Special Report No. 50
of the

ATLANTIC STATES MARINE FISHERIES COMMISSION

Recommendations Concerning the Stocking of Striped Bass in Atlantic Coastal Waters

March 1996

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Recommendations

Concerning the Stocking of Striped Bass

in Atlantic Coastal Waters

Report from the
Striped Bass Stocking Subcommittee
of the
Atlantic States Marine Fisheries Commission

Compiled and Edited
by

Harold F. Upton Jr.

Atlantic States Marine Fisheries Commission
1444 Eye Street, N.W., 6th Floor
Washington, D.C. 20005

March 1996

Preface

During the 1980s, several Atlantic Coastal states and the U.S. Fish and Wildlife Service initiated stocking programs to determine the feasibility of using artificial propagation as a restoration tool for rebuilding Atlantic Coast striped bass populations. The ASMFC Striped Bass Stocking Subcommittee has served as a forum for the discussion of issues related to striped bass stocking and evaluation. The Subcommittee met several times and members drafted sections of the following report during 1993 and 1994. The main objectives were to revisit and update the striped bass stocking recommendations which were written in 1987, and to provide a review of the magnitude of striped bass coastal stocking efforts. Total numbers of fish stocked by year and state, tagging methods used and summaries of state programs are reported in Appendices I and II. The draft of the this report served as a guide for stocking recommendations contained in Amendment 5 of the Atlantic States Marine Fisheries Commission's Striped Bass Management Plan. This report was funded by a cooperative agreement between the Atlantic States Marine Fisheries Commission and the U. S. Fish and Wildlife Service (Grant No. 14-48-0009-93-1256) under the Federal Aid in Sportfish Restoration Program.

Acknowledgements

First and foremost, I would like to thank the Subcommittee Chairman, Roy Miller of the Delaware Division of Fish and Wildlife for chairing meetings and drafting sections of this report. In addition, both Roy Miller and Nick Parker deserve thanks for drafting the original report in 1987. Sections of this report, including its organization, were borrowed from that effort. Michael Mangold also deserves special consideration for his efforts to untangle, check and compile stocking records. He is also responsible for the accuracy of the stocking record presented in this report. I would also like to take this opportunity to thank the Subcommittee members and interested parties who attended meetings, drafted report sections or provided state summaries.

Lewis Flagg - Maine Department of Marine Resources
Kim McKown - New York Department of Environmental Conservation
Peter Himchak, Russ Allen and Tom Baum - New Jersey Division of Fish, Game and Inland Fisheries
Roy Miller - Delaware Division of Fish and Wildlife
Ben Florence - Maryland Department of Natural Resources
Richard Snyder - Pennsylvania Fish & Boat Commission
Dean Fowler - Virginia Department of Game and Inland Fisheries
Steve Taylor - North Carolina Division of Marine Fisheries
Jorgen Skjeveland - U. S. Fish and Wildlife Service, Annapolis
Albert Spells - U. S. Fish and Wildlife Service, Harrison Lake National Fish Hatchery

Finally I would like to thank Paul Perra who supported interstate coordination, documentation, and evaluation of stocking activities.

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Introduction

This report supersedes the recommendations of Special Report No. 10 of the Atlantic States Marine Fisheries Commission, "Recommendations Concerning the Striped Bass Restoration Program" published in April 1987. For the first report, a Technical Advisory Committee (TAC) was established by the Striped Bass Stocking Subcommittee of the Atlantic States Marine Fisheries Commission. The original TAC members were selected to represent Atlantic coast states from North Carolina to Maine and the U.S. Fish and Wildlife Service. The Subcommittee assigned the TAC with seven charges related to striped bass stocking concerns. The TAC investigated these charges through consultation with State and Federal agencies, and public and private institutions. The TAC then reported findings in Special Report No. 10 which included background information and recommendations for each charge.

After conducting stocking programs for a number of years, reexamination of the issues by the Striped Bass Stocking Subcommittee made evident the need for an updated and comprehensive document on Atlantic coast striped bass stocking. With this in mind, Subcommittee members revisited past Commission striped bass stocking recommendations and updated them for current relevance. This report also includes statistics on the magnitude of striped bass stocking programs, goals and objectives of these programs, and information regarding the impacts and usefulness of stocking programs.

To complete this task, the Commission's Striped Bass Stocking Subcommittee members were assigned to rewrite sections of Special Report No. 10 during 1994. Final drafts of the report were reviewed by the full membership of the Striped Bass Stocking Subcommittee and the Commission's Striped Bass Management Board.

This report is composed of two primary sections: (1) revision of Special Report No. 10 and finalization of recommendations concerning Atlantic coast striped bass stocking activities; and (2) summaries of state stocking activities. The original report was developed to address concerns related to large scale stocking and interjurisdictional considerations regarding stocking. The seven major areas reexamined were as follows:

1) Disease considerations;
2) Tagging programs;
3) Restoration criteria;
4) Genetic and hybrid concerns;
5) Stocking strategies;
6) State coordination; and
7) Evaluation.

Section 1. Disease Considerations

Original Committee Charge

The Committee was tasked with developing a system for inspecting the present and planned stocking programs to ensure the health of eggs and larvae and to protect against the transmission of harmful diseases.

Problem and Background

The original Striped Bass Technical Advisory Committee (TAC) was concerned that a system be developed for inspecting and certifying the disease classification of all striped bass eggs and larvae to be moved through the hatchery program. Disease control and certification procedures remain much better developed for coldwater hatcheries than for warmwater hatcheries. Striped bass are typically cultured in warmwater facilities and exposed to the same pathogens common to warmwater fish.

At the time that the striped bass stocking program began, the discovery of the infectious pancreatic necrosis (IPN) virus in striped bass from the Chesapeake Bay (IPN produces infectious pancreatic necrosis in susceptible hosts) seemed to be the most potentially threatening pathogen. The TAC sought information from experts in fish health research and management and attempted to answer the following questions to provide an analysis of risk:

1) What is the IPN virus?

2) Is the IPN virus the same in all species of fish?

3) Is the IPN virus lethal to all fish?

4) At what age are fish killed by the virus?

5) Would fish exposed to the pathogen, but apparently not affected, be carriers?

6) Can the IPN virus from striped bass be transmitted to other warmwater species?
   To salmonids?

7) Does IPN kill striped bass?

IPN is a double stranded RNA virus that causes severe mortalities in salmonids. The virus can be transmitted through water or via sex products (Wechsler et al. 1987). There are several different serological types or strains of IPN virus. IPN isolated from Chesapeake Bay striped bass was lethal to brook trout (Parker and Miller 1987). IPN is typically a

problem only in salmonids under 80 days old (Parker and Miller 1987). However, a secondary infection in adult salmonids can reportedly be induced by stress.

In 1984, IPN virus was found in striped bass collected from the Chesapeake Bay and in moribund juvenile fish from the Crane Aquaculture facility of Baltimore Gas and Electric Company. All U.S. Fish and Wildlife Service (USFWS) hatcheries with striped bass in the southeast region were tested in 1985 for the presence of the IPN virus. Techniques employed were the same as those listed in "Salmonid Fish Health Protection Program for the Fish and Wildlife Service." Spleen and kidney homogenates were inoculated on CHSE culture tubes and dishes. Cultures were incubated and examined for the presence of the virus. Approximately 300 fish from five hatcheries (60 fish/hatchery) were examined for IPN and all results were negative (Parker and Miller 1987).

In 1985, gametes (eggs and sperm) were collected from all striped bass spawned in Maryland and screened for the presence of IPN by Dr. Frank Hetrick, University of Maryland. Approximately 65 samples from fish spawned in hatcheries were screened; plus 50 samples of sperm and 30 samples of eggs taken from wild fish. No evidence of IPN was found in any of the samples checked in 1985. According to Dr. Hetrick , the virus has never been isolated from striped bass eggs but has been detected in some sperm samples (Parker and Miller 1987). Later work has not demonstrated vertical transmission via sex products (Wechsler et al. 1987).

Researchers have generally been unable to produce IPN carriers by exposing striped bass to IPN in the water. Wechsler et al. (1987) was able to infect fry, but fingerings were resistant to waterborne challenge. However, "Striped bass fingerlings readily became chronic carriers following ingestion of IPN contaminated food" (Wechsler et al. 1987 p. 29). In controlled laboratory tests at the National Fish Health Laboratory, Leetown, West Virginia and at the University of Maryland, researchers have been unable to kill striped bass by exposure to IPN or by injection with IPN (Parker and Miller 1987). Striped bass of 30, 60, and 90 days of age became carriers, but did not die when inoculated with IPN virus (Parker and Miller 1987). Similarly, the IPN virus isolated from flounder will not kill salmonids even when injected; however, salmonids will form antibodies to the virus. IPN appears to be a cosmopolitan organism found in watersheds throughout the range of striped bass, but apparently causes little, if any, harm to striped bass.

Status

Very little has changed since the TAC examined issues relative to IPN or other potential pathogens which are either transferred by striped bass or might result in striped bass mortality. Generally fish health policy of both federal and state governments has continued to concentrate on salmonids. For example, the USFWS inspects for seven diseases (obligate pathogens) which affect cold water species, especially salmonids.

Obligative pathogens reside in a fish host during all or part of their life history. The host is necessary to the pathogen for completion of their life cycle and usually for transmission to other fish. Conversely, facultative pathogens are ubiquitous since they occur in the organism's environment and do not require a host for survival. Stressed fish are commonly affected by facultative pathogens. For striped bass a facultative pathogen that is a good indicator of fish condition is the bacterial disease Columnaris. This disease has been one of the most commonly encountered during the striped bass program.

With respect to obligate striped bass pathogens very few have either been implicated or identified as potential fish health problems. The Lamar, Pennsylvania, US Fish and Wildlife Service Fish Health Laboratory tests all Region 5 fish hatcheries for IPN annually. Striped bass that were being transferred to Maine from the Attlboro, Massachusetts, National Fish Hatchery also were tested for IPN. In 1991, striped bass reared at the Bowden, West Virginia, National Fish Hatchery tested positive for IPN and 13,000 fish were destroyed. In Federal striped bass hatcheries this is the only case in which IPN has been found in striped bass. As mentioned in the 1987 report, IPN does not cause mortality of striped bass, but it may be possible to transfer IPN to salmonids via striped bass.

Two other pathogens that have been found in striped bass which are of concern to states that culture or manage native salmonids are Aeromonas salmonicida and Edwardsiella tarda. In both cases the incidence of these pathogens in striped bass is not common, nor has transmission to salmonids been documented. Bacteria from the genus Vibrio is another possible concern due to its occurrence in marine and estuarine areas.

The incidence of disease has not been a major impediment to the striped bass restoration program. Most problems have occurred due to facultative diseases that have affected stressed fish. However, there remain two major concerns. First, that the transport of striped bass not facilitate the transfer of diseases of known pathogenicity to other areas. This is especially true for states which raise cold water species such as salmonids. Second, that the risk for transfer of other potential disease organisms, including those common to warmwater, be minimized. Although the Committee supports sound fish health standards by all concerned states, specific policies are dependent on a given state's circumstances and management objectives such as those related to coldwater species in the state of Maine. It is the prerogative of the state receiving the fish to require screening that it considers necessary to protect its interests. Therefore, in cases where striped bass are being transported for culture or release in another state, unless prior arrangements have been made, permission to transport the striped bass and the burden of proof regarding the absence of disease organisms resides with the state or interest that is transporting the fish.

Recommendations

1) Striped bass tested and proven to be carriers of the IPN virus should not be stocked into natural waters and especially not into waters with salmonids.

2) To reduce the spread of disease, when striped bass are to be stocked or transported into states which culture salmonids, these fish should be screened for IPN and other pathogens. It is incumbent upon potential striped bass shippers to be aware of each state's policies and regulations on disease screening prior to shipping to that state.

3) States receiving striped bass may require screening for pathogens. Screening requirements and authorization to ship fish is the prerogative of the receiving state.

4) States should report shipping and disease screening requirements for striped bass to the Commission so that this information can be readily disseminated.

5) Additional research is needed on the potential of disease transfer among striped bass, other anadromous species, and warmwater species.

Section 2. Tagging of Hatchery-Reared Striped Bass

Original Committee Charge

The Committee was tasked to review the tagging programs for stocked fish and make recommendations on a coordinated tagging program for all stocked striped bass.

Problem and Background

In any system where hatchery-reared fish are to be released to enhance natural stocks, there needs to be some way to distinguish between hatchery-reared and wild fish for the following reasons: (1) to facilitate research projects (such as the calculation of wild juvenile abundance in a given system); (2) to ensure that juvenile indices are not artificially inflated; (3) to provide a means by which stocking programs can be evaluated; and (4) to ensure that the integrity of wild spawning populations can be monitored. Problems related to the identification and recovery of hatchery fish are compounded by the migratory range of striped bass. Striped bass move among at least 12 state jurisdictions, Canada and the Exclusive Economic Zone (EEZ). Therefore, a coordinated tagging and recovery program is required to evaluate the proportion of hatchery fish in the harvest and the striped bass population, movements of hatchery fish, and hatchery and stocking strategies. The program should provide concrete evidence as to the effectiveness of stocking efforts in Chesapeake Bay and elsewhere along the Atlantic Coast. Therefore it was decided that the Committee should review tagging programs for stocked fish and make recommendations on a coordinated tagging program for all stocked striped bass.

Status

As of January 1995, 10,492,489 of the 12,286,108 striped bass released coastwide were tagged with Binary Coded Wire Tags (BCWTs). Since 1983, New York tagged 2,694,835 of 3,185,853, Maryland tagged 6,706,873 of 6,911,394, Virginia tagged 889,858 of 889,858 and Delaware tagged 204,976 of 220,201 striped bass released. Summaries of BCWT tagging efforts since 1983 by year and state can be found in Appendix I. During this period several other tagging methods were also used including internal anchor tags (Floy tags), cinch tags, freeze brands, and fin clips. Summaries of these releases can also be found in Appendix I.

The number of fish to be marked is a function of the number of fish in the system and the number of fish to be stocked. The cost of tagging fish is far lower than the cost of recapture in fishery dependent and independent studies. Since sufficient quantities of fish must be tagged to ensure a statistically valid number of recaptures, up to a point it will be cost effective to achieve greater statistical precision if greater numbers of fish are marked. For example, Dr. Phil Goodyear suggested that if the population of natural stocks is 5-10 million young-of-the-year fish and if 1 million hatchery-reared fish were to be stocked, then all fish released should be marked. However, if 2 million fish were to be released then it

would not be necessary to mark all fish, but only a percentage of them (Parker and Miller 1987). The actual number of fish to be marked is dependent on the expected frequency of the marked fish in the population and the sampling effort available. Related considerations were also examined for the New York Power Authority and presented at the American Fisheries Society Tagging Symposium in 1990 (Heimbuch et al. 1990). Given budget cuts and stretched resources of virtually all state and federal programs, it is unlikely that sampling effort can be increased significantly from present levels. The Striped Bass Stocking Subcommittee still believes that all striped bass released in open systems should be marked so that they can be identified by release site and year.

Various tagging methods have been used to mark hatchery reared striped bass. In nearly all circumstances the method of choice is the Binary Coded Wire Tag. The BCWT has been used extensively in the Hudson River, Chesapeake Bay, and Delaware Bay to facilitate the evaluation of stocking programs. Short-term objectives have included determination of the percentage of stocked fish in the young-of-the-year index, validation of juvenile indices, and estimation of juvenile mortality. Long-term objectives include estimation of the contribution of cultured fish to recreational and commercial fisheries and the spawning population, and investigation of hatchery fish behavior such as movement and fidelity to river system of origin.

Marking with BCWTs allows fish to be coded for specific hatcheries, release sites, and release dates. Sufficient codes are available on the binary tags to insure that no redundant tags are used in subsequent years by other agencies or states marking and releasing striped bass along the Atlantic Coast. BCWTs have the disadvantage of not being recognizable to the public, and require the costs of tag injection and detection. Since sampling for BCWTs has been integrated into many surveys and much of the required equipment has already been purchased[1], these disadvantages have been partially overcome. BCWTs are the favored method of marking hatchery releases because:

1) the longevity of the BCWT can support long-term studies;

2) a large amount of information can be conveyed by the binary code (currently used to identify release site, hatchery and date(s) of release);

3) portable detector wands are available to states from the U.S. Fish and Wildlife Service for use in detection of BCWT positive fish in the field;

4) evaluation of striped bass releases is currently being undertaken by cooperative efforts of coastal states, the Commission and the U.S. Fish and Wildlife Service, and use of the BCWT satisfies most of these needs; and

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[1]27 detector wands are available to states from the Fish and Wildlife Service while nine injector machines have been purchased for use in MD and VA.

5) BCWTs can be implanted in large numbers of fish in a relatively short period of time at relatively low costs.

Other methods such as internal anchor tags, cinch-up tags, Passive Integrated Transponder (PIT) tags or other marks that can be used to follow releases by site and year might also be used to mark striped bass releases under certain circumstances or to supplement information obtained from BCWT recoveries. Least desirable methods include the use of freeze brands or mutilation such as fin clips. Recognition of specific release sites or year classes is more difficult if these latter methods are used alone. Recognition over long time periods is also questionable. Larval fish can be marked before release by immersion in chemicals which leave a recognizable deposit or mark on hard parts such as otoliths. However, the optimal method for marking large numbers of juvenile striped bass remains the BCWT, and other marking methods should not be considered a substitute. If hatchery fish are of sufficient size, generally greater than 120 mm, internal anchor tags might be preferred so that fishermen can recognize the tagged fish and participate in the tag recovery program. Over 90,000 anchor tagged striped bass have been released by the Virginia and Maryland programs since 1985.

Recommendations

1) If fish are to be stocked in coastal waters, a sufficient number must be marked to allow determination of survival and percentage of contribution to natural stocks. All fish should be marked in cases where hatchery-reared striped bass could confound juvenile survey indices.

2) All fish should be marked if 1 million or less are stocked.

3) If more than 1 million are to be stocked then the percentage to be marked should be calculated based on the number of fish released and the estimated number in the natural stock.

4) Binary coded wire tags should be used to mark fingerlings to be released in all coastal waters. Other tagging methods which also differentiate release sites and date might be substituted under certain circumstances.

5) Binary coded wire tag codes should contain information sufficient to identify each lot of fish stocked.

6) Under certain circumstances hatchery fish of sufficient size should be marked with tags recognizable to fishermen so that individuals may report recoveries.

Section 3. Restoration Criteria

Original Charge

The Committee was tasked to develop an evaluation program for the present restoration programs throughout the range of Atlantic striped bass migratory stocks and make recommendations as to when stocking should be stopped, whether the stocking programs are successful or not[2].

Problem and Background

Much of the early opposition to a hatchery stocking program for the Chesapeake Bay was based on the failure of hatchery programs established in the late 1800s along the Atlantic Coast. There was no assurance that success in 1985 would be any easier to achieve than it was in 1885. In those earlier programs, striped bass fry and other species were stocked into coastal waters for several years, yet produced no apparent changes in the commercial or recreational harvest. However, it is questionable whether an evaluation program existed in the 1800s that could have detected changes in abundance due to stocking.

In recent years, striped bass fisheries have been established and maintained in inland reservoirs through use of hatchery-reared striped bass. In addition to the Mid-Atlantic, stocking in coastal areas has also been undertaken in Alabama, California, and North Carolina. Programs were evaluated by tag recoveries, appearance of hatchery fish in creel surveys, and the popularity of the programs with recreational fishermen.

In 1987, when this document was originally drafted, there was a moratorium on striped bass fishing in the Chesapeake Bay. Therefore, fishery dependent surveys were not considered for evaluation of striped bass stocking programs. At that time, the Technical Advisory Committee (TAC) considered four evaluation criteria, as follows, that might indicate restoration, or failure of restoration, of striped bass in Chesapeake Bay and measure the contribution of the stocked fish.

1) Return of marked and stocked striped bass to the spawning grounds as brood fish.

2) Change or failure of change in young-of-the-year indices.

3) Changes in the viability of eggs and larvae.

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[2]This section develops criteria regarding the success or failure of stocking programs while Section 7 examines evaluation programs and research.

4) Changes in the ratio of juvenile marked hatchery fish to unmarked fish in collections made by beach seine, gill nets, pound nets and electrofishing.

The restoration program would be considered successful if three successive year classes of hatchery-reared striped bass were to return to the spawning grounds and produce viable fry. Conversely, it would be considered a failure if stocked fish failed to return as brood fish or if progeny of those fish failed to survive. Since females commonly mature when they are five to eight years old, it would require a minimum of five or six years for return of the first year-class stocked. Therefore, a minimum of eight to nine years would be required to evaluate the success or failure of the first three years of stocking efforts.

Restoration will only be fully successful if progeny of the brood fish survive to produce the next generation. If environmental conditions are unsuitable for survival of fry, but suitable for fingerlings, then the stocking program will be judged as a success, but the full restoration program will be judged a failure. If stocked fish survive and return as brood fish, but do not produce the next generation, then this would indicate that a mitigation program might successfully support a put-grow-and-take fishery.

Status

Since 1987, the Chesapeake Bay striped bass population has recovered at a remarkable rate. In Maryland, the YOY index was exceptionally high in 1989 at 25.2. This allowed for the reopening of a limited fishery. Another exceptional year in 1993 with an index of 39.8 indicates that at least on a bay-wide basis, environmental conditions are suitable for survival of fry. It also indicates that if environmental conditions in a given year are suitable, current levels of spawning biomass are sufficient to produce year classes that are above the Maryland YOY average established between 1956 and 1981.

Since a limited fishery was reopened in the Chesapeake Bay in 1990, fishery dependent surveys have become another means of hatchery evaluation that was not envisioned in the original document. Therefore in addition to the four evaluation criteria considered by the TAC, a fifth is the contribution of hatchery fish to recreational and commercial fisheries. The following is a summary of developments relevant to the evaluation of criteria.

1) Spawning ground returns

Hatchery-reared striped bass have returned to the spawning grounds in Maryland and surveys have shown that hatchery fish are also present on the spawning grounds of Virginia tributaries of the Chesapeake Bay, the Delaware River, and the Hudson River. The proportion of hatchery fish in a given system varies depending on the number released and the size of the wild population. The first spawning ground surveys for hatchery fish in Maryland and Virginia began in 1991.

In Maryland, large numbers of hatchery-reared males have been encountered on the spawning grounds of the Patuxent and Choptank Rivers. Lower proportions of hatchery males have also been detected on the spawning grounds of other stocked Maryland systems such as the Nanticoke River and the Upper Chesapeake Bay. Although the Potomac River has not been stocked, the Maryland Department of Natural Resources (MDDNR) spring spawning ground survey has detected hatchery males on the Potomac River spawning grounds since 1991. The largest concentration of hatchery fish has been found in the Patuxent River where 30 to 40 percent of males are of hatchery origin. The hatchery proportion in other Maryland river systems has ranged between one and six percent. Mature females have been collected from the Upper Chesapeake Bay, Choptank, Nanticoke and Patuxent spawning grounds during the last three years. Hatchery-reared female striped bass have been recaptured on Patuxent and Nanticoke spawning grounds and successfully spawned at the Manning Hatchery in Maryland. In 1993, a gravid 941 mm female was captured on the Patuxent River spawning grounds that was released in the Patuxent River during 1985. From 1991 to 1994, eight hatchery males of Maryland origin were captured in Virginia Chesapeake Bay tributaries during brood stock collection and spawning ground surveys. Hatchery males and one female of Maryland origin have been recovered on the Delaware River spawning grounds since scanning for hatchery fish began in 1991. Two hatchery males that were released in Maryland were recovered near the Navesink River, New Jersey, during spawning surveys.

In Virginia hatchery-reared males and females have been recovered during spawning surveys on the Pamunkey and Mattaponi Rivers. Stocking of these rivers and tagging with BCWTS began during 1988. In New Jersey, striped bass were reintroduced to the Navesink River by stocking during the middle and late 1980s. Since 1991, mature males and a small number of mature females have been recovered by spawning surveys. Navesink River ichthyoplankton surveys during 1992 and 1993 have recovered striped bass eggs and larvae. During the 1980s stocking was also initiated in Maine to reintroduce striped bass to several estuaries. Juveniles have reappeared during the 1990s in stocked estuaries. However, reproduction in both Maine and New Jersey may also be the result of wild striped bass immigration from other areas. During limited work on the Hudson River, one male hatchery-reared 1987 Hudson River release was detected on the spawning grounds in 1993.

In Maryland, hatchery-reared female striped bass from only the first three hatchery year classes have been fully recruited to the spawning population. Additional work is needed to improve estimates of their abundance and to test what proportion return to their system of origin. However, it is clear that objective 1 (return of marked and stocked striped bass to the spawning grounds as brood fish) has been met.

2) Change of the Y-O-Y index

Chesapeake systems exhibit extreme inter-annual variation in the striped bass YOY index. Yet on average, during the last five years there has been an upward trend in the

Maryland YOY index. On a bay-wide basis it is impossible to link this trend with hatchery releases due to the relatively large size of the Chesapeake Bay wild population and its current recovery. However, in the Patuxent River there appears to be a significant hatchery contribution to the spawning population and viable fry. The relatively small size of the Patuxent River system, nine years of intensive stocking efforts, and a severely depressed wild population are factors which have resulted in a relatively high proportion of hatchery fish. Previous studies have demonstrated that Patuxent River brood stock of hatchery origin are capable of producing viable eggs and fry in the hatchery. Since 1992, the Patuxent River YOY index has climbed to higher levels than all previous annual indices measured since 1983. In 1993, the Patuxent River YOY index was 104.3, an extremely high level when compared to the 1983 to 1991 average of 1.4. Further study of this system should provide improved estimates of the hatchery contribution to the Patuxent spawning population, and strengthen the link that can be made between stocking and changes in the YOY index.

3) Viability of eggs and larvae

The TAC stressed that the restoration program could not be considered successful if hatchery-reared striped bass could not produce viable eggs and larvae. There were two concerns at the time the program was initiated: 1) whether environmental conditions in spawning areas could support development of hatchery-reared striped bass eggs and larvae; and 2) whether hatchery fish could produce viable eggs and larvae. Hatchery-reared females that were recaptured on the spawning grounds in Maryland were successfully spawned at the Manning Fish Hatchery in Maryland. Therefore, it is reasonable to assume that the viability of eggs and larvae of hatchery fish and wild fish are similar.

Striped bass studies have identified contaminants and fluctuations in environmental variables as potential casual factors in generating low survival, but no general explanation that applies to all cases has been found (ASMFC 1990). The general upward trend of the Maryland YOY index indicates that on a bay-wide basis striped bass spawning has been successful. Although the effects of environmental degradation should not be completely discounted, it appears that egg and larvae viability are not presently limiting stock recovery or the success of stocking activities.

4) Ratio of hatchery and wild juvenile striped bass

Changes in the ratio of juvenile marked hatchery fish to unmarked wild fish is dependent on the number of hatchery fish stocked and the strength of a given year-class. Annual collections in the Patuxent River have shown that hatchery fish have comprised as much as 85 percent of the fish present to as low as one percent. The latter was measured in the presence of the dominant 1993 year class. Above average striped bass reproduction in three of the last five years indicates that recovery is taking place and that in most cases supplementation with hatchery fish appears unnecessary.

5) Hatchery contribution to recreational and commercial fisheries

Surveys of Maryland commercial and recreational fisheries from 1991 to 1993 have shown a consistent bay-wide hatchery fish contribution of 4.5 to 7.5%. Incidence rates were highest in the Patuxent River and lowest in the Upper Bay area. The consistency of hatchery contribution estimates to these fisheries is reassuring. In spite of the differing features of these fisheries, variation in the intensity and scope of sampling, and the assumptions necessary to partition the catch, the estimates spanned a fairly narrow range. These surveys have proven that significant numbers, as high as 40 percent of the catch in the Patuxent River, of hatchery-reared striped bass have been recruited to these fisheries.

Revisiting of Previous Recommendations of Special Report No. 10

1) *Continue the stocking and evaluation program for nine years to allow maturation and return of adult females from three year-classes.*

The stocking and evaluation program has continued for the recommended nine years and allowed for maturation and return of adult females from three year-classes.

2) *Continue to conduct research to determine limiting factors affecting recruitment. This research should not be contingent upon the success or failure of the hatchery program.*

Research has continued on factors affecting recruitment such as larval and juvenile mortality. The most recent studies concern larval and juvenile mortality and abundance in the Nanticoke and Patuxent Rivers. This work was undertaken by the Chesapeake Biological Laboratory and MD-DNR.

3) *Terminate stocking if restoration is successful as judged by return of Y-O-Y indices for a period of 3 years to levels determined acceptable by each region, and the ratio of marked hatchery fish to non-marked recruited fish declines.*

YOY indices have increased largely due to the recovery of the wild population. The proportion of hatchery fish detected in the Chesapeake Bay and in coastal areas appears to be decreasing due to larger wild year classes recruiting to fisheries and the coastal striped bass population. Stocking in most parts of the Chesapeake Bay ceased in 1994 except for stocking for specific research projects.

4) *Terminate stocking if marked and stocked fish fail to return as brood fish.*

Maryland Chesapeake Bay hatchery fish returned as brood fish in 1991 to 1993. Therefore criterion (1) was not violated.

5) *Terminate restoration program if fish return as brood fish but progeny fail to survive due to environmental conditions in nursery grounds.*

It is likely that progeny of hatchery as well as wild fish are surviving in the nursery grounds and that previous environmental degradation may not be limiting recovery on a bay-wide basis. Therefore criterion concerning the viability of progeny was not violated although it is suspected that in specific systems environmental problems could exist (ASMFC 1990).

Conclusion

The restoration criteria of three successive year-classes of hatchery-reared fish to the spawning grounds as brood fish has been met in Maryland. The magnitude of these returns has yet to be determined, although continued evaluation in all stocked systems should yield more definitive results during the next three to five years. The recovery of the wild Chesapeake Bay striped bass population indicates that criteria 3 and 4 may not have been as important as they were believed to be in 1987. The MD YOY index has shown an upward trend, the viability of eggs and larvae do not presently appear to be a limiting factor except perhaps in specific systems, and the ratio of juvenile marked striped bass to wild juveniles has generally decreased due to improved wild reproduction. Hatchery-reared fish have also entered Maryland recreational and commercial fisheries in measurable numbers as their size has become greater than 18 inches.

Recommendations

1) Continue to evaluate the return of adult females to the spawning grounds for all studies in which significant numbers of hatchery fish were marked.

2) Continue research concerning larval and juvenile mortality and abundance for improved understanding of factors affecting recruitment and possible calibration of juvenile indices.

3) Stocking for enhancement purposes should be terminated except in those systems where striped bass have been absent or when the adult population and reproduction have been at low levels for several years as measured by juvenile and spawning surveys.

4) Continue to survey recreational and commercial fisheries in order to quantify benefits of stocking programs to both pre-migratory and coastal populations.

5) Stocking of hatchery-reared fish should be recognized as only one tool available to resource managers and that the appropriateness of this tool will vary with circumstances.

6) Stocking should be at the discretion of the state in cases where agreements between power companies and a given state are in effect.

Section 4. Genetic and Hybrid Concerns

Original Committee Charge

The Committee was tasked with reviewing the stocking practices of both public and private entities to determine if they threaten the integrity of native striped bass along the Atlantic Coast.

Problem and Background

Striped bass introduced into new habitats may compete with native fish for resources or may spawn with the native fish and alter genetic integrity. Striped bass from Chesapeake Bay are phenotypically different than those from further north, such as the Hudson River, and from those further south such as in North and South Carolina. Eggs from these fish have a small oil globule as compared to those from Chesapeake Bay. Some other much more subtle genetic differences have been documented and others likely exist. The variation in traits and characteristics of striped bass along the Atlantic Coast may well reflect their adaptation to unique environmental conditions.

Striped bass and hybrids have been and continue to be introduced into coastal waters and drainages along the Gulf Coast formerly inhabited by the Gulf Coast strain of striped bass. Introductions of these non-native fish have placed additional pressures on the native striped bass and complicated restoration efforts. Similar hatchery programs for salmon on the West Coast have increased competition that native fish face for resources, spawning sites, and nursery space in their historic range. In many river systems hatchery fish now dominate salmon runs due to the effects of environmental degradation and dams on wild populations while numbers of hatchery fish are guaranteed by annual hatchery production. In the many areas where salmon are propagated through hatchery techniques, commercial and recreational fisheries have become completely dependent on releases of hatchery-reared fish.

Status

In 1987, the TAC commented that only limited numbers of non-native striped bass and hybrids have been released along the Atlantic Coast. The Committee found no documented evidence that the small numbers of non-native fish released to date have changed the genetic integrity of native stocks, but additional releases of non-native fish are not recommended. According to a recent study conducted by Reginal Harrel of the University of Maryland:

> "Recent capture of gravid hybrid striped bass females and ripe males on the spawning grounds in the Chesapeake Bay, Maryland have caused concern about the potential of introgressive hybridization with the native striped bass (*M. saxatilis*). We isolated several striped bass genomic probes that discriminate between white bass (*M.*

chrysops) and striped bass alleles, and used them to determine whether wild caught hybrids were the result of previous intentional stockings or outcrosses. White bass genes are being introgressed into the *Morone* population, since 3% of the field identified hybrids from the winter of 1991 proved to be backcrossed individuals. However, if the stocking of hybrids into the Chesapeake watershed is not resumed, this problem is likely to eventually be eliminated (Harrel et al. 1993)."

Releases of hybrids into the Susquehanna River watershed during the middle 1980s and releases into the Patuxent River in early 1980s have contributed to this problem. Maryland discontinued stocking hybrids with the start of the striped bass program in 1984-85. Pennsylvania has discontinued stocking hybrids that are likely to escape freshwater reservoirs and have begun using striped bass. According to the Maryland Department of Natural Resources, the number of hybrids in the Upper Chesapeake Bay area has decreased during the last two years (MD DNR 1993).

Aquaculture is an expanding industry in the U.S. and commercial production of striped bass and hybrids has been established from New York to Virginia. There is concern that non-native fish could be accidentally released into coastal waters by either public or private groups.

Fishery genetics and hatchery practices have gained greater sophistication during the last decade. The initial policies regarding striped bass brood fish may have taken a somewhat conservative approach. In nearly all cases, except where a reproducing population had been eliminated, brood stock have been taken from their system of origin. Although to date there is no conclusive evidence of genetic variation among striped bass from different systems within Chesapeake Bay, the progeny of brood stock have always been stocked in the brood fish river of origin.

Several precautions have been followed in the selection of brood stock in Maryland. Brood fish are selected from the entire run including late and early spawners and small versus large spawners. Several females are used from each river system to prevent over representation of one individual in the offspring. Future selection and collection of brood fish should be based on whether the number and characteristics of the individuals chosen are representative of the genetic variability in the wild population. Future work is needed for determination of the number of females required to adequately represent the population's genetic makeup. It would also be desirable to screen hybrid-striped bass back crosses from hatchery production. It is the general consensus of the current Striped Bass Stocking Committee that hatchery fish should not be used as brood stock.

Recommendations

1) Genetic integrity of Atlantic coast striped bass should be maintained within river basins including specific rivers of the Chesapeake Bay.

2) Only progeny from native brood stock, when available, should be stocked in river basins and coastal waters.

3) Progeny from brood stock of adjacent rivers or hydrologically similar systems should be used if native brood stock do not exist. If non-native fish are to be stocked these activities should be reported to the Commission.

4) Brood stock requirements such as the number of females needed for hatchery production from a specific system, detection of striped bass-hybrid backcrosses, and the use of hatchery-reared fish as brood stock should be further investigated, especially if any new stocking initiative is to take place. Interim policy dictates a conservative approach by using as many females as possible and avoiding the use of hatchery-reared females or males to prevent over representation from a particular gene pool.

5) Hybrids should be restricted to inland freshwater reservoirs or to other systems in which escapement and reproduction is not likely. The Committee recommends the use of pure striped bass for inland stocking programs.

6) Neither striped bass nor hybrids should be stocked in coastal or inland waters without prior notification and approval of the proper and official state fishery agencies.

7) Commercial aquaculture operators must understand that escapement of hybrids and non-native striped bass will not be allowed, and that concerned agencies should be alerted to this policy. The Committee encourages the development and use of sterile fish for aquaculture operations.

In summary, a better understanding of the genetic implications of interactions between hatchery stocks and endemic populations is needed. Areas of concern include: the loss of genetic variability among and within populations; tradeoffs (genetic) of supportive or supplemental stocking; and brood stock management practices.

Section 5. Stocking Strategies

Original Committee Charge

The Committee was tasked with reviewing the strategies for stocking in various systems and make recommendations as to strains of fish to be used, phase of young to be stocked, and timing of stockings.

Background and Problem

Since fish stocked into an open system are free to migrate along the coast, there is a potential for activities in one state to interfere with or be counter productive to actions in other states. There also exists the possibility that strains of fish stocked into an area with native fish might irreversibly alter the gene pool of resident stocks. Therefore, in addition to maximizing benefits from the stocking program, stocking strategies should also minimize the potential for conflicts in other areas.

Several Atlantic Coast states have conducted or currently have stocking programs for striped bass in coastal waters. These programs have one of the three following goals: (1) to restore depleted striped bass stocks; (2) to augment existing stocks; or (3) to establish stocks to support special programs. Section 4 has already recommended practices to protect native brood stock and addressed the strain of fish to be stocked in a given situation.

Status

YOY indices used in several coastal states appear to be a useful indicator of initial population size for a given year class. Releasing hatchery-reared fish with age and size that is similar to wild fish compromises the YOY index and all subsequent estimates of population size unless hatchery-reared fish are marked and distinguishable from wild fish. Initially there was some question as to whether phase I striped bass could be marked with BCWTs in order to differentiate them from wild fish. In 1987 and 1988, Maryland phase I tagging efforts illustrated marking with BCWTs was possible at a size that is generally greater than 1/2 inches. This gave managers the flexibility to stock three to four months earlier. Maryland field personnel scan all fish encountered in the YOY survey to avoid inclusion of hatchery fish in the calculation of the YOY index. Both phase I and phase II striped bass have been stocked by Maryland and Virginia.

In 1987, according to the TAC, there was little evidence that stocking fry into coastal waters has ever produced a significant change in the fishery. Similarly, while some phase I fish have survived when stocked in coastal waters, experience from the Gulf Coast states indicates that phase II fish were more readily recruited into the fishery. In California, phase II fish are maintained in hatcheries through the winter and released as yearlings in the spring. The number of fish that can be reared in a given hatchery declines as their size increases. Conversely, the quality, expected survival, and cost of fish increases as size

increases from fry, to phase I, to phase II, to yearlings. The TAC concluded from the evidence examined to date, that phase II fish are the most cost-efficient fish to rear, mark, release, and evaluate in systems with natural reproduction.

Experience in Maryland suggests that the Committee's original assumptions in this area may have been wrong. Although additional work needs be done, larval, juvenile, and adult surveys all indicate that stocking at earlier life stages may result in greater survival than previously thought. Nanticoke River research conducted by the Chesapeake Biological Laboratory suggests that in areas where natural reproduction is low, larvae releases can makeup a significant percentage of the river's larval population. Juvenile and adult studies also indicate that phase I fish survive and are recruited to Chesapeake Bay fisheries. Returns as percentage of releases show that phase II survival is greater than phase I survival. However, the lower cost of phase I production is likely to offset the benefits of greater phase II survival. Definitive conclusions regarding the most cost effective release strategy are unknown at this time.

Recommendations

1) In areas with or without natural reproduction, phase I or phase II fish should be stocked as long as they are marked to avoid confounding YOY surveys.

2) Juvenile and adult surveys should be continued to determine the most cost effective release strategies including age at release and optimal release conditions such as salinity, temperature, and time of day for future potential stocking programs.

Section 6. State Coordination

Original Committee Charge

The Committee was tasked with reviewing the present stocking programs in each state to ensure that state programs are non-conflicting on a coast-wide basis.

Background and Problem

Anadromous striped bass do not observe state or political boundaries and may migrate from inland to coastal waters and along the Atlantic Coast. Fish stocked by one state could enter the waters of neighboring states, thus confusing abundance estimates and adversely affecting management decisions and actions based on that abundance. Topics of growing concern include, but are not limited to, commercial aquaculture, public stocking of hybrids, loss of genetic diversity as a result of massive hatchery releases, and tagging of all hatchery releases.

Status

Since 1985, striped bass have been stocked in the states of Maine, New York, New Jersey, Delaware, Pennsylvania, Maryland, Virginia, and North Carolina. Numbers stocked by state and tagging methods are found in Appendix I.

As summarized in Appendices I and II, a number of tagging methods have been utilized, untagged fish have been released, and hybrids have been stocked in the past with little or no state coordination. Recently, concerns have arisen over the use of hybrids due to potential back-crosses of hybrids and wild striped bass. This has prompted states to take an increasingly conservative approach toward stocking of hybrids.

Most striped bass are currently tagged with BCWTs, including phase I fish, before release to areas immediately adjacent to or in coastal waters. Yet, additional coordination and dialogue among states, and adherence to Commission guidelines are needed.

Although commercial fisheries have been reopened in some coastal states, landings and seasons are still strictly limited. Until recently culture has been directed primarily toward research, mitigation for environmental degradation, or enhancement of natural stocks. Commercial production of striped bass and/or hybrids now exists at some level in New York, Delaware, Maryland, Virginia, and North Carolina. Undoubtedly production will grow and other states will follow as production techniques improve and demand for striped bass increases. The Committee recognizes the potential for farm raised fish to supplement the market for striped bass and to reduce pressures on native populations. However, the Committee also recognizes the potential negative effects (altered gene pool, escapement of non-native fish, hybrid back-crosses, introduction of diseases, etc.) that might result from uncontrolled aquaculture releases of striped bass. The Committee therefore urges each

state and the aquaculture industry to make every effort to prevent escapement of aquaculture products. Cage culture of striped bass in open estuarine systems should be avoided and prohibited for hybrids due to the potential for genetic mixing and/or disease transmission from escapees.

Recommendations

1) Programs among and within states should be coordinated by adhering to recommendations made by this Committee.

2) Each state should take appropriate regulatory or statutory action to insure that striped bass stocked by private entities into coastal waters be in accordance with recommendations of the Committee.

3) Stocking and evaluation activities should be reported to the Commission to allow for the dissemination of information to other interested parties.

Section 7. Evaluation

Original Charge

The Committee was tasked with developing a system to evaluate the contribution of stocked fish to striped bass spawning populations. This system would also include marking and tagging methods.

Problem and Background

Hatcheries and hatchery-reared fish are tools that can be used by managers to restore depleted stocks of native fish. Hatchery reared fish can also be used as a management tool for population studies such as the validation of juvenile indices. However, without adequate evaluation there is no assurance, nor can there be any proof that stocked fish contributed to population recovery. Without an evaluation program, underlying causes for changes in striped bass abundance will not be determined, but will be left to speculation.

The experimental designs of evaluation programs have usually been an afterthought to the actual stocking of fish. In addition to asking meaningful research questions, future programs need to lay out specific evaluation plans regarding who, how, when, and at what cost.

Status

Striped bass hatchery evaluation currently includes the following:

1) Examination of the ratio of hatchery-reared fish to wild fish by year class in both recreational and commercial fisheries. This should allow managers to quantify direct benefits to users.

2) Estimation of mortality rates and relative abundance in specific river systems using young-of-the-year and one year old hatchery fish. These surveys will improve our understanding of early life stages of striped bass and allow managers to compare YOY indices and estimated wild abundance.

3) Sampling for hatchery striped bass returns to the spawning grounds, especially mature females, to determine the hatchery contribution to the spawning population. In Maryland, from 1991 to 1993, twelve mature females and hundreds of males of hatchery origin have been recaptured on the spawning grounds.

4) Fishery independent studies in coastal and estuarine areas to improve our understanding of hatchery-reared striped bass behavior and contribution to striped bass populations.

The Committee previously stated that in the Chesapeake Bay use of binary coded wire tags (BCWTs) is the preferred method of marking hatchery-reared striped bass. This method has proven to be a relatively affordable, and reliable, method to mark large numbers of both phase I and phase II striped bass. Tag recovery programs have been in place for three seasons in Maryland, Virginia, Delaware, New Jersey, and Long Island, New York. Over 75,000 striped bass have been scanned for BCWTs and over 2,000 tags have been recovered from these programs.

Spawning ground surveys have been ongoing for three spawning seasons in Maryland, Delaware and Virginia and each year hatchery males and females have been recovered. These surveys provide opportunities to estimate the contribution of hatchery fish to the spawning population and to determine whether hatchery fish return to their natal streams to spawn. Regular scanning for hatchery fish and recovery of BCWTs should also be undertaken as part of Hudson River spawning surveys.

The reasons for stocking such as research and enhancement should be documented, and evaluation of the proposed stocking activities should be planned before new programs are initiated. Experimental designs and sampling programs must be formulated before any fish are stocked. Factors such as hatchery practices and stocking strategies should also be considered while attempting to answer questions of pertinence to managers.

Recommendations

1) The tagging program should be coordinated on a coast-wide basis in order to avoid duplication of tag codes, and to make sure that resources such as wand tag detectors are used to the fullest possible extent.

2) A central database and archive for the binary coded wire tags and data should be maintained by the Commission and the USFWS so that standardization and sharing of data will be facilitated. This should allow for a flow of information among State and Federal agencies, and interested parties.

3) Binary coded wire tags should be placed only in the left operculum.

4) Stocking strategies should be further investigated and evaluated in order to maximize benefits achieved through stocking.

5) The purpose of stocking and planned evaluation must be documented before further stocking programs are initiated.

6) The evaluation program should be budgeted at a value equal to the cost of the stocking program.

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Appendix I

Table 1. Major striped bass releases by year and state from 1983 to 1995. Maryland, New York, Virginia and Delaware annual totals only include fish tagged with BCWTs.

-North Carolina released 14,000 fish in 1980, 87,181 in 1981, and 47,648 in 1982. In all years a proportion of North Carolina releases were marked with cinch - up tags, the Carlin disc and internal anchor (Floy) tags.
-In all years Maryland tagged all releases with BCWTs except for, 147,738 fish in 1985 and 1,500 in 1986 which were not marked, and 17,100 in 1986, 9,154 in 1987, 22,133 in 1988, and 3,100 in 1989 which were freeze branded.
-New York releases of 234,387 fingerlings in 1990, and of 256,631 fingerlings in 1992, were not marked with BCWTs.
-Approximately one-third of New Jersey releases were fin clipped.
-Approximately one percent of Maine releases were tagged with internal anchor tags.
-BCWTs were not used in New Jersey, Maine or North Carolina.

Year	Total Stocked	Total Tagged with BCWTs	Maryland	New York	Virginia	Delaware	Maine	New Jersey	North Carolina
1983	312,139	61,357	0	61,357	0	0	0	0	250,782
1984	515,293	147,153	0	147,153	0	0	2,506	46,955	318,679
1985	692,848	471,504	186,926	284,578	0	0	46,759	26,847	0
1986	1,169,960	889,777	360,214	529,563	0	0	31,317	26,952	203,314
1987	1,202,849	1,141,947	817,147	324,800	0	0	0	18,320	33,428
1988	1,213,837	1,018,943	937,413	48,611	22,311	10,941	66,943	29,393	76,092
1989	1,397,026	1,214,893	987,076	202,068	4,830	20,919	67,535	30,967	80,531
1990	1,476,110	1,112,613	815,456	0	204,610	92,547	65,233	0	63,877
1991	1,056,391	755,023	507,361	0	247,662	0	10,942	0	33,795
1992	1,546,385	1,427,100	888,617	210,815	286,957	40,711	0	0	119,285
1993	1,808,042	1,687,162	951,812	571,661	123,821	39,868	0	0	120,780
1994	565,017	565,017	250,788	314,229	0	0	0	0	0
1995	778,945	778,945	165,187	613,758	0	0	0	0	0
Totals	13,734,840	11,271,434	6,867,997	3,308,593	890,191	204,986	291,235	179,434	1,300,563

Table 2. Releases of hatchery-reared striped bass tagged with binary coded wire tags from 1985 to 1994 by system and year.

RIVER	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	TOTAL
Patuxent River	99,767	292,066	393,048	271,901	298,342	356,758	346,306	554,478	202,340	0	2,815,006
Nanticoke River	52,256	8,866	68,441	33,042	0	0	0	334,139	724,186	250,788	1,471,718
Choptank River	0	0	324,529	433,848	261,888	54,814	161,055	0	0	0	1,236,134
Upper Ches. Bay	34,903	59,282	31,129	198,622	426,846	403,884	0	0	0	0	1,154,666
Chester River	0	0	0	0	0	0	0	0	25,286	0	25,286
Hudson River	284,578	529,563	324,800	48,611	202,068	0	0	210,815	571,661	314,229	2,486,325
Delaware River	0	0	0	0	20,919	92,547	0	40,711	39,868	0	194,045
C&D Canal DE	0	0	0	10,941	0	0	0	0	0	0	10,941
Pamunkey River, VA	0	0	0	0	0	31,056	82,994	153,744	21,910	0	289,704
Mattaponi River, VA	0	0	0	21,987	4,830	173,554	164,668	133,213	37,773	0	536,692
Rappahan River VA	0	0	0	0	0	0	0	0	64,138	0	64,138
TOTAL	471,504	889,777	1,141,947	1,018,619	1,214,893	1,112,613	755,023	1,427,100	1,687,162	565,017	

For Tables 3 through 12, BCWT stands for Binary Coded Wire Tag. BCWTs are injected into the cheek muscle of fingerlings before release. In North Carolina, cinch-up tags were used until 1989. In New Jersey, pectoral and pelvic fins were fin clipped. In Maine, a fine fabric anchor tag with 1-inch vinyl tubing was used. From 1985 to 1993, between 1.5 to 3.5 percent of Maryland releases were marked with both internal anchor (Floy) tags and BCWTs. Maryland Floy tag releases can be found by year and system in Table 13. A small proportion of Virginia releases were also marked with both Floy tags and BCWTs. Phase I fish are generally stocked during the early summer at 40 to 60mm. Phase II fish are stocked in the fall at approximately 120 to 180mm.

Table 3. Releases of hatchery-reared striped bass in coastal estuaries during 1985.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
Maine				
Kennebec River	46,759	-	-	-
New Jersey				
Navesink River	4,408	0	-	phase I
Navesink River	22,839	22,839	Clip	phase II
Total	26,847	22,839		
New York				
Hudson River	571,661	571,661	BCWT	3 inch
Maryland				
Patuxent River	100,261	0		phase I
Patuxent River	125,612	99,767	BCWT	phase II
Nanticoke River	52,256	52,256	BCWT	phase I
Upper Chesapeake	56,535	34,903	BCWT	phase II
Total	334,664	186,926		

Table 4. Releases of hatchery-reared striped bass in coastal estuaries during 1986. Pennsylvania stocking in Conowingo Pool is included because of the movement of fish to the Upper Chesapeake Bay. Hybrid striped bass stocking in the Susquehanna River was terminated after 1986. Due to a misunderstanding 15,000 striped bass X white bass hybrids were stocked in Conowingo Pool during 1986.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
Maine				
Kennebec River	26,676	1,900	Floy	phase II
Androscoggin River	3,641	0	-----	phase II
Eastern River	1,000	0	-----	phase II
Total	31,317	1,900		
New Jersey				
Navesink River	13,300	0	-----	phase I
Navesink River	13,650	13,650	Clipped	phase II
Total	26,952	13,650		
New York				
Hudson River	529,563	529,563	BCWT	3 inch
Pennsylvania				
Conowingo Pool	54,000	0	-----	phase I
Maryland				
Nanticoke River	6,975	6,975	Branded	phase II
Nanticoke River	8,866	8,866	BCWT	phase II
Patuxent River	10,125	10,125	Branded	phase I
Patuxent River	293,566	292,066	BCWT	phase II
Upper Chesapeake	59,282	59,282	BCWT	phase II
Total	378,814	377,314		
North Carolina				
Albemarle Sound	118,345	4,999	Cinch-up	phase II
Albemarle Sound	45,200	1,100	Cinch-up	phase II
Neuse River	39,769	2,119	Cinch-up	phase II
Total	203,314	8,228		

Table 5. Releases of hatchery-reared striped bass in coastal estuaries during 1987. Pennsylvania stocking included 26,000 phase I striped bass supplied by Georgia and 200,000 phase I striped bass supplied by Maryland.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
New Jersey				
Navesink River	18,320	0	-----	phase I
New York				
Hudson River	324,800	324,800	BCWT	3 inch
Pennsylvania				
Conowingo Pool	226,000	0	-----	phase I
Maryland				
Choptank River	324,529	324,529	BCWT	phase II
Nanticoke River	68,441	68,441	BCWT	phase II
Nanticoke River	9,154	9,154	Branded	phase II
Patuxent River	15,806	15,806	BCWT	phase I
Patuxent River	377,242	377,242	BCWT	phase II
Upper Chesapeake	31,129	31,129	BCWT	phase II
Total	826,301	826,301		
North Carolina				
Pasquotank	15,435	2,500	Cinch-up	phase II
Pamlico River	17,993	2,500	Cinch-up	phase II
Total	33,428	5,000		

Table 6. Releases of hatchery-reared striped bass in coastal estuaries during 1988. In Virginia 295 releases were marked with both internal anchor (Floy) tags and BCWTs.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
Maine				
Kennebec River	51,501	150	Floy	phase II
Androscoggin River	15,442	1,100	Floy	phase II
Total	66,942	1,250		
New Jersey				
Navesink/Swimming R.	29,393	0	-----	phase I
New York				
Hudson River	48,611	48,611	BCWT	3 inch
Pennsylvania				
Conowingo Res.	200,000	0	-----	phase I
Conowingo Res.	21,400	21,400	BCWT	phase II
Total	221,400	21,400		
Delaware				
C&D Canal	10,941	10,941	BCWT	phase II
Maryland				
Choptank River	433,848	433,848	BCWT	phase II
Nanticoke River	33,042	33,042	BCWT	phase II
Nanticoke River	22,133	22,133	Branded	phase I
Patuxent River	100,208	100,208	BCWT	phase I
Patuxent River	171,693	171,693	BCWT	phase II
Upper Chesapeake	198,622	198,622	BCWT	phase II
Total	959,546	959,546		
Virginia				
Mattaponi	22,311	22,311	BCWT	phase II
North Carolina				
Cashie River	5,000	5,000	Cinch-up	phase II
Neuse River	71,092	2,500	Cinch-up	phase II
Total	76,092	7,500		

Table 7. Releases of hatchery-reared striped bass in coastal estuaries during 1989.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
Maine				
Kennebec River	58,935	0	-----	phase II
Androscoggin River	8,600	0	-----	phase II
Total	67,535	0		
New York				
Hudson River	202,068	202,068	BCWT	3 inch
New Jersey				
Navesink/Swimming R.	30,967	0	-----	phase I
Pennsylvania				
Conowingo Pool	210,025	0	-----	phase I
Delaware				
Delaware River	36,134	20,919	BCWT	phase II
Maryland				
Choptank River	261,888	261,888	BCWT	phase II
Nanticoke River	3,100	3,100	Branded	phase II
Patuxent River	101,987	101,987	BCWT	phase I
Patuxent River	196,355	196,355	BCWT	phase II
Upper Chesapeake	426,846	426,846	BCWT	phase II
Total	990,176	990,176		
Virginia				
Mattaponi River	4,830	4,830	BCWT	phase II
North Carolina				
Albemarle Sound	3,289	1,400	Cinch	phase II
Cape Fear River	77,242	1,300	Cinch	phase II
Total	80,531	2,700		

Table 8. Releases of hatchery-reared striped bass in coastal estuaries during 1990. In Virginia, 1,301 Mattaponi River releases and 700 Pamunkey River releases were tagged with both Floy tags and BCWTs. Maryland Floy tag releases can be found in Table 13.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
Maine				
Kennebec River	58,497	0	-----	phase II
Androscoggin River	6,736	0	-----	phase II
Total	65,233			
New York				
Hudson River	234,387	0	-----	3 inch
Pennsylvania				
Conowingo Pool	155,400	0	-----	phase I
Delaware				
Delaware River	92,547	92,547	BCWT	phase II
Maryland				
Choptank River	54,814	54,814	BCWT	phase II
Patuxent River	356,758	356,758	BCWT	phase II
Upper Chesapeake	403,884	403,884	BCWT	phase II
Total	815,456	815,456		
Virginia				
Mattaponi River	173,554	173,554	BCWT	phase II
Pamunkey River	31,056	31,056	BCWT	phase II
Total	204,610	204,619		
North Carolina				
Albemarle Sound	2,000	2,000	Floy	phase II
Cape Fear River	61,877	2,992	Cinch	phase II
Total	63,877	4,992		

Table 9. Releases of hatchery-reared striped bass in coastal estuaries during 1991. In Virginia, 1,935 Mattaponi releases and 1,466 Pamunkey releases were marked with both internal anchor (Floy) tags and BCWTs. Maryland hatchery Floy tag releases can be found in Table 13.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
Maine				
Kennebec River	9,893	0	-----	phase II
Androscoggin River	1,049	0	-----	phase II
Total	10,942			
New York				
Hudson River	256,631	0	-----	3 inch
Pennsylvania				
Conowingo Pool	54,000	0	-----	phase I
Maryland				
Choptank River	108,130	108,130	BCWT	phase I
Choptank River	52,925	52,925	BCWT	phase II
Patuxent River	105,915	105,915	BCWT	phase I
Patuxent River	240,391	240,391	BCWT	phase II
Total	507,361	507,361		
Virginia				
Mattaponi River	36,088	36,088	BCWT	phase I
Mattaponi River	128,580	128,580	BCWT	phase II
Pamunkey River	82,994	82,994	BCWT	phase II
Total	247,662	247,662		
North Carolina				
Albemarle Sound	2,994	2,994	Floy	phase II
Pamlico River	30,801	3,561	Cinch	phase II
Total	33,795	6,555		

Table 10. Releases of hatchery-reared striped bass in coastal estuaries during 1992. In Virginia 1,901 Mattaponi River releases and 829 Pamunkey River releases were marked with both internal anchor (Floy) tags and BCWTs.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
New York				
Hudson River	210,815	210,815	BCWT	3 inch
Delaware				
Delaware River	40,711	40,711	BCWT	phase II
Maryland				
Patuxent River	283,195	283,195	BCWT	phase I
Patuxent River	271,283	271,283	BCWT	phase II
Nanticoke River	98,067	98,067	BCWT	phase I
Nanticoke River	236,072	236,072	BCWT	phase II
Total	888,617	888,617		
Virginia				
Mattaponi River	133,213	133,213	BCWT	phase II
Pamunkey River	153,744	153,744	BCWT	phase II
Total	286,957	286,957		
North Carolina				
Albemarle Sound	2,465	2,465	Floy	phase II
Cape Fear River	116,820	2,527	Floy	phase II
Total	119,285	4,992		

Table 11. Releases of hatchery-reared striped bass in coastal estuaries during 1993.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
New York				
Hudson River	571,661	571,661	BCWT	3 inch
Delaware				
Delaware River	39,868	39,868	BCWT	phase II
Maryland				
Chester River	25,286	25,286	BCWT	phase I
Patuxent River	85,702	85,702	BCWT	phase I
Patuxent River	116,638	116,638	BCWT	phase II
Nanticoke River	278,844	278,844	BCWT	phase I
Nanticoke River	445,342	445,342	BCWT	phase II
Total	951,812	951,812		
Virginia				
Mattaponi River	37,773	37,773	BCWT	phase II
Pamunkey River	21,910	21,910	BCWT	phase II
Rappahannock River	64,138	64,138	BCWT	phase I
Total	123,821	123,821		
North Carolina				
Albemarle Sound	2,180	2,180	Anchor	phase II
Pamlico River	118,600	2,204	Anchor	phase II
Total	120,780	4,384		

Table 12. Releases of hatchery-reared striped bass in coastal estuaries during 1994. In addition, during 1995, 165,187 striped bass were released in the Nanticoke River, Maryland, and 613,758 were released in the Hudson River, New York. All 1995 releases were marked with BCWTs. Most striped bass stocking was suspended in 1995.

State and River of Release	Number Stocked	Number Marked	Tag Type	Size at Release
New York				
Hudson River	314,229	314,229	BCWT	3 inch
Maryland				
Nanticoke River	129,507	129,507	BCWT	phase I
Nanticoke River	121,281	121,281	BCWT	phase II
Total	250,788	250,788		

Table 13. Maryland hatchery-reared striped bass marked with both BCWTs and internal anchor tags from 1985 to 1993.

Year Stocked	Patuxent River	Upper Ches. Bay	Choptank River	Nanticoke River	Totals
1985	1,950			2,050	4,000
1986	6,215	3,534			9,749
1987	575	1,000	7,925	1,000	10,500
1988	500	5,000	4,997	1,498	11,995
1989	2,000	3,495	3,400		8,895
1990	7,424	2,507	2,500		12,431
1991	7,590		2,500		10,045
1992	5,835		2,284	2,665	8,500
1993	6,756			2,000	8,756
Totals	38,845	15,536	23,606	9,213	87,200

Appendix II

STATE SUMMARIES OF STOCKING AND TAGGING ACTIVITIES

The following State summaries provide background information regarding stocking activities and program evaluation. For additional information regarding evaluation activities in Maryland and Virginia refer to ASMFC Special Report No. 43, Proceedings of a Workshop on the Striped Bass Binary Coded Wire Tag Recovery Program.

State of Maine Striped Bass Stocking Program 1982-1992

Lewis N. Flagg and Thomas S. Squiers, Jr.
Maine Department of Marine Resources
State House Station #21
Augusta, ME 04333-0021

Introduction

Prior to the late 1920s, a resident spawning population of striped bass inhabited the tidal waters of the Kennebec and Androscoggin Rivers, including Merrymeeting Bay and its tidal tributaries (Cathance, Abagadasset, Muddy, and Eastern Rivers). This population was exterminated because of industrial and municipal pollution which persisted in these tidal waters from the 1930s through 1976. Major portions of these waters were completely devoid of dissolved oxygen annually from mid-July through August. Extensive pollution abatement efforts in the early 1970s resulted in dramatic improvement of water quality in the Kennebec, Androscoggin and Merrymeeting Bay estuarial waters. Since 1977, dissolved oxygen levels have exceeded 6.5 PPM during the critical mid-summer periods of elevated water temperatures and low river discharges. Due to these water quality improvements, the Department of Marine Resources initiated a Striped Bass Restoration Program in 1982. Following is a summary of Maine's program and accomplishments to date.

Objectives

- Stock 20,000-30,000 phase II striped bass fingerlings for six consecutive years
- Restore a self-sustaining population of striped bass to the Kennebec and Androscoggin River estuarial complex, including Merrymeeting Bay and its tidal tributaries.
- Manage restored indigenous stocks of striped bass to support local striped bass recreational fisheries.

Methods

Obtain 15-30 day old striped bass larvae, rear to phase II fall fingerlings in hatcheries, and stock in waters where restoration is proposed. The goal was to stock 20,000-30,000 phase II fall

fingerlings per year for six consecutive years. Evaluation of stocking results was accomplished by ichthyoplankton surveys of potential spawning areas and beach seine surveys of nursery areas to capture wild larvae and young of the year striped bass.

Results

From 1985 to 1990, the stocking objectives were exceeded for five of the six years. The project was unable to obtain striped bass in 1987. In each year from 1987 to 1993, wild striped bass juveniles have been found in these waters. Since coastal migratory striped bass also utilize these waters along with local stocks, we were unable to evaluate the impact of locally produced striped bass on recreational fisheries.

Cooperators

Maine Department of Marine Resources
New York State Department of Environmental Conservation
Consolidated Edison Company of New York, Inc.
U.S. Fish and Wildlife Service
Maine Citizens Committee to Restore Striped Bass to the Kennebec River

Summary

While overall stocking objectives were achieved, the resident striped bass population is considered to be at a low level of abundance and will require a number of years before it becomes fully restored.

Hudson River Striped Bass Hatchery Summary

New York State Department of Environmental Conservation
Bldg. #40
Stony Brook, New York 11790-2356

The striped bass hatchery program in New York State was initiated by several New York utilities (Central Hudson Gas and Electric Corporation; Consolidated Edison Company of New York, Inc.; New York Power Authority; Niagara Mohawk Power Corporation; and Orange and Rockland Utilities, Inc.) in 1983. The 1980 Hudson River Cooling Tower Settlement Agreement required the utilities to construct, lease, or contract for operation a hatchery to produce striped bass for stocking the Hudson River. The hatchery is located on the Hudson River in Verplanck, New York. The two main objectives of stocking were to mitigate for mortality associated with impingement on power plant intake screens, and to evaluate supplementation of wild stocks with hatchery-reared striped bass (Dunning et al. 1990).

Stocking was initiated in 1983 with the release of 63,561 three inch fingerlings and has continued through 1995. To facilitate evaluation of the program, all releases have been marked with binary coded wire tags except in 1990 and 1991. The Utilities also conduct a hatchery evaluation survey in the lower Hudson River during the winter and spring. Studies have attempted to estimate the hatchery contribution to the wild population and examine hatchery fish behavior such as movements in the Hudson estuary.

Hatchery Program Objectives

The ultimate goal of the hatchery program is to realize a production goal of 600,000 three inch fingerlings. Although this goal has been approached, production has fallen short in all years. Two objectives related to reaching this goal involve: 1) identification of stressors involved; and 2) identification of operational techniques leading to substantial improvement in survival of fish.

The single largest constraint preventing annual production of 600,000 fingerlings is the annually recurring episode of mortality observed in the 30 to 40 day old fish. The principle cause is environmental/bacterial gill disease (E/BGD). The two most frequently suggested prevention measures involve: 1) institute lower holding densities; and 2) reduce water reuse rates. Both of these measures were unsuccessful. Hence, chemotherapeutic measures were recommended along with emphasis on lower rearing density as the main method for solving the problem. The use of chemical applications have not been consistently successful. When applied prophylactically with lower densities and with no water reuse during the first 40 days of rearing, substantially improved survival of fish through 40 days has been realized.

Evaluation Program Objectives

Objectives of the 1990-1991 striped bass hatchery evaluation program were:

1) Determine if hatchery striped bass, stocked during any year between 1983 and 1989, can be detected in the Hudson River population as 1+ or older fish;

2) Estimate the proportion of age 1+ through 4+ Hudson River striped bass composed of hatchery fish if sufficient numbers of fish are present; and

3) Compare the growth of hatchery and wild striped bass cohorts in the Hudson River.

Proportion and confidence limits of hatchery striped bass caught during winter trawl surveys.

Winter 1986-1987	95% Confidence limits
1.3% of age 0+	(0.9% to 1.9%)
1.5% of age 1+	(1.0% to 1.9%)
0.1% of age 2+	(.03% to 0.2%)
0.0% of age 3+	
Winter 1987-1988	
0.2% of age 0+	(0.1% to 0.3%)
1.6% of age 1+	(1.3% to 1.9%)
3.1% of age 2+	(2.4% to 3.9%)
0.3% of age 3+	(0.1% to 0.8%)
Winter 1988-1989	
1.6% age 0+	(1.3% to 1.9%)
0.2% age 1+	(0.1% to 0.3%)
3.5% age 2+	(2.5% to 5.0%)
2.4% age 3+	(0.7% to 6.5%)
Winter 1989-1990	
0.7% age 0+	(0.5% to 0.9%)
0.4% age 1+	(0.3% to 0.5%)
0.1% age 2+	(.02% to 0.3%)
Winter 1990-1991	
0.2% age 1+	(0.15% to 0.35%)
0.2% age 2+	(0.1% to 0.3%)
0.1% age 3+	(0.0% to 1.0%)

Hatchery fish are not randomly distributed during the fall after stocking (Wells et al. 1991), and there is no evidence that these fish become randomly distributed during the first winter after stocking. The proportions of 0+ hatchery fish are considered the least reliable.

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Navesink River Striped Bass Restoration

by
Russell Allen, Peter Himchak and Thomas Baum

New Jersey Department of Environmental Protection and Energy
Division of Fish, Game, and Wildlife
Marine Fisheries Administration
Bureau of Marine Fisheries

Introduction

The Navesink River has a history of striped bass commercial and recreational fisheries. During the 1890s, striped bass were taken from the Navesink to be stocked in California. These fish were the source of the West Coast populations that still exist today. Although large numbers of striped bass utilized the Navesink system in the past, no evidence of a separate Navesink stock has been detected. During the late 1970s and early 1980s, striped bass populations dwindled to alarmingly low levels along the East Coast. The Navesink River was no exception, and coupled with destruction or loss of possible spawning habitat, it was not known if they would return.

In 1984, New Jersey's Division of Fish, Game and Wildlife initiated a striped bass restoration program in order to establish a self-sustaining population of striped bass within the Navesink River system. With the stocking of non-migratory striped bass, Weldon and Brookneal strain, obtained from the U.S. Fish and Wildlife Service (USFWS) Edenton Fish Hatchery in North Carolina, it was hoped that these fish would remain in the system to provide a year round sportfishery. Stocking took place over a six-year period from 1984-1989. Monitoring efforts utilizing various gear (gill net, seines, and trap nets) have continued since 1984. Ichthyoplankton sampling was conducted prior to the first stocking in 1984. Since 1991, ichthyoplankton sampling has been resumed and conducted annually.

Ichthyoplankton

During 1984, ichthyoplankton sampling was initiated utilizing 0.5 meter nets set from an anchored boat. Eighty samples were taken, and no evidence of striped bass spawning was found. Sampling was resumed from 1991 to 1993 using the same gear and methods that were used in 1984. The sixty samples that were taken in 1991 also failed to produce evidence of spawning. Sampling during 1992 produced six striped bass eggs, but no larvae in 91 samples. This was the first evidence of striped bass spawning in this system. Sampling during 1993 produced 134 striped bass eggs and three striped bass larvae in 84 samples. Numerous striped bass eggs casings were also collected. All striped bass eggs and larvae were taken during May. Eggs were found at all stations.

Stocking Activities

Striped bass stocking in the Navesink River took place over a six-year period from 1984 to 1989. Approximately 180,000 fish were stocked in Hockhockson Brook. From 1984 through 1986, 43,315 of the 100,754 releases were phase I fingerlings. The rest were grownout to phase II size at the Division's Hackettstown Fish Hatchery. Their fins were then clipped before stocking in the Fall. Fin clipping involved the removal of one complete fin (either right or left pectoral or left pelvic). In an attempt to determine if stocking larger fish increased survival, we attempted to stock striped bass at one inch size intervals. Captures during seining surveys would help to assess survival of unclipped and clipped fish.

An additional 78,680 striped bass were stocked from 1987 to 1989. All fish were stocked directly into Hockhockson Brook from the USFWS Edenton National Fish Hatchery. Comparison of fin clipped and unclipped fish demonstrated no difference in survival or growth.

Field Monitoring of Stocked Fish

Monitoring efforts have changed over time as striped bass releases have matured. Initial emphasis was placed on young of the year surveys. In later years, gill netting and seining have been the major sampling techniques while electroshocking and trap netting have also been attempted.

Of 926 striped bass sampled since 1984, 206 showed evidence of fin clipping. Seining for Y-O-Y striped bass was initiated in an attempt to determine if striped bass were surviving, and if so, how the growth of wild fish compared to that of hatchery-reared fish. Young of the year sampling from 1984 to 1989 showed that hatchery and wild fish had comparable growth and survival rates. Sampling for larger fish such as yearlings started in 1985 and continued through 1993. Utilization of gill nets of various mesh sizes (one to seven inches stretch), were set throughout the Navesink/Swimming River system. Sampling was supplemented with occasional trap net and seine catches. Mature males and females have been captured near the original stocking site. Ripe males were first taken in 1990, and increased steadily in numbers to more than 40 in 1993. In 1991, the first mature female of nearly 34 inches in length was captured. Few mature females have been captured since 1991 although three were taken in 1993. Two BCWTs from hatchery fish released in Maryland were also recovered during these surveys.

Conclusion

The continuing occurrence of mature male and female striped bass in the Navesink River system each spring, coupled with the collection of viable eggs and larvae indicate that achievement of the program's primary objective is imminent. Ichthyoplankton sampling and seining will continue to assess the objective of establishing a self-sustaining population of striped bass in the Navesink River system.

Table 14. Striped bass captured in the Navesink/Swimming River from 1984 to 1993. Of 179,434 striped bass stocked in New Jersey, 57,439 were fin clipped.

Year	Captures	Fin Clipped	Size Range TL in.
1984	0	0	-
1985	117	77	2.56 - 5.91
1986	207	90	2.44 - 15.08
1987	3	0	12.64 - 17.01
1988	148	2	2.25 - 29.53
1989	111	9	1.50 - 27.20
1990	97	12	5.71 - 28.74
1991	82	6	4.13 - 33.90
1992	87	8	14.69 - 30.71
1993	74	2	17.09 - 32.20
Total	926	206	

Delaware State Stocking Report

by
Roy Miller
Delaware Division of Fish and Wildlife

Delaware began stocking activities in estuarine waters in 1988. From 1988 to 1993, with the exception of 1991, some quantity of striped bass were stocked into the Delaware River each year. These stockings were conducted for a variety of purposes. The 10,941 fingerlings stocked in 1988 were supplied by Delmarva Power and Light Co. (DP&L) as mitigation for fishes killed as a result of a blasting operation in the Delaware River. This became necessary when a ship knocked out one of their transmission towers near Pea Patch Island. These fish, as well as all subsequent stockings, were tagged with binary coded wire tags (BCWTs). Brood stock were taken from the C&D Canal. The fingerlings were stocked in the old canal near its entrance to the Delaware River at Delaware City.

In 1989, the Delaware River Fish and Wildlife Management Cooperative with its member fisheries management agencies from Pennsylvania, New Jersey, Delaware, New York, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Delaware Basin Commission undertook a research project that involved stocking striped bass. Striped bass larvae were needed as test animals for some in-situ bioassays in the Delaware River to see if river conditions were conducive for striped bass larval survival. Since the number of larvae needed for the experiment were minimal, the remaining larvae were reared to the phase II fingerling size at the USFWS Bowden National Fish Hatchery, West Virginia. They were released that fall in the Delaware River at Augustine Beach just below the mouth of the C&D Canal. Although 36,134 fish were released, only 20,919 of these were tagged with BCWTs. At the time it was felt that the others were too small to be tagged. Brood stock for these fingerlings were electrofished from the Delaware River near Wilmington, Delaware, and from the mouth of Oldman's Creek in New Jersey during May of 1989. A dual purpose of this stocking was to test the feasibility of rearing striped bass fingerlings using wild Delaware River brood stock in case the Cooperative opted for a hatchery enhancement program for the Delaware River.

In 1990, the Delaware Cooperative stocked another 56,395 phase II striped bass fingerlings marked with BCWTs. They were stocked in a variety of locations in the lower Delaware River. Although 92,547 fingerlings were reared and tagged at the USFWS Lamar Fish Hatchery, Pennsylvania, the official number stocked reflects subtractions for tag loss and handling-related mortality. The principal objective of the 1990 stocking was to support a mark and recapture estimate for juvenile striped bass in the Delaware River. This population estimate was successful (990,025 wild fingerlings in the Delaware river between New Castle, DE and Essington, PA).

There were no striped bass stocked in Delaware during 1991. In 1992, DP&L expressed an interest in undertaking a striped bass rearing program for the Delaware River. Brood stock

were obtained with gill nets and electrofished from the Delaware River and C&D Canal in May 1992. These fish were spawned at a hatchery facility created by DP&L at the Edge Moor Power Plant site opposite Wilmington, DE. Although survival at the plant using river water was poor that summer, enough Delaware origin striped bass fingerlings were reared in ponds in another state that DP&L was able to mark 40,702 with BCWTs and release them in the Delaware River at Augustine Beach in August 1992.

DP&L continued their hatchery rearing efforts in 1993 using Delaware River brood stock. Tagging and stocking were initiated in August 1993 and approximately 39,500 were tagged with BCWTs and released.

DP&L feels that the positive public relations generated by this stocking program are worth the expense. Potential advantages to Delaware in addition to publicity (the Division of Fish & Wildlife does the actual stocking), are the potential to support additional mark and recapture population estimates and/or validate the annual juvenile index calculated from the state of New Jersey seine surveys.

Striped Bass Stocking Program

Pennsylvania Fish and Boat Commission
Bureau of Fisheries
Division of Fisheries Management
450 Robinson Lane
Bellefonte, PA 16823

Commission interest in creating inland striper (striped bass and striped bass hybrids) fisheries began in 1970. Early efforts involved striped bass in smaller impoundments on the "trial and error" basis. Selection of potential waters became more structured as research findings became available. Stripers were intended for larger systems (1,000 acres or more) and where an abundant forage fish base (gizzard shad and/or alewife) occurred. Introductory and maintenance stockings were subject to availability of hatchery stocks from out-of-state sources of fry or fingerlings.

The advent and availability of hybrid striped bass encouraged the Commission to diversify recreational angling opportunities on various waterways. This included waterways considered too small for striped bass or those not meeting the cooler thermal requirements of adult striped bass. Hybrid striped bass have been stocked in both Susquehanna and Delaware River drainages. Dependence on out-of-state sources and related problems with holding and growout due to the lack of facilities hampered stocking of both striped bass and hybrids. The intent of the following summary is to cover stocking programs for East Coast drainages with particular attention to the Susquehanna River.

Conowingo Pool (Susquehanna River)

Construction of the Conowingo hydropower dam eliminated the run of striped bass into the lower Susquehanna River. The establishment of a gizzard shad population in Conowingo Pool played a role in the Commission's decision to stock striped bass hybrids (1973) to take advantage of the forage base and to provide a new fishery. In the mid-1980s, in deference to concerns about the potential for back-crossing of hybrids from Conowingo Pool with stripers in Chesapeake Bay, Pennsylvania terminated the use of hybrids in favor of striped bass. Hybrid stockings were to be discontinued after 1985. Unfortunately, an error in shipping instructions resulted in the stocking of 15,000 hybrids in Conowingo Pool in 1986. With the exception of that one shipment all stockings since 1985 have been striped bass. Except for 54,000 fingerlings in 1986 and 26,000 fingerlings in 1987, all striped bass have been provided by the state of Maryland.

The objective of striped bass management in Conowingo Pool is to provide a year round recreational fishery with primary emphasis on the cooling water discharge fishery at Philadelphia Electric's Peach Bottom Nuclear Power Plant. This fishery occurs from late November through March. Relatively little biological data is available on the status of the striped bass population. Angler use and harvest information was last collected at the warm water discharge fishery by a

consulting firm in the mid-1980s when hybrids were still being stocked. Sporting goods stores report good fishing for striped bass during most winters, with frequent harvest of 18 to 22 pound stripers. Staff anticipates biological sampling of the fishery in 1994. Some of the 1988 and all of the 1990 stockings were tagged with BCWTs.

Other Main Stem Susquehanna River Waters

As a result of the popularity of the hybrid program in the Conowingo Pool, the Commission extended stocking further upstream into Lake Aldred and Lake Clark. The last hybrids were stocked in these waters during 1986 with 14,000 phase I fish released in each lake. Hybrids were also stocked in the river from the York Haven Dam downstream to Lake Clark Pool in 1988 with 14,950 fish and in 1990 with 12,500 fish. Hybrids will no longer be stocked in the main steam primarily due to East Coast striped bass restoration efforts.

Other Susquehanna River Drainage Stocking Programs

-Striped bass have been stocked at 8,300 acre Raystown Lake on the Raystown Branch of the Juniata River over 175 miles from Conowingo Dam since 1973.

-Conewago Lake, a 340 acre state park lake on Beaver Creek, a tributary to the Susquehanna River 80 miles from Conowingo Dam, has been stocked with hybrid striped bass since 1984. Stocking numbers included: 4,500 in 1986; 3,500 in 1988; 3,500 in 1989; 5,000 in 1990; and 5,000 in 1991.

-Lake Redman, a 290 acre reservoir in the Codorous Creek drainage, is one of the newer hybrid fisheries. Stocking was initiated in 1991 with 1,300 phase I fingerlings to take advantage of an established gizzard shad population. Hybrids moving out of Lake Redman must first pass through 220 acre Lake Williams if they are to continue downstream. Lake Redman is 73 river miles from Conowingo Dam.

Striped Bass Stocking Efforts in Maryland

Most of the information for this section if from "Striped bass restoration along the Atlantic Coast: A multistate and federal cooperative stocking and tagging effort" by C.M. Wooley, N.C. Parker, B. M. Florence and R. M. Miller.

Stocking of striped bass in the Maryland portion of the Chesapeake Bay was initiated in response to the decline of the striped bass population during the 1980s.

> "Because of the limited stock of adult striped bass and extensive reproductive failure within the Chesapeake Bay, the U.S. Fish and Wildlife Service (USFWS) and the Maryland Department of Natural Resources (MDDNR) signed a cooperative agreement in 1985. This agreement was to implement an experimental program to tag and evaluate hatchery-reared striped bass in the Chesapeake Bay. The intent of these efforts was to maintain the viability of the resource by artificial means, (i.e., by stocking hatchery-reared fish) until the quality of habitat improved, the fishery was brought under coordinated control, and natural reproduction and recruitment were restored." (Wooley et al. 1990).

A similar agreement was also signed with Virginia during the following year. Between 1985 and 1994, nearly seven million striped bass were released in Maryland tributaries to the Chesapeake Bay. Brood fish were collected and spawned by MDDNR and the USFWS, and transferred as fry to rearing hatcheries for growout to phase II size. Under the agreement, six federal hatcheries were committed to the production of phase II fingerlings, releases of five to eight inches in size. Phase I fingerlings of two to three inches were also stocked beginning in 1987. Power companies including the Potomac Electric Power Company (PEPCO) and Baltimore Gas and Electric (BG&E) produced approximately 35 percent of Maryland releases as part of an agreement with Maryland. Maryland also built a new hatchery, the Manning State Fish Hatchery, for striped bass related work. Early work was undertaken at the Cedarville State Hatchery which is at the same site. Fish reared at federal hatcheries and power companies were returned to the Manning hatchery for tagging and stocking. Maryland also raised nearly 250,000 fish at the Manning facility. The four major tributaries that were stocked included the Choptank River, Nanticoke River, Patuxent River and the Upper Chesapeake Bay.

Evaluation efforts in Maryland have included juvenile surveys, fishery dependent surveys, and spawning surveys. Several coastal surveys have included scanning for BCWTs as part of their striped bass monitoring efforts. The principal goal of Maryland juvenile surveys was to assess the contribution of hatchery produced striped bass to the juvenile population. Work in this area included estimation of wild population size, juvenile mortality and correlation to juvenile indices. Fishery dependent surveys that recover striped bass stocked in Maryland include the Maryland Chesapeake Bay recreational/charter fisheries, commercial gill net and pound net fisheries, the Virginia Chesapeake Bay commercial fishery, and bycatch from the Delaware Bay shad and perch fisheries. Spawning surveys have included MDDNR spawning surveys on the

Upper Chesapeake Bay, Choptank River and Potomac River, electrofishing on Chesapeake estuaries with concentration on the Patuxent, Choptank and Nanticoke Rivers and spawning surveys on the Delaware River conducted by the Delaware Division of Fish and Wildlife. Coastal surveys include the Long Island New York Ocean Haul Seine Survey, the New Jersey Lower Delaware Bay Striped Bass Tagging Survey, and the Cooperative Winter Tagging Cruise off the coast of North Carolina and Virginia.

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Virginia Striped Bass Restoration Efforts 1988-1993

Dean Fowler
Virginia Department of Game and Inland Fisheries

Cooperating Agencies

Virginia Department of Game and Inland Fisheries (VDGIF), U. S. Fish & Wildlife Service (USFWS), Virginia Institute of Marine Science (VIMS), and Virginia Marine Resources Commission (VMRC).

Since 1988, the agencies listed above have been conducting a cooperative experimental restoration effort to enhance the spawning stock of striped bass in Chesapeake Bay. Phase II hatchery-reared striped bass fingerlings have been marked with binary coded wire tags (BCWTs) and stocked in the Mattaponi and Pamunkey Rivers, (York River system). The stocking phase of this program was completed in 1993. An important component of this effort is the evaluation of survival and distribution patterns of stocked fish.

On a pilot basis, BCWT tagged phase I striped bass were also used for short-term mark recapture experiments on the Mattaponi and Rappahannock Rivers to determine the YOY population size. The long-term goal of these projects involved the calibration of the juvenile indices generated for each major spawning tributary. It is hoped that this would eventually lead to a properly weighted baywide juvenile index.

Objectives

1) To evaluate the survival and distribution patterns of hatchery-reared striped bass tagged with BCWTs and the contribution to the spawning stocks of Virginia's tributaries to the Chesapeake Bay.

2) Utilize phase I hatchery-reared striped bass tagged with BCWTs to calibrate Virginia's juvenile indices.

Methods

Personnel from VDGIF and USFWS took advantage of the opportunity to collect spawning stock data and monitor for BCWTs while electrofishing for hatchery broodstock on the Mattaponi and Pamunkey Rivers from February - June of 1989-1993. In addition, opportunistic monitoring was conducted by VDGIF during general fisheries surveys in tidal rivers/streams during other seasons. VMRC staff has been scanning between one and two thousand striped bass since 1991 while conducting sampling of commercial pound net and gill net fisheries in the fall. VIMS scanned all YOY striped bass collected during their annual juvenile seine survey for

BCWTs after phase I stocking of the Mattaponi River in late June of 1991. Additional seine samples were taken throughout the summer to increase the potential for the recapture of tagged hatchery fish.

Results

Opportunistic surveys to date have detected mature hatchery-reared striped bass on the spawning grounds of the York River system. Given that large numbers of fish were not stocked until 1990 in Virginia, it will take several more years to survey data to determine whether these fish can make a significant contribution to the spawning population of the rivers in which they were stocked. A directed coded wire tag recovery program is recommended for spawning areas of Virginia's Chesapeake tributaries from 1994 to 1999.

Summary of Albemarle Sound Area, North Carolina
Striped Bass Tagging Programs
1981 - 1992

by
Sara E. Winslow, Biologist Supervisor
(Only relevant portions of the report have been summarized in this section)

The phase II striped bass stocking and tagging program began in North Carolina during 1980. All of the stockings occurred in the natural striped bass nursery area. A total of 689,794 phase II striped bass have been released in the Albemarle Sound area since 1981 of which 41,441 were tagged. Ten percent (4,163) of the tags have been returned. Throughout this program, only 14 returns (0.3%) have occurred from outside North Carolina's internal waters. Returns from gill nets dominated the percentages by recapture gears. The following table shows the release dates, locations, number released, number tagged and the percent of returns to date. Tables in Appendix I also account for additional stocking activities in other North Carolina rivers.

Three types of tags have been utilized since the program began. The Carlin disc was used in 1981 and January of 1983. From December of 1983 through December of 1989 phase II fish were tagged with cinch-up tags prior to release. Both of these tag types became easily entangled in gill nets prior to the fish recruiting to the fishery. These early returns however, provided valuable data on pre-recruit movements. The internal anchor tag was first employed in North Carolina during 1990 in phase II fish. Recaptures prior to legal recruitment into fisheries has essentially been eliminated with the use of the internal anchor tag because it does not become entangled in gill nets.

Table 15. Phase II striped bass stockings in the Albemarle Sound area, NC, 1981-1991.

Release date	Stocking Location	Year Class	Number Stocked	Number Tagged	Number Returned	Percent Returned
Jan 1981	Yeopim River	1980	87,181	10,000	1,814	18.1
Jan 1983	Albemarle Sound	1982	106,675	2,500	717	28.7
Dec 1983	Edenton Bay	1983	67,433	2,493	273	11
Dec 1984	Albemarle Sound	1984	236,242	6,445	570	8.8
Jan 1986	Albemarle Sound	1985	45,200	1,110	36	3.2
Dec 1986	Albemarle Sound	1986	118,345	4,999	447	8.9
Dec 1987	Pasquotank River	1987	15,435	2,500	179	7.1
Dec 1988	Cashie River	1988	5,000	5,000	90	1.8
Dec 1989	Albemarle Sound	1989	3,289	1,400	20	1.4
Dec 1990	Albemarle Sound	1990	2,000	2,000	11	0.6
Dec 1991	Albemarle Sound	1991	2,994	2,994	6	0.2
	Total		689,794	41,441	41,441	10

Appendix III

Atlantic States Marine Fisheries Commission Striped Bass Stocking Subcommittee

Members and interested individuals

Russ Allen
NJ Div. Fish & Wildlife
Nacote Creek Res. Station
P.O. Box 418
Port Republic, NJ 08241
Phone: (609) 748-2020
Fax: (609) 748-2032

David Boyd
VA Marine Res. Commission
P.O. Box 756
Newport News, VA 23607
Phone: (804) 247-2244
Fax: (804) 247-2020

John Field
ASMFC
1444 Eye Street, N.W., 6th Floor
Washington, DC 20005
Phone: (202) 289-6400
Fax: (202) 289-6051

Lewis Flagg
Maine Dept. Marine Resources
State House Station 21
Augusta, ME 04333
Phone: (207) 624-6340
Fax: (207) 624-6024

Ben Florence
MD DNR
Building C-2
Tawes State Office Building
Annapolis, MD 21401
Phone: (410) 974-3733
Fax: (410) 974-2600

Dean Fowler
VA Dept. Game, Inland Fisheries
5806 Mooretown Road
Williamsburg, VA 23188
Phone: (804) 253-4180
Fax: (804) 253-4182

Harrel Johnson
NC Division of Marine Fisheries
1367 US 17 South
Elizabeth City, NC 27909
Phone: (919) 264-3911
Fax: (919) 264-3723

Andrew Kahnle
NY DEC, Hudson River Fisheries
21 S. Putt Corners Road
New Paltz, NY 12561
Phone: (914) 255-5453
Fax: (914) 255-3042

Kim McKown
NY DEC, Marine Resources
Building #40, SUNY
Stony Brook, NY 11790-2356
Phone: (516) 751-8200
Fax: (516) 444-0373

Roy Miller
DE Div. of Fish & Wildlife
P.O. Box 1401
Dover, DE 19903
Phone: (302) 739-4782
Fax: (302) 739-6780

Jorgen Skjeveland
U. S. Fish and Wildlife Service
177 Admiral Cochrane Drive
Annapolis, MD 21401
Phone: (410) 263-2604
Fax: (410) 263-2608

Albert Spells
USFSW
Harrison Lake NFH
11110 Kimages Road
Charles City 23030
Phone: (804) 829-2421

Richard Snyder
PA Fish & Boat Commission
450 Robinson Lane
Bellefonte, PA 16823-9616
Phone: (814) 359-5150
Fax: (814) 359-5153

Harold Upton
2388 Post Road
Wakefield, RI 02879
Phone: (401) 789-5307