MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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DATE: June 19, 2017

TO: Tidal Fisheries Advisory Commission

FROM: Maryland Department of Natural Resources Fishing and Boating Services

RE: Commission Request to Investigate Resumed Stocking of Tidal Striped Bass in Chesapeake Bay

Summary

Atlantic Coast striped bass management was initiated in 1979, due to concern about the decline in the population of the Atlantic striped bass stock, through enactment of the Anadromous Fish Conservation Act.

Striped bass are prolific spawners with a long reproductive lifespan. Recruitment success is highly variable, and is impacted by biotic and abiotic factors that occur in the spawning and nursery habitats. Uphoff (2008) estimated that Maryland's striped bass spawning stock produces 37.6 billion eggs annually (69% of the eggs produced in the Chesapeake Bay). Spawning stock biomass of the coastal stock was estimated at approximately 20 million pounds in 1982. A fishing moratorium in Maryland (1985-89) and subsequent conservative management actions resulted in a large increase of spawning stock biomass that was estimated at 129 million pounds in 2015. Under the current stock conditions, this high reproductive potential dwarfs any feasible hatchery stocking effort.

In response to interstate management plans that recommended experimental stocking, U.S. Fish & Wildlife Service and the state of Maryland entered into a cooperative agreement in 1985 to produce, mark and stock Chesapeake Bay juvenile striped bass. Maryland's striped bass stocking program was an expansive, cooperative effort that combined state and federal resources, at a time when the future of the Atlantic striped bass population appeared to be in peril. Management justifications for the stocking during the population's low point in the 1980s included:

- No strong year class for the previous 15 years (since 1970)
- Spawning success was weak, particularly in the upper Chesapeake Bay
- Notable scarcity of mature female striped bass on spawning grounds

Thirteen federal, state, and private hatcheries supported the cooperative Chesapeake Bay stocking program specifically in the 1980s and early 1990s. An average of 200 males and 50 females were collected from target tributaries and spawned at Maryland's Joseph Manning Hatchery. Approximately 45 million viable eggs were produced to propagate 25 million larvae (D. Sien, Maryland DNR pers. comm.) that were transported to hatcheries for grow out. Maryland stocking efforts were conducted primarily in the Patuxent River, Choptank River, Nanticoke River, and upper Chesapeake Bay. Approximately one million juveniles were stocked annually during peak years of the restoration. The total annual operating costs greatly exceeded $850,000 after inclusion of capital expenditures, state

costs, and monitoring. This is equivalent to $1.42 million/year in 2017 dollars after consideration of the 65% cumulative inflation rate.

The stocking effort was a reasonable management strategy at the time it was implemented, but it is not a practical approach when wild populations are stable. Results indicate that stocking may have merely enhanced recovery in some localized areas of Chesapeake Bay, and was less effective than reductions in fishing mortality. Population recovery was likely accelerated by stocking within small systems such as the Patuxent River.

Federal, state, and private hatcheries that previously participated in the effort are no longer accessible. Any additional striped bass production undertaken by department hatcheries would severely curtail or eliminate production of nearly one dozen other species that are produced to meet a variety of management needs statewide. The major funding source for Maryland's warm water species production is the U.S. Fish & Wildlife Service Sport Fish Restoration Program, which would not be applicable considering the current robust, sustainably managed striped bass population. There are currently no funding, staffing, or propagation resources available to conduct a hatchery based enhancement project.

All available data indicate that there is no resource management need to resume striped bass stocking in tidal waters. Any proposal to stock striped bass would need to be vetted and approved through the standard Atlantic States Marine Fisheries Commission process and is not likely to be favorably reviewed. Finally, federal agencies will not participate in enhancement activities to support a recovered population.

Legislative History

Atlantic Coast striped bass management was initiated in 1979, due to concern about the decline in the population of the Atlantic striped bass stock, through enactment of the Anadromous Fish Conservation Act by the U.S. Congress. Striped bass stocking in Maryland was initiated under the auspices of the Atlantic Striped Bass Conservation Act in 1984, which authorized appropriations of $200,000/year for Maryland and Virginia (FY86 and FY87) propagation of Chesapeake Bay striped bass.

Management Milestones

The Atlantic States Marine Fisheries Commission adopted a fishery management plan for coastal striped bass in 1981. Congress enacted the Atlantic Striped Bass Conservation Act in 1984 to require the adherence of Atlantic coastal states to commission management measures. Consequently, Maryland closed the fishery from 1985-1989 (Field 1997). In addition to substantial reductions in fishing mortality, the commission and the Atlantic Striped Bass Conservation Act recommended implementation of an experimental striped bass stocking trial for Atlantic coastal stock. Management justifications for the stocking trial included:

- No strong year class for the previous 15 years (since 1970)
- Spawning success was weak, particularly in the upper Chesapeake Bay
- Notable scarcity of mature female striped bass on spawning grounds

Management plans dictated that stocking programs would terminate when natural reproduction reached normal levels. The commission declared stock recovery in 1995.

Chesapeake Bay Stocking

In response to interstate management plans that recommended experimental stocking, U.S. Fish & Wildlife Service and the states of Maryland and Virginia entered into a cooperative agreement to produce, mark and stock Chesapeake Bay striped bass. Under the terms of the cooperative agreement, stocking was to continue until qualitative criteria were attained:

- Quality of spawning/rearing habitat improves
- Fisheries are brought under coordinated control
- Natural productivity is fully restored

The goal of the cooperative Chesapeake program "was to supplement spawning stocks of striped bass in order to maintain the viability of the resource until wild recruitment improved. However, it was considered to be a pilot program to explore the potential of hatchery production, not a program that would provide full restoration" (Wooley et al. 1990). It was hypothesized that spawning stock supplementation would occur as stocked hatchery-produced juveniles recruited to the adult population. In addition to stocking, the commission recommended that states implement monitoring programs to evaluate the efficacy of stocking hatchery fish.

During peak stocking program years, U.S. Fish & Wildlife Service alone spent approximately $1.1 million/year on hatchery operations and support (ASMFC 1994) for the coastal striped bass stocking

program. The estimated coast wide cost of the hatchery effort from 1985-1995 was $8.7 million, excluding costs for capital expenditures at federal hatcheries, or associated federal and state research, monitoring, and evaluation costs (Upton and Mangold 1996). The total annual operating costs greatly exceeded $850,000 after consideration of capital expenditures, state costs, and monitoring. This is equivalent to $1.42 million/year in 2017 dollars after consideration of the 65% cumulative inflation rate since 1994 (https://www.bls.gov/data/inflation_calculator.htm). The majority of funds supported Maryland and Virginia stocking, since more than twice as many striped bass were stocked into Chesapeake Bay than in New York and Delaware combined.

Approach

Brood fish were collected from target tributaries and spawned at Maryland's Joseph Manning Hatchery. Annual production required brood stock collection of 200 males and 50 females on average. Approximately 45 million viable eggs were produced to propagate 25 million larvae (D. Sien, Maryland DNR pers. comm.). Larvae were transported to various state, federal, and private hatcheries for grow out to Phase I (50.0 mm, stocked in June or July) and Phase II (100-200 mm, stocked in fall). As many as 17 hatcheries supported the coast wide effort (USDOI and USDOC 1994). Thirteen hatcheries supported the cooperative Chesapeake Bay stocking program specifically (Table 1). Fish stocked in Maryland were transported back to Manning Hatchery where they were implanted with coded wire tags, and then stocked into their river of origin (Table 2). Maryland stocking efforts were conducted primarily in the Patuxent River, Choptank River, Nanticoke River, and upper Chesapeake Bay. Approximately 1 million juveniles were stocked annually during peak years of the restoration.

Various assessment surveys were initiated to evaluate the impacts of stocking on juvenile abundance, and the contribution of hatchery fish to the adult spawning stock.

Stocking Results

The cooperative effort produced and stocked 7.8 million Chesapeake Bay striped bass that were marked with coded wire tags. Approximately 6.7 million striped bass juveniles were tagged and stocked into Maryland tributaries. Coastal stocking exceed 13 million striped bass juveniles (>12 million tagged).

Monitoring Results-Juveniles

Stocking of hatchery produced fish can have a high impact on juvenile populations, particularly in years of poor natural recruitment. A study by Minkkinen et al. (1994) evaluated the contribution of hatchery fish to the wild juvenile population in the Patuxent River from 1989-1993. Hatchery fish comprised 30, 72, 85, 48, and 5% of the juvenile population for those years respectively. The corresponding wild juvenile population during those years was 586,000, 125,000, 39,000, 413,000, and 2,575,000. Natural mortality estimates varied tenfold over the study period. A hatchery contribution of 85% does not indicate the relative value of stocking to the population when the overall juvenile abundance is also considered. The ratio of hatchery fish to wild fish is driven by natural recruitment success. Minkkinen et al. (1994) also hypothesized that density dependent mortality is suggested in some Maryland Chesapeake Bay tributaries, and some rivers would benefit less from stocking inputs than other rivers.

Monitoring Results-Adults

Rago et al. (1992) estimated that the proportion of hatchery fish in Maryland commercial fisheries was 5.1-7.4% in 1991-92. The incidence of hatchery fish was much higher in the mid-Bay near stocking tributaries. They estimated contribution of hatchery fish to the recreational/charter fisheries in Maryland at 6.1% in 1991.

Minkkinen estimated hatchery impacts to Maryland's recreational/charter fishing harvest in 1991. Hatchery fish comprised 4.3% of harvest biomass and 12.3% of fish harvested (DNR, unpublished data).

Maryland fishery dependent (recreational and commercial) data indicate a range of 3-7% hatchery ratio from 1990-1994 (ASMFC 1994).

Relative Value of Stocking and Reduction in Fishing Mortality

The stocking effort was a reasonable management strategy at the time it was implemented, but it is not a reasonable approach when wild populations are stable. Upton and Mangold (1996) state "However, the support of a put-and-take fishery, especially with the wild population is growing, is not advisable. It appears that stocking to boost production in systems with poor reproduction in combination with management measures is a viable option".

The relative gain in recovery from stocking compared to fishery conservation is minimal. Richards and Rago (1999) observed that "if 4.5 million hatchery fish contributed 5-7% to the fishable population, it would have required stocking 70.5 million fish to achieve 1:1 ratio of contribution to recruitment during 1985-1993".

Dorazio et al. (1991) found that "enormous numbers of Phase I fingerlings (50.0 mm) would be required to increase significantly the abundance of young of year striped bass in Chesapeake Bay. Restoration of Atlantic striped bass might be served better if stocking of Phase I fingerlings was used to validate the catch per unit effort indices of young of year abundance measured routinely in various spawning areas of the Bay by Maryland DNR."

Discussion

Striped bass are prolific spawners with a long reproductive lifespan. Recruitment success is highly variable, and is impacted by biotic and abiotic factors that occur in the spawning and nursery habitats. Uphoff (2008) estimated that Maryland's striped bass spawning stock produces 37.6 billion eggs annually (69% of the eggs produced in the Chesapeake Bay). Coastal spawning stock biomass was estimated at approximately 20 million pounds in 1982. The moratorium in Maryland and subsequent conservative management actions resulted in a large increase of spawning stock biomass that was estimated at 129 million pounds in 2015. There were three dominant juvenile year-classes between 1958 and 1970. Another dominant year class was not produced until 1993. Since then (and including 1993) there have been six dominant year-classes, including 2011 and 2015. Dominant year-classes have high contributions from all four major spawning areas. Under the current stock conditions, this high reproductive potential dwarfs any feasible hatchery stocking effort.

Analysis of the stocking effort in the Patuxent River (1988-89) illustrates the substantial reproductive potential that can result in high recruitment success (Dorazio et al. 1991). Approximately 100,000 Phase I striped bass were stocked into the Patuxent River in each year. Mortality rates were similar between wild and hatchery fish. In 1988, wild recruitment was poor and hatchery fish comprised 56% of the juvenile population. In 1989, baywide young of year indices were 3-7 times higher than in 1988, and wild juveniles outnumbered hatchery juveniles 11:1 in the Patuxent River (Dorazio et al. 1991).

A massive, interjurisdictional (Maryland, Virginia, Delaware, New York) stocking program was able to produce and stock sufficient numbers of juvenile striped bass to result in a 3-7% contribution to subsequent coastal samples during 1991-1993 (ASMFC 1994). Fishery dependent and fishery independent surveys in Maryland indicated higher contributions (up to 35%) to the sub-adult and adult population within smaller systems such as the Patuxent River during those years. Atlantic States Marine Fisheries Commission catch-at-age models estimate that the 1991 coastal population of fish age 5+ was 9.0 million. The 2014 estimates indicate that the Atlantic coast population numbered 17.8 million. That would effectively reduce the relative impact of similar stocking efforts to a coast wide hatchery contribution of 2-4% at today's abundance levels.

The commission estimates that the age 1 Atlantic striped bass population numbered 19.2 million in 1982. The estimate of age 1 striped bass in 2015 was 122.8 million. It is clear that the current juvenile striped bass population is approximately six times larger than it was when stocking was first implemented, and the need to supplement juvenile recruitment with hatchery produced fish is no longer extant. Peer reviewed research and commission technical experts concur with this assessment.

Richards and Rago (1999) found that stocking may have merely enhanced recovery in some localized areas of Chesapeake Bay. A commission tagging workshop drew similar conclusions:

- Stocking is less effective than reductions in fishing mortality
- Stocking can help to accelerate recovery in localized regions if fishing is concurrently curbed

- The stocking program occurred under ideal conditions, since fishing mortality was extensively curtailed
- Population recovery was likely accelerated by stocking in systems such as the Patuxent River

The workshop technical experts also concluded that as wild populations recovered, the proportion of hatchery fish decreased, in spite of constant survey and stocking effort (ASMFC 1994).

The stocking program produced numerous positive outcomes that are not directly related to coastal or regional stock recovery. The techniques learned from this large scale hatchery production, tagging, and assessment project were incredibly beneficial in application to subsequent hatchery-based management efforts in Maryland, such as American shad and hickory shad restoration. Peer reviewed literature developed from this cooperative effort contributed to the global scientific knowledge base. Refinement of striped bass culture and marking techniques directly benefitted the scientific and aquaculture communities. Application of standard mark-recapture models using tagged, stocked striped bass juveniles provided insight into river-specific density dependency and carrying capacity, juvenile survival, juvenile abundance, and juvenile striped bass behavior. Stocking substantial numbers of juvenile striped bass into smaller, less productive spawning tributaries resulted in relatively large impacts to the adult spawning populations in the short term. Presence of large numbers of marked fish in the migratory population provided the opportunity to evaluate fidelity to natal rivers. Finally, the cooperative nature of this project produced collaborative relationships between federal, state, and private partners that still exist and thrive today.

Conclusion

Maryland's striped bass stocking program was an expansive, cooperative effort that combined state and federal resources, at a time when the future of the Atlantic striped bass population appeared to be in peril. While numerous positive benefits were realized from the program, this enhancement strategy is not a practical solution considering the current status of the coastal striped bass population.

Federal, state, and private hatcheries that previously participated in the effort are no longer accessible. Any additional striped bass production undertaken by department hatcheries would severely curtail or eliminate production of nearly one dozen other species that are produced to meet a variety of management needs statewide. The major funding source for Maryland's warm water species production is the U.S. Fish & Wildlife Service Sport Fish Restoration Program, which would not be applicable considering the current robust, sustainably managed striped bass population. There are currently no funding, staffing, or propagation resources available to conduct a hatchery based enhancement project.

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Table 1. Hatcheries that supported the Maryland Chesapeake Bay striped bass stocking effort, 1985-1994.

Hatchery	Operator
Joseph Manning Hatchery	State
Elkton	State
Horn Point	State
Baltimore Gas & Electric	Private
Potomac Electric Power Company	Private
Bowden NFH	Federal
Warm Springs NFH	Federal
Millen NFH	Federal
Harrison Lake NFH	Federal
McKinney Lake NFH	Federal
Senecaville NFH	Federal
Edenton NFH	Federal
Leetown USFWS	Federal

Table 2. Striped bass stocking of tagged fish in Maryland by year and river.

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 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**
Total	**186,926**	**360,214**	**817,147**	**937,413**	**987,076**	**815,456**	**507,361**	**888,617**	**951,812**	**250,788**	**6,702,810**