

6.0 STATUS OF THE STOCKS

6.1 ALBEMARLE/ROANOKE STOCK (ASMA AND RRMA)

6.1.1 Historical Condition 1955 to 1984

Dr. W. W. Hassler of NCSU conducted extensive research on striped bass fisheries and the A/R striped bass stock from 1955 to 1984 (Hassler et al. 1981, Hassler 1984; Hassler and Taylor, 1984). For most of those years Hassler estimated spawning population abundance through mark-recapture and regression of catch and effort, estimated egg production and egg viability, conducted juvenile abundance surveys, and estimated exploitation. Landings and effort for the primary commercial and recreational fisheries for striped bass in the Roanoke River and Albemarle Sound were also tabulated, however, that information is addressed in the description of the fisheries. Except where noted, information used to develop the following assessment of historic stock condition is all excerpted from Dr. Hassler's final reports (Hassler 1984, Hassler et al. 1984, and Hassler and Taylor, 1984).

Hassler estimated the size of the spring spawning run in the Roanoke River from 1956 to 1984. Two methods were used: 1) a Petersen mark-recapture method, based on annual estimates of exploitation from tag recoveries and total Roanoke River catch, for 1956-1984; and 2) Ricker's (Ricker 1940) regression of catch per unit effort for the commercial fishery, from 1956 to 1977. Hassler and Taylor (1984) noted a considerable decline in tag returns in 1981 following the imposition of considerable regulatory constraints. To avoid introducing a bias from the regulatory changes, they slightly modified the Petersen method and estimated spawning population abundance from annual Roanoke River harvest and average Roanoke River exploitation (tag derived), and provided updated estimates for the entire time series (1956-1984). All three estimates give similar pictures of spawner abundance over time (Figure 6.1). From 1956 to 1979 spawner abundance was variable, averaging around 300,000 fish and never falling below 100,000 fish. Estimated spawner abundance dropped nearly 70% between 1979 and 1980, and then declined even further in 1981 to only 12% of the 25 year average. Spawner abundance remained low in 1982 and 1983, although values for those years may be biased slightly low if regulatory changes imposed in 1981 reduced both harvest and exploitation.

Hassler developed a juvenile abundance index (JAI) based on trawl sampling in western Albemarle Sound. These data provide a long time series based on consistent methodology from which relative trends in abundance can be evaluated. Juvenile abundance varied considerably during the 1960s and 1970s, averaging 6.5 and ranging from 0.2 in 1958 to 23.4 in 1959. Between 1955 and 1977 only one observation fell below 2.0, while JAI values in 5 of the 6 years from 1978 to 1983 fell below 2.0 (Figure 6.2).

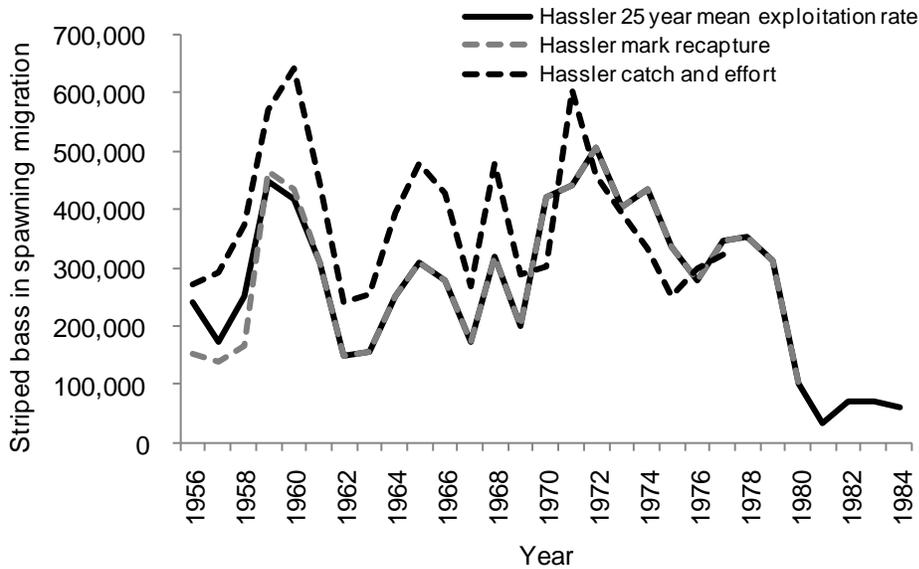


Figure 6.1 Estimated numbers of striped bass in the spawning migration ascending the Roanoke River, NC, 1956-1984.

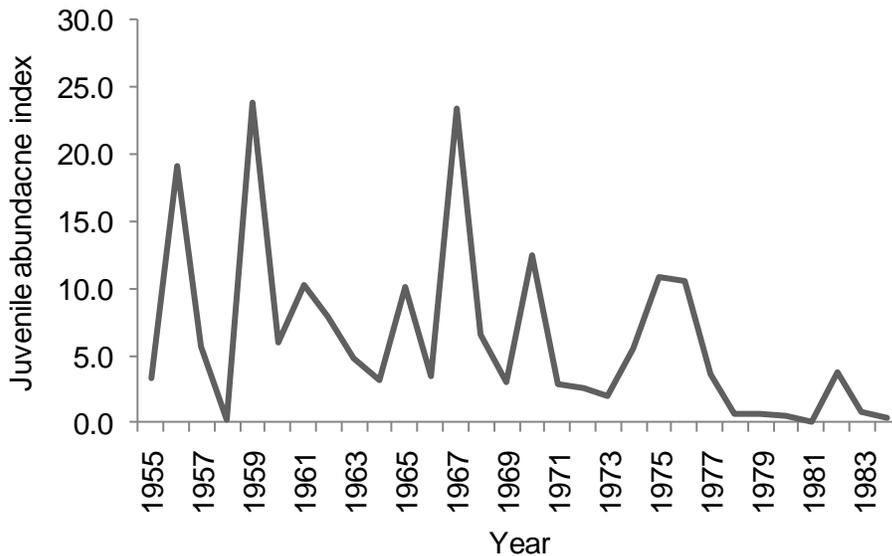


Figure 6.2 Juvenile abundance index values, 1955-1984.

Single year and multiple year exploitation rates were estimated annually from 1956-1984 (except 1975 due to lack of funds), based on the ratio of the tag returns to the total number of striped bass tagged annually. Striped bass were tagged in the lower Roanoke during April of each year. For the single year exploitation values, only the tags returned from the yearly tagging event through March 31 of the following year were used. The multiple year exploitation values utilized all tags returned, no matter how many years at large. In a few years some striped bass were tagged in the Albemarle Sound as well. The number of striped bass tagged annually ranged from 77 to 889 and averaged 451. During the 28 years of the tagging program

a total of 12,619 striped bass were tagged in the Roanoke River (n=12,262) and Albemarle Sound (n=357), with a total of 3,328 tags recovered (26.4%).

As with all long-term tagging programs, several conditions can affect the validity of both the yearly values and the time series trend. First, the reporting rate (proportion of tags recovered that are actually reported) must be constant. Hassler notes that the apparent reporting rate dropped considerably following regulatory changes in 1981, and changed the estimation procedure for spawner abundance accordingly. Tagging programs are also vulnerable to a decline in reporting rate over time, as anglers become saturated with the rewards and the novelty of capturing a tagged fish wanes. Second, tags must be retained for the annual values to be valid, and the retention rate must not change over time for the time series to be valid. Fish were tagged with three separate tags over the study: 1956-1964, streamer tag; 1965-1969, spaghetti tag; and 1970-1984 Floy T-bar anchor tag. Hassler attributed the decline in the proportion of tags recovered after 1970 to tag retention problems stemming from inadequately anchoring the T-bar tags. Finally, tagged and untagged fish must be equally vulnerable to harvest. Most fish were tagged in the lower Roanoke River, and many were recaptured soon after and downstream of release. Striped bass have a tendency to 'fall back', or return downstream toward estuarine areas when handled during migration (Carmichael et al. 1998), and thus the vulnerability of tagged fish to capture by the significant upriver fisheries was likely reduced.

The single year rate of exploitation and multiple year rate of exploitation follow similar trends, with the multiple year exploitation slightly higher than the single year exploitation (Figure 6.3). These data show considerable fluctuations in the rate of exploitation. Moreover, the exploitation rates decline after 1970 when the program adopted the T-bar anchor tags (with known retention problems).

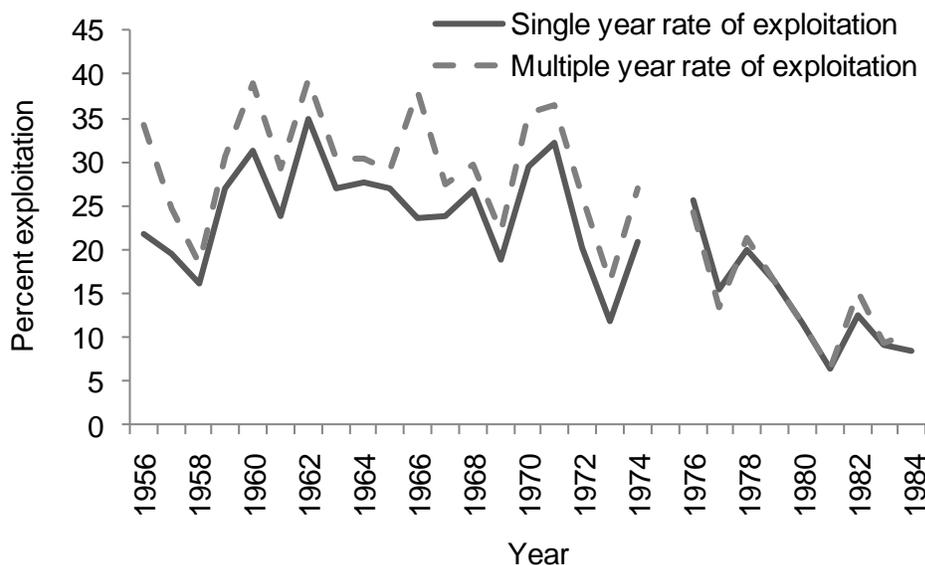


Figure 6.3 Single year and multiple year rates of exploitation for striped bass in the Roanoke River and Albemarle Sound, NC, 1956-1984.

Hassler estimated both egg production and egg viability. Egg production provides a measure of the magnitude of annual spawning, and egg viability provides a measure of egg survival. The

two measures together provide an indication of overall spawning success, with the product of eggs spawned and percent viability a measure of total viable egg production. Egg production increased during the 1960s, to a high of nearly 5 billion in 1972. Production dropped to around 2 million until 1979, then dropped sharply in 1980 and 1981 (Figure 6.4). Viability averaged nearly 90% until 1975 when it dropped to below 60%. There was some recovery in 1980 and 1981, but viability did not reach the pre-1975 average and dropped again in 1983. Although egg production did not vary appreciably from the long-term average until 1980, the decline in viability led to an overall decline in viable egg production after the 1972 peak, with viable egg production falling below 1 million by 1976 and remaining low for the next 8 years (Figure 6.5).

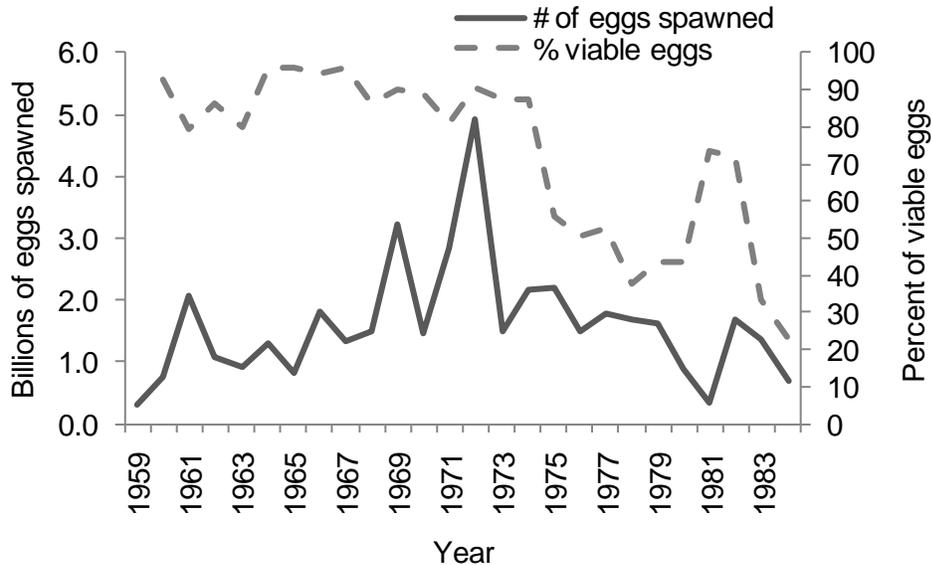


Figure 6.4 Total egg production and percentage of viable eggs, 1959-1984.

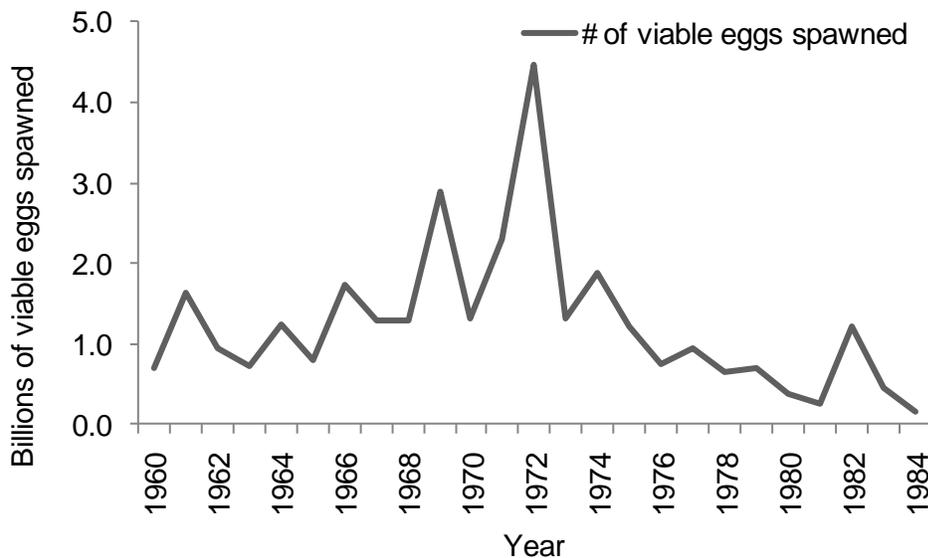


Figure 6.5 Total number of viable eggs spawned, 1960-1984.

A number of factors contributed to the decline in A/R striped bass stock in the late 1970s and early 1980s. Exploitation rates were beyond any level now believed to be sustainable throughout the series, and were at their highest levels in the late 1960s and early 1970s when declining egg production and poor juvenile survival began to drive down recruitment success. Any stock experiencing even moderate exploitation and reduced recruitment will begin to decline in abundance and biomass, and a stock that has sustained high exploitation for several generations has less reserve capacity and will typically show signs of decline within a few years. Spawning success generally declines as the average age in the population declines, and spawning magnitude declines as overall mature biomass declines.

Successful recruitment requires more than just spawning success and egg production; eggs must also hatch and juveniles must survive. Comparing juvenile abundance and total viable egg production, it is apparent that decreased juvenile survival may have been one of the earliest challenges to the stock (Figure 6.6). Egg production was highest in 1969 and 1972, yet JAI values in those years are among the lower values of the series. From the JAI, the only good year class produced from 1969 to 1973 was in 1970, even though viable egg production over these years was better than average. This suggests that poor larval survival may have been the cause of the initial recruitment failures.

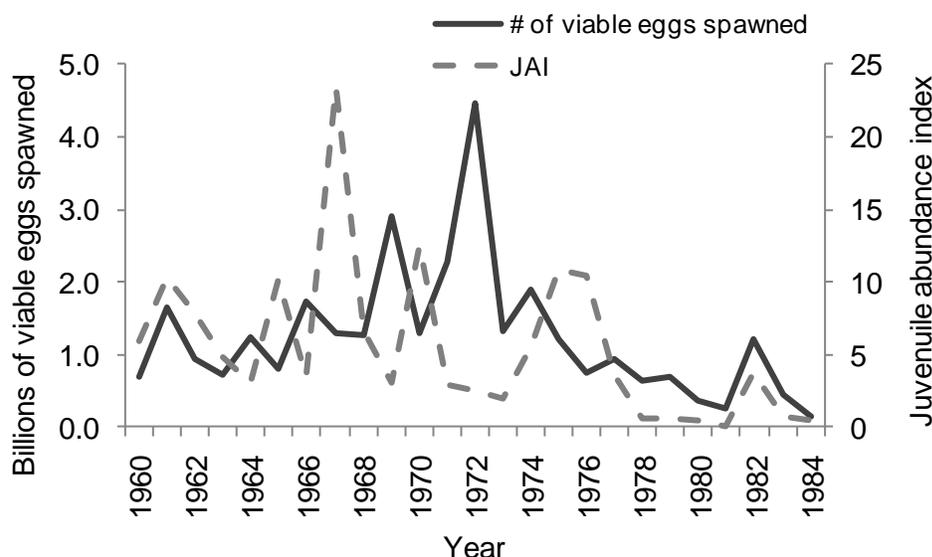


Figure 6.6 Juvenile abundance index and total viable egg production, 1960-1984.

High fishing mortality likely harvested any surplus stock generated by the strong 1970 year class within a few years, and with no other strong cohorts coming into the population, spawning stock abundance declined sharply after 1979. Reduced egg viability combined with declining egg production resulted in a steady decline in viable egg production after the 1972 peak. There is little information available from which to judge the reliability of the estimated decline in egg viability; the trend may be real or it may be an artifact of sampling. The USFWS Striped Bass Study Report to Congress (May 1992) suggests that the population age structure was truncated by the 1950s. Given that mortality estimates are high during the 1960s and 1970s, the age structure may have become severely truncated by the 1970s, with the spawning stock possibly composed of primarily first time spawners. First-time spawners produce fewer eggs and have a lower proportion of viable eggs than fish that have spawned multiple times. Some combination of truncated age structure, the possibility for a majority of the stock consisting of first-time spawners, an altered flow regime, and environmental degradation are likely to blame for the

decline in viable egg production reported by Hassler et al. (1980) in the mid-1970s. The moderate 1975 and 1976 year classes indicated by the JAI apparently sustained the fishery and the spawning stock biomass through 1979, but were largely removed by fishing by 1980, therefore spawner abundance dropped markedly. Support for this scenario is provided by NCDMF sampling of the age composition of the Albemarle Sound commercial fishery, which shows that in 1980 and 1981 nearly 80% of the harvest was composed of age 1 and 2 fish from the 1978-1980 cohorts.

Although additional management measures were imposed in 1981, the damage to the stock had already occurred. The few recruits produced by the stock in the early 1980s largely supported the fisheries and provided no improvement in spawner abundance. Commercial fishery harvest shifted from 3 to 5 year old fish in the 1970s to 1 and 2 year old fish in 1980 and 1981, then 2 and 3 year old fish under the increased minimum size after 1981. It is likely that recreational fisheries exhibited a similar shift, although no data are available on the recreational fishery age composition until the 1990s. The stock remained at low abundance and fishery yields remained low for over 10 years until the late 1990s.

6.1.2 Current Condition

The following information is excerpted from the most recent A/R striped bass stock assessment (Takade-Heumacher 2010) and annual ASMFC compliance reports summarizing monitoring programs conducted on the A/R striped bass stock (Godwin et al. 2010). The entire stock assessment document can be found in appendix 14.6.

Currently the A/R stock is not experiencing overfishing and is producing a sustainable harvest. The uncertainty associated with the precise level of spawning stock biomass (SSB) as estimated from the stock assessment prevents a determination from being made on the overfished status of the stock. However, based on annual monitoring programs conducted by the NCDMF and NCWRC, the SSB appears to be healthy, with a good amount of age 6+ females in the population, and a broad age structure with the current maximum age observed on the spawning grounds of 17.

Recruitment (age-1 fish) was below the estimated time series average (312,111 fish) for the first eight years of the stock assessment. In contrast, only three of the last eight years were below the time series average for age-1 fish. Recruitment estimated for the terminal year (2008) of the assessment was 202,000 fish. Peak recruitment of 618,000 fish occurred in 2006, and the minimum recruitment (45,000 fish) during the time series occurred in 1988 (Figure 6.7).

Spawning stock biomass has been increasing steadily since 1991. In 1991, the estimated SSB was 267,377 lb, with the highest SSB occurring in the terminal year at 3,998,921 lb. Between 1991 and 2008, there have been consistent gains in SSB. The lowest SSB occurred in 1985 at 244,823 lb (Figure 6.8).



Figure 6.7 Estimated recruitment of striped bass at age-1, 1982-2008.

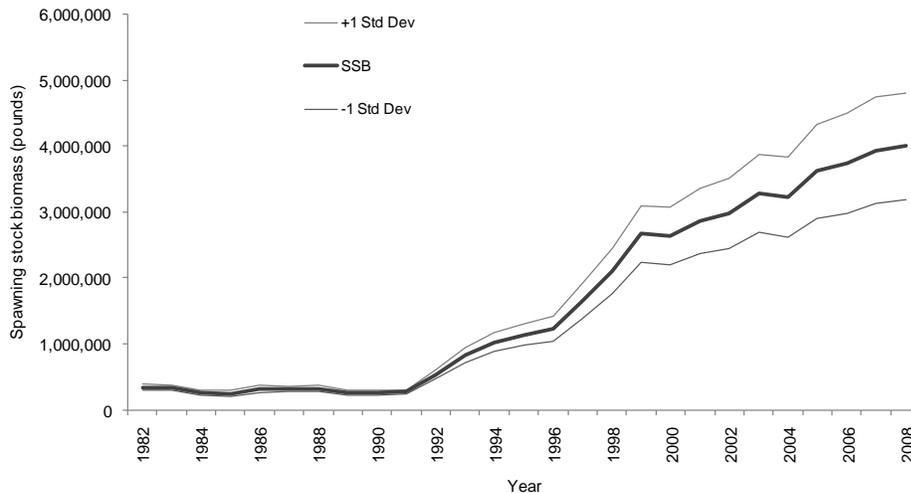


Figure 6.8 Spawning stock biomass of female striped bass, 1982-2008.

Total abundance showed an increasing trend for most of the time series. Total abundance peaked in 2007 at 2,051,000 fish. Prior to 1994, the total abundance was less than one million fish, while every year since 1994 the total abundance has been greater than one million fish (Figure 6.9). The abundance of age-9+ fish has also increased significantly, beginning in 1997. The terminal year age 9+ abundance was estimated to be 258,000 fish, which was a significant increase from the 1982 age-9+ abundance of 15,000 fish.

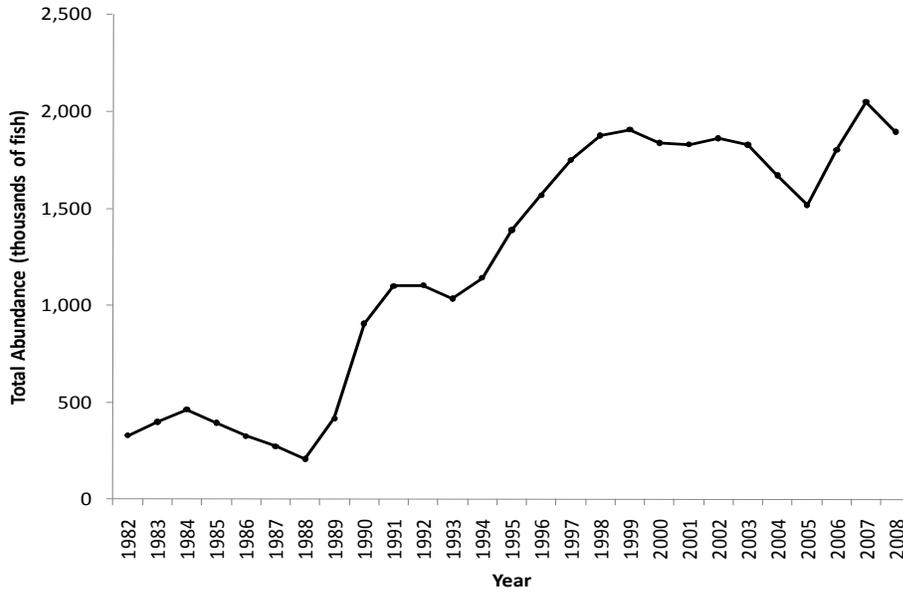


Figure 6.9 Estimated total striped bass annual abundance, 1982-2008.

The overall trend of fishing mortality (F) showed a recent decline from the earliest part of the time series. The average F on ages 4-6 peaked once in 1984 at 1.01. After 1988, there was a decline in F to one of the lowest in the time series in 1995 at 0.13. The F then began to slowly increase and hit a plateau from 2000 through 2004. Since 2004, the F has decreased from 0.34 to 0.10 in 2008, the lowest in the time series (Figure 6.10).

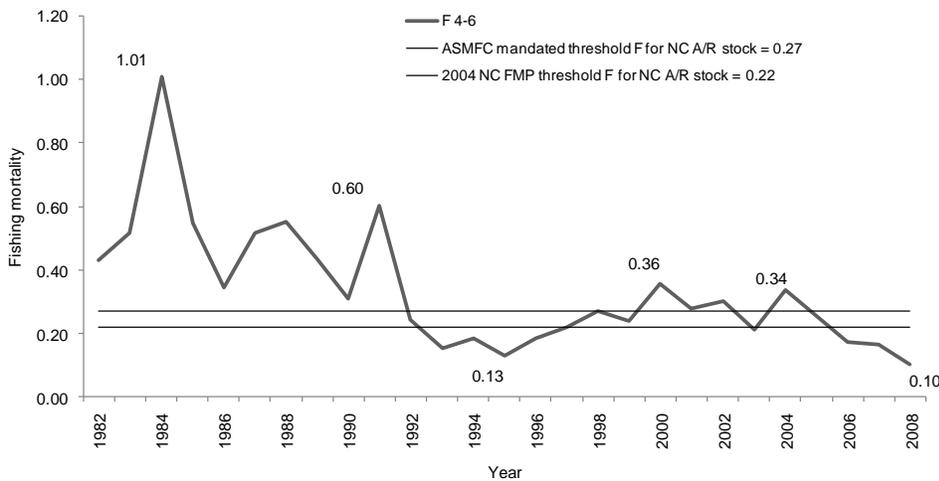


Figure 6.10 Estimated striped bass fishing mortality on ages 4-6, 1982-2008.

In comparing results from the stock assessment to independent monitoring data, both the total abundance and abundance of age 9+ fish sampled in the annual Roanoke River spawning stock electrofishing survey has increased steadily since the survey began in 1991 (Figures 6.11 and 6.12). The overall relative abundance of fish sampled on the spawning grounds is dominated by 3 and 4 year old males, which often comprise 80%-90% of the sample. In 2009, 4,761 fish were

sampled by electrofishing on the spawning grounds, of which 4,132 were age 2-4 (males = 3,448 and females = 684). The number of age 9+ fish collected in 2009 totaled 127. To date, the oldest fish collected on the spawning grounds is 17 years old. By contrast, in the early years of the survey the age structure of the stock was truncated, with few fish over 6 years old collected. This expansion in the age structure of the stock supports the conclusion of the stock assessment that the A/R stock is not experiencing overfishing. A broad age structure is also vital to maintain a healthy stock as females tend to produce more viable eggs as they age. The fecundity (amount of eggs produced) of female striped bass increases about 100,000-200,000 eggs with each year of growth. Average fecundity of a 3 year old mature female is about 181,000 while a 16 year old fish may produce 5,000,000 eggs (Olsen and Rulifson 1992). A broad age structure also helps protect the stock from single year or consecutive years of spawning failures due to uncontrollable environmental conditions, such as flood or drought conditions during the spawning period.

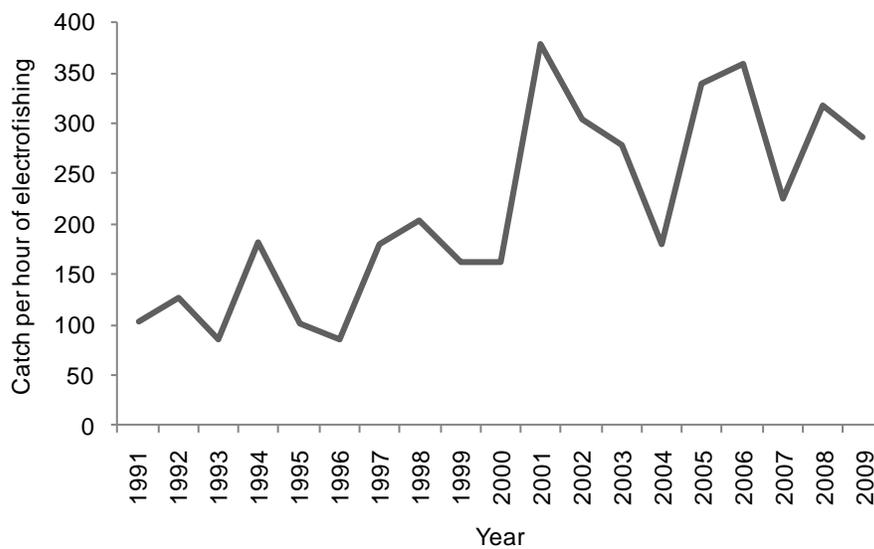


Figure 6.11 Catch per unit of effort (fish/hour) of striped bass collected on the spawning grounds during the A/R striped bass spawning stock electrofishing survey, Roanoke River, North Carolina.

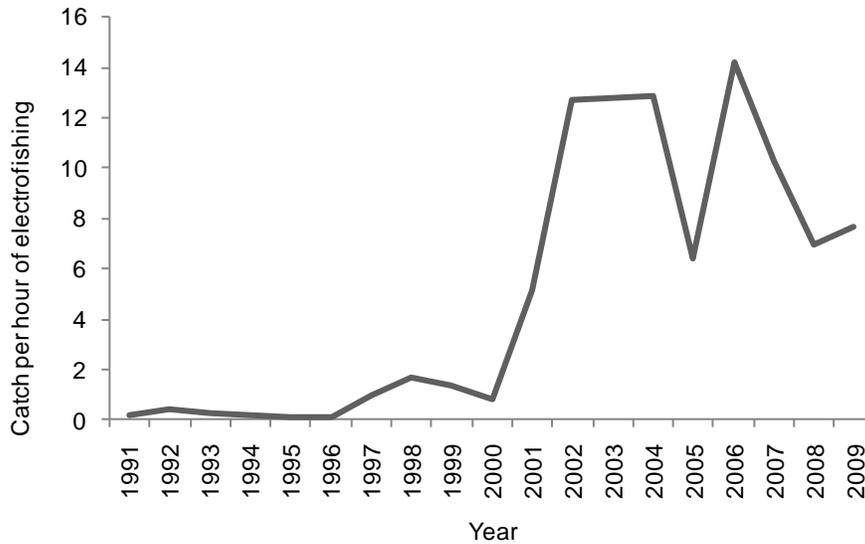


Figure 6.12 Catch per unit of effort (fish/hour) of age 9+ striped bass collected on the spawning grounds during the A/R striped bass spawning stock electrofishing survey, Roanoke River, North Carolina.

While total abundance has seen an overall increase during the time series, the stock did experience a decline in abundance of age 4-6 fish in 2007 and 2008 when compared to the abundance in 2000-2006 (Figure 6.13). As noted in Figure 6.13, juvenile production as measured by the A/R JAI was variable from 1955 through 1977, with a few really good years of spawning success, a few really poor years, and the rest could be classified as average. This is typical of anadromous fish that spawn in inland coastal rivers where environmental conditions can be highly variable from year to year. This environmental variability is most closely related to spring rains and hence river flow. River flow is one of the most critical components of striped bass spawning success.

The average JAI for 1955-1977 was 8.4. In 1978 the stock experienced the first of several years of continued spawning failures. From 1978-1987 the average JAI was 0.82, with only 1982 having what could be considered even close to an average JAI of 3.82. In 1988 and 1989 the stock experienced successful spawns in consecutive years for the first time in 11 years, since 1975 and 1976. By the early 1990s state and federal fishery managers were doing everything possible to protect what part of the stock remained as well as improve spawning success. Actions included harvest reductions of 80%, the implementation of three additional monitoring programs, numerous studies determining the optimal springtime flow regime in the Roanoke River that would provide the potential for successful spawning, and the formation of a committee to work cooperatively with the United States Army Corps of Engineers (USACE) to implement an optimal spawning flow regime.

All of these efforts set the stage for what would become a remarkable stock recovery. For six consecutive years, 1993-1998, the stock experienced successful spawns, with three of those years, 1993, 1994, and 1996, having the highest JAIs on record to date. There was an unsuccessful spawn in 1999, followed in 2000 by what remains the highest JAI on record of 58.8. The average JAI from 1993-2000 was 24.5, three times the average JAI of the entire time series prior to stock collapse in 1978. The unprecedented spawning success from 1993-2000 led to very high levels of age 4-6 abundance and thus the increased harvest rates in the commercial and recreational fisheries.

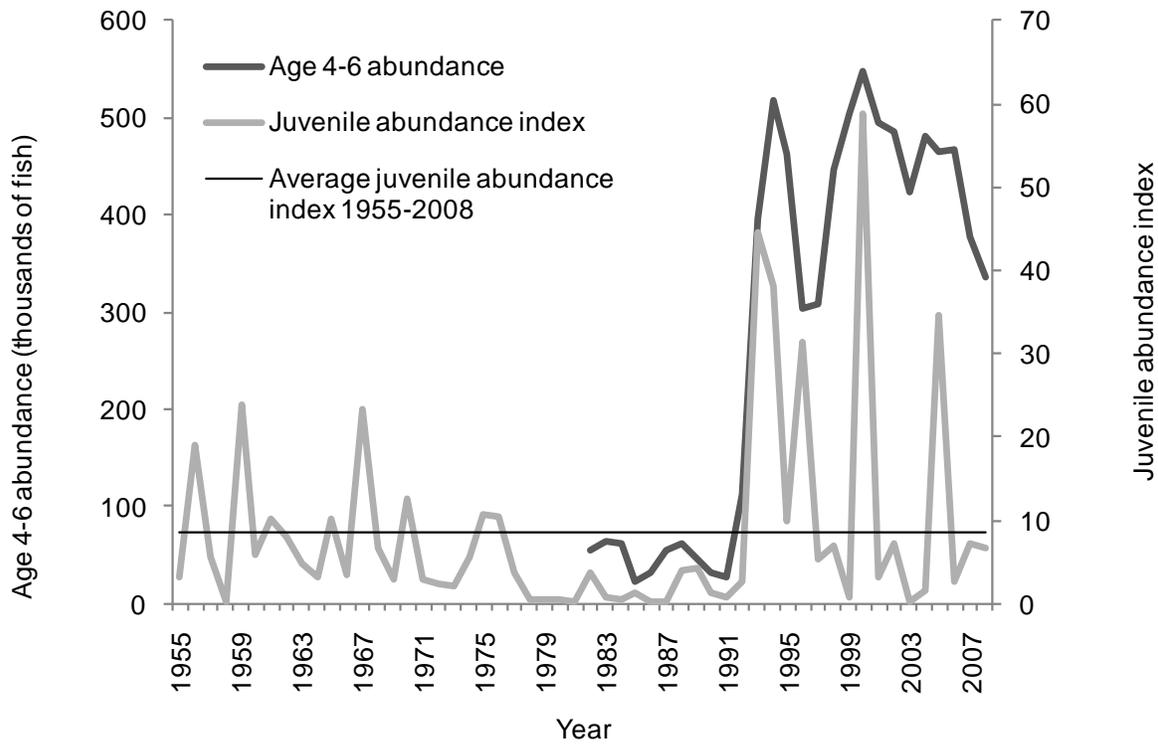


Figure 6.13 Estimated abundance of age 4-6 A/R striped bass from the latest stock assessment (1982-2008), and the annual juvenile abundance index for the A/R stock (1955-2008).

It was not reasonable to expect this level of spawning success, and therefore harvest, to continue. The period from 2001-2008 had an average JAI of 8.0, which is close to the historical average JAI prior to stock collapse of 7.9. The stock also experienced two consecutive years of very poor spawns, in 2003 and 2004. This led to the decline in age 4-6 abundance seen in the last few years of the stock assessment. Since the last exceptional spawn in 2005, the stock has averaged a JAI of 5.2 (2006-2010), slightly below the long-term series average of 8.4.

6.2 CENTRAL SOUTHERN MANAGEMENT AREA STOCKS

6.2.1. Historical Conditions

In North Carolina, estuarine striped bass of the Tar/Pamlico, Neuse and Cape Fear watersheds are managed as an internal stock in a management unit recognized formally as the CSMA. The CSMA striped bass historical conditions are not as well documented as those of the ASMA. The CSMA striped bass catch has accounted for an average of 5.9% of the North Carolina striped bass commercial landings from 1930 through 1960 (Chestnut and Davis 1975, NCDMF 2004). Since the CSMA commercial quota has been established, CSMA striped bass landings have accounted for a total of 13% of all striped bass commercial landings in internal waters. For more information refer to Section 7 Status of the Fisheries.

In the 2004 North Carolina Estuarine Striped Bass FMP (NCDMF 2004) exploitation rates for the CSMA were estimated from catch curves using data from electrofishing surveys conducted by the NCWRC on the spawning grounds of the Tar/Pamlico and Neuse rivers. Available data at the time were inadequate to estimate F and SSB targets and thresholds, so the ASMA target F of 0.22 was used as a proxy for the CSMA stocks. The CSMA F rates from the catch curves for the Tar/Pamlico and Neuse river stocks were compared to the F target to determine the stock status. The Tar/Pamlico and Neuse River striped bass F rates were significantly higher than the target F and thus, it was determined that overfishing was occurring on these stocks (NCDMF 2004). Regulatory actions were implemented in July 2008 by the NCWRC and the NCMFC with the objective of reducing overall fishing mortality in the Neuse and Tar/Pamlico rivers by ~64% and disallowing any commercial and recreational harvest in the Cape Fear River. (See Section 7.0 and Appendix 14.7).

Given the lack of historical data it is difficult to compare the current stock condition to historical stock conditions. Also, a reasonable expectation of what constitutes a “good” population in the CSMA riverine systems is needed in order to judge the current stock condition. In some instances comparisons from other systems might be used in order to determine a “good” stock level. Unfortunately there are many variables that differ between the CSMA and other systems (see Section 10.0 Environmental Status).

6.2.2. Current CSMA Stocks Conditions

The index-based method of catch curve analysis was used to assess the status of striped bass populations in the CSMA (NCDMF 2010, Appendix 14.7). Exploitation and mortality were estimated for the Tar/Pamlico and Neuse river stocks using CPUE from the NCWRC electrofishing spawning grounds survey and the NCDMF Program 915 independent gill net survey. Catch curve techniques in this case, will not detect small scale changes in population characteristics. For this reason, catch curve results (especially annual estimates of mortality) were supplemented with additional quantitative information (such as trends in mean CPUE).

As shown in the CSMA 2010 stock assessment the large confidence intervals and lack of precision in the catch curves Z estimates (total mortality rate) make them unsuitable for making a stock determination (NCDMF 2010). This view was supported by the peer reviewer comments. The lack of adequate data causes the CSMA stocks to be quantitatively assessed as unknown and to be listed as “concern” in the NCDMF annual stock status report (NCDMF 2010). The stocks may be reassessed during the next five year FMP amendment as more data become available through the completion of the numerous research recommendations (List 1). Improvements in the age structure of the CSMA striped bass stocks are expected from the regulatory restrictions implemented under the 2004 FMP and from the protective measures for endangered species implemented in May 2010 (see Section 8). The need for continued conservation management efforts at this time are supported by the constrained size and age distributions, low abundance, and the absence of older fish in the spawning ground surveys. Since the 2004 FMP there has been little change in the size and age distribution with few age 6 and older fish observed from any given cohort in any system.

In order to perform a thorough stock assessment in the future there are several research gaps that need to be fulfilled (NCDMF 2010):

List 1. Research Recommendations from the CSMA stock assessment (2010) (H- High priority, M- Medium priority, and L- Low priority).

Life History

- Determine system of origin of fish on the spawning grounds (H).
- Acquire life history information: maturity, fecundity, size and weight at age, egg and larval survival (short term research projects) (H).
- Conduct a mark-recapture study utilizing conventional tags and telemetry approaches (expanded program) (H).
- Determine if suitable striped bass spawning conditions exist in the Tar/Pamlico, Neuse, and Cape Fear rivers (M).
- Conduct egg abundance and egg viability studies (M).
- Determine contribution of stocked fish to spawning stock (M).
- Determine extent of spawning grounds (L).

Fishery Dependent Surveys - Recreational and Commercial

- Improve discard estimates and discard biological characteristics from commercial fisheries (trip level observer coverage) (M).
- Obtain biological characteristics such as length, weight, age, and sex of recreational harvest (expanded creel surveys) (M).
- Obtain biological characteristics such as length, weight, age, and sex of commercial harvest (increased sampling, age structure collection) (M).
- Improve discard estimates and discard biological characteristics from recreational fisheries (creel survey) (L).
- Conduct delayed mortality studies for recreational and commercial gear (short term research projects) (L).

Fisheries Independent Surveys

- Conduct independent surveys that adequately capture all life stages of striped bass (H).
- Conduct a short term study to determine vulnerability-at-length for survey gears (L).

6.2.3 Tar/Pamlico River Stock

The Tar River and Neuse River stocks are similar and showing no signs of improvement. Results of the 2004 FMP estimated that total mortality was excessive. The size and age distributions have not changed with few fish older than age 6 being collected. Annual CPUE were generally higher in the Tar River than the Neuse River. The NCWRC spawning grounds survey (1996- 2009) ranged from 19.5 fish/ hour in 1996 to 80.2 fish /hour in 2005 while the NCDMF Program 915 ranged from 0.7 to 1.7 fish per sample. Catch curves for the Tar River included ages 3 through 7. For the NCWRC spawning grounds survey, ages 3 through 5 varied over time with no trends until 2005 where there is a slight increasing trend. There has been increase in age 3 fish observed since 2005 while age 6 have been declining since 2000 and age 7 have been declining since 2004. NCDMF Program 915 trends are similar to those of the NCWRC survey (Appendix 14.7).

6.2.4 Neuse River Stock

Results of the 2004 catch curve analysis suggested that cohort mortality was excessive for the Neuse River stock of striped bass. Since the 2004 FMP, there has been little change to the size and age distributions and few older fish (age > 6) have been collected. Annual CPUE from the NCWRC spawning grounds survey on the Neuse River ranges from a low of 4.8 fish per hour in 2006 to a peak of 22.7 fish per hour in 2009 while the NCDMF Program 915 survey CPUE

ranged from 0.6 to 1.2 per sample. Catch at age showed little to no trend for ages 3 through 5 while age 6 showed a decreasing trend in both surveys.

6.2.5. Cape Fear River Stock

A no harvest moratorium was established for striped bass in the Cape Fear River and its tributaries by the NCMFC and the NCWRC in 2008 as a result of research recommendations identified in the 2004 North Carolina Estuarine Striped Bass Fishery Management Plan (NCDMF 2007). Recreational and commercial harvest was closed due to apparent overfishing and low abundance of striped bass in the spawning ground survey conducted by the NCWRC. Efforts to quantify the current trends in the population size of striped bass in the Cape Fear River have been hindered by a limited time series as well as an incomplete cohort comprised of relatively few fish as compared to the other systems in the CSMA.