quad ,$$

and the instantaneous fishing mortality rate (F_x) estimated from eq. 2:

$$0.161 = -\log_e(1-0.149) \quad .$$

The fishing effort (f_x) in 1980 was 897 gillnet days, resulting in a catchability coefficient (q) by eq. 3:

$$0.00018 = 0.161/897 \quad .$$

Table 1. Catch (C_x), effort (f_x), instantaneous commercial fishing rate (F_x) and population size (N_x) of American shad in the Conneticut River from 1975 through 1979-see example 1.

Year (x)	Catch in No. (C_x)	Gillnet Days (f_x)	(F_x)1/	Population size (N_x)2/
1975	123344	1051	0.189	716227
1976	138650	1070	0.193	789947
1977	96974	1176	0.212	507623
1978	85962	1068	0.192	492074
1979	73321	975	0.175	456706

1/ $F_x=0.00018*f_x$

2/ $N_x=C_x/1-exp(-\bar{q}*f_x)$

Given the gillnet landings (C_u) and fishing effort (f_u) from 1975 through 1979, the corresponding instantaneous fishing rates (F_u) and population sizes (N_u) were estimated by eqs. 4 and 5, respectively (Table 1).

For a population in which male and female fish experience different rates of fishing mortality, the change in the sex ratio among surviving fish can be used to estimate total population size (N_{tot}) and the fishing rate (u) (Ricker 1975, pages 199-200). If data are available on the sex ratio before (f_1/n_1) and after (f_2/n_2) exploitation, as well as the commercial or recreational catch of male (C_m) and female (C_f) shad, the population size of female shad (N_f) can be computed by a ratio estimate:

$$N_f=f_1/n_1(C_f-(f_2/n_2*C_{tot}))/f_1/n_1-f_2/n_2, \quad (6)$$

where: C_{tot}= the total catch of male and female shad.

The total shad population (N_{tot}) can be estimated by:

$$N_{tot}=C_f-(f_2/n_2*C_{tot})/f_1/n_1-f_2/n_2, \quad (7)$$

so that the male population size (N_m) can be estimated by subtraction:

$$N_m=N_{tot}-N_f \quad . \quad (8)$$

The annual exploitation rate of female shad (u_f) can be expressed by:

$$u_f=C_f/N_f \quad , \quad (9)$$

and the male exploitation rate (u_m) by:

$$u_m=C_m/N_m \quad . \quad (10)$$

Methods of calculating the asymptotic standard errors about N_f, N_m, N_{tot} are given in the original reference (Chapman 1955).

Example 2- The 1985 female sex ratio (f_1/n_1) of American shad at the mouth of the Connecticut River was 0.45 and was 0.44 (f_2/n_2) at the Holyoke lift after commercial fishing ended. The commercial fishery in 1985 harvested 89,303 shad (C_{tot}), of which 52,689 were female (C_f) and 36,614 were male (C_m). The 1985 population estimate of female shad (N_f) was determined by eq. 6:

$$602,806= 0.45(52,689-0.44(89,303))/0.45-0.44 \quad .$$

The total shad population (N_{tot}) was estimated by eq.7:

$$1,339,568= 52,689-0.44(89,303)/0.45-0.44 \quad ,$$

and the 1985 population estimate of male shad (N_m) was computed by eq. 8:

$$736{,}762 = 1{,}339{,}568 - 602{,}806 \quad .$$

The annual fishing rates on male (u_m) and female (u_f) shad were estimated by eqs. 9 and 10, respectively:

$$0.05 = 36{,}614/736{,}762 \quad ,$$

and

$$0.087 = 52{,}689/602{,}806 \quad .$$

Once u_m, u_f and u are known, instantaneous fishing mortality (F) is then calculated from eq. 2. Although an estimate of population size from eqs. 6-8 requires that the total catch be separated by sex, exploitation rate may be estimated by using only a random sample of the catch. In that case C_f and C_m become the number of females and males in the sample. A potential bias in eqs. 6-10 involves the discard of male and spent female shad by commercial fisherman that represents fishing mortality not accounted for in the sampled catch. This would introduce error into estimates of the component sizes (N_m, N_f) and exploitation rates (u_m, u_f).

Indirect Estimates of Fishing Mortality

When repeat spawners are present in the spawning stock, fishing mortality rates (F) can be estimated indirectly by subtraction:

$$F = Z - M \quad , \qquad (11)$$

when total (Z) and natural (M) mortaliy rates are estimated independently. Given below are several methods to estimate total fishing mortality for shad stocks with repeat spawning.

Total Mortality (Z)-

The fraction of repeat spawners (P_{x+1}) in year x+1 represent fish that have survived exploitation and postspawning mortality in year x. Therefore, P_x is the annual survival rate between x and x+1, so total mortality (Z) can be expressed by:

$$Z_x = -\log_e(P_x) \quad . \qquad (12)$$

When data are limited to only one year, the Z_x estimate from eq. 12 may be seriously biased by recruitment variability in the spawning population. This bias can be removed if data on abundance (N_x), age and repeat spawning are accessible over several consecutive years. Total mortality (Z_{jx}) can then be expressed by year-class (j):

$$Z_{jx} = -\log_e(P_{jx+1} * N_{jx+1} / N_{jx}) \quad , \qquad (13)$$

where: $P_{j,x+1}$ = the fraction of repeat spawners of year-class j in year x+1 ;

$N_{j,x+1}$ = the absolute population size of year-class j in year x+1 ;

$N_{j,x}$ = the absolute population size of year-class j in year x.

If relative rather than absolute abundance data are taken, then $N_{j,x}$ and $N_{j,x+1}$ are replaced by $C/f_{j,x}$ and $C/f_{j,x+1}$ in eq. 13. Unbiased estimates of $Z_{j,x}$ from eq. 14 depend on the assumptions that age composition and spawning history data reflect the true age and spawning history composition, and that relative changes in stock abundance between year x and x+1 reflect unbiased changes.

Example 3- Walburg (1961) collected relative abundance (C/f), age and repeat spawning data for American shad in the Connecticut River from 1956 through 1959. In 1956, repeat spawners (P_x) comprised 42.5% of the run. The total instantaneous mortality rate (Z_x) from eq. 13 was:

$$0.856=-\log_e(0.425) .$$

Example 4- Walburg (1961) found that the relative abundance (C/f) of the 1951 year-class in 1956 (age 5) was 1698 fish/gillnet hour and 901 fish/gillnet hour in 1957 (age 6), of which 415 were repeat spawners. Let 1698= C/f_{jx}, 901= C/f_{jx+1} and 415/901=0.461=P_{jx+1}. The total mortality rate (Z_{jx}) of the 1951 year-class between ages 5 and 6 was estimated by eq. 14:

$$1.41=-\log_e(.46*901/1698) .$$

Catch Curve Analysis

Another way of estimating total instantaneous mortality (Z) is by catch curve analysis (Gulland 1985), where relative (C/f_A) or absolute (N_A) abundance is plotted in a linear model against their respective age (A):

$$\log_e(C/f_A)=a+Z*A . \qquad (14)$$

The descending limb of the curve in the log scale is usually straight with the slope (sign changed) equal to the total mortality rate (Z). Despite the widespread use of catch curve analysis, eq. 14 is not very useful for American shad and other anadromous alosids in which recruitment to the spawning population and fishing gear occurs gradually over ages 3 to 6 (Leggett 1969). As a result, catch curve analysis for American shad should be confined to the plot of log abundance over ages 6 to 10 when only repeat spawners are present. A better approach is to construct a catch curve by plotting the log of spawning group frequency against the corresponding number of times spawned (assuming that consecutive spawning is the rule):

$$\log_e(S_{f,x}) = a + Z*W_{f,x} \quad , \qquad (15)$$

where: $S_{f,x}$ = the number of shad with 1,2,...f spawning marks in year x;
$W_{f,x}$ = the frequency of spawning scars (1,2,...f) in year x.

Many American shad that are first and second time spawners (0 and 1 spawning marks on scales) are not large enough to be fully vulnerable to commercial gillnet fisheries (Walburg 1961). Therefore, if the spawning history data were obtained from a gill net fishery, only fish with two or more spawning marks should be included in eg. 15. It is also desireable to estimate Z separately for male and female shad since female shad are larger, generally mature later than males (Leggett 1969) and are selected for in sport and commercial fisheries.

The validity of egs. (14) and (15) for estimating Z depends on the assumptions that both fishing (F) and natural (M) mortality rates are constant over all ages and population sizes, and that recruitment to the spawning population is constant. The assumption of constant recruitment is seldom satisified, particularly for short-lived alosid species. However, if relative abundance data are available for several consecutive years, the effects of recruitment variability can be removed by estimating total mortality (Z) by year-class (j):

$$\log_e(S_{j,f,x}) = a + Z_j W_{j,f,x}, \qquad (16)$$

where: $S_{j,f,x}$ = the number of shad of year class (j) with 1,2...f spawning marks in year x;

$W_{j,f,x}$ = the frequency of spawning scars (1,2 f) of year-class (j) in year x.

Example 5. Walburg (1961) estimated the relative abundance (C/f), age and spawning frequency of American Shad from 1956 though 1959. Total mortality (Z) for the 1957 data was estimated with eg.14 by plotting the $\log_e$ of C/f for ages 6 to 9 against the respective age (A).

Age (A)	C/f	$\log_e$ (C/f)
6	1485	7.30
7	545	6.30
8	193	5.26
9	18	2.89

$\log_e$ (C/f) data were related to age (A) in a linear model:

$$\log_e (C/f) = 16.12 - 1.43\ A,$$

where total mortality (Z) is the slope (1.43).

Example 6. To use eg. 15 to estimate Z, the $\log_e$ of the spawning group frequency ($S_{f.x}$) in 1957 was plotted against the frequency of two or more spawning scars ($W_{f.x}$).

f,x	$\log_e S_{f.x}$	$W_{f.x}$
889	6.79	2
217	5.38	3
111	4.71	4

The linear regression model was:

$$\log_e (S_{f.x}) = 8.75 - 1.04\ W_{f.x},$$

where Z is the slope (1.04).

Example 7. The relative abundance (C/f) and frequency of repeat spawning for the 1950 year-class (Walburg 1961) are given through its fishable lifespan (1956-1959)

Year	Age	$S_{j,f,x}$	$\log_e S_{j,f,x}$	$W_{j,f,x}$
1956	6	639	6.46	2
1957	7	217	5.38	3
1958	8	153	5.03	4
1959	9	39	3.66	5

Total mortality (Z) for the 1950 year-class was estimated by eg. (16):

$$\log_e (S_{j.f.x}) = 8.192 - 0.87\ W_{j.f.x},$$

where Z is the slope (0.87). The above procedure can also be used to estimate Z for all other year-classes in the spawning population.

Total mortality (Z) from von Bertalanffy Equation

If only length frequency data are gathered annually, it is still possible to estimate total mortality with the growth parameters (K, L_∞) of the von Bertalanffy growth model:

$$L_t = L_\infty (1 - \exp - K(t - t_o)), \qquad (17)$$

where: L_t = The mean length at age t;
L_∞ = The maximum length in the population;
t_o= The length at 0 age;
K = rate at which L_t approaches L_∞.

This method is predicated on the theory that a decline in the abundance of older and larger fish is caused by a rise in total mortality (Z) (Beverton and Holt 1959). As a result, the mean length ($\bar{L}$) of the stock greater than the length at full recruitment to the fishery (L_c) is expressed by:

$$\bar{L} = L_c + ((K/(Z+K)/(L_\infty - L_c)), \qquad (18)$$

which can be rearranged to estimate total mortality (Z):

$$Z = K(L_\infty - \bar{L})/(\bar{L} - L_c). \qquad (19)$$

A slightly different approach for estimating Z was developed by Ssentongo and Larkin (1973):

$$Z = K(n/n+1)*(1/\bar{Y} - Y_c) \qquad (20)$$

where: $Y_i = -\log_e (1 - L_i/L_\infty)$;
$\bar{Y} = (\sum_{i=1}^{n} Y_i)/n$
$Y_c = -\log_e (1 - L_c/L_\infty)$;
n = sample size of the length (L_i) frequency distribution between L_c and L_∞.

It is important to note that $\bar{Y} \neq -\ln(1-\bar{L}/L_\infty)$, but must be calculated from individual values of Y_i.

To use eqs. 19 and 20 properly for American shad, L_c should be selected as the mean length at age 6 when nearly all shad of a year-class have attained sexual maturity. It is also desirable to separate the length frequencies by sex since the growth parameters (K, L_∞) differ considerably between male and female shad.

An easy way to estimate K and L_∞ is from a Ford-Walford plot (Ricker 1975) in which mean length at age t is fitted by linear regression against the mean length (L_{t+1}):

$$L_{t+1} = a + b*L_t, \qquad (21)$$

from which L_∞ is expressed by

$$L_\infty = a/1-b, \qquad (22)$$

and K by

$$K = -\log_e b. \qquad (23).$$

Although eqs. 21-23 furnish approximate estimates of K and L_∞, the most accurate and precise estimates are generated by fitting length and age data with a nonlinear least square regression (SAS 1982).

Example 8- Mean fork length-at-age data are available for male and female shad from the Connecticut River.

	Male		Female	
Age	Number	Mean F.L.(cm)	Number	Mean F.L.(cm)
3	12	34.5	-	-
4	116	41.7	66	45.1
5	88	44.6	137	48.7
6	39	47.4	72	51.7
7	7	48.7	14	53.3
8	3	49.4	4	55.1

These data are rearranged in a Ford-Walford plot.

Males L_t	Males L_{t+1}	Females L_t	Females L_{t+1}
34.5	41.7	45.1	48.7
41.7	44.6	48.7	51.7
44.6	47.4	51.7	53.3
47.4	48.7	53.3	55.1
48.7	49.4	55.1	-
49.4	-	-	-

Length at L_t is plotted in a linear model with L_{t+1} as in eq. 21 for males:

$$L_{t+1}= 22.16+0.558*L_t \quad ,$$

and female shad:

$$L_{t+1}= 15.05+0.747*L_t \quad .$$

The parameter K was estimated from eq. 23

Male	Female
$0.583= -\log_e(0.558)$	$0.292= -\log_e(0.741)$

and L_∞ from eq. 22

Male	Female
$50.1= 22.16/1-0.558$	$59.5= 15.05/1-0.747$

Example 9- In 1981, 1500 male and female American shad were measured to fork length (L_i) in the Connecticut River. The mean fork length ($\bar{L}$) from L_c to L_∞ was 48.2 cm for male shad and 52.9 cm for female shad. The mean length at age 6 (L_c) was 47.4 cm for male shad and 51.7 cm for female shad (see example 8). Total mortality (Z) was estimated by substituting L_∞, K, L_c and $\bar{L}$ into eq. 19:

Males- $1.38= 0.583(50.1-48.2)/48.2-47.4$,

Females- $1.61= 0.292(59.5-52.9)/52.9-51.7$.

Total mortality (Z) was also estimated by eq. 20 using L_i, Y_i, $\bar{Y}$ and Y_c:

Males- $\bar{Y}= (\sum_{i}^{n} Y_i)/n = 3.27$

$Y_c= -\log_e(1-47.4/50.1)= 2.92$

$$Z = (1500/1501)(.583)(1/3.27-2.92) = 1.66$$

Females-

$$\bar{Y} = (\sum_{i=1}^{n} Y_i)/n = 2.20$$
$$Y_c = -\log_e(1-51.7/59.5) = 2.03$$
$$Z = (1300/1301)(.292)(1/2.2-2.03) = 1.72$$

Estimating Natural Mortality

Several methods are available to indirectly estimate natural mortality for American shad stocks with repeat spawning. If population estimates (N_x), catch (C_x), age and repeat spawning data are present for two consecutive years, natural mortality ($M_{x,x+1}$) between years x and x+1 can be estimated by:

$$M_{x,x+1} = -\log_e(P_{x+1}*N_{x+1})/(N_x-C_x) \quad , \qquad (24)$$

where:

P_{x+1}= The percentage of repeat spawners in year x+1;
N_{x+1}= The population size in year x+1;
N_x= The population size in year x;
C_x= The catch by the sport and commercial fisheries in year x.

The natural mortality estimates from eq. 24 include losses due to postspawning mortality, oceanic fishing, disease and predation.

If relative (C/f_x) rather than absolute (N_x) abundance data are accessible for two or more years, natural mortality can still be estimated if the rate of exploitation (u_x) is known:

$$M_{x,x+1} = -\log_e(P_{x+1}*C/f_{x+1})/(C/f_x*(1-u_x) \quad , \qquad (25)$$

where the annual rate of exploitation (u_x) is estimated by eqs. 1, 9, or 10.

Example 10- In a hypothetical example, the 1979 shad run is 560,000 fish (N_x) and the 1979 commercial catch is 86,000 fish (C_x). In 1980, the shad run is 480,000 fish (N_{x+1}), of which the fraction 0.3 (P_{x+1}) were repeat spawners. An estimate of the natural mortality rate ($M_{x,x+1}$) between 1979 and 1980 was estimated by eq. 24 :

$$1.19 = -\log_e(0.3*480{,}000)/(560{,}000-86{,}000) \quad .$$

Example 11- The mean catch per net haul (C/f_x) in 1979 was 53.1 and the corresponding commercial exploitation rate (u_x) was 0.22. In 1980, the mean catch per net haul (C/f_{x+1}) was 47.3, of which a fraction of 0.23 (P_{x+1}) were repeat spawners. An estimate of natural mortality ($M_{x,x+1}$) between 1979 and 1980 was estimated by eq. 25:

$$1.34 = -\log_e(0.23*47.3)/(53.1*(1-0.22)$$

If total mortality (Z) and fishing effort (f) were estimated for a number of years, natural mortality (M) can be estimated by a linear regression (Gulland 1985) of Z on f:

$$Z= M+q*f \quad , \qquad (26)$$

where the y-axis intercept is the natural mortality rate (M) and the slope (q) is the catchability coefficient. Unbiased estimates of natural mortality from eq. 26 depend on the assumption that the catchability coefficient (q) is constant over time.

There are also several methods available to estimate natural mortality from specific life history characteristics. Rikhter and Effanov (1976) found that natural mortality among fish stocks is inversely related to the age of sexual maturity by:

$$M= (1.521/T_m^{0.72})-0.155 \qquad (27)$$

where: T_m= the age at which 50% of the population reaches sexual maturity. Hoenig (1983) developed a predictive equation for estimating natural mortality based on the inverse relationship between M and maximum age (T_{max}) of 84 fish stocks:

$$\log_e(M)= 1.46-1.01*\log_e(T_{max}) \quad . \qquad (28)$$

Lastly, Pauly (1980) noted that natural mortality rates of 175 fish stocks were related to the von Bertalanffy coefficients ($L\infty$,K) and the mean annual temperature (T) within which the fish species commonly occurs. This relationship was expressed in a multiple linear regression:

$$\log_e(M)= -0.0006-0.279\log_e(L\infty)+0.6543\log_e(K)+0.4634\log_e(T) \qquad (29)$$

Since the mean annual temperature (T) may be difficult to determine for many fishes, a range of temperature should be substituted into eq. 29.

Eqs. 27-29 were originally developed for fish stocks in which natural mortality remains constant over the fishable lifespan. Given that natural mortality of American shad rises markedly after sexual maturity due to the rigors of migration and spawning (Carscadden and Leggett 1975), several modifications of eqs. 27-29 are needed. Firstly, the T_m value in eq. 27 would usually be about 4.5 years for northern shad stocks (Leggett 1969). However, T_m should be reduced to about 1.5 years to reflect lower natural mortality rates among pre-adult fish between ages 1 and 3.0 (i.e. 4.5-3= 1.5 years). Secondly, although the maximum age (T_{max}) in eq. 28 would be about 10 years for northern shad stocks (Walburg and Nichols 1967), it should be reduced to 4 years to include only the age interval between full sexual maturity (age 6) and the maximum (age 10). Lastly, to use eq. 29 for American shad, the K parameter of the von Bertalanffy equation should be about 0.75 to reflect the adjusted T_{max} of 4 years according to the expression of Pauley (1983):

$$K= 3/T_{max} \quad . \qquad (30)$$

Example 12- Assuming the adjusted age (T_m) at which 50% of the shad mature is 1.5, an estimate of natural mortality from eq. 27 is:

$$0.98= (1.521/1.5^{.72})-0.155 \quad .$$

Given an adjusted T_{max} value of 4 years, eq. 28 was used to estimate natural mortality:

$$\log_e(0.06)= 1.46-1.01*\log_e(4)$$

therefore, $M= \exp(0.06)= 1.06$.

Using the $L\infty$ value of 50.1 cm for male shad (see example 8), the adjusted K value of 0.75 and a mean annual temperature (T) of 12 C, natural mortality was estimated by substituting $L\infty$ (50.1 cm), K (0.75) and T (12 C) in eq. 29:

$$\log_e(0.129)=-0.0006-0.279\log_e(50.1)+0.6543\log_e(0.75)+$$

$$0.4634\log_e(12),$$

therefore, $M= \exp(-0.129)= 0.880$.

Once total (Z) and natural (M) mortality are estimated by various methods (eqs. 13-30), fishing mortality (F) can be estimated by subtraction (eq. 11):

$$F= Z-M \quad .$$

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APPENDIX C

HISTORICAL EXPLOITATION RATES OF EAST COAST AMERICAN SHAD STOCKS

(NOT YET RECEIVED)

APPENDIX C

SUMMARY REPORT OF THE SHAD AND RIVER HERRING STOCK ASSESSMENT COMMITTEE

July 1987

SUMMARY REPORT OF THE SHAD AND RIVER HERRING STOCK ASSESSMENT COMMITTEE

INTRODUCTION

The American shad spawns in a number of Atlantic coast rivers and supports valuable sport and commercial fisheries. The total coastwide landings of American shad rose steadily during the 1960's then declined steadily thereafter, particularly from midAtlantic and south-Atlantic rivers. The underlying causes for the recent decline in shad landings are unclear and no comprehensive stock assessment of Atlantic coast shad has ever been conducted.

This stock assessment was performed by several state biologists under the auspices of the Atlantic States Marine Fisheries Commission. The objectives of the assessment were to: 1) estimate maximum sustainable yields (MSY) and F_{MSY} levels for selected shad populations; 2) compare current rates of fishing mortality rates in these rivers to the F_{MSY} value; and 3) examine how certain biotic (fecundity, fish size, natural mortality) and abiotic factors (river flows) might affect latitudinal changes in MSY and F_{MSY}.

METHODS

The assessment was done on 17 shad stocks from Rhode Island to Florida based on 10 to 65 years of age structure, juvenile indices, catch and effort statistics. An assessment was also attempted on shad data from several other rivers, but this analysis was terminated due to the short time series and poor quality of the data bases. In the analysis we assumed the existence of density-dependent mortality underlying the parent-progeny relationship of American shad. The stock-recruitment relationship was expressed by the three parameter Shepherd S-R model which predicts equilibrium yield by combining yield-per-recruit (Y/R) and biomass-per-recruit (B/R) analyses with the stock-recruitment characteristics of each stock. The sequence of analytical procedures were: 1) estimate population size from catch-effort statistics and tagging studies; 2) determine spawning stock size as the initial population size minus the commercial landings; 3) estimate current fishing rates (F) by catch curve analyses and tagging studies; 4) estimate recruitment from juvenile indices or from age structure and populations sizes lagged 4, 5, and 6 years later; 5) fit the Shepherd S-R model to the stock recruitment data by non linear least squares regression, where the A parameter represents the recruitment rate at the origin, B is the coefficient of density-dependent mortality and K is a scaling parameter that is related to the carrying capacity of each river; 6) generate Y/R and B/R for various levels of F with the Thompson-Bell yield-per-recruit model; and 7) merge the results of the S-R model with Y/R and B/R using several equations from Shepherd (1982) to estimate total yields at each level of F. This analysis was further confined to shad stocks where the S-R parameters (A,B,K) were estimated with reasonably high precision (CV<25%). The MSY and F_{MSY} levels were represented by the peak of the equilibrium yield curve. To determine whether shad stocks may be presently overfished, the F_{MSY} values for each stock was compared to the current fishery rate.

RESULTS

Fits of the general Shepherd recruitment function to shad S-R data were highly variable. Coefficients of determination ranged from .017 to .624. Precision of the parameter estimates as judged by the coefficients of variation (C.V.) ranged from .03 to 1.54. A wide range of recruitment scatter patterns were observed. In depressed populations an ascending limb was clearly observed. For those populations which had not experienced significant stock declines, a dome and descending limb were apparent. In several stocks, the relationship was indeterminant.

Estimated instantaneous rates of fishing mortality for sustainable yields (F_{MSY}) ranged from .4 to 1.2 (Table 3.3.1). Estimated F_{MSY} was controlled by the slope of the stock-recruit function (a). Estimates of "a" were positively correlated with fecundity suggesting that the S-R analysis had accurately captured the productivity of the stocks. "a" was also related to environmental stability. Northern shad have lower fecundity and productivity, reaffirming the hypothesis of adaptive life history variation (iteroparous vs. semelparous spawning) in response to local environmental effects. Historical estimates of yield (1895-1905) were correlated to the estimates of K from the S-R analysis.

A potential source of bias lies in the estimates of spawning stock and the fitting procedure used. Simulation studies with Pacific salmon suggest that errors in the measurement of spawning stocks and a non-zero expected (time series bias) error term due to "natural" vs. "planned" experiments may result in an overestimate of stock productivity. Because of this potential problem, a general S-R model was constructed using only those parameter estimates having a C.V. $\leq$ 25%, from the most reliable data sets. When merged with Y/R and B/R models, the procedure gives F_{MSY} values ranging from .6 - .8. It was therefore recommended that exploitation rates for shad be held below 45 - 50% of adult stock until the potential bias in higher estimates can be evaluted.

Estimates of current fishing mortality rates were generally at or below recommended rates. Notable exceptions were the Susquehanna, Nanticoke, Ogeechee and Cape Fear rivers.

CONCLUSIONS

Density-dependent stock and recruitment models were applied to shad populations with varying degrees of success. The productivity parameter (a) was critical in estimating the fishing mortality rate producing maximum sustainable yield. "a" was correlated with independent biological and physical factors. Estimates of maximum rate of exploitation (u) ranged from 33% to 71% of adult stock. A relationship between maximum fishing rates and adaptive life history strategy was suggested, although 'errors in variables' bias could also be responsible. Stocks are not producing as well as they did at the turn of the century. Conservative exploitation rates of 45% to 54% are recommended until the error bias is further investigated. The ASMFC plan for shad exploitation is 40%. This rate was recommended to the states but there is no obligation to comply.

Estimated fishing mortality rate at MSY (F_{MSY}), exploitation rate at MSY (U_{MSY}), MSY and current fishing mortality rate (F_c) for 17 rivers from New England to Florida.

SITE	F m.s.y.	U m.s.y.	M.S.Y.	Fc
Pawcatuck	.605	.454	39,200	.008
Connecticut	.600	.451	684,200	.151
Hudson	.600	.451	2,722,128	.375
Delaware	.795	.548	651,500	.321
Susquehanna	.700	.503	1,342,000	.942
Nanticoke	.400	.330	85,000	.801
James	.500	.393	814,440	.448
Chowan	1.250	.713	282,100	.675
Tar	1.030	.643	340,000	.794
Neuse	1.000	.632	430,874	.641
Cape Fear	1.100	.667	46,007	1.657
Waccamaw-Pee Dee	.900	.593	106,200	.677
Edisto	.800	.551	136,317	.135
Savannah	1.120	.674	261,000	.416
Altamaha	.700	.503	288,640	.573
Ogeeche	1.200	.699	45,563	.496
St. John's	.600	.451	768,928	.110

S-R ANALYSIS - PARAMETER ESTIMATES (S.E)

River	A	B	K	r 2
Pawcatuck	0.741 (0.056)	1.500 (fixed)	80000.00	0.592
Connecticut	0.889 (0.337)	2.500 (fixed)	565100.00	0.270
Hudson	0.471 (0.102)	2.346 (1.338)	4318000.00	0.350
Delaware	0.777 (0.204)	2.217 (1.340)	822883.00	0.521
Susquehanna	0.817 (0.380)	1.560 (0.340)	1866000.00	0.380
Nanticoke	0.611 (0.123)	1.200 (fixed)	238000.00	0.180
James	1.175 (0.309)	1.600 (fixed)	2574000.00	0.422
Chowan	1.243 (0.137)	3.092 (0.538)	163836.00	0.624
Tar	1.009 (0.373)	2.582 (1.296)	286258.00	0.106
Neuse	1.548 (0.816)	1.230 (0.410)	226200.00	0.437
Cape Fear	1.176 (1.315)	2.128 (1.649)	34320.00	0.091
Waccamaw-Pee Dee	1.275 (0.370)	1.500 (fixed)	92801.00	0.025
Edisto	0.848 (0.331)	4.997 (6.612)	170300.00	0.266
Savannah	1.522 (0.646)	1.808 (0.421)	164010.00	0.233
Altamaha	0.691 (0.183)	2.080 (0.068)	219364.00	0.400
Ogeeche	1.596 (2.456)	1.861 (1.895)	27210.00	0.017
St. John's	1.044 (0.969)	1.400 (1.253)	1534000.00	0.144
Means	1	2.00	608286.00	-

APPENDIX D

RESEARCH REPORTS

<u>APPENDIX D-1</u>

BAY OF FUNDY AMERICAN SHAD RESEARCH

APPENDIX D-1

Bay of Fundy American Shad Research

July 10, 1987
M.J. Dadswell

Tagging Studies

Shad tagging studies were terminated during 1985. A total of 31,550 shad were tagged in the Bay of Fundy between 1979-1985 (Dadswell et al. (in press)). To date, there are approximately 1100 tag returns (4-5%). Of these, approximately 70% are from the U.S.A., 2/3's from river fisheries and 1/3 from coastal fisheries. Working up this data will provide a complete picture of the migration timing along the U.S.A. coast and the sites of fisheries which exploit shad. Using stock discrimination, information from the Bay of Fundy may provide exploitation rates for some fisheries in the United States. Catch/effort data from the Bay of Fundy should provide a reasonable measure of the natural mortality of juvenile and sub-adult shad since these fish were caught in experimental gear and represent year-classes and ages not exploited commercially.

The tag-return information indicates there are three sites of winter concentrations and three summer concentrations of shad along the east coast. Fish overwinter off Florida, in the mid-Atlantic Bight and on the Scotian Shelf. Summer concentrations are in the Bay of Fundy, the St. Lawrence estuary, and off Labrador (Dadswell et al. (in press)).

Turbine Mortality Studies

During 1985 and 1986 turbine mortality studies were carried out on American shad post-spawning adults at the Annapolis Royal tidal turbine. The Annapolis Royal hydroelectric plant consists of a single, low-head STRAFLO rim-generating turbine producing 17-19 MW at flows approximately 400 m^3/s. Experiments consisted of passing sonic tagged shad through the turbine during generation and observing the mortality rate against the mortality rate of similarly handled control shad that were not passed through the turbine. Additionally, using SCUBA, a watch was kept on the area below the turbine for mortalities of wild fish.

Mortality of adult shad during the 1985 experiment was 46.3±34.7% accounting for controls, and during the 1986 experiments was 21.3±15.2% (90% C.L.). Reduced mortality during 1986 may have been the result of better handling procedures. Control survival in 1986 was 97.1±4.0% compared to 74.4±10.0% during 1985. Additionally, during both 1985 and 1986, 10% of fish that passed through the turbine disappeared and may have received a direct strike. All shad which died during turbine passage and recovered by SCUBA were diagnosed as dieing from pressure effects.

Wild fish which were recovered by SCUBA downstream of the turbine represented all species of anadromous fish known from the Annapolis except Atlantic salmon (TPH reports). Death was attributed to mechanical, shear, pressure and cavitation.

APPENDIX D-2

RESTORATION OF AMERICAN SHAD TO THE SUSQUEHANNA RIVER

APPENDIX D-2

ABSTRACT

RESTORATION OF AMERICAN SHAD TO THE SUSQUEHANNA RIVER

Richard A. St. Pierre
U.S. Fish and Wildlife Service
P.O. Box 1673
Harrisburg, PA 17105

Fishery resource agencies from New York, Pennsylvania and Maryland and the U.S. Fish and Wildlife Service are working cooperatively with four private utility companies to restore American shad to historically important spawning and nursery areas above hydroelectric dams in the Susquehanna River. A trap and lift at Conowingo Dam, MD is used each spring to collect returning adult shad for transport above all dams to the river at Harrisburg, PA. Additionally, thousands of adults are seined from the Hudson River and are transplanted into the Susquehanna. With financial support from the utilities, the PA Fish Commission operates a shad hatchery on a major Susquehanna tributary. In addition to reseeding nursery waters with spawners and cultured juveniles, numerous research efforts are underway to improve survival of downstream migrant shad past hydroprojects. These include studies of movement, timing and behavior using hydroacoustics and radio-telemetry and evaluation of effectiveness of controlled spills at dams. Since all hatchery fish are chemically marked, analysis of autumn collections of outmigrating shad indicate the relative contribution of natural production versus hatchery stockings.

Shad returns to Conowingo Dam have grown dramatically in recent years from an average annual 127 fish per year in the trap throughout the 1970's

to a record 5,200 shad in 1986. With most of these fish successfully hauled upstream last year, the addition of 5,000 Hudson River adults and a record 16 million shad fry produced at the hatchery, we anticipate continued growth of the stock returning to spawn in the Susquehanna River. Success in this demonstration phase of the restoration program should result in construction of permanent fish passage facilities at all dams capable of eventually supporting an annual run of 2 million shad.

APPENDIX D-3

FCZ CATCH OF RIVER HERRING

APPENDIX D-3

FCZ CATCH OF RIVER HERRING

Gary Shepherd
NMFS

Atlantic mackerel have been the target of commercial fishing operations in which river herring are taken as a by-catch. The commercial ventures involve either a directed U.S. fishery, a directed foreign fishery under quota restrictions, or a joint venture between U.S. and foreign vessels also operating under a quota restriction. Maximum by-catch allocations were equivalent to previous levels of 100 MT (see Table 1) and based on percent of the mackerel catch relative to 37°30'N. In 1987 the catch south of the line exceeded the limit of 0.25% of the mackerel catch and the fishery was halted in that area. In previous years the maximum amount of river herring taken was 76.4 MT in 1985 and the percentages relative to mackerel catch was highest in 1984 at 0.41%.

In addition to the commercial fishery, an allocation of mackerel was given to Poland for research purposes. Length frequency data of the river herring by-catch collected are presented in Figures 1 and 2. The majority of the catch consisted of adult fish greater than 20 cm. This compares with length data available from the commercial fishery which also shows the by-catch consists of adult fish greater than 20 cm. The Polish research data also substantiates that the majority of the by-catch consists of blueback herring. The total river herring by-catch consisted of less than 0.5% of the total mackerel catch.

FOREIGN DIRECTED LANDINGS

1986

RIVER HERRING	19.2 MT
AM. SHAD	3.3 MT
MACKEREL	19041.6 MT
% RIVER HERRING BY-CATCH	0.10%

1985

RIVER HERRING	76.4 MT
AM. SHAD	7.7 MT
MACKEREL	26104.1 MT
% RIVER HERRING BY-CATCH	0.29%

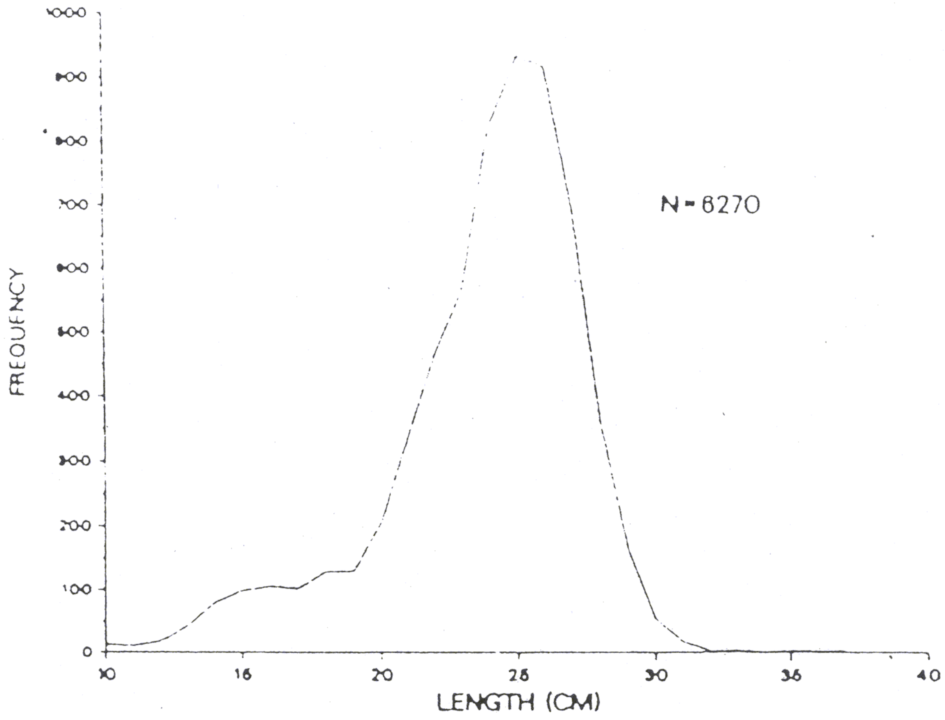
1984

RIVER HERRING	38.0 MT
AM. SHAD	5.3 MT
MACKEREL	9252.9 MT
% RIVER HERRING BY-CATCH	0.41%

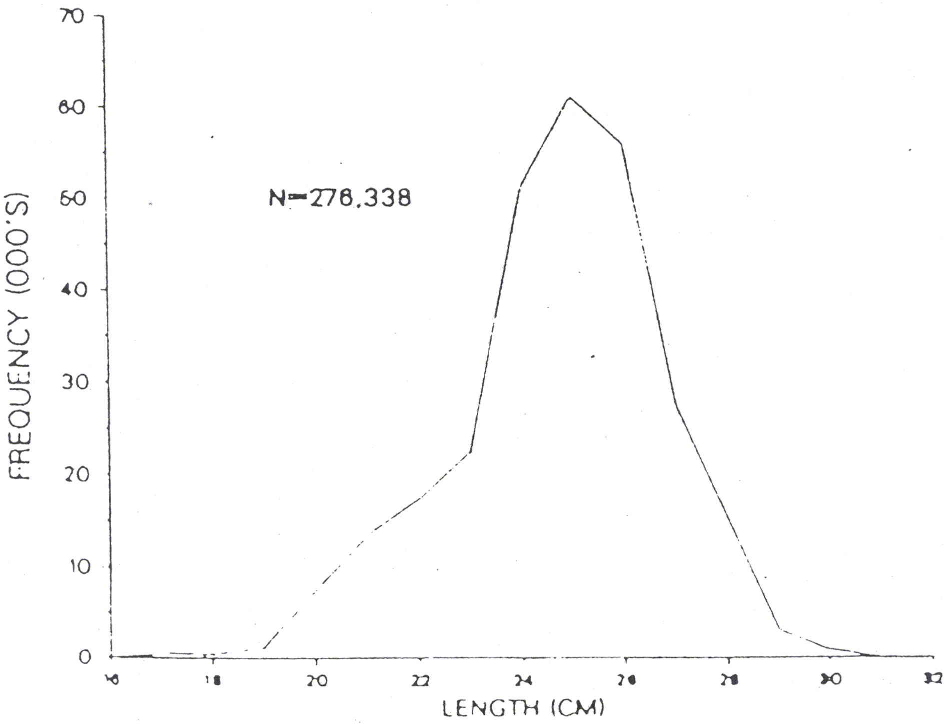
1983

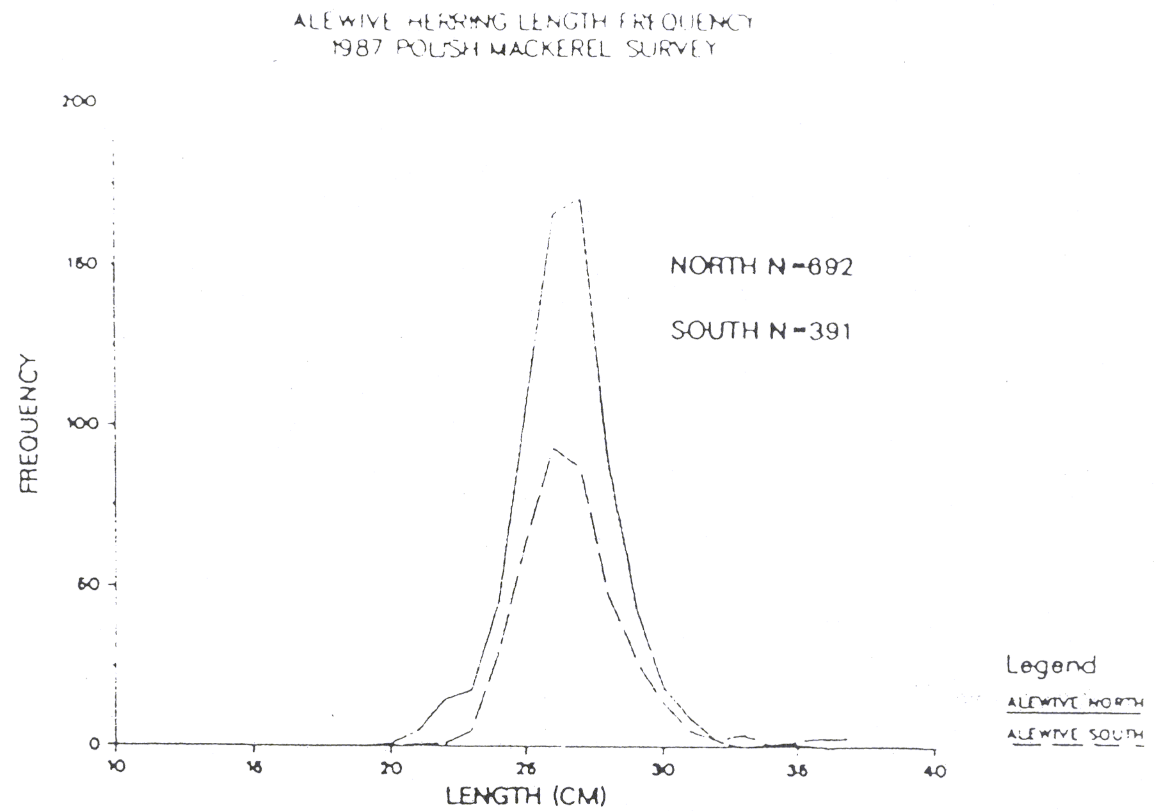
RIVER HERRING	9.1 MT
AM. SHAD	5.2 MT
MACKEREL	6217.1 MT
% RIVER HERRING BY-CATCH	0.15%

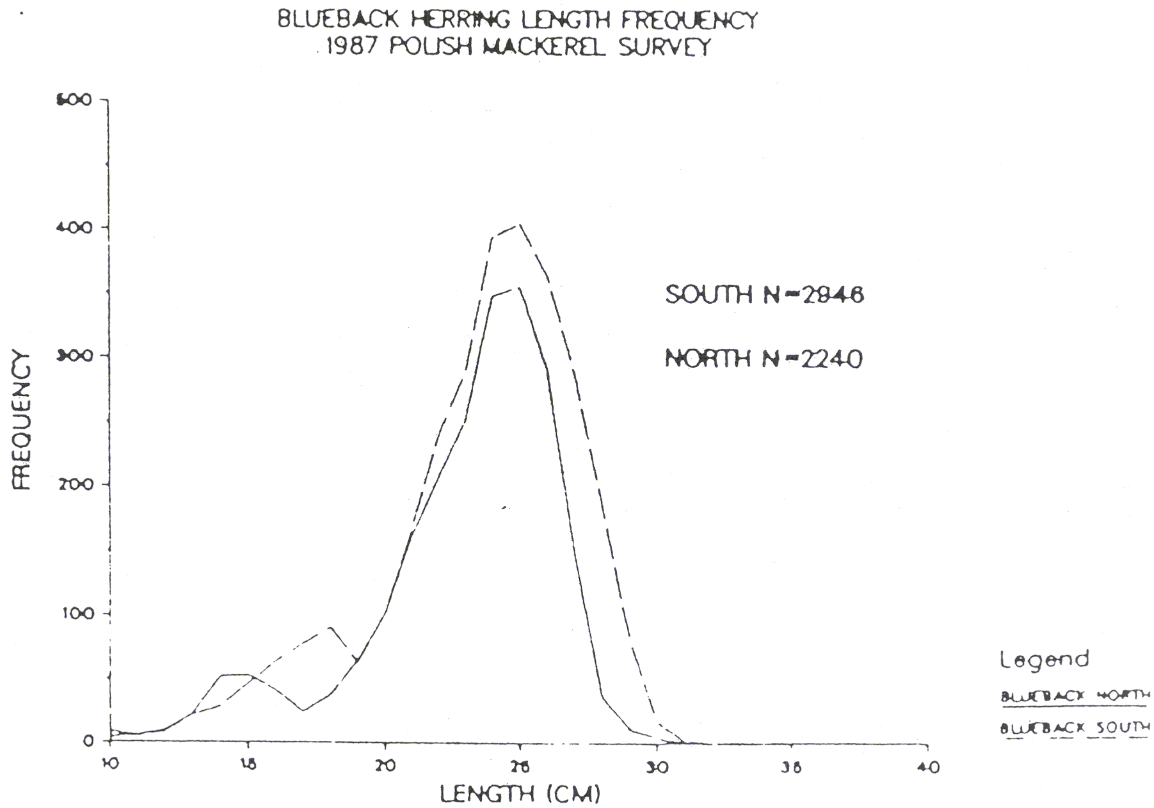
RIVER HERRING LENGTH FREQUENCY
1987 POLISH MACKEREL SURVEY



RIVER HERRING LENGTH FREQUENCY
1987 FOREIGN OBSERVER DATA
DIRECTED FOREIGN MACKEREL FISHERY




ALEWIVE HERRING LENGTH FREQUENCY
1987 POLISH MACKEREL SURVEY
NORTH N=892
SOUTH N=391
FREQUENCY
LENGTH (CM)
Legend
ALEWIVE NORTH
ALEWIVE SOUTH


BLUEBACK HERRING LENGTH FREQUENCY
1987 POLISH MACKEREL SURVEY
SOUTH N=2846
NORTH N=2240
FREQUENCY
LENGTH (CM)
Legend
BLUEBACK NORTH
BLUEBACK SOUTH

APPENDIX D-4

APPENDIX D-4

Memorandum • ATLANTIC STATES MARINE FISHERIES COMMISSION

TO Dr. Bill Richkus, Versar, Inc. DATE: 12/29/87

FROM George Lapointe, Council Liaison

SUBJECT: Atlantic mackerel fishery and river herring bycatch NUMBER M 87-42

Paul Perra asked that I send you the 1987 Atlantic mackerel fishery/river herring bycatch information from the Mid-Atlantic Fishery Management Council. The 1987 and recommended 1988 mackerel specifications (in metric tons) are:

	1987	1988
ABC	294,000	323,000
IOY	154,676	106,000
DAH	69,600	46,000
DAP	29,000	12,000
JVP	28,000	20,000
TALFF	85,076	60,000

ABC = acceptable biological catch, IOY = initial optimum yield, DAH = domestic annual harvest, DAP = domestic annual processing, JVP = joint venture processing, TALFF = total allowable level of foreign fishing.

The recommended river herring bycatch will not change in 1988; 100 mt subject to an increase to 200 mt upon concurrence of the Mid-Atlantic and New England Councils and the Regional Director (NERO).

The river herring bycatch is not to exceed 1% of the mackerel directed foreign fishing and over-the-side transfers north of 37 30 N and 0.25% of these respective catches south of 37 30 N.

Also enclosed is the NMFS report given to the shad S+S committee in July 1987. This report includes the river herring and shad bycatch landings for 1983 through 1986, with incomplete 1987 landings which I've added. The number of participants in the fishery seems to have a major influence on total river herring bycatch. Four countries have applied for directed mackerel fishing in 1988, as opposed to two in 1985, one in 1986, and two in 1987.

I've also included for your information a summary of the Dutch joint venture with Scan Ocean. The Scan Ocean representative said that two catches accounted for 48% of their river herring bycatch, 12.1 mt and 14.4 mt. They fish a net with an opening the size of a football field (5m mesh, 1000-1500 mesh circumference) and do lengthy tows. I believe that this is a good illustration of the fishing power of the gear and the potential for a significant portion of the herring bycatch being caught in a small number of tows.

Please let me know if you need further information for the Shad and River Herring FMP.

Enclosures (4)

cc: Paul Perra

bycatch report from NMFS to Shad S+S, July 1987.

Atlantic mackerel have been the target of commercial fishing operations in which river herring are taken as a by-catch. The commercial ventures involve either a directed U.S. fishery, a directed foreign fishery under quota restrictions, or a joint venture between U.S. and foreign vessels also operating under a quota restriction. Maximum by-catch allocations were equivalent to previous levels of 100 MT (see Table 1) and based on percent of the mackerel catch relative to 37°30'N. In 1987, the catch south of the line exceeded the limit of 0.25% of the mackerel catch and the fishery was halted in that area. In previous years, the maximum amount of river herring taken was 76.4 MT in 1985 and the percentages relative to mackerel catch was highest in 1984 at 0.41%.

In addition to the commercial fishery, an allocation of mackerel was given to Poland for research purposes. Length frequency data of the river herring by-catch collected are presented in Figures 1 and 2. The majority of the catch consisted of adult fish greater than 20 cm. This compares with length data available from the commercial fishery which also shows the by-catch consists of adult fish greater than 20 cm. The Polish research data also substantiates that the majority of the by-catch consists of blueback herring. The total river herring by-catch consisted of less than 0.5% of the total mackerel catch.

foreign fishing, JV application summaries, 11/87

Summary of Applications Received for 1988
Directed Foreign Fishing and Joint Ventures

Country	US Partner	Species	Directed (mt)	Joint Venture (mt)	Purchases (mt)
German Democratic Republic	Mayflower	Atl. Mackerel	22,000	8,000	
		River Herring	50		
		Silver Hake	50		
		Red Hake	25		
		Butterfish	20		
		Illex Squid	10		
		Loligo Squid	10		
		Other Finfish	200		
Netherlands	Scan Ocean/ Lund's	Atl. Mackerel	30,000	2,000	2,670
Poland	Mayflower	Atl. Mackerel (WITHDRAWN)	21,000	7,000	
USSR	Resource Trading Co.	Atl. Mackerel	13,500	4,500	2,000
Poland	Scan Ocean	Atl. Mackerel	16,200	3,800	500
Japan	Lund's	_Illex_ Squid			
		Loligo Squid			
Japan	Pt. Judith Fishermen's Cooperative	_Illex_ Squid			
		Loligo Squid			

SEL/0591D 11/25/87

FOREIGN DIRECTED LANDINGS

1986

RIVER HERRING	19.2 MT
AM. SHAD	3.3 MT
MACKEREL	19041.6 MT
% RIVER HERRING BY-CATCH	0.10%

1985

RIVER HERRING	76.4 MT
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% RIVER HERRING BY-CATCH	0.41%

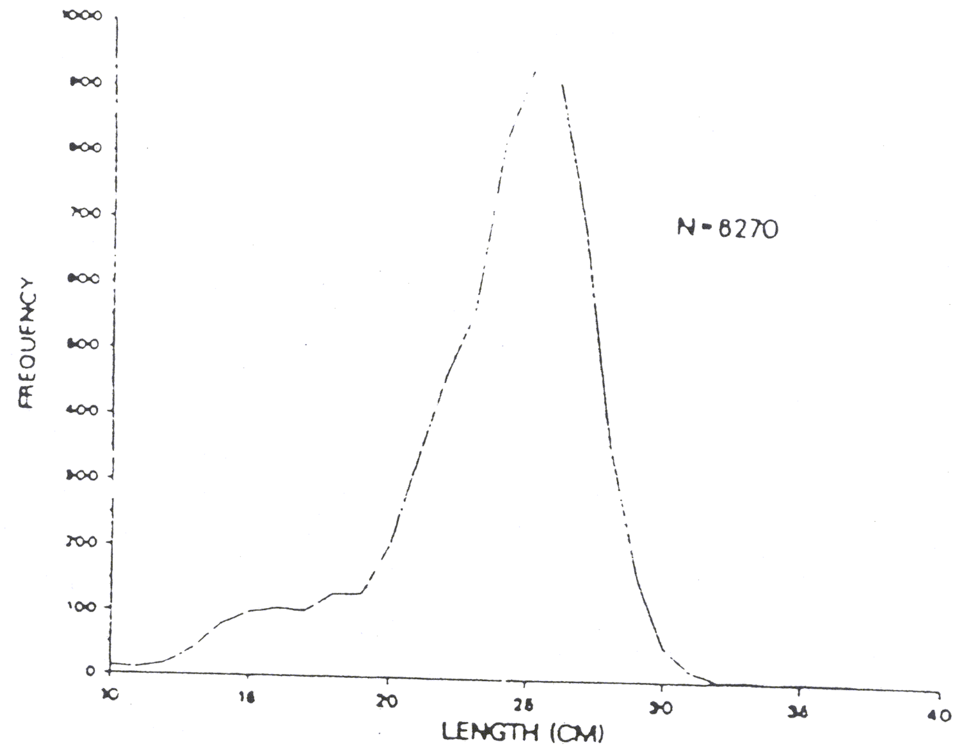
1983

RIVER HERRING	9.1 MT
AM. SHAD	5.2 MT
MACKEREL	6217.1 MT
% RIVER HERRING BY-CATCH	0.15%

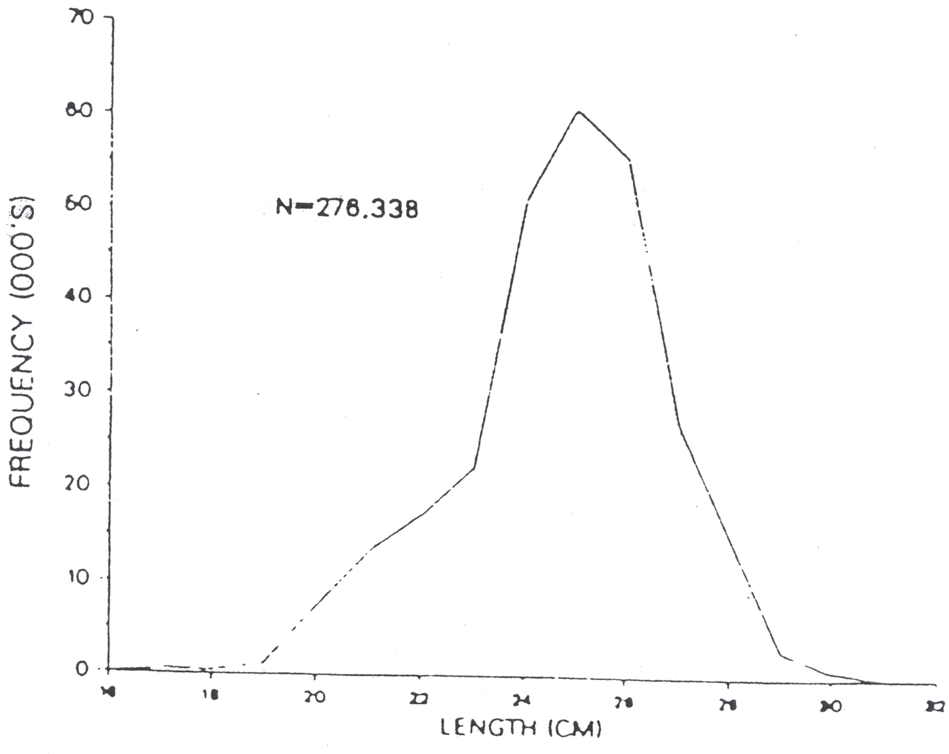
1987 (through September) - added by George Lapointe

RIVER HERRING 105 MT (60 MT - E. Germany, 55 MT - Netherlands)

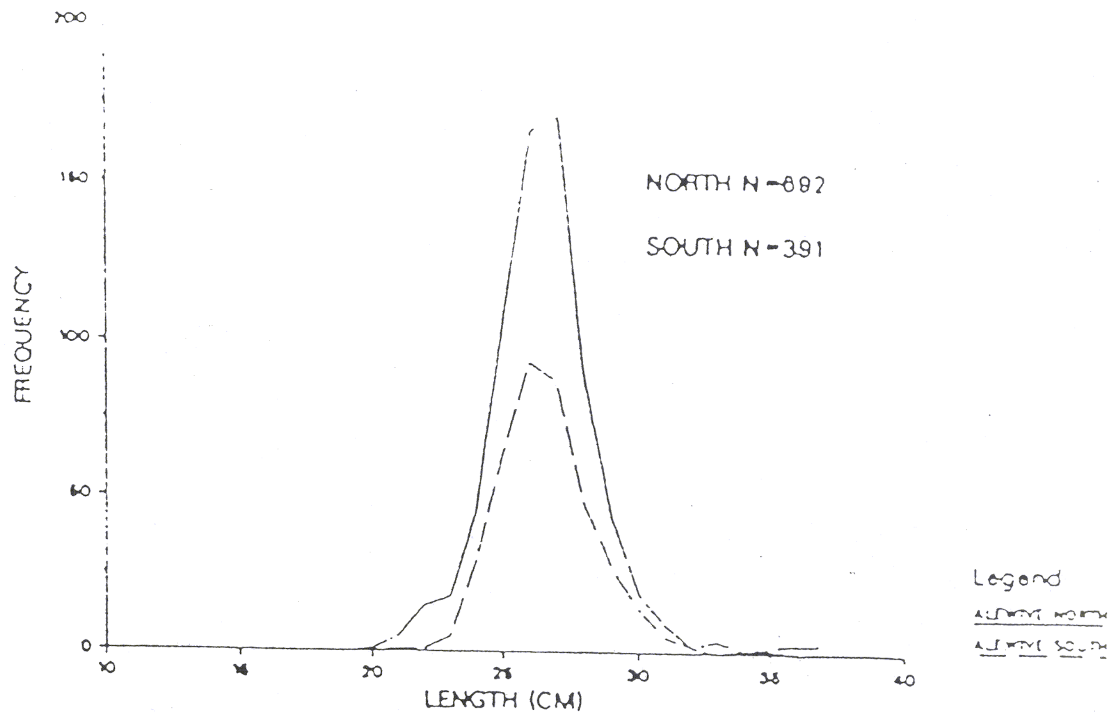
RIVER HERRING LENGTH FREQUENCY
1987 POLISH MACKEREL SURVEY



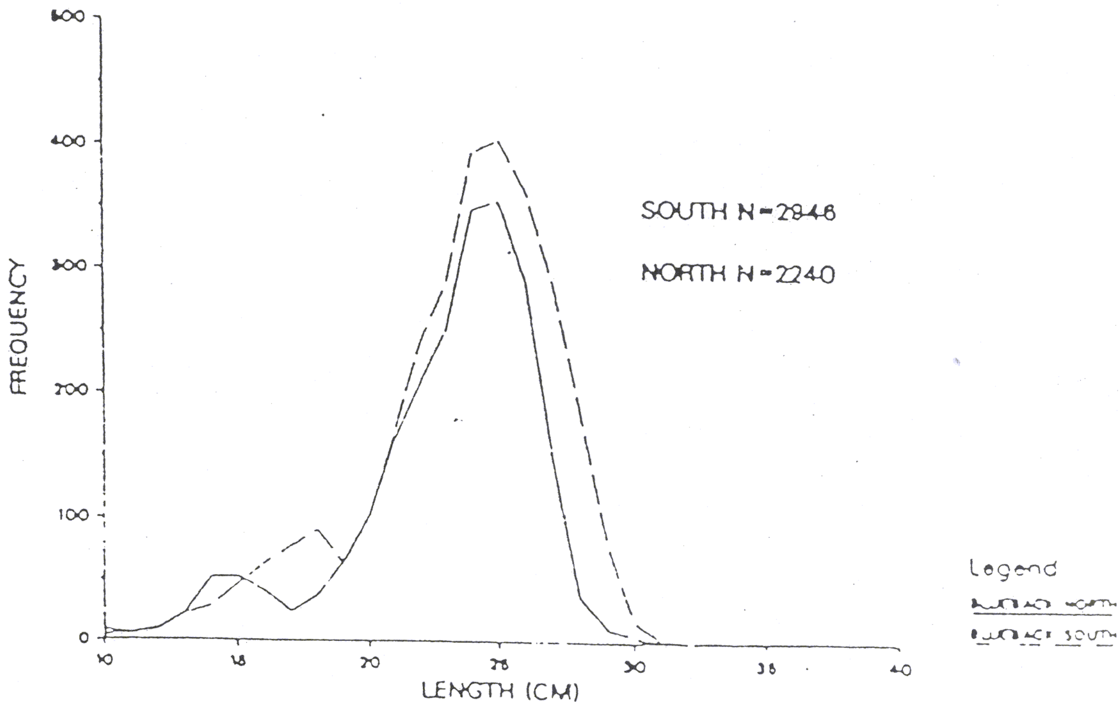
RIVER HERRING LENGTH FREQUENCY
1987 FOREIGN OBSERVER DATA
DIRECTED FOREIGN MACKEREL FISHERY



ALEWIVES HERRING LENGTH FREQUENCY
1987 POLISH MACKEREL SURVEY



BLUEBACK HERRING LENGTH FREQUENCY
1987 POLISH MACKEREL SURVEY



SCAN OCEAN memo to Mid-Atlantic Council re. herring bycatch, 9/87

SCAN OCEAN INC.

DUTCH JV 1987

Dutch Harvest - requested - approved

	Direct M/T	JV M/T	Domestic Purchase M/T
Atlantic Mackerel	21,000	1,000	2,000

Total Actual Catch:

	Direct M/T	JV M/T	Domestic Purchase M/T
Atlantic Mackerel	10,789.7	915.6	863.5
Atlantic Butterfish	0.1		
River Herring	55.1		
Silver Hake	1.5		
Other Finfish	81.1		
Loligo Squid	0.9		
M/T Total	10,928.4	915.6	863.5

NMFS Approved:

Total Mackerel Talff = 85,000.00 M/T

By-Catch River Herring Talff = 100 M/T plus 100 M/T if needed
By-Catch River Herring Caught = 110 M/T (approximately)
By-Catch River Herring Formula =

1/4 % south 37.30 N @ 2,300 M/T Mackerel =	5.7 M/T
1% North 37.30 N @ 8,489 M/T Mackerel =	84.9 M/T
Allowable catch using formula	90.6 M/T
NMFS approved allocation Dutch River Herring =	60 M/T
Actual Dutch River Herring caught	55.1 M/T
Percentage of total Mackerel	.005

Dutch Vessels -

Vessel	No. Tows:
Geertrude Margreta	79
Zeeland	64
Dirk Dirk	41
Astrid	41
No. Tows:	225

There were 225 tows during the entire operation, of which only two tows accounted for 48% of the total river herring catch.

42 Rogers Street Gloucester, MA 01930 USA (617) 283-1004 Telex 200278 (SOCE UR) FAX (617) 283-1412

3/5/87 Tow #64 caught 12.1 M/T River Herring - 3618-7521

2/28/87 Tow #47 caught 14.4 M/T River Herring - 3621-7510

If these two tows are disregarded, the River Herring catch, 223 tows (99%), would be .0026 which is at the lowest formula figure. The Dutch nets are capable of catching 140 M/T in one tow.

In spite of this, the total catch is .005 of the total mackerel caught which is in line with the Polish catch figures.

Polish Fishing Report

Ed Bowman reported to the Mid-Atlantic Council June 24th, the following statistics:

Atlantic Mackerel catch	5,800 M/T
Adm. Arciszeski - average tow	11.3 M/T
Kulbin - average tow	7.5 M/T
River Herring By-Catch	.004
% Polish Mackerel Catch of Total	98%
% Dutch Mackerel Catch of Total	99%

To summarize, the Polish in spite of smaller nets and tows, caught the same percentage of river herring as the Dutch. These figures are in line with the catch totals set by the Councils.

For information purposes only:

Domestic Fishing - unregulated:

River Herring Catch 1986 - East Coast	3,989.3 M/T
Total Allocation Talff (includes extra 100 M/T)	200 M/T
Total Foreign Talff (percentage of domestic)	.05
Foreign J/V Catch River Herring (percentage of domestic)	.028
Dutch J/V Catch (percentage of domestic)	.013

Summary

Judging from the catch data, it is apparent that the Dutch Captain did in fact make very conscientious efforts to limit the River Herring catch, all except two unfortunate tows, to a level of .002 of the Mackerel catch. After these two tows even tighter catch control was placed on limiting the River Herring. The following letters and memorandums from; a NMFS observer, the Dutch Captains and Scan Ocean observer, attest to the total regard and respect the Dutch Captains' had for complying with U.S. fishing guidelines.

proposed 1988 specifications from Federal Register, 12/87

would be inconsistent with the fulfillment of the Foundation program.

(c) *Limitation.* (1) Offers shall be requested from as many potential offerors as is practicable under the circumstances.

(2) The contract file must include an appropriate explanation and support justifying award without full and open competition, as provided in FAR 6.303, except that determinations made under paragraph (b)(3), of this section will not be subject to the requirements for contracting officer certification or to approvals in accord with FAR 6.304.

ADF Agency Number 11010006

ADF BOAC Number 953901

December 1, 1987.

Leonard H. Robinson, Jr.,

President, African Development Foundation.

[FR Doc. 87-28285 Filed 12-10-87; 8:45 am]

BILLING CODE 6116-01-M

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 655

[Docket No. 71264-7264]

Atlantic Mackerel, Squid, and Butterfish Fisheries

AGENCY: National Marine Fisheries Service (NMFS), NOAA, Commerce.

ACTION: Notice of preliminary initial specifications for 1988 and requests for comments.

SUMMARY: NOAA issues this notice of preliminary initial specifications for the 1988 fishing year for Atlantic mackerel, squid, and butterfish, and requests public comments. Regulations governing these fisheries require the Secretary of Commerce (Secretary) to publish preliminary initial specifications. This action will provide data and request comments for NOAA's determination of the initial specifications for the 1988 fishing year.

DATE: Comments must be received on or before January 7, 1988.

ADDRESS: Send comments to Kathi L. Rodrigues, Northeast Regional Office, NMFS, 2 State Fish Pier, Gloucester, MA 01930-3097. Mark on the outside of the envelope, "Comments on 1988 Annual Specifications".

FOR FURTHER INFORMATION CONTACT: Kathi L. Rodrigues, 617-281-3600, ext. 324.

SUPPLEMENTARY INFORMATION: Regulations implementing the Fishery Management Plan for Atlantic Mackerel, Squid, and Butterfish Fisheries (FMP) provide at § 655.22(b) that the Secretary will publish a notice specifying the preliminary initial annual amounts of the initial optimum yields (IOYs) as well as the amounts for domestic annual harvest (DAH), domestic annual processing (DAP), joint venture processing (JVP), and total allowable levels of foreign fishing (TALFF) for the species managed under the FMP. Note that DAH = DAP + JVP. No reserves are provided under the FMP for any of these species.

Procedures for determining the initial annual amounts are found at § 655.21. The Secretary is required to publish this notice on or about November 1 of each year and to provide a 30-day comment period on the preliminary specifications. These specifications are based on recommendations submitted by the Mid-Atlantic and New England Fishery Management Councils.

The Mid-Atlantic Fishery Management Council (Council), the lead Council for the FMP, has prepared an analysis of the nine economic factors specified at § 655.21(b)(1)(ii). Both Councils' recommendations and other relevant data are available for inspection at the NMFS Regional Office at the above address during the comment period.

The following table lists the preliminary initial specifications in metric tons (mt) for the allowable biological catch (ABC), initial optimum yield (IOY), which comprises DAH (DAP + JVP), and TALFF for Atlantic mackerel, *Illex* and *Loligo* squids, and butterfish. These initial specifications are the amounts that the NMFS Director, Northeast Region (Regional Director), is proposing for the 1988 fishing year beginning January 1. The maximum optimum yield (Max OY) is set by the FMP and provided as a point of reference for the proposed specifications.

TABLE.—PRELIMINARY INITIAL ANNUAL SPECIFICATIONS FOR ATLANTIC MACKEREL, SQUID, AND BUTTERFISH FOR THE 1988 FISHING YEAR, JANUARY 1 THROUGH DECEMBER 31, 1988

[In metric tons]

Specifications	Squid		Atlantic Mackerel	Butterfish
	Loligo	Illex		
Max OY[a]	44,000	30,000	N/A[b]	16,000
ABC[c]	37,000	22,500	323,000	16,000
IOY	14,024	17,000	106,000	10,048
DAH	14,000	17,000	[d]46,000	10,000
DAP	14,000	10,000	12,000	10,000
JVP	0	[e]7,000	20,000	0
TALFF	24	0	[f]60,000	48

[a] Maximum OYs as stated in the FMP.
[b] Not applicable; see the FMP.
[c] IOY can rise to this amount.
[d] Includes 14,000 mt projected recreational catch.
[e] For every 4 mt taken in joint ventures (JV), foreign partner is required to purchase 1 mt U.S.-processed *Illex*.
[f] For every 9 mt TALFF, foreign partner is required to purchase either 3 mt in a joint venture or 1 mt U.S.-processed product.

The Regional Director has determined that the IOY levels proposed for the 1988 fishing year will provide the greatest overall benefit to the United States. These levels were set to encourage continued growth in both the harvesting and processing sectors of the U.S. fishing industry in accordance with the purposes of the Magnuson Act. They were selected after meetings and discussions with the Council, considering information from industry groups a-d foreign national representatives, and review of the performance of U.S. fishermen, processors, projected domestic landings, and joint venture information.

The initial *Loligo* IOY is set at a level which results in a JVP of zero. The Council projects that domestic processors have the capacity and intent to utilize the entire amount which is reasonably expected to be harvested. This is the DAH amount. Both Councils indicated a need for an *Illex* IOY which allows for a DAH amount 7,000 mt above the amount domestic processors have the capacity and intent to utilize. The Regional Director has agreed with this recommendation including the stipulation that JVP partners must purchase one mt of U.S.-processed *Illex* for every four mt of JVP amount received.

Domestic landings of *Loligo* for 1987, excluding joint venture harvest, are expected to be about 10,000 mt. The Council has projected an improvement for the 1988 fishing year, setting the IOY at a level which results in a *Loligo* DAH of 14,000 mt. *Illex* landings for 1987 are expected to reach approximately 6,500 mt. However, given that the proposed 1988 *Illex* JVP is 7,000 mt, the Regional Director has agreed with the New England Council's recommendation that the IOY for *Illex* be set at a level which allows for a DAP of 10,000 mt, thereby setting DAP potential at a level higher than JVP.

As in the previous fishing year, specifications give priority to domestic users. Squid IOYs, as proposed by both the Mid-Atlantic and New England Councils, are set at levels which provide squid TALFFs at bycatch levels only, according to the formula established in the FMP. *Loligo* TALFF is sufficient to provide for the Atlantic mackerel foreign fishery. As in 1987, the Council has recommended an *Illex* IOY which results in an *Illex* TALFF of zero based upon its recommendation that there be no foreign directed fishing for silver and red hake during 1988. Therefore, there is no need for a bycatch TALFF of *Illex*.

The annual specifications for the hakes have not been completed at this time nor have any applications for foreign fishing been received. Until the hake specifications are determined, and allocations for foreign fishing made, the Regional Director proposes to set the *Illex* IOY at a level which results initially in an *Illex* TALFF of zero. If a directed fishery for hakes by foreign nations is allowed during 1988, the appropriate bycatch, as specified in the FMP, will be added to the TALFFs.

The Atlantic mackerel ABC amount has been increased because of the continued rebuilding of the mackerel stocks. The Atlantic mackerel IOY has been set at a level that allows for TALFF and JVP amounts to accommodate the applications for foreign fishing received to date. The Council further recommended that, for this year, the foreign nation be required to purchase either 3 mt of Atlantic mackerel in a joint venture or 1 mt of U.S.-processed product for every 8 mt of TALFF. The Council intends to recommend that the foreign partner make a joint venture purchase and a processed product purchase for fishing year 1989. The 1989 ratio of TALFF to required purchases may be modified to reflect any change in world market and supply conditions.

The Regional Director has adopted the Council's 1988 recommendation for Atlantic mackerel as well as recommendations that foreign fishing applications stipulate that any Atlantic mackerel product taken or purchased will not appear in North American markets and that preference be given to foreign vessels having at least a 30 mt per day processing capacity and refrigerated sea water holding tanks.

In accordance with the provisions of the FMP, a butterfish TALFF of 48 mt is provided for bycatch in other fisheries.

The Councils' recommendations, and all public comments on the annual specifications will be considered in the final decision, which will be published in the Federal Register.

Classification

This action is authorized by 50 CFR Part 655 and complies with Executive Order 12291.

(16 U.S.C. 1801 et seq.)

List of Subjects in 50 CFR Part 655

Fisheries, Reporting and recordkeeping requirements.

Dated: December 8, 1987.

James E. Douglas, Jr.,

Deputy Assistant Administrator For Fisheries, National Marine Fisheries Service.

[FR Doc. 87-28553 Filed 12-8-87; 4:37 pm]

BILLING CODE 3510-22-M

May 11, 1987
P.O. Box 311
Gloucester, MA 01931

MAY 15 1987

Dave Ellenton
Scan Ocean
42 Rogers St.
Gloucester, MA 01931

re: Dirk Dirk inspection assignment

Dear Mr. Ellenton:

This is in reference to the general fishing practices of the "Dirk Dirk", a Dutch stern trawlwer which fished in American waters form March 14-April 1,1987.

As a foreign fishery Compliance Inspector (Observer), I noticed that the assigned officers showed great discretion in the setting of their nets. They used the sophisticated technology onboard, and would diligently monitor the types of fish on the screen. If the indications showed even the slightest hint of referring to River Herring, the nets were NOT set. The effort to avoid the capture of River Herring was very noticeable, and in my three weeks of observing the amount caught was minimal.

In conclusion, I would like to report that in my observation they were very responsible and law abiding in their fishing practices, and in full compliance of all existing regulations.

Sincerely,

Marie L Socha

Marie L. Socha,
Fishery Compliance Inspector
National Marine Fishery Service

STATEMENT PREPARED BY COMPLIANCE INSPECTOR

MICAH KIEFFER ON 04/20/87

It has been brought to my attention that the question has arisen as to whether or not the Dutch are making efforts to avoid large river herring catches. I worked on board the Zeeland as a fisheries compliance inspector along with Captain Pieter de Viet. In my opinion, Captain de Viet was conscious to the sensitive nature of river herring bycatch. I witnessed Captain de Viet retrieve his fishing gear after he decided the sonar "marks" which were set upon by his first mate were not mackered, rather river herring or menhaden. At no time did I find it necessary to suggest to Captain de Viet that we move to another area due to river herring bycatch.

It is my understanding that this statement could be presented during the fisheries council meeting.

Compliance Inspector

Micah C. Kieffer

04/20/87

Dear Sirs:

The Zeeland under my command worked in the U.S. Mackerel Fishery 1987 from January 14th 1987 to March 7th, 1987. During this time I caught 2773 tonnes of Mackerel and received from U.S. Vessels 514 tonnes.

I am very aware of the restrictions and the minimal amount of River Herring that was available to the Dutch fleet, and to the best of my abilities and with full use of all my electronic equipment, I tried at all times to avoid the catching of River Herring during my search for Mackerel.

Unfortunately, out of my total of Mackerel, I caught 24.0 tonnes of River Herring; the largest amounts being 17.0 tonnes in one haul that I was powerless to avoid as before setting my traul, I had criss crossed and tracked over the area I intended to fish with my gear still on board and seen only mackerel indications on my sonar and two fish scopes. Then after setting the traul and taking one small mackerel mark, a mark of River Herring suddenly appeared on my net sounder by which time it was already entering my net. I hauled immediately and found I had 17.0 tonnes of Herring much to my regret. On many occasions I have seen mackerel indications but have decided not to fish as there were some River Herring marks in the same area.

I would like to state that myself and my crew have enjoyed good cooperation in U.S. waters and in the past and are grateful for the opportunity to fish here and hope to continue to do so in the future.

Captain Pete DeNigt
MFV Zeeland

SCAN OCEAN INC.

To Whom It May Concern:

Dear Sirs:

I have taken part in the last three mackerel seasons, four years, that the Dutch vessels have been in U.S. waters and contrary to reports, it has been my experience that the Dutch captains, with the full use of all their equipment, do take positive measures to avoid catching River Herring. It can be verified by official log books and NMFS observers that when the River Herring is taken, it is usually part of a large haul back of mackerel. Many hauls are in excess of 100 tons and with large concentrations of fish like this around, it is difficult if not impossible to pinpoint small indications of River Herring among the mackerel indications, and they are only aware of the River Herring after the haulback.

I would also like to point out that the Dutch captains are aware of the River Herring problem and in many instances have steamed away from some areas where River Herring indications have been identified along with the mackerel. Also the Dutch appreciate the opportunity to fish in U.S. waters and would like to continue to do so in years to come.

Regards,

D Hinchcliffe

Captain David Hinchcliffe
Fishery Consultant and
Former Fishing Captain

42 Rogers Street Gloucester MA. 01930 USA (617) 283-1004 Telex 200278 (SOCE UR)

To Whom It May Concern:

I with my vessel Geetrude Margreta have taken part in the U.S. Mackerel Season 1987 between 14th January and 4th April. During this time I caught 4,281 tonnes of mackerel and took from U.S. vessels 400.7 tonnes.

Unfortunately, I also caught 27.9 tonnes of River Herring during my 3 voyages which varied in positions from 36°00N to 40°N. During all my time fishing here I took every precaution possible to avoid catching River Herring with full use of all my many fish finding electronic appliances that are the newest and the best available, but still mixed with various catches of mackerel were the River Herring. I do not take lightly the importance of the River Herring issue, as myself and my crew have considered fishing in U.S. waters to be a very important part of our fishing year and we are grateful to be given the opportunity to fish here and hope that we can return in the future.

Captain Aad Yonker
MFV Geertrude Margreta

To Whom It May Concern:

This was my first voyage to the U.S. Mackerel Fishery, though the second for my vessel. During my time here, 13th March to 4th April, I caught 1676.9 tonnes of Mackerel and only encountered a small amount of River Herring 1.4 tonnes.

I had been made aware of the situation by conversation with my colleagues on the other Dutch vessels during my passage across the Atlantic, but we were very lucky in that we did not encounter a great amount of River Herring during this voyage. Quite honestly I was very apprehensive about fishing here after the talks with other Dutch Captains about the River Herring shoals they had seen this year, but we were very fortunate in our time here. I would like to thank those who made my voyage to U.S. waters possible and hope to return in the future.

Captain Hubert Meeuwendord
MFV Dirk Dirk

To Whom It May Concern:

I have been engaged in the U.S. mackerel fishery, this year 1987. Unfortunately only for one voyage, 6th April to 17th April. During this voyage we had excellent results with very little by catch of other species (2055 tonnes mackerel) (8.9tonnes by catch). Of the River Herring, we took in the first instance 100 kg included in one very good haul of 130 tonnes of mackerel and the other 1.7 tonnes was taken in the same area where we had been fishing for 10 days for a total of 1100 tonnes. Suddenly one haul amongst the mackerel was 1.7 tonnes of River Herring so consequently we changed our position as I am aware of the problems that have arisen this season after conversations with other Dutch Captains who were very aware and concerned with the River Herring situation this year.

The last time the Astrid and myself were in U.S. waters was two years ago and like this voyage, was bery good fishing without any problems and excellent cooperation from U.S. authorities and fishermen. We look forward to future voyages in U.S. waters.

Captain C.A. Schonenberg
MFV Astrid

APPENDIX D-5

HABITAT ACIDIFICATION RESEARCH ON ANADROMOUS ALOSIDS

APPENDIX D-5

Habitat Acidification Research on Anadromous Alosids[a]

Ronald J. Klauda
The Johns Hopkins University
Applied Physics Laboratory
Shady Side, MD 20764

Abstract

The freshwater reaches of Chesapeake Bay tributaries serve as important spawning and nursery areas for anadromous alosids such as American shad, blueback herring, and alewife. These streams drain the Coastal Plain, a region characterized as sensitive to acidic deposition. This physiographic province is overlain by thick acidic soils (sands, silts, clays) with low base saturation levels. Such soils possess limited capacities to neutralize acidic inputs to the lower order reaches of Coastal Plain tributaries. Major spring storms can stimulate acidic spates to below pH 6.0 in some streams. These pH depressions are often accompanied by elevated levels of aluminum (Al).

Under sponsorship of Maryland's Department of Natural Resources, Power Plant Research Program, our laboratory is conducting a series of experiments designed to assess the risk of alosid populations to habitat acidification. We are measuring the sensitivity of eggs and larvae of blueback herring and American shad to pH and Al in the laboratory. Organisms are being tested under continuous and episodic exposure designs. We are also striving to verify the laboratory findings for blueback herring at a field study site on Lyons Creek, a tributary to Maryland's Patuxent River.

The laboratory experiments demonstrated that moderately acidic pulses dramatically decreased the survival of blueback herring yolk-sac larvae. Mortality doubled from 25 to 50% when the duration of acid-only pulses (pH 5.5-5.6) doubled from 12 to 24 hours during 4-day experiments. Single pulses of 60-100 µg/l Al (total monomeric form) coincident with acid pulses (pH 5.5-5.6) lasting 8 and 12 hours killed almost 70% and 100% of the yolk-sac larvae. Blueback herring embryos (20-24 hour post-fertilization) were more tolerant than yolk-sac larvae to all but the most severe treatments: an acidic pulse of pH 5.5-5.6 and 90 µg/l Al (total monomeric) lasting 24 hours killed 48% of the embryos. Preliminary laboratory data also suggest that the early life stages of American shad are about as sensitive to pH but more sensitive to Al, compared to blueback herring.

The relatively dry springs of 1985 and 1986 in Maryland's Coastal Plain precluded field verification of the laboratory findings. Studies conducted during spring 1987 also included field bioassays in Lyons Creek, a Chesapeake Bay tributary used for spawning by blueback herring that responds quickly to major storms. In early June of 1985, for example, a 2.3 inch rainstorm triggered an acidic spate which depressed Lyons Creek pH to 5.83 and elevated total monomeric Al levels to 64 µg/l with about 4 hours. Our laboratory bioassay results predict that this combination of acidity and dissolved inorganic Al would be moderately to highly toxic to blueback herring eggs and yolk-sac larvae.

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[a]Invited presentation given at a meeting of the Shad and River Herring S&S Committee sponsored by the Atlantic States Marine Fisheries Commission, Annapolis, MD, 7 July 1987.

APPENDIX D-6

OCEAN MIGRATION AND LIFE HISTORY ASPECTS OF ALEWIFE AND BLUEBACK HERRING IN THE UPPER BAY OF FUNDY, CANADA

APPENDIX D-6

OCEAN MIGRATION AND LIFE HISTORY ASPECTS OF ALEWIFE AND BLUEBACK HERRING IN THE UPPER BAY OF FUNDY, CANADA

by

Roger A. Rulifson
Institute for Coastal and Marine Resources, and Department of Biology
East Carolina University
Greenville, North Carolina 27858

Introduction

In the Canadian Maritime Provinces, alewife and blueback herring (river herring) are known collectively as "gaspereau". Canadian fisheries statistics report landings under the heading "alewife". Blueback herring are not common in Canada. Specimens have been collected in Nova Scotia from Cape Breton Island and the Shubenacadie-Stewiacke watershed, and in New Brunswick from watersheds emptying into the Bay of Fundy. Blueback herring are abundant along the USA eastern seaboard from New England south to Florida. Alewife are very abundant in Canadian waters from Newfoundland through New Brunswick, and in USA waters south to the Carolinas. Blueback herring contribute little to the riverine and estuarine gaspereau harvest each year.

Gaspereau are harvested from rivers and estuaries in the spring using drift gillnets, pound nets, and square nets. Ocean (Bay of Fundy) harvest is by weir and pound net from late June through July and August. Gaspereau are pickled in salt brine and packed for export, primarily to the country of Haiti. A portion of the harvest is consumed locally -- either salted or smoked -- and used also for lobster bait. Highest commercial landings are in northern New Brunswick and Cape Breton (Figure 1). Landings were highest in the early 1950s (Figure 2); landings data since 1973 have not been compiled.

Recent interest in developing a strong interjurisdictional management plan and increasing concern about potential effects of Canadian tidal power development precipitated this study. Objectives of my study were: (1) to determine rivers of origin of river herring in the Bay of Fundy; (2) to determine the relative contribution of U.S. river herring stocks to the Canadian gaspereau fishery; and (3) to estimate potential effects of tidal power development on stocks through determining local and long-distance migration patterns. The study was funded by the National Marine Fisheries Service, the State of North Carolina, and East Carolina University under the auspices of the Anadromous Fish Conservation Act (PL89-304). Additional support was provided by Fisheries and Oceans Canada, the Fundy Weir Fisherman's Association, and the Hudson River Foundation.

Study Site

The Nova Scotia side of the upper Bay of Fundy was selected as the study site: (1) because of its possible role in tidal power development; and (2) because of the presence of an active commercial weir fishery. Minas Basin (Figure 3) is the larger outer embayment dominated by cool, clear seawater from the Bay of Fundy. Cobequid Bay is the shallow elongated headwater of Minas Basin; waters are warmer, brackish and highly turbid. The two areas are separated by landward projections at Economy Point and Tennycape, which is the most likely site for construction of a tidally-driven hydropower station (site B9).

Methods

Ocean tagging and life history studies were conducted in 1983, 1985 and 1986. The majority of the work was accomplished in 1985. Gaspereau catches from two weirs in Cobequid Bay (near Economy) and one weir in Minas Basin (Five Islands) were monitored on each low tide from July through October 1985. Fifty gaspereau were subsampled from each catch (season total = 6,500) for laboratory examination to determine species composition, sex ratio, length frequency distribution, gonadal maturity, and fat deposition. Only the species composition and sex ratio data are summarized in this report. Fish were tagged with Floy FD-68B anchor tags and released back into the weir. Additionally, gaspereau were caught by midwater trawl towed by the Canadian research vessel J.L. Hart positioned between Economy Point and Tennycape. Fish were tagged and released in the manner described above. Tags were imprinted with individual numbers and bore either a North Carolina or Canadian return address. A total of 18,958 river herring were released during the study: 3,584 in 1983; 13,428 in 1985; and 1,946 in 1986. July was the best tagging month (10,211 tags released), followed by June (7,745) and August (1,002). Fall-run fish were too small for tagging. The tag return rate has been low, perhaps due to the (mass harvest) fishing and processing methods employed by various river herring fisheries along the Atlantic seaboard.

Blueback Herring

Results indicate that most blueback herring in the upper Bay of Fundy are probably not of local origin and therefore must exhibit long distance migration typical of the American shad (see Dadswell's companion report). Blueback herring dominated river herring catches in both bays during July and August of 1985 (Figure 4). Late July Minas Basin catches were 70-100% blueback herring a major portion of the time. Alewife dominated from mid-August through October, with the occasional reappearance of bluebacks in late September and October. Most blueback herring were sexually mature; some juveniles migrated through Minas Basin in early July and again in late September and October. The male:female ratio varied between 30% and 70% until the appearance of juveniles in late fall; no distinct patterns in sex ratio were observed.

In Cobequid Bay, bluebacks comprised 50-70% of river herring catches during July (Figure 5); few adult bluebacks were present in samples after that time. All bluebacks in late fall were juveniles, suggesting local origin. No patterns in sex ratio were apparent.

Tag returns indicate that blueback herring move through Minas Basin into Cobequid Bay within a one- to two-day period and remain there for only several days before leaving the system (Table 1). Tagged blueback herring have been recaptured on natal spawning grounds as far south as the Roanoke River, North Carolina (2,400 km) one to two years after leaving the Bay of Fundy.

Alewife

Alewife in the upper Bay of Fundy are probably of regional and local origin, but may include fish from New England stocks. Alewife dominated river herring catches in Minas Basin from mid-August through October (Figure 4). In Minas Basin, most alewife were sexually mature; some juveniles moved through the area in mid-July and mid-September. The sex ratio varied wildly on a daily basis in July but stabilized later in the season. No sex ratio patterns were apparent.

In Cobequid Bay, alewives made up to 50% of river herring catches early in the season, then dominated catches from mid-August through October. Maturity of these fish varied widely throughout the season; large numbers of juveniles were observed on numerous occasions in 1985. Alewife catches were dominated by females.

Tag returns suggest that alewives move more slowly through the upper Bay of Fundy, then return to offshore waters. Alewife pass quickly through Minas Basin and spend up to three weeks in Cobequid Bay (Table 1). Recaptures of alewife from spawning grounds in Nova Scotia rivers draining into the upper Bay of Fundy (Shubenacadie, Gaspereau), and from rivers draining into the Atlantic Ocean (Tusket, Wellington), indicate that local and regional populations frequent upper Bay of Fundy waters during the summer. The lack of alewife recaptures from USA waters may be an artifact of low population biomass for USA stocks as indicated from data presented by ASMFC member states at the Shad and River Herring S&S Committee meeting in Annapolis (June 7-9, 1987).

Conclusions

1. River herring are capable of migrating long distances (over 2,000 km) in ocean waters of the Atlantic seaboard.
2. Patterns of river herring migration may be similar to those of American shad, but low numbers of tag returns preclude detailed analysis.
3. U.S. river herring, primarily blueback herring, contribute to the Canadian ocean fishery for gaspereau, but probably are not involved in the river fishery.
4. Alewives in the upper Bay of Fundy are mostly of northern stock origin, perhaps an artifact of reduced population levels in the U.S.
5. Cobequid Bay acts as an extensive nursery and feeding area for the species, up to three weeks and more during summer months.
6. Tidal power development in this area will no doubt alter water circulation patterns and affect fish migration patterns. River herring stocks as far south as North Carolina will be affected, but the extent of impact on U.S. stocks is unknown.

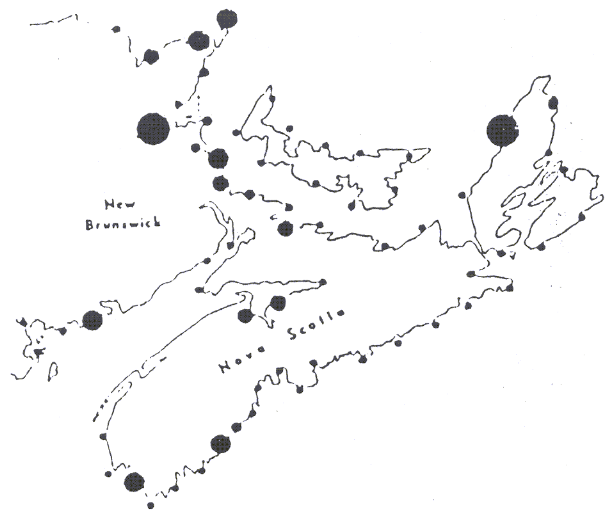

Fig. 1. Relative contributions of commercial landings of river herring in Canadian Maritime Provinces from 1957-1973.

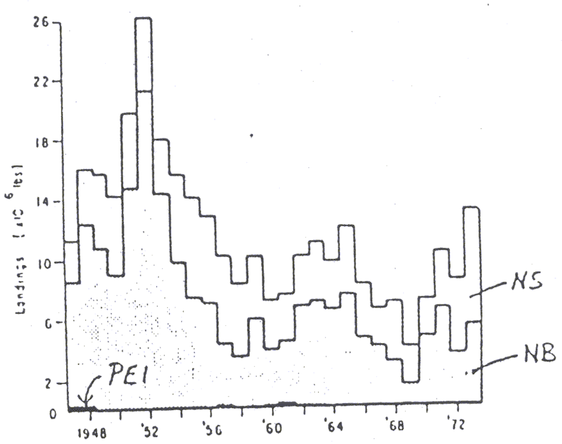

Fig. 2. Commercial landings of river herring in Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI) from 1948-1973. Data from St. John River (NB) fishery not included.

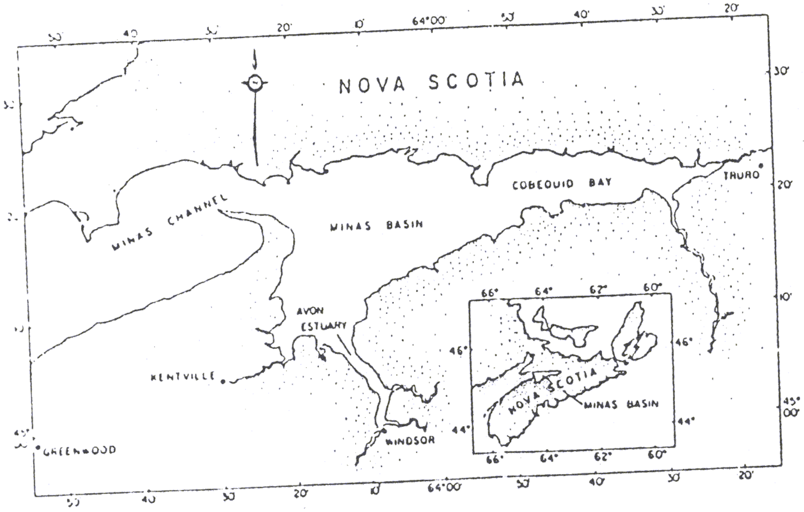

Fig. 3. Map of the Minas Basin and Cobequid Bay research areas.

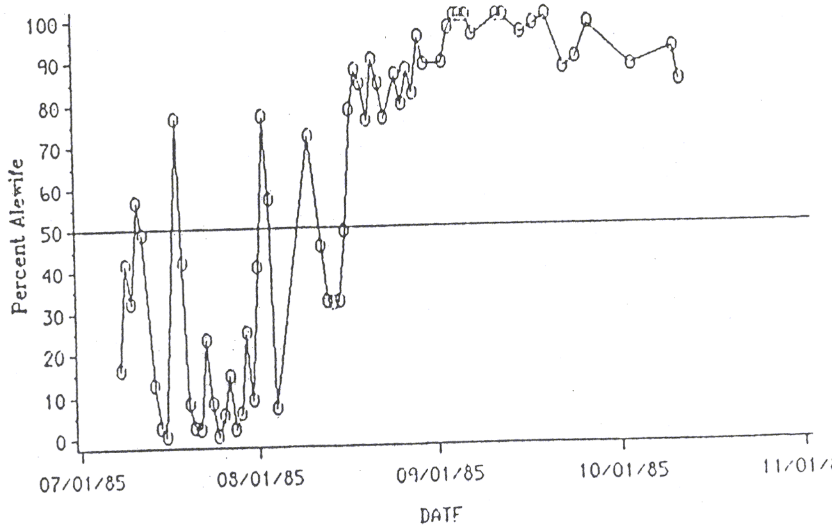

Fig. 4. Contribution (%) of alewife to river herring catches from commercial weirs on the north shore of Minas Basin, Nova Scotia, during July through October 1985.

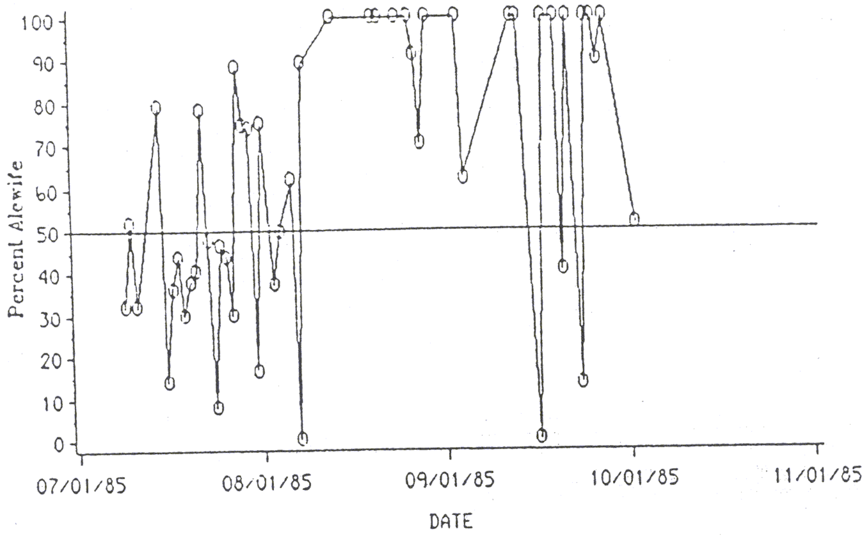

Fig. 5. Contribution (%) of alewife to river herring catches from commercial weirs on the north shore of Cobequid Bay, Nova Scotia, during July through October 1985.

Table 1. Number of days at liberty and distance traveled of alewife and blueback herring marked and released in Cobequid Bay and Minas Basin, Nova Scotia, during 1985.

		1986								1983			
		Alewife Days from release				Blueback herring Days from release				Unidentified Days from release			
Recapture Site	Distance from release site (km)	n	avg.	min.	max.	n	avg.	min.	max.	n	avg.	min.	max.
Cobequid Bay, NS	0-22	8	9	3	18	2	3	1.5	4.5				
Minas Basin, NS	0	17	<1	1	7	16	<1	1	2	2	158	4	311
Shubenacadie R., NS	35	2	506	350	663								
Gaspereau R., NS	55-60	5	350	327	377					8	356	310	366
Tusket R., Yarmouth Co., NS	350	1	-	666	666								
Wellington, Lunenburg Co., NS	550	1	-	337	337								
Ipswich Bay, Cape Ann, MA	660	1	-	153	153								
Wicomico R., Salisbury, MD	1,800					1	-	304	304				
Roanoke R. and western Albemarle Sound, NC	2,300-2,400					3	381	240	623				

APPENDIX D-7

STUDIES OF AMERICAN SHAD IN THE SAVANNAH RIVER

APPENDIX D-7

STUDIES OF AMERICAN SHAD IN THE SAVANNAH RIVER

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The U.S. Fish and Wildlife Service, in concert with the U.S. Corps of Engineers and the states of Georgia and South Carolina initiated a tudy in 1986 of anadromous fish on the upper Savannah River.

An excellent recreational fishery for American shad had developed at the New Savannah Bluff Lock and Dam (NSBLD) near Augusta, Georgia, ca. river mile 187. Potential development and water use at and above the Lock and Dam prompted the study.

Providing passage for American shad and other anadromous fishes to the twenty miles of excellent spawning habitat above NSBLD in low water years was investigated. A successful regimen of gates and valves operation has been developed which allows for lockage of American shad on their spawning migration, regardless of river flow conditions. Low water year passage through the dam gates was investigated but proved unsuccessful without excessive water usage. An eighteen foot blockage to fish passage was negated.

The 1986 year class out-migrants were counted as they passed NSBLD. At least 70,000 American shad passed through NSBLD dam gates between September 26 and December 5, 1986 on their run downstream. Growth rates in the upstream nursery area were monitored and will be compared to 1987 rates for the same area.

The Savannah River receives hypolimnetic releases from COE Clark Hill Reservoir. The highest summer water temperature recordings at NSBLD are about 71°F (21.6°C). The cool water temperatures may account for the smaller mean sizes when compared to those reported for hatchery released American shad to the Susquehanna River. Adult American shad were still in the NSBLD area July 16, 1987 (69°F) but only emaciated males were captured.

APPENDIX D-8

STATE REPORTS

APPENDIX D-8a

Summary of Activities Related to American Shad and River Herring

Arthur J. Lupine

New Jersey Division of Fish, Game and Wildlife

Delaware River American Shad Population Estimate

In 1986, mark and recapture data yielded a population estimate of 595,407 ± 231,060 at a 95% confidence interval. The 1986 estimate was the highest recorded since the monitoring program begin in 1975.

Although a population estimate was not conducted in 1987, information gathered from various sources suggests that this year's spawning run was equal to, and perhaps, was larger than in recent years.

Delaware River American Shad Population Estimates from 1975 to 1986

Year	Petersen Method	Schaefer Method
1975*	118,700 ± 93,733	
1976*	178,760 ± 96,150	150,187
1977*	106,202 ± 65,058	88,415
1978*	233,060 ± 171,126	
1979	111,839 ± 82,191	101,249
1980	181,880 ± 55,058	137,641
1981	546,215 ± 133,590	551,599
1982	509,102 ± 176,680	450,200
1983	249,578 ± 87,342	212,428
1984	—	—
1985	—	—
1986	595,407 ± 231,060	—

* Conducted by the Delaware River Basin Fish and Wildlife Management Cooperative Fishery Project.

American shad commercial landings in New Jersey* 1979-87

Year	Pounds (x 1000)
1979	149
1980	293
1981	264
1982	391
1983	233
1984	293
1985	292
1986	335
1987	262

* Includes Raritan Bay, Atlantic Coast and Delaware Bay.

The juvenile American shad CPUE* for the Delaware River, 1979-1986

Year	CPUE (shad/seine haul)
1979	64.5
1980	125.0
1981	172.0
1982	152.9
1983	339.0
1984	248.7
1985	191.5
1986	203.0

* mean of 5 sampling stations.

Since 1979 juvenile shad production has gradually increased with a strong year-class in 1983. However, based on the data gathered, juvenile shad abundance hasn't changed significantly since 1984.

Net licenses issued in New Jersey 1984-1987

Type of Net	Years			
	1984	1985	1986	1987
Drifting gill net	198	226	253	221
Staked and anchored	746	672	942	910
Drifting shad	39	41	*	*
Staked and anchored shad	57	48	*	*

Changed to new license forms.

American Shad Restoration

Raritan River

Adult shad returnees were captured in 1986 and 1987, natural reproduction was confirmed in 1986 with the collection of juvenile shad in the lower non-tidal section of the Raritan River. The adult returnees were probably a result of adult shad transfers from the Delaware River.

Investigation of Shad Spawning Runs

In 1987, adult shad were collected in the Maurice River and Rancocas Creek*. This was the first time adult shad were found in Rancocas Creek in many years. Also, young shad were collected in the Salem River. Scale examination indicated that these shad over-wintered in the Salem River estuary. Adult shad were not found in the Salem River.

* Documented by Versar, Inc.

River Herring Restoration (D. Byrne/Marine Fisheries)

A fishway designed by the US Fish and Wildlife Service was installed at Lake Takanassee in February 1987 at a cost of just under $9,000. Two herring were observed using the fishway during the spring. Adult herring are to be transferred to Lake Takanassee.

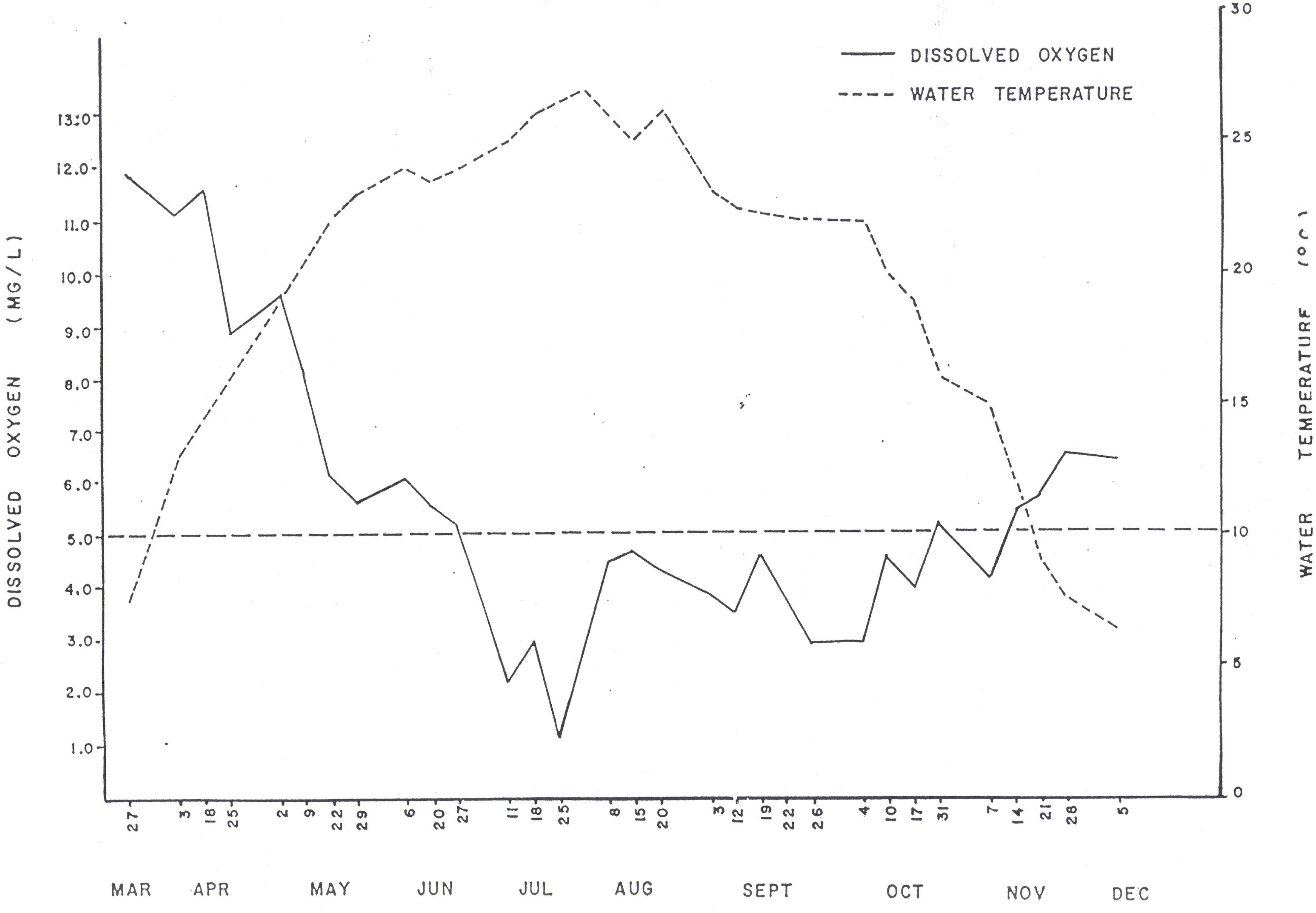
Shadow Lake is to receive a fishway sometime in 1989. Also, barriers at Tuckahoe and Fenwick Rivers will be modified to allow herring passage.

Delaware River Angler Utilization and Economic Survey

In a cooperative effort with the US Fish and Wildlife Service and funded by the Delaware River Shad Fishermans Association, an angler utilization, harvest and economic survey of the American shad fishery in the Delaware was completed in 1986. A copy of the final report is attached.

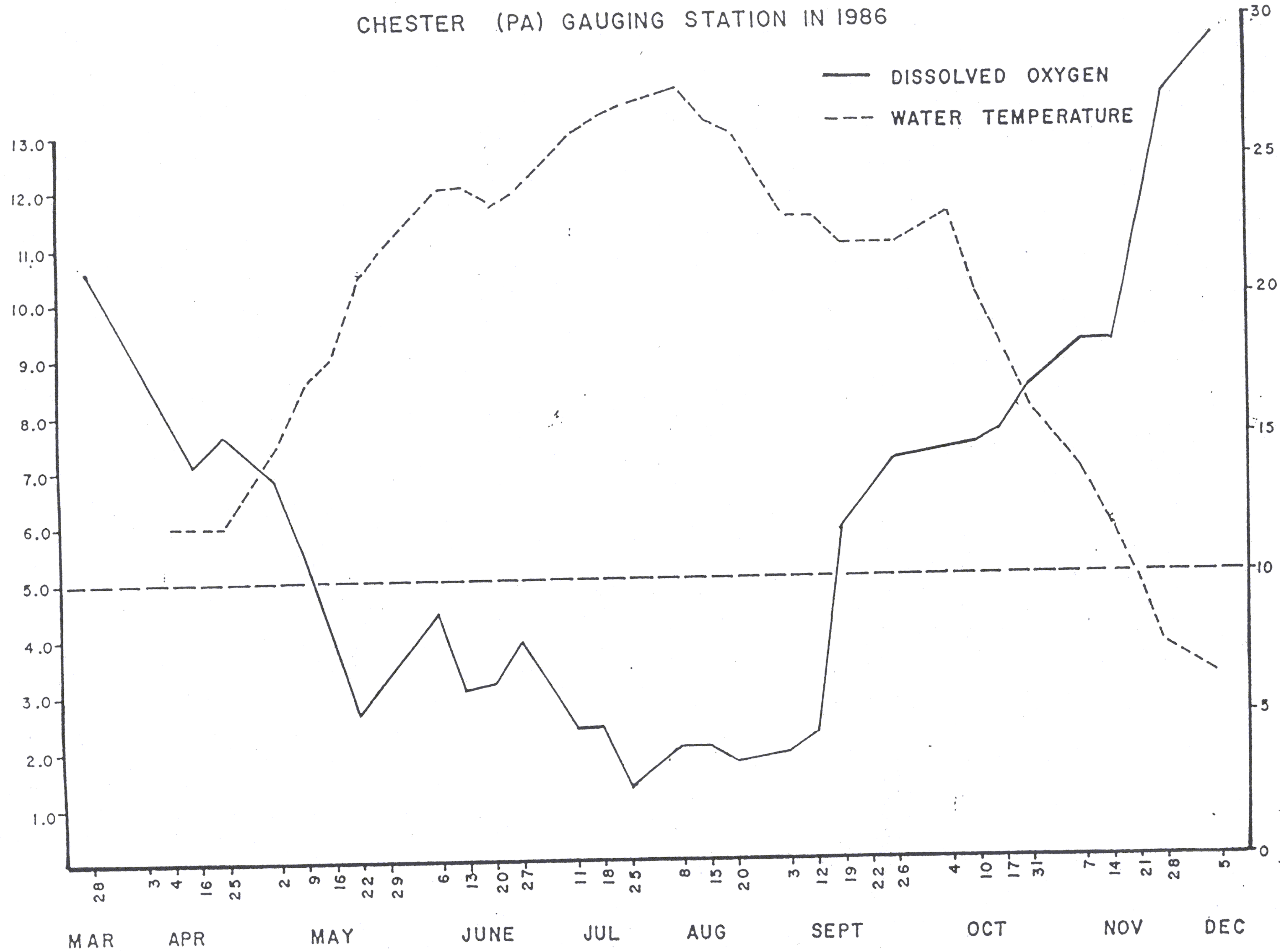
FIGURE 2

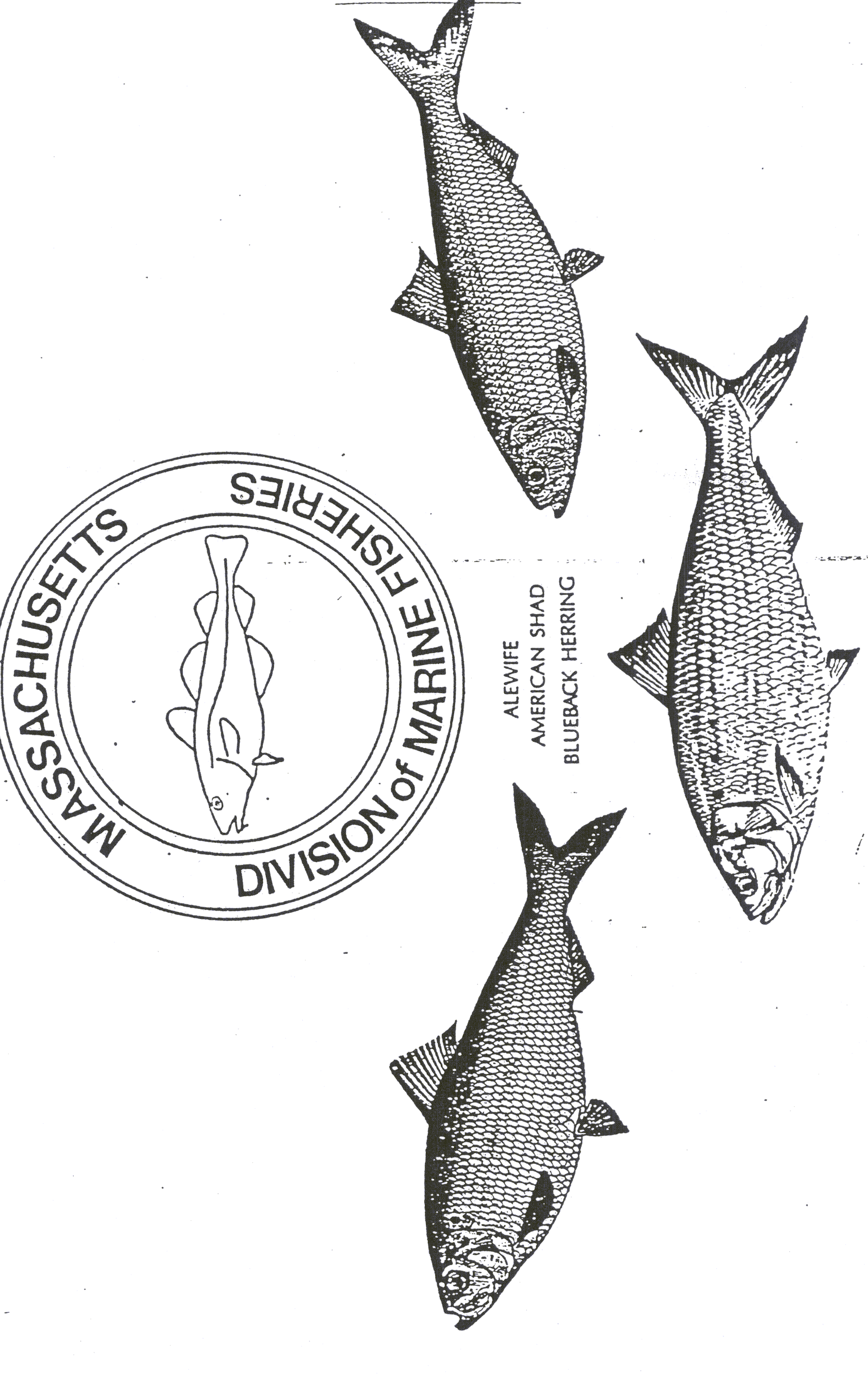
DISSOLVED OXYGEN AND WATER TEMPERATURE DATA RECORDED AT U.S.G.S. PIER 11 (PA.) GAUGING STATION IN 1986



GURE 3

DISSOLVED OXYGEN AND WATER TEMPERATURE DATA RECORDED AT U.S.G.S. CHESTER (PA) GAUGING STATION IN 1986




MASSACHUSETTS
DIVISION of MARINE FISHERIES
ALEWIFE
AMERICAN SHAD
BLUEBACK HERRING

SHAD

The American shad (*Alosa sapidissima*) was once abundant in the larger coastal rivers of Massachusetts, but today only four systems; the North River in Scituate, the Palmer River in Rehoboth, the Merrimack River and the Connecticut River, have runs capable of supporting a sport fishery. The Massachusetts Division of Marine Fisheries (DMF) adult shad stocking effort has centered on two historic river systems in the Commonwealth: the Taunton River, 40 miles in length and watershed drainage of 530 square miles; and the state's largest river, the Charles, at 80 miles in length and a drainage of 307 square miles.

Since 1971, DMF has annually transported eggs or gravid adult shad from the Connecticut River into the Charles or Taunton River systems. Initial stockings were actually begun in 1969 with placement of hatching boxes in the Nemasket River, Middleborough, a major tributary of the Taunton. Approximately sixty million eggs and over 17,500 prespawning adult fish have been transported in the course of the program.

Work in the Charles River began with the stocking of 436,700 fertilized eggs. During the next seven years, approximately ten million eggs were transferred to the river's potential spawning sites before transport of prespawning adults replaced the fertilized egg program. Since 1978, 12,503 running ripe fish, roughly 1,250 per year, have been introduced to the spawning grounds along the Charles River. Due to the large size of the river system and the small number of documented returns to date, the stocking level was increased with approximately 2,150 adult fish deposited at the river's two stocking stations this spring.

Massachusetts Shad Transport

Live Stockings, 1978-1987

Year	Charles River	Taunton River
1978	853	65
1979	1,034	262
1980	1,246	962
1981	865	886
1982	1,145	312
1983	1,384	886
1984	1,201	--
1985	1,362	1,009
1986	1,282	424
1987	2,150	211

Shad eggs stocked for restoration purposes, 1969-1978.

Year	River: Merrimack	Charles	Agawam	Taunton	
1969	--	--	--	579,750	
1970	--	--	--	1,530,300	
1971	1,102,200	436,700	564,300	1,092,400	
1972	2,481,600	946,000	748,000	3,175,750	
1973	2,545,400	1,000,600	—	1,666,000	
1974	4,470,400	1,715,600	—	4,255,900	
1975	3,963,600	1,574,100	—	1,698,100	
1976	6,473,500	2,989,800	—	6,045,600	
1977	1,667,600	773,200	—	2,881,900	
1978	779,900	--	--	2,082,600	
Total:	23,484,200	9,436,000	1,312,300	25,008,300	= 59,240,800

The number of shad eggs stocked in the Massachusetts rivers listed above totaled 59,240,800. An additional 3,491,600 eggs were stocked in the Northfield River and 6,440,150 eggs were provided to other state agencies, universities, and private organizations for stocking and research purposes. A total of 69,172,550 eggs were taken from the Connecticut River by the Massachusetts Division of Marine Fisheries between 1969 and 1978.

Box trap sampling in the Watertown fishway (the second upriver obstruction) has produced 30 natal returns since the spring of 1984 (four 1984, ten 1985, fourteen 1986, two 1987). Fish ranged in size from 18-24 inches total length and 2½ - 6½ pounds in weight. An additional number of unconfirmed sightings have been reported to Division personnel both in the Charles River and at the Amelia Earhart Dam locks of the Mystic River, which also empties into Boston Harbor approximately 1 kilometer north of the Charles River discharge. Until the spring of 1985, upstream passage was restricted to the base of the 4th river obstruction, the Bleachery Dam. Following breeching of this dam and modifications and new construction at other locations by the Metropolitan District Commission (MDC) fish will now be able to pass through river obstruction number seven to the base of the Metropolitan Circular Dam, river mile nineteen, adding an additional 250,000 square yards of suitable spawning area.

As previously mentioned, restoration work in the Taunton River commenced two years earlier than the Charles. During the ten year period from 1969 to 1978, over 25 million fertilized eggs were deposited within that system. As with the Charles River, adult transplants were selected over egg transfers for propigational purposes in 1978. Five thousand and seventeen Connecticut River fish were stocked into the Taunton River over the next decade. No documented returns have yet been recorded, however, anecdotal reports have been received on several occasions. No juvenile production has been documented for the river's upper reaches, however juvenile and young shad have been collected by otter trawl and from intake screen washes at the Brayton Point Power Plant, Somerset, Mass.

Massachusetts Commercial Landings
(actual pounds reported landed in MA ports)
1966 - 1987

Year	Alewives	Shad	Smelt
1966	6,633,000	12,000	7,000
1967	5,432,000	509,000	6,000
1968	117,000	2,000	6,000
1969	100,000	5,000	6,000
1970	1,156,000	1,000	5,000
1971	222,000	NR	3,000
1972	1,907,000	1,000	2,000
1973	695,000	1,000	3,000
1974	229,000	3,000	1,000
1975	1,717,000	2,000	NR
1976	45,000	NR	NR
1977	132,000	(1)	(1)
1978	620,000	(1)	NR
1979	(1)	2,000	(1)
1980	NR	8,000	NR
1981	NR	17,000	NR
1982	NR	29,000	NR
1983	(1)	13,000	NR
1984	111,000	30,000	NR
1985	NR	22,000	NR
1986	NR	60,000	NR
1987	?	?	?

(1) = less than 500 lbs.

NR = none reported

River Herring

The alewife or "herring" is the most abundant anadromous fish in Massachusetts. Many of the herring runs of the Commonwealth, of which there are more than 100, support two species of "herring", the alewife (*Alosa pseudoharengus*) and the blueback herring (*Alosa aestivalis*) and although the biology of the species is different for purposes of management or utilization they are considered the same.

For the past four years, DMF has studied the spawning migrations of the alewife and blueback in the Monument River, Bournedale system. Total counts of the combined runs have ranged from approximately 176,000 to 235,000 fish for the 190 hectare system. Estimated sizes of the alewife population ranged from a low of 111,000 (1986) to 131,000 (1984) while the smaller blueback population was between 53,000 (1987) and 105,000 (1984) fish.

Commercially harvested by the town of Bourne, harvesting levels have been calculated to be between 17% - 41% of the combined yearly populations. Trend analysis of the town catch data through 1986 is attached.

Although population numbers are well below historical levels, counts, age structure, and harvest data from this run support the belief, based on field observations, that these stocks are evidencing relative stability.

Alewife and blueback herring spawning runs in Monument (Herring) River, Bournedale Massachusetts: 1984-1987.

Year	Total Counts	# Alewife	# Bluebacks	# Harvested	% Harvested
1984	235,354	130,709	104,645	97,000	41.2
1985	178,031	124,316	53,715	47,000	26.4
1986	186,537	110,803	75,734	31,320	16.8
1987	175,621	122,935	52,686	49,335	28.1

River Herring Harvests Monument (Herring) River

Bournedale, Massachusetts

The Monument (Herring) River run originates in Little and Great Herring Ponds ($\cong$ 190 hectares) of Plymouth and Bourne, Massachusetts. The run is accessible to river herring from both Buzzards Bay and Cape Cod Bay via the Cape Cod Canal. The Monument River herring fishery was established in 1834 with passage of fishing restrictions for methods and location of harvest, limitation on fishing period, appointment of wardens and legislative provisions for passage of obstacles to migration.

Reputed yields of 5,000 barrels of fish a season, maintaining an average level of 1,500 barrels yearly were reported through 1912, when the fishery was seriously affected by the dredging of the Cape Cod Canal. Belding (1921) estimated the run was reduced to forty percent of its former production following alterations due to canal construction.

Currently, Bourne Resource Officers seine the town's catching pool twice a week, three and a half hours per day, providing fish as demand warrants. Since 1972, harvests have ranged from a low of 65.5 barrels to a high of 450.5 barrels averaging 188 barrels per year. During the 1986 fishery season, officers noted that there were more fish than customers.

Figure 1 presents the CPUE (bushels/hr) rates for the past fifteen years, the semi-average time trend line and a four year moving average for this data. Harvest rates evidenced wide yearly fluctuations differing by as much as a factor of four. Values ranged from a low of 3.7 bushels/hr (1978) to a high of 16.4 bushels/hr (1983), and averaged 9.3 bushels/hr. Harvest values represent fish taken from both the alewife and blueback herring populations which share this spawning area. Spawning runs overlap from late April to approximately mid to late May.

Semi-average analysis indicate a CPUE increase of one bushel per hour between 1975 and 1983 or 0.12 bushels/hr per year. Trend values T (bushels/hr) generated from this computation are presented below.

Year	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
T	8.5	8.6	8.7	8.8	8.9	9.0	9.2	9.3	9.4	9.5	9.6	9.8	9.9	10.0	10.1

Literature Cited

Belding, D.L. 1921. A report upon the alewife fisheries of Massachusetts. Mass. Div. Fish Game, Mar. Fish. Ser. No. 1. 135 p.

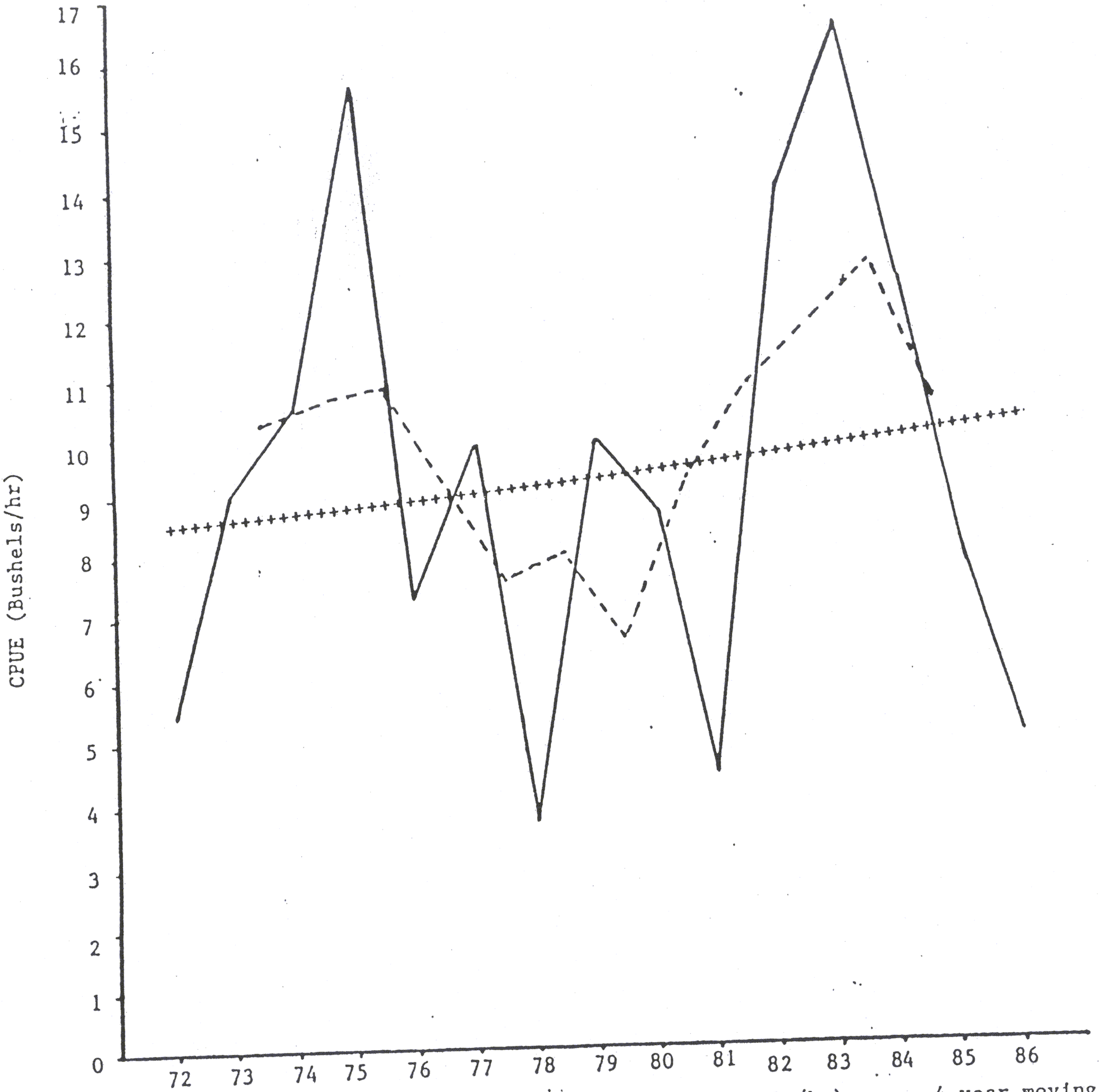


Figure 1. Bourne river herring harvests CPUE (bushels/hr) ____, 4 year moving average ----, semi-average trend line ****, for Monument (Herring) River, Bournedale run 1972-1986.

APPENDIX D-8c

STRATEGIC FISHERY MANAGEMENT PLAN FOR

AMERICAN SHAD RESTORATION IN THE SCHUYLKILL AND LEHIGH RIVER BASINS

STRATEGIC FISHERY MANAGEMENT PLAN
FOR
AMERICAN SHAD RESTORATION
IN THE
SCHUYLKILL AND LEHIGH RIVER BASINS

1984

REVISED 1988

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INTRODUCTION

Since the turn of the twentieth century, the American shad and other diadromous fish stocks on the Atlantic Coast have declined drastically. The harvest of shad from the Delaware River between 1896 and 1901 was the largest from any river system on the coast. Harvest estimates of up to 4 million fish in the late 1890's demonstrate a dramatic contrast to the average yield of 9,200 shad recorded during the early 1970's. At one time extensive shad spawning and rearing occurred throughout the tidal and non-tidal waters of the Delaware River Basin. Although present spawning and nursery activity occurs primarily in the upper reaches of the main stem, recent indications are that increased spawning and nursery activity is taking place in the lower river and upper tidal zone (Weisberg, et. al, 1987). A substantial sport fishery also exists in the upper Delaware River where an angler use and fish harvest survey conducted in 1982 determined an average catch of one American shad per angler trip, in more than 17,000 trips (Hoopes, Lahr and Billingsley), 1983). A more recent survey conducted in 1987 indicated a similar average catch of 0.87 American shad per angler trip in more than 65,000 trips (Miller and Lupine, 1987).

The Delaware Basin Fish and Wildlife Management Cooperative (DBFWMC) has recognized the need for a unified approach to management of the interstate fishery resources of the Delaware River Basin. Through its representation it has provided an excellent forum and the expertise necessary for developing a comprehensive fishery management plan. Strategic and operational plans for American shad were the first to be formulated and they have served to provide the initial step toward development of a comprehensive fishery management plan for the Basin which will include other pertinent diadromous and resident species.

A comprehensive fishery management plan on the Delaware River Basin would not be complete unless it contained provisions for adopting the necessary measures for restoration and management of the diadromous fishes of historic importance, particularly American shad, in the Schuylkill and Lehigh Rivers.

The style and format of this plan follows that used by the DBFWMC for the "Strategic Fishery Management Plan for the American Shad (*Alosa sapidissima*) in the Delaware River Basin," to assure continuity and consistency in the overall management goal and objectives for American shad in this Basin.

GOAL

Restore and manage American shad, Alosa sapidissima, in the Schuylkill and Lehigh Rivers for optimum sustainable yield and public benefit.

OBJECTIVES

1. Restore annual migrations of American shad to the Schuylkill and Lehigh Rivers.

2. Achieve an annual spawning population of 300,000 to 850,000 American shad in the Schuylkill River.

3. Achieve an annual spawning population of 165,000 to 465,000 American shad in the Lehigh River.

*4. Provide 60,000 to 170,000 sport angler trips, having a recreational value of $1,524,000 to $4,318,000 annually, for American shad anglers on the Schuylkill River.

*5. Provide 20,000 to 100,000 sport angler trips, having a recreational value of $508,000 to $2,540,000 annually for American shad anglers on the Lehigh River.

* These values are based on average expenditures of $25.40 per angler trip on the Delaware River (Miller and Lupine, 1987).

RATIONALE FOR OBJECTIVES

Commercial harvest statistics for American shad from the Delaware Basin during the 1890's indicated that the population numbered in the millions (Stevenson, 1899). It can also be assumed from the limited but significant information on other diadromous fishes, such as the river herrings and American eel, that their numbers were also substantial, even though dams erected in the early 1800's had blocked their utilization of the Basin's two largest tributaries, the Schuylkill and Lehigh Rivers (Mansueti and Kolb, 1953). The true impact of the construction of these dams on the diadromous fish populations in general will never be known, but their presence has effectively prohibited these fishes from utilizing significant portions of their historic spawning and rearing grounds for more than a century and a half. Other major factors such as water quality degradation and commercial overfishing have also contributed heavily to the recent catastrophic population declines in diadromous fishes, especially American shad, along the Atlantic Coast. These factors are being seriously addressed, but even their total resolution cannot assure restoration of diadromous species to waters blocked by dams. Therefore, the provision of fish passage facilities at all existing dams on the main stems of both rivers is absolutely essential if an optimum Basin restoration program is to be realized. Fishway design and construction can be accomplished in concert with the development of low-head hydropower generation projects now under consideration at all existing dams.

A concerted program for American shad restoration and management in the Schuylkill and Lehigh Rivers will not only serve to correct the long-standing and serious man-indiced prohibition of this valuable species from its historic ranges, but will simultaneously provide facilities for restoration of other valuable diadromous species. The increasing need for food and recreational fishing, particularly in the heavily urbanized areas along both rivers, provides substantial justification for these restoration and management efforts. It is sobering to consider that millions of American shad were commercially harvested from the Delaware River in the late 1800's even without the benefit of recruitment from the blocked Schuylkill and Lehigh Rivers. These historic harvest records not only indicate the high productive potential of the Delaware River, but also imply that the restoration of between 100 and 200 additional miles of historic spawning and nursery habitat on these major tributaries will have a substantial positive impact on American shad populations both in the Basin and along their entire Atlantic Coastal range.

SCHUYLKILL RIVER

Until the construction of dams in the early 1800's, American shad annually migrated as far upstream as Pottsville, 120 miles from the confluence with the Delaware River. Implementation of pollution abatement programs in recent years has resulted in significant improvement in water quality to the extent that in 1973 the Pennsylvania Fish Commission initiated a four year study of the feasibility of restoring shad to the Schuylkill River (Marshall, 1974). This study revealed that American shad were present below Fairmount Dam, 9 miles from the confluence with the Delaware River, on a total of 18 out of 26 days of sampling in 1974, 1975, and 1976, and that adult alewife and blueback herring and juvenile American eels also ascended the river to that point. Evaluations of water quality data indicated that no prohibitive adverse effects on restoration could be expected at least as far upriver as Felix Dam (River Mile 79) and possibly as far as the Kernsville Dam (River Mile 100). However, significant pollution problems persisted in the lower section of river in Philadelphia and the possibility of at least some effects on migrating fishes did exist.

Studies of invertebrate populations between Philadelphia and Felix Dam, when correlated with food preference studies of juvenile shad, indicated the existence of a substantial forage base. Fertilized shad eggs placed in hatching boxes at 12 stations between Philadelphia and Felix Dam exhibited satisfactory survival and hatching rates. No juvenile shad were recovered as a result of these egg plantings, but this was attributed to sampling limitations rather than an indication of failure of the larvae to survive and grow.

As a direct result of this study, the Fish Commission and the City of Philadelphia collaborated in the design and construction of a fishway at the Fairmount Dam. The fishway was completed and placed into operation on April 2, 1979. Diadromous fishes, including American shad, and more than 30 resident species have passed through the fishway each year since its installation.

The Pennsylvania Department of Environmental Resources and the Pennsylvania Fish Commission have cooperated in deriving conceptual fishway designs for Flat Rock Dam. However, progress in resolving fishway issues on this and the remaining upstream dams has been slowed by ongoing considerations for low-head hydropower generation projects.

Structural deficiencies at the Norristown Dam, which is the fourth dam from the mouth of the river, led to ongoing negotiations with its owner, the Philadelphia Electric Company, for the installation of fish passage facilities when renovation of the structure was to be undertaken. The Philadephia Electric Company agreed in principle to construct the fishways but only when passage efforts were also taken at Flat Rock and Plymouth Dams.

Subsequent to the 1974-76 study, an inventory of the river was conducted from 1977-1981 by the Area Fisheries Management staff (Marshall, 1977-79; Kaufmann, 1980-81). Social, physical, biological and chemical parameters were investigated. This inventory substantiated the findings of the previous survey. Coupled with data obtained from the existing fishway at the Fairmount Dam in which successful passage of diadromous fishes including American shad have been documented, and significant survival and growth of marked fry from stockings in 1985, 1986 and 1987 (Young, 1987), diadromous fish restoration in the Schuylkill River is now more promising than ever.

LEHIGH RIVER

Until the construction of dams in the 1820's, American shad annually migrated up the Lehigh River. From 1973 to 1976 the Pennsylvania Fish Commission completed a study designed to determine the feasibility of restoring American shad to the Lehigh River (Marshall, 1974). At the time of the study, a serious upper river pollution problem existed from the deleterious effects of coal mine drainage. The area affected extended from Sandy Run downstream to the Palmerton area (River Mile 35). With the cumulative effect of the flows of good water quality from several substantial tributaries, the middle section of river had relatively good water quality from the Palmerton area downstream to Allentown (River Mile 14). The lower river from Allentown to the mouth at Easton had generally degraded water quality from municipal and industrial wastes and significantly reduced dissolved oxygen levels. American shad eggs planted in the middle and lower sections of the river, however, showed excellent survival and hatching despite the problems mentioned.

Aquatic invertebrate data demonstrated that those organisms known to form the major portion of the diet of juvenile shad were presented in substantial numbers throughout the middle and lower river sections.

Despite the positive determinations from the study, the prevailing pollution problems were deemed to constitute such a significant impediment to shad restoration that it was not considered feasible until water quality was improved.

In 1980-1982 the Area Fisheries Management staff conducted an intensive social, physical, biological and chemical inventory of the Lehigh River (Billingsley, 1980-82). As a result of this inventory, it was determined that the overall conditions in the river, particularly in 75 miles of the middle and lower sections, had improved since the earlier study and is now suitable for diadromous fish restoration provided that fish passage can be effected at existing dams. In 1982 and 1983, the Lehigh River Preservation and Protection and Improvement Foundation, with the cooperation of the Pennsylvania Fish Commission and the U. S. Fish and Wildlife Service, transferred prespawned adult American shad from the Delaware to the Lehigh and placed shad eggs at several points in the Lehigh for hatching. Juvenile shad resulting from these activities were captured for the first time in the lower river later in 1983, therefore verifying the Lehigh's suitability for restoration.

Then in 1985, 1986 and 1987 the Pennsylvania Fish Commission stocked marked American shad fry which were later monitored and determined to have good survival and growth (Young, 1987).

On March 2, 1983, an order was issued to the Pennsylvania Department of Environmental Resources and the City of Easton to show cause why a final order should not be sent to initiate fish passage facility construction at the Chain Dam, which is one of the two remaining dams blocking diadromous fish migration (Abele, 1983). Negotiations to establish a memorandum of agreement among the parties to the extent that fish passage facilities at both the Chain Dam and Easton Dam would be considered and a plan for their construction would be formulated was postponed due to pending legislation being considered for financing fishway construction at both dams through general fund allocations.

MANAGEMENT PROBLEMS

Several specific management problems must be resolved before restoration of American shad in the Schuylkill and Lehigh River Basins canbe successful. There are two major persistent problems in both Basins, the presence of dams and areas of degraded water quality. On the other hand, there are less serious problems such as the mechanics of restoration regulation and monitoring restoration activities and how to provide proper angling and boating access once a fishable population of target species is restored.

Even though some of these perceived management problems may require little immediate action, they are pertinent to the overall strategy with which the subject of American shad restoration and management must be addressed. Using this approach, several specific strategic management problems have been identified.

DAMS

The Schuylkill and Lehigh Rivers are prime examples of lost historic spawning and rearing habitat for diadromous fishes. This loss is due to the construction of numerous low-head dams in the early 1800's primarily for public and industrial water supplies. These dams collectively represent the major obstacle in preventing diadromous fishes, especially American shad, from reestablishing their migratory runs in significant segments of both rivers.

Investigations are needed on the present uses of existing dams; the location and status of low-head hydropower development projects and whether the design of these projects is compatible with an American shad restoration program; the determination of whether the alternative of breaching is more acceptable than the construction of fishways; the appropriate facility design at each dam to permit both upstream adult migration and downstream juvenile migration of American shad; and, the ultimate development of a prioritized schedule for systematically dealing with the individual problems at each dam.

Dams located within the two river areas suitable for American shad restoration are represented in the following charts:

SCHUYLKILL RIVER

River Mile	Dam	Location	Height	Owner
9	*Fairmount	Philadelphia	13 feet	City of Philadelphia
15	Flat Rock	Manayunk	17 feet	Commonwealth of PA
18	Plymouth	Conshohocken	8 feet	Commonwealth of PA
21	Norristown	Norristown	16 feet	Phila. Electric Co.
34	Black Rock	Phoenixville	12 feet	Phila. Electric Co.
42	Vincent	Linfield	7 feet	Commonwealth of PA
79	Felix	Reading	17 feet	Commonwealth of PA
100	Kernsville	Hamburg	29 feet	Commonwealth of PA

* Fairmount Dam now contains an operational fishway.

LEHIGH RIVER

River Mile	Dam	Location	Height	Owner
0	Easton	Easton	30 feet	Commonwealth of PA
3	Chain	Glendon	20 feet	Commonwealth of PA
14	*Hamilton St.	Allentown	13 feet	Commonwealth of PA

* The Hamilton Street Dam now contains an operational fishway.

WATER QUALITY

Although water quality improvement in both the Schuylkill and Lehigh Rivers is still necessary, it has been improved considerably in both Basins during the past ten years to the extent that restoration is now possible.

SCHUYLKILL

The recent Pennsylvania Fish Commission studies and inventories referred to previously have determined that prevailing water quality would not prohibit successful American shad restoration up to and possibly beyond the Kernsville Dam at River Mile 100. However, some localized river sections in and near major urban areas such as Reading and Philadelphia, are impacted with significant water quality problems which need further attention.

General problem areas for uptake of heavy metals and exotic chlorinated hydrocarbons such as PCB's have been identified and continue to persist in the lower river area (Brezina and Arnold, 1976). However, the only diadromous species which would likely be seriously impacted by these problems is the catadromous American eel, primarily because it resides in the river system for several years until it reaches sexual maturity. Continued periodic monitoring of the river water and fish flesh, in cooperation with appropriate state and federal agencies will be necessary for maintaining a current status of these problems.

Dissolved oxygen levels, under certain low steam flow regimes, can be problematic in the urban areas mentioned. With the combination of low stream discharge, either in spring or autumn, and warm water temperatures, periodic difficulty could be encountered by spawning adults and out-migrating juveniles. This problem will also require frequent periodic monitoring with other appropriate agencies to determine its current status.

LEHIGH

The American shad heavily utilized this river until the advent of low-head dams in the early 1800's (Marshall, 1974). Later, coal mine and steel plant wastes and municipal pollution became serious problems even for resident fishes.

Pollution abatement programs in the upper river coal mining areas, plus recent improvements in the waste treatment facilities of Allentown and Bethlehem and the Bethlehem Steel Company have greatly enhanced the overall river water quality. Even though some pollution problems persist, diadromous fish restoration is feasible in approximately 40 miles of river. However, continued water quality improvement would enhance egg hatching viability and juvenile production. Frequent periodic water quality monitoring with other state and federal agencies will be necessary, particularly in the upper and lower river areas, to maintain a current data base.

ANGLER USE AND HARVEST

Presently no fishery for American shad exists in the Lehigh River, but in the past ten years the sport fishing effort for American shad and other diadromous species in the Delaware River and lower Schuylkill River, downstream from the Fairmount Dam, has increased dramatically. Although this increase has been observed, limited angler use and harvest evaluations have been made to monitor the impact on the stocks.

In any fishery management program, especially one involved with restoration of a species, controlling harvest of adult spawning stocks is an extremely important consideration. Commercial exploitation will not likely become a factor in the Schuylkill River, at least until such time as significant stock restoration is evident and an interest in commercial harvest is generated. On the other hand, sport fishing exploitation becomes a factor as soon as stocks are present and the angler has access to them. For this reason, when restoration begins, as it already has at Fairmount Dam, stringent use and harvest regulations, perhaps even no kill regulations, must be promulgated to protect the spawning American shad stocks until restoration monitoring can produce adequate data to justify more liberal regulations. Whenever use and harvest eventually begins, a program for assessing these impacts must be initiated.

Alternative sources of funding such as that provided by the Coastal Zone Management program can be sought to help defray the costs of this type of assessment.

RESTORATION MONITORING AND REGULATION

Timely and strategic monitoring of American shad stocks, both adult and juvenile, is necessary to determine the extent of restoration success.

This program must include a means of monitoring the success of each fish passage facility for upstream and downstream migration of adults and juvniles; and continued use of such measures as juvenile marking for stock identification and future returning adult population estimates.

When adequate data become available, current management decisions can then be made regarding such things as management regulations, passage facility monitoring and adjusting stocking programs.

STOCK AUGMENTATION

Because stock of American shad have been prohibited from making annual migrations up the Schuylkill and Lehigh Rivers for over 150 years, some difficulty in attaining desirable early adult spawning stock numbers may be encountered following fishway installations. This may result in slower annual increases in progeny than would be the case if supplementary adult prespawned stocks were moved from the Delaware River and/or fry and fingerling stockings were made annually into appropriate areas of each river.

Therefore, a program for transplanting adult prespawned stocks should be undertaken and stocking of marked fry and/or fingerling American shad should be in the overall restoration effort. The magnitude of such an increased program would depend upon the rate of restoration ultimately desired in the program implementation phase.

WATER USE AND STREAM FLOW

The water of the Schuylkill and Lehigh Rivers is used for a variety of purposes, generally categorized as either instream or withdrawal. Examples of instream uses include fish and wildlife habitat, water quality maintenance, hydropower and general environmental and aesthetic values. Withdrawal water uses are those which require the removal of water from its source and include both consumptive and nonconsumptive uses. Consumptive water use is the sum of consumptive losses and interbasin and/or interwatershed transfer losses. Public water supply uses are the major contributor to interbasin transfer losses primarily through discharge of sewage to a different basin. Major consumptive uses are power generation, irrigation, manufacturing and public water supply.

Water use totals for 1980 and a projection for 1990 are as follows:

River	1980 (MGD)		
	Total Use	Consumptive Losses	Interbasin Transfer Losses
Schuylkill	*1,154.1	96.7	171.4
River	* 474.0	50.7	5.1

River	1990 (MGD)		
	Total Use	Consumptive Losses	Interbasin Transfer Losses
Schuylkill	*1,276.7	143.7	159.3
River	* 516.0	55.7	5.6

* Figures to most significant tenth of an MGD.

SCHUYLKILL

The Schuylkill River is the most heavily reused water in the Commonwealth and population increase projections for 1990 vary from 10.1% to 57.8% among the six watershed areas comprising the basin. The prospect for increased water usage in the future is therefore high.

The only major impoundment on the basin with flow augmentation capability is Blue Marsh Reservoir on the Tulpehocken Creek. It also provides flood control and water supply.

With a projected increase in use it will be necessary to establish and maintain adequate minimum flow objectives in the Schuylkill River as close as possible to historic flows. These objectives will not only assure continuation of present legitimate use, but also assure critical flows for the protection and enhancement of resident fishes and the restoration of diadromous fishes. The maintenance of critical seasonal flows for American shad nursery habitat and juvenile outmigration in late summer and autumn, must be assured if restoration is to be successful.

LEHIGH

The Lehigh River presently receives moderate usage, but does not suffer the high interbasin transfer losses characteristic of the Schuylkill.

Population increase projections on the three watershed areas comprising the basin range from 7.8% to 42%. Therefore moderate increases in water usage in the future can be anticipated.

The existing major impoundments on the Lehigh having flow augmentation potential are the Francis B. Walter and Beltzville Reservoirs. Both impoundments also provide flood control and flow augmentation. Francis B. Walter Reservoir will be modified and enlarged to provide, among other benefits, additional augmentation flows for present and future uses.

With projected increases in most uses in the future, it will be necessary to establish and maintain adequate minimum flow objectives as close to historic flows as possible. These objectives will not only assure continuation of present legitimate uses but also critical flows for the protection and enhancement of resident fishes and the restoration of diadromous fishes. The maintenance of critical seasonal flows for American shad nursery habitat and juvenile outmigration in late summer and autumn must be assured if restoration is to be successful.

ENTRAINMENT AND IMPINGEMENT

Entrainment and impingement are not major problems in either the Schuylkill or Lehigh Rivers at this time. However, when American shad restoration is initiated and greater number of juveniles become available, entrainment and impingement at existing intakes could become significant, particularly during juvenile outmigration. Furthermore, existing facilities containing intake structures should be inventoried and their owners required to adapt these structures to minimize problems. All new water projects to be developed, such as impending low-head hydropower plants, should have acceptable intake structure design included in the original planning.

ANGLER AND BOATING ACCESS

Public angler and boating access to both rivers is highly inadequate. This represents a serious problem on these improving resources which flow through some of the most densely populated areas in Pennsylvania. These areas have the highest potential for increased fishing and boating usage in the Commonwealth.

A systematic inventory and strategic access siting program would be a major asset in promoting use and harvest of the restored fishery. Such a program must be based upon current and projected angling and boating use data in order to assure that the best available strategic locations are developed to accommodate the user and assure the most equitable use of the resource.

RESTORATION INFORMATION AND PROMOTION

The information and promotion efforts concerning the construction and ultimate installation of the Fairmount Fishway were excellent. However, other restoration activities since that time have only received a modest amount of discussion or promotion in the news media.

On the other hand, activities concerning the Hamilton Street Dam Fishway have received good local publicity. The activities of the Lehigh River Pre servation, Protection and Improvement Foundation have received excellent promotion and publicity.

Excellent coverage was given to the stocking of marked fry in 1985, 1986 and 1987 and to the impending legislation for fishway financing on the Lehigh's two dams.

A concerted public education program is vitally necessary to enlist public support for restoration and promotion of the American shad fishery resulting from the restoration program. An attempt to enlist organized sportsmen support for the Schuylkill restoration similar to that on the Lehigh is an example of a specific activity requiring promotional effort.

STRATEGIES

1. Provide for unimpeded upstream migration of adult American shad in the Schuylkill and Lehigh Rivers.

2. Provide adequate and suitable spawning and nursery habitat for American shad in the Schuylkill and Lehigh Rivers.

3. Provide for unimpeded downstream migration of post spawning adult and juvenile American shad in the Schuylkill and Lehigh Rivers.

4. Monitor all phases of the American shad restoration programs for the Schuylkill and Lehigh Rivers and provide for the appropriate regulations and management measures which will assure successful programs.

5. Provide a comprehensive and systematic angler and boating access program for each river.

6. Provide an aggressive restoration information and promotion program.

7. Continue to provide staff and support to assure interstate coordination and compatibility of the American shad restoration program for the Schuylkill and Lehigh Rivers with the Delaware Basin Fish and Wildlife Cooperative's American Shad Restoration Plan.

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APPENDIX D-8d

SURVEY OF THE TAILRACE CANAL RECREATIONAL SHAD FISHERY, 1985-1987

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INTRODUCTION

Historically, the recreational shad fishery in South Carolina has been small compared to that in other east coast states. Most of the limited activity has been directed at the Edisto, Combahee and Savannah Rivers. The recreational catch has been considered negligible relative to the commercial catch.

In recent years, anglers have shown increasing interest in the shad fishery potential of the tailrace canal at Moncks Corner. The tailrace provides (at times) a combination of strong water flow and migration barrier that concentrates the fish and increases their availability to sportfishermen. Shad offer an opportunity when other sportfishing alternatives in the area are limited. The tailrace is convenient to a large angling population and is somewhat protected from inclement weather. Efforts to popularize the shad have also contributed to increasing angler interest in the tailrace shad fishery.

Little information was available regarding the tailrace recreational shad fishery prior to the rediversion project, completed in March 1985. Because of the projected decrease in water volume in the tailrace, the Marine Resources Division considered it appropriate to obtain data on the shad fishery before and after rediversion. This report contains results of a study of angler participation and catch during the 1985 season immediately prior to and following the rediversion. The fishery was also surveyed during comparable periods in 1986 and 1987. These results are included for comparison with the 1985 data.

METHODS

Nearly all of the shad fishing takes place just below the dam. While trolling is popular in the Edisto River and Georgetown area, the most widely practiced method in the tailrace is to anchor just below the dam and trail small jigs at various depths. Because shore fishing access there is extremely limited, only boat anglers were addressed. In 1985, there were three access points near the power plant: 1) a small, private facility at the Dock Restaurant, 2) an undeveloped place at the end of the road leading into the Dock Restaurant, and 3) a large public launching ramp across the canal from the restaurant (Fig. 1). In 1986, another launching ramp was built as part of a private housing complex (Hidden Cove). A $5 launching fee was required and virtually no anglers seemed to utilize this site, judging from the absence of trailers. Fishermen also travel up the canal from more distant access points. An observer at the public ramp can count boats and occupants returning to either of the sites by the restaurant, as well as boaters traveling down the canal.

Preliminary information suggested that most shad fishing occurred after noon and that weekends were most popular. Most of the 1985 survey effort (90%) was therefore directed at afternoons and weekends, although several morning trips were included to verify these assumptions. Information from angler interviews indicated that there was appreciable shad fishing activity after mid-morning, so the level of morning survey effort was increased to 25% in 1986 and 1987. Survey hours were distributed as follows:

	Weekend		Weekday				
	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
1985 (8 March-12 April)							
AM	0	2	0	0	0	2	2
PM	10	9	0	9	8	3	14
1986 (2 March-12 April)							
AM	0	7	0	1	2	2	2
PM	5	17	0	4	4	8	4
1987 (2 March-10 April)							
AM	4	6	0	2	0	0	4
PM	4	14	0	7	0	4	11

Total sampling time was 59 hours in 1985 and 56 hours each in 1986 and 1987.

The daily routine consisted of the observer, stationed at the public ramp, counting boats and their occupants as they returned to either of the three access points or proceeded down the canal (away from the power plant). All occupants of a boat were considered as fishermen, unless they were small children or indicated during interviews that they had not fished. In each year, less than 8% of the boats checked contained no anglers and these were not included in the data. Fishermen returning to the public ramp were interviewed by asking them what species they sought (target species) and how many they caught and retained. Target species were designated as shad, herring, panfish, and catfish, although in 1985 catch figures were obtained for shad only. In 1986 and 1987, catch figures were obtained for other species as well. These figures represent anglers' estimates and usually no attempt was made to verify them by fish counts; time constraints, the frequency of interviews, and the numbers of fish caught often made this impractical. Upon leaving the ramp, the observer counted the trailers remaining at each launching site. These figures were considered equivalent to the number of boats still on the water.

In 1986, a card drop box was placed at the public site in an effort to obtain additional data from periods in which no observer was present, particularly late afternoon and early morning. Respondents were asked to specify the number of fishermen in their boat, the day and hours they fished, time returned, target species, and approximate numbers of fish retained. They were also asked to estimate the number of times a season they fished specifically for shad.

Counts of boats and their occupants were compiled hourly for each site (not including the subdivision ramp) and in transit (i.e., down the canal). For each weekly interval, count data for weekdays were combined and the average number of boats returning to all sites during 1200-1600 hours was calculated. This procedure was repeated for weekend days. The average number of fishermen per boat was calculated for each site (including downriver), then the unweighted mean of these values was determined (i.e., $\bar{x}$ anglers/boat). These were calculated for the weekday and weekend categories. The average trailer counts at the end of the weekday and weekend interview periods were calculated. Then the total amount of fishing effort in each weekly interval was estimated as follows (number of days in incomplete weeks were adjusted as appropriate):

Weekdays:

Number of boats per day = ($\bar{x}$ boats/hr)(4 hrs) + $\bar{x}$ trailer count

Number of anglers per day = (number of boats/day)($\bar{x}$ anglers/boat)

Number of anglers per week= 5(number of anglers/day)

Weekends:

(Number of boats/day and anglers/day as above)

Number of anglers per week = 2(number of anglers/day)

In 1986, the number of boats counted during 1000-1200 hours was 23% of the total counted during the afternoon. In 1987, the corresponding figure was 30%. The estimated total morning fishing effort was therefore calculated as these percentages times the afternoon effort. An arbitrary value of 25% was assigned to the 1985 data in the absence of sufficient morning samples.

For each weekly interval, the percentage of fishermen targeting shad was calculated from the numbers of anglers interviewed. The total number of fishermen in each interval was multiplied by the appropriate percentage to derive the estimated anglers that fished for shad. The average number of shad retained per angler-trip during each interval was multiplied by the estimated number of shad fishermen to generate the catch estimates.

RESULTS

The numbers of boats and anglers counted during site visits are shown in Table 1. In all years, the average number of anglers per boat was somewhat higher on weekends than on weekdays. The numbers of boats and their occupants who were interviewed are listed in Table 2. In 1985, anglers in 55% of the boats returning to the public ramp were interviewed. In 1986 and 1987, the figures were 84% and 88%, respectively. The average hourly boat counts and end-of-visit trailer counts during the periods of peack activity are shown in Table 3.

The diel distribution of shad fishing effort and success is shown in Table 4. It indicates that, while the effort is rather uniformly distributed, those anglers returning in the mid-afternoon have had the greatest success. Given the average trip duration, this implies that shad fishing effort during the early to mid-morning was relatively unsuccessful most of the time.

In 1985, 38% of the fishermen interviewed were fishing primarily for shad, while the corresponding value was about 30% in both 1986 and 1987. As can be seen in Table 5, shad CPUE and angler interest, as indicated by the percentage of fishermen seeking shad, dropped off appreciably after the third week of March in all years.

Estimated total fishing effort, shad fishing effort, and the shad catch are shown in Table 6. Many anglers interviewed in 1985 and 1986 indicated that they culled their catch and retained only the roe fish, thus catch figures for these years are underestimates of the actual number of fish caught.

The information from the card returns in 1986 was used to check against data gathered from interviews and to aid in interpreting results. The 24 returns were rather evenly distributed in terms of days of the week. Of the 61 anglers represented, 16 had fished for shad with a catch of 30, for an average CPUE of 1.9 fish/angler-trip. The average trip duration for shad was the same (4.6 hrs) as for other species, so the mean catch rate in fish/hr was about 0.7 shad. This was higher than for any other species except herring (catfish CPUE was 0.4 fish/hr, as was that for white perch). All of the shad fishermen reported returning between 1200 and 1430 and 83% of the returns occurred between 1000-1800 for all anglers combined. Few of the fishermen seeking other species indicated that they ever fished for shad, while all of the shad fishermen replied that they made 4-5 trips a year specifically for shad.

DISCUSSION

In 1985, the period of significant shad fishing activity probably extended from the last week of February through the first week of April. There were wide fluctuations in water levels and flow rates and, due to drought conditions, levels and flows were reduced during much of the preferred fishing hours. Nevertheless, fishing for shad was very good through the third week of March. The rediversion officially took place at 1201, 23 March. After this date, CPUE (Fig. 2) appeared to drop off sharply. The estimated catch of about 10,000 fish (retained) is probably conservative, due to the fact that most of the sport catch is bucks and many fishermen save only the roe-bearing females. Even so, at an average individual weight of about 4.0 pounds, this catch would have represented about 11% of the statewide commercial catch that was reported.

In 1986, low water levels and weak flows again prevailed during most of the season, due to reduced spring rainfall. Both the percentage of fishermen targeting shad and the overall number of anglers appeared to decline. The trend in CPUE was temporally similar to that in 1985, although the overall average for a comparable period was well below that seen in 1985 (3.0 vs 4.4 fish per angler-trip). The total shad catch appeared to be much lower than in 1985, being estimated at about 46% of the previous year's. The statewide commercial catch, however, increased substantially.

The 1987 season was largely a failure. Wet, windy weather prevailed during most of February and the first reports of recreational shad catches at the dam were during the last week of the month. The first 10 days of March were also predominantly rainy, with high winds, and there probably was relatively little effort then. Unlike in the past two years, there was no increase in CPUE as March progressed and good fishing failed to materialize as the weather improved. Water levels and flow rates were highly erratic and the water remained very turbid throughout the period of normally good fishing. Fishing success for other seasonal species, e.g. white perch and herring, appeared to be well below the previous year's level as well. Many anglers blamed the weak, erratic flow and cold dirty water for the poor fishing. It should be noted that commercial shad fishing elsewhere in the state was unusually slow during this period also. The estimated catch was only about 15% of that calculated for 1985 and overall CPUE was extremely low (0.8) compared to the previous two years.

These estimates of catch and effort provide insight into the relative condition of the tailrace shad fishery during the years considered, but the catch figures should be accepted with caution as to their absolute value. During both 1985 and 1986, about 13% of the boats with anglers fishing for shad reported catching no fish and observed catch rates were extremely variable over a wide range (from 0 to 40 or 50 fish on many days). The coefficient of variation associated with the overall seasonal CPUE estimator was very high (1.23) for the 1985 data. During the 1986 season, the interview effort was increased from about 55% of the boats returning to over 80% in an attempt to reduce this variability, although the overall sample size did not increase because of the reduced shad fishing effort. There was virtually no change in the coefficient of variation (1.31) for the 1986 data and thus no improvement in the precision of the CPUE estimates. During the 1987 season, both the percentage of boats intercepted and the sample size were increased (although not by much due to reduced participation during the second half of the sampling interval). About 51% of the boats with shad anglers reported catching no fish. This high an incidence of null values in a small sample greatly reduces the precision of the observed mean, under normal circumstances, and the coefficient of variation (1.77) was appreciably higher than in the previous two years.

The conclusion that can be drawn from these efforts is that the catch of shad in this fishery would be difficult to estimate very accurately if this became necessary for management purposes. A substantial increase in the percentage of boats intercepted produced no measurable improvement in the accuracy of the CPUE estimates. The observed level of fluctuation common to a feast-or-famine type of fishery generally requires that the fishery be observed during a substantial portion of its duration, in order to achieve any reasonable level of precision associated with catch rate estimates. The accurate estimation of shad catches would require a much more frequent and intensive sampling effort.

Table 1. Boats and anglers counted during site visits.

	Boats				Anglers			
	Weekday		Weekend day		Weekday		Weekend day	
	AM	PM	AM	PM	AM	PM	AM	PM
1985								
Dock Rest.	4	49	1	62	8	111	4	124
Road end	0	17	0	8	0	39	0	16
Public ramp	6	264	8	263	16	613	18	559
Downriver	7	52	1	37	17	119	2	76
1986								
Dock Rest.	5	33	8	55	6	67	17	128
Road end	1	2	2	5	2	5	3	10
Public ramp	18	124	25	175	33	256	52	394
Downriver	7	27	20	94	14	58	41	230
1987								
Dock Rest.	5	27	13	21	8	58	30	44
Road end	0	3	1	2	0	7	1	4
Public ramp	12	146	42	156	24	300	105	365
Downriver	2	34	41	70	4	63	89	146

Table 2. Boats and anglers intercepted at the public ramp.

	Boats				Anglers			
	Weekday		Weekend day		Weekday		Weekend day	
Target species	AM	PM	AM	PM	AM	PM	AM	PM
				1985				
Shad	0	52	0	63	0	124	0	132
Herring	0	18	0	18	0	44	0	37
Catfish	0	4	1	19	0	11	2	43
Panfish	2	62	6	54	4	148	15	115
Total	2	136	7	154	4	327	17	327
				1986				
Shad	7	45	3	39	12	94	7	83
Herring	2	13	5	24	3	29	13	63
Catfish	3	9	3	15	6	19	6	31
Panfish	5	49	9	69	10	104	15	168
Total	17	116	20	147	31	246	41	345
				1987				
Shad	6	53	16	21	11	106	37	47
Herring	3	14	7	22	8	33	17	65
Catfish	1	13	4	13	2	27	10	32
Panfish	2	64	12	61	3	128	31	132
Total	12	144	39	117	24	294	95	276

Table 3. Average numbers of boats returning each hour to all sites during 1200-1600 hours and trailer counts at end of visits. Values in () are estimates used in the effort calculations.

	Boats		Trailers	
	Weekdays	Weekend days	Weekdays	Weekend days
1985				
8-14 March	13.6	18.4	36.5	43.5
15-21 March	8.7	(18.4)	32.0	(43.5)
22-28 March	8.4	20.7	32.5	44.5
29 March-4 April	9.4	(20.7)	36.5	(44.5)
1986				
6-13 March	7.3	23.8	26.0	33.0
14-20 March	11.8	14.5	25.0	(33.0)
21-27 March	9.8	10.6	46.0	26.0
28 March-3 April	8.0	10.5	13.0	37.0
1987				
8-14 March	11.0	(14.5)	42.0	(41.0)
15-21 March	10.8	20.6	32.0	48.0
22-28 March	(9.0)	15.2	(29.0)	63.5
29 March-4 April	7.3	7.5	26.0	32.5

Table 4. Shad fishing activity by time period. CPUE values are average-of-ratios means, in shad per angler-trip.

Time period	Total anglers	Shad anglers	Percent shad anglers	CPUE
		1985		
1200-1300	23	8	35	2.9
1300-1400	121	58	48	3.5
1400-1500	177	55	31	5.0
1500-1600	178	63	35	5.0
1600-1700	141	65	46	2.7
		1986		
1000-1100	16	6	38	0.9
1100-1200	41	8	20	2.6
1200-1300	73	24	33	4.2
1300-1400	165	37	22	2.4
1400-1500	118	45	38	3.2
1500-1600	132	41	31	2.9
1600-1700	51	19	37	3.2
		1987		
1000-1100	30	15	50	0.1
1100-1200	89	33	37	0.5
1200-1300	108	23	21	1.1
1300-1400	125	23	18	1.5
1400-1500	166	55	33	1.5
1500-1600	148	45	30	0.5
1600-1700	21	7	33	1.0

Table 5. Estimated percentages of shad fishermen and their CPUE by weekly interval.

Week	Percent shad anglers	Fish/angler-trip
	1985	
8-14 March	49.6	4.7
15-21 March	52.1	7.8
22-28 March	28.5	1.6
29 March-4 April	6.0	1.6
	1986	
6-13 March	41.5	2.4
14-20 March	39.5	4.7
21-27 March	30.0	1.9
28 March-3 April	16.1	1.9
	1987	
8-14 March	58.6	1.3
15-21 March	34.8	0.5
22-28 March	8.0	0.1
29 March-4 April	16.0	0.4

Table 6. Estimated total angler effort (angler-trips), shad effort, and shad catch.

Week	Total effort 1000-1200	Total effort 1200-on	Shad effort 1000-1200	Shad effort 1200-on	Shad catch 1000-1200	Shad catch 1200-on
			1985			
8-14 March	368	1,472		730		3,431
15-21 March	306	1,224		638		4,976
22-28 March	316	1,264		360		576
29 March-4 April	337	1,346		81		130
Total	1,327	5,306	452	1,809	911	9,113
			1986			
6-13 March	263	1,142		474		1,138
14-20 March	264	1,146		453		2,129
21-27 March	270	1,176		353		671
28 March-3 April	188	816		131		249
Total	985	4,280	246	1,411	443	4,187
			1987			
8-14 March	401	1,337		783		1,018
15-21 March	410	1,366		475		238
22-28 March	392	1,308		105		11
29 March-4 April	256	854		137		55
Total	1,459	4,865	584	1,500	175	1,322

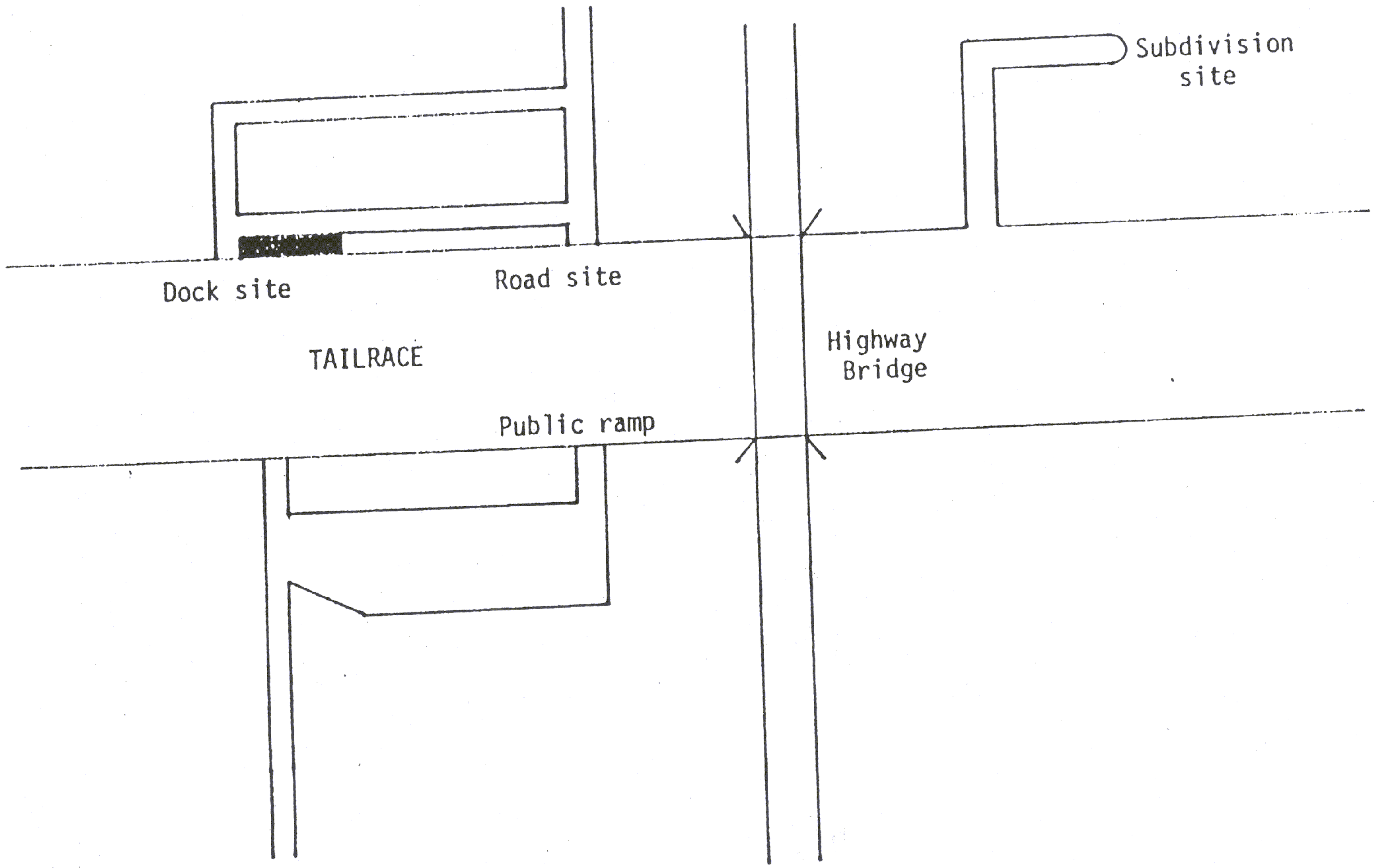

Fig. 1. Access points nearest to power plant.

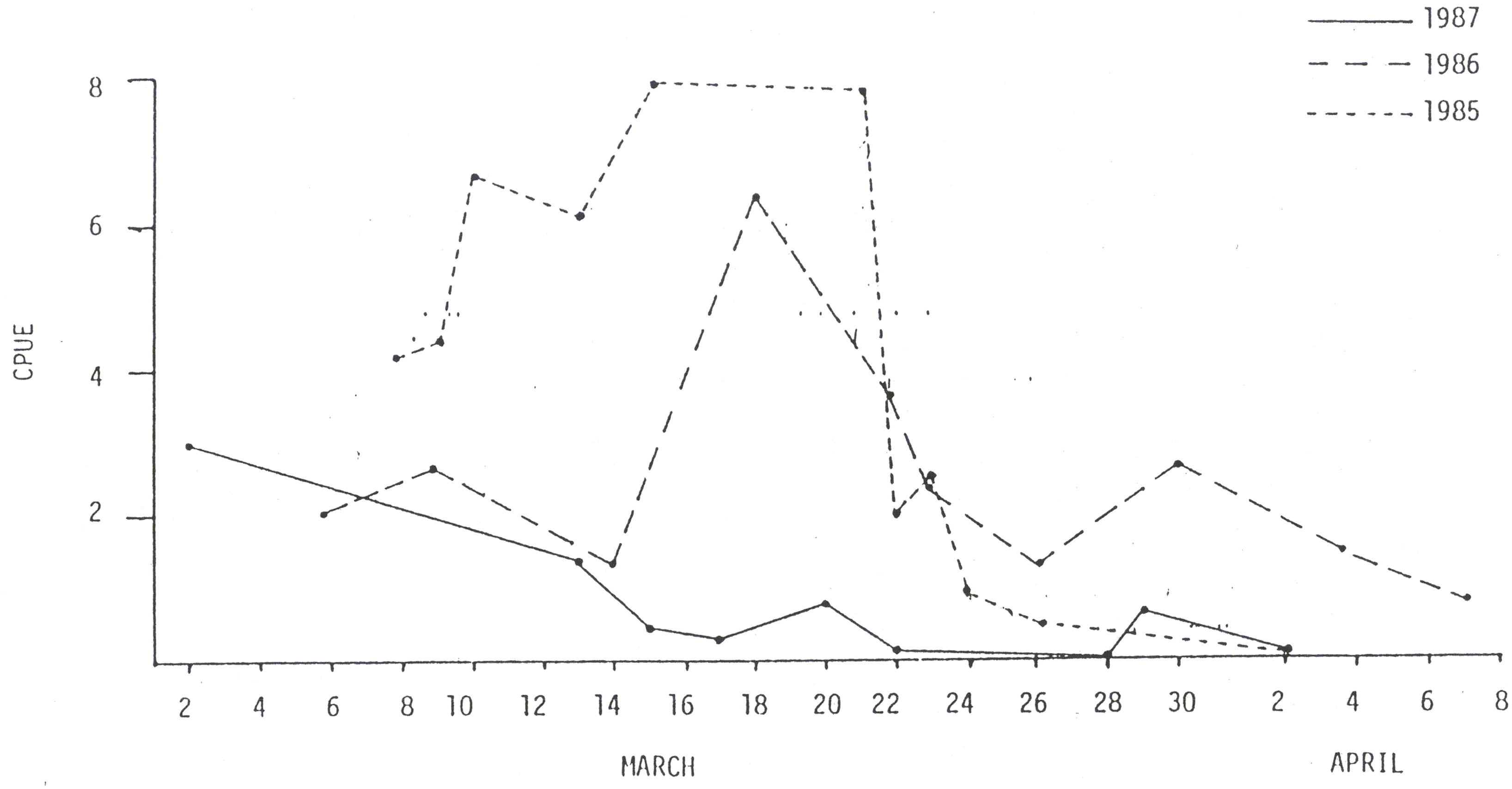

Fig. 2. Time trend in CPUE (fish/angler-trip) for shad.

South Carolina
Wildlife & Marine
Resources Department

S.C. WILDLIFE AND MARINE RESOURCES DEPT.
Equal Opportunity Agency

James A. Timmerman, Jr., Ph.D.
Executive Director
W. Brock Conrad, Jr.
Director of
Wildlife and Freshwater Fisheries

July 20, 1987

Mr. Billy McCord
SCW&MRD
P. O. Box 12559
Charleston, S. C. 29412

Dear Billy,

Enclosed is a summary of project plans for the Santee-Cooper blueback herring studies. To summarize results at this point in the study would be inconclusive however, it is apparent that herring population in Cooper River have been greatly reduced since rediversion while populations in the Santee appear to be expanding.

If you have additional questions, please call.

Sincerely,

Dick

Richard W. Christie
Fisheries Biologist

RWC/lcy

P. O. Drawer 190 ☐ Bonneau, South Carolina 29431 ☐ Telephone (803) 825-3387

Summary of Santee Cooper Blueback Herring Project

The Santee Cooper blueback herring studies have been conducted since November, 1976, to evaluate the effects of a large scale water rediversion project on fish populations in the Santee and Cooper rivers. This project receives State and Federal (USCOE) funding. Blueback herring were selected as the species to intensively study in this system due to their importance locally as a commercial bait fish and forage for striped bass.

Three main work items have been selected for intensive pre-post rediversion comparisions. They are:

1) effects of rediversion on migration of adult blueback herring.
2) effects of rediversion on spawning of blueback herring in the Santee and Cooper rivers, and
3) effects of rediversion on movement of herring from the Santee and Cooper rivers into Lake Moultrie.

Objectives for the first work item are to estimate the population size of adult blueback herring in Santee River, to determine population parameters and commercial harvest of adult herring from Santee River, and to correlate the migration and abundance of adult herring in Santee River with environmental variables.

Objectives for the second work item are to assess the significance of tributaries, hardwood swamp and the main channel of Santee River as spawning habitat for blueback herring, to define the relative importance of various Cooper River ecotypes as spawning habitat and to determine selected water quality parameters associated with spawning habitat.

Objectives for the final work item are to determine numbers of adult herring migrating into Lake Moultrie prior to and after rediversion, to determine numbers of herring passed into Lake Moultrie via St. Stephen fishlift, and to evaluate the total numbers of blueback herring entering Lake Moultrie prior to and after rediversion.

APPENDIX D-8f

Current Status of American Shad Alewife and Blueback Herring in New York Waters

Prepared for
Atlantic States Marine Fisheries Commission
Shad and River Herring Scientific and
Statistical Committee

Prepared By:
R. E. Brandt
Hudson River Fisheries Specialist
July 15, 1987
Revised December 14, 1988

The Atlantic State Marine Fisheries Commission adopted a Fisheries Management Plan for American Shad and River Herrings in October, 1985. As a part of the continuing management of these species the Shad and River Herring Scientific and Statistical Committe consisting of appointed representatives of each of the coastal states, Maine to Florida meets annually to review the status of various affected fish stocks. This overview is prepared to describe the current status of Hudson River shad and river herring stocks.

Overview

American shad are currently harvested in the Hudson River Estuary from the George Washington Bridge in New York City (River Mile 12) to the Port of Albany (River Mile 145). Noticeable improvements in water quality in the upper Hudson Estuary has resulted in increases in numbers of all anadramous fish utilizing the upper tidal reaches of the estuary. Commercial netting of American shad is prosecuted in New York waters using three fishing techniques; drift nets are employed throughout the river above Peekskill (River Mile 45) drifting over short reaches (up to 3 miles) and soak times generally less than 2 hours. Below Peekskill staked or anchored nets are employed depending on water depths and preferences of individual fishers. During 1986, 69 individuals obtained 147 licenses to operate 181,320 linear feet of gill net. Stretched mesh sizes in the shad fishery range from 5 to 6 inches with 5 1/2 and 6 inch meshes predominating.

Reported New York Hudson River landings were 615,768 pounds with an additional 118,998 pounds landed in New Jersey. The 734,776 pounds reported landed for 1986 is well within the recent historical range of approximately 200,000 to 1,300,000 pounds. Expansion of the commercial shad fishery is market-limited by chronically low market prices. Notable reductions in both market price and fishing effort coincide with the arrival of peak abundance of shad in the lower Hudson Estuary.

River, herring, alewife and blueback herring have very limited commercial utilization, primarily as bait and also a limited recreational fishery utilizing scap nets, dip nets and very limited angling.

Recent Management Actions

Management of Hudson River American shad and river herring stocks has consisted of monitoring of annual recruitment, commercial fishery catch-per-unit of effort and adult abundance. Age structure of both the commercial catch (by gear type) and the adult stock are characterized annually.

These monitoring objectives are accomplished by direct monitoring of approximately 60 days of commercial fishing effort, low-biased haul seine collections of adult shad from spawning areas and 100 foot x 10 foot beach seine sampling of juveniles at standard sampling sites. The results related in this report are excerpted from the Hudson River Fishery Research Unit 1986 Annual Report.

Overall the sampling results have depicted a lightly-exploited adult shad stock with high incidence of repeat spawning and females ages 4 to 12 represented in the catches. Juvenile recruitment of shad during 1986 was the highest measured since initiation of sampling in 1980.

Status of the Stocks

Commercial Fishery Monitoring

American shad appeared to be more abundant in 1986 than 1985 with weekly c/f measures greater for both males and females in all gears. Ages five and six shad dominated with an age structure similar to that reported by Talbot (1954). Greater numbers of older shad (8 years of age) were found in the River by Crecco et al. (1981). Length at age for Hudson Rivers and Connecticut Rivers are similar.

Observed catch-per-unit-effort (CPUE) of American shad during 1986 was highest for all gear types since monitoring began in 1980. The 1986 data indicate a strong selectivity toward roe shad.

Catch Description

The fork length distribution of American shad observed in the commercial net fishery in the Hudson River Estuary during 1986 based upon 642 observations ranged from 415 to 582 mm for males ($\bar{X}$ = 480) and 440 to 628 mm for females ($\bar{X}$ = 520) for staked, anchored and drift net gears combined. Weights of fish sampled ranged from 1100 to 3280 g for males ($\bar{X}$ = 1919) and 1560 to 4570 ($\bar{X}$ = 2636) for females. Ages of shad caught ranged from age 4 to 12 based upon analysis of scale annulus formation. Catch-per-unit-effort peaked during the week of April 13-19 in the anchored gill net fishery, April 20-26 in the staked gill net fishery and later, April 27 to May 3 in the upriver drift gill net fishery.

Adult Stock Monitoring

Sampling of the adult stock was accomplished during 1986 by use of a 100 ft x 12 ft x 4 inch stretched mesh haul seine fished in spawning areas. The non size-selectivity of the haul seine was used to alleviate and characterize biases associated with the narrow range of gillnet mesh sizes in the commercial shad fishery.

A total of 50 seine hauls resulted in collection of 1987 American shad from seven sites. Distribution of sampling effort was made to obtain temporal and spatial distribution of sampling effort, not maximize catches.

Mean fork length of male American shad captured in the haul seine was 17.1 in (435 mm) and mean weight was 2.9 lbs. (2040 g). Length frequency of both sexes appeared distributed normally around mean length.

Age structure and frequency of repeat spawning is depicted in Attachment 15. Mean fork length at age is described in Attachment 16.

Juvenile Abundance

A total of 380 valid seine hauls were completed using 100 ft by 10 ft by 1/4 inch mesh netting. The net was set perpindicular to shore and the deepwater and swept toward the beach. A total of 114,333 fish representing 53 species were collected during the 1986 beach seine program. Collections were made at standard station sites located between the vicinity of Newburg and Albany (River Miles 55-140). Indices of annual abundance were calculated for five target fish species; blueback herring, alewife, American shad, white perch and striped bass. Mean CPUE by sampling week for blueback herring, Alewife and American shad are depicted in Attachments 18 through 20 respectively. The annual CPUE for young-of-the-year American shad during 1986 was the highest measured during seven years of sampling from 1980 - 1986.

Conclusion

The Hudson River American shad adult population is strong and appears to be subject to light fishing exploitation as indicated by the high incidence of repeat spawning females and the presence of fish up to age 12 in the population. Monitoring of commercial fishing catch and effort has occurred annually since 1980, 1986 CPUE was highest for all gear types since initiation of the program. Catch per effort of juvenile shad from the 1986 year class was also greatest since annual abundance indexing begain in 1980. Large adult runs are anticipated for 1987 and 1988 based upon the large 1983 year class.

THE EFFECT OF SPORT FISHING ON THE DYNAMICS OF THE PAWCATUCK RIVER SHAD POPULATION (A PRELIMINARY ASSESSMENT)

Introduction

Efforts to restore the American Shad to the Pawcatuck River have been very successful to date. Adult transplants have been made since 1975 and first returns were achieved in 1979 (O'Brien 1979). Current returns are, approximately, 4,200 fish (Fig. 1). Estimates based on other populations place the maximum population size at 25,000 fish. It is expected that the population will follow the logistic growth projected in Figure 1. It has been shown that returns, to date, are highly correlated to the number of spawning females in previous generations (Gibson 1984). This is consistent with current stock-recruit theory which indicates that at low population sizes, parental stock will strongly influence recruitment. Environmental effects are abated since the stock is not near K, the carrying capacity of the habitat.

American Shad are quite popular as a gamefish in the Northeast. Significant sport fisheries exist on the Connecticut and Delaware Rivers valued in excess of one million dollars. Catches are on the order of 16,000 to 25,000 annually.

In response to angler interest, this Division will open a limited sport fishery for shad in the Pawcatuck River in 1986. In view of the high intrinsic value of these fisheries when fully developed, it is important to assess the effects of fishing, such that premature harvests do not damage the stock's ability to attain full capacity and value.

This analysis is a preliminary assessment, drawing on data from early returns to the Pawcatuck River, as well as data from other nearby shad populations.

Methods

Projections of population growth require an estimate of the upper population bound and and a parent-progeny relationship. A population asymptote was established by using a production figure established for the Connecticut River of 2.3 adults per 100 square yards of spawning habitat (ASMFC 1985). Upon completion of fishway construction, 39.1 miles of rivers (Potter Hill to Upper Wood and Queens Rivers), averaging 17.1 yds. in width, will be open to spawning American Shad. This amounts to 11,836 production units. The estimated maximum population is 27,224 shad. The parent-progeny relationship was developed by using data on spawning stock and subsequent recruitments for years 1975-1985. Parental stock was comprised of two components, transplanted as well as home returning females. These were equated using the weighting coefficients of the regression model in Gibson (1984). Transplanted females could then be expressed in terms of native females and their sum, multiplied by 2.5 to account for males was the spawning stock for that year (n). Recruitments were the sum of age III returns in year n+3 and age IV's in n+4 divided by .31, the percentage of an average return that these ages constitutes. This has the effect of scaling up recruitments to account for age 5, 6, and 7 fish of the same year class. An additional hypothetical point was included to shape the recruitment curve so that it conformed to the estimated population size as well as known reproductive strategy in shad. At a spawning stock of 25,000 adults, it was hypothesized that compensation would occur and only 20,000 recruits would be produced. The data used is summarized in Table 1. The recruitment model chosen was that of Ricker (1954).

$$R = \alpha P e^{-BP}$$

River hydrographic conditions such as June discharge, have been shown to strongly modulate cohort production in shad (Crecco and Savoy (1984). In view of this, a second function was generated which included an environmental effects parameter (June flow).

$$R = \alpha P e^{(-B_1 P + B_2 J)}$$

This parameter, acting in a multiplicative fashion, can be used to introduce stochastic variation into the recruitment process.

Using the second relationship, recruitments could be predicted from spawning stocks. It was assumed that the recruitment produced, returned as age 3, 4, 5, 6 and 7 virgin spawners in the following proportions: .034, .276, .452, .216, and .022. For simplification, no attempt was made to include repeat spawners nor account for sex specific maturity schedules. Projected parental stocks were then the sum of age 3, 4, 5, 6 and 7 fish returning in that year which, in turn, predicted future returns. The population was simulated from 1979 to year 2013 under a series of exploitation rates ranging from 0 to .75 by removing the appropriate percentage of parental stock prior to entry into the recruitment function. Environmental variation in the form of June flow was added using a random number table based on the probability of occurrence of a given discharge from a time series of U.S.G.S. flow data.

Statistical fits were performed using the SAS non-linear regression procedures of the University of Rhode Island Computer Center. Population projections were made using a programmable calculator.

Results

The fitted stock-recruit functions were as follows:

$$R = 3.81\, P e^{-.00006P} \quad (1)$$

and

$$R = 3.28\, P e^{(-.000063P + .000032J)} \quad (2)$$

where:

R = Recruitment Produced
P = Parental Stock
J = Mean June Discharge

Given the second relationship, the following would hold:

Replacement level	-	18,855
Maximum recruitment	-	19,823
Spawners needed for R_{max}	-	15,873
M.S.Y.	-	7,479
Exploitation rate at M.S.Y.	=	.567
Limiting rate of exploitation	=	.695

This relationship accounted for over 90% of the variation in observed recruitments. Projected population growth under various rates of fishing are found in Figure 2. With no fishing, the population follows the familiar logistic curve and increases rapidly from 1985-1995. Moderate rates of exploitation (10-20%) produce a reduced rate of growth, however, the population still reaches a plateau of about 20,000 spawners. Under more extreme rates (50%), the population grows much more slowly and reaches a size of only 15,000 spawners. Fishing rates approaching 75% will cause a stock collapse.

Discussion

The hypothesized stock-recruit functions (Figure 3) for Pawcatuck River shad bear resemblance to those generated for Connecticut River shad by Crecco et al (1985). Values of "a", which determine the shape of the curve and hence recruitment dynamics, were similar (1.34 vs. 1.56). Sustainable and limiting rates of exploitation were also comparable. Since the Connecticut curve is based on population estimates derived from Holyoke lift data, it would be indicative of an expanding shad population. It is believed that the functions used to model the Pawcatuck, a growing population, were therefore appropriate.

This analysis indicates that limited exploitation (< 10%) beginning in 1986 will probably not adversely impact the development of the Pawcatuck River shad population. The population has entered a phase of exponential growth where the surplus production margin is high (Figure 3). Estimates of exploitation rates by sport fishermen in the Connecticut and Delaware Rivers range from 4-11% (Crecco and Gunn 1982, Miller et al 1982). Sport fishermen in Maryland catch about 5% of the Susquehanna River shad despite a closed season (Carter and Weinrich 1982). It seems unlikely that fishing rates in the Pawcatuck could exceed 10% in the first season, although the actual rate cannot be estimated without knowledge of fishing effort and catchability.

The Atlantic States Marine Fisheries Commission Management Plan for shad (A.S.M.F.C. 1985) has recommended allowable exploitation rates based on modeling work in the Connecticut River.

Severely Depleted Runs	- 0
Depleted Runs	< 25%
Stable Runs	< 40%

The Pawcatuck would probably fall in the depleted category since it has not yet reached the full capacity of the river. A 10% sport harvest seems to be about right.

There are, however, several areas of concern. Discard rates have been shown to be substantial in the Connecticut River sport fishery, ranging from 12.8-60.5% (Crecco and Gunn 1982). Fishermen discard smaller fish in favor of larger fish and males in favor of females. Mortality rates are not known for "played out" fish, but are believed high (Victor Crecco - personal communication). Thus, a 1-fish per day limit may actually kill more fish than expected. The regulations should specify that fishermen are done for the day after one capture, regardless if the fish is released. Consideration might be given to closing the season during periods when females are most abundant.

Also, this analysis was not particularly sensitive to environmental effects. Early recruitments in the Pawcatuck system have been controlled almost entirely by the magnitude of the parental stock. This is in contrast to the Connecticut River where hydrographic conditions, particularly June flow, strongly influence cohort production. This disparity is due to two factors. Firstly, the Pawcatuck is a neophyte population, as opposed to an established one. When the population is far below K the carrying capacity, increments in spawning stock strongly influence recruitment, enviornmental variability notwithstanding. Secondly, recruitments which have been enumerated in the Pawcatuck so far, originate from year classes 1975-1981. As estimated by the Connecticut River juvenile index, these year classes were all average, or above. Year 1977 and 1980, in particular, were good. Year classes 1982 and 1984 were poor in the Connecticut, the 1982 index being the lowest ever reported. These failures stem from the severe flooding that took place in June of those years, conditions which also occurred in the Pawcatuck. These data were not included in the stock-recruit analysis since the recruitments have not yet been realized. Thus, the analysis is for year classes produced in average or better years and may be upwardly biased in terms of population growth rate. If, in fact, the 1982 and 1984 year classes are as weak as indicated by the Connecticut index, returns in years 1987-1990 may be reduced below that projected by the analysis and may be more vulnerable to fishing.

Finally, it has been demonstrated in the Connecticut River that catchability coefficients for shad are inversely related to population size (Crecco and Savoy 1985). At low stock sizes, fishermen, acting as non-random predators, are able to concentrate effort on contagiously distributed shad, thereby increasing the catchability. Thus, when stocks are at low levels, such as currently existing, fishermen may harvest a greater number of shad per unit of effort than at high stock sizes. These three factors may cause the kill to be higher than we expect, to the detriment of the stock. It is recommended that we develop a method of assessing stock size and harvest simultaneously so that the fishery may be managed at an exploitation rate of 10% or less.

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TABLE 1 - Data used to fit the stock-recruit functions and computational methods.

Recruitment[1]	Effective Spawning Stock[2]	Mean June Discharge C.F.S
13	25	530
400	225	233
445	190	366
126	148	517
1,058	328	654
1,926	423	315
3,023	898	230
3,271	788	800
20,000	25,000	539

[1] $(R_{n+3} + R_{n+4})$ /.310

[2] $(H_n + T_n$ /9.8) 2.5

[3] From U.S.G.S. Records

R_{n+3} = Age III recruits in n+3
R_{n+4} = Age IV recruits in year n+4
H_n = Home return females in year n
T_n = Transplanted females in year n

Fig. 1 Pawcatuck River Shad Population— Projected Growth

PLOT OF POP*YEAR   SYMBOL USED IS *

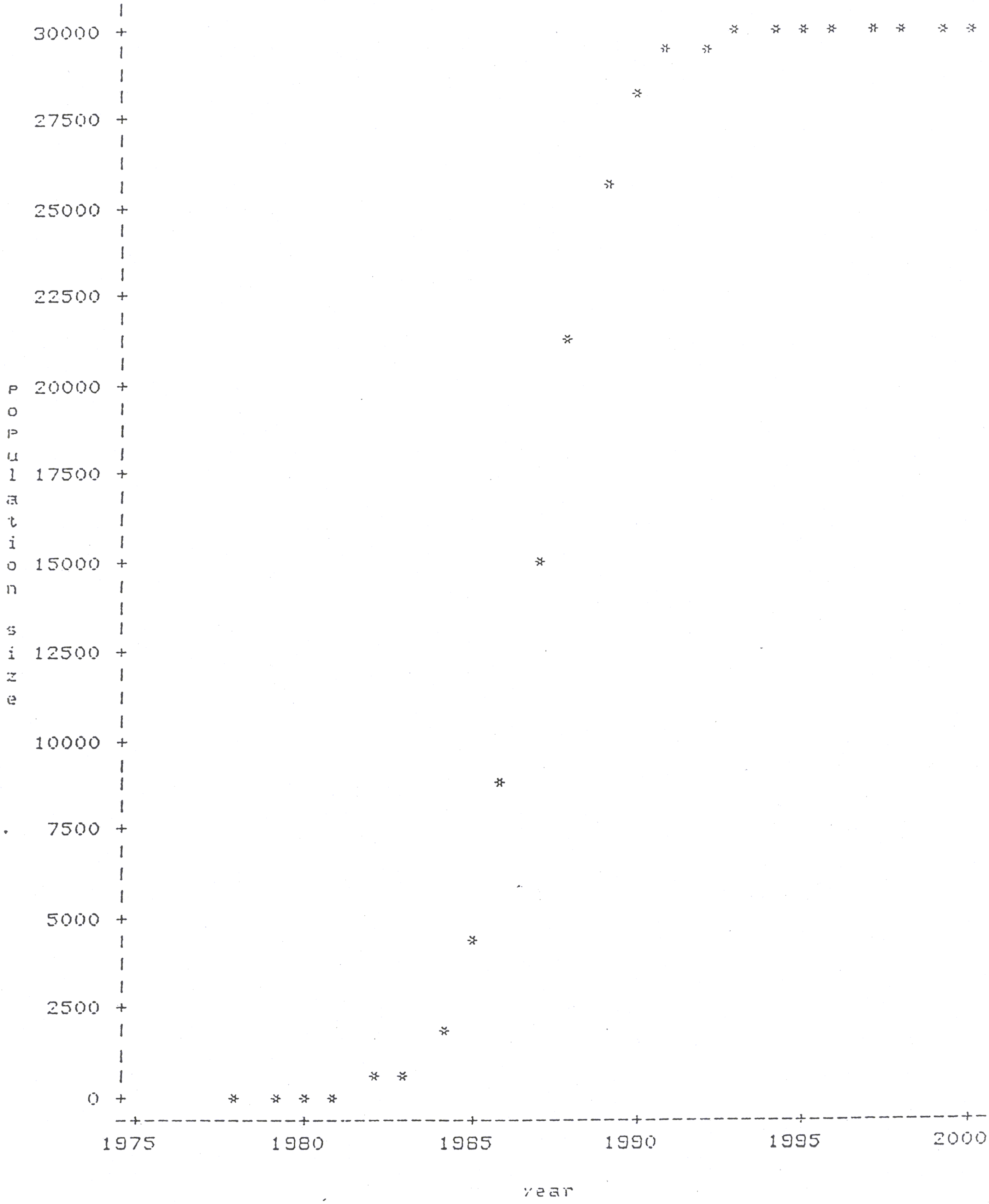


Fig. 2 Pawcatuck River Shad Population Under Various Rates of Exploitation

PLOT OF POP*YEAR   SYMBOL USED IS *

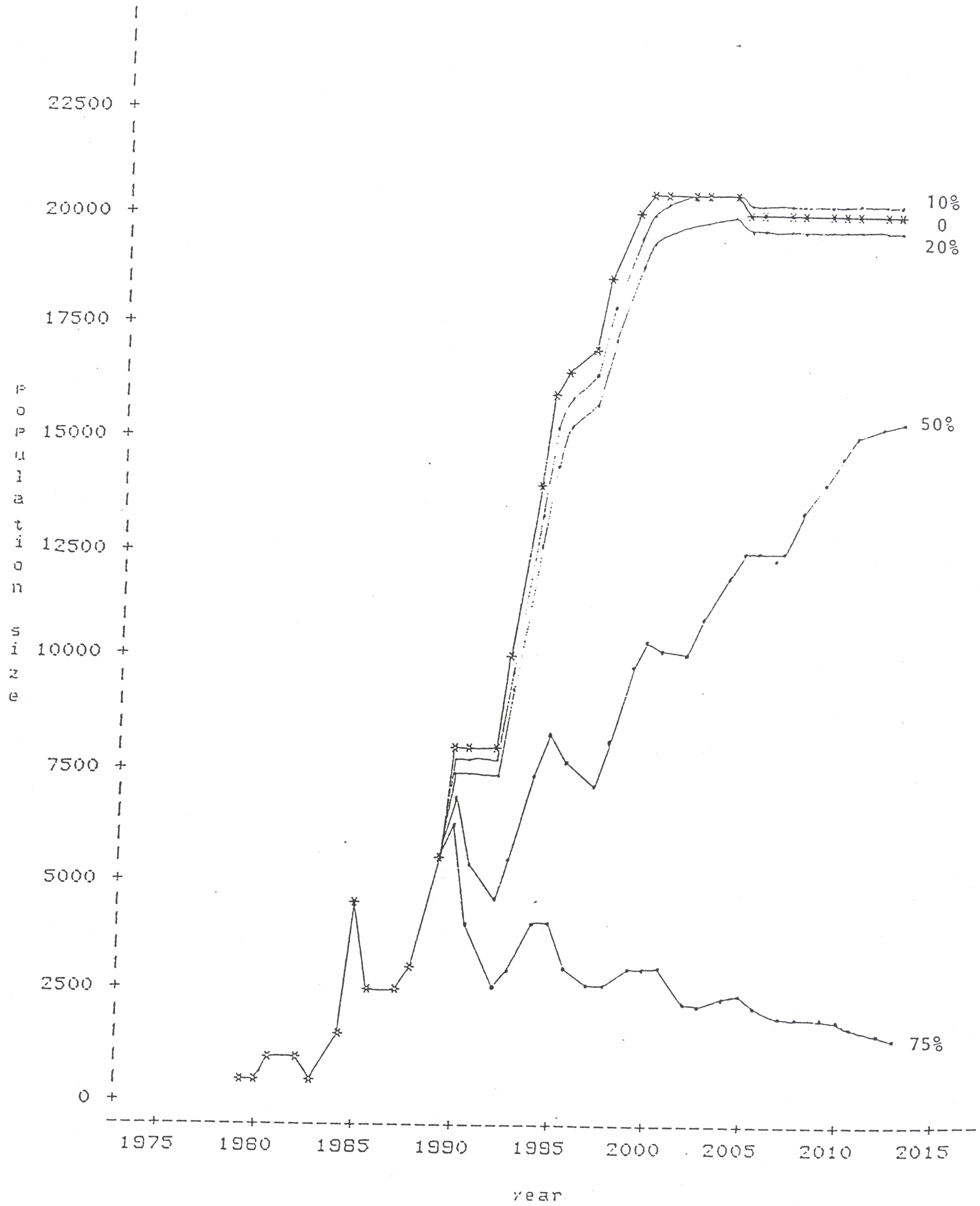
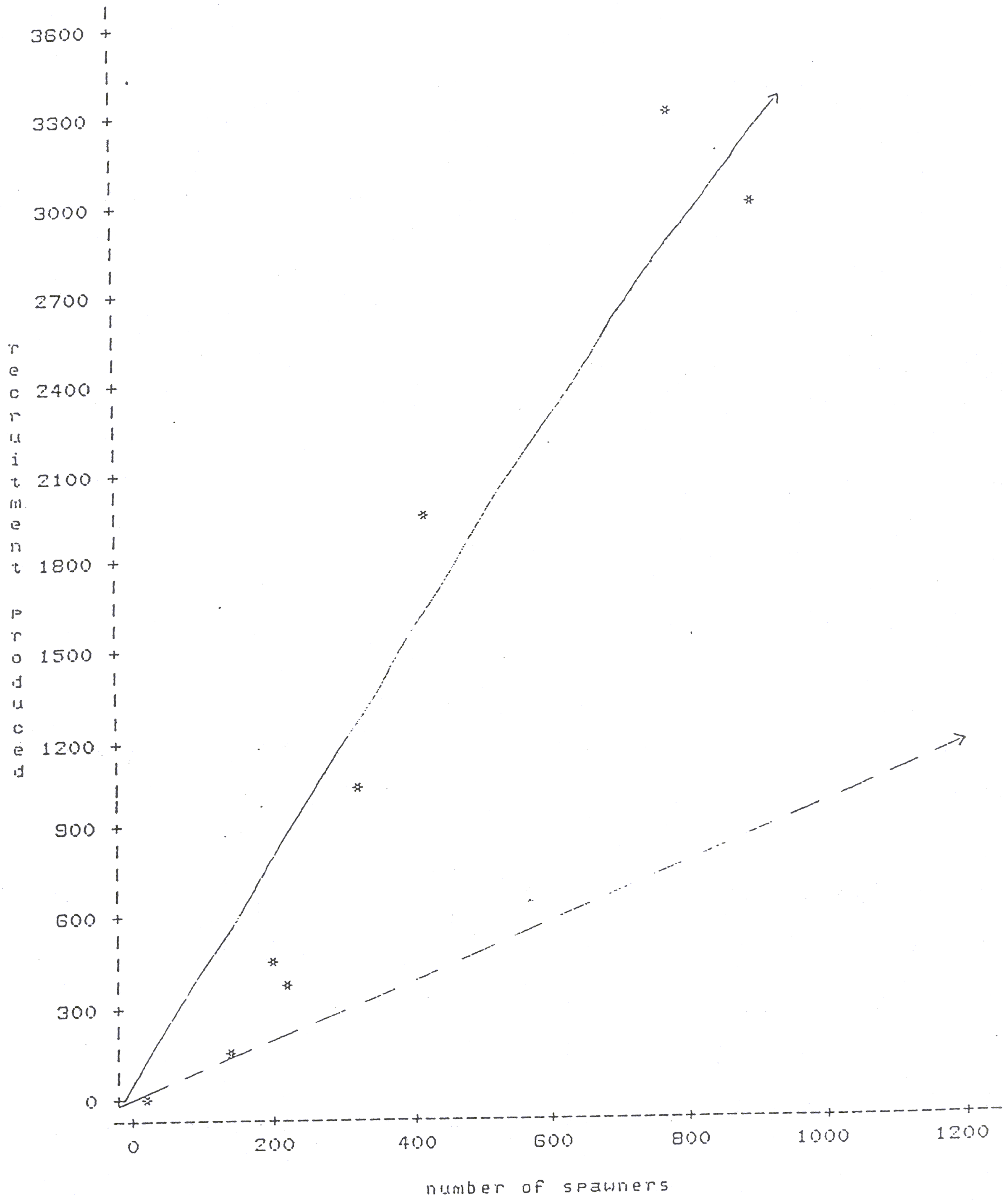


Fig. 3 Pawcatuck River Shad-Parent Progeny Relationship

PLOT OF REC*SPAWN   SYMBOL USED IS *



APPENDIX D-8h

Pending Water Quality Regulations
State of Maryland

CLASS: II - Fresh Nontidal Warm Water Streams, Creeks & Rivers

SUBCLASS: B - Anadromous Fish Spawning Areas

SPECIES PROTECTED: American Shad, Hickory Shad, Alewife Herring, Blueback Herring, Yellow Perch, White Perch, Striped Bass, Atlantic Sturgeon, and Shortnose Sturgeon.

LIFE STATE PROTECTED: Egg and larvae.

DESIGNATION CRITERIA:

Class II-B waters:

1. are nontidal,

2. are not blocked by a migration barrier,

3. have a minimum of 2.0 miles of perennial freshwater or tidal streamflow, or this potential, and

4. are not entirely enclosed in a pipe nor entirely lined with concrete.

HABITAT PROTECTION CRITERIA:

These criteria only apply to Class II-B waters from March 1st to May 31st. During the remainder of the year waters assigned to Class II-B will revert to Class II-A (nontidal waters).

WATER QUALITY

	OPTIMUM CONDITIONS		
	VALUE	RANGE	LETHAL RANGE
Temperature (F)	64	61 - 75	
Dissolved Oxygen (mg/1)	$\geq$5.0		
Fecal Coliform (MPN/100 ml)		0 - 200	N/A
pH		6.5 - 8.5	4.2 - 6.0
Turbidity (NTU)	$\geq$50		
Suspended Solids (mg/1)	30	0 - 70	100 - 5,380

Priority Pollutants: (See the table headed "1980 EPA Ambient Water Quality Criteria.)

PHYSICAL HABITAT

1. Structures which may impede fish from migrating within the watercourse shall be constructed in a manner which minimizes the potential for obstructing fish passage.

2. Activities which may affect existing cover, or obstruct the re-establishment of cover, should be minimized.

3. Activities which modify instream flow shall be conducted in a manner which maintains sufficient flow to support adequate habitat for fish and other living resources.

4. Activities which increase the amount of sunlight reaching a waterway should be minimized in order to prevent the occurrence of excessive water temperatures.

CLASS: III - Tidal Estuarine Waters & Chesapeake Bay

SUBCLASS: A - Resident Fish & Living Resource Areas

SPECIES PROTECTED: Bluefish, Atlantic Menhaden, Croaker, Seatrout, Spot, American Shad, Hickory Shad, Alewife Herring, Blueback Herring, Yellow Perch, White Perch, Striped Bass, Shortnose Sturgeon, Atlantic Sturgeon, Channel Catfish, White Catfish, Brown Bullhead, Yellow Bullhead, Largemouth Bass, Chain Pickerel, Redfin Pickerel, Northern Pike, Muskellunge, and Blue Crab.

LIFE STAGE PROTECTED: Juvenile, and adult growth.

DESIGNATION CRITERIA:

Class III-A waters are all tidal waters in Maryland, except those areas which are blocked by a migration barrier which cannot be reasonably mitigated to provide for fish passage.

HABITAT PROTECTION CRITERIA:

WATER QUALITY

	OPTIMUM CONDITIONS VALUE	RANGE	LETHAL RANGE
Temperature (F)	79	70 - 81	82 - 93
Dissolved Oxygen (mg/1)	$\geq$50		
Fecal Coliform (MPN/100 ml)		0 - 200	n/a
pH		6.5 - 8.5	3.9 - 6.0
Turbidity (NTU)	$\geq$50		
Suspended Solids (mg/1)	30	0 - 70	100 - 5,380

Priority Pollutants: (See the table headed "1980 EPA Ambient Water Quality Criteria.)

PHYSICAL HABITAT

1. Activities which may affect existing cover, or obstruct the re-establishment of cover, should be minimized.

CLASS: III - Tidal Estuarine Waters & Chesapeake Bay

SUBCLASS: B - Anadromous Fish Spawning Areas

SPECIES PROTECTED: American Shad, Hickory Shad, Alewife Herring, Blueback

Herring, Yellow Perch, White Perch, Striped Bass, Atlantic Sturgeon, and Shortnose Sturgeon.

LIFE STAGE PROTECTED: Egg and larvae.

DESIGNATION CRITERIA:

Class III-B waters:

1. are tidal, with a salinity of 6.0 ppt or less during the spring spawning season (March 1 - May 31),

2. are not blocked by a migration barrier,

3. have a minimum of 2.0 miles of perennial freshwater or tidal streamflow, or this potential, and

4. are not entirely enclosed in a pipe nor entirely lined with concrete.

HABITAT PROTECTION CRITERIA:

These criteria only apply to Class II-B waters from March 1st to May 31st. During the remainder of the year, waters assigned to Class II-B will revert to Class III-B.

WATER QUALITY

	OPTIMUM CONDITIONS VALUE	RANGE	LETHAL RANGE
Temperature (F)	64	61 - 75	
Dissolved Oxygen (mg/1)	$\geq$5.0		
Fecal Coliform (MPN/100 ml)		0 - 200	n/a
pH		6.5 - 8.5	4.2 - 4.8
Turbidity (NTU)	$\geq$50		
Suspended Solids (mg/1)	30	0 - 70	100 - 5,380

Priority Pollutants: (See the table headed "1980 EPA Ambient Water Quality Criteria.)

PHYSICAL HABITAT

1. Activities which may affect existing cover, or obstruct the re-establishment of cover, should be minimized.

Basis For Water Quality Values Contained In The Habitat Protection Criteria Section Of The Proposed Redefinition Of The Maryland Water Use Classification And Water Quality Standards System

Following is a description of the rationale for the water quality criteria contained in the proposed revisions to Maryland's water use classification scheme and receiving water standards. The existing standards, contained in the Maryland Department of Health and Mental Hygiene's "Water Quality and Water Pollution Control" regulations (COMAR 10.50.01), list numerical limits for the following parameters; fecal coliforms, dissolved oxygen, temperature, pH, turbidity, and six pesticides. Additionally, a total residual chlorine limitation has been established for the existing Class III and IV waters.

The revisions proposed herein would add limitations for suspended solids and a number of the substances deemed "priority pollutants" by the U.S. Environmental Protection Agency (EPA). The fecal coliform and pH remain unchanged. During the review of the literature only a small amount of information was found on the effects of turbidity upon living resources. A far greater quantity of information was found on the relationship between suspended solids and living resources. Therefore, this proposal uses the same turbidity criteria contained in the existing water quality standards. However, it is recommended that emphasis be placed upon meeting the proposed suspended solids criteria, if a choice must be made between the two.

An extensive review of the literature was performed by Klein (1985) to develop recommendations for the protection of living resources from the effects of suspended solids (sediment pollution). Available data on the various effects of suspended solids upon living resources is presented in Table 5 of the literature review (see Appendix A). Although the many species of living resources do show considerable variation in the concentration at which mortality occurs, the variability of the "no effects" level is far less. Because of this finding, all proposed water use classes carry the same criteria for suspended solids. To maintain opitumum conditions for growth and reproduction the suspended solids concentration should average 30 mg/1 or less and the maximum concentration should not exceed 70 mg/1.

In 980 the U.S. Environmental Protection Agency began publishing "ambient water qualty criteria" for the priority pollutants. These criteria are based upon a very extensive review of the available data on the effects of priority pollutants upon living resources and human health. The criteria established by EPA, as of this date, are summarized in the table contained in Appendix B. In the case of the priority pollutants it is exceedingly important to keep in mind the combined effects of simultaneous exposure to several contaminants. Much of the data reviewed by EPA was derived from studies in which all other environmental factors, except the priority pollutant under investigation, was maintained at optimum levels. In the real world optimum conditions rarely exist for all environmental variables. Therefore, as other environmental factors recede from the optimum level, the degree of safety afforded by the criteria listed in Appendix B will decrease proportionately.

Specific changes have been proposed for temperature and dissolved oxygen.

These changes are described in the following pages. The proposed dissolved oxygen criteria are, for the most part, based upon an extensive literature review focused upon Canadian fish species, there is no reason to believe that his conclusions are not applicable to conditions in Maryland. Davis' review will be found in Appendix C.

APPENDIX D-8i

ADDITIONAL STATE REPORTS ISSUED SINCE 1985

Savoy, T., V. Crecco and R. Langan. 1987. Population dynamics studies of American shad, Alosa sapidissima, in the Connecticut River. Completion Report, Project AFC-15-3, Connecticut Department of Environmental Protection.

Crecco, V. and T. Savoy. 1987. Fishery Management Plan for American shad in the Connecticut River. State of Connecticut, Department of Environmental Protection, Bureau of Fisheries.

Miller, J.P. and A.J. Lupine. 1987. Angler utilization and economic survey of the American shad fishery in the Delaware River. Funded by the Delaware River Shad Fishermens Association, 501 Magnolia Road, Hellertown, PA.

O'Brien, J.F. and M.R. Gibson. 1986. American shad restoration studies, January 1, 1986 to December 31, 1986. Rhode Island Division of Fish and Wildlife Publication, Performance Report, Project Number: F-26-R-21, Job Number: III-2, Rhode Island Department of Environmental Management.

Gibson, M.R. 1987. Disparities between observed and expected stock dynamics in American shad exposed to dredge operations. Rhode Island Division of Fish and Wildlife Publication, Research Reference Document 87/6, State of Rhode Island Department of Environmental Management.

DiCarlo, J.S. 1987. Anadromous Fisheries Management. Final Completion Report, Anadromous Fish Conservation Act, NA84EAD 00025, Project Number: Massachusetts AFC-19, Massachusetts Division of Marine Fisheries, 18 Route 6A, Sandwich, MA. Appendix I. Population biology of the alewife (Alosa pseudoharengus) in Monument (Herring) River, Bourne, MA 1984-1986, by P.D. Brady. Appendix II. Population biology of the blueback herring (Alosa aestivalis) in Monument (Herring) River, Bourne, MA 1984-1986, by P.D. Brady.

Susquehanna River Anadromous Fish Restoration Committee. 1988. Restoration of American shad to the Susquehanna River, Annual Progress Report, 1987. Susquehanna River Coordinator, U.S. Fish and Wildlife Service, P.O. Box 1673, Harrisburg, PA 17105.

APPENDIX D-8j

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Northeast Fisheries Center
Woods Hole Laboratory
Woods Hole, Massachusetts 02543

May 23, 1988 F/NEC1:grs

Dr. William Richkus
Versar Inc.
9200 Rumsey Rd.
Columbia, MD 21045

Dear Bill,

Enclosed is a listing, by state, of river herring and American shad commercial landings for 1984-1987, per your request. A few points concerning the data are worth reiterating. As you are probably aware, the data are considered preliminary until published in the Fisheries Statistics of the U.S., which is about a seven year lag. Also, please note that all North Carolina landings for American shad and 1987 river herring landings are from the northern counties only. Since the NEFC jurisdiction extends only to Cape Hatteras, our year end canvas data are limited to that extent. The rest of the North Carolina river herring landings were from a listing of catches by distance from shore provided by the Washington office. The state data not listed in the table may be available from the state agencies, or from the NMFS Washington statistics office. I apologize for the delay in responding to your request, but the year end canvas data has just recently been finalized for inclusion in the totals. Feel free to contact me if you have any questions concerning this information.

Regards,

Gary

Gary Shepherd
Coastal/Estuarine Fisheries Investigation

cc: E.Bowman
W.Gabriel

American Shad and River Herring commercial landings (000's of lbs)

	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	N
River Herring											
1984	817	90	94	1	40	4	3	10	131	1257	651
1985	1345	61	47	0	35	0	5	15	184	432	1154
1986	1010	30	40	0	30	3	4	6	146	758	681
1987	792	18	35	3	40	3	5	5	755	783	*319
Am.Shad											
1984	33	5	29	36	399	601	292	220	70	909	*379
1985	15	7	21	90	402	774	292	203	189	633	*221
1986	22	17	60	52	322	689	335	195	! 9	519	*176
1987	27	34	41	104	329	605	268	25	123	302	*210

*northern counties only

! value checked, apparently okay

APPENDIX E

REVIEW OF THE ATLANTIC STATES MARINE FISHERIES COMMISSION'S INTERSTATE FISHERY MANAGEMENT PLAN FOR SHAD AND RIVER HERRING

APPENDIX E

REVIEW OF THE ATLANTIC STATES MARINE FISHERIES COMMISSION'S INTERSTATE FISHERY MANAGEMENT PLAN FOR SHAD AND RIVER HERRING

September, 1987
(Revised)

Prepared By: ASMFC Review Subcommittee
Lewis Flagg
Harrel Johnson
Victor Crecco
Richard St. Pierre
Harry Mears

I. Status of FMP: Specific Objectives of the Plan

The Committee reviewed the goal and objectives of the Shad and River Herring Plan adopted by the Atlantic States Marine Fisheries Commission in October, 1985.

The goal of the FMP is to promote, in a coordinated coast-wide manner, the protection and enhancement (including restoration) of shad and river herring stocks occurring on the Atlantic seaboard. The four (4) management objectives of the plan are as follows:

1) Regulate exploitation to achieve fishing mortality rates sufficiently low to ensure survival and enhancement of depressed stocks and the continued well-being of those 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.
2) Improve habitat accessibility and quality in a manner consistent with appropriate management actions for non-anadromous fisheries.
3) Initiate programs to introduce alosid stocks into waters which historically supported, but do not presently support, natural spawning migrations; expand existing stock restoration programs; and initiate new programs to enhance depressed stocks.
4) Recommend and support research programs which will produce data needed for the development of scientifically rigorous management recommendations relating to sustainable and acceptable yields, the preservation of acceptable stock levels, and optimal utilization of those stocks.

The plan objectives are sound, achievable, and relevant to the current problems and needs of the alosid populations addressed within the FMP. The plan is necessary and essential to assure coast-wide coordination of research and management of these species. The inclusion of four (4) species in a single plan has tended to focus attention on the more economically important species, such as American shad, at the expense of the other species, in particular, hickory shad.

Status of the Stocks

American Shad - New England (Maine through Connecticut)

In recent years there has been no substantial directed ocean fishery, although from 1980 to the present the individual state ocean landings have ranged from 23,000 to 68,000 pounds annually. Stocks are currently down in the Connecticut (CT) and Pawcatuck (RI) Rivers, while the Merrimack River run is expanding.

Mid-Atlantic (New York through Virginia)

Since 1980, ocean fisheries for shad have shown stable or moderate to sharp increases in landings. Sharp increases in landings were most notable in New York (Eastern Long Island) and Virginia (Rudy Inlet area). The Hudson and Delaware Rivers in 1986 showed the best YOY indices ever recorded and Maryland's Upper Bay and Susquehanna River showed an increased run of 27,000 adult fish, up from 11,000 fish the previous year. Virginia stocks are reported to be relatively stable in recent years.

Southeast Atlantic (North Carolina through Florida)

The 1986 South Carolina ocean fishery contributed 48% of state-wide landings and the North Carolina ocean fishery for shad around Cape Fear has increased substantially.

River Herring - New England

Since 1976, Maine has been the major contributor to New England river herring landings. Landings throughout the region have shown a major downward trend since the early 1970's and in the past four (4) years, Maine landings have declined dramatically in those rivers which traditionally contributed the majority of the catch.

Mid-Atlantic

Landings have declined dramatically since the mid-1960's and have remained very low in recent years, particularly in Maryland and Virginia which were traditionally the major producers in the mid-Atlantic area.

Southeast Atlantic

Landings reached a low in the early 1980's and have begun to recover since that time. North Carolina is the major contributor to landings in the southeast region.

Status of Research and Monitoring

Maine, Rhode Island, New York, Delaware, Pennsylvania, Maryland, South Carolina and Georgia have implemented or expanded research and monitoring measures since development of the plan. Those states which have ongoing projects involving American shad and river herring are achieving the plan's objectives and developing baseline data through YOY indices and determination of exploitation rates. The Committee is working to establish information on exploitation rates of American shad in eleven (11) different river systems. However, some states with stable or increasing stocks have not seen a need to dedicate funding and manpower for data gathering purposes.

Except for North Carolina, there is a clear lack of activity in gathering information on hickory shad throughout the entire range of this species. Little data is available - outside North Carolina - on the basic life history of the species and little effort is expended on gathering recreational/commercial landings data.

Status of Management Measures

Objective #1 has been slow in implementation with respect to coastal intercept fisheries because of lack of knowledge of the origin of these stocks. Recent tag/recapture studies undertaken by South Carolina indicate that a high proportion of coastal catches may be originating from South Carolina rivers or rivers to the south of South Carolina. An emerging ocean fishery in the Cape Fear area may be exploiting more northerly shad stocks. North Carolina intends to initiate an ocean tagging program in this area to attempt to determine sources of stock in this fishery. However, the timely ISFMP involvement in the Mid-Atlantic Council plans for allocation of mackerel to foreign fisheries has averted a serious potential problem for recovery of Chesapeake Bay alosid stocks.

Objective #2 - Improvement in habitat quality (water quality and establishment of instream minimum flows), fish protection devices (downstream migrant facilities and screens to prevent impingement/entrainment mortalities), and improvement in habitat accessibility (upstream fish passages), has been particularly successful in New England and is gaining momentum in the middle Atlantic states. However, Chesapeake Bay stocks have not yet demonstrated any signs of significant recovery from the precipitous declines of the early 1980's.

Objective #3 - Efforts to restore alosid stocks to historical spawning areas and to rehabilitate depressed stocks are showing progress in New England and selected areas of the mid-Atlantic (e.g., Delaware River, James River, and Potomac River).

Objective #4 - Support for research to produce essential management/restoration data is being undertaken by a number of states, especially with respect to American shad and, to a lesser degree, with river herring. Little or no effort is currently being expended on hickory shad.

Recommendations

1) Investigate the feasibility of expanding cooperative river basin studies and programs in the southeast which are similar to the northeast and mid-Atlantic programs to address habitat and resource needs of southeastern alosid stocks;
2) Continue program coordination through annual meetings of the Board and S&S Committees;
3) Provide funding support to expand the coastal shad tagging programs in North and South Carolina to determine origin of stocks in these fisheries;
4) Sponsor and support a stock assessment workshop on shad and river herring;
5) Carry out a state-by-state review of water quality standards and provide a current status report on habitat and water quality;
6) Add to research needs the following item: studies to determine the age at first maturity for American shad;

7) Determine the existence and extent of intercept fisheries for Maryland shad and river herring in the lower Chesapeake Bay;

8) Encourage studies of life history of hickory shad by individual states, universities, or private research groups;

9) Increase effort to collect recreational catch data on American shad, hickory shad, and river herring; and

10) Initiate studies concerning the impacts of anadromous alosid restoration programs on water quality and resident inland species.

SUMMARY

1985 Shad & River Herring Fishery Management Plan Review

The goal of the plan is to promote, in a coordinated coast-wide manner, the protection and enhancement (including restoration) of shad and river herring stocks occurring on the Atlantic seaboard. The plan's objectives focus on the need to control harvest, improve habitat accessibility and quality, restore and enhance extant and depleted alosid stocks respectively, and recommend/support research programs to provide data for management purposes. A number of individual states' studies are ongoing to acquire those data necessary to achieve plan objectives. A major contribution of this plan is that the Board and S&S Committee serve as a focal point to address problems of common interest, such as the impact of the mackerel foreign fishery allocation on alosid stocks of the mid-Atlantic states. Additionally, the plan provides a vehicle for coordination of research and management of alosid stocks, particularly as it relates to coastal intercept fisheries. The plan is adequate and relevant to the current problems and needs of alosid populations and fisheries.

Recommendations: 1) Investigate the feasibility of expanding cooperative river basin studies and programs in the southeast to address habitat and resource needs of southeastern alosid stocks; 2) continue program coordination through annual meetings of the Board and S&S Committees; 3) provide funding support to expand the coastal shad tagging programs in North and South Carolina to determine origin of stocks in these fisheries; 4) sponsor and support a stock assessment workshop on shad and river herring; 5) carry out a state-by-state review of water quality standards and provide a current status report on habitat and water quality; 6) add to research needs the following item: studies to determine the age at first maturity for American shad; 7) determine the existence and extent of intercept fisheries for shad and river herring in the lower Chesapeake Bay; 8) encourage studies of life history of hickory shad by individual states, universities, or private research groups; 9) increase effort to collect recreational catch data on American shad, hickory shad, and river herring; and 10) initiate studies

concerning the impacts of anadromous alosid programs on water quality and resident inland species.

September, 1987
River Herring Review Subcommittee

SUPPLEMENT TO

FISHERY MANAGEMENT PLAN FOR

AMERICAN SHAD AND RIVER HERRINGS

Atlantic States Marine Fisheries Commission
1400 Sixteenth St., NW
Washington, DC 20036

OCTOBER 1988

FOREWORD

This supplement to the ASMFC Fishery Management Plan for American Shad and River Herrings was prepared by Dr. William A. Richkus, of Versar, Inc., ESM Operations, under Contract #86-2 from the Atlantic State Marine Fisheries Commission. Included in this document are reports prepared by the ASMFC Shad and River Herring Stock Assessment Subcommittee, chaired by Dr. Victor Crecco of Connecticut, and summaries of material presented at a research workshop held in Annapolis, Maryland, in July 1987. Funds were provided by the U.S. Department of Commerce, NOAA, National Marine Fisheries Service (Northeast Region) under P.L. 89-304, project AFC-4. For bibliographic purposes, this document should be cited as follows:

> Atlantic States Marine Fisheries Commission. 1988. Supplement to the Fishery Management Plan for the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring. Washington, DC. 210 pgs.