Amendment #1
1989 Chesapeake Bay Striped Bass Fishery Management Plan (CB SBFMP)

Background

As a result of cooperative management actions by the coastal states from Maine to North Carolina, the striped bass stock has been restored to historic levels. The biological target for determining the restored status was defined as “the average spawning stock biomass (SSB) or total weight of sexually mature striped bass females observed between 1960 and 1972" (Figure 1). Management strategies for striped bass were first recommended in 1981 when the Atlantic States Marine Fisheries Commission (ASMFC) Striped Bass Fishery Management Plan (FMP) was developed and adopted. The plan was not completely effective because states were at their own discretion to implement ASMFC recommendations. In 1984, Congress passed legislation providing federal authority to close striped bass fisheries in those states which did not comply with ASMFC recommendations. The increased importance associated with ASMFC recommendations resulted in the development of additional management measures. Since the adoption of the ASMFC Striped Bass FMP in 1981, the plan has been amended five times and two addendums have been added.

In order to address striped bass management issues within the Chesapeake Bay, a Bay Program FMP for striped bass was developed and adopted in 1989. The Chesapeake Bay plan addressed the following topics: overfishing; reduced spawning stock; allocation; gear restrictions; selling and buying; seasons, creel limits and fishing areas; monitoring needs and procedures; enforcement authority; stock assessment; research needs; and water quality. As states along the coast began implementing harvest restrictions, striped bass abundance began to improve. In the Chesapeake region, limited recreational and commercial fisheries were reopened for the 1990/1991 season. As the specifics of the Chesapeake Bay Striped Bass Fishery Management Plan (CBSB FMP) changed with the improving status of the resource, the plan was updated in an annual report prepared by the Maryland Department of Natural Resources (MDNR) and the Virginia Marine Resources Commission (VMRC) fishery management staff.

In 1995 when the stock was formally declared recovered, ASMFC Amendment #5 was adopted and replaced the original ASMFC FMP. Addendum I and II were developed to specify fishing regulations in 1997 and 1998. Addendum II also revised the target fishing mortality rate and adopted a new assessment tool for the Atlantic coastal stocks. After critically reviewing the ASMFC Amendment #5, the Chesapeake Bay Program's Fishery Management Workgroup agreed to adopt the goals and objectives, management program specifications/elements, management program implementation and compliance items as detailed in ASMFC Amendment #5. As a result, this document, Amendment #1 to the Chesapeake Bay Striped Bass FMP, supersedes the 1989 CBSB FMP. It formally adopts the ASMFC Amendment #5 as part of the Chesapeake Bay management strategy. In addition, the CBSB FMP Amendment #1 has expanded the habitat section which defines striped bass habitat within the Chesapeake Bay and specifies management strategies for protecting striped bass habitat. Protecting striped bass spawning habitat is critical since the Chesapeake Bay produces a major portion of coastal migratory striped bass.

The management strategy for protecting the striped bass stock from overharvest and maintaining an adequate spawning stock is to adopt a target fishing mortality rate. Amendment #5 specified target fishing mortality rates (F) over several years adjusting the target until it reached a F at maximum sustainable yield (MSY). A fishing rate at MSY is believed to be the threshold at which overfishing occurs. Under Addendum II, a F less than F_{msy} was adopted. The lower reference point will provide a larger margin of safety for the striped bass stock and help prevent overfishing. Other F's may be determined at a later date based on the best available information and the status of the stock. As a result of Amendment #5's adaptive management approach, each state has some flexibility in implementing commercial and recreational restrictions to meet the target but must use the guidelines established by Amendment #5. An "adaptive approach" means that "regulatory measures will be evaluated to determine the response of the striped bass population and changes in the population may result in changes to the regulations." Adaptive management requires a monitoring program to assess the impacts of regulations on the striped bass stock and the ability to make necessary corrections if the population is decreasing or increasing.

Goals and Objectives

The goal of striped bass management along the Atlantic coast and in the Chesapeake Bay is:

> *"to perpetuate the stock of striped bass so as to allow a commercial and recreational harvest consistent with the long-term maintenance of a self-sustaining spawning stock and provide for the restoration and maintenance of essential habitat."*

The objectives to achieve this goal include: prevent overfishing; allow for harvest while maintaining an adequate spawning stock at or above historical levels; use young-of-the-year indices, SSB, or other measures of spawning success; implement compatible and equitable management measures among coastal jurisdictions; promote interstate research, monitoring and law enforcement; identify critical habitats; adopt standards of environmental quality; and, establish procedures for plan implementation. The management unit for striped bass is all coastal migratory stocks of the east coast up to 3 miles offshore. Striped bass in the Exclusive Economic Zone (EEZ), 3 to 200 miles offshore, historically accounted for approximately 2% of the landings, and are managed by the National Marine Fisheries Service. Harvesting striped bass from the EEZ is currently prohibited.

Section I. Management Program Specifications/Elements

As part of the procedures described under the management program specifications and elements, Amendment #5 makes a distinction between producer areas and coastal areas since they can have different regulatory and operational considerations. Currently, the Chesapeake Bay (Maryland, Potomac River Fisheries Commission, District of Columbia, Virginia) is considered a producer area. As part of the management program specifications, states are required to assess annual recruitment, measure fishing mortality, and implement monitoring programs.

The following is a synopsis of the ASMFC Amendment #5. For greater detail, refer to Fisheries Management Report No. 24 of the Atlantic States Marine Fisheries Commission, Amendment #5 to the Interstate Fishery Management Plan for Atlantic Striped Bass (March 1995).

1) Monitoring Requirements

Each state must compile the results of their commercial and recreational fisheries on an annual basis and submit them to the ASMFC (Refer to ASMFC Amendment #5, Tables 1 and 2, for details). Specific monitoring requirements may change based on the Technical Committee's recommendations in subsequent years.

2) Assessment of Recruitment

Six states (including Maryland and Virginia) are required to conduct juvenile abundance surveys on an annual basis. The juvenile indices were used in the spawning stock biomass model to provide a measure of future stock abundance and are currently used to adjust the virtual population analysis (VPA). The Technical Committee will examine trends in all juvenile surveys on an annual basis. If any index is lower than 90% of all other values in the data set for three consecutive years, then appropriate action will be recommended by the Management Board.

3) Spawning Stock Biomass

Spawning stock biomass represents the reproductive potential of the stock. Prior to 1997, a spawning stock biomass (SSB) model was used to estimate the weight of the spawning stock and utilized the juvenile index from the Maryland portion of the Chesapeake Bay. A reference or target SSB based on the estimated SSB from 1960-1972 was used to define a "recovered" striped bass stock. The Technical Committee has used the SSB model in conjunction with fishing mortality rates and juvenile indices to assess stock status. With the adoption of Addendum II in 1997, a new assessment tool, virtual population analysis (VPA), was adopted to estimate the reproductive potential of the Atlantic coast stocks. The VPA uses landings records and scientific survey data compiled by each state, thereby, incorporating data from all of the producer areas and not just the Chesapeake Bay region. The VPA will be used in conjunction with the SSB model to assess the striped bass stock. If SSB decreases below the reference level (estimated from 1960-1972), the current harvest regulations will be evaluated to determine if they need revision.

The relative size of the spawning stock is also estimated directly from fishery-independent surveys in various producer areas. Maryland and Virginia and several other producer areas are responsible for conducting spawning stock assessment surveys. If the results of the SSB model, VPA and the estimates of spawning stock from the fishery-independent surveys differ significantly, the Technical Committee will determine if fishery regulations should be modified.

4) Fishing Mortality

Fishing mortality rates (F) have been determined for the striped bass stock based on a F at maximum sustainable yield. In order to gradually increase fishing pressure without overshooting the target rate when the fishery was reopened after the moratorium, interim rates were implemented. With the adoption of Addendum II, F will remain below the maximum rate to provide a larger margin of safety and prevent overfishing. The states are required to: implement appropriate regulations to ensure the target mortality rate is not exceeded; collect catch composition information from both the recreational and commercial fisheries; and, continue tagging programs to generate estimates of migration and mortality rates. If coastwide estimates of mortality exceed the target for two consecutive years, then harvest reductions will be recommended for the following fishing year. The ASMFC management board will make the decision regarding final harvest levels.

5) Stocking

Stocking programs must follow the requirements set forth by ASMFC Amendment #5 and be coordinated through ASMFC. All monitoring and evaluation activities must also be reported to ASMFC. Care must be taken to maintain the health, genetic integrity and biodiversity of the stock.

6) Bycatch Reduction

Efforts must be made to assess the magnitude of bycatch discard mortality for each state. Documentation should include: location, target species, and season of the fishery; gear and gear specifications used in the fishery; and an estimate of pounds or numbers of striped bass taken per unit of effort and an estimate of total bycatch.

Section II. Management Program Implementation

1) Habitat

Each state should implement measures which ensure protection of striped bass habitat. These measures need to identify habitats used by striped bass, specify areas targeted for restoration, and encourage an increase in the quantity and quality of habitats. Measures to protect striped bass habitat in the Chesapeake Bay have been developed (see section V).

2) Recreational Fisheries

Recreational fisheries will be managed by a combination of size limits, creel limits and seasons to achieve annual fishing mortality rates. States have the flexibility to implement alternative management measures as long as the target fishing mortality rate is met. Recreational fisheries are discouraged on spawning grounds during spawning season. Producer areas will be allowed to conduct a spring fishery on migratory striped bass but the specifics of such a fishery must be reviewed by the ASFMC Technical Committee and approved by the Management Board.

3) Commercial Fisheries

Commercial fisheries will be managed by a size limit and a state quota system. Commercial fisheries are discouraged on spawning grounds during spawning season. Quotas may be changed annually in response to the current status of the striped bass stock. If a state exceeds its quota, the excess must be deducted from the following year's quota.

4) Adaptive Management

Requirements specified by ASMFC Amendment #5 may vary as part of the dynamic, adaptive management process. The status of the stock will be continually monitored and adjustments made in management recommendations if necessary.

Section III. Compliance

All states including Washington, D.C. and the Potomac River Fisheries Commission are required to implement the provisions of ASMFC Striped Bass Amendment #5. Refer to the Amendment #5 document for specifications.

Section IV. Research Needs

Specific research needs for striped bass have been delineated in Amendment #5. Additionally, the following research needs have been prioritized for the Chesapeake Bay.

1) Continue to support the development and refinement of coastal VPA modeling efforts. This includes obtaining Chesapeake Bay-specific data from monitoring the commercial and recreational fisheries to obtain accurate estimates of harvest and providing biological data to characterize the size, age, and sex distribution of the catch.

2) Investigate multispecies interactions and correlations with striped bass abundance.

Section V. Striped Bass Habitat Utilization and Management Recommendations for the Chesapeake Bay

<u>Background</u>

Egg Deposition and Development

The principal spawning areas of striped bass along the Atlantic coast are found in the Chesapeake Bay and its tributaries (Merriman 1941; Raney 1957). Spawning in the Chesapeake Bay primarily occurs in tidal freshwater areas just above the salt wedge (salinity >0.5%) (Uphoff 1989). Maryland's portion of the Chesapeake Bay, including its tributaries, has been reputed to produce more striped bass than all other propagation areas of North America combined (Vladykov and Wallace 1952; Mansueti and Hollis 1963). The lower Susquehanna River, long thought to be the major striped bass spawning area in the Chesapeake, has not made a substantial contribution to the reproduction of striped bass during the past century. It would appear that changes in two important environmental factors, water movements and salinity as affected by physical alterations in the construction of the Conowingo Dam and Chesapeake & Delaware Canal, have probably been important factors in the shift of spawning areas (Dovel and Edmunds IV 1971). Today's major spawning sites within the Chesapeake Bay are summarized in Table 1 and illustrated in Figure 1.

Striped bass spawn in the Chesapeake Bay from the beginning of April through the first week of June at water temperatures ranging from 11-24^{o}C (Setzler et al. 1980). Peak spawning activity occurs from early-April to mid-May and has been observed at water temperatures from 14-19^{o}C (Setzler et al. 1980; Uphoff 1992). Spawning peaks are triggered by a noticeable increase in water temperature and vary greatly from year to year. Multiple peaks may occur during each spawning season, particularly when the spawning stock is comprised of several year-classes. Temperatures at or below 12^{o}C are considered lethal to striped bass eggs and have been a suspected cause of high mortalities of eggs (Funderburk et al. 1991; Rose et al. 1993).

Spawning occurs at or near the surface (Woodhull 1947; Calhoun et al. 1950; Raney 1952; Surber 1958). Eggs are broadcast loosely into the water, while males discharge milky white clouds of milt. Live striped bass eggs are characteristically greenish or golden green (Mansueti 1958). The number of eggs produced by each female depends on its size. A 6-pound, 5-year old female produced 426,000 eggs, while a 50-pound, 17-year old female discharged about 4.2 million eggs (They're Back). Younger females not only produce fewer eggs, but their eggs are less viable as well (Zastrow et al. 1989 and NOAA 1993).

Fertilized eggs are spherical (about 1.6 mm in diameter), nonadhesive, and semibuoyant (Mansueti 1958). Eggs are slightly denser than water and sink slowly towards the bottom from the moment the female discharges them into the water. Albrecht (1964) stated that a velocity of 1 ft/sec in fresh water is required for egg suspension and good survival. Fish (1959) has shown that newly deposited eggs require a vertical water movement of 1.25 mm/min to keep them suspended. Eggs that fall to the bottom perish. Striped bass eggs hatch from 29(22^{o}C) to 80 hours (11^{o}C) after fertilization (Funderburk et al. 1991).

Larval Stage

The larval stage is believed to be the most critical. Larval survival rates determine juvenile numbers and year-class strength (Polgar 1977; Goodyear et al. 1985; Uphoff 1989). Density-independent factors (including environmental quality factors) are primarily responsible for recruitment variability (Ulanowicz and Polgar 1980; Cooper and Polgar 1981; and Uphoff 1989).

Larvae range from 2.0 - 3.7 mm (TL) at hatching and derive their nourishment from the yolk-sac and an oil globule suspended under the forward half of their body. Newly hatched larvae require sufficient turbulence to keep them from settling to the bottom; otherwise they will be smothered (Barkuloo 1970). Optimal water temperatures for larvae range from 18-21^{o}C (Rogers et al. 1977), although larvae can tolerate water temperatures from 12-23^{o}C (Doroshev 1970). Temperatures below 12^{o}C greatly reduce the survival of larvae (Rogers et al. 1977; Morgan et al. 1981; Crance 1984; and Uphoff 1992).

At approximately 5 days post-hatch and 5 mm (TL), striped bass larvae begin feeding on microscopic organisms known as zooplankton (Funderburk et al. 1991). Larvae feed primarily on copepodite and adult stages of copepods and cladocerans. The calanoid copepod *Eurytemora affinis* is a major prey in April. Major foods in late-may and early-June are the copepods, *Acartia tonsa* and *Cyclops* spp., and the cladocerans, *Bosmina longirostris* and *Daphnia* spp. (Funderburk et al. 1991 and Uphoff 1989). The availability of sufficient concentrations of suitable prey which are required for the first several days of feeding is a critical factor in the success of any larval year-class. Runoff in rivers with inadequate riparian buffer zones can increase the water's suspended solid concentration to the point of reducing the feeding efficiency (200-500 mg/l) (Breitburg 1988) and survival (500 and 1,000 mg/l (auld and Schubel 1978) of striped bass larvae.

Regan et al. ( ) reported that a pH of 6.0 to 10.0 is favorable for survival of striped bass larvae and young; an optimum of 7.5 was found by Davies (1968); an instant change of 0.8 - 1.0 units caused high mortality. Studies at the Columbia National Fisheries Research laboratory indicate that a pH of 6.5 is toxic to 19-day old striped bass larvae after 7 days exposure (Mehrle et al. 1984); addition of 0.1 mg/l Al at pH 6.5 killed all 19-day old striped bass after 5 days of exposure in soft water. Laboratory tests have revealed that exposure of larval striped bass (<50-days old) to pHs <+6.0 causes rapid mortality and that the toxicity of total aluminum increases with decreasing pH. The toxicity of low pH declines after 50-80 days of age (Buckler et al. 1987). Increased water hardness (290 ppm) and increased salinity (5 ppt) (Palaqaki et al. 1985) reduce the toxic effects of low pH and inorganic contaminants (Rago).

As larvae grow they are found progressively deeper in the water column (Mihursky et al. 1981 and Houde et al. 1988). By 13 mm (TL), larvae begin forming schools and move inshore.

Young-of-Year

Striped bass larvae begin metamorphosis to the juvenile stage at about 20 mm (Setzler-Hamilton 1981). At this time, young striped bass begin moving into near-shore, shoal areas less than 6-feet deep (1.8 m) deep (Boreman and Klauda 1988; Boynton et al. 1981; Setzler-Hamilton 1981). Juveniles are more resistant to acidity and have a higher thermal niche of about 24-28^{o}C than larvae (Coutant 1985; Matthews et al. 1989; Rago).

Nursery areas with dissolved oxygen concentrations >5-6 mg/l are preferable for juvenile striped bass. Low dissolved oxygen concentrations (<4.0 mg/l) can modify juvenile growth rates, feeding rates, habitat use, and susceptibility to predation (Magnuson et al. 1985; Suthers and Gee 1986; USEPA 1986; Kramer 1987; Poulin et al. 1987; Sanint Paul and Soares 1987; Breitburg 1994). Juvenile mortality was observed at dissolved oxygen concentrations <3.0 mg/l (Chittenden 1972; Coutant 1985; Krouse 1968).

Young striped bass (25-100 mm) are opportunistic predators that consume a wide range of planktonic and benthic prey (Markly and Grant 1970; Boynton et al. 1981; Funderburk 19910. Boynton et al. (1981) found that oligochaetes and insects were the most abundant prey of juvenile striped bass in freshwater portions of the Potomac river, whereas amphipods, mysids, fish larvae, and to a lesser extent, polychaetes and mollusks were more important in higher salinity areas. Fish become increasingly more important in the diets of juvenile striped bass larger than 100 mm (TL). As juveniles grow, they move progressively downriver into higher salinity waters during their first summer and autumn (NMFS 1981).

Subadults and Adults

The migratory behavior of striped bass is more complex than that of most other anadromous species with seasonal movements and locations of the fish related to age, sex, degree of maturity, and natal river. In addition, there is considerable variation in the migratory behavior patterns of fish of the same age, sex, and degree of maturity. Despite these differences, certain behavior patterns are common to most stocks. Generally, sexually immature fish of both sexes remain in their natal estuary until about age 2. After age 2, the majority of females and some males begin to leave the estuary and undertake season coastal migrations (Funderburk et al. 1991).

The migratory behavior of Chesapeake bay striped bass stocks is a topic of continuing research. A survey conducted by the Maryland Department of natural Resources (MDNR) during the striped bass moratorium (1985-90) indicated the following migration rates from the Bay: 0% of age 1, 10% of age 2 (both male and female), and 42.55 of the remaining ages (505 of females and 355 of males). Sexual maturation appears to be related to latitude or ambient temperatures; fish from southern waters generally mature at an earlier age than those from regions to the north (Funderburk et al. 1991). In the Chesapeake bay, most males are sexually mature by ages 2 or 3 (Jones et al. 1977). Recent intensive studies conducted in Maryland waters suggest that very few females are sexually mature at age 3 (<500 mm (TL)) and that only a small percentage of age 4 females (>500 mm(TL)) return to spawn. The National Marine Fisheries Service suggests that 50% maturity for male and female striped bass is attained at ages 2 and 6, respectively (NMFS 1981). Complete recruitment of females to the spawning stock may not occur until ages 7 or 8 (MDNR 1987). Coastal tagging studies suggest that immature females that join the coastal migratory stock do not participate in spring spawning migrations to the Chesapeake bay until they are sexually mature.

Large numbers of sexually immature and mature striped bass reside in the Chesapeake Bay year-round. These fish comprise the Chesapeake bay striped bass resident stock. The majority of these fish are premigratory and will join the coastal migratory stock upon reaching maturity. Tag return data indicates that some striped bass remain in the Bay upon maturity. Some of these fish will eventually join the coastal stock and it has been suggested that others will live their entire lives within the Chesapeake Bay (pers. comm. P. Jones). Surveys conducted by the MDNR indicate that striped bass ages 3-12 comprise the resident stock (MDNR 1995).

Resident striped bass have a thermal niche preference of 19-23^{o}C and higher preferences, up to 26^{o}C for successively smaller individuals. Adults have a strong tendency to avoid water temperatures >25^{o}C (Coutant 1985 and Matthews et al. 1989). Dissolved oxygen concentrations >5mg/l are required for resident striped bass (Funderburk 1991).

LITERATURE CITED

Albrecht, A.B. 1964. Some observations on factors associated with survival of striped bass eggs and larvae. Calif. Fish Game. Vol. 59, No. 2, pp. 100-113.

Auld, A.h and J.A. Schubel. 1978. Effects of suspended sediments on fish eggs and larvae: a laboratory assessment. Estuarine and coastal mar. Sci. Vol. 6, pp. 153-164.

Barkuloo, J.M. 1970. Taxonomic status and reproduction of striped bass (Morone saxatilis) in Florida. U.S. Bur. Sport Fish. Wild., Tech. Pap. 44, 16 p.

Breitburg, D.L. 1988. Effects of turbidity on prey consumption by striped bass larvae. Trans. Am. Fish. Soc. Vol. 117, pp. 71-111.

Calhoun, A.J., C.A. Woodhull, and W.C. Johnson. 1950. Striped bass reproduction in the Sacramento River system in 1948. Calif. Fish Game. Vol. 36, pp. 135-145.

Cooper and Polgar. 1981.

Crance, J.H. 1984. Habitat suitability index models and instream flow suitability curves: inland stocks of striped bass. FWS/OBS-82/10.85. U.S. Fish Wild. Serv. Fort Collins, CO.

Dovel, W.L. and J.R. Edmunds, IV. 1971. Recent changes in striped bass (*Morone saxatilis*) spawning sites and commercial fishing areas in upper Chesapeake bay; possible influencing factors. Ches. Sci. Vol. 12, No. 1, pp. 33-39.

Fish, F.F. 1959. Report of the steering committee for Roanoke River studies, 1955-58. U.S. Public Health Service, Raleigh, N.C. 279 p.

Funderburk, S.L., S.J. Jordan, J.A. Mihursky, and D. Riley. 1991. Habitat requirements for Chesapeake Bay living resources. Chesapeake Bay Program, Annapolis, MD. pp. 13-1 to 13-31.

Goodyear, C.P. 1985. Relationship between reported commercial landings and abundance of young striped bass in Chesapeake Bay, Maryland. Trans. of the Amer. Fish. Soc. Vol. 114, pp. 92-96.

Mansueti, R.J. 1958. Eggs, larvae, and young striped bass, *Roccus saxatilis*. Chesapeake biol. Lab. Contrib. Vol. 112, 35 p.

Mansueti, R.J. and E.H. Hollis. 1963. Striped bass in Maryland tidewater. Educ. Ser. No. 61, nat. Res. Institute, Univ. Of MD, pp. 1-28.

Merriman, D. 1941. Studies on the striped bass (*Roccus saxatilis*) of the Atlantic Coast. U.S. Fish & Wildlife Service, Fish. Bull. Vol. 50, pp. 1-77.

National Oceanic and Atmospheric Administration (NOAA). 1993. Our living oceans. Report on the status of U.S. living marine resources, 1993. NOAA Tech. Memo. NMFS-F/SPO-15. pp. 25-32.

Morgan, R.P., V.J. Rasin, and R.L. Copp. 1981. Temperature and salinity effects on development of striped bass eggs and larvae. Trans. of the Am. Fish. Soc. Vol. 110, pp. 95-99.

Polgar, T.T. 1977. Striped bass ichthyoplankton abundance, mortality, and production estimation for the Potomac River population. Pages 110-126 in W. Van Winkle, editor. Proceedings of the conference on assessing the effects of power-plant-induced mortality on fish populations. Pergamon Press, New York.

Raney, E.C. 1952. The life history of striped bass, *Roccus saxatilis* (Walbaum). Bull. Bingham Oceanogr. Collect., Yale Univ. Vol. 14, No. 1, pp. 5-97.

Raney, E.C. 1957. Subpopulations of the striped bass *Roccus saxatilis* (Walbaum), in tributaries of Chesapeake bay. In J. C. Marr (coordinator), contributions to the study of subpopulations of fishes. pp. 85-107. U.S. Fish & Wildlife Service, Special Sci. Rep. Fish. p. 208.

Rogers, B.A., D.T. Westin, and S.B. Saila. 1977. Life stage duration studies on Hudson River striped bass, *Morone saxatilis* (Walbaum). Univ. Of RI Mar. Tech. Rpt. 31. Kingston, RI.

Rose, K.A., J.H. Cowan, Jr., E.D. Houde, and C.C. Coutant. 1993. Individual-based modeling of environmental quality effects on early life stages of fishes: a case study using striped bass. Amer. Fish. Soc. Sym. Vol. 14, pp. 125-145.

Setzler, E.M., W.R. Boynton, K.V. Wood, H.H. Zion, L. Lubbers, N.A. Mountford, P. Frere, L. tucker, and J.A. Mihursky. 1980. Synopsis of biological data on striped bass, *Morone saxatilis* (Walbaum). NOAA Tech. Rept., NMFS Circ. 433, 69 p.

Surber, E.W. 1958. Results of striped bass (*Roccus saxatilis*) introduction into freshwater impoundments. Proc. 11th Annu. Conf. Southeast. Assoc. Game Fish Comm. 1957, pp. 273-276.

Ulanoqicz, R.E. and T.T. Polgar. 1980. Influences of anadromous spawning behavior and optimal environmental conditions upon striped bass (Morone saxatilis) year-class success. Can. J. of Fish and Aqu. Sci. Vol. 37, pp. 143-153.

Uphoff, J.H. 1989. Environmental effects on survival of eggs, larvae, and juveniles of striped bass in the Choptank River, Maryland. Trans. of the Amer. Fish. Soc. Vol. 118, pp. 251-263.

Uphoff, J.H. 1992. Survival of eggs, larvae, and juveniles of striped bass in the Choptank River, Maryland, in relation to environmental conditions during 1980-1988. MD Dept. of Nat. Res., Chesapeake Bay Research and Monitoring Division. CBRM-HI-92-1. 28 p.

Vladykov, V.D. and D.H. Wallace. 1952. Studies of the striped bass, *Roccus saxatilis* (Walbaum), with special reference to the Chesapeake bay region during 1936-1938. Bull. Bing. Oceanogr. Coll. Vol. 14, No. 1, pp. 132-177.

Woodhull, C. 1947. Spawning habits of the striped bass (*Roccus saxatilis*) in California waters. Calif. Fish Game. Vol. 33, pp. 97-102.

Zastrow, C.E., E.D. Houde, and E.H. Saunders. 1989. Quality of striped bass (Morone saxatilis) eggs in relation to river source and female size. J. rapp. P-v. Reun. Cons. Int. Explor. Mer. Vol. 191, pp. 334-342.