Population Dynamics of Atlantic Coast Striped Bass, *Morone saxatilis*

Recommendations for Management Strategy and Monitoring and Research Programs

Final Report

Contract No. NA-79-FA-C-00051

Submitted by

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INTRODUCTION

The striped bass, Morone saxatilis, was designated in 1977 as a priority species for the development of a management plan by the Northeast Marine Fisheries Board of the State-Federal Fisheries Management Program. A meeting was held in September 1977 in Baltimore to scope out the general plan of work. Subsequently the Board appointed a striped bass sub-board composed of state representatives from Maine through North Carolina to develop a management plan. The sub-board designated a Scientific and Statistics (S&S) Committee composed of scientists from each of the member states.

The S&S Committee was charged with helping the Project Manager to develop a draft plan for submission to the Sub-board. The Committee identified areas where there were insufficient data or information to develop the plan and reviewed existing tagging and catch data for their applicability in assessing current mortality rates.

While the striped bass is one of the most extensively studied species, there is insufficient population information to develop a plan. As such, it was most difficult to decide upon which management strategy to employ. The S&S Committee arrived at the decision that a workshop should be held to examine the population structure of the striped bass stocks with particular emphasis on developing recommendations to the Project Manager for the appropriate management strategy to employ, and to determine extant or needed data on

differential mortality, recruitment, and other population parameters as may be needed for a management plan.

Subsequently the S&S Committee recommended to the Sub-board that such a workshop be held and, following their approval, the NMFS Northeast Regional Office agreed to fund such an endeavor through the State-Federal Fisheries Management Program. Funds were provided to the Virginia Institute of Marine Science of the College of William and Mary to convene such a workshop series.

METHODOLOGY

Two 2-day workshops were held in Washington, D.C. The panel of population dynamics biologists (Appendix I) designated what they felt were the necessary population parameters to monitor for a management plan, and the most appropriate strategy to employ in management of the fishery for biological purposes.

The first workshop (Agenda, Appendix II) was held on 3-4 December 1979. The focus of the session was to identify potential biological management alternatives and selection of a preferred alternative along with data needs.

The results of the discussion were reported in detail by Project Manager Mike Leverone and Workshop Chairman Herb Austin to the combined Sub-Board, Scientific and Statistical, and Citizens Advisory Committees meeting on 10 December 1979 (Appendix III).

The second workshop (Agenda, Appendix IV) was held on 4-5 February 1980, in Washington to consider research and monitoring programs that would best provide the data identified at the previous workshop as essential to future operation of a striped bass management program. Due to the passage of the Chafee Emergency Striped Bass Amendment, and the fact that several members of the workshop were also members on NMFS and USF&WS workgroups or planning teams to consider how to appropriate the funds, considerable time was also spent discussing short-term research and monitoring initiatives that would be covered by the Chafee Amendment.

Draft copies of the minutes were made available to other (e.g. EPA) agency members of the planning team at their Philadelphia meeting in February.

DISCUSSION

Examination of data relating to striped bass abundance indicates that the population is characteristic by periodic (cyclic ?) dominant year classes, particularly in the Chesapeake Bay where environmental factors account for up to 80% of the year class variance, exacerbating the troughs and peaks. This suggests that striped bass populations of the Atlantic coast are density-independent; that is, there is little or no relationship between the size of the year class produced and the abundance of spawning adults. Under the circumstances, regulation of the fishery to maintain brood stock abundance at a prescribed level would have little effect on the level of recruitment (e.g. year class

strength) to the fishery. The consensus of the workshop participants was that an appropriate approach to management in the case of striped bass would be to reduce the interannual variability of the catch, or "smoothing" of the peaks and troughs, through control of fishing effort. This technique essentially would distribute the catch from a dominant year class over a greater number of years than has historically occurred in the fishery, thereby tending to maintain population abundance in the years between the production of dominant year classes. While this technique is capable of reducing the peaks and filling in the troughs in the annual catch, it will not necessarily "fill in" the troughs by an amount equivalent to the reduction in the peaks, nor will it necessarily increase the frequency of production of major year classes.

Current fishing effort shows the Chesapeake Bay commercial fishery to be dependent on the 2 to 3 year old males, and the coastal recreational fishery dependent on 4 to 6 year old females. Both fisheries have become further dependent upon the periodic (approximately every six years) dominant year classes; and the expanded fishery of the early 1970's (on the 1970 year class) has acutely missed the expected 1976 or 1977 dominant production. The reduced commercial catch during the 1976-1978 period is typical of that from the 1930's; the number of recreational fishermen, however, has increased significantly since then, and despite reduced landings, has remained large.

The age specific differential migration patterns, (e.g. 1-2 year olds remaining in the Bay and 3 years and older migrating up the

coast and the resultant differentiation between Chesapeake Bay commercial and Middle Atlantic-New England states recreational catches create interstate socio-economic and political differences that make the striped bass a unique and difficult species for which to effect an interstate management regime.

With the complexities and objective of reducing catch variability in mind, the following recommendations were made by the group at the December 1979 meeting:

MANAGEMENT RECOMMENDATIONS

The management strategy to follow should be an "empirical" approach that would allow state regulatory agencies the flexibility to make annual adjustments to the management regime as the size of the stock fluctuates. Three alternatives were considered:

1. Status quo, no new management effort. This operates on the premise of supply and demand. While prices will go up during periods of low abundance, the cost of fishing on the stock will not be offset and commercial fishermen will direct their efforts toward other species. Recreational fishermen, without benefit of the positive reinforcement of catch will also redirect their efforts towards other species, thereby allowing the stock to recover.

2. Reduce variability of catch by increasing the mean age of the stock. This would be accomplished primarily through a

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2. Reduce variability of catch by increasing the mean age of the stock. This would be accomplished primarily through a

reduction of mortality on smaller fish. The effect would be to extend the longevity of cohorts, which in addition to increasing the mean age would increase the stock size of five to seven year old females, the ideal age/abundance ratio for maximum viable egg production.

3. Reduce overall mortality rates and possibly enhance stock production by supplemental hatchery operations and/or habitat protection. This alternative will require significant increases in funding and may not, in the end, show tangible results.

Alternative 2 was selected the most practical and compatible with current management practices, and knowledge of the fishery. Four possible means of implementation and enforcement/regulation were suggested.

1. Minimum mesh (commercial) and/or size (commercial and recreational) regulations that could be adjusted up or down as the size of the stock warranted.

2. Geographic/seasonal recreational creel limits that would change according to local stock conditions. Age/size specific quotas could also be recommended for commercial catch by geographic area.

3. Geographic and seasonal restrictions on catch to protect particular sex or size groups (e.g., no fishing on spawning grounds during spawning season).

4. Regulation of effort by season, time of day, location, or gear.

These recommendations will require two major commitments by the states. 1) Long-term funding will be necessary for a continued monitoring/statistics program of annual recruitment and catch; and 2) the individual state regulatory/management agencies must be given the authority to make routine changes in quota, mesh size, season, etc. according to the annual results of recruitment and catch monitoring.

Following up on these recommendations, the group identified several information needs for development, implementation and operation of a management plan. These include a reliable annual juvenile (young-of-the-year) index, and a program for the collection of catch and effort data. The specifics are detailed in the next section, Research and Monitoring, and were developed at the February 1980 meeting.

RESEARCH AND MONITORING

RECOMMENDATIONS

Four major areas for research and monitoring of striped bass stocks were given highest priority, based upon the recommendations of the December management strategy meeting. These included:

1. MORTALITY
2. RECRUITMENT
3. STOCK STRUCTURE
4. SPECIAL BIOLOGICAL STUDIES
   - Reproductive success (e.g. fecundity, senility) related to habitat condition.

These priorities were considered from two perspectives: the development and operation of a State-Federal Fisheries Management Plan, and research under the aegis of the Chafee Amendment to the Anadromous Fish Conservation Act (PL89-304). There was unanimity as to the four major areas of research and monitoring but not so on the actual methods to use. The following is a distillation of these discussions, including the "pros-and-cons" of each approach, general comments and consensus recommendations. (Remembering that by definition a consensus does not imply unanimity.)

MORTALITY

Monitoring of mortality rates is a necessary program for the operation of the management plan, regardless of the approach.

Analysis of differential rates by age, size, sex, and location will allow the closure of areas to protect spawning, juveniles, and small year classes, and provide justification for geopolitical differences in regulations/codes.

Mortality estimates should include rates by sex, age, gear, location, and season. Three basic approaches for this assessment include:

- Mark-Recapture
- Cohort Analysis
- Catch-Effort Analysis

Mark-Recapture

Mark-Recapture studies pose a problem in that tag shedding can disrupt the results, and a tagged fish becomes "abnormal" to the other fish. Juveniles should be tagged but their tagging mortality can exceed 60%. Tags that do not produce excessive mortality, such as internal nose tags, can be used in areas of concentrated commercial effort but give almost no returns from predominantly recreational areas (e.g. the coastal fishery). An incentive to return the tags, perhaps monetary, should be developed.

The advantage of tagging is that it allows a separation of natural and fishing mortality, and commercial from recreational. Large scale tagging efforts during spawning, when the fish are concentrated, is efficient; but such efforts can produce a

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The advantage of tagging is that it allows a separation of natural and fishing mortality, and commercial from recreational. Large scale tagging efforts during spawning, when the fish are concentrated, is efficient; but such efforts can produce a

disproportionate number of males with most returns being over a short time frame. These early returns could be disregarded.

The number of fish that need to be tagged is based upon the variance which is approximately the inverse of the number of returns. Generally speaking 600 fish per size range is acceptable.

Cohort Analyses

Fishing mortality can be derived from a knowledge of the age composition of the catch (natural mortality must be known as well as population size, hence the need for tagging). Estimates must be stock specific, even where stocks mix.

The lack of effort data, particularly in the sportfishery, will hamper analyses; however, catch curves can be constructed.

Cohort data can best be obtained, in areas such as the Chesapeake, Roanoke, or Hudson from scientific surveys. The cost, however, precludes this approach for any long term analysis. Commercial catch monitoring will be necessary, as will development of a means to monitor the recreational catch. In all cases data on age, sex, and size must be collected.

Catch-Effort Analysis (catch or landing data)

Even with scientific surveys, routine (monthly) catch statistics will still be needed. Some 30-40 fish from each size range will

be needed from each area (e.g., river) for sex, size, and age composition. The number of sampling sites and frequency will vary from location to location depending upon the sample variance.

A standardized "catch sheet" is needed for all to use. This would include number of fish caught, a scale sample, sex, size, and possibly a flesh or organ (testes, ovaries, kidney, blood) subsample for later contaminate analyses.

Recommendations

A tagging program, in concert with a cohort analysis, should be conducted to determine mortality rates, with at least 600 fish of each size category being tagged from each area. These should include the major spawning grounds and along the coast.

Juveniles should be tagged in the nursery areas with metallic nose tags and the commercial fish houses monitored for returns.

A standardized routine catch reporting system should be instituted among all states that would include at least monthly data on:

- number of fish caught
- scale sample
- sex
- size
- flesh sample if possible

The sample size should be around 30-40 fish from each area, the frequency and number of sites to be determined from analyses of sample variance.

RECRUITMENT

The only accurate recruitment surveys are the Maryland Tidewater Fisheries Administration Annual Production Surveys which provide an index of young-of-the-year from Maryland's spawning rivers, and the Roanoke young-of-the-year indices for North Carolina. These are essentially "pre-recruit" indices. Recruitment surveys such as these, for the Virginia waters of the Chesapeake Bay and the Hudson River will allow forecasts of relative harvests 2 to 3 years in advance.

Night time sampling may be an effective way to eliminate cloudy-sunny day biases; and random sampling, while preferred may not be possible due to the shoreline configuration. Further, due to interannual variations in the environment, the actual center of the nursery ground may shift upstream or downstream causing an additional source of error. Variance estimates of catch would give a degree of quantification to the sampling and dictate how many samples or sites to collect.

To the extent possible, sampling techniques should be standardized between states. (In fact, previous discussions by S&S Committee members have resulted in an agreement between New York, Maryland, Virginia and North Carolina to conduct comparison sampling during the summer of 1980.

Recommendations

Standardized pre-recruit (annual monitoring) for young-of the-year bass should be conducted on nursery grounds.

STOCK STRUCTURE

There was no consensus on the priority of stock structure studies; however, it was felt that mortality was more important. Four basic techniques were discussed:

- Biochemical Analyses
- Use of Contaminants
- Meristics
- Tagging

Biochemical

Previous studies (e.g. Krantz and Morgan) showed good results the first year but not the second. The discriminate function analysis of blood serum was not very convincing; perhaps techniques for collection need to be more rigorous. Enzymes have been used, but this requires fresh caught specimens, so commercial catch cannot be used. Biochemical studies are a "long range" approach.

There was some feeling that since biochemical studies for striped bass have not been proven, perhaps a high priority focus should be directed towards testing the validity of the techniques.

Hatchery test animals of "pure" lineage might be a way to test methods.

Contaminants

Contaminants may prove to be a good stock "tag" if significant local pollutants can be identified. PCB's in the Hudson River seem a good possibility due to the river's background levels and the chemical's long biological retention time; and Kepone appears to be a good James River tag, as does the "red sore" disease in North Carolina. It was also noted that heavy metals have been used to discriminate among Pacific salmon stocks. A combination of tagging and contaminants studies may be the best way to go.

Meristics

There was little discussion on the use of meristic studies beyond the fact that they have been commonly used and have problems. They can be used with commercial landings and hence their wide use.

Tagging

There have been numerous problems over the years using tagging, however, as with meristic studies, it continues to be a popular method.

Tagging requires large numbers of captures; however, the sample size can be reduced if the study focuses on one size of fish (e.g. "cows").

Tagging can also be used with any of the other three methods as "yes or no" supporting data. If conducted over time it can show relative annual contributions of different areas. It can show not only what 3-5 year olds leave the Chesapeake and migrate northward, but what returns.

Handling of the fish has always been a problem. Gill nets have been used in Maryland rivers but have to be tended closely. Haul seines have not worked in Maryland's waters but have been very successful on New York's ocean beaches.

Recommendations

High priority (including Chafee Amendment funds) should be placed on basic research directed at testing the validity of biochemical stock structure studies. "Pure" hatchery fish might be used as a baseline stock.

Tagging should be conducted as it also provides data on mortality, migration, and growth. A combined tagging/contaminant tag study would be most useful and should be conducted annually until the "technology" is worked out, then once every 5 years.

SPECIAL BIOLOGICAL STUDIES

Reproductive Success

The Scientific and Statistics Committee research priorities call for an examination of egg/larval viability (as does the Chaffee Amendment). The most important factors to consider would be

changes due to direct contact with environmental contaminants after spawning and prior to spawning from the adult body burden.

The question of egg viability is not new as several earlier papers (1950's) questioned the protection of cows that may be reproductively senile.

Studies should focus on oil drop analyses and food chains. Food chain studies would include both the roles of striped bass as predators, and the effects of cannibalism. The work at the Tiburon Laboratory in California has suggested that the color, size and nutritional make up, as well as contaminant load of the oil drop may be significant controlling factors in determining yearclass strength.

Histological studies of the ovaries, in conjunction with oil drop analyses, could also provide insight into egg viability.

Egg viability studies, while the most critical, will be the most difficult, and perhaps Chafee monies should be used to develop techniques or get programs started. Probably the question will not be answered within the 3 year funding period. A good place to start however, might well be with hatchery reared fish where the water quality can be controlled. Second generation brood stock of known contaminant burden could then be used experimentally in bioassays. Laboratory bioassays can also be run now with known contaminants on eggs and larvae, and this is probably a good place to start.

The problem of separating natural from contaminant-induced spawning success variability will also be very difficult, but necessary to an understanding of viability. No efforts have been directed toward relating actual stock fecundity to the young-of-the-year indices or to the intermediate egg/larval stages.

The possibility that interannual fluctuations in available forage plays an important role in determining yearclass strength needs to be evaluated.

The question of the importance of the size of available spawning and nursery grounds was discussed and considered hard to quantify. The salinity distribution in the San Joaquin estuary of California was cited as an example of a quantifiable variable impacting year class strength just as it does for blue crabs in the Chesapeake. While such factors may be statistically quantified, the loss of spawning/nursery grounds to landfill or damming will be difficult if not impossible to quantify.

The possiblity (probability) that some stocks are primarily under the influence of natural factors, while others are influenced by contaminants further complicates the problem. Some light may be shed on this with a combination tagging/contaminant stock study.

Recommendations

Egg viability studies, while perhaps the most important, will be the most difficult to quantify. Laboratory studies should be

conducted of specific pollutants vs. egg viability. The question of naturally decreasing viability with age must also be considered, as must the impact of natural environmental fluctuations. [While not considered by the participants, an examination of sperm count and viability might also be considered. Editor's note.]

In addition to laboratory bioassays, the question of egg viability should be examined by analyses of the egg oil drops for contaminants and nutritional value, as should the condition (e.g. histological) of the parental ovary. The condition index (perhaps a liver condition index) of the parent, as well as body burdens should be determined for probable contaminants. Contaminant routes in the food chain must also be determined.

Natural fluctuations in salinity or forage may cause variations and should be examined; however, demographic changes (i.e. land fill) will be most difficult to quantify and should probably have a low priority.

APPENDIX I

List of Participants

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APPENDIX II

STATE/FEDERAL STRIPED BASS MANAGEMENT PROGRAM

Population Dynamics Workshop
3-4 December 1979
Washington, D.C.

AGENDA

December 3, 1300

I. Opening remarks and charge to the group (H. Austin, VIMS/S&S Committee).

II. Introduction around the table, including invited guests.

III. Comments by NMFS State/Federal representative (R. Schaefer) and ASMFC representative (I. Alperin).

IV. Comments by Striped Bass Program Manager (M. Leverone).

V. Discussion of precepts and objectives (R. Fairbanks, Chairman S&S Committee and M. Leverone, Project Manager).

VI. Open discussion on management strategies for striped bass.

December 4, 0800

VII. Recap of previous day's afternoon discussion and development of working groups.

0830

VIII. Break up into working groups.

1100

IX. Reconvene and discuss strategy recommendations.

1200

Adjourn

B. COULTER
RETARY

STATE OF MARYLAND
DEPARTMENT OF NATURAL RESOURCES
TAWES STATE OFFICE BUILDING
ANNAPOLIS 21401
Tidewater Administration

LOUIS N. PHIPPS, JR.
DEPUTY SECRETARY

269-3558

State/Federal
Striped Bass Management Project

Population Dynamics Workshop

Page Office Building Complex
National Marine Fisheries Service
Washington, D.C.
December 3-4, 1979

Attendance

Participants

Herbert M. Austin	Virginia Institute of Marine Science
Jon C. Cooper	U.S. Environmental Protection Agency
Richard B. Deriso	University of North Carolina
C. Phillip Goodyear	National Power Plant Team, USFWS
Michael F. Leverone	State/Federal Striped Bass Project
Joseph G. Loesch	Virginia Institute of Marine Science
Tibor T. Polgar	Martin Marietta Corporation
Michael P. Sissenwine	Northeast Fisheries Center, NMFS
Webb Van Winkle	Oak Ridge National Laboratory

Observers

Irwin M. Alperin	Atlantic States Marine Fisheries Commission
Kenneth L. Beal	National Marine Fisheries Service
Benjamin M. Florence	Maryland Tidewater Administration
James A. Hutcheson	U.S. Fish & Wildlife Service
Norris B. Jeffrey	National Marine Fisheries Service
W. Peter Jensen	Maryland Tidewater Administration
Thor Lassen	Virginia Institute of Marine Science
Austin R. Magill	National Marine Fisheries Service

Striped Bass Fishery Management Discussion Paper

Background

The following management characteristics are evident in the East Coast Striped Bass system:

1. The fishery is exploited by both commercial and recreational fishermen.
2. The production of the resource is concentrated in several major estuarine systems: the Roanoke, Chesapeake Bay, and Hudson Rivers, for the most part.
3. Coastal fisheries depend on age; sex; and spawning-origin specific migratory behavior.
4. Reproduction success or year class strength varies by approximately an order of magnitude and appears to be independent of reproductive patterns. The variability seems related to abiotic environmental factors
5. Both commercial and recreational fisheries thrive on sporadically recurring dominant year classes.

The state of the fishery can be described as follows:

1. The most recent dominant year class in major spawning systems occurred in 1970.
2. Commercial catches peaked coast-wide in 1973 and have declined rapidly as the contribution of the 1970 year class dissipated. Although recreational catches are not well documented, it appears that they have been undergoing similar changes.
3. Current catch has declined to a level typical of the 1930's.

Management Alternatives

In light of these facts, some of the management alternatives are:

1. Status quo - no new action to be taken. This alternative assumes that user groups will optimize their own benefits within the observed system of highly variable productivity.
2. Reduce concomitant variability in catches by increasing the mean age of the catch. This alternative implies a reduction in mortality rates in either or both commercial and recreational components of the fishery.
3. Reduce mortality rates and possibly enhance stock production by hatchery operation and habitat protection measures. This alternative involves substantial additional commitment in funding and closer cooperation among state and federal agencies.

Discussion

Alternative 2 above seems to be compatible with current forces supportive of additional management of striped bass and with the current state of knowledge about the fishery. The momentum of management has been historically related to the appearance and dissipation of the dominant year classes. Therefore, there is little justification for exceeding reasonable strategies for delaying the dissipation of the dominant year classes.

The following specific measures would effect desirable changes to the various age/sex/location components of the resource:

1. Mesh or minimum size regulations in the commercial fishery, consistent with economic and resource conditions.

2. Minimum size and creel limit regulations in the recreational fishery, consistent with economic and resource conditions.

3. Geographic and seasonal restrictions on yield on both the commercial and recreational fisheries to reduce mortality on particular age-sex components of the resource.

4. Geographic, seasonal and user group catch quotas, consistent with reduced mortality rate objectives. This approach is most heavily dependent on the ability to precisely monitor conditions of the resource on a continuing basis.

5. Regulations controlling fishing efforts, eg. limiting hours fished per unit time and number of recreational licenses.

Management Strategy

1. Focus commercial fishing on males - Chesapeake Bay
   a. Technique
      - Location and timing of fishing effort
   b. Reasons
      - Primarily a male fishery now
      - No problems with sufficient male stock
      - Primary concern on stocks is on availability of females for anglers and spawning stock
   c. Contra
      - Reduced landings biomass by excluding females

2. Sport Fishery in Chesapeake Bay
   a. Technique
      - Reduce effective effort to reduce fishing mortality
   b. Reasons
      - Extend the longevity of cohorts
      - Increase the frequency of large fish
      - Increase the annual egg deposition
   c. Contra
      - Increase migration to coastal water and, therefore, a decrease numbers and biomass landed. However, could be affected by the females spared by the commercial fishery

3. Sport and Commercial Fishery on the Coast
   a. Technique
      - Reduce effective effort to reduce mortality
   b. Reasons
      - Extend the longevity of cohorts
      - Increase frequency of large fish
      - Increase annual egg deposition
   c. Contra
      - May reduce yield in numbers and biomass especially in commercial fishery. However, this decrease may be affected by increased emigration associated with Item 2 above.

- C. Phillip Goodyear

APPENDIX IV

S-F FISHERIES MANAGEMENT PROGRAM

ATLANTIC STATES MARINE FISHERIES COMMISSION

Striped Bass Population Dynamics Workshop/S&S Committee
4-5 February 1980

AGENDA

1300 Monday, 4 February

Review of charge (Austin)
Introduction of S-F S&S Committee, observers and groupies.

1315

Review of management strategy recommendations from December meeting as presented to Sub-Board by Project Manager and their feedback (Leverone).

1400-1700

Review and discussion of research/monitoring priorities and data needs (Austin).

Break-up into work groups with S&S members, if necessary.

1700

Adjourn

0800 Tuesday, 5 February

Report by groups on priorities/data needs.

0900

Develop recommendations for research/monitoring strategies

- with Chafee money
- long term

1130

Wrap up