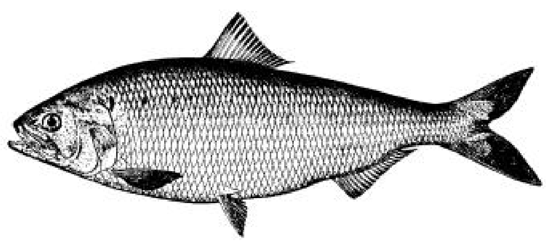
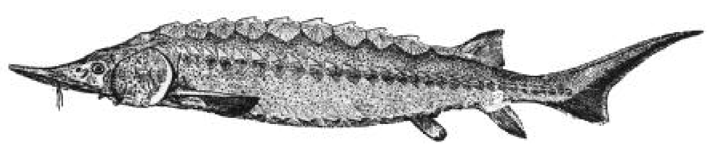
Atlantic States Marine Fisheries Commission

American Shad and Atlantic Sturgeon
Stock Assessment Peer Review

Terms of Reference and Advisory Report





July 1998

Atlantic States Marine Fisheries Commission

American Shad and Atlantic Sturgeon
Stock Assessment Peer Review

Terms of Reference and Advisory Report

Conducted on
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Atlantic States Marine Fisheries Commission
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Table of Contents

Introduction

The Stock Assessment Peer Review Process, adopted in May 1997 by the Commission's Interstate Fisheries Management Program (ISFMP) Policy Board, was developed to standardize the process of stock assessment reviews and validate the Commission's stock assessments. The purpose of the peer review process is to 1) ensure that stock assessments for all species managed by the Commission periodically undergo a formal peer review; 2) improve the quality of Commission stock assessments; 3) improve the credibility of the scientific basis for management; and 4) improve public understanding of fisheries stock assessments. The definition of stock assessment adopted for this process includes model development, parameter development, and data review.

The Stock Assessment Peer Review Process report outlines four options for conducting a peer review of Commission managed species. These options are, in order of priority:

1) The Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) conducted by the National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC).

2) A Commission stock assessment review panel composed of 3-4 stock assessment biologists (state, federal, university) will be formed for each review. The Commission review panel will include scientists from outside the range of the species to improve objectivity.

3) A formal review using the structure of existing organizations (i.e. American Fisheries Society (AFS), International Council for Exploration of the Sea (ICES), or the National Academy of Sciences).

4) An internal review of the stock assessment conducted through the Commission's existing structure (i.e. Technical Committee, Stock Assessment Committee).

Twice annually, the Policy Board prioritizes all Commission managed species based on species Management Board advice and other prioritization criteria. The species with highest priority are assigned to a review process to be conducted in a timely manner.

In October 1997, American shad and Atlantic sturgeon were prioritized for an external peer review to be conducted in early 1998. An external review panel was formed of four stock assessment biologists with expertise in anadromous species. Panel members included Dave Perkins, US Geological Service; Roger Rulifson, East Carolina University; Ray Schaffter, California Department of Fish and Game; and Saul Saila, University of Rhode Island (retired). Dr. Saila was unable to attend the review and his comments are not included in the following reports.

Terms of reference were developed for both species and were used to focus discussions during a three day meeting (March 17-19, 1998) to review stock assessments for American shad and Atlantic sturgeon. This summary report includes the evaluation of the terms of reference, management recommendations, and summary information on the assessments. A Stock Assessment Peer Review Report for each species is also available. These reports include detailed stock assessments for both species, including data input, model parameters, assessment results, and management advice. If you are interested in obtaining copies of the Stock Assessment Peer Review Reports, please contact Dr. Lisa L. Kline at (202) 289-6400 or lkline@asmfc.org.

Table of Contents

Terms of Reference for Atlantic Sturgeon

1. Assess current status of Atlantic coastal stocks of Atlantic sturgeon based on commercial landings data, population estimates, and indices of relative abundance.

The stock assessment report presented a comprehensive review of the current status of Atlantic sturgeon in the U.S. From this review it is obvious that fishing seriously depleted the Atlantic sturgeon by the early 1900=s. Since that time, some stocks[1] are believed to have been extirpated, while others have persisted at very low levels. Catches of juveniles suggest that sporadic spawning is occurring in some of the larger rivers throughout the historic range, but because of the migratory nature of juvenile Atlantic sturgeon, the origin of these juveniles older than age 2 is uncertain. Although time series are sparse for most river stocks, declines in abundance have been noted for some stocks during the last 10-15 years.

2. Review estimates of target fishing rate and yield-per-recruit, and evidence for recent overharvest for the Hudson River stock.

The target F_{50} of 0.03 for a recovered stock, which equates to an annual harvest of 3% of the fish \$ 1.5 m TL, appears reasonable given the available data. This target includes sturgeon harvested from directed fisheries and bycatch. The Review Panel concurred with the stock assessment report that, given an F_{50} of 0.03, the Hudson River stock was probably overharvested in the commercial fishery in NY and NJ from 1990 to 1995. However, further analyses to assess the sensitivity of F_{50} to model inputs would be useful. Specific suggestions include:

a. Examine sensitivity of F_{50} to changes in maximum age (40 and 60 years), and associated changes in natural mortality.

b. Estimate bycatch component in the absence of a directed

[1] The term Astock@ as used herein, is synonymous with Apopulation@.

fishery and at an age-at-capture of 30 years.

c. Examine sensitivity of F_{50} to spawning periodicity (Females, 2 to 6 years).

d. Re-evaluate the fecundity curve with zero fecundity at age 9 (or 10).

e. Examine the sensitivity of F_{50} to changes in size at recruitment (5-10 feet TL).

f. Examine F_{50} with slot size limits that would exclude harvest of large, highly fecund females.

3. Review information on current bycatch of Atlantic sturgeon, including: a) distribution over time, space, and fisheries; b) trends; and c) population level estimates of bycatch induced mortality rates.

Sturgeon are bycatch in a wide variety of trawl and gill net fisheries throughout much of the species' range. The catch rate of sturgeon as bycatch appears low, but the cumulative amount of bycatch could not be assessed because effort data were not available for these fisheries. The lack of effort data also makes it inappropriate to examine trends in bycatch data.

An important, but poorly studied aspect of bycatch is the proportion of dead vs. live sturgeon in the bycatch of different fisheries and gear types. Current data suggest the following: 5% dead from trawls (north and south), 10-40% dead from gillnets (north), 9-16% dead from gillnets (south), 0% dead from pound nets. Assumptions concerning nonreporting of tags and tag loss also need to be evaluated more thoroughly since these could have a large effect on estimated levels of bycatch.

The stock assessment attempted to estimate the annual mortality (i.e., at the population level) that results from bycatch; however, data needed for such estimates are sorely lacking, and little confidence can be ascribed to reported estimates.

4. Review management and research recommendations.

The Review Panel agrees that a coastwide moratorium on harvest and possession of sturgeon is justified to protect and restore stocks. Restoration will likely require multiple decades, dependent on recovery objectives and the definition of a recovered stock. Given the apparent life history differences among sturgeon from different rivers, managers should consider management on a river-by-river basis, unless future studies indicate that stocks are structured at a larger scale.

The research and information needs for the Atlantic sturgeon are great, as evidenced by the lack of basic information which is apparent throughout the stock assessment. Because of the migratory nature of Atlantic sturgeon, coastwide coordination among agencies will be a critical aspect for many of the needed studies such as mark/recapture efforts. Management agencies will also need to play an important role in working cooperatively with commercial fishermen to obtain data on sturgeon and to identify reporting problems.

Atlantic Sturgeon Advisory Report

State of Stocks[1]

Reported landings peaked in 1890 at 3.4 million kg and declined precipitously thereafter (Figure I-1). Currently, populations of Atlantic sturgeon throughout the species= range are either extirpated or at historically low abundance. Recruitment is variable at low levels in all regions. Impediments to recovery include overharvest and loss of spawning and nursery habitats. Survival of Atlantic sturgeon during the 20th century implies that enough spawning and nursery habitats exist to perpetuate the species. In the absence of major threats to existing habitat, reduced fishing mortality is of greater importance to stock restoration efforts than habitat limitations.

Management Advice

Atlantic coastal states should implement a moratorium on harvest and possession of Atlantic sturgeon. Furthermore, harvest should not be permitted in the exclusive economic zone (EEZ). The best available data indicate that river-specific populations are appropriate management units. It is recommended that the moratorium remain in place for each population until it can be documented that the spawning population includes at least 20 year classes of adult females (half the number of year classes that probably existed in unfished populations). Given that female Atlantic sturgeon do not mature until about 20 years of age, the moratorium can be expected to remain in place for several decades once harvest of a given population is ended. As populations increase during restoration, bycatch of sturgeon will increase; hence, managers should ensure that mechanisms are in place to monitor the level of bycatch and make reductions if necessary.

Forecast for 1998/1999

No forecasts were performed.

Stock Identification and Distribution

[1]The term Astock@ as used herein, is synonymous with Apopulation.@

Atlantic sturgeon is an anadromous species, found in all Atlantic coastal waters from Florida to Canada. Data indicate separate river populations with possible mixing.

Management Unit

River-specific populations of Atlantic sturgeon from Maine to Florida.

Landings

During the turn of the century, the Atlantic sturgeon fishery was concentrated in the Delaware River and the Chesapeake systems. Substantial landings also came from the southeastern states of North Carolina, South Carolina and Georgia. After the collapse of sturgeon populations in the mid-Atlantic states, landings from North Carolina, South Carolina, and Georgia dominated the coastal harvest. Landings for these states declined by the 1980s and coastwide harvest shifted to New York and New Jersey.

Data and Assessment

The Atlantic sturgeon assessment relies on data from Maine, the Hudson River, the Delaware Bay, South Carolina and Georgia. Egg-per-recruit (EPR) and yield-per-recruit (YPR) models were used to estimate a target fishing rate (F) and potential yield in number of recent age-one abundance (recruitment) estimates. Mortality rates associated with targeted fisheries were estimated for the Hudson River population through a catch-at-age analysis.

Biological Reference Points

The target fishing rate was defined as that level of F that generated an egg-per-recruit (EPR) equal to 50% of the EPR at F = 0.0. This rate (F_{50}) equals 0.03 (annual harvest of 3%). This estimate is based on the following parameters: longevity of Atlantic sturgeon is 60 years, sturgeon recruit to the fishery at a 1.5 m TL minimum size limit (females age nine and males age 10), natural mortality (M) is 0.07, and spawning occurs every three years after the age of full maturity.

Fishing Mortality

Fishing mortality rates for the Hudson River population during the recent open fishery ranged from 0.01 - 0.12 for females (Figure I-2) and 0.15 - 0.24

for males (Figure I-3) at an M=0.07.

Recruitment

Recruitment is variable at low levels in all regions.

Spawning Stock Biomass

The spawning stock biomass (SSB) is undocumented for all river systems.

Bycatch

Atlantic sturgeon is a bycatch of commercial fisheries along the entire Atlantic coast, particularly in trawl and gillnet fisheries. The National Marine Fisheries Service Observer Program routinely records Atlantic sturgeon encounters in coastal fisheries, but has not recorded fish sizes. Data needed to estimate annual mortality from bycatch are sorely lacking, and little confidence can be ascribed to current estimates.

Special Comments

The research and information needs for the Atlantic sturgeon are great; management and population restoration will be hindered until more information is available.

Sources of Information

Kahnle, A., K. Hattala, K. McKown, C. Shirey, M. Collins, T. Squiers, Jr., and T. Savoy. 1998. Stock Status of Atlantic Sturgeon of Atlantic Coast Estuaries. Report for the Atlantic States Marine Fisheries Commission. ASMFC, Washington, D.C.

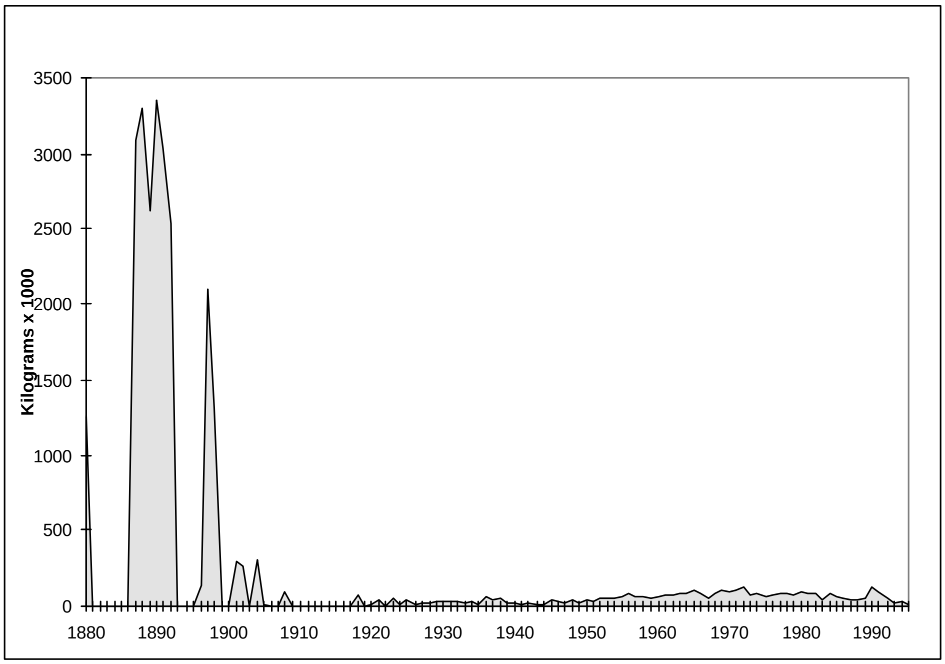
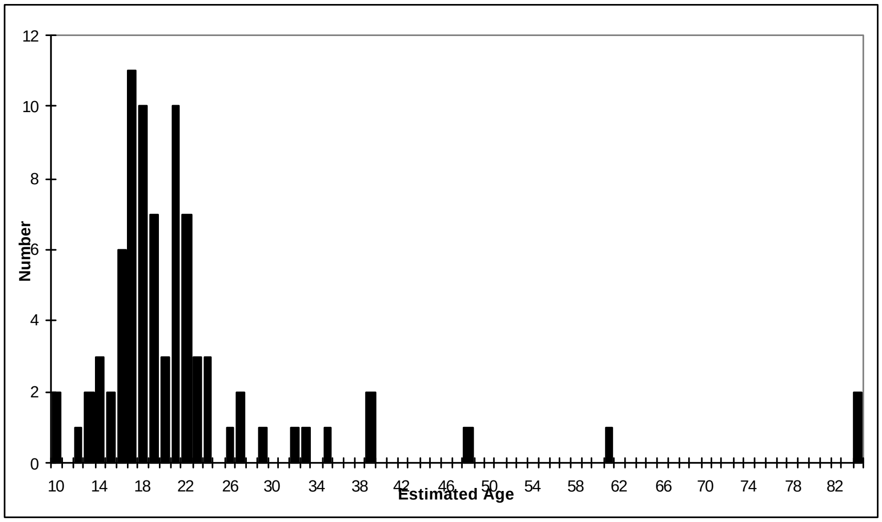


Figure I-1. Coast wide commercial landings of Atlantic sturgeon.



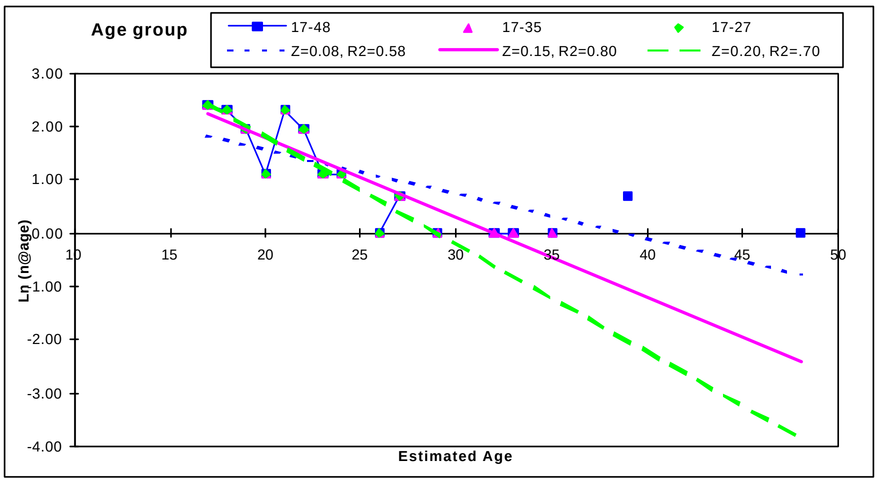


Figure 1-2. Estimated age structure and total instantaneous mortality estimates of female Atlantic sturgeon harvested in the commercial fishery in the Hudson River Estuary, 1993-1995.

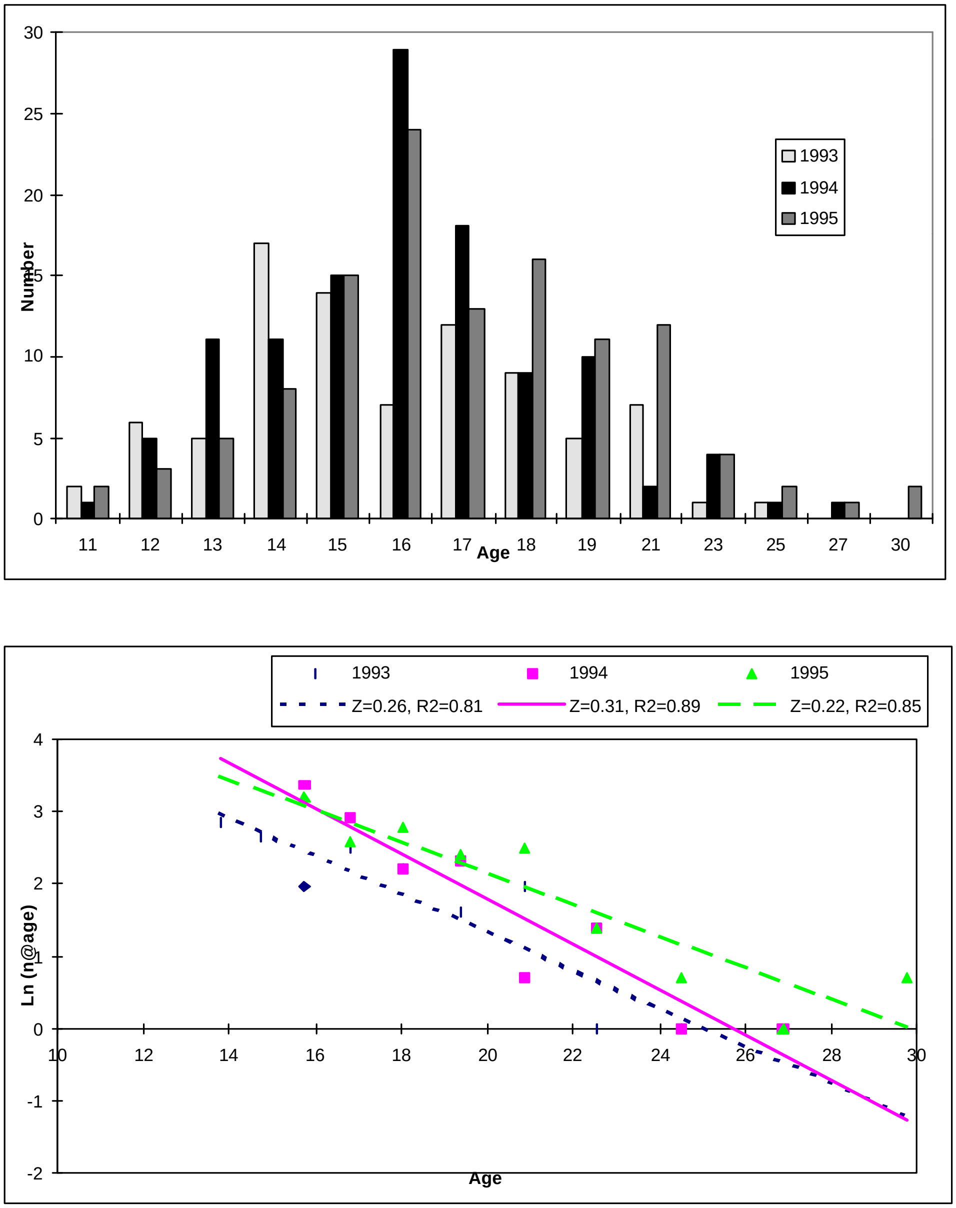


Figure I-3. Estimated age structure and total instantaneous mortality estimates of male Atlantic sturgeon harvested in the commercial fishery in the Hudson River Estuary 1993-1995.

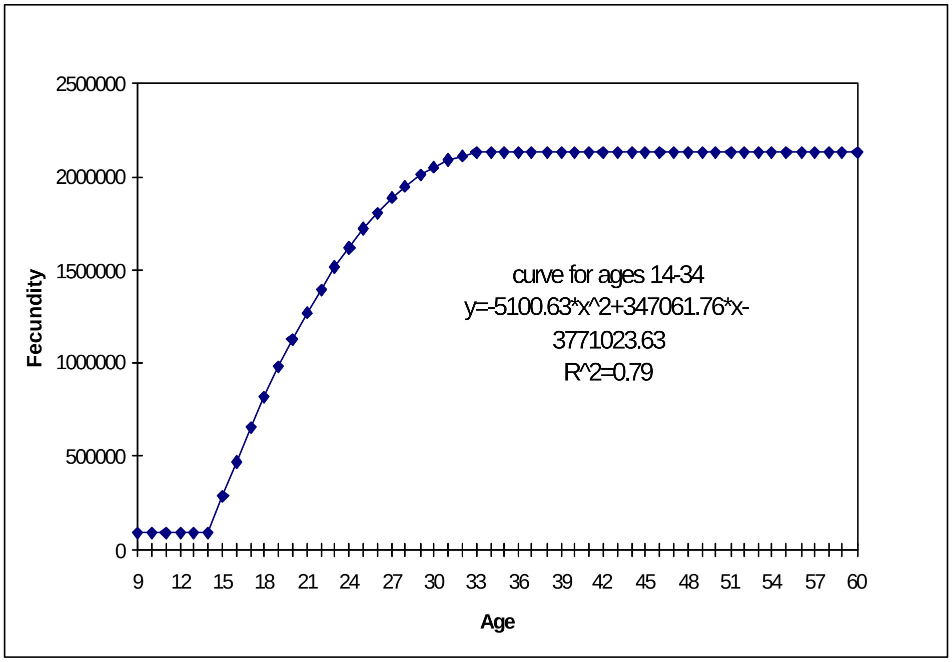


Figure 1-4. Fecundity estimates for Hudson River Atlantic sturgeon (Van Eenennaam, personal communication).

Table of Contents

Terms of Reference for American Shad

1. Estimate natural mortality (M) for American shad stocks by major river system or geographic region (ME-CT, NY-VA, NC-FL).

Given the evidence for differences in natural mortality rates (M) among shad stocks[2], the extrapolation of M from one river to another, although necessary because of limited data, is prone to inaccuracy. For example, values used for natural mortality (Table II-2) occasionally exceeded separate estimates of total mortality (e.g., Albemarle Sound and Pawcatuck River) (Table II-3). These inaccuracies in M have a direct effect on estimates of fishing mortality (F) and can affect whether or not a stock is considered overfished. For example, Hattala and Kahnle (1997) demonstrated that the exploitation status of the shad stock in the Hudson River varies dependent on the value of M. To help assess the potential error in F, sensitivity analyses should be performed that examine the effect of various values of M on F for all river systems in the assessment. Such an analysis may help assess the level of confidence associated with estimates of exploitation status.

Recent evidence indicates that repeat spawning for the Albemarle Sound stock was more prevalent than previously thought (Sara Winslow, personal communication); if so, the value of M used in the Albemarle Sound stock assessment was too high.

The appropriate values of M for shad in the Hudson River are contentious and remain unresolved. Resolution of the issue might be aided if the ages of shad from the Hudson River were corroborated, and resulting information on age structure was used to estimate M.

[2] The term Astock@ as used herein, is synonymous with Apopulation@.

2. Assess relative status of American shad stocks in the Merrimack, Pawcatuck, Connecticut, Hudson, Delaware, James, York, Rappahannock, Edisto, Santee, and Altamaha Rivers through analysis of fishway counts, mark/recapture techniques, hydroacoustic surveys, or commercial catch per unit effort data.

The stock assessment report contains an impressive array of data related to the status of American shad. The methods and data used in the assessment were generally sound, although population estimates should be viewed cautiously (see Term of Reference #3). The main summary of stock status Table II-4) has several shortcomings that could lead the casual reader to erroneous conclusions about stock status.

1) The time frame (1992-1996) for the trends in stock abundance was not indicated. Although a simple omission, interpretation of stock trends can be significantly affected by the period of reference. The trends of many stocks that have been Astable@ over the past 5 years, would probably be Adecreasing@ when examined over the last 30 years.

2) Stock size, which is a critical component of stock status, was not indicated. Reliance on stock trends, without stock size information, may give the false impression that an Aincreasing@ stock is in good shape, when it could be at historically low levels of abundance, or below management objectives.

3) Stocks with F values close to the overfishing definition (i.e., Hudson, Edisto, and Altamaha rivers) were not indicated. The uncertainty in estimates of fishing mortality (F) warrants recognition that these stocks may be overfished.

4) With such a short time series (6 years), inclusion of landings data seems inappropriate because, as the author noted, use of landings data to infer trends in stock abundance can be misleading because of a poor understanding of fishing effort, lack of socio-economic information, and under-reported landings. Landings declines of large magnitude over a much longer period may, however, provide a general indication of declining abundance.

Decisions about the appropriate harvest level of American shad fisheries should consider absolute stock size, rather than just stock trends. Stock size should be considered in the context of historical abundance and stock-specific management objectives.

3. **Review population estimates of American shad in the upper Chesapeake Bay based on mark-recapture techniques.**

Estimates of the number of American shad in the upper Chesapeake Bay are considered suspect due to violations of assumptions associated with mark-recapture. One of the potentially major violations was marking fish below the Conowingo Dam because these fish may not have been a random mixture of the Upper Bay fish. Estimates for the Apopulation@ of American shad in the tailrace of the Conowingo dam appear to be affected to a lesser, but not insignificant, extent by violation of model assumptions, (e.g., differential catchability and recognition of marked fish between the two recapture methods, i.e., fish lifts). Data necessary to assess the magnitude or direction of inaccuracy caused by invalid assumptions were not available to the review panel. Until the inaccuracy is better understood, the appropriate use of these population estimates is limited to indicators of trends over time, rather than absolute abundance.

Estimates of other populations (e.g., Hudson River) in the stock assessment were not scrutinized as closely as the estimate for the upper Chesapeake Bay, but it seems likely that other estimates could be inaccurate because of the difficulty of meeting model assumptions for shad.

4. **Review biological reference points, coastal fishing mortality, and in-river fishing mortality (sexes combined) for the Connecticut, Hudson, Delaware, Upper Chesapeake Bay, Edisto, Santee, and Altamaha Rivers.**

Given our present knowledge of the American shad, F_{30} seems to be a reasonable overfishing threshold for populations currently at desired levels of abundance. However, many of the shad stocks appear to be at low levels of abundance. For these stocks, managers should consider lower levels of fishing or fishing moratoriums until stocks reach desired levels of abundance. Values of F_{30} are dependent on values of M. Given the uncertainty of values used for M (see Term of Reference #1), it would be useful to assess the sensitivity of F_{30} to changes in M for all river systems included in the stock assessment. In addition, efforts should be made to validate the different values of M used for shad stocks (e.g. through verification of shad aging techniques and repeat spawning information), and thereby increase the reliability of estimates of fishing mortality and exploitation rates.

Estimates of total fishing mortality are confounded by unknown levels of bycatch and other sources of mortality, particularly on sub-adult life stages. The apparent decoupling of juvenile abundance indices and subsequent adult abundance noted in several systems suggests immature (ages 1-3) mortality is underestimated. Additional sources of mortality should be evaluated, including bait and reduction fisheries.

5. Evaluate the risk of mixed stock (ocean intercept) fisheries to depleted and hatchery-supplemented stocks, given the assumed stock contributions to ocean landings.

The risk associated with mixed-stock fisheries is dependent upon the magnitude and stock composition of fish harvested, relative to the stocks of interest. Given the limitations of genetic and tagging studies that have been completed to date, the estimates of stock contributions to mixed-stock fisheries were considered too unreliable to assess the risk that a particular fishery poses to a particular stock. However, the magnitude of the mixed-stock (intercept) fisheries is sufficient to threaten small stocks and to hinder restoration efforts of hatchery-supplemented stocks.

American Shad Advisory Report

State of Stocks[1]

Current stock levels appear greatly reduced from historic levels. Estimates of exploitation status were not provided for the majority of American shad stocks (12 of 19). Three of the seven stocks assessed (Hudson, Edisto, and Altamaha Rivers) were fully exploited. A conservative approach should be used to determine the status of the other assessed stocks due to uncertainties in available data and model inputs. During the period 1992-1996, most stocks varied without trend (i.e., stable), but some stocks were increasing (in part due to hatchery supplementation) and the Hudson River stock was declining. The York River stock declined during the period 1980-1993. These trends in abundance over the 1992-1996 period may reflect natural variability, changes in fishing pressure, or both. The short time series is of limited applicability in analyzing the long term health of American shad stocks.

Management Advice

The best available data indicate that river-specific populations are appropriate management units. Management objectives need to be specified for each population before appropriate management actions can be recommended. F_{30} seems to be a reasonable overfishing threshold for populations currently at desired levels of abundance. However, many shad stocks appear to be at low levels of abundance. For these stocks, managers should consider lower levels of fishing or fishing moratoriums until stocks reach desired levels of abundance. Genetic and tagging data indicate that shad harvested in ocean fisheries are composed of a mixture of geographically-distant stocks. Accurate estimates of the contribution of individual stocks to different ocean fisheries are not possible due to insufficient data, but the magnitudes of mixed-stock (intercept) fisheries are sufficient to threaten small stocks and to hinder restoration efforts of hatchery-supplemented stocks.

[1] The term Astock@ as used herein, is synonymous with Apopulation.@

Forecast for 1998/99

No forecasts were performed.

Life History and Distribution

The American shad is an anadromous clupeid found in many Atlantic coast rivers from Florida to Newfoundland. Shortly after recruitment, juveniles emigrate from estuarine nursery areas and join a mixed-stock, migratory population. After four to six years as coastal migrants, individuals become sexually mature and migrate to their natal rivers during spring spawning seasons that vary by latitude.

Management Unit

River-specific populations of American shad from Maine to Florida.

Fisheries

Fisheries are executed in riverine, estuarine, and coastal areas. Although few recreational monitoring programs exist, most harvest is believed to occur in the commercial fishery. Historically, most commercial fishing was concentrated in riverine fisheries. However, perceived or real declines in stock abundance led to severe restrictions in these areas and a rise in coastal mixed stock harvest in the mid-1990s.

Landings

Commercial landings have declined in all American shad stocks on the Atlantic coast with the exception of Maine rivers, the Santee River and the Altamaha River in Georgia for the period 1992 - 1996. The total inriver commercial landings have declined steadily from over 3.2 million pounds in 1980 to less than 600 thousand pounds in 1996 (Figure II-1). Coastal intercept landings rose steadily from 1980 to a peak of 2.0 million pounds in 1989, then declined thereafter to about a million pounds in 1996. Conclusions based solely on declining historic trends in shad landings, however, can be misleading without considering changes in the ratio of landings to fishing effort.

Data and Assessment

A combination of commercial landings, nominal fishing effort, catch per unit effort, fishway counts, population estimates, juvenile abundance and age structure data were included for 19 shad stocks (Table II-1). When sufficient data existed, population abundance and/or fishing mortality trends were estimated.

Biological Reference Point

The Thompson-Bell yield-per-recruit (YPR) model was used to derive an overfishing definition for American shad based on a F_{30} biological reference point (Table II-2). The F_{30} level refers to the fishing mortality rate that generates 30% of maximum spawning potential for an unfished stock (F=0) as measured in the YPR model by biomass-per-recruit. F_{30} values for seven river systems (Table II-3) ranged from 0.39 to 0.48. However, uncertainty in model inputs (e.g., natural mortality) indicates that F_{30} values should be viewed as rough approximations of true values.

Fishing Mortality

Estimated mean total fishing mortality rates were close to the overfishing definition (F_{30}) for three of seven stocks. F_{total} values ranged from 0.17 - 0.45 (Table II-3). The potentially large inaccuracy of some population estimates, the uncertainty regarding appropriate values for M, and the uncertainty of bycatch mortality, reduces the reliability of F estimates.

Recruitment

Juvenile abundance indices have been calculated for nine of nineteen stocks in the assessment (Table II-1). None of these data sets indicate recruitment failure through their time series.

Bycatch

The risk associated with mixed-stock fisheries is dependent upon the magnitude and stock composition of fish harvested, relative to the stocks of interest. Given the limitations of genetic and tagging studies that have been completed to date, the estimates of stock contributions to mixed-stock fisheries were considered too unreliable to assess the risk that a particular fishery poses to a particular stock. However, the magnitude of the mixed-stock (intercept) fisheries is sufficient to threaten small stocks and to hinder restoration efforts of hatchery-supplemented stocks.

Special Comments

A recent report by the National Research Council (1997), *Improving Fish Stock Assessments*, recommended that stock assessments Apresent realistic measures of the uncertainty in model outputs whenever feasible@. This advice holds true for the shad assessment reviewed herein. As with many stock assessments, much of the shad assessment was based on uncertain model inputs that significantly affect model outputs. Specification of uncertainty in model inputs, rather than assuming known values, would allow managers to evaluate the risk associated with model results.

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Maryland Department of Natural Resources, Fisheries Service. 1998. Review of American Shad Petersen Population Estimates for the Upper Chesapeake Bay, 1980-1997. Maryland Department of Natural Resources, Matapeake Station, Matapeake, MD.

Hattala, K. and A. Kahnle. 1997. Stock Status and Definition of Over-Fishing Rate for American Shad of the Hudson River Estuary. New York State Department of Environmental Conservation, Hudson River Fisheries Unit, New Paltz, NY.

Hattala, K., R. Allen, N. Lazar, and R. O=Reilly. 1997. Stock Contributions for American Shad Landings in Mixed Stock Fisheries Along the Atlantic Coast. ASMFC, Washington, D.C.

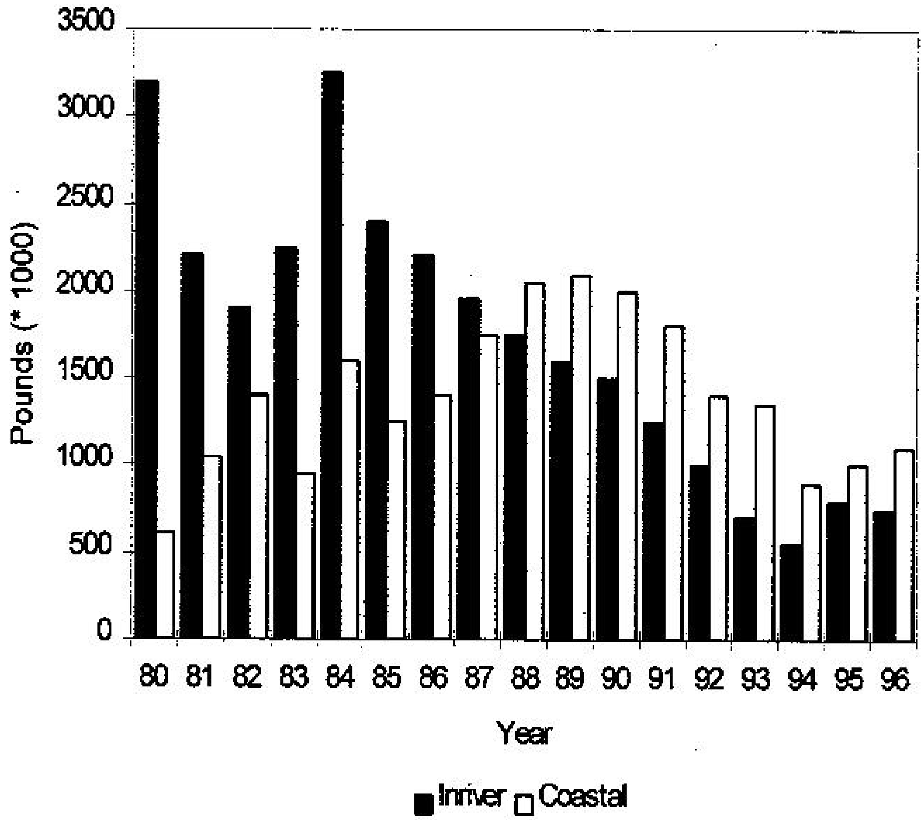

Figure II-1. Commercial landings of American shad.

Table II-1. American shad rivers or systems and the respective time series of fisheries-dependent and fisheries-independent data used in the 1996 stock assessment.

River	Juvenile Production	Landings	Population Size [1/]	F [2/]
Maine R.	yes	yes [3/]	no	no
Merrimack R.	no	no	yes	no
Pawcatuck R.	yes	no	yes	yes
Connecticut R.	yes	yes	yes	yes
Hudson R.	yes	yes	yes	yes
Delaware R.	yes	yes	yes	yes
Upper Bay MD	yes	yes	yes	yes
James R.	no	yes	yes	yes
York R.	yes	yes	yes	yes
Rappahannock	no	yes	yes	yes
Albemarle	yes	yes	no	yes
Neuse R.	no	yes	no	no
Pamlico R.	no	yes	no	no
Cape Fear R.	no	yes	no	no
Wacc-Pee Dee	no	yes	no	no
Edisto R.	no	yes	yes	yes
Santee R.	no	yes	yes	yes
Savannah R.	no	yes	no	no
Altamaha R.	yes	yes	yes	yes

1/ Either relative (CPUE) or absolute stock size.
2/ Either fishing (F), total mortality (Z) and/or relative exploitation rates available.
3/ Only coastal shad landings are available for Maine.

Table II-2. Input parameters for the Thompson-Bell Yield-Per-Recruit Model (YPR) for each shad stock to estimate F_{30}. Northern Rivers include the Pawcatuck RI to Upper Bay MD. Southern Rivers include the Edisto SC, Santee SC and Altamaha GA.

Input Parameter	Age/Parameter	Estimate	River System
Maturation Schedule	Ages 1 - 3	0.0	All rivers
	Age 4	0.20	All rivers
	Age 5	0.60	All rivers
	Age 6+	1.00	All rivers
Natural Mortality (M)	Ages 1 - 3	0.30	All rivers
	Ages 4 - 10	1.50	Northern rivers
	Ages 4 - 10	0.60	Hudson River
	Ages 4 - 8	2.50	Southern rivers
Partial Recruitment Vector	Age 4	0.45	All rivers
	Age 5	0.90	All rivers
	Ages 6-10	1.00	All rivers
Von Bertalanffy Growth Parameters	K	0.32	All rivers
	t_0	0.26	All rivers
	W_4	10.0 lbs	Northern rivers
	W_4	7.0 lbs	Southern rivers
	W_4	13.0 lbs	Hudson River

Table II-3. Mean (1992-96) inriver fishing mortality rates (F_r), mean (1992-96) coastal fishing mortality rates (F_C) and mean (1992-96) total fishing mortality rates (F_{total}) (sexes combined) as compared to the overfishing definition (F_{30}) for American shad from selected Atlantic coast rivers.

River	F_r	F_C	F_{total}	F_{30}
Connecticut R.	0.13	0.09	0.22	0.43
Hudson R.[1]	0.17	0.16	0.33	0.39
Delaware R.	0.02	0.15	0.17	0.43
Upper Bay MD	0.01	0.11	0.12	0.43
Edisto R.[2]	0.21	0.24	0.45	0.48
Santee R.	0.17	0.02	0.19	0.48
Altamaha R.	0.36	0.03	0.39	0.48

[1] 1995 population size (without coastal landings) = 526,000 based on 1951 tag-recapture study in the Hudson River (Talbot, 1954)

[2] Current fishing mortality rates (F) for Edisto River based on 1994-97 F estimates.

Table II-4. Status of American shad rivers or systems in the 1996 stock assessment.

TRENDS			
River	**Based on Stock**	**Based on Landings**	**Overfished ???**
Maine R.	---	Stable[1/]	Uncertain
Merrimack R.	Stable	----	Uncertain
Pawcatuck R.	Stable	----	Probably Not
Connecticut R.	Stable	Decline	No
Hudson R.	Decline	Decline	No
Delaware R.	Stable	Decline	No
Upper Bay MD	Increase	----	No
James R.	Stable	Decline	No
York R.	Decline	Decline	No
Rappahannock	Stable	Decline	No
Albemarle	----	Decline	Uncertain
Neuse R.	----	Decline	Uncertain
Pamlico R.	----	Decline	Uncertain
Cape Fear R.	----	Decline	Uncertain
Wacc-Pee Dee	----	Decline	Uncertain
Edisto R.	Stable	Decline	No
Santee R.	Increase	Increase	No
Savannah R.	----	Decline	Uncertain
Altamaha R.	Increase	Increase	No

1/ Maine shad rivers are regarded as Aremnant stocks at low levels@ (Tom Squiers MDMR, pers. comm).