Northeast Fisheries Science Center Reference Document 08-03a & b

*A Report of the 46th Northeast Regional Stock Assessment Workshop*

# 46th Northeast Regional Stock Assessment Workshop (46th SAW)

## Part A. Assessment Report
## Part B. Assessment Report Appendixes

February 2008

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07-21 *Monkfish Assessment Report for 2007*, by the Northeast Data Poor Stocks Working Group. December 2007.

07-22 *Validating the Stock Apportionment of Commercial Fisheries Landings Using Positional Data from Vessel Monitoring Systems (VMS)*, by MC Palmer and SE Wigley. December 2007.

08-01 *46th SAW Assessment Summary Report*, by the 46th Northeast Regional Stock Assessment Workshop (46th SAW). January 2008.

08-02 *A brief description of the discard estimation for the National Bycatch Report*, by SE Wigley, MC Palmer, J Blaylock, and PJ Rago. January 2008.

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# Part A. Assessment Report

**U.S. DEPARTMENT OF COMMERCE**
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

February 2008

## Northeast Fisheries Science Center Reference Documents

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# INTRODUCTION TO SAW-46 ASSESSMENT REPORT

The Northeast Regional Stock Assessment Workshop (SAW) process has three parts: preparation of stock assessments by the SAW Working Groups and/or by the Atlantic States Marine Fisheries Commission (ASMFC) Technical Committees/Assessment Committees; peer review of the assessments by a panel of outside experts who judge the adequacy of the assessment as a basis for providing scientific advice to managers; and a presentation of the results and reports to the Region's fishery management bodies.

Starting with SAW-39 (June 2004), the process was revised in two fundamental ways. First, the Stock Assessment Review Committee (SARC) is now a smaller panel with panelists provided by the University of Miami's Independent System for Peer Review (Center of Independent Experts, CIE). Second, the SARC no longer provides management advice. Instead, Council and Commission teams (e.g., Plan Development Teams, Monitoring and Technical Committees) formulate management advice, after an assessment has been accepted by the SARC.

Reports that are produced following SAW/SARC meetings include: a*ssessment summary report* – a brief summary of the assessment results in a format useful to managers; this a*ssessment report* – a detailed account of the assessments for each stock; and the *SARC panelist report* – a summary of the reviewers' opinions and recommendations as well as appendixes consisting of a report from each panelist. SAW/SARC assessment reports are available online at http://www.nefsc.noaa.gov/nefsc/publications/series/crdlist.htm. The CIE review reports and assessment reports can be found at http://www.nefsc.noaa.gov/nefsc/saw/.

The 46th SARC was convened in Woods Hole at the Northeast Fisheries Science Center, November 26–29, 2007, to review one assessment (striped bass, *Morone saxatilis*). CIE reviews for SARC-46 were based on detailed reports produced by the ASMFC Striped Bass Technical, Stock Assessment, and Tagging Committees.

This introduction contains a brief summary of the SARC comments, a list of SARC panelists, the meeting agenda, a list of working group meetings, and a list of attendees (Tables 1–4). Maps of the Atlantic coast of the USA and Canada are also provided (Figures 1–5).

**Outcome of Stock Assessment Review Meeting**

The SARC review committee concluded that the assessment team successfully met all of its terms of reference. The extensive data available for the assessment appeared to be correctly compiled and used in the assessment, and the analyses were made in accordance with good scientific practice.

The review committee found that, of the candidate assessment models, the statistical catch-at-age model (SCA) best estimated parameters that could be judged against the current biological benchmarks, 1995 spawning stock biomass and fully recruited fishing mortality rate at maximum sustainable yield. Based on these, the SARC agreed with the assessment team's stock status determination that striped bass is not currently overfished and overfishing is not occurring. Fishing mortality has increased in recent years and is currently (data up to and including 2006) at or very near the target level.

The review committee was impressed with the amount of detailed spatial data that was available. They suggested that this has the potential to be used more fully, which might reduce the difficulties encountered in the current global assessment model, e.g. conflicting abundance indices.

In addition, the SARC identified topics that deserve special attention or could be improved in future assessments. These include: examining sensitivity of assessment results to discard estimates and improving those estimates; age determination for striped bass older than about age 10; extracting more information out of the young-of-year indices; employing better methods of averaging multiple survey indices; using regional surveys to get direct information about differences in recruitment levels for the sub-stocks of the fishery; and better standardization of state surveys.

***EDITOR'S NOTE: The appendixes referred to in this striped bass assessment report are published as Northeast Fisheries Science Center Reference Document (CRD) 08-23b, at the back of this volume.***

Table 1. 46th Stock Assessment Review Committee Panel

46th Northeast Regional Stock Assessment Workshop (SAW 46)
**Stock Assessment Review Committee (SARC) Meeting**

November 26-29, 2007
Woods Hole MA

**SARC Chairman:**

Michael Murphy, chair
Florida Fish and Wildlife Conservation Commission
Fish and Wildlife Research Institute
100 Eighth Avenue SE
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Email: Mike.Murphy@MyFWC.com

**SARC Panelists (CIE):**

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Table 2. Agenda, 46th Stock Assessment Review Committee Meeting

46th Northeast Regional Stock Assessment Workshop (SAW 46)
**Stock Assessment Review Committee (SARC) Meeting**

Stephen H. Clark Conference Room – Northeast Fisheries Science Center
Woods Hole, Massachusetts
**November 26 - 29, 2007**
Sessions are open to the public, except where indicated.
AGENDA (11-24-07)

| TOPIC | PRESENTERS | RAPPORTEURS |
|---|---|---|
| **Monday, 26 November (1:00 – 5:00 PM)……………………………………….………** | | |
| Welcome | James Weinberg, SAW Chairman | |
| Introduction | Mike Murphy, SARC Chairman | |
| Agenda | | |
| Conduct of Meeting | | |
| Striped bass (A) | Gary Nelson & Beth Versak | |
| | Gary Shepherd & Nichola Meserve | |
| SARC Discussion | Mike Murphy | |
| **Tuesday, 27 November (9 AM – Noon)…………………………………..……** | | |
| Striped bass (A) – finish presentations. | | |
| | Beth Versak, Gary Nelson, Doug Grout Gary Shepherd & Nichola Meserve | |
| SARC Discussion | Mike Murphy | |
| **Tuesday, 27 November (1:15 PM – 5 PM)……..…………………………………** | | |
| Q&A #1 between Reviewers and All Presenters, clarification of any issues. (Open Meeting) | | |
| | Gary Shepherd & Nichola Meserve | |
| SARC Discussion | Mike Murphy | |
| **Wednesday, 28 November (9 AM – Noon) ……………………………….….……** | | |
| SARC Panel deliberations/report writing (Closed Meeting). | | |
| **Wednesday, 28 November (1:15 PM – 3:45 PM)………………………….….……** | | |
| Q&A #2 between Reviewers and All Presenters, clarification of any issues. (Open Meeting) | | |
| | Gary Shepherd & Nichola Meserve | |
| SARC Discussion | Mike Murphy | |
| **Wednesday, 28 November (3:45 PM – ) ………………………………….….……** | | |
| SARC Report writing (Closed Meeting). | | |
| **Thursday, 29 November ……………………..……………………………….….……** | | |
| SARC Report writing (Closed Meeting). | | |

Table 3. 46th Stock Assessment Workshop, list of working groups and meetings

| Assessment Group | Chair | Species | Meeting Date/Place |
|---|---|---|---|
| ASMFC Technical Committee | | | |
| | Mr. Doug Grout, New Hampshire Fish and Game | | |
| ASMFC Stock Assessment Committee | | | |
| | Dr. Gary Nelson, Mass. Division of Marine Fisheries | | |
| ASMFC Tagging Committee | | | |
| | Ms. Beth Versak, Maryland Dept. Natural Resources | | |

**Committee Members:**
Michael Brown, Maine Department of Marine Resources
Gary Shepherd, Northeast Fisheries Science Center
Laura Lee, Rhode Island Division of Fish and Wildlife
Dr. Vic Crecco, Connecticut Bureau of Marine Fisheries
Andy Kahnle, New York DEC Marine Resources
Vic Vecchio, New York DEC Marine Resources
Kathy Hattala, New York DEC Marine Resources
Brandon Muffley, New Jersey Department of Fish, Game and Wildlife
Heather Corbett, New Jersey Department of Fish, Game and Wildlife
Dr. Des Kahn, Delaware Division of Fish and Wildlife
Dr. Alexei Sharov, Maryland Department of Natural Resources
Dr. Linda Barker, Maryland Department of Natural Resources
Rob O'Reilly, Virginia Marine Resources Commission
Dr. John Hoenig, Virginia Institute of Marine Science
Robert Harris, Virginia Institute of Marine Science
Phil Sadler, Virginia Institute of Marine Science
Dr. Stuart Welsh, West Virginia Wildlife and Fisheries Cooperative Research Unit
Charlton Godwin, North Carolina Division of Marine Fisheries
Dr. Wilson Laney, US Fish and Wildlife Service
Tina McCrobie, US Fish and Wildlife Service
and
Nichola Meserve, ASMFC Coordinator

Table 4. 45th SAW/SARC, List of Attendees

| | |
|---|---|
| D. Dow | NEFSC |
| S. Pautzke | NEFMC |
| S. Lucey | NEFSC |
| G. Nesslage | ASMFC |
| L. Brooks | NEFSC |
| J. Blaylock | NEFSC |
| C. Legault | NEFSC |
| J. S. Thompson | MASS. DMF |
| P. Nitschke | NEFSC |
| M. Fogarty | NEFSC |

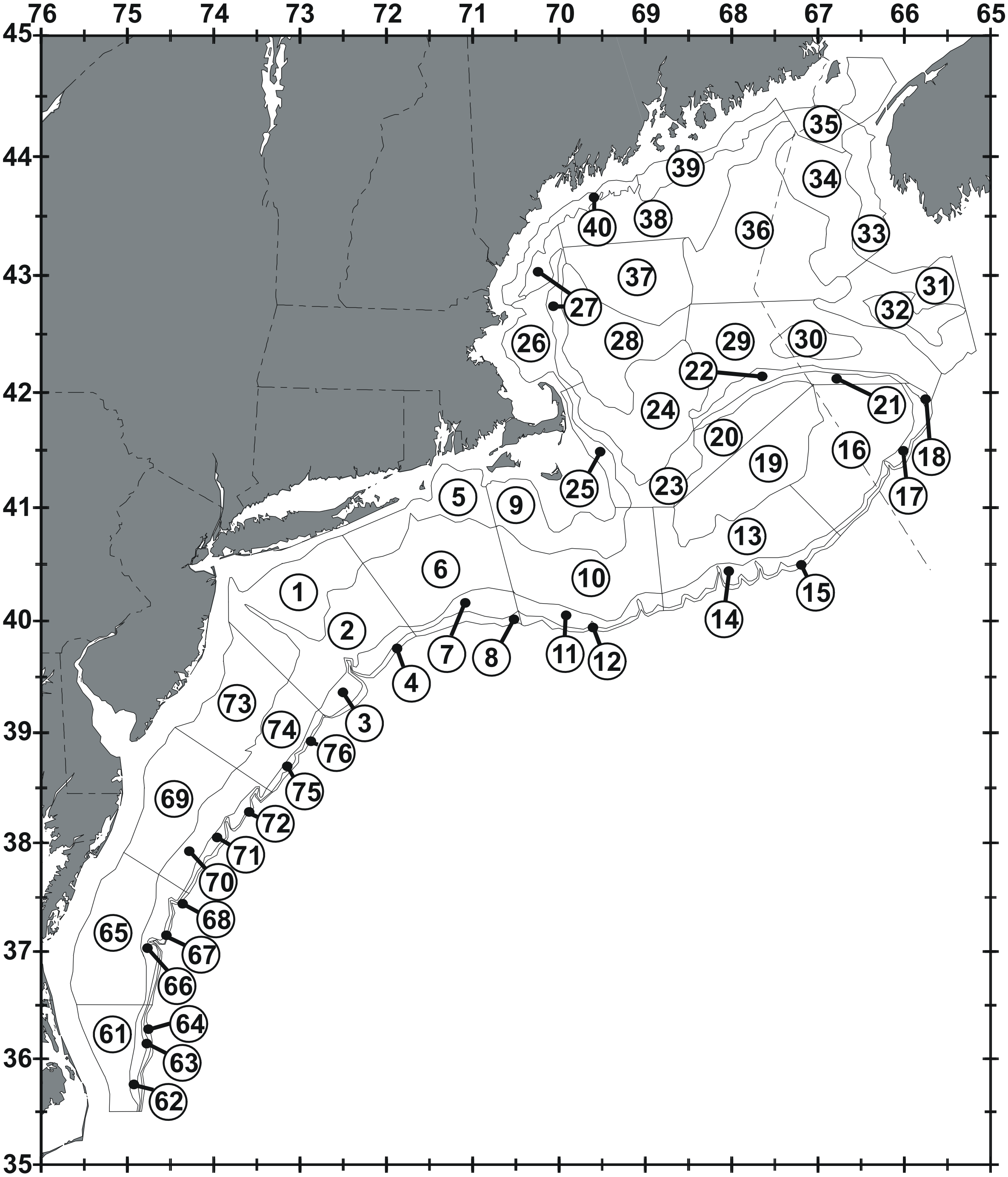


Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

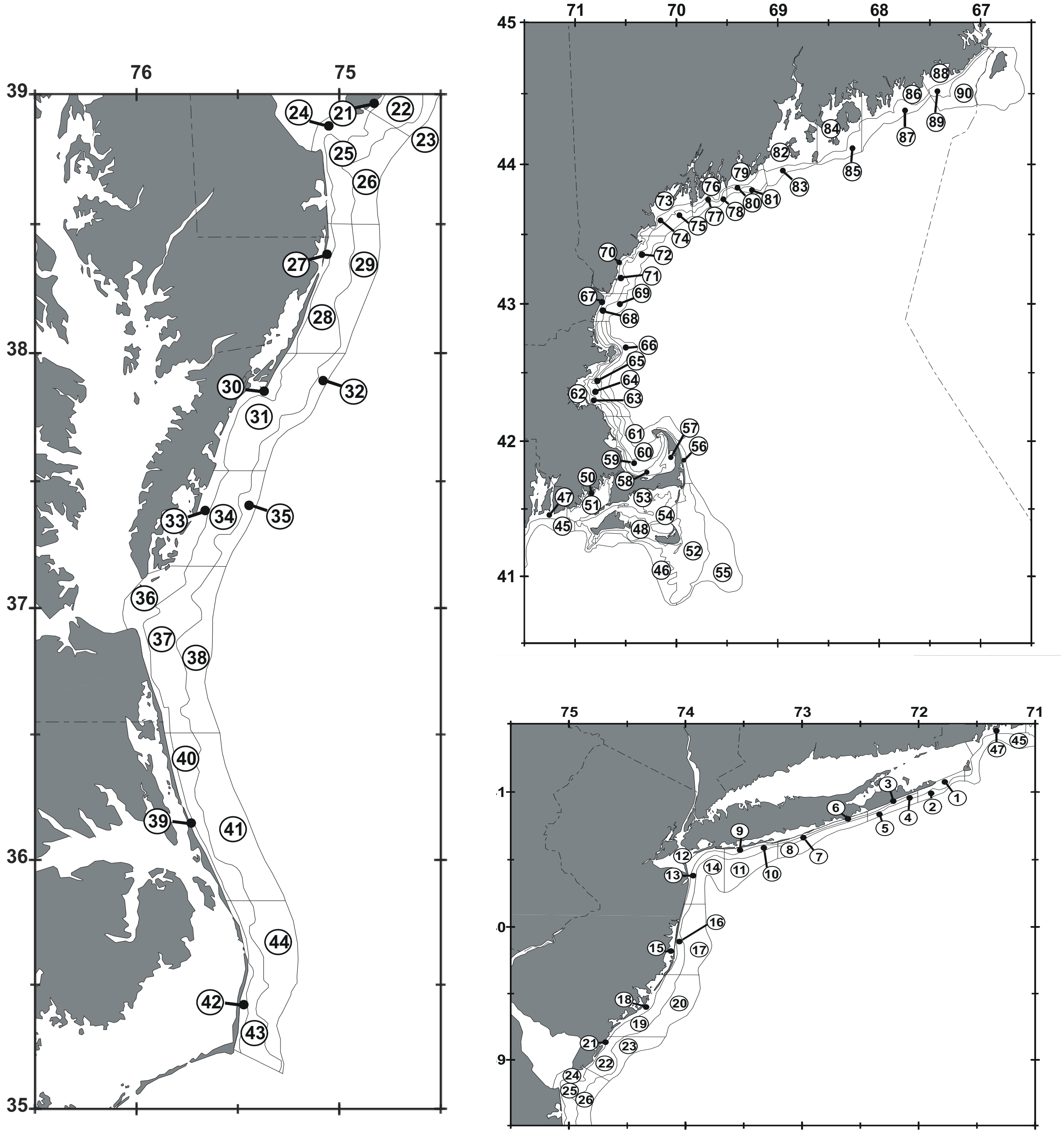


Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

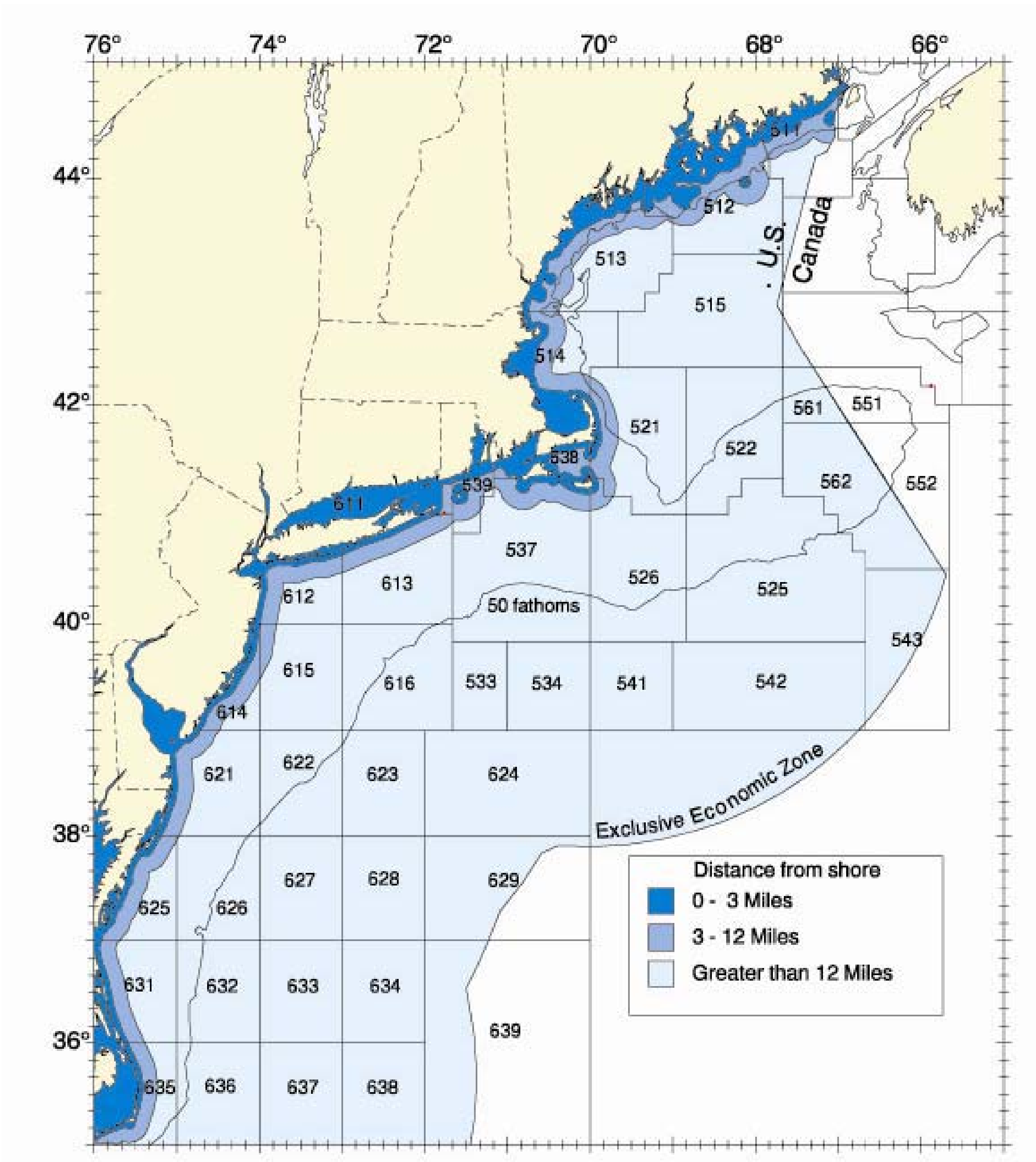


Figure 3. Statistical areas used for reporting commercial catches.

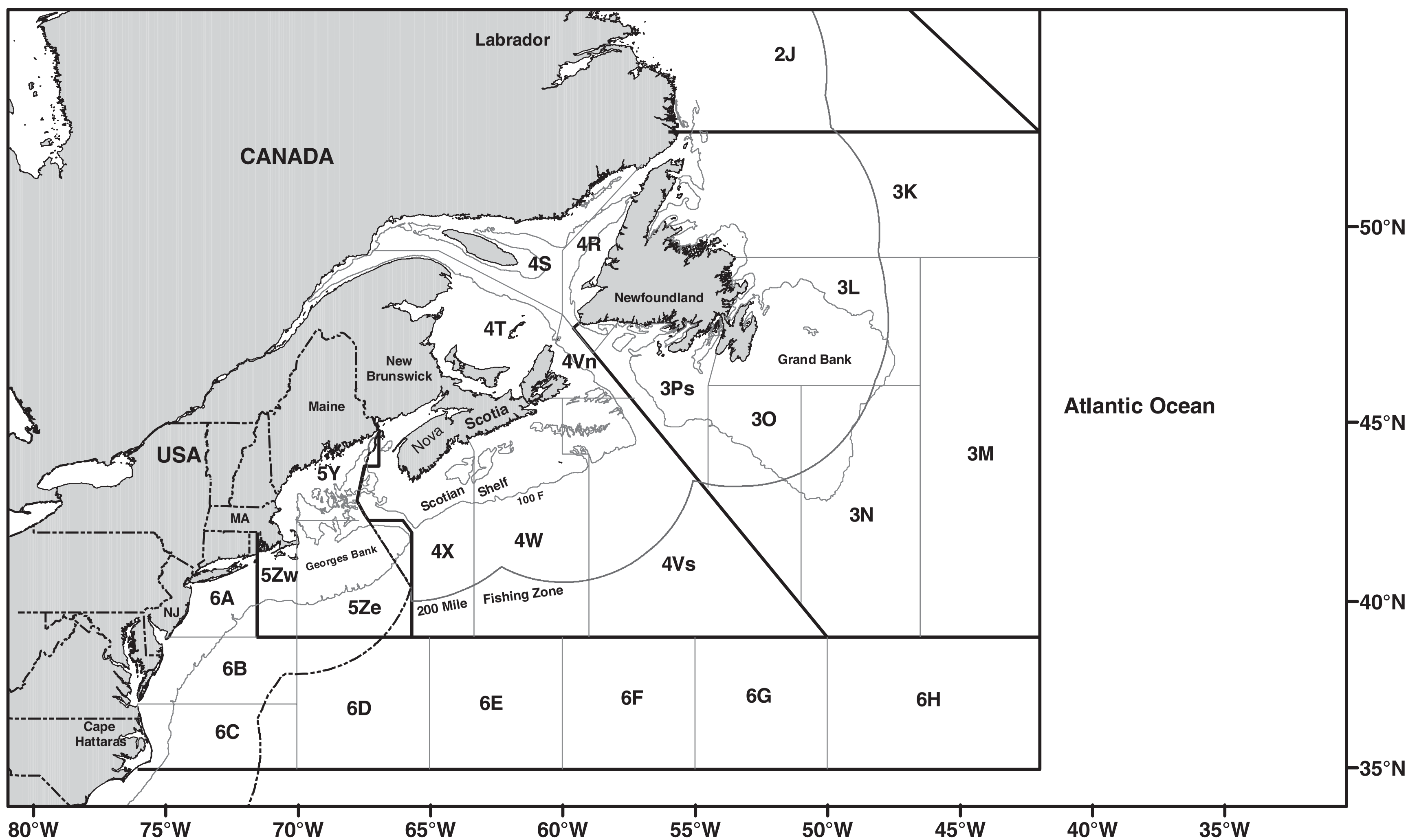


Figure 4. Catch reporting areas of the Northwest Atlantic Fisheries Organization (NAFO) for Subareas 3-6.

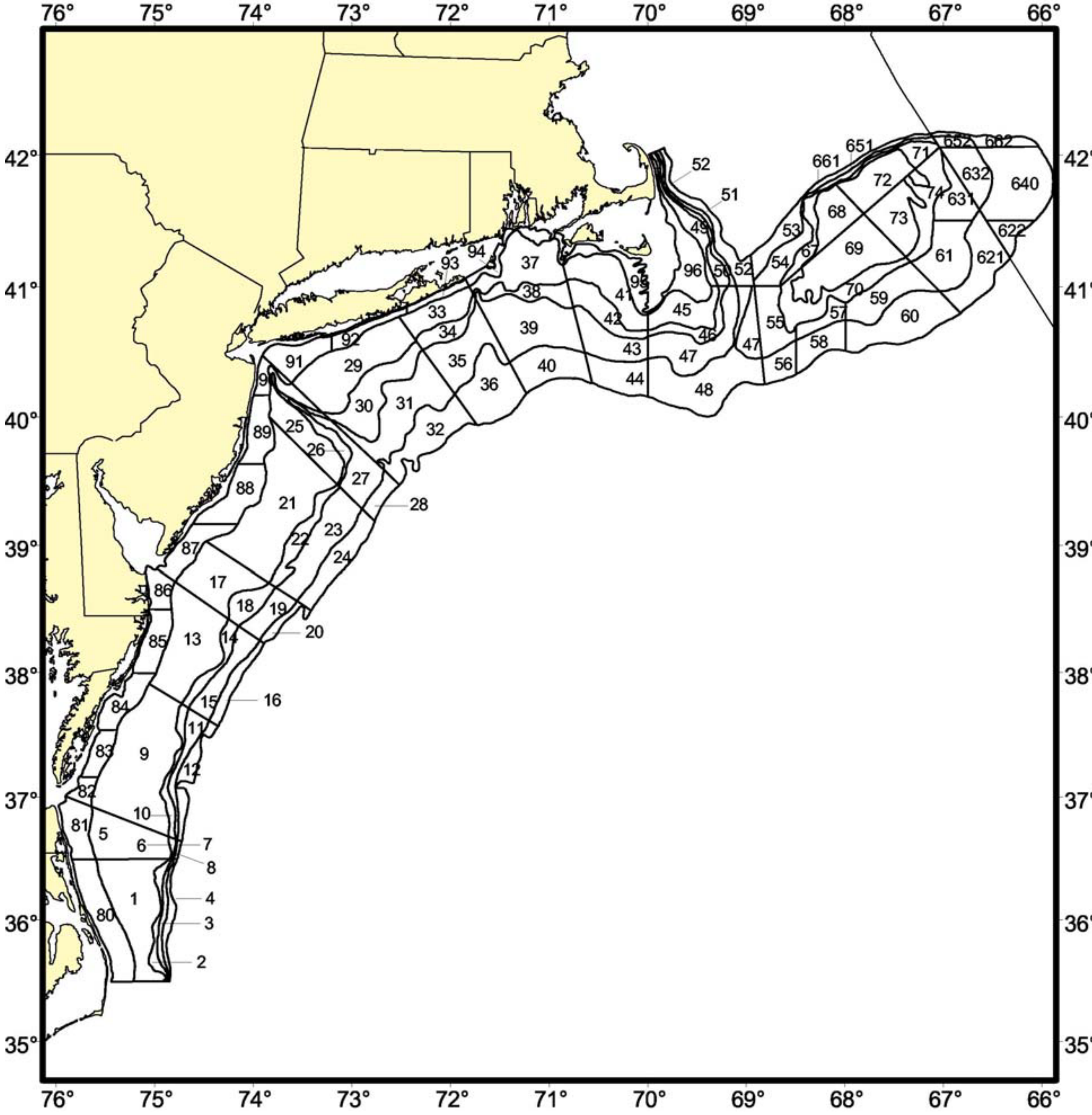


Figure 5. Shellfish strata for NEFSC resource surveys.

# A. ASSESSMENT OF ATLANTIC STRIPED BASS

## A1.0 CONTRIBUTORS

See Table 3 in the Introduction.

## A2.0 TERMS OF REFERENCE (TOR) FOR STRIPED BASS

1. Characterize the commercial and recreational catch including landings and discards.
2. Characterize the fisheries independent and dependent indices of abundance.
3. Evaluate the Statistical Catch at Age (SCA) model and its estimates of F, spawning stock biomass, and total abundance of Atlantic striped bass, along with the uncertainty of those estimates.
4. Evaluate the Baranov's catch equation method and associated model components applied to the Atlantic striped bass tagging data. Evaluate estimates of F and abundance from coastwide and Chesapeake Bay-specific tag programs along with the uncertainty of those estimates.
5. Review the Instantaneous Rates Tag Return Model Incorporating Catch-Release Data (IRCR) and estimates of F on Atlantic striped bass. Provide suggestions for further development of this model for future use in striped bass stock assessments.
6. Review the Forward-Projecting Statistical Catch-At-Age Model Incorporating the Age-Independent Instantaneous Rates Tag Return Model and estimates of F, spawning stock biomass, and total abundance of striped bass. Provide suggestions for further development of this model for future use in striped bass stock assessments.
7. Evaluate the current biological reference points for Atlantic striped bass from Amendment 6 and determine stock status based on those reference points*.

***EDITOR'S NOTE: In this striped bass assessment report, the meaning of TOR 7 was clarified during the independent peer review. In addition to determining stock status, the purpose of TOR 7 was to review the methods used to determine the current biological reference points, and to get the reviewer's opinion on whether the BRPs were developed appropriately and whether those approaches should be continued.***

## A3.0 EXECUTIVE SUMMARY

### A3.1 MAJOR FINDINGS FOR TOR 1 - COMMERCIAL AND RECREATIONAL CATCH INCLUDING LANDINGS AND DISCARDS

Commercial landings in the Atlantic striped bass fishery increased from roughly 313 mt (800,000 pounds) in 1990 to 3,073 mt (7.6 million pounds) in 2006. In 2005 and 2006, the commercial coastwide harvest was composed primarily of ages 4–10 striped bass, while harvest in Chesapeake Bay fisheries (Maryland, Virginia, and the PRFC) was composed mostly of ages 3–6.

The estimates of dead commercial discards were 776,951 and 216,753 fish for 2005 and 2006, respectively. The highest discard losses occurred in anchor gill net, pounds net, and hook-and-line fisheries. Most commercial dead discards since 2004 were fish aged 3–8. Total commercial striped bass removals (harvest and dead discards) were 1.7 million and 1.2 million fish in 2005 and 2006, respectively. Removals in 2005 exceeded the peak observed in 2000. Commercial harvest has generally exceeded dead discards since the mid 1990s.

Recreational harvest increased from 1,010 mt (2.2 million pounds) in 1990 to 13,814 mt (29.1 million pounds) in 2006. In numbers of fish, recreational harvest of striped bass was greater than 1.3 million fish from 1997 through 2006, and more than 2 million striped bass during 2003–2006. Coastwide recreational harvest was dominated by the 2000 (age 5) and 1996 (age 9) year-classes in 2005, and by the 2001 (age 5) and 1996 (age 10) year-classes in 2006. Ages 4–10 made up >77% of the coastwide harvest, and ages 8+ made up about 50% in both years. Recreational harvest from the coast (includes Delaware Bay) was composed mostly of ages 5–11, while harvest in Chesapeake Bay was dominated by ages 4–8.

The number of striped bass that die due to catch and release increased from 132 thousand fish in 1990 to 1.2 million fish in 1997. Releases have remained around 1.2 million fish through 2003, but increased to the series maximum of 2 million fish in 2006. Ages of coastwide recreational dead releases ranged from 0–13+, but most dead releases were ages 2–6. The dead releases were dominated by the 2001 and 2003 year-classes in both years. Recreational dead releases from the coast (includes Delaware Bay) were made up of fish ages 2–5 and ages 3–6 in 2005 and 2006, respectively, but the 2001 and 2003 year-classes dominated. In Chesapeake Bay, dead releases were composed of ages 2–4 and were dominated by the 2003 year-class in both years (ages 2 and 3). Total recreational striped bass removals (harvest and dead discards) in 2005 and 2006 were 3.9 million and 4.8 million fish, respectively. See Section A5 for details.

### A3.2 MAJOR FINDINGS FOR TOR 2 – FISHERIES-DEPENDENT AND FISHERIES-INDEPENDENT INDICES

States provided age-specific and aggregate indices from fisheries-dependent and fisheries-independent sources that were assumed to reflect trends in striped bass relative abundance. A formal review of age-2+ abundance indices was conducted by ASMFC at a workshop in July of 2004. The 2004 workshop developed a set of evaluation criteria and tasked states with a review of indices. Both the Striped Bass Technical Committee and the Management Board approved of the criteria and of the review. The resulting review led to revisions and elimination of some indices used in previous stock assessments. All indices were given equal lambda weight. However, each survey's annual coefficients of variation (CV) were incorporated into the likelihood function, so if a survey produced poor estimates, the estimates were down-weighted by the CVs. See Section A6 for details. The following sources were used as tuning indices in the current stock assessment:

- Massachusetts Commercial Total Catch Rate Index
- Connecticut Recreational CPUE
- MRFSS Total Catch Rate Index
- Maryland Gillnet Survey
- New York Ocean Haul Seine Survey
- Northeast Fisheries Science Center Bottom Trawl Survey
- All Young-of-the-Year and Age 1 Indices
- Connecticut Bottom Trawl Survey
- New Jersey Bottom Trawl Survey
- Delaware Electrofishing Spawning Stock Survey

### A3.3 MAJOR FINDINGS FOR TOR 3 – STATISTICAL CATCH AT AGE MODEL AND ITS ESTIMATES OF FISHING MORTALITY, SPAWNING STOCK BIOMASS, AND TOTAL ABUNDANCE OF ATLANTIC STRIPED BASS

The estimate of fully-recruited (age 10) fishing mortality from the SCA model (preferred catch-at-age model method) in 2006 was 0.32 and its CV was 0.13. The 2006 average fishing mortality rate (F) for ages 8 through 11, which is compared to target and threshold reference points, equaled 0.31. Annual estimates for 1982 to 2005 range from 0.08 to 0.28. Average F on ages 3–8, which are generally targeted in producer areas (Chesapeake Bay, Delaware Bay, and Hudson River), was 0.23. Among the individual age groups, the highest values of F in 2006 (0.31–0.32) were estimated for ages 9–13+. Striped bass total abundance (1+) increased steadily from 1982 through 1997 when it peaked around 65 million fish. Total abundance declined thereafter and has averaged 57 million fish since 2000. The 2003 cohort remained strong at 16 million fish at age 3 in 2006 and exceeded the sizes of the strong 1993 and 2001 year classes at the same age. Abundance of striped bass age 8+ increased steadily through 2004 to 8.5 million, but has since declined to 6.2 million fish in 2006. Female SSB grew steadily from 1982 through 2003 when it peaked at about 33 thousand mt. Female SSB has declined since then and was estimated at 25 thousand mt in 2006. Retrospective bias was evident in estimates of fully-recruited F, SSB, and age 8+ abundance of SCA suggesting F is overestimated and abundance estimates were underestimated. ADAPT and ASAP modeling confirms the general trend and magnitudes of fishing mortalities. See Section A7 for details.

### A3.4 MAJOR FINDINGS FOR TOR 4 - BARANOV'S CATCH EQUATION METHOD APPLIED TO THE ATLANTIC STRIPED BASS TAGGING DATA AND ESTIMATES OF F AND ABUNDANCE FROM COASTWIDE AND CHESAPEAKE BAY SPECIFIC TAG PROGRAMS

Estimates of F obtained via Baranov's catch equation (the preferred tag-based model method) in 2006 for the fully-recruited fish (≥28 inches) were 0.15 ± 0.06 (95% CI) in the coastal areas and 0.17 ± 0.08 in the producer areas (Chesapeake Bay, Delaware Bay, and Hudson River), resulting in a coastwide mean of 0.16. The 2006 estimate of F for fish ≥ 18 inches was

0.16 ± 0.07 in producer area programs and 0.09 ± 0.03 for the coastal programs, resulting in a coastwide mean of 0.12. F estimates peaked for both size groups in the late 1990's and were at or below the target (0.30) for all years of the time series. Retrospective analyses for the MARK estimates were not attempted because reducing the tag recovery matrices and models was very laborious. Abundance of striped bass age 7+ (comparable to fish ≥ 28 inches) exhibited fair stability with a period of rapid stock growth around 2000. The 2006 estimate of 13 million fish has been approximately stable since 2002. Stock size estimates for fish age 3+ (comparable to fish ≥18 inches) showed fairly consistent growth and the 2006 value is the highest in the time series at 47.9 million fish.

In the Chesapeake Bay specific analysis, F in 2006 for both Maryland and Virginia individually and bay-wide were all below the target value of 0.27. The 2006 estimate for Maryland was 0.14; Virginia was 0.16. F estimates in Maryland steadily increased to a peak in 1998 (0.19), then declined and have fluctuated between 0.11–0.14 without trend since that time. Estimates of F from Virginia data vary without trend between 0.06–0.16 over the time series. The bay-wide F, calculated as a weighted mean, shows a trend similar to Maryland with a 2006 value of 0.14 ± 0.12. See Section A8 for additional details.

### A3.5 MAJOR FINDINGS FOR TOR 5 – REVIEW INSTANTANEOUS RATES TAG RETURN MODEL INCORPORATING CATCH-RELEASE DATA AND ESTIMATES OF F

In the first year of using the Instantaneous Rates - Catch and Release (IRCR) model, estimates of F were at or below the target (0.30) for all years of the time series. The 2006 estimate for the fully-recruited fish (≥ 28 inches) was 0.13 ± 0.015 (95% CI) in both the coastal areas and producer areas, which resulted in a coastwide mean F of 0.13. The 2006 estimate of F for fish ≥18 inches was 0.10 ± 0.03 in producer area programs and 0.09 ± 0.015 for the coastal programs, resulting in a coastwide mean of 0.09. Estimates from the IRCR model showed the same trends as those from the catch equation. Stock size estimates for fish age 7+ (≥28 inches) exhibited fair stability with a period of rapid stock growth around 2000. The 2006 estimate for fish ≥28 inches (16.6 million fish) has been approximately stable since 2003. Stock size estimates for fish age 3+ (≥18 inches) have shown fairly consistent growth and the 2006 value is the highest in the time series at 60.8 million fish.

In the Chesapeake Bay specific analysis, F estimates obtained using the IRCR model varied depending on model structure. F estimates produced when natural mortality (M) is assumed constant over the time series are lower in more recent years than those produced when the model allows for two or three periods of M. However, in all scenarios, the estimates of F for Maryland and Virginia and bay-wide were all below the target value of 0.27. Bay-wide average F values were as follows: 0.05 ± 0.015 for one period of M, 0.11 ± 0.02 for two periods of M and 0.12 ± 0.03 for three periods of M. See section A9 for additional details.

### A3.6 MAJOR FINDINGS FOR TOR 6 – REVIEW FORWARD-PROJECTING STATISTICAL CATCH-AT-AGE MODEL INCORPORATING AGE-INDEPENDENT INSTANTANEOUS RATES TAG RETURN MODEL

An age-structured statistical catch-at-age model incorporating tag return data for the Atlantic coast migratory stocks of striped bass was constructed as an alternative to separate catch-at-age model and tag return analyses. The same structure as the SCA model was used and the age-independent model of Jiang et al. (2007) is used as a bridge between the catch-at-age and tag return data. The link between the two models is fully-recruited F. The benefits of this instantaneous rates model are that data from tagged fish that are recaptured and released alive are directly incorporated in the estimation of fishing mortality. The 2006 average F for ages 8–11 equaled 0.14, much lower than the value obtained in the SCA model. The assumption that fish $\geq$28 inches are fully-recruited may be violated in early years of the time series and it is recommended that a fully age-structured tag model be used in the future.

### A3.7 MAJOR FINDINGS FOR TOR 7 – EVALUATE THE CURRENT BIOLOGICAL REFERENCE POINTS FOR ATLANTIC STRIPED BASS FROM AMENDMENT 6 AND DETERMINE STOCK STATUS BASED ON THOSE REFERENCE POINTS

The existing reference points for striped bass, as defined in Amendment 6 to the FMP (ASMFC 2003) are:

Female Spawning Stock Biomass Threshold ($SSB_{Threshold}$) = 14,000 mt
Female Spawning Stock Biomass Target ($SSB_{Target}$) = 17,500 mt
Fishing Mortality Rate Threshold ($F_{MSY}$) = 0.41
Fishing Mortality Rate Target ($F_{Target}$) = 0.30*
**The target fishing mortality rate for Chesapeake Bay is* $F_{Target}$ *= 0.27.*

Estimates of fully recruited F in 2006 from the catch equation method (F for fish $\geq$28 inches = 0.16) and the SCA model ($F_{age\ 8\text{-}11}$ = 0.31) are both below the Amendment 6 threshold. Therefore, overfishing is not occurring on the coastal migratory stocks of Atlantic striped bass. The 2006 estimate of spawning stock biomass is above both the $SSB_{Threshold}$ and $SSB_{Target}$ and therefore striped bass are not overfished.

The assessment covers the entire stock of the Atlantic coast migratory striped bass. The EEZ is managed under Federal authority and is closed to fishing for striped bass whereas fisheries in state waters are managed under the authority of the ASMFC. Although the EEZ is managed separately, striped bass present in these waters are still considered part of the coastal migratory stock. The estimates of fishing mortality and biomass obtained from the stock assessment are intended to represent the status of the entire stock of striped bass.

## A4.0 INTRODUCTION

### A4.1 MANAGEMENT HISTORY

Striped bass (*Morone saxatilis*) has been the focus of fisheries from North Carolina to New England for several centuries and has played an integral role in the development of numerous coastal communities. Striped bass regulations in the United States date to pre-Colonial times, when striped bass were prohibited from being used as fertilizer (circa 1640). During the 20$^{th}$ century, initial attempts at regulation were made by states during the 1940s, when size limits were imposed. Minimum size limits ranged from 16 inches for many coastal states to 10 inches in some southern states. By the 1970s it became increasingly evident that stronger regulations would be needed to maintain stocks at a sustainable level. Recruitment in the Chesapeake Bay stock had reached an all time low, as determined by a juvenile survey conducted by Maryland Department of Natural Resources since 1954. In response to the decline, the Atlantic States Marine Fisheries Commission (ASMFC) developed a fisheries management plan (FMP) in 1981 to increase restrictions in commercial and recreational fisheries. Two amendments were passed in 1984 recommending management measures to reduce fishing mortality. To strengthen the regulations, a federal law was passed in late 1984, which mandated that coast wide regulations already implemented would be adhered to by Atlantic states between North Carolina and Maine (for striped bass management, the areas under the jurisdiction of ASMFC include coastal waters of North Carolina, Virginia, the Potomac River Fisheries Commission, the District of Columbia, Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine).

The first enforceable version of the ASMFC plan to restore striped bass (Amendment 3 in 1985) called for size regulations to protect the 1982 year class, which was the first modest-sized cohort since the previous decade. The objective was to increase size limits to allow at least 95% of the females in the cohort to spawn at least once. This required an increase in the size limit as the cohort grew, and resulted in a 36-inch size limit by 1990. However, estuaries have traditionally been considered producer areas and have been managed under different minimum sizes than coastal waters. The rationale is that the migration of fish out of the producer areas after spawning reduces the availability of larger fish. Several states, beginning with Maryland in 1985, opted for a more conservative approach and imposed a total moratorium on striped bass landings. By 1989, Massachusetts was the only state with an active commercial fishery.

Most of the restrictive regulations were intended to restore production in Chesapeake Bay. The Hudson stock did not suffer the same decline in production, in part because the fishery in the river was closed in the 1970s due to PCB contamination.

In addition to the restrictions, Amendment 3 contained a trigger mechanism to reopen the fisheries when the 3-year moving average of the Maryland juvenile index exceeded an arithmetic mean of 8.0. That level was attained with the recruitment of the 1989 year class. Consequently the management plan was amended for the fourth time to allow state fisheries to reopen in 1990 under a target F of 0.25, which was half the 1990 $F_{msy}$ estimate of 0.5.

Amendment 4 to the FMP would allow an increase in the target F once the spawning stock biomass (SSB) was restored to levels estimated during the late 1960s and early 1970s. The dual size limit concept was maintained with a 28-inch minimum size limit in coastal jurisdictions and 18 inches in producer areas. In 1995, striped bass were declared restored by the ASMFC. The basis was the results of a model simulation of the increase in spawning stock biomass. The model, known as the SSB model, was a life history model resulting in a relative index of SSB (Rugolo et al. 1994). When the time series of SSB crossed the level comparable to the 1960–1972 average, the stock reached the criteria for a restored stock. Consequently, under Amendment 5 (adopted in 1995), target F was increased to 0.31, midway between the initial F (0.25) and $F_{msy,}$ which was revised to equal 0.4.

Amendment 5 retained the same size regulations in coastal waters (28-inch minimum size, two fish per day, and commercial quota) but allowed two fish per day at 20 inches and commercial quota in producer areas.[1] Commercial fisheries have operated under quotas based on state allocations during the period 1972–1979 (with the exception of Maryland, which calculated quotas based on estimated biomass). States may adjust the minimum size as long as

[1] Size limits on the coast were increased to 34” in 1994, but reduced to 28” in 1995.

the size change is compensated with a change in season length, bag limits, commercial quota, or a combination of changes. However, no size limit could be less than 18 inches.

Amendment 6 was approved in 2003. It addressed five limitations within the previous management program: potential inability of the management program contained in Amendment 5 to prevent the exploitation target in Amendment 5 from being exceeded; perceived decrease in availability or abundance of large striped bass in the coastal migratory population; a lack of management direction with respect to target and threshold biomass levels; inequitable impacts of regulations on the recreational, commercial, coastal, and producer area sectors of the striped bass fisheries; and excessively frequent changes to the management program.

Amendment 6 established a control rule that sets both a target and a threshold for the F rate and female spawning stock biomass. Based on the targets and threshold, as well as juvenile abundance indices, Amendment 6 implemented a list of management triggers, which if any (or all) are reached in any year will require the Management Board to alter the management program to ensure achievement of the Amendment 6 objectives. A planning horizon established the beginning of 2006 as a time at which any management measures established by the Management Board would be maintained by the states for three years, unless a target or threshold is violated.

| | FISHING MORTALITY RATE | FEMALE SPAWNING STOCK BIOMASS |
|---|---|---|
| TARGET | F = 0.30* | 17,500 mt (38.6 million pounds) |
| THRESHOLD | F = 0.41 | 14,000 mt (30.9 million pounds) |

**The target fishing mortality rate for the Chesapeake Bay and Albemarle-Roanoke stock is F=0.27*

The assessment covers the entire stock of the Atlantic coast migratory striped bass. The EEZ is managed under federal authority and is closed to fishing for striped bass whereas fisheries in state waters are managed under the authority of the ASMFC. Although the EEZ is managed separately, striped bass present in these waters are still considered part of the coastal migratory stock. The estimates of F and biomass obtained from the stock assessment are intended to represent the status of the entire stock of striped bass.

The recreational striped bass fisheries are constrained by minimum size limits meant to achieve target fishing mortalities, rather than annual harvest quotas or caps. Most recreational fisheries are constrained by a two fish creel limit, a 365-day fishing season, and a 28-inch minimum size limit. Through Management Program Equivalency, Albemarle Sound/Roanoke River, and Chesapeake Bay are granted the ability to employ different creel limits and smaller minimum size limits (18 inches) with the penalty of a target F rate of 0.27.

The commercial striped bass fisheries are constrained by minimum size limits and state-by-state quotas. The same size standards regulate the commercial fisheries as the recreational fishery, except for a 20 inch size limit in the Delaware Bay shad gillnet fishery. Amendment 6 restores the coastal commercial quotas to the average reported landings from 1972-1979, except for Delaware’s coastal commercial quota, which remains at the level allocated in 2002. The Chesapeake Bay and Albemarle Sound/Roanoke River commercial fisheries are managed to not exceed the 0.27 F target.

States are granted the flexibility to deviate from these standards by submitting proposals for review by the Striped Bass Technical Committee and Advisory Panel and contingent upon the approval of the Management Board. Alternative proposals must be “conservationally equivalent” to the management standards, which has resulted in some variety of regulations among states

(Table A4.1). These management measures were intended to maintain the fishing mortality at or below the target F (0.30).

Fishing in the Exclusive Economic Zone (EEZ) was closed in 1990 and has remained closed to the harvest and possession of striped bass by both commercial and recreational fishermen.

## A4.2 MANAGEMENT UNIT DEFINITION

The management unit includes all coastal migratory striped bass stocks on the East Coast of the United States, excluding the EEZ (3–200 nautical miles offshore), which is managed separately by NOAA Fisheries. The coastal migratory striped bass stocks occur in the coastal and estuarine areas of all states and jurisdictions from Maine through North Carolina. Inclusion of these states in the management unit is also congressionally mandated in the Atlantic Striped Bass Conservation Act (PL 98–613; Figure A4.1).

The Chesapeake Bay management area is defined as the striped bass residing between the baseline from which the territorial sea is measured as it extends from Cape Henry to Cape Charles to the upstream boundary of the fall line. The striped bass in the Chesapeake Bay are part of the coastal migratory stock and are part of the coastal migratory striped bass management unit. Amendment 6 implements a separate management program for the Chesapeake Bay due to the size availability of striped bass in this area.

The Albemarle-Roanoke stock is currently managed as a non-coastal migratory stock by the state of North Carolina under the auspices of ASMFC. The Albemarle-Roanoke management unit is defined as the striped bass inhabiting the Albemarle, Currituck, Croatan, and Roanoke Sounds and their tributaries, including the Roanoke River. The Virginia/North Carolina line bound these areas to the north and a line from Roanoke Marshes Point to the Eagle Nest Bay bounds the area to the south. The Bonner Bridge at Oregon Inlet defines the ocean boundary of the Albemarle-Roanoke management area.

There has been some debate in recent years whether to continue to include the Albemarle-Roanoke stock of striped bass in the management unit based on the argument that historical and recent tagging studies have suggested very limited migration of this stock into the Atlantic Coastal area. With such little mixing of Albemarle-Roanoke fish with other coastal migratory stocks, it is difficult to include the Albemarle-Roanoke stock in current coastwide stock assessment because methods used assume that fish from various stocks are equally mixed on the coast. On the other hand, fish tagged on the spawning grounds of Chesapeake Bay, Hudson River, and Delaware River have been recovered in the Albemarle Sound-Roanoke River area.[2] This indicates that coastal migratory fish from other stocks mix with Albemarle-Roanoke fish in North Carolina waters, which argues for having the stock remain within the management unit.

## A4.3 ASSESSMENT HISTORY

### A4.3.1 Past Assessments

The first analytical assessment of Atlantic striped bass stocks using virtual population analysis (VPA) was conducted in 1997 for years 1982–1996 and reviewed by the 26th Stock Assessment Review Committee at the Northeast Fisheries Science Center. The results of the review were reported in the proceedings of the 26th Northeast Regional Stock Assessment Workshop (NEFSC 1998). Subsequent to this peer review, annual updates were made to the

[2] USFWS tagging data

VPA-based assessment, and in 2001 estimates of F and exploitation rates using coastwide tagging data were incorporated into the assessment. The tagging data analysis protocol was based on assumptions described in Brownie et al. (1985) and the tag recovery data was analyzed in program MARK (White and Burnham 1999). Adjusted R/M ratios (recovered tags/total number of tags released) were used to calculate exploitation rates.

The stock status and assessment procedures were reviewed once again at the 36th SAW in December 2002 and this time included review of the tag-based portion of the assessment in addition to the ADAPT VPA portion of the assessment. Since then, annual updates to the assessment were conducted from 2003 through 2005.

In the 2005 assessment, Baranov's catch equation was used with the tagging data to develop estimates of F. By using the Z values from the Brownie models and $\mu$ from R/M (recovered tags/total number of tags released), F estimates could be developed for the first time without the assumption of constant natural mortality. In addition, two changes were made to the VPA input data. Modifications were made to the suite of tuning indices used in the VPA following a comprehensive review of the various indices. In addition, current and historical estimates of recreational harvest during January and February in North Carolina and Virginia were added to the catch at age matrix.

### A4.3.2 Current Assessment and Changes from Past Assessments

In the 2004 and 2005 ASMFC assessments of striped bass, the ADAPT VPA model produced high estimates of terminal-year fishing mortality. The consensus of the Technical Committee members was that the ADAPT estimates were likely overestimated given the uncertainty and retrospective bias in the terminal year estimate, especially the F on the older ages which are compared to the overfishing reference point. A recent run with data updated through 2006 showed even worse overestimation of terminal F (at age 10, F =2.2).

As an alternative to ADAPT, an age-structured forward projecting statistical catch-at-age (SCA) model for the Atlantic coast migratory stocks of striped bass was constructed and is used to estimate fishing mortality, abundance, and spawning stock biomass during 1982–2006. This is considered the preferred model over ADAPT and ASAP. See Section A7 for discussion

In addition, the Baranov's catch equation method applied to tagging data was considered appropriate for estimating fishing mortality because natural mortality is allowed to change over time. This approach is used because of high and increasing estimates of F from the tag analysis when M was assumed constant. This conflicted with other estimates of exploitation and F in the bay from tag programs, and it coincided with the development of an epidemic of mycobacteriosis in the Bay. Also, estimates of abundance could be made.

## A4.4 LIFE HISTORY AND BIOLOGY

### A4.4.1 Geographic Range

Atlantic coast migratory striped bass live along the eastern coast of North America from the St. Lawrence River in Canada to the Roanoke River and other tributaries of Albemarle Sound in North Carolina (ASMFC 1990). Stocks which occupy coastal rivers from the Tar-Pamlico River in North Carolina south to the St. Johns River in Florida are believed primarily endemic and riverine and apparently do not presently undertake extensive Atlantic Ocean migrations as do stocks from the Roanoke River north (ASMFC 1990), although at least one individual tagged in the Cape Fear River recently did so, being recaptured at Montauk Lighthouse, New York.

Striped bass are also naturally found in the Gulf of Mexico from the western coast of Florida to Louisiana (Musick et al. 1997). Striped bass were introduced to the Pacific Coast using transplants from the Atlantic Coast in 1879. Striped bass also were introduced into rivers, lakes, and reservoirs throughout the US, and to foreign countries such as Russia, France and Portugal (Hill et al. 1989). The following life history information applies to the Atlantic coast migratory population.

**A4.4.2 Age**

The age of a fish is frequently used as a milestone in characterizing many aspects of the fish's life history such as age of maturity. Scales of striped bass collected in North Carolina show annulus formation taking place from late October through early January, with the peak occurring in early December. Annuli form on scales of striped bass caught in Virginia between April and June, or during the spawning season (Grant 1974).

Age data has also been fundamental to VPA-based stock assessments of striped bass. Since 1996, catch-at-age models have used scale age, principally because the time series of catch data extends back to 1982 and scales have been the only consistent collected age structure, even in more recent years. In the near future, the ASMFC plans an otolith collection program for 800 mm striped bass or larger as the state ageing programs have shown high precision in scale ageing striped bass up to age 10.

Generally, longevity of striped bass has been estimated as 30 years, although in recent years, a striped bass was aged as 31 years based on otoliths (Secor 2000). This longevity suggests that striped bass populations can persist during long periods of poor recruitment due to a long reproductive lifespan, and may have also conferred resiliency against an extended period of recruitment overfishing in the Chesapeake Bay (Secor 2000). Based on VPA estimates, young fish dominate the age composition of striped bass, but recent estimates of older striped bass (age-8 or older) indicate this grouping averaged 10% of striped bass age-1 or older, since 2000. This amount represents nearly a doubling of the proportion of age-8 and older striped bass during the decade of the 1990s.

**A4.4.3 Growth**

As a relatively long-lived species, striped bass are capable of attaining moderately large size, reaching as much as 125 lbs (Tresselt 1952). Fish weighing 50 or 60 lbs are not exceptional, and several fish harvested in North Carolina and Massachusetts, recorded in excess of 100 pounds, were estimated to have been at least 6 feet long (Smith and Wells 1977). Females do grow to a considerably larger size than males; striped bass over about 30 lbs are almost exclusively female (Bigelow and Schroeder 1953). Both sexes grow at the same rate until 3 years old; beginning at age 4, females grow faster and larger than males.

Growth occurs during the seven-month period between April and October. Within this time frame, striped bass stop feeding for a brief period just before and during spawning, but feeding continues during the upriver spawning migration and begins again soon after spawning (Trent and Hassler 1966). From November–March, growth is negligible.

Growth rates of striped bass are variable, depending on a combination of the season, location, age, sex, and competition. For example, a 35 inch striped bass can be anywhere from 7–15 years of age and a 10-lb striped bass can be from 6 to 16 years old (ODU CQFE 2006). Growth (in length) is more rapid during the second and third years of life, before reaching sexual maturity, than during later years. Merriman (1941) observed that striped bass of the 1934 year-class showed their greatest growth during the 3rd year, at which age migratory movements begin. Thereafter the rate dropped sharply at age 4 and remained nearly constant at 6.5–8.0 cm per year up to about age 8. The growth rate probably decreases even further after the 8th year.

Compensatory growth, in which the smaller fish in a year-class, growing at an accelerated pace, reduce or eliminate the size differences between themselves and other larger members of that age group, has been shown to occur in age 2 striped bass in Chesapeake Bay (Tiller 1942) and in age 2 and 3 fish from Albemarle Sound (Nicholson 1964).

**A4.4.4 Reproduction**

Striped bass are anadromous, ascending coastal streams in early spring to spawn, afterward returning to ocean waters. Spawning takes place in the shallow stretches of larger rivers and streams, generally within about the first 40 km of freshwater in rivers flowing into estuaries (Figures A4.2–A4.4) (Tresselt 1952). The actual distance upstream of the center of spawning varies from river to river and even within the same river from year to year. Striped bass spawning areas characteristically are turbid and fresh, with significant current velocities due to normal fluvial transport or tidal action. Tributaries of Chesapeake Bay, most notably the Potomac River, and also the James, York, and most of the smaller rivers on the eastern shore of Maryland, are collectively considered the major spawning grounds of striped bass, but other rivers (Hudson and Delaware) make substantial contributions to the population along the middle Atlantic coast. The spawning population is made up of males 2 years or older and females 4 or more years old.

The spawning season along the Atlantic coast usually extends from April to June, but it begins as early as January or February in Florida, and is governed largely by water temperature (Smith and Wells 1977). Striped bass spawn at temperatures between 10 and 23° C, but seldom at temperatures below 13–14°C. Peak spawning activity occurs at about 18° C and declines rapidly thereafter (Smith and Wells 1977).

The number of mature ova in female striped bass varies by age, weight, and fork length. Jackson and Tiller (1952) found that fish from Chesapeake Bay produced from 62,000–112,000 eggs/pound of body weight, with older fish producing more eggs than younger fish. Raney (1952) observed egg production varying with size, with a 3-pound female producing 14,000 eggs and a 50-pound specimen producing nearly 5,000,000. When ripe, the ovaries are greenish-yellow in color (Scofield 1931). After fertilization, the semi-buoyant eggs of striped bass are transported downstream or, if spawned in slightly brackish water, back and forth by tidal circulation. Hatching occurs in about 70–74h at 14–15°C, in 48h at 18–19°C, and in about 30h at 21–22°C (Bigelow and Schroeder 1953).

Newly hatched bass larvae remain in fresh or slightly brackish water until they are about 12–15mm long. At that time, they move in small schools toward shallow protected shorelines, where they remain until fall. Over the winter, the young concentrate in deep water of rivers. These nursery grounds appear to include that part of the estuarine zone with salinities less than $3.2^0/_{00}$ (Smith 1970).

Maryland data suggest that full maturity of females is not achieved until age 8. Maryland data were accepted as valid and were used to guide changes in size limits needed to meet the management requirements of Amendment 3 to the FMP (i.e., to protect 95% of females of the 1982 and subsequent year-classes until they had an opportunity to spawn at least once). Maryland maturity data were also incorporated into modeling work performed in order to develop management regimes specified in Amendment 4 to the FMP (ASMFC 1990).

There are indications that some older striped bass may not spawn every year (Raney 1952). Merriman (1941) reported that large, ripe females are regularly taken from Connecticut waters in late spring and early summer, during the regular spawning period. Jackson and Tiller (1952) reported curtailment of spawning in about 1/3 of the fish age 10 and older taken from Chesapeake Bay, though they also found striped bass up to age 14 in spawning condition.

**A4.4.5 Movements and Migration**

Migration of striped bass may occur at both juvenile and adult stages, although migratory patterns for all life stages vary by location. In general, juveniles migrate downstream in summer and fall, while adults migrate upriver to spawn in spring, afterwards returning to the ocean and moving north along the coast in summer and fall, and south during the winter (Shepherd 2007). As young and as adults, striped bass move in schools, except for larger fish, which either travel alone or with a few others of similar size.

Juvenile striped bass move down river in schools from their parent stream to low salinity bays or sounds when a year old (Richards and Rago 1999; Smith and Wells 1977). The timing of this juvenile migration varies by location. In Virginia, Setzler-Hamilton et al. (1980) observed the movement downstream during summer. In the Hudson River, striped bass begin migrating in July, as documented through an increase in the number of juvenile striped bass caught along the beaches and a subsequent decline in the numbers in the channel areas after mid-July. Downstream migration continues through late summer, and by the fall, juveniles start to move offshore into Long Island Sound (Raney 1952). Juveniles infrequently complete coastal migrations, but even though fish that are under the age of two are largely non-migratory, many do leave their birthplaces when they are two or more years old.

Most adult striped bass along the Atlantic coast are involved in two types of migrations: an upriver spawning migration from late winter to early spring, and coastal migrations that are apparently not associated with spawning activity. Not all fish take part in the coastal migrations. Otolith microchemical analysis of striped bass from the Hudson River and from the Roanoke River, indicate that individuals in these populations exhibited multiple life history strategies (Morris et al. 2003; Zlokovitz et al. 2003). In both populations, some individuals were permanent residents of the river, while others exhibited varying degrees of migratory behavior beginning at varying ages.

From Cape Hatteras NC to New England, striped bass coastal migrations are generally northward in summer and southward in winter. Results from tagging 6,679 fish from New Brunswick, Canada, to the Chesapeake Bay during 1959–1963, suggest that substantial numbers of striped bass leave their birthplaces when they are 3+ years old and thereafter migrate in groups along the open coast (Nichols and Miller 1967). These fish are often referred to collectively as the "coastal migratory stock," suggesting they form one homogeneous group, but this group is probably, in itself, heterogeneous, consisting of many migratory contingents of diverse origin (Clark 1968).

Coastal migrations may be quite extensive; striped bass tagged in Chesapeake Bay have been recaptured in the Bay of Fundy. They are also quite variable, with the extent of the migration varying between sexes and populations (Hill et al. 1989). Larger bass, typically the females, tend to migrate farther distances. However, striped bass are not usually found more than 6–8 km offshore (Bain and Bain 1982). Recently, Welsh et al. (2007) determined from tag recovery locations that striped bass tagged off North Carolina and Virginia in winter migrated northward during summer as far as Maine, although the largest numbers were recovered from

New York to Massachusetts, as well as waters of Maryland. During spring months (April, May, and June), the largest numbers of tagged striped bass were caught within waters of Maryland (Chesapeake Bay) and New York (Hudson River). Although usually beginning in early spring, the time period of migration can be prolonged by the migration of bass that are late-spawning.

Some areas along the coast are used as wintering grounds for adult striped bass. The inshore zones between Cape Henry, Virginia, and Cape Lookout, North Carolina, serve as the wintering grounds for the migratory segment of the Atlantic coast striped bass population (Setzler-Hamilton et al. 1980). There are three groups of fish found in nearshore ocean waters of Virginia and North Carolina between the months of November and March, the wintering period. These three groups are bass from Albemarle and Pamlico Sounds, North Carolina, fish from the Chesapeake Bay, and large bass that spend the summer in New Jersey and north (Holland and Yelverton 1973). Based on tagging studies conducted under the auspices of the ASMFC and Southeast Area Monitoring and Assessment Program (SEAMAP; Welsh et al. 2007) each winter since 1988, striped bass wintering off Virginia and North Carolina range widely up and down the Atlantic Coast, at least as far north as Nova Scotia, and represent all major migratory stocks (Welsh et al. 2007, Appendix A1).

**A4.4.6 Stock Definitions**

The anadromous populations of the Atlantic coast are primarily the product of four distinct spawning stocks: a Roanoke River/Albemarle Sound stock, a Chesapeake Bay stock, a Delaware River stock, and a Hudson River stock (ASMFC 1998). The Atlantic coast fisheries, however, rely primarily on production from the spawning populations in the Hudson and Delaware rivers and in tributaries of Chesapeake Bay. Therefore, the inside fisheries of the Albemarle Sound and Roanoke River are managed separately from the Atlantic coastal migratory population, which includes all other migratory stocks occurring in coastal and estuarine areas of all states and jurisdictions from Maine through North Carolina. The Atlantic coast management unit, excluding the fisheries on the Roanoke River/Albemarle Sound stock, is the basis of this stock assessment.

The Chesapeake Bay stock of striped bass is widely regarded as the largest of the four major spawning stocks (Goodyear et al. 1985; Kohlenstein 1980; Fabrizio 1987). However, during most of the 1970s and 1980s, juvenile production in the Chesapeake Bay was extremely poor, causing a severe decline in commercial and recreational landings. The poor recruitment was probably due primarily to overfishing; but poor water quality in spawning and nursery habitats likely also contributed (Richards and Rago 1999).

Recent tag-recovery studies in the Rappahannock River and upper Chesapeake Bay show that larger and older (ages 7+) female striped bass, after spawning, move more extensively along the Atlantic coast than stripers from the Hudson River stock (ASMFC 2004). Tag recoveries of Chesapeake stripers from July–November have occurred as far south as Virginia to as far north as Nova Scotia, Canada. Like the Hudson River stock, nearly all tag recoveries from mature female stripers from the Chesapeake Bay stock have taken place during winter (December and February) off Virginia and North Carolina (Crecco 2005).

Following extensive pollution abatement during the mid 1980s, striped bass abundance in the Delaware River, as measured by juvenile seine surveys, rose steadily thereafter to peak abundance in 2003 and 2004.[3] Like the Chesapeake Bay and Hudson stocks, spawning migration in the Delaware River begins during early April and extends through mid June (ASMFC 1990).

[3] Tom Baum, NJ BMF, pers. comm.

Recent tagging studies in the Delaware River show that larger and older (ages 7+) female striped bass undergo extensive migration northward into New England from July to November that spatially overlap the migratory range of Chesapeake striped bass (ASMFC 2004). Like the Hudson River and Chesapeake Bay stocks, many tag recoveries from mature female stripers from the Delaware River have taken place between December and February off Virginia, North Carolina, New England, and Long Island (Crecco 2005). The Delaware River stock was officially declared restored in 1998 (Kahn et al. 1998).

**A4.4.7 Disease**

A rise in Mycobacterium disease in Chesapeake Bay could be causing increases in natural mortality (Pieper 2006; Ottinger and Jacobs 2006). Two primary hypotheses have emerged regarding the mechanism for increased natural mortality (Vogelbein et al. 2006). One is that elevated nutrient inputs to the Bay, with associated eutrophication, results in loss of thermal refugia for striped bass, forcing them into suboptimal and stressful habitat during the summer. A second is that alternations in trophic structure and starvation have resulted due to over-harvest of key prey species such as Atlantic menhaden (*Brevoortia tyrannus*) and reductions in the forage base in Chesapeake Bay. More studies are necessary in order to determine linkages between these factors and mortality of older juvenile and adult striped bass (Ottinger and Jacobs 2006).

**A4.4.8 Predators and Prey**

Bluefish, weakfish, and other piscivores prey on juvenile striped bass (Hartman and Brandt 1995b; Buckel et al. 1999). Adult striped bass consume of a variety of fish (e.g., *Brevoortia tyrannus*, *Anchoa mitchilli*, *Mendia* spp.) and invertebrates (e.g., *Callinectes sapidus*, *Cancer irroratus*, *Homarus americanus*), but the species consumed depends upon predator size, time of year, and foraging habitat (Schaefer 1970; Hartman and Brandt 1995a; Nelson et al. 2003).

## A4.5 FISHERY DESCRIPTIONS

Commercial fisheries operate in eight of the 14 jurisdictions regulated by the Commission's FMP (Massachusetts, Rhode Island, New York, Delaware, Maryland, Virginia, Potomac River, and North Carolina; Table A4.1). Commercial fishing for striped bass is prohibited in New Jersey, Pennsylvania, Connecticut, New Hampshire, Maine and the District of Columbia. The predominant gear types in the commercial fisheries are gillnets, pound nets, and hook and line. In a few states, the trap gear is an important part of this fishery. Massachusetts allows commercial fishing with hook-and-line gear only, while other areas allow net fisheries. Most commercial fisheries are seasonal in nature because of bass movements and management regulations. Following the reopening of striped bass fisheries in 1990, a rebuilding management strategy remained in effect until 1995, when the stock was considered recovered. Subsequently, management constraints were relaxed to the extent that states were afforded increases in commercial quotas (Table A4.1)

Recreational fisheries operate in all 14 jurisdictions regulated by the Commission's FMP. The predominant gear type is hook and line (Table A4.1). Following the reopening of striped bass fisheries in 1990, state fisheries were limited to a 2-fish possession limit, 28-inch minimum size limit (except "producer" areas, such as the Chesapeake jurisdictions, were allowed to implement 18-inch minimum size limits) and modest open fishing seasons. By 1995, coincident with the recovered status of striped bass, open fishing seasons were extended, with some states establishing year-round open seasons (Table A4.1). In Chesapeake Bay, recreational caps have been established for specific seasonal fisheries.

## A5.0 CHARACTERIZE COMMERCIAL AND RECREATIONAL CATCH INCLUDING LANDINGS AND DISCARDS. (TOR #1)

### A5.1 COMMERCIAL DATA SOURCES

Strict quota monitoring is conducted by states through various state and federal dealer and fishermen reporting systems, and landings are compiled annually from those sources by state biologists (Appendix A2). Commercial harvest in some states is recorded in pounds and is converted to number of fish using conversion methods (Appendix A2). Biological data (e.g., length, weight, etc.) and age structures (scales) from commercial harvest are collected from a variety of gear types through state-specific port sampling programs (Appendix A2). Harvest numbers are apportioned to age classes using length frequencies and age-length keys derived from biological sampling. Sample sizes for lengths and age structures are summarized by state for 2000–2006 in Table A5.1.

### A5.2 COMMERCIAL LANDINGS

#### A5.2.1 Commercial Total Landings

Historically, annual commercial harvest of striped bass peaked at almost 6,804 mt (15 million pounds) in 1973, but through management actions, it declined by 99 percent to 63 mt (140,000 pounds) in 1986. Commercial landings have increased from 313 mt (800,000 pounds) in 1990 to 3,073 mt (7.6 million pounds) in 2006 (Table A5.2) following liberalization of fishery regulations.

#### A5.2.2 Commercial Landings in Numbers

Commercial harvest of striped bass was over one million fish from 1997–2000 and near one million fish through 2006 (Table A5.2). In 2006, landings increased 8.4% in numbers (81 thousand fish) but decreased 5.1% in weight (167 MT) compared to 2005. The Chesapeake Bay jurisdictions (Maryland, Virginia, and the Potomac River Fisheries Commission) usually account for a major portion of the coastwide commercial harvest. In 2006, Chesapeake Bay jurisdictions accounted for 65% of the striped bass harvest, by weight, and 81.7% of the number of striped bass harvested (Table A5.3).

#### A5.2.3 Commercial Landings Age Composition

The age structure of commercial harvest varies by state due to size regulations and season of the fisheries. In 2005 and 2006, the commercial harvest was composed primarily of ages 4–10 striped bass (Table A5.4). Harvest in Chesapeake Bay fisheries (Maryland, Virginia, and the PRFC) was composed mostly of ages 3–6 (Table A5.4; Figure A5.1).

## A5.3 COMMERCIAL DISCARDS

### A5.3.1 Estimation of Discards

Few states collect reliable information on the discarding of striped bass in commercial fisheries. Direct measurements of commercial discards of striped bass are generally only available for fisheries in the Hudson River Estuary and were available from Delaware Bay during 2001–2003 (Clark and Kahn, MS). Discard estimates for fisheries in Chesapeake Bay, and coastal locations since 1982 are based on the ratio of tags reported from discarded fish in the commercial fishery to tags reported from discarded fish in the recreational fishery, scaled by total recreational discards:

CD = RD*(CT/RT)
where:
CD = unadjusted estimate of the number of fish discarded by commercial fishery,
RD = number of fish discarded by recreational fishery, estimates provided by the NOAA Marine Recreational Fisheries Survey (MRFSS),
CT = number of tags returned from discarded fish by commercial fishermen,
RT = number of tags returned from discarded fish by recreational fishermen.

Tag return data by gear for 2005 and 2006 are given in Table A5.5. Starting in 1998, the Technical Committee attempted to improve the estimate of commercial discards by calculating tag return ratios and discards separately for Chesapeake Bay and the coast. A separate estimate for Delaware Bay was added in 2004. The ratios of tags from fish discarded by commercial fishermen to tags returned from fish discarded by recreational fishermen are shown in Table A5.6 for 2005 and 2006.

Expanding recreational discards to commercial discards based on reported tag returns assumes equal reporting tag rates in commercial and recreational fisheries but in fact this is not true. To correct for this bias, a correction factor is calculated by dividing the three-year mean of ratios of commercial to recreational landings by the three-year mean of ratios of tags returned by the two fisheries (Tables A5.6 and A5.7). The adjusted correction factors and estimates of total discards for 2005 and 2006 are shown in Table A5.7. Total discards in 2005 and 2006 were estimated to be 6.0 million and 1.8 million fish, respectively.

### A5.3.2 Estimation of Dead Discards

Total discards are allocated to fishing gears based on the relative number of tags recovered by each gear (Tables A5.5 and A5.8). Discards by fishing gear were multiplied by gear specific release mortalities and summed to estimate total number of dead discards in a given year (Table A5.8). The estimates of dead discards are 776,951 and 216,753 fish for 2005 and 2006, respectively. The highest discard losses occurred in anchor gill net, pound net, and hook-and-line fisheries (Table A5.8).

### A5.3.3 Age Composition of Commercial Dead Discards

Commercial discard proportions at age were obtained by applying age distributions from fishery dependent sampling or independent surveys that used comparable gear types (Table A5.9). Gear specific proportions at age were applied to discard estimates by gear and expanded estimates summed across all gears. Most commercial discards since 2004 were fish of ages 3–7 (Table A5.10; Figure A5.2).

## A5.4. TOTAL REMOVALS BY COMMERCIAL FISHERIES

Total commercial striped bass removals (harvest and discards) were 1.7 million and 1.2 million fish in 2005 and 2006, respectively (Figure A5.3). Removals in 2005 exceeded the peak observed in 2000 (Figure A5.3). Harvest has generally exceeded dead discards since the mid 1990s (Figure A5.3). Commercial losses in 2005 and 2006 were dominated by the 2001 year class (ages 4 and 5, respectively; Figure A5.4).

## A5.5 RECREATIONAL DATA SOURCES

Data on harvest and release numbers, harvest weight, and sizes of harvested striped bass come from the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS). The MRFSS data collection consists of a stratified intercept survey of anglers at fishing access sites that obtains numbers of fish harvested and released per angler trip, and a telephone survey that derives numbers of angler trips. Estimates of harvest and release numbers of striped bass for the Atlantic coast are derived on a bi-monthly basis beginning in March (wave 2). For detailed descriptions of the MRFSS program, see the MRFSS website (http://www.st.nmfs.gov/st1/recreational/overview/overview.html). Total number of interviews, total number of striped bass interviews, numbers of harvested striped bass measured, estimates of numbers harvested and released with proportional standard errors by state and years 2000–2006 are listed in Table A5.11.

Anecdotal evidence had suggested that North Carolina, Virginia, and possibly other states had sizeable wave-1 fisheries beginning in 1996 (wave-1 sampling that began in 2004 in North Carolina waters and large wave-1 tag return data for North Carolina and Virginia supported this contention). However, MRFSS did not sample in January and February (wave-1) prior to 2004; therefore, there was little information for the winter fishery (Jan, Feb) that had developed off of North Carolina and Virginia. Harvest in wave 1 for these fisheries was estimated back to 1996 using observed relationships between landings and tag returns (Appendix A3). For North Carolina, the ratio of estimated landings to tag returns in wave-1 of 2004 and annual tag returns in wave-1 were used to estimate annual landings from tag returns in January and February of 1996–2003. For Virginia waters, the 1996–2004 mean ratio of landings and tag returns in wave-6 and annual tag returns in wave-1 were used to estimate landings from tag returns in January and February of 1996–2004. Estimates of wave-1 harvest for both Virginia and North Carolina in 1996–2004 are listed in Appendix A3. For 2005 and 2006, MRFSS wave-1 estimates of harvest for the winter fishery in Virginia waters were still unavailable; therefore, they were estimated. The approach used to estimate wave-1 harvest in prior years was abandoned because correlation between wave 6 harvest and tag returns off Virginia weakened significantly. A new method was developed in which the ratio of wave-1 harvest to wave-1 tag returns from North Carolina were multiplied by the wave-1 tag returns in Virginia to estimate Virginia wave-1 harvest (Appendix A3). Dead releases for the winter recreational fishery in North Carolina or Virginia were not estimated.

Most states use the length frequency distributions of harvested striped bass measured by the MRFSS. The MRFSS measurements are converted from fork length (inches) to total length (inches) using conversion equations. Proportions-at-length are calculated and multiplied by the MRFSS harvest numbers to obtain total number harvested-at-length. The sample sizes of harvested bass measured by MRFSS may be inadequate for estimation of length frequencies; therefore, some states use harvest length data collected from other sources (e.g., volunteer angler programs) to increase sample sizes (Table A5.11). Full descriptions of state-specific programs are presented in Appendix A4.

Data on sizes of released striped bass come mostly from state-specific sampling or volunteer angling programs (Table A5.11). Proportions-at-length are calculated and multiplied by the MRFSS dead releases numbers to obtain total number dead releases-at-length. For those programs that do not collect data on released fishes, the lengths of tagged fish released by anglers participating in the American Littoral Society's striped bass tagging program or from state-sponsored tagging programs are used. Details on calculations are given in Appendix A4.

Many states collect scale samples during state sampling programs designed to collect information on harvest and released striped bass from the recreational fishery (Table A5.11). Age-length keys are usually constructed and applied to harvest and dead release numbers-at-length. When sampling of the recreational fishery does not occur, age-length keys are constructed by using data on age-length from commercial sampling, fisheries-independent sampling or striped bass tagging programs. For those states that do not collect scale samples, age-length keys are usually borrowed from neighboring states. Detailed descriptions of how age samples are collected, processed, and aged are given in Appendix A4.

Age composition of the January/February recreational fishery in North Carolina and Virginia was estimated from length-frequency data collected by MRFSS and appropriate state age-length keys. Length-frequencies for the North Carolina winter harvest of 2004 came from data in wave-6 of 2003 and wave-1 of 2004. Length-frequencies for the winter harvests of 1996–2003 came from wave-6 of year t-1. Lengths were converted to age for North Carolina with a combined age-length key from New York and North Carolina. Length-frequencies for the Virginia winter harvest in 1996–2006 came from MRFSS data in wave-6 of year t-1. We converted the Virginia lengths to age with a Virginia age-length key. Estimates of wave-1 harvest at age for North Carolina and Virginia were added to the existing CAA matrix for 1996 through 2006.

## A5.6 RECREATIONAL LANDINGS

### A5.6.1 Recreational Total Landings

Figure A5.5 traces the impressive growth of the Atlantic coast recreational fisheries from 1982 through 2006. Harvest increased from 1,010 mt (2.2 million pounds) in 1990 to 13,814 mt (29.1 million pounds) in 2006 (Table A5.2).

### A5.6.2 Recreational Landings in Numbers

In numbers of fish, recreational harvest of striped bass was greater than 1.4 million fish from 1997 through 2006, and more than two million striped bass during 2003–2006 (Table A5.2). Harvest was generally highest in Virginia, Maryland, New Jersey, and Massachusetts (Table A5.12). The annual Atlantic coast harvest (in numbers) has been a small fraction of the catch (harvest and releases, combined) since the 1980s because the releases (B2s) have accounted for 85 to 90% of the annual catch in most years (see Section A5.6).

### A5.6.3 Age Composition of Recreational Landings

Coastwide recreational harvest was dominated by the 2000 (age 5) and 1996 (age 9) year-classes in 2005, and by the 2001 (age 5) and 1996 (age 10) year-classes in 2006 (Table A5.13; Figure A5.6). Ages 4–10 made up >77% of the coastwide harvest, and ages 8+ made up about 50% in both years (Table A5.13). Recreational harvest from the coast (includes Delaware Bay) was composed mostly of ages 5–11, while harvest in Chesapeake Bay was dominated by ages 4–8 (Figure A5.7).

## A5.7 RECREATIONAL RELEASES

### A5.7.1. Estimation of Releases

The number of striped bass that are caught and released (B2) is estimated by MRFSS (Table A5.14). The releases have accounted for 85 to 90% of the annual catch in most years (Figure A5.8).

### A5.7.2 Estimation of Dead Releases

The number of releases that die due to the capture and release process is estimated by multiplying the total release numbers (B2) by an estimate of hooking mortality (0.08) derived by Diodati and Richards (1996) prior to publication. Estimates of the number of dead releases are presented in Table A5.15. The numbers of fish released dead increased from 132 thousand fish in 1990 to 1.2 million fish in 1997. Releases remained around 1.2 million through 2003, but have increased to the series maximum of 2 million fish in 2006. The numbers of fish released dead are generally highest in Massachusetts and Maryland (Table A5.15).

### A5.7.3 Age Composition of Dead Releases

Ages of coastwide recreational dead releases ranged from 0 to 13+, but most dead releases were ages 2–6 (Table A5.16; Figure A5.6). The dead releases were dominated by the 2001 and 2003 year-classes in both years (Table A5.16; Figure A5.6). Recreational dead releases from the coast (includes Delaware Bay) were composed of fish ages 2–5 and ages 3–6 in 2005 and 2006, respectively, but the 2001 and 2003 year-classes dominated (Table A5.16; Figure A5.7). In Chesapeake Bay, dead releases were composed of ages 2–4 and were dominated by the 2003 year-class in both years (ages 2 and 3; Figure A5.7).

## A5.8 TOTAL REMOVALS BY RECREATIONAL FISHERIES

Total recreational striped bass removals (harvest and dead discards) in 2005 and 2006 were 3.9 million and 4.8 million fish, respectively (Table A5.17; Figure A5.9). Total removals were highest in Massachusetts, New Jersey, Maryland, and Virginia (Table A5.17). The harvest and dead releases combined were dominated by ages 2, 4–6, and 9 in 2005, and ages 3, 5–6, and 10 in 2006 (Figure A5.10). Total recreational dead releases and harvest losses have generally increased since 1982, with intermittent declines in 1998–1999 and 2001–2002 (Figure A5.9). Recreational removals in 2006 were the highest of the time series (Figure A5.9).

## A5.9 TOTAL REMOVALS BY COMMERCIAL AND RECREATIONAL FISHERIES

Combined losses showed that the recreational fishery removed the largest number of striped bass in 2005 and 2006 (Figure A5.11). Historically, the recreational fishery has been the dominant source of fishing removals since 1991 (Figure A5.12). The above components were totaled by year to produce the overall catch at age matrix (Table A5.18). The total removals of striped bass in 2006 (6.11 million fish) were the highest in the time series and reflect an 8% and a 14% increase from 2005 and 2004, respectively. More importantly, removals of fish age 8+ increased in 2006 by 7% compared to 2005 (Figure A5.13). Ages 3 (2003 year-class) and 5 (2001 year-class) sustained the highest losses in 2006 (Table A5.18).

## A5.10 CATCH WEIGHT AT AGE

Catch mean-weight-at-age data, which is used to calculate total biomass and spawning stock biomass, was calculated for the period 1998–2002 using all available weight data from MA, NY, MD, VA, NH, and CT (1998–2001) and adding data from RI and DE in 2002 (Appendix A5). For 2003–2006, mean weights at age for the 2003–2006 striped bass catches were determined as a result of the expansion of catch and weight at age. Data came from Maine and New Hampshire recreational harvest and discards; Massachusetts recreational and commercial catch; Rhode Island recreational and commercial catch; Connecticut recreational catch; New York recreational catch and commercial landings; New Jersey recreational catch; and Delaware, Maryland, Virginia, and North Carolina recreational and commercial catch (Appendix A5). Weighted mean weights at age were calculated as the sum of weight at age multiplied by the catch at age in numbers, divided by the sum of catch at age in numbers. Details of developing weights at age for 1982–1996 can be found in the SAW-26 consensus summary (Northeast Fisheries Science Center 1998). Weights at age for 1982–2006 are presented in Table A5.19.

# A6.0 CHARACTERIZE THE FISHERIES-INDEPENDENT AND -DEPENDENT INDICES OF RELATIVE ABUNDANCE. (TOR#2)

## A6.1 DATA SOURCES

States provide age-specific and aggregate indices from fisheries-dependent and fisheries-independent sources that are assumed to reflect trends in striped bass relative abundance. A formal review of age-2+ abundance indices was conducted by ASMFC at a workshop in July of 2004 (Appendix A6). Young of-the-year and age-1 indices had been reviewed and validated (ASMFC 1996). The 2004 workshop developed a set of evaluation criteria and tasked states with a review of indices. Both the Striped Bass Technical Committee and the Management Board approved the criteria and the review. The resulting review led to revisions and elimination of some indices formerly used in ADAPT (Appendix A6).

Based on the review of survey programs and technical committee recommendations (see Section 6.0), major changes were made to the suite of indices used in the ADAPT model. The NEFSC spring inshore survey, originally age-specific, was reduced to an aggregate index (ages 2–9) and was truncated at 1991 due to missed sampling of inshore survey strata prior to 1991. The Massachusetts commercial CPUE, originally age-specific harvest-per-trip indices, were redeveloped as age-specific (ages 2–13+) total catch-per-hour indices. The New Jersey trawl, originally an aggregate index, was further apportioned into age-specific mean indices for ages 2–13+. The New York ocean haul seine survey indices for ages 8–13+ were aggregated into an 8+ index. Connecticut age-specific recreational catch indices for ages 10–13+ were aggregated to 10+. The Virginia pound net survey, a single fixed station, commercial pound net index, was eliminated from the input because few analyses conducted could support its continued use as an index that reflected striped bass abundance. Two new surveys were added: age-specific (ages 2–13+) Delaware River electrofishing spawning stock indices and the coastwide MRFSS aggregate (2–13+) total catch rate index.

Descriptions of the current survey indices are given below and reflect changes to surveys following the formal review. A summary of index information is provided in Table A6.1.

### A6.1.1 Fisheries-Dependent Catch Rates

#### *A.6.1.1.1 Massachusetts Commercial Total Rate Index (MACOMM)*

Age-specific (2–13+) indices of relative abundance for 1991 to present are generated from commercial catch data. All fishermen who sell striped bass are required to report the total hours fished, number and pounds of fish caught by disposition category (i.e., released sub-legal, released legal, sold, and consumed), area fished, and the fishing method (Surf, Boat, Both) by month. A generalized linear model (GLM) is used to generate a standardized CPUE aggregate index (Hilborn and Walters 1992). Each record is the summarization of a fisher's monthly number and pounds of fish caught and hours fished by year, month, area fished (reduced to 4 regions: Cape Cod Canal, Southern MA, Cape Cod Bay, North MA), and fishing mode. The catch rate for each record is calculated by dividing the total numbers caught by the total number of hours fished. The catch rate is standardized using PROC GLM in SAS. To partition the annual aggregate index into age-specific indices, annual length frequencies of all fish caught reported by fishers on voluntary logsheets are applied to age-length keys derived for each year to estimate proportions-at-age. The proportions-at-age are then multiplied by the annual aggregate index to obtain age-specific indices.

#### *A6.1.1.2 Connecticut Recreational CPUE (CTCPUE)*

An aggregate Connecticut CPUE index (CPUE) for striped bass (1981–2006) is derived as a ratio of annual Connecticut recreational catches (A, B1, B2) from the MRFSS to annual directed fishing effort (DE in trips) on striped bass:

$$CPUE = C / DE$$

Directed fishing effort is estimated annually as the product of the total fishing trips made annually in Connecticut based on MRFSS times the fraction of positive striped bass intercepts (fracp) from MRFSS. This quantity (E*fracp) is then divided by the fraction of successful striped bass trips (fracs) recorded annually in logbooks from the Connecticut Volunteer Angler Survey (CVAS):

$$DE = (E*fracp)/ fracs)$$

To disaggregate the time series (1981–2006) of indices by age, the annual index (CPUE) is first apportioned into length frequencies reported from logbooks in the CVAS. Each year, between 70 and 95 volunteer anglers record a total of 2,800 to 4,000 length measurements (length range: 6 to 51 inches TL) of striped bass in their catches. Once the length frequencies is established, an age frequency of the annual index is derived as a product of the annual length frequency and an annual age-length key for Long Island Sound stripers derived by biologists from the NY DEC.

***A6.1.1.3 MRFSS Total Catch Rate Index (MRFSS)***

An aggregate index of relative abundance for 1988 to present is generated from MRFSS intercept data. Generalized linear modeling (McCullagh and Nelder 1989) is used to derive annual mean catch-per-hour estimates by adjusting the number of caught fish per trip for the classification variables of state, year, two-month sampling wave, number of days fished in the past 12 months (as a measure of avidity), and number of hours fished. In the analyses, only data from anglers who reported that they targeted striped bass is used to insure methods used among anglers are as consistent as possible and to identify those targeting anglers that did not catch striped bass (zero catches). Also, only data from private boats fishing in the Ocean during waves 3–6 is used.

A delta-lognormal model (Lo et al. 1992) was selected as the best approach to estimate year effects after examination of model dispersion (Terceiro 2003) and standardized residual deviance versus linear predictor plots (McCullagh and Nelder 1989). In the delta-lognormal model, catch data is decomposed into catch success/failure and positive catch components. Each component is analyzed separately using appropriate statistical techniques and then the statistical models are recombined to obtain estimates of the variable of interest. The catch success/failure was modeled as a binary response to the categorical variables using multiple logistic regression:

$$\log it(p) = \log(p/1-p) = \alpha + \sum_{i=1}^{n} \beta_i X_i + \varepsilon$$

where p is the probability of catching a fish, α is the intercept, $\beta_i$ is the slope coefficient of the *i*th factor, $X_i$ is the *i*th categorical variable (coded as 0 or 1), and ε is the error term. PROC LOGISTIC in SAS is used to estimate parameters, and goodness-of-fit was assessed using concordance measures and the Hosmer-Lemeshow test.

Positive catches, transformed using the natural logarithm, is modeled assuming a normal error distribution using PROC GLM:

$$\log(y) = \alpha + \sum_{i=1}^{n} \beta_i X_i + \varepsilon$$

where *y* is the observed positive catch, $\beta_i$ ,and $X_i$ are the same symbols as defined earlier, and ε is the normal error term. Any variable not significant at $\alpha$=0.05 with type-III (partial) sum of squares is dropped from the initial GLM model and the analysis is repeated. First-order interactions were considered in the initial analyses but it was not always possible to generate annual means by the least-square methods with some interactions included (Searle et al. 1980); therefore, only main effects are considered.

The annual index of striped bass total catch is estimated by combining the two component models. The estimate in year *i* from the models is given by

$$\hat{I}_i = \hat{p}_i * \hat{y}_i$$

where $p_i$ and $y_i$ are the predicted annual responses from the logistic and GLM. $p_i$ is calculated as

$$\hat{p}_i = \frac{\exp(\hat{\alpha} + \hat{\beta}_i)}{1 + \exp(\hat{\alpha} + \hat{\beta}_i)}$$

and $y_i$ is calculated as

$$\hat{y}_i = \exp(LSM_i + \sigma^2 / 2)$$

where $LSM_i$ is the least squares mean for year *i* and $\sigma^2$ is the mean square error.

### A6.1.2 Fisheries-Independent Survey Data

#### *A6.1.2.1 Connecticut Trawl Survey (CTTRL)*

Connecticut provides an aggregate (ages 2–4) index of relative abundance from a bottom trawl survey. The Long Island Sound Trawl Survey (LISTS) began in 1984 to provide fishery independent monitoring of important recreational species in Long Island Sound. Length data for these species are collected from every tow. All species are identified and counted. No information on the sizes of striped bass released is collected. Sampling is conducted monthly from April through November to establish seasonal patterns of abundance and distribution. LISTS is conducted from longitude 72° 03' (New London, Connecticut) to longitude 73° 39' (Greenwich, Connecticut). The sampling area includes Connecticut and New York waters from 5 to 46 m in depth and over mud, sand, and transitional (mud/sand) sediment types. Sampling is divided into spring (April–June) and fall (September–October) periods, with 40 sites sampled monthly for a total of 200 sites annually. The sampling gear employed is a 14 m otter trawl with a 51 mm codend. To reduce the bias associated with day-night changes in catchability of some species, sampling is conducted during daylight hours (Sissenwine and Bowman 1978).

LISTS employs a stratified-random sampling design. The sampling area is divided into 1.85 x 3.7 km (1x2 nautical miles) sites, with each site assigned to one of 12 strata defined by depth interval (0–9.0 m, 9.1–18.2 m, 18.3–27.3 m or, 27.4+ m) and bottom type (mud, sand, or transitional). For each monthly sampling cruise, sites are selected randomly from within each stratum. The number of sites sampled in each stratum is determined by dividing the total stratum area by 68 $km^2$ (20 square nautical miles), with a minimum of two sites sampled per stratum. Discrete stratum areas smaller than a sample site are not sampled. The CTTRL index is computed as the stratified geometric mean number per tow.

#### *A6.1.2.2 Northeast Fisheries Science Center Bottom Trawl Survey (NEFSC)*

The Northeast Fisheries Science Center provides an aggregate (2–9) index of relative abundance from the spring stratified-random bottom trawl survey. The survey covers waters from the Gulf of Maine to Cape Hatteras, NC. Only data from inshore strata from 1991–2006 are used.

#### *A6.1.2.3 New Jersey Bottom Trawl Survey (NJTRL)*

New Jersey provides age-specific (2–9+) geometric mean indices of relative abundance for striped bass from a stratified-random bottom trawl initiated in 1989. The survey area consists of NJ coastal waters from Ambrose Channel, or the entrance to New York harbor, south to Cape Henlopen Channel, or the entrance to Delaware Bay, and from about the 3 fathom isobath inshore to approximately the 15 fathom isobath offshore. This area is divided into 15 sampling strata. Latitudinal boundaries are identical to those which define the sampling strata of the National Marine Fisheries Service (NMFS) Northwest Atlantic groundfish survey. Exceptions are those strata at the extreme northern and southern ends of NJ. Where NMFS strata are extended into NY or DE waters, truncated boundaries were drawn which included only waters adjacent to NJ, except for the ocean waters off the mouth of Delaware Bay, which are also included. Samples are collected with a three-in-one trawl, so named because all the tapers are three to one. The net is a two seam trawl with forward netting of 12 cm (4.7 inches) stretch mesh and rear netting of 8 cm (3.1 inches) stretch mesh. The codend is 7.6 cm stretch mesh (3.0 inches) and is lined with a 6.4 mm (0.25 inch) bar mesh liner. The headrope is 25 m (82 feet) long and the footrope is 30.5 m (100 feet) long. Trawl samples are collected by towing the net for 20 minutes. The total weight of each species is measured with hanging metric scales and the length of all individuals comprising each species caught, or a representative sample by weight for large catches, is measured to the nearest cm. Total length is measured and only data from April are used for striped bass.

***A6.1.2.4 New York Ocean Haul Seine Survey (NYOHS)***

New York provides age-specific geometric mean indices of relative abundance for striped bass generated from an ocean haul seine survey. Since 1987, NY DEC has been sampling the mixed coastal stocks of striped bass by ocean haul seine. Sampling is conducted annually during the Fall migration on the Atlantic Ocean facing beaches off the east end of Long Island. A crew of commercial haul seine fishermen is contracted to set and retrieve the gear, and assist department biologists in handling the catch. The survey seine measures approximately 1,800 feet long and is composed of two wings attached to a centrally located bunt and cod end. The area swept is approximately ten acres. The seine is fifteen feet deep in the wings and twenty feet deep in the bunt.

Under the original design, sampling dates were selected at random to create a schedule of thirty dates. For each date selected, two of ten fixed stations were chosen at random, without replacement, as the sampling locations for that day. Since this design was difficult to implement due to weather-related delays, the sampling design was altered in 1990. Instead of randomly selecting thirty days, sixty consecutive working days were identified during the fall. One station was randomly selected, without replacement, for each working day until six "rounds" of ten hauls had been scheduled. Hauls that were missed due to bad weather or equipment failure were added to the next scheduled sampling day. No more than three hauls were attempted for any given day so that sampling was evenly distributed over time. Sixty hauls were scheduled for each year.

Since 1995, the survey team has been prohibited from gaining access to several of the fixed stations. Instead of the original ten stations, two of the original stations plus three alternate sites have been used to complete the annual survey. These alternate stations occur within the geographic range of the original standard stations. Also since 1995, funding delays have resulted in a one-month delay in the commencement of field sampling activities. Between 1987 and 1994 field sampling began in early September. Since 1995, sampling has begun in late September to early October. In addition, decreases in funding have led to reductions in annual sampling effort from sixty seine hauls to forty-five seine hauls per season since 1997. The time series of catch and catch-at-age has been standardized by date for the entire time series.

***A6.1.2.5 Maryland Spawning Stock Survey (MDSSN)***

Maryland provides spawning stock age-specific (2–13+) mean indices of relative abundance for striped bass in Chesapeake Bay from a gillnet survey initiated in 1985. Multi-panel experimental drift gill nets are deployed in spawning areas in the Potomac River and in the

Upper Chesapeake Bay during the spring spawning season in April and May. There are generally 20–25 sampling days in a season. Ten mesh panels 150 feet long that range from 8 to 11.5 feet deep are used. The panels are constructed of multifilament nylon webbing in 3.00–10.00-inch stretch-mesh. In the Upper Bay, the entire suite of 10 meshes is fished simultaneously. In the Potomac River, two suites of 5 panels are fished simultaneously. Overall, soak times for each mesh panel range from 15 to 65 minutes. In both systems, all 10 meshes are fished twice daily (20 sets) unless weather or other circumstances prohibit a second soak. Sampling locations are assigned using a stratified random survey design. Each sampled spawning area is considered a stratum. One randomly chosen site per day is fished in each spawning area. The Potomac River sampling area consists of 40 0.5-square-mile quadrants and the Upper Bay sampling area consists of 31 1-square-mile quadrants. The Choptank River was also sampled between 1985–1996. A sub-sample of striped bass captured in the nets is aged. Scales are removed from two-three randomly chosen male striped bass per one cm length group, per week, for a maximum of ten scales per length group over the entire season. Scales are taken from all males over 700 mm TL and all females regardless of total length.

CPUEs for individual mesh sizes and length groups are calculated for each spawning area. Mesh-specific CPUEs ($CPUE_{i,j}$) are calculated by summing the catch in each length group across days and sets, and dividing the result by the total effort for each mesh. Sex-specific mesh selectivity coefficients are then used to correct the mesh-specific length group CPUE estimates. Sex-specific models are used to develop selectivity coefficients for fish sampled from the Potomac River and Upper Bay. Model building and hypothesis testing has determined that male and female striped bass possess unique selectivity characteristics, but no differences are evident between the Upper Bay and the Potomac River. Therefore, sex-specific selectivity coefficients for each mesh and length group are estimated by fitting a skew-normal model to spring data from 1990 to 2000 following the procedure presented in Helser et al. (1998). Model residuals are re-sampled 1,000 times to generate a population of 1,000 mesh- and size class-specific selectivity coefficients for each year, sample area, and sex. The CPUE for each size class and mesh are then divided by the appropriate selectivity coefficient to generate 1,000 replicate matrices of mesh- and length-specific corrected catch frequencies. A vector of selectivity-corrected length-group CPUEs for each spawning area and sex is then developed. The selectivity-corrected CPUEs are averaged across meshes, using a mean that is weighted by the capture efficiency of the mesh. Finally, area- and sex-specific estimates of relative abundance are pooled to develop bay-wide estimates of relative abundance.

#### *A6.1.2.6 Delaware Spawning Stock Electrofishing Survey (DESSN)*

Delaware provides spawning stock age-specific (2–13+) mean indices of relative abundance for striped bass in the Delaware River from an electroshock survey initiated in 1996. Striped bass are sampled in the Delaware River from the vicinity of Big Timber Creek and League Island near river kilometer 152 located between Central Philadelphia downstream to the Delaware Memorial Bridge below Wilmington, DE at river kilometer 110. A stratified-random sampling design is used and a Smith-Root model 18-E boat electrofisher is used to collect striped bass. Typically, sampling is conducted with the boat moving in the direction of the tidal flow and in a zigzag pattern. Only striped bass approximately >200 mm total length are collected. Sampling is conducted weekly during mid-April to May (two days per week) and seven 12-minute timed samples are made per day. Length, weight, and sex are recorded and scales are collected from each fish.

*A6.1.2.7 New York Young-of-the-Year and Yearling Survey (NYYOY and NY Age 1)*

New York provides an index of relative abundance for young-of-the year striped bass in the Hudson River for years 1980 to present. The beach seine survey samples fixed stations between Tappan Zee to Haverstraw Bay area using a 61-m, 5-mm stretched mesh bag and 6 mm stretched mesh wing. A total of 33 fixed stations are sampled. Twenty-five stations are sampled biweekly from mid-July through early November. The arithmetic mean is used as the relative index.

New York also provides an index of relative abundance for yearling striped bass in western Long Island sound. The beach seine (61-m) survey samples fixed stations during May–October. The arithmetic mean is used as the relative index.

*A6.1.2.8 New Jersey Young-of-the-Year Survey (NJYOY)*

New Jersey provides an index of relative abundance for young-of-the year striped bass in the Delaware River for years 1980 to present. A bagged beach seine is used at fixed and random stations, which are sampled biweekly from August–October. About 256 samples are taken per year. Relative abundance index for striped bass is calculated as the mean geometric number of young-of-the-year captured per seine haul.

*A6.1.2.9 Virginia Young-of-the-Year Survey (VAYOY)*

Virginia provides an index of relative abundance for young-of-the-year bass in the Virginia portion of Chesapeake Bay. Begun in 1980, the fixed station survey is conducted in the James, York, and Rappahannock river systems. Eighteen index stations are sampled five times a year on a biweekly basis from mid-July through September. Twenty auxiliary stations provide geographically expanded coverage during years of unusual precipitation or drought when the normal index stations do not yield samples. A bagged beach seine (30.5 m long) is set by hand with one end fixed on the beach and the other fully extended perpendicular to the beach. The seine is swept with the current. Two hauls are made at each site. Abundance indices are computed as the geometric mean number of young-of-the-year or yearling bass per haul.

*A6.1.2.10 Maryland Young-of-the-Year and Yearlings Surveys (MDYOY and MD Age1)*

Maryland provides an index of relative abundance for young-of-the-year and yearling striped bass in the Maryland portion of Chesapeake Bay. Begun in 1954, the fixed station survey is conducted in the Upper Bay, Choptank, Nanticoke, and Potomac Rivers. Each station is sampled once during each monthly round performed during July, August, and September. A bagless beach seine (30.5 m long) is set by hand with one end fixed on the beach and the other fully extended perpendicular to the beach. The seine is swept with the current. Two hauls are made at each site. Abundance indices are computed as the geometric mean number of young-of-the-year or yearling bass per haul.

## A6.2 COMPARISON OF FISHERIES-DEPENDENT AND FISHERIES-INDEPENDENT INDICES

Time series of each index used in 2005 and current assessments before aggregating and tuning adjustments were done are shown in Table A6.2. The original indices are a mixture of geometric and arithmetic mean estimates. For comparative purposes, the indices of presented in both forms where possible.

Among the fisheries-dependent indices, trends in the aggregated MA Commercial index suggests a steady abundance since the mid 90s, the CT Recreational CPUE suggests steady population levels from 1996 to 2004, but abundance increased in 2005 and 2006, while the coastwide MRFSS index suggests a decline in abundance from 1998 to 2003 and a steady rise through 2006 (Figure A6.1).

The fishery-independent indices for combined ages generally indicate an increase in population abundance from the early 1990s through the mid 1990s, and relatively stable levels thereafter (Figure A6.2). The exception is the Maryland gillnet survey which shows a relatively stable population since the mid 1980s (Figure A6.2).

Indices of young-of-the-year abundance show some pattern of decline since 2003. Recruitment in 2006 was close to lows of the time series since 1990 in Chesapeake Bay (Maryland index), Delaware Bay, and the Hudson River in 2006 (Figure A6.3). Strong year-classes were evident in 1993, 1996, 2001, and 2003 in Chesapeake Bay (Maryland and Virginia), and in 1993, 1995, 1999, and 2003 in Delaware Bay, in 1997, 1999, and 2001 in Hudson River (Figure A6.3).

## A7.0 EVALUATE THE STATISTICAL CATCH AT AGE (SCA) MODEL AND ITS ESTIMATES OF F, SPAWNING STOCK BIOMASS, AND TOTAL ABUNDANCE OF ATLANTIC STRIPED BASS, ALONG WITH THE UNCERTAINTY OF THOSE ESTIMATES. (TOR #3)

### A7.1 SCA MODEL

A forward-projecting age-structured statistical catch-at-age (SCA) model for the Atlantic coast migratory stocks of striped bass was constructed and is used to estimate fishing mortality, abundance, and spawning stock biomass during 1982–2006 from total removals-at-age and fisheries-dependent and fisheries-independent survey indices.

### A7.2 MODEL STRUCTURE

The structure of the population model is aged-based and projects the population numbers-at-age forward through time given model estimates of recruitment and age-specific total mortality. The population numbers-at-age matrix has dimensions Y x A, where Y is the number of years and A is the oldest age group. The time horizon for striped bass is 1982–2006 since complete catch data are only available back to 1982. However, there are relative abundance data (Maryland young-of-the-year indices) available for earlier years. To use those earlier data, the dimensions of population numbers-at-age are expanded to (Y+A-1) x (A) matrix (Figure A7.1). The number of year classes in the model was 13, representing ages 1 through 13+.

Population numbers-at-age ($a<A$) are calculated through time by using the exponential cohort survival model

$$\hat{N}_{y,a} = \hat{N}_{y-1,a-1}\, exp^{-\hat{F}_{y-1,a-1} - M} \qquad (1)$$

where $\hat{N}_{y,a}$ is abundance of age $a$ in year $y$, $\hat{N}_{y-1,a-1}$ is abundance of age $a-1$ in year $y-1$, $F_{y-1,a-1}$ is the instantaneous fishing mortality rate for age $a-1$ in year $y-1$, and $M$ is the instantaneous natural mortality (assumed constant across years and ages). For the plus group ($A$), numbers-at-age are the sum of survivors of $A$-$1$ in year $y$-$1$ and survivors from the plus group in year $y$-$1$:

$$\hat{N}_{y,A} = \hat{N}_{y-1,A-1}\, exp^{-\hat{F}_{y-1,A-1} - M} + \hat{N}_{y-1,A}\, exp^{-\hat{F}_{y-1,A} - M} \qquad (2)$$

Recruitment (numbers of age-1 bass) in year $y$ ($N_{y,1}$ ) is estimated and it is modeled as a log-normal deviation from average recruitment:

$$\hat{N}_{y,1} = \hat{\bar{N}}_1 \cdot exp^{\hat{e}_y} \qquad (3)$$

where $N_{y,1}$ is the number of age 1 fish in year $y$, $\hat{N}_1$ is the average recruitment parameter, and $e_y$ are independent and identically distributed normal random variables with zero mean and constant variance and are constrained to sum to zero over all years. A penalty function is used to help constrain the recruitment deviations and is included in the total likelihood:

$$P_{rdev} = \lambda_R \sum_y e_y^2 \qquad (4)$$

where $\lambda_R$ is a user-specified weight. The initial population abundance-at-age for 2-13+ in 1970 is calculated by using $\hat{N}_{1970,1}$ and assuming $F_{1982,a-1}$:

$$\hat{N}_{1970,a} = \hat{N}_{1970,a-1}\, exp^{-\hat{F}_{1982,a-1} - M} \qquad (5)$$

Estimation of fishing mortality-at-age is accomplished by assuming that fishing mortality can be decomposed into yearly and age-specific components (separability):

$$\hat{F}_{y,a} = \hat{F}_y \cdot \hat{s}_a \qquad (6)$$

where $F_y$ is the fully-recruited fishing mortality in year $y$ and $s_a$ is the average selectivity value of fish of age $a$. The dimensions of the F-at-age matrix are Y x A. Similar to recruitment, $F_y$ is modeled as a log-normal deviation from average fishing mortality:

$$\hat{F}_y = \hat{\bar{F}} \cdot exp^{d_y} \qquad (7)$$

where $F_y$ is the fishing mortality in year y, $\hat{F}$ is the average recruitment parameter, and $d_y$ are independent and identically distributed normal random variables with zero mean and constant variance and are constrained to sum to zero over all years. For years earlier than 1982, the fishing mortality-at-age is assumed equal to the values for 1982. A penalty function is used to help constrain the fishing mortality deviations and is included in the likelihood function:

$$P_{fdev} = \lambda_F \sum_y d_y^2 \qquad (8)$$

where $\lambda$ is a user-specified weight. Following Brodziak (2002), a fishing mortality penalty is imposed to ensure that extremely small Fs are not produced during the early phases of the estimation process:

$$P_{f_{add}} = \begin{cases} \text{phase} < 3, & \lambda_F \cdot 10 \cdot \sum_y (F_y - 0.15)^2 \\ \text{phase} \geq 3, & \lambda_F \cdot 0.001 \cdot \sum_y (F_y - 0.15)^2 \end{cases} \quad (9)$$

Selectivity for ages $a<A$ is modeled by using the Gompertz equation, and to ensure at least one age had a maximum selectivity of 1, $s_a$ is calculated as

$$s_a = \frac{exp^{(-exp^{-\hat{\beta}(a-\hat{\alpha})})}}{max_a(exp^{(-exp^{-\hat{\beta}(a-\hat{\alpha})})})} \quad (10)$$

where $\alpha$ and $\beta$ are estimates. Based on historical changes in size and catch regulations and model comparisons (see *Exploratory Analyses* below), selectivity patterns are estimated for 4 periods: 1982–1984, 1985–1989, 1990–1995, and 1996–2006. $s_a$ for the plus group ($A$) is assumed equal to $s_a$ of age $A-1$.

For ease of computation, total mortality-at-age (Z) is calculated as

$$Z_{y,a} = F_{y,a} + M \quad (11)$$

and fills a matrix of dimension Yx A. For years earlier than 1982, Z is assumed equal to the Z values of 1982.

For total catch and survey indices data, lognormal errors are assumed throughout and the concentrated likelihood, weighted for variation in each observation, was calculated. The generalized concentrated negative log-likelihood ($-L_l$) (Parma 2002; Deriso et al. 2007) is

$$-L_l = 0.5 * \sum_i n_i * \ln\left(\frac{\sum_i RSS_i}{\sum_i n_i}\right) \quad (12)$$

where $n_i$ is the total number of observations and $RSS_i$ is the weighted residual sum-of-squares from dataset $i$. Equations for the weighted residual sum-of-squares are shown following the description (given below) of each dataset.

For the catch and survey age compositions, multinomial error distributions are assumed throughout and the negative log-likelihoods are calculated using the general equation

$$-L = \sum_y -n_y \sum_a P_{y,a} \cdot \ln\left(\hat{P}_{y,a}\right) \quad (13)$$

Specific equations for each dataset are shown following the description of each dataset.

Total catch (recreational and commercial harvest numbers plus number of discards that die due to handling and release) and the proportions of catch-at-age of striped bass fisheries are the primary data from which fishing mortalities, selectivities, and recruitment numbers are estimated. Given estimates of F, M, and population numbers, predicted catch-at-age is computed from Baranov's catch equation (Ricker 1975):

$$\hat{C}_{y,a} = \frac{\hat{F}_{y,a}}{\hat{F}_{y,a} + M} \cdot (1 - exp^{-\hat{F}_{y,a} - M}) \cdot \hat{N}_{y,a} \qquad (14)$$

where $\hat{C}_{y,a}$ is the predicted removals of age *a* during year *y* and other variables are as defined above. All predictions are stored in a matrix of dimension *Y* x *A*. Predicted catch-at-age data are then compared to the observed total catch and proportions of catch-at-age through the equations:

*Predicted Total Catch*

$$\hat{C}_y = \sum_a \hat{C}_{y,a} \qquad (15)$$

*Predicted Proportions of Catch-At-Age*

$$\hat{P}_{y,a} = \frac{\hat{C}_{y,a}}{\sum_a \hat{C}_{y,a}} \qquad (16)$$

where $\hat{C}_y$ is the predicted total catch in year *y* and $P_{y,a}$ is the predicted proportions of age *a* in the catch during year *y*.

The weighted lognormal residual sum-of-squares ($RSS_c$) for total catch is calculated as

$$RSS_c = \lambda_c \sum_y \left( \frac{\ln\left(C_y + 1e^{-5}\right) - \ln\left(\hat{C}_y + 1e^{-5}\right)}{CV_y} \right)^2 \qquad (17)$$

where $C_y$ is the observed catch in year *y*, $\hat{C}_y$ is the predicted catch in year *y*, $CV_y$ is the CV for observed catch in year *y,* and $\lambda_c$ is the relative weight (Parma 2002; Deriso et al. 2007). Total catch CVs are assumed equal to the PSEs of MRFSS total catch estimates for the entire Atlantic coast (less South Carolina, Georgia and East Florida records) since it is assumed that only the estimates of recreational kill and dead discards have error.

In addition, the predicted proportions of catch-at-age are compared to the observed proportions of catch-at-age through a multinomial probability model. The proportions of catch-at-age negative log-likelihood ($L_p$) is

$$-L_p = \lambda_p \sum_y -n_y \sum_a P_{y,a} \cdot \ln\left(\hat{P}_{y,a} + 1e - 7\right) \qquad (18)$$

where $n_y$ is the effective number of fish aged in year y and $P_{y,a}$ is the observed proportion of catch-at-age. The multinomial probability assumes that the number of aged fish used to apportion the catch into age classes are sampled randomly and independently of each other. This is truly not the case because gear and fishing practices collect fish in groups or clusters; thus, the effective sample size is much smaller than the actual number of fish aged. Therefore, the effective sample size was estimated by using the manual, iterative method of McAllister and Ianelli (1997). The effective sample size for each year is the average over all years and it is set to 380 fish in this model.

The observed total catch and catch age compositions were generated from all state reported landings-at-age, recreational dead discards-at-age, and commercial dead discards-at-age. Total catch by year was calculated by summing catch across age classes. The catch age composition was calculated by dividing the catch-at-age for a given year by yearly total catch.

Young-of-the-year (YOY) and yearlings indices from New York (Hudson River YOY: 1980–2006; West Long Island Sound Age 1: 1986–2006), New Jersey (Delaware Bay YOY: 1981–2006), Maryland (Chesapeake Bay YOY and Age 1: 1970–2006), and Virginia (Chesapeake Bay YOY: 1983–2006) were incorporated into the model by linking them to corresponding age abundances and time of year:

$$\hat{I}_{t,y,\mathrm{a}} = \hat{q}_t \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}} \qquad (19)$$

where $\hat{I}_{t,y,a}$ is the predicted index of survey $t$ for age $a$ in year $y$, $q_t$ is the catchability coefficient of index $t$, $N_{y,a}$ is the abundance of age $a$ in year $y$, $p$ is the fraction of total mortality that occurs prior to the survey, and $Z_{y,a}$ is the total instantaneous mortality rate. All $q$s are estimated as free parameters. Because age 0 striped bass are not modeled, the YOY and yearling indices were advanced one year and are linked to age 1 and age 2 abundances, respectively, and are tuned to January 1$^{st}$ (p=0;Table A7.1). All YOY and yearling indices are arithmetic means and corresponding CVs. More information on these surveys can be found in ASMFC (1996).

The aggregate indices (no or borrowed age data or other reasons) from the Marine Recreational Fisheries Statistics Survey (MRFSS: 1988–2006), Connecticut (Recreational CPUE: 1982–2006; bottom trawl survey: 1984–2006), Northeast Fisheries Science Center (NEFSC spring bottom trawl survey: 1991–2006) and Massachusetts (commercial total catch rates: 1991–2006) are incorporated into the model by linking them to aggregate age abundances and the time of year (Table A7.1):

$$\hat{I}_{t,y,\Sigma a} = \hat{q}_t \cdot \sum_a \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}} \qquad (20)$$

All aggregate indices are arithmetic means of the survey estimate. The annual CVs for the MRFSS index were calculated by dividing model estimates of standard errors by the index. The CVs for the Connecticut Recreational CPUE index were assumed equal to the CVs of the total recreational catch values for Connecticut generated by MRFSS. CVs for the remaining surveys were estimated from survey data.

The age-aggregated indices and age composition data from New York (ocean haul seine: 1987–2006), New Jersey (bottom trawl: 1989–2006), Maryland (gillnet: 1985–2006), and Delaware (electrofishing: 1996–2006) surveys are incorporated into the model by linking them to age abundances and the time of year:

$$\hat{I}_{t,y} = \hat{q}_t \sum_a \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}} \qquad (21)$$

where $s_{t,a}$ is the selectivity coefficient for age *a* in survey *t*. The fraction of the year and ages to which each survey is linked is listed in Table A7.1. The weighted residual sum of squares for survey *t* is given by:

$$RSS_t = \lambda_t \sum_y \left( \frac{\ln\left(I_{t,y} + 1e^{-5}\right) - \ln\left(\hat{I}_{t,y} + 1e^{-5}\right)}{CV_{t,y}} \right)^2 \qquad (22)$$

The Gompertz equation is used to estimate the selectivity pattern for the Delaware spawning stock survey because theory indicates that vulnerability to electric fields increases with surface area of the fish (Reynolds 1983). Because MD survey estimates are corrected for mesh-size selectivity, it was determined by trial-and-error that only the selectivity value for age 2 had to be estimated; for ages $\geq$ 3, selectivity was set to 1. For the New York ocean haul survey, the Thompson's exponential-logistic model (Thompson 1994) is used to estimate the selectivity pattern

$$\hat{s}_a = \frac{1}{1-\gamma} \cdot \left( \frac{1-\gamma}{\gamma} \right)^{\gamma} \frac{\exp^{\alpha\gamma(\beta - a)}}{1 + \exp^{\alpha(\beta - a)}} \qquad (23)$$

For the New Jersey survey, a gamma function is used to estimate the selectivity pattern:

$$\hat{s}_a = \frac{a^{\alpha} \exp^{\beta \cdot a}}{\max_a (a^{\alpha} \exp^{\beta \cdot a})} \qquad (24)$$

Total aggregate index by year is calculated by summing age-specific indices across age classes. The survey age composition is calculated by dividing the age-specific indices by the total aggregate index for a given year. The predicted age composition (proportions-at-age) of each survey is modeled and compared to the observed proportions-at-age through a multinomial probability model. The predicted survey indices-at-age are calculated as

$$\hat{I}_{t,y,a} = \hat{q}_t \cdot \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}} \qquad (25)$$

and predicted age composition is calculated as

$$\hat{U}_{t,y,a} = \frac{\hat{I}_{t,y,a}}{\sum_a \hat{I}_{t,y,a}} \qquad (26)$$

The age composition negative log-likelihood for survey *t* is

$$-L_t^U = \lambda_t \sum_y - n_{t,y} \sum_a U_{t,y,a} \cdot \ln\left(\hat{U}_{t,y,a} + 1e^{-7}\right) \qquad (27)$$

where $n_{t,y}$ is the effective sample size of fish aged in year $y$ from survey $t$, and $U_{t,y,a}$ and $U_{t,y,a}$ are the observed and predicted proportions of age $a$ in year $y$ from survey $t$. Used as starting values, the average effective sample size for each survey was calculated by using methods in Pennington and Volstad (1994) and Pennington et al. (2002). In essence, effective sample size was estimated by first calculating the length sample variance using the simple random sampling equation and dividing into it the cluster sampling variance of mean length derived through bootstrapping, assuming each seine/trawl haul, gillnet set, or electrofishing run was the sampling unit. The average of the annual effective sample sizes was used as starting values in each survey multinomial error distribution (Table A7.2).

Model fit for all components was checked by using residual plots. In addition, predicted average effective sample size for the catch and survey age composition data were compared to the observed starting values used in the model. Predicted average effective sample size ($\hat{\bar{t}}$) is calculated following McAllister and Ianelli (1997):

$$\hat{\bar{t}} = \frac{\sum_y \hat{t}_y}{d_y} \qquad (28)$$

and $\hat{t}_y$ is defined as

$$\hat{t}_y = \frac{\sum_a \hat{c}_{a,y}(1 - \hat{c}_{a,y})}{\sum_a (o_{a,y} - c_{a,y})^2}$$

where $\hat{c}_{a,y}$ is the predicted proportion-at-age $a$ in year $y$ from the catch or survey, $o_{a,y}$ is the observed proportion-at-age, and $d_y$ is the number of years of data for catch or survey series. The effective sample sizes for catch and survey proportions were repeatedly adjusted until the predicted sample sizes stabilized under equal weighting of all components. The effective sample sizes for NJ trawl and NY ocean haul survey did not change from the starting values, but those for the MD gillet and DE electrofishing surveys increased from 68 to 77, and 68 to 87, respectively. The average effective sample size for the catch proportions was estimated to be 380.

The total log-likelihood of the model is

$$f = -L_l - L_p - L^U_{NYOHS} - L^U_{NTrawl} - L^U_{NYOHS} - L^U_{MDSSN} + P_{rdev} + P_{fdev} + P_{fadd} \qquad (29)$$

The total log-likelihood is used by the autodifferentiation routine in AD Model Builder to search for the "best" selectivity parameters, average recruitment, recruitment deviations, average F, fishing mortality deviations, and catchability coefficients that minimize the total log-likelihood. AD Model Builder allows the minimization process to occur in phases. During each phase, a subset of parameters is held fixed and minimization is done over another subset of parameters until eventually all parameters have been included. In this model, the following parameters were solved over ten phases:

Phase
1 average recruitment
2 average fishing mortality and fishing mortality deviations
3 recruitment deviations
4 catch selectivity parameters
5 catchability coefficients of YOY/Yearling and aggregate survey indices
6 catchability coefficients of survey indices with age composition data
7 NY survey selectivity parameters
8 NJ survey selectivity parameters
9 DE survey selectivity parameters
10 MD survey selectivity parameters

The estimation proceeds by first calculating $F_{a,y}$ using initial starting values for $F_y$ and $s_a$ (initial parameters estimates are used for the selectivity equations) and, with M (which is fixed at 0.15) and initial values of average recruitment by year, the abundance matrix is filled (Figure A7.1). Note that recruitment is actually estimated back to 1970 in order to provide more realistic estimates of N in the first year of data (1982). Also, this allowed the incorporation of indices (e.g., Maryland young-of-the-year index) back to 1970 unlike the ADAPT model. All predicted values were calculated using the equations described above. Initial starting values for all parameters are given in Table A7.3 and were selected based on trial-and-error.

### A7.2.1 Code Checking

To check accuracy of model code (Appendix A7), a virtual population of striped bass was simulated in EXCEL and catch numbers, catch age composition, one age-1 index, one aggregate index and one survey index with age composition data were generated using the above model equations and known values of fishing mortality, natural mortality, recruitment, catch and survey selectivities, and catchability coefficients. The catch and survey data and known parameters were then input into the model and the model was run without minimization to check if the code produced the exact values of the simulated population. The model was then run with minimization to check estimation. Both trials showed that the model duplicated the simulated population quantities.

## A7.3 EXPLORATORY ANALYSES

### A7.3.1 Catch Selectivity Functions

In the initial development of the model, four catch selectivity functions were examined: logistic (flat-top), Gompertz (flat-top), double logistic (dome-shaped), and gamma (dome-shaped). Through run comparisons, the Gompertz and gamma functions were shown to produce better predictions of catch age composition than the remaining two functions. Also, the model was slightly unstable using the double logistic (because four-parameters are estimated instead of two). To evaluate the "best" number of periods and most appropriate function to use, the number and type of function was varied over model runs with the striped bass data through 2006 and equal weighting across all components. Periods were >1982 (1 selectivity equation); 1982–1984 and $\geq$1985 (2 equations); 1982–1984, 1985–1989, and $\geq$1990 (3 equations); 1982–1984, 1985–1989, 1990–1995, and $\geq$1996 (4 equations); 1982–1984, 1985–1989, 1990–1995, 1996–2002, >2003 (5 equations). Each period designates a major change in management regulations. The

Akaike's Information Criterion (AIC; Burnham and Anderson 2002) for each run was calculated and the likelihood ratio test (LRT) was used to determine if the addition of a selectivity period significantly accounted for more variation than the previous run. Under equal weighting of all components, the values for AIC and LRT indicated that the best configuration was the model with 4 catch selectivity periods using the Gompertz function (Figure A7.2).

### A7.3.2 Total Catch Lambda Weights

The model runs under the variable selectivity periods (see above) showed that the total catch was not predicted well in early years of the time series and large, unreasonable estimates of fully-recruited fishing mortality resulted (Figure A7.3). When the lambda weight of total catch was increased to 5 or 10, improved fit between observed and predicted and more reasonable estimates of fully-recruited fishing mortality occurred (Figure A7.4). However, as the lambda weight increased, the AIC values and fully-recruited F in 2006 estimates increased (Figure A7.5); regardless, the improved fit near the start of the time series warranted the use of the total catch lambda weight = 10.

### A7.3.3 Component Contribution

The sensitivity of each data source under equal weighting of all components and the four period selectivity configuration was investigated by de-emphasizing each index one-at-a-time using a lambda of 0.5 and re-running the model. Relative changes between the base 2006 F and the 2006 F of de-emphasized cases were minor (<5% change), indicating that no single component had a major influence on model results (Table A7.4).

### A7.3.4 Retrospective Analysis

Additional model runs were made to examine the effect of changing the number of selectivity periods (Gompertz functions) and total catch lambda weights on the retrospective pattern of the model. A retrospective index (the average of the differences between the 2004 and 2005 terminal F estimates and the same yearly estimate from the 2006 run) was calculated to compare retrospective patterns across levels. Retrospective plots (Figure A7.6) and comparison of the retrospective index (Figure A7.7) among model runs indicated that the retrospective bias was lowest at equal weights across all components and when 4 or less selectivity periods were used. Retrospective bias increased when larger total catch lambda weights were used and five selectivity periods were assumed (Figure A7.7).

## A7.4 FINAL MODEL CONFIGURATION AND RESULTS

Based on the above analyses and recommendations from the ASMFC's striped bass stock assessment and technical committees, the final model contained four catch selectivity periods (using the Gompertz function), the total catch lambda weight=10, and all indices (except Massachusetts commercial index) and all survey selectivity functions. In addition, the aggregate age values for the Connecticut trawl survey were changed from ages 4–6 to ages 2–4 to reflect current opinion on the ages of trawl-caught striped bass, and aggregate age values for the MRFSS index were changed from ages 2–13 to ages 3–13 to reflect the age structure of larger fish found in offshore waters. The data used for the final model run configuration were updated and are different from those used in Section A7.3 because changes in the 2004 MRFSS harvest and release numbers occurred, and estimates of wave 1 harvest from Virginia waters in 2005 and

2006 were added. Initial starting values for all parameters are given in Table A7.3; there were 94 parameters estimated in the model.

**A7.4.1 Results**

Resulting contributions to total likelihood are listed in Table A7.5. The converged total likelihood was 28,809.5 (Table A7.5). Estimates of fully-recruited fishing mortality, recruitment, parameters of the Gompertz functions for the four selectivity periods, catchability coefficients for all surveys, and parameters of the survey selectivity functions are given in Table A7.6 and are shown graphically in Figure A7.8. Graphs depicting the observed and predicted values, as well as residuals for the catch age composition, survey indices, and survey compositions are given in Appendix A8. The model fit the observed total catch (Figure A7.8) and catch age composition well (Appendix A8), and the YOY, age 1, MRFSS, CTCPUE, CTTrawl, NEFSC indices reasonably well (Appendix A8). Except for MD SSN, the predicted trends matched the observed trends in survey indices, and predicted the survey age composition reasonably well (Appendix A8). The predicted values of effective sample size for the catch and survey age compositions using total catch lambda=10 were close to values derived under equal weighting of all components (Figure A7.9).

**A7.4.1.1 Fishing Mortality**

Fully-recruited fishing mortality in 2006 was 0.32 (ages 10–12; Table A7.6). The 2006 average fishing mortality rate (F) for ages 8 through 11 equaled 0.31 (95% CI: 0.233-0.404) and is slightly above the current target (0.30) but is not over the threshold (0.41)(Table A7.7; Figures A7.10 and A7.11). Average fishing mortality on ages 3–8, which are generally targeted in producer areas, was 0.22 (Table A7.7; Figure A7.10). Among the individual age groups, the highest values of F in 2006 (0.31–0.32) were estimated for ages 9–13+ (Table A7.8). An average F weighted by N was calculated for comparison to tagging results since the tag releases and recaptures are weighted by abundance as part of the experimental design. The 2006 F weighted by N for ages 7–11 (age 7 to compare with tagged fish ≥28") was 0.31 (Table A7.7; Figure A7.10). An F weighted by N for ages 3–8, comparable to the direct enumeration estimate for Chesapeake Bay, was equal to 0.16 (Table A7.7; Figure A7.10).

Fishing mortality-at-age in 2005 and 2006 was partitioned into various components of the recreational and commercial fisheries using ratios of component catch-at-age to total catch-at-age. Results showed that, although the recreational fishery induced the highest mortality, the contribution of the recreational release and harvest components to the total fishing mortality changed with fish age (Figure A7.11).

***A7.4.1.2 Population Abundance (January 1)***

Striped bass abundance (1+) increased steadily from 1982 through 1997, when it had around 65 million fish (Table A7.9, Figure A7.8). Total abundance declined thereafter and has average around 57 million fish since 2000. Total abundance in 2006 was 55.8 million (95% CI: 44,339,600–68,642,300; Figure A7.12). The 2003 cohort remained strong at 16 million fish in 2006 (ages 3) and exceeded the sizes of the strong 1993, 1996, and 2001 year classes at the same age (Table A7.9). Abundance of striped bass age 8+ increased steadily through 2004 to 8.5 million, but has since declined to 6.2 million fish (95% CI: 4,587,450–7,932,800) in 2006 (Table A7.9, Figures A7.8 and A7.12).

*A7.4.1.3 Spawning Stock Biomass*

Weights-at-age used to calculate spawning stock biomass were generated from catch weights-at-age and the Rivard algorithm described in the NEFSC's VPA/ADAPT program. Sex ratio at age was assumed 50:50. Female SSB grew steadily from 1982 through 2003 when it peaked at about 33 thousand mt (Table A7.10, Figure A7.13). Female SSB has declined since then and was estimated at 25 thousand metric tons (95% CI: 18,563–32,169) in 2006 (Table A7.10; Figure A7.12). The estimated SSB in 2006 remained above the threshold level of 14 thousand metric tons and indicates that the striped bass are not overfished.

*A7.4.1.4 Retrospective Analysis*

Retrospective bias was evident in the estimates of fully-recruited F, SSB, and age 8+ abundance of SCA (Figure A7.14). The retrospective pattern suggests that fishing mortality is likely over-estimated and could decrease with the addition of future years of data. Similar retrospective trends have been observed in the previous assessment of striped bass using the ADAPT VPA (ASMFC 2005) and in the supporting ASAP and ADAPT models presented in the current assessment. Experiences from other assessments indicate that it is possible for the magnitude and direction of the retrospective pattern to change in subsequent assessments. For example, the retrospective analysis from the 2003 assessment of striped bass showed an underestimation of the terminal year estimation of fully recruited F while the retrospective analysis from the 2005 assessment showed an over estimation of F (ASMFC 2003b; ASMFC 2005).

**A7.4.2 Sensitivity Analyses**

*A7.4.2.1 Starting Values*

Starting values for the minimization routine are important to achieve proper convergence at the global minimum. The starting values were selected based on trial-and-error. Many runs were conducted to find values that appeared to be reliable and for which the global minimum was reached consistently. To further check the convergence properties of the model, 100 model runs using total catch lambda weight=10 were made, and for each run, starting values were randomly permuted by ±50%. A plot of fully-recruited Fs in 2006 and corresponding total log-likelihoods assessed convergence stability. The model demonstrated excellent convergence properties because 100 out of 100 trials converged at the same likelihood and estimated the same 2006 fishing mortality rate (Figure A7.15). Examples of randomized ±50% starting values are shown in Table A7.11.

*A7.4.2.2 Natural Mortality*

The effects of varying M above or below the assumed M of 0.15 are shown in Figure A7.16. Higher fully-recruited fishing mortality estimates were generated when M was decreased, and lower fully-recruited fishing mortality estimates were generated when M was increased.

The effects of increasing M to 1.0, 0.5, and 0.35 for ages 1–3, respectively, were also investigated. The time series of fully-recruited F estimates changed little when the higher natural mortality rates were used, but the recruit abundance estimates quadrupled in magnitude (Figure A7.17).

The effects of increasing M for all ages after 1996 was also investigated to determine if the retrospective pattern observed in fully-recruited F may be attributed to changes in M (due to the

*Mycobacterium* outbreak in Chesapeake Bay). M was set to 0.30 for years 1997–2006. Increasing M had a negative impact on the retrospective pattern because the retrospective bias increased (Figure A7.18) compared to the retrospective pattern assuming constant M=0.15 across all ages (Figure A7.14).

***A7.4.2.3 Effects of Deleting Survey Datasets***

The contribution of each survey data source to the results of the final model configuration was investigated by removing each dataset one-at-a-time and re-running the model. Changes in the time series of F estimates for 1982–2006 between base run (all indices) and each one removed one-at-a-time were minor (Figure A7.19). The removal of the NY YOY survey index had the largest impact on F estimates near the terminal year, and the removal of the MD gillnet survey had the largest impact on F estimates at the beginning of the time series (Figure A7.19)

A7.4.2.4 Effects of Changing Estimation Phases

The influence of the assigned estimation phases on the results (fishing mortality and total log-likelihood) of the final model configuration was investigated by changing the phase during which each parameter set was estimated. There were no differences between fully-recruited fishing mortality and total log-likelihoods of the three runs made (Table A7.12).

***A7.4.2.5 Effects of Decreasing Effective Sample Sizes of Catch and Survey Multinomials***

The influence of the magnitude of average effective sample sizes of the catch and survey multinomial likelihoods on the estimates of fully-recruited fishing mortality were investigated. When the average effective sample sizes were decreased to 10% of the original values, fully-recruited F estimates for years 1982–1989 varied from the original estimates but F estimates after 1989 changed little (Figure A7.20). In addition, when data from selected surveys were also deleted one-at-a-time, only slight differences in fully-recruited fishing mortality from 1990 to 2006 occurred (Figure A7.20).

## A7.5 COMPARISON OF SCA MODEL RESULTS TO ADAPT AND ASAP MODELS RESULTS

The ADAPT Virtual Population (Appendix A9) and the ASAP statistical catch-at-age (Appendix A10) models were applied to the catch-at-age data and relative abundance indices (the same complement of indices used in 2005) and estimates of F were compared to the SCA model estimates. The ADAPT model produced the highest Fs for 1986–1999, while the SCA produced the highest Fs for 2001–2005 (Figure A7.21). All estimates of F were $\leq$0.34 in 2006. Although the SCA model did show slightly more retrospective bias in the estimates of fishing mortality and abundance than the ADAPT and ASAP models, the SCA was selected as the primary analytical model for several reasons. For the ADAPT model to get realistic fishing mortality estimates, many indices had to be removed (Appendix A9); therefore, the results may not be best at capturing all the information among all stock components. In the SCA model, all indices (except MA COMM) were used and the estimates of F were robust to the inclusion/exclusion of indices. Although the ASAP works well in predicting catch at age in recent years, it was necessary to fix the selectivity pattern (Appendix A10) based on the selectivity pattern from ADAPT which may perpetuate any errors from that model. Also, the indices in the ASAP were not fit well in many cases. In the SCA model, the number and form of the selectivity patterns were chosen based on analytical methods and were estimated in the model. Although the SCA model did not predict every index well, the results were not affected by the deletion of an index.

## A7.6 COMPARISON OF SCA RESULTS TO CATCH CURVE ANALYSIS AND RELATIVE F ESTIMATES

Cohort catch curves and a year specific total mortality estimate derived from the cohort specific catch curve data were calculated by using the total catch-at-age matrix and linear regression (Appendix A11). In addition, relative F (Sinclair 1998) was derived as a ratio of landings to several selected tuning indices that were considered informative about changes in fully recruited (ages 8+) stock size (Appendix 12). The trend in relative F was similar (except for the decline in 2005 and 2006) to the trend in the average F for ages 8–11 from the SCA, ASAP and ADAPT (Figure A7.21). However, average total mortality (Z) from the catch curve analysis showed a declining trend after 2000 while Z from the SCA, ADAPT, and ASAP models showed increasing trend. Note that if M of 0.15 was subtracted from the catch curve Z, most estimate of F would be below 0.10 after 2002.

## A7.7 SOURCES OF UNCERTAINTY IN SCA

Accurate estimates of catch at age require that we know the total loss in numbers and that we apportion this loss correctly to age. The best data on loss comes from the directed recreational and commercial fisheries. In this year's assessment, we had to estimate wave 1 recreational harvest of the winter fishery off Virginia by using North Carolina harvest and tag returns, along with Virginia tag returns, because MRFSS sampling is not conducted during this time. There is less confidence in estimates of discards in commercial and recreational fisheries because little of the data is measured directly. Moreover, gear specific discard/release mortalities are assumed to be constant even though mortalities may vary with season and with changes in gear specifics such as increased use of circle hooks. The quality of data on age composition varies among fisheries and region. In most cases, fish in catches or discards are measured and length frequencies are converted to age frequencies with age length keys. States with large harvests usually sample fisheries directly and develop age length keys from the fishery and time of year of the fishery. However, states with small fisheries must often rely on length data from small samples or fishery independent collections or use age length keys developed by neighboring jurisdictions. Finally, the assignment of age to scales samples becomes less certain with increasing fish age ($\geq$ age 10).

The abundance indices used in the SCA models were the suite of available indices approved through a reasoned and objective evaluation process. The review reduced the number of indices and the number of indices at age, especially for fish age eight and older. The CTCPUE indices were aggregated into separate indices because age-length data from New York were used to partition the CTCPUE into age-specific indices.

Estimates of F and population size from the catch at age analyses at the beginning of the time series, not the terminal year, are the most uncertain estimates. However, retrospective analysis indicated that the terminal year estimates are positively biased and may decrease somewhat with an additional year of data.

# A8.0 EVALUATE THE BARANOV'S CATCH EQUATION METHOD AND ASSOCIATED MODEL COMPONENTS APPLIED TO THE ATLANTIC STRIPED BASS TAGGING DATA. EVALUATE ESTIMATES OF F AND ABUNDANCE FROM COASTWIDE AND CHESAPEAKE BAY SPECIFIC PROGRAMS ALONG WITH THE UNCERTAINTY OF THOSE ESTIMATES. (TOR #4)

## A8.1 INTRODUCTION

This report summarizes the results of the United States Fish and Wildlife Service's (USFWS) Atlantic coastwide cooperative striped bass tagging program through the 2006 tagging year. The Striped Bass Tagging Subcommittee (SBTS) of the Striped Bass Technical Committee of ASMFC analyzes the data gathered by the tagging program. The subcommittee is composed of members from participating state agencies and USFWS.

Two modeling approaches were used for the 2006 assessment. Previously, the SBTS had used Program MARK to estimate a time series of annual survival rates (S) (Smith et al. 2000). Post modeling, instantaneous total mortality (Z as $-\log_e$ S) was partitioned into instantaneous fishing (F) and natural (M) mortalities using a biologically-based constant value of M (0.15). The use of this method produced estimates of F that were sometimes nonsensical and conflicted with other indicators of stock status. In an attempt to move away from an assumed M, the SBTS changed to a method based on estimates of survival estimates produced by Program MARK (White and Burnham 1999) and subsequent use of Baranov's catch equation (Ricker 1975) proposed by Pollock et al. (1991), to parse Z into F and M. Additionally, the SBTS is also presenting a new approach for the 2006 assessment – a formulation of Jiang et al. (2007) instantaneous (mortality) rates model. While additional assessment of this method needs to be performed, the committee would like to move towards this as the primary tag-based model in the future.

## A8.2 DESCRIPTION OF ATLANTIC COASTWIDE STRIPED BASS TAGGING PROGRAM

Eight tagging programs participate in the USFWS Atlantic coastwide striped bass tagging program, and have been in progress for at least 14 years. As striped bass are a highly migratory anadromous species, the tagging programs are divided into two categories, producer area programs and coastal programs. Most programs tag striped bass (primarily fish $\geq$ 18 inches total length (TL)) during routine state monitoring programs.

Producer area tagging programs primarily operate during spring spawning on the spawning grounds. Several capture methods are used, such as pound nets, gill nets, seines and electroshocking. The producer area programs are:

- Delaware and Pennsylvania (DE/PA) - fish tagged in the Delaware River primarily in April and May;
- Hudson River (HUDSON) - fish tagged in May;
- Maryland (MDCB) - fish tagged in the Potomac River and the upper Chesapeake Bay primarily in April and May; and
- Virginia spawning stock program (VARAP) - fish tagged in the Rappahannock River during April and May.

Coastal programs tag striped bass from mixed stocks during fall, winter, or early spring. Gears include hook and line, seine, gill net, and otter trawl. The coastal tagging programs are:

- Massachusetts (MADFW) - fish tagged during September–October months;
- North Carolina winter trawl survey (NCCOOP) - fish tagged primarily in January;
- New Jersey Delaware Bay (NJDEL) - fish tagged in March and April; and
- New York ocean haul seine survey (NYOHS) - fish tagged during October–November months.

Tag recovery matrices for each program used in the current assessment are presented in Appendix A13.

### A8.3 ASSUMPTIONS AND STRUCTURE OF THE MODEL

Survival estimates are generated from Program MARK using analysis protocol based on assumptions described in Brownie et al. (1985) and elaborated for striped bass in Smith et al. (2000). Important assumptions (Brownie et al. 1985) are:

1. the sample is representative of the target population;
2. there is no tag loss;
3. survival rates are not affected by the tagging itself;
4. the year of tag recoveries is correctly tabulated;
5. the fate of each tagged fish is independent of the fate of other tagged fish;
6. the fate of a given tagged fish is a multinomial random variable; and
7. all tagged individuals of an identifiable class (age, sex) in the sample have the same annual survival and recovery rates.

In this method, Program MARK (White and Burnham 1999) was used to develop estimates of survival. Program MARK is based on Kullback-Leibler information theory and Akaike's information criterion (AICc; Akaike 1973; Burnham and Anderson 1992, 2003). Maximum likelihood estimates of the multinomial parameters of survival and recovery are calculated based on the observed matrix of recaptures. Candidate models are fit to the tag recovery data and arranged in order of goodness-of-fit by a second-order adjustment to the Akaike's information criterion.

Candidate models were selected before analysis and were based on biologically-reasonable hypotheses. Parameters of the models define various patterns of survival and recovery as follows (model formulas are explained more fully in Table A8.1):

- the global model {S(t) r(t), i.e., fully parameterized model} is a time-saturated model and was used to estimate over-dispersion and model fit statistics (*see Model Diagnostics*);
- models {S(p)r(p), S(p)r(t), S(d)r(p) and S(v)r(p)} parameterize survival as constant within time periods that are based on regulatory changes between 1987 and 2006 (regulatory periods are explained in Table A8.2);
- one model estimates the terminal year separately {S(d)r(p)} and another estimates the most recent two years separately {S(v)r(p)} in order to provide more exact estimates of recent years for management; and
- constant models {S(.)r(.), S(.)r(p), S(.)r(t)} that hold survival and/or recovery constant over time are also reasonable and was included. Selection of a constant model does not

mean *"no"* variation in survival across the time series, but suggests that year-to-year variation in annual survival is "...relatively small in relation to the information contained in the sample data" (Burnham and Anderson 2003).

Models with time as a covariate within regulatory periods {S(Tp)r(Tp), S(Tp)r(t), S(Tp)r(p)}, designed to indicate increasing or decreasing monotonic trends in survival within regulatory periods, were removed from the suite of models this year. Analyses of simulated data showed trend models tended to underestimate the terminal year estimate of survival (overestimate F) by forcing a monotonic trend, when the true trend may not be linear through the entire period (Welsh 2004). Given that fisheries management emphasizes terminal year estimates, along with the use of a more comprehensive suite of models that can evaluate changes in latter years, the SBTS concluded there was no biological reason to continue using the trend models.

## A8.4 MODEL DIAGNOSTICS

Model adequacy is a major concern when deriving inference from a model or a suite of models. Over-dispersion, inadequate data (such as low sample size) or poor model structure may cause a lack of model fit. Over-dispersion is expected in striped bass tagging data, given that a lack of independence may result from schooling behavior.

After running the suite of models in Program MARK, an estimate of the variance inflation factor ("c-hat") was used to adjust for over-dispersion, if detected (Anderson et al. 1994). Over-dispersion was examined through the goodness-of-fit of the global model. The goodness-of-fit probability of the global model was quantified as a bootstrap-derived p-value based on model deviance (Burnham and Anderson 2003). A low p-value (<0.15) and a large estimate of c-hat (> 4) imply inappropriate model structure (Burnham and Anderson 2003). A low bootstrap-derived p-value (<0.15) and a moderate estimate of c-hat (>1 and <4) support over-dispersion, with appropriate model structure. C-hat was estimated by dividing the observed Pearson chi-square value (goodness-of-fit statistic of the global model) by the expected Pearson chi-square value (derived from a bootstrap analysis of the global model).

## A8.5 MODEL AVERAGING

After model diagnostics were performed, model averaging was performed to estimate program-specific annual survival rates. Survival rates were estimated for two size groups (fish ≥ 18 inches TL and fish ≥ 28 inches TL). These estimates were calculated as weighted averages across all models, where weight was a function of model fit (Buckland et al. 1997). Model averaging eliminated the need to select the single "best" model, and allowed the uncertainty of model selection to be incorporated into the variance of parameter estimates (Burnham and Anderson 2003). Survival is inestimable for the terminal year in the fully time-saturated {S(t)r(t)} model, so this model was excluded from the model-averaged survival estimate for the terminal year. A weighted average of unconditional variances was estimated for the model-averaged estimates of survival (Buckland et al. 1997).

## A8.6 BIAS ADJUSTMENT

Because only harvested recoveries are modeled in Program MARK, the practice of catch-and-release fishing causes bias in the survival estimates. Therefore, an adjustment was made to the survival estimates according to the method of Smith et al. (2000).

Live release bias is defined as:

$$bias = -\left[\frac{\theta \cdot P_L \cdot \frac{f}{\lambda}}{(1-(1-\theta \cdot P_L)\frac{f}{\lambda}}\right] \qquad \textit{Eqn. 1}$$

where:

$\theta$ = release survival rate (0.92), based on the 8% hook-and-release mortality rate estimated by Diodati and Richards (1996);

$P_L$ = annual proportion of tagged striped bass released alive;

$f$ = annual recovery rate, estimated by a separate MARK run, using a Brownie recovery model (Brownie et al. 1985); and

$\lambda$ = reporting rate.

Bias-corrected estimates of survival are then obtained by:

bias-corrected S = uncorrected S/(1+*bias*) *Eqn.2*

Accurate adjustment for live-release bias should also include estimates of tagging mortality and tag loss. Gear-specific tagging mortality was not included in bias adjustment because estimates were unavailable for most gear types. However, reported rates of general tag-induced mortality are low (0%, Goshorn et al. 1998; 1.3% Rugolo and Lange 1993), so tag-induced mortality was excluded from the bias adjustment. Reported rates of tag loss are also quite low (0% by Goshorn et al. 1998, 2% by Dunning et al. 1987, and 2.6% by Sprankle et al. 1996), so tag loss was also excluded from the bias adjustment.

## A8.7 COASTWIDE TAGGING ASSESSMENT

### A8.7.1 Methods for Estimation of F and M

In prior years' assessments, F was estimated by converting the adjusted survival (S) to Z as follows:

$$Z = -\log_e(S) \qquad \textit{Eqn. 3}$$

and parsing Z into F and M by subtracting a constant value for M. A value of M = 0.15 was assumed (ASMFC 1987). Using this technique, natural mortality was held fixed, and any change in Z resulted in an equal change in F.

There is general agreement among the SBTS that the use of an assumed constant value for M to estimate F is a weakness. Unreasonably high estimates of F seemed to contradict stable high harvests and continued high reproduction. Additionally, there has been concern that

Chesapeake Bay may have been experiencing higher natural mortality during the past decade due to an increase in the prevalence of mycobacteriosis.

Therefore, beginning in 2004, the bias-adjusted value of S has been used with a form of Baranov's catch equation to estimate program-specific values of F and M. Ricker (1975, p. 11) presented a formulation to solve for the exploitation rate (μ). He cautioned that it is applicable only for Type 2 fisheries, in which fishing and natural mortalities occur concurrently. This is the case for striped bass, where the fishery operates over much of the year. Pollock et al. (1991) used the same formula to solve for F as follows:

$$F = \mu / A * Z \qquad \textit{Eqn. 4}$$

where:

μ = exploitation rate;
A = annual total mortality rate (1 – S); and
Z = - $\log_e$(S)

and μ is calculated as follows:

$$\mu = ((R_k + R_L(1 - \theta)) / \lambda) / M \qquad \textit{Eqn. 5}$$

where:

$R_k$ = the number of killed recaptures;
$R_L$ = the number of recaptures released alive;
$\theta$ = release survival rate (0.92)
M = the number of fish tagged or marked at the beginning of the year; and
$\lambda$ = reporting rate (0.43).

Once F is estimated, M is estimated by subtracting F from Z (Crecco 2003).

Variances associated with the estimates of F were calculated using the formulas in Pollock et al. (1991). These estimates were developed without inclusion of the covariance terms (because covariance terms could not be estimated from these data, they were assumed to be negligible). 95% confidence intervals were subsequently developed for each program's F.

Area fishing mortalities were calculated as mean values among the coastal and producer areas. Coastal F was calculated as the arithmetic mean of the coastal programs' values. The producer area F was calculated as a weighted mean of the producer area programs' values. The weights were based on each program area's proportional contribution to the coastwide stock. The values are:

- Hudson (0.13);
- Delaware (0.09); and
- Chesapeake Bay (0.78), with MD (0.67) and VA (0.33).

Variance associated with the area mean F estimates was calculated as additive variances. The additive variance for the unweighted coastal mean F was calculated as:

$$\mathrm{var}(\bar{x}_{coast}) = \sum w_i^2 \, \mathrm{var}(\bar{x}_{state}) \qquad \textit{Eqn. 6}$$

where:

$w_i$ = (1 / number of coastal programs; will be equal);

var($\bar{x}_{state}$) = individual state's variance of mean F.

The additive variance for the weighted producer area mean F was calculated as:

$$\text{var}(\bar{x}_{producer}) = \sum w_i^2 \ \text{var}(\bar{x}_{state}) \qquad \textit{Eqn. 7}$$

where:

$w_i$ = 0.09 for Delaware;

$w_i$ = 0.13 for Hudson;

$w_i$ = 0.78 for Chesapeake Bay; with 0.67 for Maryland and 0.33 for Virginia;

var($\bar{x}_{state}$) = individual state's variance of the mean F.

95% confidence intervals were subsequently developed for each area's F.

The annual coastwide fishing mortality was calculated as the arithmetic mean of the coastal and producer area means. No associated variance was calculated.

**A8.7.2 Methods for Estimation of Stock Size**

Stock size was estimated for fish $\geq$ 18 inches TL, corresponding roughly to 3-year-old and older striped bass, and for fish $\geq$ 28 inches TL, corresponding to 7-year-old and older fish. A form of Baranov's catch equation was used:

$$\text{average stock size} = \text{catch} / F \qquad \textit{Eqn. 8}$$

Since F was based on an exploitation rate that included discard mortality from released fish, total catch was used.

**A8.7.3 Reporting Rate**

The reporting rate used throughout these calculations is the proportion of recaptured fish whose tags are reported to the USFWS. Currently, a constant value of 0.43 is used, based on a high-reward tag study conducted on the Delaware River stock but employing tag returns from the whole Atlantic coast (Kahn and Shirey 2000). This estimate was substantiated by Smith et al. (2000). However, the subcommittee recognizes that a constant reporting rate is unlikely.

A sensitivity analysis was performed to quantify the effect of inaccuracy in reporting rate on estimates of exploitation rate and fishing mortality. Four values of reporting rate were used with Program MARK, the catch equation and the IRCR model to estimate a time series of values for exploitation rate and fishing mortality. The values of reporting rate used in the sensitivity analysis were:

0.23 (a lower bound to show significant effect);

0.43 (the estimate currently used in the assessment);

0.63 (a middle value); and

0.83 (an upper bound from the 2006 Maryland pilot study using recreational returns, see section A8.7.4.7).

### A8.7.4 Coastwide Results and Discussion

#### *A8.7.4.1 Model Diagnostics*

The Akaike weights assigned to the candidate models are presented in Table A8.3 (fish ≥ 28 inches) and Table A8.4 (fish ≥ 18 inches). For fish ≥ 28 inches, multiple models are used by all programs. The period models received the majority of the weight for the producer area programs. For fish ≥ 18 inches, one model received essentially all weight for all programs except DE/PA. For the coastal programs, all but MADFW use the global model.

Retrospective analyses of catch equation fishing mortality results are presented in Figure A8.1 (fish ≥ 28 inches) and Figure A8.2 (fish ≥ 18 inches). Because this method has only been in use for the last two stock assessments, the analysis was limited to 2 years of results. Retrospective bias was evident for some programs, while others showed no change.

As each year of data is added to the time series, Program MARK is run again on the entire matrix. For many of the tagging programs, MARK selects and assigns different weights to a different group of models every year. The cause of this is not clearly understood, but raises questions about the legitimacy of comparing results among years.

The catch equation method uses both the recovery matrix for the entire time series (calculation of S) and the most recent year's recovery vector (calculation of exploitation). Some concern has been expressed about the use of two different time scales of the recovery data in the same equation, but the effect has not been investigated.

#### *A8.7.4.2 Exploitation Rates*

The exploitation rates for fish ≥ 28 inches are presented by program and as an unweighted coastwide mean (Table A8.5). 2006 estimates of exploitation ranged from a maximum of 0.21 (DE/PA) to 0.10 (MADFW). The 2006 overall coastwide mean exploitation rate was 0.14, which continued a decline since a peak value of 0.26 in 1997.

The exploitation rates for fish ≥ 18 inches (Table A8.6) were lower than those for fish ≥ 28 inches. The 2006 mean exploitation rate of 0.09 was a continuation of a decline similar to that seen for the larger fish.

As input to the catch equation, estimates of exploitation impact the estimates of fishing mortality. Most programs have had relatively low exploitation rates in recent years, resulting in low fishing mortality estimates. The mean exploitation rates for both size groups of fish peaked in the late 1990s and have been declining since.

#### *A8.7.4.3 Survival Rates*

Program MARK produces estimates of survival that are biased low due to the practice of catch-and-release fishing (uncorrected S). These uncorrected and the bias-corrected estimates of survival are presented by program in Table A8.7 (fish ≥ 28 inches) and Table A8.8 (fish ≥ 18 inches). The 2006 bias-corrected estimates of S for fish ≥ 28 inches ranged from 0.54 (NJDEL) to 0.77 (MADFW). The Chesapeake Bay states of MD and VA had estimates in the middle of this range (0.63 and 0.66, respectively).

The 2006 bias-corrected estimates of S for fish ≥ 18 inches ranged from 0.55 (MDCB and VARAP) to 0.77 (MADFW). The Chesapeake Bay states of MD and VA, NYOHS and DE/PA had estimates in the lower part of this range.

***A8.7.4.4 Fishing Mortality***

Results for each program are presented in Table A8.9 (fish $\geq$ 28 inches) and Table A8.10 (fish $\geq$ 18 inches), which provide the catch equation input values of A, Z and u, as well as estimates of F and M. Figure A8.3 presents the coastal and producer area mean fishing mortality estimates and their 95% confidence intervals.

The 2006 estimates of F for the fully-recruited fish were lower than the target value of 0.30 for all programs, and produced a coastwide mean of 0.16 (Table A8.11). The 2006 catch equation estimates of F for fish $\geq$ 28 inches among the producer area programs were 0.18 for HUDSON, 0.16 for MDDNR, 0.17 for VARAP, and 0.26 for DE/PA, producing a mean value of 0.17 $\pm$ 0.08 (95% CI, Table A8.12). The 2006 estimates of F for fish $\geq$ 28 inches among the coastal programs were 0.11 for MADFW, 0.17 for NYOHS, 0.19 for NJDEL, and 0.15 for NCCOOP, producing a low mean coastal area F of 0.15 $\pm$ 0.06 (95% CI, Table A8.12).

The 2006 estimates of F for fish $\geq$ 18 inches were also lower than the target value of 0.30 for all programs, and produced a coastwide mean of 0.12, the lowest in a continuing decline since the peak estimate of 0.18 in 1997 (Table A8.11). The 2006 mean fishing mortalities for fish $\geq$ 18 inches for the producer area programs was 0.16 $\pm$ 0.07 (95% CI) and was 0.09 $\pm$ 0.03 (95% CI) for the coastal programs (Table A8.13).

In general, use of the catch equation produces biologically reasonable F estimates. Because M is not held constant, there is not a set amount partitioned into natural mortality. F estimates reflect exploitation rate, which is generally low for fish between 18 and 28 inches (Tables A8.5 and A8.6).

***A8.7.4.5 Natural Mortality***

The mean natural mortality values for fish $\geq$ 28 inches were not significantly different between the producer area programs and coastal programs, and these mean values were approximately twice that of the previously assumed value of 0.15 (Table A8.14). The 2006 catch equation estimates of M for fish $\geq$ 28 inches among the producer area programs were 0.16 for HUDSON, 0.19 for DE/PA, and slightly higher for the Chesapeake Bay states (0.25 for VARAP and 0.33 for MDDNR), resulting in a producer area mean of 0.28 $\pm$ 0.20 (95% CI). The 2006 estimates of M for fish $\geq$ 28 inches among the coastal programs were 0.16 for MADFW, 0.42 for NYOHS, 0.43 for NJDEL, and 0.22 for NCCOOP, producing a coastal mean of 0.31 $\pm$ 0.12 (95% CI) (Table A8.14).

The 2006 mean natural mortality estimates for fish $\geq$ 18 inches followed the same pattern (Table A8.15). The 2006 estimates of natural mortality for fish $\geq$ 18 inches in the producer areas were 0.21 for HUDSON, 0.42 for DE/PA, 0.46 for VARAP and 0.48 for MDCB, resulting in a producer area mean of 0.43 $\pm$ 0.13 (95% CI). Estimates of M in the coastal programs covered a wide range, from 0.17 for MADFW to 0.52 for NYOHS, resulting in a coastal mean of 0.34 $\pm$ 0.08 (95% CI).

While the catch equation produced reasonable estimates of fishing mortality, natural mortality estimates were fairly high for most programs and lacked precision (Figure A8.4). Nonsensical, negative values appear throughout the time series for several programs in both size groups. The highest estimates were observed for fish $\geq$ 18 inches in DE/PA, MDCB and VARAP. The recent increases in estimates of M from these tagging programs are consistent with the increased incidence of mycobacteria in Chesapeake Bay and Delaware Bay which likely is resulting an increase in natural mortality of striped bass in these areas (Kahn and Crecco

2006). High values were also observed in NYOHS, and values in that program were very erratic over the time series.

#### *A8.7.4.6 Stock Size*

The time series of stock size estimates based on the catch equation are presented in Table A8.11 and Figure A8.5 (fish $\geq$ 28 inches approximating age 7+, and fish $\geq$ 18 inches approximating age 3+). The stock size estimates for fish $\geq$ 28 inches exhibit fair stability with a period of rapid stock growth around 2000. The 2006 estimate for fish $\geq$ 28 inches (13 million fish) has been approximately stable since 2002. Stock size estimates for fish $\geq$ 18 inches show fairly consistent growth and the 2006 value is the highest in the time series at 47.9 million fish.

#### *A8.7.4.7 Reporting Rate*

The results of the sensitivity analysis of reporting rate on the estimates of exploitation and fishing mortality are shown in Figure A8.6. Results from Program MARK, the catch equation and the IRCR model are similar. Reporting rate acts as a non-linear scalar, with lesser effect on F estimates at higher values. For the catch equation and IRCR methods, an increase in reporting rate results in a decrease in F. However, for the constant M method, the opposite effect is seen. This is because an increase in reporting rate causes an increase in bias (Equation 1), with a consequent decrease in S.

A constant reporting rate of 0.43 is used throughout these calculations, based on a high-reward tag study conducted on the Delaware River stock in 1999. The Delaware Division of Fish and Wildlife and the Pennsylvania Fish and Boat Commission conduct a cooperative survey of the Delaware River spawning stock of striped bass every spring (Kahn and Shirey 2000). Both agencies tag fish at that time as part of the USFWS cooperative striped bass tagging program. In 1999, a high reward tagging study was conducted in conjunction with the standard tagging program releasing 159 high reward tags on fish greater than 20 inches in length and 411 standard tags on fish greater than 18 inches in length. The reward for reporting a high reward tag was $100, a monetary reward believed to be high enough to precipitate a reporting rate response of 100% (Nichols et al. 1991). Total recoveries from the 1999 recovery year were 27 high reward tags and 37 standard tags. Only one high reward tag and 6 standard tags were recovered from the commercial fishery, so the 0.43 estimate of tag reporting rate was based on only the recreational fishery.

However, there is evidence that this estimate may be low. The most recent information for reporting rate is from a high reward tagging study implemented by Maryland Department of Natural Resources in the spring of 2006. In April and May of 2006 tagging efforts were increased to include marking striped bass with high reward tags concurrently with standard tags from the USFWS Cooperative Coastal Striped Bass Tagging Program. Fish were tagged in the upper Chesapeake Bay and the upper Potomac River. High reward tags were applied to every sixth fish resulting in approximately 20% of all fish tagged having high reward tags. Returns of tags with a $125 reward were used to estimate the tag-reporting rate. This value represented a 25% increase over the $100 high reward used by Nichols et al. (1991) and a considerable increase from their estimate of $70 to elicit 100% reporting. All tags reported within the 13-month period following tag deployment were included in analysis, so the reporting period was April 2006 through May 2007. A total of 772 striped bass were tagged with standard tags and 153 with high reward tags. Recoveries were used from both Chesapeake Bay and Atlantic coast fisheries for a total of 61 standard tag recoveries and 16 high reward tag recoveries. Tag reporting rate was estimated to be 0.756 (±0.045 SE) from all fisheries dependent sources and all areas of recovery. The recreational reporting rate was 0.826 (±0.070) and the commercial reporting rate was 0.545 (±0.101).

The Maryland results are from one release area, and will complement expanded high reward tagging studies initiated in 2007. The expansion of the high reward study to additionally include the Delaware and Hudson Rivers for tagging in 2007 will help address further precision and accuracy of tag reporting rates, both from an increased sample size perspective, and an assessment of possible geographic differences. Results from the first year of this study will be available in 2008 for use in assessment of the 2007 data.

For the 2006 assessment, the SBTS chose to continue with current convention and use the 0.43 reporting rate estimate from Kahn and Shirey (2000) for several reasons. Primarily, the work conducted by Maryland DNR in 2006 is considered a pilot study and will be complemented in subsequent years with the addition of Virginia's Chesapeake Bay, Delaware and Hudson River's high reward tagging projects. Additionally, the 43% reporting rate is considered conservative in terms of producing F estimates. Finally, use of the 43% reporting rate in the current assessment provided continuity with previous assessments.

## A8.8 CHESAPEAKE BAY TAGGING ASSESSMENT

Amendment 6 implemented a separate management program for the Chesapeake Bay due to the size availability of striped bass in this area. It also specified a separate fishing mortality target of 0.27 (ASMFC 2003). Therefore, a separate estimate of fishing mortality is produced. The striped bass fishery in Chesapeake Bay exploits the pre-migratory/resident striped bass population that consists of smaller fish (TL < 28 inches), mostly ages 3 through 6. Fishing mortality in Chesapeake Bay was calculated using data from the same Maryland and Virginia tagging programs described above. The migratory rates reported by Dorazio et al. (1994) suggest that striped bass between 18 and 28 inches TL are predominantly resident fish. MDDNR data have shown that males make up 80–90% of the resident fish population. Therefore, the data were limited to male striped bass in this size range to estimate fishing mortality on resident fish.

### A8.8.1 Methods for Estimation of F and M

Fishing mortality for resident striped bass in Chesapeake Bay was estimated using the catch equation method described in section A8.5.1.

### A8.8.2 Reporting Rate

Two high-reward tagging studies have been conducted in the Chesapeake Bay to determine a Bay-specific reporting rate. In 1993, a rate of 0.75 was estimated by Rugolo et al. (1994). The study was repeated in 1999 and resulted in a slightly lower estimate of 0.64 (Hornick et al. 2000). Although the current coastwide assessment uses a value of 0.43 (section A8.7.4.7), a value of 0.64 is used for the Chesapeake Bay analysis because it is the most recent area-specific value. A current Chesapeake-Bay-specific value is anticipated to be available in 2008.

### A8.8.3 Chesapeake Bay Results and Discussion

#### *A8.8.3.1 Model Diagnostics*

The Akaike weights assigned to the candidate models from Program MARK for Maryland and Virginia are presented in Table A8.16. For Maryland, model S(t) r(p), in which survival varies over time and reporting varies by regulatory period, received the majority of weight. The global model received all the weight for Virginia fish.

#### *A8.8.3.2 Exploitation Rates*

Exploitation rates estimated for the Chesapeake Bay resident fish are presented in Table A8.17.

#### *A8.8.3.3 Survival Rates*

Program MARK produces estimates of survival that are biased low due to the practice of catch-and-release fishing (uncorrected S). These uncorrected and the bias-corrected estimates of Chesapeake Bay survival are presented in Table A8.18. Maryland estimates of survival show a general decline over the time series, but have been fairly stable since 2000. The 2006 bias-corrected estimate of S for Maryland fish was 0.43. The Virginia estimates also show an overall decline, but mimic the erratic values observed in the coastwide analysis for the VARAP $\geq$ 18 inch fish. The 2006 bias-corrected estimate of S for Virginia fish is biologically unreasonable at 0.05.

#### *A8.8.3.4 Fishing Mortality*

Estimates of F for both states and bay-wide were all below the target value of 0.27. Results are presented in Table A8.19 (catch equation input values of A, Z and u, and estimates of F and M for the programs). Fishing mortality in MD steadily increased from near zero values in the early 1990s (when the fishery reopened) to a peak in 1998 (0.19 year$^{-1}$), then declined and have fluctuated between 0.11 – 0.14 year$^{-1}$ without trend since that time (Figure A8.7). The 2006 estimate for MD was 0.14 year$^{-1}$. In general, estimates of F from VA data vary without trend between 0.06 and 0.16 year$^{-1}$, with a few higher values in 1991, 1992 and 1994. These values are likely the consequence of few fish in the size range of 18–28 inches tagged in these years. When these years are removed from the VA data set, the overall range of estimated Fs for MD and VA are very similar. The 2006 F estimate for VA was 0.16 year$^{-1}$. The bay-wide F, calculated as a weighted mean, shows a trend similar to MD with a 2006 value of 0.14 (Table A8.20).

#### *A8.8.3.5 Natural Mortality*

Estimates of natural mortality for VA varied from near-zero values to 2.8 year $^{-1}$. (Figure A8.8, Table A8.19). Very large inter-annual variation and large estimates of M are not biologically reasonable and should be viewed with caution. The natural mortality estimates for MD seem to be steadily increasing from 0.15 – 0.2 in the early 1990s to 0.4 by the middle of the 1990s to between 0.6–1.0 year $^{-1}$ since 1998 (Figure A8.8, Table A8.19). Although the values of M for recent years seem excessively high (between 0.8–1.0), the overall trend of increasing M is supported by some field observations. A number of studies in recent years have indicated a development of mycobacteriosis, a bacterial disease in Chesapeake Bay striped bass beginning around 1997 (Ottinger 2006, Panek and Bobo 2006, Pieper 2006). The disease is believed to have spread significantly thereafter. It has been suggested that mycobacteriosis might lead to an increase in striped bass mortality. Kahn and Crecco (2006) analyzed MD and VA spring tagging data for two groups of fish (fish $\geq$ 18 inches TL and fish $\geq$ 28 inches TL) using Program MARK and the catch equation. They reported high natural mortality rates similar to those estimated in the present analysis and suggested that their high estimates of natural mortality were related to mycobacteriosis.

## A8.9 SOURCES OF UNCERTAINTY IN CATCH EQUATION METHOD

- The reporting rate is used in the bias adjustment and in the calculation of exploitation rate, which is used to estimate F in the catch equation method. Based on the most recent information, 0.43 is low. A current estimate is needed, and will be available in 2008.
- Potential violations of Program MARK assumptions. There is a general consensus in the SBTC that effects are minor.
  - The sample is representative of the target population;
    - Geographic distributions of recaptures, by tagging program, indicate most tagged fish follow the same movement patterns and are exposed to the same fisheries.
  - There is no tag loss;
    - Dunning et al. (1987) and Sprankle et al. (1996) report tag loss to be low.
  - Survival rates are not affected by the tagging itself;
    - Goshorn et al. (1998) and Rugolo and Lange (1993) found tag-induced mortality to be low, however, it can vary with experience of the tagger.
  - The year of tag recoveries is correctly tabulated;
    - Quality control checks are performed on the data, and vary by each individual program.
  - The fate of each tagged fish is independent of the fate of other tagged fish;
    - Striped bass are a schooling fish, but the overdispersion adjustment of c-hat is an attempt to correct for a violation of this assumption.
    - Examination of the spatial and temporal distributions of recaptures has shown that tagged fish from each program exhibit the same basic patterns (Appendix 14).
  - The fate of a given tagged fish is a multinomial random variable; and
  - All tagged individuals of an identifiable class (age, sex) in the sample have the same annual survival and recovery rates.
- Model averaging incorporates the uncertainty of model selection into the variance of parameter estimates (Burnham and Anderson 2003).
- Bias adjustment is affected by release survival rate. A constant value of 0.92 is used, but studies have shown that survival varies by age, type of hook, and temperature.
- 95% confidence intervals for the area F estimates were calculated without inclusion of the covariance terms (because covariance terms could not be estimated from these data, they were assumed to be negligible). The magnitude of those terms is unknown.
- The catch equation method uses both the recovery matrix for the entire time series (calculation of S) and the most recent year's recovery vector (calculation of exploitation). Some concern has been expressed about the use of two different time scales of the recovery data in the same equation.
- Program MARK may choose and weight the models differently each year as that year's data are added to the recovery matrix.
- While the catch equation provides reasonable estimates of F, there is considerable variation and some nonsensical values in the estimates of M.

## A9.0 REVIEW THE INSTANTANEOUS RATES TAG RETURN MODEL INCORPORATING CATCH-RELEASE DATA (IRCR) AND ESTIMATES OF F ON ATLANTIC STRIPED BASS. PROVIDE SUGGESTIONS FOR FURTHER DEVELOPMENT OF THIS MODEL FOR FUTURE USE IN STRIPED BASS STOCK ASSESSMENTS (TOR #5)

### A9.1 INSTANTANEOUS RATES MODEL

Use of the catch equation with Program MARK was intended to provide more reasonable estimates of instantaneous mortality than were seen with the use of Program MARK and a pre-determined value for M. However, like the use of a constant M, the catch equation method uses the survival estimate produced by MARK and parses Z into its component parts. Therefore, the values of F and M are not independent. Several tagging programs have continued to produce occasional unreasonable values (negative values for M) with the use of the catch equation.

The committee is now exploring the use of an instantaneous rates model. Hoenig et al. published a basic instantaneous rates model in 1998. In this model, observed recovery matrices from harvested fish were compared to expected recovery matrices to estimate model parameters. Jiang et al. published an expanded version of the instantaneous rates model in 2007 that accounts for the release of caught, tagged fish. Since many of the tagging programs do not age all tagged fish, the subcommittee elected to use an age-independent form of the "instantaneous rates – catch and release" (IRCR) model by Jiang et al. (2007). The model was programmed in AD Model Builder by Gary Nelson (MA DFW) and tested using data provided in Jiang (2005). Details of model algorithms are provided in Jiang et al. (2007) and can be found in Appendix A15. Tag return data for each program used in the IRCR model are presented in Appendix A14. Like Program MARK, several biologically-reasonable candidate models were formulated based on historical changes in striped bass management (Table A9.1). These models are analogous in structure to the models used in program MARK, but estimate instantaneous mortality rates instead of S. The output from the IRCR model consists of estimates of S, F, F' (tag mortality), M and associated standard errors for each of the candidate models.

### A9.2 ASSUMPTIONS AND STRUCTURE OF THE MODEL

Similar to Hoenig et al. (1998), observed recovery matrices from the harvested and caught and released fish with tags removed before release are compared to expected recovery matrices to estimate model parameters. The expected number of tag returns from harvested fish ($R_{i,y}$) and caught-and-released fish ($R'_{iy}$) follow a multinomial distribution so that the full likelihood is the product multinomial of the cells (Hoenig et al. 1998). Tagged fish are assumed to be fully recruited to the fishery.

The expected number of tag returns from fish tagged and released in year *i* and harvested in year *y* is:

$$\hat{R}_{i,y} = N_i \hat{P}_{i,y} \qquad \textit{Eqn. 1}$$

where:

$N$ = the number of fish tagged and released in year *i*; and

$P_{i,y}$ = the probability that a fish tagged and released in year *i* will be harvested and its tag reported in year *y*.

$P_{i,y}$ is defined as:

$$\hat{P}_{i,y} = \begin{cases} \left(\prod_{v=i}^{y-1} \hat{S}_v\right)\left(1-\hat{S}_y\right)\dfrac{\hat{F}_y}{\hat{F}_y+\hat{F}_y^{'}+M}\hat{\lambda} & (when\ y > i) \\ \left(1-\hat{S}_y\right)\dfrac{\hat{F}_y}{\hat{F}_y+\hat{F}_y^{'}+M}\hat{\lambda} & (when\ y = i) \end{cases}$$

*Eqn. 2*

where: *Eqn. 3*

$$S_y = e^{-\hat{F}_y-\hat{F}_y^{'}-M},$$

and:

$F_j$ = instantaneous rate of fishing mortality on fish in year;
$M$ = instantaneous rate of natural mortality;
λ = tag reporting given that a tagged fish is harvested; and
$S_y$ = annual survival rate in year *y* for tags on fish alive at the beginning of year *y*.

The expected number of tag returns from fish tagged and released in year *i* and recaptured and released without a tag in year *y* is:

$$\hat{R}'_{i,y} = N_i \hat{P}'_{i,y}$$ *Eqn. 4*

where $N_i$ = number of fish tagged and released in year *i*; and
$P'_{i,y}$ = probability that a fish tagged and released in year *i* will be caught and released and its tag reported in year *y*.

$P'_{i,y}$ is defined as:

$$\hat{P}'_{i,y} = \begin{cases} \left(\prod_{v=i}^{y-1} \hat{S}_v\right)\left(1-\hat{S}_y\right)\dfrac{\hat{F}'_y}{\hat{F}_y+\hat{F}_y^{'}+M}\hat{\lambda}' & (when\ y > i) \\ \left(1-\hat{S}_y\right)\dfrac{\hat{F}'_y}{\hat{F}_y+\hat{F}_y^{'}+M}\hat{\lambda}' & (when\ y = i) \end{cases}$$ *Eqn.5*

where: $$\hat{S}_y = e^{-\hat{F}_y-\hat{F}_y^{'}-M}$$ *Eqn. 6*

and:

$F'_j$ = instantaneous rate of fishing mortality in year *y* on the tags taken from fish that are caught and released and
λ' = tag reporting given that a tagged fish is recaptured, the tag is clipped off, and the fish is released alive.

## A9.3 MODEL DIAGNOSTICS

The post-model calculations of F and M for each program followed the same procedures used in the MARK modeling. Over-dispersion was corrected with a c-hat adjustment. The pooled Pearson chi-square statistic was used in the c-hat estimate, and was calculated by pooling expected cells (observed cells were pooled to match the expected cells) until the value was $\geq$1.

## A9.4 COASTWIDE TAGGING ASSESSMENT

### A9.4.1 Methods for Estimation of S, F and M

Estimates of survival and fishing and natural mortality and associated standard errors from each IRCR run were imported into an EXCEL spreadsheet where the final estimates were calculated as weighted averages across all models. The corresponding variances were calculated as weighted averages of unconditional variances (conditional on the set of models).

### A9.4.2 Methods for Estimation of Stock Size

Stock size was estimated using the IRCR model results for F and the same methodology used with Program MARK and the catch equation.

### A9.4.3 Coastwide Results and Discussion

#### *A9.4.3.1 Model Diagnostics*

In general, the period models were weighted most heavily for both size groups of fish. For fish $\geq$28 inches, the period models received the majority of the weight for all programs. For fish $\geq$18 inches, the period models received the majority of the weight for all coastal programs, while various models were chosen in the producer areas. The Akaike weights assigned to the candidate models are presented in Table A9.2 (fish $\geq$ 28 inches) and Table A9.3 (fish $\geq$ 18 inches).

Model choice and weighting were fairly consistent among the majority of programs. For coastal programs, models in which F was constant during regulatory periods tended to receive the majority of weight in both size groups of fish. In the producer areas, the period models and models in which F varied each year tended to receive the majority of weight, with the exception of DE/PA where a constant F model received the most weight.

#### *A9.4.3.2 Survival Rates*

Model averaged estimates of S produced from the IRCR model are presented in Table A9.4 (fish $\geq$ 28 inches) and Table A9.5 (fish $\geq$ 18 inches). The 2006 estimates of S for fish $\geq$ 28 inches ranged from 0.65 (DE/PA) to 0.79 (MDCB) for the producer areas, and 0.74 (NCCOOP) to 0.81 (MADFW) for the coastal programs. The producer area weighted average for 2006 was 95% CI = 0.74 $\pm$ 0.03 and the coastal program mean was 95% CI = 0.79 $\pm$ 0.03 (Table A9.4).

The 2006 estimates of S for fish $\geq$ 18 inches ranged from 0.57 (VARAP) to 0.78 (HUDSON) in the producer areas and 0.70 (NCCOOP) to 0.80 (MADFW) in the coastal programs. The producer area weighted average for 2006 was 95% CI = 0.70 $\pm$ 0.02 and the coastal program mean was 95% CI = 0.76 $\pm$ 0.02 (Table A9.5).

*A9.4.3.3 Fishing Mortality*

The time series of program F estimates, along with the 2006 producer area and coastal area mean F's are presented in Table A9.6 (fish $\geq$ 28 inches) and Table A9.7 (fish $\geq$ 18 inches).

The 2006 IRCR estimates of F for fish $\geq$ 28 inches were quite low and were not significantly different between the producer and coastal areas. Producer area F estimates were all below the target value of 0.30 and were fairly evenly distributed throughout the range of values (0.18 for HUDSON, 0.26 for DE/PA, 0.10 for MDDNR and 0.11 for VARAP). The resulting 2006 producer area F was quite low (95% CI = 0.13 + 0.015). The 2006 estimates of F for fish $\geq$ 28 inches among the coastal programs showed a bimodal distribution, with very low values for three of the programs (0.10 for MADFW, 0.12 for NJDEL and 0.12 for NCCOOP) and 0.19 for NYOHS. The 2006 coastal mean F was therefore low (95% CI = 0.13 + 0.015) and was the same value as for the producer area programs.

The 2006 IRCR estimates of F for fish $\geq$ 18 inches were also low and were not significantly different between the producer and coastal areas. Producer area F estimates among the producer area programs were all low (0.12 for HUDSON, 0.16 for DE/PA, 0.08 for MDDNR and 0.09 for VARAP). The subsequent value for the 2006 weighted mean producer area F was also quite low (95% CI = 0.10 + 0.03). The 2006 estimates of F for fish $\geq$ 18 inches among the coastal programs were also very low (0.09 for MADFW, 0.05 for NYOHS, 0.12 for NJDEL, and 0.09 for NCCOOP). The 2006 coastal mean F was therefore low as well (95% CI = 0.09 + 0.015).

*A9.4.3.4 Natural Mortality*

Whereas there was considerable variation among programs, the combined M estimates based on the IRCR model were very close to the value of 0.15 used in the previous method (the IRCR model estimates one M value over the entire time series for each program). For fish > 28 inches, the natural mortality estimates for producer area programs were 0.09 for HUDSON, 0.16 for DE/PA, 0.14 for MDDNR and 0.28 for VARAP (Table A9.8). The weighted mean M for producer areas was 0.17 + 0.02 (95% CI). Coastal program M values for fish > 28 inches were 0.11 for MADFW, 0.09 for NYOHS, 0.09 for NJDEL, and 0.18 for NCCOOP. The mean M for coastal programs was 0.12 + 0.01 (95% CI).

IRCR estimates of natural mortality for both producer and coastal areas were higher for fish > 18 inches than for fish > 28 inches (Table A9.9). Producer area values were 0.12 for HUDSON, 0.25 for DE/PA, 0.20 for MDDNR and 0.47 for VARAP, producing a weighted mean M of 0.26 + 0.02 (95% CI). Coastal program M values for fish > 18 inches were 0.12 for MADFW, 0.24 for NYOHS, 0.15 for NJDEL, and 0.26 for NCCOOP, producing a mean of 0.19 + 0.01 (95% CI).

*A9.4.3.5 Stock Size*

The time series of stock size estimates from the IRCR model are also presented in Table A9.10 (fish $\geq$ 28 inches, approximating age 7+ and fish $\geq$ 18 inches, approximating age 3+). The stock size estimates for fish $\geq$ 28 inches also exhibit fair stability with a period of rapid stock growth around 2000. The 2006 estimate for fish $\geq$ 28 inches (16.6 million fish) has been approximately stable since 2003. Stock size estimates for fish $\geq$ 18 inches has shown fairly consistent growth and the 2006 value is the highest in the time series at 60.8 million fish.

**A9.5 CHESAPEAKE BAY TAGGING ASSESSMENT**

The instantaneous rates model can be structured to estimate natural mortality as a constant for the entire period of the study or estimate different natural mortality values within time periods. Some studies have suggested that natural mortality of striped bass in Chesapeake Bay has increased since 1997 due to disease (mycobacteriosis) and reduced forage base (Ottinger 2006, Panek and Bobo 2006, Pieper 2006). Following these assumptions, estimates of fishing mortality for both Maryland and Virginia data sets were calculated using the IRCR model for three natural mortality scenarios – constant natural mortality for the entire period, separate estimates of natural mortality for two periods (1987–1997 and 1998–2006), and for three periods (1987–1997, 1998–2000 and 2001– 2006).

**A9.5.1 Methods for Estimation of F and M**

The model and the software used in Chesapeake data analysis are identical to those described in section A9.2.

**A9.5.2 Reporting Rate**

See section A8.6.2

**A9.5.3 Chesapeake Bay Results and Discussion**

***A9.5.3.1 Fishing Mortality***

IRCR estimates of F for both states and bay-wide were all below the target value of 0.27 (Tables A9.11, 12 and 13).

Under the assumption of constant natural mortality, fishing mortality estimated from MD data increased from near-zero values during the moratorium period to 0.15 $year^{-1}$ in 1992, fluctuated upward to a maximum of 0.17 $year^{-1}$ in 1998, then declined to 0.05 $year^{-1}$ in 2005–2006 (Table A9.11, Figure A9.1). When two and three different periods of M were considered, similar trends and values were observed up to 1997, but there was no declining trend for the 1998–2006 period (Tables A9.12, 13).

Analysis of Virginia data indicated that regardless of model structure for estimating M, fishing mortality was low and relatively stable, fluctuating between 0.04 and 0.09 $year^{-1}$ (Tables A9.11, 12, 13 and Figure A9.2). A single peak in 1992 is likely to be an artifact caused by the very low number of fish marked in that year.

***A9.5.3.2 Natural Mortality***

Using MD data, the IRCR model estimated levels of natural mortality that were up to four times the previously assumed value of 0.15 $year^{-1}$ and suggested that most of total mortality is due to natural causes (Figure A9.3). For the constant M scenario natural mortality was estimated at 0.33 $year^{-1}$, for two periods M was 0.27 $year^{-1}$ for 1987–96 and 0.68 $year^{-1}$ for 1997–2006, for three periods M was 0.28 $year^{-1}$ for 1987–96, 0.65 $year^{-1}$ for 1997–2000, and 0.74 $year^{-1}$ for 2001–2006. When a constant M was considered, total mortality seemed to have two stable periods, with mortality around 0.45 $year^{-1}$ during 1992–1998 and a slightly lower value (0.40 $year^{-1}$) in the more recent period (1999–2006). When two or three periods of M were assumed, there were also two periods of Z, but their values were drastically different. During 1990–1996 total mortality was 0.3–0.4 $year^{-1}$ and from 1997–2006 it was 0.8 – 0.9 $year^{-1}$. These results suggest a substantial increase in natural mortality during the last decade.

Similar to the MD analysis, the estimated M values from VA data were very high in all scenarios. Natural mortality was estimated at 0.6 year$^{-1}$ for constant M, for two periods M was 0.85 year$^{-1}$ during 1988–1996 and 0.9 year$^{-1}$ for 1997–2006, and for three periods M was 0.35 year$^{-1}$ for 1988–96, 0.99 year$^{-1}$ for 1997–2000, and 0.81 year$^{-1}$ for 2001–2006 (Figure A9.4).

A significant advantage of the catch equation method and the IRCR model is the ability to estimate natural mortality in addition to fishing mortality, either through the use of external model results (the catch equation uses survival estimates from Program MARK) or internally (IRCR model). As reported above, estimated values of natural mortality from both methods were substantially higher than the life-history-based fixed level of natural mortality traditionally used in the analyses (0.15 year$^{-1}$). A significant increase in natural mortality of striped bass in Chesapeake Bay may have a significant effect on population dynamics and serious implications for management. An obvious effect of increase in M is a faster decay of individual cohort size (increase in the catch curve slope) and overall decline of population abundance. Using these levels of natural mortality, the IRCR model estimates total mortality for striped bass in the Bay of 0.9 – 1.1 year$^{-1}$ since 1997. Such levels of mortality are not sustainable and a significant decline in population should have been observed. Figure A9.5 provides an illustration of the Chesapeake Bay striped bass exploitable biomass using constant M of 0.15 year$^{-1}$ and the IRCR model with variable M. These calculations were completed with the Harvest Control Model (Rugolo and Jones 1989), which projects the age-0 index forward using year-specific estimates of fishing and natural mortality. A significant decline in population size should in turn affect fish availability and lead to a decline in CPUE and total harvest. However, the actual landings increased, reaching record harvest values in 2006. This lack of agreement between model results and observed fishery data suggests a need for careful evaluation of the tagging analysis assumptions (full mixing and equal probability of marked fish to be recovered) and interpretation of the results. What is currently interpreted in the model as total mortality can be more generally described as a rate of disappearance, where disappearance includes total mortality and emigration. Striped bass emigrate from Chesapeake Bay as they age and if the fish are moving to areas that are not fished or very lightly fished (for example, the EEZ) the probability of tagged fish being recovered becomes extremely low. In this case the decline in the number of recovered tags is interpreted in the model as a decline in survival and increase in natural mortality. A simulation analysis is recommended to investigate the ability of the instantaneous rates model to differentiate natural mortality from emigration to areas with different or no fishing activity / tag return.

## A9.6 SOURCES OF UNCERTAINTY IN IRCR MODEL

- The reporting rate is used in the bias adjustment and in the calculation of exploitation rate, which is used to estimate F in the IRCR model. Based on the most recent information, 0.43 is low. A current estimate is needed, and will be available in 2008.

- Due to the relatively short time the committee has been working with the IRCR model, it is not presented as the primary model. Additional assessment of the suite of candidate models and diagnostic tests are recommended.

## A9.7 COMPARISON OF IRCR MODEL AND CATCH EQUATION METHOD

### A9.7.1 Coastwide

The two methods produced similar estimates of F for both size groups of fish, however the catch equation estimates were much less precise. Coastal and producer area mean F estimates generated from these methods are compared for fish $\geq$ 28 inches (Figure A9.6) and fish $\geq$ 18 inches (Figure A9.7). For fish $\geq$ 18 inches, the erratic values produced by the previous method assuming constant M are also shown for comparison.

In general the M estimates generated from the IRCR model were slightly lower than the catch equation estimates in the most recent years and more precise. Coastal and producer area mean M estimates generated from the IRCR model and catch equation method are compared for fish $\geq$ 28 inches (Figure A9.8) and fish $\geq$ 18 inches (Figure A9.9). The candidate models for the IRCR model held M constant over the time series. Additional candidate models will be explored which allow M to vary over time and/or regulatory periods.

The bias-corrected mean S estimates from Program MARK and the IRCR model are compared for fish $\geq$ 28 inches in Figure A9.10 and for fish$\geq$ 18 inches in Figure A9.11. For fish $\geq$ 28 inches, the IRCR model estimates were stable and similar to those from Program MARK until 2003, when the MARK estimates declined. For fish $\geq$ 18 inches, the IRCR estimates were fairly stable throughout the time series, whereas estimates from Program MARK were erratic throughout the time series and dropped in more recent years.

Stock size estimates from these methods are compared in Figure A9.12. Estimates for age 7+ fish are fairly similar for all methods through 2002. After 2002, the method assuming constant M shows decreasing stock size but the catch equation and IRCR model show continuing increase. Estimates for age 3+ fish from the method assuming constant M show stable abundance while estimates from the catch equation and IRCR show continued growth. Estimates of stock size for both groups of fish computed from the catch equation F's are lower than those obtained with the IRCR model (because estimates of F based on the catch equation are higher, lower stock size is estimated for the same harvest).

### A9.7.2 Chesapeake Bay

All models showed the same trend for Maryland data – a stable increase in fishing mortality from near-zero values during the moratorium period to a peak of 0.15–0.2 year$^{-1}$ in 1998, followed by fluctuation without trend in a narrow range of 0.08 – 0.17 year$^{-1}$ thereafter. An instantaneous rates model formulation that estimated a constant M for the entire period of analysis differed slightly and showed a decline in F after 1998. This trend and the range of variation were similar to the fishing mortality estimates based on the summer-fall tagging study, which was an independent source of data (Figure A9.13). Despite slight differences in fishing mortality estimates among the models, all annual estimates of fishing mortality were below the Bay F target of 0.27 year$^{-1}$ (Figure A9.13).

The general trend of fishing mortality of fish tagged in Maryland is consistent with additional information on the status of the coastwide stock. Since the reopening of the fishery, landings have consistently risen both in Chesapeake Bay and coastwide. The stock has been increasing in size, based on the VPA assessment (ASMFC 2005). The F estimates in Maryland are also comparable to F's for ages 3–8, weighted by numbers from the 2005 VPA assessment (Figure A9.13). The weighted-by-numbers fishing mortality for ages 3–8 has been used by the

Technical Committee in the past to characterize F in producer areas, of which Chesapeake Bay is dominant.

Fishing mortality estimates for the Virginia component of the resident stock were generally flat and low in values. With the exception of the catch equation results, F ranged between 0.03 – 0.1 $year^{-1}$ (Figure A9.14). High values of F for 1992 and 1994 are most likely an artifact resulting from small sampling size (number of fish marked). Low fishing mortality for VA is somewhat surprising, considering the total striped bass harvest in Virginia's portion of Chesapeake Bay. Lack of spatial coverage could potentially explain VA's low estimated fishing mortality values. Tagging in Virginia is conducted in one location (the Rappahannock River) using one pound net. Consequently, tags could have been applied to the specific strain of fish from a Rappahannock spawning population, which are not necessarily representative of the entire group of resident striped bass in Virginia waters. This hypothesis is supported in part by the results presented in Hoenig et al. (2004), in which the Virginia tagging dataset showed a non-mixing effect. Although non-mixing can be accounted for by using a non-mixing model, this would not guarantee that corrected fishing mortality estimates would be representative of the Bay population and not of the Rappahannock River population itself. An expansion of geographical coverage would be the best solution for the problem.

The analyses of Maryland and Virginia data have been presented separately in this report to account for differences in tagging methodology and geographical coverage. A bay-wide average estimate of F weighted by the number of fish landed in each state shows no trend within the entire time series, varying between 0.05 and 0.15 $year^{-1}$ (Figure A9.15). The 1992 and 1994 estimates of F in VA are suspected to be due to low sampling size. Based on the results of the spring tagging data analysis, the fishing mortality in Chesapeake Bay has been low in general since the late 1980s and never exceeded the target threshold for Chesapeake Bay established by Amendment 6 (0.27 $year^{-1}$). These conclusions are corroborated by other sources such as the summer–fall tagging program and the age structured analysis (VPA) from the 2005 assessment.

The IRCR model and the catch equation method both indicated high levels of natural mortality for striped bass since 1997, ranging between 0.64 and 1.0 $year^{-1}$. These estimates are inconsistent with trends in harvest and projected population size. A careful review of the tagging model assumptions is recommended. A test of the IRCR model's ability to estimate natural mortality in the presence of emigration and refuge from the fishery is also recommended. Care should be exercised in interpreting natural mortality estimates until such analyses are completed.

## A10.0 REVIEW THE FORWARD-PROJECTING STATISTICAL CATCH-AT-AGE MODEL INCORPORATING THE AGE-INDEPENDENT INSTANTANEOUS RATES TAG RETURN MODEL (SCATAG) AND ESTIMATES OF F, SPAWNING STOCK BIOMASS, AND TOTAL ABUNDANCE OF STRIPED BASS. PROVIDE SUGGESTIONS FOR FURTHER DEVELOPMENT OF THIS MODEL FOR FUTURE USE IN STRIPED BASS STOCK ASSESSMENTS (TOR #6)

### A10.1 *SCATAG* MODEL

The 36th SARC reviewers recommended that an assessment model incorporating tag returns and catch-at-age data for striped bass should be constructed to provide only one estimate of fishing mortality. In response, the committee constructed a forward-projecting age-structured statistical catch-at-age model incorporating tag return data for the Atlantic coast migratory stocks of striped bass during 1982–2006.

## A10.2 MODEL STRUCTURE

### A10.2.1 Catch-at-Age Structure (same as SCA model)

The structure of the population model is aged-based and projects the population numbers-at-age forward through time given model estimates of recruitment and age-specific total mortality, and is the same structure as the SCA model. The population numbers-at-age matrix has dimensions Y x A, where Y is the number of years and A is the oldest age group. The time horizon for striped bass is 1982–2004 since complete catch data are only available back to 1982. However, there are relative abundance data (Maryland young-of-the-year indices) available for earlier years. To use those earlier data, the dimensions of population numbers-at-age were expanded to Y+A-1 x A matrix (Figure A10.1). The number of year classes in the model was 13, representing ages 1 through 13+.

Population numbers-at-age ($a<A$) are calculated through time by using the exponential cohort survival model

$$\hat{N}_{y,a} = \hat{N}_{y-1,a-1}\, exp^{-\hat{F}_{y-1,a-1} - M} \qquad (1)$$

where $\hat{N}_{y,a}$ is abundance of age $a$ in year $y$, $\hat{N}_{y-1,a-1}$ is abundance of age $a-1$ in year $y-1$, $F_{y-1,a-1}$ is the instantaneous fishing mortality rate for age $a-1$ in year $y-1$, and $M$ is the instantaneous natural mortality (assumed constant across years and ages). For the plus group ($A$), numbers-at-age are the sum of survivors of $A-1$ in year $y-1$ and survivors from the plus group in year $y-1$:

$$\hat{N}_{y,A} = \hat{N}_{y-1,A-1}\, exp^{-\hat{F}_{y-1,A-1} - M} + \hat{N}_{y-1,A}\, exp^{-\hat{F}_{y-1,A} - M} \qquad (2)$$

Recruitment (numbers of age-1 bass) in year $y$ ($N_{y,1}$) is estimated and it is modeled as a log-normal deviation from average recruitment:

$$\hat{N}_{y,1} = \hat{\bar{N}}_1 \cdot exp^{\hat{e}_y} \qquad (3)$$

where $N_{y,1}$ is the number of age 1 fish in year $y$, $\hat{\bar{N}}_1$ is the average recruitment parameter, and $e_y$ are independent and identically distributed normal random variables with zero mean and constant variance and are constrained to sum to zero over all years. A function is used to help constrain the recruitment deviations and is included in the total likelihood:

$$P_{rdev} = \lambda_R \sum_y e_y^2 \qquad (4)$$

where $\lambda_R$ is a user-specified weight. The initial population abundance-at-age for 2–13+ in 1970 is calculated by using the $\hat{N}_{1970,1}$ and assuming $F_{1982,a-1}$:

$$\hat{N}_{1970,a} = \hat{N}_{1970,a-1}\, exp^{-\hat{F}_{1982,a-1} - M} \qquad (5)$$

Estimation of fishing mortality-at-age is accomplished by assuming that fishing mortality can be decomposed into yearly and age-specific components (separability):

$$\hat{F}_{y,a} = \hat{F}_y \cdot \hat{s}_a \tag{6}$$

where $F_y$ is the fully-recruited fishing mortality in year $y$ and $s_a$ is the average selectivity pattern of fish of age $a$. The dimensions of the F-at-age matrix are Y x A. Similar to recruitment, $F_y$ is modeled as a log-normal deviation from average fishing mortality:

$$\hat{F}_y = \hat{\bar{F}} \cdot exp^{d_y} \tag{7}$$

where $F_y$ is the fishing mortality in year y, $\hat{F}$ is the average recruitment parameter, and $d_y$ are independent and identically distributed normal random variables with zero mean and constant variance and are constrained to sum to zero over all years. For years earlier than 1982, the fishing mortality-at-age is assumed equal to the values for 1982. A function is used to help constrain the fishing mortality deviations and is included in the likelihood function:

$$P_{fdev} = \lambda_F \sum_y d_y^2 \tag{8}$$

where λ is a user-specified weight. Following Brodziak (2002), a fishing mortality penalty is imposed to ensure that the observed catch could not produce extremely small Fs during the early phases of the estimation process:

$$P_{f_{add}} = \begin{cases} \text{phase} < 3, & \lambda_F \cdot 10 \cdot \sum_y (F_y - 0.15)^2 \\ \text{phase} \geq 3, & \lambda_F \cdot 0.001 \cdot \sum_y (F_y - 0.15)^2 \end{cases} \tag{9}$$

Selectivity for $a<A$ is modeled by using the Gompertz equation, and to ensure at least one age had a maximum selectivity of 1, $s_a$ is calculated as

$$s_a = \frac{exp^{(-exp^{-\hat{\beta}(a-\hat{\alpha})})}}{max_a(exp^{(-exp^{-\hat{\beta}(a-\hat{\alpha})})})} \tag{10}$$

where α and β are estimates. Based on historical changes in size and catch regulations and model comparisons (see *Exploratory Analyses* below), selectivity patterns are estimated for 4 periods: 1982–1984, 1985–1989, 1990–1995, and 1996–2006. $s_a$ for the plus group ($A$) is assumed equal to $s_a$ for age $A$-$1$.

For ease of computation, total mortality-at-age (Z) is calculated as

$$Z_{y,a} = F_{y,a} + M \tag{11}$$

and fills a matrix of dimension Y x A. For years earlier than 1982, Z is assumed equal to the values for 1982.

For total catch and survey indices data, lognormal errors were assumed throughout and the concentrated likelihood weighted for variation in each observation was calculated. The generalized concentrated negative log-likelihood ($L_l$) (Parma 2002; Deriso et al. 2007) is

$$L_l = 0.5 * \sum_i n_i * \ln\left( \frac{\sum_i RSS_i}{\sum_i n_i} \right) \qquad (12)$$

where $n_i$ is the total number of observations and $RSS_i$ is the weighted residual sum-of-squares from dataset $i$. Equations for the weighted residual sum-of-squares are shown following the description (given below) of the estimation of predicted values for each data type.

For the catch and survey age compositions, multinomial error distributions were assumed throughout and the negative log-likelihoods were calculated using the general equation,

$$L = \sum_y - n_y \sum_a P_{y,a} \cdot \ln\left(\hat{P}_{y,a}\right) \qquad (13)$$

Specific equations for each dataset are shown following the description of the estimation of predicted values.

Total catch (recreational and commercial harvest numbers plus number of discards that die due to handling and release) and the proportions of catch-at-age of striped bass fisheries are primary data from which fishing mortalities, selectivities, and recruitment numbers are estimated. Given estimates of F, M, and population numbers, predicted catch-at-age is computed from Baranov's catch equation (Ricker, 1975):

$$\hat{C}_{y,a} = \frac{\hat{F}_{y,a}}{\hat{F}_{y,a} + M} \cdot (1 - exp^{-\hat{F}_{y,a} - M}) \cdot \hat{N}_{y,a} \qquad (14)$$

where $\hat{C}_{y,a}$ is the predicted removals of age $a$ during year $y$ and other variables are as defined above. All predictions are stored in a matrix of dimension $Y$ x $A$. Predicted catch-at-age data are then compared to the observed total catch and proportions of catch-at-age through the equations:

*Predicted Total Catch*

$$\hat{C}_y = \sum_a \hat{C}_{y,a} \qquad (15)$$

*Predicted Proportions of Catch-At-Age*

$$\hat{P}_{y,a} = \frac{\hat{C}_{y,a}}{\sum_a \hat{C}_{y,a}} \qquad (16)$$

where $\hat{C}_{y,a}$ is the predicted total catch in year $y$ and $P_{y,a}$ is the predicted proportions of age $a$ in the catch during year $y$. The weighted lognormal residual sum-of-squares ($RSS_c$) is calculated as

$$RSS_c = \lambda_c \sum_y \left( \frac{\ln\left(C_y + 1e^{-5}\right) - \ln\left(\hat{C}_y + 1e^{-5}\right)}{CV_y} \right)^2 \qquad (17)$$

where $C_y$ is the observed catch in year $y$, $\hat{C}_{y,a}$ is the predicted catch in year $y$, $CV_y$ is the CV for observed catch in year $y$, and $\lambda_c$ is the relative weight (Parma 2002; Deriso et al. 2007). Total catch CVs were assumed equal to the PSEs of the MRFSS total catch estimates for the entire Atlantic coast (less South Carolina, Georgia and East Florida records) since it is assumed that only the estimates of recreational kill and dead discards have error.

In addition, the predicted proportions of catch-at-age are compared to the observed proportions of catch-at-age through a multinomial probability model. The proportions of catch-at-age negative log-likelihood ($L_p$) is

$$L_p = \lambda_p \sum_y - n_y \sum_a P_{y,a} \cdot \ln\left(\hat{P}_{y,a} + 1e-7\right) \qquad (18)$$

where $n_y$ is the effective number of fish aged in year y and $P_{y,a}$ is the observed proportion of catch-at-age. The multinomial probability assumes that the numbers of aged fish used to apportion the catch into age classes are sampled randomly and independently of each other. This is truly not the case because gear and fishing practices collected fish in groups or clusters, so the effective sample size is much smaller than the actual number of fish aged. Therefore, the effective sample size was estimated by using the manual, iterative method of McAllister and Ianelli (1997). The effective sample size for each year is the average over all years and it is set to 380 fish in this model.

The observed total catch and catch age composition data were generated from all state reported landings-at-age, recreational dead discards-at-age, and commercial dead discards-at-age. Total catch by year was calculated by summing catch across age classes. The catch age composition was calculated by dividing the catch-at-age for a given year by yearly total catch.

Young-of-the-year (YOY) and yearlings indices from New York (Hudson River), New Jersey (Delaware Bay), Maryland (Chesapeake Bay), and Virginia (Chesapeake Bay) were incorporated into the model by linking them to corresponding age abundances depending on the time of year the survey was conducted:

$$\hat{I}_{t,y,a} = \hat{q}_t \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}} \qquad (19)$$

where $\hat{I}_{t,y,a}$ is the predicted index of survey $t$ for age $a$ in year $y$, $q_t$ is the catchability coefficient of index $t$, $N_{y,a}$ is the abundance of age $a$ in year $y$, $p$ is the fraction of total mortality that occurs prior to the survey, and $Z_{y,a}$ is the total instantaneous mortality rate. All $q$s were estimated as free parameters. The YOY and yearling indices were advanced one year and were linked to age 1 and age 2 abundances, respectively and were tuned to January 1st (p=0;Table A10.1). All YOY and yearling indices are arithmetic means and corresponding CVs. More information on these surveys can be found in ASMFC (1995).

The aggregate indices (no or borrowed age data or other reasons) from the Marine Recreational Fisheries Statistics Survey (MRFSS), Connecticut (Recreational CPUE and bottom trawl survey), Northeast Fisheries Science Center (NEFSC: spring bottom trawl survey) and Massachusetts (commercial total catch rates) were incorporated into the model by linking them to summed age abundances depending on the time of year of the survey and the ages included in the index (Table A10.1). The predicted index equation is:

$$\hat{I}_{t,y,\Sigma a} = \hat{q}_t \cdot \sum_a \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}} \qquad (20)$$

All aggregate indices are arithmetic means of the survey estimate. The CVs for the MRFSS index were calculated by dividing model estimates of standard errors by the index. The CVs for the Connecticut Recreational CPUE index were assumed equal to the CVs of the total recreational catch values for Connecticut generated by MRFSS.

The age-aggregated indices and age composition data from New York (ocean haul seine), New Jersey (bottom trawl), Maryland (gillnet spawning stock survey), and Delaware (electrofishing spawning stock survey) surveys are incorporated into the model by linking them to age abundances depending on the time of year the survey and the ages included in the index:

$$\hat{I}_{t,y} = \hat{q}_t \sum_a \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}} \qquad (21)$$

where $s_{t,a}$ is the selectivity coefficient for age $a$ in survey $t$. The fraction of the year and ages to which each survey is linked is listed in Table A10.1. The weighted residual sum of squares for survey index $t$ is given by:

$$RSS_t^I = \lambda_t \sum_y \left( \frac{\ln\left(I_{t,y} + 1e^{-5}\right) - \ln\left(\hat{I}_{t,y} + 1e^{-5}\right)}{CV_{t,y}} \right)^2 \qquad (22)$$

The Gompertz equation is used to estimate the selectivity pattern for the Delaware spawning stock surveys because the survey is an electrofishing survey and theory indicates that vulnerability increases with surface area of the fish. Because MD survey estimates are corrected mesh-size selection, by trial-and-error, it was determined that only the selectivity value for age 2 had to be estimated; for ages $\geq 3$, selectivity was set to 1. For the New York ocean haul survey, the Thompson's exponential-logistic model (Thompson 1994) is used to estimate the selectivity pattern

$$\hat{s}_a = \frac{1}{1-\gamma} \cdot \left(\frac{1-\gamma}{\gamma}\right)^{\gamma} \frac{\exp^{\alpha\gamma(\beta-a)}}{1+\exp^{\alpha(\beta-a)}} \qquad (23)$$

For the New Jersey survey, a gamma function is used to estimate the selectivity pattern:

$$\hat{s}_a = \frac{a^{\alpha} \exp^{\beta \cdot a}}{\max_a (a^{\alpha} \exp^{\beta \cdot a})} \quad (24)$$

The predicted age composition (proportions-at-age) of each survey is modeled and compared to the observed proportions-at-age through a multinomial probability model. The survey indices-at-age are calculated as

$$\hat{I}_{t,a,y} = \hat{q}_t \cdot \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}} \quad (25)$$

and predicted age composition is calculated as

$$\hat{U}_{t,y,a} = \frac{\hat{I}_{t,y,a}}{\sum_a \hat{I}_{t,y,a}} \quad (26)$$

The age composition negative log-likelihood for survey $t$ is

$$L_t^U = \lambda_t \sum_y - n_{t,y} \sum_a U_{t,y,a} \cdot \ln\left(\hat{U}_{t,y,a} + 1e^{-7}\right) \quad (27)$$

where $n_{t,y}$ is the effective sample size of fish aged in year $y$ from survey $t$, and $U_{t,y,a}$ and $U_{t,y,a}$ are the observed and predicted proportions of age $a$ in year $y$ from survey $t$. Used as starting values, the average effective sample size for each survey was calculated by using methods in Pennington and Volstad (1994) and Pennington et al. (2002). In essence, effective sample size was estimated by first calculating the length sample variance using the simple random sampling equation and dividing into it the cluster sampling variance of mean length derived through bootstrapping, assuming each seine/trawl haul, gillnet set, or electrofishing run was the sampling unit. The average over the years of data received was used as the effective sample size for all years (Table A10.2).

Model fit for all components was checked by using residual plots. In addition, predicted average effective sample size for the catch and survey age composition data were compared to the observed average values used in the model. Predicted average effective sample size ($\hat{\bar{t}}$) is calculated following McAllister and Ianelli (1997):

$$\hat{\bar{t}} = \frac{\sum_y \hat{t}_y}{d_y} \quad (28)$$

and $\hat{t}$ is defined as

$$\hat{t}_y = \frac{\sum_a \hat{c}_{a,y}(1 - \hat{c}_{a,y})}{\sum_a (o_{a,y} - c_{a,y})^2}$$

where $\hat{c}_{a,y}$ is the predicted proportion-at-age $a$ in year $y$ from the catch or survey, $o_{a,y}$ is the observed proportion-at-age, and $d_y$ is the number of years of data for catch or survey series.

### A10.2.2 Tag Returns Model Structure

The age-independent model of Jiang et al. (2007) is used to bridge the catch-at-age and tag return data. The benefits of this instantaneous rates model are that data from tagged fish that are recaptured and released alive are directly incorporated in the estimation of fishing mortality. This model assumes that tagged fish are fully-recruited to the fishery. Similar to Hoenig et al. (1998), observed recovery matrices from the harvest and catch/release fish with removed tags are compared to expected recovery matrices to estimate model parameters.

The expected number of tag returns ($R_{i,y}$)from fish tagged and released in year $i$ and harvested in year $y$ is

$$\hat{R}_{i,y} = N_i \hat{P}_{i,y} \qquad (29)$$

where $N_i$ is the number of fish tagged and released in year $i$, $P_{i,y}$ is the probability that a fish tagged and released in year $i$ will be harvested and its tag reported in year $y$ and is defined as

where $F_y$ is the instantaneous rate of fishing mortality on fish in year $y$, $F'_y$ is the instantaneous rate of fishing mortality in year $y$ on the tags taken from fish that are caught and released, λ is the tag reporting given that a tagged fish is harvested, and $S_y$ is the annual survival rate in year $y$ for tags on fish alive at the beginning of year $y$,

The expected number of tag returns ($R'_{i,y}$)from fish tagged and released in year $i$ and recaptured and released without a tag in year $y$ is

$$\hat{R}'_{i,y} = N_i \hat{P}'_{i,y} \qquad (30)$$

$$\hat{P}_{i,y} = \begin{cases} \left( \prod_{v=i}^{y-1} \hat{S}_v \right) \left(1 - \hat{S}_y\right) \dfrac{\hat{F}_y}{\hat{F}_y + \hat{F}'_y + M} \hat{\lambda} & (when\ y > i) \\ \left(1 - \hat{S}_y\right) \dfrac{\hat{F}_y}{\hat{F}_y + \hat{F}'_y + M} \hat{\lambda} & (when\ y = i) \end{cases}$$

$$\hat{S}_y = e^{-\hat{F}_y - \hat{F}'_y - M},$$

where $N_i$ is the number of fish tagged and released in year $i$, $P'_{i,y}$ is the probability that a fish tagged and released in year $i$ will be caught and released and its tag reported in year $y$ and is defined as

$$\hat{P}'_{i,y} = \begin{cases} \left( \prod_{v=i}^{y-1} \hat{S}_v \right) \left(1 - \hat{S}_y\right) \dfrac{\hat{F}'_y}{\hat{F}_y + \hat{F}'_y + M} \hat{\lambda}' & (when\ y > i) \\ \left(1 - \hat{S}_y\right) \dfrac{\hat{F}'_y}{\hat{F}_y + \hat{F}'_y + M} \hat{\lambda}' & (when\ y = i) \end{cases}$$

$$\hat{S}_y = e^{-\hat{F}_y - \hat{F}'_y - M}$$

where $F'_y$ is the instantaneous rate of fishing mortality in year $y$ on the tags taken from fish that are caught and released and λ' is the tag reporting given that a tagged fish is recaptured, the tag is clipped off, and the fish is released alive. $R_{iy}$ and $R'_{iy}$ follow a multinomial distribution so that the full likelihood is the product multinomial of the cells (see Hoenig et al. 1998). See Jiang et al. (2007) for more details of the model.

**A10.2.3 Link Between Catch-at-Age and Tag Return Models**

The link between the two models is fully-recruited fishing mortality ($F_y$). Both component models assume a Type 2 fishery (Ricker, 1975). Only data from tagged striped bass ≥28 inches were used to represent fish that are fully-recruited to the fisheries. There are eight tagging programs along the Atlantic coast and they are described in the "Tagging Data Analyses". Data from all programs are used in this model.

The log-likelihood for tagging program $r$ is:

$$-L_r = \lambda_r \sum_{a=1}^{A}\sum_{i=1}^{I}(N_{i,a} - \sum_{v=i}^{Y} R_{i,v,a} + R'_{i,v,a}) \cdot \ln(1 - \sum_{v=i}^{Y} \hat{P}_{i,v,a} + \hat{P}'_{i,v,a}) + \sum_{y=1}^{Y} R_{i,y,a} \ln(\hat{P}_{i,y,a}) + R'_{i,y,a} \ln(\hat{P}'_{i,y,a}) \qquad (31)$$

The current total log-likelihood of the full model is

$$f = -L_l - L_p - L^U_{NYOHS} - L^U_{NTrawl} - L^U_{NYOHS} - L^U_{MDSSN} - MAtag - NYtag - Hudsontag - NJtag - MDtag - VAtag - NCtag - DEtag + P_{rdev} + P_{fdev} + P_{fadd}$$

The total log-likelihood is used by the autodifferentiation routine in AD Model Builder to search for the "best" selectivity parameters, average recruitment, recruitment deviations, average F, fishing mortality deviations, annual tag mortality, and catchability coefficients that minimize the total log-likelihood. AD Model Builder allows the minimization process to occur in phases. During each phase, a subset of parameters is held fixed and minimization is done over another subset over parameter until eventually all parameters are included in the estimation. In this model, the following parameters were solved over eleven phases:

Phase
1 average recruitment
2 average fishing mortality and fishing mortality deviations
3 recruitment deviations
4 catch selectivity parameters
5 catchability coefficients of YOY/Yearling and aggregate survey indices
6 catchability coefficients of survey indices with age composition data
7 NY survey selectivity parameters
8 NJ survey selectivity parameters
9 DE survey selectivity parameters
10 MD survey selectivity parameters
11 fishing mortality on tags for each year

The estimation procedure proceeds by first calculating $F_{a,y}$ using initial starting values for average F, $F'_y$, average R, and parameters estimates for the selectivity equations, and M (which is fixed at 0.15), and then the abundance matrix is filled (Figure A10.1). Note that in this model recruitment is actually estimated back to 1970 in order to provide more realistic estimates of N in the first year of data (1982). Also, this allowed the incorporation of data (e.g., Maryland young-of-the-year index) back to 1970 which cannot done in the ADAPT model. All predicted values were calculated using the equations described above. A constant reporting rate of 0.43 and a constant phi of 1 were used for all harvest and released tag returns.

**A10.2.4 Code Checking**

As described in the SCA document, the SCA code was checked for accuracy by inputting catch and survey index data from a simulated population with known parameters and the model estimated the parameters exactly (see SCA document). The tag model code was checked using data provided in Jiang (2005) and Hoenig et al. (1998).

**A10.3 RESULTS**

**A10.3.1 Initial Analyses**

The initial model run was based on all current data, aforementioned model equations, initial starting values (Table A10.3), equal weighting of all components in the total log-likelihood, and the final model configuration of the SCA. Equal weighting of all components provided poor estimates of total catch at the beginning and end of the time series, but provided reasonably precise estimates of fully-recruited Fs (Figure A10.2). Fishing mortality on the tags (F') had moderate variances (Figure A10.2).

**A10.3.2 Final Model Configuration**

To improve the fit of total catch, the total catch lambda was increased to 50 (Figure A10.3). Comparisons of the equal and 50 weight for total catch suggested that the higher lambda weight had little effect on fishing mortality estimates post-1985 (Figure A10.4). Therefore, the remaining analyses were completed with total catch lambda weight=50. Resulting contributions to total likelihood are listed in Table A10.4. Estimates of fully-recruited fishing mortality, recruitment, parameters of the Gompertz functions for the four selectivity periods, catchability coefficients for all surveys, and parameters of the survey selectivity functions are given in Table A10.5 and are shown graphically in Figure A10.3. Graphs depicting the observed and predicted values, and residuals for the catch age composition, survey indices, survey compositions and tag return residuals are given in Appendix A16.

The model fit the observed total catch (Figure A10.3), catch age composition, and the YOY and age 1 indices reasonable well (Appendix A16). The model did less well at predicting MRFSS, CTTrawl, and NEFSC, aggregate indices, and the survey indices with age composition data (NYOHS, NJ Trawl, MDSSN and DESSN). The observed age composition for each survey (NYOHS, NJ Trawl, MDSSN and DESSN) was predicted with some accuracy (Appendix A16). The patterns in residuals of the harvest and catch/release observed and predicted tag recoveries varied depending on the tagging program. In general, the model under-estimated tag returns from the Hudson River, NYOHS, and New Jersey programs (positive residuals) and it over-estimated tag returns from Virginia, Massachusetts, and North Carolina (negative residuals), but results were mixed for Delaware and Maryland (Appendix A16).

***A10.3.2.1 Fishing Mortality***

The converged total likelihood was 77,162.7 and the fully-recruited fishing mortality in 2006 was 0.15 (Table A10.5). The 2006 average fishing mortality rate (F) for ages 8 through 11 equaled 0.14 and is below the current target (0.30) and threshold (0.41)(Table A10.6; Figure A10.5). Average fishing mortality on ages 3–8, which are generally targeted in producer areas, was 0.09 (Table A10.6; Figure A10.5). An average F weighted by N was calculated for comparison to tagging results since the tag releases and recaptures are weighted by abundance as part of the experimental design. The 2006 F weighted by N for ages 7–11 (age 7 to compare with tagged fish ≥28") was 0.14 (Table A10.6; Figure A10.5). An F weighted by N for ages 3–8, comparable to the direct enumeration estimate for Chesapeake Bay, was equal to 0.08 (Table A10.6; Figure A10.5). Among the individual age groups, the highest values of F in 2006 (0.14–0.15) were estimated for ages 9–12 (Table A10.7).

***A10.3.2.2 Population Abundance (January 1)***

Striped bass abundance (1+) increased steadily from 1982 through 2004 when it peaked around 131 million fish (Table A10.8; Figure A10.6). Total abundance declined to 115 million through 2006. The 2003 cohort remained strong at 38 million fish in 2006 and exceeded the size of the strong 1993 and 2001 year classes the same age (Table A10.8). Abundance of striped bass age 8+ increased steadily through 2004 and averaged around 11.9 million through 2006 (Table A10.8, Figure A10.6).

***A10.3.2.3 Spawning Stock Biomass***

Female spawning stock biomass (SSB) is higher than those produced by the SCA model because higher abundances were estimated in the SCATAG model. Female SSB grew steadily from 1982 through 2006 when it peaked at about 49 thousand metric tons (Table A10.9, Figure A10.7). The estimated SSB in 2006 remained above the threshold level of 14.6 metric tons and indicates the stock is not overfished.

***A10.3.2.4 Retrospective Analysis***

Only slight retrospective bias was evident in estimates of fully-recruited F and age 8+ abundance (Figure A10.8); therefore, the 2006 fishing mortality estimate may decrease slightly when another year of data in added in the future.

***A10.3.2.5 Influence of Reporting Rate***

The effects of varying reporting rate on estimates of fully-recruited fishing mortality above and below the assumed $\lambda$=0.43 were explored. Fishing mortality rates over the entire time series declined rapidly as reporting rate was increased from 0.23 to 0.73, particularly in the most recent years, indicating the results of the SCATAG model are highly dependent on the reporting rate (Figure A10.9).

***A10.3.2.6 Tagging Program Influence***

The influence that the tag return data from each program had on the estimation of fully-recruited fishing mortality was investigated by removing each dataset one-at-a-time and re-running the model. Changes in the time series of F estimates for 1982–2006 when each dataset was removed one-at-a-time were minor (Figure A10.10). No single tagging program had a major influence.

The effects of using tagging data from only coastal programs whose releases are believed to be subjected to the full coastwide fishing mortality was explored. Only minor changes in the time series of F estimates for 1982–2006 occurred when data from NYOHS, NJ, and NCCOOP programs were used (Figure A10.11).

### A10.4 SOURCES OF UNCERTAINTY

The same sources of uncertainty discussed for the SCA model apply to the SCATAG model. The unique source of uncertainty that has a large impact on SCATAG results is the reporting rate. The current estimate of 0.43 is assumed constant across all years and is outdated; luckily, John Hoenig of VIMS is currently conducting a coastwide high reward tag return study which will provide a more up-to-date estimate. It is possible to estimate reporting rate in the model, but the estimate is not an independent one because it is very highly correlated with other parameters (natural mortality, some F deviations) in the model.

The model as implemented assumes that tagged fish 28 inches and greater are fully recruited to the fishery over time, but this may not have been entirely true during 1980s when large minimum size regulations were in place. A better model configuration would be the age-dependent model of Jiang et al. (2007), and when incorporated in SCA, common selectivity functions could be estimated for both the catch and tag data.

### A10.5 FUTURE OF THE SCATAG MODEL

To date, the age-dependent tag return model of Jiang et al. (2007) has been incorporated into the SCATAG, but results can not be obtained because decisions have to be made on how to assign ages to tagged fish for which ages were not determined, what programs to use, and how to group data because sample sizes drop dramatically when two recapture matrices per age are produced. Although Jiang et al. (2007) assumes similar age selectivity patterns among harvest and released tag returns, selectivity functions can be estimated for each disposition separately by making slight changes to the code. These selectivity patterns can be linked to the catch data, but the proportions-at-age matrix and total catch will have to be split into harvest and dead releases matrices and it will take considerable work to do so.

## A11.0 EVALUATE THE CURRENT BIOLOGICAL REFERENCE POINTS FOR ATLANTIC STRIPED BASS FROM AMENDMENT 6 AND DETERMINE STOCK STATUS BASED ON THOSE REFERENCE POINTS. (TOR #7)*

***EDITOR'S NOTE: In this striped bass assessment report, the meaning of TOR 7 was clarified during the independent peer review. In addition to determining stock status, the purpose of TOR 7 was to review the methods used to determine the current biological reference points, and to get the reviewer's opinion on whether the BRPs were developed appropriately and whether those approached should be continued.***

### A11.1 HISTORY OF STRIPED BASS REFERENCE POINTS AND AGE AT FULL F

In the early 1990s, the status of Atlantic striped bass stocks was determined using annual tag based estimates of survival and the associated fishing mortality. Fishing mortalities that produced a sustainable population were estimated in simulation models developed by Rago and Dorazio, as well as Crecco, and described in the Amendment 4 source document (ASMFC 1990). Subsequent to Amendment 4, a relative index of spawning stock biomass was developed using a forward projecting model of age-0 recruits as determined by the time series of MD juvenile indices (ASMFC 1998). The SSB index served as the basis for developing a biomass threshold for evaluation of the stock rebuilding status. The SSB index increased to a level comparable to historic abundance in the 1960s and consequently, in 1995 striped bass was declared restored. The modeling approach used for the SSB index also served as the basis for the Crecco model for biological reference points, specifically $F_{msy}$ (ASMFC 1998). The model applied a combination of minimum sizes (20" in producer areas and 28" on the coast) to define full recruitment to the fisheries. The biological reference point of $F_{msy} = 0.40$ was adopted in Amendment 5 and a target F of 0.31 was established with a subsequent addendum to the FMP. A lower target F of 0.28 for the producer areas was derived based on equivalent SSB/R when the jurisdictions requested a reduction in their minimum size limit from 20 to 18 inches. These values were compared against annual tag based estimates of F for determination of stock status.

In 1997, the ASMFC Technical Committee adopted the results of a VPA model as the method for determination of stock status. Average F was calculated for the ages at full recruitment with age at full F based on the distributions of ages in the catch. The fully recruited F was defined as ages 4–13. Comparisons were made to target F (and $F_{msy}$) which were products of the Crecco model.

In 2003, the ASMFC adopted Amendment 6 to the Striped Bass FMP. As part of the amendment, new biological reference points ($SSB_{target}$, $SSB_{threshold}$, $F_{target}$, and $F_{threshold}$) were established. $F_{msy}$, estimated using a Shepherd/Sissenwine model, was adopted as $F_{threshold}$. An exploitation rate of 24%, or F=0.30 was chosen as $F_{target}$. Target F for the producer area, Chesapeake Bay, was reduced proportionately to 0.27. $SSB_{threshold}$ (14,000 mt) was chosen to be slightly greater than the female spawning stock biomass in 1995 when the population was declared recovered. $SSB_{target}$ (17,500 mt) was 25% greater than $SSB_{threshold.}$ No biomass targets were chosen specifically for Chesapeake Bay.

Striped bass present a particularly difficult species for estimating biological reference points because of the differences in fisheries among areas and sexes. Under current management, striped bass fisheries are managed under one suite of regulations along the coast and alternative regulations within Chesapeake Bay. The Bay fisheries are generally understood to be primarily male bass which mature younger (age 2) and have a shorter life-span than females. Coastal fisheries with larger size limits target primarily females which mature at ages 5–8 and have a potential life span of 30+ years. Reference points were developed as a compromise between maximizing yield on males and conserving spawning biomass in females.

A Thompson-Bell yield per recruit model was fitted with natural mortality equal to 0.15 and a maximum age of 25 (Figure A11.1). A maturity ogive was developed for combined sexes: age 2 - 25%, age 3 - 38%, age 4 - 52%, age 5 – 57%, age 6 – 73%, age 7 – 95% and ages 8 to 25 at 100% mature. Weight at age were averages from VPA input for years 1982–2000 up to age 13, and ages 14–25 from growth equations developed from fishery independent and dependent sources. The same weights at age were applied to catch and stock weights. Partial recruitment values in the YPR model came from the VPA output average for the period 1995–2000. Full recruitment occurred at age 9 and remained flat-topped through age 25. Age specific partial recruitments are presented in Figure A11.2. Sex ratios at age were assumed 50:50.

Annual spawning stock biomass (male and female maturity ogives applied to a 50:50 split of total biomass) and age one abundance for 1982–2000 were fitted to a Shepherd stock-recruitment model with parameter estimates: a = 0.53, b = 1.87, and k = 41,500 (Figure A11.3). The S/R parameters were used in conjunction with the YPR results (Sissenwine and Shepherd 1987) to estimate an $F_{msy}$ = 0.41.

## A11.2 CURRENT STOCK STATUS IN RELATIONSHIP TO REFERENCE POINTS.

The existing reference points for striped bass, as defined in Amendment 6 to the FMP (ASMFC 2003) are:

Female Spawning Stock Biomass Threshold ($SSB_{Threshold}$) = 14,000 mt
Female Spawning Stock Biomass Target ($SSB_{Target}$) = 17,500 mt
Fishing Mortality Rate Threshold ($F_{MSY}$) = 0.41
**The target fishing mortality rate for Chesapeake Bay is* $F_{Target}$ *= 0.27.*

The assessment covers the entire stock of the Atlantic coast migratory striped bass. The EEZ is managed under Federal authority and is closed to fishing for striped bass whereas fisheries in state waters are managed under the authority of the ASMFC. Although the EEZ is managed separately, striped bass present in these waters are still considered part of the coastal migratory stock. The estimates of F and biomass obtained from the stock assessment are intended to represent the status of the entire stock of striped bass.

Estimates of fully recruited F in 2006 from the CEM (F for fish $\geq$ 28 inches = 0.16) and the SCA model ($F_{age\ 8\text{-}11}$ = 0.31) are both below the Amendment 6 threshold (Tables A7.7 and A8.11). Therefore, overfishing is not occurring on the coastal migratory stocks of Atlantic striped bass.

Time series F estimates from the CEM and SCA model (as well as the IRCS, SCATAG and other supporting models) show similar trends through 2002 (Figure A11.4). After this point, the F estimates from SCA (and the supporting ASAP and ADAPT models) continued to increase while trends from the other models and methods were flat or declining. Only the terminal estimate of F from the SCA model (and the supporting ADAPT model) exceed the target F of 0.30. However, retrospective bias was evident in estimates of fully-recruited F from SCA (Figure A7.12). The pattern suggests that the 2006 F estimate is likely over-estimated and could decrease with the addition of future years' data. For example, the 2002 estimate of fully recruited F from the SCA base model run is 23% lower than the estimate from a run with 2002 as the terminal year. Similar retrospective trends have been observed in the previous assessment of striped bass using the ADAPT VPA (ASMFC 2005) and in the supporting ASAP and ADAPT models presented in the current assessment. However, experiences from other assessments indicate that it is possible for the magnitude and direction of the retrospective pattern to change in subsequent assessments.

A lower target F of 0.27 is used to assess the striped bass fishery on resident fish in Chesapeake Bay because of the 18 inch minimum size limit that is below the 20 inch standard in Amendment 6 for producer areas. F estimates from the CEM (as well as the IRCS model) are continuously below $F_{Target}$ throughout the time series (Figure A9.15).

Estimates of female SSB from the SCA model show a steady increase through 2003 before declining somewhat to the 2006 estimate of 25,000 mt (Table A7.10). The 2006 estimate is above both the $SSB_{Threshold}$ and $SSB_{Target}$ and therefore striped bass are not overfished. Retrospective bias was evident in estimates of SSB from SCA (Figure A7.12). This pattern suggests that the 2006 SSB estimate is likely under-estimated and could increase with the addition of future years of data. For example, the 2002 estimate of SSB from the SCA base model run is 33% higher than the estimate from a run with 2002 as the terminal year. Similar retrospective trends have been observed in the supporting ADAPT model presented in the current assessment and in previous assessments of striped bass using the ADAPT VPA (ASMFC 2005). However, experiences from other assessments indicate that it is possible for the magnitude and direction of the retrospective pattern to change in subsequent assessments.

Trends in SSB from the SCA, ADAPT, and SCATAG models show an increasing trend through 2002 or 2003 (Figures A7.11 & A10.7; Appendix 8). After this point, the SCATAG SSB continues to increase through 2006 while SCA and ADAPT show a modest decline.

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# A14.0 TABLES

Table A4.1. Atlantic Coast Fisheries Regulations, 2006 – Commercial

| State | Area | Gear | Size Limit (inches TL) | Open Season | Possession Limit (or other) | Quota (pounds) |
|---|---|---|---|---|---|---|
| ME | No commercial fishing or sale of striped bass caught in Maine waters. Possession limit of 1 fish as import. | | | | | |
| NH | The taking of striped bass by netting of any form is prohibited. The sale of striped bass is prohibited regardless of origin. | | | | | |
| MA | Statewide | Hook and line | 34" min. | 7/12 - 8/10 | 5 fish/day (Sun.); 30 fish per day on Tues. - Thurs. | 1,094,962 |
| RI | Statewide | General (Hook&Line, mainly) | 34" min. | Closed 1/1- 5/31 | 4 fish (6/10-8/31); 3 fish (9/1-12/31 | Overall: 243,625 |
| | | Trap | 28" min. | All year | None | |
| CT | Commercial fishing for striped bass is prohibited in all waters of the state | | | | | |
| NY | Coastal | Gill nets (6 - 8" stretched mesh), pound nets, hook&line, trawls, gill nets (<6" or >8" | 24" - 36" | 7/1 - 12/15 | 7/fish by-catch limit/trip, except a 21 fish limit for trawl | 828,293 |
| NJ | No netting and no sale of striped bass in the state. The commercial allocation is basis of the Bonus Fish Program | | | | | |
| PA | No commercial harvest or sale | | | | | |
| DE | Various | Gill net: no fixed nets Delaware River; 5 1/2" and 0.28 twine size max.: Nanticoke; 2/15 - 2/28 and 5/1-31 drift gill net only | 20 min. (spring gill net season Delaware River and Bay and Nanticoke) 28 all other | Gill net spring: 2/15 - 5/31 (3/1 - 3/31,Nanticoke River); gill net fall: 11/15 - 12/31. Hook&line- 4/1 - 12/31 | Mandatory daily accounting of pounds and number of fish landed. All fish were tagged twice; once by the fisherman and by an authorized weigh-station. | Statewide: 193,447 |
| MD | Chesapeake Bay | Pound net/Haul seine; Hook&Line;Drift Gill Net | 18" - 36" only | Pound net/haul seine: 6/1 - 11/30; Hook&Line: 6/14 - 11/30 (select days only); Drift gill net: 1/1 - 2/28 and 12/1 - 12/31 | Pound net/haul seine: 200 pounds/licensee/day; Hook&line: 800 pounds/licensee/week; drift gill: 500 pounds/licensee/day | Bay & Rivers= 2,134,116 |
| | Atlantic Coast | Drift gill net/Otter trawl | 24 | 1/1 - 4/30 and 11/1 - 12/31 | No trip limit | 131,560 |
| D.C. | Commercial fishing for striped bass is prohibited in the District of Columbia. | | | | | |
| PRFC | Potomac River | Gill net; pound net; hook&line; haul seine; fyke net, trot line, fish pot | Min.: 18"; Max. 36" (1/1 - 3/25) | 2/15 - 3/25 & 6/1 - 12/31 | | 791,195 |
| VA | Chesapeake Bay | Any legal gear. Gill net, hook&line, pound net, haul seine are typical | Min.: 18"; Max. 28" (3/25 - 6/15) | 2/1 - 12/31 | Individual Transferable Quota system in Bay since 1998; roughly 450 shares of the quota | Bay & Rivers=1,554,302 |
| | Atlantic Coast | Gill net, hook&line, haul seine | 28" min. | 2/1 - 12/31 | Itq; 34 shares (since 2003) | 184,853 |
| NC | Atlantic Coast | Beach seine, gill nets, trawl | 28" min. | Winter | Lbs.-seine (50); gill net(10) trawl (100) | 480,480 |

Table A4.1 cont. – Recreational

| State | Size Limits | Gear | Possession Limit (or other) | Open Season |
|---|---|---|---|---|
| **ME** | 1 fish 20-26' OR 1 fish >40" | Hook and line only | 1 fish | All year except spawning areas; 12/1 - 4/30 spawning areas; 5/1 - 6/30 catch & release |
| **NH** | 28" | No gaffing; culling is prohibited | 2; only 1 fish >40" | All year |
| **MA** | 28" | Hook and line | 2 fish | All year |
| **RI** | 28" | | 2 fish | All year |
| **CT** | 28" | | 2 fish | All year |
| **NY** | ***Marine District*** -Licensed Party/Charter Boat anglers: Min. Length 28". All other Anglers: Min. Length 28 - 40". ***Hudson River*** - 18". ***Delaware River*** - 28" total length. | | ***Marine District*** - Licensed Party/Charter Boat anglers: 2 fish. All other Anglers: 1 fish, and > 40 inches, 1 fish. ***Hudson River*** - 1 fish. ***Delaware River*** - 2 fish | ***Marine District*** : 4/15- 12/15. ***Hudson River*** - 3/15 - 11/30. ***Delaware River*** - All year. |
| **NJ** | 28' | Anglers fishing w/ natural bait in the Delaware River are required to use non-offset circle hooks from 4/1 - 5/31. | 2 striped bass- all waters | Closed Seasons: Jan. - Feb. in all intra-coastal waters; Apr. - May in the lower Delaware River (Spawning ground closure) |
| **PA** | 28" | | 2 fish | From Trenton Falls downstream - Open 3/1 - 3/31 & 6/1 - 12/31. All year for the rest of the river. |
| **DE** | 28" | Legal gear: Hook and line, spear (for divers); striped bass may not be harvested from recreational gill nets. | 2 fish | All year except spawning grounds. Spawning ground closures: Closed to harvest 4/1 - 5/31. Circle hooks required during 4/1 - 5/31. |
| **MD** | ***Spring Trophy*** : 33" ***Summer/Fall*** : 18 - 28" ***Ocean*** : 28". | | ***Spring Trophy*** : 1 fish ***Summer/Fall*** : 2 fish 18-28" OR 1 fish 18-28" plus 1 fish > 28". ***Ocean*** : 2 fish | ***Susquehanna Flats Catch and Release*** : 3/1 - 5/3. ***Spring Trophy*** : 4/15 - 5/15. ***Summer/Fall*** : Boundaries changed according to the following schedule: 5/16 - 5/31. All other tributaries, bays, creeks, rivers, and sounds closed except Tangier and Pocomoke |
| **D.C.** | 18"-36" | | 2 fish | 5/1 - 11/19 |
| **PRFC** | ***Spring Trophy*** : 28" ***Summer/Fall*** : 18" | | ***Spring Trophy*** : 1 fish ***Summer/Fall*** : 2 fish | ***Spring Trophy*** : 4/15 - 5/15 ***Summer/Fall*** : 5/15 -12/31 |
| **VA** | ***Bay & Coastal Trophy*** : 32". **Potomac Tribs Spring**: 28". ***Ches. Spring*** : 18" min 28" max. ***Ches. Fall*** : 18" min 28" max. ***Potomac Tribs Fall*** : 18" min 28" max. ***Coastal*** : 28" min. | | ***Bay & Coastal Trophy and Potomac Tribs Spring*** : 1 fish. ***Ches. Spring & Fall, Potomac Tribs Fall & Coastal*** : 2 fish | ***Bay & Coastal Trophy*** : 5/1 - 5/15. ***Potomac Tribs Spring*** : 4/15 - 5/15. ***Ches. Spring*** : 5/16 - 6/15. ***Ches. Fall*** : 10/4 - 12/31. ***Potomac Tribs Fall*** : 5/16 - 12/31. ***Coastal*** : 1/1 - 3/31 & 5/16 - 12/31. |
| **NC** | ***Ocean*** : 28" min. | | ***Ocean*** : 2 fish | ***Ocean*** : All year |

Table A5.1. State-specific summaries of commercial harvest and biological samples collected by gear type and quarter

Gear Type

| | | Hook and Line | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Harvest | | Hours | Length | Samples |
| State | Year | Quarter | Pounds | Number | Fished | Samples | Aged |
| MA | 2000 | 3 | 779,736 | 40256 | 113321 | 481 | 481 |
| | 2001 | 3 | 815,054 | 40248 | 101395 | 540 | 193 |
| | 2002 | 3 | 924,890 | 44897 | 106478 | 544 | 197 |
| | 2003 | 3 | 1,055,439 | 55433 | 95046 | 628 | 249 |
| | 2004 | 3 | 1,206,305 | 60632 | 121474 | 855 | 249 |
| | 2005 | 3 | 1,104,737 | 59473 | 93861 | 742 | 251 |
| | 2006 | 3 | 1,312,168 | 69,986 | 94797 | 607 | 306 |

Gear Type

| | | Trap | | | | | | Rod & Reel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Harvest | | | Length | Samples | | Harvest | | | Length | Samples |
| State | Year | Quarter | Pounds | Number | Effort | Samples | Aged | Quarter | Pounds | Number | Effort | Samples | Aged |
| RI | 2000 | | | | | 0 | 0 | | | | | 0 | 0 |
| | 2001 | 1-4 | 54,312 | 6,075 | | 139 | 135* | 1-4 | 109,431 | 5,848 | | 0 | 0 |
| | 2002 | 1-4 | 63,375 | 6,586 | | 0 | 0 | 1-4 | 107,798 | 5,814 | | 197 | 185* |
| | 2003 | 1-4 | 66,870 | 6,874 | | 314 | 314* | 1-4 | 171,155 | 9,150 | | 185 | 185* |
| | 2004 | 1-4 | 78,559 | 7,681 | | 244 | 157 | 1-4 | 166,645 | 8,211 | | 319 | 82 |
| | 2005 | 1-4 | 68,219 | 6,446 | | 412 | 412 | 1-4 | 174,084 | 8,366 | | 492 | 490 |
| | 2006 | 1-4 | 63,827 | 6,562 | | 425 | 188 | 1-4 | 174,970 | 8,867 | | 424 | 0 |

| | | Mixed Gear Types | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Harvest | | | Length | Samples |
| State | Year | Quarter | Pounds | Number | Effort | Samples | Aged |
| NY | 2000 | 3-4 | 542,659 | 54,895 | | 814 | 814 |
| | 2001 | 3-4 | 633,095 | 58,296 | | 839 | 839 |
| | 2002 | 3-4 | 518,573 | 47,143 | | 508 | 508 |
| | 2003 | 3-4 | 753,261 | 68,354 | | 524 | 524 |
| | 2004 | 3-4 | 741,668 | 70,367 | | 481 | 481 |
| | 2005 | 3-4 | 689,821 | 70,560 | | 185 | 185 |
| | 2006 | 3-4 | 687,204 | 73,528 | | 580 | 580 |

Table A5.1 cont.

| | | Gear Type | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hook and Line | | | | | | Gillnet landings | | | | | | Striped Bass discards from gill nets | |
| | | | Harvest | | Effort | Length | Samples | | Harvest | | Effort | Measured | Samples | Length | Samples |
| State | Year | Quarter | Pounds | Number | (man-days) | Samples | Aged | Quarter | Pounds | Number | (yard-days) | Bass | Aged | Samples | Aged |
| Delaware | 2000 | 1+2 | 0 | 0 | | | | 1+2 | 108,177 | 19147 | 325,720 | 412 | 252 | 188 | 139 |
| | | 3+4 | 4800 | 857 | 100 | 80 | 79 | 3+4 | 27,658 | 5184 | 59,126 | 125 | 104 | | |
| | 2001 | 1+2 | | | | | | 1+2 | 193,070 | 33416 | 278,675 | 374 | 137 | 721 | 310 |
| | | 3+4 | 5732 | 957 | | 56 | 56 | 3+4 | 0 | 0 | | | | | |
| | 2002 | 1+2 | 0 | 0 | 0 | | | 1+2 | 135,371 | 21948 | 250,655 | 260 | 260 | 621 | 215 |
| | | 3+4 | 6,883 | 1130 | | 32 | 32 | 3+4 | 18,306 | 3449 | 29,319 | 76 | 76 | | |
| | 2003 | 1+2 | 0 | 0 | | | | 1+2 | 168,945 | 28084 | 223,522 | 493 | 430 | 235 | 235 |
| | | 3+4 | 6,922 | 1,183 | | 35 | 34 | 3+4 | 12,522 | 2263 | 40,150 | 100 | 91 | | |
| | 2004 | 1+2 | | | | | | 1+2 | 171,630 | 27553 | 264,697 | 176 | 176 | - | - |
| | | 3+4 | 4,571 | 287 | | 32 | 32 | 3+4 | 5,773 | 566 | 28,480 | 3 | 3 | | |
| | 2005 | 1+2 | | | | | | 1+2 | 144,803 | 22914 | 360,274 | 133 | 133 | - | - |
| | | 3+4 | 2,956 | 353 | | 6 | 6 | 3+4 | 26,056 | 3069 | 856,096 | 11 | 11 | | |
| | 2006 | 1+2 | | | | | | 1+2 | 157,772 | 28,213 | 350,125 | 212 | 212 | - | - |
| | | 3+4 | 5,787 | 459 | | 2 | 2 | 3+4 | 15,904 | 1,540 | 66,076 | 185 | 160 | | |

| | | Gear Type | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hook and Line | | | | | | Poundnet/haul seine | | | | | | Gillnet | | | | | |
| | | | Harvest | BOATDAYS*TOT | Measured | Length | | | Harvest | FISHDAY*NUMI | Length | Samples | | | Harvest | BOATDAYS*TOT | Length | Samples | |
| State | Year | Quarter | Pounds | Number | Effort | Bass | Samples | Quarter | Pounds | Number | Effort | Samples | Aged | Quarter | Pounds | Number | Effort | Samples | Aged |
| MD | 2000 | 2 | 76,140 | 29,679 | 2,769 | 444 | | 2 | 135,462 | 32,491 | 2,277 | 98 | | 1 | 865,131 | 243571 | 4,287,596 | 3009 | |
| | | 3 | 471,945 | 123,394 | 13,700 | 930 | | 3 | 154,967 | 44,504 | 5,894 | 253 | | 4 | 128,851 | 0 | 931,529 | 1062 | |
| | | 4 | 197,903 | 58,153 | 5,973 | 558 | 209 | 4 | 171,821 | 25,366 | 4,867 | 282 | 209 | | | | | | |
| | 2001 | 2 | 85,554 | 21,895 | 1,462 | 450 | | 2 | 81,441 | 12,906 | 2,494 | 13 | | 1 | 422135 | 74660 | 2,573,909 | 2529 | |
| | | 3 | 222,671 | 62,662 | 7,323 | 898 | | 3 | 205,537 | 55,647 | 7,349 | 581 | | 4 | 164,550 | 40833 | 858,155 | 1243 | 184 |
| | | 4 | 63,629 | 22,572 | 5,555 | 345 | 226 | 4 | 365,628 | 87,015 | 7,714 | 521 | 226 | | | | | | |
| | 2002 | 2 | 46,976 | 12,491 | 1,957 | 154 | | 2 | 122,146 | 33,521 | 2,378 | 114 | | 1 | 422,135 | 175947 | 3,005,879 | 2802 | |
| | | 3 | 174,073 | 62,662 | 5,232 | 948 | | 3 | 141,062 | 55,647 | 5,379 | 542 | | 4 | 240,542 | 40833 | 948,110 | 1289 | 165 |
| | | 4 | 138,295 | 22,572 | 3,699 | 595 | 217 | 4 | 208,185 | 87,015 | 19,484 | 424 | 217 | | | | | | |
| | 2003 | 2 | 57,869 | 14,716 | 1,479 | 319 | | 2 | 148,648 | 39,974 | 2,105 | 138 | | 1 | 583788 | 132657 | 2,093,349 | 1836 | |
| | | 3 | 178,263 | 53,639 | 5,147 | 1079 | | 3 | 110,700 | 35,287 | 3,291 | 394 | | 4 | 160,980 | 60758 | 681,900 | 974 | |
| | | 4 | 137,060 | 38,606 | 3,205 | 379 | 182 | 4 | 343,400 | 47,350 | 3,151 | 758 | 182 | | | | | | |
| | 2004 | 2 | 23,309 | 7,027 | 839 | 307 | | 2 | 55,905 | 10,033 | 1,136 | 128 | | 1 | 702507 | 128417 | 2,867,549 | 2556 | |
| | | 3 | 167,728 | 55,990 | 4,675 | 883 | | 3 | 130,630 | 49,280 | 3,381 | 395 | | 4 | 218,810 | 61701 | 688,740 | 1035 | |
| | | 4 | 164,592 | 56,738 | 11,147 | 775 | 256 | 4 | 320,575 | 77,290 | 3,457 | 330 | 156 | | | | | | |
| | 2005 | 2 | 28,384 | 5,887 | 1,293 | 369 | | 2 | 67,522 | 13,355 | 1,601 | 202 | | 1 | 919689 | 86686 | 2,931,860 | 2341 | |
| | | 3 | 105,527 | 33,264 | 4,708 | 1071 | | 3 | 79,632 | 28,939 | 2,748 | 536 | | 4 | 347,528 | 91393 | 962,654 | 1040 | 142 |
| | | 4 | 149,892 | 47,945 | 2,477 | 718 | 210 | 4 | 366,365 | 107,417 | 2,781 | 421 | 210 | | | | | | |
| | 2006 | 2 | 21786 | 6,337 | 953 | 393 | | 2 | 113,514 | 26,562 | 1,172 | 78 | | 1 | 882,553 | 233444 | 2,293,187 | 2566 | |
| | | 3 | 234710 | 79,416 | 6,766 | 1065 | | 3 | 241,249 | 86,950 | 3,007 | 436 | | 4 | 46,987 | 12023 | 376,090 | 408 | 183 |
| | | 4 | 257523 | 84,111 | 4,058 | 648 | 196 | 4 | 317,935 | 102,333 | 2,597 | 430 | 196 | | | | | | |

Table A5.1 cont.

| | | | atl trwlgill | | | | |
|---|---|---|---|---|---|---|---|
| | | | Harvest | | BOATDAYS*TOT | Length | Samples |
| State | Year | Quarter | Pounds | Number | Effort | Samples | Aged |
| MD | 2000 | 1 | 26494 | 3786 | 268,815 | 0 | |
| | | 2 | 17,755 | 1,890 | 110,790 | 0 | |
| | | 4 | 51,600 | 6,359 | 20,726 | 0 | 0 |
| | 2001 | 1 | 9384 | 1420 | 60,366 | 0 | |
| | | 2 | 26,251 | 3,408 | 11,840 | 0 | |
| | | 4 | 56,151 | 6,259 | 19,902 | 0 | 0 |
| | 2002 | 1 | 32421 | 4335 | 43,836 | 0 | |
| | | 2 | 14,933 | 1,477 | 20,819 | 0 | |
| | | 4 | 42,032 | 6,259 | 37,002 | 0 | 0 |
| | 2003 | 1 | 26295 | 3342 | 14,555 | 0 | |
| | | 2 | 17,064 | 1,769 | 13,367 | 0 | |
| | | 4 | 54,790 | 4,405 | 42,139 | 0 | 0 |
| | 2004 | 1 | 7720 | 893 | 18,235 | 0 | |
| | | 2 | 4,593 | 410 | 80,134 | 0 | |
| | | 4 | 100,791 | 12,495 | 95,139 | 0 | 0 |
| | 2005 | 1 | 12632 | 1795 | 6,026 | 0 | |
| | | 2 | 1,055 | 112 | 5,489 | 0 | |
| | | 4 | 33,184 | 4,198 | 72,273 | 0 | 0 |
| | 2006 | 1 | 17936 | 2106 | 20,497 | 156 | |
| | | 2 | 13,242 | 1,308 | 12,057 | 150 | |
| | | 4 | 59,915 | 7,121 | 104,178 | 254 | 127 |

Table A5.1 cont.

| | | Gill Net | | | | | | Hook-and-Line | | | | | | Pound Net | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Harvest | | | Measured | Samples | | Harvest | | | Length | Samples | | Harvest | | | Length | Samples |
| State | Year | Quarter | Pounds | Number | Effort | Bass | Aged | Quarter | Pounds | Number | Effort | Samples | Aged | Quarter | Pounds | Number | Effort | Samples | Aged |
| VA | 2000 | 1-2 | 680,224 | 74,079 | 2,983 | 345 | 121 | 1-2 | 15,039 | 1,986 | 116 | 0 | 0 | 1-2 | 72,225 | 11,489 | 791 | 99 | 20 |
| | | 3-4 | 907,117 | 75,361 | 1,898 | 1,071 | 54 | 3-4 | 93,819 | 4,787 | 664 | 117 | 84 | 3-4 | 93,850 | 24,365 | 953 | 385 | 58 |
| | 2001 | 1-2 | 1,103,773 | 88,443 | 3,192 | 815 | 60 | 1-2 | 15,967 | 2,866 | 124 | 25 | 0 | 1-2 | 36,565 | 6,289 | 575 | 98 | 22 |
| | | 3-4 | 365,583 | 26,620 | 1,338 | 212 | 186 | 3-4 | 63,097 | 3,332 | 455 | 187 | 150 | 3-4 | 71,462 | 15,543 | 657 | 703 | 375 |
| | 2002 | 1-2 | 1,222,020 | 91,362 | 2,816 | 802 | 437 | 1-2 | 68,273 | 4,404 | 216 | 63 | 30 | 1-2 | 26,780 | 5,887 | 536 | 149 | 130 |
| | | 3-4 | 176,194 | 14,789 | 750 | 179 | 2 | 3-4 | 63,888 | 5,053 | 368 | 165 | 66 | 3-4 | 40,028 | 9,047 | 537 | 512 | 200 |
| | 2003 | 1-2 | 1,072,165 | 93,686 | 2,452 | 1,592 | 663 | 1-2 | 15,021 | 1,094 | 113 | 47 | 47 | 1-2 | 57,840 | 12,237 | 592 | 170 | 39 |
| | | 3-4 | 530,391 | 34,526 | 1,319 | 417 | 239 | 3-4 | 119,612 | 8,931 | 497 | 92 | 57 | 3-4 | 39,138 | 8,280 | 387 | 288 | 163 |
| | 2004 | 1-2 | 996,594 | 82,754 | 2,036 | 255 | 236 | 1-2 | 42,414 | 3,630 | 122 | 37 | 37 | 1-2 | 31,140 | 5,754 | 376 | 160 | 92 |
| | | 3-4 | 470,252 | 40,676 | 1,336 | 333 | 171 | 3-4 | 69,168 | 6,249 | 467 | 51 | 36 | 3-4 | 36,859 | 6,811 | 400 | 414 | 227 |
| | 2005 | 1-2 | 1,153,431 | 74,333 | 2,087 | 993 | 421 | 1-2 | 15,584 | 958 | 80 | 1 | 1 | 1-2 | 39,357 | 5,850 | 477 | 197 | 67 |
| | | 3-4 | 436,730 | 26,807 | 1,050 | 1,175 | 779 | 3-4 | 59,097 | 4,507 | 335 | 108 | 26 | 3-4 | 26,705 | 4,485 | 318 | 220 | 106 |
| | 2006 | 1-2 | 847,600 | 53,876 | 2,325 | 1,108 | 527 | 1-2 | 53,453 | 4,894 | 192 | 81 | 65 | 1-2 | 24,620 | 4,467 | 365 | 78 | 39 |
| | | 3-4 | 349,250 | 26,193 | 1,339 | 1,503 | 150 | 3-4 | 87,502 | 6,473 | 514 | 93 | 45 | 3-4 | 35,846 | 6,281 | 240 | 214 | 45 |

| | | Haul Seine | | | | | | Fyke net | | | | | | Other | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Harvest | | | Length | Samples | | Harvest | | (Trips) | Length | Samples | | Harvest | | (Trips) | Length | Samples |
| State | Year | Quarter | Pounds | Number | Effort | Samples | Aged | Quarter | Pounds | Number | Effort | Samples | Aged | Quarter | Pounds | Number | Effort | Samples | Aged |
| VA | 2000 | 1-2 | 3,217 | 512 | 26 | 0 | 0 | 1-2 | 7,632 | 1,214 | 46 | 22 | 22 | 1-2 | 108 | 17 | 6 | 0 | 0 |
| | | 3-4 | 9,796 | 2,543 | 15 | 0 | 0 | 3-4 | 598 | 155 | 10 | 0 | 0 | 3-4 | 231 | 60 | 13 | 0 | 0 |
| | 2001 | 1-2 | 7,101 | 1,221 | 14 | 0 | 0 | 1-2 | 9,046 | 1,556 | 45 | 0 | 0 | 1-2 | 90 | 15 | 2 | 0 | 0 |
| | | 3-4 | 602 | 131 | 6 | 13 | 0 | 3-4 | 2,168 | 472 | 16 | 0 | 0 | 3-4 | 15 | 3 | 6 | 0 | 0 |
| | 2002 | 1-2 | 7,255 | 1,595 | 21 | 2 | 0 | 1-2 | 0 | 0 | 0 | 0 | 0 | 1-2 | 77 | 17 | 3 | 0 | 0 |
| | | 3-4 | 122 | 28 | 2 | 0 | 0 | 3-4 | 0 | 0 | 0 | 0 | 0 | 3-4 | 36 | 8 | 7 | 0 | 0 |
| | 2003 | 1-2 | 16,997 | 3,596 | 11 | 0 | 0 | 1-2 | 3,510 | 743 | 51 | 0 | 0 | 1-2 | 0 | 0 | 0 | 0 | 0 |
| | | 3-4 | 113 | 24 | 3 | 7 | 6 | 3-4 | 1,714 | 363 | 17 | 0 | 0 | 3-4 | 330 | 70 | 4 | 0 | 0 |
| | 2004 | 1-2 | 15,790 | 2,918 | 17 | 0 | 0 | 1-2 | 4,295 | 794 | 20 | 0 | 0 | 1-2 | 0 | 0 | 0 | 0 | 0 |
| | | 3-4 | 1,780 | 329 | 14 | 31 | 31 | 3-4 | 0 | 0 | 0 | 0 | 0 | 3-4 | 15 | 3 | 3 | 0 | 0 |
| | 2005 | 1-2 | 5,063 | 753 | 5 | 0 | 0 | 1-2 | 6,364 | 946 | 12 | 0 | 0 | 1-2 | 0 | 0 | 0 | 0 | 0 |
| | | 3-4 | 1,511 | 254 | 8 | 0 | 0 | 3-4 | 1,394 | 234 | 19 | 0 | 0 | 3-4 | 159 | 27 | 0 | 0 | 0 |
| | 2006 | 1-2 | 10,473 | 674 | 14 | 53 | 34 | 1-2 | 871 | 158 | 21 | 0 | 0 | 1-2 | 3,698 | 671 | 2 | 0 | 0 |
| | | 3-4 | 83 | 5 | 1 | 0 | 0 | 3-4 | 0 | 0 | 0 | 0 | 0 | 3-4 | 122 | 21 | 10 | 0 | 0 |

Table A5.1 cont.

Gear Type

| State | Year | Beach haul seine Quarter | Harvest Pounds | Harvest Number | Effort | Length Samples | Samples Aged | Year | Ocean Gillnet Quarter | Harvest Pounds | Harvest Number | Effort | Length Samples | Samples Aged |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NC | 2000 | 4 | 68,824 | 3037 | | 281 | 281 | 2000 | 1 | No fishery due to overage previous year | | | | |
| | 2001 | 4 | 103,579 | 5459 | | 161 | 161 | 2001 | 1 | 105,219 | 4643 | | 69 | 69 |
| | 2002 | 4 | 233,180 | 12495 | | 288 | 288 | 2002 | 1 | 111,116 | 5856 | | 83 | 83 |
| | 2003 | 4 | No fishery due to overage previous year | | | | | 2003 | 1 | 140,793 | 7544 | | 170 | 170 |
| | 2004 | 4 | 181,509 | 9550 | | 178 | 178 | 2004 | 1 | 204,018 | 9405 | | 211 | 211 |
| | 2005 | 4 | 329,702 | 13612 | | 299 | 299 | 2005 | 1 | 219,733 | 11563 | | 186 | 186 |

| State | Year | Year | Ocean Trawl Quarter | Harvest Pounds | Harvest Number | Effort | Length Samples | Samples Aged |
|---|---|---|---|---|---|---|---|---|
| NC | 2000 | 2000 | 1 | 99,532 | 4864 | | 270 | 270 |
| | 2001 | 2001 | 1 | 176,237 | 7776 | | 103 | 103 |
| | 2002 | 2002 | 1 | 84,795 | 4469 | | 160 | 160 |
| | 2003 | 2003 | 1 | 108,150 | 5795 | | 239 | 239 |
| | 2004 | 2004 | 1 | 220,166 | 10150 | | 285 | 285 |
| | 2005 | 2005 | 1 | 39,627 | 2085 | | 33 | 33 |

**Notes**

RI *= value indicates the number of scales that were collected; the number that were actually processed for ageing is not known

VA

Note: Changes made in database for 2003 and 2004, these numbers represent the current pounds and numbers and does not reflect the data found in the 2003 and 2004 Annual Striped Bass Reports
Note: In 2005 the Pound net data included in the Annual Report includes the data from Haul seine and fyke nets.
Note: In 2004 the Pound net data included in the Annual Report includes the data from Haul seine
Note: In 2003 and 2004 the hook and line data were included with the GN data in the StrB Annual Report
Note: In 2003 the PN data included in the Annual Report includes the HS, FN, trot line and crab pot gears (under other gear above)
2000 hook and line used 2000 and 2001 (combined) stock assessment data to get average weights
2001 stock assessment data used for 2001 averages, 2002 stock assessment data used for 2002 average data
2005 only 1 HL fish in the spring, from the coastal area, used the average weight from gn coast spring
Note: Used the pound net average weight for the haul seine, fyke net and other gear types.

Table A5.2. Total harvest (metric tons and numbers) of striped bass along the Atlantic Coast, 1982–2006

| **Year** | **Commercial** | | **Recreational** | | | **Total** | |
|---|---|---|---|---|---|---|---|
| | *metric tons* | *number* | *metric tons* | *number* | | *metric tons* | *number* |
| 1982 | 992 | 428,630 | 1,144 | 217,256 | | 2,135 | 645,886 |
| 1983 | 639 | 357,541 | 1,224 | 307,134 | | 1,863 | 664,675 |
| 1984 | 1,104 | 870,871 | 582 | 117,993 | | 1,685 | 988,864 |
| 1985 | 431 | 174,621 | 376 | 139,494 | | 807 | 314,115 |
| 1986 | 63 | 17,681 | 502 | 115,576 | | 565 | 133,257 |
| 1987 | 63 | 13,552 | 388 | 43,755 | | 451 | 57,307 |
| 1988 | 117 | 33,310 | 578 | 92,499 | | 694 | 125,809 |
| 1989 | 91 | 7,402 | 336 | 38,074 | | 427 | 45,476 |
| 1990 | 313 | 115,636 | 1,010 | 163,242 | | 1,323 | 278,878 |
| 1991 | 668 | 153,798 | 1,653 | 262,469 | | 2,321 | 416,267 |
| 1992 | 650 | 230,714 | 1,830 | 300,530 | | 2,480 | 531,244 |
| 1993 | 794 | 312,860 | 2,563 | 428,719 | | 3,357 | 741,579 |
| 1994 | 806 | 307,443 | 3,083 | 565,671 | | 3,889 | 873,114 |
| 1995 | 1,555 | 534,914 | 5,709 | 1,108,553 | | 7,264 | 1,643,467 |
| 1996 | 1,541 | 766,518 | 6,040 | 1,199,957 | | 7,581 | 1,966,475 |
| 1997 | 2,679 | 1,058,181 | 7,336 | 1,648,127 | | 10,015 | 2,706,308 |
| 1998 | 2,936 | 1,223,828 | 5,850 | 1,457,057 | | 8,786 | 2,680,885 |
| 1999 | 2,963 | 1,103,783 | 6,335 | 1,446,388 | | 9,299 | 2,550,171 |
| 2000 | 3,038 | 1,057,711 | 8,060 | 2,025,113 | | 11,099 | 3,082,824 |
| 2001 | 2,843 | 941,733 | 8,880 | 2,085,130 | | 11,723 | 3,026,863 |
| 2002 | 2,740 | 654,062 | 8,449 | 1,973,171 | | 11,189 | 2,627,233 |
| 2003 | 3,199 | 868,987 | 10,405 | 2,545,052 | | 13,603 | 3,414,039 |
| 2004 | 3,332 | 907,501 | 12,596 | 2,615,629 | | 15,928 | 3,523,130 |
| 2005 | 3,240 | 968,206 | 11,765 | 2,335,391 | | 15,005 | 3,303,597 |
| 2006 | 3,073 | 1,049,587 | 13,814 | 2,774,542 | | 16,887 | 3,824,129 |

Table A5.3. Commercial landings (numbers) of striped bass along the Atlantic Coast by state, 1982–2006

| Year | ME | NH | MA | RI | CT | NY | NJ | DE | MD | PRFC | VA | NC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | | | 26,183 | 52,896 | 207 | 74,935 | | 12,794 | 189,089 | 54,421 | 14,905 | 3,200 | 428,630 |
| 1983 | | | 9,528 | 48,173 | 83 | 66,334 | | 5,806 | 147,079 | 63,171 | 15,962 | 1,405 | 357,541 |
| 1984 | | | 5,838 | 8,878 | 192 | 70,472 | | 12,832 | 392,696 | 372,924 | 6,507 | 532 | 870,871 |
| 1985 | 90 | | 7,601 | 7,173 | 350 | 52,048 | | 1,359 | | 82,550 | 23,450 | | 174,621 |
| 1986 | | | 3,797 | 2,668 | | | | | | 10,965 | 251 | | 17,681 |
| 1987 | | | 3,284 | 23 | | | | | | 9,884 | 361 | | 13,552 |
| 1988 | | | 3,388 | | | | | | | 19,334 | 10,588 | | 33,310 |
| 1989 | | | 7,402 | | | | | | | | | | 7,402 |
| 1990 | | | 5,927 | 784 | | 11,784 | | 698 | 534 | 38,884 | 56,222 | 803 | 115,636 |
| 1991 | | | 9,901 | 3,596 | | 15,426 | | 3,091 | 31,880 | 44,521 | 44,970 | 413 | 153,798 |
| 1992 | | | 11,532 | 9,095 | | 20,150 | | 2,703 | 119,286 | 23,291 | 42,912 | 1,745 | 230,714 |
| 1993 | | | 13,099 | 6,294 | | 11,181 | | 4,273 | 211,089 | 24,451 | 39,059 | 3,414 | 312,860 |
| 1994 | | | 11,066 | 4,512 | | 15,212 | | 4,886 | 208,914 | 25,196 | 32,382 | 5,275 | 307,443 |
| 1995 | | | 44,965 | 19,722 | | 43,704 | | 5,565 | 280,051 | 29,308 | 88,274 | 23,325 | 534,914 |
| 1996 | | | 38,354 | 18,570 | | 39,707 | | 20,660 | 415,272 | 46,309 | 184,495 | 3,151 | 766,518 |
| 1997 | | | 44,841 | 7,061 | | 37,852 | | 33,223 | 656,416 | 87,643 | 165,583 | 25,562 | 1,058,181 |
| 1998 | | | 43,315 | 8,835 | | 45,149 | | 31,386 | 780,893 | 93,299 | 204,911 | 16,040 | 1,223,828 |
| 1999 | | | 40,838 | 11,559 | | 49,795 | | 34,841 | 650,022 | 90,575 | 205,143 | 21,010 | 1,103,783 |
| 2000 | | | 40,256 | 9,418 | | 54,894 | | 25,188 | 627,777 | 91,471 | 202,227 | 6,480 | 1,057,711 |
| 2001 | | | 40,248 | 10,917 | | 58,296 | | 34,373 | 538,808 | 87,809 | 148,346 | 22,936 | 941,733 |
| 2002 | | | 44,897 | 11,653 | | 47,142 | | 30,440 | 296,635 | 80,300 | 127,211 | 15,784 | 654,062 |
| 2003 | | | 55,433 | 15,497 | | 68,354 | | 31,530 | 439,482 | 83,090 | 161,778 | 13,823 | 868,987 |
| 2004 | | | 60,632 | 16,040 | | 70,367 | | 28,406 | 461,064 | 91,980 | 147,998 | 31,014 | 907,501 |
| 2005 | | | 59,966 | 14,949 | | 70,560 | | 26,336 | 569,964 | 80,615 | 119,244 | 26,572 | 968,206 |
| 2006 | | | 69,986 | 15,429 | | 73,528 | | 30,212 | 655,951 | 92,288 | 109,395 | 2,798 | 1,049,587 |

Table A5.4. Age structure of commercial harvest in 2005 and 2006 by state

| 2005 | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | | | | | | | | | | | | | | |
| NH | | | | | | | | | | | | | | |
| MA | | | | | | | 1197 | 11950 | 16842 | 10777 | 8190 | 4103 | 6907 | 59,966 |
| RI | | | | 27 | 172 | 632 | 1,337 | 3,019 | 2,896 | 2,789 | 1,880 | 1,002 | 1,195 | 14,949 |
| CT | | | | | | | | | | | | | | |
| NY | | | 417 | 6,635 | 11,375 | 12,764 | 11,959 | 4,124 | 10,307 | 7,814 | 2,786 | 2,061 | 317 | 70,560 |
| NJ | | | | | | | | | | | | | | |
| DE | | | | 525 | 4,332 | 5,395 | 4,096 | 4,726 | 4,143 | 2,690 | 280 | 150 | 0 | 26,336 |
| MD | | 144 | 42,952 | 214,726 | 203,839 | 62,171 | 21,599 | 11,773 | 7,424 | 2,928 | 2,164 | 105 | 139 | 569,964 |
| PRFC | | | | 14,396 | 26,735 | 14,396 | 9,049 | 10,283 | 5,347 | 411 | | | | 80,615 |
| VA | | | 90 | 3,387 | 5,078 | 5,710 | 6,791 | 8,975 | 24,725 | 19,079 | 19,509 | 12,624 | 13,277 | 119,244 |
| NC | | | | | | 51 | 0 | 758 | 2,627 | 3,587 | 6,719 | 5,860 | 6,971 | 26,572 |
| **Total** | | 144 | 43,459 | 239,696 | 251,531 | 101,118 | 56,027 | 55,607 | 74,311 | 50,075 | 41,527 | 25,904 | 28,806 | 968,206 |

| 2006 | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | | | | | | | | | | | | | | |
| NH | | | | | | | | | | | | | | |
| MA | | | | | | | 460 | 2,868 | 11,125 | 19,766 | 15,563 | 9,697 | 10,506 | 69,985 |
| RI | | | | | 50 | 46 | 1,319 | 3,325 | 4,016 | 2,832 | 1,878 | 970 | 993 | 15,429 |
| CT | | | | | | | | | | | | | | |
| NY | | | 127 | 1,411 | 18,155 | 14,102 | 9,681 | 8,671 | 6,587 | 7,623 | 4,568 | 1,186 | 1,418 | 73,528 |
| NJ | | | | | | | | | | | | | | |
| DE | | | | 13 | 4,755 | 14,373 | 4,281 | 2,548 | 1,157 | 1,099 | 332 | 840 | 813 | 30,212 |
| MD | | | 90,171 | 154,029 | 254,656 | 104,954 | 25,365 | 14,508 | 5,655 | 3,488 | 2,194 | 187 | 743 | 655,951 |
| PRFC | | | 185 | 35,808 | 49,282 | 4,522 | 369 | 1,015 | 554 | 554 | | | | 92,288 |
| VA | | 81 | 336 | 1,303 | 8,694 | 11,275 | 6,097 | 9,713 | 16,389 | 25,124 | 14,064 | 9,195 | 7,123 | 109,395 |
| NC | | | | | | | | 17 | 85 | 326 | 684 | 656 | 1,031 | 2,798 |
| **Total** | | 81 | 90,819 | 192,564 | 335,592 | 149,273 | 47,573 | 42,664 | 45,568 | 60,812 | 39,283 | 22,731 | 22,628 | 1,049,586 |

Table A5.5. Tag returns of striped bass by commercial gear in 2005 and 2006

**2005**

| | Area | Commercial Gear | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Anchor Gill Net | Drift Gill Net | Hook & Line | Other | Pound Net | Seine | Trawl | |
| *Number* | Coast | 9 | 8 | 33 | 3 | 10 | 5 | 4 | 72 |
| | Chesapeake Bay | 35 | 12 | 5 | 2 | 131 | 2 | 0 | 187 |
| | Delaware Bay | 4 | 1 | 39 | | | | | 44 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Proportion* | Coast | 0.125 | 0.111 | 0.458 | 0.042 | 0.139 | 0.069 | 0.056 |
| | Chesapeake Bay | 0.187 | 0.064 | 0.027 | 0.011 | 0.701 | 0.011 | 0.000 |
| | Delaware Bay | 0.091 | 0.023 | 0.886 | 0.000 | 0.000 | 0.000 | 0.000 |

**2006**

| | Area | Commercial Gear | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Anchor Gill Net | Drift Gill Net | Hook & Line | Other | Pound Net | Seine | Trawl | |
| *Number* | Coast | 1 | 6 | 37 | 1 | 7 | 0 | 4 | 56 |
| | Chesapeake Bay | 27 | 8 | 11 | 1 | 61 | 0 | 0 | 108 |
| | Delaware Bay | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Proportion* | Coast | 0.018 | 0.107 | 0.661 | 0.018 | 0.125 | 0.000 | 0.071 |
| | Chesapeake Bay | 0.250 | 0.074 | 0.102 | 0.009 | 0.565 | 0.000 | 0.000 |
| | Delaware Bay | 0.250 | 0.750 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Table A5.6. Landings and tag recapture ratios (commercial: recreational) used in estimating total commercial discards for the Atlantic Coast in 2005 and 2006. The correction factors (CF) are used to adjust the tag return ratios for underreporting.

| Year | Data | Chesapeake Bay | | | | Coast | | | | Delaware Bay | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Commercial | Recreational | Ratio | CF | Commercial | Recreational | Ratio | CF | Commercial | Recreational | Ratio | CF |
| **2003** | **landings** | 662,518 | 886,330 | 0.75 | | 203,171 | 1,426,035 | 0.14 | | 31,530 | 122,864 | 0.26 | |
| | **Killed tags** | 407 | 523 | 0.78 | 0.96 | 34 | 774 | 0.04 | 3.24 | 2 | 59 | 0.03 | 7.57 |
| | **discard tags** | 79 | 279 | 0.28 | | 13 | 649 | 0.02 | | 5 | 42 | 0.12 | |
| **2004** | **landings** | 677,662 | 730,222 | 0.93 | | 228,003 | 1,375,182 | 0.17 | | 28,406 | 179,657 | 0.16 | |
| | **Killed tags** | 348 | 497 | 0.70 | 1.33 | 74 | 731 | 0.10 | 1.64 | 2 | 59 | 0.03 | 4.66 |
| | **discard tags** | 104 | 221 | 0.47 | | 23 | 600 | 0.04 | | 5 | 42 | 0.12 | |
| **2005** | **landings** | 752,007 | 798,189 | 0.94 | | 189,370 | 1,441,825 | 0.13 | | 26,336 | 224,759 | 0.12 | |
| | **Killed tags** | 90 | 364 | 0.25 | 3.81 | 51 | 588 | 0.09 | 1.51 | 4 | 39 | 0.10 | 1.14 |
| | **discard tags** | 97 | 141 | 0.69 | | 17 | 581 | 0.03 | | 1 | 34 | 0.03 | |

| | Chesapeake Bay | Coast | Delaware Bay |
|---|---|---|---|
| Three year mean of landings ratios (2003–2005) | 0.87 | 0.15 | 0.18 |
| Three year mean of landed tags ratios (2003–2005) | 0.58 | 0.08 | 0.06 |
| Correction factor | 1.52 | 1.90 | 3.12 |

**2006**

| Year | Data | Chesapeake Bay | | | | Coast | | | | Delaware Bay | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Commercial | Recreational | Ratio | CF | Commercial | Recreational | Ratio | CF | Commercial | Recreational | Ratio | CF |
| **2004** | Landings | 677,662 | 730,222 | 0.93 | | 228,003 | 1,375,182 | 0.17 | | 28,406 | 179,657 | 0.16 | |
| | Landed tags | 348 | 497 | 0.70 | 1.3 | 74 | 731 | 0.10 | 1.6 | 2 | 59 | 0.03 | 4.7 |
| | Discard tags | 104 | 221 | 0.47 | | 23 | 600 | 0.04 | | 5 | 42 | 0.12 | |
| **2005** | Landings | 752,007 | 798,189 | 0.94 | | 189,370 | 1,441,825 | 0.13 | | 26,336 | 224,759 | 0.12 | |
| | Landed tags | 90 | 364 | 0.25 | 3.8 | 51 | 588 | 0.09 | 1.5 | 4 | 39 | 0.10 | 1.1 |
| | Discard tags | 97 | 141 | 0.69 | | 17 | 581 | 0.03 | | 1 | 34 | 0.03 | |
| **2006** | Landings | 834,425 | 1,061,170 | 0.79 | | 219,223 | 1,047,054 | 0.21 | | 30,212 | 111,297 | 0.27 | |
| | Landed tags | 97 | 293 | 0.33 | 2.4 | 42 | 627 | 0.07 | 3.1 | 2 | 33 | 0.06 | 4.5 |
| | Discard tags | 11 | 186 | 0.06 | | 14 | 548 | 0.03 | | 2 | 38 | 0.05 | |

| | Chesapeake Bay | Coast | Delaware Bay |
|---|---|---|---|
| Three year mean of landings ratios (2004–2006) | 0.89 | 0.17 | 0.18 |
| Three year mean of landed tags ratios (2004–2006) | 0.43 | 0.086 | 0.066 |
| Correction factor | 2.1 | 2.0 | 2.0 |

Table A5.7. Estimate of total discards of striped bass by commercial fisheries.

| **2005** | | | |
|---|---|---|---|
| | Bay | Coast | DELBAY |
| Rec Discard | 5,074,723 | 13,395,246 | 224,841 |
| Disc Tag Ratio | 0.688 | 0.029 | 0.029 |
| Adj Disc Tag Ratio | 1.044 | 0.055 | 0.092 |
| Commercial Discards | 5,295,680 | 743,026 | 20647 |
| | | | |
| | | | |
| **2006** | Ches Bay | Coast | DE Bay (D |
| Rec Discard | 5,335,429 | 20,317,732 | 596,907 |
| Disc Tag Ratio | 0.059 | 0.026 | 0.053 |
| Adj Disc Tag Ratio | 0.123 | 0.051 | 0.107 |
| Commercial Discards | 655,620 | 1,030,721 | 63,830 |

Table A5.8. Total discards, gear-specific discard mortality and estimates of dead discards by gear type for 2005 and 2006.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Total Discards** | | | | | |
| **2005** | Anchor | Drift | Hook & Line | Other | Pound | Seine | Trawl | |
| Coast | 92878 | 82558 | 340553 | 30959 | 103198 | 51599 | 41279 | |
| Ches Bay | 991170 | 339830 | 141596 | 56638 | 3709808 | 56638 | 0 | |
| Del Bay | 1877 | 469 | 18301 | 0 | 0 | 0 | 0 | |
| | | | | | | | | |
| **2006** | Anchor | Drift | Hook & Line | Other | Pound | Seine | Trawl | |
| Coast | 18,406 | 110,434 | 681,012 | 18,406 | 128,840 | 0 | 73,623 | |
| Ches Bay | 163,905 | 48,564 | 66,776 | 6,071 | 370,304 | 0 | 0 | |
| Del Bay | 15,958 | 47,873 | 0 | 0 | 0 | 0 | 0 | |
| | | | | | | | | |
| | | | **Gear-specific Discard Mortality** | | | | | |
| | Anchor | Drift | Hook & Line | Other | Pound | Seine | Trawl | |
| | 0.43 | 0.08 | 0.08 | 0.20 | 0.05 | 0.15 | 0.35 | |
| | | | | | | | | |
| | | | **Dead Commercial Discards** | | | | | |
| **2005** | Anchor | Drift | Hook & Line | Other | Pound | Seine | Trawl | Total |
| Coast | 39,705 | 6,605 | 27,244 | 6,192 | 5,160 | 7,740 | 14,448 | 107,094 |
| Ches Bay | 423,725 | 27,186 | 11,328 | 11,328 | 185,490 | 8,496 | - | 667,553 |
| Del Bay | 802 | 38 | 1,464 | - | - | - | - | 2,304 |
| | | | | | | | | |
| **2006** | Anchor | Drift | Hook & Line | Other | Pound | Seine | Trawl | Total |
| Coast | 7,868 | 8,835 | 54,481 | 3,681 | 6,442 | - | 25,768 | 107,075 |
| Ches Bay | 70,069 | 3,885 | 5,342 | 1,214 | 18,515 | - | - | 99,026 |
| Del Bay | 6,822 | 3,830 | - | - | - | - | - | 10,652 |

Table A5.9. Data sources for estimating striped bass age structure of commercial discards and discard mortality estimates applied to gear types in 2005 and 2006

| Area | Gear | Data Source | Data Type | Conversion to Age |
|---|---|---|---|---|
| Coastal | Gill Net | NEFSC Observer Program—2005 & 2006 | length-frequency | state age-length key |
| | Hook & Line | Hook & line discards<br>MA compliance report—2005 & 2006 | age structure | |
| | Pound Net | Trap net discards<br>RI compliance report—2005 & 2006 | age structure | |
| | Otter Trawl | NEFSC Observer Program—2005 & 2006 | length-frequency | state age-length key |
| Chesapeake Bay | Anchor Gill Net | Fishery-independent sampling, James & Rappahannock Rivers<br>VA compliance report—2005 & 2006 | age structure | |
| | Drift Gill Net | Drift gill net harvest<br>MD compliance report—2005 & 2006 | age structure | |
| | Hook & Line | Hook & line and pound net harvest<br>MD compliance report—2005 & 2006 | age structure | |
| | Pound Net | Fishery-independent sampling, Rappahannock River<br>VA compliance report—2005 & 2006 | age structure | |
| Delaware Bay | Gill Net | NJ Delaware Bay tagging program<br>USFWS coastwide tagging database | length-frequency | state age-length key |

Table A5.10. Commercial dead discards apportioned into age classes, 2005 and 2006

| 2005 | | | | | | | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Area** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13+** | **Total** |
| Coast | 0 | 474 | 5,687 | 4,201 | 9,159 | 15,558 | 15,382 | 16,699 | 10,990 | 12,551 | 8,626 | 4,546 | 1,098 | 2,123 | 107,094 |
| Chesapeake Bay | 0 | 0 | 5,146 | 95,856 | 227,822 | 148,594 | 51,815 | 37,026 | 31,955 | 30,564 | 14,125 | 11,369 | 6,929 | 6,353 | 667,554 |
| Delaware Bay | 116 | 154 | 137 | 316 | 407 | 278 | 203 | 160 | 223 | 106 | 114 | 71 | 7 | 11 | 2,303 |
| **Total** | 116 | 628 | 10,970 | 100,373 | 237,388 | 164,430 | 67,400 | 53,885 | 43,168 | 43,221 | 22,865 | 15,986 | 8,034 | 8,487 | 776,951 |

| 2006 | | | | | | | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Area** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13+** | **Total** |
| Coast | 0 | 0 | 112 | 2339 | 2124 | 16642 | 19911 | 13286 | 15775 | 11161 | 10282 | 7522 | 3474 | 4446 | 107,075 |
| Chesapeake Bay | 0 | 0 | 452 | 23324 | 26533 | 21906 | 7232 | 3115 | 3340 | 3580 | 4840 | 1535 | 1479 | 1689 | 99,026 |
| Delaware Bay | 0 | 0 | 0 | 0 | 0 | 1667 | 5125 | 1506 | 894 | 402 | 373 | 104 | 343 | 238 | 10,652 |
| **Total** | **0** | 0 | 564 | 25,663 | 28,656 | 40,215 | 32,269 | 17,907 | 20,009 | 15,143 | 15,496 | 9,162 | 5,296 | 6,373 | 216,753 |

Table A5.11. MRFSS total number of interviews, total number of striped bass interviews, numbers of harvested striped bass measured, estimates of numbers harvested and released by state and for years 2000–2006. VAP=volunteer angler program, ALS=American Littoral Society.

| State | Year | Total Interviews | Striped Bass Interviews | Striped Bass Harvested | PSE | Harvest Length Samples By MRFSS | Additional Harvest Length Samples By VAP/State/ALS | Striped Bass Released Alive | PSE | Released Bass Length Samples Measured By VAP/State/ALS | Number of Samples Aged (Har.+Rel.) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | 2000 | 1,717 | 450 | 62,186 | 14.3 | 92 | 882 | 942,593 | 15.2 | 7,133 | Uses | 1 |
| | 2001 | 2,549 | 616 | 59,947 | 12.2 | 154 | 987 | 870,522 | 12.6 | 8,186 | MA age-length | 1 |
| | 2002 | 2,167 | 726 | 71,907 | 11.4 | 117 | 500 | 1,392,200 | 10.2 | 4,819 | Key | 1 |
| | 2003 | 1,601 | 396 | 57,765 | 16.2 | 81 | 600 | 846,708 | 15.0 | 6,129 | | 1 |
| | 2004 | 1,580 | 382 | 36,886 | 17.0 | 75 | 615 | 748,388 | 14.9 | 7,238 | | 1 |
| | 2005 | 1,653 | 592 | 68,838 | 15.8 | 94 | 576 | 3,024,291 | 15.3 | 8,613 | | 1 |
| | 2006 | 1,357 | 648 | 73,385 | 18.4 | 58 | 383 | 4,070,305 | 13.8 | 7,684 | | 1 |
| NH | 2000 | 2,302 | 339 | 4,262 | 23.1 | 16 | 190 | 209,606 | 14.7 | 5,354 | Uses | 2 |
| | 2001 | 2,390 | 278 | 15,291 | 17.0 | 52 | 603 | 164,336 | 13.7 | 4,269 | MA age-length | 2 |
| | 2002 | 2,421 | 407 | 12,857 | 14.5 | 69 | 467 | 238,003 | 12.6 | 5,971 | Key | 2 |
| | 2003 | 2,888 | 340 | 24,878 | 15.9 | 96 | 239 | 260,167 | 13.7 | 3,544 | | 2 |
| | 2004 | 2,889 | 344 | 10,359 | 19.7 | 46 | 228 | 196,806 | 15.5 | 3,714 | | 2 |
| | 2005 | 2,992 | 414 | 26,026 | 21.2 | 50 | 178 | 512,771 | 15.1 | 3,868 | | 2 |
| | 2006 | 2,667 | 817 | 14,760 | 19.8 | 25 | 288 | 567,921 | 12.9 | 4,317 | | 2 |
| MA | 2000 | 5,708 | 1,732 | 181,295 | 9.2 | 62 | 0 | 7,382,031 | 6.4 | 961 (ALS) | 1,805 | 3 |
| | 2001 | 6,735 | 1,754 | 288,032 | 5.9 | 199 | 0 | 5,410,899 | 5.3 | 1,398 (ALS) | 286 | 3 |
| | 2002 | 5,296 | 1,417 | 308,749 | 6.7 | 262 | 0 | 5,718,984 | 5.9 | 2,093 | 661 | 4 |
| | 2003 | 5,963 | 1,404 | 407,100 | 7.0 | 224 | 382 | 4,361,710 | 6.9 | 1,898 | 875 | 4 |
| | 2004 | 4,493 | 1,125 | 400,252 | 9.6 | 138 | 367 | 5,891,661 | 8.0 | 2,448 | 735 | 4 |
| | 2005 | 4,593 | 1,127 | 368,422 | 8.1 | 334 | 326 | 4,839,752 | 8.0 | 1,943 | 773 | 4 |
| | 2006 | 5,043 | 2,038 | 345,105 | 8.8 | 250 | 149 | 8,662,771 | 6.6 | 1,241 | 655 | 4 |
| RI | 2000 | 3,573 | 593 | 95,496 | 12.6 | 50 | 0 | 541,516 | 12.4 | 2,818 | Uses | 5 |
| | 2001 | 4,103 | 499 | 80,125 | 10.5 | 132 | 0 | 377,474 | 12.3 | 2,349 | MA-NY age-length | 5 |
| | 2002 | 4,232 | 583 | 78,190 | 9.4 | 175 | 0 | 530,402 | 14.2 | 2,262 | keys | 5 |
| | 2003 | 5,545 | 876 | 115,471 | 8.8 | 215 | 0 | 448,707 | 9.2 | 2,457 | | 5 |
| | 2004 | 5,193 | 719 | 84,814 | 10.4 | 125 | 0 | 669,975 | 13.6 | 2,544 | | 5 |
| | 2005 | 4,076 | 693 | 112,418 | 12.8 | 106 | 0 | 741,022 | 13.6 | 3,306 | | 5 |
| | 2006 | 3,442 | 1,036 | 75,279 | 13.4 | 38 | 0 | 1,357,084 | 15.2 | 4,306 | | 5 |
| CT | 2000 | 2,031 | 415 | 53,191 | 16.0 | 48 | 352 | 926,367 | 17.5 | - | Uses NY | 6 |
| | 2001 | 2,553 | 395 | 54,165 | 14.5 | 60 | 305 | 1,107,707 | 15.3 | - | age-length | 6 |
| | 2002 | 2,287 | 341 | 51,060 | 17.3 | 36 | 269 | 696,976 | 13.6 | 3,382 | keys | 6 |
| | 2003 | 3,228 | 642 | 95,983 | 12.1 | 189 | 328 | 843,037 | 16.8 | 2,370 | | 6 |
| | 2004 | 2,171 | 502 | 75,244 | 16.6 | 83 | 215 | 1,079,304 | 18 | 2,679 | | 6 |
| | 2005 | 1,917 | 490 | 114,965 | 22.8 | 87 | 297 | 1,713,541 | 15.9 | 3,296 | | 6 |
| | 2006 | 1,478 | 240 | 83,776 | 16.3 | 63 | 271 | 1,683,242 | 18.9 | 4,360 | | 6 |

Table A5.11 cont.

| State | Year | Total Interviews | Striped Bass Interviews | Striped Bass Harvested | PSE | Harvest Length Samples By MRFSS | Additional Harvest Length Samples By VAP/State/ALS | Striped Bass Released Alive | PSE | Released Bass Length Samples Measured By VAP/State/ALS | Number of Samples Aged (Har.+Rel.) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NY | 2000 | 2,730 | 488 | 270,798 | 10.2 | 52 | 781* | 1,373,069 | 9.5 | 5576 (ALS) | 3,856 | 7 |
| | 2001 | 4,188 | 452 | 189,714 | 8.7 | 72 | 909* | 824,278 | 9.7 | 6037 (ALS) | 2,263 | 7 |
| | 2002 | 3,119 | 255 | 202,075 | 11.7 | 81 | 860* | 588,155 | 12.3 | 5655 (ALS) | 2,188 | 7 |
| | 2003 | 4,990 | 444 | 313,761 | 7.9 | 174 | 684* | 1,083,808 | 11.1 | 5235 (ALS) | 2,385 | 7 |
| | 2004 | 3,927 | 426 | 242,623 | 10.6 | 233 | 630* | 1,492,703 | 21.4 | 4667 (ALS) | 2,827 | 7 |
| | 2005 | 3,919 | 506 | 298,387 | 12.1 | 366 | 777* | 1,348,377 | 12.2 | 5595 (ALS) | 2,417 | 7 |
| | 2006 | 3,823 | 861 | 310,441 | 10.2 | 283 | 667* | 1,578,073 | 11.9 | 6995 (ALS) | 3,316 | 7 |
| NJ | 2000 | 3,107 | 189 | 402,302 | 14.6 | 79 | 12,401 | 885,289 | 17.6 | 14,003 | 2,171 | 8 |
| | 2001 | 7,180 | 592 | 560,208 | 7.5 | 360 | 21,514 | 965,650 | 11.1 | 19,254 | 1,570 | 8 |
| | 2002 | 5,370 | 401 | 416,455 | 10 | 232 | 24,067 | 715,099 | 13.5 | 22,659 | 1,537 | 8 |
| | 2003 | 7,156 | 526 | 391,842 | 8.3 | 347 | 26,101 | 925,885 | 11.3 | 26,905 | 2,952 | 8 |
| | 2004 | 6,179 | 562 | 448,524 | 9.2 | 371 | 15,670 | 1,323,535 | 11.5 | 22,131 | 2,101 | 8 |
| | 2005 | 5,644 | 623 | 327,616 | 11 | 351 | 8,871 | 1,197,440 | 11.6 | 18,527 | 1,875 | 8 |
| | 2006 | 4,844 | 1,021 | 489,501 | 11.2 | 197 | 16,100 | 2,100,560 | 11 | 44,470 | 1,558 | 8 |
| DE | 2000 | 3,293 | 261 | 39,543 | 16.0 | 126 | 0 | 151,838 | 14.6 | 0 | | |
| | 2001 | 3,859 | 288 | 41,195 | 16.8 | 141 | 0 | 162,677 | 18.3 | 0 | | |
| | 2002 | 4,493 | 385 | 29,149 | 13.6 | 181 | 0 | 114,650 | 11.6 | 0 | | |
| | 2003 | 4,687 | 283 | 29,522 | 14.5 | 146 | 0 | 169,012 | 13.2 | 0 | | |
| | 2004 | 4,324 | 372 | 25,178 | 15.4 | 284 | 0 | 151,179 | 12.8 | 106 | | |
| | 2005 | 5,178 | 386 | 19,955 | 21.2 | 194 | 0 | 224,841 | 15 | 139 | | |
| | 2006 | 4,211 | 542 | 18,679 | 18.1 | 108 | 0 | 245,304 | 13.8 | | | |
| MD | 2000 | 4,020 | 866 | 506,462 | 9.7 | 456 | 1,099 | 3,244,731 | 10.0 | 2,892 | 592 | 9 |
| | 2001 | 3,629 | 753 | 382,557 | 10.0 | 348 | 406 | 2,890,054 | 11.2 | 835 | 880 | 9 |
| | 2002 | 4,196 | 838 | 282,429 | 11.1 | 445 | 731 | 2,928,589 | 9.9 | 256 | 525 | 9 |
| | 2003 | 4,355 | 1,167 | 525,191 | 8.1 | 837 | 1,349 | 4,652,800 | 9.1 | 1,305 | 615 | 9 |
| | 2004 | 4,045 | 1,043 | 380,461 | 8.5 | 790 | 479 | 3,738,523 | 10.6 | 597 | 662 | 9 |
| | 2005 | 4,054 | 999 | 490,275 | 9.5 | 1,250 | 1,023 | 3,753,328 | 12.1 | 809 | 715 | 9 |
| | 2006 | 3,573 | 930 | 660,462 | 8.3 | 1,211 | 10,340 | 3,905,212 | | 6,088 | 771 | 9 |
| VA | 2000 | 3,174 | 350 | 335,259 | 12.8 | 293 | 0 | 1,022,040 | 12.8 | 0 | | |
| | 2001 | 5,511 | 737 | 301,153 | 9.9 | 861 | 0 | 620,947 | 10.9 | 0 | Uses commercial | |
| | 2002 | 4,695 | 497 | 321,470 | 11.7 | 624 | 0 | 706,729 | 13.0 | 0 | age-length keys from | |
| | 2003 | 4,368 | 494 | 401,945 | 9.5 | 478 | 0 | 970,554 | 12.4 | 0 | hook-and-line | |
| | 2004 | 4,645 | 756 | 477,402 | 8.4 | 708 | 0 | 1,767,596 | 10.3 | 0 | augments with | |
| | 2005 | 3,600 | 469 | 367,801 | 13.1 | 502 | 0 | 1,484,540 | 13.0 | 0 | data from gillnet | |
| | 2006 | 3,693 | 1,121 | 528,190 | 9.5 | 661 | 0 | 1,695,963 | 13.0 | 0 | | |

Table A5.11 cont.

| State | Year | Total Interviews | Striped Bass Interviews | Striped Bass Harvested | PSE | Harvest Length Samples By MRFSS | Additional Harvest Length Samples By VAP/State/ALS | Striped Bass Released Alive | PSE | Released Bass Length Samples Measured By VAP/State/ALS | Number of Samples Aged (Har.+Rel.) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NC | 2000 | 17,849 | 282 | 12,908 | 24.4 | 201 | 0 | 129,729 | 15.7 | 0 | 0 | |
| | 2001 | 21,305 | 285 | 40,016 | 20.3 | 375 | 0 | 49,953 | 17.7 | 0 | 0 | |
| | 2002 | 17,840 | 293 | 33,610 | 31.2 | 486 | 0 | 63,269 | 20.6 | 0 | 0 | |
| | 2003 | 16,021 | 440 | 48,513 | 26.0 | 794 | 0 | 48,945 | 31.9 | 0 | 0 | |
| | 2004 | 15,703 | 776 | 278,270 | 17.6 | 2,131 | 0 | 230,356 | 19.2 | 0 | 0 | |
| | 2005 | 13,817 | 438 | 104,997 | 19.4 | 1,264 | 0 | 109,535 | 19.8 | 0 | 0 | |
| | 2006 | 15,227 | 417 | 90,820 | 21.7 | 557 | 0 | 82,973 | 19.9 | 0 | 0 | |

1 Volunteer Angler Program
2 released VAP measurements are both released & harvested combined; Harv. VAP # measured derived by multipling 0.42 by the # of 28”+ fish measured (32”+ fish for 2000)
3 from Diet/Tagging Studies using Rod&Reel
4 from VAP/Tagging Study
5 Released bass length dist from ALS; ALK is combined MA-NY
6 VAP
7 * - VAP samples, not segregated by kept/released
8 Lengths (both harvested and released) from VAP and party/charter boat logbooks
Ages from harvested fish, spring gill net survey, ocean trawl survey
9 Lengths (both harvested and released) from VASand party/charter boat logbooks as well as creel survey
Ages from all spring gill net and harvested fish from creel survey, and sub-legals from poundnets

Table A5.12. Total recreational harvest (numbers, includes wave-1 harvest estimates for VA and NC) of striped bass along the Atlantic Coast by state, 1982–2006.

| Year | ME | NH | MA | RI | CT | NY | NJ | DE | MD | VA | NC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 929 | | 83,933 | 1,757 | 50,081 | 21,278 | 58,294 | | 984 | | | 217,256 |
| 1983 | 7,212 | 4,576 | 39,316 | 1,990 | 42,826 | 43,731 | 127,912 | 135 | 31,746 | | 7,690 | 307,134 |
| 1984 | | | 3,481 | 1,230 | 5,678 | 57,089 | 13,625 | 16,571 | 16,789 | | 3,530 | 117,993 |
| 1985 | 11,862 | | 66,019 | 670 | 15,350 | 23,107 | 13,145 | | 2,965 | 404 | 5,972 | 139,494 |
| 1986 | | | 29,434 | 3,291 | 1,760 | 27,477 | 36,999 | | 14,077 | 1,585 | 953 | 115,576 |
| 1987 | | 90 | 10,807 | 2,399 | 522 | 14,191 | 9,279 | | 4,025 | 2,442 | | 43,755 |
| 1988 | | 647 | 21,050 | 5,226 | 2,672 | 20,230 | 12,141 | | 133 | 24,259 | 6,141 | 92,499 |
| 1989 | 738 | | 13,044 | 4,303 | 5,777 | 12,388 | 1,312 | | | | 512 | 38,074 |
| 1990 | 2,912 | 617 | 20,515 | 4,677 | 6,082 | 24,799 | 44,878 | 2,009 | 736 | 56,017 | | 163,242 |
| 1991 | 3,265 | 274 | 20,799 | 17,193 | 4,907 | 54,502 | 38,300 | 2,741 | 77,873 | 42,224 | 391 | 262,469 |
| 1992 | 6,357 | 2,213 | 57,084 | 14,945 | 9,154 | 45,162 | 41,426 | 2,400 | 99,354 | 21,118 | 1,317 | 300,530 |
| 1993 | 612 | 1,540 | 58,511 | 17,826 | 19,253 | 78,560 | 64,935 | 4,055 | 104,682 | 78,481 | 264 | 428,719 |
| 1994 | 3,771 | 3,023 | 74,538 | 5,915 | 16,929 | 87,225 | 34,877 | 4,140 | 199,378 | 127,945 | 7,930 | 565,671 |
| 1995 | 2,189 | 3,902 | 73,806 | 29,997 | 38,261 | 155,821 | 254,055 | 15,361 | 355,237 | 149,103 | 30,821 | 1,108,553 |
| 1996 | 1,893 | 6,461 | 68,300 | 60,074 | 62,840 | 225,428 | 127,952 | 22,867 | 337,415 | 250,731 | 35,996 | 1,199,957 |
| 1997 | 35,259 | 13,546 | 199,373 | 62,162 | 64,639 | 236,902 | 67,800 | 19,706 | 334,068 | 518,483 | 96,189 | 1,648,127 |
| 1998 | 38,094 | 5,929 | 207,952 | 44,890 | 64,215 | 166,868 | 88,973 | 18,758 | 391,824 | 383,786 | 45,768 | 1,457,057 |
| 1999 | 21,102 | 4,641 | 126,755 | 56,320 | 55,805 | 195,261 | 237,010 | 8,772 | 263,191 | 411,873 | 65,658 | 1,446,388 |
| 2000 | 62,186 | 4,262 | 181,295 | 95,496 | 53,191 | 270,798 | 402,302 | 39,543 | 506,462 | 389,126 | 20,452 | 2,025,113 |
| 2001 | 59,947 | 15,291 | 288,032 | 80,125 | 54,165 | 189,714 | 560,208 | 41,195 | 382,557 | 355,020 | 58,876 | 2,085,130 |
| 2002 | 71,907 | 12,857 | 308,749 | 78,190 | 51,060 | 202,075 | 416,455 | 29,149 | 282,429 | 411,248 | 109,052 | 1,973,171 |
| 2003 | 57,765 | 24,878 | 407,100 | 115,471 | 95,983 | 313,761 | 391,842 | 29,522 | 525,191 | 455,812 | 127,727 | 2,545,052 |
| 2004 | 36,886 | 10,359 | 400,252 | 84,814 | 75,244 | 242,623 | 448,524 | 25,178 | 380,461 | 633,018 | 278,270 | 2,615,629 |
| 2005 | 68,638 | 26,026 | 368,422 | 112,918 | 114,965 | 298,387 | 327,016 | 19,955 | 490,275 | 403,792 | 104,997 | 2,335,391 |
| 2006 | 73,385 | 14,760 | 345,105 | 75,279 | 83,776 | 310,441 | 489,501 | 18,679 | 660,462 | 612,334 | 90,820 | 2,774,542 |

Table A5.13. Total recreational harvest (numbers) of striped bass along the Atlantic Coast by age and by state, 2005 and 2006.

| 2005 | | | | | | | Age | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | 0 | 0 | 10,396 | 32,204 | 20,364 | 3,860 | 682 | 340 | 47 | 143 | 218 | 185 | 201 | 68,638 |
| NH | 0 | 0 | 0 | 295 | 2,964 | 5,565 | 6,251 | 6,077 | 3,553 | 1,120 | 153 | 40 | 8 | 26,026 |
| MA | 0 | 0 | 0 | 2,350 | 34,508 | 53,230 | 58,057 | 75,263 | 63,498 | 32,750 | 21,128 | 11,192 | 16,446 | 368,422 |
| RI | 0 | 0 | 0 | 465 | 3,861 | 8,510 | 11,999 | 18,660 | 21,979 | 14,758 | 12,606 | 8,119 | 11,960 | 112,918 |
| CT | 0 | 0 | 0 | 948 | 6,910 | 16,698 | 22,542 | 10,537 | 21,149 | 16,141 | 13,331 | 3,768 | 2,941 | 114,965 |
| NY | 0 | 0 | 0 | 3,864 | 22,774 | 42,077 | 50,868 | 25,652 | 50,321 | 39,216 | 34,455 | 17,342 | 11,818 | 298,387 |
| NJ | 0 | 0 | 0 | 29,415 | 68,958 | 50,265 | 30,896 | 34,369 | 35,050 | 22,347 | 34,027 | 3,672 | 18,018 | 327,016 |
| DE | 0 | 0 | 0 | 148 | 1,208 | 2,077 | 3,435 | 1,746 | 2,403 | 2,934 | 5,131 | 618 | 256 | 19,955 |
| MD | 0 | 342 | 26,503 | 95,850 | 106,113 | 45,436 | 38,519 | 26,061 | 42,051 | 34,298 | 35,952 | 21,677 | 17,473 | 490,275 |
| VA | 0 | 0 | 3,697 | 85,253 | 65,988 | 49,754 | 42,895 | 31,300 | 47,780 | 33,399 | 22,831 | 10,306 | 10,589 | 403,792 |
| NC | 0 | 0 | 0 | 0 | 0 | 0 | 1,073 | 8,878 | 26,768 | 34,211 | 19,764 | 7,863 | 6,439 | 104,997 |
| Total | 0 | 342 | 40,597 | 250,792 | 333,647 | 277,472 | 267,216 | 238,884 | 314,599 | 231,318 | 199,596 | 84,781 | 96,147 | 2,335,391 |

| 2006 | | | | | | | Age | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | 0 | 0 | 8,709 | 11,722 | 35,478 | 14,798 | 1,760 | | 13 | 13 | 275 | 186 | 430 | 73,385 |
| NH | 0 | 0 | 0 | 0 | 1,467 | 3,114 | 1,799 | 2,199 | 1,528 | 1,969 | 1,250 | 664 | 770 | 14,760 |
| MA | 0 | 0 | 0 | 0 | 11,558 | 32,235 | 26,771 | 43,404 | 44,581 | 69,177 | 50,245 | 30,376 | 36,757 | 345,104 |
| RI | 0 | 0 | 0 | 806 | 9,085 | 11,997 | 9,364 | 12,382 | 8,657 | 9,750 | 7,099 | 3,452 | 2,688 | 75,279 |
| CT | 0 | 0 | 0 | 658 | 4,599 | 10,904 | 15,210 | 6,343 | 15,697 | 11,870 | 9,281 | 3,155 | 6,060 | 83,776 |
| NY | 0 | 0 | 0 | 7,530 | 55,500 | 64,912 | 37,289 | 42,998 | 26,998 | 34,832 | 21,297 | 13,128 | 5,955 | 310,441 |
| NJ | 0 | 0 | 0 | 4,615 | 25,036 | 51,240 | 82,537 | 71,058 | 68,643 | 76,010 | 53,236 | 32,312 | 24,818 | 489,504 |
| DE | 0 | 0 | 0 | 406 | 2,044 | 2,284 | 2,895 | 2,190 | 2,016 | 2,884 | 1,786 | 1,361 | 815 | 18,680 |
| MD | 0 | | 69,790 | 102,755 | 174,591 | 68,894 | 28,592 | 31,184 | 40,461 | 49,265 | 34,615 | 23,490 | 36,825 | 660,462 |
| VA | 0 | 9,430 | 33,943 | 88,366 | 86,584 | 92,170 | 39,661 | 40,569 | 49,628 | 77,917 | 43,324 | 20,834 | 29,909 | 612,335 |
| NC | 0 | 0 | 0 | 0 | 0 | 0 | 1,648 | 8,672 | 16,939 | 22,344 | 20,368 | 11,591 | 9,259 | 90,820 |
| Total | 0 | 9,430 | 112,442 | 216,858 | 405,942 | 352,548 | 247,525 | 260,998 | 275,161 | 356,029 | 242,776 | 140,550 | 154,285 | 2,774,546 |

Table A5.14. MRFSS estimates of release (B2) numbers of striped bass by year and state, 1982–2006.

| Year | ME | NH | MA | RI | CT | NY | NJ | DE | MD | VA | NC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 687 | 0 | 6,441 | 2,551 | 643,187 | 12,297 | 87,648 | 0 | 30,376 | 0 | 0 | 783,187 |
| 1983 | 0 | 0 | 34,018 | 5,444 | 0 | 1,469 | 117,807 | 0 | 213,487 | 11,997 | 0 | 384,222 |
| 1984 | 1,887 | 0 | 98,405 | 85,135 | 31,176 | 40,469 | 52,930 | 0 | 104,095 | 8,775 | 3,530 | 426,402 |
| 1985 | 81,153 | 93 | 12,360 | 40,567 | 26,946 | 57,540 | 5,524 | 702 | 147,103 | 2,598 | 0 | 374,586 |
| 1986 | 4,379 | 0 | 442,298 | 2,014 | 10,494 | 123,842 | 0 | 0 | 390,063 | 7,528 | 12,032 | 992,650 |
| 1987 | 18,106 | 435 | 93,660 | 63,849 | 78,434 | 253,986 | 56,697 | 16,988 | 118,395 | 7,611 | | 708,161 |
| 1988 | 4,528 | 6,699 | 209,632 | 23,347 | 25,532 | 92,611 | 486,306 | 2,455 | 132,250 | 5,631 | 12,877 | 1,001,868 |
| 1989 | 16,028 | 4,822 | 193,067 | 38,007 | 125,370 | 365,712 | 265,958 | 4,807 | 114,269 | 72,766 | 0 | 1,200,806 |
| 1990 | 12,542 | 15,518 | 339,511 | 67,509 | 89,490 | 265,099 | 254,384 | 14,411 | 420,084 | 175,046 | | 1,653,594 |
| 1991 | 67,490 | 6,559 | 448,735 | 30,975 | 301,476 | 756,663 | 166,198 | 38,334 | 1,036,011 | 208,350 | 481 | 3,061,272 |
| 1992 | 31,177 | 27,613 | 779,814 | 120,410 | 292,259 | 799,149 | 413,506 | 36,932 | 749,959 | 115,899 | 1,342 | 3,368,060 |
| 1993 | 373,064 | 14,979 | 833,566 | 100,993 | 271,318 | 694,107 | 308,253 | 89,543 | 1,556,848 | 100,374 | 2,161 | 4,345,206 |
| 1994 | 363,703 | 43,501 | 2,102,514 | 138,989 | 489,967 | 1,132,707 | 568,047 | 103,992 | 2,785,392 | 197,022 | 9,120 | 7,934,954 |
| 1995 | 505,758 | 285,486 | 3,280,882 | 356,324 | 507,124 | 1,209,585 | 694,889 | 115,363 | 2,401,277 | 370,949 | 31,306 | 9,758,943 |
| 1996 | 1,626,705 | 292,820 | 3,269,746 | 314,336 | 1,051,612 | 1,436,091 | 776,165 | 99,372 | 2,545,238 | 759,916 | 262,555 | 12,434,556 |
| 1997 | 1,417,976 | 279,298 | 5,417,751 | 606,746 | 722,708 | 1,018,892 | 736,734 | 130,073 | 4,019,987 | 1,232,323 | 302,320 | 15,884,808 |
| 1998 | 691,378 | 243,301 | 7,184,358 | 613,421 | 1,026,192 | 884,626 | 488,319 | 185,016 | 2,641,680 | 796,372 | 421,273 | 15,175,936 |
| 1999 | 649,816 | 145,730 | 4,576,208 | 360,121 | 704,025 | 1,228,628 | 1,152,682 | 105,696 | 2,387,615 | 940,755 | 521,410 | 12,772,686 |
| 2000 | 942,593 | 209,606 | 7,382,031 | 541,516 | 926,367 | 1,373,069 | 885,289 | 151,838 | 3,244,731 | 1,022,040 | 252,440 | 16,931,520 |
| 2001 | 870,522 | 164,336 | 5,410,899 | 377,474 | 1,107,707 | 824,278 | 965,650 | 162,677 | 2,890,054 | 620,947 | 118,664 | 13,513,208 |
| 2002 | 1,392,200 | 238,003 | 5,718,984 | 530,402 | 696,976 | 588,155 | 715,099 | 114,650 | 2,928,589 | 706,729 | 154,705 | 13,784,492 |
| 2003 | 846,708 | 260,167 | 4,361,710 | 448,707 | 843,037 | 1,083,808 | 925,885 | 169,012 | 4,652,800 | 970,554 | 284,754 | 14,847,142 |
| 2004 | 748,388 | 196,806 | 5,891,661 | 669,975 | 1,079,304 | 1,492,703 | 1,323,535 | 151,179 | 3,738,523 | 1,767,596 | 230,356 | 17,290,026 |
| 2005 | 3,024,291 | 512,771 | 4,839,752 | 741,022 | 1,713,541 | 1,348,377 | 1,197,440 | 224,841 | 3,753,328 | 1,484,540 | 109,535 | 18,949,438 |
| 2006 | 4,070,305 | 567,921 | 8,662,771 | 1,357,084 | 1,683,242 | 1,578,073 | 2,100,560 | 245,304 | 3,905,212 | 1,695,963 | 37,734 | 25,904,169 |

Table A5.15. Estimates of dead releases from the striped bass recreational fishery by year and state, 1982–2006

| Year | ME | NH | MA | RI | CT | NY | NJ | DE | MD | VA | NC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 55 | 0 | 515 | 204 | 51,455 | 984 | 7,012 | 0 | 2,430 | 0 | 0 | 62,655 |
| 1983 | 0 | 0 | 2,721 | 436 | 0 | 118 | 9,425 | 0 | 17,079 | 960 | 0 | 30,738 |
| 1984 | 151 | 0 | 7,872 | 6,811 | 2,494 | 3,238 | 4,234 | 0 | 8,328 | 702 | 282 | 34,112 |
| 1985 | 6,492 | 7 | 989 | 3,245 | 2,156 | 4,603 | 442 | 56 | 11,768 | 208 | 0 | 29,967 |
| 1986 | 350 | 0 | 35,384 | 161 | 840 | 9,907 | 0 | 0 | 31,205 | 602 | 963 | 79,412 |
| 1987 | 1,448 | 35 | 7,493 | 5,108 | 6,275 | 20,319 | 4,536 | 1,359 | 9,472 | 609 | 0 | 56,653 |
| 1988 | 362 | 536 | 16,771 | 1,868 | 2,043 | 7,409 | 38,904 | 196 | 10,580 | 450 | 1,030 | 80,149 |
| 1989 | 1,282 | 386 | 15,445 | 3,041 | 10,030 | 29,257 | 21,277 | 385 | 9,142 | 5,821 | 0 | 96,064 |
| 1990 | 1,003 | 1,241 | 27,161 | 5,401 | 7,159 | 21,208 | 20,351 | 1,153 | 33,607 | 14,004 | 0 | 132,288 |
| 1991 | 5,399 | 525 | 35,899 | 2,478 | 24,118 | 60,533 | 13,296 | 3,067 | 82,881 | 16,668 | 38 | 244,901 |
| 1992 | 2,494 | 2,209 | 62,385 | 9,633 | 23,381 | 63,932 | 33,080 | 2,955 | 59,997 | 9,272 | 107 | 269,444 |
| 1993 | 29,845 | 1,198 | 66,685 | 8,079 | 21,705 | 55,529 | 24,660 | 7,163 | 124,548 | 8,030 | 173 | 347,617 |
| 1994 | 29,096 | 3,480 | 168,201 | 11,119 | 39,197 | 90,617 | 45,444 | 8,319 | 222,831 | 15,762 | 730 | 634,797 |
| 1995 | 40,461 | 22,839 | 262,471 | 28,506 | 40,570 | 96,767 | 55,591 | 9,229 | 192,102 | 29,676 | 2,504 | 780,715 |
| 1996 | 130,136 | 23,426 | 261,580 | 25,147 | 84,129 | 114,887 | 62,093 | 7,950 | 203,619 | 60,793 | 21,004 | 994,764 |
| 1997 | 113,438 | 22,344 | 433,420 | 48,540 | 57,817 | 81,511 | 58,939 | 10,406 | 321,599 | 98,586 | 24,186 | 1,270,785 |
| 1998 | 55,310 | 19,464 | 574,749 | 49,074 | 82,095 | 70,770 | 39,066 | 14,801 | 211,334 | 63,710 | 33,702 | 1,214,075 |
| 1999 | 51,985 | 11,658 | 366,097 | 28,810 | 56,322 | 98,290 | 92,215 | 8,456 | 191,009 | 75,260 | 41,713 | 1,021,815 |
| 2000 | 75,407 | 16,768 | 590,562 | 43,321 | 74,109 | 109,846 | 70,823 | 12,147 | 259,578 | 81,763 | 20,195 | 1,354,521 |
| 2001 | 69,642 | 13,147 | 432,872 | 30,198 | 88,617 | 65,942 | 77,252 | 13,014 | 231,204 | 49,676 | 9,493 | 1,081,057 |
| 2002 | 111,376 | 19,040 | 457,519 | 42,432 | 55,758 | 47,052 | 57,208 | 9,172 | 234,287 | 56,538 | 12,376 | 1,102,759 |
| 2003 | 67,737 | 20,813 | 348,937 | 35,897 | 67,443 | 86,705 | 74,071 | 13,521 | 372,224 | 77,644 | 22,780 | 1,187,771 |
| 2004 | 59,871 | 15,744 | 471,333 | 53,598 | 86,344 | 119,416 | 105,883 | 12,094 | 299,082 | 141,408 | 18,428 | 1,383,202 |
| 2005 | 241,943 | 41,022 | 387,180 | 59,282 | 137,083 | 107,870 | 95,795 | 17,987 | 300,266 | 118,763 | 8,763 | 1,515,955 |
| 2006 | 325,624 | 45,434 | 693,022 | 108,567 | 134,659 | 126,246 | 168,045 | 19,624 | 312,417 | 135,677 | 3,019 | 2,072,334 |

Table A5.16. Total recreational dead discards (numbers) of striped bass along the Atlantic Coast by age and by state, 2005 and 2006

| 2005 | | | | | | | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | 0 | 0 | 43,368 | 65,239 | 78,653 | 33,280 | 9,269 | 4,165 | 3,756 | 2,367 | 1,005 | 435 | 208 | 198 | 241,943 |
| NH | 0 | 0 | 13,278 | 7,133 | 10,027 | 6,484 | 2,038 | 715 | 551 | 342 | 184 | 104 | 66 | 99 | 41,022 |
| MA | 0 | 0 | 63,042 | 58,533 | 99,799 | 79,088 | 31,005 | 15,771 | 16,133 | 11,524 | 5,517 | 2,857 | 1,657 | 2,253 | 387,180 |
| RI | 0 | 182 | 25,261 | 4,806 | 9,788 | 7,837 | 3,982 | 2,514 | 1,649 | 1,315 | 694 | 512 | 267 | 477 | 59,282 |
| CT | 69 | 2,310 | 47,579 | 12,246 | 32,133 | 14,856 | 7,454 | 5,992 | 2,419 | 4,826 | 3,365 | 2,544 | 703 | 589 | 137,083 |
| NY | 0 | 110 | 34,834 | 10,287 | 30,485 | 13,421 | 4,691 | 3,569 | 1,672 | 3,049 | 2,321 | 2,040 | 1,027 | 365 | 107,870 |
| NJ | 6 | 208 | 7,975 | 11,409 | 25,597 | 19,483 | 7,635 | 7,991 | 5,767 | 5,153 | 1,797 | 1,969 | 122 | 682 | 95,795 |
| DE | 0 | 8,132 | 580 | 1,488 | 1,692 | 2,823 | 410 | 580 | 544 | 591 | 595 | 270 | 179 | 104 | 17,987 |
| MD | 0 | 7,193 | 135,950 | 48,116 | 58,836 | 23,165 | 5,573 | 4,906 | 3,760 | 4,742 | 3,039 | 2,539 | 1,738 | 708 | 300,266 |
| VA | 0 | 0 | 70,853 | 14,396 | 20,607 | 5,813 | 1,447 | 1,541 | 823 | 1,101 | 566 | 875 | 544 | 197 | 118,763 |
| NC | 0 | 105 | 2,574 | 1,358 | 2,137 | 1,199 | 427 | 278 | 216 | 204 | 111 | 82 | 38 | 33 | 8,763 |
| Total | 75 | 18,240 | 445,293 | 235,013 | 369,756 | 207,448 | 73,931 | 48,022 | 37,289 | 35,214 | 19,194 | 14,225 | 6,549 | 5,705 | 1,515,954 |

| 2006 | | | | | | | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | 0 | 0 | 19,839 | 200,717 | 42,932 | 36,686 | 16,820 | 2,959 | 1,849 | 1,147 | 1,184 | 771 | 342 | 379 | 325,624 |
| NH | 0 | 0 | 3,407 | 26,485 | 5,138 | 6,078 | 3,006 | 476 | 229 | 165 | 184 | 117 | 63 | 86 | 45,434 |
| MA | 0 | 0 | 30,649 | 291,125 | 79,370 | 138,094 | 89,946 | 18,457 | 12,147 | 9,464 | 11,359 | 6,486 | 3,330 | 2,594 | 693,021 |
| RI | 0 | 852 | 17,704 | 53,907 | 7,680 | 16,082 | 6,798 | 2,529 | 1,431 | 743 | 388 | 250 | 104 | 97 | 108,567 |
| CT | 0 | 3,050 | 25,993 | 62,401 | 8,039 | 15,567 | 7,408 | 3,028 | 2,776 | 1,984 | 1,136 | 1,227 | 693 | 1,360 | 134,659 |
| NY | 0 | 213 | 8,757 | 58,721 | 12,237 | 23,589 | 8,374 | 3,827 | 3,236 | 1,940 | 2,411 | 1,481 | 903 | 554 | 126,246 |
| NJ | 15 | 340 | 6,632 | 44,840 | 25,896 | 49,021 | 19,584 | 7,049 | 4,371 | 3,061 | 3,293 | 2,006 | 1,150 | 788 | 168,045 |
| DE | 0 | 65 | 1,022 | 5,451 | 3,713 | 5,555 | 1,758 | 718 | 397 | 225 | 268 | 193 | 112 | 147 | 19,624 |
| MD | 0 | 17,232 | 65,843 | 131,574 | 26,917 | 16,711 | 12,000 | 7,257 | 8,698 | 8,630 | 9,672 | 3,998 | 2,300 | 1,584 | 312,417 |
| VA | 0 | 12,003 | 36,071 | 63,079 | 10,020 | 7,060 | 2,353 | 1,023 | 957 | 605 | 614 | 937 | 370 | 585 | 135,677 |
| NC | 0 | 51 | 307 | 1,360 | 333 | 454 | 247 | 70 | 54 | 43 | 47 | 27 | 14 | 12 | 3,019 |
| Total | 15 | 33,806 | 216,225 | 939,659 | 222,275 | 314,898 | 168,294 | 47,393 | 36,146 | 28,007 | 30,555 | 17,494 | 9,382 | 8,185 | 2,072,333 |

Table A5.17. Total removals (harvest and dead releases) by the recreational fishery in 2005 and 2006

| 2005 | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | 0 | 0 | 43,368 | 75,635 | 110,857 | 53,644 | 13,130 | 4,846 | 4,096 | 2,414 | 1,148 | 652 | 393 | 399 | 310,581 |
| NH | 0 | 0 | 13,278 | 7,133 | 10,323 | 9,448 | 7,603 | 6,966 | 6,628 | 3,895 | 1,304 | 257 | 106 | 107 | 67,048 |
| MA | 0 | 0 | 63,042 | 58,533 | 102,149 | 113,596 | 84,235 | 73,828 | 91,396 | 75,023 | 38,267 | 23,984 | 12,849 | 18,699 | 755,602 |
| RI | 0 | 182 | 25,261 | 4,806 | 10,253 | 11,699 | 12,492 | 14,513 | 20,308 | 23,294 | 15,453 | 13,118 | 8,385 | 12,437 | 172,200 |
| CT | 69 | 2,310 | 47,579 | 12,246 | 33,081 | 21,765 | 24,152 | 28,534 | 12,955 | 25,975 | 19,505 | 15,875 | 4,471 | 3,531 | 252,048 |
| NY | 0 | 110 | 34,834 | 10,287 | 34,350 | 36,195 | 46,768 | 54,437 | 27,324 | 53,370 | 41,537 | 36,494 | 18,369 | 12,183 | 406,257 |
| NJ | 6 | 208 | 7,975 | 11,409 | 55,012 | 88,441 | 57,900 | 38,887 | 40,137 | 40,203 | 24,144 | 35,996 | 3,794 | 18,700 | 422,811 |
| DE | 0 | 8,132 | 580 | 1,488 | 1,840 | 4,031 | 2,487 | 4,015 | 2,290 | 2,994 | 3,529 | 5,400 | 797 | 359 | 37,942 |
| MD | 0 | 7,193 | 136,292 | 74,619 | 154,686 | 129,277 | 51,010 | 43,426 | 29,821 | 46,793 | 37,337 | 38,491 | 23,416 | 18,180 | 790,541 |
| VA | 0 | 0 | 70,853 | 18,094 | 105,861 | 71,801 | 51,201 | 44,436 | 32,123 | 48,881 | 33,965 | 23,706 | 10,850 | 10,786 | 522,555 |
| NC | 0 | 105 | 2,574 | 1,358 | 2,137 | 1,199 | 427 | 1,350 | 9,094 | 26,972 | 34,322 | 19,846 | 7,901 | 6,472 | 113,760 |
| Total | 75 | 18,240 | 445,635 | 275,610 | 620,548 | 541,095 | 351,404 | 315,239 | 276,173 | 349,813 | 250,511 | 213,821 | 91,330 | 101,852 | 3,851,345 |

| 2006 | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| ME | 0 | 0 | 19,839 | 209,426 | 54,654 | 72,164 | 31,618 | 4,719 | 1,849 | 1,160 | 1,197 | 1,045 | 529 | 809 | 399,009 |
| NH | 0 | 0 | 3,407 | 26,485 | 5,138 | 7,545 | 6,120 | 2,275 | 2,428 | 1,693 | 2,153 | 1,368 | 727 | 856 | 60,194 |
| MA | 0 | 0 | 30,649 | 291,125 | 79,370 | 149,652 | 122,181 | 45,228 | 55,551 | 54,045 | 80,536 | 56,731 | 33,706 | 39,351 | 1,038,125 |
| RI | 0 | 852 | 17,704 | 53,907 | 8,486 | 25,167 | 18,795 | 11,893 | 13,813 | 9,400 | 10,138 | 7,349 | 3,556 | 2,784 | 183,846 |
| CT | 0 | 3,050 | 25,993 | 62,401 | 8,697 | 20,165 | 18,312 | 18,238 | 9,119 | 17,680 | 13,006 | 10,508 | 3,848 | 7,420 | 218,435 |
| NY | 0 | 213 | 8,757 | 58,721 | 19,767 | 79,089 | 73,287 | 41,116 | 46,235 | 28,939 | 37,243 | 22,779 | 14,031 | 6,509 | 436,687 |
| NJ | 15 | 340 | 6,632 | 44,840 | 30,511 | 74,057 | 70,824 | 89,586 | 75,429 | 71,704 | 79,302 | 55,242 | 33,462 | 25,606 | 657,549 |
| DE | 0 | 65 | 1,022 | 5,451 | 4,119 | 7,599 | 4,042 | 3,613 | 2,587 | 2,241 | 3,152 | 1,978 | 1,473 | 962 | 38,304 |
| MD | 0 | 17,232 | 65,843 | 201,363 | 129,673 | 191,302 | 80,893 | 35,849 | 39,883 | 49,091 | 58,936 | 38,614 | 25,791 | 38,409 | 972,879 |
| VA | 0 | 12,003 | 45,501 | 97,022 | 98,385 | 93,645 | 94,522 | 40,684 | 41,525 | 50,233 | 78,531 | 44,261 | 21,204 | 30,494 | 748,012 |
| NC | 0 | 51 | 307 | 1,360 | 333 | 454 | 247 | 1,717 | 8,726 | 16,981 | 22,390 | 20,395 | 11,606 | 9,271 | 93,839 |
| Total | 15 | 33,806 | 225,655 | 1,052,102 | 439,133 | 720,840 | 520,842 | 294,919 | 297,145 | 303,168 | 386,584 | 260,270 | 149,932 | 162,470 | 4,846,879 |

Table A5.18. Total removals (thousands of fish) – including recreational and commercial harvest and dead discards – of striped bass along the Atlantic Coast by age, 1982–2006

| | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| 1982 | 1.8 | 105.6 | 256.7 | 220.8 | 58.4 | 19.2 | 24.2 | 16.8 | 11.7 | 10.6 | 11.0 | 13.7 | 15.7 | 766.2 |
| 1983 | 3.6 | 110.3 | 178.2 | 193.1 | 150.0 | 39.3 | 18.7 | 4.1 | 2.9 | 3.7 | 4.6 | 5.6 | 13.6 | 727.7 |
| 1984 | 5.6 | 542.8 | 302.7 | 82.4 | 60.4 | 51.7 | 18.3 | 4.7 | 2.1 | 2.1 | 0.7 | 0.3 | 11.1 | 1084.9 |
| 1985 | 1.3 | 72.5 | 102.0 | 40.5 | 58.7 | 43.1 | 43.5 | 17.3 | 6.4 | 3.4 | 1.0 | 0.8 | 10.3 | 400.8 |
| 1986 | 11.3 | 21.0 | 63.8 | 132.9 | 49.9 | 32.0 | 20.4 | 24.0 | 9.2 | 5.3 | 3.4 | 1.6 | 10.1 | 384.9 |
| 1987 | 1.4 | 10.9 | 37.6 | 51.4 | 67.3 | 25.0 | 13.2 | 6.5 | 6.4 | 3.0 | 1.5 | 2.0 | 12.9 | 239.1 |
| 1988 | 2.6 | 30.9 | 41.8 | 63.2 | 107.1 | 97.9 | 40.6 | 24.4 | 14.0 | 5.8 | 3.7 | 3.3 | 9.6 | 444.9 |
| 1989 | 0.7 | 36.0 | 79.7 | 68.2 | 104.9 | 95.4 | 45.7 | 21.0 | 10.4 | 3.8 | 3.2 | 2.0 | 8.9 | 479.9 |
| 1990 | 2.1 | 46.2 | 124.5 | 187.8 | 173.2 | 165.2 | 104.1 | 67.9 | 20.7 | 7.3 | 5.1 | 3.5 | 13.7 | 921.3 |
| 1991 | 1.8 | 72.8 | 145.3 | 208.7 | 162.0 | 101.4 | 91.3 | 82.9 | 58.8 | 24.1 | 14.2 | 2.8 | 22.3 | 988.4 |
| 1992 | 2.9 | 45.8 | 199.7 | 189.2 | 177.1 | 109.5 | 62.4 | 67.8 | 58.4 | 44.8 | 9.3 | 4.1 | 15.9 | 986.9 |
| 1993 | 0.3 | 69.6 | 185.3 | 327.3 | 288.5 | 185.4 | 86.6 | 67.3 | 82.6 | 76.2 | 41.1 | 9.3 | 17.5 | 1437.0 |
| 1994 | 5.7 | 145.4 | 348.8 | 290.6 | 367.8 | 232.4 | 135.4 | 86.7 | 99.9 | 81.0 | 36.0 | 22.3 | 14.6 | 1866.6 |
| 1995 | 4.1 | 433.5 | 470.8 | 456.1 | 405.3 | 489.9 | 214.5 | 196.0 | 153.8 | 90.6 | 53.4 | 17.5 | 14.2 | 2999.7 |
| 1996 | 1 | 98.8 | 649.4 | 650.1 | 542.9 | 468.7 | 442.2 | 209.6 | 136.8 | 68.9 | 42.5 | 46.3 | 19.0 | 3376.2 |
| 1997 | 3.3 | 291.5 | 602.0 | 971.2 | 685.3 | 655.7 | 458.6 | 415.7 | 223.5 | 140.6 | 70.0 | 34.0 | 28.7 | 4580.1 |
| 1998 | 26.4 | 183.4 | 485.4 | 706.7 | 1125.0 | 510.9 | 280.4 | 265.0 | 215.5 | 113.8 | 95.1 | 45.2 | 65.5 | 4118.3 |
| 1999 | 8.4 | 108.3 | 419.6 | 648.8 | 642.2 | 730.2 | 351.8 | 238.9 | 205.4 | 148.4 | 104.5 | 48.6 | 49.2 | 3704.3 |
| 2000 | 37.95 | 321.5 | 417.7 | 984.5 | 1020.0 | 781.6 | 744.0 | 313.7 | 161.3 | 142.0 | 59.8 | 29.4 | 30.9 | 5044.4 |
| 2001 | 31.53 | 156.4 | 432.2 | 598.4 | 832.9 | 700.7 | 579.7 | 484.1 | 206.5 | 120.1 | 103.4 | 49.8 | 48.2 | 4344.0 |
| 2002 | 24.5 | 201.5 | 224.5 | 252.4 | 450.1 | 654.0 | 670.8 | 499.9 | 342.9 | 260.7 | 110.0 | 86.7 | 111.5 | 3889.5 |
| 2003 | 28.32 | 252.5 | 479.7 | 599.6 | 708.1 | 603.7 | 707.4 | 494.9 | 374.8 | 284.5 | 128.0 | 81.0 | 93.8 | 4836.2 |
| 2004 | 70.29 | 176.9 | 797.1 | 740.9 | 510.9 | 541.2 | 517.0 | 628.6 | 440.3 | 330.9 | 264.7 | 123.5 | 130.3 | 5272.7 |
| 2005 | 18.87 | 456.7 | 419.4 | 1097.6 | 957.1 | 519.9 | 425.2 | 374.9 | 467.3 | 323.5 | 271.3 | 125.3 | 139.1 | 5596.3 |
| 2006 | 33.81 | 226.3 | 1168.6 | 660.4 | 1096.7 | 702.4 | 360.4 | 359.8 | 363.9 | 462.9 | 308.7 | 178.0 | 191.5 | 6113.2 |

Table A5.19. Catch mean weights (kg) at age for striped bass, 1982–2006

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | 0.1 | 0.6 | 1.1 | 1.5 | 2.4 | 3.8 | 4.8 | 5.8 | 6.2 | 8.7 | 10.8 | 11.2 | 14.1 |
| 1983 | 0.2 | 0.6 | 0.9 | 1.4 | 2.4 | 3.3 | 3.8 | 5.4 | 6.0 | 8.1 | 9.6 | 10.4 | 11.1 |
| 1984 | 0.2 | 0.6 | 1.7 | 1.6 | 2.7 | 3.4 | 5.1 | 5.7 | 6.8 | 7.8 | 8.4 | 12.7 | 12.4 |
| 1985 | 0.1 | 0.6 | 1.1 | 1.7 | 2.2 | 3.6 | 4.9 | 5.5 | 6.8 | 7.5 | 9.0 | 10.7 | 13.9 |
| 1986 | 0.1 | 0.6 | 1.3 | 2.4 | 2.4 | 3.1 | 4.0 | 5.1 | 5.4 | 6.1 | 7.8 | 9.2 | 12.8 |
| 1987 | 0.2 | 0.8 | 1.4 | 2.1 | 2.5 | 2.9 | 3.6 | 4.7 | 5.5 | 6.5 | 7.8 | 9.8 | 13.2 |
| 1988 | 0.3 | 0.9 | 1.1 | 2.0 | 3.1 | 4.0 | 4.4 | 4.7 | 5.2 | 5.6 | 8.6 | 10.4 | 13.3 |
| 1989 | 0.2 | 0.8 | 1.2 | 2.2 | 3.1 | 4.5 | 5.4 | 6.2 | 6.0 | 8.7 | 8.9 | 9.7 | 13.4 |
| 1990 | 0.1 | 0.9 | 1.1 | 2.1 | 2.4 | 3.8 | 4.9 | 6.0 | 5.7 | 6.0 | 7.4 | 9.1 | 12.6 |
| 1991 | 0.2 | 0.9 | 1.3 | 2.2 | 2.6 | 3.2 | 4.8 | 5.6 | 6.5 | 6.2 | 9.5 | 8.3 | 14.2 |
| 1992 | 0.1 | 0.7 | 1.3 | 1.9 | 2.8 | 3.7 | 4.9 | 5.8 | 7.0 | 8.2 | 9.8 | 12.4 | 14.0 |
| 1993 | 0.1 | 0.8 | 1.3 | 2.0 | 2.8 | 3.6 | 4.8 | 6.1 | 7.0 | 8.0 | 9.5 | 10.8 | 14.6 |
| 1994 | 0.2 | 1.1 | 1.7 | 2.2 | 2.9 | 3.5 | 4.9 | 6.2 | 6.8 | 7.5 | 9.7 | 10.7 | 12.7 |
| 1995 | 0.3 | 0.7 | 1.4 | 2.2 | 2.8 | 3.7 | 5.4 | 6.2 | 7.3 | 8.9 | 7.6 | 9.7 | 16.7 |
| 1996 | 0.1 | 1.1 | 1.5 | 2.3 | 3.2 | 4.5 | 6.4 | 7.1 | 7.8 | 9.2 | 9.3 | 10.1 | 13.7 |
| 1997 | 0.1 | 0.6 | 1.2 | 2.5 | 2.8 | 3.6 | 4.5 | 5.1 | 6.7 | 9.2 | 9.9 | 10.2 | 14.8 |
| 1998 | 0.4 | 0.8 | 1.2 | 1.6 | 2.3 | 3.0 | 4.7 | 5.7 | 6.8 | 7.0 | 7.8 | 9.9 | 11.9 |
| 1999 | 0.6 | 0.9 | 1.1 | 1.4 | 1.9 | 2.5 | 3.4 | 5.0 | 6.6 | 7.9 | 8.7 | 9.8 | 12.0 |
| 2000 | 0.4 | 0.6 | 1.1 | 1.5 | 2.0 | 2.8 | 3.9 | 5.1 | 7.1 | 7.4 | 9.7 | 10.7 | 13.6 |
| 2001 | 0.2 | 0.4 | 1.1 | 1.8 | 2.2 | 3.3 | 4.1 | 5.0 | 6.4 | 7.8 | 8.7 | 8.3 | 10.9 |
| 2002 | 0.1 | 0.3 | 1.1 | 1.5 | 2.2 | 3.2 | 4.2 | 5.5 | 6.0 | 7.6 | 9.1 | 9.8 | 11.5 |
| 2003 | 0.1 | 0.6 | 1.0 | 1.4 | 2.2 | 3.2 | 4.1 | 5.2 | 6.1 | 7.2 | 8.5 | 9.4 | 11.0 |
| 2004 | 0.2 | 0.3 | 0.8 | 1.4 | 2.4 | 3.1 | 4.1 | 5.2 | 6.1 | 7.1 | 8.2 | 9.0 | 10.7 |
| 2005 | 0.1 | 0.6 | 1.0 | 1.6 | 2.2 | 3.2 | 4.0 | 5.6 | 6.2 | 6.7 | 8.0 | 8.9 | 11.7 |
| 2006 | 0.2 | 0.5 | 0.8 | 1.3 | 2.0 | 2.8 | 4.1 | 4.9 | 6.2 | 7.0 | 8.1 | 9.0 | 11.1 |

Table A6.1. Summary of surveys currently available for use in stock assessment models.

| State | Index | Design | Time of Year | What Stock? | Ages | ADAPT VPA Tuned To |
|---|---|---|---|---|---|---|
| Massachusetts Commercial | Total Catch Rate Index | None | July-Aug | Mixed | 2-13+ | Mean current year |
| Connecticut Recreational CPUE | Total Catch Rate Index | MRFSS | May-Dec | Mixed | 2-13+ | Mean current year |
| Marine Recreational Fisheries Survey | Total Catch Rate Index | Stratified Random | May-Dec | Mixed | Aggregate (3-13+) | Mean current year |
| Connecticut Trawl Survey | Mean number per tow | Stratified Random | April-June | Mixed | Aggregate (2-4) | 1-Jan current year |
| NEFSC Trawl Survey | Mean number per tow | Stratified Random | March-May | Mixed | Aggregate (2-9) | 1-Jan current year |
| New Jersey Trawl Survey | Mean number per tow | Stratified Random | April | Mixed | 2-13+ | 1-Jan current year |
| New York Ocean Haul Seine Survey | Mean number per haul | Random | Sept-Nov | Mixed | 2-13+ | 1-Jan following year |
| Maryland Gillnet Survey | Mean number per set | Stratified Random | April-May | Chesapeake | 2-13+ | 1-Jan current year |
| Delaware Electrofishing Survey | Mean number per hour | Lattice | April-May | Delaware | 2-13+ | 1-Jan current year |
| New York YOY Seine Survey | Mean number per haul | Fixed | July-Nov | Hudson | 0 | 1-Jan following year |
| New York W. Long Island Seine Survey | Mean number per haul | Fixed | May-Oct | Hudson | 1 | 1-Jan following year |
| New Jersey YOY Seine Survey | Mean number per haul | Fixed/Random | Aug-Oct | Delaware | 0 | 1-Jan following year |
| Virginia YOY Seine Survey | Mean number per haul | Fixed | July-Sept | Chesapeake | 0 | 1-Jan following year |
| Maryland YOY and Age 1 Seine Survey | Mean number per haul | Fixed | July-Sept | Chsapeake | 0-1 | 1-Jan following year |

Table A6.2. Available indices of striped bass relative abundance, 1982–2006.

Massachusetts Commercial Total CPUE (MACOMM)

| | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | | | | | | | | | | | | |
| 1983 | | | | | | | | | | | | |
| 1984 | | | | | | | | | | | | |
| 1985 | | | | | | | | | | | | |
| 1986 | | | | | | | | | | | | |
| 1987 | | | | | | | | | | | | |
| 1988 | | | | | | | | | | | | |
| 1989 | | | | | | | | | | | | |
| 1990 | | | | | | | | | | | | |
| 1991 | 0.018 | 0.038 | 0.081 | 0.077 | 0.077 | 0.083 | 0.131 | 0.142 | 0.087 | 0.020 | 0.009 | 0.067 |
| 1992 | 0.001 | 0.015 | 0.038 | 0.047 | 0.060 | 0.083 | 0.173 | 0.205 | 0.133 | 0.030 | 0.014 | 0.074 |
| 1993 | 0.006 | 0.013 | 0.029 | 0.057 | 0.064 | 0.063 | 0.098 | 0.193 | 0.174 | 0.080 | 0.017 | 0.090 |
| 1994 | 0.008 | 0.015 | 0.028 | 0.052 | 0.077 | 0.063 | 0.086 | 0.163 | 0.170 | 0.090 | 0.033 | 0.072 |
| 1995 | 0.006 | 0.009 | 0.019 | 0.028 | 0.057 | 0.097 | 0.173 | 0.174 | 0.163 | 0.105 | 0.058 | 0.081 |
| 1996 | 0.011 | 0.019 | 0.030 | 0.033 | 0.065 | 0.115 | 0.223 | 0.212 | 0.185 | 0.099 | 0.053 | 0.070 |
| 1997 | 0.013 | 0.030 | 0.040 | 0.040 | 0.070 | 0.118 | 0.263 | 0.123 | 0.141 | 0.085 | 0.042 | 0.064 |
| 1998 | 0.018 | 0.031 | 0.059 | 0.076 | 0.087 | 0.118 | 0.191 | 0.177 | 0.106 | 0.089 | 0.034 | 0.067 |
| 1999 | 0.001 | 0.022 | 0.027 | 0.044 | 0.080 | 0.072 | 0.092 | 0.183 | 0.177 | 0.098 | 0.064 | 0.099 |
| 2000 | 0.005 | 0.019 | 0.034 | 0.047 | 0.092 | 0.152 | 0.141 | 0.213 | 0.188 | 0.098 | 0.043 | 0.068 |
| 2001 | 0.012 | 0.068 | 0.092 | 0.125 | 0.113 | 0.203 | 0.170 | 0.123 | 0.062 | 0.069 | 0.029 | 0.046 |
| 2002 | 0.012 | 0.032 | 0.062 | 0.081 | 0.217 | 0.139 | 0.155 | 0.109 | 0.065 | 0.065 | 0.039 | 0.101 |
| 2003 | 0.006 | 0.026 | 0.050 | 0.092 | 0.101 | 0.220 | 0.163 | 0.155 | 0.087 | 0.049 | 0.046 | 0.049 |
| 2004 | 0.000 | 0.018 | 0.054 | 0.100 | 0.160 | 0.210 | 0.278 | 0.132 | 0.088 | 0.059 | 0.026 | 0.051 |
| 2005 | 0.003 | 0.018 | 0.064 | 0.129 | 0.108 | 0.106 | 0.187 | 0.173 | 0.094 | 0.063 | 0.039 | 0.046 |
| 2006 | 0.001 | 0.024 | 0.017 | 0.104 | 0.132 | 0.098 | 0.137 | 0.123 | 0.175 | 0.124 | 0.070 | 0.090 |

Table A6.2 cont.

Connecticut Recreational CPUE (CTCPUE)

| | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | 0.33 | 0.21 | 0.11 | 0.09 | 0.08 | 0.04 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| 1983 | 0.40 | 0.19 | 0.08 | 0.04 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1984 | 0.12 | 0.33 | 0.23 | 0.14 | 0.05 | 0.04 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1985 | 0.06 | 0.32 | 0.22 | 0.12 | 0.09 | 0.04 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1986 | 0.08 | 0.20 | 0.47 | 0.45 | 0.18 | 0.05 | 0.01 | 0.05 | 0.02 | 0.00 | 0.00 | 0.01 |
| 1987 | 0.04 | 0.24 | 0.34 | 0.20 | 0.14 | 0.06 | 0.04 | 0.03 | 0.03 | 0.01 | 0.00 | 0.01 |
| 1988 | 0.02 | 0.52 | 0.28 | 0.18 | 0.15 | 0.12 | 0.05 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 |
| 1989 | 0.27 | 0.48 | 0.47 | 0.16 | 0.18 | 0.13 | 0.09 | 0.03 | 0.02 | 0.01 | 0.00 | 0.00 |
| 1990 | 0.17 | 0.58 | 0.56 | 0.27 | 0.12 | 0.13 | 0.15 | 0.13 | 0.05 | 0.02 | 0.01 | 0.01 |
| 1991 | 0.15 | 0.67 | 0.43 | 0.35 | 0.14 | 0.07 | 0.09 | 0.13 | 0.09 | 0.03 | 0.01 | 0.00 |
| 1992 | 0.17 | 0.48 | 0.57 | 0.29 | 0.23 | 0.11 | 0.10 | 0.16 | 0.15 | 0.09 | 0.02 | 0.01 |
| 1993 | 0.07 | 0.70 | 0.62 | 0.49 | 0.28 | 0.22 | 0.10 | 0.08 | 0.11 | 0.10 | 0.05 | 0.03 |
| 1994 | 0.21 | 0.61 | 0.88 | 0.46 | 0.57 | 0.36 | 0.23 | 0.16 | 0.20 | 0.14 | 0.07 | 0.06 |
| 1995 | 0.60 | 1.20 | 1.34 | 0.59 | 0.59 | 0.32 | 0.18 | 0.19 | 0.19 | 0.12 | 0.05 | 0.03 |
| 1996 | 0.47 | 1.09 | 2.39 | 0.90 | 0.84 | 0.38 | 0.60 | 0.37 | 0.23 | 0.10 | 0.08 | 0.13 |
| 1997 | 0.18 | 1.11 | 1.28 | 1.64 | 0.58 | 0.31 | 0.23 | 0.21 | 0.12 | 0.06 | 0.07 | 0.20 |
| 1998 | 0.21 | 2.29 | 1.53 | 0.74 | 1.59 | 0.43 | 0.21 | 0.17 | 0.20 | 0.03 | 0.10 | 0.07 |
| 1999 | 0.38 | 0.43 | 1.28 | 0.37 | 0.39 | 0.60 | 0.62 | 0.41 | 0.24 | 0.42 | 0.21 | 0.18 |
| 2000 | 0.00 | 0.01 | 0.65 | 1.04 | 1.11 | 2.46 | 0.55 | 0.30 | 0.30 | 0.23 | 0.15 | 0.07 |
| 2001 | 0.89 | 0.67 | 0.56 | 2.24 | 1.12 | 0.67 | 0.65 | 0.41 | 0.05 | 0.08 | 0.12 | 0.10 |
| 2002 | 1.41 | 1.13 | 0.58 | 1.61 | 0.22 | 0.20 | 0.26 | 0.19 | 0.06 | 0.05 | 0.04 | 0.12 |
| 2003 | 1.33 | 1.36 | 0.63 | 0.75 | 0.41 | 0.39 | 0.38 | 0.34 | 0.28 | 0.17 | 0.06 | 0.25 |
| 2004 | 1.07 | 2.45 | 1.75 | 0.62 | 0.65 | 0.32 | 0.50 | 0.32 | 0.17 | 0.18 | 0.08 | 0.04 |
| 2005 | 4.67 | 1.16 | 3.11 | 1.47 | 0.71 | 0.57 | 0.23 | 0.48 | 0.38 | 0.23 | 0.08 | 0.04 |
| 2006 | 2.25 | 6.05 | 0.97 | 1.73 | 0.94 | 0.42 | 0.38 | 0.27 | 0.17 | 0.10 | 0.11 | 0.16 |

Table A6.2 cont.

MRFSS

| Year | Ages 2-13+ |
|---|---|
| 1982 | |
| 1983 | |
| 1984 | |
| 1985 | |
| 1986 | |
| 1987 | |
| 1988 | 0.36 |
| 1989 | 0.27 |
| 1990 | 0.24 |
| 1991 | 0.41 |
| 1992 | 0.75 |
| 1993 | 0.61 |
| 1994 | 0.91 |
| 1995 | 1.17 |
| 1996 | 1.33 |
| 1997 | 1.37 |
| 1998 | 1.71 |
| 1999 | 1.61 |
| 2000 | 1.51 |
| 2001 | 1.26 |
| 2002 | 1.05 |
| 2003 | 0.93 |
| 2004 | 1.01 |
| 2005 | 1.17 |
| 2006 | 1.39 |

Table A6.2 cont.

| | NEFSC (Ages 2-9) | | Connecticut Trawl (CTTRL) Ages 4-6 | |
|---|---|---|---|---|
| Year | Geometric | Arithmetic | Geometric | Arithmetic |
| 1982 | | | | |
| 1983 | | | | |
| 1984 | | | 0.02 | 0.00 |
| 1985 | | | 0.00 | 0.00 |
| 1986 | | | 0.00 | 0.00 |
| 1987 | | | 0.05 | 0.10 |
| 1988 | | | 0.04 | 0.10 |
| 1989 | | | 0.06 | 0.10 |
| 1990 | | | 0.16 | 0.40 |
| 1991 | 0.235 | 0.258 | 0.15 | 0.30 |
| 1992 | 0.237 | 0.247 | 0.22 | 0.40 |
| 1993 | 0.481 | 0.634 | 0.27 | 0.50 |
| 1994 | 1.394 | 3.441 | 0.30 | 0.50 |
| 1995 | 0.952 | 1.101 | 0.59 | 1.30 |
| 1996 | 0.602 | 0.807 | 0.63 | 1.50 |
| 1997 | 1.182 | 1.373 | 0.85 | 2.00 |
| 1998 | 0.729 | 0.81 | 0.97 | 3.00 |
| 1999 | 0.448 | 0.767 | 1.10 | 2.80 |
| 2000 | 1.274 | 1.409 | 0.84 | 1.90 |
| 2001 | 0.623 | 0.795 | 0.61 | 1.50 |
| 2002 | 0.981 | 1.156 | 1.30 | 3.50 |
| 2003 | 0.774 | 1.049 | 0.87 | 1.70 |
| 2004 | 0.335 | 0.359 | 0.56 | 1.10 |
| 2005 | 0.293 | 0.312 | 1.17 | 3.50 |
| 2006 | 0.628 | 0.792 | 0.61 | 1.20 |

Table A6.2 cont.

New Jersey Bottom Trawl Survey (NJTRL)
Geometric
Age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | | | | | | | | | | | | |
| 1983 | | | | | | | | | | | | |
| 1984 | | | | | | | | | | | | |
| 1985 | | | | | | | | | | | | |
| 1986 | | | | | | | | | | | | |
| 1987 | | | | | | | | | | | | |
| 1988 | | | | | | | | | | | | |
| 1989 | 0.06 | 0.10 | 0.00 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| 1990 | 0.07 | 0.21 | 0.02 | 0.47 | 0.15 | 0.03 | 0.11 | 0.01 | 0.07 | 0.00 | 0.00 | 0.00 |
| 1991 | 0.39 | 0.40 | 0.03 | 0.03 | 0.21 | 0.19 | 0.02 | 0.05 | 0.06 | 0.03 | 0.00 | 0.00 |
| 1992 | 0.17 | 0.31 | 0.04 | 0.04 | 0.04 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1993 | 0.16 | 0.24 | 0.10 | 0.06 | 0.08 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 0.42 | 0.54 | 0.23 | 0.13 | 0.07 | 0.05 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1995 | 2.77 | 0.73 | 0.28 | 0.19 | 0.13 | 0.05 | 0.03 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 |
| 1996 | 0.91 | 3.28 | 0.91 | 0.34 | 0.12 | 0.07 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1997 | 1.09 | 2.38 | 1.37 | 0.66 | 0.20 | 0.07 | 0.03 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| 1998 | 2.22 | 0.97 | 0.21 | 0.65 | 0.43 | 0.27 | 0.13 | 0.07 | 0.06 | 0.01 | 0.01 | 0.00 |
| 1999 | 0.27 | 1.12 | 0.64 | 0.90 | 0.40 | 0.11 | 0.04 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2000 | 0.81 | 0.74 | 0.83 | 1.46 | 0.89 | 0.39 | 0.14 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 |
| 2001 | 0.23 | 0.26 | 0.31 | 0.47 | 0.16 | 0.07 | 0.04 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2002 | 0.01 | 0.05 | 0.15 | 0.44 | 0.77 | 0.49 | 0.16 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2003 | 2.08 | 1.62 | 0.28 | 0.86 | 0.66 | 0.83 | 0.34 | 0.10 | 0.04 | 0.01 | 0.01 | 0.00 |
| 2004 | 1.10 | 3.14 | 0.54 | 0.24 | 0.35 | 0.26 | 0.22 | 0.13 | 0.05 | 0.02 | 0.01 | 0.00 |
| 2005 | 3.16 | 1.40 | 0.39 | 0.68 | 0.30 | 0.27 | 0.12 | 0.06 | 0.02 | 0.01 | 0.00 | 0.00 |
| 2006 | 0.16 | 0.26 | 0.14 | 0.64 | 0.67 | 0.26 | 0.18 | 0.12 | 0.12 | 0.03 | 0.02 | 0.00 |

Table A6.2 cont.

New Jersey Bottom Trawl Survey (NJTRL)
Arithmetic
Age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | | | | | | | | | | | | |
| 1983 | | | | | | | | | | | | |
| 1984 | | | | | | | | | | | | |
| 1985 | | | | | | | | | | | | |
| 1986 | | | | | | | | | | | | |
| 1987 | | | | | | | | | | | | |
| 1988 | | | | | | | | | | | | |
| 1989 | 0.08 | 0.12 | 0.00 | 0.04 | 0.01 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| 1990 | 0.12 | 0.36 | 0.04 | 0.81 | 0.26 | 0.06 | 0.19 | 0.01 | 0.12 | 0.00 | 0.00 | 0.00 |
| 1991 | 0.68 | 0.70 | 0.05 | 0.05 | 0.36 | 0.33 | 0.04 | 0.08 | 0.11 | 0.05 | 0.00 | 0.00 |
| 1992 | 0.27 | 0.49 | 0.06 | 0.07 | 0.06 | 0.08 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1993 | 0.26 | 0.38 | 0.16 | 0.09 | 0.13 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 0.62 | 0.79 | 0.33 | 0.19 | 0.10 | 0.07 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1995 | 4.71 | 1.23 | 0.48 | 0.32 | 0.23 | 0.09 | 0.05 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 |
| 1996 | 3.02 | 10.84 | 2.99 | 1.14 | 0.38 | 0.23 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1997 | 2.55 | 5.57 | 3.22 | 1.54 | 0.48 | 0.16 | 0.07 | 0.01 | 0.04 | 0.00 | 0.00 | 0.00 |
| 1998 | 3.57 | 1.56 | 0.34 | 1.05 | 0.70 | 0.44 | 0.20 | 0.11 | 0.09 | 0.02 | 0.01 | 0.00 |
| 1999 | 0.48 | 2.01 | 1.14 | 1.60 | 0.72 | 0.20 | 0.07 | 0.03 | 0.02 | 0.00 | 0.01 | 0.00 |
| 2000 | 1.29 | 1.19 | 1.33 | 2.33 | 1.42 | 0.62 | 0.23 | 0.05 | 0.02 | 0.01 | 0.00 | 0.00 |
| 2001 | 0.35 | 0.40 | 0.47 | 0.71 | 0.25 | 0.10 | 0.06 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2002 | 0.02 | 0.07 | 0.23 | 0.66 | 1.14 | 0.73 | 0.24 | 0.08 | 0.01 | 0.00 | 0.00 | 0.00 |
| 2003 | 3.17 | 2.48 | 0.43 | 1.31 | 1.01 | 1.27 | 0.52 | 0.16 | 0.06 | 0.01 | 0.01 | 0.00 |
| 2004 | 1.69 | 4.82 | 0.83 | 0.37 | 0.54 | 0.40 | 0.33 | 0.20 | 0.07 | 0.04 | 0.01 | 0.00 |
| 2005 | 4.61 | 2.04 | 0.57 | 0.99 | 0.44 | 0.39 | 0.18 | 0.08 | 0.02 | 0.02 | 0.00 | 0.01 |
| 2006 | 0.24 | 0.40 | 0.22 | 0.98 | 1.01 | 0.40 | 0.27 | 0.18 | 0.18 | 0.05 | 0.03 | 0.00 |

Table A6.2 cont.

New York Ocean Haul Seine (NYOHS)
Geometric
Age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | | | | | | | | | | | | |
| 1983 | | | | | | | | | | | | |
| 1984 | | | | | | | | | | | | |
| 1985 | | | | | | | | | | | | |
| 1986 | | | | | | | | | | | | |
| 1987 | 1.13 | 6.93 | 12.77 | 9.91 | 3.14 | 1.24 | 0.24 | 0.06 | 0.00 | 0.02 | 0.00 | 0.10 |
| 1988 | 6.41 | 7.64 | 5.53 | 4.72 | 2.42 | 0.62 | 0.41 | 0.11 | 0.06 | 0.02 | 0.00 | 0.38 |
| 1989 | 1.86 | 2.73 | 1.50 | 1.62 | 1.04 | 0.95 | 0.22 | 0.03 | 0.02 | 0.03 | 0.02 | 0.10 |
| 1990 | 1.89 | 9.19 | 9.52 | 3.54 | 3.06 | 1.73 | 1.38 | 0.49 | 0.18 | 0.03 | 0.00 | 0.06 |
| 1991 | 5.23 | 9.26 | 6.16 | 1.31 | 0.42 | 0.64 | 1.05 | 0.58 | 0.16 | 0.05 | 0.09 | 0.29 |
| 1992 | 1.49 | 7.84 | 4.85 | 2.28 | 0.62 | 0.27 | 0.32 | 0.47 | 0.33 | 0.06 | 0.11 | 0.20 |
| 1993 | 3.81 | 9.43 | 7.09 | 1.71 | 0.80 | 0.23 | 0.22 | 0.28 | 0.32 | 0.17 | 0.06 | 0.25 |
| 1994 | 2.22 | 4.26 | 2.46 | 2.12 | 1.31 | 0.86 | 0.59 | 0.35 | 0.64 | 0.20 | 0.38 | 0.30 |
| 1995 | 3.20 | 3.52 | 3.32 | 0.94 | 0.86 | 0.46 | 0.16 | 0.07 | 0.16 | 0.15 | 0.04 | 0.10 |
| 1996 | 11.75 | 105.61 | 16.13 | 4.64 | 1.33 | 1.03 | 0.38 | 0.19 | 0.10 | 0.00 | 0.07 | 0.04 |
| 1997 | 20.24 | 23.79 | 44.23 | 6.56 | 1.81 | 0.36 | 0.36 | 0.38 | 0.17 | 0.07 | 0.09 | 0.06 |
| 1998 | 19.60 | 31.02 | 17.91 | 29.83 | 3.82 | 0.95 | 0.61 | 0.30 | 0.02 | 0.10 | 0.16 | 0.12 |
| 1999 | 1.97 | 17.75 | 4.87 | 1.68 | 1.24 | 0.14 | 0.09 | 0.13 | 0.10 | 0.11 | 0.02 | 0.14 |
| 2000 | 7.79 | 11.81 | 26.54 | 9.43 | 2.23 | 2.25 | 0.25 | 0.24 | 0.10 | 0.11 | 0.06 | 0.29 |
| 2001 | 1.49 | 12.94 | 4.19 | 6.05 | 2.09 | 0.78 | 0.55 | 0.09 | 0.11 | 0.03 | 0.00 | 0.08 |
| 2002 | 7.33 | 5.14 | 4.19 | 1.83 | 1.67 | 1.30 | 0.45 | 0.45 | 0.03 | 0.11 | 0.04 | 0.13 |
| 2003 | 11.51 | 20.76 | 7.12 | 5.25 | 2.31 | 3.68 | 2.88 | 1.29 | 1.01 | 0.72 | 0.05 | 0.29 |
| 2004 | 5.46 | 62.09 | 29.79 | 6.84 | 2.42 | 0.83 | 0.67 | 0.39 | 0.12 | 0.15 | 0.19 | 0.02 |
| 2005 | 9.72 | 5.09 | 16.41 | 5.45 | 1.34 | 0.55 | 0.14 | 0.36 | 0.26 | 0.14 | 0.15 | 0.18 |
| 2006 | 3.90 | 38.77 | 4.44 | 9.81 | 2.59 | 0.88 | 0.35 | 0.15 | 0.02 | 0.06 | 0.00 | 0.00 |

Table A6.2 cont.

New York Ocean Haul Seine (NYOHS)
Arithmetic
Age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | | | | | | | | | | | | |
| 1983 | | | | | | | | | | | | |
| 1984 | | | | | | | | | | | | |
| 1985 | | | | | | | | | | | | |
| 1986 | | | | | | | | | | | | |
| 1987 | 2.86 | 17.58 | 32.38 | 25.12 | 7.95 | 3.15 | 0.60 | 0.16 | 0.00 | 0.05 | 0.00 | 0.27 |
| 1988 | 13.69 | 16.32 | 11.82 | 10.08 | 5.17 | 1.31 | 0.87 | 0.23 | 0.12 | 0.04 | 0.00 | 0.81 |
| 1989 | 3.92 | 5.75 | 3.16 | 3.42 | 2.18 | 2.00 | 0.46 | 0.07 | 0.04 | 0.07 | 0.04 | 0.22 |
| 1990 | 7.00 | 34.07 | 35.31 | 13.13 | 11.34 | 6.41 | 5.11 | 1.82 | 0.66 | 0.12 | 0.00 | 0.24 |
| 1991 | 41.55 | 73.60 | 48.97 | 10.38 | 3.35 | 5.09 | 8.37 | 4.63 | 1.30 | 0.38 | 0.73 | 2.34 |
| 1992 | 9.89 | 52.09 | 32.22 | 15.15 | 4.12 | 1.82 | 2.13 | 3.14 | 2.23 | 0.41 | 0.71 | 1.30 |
| 1993 | 7.05 | 17.45 | 13.12 | 3.16 | 1.48 | 0.43 | 0.40 | 0.52 | 0.60 | 0.32 | 0.11 | 0.46 |
| 1994 | 14.45 | 27.76 | 16.04 | 13.81 | 8.50 | 5.61 | 3.81 | 2.29 | 4.20 | 1.33 | 2.45 | 1.93 |
| 1995 | 36.36 | 39.89 | 37.67 | 10.71 | 9.77 | 5.27 | 1.85 | 0.74 | 1.76 | 1.68 | 0.47 | 1.12 |
| 1996 | 32.60 | 293.15 | 44.78 | 12.89 | 3.69 | 2.85 | 1.04 | 0.54 | 0.27 | 0.00 | 0.19 | 0.10 |
| 1997 | 126.82 | 149.04 | 277.16 | 41.13 | 11.34 | 2.23 | 2.27 | 2.36 | 1.05 | 0.46 | 0.54 | 0.40 |
| 1998 | 159.55 | 252.53 | 145.76 | 242.83 | 31.11 | 7.76 | 5.00 | 2.40 | 0.18 | 0.80 | 1.29 | 0.99 |
| 1999 | 7.25 | 65.36 | 17.92 | 6.19 | 4.58 | 0.51 | 0.35 | 0.47 | 0.36 | 0.40 | 0.09 | 0.53 |
| 2000 | 29.32 | 44.46 | 99.95 | 35.51 | 8.40 | 8.48 | 0.94 | 0.91 | 0.38 | 0.41 | 0.24 | 1.08 |
| 2001 | 8.60 | 74.46 | 24.08 | 34.82 | 12.01 | 4.50 | 3.14 | 0.50 | 0.66 | 0.18 | 0.00 | 0.44 |
| 2002 | 59.31 | 41.57 | 33.87 | 14.80 | 13.47 | 10.51 | 3.63 | 3.62 | 0.24 | 0.89 | 0.31 | 1.08 |
| 2003 | 87.86 | 158.49 | 54.35 | 40.10 | 17.63 | 28.11 | 21.97 | 9.84 | 7.70 | 5.51 | 0.42 | 2.24 |
| 2004 | 14.11 | 160.37 | 76.95 | 17.67 | 6.25 | 2.16 | 1.74 | 1.01 | 0.32 | 0.38 | 0.50 | 0.05 |
| 2005 | 58.53 | 30.66 | 98.81 | 32.81 | 8.06 | 3.30 | 0.84 | 2.15 | 1.56 | 0.85 | 0.88 | 1.07 |
| 2006 | 21.64 | 215.39 | 24.67 | 54.52 | 14.37 | 4.87 | 1.94 | 0.86 | 0.09 | 0.35 | 0.00 | 0.00 |

Table A6.2 cont.

Maryland Gillnet Survey (MDSSN)

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | | | | | | | | | | | | | |
| 1983 | | | | | | | | | | | | | |
| 1984 | | | | | | | | | | | | | |
| 1985 | 0 | 140.5 | 305.5 | 31.9 | 4.8 | 1.3 | 2.2 | 0.0 | 0.4 | 0.1 | 0.0 | 0.4 | 1.0 |
| 1986 | 0 | 230.2 | 261.1 | 497.6 | 4.0 | 5.3 | 2.0 | 2.9 | 2.8 | 0.0 | 0.0 | 0.0 | 0.9 |
| 1987 | 0 | 142.2 | 258.0 | 115.1 | 176.1 | 17.9 | 2.2 | 2.6 | 0.2 | 0.0 | 0.0 | 0.0 | 0.6 |
| 1988 | 0 | 40.8 | 77.6 | 71.3 | 57.0 | 74.6 | 1.3 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 0.4 |
| 1989 | 0 | 33.1 | 154.7 | 80.5 | 45.5 | 48.8 | 32.9 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1990 | 0 | 78.1 | 158.1 | 120.4 | 48.3 | 34.3 | 32.0 | 29.8 | 0.9 | 0.1 | 0.1 | 0.5 | 1.0 |
| 1991 | 0 | 73.4 | 191.1 | 62.2 | 47.1 | 26.7 | 26.1 | 19.2 | 10.7 | 0.4 | 1.5 | 0.0 | 2.3 |
| 1992 | 0.1 | 27.4 | 221.1 | 153.5 | 58.6 | 69.9 | 42.9 | 29.1 | 13.7 | 7.0 | 3.3 | 0.0 | 2.4 |
| 1993 | 0 | 41.0 | 132.0 | 187.2 | 88.2 | 51.0 | 51.9 | 37.1 | 22.6 | 7.4 | 3.1 | 0.8 | 2.9 |
| 1994 | 0 | 26.8 | 103.5 | 98.0 | 117.9 | 59.5 | 34.0 | 42.9 | 17.6 | 8.6 | 3.1 | 1.3 | 0.3 |
| 1995 | 0 | 50.0 | 117.2 | 67.3 | 60.9 | 51.8 | 40.2 | 25.1 | 19.8 | 11.6 | 9.7 | 3.5 | 4.7 |
| 1996 | 0 | 4.0 | 368.3 | 102.2 | 34.7 | 69.5 | 64.4 | 42.3 | 35.4 | 16.7 | 15.2 | 4.7 | 1.6 |
| 1997 | 0 | 40.6 | 46.3 | 134.6 | 46.0 | 21.7 | 19.7 | 25.8 | 22.3 | 12.3 | 12.0 | 3.7 | 1.8 |
| 1998 | 0 | 36.1 | 142.8 | 32.7 | 149.3 | 32.3 | 13.2 | 18.5 | 17.3 | 15.0 | 9.1 | 9.9 | 2.5 |
| 1999 | 0 | 7.0 | 174.2 | 80.1 | 56.8 | 35.3 | 11.4 | 6.6 | 11.1 | 5.2 | 5.1 | 2.7 | 1.2 |
| 2000 | 0 | 10.2 | 50.7 | 107.6 | 50.3 | 58.2 | 27.2 | 14.1 | 8.1 | 7.9 | 7.8 | 4.9 | 5.5 |
| 2001 | 0 | 4.7 | 39.1 | 52.3 | 51.6 | 23.2 | 28.5 | 38.0 | 13.2 | 11.9 | 9.8 | 5.5 | 4.7 |
| 2002 | 0 | 96.3 | 41.5 | 38.5 | 83.3 | 34.0 | 29.9 | 31.6 | 22.8 | 7.4 | 4.1 | 5.4 | 5.5 |
| 2003 | 0 | 17.7 | 110.0 | 47.8 | 37.1 | 61.5 | 56.8 | 30.8 | 27.5 | 34.4 | 9.9 | 10.6 | 10.9 |
| 2004 | 0 | 31.3 | 179.1 | 121.7 | 41.0 | 32.9 | 43.9 | 46.5 | 37.2 | 26.4 | 27.3 | 8.1 | 15.5 |
| 2005 | 0 | 67.7 | 105.6 | 73.9 | 97.1 | 24.3 | 25.8 | 21.7 | 27.4 | 20.4 | 17.5 | 11.3 | 7.6 |
| 2006 | 0 | 8.8 | 266.0 | 41.3 | 49.0 | 30.3 | 15.0 | 12.8 | 18.5 | 21.5 | 13.4 | 10.7 | 18.5 |

Table A6.2 cont.

Delaware Electrofishing Survey (DESSN)

| | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | | | | | | | | | | | | |
| 1983 | | | | | | | | | | | | |
| 1984 | | | | | | | | | | | | |
| 1985 | | | | | | | | | | | | |
| 1986 | | | | | | | | | | | | |
| 1987 | | | | | | | | | | | | |
| 1988 | | | | | | | | | | | | |
| 1989 | | | | | | | | | | | | |
| 1990 | | | | | | | | | | | | |
| 1991 | | | | | | | | | | | | |
| 1992 | | | | | | | | | | | | |
| 1993 | | | | | | | | | | | | |
| 1994 | | | | | | | | | | | | |
| 1995 | | | | | | | | | | | | |
| 1996 | 0.1 | 7.7 | 3.5 | 1.1 | 1.6 | 1.4 | 1.2 | 1.1 | 0.3 | 0.2 | 0.2 | 0.2 |
| 1997 | 2.0 | 1.6 | 8.6 | 3.0 | 1.1 | 1.4 | 1.6 | 0.7 | 0.7 | 0.5 | 0.2 | 0.5 |
| 1998 | 1.1 | 2.4 | 2.7 | 9.6 | 2.5 | 1.7 | 2.9 | 2.6 | 0.9 | 0.7 | 0.2 | 0.3 |
| 1999 | 0.0 | 1.6 | 2.2 | 2.7 | 3.6 | 1.1 | 0.8 | 1.2 | 0.9 | 0.8 | 0.2 | 0.2 |
| 2000 | 0.9 | 0.9 | 5.2 | 4.3 | 3.4 | 5.6 | 1.6 | 0.7 | 1.0 | 0.8 | 0.2 | 0.2 |
| 2001 | 0.1 | 2.3 | 2.0 | 3.7 | 2.2 | 2.8 | 4.0 | 1.0 | 0.3 | 0.8 | 0.4 | 0.4 |
| 2002 | 0.7 | 1.4 | 3.8 | 3.6 | 3.2 | 2.3 | 1.8 | 1.9 | 0.5 | 0.3 | 0.2 | 0.4 |
| 2003 | 0.5 | 2.4 | 2.4 | 3.3 | 2.2 | 2.7 | 3.1 | 2.6 | 3.0 | 0.8 | 0.7 | 0.9 |
| 2004 | 0.2 | 4.9 | 6.8 | 2.9 | 2.0 | 1.6 | 3.3 | 2.3 | 2.4 | 1.3 | 0.4 | 1.4 |
| 2005 | 1.9 | 3.1 | 3.3 | 3.9 | 1.6 | 0.9 | 0.6 | 0.7 | 1.2 | 0.7 | 0.9 | 0.9 |
| 2006 | 1.6 | 5.4 | 2.6 | 3.8 | 3.8 | 1.9 | 1.4 | 1.1 | 1.3 | 1.3 | 1.0 | 1.7 |

Table A6.2 cont.

| | New York | | | | New Jersey | | Virginia | | Maryland | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | YOY | | Age 1 | | YOY | | YOY | | YOY | | Age 1 | |
| Year | Geometric | Arithmetic | Geometric | Arithmetic | Geometric | Arithmetic | Geometric | Arithmetic | Geometric | Arithmetic | Geometric | Arithmetic |
| 1969 | | | | | | | | | 2.81 | 10.52 | 0.23 | 0.71 |
| 1970 | | | | | | | | | 12.52 | 30.52 | 0.12 | 0.22 |
| 1971 | | | | | | | | | 4.02 | 11.77 | 0.86 | 7.31 |
| 1972 | | | | | | | | | 3.26 | 11.01 | 0.38 | 1.73 |
| 1973 | | | | | | | | | 2.32 | 8.92 | 0.38 | 0.86 |
| 1974 | | | | | | | | | 2.63 | 10.13 | 0.23 | 0.44 |
| 1975 | | | | | | | | | 2.81 | 6.69 | 0.20 | 0.46 |
| 1976 | | | | | | | | | 1.58 | 4.91 | 0.12 | 0.42 |
| 1977 | | | | | | | | | 1.60 | 4.85 | 0.06 | 0.10 |
| 1978 | | | | | | | | | 3.75 | 8.45 | 0.16 | 0.31 |
| 1979 | 2.15 | 5.0 | | | | | | | 1.78 | 4.24 | 0.26 | 0.80 |
| 1980 | 6.08 | 23.9 | | | 0.05 | 0.070 | | | 1.02 | 1.98 | 0.16 | 0.30 |
| 1981 | 8.86 | 21.4 | | | 0.00 | 0.000 | | | 0.59 | 1.22 | 0.02 | 0.04 |
| 1982 | 14.17 | 30.5 | | | 0.12 | 0.170 | 2.71 | 3.05 | 3.57 | 8.45 | 0.02 | 0.02 |
| 1983 | 16.25 | 48.0 | | | 0.03 | 0.050 | 3.40 | 2.90 | 0.61 | 1.37 | 0.28 | 0.63 |
| 1984 | 15.00 | 37.1 | | | 0.29 | 0.470 | 4.47 | 5.63 | 1.64 | 4.21 | 0.00 | 0.00 |
| 1985 | 1.92 | 3.8 | 0.61 | 2.81 | 0.02 | 0.040 | 2.41 | 2.27 | 0.91 | 2.93 | 0.15 | 0.36 |
| 1986 | 2.92 | 6.1 | 0.30 | 0.78 | 0.27 | 0.480 | 4.74 | 4.65 | 1.34 | 4.14 | 0.03 | 0.05 |
| 1987 | 15.90 | 60.7 | 0.21 | 0.62 | 0.41 | 1.110 | 15.74 | 15.22 | 1.46 | 4.80 | 0.06 | 0.15 |
| 1988 | 33.46 | 52.3 | 0.81 | 7.07 | 0.34 | 0.570 | 7.64 | 7.49 | 0.73 | 2.65 | 0.07 | 0.11 |
| 1989 | 21.35 | 41.9 | 1.78 | 9.25 | 1.03 | 2.710 | 11.23 | 10.99 | 4.87 | 25.20 | 0.18 | 0.40 |
| 1990 | 19.08 | 38.0 | 0.37 | 0.96 | 1.00 | 2.060 | 7.34 | 6.94 | 1.03 | 2.14 | 0.28 | 0.75 |
| 1991 | 3.60 | 6.9 | 1.26 | 7.59 | 0.50 | 1.160 | 3.76 | 3.71 | 1.52 | 4.44 | 0.18 | 0.34 |
| 1992 | 11.43 | 17.3 | 1.34 | 5.66 | 1.21 | 3.990 | 7.35 | 9.83 | 2.34 | 9.03 | 0.14 | 0.32 |
| 1993 | 12.59 | 26.5 | 0.75 | 3.46 | 1.81 | 5.970 | 18.11 | 12.91 | 13.97 | 39.76 | 0.18 | 0.44 |
| 1994 | 17.64 | 28.5 | 1.43 | 13.21 | 0.96 | 2.320 | 10.48 | 8.39 | 6.40 | 16.12 | 0.58 | 2.51 |
| 1995 | 16.23 | 27.4 | 1.29 | 4.85 | 1.98 | 7.610 | 5.45 | 5.14 | 4.41 | 9.27 | 0.12 | 0.23 |
| 1996 | 8.93 | 14.7 | 1.54 | 11.09 | 1.61 | 4.300 | 23.00 | 20.88 | 17.61 | 59.39 | 0.08 | 0.23 |
| 1997 | 22.30 | 50.3 | 1.00 | 4.34 | 1.01 | 2.250 | 9.35 | 8.24 | 3.91 | 7.98 | 0.23 | 0.62 |
| 1998 | 13.39 | 22.9 | 2.10 | 10.09 | 1.31 | 3.510 | 13.25 | 11.58 | 5.50 | 12.67 | 0.16 | 0.35 |
| 1999 | 26.64 | 52.5 | 2.05 | 7.51 | 1.90 | 4.850 | 2.80 | 2.46 | 5.34 | 18.12 | 0.31 | 0.79 |
| 2000 | 3.16 | 7.8 | 1.56 | 11.39 | 1.77 | 6.050 | 16.18 | 15.23 | 7.42 | 13.77 | 0.23 | 0.52 |
| 2001 | 22.98 | 91.2 | 2.16 | 7.55 | 1.07 | 2.470 | 14.17 | 14.58 | 12.57 | 50.75 | 0.28 | 0.56 |
| 2002 | 12.32 | 21.5 | 2.53 | 8.88 | 0.52 | 1.290 | 3.98 | 4.52 | 2.20 | 4.73 | 0.58 | 1.61 |
| 2003 | 17.36 | 35.0 | 1.19 | 3.10 | 2.42 | 8.670 | 22.89 | 18.92 | 10.83 | 25.75 | 0.07 | 0.13 |
| 2004 | 8.81 | 14.3 | 2.41 | 11.24 | 1.13 | 2.980 | 12.70 | 10.71 | 4.85 | 11.44 | 0.55 | 1.91 |
| 2005 | 8.61 | 35.0 | 0.64 | 2.99 | 1.21 | 2.470 | 9.09 | 7.51 | 6.91 | 17.79 | 0.25 | 0.64 |
| 2006 | 3.82 | 8.3 | 2.02 | 7.51 | 0.68 | 1.29 | 10.10 | 7.82 | 1.78 | 4.25 | 0.25 | 0.6 |

Table A7.1. The fraction of total mortality (p) that occurs prior to the survey and ages to which survey indices are linked

| | p | Linked Ages |
|---|---|---|
| Age-specific | | |
| NY YOY | 0 | 1 (January 1st) |
| NJ YOY | 0 | 1 (January 1st) |
| MD YOY | 0 | 1 (January 1st) |
| VA YOY | 0 | 1 (January 1st) |
| MD Age 1 | 0 | 2 (January 1st) |
| NY (WLI) Age 1 | 0 | 2 (January 1st) |
| | | |
| Aggregate | | |
| MRFSS | 0.5 | 3-13+ |
| CTCPUE | 0.5 | 2-13+ |
| NEFSC | 0.333 | 2-9 |
| CT Trawl | 0.333 | 2-4 |
| MA COMM | 0.5 | 3-13+ |
| | | |
| Indices with age compositions | | |
| NY OHS | 0.75 | 2-13+ |
| NJ Trawl | 0.25 | 2-13+ |
| MD SSN | 0.25 | 2-13+ |
| DE SSN | 0.25 | 2-13+ |

Table A7.2. Estimates of effective sample size from the New Jersey, Delaware, Maryland, and New York fishery-independent surveys

| Survey | Year | No. Hauls With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| NJ | 1999 | 22 | 298 | 45.2 | 181.893 | 46.5 | 9.199 | 20 |
| | 2000 | 28 | 280 | 51.8 | 278.077 | 51.7 | 12.715 | 22 |
| | 2001 | 23 | 94 | 51.7 | 291.755 | 51.9 | 10.24 | 28 |
| | | | | | | | Average | 23 |

| Survey | Year | No. Runs With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| DE | 1999 | 50 | 281 | 611.9 | 30784.3 | 610.4 | 357.375 | 86 |
| | 2000 | 37 | 304 | 565.7 | 24952.6 | 546.5 | 502.028 | 50 |
| | 2001 | 44 | 288 | 617.6 | 26952.1 | 616.6 | 402.063 | 67 |
| | | | | | | | Average | 68 |

Assuming Sets is Sampling Units

| Survey | Year | No. of Sets With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| MD | 1999 | 20 | 2883 | 478.1 | 18555.6 | 474.5 | 395.414 | 47 |
| | 2000 | 20 | 2349 | 519.5 | 20641.4 | 518.4 | 205.491 | 100 |
| | 2001 | 20 | 1868 | 597.2 | 32827.2 | 597 | 140.701 | 233 |
| | 2002 | 20 | 2212 | 550.9 | 27542.1 | 547.5 | 466.204 | 59 |
| | 2003 | 21 | 2115 | 547.6 | 29745.5 | 544.1 | 827.03 | 36 |
| | 2004 | 20 | 2325 | 540.3 | 34938.5 | 534.1 | 1459.24 | 24 |
| | 2005 | 20 | 1650 | 551.2 | 35616.4 | 548.3 | 1110.37 | 32 |
| | 2006 | 20 | 1766 | 522.5 | 34920.8 | 511.5 | 2001.31 | 17 |
| | | | | | | | Average | 68.5 |

| Survey | Year | No. of Sets With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| NY | 1987 | 56 | 1949 | 639.2 | 8160.28 | 641.0 | 133.62 | 61 |
| | 1988 | 58 | 2098 | 604.0 | 17370.60 | 604.1 | 212.23 | 82 |
| | 1989 | 59 | 1195 | 621.4 | 18716.80 | 621.1 | 219.26 | 85 |
| | 1990 | 58 | 2042 | 658.7 | 13897.90 | 661.7 | 425.84 | 33 |
| | 1991 | 55 | 1788 | 552.1 | 15240.70 | 547.8 | 364.91 | 42 |
| | 1992 | 58 | 1605 | 570.5 | 10023.30 | 566.9 | 256.25 | 39 |
| | 1993 | 59 | 2201 | 604.9 | 17746.40 | 605.6 | 288.53 | 62 |
| | 1994 | 59 | 1710 | 613.1 | 15112.60 | 608.4 | 290.56 | 52 |
| | 1995 | 57 | 1491 | 438.3 | 9199.04 | 427.2 | 769.23 | 12 |
| | 1996 | 54 | 2198 | 485.7 | 6536.21 | 485.8 | 113.08 | 58 |
| | 1997 | 45 | 1665 | 492.8 | 4449.32 | 492.9 | 37.65 | 118 |
| | 1998 | 44 | 1591 | 545.0 | 7387.53 | 545.9 | 263.46 | 28 |
| | 1999 | 45 | 1398 | 519.5 | 5399.00 | 516.1 | 140.50 | 38 |
| | 2000 | 44 | 1520 | 597.1 | 13592.10 | 598.5 | 222.20 | 61 |
| | 2001 | 45 | 1052 | 549.5 | 7082.03 | 541.1 | 470.01 | 15 |
| | 2002 | 44 | 1220 | 514.5 | 13092.00 | 513.4 | 131.26 | 100 |
| | 2003 | 25 | 833 | 572.5 | 11641.00 | 572.3 | 246.95 | 47 |
| | 2004 | 44 | 1524 | 526.4 | 8424.27 | 526.4 | 71.92 | 117 |
| | 2005 | 40 | 1037 | 535.9 | 9950.54 | 540.7 | 443.79 | 22 |
| | | | | | | | Average | 56.4210526 |

Table A7.3. Starting values for model parameters

| | | |
|---|---|---|
| *Average recruitment (log)* | | 10.6 |
| *Average fishing mortality(log)* | | -2.6 |
| *Catch Selectivity Parameters* | | |
| | α | 3 |
| | β | 1 |
| | | |
| *Survey Selectivity - NJ Trawl, DE SSN, MDSSN* | | |
| | α | 3 |
| | β | 1 |
| | - MD SSN | |
| | $s_2$ | 0.3 |
| | | |
| | *-NYOHS* | |
| | γ | 0.95 |
| | α | -1 |
| | β | 1 |
| | | |
| *Catchability Coefficients (log)* | | |
| YOY/Age1 Indices | q | -20.4 |
| Aggregate Indices | q | -19.7 |
| Survey/Age Comp Indices | q | -20.2 |

Table A7.4. Model runs under equal weighting with the likelihood components of various components de-emphasized one-at-a-time (shading) using  lambda =0.5.

| | | Likelihoods | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Component | Base | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Total Catch | 199.201 | 156.124 | 169.323 | 198.776 | 198.111 | 189.096 | 198.26 | 194.805 | 199.624 | 198.098 | 199.179 | 197.852 | 198.955 | 197.695 | 198.636 | 191.059 | 198.759 | 148.788 | 201.62 | 197.778 | 199.828 | 198.673 | 182.34 | 206.685 |
| NY YOY | 1231.16 | 1212.98 | 641.46 | 1217.33 | 1225.65 | 1232.24 | 1231.52 | 1228.47 | 1231.26 | 1225.08 | 1231.40 | 1223.13 | 1232.41 | 1227.05 | 1229.95 | 1241.78 | 1230.92 | 1198.87 | 1231.54 | 1225.40 | 1228.52 | 1230.62 | 1242.90 | 1229.68 |
| NJ YOY | 371.94 | 380.88 | 357.65 | 188.54 | 374.28 | 370.13 | 372.10 | 372.02 | 371.80 | 374.22 | 371.75 | 374.24 | 371.47 | 372.98 | 372.07 | 367.67 | 372.01 | 376.10 | 370.58 | 371.75 | 371.97 | 373.02 | 365.60 | 373.41 |
| MD YOY | 370.50 | 376.20 | 357.47 | 370.70 | 192.64 | 366.84 | 370.06 | 374.05 | 370.28 | 371.64 | 370.01 | 369.36 | 370.12 | 370.33 | 370.17 | 368.88 | 370.49 | 336.45 | 377.45 | 370.10 | 365.75 | 369.87 | 369.84 | 371.83 |
| VA YOY | 311.36 | 302.46 | 314.60 | 310.15 | 310.31 | 160.35 | 311.05 | 310.90 | 311.33 | 310.32 | 311.25 | 310.27 | 311.77 | 310.01 | 311.04 | 313.07 | 311.35 | 299.43 | 314.97 | 308.69 | 318.91 | 311.90 | 313.32 | 312.85 |
| NY 1 | 99.70 | 101.26 | 99.36 | 99.91 | 99.72 | 99.09 | 49.98 | 99.59 | 99.69 | 99.84 | 99.74 | 99.92 | 99.64 | 99.79 | 99.67 | 99.13 | 99.70 | 100.39 | 99.90 | 99.36 | 98.39 | 99.21 | 99.31 | 99.73 |
| MD 1 | 303.36 | 304.33 | 297.09 | 302.28 | 307.70 | 301.54 | 303.04 | 155.77 | 303.22 | 303.80 | 303.00 | 302.48 | 303.20 | 303.12 | 303.18 | 302.60 | 303.35 | 284.99 | 307.19 | 303.42 | 300.64 | 303.23 | 301.86 | 303.18 |
| MRFSS | 12.18 | 13.24 | 12.42 | 12.05 | 12.03 | 12.14 | 12.18 | 12.07 | 6.13 | 11.93 | 12.27 | 12.09 | 12.21 | 12.12 | 12.18 | 12.28 | 12.15 | 12.02 | 11.68 | 12.30 | 12.31 | 12.48 | 12.34 | 12.15 |
| CTCPUE | 55.38 | 56.06 | 48.74 | 57.83 | 56.81 | 54.04 | 55.42 | 56.08 | 55.11 | 28.90 | 54.96 | 56.93 | 54.94 | 56.59 | 55.57 | 52.99 | 55.51 | 58.10 | 56.29 | 55.84 | 54.79 | 55.19 | 52.58 | 55.72 |
| NEFSC | 65.85 | 68.16 | 65.55 | 65.82 | 65.72 | 65.59 | 65.93 | 65.67 | 65.93 | 65.57 | 33.02 | 65.86 | 65.85 | 65.83 | 65.85 | 65.79 | 65.82 | 65.92 | 65.22 | 66.07 | 65.33 | 66.20 | 65.95 | 65.72 |
| CTTRL | 247.08 | 252.01 | 239.63 | 249.74 | 247.57 | 245.70 | 247.31 | 247.25 | 246.99 | 248.61 | 246.99 | 124.66 | 246.75 | 247.97 | 247.25 | 243.51 | 247.13 | 250.14 | 244.11 | 247.52 | 251.15 | 246.85 | 244.04 | 248.12 |
| MACOMM | 10.65 | 10.43 | 12.14 | 10.18 | 10.34 | 11.10 | 10.61 | 10.52 | 10.68 | 10.22 | 10.67 | 10.33 | 5.44 | 10.34 | 10.60 | 11.13 | 10.64 | 9.84 | 10.51 | 10.23 | 11.56 | 10.61 | 11.11 | 10.66 |
| NYOHS Index | 155.54 | 158.30 | 151.90 | 156.88 | 156.59 | 154.25 | 155.92 | 155.85 | 155.49 | 156.96 | 155.76 | 156.56 | 155.24 | 78.26 | 155.71 | 154.57 | 155.57 | 157.25 | 156.44 | 156.54 | 152.17 | 156.18 | 154.31 | 154.82 |
| NJTRL Index | 59.10 | 60.00 | 58.23 | 59.29 | 59.18 | 58.76 | 59.11 | 59.17 | 59.10 | 59.28 | 59.11 | 59.27 | 59.05 | 59.28 | 29.58 | 58.85 | 59.10 | 59.05 | 59.29 | 59.27 | 58.67 | 59.49 | 58.83 | 58.93 |
| MDSSN Index | 173.75 | 166.13 | 185.43 | 169.86 | 173.44 | 175.43 | 173.55 | 173.62 | 173.84 | 171.69 | 173.98 | 170.43 | 174.19 | 172.57 | 173.50 | 89.80 | 173.69 | 173.78 | 179.14 | 173.24 | 164.07 | 173.21 | 178.58 | 171.57 |
| DESSN Index | 11.22 | 10.89 | 11.09 | 11.32 | 11.30 | 11.21 | 11.22 | 11.27 | 11.19 | 11.36 | 11.19 | 11.28 | 11.20 | 11.25 | 11.22 | 11.17 | 5.62 | 11.54 | 11.38 | 11.14 | 11.14 | 11.11 | 11.14 | 11.20 |
| Catch Age Comps | 20418.70 | 20416.00 | 20419.70 | 20419.50 | 20418.10 | 20418.80 | 20418.90 | 20418.50 | 20418.70 | 20419.00 | 20418.80 | 20419.20 | 20418.70 | 20419.00 | 20418.80 | 20419.00 | 20418.70 | 10224.60 | 20417.10 | 20419.40 | 20413.60 | 20415.80 | 20418.90 | 20417.80 |
| NYOHS Age Comp | 1871.07 | 1871.01 | 1870.74 | 1870.74 | 1871.14 | 1870.99 | 1870.88 | 1871.18 | 1871.04 | 1870.93 | 1870.85 | 1870.69 | 1871.06 | 1871.08 | 1871.07 | 1871.11 | 1871.08 | 1868.57 | 937.69 | 1871.22 | 1868.16 | 1870.81 | 1871.12 | 1870.85 |
| NJTRL Age Comp | 765.37 | 765.26 | 765.20 | 765.42 | 765.40 | 765.27 | 765.37 | 765.42 | 765.37 | 765.41 | 765.39 | 765.43 | 765.35 | 765.43 | 765.39 | 765.35 | 765.37 | 766.38 | 765.72 | 383.02 | 764.64 | 765.10 | 765.33 | 765.41 |
| MDSSN Age Comp | 3256.64 | 3256.50 | 3256.91 | 3256.65 | 3256.45 | 3256.98 | 3256.55 | 3256.59 | 3256.65 | 3256.57 | 3256.58 | 3256.82 | 3256.68 | 3256.52 | 3256.64 | 3256.21 | 3256.64 | 3248.06 | 3254.07 | 3255.89 | 1633.89 | 3257.85 | 3256.35 | 3256.79 |
| DESSN Age Comp | 2125.07 | 2124.99 | 2125.06 | 2125.09 | 2125.01 | 2125.07 | 2125.01 | 2125.06 | 2125.08 | 2125.03 | 2125.05 | 2125.03 | 2125.07 | 2125.10 | 2125.09 | 2125.01 | 2125.06 | 2121.15 | 2124.82 | 2124.76 | 2126.29 | 1064.03 | 2125.06 | 2125.07 |
| Recr Devs : | 13.01 | 12.15 | 13.98 | 12.80 | 12.96 | 13.20 | 13.03 | 13.00 | 13.02 | 12.90 | 13.05 | 12.93 | 13.04 | 12.99 | 13.02 | 13.31 | 13.01 | 13.11 | 13.06 | 12.99 | 12.71 | 13.01 | 7.20 | 12.74 |
| F Devs : | 7.71 | 7.82 | 7.58 | 7.73 | 7.75 | 7.74 | 7.70 | 7.68 | 7.71 | 7.72 | 7.70 | 7.72 | 7.71 | 7.67 | 7.70 | 7.66 | 7.71 | 7.02 | 7.57 | 7.75 | 7.79 | 7.71 | 7.46 | 4.41 |
| Total Likelihood : | 28880.50 | 28874.20 | 28846.00 | 28870.70 | 28870.70 | 28872.20 | 28877.80 | 28872.70 | 28880.20 | 28878.90 | 28878.70 | 28874.00 | 28880.20 | 28876.60 | 28879.00 | 28875.80 | 28880.20 | 18664.90 | 27943.90 | 28497.50 | 27249.40 | 27817.20 | 28873.70 | 28876.40 |
| F2006 | 0.28 | 0.27 | 0.27 | 0.29 | 0.29 | 0.28 | 0.28 | 0.29 | 0.28 | 0.29 | 0.28 | 0.29 | 0.28 | 0.29 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.28 | 0.29 | 0.29 | 0.28 | 0.28 |
| %Change F | | -4.53 | -4.06 | 1.83 | 1.21 | -0.78 | -0.12 | 0.84 | -0.30 | 2.27 | -0.58 | 1.06 | -0.38 | 1.07 | 0.17 | -1.81 | 0.17 | -0.48 | -0.35 | 0.16 | 1.87 | 1.77 | -1.82 | 0.27 |

Table A7.5. Likelihood components with respective contributions from final model run

Likelihood Components

| | | Weight | RSS |
|---|---|---|---|
| Total Catch | : | 10 | 123.862 |
| YOY/Yearl Surveys | | | |
| NY YOY | : | 1 | 1311.820 |
| NJ YOY | : | 1 | 350.719 |
| MD YOY | : | 1 | 435.954 |
| VA YOY | : | 1 | 326.327 |
| NY Age 1 | : | 1 | 99.617 |
| MD Age 1 | : | 1 | 323.234 |
| Aggregate Surveys | | | |
| MRFSS | : | 1 | 9.539 |
| CT REC CPUE | : | 1 | 60.405 |
| NEFSC | : | 1 | 62.602 |
| CT Trawl | : | 1 | 278.141 |
| Age Survey Indices | | | |
| NY OHS | : | 1 | 155.059 |
| NJ Trawl | : | 1 | 57.779 |
| MD SSN | : | 1 | 186.536 |
| DE SSN | : | 1 | 13.805 |
| | | | |
| Total RSS | | | 3795.400 |
| No. of Obs | | | 351 |
| Conc. Likelihood | | | 417.823 |
| | | | |
| Catch Age Comps | : | 1 | 20345.900 |
| Survey Age Comps | | | |
| NY OHS | : | 1 | 1870.960 |
| NJ Trawl | : | 1 | 764.842 |
| MD SSN | : | 1 | 3258.780 |
| DE SSN | : | 1 | 2124.400 |
| | | | |
| Recr Devs | : | 1 | 21.534 |
| F Devs | : | 1 | 5.214 |
| | | | |
| Total Likelihood | : | | 28809.5 |

Table A7.6. Parameter estimates and associated standard deviations of final model configuration

| Year | Full F | SD | CV |
|---|---|---|---|
| 1982 | 0.45 | 0.024 | 0.05 |
| 1983 | 0.42 | 0.108 | 0.26 |
| 1984 | 0.31 | 0.059 | 0.19 |
| 1985 | 0.22 | 0.040 | 0.18 |
| 1986 | 0.16 | 0.033 | 0.21 |
| 1987 | 0.08 | 0.013 | 0.17 |
| 1988 | 0.15 | 0.044 | 0.29 |
| 1989 | 0.11 | 0.021 | 0.20 |
| 1990 | 0.12 | 0.012 | 0.10 |
| 1991 | 0.11 | 0.012 | 0.11 |
| 1992 | 0.09 | 0.007 | 0.08 |
| 1993 | 0.11 | 0.010 | 0.09 |
| 1994 | 0.12 | 0.010 | 0.08 |
| 1995 | 0.17 | 0.012 | 0.07 |
| 1996 | 0.20 | 0.015 | 0.07 |
| 1997 | 0.24 | 0.016 | 0.07 |
| 1998 | 0.20 | 0.014 | 0.07 |
| 1999 | 0.17 | 0.012 | 0.07 |
| 2000 | 0.22 | 0.015 | 0.07 |
| 2001 | 0.20 | 0.014 | 0.07 |
| 2002 | 0.19 | 0.014 | 0.07 |
| 2003 | 0.24 | 0.020 | 0.08 |
| 2004 | 0.27 | 0.025 | 0.09 |
| 2005 | 0.29 | 0.031 | 0.11 |
| 2006 | 0.32 | 0.040 | 0.13 |

| Year | Recruits | SD | CV |
|---|---|---|---|
| 1970 | 1.60E+07 | 5.71E+06 | 0.36 |
| 1971 | 3.40E+07 | 1.03E+07 | 0.30 |
| 1972 | 1.42E+07 | 4.46E+06 | 0.31 |
| 1973 | 8.79E+06 | 2.53E+06 | 0.29 |
| 1974 | 4.90E+06 | 1.30E+06 | 0.27 |
| 1975 | 3.37E+06 | 834362 | 0.25 |
| 1976 | 2.71E+06 | 523628 | 0.19 |
| 1977 | 1.84E+06 | 330758 | 0.18 |
| 1978 | 2.26E+06 | 306056 | 0.14 |
| 1979 | 3.83E+06 | 396848 | 0.10 |
| 1980 | 2.49E+06 | 247447 | 0.10 |
| 1981 | 1.67E+06 | 164029 | 0.10 |
| 1982 | 1.78E+06 | 145104 | 0.08 |
| 1983 | 4.30E+06 | 253501 | 0.06 |
| 1984 | 3.58E+06 | 208215 | 0.06 |
| 1985 | 3.53E+06 | 205713 | 0.06 |
| 1986 | 3.28E+06 | 194850 | 0.06 |
| 1987 | 4.43E+06 | 241034 | 0.05 |
| 1988 | 5.27E+06 | 273369 | 0.05 |
| 1989 | 6.47E+06 | 319641 | 0.05 |
| 1990 | 9.17E+06 | 421163 | 0.05 |
| 1991 | 7.65E+06 | 383671 | 0.05 |
| 1992 | 8.08E+06 | 412872 | 0.05 |
| 1993 | 1.04E+07 | 499330 | 0.05 |
| 1994 | 2.06E+07 | 816930 | 0.04 |
| 1995 | 1.32E+07 | 631695 | 0.05 |
| 1996 | 1.50E+07 | 728187 | 0.05 |
| 1997 | 1.65E+07 | 834198 | 0.05 |
| 1998 | 9.84E+06 | 607299 | 0.06 |
| 1999 | 9.33E+06 | 631004 | 0.07 |
| 2000 | 7.42E+06 | 585098 | 0.08 |
| 2001 | 1.28E+07 | 1.01E+06 | 0.08 |
| 2002 | 1.51E+07 | 1.36E+06 | 0.09 |
| 2003 | 7.70E+06 | 867156 | 0.11 |
| 2004 | 2.23E+07 | 2.55E+06 | 0.11 |
| 2005 | 8.24E+06 | 1.29E+06 | 0.16 |
| 2006 | 1.00E+07 | 2.22E+06 | 0.22 |

Catch Selectivtiy Parameters

| | Estimate | SD | CV |
|---|---|---|---|
| 1982-1984 | | | |
| α | 1.79 | 0.043 | 0.02 |
| β | 2.16 | 0.134 | 0.06 |
| 1985-1989 | | | |
| α | 3.97 | 0.194 | 0.05 |
| β | 0.52 | 0.034 | 0.07 |
| 1990-1995 | | | |
| α | 2.97 | 0.086 | 0.03 |
| β | 0.86 | 0.052 | 0.06 |
| 1996-2006 | | | |
| α | 3.42 | 0.093 | 0.03 |
| β | 0.62 | 0.029 | 0.05 |

Survey Selectivity Parameters

| | | | |
|---|---|---|---|
| NYOHS | | | |
| γ | 0.94 | 0.027 | 0.03 |
| α | -3.97 | 1.399 | 0.36 |
| β | 2.31 | 0.136 | 0.06 |
| NJ Trawl | | | |
| α | 1.44 | 0.425 | 0.30 |
| β | 0.36 | 0.098 | 0.27 |
| DE SSN | | | |
| α | 3.26 | 0.178 | 0.05 |
| β | 0.70 | 0.100 | 0.14 |
| MDSSN | | | |
| $s_2$ | 0.29 | 0.024 | 0.08 |

Catchability Coefficients

| | Estimate | SD | CV |
|---|---|---|---|
| NY YOY | 2.71E-06 | 2.22E-07 | 0.08 |
| NJ YOY | 2.32E-07 | 3.05E-08 | 0.13 |
| MD YOY | 1.14E-06 | 1.19E-07 | 0.10 |
| VA YOY | 8.73E-07 | 8.17E-08 | 0.09 |
| NY Age 1 | 6.42E-07 | 1.47E-07 | 0.23 |
| MD Age 1 | 7.92E-08 | 1.32E-08 | 0.17 |
| MRFSS | 4.15E-08 | 7.31E-09 | 0.18 |
| CTCPUE | 1.63E-07 | 2.26E-08 | 0.14 |
| NEFSC | 1.89E-08 | 3.60E-09 | 0.19 |
| CTTRL | 2.17E-08 | 3.87E-09 | 0.18 |
| NYOHS | 9.70E-06 | 1.95E-06 | 0.20 |
| NJTRL | 1.62E-07 | 4.51E-08 | 0.28 |
| MDSSN | 2.16E-05 | 3.93E-06 | 0.18 |
| DESSN | 9.87E-07 | 2.09E-07 | 0.21 |

Table A7.7. Average and N weighted F estimates for various ages

| | Average F | | N Weighted F | |
|---|---|---|---|---|
| Year | 8-11 | 3-8 | 7-11 | 3-8 |
| 1982 | 0.45 | 0.45 | 0.45 | 0.44 |
| 1983 | 0.42 | 0.41 | 0.42 | 0.41 |
| 1984 | 0.31 | 0.31 | 0.31 | 0.30 |
| 1985 | 0.21 | 0.13 | 0.19 | 0.07 |
| 1986 | 0.15 | 0.09 | 0.14 | 0.06 |
| 1987 | 0.08 | 0.05 | 0.07 | 0.03 |
| 1988 | 0.14 | 0.09 | 0.13 | 0.07 |
| 1989 | 0.10 | 0.07 | 0.09 | 0.05 |
| 1990 | 0.12 | 0.09 | 0.11 | 0.08 |
| 1991 | 0.11 | 0.08 | 0.10 | 0.07 |
| 1992 | 0.09 | 0.07 | 0.08 | 0.06 |
| 1993 | 0.11 | 0.09 | 0.11 | 0.07 |
| 1994 | 0.12 | 0.10 | 0.12 | 0.09 |
| 1995 | 0.17 | 0.14 | 0.17 | 0.12 |
| 1996 | 0.19 | 0.14 | 0.19 | 0.10 |
| 1997 | 0.23 | 0.17 | 0.23 | 0.13 |
| 1998 | 0.19 | 0.14 | 0.19 | 0.11 |
| 1999 | 0.16 | 0.11 | 0.16 | 0.09 |
| 2000 | 0.22 | 0.15 | 0.21 | 0.14 |
| 2001 | 0.19 | 0.14 | 0.19 | 0.13 |
| 2002 | 0.18 | 0.13 | 0.18 | 0.12 |
| 2003 | 0.23 | 0.16 | 0.23 | 0.14 |
| 2004 | 0.26 | 0.19 | 0.26 | 0.15 |
| 2005 | 0.28 | 0.20 | 0.28 | 0.17 |
| 2006 | 0.31 | 0.22 | 0.31 | 0.16 |

Table A7.8. Estimates of fishing mortality by age

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | 0.00 | 0.24 | 0.42 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |
| 1983 | 0.00 | 0.22 | 0.39 | 0.41 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 |
| 1984 | 0.00 | 0.16 | 0.29 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 |
| 1985 | 0.00 | 0.01 | 0.04 | 0.08 | 0.12 | 0.16 | 0.18 | 0.20 | 0.21 | 0.21 | 0.22 | 0.22 | 0.22 |
| 1986 | 0.00 | 0.01 | 0.03 | 0.06 | 0.09 | 0.11 | 0.13 | 0.14 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 |
| 1987 | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| 1988 | 0.00 | 0.01 | 0.03 | 0.06 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 |
| 1989 | 0.00 | 0.01 | 0.02 | 0.04 | 0.06 | 0.08 | 0.09 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 |
| 1990 | 0.00 | 0.01 | 0.04 | 0.08 | 0.10 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| 1991 | 0.00 | 0.01 | 0.04 | 0.07 | 0.09 | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 1992 | 0.00 | 0.01 | 0.03 | 0.06 | 0.07 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| 1993 | 0.00 | 0.01 | 0.04 | 0.07 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 1994 | 0.00 | 0.01 | 0.05 | 0.08 | 0.10 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| 1995 | 0.00 | 0.02 | 0.07 | 0.12 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| 1996 | 0.00 | 0.02 | 0.05 | 0.10 | 0.14 | 0.16 | 0.18 | 0.19 | 0.19 | 0.20 | 0.20 | 0.20 | 0.20 |
| 1997 | 0.00 | 0.02 | 0.07 | 0.12 | 0.17 | 0.20 | 0.22 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.24 |
| 1998 | 0.00 | 0.02 | 0.05 | 0.10 | 0.14 | 0.16 | 0.18 | 0.19 | 0.19 | 0.20 | 0.20 | 0.20 | 0.20 |
| 1999 | 0.00 | 0.01 | 0.05 | 0.08 | 0.11 | 0.14 | 0.15 | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 | 0.17 |
| 2000 | 0.00 | 0.02 | 0.06 | 0.11 | 0.15 | 0.18 | 0.20 | 0.21 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| 2001 | 0.00 | 0.02 | 0.05 | 0.10 | 0.14 | 0.16 | 0.18 | 0.19 | 0.19 | 0.20 | 0.20 | 0.20 | 0.20 |
| 2002 | 0.00 | 0.02 | 0.05 | 0.09 | 0.13 | 0.15 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 | 0.19 |
| 2003 | 0.00 | 0.02 | 0.07 | 0.12 | 0.16 | 0.20 | 0.22 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.24 |
| 2004 | 0.00 | 0.02 | 0.07 | 0.13 | 0.19 | 0.22 | 0.24 | 0.26 | 0.26 | 0.27 | 0.27 | 0.27 | 0.27 |
| 2005 | 0.00 | 0.03 | 0.08 | 0.15 | 0.20 | 0.24 | 0.26 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 |
| 2006 | 0.00 | 0.03 | 0.09 | 0.16 | 0.22 | 0.26 | 0.29 | 0.31 | 0.31 | 0.32 | 0.32 | 0.32 | 0.32 |

Table A7.9. Estimates of population abundance (thousands) by age

| | Age | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total | 8+ |
| 1982 | 1,785 | 1,433 | 1,453 | 1,258 | 408 | 182 | 146 | 100 | 79 | 78 | 68 | 90 | 51 | 7,129 | 465 |
| 1983 | 4,304 | 1,534 | 971 | 820 | 690 | 223 | 99 | 80 | 54 | 43 | 42 | 37 | 77 | 8,976 | 334 |
| 1984 | 3,579 | 3,699 | 1,059 | 567 | 467 | 392 | 127 | 56 | 45 | 31 | 25 | 24 | 65 | 10,134 | 246 |
| 1985 | 3,527 | 3,077 | 2,700 | 682 | 358 | 294 | 247 | 80 | 35 | 29 | 19 | 15 | 56 | 11,119 | 235 |
| 1986 | 3,275 | 3,029 | 2,612 | 2,228 | 541 | 273 | 217 | 177 | 56 | 25 | 20 | 13 | 49 | 12,515 | 342 |
| 1987 | 4,434 | 2,815 | 2,581 | 2,181 | 1,807 | 426 | 210 | 164 | 133 | 42 | 18 | 15 | 46 | 14,872 | 418 |
| 1988 | 5,267 | 3,813 | 2,410 | 2,188 | 1,821 | 1,487 | 346 | 169 | 131 | 106 | 33 | 15 | 48 | 17,836 | 503 |
| 1989 | 6,466 | 4,527 | 3,251 | 2,015 | 1,779 | 1,440 | 1,150 | 263 | 127 | 98 | 79 | 25 | 47 | 21,266 | 639 |
| 1990 | 9,166 | 5,560 | 3,869 | 2,739 | 1,664 | 1,439 | 1,146 | 904 | 205 | 99 | 76 | 61 | 55 | 26,982 | 1,400 |
| 1991 | 7,647 | 7,885 | 4,729 | 3,187 | 2,183 | 1,299 | 1,112 | 881 | 694 | 158 | 76 | 58 | 89 | 29,998 | 1,955 |
| 1992 | 8,076 | 6,578 | 6,714 | 3,910 | 2,556 | 1,719 | 1,013 | 863 | 683 | 537 | 122 | 59 | 114 | 32,945 | 2,378 |
| 1993 | 10,436 | 6,948 | 5,613 | 5,593 | 3,179 | 2,047 | 1,365 | 802 | 683 | 540 | 424 | 96 | 136 | 37,862 | 2,681 |
| 1994 | 20,589 | 8,978 | 5,915 | 4,636 | 4,480 | 2,497 | 1,592 | 1,058 | 620 | 527 | 417 | 328 | 179 | 51,815 | 3,129 |
| 1995 | 13,237 | 17,711 | 7,630 | 4,857 | 3,674 | 3,473 | 1,915 | 1,215 | 805 | 472 | 401 | 317 | 385 | 56,091 | 3,594 |
| 1996 | 14,959 | 11,384 | 14,978 | 6,149 | 3,726 | 2,733 | 2,544 | 1,393 | 881 | 583 | 341 | 290 | 508 | 60,469 | 3,996 |
| 1997 | 16,493 | 12,847 | 9,627 | 12,212 | 4,794 | 2,797 | 1,999 | 1,831 | 993 | 625 | 413 | 241 | 563 | 65,435 | 4,667 |
| 1998 | 9,837 | 14,158 | 10,824 | 7,759 | 9,322 | 3,495 | 1,976 | 1,385 | 1,255 | 677 | 424 | 280 | 545 | 61,937 | 4,566 |
| 1999 | 9,329 | 8,448 | 11,973 | 8,824 | 6,048 | 6,995 | 2,556 | 1,422 | 988 | 890 | 479 | 300 | 582 | 58,834 | 4,661 |
| 2000 | 7,421 | 8,015 | 7,165 | 9,848 | 6,990 | 4,641 | 5,253 | 1,894 | 1,046 | 723 | 650 | 349 | 643 | 54,636 | 5,305 |
| 2001 | 12,792 | 6,371 | 6,764 | 5,804 | 7,587 | 5,162 | 3,330 | 3,702 | 1,321 | 725 | 500 | 449 | 684 | 55,193 | 7,382 |
| 2002 | 15,122 | 10,986 | 5,388 | 5,513 | 4,523 | 5,692 | 3,773 | 2,395 | 2,639 | 937 | 513 | 353 | 799 | 58,632 | 7,636 |
| 2003 | 7,700 | 12,989 | 9,301 | 4,408 | 4,325 | 3,424 | 4,205 | 2,747 | 1,729 | 1,895 | 671 | 367 | 824 | 54,584 | 8,232 |
| 2004 | 22,279 | 6,610 | 10,945 | 7,500 | 3,367 | 3,157 | 2,423 | 2,919 | 1,886 | 1,180 | 1,289 | 456 | 808 | 64,818 | 8,537 |
| 2005 | 8,237 | 19,120 | 5,555 | 8,752 | 5,643 | 2,407 | 2,178 | 1,636 | 1,947 | 1,249 | 778 | 849 | 831 | 59,182 | 7,290 |
| 2006 | 10,038 | 7,067 | 16,037 | 4,416 | 6,515 | 3,974 | 1,632 | 1,443 | 1,069 | 1,263 | 807 | 502 | 1,081 | 55,844 | 6,165 |

Table A7.10. Estimates of female spawning stock biomass (metric tons)

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| 1982 | 0 | 0 | 0 | 28 | 50 | 139 | 271 | 241 | 195 | 291 | 342 | 449 | 325 | 2,330 |
| 1983 | 0 | 0 | 0 | 18 | 78 | 129 | 151 | 174 | 146 | 140 | 176 | 180 | 389 | 1,582 |
| 1984 | 0 | 0 | 0 | 13 | 53 | 230 | 212 | 112 | 126 | 97 | 93 | 122 | 369 | 1,427 |
| 1985 | 0 | 0 | 0 | 22 | 41 | 191 | 418 | 184 | 102 | 94 | 76 | 68 | 362 | 1,557 |
| 1986 | 0 | 0 | 0 | 67 | 67 | 151 | 340 | 389 | 144 | 75 | 71 | 57 | 295 | 1,656 |
| 1987 | 0 | 0 | 0 | 68 | 272 | 241 | 296 | 314 | 330 | 117 | 60 | 60 | 287 | 2,045 |
| 1988 | 0 | 0 | 0 | 69 | 286 | 997 | 516 | 307 | 306 | 276 | 117 | 61 | 301 | 3,237 |
| 1989 | 0 | 0 | 0 | 60 | 269 | 1,148 | 2,237 | 608 | 319 | 311 | 262 | 106 | 293 | 5,612 |
| 1990 | 0 | 0 | 0 | 82 | 233 | 1,041 | 2,258 | 2,257 | 575 | 278 | 286 | 257 | 326 | 7,594 |
| 1991 | 0 | 0 | 0 | 95 | 310 | 750 | 1,996 | 2,049 | 2,023 | 442 | 267 | 215 | 594 | 8,740 |
| 1992 | 0 | 0 | 0 | 117 | 387 | 1,130 | 1,673 | 2,017 | 2,015 | 1,835 | 448 | 299 | 749 | 10,669 |
| 1993 | 0 | 0 | 0 | 170 | 450 | 1,373 | 2,397 | 1,938 | 2,046 | 1,893 | 1,757 | 464 | 930 | 13,417 |
| 1994 | 0 | 0 | 0 | 149 | 652 | 1,642 | 2,796 | 2,544 | 1,874 | 1,799 | 1,725 | 1,551 | 1,072 | 15,804 |
| 1995 | 0 | 0 | 0 | 175 | 553 | 2,355 | 3,452 | 2,941 | 2,523 | 1,708 | 1,412 | 1,438 | 2,996 | 19,554 |
| 1996 | 0 | 0 | 0 | 205 | 602 | 2,033 | 5,100 | 3,773 | 2,846 | 2,220 | 1,443 | 1,181 | 3,240 | 22,643 |
| 1997 | 0 | 0 | 0 | 436 | 743 | 2,009 | 3,733 | 4,548 | 3,187 | 2,453 | 1,829 | 1,091 | 3,860 | 23,890 |
| 1998 | 0 | 0 | 0 | 202 | 1,335 | 2,116 | 3,389 | 3,066 | 3,438 | 2,167 | 1,667 | 1,289 | 3,010 | 21,678 |
| 1999 | 0 | 0 | 0 | 219 | 649 | 3,504 | 3,350 | 3,035 | 2,813 | 3,043 | 1,747 | 1,219 | 3,255 | 22,834 |
| 2000 | 0 | 0 | 0 | 235 | 714 | 2,248 | 6,799 | 3,423 | 2,906 | 2,337 | 2,636 | 1,564 | 4,045 | 26,906 |
| 2001 | 0 | 0 | 0 | 151 | 827 | 2,739 | 4,686 | 7,166 | 3,501 | 2,513 | 1,859 | 1,874 | 3,462 | 28,779 |
| 2002 | 0 | 0 | 0 | 135 | 538 | 3,170 | 5,787 | 4,991 | 6,770 | 3,028 | 2,012 | 1,512 | 4,292 | 32,236 |
| 2003 | 0 | 0 | 0 | 101 | 479 | 1,895 | 6,271 | 5,595 | 4,637 | 5,792 | 2,495 | 1,572 | 4,202 | 33,038 |
| 2004 | 0 | 0 | 0 | 166 | 376 | 1,726 | 3,638 | 5,848 | 4,901 | 3,595 | 4,573 | 1,845 | 3,998 | 30,666 |
| 2005 | 0 | 0 | 0 | 190 | 599 | 1,400 | 3,163 | 3,421 | 5,088 | 3,675 | 2,710 | 3,340 | 4,483 | 28,070 |
| 2006 | 0 | 0 | 0 | 94 | 704 | 2,053 | 2,426 | 2,766 | 2,899 | 3,827 | 2,734 | 1,957 | 5,519 | 24,979 |

Table A7.11. Examples of randomized starting values used to test the convergence properties of the SCA model

| Components | Parameter | Base | Randomized Values | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Run 2 | Run 17 | Run 23 | Run 30 | Run 43 | Run 55 | Run 61 | Run 79 | Run 87 | Run 92 |
| NYOHS Selectivity | γ | 0.95 | 0.91 | 0.55 | 0.63 | 0.89 | 0.64 | 0.84 | 0.79 | 0.58 | 0.60 | 0.57 |
| | α | -1 | -1.44 | -0.66 | -1.20 | -1.10 | -0.69 | -0.52 | -1.37 | -0.80 | -1.04 | -1.36 |
| | β | 1 | 1.17 | 0.87 | 1.13 | 1.15 | 1.23 | 1.28 | 1.10 | 1.41 | 0.73 | 1.08 |
| NJ Trawl Selectivity | α | 3 | 3.06 | 1.89 | 2.41 | 3.30 | 3.67 | 3.57 | 2.43 | 2.41 | 2.32 | 4.47 |
| | β | 1 | 1.01 | 0.55 | 0.64 | 1.44 | 1.14 | 1.44 | 1.09 | 1.20 | 1.28 | 0.76 |
| MDSSN Selectivity | $s_2$ | 0.3 | 0.38 | 0.23 | 0.34 | 0.39 | 0.30 | 0.21 | 0.33 | 0.39 | 0.25 | 0.44 |
| DESSN Selectivity | α | 3 | 2.89 | 2.65 | 1.56 | 3.07 | 2.85 | 2.47 | 3.48 | 3.26 | 3.41 | 4.08 |
| | β | 1 | 1.36 | 1.26 | 1.01 | 0.87 | 0.77 | 1.41 | 0.96 | 0.94 | 0.97 | 1.27 |
| Avg R (log) | R | 10.6 | 8.51 | 13.36 | 13.26 | 14.29 | 10.38 | 13.46 | 6.55 | 5.57 | 9.23 | 10.32 |
| Avg F (log) | F | -2.6 | -1.96 | -1.59 | -2.65 | -2.90 | -1.40 | -3.43 | -3.39 | -2.15 | -1.55 | -2.99 |
| Catch Selectivity 1982-1984 | α | 3 | 3.80 | 3.62 | 2.62 | 1.70 | 3.98 | 2.02 | 1.51 | 3.85 | 2.62 | 1.74 |
| | β | 1 | 0.79 | 0.88 | 0.58 | 1.12 | 0.77 | 1.36 | 1.23 | 0.73 | 0.90 | 0.62 |
| Catch Selectivity 1985-1989 | α | 3 | 1.52 | 2.58 | 1.89 | 1.72 | 3.76 | 4.21 | 1.80 | 2.35 | 4.33 | 3.23 |
| | β | 1 | 1.03 | 0.93 | 1.36 | 1.15 | 0.72 | 0.78 | 1.06 | 1.23 | 0.96 | 1.08 |
| Catch Selectivity 1990-1995 | α | 3 | 4.30 | 2.20 | 4.26 | 4.33 | 4.03 | 3.51 | 1.94 | 3.94 | 2.67 | 3.25 |
| | β | 1 | 0.92 | 1.19 | 0.63 | 1.06 | 0.53 | 1.05 | 0.69 | 0.75 | 1.37 | 1.45 |
| Catch Selectivity 1996-2006 | α | 3 | 3.91 | 3.93 | 3.61 | 4.35 | 4.25 | 3.38 | 3.49 | 2.19 | 1.64 | 1.63 |
| | β | 1 | 0.70 | 1.37 | 0.57 | 1.37 | 1.23 | 1.06 | 1.10 | 0.91 | 0.85 | 0.56 |
| NY YOY | q | -20.4 | -24.25 | -22.21 | -23.13 | -26.65 | -11.15 | -28.69 | -14.79 | -18.97 | -18.53 | -27.41 |
| NJ YOY | q | -20.4 | -30.50 | -18.24 | -10.85 | -11.41 | -25.10 | -29.70 | -28.12 | -26.07 | -28.48 | -13.06 |
| MD YOY | q | -20.4 | -21.58 | -13.63 | -26.01 | -26.83 | -14.52 | -25.41 | -21.31 | -29.20 | -15.30 | -15.08 |
| VA YOY | q | -20.4 | -10.48 | -17.01 | -23.98 | -11.04 | -16.12 | -19.36 | -27.54 | -18.40 | -15.85 | -29.94 |
| NY Age 1 | q | -20.4 | -16.02 | -20.42 | -27.34 | -15.71 | -20.71 | -10.77 | -11.18 | -17.94 | -14.39 | -26.90 |
| MD Age 1 | q | -20.4 | -17.60 | -14.12 | -25.96 | -15.27 | -28.08 | -24.11 | -24.32 | -19.62 | -19.45 | -22.38 |
| MRFSS | q | -19.7 | -29.27 | -24.81 | -25.63 | -23.41 | -13.81 | -11.65 | -15.36 | -29.13 | -29.38 | -20.12 |
| CTCPUE | q | -19.7 | -18.55 | -15.70 | -26.20 | -27.46 | -13.00 | -25.27 | -23.52 | -25.75 | -29.29 | -17.45 |
| NEFSC | q | -19.7 | -28.26 | -12.43 | -17.69 | -25.86 | -19.01 | -17.85 | -17.93 | -16.16 | -26.10 | -18.96 |
| CTTRL | q | -19.7 | -21.23 | -25.20 | -25.70 | -28.76 | -20.97 | -17.45 | -22.68 | -13.50 | -29.02 | -9.94 |
| NYOHS | q | -20.2 | -18.11 | -11.52 | -14.31 | -17.75 | -21.60 | -25.70 | -17.54 | -23.15 | -22.59 | -11.17 |
| NJTRL | q | -20.2 | -17.29 | -29.78 | -10.26 | -10.45 | -25.45 | -28.79 | -18.85 | -27.19 | -20.67 | -24.81 |
| MDSSN | q | -20.2 | -22.30 | -14.51 | -13.19 | -12.17 | -11.97 | -21.49 | -19.31 | -14.54 | -10.39 | -20.18 |
| DESSN | q | -20.2 | -22.42 | -24.29 | -12.30 | -21.92 | -17.24 | -29.13 | -28.62 | -20.25 | -10.49 | -13.06 |

Table A7.12. Results of changing parameter phase on estimates of fully-recruited fishing mortality and total log-likelihood.

| | Phase | | | |
|---|---|---|---|---|
| Parameters | Base | Run 1 | Run 2 | Run 3 |
| Average Recruitment | 1 | 1 | 1 | 1 |
| Average Fishing Mortality/ Fishing Mortality Deviations | 2/2 | 2/2 | 3/4 | 2/5 |
| Recruitment Deviations | 3 | 3 | 2 | 7 |
| Catch Selectivity | 4 | 5 | 10 | 3 |
| Catchability Coefficients of YOY/Yearling and Aggregate Survey I | 5 | 4 | 9 | 5 |
| Catchability Coefficients of Survey Indices with Age Compositions | 6 | 9 | 7 | 8 |
| NY OHS Selectivity | 7 | 8 | 5 | 4 |
| NJ Trawl Survey Selectivity | 8 | 10 | 6 | 6 |
| DE SSN Survey Selectivity | 9 | 6 | 8 | 10 |
| MD Survey Selectivity | 10 | 7 | 7 | 9 |

Fully-Recruited Fishing Mortality

| Year | Base | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| 1982 | 0.45 | 0.45 | 0.45 | 0.45 |
| 1983 | 0.42 | 0.42 | 0.42 | 0.42 |
| 1984 | 0.31 | 0.31 | 0.31 | 0.31 |
| 1985 | 0.22 | 0.22 | 0.22 | 0.22 |
| 1986 | 0.16 | 0.16 | 0.16 | 0.16 |
| 1987 | 0.08 | 0.08 | 0.08 | 0.08 |
| 1988 | 0.15 | 0.15 | 0.15 | 0.15 |
| 1989 | 0.11 | 0.11 | 0.11 | 0.11 |
| 1990 | 0.12 | 0.12 | 0.12 | 0.12 |
| 1991 | 0.11 | 0.11 | 0.11 | 0.11 |
| 1992 | 0.09 | 0.09 | 0.09 | 0.09 |
| 1993 | 0.11 | 0.11 | 0.11 | 0.11 |
| 1994 | 0.12 | 0.12 | 0.12 | 0.12 |
| 1995 | 0.17 | 0.17 | 0.17 | 0.17 |
| 1996 | 0.20 | 0.20 | 0.20 | 0.20 |
| 1997 | 0.24 | 0.24 | 0.24 | 0.24 |
| 1998 | 0.20 | 0.20 | 0.20 | 0.20 |
| 1999 | 0.17 | 0.17 | 0.17 | 0.17 |
| 2000 | 0.22 | 0.22 | 0.22 | 0.22 |
| 2001 | 0.20 | 0.20 | 0.20 | 0.20 |
| 2002 | 0.19 | 0.19 | 0.19 | 0.19 |
| 2003 | 0.24 | 0.24 | 0.24 | 0.24 |
| 2004 | 0.27 | 0.27 | 0.27 | 0.27 |
| 2005 | 0.29 | 0.29 | 0.29 | 0.29 |
| 2006 | 0.32 | 0.32 | 0.32 | 0.32 |
| Log-Likelihood | 28809.5 | 28809.5 | 28809.5 | 28809.5 |

Table A8.1. Candidate models used in the analyses of striped bass tag recoveries in Program MARK.

| | |
|---|---|
| S(.) r(.) | Constant survival and reporting |
| S(t) r(t) | Time specific survival and reporting – the global model |
| S(.) r(t) | Constant survival and time specific reporting |
| S(p) r(t) | *Regulatory period based survival and time specific reporting |
| S(p) r(p) | *Regulatory period based survival and reporting |
| S(.) r(p) | *Constant survival and regulatory period based reporting |
| S(t) r(p) | *Time specific survival and regulatory period reporting |
| S(d) r(p) | **Regulatory period based survival with unique terminal year and regulatory period based reporting |
| S(v) r(p) | ***Regulatory period based survival with 2 terminal years unique and regulatory period based reporting |
| * Periods (p) | 1 = {1987-1989}, 2 = {1990-1994}, 3 = {1995- 1999}, 4 = {2000-2002}, 5 = {2003-2006} |
| ** Periods (d) | 1 = {1987-1989}, 2 = {1990-1994}, 3 = {1995- 1999}, 4 = {2000-2002}, 5 = {2003-2005}, 6 = {2006} |
| *** Periods (v) | 1 = {1987-1989}, 2 = {1990-1994}, 3 = {1995- 1999}, 4 = {2000-2002}, 5 = {2003-2004}, 6 = {2005-2006} |

Table A8.2. Justification of modeling periods used in candidate model set.

| Regulatory Period | Explanation |
|---|---|
| 1987-1989 | Partial moratorium and large minimum size limits. |
| 1990-1994 | Interim fishery under Amendment 4: Commercial fisheries reopen in some states at 80% of historical harvest. Preferred size limit reduced to 28” on coast and 18” in Hudson and Chesapeake Bay. Combination of size limits, seasons, and bag limits used to attain target fishing mortality rate. |
| 1995-1999 | Fully recovered fishery under Amendment 5: Target F=0.33. Recreational fisheries: 20” minimum size, 1 fish creel limit, variable season lengths in the producer areas (Chesapeake Bay, Hudson River,) and 28” minimum size, 2 fish creel limit, 365 day season along the coast. Commercial fisheries: flexible quota, same size limits as the recreational fishery. Establishes quotas based on size limits and has paybacks for quota overages. Target reduced to F=0.31 in 1997, minimum size limits maintained. |
| 2000-2002 | Addendum IV to Amendment 5: reduce F on age 8 and older striped bass by 14% through creel and size limits. Credit was given to states already more conservative. |
| 2002-2006 | Amendment 6: Target F = 0.30. Coastal commercial quotas increased to 100% of historical harvest. Some states’ minimum size limits increased to 28” on the coast. |

Table A8.3. Akaike weights used to derive model averaged parameter estimates. Results are for striped bass >28 inches. Models are described in Table A8.1.

**Coast Programs**

| Model | MADFW | NYOHS | NJDEL | NCCOOP |
|---|---|---|---|---|
| {S(.)r(.)} | 0 | 0 | 0 | 0 |
| {S(.)r(p)} | **0.7830** | 0.0005 | 0 | **0.5230** |
| {S(.)r(t)} | 0.0004 | 0 | 0.0004 | 0.0459 |
| {S(p)r(p)} | **0.1198** | **0.5500** | **0.1323** | **0.1690** |
| {S(p)r(t)} | 0.0003 | 0.0001 | **0.2132** | 0.0083 |
| {S(d)r(p)} | 0.0511 | **0.2188** | **0.1393** | **0.1035** |
| {S(v)r(p)} | 0.0450 | **0.2305** | **0.4130** | 0.0648 |
| {S(t)r(p)} | 0.0005 | 0.0001 | **0.1008** | 0.0011 |
| {S(t)r(t)} | 0 | 0 | 0.0011 | 0.0845 |

**Producer Area Programs**

| Model | DE/PA | HUDSON | MDCB | VARAP |
|---|---|---|---|---|
| {S(.)r(.)} | **0.5232** | 0.0000 | 0 | 0 |
| {S(.)r(p)} | 0.0792 | **0.3721** | 0 | 0.0265 |
| {S(.)r(t)} | 0.0003 | 0.0025 | 0 | 0.0074 |
| {S(p)r(p)} | **0.2093** | **0.3229** | **0.4988** | **0.2117** |
| {S(p)r(t)} | 0.0014 | 0.0005 | 0.0112 | 0.0006 |
| {S(d)r(p)} | 0.0885 | **0.1454** | **0.2626** | 0.0787 |
| {S(v)r(p)} | 0.0973 | **0.1282** | **0.1926** | **0.6748** |
| {S(t)r(p)} | 0.0009 | 0.0285 | 0.0316 | 0.0001 |
| {S(t)r(t)} | 0 | 0.0000 | 0.0033 | 0.0002 |

Table A8.4. Akaike weights used to derive model averaged parameter estimates. Results are for striped bass >18 inches. Models are described in Table A8.1.

**Producer Area Programs**

| Model | HUDSON | DE/PA | MDCB | VARAP |
|---|---|---|---|---|
| {S(.)r(.)} | 0 | 0 | 0 | 0 |
| {S(.)r(p)} | 0 | 0 | 0 | 0 |
| {S(.)r(t)} | 0 | 0.01128 | 0 | 0 |
| {S(p)r(p)} | 0 | 0.00816 | 0 | 0 |
| {S(p)r(t)} | **1.0000** | **0.43311** | **0.91164** | 0 |
| {S(d)r(p)} | 0 | 0.00347 | 0 | 0 |
| {S(v)r(p)} | 0 | 0.00300 | 0 | 0 |
| {S(t)r(p)} | 0 | 0.00858 | 0.00004 | 0 |
| {S(t)r(t)} | 0 | **0.53240** | 0.08832 | **1.0000** |

**Coast Programs**

| Model | MADFW | NYOHS | NJDEL | NCCOOP |
|---|---|---|---|---|
| {S(.)r(.)} | 0 | 0 | 0 | 0 |
| {S(.)r(p)} | **0.8362** | 0 | 0 | 0 |
| {S(.)r(t)} | 0.0089 | 0 | 0 | 0 |
| {S(p)r(p)} | 0.0837 | 0 | 0 | 0 |
| {S(p)r(t)} | 0.0026 | 0 | 0.0009 | 0 |
| {S(d)r(p)} | 0.0358 | 0 | 0 | 0 |
| {S(v)r(p)} | 0.0316 | 0 | 0 | 0 |
| {S(t)r(p)} | 0.0014 | 0 | 0.0002 | 0 |
| {S(t)r(t)} | 0 | **1.0000** | **0.9989** | **1.0000** |

Table A8.5. R/M estimates of exploitation rates of >28 inch striped bass from tagging programs. Exploitation rate, an input to the catch equation, is the proportion of tagged fish that were harvested or killed (with reporting rate adjustment of 0.43, and hooking mortality rate adjustment of 0.08)

| Year | NJDEL | NYOHS | NCCOOP | MADFW | VARAP | MDCB | DE/PA | HUDSON | **MEAN** |
|---|---|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | | | |
| 1988 | | 0.05 | 0.06 | | | 0.07 | | 0.10 | **0.07** |
| 1989 | 0.02 | 0.04 | 0.04 | | | 0.04 | | 0.07 | **0.04** |
| 1990 | 0.04 | 0.07 | 0.09 | | 0.25 | 0.08 | | 0.12 | **0.11** |
| 1991 | 0.31 | 0.12 | 0.07 | | 0.36 | 0.12 | | 0.11 | **0.18** |
| 1992 | 0.07 | 0.11 | 0.13 | 0.05 | 0.37 | 0.12 | | 0.13 | **0.14** |
| 1993 | 0.09 | 0.14 | 0.11 | 0.07 | 0.37 | 0.12 | 0.13 | 0.17 | **0.15** |
| 1994 | 0.05 | 0.08 | 0.08 | 0.05 | 0.25 | 0.11 | 0.12 | 0.12 | **0.11** |
| 1995 | 0.11 | 0.21 | 0.14 | 0.05 | 0.41 | 0.20 | 0.14 | 0.15 | **0.18** |
| 1996 | 0.20 | 0.14 | 0.11 | 0.09 | 0.18 | 0.17 | 0.32 | 0.23 | **0.18** |
| 1997 | 0.23 | 0.36 | 0.18 | 0.17 | 0.38 | 0.23 | 0.27 | 0.29 | **0.26** |
| 1998 | 0.35 | 0.17 | 0.20 | 0.10 | 0.45 | 0.20 | 0.28 | 0.22 | **0.25** |
| 1999 | 0.12 | 0.31 | 0.24 | 0.13 | 0.28 | 0.32 | 0.15 | 0.22 | **0.22** |
| 2000 | 0.14 | 0.18 | 0.06 | 0.13 | 0.27 | 0.17 | 0.30 | 0.14 | **0.17** |
| 2001 | 0.16 | 0.11 | 0.15 | 0.09 | 0.23 | 0.11 | 0.27 | 0.14 | **0.16** |
| 2002 | 0.12 | 0.23 | 0.12 | 0.08 | 0.31 | 0.10 | 0.24 | 0.19 | **0.17** |
| 2003 | 0.15 | 0.15 | 0.11 | 0.11 | 0.24 | 0.10 | 0.17 | 0.14 | **0.15** |
| 2004 | 0.16 | 0.14 | 0.12 | 0.10 | 0.13 | 0.08 | 0.24 | 0.21 | **0.15** |
| 2005 | 0.17 | 0.26 | 0.07 | 0.07 | 0.16 | 0.11 | 0.15 | 0.17 | **0.15** |
| 2006 | 0.14 | 0.13 | 0.12 | 0.10 | 0.14 | 0.13 | 0.21 | 0.15 | **0.14** |

* Years when few or no striped bass were tagged and released.

Table A8.6. R/M estimates of exploitation rates of >18 inch striped bass from tagging programs. Exploitation rate, an input to the catch equation, is the proportion of tagged fish that were harvested or killed (with reporting rate adjustment of 0.43, and hooking mortality rate adjustment of 0.08).

| Year | NJDEL | NYOHS | NCCOOP | MADFW | VARAP | MDCB | DE/PA | HUDSON | **MEAN** |
|---|---|---|---|---|---|---|---|---|---|
| 1987 | | | | | | 0.01 | | | **0.01** |
| 1988 | | 0.02 | 0.03 | | | 0.01 | | 0.05 | **0.03** |
| 1989 | 0.04 | 0.03 | 0.03 | | | 0.01 | | 0.05 | **0.03** |
| 1990 | 0.09 | 0.04 | 0.06 | | 0.17 | 0.07 | | 0.15 | **0.10** |
| 1991 | 0.04 | 0.06 | 0.08 | | 0.14 | 0.10 | | 0.08 | **0.08** |
| 1992 | 0.04 | 0.04 | 0.14 | 0.05 | 0.31 | 0.13 | | 0.10 | **0.12** |
| 1993 | 0.03 | 0.05 | 0.11 | 0.06 | 0.23 | 0.11 | 0.13 | 0.10 | **0.10** |
| 1994 | 0.04 | 0.04 | 0.08 | 0.05 | 0.25 | 0.12 | 0.12 | 0.08 | **0.10** |
| 1995 | 0.06 | 0.05 | 0.14 | 0.04 | 0.19 | 0.18 | 0.12 | 0.05 | **0.10** |
| 1996 | 0.10 | 0.03 | 0.11 | 0.07 | 0.15 | 0.17 | 0.18 | 0.16 | **0.12** |
| 1997 | 0.09 | 0.04 | 0.15 | 0.12 | 0.20 | 0.20 | 0.11 | 0.22 | **0.14** |
| 1998 | 0.12 | 0.03 | 0.14 | 0.10 | 0.15 | 0.19 | 0.14 | 0.17 | **0.13** |
| 1999 | 0.06 | 0.05 | 0.22 | 0.09 | 0.13 | 0.16 | 0.10 | 0.14 | **0.12** |
| 2000 | 0.07 | 0.03 | 0.08 | 0.09 | 0.13 | 0.13 | 0.15 | 0.10 | **0.10** |
| 2001 | 0.09 | 0.05 | 0.11 | 0.06 | 0.18 | 0.12 | 0.15 | 0.10 | **0.11** |
| 2002 | 0.06 | 0.06 | 0.12 | 0.09 | 0.17 | 0.12 | 0.14 | 0.08 | **0.10** |
| 2003 | 0.08 | 0.04 | 0.11 | 0.08 | 0.17 | 0.13 | 0.15 | 0.10 | **0.11** |
| 2004 | 0.12 | 0.04 | 0.12 | 0.09 | 0.11 | 0.10 | 0.15 | 0.13 | **0.11** |
| 2005 | 0.09 | 0.03 | 0.06 | 0.07 | 0.12 | 0.11 | 0.10 | 0.09 | **0.08** |
| 2006 | 0.06 | 0.03 | 0.10 | 0.09 | 0.10 | 0.13 | 0.11 | 0.10 | **0.09** |

* Years when few or no striped bass were tagged and released.

Table A8.7. Unadjusted (unadj.) and bias-corrected (adj.) estimates of survival (S) and fishing mortality (F) for striped bass ≥ 28 inches, from Program MARK and assuming a constant natural mortality, for each tagging program. S(adj.) (converted to Z) is an input to the catch equation.

**Coast Programs**

Massachusetts
C-hat adjustment = 1.00; bootstrap GOF probability = 0.8 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1992 | 0.73 | 0.16 | 0.06 | 0.75 | -0.11 | **0.82** | 0.05 | -0.01 | 0.12 |
| 1993 | 0.73 | 0.16 | 0.07 | 0.57 | -0.09 | **0.80** | 0.07 | 0.01 | 0.14 |
| 1994 | 0.73 | 0.16 | 0.06 | 0.52 | -0.07 | **0.79** | 0.09 | 0.03 | 0.16 |
| 1995 | 0.72 | 0.18 | 0.07 | 0.38 | -0.06 | **0.77** | 0.12 | 0.08 | 0.16 |
| 1996 | 0.72 | 0.18 | 0.09 | 0.26 | -0.06 | **0.77** | 0.11 | 0.07 | 0.16 |
| 1997 | 0.72 | 0.18 | 0.10 | 0.22 | -0.06 | **0.77** | 0.12 | 0.08 | 0.16 |
| 1998 | 0.72 | 0.18 | 0.09 | 0.28 | -0.06 | **0.77** | 0.11 | 0.07 | 0.15 |
| 1999 | 0.72 | 0.18 | 0.08 | 0.28 | -0.06 | **0.76** | 0.12 | 0.08 | 0.16 |
| 2000 | 0.72 | 0.17 | 0.07 | 0.21 | -0.04 | **0.75** | 0.13 | 0.08 | 0.19 |
| 2001 | 0.72 | 0.17 | 0.06 | 0.33 | -0.04 | **0.76** | 0.13 | 0.07 | 0.19 |
| 2002 | 0.72 | 0.17 | 0.07 | 0.32 | -0.06 | **0.77** | 0.12 | 0.06 | 0.18 |
| 2003 | 0.73 | 0.17 | 0.05 | 0.18 | -0.02 | **0.74** | 0.15 | 0.09 | 0.22 |
| 2004 | 0.73 | 0.17 | 0.05 | 0.22 | -0.02 | **0.74** | 0.15 | 0.08 | 0.22 |
| 2005 | 0.73 | 0.17 | 0.05 | 0.27 | -0.03 | **0.75** | 0.14 | 0.07 | 0.22 |
| 2006 | 0.72 | 0.17 | 0.06 | 0.35 | -0.05 | **0.77** | 0.12 | 0.04 | 0.21 |

New York - Ocean Haul Seine
C-hat adjustment = 1.172; bootstrap GOF probability = 0.094 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0.81 | 0.06 | 0.12 | 0.90 | -0.24 | **1.06** | -0.21 | -0.31 | -0.04 |
| 1989 | 0.81 | 0.06 | 0.10 | 0.86 | -0.19 | **1.01** | -0.16 | -0.26 | 0.01 |
| 1990 | 0.63 | 0.32 | 0.09 | 0.66 | -0.14 | **0.73** | 0.17 | 0.12 | 0.23 |
| 1991 | 0.63 | 0.32 | 0.11 | 0.53 | -0.15 | **0.74** | 0.16 | 0.11 | 0.21 |
| 1992 | 0.63 | 0.32 | 0.15 | 0.54 | -0.20 | **0.79** | 0.09 | 0.04 | 0.15 |
| 1993 | 0.63 | 0.32 | 0.11 | 0.43 | -0.12 | **0.71** | 0.19 | 0.14 | 0.25 |
| 1994 | 0.63 | 0.32 | 0.11 | 0.49 | -0.13 | **0.72** | 0.17 | 0.12 | 0.23 |
| 1995 | 0.65 | 0.28 | 0.15 | 0.34 | -0.14 | **0.76** | 0.13 | 0.07 | 0.20 |
| 1996 | 0.65 | 0.28 | 0.14 | 0.30 | -0.11 | **0.73** | 0.16 | 0.10 | 0.23 |
| 1997 | 0.65 | 0.28 | 0.16 | 0.21 | -0.10 | **0.72** | 0.18 | 0.12 | 0.24 |
| 1998 | 0.65 | 0.28 | 0.11 | 0.19 | -0.05 | **0.69** | 0.23 | 0.17 | 0.29 |
| 1999 | 0.65 | 0.28 | 0.14 | 0.10 | -0.04 | **0.68** | 0.24 | 0.18 | 0.31 |
| 2000 | 0.78 | 0.10 | 0.12 | 0.22 | -0.07 | **0.84** | 0.03 | -0.08 | 0.21 |
| 2001 | 0.78 | 0.10 | 0.10 | 0.24 | -0.06 | **0.83** | 0.04 | -0.07 | 0.22 |
| 2002 | 0.78 | 0.10 | 0.11 | 0.40 | -0.11 | **0.88** | -0.02 | -0.13 | 0.16 |
| 2003 | 0.51 | 0.53 | 0.08 | 0.21 | -0.05 | **0.53** | 0.49 | 0.28 | 0.74 |
| 2004 | 0.51 | 0.53 | 0.10 | 0.35 | -0.09 | **0.56** | 0.44 | 0.23 | 0.70 |
| 2005 | 0.52 | 0.50 | 0.13 | 0.17 | -0.06 | **0.55** | 0.44 | 0.16 | 0.86 |
| 2006 | 0.53 | 0.48 | 0.09 | 0.18 | -0.04 | **0.56** | 0.44 | 0.11 | 0.98 |

Table A8.7 continued.

New Jersey - Delaware Bay
C-hat adjustment = 1.00; bootstrap GOF probability = 0.79 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1989 | 0.89 | -0.04 | 0.11 | 1.00 | 0.00 | **0.89** | -0.04 | -0.11 | 0.14 |
| 1990 | 0.64 | 0.29 | 0.12 | 0.50 | -0.15 | **0.75** | 0.13 | 0.00 | 0.30 |
| 1991 | 0.61 | 0.34 | 0.25 | 0.38 | -0.33 | **0.91** | -0.05 | -0.22 | 0.17 |
| 1992 | 0.63 | 0.31 | 0.09 | 1.00 | -0.20 | **0.80** | 0.08 | -0.04 | 0.22 |
| 1993 | 0.63 | 0.31 | 0.10 | 0.77 | -0.18 | **0.76** | 0.12 | 0.00 | 0.26 |
| 1994 | 0.64 | 0.30 | 0.11 | 0.79 | -0.20 | **0.79** | 0.08 | -0.03 | 0.21 |
| 1995 | 0.67 | 0.25 | 0.11 | 0.61 | -0.16 | **0.79** | 0.08 | 0.02 | 0.14 |
| 1996 | 0.66 | 0.26 | 0.13 | 0.42 | -0.15 | **0.78** | 0.10 | 0.05 | 0.16 |
| 1997 | 0.67 | 0.26 | 0.09 | 0.42 | -0.10 | **0.74** | 0.15 | 0.10 | 0.21 |
| 1998 | 0.66 | 0.27 | 0.16 | 0.30 | -0.14 | **0.76** | 0.12 | 0.05 | 0.19 |
| 1999 | 0.67 | 0.25 | 0.12 | 0.30 | -0.10 | **0.74** | 0.15 | 0.09 | 0.21 |
| 2000 | 0.75 | 0.13 | 0.10 | 0.30 | -0.07 | **0.81** | 0.06 | -0.02 | 0.15 |
| 2001 | 0.75 | 0.14 | 0.09 | 0.29 | -0.07 | **0.81** | 0.06 | -0.01 | 0.16 |
| 2002 | 0.75 | 0.13 | 0.08 | 0.34 | -0.07 | **0.81** | 0.07 | -0.01 | 0.16 |
| 2003 | 0.53 | 0.48 | 0.10 | 0.35 | -0.09 | **0.58** | 0.39 | 0.28 | 0.52 |
| 2004 | 0.53 | 0.49 | 0.11 | 0.36 | -0.10 | **0.59** | 0.38 | 0.27 | 0.52 |
| 2005 | 0.47 | 0.60 | 0.13 | 0.22 | -0.08 | **0.51** | 0.52 | 0.24 | 0.89 |
| 2006 | 0.49 | 0.57 | 0.11 | 0.32 | -0.09 | **0.54** | 0.47 | 0.17 | 0.90 |

North Carolina - Cooperative Winter Trawl Survey
C-hat adjustment = 1.395; bootstrap GOF probability = 0.496 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0.70 | 0.20 | 0.09 | 0.72 | -0.16 | **0.84** | 0.03 | -0.13 | 0.29 |
| 1989 | 0.68 | 0.23 | 0.06 | 0.78 | -0.10 | **0.76** | 0.12 | 0.00 | 0.29 |
| 1990 | 0.68 | 0.24 | 0.07 | 0.64 | -0.11 | **0.76** | 0.12 | 0.03 | 0.24 |
| 1991 | 0.68 | 0.24 | 0.09 | 0.56 | -0.12 | **0.77** | 0.12 | 0.03 | 0.22 |
| 1992 | 0.70 | 0.21 | 0.10 | 0.50 | -0.12 | **0.80** | 0.08 | -0.09 | 0.35 |
| 1993 | 0.68 | 0.23 | 0.09 | 0.47 | -0.10 | **0.76** | 0.12 | 0.00 | 0.27 |
| 1994 | 0.67 | 0.25 | 0.08 | 0.50 | -0.09 | **0.74** | 0.15 | 0.03 | 0.32 |
| 1995 | 0.68 | 0.23 | 0.10 | 0.34 | -0.09 | **0.75** | 0.14 | -0.02 | 0.39 |
| 1996 | 0.66 | 0.27 | 0.05 | 0.28 | -0.03 | **0.68** | 0.24 | 0.15 | 0.34 |
| 1997 | 0.65 | 0.29 | 0.09 | 0.27 | -0.06 | **0.69** | 0.22 | 0.07 | 0.43 |
| 1998 | 0.66 | 0.27 | 0.11 | 0.22 | -0.07 | **0.71** | 0.20 | 0.06 | 0.38 |
| 1999 | 0.68 | 0.24 | 0.10 | 0.23 | -0.06 | **0.72** | 0.18 | -0.01 | 0.51 |
| 2000 | 0.66 | 0.26 | 0.05 | 0.31 | -0.04 | **0.69** | 0.22 | 0.07 | 0.45 |
| 2001 | 0.68 | 0.24 | 0.09 | 0.24 | -0.05 | **0.72** | 0.18 | 0.09 | 0.31 |
| 2002 | 0.69 | 0.22 | 0.06 | 0.31 | -0.05 | **0.72** | 0.18 | 0.05 | 0.35 |
| 2003 | 0.66 | 0.27 | 0.06 | 0.27 | -0.04 | **0.69** | 0.23 | 0.13 | 0.35 |
| 2004 | 0.68 | 0.24 | 0.07 | 0.27 | -0.05 | **0.71** | 0.19 | 0.01 | 0.49 |
| 2005 | 0.65 | 0.28 | 0.05 | 0.27 | -0.03 | **0.67** | 0.25 | 0.10 | 0.47 |
| 2006 | 0.66 | 0.27 | 0.07 | 0.28 | -0.05 | **0.69** | 0.22 | 0.12 | 0.33 |

Table A8.7. Continued.

**Producer Area Programs**

Delaware / Pennsylvania - Delaware River
C-hat adjustment = 1.02; bootstrap GOF probability = 0.79 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1993 | 0.71 | 0.20 | 0.11 | 0.29 | -0.084 | **0.77** | 0.11 | -0.21 | 0.59 |
| 1994 | 0.70 | 0.20 | 0.11 | 0.33 | -0.095 | **0.78** | 0.10 | -0.22 | 0.58 |
| 1995 | 0.60 | 0.37 | 0.12 | 0.40 | -0.125 | **0.68** | 0.23 | 0.16 | 0.32 |
| 1996 | 0.60 | 0.37 | 0.14 | 0.28 | -0.109 | **0.67** | 0.25 | 0.18 | 0.34 |
| 1997 | 0.60 | 0.37 | 0.11 | 0.31 | -0.089 | **0.65** | 0.28 | 0.20 | 0.36 |
| 1998 | 0.59 | 0.37 | 0.14 | 0.18 | -0.074 | **0.64** | 0.29 | 0.22 | 0.38 |
| 1999 | 0.59 | 0.37 | 0.09 | 0.19 | -0.044 | **0.62** | 0.32 | 0.24 | 0.41 |
| 2000 | 0.60 | 0.36 | 0.14 | 0.17 | -0.070 | **0.65** | 0.29 | 0.20 | 0.39 |
| 2001 | 0.60 | 0.36 | 0.14 | 0.10 | -0.043 | **0.63** | 0.31 | 0.23 | 0.41 |
| 2002 | 0.60 | 0.35 | 0.09 | 0.20 | -0.046 | **0.63** | 0.31 | 0.21 | 0.41 |
| 2003 | 0.60 | 0.36 | 0.11 | 0.33 | -0.095 | **0.66** | 0.26 | 0.16 | 0.38 |
| 2004 | 0.60 | 0.36 | 0.11 | 0.24 | -0.071 | **0.65** | 0.29 | 0.18 | 0.40 |
| 2005 | 0.60 | 0.35 | 0.10 | 0.25 | -0.065 | **0.65** | 0.29 | 0.16 | 0.43 |
| 2006 | 0.60 | 0.36 | 0.11 | 0.18 | -0.054 | **0.64** | 0.30 | 0.14 | 0.50 |

Maryland - Chesapeake Bay Spring Spawning Stock
C-hat adjustment = 1.0; bootstrap GOF probability = 0.86 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1987 | 0.90 | -0.05 | 0.03 | | 0.00 | **0.90** | -0.05 | -0.12 | 0.19 |
| 1988 | 0.90 | -0.05 | 0.04 | 0.67 | -0.06 | **0.96** | -0.11 | -0.18 | 0.10 |
| 1989 | 0.90 | -0.05 | 0.05 | 0.79 | -0.09 | **0.99** | -0.14 | -0.21 | 0.07 |
| 1990 | 0.67 | 0.26 | 0.07 | 0.57 | -0.09 | **0.73** | 0.16 | 0.11 | 0.22 |
| 1991 | 0.66 | 0.26 | 0.12 | 0.59 | -0.18 | **0.81** | 0.07 | 0.00 | 0.14 |
| 1992 | 0.66 | 0.26 | 0.11 | 0.52 | -0.14 | **0.78** | 0.10 | 0.06 | 0.15 |
| 1993 | 0.67 | 0.26 | 0.10 | 0.46 | -0.11 | **0.75** | 0.14 | 0.09 | 0.19 |
| 1994 | 0.67 | 0.26 | 0.09 | 0.47 | -0.11 | **0.75** | 0.14 | 0.09 | 0.20 |
| 1995 | 0.64 | 0.29 | 0.12 | 0.26 | -0.08 | **0.70** | 0.21 | 0.16 | 0.26 |
| 1996 | 0.64 | 0.29 | 0.09 | 0.28 | -0.07 | **0.69** | 0.22 | 0.17 | 0.28 |
| 1997 | 0.64 | 0.29 | 0.11 | 0.22 | -0.07 | **0.69** | 0.22 | 0.16 | 0.29 |
| 1998 | 0.64 | 0.30 | 0.09 | 0.19 | -0.05 | **0.67** | 0.25 | 0.18 | 0.32 |
| 1999 | 0.64 | 0.29 | 0.12 | 0.19 | -0.06 | **0.68** | 0.23 | 0.17 | 0.29 |
| 2000 | 0.61 | 0.34 | 0.08 | 0.19 | -0.04 | **0.64** | 0.30 | 0.19 | 0.43 |
| 2001 | 0.61 | 0.35 | 0.07 | 0.25 | -0.05 | **0.64** | 0.30 | 0.19 | 0.43 |
| 2002 | 0.61 | 0.34 | 0.06 | 0.36 | -0.05 | **0.65** | 0.28 | 0.18 | 0.42 |
| 2003 | 0.62 | 0.33 | 0.07 | 0.20 | -0.04 | **0.65** | 0.29 | 0.15 | 0.47 |
| 2004 | 0.62 | 0.32 | 0.05 | 0.17 | -0.02 | **0.63** | 0.30 | 0.16 | 0.49 |
| 2005 | 0.63 | 0.32 | 0.06 | 0.23 | -0.03 | **0.65** | 0.28 | 0.12 | 0.50 |
| 2006 | 0.61 | 0.35 | 0.07 | 0.22 | -0.04 | **0.63** | 0.31 | 0.08 | 0.66 |

Table A8.7 continued.

Virginia - Rappahannock River
C-hat adjustment = 1.16; bootstrap GOF probability = 0.16 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 0.63 | 0.31 | 0.09 | 0.58 | -0.13 | **0.72** | 0.18 | 0.10 | 0.26 |
| 1991 | 0.63 | 0.31 | 0.09 | 0.56 | -0.13 | **0.72** | 0.17 | 0.10 | 0.26 |
| 1992 | 0.63 | 0.31 | 0.12 | 0.53 | -0.17 | **0.76** | 0.12 | 0.05 | 0.21 |
| 1993 | 0.63 | 0.31 | 0.10 | 0.35 | -0.09 | **0.69** | 0.21 | 0.14 | 0.30 |
| 1994 | 0.63 | 0.31 | 0.08 | 0.32 | -0.07 | **0.68** | 0.24 | 0.16 | 0.33 |
| 1995 | 0.59 | 0.38 | 0.13 | 0.20 | -0.08 | **0.64** | 0.30 | 0.21 | 0.40 |
| 1996 | 0.59 | 0.38 | 0.05 | 0.13 | -0.02 | **0.60** | 0.37 | 0.28 | 0.47 |
| 1997 | 0.59 | 0.38 | 0.08 | 0.17 | -0.04 | **0.61** | 0.35 | 0.26 | 0.45 |
| 1998 | 0.59 | 0.38 | 0.13 | 0.22 | -0.08 | **0.64** | 0.29 | 0.20 | 0.40 |
| 1999 | 0.59 | 0.38 | 0.10 | 0.20 | -0.06 | **0.62** | 0.32 | 0.23 | 0.43 |
| 2000 | 0.67 | 0.25 | 0.08 | 0.35 | -0.07 | **0.72** | 0.18 | 0.07 | 0.33 |
| 2001 | 0.67 | 0.25 | 0.07 | 0.30 | -0.05 | **0.71** | 0.20 | 0.09 | 0.35 |
| 2002 | 0.67 | 0.25 | 0.09 | 0.30 | -0.07 | **0.72** | 0.18 | 0.06 | 0.32 |
| 2003 | 0.52 | 0.51 | 0.09 | 0.25 | -0.06 | **0.55** | 0.45 | 0.24 | 0.71 |
| 2004 | 0.52 | 0.51 | 0.06 | 0.32 | -0.05 | **0.55** | 0.46 | 0.25 | 0.72 |
| 2005 | 0.62 | 0.32 | 0.06 | 0.24 | -0.04 | **0.65** | 0.29 | 0.01 | 0.78 |
| 2006 | 0.63 | 0.32 | 0.07 | 0.29 | -0.05 | **0.66** | 0.27 | -0.01 | 0.78 |

Hudson River
C-hat adjustment = 0.83; bootstrap GOF probability = 0.11 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0.71 | 0.20 | 0.09 | 0.56 | -0.12 | **0.80** | 0.07 | -0.05 | 0.24 |
| 1989 | 0.70 | 0.20 | 0.11 | 0.79 | -0.20 | **0.88** | -0.02 | -0.14 | 0.15 |
| 1990 | 0.64 | 0.29 | 0.13 | 0.69 | -0.22 | **0.83** | 0.04 | -0.01 | 0.09 |
| 1991 | 0.65 | 0.29 | 0.11 | 0.61 | -0.15 | **0.76** | 0.12 | 0.08 | 0.17 |
| 1992 | 0.64 | 0.29 | 0.13 | 0.61 | -0.19 | **0.80** | 0.07 | 0.03 | 0.12 |
| 1993 | 0.64 | 0.29 | 0.13 | 0.55 | -0.18 | **0.78** | 0.09 | 0.05 | 0.14 |
| 1994 | 0.65 | 0.29 | 0.12 | 0.60 | -0.18 | **0.79** | 0.09 | 0.05 | 0.14 |
| 1995 | 0.65 | 0.28 | 0.11 | 0.46 | -0.13 | **0.75** | 0.14 | 0.10 | 0.18 |
| 1996 | 0.65 | 0.28 | 0.13 | 0.29 | -0.10 | **0.73** | 0.17 | 0.13 | 0.21 |
| 1997 | 0.65 | 0.28 | 0.16 | 0.24 | -0.11 | **0.73** | 0.16 | 0.12 | 0.20 |
| 1998 | 0.65 | 0.28 | 0.13 | 0.28 | -0.10 | **0.72** | 0.17 | 0.14 | 0.21 |
| 1999 | 0.65 | 0.28 | 0.13 | 0.31 | -0.11 | **0.73** | 0.16 | 0.12 | 0.20 |
| 2000 | 0.66 | 0.26 | 0.08 | 0.40 | -0.08 | **0.72** | 0.18 | 0.12 | 0.24 |
| 2001 | 0.66 | 0.26 | 0.08 | 0.33 | -0.06 | **0.70** | 0.20 | 0.15 | 0.26 |
| 2002 | 0.66 | 0.26 | 0.11 | 0.20 | -0.06 | **0.70** | 0.20 | 0.14 | 0.28 |
| 2003 | 0.67 | 0.25 | 0.09 | 0.40 | -0.09 | **0.74** | 0.15 | 0.08 | 0.23 |
| 2004 | 0.67 | 0.25 | 0.11 | 0.25 | -0.07 | **0.72** | 0.17 | 0.10 | 0.26 |
| 2005 | 0.67 | 0.24 | 0.10 | 0.32 | -0.08 | **0.73** | 0.16 | 0.08 | 0.26 |
| 2006 | 0.67 | 0.25 | 0.09 | 0.28 | -0.06 | **0.71** | 0.19 | 0.09 | 0.30 |

Table A8.8. Unadjusted (unadj.) and bias-corrected (adj.) estimates of survival (S) and fishing mortality (F) for striped bass ≥ 18 inches, from Program MARK and assuming a constant natural mortality, for each tagging program. S(adj.) (converted to Z) is an input to the catch equation.

**Producer Area Programs**

Hudson River
C-hat adjustment = 0.75129; bootstrap GOF probability =0.01 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0.93 | -0.08 | 0.07 | 0.75 | -0.11 | **1.05** | -0.19 | -0.26 | 0.38 |
| 1989 | 0.33 | 0.96 | 0.08 | 0.83 | -0.16 | **0.39** | 0.79 | 0.64 | 0.96 |
| 1990 | 0.77 | 0.11 | 0.25 | 0.81 | -0.52 | **1.60** | -0.62 | -0.66 | -0.58 |
| 1991 | 0.84 | 0.02 | 0.12 | 0.75 | -0.21 | **1.07** | -0.22 | -0.31 | -0.01 |
| 1992 | 0.63 | 0.32 | 0.11 | 0.64 | -0.16 | **0.75** | 0.14 | 0.01 | 0.30 |
| 1993 | 0.67 | 0.26 | 0.10 | 0.64 | -0.16 | **0.79** | 0.09 | -0.05 | 0.28 |
| 1994 | 0.68 | 0.23 | 0.10 | 0.67 | -0.15 | **0.80** | 0.07 | -0.07 | 0.29 |
| 1995 | 0.65 | 0.28 | 0.09 | 0.50 | -0.11 | **0.73** | 0.16 | 0.03 | 0.35 |
| 1996 | 0.64 | 0.30 | 0.11 | 0.44 | -0.12 | **0.72** | 0.17 | 0.00 | 0.43 |
| 1997 | 0.66 | 0.26 | 0.13 | 0.31 | -0.11 | **0.74** | 0.15 | -0.04 | 0.44 |
| 1998 | 0.68 | 0.23 | 0.11 | 0.33 | -0.10 | **0.76** | 0.13 | -0.02 | 0.35 |
| 1999 | 0.57 | 0.42 | 0.10 | 0.38 | -0.10 | **0.63** | 0.31 | 0.15 | 0.52 |
| 2000 | 0.88 | -0.02 | 0.08 | 0.57 | -0.11 | **0.98** | -0.13 | -0.23 | 0.21 |
| 2001 | 0.75 | 0.13 | 0.07 | 0.51 | -0.08 | **0.82** | 0.05 | -0.11 | 0.36 |
| 2002 | 0.49 | 0.57 | 0.07 | 0.58 | -0.10 | **0.54** | 0.47 | 0.27 | 0.71 |
| 2003 | 0.67 | 0.26 | 0.09 | 0.55 | -0.11 | **0.75** | 0.14 | -0.01 | 0.34 |
| 2004 | 0.71 | 0.19 | 0.09 | 0.44 | -0.10 | **0.79** | 0.08 | -0.07 | 0.34 |
| 2005 | 0.70 | 0.21 | 0.08 | 0.55 | -0.10 | **0.77** | 0.11 | -0.09 | 0.48 |
| 2006 | 0.66 | 0.26 | 0.07 | 0.43 | -0.08 | **0.72** | 0.18 | 0.11 | 0.27 |

Delaware / Pennsylvania - Delaware River
C-hat adjustment = 0.80; bootstrap GOF probability = 0.89 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1993 | 0.72 | 0.18 | 0.10 | 0.42 | -0.10 | **0.80** | 0.08 | -0.13 | 0.49 |
| 1994 | 0.62 | 0.32 | 0.10 | 0.58 | -0.14 | **0.72** | 0.17 | -0.02 | 0.45 |
| 1995 | 0.53 | 0.49 | 0.12 | 0.56 | -0.16 | **0.63** | 0.31 | 0.05 | 0.67 |
| 1996 | 0.73 | 0.17 | 0.16 | 0.54 | -0.23 | **0.94** | -0.09 | -0.32 | 0.51 |
| 1997 | 0.67 | 0.25 | 0.09 | 0.52 | -0.11 | **0.75** | 0.13 | -0.06 | 0.46 |
| 1998 | 0.57 | 0.41 | 0.10 | 0.53 | -0.13 | **0.66** | 0.27 | 0.08 | 0.52 |
| 1999 | 0.56 | 0.43 | 0.08 | 0.53 | -0.10 | **0.62** | 0.33 | 0.12 | 0.60 |
| 2000 | 0.58 | 0.39 | 0.11 | 0.42 | -0.11 | **0.66** | 0.27 | 0.13 | 0.46 |
| 2001 | 0.61 | 0.35 | 0.10 | 0.41 | -0.11 | **0.68** | 0.24 | 0.07 | 0.46 |
| 2002 | 0.58 | 0.40 | 0.08 | 0.40 | -0.07 | **0.62** | 0.32 | 0.16 | 0.53 |
| 2003 | 0.53 | 0.49 | 0.11 | 0.46 | -0.13 | **0.61** | 0.35 | 0.11 | 0.67 |
| 2004 | 0.46 | 0.63 | 0.08 | 0.38 | -0.08 | **0.49** | 0.55 | 0.28 | 0.91 |
| 2005 | 0.50 | 0.53 | 0.11 | 0.51 | -0.14 | **0.59** | 0.38 | 0.11 | 0.77 |
| 2006 | 0.50 | 0.55 | 0.10 | 0.53 | -0.13 | **0.57** | 0.41 | 0.28 | 0.57 |

Table A8.8 continued.

Maryland - Chesapeake Bay Spring Spawning Stock
C-hat adjustment = 1.0005; bootstrap GOF probability =0.11 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1987 | 0.85 | 0.02 | 0.07 | 0.95 | -0.15 | **0.99** | -0.14 | -0.19 | -0.08 |
| 1988 | 0.84 | 0.02 | 0.04 | 0.84 | -0.08 | **0.91** | -0.05 | -0.11 | 0.03 |
| 1989 | 0.86 | 0.01 | 0.03 | 0.93 | -0.07 | **0.92** | -0.07 | -0.14 | 0.06 |
| 1990 | 0.63 | 0.31 | 0.06 | 0.58 | -0.07 | **0.68** | 0.23 | 0.17 | 0.30 |
| 1991 | 0.64 | 0.30 | 0.08 | 0.46 | -0.09 | **0.70** | 0.20 | 0.15 | 0.26 |
| 1992 | 0.63 | 0.31 | 0.11 | 0.43 | -0.12 | **0.72** | 0.18 | 0.13 | 0.23 |
| 1993 | 0.63 | 0.31 | 0.09 | 0.38 | -0.08 | **0.69** | 0.22 | 0.17 | 0.27 |
| 1994 | 0.64 | 0.30 | 0.10 | 0.43 | -0.11 | **0.71** | 0.19 | 0.15 | 0.24 |
| 1995 | 0.59 | 0.38 | 0.12 | 0.32 | -0.10 | **0.65** | 0.27 | 0.22 | 0.34 |
| 1996 | 0.59 | 0.38 | 0.11 | 0.35 | -0.10 | **0.65** | 0.28 | 0.21 | 0.35 |
| 1997 | 0.59 | 0.37 | 0.11 | 0.27 | -0.08 | **0.64** | 0.29 | 0.20 | 0.40 |
| 1998 | 0.57 | 0.41 | 0.11 | 0.25 | -0.07 | **0.62** | 0.33 | 0.19 | 0.50 |
| 1999 | 0.58 | 0.39 | 0.11 | 0.21 | -0.06 | **0.62** | 0.33 | 0.25 | 0.42 |
| 2000 | 0.48 | 0.57 | 0.09 | 0.36 | -0.09 | **0.53** | 0.48 | 0.37 | 0.61 |
| 2001 | 0.48 | 0.59 | 0.08 | 0.33 | -0.06 | **0.51** | 0.52 | 0.41 | 0.65 |
| 2002 | 0.49 | 0.57 | 0.07 | 0.32 | -0.06 | **0.52** | 0.51 | 0.38 | 0.66 |
| 2003 | 0.52 | 0.50 | 0.09 | 0.24 | -0.05 | **0.55** | 0.44 | 0.30 | 0.62 |
| 2004 | 0.52 | 0.51 | 0.07 | 0.25 | -0.04 | **0.54** | 0.47 | 0.32 | 0.63 |
| 2005 | 0.51 | 0.52 | 0.06 | 0.28 | -0.04 | **0.53** | 0.48 | 0.31 | 0.69 |
| 2006 | 0.52 | 0.50 | 0.09 | 0.27 | -0.06 | **0.55** | 0.45 | 0.33 | 0.58 |

Virginia - Rappahannock River
C-hat adjustment = 1.60; bootstrap GOF probability = 0.108 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 0.82 | 0.05 | 0.11 | 0.48 | -0.14 | **0.95** | -0.10 | -0.24 | 0.25 |
| 1991 | 0.28 | 1.14 | 0.06 | 0.52 | -0.08 | **0.30** | 1.05 | 0.70 | 1.45 |
| 1992 | 0.80 | 0.07 | 0.12 | 0.41 | -0.14 | **0.94** | -0.09 | -0.27 | 0.81 |
| 1993 | 0.60 | 0.35 | 0.09 | 0.46 | -0.11 | **0.68** | 0.24 | -0.07 | 0.84 |
| 1994 | 0.57 | 0.42 | 0.09 | 0.38 | -0.09 | **0.62** | 0.32 | -0.01 | 0.92 |
| 1995 | 0.68 | 0.23 | 0.08 | 0.26 | -0.05 | **0.72** | 0.17 | -0.08 | 0.77 |
| 1996 | 0.64 | 0.30 | 0.06 | 0.27 | -0.04 | **0.67** | 0.26 | -0.03 | 0.85 |
| 1997 | 0.57 | 0.42 | 0.07 | 0.33 | -0.06 | **0.60** | 0.36 | 0.06 | 0.84 |
| 1998 | 0.41 | 0.73 | 0.06 | 0.36 | -0.06 | **0.44** | 0.67 | 0.34 | 1.11 |
| 1999 | 0.37 | 0.85 | 0.08 | 0.29 | -0.06 | **0.39** | 0.79 | 0.47 | 1.18 |
| 2000 | 0.43 | 0.69 | 0.07 | 0.44 | -0.07 | **0.47** | 0.61 | 0.34 | 0.96 |
| 2001 | 0.48 | 0.59 | 0.07 | 0.37 | -0.07 | **0.51** | 0.52 | 0.17 | 1.04 |
| 2002 | 0.62 | 0.33 | 0.06 | 0.37 | -0.06 | **0.66** | 0.27 | -0.04 | 0.88 |
| 2003 | 0.76 | 0.12 | 0.07 | 0.27 | -0.05 | **0.80** | 0.07 | -0.14 | 0.70 |
| 2004 | 0.31 | 1.03 | 0.05 | 0.28 | -0.04 | **0.32** | 0.99 | 0.58 | 1.48 |
| 2005 | 0.37 | 0.83 | 0.05 | 0.28 | -0.03 | **0.39** | 0.80 | 0.35 | 1.41 |
| 2006 | 0.51 | 0.51 | 0.07 | 0.36 | -0.07 | **0.55** | 0.45 | 0.16 | 0.85 |

Table A8.8 continued.

**Coast Programs**

North Carolina - Cooperative Winter Trawl Survey
C-hat adjustment = 2.55; bootstrap GOF probability < 0.001 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0.91 | -0.06 | 0.09 | 0.85 | -0.17 | **1.10** | -0.24 | -0.27 | -0.21 |
| 1989 | 0.62 | 0.32 | 0.04 | 0.89 | -0.08 | **0.68** | 0.24 | 0.06 | 0.49 |
| 1990 | 0.54 | 0.47 | 0.07 | 0.69 | -0.11 | **0.60** | 0.36 | 0.18 | 0.58 |
| 1991 | 0.63 | 0.31 | 0.09 | 0.60 | -0.13 | **0.72** | 0.18 | 0.00 | 0.43 |
| 1992 | 0.78 | 0.10 | 0.10 | 0.51 | -0.12 | **0.88** | -0.03 | -0.21 | 0.47 |
| 1993 | 0.79 | 0.09 | 0.09 | 0.50 | -0.10 | **0.88** | -0.02 | -0.19 | 0.44 |
| 1994 | 0.48 | 0.58 | 0.07 | 0.55 | -0.09 | **0.53** | 0.48 | 0.29 | 0.71 |
| 1995 | 0.91 | -0.05 | 0.09 | 0.47 | -0.11 | **1.02** | -0.17 | -0.19 | -0.14 |
| 1996 | 0.57 | 0.41 | 0.05 | 0.42 | -0.05 | **0.60** | 0.36 | 0.14 | 0.68 |
| 1997 | 0.50 | 0.54 | 0.08 | 0.37 | -0.07 | **0.54** | 0.46 | 0.18 | 0.86 |
| 1998 | 0.64 | 0.29 | 0.10 | 0.36 | -0.09 | **0.71** | 0.19 | -0.05 | 0.65 |
| 1999 | 0.91 | -0.06 | 0.09 | 0.34 | -0.08 | **0.99** | -0.14 | -0.17 | -0.11 |
| 2000 | 0.30 | 1.04 | 0.06 | 0.47 | -0.06 | **0.33** | 0.97 | 0.75 | 1.22 |
| 2001 | 0.58 | 0.40 | 0.08 | 0.41 | -0.08 | **0.62** | 0.32 | 0.13 | 0.58 |
| 2002 | 0.56 | 0.43 | 0.07 | 0.41 | -0.07 | **0.60** | 0.35 | 0.15 | 0.63 |
| 2003 | 0.57 | 0.42 | 0.07 | 0.36 | -0.06 | **0.60** | 0.35 | 0.14 | 0.65 |
| 2004 | 0.93 | -0.08 | 0.07 | 0.37 | -0.06 | **0.99** | -0.14 | -0.16 | -0.13 |
| 2005 | 0.29 | 1.11 | 0.04 | 0.41 | -0.03 | **0.29** | 1.07 | 0.80 | 1.38 |
| 2006 | 0.62 | 0.33 | 0.07 | 0.35 | -0.06 | **0.66** | 0.27 | 0.17 | 0.39 |

New Jersey - Delaware Bay
C-hat adjustment = 1.25; bootstrap GOF probability = 0.08 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Released | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1989 | 0.81 | 0.06 | 0.12 | 0.92 | -0.25 | **1.08** | -0.23 | -0.41 | 0.50 |
| 1990 | 0.83 | 0.04 | 0.12 | 0.83 | -0.23 | **1.09** | -0.23 | -0.40 | 0.80 |
| 1991 | 0.57 | 0.42 | 0.09 | 0.77 | -0.15 | **0.67** | 0.26 | 0.01 | 0.61 |
| 1992 | 0.62 | 0.32 | 0.08 | 0.88 | -0.16 | **0.74** | 0.15 | 0.00 | 0.36 |
| 1993 | 0.54 | 0.47 | 0.08 | 0.84 | -0.16 | **0.64** | 0.30 | 0.18 | 0.44 |
| 1994 | 0.66 | 0.27 | 0.08 | 0.86 | -0.16 | **0.79** | 0.09 | -0.01 | 0.21 |
| 1995 | 0.81 | 0.06 | 0.09 | 0.66 | -0.14 | **0.94** | -0.09 | -0.18 | 0.05 |
| 1996 | 0.72 | 0.19 | 0.12 | 0.60 | -0.17 | **0.86** | 0.00 | -0.15 | 0.23 |
| 1997 | 0.54 | 0.46 | 0.10 | 0.50 | -0.12 | **0.61** | 0.34 | 0.16 | 0.57 |
| 1998 | 0.71 | 0.20 | 0.12 | 0.47 | -0.15 | **0.83** | 0.03 | -0.09 | 0.22 |
| 1999 | 0.70 | 0.21 | 0.08 | 0.50 | -0.10 | **0.77** | 0.11 | 0.00 | 0.25 |
| 2000 | 0.69 | 0.22 | 0.09 | 0.50 | -0.10 | **0.77** | 0.11 | 0.01 | 0.26 |
| 2001 | 0.80 | 0.08 | 0.09 | 0.46 | -0.10 | **0.89** | -0.03 | -0.14 | 0.17 |
| 2002 | 0.55 | 0.45 | 0.06 | 0.42 | -0.06 | **0.58** | 0.39 | 0.24 | 0.56 |
| 2003 | 0.53 | 0.48 | 0.09 | 0.48 | -0.10 | **0.59** | 0.37 | 0.23 | 0.54 |
| 2004 | 0.66 | 0.26 | 0.10 | 0.43 | -0.11 | **0.75** | 0.14 | -0.02 | 0.39 |
| 2005 | 0.55 | 0.45 | 0.10 | 0.42 | -0.10 | **0.61** | 0.34 | 0.11 | 0.67 |
| 2006 | 0.57 | 0.41 | 0.08 | 0.45 | -0.09 | **0.62** | 0.32 | 0.23 | 0.42 |

Table A8.8. Continued.

Massachusetts
C-hat adjustment= 1.026, bootstrap GOF probablitlity = 0.43 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** | F(adj.) | 95%LCL F(adj) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1992 | 0.74 | 0.16 | 0.07 | 0.76 | -0.11 | **0.83** | 0.03 | -0.01 | 0.08 |
| 1993 | 0.74 | 0.16 | 0.06 | 0.59 | -0.08 | **0.80** | 0.07 | 0.03 | 0.12 |
| 1994 | 0.74 | 0.16 | 0.06 | 0.58 | -0.08 | **0.80** | 0.08 | 0.03 | 0.13 |
| 1995 | 0.73 | 0.16 | 0.06 | 0.47 | -0.06 | **0.78** | 0.10 | 0.07 | 0.13 |
| 1996 | 0.73 | 0.16 | 0.09 | 0.43 | -0.10 | **0.81** | 0.06 | 0.03 | 0.10 |
| 1997 | 0.73 | 0.16 | 0.08 | 0.28 | -0.06 | **0.78** | 0.10 | 0.07 | 0.14 |
| 1998 | 0.73 | 0.16 | 0.08 | 0.33 | -0.07 | **0.78** | 0.09 | 0.06 | 0.13 |
| 1999 | 0.73 | 0.16 | 0.06 | 0.32 | -0.05 | **0.77** | 0.12 | 0.09 | 0.15 |
| 2000 | 0.73 | 0.16 | 0.05 | 0.24 | -0.03 | **0.76** | 0.13 | 0.09 | 0.18 |
| 2001 | 0.73 | 0.16 | 0.05 | 0.35 | -0.04 | **0.76** | 0.12 | 0.08 | 0.17 |
| 2002 | 0.73 | 0.16 | 0.07 | 0.29 | -0.05 | **0.77** | 0.11 | 0.07 | 0.16 |
| 2003 | 0.73 | 0.16 | 0.05 | 0.23 | -0.03 | **0.75** | 0.14 | 0.09 | 0.19 |
| 2004 | 0.73 | 0.16 | 0.04 | 0.22 | -0.02 | **0.75** | 0.14 | 0.09 | 0.20 |
| 2005 | 0.73 | 0.16 | 0.05 | 0.29 | -0.04 | **0.76** | 0.13 | 0.07 | 0.19 |
| 2006 | 0.73 | 0.16 | 0.06 | 0.34 | -0.05 | **0.77** | 0.12 | 0.05 | 0.19 |

New York Ocean Haul Seine
C-hat adjustment = 1.923; bootstrap GOF probability = 0 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery | % Released | Bias Live Release | **S(adj.)** | F(adj.) | LCLM (F) | 95%UCL F(adj) |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0.55 | 0.45 | 0.08 | 0.94 | -0.16 | **0.65** | 0.28 | 0.12 | 0.47 |
| 1989 | 0.91 | -0.05 | 0.09 | 0.93 | -0.19 | **1.12** | -0.26 | -0.28 | -0.24 |
| 1990 | 0.55 | 0.45 | 0.07 | 0.83 | -0.14 | **0.64** | 0.30 | 0.13 | 0.52 |
| 1991 | 0.76 | 0.13 | 0.08 | 0.69 | -0.13 | **0.87** | -0.01 | -0.15 | 0.26 |
| 1992 | 0.93 | -0.08 | 0.07 | 0.72 | -0.11 | **1.05** | -0.20 | -0.21 | -0.18 |
| 1993 | 0.50 | 0.55 | 0.05 | 0.62 | -0.08 | **0.54** | 0.47 | 0.30 | 0.68 |
| 1994 | 0.68 | 0.23 | 0.06 | 0.71 | -0.10 | **0.76** | 0.13 | -0.02 | 0.33 |
| 1995 | 0.94 | -0.09 | 0.06 | 0.55 | -0.08 | **1.02** | -0.17 | -0.18 | -0.16 |
| 1996 | 0.74 | 0.15 | 0.06 | 0.61 | -0.08 | **0.81** | 0.07 | -0.09 | 0.34 |
| 1997 | 0.64 | 0.30 | 0.05 | 0.57 | -0.07 | **0.69** | 0.22 | 0.02 | 0.54 |
| 1998 | 0.49 | 0.56 | 0.05 | 0.57 | -0.07 | **0.53** | 0.49 | 0.26 | 0.78 |
| 1999 | 0.69 | 0.21 | 0.06 | 0.49 | -0.06 | **0.74** | 0.15 | -0.05 | 0.51 |
| 2000 | 0.59 | 0.38 | 0.05 | 0.58 | -0.06 | **0.62** | 0.32 | 0.10 | 0.65 |
| 2001 | 0.62 | 0.33 | 0.05 | 0.51 | -0.06 | **0.66** | 0.27 | 0.04 | 0.63 |
| 2002 | 0.74 | 0.16 | 0.06 | 0.52 | -0.07 | **0.80** | 0.08 | -0.13 | 0.58 |
| 2003 | 0.56 | 0.42 | 0.05 | 0.43 | -0.05 | **0.59** | 0.37 | 0.08 | 0.86 |
| 2004 | 0.58 | 0.39 | 0.05 | 0.48 | -0.06 | **0.62** | 0.33 | 0.03 | 0.86 |
| 2005 | 0.41 | 0.74 | 0.05 | 0.65 | -0.08 | **0.44** | 0.66 | 0.27 | 1.19 |
| 2006 | 0.51 | 0.52 | 0.07 | 0.63 | -0.10 | **0.57** | 0.41 | 0.10 | 0.87 |

Table A8.9. Estimates of fishing mortality for ≥28 inch striped bass obtained without assuming constant natural mortality, based on exploitation rate and Baranov's catch equation, using bias-adjusted estimates of survival from Table A8.7. Column headings are S: bias-corrected survival rate, Z: total instantaneous mortality, A: annual percentage mortality expressed as a proportion, U: annual exploitation rate, F: instantaneous fishing mortality rate and M: instantaneous natural mortality rate.

**Coast Programs**

Massachusetts Fall Tagging

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | 0.20 | 0.18 | 0.05 | **0.06** | 0.14 |
| 1993 | 0.22 | 0.20 | 0.07 | **0.08** | 0.14 |
| 1994 | 0.24 | 0.21 | 0.05 | **0.05** | 0.19 |
| 1995 | 0.27 | 0.23 | 0.05 | **0.06** | 0.21 |
| 1996 | 0.26 | 0.23 | 0.09 | **0.11** | 0.16 |
| 1997 | 0.27 | 0.23 | 0.17 | **0.20** | 0.07 |
| 1998 | 0.26 | 0.23 | 0.10 | **0.12** | 0.15 |
| 1999 | 0.27 | 0.24 | 0.13 | **0.15** | 0.12 |
| 2000 | 0.28 | 0.25 | 0.13 | **0.15** | 0.13 |
| 2001 | 0.28 | 0.24 | 0.09 | **0.10** | 0.18 |
| 2002 | 0.27 | 0.23 | 0.08 | **0.09** | 0.18 |
| 2003 | 0.30 | 0.26 | 0.11 | **0.13** | 0.17 |
| 2004 | 0.30 | 0.26 | 0.10 | **0.11** | 0.18 |
| 2005 | 0.29 | 0.25 | 0.07 | **0.08** | 0.20 |
| 2006 | 0.27 | 0.23 | 0.10 | **0.11** | 0.16 |
| **Average** | **0.26** | **0.23** | **0.09** | **0.11** | **0.16** |

New York Ocean Haul Seine Fall Tagging

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | -0.06 | -0.06 | 0.05 | **0.05** | -0.11 |
| 1989 | -0.01 | -0.01 | 0.04 | **0.04** | -0.05 |
| 1990 | 0.32 | 0.27 | 0.07 | **0.08** | 0.24 |
| 1991 | 0.31 | 0.26 | 0.12 | **0.14** | 0.17 |
| 1992 | 0.24 | 0.21 | 0.11 | **0.13** | 0.11 |
| 1993 | 0.34 | 0.29 | 0.14 | **0.17** | 0.18 |
| 1994 | 0.32 | 0.28 | 0.08 | **0.10** | 0.22 |
| 1995 | 0.28 | 0.24 | 0.21 | **0.24** | 0.04 |
| 1996 | 0.31 | 0.27 | 0.14 | **0.17** | 0.15 |
| 1997 | 0.33 | 0.28 | 0.36 | **0.42** | -0.09 |
| 1998 | 0.38 | 0.31 | 0.17 | **0.20** | 0.17 |
| 1999 | 0.39 | 0.32 | 0.31 | **0.37** | 0.02 |
| 2000 | 0.18 | 0.16 | 0.18 | **0.20** | -0.02 |
| 2001 | 0.19 | 0.17 | 0.11 | **0.12** | 0.07 |
| 2002 | 0.13 | 0.12 | 0.23 | **0.24** | -0.11 |
| 2003 | 0.64 | 0.47 | 0.15 | **0.20** | 0.43 |
| 2004 | 0.59 | 0.44 | 0.14 | **0.19** | 0.40 |
| 2005 | 0.59 | 0.45 | 0.26 | **0.34** | 0.25 |
| 2006 | 0.59 | 0.44 | 0.13 | **0.17** | 0.42 |
| **Average** | **0.32** | **0.26** | **0.16** | **0.19** | **0.13** |

New Jersey Delaware Bay February-April

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | 0.11 | 0.11 | 0.02 | **0.02** | 0.09 |
| 1990 | 0.28 | 0.25 | 0.04 | **0.05** | 0.23 |
| 1991 | 0.10 | 0.09 | 0.31 | **0.33** | -0.23 |
| 1992 | 0.23 | 0.20 | 0.07 | **0.08** | 0.15 |
| 1993 | 0.27 | 0.24 | 0.09 | **0.10** | 0.17 |
| 1994 | 0.23 | 0.21 | 0.05 | **0.06** | 0.17 |
| 1995 | 0.23 | 0.21 | 0.11 | **0.12** | 0.11 |
| 1996 | 0.25 | 0.22 | 0.20 | **0.23** | 0.02 |
| 1997 | 0.30 | 0.26 | 0.23 | **0.27** | 0.04 |
| 1998 | 0.27 | 0.24 | 0.35 | **0.40** | -0.13 |
| 1999 | 0.30 | 0.26 | 0.12 | **0.14** | 0.15 |
| 2000 | 0.21 | 0.19 | 0.14 | **0.15** | 0.06 |
| 2001 | 0.21 | 0.19 | 0.16 | **0.18** | 0.04 |
| 2002 | 0.22 | 0.19 | 0.12 | **0.13** | 0.09 |
| 2003 | 0.54 | 0.42 | 0.15 | **0.19** | 0.35 |
| 2004 | 0.53 | 0.41 | 0.16 | **0.21** | 0.33 |
| 2005 | 0.67 | 0.49 | 0.17 | **0.23** | 0.44 |
| 2006 | 0.62 | 0.46 | 0.14 | **0.19** | 0.43 |
| **Average** | **0.31** | **0.26** | **0.15** | **0.17** | **0.14** |

North Carolina Winter Trawl Survey

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | 0.18 | 0.16 | 0.06 | **0.07** | 0.11 |
| 1989 | 0.27 | 0.24 | 0.04 | **0.05** | 0.22 |
| 1990 | 0.27 | 0.24 | 0.09 | **0.10** | 0.17 |
| 1991 | 0.27 | 0.23 | 0.07 | **0.08** | 0.18 |
| 1992 | 0.23 | 0.20 | 0.13 | **0.14** | 0.08 |
| 1993 | 0.27 | 0.24 | 0.11 | **0.13** | 0.14 |
| 1994 | 0.30 | 0.26 | 0.08 | **0.09** | 0.21 |
| 1995 | 0.29 | 0.25 | 0.14 | **0.16** | 0.13 |
| 1996 | 0.39 | 0.32 | 0.11 | **0.13** | 0.25 |
| 1997 | 0.37 | 0.31 | 0.18 | **0.22** | 0.15 |
| 1998 | 0.35 | 0.29 | 0.20 | **0.24** | 0.11 |
| 1999 | 0.33 | 0.28 | 0.24 | **0.28** | 0.05 |
| 2000 | 0.37 | 0.31 | 0.06 | **0.07** | 0.30 |
| 2001 | 0.33 | 0.28 | 0.15 | **0.18** | 0.16 |
| 2002 | 0.33 | 0.28 | 0.12 | **0.14** | 0.19 |
| 2003 | 0.38 | 0.31 | 0.11 | **0.14** | 0.24 |
| 2004 | 0.34 | 0.29 | 0.12 | **0.14** | 0.19 |
| 2005 | 0.40 | 0.33 | 0.07 | **0.09** | 0.31 |
| 2006 | 0.37 | 0.31 | 0.12 | **0.15** | 0.22 |
| **Average** | **0.32** | **0.27** | **0.12** | **0.14** | **0.18** |

Table A8.9 continued.

**Producer Area Programs**

Maryland - Chesapeake Bay Spring Spawning Stock

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | 0.17 | 0.10 | | | 0.10 |
| 1988 | 0.17 | 0.10 | 0.07 | **0.08** | 0.02 |
| 1989 | 0.16 | 0.10 | 0.04 | **0.04** | 0.06 |
| 1990 | 0.46 | 0.41 | 0.08 | **0.10** | 0.30 |
| 1991 | 0.45 | 0.41 | 0.12 | **0.15** | 0.26 |
| 1992 | 0.46 | 0.41 | 0.12 | **0.15** | 0.26 |
| 1993 | 0.46 | 0.41 | 0.12 | **0.15** | 0.26 |
| 1994 | 0.45 | 0.41 | 0.11 | **0.14** | 0.27 |
| 1995 | 0.53 | 0.44 | 0.20 | **0.25** | 0.19 |
| 1996 | 0.53 | 0.44 | 0.17 | **0.21** | 0.24 |
| 1997 | 0.52 | 0.44 | 0.23 | **0.29** | 0.15 |
| 1998 | 0.56 | 0.45 | 0.20 | **0.24** | 0.20 |
| 1999 | 0.54 | 0.44 | 0.32 | **0.40** | 0.04 |
| 2000 | 0.72 | 0.49 | 0.17 | **0.22** | 0.28 |
| 2001 | 0.74 | 0.50 | 0.11 | **0.14** | 0.36 |
| 2002 | 0.72 | 0.49 | 0.10 | **0.12** | 0.37 |
| 2003 | 0.65 | 0.48 | 0.10 | **0.13** | 0.34 |
| 2004 | 0.66 | 0.47 | 0.08 | **0.11** | 0.37 |
| 2005 | 0.67 | 0.47 | 0.11 | **0.13** | 0.33 |
| 2006 | 0.65 | 0.50 | 0.13 | **0.16** | 0.33 |
| **Average** | **0.51** | **0.40** | **0.14** | **0.17** | **0.24** |

Virginia - Rappahannock River Spring Spawning Stock

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | 0.33 | 0.28 | 0.25 | **0.30** | 0.03 |
| 1991 | 0.32 | 0.28 | 0.36 | **0.43** | -0.11 |
| 1992 | 0.27 | 0.24 | 0.37 | **0.42** | -0.15 |
| 1993 | 0.36 | 0.31 | 0.37 | **0.44** | -0.08 |
| 1994 | 0.39 | 0.32 | 0.25 | **0.31** | 0.08 |
| 1995 | 0.45 | 0.36 | 0.41 | **0.51** | -0.06 |
| 1996 | 0.52 | 0.40 | 0.18 | **0.23** | 0.29 |
| 1997 | 0.50 | 0.39 | 0.38 | **0.48** | 0.02 |
| 1998 | 0.45 | 0.36 | 0.45 | **0.56** | -0.12 |
| 1999 | 0.48 | 0.38 | 0.28 | **0.35** | 0.12 |
| 2000 | 0.33 | 0.28 | 0.27 | **0.32** | 0.01 |
| 2001 | 0.35 | 0.29 | 0.23 | **0.28** | 0.07 |
| 2002 | 0.33 | 0.28 | 0.31 | **0.36** | -0.04 |
| 2003 | 0.60 | 0.45 | 0.24 | **0.32** | 0.28 |
| 2004 | 0.61 | 0.45 | 0.13 | **0.18** | 0.43 |
| 2005 | 0.43 | 0.35 | 0.16 | **0.20** | 0.24 |
| 2006 | 0.41 | 0.34 | 0.14 | **0.16** | 0.25 |
| **Average** | **0.42** | **0.34** | **0.28** | **0.34** | **0.07** |

Delaware River - Delaware/Pennsylvania Spring Spawning Stock

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | | | | | |
| 1993 | 0.26 | 0.23 | 0.13 | **0.15** | 0.11 |
| 1994 | 0.25 | 0.22 | 0.12 | **0.14** | 0.11 |
| 1995 | 0.38 | 0.32 | 0.14 | **0.17** | 0.22 |
| 1996 | 0.40 | 0.33 | 0.32 | **0.39** | 0.02 |
| 1997 | 0.43 | 0.35 | 0.27 | **0.33** | 0.10 |
| 1998 | 0.44 | 0.36 | 0.28 | **0.35** | 0.10 |
| 1999 | 0.47 | 0.38 | 0.15 | **0.19** | 0.28 |
| 2000 | 0.44 | 0.35 | 0.30 | **0.37** | 0.07 |
| 2001 | 0.46 | 0.37 | 0.27 | **0.33** | 0.13 |
| 2002 | 0.46 | 0.37 | 0.24 | **0.29** | 0.16 |
| 2003 | 0.41 | 0.34 | 0.17 | **0.21** | 0.20 |
| 2004 | 0.44 | 0.35 | 0.24 | **0.30** | 0.14 |
| 2005 | 0.44 | 0.35 | 0.15 | **0.19** | 0.25 |
| 2006 | 0.45 | 0.36 | 0.21 | **0.26** | 0.19 |
| **Average** | **0.41** | **0.33** | **0.21** | **0.26** | **0.15** |

Hudson River Spring Spawning Stock

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | 0.22 | 0.20 | 0.10 | **0.11** | 0.11 |
| 1989 | 0.13 | 0.12 | 0.07 | **0.07** | 0.06 |
| 1990 | 0.19 | 0.17 | 0.12 | **0.13** | 0.06 |
| 1991 | 0.27 | 0.24 | 0.11 | **0.12** | 0.15 |
| 1992 | 0.22 | 0.20 | 0.13 | **0.15** | 0.08 |
| 1993 | 0.24 | 0.22 | 0.17 | **0.19** | 0.06 |
| 1994 | 0.24 | 0.21 | 0.12 | **0.13** | 0.11 |
| 1995 | 0.29 | 0.25 | 0.15 | **0.17** | 0.12 |
| 1996 | 0.32 | 0.27 | 0.23 | **0.27** | 0.05 |
| 1997 | 0.31 | 0.27 | 0.29 | **0.33** | -0.02 |
| 1998 | 0.32 | 0.28 | 0.22 | **0.25** | 0.07 |
| 1999 | 0.31 | 0.27 | 0.22 | **0.25** | 0.06 |
| 2000 | 0.33 | 0.28 | 0.14 | **0.16** | 0.17 |
| 2001 | 0.35 | 0.30 | 0.14 | **0.16** | 0.19 |
| 2002 | 0.35 | 0.30 | 0.19 | **0.23** | 0.12 |
| 2003 | 0.30 | 0.26 | 0.14 | **0.16** | 0.14 |
| 2004 | 0.32 | 0.28 | 0.21 | **0.25** | 0.08 |
| 2005 | 0.31 | 0.27 | 0.17 | **0.19** | 0.11 |
| 2006 | 0.34 | 0.29 | 0.15 | **0.18** | 0.16 |
| **Average** | **0.28** | **0.24** | **0.16** | **0.18** | **0.10** |

Table A8.10. Estimates of fishing mortality for ≥18 inch striped bass obtained without assuming constant natural mortality, based on exploitation rate and Baranov's catch equation, using bias-adjusted estimates of survival from Table A8.8. The tables also present annual estimates of instantaneous natural mortality, M. Column headings are S: bias-corrected survival rate, Z: total instantaneous mortality, A: annual percentage mortality expressed as a proportion, U: annual exploitation rate, F: instantaneous fishing mortality rate and M: instantaneous natural mortality rate.

**Producer Area Programs**

Maryland Chesapeake Bay Spring Spawning Stock

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | 0.17 | 0.15 | 0.01 | **0.01** | 0.16 |
| 1988 | 0.17 | 0.16 | 0.01 | **0.02** | 0.16 |
| 1989 | 0.16 | 0.14 | 0.01 | **0.01** | 0.15 |
| 1990 | 0.46 | 0.37 | 0.07 | **0.08** | 0.38 |
| 1991 | 0.45 | 0.36 | 0.10 | **0.12** | 0.33 |
| 1992 | 0.46 | 0.37 | 0.13 | **0.16** | 0.29 |
| 1993 | 0.46 | 0.37 | 0.11 | **0.14** | 0.32 |
| 1994 | 0.45 | 0.36 | 0.12 | **0.14** | 0.31 |
| 1995 | 0.53 | 0.41 | 0.18 | **0.24** | 0.29 |
| 1996 | 0.53 | 0.41 | 0.17 | **0.21** | 0.32 |
| 1997 | 0.52 | 0.41 | 0.20 | **0.25** | 0.27 |
| 1998 | 0.56 | 0.43 | 0.19 | **0.25** | 0.31 |
| 1999 | 0.54 | 0.42 | 0.16 | **0.21** | 0.33 |
| 2000 | 0.72 | 0.52 | 0.13 | **0.19** | 0.54 |
| 2001 | 0.74 | 0.52 | 0.12 | **0.17** | 0.57 |
| 2002 | 0.72 | 0.51 | 0.12 | **0.16** | 0.55 |
| 2003 | 0.65 | 0.48 | 0.13 | **0.18** | 0.47 |
| 2004 | 0.66 | 0.48 | 0.10 | **0.14** | 0.52 |
| 2005 | 0.67 | 0.49 | 0.11 | **0.15** | 0.52 |
| 2006 | 0.65 | 0.48 | 0.13 | **0.18** | 0.48 |
| **Average** | **0.51** | **0.39** | **0.11** | **0.15** | **0.36** |

Virginia Rappahanock River Spring Spawning Stock Survey

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | 0.05 | 0.05 | 0.17 | **0.18** | -0.13 |
| 1991 | 1.20 | 0.70 | 0.14 | **0.24** | 0.96 |
| 1992 | 0.06 | 0.06 | 0.31 | **0.32** | -0.25 |
| 1993 | 0.39 | 0.32 | 0.23 | **0.28** | 0.12 |
| 1994 | 0.47 | 0.38 | 0.25 | **0.31** | 0.16 |
| 1995 | 0.32 | 0.28 | 0.19 | **0.22** | 0.10 |
| 1996 | 0.41 | 0.33 | 0.15 | **0.18** | 0.23 |
| 1997 | 0.51 | 0.40 | 0.20 | **0.25** | 0.26 |
| 1998 | 0.82 | 0.56 | 0.15 | **0.22** | 0.60 |
| 1999 | 0.94 | 0.61 | 0.13 | **0.20** | 0.73 |
| 2000 | 0.76 | 0.53 | 0.13 | **0.19** | 0.57 |
| 2001 | 0.67 | 0.49 | 0.18 | **0.25** | 0.42 |
| 2002 | 0.42 | 0.34 | 0.17 | **0.21** | 0.21 |
| 2003 | 0.22 | 0.20 | 0.17 | **0.19** | 0.03 |
| 2004 | 1.14 | 0.68 | 0.11 | **0.18** | 0.95 |
| 2005 | 0.95 | 0.61 | 0.12 | **0.18** | 0.77 |
| 2006 | 0.60 | 0.45 | 0.10 | **0.13** | 0.46 |
| **Average** | **0.58** | **0.41** | **0.17** | **0.22** | **0.36** |

Delaware River - DE/PA Spring Spawning Stock

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | | | | | |
| 1993 | 0.23 | 0.20 | 0.13 | **0.15** | 0.08 |
| 1994 | 0.32 | 0.28 | 0.12 | **0.14** | 0.18 |
| 1995 | 0.46 | 0.37 | 0.12 | **0.16** | 0.31 |
| 1996 | 0.06 | 0.06 | 0.18 | **0.18** | -0.12 |
| 1997 | 0.28 | 0.25 | 0.11 | **0.13** | 0.16 |
| 1998 | 0.42 | 0.34 | 0.14 | **0.17** | 0.25 |
| 1999 | 0.48 | 0.38 | 0.10 | **0.13** | 0.35 |
| 2000 | 0.42 | 0.34 | 0.15 | **0.19** | 0.24 |
| 2001 | 0.39 | 0.32 | 0.15 | **0.18** | 0.20 |
| 2002 | 0.47 | 0.38 | 0.14 | **0.17** | 0.30 |
| 2003 | 0.50 | 0.39 | 0.15 | **0.19** | 0.31 |
| 2004 | 0.70 | 0.51 | 0.15 | **0.21** | 0.49 |
| 2005 | 0.53 | 0.41 | 0.10 | **0.12** | 0.41 |
| 2006 | 0.56 | 0.43 | 0.11 | **0.14** | 0.42 |
| **Average** | **0.42** | **0.33** | **0.13** | **0.16** | **0.25** |

Hudson River Spring Spawning Stock Survey

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | -0.04 | -0.05 | 0.05 | **0.05** | -0.09 |
| 1989 | 0.94 | 0.61 | 0.05 | **0.07** | 0.87 |
| 1990 | -0.47 | -0.60 | 0.15 | **0.12** | -0.59 |
| 1991 | -0.07 | -0.07 | 0.08 | **0.07** | -0.14 |
| 1992 | 0.29 | 0.25 | 0.10 | **0.11** | 0.18 |
| 1993 | 0.24 | 0.21 | 0.10 | **0.12** | 0.12 |
| 1994 | 0.22 | 0.20 | 0.08 | **0.09** | 0.13 |
| 1995 | 0.31 | 0.27 | 0.05 | **0.05** | 0.26 |
| 1996 | 0.32 | 0.28 | 0.16 | **0.19** | 0.13 |
| 1997 | 0.30 | 0.26 | 0.22 | **0.25** | 0.04 |
| 1998 | 0.28 | 0.24 | 0.17 | **0.20** | 0.08 |
| 1999 | 0.46 | 0.37 | 0.14 | **0.18** | 0.29 |
| 2000 | 0.02 | 0.02 | 0.10 | **0.10** | -0.08 |
| 2001 | 0.20 | 0.18 | 0.10 | **0.11** | 0.09 |
| 2002 | 0.62 | 0.46 | 0.08 | **0.11** | 0.51 |
| 2003 | 0.29 | 0.25 | 0.10 | **0.11** | 0.17 |
| 2004 | 0.23 | 0.21 | 0.13 | **0.15** | 0.09 |
| 2005 | 0.26 | 0.23 | 0.09 | **0.10** | 0.16 |
| 2006 | 0.33 | 0.28 | 0.10 | **0.12** | 0.21 |
| **Average** | **0.25** | **0.19** | **0.11** | **0.12** | **0.13** |

Table 8.10 continued.

**Coast Programs**

Massachusetts Fall Tagging

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | 0.18 | 0.17 | 0.05 | **0.06** | 0.13 |
| 1993 | 0.22 | 0.20 | 0.06 | **0.06** | 0.16 |
| 1994 | 0.23 | 0.20 | 0.04 | **0.05** | 0.18 |
| 1995 | 0.25 | 0.22 | 0.04 | **0.04** | 0.20 |
| 1996 | 0.21 | 0.19 | 0.07 | **0.07** | 0.14 |
| 1997 | 0.25 | 0.22 | 0.12 | **0.13** | 0.12 |
| 1998 | 0.24 | 0.22 | 0.10 | **0.11** | 0.13 |
| 1999 | 0.27 | 0.23 | 0.09 | **0.10** | 0.17 |
| 2000 | 0.28 | 0.24 | 0.09 | **0.11** | 0.17 |
| 2001 | 0.27 | 0.24 | 0.06 | **0.07** | 0.20 |
| 2002 | 0.26 | 0.23 | 0.09 | **0.10** | 0.16 |
| 2003 | 0.29 | 0.25 | 0.08 | **0.09** | 0.19 |
| 2004 | 0.29 | 0.25 | 0.09 | **0.10** | 0.19 |
| 2005 | 0.28 | 0.24 | 0.07 | **0.08** | 0.20 |
| 2006 | 0.27 | 0.23 | 0.09 | **0.10** | 0.17 |
| **Average** | **0.25** | **0.22** | **0.08** | **0.09** | **0.17** |

New York Ocean Haul Seine Fall Tagging

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1988 | 0.43 | 0.35 | 0.02 | **0.03** | 0.40 |
| 1989 | -0.11 | -0.12 | 0.03 | **0.03** | -0.14 |
| 1990 | 0.45 | 0.36 | 0.04 | **0.05** | 0.40 |
| 1991 | 0.14 | 0.13 | 0.06 | **0.06** | 0.08 |
| 1992 | -0.05 | -0.05 | 0.04 | **0.04** | -0.09 |
| 1993 | 0.62 | 0.46 | 0.05 | **0.06** | 0.56 |
| 1994 | 0.28 | 0.24 | 0.04 | **0.04** | 0.23 |
| 1995 | -0.02 | -0.02 | 0.05 | **0.05** | -0.07 |
| 1996 | 0.22 | 0.19 | 0.03 | **0.03** | 0.18 |
| 1997 | 0.37 | 0.31 | 0.04 | **0.05** | 0.33 |
| 1998 | 0.64 | 0.47 | 0.03 | **0.04** | 0.60 |
| 1999 | 0.30 | 0.26 | 0.05 | **0.05** | 0.25 |
| 2000 | 0.47 | 0.38 | 0.03 | **0.04** | 0.43 |
| 2001 | 0.42 | 0.34 | 0.05 | **0.06** | 0.36 |
| 2002 | 0.23 | 0.20 | 0.06 | **0.07** | 0.16 |
| 2003 | 0.52 | 0.41 | 0.04 | **0.05** | 0.48 |
| 2004 | 0.48 | 0.38 | 0.04 | **0.05** | 0.43 |
| 2005 | 0.81 | 0.56 | 0.03 | **0.05** | 0.76 |
| 2006 | 0.56 | 0.43 | 0.03 | **0.04** | 0.52 |
| **Average** | **0.36** | **0.28** | **0.04** | **0.05** | **0.31** |

North Carolina Winter Trawl Survey

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1988 | -0.09 | -0.10 | 0.03 | **0.03** | -0.13 |
| 1989 | 0.39 | 0.32 | 0.03 | **0.03** | 0.35 |
| 1990 | 0.51 | 0.40 | 0.06 | **0.08** | 0.43 |
| 1991 | 0.33 | 0.28 | 0.08 | **0.10** | 0.23 |
| 1992 | 0.12 | 0.12 | 0.14 | **0.15** | -0.02 |
| 1993 | 0.13 | 0.12 | 0.11 | **0.11** | 0.02 |
| 1994 | 0.63 | 0.47 | 0.08 | **0.11** | 0.52 |
| 1995 | -0.02 | -0.02 | 0.14 | **0.13** | -0.15 |
| 1996 | 0.51 | 0.40 | 0.11 | **0.13** | 0.37 |
| 1997 | 0.61 | 0.46 | 0.15 | **0.21** | 0.40 |
| 1998 | 0.34 | 0.29 | 0.14 | **0.17** | 0.18 |
| 1999 | 0.01 | 0.01 | 0.22 | **0.22** | -0.21 |
| 2000 | 1.12 | 0.67 | 0.08 | **0.13** | 0.99 |
| 2001 | 0.47 | 0.38 | 0.11 | **0.14** | 0.33 |
| 2002 | 0.50 | 0.40 | 0.12 | **0.15** | 0.35 |
| 2003 | 0.50 | 0.40 | 0.11 | **0.14** | 0.37 |
| 2004 | 0.01 | 0.01 | 0.12 | **0.12** | -0.11 |
| 2005 | 1.22 | 0.71 | 0.06 | **0.10** | 1.13 |
| 2006 | 0.42 | 0.34 | 0.10 | **0.13** | 0.29 |
| **Average** | **0.41** | **0.30** | **0.10** | **0.12** | **0.28** |

New Jersey Delaware Bay February-April

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1988 | | | | | |
| 1989 | -0.08 | -0.08 | 0.04 | **0.03** | -0.11 |
| 1990 | -0.08 | -0.09 | 0.09 | **0.09** | -0.17 |
| 1991 | 0.41 | 0.33 | 0.04 | **0.05** | 0.35 |
| 1992 | 0.30 | 0.26 | 0.04 | **0.05** | 0.25 |
| 1993 | 0.45 | 0.36 | 0.03 | **0.04** | 0.42 |
| 1994 | 0.24 | 0.21 | 0.04 | **0.04** | 0.20 |
| 1995 | 0.06 | 0.06 | 0.06 | **0.06** | 0.00 |
| 1996 | 0.15 | 0.14 | 0.10 | **0.11** | 0.04 |
| 1997 | 0.49 | 0.39 | 0.09 | **0.12** | 0.37 |
| 1998 | 0.18 | 0.17 | 0.12 | **0.13** | 0.05 |
| 1999 | 0.26 | 0.23 | 0.06 | **0.07** | 0.19 |
| 2000 | 0.26 | 0.23 | 0.07 | **0.08** | 0.18 |
| 2001 | 0.12 | 0.11 | 0.09 | **0.10** | 0.02 |
| 2002 | 0.54 | 0.42 | 0.06 | **0.08** | 0.46 |
| 2003 | 0.52 | 0.41 | 0.08 | **0.10** | 0.42 |
| 2004 | 0.29 | 0.25 | 0.12 | **0.14** | 0.15 |
| 2005 | 0.49 | 0.39 | 0.09 | **0.11** | 0.38 |
| 2006 | 0.47 | 0.38 | 0.06 | **0.08** | 0.39 |
| **Average** | **0.28** | **0.23** | **0.07** | **0.08** | **0.20** |

Table A8.11. Coastwide fishing mortality rates, presented as an unweighted average of producer and coastal programs' means developed using the catch equation, and coastwide stock size estimates (in numbers of fish) for age 7+ and age 3+ fish, obtained via "Kill = F * Stock Size".

**Catch Equation Method**

| Year | Fishing Mortality | Age 7+ Kill includes discards | Total Stock Size Thousands |
|---|---|---|---|
| 1988 | 0.06 | 101.4 | 1,607 |
| 1989 | 0.04 | 95 | 2,608 |
| 1990 | 0.11 | 222.3 | 1,996 |
| 1991 | 0.19 | 296.4 | 1,526 |
| 1992 | 0.15 | 262.7 | 1,715 |
| 1993 | 0.17 | 380.6 | 2,211 |
| 1994 | 0.13 | 475.9 | 3,741 |
| 1995 | 0.22 | 740 | 3,317 |
| 1996 | 0.20 | 965.3 | 4,903 |
| 1997 | 0.31 | 1371.1 | 4,413 |
| 1998 | 0.29 | 1080.5 | 3,755 |
| 1999 | 0.29 | 1146.8 | 3,930 |
| 2000 | 0.20 | 1471.8 | 7,504 |
| 2001 | 0.17 | 1583.2 | 9,399 |
| 2002 | 0.18 | 2075.4 | 11,437 |
| 2003 | 0.18 | 2163.1 | 12,168 |
| 2004 | 0.16 | 2376.2 | 14,727 |
| 2005 | 0.17 | 2132.5 | 12,186 |
| 2006 | 0.16 | 2139.3 | 12,985 |

**Catch Equation Method**

| Year | Fishing Mortality | Age 3+ Kill includes discards | Total Stock Size Thousands |
|---|---|---|---|
| 1988 | 0.02 | 444.9 | 18,473 |
| 1989 | 0.02 | 479.9 | 19,562 |
| 1990 | 0.09 | 921.3 | 10,469 |
| 1991 | 0.10 | 988.4 | 9,693 |
| 1992 | 0.13 | 986.9 | 7,736 |
| 1993 | 0.12 | 1,437.0 | 11,993 |
| 1994 | 0.12 | 1,866.6 | 15,572 |
| 1995 | 0.14 | 2,999.7 | 21,821 |
| 1996 | 0.14 | 3,376.2 | 23,624 |
| 1997 | 0.18 | 4,580.2 | 24,973 |
| 1998 | 0.17 | 4,118.3 | 24,049 |
| 1999 | 0.15 | 3,704.4 | 24,194 |
| 2000 | 0.13 | 5,044.4 | 37,659 |
| 2001 | 0.14 | 4,344.0 | 31,562 |
| 2002 | 0.13 | 3,889.5 | 28,890 |
| 2003 | 0.13 | 4,836.2 | 36,144 |
| 2004 | 0.13 | 5,184.8 | 39,512 |
| 2005 | 0.12 | 5,125.5 | 44,350 |
| 2006 | 0.12 | 5,763.4 | 47,901 |

Table A8.12. Unweighted average of annual instantaneous **fishing mortality** for coastal programs, and weighted average of annual instantaneous fishing mortality for producer areas, along with 95% confidence intervals, for striped bass ≥ 28 inches, using the catch equation, without assuming constant natural mortality. When missing values are present, weights do not add to 1.

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | Unweighted average | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1988 | | 0.05 | | 0.07 | **0.06** | 0.04 | 0.08 |
| 1989 | | 0.04 | 0.02 | 0.05 | **0.04** | 0.02 | 0.05 |
| 1990 | | 0.08 | 0.05 | 0.10 | **0.08** | 0.05 | 0.11 |
| 1991 | | 0.14 | 0.33 | 0.08 | **0.18** | 0.07 | 0.30 |
| 1992 | 0.06 | 0.13 | 0.08 | 0.14 | **0.10** | 0.06 | 0.14 |
| 1993 | 0.08 | 0.17 | 0.10 | 0.13 | **0.12** | 0.07 | 0.17 |
| 1994 | 0.05 | 0.10 | 0.06 | 0.09 | **0.08** | 0.05 | 0.10 |
| 1995 | 0.06 | 0.24 | 0.12 | 0.16 | **0.15** | 0.09 | 0.20 |
| 1996 | 0.11 | 0.17 | 0.23 | 0.13 | **0.16** | 0.10 | 0.22 |
| 1997 | 0.20 | 0.42 | 0.27 | 0.22 | **0.27** | 0.17 | 0.38 |
| 1998 | 0.12 | 0.20 | 0.40 | 0.24 | **0.24** | 0.14 | 0.34 |
| 1999 | 0.15 | 0.37 | 0.14 | 0.28 | **0.23** | 0.13 | 0.34 |
| 2000 | 0.15 | 0.20 | 0.15 | 0.07 | **0.14** | 0.08 | 0.21 |
| 2001 | 0.10 | 0.12 | 0.18 | 0.18 | **0.14** | 0.09 | 0.19 |
| 2002 | 0.09 | 0.24 | 0.13 | 0.14 | **0.15** | 0.10 | 0.20 |
| 2003 | 0.13 | 0.20 | 0.19 | 0.14 | **0.16** | 0.10 | 0.22 |
| 2004 | 0.11 | 0.19 | 0.21 | 0.14 | **0.16** | 0.11 | 0.22 |
| 2005 | 0.08 | 0.34 | 0.23 | 0.09 | **0.19** | 0.10 | 0.28 |
| 2006 | 0.11 | 0.17 | 0.19 | 0.15 | **0.15** | 0.09 | 0.22 |

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | Weighted average* | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | 0.11 | | 0.08 | | **0.07** | 0.01 | 0.12 |
| 1989 | 0.07 | | 0.04 | | **0.04** | 0.01 | 0.06 |
| 1990 | 0.13 | | 0.10 | 0.30 | **0.15** | 0.07 | 0.23 |
| 1991 | 0.12 | | 0.15 | 0.43 | **0.20** | 0.10 | 0.31 |
| 1992 | 0.15 | | 0.15 | 0.42 | **0.20** | 0.06 | 0.35 |
| 1993 | 0.19 | 0.15 | 0.15 | 0.44 | **0.23** | 0.12 | 0.33 |
| 1994 | 0.13 | 0.14 | 0.14 | 0.31 | **0.18** | 0.09 | 0.27 |
| 1995 | 0.17 | 0.17 | 0.25 | 0.51 | **0.30** | 0.16 | 0.44 |
| 1996 | 0.27 | 0.39 | 0.21 | 0.23 | **0.24** | 0.12 | 0.35 |
| 1997 | 0.33 | 0.33 | 0.29 | 0.48 | **0.35** | 0.19 | 0.50 |
| 1998 | 0.25 | 0.35 | 0.24 | 0.56 | **0.34** | 0.18 | 0.50 |
| 1999 | 0.25 | 0.19 | 0.40 | 0.35 | **0.35** | 0.15 | 0.55 |
| 2000 | 0.16 | 0.37 | 0.22 | 0.32 | **0.25** | 0.13 | 0.37 |
| 2001 | 0.16 | 0.33 | 0.14 | 0.28 | **0.19** | 0.11 | 0.28 |
| 2002 | 0.23 | 0.29 | 0.12 | 0.36 | **0.21** | 0.11 | 0.32 |
| 2003 | 0.16 | 0.21 | 0.13 | 0.32 | **0.19** | 0.10 | 0.28 |
| 2004 | 0.25 | 0.30 | 0.11 | 0.18 | **0.16** | 0.09 | 0.23 |
| 2005 | 0.19 | 0.19 | 0.13 | 0.20 | **0.16** | 0.08 | 0.24 |
| 2006 | 0.18 | 0.26 | 0.16 | 0.17 | **0.17** | 0.09 | 0.26 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

Table A8.13. Unweighted average of annual instantaneous **fishing mortality** for coastal programs, and weighted average of annual instantaneous fishing mortality for producer areas, along with 95% confidence intervals, for striped bass ≥18 inches, using the catch equation, without assuming constant natural mortality. When missing values are present, weights do not add to 1.

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | **Weighted Average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.01 | | **0.01** | 0.00 | 0.01 |
| 1988 | 0.05 | | 0.02 | | **0.02** | 0.01 | 0.02 |
| 1989 | 0.07 | | 0.01 | | **0.02** | 0.01 | 0.02 |
| 1990 | 0.12 | | 0.08 | 0.18 | **0.10** | 0.06 | 0.15 |
| 1991 | 0.07 | | 0.12 | 0.24 | **0.13** | 0.07 | 0.20 |
| 1992 | 0.11 | | 0.16 | 0.32 | **0.18** | 0.09 | 0.28 |
| 1993 | 0.12 | 0.15 | 0.14 | 0.28 | **0.17** | 0.10 | 0.24 |
| 1994 | 0.09 | 0.14 | 0.14 | 0.31 | **0.18** | 0.09 | 0.27 |
| 1995 | 0.05 | 0.16 | 0.24 | 0.22 | **0.20** | 0.11 | 0.30 |
| 1996 | 0.19 | 0.18 | 0.21 | 0.18 | **0.20** | 0.11 | 0.28 |
| 1997 | 0.25 | 0.13 | 0.25 | 0.25 | **0.24** | 0.13 | 0.35 |
| 1998 | 0.20 | 0.17 | 0.25 | 0.22 | **0.23** | 0.13 | 0.33 |
| 1999 | 0.18 | 0.13 | 0.21 | 0.20 | **0.20** | 0.10 | 0.29 |
| 2000 | 0.10 | 0.19 | 0.19 | 0.19 | **0.18** | 0.10 | 0.25 |
| 2001 | 0.11 | 0.18 | 0.17 | 0.25 | **0.18** | 0.10 | 0.26 |
| 2002 | 0.11 | 0.17 | 0.16 | 0.21 | **0.17** | 0.09 | 0.25 |
| 2003 | 0.11 | 0.19 | 0.18 | 0.19 | **0.17** | 0.10 | 0.25 |
| 2004 | 0.15 | 0.21 | 0.14 | 0.18 | **0.16** | 0.10 | 0.22 |
| 2005 | 0.10 | 0.12 | 0.15 | 0.18 | **0.15** | 0.08 | 0.22 |
| 2006 | 0.12 | 0.14 | 0.18 | 0.13 | **0.16** | 0.09 | 0.22 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | **Unweighted average** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.03 | | 0.03 | **0.03** | 0.02 | 0.04 |
| 1989 | | 0.03 | 0.03 | 0.03 | **0.03** | 0.02 | 0.04 |
| 1990 | | 0.05 | 0.09 | 0.08 | **0.07** | 0.05 | 0.10 |
| 1991 | | 0.06 | 0.05 | 0.10 | **0.07** | 0.05 | 0.09 |
| 1992 | 0.06 | 0.04 | 0.05 | 0.15 | **0.07** | 0.05 | 0.10 |
| 1993 | 0.06 | 0.06 | 0.04 | 0.11 | **0.07** | 0.05 | 0.09 |
| 1994 | 0.05 | 0.04 | 0.04 | 0.11 | **0.06** | 0.04 | 0.08 |
| 1995 | 0.04 | 0.05 | 0.06 | 0.13 | **0.07** | 0.05 | 0.10 |
| 1996 | 0.07 | 0.03 | 0.11 | 0.13 | **0.09** | 0.06 | 0.12 |
| 1997 | 0.13 | 0.05 | 0.12 | 0.21 | **0.13** | 0.08 | 0.17 |
| 1998 | 0.11 | 0.04 | 0.13 | 0.17 | **0.11** | 0.07 | 0.15 |
| 1999 | 0.10 | 0.05 | 0.07 | 0.22 | **0.11** | 0.06 | 0.16 |
| 2000 | 0.11 | 0.04 | 0.08 | 0.13 | **0.09** | 0.06 | 0.12 |
| 2001 | 0.07 | 0.06 | 0.10 | 0.14 | **0.09** | 0.06 | 0.12 |
| 2002 | 0.10 | 0.07 | 0.08 | 0.15 | **0.10** | 0.07 | 0.13 |
| 2003 | 0.09 | 0.05 | 0.10 | 0.14 | **0.09** | 0.06 | 0.12 |
| 2004 | 0.10 | 0.05 | 0.14 | 0.12 | **0.10** | 0.07 | 0.13 |
| 2005 | 0.08 | 0.05 | 0.11 | 0.10 | **0.08** | 0.06 | 0.11 |
| 2006 | 0.10 | 0.04 | 0.08 | 0.13 | **0.09** | 0.06 | 0.11 |

Table A8.14. Unweighted average of annual instantaneous **natural mortality** for coastal programs, and weighted average of annual instantaneous natural mortality for producer areas, along with 95% confidence intervals, for striped bass ≥28 inches, using the catch equation. Negative values of M are not included in the means. When negative or missing values are present, weights do not add to 1.

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | **Unweighted average** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | -0.11 | | 0.11 | **0.11** | 0.07 | 0.16 |
| 1989 | | -0.05 | 0.09 | 0.22 | **0.16** | 0.12 | 0.20 |
| 1990 | | 0.24 | 0.23 | 0.17 | **0.22** | 0.17 | 0.26 |
| 1991 | | 0.17 | -0.23 | 0.18 | **0.18** | 0.14 | 0.21 |
| 1992 | 0.14 | 0.11 | 0.15 | 0.08 | **0.12** | 0.05 | 0.19 |
| 1993 | 0.14 | 0.18 | 0.17 | 0.14 | **0.16** | 0.09 | 0.22 |
| 1994 | 0.19 | 0.22 | 0.17 | 0.21 | **0.20** | 0.15 | 0.25 |
| 1995 | 0.21 | 0.04 | 0.11 | 0.13 | **0.12** | 0.05 | 0.19 |
| 1996 | 0.16 | 0.15 | 0.02 | 0.25 | **0.15** | 0.08 | 0.21 |
| 1997 | 0.07 | -0.09 | 0.04 | 0.15 | **0.09** | 0.01 | 0.17 |
| 1998 | 0.15 | 0.17 | -0.13 | 0.11 | **0.07** | -0.01 | 0.15 |
| 1999 | 0.12 | 0.02 | 0.15 | 0.05 | **0.09** | -0.03 | 0.20 |
| 2000 | 0.13 | -0.02 | 0.06 | 0.30 | **0.16** | 0.10 | 0.22 |
| 2001 | 0.18 | 0.07 | 0.04 | 0.16 | **0.11** | 0.04 | 0.18 |
| 2002 | 0.18 | -0.11 | 0.09 | 0.19 | **0.15** | 0.10 | 0.20 |
| 2003 | 0.17 | 0.43 | 0.35 | 0.24 | **0.30** | 0.22 | 0.38 |
| 2004 | 0.18 | 0.40 | 0.33 | 0.19 | **0.28** | 0.19 | 0.36 |
| 2005 | 0.20 | 0.25 | 0.44 | 0.31 | **0.30** | 0.17 | 0.43 |
| 2006 | 0.16 | 0.42 | 0.43 | 0.22 | **0.31** | 0.18 | 0.43 |

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | **Weighted average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.10 | | **0.07** | -0.01 | 0.15 |
| 1988 | 0.11 | | 0.02 | | **0.03** | -0.07 | 0.13 |
| 1989 | 0.06 | | 0.06 | | **0.05** | -0.03 | 0.13 |
| 1990 | 0.06 | | 0.30 | 0.03 | **0.17** | 0.09 | 0.26 |
| 1991 | 0.15 | | 0.26 | -0.11 | **0.16** | 0.08 | 0.23 |
| 1992 | 0.08 | | 0.26 | -0.15 | **0.15** | 0.08 | 0.22 |
| 1993 | 0.06 | 0.11 | 0.26 | -0.08 | **0.15** | 0.08 | 0.23 |
| 1994 | 0.11 | 0.11 | 0.27 | 0.08 | **0.19** | 0.08 | 0.29 |
| 1995 | 0.12 | 0.22 | 0.19 | -0.06 | **0.14** | 0.03 | 0.24 |
| 1996 | 0.05 | 0.02 | 0.24 | 0.29 | **0.21** | 0.09 | 0.33 |
| 1997 | -0.02 | 0.10 | 0.15 | 0.02 | **0.09** | -0.07 | 0.25 |
| 1998 | 0.07 | 0.10 | 0.20 | -0.12 | **0.12** | 0.01 | 0.24 |
| 1999 | 0.06 | 0.28 | 0.04 | 0.12 | **0.09** | -0.12 | 0.30 |
| 2000 | 0.17 | 0.07 | 0.28 | 0.01 | **0.17** | 0.03 | 0.31 |
| 2001 | 0.19 | 0.13 | 0.36 | 0.07 | **0.24** | 0.13 | 0.35 |
| 2002 | 0.12 | 0.16 | 0.37 | -0.04 | **0.22** | 0.13 | 0.32 |
| 2003 | 0.14 | 0.20 | 0.34 | 0.28 | **0.29** | 0.15 | 0.42 |
| 2004 | 0.08 | 0.14 | 0.37 | 0.43 | **0.33** | 0.20 | 0.45 |
| 2005 | 0.11 | 0.25 | 0.33 | 0.24 | **0.27** | 0.11 | 0.43 |
| 2006 | 0.16 | 0.19 | 0.33 | 0.25 | **0.28** | 0.07 | 0.48 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

Table A8.15. Unweighted average of annual instantaneous **natural mortality** for coastal programs, and weighted average of annual instantaneous natural mortality for producer areas, along with 95% confidence intervals, for striped bass ≥18 inches, using the catch equation. Negative values of M are not included in the means. When negative or missing values are present, weights do not add to 1.

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | Weighted average* | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.16 | | **0.11** | 0.07 | 0.14 |
| 1988 | -0.09 | | 0.16 | | **0.11** | 0.06 | 0.15 |
| 1989 | 0.87 | | 0.15 | | **0.21** | 0.15 | 0.27 |
| 1990 | -0.59 | | 0.38 | -0.13 | **0.25** | 0.21 | 0.30 |
| 1991 | -0.14 | | 0.33 | 0.96 | **0.42** | 0.32 | 0.52 |
| 1992 | 0.18 | | 0.29 | -0.25 | **0.22** | 0.15 | 0.29 |
| 1993 | 0.12 | 0.08 | 0.32 | 0.12 | **0.22** | 0.09 | 0.35 |
| 1994 | 0.13 | 0.18 | 0.31 | 0.16 | **0.24** | 0.09 | 0.38 |
| 1995 | 0.26 | 0.31 | 0.29 | 0.10 | **0.24** | 0.09 | 0.39 |
| 1996 | 0.13 | -0.12 | 0.32 | 0.23 | **0.24** | 0.09 | 0.39 |
| 1997 | 0.04 | 0.16 | 0.27 | 0.26 | **0.23** | 0.07 | 0.38 |
| 1998 | 0.08 | 0.25 | 0.31 | 0.60 | **0.35** | 0.19 | 0.50 |
| 1999 | 0.29 | 0.35 | 0.33 | 0.73 | **0.43** | 0.30 | 0.56 |
| 2000 | -0.08 | 0.24 | 0.54 | 0.57 | **0.45** | 0.33 | 0.57 |
| 2001 | 0.09 | 0.20 | 0.57 | 0.42 | **0.44** | 0.29 | 0.58 |
| 2002 | 0.51 | 0.30 | 0.55 | 0.21 | **0.44** | 0.28 | 0.59 |
| 2003 | 0.17 | 0.31 | 0.47 | 0.03 | **0.30** | 0.15 | 0.46 |
| 2004 | 0.09 | 0.49 | 0.52 | 0.95 | **0.57** | 0.43 | 0.71 |
| 2005 | 0.16 | 0.41 | 0.52 | 0.77 | **0.53** | 0.36 | 0.70 |
| 2006 | 0.21 | 0.42 | 0.48 | 0.46 | **0.43** | 0.30 | 0.57 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | Unweighted average | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.40 | | -0.13 | **0.40** | 0.37 | 0.43 |
| 1989 | | -0.14 | -0.11 | 0.35 | **0.35** | 0.31 | 0.39 |
| 1990 | | 0.40 | -0.17 | 0.43 | **0.42** | 0.37 | 0.47 |
| 1991 | | 0.08 | 0.35 | 0.23 | **0.22** | 0.14 | 0.30 |
| 1992 | 0.13 | -0.09 | 0.25 | -0.02 | **0.19** | 0.15 | 0.23 |
| 1993 | 0.16 | 0.56 | 0.42 | 0.02 | **0.29** | 0.21 | 0.36 |
| 1994 | 0.18 | 0.23 | 0.20 | 0.52 | **0.28** | 0.23 | 0.34 |
| 1995 | 0.20 | -0.07 | 0.00 | -0.15 | **0.10** | 0.07 | 0.13 |
| 1996 | 0.14 | 0.18 | 0.04 | 0.37 | **0.18** | 0.10 | 0.26 |
| 1997 | 0.12 | 0.33 | 0.37 | 0.40 | **0.31** | 0.21 | 0.40 |
| 1998 | 0.13 | 0.60 | 0.05 | 0.18 | **0.24** | 0.15 | 0.33 |
| 1999 | 0.17 | 0.25 | 0.19 | -0.21 | **0.20** | 0.13 | 0.27 |
| 2000 | 0.17 | 0.43 | 0.18 | 0.99 | **0.44** | 0.37 | 0.52 |
| 2001 | 0.20 | 0.36 | 0.02 | 0.33 | **0.23** | 0.15 | 0.31 |
| 2002 | 0.16 | 0.16 | 0.46 | 0.35 | **0.28** | 0.19 | 0.37 |
| 2003 | 0.19 | 0.48 | 0.42 | 0.37 | **0.37** | 0.27 | 0.46 |
| 2004 | 0.19 | 0.43 | 0.15 | -0.11 | **0.26** | 0.17 | 0.35 |
| 2005 | 0.20 | 0.76 | 0.38 | 1.13 | **0.62** | 0.51 | 0.72 |
| 2006 | 0.17 | 0.52 | 0.39 | 0.29 | **0.34** | 0.26 | 0.42 |

Table A8.16. Akaike weights used to derive model averaged parameter estimates. Results are for male striped bass 18 - 28 inches, recaptured in Chesapeake Bay. Models are described in Table A8.1.

| Model | Maryland | Virginia |
|---|---|---|
| {S(.)r(.)} | 0 | 0 |
| {S(.)r(p)} | 0 | 0 |
| {S(.)r(t)} | 0 | 0 |
| {S(p)r(p)} | 0 | 0 |
| {S(p)r(t)} | 0.0019 | 0 |
| {S(d)r(p)} | 0 | 0 |
| {S(v)r(p)} | 0 | 0 |
| {S(t)r(p)} | **0.9971** | 0 |
| {S(t)r(t)} | 0.0010 | **1.0000** |

Table A8.17. R/M estimates of exploitation rates of 18 - 28 inch male striped bass recaptured in Chesapeake Bay. Exploitation rate, an input to the catch equation, is the proportion of tagged fish that were harvested or killed (with reporting rate adjustment of 0.64, and hooking mortality rate adjustment of 0.08).

| Year | Maryland | Virginia | **MEAN** |
|---|---|---|---|
| 1987 | 0.01 | | **0.01** |
| 1988 | 0.01 | | **0.01** |
| 1989 | 0.00 | | **0.00** |
| 1990 | 0.04 | 0.03 | **0.04** |
| 1991 | 0.05 | 0.13 | **0.09** |
| 1992 | 0.09 | 0.21 | **0.15** |
| 1993 | 0.07 | 0.09 | **0.08** |
| 1994 | 0.07 | 0.13 | **0.10** |
| 1995 | 0.12 | 0.08 | **0.10** |
| 1996 | 0.10 | 0.08 | **0.09** |
| 1997 | 0.11 | 0.07 | **0.09** |
| 1998 | 0.13 | 0.05 | **0.09** |
| 1999 | 0.09 | 0.06 | **0.07** |
| 2000 | 0.08 | 0.06 | **0.07** |
| 2001 | 0.08 | 0.10 | **0.09** |
| 2002 | 0.08 | 0.06 | **0.07** |
| 2003 | 0.10 | 0.07 | **0.08** |
| 2004 | 0.07 | 0.06 | **0.07** |
| 2005 | 0.07 | 0.07 | **0.07** |
| 2006 | 0.09 | 0.05 | **0.07** |

Table A8.18. Unadjusted (unadj.) and bias-corrected (adj.) estimates of survival (S) and fishing mortality (F) for male striped bass 18 - 28 inches, recaptured in Chesapeake Bay, from Program MARK, for Maryland and Virginia. S(adj.) (converted to Z) is an input to the catch equation.

Maryland
C-hat adjustment = 1.0; bootstrap GOF probability = 0.38 for the full parameterized model.

| Year | S(unadj.) | F(unadj.) | Recovery Rate | % Live Release | Bias Live Release | **S(adj.)** |
|---|---|---|---|---|---|---|
| 1987 | 0.72 | 0.18 | 0.07 | 0.94 | -0.09 | **0.79** |
| 1988 | 0.81 | 0.06 | 0.04 | 0.86 | -0.05 | **0.85** |
| 1989 | 0.87 | -0.01 | 0.03 | 0.93 | -0.04 | **0.90** |
| 1990 | 0.74 | 0.15 | 0.06 | 0.57 | -0.05 | **0.78** |
| 1991 | 0.71 | 0.20 | 0.07 | 0.41 | -0.04 | **0.74** |
| 1992 | 0.55 | 0.45 | 0.10 | 0.41 | -0.07 | **0.59** |
| 1993 | 0.60 | 0.35 | 0.08 | 0.31 | -0.04 | **0.63** |
| 1994 | 0.57 | 0.41 | 0.10 | 0.40 | -0.06 | **0.61** |
| 1995 | 0.52 | 0.51 | 0.11 | 0.35 | -0.07 | **0.55** |
| 1996 | 0.52 | 0.50 | 0.11 | 0.40 | -0.07 | **0.56** |
| 1997 | 0.49 | 0.57 | 0.11 | 0.32 | -0.06 | **0.52** |
| 1998 | 0.40 | 0.77 | 0.13 | 0.30 | -0.06 | **0.43** |
| 1999 | 0.59 | 0.37 | 0.09 | 0.27 | -0.04 | **0.62** |
| 2000 | 0.32 | 1.00 | 0.10 | 0.41 | -0.07 | **0.34** |
| 2001 | 0.42 | 0.72 | 0.08 | 0.38 | -0.04 | **0.44** |
| 2002 | 0.46 | 0.63 | 0.07 | 0.30 | -0.03 | **0.47** |
| 2003 | 0.40 | 0.78 | 0.09 | 0.22 | -0.03 | **0.41** |
| 2004 | 0.32 | 0.98 | 0.09 | 0.30 | -0.04 | **0.34** |
| 2005 | 0.42 | 0.71 | 0.07 | 0.33 | -0.03 | **0.44** |
| 2006 | 0.42 | 0.72 | 0.09 | 0.27 | -0.04 | **0.43** |

Virginia
C-hat adjustment = 0.66; bootstrap GOF probability = 0.186 for the full parameterized model.

| Year | S(unadj) | F(unadj) | Recovery Rate | % Live Release | Bias Live Release | **S(adj)** |
|---|---|---|---|---|---|---|
| 1990 | 0.22 | 1.35 | 0.11 | 0.45 | -0.08 | **0.24** |
| 1991 | 0.42 | 0.73 | 0.17 | 0.52 | -0.16 | **0.49** |
| 1992 | 0.62 | 0.33 | 0.13 | 0.17 | -0.04 | **0.64** |
| 1993 | 0.85 | 0.01 | 0.07 | 0.53 | -0.06 | **0.90** |
| 1994 | 0.32 | 0.98 | 0.05 | 0.58 | -0.05 | **0.34** |
| 1995 | 0.38 | 0.82 | 0.11 | 0.59 | -0.10 | **0.42** |
| 1996 | 0.89 | -0.04 | 0.07 | 0.26 | -0.03 | **0.92** |
| 1997 | 0.41 | 0.73 | 0.06 | 0.42 | -0.04 | **0.43** |
| 1998 | 0.21 | 1.43 | 0.04 | 0.43 | -0.03 | **0.21** |
| 1999 | 0.26 | 1.21 | 0.08 | 0.31 | -0.04 | **0.27** |
| 2000 | 0.26 | 1.18 | 0.08 | 0.38 | -0.05 | **0.28** |
| 2001 | 0.37 | 0.85 | 0.09 | 0.36 | -0.06 | **0.39** |
| 2002 | 0.67 | 0.25 | 0.06 | 0.47 | -0.04 | **0.70** |
| 2003 | 0.56 | 0.43 | 0.06 | 0.34 | -0.03 | **0.58** |
| 2004 | 0.16 | 1.70 | 0.05 | 0.23 | -0.02 | **0.16** |
| 2005 | 0.34 | 0.94 | 0.04 | 0.29 | -0.02 | **0.34** |
| 2006 | 0.05 | 2.90 | 0.07 | 0.38 | -0.05 | **0.05** |

Table A8.19. Estimates of fishing mortality for 18 - 28 inch male striped bass recaptured in Chesapeake Bay, based on exploitation rate and Baranov's catch equation, using bias-adjusted estimates of survival from Table A8.18. The tables also present annual estimates of instantaneous natural mortality, M. Column headings are S: bias-corrected survival rate, Z: total instantaneous mortality, A: annual percentage mortality expressed as a proportion, U: annual exploitation rate, F: instantaneous fishing mortality rate and M: instantaneous natural mortality rate.

Maryland

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | 0.23 | 0.21 | 0.01 | 0.01 | 0.22 |
| 1988 | 0.16 | 0.15 | 0.01 | 0.01 | 0.15 |
| 1989 | 0.10 | 0.10 | 0.00 | 0.00 | 0.10 |
| 1990 | 0.25 | 0.22 | 0.04 | 0.05 | 0.20 |
| 1991 | 0.31 | 0.26 | 0.05 | 0.06 | 0.24 |
| 1992 | 0.54 | 0.41 | 0.09 | 0.11 | 0.42 |
| 1993 | 0.46 | 0.37 | 0.07 | 0.09 | 0.37 |
| 1994 | 0.50 | 0.39 | 0.07 | 0.09 | 0.40 |
| 1995 | 0.59 | 0.45 | 0.12 | 0.16 | 0.44 |
| 1996 | 0.57 | 0.44 | 0.10 | 0.13 | 0.44 |
| 1997 | 0.66 | 0.48 | 0.11 | 0.15 | 0.51 |
| 1998 | 0.85 | 0.57 | 0.13 | 0.19 | 0.66 |
| 1999 | 0.48 | 0.38 | 0.09 | 0.11 | 0.37 |
| 2000 | 1.08 | 0.66 | 0.08 | 0.13 | 0.95 |
| 2001 | 0.82 | 0.56 | 0.08 | 0.12 | 0.70 |
| 2002 | 0.75 | 0.53 | 0.08 | 0.11 | 0.64 |
| 2003 | 0.89 | 0.59 | 0.10 | 0.14 | 0.75 |
| 2004 | 1.09 | 0.66 | 0.07 | 0.12 | 0.96 |
| 2005 | 0.82 | 0.56 | 0.07 | 0.11 | 0.72 |
| 2006 | 0.83 | 0.57 | 0.09 | 0.14 | 0.70 |
| **Average** | **0.60** | **0.43** | **0.07** | **0.10** | **0.50** |

Virginia

| Year | Z | A | U | F | M |
|---|---|---|---|---|---|
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | 1.42 | 0.76 | 0.03 | 0.06 | 1.36 |
| 1991 | 0.71 | 0.51 | 0.13 | 0.18 | 0.52 |
| 1992 | 0.44 | 0.36 | 0.21 | 0.26 | 0.18 |
| 1993 | 0.10 | 0.10 | 0.09 | 0.10 | 0.00 |
| 1994 | 1.08 | 0.66 | 0.13 | 0.21 | 0.87 |
| 1995 | 0.86 | 0.58 | 0.08 | 0.12 | 0.74 |
| 1996 | 0.08 | 0.08 | 0.08 | 0.08 | 0.00 |
| 1997 | 0.84 | 0.57 | 0.07 | 0.11 | 0.73 |
| 1998 | 1.55 | 0.79 | 0.05 | 0.10 | 1.45 |
| 1999 | 1.32 | 0.73 | 0.06 | 0.11 | 1.21 |
| 2000 | 1.28 | 0.72 | 0.06 | 0.11 | 1.17 |
| 2001 | 0.94 | 0.61 | 0.10 | 0.15 | 0.79 |
| 2002 | 0.35 | 0.30 | 0.06 | 0.07 | 0.29 |
| 2003 | 0.54 | 0.42 | 0.07 | 0.09 | 0.45 |
| 2004 | 1.83 | 0.84 | 0.06 | 0.13 | 1.71 |
| 2005 | 1.06 | 0.66 | 0.07 | 0.11 | 0.96 |
| 2006 | 3.00 | 0.95 | 0.05 | 0.16 | 2.84 |
| **Average** | **1.02** | **0.57** | **0.08** | **0.13** | **0.90** |

Table A8.20. Weighted average of annual instantaneous **fishing mortality** for the Chesapeake Bay specific analysis, along with 95% confidence intervals, for male striped bass 18 - 28 inches, using the catch equation. When missing values are present, weights do not add to 1

| Year | Maryland | Virginia | **Weighted average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|
| 1987 | 0.01 | | **0.00** | 0.00 | 0.01 |
| 1988 | 0.01 | | **0.01** | 0.00 | 0.01 |
| 1989 | 0.00 | | **0.00** | 0.00 | 0.01 |
| 1990 | 0.05 | 0.06 | **0.05** | 0.02 | 0.09 |
| 1991 | 0.06 | 0.18 | **0.10** | 0.03 | 0.17 |
| 1992 | 0.11 | 0.26 | **0.16** | 0.03 | 0.30 |
| 1993 | 0.09 | 0.10 | **0.09** | 0.04 | 0.14 |
| 1994 | 0.09 | 0.21 | **0.13** | 0.01 | 0.25 |
| 1995 | 0.16 | 0.12 | **0.14** | 0.07 | 0.21 |
| 1996 | 0.13 | 0.08 | **0.12** | 0.06 | 0.18 |
| 1997 | 0.15 | 0.11 | **0.14** | 0.07 | 0.20 |
| 1998 | 0.19 | 0.10 | **0.16** | 0.08 | 0.24 |
| 1999 | 0.11 | 0.11 | **0.11** | 0.05 | 0.17 |
| 2000 | 0.13 | 0.11 | **0.12** | 0.06 | 0.18 |
| 2001 | 0.12 | 0.15 | **0.13** | 0.07 | 0.19 |
| 2002 | 0.11 | 0.07 | **0.10** | 0.04 | 0.15 |
| 2003 | 0.14 | 0.09 | **0.13** | 0.06 | 0.19 |
| 2004 | 0.12 | 0.13 | **0.12** | 0.06 | 0.19 |
| 2005 | 0.11 | 0.11 | **0.11** | 0.05 | 0.16 |
| 2006 | 0.14 | 0.16 | **0.14** | 0.02 | 0.27 |

* Weighting Scheme: MD (0.67) and VA (0.33)

Table A9.1. Candidate models used in the analyses of striped bass tag recoveries in the IRCR.

| Model Number | Model Name | Description |
|---|---|---|
| 1 | Fy, F'y, M87-06 (Global Model) | F and F' estimated each year, constant M for entire period |
| 2 | F87-89, F90-94, F95-99, F00-02, F03-06, F'y, M87-06 | Constant F for each regulatory period, F' estimated each year, constant M for entire period |
| 3 | F87-06, F'y, M87-06 | Constant F over entire period, F' estimated each year, constant M for entire period |
| 4 | Fy, F'87-89, F'90-94, F'95-99,F'00-02, F'03-06,M87-06 | F estimated each year, constant F' for each regulatory period, constant M for entire period |
| 5 | Fy, F'87-06,M87-06 | F estimated each year, constant F' for entire period, constant M |
| 6 | F87-89, F90-94, F95-99,F00-02, F03-06, F87-89,F'90-94, F'95-99,F'00-02, F'03-06,M87-06 | Constant F for each regulatory period, constant F' for each regulatory period, constant M for entire period |
| 7 | F87-06,F'87-06,M87-06 | Constant F for entire period, constant F' for entire period, constant M for entire period |

Table A9.2. Akaike weights used to derive model averaged parameter estimates. Results are for striped bass ≥28 inches. Models are described in Table A9.1.

**Coast Programs**

| Model | MADFW | NYOHS | NJDEL | NCCOOP |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0.0014 |
| 2 | 0.0002 | **0.9916** | 0 | 0.0123 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0.0244 | 0 | **0.8043** | **0.1034** |
| 5 | 0 | 0 | 0.0003 | 0 |
| 6 | **0.9753** | 0.0049 | **0.1611** | **0.8829** |
| 7 | 0 | 0 | 0 | 0 |

**Producer Area Programs**

| Model | DE/PA | HUDSON | MDCB | VARAP |
|---|---|---|---|---|
| 1 | 0 | 0 | 0.0031 | 0 |
| 2 | 0.0002 | **0.1475** | 0.0019 | 0.0004 |
| 3 | 0.0002 | 0 | 0 | 0 |
| 4 | 0.0009 | 0.0001 | 0 | **0.1107** |
| 5 | 0.0043 | 0 | 0 | 0 |
| 6 | **0.2548** | **0.8515** | **0.9950** | **0.8888** |
| 7 | **0.7397** | 0 | 0 | 0 |

Table A9.3. Akaike weights used to derive model averaged parameter estimates. Results are for striped bass ≥18 inches. Models are described in Table A9.1.

**Coast Programs**

| Model | MADFW | NYOHS | NJDEL | NCCOOP |
|---|---|---|---|---|
| 1 | 0 | 0 | 0.0052 | 0.0008 |
| 2 | 0.0003 | **0.9995** | 0.0150 | 0.0157 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0.0163 | 0 | 0.0776 | 0.0518 |
| 5 | 0 | 0 | 0 | 0 |
| 6 | **0.9835** | 0.0003 | **0.9022** | **0.9317** |
| 7 | 0 | 0 | 0 | 0 |

**Producer Area Programs**

| Model | DE/PA | HUDSON | MDCB | VARAP |
|---|---|---|---|---|
| 1 | 0 | 0.0549 | **1.0000** | 0.0003 |
| 2 | 0.0003 | **0.9450** | 0 | 0.0002 |
| 3 | 0.0031 | 0 | 0 | 0 |
| 4 | 0.0001 | 0 | 0 | **0.7114** |
| 5 | 0.0002 | 0 | 0 | 0 |
| 6 | 0.0915 | 0.0001 | 0 | **0.2880** |
| 7 | **0.9049** | 0 | 0 | 0 |

Table A9.4. Summaries of tag-based estimates of annual **survival** of striped bass ≥28" based on the Instantaneous Rates Model, along with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals. When missing values are present, weights do not add up to 1.

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | **Unweighted average** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.88 | | 0.79 | **0.84** | 0.82 | 0.85 |
| 1989 | | 0.87 | 0.82 | 0.79 | **0.83** | 0.80 | 0.85 |
| 1990 | | 0.82 | 0.80 | 0.74 | **0.79** | 0.76 | 0.81 |
| 1991 | | 0.77 | 0.79 | 0.75 | **0.77** | 0.74 | 0.79 |
| 1992 | 0.82 | 0.77 | 0.80 | 0.74 | **0.78** | 0.76 | 0.81 |
| 1993 | 0.82 | 0.74 | 0.81 | 0.74 | **0.78** | 0.75 | 0.81 |
| 1994 | 0.82 | 0.80 | 0.85 | 0.74 | **0.80** | 0.78 | 0.82 |
| 1995 | 0.74 | 0.72 | 0.80 | 0.69 | **0.74** | 0.72 | 0.76 |
| 1996 | 0.74 | 0.71 | 0.73 | 0.70 | **0.72** | 0.70 | 0.74 |
| 1997 | 0.74 | 0.66 | 0.74 | 0.69 | **0.71** | 0.68 | 0.73 |
| 1998 | 0.74 | 0.63 | 0.67 | 0.69 | **0.68** | 0.65 | 0.71 |
| 1999 | 0.74 | 0.66 | 0.73 | 0.69 | **0.71** | 0.67 | 0.74 |
| 2000 | 0.78 | 0.74 | 0.76 | 0.73 | **0.75** | 0.72 | 0.79 |
| 2001 | 0.79 | 0.74 | 0.75 | 0.73 | **0.75** | 0.72 | 0.78 |
| 2002 | 0.78 | 0.74 | 0.76 | 0.73 | **0.75** | 0.72 | 0.78 |
| 2003 | 0.81 | 0.71 | 0.75 | 0.74 | **0.75** | 0.72 | 0.78 |
| 2004 | 0.81 | 0.73 | 0.76 | 0.74 | **0.76** | 0.74 | 0.78 |
| 2005 | 0.81 | 0.78 | 0.76 | 0.74 | **0.77** | 0.74 | 0.80 |
| 2006 | 0.81 | 0.81 | 0.81 | 0.74 | **0.79** | 0.76 | 0.82 |

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | **Weighted average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.87 | | **0.58** | 0.57 | 0.60 |
| 1988 | 0.82 | | 0.84 | | **0.67** | 0.63 | 0.71 |
| 1989 | 0.82 | | 0.84 | | **0.67** | 0.64 | 0.70 |
| 1990 | 0.76 | | 0.77 | 0.65 | **0.67** | 0.63 | 0.71 |
| 1991 | 0.76 | | 0.67 | 0.65 | **0.62** | 0.57 | 0.67 |
| 1992 | 0.76 | | 0.72 | 0.65 | **0.64** | 0.60 | 0.68 |
| 1993 | 0.76 | 0.67 | 0.73 | 0.65 | **0.71** | 0.67 | 0.74 |
| 1994 | 0.76 | 0.67 | 0.75 | 0.64 | **0.72** | 0.68 | 0.75 |
| 1995 | 0.70 | 0.65 | 0.66 | 0.60 | **0.65** | 0.61 | 0.69 |
| 1996 | 0.70 | 0.65 | 0.70 | 0.60 | **0.67** | 0.64 | 0.71 |
| 1997 | 0.70 | 0.65 | 0.66 | 0.60 | **0.65** | 0.61 | 0.69 |
| 1998 | 0.70 | 0.65 | 0.63 | 0.60 | **0.63** | 0.59 | 0.68 |
| 1999 | 0.70 | 0.65 | 0.63 | 0.60 | **0.63** | 0.58 | 0.69 |
| 2000 | 0.76 | 0.64 | 0.72 | 0.67 | **0.71** | 0.66 | 0.76 |
| 2001 | 0.76 | 0.64 | 0.72 | 0.67 | **0.71** | 0.66 | 0.75 |
| 2002 | 0.76 | 0.64 | 0.79 | 0.67 | **0.74** | 0.70 | 0.78 |
| 2003 | 0.76 | 0.65 | 0.76 | 0.67 | **0.73** | 0.69 | 0.77 |
| 2004 | 0.76 | 0.65 | 0.79 | 0.67 | **0.74** | 0.71 | 0.78 |
| 2005 | 0.76 | 0.65 | 0.79 | 0.68 | **0.75** | 0.71 | 0.78 |
| 2006 | 0.76 | 0.65 | 0.79 | 0.68 | **0.74** | 0.71 | 0.78 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

Table A9.5. Summaries of tag-based estimates of annual **survival** of striped bass ≥18" based on the Instantaneous Rates Model, along with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals. When missing values are present, weights do not add up to 1.

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | **Weighted average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.81 | | **0.55** | 0.54 | 0.55 |
| 1988 | 0.83 | | 0.81 | | **0.65** | 0.64 | 0.66 |
| 1989 | 0.82 | | 0.81 | | **0.65** | 0.64 | 0.66 |
| 1990 | 0.77 | | 0.76 | 0.59 | **0.65** | 0.63 | 0.66 |
| 1991 | 0.77 | | 0.72 | 0.58 | **0.62** | 0.61 | 0.64 |
| 1992 | 0.77 | | 0.67 | 0.55 | **0.59** | 0.57 | 0.61 |
| 1993 | 0.78 | 0.66 | 0.70 | 0.56 | **0.67** | 0.65 | 0.69 |
| 1994 | 0.78 | 0.66 | 0.70 | 0.54 | **0.67** | 0.65 | 0.69 |
| 1995 | 0.72 | 0.66 | 0.65 | 0.54 | **0.63** | 0.61 | 0.65 |
| 1996 | 0.72 | 0.66 | 0.66 | 0.56 | **0.64** | 0.62 | 0.66 |
| 1997 | 0.71 | 0.66 | 0.62 | 0.55 | **0.62** | 0.59 | 0.64 |
| 1998 | 0.71 | 0.66 | 0.60 | 0.55 | **0.61** | 0.58 | 0.63 |
| 1999 | 0.71 | 0.66 | 0.63 | 0.54 | **0.62** | 0.59 | 0.65 |
| 2000 | 0.77 | 0.66 | 0.68 | 0.58 | **0.66** | 0.63 | 0.69 |
| 2001 | 0.77 | 0.66 | 0.70 | 0.57 | **0.67** | 0.65 | 0.70 |
| 2002 | 0.77 | 0.66 | 0.73 | 0.57 | **0.69** | 0.67 | 0.71 |
| 2003 | 0.78 | 0.66 | 0.71 | 0.56 | **0.68** | 0.65 | 0.70 |
| 2004 | 0.78 | 0.66 | 0.74 | 0.56 | **0.69** | 0.67 | 0.71 |
| 2005 | 0.78 | 0.66 | 0.76 | 0.57 | **0.70** | 0.68 | 0.72 |
| 2006 | 0.78 | 0.66 | 0.75 | 0.57 | **0.70** | 0.68 | 0.72 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | **Unweighted average** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.79 | | 0.75 | **0.77** | 0.76 | 0.78 |
| 1989 | | 0.78 | 0.82 | 0.75 | **0.78** | 0.77 | 0.79 |
| 1990 | | 0.76 | 0.81 | 0.69 | **0.75** | 0.74 | 0.76 |
| 1991 | | 0.74 | 0.81 | 0.69 | **0.75** | 0.74 | 0.76 |
| 1992 | 0.82 | 0.75 | 0.81 | 0.69 | **0.77** | 0.76 | 0.78 |
| 1993 | 0.82 | 0.73 | 0.81 | 0.69 | **0.76** | 0.75 | 0.77 |
| 1994 | 0.82 | 0.76 | 0.81 | 0.69 | **0.77** | 0.76 | 0.78 |
| 1995 | 0.76 | 0.74 | 0.75 | 0.65 | **0.73** | 0.71 | 0.74 |
| 1996 | 0.76 | 0.73 | 0.74 | 0.65 | **0.72** | 0.71 | 0.73 |
| 1997 | 0.76 | 0.73 | 0.74 | 0.65 | **0.72** | 0.71 | 0.73 |
| 1998 | 0.76 | 0.74 | 0.74 | 0.65 | **0.72** | 0.71 | 0.73 |
| 1999 | 0.76 | 0.74 | 0.74 | 0.65 | **0.72** | 0.71 | 0.74 |
| 2000 | 0.79 | 0.76 | 0.75 | 0.69 | **0.75** | 0.73 | 0.76 |
| 2001 | 0.79 | 0.75 | 0.74 | 0.69 | **0.74** | 0.73 | 0.76 |
| 2002 | 0.79 | 0.74 | 0.75 | 0.69 | **0.74** | 0.73 | 0.76 |
| 2003 | 0.80 | 0.74 | 0.75 | 0.70 | **0.75** | 0.74 | 0.76 |
| 2004 | 0.80 | 0.75 | 0.75 | 0.70 | **0.75** | 0.74 | 0.76 |
| 2005 | 0.80 | 0.76 | 0.75 | 0.70 | **0.75** | 0.74 | 0.77 |
| 2006 | 0.80 | 0.76 | 0.75 | 0.70 | **0.76** | 0.74 | 0.77 |

Table A9.6. Summaries of tag-based estimates of annual instantaneous **fishing mortality** of striped bass ≥28" based on the Instantaneous Rates Model, along with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals. When missing values are present, weights do not add up to 1.

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | **Weighted average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.03 | | **0.02** | 0.00 | 0.04 |
| 1988 | 0.09 | | 0.03 | | **0.03** | 0.01 | 0.05 |
| 1989 | 0.09 | | 0.03 | | **0.03** | 0.01 | 0.05 |
| 1990 | 0.16 | | 0.16 | 0.14 | **0.14** | 0.12 | 0.16 |
| 1991 | 0.16 | | 0.16 | 0.14 | **0.14** | 0.12 | 0.16 |
| 1992 | 0.16 | | 0.16 | 0.14 | **0.14** | 0.12 | 0.16 |
| 1993 | 0.16 | 0.23 | 0.16 | 0.15 | **0.16** | 0.14 | 0.19 |
| 1994 | 0.16 | 0.23 | 0.16 | 0.15 | **0.17** | 0.14 | 0.19 |
| 1995 | 0.26 | 0.27 | 0.26 | 0.23 | **0.25** | 0.23 | 0.28 |
| 1996 | 0.26 | 0.27 | 0.26 | 0.22 | **0.25** | 0.22 | 0.28 |
| 1997 | 0.26 | 0.27 | 0.26 | 0.23 | **0.25** | 0.23 | 0.28 |
| 1998 | 0.26 | 0.27 | 0.26 | 0.23 | **0.25** | 0.23 | 0.28 |
| 1999 | 0.26 | 0.27 | 0.26 | 0.24 | **0.26** | 0.23 | 0.28 |
| 2000 | 0.18 | 0.28 | 0.14 | 0.12 | **0.15** | 0.13 | 0.18 |
| 2001 | 0.18 | 0.28 | 0.14 | 0.12 | **0.15** | 0.13 | 0.18 |
| 2002 | 0.18 | 0.28 | 0.14 | 0.12 | **0.15** | 0.13 | 0.18 |
| 2003 | 0.18 | 0.26 | 0.10 | 0.12 | **0.13** | 0.11 | 0.15 |
| 2004 | 0.18 | 0.26 | 0.10 | 0.11 | **0.13** | 0.11 | 0.15 |
| 2005 | 0.18 | 0.26 | 0.10 | 0.11 | **0.13** | 0.11 | 0.14 |
| 2006 | 0.18 | 0.26 | 0.10 | 0.11 | **0.13** | 0.11 | 0.14 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | **Unweighted average** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.04 | | 0.05 | **0.04** | 0.03 | 0.05 |
| 1989 | | 0.04 | 0.10 | 0.05 | **0.06** | 0.04 | 0.08 |
| 1990 | | 0.15 | 0.12 | 0.11 | **0.12** | 0.10 | 0.15 |
| 1991 | | 0.15 | 0.13 | 0.11 | **0.13** | 0.10 | 0.15 |
| 1992 | 0.07 | 0.15 | 0.12 | 0.11 | **0.11** | 0.09 | 0.14 |
| 1993 | 0.08 | 0.15 | 0.10 | 0.11 | **0.11** | 0.08 | 0.14 |
| 1994 | 0.08 | 0.15 | 0.05 | 0.11 | **0.10** | 0.08 | 0.11 |
| 1995 | 0.18 | 0.28 | 0.12 | 0.19 | **0.19** | 0.17 | 0.21 |
| 1996 | 0.18 | 0.28 | 0.21 | 0.18 | **0.21** | 0.19 | 0.23 |
| 1997 | 0.18 | 0.28 | 0.20 | 0.19 | **0.21** | 0.19 | 0.23 |
| 1998 | 0.18 | 0.28 | 0.30 | 0.19 | **0.24** | 0.21 | 0.26 |
| 1999 | 0.18 | 0.28 | 0.21 | 0.19 | **0.21** | 0.19 | 0.24 |
| 2000 | 0.13 | 0.20 | 0.17 | 0.13 | **0.16** | 0.13 | 0.18 |
| 2001 | 0.12 | 0.20 | 0.19 | 0.14 | **0.16** | 0.14 | 0.19 |
| 2002 | 0.13 | 0.20 | 0.18 | 0.14 | **0.16** | 0.14 | 0.18 |
| 2003 | 0.10 | 0.19 | 0.19 | 0.13 | **0.15** | 0.13 | 0.17 |
| 2004 | 0.10 | 0.19 | 0.18 | 0.13 | **0.15** | 0.13 | 0.17 |
| 2005 | 0.10 | 0.19 | 0.18 | 0.12 | **0.15** | 0.13 | 0.17 |
| 2006 | 0.10 | 0.19 | 0.12 | 0.12 | **0.13** | 0.11 | 0.15 |

Table A9.7. Summaries of tag-based estimates of annual instantaneous **fishing mortality** of striped bass ≥18" based on the Instantaneous Rates Model, along with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals. When missing values are present, weights do not add up to 1.

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | **Weighted average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.00 | | **0.00** | 0.00 | 0.01 |
| 1988 | 0.05 | | 0.01 | | **0.02** | 0.01 | 0.02 |
| 1989 | 0.05 | | 0.00 | | **0.01** | 0.01 | 0.01 |
| 1990 | 0.11 | | 0.07 | 0.06 | **0.07** | 0.05 | 0.08 |
| 1991 | 0.11 | | 0.12 | 0.07 | **0.10** | 0.08 | 0.12 |
| 1992 | 0.11 | | 0.19 | 0.11 | **0.14** | 0.12 | 0.17 |
| 1993 | 0.11 | 0.16 | 0.15 | 0.10 | **0.14** | 0.11 | 0.16 |
| 1994 | 0.11 | 0.16 | 0.15 | 0.13 | **0.14** | 0.11 | 0.17 |
| 1995 | 0.20 | 0.16 | 0.23 | 0.15 | **0.20** | 0.16 | 0.23 |
| 1996 | 0.20 | 0.16 | 0.21 | 0.10 | **0.17** | 0.14 | 0.21 |
| 1997 | 0.20 | 0.16 | 0.27 | 0.13 | **0.22** | 0.17 | 0.26 |
| 1998 | 0.20 | 0.16 | 0.31 | 0.13 | **0.23** | 0.19 | 0.28 |
| 1999 | 0.20 | 0.16 | 0.26 | 0.14 | **0.21** | 0.16 | 0.26 |
| 2000 | 0.13 | 0.17 | 0.18 | 0.07 | **0.14** | 0.10 | 0.18 |
| 2001 | 0.13 | 0.17 | 0.15 | 0.09 | **0.13** | 0.10 | 0.17 |
| 2002 | 0.13 | 0.17 | 0.11 | 0.09 | **0.11** | 0.08 | 0.14 |
| 2003 | 0.12 | 0.16 | 0.14 | 0.10 | **0.13** | 0.09 | 0.16 |
| 2004 | 0.12 | 0.16 | 0.10 | 0.11 | **0.11** | 0.08 | 0.14 |
| 2005 | 0.12 | 0.16 | 0.08 | 0.08 | **0.09** | 0.07 | 0.12 |
| 2006 | 0.12 | 0.16 | 0.08 | 0.09 | **0.10** | 0.07 | 0.13 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | **Unweighted average** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.01 | | 0.02 | **0.02** | 0.01 | 0.02 |
| 1989 | | 0.01 | 0.02 | 0.02 | **0.02** | 0.01 | 0.03 |
| 1990 | | 0.06 | 0.04 | 0.10 | **0.07** | 0.06 | 0.07 |
| 1991 | | 0.06 | 0.04 | 0.10 | **0.07** | 0.06 | 0.07 |
| 1992 | 0.07 | 0.06 | 0.04 | 0.11 | **0.07** | 0.06 | 0.08 |
| 1993 | 0.07 | 0.06 | 0.04 | 0.11 | **0.07** | 0.06 | 0.08 |
| 1994 | 0.07 | 0.06 | 0.04 | 0.11 | **0.07** | 0.06 | 0.07 |
| 1995 | 0.14 | 0.08 | 0.12 | 0.16 | **0.13** | 0.12 | 0.14 |
| 1996 | 0.14 | 0.08 | 0.13 | 0.16 | **0.13** | 0.12 | 0.14 |
| 1997 | 0.14 | 0.08 | 0.13 | 0.17 | **0.13** | 0.12 | 0.14 |
| 1998 | 0.14 | 0.08 | 0.13 | 0.17 | **0.13** | 0.12 | 0.14 |
| 1999 | 0.14 | 0.08 | 0.13 | 0.16 | **0.13** | 0.12 | 0.14 |
| 2000 | 0.11 | 0.06 | 0.13 | 0.11 | **0.10** | 0.09 | 0.11 |
| 2001 | 0.10 | 0.06 | 0.13 | 0.11 | **0.10** | 0.09 | 0.11 |
| 2002 | 0.10 | 0.06 | 0.13 | 0.11 | **0.10** | 0.09 | 0.11 |
| 2003 | 0.09 | 0.05 | 0.13 | 0.10 | **0.09** | 0.08 | 0.10 |
| 2004 | 0.09 | 0.05 | 0.13 | 0.10 | **0.09** | 0.08 | 0.10 |
| 2005 | 0.09 | 0.05 | 0.13 | 0.09 | **0.09** | 0.08 | 0.10 |
| 2006 | 0.09 | 0.05 | 0.12 | 0.09 | **0.09** | 0.08 | 0.10 |

Table A9.8. Summaries of tag-based estimates of annual instantaneous **natural mortality** of striped bass ≥28" based on the Instantaneous Rates Model, along with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals. When missing values are present, weights do not add to 1.

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | **Unweighted average** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.09 | | 0.18 | **0.14** | 0.13 | 0.14 |
| 1989 | | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1990 | | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1991 | | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1992 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1993 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1994 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1995 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1996 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1997 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1998 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 1999 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 2000 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 2001 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 2002 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 2003 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 2004 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 2005 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |
| 2006 | 0.11 | 0.09 | 0.09 | 0.18 | **0.12** | 0.11 | 0.13 |

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | **Weighted average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.14 | | **0.09** | 0.08 | 0.11 |
| 1988 | 0.09 | | 0.14 | | **0.11** | 0.09 | 0.13 |
| 1989 | 0.09 | | 0.14 | | **0.11** | 0.09 | 0.13 |
| 1990 | 0.09 | | 0.14 | 0.28 | **0.16** | 0.13 | 0.18 |
| 1991 | 0.09 | | 0.14 | 0.28 | **0.16** | 0.13 | 0.18 |
| 1992 | 0.09 | | 0.14 | 0.28 | **0.16** | 0.13 | 0.18 |
| 1993 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 1994 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 1995 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 1996 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 1997 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 1998 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 1999 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 2000 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 2001 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 2002 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 2003 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 2004 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 2005 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |
| 2006 | 0.09 | 0.16 | 0.14 | 0.28 | **0.17** | 0.15 | 0.19 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

Table A9.9. Summaries of tag-based estimates of annual instantaneous **natural mortality** of striped bass ≥18" based on the Instantaneous Rates Model, along with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals. When missing values are present, weights do not add to 1.

**Producer Area Programs**

| Year | HUDSON | DE/PA | MDCB | VARAP | Weighted average* | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | 0.20 | | **0.13** | 0.12 | 0.14 |
| 1988 | 0.12 | | 0.20 | | **0.15** | 0.14 | 0.16 |
| 1989 | 0.12 | | 0.20 | | **0.15** | 0.14 | 0.16 |
| 1990 | 0.12 | | 0.20 | 0.47 | **0.24** | 0.22 | 0.26 |
| 1991 | 0.12 | | 0.20 | 0.47 | **0.24** | 0.22 | 0.26 |
| 1992 | 0.12 | | 0.20 | 0.47 | **0.24** | 0.22 | 0.26 |
| 1993 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 1994 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 1995 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 1996 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 1997 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 1998 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 1999 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 2000 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 2001 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 2002 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 2003 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 2004 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 2005 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |
| 2006 | 0.12 | 0.25 | 0.20 | 0.47 | **0.26** | 0.25 | 0.28 |

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

**Coast Programs**

| Year | MADFW | NYOHS | NJDEL | NCCOOP | Unweighted average | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|---|---|
| 1987 | | | | | | | |
| 1988 | | 0.24 | | 0.26 | **0.25** | 0.24 | 0.26 |
| 1989 | | 0.24 | 0.15 | 0.26 | **0.22** | 0.21 | 0.23 |
| 1990 | | 0.24 | 0.15 | 0.26 | **0.22** | 0.21 | 0.23 |
| 1991 | | 0.24 | 0.15 | 0.26 | **0.22** | 0.21 | 0.23 |
| 1992 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 1993 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 1994 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 1995 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 1996 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 1997 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 1998 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 1999 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 2000 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 2001 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 2002 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 2003 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 2004 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 2005 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |
| 2006 | 0.12 | 0.24 | 0.15 | 0.26 | **0.19** | 0.18 | 0.20 |

Table A9.10. Coastwide fishing mortality rates, presented as an unweighted average of producer and coastal programs' means developed using the Instantaneous Rates Model, and coastwide stock size estimates (in numbers of fish) for age 7+ and age 3+ fish, obtained via "Kill = F * Stock Size".

**Instantaneous Rates Method**

| Year | Fishing Mortality | Age 7+ Kill includes discards | Total Stock Size Thousands |
|---|---|---|---|
| 1988 | 0.04 | 101.4 | 2,799 |
| 1989 | 0.05 | 95 | 2,074 |
| 1990 | 0.13 | 222.3 | 1,673 |
| 1991 | 0.13 | 296.4 | 2,201 |
| 1992 | 0.13 | 262.7 | 2,057 |
| 1993 | 0.14 | 380.6 | 2,786 |
| 1994 | 0.13 | 475.9 | 3,616 |
| 1995 | 0.22 | 740 | 3,309 |
| 1996 | 0.23 | 965.3 | 4,148 |
| 1997 | 0.23 | 1371.1 | 5,899 |
| 1998 | 0.25 | 1080.5 | 4,400 |
| 1999 | 0.23 | 1146.8 | 4,885 |
| 2000 | 0.16 | 1471.8 | 9,439 |
| 2001 | 0.16 | 1583.2 | 9,956 |
| 2002 | 0.16 | 2075.4 | 13,229 |
| 2003 | 0.14 | 2163.1 | 15,458 |
| 2004 | 0.14 | 2376.2 | 17,278 |
| 2005 | 0.14 | 2132.5 | 15,627 |
| 2006 | 0.13 | 2139.3 | 16,559 |

**Instantaneous Rates Method**

| Year | Fishing Mortality | Age 3+ Kill includes discards | Total Stock Size Thousands |
|---|---|---|---|
| 1988 | 0.02 | 444.9 | 27,268 |
| 1989 | 0.01 | 479.9 | 35,749 |
| 1990 | 0.07 | 921.3 | 13,771 |
| 1991 | 0.08 | 988.4 | 11,988 |
| 1992 | 0.10 | 986.9 | 9,477 |
| 1993 | 0.10 | 1437 | 14,151 |
| 1994 | 0.10 | 1866.6 | 18,054 |
| 1995 | 0.16 | 2999.7 | 18,510 |
| 1996 | 0.15 | 3376.2 | 22,333 |
| 1997 | 0.17 | 4580.2 | 26,579 |
| 1998 | 0.18 | 4118.3 | 22,583 |
| 1999 | 0.17 | 3704.4 | 21,750 |
| 2000 | 0.12 | 5044.4 | 41,091 |
| 2001 | 0.12 | 4344 | 37,125 |
| 2002 | 0.11 | 3889.5 | 36,649 |
| 2003 | 0.11 | 4836.2 | 43,798 |
| 2004 | 0.10 | 5184.8 | 51,187 |
| 2005 | 0.09 | 5125.5 | 55,488 |
| 2006 | 0.09 | 5763.4 | 60,771 |

Table A9.11. Weighted average of annual instantaneous fishing mortality for the Chesapeake Bay specific analysis, along with 95% confidence intervals, for male striped bass 18 - 28 inches, using instantaneous rates model and a constant estimable M assumption.

| Year | F Maryland | F Virginia | **Weighted F average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|
| 1987 | 0.00 | | **0.00** | 0.00 | 0.00 |
| 1988 | 0.00 | 0.01 | **0.01** | 0.00 | 0.01 |
| 1989 | 0.00 | 0.00 | **0.00** | 0.00 | 0.00 |
| 1990 | 0.05 | 0.06 | **0.05** | 0.04 | 0.07 |
| 1991 | 0.09 | 0.06 | **0.08** | 0.06 | 0.10 |
| 1992 | 0.15 | 0.17 | **0.16** | 0.13 | 0.19 |
| 1993 | 0.13 | 0.06 | **0.11** | 0.09 | 0.13 |
| 1994 | 0.12 | 0.05 | **0.10** | 0.08 | 0.12 |
| 1995 | 0.16 | 0.09 | **0.13** | 0.11 | 0.15 |
| 1996 | 0.13 | 0.04 | **0.10** | 0.08 | 0.11 |
| 1997 | 0.15 | 0.07 | **0.13** | 0.10 | 0.15 |
| 1998 | 0.17 | 0.05 | **0.13** | 0.11 | 0.15 |
| 1999 | 0.10 | 0.05 | **0.09** | 0.07 | 0.11 |
| 2000 | 0.10 | 0.04 | **0.08** | 0.06 | 0.09 |
| 2001 | 0.07 | 0.06 | **0.06** | 0.05 | 0.08 |
| 2002 | 0.07 | 0.03 | **0.06** | 0.05 | 0.07 |
| 2003 | 0.08 | 0.03 | **0.07** | 0.05 | 0.08 |
| 2004 | 0.07 | 0.05 | **0.06** | 0.05 | 0.08 |
| 2005 | 0.05 | 0.04 | **0.05** | 0.03 | 0.06 |
| 2006 | 0.05 | 0.06 | **0.05** | 0.04 | 0.07 |

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Table A9.12. Weighted average of annual instantaneous fishing mortality for the Chesapeake Bay specific analysis, along with 95% confidence intervals, for male striped bass 18 - 28 inches, using instantaneous rates model and two periods of estimable M.

| Year | F Maryland | F Virginia | **Weighted F average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|
| 1987 | 0.00 | | **0.00** | 0.00 | 0.00 |
| 1988 | 0.00 | 0.01 | **0.01** | 0.00 | 0.01 |
| 1989 | 0.00 | 0.00 | **0.00** | 0.00 | 0.00 |
| 1990 | 0.05 | 0.04 | **0.05** | 0.04 | 0.06 |
| 1991 | 0.08 | 0.04 | **0.07** | 0.06 | 0.08 |
| 1992 | 0.14 | 0.10 | **0.12** | 0.10 | 0.14 |
| 1993 | 0.12 | 0.04 | **0.09** | 0.08 | 0.11 |
| 1994 | 0.10 | 0.03 | **0.08** | 0.07 | 0.09 |
| 1995 | 0.13 | 0.06 | **0.11** | 0.09 | 0.13 |
| 1996 | 0.10 | 0.03 | **0.08** | 0.06 | 0.09 |
| 1997 | 0.14 | 0.07 | **0.11** | 0.09 | 0.13 |
| 1998 | 0.20 | 0.06 | **0.15** | 0.13 | 0.18 |
| 1999 | 0.15 | 0.07 | **0.13** | 0.10 | 0.15 |
| 2000 | 0.15 | 0.05 | **0.12** | 0.09 | 0.14 |
| 2001 | 0.11 | 0.09 | **0.10** | 0.08 | 0.13 |
| 2002 | 0.12 | 0.06 | **0.10** | 0.08 | 0.12 |
| 2003 | 0.16 | 0.05 | **0.12** | 0.09 | 0.15 |
| 2004 | 0.15 | 0.08 | **0.13** | 0.09 | 0.16 |
| 2005 | 0.10 | 0.06 | **0.09** | 0.06 | 0.11 |
| 2006 | 0.12 | 0.09 | **0.11** | 0.08 | 0.14 |

Table A9.13. Weighted average of annual instantaneous fishing mortality for the Chesapeake Bay specific analysis, along with 95% confidence intervals, for male striped bass 18 - 28 inches, using instantaneous rates model and three periods of estimable M.

| Year | F Maryland | F Virginia | **Weighted F average*** | lower 95% CI | upper 95% CI |
|---|---|---|---|---|---|
| 1987 | 0.00 | | **0.00** | 0.00 | 0.00 |
| 1988 | 0.00 | 0.01 | **0.01** | 0.00 | 0.01 |
| 1989 | 0.00 | 0.00 | **0.00** | 0.00 | 0.00 |
| 1990 | 0.05 | 0.04 | **0.05** | 0.04 | 0.06 |
| 1991 | 0.08 | 0.04 | **0.07** | 0.06 | 0.08 |
| 1992 | 0.14 | 0.10 | **0.12** | 0.10 | 0.14 |
| 1993 | 0.12 | 0.04 | **0.09** | 0.08 | 0.11 |
| 1994 | 0.11 | 0.03 | **0.08** | 0.07 | 0.09 |
| 1995 | 0.13 | 0.06 | **0.11** | 0.09 | 0.13 |
| 1996 | 0.10 | 0.03 | **0.08** | 0.06 | 0.09 |
| 1997 | 0.14 | 0.07 | **0.11** | 0.09 | 0.13 |
| 1998 | 0.20 | 0.06 | **0.15** | 0.13 | 0.18 |
| 1999 | 0.15 | 0.08 | **0.12** | 0.09 | 0.15 |
| 2000 | 0.14 | 0.05 | **0.11** | 0.09 | 0.14 |
| 2001 | 0.11 | 0.09 | **0.10** | 0.08 | 0.13 |
| 2002 | 0.12 | 0.06 | **0.10** | 0.08 | 0.13 |
| 2003 | 0.17 | 0.05 | **0.13** | 0.10 | 0.16 |
| 2004 | 0.17 | 0.07 | **0.13** | 0.10 | 0.17 |
| 2005 | 0.11 | 0.06 | **0.09** | 0.06 | 0.12 |
| 2006 | 0.13 | 0.08 | **0.12** | 0.08 | 0.15 |

Table A10.1. The fraction of total mortality (p) that occurs prior to the survey and ages to which survey indices are linked.

| | p | Linked Ages |
|---|---|---|
| Age-specific | | |
| NY YOY | 0 | 1 (January 1st) |
| NJ YOY | 0 | 1 (January 1st) |
| MD YOY | 0 | 1 (January 1st) |
| VA YOY | 0 | 1 (January 1st) |
| MD Age 1 | 0 | 2 (January 1st) |
| NY (WLI) Age 1 | 0 | 2 (January 1st) |
| | | |
| Aggregate | | |
| MRFSS | 0.5 | 3-13+ |
| CTCPUE | 0.5 | 2-13+ |
| NEFSC | 0.333 | 2-9 |
| CT Trawl | 0.333 | 2-4 |
| MA COMM | 0.5 | 3-13+ |
| | | |
| Indices with age compositions | | |
| NY OHS | 0.75 | 2-13+ |
| NJ Trawl | 0.25 | 1-13+ |
| MD SSN | 0.25 | 1-13+ |
| DE SSN | 0.25 | 2-13+ |

Table A10.2. Estimates of effective sample size from the New Jersey, Delaware, Maryland, and New York fishery-independent surveys.

| Survey | Year | No. Hauls With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| NJ | 1999 | 22 | 298 | 45.2 | 181.893 | 46.5 | 9.199 | 20 |
| | 2000 | 28 | 280 | 51.8 | 278.077 | 51.7 | 12.715 | 22 |
| | 2001 | 23 | 94 | 51.7 | 291.755 | 51.9 | 10.24 | 28 |
| | | | | | | | Average | 23 |

| Survey | Year | No. Runs With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| DE | 1999 | 50 | 281 | 611.9 | 30784.3 | 610.4 | 357.375 | 86 |
| | 2000 | 37 | 304 | 565.7 | 24952.6 | 546.5 | 502.028 | 50 |
| | 2001 | 44 | 288 | 617.6 | 26952.1 | 616.6 | 402.063 | 67 |
| | | | | | | | Average | 68 |

Assuming Sets is Sampling Units

| Survey | Year | No. of Sets With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| MD | 1999 | 20 | 2883 | 478.1 | 18555.6 | 474.5 | 395.414 | 47 |
| | 2000 | 20 | 2349 | 519.5 | 20641.4 | 518.4 | 205.491 | 100 |
| | 2001 | 20 | 1868 | 597.2 | 32827.2 | 597 | 140.701 | 233 |
| | 2002 | 20 | 2212 | 550.9 | 27542.1 | 547.5 | 466.204 | 59 |
| | 2003 | 21 | 2115 | 547.6 | 29745.5 | 544.1 | 827.03 | 36 |
| | 2004 | 20 | 2325 | 540.3 | 34938.5 | 534.1 | 1459.24 | 24 |
| | 2005 | 20 | 1650 | 551.2 | 35616.4 | 548.3 | 1110.37 | 32 |
| | 2006 | 20 | 1766 | 522.5 | 34920.8 | 511.5 | 2001.31 | 17 |
| | | | | | | | Average | 68.5 |

| Survey | Year | No. of Sets With Bass | No. Bass Measured | SRS Mean Length | SRS s2 | Cluster Sampling Mean Length | Cluster Sampling Var(Mean) | Effective Sample Size |
|---|---|---|---|---|---|---|---|---|
| NY | 1987 | 56 | 1949 | 639.2 | 8160.28 | 641.0 | 133.62 | 61 |
| | 1988 | 58 | 2098 | 604.0 | 17370.60 | 604.1 | 212.23 | 82 |
| | 1989 | 59 | 1195 | 621.4 | 18716.80 | 621.1 | 219.26 | 85 |
| | 1990 | 58 | 2042 | 658.7 | 13897.90 | 661.7 | 425.84 | 33 |
| | 1991 | 55 | 1788 | 552.1 | 15240.70 | 547.8 | 364.91 | 42 |
| | 1992 | 58 | 1605 | 570.5 | 10023.30 | 566.9 | 256.25 | 39 |
| | 1993 | 59 | 2201 | 604.9 | 17746.40 | 605.6 | 288.53 | 62 |
| | 1994 | 59 | 1710 | 613.1 | 15112.60 | 608.4 | 290.56 | 52 |
| | 1995 | 57 | 1491 | 438.3 | 9199.04 | 427.2 | 769.23 | 12 |
| | 1996 | 54 | 2198 | 485.7 | 6536.21 | 485.8 | 113.08 | 58 |
| | 1997 | 45 | 1665 | 492.8 | 4449.32 | 492.9 | 37.65 | 118 |
| | 1998 | 44 | 1591 | 545.0 | 7387.53 | 545.9 | 263.46 | 28 |
| | 1999 | 45 | 1398 | 519.5 | 5399.00 | 516.1 | 140.50 | 38 |
| | 2000 | 44 | 1520 | 597.1 | 13592.10 | 598.5 | 222.20 | 61 |
| | 2001 | 45 | 1052 | 549.5 | 7082.03 | 541.1 | 470.01 | 15 |
| | 2002 | 44 | 1220 | 514.5 | 13092.00 | 513.4 | 131.26 | 100 |
| | 2003 | 25 | 833 | 572.5 | 11641.00 | 572.3 | 246.95 | 47 |
| | 2004 | 44 | 1524 | 526.4 | 8424.27 | 526.4 | 71.92 | 117 |
| | 2005 | 40 | 1037 | 535.9 | 9950.54 | 540.7 | 443.79 | 22 |
| | | | | | | | Average | 56.4210526 |

Table A10.3. Starting values for the various model parameters.

| | | |
|---|---|---|
| *Average recruitment (log)* | | 10.6 |
| *Average fishing mortality(log)* | | -2.6 |
| *Catch Selectivity Parameters* | | |
| | $\alpha$ | 3 |
| | $\beta$ | 1 |
| *Survey Selectivity - NJ Trawl, DE SSN, MDSSN* | | |
| | $\alpha$ | 3 |
| | $\beta$ | 1 |
| | - MD SSN | |
| | $s_2$ | 0.3 |
| | *-NYOHS* | |
| | $\gamma$ | 0.95 |
| | $\alpha$ | -1 |
| | $\beta$ | 1 |
| *Catchability Coefficients (log)* | | |
| YOY/Age1 Indices | q | -20.4 |
| Aggregate Indices | q | -19.7 |
| Survey/Age Comp Indices | q | -20.2 |
| Fishing Mortality on Tags | F’ | -2.3 |

Table A10.4. Likelihood components with respective contributions from model run with lambda weight=50.

Likelihood Components

| | | Weight | RSS |
|---|---|---|---|
| Total Catch | : | 50 | 710.41 |
| YOY/Yearl Surveys | | | |
| NY YOY | : | 1 | 1742.86 |
| NJ YOY | : | 1 | 296.742 |
| MD YOY | : | 1 | 607.99 |
| VA YOY | : | 1 | 492.518 |
| NY Age 1 | : | 1 | 109.723 |
| MD Age 1 | : | 1 | 374.071 |
| Aggregate Surveys | | | |
| MRFSS | : | 1 | 50.8155 |
| CT CPUE | : | 1 | 21.3358 |
| NEFSC | : | 1 | 89.9807 |
| CT Trawl | : | 1 | 226.942 |
| Age Survey Indices | | | |
| NY OHS | : | 1 | 142.004 |
| NJ Trawl | : | 1 | 59.6951 |
| MD SSN | : | 1 | 290.152 |
| DE SSN | : | 1 | 21.4552 |
| | | | |
| Total RSS | | | 5236.69 |
| No. of Obs | | | 351 |
| Conc. Likelihood | | | 474.317 |
| | | | |
| Catch Age Comps | : | 1 | 20433.1 |
| Survey Age Comps | | | |
| NYOHS | : | 1 | 1863.78 |
| NJ Trawl | : | 1 | 764.115 |
| MD SSN | : | 1 | 3274.67 |
| DE SSN | : | 1 | 2131.66 |
| | | | |
| Recr Devs | : | 1 | 33.1619 |
| F Devs | : | 1 | 4.28312 |
| | | | |
| Tag Data | | | |
| Hudson River | : | 1 | 11125.9 |
| Delaware River | : | 1 | 2240.51 |
| Maryland | : | 1 | 7486.31 |
| Virginia | : | 1 | 3166.53 |
| New York OHS | : | 1 | 4472.33 |
| Massachusetts | : | 1 | 4563.36 |
| New Jersey | : | 1 | 5772.27 |
| North Carolina | : | 1 | 9356.39 |
| | | | |
| Total Likelihood | : | | 77162.7 |

Table A10.5. Parameter estimates and associated standard deviations of final model configuration.

| Year | F | SD | CV |
|---|---|---|---|
| 1982 | 0.48 | 0.024 | 0.05 |
| 1983 | 0.29 | 0.036 | 0.13 |
| 1984 | 0.29 | 0.031 | 0.11 |
| 1985 | 0.22 | 0.026 | 0.12 |
| 1986 | 0.15 | 0.020 | 0.13 |
| 1987 | 0.07 | 0.008 | 0.10 |
| 1988 | 0.09 | 0.011 | 0.12 |
| 1989 | 0.08 | 0.007 | 0.09 |
| 1990 | 0.13 | 0.006 | 0.05 |
| 1991 | 0.13 | 0.006 | 0.05 |
| 1992 | 0.11 | 0.004 | 0.04 |
| 1993 | 0.13 | 0.005 | 0.04 |
| 1994 | 0.13 | 0.005 | 0.03 |
| 1995 | 0.19 | 0.006 | 0.03 |
| 1996 | 0.22 | 0.006 | 0.03 |
| 1997 | 0.25 | 0.007 | 0.03 |
| 1998 | 0.22 | 0.006 | 0.03 |
| 1999 | 0.17 | 0.005 | 0.03 |
| 2000 | 0.20 | 0.005 | 0.03 |
| 2001 | 0.17 | 0.004 | 0.02 |
| 2002 | 0.15 | 0.004 | 0.03 |
| 2003 | 0.17 | 0.005 | 0.03 |
| 2004 | 0.16 | 0.005 | 0.03 |
| 2005 | 0.15 | 0.005 | 0.03 |
| 2006 | 0.15 | 0.005 | 0.03 |

Catch Selectivtiy Parameters

| | Estimate | SD | CV |
|---|---|---|---|
| 1982-1984 | | | |
| α | 1.77 | 0.043 | 0.02 |
| β | 2.22 | 0.138 | 0.06 |
| 1985-1989 | | | |
| α | 3.64 | 0.141 | 0.04 |
| β | 0.58 | 0.034 | 0.06 |
| 1990-1995 | | | |
| α | 3.23 | 0.069 | 0.02 |
| β | 0.74 | 0.034 | 0.05 |
| 1996-2006 | | | |
| α | 3.74 | 0.073 | 0.02 |
| β | 0.57 | 0.020 | 0.03 |

| Year | R | SD | CV |
|---|---|---|---|
| 1970 | 2.20E+07 | 8.35E+06 | 0.38 |
| 1971 | 3.97E+07 | 1.29E+07 | 0.33 |
| 1972 | 1.67E+07 | 5.49E+06 | 0.33 |
| 1973 | 1.01E+07 | 3.02E+06 | 0.30 |
| 1974 | 5.35E+06 | 1.48E+06 | 0.28 |
| 1975 | 3.52E+06 | 8.93E+05 | 0.25 |
| 1976 | 2.76E+06 | 5.46E+05 | 0.20 |
| 1977 | 1.85E+06 | 3.29E+05 | 0.18 |
| 1978 | 2.20E+06 | 2.83E+05 | 0.13 |
| 1979 | 3.59E+06 | 3.15E+05 | 0.09 |
| 1980 | 2.27E+06 | 1.69E+05 | 0.07 |
| 1981 | 1.46E+06 | 9.72E+04 | 0.07 |
| 1982 | 1.59E+06 | 9.46E+04 | 0.06 |
| 1983 | 4.01E+06 | 1.74E+05 | 0.04 |
| 1984 | 3.30E+06 | 1.55E+05 | 0.05 |
| 1985 | 3.24E+06 | 1.58E+05 | 0.05 |
| 1986 | 3.06E+06 | 1.59E+05 | 0.05 |
| 1987 | 4.21E+06 | 2.00E+05 | 0.05 |
| 1988 | 5.06E+06 | 2.34E+05 | 0.05 |
| 1989 | 6.29E+06 | 2.79E+05 | 0.04 |
| 1990 | 9.07E+06 | 3.68E+05 | 0.04 |
| 1991 | 7.81E+06 | 3.53E+05 | 0.05 |
| 1992 | 8.41E+06 | 3.88E+05 | 0.05 |
| 1993 | 1.09E+07 | 4.67E+05 | 0.04 |
| 1994 | 2.22E+07 | 7.28E+05 | 0.03 |
| 1995 | 1.46E+07 | 6.00E+05 | 0.04 |
| 1996 | 1.75E+07 | 6.97E+05 | 0.04 |
| 1997 | 2.13E+07 | 8.23E+05 | 0.04 |
| 1998 | 1.39E+07 | 6.82E+05 | 0.05 |
| 1999 | 1.46E+07 | 7.59E+05 | 0.05 |
| 2000 | 1.24E+07 | 7.61E+05 | 0.06 |
| 2001 | 2.33E+07 | 1.26E+06 | 0.05 |
| 2002 | 3.08E+07 | 1.79E+06 | 0.06 |
| 2003 | 1.69E+07 | 1.47E+06 | 0.09 |
| 2004 | 5.27E+07 | 4.11E+06 | 0.08 |
| 2005 | 1.56E+07 | 2.56E+06 | 0.16 |
| 2006 | 1.37E+07 | 3.47E+06 | 0.25 |

| Year | F' | SD | CV |
|---|---|---|---|
| 1988 | 0.08 | 0.015 | 0.19 |
| 1989 | 0.17 | 0.015 | 0.09 |
| 1990 | 0.17 | 0.013 | 0.08 |
| 1991 | 0.15 | 0.010 | 0.07 |
| 1992 | 0.14 | 0.009 | 0.06 |
| 1993 | 0.13 | 0.008 | 0.06 |
| 1994 | 0.12 | 0.007 | 0.06 |
| 1995 | 0.10 | 0.006 | 0.06 |
| 1996 | 0.08 | 0.005 | 0.07 |
| 1997 | 0.08 | 0.006 | 0.07 |
| 1998 | 0.08 | 0.006 | 0.08 |
| 1999 | 0.08 | 0.007 | 0.09 |
| 2000 | 0.06 | 0.006 | 0.10 |
| 2001 | 0.06 | 0.005 | 0.09 |
| 2002 | 0.06 | 0.005 | 0.08 |
| 2003 | 0.06 | 0.005 | 0.07 |
| 2004 | 0.05 | 0.004 | 0.07 |
| 2005 | 0.05 | 0.004 | 0.08 |
| 2006 | 0.05 | 0.004 | 0.07 |

Survey Selectivity Parameters

| | Estimate | SD | CV |
|---|---|---|---|
| NYOHS | | | |
| γ | 0.95 | 0.024 | 0.03 |
| α | 1.44 | 0.425 | 0.36 |
| β | 0.33 | 0.098 | 0.30 |
| NJ Trawl | | | |
| α | 1.44 | 0.425 | 0.29 |
| β | 0.33 | 0.098 | 0.30 |
| DE SSN | | | |
| α | 3.85 | 0.246 | 0.06 |
| β | 0.53 | 0.070 | 0.13 |
| MDSSN | | | |
| $s_2$ | 0.27 | 0.022 | 0.08 |

Table A10.6. Estimates of average and abundance weighted fishing mortality from SCATAG.

| | Average F | | N Weighted F | |
|---|---|---|---|---|
| Year | 8-11 | 3-8 | 7-11 | 3-8 |
| 1982 | 0.481 | 0.475 | 0.481 | 0.477 |
| 1983 | 0.286 | 0.283 | 0.286 | 0.278 |
| 1984 | 0.295 | 0.291 | 0.295 | 0.288 |
| 1985 | 0.209 | 0.141 | 0.199 | 0.103 |
| 1986 | 0.148 | 0.100 | 0.139 | 0.059 |
| 1987 | 0.071 | 0.048 | 0.067 | 0.031 |
| 1988 | 0.088 | 0.060 | 0.084 | 0.042 |
| 1989 | 0.076 | 0.052 | 0.073 | 0.041 |
| 1990 | 0.126 | 0.094 | 0.122 | 0.079 |
| 1991 | 0.126 | 0.094 | 0.122 | 0.078 |
| 1992 | 0.104 | 0.078 | 0.102 | 0.063 |
| 1993 | 0.127 | 0.095 | 0.125 | 0.073 |
| 1994 | 0.132 | 0.099 | 0.130 | 0.081 |
| 1995 | 0.189 | 0.142 | 0.185 | 0.120 |
| 1996 | 0.208 | 0.137 | 0.198 | 0.109 |
| 1997 | 0.245 | 0.162 | 0.232 | 0.111 |
| 1998 | 0.208 | 0.137 | 0.198 | 0.103 |
| 1999 | 0.167 | 0.110 | 0.160 | 0.085 |
| 2000 | 0.191 | 0.126 | 0.182 | 0.099 |
| 2001 | 0.165 | 0.109 | 0.154 | 0.094 |
| 2002 | 0.141 | 0.093 | 0.134 | 0.084 |
| 2003 | 0.161 | 0.106 | 0.154 | 0.098 |
| 2004 | 0.157 | 0.104 | 0.150 | 0.088 |
| 2005 | 0.148 | 0.098 | 0.143 | 0.076 |
| 2006 | 0.142 | 0.094 | 0.137 | 0.077 |

Table A10.7. Estimates of fishing mortality-at-age.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | 0.002 | 0.263 | 0.450 | 0.477 | 0.480 | 0.481 | 0.481 | 0.481 | 0.481 | 0.481 | 0.481 | 0.481 | 0.481 |
| 1983 | 0.001 | 0.156 | 0.268 | 0.284 | 0.286 | 0.286 | 0.286 | 0.286 | 0.286 | 0.286 | 0.286 | 0.286 | 0.286 |
| 1984 | 0.001 | 0.161 | 0.276 | 0.293 | 0.294 | 0.295 | 0.295 | 0.295 | 0.295 | 0.295 | 0.295 | 0.295 | 0.295 |
| 1985 | 0.002 | 0.016 | 0.051 | 0.097 | 0.138 | 0.169 | 0.189 | 0.201 | 0.208 | 0.212 | 0.214 | 0.216 | 0.216 |
| 1986 | 0.001 | 0.012 | 0.036 | 0.069 | 0.098 | 0.120 | 0.134 | 0.142 | 0.147 | 0.150 | 0.152 | 0.153 | 0.153 |
| 1987 | 0.001 | 0.006 | 0.017 | 0.033 | 0.047 | 0.057 | 0.064 | 0.068 | 0.070 | 0.072 | 0.073 | 0.073 | 0.073 |
| 1988 | 0.001 | 0.007 | 0.022 | 0.041 | 0.059 | 0.071 | 0.080 | 0.085 | 0.088 | 0.090 | 0.091 | 0.091 | 0.091 |
| 1989 | 0.001 | 0.006 | 0.019 | 0.035 | 0.051 | 0.062 | 0.069 | 0.074 | 0.076 | 0.078 | 0.078 | 0.079 | 0.079 |
| 1990 | 0.001 | 0.011 | 0.039 | 0.073 | 0.098 | 0.112 | 0.120 | 0.124 | 0.126 | 0.127 | 0.127 | 0.127 | 0.127 |
| 1991 | 0.001 | 0.011 | 0.039 | 0.072 | 0.097 | 0.112 | 0.120 | 0.124 | 0.125 | 0.126 | 0.127 | 0.127 | 0.127 |
| 1992 | 0.001 | 0.009 | 0.032 | 0.060 | 0.081 | 0.093 | 0.099 | 0.103 | 0.104 | 0.105 | 0.105 | 0.105 | 0.105 |
| 1993 | 0.001 | 0.011 | 0.039 | 0.073 | 0.099 | 0.114 | 0.121 | 0.125 | 0.127 | 0.128 | 0.129 | 0.129 | 0.129 |
| 1994 | 0.001 | 0.011 | 0.041 | 0.076 | 0.102 | 0.118 | 0.126 | 0.130 | 0.132 | 0.133 | 0.133 | 0.134 | 0.134 |
| 1995 | 0.001 | 0.016 | 0.059 | 0.109 | 0.147 | 0.169 | 0.180 | 0.186 | 0.189 | 0.190 | 0.191 | 0.191 | 0.191 |
| 1996 | 0.002 | 0.015 | 0.048 | 0.092 | 0.134 | 0.165 | 0.186 | 0.199 | 0.207 | 0.212 | 0.214 | 0.216 | 0.216 |
| 1997 | 0.002 | 0.018 | 0.056 | 0.109 | 0.157 | 0.195 | 0.219 | 0.235 | 0.244 | 0.249 | 0.253 | 0.254 | 0.254 |
| 1998 | 0.002 | 0.015 | 0.048 | 0.092 | 0.133 | 0.165 | 0.186 | 0.199 | 0.207 | 0.211 | 0.214 | 0.215 | 0.215 |
| 1999 | 0.002 | 0.012 | 0.038 | 0.074 | 0.107 | 0.132 | 0.149 | 0.160 | 0.166 | 0.170 | 0.172 | 0.173 | 0.173 |
| 2000 | 0.002 | 0.014 | 0.044 | 0.084 | 0.123 | 0.151 | 0.171 | 0.183 | 0.190 | 0.194 | 0.196 | 0.198 | 0.198 |
| 2001 | 0.002 | 0.012 | 0.038 | 0.073 | 0.106 | 0.131 | 0.147 | 0.158 | 0.164 | 0.167 | 0.170 | 0.171 | 0.171 |
| 2002 | 0.001 | 0.010 | 0.032 | 0.062 | 0.090 | 0.112 | 0.126 | 0.135 | 0.140 | 0.143 | 0.145 | 0.146 | 0.146 |
| 2003 | 0.002 | 0.012 | 0.037 | 0.071 | 0.103 | 0.128 | 0.144 | 0.154 | 0.160 | 0.164 | 0.166 | 0.167 | 0.167 |
| 2004 | 0.001 | 0.011 | 0.036 | 0.070 | 0.101 | 0.125 | 0.141 | 0.151 | 0.157 | 0.160 | 0.162 | 0.163 | 0.163 |
| 2005 | 0.001 | 0.011 | 0.034 | 0.065 | 0.095 | 0.117 | 0.132 | 0.142 | 0.147 | 0.150 | 0.152 | 0.153 | 0.153 |
| 2006 | 0.001 | 0.010 | 0.033 | 0.063 | 0.091 | 0.112 | 0.127 | 0.136 | 0.141 | 0.144 | 0.146 | 0.147 | 0.147 |

Table A10.8. Estimates of population abundance (thousands) by age

| | | | | | Age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total | 8+ |
| 1982 | 1,585 | 1,258 | 1,293 | 1,121 | 366 | 164 | 131 | 89 | 71 | 72 | 63 | 80 | 51 | 6,343 | 426 |
| 1983 | 4,012 | 1,362 | 833 | 710 | 598 | 195 | 87 | 69 | 47 | 38 | 38 | 34 | 70 | 8,093 | 296 |
| 1984 | 3,300 | 3,449 | 1,003 | 548 | 460 | 387 | 126 | 56 | 45 | 30 | 25 | 25 | 67 | 9,521 | 248 |
| 1985 | 3,236 | 2,837 | 2,527 | 655 | 352 | 295 | 248 | 81 | 36 | 29 | 20 | 16 | 59 | 10,390 | 240 |
| 1986 | 3,061 | 2,779 | 2,403 | 2,067 | 512 | 264 | 214 | 177 | 57 | 25 | 20 | 14 | 52 | 11,643 | 344 |
| 1987 | 4,212 | 2,630 | 2,364 | 1,994 | 1,661 | 399 | 202 | 161 | 132 | 42 | 19 | 15 | 48 | 13,880 | 417 |
| 1988 | 5,056 | 3,623 | 2,251 | 2,000 | 1,661 | 1,364 | 325 | 163 | 130 | 106 | 34 | 15 | 50 | 16,778 | 498 |
| 1989 | 6,288 | 4,348 | 3,097 | 1,896 | 1,652 | 1,348 | 1,093 | 258 | 129 | 102 | 83 | 27 | 51 | 20,373 | 650 |
| 1990 | 9,064 | 5,408 | 3,720 | 2,616 | 1,575 | 1,352 | 1,091 | 878 | 206 | 103 | 81 | 66 | 62 | 26,223 | 1,397 |
| 1991 | 7,804 | 7,796 | 4,606 | 3,079 | 2,094 | 1,230 | 1,040 | 833 | 668 | 157 | 78 | 62 | 97 | 29,543 | 1,894 |
| 1992 | 8,406 | 6,713 | 6,640 | 3,813 | 2,465 | 1,635 | 946 | 794 | 634 | 507 | 119 | 59 | 120 | 32,850 | 2,233 |
| 1993 | 10,870 | 7,231 | 5,727 | 5,533 | 3,090 | 1,957 | 1,282 | 738 | 617 | 491 | 393 | 92 | 139 | 38,161 | 2,470 |
| 1994 | 22,212 | 9,349 | 6,157 | 4,738 | 4,425 | 2,410 | 1,504 | 978 | 560 | 468 | 372 | 297 | 175 | 53,646 | 2,850 |
| 1995 | 14,630 | 19,105 | 7,958 | 5,087 | 3,779 | 3,438 | 1,844 | 1,141 | 739 | 422 | 352 | 280 | 356 | 59,131 | 3,291 |
| 1996 | 17,438 | 12,579 | 16,184 | 6,459 | 3,926 | 2,809 | 2,500 | 1,325 | 815 | 526 | 301 | 251 | 452 | 65,563 | 3,670 |
| 1997 | 21,327 | 14,979 | 10,665 | 13,280 | 5,070 | 2,956 | 2,050 | 1,786 | 935 | 571 | 367 | 209 | 487 | 74,683 | 4,354 |
| 1998 | 13,908 | 18,314 | 12,667 | 8,677 | 10,254 | 3,728 | 2,094 | 1,417 | 1,216 | 630 | 383 | 245 | 465 | 73,998 | 4,355 |
| 1999 | 14,629 | 11,948 | 15,529 | 10,395 | 6,812 | 7,723 | 2,721 | 1,497 | 1,000 | 851 | 439 | 266 | 493 | 74,302 | 4,546 |
| 2000 | 12,435 | 12,571 | 10,160 | 12,863 | 8,309 | 5,267 | 5,823 | 2,017 | 1,098 | 729 | 618 | 318 | 549 | 72,758 | 5,330 |
| 2001 | 23,297 | 10,683 | 10,672 | 8,370 | 10,174 | 6,326 | 3,896 | 4,225 | 1,446 | 782 | 517 | 437 | 612 | 81,439 | 8,019 |
| 2002 | 30,863 | 20,021 | 9,086 | 8,845 | 6,697 | 7,878 | 4,778 | 2,894 | 3,106 | 1,057 | 569 | 375 | 761 | 96,930 | 8,762 |
| 2003 | 16,882 | 26,529 | 17,058 | 7,572 | 7,152 | 5,266 | 6,063 | 3,625 | 2,177 | 2,324 | 788 | 424 | 845 | 96,704 | 10,183 |
| 2004 | 52,737 | 14,508 | 22,570 | 14,148 | 6,068 | 5,550 | 3,988 | 4,518 | 2,674 | 1,596 | 1,697 | 574 | 924 | 131,553 | 11,983 |
| 2005 | 15,552 | 45,324 | 12,346 | 18,736 | 11,358 | 4,721 | 4,216 | 2,982 | 3,345 | 1,968 | 1,170 | 1,242 | 1,096 | 124,056 | 11,803 |
| 2006 | 13,783 | 13,367 | 38,597 | 10,272 | 15,105 | 8,890 | 3,613 | 3,179 | 2,228 | 2,485 | 1,457 | 865 | 1,726 | 115,567 | 11,941 |

Table A10.9. Estimates of female spawning stock biomass (metric tons)

| | | | | | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | Total |
| 1982 | 0 | 0 | 0 | 25 | 45 | 125 | 241 | 214 | 176 | 268 | 315 | 399 | 321 | 2,130 |
| 1983 | 0 | 0 | 0 | 16 | 69 | 114 | 135 | 153 | 128 | 124 | 161 | 165 | 357 | 1,421 |
| 1984 | 0 | 0 | 0 | 12 | 53 | 228 | 211 | 113 | 125 | 96 | 94 | 125 | 381 | 1,437 |
| 1985 | 0 | 0 | 0 | 21 | 40 | 192 | 420 | 186 | 104 | 95 | 76 | 69 | 379 | 1,582 |
| 1986 | 0 | 0 | 0 | 62 | 63 | 146 | 337 | 387 | 145 | 76 | 71 | 58 | 308 | 1,653 |
| 1987 | 0 | 0 | 0 | 62 | 250 | 226 | 284 | 310 | 329 | 118 | 61 | 61 | 298 | 1,998 |
| 1988 | 0 | 0 | 0 | 63 | 262 | 918 | 486 | 297 | 304 | 278 | 119 | 63 | 315 | 3,104 |
| 1989 | 0 | 0 | 0 | 56 | 250 | 1,077 | 2,132 | 597 | 323 | 325 | 278 | 115 | 323 | 5,476 |
| 1990 | 0 | 0 | 0 | 78 | 220 | 978 | 2,149 | 2,190 | 576 | 289 | 307 | 280 | 366 | 7,434 |
| 1991 | 0 | 0 | 0 | 91 | 297 | 709 | 1,864 | 1,932 | 1,943 | 438 | 274 | 227 | 648 | 8,425 |
| 1992 | 0 | 0 | 0 | 114 | 373 | 1,073 | 1,561 | 1,852 | 1,865 | 1,729 | 436 | 301 | 791 | 10,094 |
| 1993 | 0 | 0 | 0 | 168 | 437 | 1,311 | 2,247 | 1,779 | 1,846 | 1,720 | 1,623 | 442 | 948 | 12,523 |
| 1994 | 0 | 0 | 0 | 152 | 644 | 1,585 | 2,639 | 2,350 | 1,692 | 1,594 | 1,539 | 1,406 | 1,043 | 14,644 |
| 1995 | 0 | 0 | 0 | 183 | 569 | 2,330 | 3,321 | 2,758 | 2,312 | 1,528 | 1,239 | 1,270 | 2,760 | 18,270 |
| 1996 | 0 | 0 | 0 | 215 | 635 | 2,089 | 5,008 | 3,586 | 2,630 | 2,002 | 1,269 | 1,018 | 2,878 | 21,329 |
| 1997 | 0 | 0 | 0 | 474 | 787 | 2,124 | 3,827 | 4,433 | 2,996 | 2,236 | 1,624 | 944 | 3,335 | 22,780 |
| 1998 | 0 | 0 | 0 | 226 | 1,469 | 2,256 | 3,590 | 3,133 | 3,325 | 2,015 | 1,500 | 1,129 | 2,563 | 21,207 |
| 1999 | 0 | 0 | 0 | 258 | 732 | 3,870 | 3,567 | 3,194 | 2,845 | 2,907 | 1,602 | 1,080 | 2,754 | 22,810 |
| 2000 | 0 | 0 | 0 | 307 | 851 | 2,559 | 7,559 | 3,656 | 3,060 | 2,360 | 2,511 | 1,429 | 3,464 | 27,757 |
| 2001 | 0 | 0 | 0 | 219 | 1,112 | 3,368 | 5,501 | 8,204 | 3,844 | 2,717 | 1,926 | 1,830 | 3,108 | 31,828 |
| 2002 | 0 | 0 | 0 | 217 | 800 | 4,406 | 7,358 | 6,056 | 8,002 | 3,430 | 2,241 | 1,613 | 4,105 | 38,227 |
| 2003 | 0 | 0 | 0 | 174 | 796 | 2,934 | 9,105 | 7,438 | 5,881 | 7,152 | 2,950 | 1,829 | 4,342 | 42,602 |
| 2004 | 0 | 0 | 0 | 316 | 684 | 3,064 | 6,049 | 9,145 | 7,023 | 4,914 | 6,086 | 2,351 | 4,623 | 44,256 |
| 2005 | 0 | 0 | 0 | 396 | 1,188 | 2,714 | 6,164 | 6,222 | 9,079 | 6,191 | 4,323 | 5,183 | 5,544 | 47,003 |
| 2006 | 0 | 0 | 0 | 212 | 1,542 | 4,471 | 5,299 | 6,128 | 6,042 | 7,851 | 5,298 | 3,588 | 8,966 | 49,398 |

**A15.0 FIGURES**

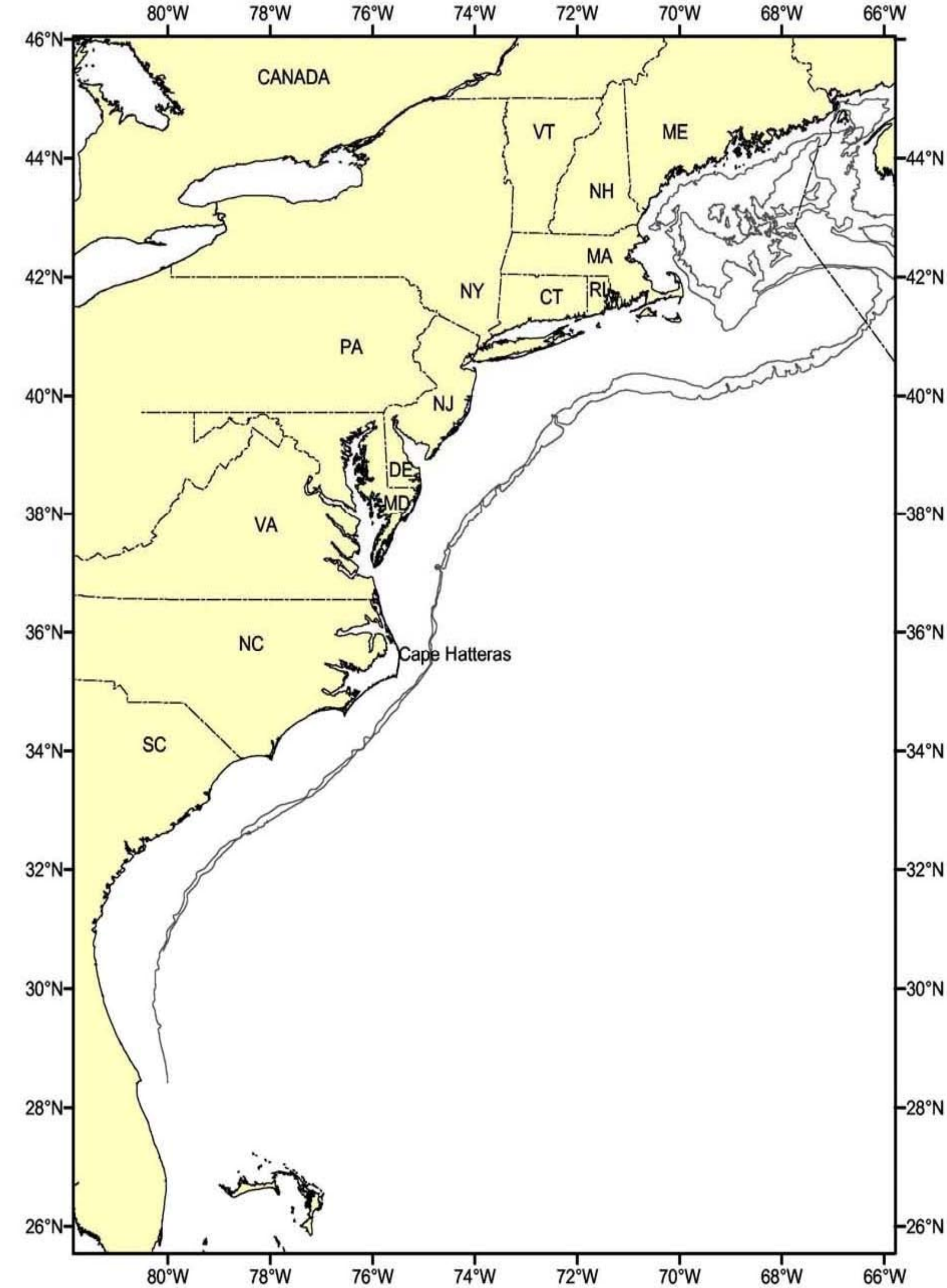



Figure A4.1 Map of the east coast of the United States.

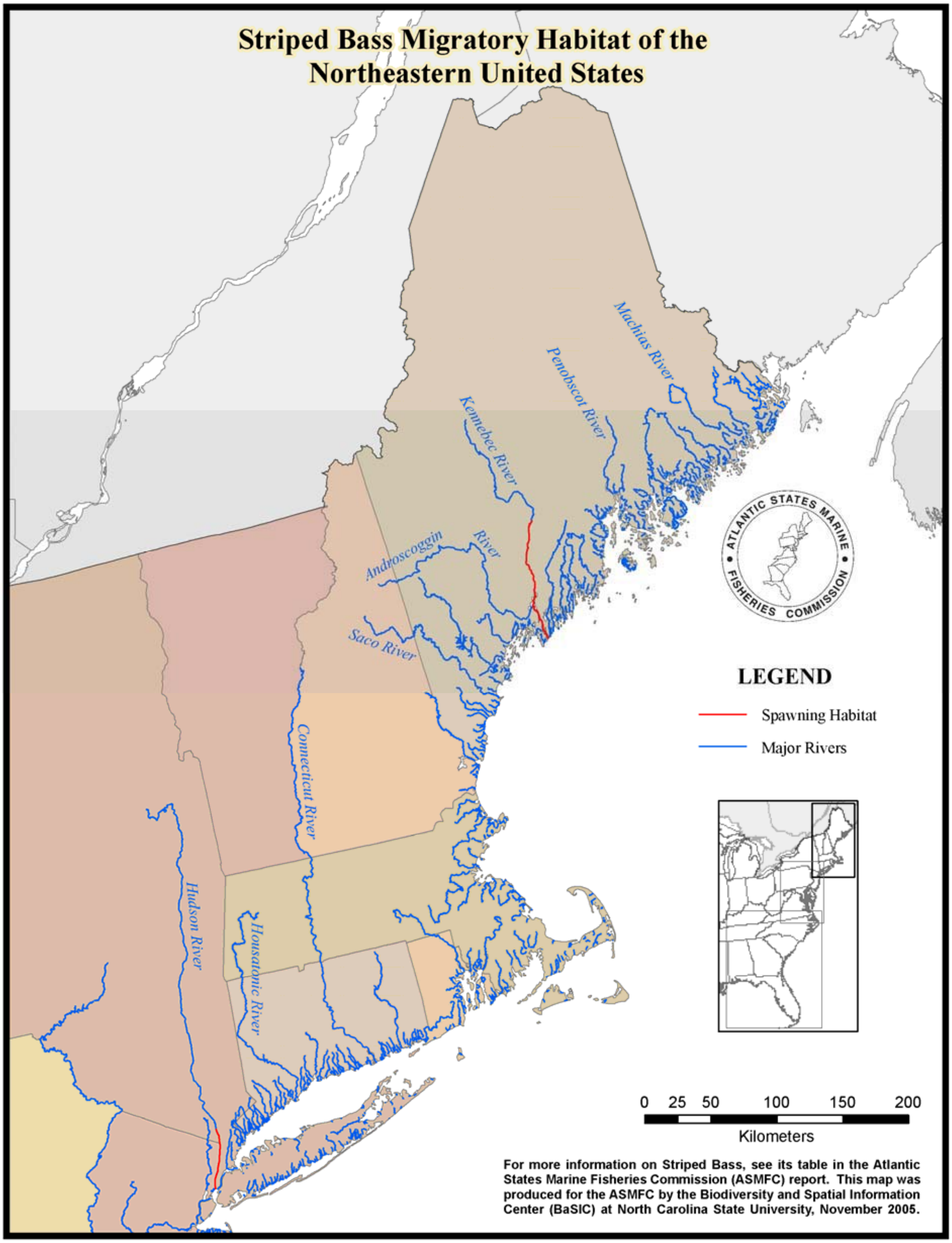



Figure A4.2. Striped Bass Spawning Habitat of Northeastern United States

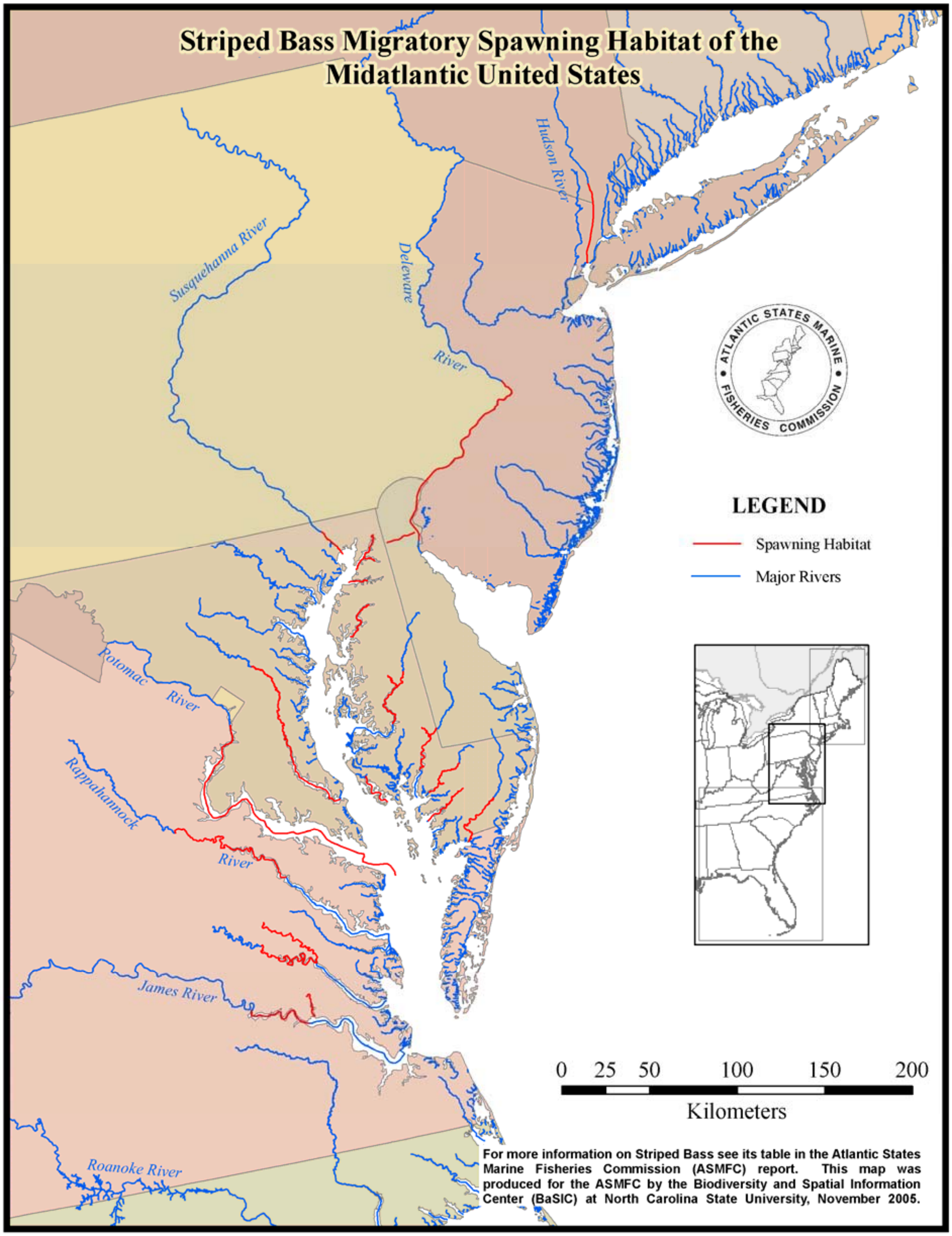



Figure A4.3. Striped Bass Spawning Habitat of Mid-Atlantic United States

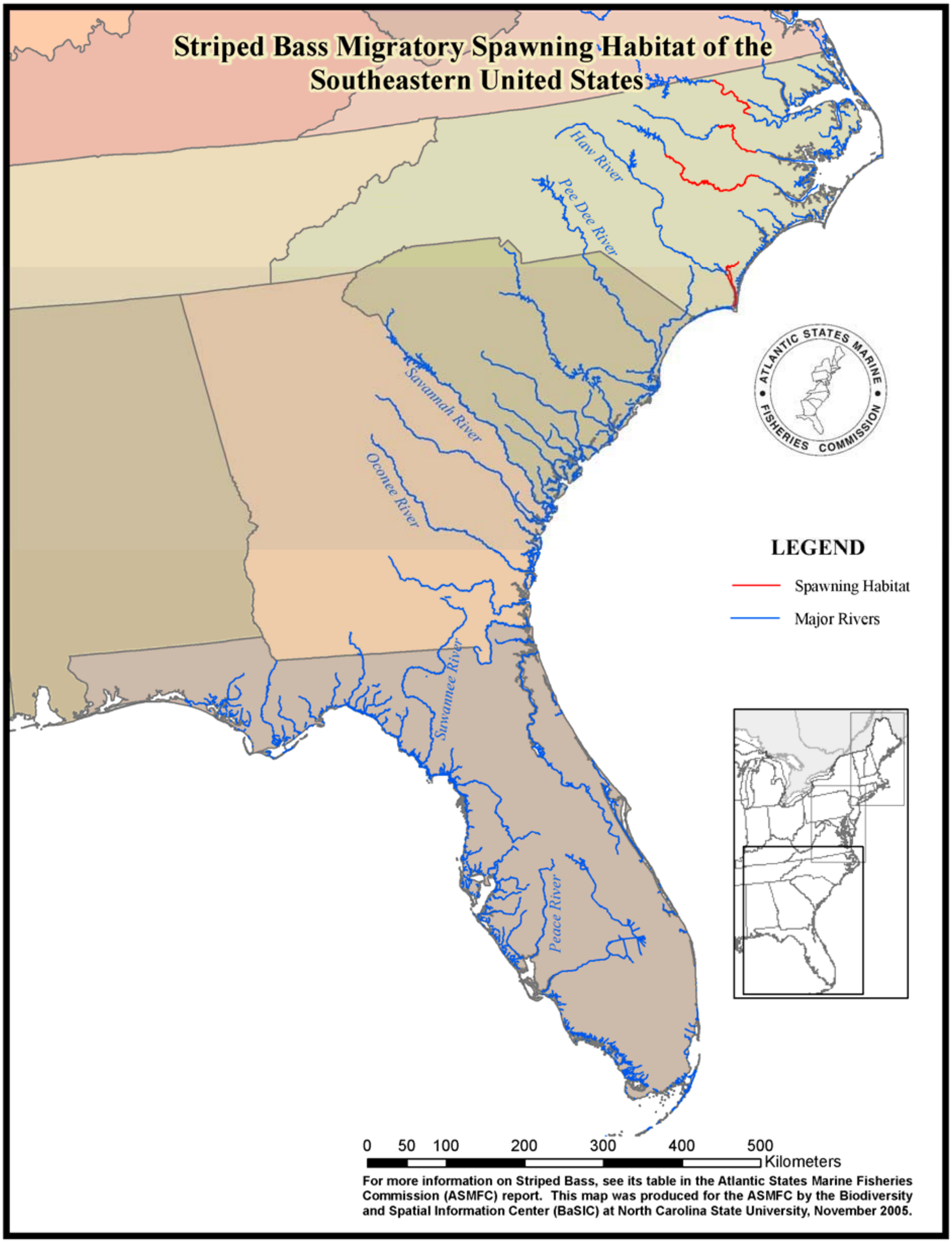



Figure A4.4 Striped Bass Spawning Habitat of Southeastern United States

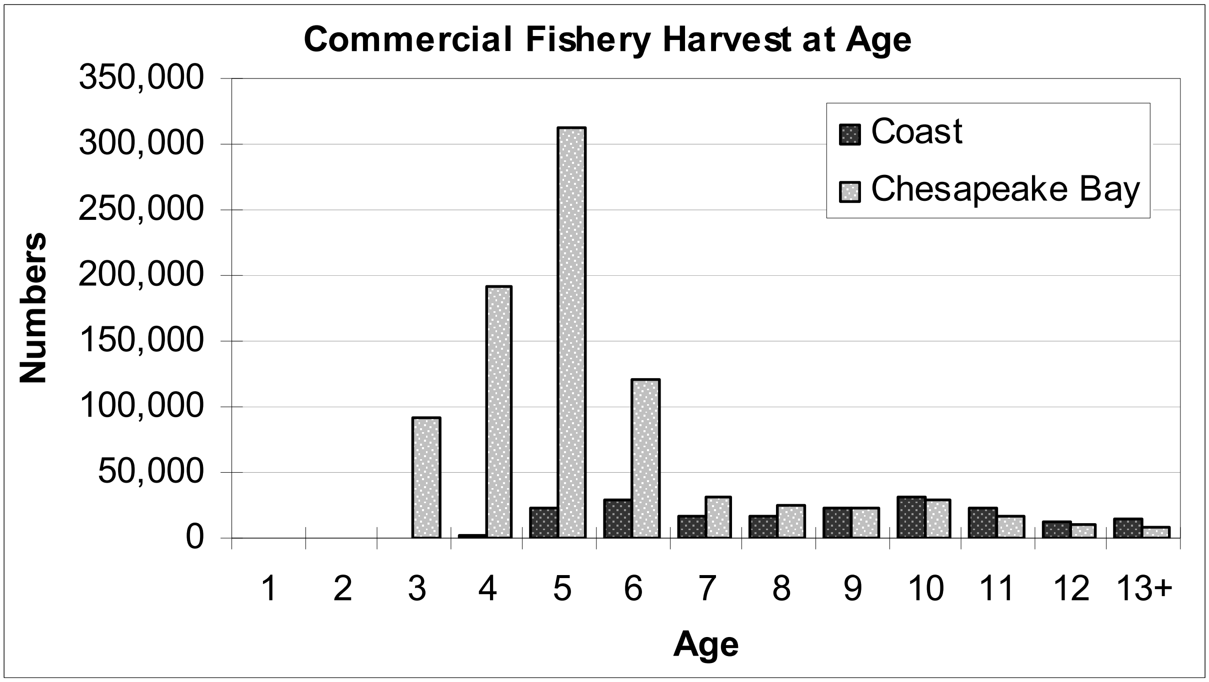



Figure A5.1. Age structure of 2006 commercial harvest by region

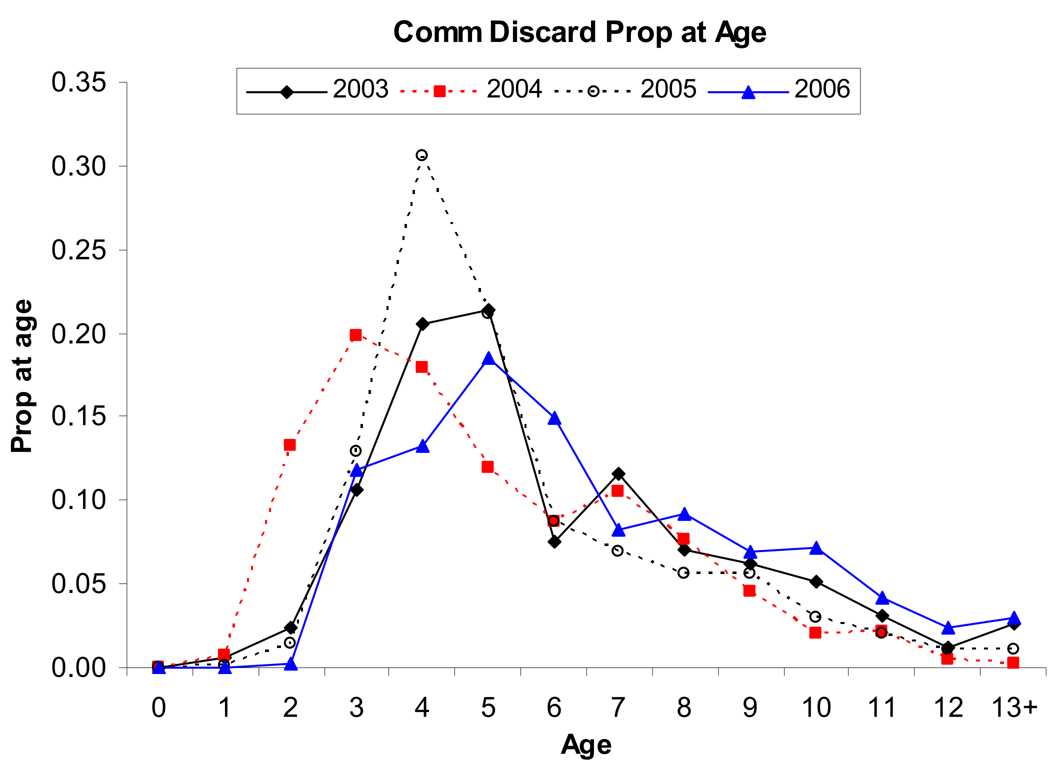



Figure A5.2. Commercial discard proportions at age, 2003-2006

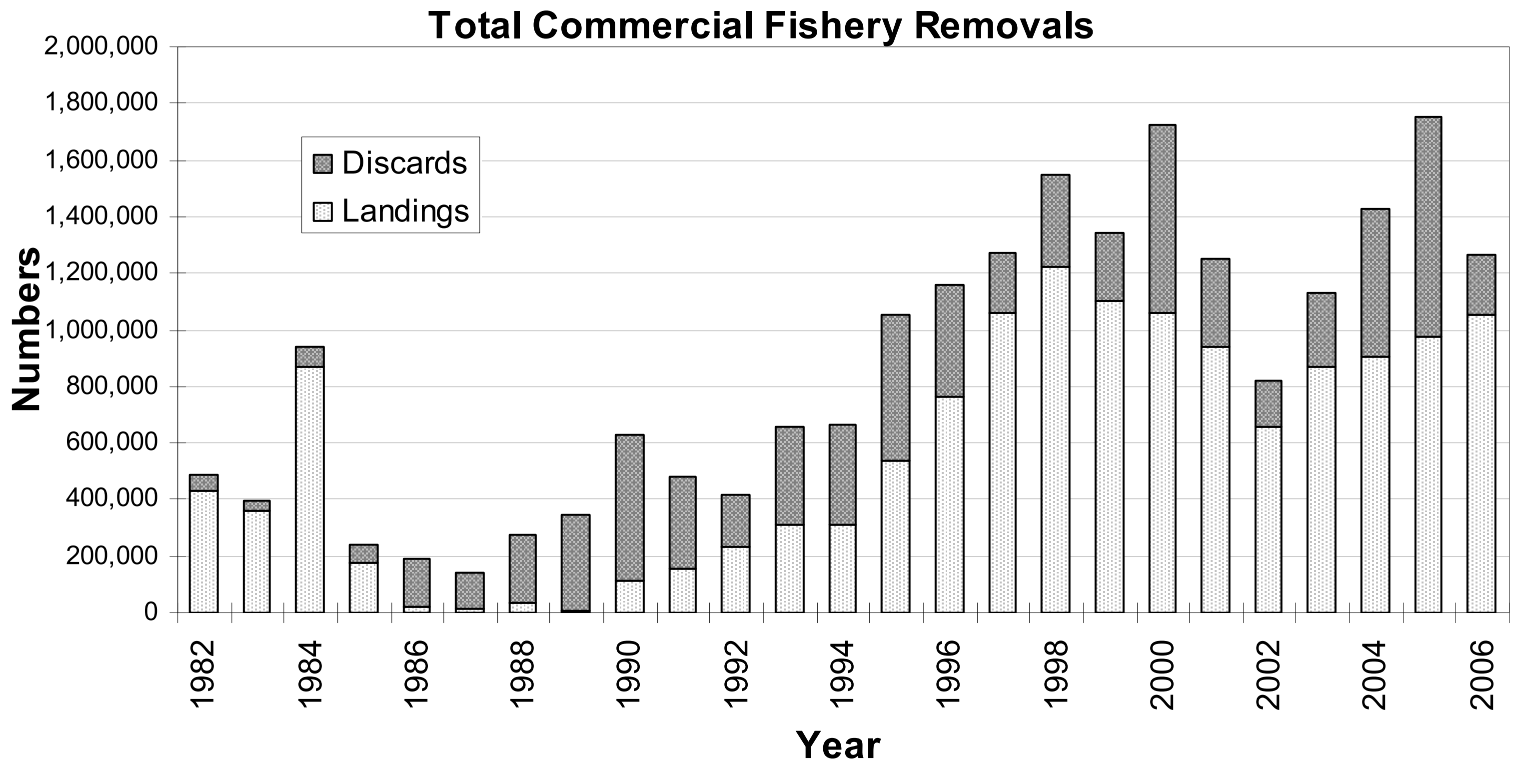



Figure A5.3. Total commercial removals (harvest and dead discards) of Atlantic striped bass, 1982-2006

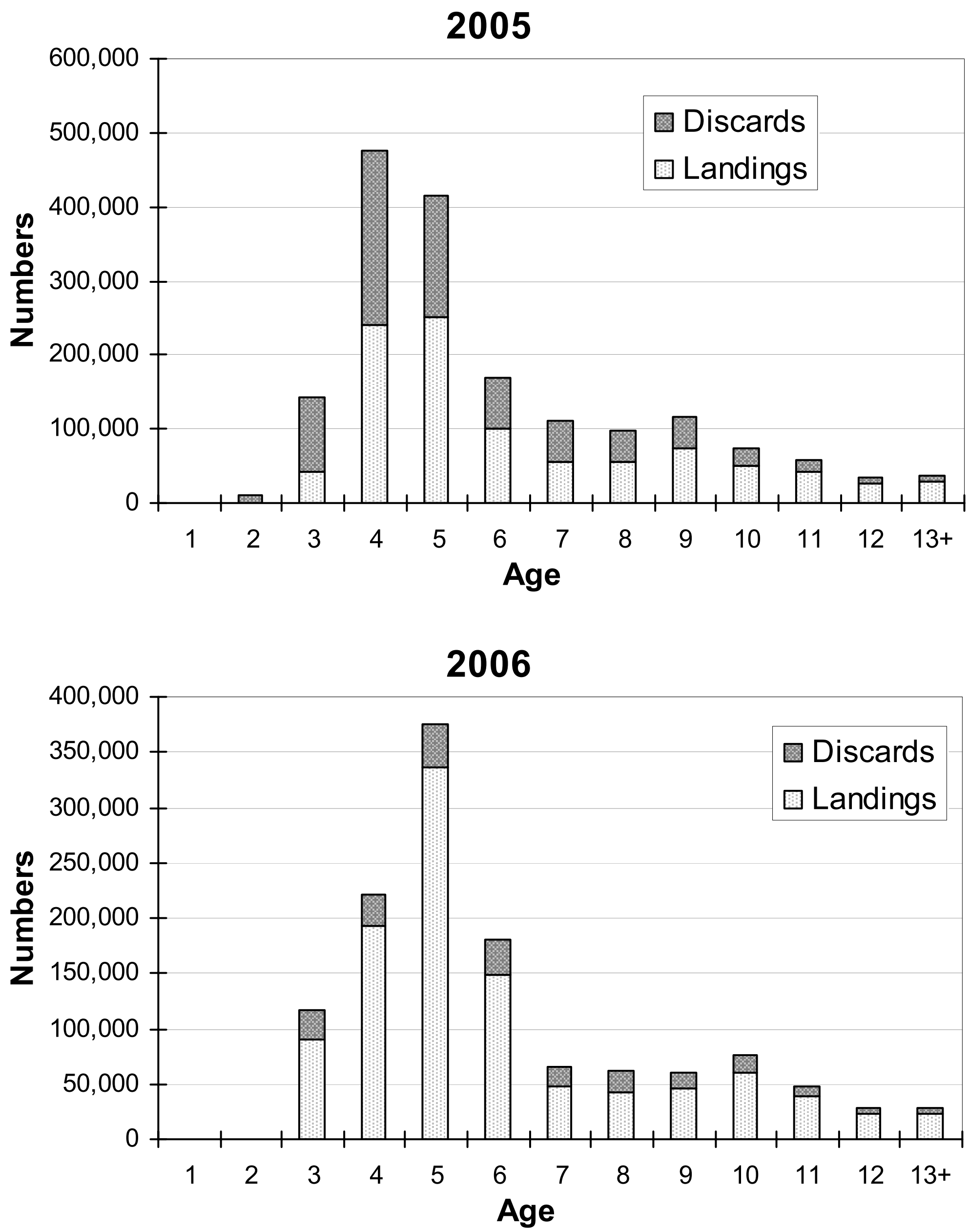



Figure A5.4. Total commercial removals (harvest and dead discards) by age of the Atlantic striped bass, 2005 and 2006

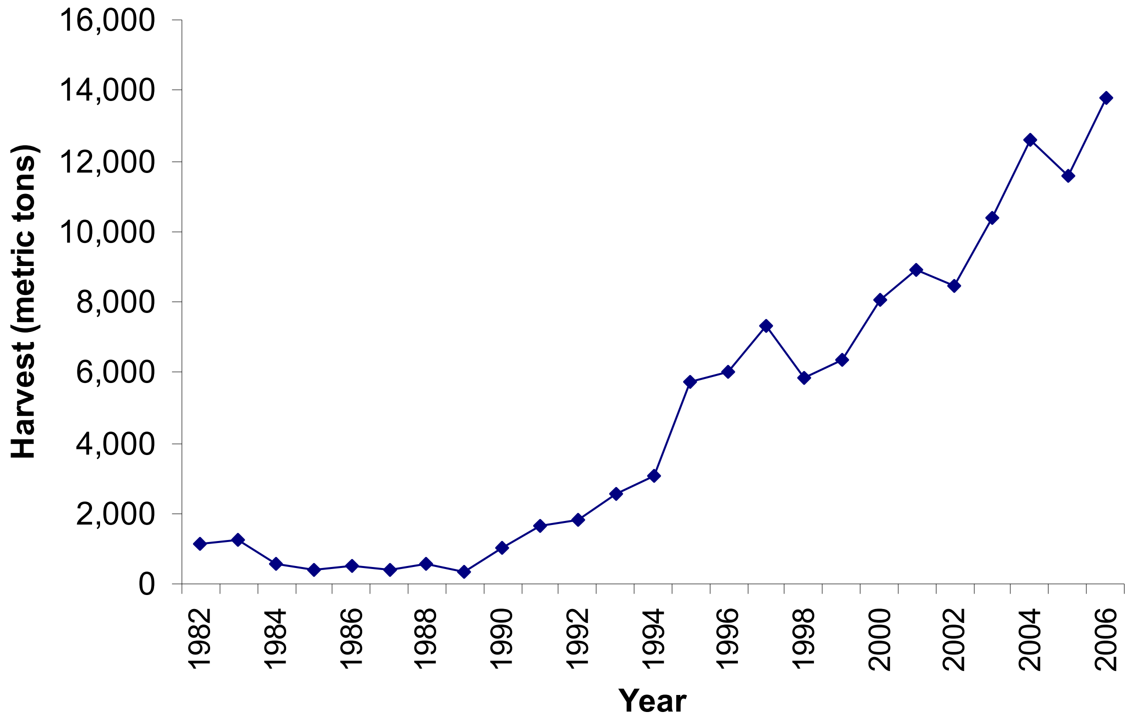



Figure A5.5. Total recreational harvest (metric tons) of striped bass along the US Atlantic coast (ME-NC), 1982-2006.

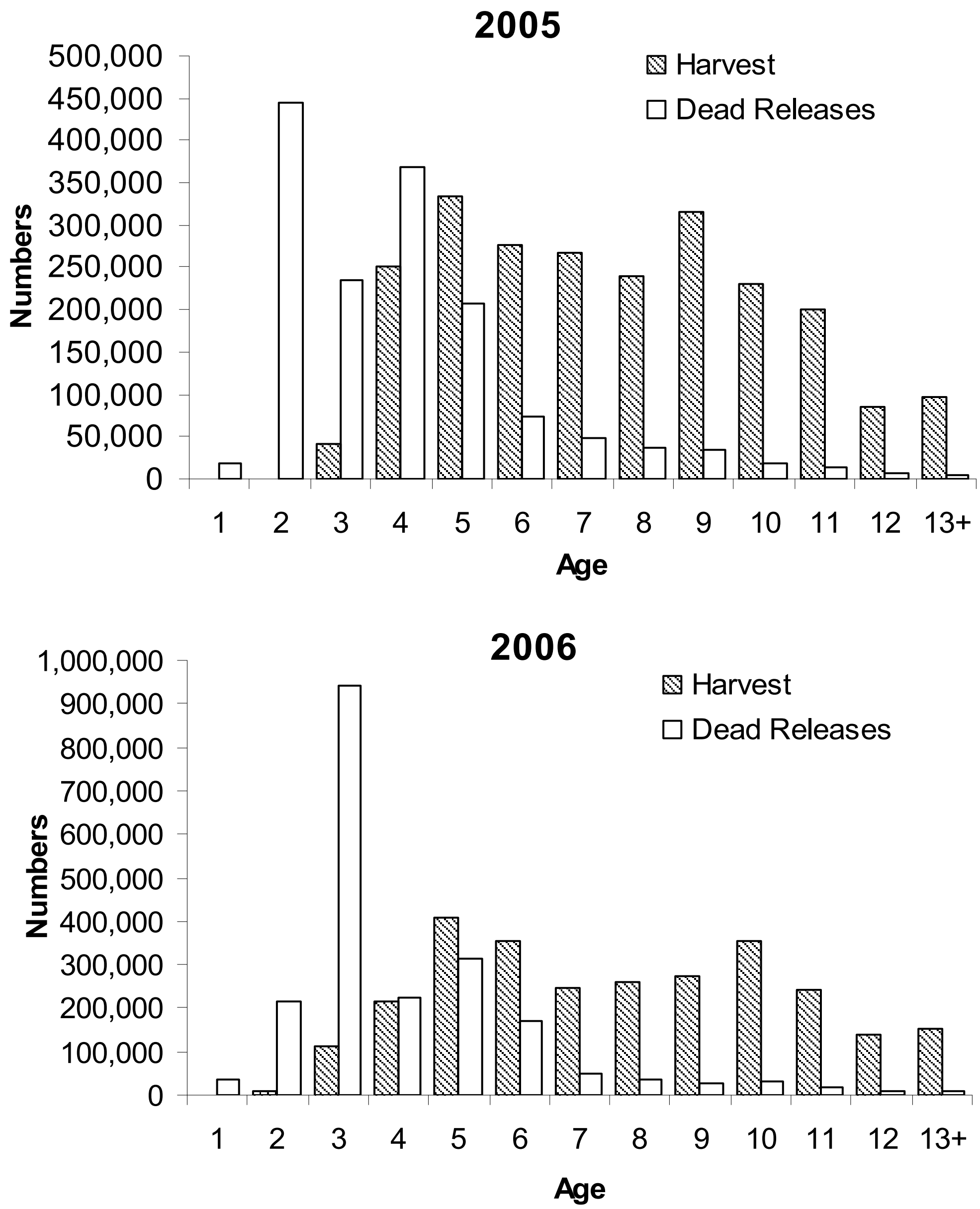
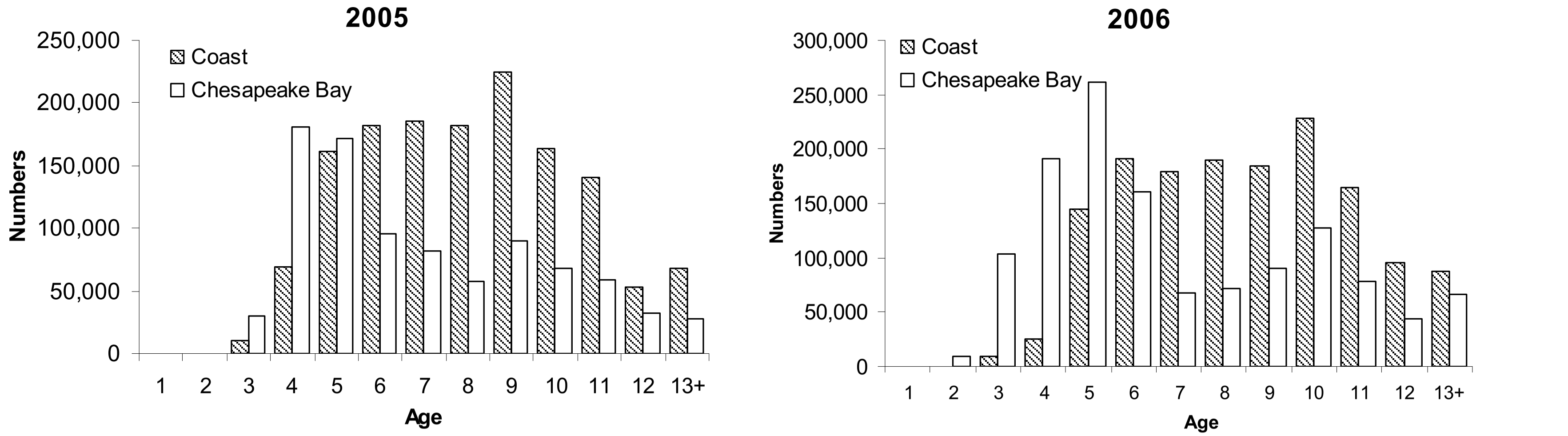



Figure A5.6. Comparison of age compositions from recreational harvest and dead release, 2005 and 2006.

A.




B.

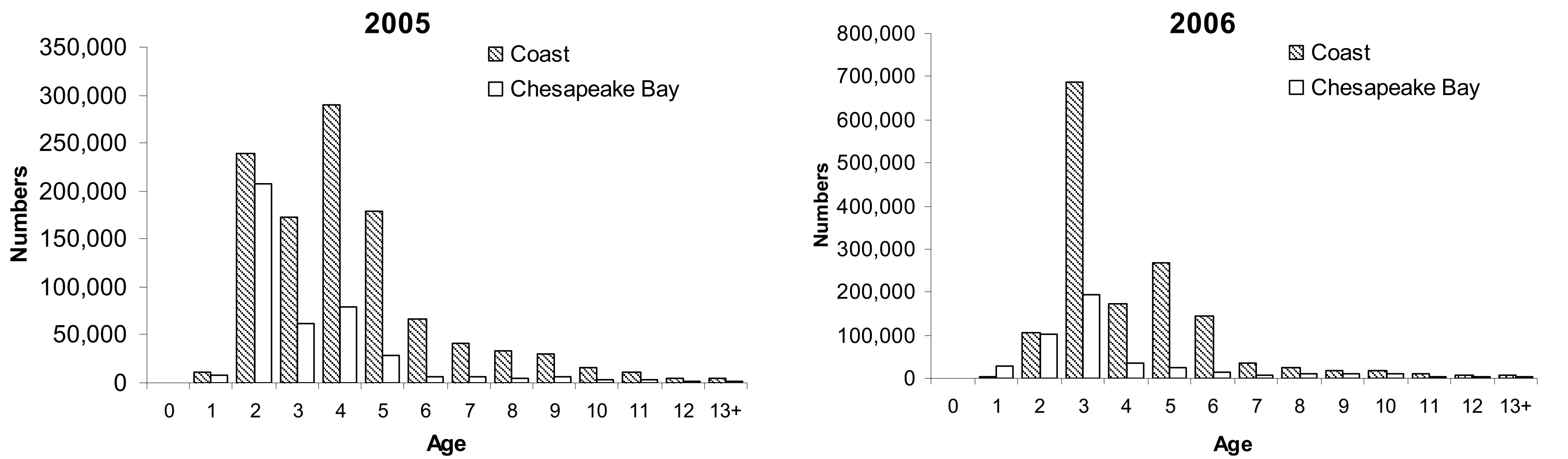



Figure A5.7. Comparison of age compositions between coast and Chesapeake Bay for A) harvested fish and B) dead releases in 2005 and 2006

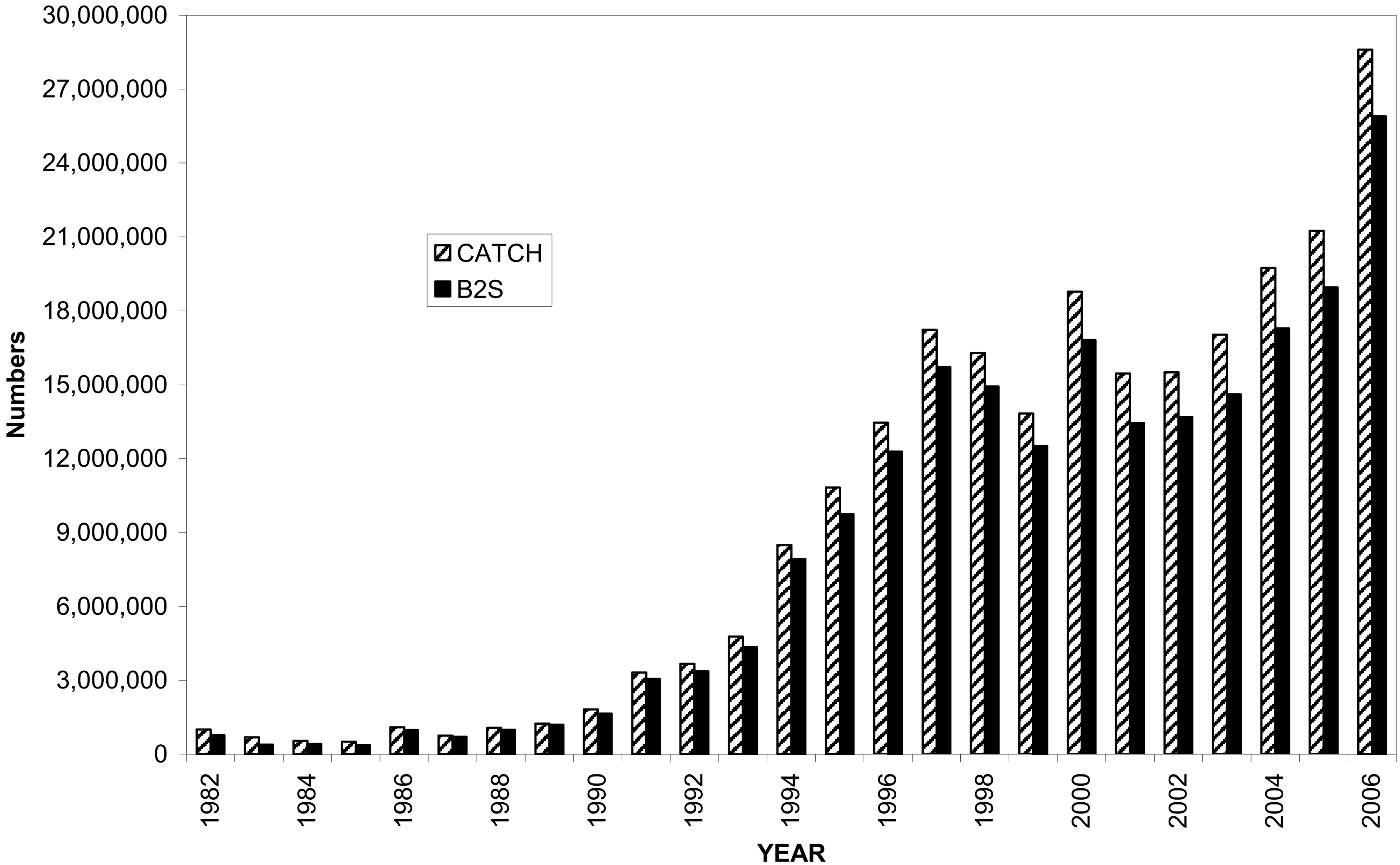



Figure A5.8. MRFSS estimates of catch and live releases (B2) for the US Atlantic coast (ME-NC), 1982-2006.

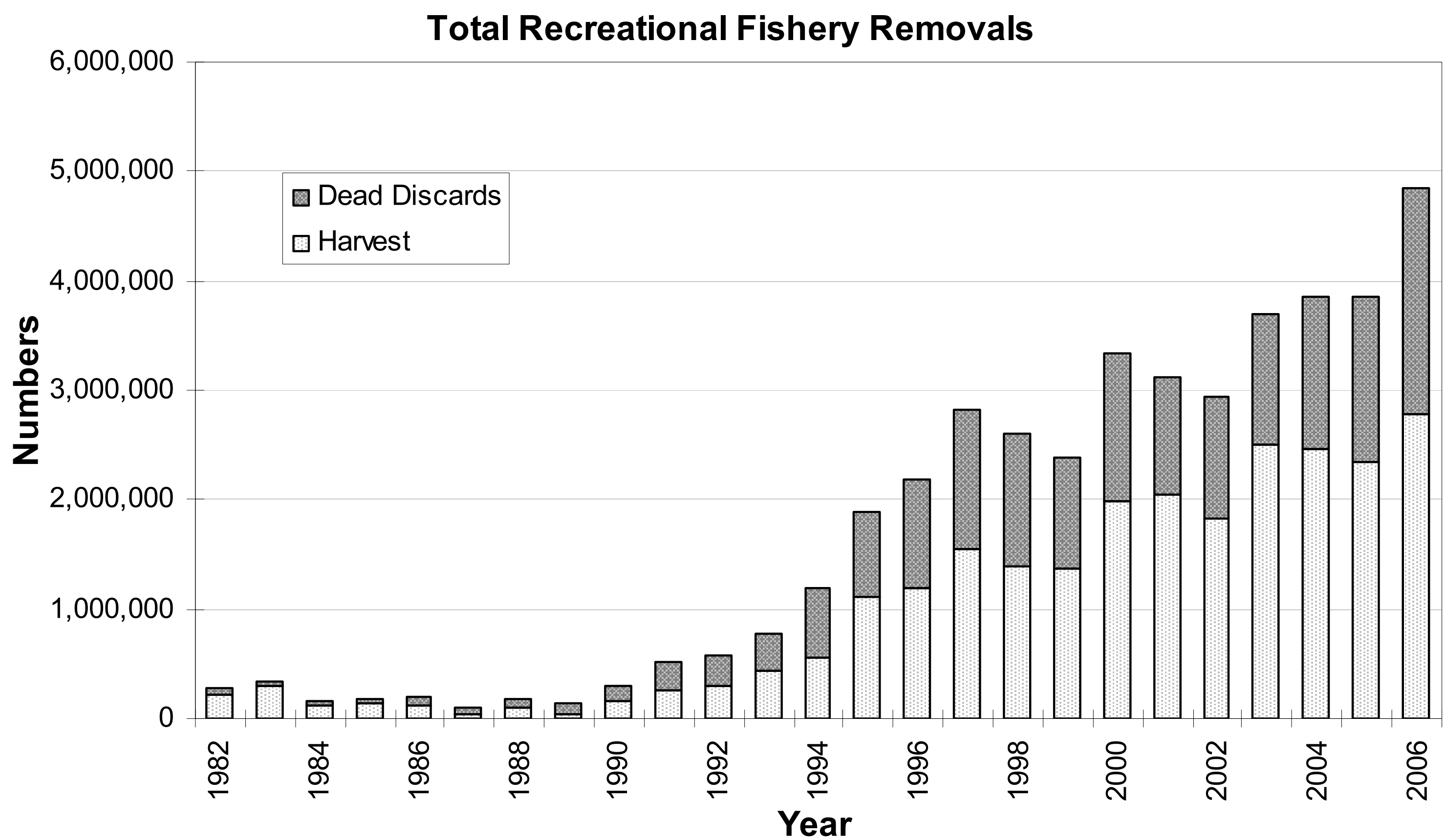



Figure A5.9. Total removals (harvest and dead discards) by the recreational fishery for striped bass, 1982-2006

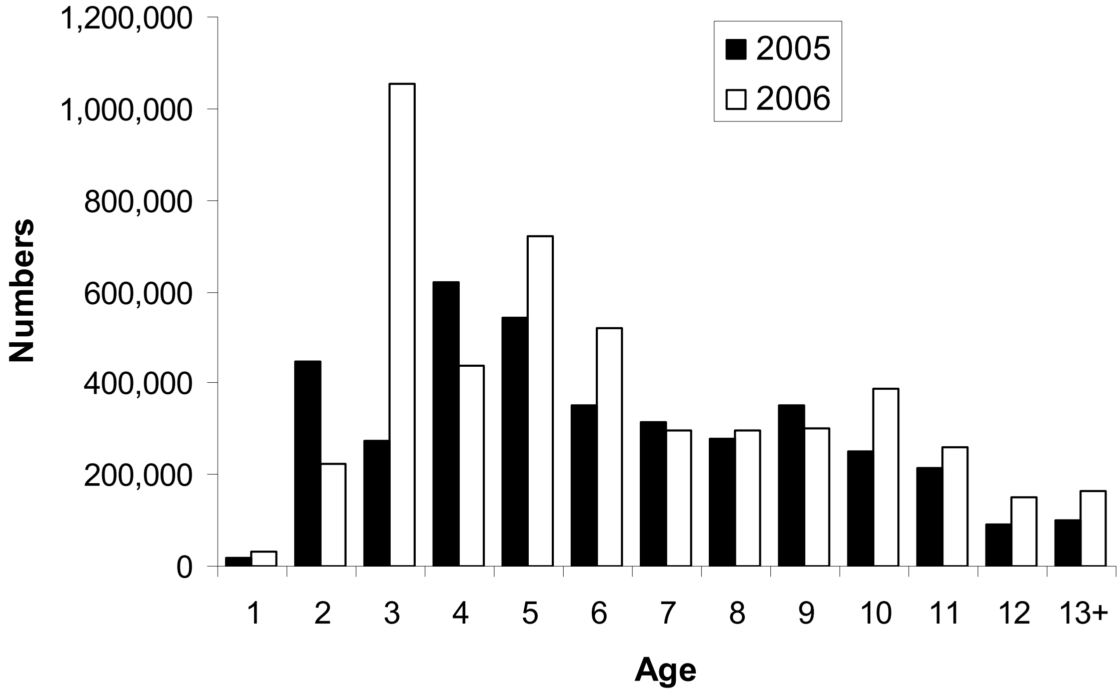



Figure A5.10. Total recreational removals (harvest and dead discards) by age, 2005-2006.

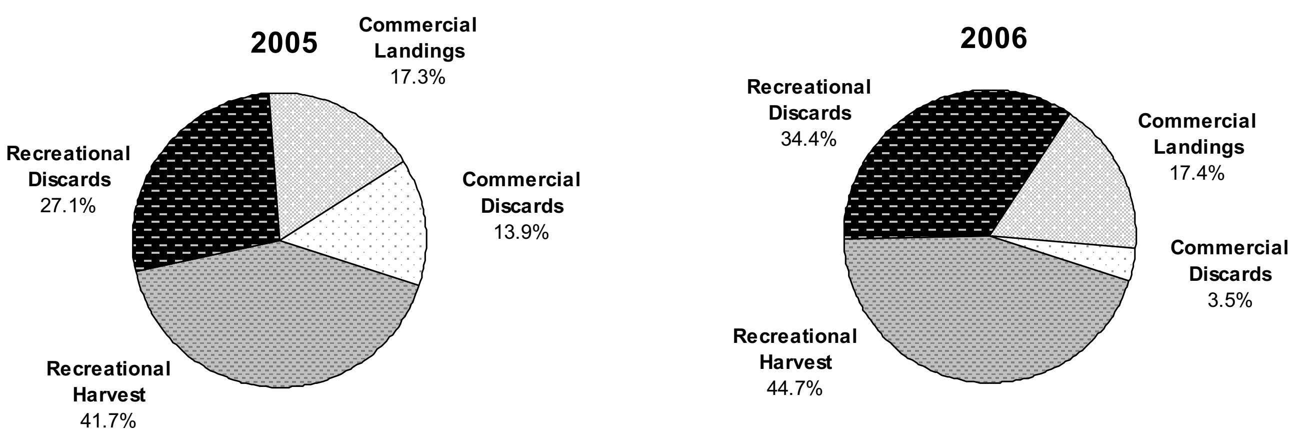



Figure A5.11. Percentage of 2005 and 2006 striped bass mortality by fishery component

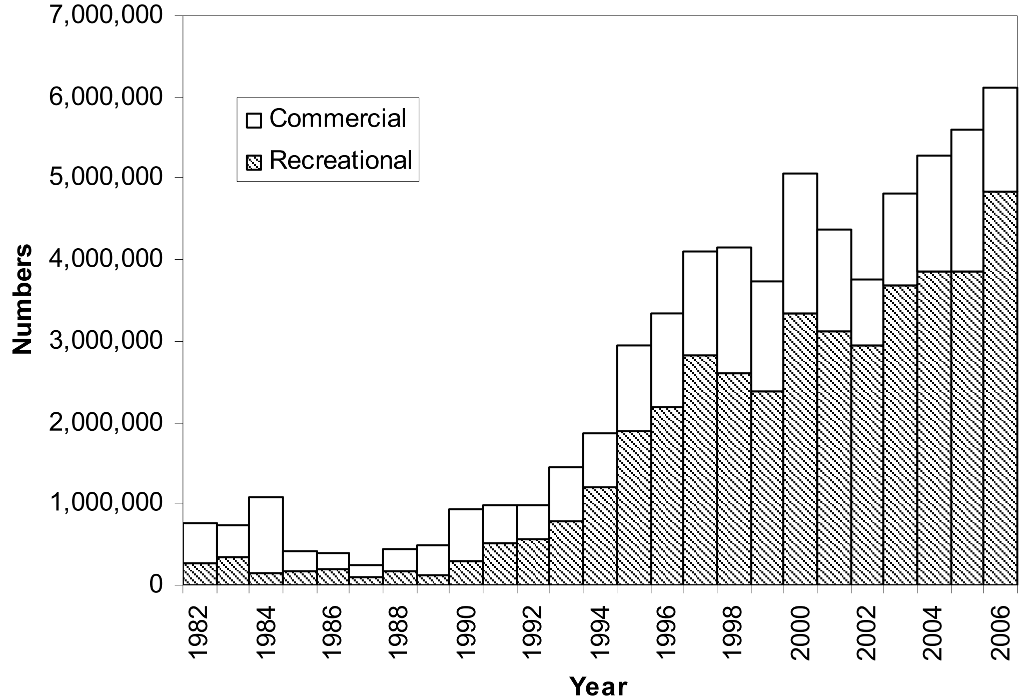



Figure A5.12. Total removals of striped bass partitioned into commercial and recreational contributions, 1982-2006.

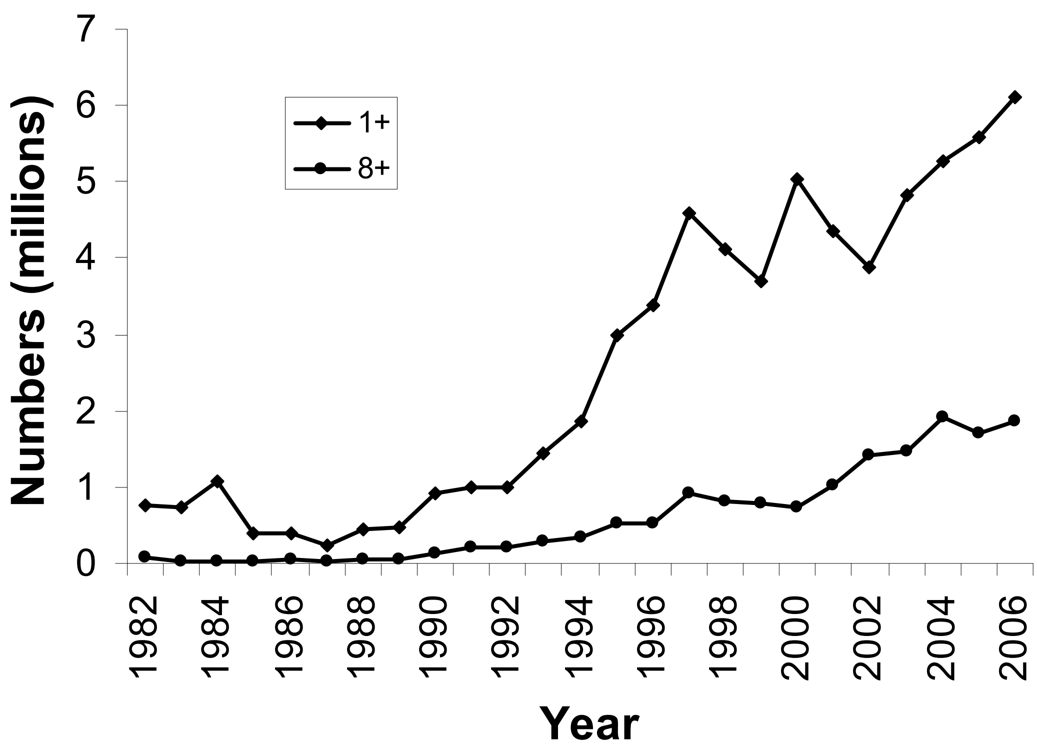



Figure A5.13. Total removals of striped bass by age group, 1982-2006

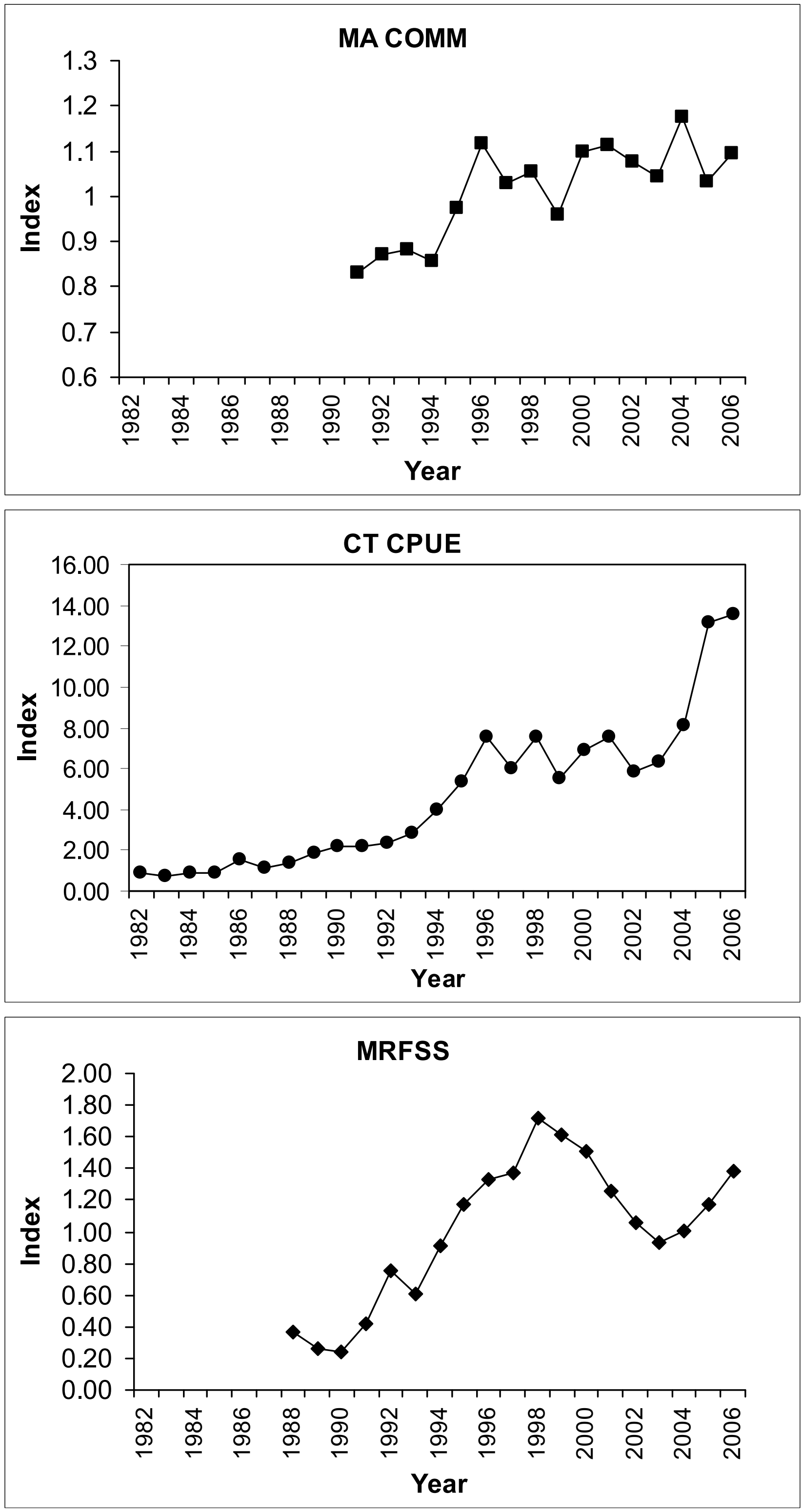



Figure A6.1. Fishery-dependent indices of relative abundance (aggregated), 1982-2006

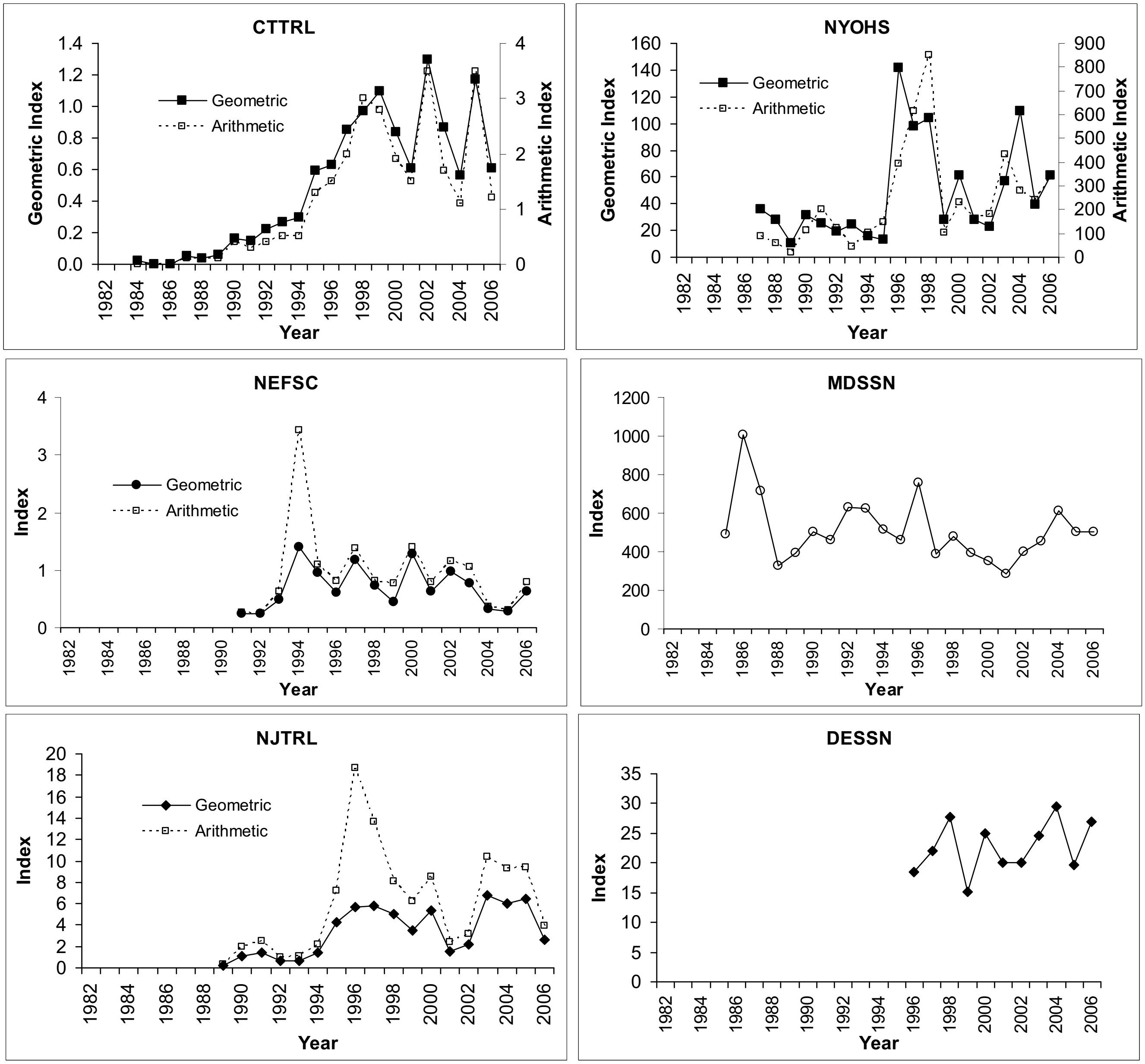



Figure A6.2. Fisheries-independent indices of relative abundance for ages 2-13+(aggregated), 1982-2006.

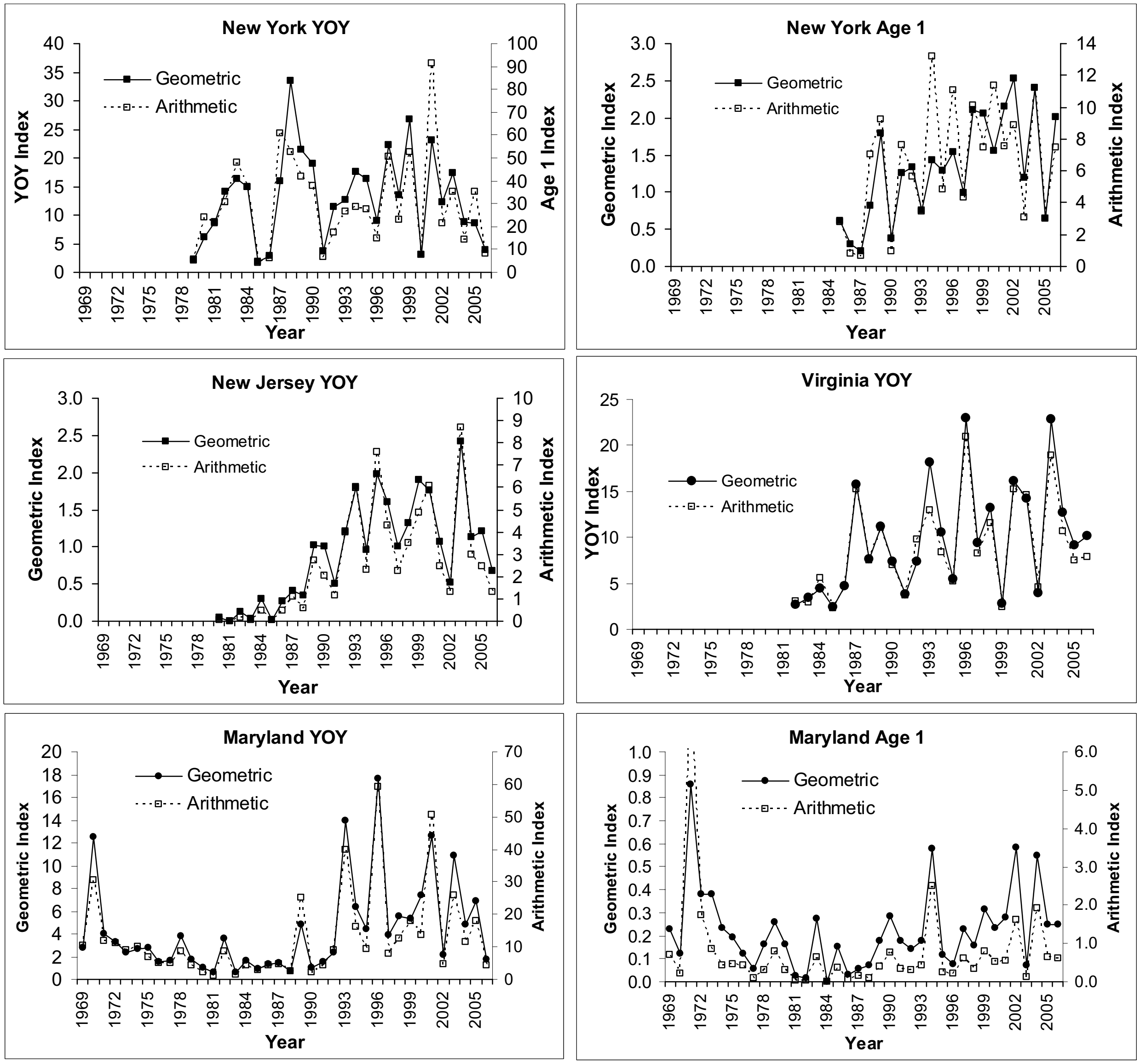



Figure A6.3. Young-of-the-year and age 1 indices of striped bass relative abundance

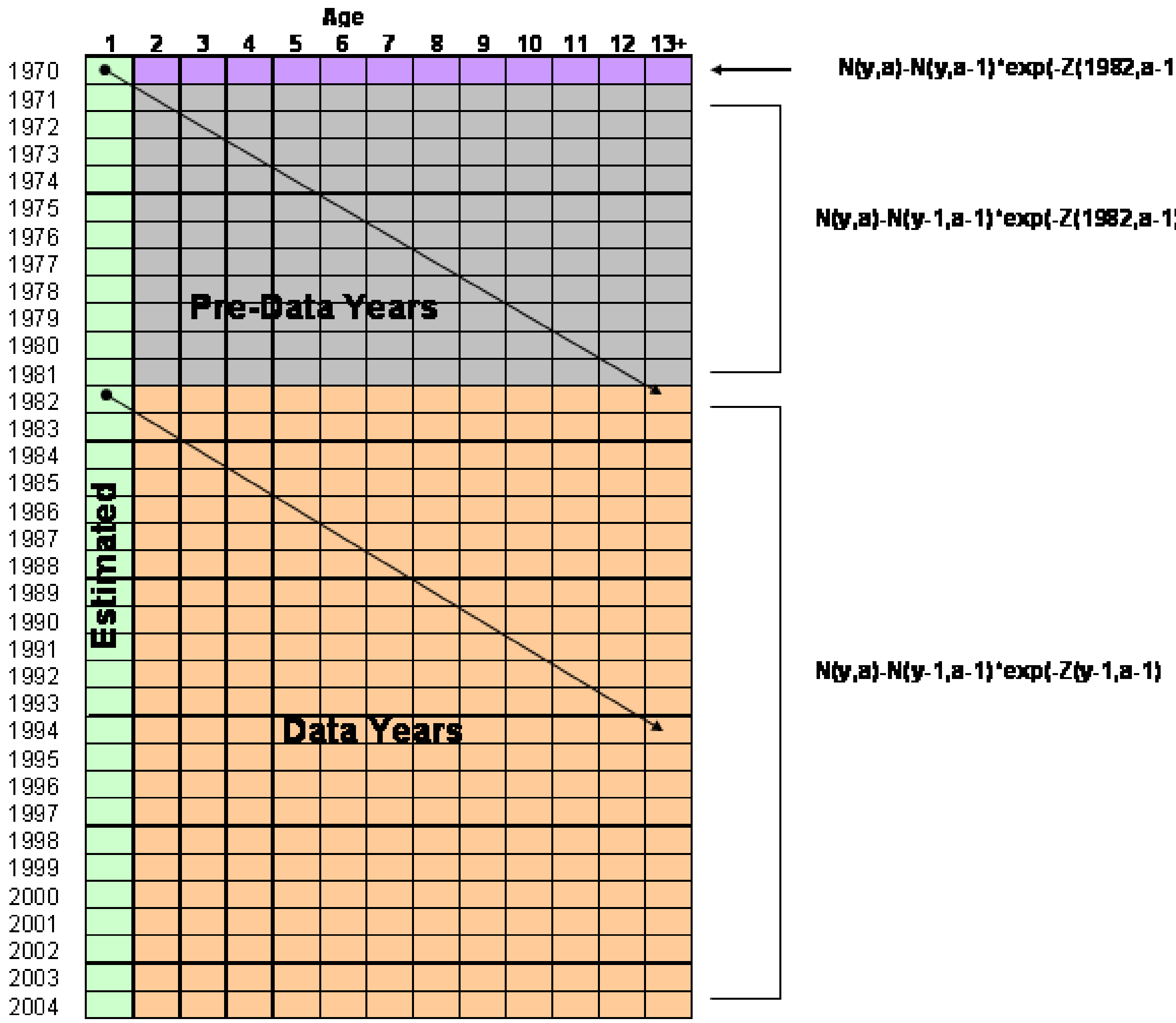



Figure A7.1. Schematic of population abundance-at-age

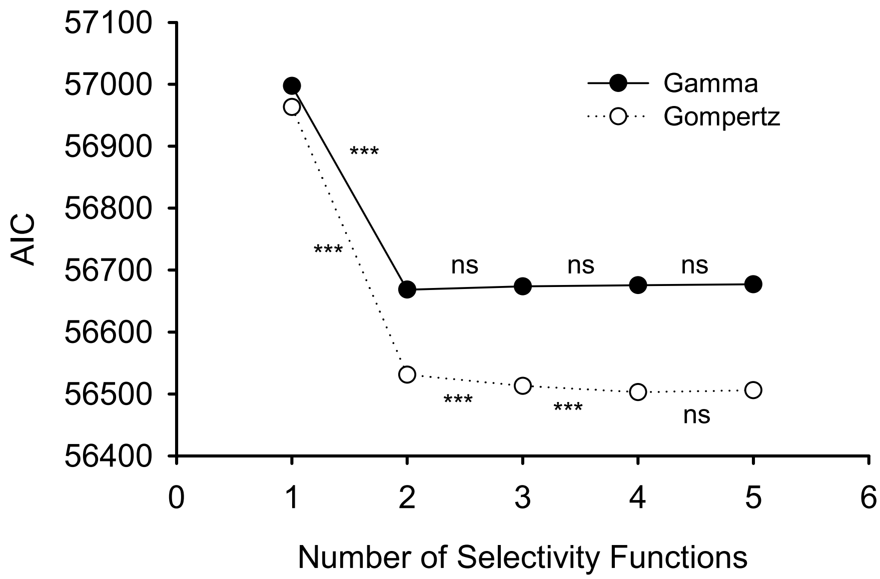



Figure A7.2. Plot of resulting AIC values from SCA model runs in which the number and type of selectivity function varied. Asterisks indicate the likelihood ratio tests' level of significance (*** p<=0.001) of comparisons between successive models.

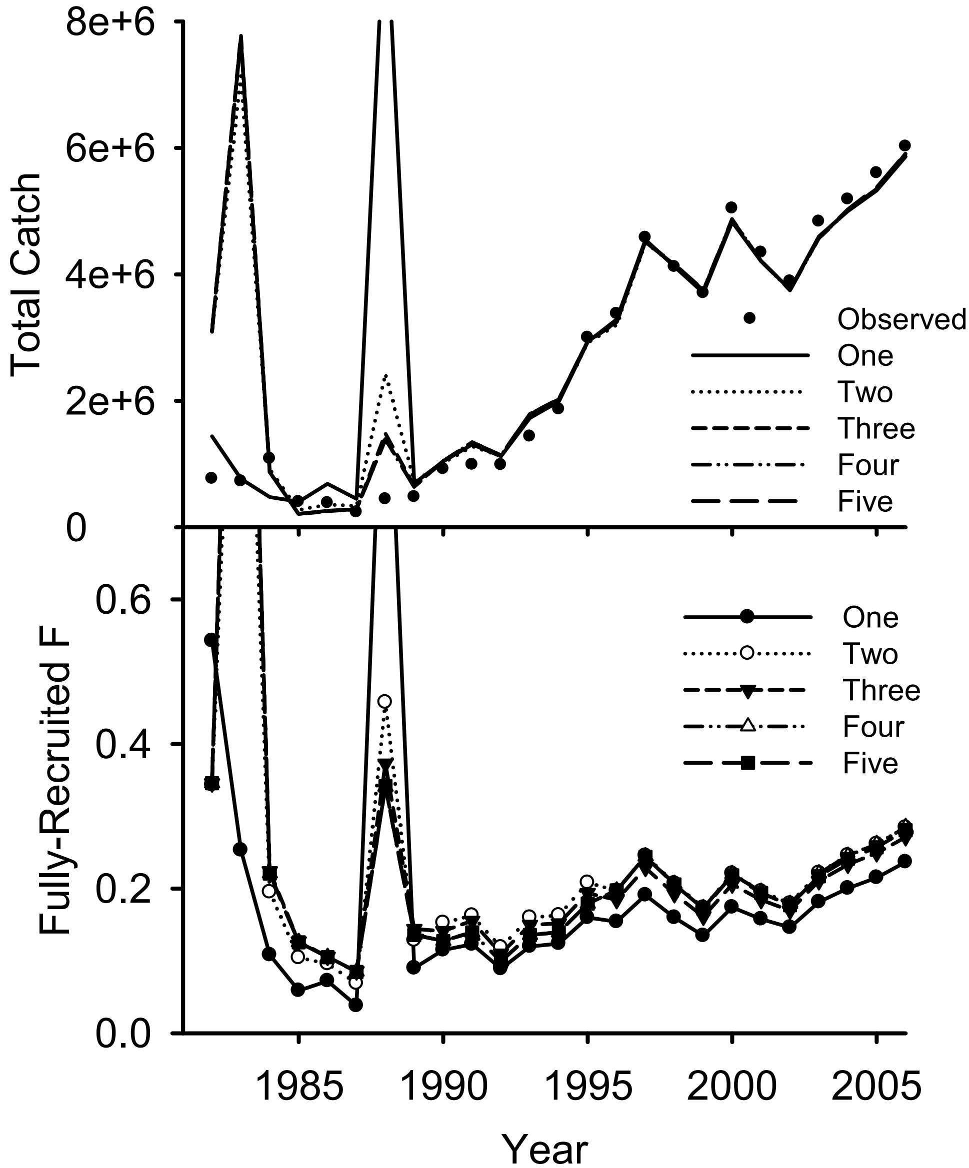



Figure A7.3. Observed and predicted total catch predictions from SCA and estimated fully-recruited fishing mortality by number of selectivity periods under equal weighting of all components.

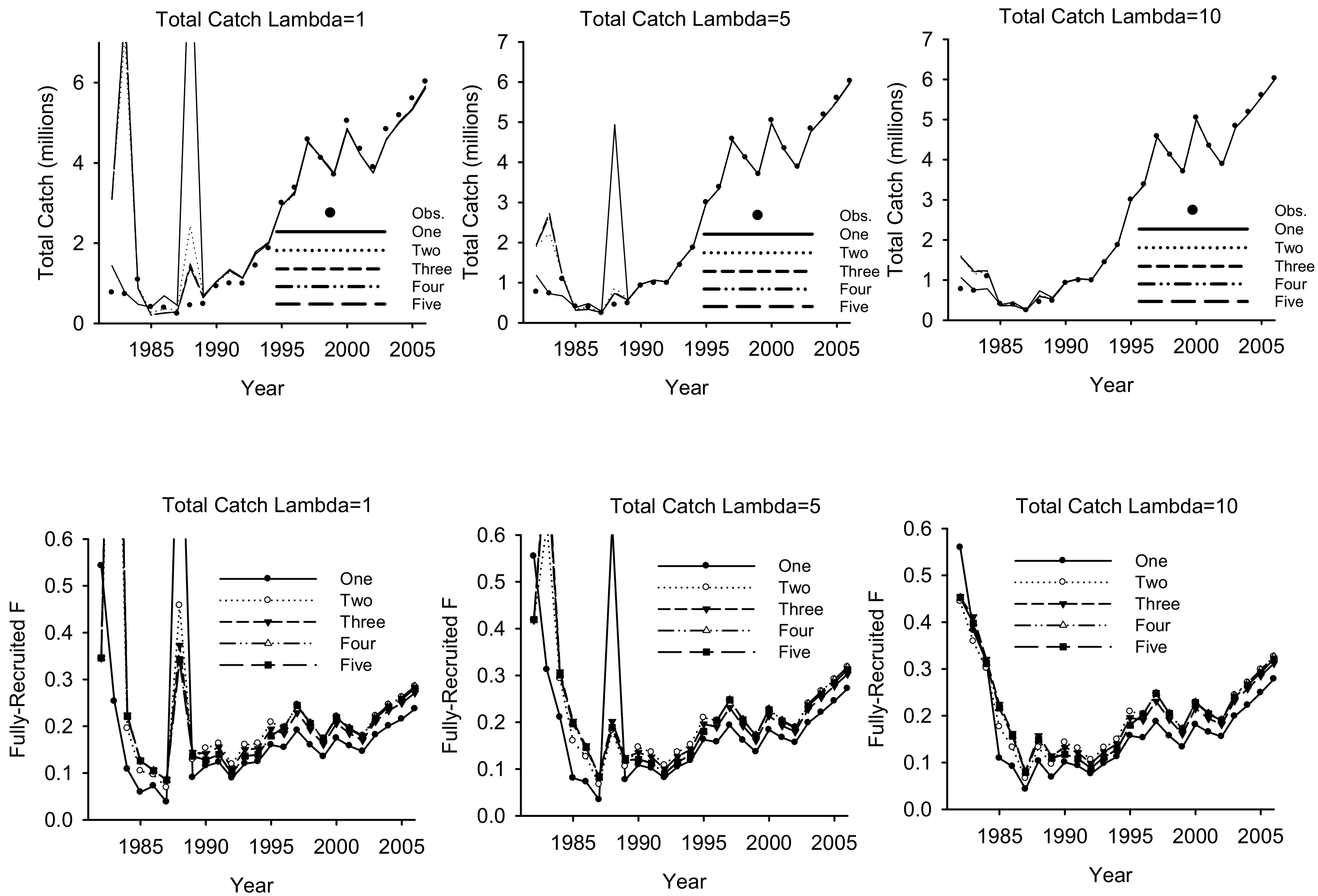
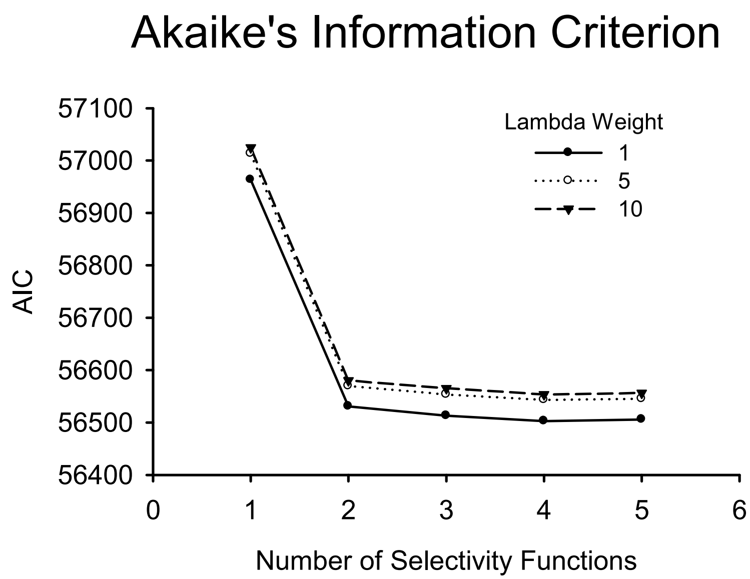



Figure A7.4. Comparison of observed and predicted total catch and fully-recruited F estimates from SCA model runs in which total catch lambda weights and number of selectivity periods (with Gompertz functions) were varied.



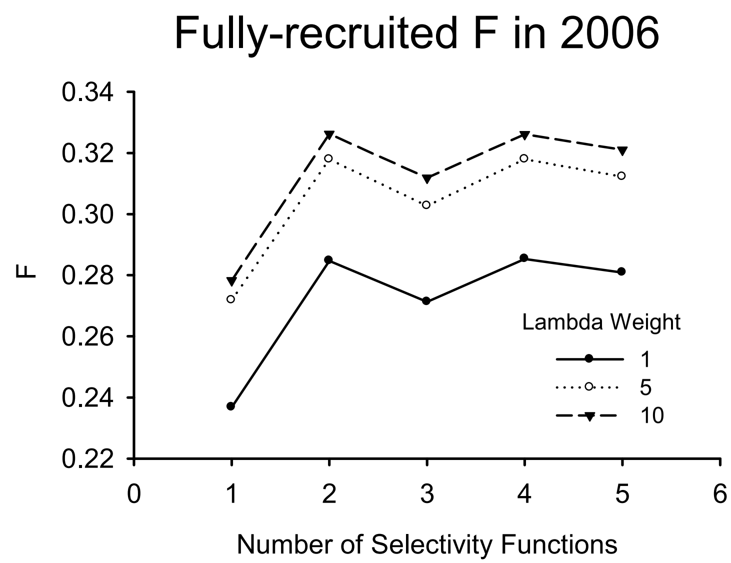




Figure A7.5. Comparison of Akaike's Information Criterion and fully-recruited F in 2006 from SCA model runs in which total catch lambda weights and number of selectivity periods (with Gompertz functions) were varied.

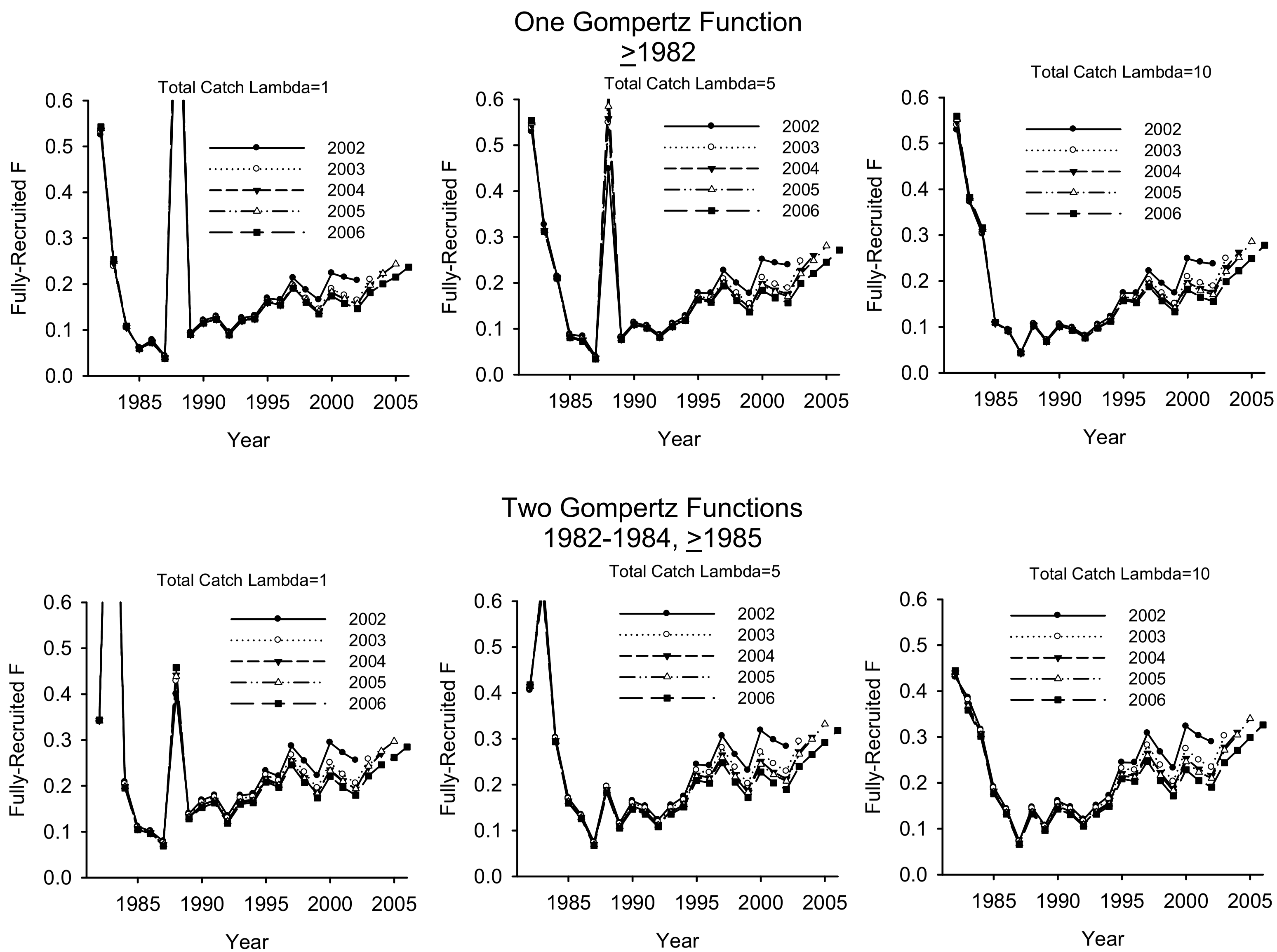



Figure A7.6. Retrospective plots for SCA model runs in which the number of selectivity periods and total catch lambda weights were varied.

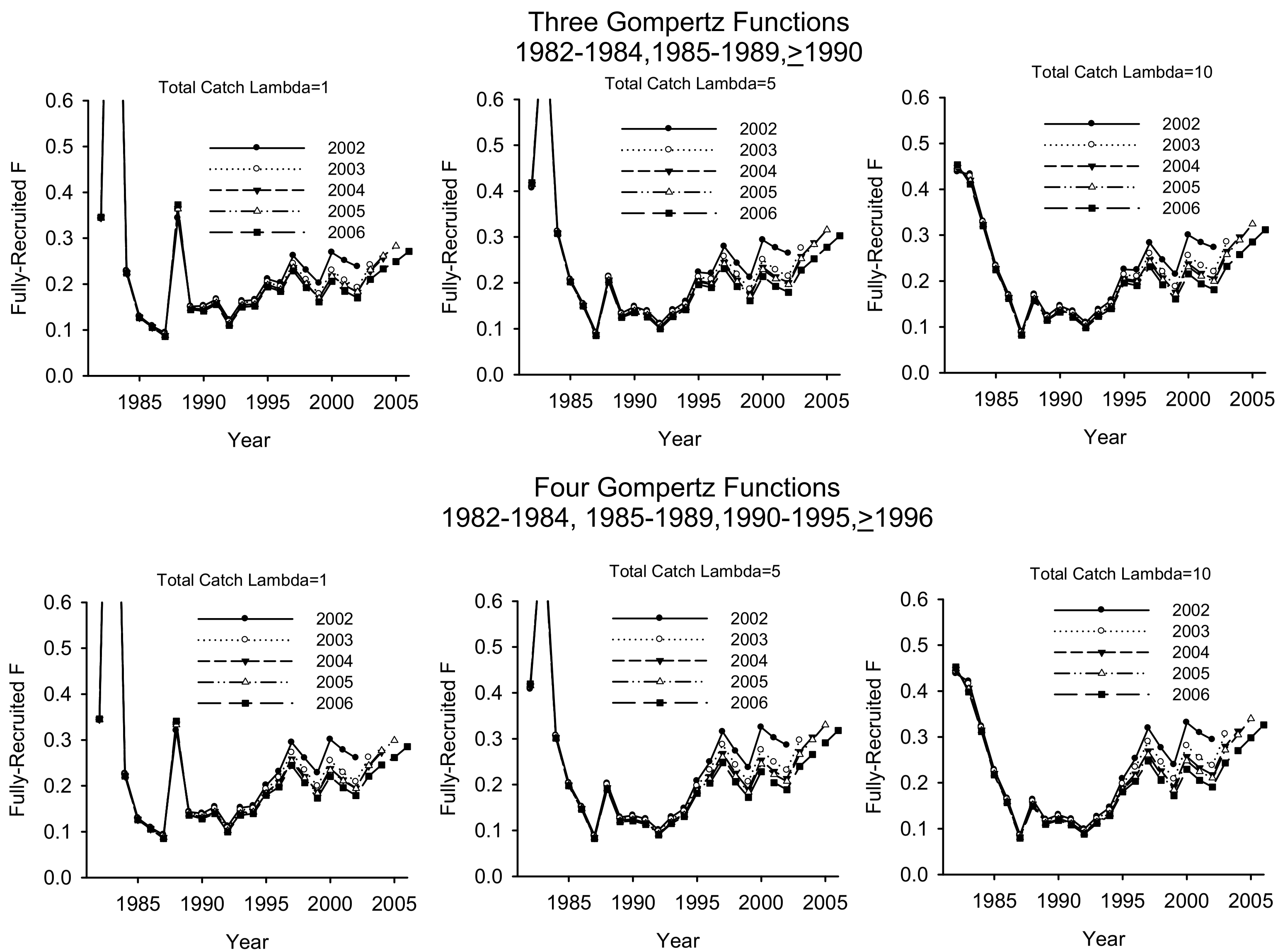



Figure A7.6 cont.

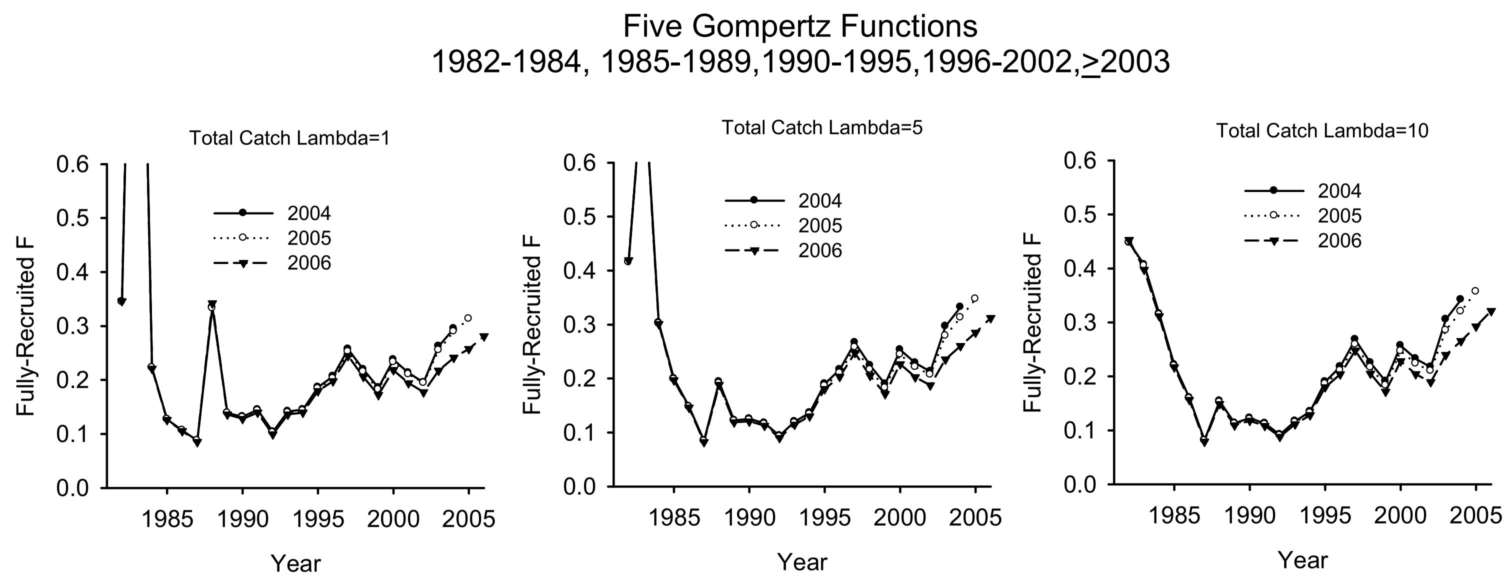


Figure A7.6 cont.

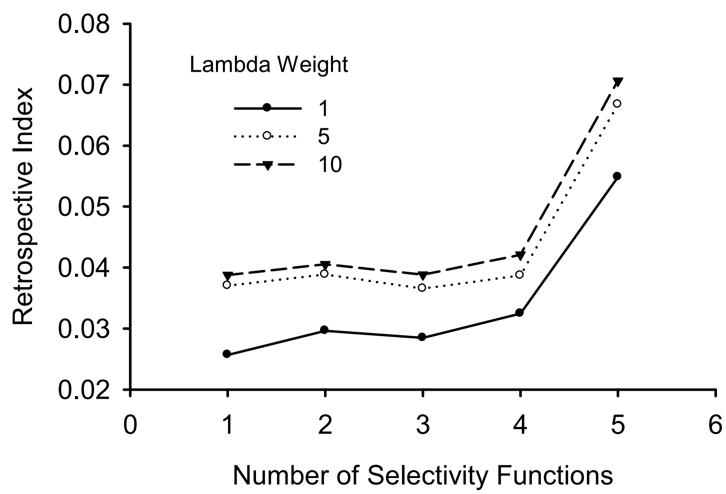


Figure A7.7. Comparison of the retrospective index among SCA model runs.

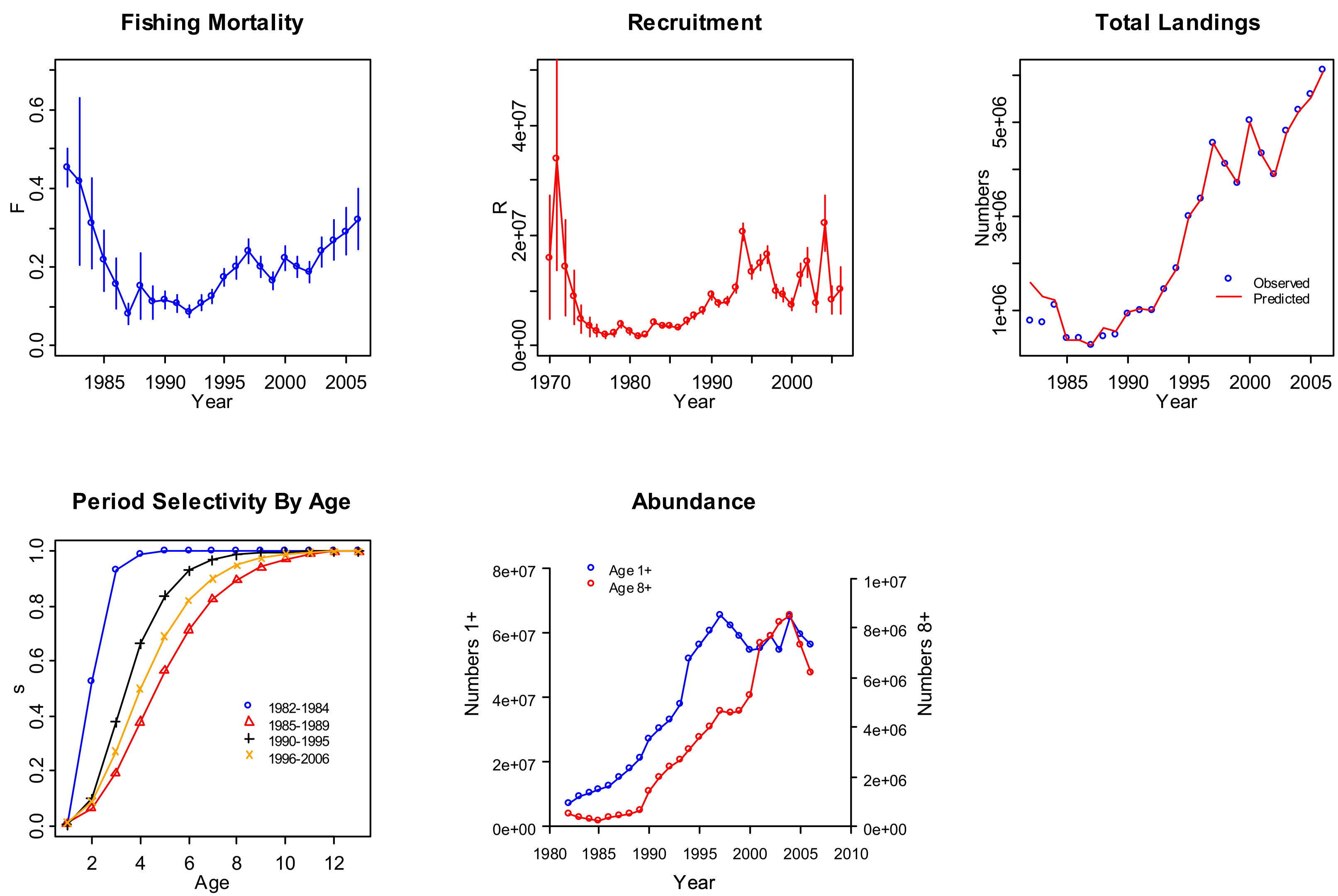



Figure A7.8. Estimates of fishing mortality (±95%CI), recruitment (±95%CI), total landings, period selectivity patterns, and abundance of ages 1+ and 8+ from the final configuration SCA model run.

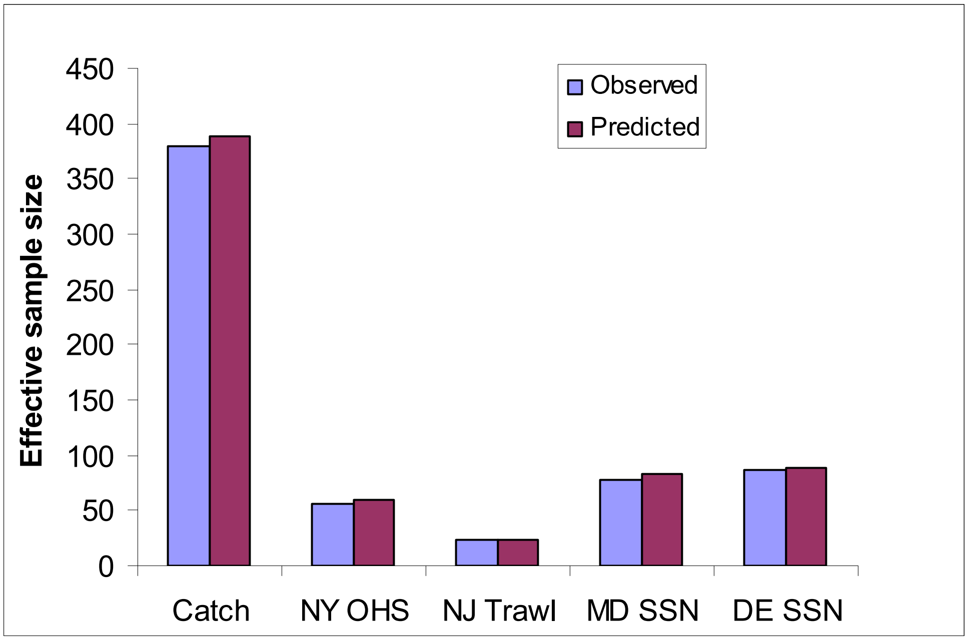



Figure A7.9. Comparison of observed (from equal weighting) and predicted effective sample sizes under the SCA final model run with total catch lambda=10.

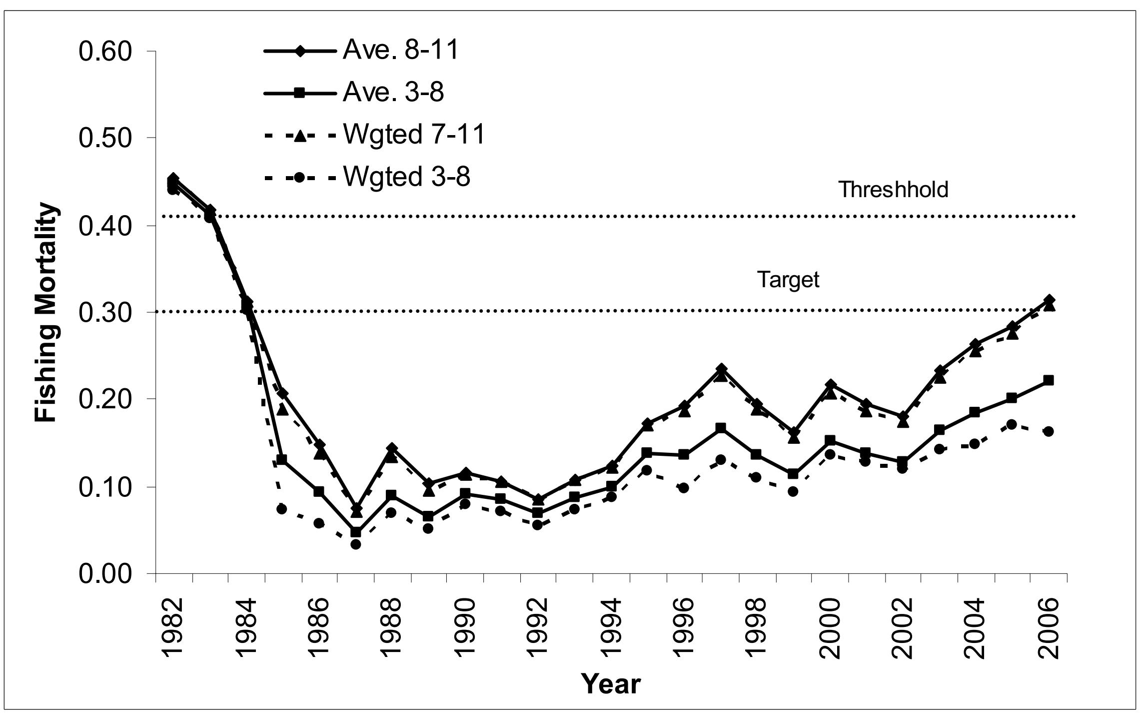



Figure A7.10. Comparison of fishing mortality estimates from the SCA model.

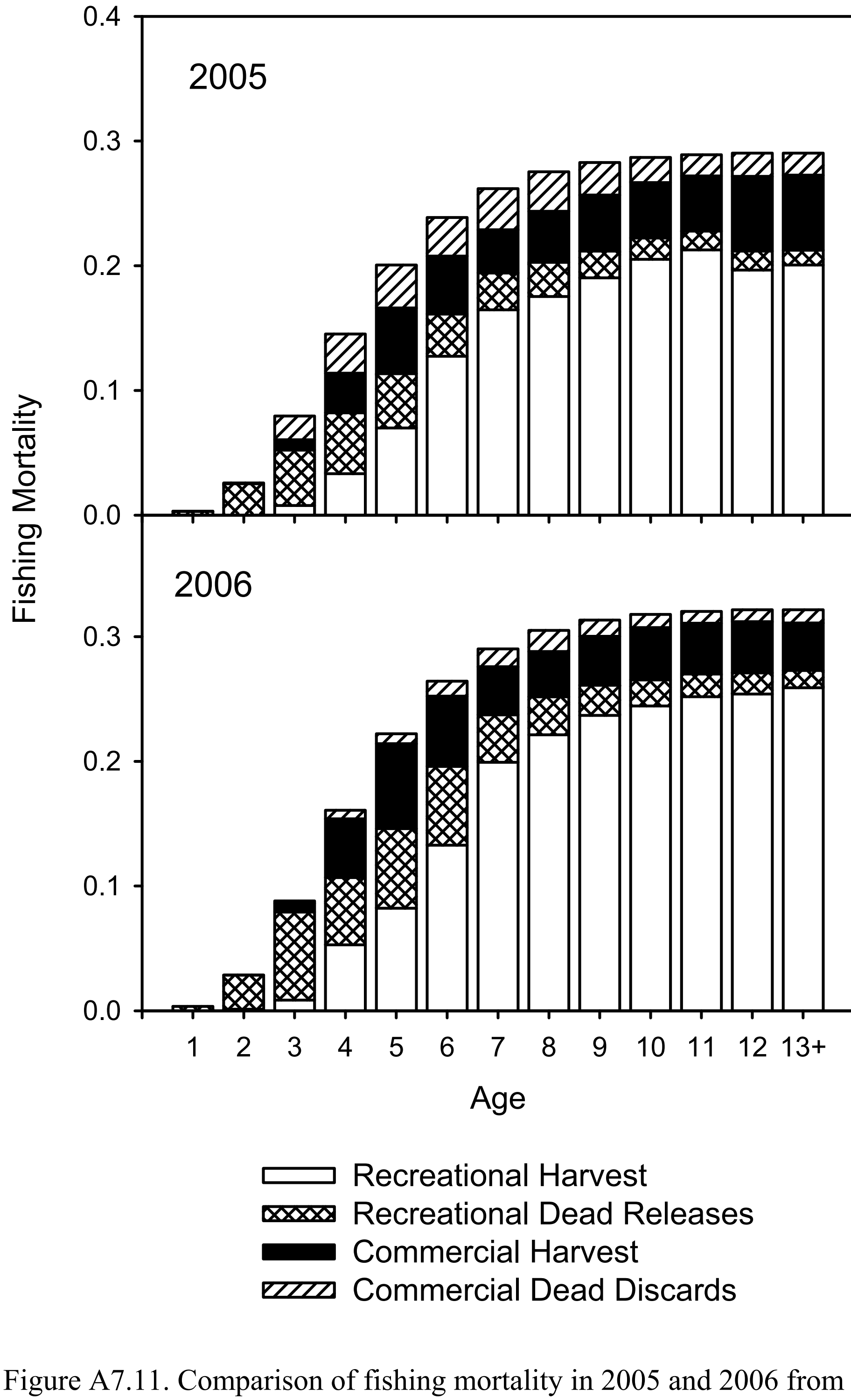



Figure A7.11. Comparison of fishing mortality in 2005 and 2006 from the SCA model partitioned into fishery components

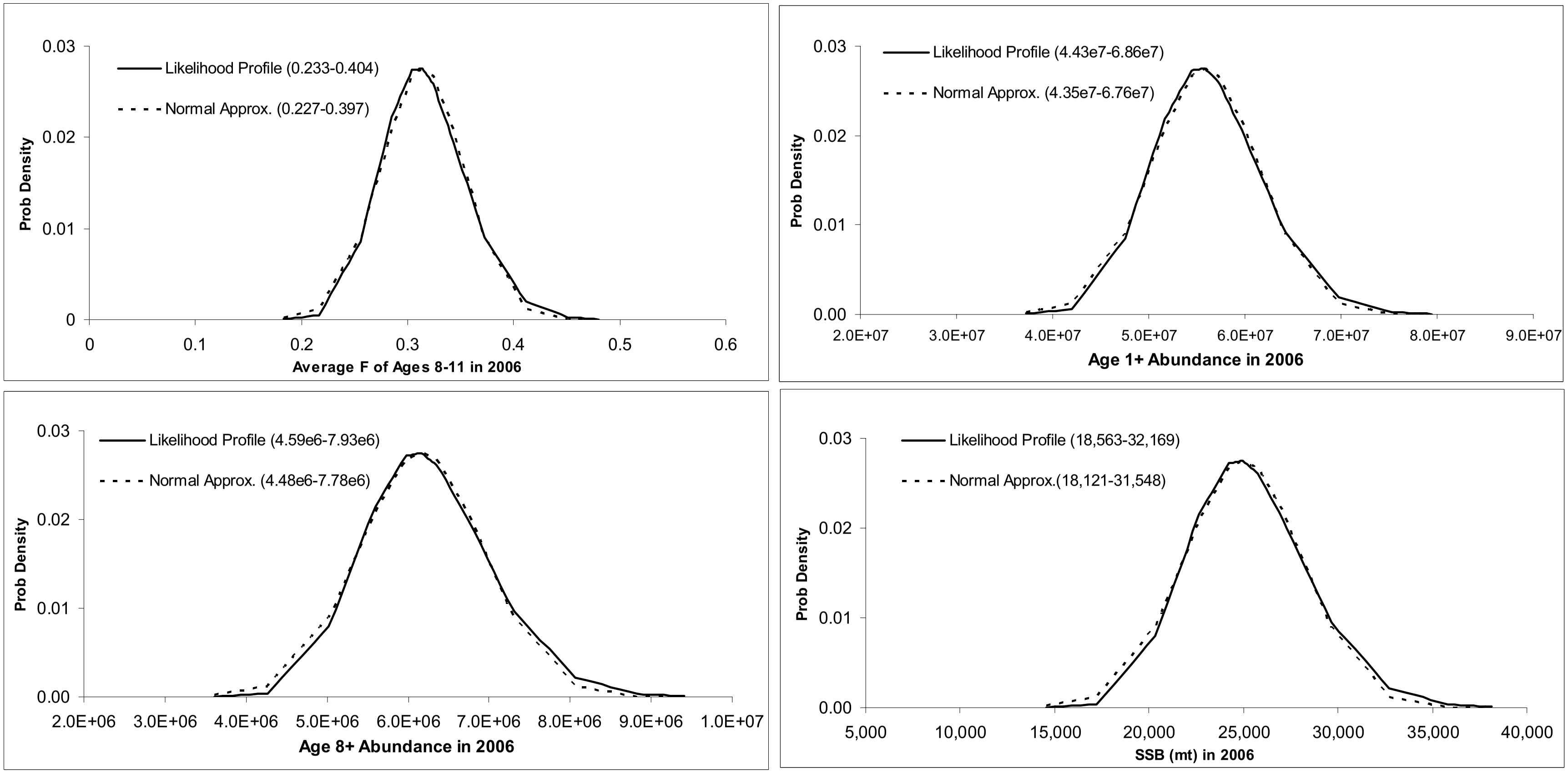



Figure A7.12. Comparison of likelihood profile and normal approximation methods for determining confidence intervals of estimates of average F of ages 8-11, age 1+ abundance, age 8+ abundance, and spawning stock biomass in 2006 from the SCA model. Lower and upper 95% confidence limits are shown in parentheses.

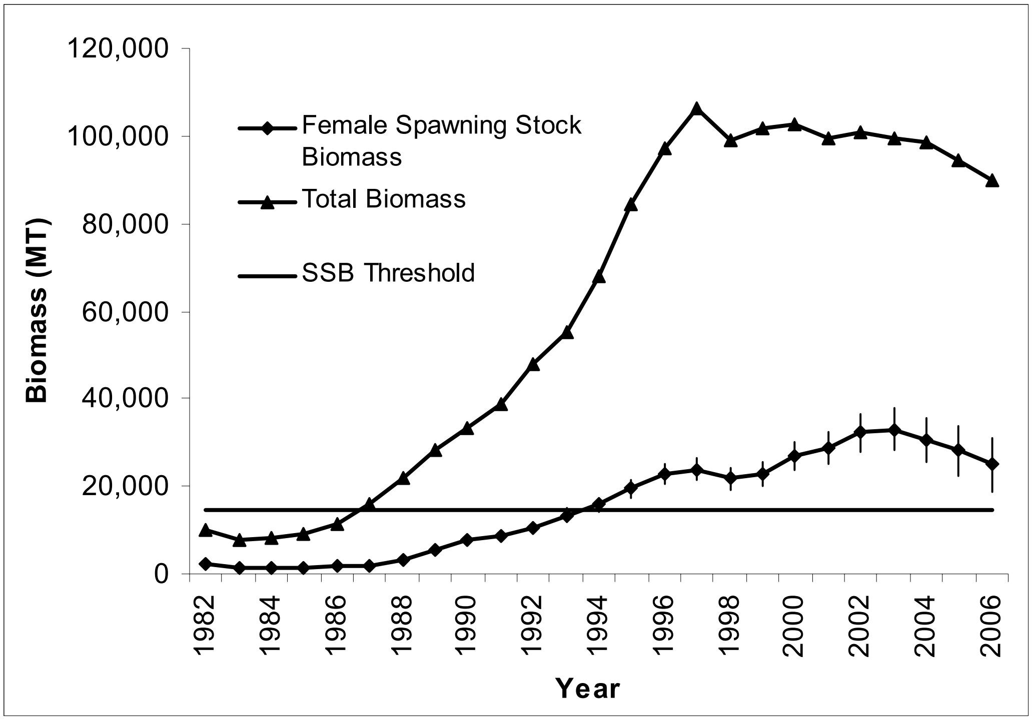



Figure A7.13. Striped bass female spawning stock biomass (mt) and Jan. 1 total biomass (mt) from the SCA model. 95% confidence intervals are shown for female spawning stock biomass.

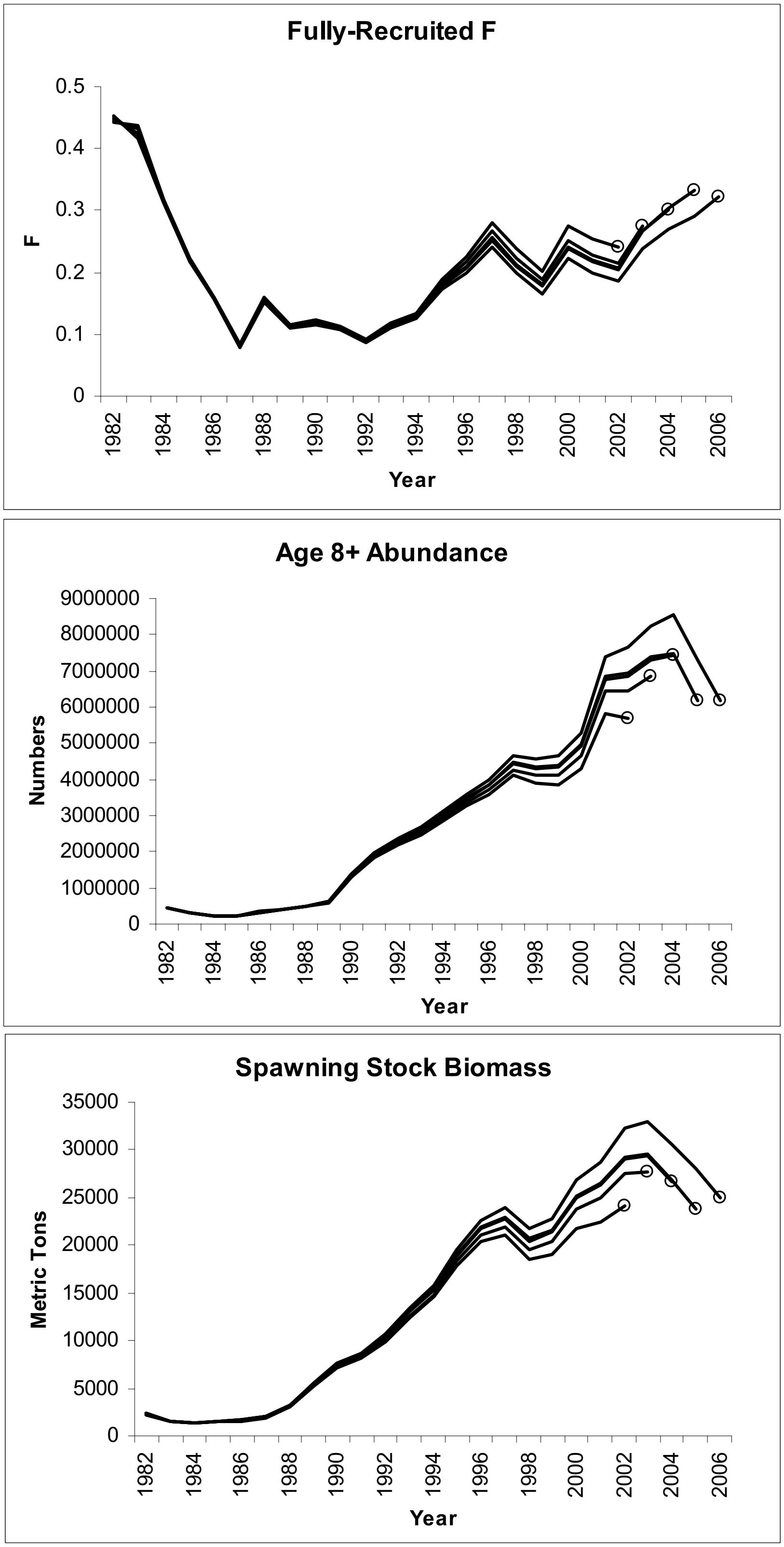



Figure A7.14. Retrospective analysis of fully-recruited fishing mortality, 8+ abundance, and spawning stock biomass from the SCA model.

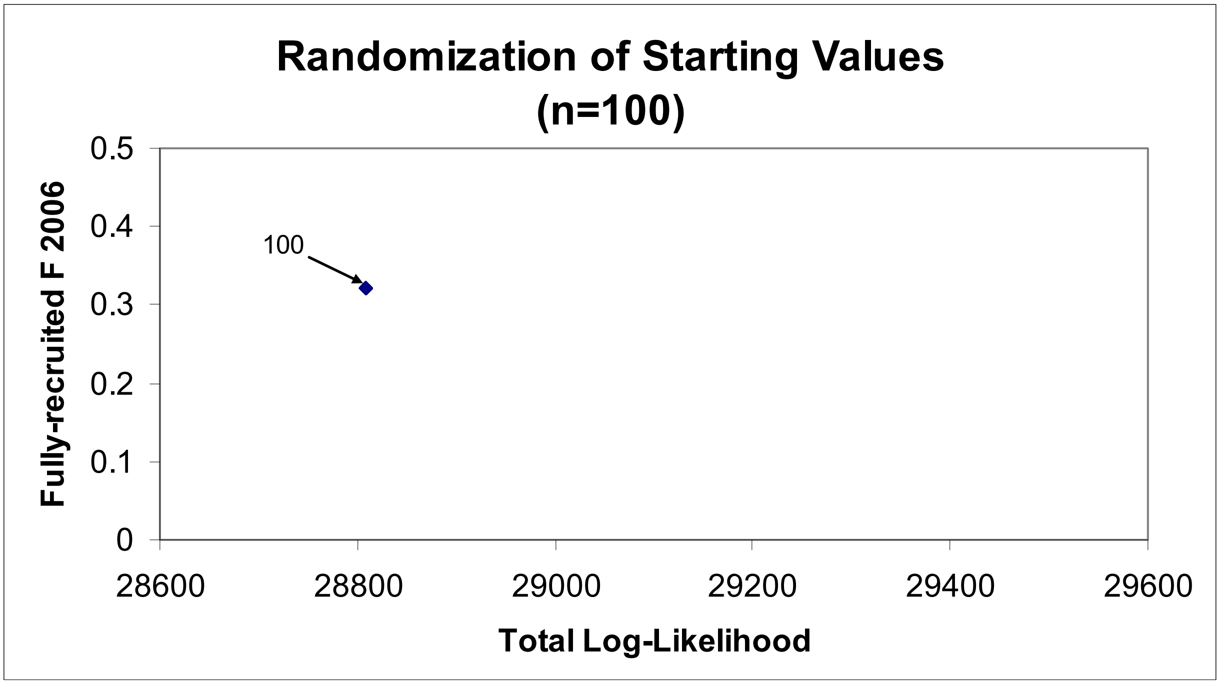



Figure A7.15. Results from 100 SCA model runs in which starting values were randomly permuted by ±50%.

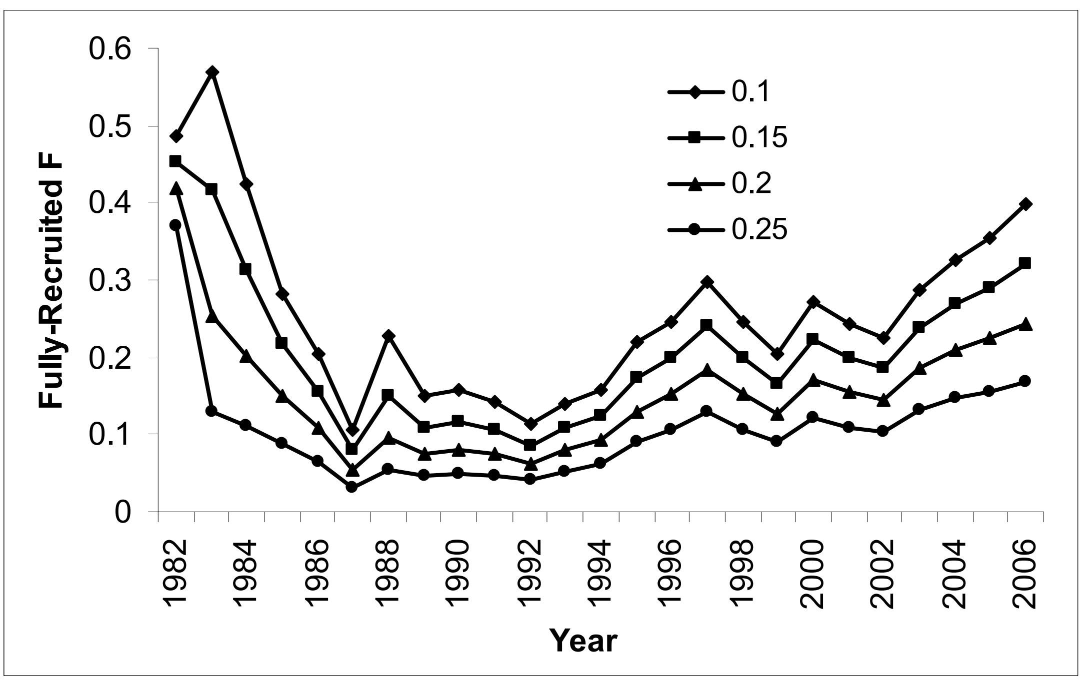



Figure A7.16. Effects of varying M on estimates of fully-recruited fishing mortality from the SCA model

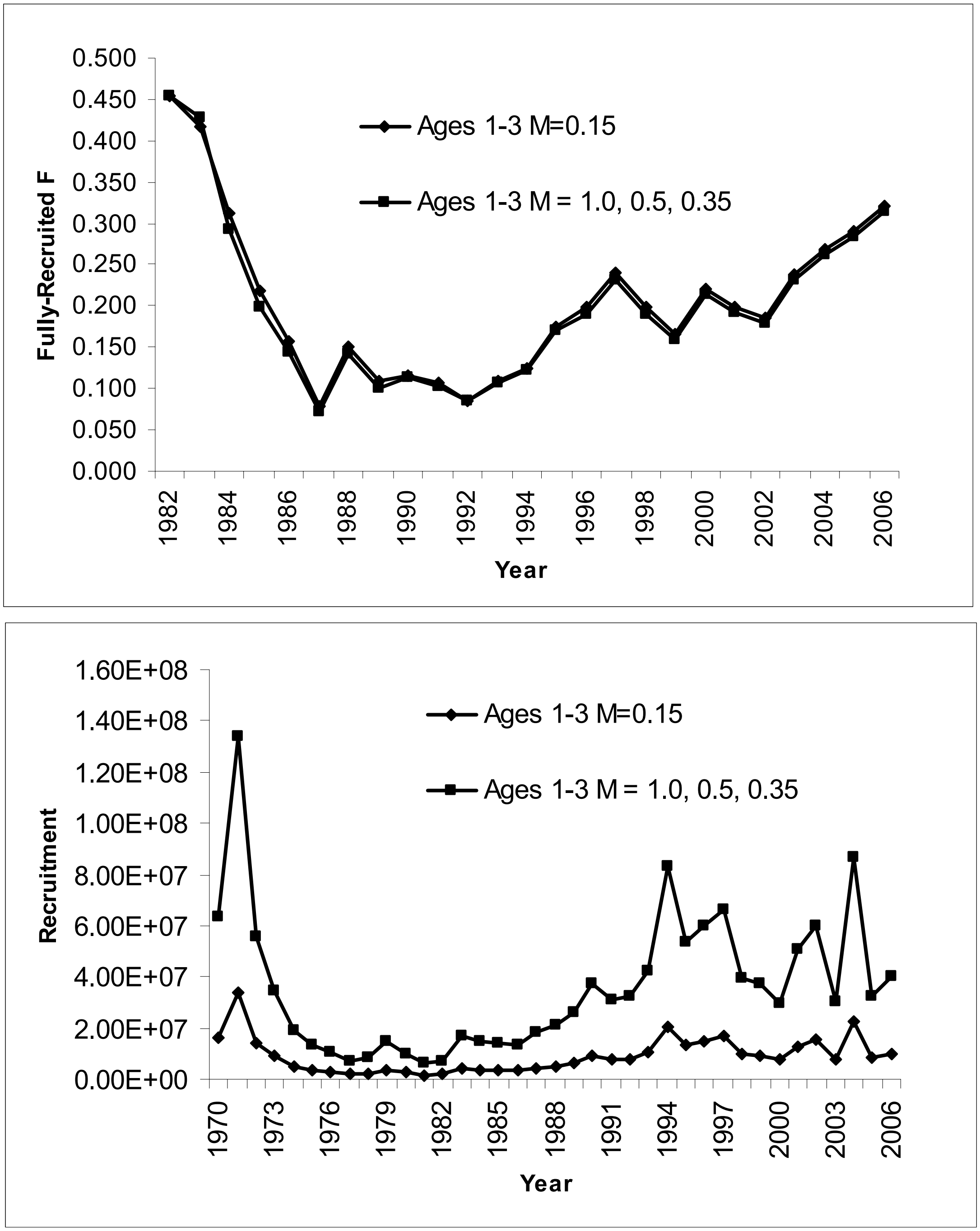



Figure A7.17. Effects of higher M for ages 1-3 on estimates of fully-recruited fishing mortality and recruitment from the SCA model.

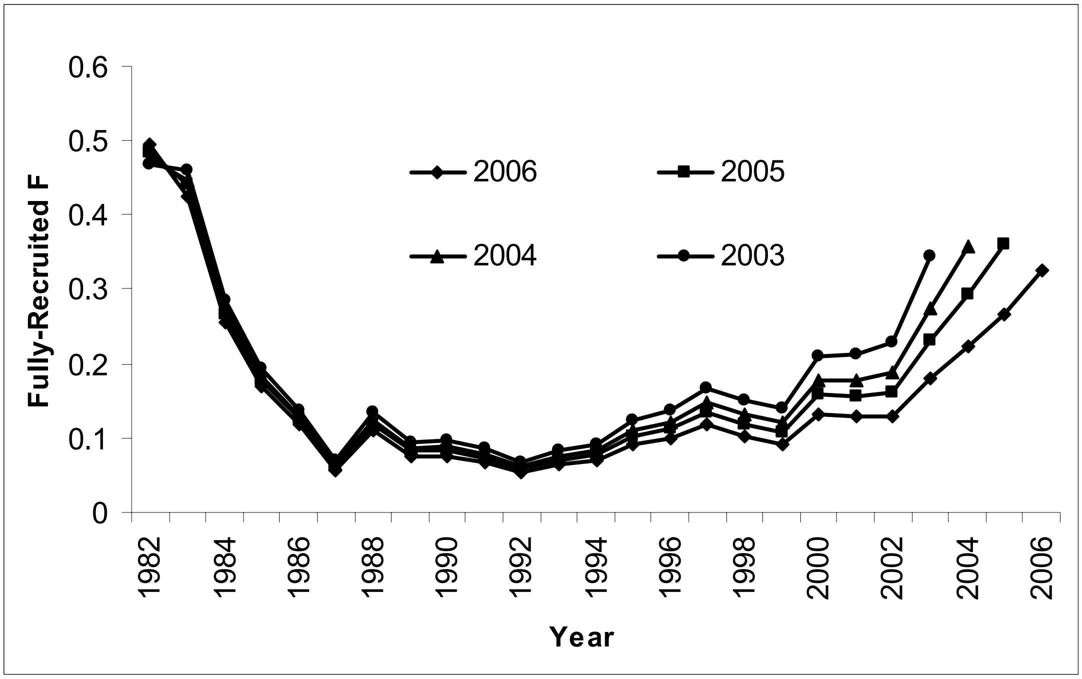



Figure A7.18. Comparison of retrospective pattern in fully-recruited F when M=0.30 after 1996

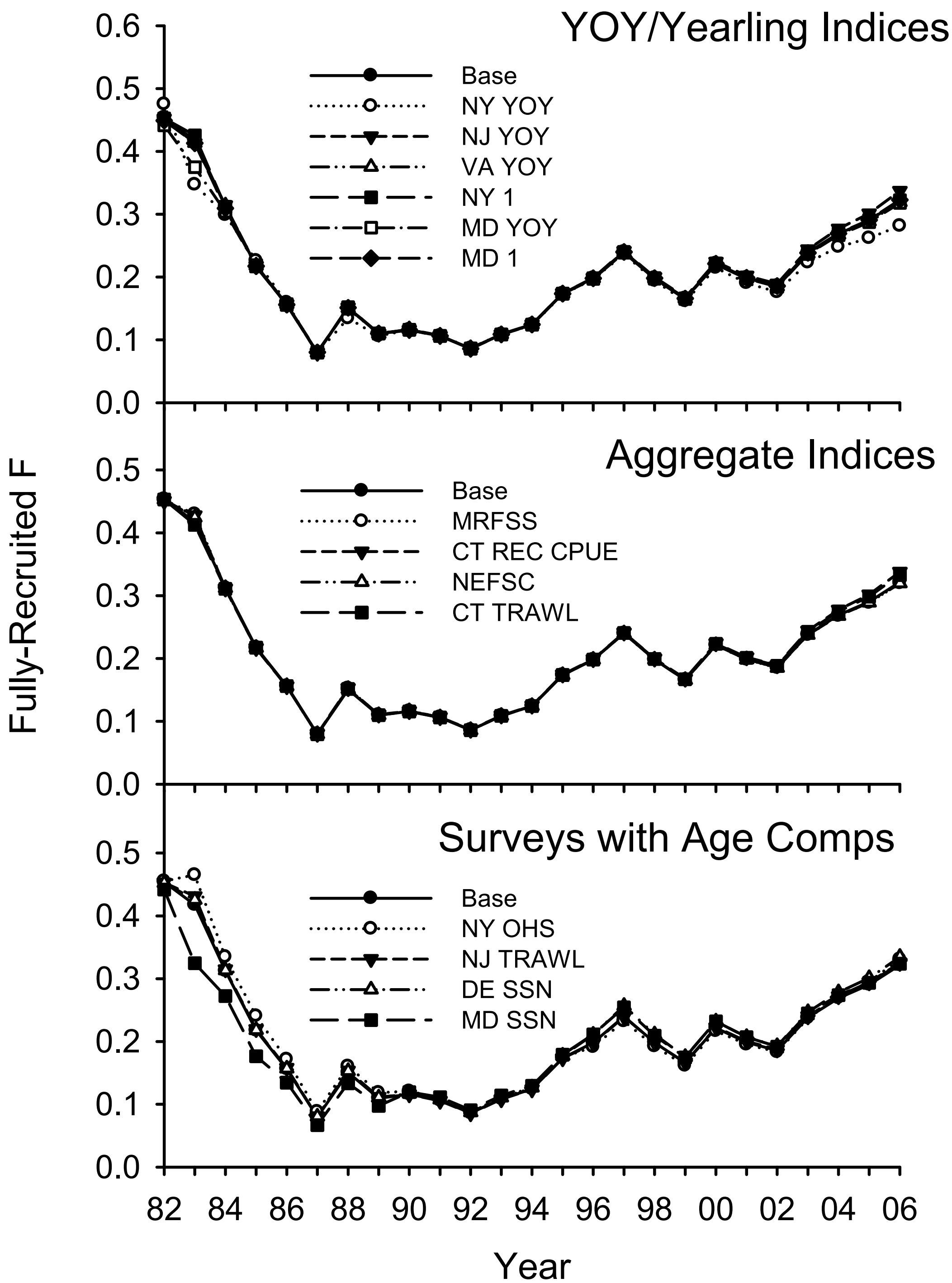
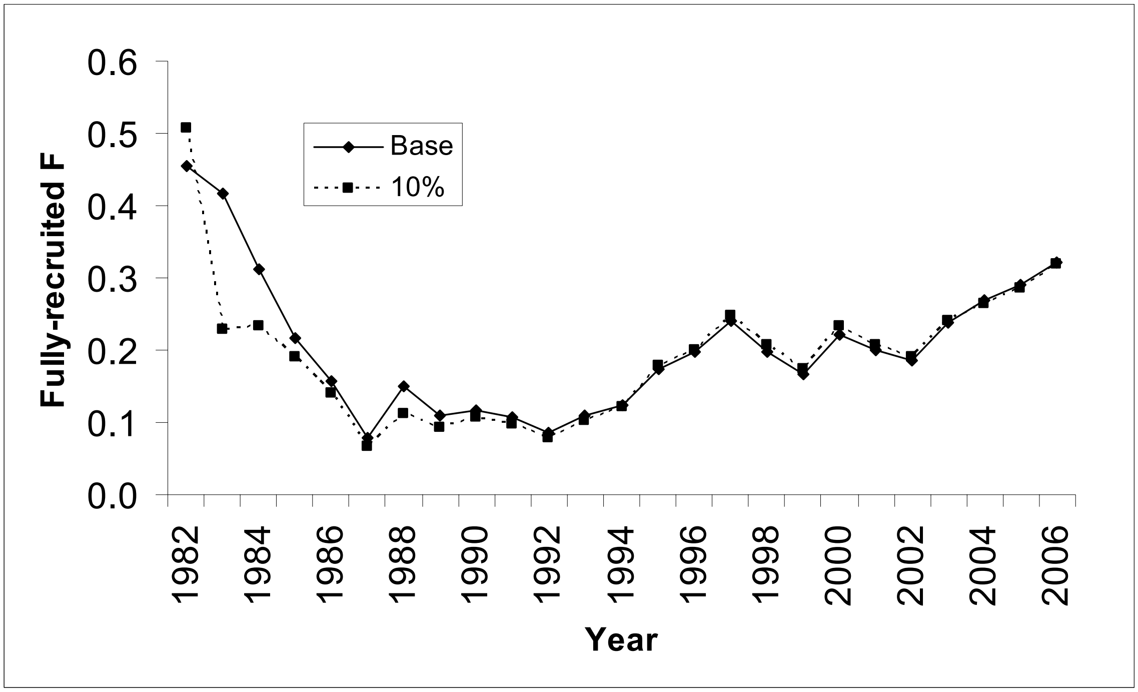



Figure A7.19. Comparison of fully-recruited F estimates when data from each survey were deleted one-at-a-time from the final SCA model configuration.

A.




B.

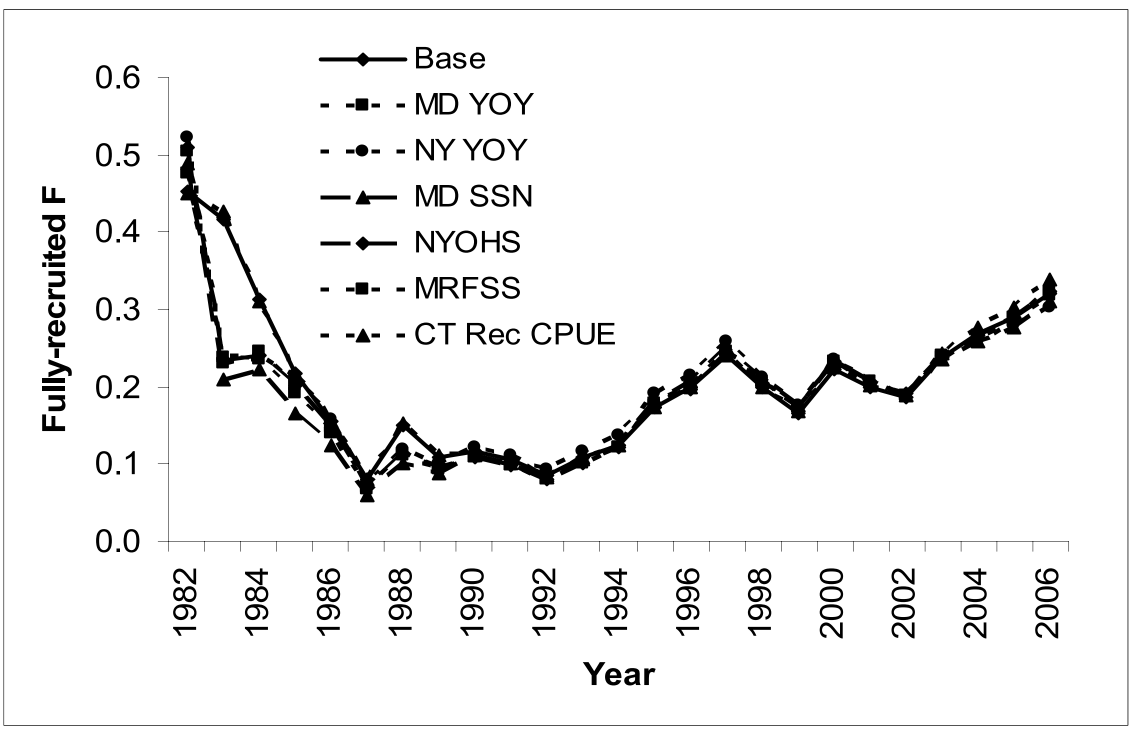
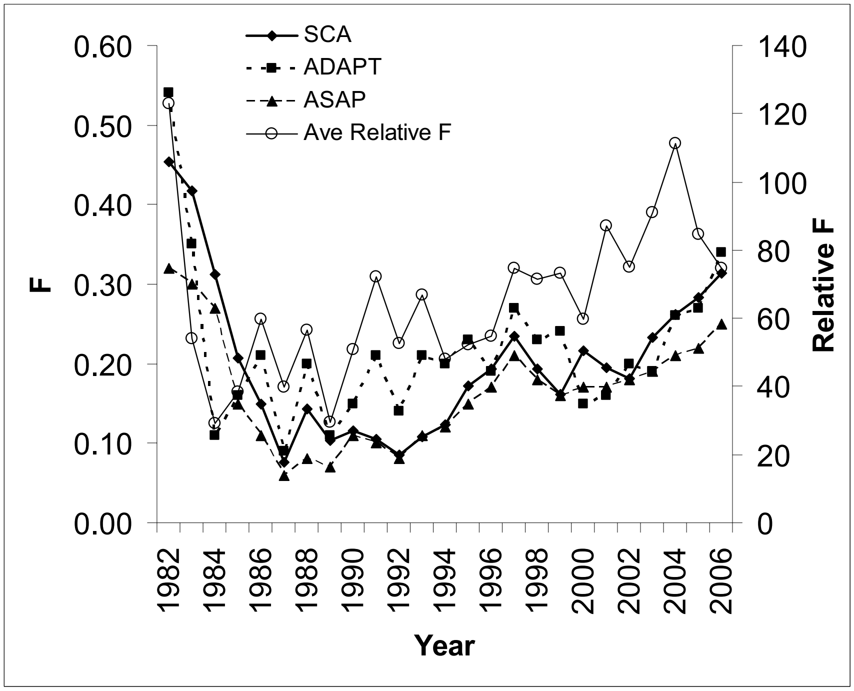



Figure A7.20. Comparison of fully-recruited F estimates from the SCA model when A) average effective sample sizes for the catch and survey multinomials were decreased to 10% of the original values and B) select surveys were deleted one-at-a-time when all average effective sample sizes were decreased to 10% of original values .

A.

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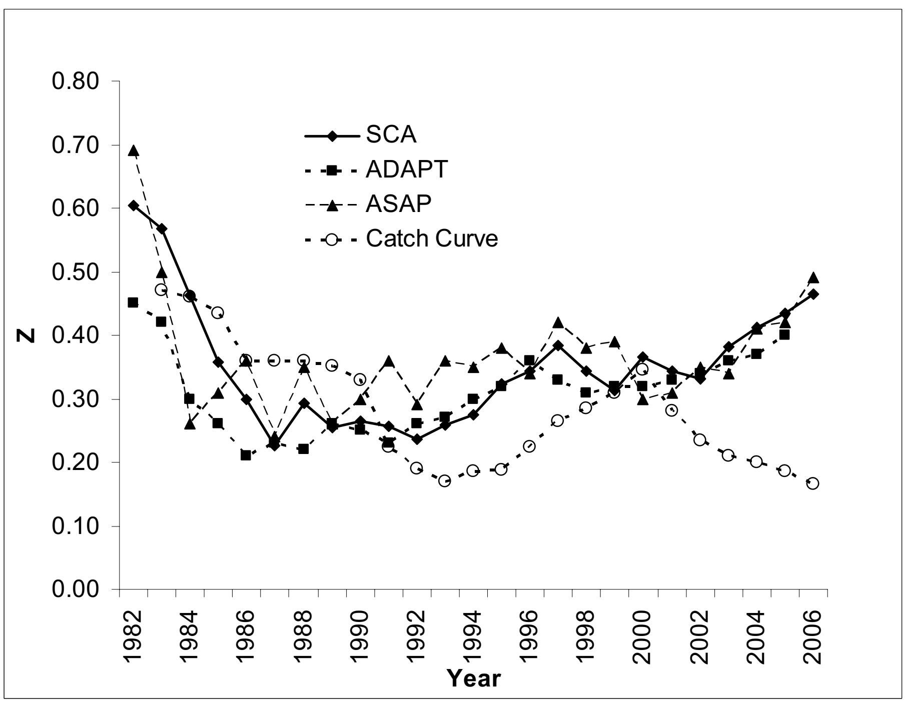



Figure A7.21. A) Comparison of SCA, ADAPT, ASAP, and relative F estimates of average fishing mortality of ages 8-11, and B) SCA, ADAPT, ASAP and catch curve analysis fully-recruited total mortality.

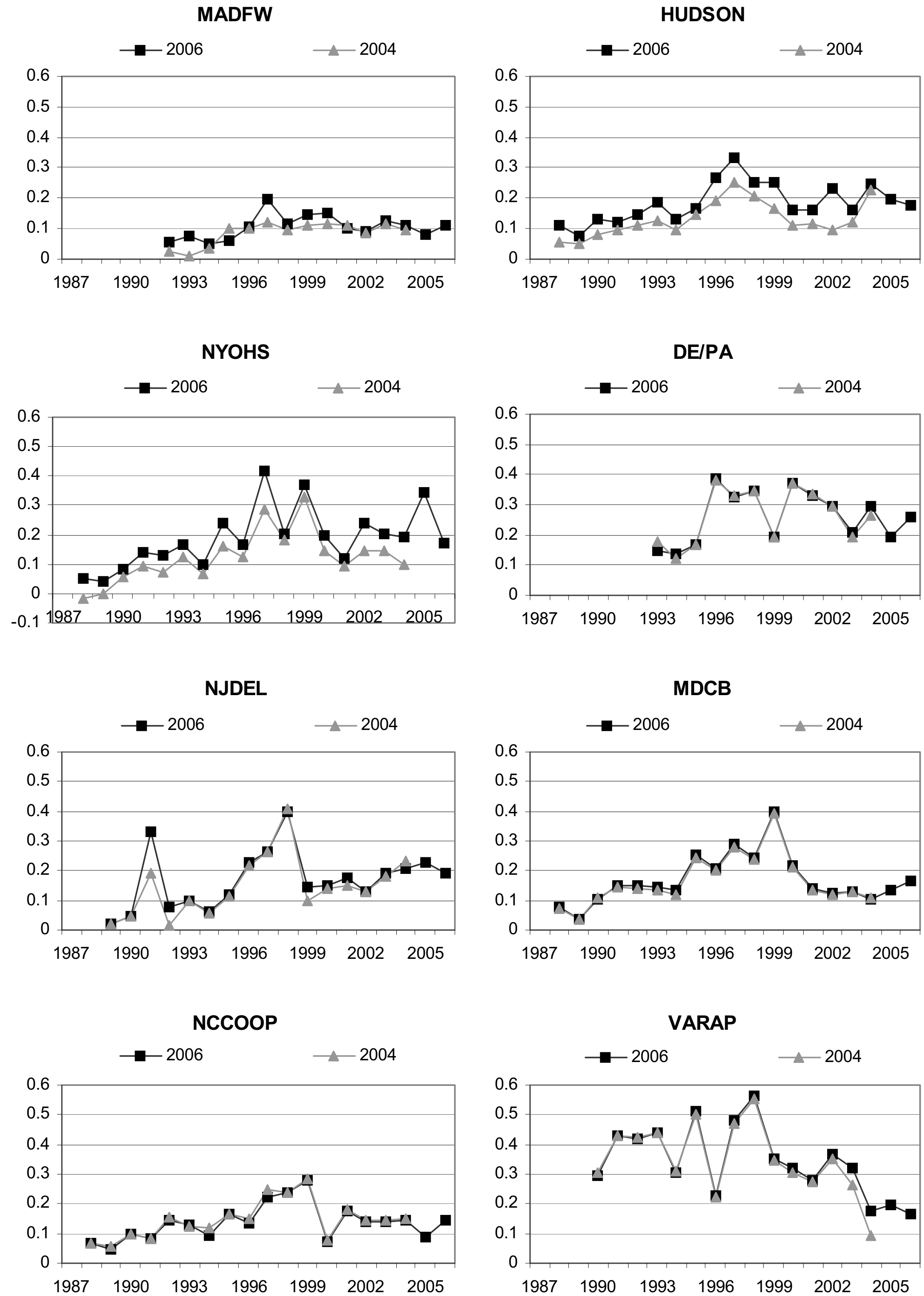



Figure A8.1. Retrospective analysis of fishing mortality estimates generated by the catch equation method for fish >28". Data shown are from the previous stock assessment in 2004 and the current in 2006.

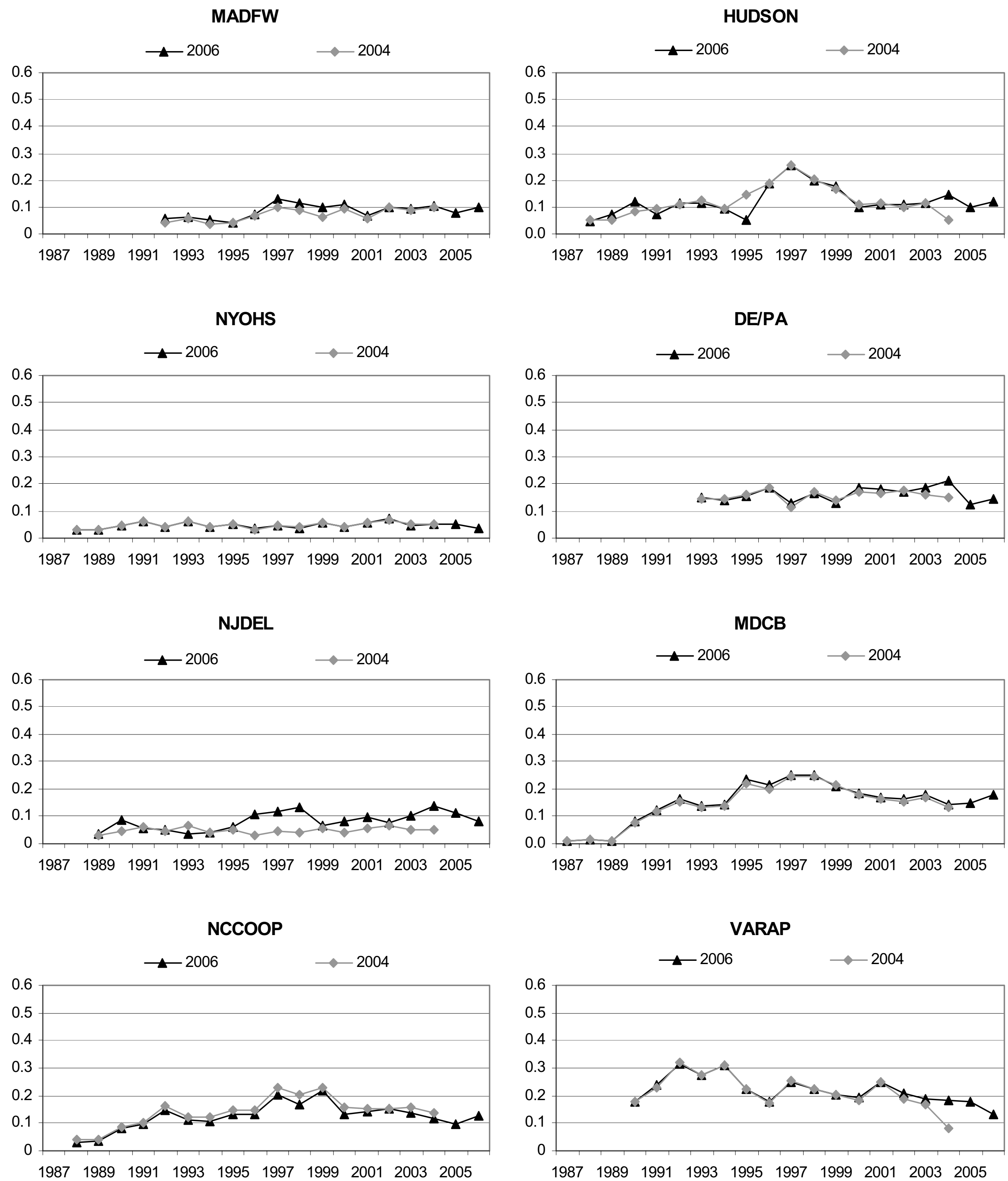
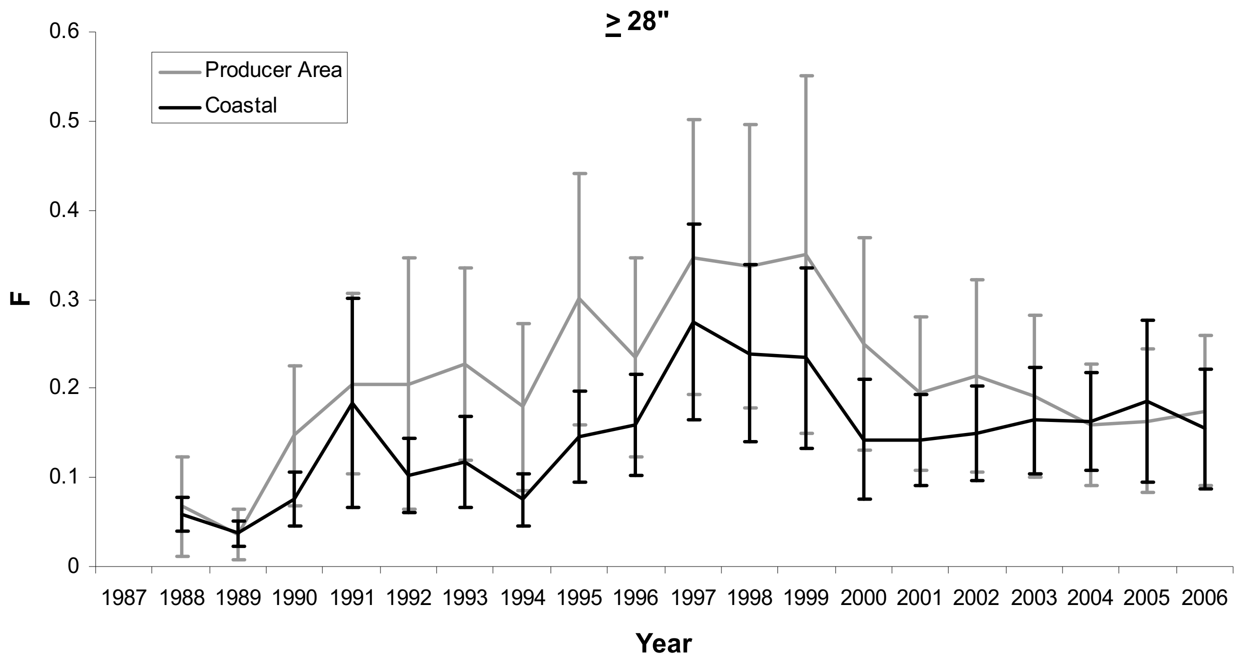



Figure A8.2. Retrospective analysis of fishing mortality estimates generated by the catch equation method for fish >18". Data shown are from the previous stock assessment in 2004 and the current in 2006.



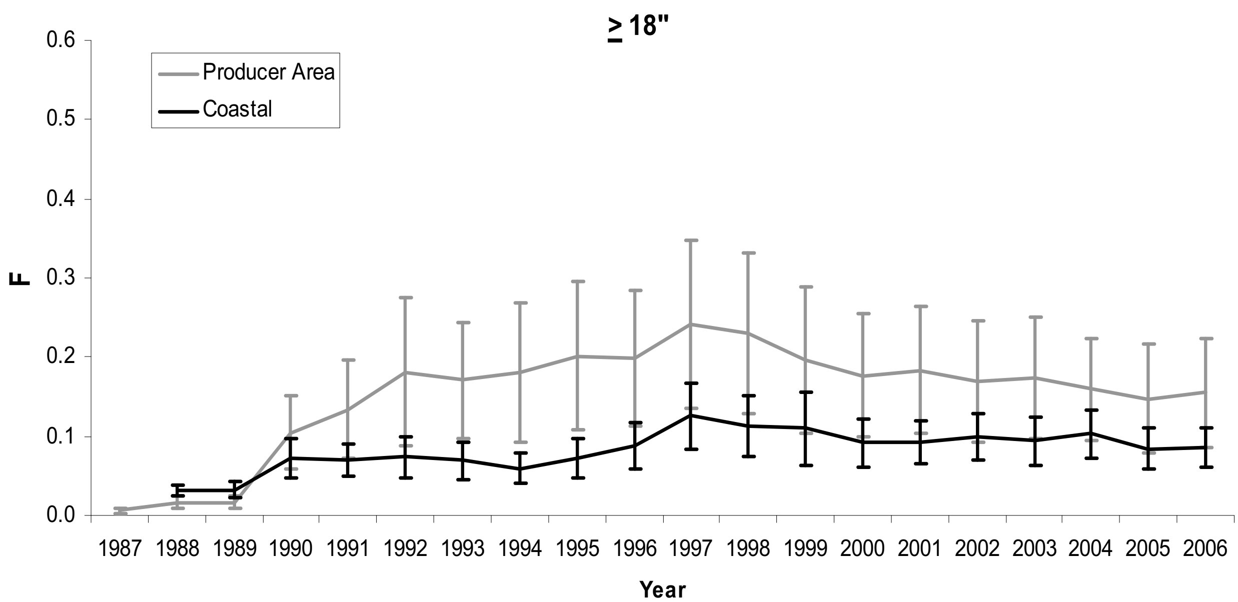
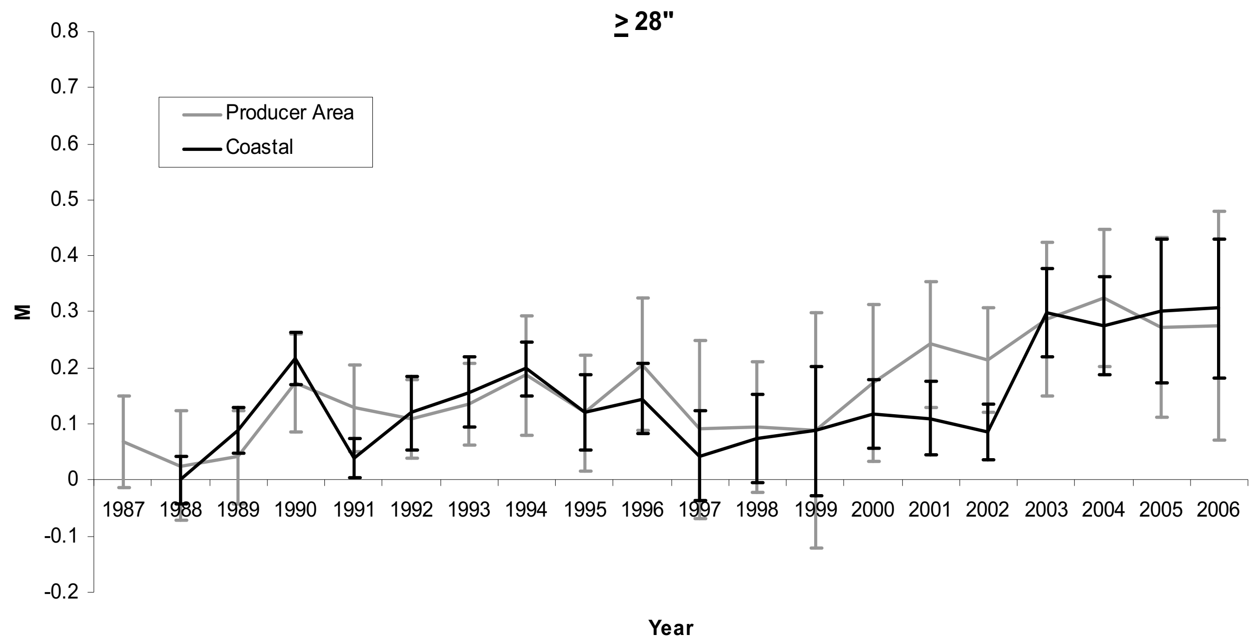




Figure A8.3. Coastal and producer area mean fishing mortality estimates and their 95% confidence intervals generated from the catch equation method for striped bass ≥ 28" and ≥ 18".



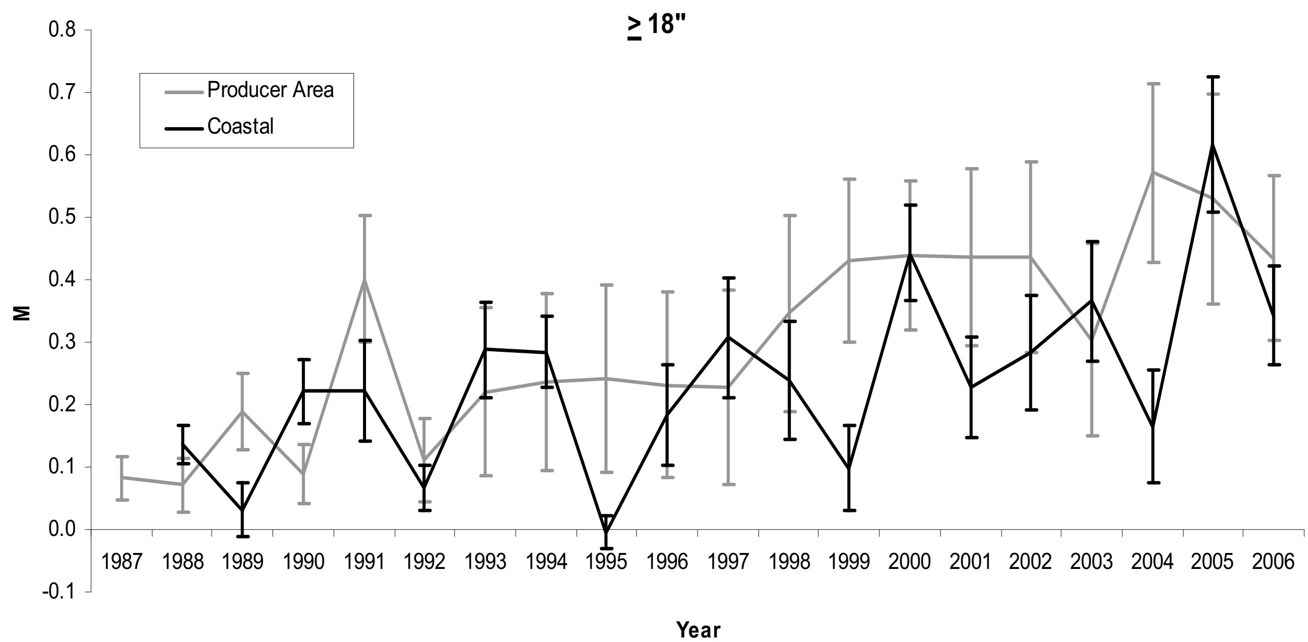




Figure A8.4. Coastal and producer area mean natural mortality estimates and their 95% confidence interval, generated from the catch equation method for striped bass ≥ 28” and ≥ 18”.

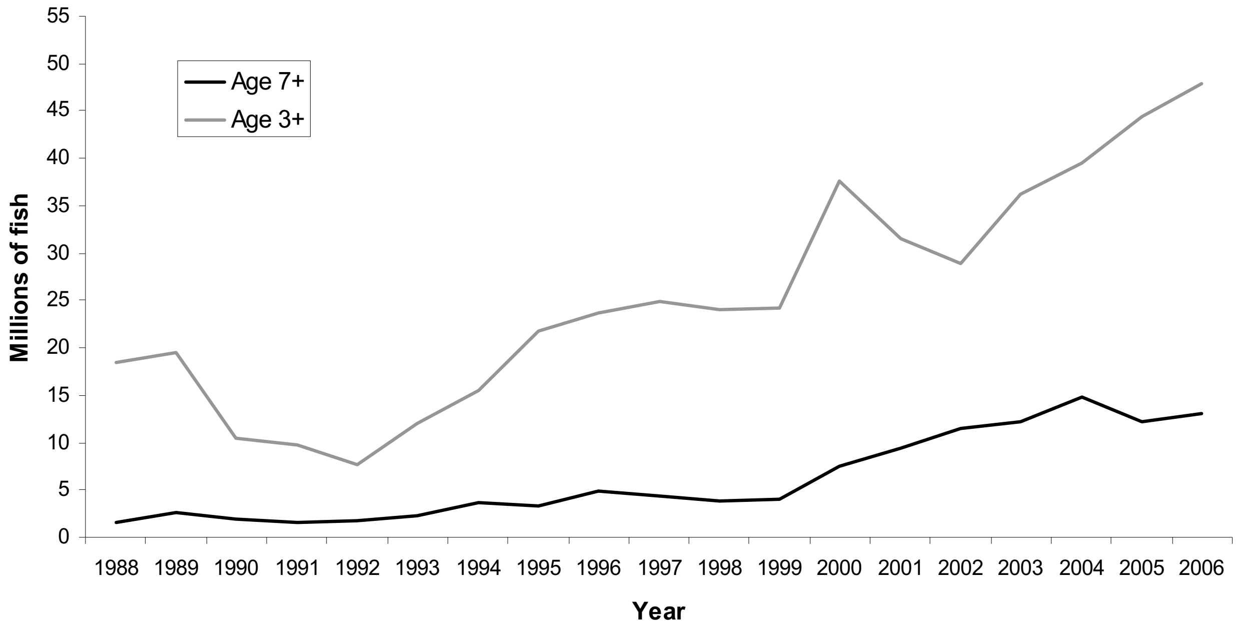



Figure A8.5. Stock size estimates generated from the catch equation method for fish age seven and older (comparable to fish > 28 inches) and fish age three and older (comparable to fish > 18 inches). Stock size obtained via "Kill (in numbers of fish) = F * Stock Size".

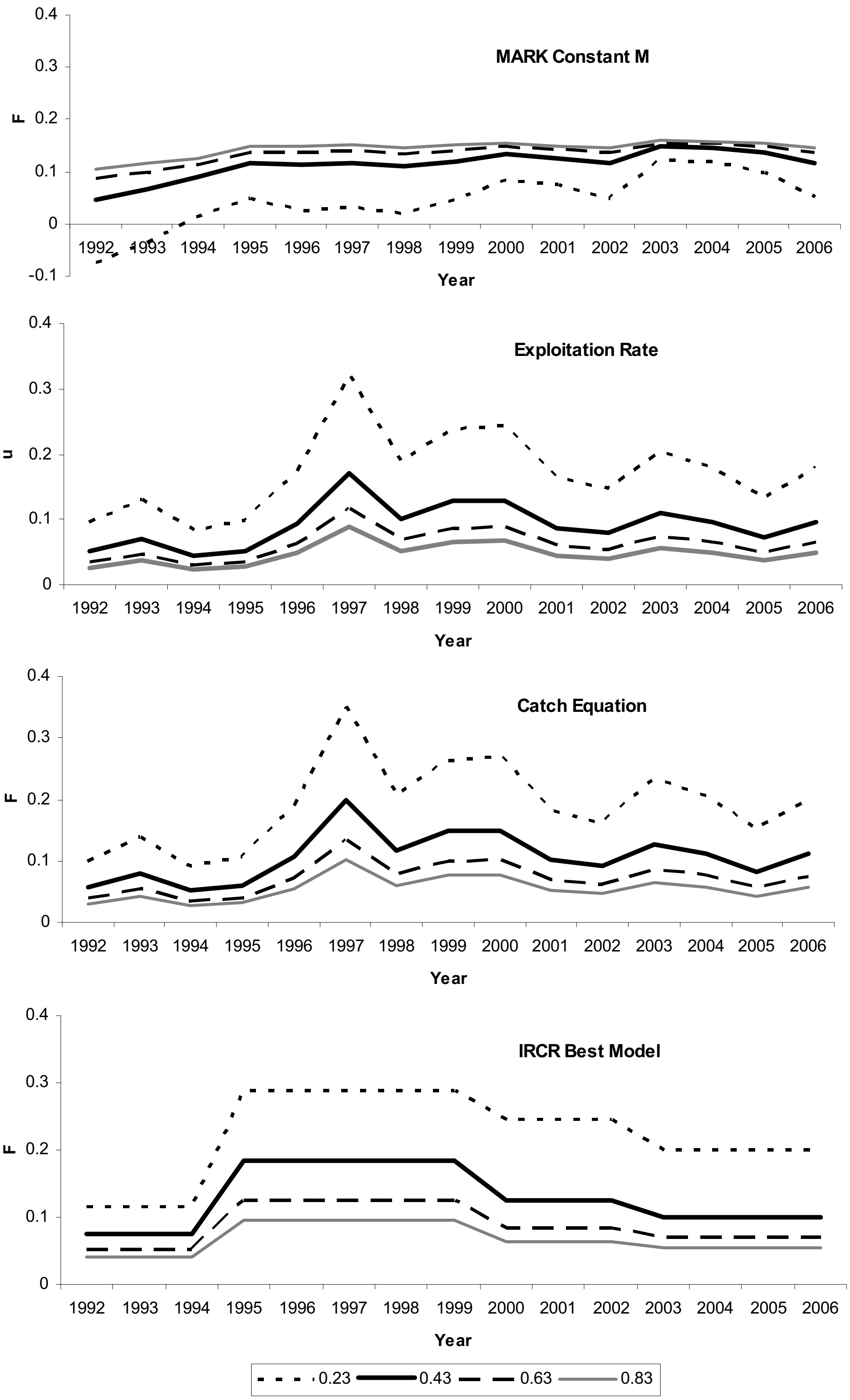



Figure A8.6. Sensitivity analysis showing effects of reporting rate values on exploitation rate and fishing mortality from different methods. Data shown are from MADFW.

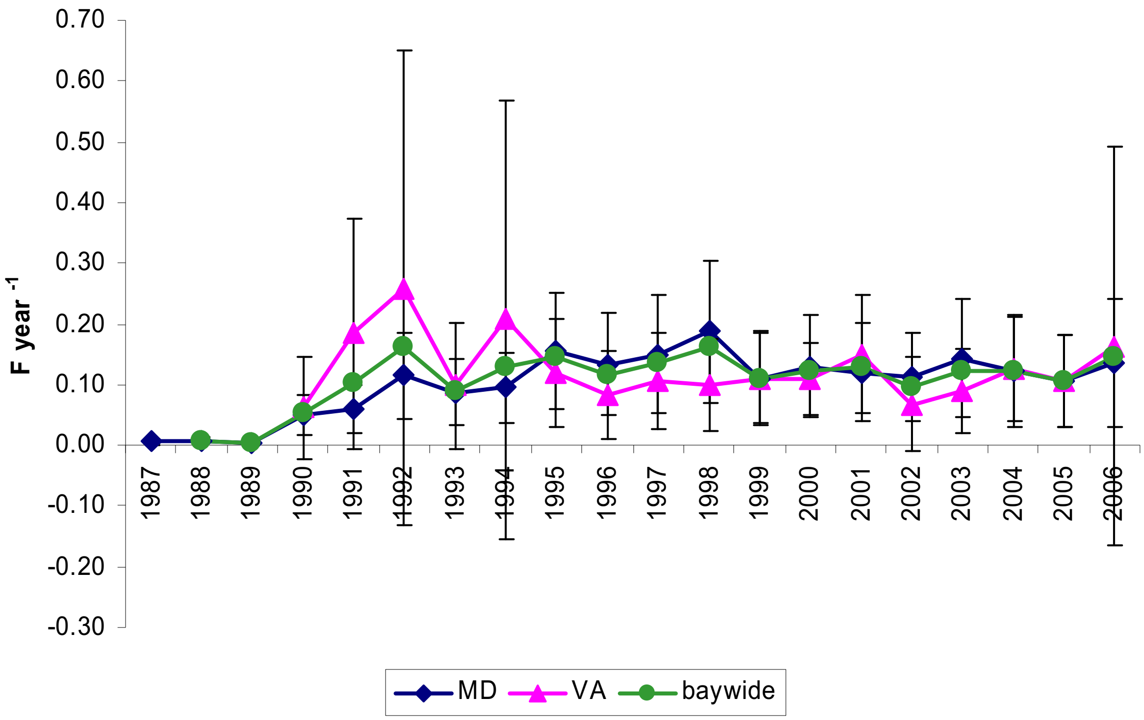



Figure A8.7. Fishing mortality of resident striped bass estimated using catch equation approach from MD and VA tagging data. Vertical bars represent 95% confidence limit intervals.

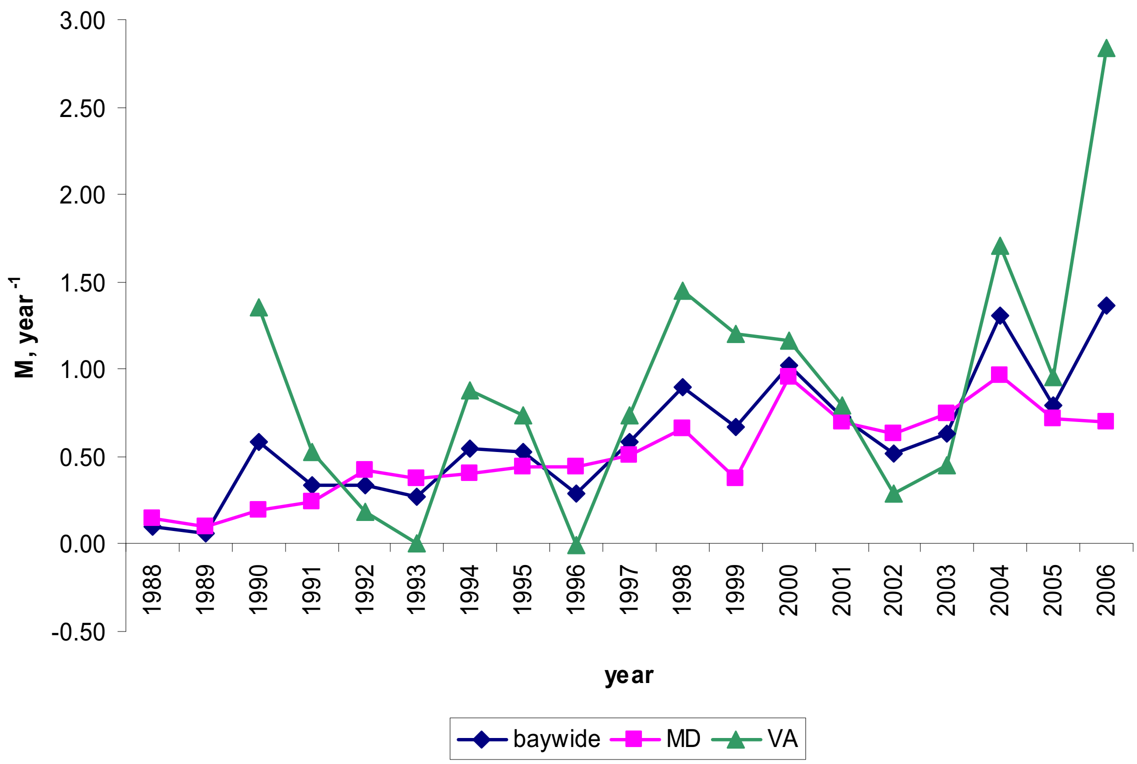



Figure A8.8. Natural mortality of resident striped bass estimated using catch equation approach from MD and VA tagging data.

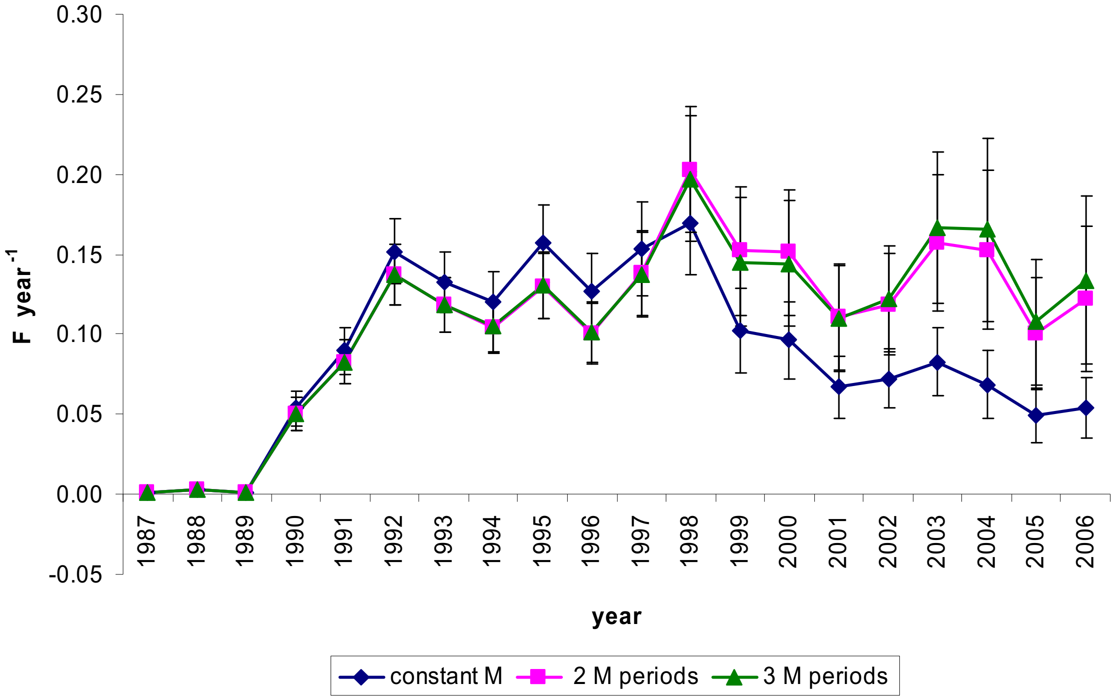



Figure A9.1. Fishing mortality of resident striped bass estimated from MD data using instantaneous rates model, assuming one, two and three different periods of natural mortality. Vertical bars represent 95% confidence limit intervals.

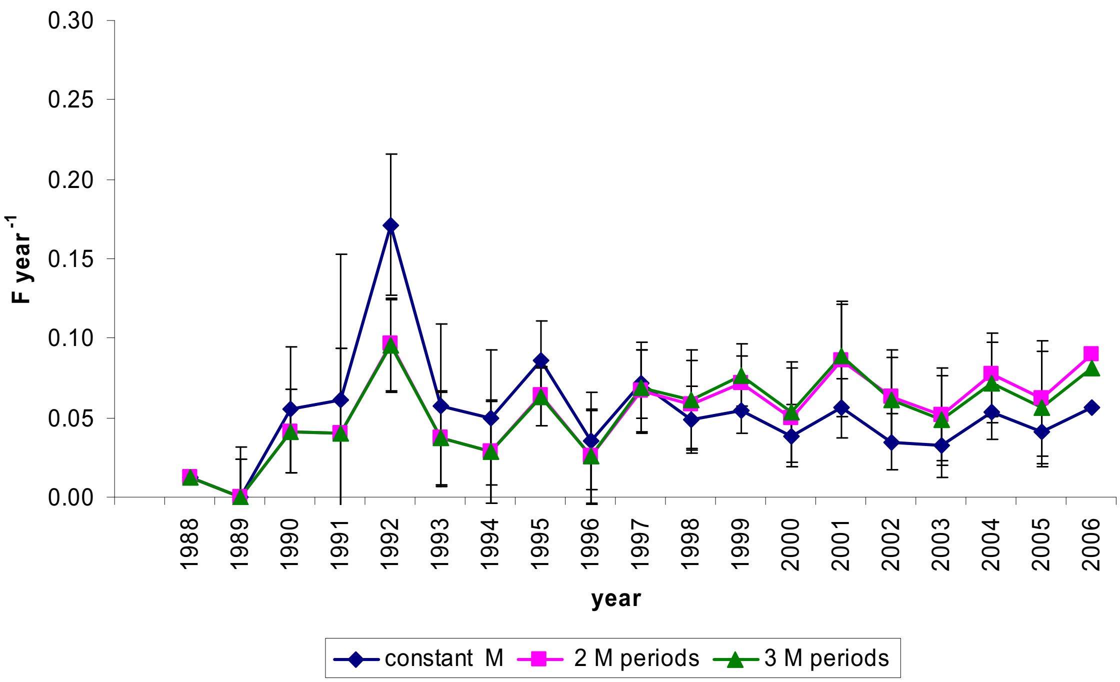



Figure A9.2. Fishing mortality of resident striped bass estimated from VA data using instantaneous rates model, assuming one, two and three different periods of natural mortality. Vertical bars represent 95% confidence limit intervals.

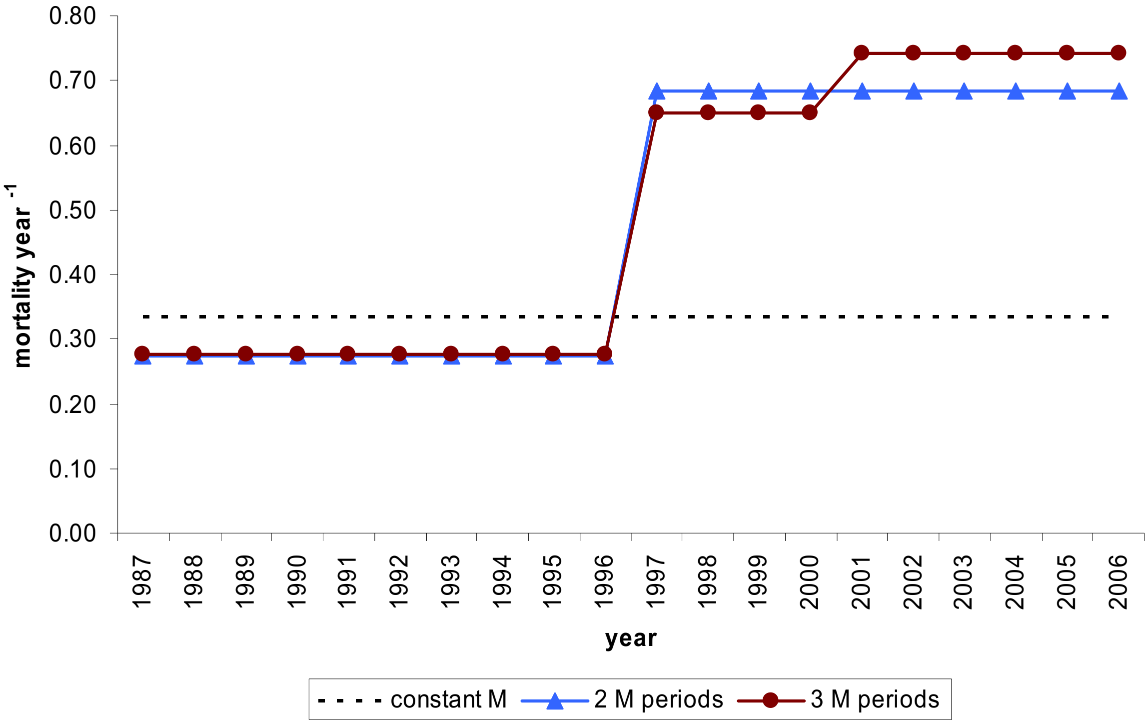



Figure A9.3. Instantaneous rates model estimates of natural mortality from MD data assuming constant M, two and three periods of different M.

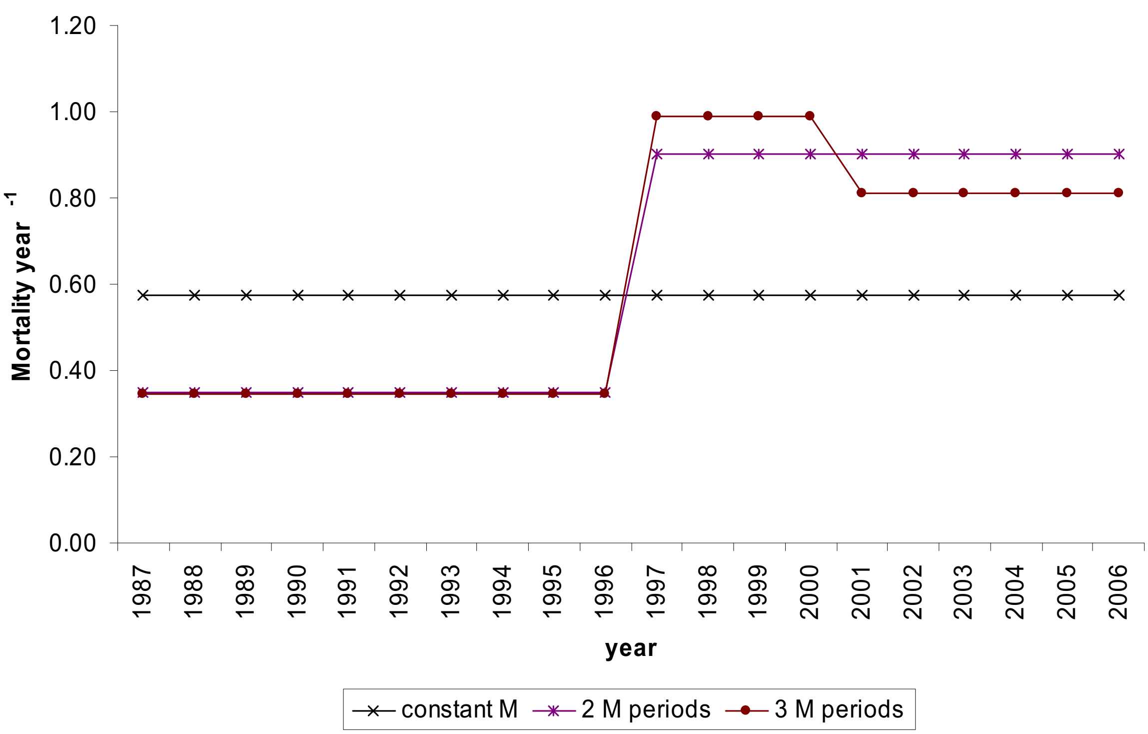



Figure A9.4. Instantaneous rates model estimates of natural mortality from VA data assuming constant M, two and three periods of different M.

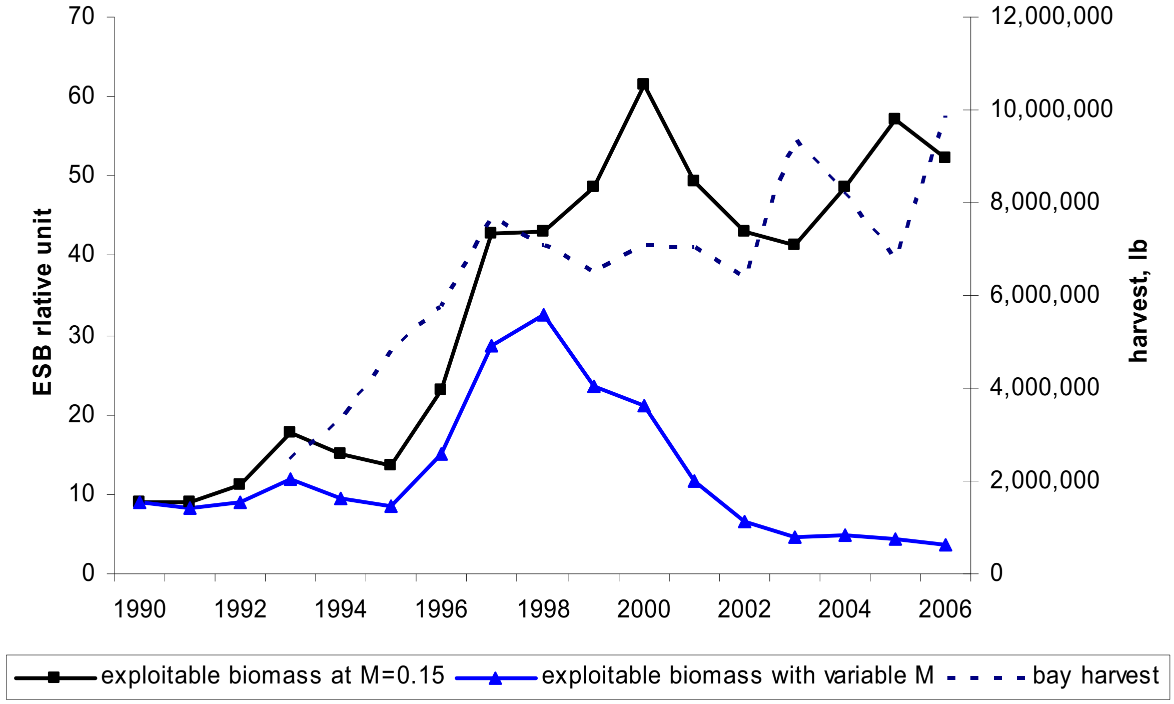
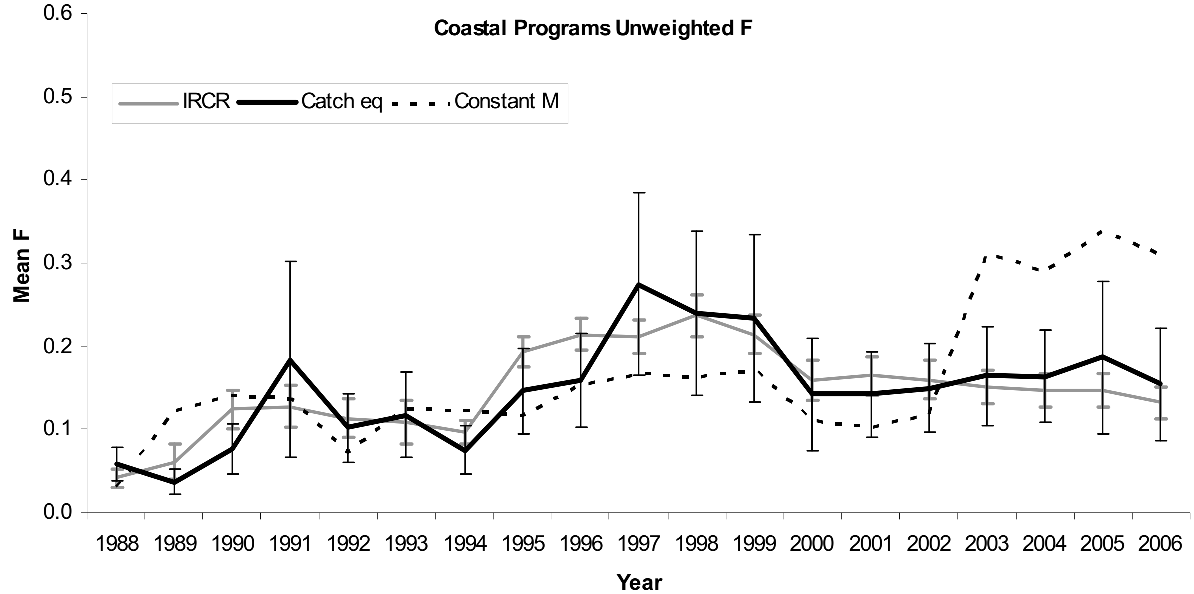



Figure A9.5. Projected Chesapeake bay exploited biomass assuming constant natural mortality M=0.15, period specific natural mortality from instantaneous model and bay-wide harvest.



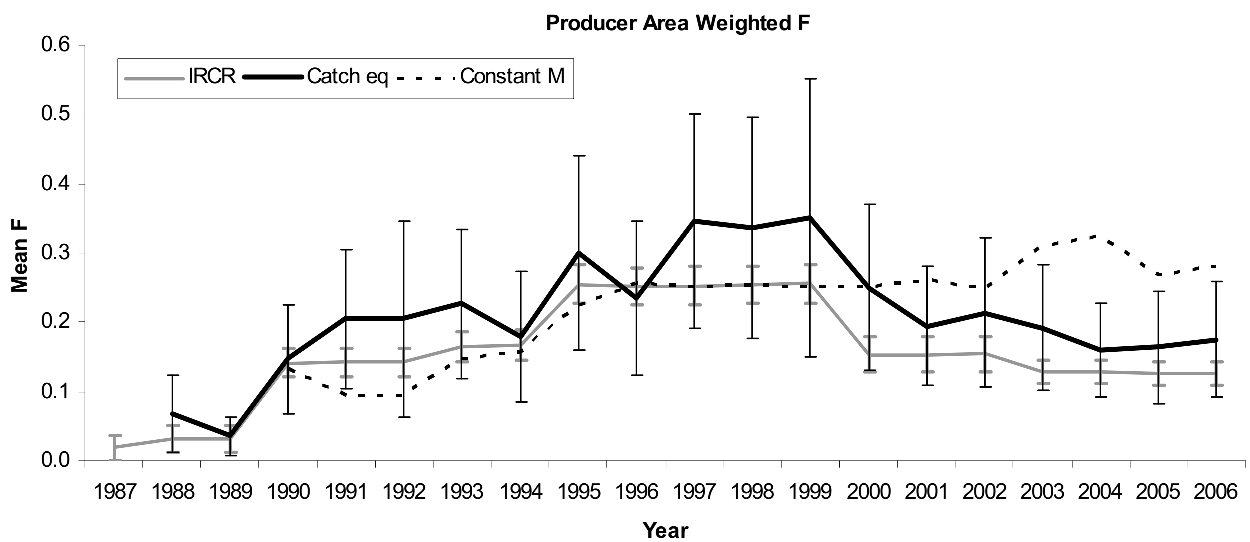
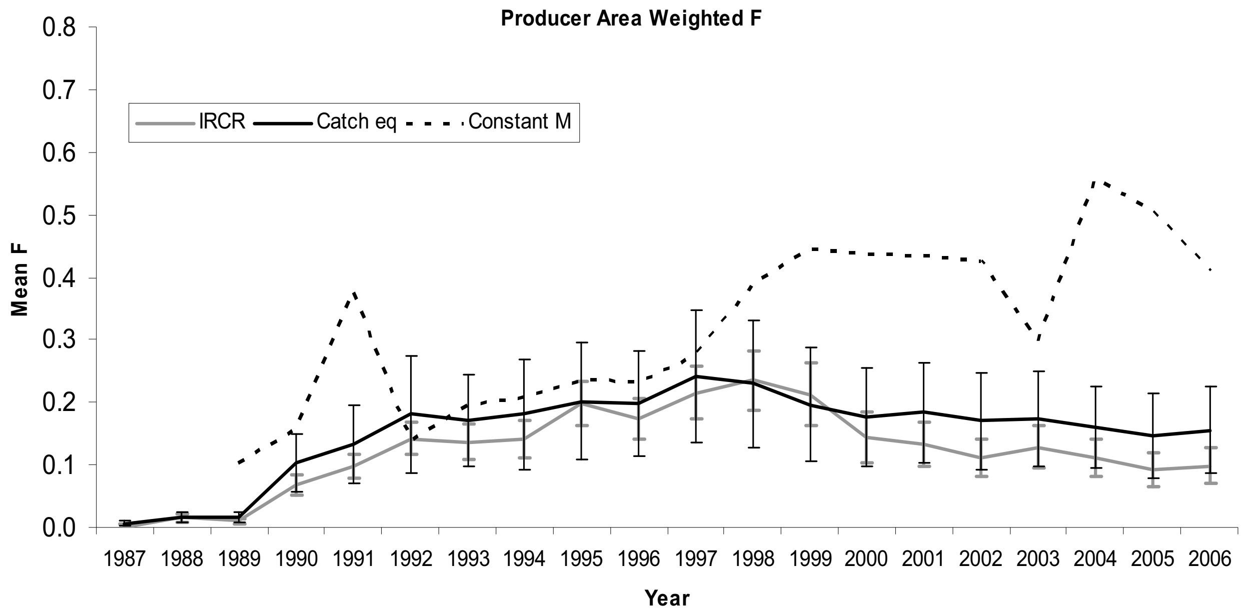




Figure A9.6. Comparison of coast program and producer area mean fishing mortality estimates from the IRCR model to the current and previous methods, for fish > 28 inches. 95% confidence intervals are shown for the catch equation and IRCR methods.



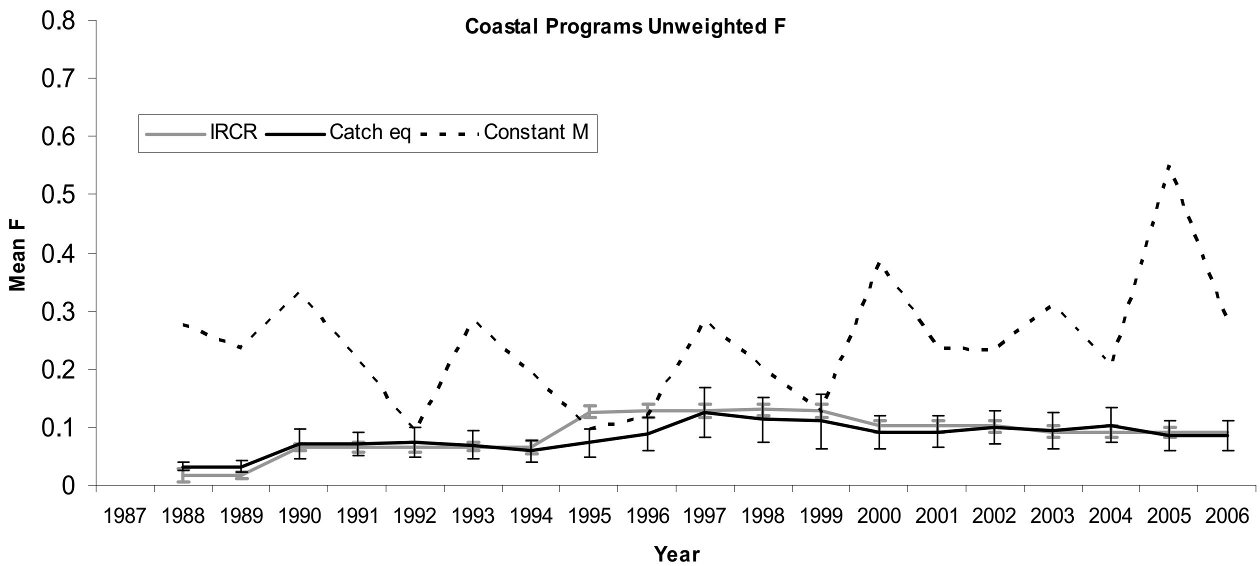
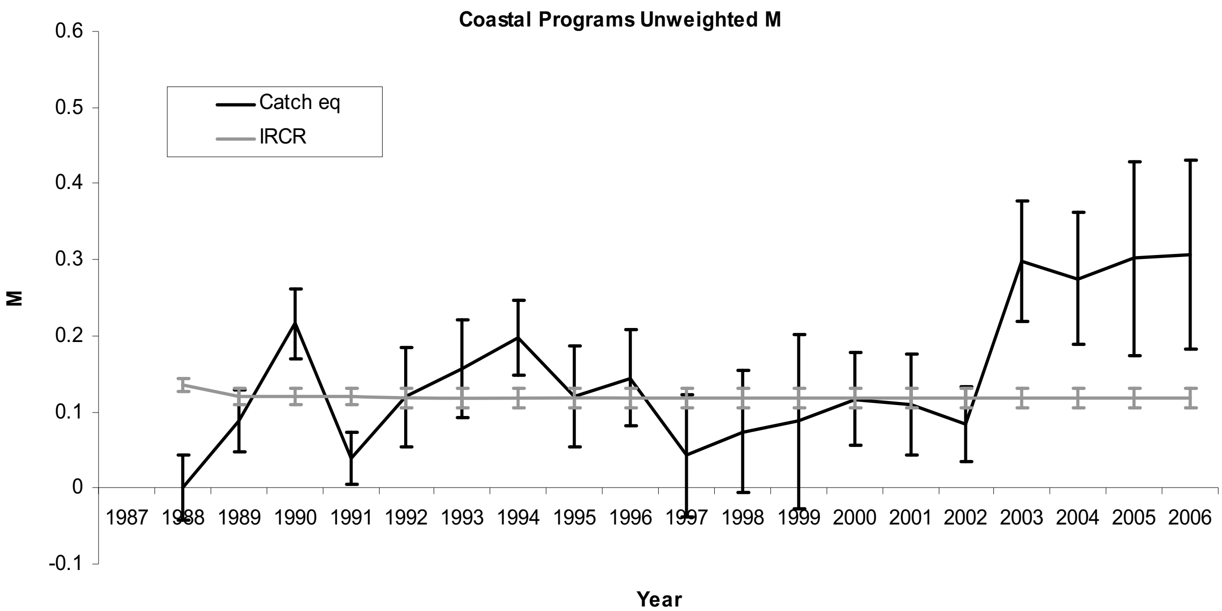




Figure A9.7. Comparison of coast program and producer area mean fishing mortality estimates from the IRCR model to the current and previous methods, for fish > 18 inches. 95% confidence intervals are shown for the catch equation and IRCR methods.



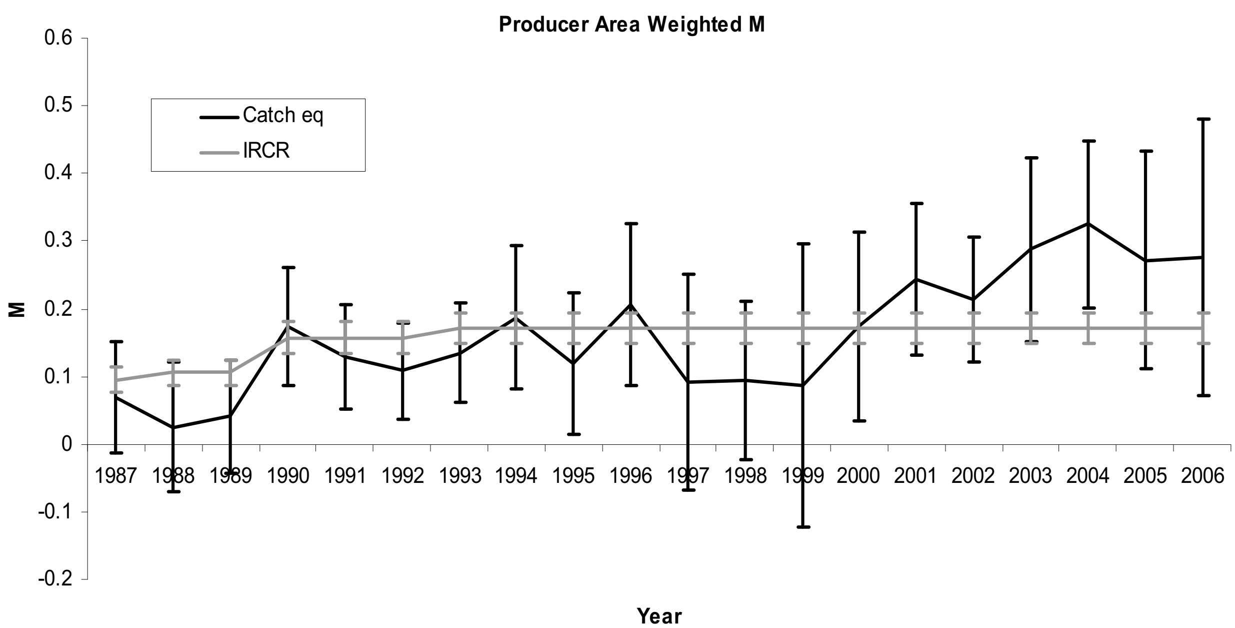
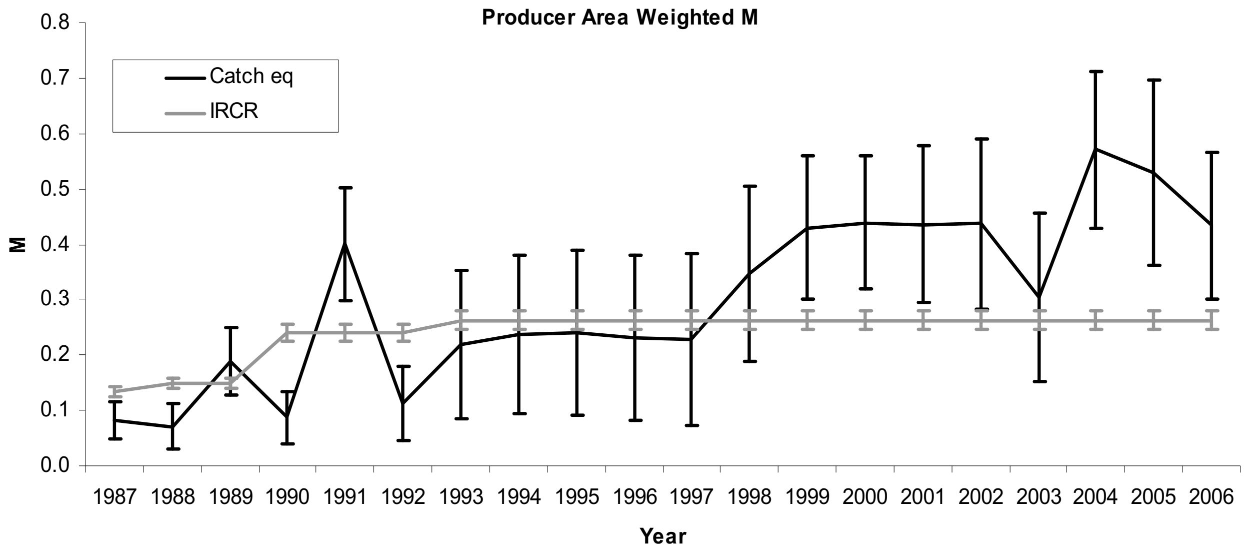




Figure A9.8. Comparison of coast program and producer area mean natural mortality estimates from the IRCR model the catch equation method, for fish > 28 inches. 95% confidence intervals are shown for both methods.



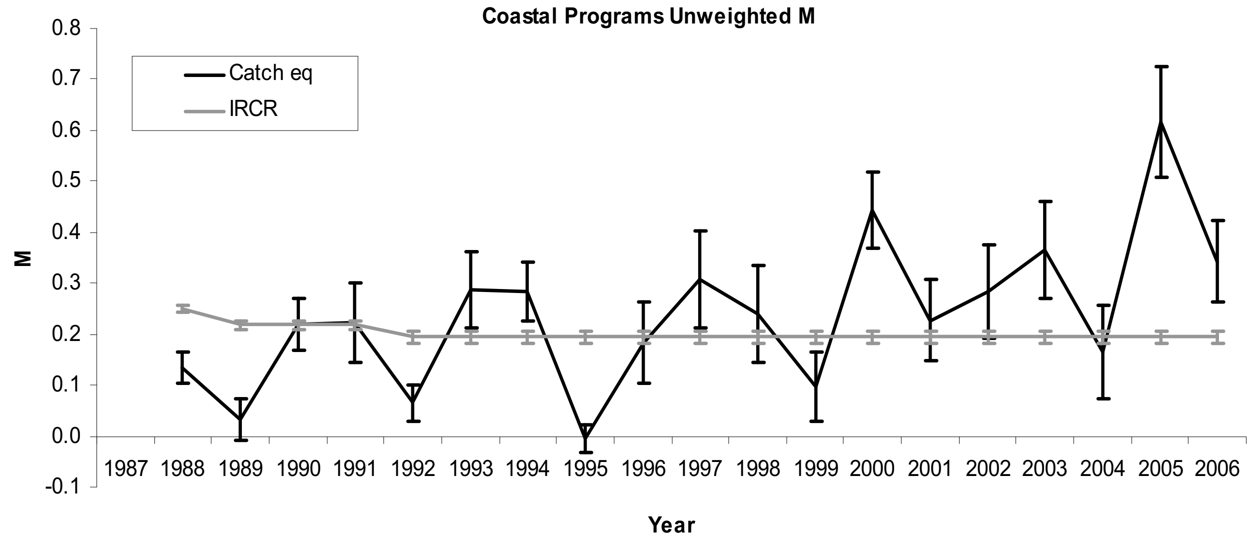
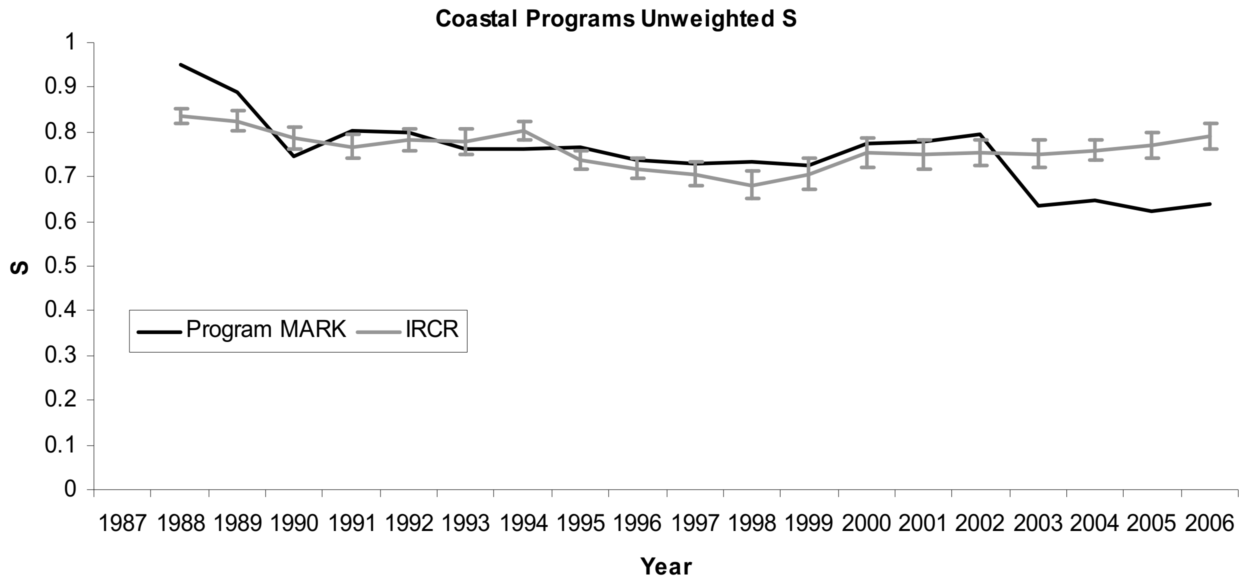




Figure A9.9. Comparison of coast program and producer area mean natural mortality estimates from the IRCR model and the catch equation method, for fish > 18 inches. 95% confidence intervals are shown for both methods.



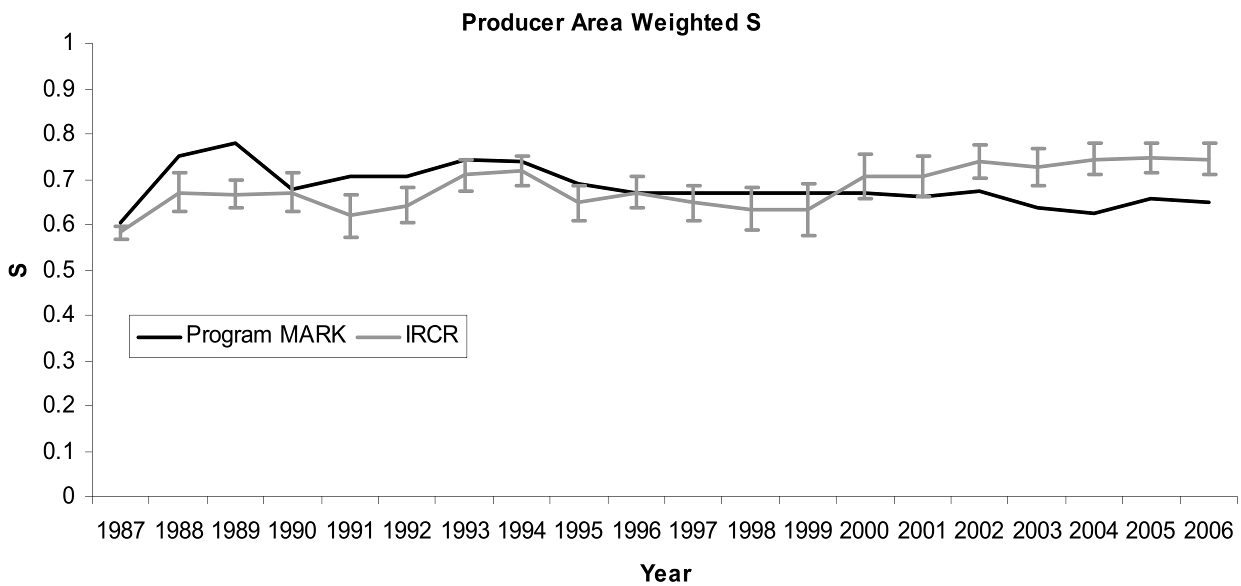
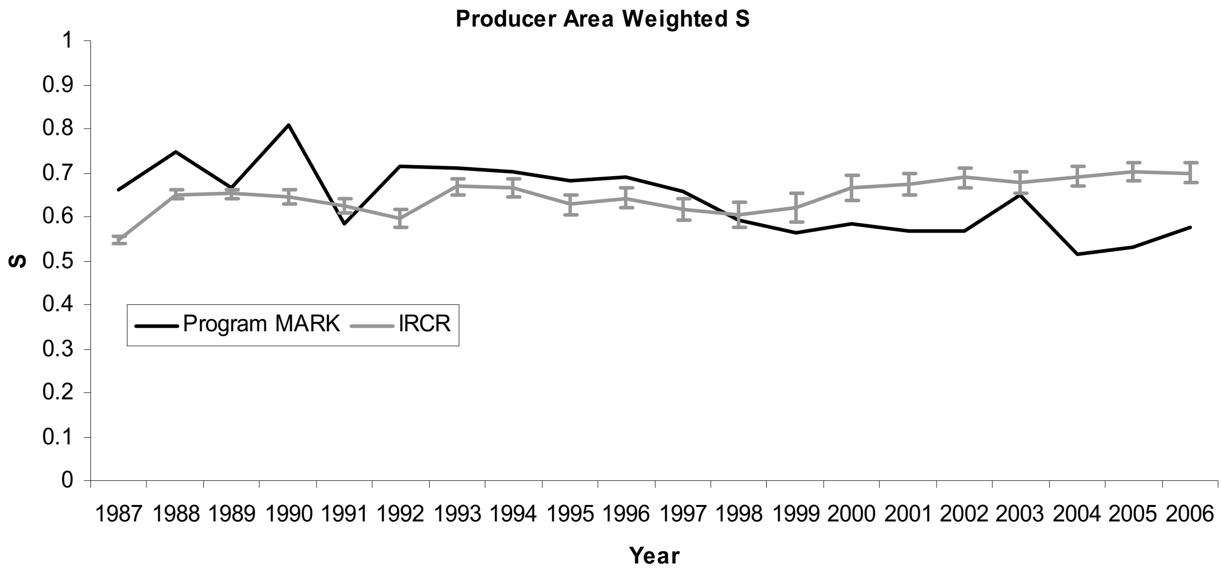




Figure A9.10. Comparison of coast program and producer area mean survival estimates from the IRCR model and Program MARK, for fish > 28 inches. 95% confidence intervals are shown for the IRCR model.



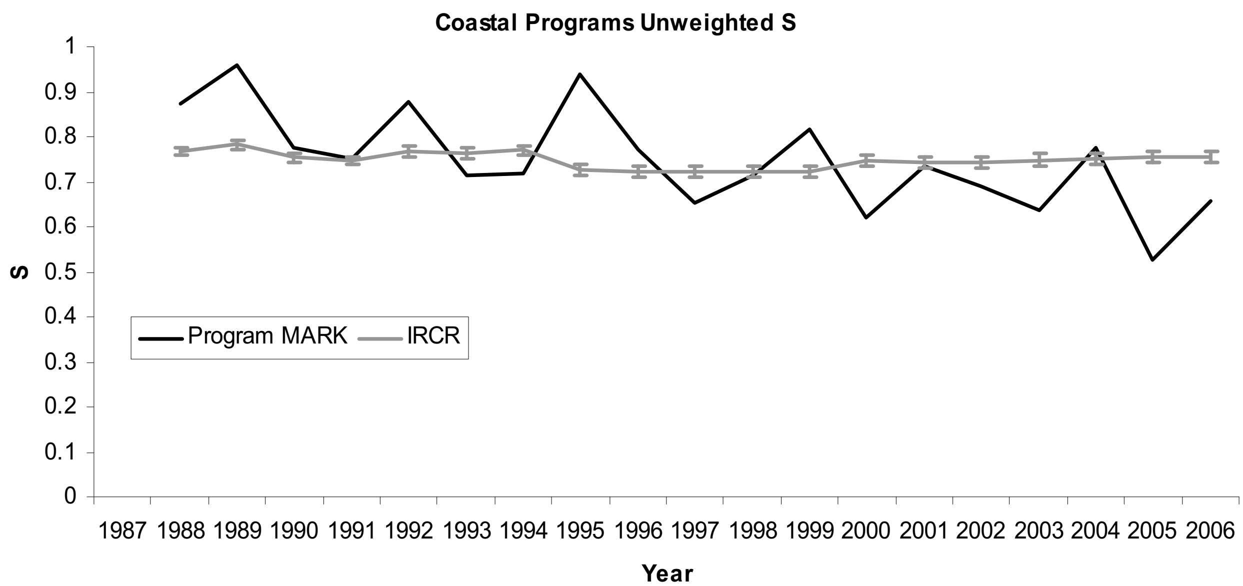




Figure A9.11. Comparison of coast program and producer area mean survival estimates from the IRCR model and Program MARK, for fish > 18 inches. 95% confidence intervals are shown for the IRCR model.

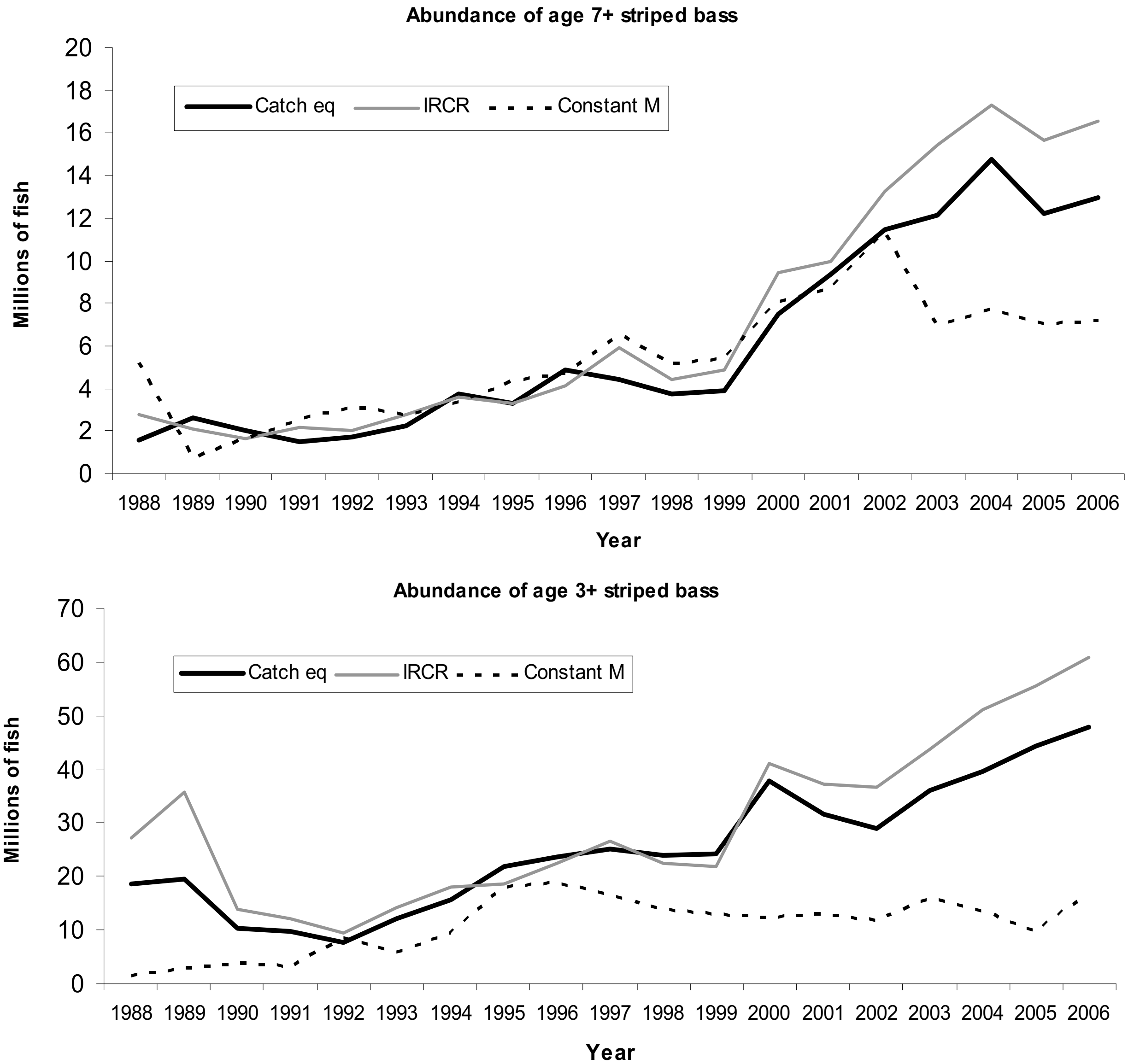



Figure A9.12. Stock size estimates generated from the IRCR model compared to the catch equation method, for fish age seven and older (comparable to fish > 28 inches) and fish age three and older (comparable to fish > 18 inches). Stock size obtained via "Kill (in numbers of fish) = F * Stock Size".

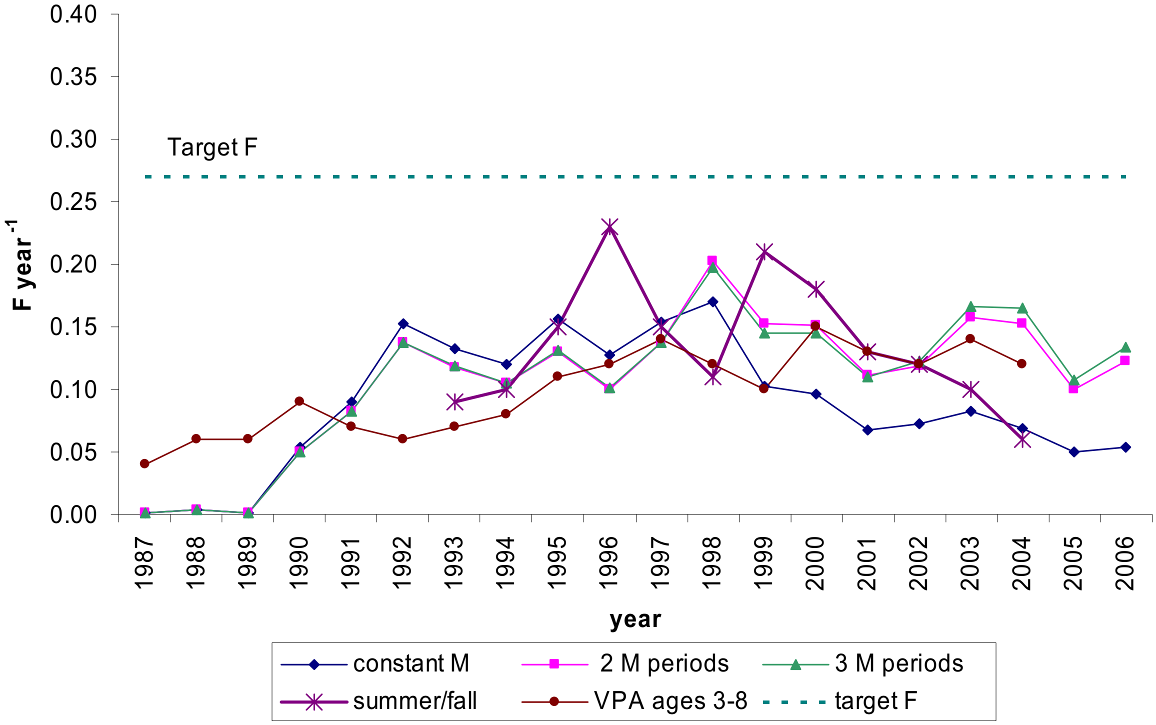



Figure A9.13. Comparison of fishing mortality estimates for MD data set from instantaneous rates model assuming constant M, two periods of M and three periods of M, with F estimates from bay-wide summer fall tagging study and coastwide VPA weighted by number F for ages 3-8.

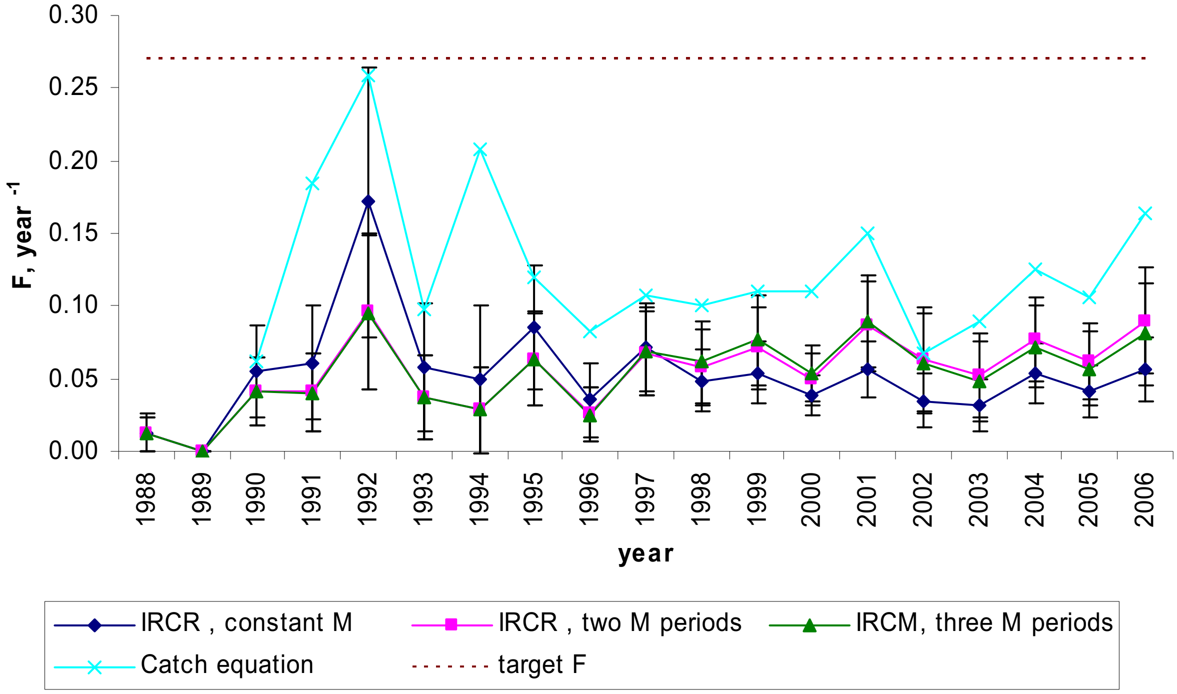



Figure A9.14. Fishing mortality estimates for VA data set from instantaneous rates model, summer fall tagging study and VPA weighted by number fishing mortality for ages 3-8.

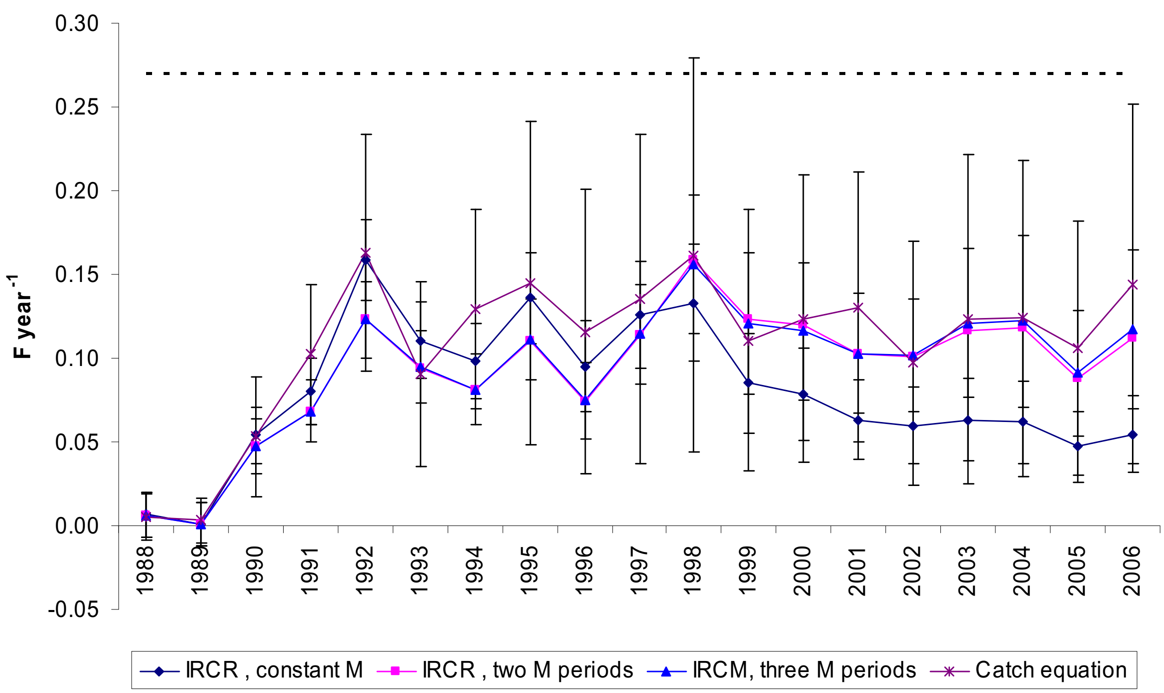



Figure A9.15. Comparison of bay-wide fishing mortality estimates from catch equation model and instantaneous rates model assuming constant M, two and three periods of M.

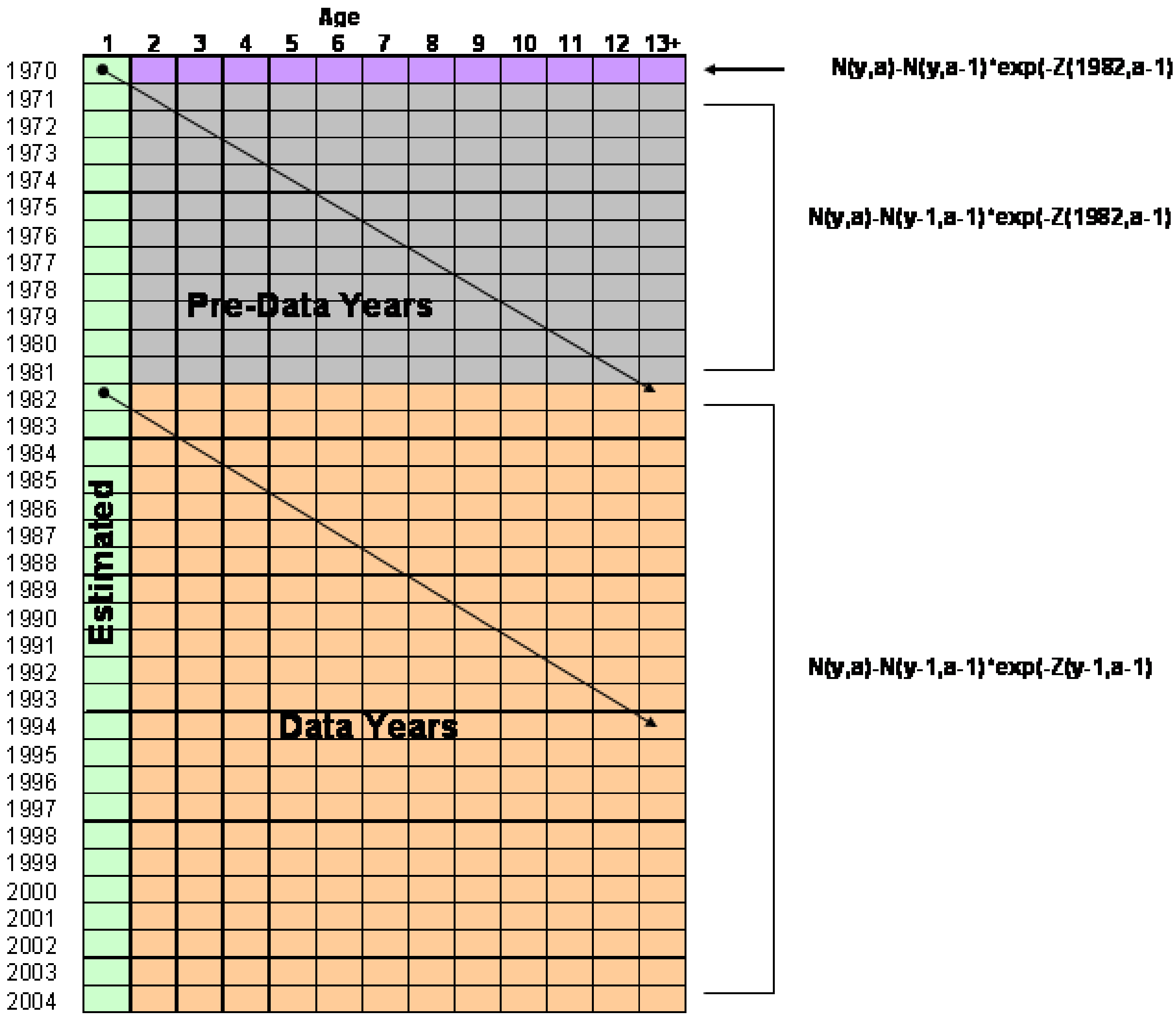



Figure A10.1. Schematic of population abundance-at-age

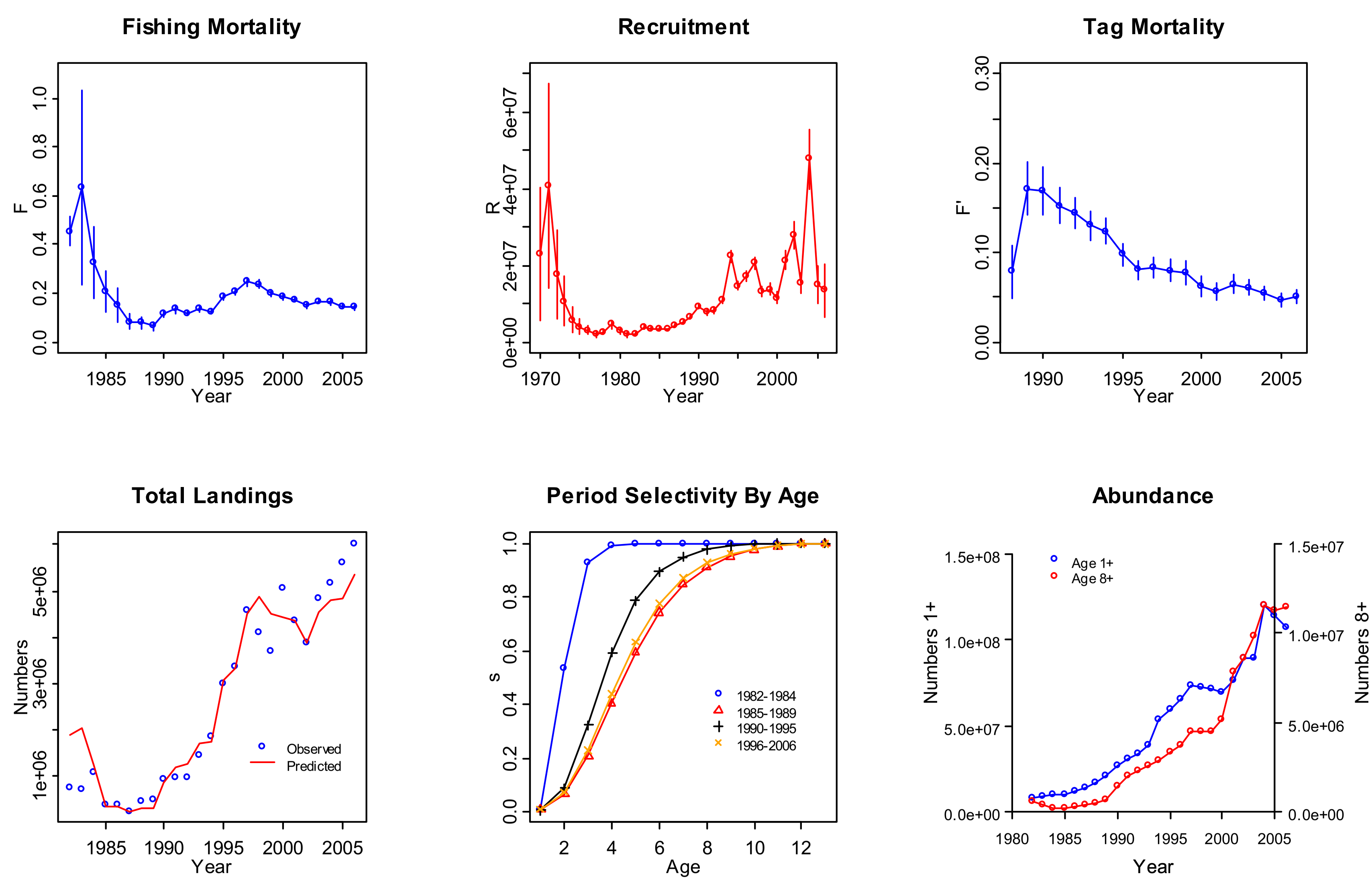



Figure A10.2. Estimates of fishing mortality (±95%CI), recruitment (±95%CI), fishing mortality on the tags, total landings, period selectivity patterns, and abundance of ages 1+ and 8+ from the SCATAG model run with equal weighting across all components.

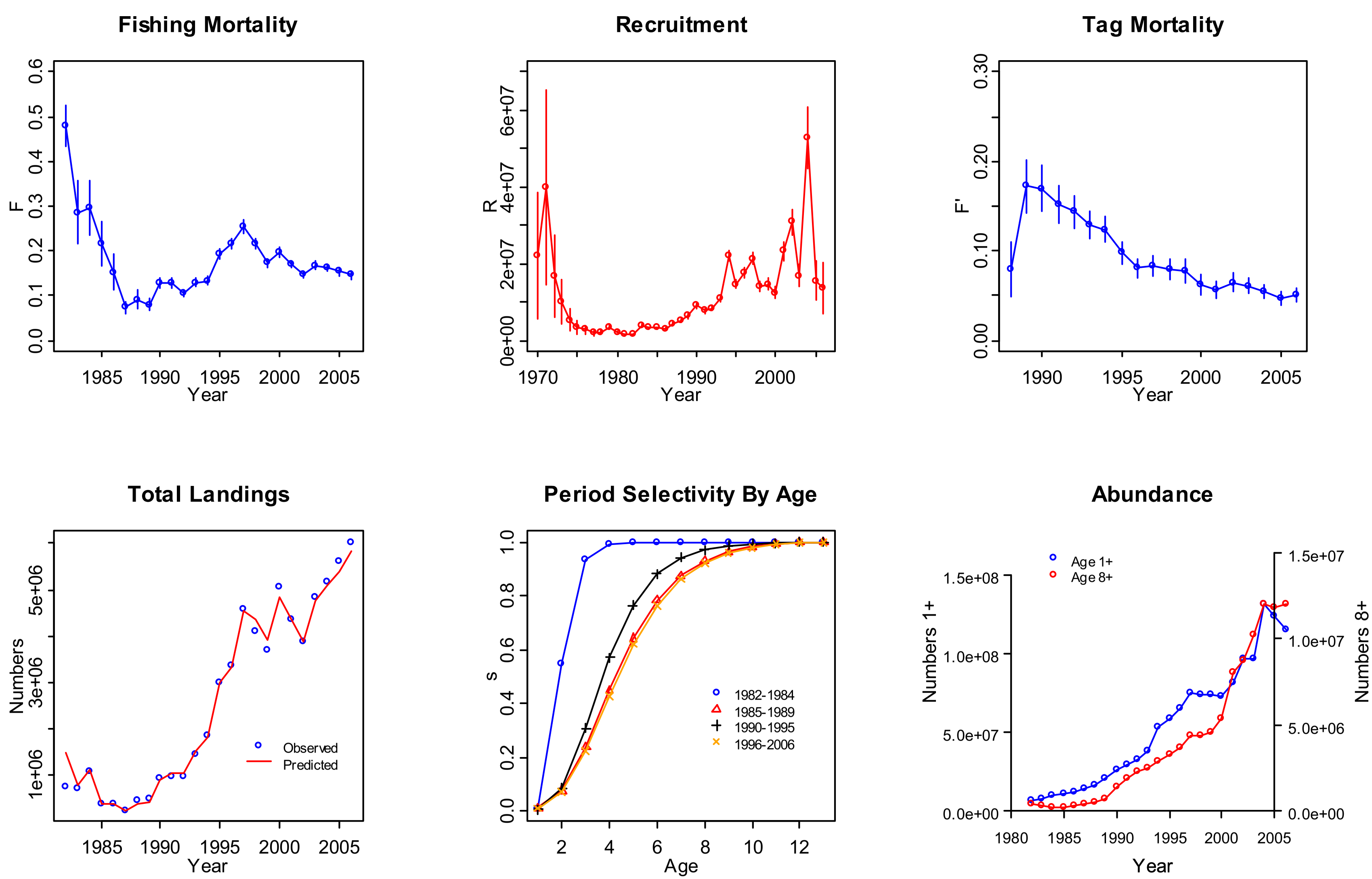



Figure A10.3. Estimates of fishing mortality (±95%CI), recruitment (±95%CI), total landings, period selectivity patterns, and abundance of ages 1+ and 8+ from SCATAG model run with total catch lambda =50.

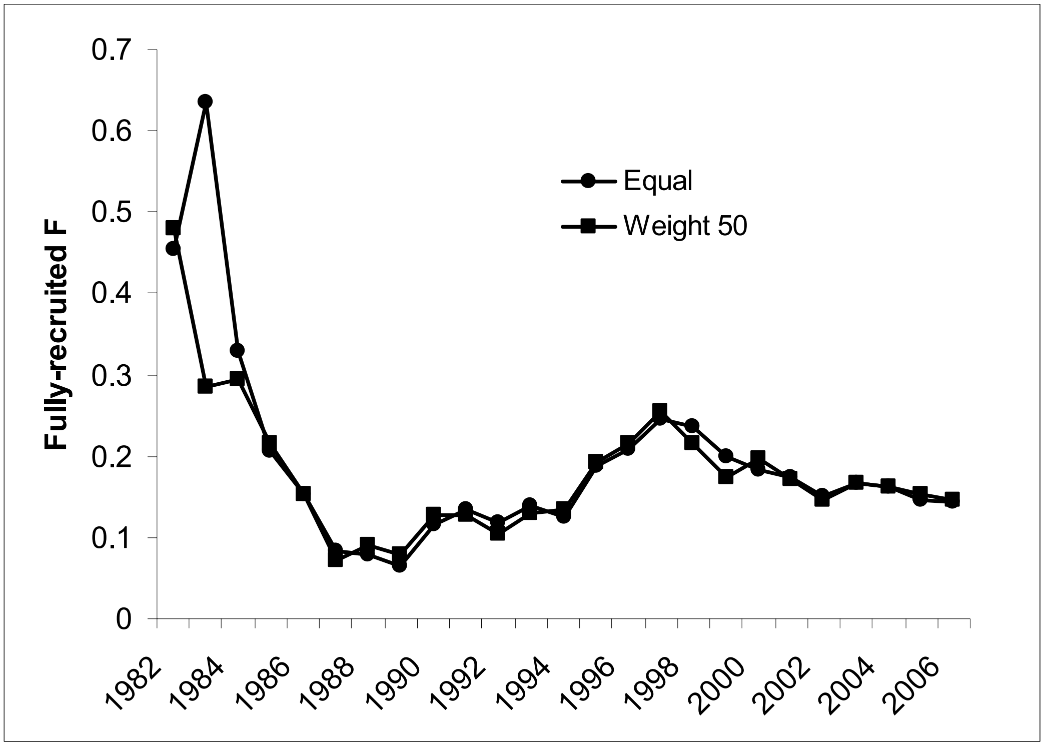



Figure A10.4. Comparison of fully-recruited fishing mortality estimates from the SCATAG model runs with equal weighting across all components and with total catch weight =50.

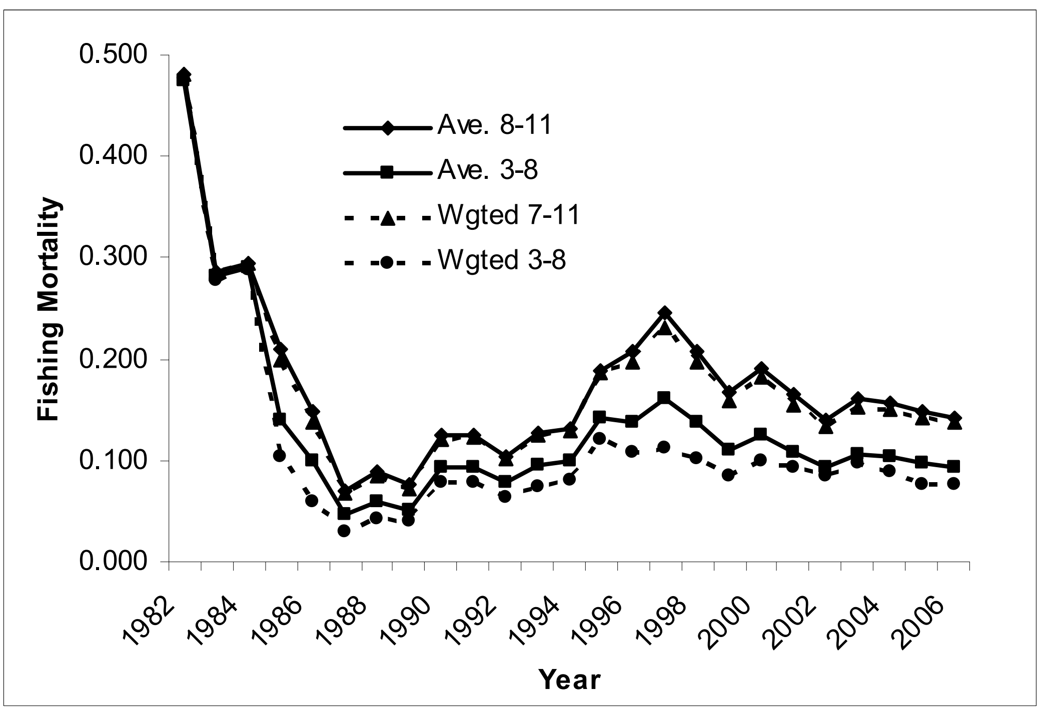



Figure A10.5. Estimates of average and abundance weighted fishing mortality from the SCATAG model under the total catch weight lambda=50.

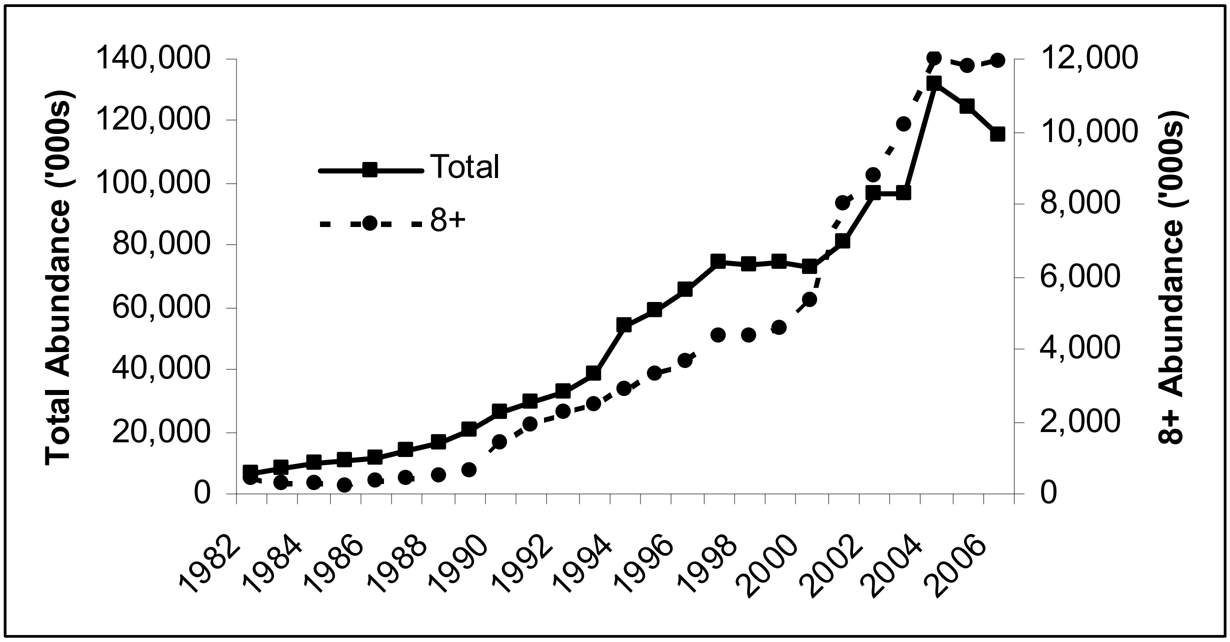



Figure A10.6. Estimates of total and 8+ abundance from the SCATAG model.

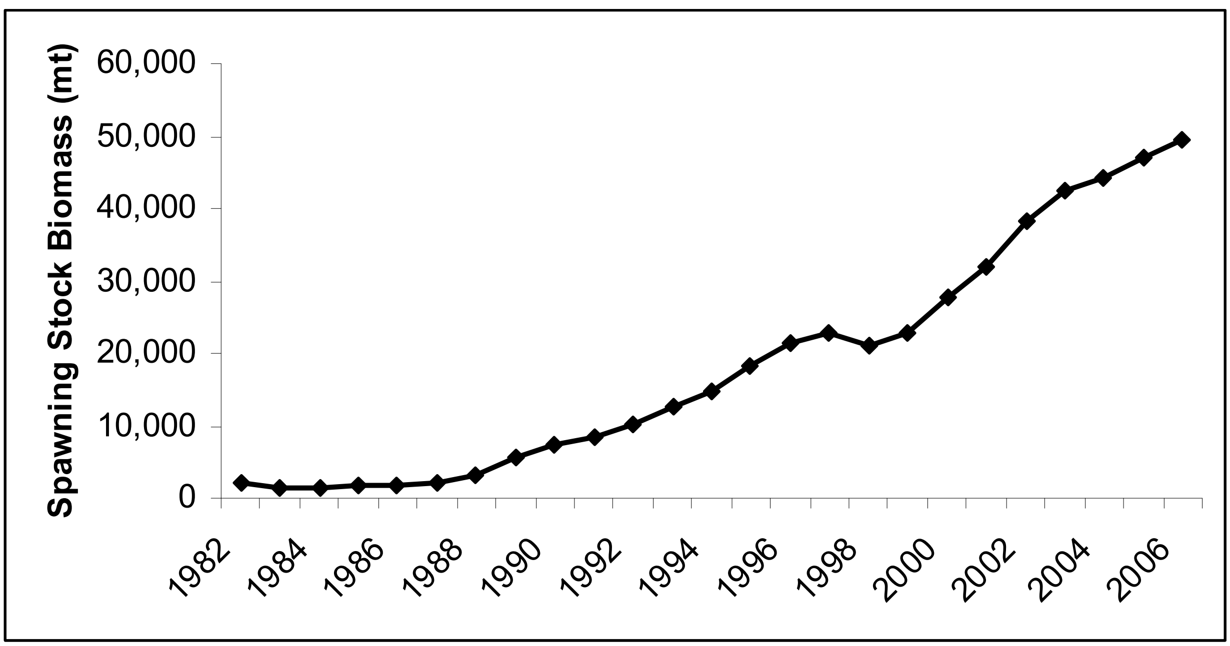
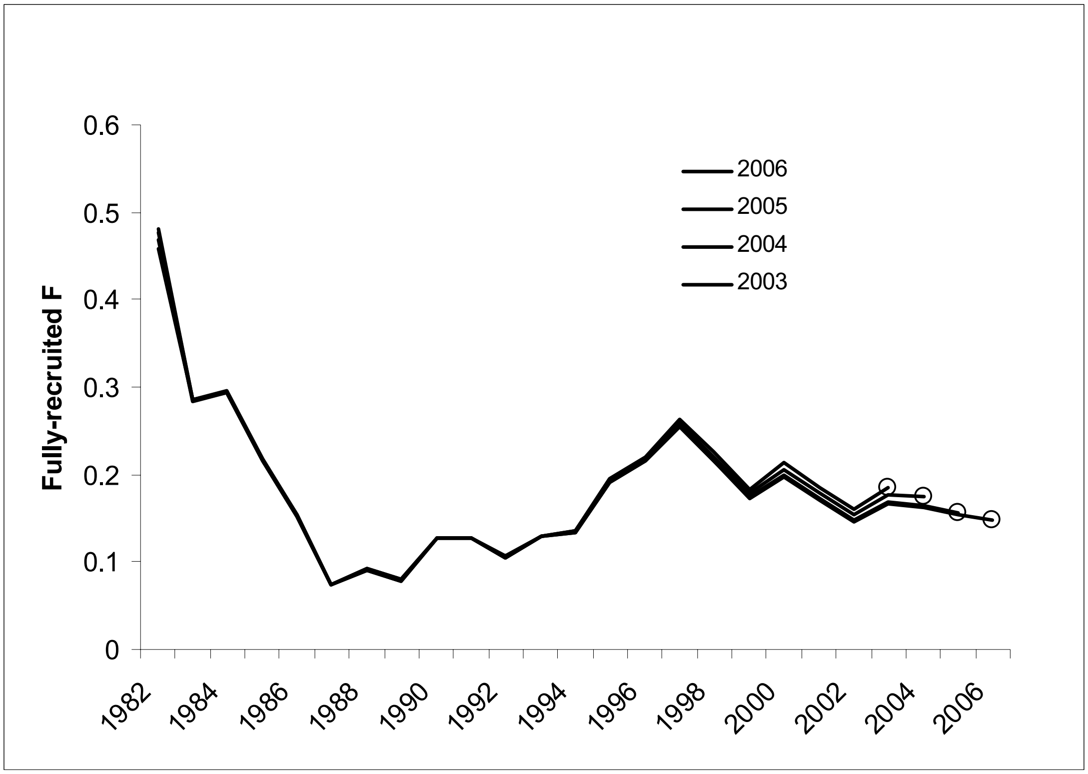



Figure A10.7. Estimates of female spawning stock biomass from the SCATAG model.



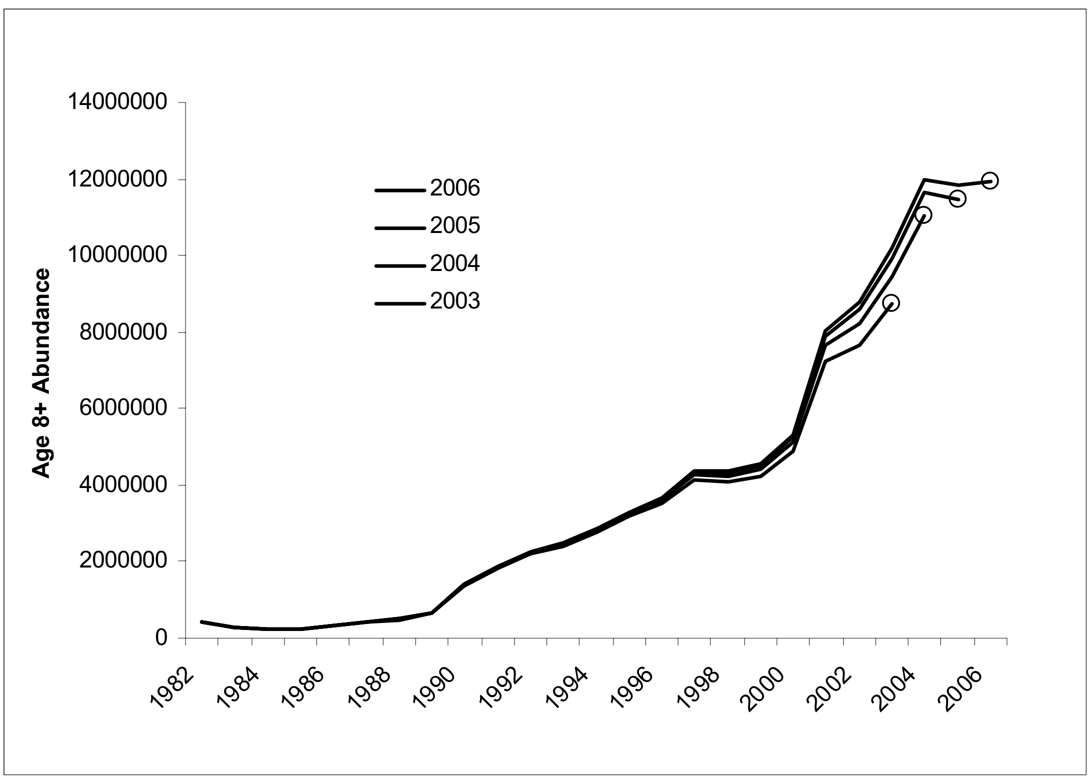




Figure A10.8. Retrospective analysis of fully-recruited fishing mortality and 8+ abundance from the SCATAG model.

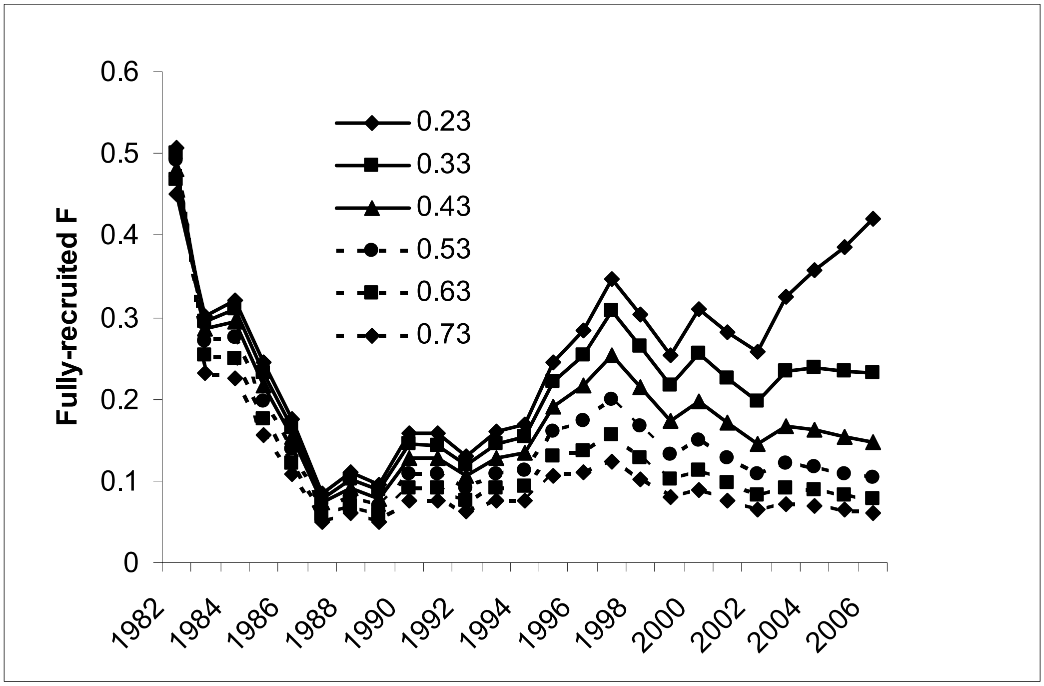



Figure A10.9. Effects of varying reporting rate on the estimates of fishing mortality from the SCATAG model.

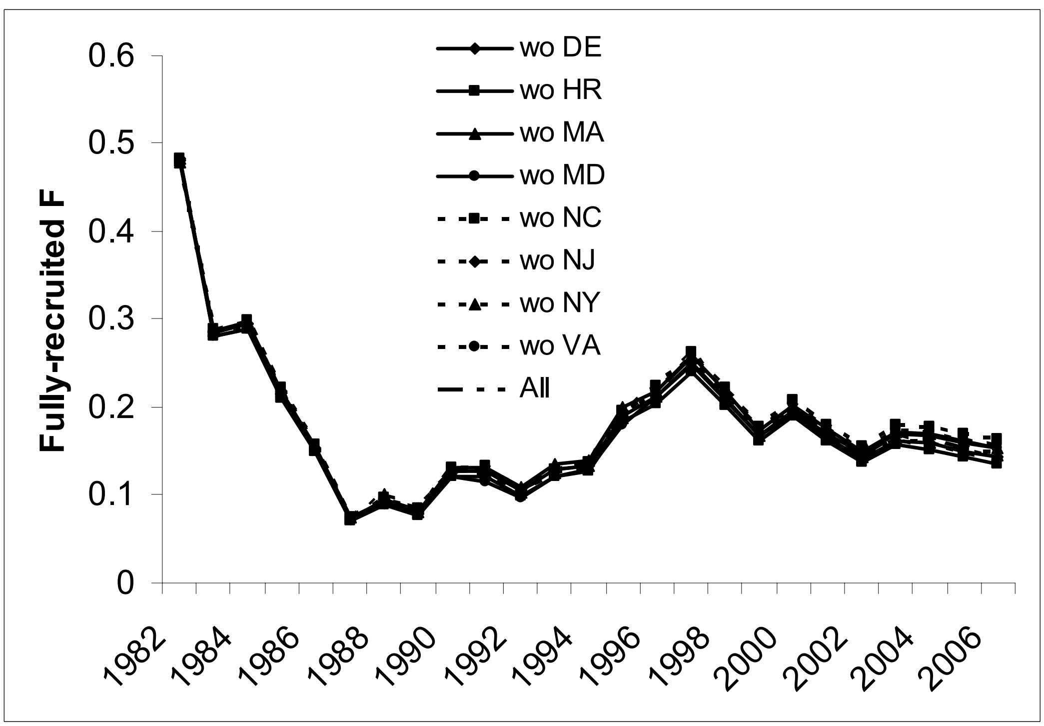



Figure A10.10. Estimates of fishing mortality when data from each tagging program are deleted from the SCATAG model.

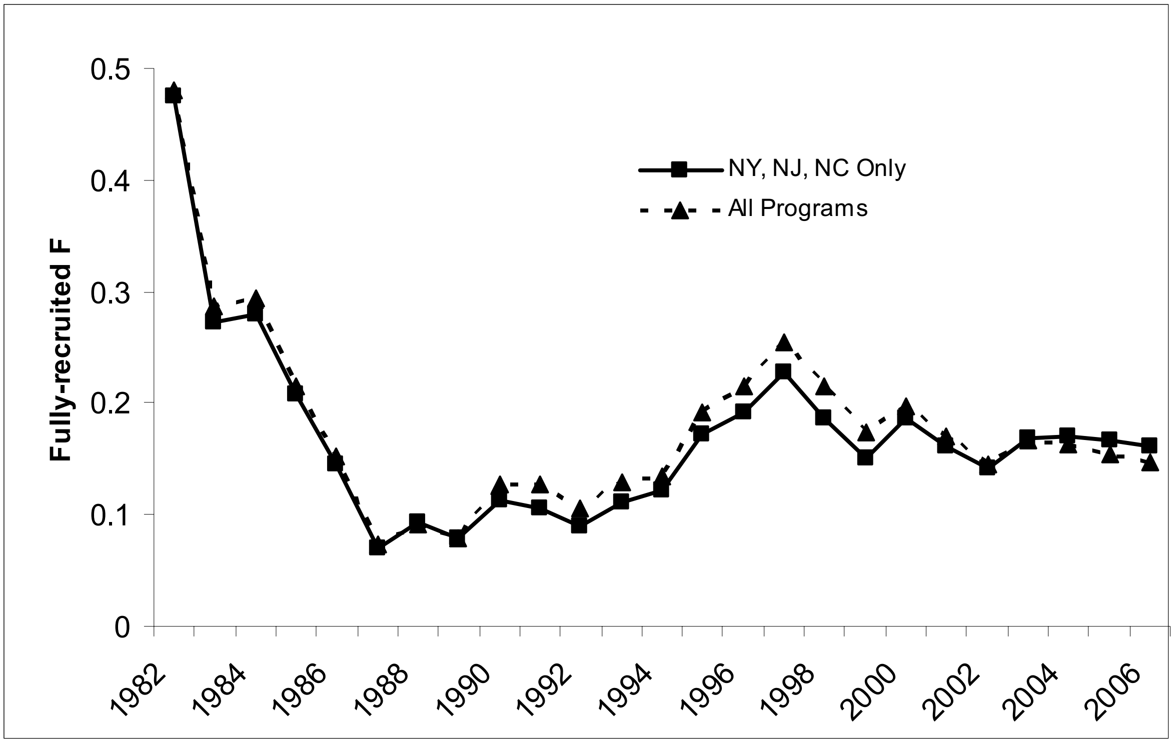



Figure A10.11. Comparison of estimates of fully-recruited fishing mortality from the SCATAG model with all programs and when only data from NYOHS, NJ, and NC COOP were used.

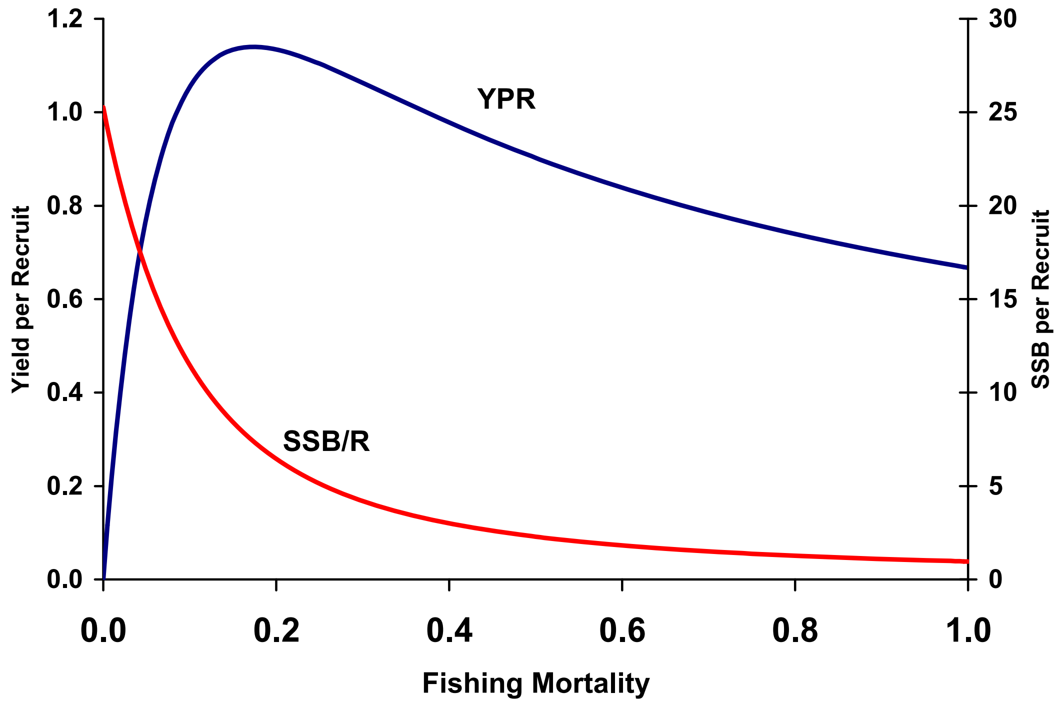



Figure A11.1. Thompson-Bell yield per recruit model for Atlantic striped bass fitted with a natural mortality equal to 0.15 and a maximum age of 25.

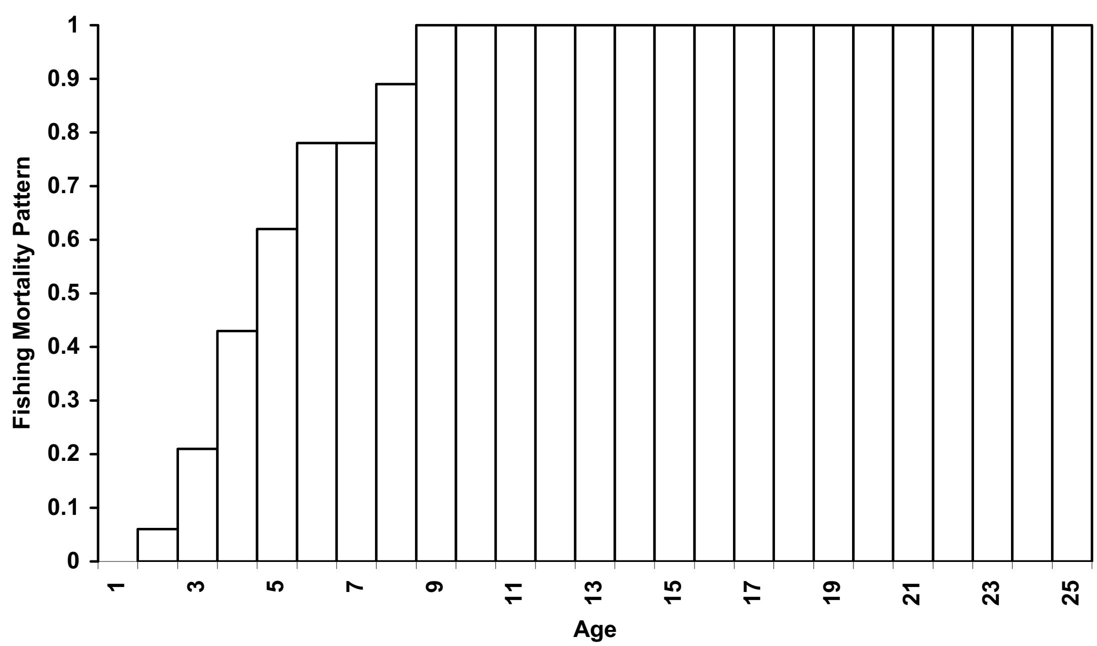



Figure A11.2. Age specific partial recruitments for Atlantic striped bass assuming a 50:50 sex ratio.

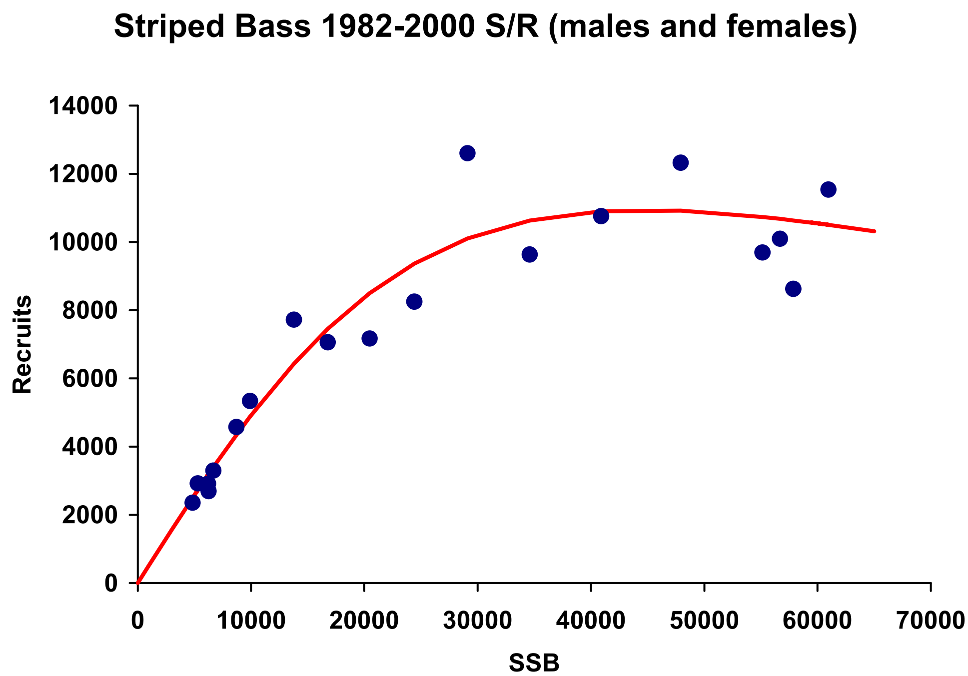



Figure A11.3. Shepherd stock-recruitment curve for Atlantic striped bass using data from the years 1982-1999

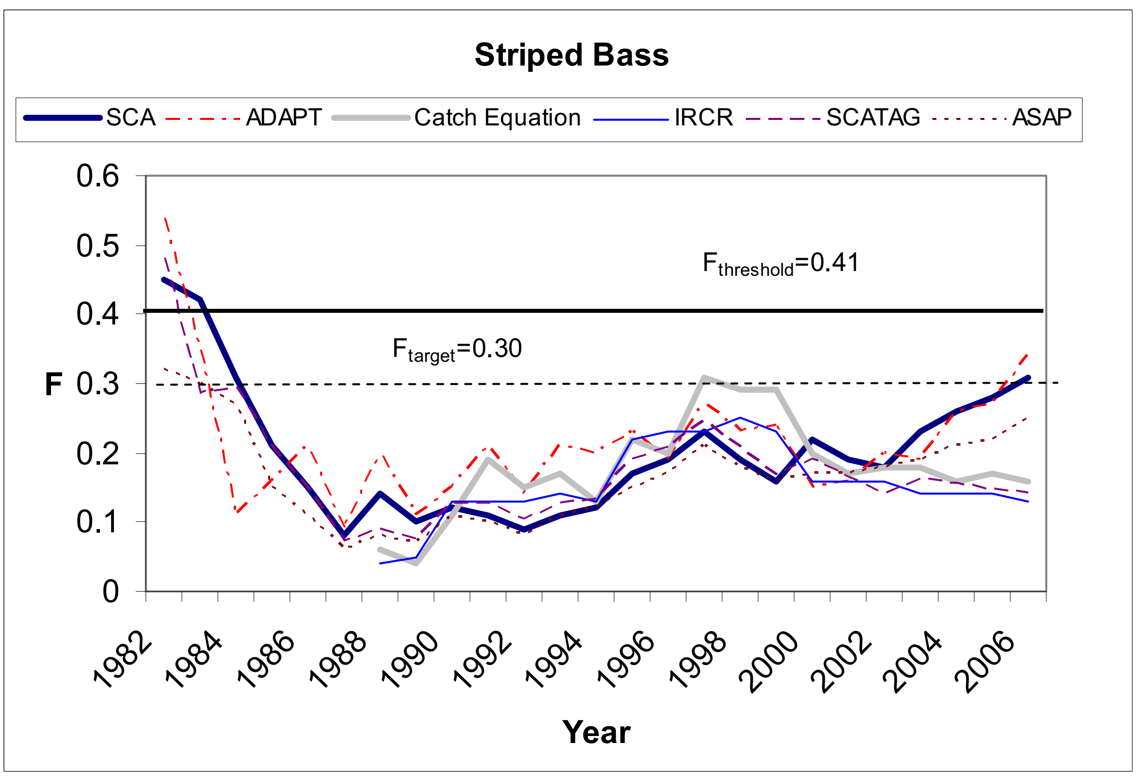



Figure A11.4. Estimates of instantaneous fishing mortality (F) from Catch Equation method, SCA, and supporting models

Northeast Fisheries Science Center Reference Document 08-03b

*A Report of the 46th Northeast Regional Stock Assessment Workshop*

# 46th Northeast Regional Stock Assessment Workshop (46th SAW)

# Part B. Assessment Report Appendixes

**U.S. DEPARTMENT OF COMMERCE**
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

February 2008

# Northeast Fisheries Science Center Reference Documents

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***EDITOR'S NOTE: This report contains appendixes to the striped bass assessment report at the front of this volume (Northeast Fisheries Science Center Reference Document [CRD] 08-03a.***

## Appendix A1: Documentation of Mixed Stock Status and GIS Mapping

DATE: 10/22/2007

TO: ASMFC Striped Bass Technical Committee

FROM: Wilson Laney, USFWS South Atlantic Fisheries Coordination Office

RE: Cooperative Winter Tagging Cruise Maps

Numerous past tagging studies have documented the fact that migratory striped bass wintering off the coasts of North Carolina and Virginia originate from stocks spawning from North Carolina north (Boreman and Lewis 1987, North Carolina Striped Bass Study Management Board 1991). As a part of the current stock assessment, the ASMFC Striped Bass Tagging Subcommittee was requested to analyze the 20-year time series of striped bass tag and recapture data from the Cooperative Winter Tagging Cruise (Cruises) conducted annually from 1988-2007 by the U.S. Fish and Wildlife Service and partners (see Welsh and others 2007, and Laney and others 2007a for descriptions of study area and methods) and prepare GIS-based maps of the distribution of released, tagged fish, and subsequent recaptures.

Raw data from the Cruises from the Maryland Department of Natural Resources-Fisheries Service database, and recapture data from the U.S. Fish and Wildlife Service coastwide striped bass tagging database, were reformatted as needed and analyzed using GIS (ArcGIS). Although maps were generated for every Cruise year (Laney and others 2007b), for the sake of brevity we have presented only those for the initial cruise year (1988) and every fifth year thereafter (1993, 1998, and 2003). Three maps for each year depict the distribution of striped bass captured, tagged, and released on the winter grounds; the distribution within the following year of all recaptures from a given Cruise; and the distribution of 28 inch or greater recaptures from a given Cruise for only the months March-April-May following the Cruise (see Figures 1-12). The latter two map types plot recaptures as the centroid of the NOAA grid cell in which the fish were recaptured, since exact locality data for most recaptures is lacking.

The resultant maps (and associated data) clearly indicate, especially when viewing spring recaptures only, that the migratory striped bass wintering off NC and VA are from multiple stocks, including the Albemarle-Roanoke, Chesapeake Bay, Delaware and Hudson, at a minimum. Results of this analysis confirm those of prior studies (Boreman and Lewis 1987, Welsh and others 2007).

**References**

Boreman J, Lewis RR. 1987. Atlantic coastal migration of striped bass. Am Fish Soc Symp 1:331-339.

Laney RW, Hightower JE, Versak BR, Mangold MF, Cole WW, Winslow SE. 2007a. Distribution, habitat use, and size of Atlantic sturgeon captured during Cooperative Winter Tagging Cruises, 1988-2006. Am Fish Soc Symp 56:167-182.

Laney RW, Newcomb DJ, Versak BR, McCrobie T, Welsh SA. 2007b. Documentation of Atlantic migratory striped bass stock mixing through tag returns. Report to the Atlantic States Marine Fisheries Commission, Striped Bass Stock Assessment Subcommittee, Striped Bass Tagging Subcommittee, Striped Bass Technical Committee and Striped Bass Management Board. U.S. Fish and Wildlife Service South Atlantic Fisheries Coordination Office, Raleigh, North Carolina. (In preparation)

North Carolina Striped Bass Study Management Board. 1991. Report on the Albemarle Sound-Roanoke River stock of striped bass. U.S. Fish and Wildlife Service, South Atlantic Fisheries Coordination Office, Morehead City, Raleigh, (NC). 56 p. + appendices.

Welsh SA, Smith DR, Laney RW, Tipton RC. 2007. Tag-based estimates of annual fishing mortality of a mixed Atlantic coastal stock of striped bass. Trans Am Fish Soc. 136:34-42.

**Appendix A1 Figures**

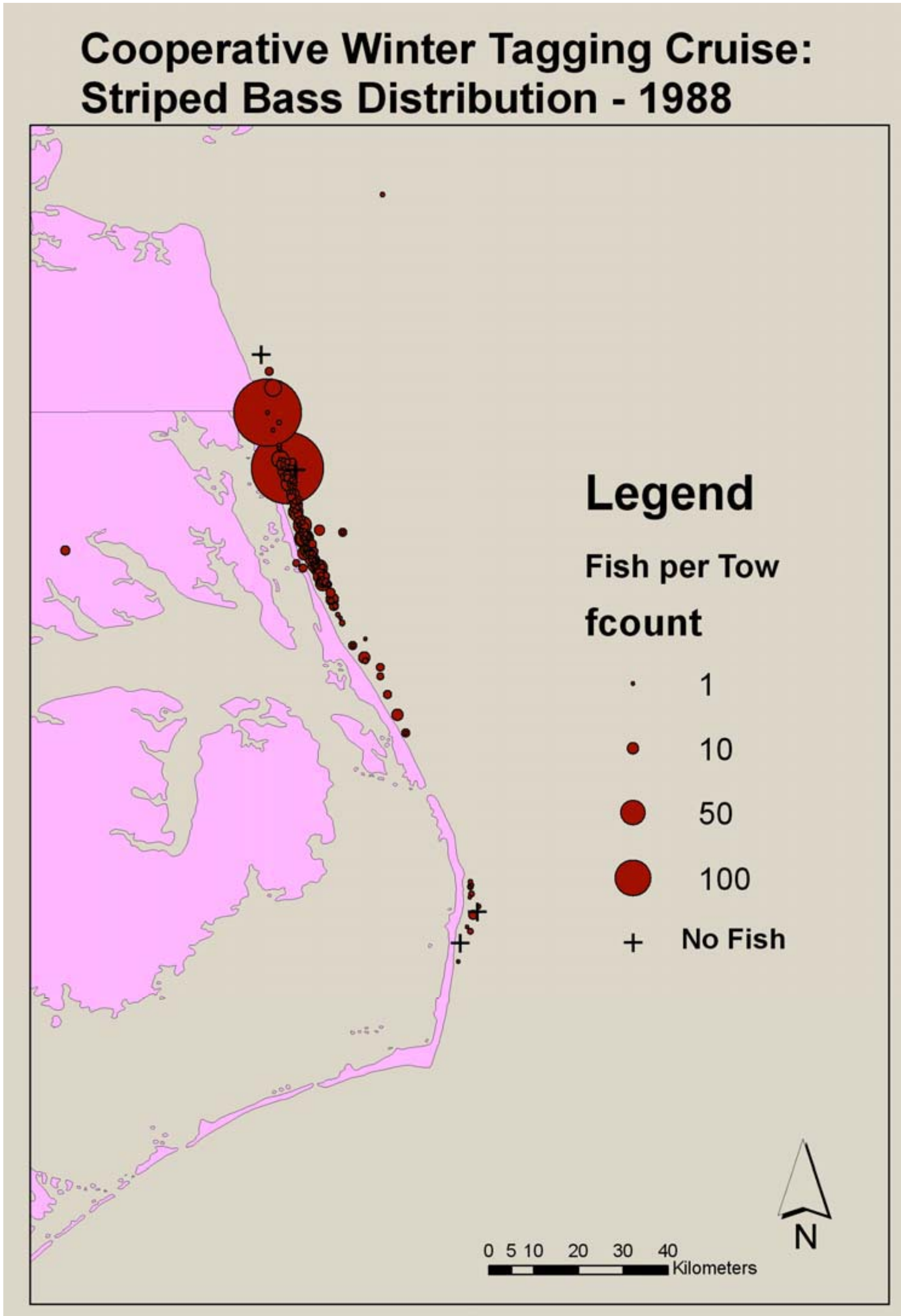


Figure 1. Distribution of striped bass captured on the wintering grounds during the 1988 Cooperative Winter Tagging Cruise

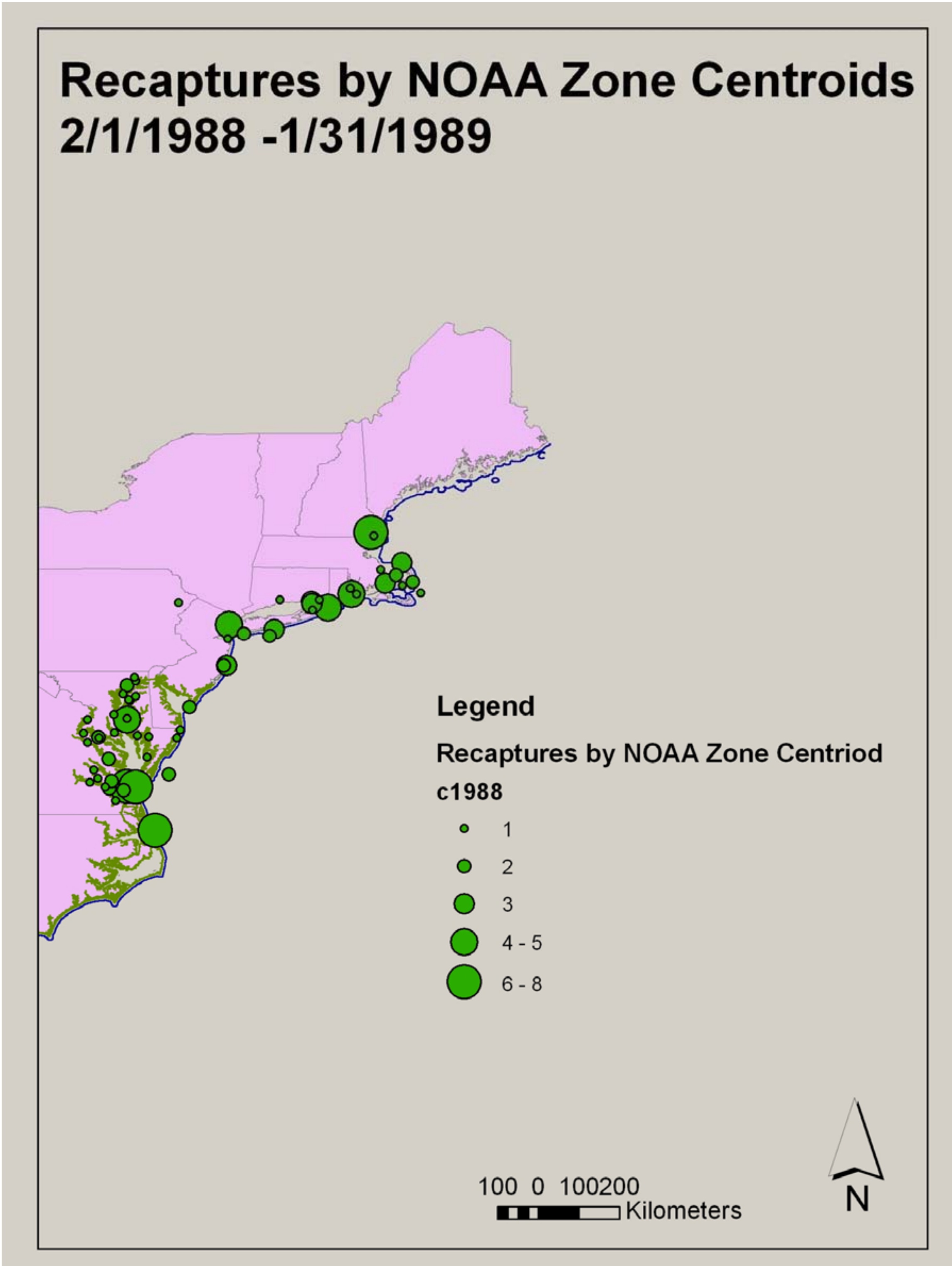


Figure 2. Distribution of all striped bass recaptures from 2/1/1988 – 1/31/1989 tagged during the 1988 Cooperative Winter Tagging Cruise

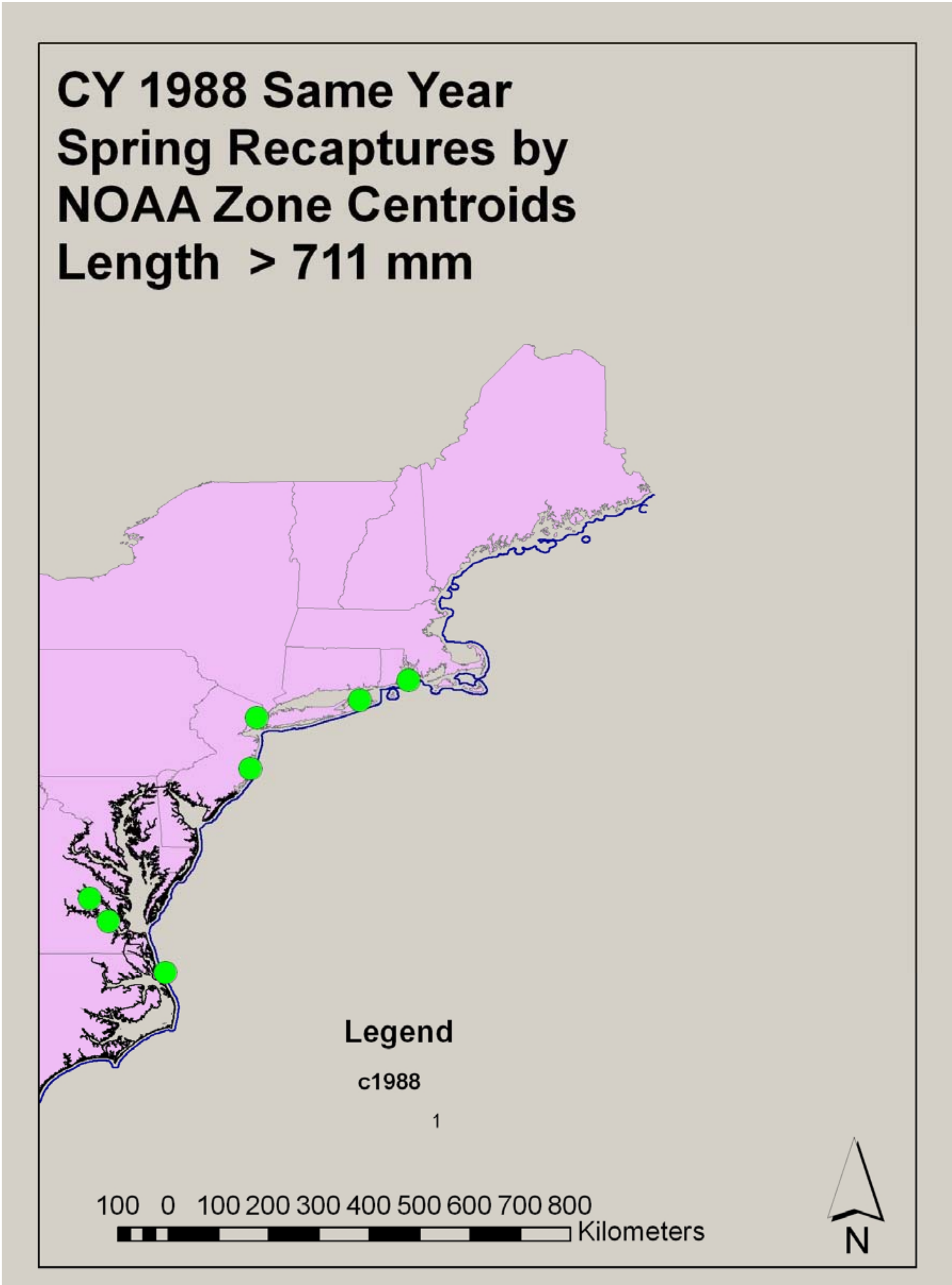


Figure 3. Distribution of 1988 spring recaptures of striped bass >711 mm and tagged during the 1988 Cooperative Winter Tagging Cruise

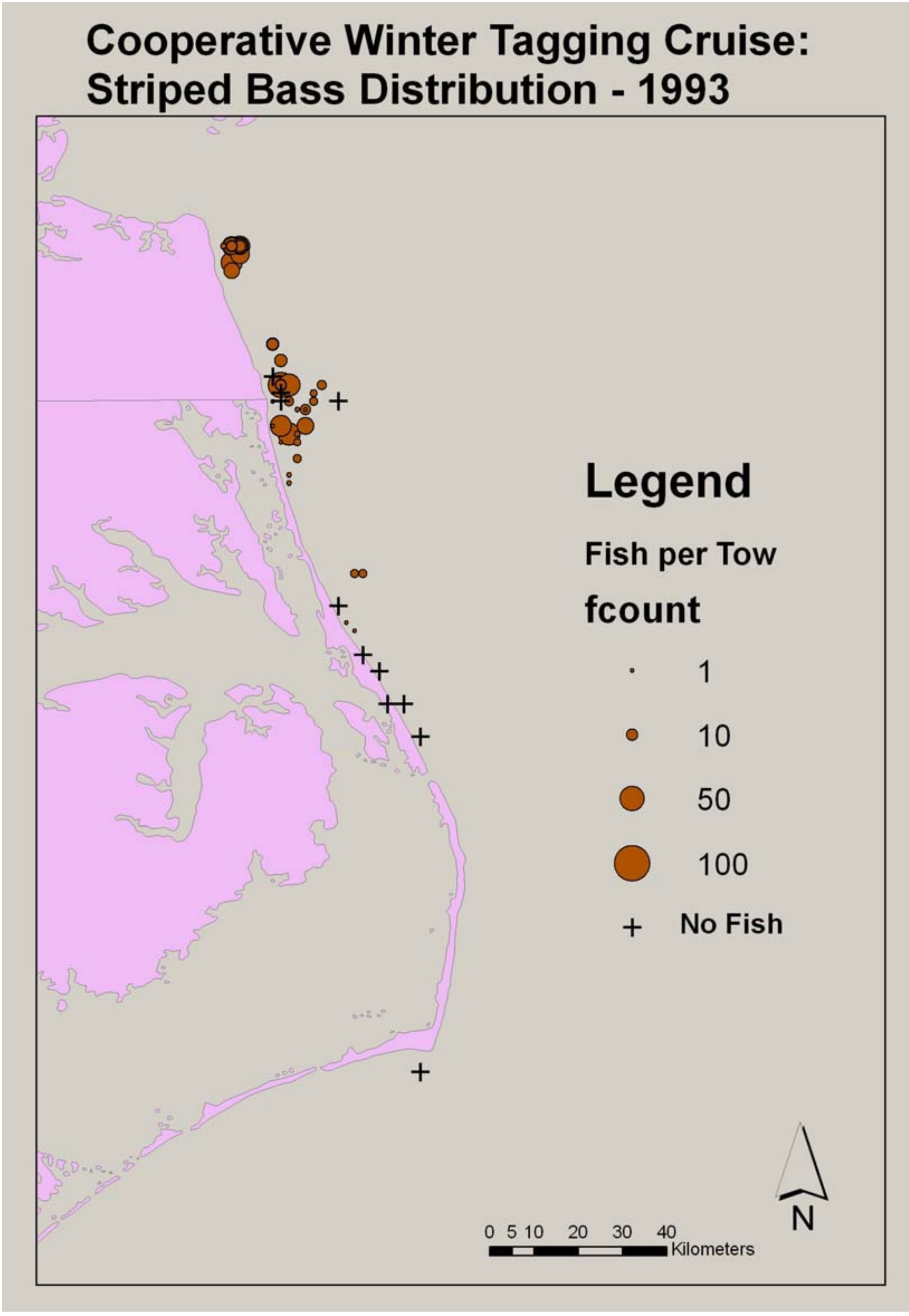


Figure 4. Distribution of striped bass captured on the wintering grounds during the 1993 Cooperative Winter Tagging Cruise

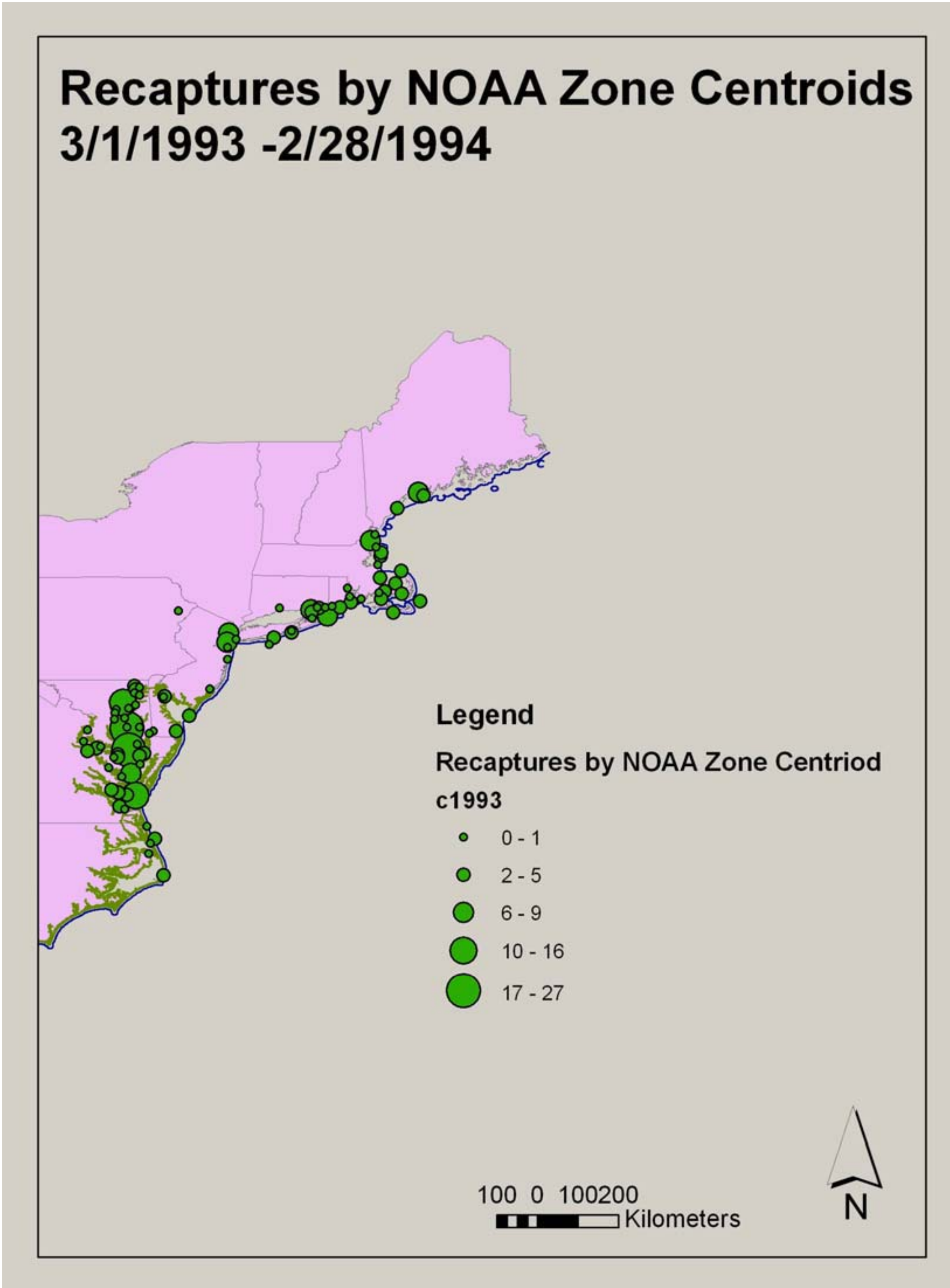


Figure 5. Distribution of all striped bass recaptures from 3/1/1993 – 2/28/1994 tagged during the 1993 Cooperative Winter Tagging Cruise

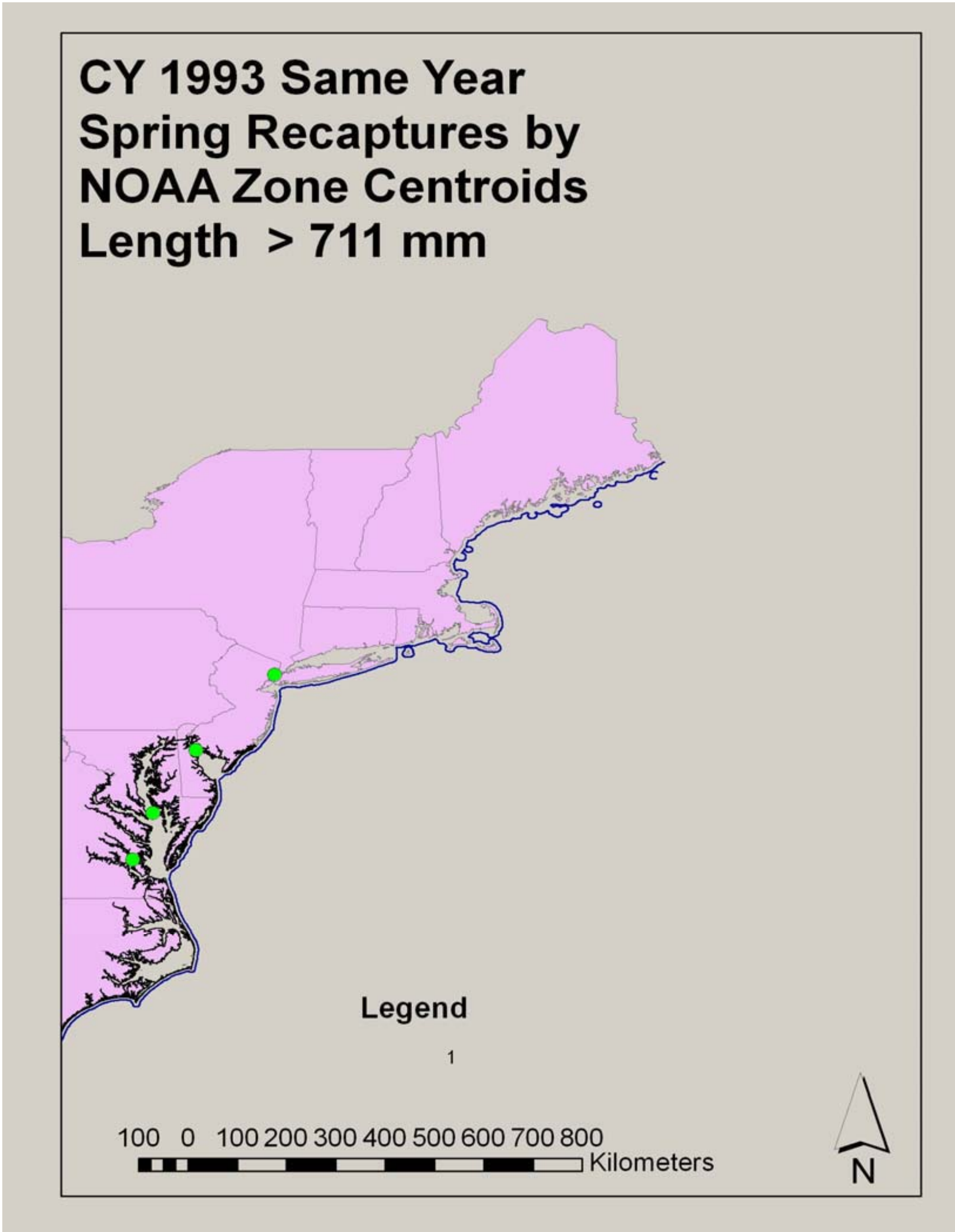


Figure 6. Distribution of 1993 spring recaptures of striped bass >711 mm and tagged during the 1993 Cooperative Winter Tagging Cruise

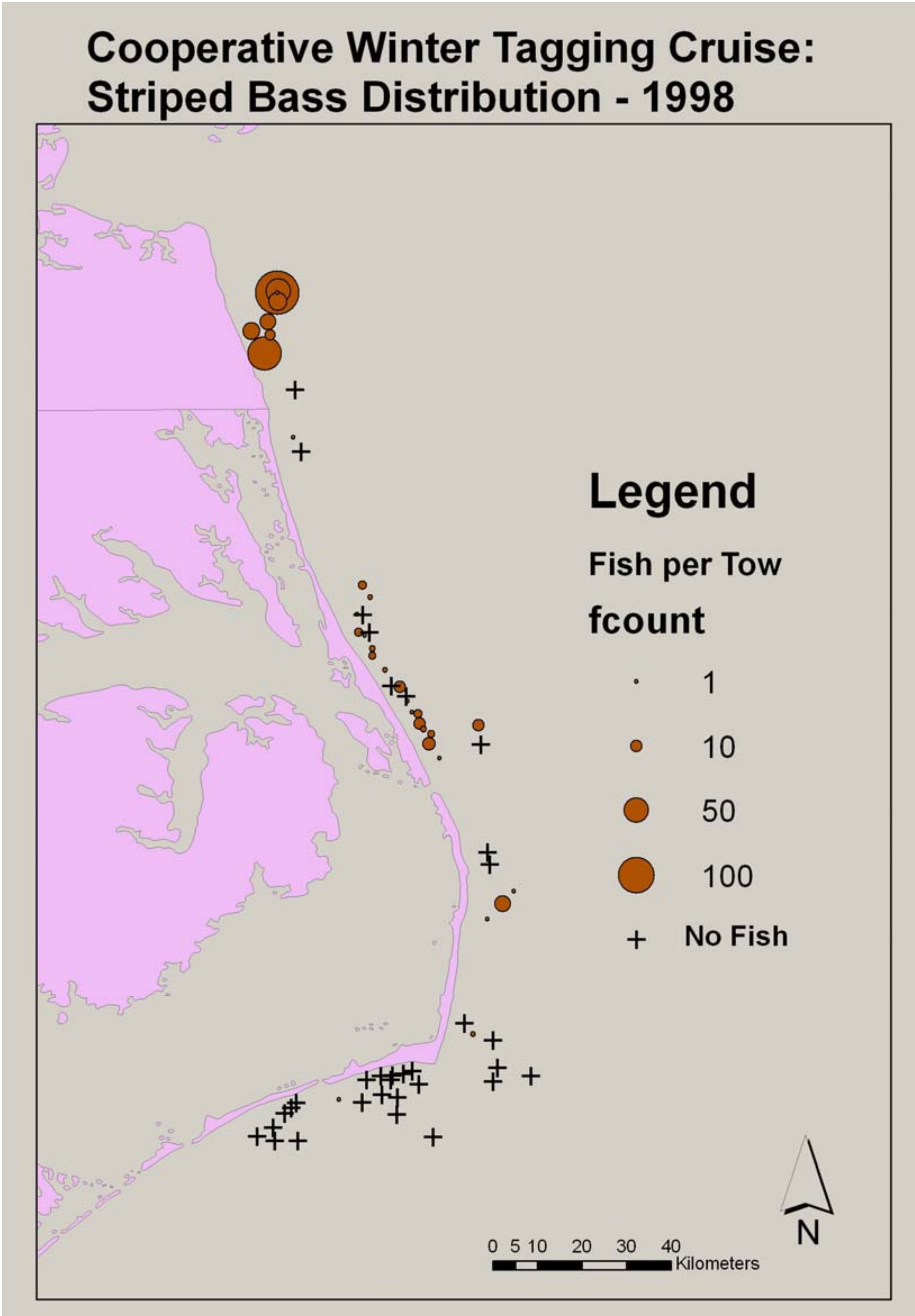


Figure 7. Distribution of striped bass captured on the wintering grounds during the 1998 Cooperative Winter Tagging Cruise

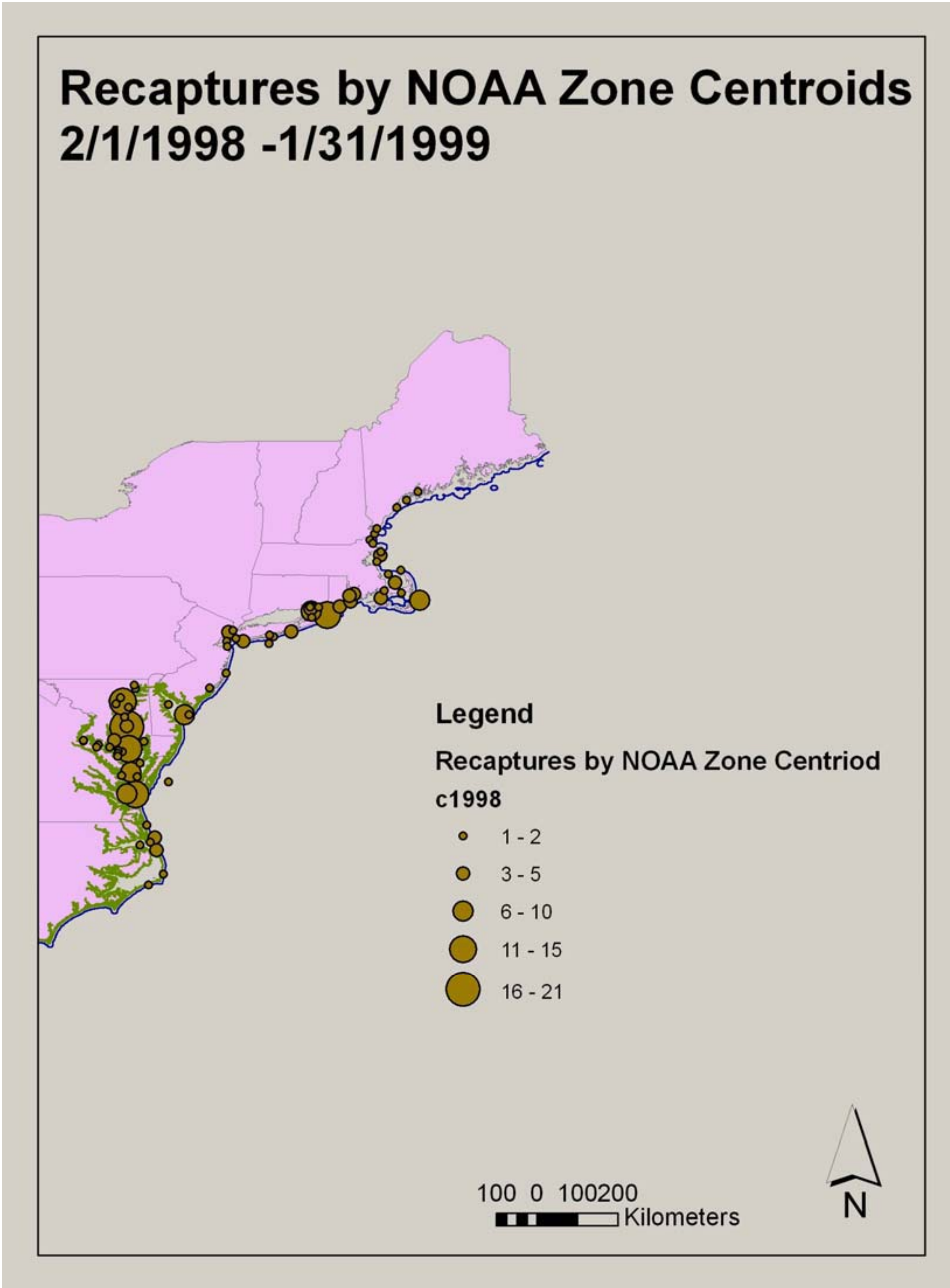


Figure 8. Distribution of all striped bass recaptures from 2/1/1998 – 1/31/1999 tagged during the 1998 Cooperative Winter Tagging Cruise

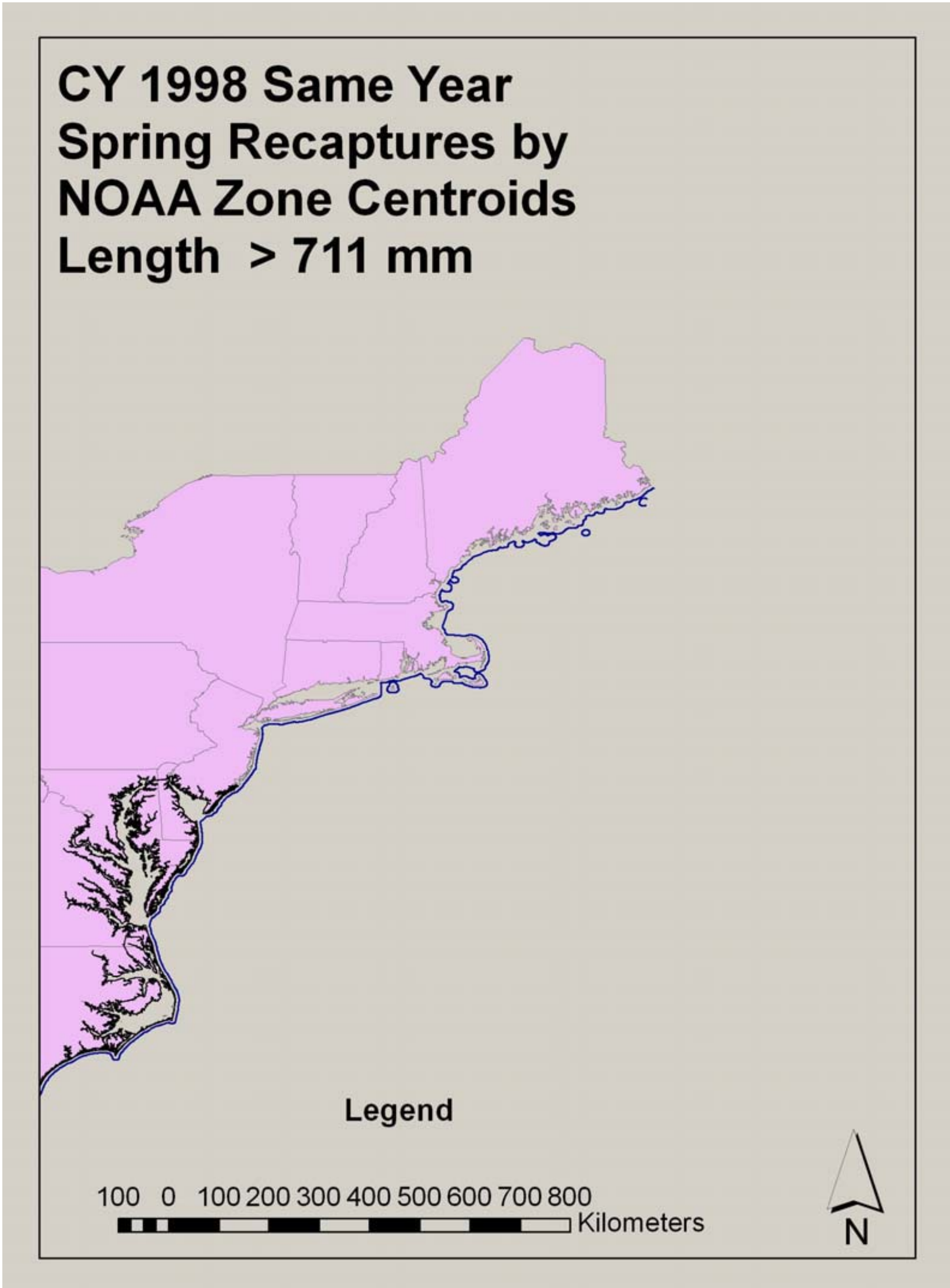


Figure 9. Distribution of 1998 spring recaptures of striped bass >711 mm and tagged during the 1998 Cooperative Winter Tagging Cruise

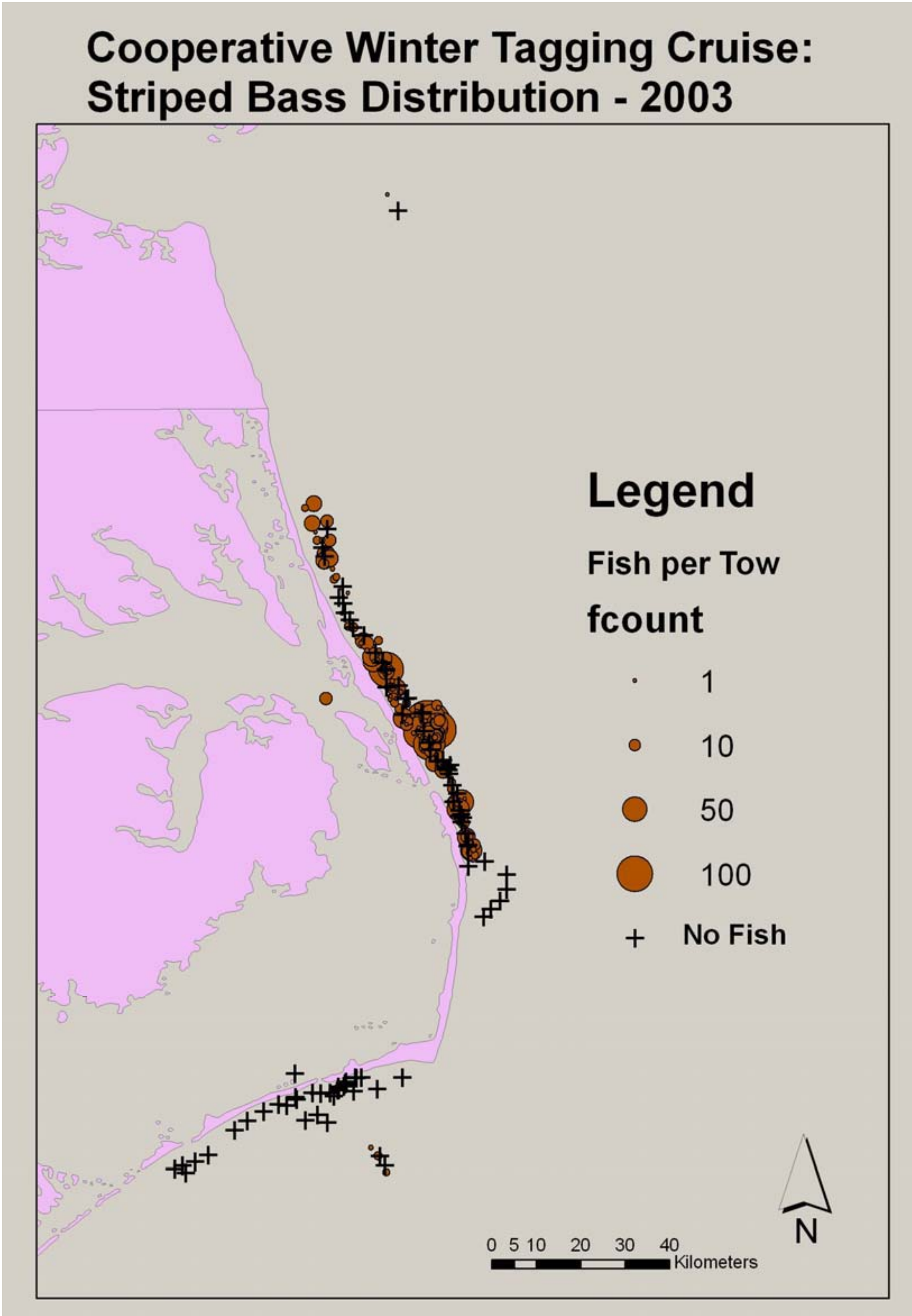


Figure 10. Distribution of striped bass captured on the wintering grounds during the 2003 Cooperative Winter Tagging Cruise

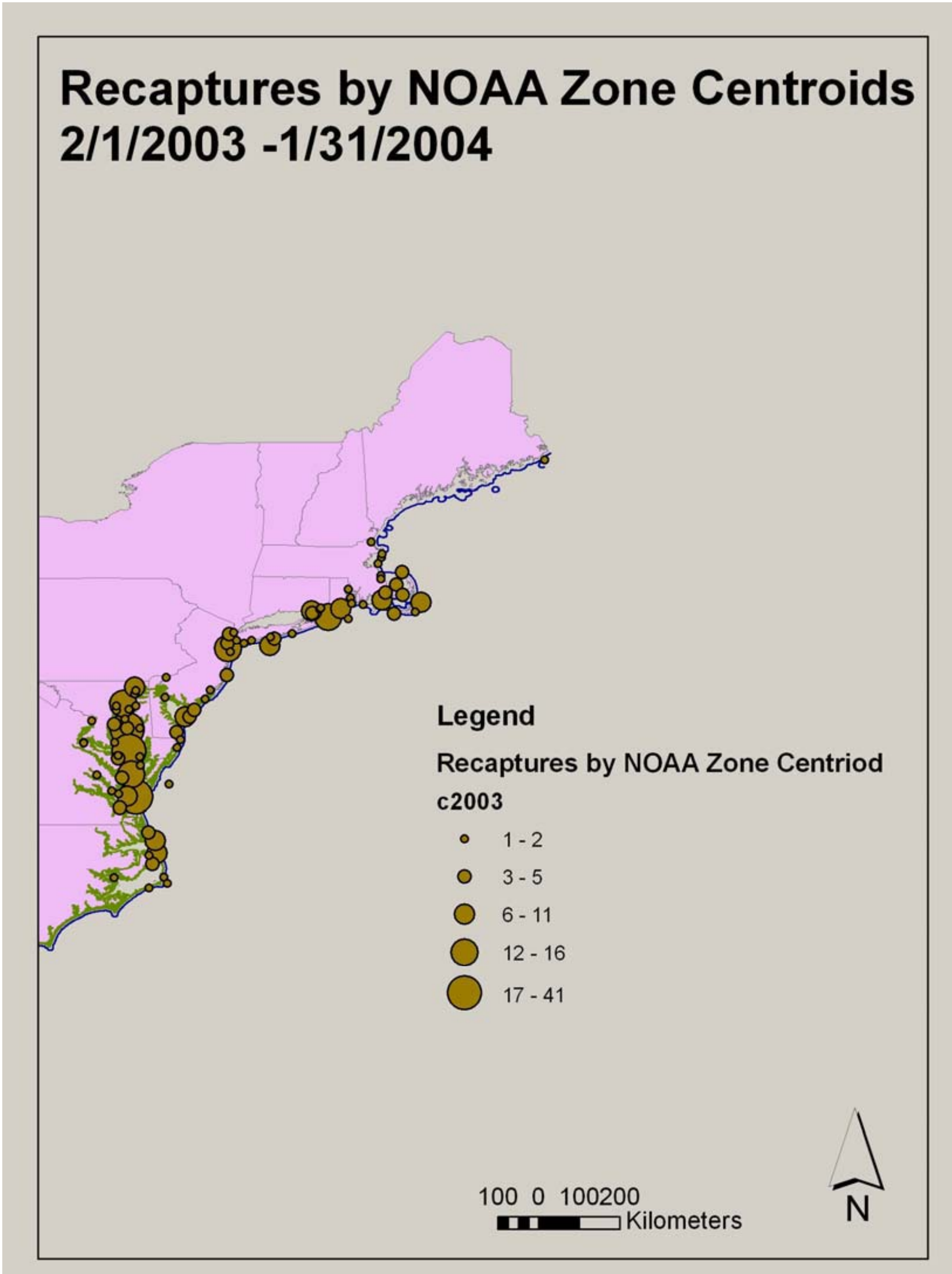


Figure 11. Distribution of all striped bass recaptures from 2/1/2003 – 1/31/2004 tagged during the 2003 Cooperative Winter Tagging Cruise

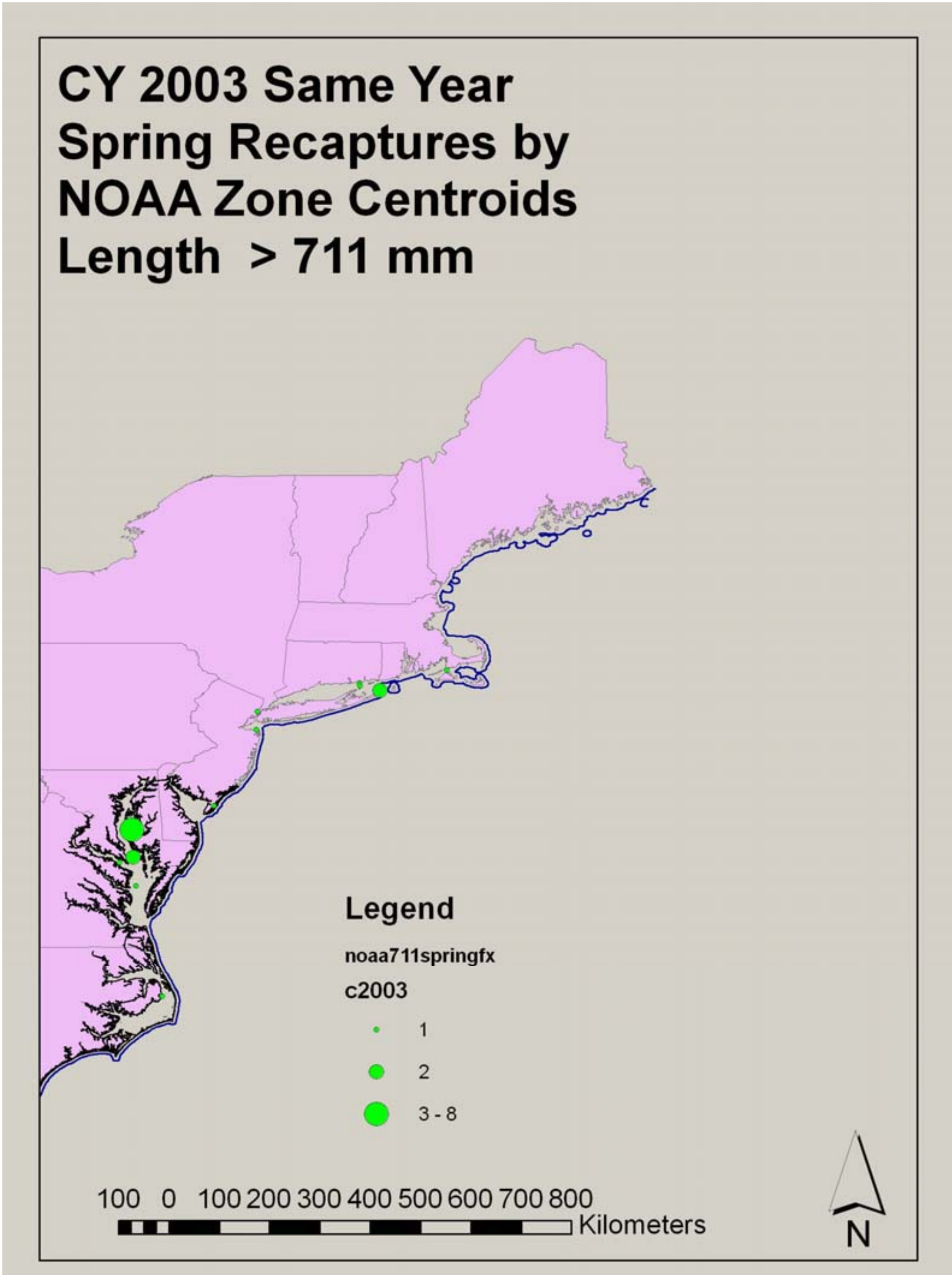


Figure 12. Distribution of 2003 spring recaptures of striped bass >711 mm and tagged during the 2003 Cooperative Winter Tagging Cruise

## Appendix A2: Commercial Landings Data Sources

### State Commercial Landings Monitoring Programs

*Massachusetts*

Fish dealers are required to obtain special authorization from the Division of Marine Fisheries (DMF) in addition to standard seafood dealer permits to purchase striped bass directly from fishermen. Dealer reporting requirements include weekly reporting to the DMF or Standard Atlantic Fisheries Information System (SAFIS) of all striped bass purchases. If sent to DMF, all harvest information is entered into SAFIS by DMF personnel. Harvest is tallied weekly to determine proximity of harvest to the quota cap. Following the close of the season, dealers are also required to provide a written transcript consisting of purchase dates, number of fish, pounds of fish, and names and permit numbers of fishermen from whom they purchased. Fishermen must have a DMF commercial fishing permit (of any type) and a special striped bass fishing endorsement to sell their catch. They are required to file catch reports at the end of the season, which include the name of the dealer(s) that they sell to and extensive information describing their catch composition and catch rates. If an angler does not file a report, he/she can not obtain a permit in the next year.

*Rhode Island*

Commercial harvest is reported through Interactive Voice Recording (IVR) and SAFIS. The IVR is a phone-in system designed to monitor quota-managed species, including striped bass. The reported data are aggregated by dealer and include gear, pounds landed, and date landed. SAFIS collects trip level data over the web in accordance with data standards developed by the Atlantic Coastal Cooperative Statistics Survey (ACCSP). Specific data fields include: vessel name, vessel identification (state registration or US Coast Guard Documentation Number), RI commercial license number, port landed, species, reported quantity, unit of measure, date landed, and price. The commercial harvest reported for RI is considered a complete census. The RI Division of Fish and Wildlife (DFW) plans to implement a harvester logbook for the commercial finfish and crustacean fishery sectors next year. The resulting two-ticket data collection system will provide catch and effort statistics and the associated gear types, gear sets, and areas fished as well as validate data reported by dealers and commercial fishermen.

*New York*

New York's annual quota (in pounds) is converted into a total number of fish, based on the mean weight of striped bass sampled during state monitoring efforts in the prior year. Each participant in the fishery is issued a fixed number of tags and a set of weekly report forms. The regulations governing the fishery require that a commercial harvester tag each legal fish taken within the slot limit for sale, and that report forms are completed daily, whether or not any fishing trips were taken. Weekly reports are due Sunday following the week of reporting. At the conclusion of the commercial season, all reports are due and any un-used tags must be returned to the department. Each participant's harvest records are examined to account for all tags issued. A complete census of the commercial harvest is reported to NMFS each year.

*Delaware*

Each fisherman has an Individual Transferable Quota (ITQ), for which they are issued tags by the Division of Fish and Wildlife (DFW). Each harvested fish must be tagged by the fisher and then tagged by a certified weigh station, which must call in catch daily. Fishers must also submit a catch log.

**Potomac River Fisheries Commission (DC)**

Mandatory reports of daily activity are submitted on a weekly basis. Failure to report can, and has, resulted in the loss of licenses. Harvest numbers are considered a complete census since all fishermen must report. Each fisherman is given a report book with one sheet for each fishing week at the beginning of the year. He/she records daily harvest (in pounds by market size category and the number of striped bass ID tags used, i.e. the number of fish harvested), amount of gear used (effort), the area of the river where the fish were caught and the port or creek of landing. The buyer records the average selling price and the estimated discards are reported for the week. The reports are mailed to the PRFC weekly and entered into the system and reported to NMFS via the Virginia Marine Resources Commission (VMRC).

*Maryland*

All commercially harvested striped bass are required to be tagged by the fishermen prior to landing with serial numbered, tamper evident tags inserted in the mouth and out through the operculum. These tags verify the harvester and easily identify legally harvested fish to the public and law enforcement. Each harvest day and prior to sale, all tagged striped bass are required to pass through a commercial fishery check station. Check station employees, acting as representatives of MD Department of Natural Resources (DNR), count, weigh, and verify that all fish are tagged. The check stations are required to call daily and report the total pounds of striped bass checked the previous day, as well as keep daily written logs detailing the activity of each fisherman, which are returned weekly by mail. Individual fishermen are required to report their striped bass harvest on monthly fishing reports and to return their striped bass permit to DNR at the end of the season.

*Virginia*

All permitted commercial harvesters of striped bass must report the previous month's harvesting activities to VMRC no later than the 5$^{th}$ day of the following month, in accordance with the VMRC regulation that governs the mandatory harvester reporting program. This regulation requires that the monthly catch report and daily catch records shall include the name and signature of the registered commercial fisherman and his license registration number, buyer or private sale information, date of harvest, city or county of landing, water body fished, gear type and amount used, number of hours gear fished, number of hours watermen fished, number of crew on board including captain, species harvested, market category, and live weight or processed weight of species harvested, and vessel identification (Coast Guard documentation number, VA license number or Hull/VIN number). Any information on the price paid for the catch may be provided voluntarily. In addition, all permitted commercial harvesters of striped bass must record and report daily striped bass tag use and specify the number of tags used on striped bass harvested in either the Chesapeake Area or Coastal Area. Daily striped bass tag use on striped bass harvested from either the Chesapeake area or Coastal area, within any month, must be recorded on forms provided by the Commission and must accompany the monthly catch report submitted no later than the 5th day of the following month. Any buyer permitted to purchase striped bass harvested from Virginia tidal waters must provide written reports to VMRC of daily purchases and harvest information on forms provided by VMRC. Such information shall include the date of the purchase; buyer and harvester striped bass permit numbers, and harvester Commercial Fisherman Registration License number. In addition, for each different purchase of striped bass harvested from Virginia waters, the buyer shall record the gear type, water area fished, city or county of landing, weight of whole fish, and number and type of tags (Chesapeake area or Coastal area) that applies to that harvest. These reports shall be completed in full and submitted monthly to VMRC no later than the 5th day of the following month. In addition, during the month of December, each permitted buyer shall call the VMRC interactive Voice Recording System, on a daily basis, to report his name and permit number, date, pounds of Chesapeake area striped bass purchased, and pounds of Coastal area striped bass purchased.

*North Carolina*

Commercial harvest is monitored real time through dealer reporting on a daily basis. Dealers report total numbers of fish and total pounds each day. Each fish must have a Division of Marine Fisheries (DMF) tag affixed through mouth and gills upon processing at the fish house. However, the final numbers and pounds used in reports come from the NC DMF trip ticket program. The trip ticket program collects gear data, species data, and total pounds per species each time a commercial fisherman makes a sale at a fish house.

**Commercial Harvest Length-Frequencies**

Data on length and weight of commercially harvested striped bass are collected through various state-specific sampling programs described below.

*Massachusetts*

Commercial port samplers visit fish houses throughout the state during the commercial season and measure striped bass being sold. All fish present on a given day are sampled or if there are too many, a sub-sample of totes containing fish are randomly selected. The number measured (TL and FL) and weighted (pounds) is based on the discretion of the port sampler. Approximately, 500-700 fish are measured each season. The length information collected is used the generate length distributions of harvested fish.

*Rhode Island*

Dockside samples are collected from commercial floating fish trap and rod and reel fisheries. Every individual striped bass observed is measured for fork length (inches) and weighed (pounds). Sampling begins in May or June and continues through October, when the majority of commercial fishing for striped bass in Rhode Island takes place. The low possession limit, especially in the rod and reel fishery, limits the number of striped bass available for sampling on any given day. The proportion of striped bass at length caught in the commercial fisheries is assumed equal to the proportion of striped bass at length sampled from the commercial harvest. The length frequency distributions are estimated separately for the trap and rod and reel fisheries and generally about 185-492 fish are measured per year per gear type. The total number of striped bass commercial harvest is estimated for each fishery by using the sample numbers and weights to extrapolate to the total weight landed. The estimated total number and the proportions at length are multiplied to compute the estimated number at length for each gear.

*New York*

Each week during the open season, staff from the Bureau of Marine Resources visit wholesale markets (packing houses), retail markets, or intercept commercial harvesters at marinas or gas docks to sample striped bass caught for commercial purposes. The open geographic area is limited in size, therefore only a few large wholesale markets/packing houses are worth visiting. The information recorded from each fish includes the tag number, fork length, total length, and weight. A sample of scales is collected from each fish. Each year, approximately 1,000 samples are collected.

*Delaware*

Commercial harvest is sampled primarily at fish houses, but sometimes samples are obtained prior to arrival at fish houses. DFW personnel are not always available to sample due to other responsibilities. No formal sampling scheme exists due to the fact that samples are often difficult to obtain because harvest can be sporadic in space and time. There is often also a problem getting access to all fish in a fish house if they have been boxed up prior to DFW personnel arrival. Usually in the two-month spring gill net season, DFW obtains 8-15 samples, totaling a few hundred fish. Each fish is measured and weighed, sex is determined if possible, and scale samples are taken.

**Potomac River Fisheries Commission (DC)**

A random sample (weekly or monthly) is purchased from local fish buyers. The samples are transported to Virginia Institute of marine Sciences (VIMS), where length, weight, sex and age (scales) are recorded. The recent average monthly harvest is used to establish a target sampling frequency and sample sizes. Samples are processed by professionally trained people at VIMS.

*Maryland*

Pound net sampling occurs during five rounds from May through October. Each round is 10 to 11 days long. Maryland waters of the Chesapeake Bay are subdivided into three regions; the Upper Bay (Susquehanna Flats south to the Bay Bridge), the Middle Bay (Bay Bridge south to a line stretching between Cove Point and Swan Harbor), and the Lower Bay (Cove Point/Swan Harbor south to the Virginia line. For each round, an optimum number of fish to be sampled is determined for each Bay region. At each net sampled, data recorded includes latitude and longitude, date the net was last fished, depth, surface salinity, surface water temperature, air temperature, secchi depth (m), and whether the net was fully or partially sampled. If the net is fully sampled, all striped bass (including sub-legal fish) are measured for total length (mm TL) and, healthy, legal-size fish (≥457 mm total length) are tagged with USFWS internal anchor streamer tags. If the pound net is partially sampled, legal-size striped bass are targeted for tagging. Check stations across Maryland are randomly sampled for pound net and hook-and-line harvested fish each month from June through November. For pound nets, sample targets of fish per month are established for June through August and for September through November. For hook-and-line, a sample target of fish per month is established over the six-month season.

*Virginia*

VMRC has been collecting striped bass biological data since 1988. The field sampling program is designed to sample striped bass harvests, in general proportion to the extent and timing of these harvests within specific water areas. Since 2003, VMRC has managed its Coastal Area and Chesapeake Area harvests by two different ITQ systems, and data collections procedures are intended to ensure adequate representation of both harvest areas. Samples of biological data are collected from seafood buyers' place of business or dockside from off-loaded striped bass caught by pound nets or haul seines. Infrequently, some gill net or commercial hook-and-line fishermen's harvests may be sampled directly. At a majority of the sites, striped bass are sampled from a 50-pound box that was previously boxed and iced. At other sites, recently landed fish are randomly sampled directly from the culling table. For each specimen, length is measured using an electronic fish measuring board (FMB), with the accuracy of +/- 2.5 millimeters, and weight is recorded directly to the FMB, from an Ohaus scale, accurate to the nearest 0.01 pound. A sub-sample of fork lengths are taken, but all striped bass are measured for total length (natural) from the tip of the fish snout to the end of its caudal fin. Sub-samples of sex information and fish hard parts (scales and otoliths) are also collected, on a 1-inch interval basis. Generally, only 40-50% of striped bass sampled for scales are also sampled for otoliths. Supplementary data is collected for each biological sample, such as date of collection, harvest location, market grade, harvest area, and gear type.

*North Carolina*

Samples are collected by DMF personnel at the fish houses or on the beach for the beach seine fishery. DMF sets a target to collect length, weight, sex (Sykes method), and scale samples from 300 fish per gear type, which is usually about 6% of the total harvest.

**Commercial Age Samples**

The primary ageing structures for striped bass are scales. All states with commercial striped bass fisheries collected samples on a routine basis. Descriptions of the sampling programs are below.

*Massachusetts*

Commercial port samplers visit fish houses throughout the commercial season and collect scale samples from striped bass being sold. Generally, scale samples from 500-800 fish are collected each season. The proportion that each age comprised the total samples is estimated from a sub-sample of 250-350 fish which guarantees a precision of $\pm$7-10% at $\alpha = 0.05$. Weighted proportions at age are generated by weighting the age proportions sampled in each county by county harvest. Scales are impressed in plastic using a heated press and aged by projecting impressions on a microfiche machine.

*Rhode Island*

Scales are removed from each striped bass that is weighed and measured in the commercial dockside sampling program. A sample of scales (typically seven or more) is removed from the area behind the pectoral fin and then cataloged for ageing. The number of age samples taken range from 185 to 492 per year per gear type.

*New York*

A sample of scales is collected from each fish sampled by staff from the Bureau of Marine Resources (as described in the previous New York section). Each year, approximately 1,000 age samples are collected. Scales are pressed into clear acetate and age assignment is completed by a minimum of two readers. Age assignments are compared for agreement. Disagreements are settled by a group reading or repress of the sample. Samples for which no agreement can be reached are often discarded from the set.

*Delaware*

Commercial harvest is sampled primarily at fish houses, but sometimes samples are obtained prior to arrival at fish houses. DFW personnel are not always available to sample due to other responsibilities. No formal sampling scheme exists due to the fact that samples are often difficult to obtain because harvest can be sporadic in space and time. There is often also a problem getting access to all fish in a fish house if they have been boxed up prior to DFW personnel arrival. Usually in the two-month spring gill net season, DFW obtains 8-15 samples, totaling a few hundred fish. Each fish is measured and weighed, sex is determined if possible, and scale samples are taken.

**Potomac River Fisheries Commission (DC)**

A random sample (weekly or monthly) is purchased from local fish buyers. The samples are transported to VIMS, where length, weight, sex and age (scales) are recorded. The recent average monthly harvest are used to establish a target sampling frequency and sample sizes. The sample is 'worked-up' by professionally trained people at VIMS.

*Maryland*

Age composition of the pound net and hook-and-line fisheries is estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). The first stage refers to total length samples taken during the surveys, which was assumed to be a random sample of the commercial harvest. In this case, the length frequencies from hook-and-line and pound net check stations were combined with the pound net tagging length frequency. In stage 2, a random sub-sample of scales was aged which were selected in proportion to the length frequency of the initial sample. The total number of scales to be aged was determined using a Vartot analysis which is a derived index measuring the precision of an age-length key (Kimura 1977, Lai 1987). Regardless of the sample size indicated by the Vartot analysis, 10 fish in each length category over 700 mm TL were aged. Year-class was determined by reading acetate impressions of the scales placed in microfiche readers, and age was calculated by subtracting year-class from collection year. The resulting ages were used to construct an age-length key.

*Virginia*

VMRC has been collecting striped bass biological data since 1988. The field sampling program is designed to sample striped bass harvests, in general proportion to the extent and timing of these harvests within specific water areas. Since 2003, Virginia has managed its

Coastal Area and Chesapeake Area harvests by two different ITQ systems, and data collections procedures are intended to ensure adequate representation of both harvest areas. Samples of biological data are collected from seafood buyers' place of business or dockside from offloaded striped bass caught by pound nets or haul seines. Infrequently, some gill net or commercial hook-and-line fisherman's harvests may be sampled directly. At a majority of the sites, striped bass are sampled from a 50-pound box that was previously boxed and iced. At other sites, recently landed fish are randomly sampled directly from the culling table. For each specimen, length is measured using an electronic fish measuring board (FMB), with the accuracy of +/- 2.5 millimeters, and weight is recorded directly to the FMB, from an Ohaus scale, accurate to the nearest 0.01 pound. A sub-sample of fork lengths are taken, but all striped bass are measured for total length (natural) from the tip of the fish snout to the end of its caudal fin. Sub-samples of sex information and fish hard parts (scales and otoliths) are also collected, on a 1-inch interval basis. Generally, only 40-50% of striped bass sampled for scales are also sampled for otoliths. Supplementary data is collected for each biological sample, such as date of collection, harvest location, market grade, harvest area, and gear type.

*North Carolina*

Scales are obtained from striped bass above the lateral line and below the dorsal fin, pressed on acetate sheets using a Carver heated hydraulic press and read by DMF personnel on a microfiche reader. Age is assigned using ASMFC striped bass ageing guidelines. A sub-sample of 15 fish per sex per 25 mm size group are aged. Year class is then assigned to the remainder of the sample.

**Commercial Harvest-At-Age**

Commercial harvest at age are usually estimated by applying corresponding length-frequency distributions and age-length keys to the reported number of fish landed by the commercial fisheries in each state. State-specific descriptions of the estimation procedures are below.

*Massachusetts*

The proportion that each age comprises the total samples of harvested fish is estimated from a sub-sample of 250-350 fish which guarantees a precision of $\pm$10% at $\alpha = 0.05$. Weighted proportions at age are generated by weighting the age proportions sampled in each county by county harvest. The number of fish harvested is then multiplied by the proportions-at-age to get numbers harvested-at-age.

*Rhode Island*

Gear-specific age-length keys are computed based on the length and age samples collected from the commercial dockside sampling program. The keys are applied to the commercial length frequencies to estimate the catch-at-age for each gear. The numbers at age are summed over gear types to provide an estimate of the total commercial catch-at-age for the year.

*New York*

Since sampling is conducted weekly throughout the open season and open geographic area, it is assumed that the annual sample is representative of the harvest. The number of fish harvested is disaggregated by the length and age frequency of the monitoring samples. No effort has been made to apportion the release data to length or age classes because no physical samples are collected.

*Delaware*

The DFW develops keys from age-length samples. In lesser fisheries, such as the commercial hook and line, personnel often does not obtain adequate samples and has to borrow from other sources, because harvest are quite sporadic and scarce (~5,000 lbs landed over several months).

**Potomac River Fisheries Commission (DC)**

Harvest is apportioned via ageing of the commercial samples. No age data (except fish < 18") are collected for released fish. Also included is information on the For-Hire fisheries, as the PRFC considers party, charter, guide and other such boats as commercial operations that carry recreational fishermen. PRFC requires a commercial license for the captain and requires him to have a sport fishing decal (license) for his boat that exempts his passengers from needing to be individually licensed. Captains use a logbook system to report their boats' catch and estimates of the released fish. PRFC also cooperates with the NMFS "For-Hire" Survey by providing a monthly list of boats and captains licensed to carry fee-paying passengers in the Potomac. This allows NMFS to include the PRFC boats in their database and to survey them. At present, NMFS is unable to produce a separate catch and release estimate for the Potomac, but the information on the total harvest is included in the MD and VA estimate. Since, the PRFC, MD and VA all share in one overall Chesapeake Bay F-base management system, there is no immediate need for a Potomac River sub-total for the "For-Hire" fishery.

*Maryland*

The harvest-at-age for each fishery is calculated by applying the age-length key developed from the hook-and-line and pound net data to the length frequencies observed in each fisheries and expanding the resulting age distribution to the harvest.

*Virginia*

Harvest data are apportioned to age classes by using an area-specific (Chesapeake Area or Coastal Area), seasonal age-length key (if possible) or annual key. Collected lengths and the age-length key are inputs, along with the harvest weight, into the template that has been used for 3 years to determine catch at age.

*North Carolina*

Total pounds landed is obtained from trip ticket program. Then year classes are apportioned to harvest based on the percentage of pounds per year class as observed in the sample taken from fish houses. Numbers of fish per year class are then assigned using the average weight per fish per year class as observed in the sample.

## Appendix A3: Estimation of Virginia and North Carolina Wave-1 Harvest, 1996-2004

DT: 7/11/2005

TO: ASMFC Striped Bass Technical Committee

FR: Joseph Grist, ASMFC

RE: MRFSS North Carolina Wave-1 2004 harvest

### Introduction

During the March 2005 Striped Bass Technical Committee (STB TC) meeting, the results for the 2004 wave-1 North Carolina (NC) harvest were reported. This was the first time wave-1 was directly sampled by the Marine Recreational Fisheries Statistics Survey (MRFSS), and the results were both predictable and a cause for concern. A total of 177,288 striped bass (equivalent to 3,615,670 lb) were harvested during wave-1 in North Carolina.

Anecdotal knowledge has suggested that North Carolina, Virginia, and possibly other states had a sizeable wave-1 fishery. The 2004 wave-1 harvest values for North Carolina and the wave-1 tag return data (Figure 1) for North Carolina and Virginia support this suggestion. However, information is still lacking on what the previous annual harvest rates were, as well as the level of exploitation in Virginia and elsewhere during wave-1. The STB TC requested an examination of the data that included suggestions for how to incorporate these data efficiently into the coastwide STB assessment.

The goal of this analysis is to determine if tag return data during wave-6 and wave-2 are correlated with the reported total harvest and, if so, if a proxy ratio may be utilized to back-calculate wave-1 data for North Carolina and Virginia.

### Data

Striped bass tag return data from North Carolina and Virginia were provided by the U.S. Fish and Wildlife Service (USFWS). Data were queried from the MRFSS website (http://www.st.nmfs.gov/st1/recreational/queries/effort/effort_time_series.html) on July 11, 2005 for North Carolina and Virginia, having selected variables by harvest (A+B1), all oceans combined, and all modes combined.

### Methods

Tag return and MRFSS data were merged by wave and by year and were analyzed for each state. SAS 9.1 was utilized to calculate Pearson's correlation coefficient (PROC CORR), generate linear regressions, and conduct ANOVA or analysis of variance (PROC REG) to test for similarities between tag return and total harvest data by wave. Only wave-6 (November and December) and Wave-2 (March and April) data were analyzed.

## Results

*North Carolina*

Tag returns were positively correlated with total harvest (0.5828) during wave-6 (Figure 2). ANOVA indicated significant evidence ($p$-value = 0.0366) that total harvest could explain the proportion of tag returns during wave-6.

Tag returns were positively correlated with total harvest (0.9518) during wave-2 (Figure 3). ANOVA indicated significant evidence ($p$-value < 0.0001) that total harvest could explain the proportion of tag returns during wave-2.

*Virginia*

Tag returns were positively correlated with total harvest (0.5827) during wave-6 (Figure 4). Although ANOVA did not indicate statistically significant evidence ($p$-value = 0.0599) that total harvest could explain the proportion of tag returns during wave 6, the given p-value indicates suggestive, but inconclusive, evidence that the null hypothesis is false, possibly representing biological significance.

Tag returns were slightly negatively correlated with total harvest (-0.4007) during wave-2 (Figure 5). ANOVA did not indicate significant evidence ($p$-value = 0.4311) that total harvest could explain the proportion of tag returns during wave-2. However, the tag return data were not consistent from year to year and a negative correlation was expected.

## Estimates of Wave-1 Harvest 1996-2004

Based on the above analyses and suggestion from the Striped Bass TC, Table 1 contains estimates for total harvest for each state.

*North Carolina*

Wave-1 total harvest for 1996-2003 is based on the NC specific 2004 wave-1 ratio of tag returns to MRFSS total harvest numbers. There were 47 tags returned during the wave-1 fishery period for the ocean fishery. The MRFSS reported harvest (A+B1) was 177,288 striped bass during the same period. This resulted in a 2004 ratio tags to harvest of 0.000265. This ratio was applied to the wave-1 tag returns for the NC ocean fishery to provide a back-calculated total harvest for wave-1 in NC.

*Virginia*

Unlike NC, a 2004 wave-1 total harvest was not reported. However, analysis of the tag returns suggested that a winter fishery similar to that of North Carolina occurred off VA during 2004. The July 11th report to the TC did indicate that VA wave-6 tag returns were positively correlated to harvest and implied biological significance, though wave-2 analysis did not. Personal communication with Sara Winslow (NCDMF) confirmed that the winter fishery begins in the latter half of wave-6 and continues into wave-1 in northeastern NC, and similar trends would be expected for southeastern VA. Anecdotally, this suggested that wave-6 and wave-1 harvest would show some level of correlation in fishing activity. Using known wave-1 tag returns, a mean ratio (0.000167) of tag returns to harvest for VA wave-6, 1996-2004, was utilized to back-calculate the total wave-1 harvest.

**Summary**

The 2004 wave-1 total harvest for North Carolina corresponds with observed recreational effort that begins during wave-6 and continues into wave-1 throughout the coastal waters of northeastern North Carolina and southeastern Virginia (Sara Winslow, NCDMF, personal communication).

Analysis indicates that tag return data can be used to explain total harvest in wave-6 and wave-2 in North Carolina. If the assumption that wave-1 follows a similar trend is acceptable by the STB TC, then wave-1 data before 2004 could be back-calculated for North Carolina striped bass harvest. There are two possible methods for back-calculation (Figure 6). One would be using the direct 2004 ratio of tag returns to reported total harvest. The other would be to use the combined ratio of tag returns to total harvest for both wave-6 and wave-2.

Correlation analysis for Virginia did indicate total harvest could be explained by tag returns, although ANOVA did not provide strong evidence for or against the reported correlation. However, tag return evidence does show a wave-1 striped bass fishery is occurring in Virginia (Figure 1), and using the wave-6 mean ratio of tag returns to reported total harvest for 1996-2004 could be utilized to back-calculate the wave-1 striped bass recreational fishery (Figure 7).

**Appendix A3 Tables**

Table 1. Estimates of wave-1 harvest by the winter striped bass recreational fisheries off Virginia and North Carolina.

| Year | Total harvest values (projected) | |
|---|---|---|
| | NC | VA |
| 1996 | 18,860 | 5,985 |
| 1997 | 49,037 | 83,793 |
| 1998 | 15,088 | 89,778 |
| 1999 | 18,860 | 107,734 |
| 2000 | 7,544 | 53,867 |
| 2001 | 18,860 | 53,867 |
| 2002 | 75,442 | 89,778 |
| 2003 | 79,214 | 53,867 |
| 2004 | 177,288* | 155,616 |

*actual harvest

## Appendix A3 Figures

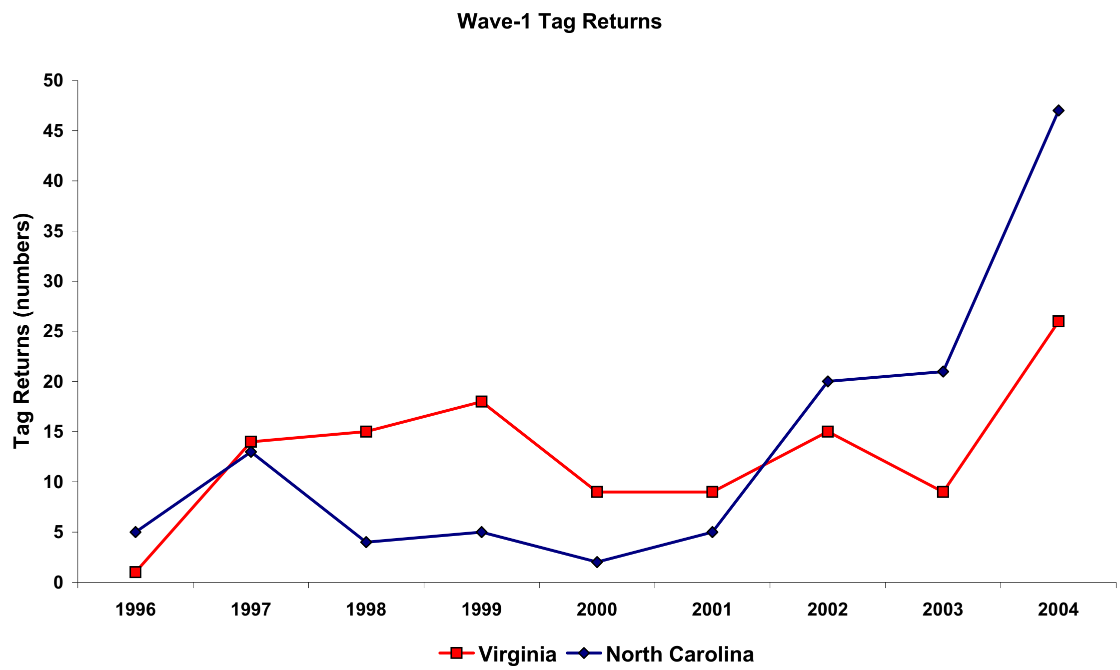


Figure 1. Wave-1 tag returns for Virginia and North Carolina

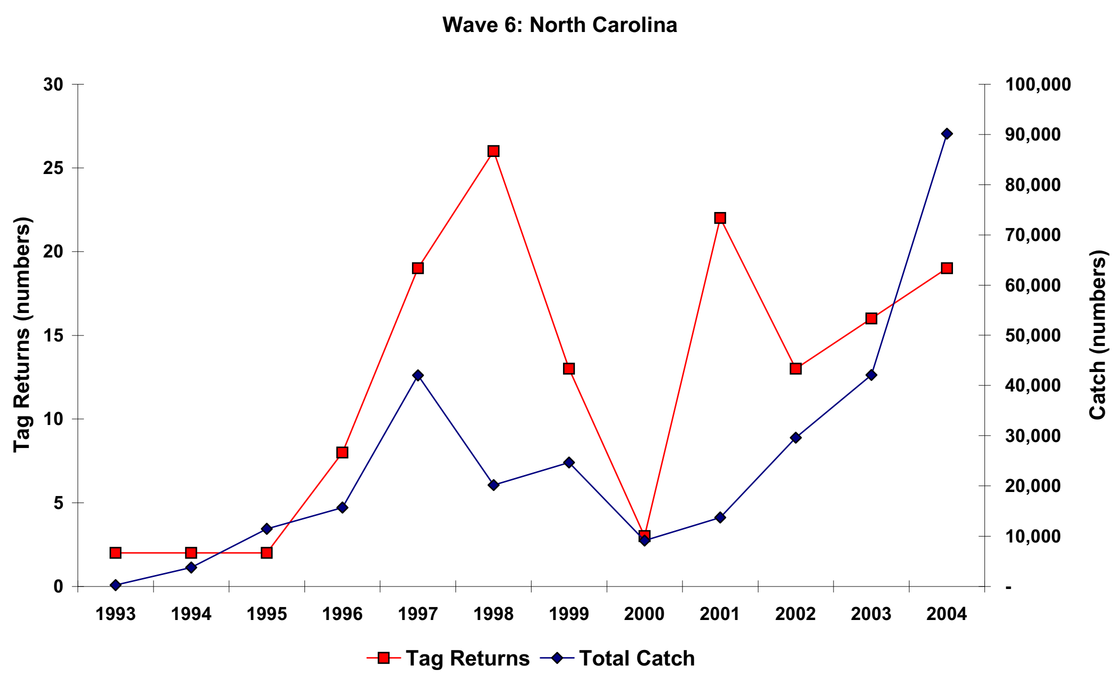


Figure 2. Wave-6 tag returns versus total harvest for North Carolina

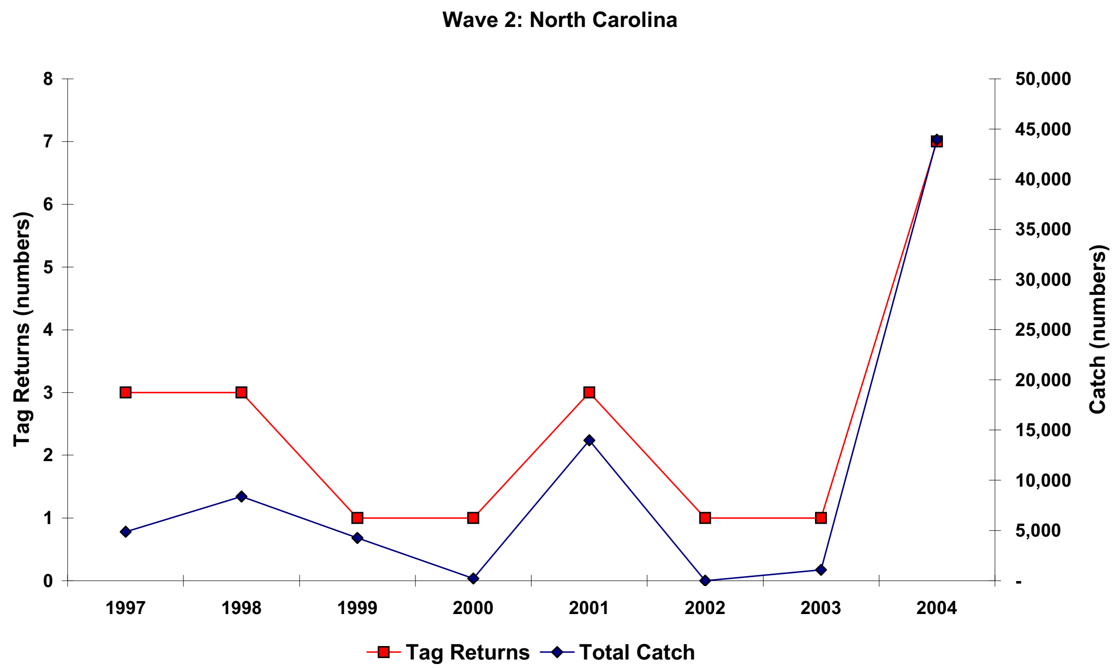


Figure 3. Wave-2 tag returns versus total harvest for North Carolina

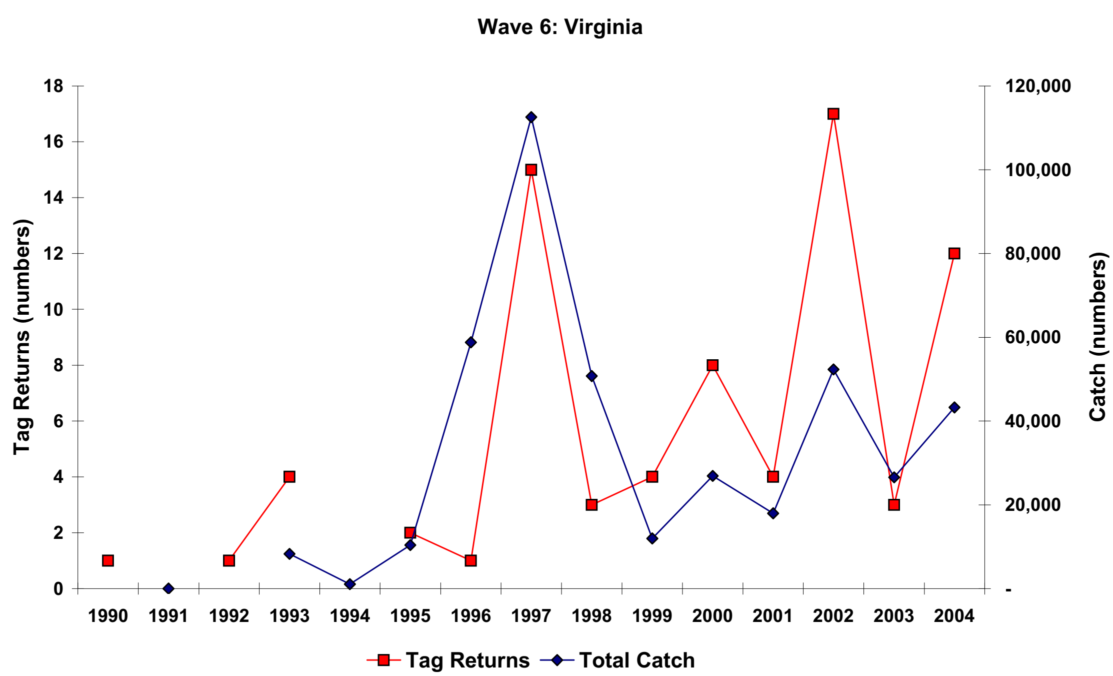


Figure 4. Wave-6 tag returns versus total harvest for Virginia.

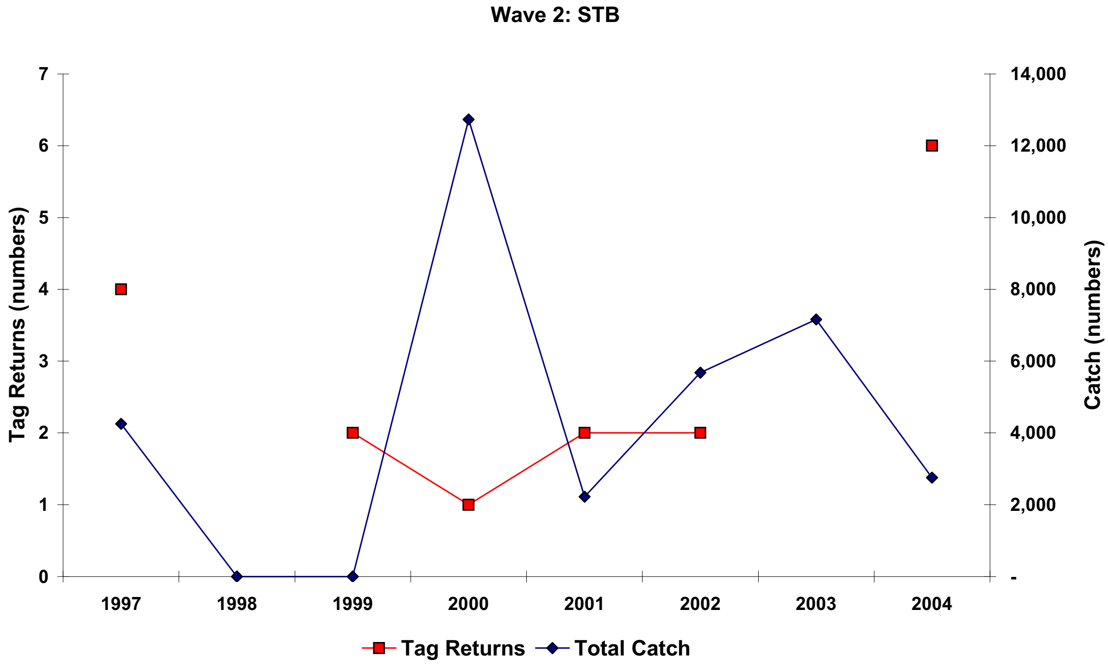


Figure 5. Wave-2 tag returns versus total harvest for Virginia

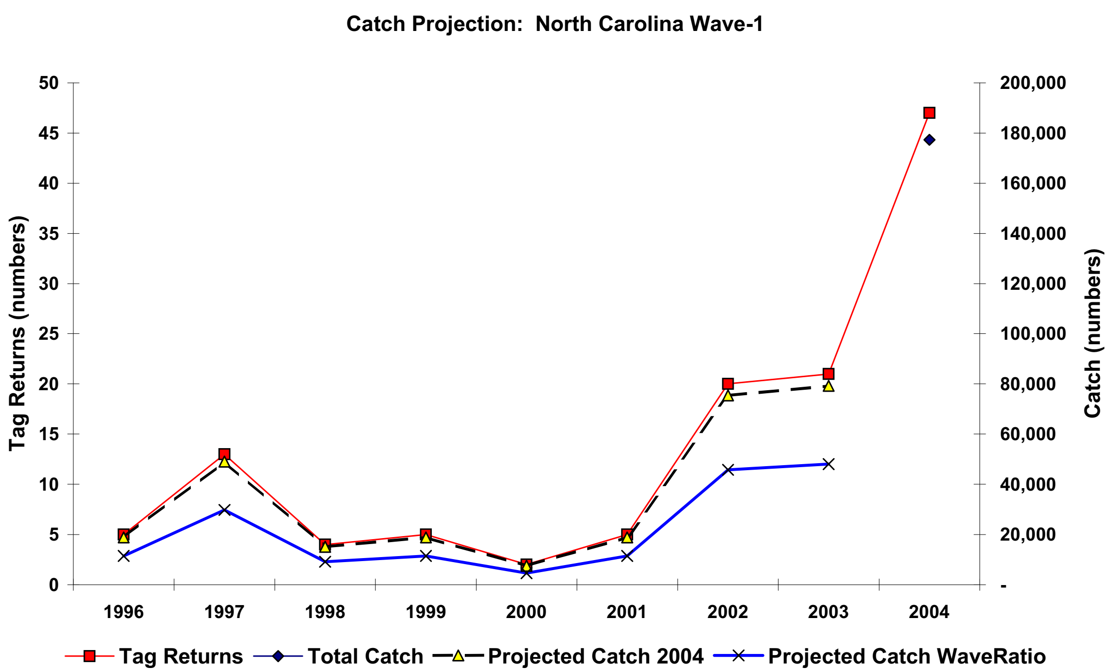


Figure 6. Comparison of harvest projections for North Carolina wave-1

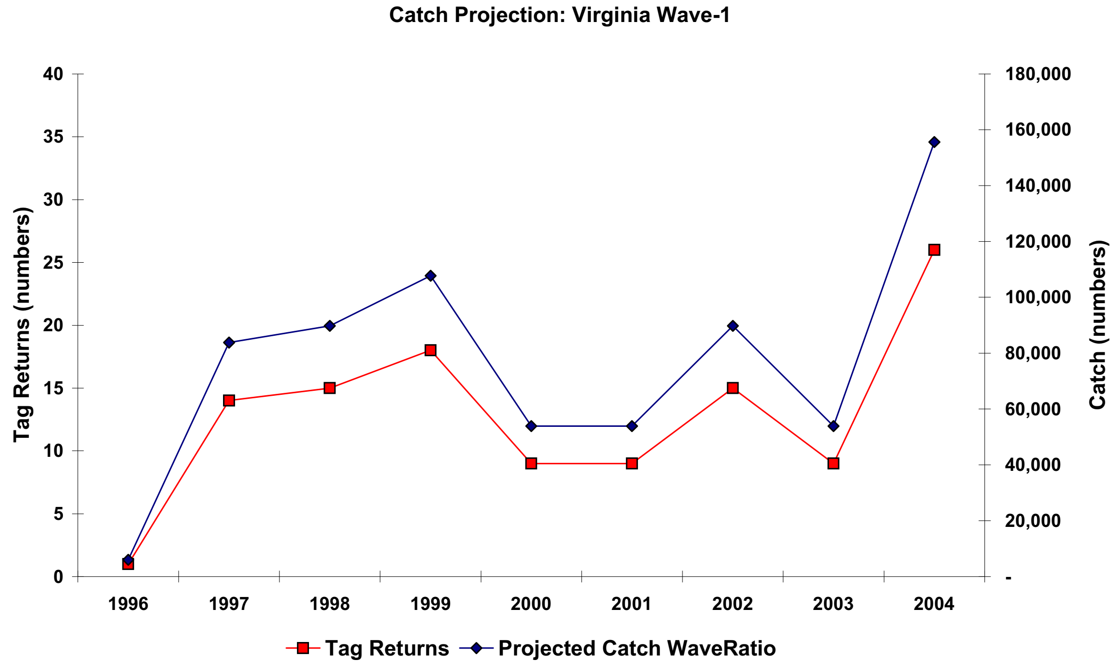


Figure 7. Harvest projection for Virginia wave-1

## Estimation of Virginia Wave 1 Harvest in 2005 and 2006

In Appendix C of the 2005 stock assessment, a memo from Joe Grist states "Personal communication with Sara Winslow (NCDMF) confirmed that the winter fishery begins in the latter half of wave-6 and continues into wave-1 in northeastern NC, and similar trends would be expected for southeastern VA." If the fisheries are similar because of their close proximity, it follows that complete information on harvest from NC in 2005 and 2006 could be used to provide more realistic estimates of harvest in Virginia during wave 1.

If it is assumed that the number of tags returned from killed fish is proportional to the numbers of fish harvested regardless of location, the ratio of the NC harvest in wave 1 to tag returns from NC harvested fish will provide a means by which harvest in Virginia can be estimated in the same wave using Virginia wave 1 tag returns:

VA harvest = NC harvest/NC tag returns*VA tag returns

"Killed" tag numbers from only recreational anglers fishing were extracted from the USFWS tag database using the following codes:

Region = "COAST",
disposition="K"
recapturertype="H" or "S",
event=1
capmonth =1 or 2
capyear=2005 or 2006
State = "NC" (or "VA")

To match the tag data, estimates of wave 1 NC harvest from charter/private boats in the state territorial seas for 2005 and 2006 were extracted from the MRFSS website.

Estimates of harvest are given below

| | Wave 1 | | | | Wave 1 | |
|---|---|---|---|---|---|---|
| | NC | NC | Ratio | | VA | Est. |
| Year | Harvest | Tag Returns | (har/tags) | | Tag Returns | Harvest |
| 2005 | 71981 | 14 | 5141.50 | | 7 | 35991 |
| 2006 | 84144 | 23 | 3658.43 | | 23 | 84144 |

## Appendix A4: Recreational Fishery Monitoring Programs

### Recreational Harvest and Releases

Information on harvest and release numbers, harvest weights, and sizes of harvested bass come from the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS). The MRFSS data collection consists of a stratified intercept survey of anglers at fishing access sites that obtains numbers of fish harvested and released per angler trip, and a telephone survey that derives numbers of angler trips. Estimates of harvest and release numbers are derived on a bi-monthly basis. For detailed descriptions of the MRFSS program, see http://www.st.nmfs.gov/st1/recreational/overview/overview.html.

### Recreational Length-Frequencies of Harvested Fish

Most states use the length frequency distributions of harvested striped bass measured by the MRFSS. The MRFSS measurements are converted from fork length (inches) to total length (inches) using conversion equations. Proportions-at-length are calculated and multiplied by the MRFSS harvest numbers to obtain total number harvest-at-length. The sample sizes of harvested bass measured by MRFSS may be inadequate for estimation of length frequencies; therefore, some states use length data from other sources (e.g., volunteer angler programs) to increase sample sizes. Descriptions of these programs are below.

*Maine*

A volunteer angler program targets avid striped bass fishermen as a means of collecting additional length data. Though this has increased the sample size of the MRFSS, it still overlooks lengths and weights on sub-legal or released stripers. Because many anglers opt for catch and release, field interviewers actually see limited numbers of fish. An angler using the Volunteer Angler Logbook (VAL) records information about fish harvested or released during each trip for themselves and any fishing companions. Information about each trip is also recorded, including time spent fishing, area fished, number of anglers, and target species. At the end of the season each angler mails his/her logbook to the Department of Marine Resources (DMR), which is then copied and sent back to the angler.

*Massachusetts*

For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month, place the scales in marked coin envelopes, and record the disposition of each fish (released or harvested), fishing mode (boat or shore-based fishing), and location. Over 2,200 samples are received each year from over 100 anglers. Starting in 2005, DMF began using the MRFSS length data and the volunteer angler harvest length data to estimate the length structure of harvested fish. This is done by first generating the percentages-at–length from MRFSS and volunteer program by fishing mode and then averaging the proportions-at-length across programs. DMF then estimates the harvest by fishing mode and applies the numbers to the correct proportions-at-length to get harvest numbers at length and fishing mode, and then sums across modes to get total numbers harvested-at-length. The volunteer angler data adds about 200-400 extra measurements to estimate harvest length distributions.

*Connecticut*

The Volunteer Angler Survey (VAS) is designed to collect fishing trip and catch information from marine recreational (hook and line) anglers who volunteer to record their angling activities via a logbook. VAS anglers contribute valuable fisheries-specific information concerning striped bass, fluke, bluefish, scup, tautog, and other important finfish species used in monitoring and assessing fish populations inhabiting Connecticut marine waters. The survey logbook is easy to fill out. Each participating angler is assigned a personal code number for confidentiality. Recording instructions are provided on the inside cover of the logbook. Upon completion, anglers tape the pre-postage paid logbook shut and drop it off in the mail. Anglers that send in logbooks are rewarded with a VAS cooler and updated results of the program. After all the logbooks are computer entered and error checked, the logbooks are returned to each participant for their own records. The CT Fisheries Division has annually supplemented the MRFSS survey with about 2,000-3,000 length measurements from the angler survey.

*New York*

The MRFSS length data are not used in any fashion. Instead, the American Littoral Society's (ALS) release data are used to estimate length distribution of both harvested fish (>28") and released fish (B2 sub-legal <28"). The sample sizes are about 5,000 fish each year.

*New Jersey*

New Jersey collects information on harvested fish through the Striped Bass Bonus Program (SBBP). NJ's historical commercial quota forms the basis of this program where a recreational angler can harvest one additional striped bass per day measuring not less than 28 inches. Any striped bass taken under the provision of the SBBP are to be transported to the nearest authorized fish checking station by the person who caught the fish on the day it was harvested. The angler is also required to fill out a non-transferable card to be filled out immediately upon harvesting the fish with the following information: date, location caught, and length. Once the fish is taken to a check station, the check stations may also record the weight (lbs) and take scale samples. Party and charter boat captains who participate in the program (this allows for a patron of the boat to harvest a 3rd fish) will also record the data mentioned above and collect scale samples from all harvested Bonus fish. All of this information, both individual and P/C boats harvest, is turned in (mandatory harvest reporting) to the NJ Bureau of Marine Fisheries for monitoring, entry, and analysis.

*Maryland*

There are two additional sources for size frequency data: a volunteer angler survey and the DNR creel survey during the spring trophy season. Neither of the additional surveys employ statistical design. The volunteer angler survey is described in the next MD section. The DNR creel survey was initiated in 2002. The survey samples access sites (docks and marinas) with the largest volume of recreational angler traffic during the spring trophy season (mid-April to mid-May). The number of intercepted boats has varied from 137 to 181, number of anglers from 180 to 461, and the number of examined fish from 460 to 510. Biological data collected during the survey includes total length, weight, sex, spawning condition, and age (both scales and otoliths are collected). Other fishing statistics are collected, such as number of hours fished, number of lines fished, boat type, number of anglers per boat, number of fish kept, and number of fish released.

**Recreational Length-Frequencies of Released Fish**

Data on sizes of released striped bass come mostly from state-specific sampling programs. Proportions-at-length are calculated and multiplied by the MRFSS dead discard numbers to obtain total number released dead-at-length. Descriptions of these programs are below.

*Maine*

Release data are collected through the Volunteer Angler Survey, as described in the previous Maine section. DMR has annually supplemented the MRFSS survey with about 5000-8000 length measurements from the Volunteer Angler Survey.

*New Hampshire*

The Fish and Game Department (FGD) uses a striped bass volunteer angler survey for anglers fishing in New Hampshire. Roughly 45-50 volunteer anglers per year report information about each striped bass fishing trip they take that originates in NH. They are asked to measure every striped bass they catch (both harvested and released fish) to the nearest inch. Volunteers report on roughly 1000-1700 trips each year and provide usable measurements on 3500-7000 fish each year. About 95% of the measured fish are released (87% sub-legal size and 8% legal size).

*Massachusetts*

For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month, place the scales in marked coin envelopes, and record the disposition of the each fish (released or harvested), and fishing mode. Over 2,200 samples are received each year from over 100 anglers. Approximately 1,000-1,500 lengths of released striped bass are reported each year.

*Rhode Island*

The size structure of striped bass released from Rhode Island's recreational fishery is based on the American Littoral Society's (ALS) release data for Rhode Island by year.

*Connecticut*

Release data come from the Volunteer Angler Survey, as described in the previous Connecticut section. About 2000-3000 length measurements of released fishes are obtained each year.

*New York*

The ALS release data are used to estimate length distribution. The ALS tags are released all around the marine district of New York all year long. Because fish can be tagged at any size, the Bureau of Marine Resources gets both legal and sub-legal length distributions, both within and outside NY's open recreational season. Thus, the length distribution for harvested fish is from the fish >28 in, and the length distribution for the released fish is from the sub-legal (i.e., <28).

*New Jersey*

Lengths of released striped bass are collected through a volunteer angler survey (VAS), as described in the previous New Jersey section. It is important to note that, although the VAS is primarily administered trough the SBBP, the VAS and the SBBP are independent data sources.

Someone does not need to harvest a Bonus fish or have the Bonus cards in order to participate in, fill out, and submit their logbooks. There is a broad range of participant avidity and apparent skill level – from someone that fishes once or twice a year and does not catch/harvest a single bass to someone that fishes 100 days of the year. The only 'screening/removal' of logbooks for analysis the Bureau of Marine Fisheries conducts is to ensure the logbooks are filled out correctly and contain the proper information. Information on the size composition of harvested and released fish as well as effort (by trip and even hours), CPUE and fishing mode are available by region. (The state is broken down into 30 different regions and each location provided by the fisherman is assigned to one of those areas.) The VAS survey was initiated in 1990 when the NJ Fish and Wildlife initiated the SBBP. VAS provides about 500-1500 length measurements on released fish per year.

In addition to the VAS, length information is also collected through Party/Charter Boat Logbooks, administered through the SBBBP. Each boat that signs up to participate in the SBBP is mailed a logbook as well as the instructions on how to fill it out properly. A Private/Charter boat does not need to use or harvest any SBBP fish to fill out or participate in the logbook survey but they do need to be a participant in the SBBP. Boat owners are asked to fill out a daily trip logbook for each trip they take when targeting striped bass, even if no striped bass are caught; they are not asked to record striped bass information when they are making trips targeting other species. They are asked to record the date, location fished, number of patrons, number of hours fished, lengths of released fish (longest length to the nearest inch), number of released fish, lengths of harvested fish, and number of harvested fish. Logbooks must be completed even if no Bonus Cards are used or all bonus cards have been used for the year. All logbooks are returned by the end of the season. Private/Charter Boat Logbooks were first collected in 1997 and have continued ever since. Much of this data has never been looked at closely or analyzed but all of the information has been entered, checked, and screened for incorrect information.

*Delaware*

The American Littoral Society's release length data for New Jersey are used. About 50 to 300 length measurements are available each year.

*Maryland*

There are two additional sources for size frequency data: a volunteer angler survey and the DNR creel survey during the spring trophy season. Neither of the additional surveys employs statistical design. The DNR creel survey is described in the previous MD section. Maryland DNR has conducted a volunteer angler survey to obtain information on size structure of kept and released striped bass in the recreational fishery since 2000. The areas and time periods covered are defined by the number of responses received from anglers. Anglers are asked to provide information on the date of fishing, number of hours fished, number of anglers in the party, and method of fishing. Anglers also record the total number of striped bass kept and the total number of striped bass released and measure and record the length for the first twenty striped bass caught. A separate form is filled for each trip even if no fish are caught. If more than one survey participant is fishing on the same boat, only one designated individual is asked to fill out the survey form for the group for that day to avoid duplication. The data are submitted to MD DNR either on paper forms or via internet entry. Participation varies from year to year, which is reflected in the total number of entries. The number of reported trips varies between 200 and 300 and the total number of measured fish varies approximately from 600 to 2000 per year. Volunteer angler survey data are combined with the MRFSS information and MD DNR Spring Trophy Survey to characterize size frequency distribution of recreational harvest by wave. Volunteer survey data are the only source for the characterization of the discards. The volunteer survey does not provide age information.

*Virginia*

Data on releases are derived from the MD DNR Volunteer Logbook Survey described above.

*North Carolina*

North Carolina does not collect information on size of releases. Usually, release length frequency data that reflect the release sizes in NC are borrowed from other states.

**Recreational Age Data**

Many states collect scale samples during state sampling programs designed to collect information on harvest and released striped bass from the recreational fishery (described above). For those states that do not collect scale samples, age-length keys are usually borrowed from neighboring states. Detailed descriptions of how age samples are collected are given below.

*Massachusetts*

For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they capture each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month and record the disposition of the each fish (released or harvested) and fishing mode. Over 2,200 samples are received each year from over 100 anglers. The size frequency of released fishes by mode are used to allocate MRFSS release numbers by mode among size classes. A sub-sample of all scale samples collected (about 450-520 fish/yr) are aged and combined with commercial samples (250 fish/yr) and tagging samples (about 150-300 fish/yr) to produce an age-length key used to convert the MRFSS size distribution into age classes. Recreational scale samples are selected using a weighted random design based on the total number of striped bass caught in each wave and mode stratum (as determined by MRFSS).

*New York*

An age-length key is created using data from NY's combined projects: the cooperative angler survey, western Long Island beach seine survey, and a Fall ocean haul seine survey. The cooperative angler (fishery-dependent) data is from both kept and released fish, but the geographical distribution of the samples are biased towards the Western Long Island Sound. Samples are at the pleasure of the cooperating fishers, collected pretty much all year long. Each year, anglers contribute anywhere from 500 to 5,000 samples, over a fairly wide range of sizes. The beach seine survey is a multi-species, fishery-independent survey conducted at fixed sampling sites in bays around the north and south shores of Long Island. Most of the samples are of small juvenile fish, but some larger adult fish are caught. Each year the beach seine survey contributes approximately 1,000 length/age samples collected over the months of April through November. The Fall ocean haul seine survey is a fishery-independent survey conducted at fixed survey sites. The geographic distribution of sampling is biased towards the eastern South Shore of Long Island, during the months of September through December. Each year, about 1,000 to 2,500 samples are collected. The survey samples the adult coastal migratory mixed striped bass stocks. The age-length key created is applied to both legal and sub-legal fish (assumed harvest and discards), broken down into two six-month seasonal keys.

*New Jersey*

New Jersey collects age (scale) samples from harvested fish through the Striped Bass Bonus Program (SBBP), described in previous NJ sections. Once a harvested fish taken under the provision of the SBBP is taken to the nearest authorized check station, the check station may record the weight (lbs) and take scale samples, to augment the non-transferable card, which collects date, location caught, and length information, filed out immediately after harvest by the angler. Party and charter boat captains who participate in the program, allowing for a patron of the boat to harvest a 3rd fish, will also record the data mentioned above and collect scale samples from all harvested Bonus fish. All of this information, both individual and Party/Charter boat harvest, is turned in (mandatory harvest reporting) to the NJ Bureau of Marine Fisheries for monitoring, entry, and analysis.

*Maryland*

Direct age data are available from the creel survey of the trophy fishery only. Both scales and otoliths are collected from the fish examined in creel survey. For periods not covered by the creel survey, an age-length key developed from the samples of commercially harvested fish is applied to recreational length frequency to characterize age structure of the recreational harvest.

*Virginia*

Most age data are collected from the commercial fishery. The sampling group will sometimes sample from one or more recreational tournaments, but not in every year. In 2004, there were two length and age samples; no sampling of tournaments occurred in 2005.

**Recreational Harvest-At-Age**

Recreational harvest-at-age is usually estimated by applying corresponding length-frequency distributions expanded to total numbers of harvest-at-length and age-length keys to the MRFSS number of fish harvested by the recreational anglers in each state. State-specific descriptions of the estimation procedures are below.

*Maine*

DMR uses age-length data collected by MA DMF. The age-length key is applied to the Volunteer Angler Survey lengths, which is then applied to MRFSS estimates of harvested fish.

*New Hampshire*

FGD uses age-length data collected by MA DMF. The age-length key is applied to the Volunteer Angler Survey lengths, which is then applied to MRFSS estimates of harvested fish.

*Massachusetts*

Harvest numbers-at-age are generated by applying total numbers of harvested fish by length to the age-length key as described above.

*Rhode Island*

Age-length data collected by NY DEC and MA DMF are combined to create annual age-length keys. The combined NY-MA age-length key is applied to the expanded length frequencies from RI's recreational fishery to estimate recreational harvest-at-age on an annual basis.

*Connecticut*

The Fisheries Division uses age-length keys from Long Island Sound provided by NY DEC and applies the numbers-at-length obtained from the volunteer angler survey.

*New York*

The MRFSS numbers of harvest and releases by wave are disaggregated by the ALS length frequency distribution (calculated by wave). The numbers at length are added by wave together into two seasonal length distributions. The seasonal length distributions are multiplied by the seasonal length/age keys created (see above) for legal (i.e., >28 inches, harvest) and sub-legal (i.e., <28 inches, releases) fish. The length distributions are adjusted, due to the conversion of ALS data from fork length to total length and the "gaps" which result, by averaging the values before and after the interval with no observed frequency. Next, the numbers are added for each season. Occasionally there is a need to re-adjust for the actual numbers of harvest or releases from MRFSS due to the adjustments and rounding.

*New Jersey*

New Jersey uses the length frequency information gained from the Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational harvest of striped bass and the MRFSS harvest data by season (fall and spring) to expand the length frequency data. A variety of age sources are then used to develop NJ's age-length key by season. For the spring key, age data from NJ's Delaware Bay Striped Bass Tagging Survey (occurs in March – May), NJ's April cruise of the Ocean Trawl Survey, and spring harvested striped bass from the SBBP are used. To develop NJ's fall age-length key, age data from the October cruise of the Ocean Trawl Survey and fall harvested fish from the SBBP are utilized. The appropriate seasonal age-length key is then expanded to the length frequency information to develop NJ's striped bass harvest by age and season.

*Delaware*

For the first half of the year, DFW uses age-length data from the spring spawning stock survey on the Delaware River (electrofishing), plus age-length data from the sample of commercial harvest in spring (gill net). This sums to several hundred fish. For the second half of year, data are limited to a small sample from the fall commercial fishery, plus a score or so of research survey catches, thus New Jersey's age-length data from the SBBP is used.

**Potomac River Fisheries Commission (DC)**

Length and age data collected from the commercial fisheries are used to generate recreational numbers-at-age.

*Maryland*

Length frequency of recreational harvest is characterized using MRFSS, VAS, and creel survey length data. The age-length key derived from the spring spawning survey is applied to length frequency for waves 2 and 3. For waves 4–6, an age length key derived from samples of commercial harvest is used.

*Virginia*

A catch-at-age matrix is developed, starting with an age-length key from the commercial samples of length and weight and proportions of harvested striped bass at length from MRFSS.

*North Carolina*

The NY age-length key is used along with length frequencies to apportion harvest numbers into age classes.

**Recreational Dead Discards-at-Age**

The number of dead discards-at-age is usually estimated by applying corresponding total numbers of dead discards-at-length to age-length keys. State-specific descriptions of the estimation procedures are below.

*Maine*

DMR uses age-length data collected by MA DMF. These data are applied to the Volunteer Angler Survey lengths, which is then applied to the dead discard estimates.

*New Hampshire*

FGD uses age-length data collected by MA DMF. These data are applied to the Volunteer Angler Survey lengths, which is then applied to the dead discard estimates.

*Massachusetts*

Dead discards-at-age are generated by applying total numbers of discards-at-length to the age-length key described above.

*Rhode Island*

Age-length data collected by NY DEC and MA DMF are combined to create annual age-length keys. The combined NY-MA age-length key is applied to the expanded length frequencies from Rhode Island's recreational fishery to estimate recreational releases-at-age on an annual basis.

*Connecticut*

The Fisheries Division uses age-length keys from Long Island Sound provided by NY DEC and applies the dead discards numbers-at-length.

*New York*

The MRFSS numbers of harvest and releases by wave are disaggregate by the ALS length frequency distribution (calculated by wave). The numbers at length are added by wave together into two seasonal length distributions. The seasonal length distributions are multiplied by the seasonal age-length keys created (see previous NY section) for legal (i.e., >28 inches, harvest) and sub-legal (i.e., <28 inches, releases) fish. The length distributions are adjusted, due to the conversion of ALS data from fork length to total length and the "gaps" which result, by averaging the values before and after the interval with no observed frequency. Once complete, the numbers are added for each season. Occasionally there is a need to re-adjust for the actual numbers of harvest or releases from MRFSS due to the adjustments and rounding.

*New Jersey*

New Jersey uses the length frequency information gained from the Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational released striped bass and the MRFSS release data by season (fall and spring) to expand the length frequency data. A variety of age sources are used to develop NJ's age-length key by season. For the spring key, age data from NJ's Delaware Bay Striped Bass Tagging Survey (occurs in March – May), NJ's April cruise of the Ocean Trawl Survey, and spring harvested striped bass from the SBBP are used. To develop NJ's fall age-length key, age data from the October cruise of the Ocean Trawl Survey and fall harvested fish from the SBBP are utilized. The appropriate seasonal age-length key is then expanded to the length frequency information to develop NJ's striped bass dead discards by age and season.

*Delaware*

For the first half of the year, DFW uses the age-length data from the spring spawning stock survey on the Delaware River (electrofishing), plus age-length data from the sample of commercial harvest in spring (gill net). This sums to several hundred fish. For the second half of year, data are limited to a small sample from the fall commercial fishery, plus a score or so of research survey catches, thus New Jersey's age-length data from the SBBP are used.

**Potomac River Fisheries Commission (DC)**

Length and age data collected from the commercial fisheries are used to generate recreational numbers-at-age.

*Maryland*

Length frequency of recreational releases is characterized using MRFSS, VAS, and creel survey length data. The age-length key derived from the spring spawning survey is applied to length frequency for waves 2 and 3. For waves 4–6, an age-length key derived from samples of commercial harvest is used.

*Virginia*

Release numbers (discards from the recreational fishery by spring (Waves 2,3) and summer-fall (Waves 4,5,6)) are apportioned to age classes, using the MD DNR Volunteer Angler Survey proportion of discards-at-age and proportion of discards-at-length, expanded according to seasonal harvest in numbers.

*North Carolina*

The NY age-length key is used, along with length frequencies, to apportion release numbers into age classes.

## Appendix A5a: Analysis and Discussion of the 1998-2002 Striped Bass Coastwide Weight-at-Age

Prepared for the Striped Bass Stock Assessment Sub-Committee Meeting
August 9 – 11, 2005

**Linda S. Barker**
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### Introduction

A crucial element of the yearly catch-age based virtual population analyses (VPA) of Atlantic striped bass is the calculation of biomass of the mixed coastal stock. This calculation requires coastwide weight-at-age (WAA). The coastwide WAA has consistently been calculated as a weighted mean:

State WAA = $\Sigma$ (state WAA * % state CAA by numbers) Eqn. 1

Coastwide WAA = $\Sigma$ (State WAA * state % coastwide CAA) Eqn. 2

The current VPA analysis uses a time series dating back to 1982. The yearly values were not calculated on a yearly basis, however. In 1997, the values for 1982-1997 were developed. These values were developed using data from all states, subdividing each year into quarterly time periods to account for growth, and weighting by numbers of fish. (Details of developing weights at age for 1982 to 1996 can be found in NEFSC Lab Ref. 98-03.) Coastwide WAA was not re-calculated in 1998 or 1999. Instead, the 1997 values were used as these years' values. The 2000, 2001 and 2002 coastwide WAA were developed at the Stock Assessment Subcommittee Workshops, weighted by total weight of fish, using readily available data sets. Therefore, the methodology and data sets used for these calculations were not consistent, either with the methodology used for the 1982-1997 WAA or with each other. The 2000-2002 values showed an apparent decline in WAA, but it was impossible to determine if this apparent trend was due to the change in method or a true change in WAA.

In 2004, a standardized report format was developed that calculated WAA as part of the CAA calculations. The 2003 coastwide WAA was developed using all states' data:

- Maine and New Hampshire recreational harvest and discards,
- Massachusetts recreational and commercial catch,
- Rhode Island recreational and commercial catch,
- Connecticut recreational catch,
- New York recreational catch and commercial landings,
- New Jersey recreational catch,
- Delaware recreational and commercial catch,
- Maryland recreational and commercial catch,
- Virginia recreational and commercial catch, and
- North Carolina recreational and commercial catch.

An apparent decline was observed between the 2001and 2002 coastwide WAA – only 2 of 13 age-classes of harvested fish did not show a reduction in WAA (Table 1). Due to concerns about this apparent decrease in coastwide WAA and the inability to compare 1998-2002 with the rest of the time series, the subcommittee decided to re-calculate these coastwide WAA values.

**Methods: Recalculation of the 1998-2002 values.**

All states were requested to provide the 1998-2002 time series of WAA, landings and discards. Because information was not received from all states, it was decided to develop the coastwide WAA from information for states with greatest catch. For 1998-2001, the coastwide WAA was calculated using the 5 major harvester states (MA, NY, NJ, MD, VA), NH and CT (Table 2). For 2002, data were available to include RI and DE (Table 3). WAA was calculated as the weighted mean, weighted by numbers for commercial harvest, recreational harvest, and recreational discard. Annual state removals were taken from the time series tables for commercial harvest, recreational harvest and recreational discard numbers in the 2004 coastwide compliance report summary prepared by Gary Sheppard if not provided by state. WAA for the nearest neighboring state was used if that state's WAA was not available. The oldest age group was designated "13+", and 1982-1997 "13+" values were recalculated as the arithmetic averages of 13- to 15-year-old age class values. A constraint imposed by the 1998-2002 data was that an annual time frame was used for all calculations, as opposed to the finer time frame used in the 1982-1997 and 2003 calculations. The time series matrix of WAA including re-calculated values is presented in Table 4.

**Discussion**

The apparent decrease in WAA from 2000 - 2002 within the "old" WAA time series. Most age classes showed a decrease between 2000 and 2002 (14 of 15 age-classes) (Table 2). However, examination of the development of the WAA revealed that this decrease was due to differences in the development of the values. Because average WAA is greater for coastal than Chesapeake Bay states for all harvested age classes, calculations are skewed if the harvest proportion is not used in the WAA calculations.

**Evaluation of the apparent decline between 2001-2002 values**

The 1982-1997 coastwide WAA time series was developed using all states' data. In contrast, the 2001 coastwide WAA was developed without data from RI, CT, MD and NC. Due to comparatively low harvest, RI, CT and NC do not contribute strongly to the coastwide WAA. However, the exclusion of MD data from the 2001 calculation had a major influence on the coastwide value. Without the MD numbers factoring in to the average, the coastwide WAA was disproportionately weighted by MA (Figure 1, Table 5). This is significant because MD is a Chesapeake Bay harvest state and MA is a coastal harvest state. Based on data from 1982-1997, the majority of fish harvested in Chesapeake Bay (ages 3–11) were, on average, 2.6 kg (5.7 lb) smaller than coastal fish (Table 6). The unnaturally strong contribution of MA in the 2001 WAA, followed by the strong contribution of MD fish in the 2002 WAA, certainly contributed to the observed decline in the coastwide WAA.

**Patterns in WAA from 2000–2003 within the recalculated WAA time series**

Coastwide WAA values for 2000 to 2002 were recalculated using a consistent method that was considered functionally equivalent to the method used for earlier calculations. Although a subset of states was used, these states constitute the majority of the harvest and therefore maintained the overall harvest proportion throughout the WAA calculations. In contrast to the earlier values, these values showed a consistent increase across the 2000–2003 time frame (Table 4). Between 2000 and 2001, 11 of the 13 age classes showed an increase in WAA, between 2002 and 2003, 12 of the 13 age classes showed an increase in WAA. The 2003 WAA was developed from information provided by all states for the 2003 stock assessment. Comparison of the 2003 WAA against the mean values for 2000-2002 showed an increase in 11 of 13 age classes.

Comparison of "old" vs. recalculated WAA values from 2000 – 2002. Although the recalculated WAA values showed an increase across the 2000-2003 time frame, these values were lower than the mean of the 1982-1996 time series (Table 7).

**Future Work**

Future years' WAA will be calculated from information provided in stock assessment "Compliance Report Template", and will therefore include all states' data. No recommendations are suggested to improve calculation methodology for future years.

It would be useful to determine if there truly was a decrease between the 1982-96 WAA and the 1998-2003 WAA. However, data are not available to recalculate 1982-2002 WAA using the current method, nor are data available to recalculate 2000-03 using the earlier method.

## Appendix A5a Figures

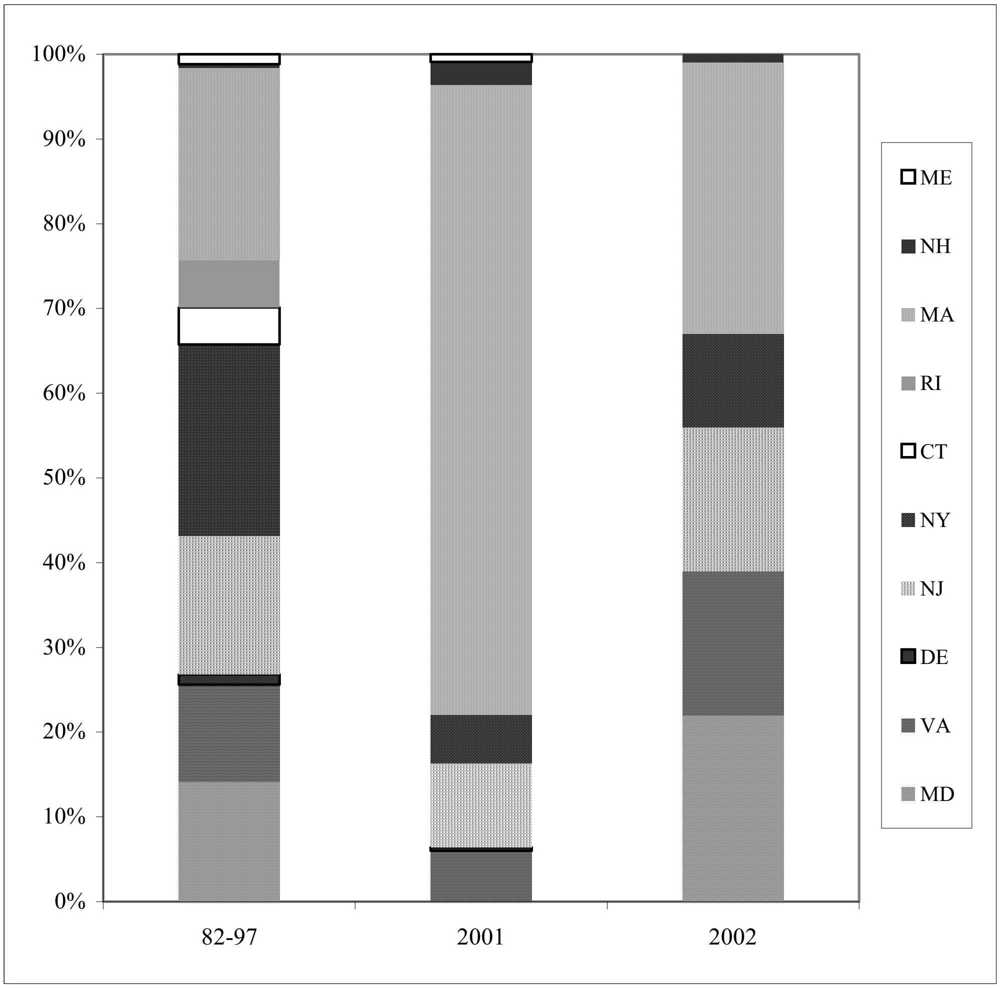



Figure 1. Composition of Striped Bass Coastwide WAA by State. 1982-1997 coastwide WAA shows a fairly even distribution from the 5 major harvest (by numbers) states (MA, NY, NJ, MD, VA). 2001 WAA is dominated by MA. 2002 WAA shows a strong contribution from MD and VA (Chesapeake Bay harvest states).

## Appendix A5a Tables

Table 1. Striped Bass Coastwide WAA (kg) Time Series Used for the 2002 Stock Assessment. 1997-1999 values are identical. Note the apparent decline in WAA between 2001-2002.

| | | | | | | | Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1982 | 0.13 | 0.64 | 1.09 | 1.54 | 2.42 | 3.75 | 4.83 | 5.79 | 6.20 | 8.68 | 10.80 | 11.20 | 12.97 | 13.26 | 15.91 |
| 1983 | 0.20 | 0.55 | 0.94 | 1.37 | 2.37 | 3.29 | 3.77 | 5.36 | 6.01 | 8.10 | 9.57 | 10.39 | 11.11 | 11.10 | 11.12 |
| 1984 | 0.24 | 0.60 | 1.69 | 1.62 | 2.67 | 3.39 | 5.07 | 5.65 | 6.76 | 7.76 | 8.41 | 12.65 | 10.65 | 11.75 | 14.75 |
| 1985 | 0.06 | 0.61 | 1.07 | 1.66 | 2.19 | 3.59 | 4.91 | 5.46 | 6.77 | 7.45 | 9.00 | 10.69 | 11.42 | 14.34 | 15.98 |
| 1986 | 0.14 | 0.57 | 1.27 | 2.40 | 2.44 | 3.12 | 3.95 | 5.05 | 5.44 | 6.09 | 7.75 | 9.16 | 10.97 | 11.55 | 15.83 |
| 1987 | 0.20 | 0.77 | 1.41 | 2.11 | 2.50 | 2.91 | 3.61 | 4.74 | 5.52 | 6.49 | 7.77 | 9.78 | 11.38 | 11.62 | 16.46 |
| 1988 | 0.31 | 0.91 | 1.10 | 1.98 | 3.12 | 4.02 | 4.38 | 4.70 | 5.24 | 5.62 | 8.58 | 10.40 | 11.50 | 11.31 | 17.00 |
| 1989 | 0.16 | 0.83 | 1.22 | 2.23 | 3.06 | 4.53 | 5.37 | 6.23 | 6.04 | 8.68 | 8.94 | 9.74 | 13.04 | 9.93 | 17.11 |
| 1990 | 0.08 | 0.89 | 1.14 | 2.05 | 2.35 | 3.83 | 4.91 | 5.96 | 5.70 | 5.97 | 7.44 | 9.08 | 9.36 | 10.80 | 17.65 |
| 1991 | 0.21 | 0.92 | 1.29 | 2.17 | 2.62 | 3.17 | 4.81 | 5.64 | 6.46 | 6.24 | 9.46 | 8.30 | 9.62 | 15.96 | 17.09 |
| 1992 | 0.10 | 0.69 | 1.31 | 1.93 | 2.81 | 3.67 | 4.90 | 5.79 | 6.96 | 8.15 | 9.77 | 12.44 | 13.10 | 11.15 | 17.65 |
| 1993 | 0.07 | 0.76 | 1.31 | 1.99 | 2.77 | 3.58 | 4.80 | 6.11 | 7.03 | 8.01 | 9.53 | 10.76 | 14.45 | 13.85 | 15.36 |
| 1994 | 0.24 | 1.05 | 1.69 | 2.21 | 2.85 | 3.50 | 4.94 | 6.20 | 6.80 | 7.53 | 9.73 | 10.69 | 11.38 | 9.06 | 17.75 |
| 1995 | 0.28 | 0.70 | 1.35 | 2.18 | 2.77 | 3.65 | 5.38 | 6.16 | 7.27 | 8.86 | 7.57 | 9.73 | 13.97 | 15.65 | 20.37 |
| 1996 | 0.14 | 1.05 | 1.47 | 2.32 | 3.23 | 4.52 | 6.39 | 7.11 | 7.81 | 9.20 | 9.31 | 10.10 | 11.36 | 12.45 | 17.30 |
| 1997 | 0.13 | 0.62 | 1.18 | 2.46 | 2.81 | 3.64 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 1998 | 0.13 | 0.62 | 1.18 | 2.46 | 2.81 | 3.64 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 1999 | 0.13 | 0.62 | 1.18 | 2.46 | 2.81 | 3.64 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 2000 | 0.14 | 1.05 | 1.47 | 2.32 | 3.23 | 4.52 | 6.39 | 7.11 | 7.81 | 9.20 | 9.31 | 10.10 | 11.36 | 12.45 | 17.30 |
| 2001 | 0.13 | 0.62 | 1.17 | 2.46 | 2.81 | 3.63 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 2002 | 0.82 | 0.81 | 1.25 | 1.75 | 2.47 | 3.30 | 4.16 | 5.48 | 6.36 | 7.45 | 8.75 | 8.89 | 9.99 | 11.03 | 13.95 |

Table 2. Revised Time Series of Striped Bass Coastwide WAA (kg).

| Year | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13+** |
| 1982 | 0.1 | 0.6 | 1.1 | 1.5 | 2.4 | 3.7 | 4.8 | 5.8 | 6.2 | 8.7 | 10.8 | 11.2 | 14.0 |
| 1983 | 0.2 | 0.6 | 0.9 | 1.4 | 2.4 | 3.3 | 3.8 | 5.4 | 6.0 | 8.1 | 9.6 | 10.4 | 11.1 |
| 1984 | 0.2 | 0.6 | 1.7 | 1.6 | 2.7 | 3.4 | 5.1 | 5.7 | 6.8 | 7.8 | 8.4 | 12.7 | 12.4 |
| 1985 | 0.1 | 0.6 | 1.1 | 1.7 | 2.2 | 3.6 | 4.9 | 5.5 | 6.8 | 7.4 | 9.0 | 10.7 | 13.9 |
| 1986 | 0.1 | 0.6 | 1.3 | 2.4 | 2.4 | 3.1 | 4.0 | 5.0 | 5.4 | 6.1 | 7.8 | 9.2 | 12.8 |
| 1987 | 0.2 | 0.8 | 1.4 | 2.1 | 2.5 | 2.9 | 3.6 | 4.7 | 5.5 | 6.5 | 7.8 | 9.8 | 13.2 |
| 1988 | 0.3 | 0.9 | 1.1 | 2.0 | 3.1 | 4.0 | 4.4 | 4.7 | 5.2 | 5.6 | 8.6 | 10.4 | 13.3 |
| 1989 | 0.2 | 0.8 | 1.2 | 2.2 | 3.1 | 4.5 | 5.4 | 6.2 | 6.0 | 8.7 | 8.9 | 9.7 | 13.4 |
| 1990 | 0.1 | 0.9 | 1.1 | 2.1 | 2.4 | 3.8 | 4.9 | 6.0 | 5.7 | 6.0 | 7.4 | 9.1 | 12.6 |
| 1991 | 0.2 | 0.9 | 1.3 | 2.2 | 2.6 | 3.2 | 4.8 | 5.6 | 6.5 | 6.2 | 9.5 | 8.3 | 14.2 |
| 1992 | 0.1 | 0.7 | 1.3 | 1.9 | 2.8 | 3.7 | 4.9 | 5.8 | 7.0 | 8.2 | 9.8 | 12.4 | 14.0 |
| 1993 | 0.1 | 0.8 | 1.3 | 2.0 | 2.8 | 3.6 | 4.8 | 6.1 | 7.0 | 8.0 | 9.5 | 10.8 | 14.6 |
| 1994 | 0.2 | 1.1 | 1.7 | 2.2 | 2.9 | 3.5 | 4.9 | 6.2 | 6.8 | 7.5 | 9.7 | 10.7 | 12.7 |
| 1995 | 0.3 | 0.7 | 1.3 | 2.2 | 2.8 | 3.7 | 5.4 | 6.2 | 7.3 | 8.9 | 7.6 | 9.7 | 16.7 |
| 1996 | 0.1 | 1.0 | 1.5 | 2.3 | 3.2 | 4.5 | 6.4 | 7.1 | 7.8 | 9.2 | 9.3 | 10.1 | 13.7 |
| 1997 | 0.1 | 0.6 | 1.2 | 2.5 | 2.8 | 3.6 | 4.5 | 5.1 | 6.7 | 9.2 | 9.9 | 10.2 | 14.8 |
| 1998 | 0.4 | 0.8 | 1.2 | 1.6 | 2.2 | 2.9 | 4.7 | 5.7 | 6.8 | 7.0 | 7.8 | 9.9 | 11.9 |
| 1999 | 0.6 | 0.9 | 1.1 | 1.4 | 1.9 | 2.5 | 3.4 | 5.0 | 6.6 | 7.8 | 8.7 | 9.8 | 12.0 |
| 2000 | 0.4 | 0.6 | 1.1 | 1.5 | 2.0 | 2.8 | 3.9 | 5.1 | 7.1 | 7.4 | 9.7 | 10.7 | 13.6 |
| 2001 | 0.2 | 0.4 | 1.1 | 1.8 | 2.2 | 3.2 | 4.1 | 5.0 | 6.4 | 7.8 | 8.6 | 8.3 | 10.9 |
| 2002 | 0.1 | 0.3 | 1.1 | 1.5 | 2.2 | 3.2 | 4.2 | 5.5 | 6.0 | 7.6 | 9.1 | 9.7 | 11.5 |

Table 3. Comparison of 2001& 2002 Data Used to Develop Striped Bass Coastwide WAA.

| STATE | 2001 | | | 2002 | | |
|---|---|---|---|---|---|---|
| | SURVEYS | % WAA | % HARVEST | SURVEYS | % WAA | % HARVEST |
| ME | COMM (harv, discards) | 1 | 1 | X | 0 | 2 |
| NH | COMM (harv, discards) | 3 | 1 | REC | 1 | 1 |
| MA | COMBINED | 74 | 16 | COMBINED | 32 | 20 |
| RI | X | 0 | 5 | X | 0 | 5 |
| CT | X | 0 | 3 | X | 0 | 3 |
| NY | COMM & REC | 6 | 13 | COMM & REC | 11 | 13 |
| NJ | REC | 10 | 23 | REC | 17 | 19 |
| DE | COMM | <1 | 2 | X | 0 | 1 |
| MD | X | 0 | 17 | COMM (C.BAY) | 22 | 15 |
| VA | COMM & REC | 6 | 17 | COMM & REC | 17 | 19 |
| NC | X | 0 | 3 | X | 0 | 3 |

Table 4. Comparison of Average Striped Bass WAA (lb) for "Coastal" (MA, NY, NJ) and "Chesapeake Bay" (MD and VA) States, based 1982-1997 Values.

| Age | Coastal | CBay | Δ |
|---|---|---|---|
| **1** | 1.8 | | |
| **2** | 1.9 | 2.3 | -0.4 |
| **3** | 3.3 | 2.4 | 0.9 |
| **4** | 4.7 | 2.7 | 2.0 |
| **5** | 6.7 | 3.5 | 3.2 |
| **6** | 8.3 | 5.5 | 2.8 |
| **7** | 10.1 | 7.4 | 2.8 |
| **8** | 12.9 | 10.4 | 2.5 |
| **9** | 14.9 | 12.3 | 2.6 |
| **10** | 17.4 | 14.1 | 3.4 |
| **11** | 20.4 | 17.3 | 3.0 |
| **12** | 22.8 | 14.9 | 7.8 |
| **13** | 24.9 | 17.7 | 7.2 |
| **14** | 27.9 | 19.4 | 8.5 |
| **15** | 35.1 | 15.8 | 19.4 |

Table 5. Information Used to Calculate 1998-2002 Striped Bass Coastwide WAA.

| REMOVAL | YEARS | HARVEST-AT-AGE | Pre-calculated WAA |
|---|---|---|---|
| NH Rec landings | 98-02 | supplied | used MA |
| NH Rec discards | 98-02 | supplied | used MA |
| MA Rec landings | 98-02 | supplied | supplied |
| MA Rec discards | 98-02 | supplied | supplied |
| MA Com landings | 98-02 | supplied | supplied |
| MA Com discards | 98-02 | supplied | supplied |
| RI Com landings | 2002 | supplied | used MA |
| RI Rec landings | 2002 | supplied | used MA |
| RI Rec discards | 2002 | supplied | used MA |
| CT Rec landings | 98-02 | GaryN CAA[3] | used MA |
| CT Rec discards | 98-00,02 | GaryN CAA[3] | used MA |
| NY all | 98-00 | | |
| NY Com landings | 01-02 | 01,02 Ann. Rpts. | 01,02 Ann. Rpts. |
| NY Rec landings | 01-02 | 01,02 Ann. Rpts. | 01,02 Ann. Rpts. |
| NY Rec discards | 01-02 | 01,02 Ann. Rpts. | 01,02 Ann. Rpts. |
| NJ Rec landings | 98-01 | | |
| NJ Rec discards | 98-01 | % of harvest #s[1] | % of harvest WAA[2] |
| NJ ALL | 2002 | supplied | supplied |
| Del Com landings | 2002 | GaryN CAA[3] | used NY |
| Del Rec landings | 2002 | GaryN CAA[3] | used NJ |
| MD Com landings | 98-02 | supplied | supplied |
| MD Rec landings | 98-02 | | |
| MD Rec discards | 98-02 | | |
| VA Com landings | 98-00,02 | GaryN CAA[3] | used MD |
| VA Rec landings | 98-00,02 | GaryN CAA[3] | used MD |
| VA Rec discards | 98-00,02 | GaryN CAA[3] | used MD |
| VA ALL | 2001 | GaryN CAA[3] | used MD |

[1] (rec harvest-at-age)*(rec discard-at-age)/(total harvest)
[2] Ages 2-5: discard WAA = 0.8*harvest WAA, Ages 6+: discard WAA = 0.9*harvest WAA
[3] Coastwide summary CAA document supplied by Gary Nelson

Table 6. Removals Used to Calculate 1998-2002 Striped Bass Coastwide WAA.

| 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|
| NH Rec landings | NH Rec landings | NH Rec landings | NH Rec landings | NH Rec landings |
| NH Rec discards | NH Rec discards | NH Rec discards | NH Rec discards | NH Rec discards |
| MA Rec landings | MA Rec landings | MA Rec landings | MA Rec landings | MA Rec landings |
| MA Rec discards | MA Rec discards | MA Rec discards | MA Rec discards | MA Rec discards |
| MA Com landings | MA Com landings | MA Com landings | MA Com landings | MA Com landings |
| MA Com discards | MA Com discards | MA Com discards | MA Com discards | MA Com discards |
| | | | | RI Com landings |
| | | | | RI Rec landings |
| | | | | RI Rec discards |
| CT Rec landings | CT Rec landings | CT Rec landings | CT Rec landings | CT Rec landings |
| CT Rec discards | CT Rec discards | CT Rec discards | | CT Rec discards |
| NY all | NY all | NY ALL | NY Com landings | NY Com landings |
| | | | NY Rec landings | NY Rec landings |
| | | | NY Rec discards | NY Rec discards |
| NJ Rec landings | NJ Rec landings | NJ Rec landings | NJ Rec landings | NJ ALL |
| NJ Rec discards | NJ Rec discards | NJ Rec discards | NJ Rec discards | |
| | | | | Del Com landings |
| | | | | Del Rec landings |
| MD Com landings | MD Com landings | MD Com landings | MD Com landings | MD Com landings |
| MD Rec landings | MD Rec landings | MD Rec landings | MD Rec landings | MD Rec landings |
| MD Rec discards | MD Rec discards | MD Rec discards | MD Rec discards | MD Rec discards |
| VA Com landings | VA Com landings | VA Com landings | VA ALL | VA Com landings |
| VA Rec landings | VA Rec landings | VA Rec landings | | VA Rec landings |
| VA Rec discards | VA Rec discards | VA Rec discards | | VA Rec discards |

[1] (rec harvest-at-age)*(rec discard-at-age)/(total harvest)
[2] Ages 2-5: discard WAA = 0.8*harvest WAA, Ages 6+: discard WAA = 0.9*harvest WAA
[3] Coastwide summary CAA document supplied by Gary Nelson

Table 7. Comparison of "Old" and "New", or Recalculated Striped Bass Coastwide WAA (kg) for 2000-2003.

| | YEAR / AGE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13/13+ | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OLD | **2000** | 0.14 | 1.05 | 1.47 | 2.32 | 3.23 | 4.52 | 6.39 | 7.11 | 7.81 | 9.2 | 9.31 | 10.1 | 11.36 | 12.45 | 17.3 |
| | **2001** | 0.13 | 0.62 | 1.17 | 2.46 | 2.81 | 3.63 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| | **2002** | 0.82 | 0.81 | 1.25 | 1.75 | 2.47 | 3.3 | 4.16 | 5.48 | 6.36 | 7.45 | 8.75 | 8.89 | 9.99 | 11.03 | 13.95 |
| | **MEAN 00-02** | 0.36 | 0.83 | 1.30 | 2.18 | 2.84 | 3.82 | 5.02 | 5.89 | 6.97 | 8.61 | 9.33 | 9.74 | 11.10 | 12.66 | 16.39 |
| | **Δ 2002 - 2001** | 0.69 | 0.19 | 0.08 | *-0.71* | *-0.34* | *-0.33* | *-0.35* | 0.41 | *-0.37* | *-1.72* | *-1.19* | *-1.35* | *-1.95* | *-3.46* | *-3.97* |
| | **Δ 2002 - 2000** | 0.68 | *-0.24* | *-0.22* | *-0.57* | *-0.76* | *-1.22* | *-2.23* | *-1.63* | *-1.45* | *-1.75* | *-0.56* | *-1.21* | *-1.37* | *-1.42* | *-3.35* |
| NEW | **2000** | 0.2 | 0.6 | 0.9 | 1.4 | 1.9 | 2.8 | 4 | 4.9 | 6.1 | 6 | 8.8 | 9.8 | 12.8 | | |
| | **2001** | 0.1 | 0.4 | 0.8 | 1.7 | 2.2 | 3.2 | 4 | 5 | 5.9 | 7.2 | 8.1 | 7.4 | 10.6 | | |
| | **2002** | 0.1 | 0.3 | 1.1 | 1.5 | 2.2 | 3.2 | 4.2 | 5.5 | 6.0 | 7.6 | 9.1 | 9.7 | 11.5 | | |
| | **2003** | 0.1 | 0.6 | 1.0 | 1.4 | 2.2 | 3.2 | 4.1 | 5.2 | 6.1 | 7.2 | 8.5 | 9.4 | 11 | | |
| NEW VS. OLD | **Δ 2000(N) - 2000(O)** | 0.06 | *-0.45* | *-0.57* | *-0.92* | *-1.33* | *-1.72* | *-2.39* | *-2.21* | *-1.71* | *-3.2* | *-0.51* | *-0.3* | 1.44 | | |
| | **Δ 2001(N) - 2001(O)** | *-0.03* | *-0.22* | *-0.37* | *-0.76* | *-0.61* | *-0.43* | *-0.51* | *-0.07* | *-0.83* | *-1.97* | *-1.84* | *-2.84* | *-1.34* | | |
| | **Δ 2002(N) - 2002(O)** | *-0.72* | *-0.51* | *-0.15* | *-0.25* | *-0.27* | *-0.10* | 0.04 | 0.02 | *-0.36* | 0.15 | 0.35 | 0.81 | *-0.16* | | |
| | **MEAN 82-96** | 0.2 | 0.8 | 1.3 | 2.0 | 2.7 | 3.6 | 4.8 | 5.7 | 6.4 | 7.5 | 8.9 | 10.3 | 13.5 | | |
| | **Δ 2003 - MEAN 82-96** | *-0.07* | *-0.17* | *-0.29* | *-0.58* | *-0.48* | *-0.43* | *-0.7* | *-0.53* | *-0.3* | *-0.32* | *-0.41* | *-0.94* | *-2.5* | | |

Negative values emphasized by italics.

**Appendix 5b: Analysis of the 2005-2006 Striped Bass Coastwide Weight-at-Age**

**Prepared for the**
**Striped Bass Stock Assessment Sub-Committee**
**by**
**Linda S. Barker and Lisa Warner**
**Maryland DNR Fisheries Service**

**FINAL**

*September 7, 2007*

## Introduction

This report presents the results of the 2005-2006 update of the Atlantic coastwide weight-at-age (WAA) analysis for striped bass. This analysis followed the procedure outlined in "Analysis and Discussion of the 1998-2002 Striped Bass Coastwide Weight-at-Age", prepared for the Striped Bass Stock Assessment Sub-Committee meeting August 9 – 11, 2005 by Linda S. Barker of Maryland DNR Fisheries Service. The data for these calculations were provided through the annual compliance report's catch-at-age (CAA) spreadsheet. This standardized template has been in use since 2004.

## Methods

It should be noted that although these calculations were performed exactly the same as those in 2005, the equation provided in the 2005 document was incorrect. The coastwide WAA was calculated as the ratio of (total weight of fish caught) to (total number of fish caught) for each age.

Subsequent analyses were performed on the WAA for the individual state fishery elements. WAA for a fishery element was calculated as the ratio of the total weight of fish harvested or discarded by that fishery element to the total number of fish harvested or discarded by that fishery element for each age. The following fishery elements were included in the calculation of the 2005 and 2006 coastwide WAA:

- Maine recreational harvest and discards,
- New Hampshire recreational harvest and discards,
- Massachusetts recreational harvest and discards and commercial harvest and discards,
- Rhode Island recreational harvest and discards and commercial harvest and discards,
- Connecticut recreational harvest and discards,
- New York recreational catch and commercial landings,
- New Jersey recreational harvest and discards,
- Delaware recreational harvest and discards and commercial harvest and discards,
- Maryland recreational harvest and discards and commercial harvest and discards,
- PRFC recreational harvest and commercial harvest,
- Virginia recreational harvest and discards and commercial harvest and discards, and
- North Carolina recreational harvest and discards and commercial harvest and discards.

**Results and Discussion**

Summary information for the coastwide CAA and WAA are shown in the attached tables and figures. Tables 1 - 4 provide the values used in the calculation of coastwide WAA – the total catch at age, the total weight of catch at age, and the ratio WAA value. The 2006 and 2005 coastwide values are provided in both pounds (Tables 1 and 3) and kilograms (Tables 2 and 4). The distributions of the 2005 and 2006 coastwide mean CAA are presented in both numbers of fish (Fig 1) and pounds (Fig 2). The distributions of the 2005 and 2006 coastwide mean WAA are presented in both pounds (Fig 3) and kg (Fig 4).

The WAA time series is provided in Table 5, but the 2003 and 2004 values are missing. These values need to be checked and updated and will be added later.

The 2005 and 2006 fishery-based tables demonstrate details of analysis. The coastwide CAA is divided into the fishery elements (recreational harvest, recreational discards, and commercial harvest in each state) in Tables 6A and 6B (numbers of fish) and Tables 7A and 7B (pounds of fish). Commercial discard data were not included in this analysis. Tables 8A and 8B present the proportional contribution of each fishery element to the coastwide CAA in 2006 and 2005.

The 2006 coastwide CAA by fishery (Table 8A) shows a shift in the proportional contribution to the coastwide catch at approximately age 6. The catch of younger fish (ages 2-6) was dominated by recreational discards. The ranges of contribution to the coastwide catch for ages 2-6 were: MD (2-51%), VA (0-36%), MA (14-25%) and ME (9-18%). The range in recreational harvest of the Bay states was also significant: MD (0-17%) and VA (0-14%). MD's commercial harvest (8-24%) was the third significant contributor to the catch for the younger ages. The catch of older fish (ages 6+) was dominated by recreational harvest. Most of the recreational harvest at each of the older ages was in the northern states: MA (13-18%), NY and NJ (both 10-13%) and CT (8-10%). The exception was MD (8-26%). 2005 numbers are shown in Table 8B.

These shifts in proportional contribution to the coastwide catch show a differential effect on the coastwide WAA. This emphasizes the importance of the accuracy of age assignments and age-length keys (ALK) among the states. In addition, some states use the ALK from a neighboring state, so the coastwide effect of those states' information is compounded. The tools and information supplied by MD, MA, NY and NJ account for the greatest overall contribution to the WAA calculations.

Figures 5A-5L show mean WAA (2-13+ years) by state and fishery element. These figures clearly show that most fisheries reported similar WAA for each age, but there were exceptions. Some fishery values were not biologically reasonable (Appendix A). Because the growth equations supplied in the state spreadsheets indicated that striped bass all along the coast are growing at similar rates, these outliers indicate possible age-related errors.

There was an apparent difference in WAA for coastal and Chesapeake Bay states in 2005 and 2006, but this did not appear to be a biological difference. 2006 WAA show wide ranges among the younger ages: age 3 (1.4 – 4.8 lbs., Figure 5B), age 4 (1.9 - 10.2 lbs., Figure 5C) and age 5 (3.1 - 11.1 lbs., Figure 5D), between states and years. This does not appear to be due to an actual difference in growth rates (i.e., females on the coast growing much faster) because growth curves indicate similar growth patterns between all states. A specific example using age 4 fish in 2006 illustrates the difference: mean weight of a NY recreational harvest fish is 10 lbs., while a ME fish of the same age weighs 2.9 lbs., and a fish from MD or VA weighs approximately 2.5 lbs. (Figure 5C). A comparison was made of coastal ALKs for recreational discards against the

MD spring ALK. The MD spring ALK should represent the complete stock on the spawning ground and should therefore contain the majority of the coastal fish. The WAA for DE, CT, NY and NJ were shifted outside of the MD minimum and maximum values for younger ages. While the young females are not encountered on the MD spawning grounds, they are sampled during a spring/early summer recreational creel survey. Mean WAAs from these data are much lower than those seen on the coast. Again, since each state's growth curves show similar patterns, these large differences in mean weight at age may be due to ageing error and should be further evaluated to provide an explanation of the differences between states.

These differences in WAA among fisheries prompted further investigation into the compliance report spreadsheets. Several errors were discovered in age-length keys and cell entries that required adjustment. Even after these corrections, the final results indicate that there may be some effects from ageing errors. See Appendix A for further details.

## Appendix 5b Tables

Table 1. 2006 Atlantic coastwide striped bass weights at age (pounds). * calculated from total numbers and total weights

| 2006<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Harvest (Fish) 2006 | 15 | 33,806 | 226,091 | 1,142,739 | 632,900 | 1,052,055 | 670,060 | 341,169 | 333,025 | 332,892 | 424,426 | 288,268 | 169,550 | 182,478 | **5,829,474** |
| Total Wt. (Lbs.) 2006 | 0 | 16,522 | 242,467 | 2,079,375 | 1,965,837 | 4,877,206 | 4,155,669 | 3,083,536 | 3,613,561 | 4,570,353 | 6,588,685 | 5,163,478 | 3,356,854 | 4,463,092 | **44,176,635** |
| WAA (Lbs.) 2006 | 0.01 | 0.49 | 1.07 | 1.82 | 3.11 | 4.64 | 6.20 | 9.04 | 10.85 | 13.73 | 15.52 | 17.91 | 19.80 | 24.46 | |

Table 2. 2006 Atlantic coastwide striped bass weights at age (kg). * calculated from total numbers and total weights

| 2006<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Catch (Fish) 2006 | 15 | 33,806 | 226,091 | 1,142,739 | 632,900 | 1,052,055 | 670,060 | 341,169 | 333,025 | 332,892 | 424,426 | 288,268 | 169,550 | 182,478 | **5,829,474** |
| Total Wt. (Kgs.) 2006 | 0 | 7,494 | 109,981 | 943,189 | 891,689 | 2,212,263 | 1,884,980 | 1,398,668 | 1,639,084 | 2,073,077 | 2,988,577 | 2,342,114 | 1,522,643 | 2,024,425 | **20,038,185** |
| WAA (Kgs.) 2006 | 0.01 | 0.22 | 0.49 | 0.83 | 1.33 | 2.02 | 2.80 | 4.10 | 4.91 | 6.22 | 7.03 | 8.12 | 8.98 | 11.09 | |

Table 3. 2005 Atlantic coastwide striped bass weights at age (pounds). * calculated from total numbers and total weights

| 2005<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Catch (Fish) 2005 | 75 | 18,261 | 446,254 | 317,592 | 859,555 | 787,390 | 444,234 | 361,636 | 328,166 | 412,818 | 296,104 | 248,357 | 115,046 | 132,895 | **4,768,383** |
| Total Wt. (Lbs.) 2005 | 8 | 5,815 | 572,054 | 727,494 | 2,911,356 | 3,691,836 | 3,034,246 | 3,119,694 | 3,897,877 | 5,600,426 | 4,376,674 | 4,350,654 | 2,260,358 | 3,436,972 | **37,985,465** |
| WAA (Lbs.) 2005 | 0.09 | 0.30 | 1.13 | 2.31 | 3.29 | 4.52 | 6.78 | 8.63 | 11.73 | 14.17 | 16.40 | 19.13 | 21.72 | 24.56 | |

Table 4. 2005 Atlantic coastwide striped bass weights at age (kg). * calculated from total numbers and total weights

| 2005<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Catch (Fish) 2005 | 75 | 18,261 | 446,254 | 317,592 | 845,159 | 760,655 | 429,839 | 352,587 | 317,883 | 407,471 | 295,693 | 248,357 | 115,046 | 132,895 | **4,687,768** |
| Total Wt. (Kgs.) 2005 | 4 | 2,637 | 259,479 | 329,986 | 1,320,569 | 1,674,589 | 1,376,311 | 1,415,069 | 1,768,047 | 2,540,310 | 1,985,226 | 1,973,424 | 1,025,281 | 1,558,984 | **17,229,917** |
| WAA (Kgs.) 2005 | 0.05 | 0.14 | 0.58 | 1.04 | 1.56 | 2.20 | 3.20 | 4.01 | 5.56 | 6.23 | 6.71 | 7.95 | 8.91 | 11.73 | |

Table 5. 1982-2006 striped bass Atlantic coastwide weights at age (kg) time series (less 2003 and 2004).

| Year | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
| 1982 | 0.1 | 0.6 | 1.1 | 1.5 | 2.4 | 3.7 | 4.8 | 5.8 | 6.2 | 8.7 | 10.8 | 11.2 | 14.0 |
| 1983 | 0.2 | 0.6 | 0.9 | 1.4 | 2.4 | 3.3 | 3.8 | 5.4 | 6.0 | 8.1 | 9.6 | 10.4 | 11.1 |
| 1984 | 0.2 | 0.6 | 1.7 | 1.6 | 2.7 | 3.4 | 5.1 | 5.7 | 6.8 | 7.8 | 8.4 | 12.7 | 12.4 |
| 1985 | 0.1 | 0.6 | 1.1 | 1.7 | 2.2 | 3.6 | 4.9 | 5.5 | 6.8 | 7.4 | 9.0 | 10.7 | 13.9 |
| 1986 | 0.1 | 0.6 | 1.3 | 2.4 | 2.4 | 3.1 | 4.0 | 5.0 | 5.4 | 6.1 | 7.8 | 9.2 | 12.8 |
| 1987 | 0.2 | 0.8 | 1.4 | 2.1 | 2.5 | 2.9 | 3.6 | 4.7 | 5.5 | 6.5 | 7.8 | 9.8 | 13.2 |
| 1988 | 0.3 | 0.9 | 1.1 | 2.0 | 3.1 | 4.0 | 4.4 | 4.7 | 5.2 | 5.6 | 8.6 | 10.4 | 13.3 |
| 1989 | 0.2 | 0.8 | 1.2 | 2.2 | 3.1 | 4.5 | 5.4 | 6.2 | 6.0 | 8.7 | 8.9 | 9.7 | 13.4 |
| 1990 | 0.1 | 0.9 | 1.1 | 2.1 | 2.4 | 3.8 | 4.9 | 6.0 | 5.7 | 6.0 | 7.4 | 9.1 | 12.6 |
| 1991 | 0.2 | 0.9 | 1.3 | 2.2 | 2.6 | 3.2 | 4.8 | 5.6 | 6.5 | 6.2 | 9.5 | 8.3 | 14.2 |
| 1992 | 0.1 | 0.7 | 1.3 | 1.9 | 2.8 | 3.7 | 4.9 | 5.8 | 7.0 | 8.2 | 9.8 | 12.4 | 14.0 |
| 1993 | 0.1 | 0.8 | 1.3 | 2.0 | 2.8 | 3.6 | 4.8 | 6.1 | 7.0 | 8.0 | 9.5 | 10.8 | 14.6 |
| 1994 | 0.2 | 1.1 | 1.7 | 2.2 | 2.9 | 3.5 | 4.9 | 6.2 | 6.8 | 7.5 | 9.7 | 10.7 | 12.7 |
| 1995 | 0.3 | 0.7 | 1.3 | 2.2 | 2.8 | 3.7 | 5.4 | 6.2 | 7.3 | 8.9 | 7.6 | 9.7 | 16.7 |
| 1996 | 0.1 | 1.0 | 1.5 | 2.3 | 3.2 | 4.5 | 6.4 | 7.1 | 7.8 | 9.2 | 9.3 | 10.1 | 13.7 |
| 1997 | 0.1 | 0.6 | 1.2 | 2.5 | 2.8 | 3.6 | 4.5 | 5.1 | 6.7 | 9.2 | 9.9 | 10.2 | 14.8 |
| 1998 | 0.4 | 0.8 | 1.2 | 1.6 | 2.2 | 2.9 | 4.7 | 5.7 | 6.8 | 7.0 | 7.8 | 9.9 | 11.9 |
| 1999 | 0.6 | 0.9 | 1.1 | 1.4 | 1.9 | 2.5 | 3.4 | 5.0 | 6.6 | 7.8 | 8.7 | 9.8 | 12.0 |
| 2000 | 0.4 | 0.6 | 1.1 | 1.5 | 2.0 | 2.8 | 3.9 | 5.1 | 7.1 | 7.4 | 9.7 | 10.7 | 13.6 |
| 2001 | 0.2 | 0.4 | 1.1 | 1.8 | 2.2 | 3.2 | 4.1 | 5.0 | 6.4 | 7.8 | 8.6 | 8.3 | 10.9 |
| 2002 | 0.1 | 0.3 | 1.1 | 1.5 | 2.2 | 3.2 | 4.2 | 5.5 | 6.0 | 7.6 | 9.1 | 9.7 | 11.5 |
| 2005 | 0.1 | .6 | 1.0 | 1.6 | 2.2 | 3.2 | 4.0 | 5.6 | 6.2 | 6.7 | 8.0 | 8.9 | 11.7 |
| 2006 | 0.2 | .5 | .8 | 1.3 | 2.0 | 2.8 | 4.1 | 4.9 | 6.2 | 7.0 | 8.1 | 9.0 | 11.1 |

Table 6A. 2006 striped bass catch at age (numbers of fish) by state and fishery.

| 2006 STATE FISHERY | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0 | 0 | 0 | 8,709 | 11,722 | 35,478 | 14,798 | 1,760 | 0 | 13 | 13 | 275 | 186 | 430 | **73,385** |
| ME RECREATIONAL DISCARDS | 0 | 0 | 19,839 | 200,717 | 42,932 | 36,686 | 16,820 | 2,959 | 1,849 | 1,147 | 1,184 | 771 | 342 | 379 | **325,624** |
| NEW HAMPSHIRE RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 0 | 1,467 | 3,114 | 1,799 | 2,199 | 1,528 | 1,969 | 1,250 | 664 | 770 | **14,760** |
| NEW HAMPSHIRE RECREATIONALDISCARDS | 0 | 0 | 3,407 | 26,485 | 5,138 | 6,078 | 3,006 | 476 | 229 | 165 | 184 | 117 | 63 | 86 | **45,434** |
| MASS RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 11,558 | 32,235 | 26,771 | 43,404 | 44,581 | 69,177 | 50,245 | 30,376 | 36,757 | **345,104** |
| MASS RECREATIONAL DISCARDS | 0 | 0 | 30,649 | 291,125 | 79,370 | 138,094 | 89,946 | 18,457 | 12,147 | 9,464 | 11,359 | 6,486 | 3,330 | 2,594 | **693,021** |
| MASS COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 460 | 2,868 | 11,125 | 19,766 | 15,563 | 9,697 | 10,506 | **69,985** |
| RI RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 806 | 9,085 | 11,997 | 9,364 | 12,382 | 8,657 | 9,750 | 7,099 | 3,452 | 2,688 | **75,279** |
| RI RECREATIONAL DISCARDS | 0 | 852 | 17,704 | 53,907 | 7,680 | 16,082 | 6,798 | 2,529 | 1,431 | 743 | 388 | 250 | 104 | 97 | **108,567** |
| RI COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 50 | 46 | 1,319 | 3,325 | 4,016 | 2,832 | 1,878 | 970 | 993 | **15,429** |
| CON RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 658 | 4,616 | 10,937 | 15,151 | 6,345 | 15,676 | 11,860 | 9,306 | 3,163 | 6,064 | **83,776** |
| CON RECREATIONAL DISCARDS | 0 | 3,050 | 25,993 | 62,401 | 8,039 | 15,567 | 7,408 | 3,028 | 2,776 | 1,984 | 1,136 | 1,227 | 693 | 1,360 | **134,659** |
| NY RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 7,530 | 55,500 | 64,912 | 37,289 | 42,998 | 26,998 | 34,832 | 21,297 | 13,128 | 5,955 | **310,441** |
| NY RECREATIONAL DISCARDS | 0 | 213 | 8,757 | 58,721 | 12,237 | 23,589 | 8,374 | 3,827 | 3,236 | 1,940 | 2,411 | 1,481 | 903 | 554 | **126,246** |
| N Y COMMERCIAL HARVEST | 0 | 0 | 0 | 127 | 1,411 | 18,155 | 14,102 | 9,681 | 8,671 | 6,587 | 7,623 | 4,568 | 1,186 | 1,418 | **73,528** |
| NJ RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 4,615 | 25,037 | 51,241 | 82,538 | 71,059 | 68,644 | 76,010 | 53,236 | 32,312 | 24,818 | **489,510** |
| NJ RECREATIONALDISCARDS | 15 | 340 | 6,632 | 44,840 | 25,896 | 49,021 | 19,584 | 7,049 | 4,371 | 3,061 | 3,293 | 2,006 | 1,150 | 788 | **168,045** |
| DEL RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 406 | 2,044 | 2,284 | 2,895 | 2,190 | 2,016 | 2,884 | 1,786 | 1,361 | 815 | **18,680** |
| DEL RECREATIONAL DISCARDS | 0 | 65 | 1,023 | 5,455 | 3,716 | 5,560 | 1,760 | 719 | 397 | 225 | 268 | 193 | 112 | 132 | **19,624** |
| DEL COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 13 | 4,755 | 14,373 | 4,281 | 2,548 | 1,157 | 1,099 | 332 | 840 | 813 | **30,212** |
| MD RECREATIONAL HARVEST | 0 | 0 | 0 | 69,790 | 102,755 | 174,591 | 68,894 | 28,592 | 31,184 | 40,461 | 49,265 | 34,615 | 23,490 | 36,825 | **660,462** |
| MD RECREATIONAL DISCARDS | 0 | 17,232 | 65,843 | 131,574 | 26,917 | 16,711 | 12,000 | 7,257 | 8,698 | 8,630 | 9,672 | 3,998 | 2,300 | 1,584 | **312,417** |
| MD COMMERCIAL HARVEST | 0 | 0 | 0 | 90,171 | 154,029 | 254,656 | 104,954 | 25,365 | 14,508 | 5,655 | 3,488 | 2,194 | 187 | 743 | **655,951** |
| PRFC COMMERCIAL HARVEST | | | | 185 | 35,808 | 49,282 | 4,522 | 369 | 1,015 | 554 | 554 | 0 | 0 | 0 | **92,288** |
| VA RECREATIONAL HARVEST | 0 | 0 | 9,430 | 33,943 | 88,366 | 86,000 | 90,715 | 37,697 | 31,866 | 30,416 | 50,052 | 28,442 | 15,383 | 25,882 | **528,191** |
| VA RECREATIONAL DISCARDS | 0 | 12,003 | 36,426 | 62,893 | 11,219 | 3,244 | 3,718 | 1,411 | 1,236 | 795 | 1,301 | 664 | 512 | 253 | **135,677** |
| VA COMMERCIAL HARVEST | 0 | 0 | 81 | 336 | 1,303 | 8,694 | 11,275 | 6,097 | 9,713 | 16,389 | 25,124 | 14,064 | 9,195 | 7,123 | **109,395** |
| NC RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,959 | 10,309 | 20,137 | 26,562 | 24,214 | 13,780 | 11,007 | **107,966** |
| NC RECREATIONAL DISCARDS | 0 | 51 | 307 | 1,360 | 333 | 454 | 247 | 70 | 54 | 43 | 47 | 27 | 14 | 12 | **3,019** |
| NC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 85 | 326 | 684 | 656 | 1,031 | **2,798** |
| TOTAL AT AGE | **15** | **33,806** | **226,091** | **1,142,739** | **632,900** | **1,052,055** | **670,060** | **341,169** | **333,025** | **332,892** | **424,426** | **288,268** | **169,550** | **182,478** | **5,829,474** |

Table 6B. 2005 striped bass catch at age (numbers of fish) by state and fishery.

| 2005 STATE FISHERY | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0 | 0 | 0 | 9,872 | 30,581 | 19,338 | 3,666 | 647 | 323 | 45 | 136 | 207 | 176 | 190 | **65,179** |
| ME RECREATIONAL DISCARDS | 0 | 0 | 43,368 | 65,239 | 78,653 | 33,280 | 9,269 | 4,165 | 3,756 | 2,367 | 1,005 | 435 | 208 | 198 | **241,943** |
| NEW HAMPSHIRE RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 312 | 3,129 | 5,875 | 6,599 | 6,415 | 3,751 | 1,182 | 162 | 42 | 8 | **27,476** |
| NEW HAMPSHIRE RECREATIONALDISCARDS | 0 | 0 | 13,278 | 7,133 | 10,027 | 6,484 | 2,038 | 715 | 551 | 342 | 184 | 104 | 66 | 99 | **41,022** |
| MASS RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 2,505 | 36,790 | 56,750 | 61,896 | 80,240 | 67,697 | 34,916 | 22,525 | 11,932 | 17,533 | **392,784** |
| MASS RECREATIONAL DISCARDS | 0 | 0 | 63,042 | 58,533 | 99,799 | 79,088 | 31,005 | 15,771 | 16,133 | 11,524 | 5,517 | 2,857 | 1,657 | 2,253 | **387,180** |
| MASS COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,888 | 12,372 | 15,613 | 9,585 | 7,073 | 4,281 | 5,915 | **57,728** |
| RI RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 442 | 3,669 | 8,086 | 11,401 | 17,730 | 20,884 | 14,023 | 11,978 | 7,714 | 11,365 | **107,293** |
| RI RECREATIONAL DISCARDS | 0 | 182 | 25,261 | 4,806 | 9,788 | 7,837 | 3,982 | 2,514 | 1,649 | 1,315 | 694 | 512 | 267 | 477 | **59,282** |
| RI COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 27 | 172 | 632 | 1,337 | 3,019 | 2,896 | 2,790 | 1,880 | 1,002 | 1,194 | **14,949** |
| CON RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 814 | 5,929 | 14,327 | 19,341 | 9,041 | 18,146 | 13,849 | 11,439 | 3,233 | 6,957 | **103,075** |
| CON RECREATIONAL DISCARDS | 69 | 2,310 | 47,579 | 12,246 | 32,133 | 14,856 | 7,454 | 5,992 | 2,419 | 4,826 | 3,365 | 2,544 | 703 | 589 | **137,083** |
| NY RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 3,103 | 18,287 | 33,787 | 40,845 | 20,598 | 40,406 | 31,489 | 27,666 | 13,925 | 10,014 | **240,119** |
| NY RECREATIONAL DISCARDS | 0 | 110 | 34,834 | 10,287 | 30,485 | 13,421 | 4,691 | 3,569 | 1,672 | 3,049 | 2,321 | 2,040 | 1,027 | 365 | **107,870** |
| N Y COMMERCIAL HARVEST | 0 | 0 | 0 | 417 | 6,635 | 11,375 | 12,764 | 11,959 | 4,124 | 10,307 | 7,814 | 2,786 | 2,061 | 317 | **70,560** |
| NJ RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 28,734 | 67,361 | 49,101 | 30,180 | 33,573 | 34,238 | 21,829 | 33,239 | 3,587 | 17,600 | **319,444** |
| NJ RECREATIONALDISCARDS | 6 | 208 | 7,975 | 11,409 | 25,597 | 19,483 | 7,635 | 7,991 | 5,767 | 5,153 | 1,797 | 1,969 | 122 | 682 | **95,795** |
| DEL RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 137 | 1,120 | 1,925 | 3,184 | 1,619 | 2,227 | 2,720 | 4,755 | 572 | 237 | **18,496** |
| DEL RECREATIONAL DISCARDS | 0 | 8,132 | 580 | 1,488 | 1,692 | 2,823 | 410 | 580 | 544 | 591 | 595 | 270 | 179 | 104 | **17,987** |
| DEL COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 525 | 4,332 | 5,395 | 4,096 | 4,726 | 4,143 | 2,690 | 280 | 150 | 0 | **26,336** |
| MD RECREATIONAL HARVEST | 0 | 0 | 326 | 25,251 | 96,875 | 107,248 | 45,922 | 38,932 | 26,339 | 42,500 | 34,665 | 36,337 | 21,909 | 17,660 | **493,964** |
| MD RECREATIONAL DISCARDS | 0 | 7,193 | 135,950 | 48,116 | 58,836 | 23,165 | 5,573 | 4,906 | 3,760 | 4,742 | 3,039 | 2,539 | 1,738 | 708 | **300,266** |
| MD COMMERCIAL HARVEST | 0 | 0 | 144 | 42,952 | 214,726 | 203,839 | 62,171 | 21,599 | 11,773 | 7,424 | 2,928 | 2,164 | 105 | 139 | **569,964** |
| PRFC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 14,396 | 26,735 | 14,396 | 9,049 | 10,283 | 5,347 | 411 | 0 | 0 | 0 | **80,615** |
| VA RECREATIONAL HARVEST | 0 | 0 | 0 | 3,738 | 86,193 | 65,312 | 49,664 | 41,334 | 26,665 | 37,613 | 25,939 | 18,078 | 8,433 | 8,882 | **371,853** |
| VA RECREATIONAL DISCARDS | 0 | 0 | 70,853 | 14,396 | 20,607 | 5,813 | 1,447 | 1,541 | 823 | 1,101 | 566 | 875 | 544 | 197 | **118,763** |
| VA COMMERCIAL HARVEST | 0 | 0 | 0 | 90 | 3,387 | 5,078 | 5,710 | 6,791 | 8,975 | 24,725 | 19,079 | 19,509 | 12,624 | 13,277 | **119,244** |
| NC RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,481 | 12,260 | 36,963 | 47,240 | 27,291 | 10,857 | 8,892 | **144,983** |
| NC RECREATIONAL DISCARDS | 1 | 126 | 3,066 | 1,618 | 2,546 | 1,428 | 509 | 331 | 257 | 242 | 132 | 98 | 45 | 39 | **10,437** |
| NC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 0 | 761 | 2,639 | 3,603 | 6,749 | 5,887 | 7,003 | **26,693** |
| TOTAL AT AGE | **75** | **18,261** | **446,254** | **317,592** | **859,555** | **787,390** | **444,234** | **361,636** | **328,166** | **412,818** | **296,104** | **248,357** | **115,046** | **132,895** | **4,768,383** |

Table 7A. 2006 striped bass catch at age (pounds of fish) by state and fishery.

| AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0.0 | 0 | 0 | 21,514 | 34,430 | 124,619 | 56,994 | 7,287 | 0 | 256 | 256 | 5,785 | 3,917 | 10,170 | **265,227** |
| ME RECREATIONAL DISCARDS | 0.0 | 0 | 16,928 | 287,155 | 101,295 | 152,002 | 80,923 | 20,355 | 18,061 | 13,222 | 17,469 | 12,183 | 6,221 | 8,216 | **734,033** |
| NEW HAMPSHIRE RECREATIONAL HAR | 0.0 | 0 | 0 | 0 | 0 | 12,271 | 28,162 | 18,332 | 24,336 | 20,814 | 31,917 | 22,707 | 13,974 | 19,808 | **192,321** |
| NEW HAMPSHIRE RECREATIONAL DIS | 0.0 | 0 | 3,381 | 40,432 | 11,945 | 24,735 | 14,593 | 3,416 | 2,455 | 2,105 | 2,975 | 2,147 | 1,327 | 2,323 | **111,834** |
| MASS RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 87,267 | 268,770 | 259,791 | 470,642 | 575,749 | 1,045,473 | 868,369 | 575,194 | 838,651 | **4,989,907** |
| MASS RECREATIONAL DISCARDS | 0.0 | 0 | 26,152 | 416,497 | 187,269 | 572,171 | 432,744 | 126,965 | 118,655 | 109,118 | 167,563 | 102,537 | 60,535 | 54,741 | **2,374,948** |
| MASS COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 5,980 | 43,574 | 171,426 | 342,627 | 285,253 | 191,736 | 265,034 | **1,305,631** |
| RI RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 68,592 | 100,033 | 90,870 | 134,261 | 111,801 | 147,347 | 122,690 | 65,358 | 59,420 | **900,372** |
| RI RECREATIONAL DISCARDS | 0.0 | 0 | 15,107 | 77,122 | 18,120 | 66,635 | 32,706 | 17,398 | 13,983 | 8,571 | 5,721 | 3,948 | 1,898 | 2,040 | **263,250** |
| RI COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 17,149 | 50,515 | 61,886 | 49,089 | 34,414 | 19,177 | 24,130 | **256,359** |
| CON RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 5,722 | 42,234 | 116,914 | 176,163 | 86,894 | 239,270 | 198,417 | 178,130 | 62,165 | 57,980 | **1,163,889** |
| CON RECREATIONAL DISCARDS | 0.0 | 1,725 | 38,477 | 182,118 | 47,061 | 121,239 | 77,352 | 35,824 | 39,896 | 37,599 | 22,320 | 29,659 | 16,840 | 25,334 | **675,443** |
| NY RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 76,886 | 571,442 | 729,836 | 462,657 | 671,208 | 524,172 | 717,637 | 530,507 | 319,763 | 164,165 | **4,768,272** |
| NY RECREATIONAL DISCARDS | 0.0 | 121 | 11,287 | 131,011 | 48,048 | 122,448 | 55,178 | 29,132 | 34,210 | 26,114 | 35,200 | 26,226 | 15,576 | 7,910 | **542,461** |
| N Y COMMERCIAL HARVEST | 0.0 | 0 | 0 | 612 | 8,340 | 117,620 | 105,681 | 84,683 | 89,114 | 76,415 | 104,220 | 64,925 | 15,952 | 20,883 | **688,446** |
| NJ RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 44,528 | 277,502 | 525,181 | 990,231 | 865,097 | 1,058,911 | 1,311,301 | 1,089,025 | 754,127 | 759,299 | **7,675,201** |
| NJ RECREATIONAL DISCARDS | 0.2 | 207 | 12,186 | 145,044 | 144,991 | 307,580 | 132,238 | 63,825 | 47,473 | 44,638 | 54,318 | 39,949 | 26,222 | 24,119 | **1,042,790** |
| DEL RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 3,353 | 17,620 | 22,498 | 34,129 | 26,588 | 31,214 | 48,433 | 36,361 | 32,440 | 25,522 | **278,159** |
| DEL RECREATIONAL DISCARDS | 0.0 | 40 | 1,783 | 19,460 | 20,629 | 34,521 | 13,547 | 7,004 | 4,252 | 3,487 | 4,745 | 4,152 | 2,975 | 4,104 | **120,700** |
| DEL COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 110 | 24,597 | 85,863 | 29,926 | 21,098 | 13,049 | 15,738 | 5,308 | 13,166 | 17,804 | **226,660** |
| MD RECREATIONAL HARVEST | 0.0 | 0 | 0 | 152,714 | 259,006 | 543,865 | 298,811 | 179,661 | 260,756 | 556,947 | 770,982 | 570,715 | 482,536 | 903,855 | **4,979,847** |
| MD RECREATIONAL DISCARDS | 0.0 | 6,746 | 42,037 | 183,660 | 51,909 | 54,419 | 61,867 | 61,324 | 80,373 | 99,760 | 118,252 | 54,404 | 34,655 | 17,977 | **867,382** |
| MD COMMERCIAL HARVEST | 0.0 | 0 | 0 | 216,857 | 408,321 | 790,627 | 410,439 | 105,075 | 68,639 | 45,124 | 27,669 | 23,729 | 2,265 | 11,257 | **2,110,003** |
| PRFC COMMERCIAL HARVEST | 0.0 | 0 | 0 | 1,081 | 209,717 | 365,599 | 44,141 | 4,684 | 18,233 | 13,513 | 16,540 | 0 | 0 | 0 | **673,508** |
| VA RECREATIONAL HARVEST | 0.0 | 0 | 23,868 | 80,076 | 242,820 | 313,674 | 362,632 | 180,648 | 242,468 | 348,852 | 672,590 | 517,157 | 284,023 | 812,252 | **4,081,059** |
| VA RECREATIONAL DISCARDS | 0.0 | 7,663 | 50,846 | 121,288 | 36,535 | 16,725 | 31,419 | 13,036 | 14,287 | 9,721 | 17,708 | 10,002 | 5,812 | 0 | **335,042** |
| VA COMMERCIAL HARVEST | 0.0 | 0 | 218 | 837 | 4,159 | 45,723 | 65,868 | 44,977 | 92,462 | 202,844 | 389,193 | 247,526 | 171,510 | 148,201 | **1,413,518** |
| NC RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 12,424 | 73,299 | 161,988 | 246,621 | 261,607 | 162,211 | 150,380 | **1,068,530** |
| NC RECREATIONAL DISCARDS | 0.0 | 20 | 196 | 1,898 | 643 | 1,478 | 1,275 | 588 | 502 | 492 | 572 | 363 | 217 | 140 | **8,384** |
| NC COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 229 | 1,296 | 5,792 | 13,701 | 15,062 | 27,378 | **63,458** |
| TOTAL POUNDS AT AGE | **0.169** | **16,522** | **242,467** | **2,079,375** | **1,965,837** | **4,877,206** | **4,155,669** | **3,083,536** | **3,613,561** | **4,570,353** | **6,588,685** | **5,163,478** | **3,356,854** | **4,463,092** | 44,176,635 |

Table 7B. 2005 striped bass catch at age (pounds of fish) by state and fishery.

| AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0 | 0 | 0 | 28,592 | 95,495 | 76,799 | 16,651 | 3,270 | 1,534 | 880 | 2,831 | 4,352 | 3,918 | 4,560 | **238,883** |
| ME RECREATIONAL DISCARDS | 0 | 0 | 40,424 | 146,596 | 255,392 | 161,151 | 61,405 | 36,327 | 42,288 | 31,327 | 15,014 | 8,303 | 4,501 | 5,189 | **807,917** |
| NEW HAMPSHIRE RECREATIONALHAI | 0 | 0 | 0 | 0 | 2,413 | 28,254 | 56,804 | 70,167 | 76,736 | 48,886 | 15,374 | 2,730 | 735 | 159 | **302,258** |
| NEW HAMPSHIRE RECREATIONALDIS | 0 | 0 | 11,807 | 15,187 | 33,377 | 32,780 | 13,263 | 6,156 | 6,302 | 5,010 | 3,138 | 2,243 | 1,574 | 2,934 | **133,771** |
| MASS RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 18,994 | 324,730 | 532,423 | 653,852 | 1,032,335 | 985,776 | 596,283 | 466,984 | 271,713 | 503,136 | **5,386,226** |
| MASS RECREATIONAL DISCARDS | 0 | 0 | 64,497 | 144,362 | 355,676 | 420,342 | 225,433 | 150,995 | 199,363 | 167,409 | 90,448 | 59,895 | 39,349 | 65,169 | **1,982,939** |
| MASS COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36,831 | 200,321 | 254,870 | 189,264 | 156,587 | 109,818 | 223,114 | **1,170,806** |
| RI RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 3,355 | 32,386 | 75,863 | 120,442 | 228,103 | 304,109 | 239,485 | 248,328 | 175,650 | 322,897 | **1,750,619** |
| RI RECREATIONAL DISCARDS | 0 | 78 | 50,326 | 16,265 | 47,131 | 55,769 | 40,231 | 31,261 | 23,369 | 20,672 | 12,070 | 10,672 | 5,994 | 26,619 | **340,458** |
| RI COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17,055 | 48,886 | 47,278 | 55,084 | 41,614 | 25,705 | 26,331 | **261,953** |
| CON RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 7,198 | 55,114 | 157,122 | 224,791 | 116,294 | 270,406 | 217,411 | 239,601 | 65,616 | 191,465 | **1,545,018** |
| CON RECREATIONAL DISCARDS | 8 | 994 | 94,789 | 41,444 | 154,730 | 105,708 | 75,314 | 74,519 | 34,287 | 75,870 | 58,481 | 53,063 | 15,799 | 32,910 | **817,916** |
| NY RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 23,156 | 138,541 | 283,382 | 384,562 | 234,458 | 557,434 | 477,337 | 467,642 | 253,232 | 198,906 | **3,018,651** |
| NY RECREATIONAL DISCARDS | 0 | 70 | 63,062 | 28,050 | 122,449 | 77,364 | 36,628 | 34,911 | 20,100 | 45,867 | 38,935 | 38,145 | 20,656 | 16,224 | **542,460** |
| N Y COMMERCIAL HARVEST | 0 | 0 | 0 | 2,363 | 39,509 | 76,375 | 100,414 | 113,736 | 43,041 | 134,493 | 98,810 | 38,261 | 37,241 | 5,577 | **689,821** |
| NJ RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 185,861 | 450,300 | 395,262 | 239,208 | 499,724 | 560,852 | 404,665 | 649,690 | 86,392 | 481,640 | **3,953,594** |
| NJ RECREATIONALDISCARDS | 0 | 68 | 10,893 | 27,233 | 101,935 | 103,587 | 54,006 | 72,232 | 69,705 | 68,449 | 26,322 | 35,450 | 2,240 | 18,352 | **590,472** |
| DEL RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 1,385 | 10,252 | 24,088 | 34,787 | 21,131 | 32,990 | 49,991 | 76,570 | 8,320 | 3,040 | **262,553** |
| DEL RECREATIONAL DISCARDS | 0 | 2,679 | 792 | 3,552 | 6,739 | 15,008 | 2,901 | 5,242 | 6,569 | 7,855 | 8,707 | 4,851 | 3,289 | 2,795 | **70,979** |
| DEL COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 2,164 | 23,076 | 31,796 | 30,634 | 41,335 | 41,255 | 30,549 | 4,139 | 2,034 | 0 | **206,981** |
| MD RECREATIONAL HARVEST | 0 | 0 | 514 | 54,397 | 260,066 | 329,920 | 200,112 | 233,241 | 263,227 | 586,891 | 548,640 | 689,157 | 480,651 | 448,705 | **4,095,520** |
| MD RECREATIONAL DISCARDS | 0 | 1,799 | 152,281 | 75,991 | 127,063 | 61,616 | 27,198 | 29,645 | 34,573 | 63,822 | 47,213 | 45,267 | 34,245 | 18,370 | **719,083** |
| MD COMMERCIAL HARVEST | 0 | 0 | 237 | 106,830 | 663,723 | 680,922 | 264,326 | 138,359 | 106,082 | 75,947 | 33,308 | 27,446 | 1,749 | 2,656 | **2,101,586** |
| PRFC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 49,536 | 123,467 | 89,947 | 81,120 | 118,253 | 65,849 | 5,289 | 0 | 0 | 0 | **533,461** |
| VA RECREATIONAL HARVEST | 0 | 0 | 0 | 11,954 | 294,362 | 265,298 | 226,062 | 219,113 | 227,754 | 458,439 | 353,368 | 282,691 | 167,681 | 191,024 | **2,697,747** |
| VA RECREATIONAL DISCARDS | 0 | 0 | 79,364 | 22,736 | 44,503 | 15,463 | 7,062 | 9,309 | 7,563 | 14,816 | 8,787 | 15,610 | 10,721 | 5,116 | **241,050** |
| VA COMMERCIAL HARVEST | 0 | 0 | 0 | 322 | 12,595 | 26,179 | 35,774 | 59,484 | 104,930 | 363,931 | 303,556 | 334,141 | 235,075 | 420,771 | **1,896,757** |
| NC RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8,107 | 84,857 | 291,930 | 417,063 | 283,549 | 132,425 | 130,500 | **1,348,432** |
| NC RECREATIONAL DISCARDS | 1 | 126 | 3,067 | 1,620 | 2,550 | 1,434 | 516 | 340 | 269 | 256 | 147 | 116 | 63 | 66 | **10,570** |
| NC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 262 | 0 | 4,488 | 16,858 | 29,103 | 63,556 | 63,972 | 88,746 | **266,985** |
| TOTAL POUNDS AT AGE | **8.150** | **5,815** | **572,054** | **727,494** | **2,911,356** | **3,691,836** | **3,034,246** | **3,119,694** | **3,897,877** | **5,600,426** | **4,376,674** | **4,350,654** | **2,260,358** | **3,436,972** | **37,985,465** |

Table 8A. Proportional contributions by fishery to the 2006 coastwide CAA (by numbers of fish).

| PROP OF HARVEST BY NUMBER | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.008 | 0.019 | 0.034 | 0.022 | 0.005 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 |
| ME RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.088 | 0.176 | 0.068 | 0.035 | 0.025 | 0.009 | 0.006 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 |
| NEW HAMPSHIRE RECREATIONAL HARVE | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.005 | 0.007 | 0.005 | 0.005 | 0.004 | 0.004 | 0.004 |
| NEW HAMPSHIRE RECREATIONAL DISCA | 0.000 | 0.000 | 0.015 | 0.023 | 0.008 | 0.006 | 0.004 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MASS RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.011 | 0.048 | 0.078 | 0.130 | 0.134 | 0.163 | 0.174 | 0.179 | 0.201 |
| MASS RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.136 | 0.255 | 0.125 | 0.131 | 0.134 | 0.054 | 0.036 | 0.028 | 0.027 | 0.022 | 0.020 | 0.014 |
| MASS COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.009 | 0.033 | 0.047 | 0.054 | 0.057 | 0.058 |
| RI RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.009 | 0.018 | 0.027 | 0.037 | 0.026 | 0.023 | 0.025 | 0.020 | 0.015 |
| RI RECREATIONAL DISCARDS | 0.000 | 0.025 | 0.078 | 0.047 | 0.012 | 0.015 | 0.010 | 0.007 | 0.004 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 |
| RI COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.010 | 0.012 | 0.007 | 0.007 | 0.006 | 0.005 |
| CON RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.016 | 0.044 | 0.019 | 0.047 | 0.028 | 0.032 | 0.019 | 0.033 |
| CON RECREATIONAL DISCARDS | 0.000 | 0.090 | 0.115 | 0.055 | 0.013 | 0.015 | 0.011 | 0.009 | 0.008 | 0.006 | 0.003 | 0.004 | 0.004 | 0.007 |
| NY RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.012 | 0.053 | 0.097 | 0.109 | 0.129 | 0.081 | 0.082 | 0.074 | 0.077 | 0.033 |
| NY RECREATIONAL DISCARDS | 0.000 | 0.006 | 0.039 | 0.051 | 0.019 | 0.022 | 0.012 | 0.011 | 0.010 | 0.006 | 0.006 | 0.005 | 0.005 | 0.003 |
| N Y COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.017 | 0.021 | 0.028 | 0.026 | 0.020 | 0.018 | 0.016 | 0.007 | 0.008 |
| NJ RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.024 | 0.076 | 0.242 | 0.213 | 0.206 | 0.179 | 0.185 | 0.191 | 0.136 |
| NJ RECREATIONAL DISCARDS | 0.998 | 0.010 | 0.029 | 0.039 | 0.041 | 0.047 | 0.029 | 0.021 | 0.013 | 0.009 | 0.008 | 0.007 | 0.007 | 0.004 |
| DEL RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 | 0.008 | 0.007 | 0.006 | 0.007 | 0.006 | 0.008 | 0.004 |
| DEL RECREATIONAL DISCARDS | 0.000 | 0.002 | 0.005 | 0.005 | 0.006 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| DEL COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.021 | 0.013 | 0.008 | 0.003 | 0.003 | 0.001 | 0.005 | 0.004 |
| MD RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.061 | 0.162 | 0.166 | 0.103 | 0.084 | 0.094 | 0.122 | 0.116 | 0.120 | 0.139 | 0.202 |
| MD RECREATIONAL DISCARDS | 0.000 | 0.510 | 0.291 | 0.115 | 0.043 | 0.016 | 0.018 | 0.021 | 0.026 | 0.026 | 0.023 | 0.014 | 0.014 | 0.009 |
| MD COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.079 | 0.243 | 0.242 | 0.157 | 0.074 | 0.044 | 0.017 | 0.008 | 0.008 | 0.001 | 0.004 |
| PRFC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.057 | 0.047 | 0.007 | 0.001 | 0.003 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 |
| VA RECREATIONAL HARVEST | 0.000 | 0.000 | 0.042 | 0.030 | 0.140 | 0.082 | 0.135 | 0.110 | 0.096 | 0.091 | 0.118 | 0.099 | 0.091 | 0.142 |
| VA RECREATIONAL DISCARDS | 0.000 | 0.355 | 0.161 | 0.055 | 0.018 | 0.003 | 0.006 | 0.004 | 0.004 | 0.002 | 0.003 | 0.002 | 0.003 | 0.001 |
| VA COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.008 | 0.017 | 0.018 | 0.029 | 0.049 | 0.059 | 0.049 | 0.054 | 0.039 |
| NC RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.031 | 0.060 | 0.063 | 0.084 | 0.081 | 0.060 |
| NC RECREATIONAL DISCARDS | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| NC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.004 | 0.006 |
| PROP OF HARVEST BY # | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table 8B. Proportional contributions by fishery to the 2005 coastwide CAA (by numbers of fish).

| PROP OF HARVEST BY NUMBER | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.031 | 0.036 | 0.025 | 0.008 | 0.002 | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| ME RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.097 | 0.205 | 0.092 | 0.042 | 0.021 | 0.012 | 0.011 | 0.006 | 0.003 | 0.002 | 0.002 | 0.001 |
| NEW HAMPSHIRE RECREATIONALHARVE | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.013 | 0.018 | 0.020 | 0.009 | 0.004 | 0.001 | 0.000 | 0.000 |
| NEW HAMPSHIRE RECREATIONALDISCA | 0.000 | 0.000 | 0.030 | 0.022 | 0.012 | 0.008 | 0.005 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.001 | 0.001 |
| MASS RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.047 | 0.128 | 0.171 | 0.245 | 0.164 | 0.118 | 0.091 | 0.104 | 0.132 |
| MASS RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.141 | 0.184 | 0.116 | 0.100 | 0.070 | 0.044 | 0.049 | 0.028 | 0.019 | 0.012 | 0.014 | 0.017 |
| MASS COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.008 | 0.038 | 0.038 | 0.032 | 0.028 | 0.037 | 0.045 |
| RI RECREATIONALHARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.018 | 0.032 | 0.054 | 0.051 | 0.047 | 0.048 | 0.067 | 0.086 |
| RI RECREATIONAL DISCARDS | 0.000 | 0.010 | 0.057 | 0.015 | 0.011 | 0.010 | 0.009 | 0.007 | 0.005 | 0.003 | 0.002 | 0.002 | 0.002 | 0.004 |
| RI COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.009 | 0.007 | 0.009 | 0.008 | 0.009 | 0.009 |
| CON RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.008 | 0.032 | 0.053 | 0.028 | 0.044 | 0.047 | 0.046 | 0.028 | 0.052 |
| CON RECREATIONAL DISCARDS | 0.919 | 0.126 | 0.107 | 0.039 | 0.037 | 0.019 | 0.017 | 0.017 | 0.007 | 0.012 | 0.011 | 0.010 | 0.006 | 0.004 |
| NY RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.023 | 0.076 | 0.113 | 0.063 | 0.098 | 0.106 | 0.111 | 0.121 | 0.075 |
| NY RECREATIONAL DISCARDS | 0.000 | 0.006 | 0.078 | 0.032 | 0.035 | 0.017 | 0.011 | 0.010 | 0.005 | 0.007 | 0.008 | 0.008 | 0.009 | 0.003 |
| N Y COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.001 | 0.008 | 0.014 | 0.029 | 0.033 | 0.013 | 0.025 | 0.026 | 0.011 | 0.018 | 0.002 |
| NJ RECREATIONALHARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.033 | 0.086 | 0.111 | 0.083 | 0.102 | 0.083 | 0.074 | 0.134 | 0.031 | 0.132 |
| NJ RECREATIONALDISCARDS | 0.074 | 0.011 | 0.018 | 0.036 | 0.030 | 0.025 | 0.017 | 0.022 | 0.018 | 0.012 | 0.006 | 0.008 | 0.001 | 0.005 |
| DEL RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.009 | 0.005 | 0.005 | 0.009 | 0.019 | 0.005 | 0.002 |
| DEL RECREATIONAL DISCARDS | 0.000 | 0.445 | 0.001 | 0.005 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.002 | 0.001 |
| DEL COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.006 | 0.012 | 0.011 | 0.014 | 0.010 | 0.009 | 0.001 | 0.001 | 0.000 |
| MD RECREATIONAL HARVEST | 0.000 | 0.000 | 0.001 | 0.080 | 0.113 | 0.136 | 0.103 | 0.108 | 0.080 | 0.103 | 0.117 | 0.146 | 0.190 | 0.133 |
| MD RECREATIONAL DISCARDS | 0.000 | 0.394 | 0.305 | 0.152 | 0.068 | 0.029 | 0.013 | 0.014 | 0.011 | 0.011 | 0.010 | 0.010 | 0.015 | 0.005 |
| MD COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.135 | 0.250 | 0.259 | 0.140 | 0.060 | 0.036 | 0.018 | 0.010 | 0.009 | 0.001 | 0.001 |
| PRFC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.017 | 0.034 | 0.032 | 0.025 | 0.031 | 0.013 | 0.001 | 0.000 | 0.000 | 0.000 |
| VA RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.012 | 0.100 | 0.083 | 0.112 | 0.114 | 0.081 | 0.091 | 0.088 | 0.073 | 0.073 | 0.067 |
| VA RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.159 | 0.045 | 0.024 | 0.007 | 0.003 | 0.004 | 0.003 | 0.003 | 0.002 | 0.004 | 0.005 | 0.001 |
| VA COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.006 | 0.013 | 0.019 | 0.027 | 0.060 | 0.064 | 0.079 | 0.110 | 0.100 |
| NC RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.037 | 0.090 | 0.160 | 0.110 | 0.094 | 0.067 |
| NC RECREATIONAL DISCARDS | 0.007 | 0.007 | 0.007 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| NC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.006 | 0.012 | 0.027 | 0.051 | 0.053 |
| PROP OF HARVEST BY # | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

## Appendix 5b Figures

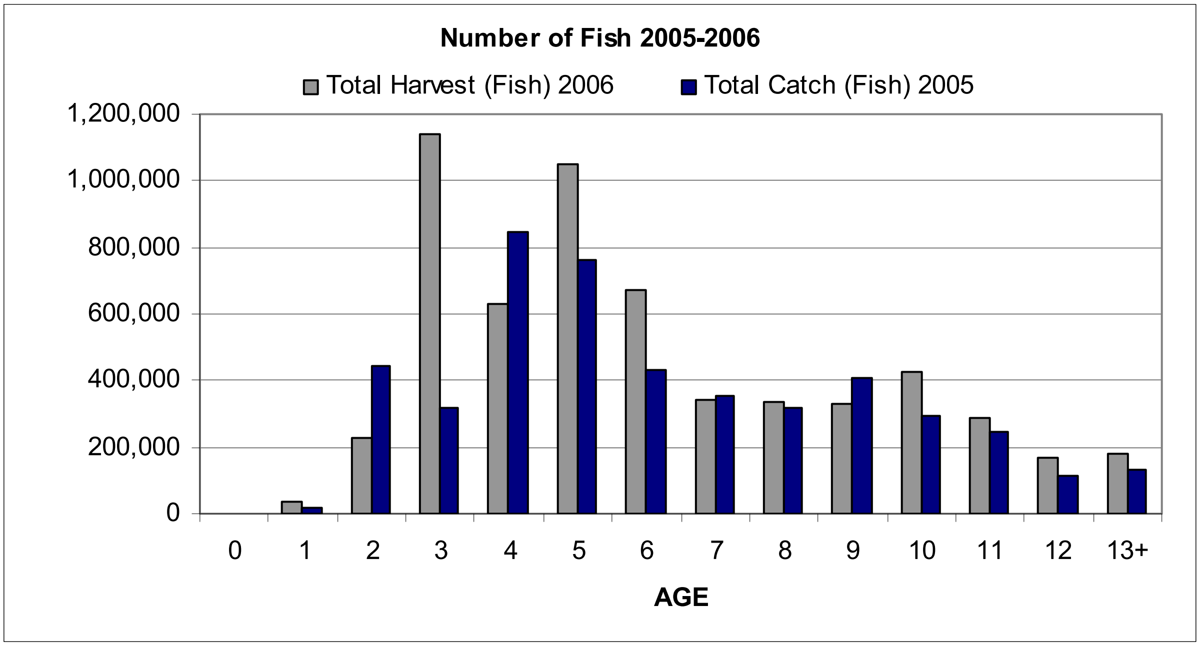



Figure 1. 2005-2006 Atlantic coastwide mean catch-at-age in numbers of striped bass.

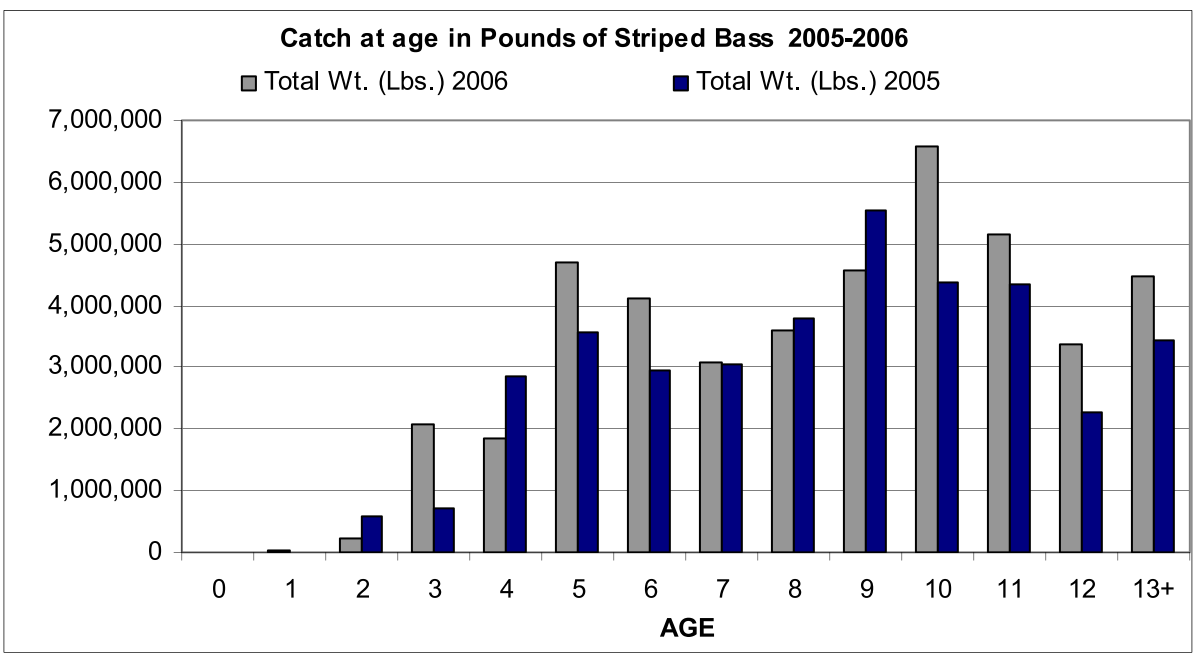



Figure 2. 2005-2006 Atlantic coastwide mean catch-at-age in pounds of striped bass.

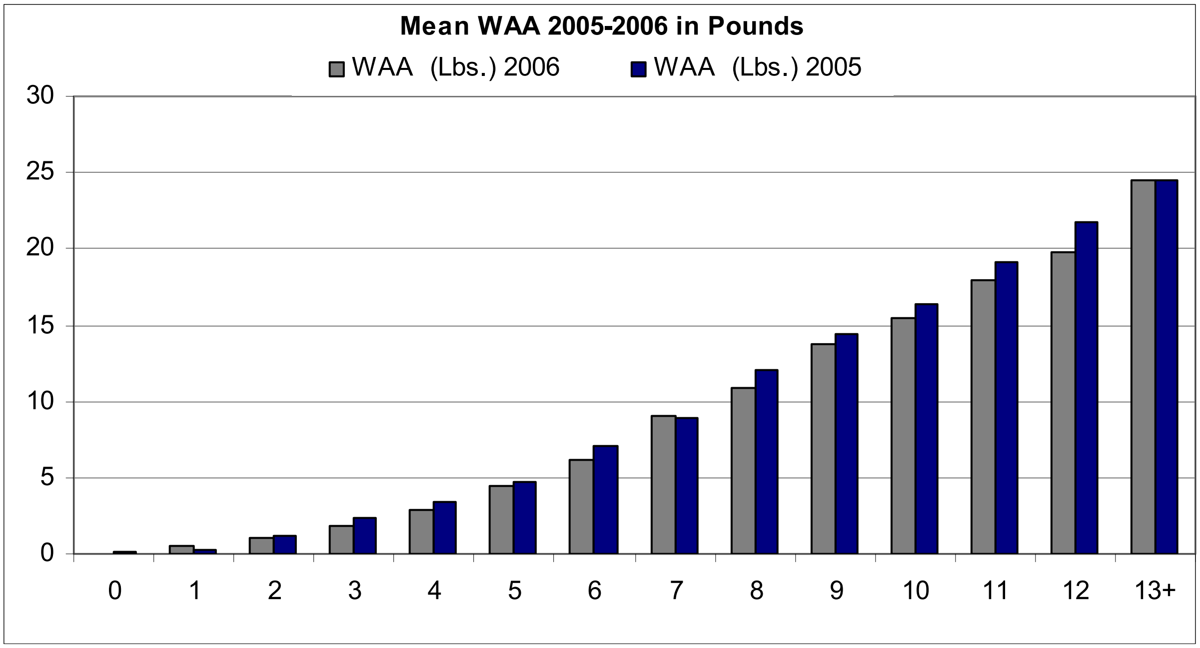



Figure 3. 2005 and 2006 Atlantic coastwide mean weight-at-age in pounds.

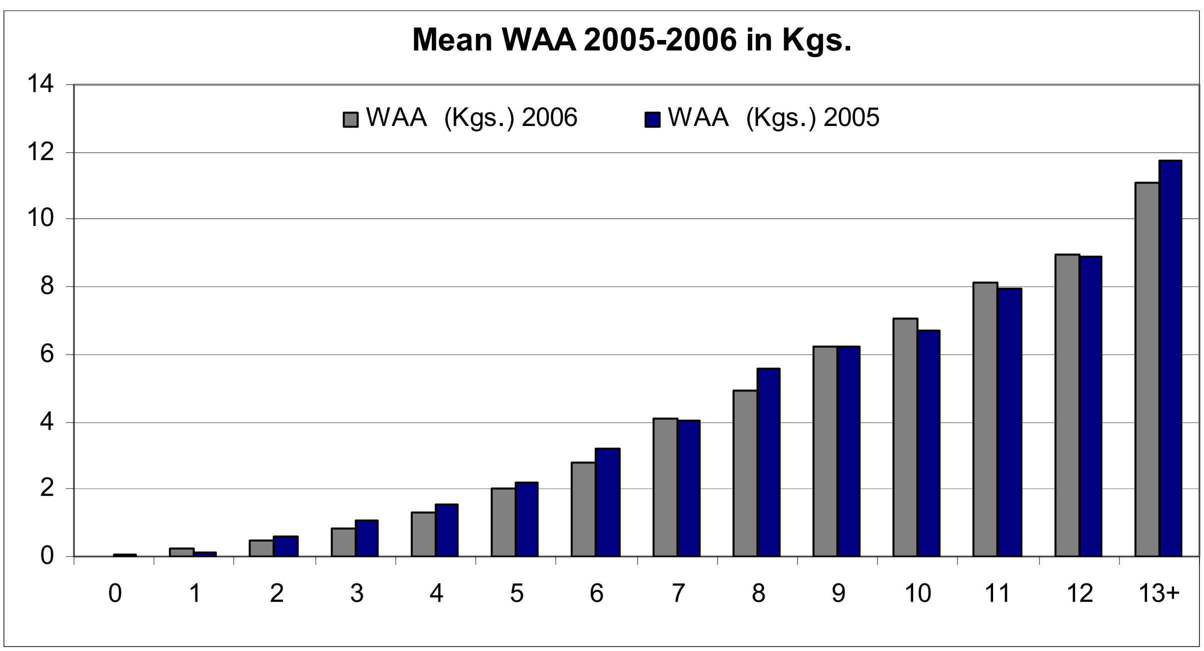
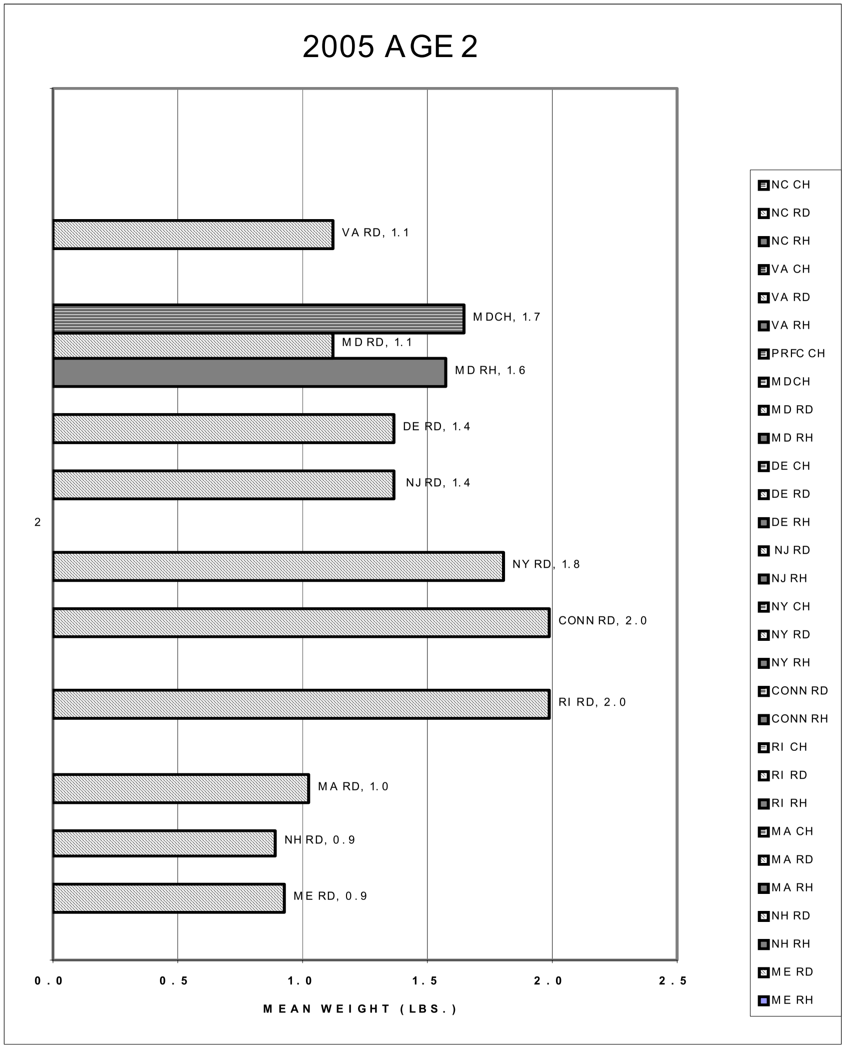



Figure 4. 2005 and 2006 Atlantic coastwide mean weight-at-age in kilograms.



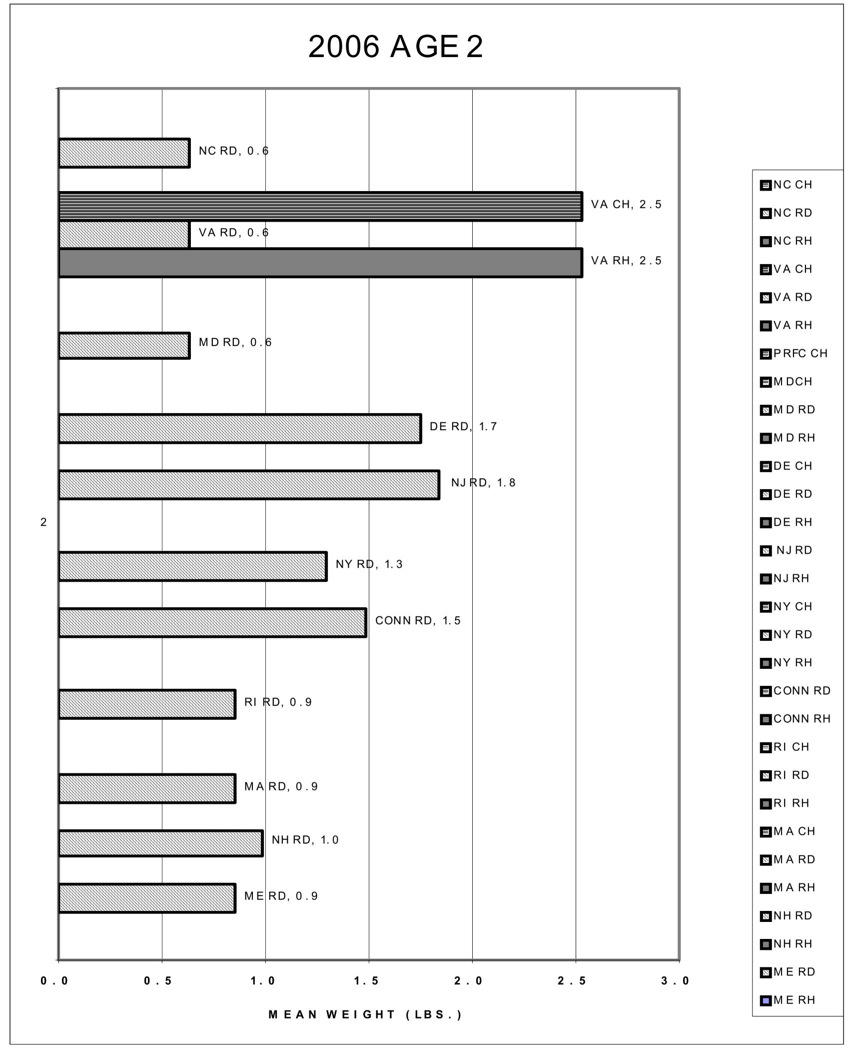
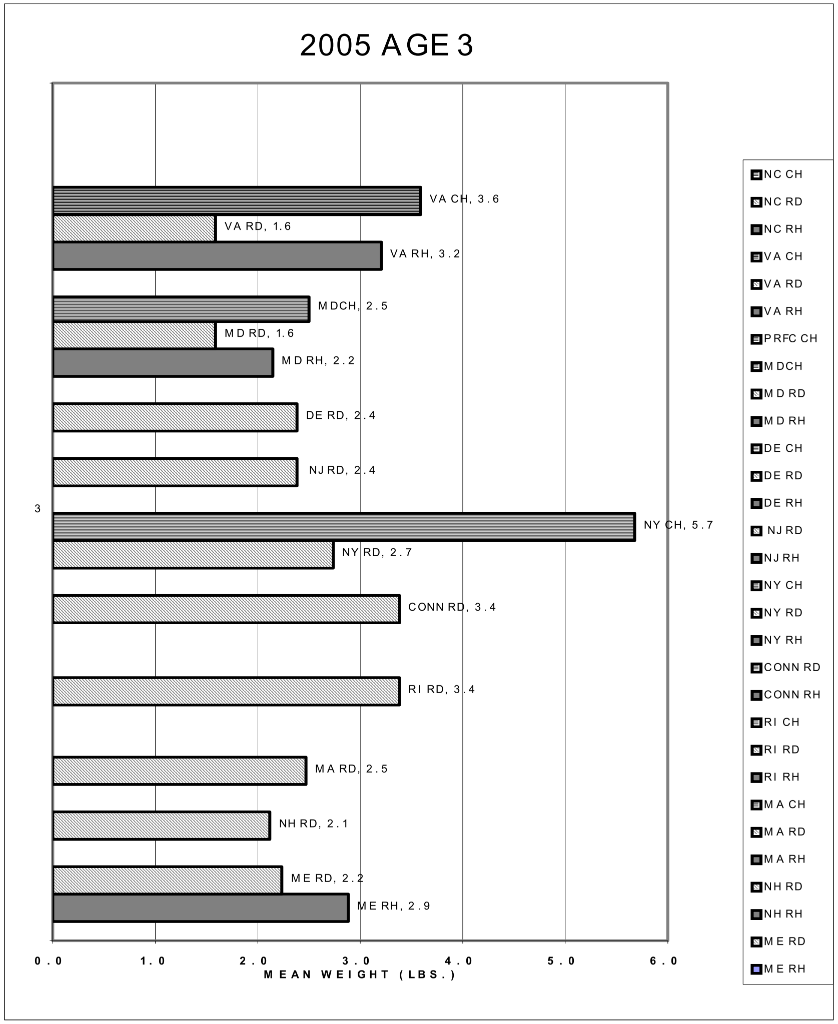




Figure 5A. 2005 and 2006 weight at age 2 by state and fishery.



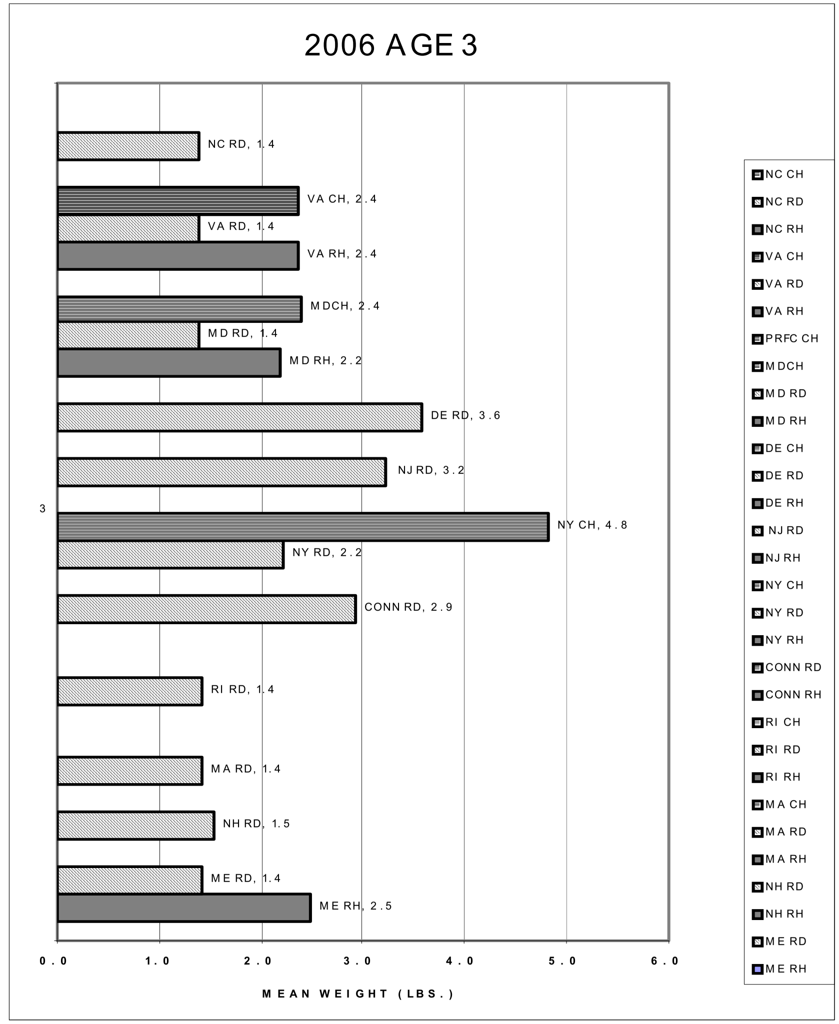
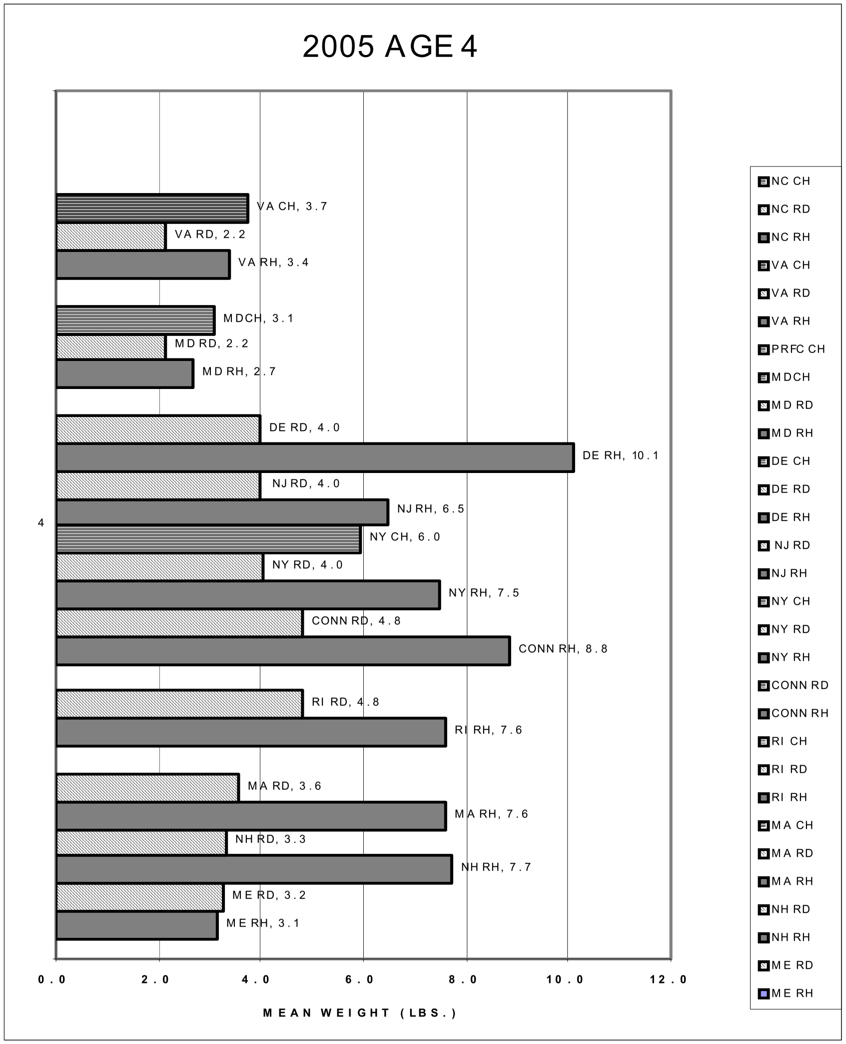




Figure 5B.2005 and 2006 weight at age 3 by state and fishery.



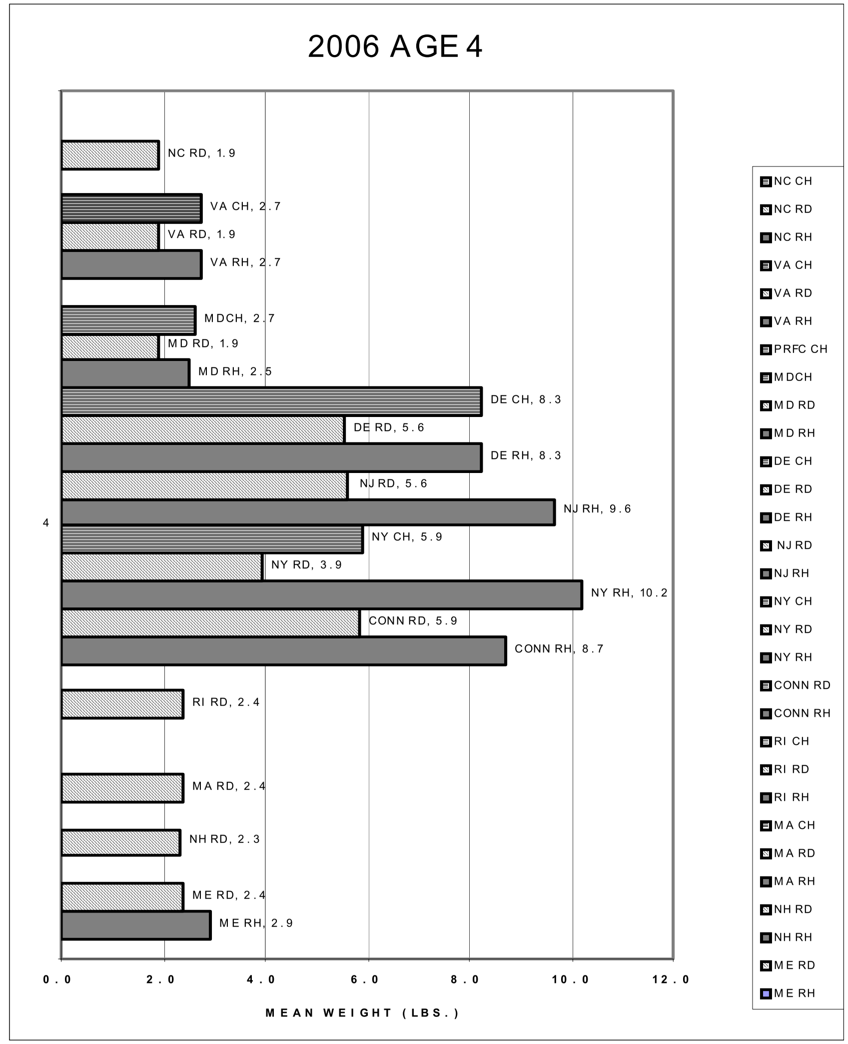




Figure 5C. 2005 and 2006 weight at age 4 by state and fishery.

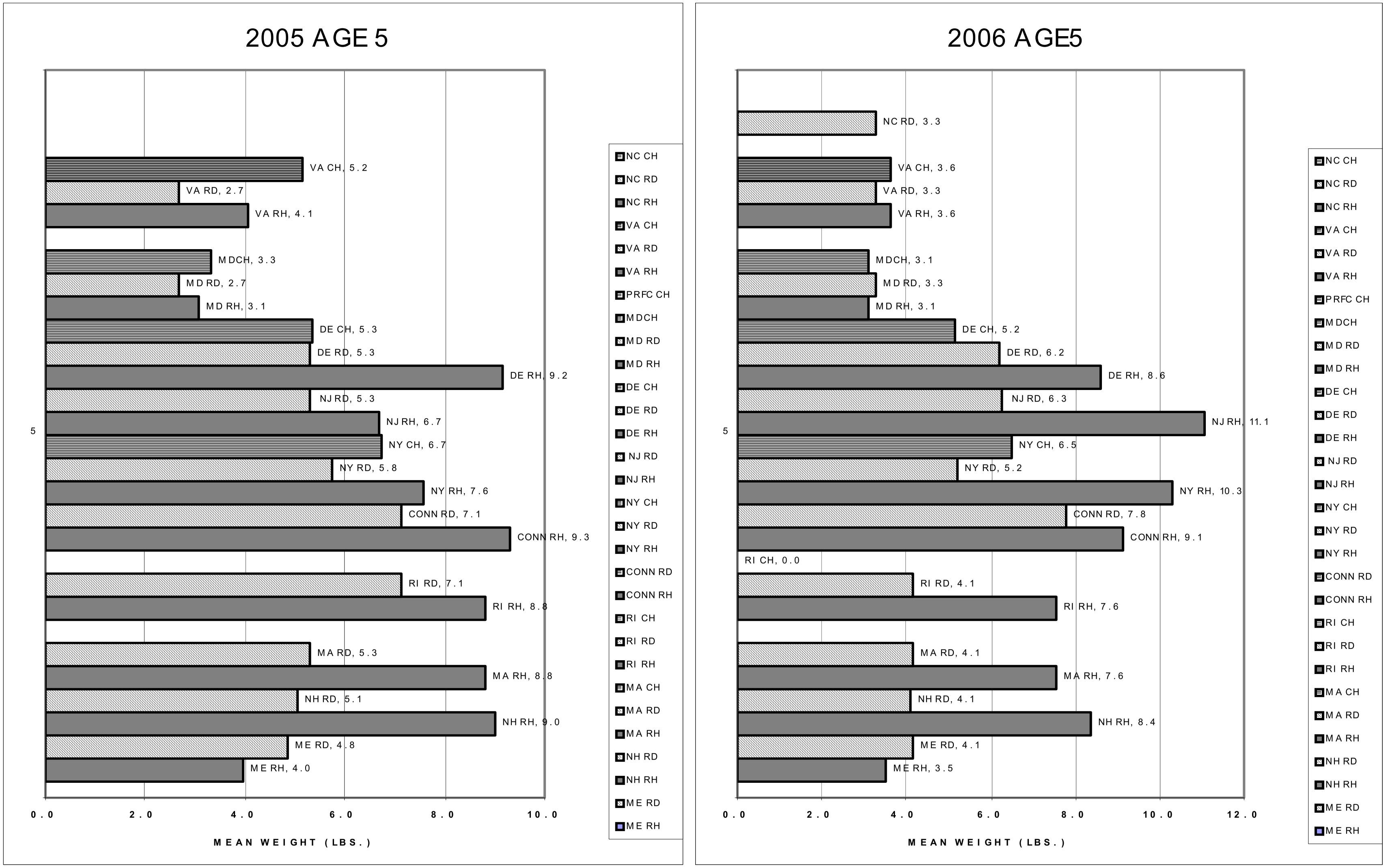
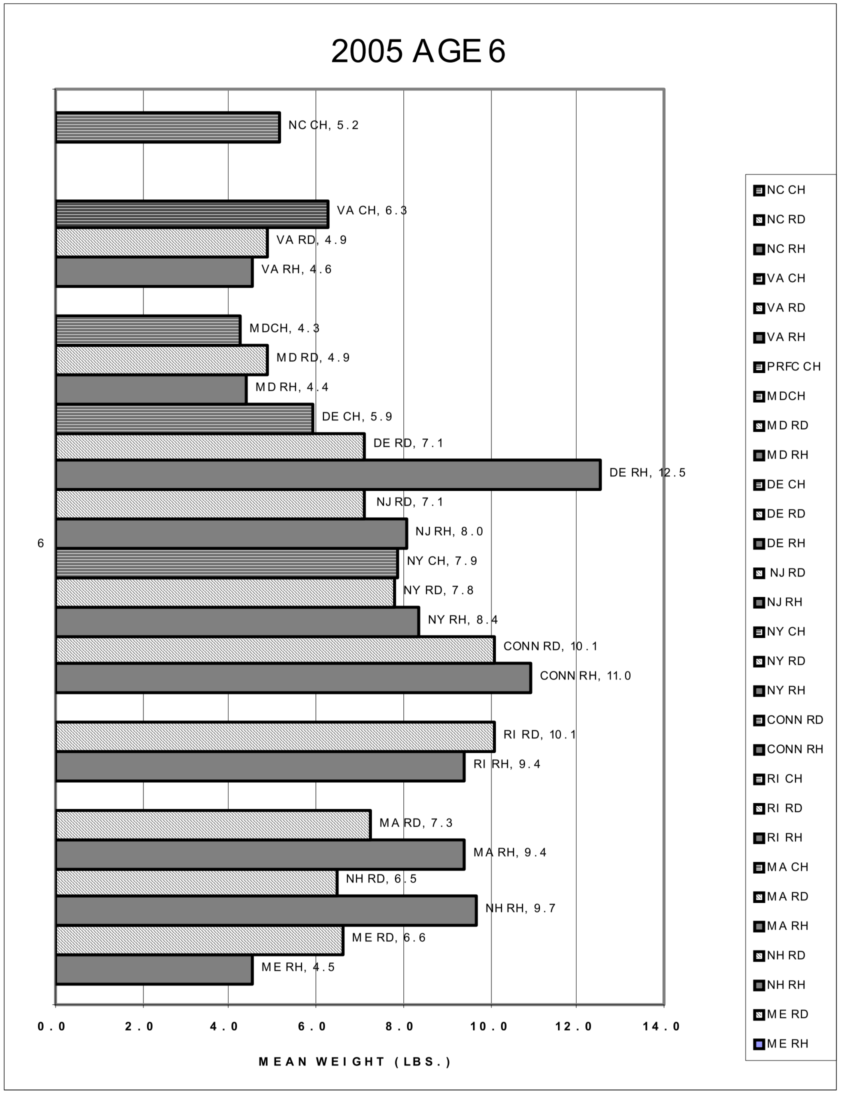



Figure 5D. 2005 and 2006 weight at age 5 by state and fishery.



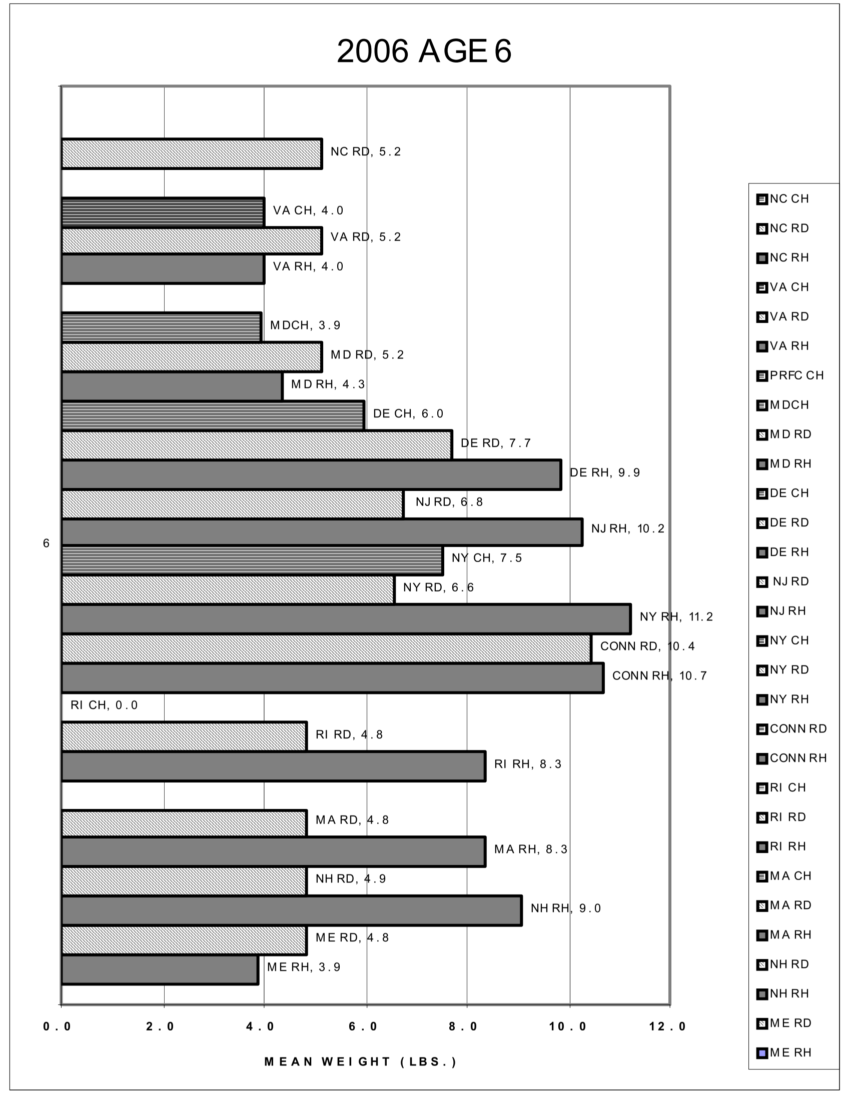
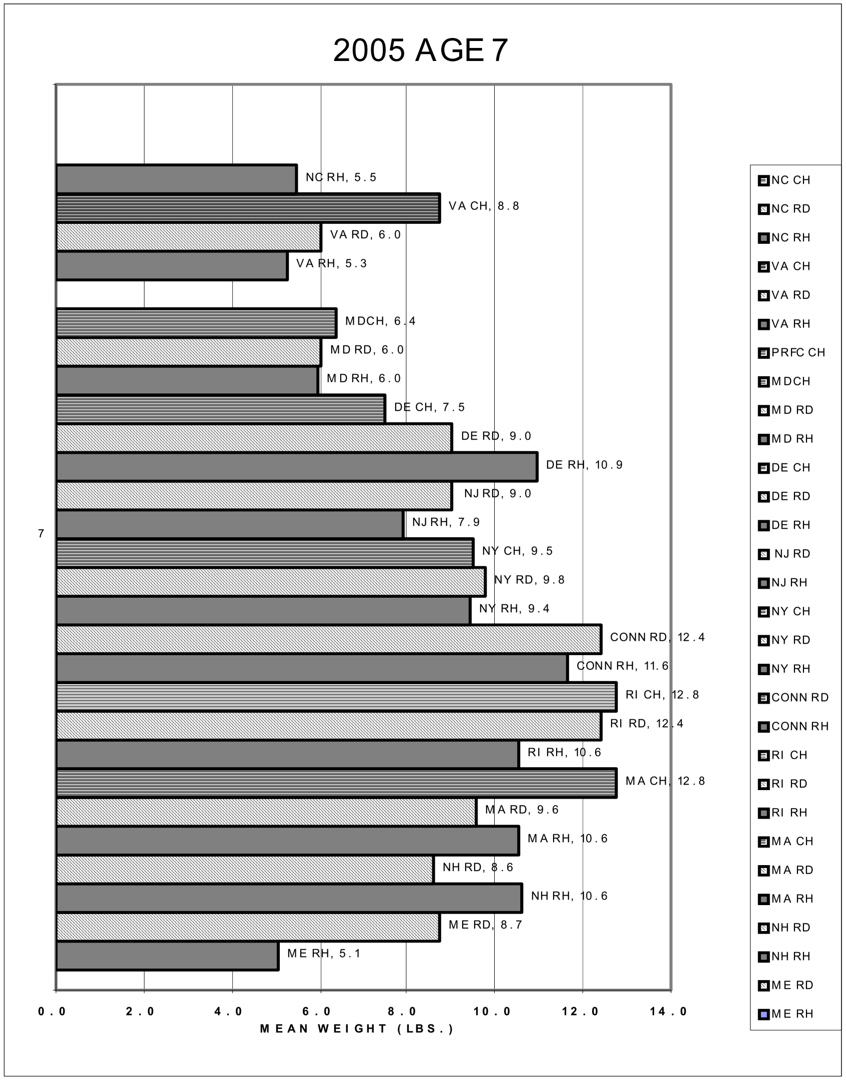




Figure 5E. 2005 and 2006 weight at age 6 by state and fishery.



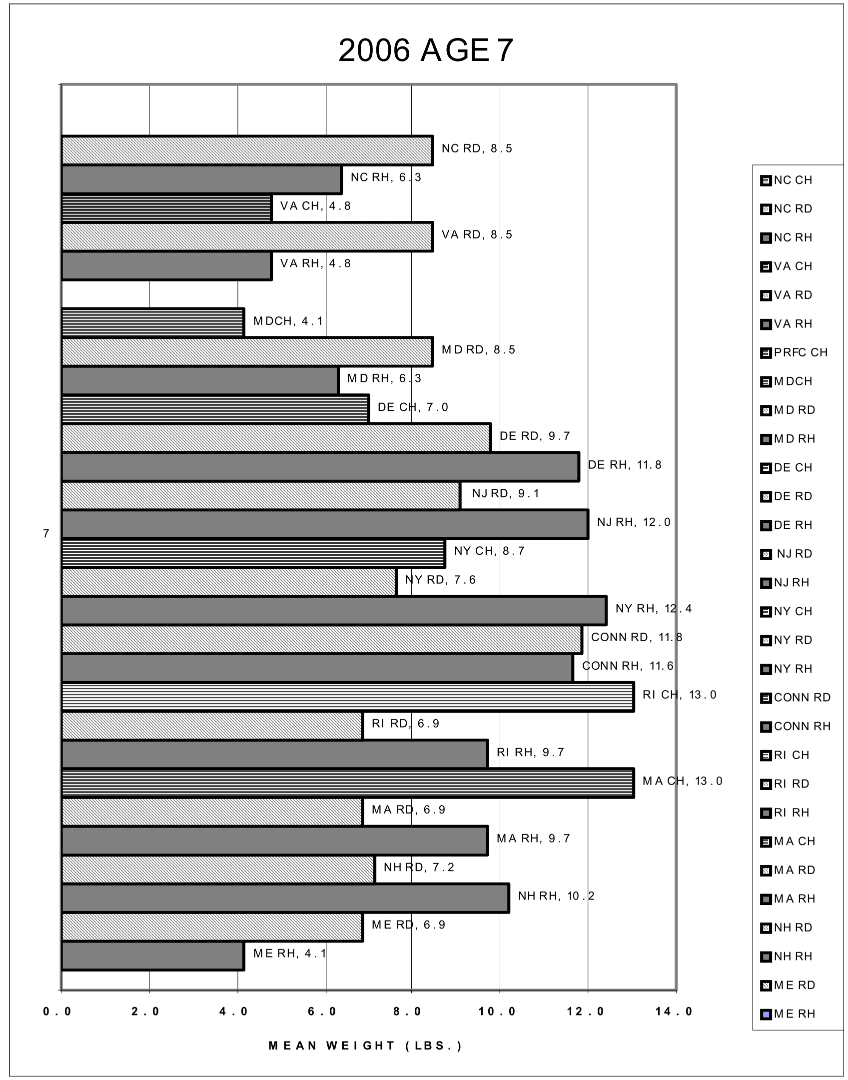
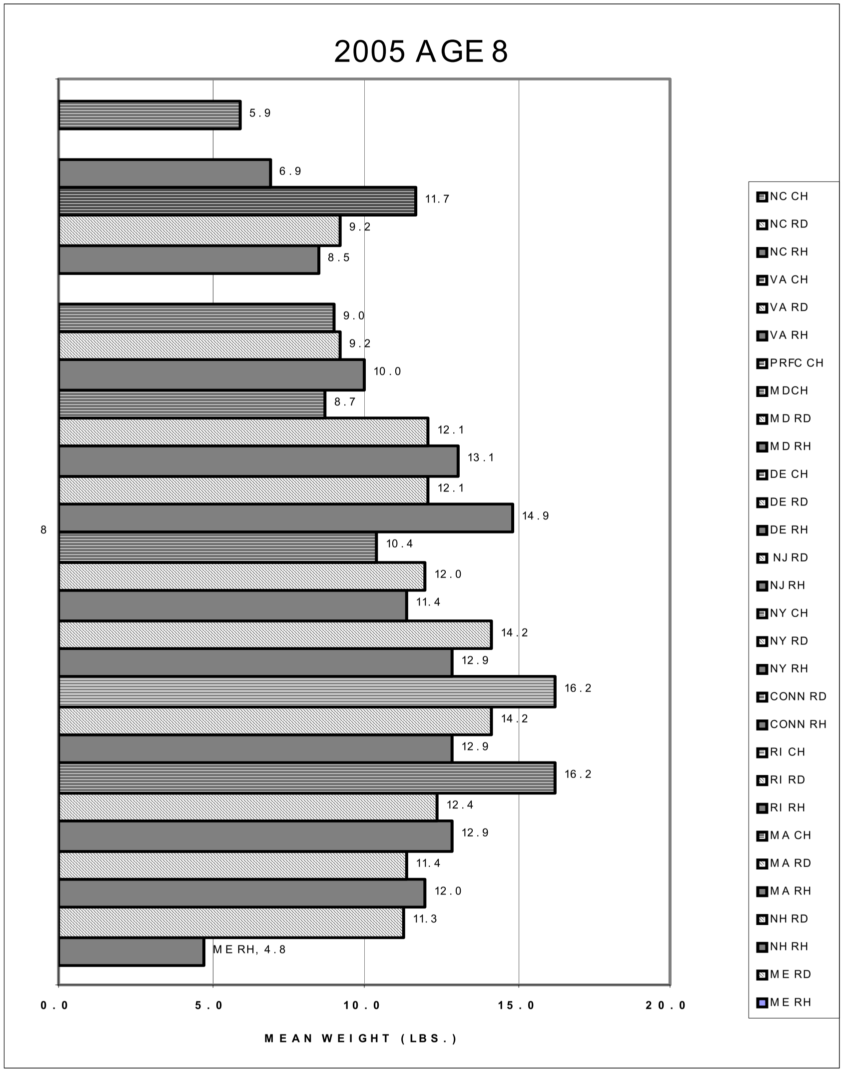




Figure 5F. 2005 and 2006 weight at age 7 by state and fishery.



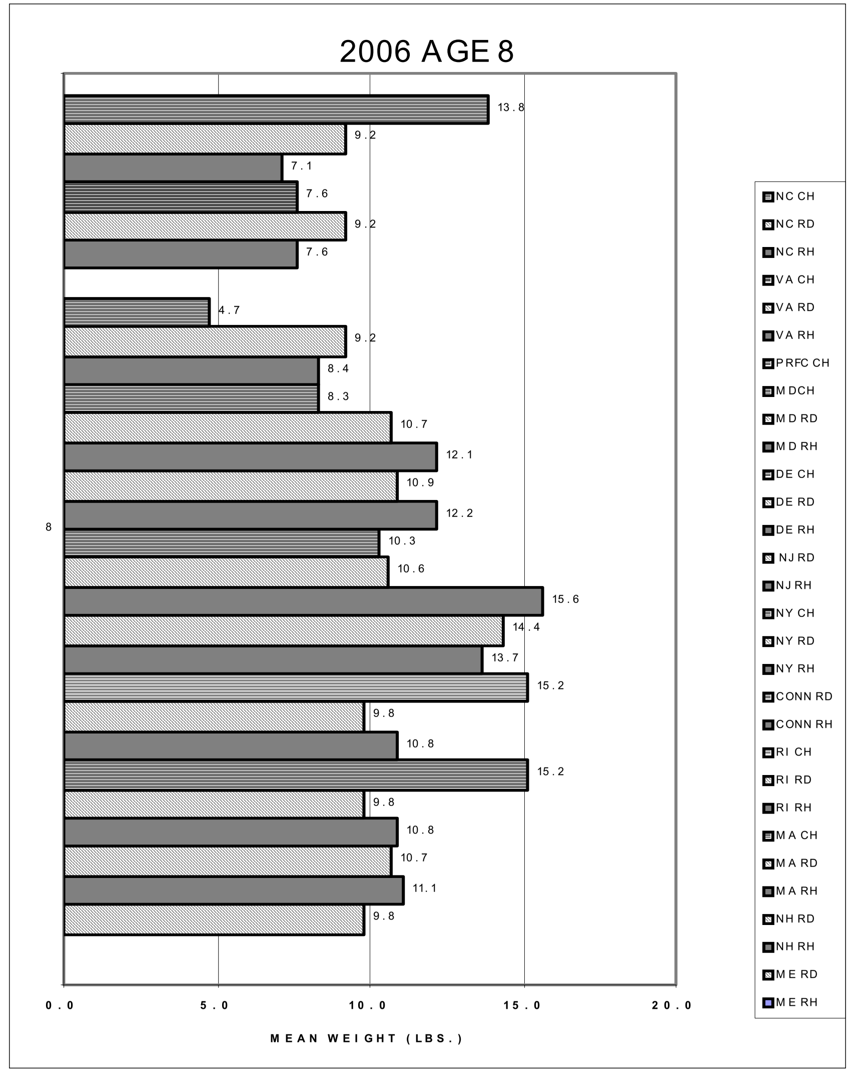




Figure 5G. 2005 and 2006 weight at age 8 by state and fishery.

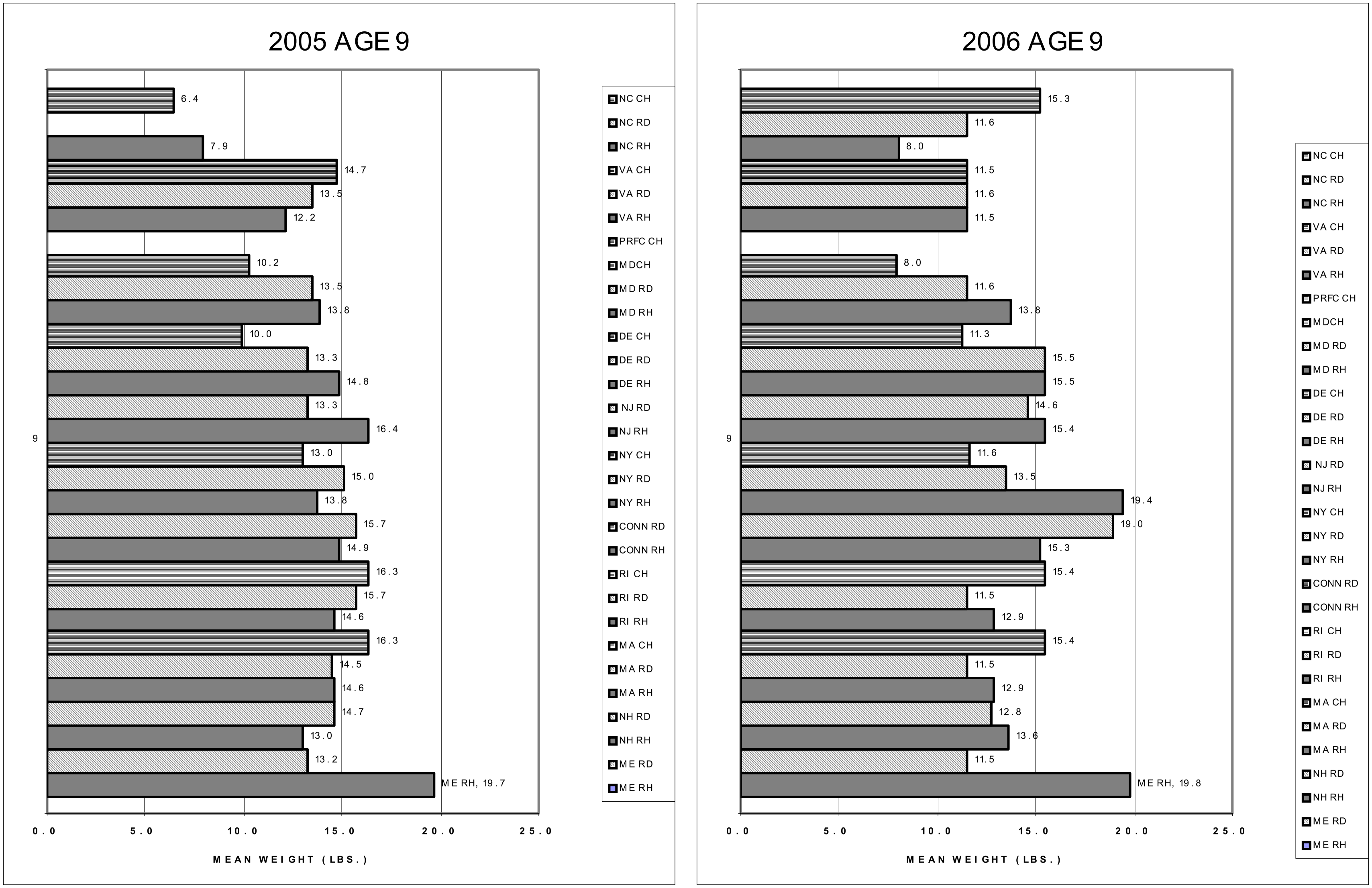



Figure 5H. 2005 and 2006 weight at age 9 by state and fishery.

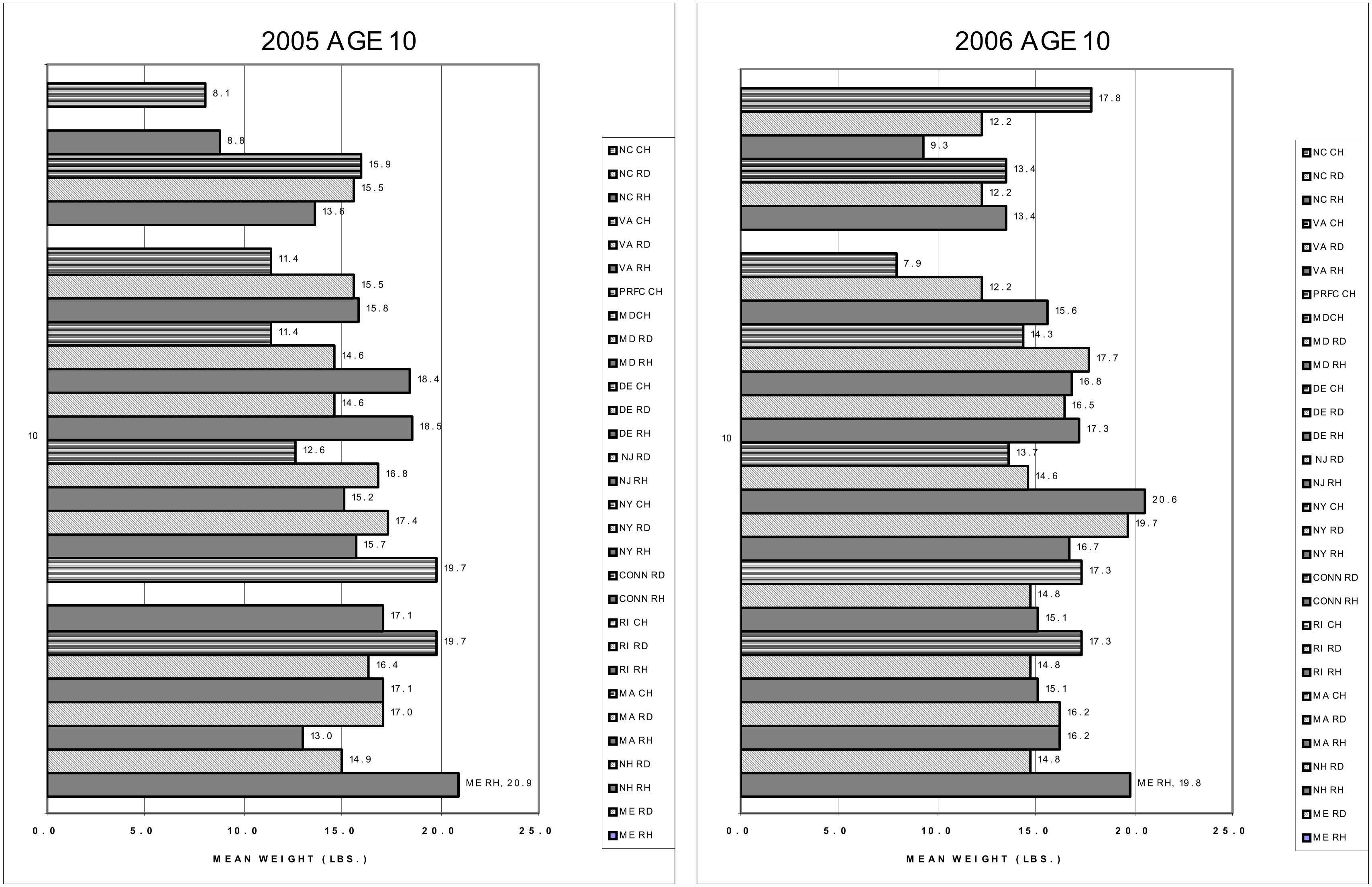



Figure 5I. 2005 and 2006 weight at age 10 by state and fishery.

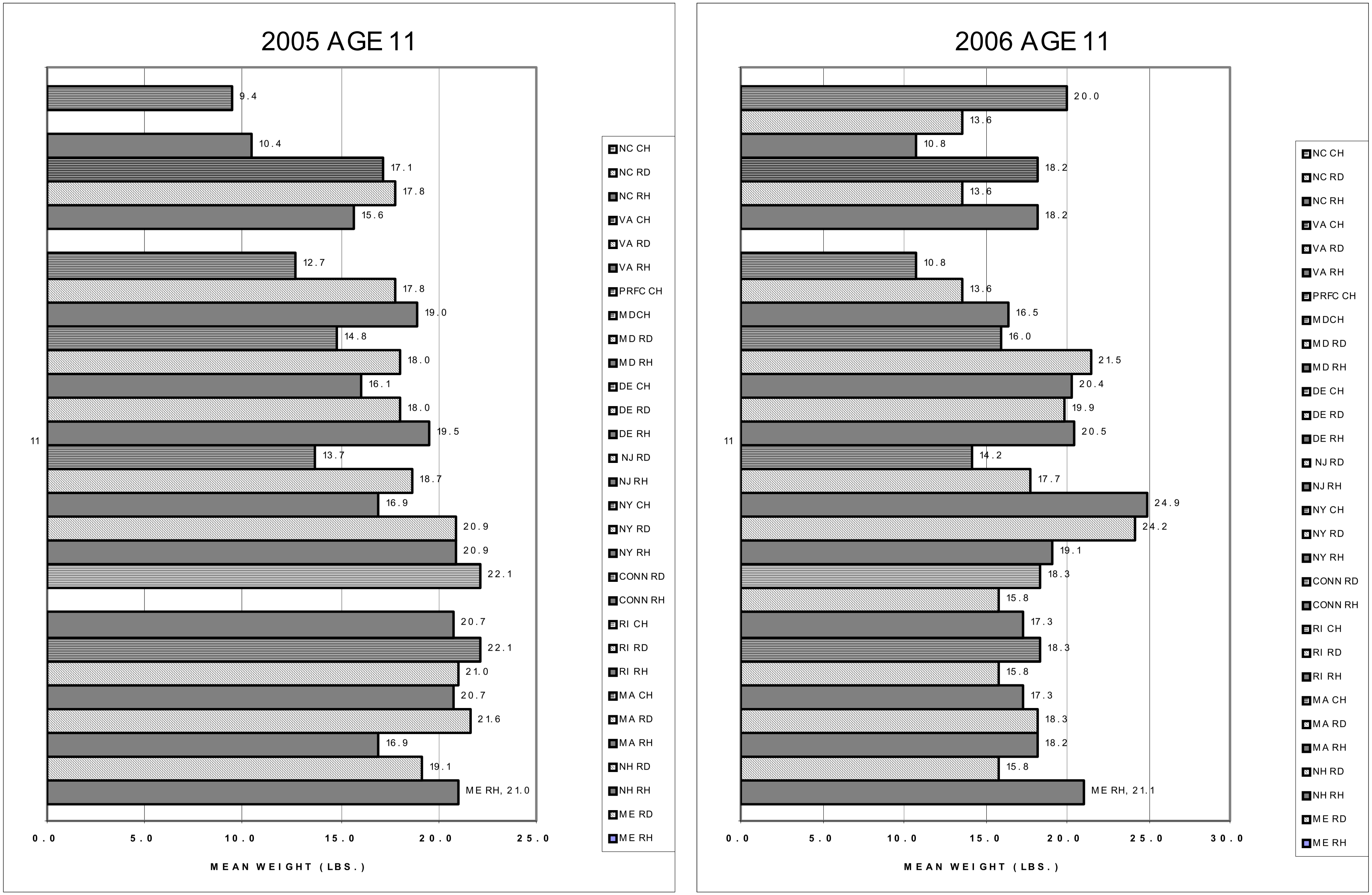
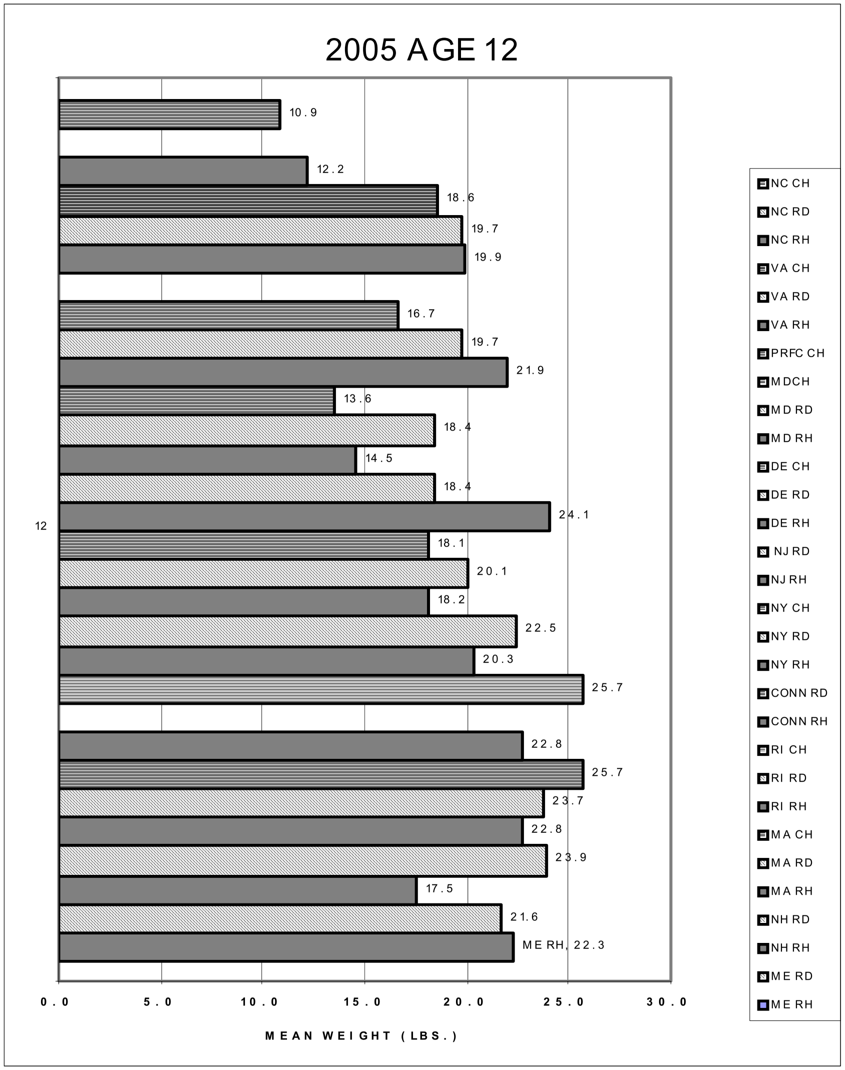



Figure 5J.  2005 and 2006 weight at age 11 by state and fishery.



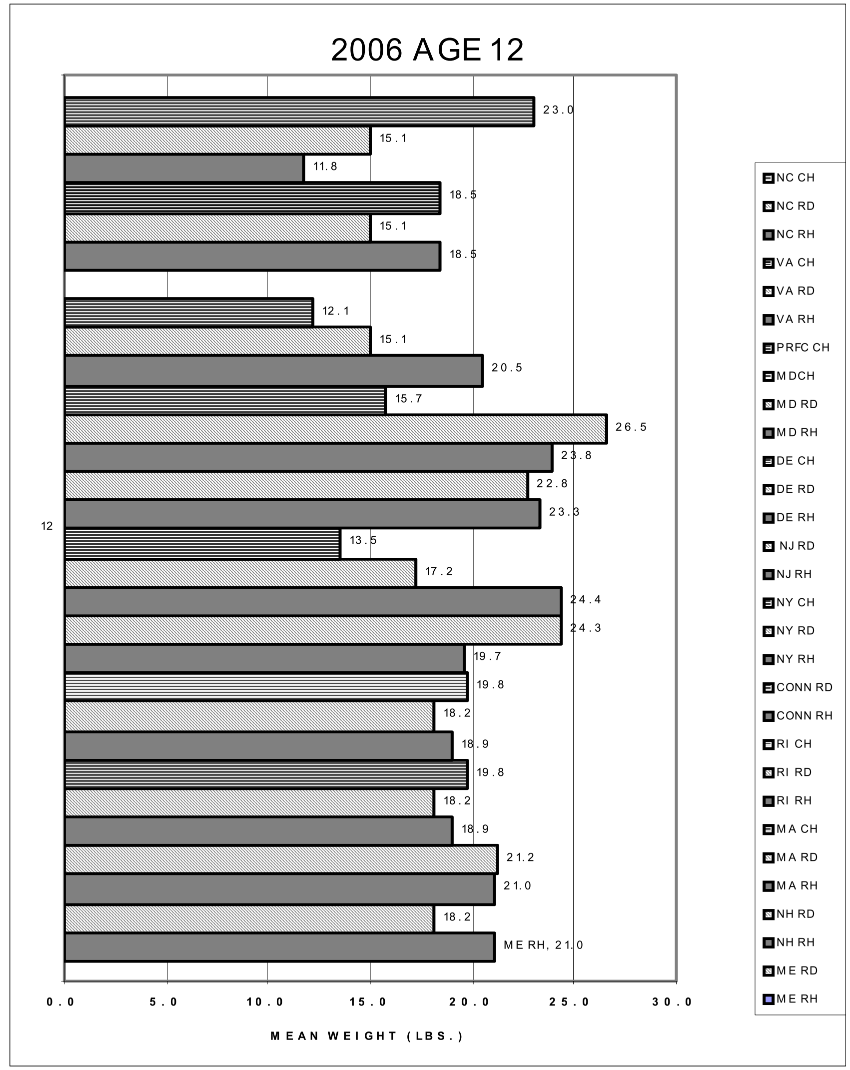
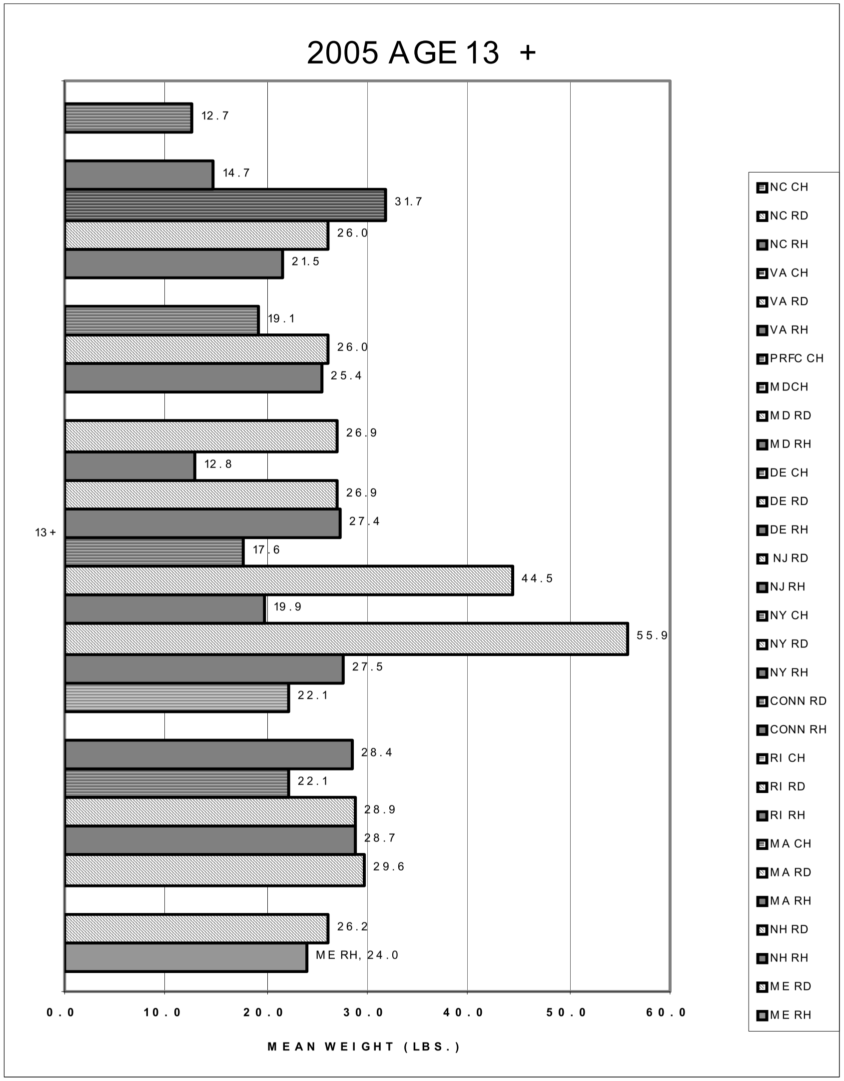




Figure 5K. 2005 and 2006 weight at age 12 by state and fishery.



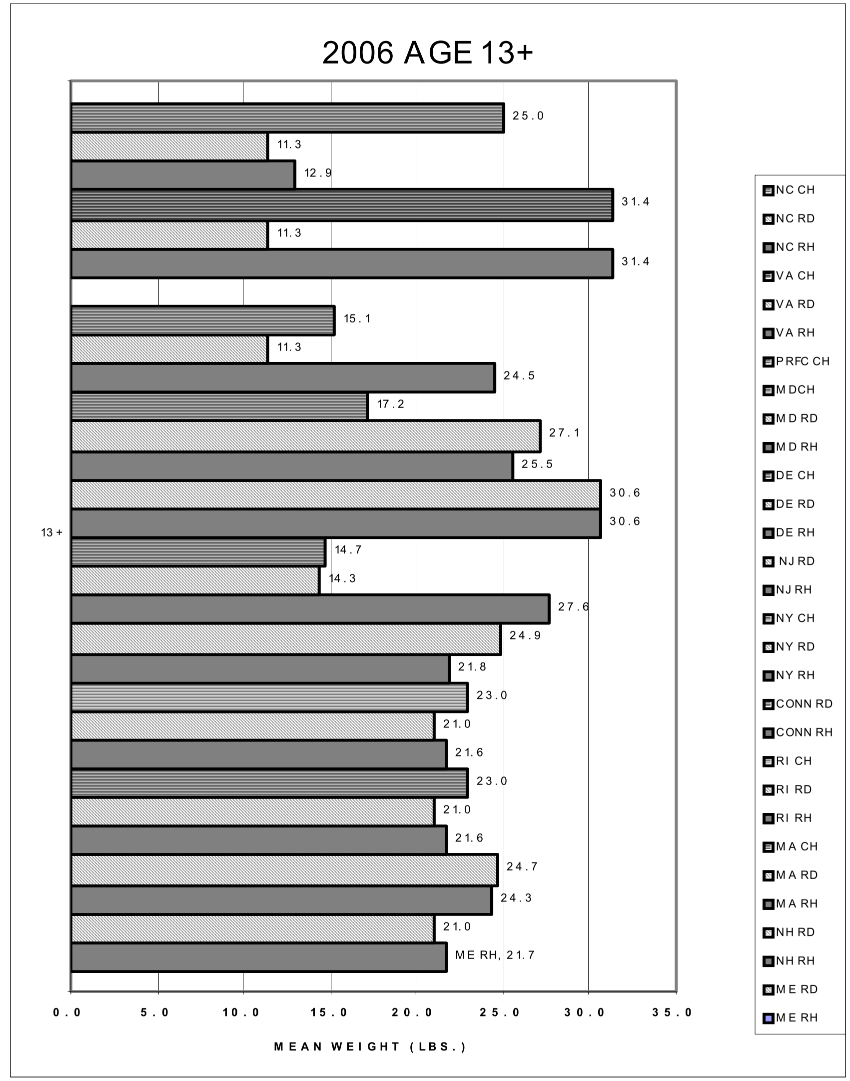




Figure 5L. 2005 and 2006 weight at ages 13+ by state and fishery.

## Appendix 5b Appendix

### Problems encountered in this analysis

Lisa Warner, a striped bass biologist with extensive experience with striped bass biology and working with age-length keys, performed these calculations. Several problems were found with the compliance report spreadsheets that required adjustment before accurate WAA calculations could be performed.

### General Comments

1. Apparent difference in weights at age between states, and Bay and coast needs to be further investigated. Weights range in younger ages – age 3 ranged from 1.4 lbs to 4.8 lbs., age 4 ranged from 1.9-10.2 lbs. and age 5 ranged from 3.1-11.1 lbs... Is it a biological difference – i.e. females on the coast grow really, really fast (age length keys contained 28" age 4 fish)? Growth curves from annual compliance reports indicate similar growth patterns between all states, therefore differences may stem from ageing error.

2. Data standardization – we need to utilize standard units for the compliance report. For example, data was in kg and pounds; total length and fork length.
Care needs to be taken to make sure there are no missing formulas or ages, especially when length groups have been collapsed. Maybe a template with locked cells would help.

3. The summary page in the compliance report needs to be re-evaluated. The way it is currently set up makes it extremely easy to make an error in the statewide summary due to sum product errors, making it unusable.( Example- ages 1-3 below) It might be easier to omit this step and save the weighting for the coastal WAA process and not have these state combined fisheries WAA. Unless there are mean weights in every cell of each age for each fishery, the weighted mean weight at age for the state will be incorrect

| Fishery: | Total # | Total wt | | Mean weight at age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Rec Harvest | 310441 | 4768272 | | - | - | - | - | 10.21 | 10.30 | 11.24 | 12.41 | 15.61 | 19.42 | 20.60 | 24.91 | 24.36 |
| Comm. | 73528 | 688446 | | - | - | - | 4.83 | 5.91 | 6.48 | 7.49 | 8.75 | 10.28 | 11.60 | 13.67 | 14.21 | 13.45 |
| Rec Discard | 142027 | 542461 | | - | 0.50 | 1.14 | 1.98 | 3.49 | 4.61 | 5.85 | 6.76 | 9.38 | 11.95 | 12.96 | 15.72 | 15.31 |
| TOTAL | 525996 | 5999179 | wt'd by wt | 0.00 | 0.05 | 0.10 | 0.73 | 9.11 | 9.34 | 10.33 | 11.48 | 14.44 | 17.84 | 19.12 | 22.85 | 22.29 |
| | | | wt'd by # | 0.00 | 0.14 | 0.31 | 1.21 | 7.79 | 8.23 | 9.26 | 10.37 | 13.18 | 16.31 | 17.57 | 20.93 | 20.39 |

## Appendix A6: VPA Indices Workshop

### Striped Bass VPA Indices Workshop – Baltimore, July 28 & 29, 2004

**List of Participants**

| NAME | AGENCY | ADDRESS |
|---|---|---|
| Linda Barker<br>Alexei Sharov | Maryland Department of Natural Resources | Tawes State Office Building<br>580 Taylor Avenue<br>Annapolis, MD 21401 |
| Tom Baum | New Jersey Department of Environmental Protection – Bureau of Marine Fisheries | P.O. Box 418<br>Port Republic, NJ 08241 |
| Peter Fricke | National Marine Fisheries Service – NOAA F/SF5 | 1315 East West Highway #3221<br>Silver Spring, MD 20910 |
| Megan Gamble<br>Patrick Kilduff | Atlantic States Marine Fisheries Commission | 1444 I Street, NW 6th Floor<br>Washington, DC 20005 |
| Bob Harris<br>John Hoenig<br>Phil Sadler | Virginia Institute of Marine Science | P.O. Box 1346<br>Gloucester Point, VA 23062-1346 |
| Des Kahn<br>Greg Murphy | Delaware Department of Natural Resources & Environmental Control, Fisheries | 254 Maine Street<br>P.O. Box 330<br>Little Creek, DE 19961 |
| Andy Kahnle | New York Department of Environmental Conservation – Bureau of Marine Fisheries | 21 South Putts Corner Road<br>New Paltz, NY 12561 |
| Laura Lee | Atlantic States Marine Fisheries Commission/ RI DEM | 3 fort Wetherill Road<br>Jamestown, RI 02835 |
| Gary Nelson | Massachusetts Division of Marine Fisheries | 30 Emerson Avenue<br>Gloucester, MA 01930 |
| Gary Shepherd | Northeast Fisheries Science Center | 166 Water Street<br>Woods Hole, MA 02543 |
| Clif Tipton | United State Fish & Wildlife Service | 177 Admiral Cochrane<br>Annapolis, MD 21401 |
| Vic Vecchio | New York Department of Environmental Conservation – Bureau of Marine Fisheries | 205 North Belle Mead Road<br>East Setauket, NY 11733 |

**Workshop Purposes**

- ***Impetus***: "An objective discrimination of which tuning indices to include or withhold from the model should be integrated in the next assessment." 36th SAW Advisory
- ***Goal***: Develop criteria for the inclusion/exclusion of current and future indices for aggregate or age-specific (≥age 2+) used in the striped bass virtual population model.
- ***Objectives***: Critically evaluate the survey design and precision of the index, and validate each index by comparing it to other area indices. If applicable, determine how the survey design should be modified to be more valuable.

**Background: The Role of Indices in the VPA**

Indices are used in the tuning process as a relative index of abundance (abundance at age). Some surveys provide an aggregrate index and others provide an age specific index. Some may be appropriate for aggregation due to precision; others are more precise as an age-specific index.

ADAPT uses the entire time series to determine relative abundance of the cohort in the terminal year. The longer the time series the more information the model has to produce an estimate. After the model produces the estimate, the stock assessment subcommittee evaluates the correlation of the index to the known abundance as the VPA has estimated it.

**Evaluation Criteria**

The Workshop participants began the discussion with the some suggested guidelines provided by Gary Nelson prior to the meeting. The guidelines are as follows:

a. Have a sampling design
b. Have an acceptable level of precision (if applicable)
c. Has it been validated? (i.e., is it correlated with indices of abundance of other life stages, etc.)

The sampling design should be appropriate to achieve the objectives of the survey. Additionally, the sampling design should produce a precise estimate. Further indication of a good index is the validation of the survey, comparing it to another index that shows similar trends. There should be a correlation between indices sampling similar portions of the coastwide stock. If an age class can be followed through time, it is also indicative of a good survey.

Taking Gary's suggestions a step further, John Hoenig developed a set of discussion points regarding the index. The following list includes the John points plus additional comments from other participants.

1) Correlation of an index with the VPA is not an appropriate evaluation criterion unless the index pertains to the whole stock. (If substocks in the North go up, as reflected in three indices, and substocks in the South go down, as reflected in one index, you'd get a biased picture if you eliminated the southern index just because it disagreed with the average (which is dominated by the North)).
2) Validity of sampling design can be used to determine inclusion. An index should not be evaluated based on an inappropriate variance. The appropriate variance can be determined based on the survey's sampling design. For example, if one site is sampled repeatedly (e.g., a pound net) the sample size is one (i.e., one site).

3) The number of sites and the number of days sampled may be useful criteria; a minimum number of fish sampled might be appropriate *in combination* with other factors (number of sites, etc.)

4) All indices should be treated "equally" to be "fair".

   a. If you evaluate one index you should evaluate all of them.
   b. You can kick out indices but there must be a way to reinstate them and there must be a way to introduce new indices that is "fair" in the sense of holding the index to the same standards as other indices.

5) If you want to make a change to the set of indices, it is important to do two assessments in parallel – one the old way and one the new way for several (e.g., 3) years. Otherwise, you can't distinguish between changes in stock perception due to methodology and changes due to stock dynamics.

6) If an index represents only a portion of the stock complex then it should receive a weight less than one. The stock assessment subcommittee has typically weighted the indices according to how well they fit the VPA, e.g., using iteratively reweighted least squares.

7) If an index is unique in representing a particular portion of the stock complex, then it may be desirable to retain the index even if it is not perfect.

8) The primary criterion thus would appear to be whether an index tracks weak and strong year classes well. An index can be considered poor if year-to-year changes in catchability obscure abundance trends.

   a. In looking for year effects, it is not appropriate to look at the residuals from the VPA unless the index being evaluated pertains to the whole stock.
   b. If one plots age-specific indices versus time, then synchronous peaks and valleys (all indices going up and down together) is problematic.

9) If age-specific indices are problematic, the program might still provide an aggregate index

10) Validation of one index against another index from the area provides support for the two indices.

Some of the indices used in the VPA assessment are age-specific and some are age-aggregated indices. It might be necessary to develop different criteria for the two kinds of indices. Before eliminating an age-specific index, the survey should be considered as an aggregated index. The problem with the index may be the ageing. It could still track the stock appropriately as an aggregate.

The Stock Assessment Subcommittee currently uses iterative reweighting for the surveys, meaning the survey weighting is based on how well the index fits the estimate produced by the VPA. The VPA is currently used to derive a single estimate of the fishing mortality on the coastal migratory stock. Ideally, there would be stock specific VPAs that are combined into one coastwide assessment.

If you believe that the particular index gives you reliable representation of the dynamics and abundance of the species in the particular area, then an estimate of variability of the index is needed. Also, you need to know if the same index is representative of the stock coastwide because we are looking for an ideal index of relative abundance that would be truly representative of the stock coastwide. An alternative to the VPA's iterative reweighting would be to assign weights to each index based on an assumed contribution to the overall coastwide migratory stock.

There is some concern about apriori weighting because an index may represent the local stock accurately. Also, as the stocks have rebuilt over time the contribution to the coastal stock has increased. There is uncertainty as to how this can be accounted for in the apriori weighting.

**Review of Sampling Program and Indices**

The participant agreed to many of the points in John Hoenig's list, but not all. The group decided to continue with a review of the sampling programs. The evaluation criteria would be further refined as the surveys are reviewed.

*Massachusetts – Commercial CPUE Index (Gary Nelson)*

The Massachusetts Commercial catch per unit effort index has been used in the VPA assessment since the Striped Bass Stock Assessment Subcommittee has used the VPA. The unit of effort has changed over the course of the time series. The method for calculating the CPUE has changed over time with different MA DMF personnel. The time series has been recalculated using a consistent methodology.

The index is really a measure of commercial harvest per effort or an estimate of the number of fish sold per trip. It uses the weight of the fish reported by the dealer and the average weight of the fish measured in the fish house. The average is then weighted by the total fish (whole fish) landed in each county. The total weight reported is an absolute (no variance), but the average weight is estimated so the variance is included. The number of trips comes from the required catch reports. Fishermen must submit catch reports to receive a license for the following year. Catch reports include information such as hours fished, number of fish sold and released by month, and dealer transactions. This survey is used as an age aggregated index and age-specific index.

The sampling design is not ideal for this index because the sampling is dependent on which fish house lands striped bass. Three counties in Massachusetts make up about 80% of the total landings. The information gathered in the fish house does not provide information about the trip, whether it was landed as a direct or indirect take. Most of the Massachusetts striped bass fishermen are weekend warriors.

There are a few problems with the survey design. Permits are issued to the boat, not individuals. Therefore, an average trip per boat is estimated not per fishermen. The number of fishermen is not collected. In Massachusetts, this fishery is hook and line only and has a trip limit of 40 fish per day. There could be five guys on a boat for one hour catching 40 fish or one guy out there all day catching 40 fish.

The catch per effort per trip is not well defined because the information is not collected. There are over 4,300 people permitted but Massachusetts only receives 100-200 voluntary logs with trip dates, numbers caught, hours fished per trip. The average hours fished is estimate from the logbooks. Average hours fished contributes to variability in the survey. There can be hours fished with zero catch. Even though commercial fishermen are required to submit catch reports, not all submit the report despite the penalty of losing the permit in the next year. So Gary has to impute the fish caught using the information he does have. Additional information may be available through the VTR data for commercial fishermen holding a federal permit.

This survey has a multiple stage sampling design, meaning it needs a randomly sample a fish house and then randomly sample the fish. The variance estimate is conditional on assumption of random sample, but sample may not be representative. The fish that end up in the fish houses are random, but the selection of which fish house is sampled is not random. Therefore, we do not know if the sample is representative of all the catch because it is not random. Bootstrapping does not confer validity on an index.

The group discussed the difficulty of setting one standard for all the surveys – the protocol for variation estimation will depend on the survey design, therefore will not be consistent across all surveys. The index should not be thrown out because it's not perfect, especially if there is not another index to replace it and its representative of the area.

The number of trips is declining because the quota is filling more quickly. There is a jump in the CPUE from 1994-1995 because there was a change in the minimum size and the commercial quota also increased. The group is not confident that the CPUE represents the population, particularly the fishery has capped out the quota since 2000. Also, in a representative catch, the cohorts can be followed through the samples. The 1993 yearclass was strong and it cannot be followed through the MA CPUE. One suggestion was to apply a length frequency to the ageing samples for a more representative sample.

For an age-specific index, Massachusetts could randomly pick a fish box to collect samples. The proportion of ages in a sample could be applied to the aggregate index. Massachusetts had to cut down on the sizes of age samples from the fish house due to personnel cut backs.

*Connecticut Recreational CPUE and Trawl Survey*

Connecticut submitted information regarding the trawl survey, but did not provide information on the recreational catch per unit effort. Additionally, there was no representative from Connecticut in attendance at the Workshop. The Connecticut surveys were not reviewed at this time.

*New York Long Island Ocean Haul Seine Survey (Vic Vecchio)*

Originally, the survey had 10 sampling locations that consisted of inshore sandy sites. The locations were randomly sampled from October to November. After the commercial striped bass fishery reopened, commercial trawls were prohibited from state waters. Some localities prohibit NY DEC from accessing traditional sampling sites. In New York, fishermen are not allowed to use ocean haul seine survey to commercially catch striped bass, but can use to fish for other species. The estimates derived from 10 sampling locations were compared to the results with fewer sampling locations. There was no difference in the ages in the catch. Additionally, funding has been reduced impacting the sampling dates and actual survey catch. The dates of the older survey have been standardized.

In reviewing the time series, it is interesting to note that the catch jumped in 1996-1998 due to the 1993 and 1996 yearclasses. Also, in some cases the coefficient of variance exceeded the catch. Bootstrapping would be appropriate for the New York data.

Age samples are taken from every fish measured in the survey. New York is able to produce an estimate of geometric mean catch at age for each survey year. The CV is then calculated for the catch at age and an averaged from 1997-2003 is produced. The survey is not very good at catching the larger fish, so the sample sizes for the older fish are pretty small.

The survey samples a mixed stock. To evaluate the survey, the ocean haul seine survey was correlated to the YOY index. Out of 13 age groups, 11 had positive correlation, but only 6 had a significant correlation.

*New Jersey Trawl Survey (Tom Baum)*

The New Jersey trawl survey has a stratified random sampling design. The survey occurs in April and October. Decreases in funding have led to reductions in annual sampling effort, from 60 to 45 seine hauls. New Jersey's survey was not designed to sample striped bass survey; it was originally for sampling groundfish. Striped bass are tagged when feasible.

In a typical year, there are 30-40 tows in 18 strata, which comes out to about 2 tows per site. The CVs are pretty low in the later half of the time series. The high CVs in the latter half of the time series could be attributed to low sample sizes at each stratum. The standard error should be checked to determine if it was calculated for a stratified random design.

The survey is used as an age aggregated index, aggregating ages from 2-13. April and October are used as separate age aggregated indices because the length frequencies differ significantly, representing different stock composition. April survey is more consistent and therefore probably the better candidate for an age-specific index. New Jersey has an age-length key for every year, so most of the information is available for switching over to an age-specific index. If the survey measures all of the fish caught, then it could be used as an age-aggregated index. It is possible to get age specific data, but New Jersey is not likely to produce the data.

To reduce the variance, some of the strata should be thrown out because no striped bass were caught in that location. The strata should only be removed from the index if there were no striped bass throughout the time series. The variance can be a problem with fixed station trawl surveys because there is no random element to the survey.

*Delaware Trawl Survey (Des Kahn)*

The Delaware trawl survey began during the 1960's, but the exact start date is not well documented. The survey collects weight rather than numbers of fish (kilograms per tow of striped bass). The time series is disjointed because a different vessel was used in the first two segments of the time series. In 2002, the survey began using a new custom-built stern rig trawler. Comparative tows were conducted to get a handle on the catchability of the two vessels.

The trawl survey uses a fixed sampling scheme. It was selected due to the lack of towable bottom in Delaware Bay. The index was conducted the whole year. Due to the number of zero tows, the data was jackknifed – used for situations were the distribution assumptions may not be true. Jackknife does not deal with the lack of distribution of the data; it does assume that the sample is representative of the population from which it is drawn.

The sample size is the number of months that were sampled. In some years, the trawl survey did not operate in March. In each month, the fixed sites were sample nine times.

The trawl survey is used as an aggregate index in the VPA (age 2-7). There is age data available from 1998 forward. To validate the index, it should be compared to another mixed stock index. The lagged juvenile index is often used to confirm trends.

*Delaware Spawning Stock Survey (Greg Murphy)*

The Delaware River spawning stock survey collects age, size, sex, and abundance estimates for striped bass. The survey began in 1991 experimenting with three different collection methods and has continued using electrofishing since 1994. The survey divided the

Delaware River into two zones based on river access. There are twelve Delaware stations and fourteen Pennsylvania stations. Over time, some of the stations have been lost due to development.

The stations cannot be considered random, but the observations at each station are random. The survey has a multistage lattice design. The strata are sampled independently of another (i.e. sampling does not affect other sites). The lattice survey design imposes a structure to control the number of times each area sampled.

Another challenge that confronts the survey has been the moving salt line, which can restrict the sample areas upstream where electrofishing is effective. Reviewing its correlation to other life stages, such as a juvenile survey, could validate this survey.

*Maryland Spawning Stock Survey (Linda Barker)*

The objective of the Maryland's spring gillnet survey is to characterize the Chesapeake Bay portion of the spawning stock biomass and provide a relative abundance at age. The survey area at one time covered the Chesapeake Bay, Choptank River and Potomac River, but the Choptank River has since been dropped from the survey. A stratified random design is used to sample the spawning areas.

The group discussed the survey's sampling design to determine if it was truly randomly stratified. Because Maryland DNR samples the same site twice in some days, the design can be referred to as two-stage cluster sampling. It is important to correctly identify the sampling design to properly calculate the variance.

For each sample, all of the striped bass are measured, all females are aged, but only males greater than 700 mm are aged and smaller males are subsampled. Since 2000, approximately 500 fish are aged per year. The group recommended developing area and sex specific age length keys. MD DNR should also look into applying selectivity coefficients.

The survey has revealed that it does not accurately capture the spawning stock biomass as it collects samples of fish ages 2-8. There is a very low variance for ages less than 8 years old and higher variable estimates for ages greater than 8 years old. The number of age 8+ appearing in the survey has increased since the moratorium. The fish caught in the survey are mostly males (age 2-8) and the ages 10 and greater are mostly females. The data is representative of the behavior of the fish, capturing mostly males. The CPUE provides a decent relative abundance at age, but it is not doing a good job of characterizing the spawning stock survey.

*Virginia Pound Net Survey (Phil Sadler)*

Since 1991, Virginia Marine Institute of Science has conducted the Viginia pound net survey. The pound net survey takes place on the striped bass spawning grounds in the Rappahannock River between river miles 44-47. VIMS has the option of sampling up to four commercial nets. The upper and lower nets are used for this survey and the middle nets are used for tagging. VIMS alternates sampling between the upper and lower nets. The sampling occurs from March 30 to May 3, when the females are on the spawning ground. The pound nets are checked twice a week, but are fishing constantly. When the samples are collected, the fish are sexed and measured, scales are taken from every fish, and a subsample of otoliths.

The sex ratio in the catch tends to be two males to every female. The females captured in the survey are generally ages 4 and older and males are age 3 and older. There appears to be no bias in net catchability.

There are several periods where no fish were caught. By averaging the CPUE data, the estimate is low. To eliminate the zero effect, VIMS could graph CPUE by date and determine the area under the curve.

The Workshop participants had a lengthy discussion on the Virginia pound net survey because it is an example of a survey that was removed in recent stock assessment due to poor performance in the VPA. The Virginia pound net survey provides an estimate of catch in the commercial fishery. If a variance is estimated, it is not an estimate of the striped bass abundance rather it is the variance for the commercial catch. The workshop participants suggested several ways to evaluate the survey. Local juvenile surveys can be used for validation. A longitudinal catch curve can also be applied to investigate year effects, specifically to detect downward trends. The catch curves explain how often the striped bass are seen and if the patterns are explainable. VIMS should also examine the temporal window and the spatial window to evaluate the survey design.

*NEFSC Trawl Survey (Gary Shepherd)*

The NEFSC trawl survey uses a stratified random design and assumes that time is irrelevant. The index samples fish from Nova Scotia to North Carolina. It is an eight-week cruise, completed in four two-week legs. Fishing occurs 24 hours per day. The survey did not really start to encounter striped bass until 1991. The survey has shown a general upward trend since 1990. The catch distribution tends to very from year to year and the sizes encountered are also variable.

The NEFSC trawl survey data would be a good candidate for an age-specific index. An age-length key from the New Jersey March-April gillnet survey could be applied to the NEFSC samples. The NEFSC survey is important because it is the only survey to cover the range of the coastal migratory stock. For a good index, the NEFSC would need 400 ageing samples. The fish are encountered in different locations in different years. So the appropriate key needs to applied to the samples. For the fish encountered in the southern range, an age-length key could be derived from the North Carolina Cooperative Cruise.

**VPA Output Compared to the Indices**

The group reviewed the ADAPT VPA output from last year's assessment to each of the indices reviewed during the workshop. The VPA predicted the indices very well when there weren't many striped bass. As the stock increased, the variance went up with the mean. If one of the criteria for inclusion was the index must follow the same trend as the VPA, then none of the indices would be used. The coastal indices should carry the same signal as the VPA output because they characterize the coastal migratory stock. Some of the indices may not align with the VPA because they were down weighted.

Several of the indices show spikes. The spikes should be compared to other indices to determine if there is correlation. The coastal indices should be reviewed to determine if there are spikes that correlate with one another or the VPA output. To determine the validation of the indices, it would be helpful to know how the VPA weighs the indices.

The stock assessment subcommittee has typically used the bootstrap estimates to determine the variation in the surveys. All of the surveys are entered into the VPA and the bootstrap estimates determine if it is appropriate to include each index.

On the other hand, the VPA produces an estimate of the overall stock complex abundance. To use the VPA to evaluate the indices may mean eliminating an index that does not track the overall stock complex, but tracks local trends accurately. An index should not be removed without a legitimate reason for removing the index. The effect of each index on the VPA should be analyzed.

**General Overview of Survey Issues**

The sampling design of each survey was a common theme for discussion during the review of the indices. There tends to be two separate types of programs. The first group includes the NEFSC trawl survey and the Maryland Spawning Stock Survey. These two surveys are randomized over space. The second group includes other programs such as MA CPUE, which is a census of commercial catch rates, but fishermen are not fishing over random fish. The New York ocean haul seine survey is not randomized over space. The Virginia pound net survey uses two nets over fixed locations. Delaware is randomized, but only 30% can be sampled.

There is confidence that the Maryland spawning stock survey and the NEFSC trawl survey are catching a representative sample of the population because both surveys are randomized over space. Both surveys can get a valid variance. The sampling design of the other surveys may not be randomized; therefore it cannot be assumed that the surveys are a good representation of the stock. Without randomization, the estimate of variance for each survey may not be appropriate.

The Virginia pound provides a good estimate of the fishermen's catch rate, but the variance is not very useful. The NEFSC survey is not designed to catch striped bass and does catch a lot of striped bass. The variance is only useful for qualitative purposes. Variance estimates are for the survey index.

In addition to variance, age information is collected through the indices, despite some of the ageing error issues. Another important measure for the indices is the ability to track cohorts over time. There needs to be confidence that the survey is tracking cohort abundance in a logical trend. Catchability can influence the ability of a survey to track a cohort over time. If the design of the survey changes, the catchability can change.

A survey could reflect logical trends for 8 of the 10 years, straying from the trend in the remaining two years. Those two years could be eliminated if there was adequate evidence that is was due to abnormal climatic conditions influencing fish abundance.

To verify a cohort trend, the survey can be compared to a local young of the year index. States would need to be careful about using the index to validate the juvenile survey and vice versa. In some areas, a young of the year index may not be available for comparison. In these situations, a catch curve could be applied to the cohort. Longitudinal catch curves could be used, not to estimate mortality rates, but to see if there is trend that is useful.

Ideally, the stock assessment will include the same indices as in previous years and then a separate run is made to remove more questionable indices. There should be some guidelines for removing an index from the model run or at the very least an explanation provided in the assessment report. To evaluate an index for inclusion, one could plot the indices by year for each cohort. If one of the indices has a dramatically different trend, the index is not tracking things well. It is important to remember that an index can be valid for a local area, but not for the stock complex. It may track a different trend or a local stock. For example, Chesapeake Bay recruitment correlates well with the Delaware River recruitment, but not the Hudson River.

Striped bass is a stock complex measured by local indices, but the stock complex abundance is supposed to be annually evaluated.

**Recommendations for criteria to evaluate the VPA indices**

The Workshop participants developed a list of evaluation steps that should be applied to each index. The state agencies should use the evaluation list for each state survey. Each program should be analyzed to determine if the survey is conducted at the appropriate time of year, i.e. bracketing the correct spawning period. Similarly, the survey design should be reviewed by the state to determine if the sampling area is correct. If the state determines there is a lot of noise in the data, the state should attempt to refine the data. For instance, if some of the stations catch striped bass consistently and others do not, can something be done to refine these data? The states should identify if the indices are sex-specific indices or age-specific due to survey design. Because a self-evaluation by each state could be subjective, the Technical Committee should evaluate the state's program evaluation and make a recommendation to the Striped Bass Stock Assessment Subcommittee.

1. Evaluate design and best method to evaluate uncertainty of index.
2. Assess the index and/or improve the index to get the best signal.
3. Validate the index before use in the VPA.
    a. Sensitivity of the VPA results to the influence each index.
    b. Validate an index to a JAI, where possible.
    c. Longitudinal catch curves, to determine the cohort trends.
    d. Plots of age specific index v. year to see if cohorts are moving in a specific direction.
4. Evaluation by the agency conducting the survey
    a. Rank (weight) index
    b. Criticisms/Supporting Evidence
5. Evaluate by the Striped Bass Technical Committee
    a. Evaluate index based on survey design, precision, and ability to track cohorts or portion of the stock targeted.
    b. Provide recommendations to the Striped Bass Stock Assessment Subcommittee on which indices should be used in the assessment.

The Workshop participants developed a matrix in Excel that includes the important components for evaluating each index (sampling design, time of year, tracking stock or catch, etc.). Also included in the matrix are recommendations to improve and evaluate the survey.

**PURPOSE: TO ESTIMATE FINAL YEAR ABUNDANCE**

| SURVEY | SINCE | SAMPLING DESIGN | TIME OF YEAR | STOCK OR CATCH | WHAT STOCK? | AGES | VARIANCE? |
|---|---|---|---|---|---|---|---|
| NMFS (TOTAL, REC HARVEST) | | SURVEY | ALL | CATCH | MIXED | | YES?? |
| NEFSC CRUISE | | STRAT RANDOM | SPRING/FALL | STOCK | MIXED | | YES |
| MASS COMM CATCH | | NONE | ALL | CATCH/HARVEST | MIXED | | |
| RI - FLOATING TRAPS? | | | | | | | |
| CONN TRAWL SURVEY | | | | STOCK | MIXED | | |
| CONN REC CATCH | | | | CATCH | MIXED | | |
| NY HAUL SEINE | | FIXED STATION | FALL | STOCK | MIXED | | |
| NY HUDSON SPAWN SURVEY | | STRAT RANDOM | | STOCK | HUDSON | 5-10 | YES |
| PA RIVER SURVEY | | | | | | | |
| NJ TRAWL SURVEY | | STRAT RANDOM | SPRING | STOCK | MIXED | | YES? |
| NJ REC CATCH | | NONE | ALL | CATCH | MIXED | | NO |
| DEL RIVER SURVEY | | CLUSTER?? | SPRING | STOCK | DEL | | |
| DEL TRAWL SURVEY | | FIXED STATION | ALL | STOCK | MIXED | | |
| MD JI | | FIXED STATIONS | SUMMER | STOCK | CBAY | | |
| MD SPRING GILLNET SURVEY | 1985 | STRAT RANDOM | SPRING | STOCK | CBAY | | |
| VA POUND NETS | 1991 | FIXED STATIONS | | CATCH | RAPP | 3+ | YES/NO |

| SURVEY | EVALUATION/CRITERIA | RECOMMENDATIONS |
|---|---|---|
| NMFS (TOTAL, REC HARVEST) | | Define what an index would be using total catch and effort |
| NEFSC CRUISE | | Age fish samples from trawls; review strata choices |
| MASS COMM CATCH | | Standardize minimum length numbers; compare lengths of subsamples to length of all; examine applying age-length keys;develop index with total catch; adjust index for covariates; examine whether change in week-end warrior composition |
| RI - FLOATING TRAPS? | | see if data is available for development of an index |
| CONN TRAWL SURVEY | | segregate into age-specific indices; use age-length key instead of VB equation |
| CONN REC CATCH | | Describe and evaluate |
| NY HAUL SEINE | AGAINST TOTAL JI? NY JI? | resestimate precision using bootstrap; compare index at age to Jis individually |
| NY HUDSON SPAWN SURVEY | | Describe and evaluate; generate age-specific indices with appropriate variance |
| PA RIVER SURVEY | | Describe and evaluate |
| NJ TRAWL SURVEY | | Examine strata choices; generate age-specific indices using April data |
| NJ REC CATCH | | determine if development of an index is possible |
| DEL RIVER SURVEY | | investigate area under curve method for possible spatial distribution issues; examine temporal disitribution within strata; compare upper river index to PA survey |
| DEL TRAWL SURVEY | | change biomass index to numbers; generate age-specific indices; compare indices to VPA for age 1 |
| MD JI | AGAINST LAGGED CATCH | |
| MD SPRING GILLNET SURVEY | | examine first vs second set;review impact of sex-specific catchabilities |
| VA POUND NETS | AGAINST JI, LONG CATCH CURVES, YEAR EFFECTS, CATCH VS. TEMPORAL WINDOW | AGAINST JI, LONG CATCH CURVES, YEAR EFFECTS, CATCH VS. TEMPORAL WINDOW; examine flow regimes; compare index to MDs |

Summary of Responses to Workshop Recommendation

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| NEFSC | Age-specific: ages 3-11 | Yes | Age fish samples in trawl;review strata choices | No | No PSEs provided for age-specific indices. Untransformed, aggregate index PSEs (91-04): range= 0.13-0.58, mean=0.29 | No |
| MA Comm Catch | Aggregate and age-specific commercial Index | Yes | Standardize min. length numbers; compare lengths of subsamples to length of all; examine applying age-length keys; develop index with total catch; adjust covariate; examine week-end warrior composition | Yes A total catch index was developed using covariates, making most recommendations moot. | Old index age 7-12 average PSE: 7-0.51,8-0.23,9-0.13,10-0.13,11-0.18,12-0.23. New Index age7-12 PSE (for 2000): 7- 0.05, 8-0.08, 9-0.10,10-0.11,11-0.15,12-0.22 | Yes, correlation of aggregate indices to other aggregate indices (MRFSS, NYOHS, NJ, CT) but no significant correlations of new age indices to other programs; only 1996 YC could be tracked over only three years; influence of age-specific and aggregate index on VPA results increased. |
| RI – Floating Traps | ? | No | See if data is available for development of an index | No | None | No |
| CT Trawl Survey | Aggregate Index (spring) | Yes | Segregate into age-specific indices using age-length keys instead of VB equation | No | Ln transformed, aggregate index PSEs: range=0.1-0.5, mean=0.20 | No |

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| CT Rec Catch | Age-specific: ages 2-11 | Yes | Describe and evaluate | No | None | No |
| NY Ocean Haul Seine | Age-specific Index: ages: 3-13+ | Yes | Re-estimate precision using bootstrap; compare index at age to juvenile indices individually | Yes | Aggregate PSEs:mean=0.08; Age-specific PSEs: 2-0.17,3-0.11,4-0.13,5-0.16,6-0.22,7-0.23,8-0.39,9-0.51 | Yes, strong correlations between CB juvenile index and indices for ages 2-5; not so for older ages. |
| NY Hudson Spawn Survey | ? | No | Describe and evaluate; generate age-specific indices | No, but survey would be inappropriate | None | No |
| PA River Survey | Electrofishing survey | No | Describe and evaluate | No | None | No |
| NJ Trawl Survey | Aggregate Index | Yes | Examine strata choices; generate age-specific indices using April data | No | Aggregate index PSEs (91-03): range 0.18-0.69, average 0.38 | No |
| NJ Rec Catch | RecCatch/Effort | No | Determine if development of an index is possible | No | None | No |

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| DE Spawning stock River Survey | Electrofishing aggregate and age-specific: ages 2-15 | No | Investigate area under the curve method for possible spatial distribution issues; examine temporal distribution within strata; compare upper river index to PA survey | Yes – claims multistage lattice design addresses spatial and temporal distribution issues. | Aggregate PSEs (96-03): mean=0.20. Age-specific mean PSEs: 2-0.52,3-0.3,4-0.31,5-0.29,6-0.27,7-0.27,8-0.26,9-0.27,10-0.36,11-0.34,12-0.47, 13-0.46 | Yes, compared age-specific indices to NJ juvenile fish index and found 6 out of 14 were significantly correlated. However, only 3 of nine comparisons between DE and PA surveys were significantly correlated. |
| DE Trawl Survey | Aggregate Index | No | Change biomass index to number; generate age-specific indices; compare indices to VPA for age 1 | Some – developed numbers index using GLM | Aggregate mean PSE (91-04): 0.29 (I calculated from Table 3) | No |
| MD Spring Gillnet Survey | Age-specific 2-13+ | Yes | Examine first vs second set;review impact of sex-specific catchabilities | In progress, showed differences in catchability and visibility | Age-specific mean PSEs (91-04):2-0.11, 3-0.02, 4-0.02,5-0.03,6-0.03,7-0.03,8-0.04,9-0.06,10-0.14,11-0.10,12-0.10,13-0.71 | No |

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| VA Pound Net Survey | Fixed Pounds Net | No | Validate Index against MD and VA juveniles indices; examine year effects,; use longitudinal catch curves; examine catch versus temporal window, flow regimes. | Yes – no relationship between river flow and index; Mar 30-3May window better for inter-annual assessment of stock | Can't be calculated due to fixed sites | Yes, compared age-specific indices for age 3 8 to VA JI index but found poor correlation; weak correlation for age 9-10; high correlation between age 11-12 index and JI; there were no correlations between index and MD juvenile indices. |

# Appendix A7. AD Model Builder Code for the Striped Bass Statistical Catch-At-Age Model

```
//--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--
//
//        Striped bass Statistical Catch-At-Age Model
//        Gary Nelson
//        Massachusetts Division of Marine Fisheries
//        Gloucester, MA 01930
//
//   Some Code Adapted from Erik H. Williams' Menhaden Statistical Catch-At-Age Model
//
//
//
//--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--
TOP_OF_MAIN_SECTION
 arrmblsize=1000000;

DATA_SECTION
 !! ad_comm::change_datafile_name("scamdata.dat");

// STARTING AND ENDING YEAR OF MODEL
 init_int styr;
 init_int endyr;

// NUMBER OF AGES
 init_int nages;

// VECTOR OF AGES FOR AGE BINS
 init_ivector agebins(1,nages);

//CALCULATE RECRUITMENT YEARS
 int styrR;
 LOCAL_CALCS
  styrR=styr-(nages-1);
 END_CALCS

//TOTAL CATCH CVs
 init_vector total_catch_CV(styr,endyr);

//TOTAL CATCH LIKELIHOOD WEIGHTS
 init_number l_wgt;

//REC & COM HARVEST AND RELEASE AND DISCARDS MORTALITY NUMBERS
 init_vector obs_total_catch(styr,endyr);

//CATCH AGE COMPOSITION
 init_vector ss_age_comp(styr,endyr);
 init_number caa_wgt;
 init_matrix obs_age_comp(styr,endyr,1,nages);

// YOY AND YEARLING SURVEYS
 init_int age_surv_num;
 init_vector age_surv_flag(1,age_surv_num);
 init_vector age_surv_ages(1,age_surv_num);
 init_vector yoy_wgt(1,age_surv_num);
 init_matrix age_surv_CV(styrR,endyr,1,age_surv_num);
 init_matrix age_obs_surv_indices(styrR,endyr,1,age_surv_num);

// AGGREGATE SURVEYS
 init_int agg_surv_num;
 init_vector agg_surv_flag(1,agg_surv_num);
 init_vector agg_surv_ages(1,agg_surv_num);
 init_vector agg_wgt(1,agg_surv_num);
 init_matrix agg_surv_CV(styrR,endyr,1,agg_surv_num);
 init_matrix agg_obs_surv_indices(styrR,endyr,1,agg_surv_num);

//SURVEYS WITH AGE COMPOSITION
 init_int ac_surv_num;
 init_vector ac_surv_flag(1,ac_surv_num);
 init_vector ac_surv_wgt(1,ac_surv_num);
 init_vector ac_age_wgt(1,ac_surv_num);
 init_matrix ac_surv_CV(styrR,endyr,1,ac_surv_num);
```

```
 init_matrix ac_obs_surv_indices(styrR,endyr,1,ac_surv_num);

//SAMPLE SIZES OF SURVEY AGE COMPOSITIONS
 init_matrix ac_ss(styrR,endyr,1,ac_surv_num);

//SURVEY AGE COMPOSITION IN PROPORTIONS
 init_3darray surv_comps(1,ac_surv_num,styrR,endyr,1,nages);

//SPAWNING STOCK WEIGHTS-AT-AGE
 init_matrix ssw(styr,endyr,1,nages);
 init_vector mat(1,nages);
 init_number pM;
 init_number pF;

//INPUT CONSTANT M
 init_number M;
 init_number R_lam;
 init_number F_lam;

 int cnt;
 int y;
 int a;
 int t;
 int realage;
 int d;
 int total;
 int n_parms;
 int df;

 LOCAL_CALCS
  n_parms=1+(endyr-styrR+1)+1+(endyr-styr+1)+2+2+2+2+2+2+2+1+age_surv_num+agg_surv_num+ac_surv_num+1;
  df=n_parms+(endyr-styr+1)+(endyr-styrR+1)+age_surv_num+agg_surv_num+ac_surv_num;
 END_CALCS
 matrix sigma(1,df,1,df+1);
 !! set_covariance_matrix(sigma);

PARAMETER_SECTION
//TEMPORARY VARIABLES
 number adds;
 number pgroup;
 number diff;
 number diff2;
 number sel;
 number aveN;
 number sump;
 number sumage;
 number maxs;
 number dodo;
 number dodo1;
 number sumdo;
 number sumdo1;
 number fpen;

//---------------------INITIATE SCAM ARRAYS--------------------------//
//AVERAGE RECRUITMENT
 init_number log_avg_R(1);

//RECRUITMENT DEVIATIONS
 init_bounded_dev_vector log_R_dev(styrR,endyr,-20.,20.,3);//Age 1 recruitment values from styr to endyr

//AVERAGE FISHING MORTALITY
 init_number log_avg_F(2);

//FISHING MORTALITY DEVIATIONS
 init_bounded_dev_vector log_F_dev(styr,endyr,-15.,15.,2);//

//NUMBERS,F,Z MATRICES
 matrix N(styrR,endyr,1,nages);//Population numbers by year and age
 matrix F(styr,endyr,1,nages);
 matrix Z(styrR,endyr,1,nages);

//CATCH SELECTIVITIES
 init_bounded_number p1_A50(0,150,4);
 init_bounded_number p1_slope(0,150,4);
 init_bounded_number p2_A50(0,150,4);
 init_bounded_number p2_slope(0,150,4);
 init_bounded_number p3_A50(0,150,4);
 init_bounded_number p3_slope(0,150,4);
 init_bounded_number p4_A50(0,150,4);
 init_bounded_number p4_slope(0,150,4);
```

```
 vector p1_sel(1,nages);
 vector p2_sel(1,nages);
 vector p3_sel(1,nages);
 vector p4_sel(1,nages);

//SURVEY SELECTIVITIES
 init_bounded_vector DE_surv(1,2,0,150,9);
 init_number MD_surv(10);
 init_vector NY_surv(1,2,7);
 init_bounded_number NY_e(1e-22,0.9999,7)
 init_vector NJ_surv(1,2,8);
 matrix surv_sel(1,nages,1,ac_surv_num);

//STARTING VALUES FOR SURVEY SELECTIVITY PARAMETERS
 LOCAL_CALCS
  NY_e=0.95;
  NY_surv(1)=-1;
  NY_surv(2)=1;
  NJ_surv(1)=3;
  NJ_surv(2)=1;
  MD_surv=0.3;
  DE_surv(1)=3;
  DE_surv(2)=1;
 END_CALCS

//SURVEY CATCHABILITY COEEFFICIENTS AND PREDICTED INDICES
 init_bounded_vector age_qs(1,age_surv_num,-50.,0.,5);
 matrix age_pred_surv_indices(styrR,endyr,1,age_surv_num);
 init_bounded_vector agg_qs(1,agg_surv_num,-50.,0.,5);
 matrix agg_pred_surv_indices(styrR,endyr,1,agg_surv_num);
 init_bounded_vector ac_qs(1,ac_surv_num,-50.,0.,6);
 matrix ac_pred_surv_indices(styrR,endyr,1,ac_surv_num);

//PREDICTED SURVEY AGE COMPOSITIONS
 3darray calc_comps(1,ac_surv_num,styrR,endyr,1,nages);
 3darray surv_pred_comps(1,ac_surv_num,styrR,endyr,1,nages);

//INDIVIDUAL LIKELIHOOD SAVE VECTORS
 vector like_age(1,age_surv_num);
 vector like_agg(1,agg_surv_num);
 vector like_ac_surv(1,ac_surv_num);
 vector like_ac_age(1,ac_surv_num);

//CATCH-AT-AGE,PREDICTED TOTAL CATCH, PREDICTED CATCH AGE COMPOSITION, AND SSB
 matrix C(styr,endyr,1,nages);
 vector pred_total_catch(styr,endyr);
 matrix pred_age_comp(styr,endyr,1,nages);
 number f_total_catch;
 number f_age_comp;
 matrix SSB(styr,endyr,1,nages);
 matrix rwgts(styr,endyr,1,nages);
 matrix W2(styr,endyr,1,nages);
 matrix jan1bio(styr,endyr,1,nages);
 matrix catchbio(styr,endyr,1,nages);
 vector tSSB(styr,endyr);

//REPORT STANDARD DEVIATIONS FOR ANNUAL FS,RS, AND CATCHABILITY COEFFICIENTS
 sdreport_vector F_ann(styr,endyr);
 sdreport_vector R(styrR,endyr);
 sdreport_vector q_YOY(1,age_surv_num);
 sdreport_vector q_Agg(1,agg_surv_num);
 sdreport_vector q_AC(1,ac_surv_num)

 objective_function_value f;

INITIALIZATION_SECTION
 //STARTING VALUES FOR REMAINING PARAMETERS
 log_avg_R 10.6;
 log_avg_F -2.6;
 p1_A50 3;
 p1_slope 1;
 p2_A50 3;
 p2_slope 1;
 p3_A50  3;
 p3_slope 1;
 p4_A50 3;
 p4_slope 1;
 age_qs -20.4;
 agg_qs -19.7;
 ac_qs  -20.2;
```

```
RUNTIME_SECTION
 maximum_function_evaluations 10000, 10000, 10000;
 convergence_criteria 1e-5, 1e-7, 1e-16;

PRELIMINARY_CALCS_SECTION
 F.initialize();
 C.initialize();
 calc_comps.initialize();

PROCEDURE_SECTION
 calc_selectivity();
 calc_F_mortality();
 calc_Z_matrix();
 calc_numbers_at_age();
 calc_catch_at_age();
 calc_pred_age_comp();
 calc_indices_selectivity();
 calc_predict_indices_age();
 calc_predict_indices_agg();
 calc_predict_indices_ac();
 scam_likelihood();
 calc_biomass();
 evaluate_the_objective_function();

//CALCULATE CATCH SELECTIVITIES VALUES FOR CURRENT PARAMETER ESTIMATES
FUNCTION calc_selectivity //gompertz function
 for (a=1;a<nages;a++){
   p1_sel(a)=exp(-1.*exp(-1.*p1_slope*(double(agebins(a))-p1_A50)));
   p2_sel(a)=exp(-1.*exp(-1.*p2_slope*(double(agebins(a))-p2_A50)));
   p3_sel(a)=exp(-1.*exp(-1.*p3_slope*(double(agebins(a))-p3_A50)));
   p4_sel(a)=exp(-1.*exp(-1.*p4_slope*(double(agebins(a))-p4_A50)));
 }
 p1_sel(nages)=p1_sel(nages-1);
 p2_sel(nages)=p2_sel(nages-1);
 p3_sel(nages)=p3_sel(nages-1);
 p4_sel(nages)=p4_sel(nages-1);

 p1_sel=p1_sel/max(p1_sel);
 p2_sel=p2_sel/max(p2_sel);
 p3_sel=p3_sel/max(p3_sel);
 p4_sel=p4_sel/max(p4_sel);

//MATCH PERIOD SELECTVITIES TO YEARS AND CALCULATE ANNUAL F AND F-AT-AGE
FUNCTION calc_F_mortality
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     if (y<1985) sel=p1_sel(a);
     if (y>=1985 && y<=1989) sel=p2_sel(a);
     if (y>=1990 && y<=1995) sel=p3_sel(a);
     if (y>=1996) sel=p4_sel(a);
     F(y,a)=sel*mfexp(log_avg_F+log_F_dev(y));
     F_ann(y)=mfexp(log_avg_F+log_F_dev(y));
   }
 }

//FILL Z MATRIX
FUNCTION calc_Z_matrix
 for(y=styrR;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     if(y<styr)Z(y,a)=F(styr,a)+M;
     if(y>=styr)Z(y,a)=F(y,a)+M;
   }
 }

//CALCULATE AND FILL NUMBERS-AT-AGE MATRIX
FUNCTION calc_numbers_at_age
 N(styrR,1)=mfexp(log_avg_R+log_R_dev(styrR));//Fill in Recruits in first year and age

 for(a=2;a<=nages;a++){
   N(styrR,a)=N(styrR,a-1)*mfexp(-1.*Z(styrR,a-1));//Fills in top row of matrix
 }
 N(styrR,nages)=N(styrR,nages-1)*mfexp(-1.*Z(styrR,nages-1))/(1.-mfexp(-1.*Z(styrR,nages)));

 for(y=styrR+1;y<=endyr;y++){  //Rest of pre-data years
   N(y,1)=mfexp(log_avg_R+log_R_dev(y));
   N(y)(2,nages)=++elem_prod(N(y-1)(1,nages-1),(mfexp(-1.*Z(y-1)(1,nages-1))));
   N(y,nages)+=N(y-1,nages)*mfexp(-1.*Z(y-1,nages));//plus  group
 }

 for(y=styrR;y<=endyr;y++){
   R(y)=mfexp(log_avg_R+log_R_dev(y));
```

```
 }

FUNCTION calc_biomass
 //Rivard weights

 for(a=2;a<=nages-1;a++){
   for(y=styr+1;y<=endyr;y++){
      W2(y,a)=(log(ssw(y,a))+log(ssw(y-1,a-1)))/2;
     }
    }
 for(y=styr;y<=endyr-1;y++){
      W2(y,1)=2.*log(ssw(y,1))-W2(y+1,2);
     }
 for(a=1;a<=nages-2;a++){
      W2(styr,a)=2.*log(ssw(styr,a))-W2(styr+1,a+1);
    }
 W2(styr,nages-1)=(W2(styr,nages-1)+W2(styr,nages-2))/2;
 W2(endyr,1)=2.*log(ssw(endyr,1))-W2(endyr,2);
 for(y=styr;y<=endyr;y++){
      W2(y,nages)=log(ssw(y,nages));
     }
 for(y=styr;y<=endyr;y++){
      for(a=1;a<=nages;a++){
      rwgts(y,a)=exp(W2(y,a));
      jan1bio(y,a)=rwgts(y,a)*N(y,a);
      catchbio(y,a)=ssw(y,a)*obs_total_catch(y)*obs_age_comp(y,a);
     }
    }
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     SSB(y,a)=(N(y,a)*rwgts(y,a)*mat(a)*mfexp(-1*(pF*F(y,a)+pM*M)))/2;
   }
 }
 tSSB=rowsum(SSB);

//CALCULATE CATCH-AT-AGE MATRIX
FUNCTION calc_catch_at_age
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     C(y,a)=N(y,a)*F(y,a)*(1.-mfexp(-1.*Z(y,a)))/Z(y,a);
   }
 }

//CALCULATE PREDICTED CATCH AGE COMPOSITION
FUNCTION calc_pred_age_comp
 for(y=styr;y<=endyr;y++){
   sumage=0;
   for(a=1;a<=nages;a++){
     sumage+=C(y,a);
   }
   pred_total_catch(y)=sumage;

   for(a=1;a<=nages;a++){
     pred_age_comp(y,a)=C(y,a)/(sumage+0.001);
   }
 }

//CALCULATE SURVEY SELECTIVITY INDICES
FUNCTION calc_indices_selectivity //NYOHS NJTRL MDAdults DESSN
 for(int s=1;s<=ac_surv_num;s++){
   maxs=0;
   for(a=1;a<nages;a++){
     surv_sel(a,s)=0;
     if(s==1){
       if(a>=2) surv_sel(a,s)=(1/(1-NY_e))*pow((1-NY_e)/NY_e,NY_e)*(exp(NY_surv(1)*NY_e*(NY_surv(2)-
double(a)))/(1+exp(NY_surv(1)*(NY_surv(2)-double(a)))));
     }

     if(s==2){
         if(a>=2) surv_sel(a,s)=pow(double(a),NJ_surv(1))*exp(-1.*NJ_surv(2)*double(a));
       }
     if(s==3){
       if (a==2) surv_sel(a,s)=MD_surv;
       if (a>=3) surv_sel(a,s)=1;
     }

     if(s==4){
       if(a>=2) surv_sel(a,s)=exp(-1.*exp(-1.*DE_surv(2)*(double(agebins(a))-DE_surv(1))));
      }
     if(surv_sel(a,s)>=maxs) maxs=surv_sel(a,s);
   }
```

```
   for(a=1;a<nages;a++){
     surv_sel(a,s)=surv_sel(a,s)/maxs;
     }
   surv_sel(nages,s)=surv_sel(nages-1,s);
 }


//CALCULATE PREDICTED YOY AND YEARLING INDICES
FUNCTION calc_predict_indices_age
 for(t=1;t<=age_surv_num;t++){
     realage=0;
     for(y=styrR;y<=endyr;y++){
       if (age_obs_surv_indices(y,t)>=0.)                              // Skip Missing Values (-1)
        {
          realage=(int)floor(age_surv_ages(t));
           age_pred_surv_indices(y,t)=mfexp(age_qs(t))*N(y,realage)*mfexp(-1.*age_surv_flag(t)*Z(y,realage));
         }
       if (age_obs_surv_indices(y,t)==-1) age_pred_surv_indices(y,t)=-1;
     }//y loop
     q_YOY(t)=mfexp(age_qs(t));
   }//t loop

//CALCULATE PREDICTED AGGREGATE INDICES
FUNCTION calc_predict_indices_agg
 for(t=1;t<=agg_surv_num;t++){
     cnt=0;
     adds=0;
     realage=0;
     diff2=0;
     for(y=styrR;y<=endyr;y++){
       if (agg_obs_surv_indices(y,t)>=0.)                              // Skip Missing Values (-1)
        {
            realage=(int)floor(agg_surv_ages(t));
            diff2=int(ceil(agg_surv_ages(t)*100.)-(floor(agg_surv_ages(t))*100.));
            pgroup=0;
            for (a=realage;a<=diff2;a++)
              {
               pgroup+=N(y,a)*mfexp(-1.*agg_surv_flag(t)*Z(y,a));
             }
              agg_pred_surv_indices(y,t)=mfexp(agg_qs(t))*pgroup;
        }//agg_surv_indices>=0
        if (agg_obs_surv_indices(y,t)==-1) agg_pred_surv_indices(y,t)=-1;
     }//y loop
     q_Agg(t)=mfexp(agg_qs(t));
  }//t loop

//CALCULATE PREDICTED SURVEY WITH AGE COMPOSITION INDICES
FUNCTION calc_predict_indices_ac
  for(int t=1;t<=ac_surv_num;t++){
       for(y=styrR;y<=endyr;y++){
          for(a=1;a<=nages;a++){
             calc_comps(t,y,a)=-1;
             if (surv_comps(t,y,a)>=0.)// Skip Missing Values (-1)
              {
                calc_comps(t,y,a)=surv_sel(a,t)*mfexp(ac_qs(t))*N(y,a)*mfexp(-1.*ac_surv_flag(t)*Z(y,a));
              }
            }//a loop
         }//y loop
      q_AC(t)=mfexp(ac_qs(t));
     }//t loop


  for(int t=1;t<=ac_surv_num;t++){
     for(y=styrR;y<=endyr;y++){
         sumage=0;
         for (a=1;a<=nages;a++){
            if(surv_comps(t,y,a)>=0.){sumage+=calc_comps(t,y,a);}
           }
            if(sumage>0.) {ac_pred_surv_indices(y,t)=sumage;}
            if(sumage<=0.){ac_pred_surv_indices(y,t)=-1;}

         for (a=1;a<=nages;a++){
            surv_pred_comps(t,y,a)=-1;
            if(sumage>0.){
              if(surv_comps(t,y,a)>=0.){surv_pred_comps(t,y,a)=calc_comps(t,y,a)/sumage;}
             }
            if(sumage<=0.){surv_pred_comps(t,y,a)=-1;}
           }
       }
    }
```

```
//CALCULATE LIKELIHOODS
FUNCTION scam_likelihood
 f_total_catch=0.;
 f_age_comp=0.;
 cnt=0;

 //CALCULATE TOTAL CATCH WEIGHTED RESIDUAL SUM OF SQUARES
    for(y=styr;y<=endyr;y++){
         f_total_catch+=square((log(obs_total_catch(y)+0.00001)-
log(pred_total_catch(y)+0.00001))/total_catch_CV(y));
      cnt+=1;
      }
     f_total_catch=f_total_catch*l_wgt;

//CALCULATE CATCH AGE COMP LIKELIHOOD
     for(y=styr;y<=endyr;y++){
       for(a=1;a<=nages;a++){
          f_age_comp-=ss_age_comp(y)*obs_age_comp(y,a)*log(pred_age_comp(y,a)+1e-7);
         }
       }
    f_age_comp=f_age_comp*caa_wgt;

//CALCULATE YOY AND YEARLING WEIGHTED RESIDUAL SUM OF SQUARES
   for(t=1;t<=age_surv_num;t++){
     like_age(t)=0;
     for(y=styrR;y<=endyr;y++){
         if(age_obs_surv_indices(y,t)>=0.){
        like_age(t)+=square((log(age_obs_surv_indices(y,t)+0.00001)-
log(age_pred_surv_indices(y,t)+0.00001))/age_surv_CV(y,t));
        cnt+=1;
           }
     }
     like_age(t)=like_age(t)*yoy_wgt(t);
   }

//CALCULATE AGGREGATE SURVEY WEIGHTED RESIDUAL SUM OF SQUARES
   for(t=1;t<=agg_surv_num;t++){
      like_agg(t)=0.;
      for(y=styrR;y<=endyr;y++){
           if(agg_obs_surv_indices(y,t)>=0.){
          like_agg(t)+=square((log(agg_obs_surv_indices(y,t)+0.00001)-
log(agg_pred_surv_indices(y,t)+0.00001))/agg_surv_CV(y,t));
          cnt+=1;
            }
      }
     like_agg(t)=like_agg(t)*agg_wgt(t);
   }

// CALCULATE SURVEY WITH AGE COMPOSITIONS WEIGHTED RESIDUAL SUM OF SQUARES
   for(t=1;t<=ac_surv_num;t++){
      like_ac_surv(t)=0;
      for(y=styrR;y<=endyr;y++){
        if(ac_obs_surv_indices(y,t)>=0.){
         like_ac_surv(t)+=square((log(ac_obs_surv_indices(y,t)+0.00001)-
log(ac_pred_surv_indices(y,t)+0.00001))/ac_surv_CV(y,t));
         cnt+=1;
        }
      }
      like_ac_surv(t)=like_ac_surv(t)*ac_surv_wgt(t);
   }

// CALCULATE SURVEY AGE COMPOSITIONS LIKELHOOD
   for(t=1;t<=ac_surv_num;t++){
      like_ac_age(t)=0.;
      for(y=styrR;y<=endyr;y++){
         for(a=1;a<=nages;a++){
           if(surv_comps(t,y,a)!=-1){
            like_ac_age(t)-=ac_ss(y,t)*surv_comps(t,y,a)*log(surv_pred_comps(t,y,a)+1e-7);
            }
         }
      }
        like_ac_age(t)=like_ac_age(t)*ac_age_wgt(t);
   }

FUNCTION evaluate_the_objective_function
  f=0;
 //CALCULATE CONCENTRATED LIKELIHOOD FOR ALL DATA WITH LOGNORMAL ERRORS
  f+=0.5*cnt*log((sum(like_age)+sum(like_agg)+sum(like_ac_surv)+f_total_catch)/cnt);
 //SUM REMAINING LIKELIHOODS
  f+=sum(like_ac_age);
```

```
  f+=f_age_comp;
  f+=R_lam*norm2(log_R_dev);

//CALCULATE PENALTY CONSTRAINT FOR F
    if(current_phase()<3){
     fpen=10.*norm2(mfexp(log_avg_F+log_F_dev)-0.15);
    }
    else{
     fpen=0.001*norm2(mfexp(log_avg_F+log_F_dev)-0.15);
    }
    if(active(log_F_dev)){
      fpen+=norm2(log_F_dev);
     }
  f+=F_lam*fpen;


REPORT_SECTION
 report <<"Likelihood Components" << endl;
 report <<" "<<endl;
 report <<"                       "<<"\t"<<"Weight"<<"   "<<"RSS"<<endl;
 report <<" Total Catch        : "<<"\t"<<l_wgt<<"\t"<<setw(10)<<f_total_catch<<endl;
 report <<" YOY/Yearl Surveys    " << endl;
 for(t=1;t<=age_surv_num;t++){
 report <<"   Survey "<<t<<"         : "<<"\t"<<yoy_wgt(t)<<"\t"<<setw(10)<<like_age(t)<<endl;
 }
 report <<" Aggregate Surveys    " << endl;
   for(t=1;t<=agg_surv_num;t++)
      {
 report <<"   Survey "<<t<<"         : "<<"\t"<<agg_wgt(t)<<"\t"<<setw(10)<<like_agg(t)<<endl;
      }
 report <<" Age Survey Indices   " << endl;

  for(t=1;t<=ac_surv_num;t++)
      {
 report <<"   Survey "<<t<<"         : "<<"\t"<<ac_surv_wgt(t)<<"\t"<<setw(10)<<like_ac_surv(t)<<endl;
      }
 report<<" "<<endl;
 report <<" Total RSS            "<<"\t"<<"
"<<"\t"<<setw(10)<<(sum(like_age)+sum(like_agg)+sum(like_ac_surv)+f_total_catch)<<endl;
 report <<" No. of Obs           "<<"\t"<<" "<<"\t"<<setw(10)<<cnt<<endl;
 report <<" Conc. Likelihood     "<<"\t"<<"  "<<"\t"<<setw(10)<<
           0.5*cnt*log((sum(like_age)+sum(like_agg)+sum(like_ac_surv)+f_total_catch)/cnt) <<endl;

 report<<" "<<endl;
 report <<" Catch Age Comps    : "<<"\t"<<caa_wgt <<"\t"<<setw(10)<<f_age_comp<<endl;
 report <<" Survey Age Comps       " <<endl;
  for(t=1;t<=ac_surv_num;t++)
      {
 report <<"   Survey "<<t<<"         : "<<"\t"<<ac_age_wgt(t)<<"\t"<<setw(10)<<like_ac_age(t)<<endl;
      }
 report <<" "<<endl;

 report <<"Recr Devs "<<"          : "<<"\t"<<R_lam<<"\t"<<setw(10)<<R_lam*norm2(log_R_dev)<<endl;
 report <<"F Devs    "<<"          : "<<"\t"<<F_lam<<"\t"<<setw(10)<<F_lam*norm2(log_F_dev)<<endl;

 report <<" "<<endl;
 report <<"Total Likelihood    : "<<"\t"<<"  "<<"\t"<<setw(10)<<f<<endl;
 report << " " << endl;
 report<<"*****************************************************************************************"<<endl;
 report<<"Mortality Rates "<<endl;
 report << "Natural" << endl;
 report << M << endl;
 report<<" "<<endl;
 report << "Fishing" << endl;
 report << mfexp(log_avg_F+log_F_dev)<< endl;
 report<<" "<<endl;
 report <<"*******************************************SCAM Output**********************"<<endl;
 report << "Total Catch" << endl;
 report << "Observed" << obs_total_catch << endl;
 report << "Predicted" << pred_total_catch <<endl;
 report <<" "<<endl;
 report << "Obs Catch Age Comp "<< endl;
 report<<obs_age_comp<<endl;
 report <<" "<<endl;
 report <<"Pred Catch Age comp"<<endl;
 report<<pred_age_comp<<endl;
 report <<" "<<endl;
 report << "Number-At-Age "<< endl;
 report << N<<endl;
 report << "Selectivity Period 1" << endl;
 report <<"Age " << agebins << endl;
```

```
report << "p1_sel" << p1_sel << endl;
report <<" "<<endl;
report << "Selectivity Period 2" << endl;
report <<"Age " << agebins << endl;
report << "p2_sel" << p2_sel << endl;
report <<" "<<endl;
report << "Selectivity Period 3" << endl;
report <<"Age " << agebins << endl;
report << "p3_sel" << p3_sel << endl;
report << "Selectivity  Period 4" << endl;
report <<"Age " << agebins << endl;
report << "p4_sel" << p4_sel << endl;
report <<" "<<endl;

report <<"Period Selectivity Parameters"<<endl;
report <<"P1: "<<p1_A50<<" "<<p1_slope<<endl;
report <<"P2: "<<p2_A50<<" "<<p2_slope<<endl;
report <<"P3: "<<p3_A50<<" "<<p3_slope<<endl;
report <<"P4: "<<p4_A50<<" "<<p4_slope<<endl;

report<<"Observed Age Indices"<<endl;
report<<age_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Age Indices"<<endl;
report<<age_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Age Survey qs"<<endl;
report<<mfexp(age_qs)<<endl;
report <<" "<<endl;
report<<"YOY/Yearling CVs"<<endl;
report<<age_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Aggregate Indices"<<endl;
report<<agg_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Aggregate Indices"<<endl;
report<<agg_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Aggregate Survey qs"<<endl;
report<<mfexp(agg_qs)<<endl;
report <<" "<<endl;
report<<"Aggregate Indices CVs"<<endl;
report<<agg_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Age Comp Indices"<<endl;
report<<ac_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Age Comps Indices"<<endl;
report<<ac_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Age Comps Survey qs"<<endl;
report<<mfexp(ac_qs)<<endl;
report <<" "<<endl;
report<<"Age Comps Indices CVs"<<endl;
report<<ac_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Survey Age Comps "<<endl;
report<<surv_comps<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps "<<endl;
report<<surv_pred_comps<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps Selectivities"<<endl;
report<<surv_sel<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps Selectivities Parameters"<<endl;
report<<NY_e<<NY_surv<<endl;
report<<NJ_surv<<endl;
report<<MD_surv<<endl;
report<<DE_surv<<endl;
report <<" "<<endl;
report<<"Fishing Mortality at age"<<endl;
report<<F<<endl;
report <<" "<<endl;
report<<"SSB at age"<<endl;
report<<SSB<<endl;
report <<" "<<endl;
report<<"Rivards Weights"<<endl;
report<<rwgts<<endl; report <<" "<<endl;
report<<"Catch Weights"<<endl;
report<<ssw<<endl; report <<" "<<endl;
```

```
 report<<"January-1 stock biomass"<<endl;
 report<<jan1bio<<endl; report <<" "<<endl;
 report<<"Catch biomass"<<endl;
 report<<catchbio<<endl; report <<" "<<endl;


FINAL_SECTION
 // Output data to files for import into R
  ofstream ofs28("effss.out");
      sumdo1=0;
      dodo1=0;
      for(y=styr;y<=endyr;y++)
        {
          sumdo=0;
          dodo=0;
          for(a=1;a<=nages;a++)
            {
               if(obs_age_comp(y,a)!=-1)
                {
                sumdo+=pred_age_comp(y,a)*(1-pred_age_comp(y,a));
                dodo+=square(obs_age_comp(y,a)-pred_age_comp(y,a));

               }
               if(obs_age_comp(y,a)==-1)
                {
                sumdo=0;
                dodo=0;
               }
            }
           if(sumdo>0 && dodo>0) sumdo1+=sumdo/dodo;
        }

     for(y=styr;y<=endyr;y++)
       {
        if (obs_total_catch(y)!=-1) dodo1+=1;
       }
     ofs28<<sumdo1/dodo1<<endl;
 //Survey age comps
   for(t=1;t<=ac_surv_num;t++)
     {
      sumdo1=0;
      dodo1=0;
      for(y=styrR;y<=endyr;y++)
        {

          sumdo=0;
          dodo=0;
          for(a=1;a<=nages;a++)
            {
               if(surv_comps(t,y,a)!=-1)
                {
                sumdo+=surv_pred_comps(t,y,a)*(1-surv_pred_comps(t,y,a));
                dodo+=square(surv_comps(t,y,a)-surv_pred_comps(t,y,a));

               }
               if(surv_comps(t,y,a)==-1)
                {
                sumdo=0;
                dodo=0;
               }
            }
           if(sumdo>0 && dodo>0) sumdo1+=sumdo/dodo;
       }

     for(y=styrR;y<=endyr;y++)
       {
        if (ac_obs_surv_indices(y,t)!=-1) dodo1+=1;
       }
     ofs28<<sumdo1/dodo1<<endl;

    }
 // Calculate F and sd
   ofstream ofs1("F.out");
   d=n_parms+1;
   for(t=styr;t<=endyr;t++)
     {
       ofs1<<F_ann(t)<<"\t"<<sigma(d,1)<<endl;
       d+=1;
     }
 //Calculate R and sd
  ofstream ofs2("R.out");
```

```
   for(t=styrR;t<=endyr;t++)
   {
       ofs2<<R(t)<<"\t"<<sigma(d,1)<<endl;
       d+=1;
   }
//Output Indices qs
  ofstream ofs13("YOYqs.out");
    for(t=1;t<=age_surv_num;t++)
   {
     ofs13<<mfexp(age_qs(t))<<"\t"<<sigma(d,1)<<endl;
     d+=1;
   }
   ofstream ofs14("Aggqs.out");
     for(t=1;t<=agg_surv_num;t++)
   {
    ofs14<<mfexp(agg_qs(t))<<"\t"<<sigma(d,1)<<endl;
    d+=1;
   }
  ofstream ofs15("ACqs.out");
    for(t=1;t<=ac_surv_num;t++)
   {
    ofs15<<mfexp(ac_qs(t))<<"\t"<<sigma(d,1)<<endl;
    d+=1;
   }
//Output N-at-age
  ofstream ofs4("N.out");
  ofs4<<N<<endl;
//Output Catch Age Comp
  ofstream ofs5("CACpred.out");
  ofs5<<pred_age_comp<<endl;
//Output Catch Age Comp
  ofstream ofs51("CACobs.out");
  ofs51<<obs_age_comp<<endl;
//Output Total Catch
  ofstream ofs6("CatPred.out");
  for(y=styr;y<=endyr;y++)
    {
     ofs6<<pred_total_catch(y)<<endl;
    }
 //Output Total Catch
  ofstream ofs61("CatObs.out");
  for(y=styr;y<=endyr;y++)
    {
     ofs61<<obs_total_catch(y)<<endl;
    }
//Output Total Catch
  ofstream ofs7("Fatage.out");
     ofs7<<F<<endl;
//Output Selectivity
  ofstream ofs8("Select.out");
  for(a=1;a<=nages;a++)
    {
    ofs8<<p1_sel(a)<<"\t"<<p2_sel(a)<<"\t"<<p3_sel(a)<<"\t"<<p4_sel(a)<<endl;
    }
//Output Selectivity Parameters
  ofstream ofs9("Selparms.out");
    ofs9<<p1_A50<<"\t"<<p1_slope<<endl;
    ofs9<<p2_A50<<"\t"<<p2_slope<<endl;
    ofs9<<p3_A50<<"\t"<<p3_slope<<endl;
    ofs9<<p4_A50<<"\t"<<p4_slope<<endl;
//Output Indices
  ofstream ofs10("YOYPred.out");
     ofs10<<age_pred_surv_indices<<endl;

   ofstream ofs101("YOYObs.out");
     ofs101<<age_obs_surv_indices<<endl;

   ofstream ofs11("AggPred.out");
     ofs11<<agg_pred_surv_indices<<endl;
   ofstream ofs111("AggObs.out");
     ofs111<<agg_obs_surv_indices<<endl;

  ofstream ofs12("ACPred.out");
     ofs12<<ac_pred_surv_indices<<endl;
  ofstream ofs121("ACObs.out");
     ofs121<<ac_obs_surv_indices<<endl;


//Output Sruvey age comps
  ofstream ofs16("survacpred.out");
     ofs16<<surv_pred_comps<<endl;
```

```
 ofstream ofs161("survacobs.out");
     ofs161<<surv_comps<<endl;
 ofstream ofs169("calccomps.out");
     ofs169<<calc_comps<<endl;


//Output Sruvey select
  ofstream ofs17("survsel.out");
     ofs17<<surv_sel<<endl;
//Output Sruvey select parms

 // ofstream ofs18("survparms.out");
 //    ofs18<<surv_A50<<endl;
  //   ofs18<<surv_slope<<endl;


//Output Total SSB
  ofstream ofs27("SSB.out");
     ofs27<<SSB<<endl;

//Output jani1biomass
  ofstream ofs29("jan1bio.out");
     ofs29<<jan1bio<<endl;
//Output catch biomass
  ofstream ofs30("catchbio.out");
     ofs30<<catchbio<<endl;
```

## Data used in the striped bass statistical catch-at-age model.

```
#Starting and ending year of catch data
1982
2006

#Number of ages
13

#Agebin vector
1 2 3 4 5 6 7 8 9 10 11 12 13

# CV of catch (harvest+dead discards)
0.40 0.23 0.19 0.17 0.21 0.14 0.27 0.18 0.08 0.09 0.06 0.07 0.06 0.05 0.05 0.04 0.04 0.04
0.04 0.03 0.03 0.04 0.04 0.04 0.04

# Total catch likelihood weight
10

#Total catch (numbers)
766200 727700 1084900 400800 384900 239100 444900 479900 921300 988400 986900 1437000 1866600 2999700 3376200
4580100
4118300 3704300 5044400 4344000 3889500 4836200 5272677 5596311 6113218
#Catch age comp samples sizes
380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380

#Catch age comp likelihood weight
1

#Fishery age comp data
0.002 0.138 0.335 0.288 0.076 0.025 0.032 0.022 0.015 0.014 0.014 0.018 0.020
0.005 0.152 0.245 0.265 0.206 0.054 0.026 0.006 0.004 0.005 0.006 0.008 0.019
0.005 0.500 0.279 0.076 0.056 0.048 0.017 0.004 0.002 0.002 0.001 0.001 0.010
0.003 0.181 0.254 0.101 0.146 0.108 0.109 0.043 0.016 0.008 0.002 0.002 0.026
0.029 0.055 0.166 0.345 0.130 0.083 0.053 0.062 0.024 0.014 0.009 0.004 0.026
0.006 0.046 0.157 0.215 0.281 0.105 0.055 0.027 0.027 0.013 0.006 0.008 0.054
0.006 0.069 0.094 0.142 0.241 0.220 0.091 0.055 0.031 0.013 0.008 0.007 0.022
0.001 0.075 0.166 0.142 0.219 0.199 0.095 0.044 0.022 0.008 0.007 0.004 0.019
0.002 0.050 0.135 0.204 0.188 0.179 0.113 0.074 0.022 0.008 0.006 0.004 0.015
0.002 0.074 0.147 0.211 0.164 0.103 0.092 0.084 0.059 0.024 0.014 0.003 0.023
0.003 0.046 0.202 0.192 0.179 0.111 0.063 0.069 0.059 0.045 0.009 0.004 0.016
0.001 0.048 0.129 0.228 0.201 0.129 0.060 0.047 0.057 0.053 0.029 0.006 0.012
0.003 0.078 0.187 0.156 0.197 0.125 0.073 0.046 0.054 0.043 0.019 0.012 0.008
0.001 0.145 0.157 0.152 0.135 0.163 0.072 0.065 0.051 0.030 0.018 0.006 0.005
0.001 0.029 0.192 0.193 0.161 0.139 0.131 0.062 0.041 0.020 0.013 0.014 0.006
0.001 0.064 0.131 0.212 0.150 0.125 0.100 0.091 0.049 0.031 0.015 0.007 0.006
0.006 0.045 0.118 0.172 0.273 0.124 0.068 0.064 0.052 0.028 0.023 0.011 0.016
0.002 0.029 0.113 0.175 0.173 0.197 0.095 0.064 0.055 0.040 0.028 0.013 0.013
0.008 0.064 0.083 0.195 0.202 0.155 0.147 0.062 0.032 0.028 0.012 0.006 0.006
0.007 0.036 0.099 0.138 0.192 0.161 0.133 0.111 0.048 0.028 0.024 0.011 0.011
0.007 0.055 0.081 0.122 0.151 0.197 0.137 0.095 0.074 0.028 0.023 0.013 0.017
0.006 0.053 0.101 0.125 0.147 0.124 0.145 0.101 0.077 0.058 0.026 0.017 0.019
0.013 0.034 0.151 0.141 0.097 0.103 0.098 0.119 0.084 0.063 0.050 0.023 0.025
0.003 0.082 0.075 0.196 0.171 0.093 0.076 0.067 0.084 0.058 0.048 0.022 0.025
0.006 0.037 0.191 0.108 0.179 0.115 0.059 0.059 0.060 0.076 0.050 0.029 0.031

#################################################################################
# YOY and Yearling Surveys - NY YOY, NJ YOY, MD YOY, VA YOY, NY 1, MD 1
#################################################################################
#Number of No age comp surveys
6

#Survey time of year fractions
0 0 0 0 0 0

# Survey ages
1 1 1 1 2 2

# YOY/Yearling Likelihood Weight
1 1 1 1 1 1

#Survey CVs
-1 -1 0.19 -1 -1 0.33
-1 -1 0.13 -1 -1 0.26
-1 -1 0.16 -1 -1 0.31
-1 -1 0.21 -1 -1 0.39
-1 -1 0.20 -1 -1 0.18
-1 -1 0.22 -1 -1 0.19
-1 -1 0.13 -1 -1 0.31
-1 -1 0.24 -1 -1 0.45
```

```
-1 -1 0.20 -1 -1 0.41
-1 -1 0.12 -1 -1 0.24
0.15 -1 0.16 -1 -1 0.36
0.20 0.714 0.15 -1 -1 0.26
0.172 1.000 0.193 -1 -1 0.52
0.132 0.353 0.136 0.215 -1 0.57
0.189 0.600 0.229 0.202 -1 0.21
0.200 0.255 0.194 0.299 -1 1.00
0.123 1.000 0.216 0.158 0.556 0.43
0.121 0.271 0.232 0.146 0.360 0.51
0.212 0.216 0.224 0.119 0.351 0.53
0.072 0.140 0.268 0.119 0.449 0.29
0.113 0.210 0.264 0.159 0.302 0.29
0.096 0.136 0.149 0.118 0.307 0.26
0.098 0.164 0.174 0.162 0.322 0.24
0.074 0.190 0.228 0.170 0.288 0.39
0.106 0.211 0.238 0.089 0.387 0.33
0.092 0.164 0.128 0.100 0.375 0.26
0.136 0.210 0.131 0.127 0.297 0.35
0.108 0.144 0.315 0.101 0.394 0.64
0.107 0.138 0.116 0.105 0.500 0.34
0.093 0.225 0.141 0.105 0.364 0.34
0.143 0.169 0.178 0.128 0.243 0.34
0.182 0.182 0.103 0.099 0.257 0.25
0.208 0.174 0.264 0.130 0.226 0.20
0.106 0.209 0.121 0.149 0.246 0.15
0.092 0.224 0.117 0.086 0.197 0.34
0.095 0.144 0.152 0.122 0.408 0.20
0.212 0.126 0.202 0.104 0.486 0.28

#Survey Indices, -1 for missing data
-1 -1 10.52 -1 -1 0.71
-1 -1 30.52 -1 -1 0.22
-1 -1 11.77 -1 -1 7.31
-1 -1 11.01 -1 -1 1.73
-1 -1 8.92 -1 -1 0.86
-1 -1 10.13 -1 -1 0.44
-1 -1 6.69 -1 -1 0.46
-1 -1 4.91 -1 -1 0.42
-1 -1 4.85 -1 -1 0.10
-1 -1 8.45 -1 -1 0.31
5.00 -1 4.24 -1 -1 0.80
23.91 0.07 1.98 -1 -1 0.30
21.44 0 1.22 -1 -1 0.04
30.50 0.17 8.45 3.05 -1 0.02
48.03 0.05 1.37 2.90 -1 0.63
37.11 0.47 4.21 5.63 -1 0.00
3.85 0.04 2.93 2.27 2.81 0.36
6.14 0.48 4.14 4.65 0.78 0.05
60.67 1.11 4.80 15.22 0.62 0.15
52.30 0.57 2.65 7.49 7.07 0.11
41.94 2.71 25.20 10.99 9.25 0.40
37.97 2.06 2.14 6.94 0.96 0.75
6.85 1.16 4.44 3.71 7.59 0.34
17.29 3.99 9.03 9.83 5.66 0.32
26.49 5.97 39.76 12.91 3.46 0.44
28.49 2.32 16.12 8.39 13.21 2.51
27.39 7.61 9.27 5.14 4.85 0.23
14.66 4.3 59.39 20.88 11.09 0.23
50.35 2.25 7.98 8.24 4.34 0.62
22.91 3.51 12.67 11.58 10.09 0.35
52.54 4.85 18.12 2.46 7.51 0.79
7.82 6.05 13.77 15.23 11.39 0.52
91.24 2.47 50.75 14.58 7.55 0.56
21.53 1.29 4.73 4.52 8.88 1.61
34.97 8.67 25.75 18.92 3.10 0.13
14.33 2.98 11.44 10.71 11.24 1.91
35.01 2.47 17.79 7.51 2.99 0.64

#################################################################################
# Aggregate Surveys MRFSS CTCPUE NEFSC CTTRL
##################################################################################

#Number of No age comp surveys
4

#Survey time of year fractions
0.5 0.5 0.3333 0.3333

# Survey ages
3.13 2.13 2.09 2.04
```

```
#Aggregate Surveys Likelihood Weights
1 1 1 1

#Survey CVs
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 0.574 -1 -1
-1 0.453 -1 -1
-1 0.553 -1 1
-1 0.32 -1 1
-1 0.494 -1 1
-1 0.275 -1 0.40
0.79 0.268 -1 0.50
0.85 0.177 -1 0.33
0.77 0.165 -1 0.25
0.38 0.415 0.156 0.33
0.24 0.194 0.373 0.25
0.21 0.141 0.357 0.20
0.2 0.227 0.579 0.20
0.2 0.291 0.229 0.23
0.2 0.235 0.305 0.20
0.2 0.175 0.332 0.20
0.2 0.217 0.128 0.27
0.2 0.207 0.14 0.21
0.2 0.165 0.284 0.21
0.2 0.146 0.363 0.27
0.2 0.127 0.157 0.29
0.2 0.151 0.332 0.18
0.2 0.169 0.302 0.18
0.2 0.15 0.238 0.26
0.2 0.18 0.534 0.25

#Survey Indices, -1 for missing data
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 0.903 -1 -1
-1 0.751 -1 -1
-1 0.922 -1 0.022
-1 0.891 -1 0
-1 1.518 -1 0
-1 1.135 -1 0.053
0.362145961 1.361 -1 0.036
0.266005882 1.84 -1 0.063
0.24098429 2.203 -1 0.162
0.41409724 2.163 0.258 0.146
0.749170058 2.377 0.247 0.22
0.610929185 2.845 0.634 0.273
0.908054028 3.954 3.441 0.296
1.174633583 5.396 1.101 0.6
1.333341093 7.583 0.807 0.63
1.369797852 5.99 1.373 0.85
1.714551001 7.574 0.81 0.97
1.614670646 5.526 0.767 1.1
1.510928023 6.873 1.409 0.84
1.2616274 7.56 0.795 0.613
1.052792365 5.87 1.156 1.3
0.929391076 6.35 1.049 0.87
1.009113292 8.15 0.359 0.56
1.168405332 13.15470042 0.312 1.17
1.386671533 13.52818536 0.792 0.61
```

```
###########################################################################
#Surveys with Age Data - NYOHS NJTRL MDAdults DESSN
###########################################################################
#Number of Age surveys
4

#Survey time of year fractions
0.75 0.25 0.25 0.25

#Surveys Indices with Age Data Likelihood Weights
1 1 1 1

# Survey Age Comp Likelihood Weights
1 1 1 1

#Survey CVs
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 0.3 -1
-1 -1 0.3 -1
0.250804572 -1 0.25 -1
0.185277089 -1 0.25 -1
0.17721519 0.551 0.25 -1
0.285590278 0.607 0.25 -1
0.32486298 0.612 0.25 -1
0.407348243 0.449 0.25 -1
0.173025732 0.681 0.25 -1
0.73776908 0.482 0.25 -1
0.562797013 0.173 0.25 -1
0.184391737 0.752 0.25 0.190
0.260247235 0.327 0.25 0.232
0.25758645 0.229 0.25 0.250
0.4625 0.550 0.25 0.183
0.27466319 0.332 0.25 0.209
0.567319461 0.217 0.25 0.224
0.49045281 0.592 0.25 0.220
0.377706126 0.337 0.25 0.140
0.177619893 0.360 0.25 0.172
0.373695198 0.380 0.25 0.177
0.261588426 0.674 0.25 0.199

#Survey Indices, -1 for missing data
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 488.1 -1
-1 -1 1006.9 -1
90.11 -1 715.0 -1
60.45 -1 327.4 -1
21.33 0.280 395.9 -1
115.2 1.961 503.6 -1
200.7 2.461 460.8 -1
125.2 1.034 629.0 -1
45.08 1.083 625.3 -1
102.2 2.145 513.5 -1
147.3 7.165 461.8 -1
```

```
392.1 18.687 759.2 4.044
614.8 13.626 387.1 4.659
850.2 8.087 478.8 5.600
104 6.270 396.6 3.261
230.1 8.492 352.5 4.000
163.4 2.385 282.6 4.889
183.3 3.177 400.3 4.021
434.2 10.427 455.0 4.913
281.5 9.304 610.9 5.899
239.5 9.360 500.3 3.908
338.7 3.951 505.8 5.333

# Age Samples for Age Comps - (Survey (column) sample size (row))
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 77 -1
-1 -1 77 -1
56 -1 77 -1
56 -1 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
# Age Comp Data for Surveys: Ages 1-13 must be present
#NYOHS
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.0318 0.1949 0.3591 0.2787 0.0883 0.0349 0.0067 0.0017 0 0.0006 0 0.0028
-1 0.2255 0.2687 0.1945 0.166 0.0851 0.0218 0.0144 0.0039 0.0021 0.0007 0 0.0137
-1 0.1833 0.269 0.1478 0.1596 0.1025 0.0936 0.0217 0.003 0.002 0.003 0.002 0.0108
-1 0.0608 0.2957 0.3063 0.1139 0.0985 0.0557 0.0444 0.0158 0.0058 0.001 0 0.0023
-1 0.207 0.3666 0.2439 0.0519 0.0166 0.0253 0.0416 0.023 0.0063 0.002 0.0036 0.0115
-1 0.0792 0.4166 0.2577 0.1211 0.0329 0.0143 0.017 0.025 0.0175 0.0032 0.0058 0.0096
-1 0.1563 0.3868 0.2908 0.0701 0.0328 0.0094 0.009 0.0115 0.0131 0.007 0.0025 0.0082
-1 0.141 0.2705 0.1562 0.1346 0.0832 0.0546 0.0375 0.0222 0.0406 0.0127 0.0241 0.0203
-1 0.245 0.2695 0.2542 0.072 0.0658 0.0352 0.0123 0.0054 0.0123 0.0115 0.0031 0.0084
-1 0.0832 0.7475 0.1142 0.0328 0.0094 0.0073 0.0027 0.0013 0.0007 0 0.0005 0.0003
-1 0.2063 0.2425 0.4508 0.0669 0.0184 0.0037 0.0037 0.0039 0.0017 0.0007 0.0009 0.0006
-1 0.1876 0.2969 0.1714 0.2855 0.0366 0.0091 0.0058 0.0029 0.0002 0.001 0.0015 0.0011
```

```
-1 0.0697 0.6277 0.1722 0.0594 0.0438 0.005 0.0032 0.0046 0.0035 0.0039 0.0007 0.0046
-1 0.1273 0.193 0.4338 0.1541 0.0364 0.0368 0.0041 0.0039 0.0016 0.0018 0.001 0.0044
-1 0.0524 0.4553 0.1474 0.2129 0.0735 0.0274 0.0194 0.0032 0.0039 0.0011 0 0.0025
-1 0.3225 0.2261 0.1843 0.0805 0.0735 0.0572 0.0198 0.0198 0.0013 0.0048 0.0018 0.0057
-1 0.2022 0.3647 0.1251 0.0922 0.0406 0.0646 0.0506 0.0227 0.0177 0.0126 0.0009 0.0049
-1 0.0501 0.5698 0.2734 0.0628 0.0222 0.0076 0.0061 0.0036 0.0011 0.0014 0.0017 0.0002
-1 0.2444 0.1280 0.4126 0.1370 0.0336 0.0138 0.0035 0.0090 0.0065 0.0035 0.0037 0.0045
-1 0.0639 0.6359 0.0728 0.1610 0.0424 0.0144 0.0057 0.0025 0.0003 0.0010 0.0000 0.0000
 #NJTRL
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.278 0.444 0.006 0.137 0.052 0.011 0.016 0 0.056 0 0 0
-1 0.061 0.182 0.02 0.414 0.132 0.029 0.097 0.005 0.061 0 0 0
-1 0.277 0.284 0.021 0.02 0.148 0.132 0.017 0.034 0.046 0.021 0 0
-1 0.258 0.478 0.061 0.064 0.055 0.074 0.01 0 0 0 0 0
-1 0.238 0.353 0.15 0.087 0.123 0.024 0.025 0 0 0 0 0
-1 0.287 0.37 0.155 0.09 0.048 0.031 0.01 0.009 0 0 0 0
-1 0.658 0.172 0.067 0.045 0.032 0.012 0.007 0.004 0.003 0 0 0
-1 0.162 0.58 0.16 0.061 0.021 0.013 0.004 0 0 0 0 0
-1 0.187 0.409 0.236 0.113 0.035 0.012 0.005 0.001 0.003 0 0 0
-1 0.442 0.193 0.043 0.13 0.086 0.054 0.025 0.014 0.011 0.002 0.001 0
-1 0.077 0.32 0.181 0.256 0.115 0.032 0.011 0.005 0.003 0 0.001 0
-1 0.152 0.14 0.157 0.274 0.167 0.073 0.027 0.006 0.002 0.001 0 0
-1 0.148 0.167 0.199 0.299 0.103 0.042 0.023 0.013 0.006 0.001 0 0
-1 0.005 0.023 0.071 0.206 0.359 0.23 0.076 0.024 0.004 0 0 0
-1 0.304 0.238 0.041 0.126 0.097 0.122 0.049 0.015 0.006 0.001 0.001 0
-1 0.182 0.519 0.09 0.04 0.058 0.043 0.036 0.021 0.008 0.004 0.001 0
-1 0.493 0.218 0.061 0.106 0.047 0.042 0.019 0.009 0.002 0.002 0.000 0.001
-1 0.061 0.100 0.055 0.248 0.256 0.100 0.069 0.046 0.045 0.013 0.007 0.001
#MD SSN
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
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-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.288 0.626 0.065 0.010 0.003 0.005 0.000 0.001 0.000 0.000 0.001 0.002
-1 0.229 0.259 0.494 0.004 0.005 0.002 0.003 0.003 0.000 0.000 0.000 0.001
-1 0.199 0.361 0.161 0.246 0.025 0.003 0.004 0.000 0.000 0.000 0.000 0.001
-1 0.125 0.237 0.218 0.174 0.228 0.004 0.000 0.000 0.013 0.000 0.000 0.001
-1 0.084 0.391 0.203 0.115 0.123 0.083 0.000 0.000 0.000 0.000 0.000 0.000
-1 0.155 0.314 0.239 0.096 0.068 0.064 0.059 0.002 0.000 0.000 0.001 0.002
-1 0.159 0.415 0.135 0.102 0.058 0.057 0.042 0.023 0.001 0.003 0.000 0.005
-1 0.043 0.352 0.244 0.093 0.111 0.068 0.046 0.022 0.011 0.005 0.000 0.004
-1 0.065 0.211 0.299 0.141 0.082 0.083 0.059 0.036 0.012 0.005 0.001 0.005
-1 0.052 0.202 0.191 0.230 0.116 0.066 0.084 0.034 0.017 0.006 0.002 0.001
-1 0.108 0.254 0.146 0.132 0.112 0.087 0.054 0.043 0.025 0.021 0.008 0.010
-1 0.005 0.485 0.135 0.046 0.092 0.085 0.056 0.047 0.022 0.020 0.006 0.002
-1 0.105 0.120 0.348 0.119 0.056 0.051 0.067 0.058 0.032 0.031 0.010 0.005
-1 0.075 0.298 0.068 0.312 0.067 0.028 0.039 0.036 0.031 0.019 0.021 0.005
-1 0.018 0.439 0.202 0.143 0.089 0.029 0.017 0.028 0.013 0.013 0.007 0.003
-1 0.029 0.144 0.305 0.143 0.165 0.077 0.040 0.023 0.023 0.022 0.014 0.016
-1 0.017 0.138 0.185 0.183 0.082 0.101 0.134 0.047 0.042 0.035 0.020 0.017
-1 0.241 0.104 0.096 0.208 0.085 0.075 0.079 0.057 0.019 0.010 0.013 0.014
-1 0.039 0.242 0.105 0.082 0.135 0.125 0.068 0.060 0.076 0.022 0.023 0.024
```

```
-1 0.051 0.293 0.199 0.067 0.054 0.072 0.076 0.061 0.043 0.045 0.013 0.025
-1 0.135 0.211 0.148 0.194 0.049 0.052 0.043 0.055 0.041 0.035 0.023 0.015
-1 0.017 0.526 0.082 0.097 0.060 0.030 0.025 0.037 0.043 0.026 0.021 0.037
 #DE SSN
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
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-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.006 0.417 0.192 0.061 0.085 0.076 0.064 0.058 0.015 0.009 0.009 0.009
-1 0.093 0.074 0.391 0.137 0.051 0.064 0.073 0.032 0.03 0.023 0.009 0.023
-1 0.04 0.087 0.098 0.347 0.09 0.061 0.105 0.095 0.034 0.025 0.008 0.011
-1 0 0.105 0.144 0.177 0.235 0.072 0.054 0.076 0.058 0.051 0.014 0.014
-1 0.036 0.036 0.21 0.171 0.138 0.223 0.066 0.03 0.039 0.032 0.01 0.01
-1 0.006 0.115 0.1 0.185 0.11 0.14 0.2 0.05 0.015 0.04 0.02 0.02
-1 0.034 0.071 0.191 0.178 0.157 0.113 0.089 0.097 0.026 0.016 0.01 0.018
-1 0.02 0.097 0.097 0.134 0.089 0.111 0.125 0.105 0.121 0.034 0.028 0.038
-1 0.007 0.166 0.231 0.098 0.068 0.054 0.112 0.078 0.081 0.044 0.014 0.047
-1 0.096 0.157 0.168 0.198 0.081 0.046 0.03 0.036 0.061 0.036 0.046 0.046
-1 0.059 0.201 0.097 0.141 0.141 0.071 0.052 0.041 0.048 0.048 0.037 0.063
#########################Catch Weight-at-age############################################
0.13 0.64 1.09 1.54 2.42 3.75 4.83 5.79 6.2 8.68 10.8 11.2 14.05
0.2 0.55 0.94 1.37 2.37 3.29 3.77 5.36 6.01 8.1 9.57 10.39 11.11
0.24 0.6 1.69 1.62 2.67 3.39 5.07 5.65 6.76 7.76 8.41 12.65 12.38
0.06 0.61 1.07 1.66 2.19 3.59 4.91 5.46 6.77 7.45 9 10.69 13.91
0.14 0.57 1.27 2.4 2.44 3.12 3.95 5.05 5.44 6.09 7.75 9.16 12.78
0.2 0.77 1.41 2.11 2.5 2.91 3.61 4.74 5.52 6.49 7.77 9.78 13.15
0.31 0.91 1.1 1.98 3.12 4.02 4.38 4.7 5.24 5.62 8.58 10.4 13.27
0.16 0.83 1.22 2.23 3.06 4.53 5.37 6.23 6.04 8.68 8.94 9.74 13.36
0.08 0.89 1.14 2.05 2.35 3.83 4.91 5.96 5.7 5.97 7.44 9.08 12.6
0.21 0.92 1.29 2.17 2.62 3.17 4.81 5.64 6.46 6.24 9.46 8.3 14.22
0.1 0.69 1.31 1.93 2.81 3.67 4.9 5.79 6.96 8.15 9.77 12.44 13.97
0.07 0.76 1.31 1.99 2.77 3.58 4.8 6.11 7.03 8.01 9.53 10.76 14.55
0.24 1.05 1.69 2.21 2.85 3.5 4.94 6.2 6.8 7.53 9.73 10.69 12.73
0.28 0.7 1.35 2.18 2.77 3.65 5.38 6.16 7.27 8.86 7.57 9.73 16.66
0.14 1.05 1.47 2.32 3.23 4.52 6.39 7.11 7.81 9.2 9.31 10.1 13.7
0.13 0.62 1.18 2.46 2.81 3.64 4.51 5.07 6.73 9.17 9.94 10.24 14.78
0.39 0.77 1.2 1.62 2.25 2.95 4.69 5.66 6.82 7.03 7.76 9.87 11.87
0.62 0.9 1.11 1.44 1.91 2.51 3.36 5.03 6.56 7.85 8.69 9.76 11.98
0.37 0.55 1.1 1.45 1.96 2.79 3.89 5.09 7.11 7.37 9.7 10.7 13.55
0.16 0.38 1.12 1.75 2.21 3.25 4.12 5.02 6.36 7.79 8.65 8.29 10.87
0.12 0.31 1.06 1.51 2.18 3.17 4.19 5.48 6.03 7.56 9.09 9.75 11.52
0.1 0.6 1 1.4 2.2 3.2 4.1 5.2 6.1 7.2 8.5 9.4 11
0.23 0.33 0.84 1.4 2.43 3.11 4.14 5.17 6.07 7.12 8.18 9.03 10.71
0.1 0.6 1.0 1.6 2.2 3.2 4.0 5.6 6.2 6.7 8.0 8.9 11.7
0.2 0.5 0.8 1.3 2.0 2.8 4.1 4.9 6.2 7.0 8.1 9.0 11.1
#####Maturity-at-age############################################
0 0 0 0.04 0.13 0.45 0.89 0.94 1 1 1 1 1
####Proportion of Natural Mortality Before Spawning############
0.33
####Proportion of Fishing Mortality Before Spawning############
0.1
####Natural Mortality###########################################
0.15
####Recruitment dev weight######################################
1
####F dev weight################################################
```

# Appendix A8. Plots of SCA model output

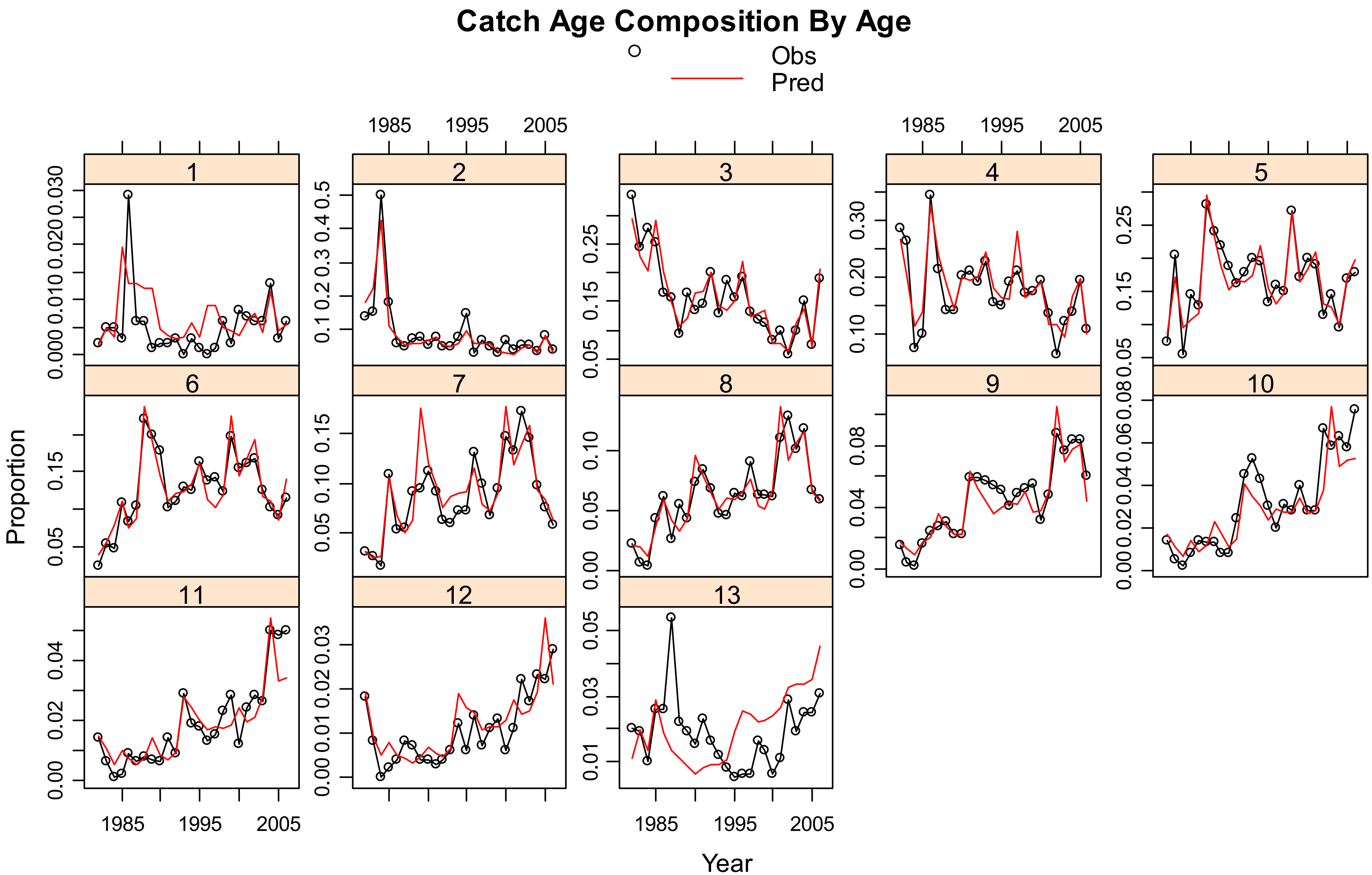



Figure 1. Plots of observed and predicted catch proportions-at-age by age

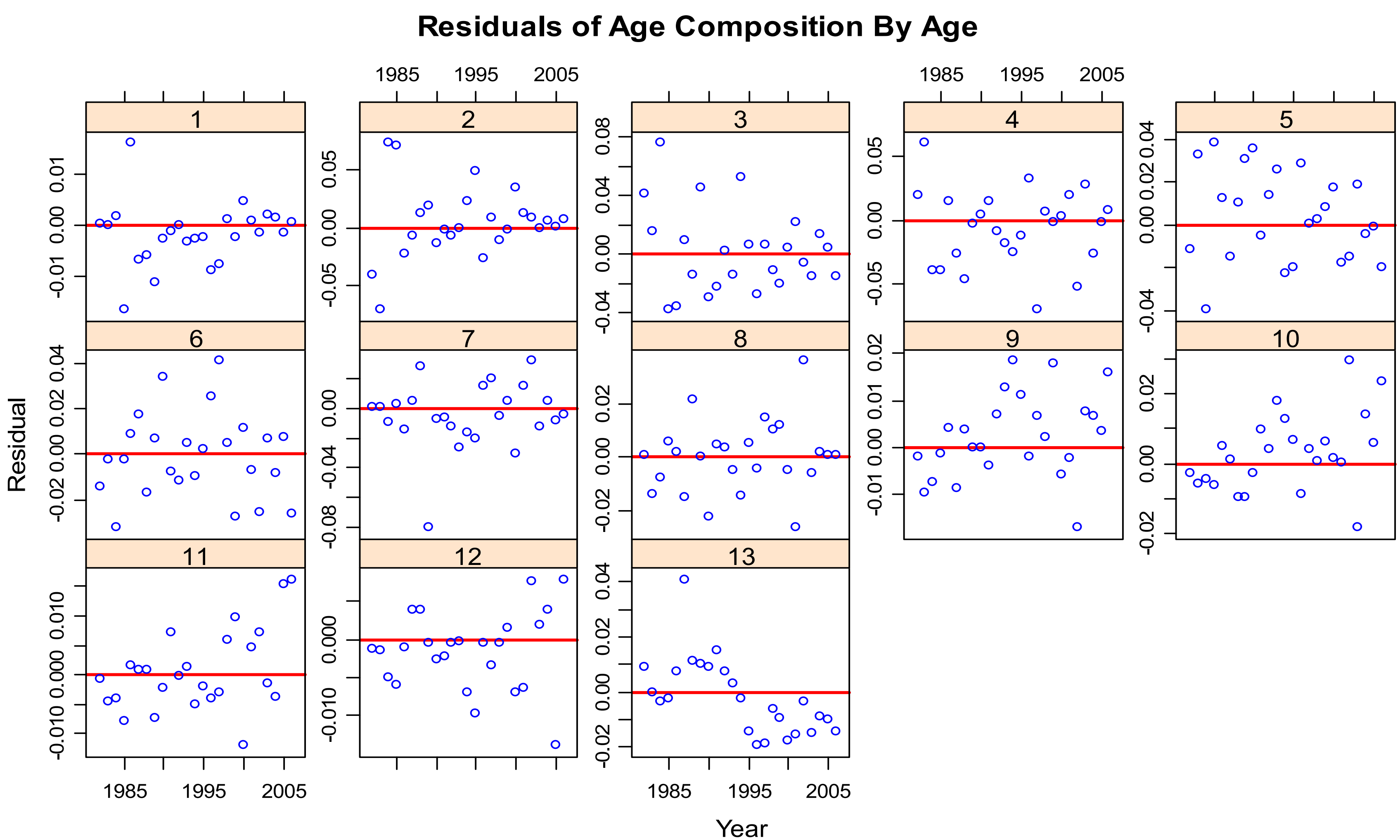



Figure 2. Residuals of catch proportions-at-age by age.

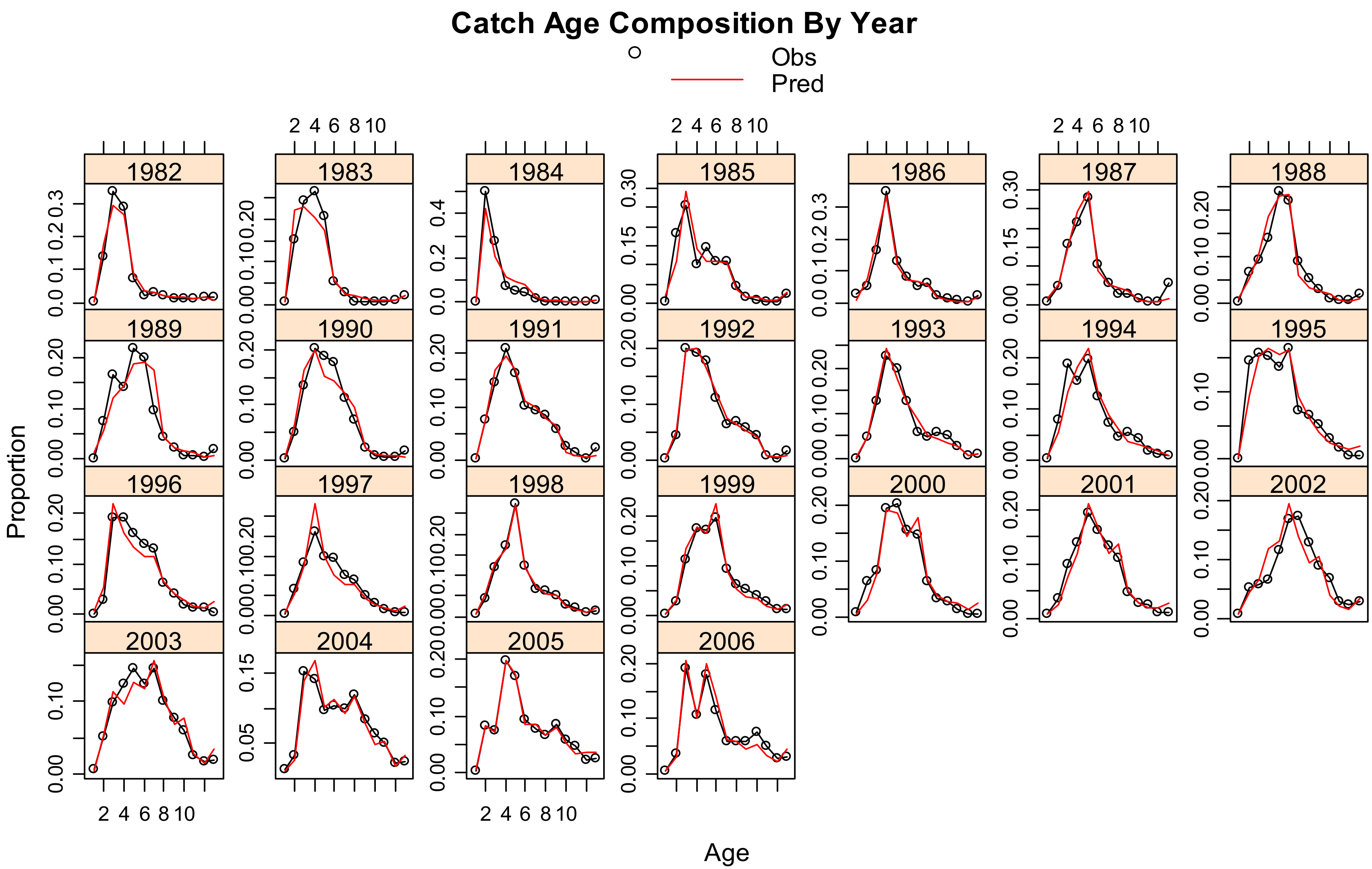



Figure 3. Observed and predicted catch proportions-at-age by year.

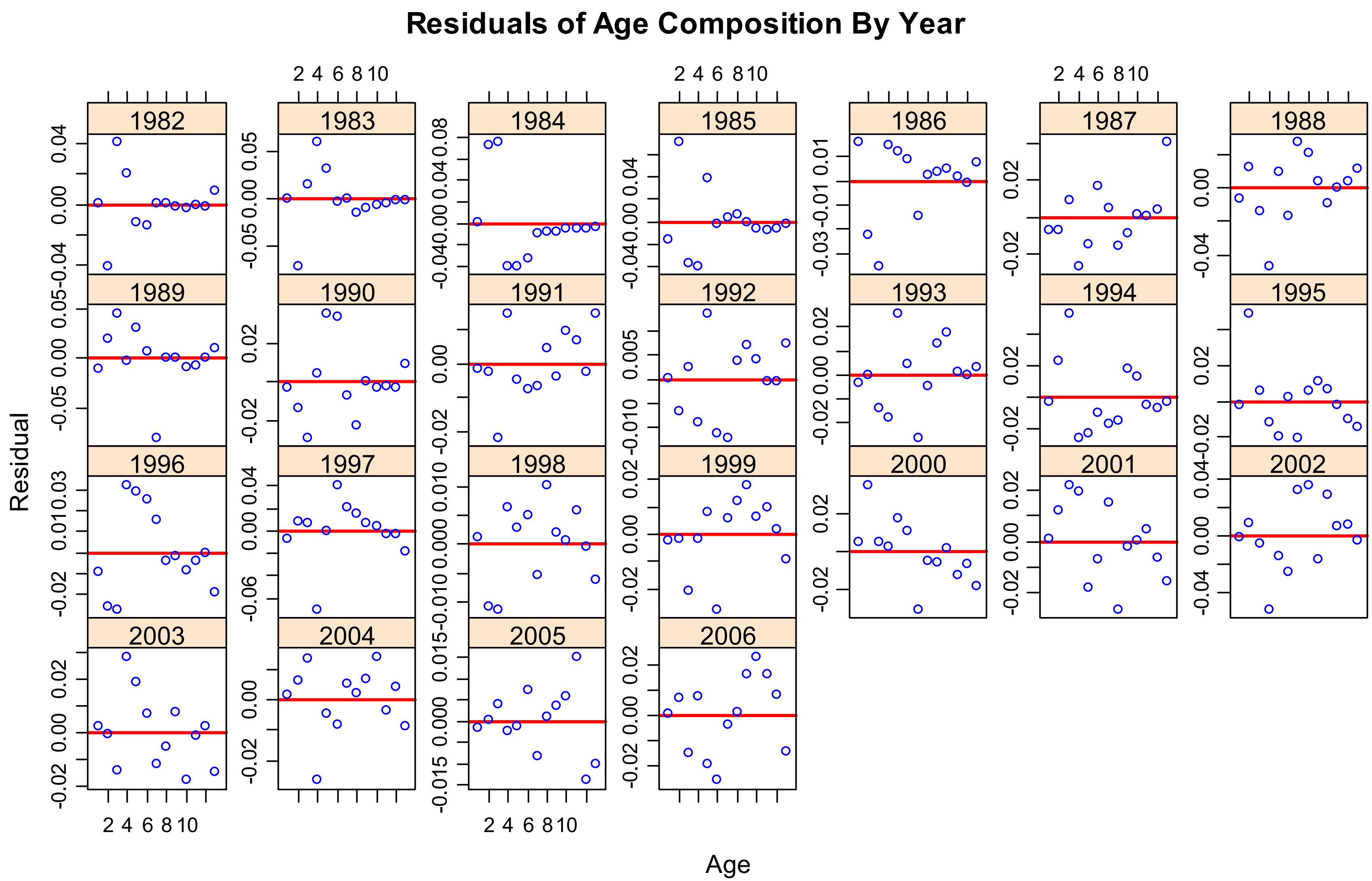



Figure 4. Residuals of catch proportions-at-age by year.

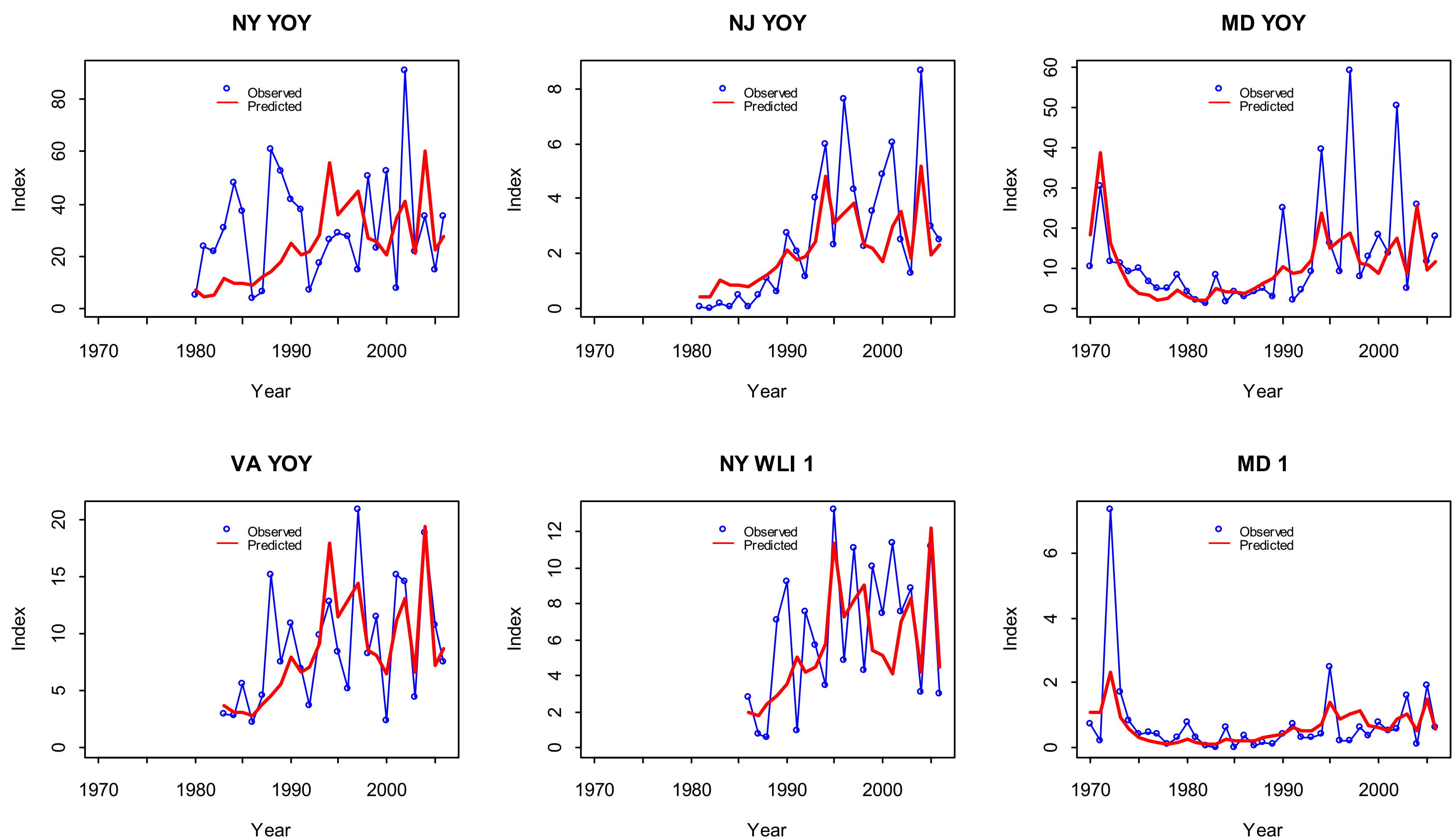



Figure 5. Young-of-the-year and yearling surveys tuned to Age 1 and 2, respectively.

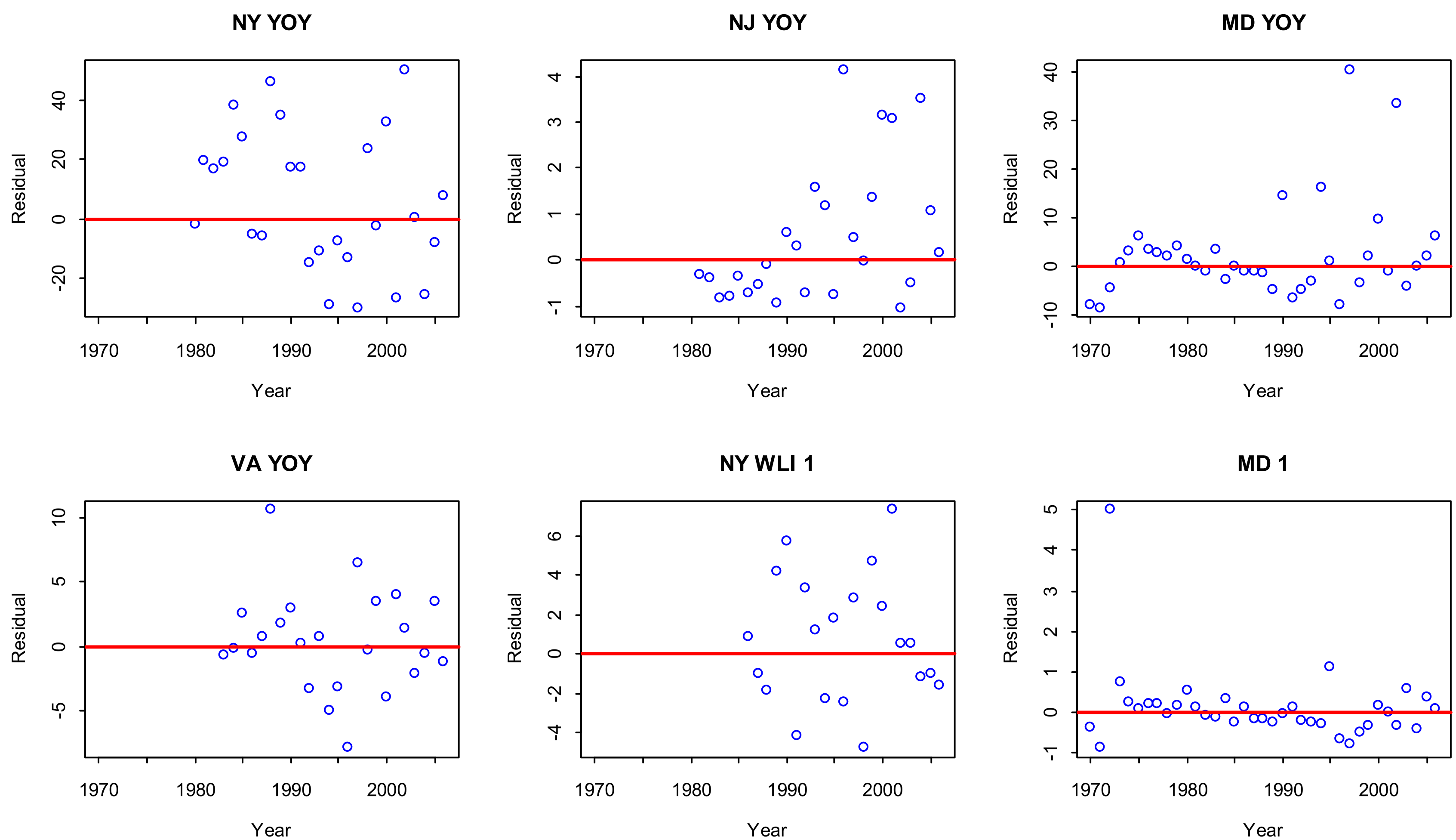



Figure 6. Residuals (observed-predicted) for young-of-the-year and yearling surveys.

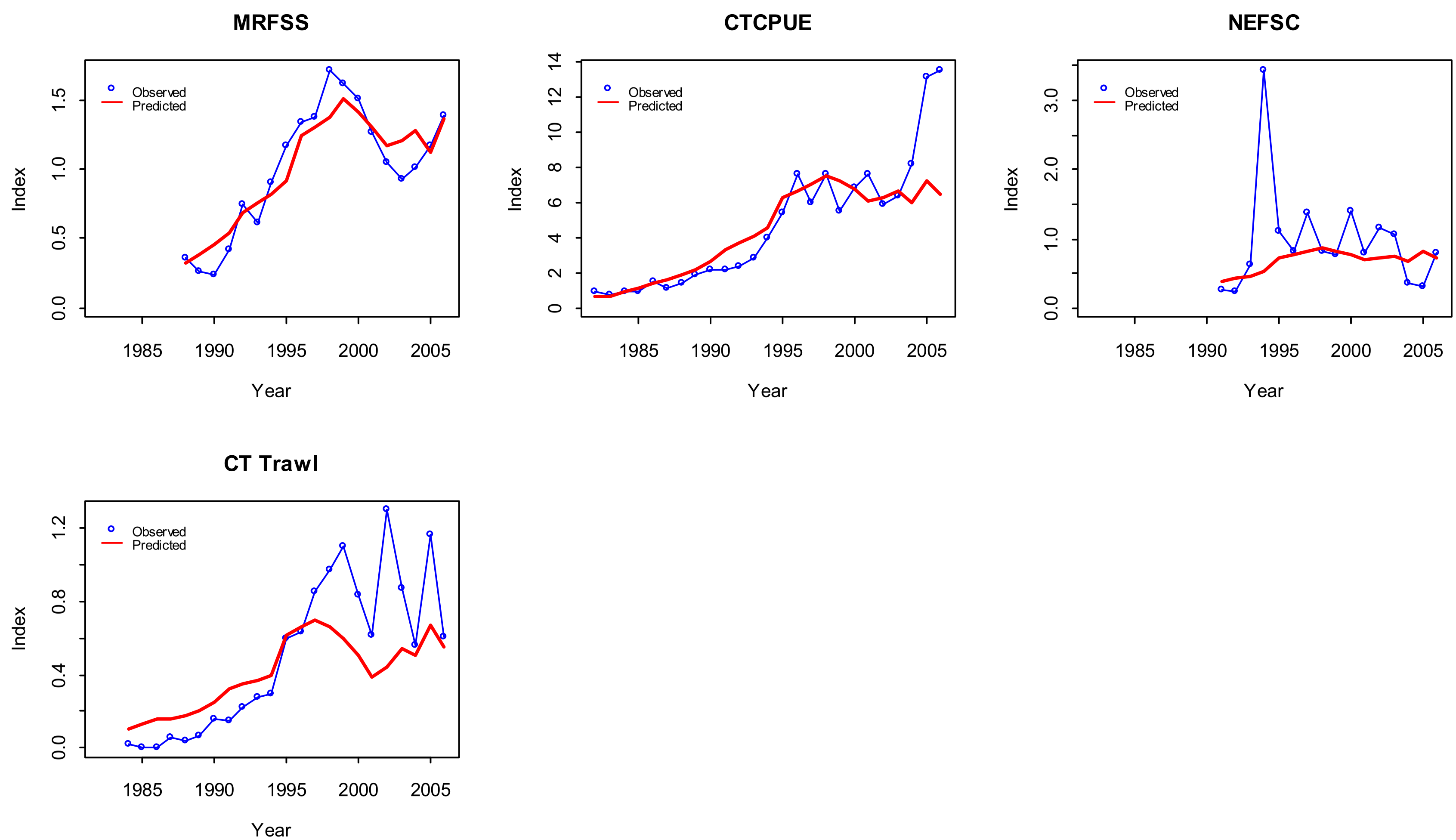



Figure 7. Observed and predicted aggregate indices.

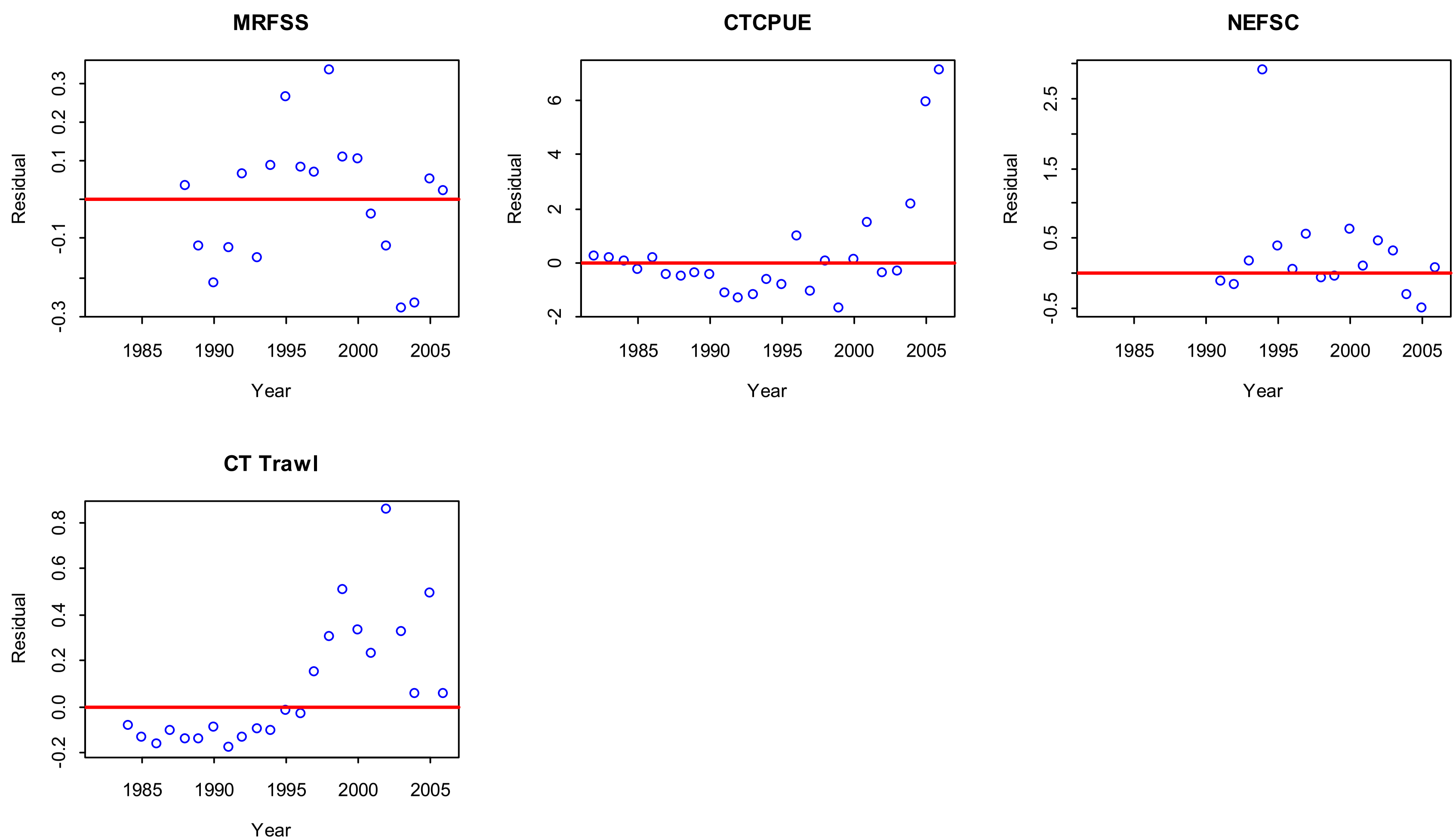



Figure 8. Residuals for aggregate indices.

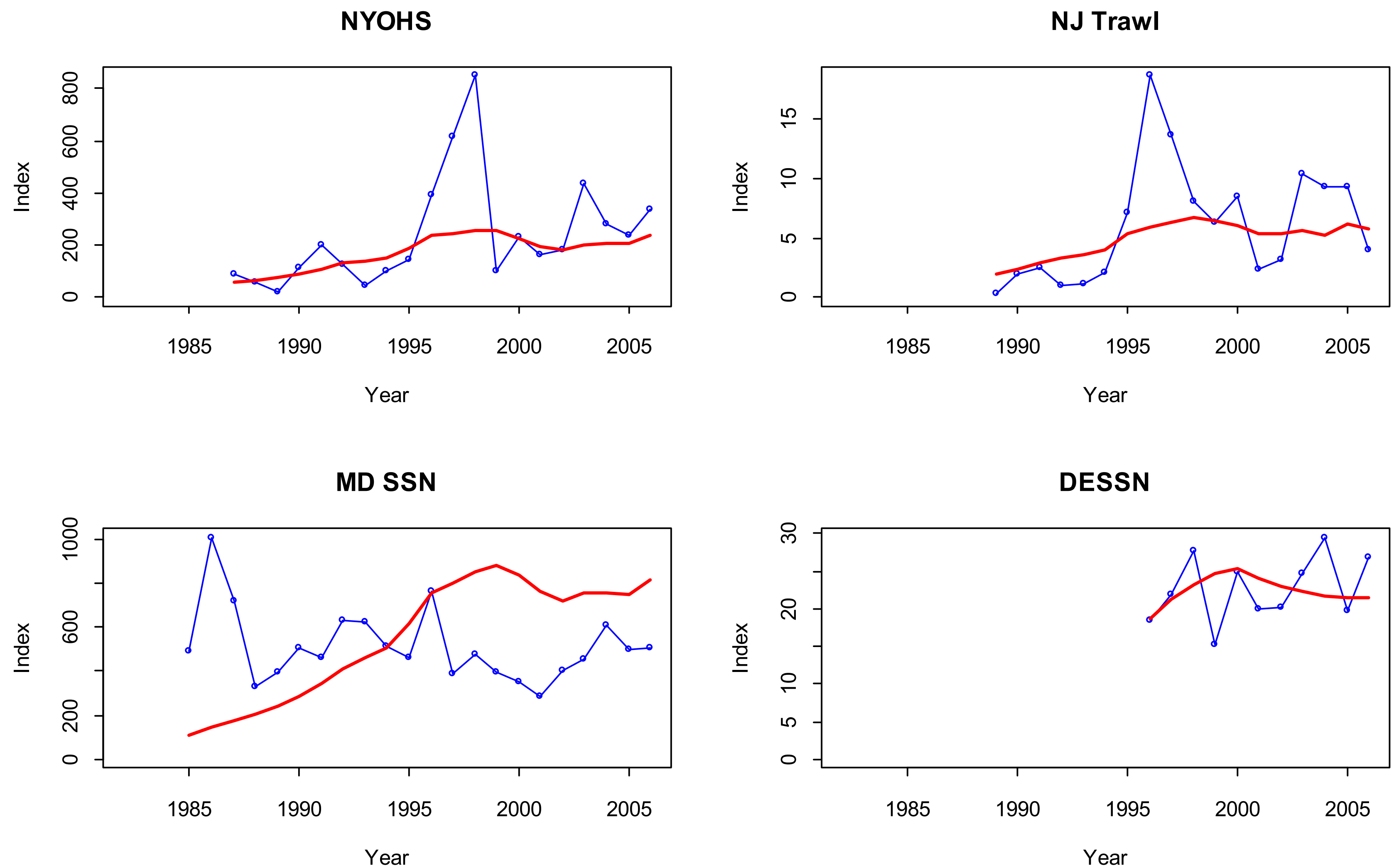



Figure 9. Observed (blue) and predicted (red) aggregate indices for surveys with age composition data.

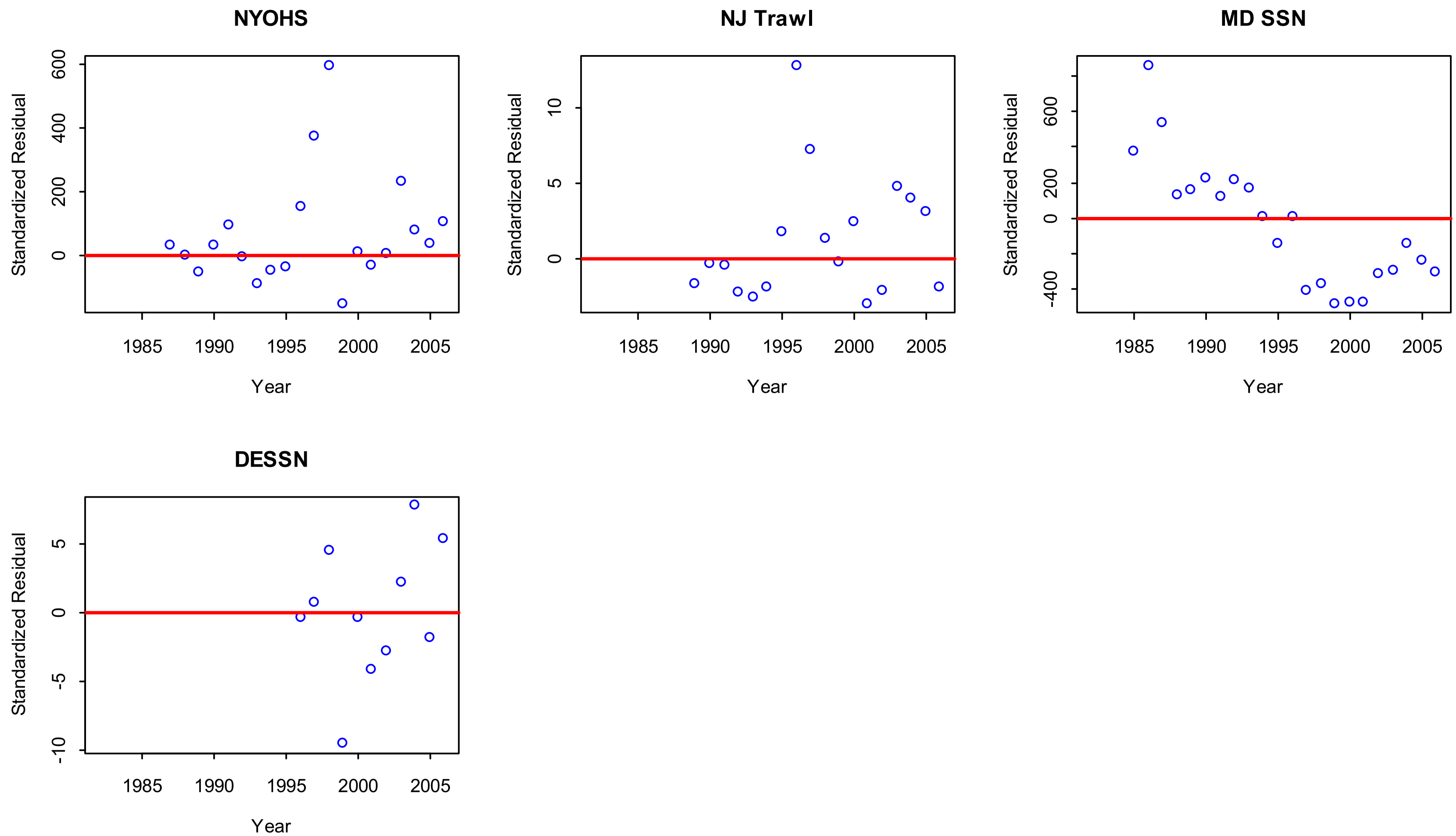



Figure 10. Residuals for aggregate indices with age composition data.

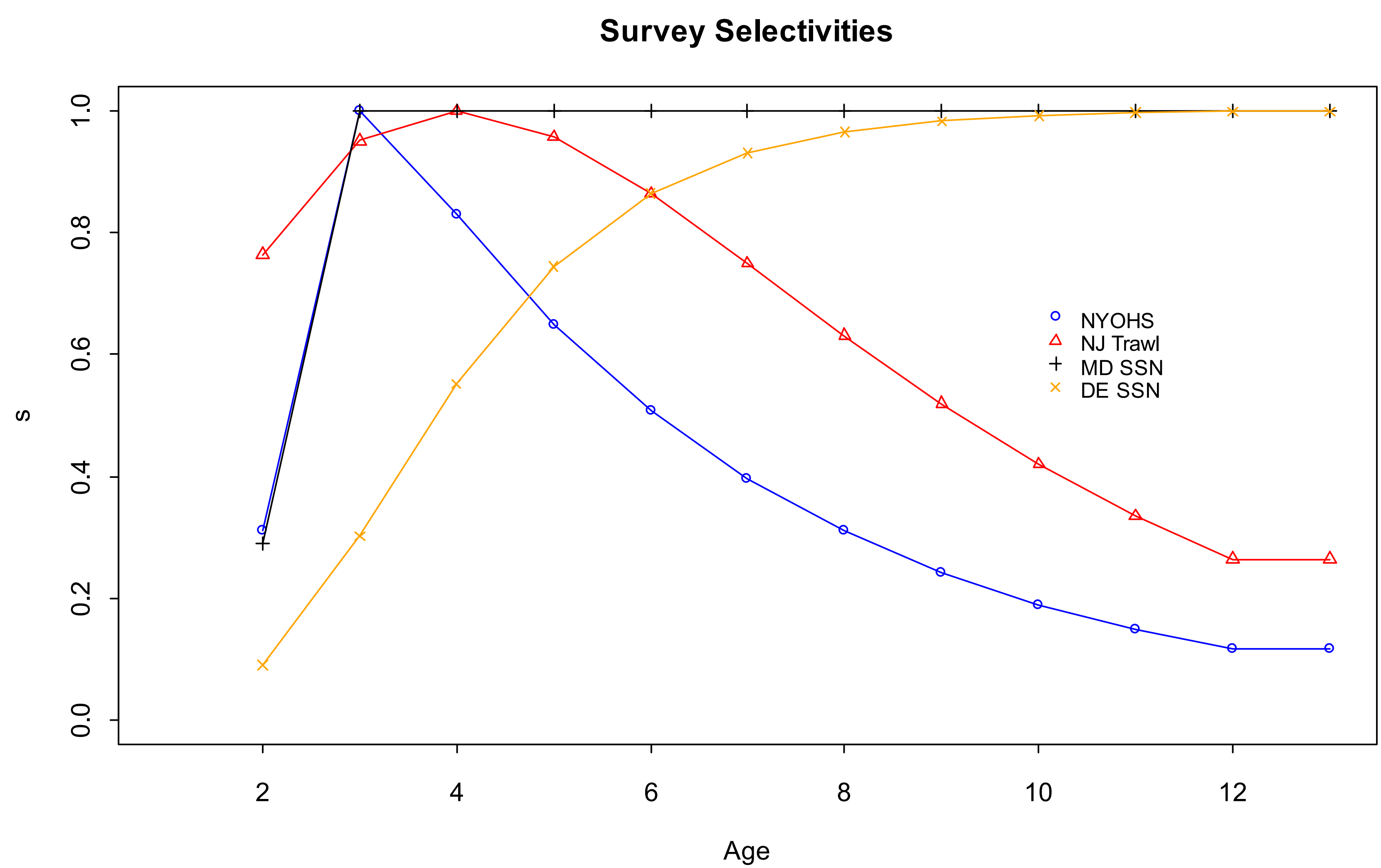



Figure 11. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD SSN, and DE SSN surveys.

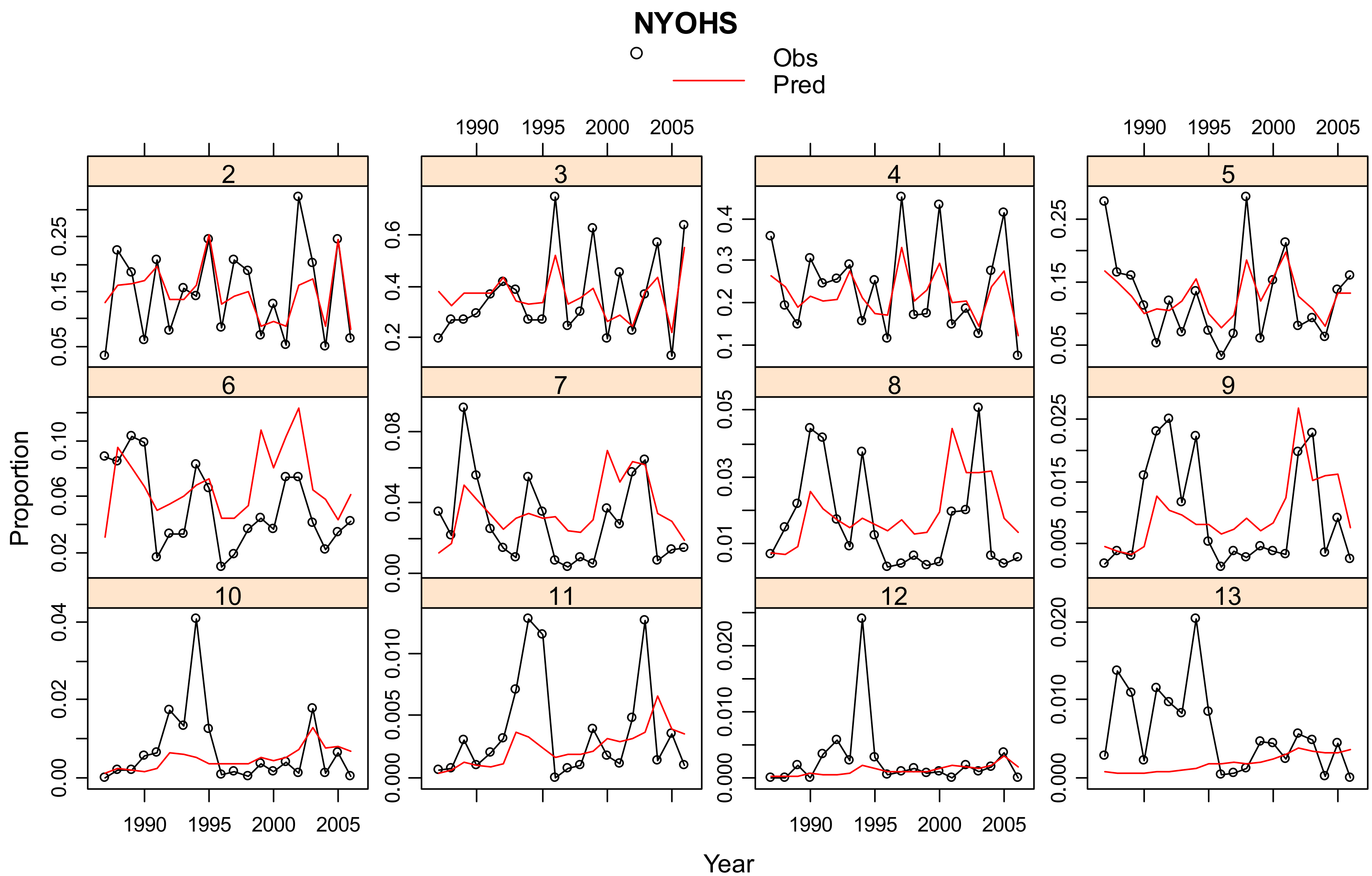



Figure 12. Observed and predicted proportions-at-age for each year by age for the NYOHS survey.

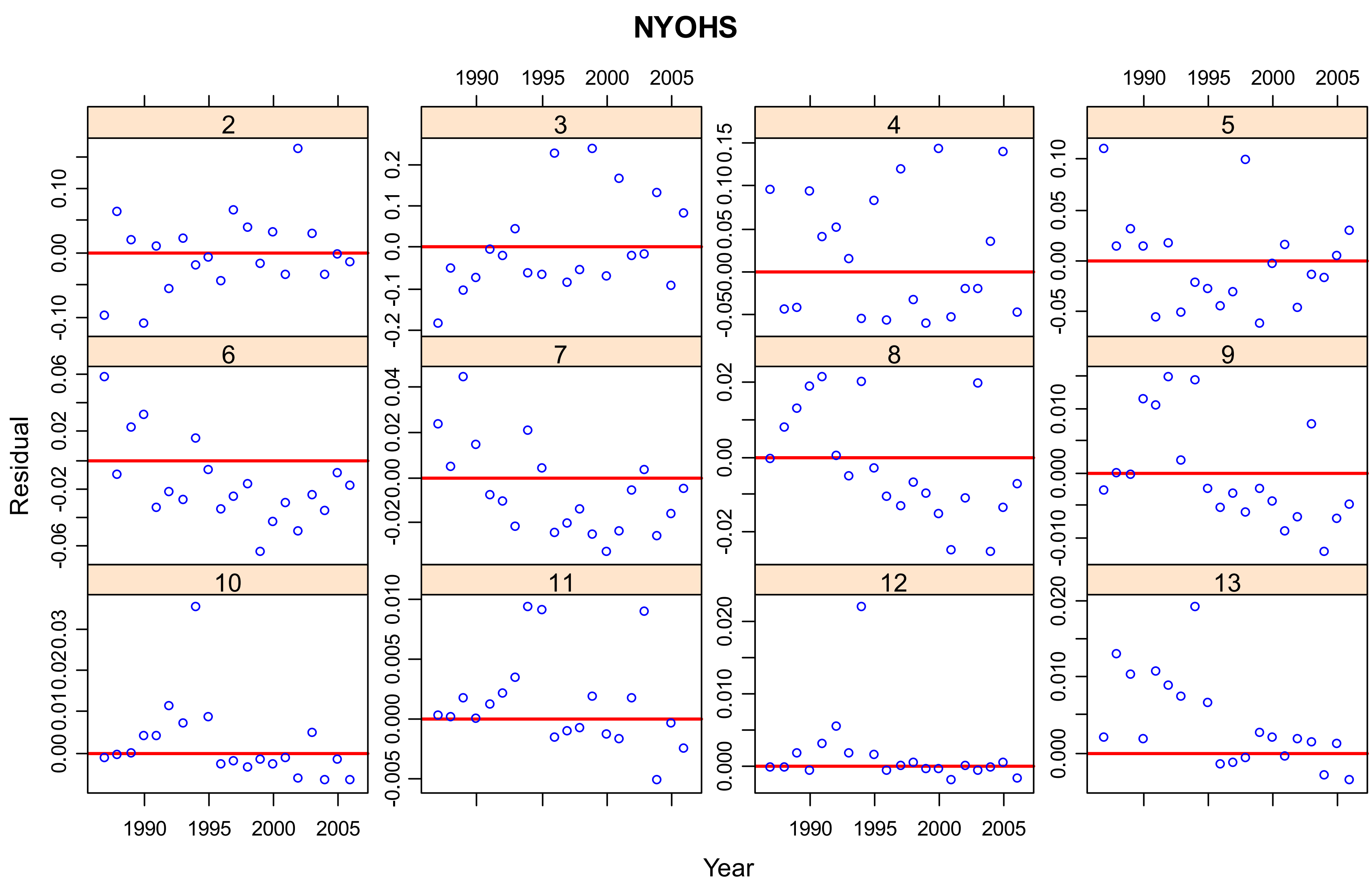



Figure 13. Residuals of proportions-at-age in each year by age for the NYOHS survey.

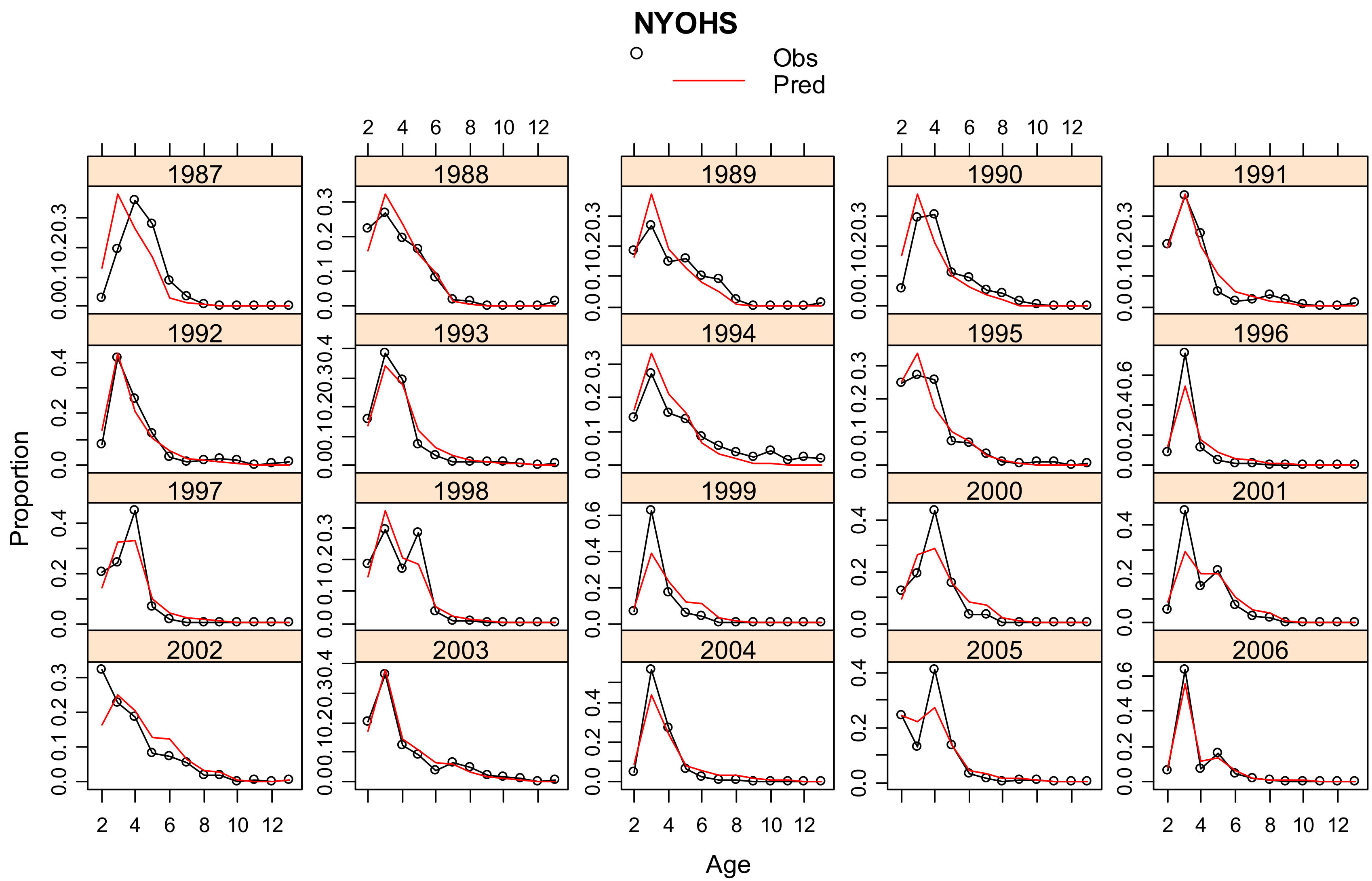



Figure 14. Observed and predicted proportions-at-age for each age by year for the NYOHS survey.

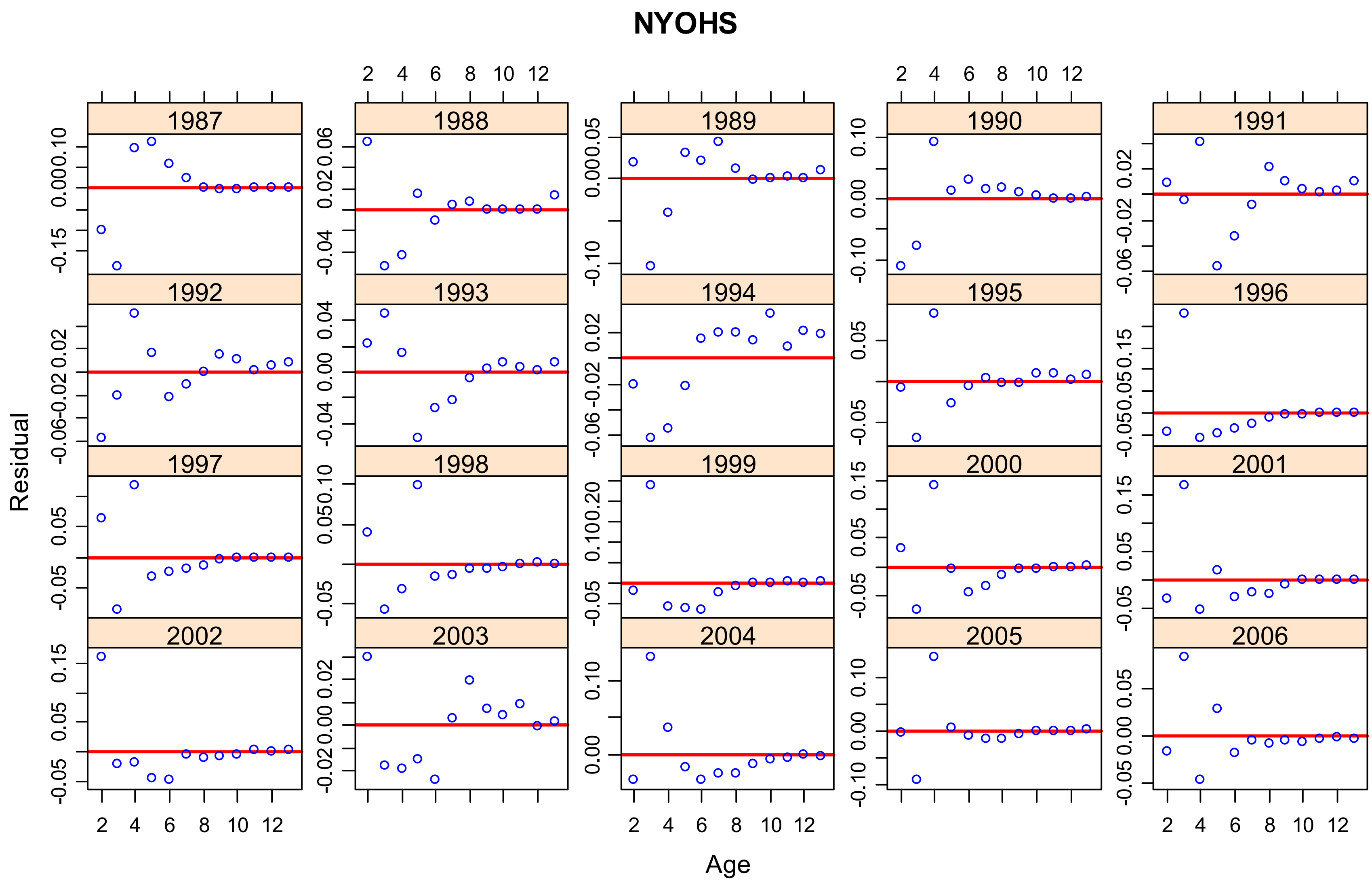



Figure 15. Residuals of proportions-at-age for each age by year for the NYOHS survey.

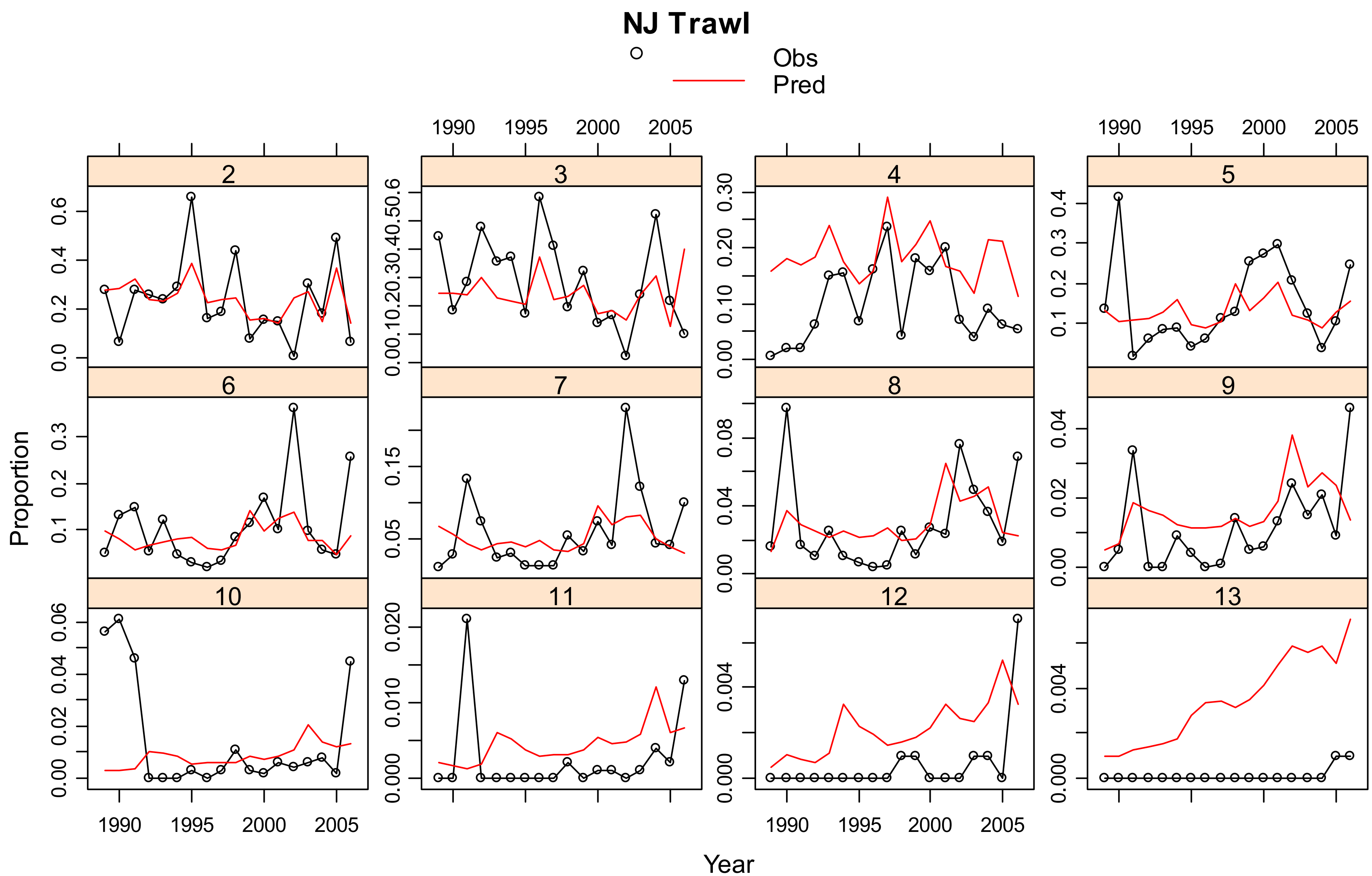



Figure 16. Observed and predicted proportions-at-age for each year by age for the NJ Trawl survey.

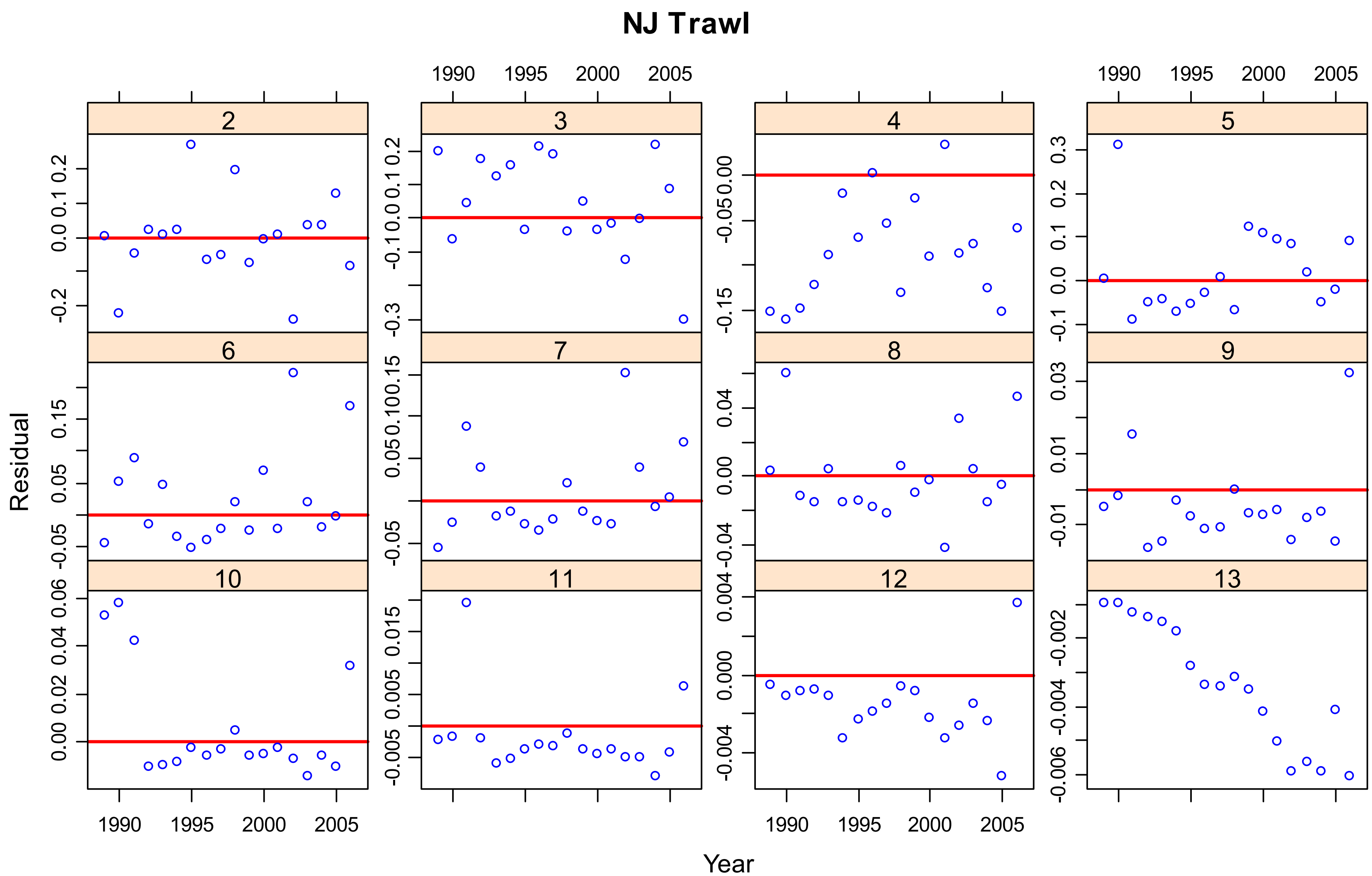



Figure 17. Residuals of proportions-at-age for each year by age for the NJ Trawl survey.

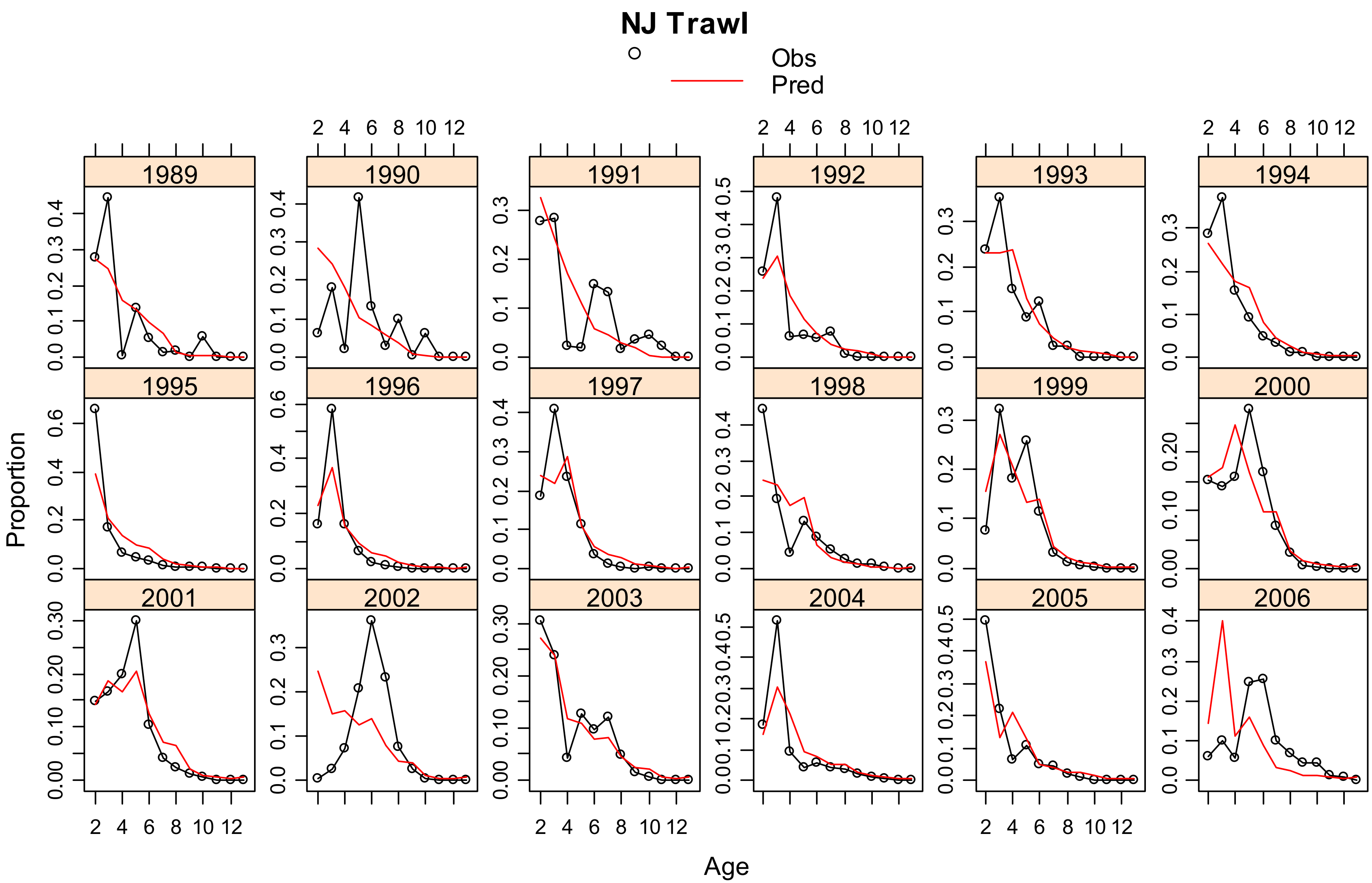



Figure 18. Observed and predicted proportions-at-age for each age by year for the NJ Trawl survey.

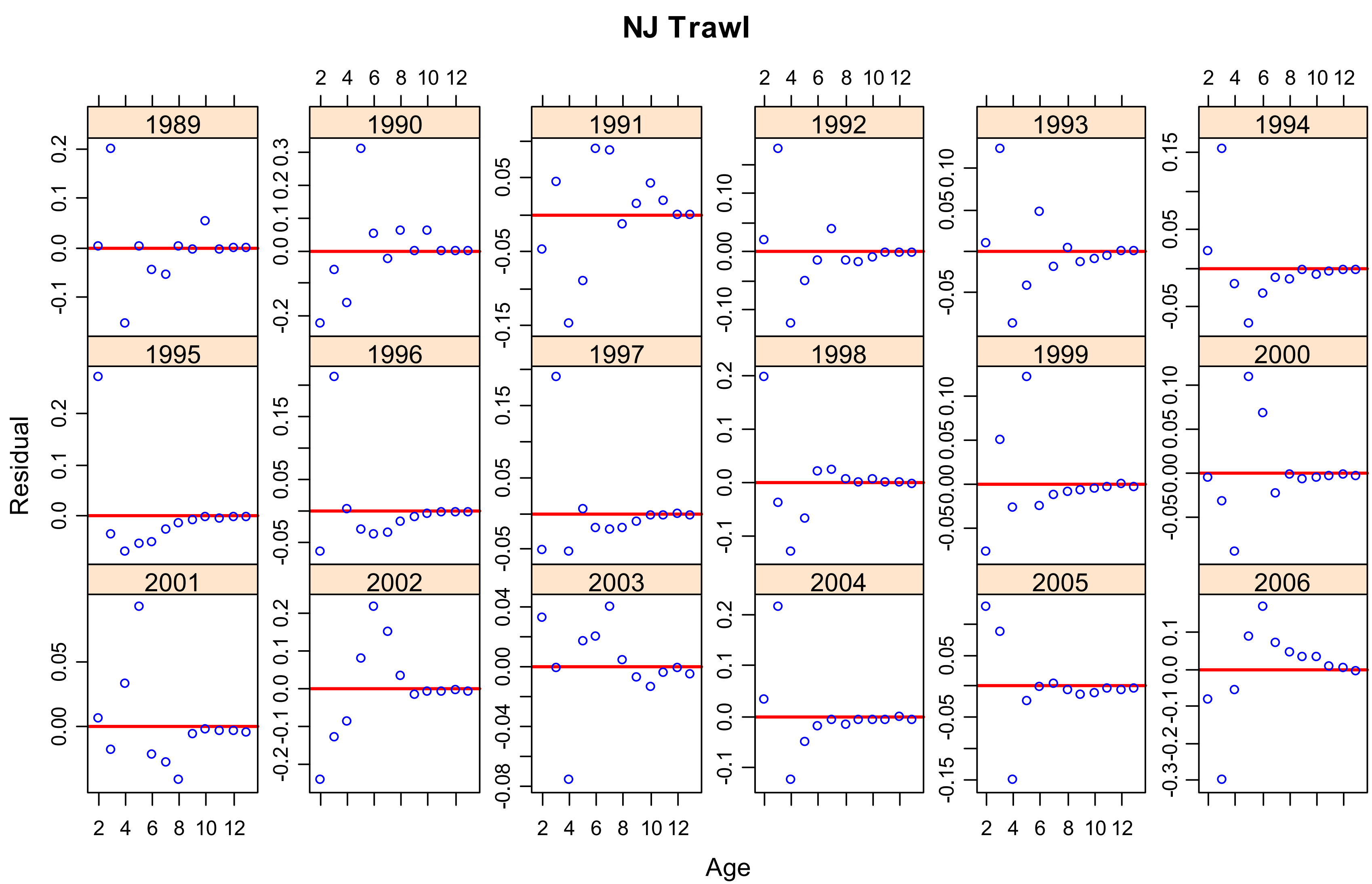



Figure 19. Residuals of proportions-at-age for each age by year for the NJ Trawl survey.

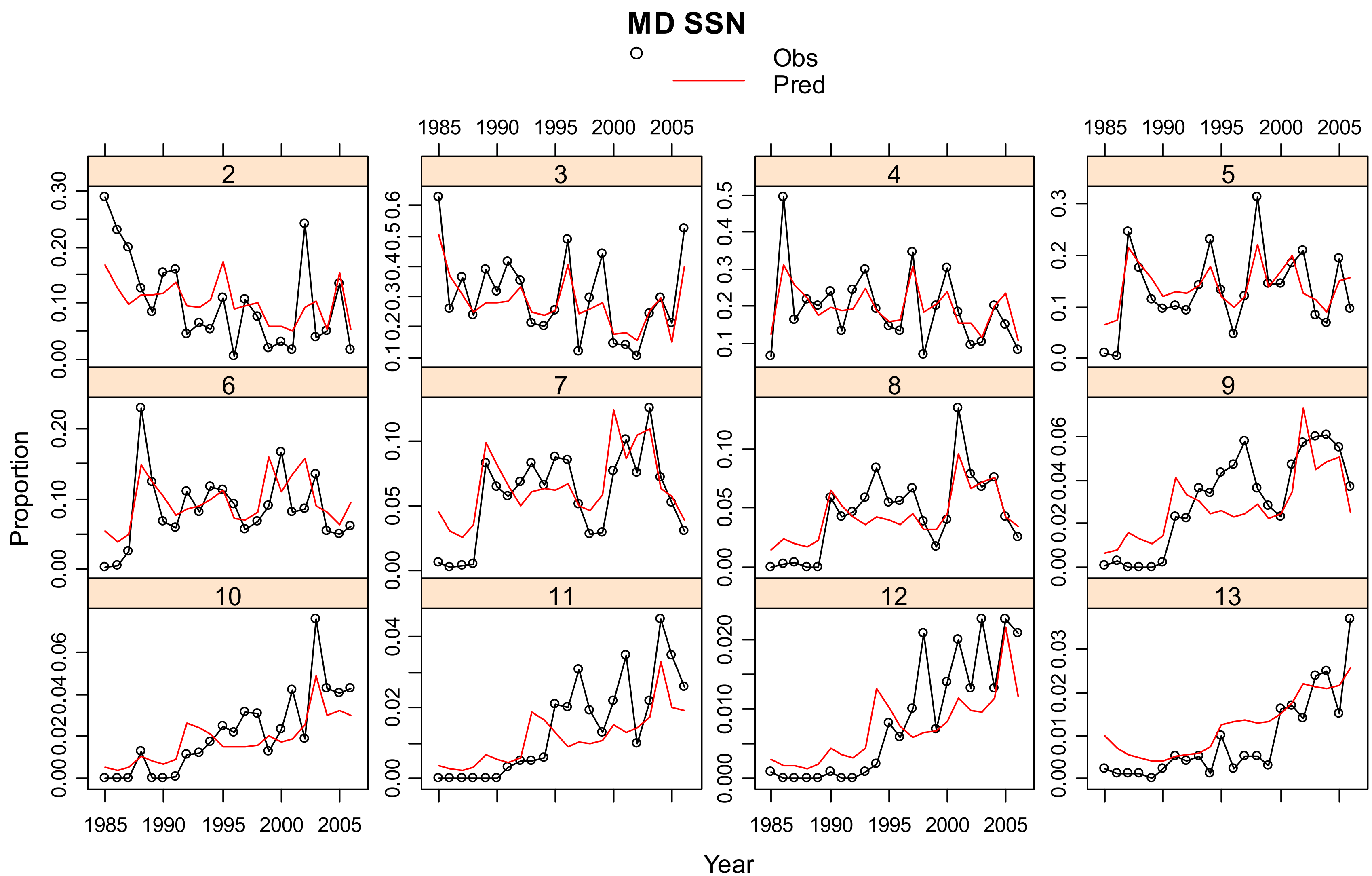



Figure 20. Observed and predicted proportions-at-age for each year by age for the MD SSN gillnet survey.

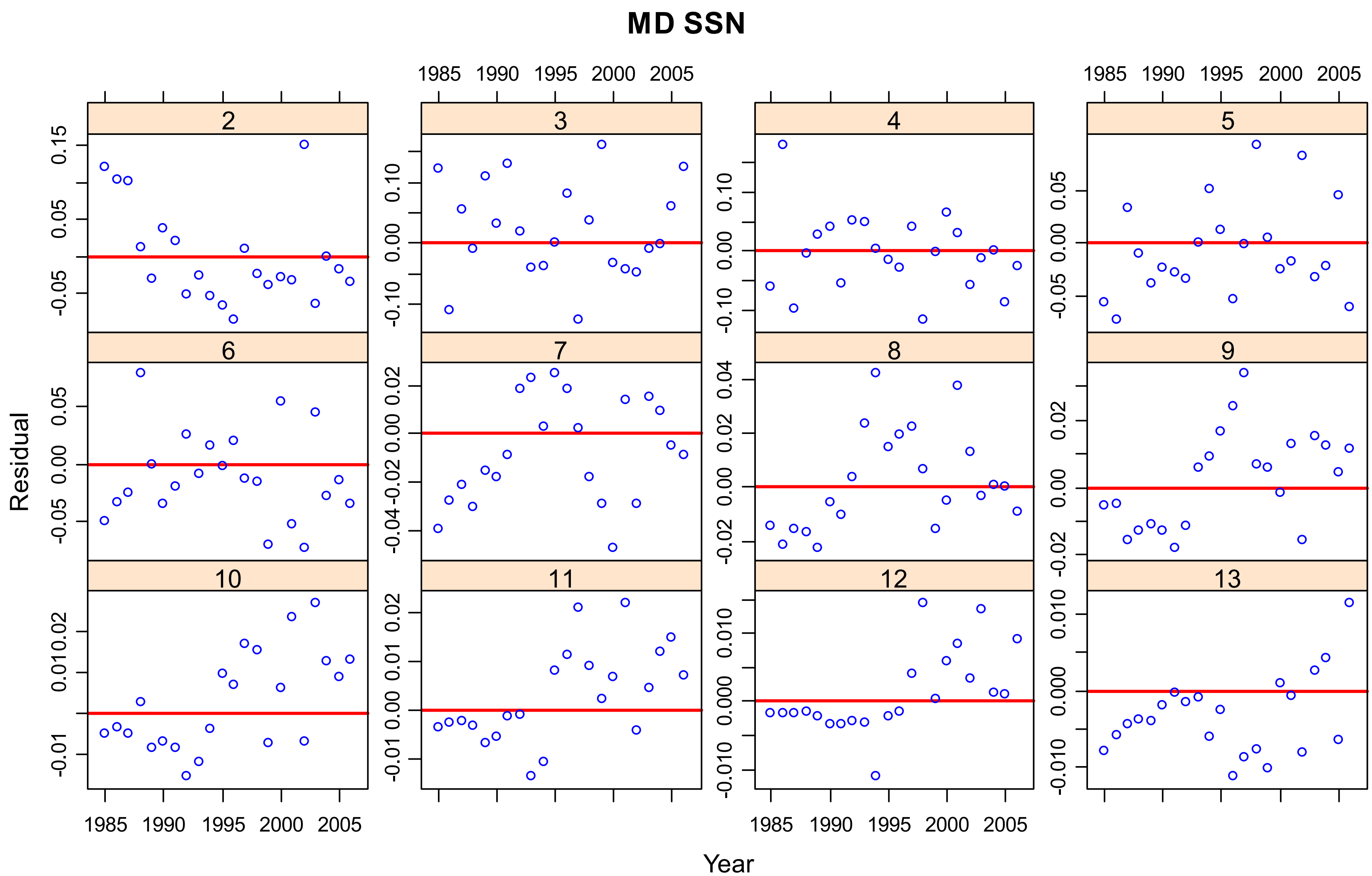



Figure 21. Residuals of proportions-at-age for each age by year for the MD SSN gillnet survey.

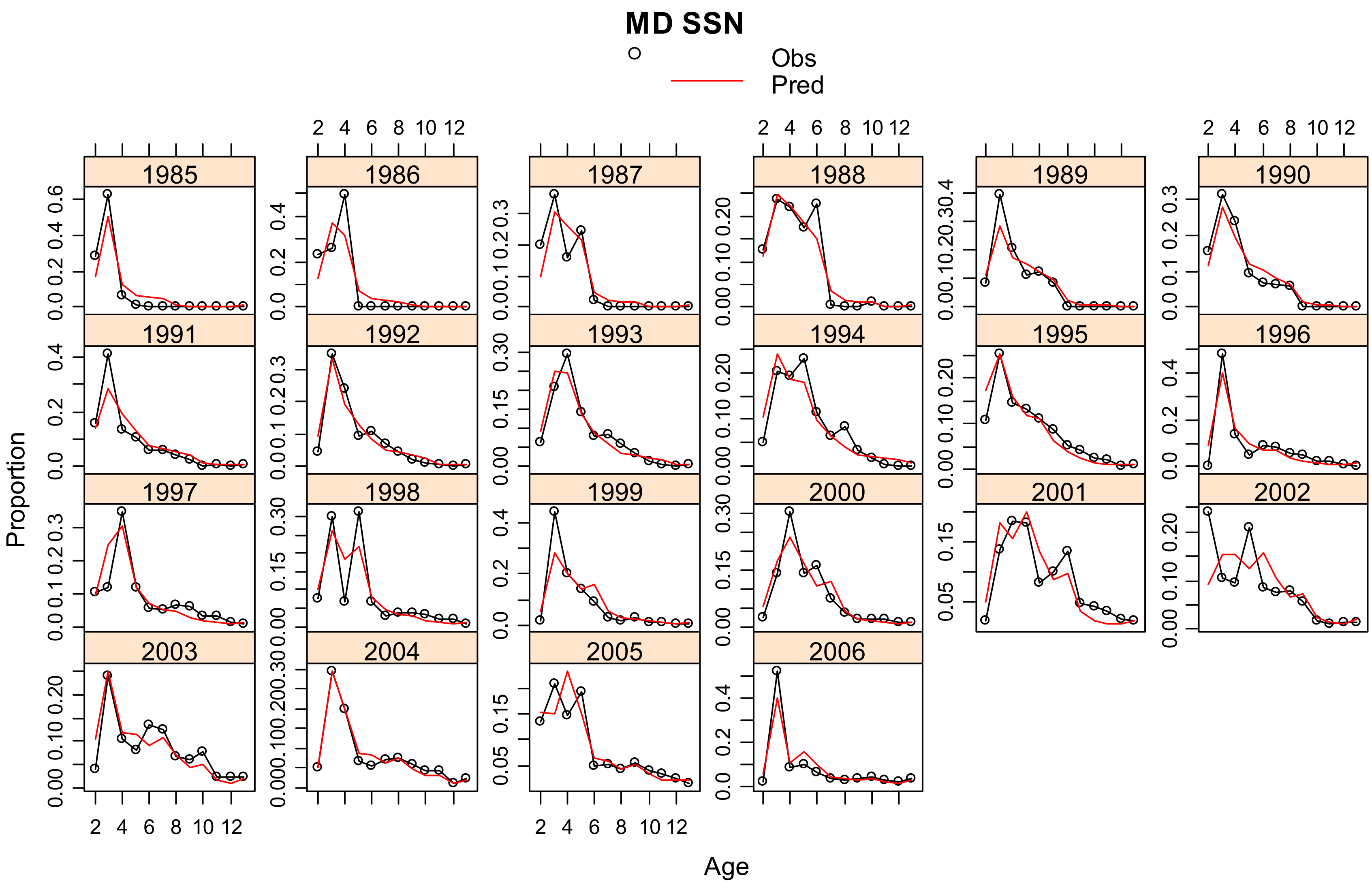



Figure 22. Observed and predicted proportions-at-age for each age by year for the MD SSN gillnet survey.

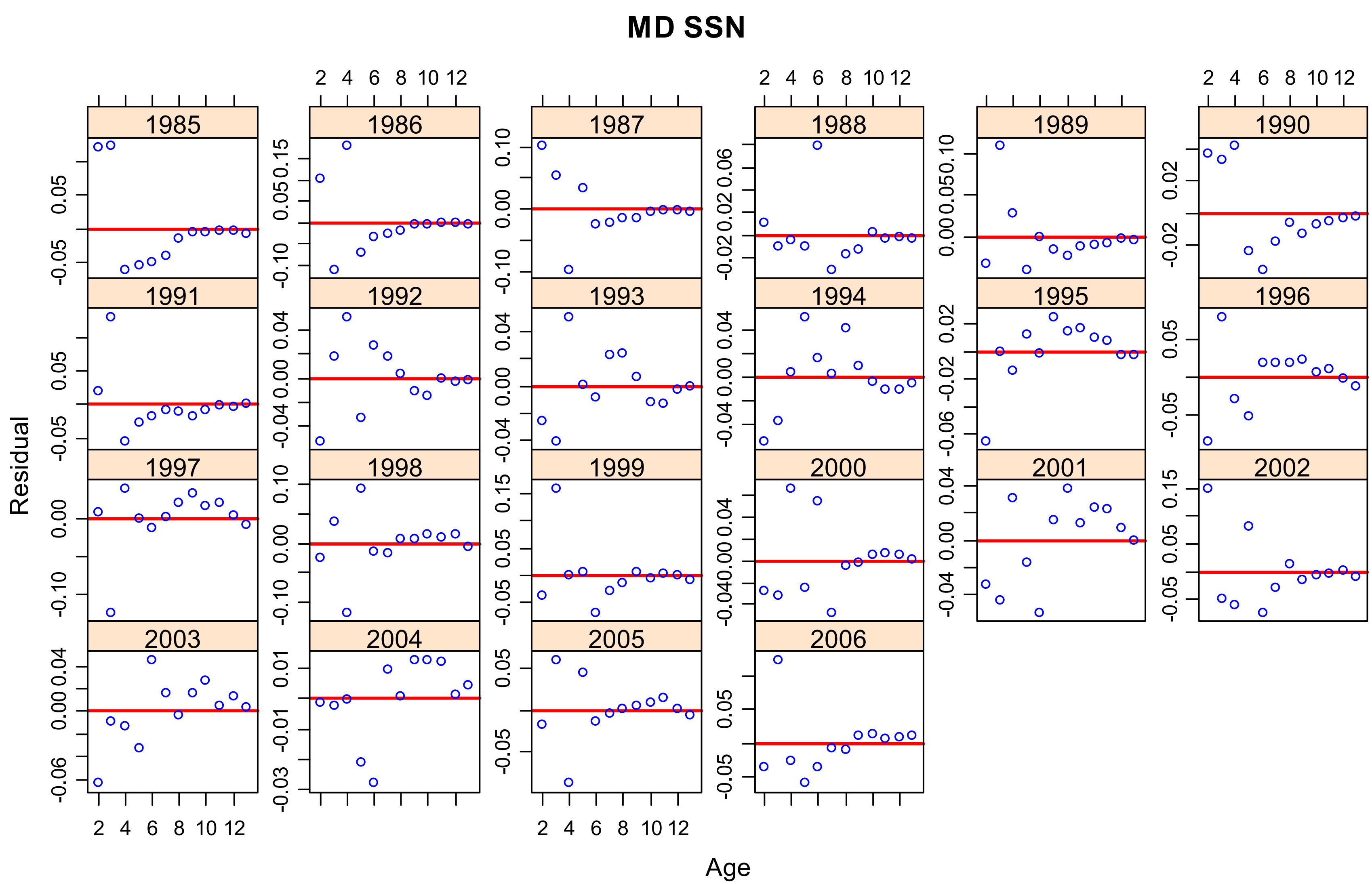



Figure 23. Residuals of proportions-at-age for each age by year for the MD SSN gillnet survey.

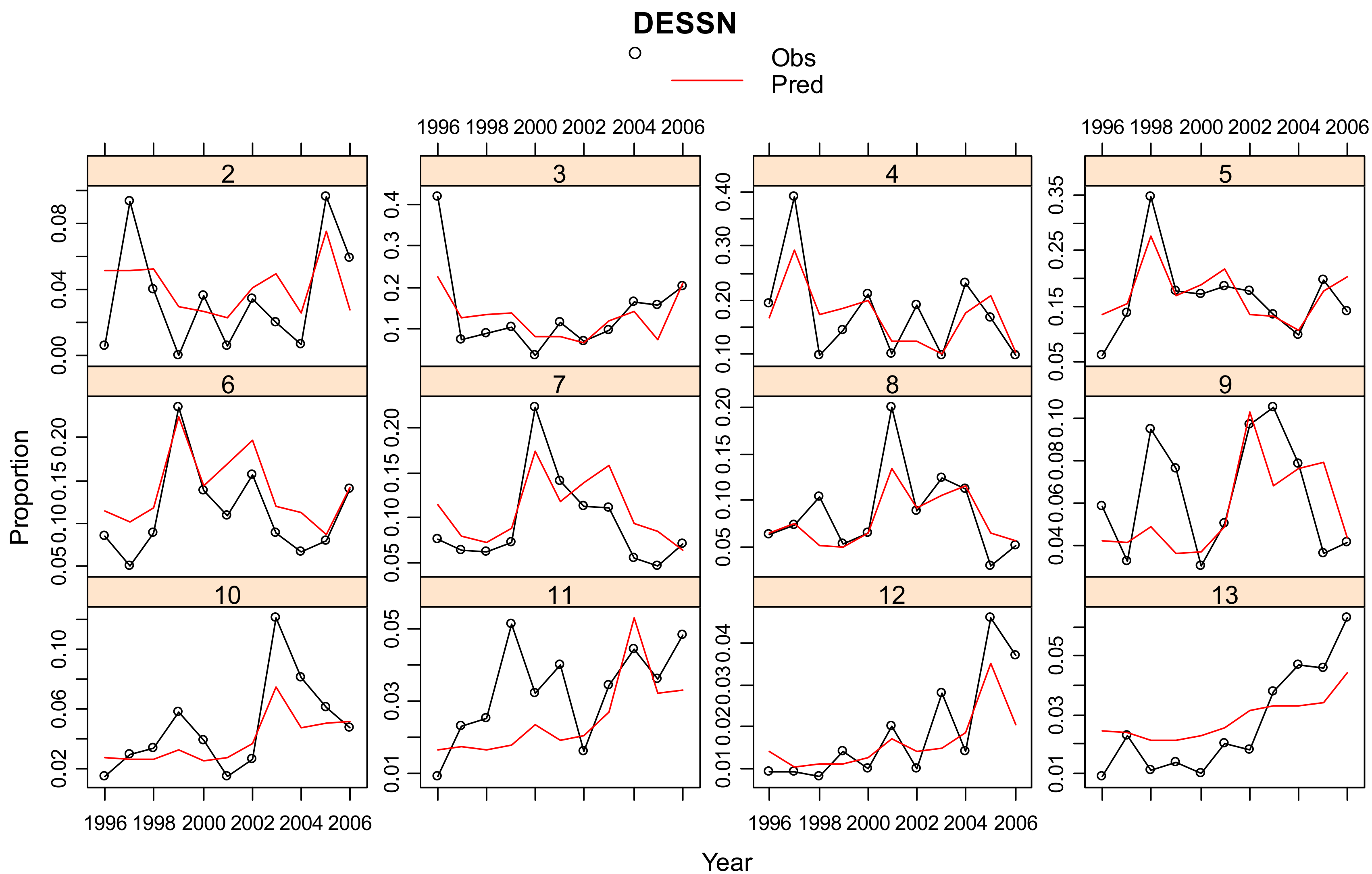



Figure 24. Observed and predicted proportions-at-age for each year by age for the DE SSN electrofishing survey.

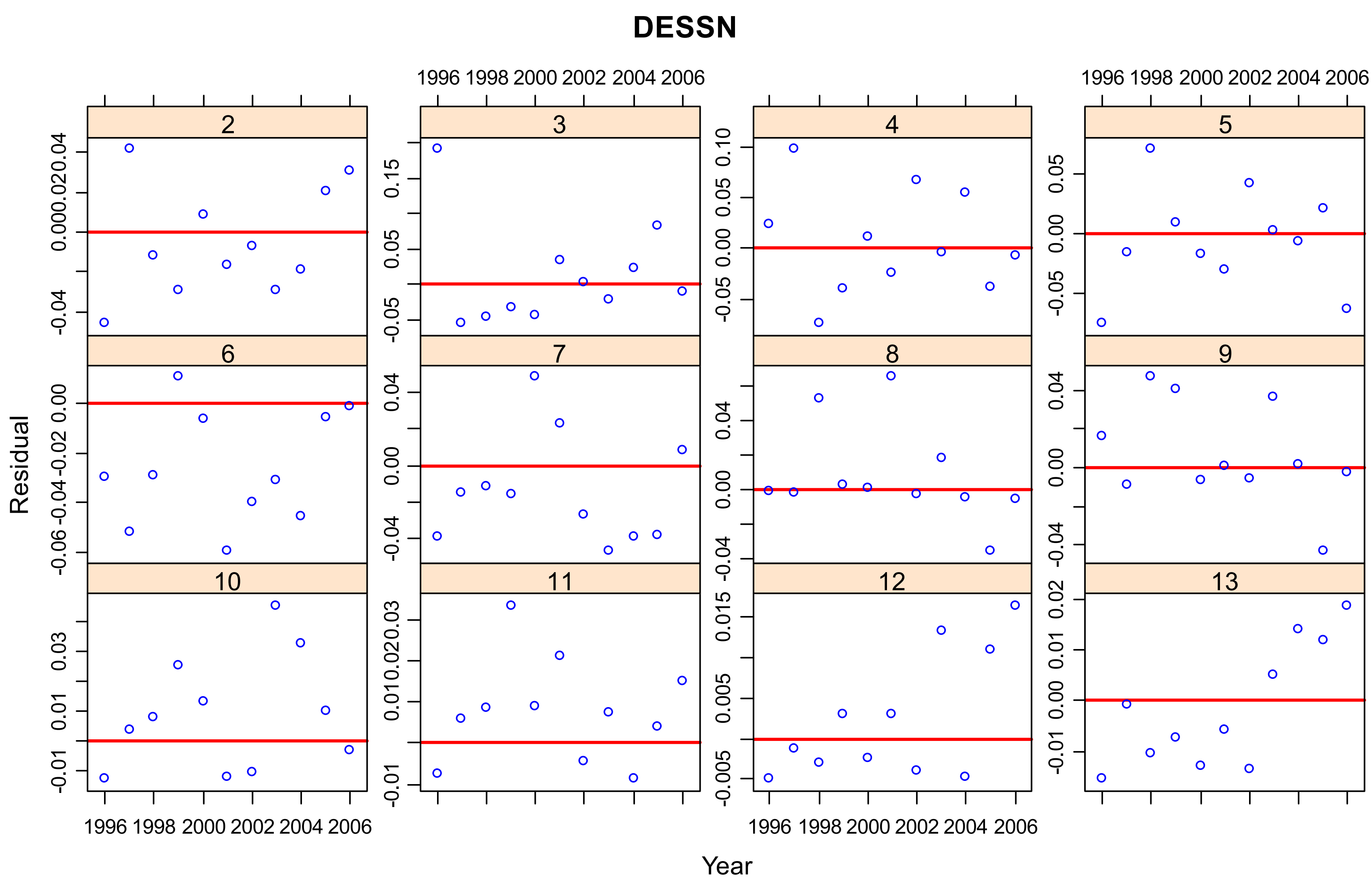



Figure 25. Residuals of proportions-at-age for each year by age for the DE SSN electrofishing survey.

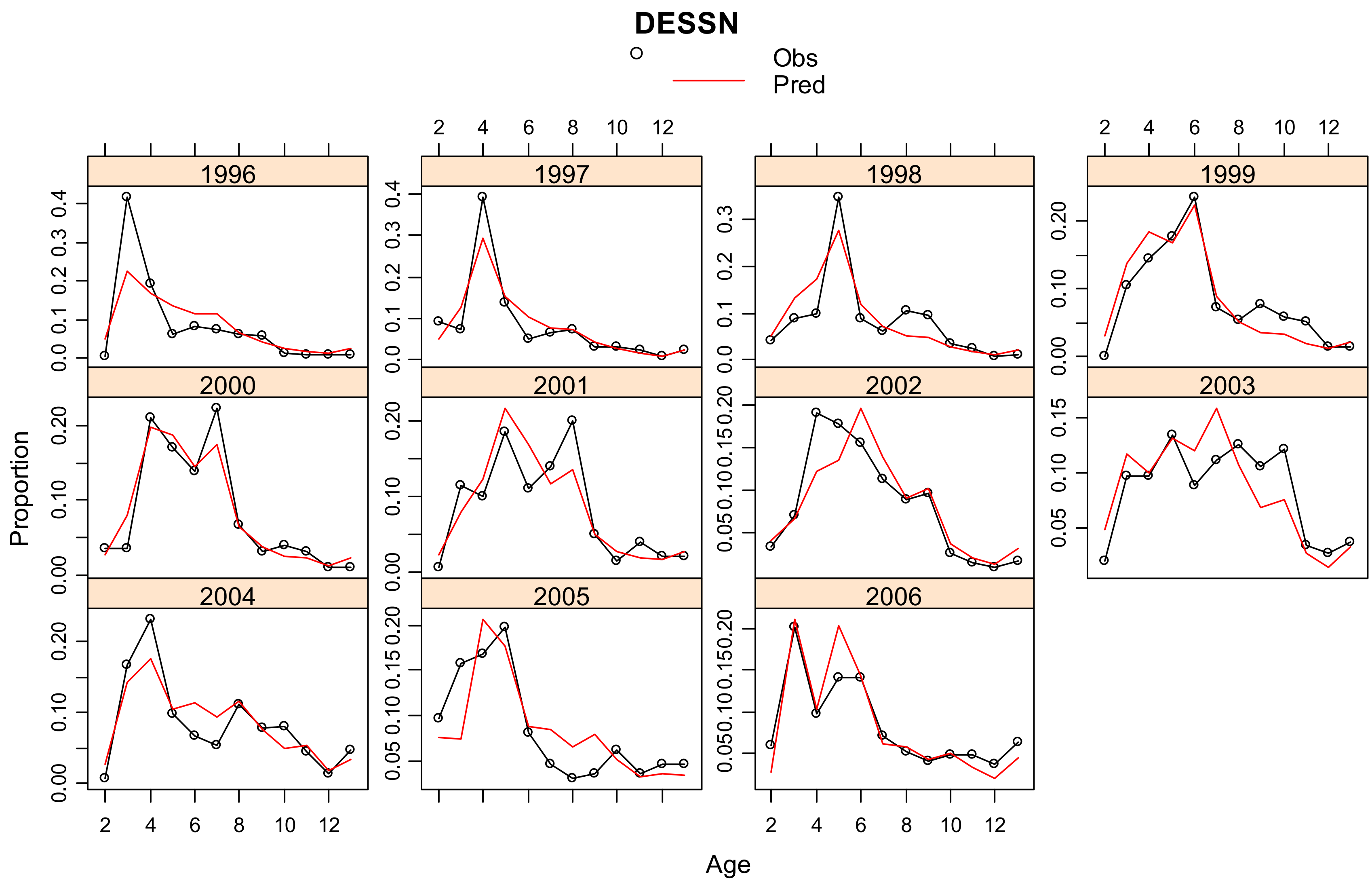



Figure 26. Observed and predicted proportions-at-age for each age by year for the DE SSN electrofishing survey.

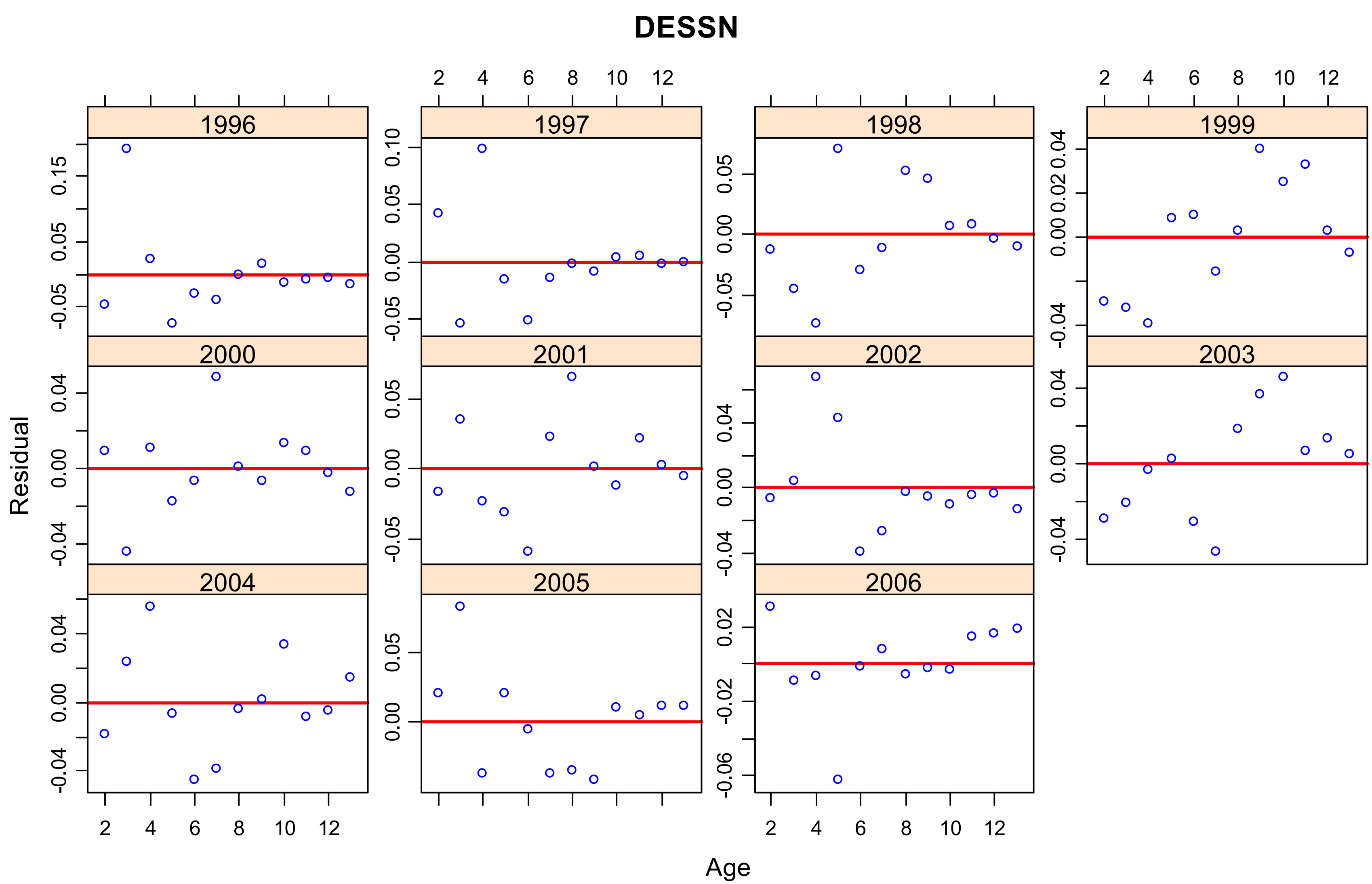



Figure 27. Residuals of proportions-at-age for each year by age for the DE SSN electrofishing survey.

## Appendix A9. ADAPT Virtual Population Analysis

### Catch at Age and Indices

Initial runs of ADAPT for the 2007 assessment used a combination of 62 age-specific and age aggregated fishery independent and fishery dependent indices under TOR 1 and 2. Model results indicated a significant increase in fishing mortality among 9-11 year old fish in the terminal year. The increases, particularly at age 10 from which increased from 0.5 in 2005 to 2.2 in 2006, were unrealistic and further evaluation of the chosen indices was warranted (Figure 1). Residual plots (Figure 2) showed systematic trends in residuals for some survey indices and suggests that the MD spawning stock indices for ages 3 to 9, the New York haul seine index for combined ages 9 to13, the CT trawl index and the DE trawl index should be removed from the updated analysis. Similarly, fishery dependent indices from MA commercial CPUE, MRFSS and CT recreational CPUE were also removed (the MA commercial indices failure to track strong year classes which provided additional justification for exclusion from analysis).

*Model Configuration*

The remaining 34 indices were used in the final run of ADAPT. Indices included the MD SSB index for ages 10-13+, NY Ocean Haul seine ages 3-8, NEFSC aggregated for ages 2-9, young-of-year (age 0) in Maryland, Virginia, New York and New Jersey, age 1 index for Maryland and Long Island, New York, DE spawning stock for ages 2-9, and aggregated for 10-13, and the NJ trawl index for ages 2-8 and aggregated for 9-13. The ADAPT run used the following input options: full F in terminal year was calculated using an averaging method; F at oldest true age for all years, including terminal year was calculated using Heincke's method and ages 8 through 11 were used to calculate the oldest true age. Plus group abundance was calculated using the backward method and the model assumed a flat topped partial recruitment. Natural mortality was fixed at M=0.15. In past assessments, an iterative re-weighting of the survey indices was applied to the model. Generally the result was an improvement in the CVs at age and the overall standard deviation. In the current model configuration, the CVs and standard deviation was better without re-weighting. Consequently the re-weighting is turned off and all indices given equal weighting.

*Partial Recruitment Vector*

A flat top partial recruitment vector was assumed for the ADAPT model. Initial PR values were calculated using the three year geometric mean fishing mortality for each age from the previous ADAPT model scaled to the highest value of F among all ages.

*Bootstrap*

The model was bootstrapped 1000 times to produce a distribution of F, SSB and abundance in the terminal year.

## ADAPT Results

*Tuning Indices*

Plots of observed and predicted indices (Figure 3) and the residuals (Figure 4) for the 34 remaining indices suggested better fit with this model configuration.

*Fishing Mortality*

The 2006 average fishing mortality rate (F) for fully recruited ages 8 through 11 equaled 0.34 and was above the current target (0.30)(Table 1 and 2). This represents a decrease in F on fully recruited ages from that reported for 2003 (reported as F = 0.62 in 2004, SBSASC 2004). This may reflect the shift in model indices and a reduced in the retrospective effect on terminal year F. The 2003 value of F in the current run was 0.19. Fishing mortality in 2006 on ages 3-8, which are generally targeted in producer areas, was F = 0.15 (Table 2). Among the individual age groups, the highest value of F (0.46) was estimated for 9 year old fish (1997 year class) (Table 1). Estimates of age 8-11 F increased from 0.27 in 2005 to 0.34 in 2006 (Table 2). Bootstrap estimates of age 8-11 F, based on 1000 iterations, are presented in Figure 5; the distribution of Fs was characterized by a highly skewed distribution with values to 1.32.

*Population Abundance (January 1)*

Striped bass abundance increased steadily from 1982 through 1997 when it reached a level around 70 million fish (Table 3). Total abundance declined to 60 million fish in 2000, increased to 78 million fish in 2004 and has since declined to 61 million in 2007. The 2001 and 2003 cohort remained strong in 2007 and exceeded the size of the strong 1993 and 1996 year classes. Estimates of abundance obtained this year were higher than those reported in 2004 (SBSAC 2004). Bootstrap estimates for abundance at age are presented in Figure 6; the total abundance estimates followed near- normal distribution.

Abundance of striped bass age 8+ increased steadily from 1982 through 2004 to 5.6 million fish. It has since decreased to a 1 Jan 2007 estimate 6.1 million fish (Table 3).

*Spawning Stock Biomass*

Female spawning stock biomass (SSB) grew steadily from 1982 through 2002 when it peaked at about 36.7 thousand metric tons (Table 4). Female SSB has declined since then and was estimated at 29.8 thousand metric tons in 2006, assuming 1:1 male- female ratio. The estimated SSB remained above the threshold level of 1995. Bootstrap estimates for SSB are presented in Figure 7; the SSB estimates followed a near- normal distribution.

*Retrospective Patterns*

A retrospective analysis was conducted on the VPA results extending back to 2000 in order to determine trends in estimation of F, total abundance, female SSB and recruitment in the terminal year. The analysis revealed that average fishing mortality estimates for ages 8-11 were overestimated in 2000 but improved significantly in subsequent years (Figure 8). The terminal year estimate for 2005 was 0.28 compared to the 2005 estimate in the 2006 model of 0.27. There was limited bias in terminal year estimates of total abundance, recruitment or female SSB (Figure 8) which were all underestimated.

*Sensitivity Runs*

Natural mortality was changed to 1.0, 0.5, and 0.35 for ages 1, 2 and 3 respectively to determine the sensitivity to age specific values. As expected, the increase in M at age increased the estimates of population abundance for the corresponding ages.

*Additional Estimates*

Estimates of total and catch biomass are given in Tables 5 and 6.

*Sources of Uncertainty*

The ADAPT VPA abundance indices used this year's analysis were improved through a reasoned and objective evaluation process described in ASMFC 2004. The review reduced the number of indices and the number of indices at age, especially for fish age eight and older. This year's ADAPT VPA analysis was highly sensitive to the selection of indices, especially to those for the older ages. As the striped bass population abundance increased beginning in 1982, the indices produced a strong signal of trend. However, as abundance peaked and fluctuated around the recent level, the trends are less evident in the indices, as used by this model. There is clearly a need to develop additional fishery independent indices of abundance for older fish in the fished subset of the population.

*ADAPT Summary*

The striped bass population remains at high level of abundance due, in part, to strong incoming cohorts. The fully exploited population abundance (age 8+) has decreased since 2004, but remains above the abundance in 2000. Average fishing mortality for fully recruited ages (8-11) in 2006 was estimated at 0.35. The F estimate for 2003 was 0.19 which is much lower than the F for the same year (0.62) estimated in the 2004 assessment (SBSASC 2004). However, this difference is due primarily to the selection of tuning indices and the presence of a retrospective problem in the previous model. The 2006 fully recruited fishing mortality estimate is above the target of 0.3. However, the bootstrap distribution of F and suggests that the mean is not the appropriate metric and true F is likely less than 0.3. Spawning stock biomass has decreased from levels in 2002 but remains well above the 1995 threshold level.

## Appendix A9 Tables

Table 1. Fishing mortality estimates from ADAPT model using reduced suite of indices.

| | Fishing | Mortality | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGE | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.12 | 0.09 | 0.24 | 0.04 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 3 | 0.38 | 0.29 | 0.37 | 0.06 | 0.04 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 |
| 4 | 0.37 | 0.52 | 0.20 | 0.07 | 0.10 | 0.04 | 0.03 | 0.04 | 0.08 | 0.07 | 0.06 | 0.07 |
| 5 | 0.28 | 0.44 | 0.29 | 0.20 | 0.11 | 0.06 | 0.10 | 0.06 | 0.14 | 0.09 | 0.07 | 0.11 |
| 6 | 0.19 | 0.28 | 0.25 | 0.32 | 0.15 | 0.07 | 0.12 | 0.12 | 0.12 | 0.11 | 0.08 | 0.10 |
| 7 | 0.33 | 0.26 | 0.20 | 0.33 | 0.23 | 0.08 | 0.16 | 0.07 | 0.17 | 0.09 | 0.08 | 0.08 |
| 8 | 0.59 | 0.08 | 0.09 | 0.27 | 0.29 | 0.10 | 0.20 | 0.11 | 0.13 | 0.19 | 0.08 | 0.12 |
| 9 | 0.67 | 0.17 | 0.05 | 0.16 | 0.21 | 0.11 | 0.31 | 0.12 | 0.14 | 0.15 | 0.19 | 0.13 |
| 10 | 0.71 | 0.43 | 0.18 | 0.10 | 0.19 | 0.10 | 0.13 | 0.12 | 0.11 | 0.22 | 0.16 | 0.38 |
| 11 | 0.20 | 0.73 | 0.13 | 0.11 | 0.13 | 0.07 | 0.15 | 0.09 | 0.23 | 0.29 | 0.12 | 0.20 |
| 12 | 0.64 | 0.14 | 0.08 | 0.20 | 0.25 | 0.10 | 0.21 | 0.11 | 0.13 | 0.18 | 0.12 | 0.16 |
| 13 | 0.64 | 0.14 | 0.08 | 0.20 | 0.25 | 0.10 | 0.21 | 0.11 | 0.13 | 0.18 | 0.12 | 0.16 |
| 8 - 11 F | 0.54 | 0.35 | 0.11 | 0.16 | 0.21 | 0.09 | 0.20 | 0.11 | 0.15 | 0.21 | 0.14 | 0.21 |
| 3 - 8 F | 0.35 | 0.31 | 0.23 | 0.21 | 0.15 | 0.06 | 0.10 | 0.07 | 0.11 | 0.10 | 0.07 | 0.08 |

| 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.01 | 0.03 | 0.01 | 0.02 | 0.01 | 0.01 | 0.04 | 0.02 | 0.02 | 0.01 | 0.03 | 0.02 | 0.03 |
| 0.05 | 0.06 | 0.06 | 0.06 | 0.04 | 0.04 | 0.06 | 0.06 | 0.04 | 0.05 | 0.05 | 0.08 | 0.07 |
| 0.06 | 0.09 | 0.10 | 0.11 | 0.08 | 0.07 | 0.11 | 0.12 | 0.04 | 0.13 | 0.09 | 0.09 | 0.15 |
| 0.10 | 0.10 | 0.14 | 0.14 | 0.17 | 0.10 | 0.14 | 0.12 | 0.11 | 0.15 | 0.15 | 0.16 | 0.12 |
| 0.12 | 0.17 | 0.15 | 0.23 | 0.14 | 0.15 | 0.15 | 0.13 | 0.12 | 0.21 | 0.16 | 0.21 | 0.16 |
| 0.09 | 0.15 | 0.22 | 0.20 | 0.14 | 0.13 | 0.21 | 0.15 | 0.16 | 0.18 | 0.26 | 0.17 | 0.21 |
| 0.10 | 0.17 | 0.20 | 0.31 | 0.16 | 0.16 | 0.15 | 0.19 | 0.18 | 0.16 | 0.23 | 0.29 | 0.20 |
| 0.24 | 0.24 | 0.17 | 0.32 | 0.25 | 0.18 | 0.14 | 0.13 | 0.19 | 0.19 | 0.21 | 0.26 | 0.46 |
| 0.17 | 0.34 | 0.15 | 0.25 | 0.25 | 0.26 | 0.17 | 0.14 | 0.23 | 0.23 | 0.25 | 0.22 | 0.40 |
| 0.30 | 0.15 | 0.25 | 0.22 | 0.25 | 0.36 | 0.15 | 0.17 | 0.18 | 0.16 | 0.34 | 0.31 | 0.30 |
| 0.15 | 0.22 | 0.18 | 0.30 | 0.20 | 0.18 | 0.15 | 0.17 | 0.20 | 0.18 | 0.23 | 0.25 | 0.32 |
| 0.15 | 0.22 | 0.18 | 0.30 | 0.20 | 0.18 | 0.15 | 0.17 | 0.20 | 0.18 | 0.23 | 0.25 | 0.32 |
| 0.20 | 0.23 | 0.19 | 0.27 | 0.23 | 0.24 | 0.15 | 0.16 | 0.20 | 0.19 | 0.26 | 0.27 | 0.34 |
| 0.09 | 0.12 | 0.14 | 0.17 | 0.12 | 0.11 | 0.14 | 0.13 | 0.11 | 0.15 | 0.16 | 0.17 | 0.15 |

Table 2. Average fishing mortality for ages 8-11 estimated in ADAPT model.

| Year | 8-11 Average F | F wt'd by N | 3 - 8 average F |
|---|---|---|---|
| 1982 | 0.54 | 0.45 | 0.35 |
| 1983 | 0.35 | 0.20 | 0.31 |
| 1984 | 0.11 | 0.09 | 0.23 |
| 1985 | 0.16 | 0.20 | 0.21 |
| 1986 | 0.21 | 0.23 | 0.15 |
| 1987 | 0.09 | 0.10 | 0.06 |
| 1988 | 0.20 | 0.20 | 0.10 |
| 1989 | 0.11 | 0.11 | 0.07 |
| 1990 | 0.15 | 0.13 | 0.11 |
| 1991 | 0.21 | 0.19 | 0.10 |
| 1992 | 0.14 | 0.12 | 0.07 |
| 1993 | 0.21 | 0.17 | 0.08 |
| 1994 | 0.20 | 0.16 | 0.09 |
| 1995 | 0.23 | 0.21 | 0.12 |
| 1996 | 0.19 | 0.18 | 0.14 |
| 1997 | 0.27 | 0.29 | 0.17 |
| 1998 | 0.23 | 0.21 | 0.12 |
| 1999 | 0.24 | 0.20 | 0.11 |
| 2000 | 0.15 | 0.15 | 0.14 |
| 2001 | 0.16 | 0.17 | 0.13 |
| 2002 | 0.20 | 0.19 | 0.11 |
| 2003 | 0.19 | 0.18 | 0.15 |
| 2004 | 0.26 | 0.24 | 0.16 |
| 2005 | 0.27 | 0.26 | 0.17 |
| 2006 | 0.34 | 0.32 | 0.15 |

Table 3. Population abundance estimate (000s) from ADAPT model using reduced suite of indices.

1-Jan Population Numbers

| AGE | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1547 | 3222 | 2432 | 3690 | 2816 | 4085 | 5476 | 5828 | 8703 | 9254 | 9690 | 12287 |
| 2 | 1003 | 1329 | 2770 | 2088 | 3175 | 2413 | 3515 | 4711 | 5015 | 7489 | 7964 | 8338 |
| 3 | 867 | 766 | 1042 | 1883 | 1730 | 2713 | 2067 | 2997 | 4021 | 4274 | 6378 | 6812 |
| 4 | 760 | 510 | 494 | 618 | 1526 | 1430 | 2300 | 1740 | 2505 | 3346 | 3544 | 5305 |
| 5 | 261 | 451 | 261 | 349 | 494 | 1190 | 1183 | 1921 | 1435 | 1983 | 2686 | 2875 |
| 6 | 122 | 170 | 250 | 169 | 246 | 379 | 962 | 919 | 1557 | 1075 | 1556 | 2148 |
| 7 | 93 | 87 | 110 | 167 | 105 | 183 | 303 | 738 | 703 | 1187 | 831 | 1238 |
| 8 | 41 | 58 | 58 | 78 | 104 | 72 | 145 | 223 | 592 | 509 | 937 | 657 |
| 9 | 26 | 19 | 46 | 45 | 51 | 67 | 56 | 102 | 173 | 447 | 361 | 744 |
| 10 | 22 | 11 | 14 | 38 | 33 | 36 | 52 | 35 | 78 | 130 | 330 | 257 |
| 11 | 66 | 10 | 6 | 10 | 29 | 24 | 28 | 39 | 27 | 61 | 89 | 243 |
| 12 | 31 | 46 | 4 | 5 | 8 | 22 | 19 | 20 | 31 | 18 | 39 | 68 |
| 13 | 36 | 112 | 147 | 61 | 49 | 142 | 55 | 91 | 121 | 146 | 151 | 128 |
| Total | 4873 | 6792 | 7633 | 9200 | 10366 | 12755 | 16160 | 19365 | 24960 | 29917 | 34558 | 41100 |
| 8+ | 222 | 256 | 275 | 237 | 274 | 363 | 355 | 510 | 1022 | 1311 | 1907 | 2097 |

| 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17353 | 16043 | 17701 | 16997 | 10063 | 11310 | 8842 | 14968 | 22700 | 8684 | 24413 | 11195 | 12938 | 6050 |
| 10575 | 14931 | 13805 | 15234 | 14626 | 8637 | 9727 | 7575 | 12854 | 19516 | 7448 | 20947 | 9618 | 11104 |
| 7112 | 8967 | 12449 | 11790 | 12842 | 12419 | 7334 | 8074 | 6375 | 10877 | 16563 | 6246 | 17605 | 8069 |
| 5691 | 5798 | 7282 | 10114 | 9590 | 10603 | 10300 | 5925 | 6549 | 5279 | 8918 | 13510 | 4987 | 14071 |
| 4263 | 4629 | 4568 | 5666 | 7806 | 7600 | 8525 | 7954 | 4546 | 5403 | 3989 | 6981 | 10612 | 3682 |
| 2208 | 3328 | 3609 | 3429 | 4242 | 5678 | 5947 | 6394 | 6075 | 3496 | 3995 | 2954 | 5123 | 8120 |
| 1677 | 1685 | 2412 | 2673 | 2346 | 3179 | 4212 | 4396 | 4855 | 4624 | 2451 | 2930 | 2062 | 3761 |
| 986 | 1318 | 1252 | 1667 | 1877 | 1760 | 2410 | 2937 | 3247 | 3558 | 3326 | 1623 | 2128 | 1442 |
| 504 | 768 | 953 | 884 | 1051 | 1370 | 1293 | 1784 | 2081 | 2332 | 2605 | 2269 | 1048 | 1500 |
| 564 | 341 | 519 | 694 | 554 | 705 | 989 | 964 | 1345 | 1474 | 1661 | 1826 | 1512 | 567 |
| 151 | 410 | 210 | 383 | 468 | 372 | 470 | 720 | 719 | 917 | 1005 | 1117 | 1261 | 875 |
| 171 | 96 | 304 | 141 | 265 | 315 | 224 | 349 | 524 | 517 | 670 | 615 | 704 | 801 |
| 112 | 78 | 125 | 119 | 384 | 318 | 235 | 338 | 674 | 599 | 709 | 679 | 757 | 917 |
| 51365 | 58394 | 65188 | 69791 | 66114 | 64266 | 60509 | 62380 | 72545 | 67275 | 77754 | 72893 | 70355 | 60959 |
| 2488 | 3011 | 3363 | 3888 | 4599 | 4840 | 5621 | 7092 | 8590 | 9397 | 9976 | 8129 | 7410 | 6102 |

Table 4. Female spawning biomass (000s MT) from ADAPT model using a reduced suite of indices.

| | Female Spawning Stock Biomass (000s mt) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AGE** | **1982** | **1983** | **1984** | **1985** | **1986** | **1987** | **1988** | **1989** | **1990** | **1991** | **1992** | **1993** | **1994** |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 17.5 | 11.5 | 11.5 | 19.5 | 46 | 44.5 | 73 | 51.5 | 75 | 99.5 | 106 | 162 | 183.5 |
| 5 | 32.5 | 51 | 30 | 40 | 61 | 179 | 186 | 291 | 200.5 | 281.5 | 407.5 | 406.5 | 622 |
| 6 | 95.5 | 100 | 148 | 108.5 | 136 | 215 | 645.5 | 731 | 1127.5 | 621.5 | 1025.5 | 1445 | 1454.5 |
| 7 | 175 | 135 | 187 | 279.5 | 164.5 | 257.5 | 451.5 | 1441 | 1379.5 | 2139 | 1375.5 | 2184 | 2960.5 |
| 8 | 97 | 130.5 | 118 | 178.5 | 224.5 | 138 | 261.5 | 516.5 | 1479.5 | 1174.5 | 2194 | 1590.5 | 2381 |
| 9 | 61.5 | 53.5 | 130.5 | 131 | 130 | 166.5 | 128.5 | 256 | 483.5 | 1300 | 1056 | 2229.5 | 1508 |
| 10 | 82 | 36.5 | 45 | 125.5 | 99 | 99.5 | 135.5 | 111.5 | 221.5 | 359.5 | 1123 | 878 | 1919 |
| 11 | 337 | 38.5 | 24.5 | 40 | 104 | 76.5 | 97 | 131 | 100 | 210.5 | 328 | 998.5 | 614.5 |
| 12 | 152 | 230 | 20.5 | 21 | 33 | 90 | 79 | 88 | 130.5 | 67.5 | 199 | 327.5 | 809.5 |
| 13 | 223 | 586.5 | 856.5 | 396.5 | 292.5 | 877 | 339.5 | 573.5 | 713 | 970 | 995 | 875 | 668.5 |
| Total | 1,273 | 1,373 | 1,572 | 1,340 | 1,291 | 2,144 | 2,397 | 4,191 | 5,911 | 7,224 | 8,810 | 11,097 | 13,121 |

| **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 210 | 243 | 362 | 250.5 | 263.5 | 246 | 154.5 | 161.5 | 121 | 199 | 276.5 | 101.5 |
| 701.5 | 739.5 | 882.5 | 1117 | 819 | 874 | 870.5 | 543 | 600 | 448.5 | 784 | 1196.5 |
| 2259.5 | 2694 | 2461 | 2579.5 | 2847 | 2895 | 3412.5 | 3401.5 | 1937 | 2202 | 1702.5 | 2968.5 |
| 3051.5 | 4825.5 | 5008 | 4048.5 | 4185 | 5457.5 | 6215.5 | 7466.5 | 6934 | 3680.5 | 4377 | 3068.5 |
| 3197 | 3395 | 4114 | 4172 | 3763 | 4392 | 5694 | 6777.5 | 7310 | 6691.5 | 3264.5 | 4316 |
| 2395 | 3094.5 | 2818 | 2868.5 | 3903.5 | 3628.5 | 4767.5 | 5342 | 6296.5 | 6822.5 | 5897 | 2667 |
| 1218.5 | 1988.5 | 2727.5 | 1769.5 | 2394 | 3219 | 3365.5 | 4335 | 4514.5 | 5081.5 | 5588 | 4546.5 |
| 1452 | 885.5 | 1704.5 | 1831 | 1334.5 | 1923.5 | 2691 | 2826.5 | 3440 | 3549 | 3931.5 | 4441 |
| 437 | 1241.5 | 638 | 1223.5 | 1279 | 1010.5 | 1466 | 2246.5 | 2232 | 2733 | 2454 | 2789 |
| 607.5 | 798 | 815 | 2124.5 | 1782.5 | 1492.5 | 1720 | 3624.5 | 3075.5 | 3531 | 3375.5 | 3739.5 |
| 15,530 | 19,905 | 21,531 | 21,985 | 22,571 | 25,139 | 30,357 | 36,725 | 36,461 | 34,939 | 31,651 | 29,834 |

Table 5. Biomass estimates (Jan. 1 000s MT) from ADAPT model using reduced suite of indices.

1-Jan Biomass (000s mt)

| AGE | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 98 | 372 | 366 | 72 | 168 | 383 | 1038 | 395 | 205 | 1073 | 352 | 222 | 2438 |
| 2 | 530 | 355 | 960 | 799 | 587 | 792 | 1499 | 2389 | 1893 | 2032 | 3032 | 2299 | 2867 |
| 3 | 843 | 594 | 1005 | 1508 | 1523 | 2432 | 1902 | 3158 | 3911 | 4579 | 7002 | 6476 | 8060 |
| 4 | 944 | 623 | 610 | 1035 | 2445 | 2340 | 3844 | 2726 | 3962 | 5262 | 5592 | 8565 | 9684 |
| 5 | 541 | 861 | 499 | 658 | 995 | 2916 | 3035 | 4729 | 3284 | 4594 | 6634 | 6648 | 10151 |
| 6 | 455 | 480 | 708 | 523 | 644 | 1010 | 3050 | 3455 | 5329 | 2933 | 4826 | 6813 | 6874 |
| 7 | 426 | 327 | 450 | 682 | 397 | 613 | 1082 | 3427 | 3314 | 5094 | 3275 | 5197 | 7054 |
| 8 | 230 | 294 | 266 | 410 | 516 | 311 | 597 | 1167 | 3352 | 2676 | 4945 | 3598 | 5376 |
| 9 | 139 | 115 | 276 | 280 | 279 | 354 | 279 | 544 | 1030 | 2774 | 2262 | 4745 | 3246 |
| 10 | 185 | 80 | 96 | 266 | 212 | 211 | 288 | 237 | 470 | 773 | 2398 | 1917 | 4101 |
| 11 | 723 | 87 | 52 | 85 | 222 | 162 | 207 | 278 | 215 | 456 | 697 | 2141 | 1331 |
| 12 | 341 | 491 | 44 | 45 | 71 | 191 | 170 | 187 | 277 | 144 | 424 | 700 | 1727 |
| 13 | 499 | 1249 | 1815 | 850 | 630 | 1862 | 728 | 1218 | 1518 | 2076 | 2116 | 1868 | 1426 |
| Total | 5,954 | 5,928 | 7,146 | 7,213 | 8,688 | 13,578 | 17,719 | 23,911 | 28,762 | 34,466 | 43,554 | 51,189 | 64,335 |

| 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2320 | 1177 | 908 | 2583 | 7445 | 3228 | 1720 | 1219 | 478 | 4687 | 2149 | 2484 | 1162 |
| 6120 | 7485 | 4488 | 4628 | 5117 | 5680 | 2841 | 2863 | 5236 | 1353 | 5771 | 2650 | 2712 |
| 10676 | 12629 | 13124 | 11077 | 11481 | 7297 | 6337 | 4046 | 6056 | 11758 | 3289 | 9269 | 4741 |
| 11129 | 12887 | 19232 | 13260 | 13938 | 13068 | 8221 | 8517 | 6431 | 10551 | 14650 | 5408 | 15723 |
| 11454 | 12122 | 14466 | 18365 | 13369 | 14323 | 14239 | 8879 | 9847 | 7358 | 12877 | 19574 | 6792 |
| 10735 | 12771 | 11759 | 12214 | 13494 | 13728 | 16138 | 16081 | 9234 | 10451 | 8120 | 14085 | 21960 |
| 7312 | 11647 | 12069 | 9692 | 10008 | 13160 | 14903 | 17916 | 16670 | 8922 | 10512 | 7397 | 13560 |
| 7273 | 7742 | 9488 | 9482 | 8546 | 9968 | 12980 | 15428 | 16609 | 15311 | 7511 | 9844 | 6660 |
| 5156 | 6613 | 6112 | 6180 | 8349 | 7735 | 10153 | 11447 | 13485 | 14634 | 12714 | 5871 | 8409 |
| 2648 | 4244 | 5874 | 3812 | 5162 | 6879 | 7175 | 9325 | 9710 | 10946 | 12005 | 9941 | 3733 |
| 3097 | 1907 | 3661 | 3944 | 2906 | 4102 | 5750 | 6048 | 7347 | 7716 | 8523 | 9621 | 6693 |
| 939 | 2656 | 1381 | 2623 | 2737 | 2156 | 3132 | 4814 | 4778 | 5874 | 5290 | 6049 | 6925 |
| 1304 | 1707 | 1765 | 4556 | 3814 | 3185 | 3675 | 7767 | 6584 | 7590 | 7275 | 8111 | 9821 |
| 80,163 | 95,587 | 104,329 | 102,416 | 106,367 | 104,511 | 107,263 | 114,350 | 112,466 | 117,153 | 110,685 | 110,304 | 108,889 |

Table 6. Catch biomass estimates (000s MT) from ADAPT model using reduced suite of indices.

| Catch AGE | Biomass 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | 1 | 1 | - | 2 | - | 1 | - | - | - | - | - | 1 |
| 2 | 68 | 61 | 326 | 44 | 12 | 8 | 28 | 30 | 41 | 67 | 32 | 53 | 153 |
| 3 | 280 | 168 | 512 | 109 | 81 | 53 | 46 | 97 | 142 | 187 | 262 | 243 | 589 |
| 4 | 340 | 265 | 133 | 67 | 319 | 108 | 125 | 152 | 385 | 453 | 365 | 651 | 642 |
| 5 | 141 | 356 | 161 | 129 | 122 | 168 | 334 | 321 | 407 | 424 | 498 | 799 | 1,048 |
| 6 | 72 | 129 | 175 | 155 | 100 | 73 | 394 | 432 | 633 | 321 | 402 | 664 | 813 |
| 7 | 117 | 70 | 93 | 214 | 81 | 48 | 178 | 245 | 511 | 439 | 306 | 416 | 669 |
| 8 | 97 | 22 | 27 | 94 | 121 | 31 | 115 | 131 | 405 | 468 | 393 | 411 | 538 |
| 9 | 73 | 17 | 14 | 43 | 50 | 35 | 73 | 63 | 118 | 380 | 406 | 581 | 679 |
| 10 | 92 | 30 | 16 | 25 | 32 | 19 | 33 | 33 | 44 | 150 | 365 | 610 | 610 |
| 11 | 119 | 44 | 6 | 9 | 26 | 12 | 32 | 29 | 38 | 134 | 91 | 392 | 350 |
| 12 | 153 | 58 | 4 | 9 | 15 | 20 | 34 | 19 | 32 | 23 | 51 | 100 | 238 |
| 13 | 221 | 151 | 137 | 143 | 129 | 170 | 127 | 119 | 173 | 317 | 222 | 255 | 186 |
| Total | 1,773 | 1,371 | 1,606 | 1,041 | 1,089 | 745 | 1,520 | 1,671 | 2,928 | 3,365 | 3,392 | 5,174 | 6,518 |

| 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | - | 10 | 5 | 14 | 5 | 3 | 3 | 16 | 2 | 4 |
| 303 | 104 | 181 | 141 | 97 | 177 | 59 | 62 | 152 | 59 | 215 | 79 |
| 636 | 955 | 710 | 582 | 466 | 459 | 484 | 238 | 480 | 677 | 420 | 771 |
| 994 | 1,508 | 2,389 | 1,145 | 934 | 1,428 | 1,047 | 381 | 839 | 1,050 | 1,636 | 766 |
| 1,123 | 1,754 | 1,926 | 2,531 | 1,227 | 1,999 | 1,841 | 981 | 1,558 | 1,260 | 2,001 | 2,049 |
| 1,788 | 2,119 | 2,387 | 1,507 | 1,833 | 2,181 | 2,277 | 2,073 | 1,932 | 1,712 | 1,596 | 1,894 |
| 1,154 | 2,826 | 2,068 | 1,315 | 1,182 | 2,894 | 2,388 | 2,811 | 2,900 | 2,179 | 1,656 | 1,454 |
| 1,207 | 1,490 | 2,108 | 1,500 | 1,202 | 1,597 | 2,430 | 2,739 | 2,573 | 3,317 | 2,043 | 1,738 |
| 1,118 | 1,068 | 1,504 | 1,470 | 1,347 | 1,147 | 1,313 | 2,068 | 2,286 | 2,731 | 2,927 | 2,240 |
| 803 | 634 | 1,289 | 800 | 1,165 | 1,047 | 936 | 1,971 | 2,048 | 2,410 | 2,237 | 3,225 |
| 404 | 396 | 696 | 738 | 908 | 580 | 894 | 1,000 | 1,088 | 2,215 | 2,197 | 2,490 |
| 170 | 468 | 348 | 446 | 474 | 315 | 413 | 845 | 761 | 1,140 | 1,141 | 1,590 |
| 237 | 260 | 424 | 777 | 589 | 419 | 524 | 1,284 | 1,032 | 1,430 | 1,521 | 2,117 |
| 9,939 | 13,581 | 16,031 | 12,964 | 11,430 | 14,255 | 14,612 | 16,457 | 17,653 | 20,195 | 19,591 | 20,417 |

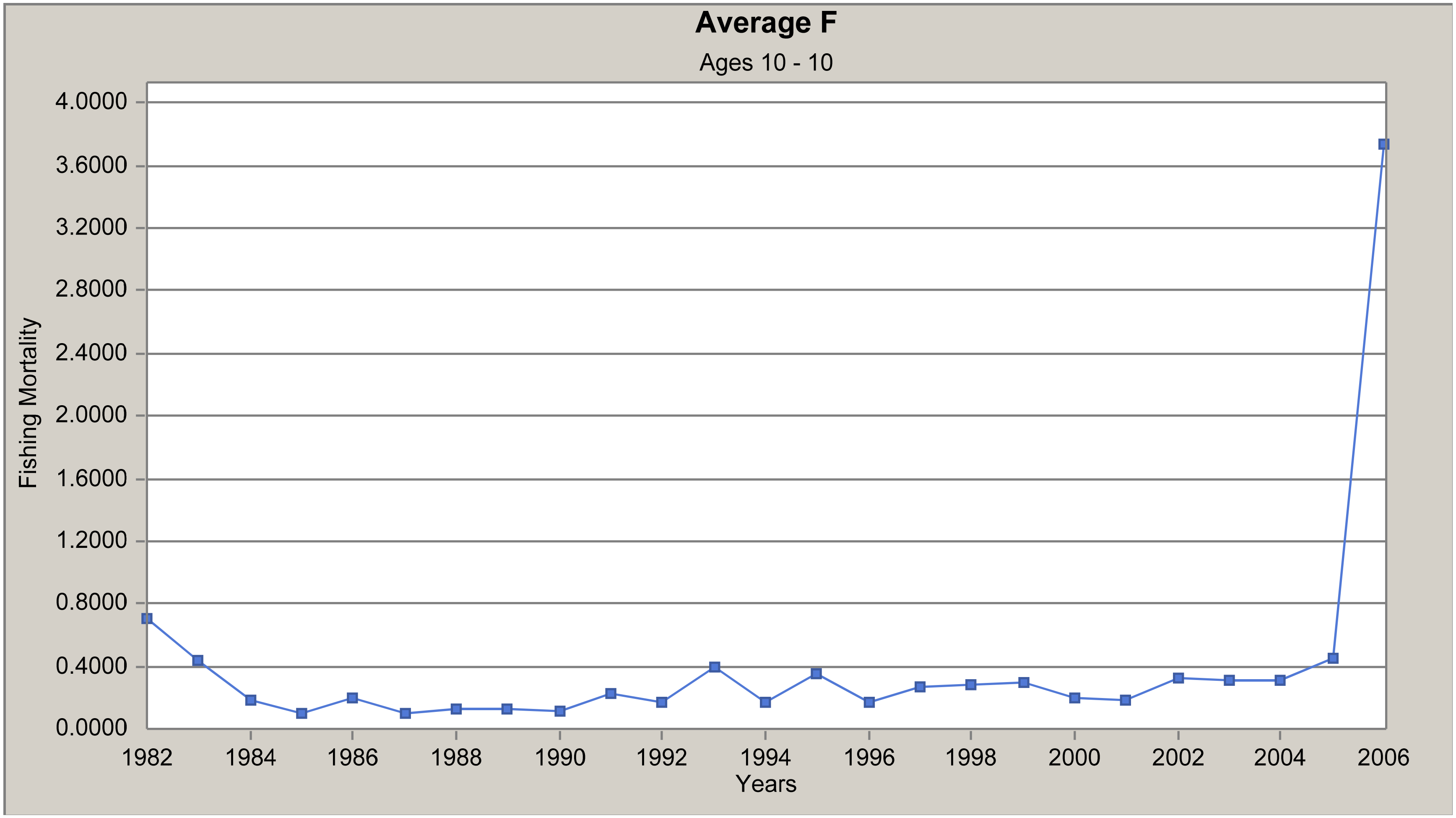



Figure 1. Age 10 fishing mortality from full ADAPT model with index selection comparable to previous assessment.

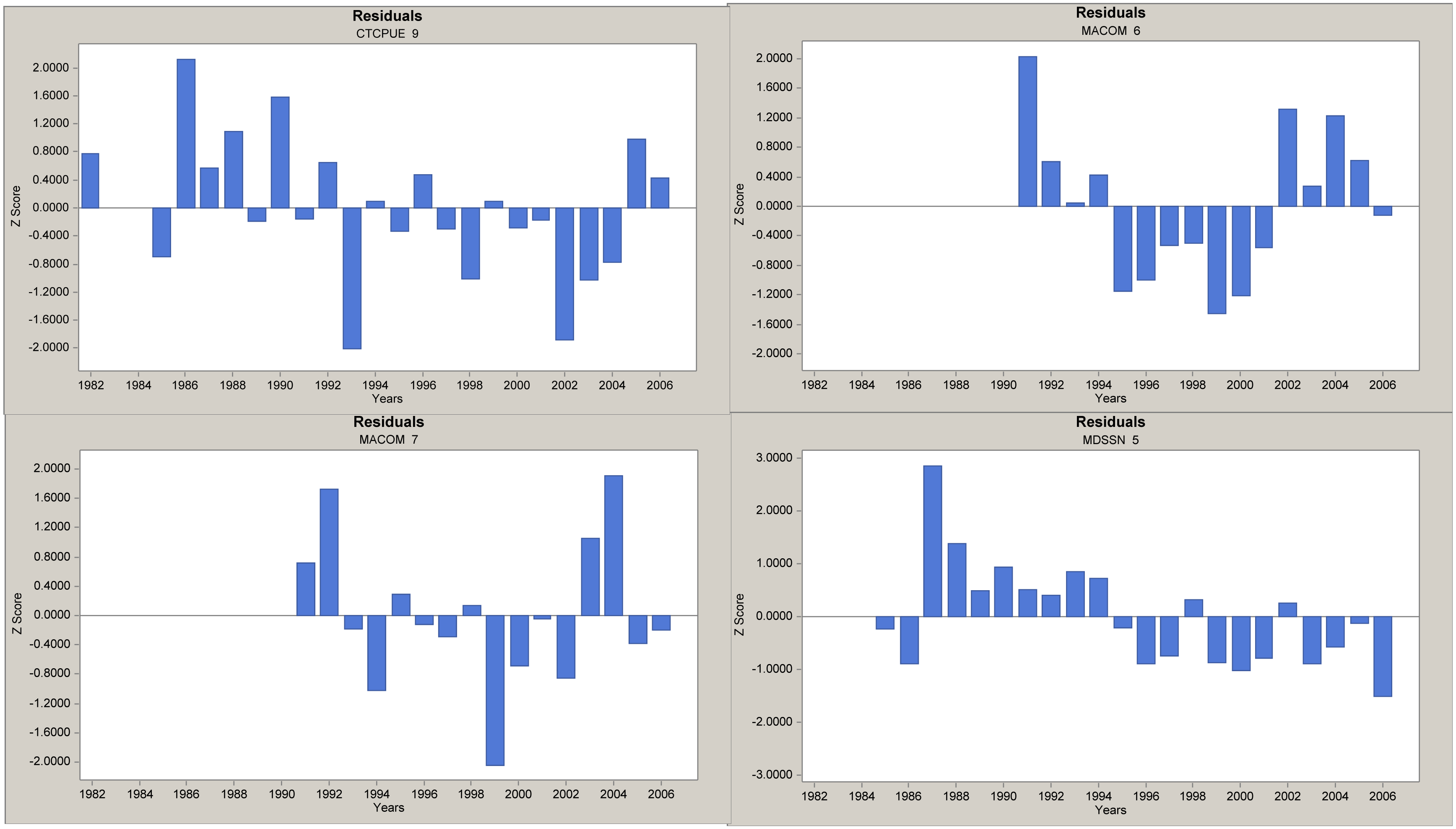



Figure 2. Residual plots from ADAPT model using index selection from previous assessment.

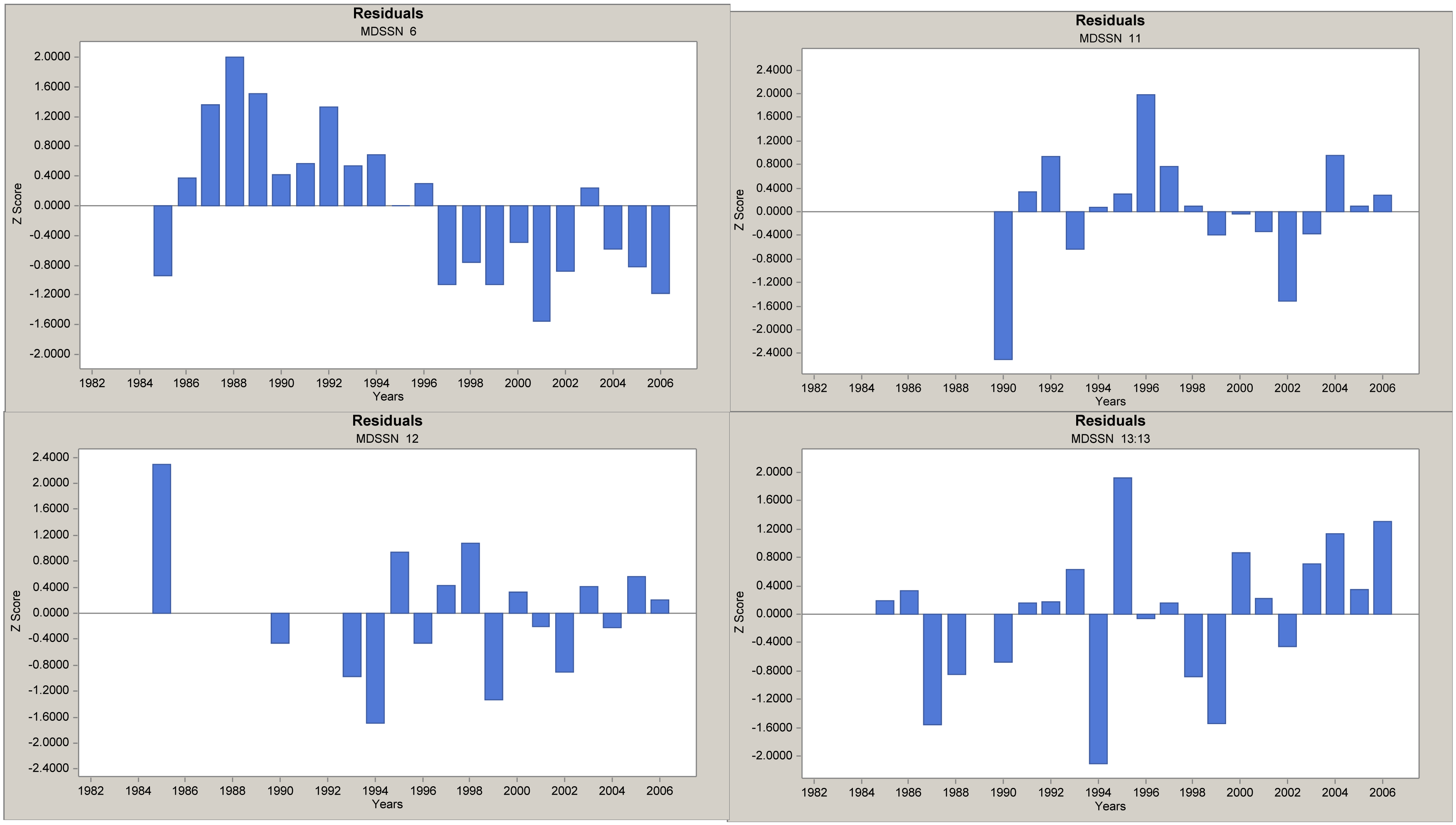



Figure 2 continued.

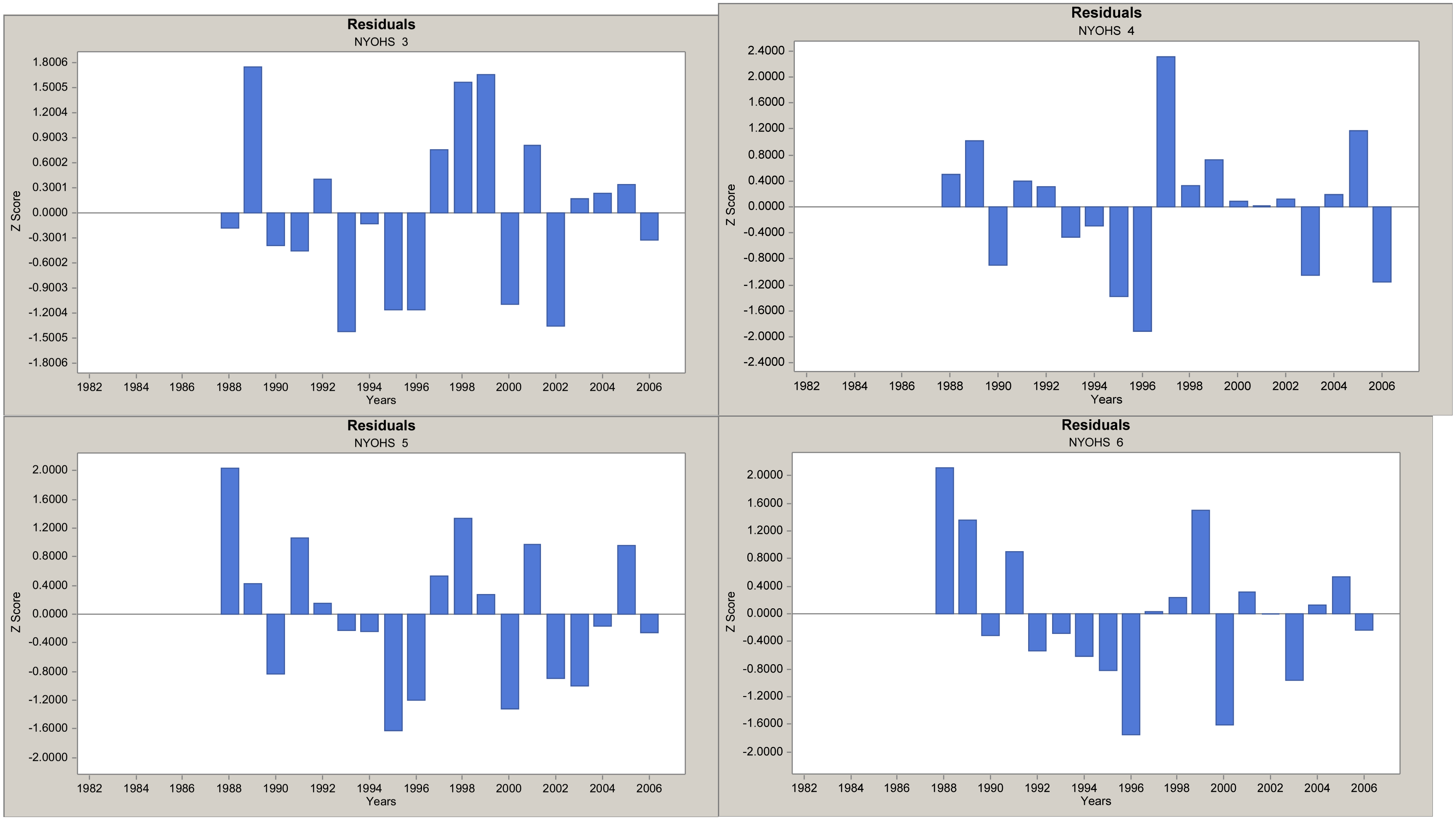



Figure 2 continued.

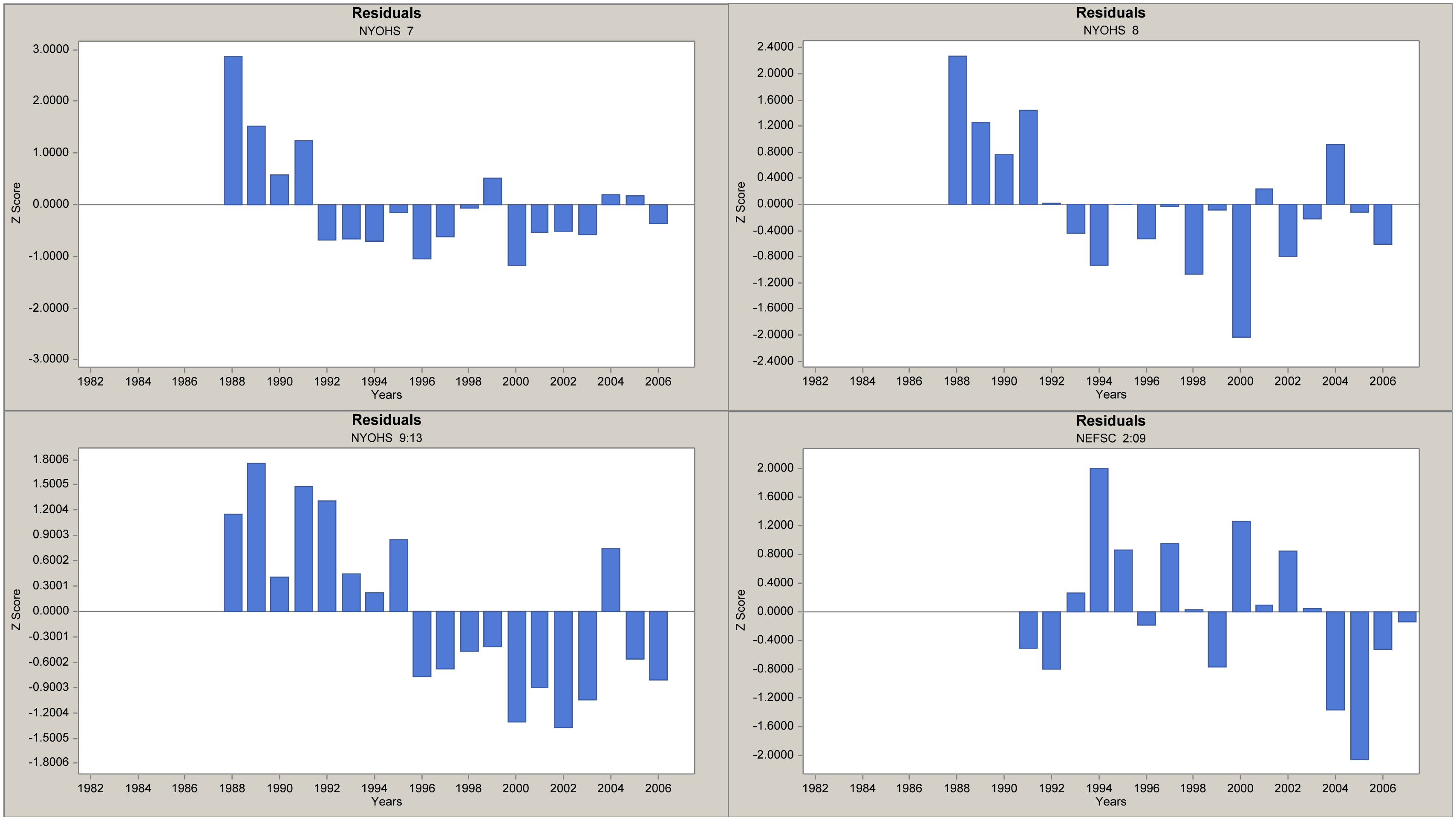



Figure 2 continued.

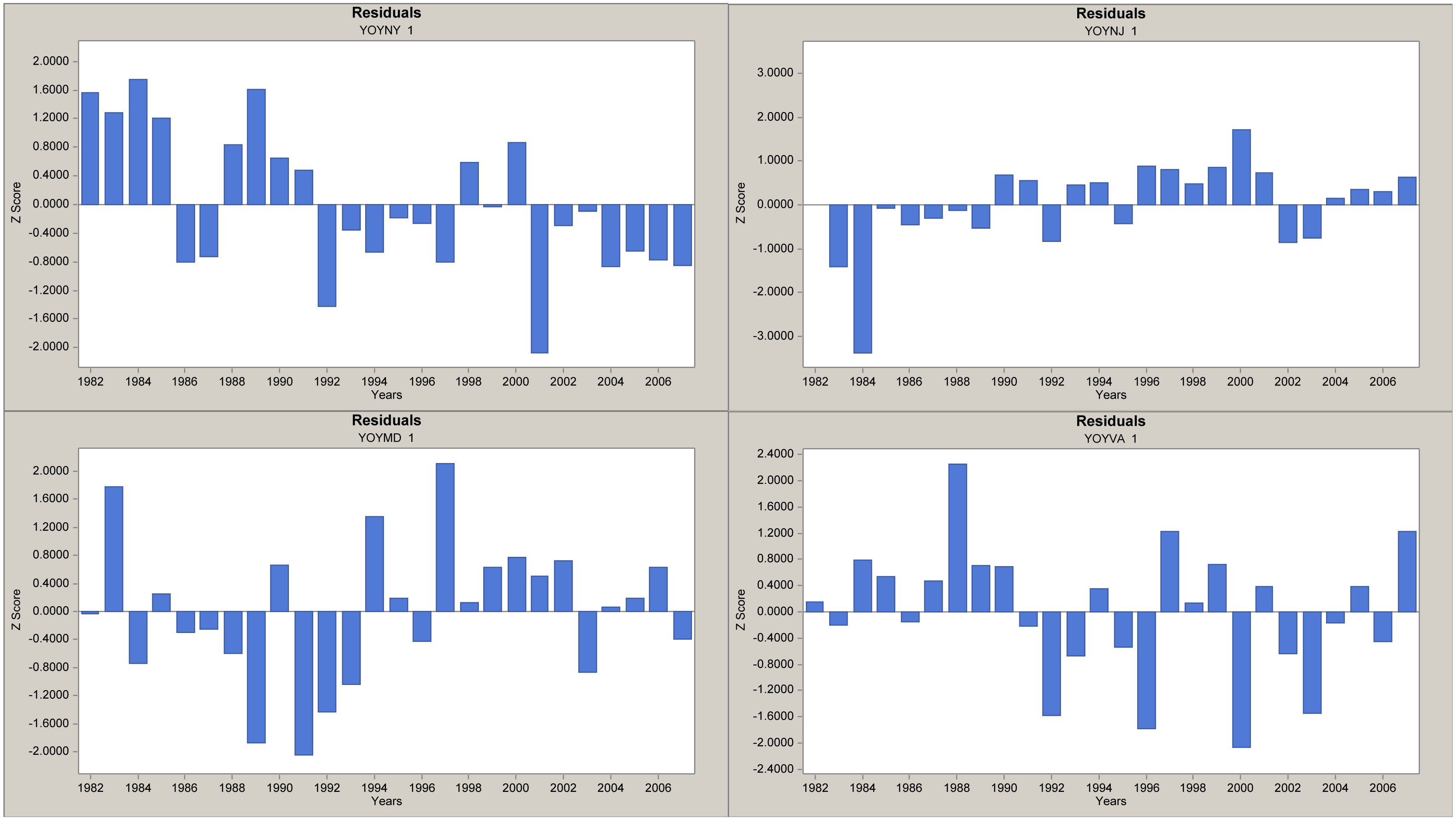



Figure 2 continued.

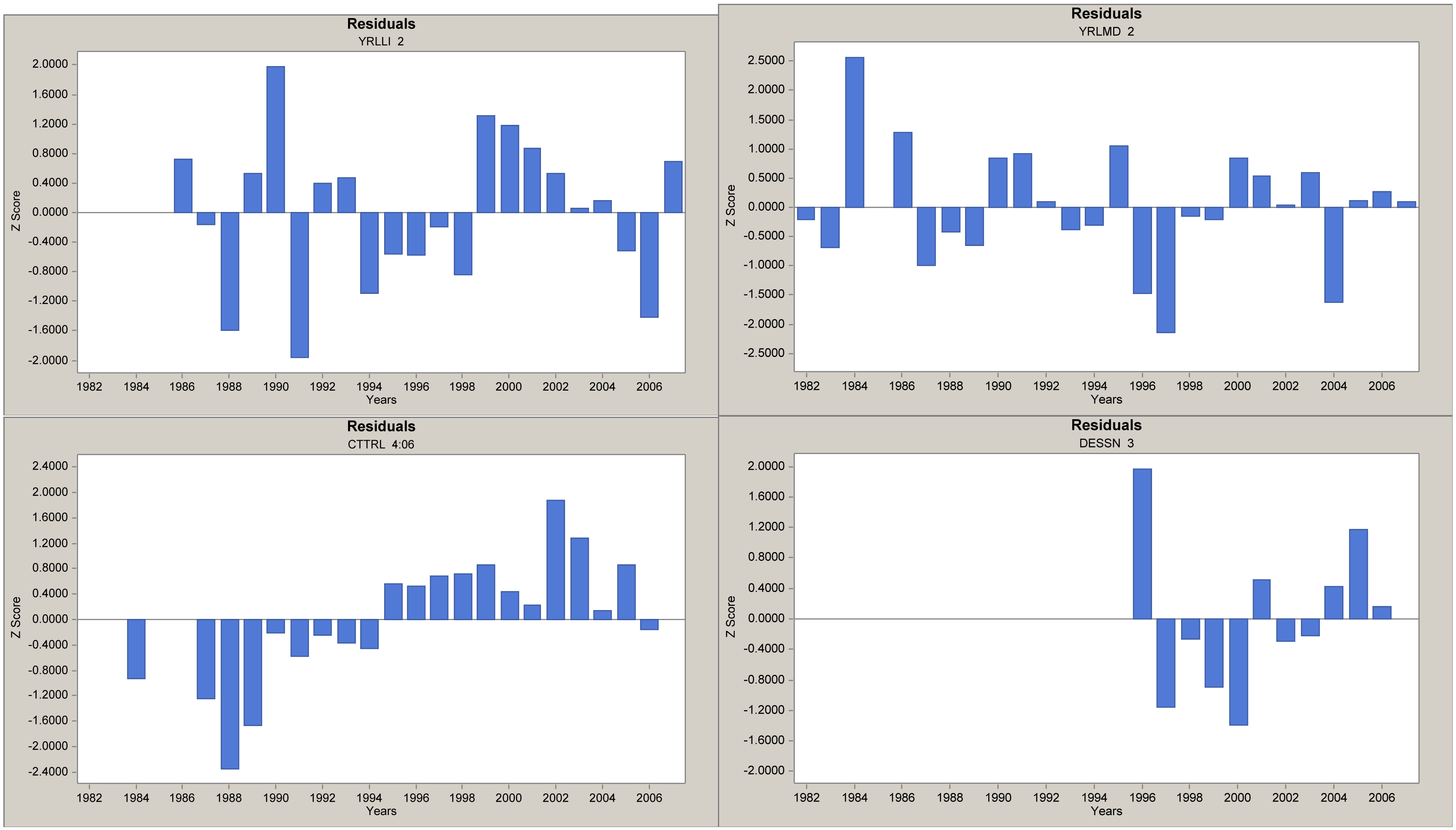



Figure 2 continued.

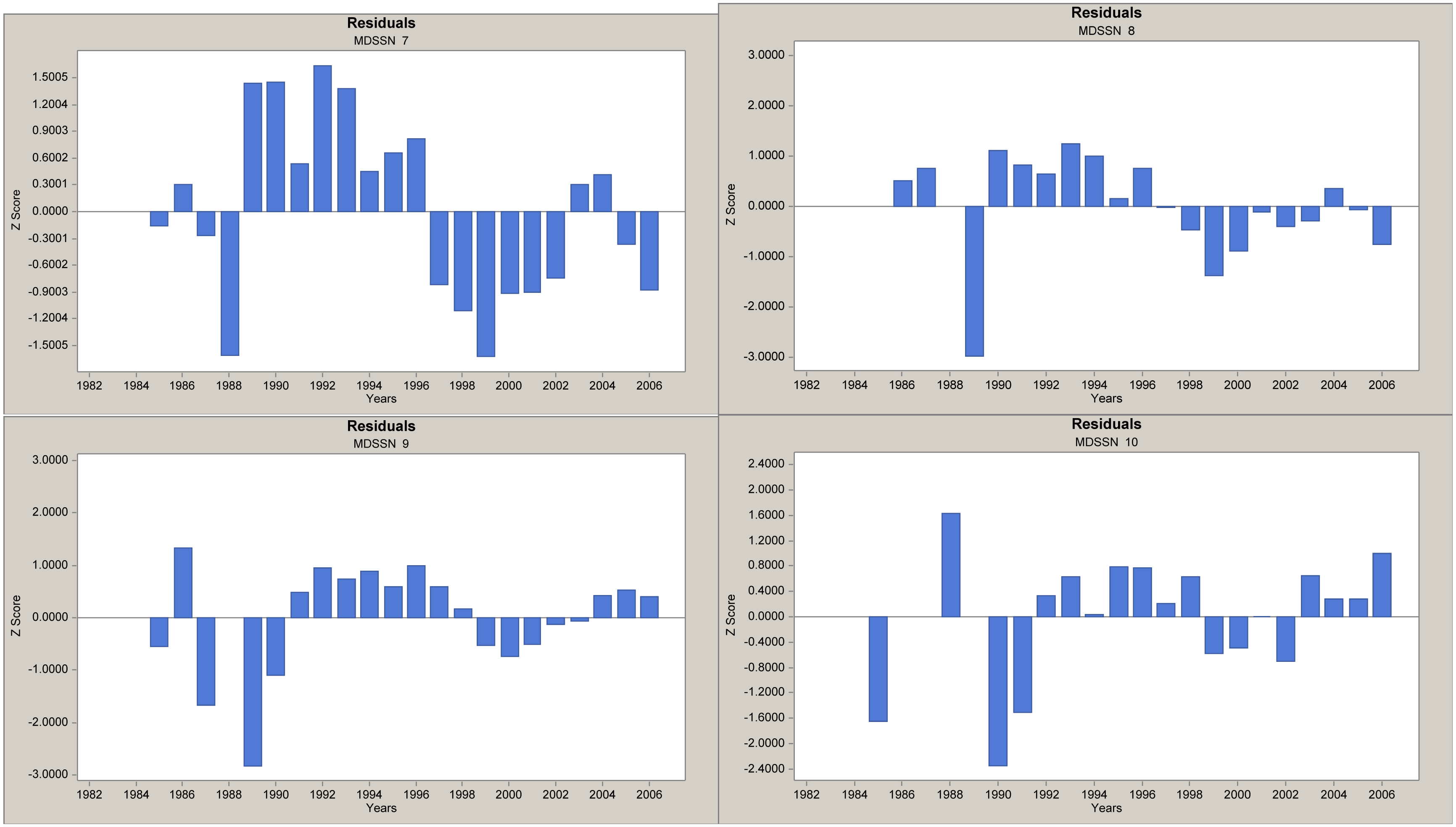



Figure 2 continued.

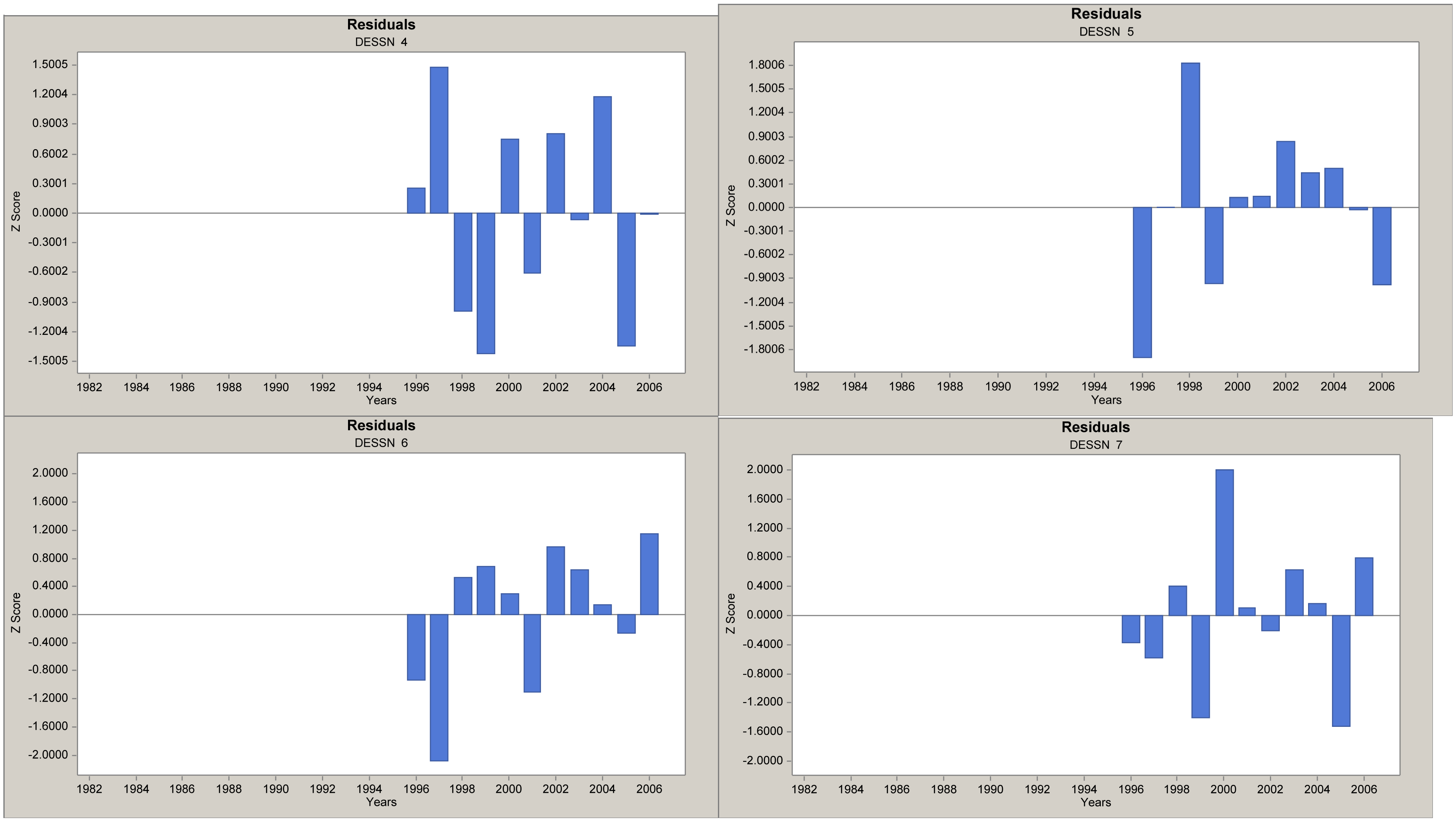



Figure 2 continued.

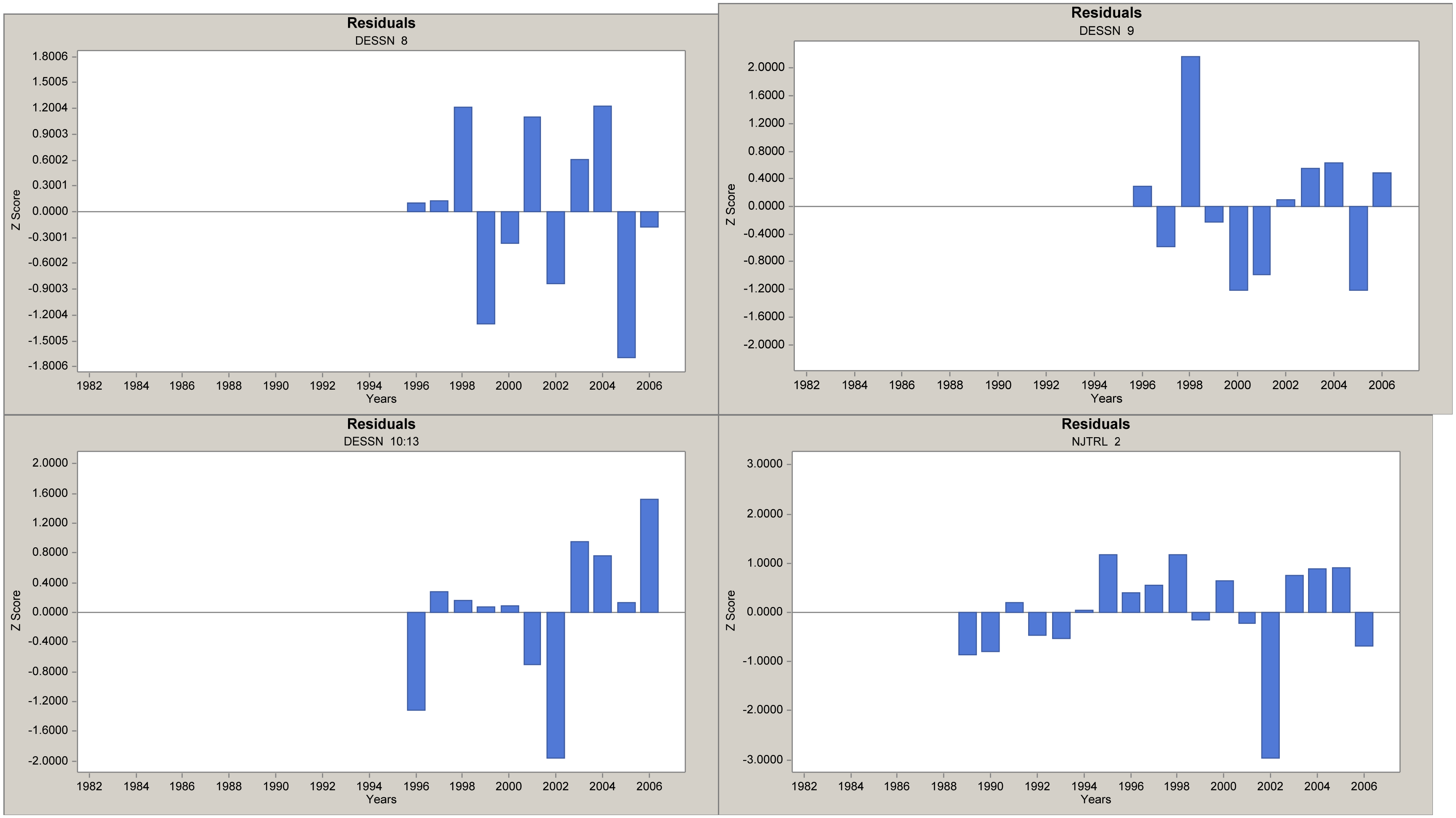



Figure 2 continued.

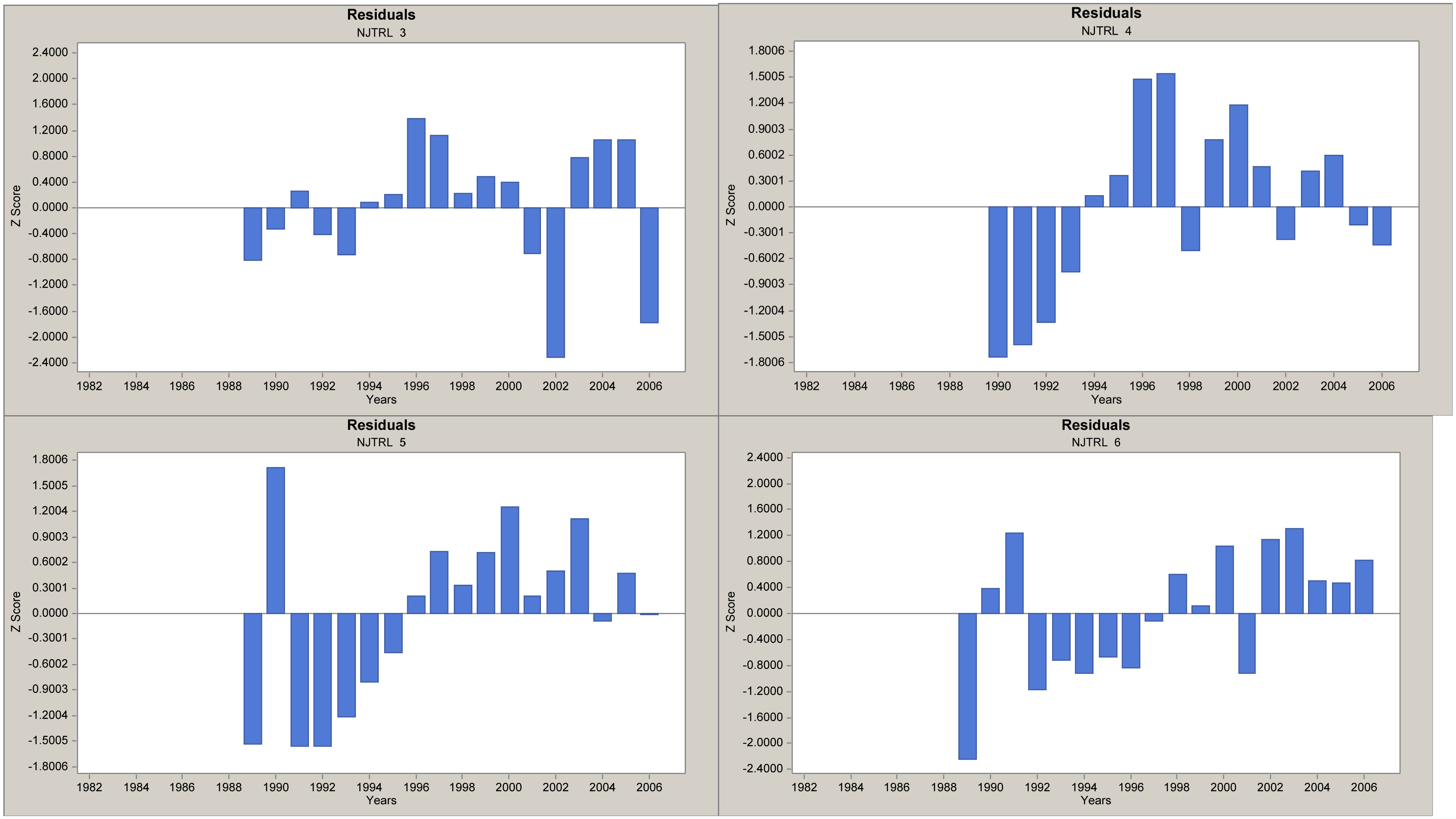
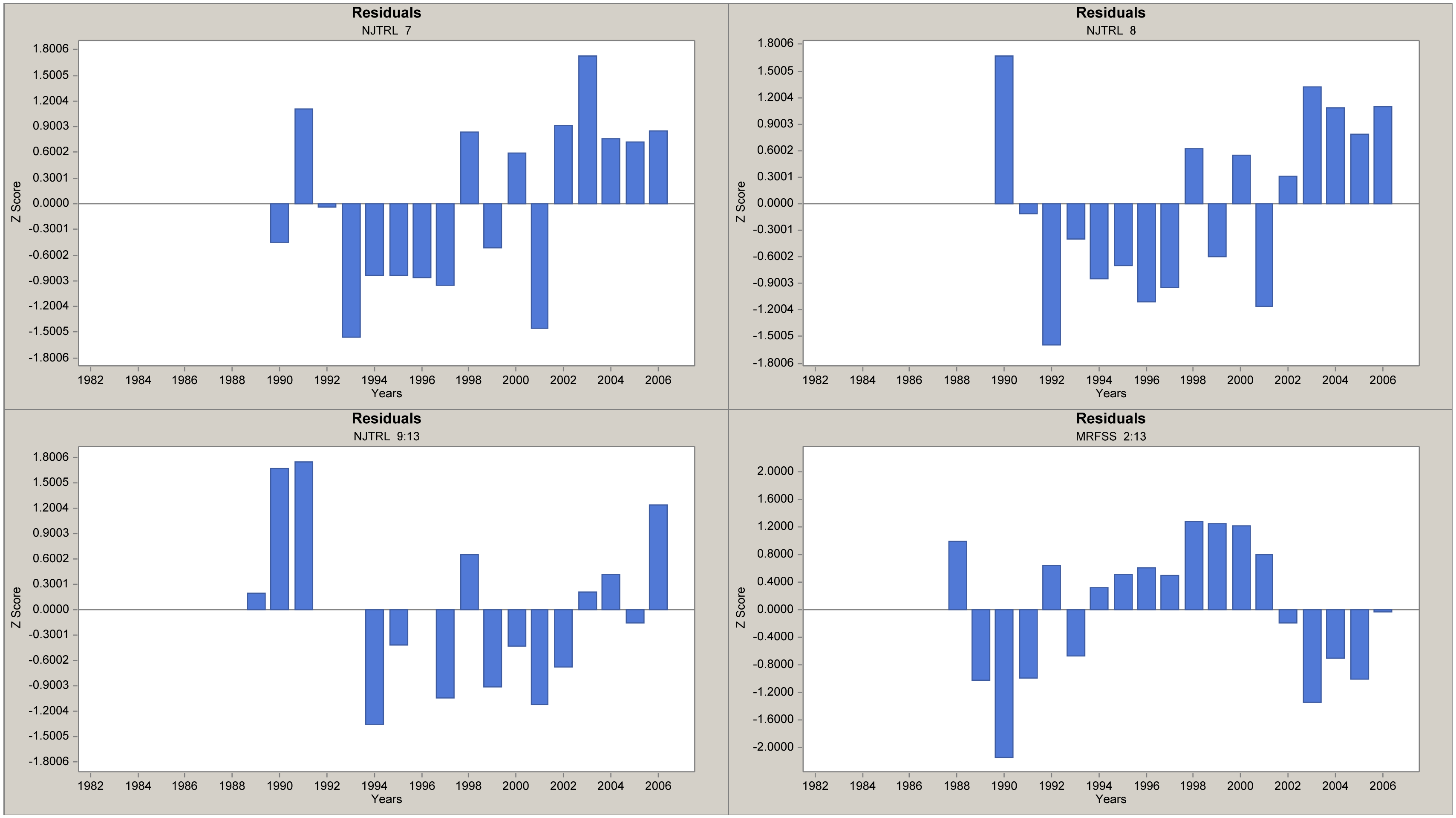



Figure 2 continued.

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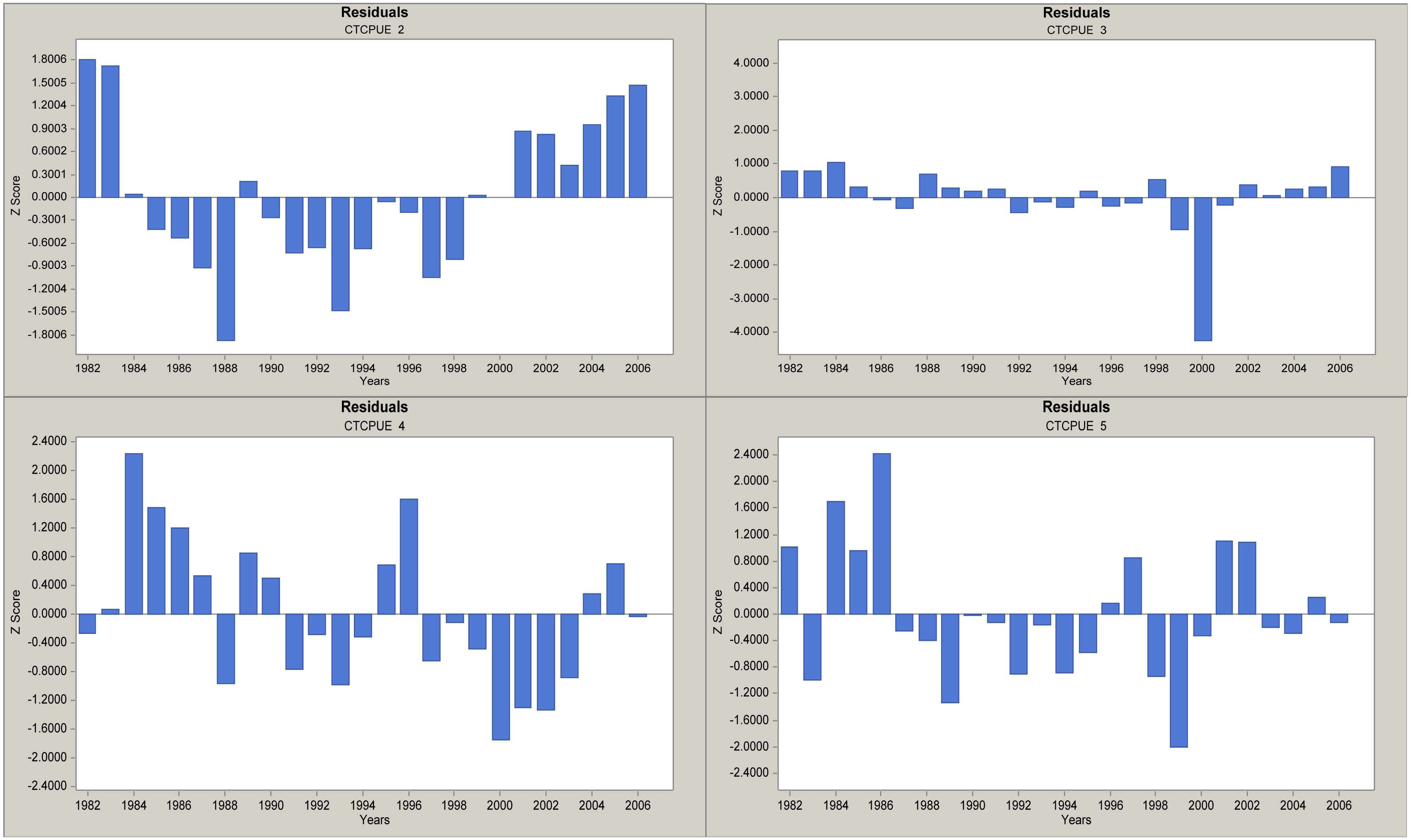



Figure 2 continued.

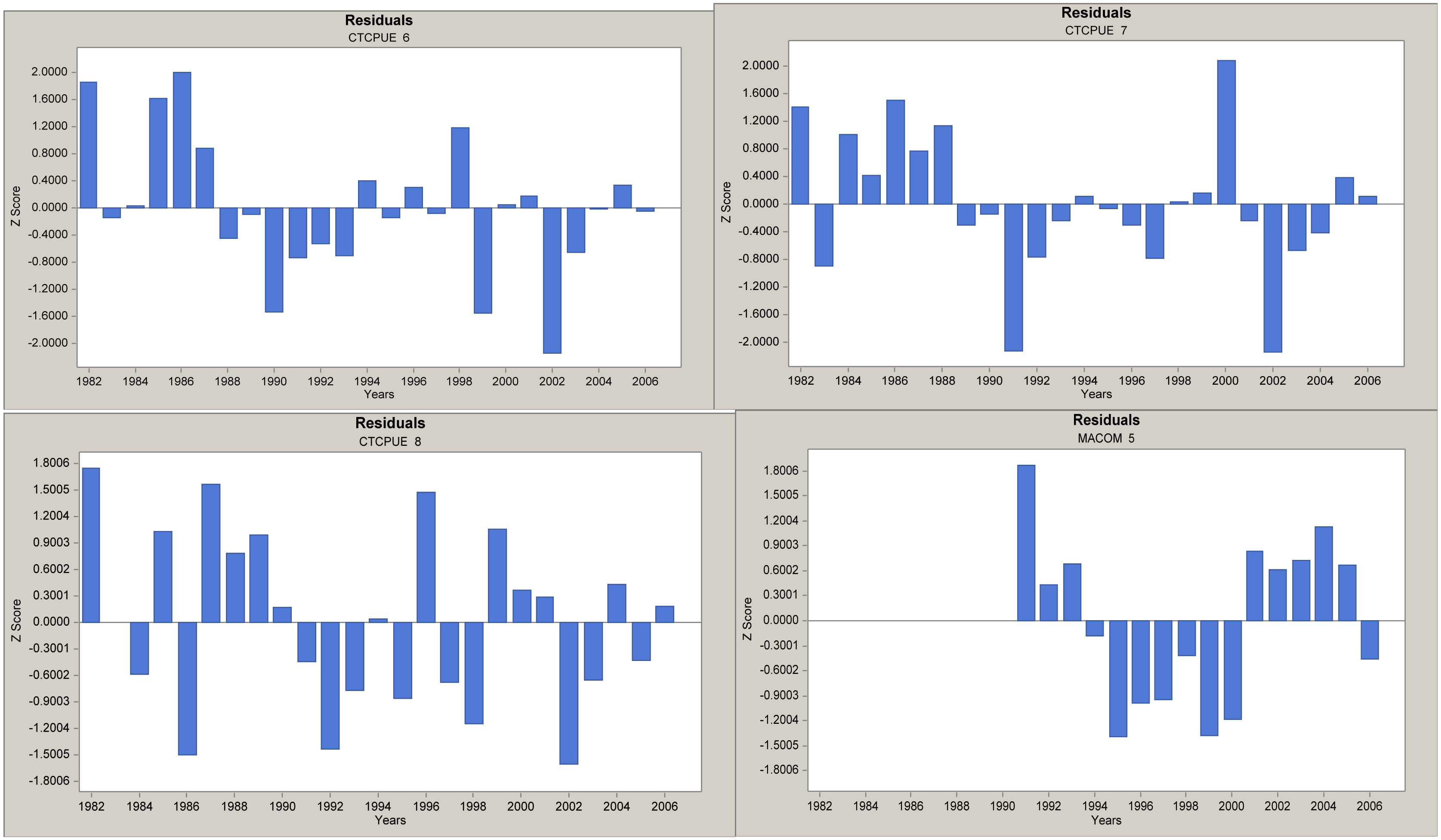



Figure 2 continued.

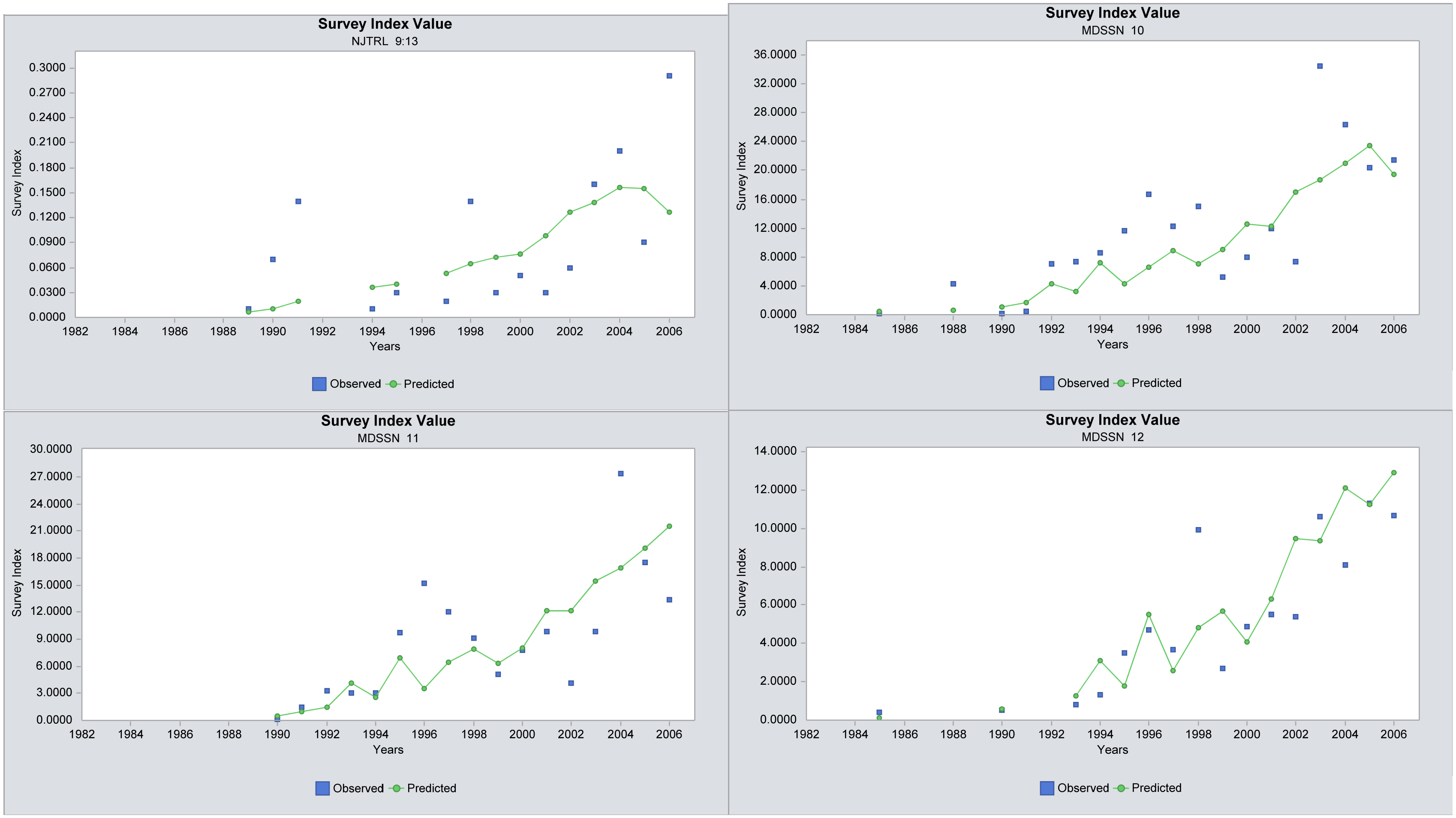



Figure 3. Observed vs. predicted indices from ADAPT model with reduced suite of indices

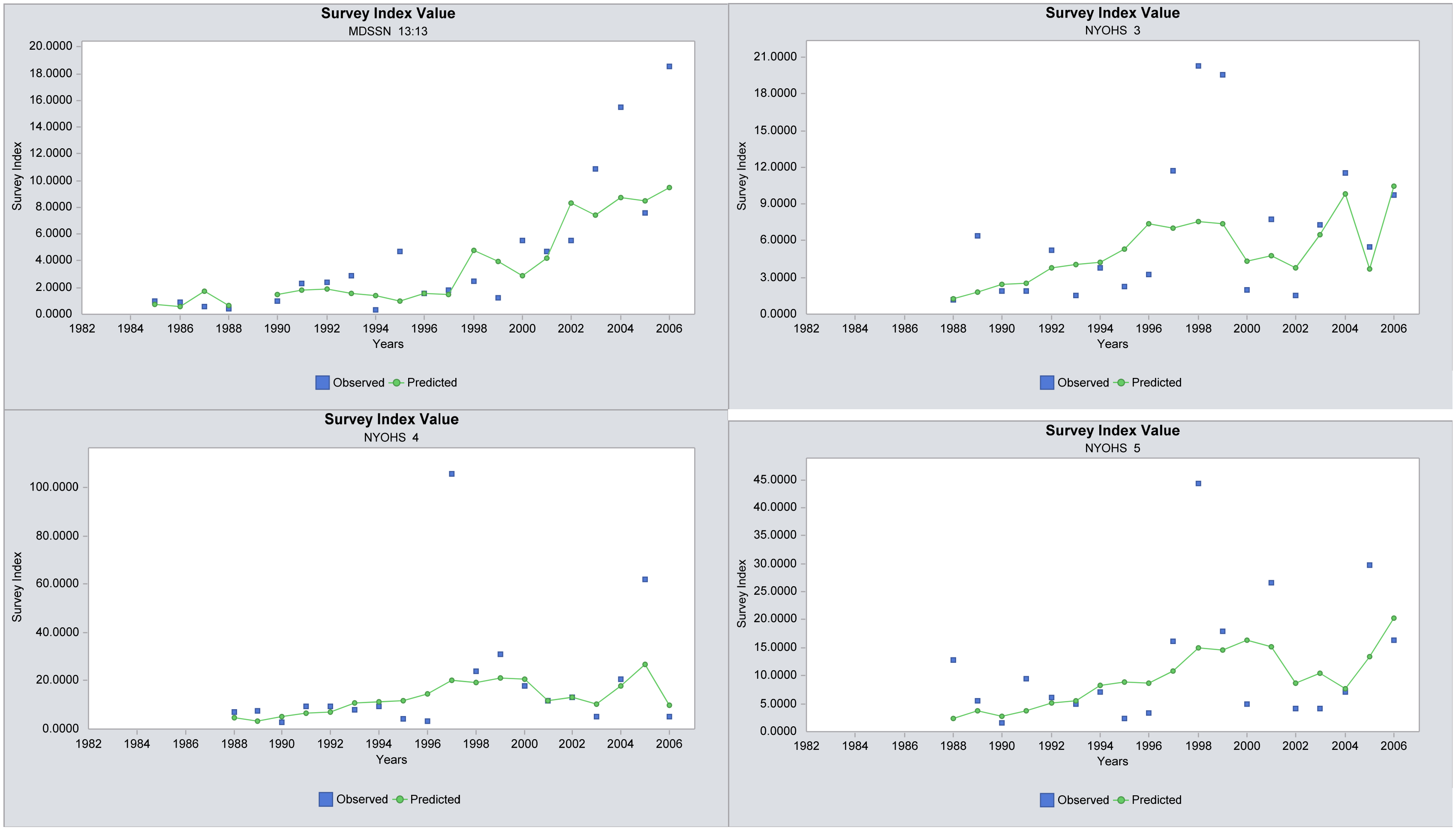



Figure 3 continued.

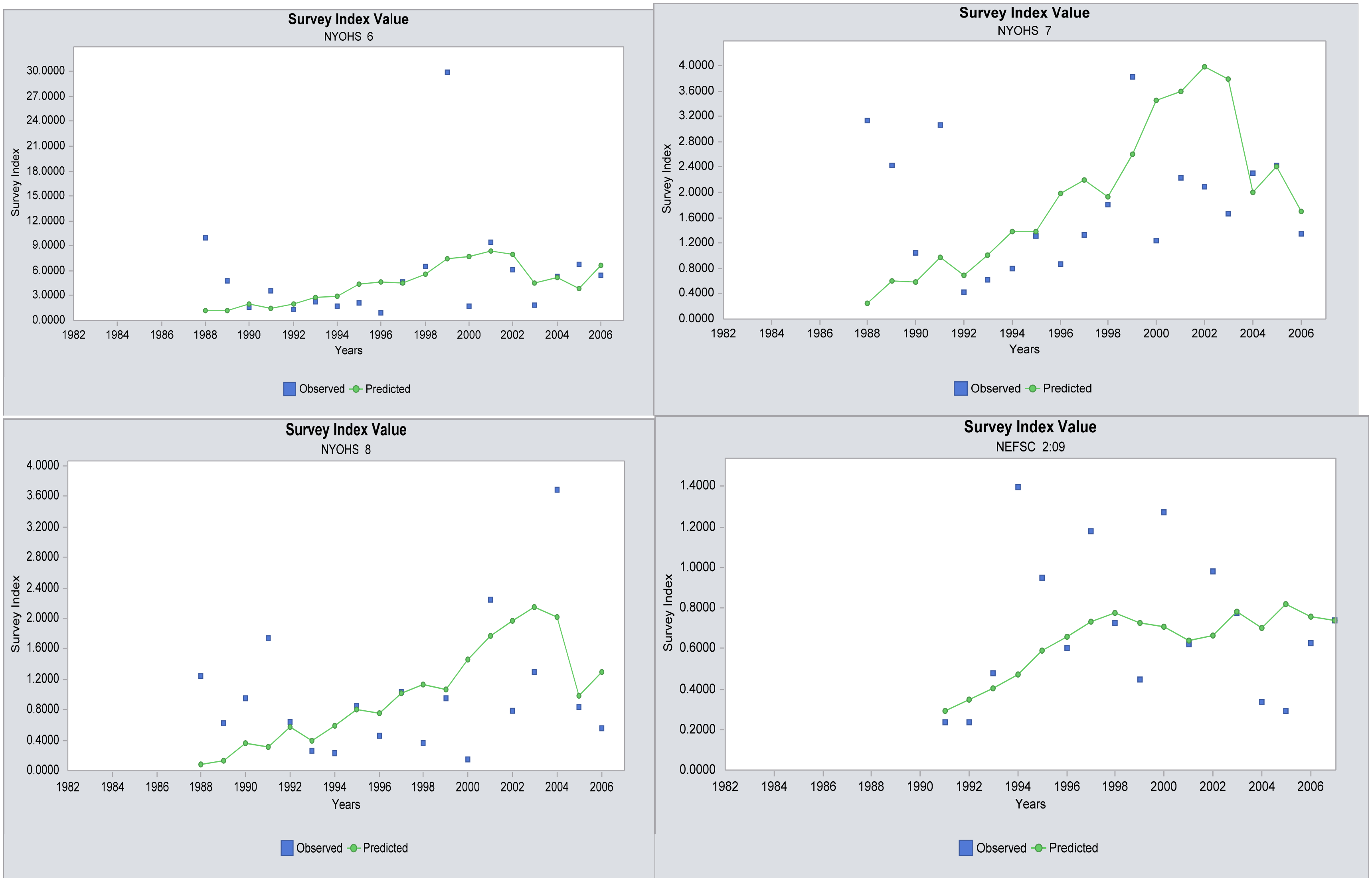



Figure 3 continued.


Figure 3 continued.


Figure 3 continued.

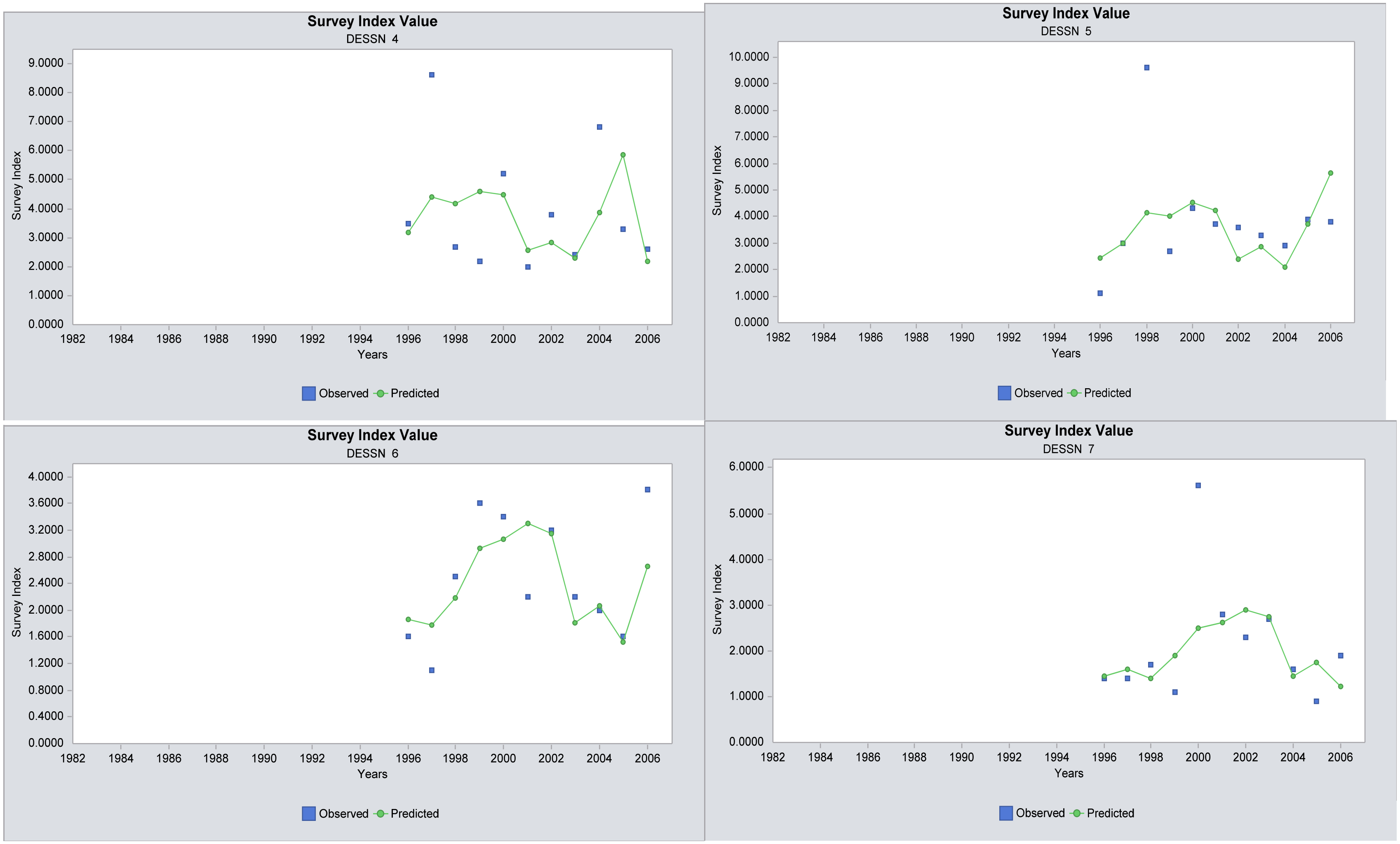



Figure 3 continued.

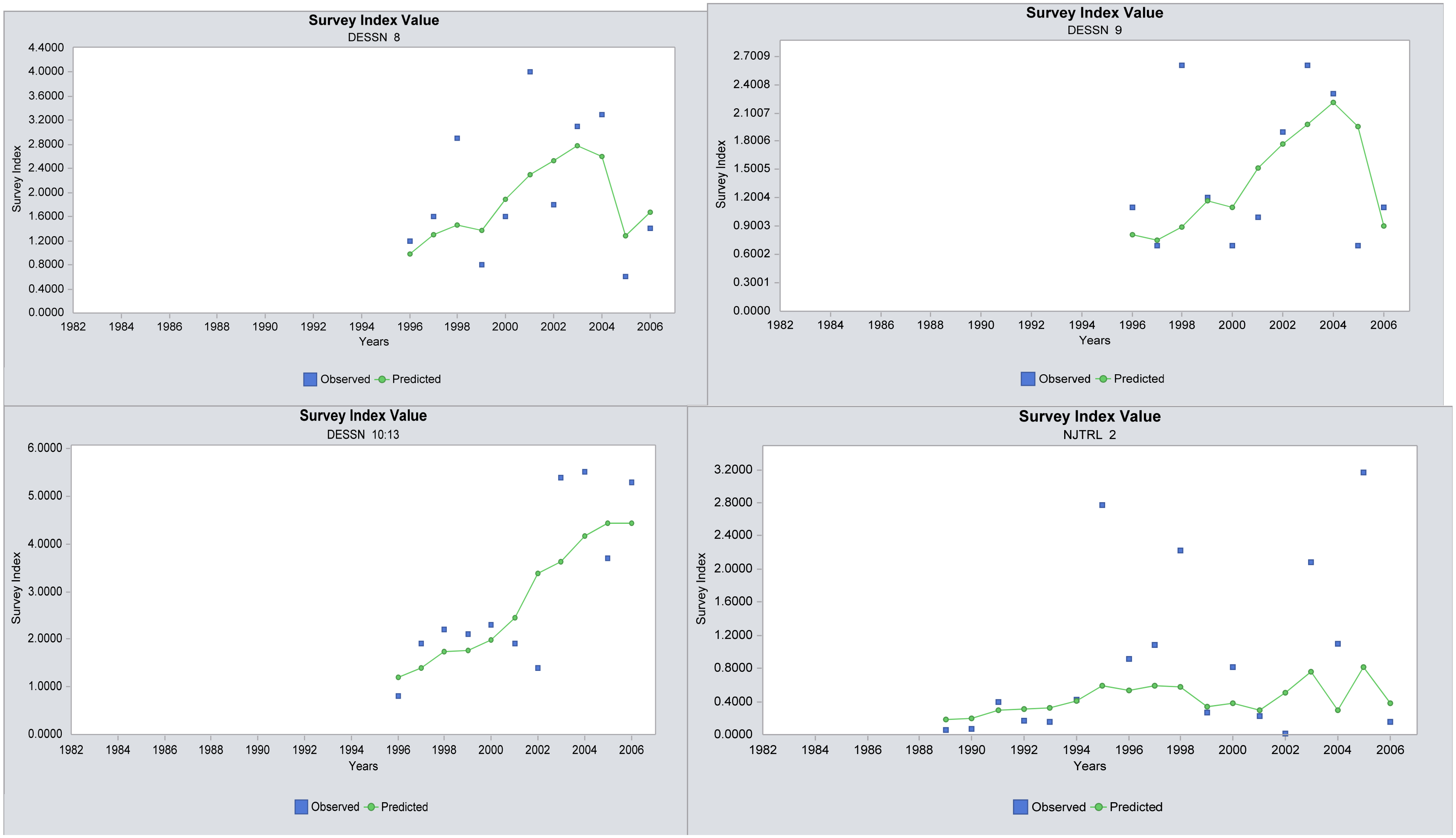



Figure 3 continued.

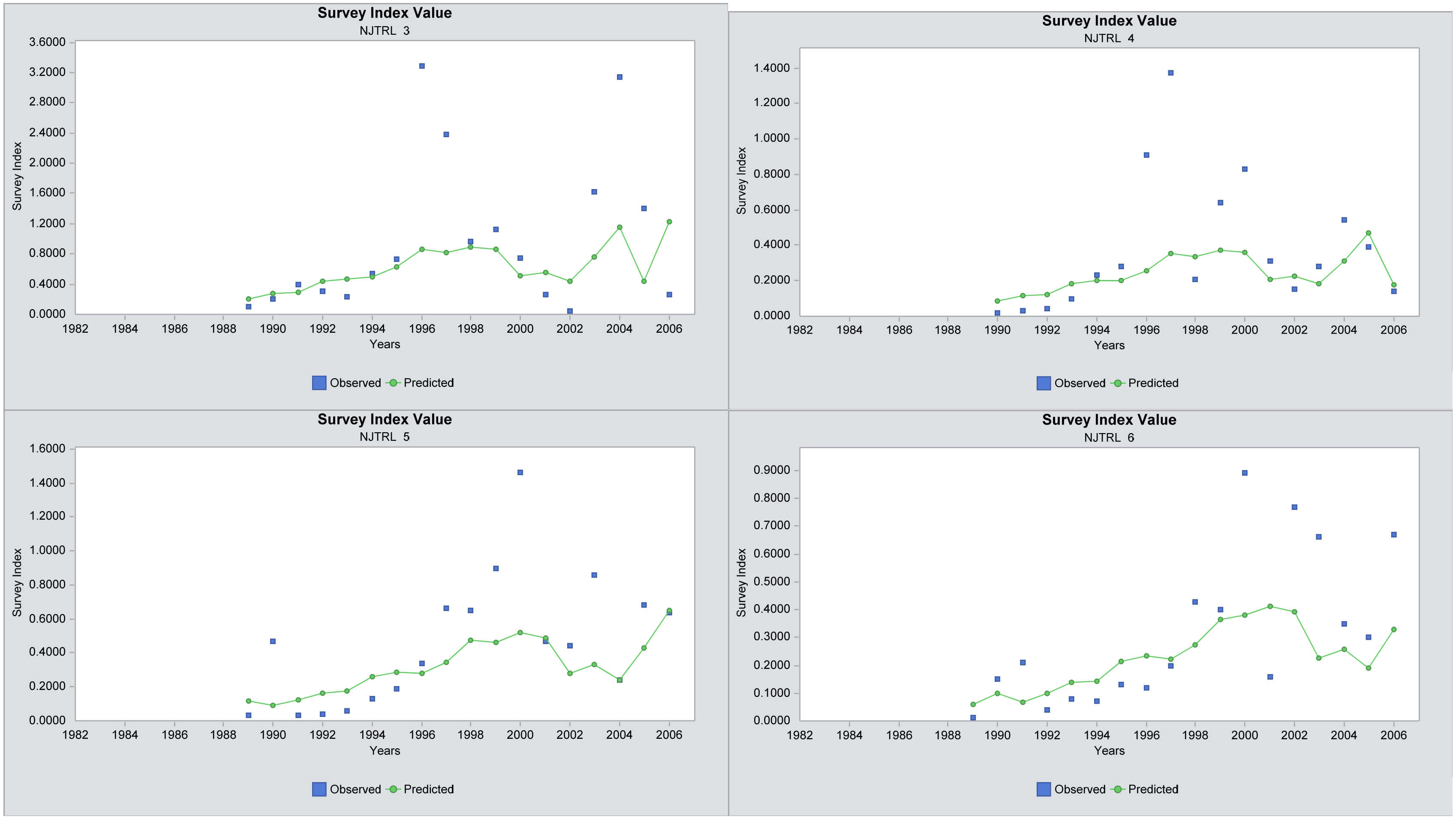
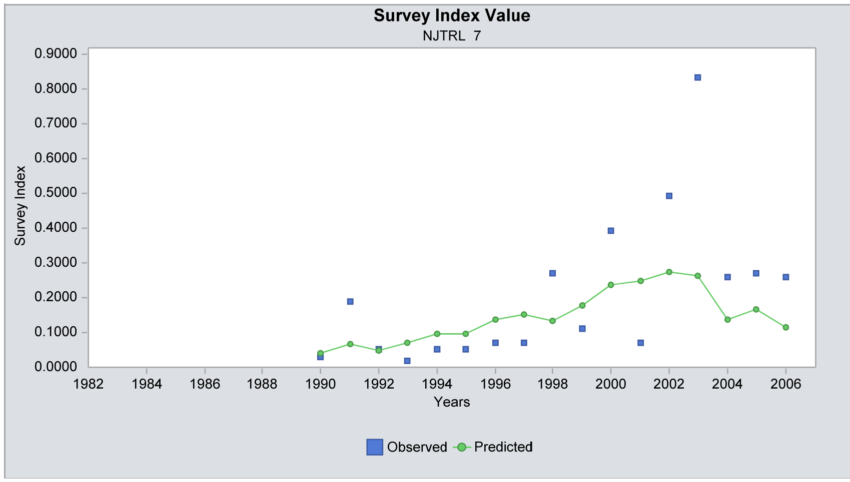



Figure 3 continued.



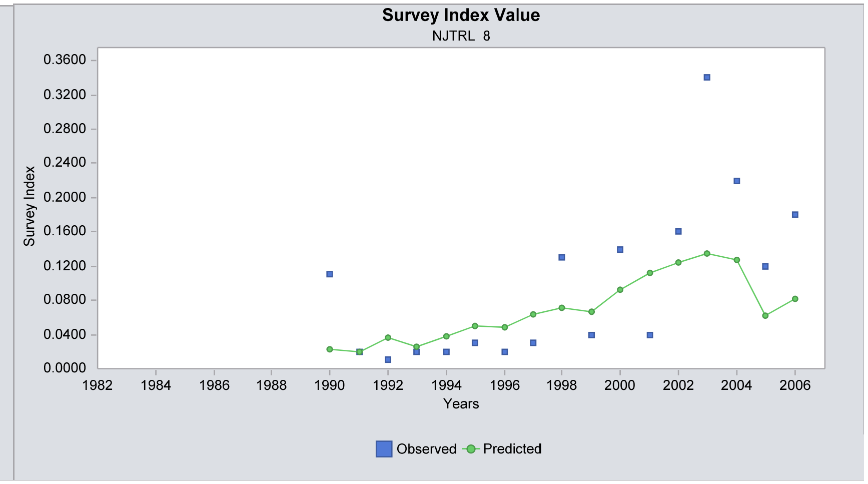




Figure 3 continued.

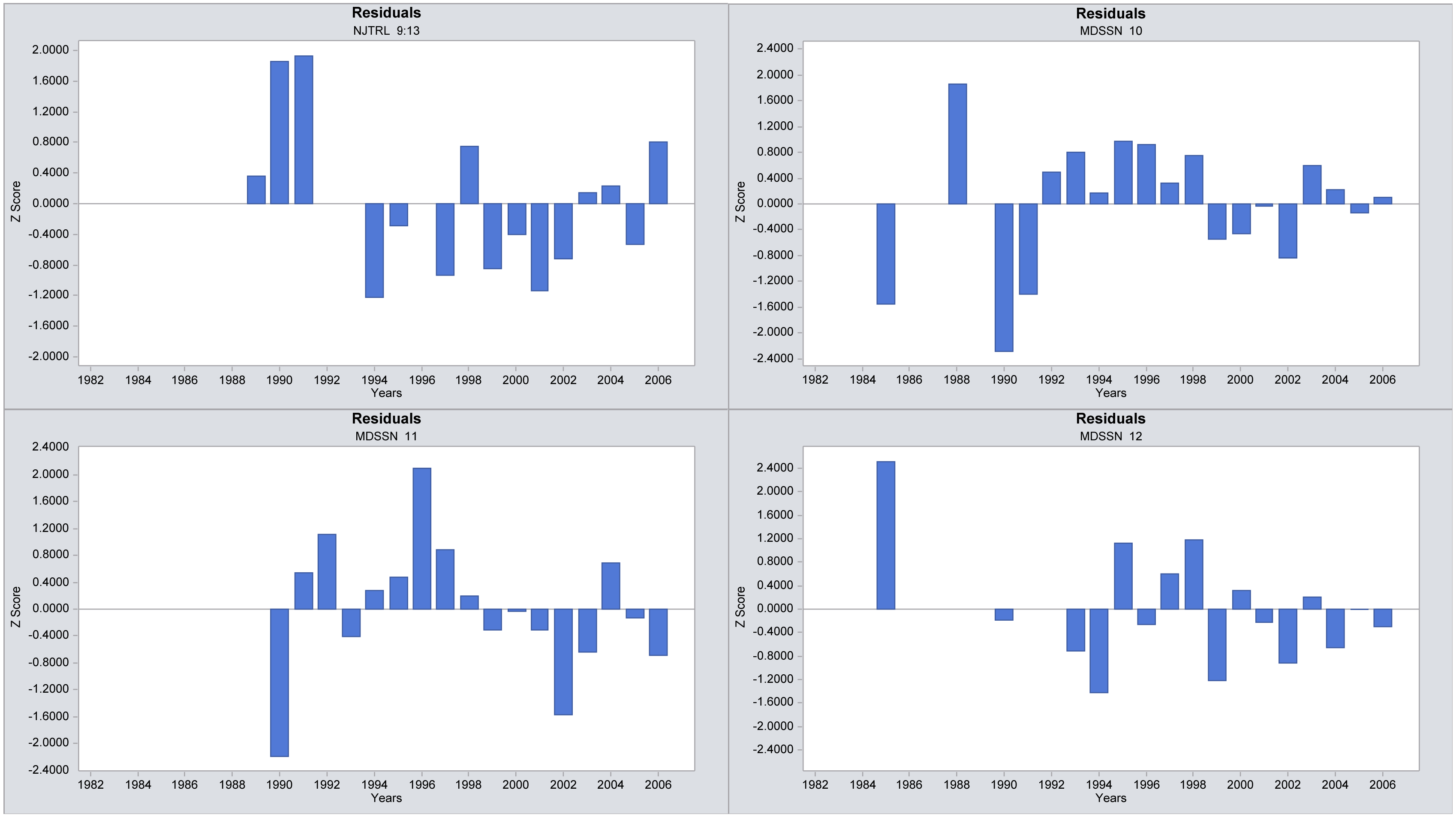



Figure 4. Residual plots from ADAPT model using reduced suite of indices.

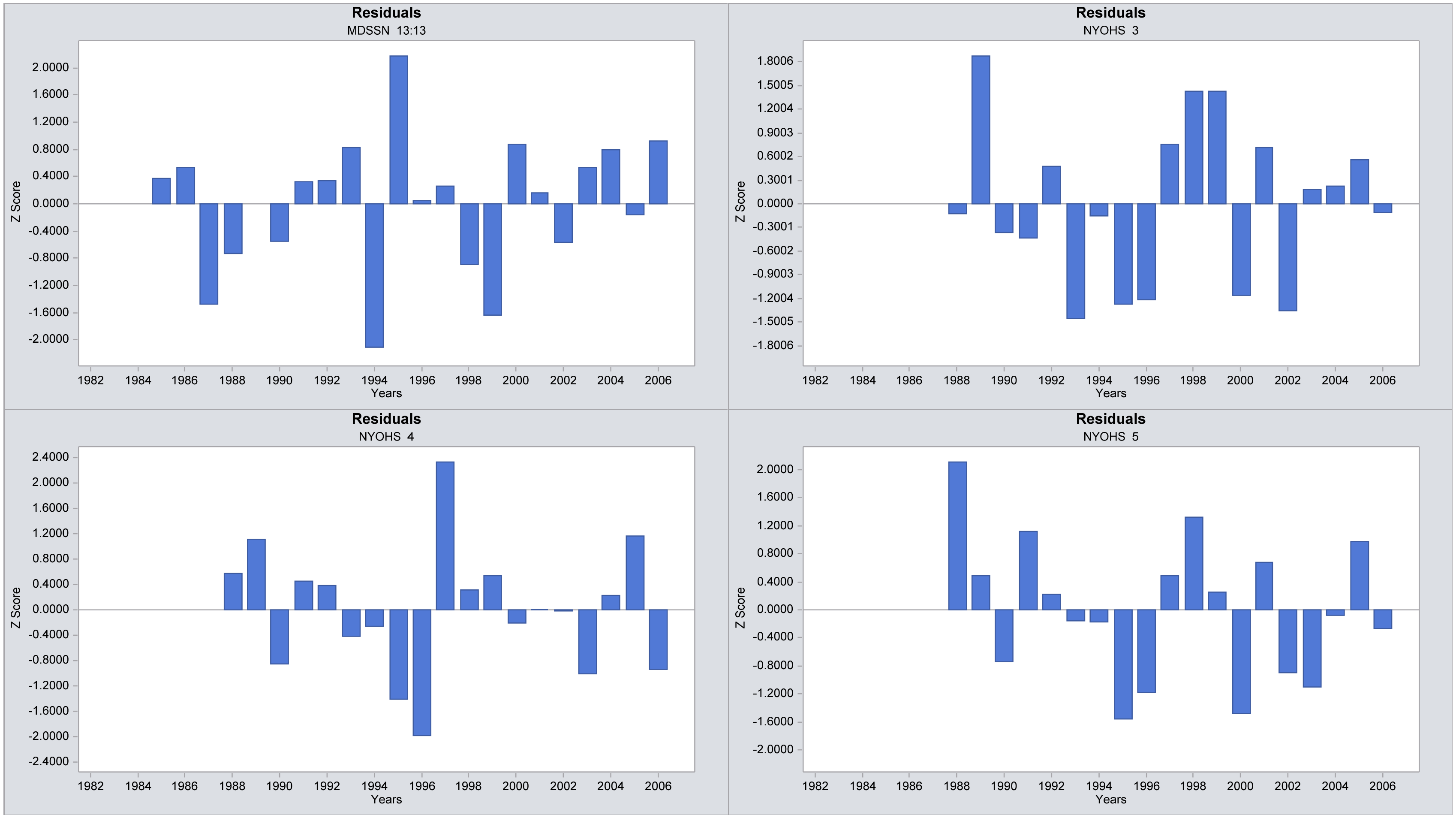



Figure 4 continued.

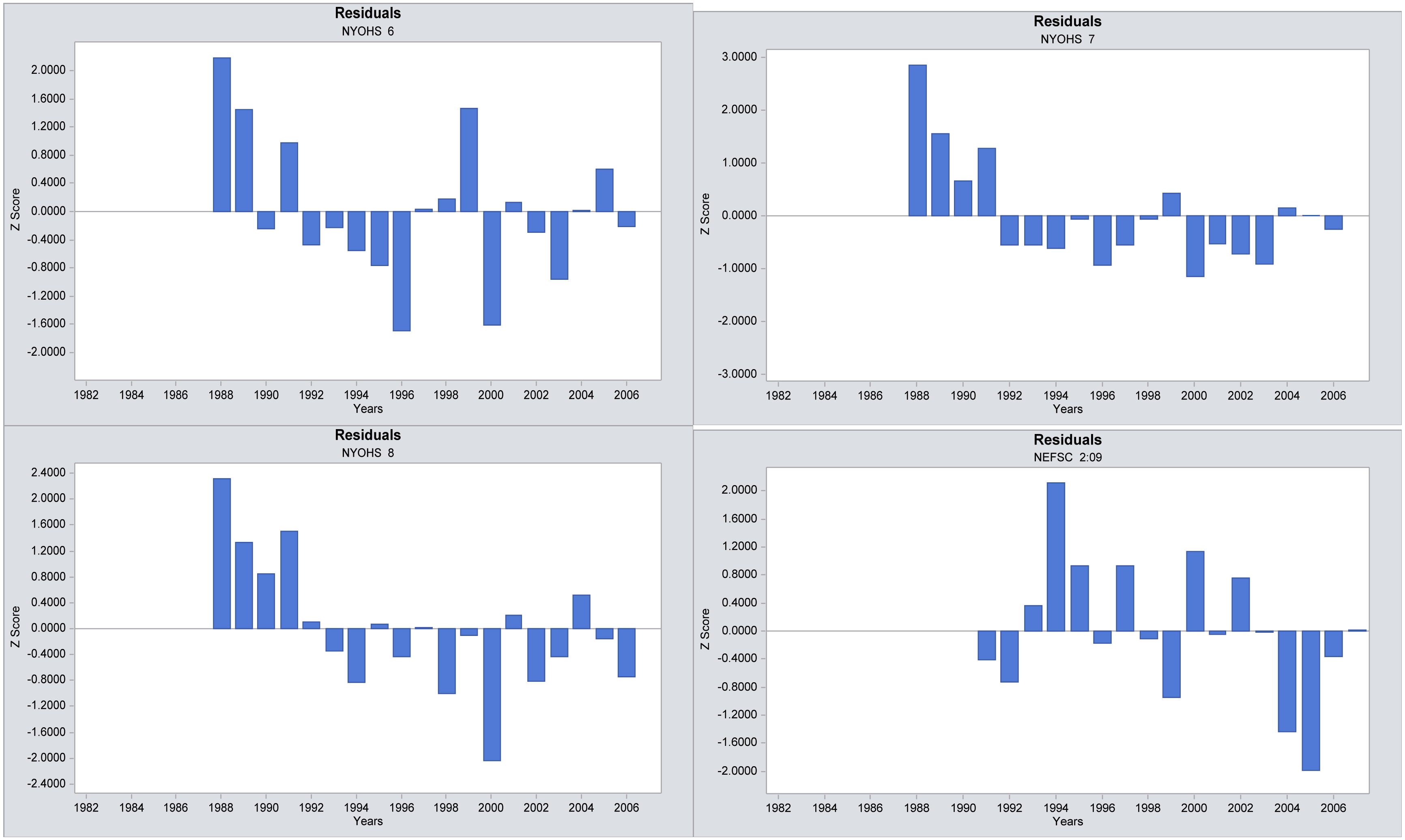



Figure 4 continued.

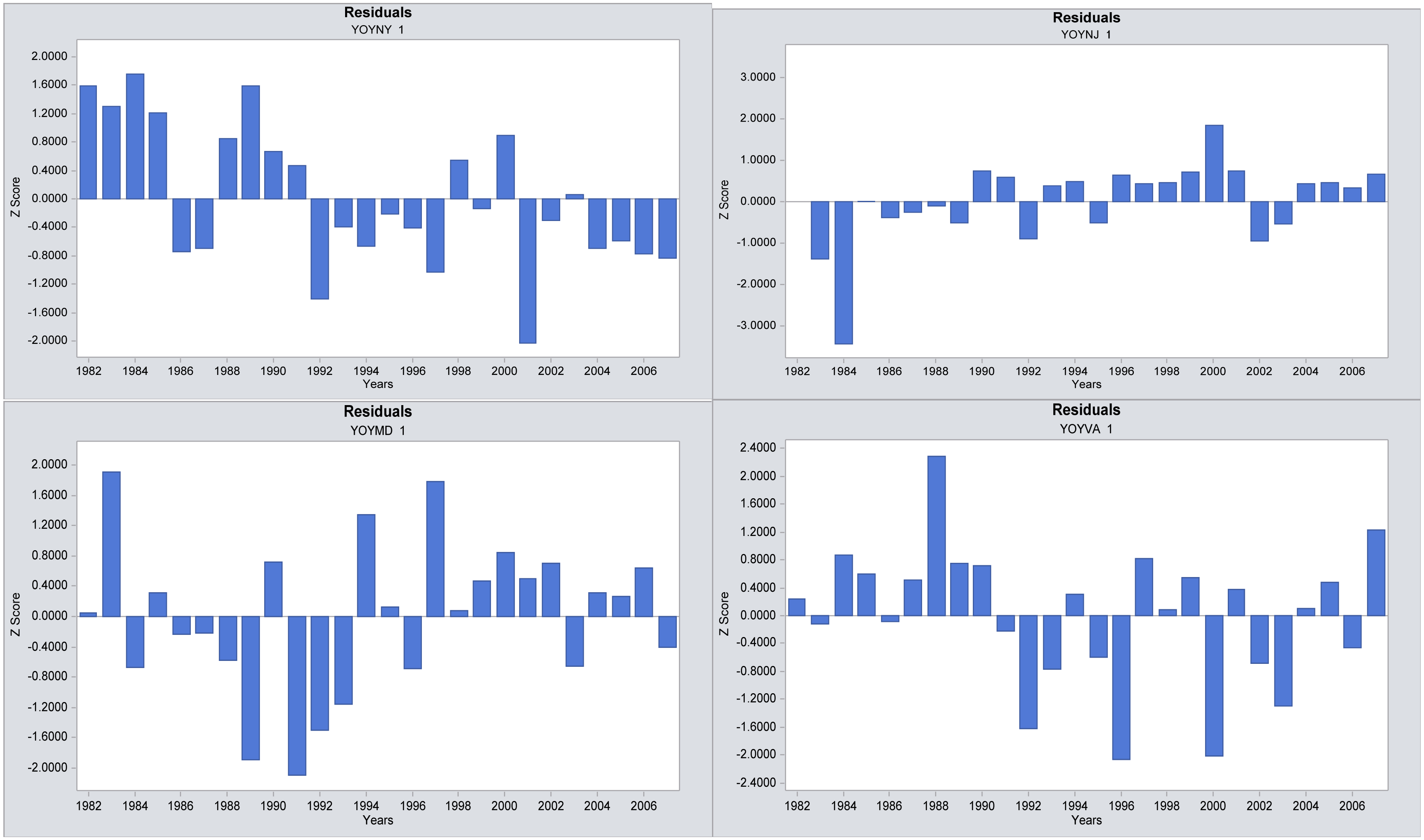



Figure 4 continued.

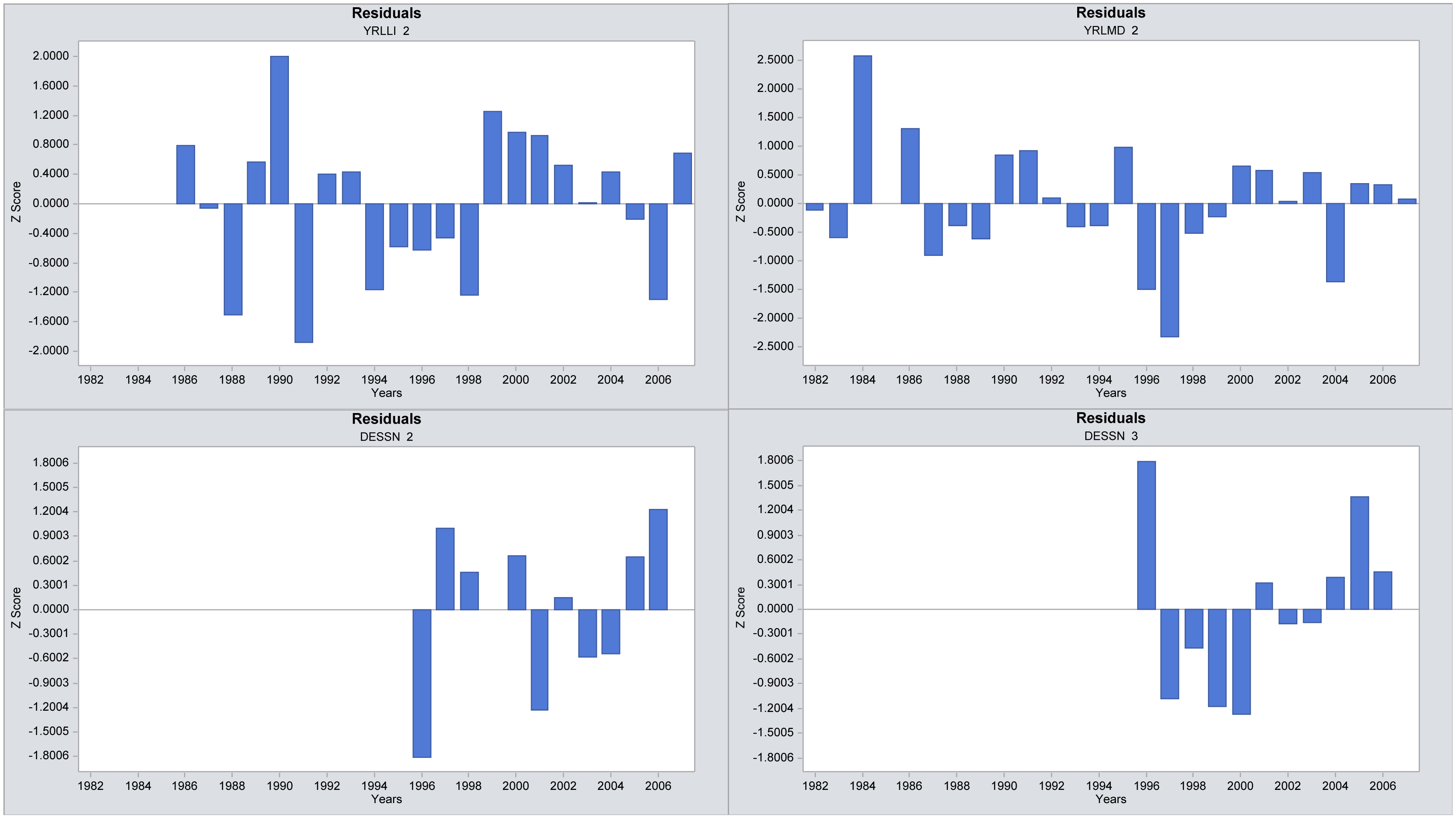



Figure 4 continued.

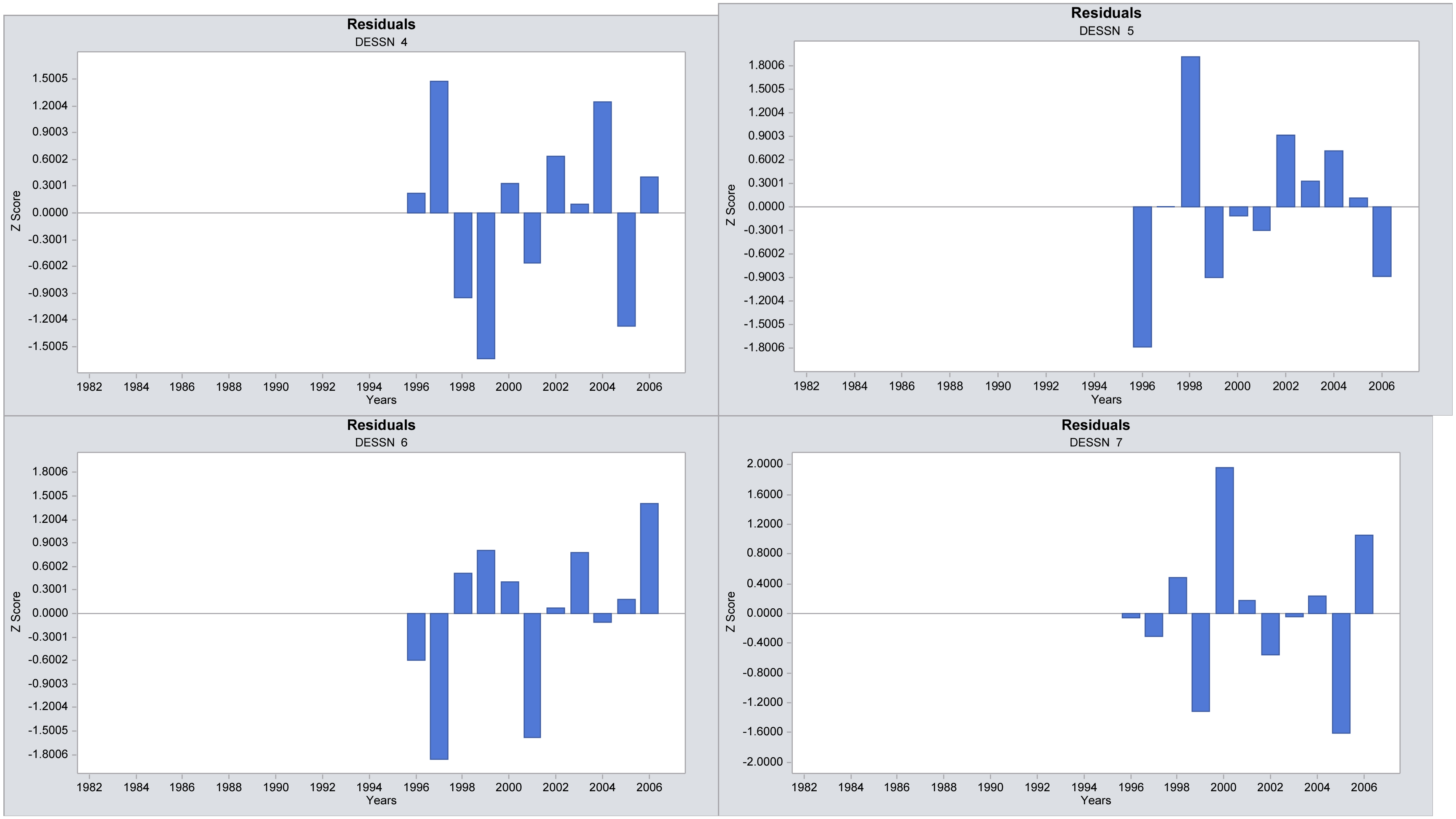
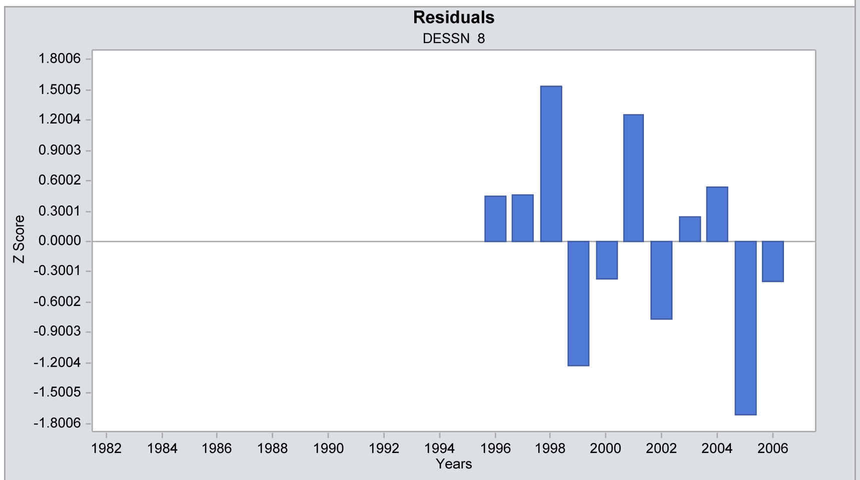
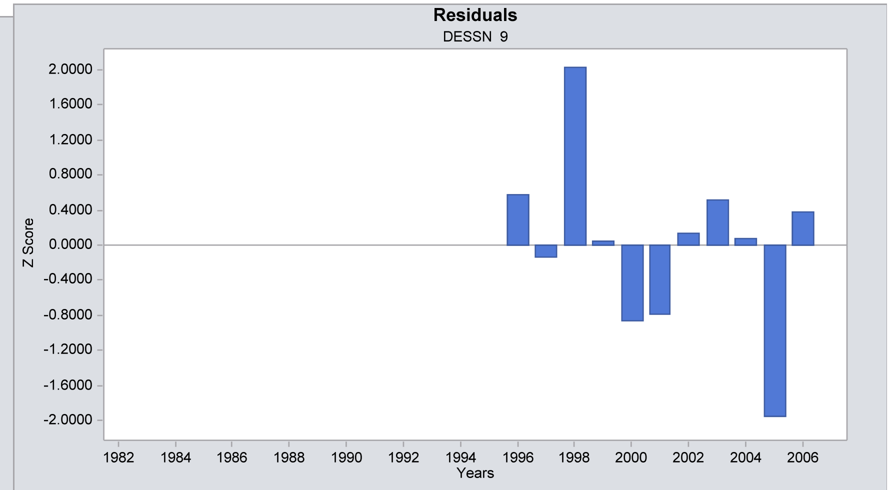
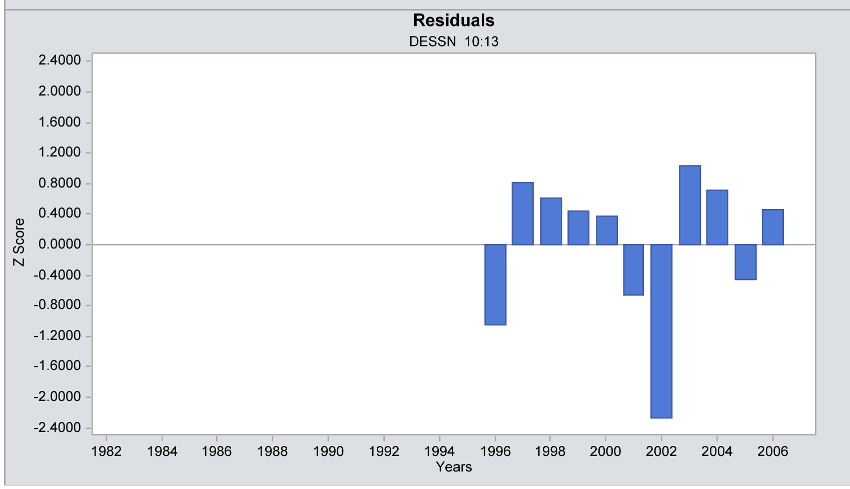



Figure 4 continued.



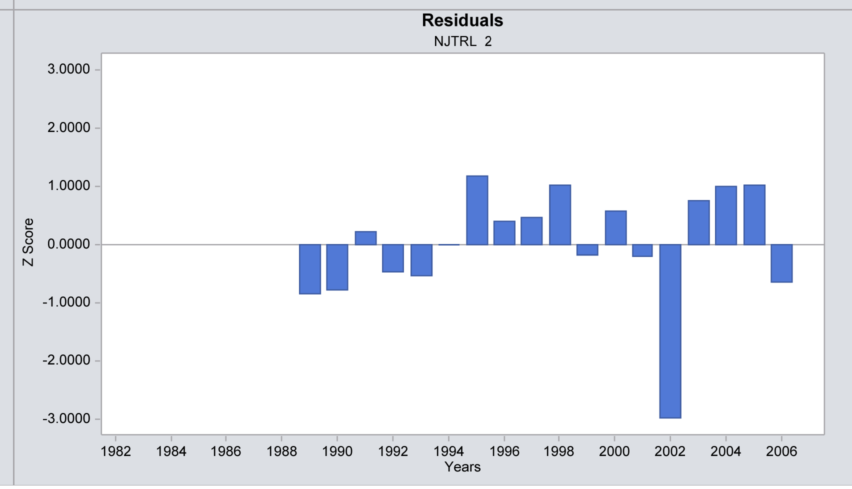
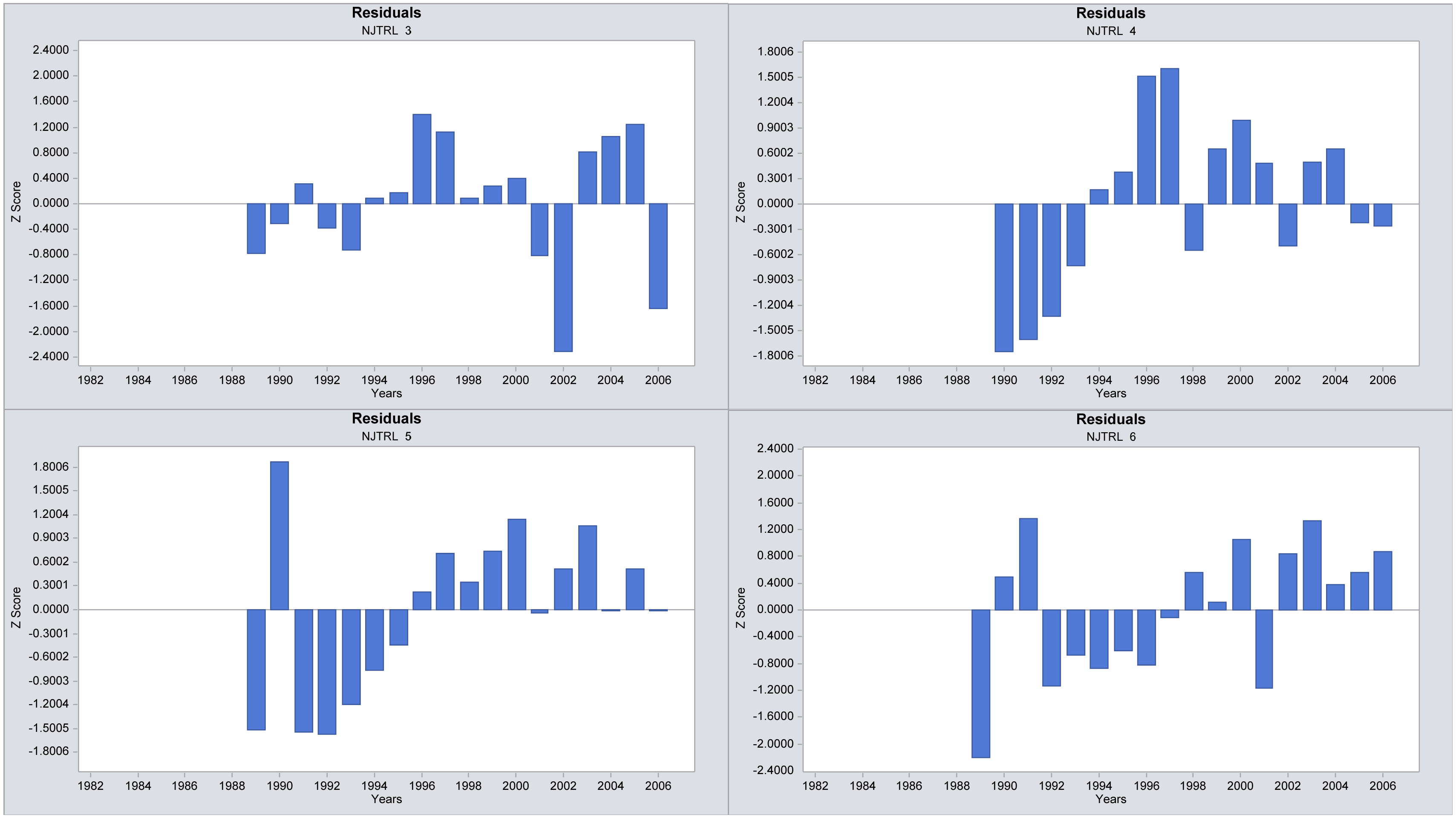




Figure 4 continued.

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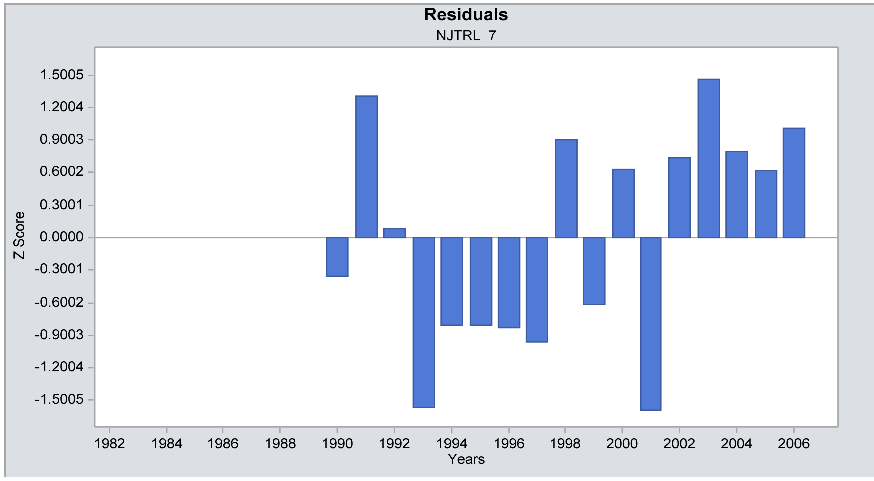


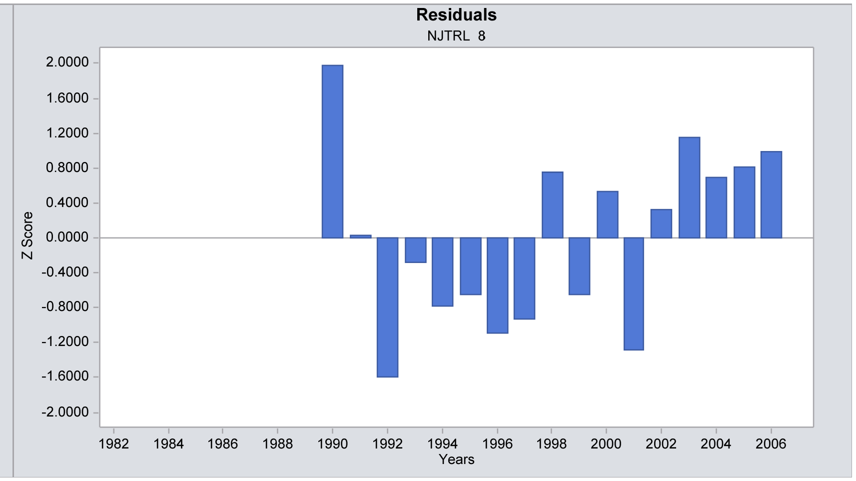




Figure 4 continued.

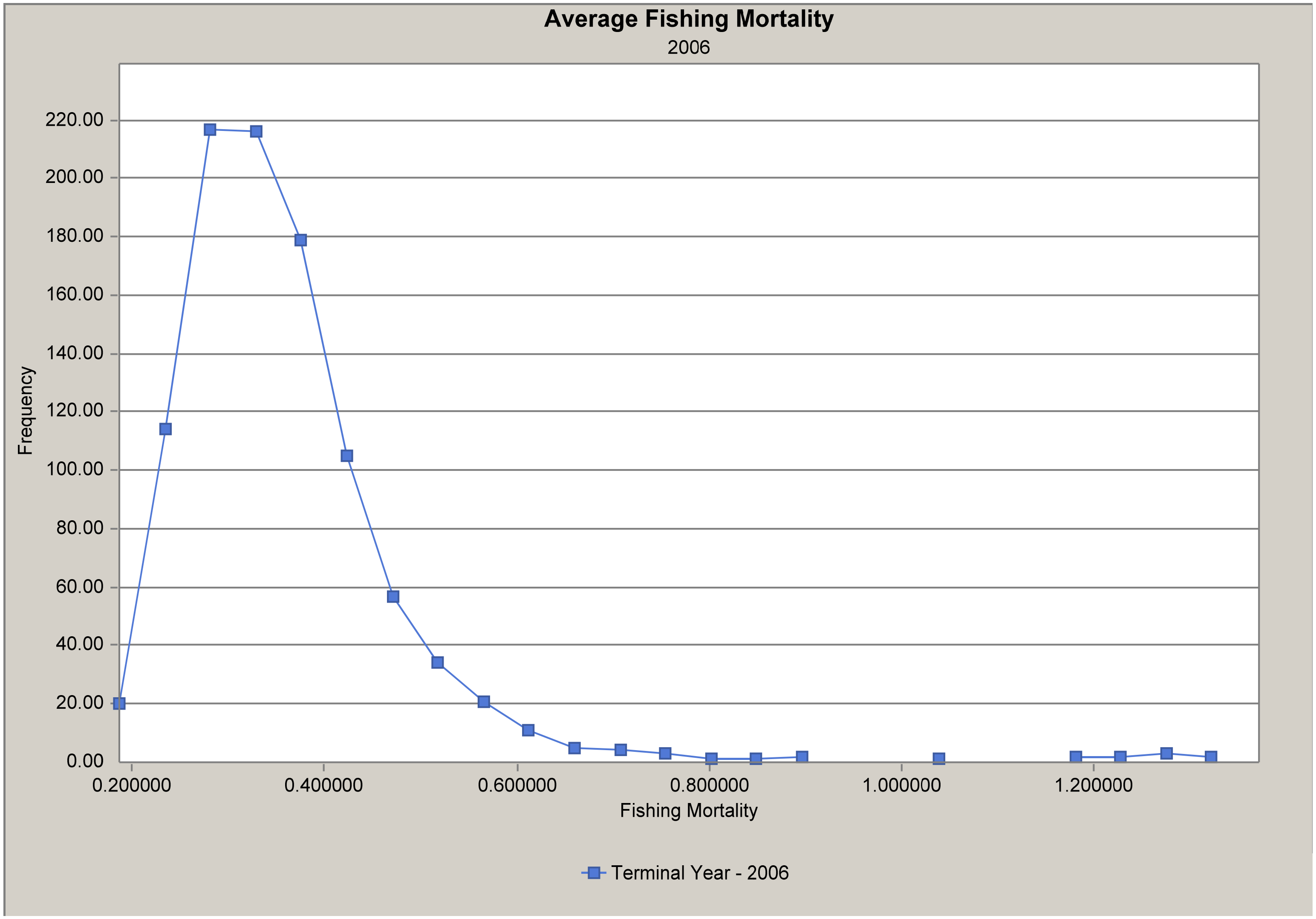



Figure 5. Bootstrap plot of fishing mortality from ADAPT model using reduced suite of indices

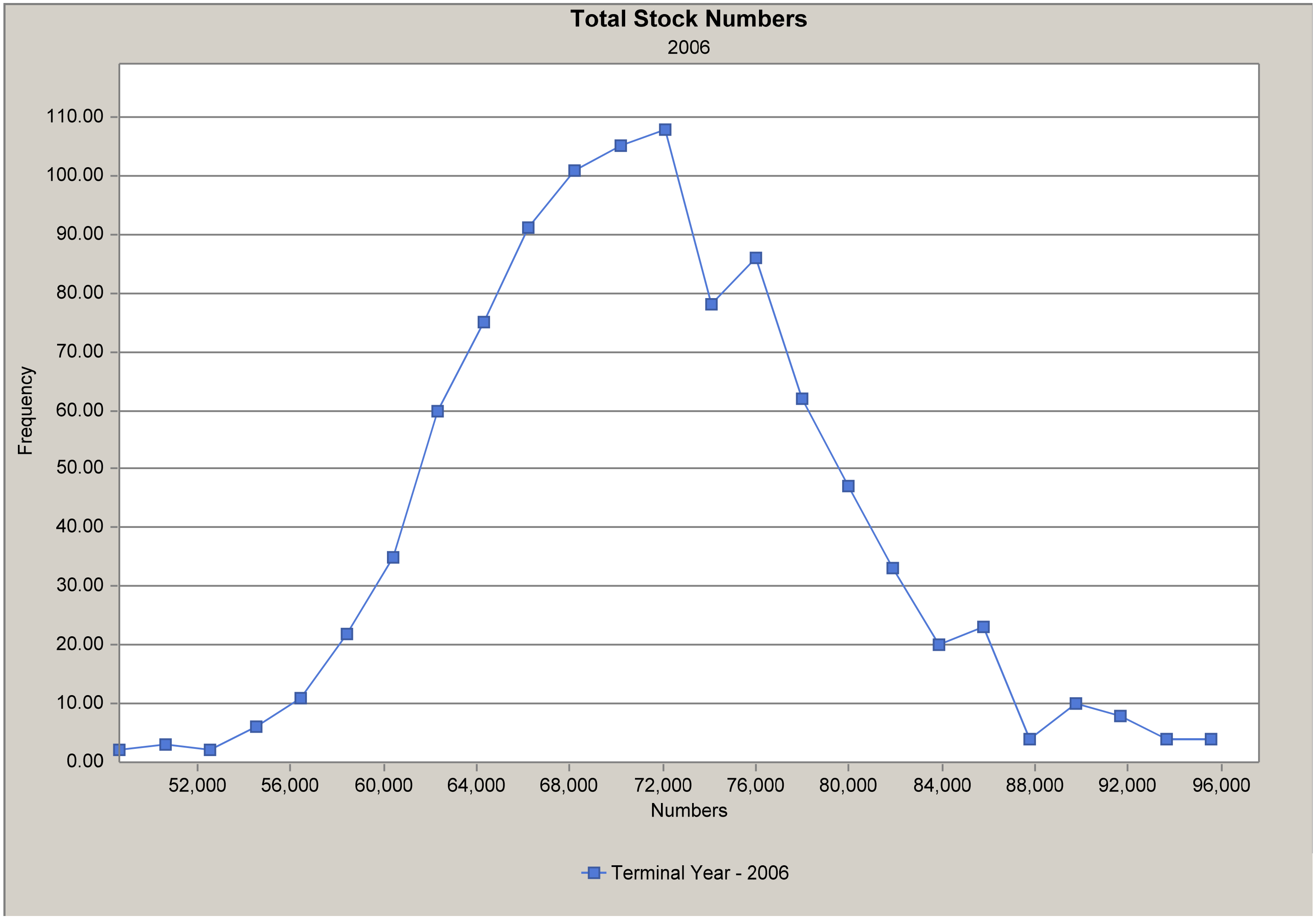



Figure 6. Bootstrap plot of stock numbers from ADAPT model using reduced suite of indices.

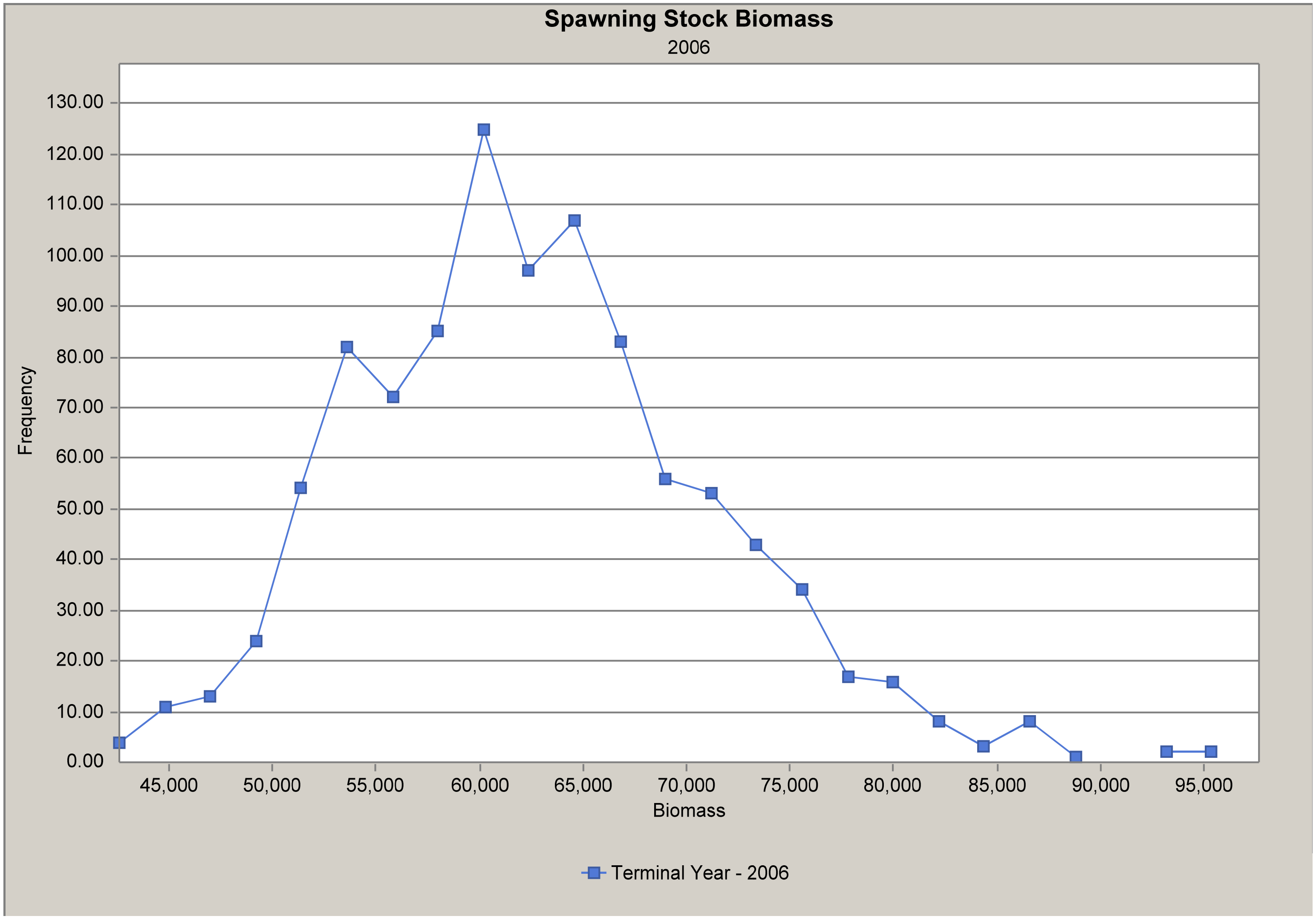
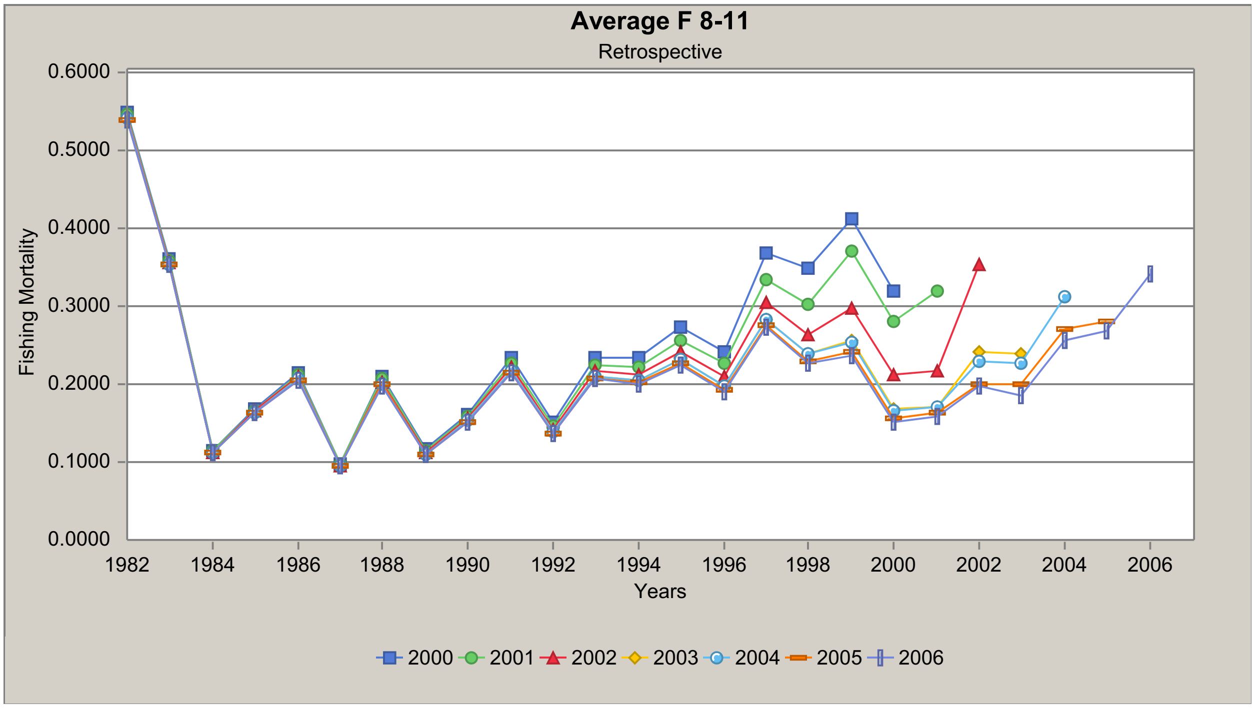



Figure 7. Bootstrap plot of spawning stock biomass from ADAPT model using reduced suite of indices.



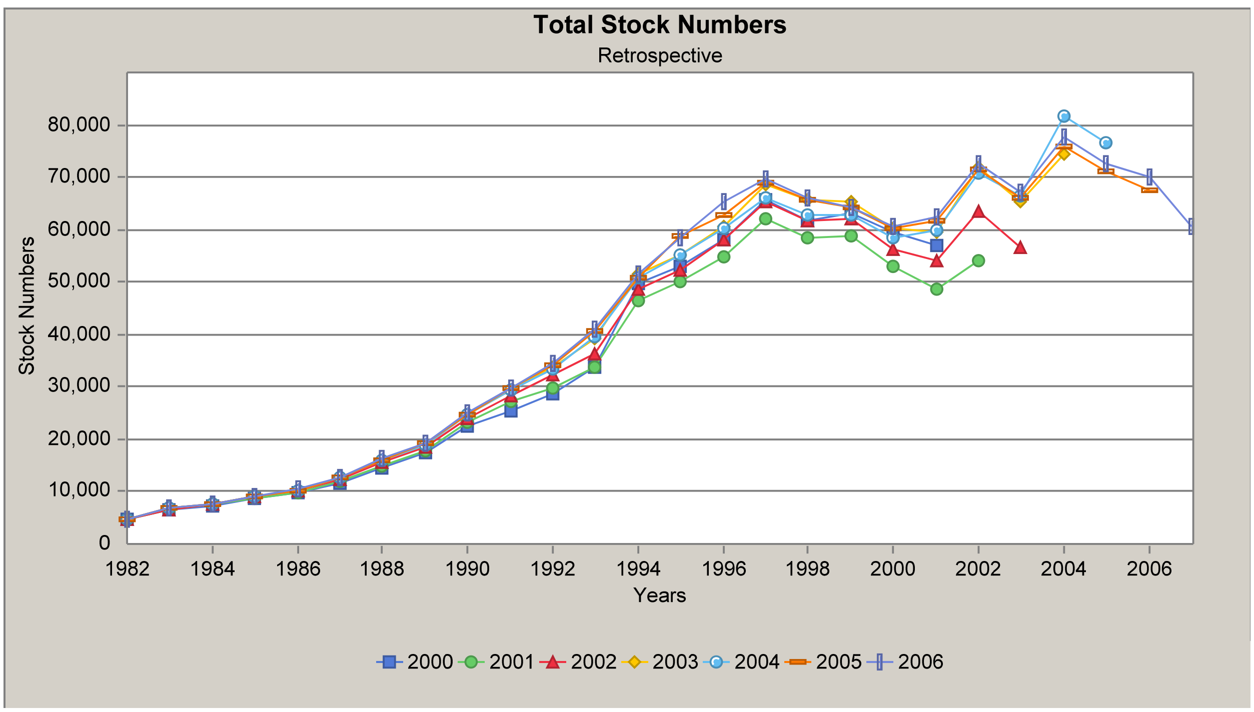
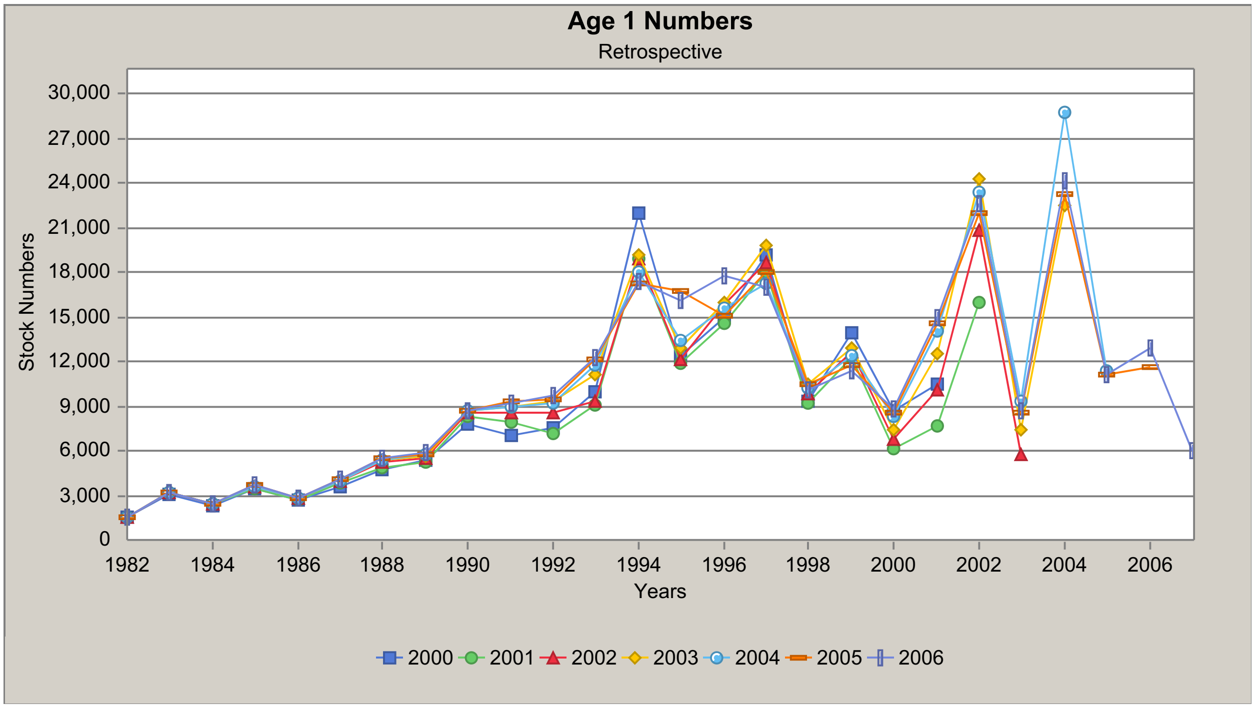




Figure 8. Retrospective plot of average fishing mortality and total stock abundance from ADAPT model using reduced suite of indices



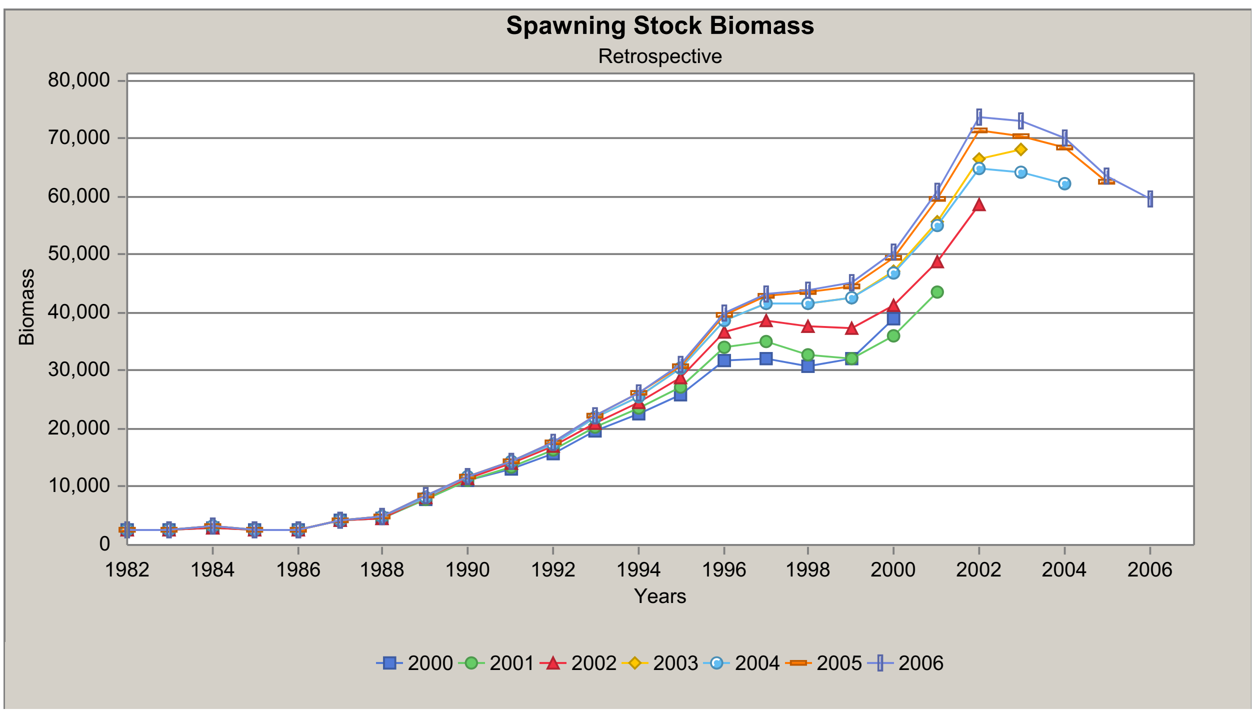




Figure 8 continued.

## Appendix A10. Age-Structured Assessment Program (ASAP)

### Catch at Age and Indices

As an alternative to the ADAPT VPA, a forward projecting catch at age model was evaluated. The model was developed by Legault and Restrepo (1998) and the corresponding software is available in the NMFS Fisheries toolbox as ASAP. The input values from ADAPT were used as initial values for the ASAP model. ASAP allows selectivity and catchability patterns to vary over time. The model was structured to allow greater deviations from the indices than from the catch-at-age data.

### Partial Recruitment Vector

Initial model runs indicated that estimation of selectivity parameters was not reasonable and therefore a selectivity pattern was fixed. Selectivity was calculated from the average F at age in the VPA model from 1982-2004 (PR relative to maximum average F). Full recruitment occurred at age 10 and was 1.0 through ages 13+ (Table 1).

### Model Configuration

$F_{mult}$, recruitment and abundance were allowed to deviate from the fitted model. Effective sample size was fixed at 150 for the time series (Figure 1A) and initial CV for recruitment was 0.5. All available indices were used with the MA commercial CPUE and DE trawl indices down weighted by a factor of 5.

### ASAP model results

The final model configuration produced a residual sum of squares of 0.00178. The model closely predicted catch at age for the combined time series and annual catch when compared to the observed catch (Figure 1B). Annual catch at age predictions were less accurate, particularly in the beginning of the time series (Figure 2). The fishery prior to 1985 produced a bimodal selectivity pattern because of intense fisheries of age 2 fish in Chesapeake Bay. The pattern changed following the closure of that fishery in 1985. Since the selectivity in the model was fixed at the long term average, those early years did not fit the predicted catch well. Similarly, the fixed selectivity pattern created problems when large cohorts dominated the fisheries in recent years (Figure 2).

Predicted indices varied from observed estimates in part due to the level of noise apparent in the index signal (Figure 3). Negative log-likelihood values were lowest for Delaware spawning stock indices at age, MRFSS CPUE and the young of year/age 1 indices (Table 2).

Fishing mortality estimates in ASAP are based on a separability assumption. $F_{MULT}$ is the product of $F$ at age and selectivity. The 2006 $F_{MULT}$ value equals 0.25 (Table 3). The trend in $F$ was a steady increase between 1987 at 0.06 to 1997 when F equaled 0.21 (Table 3). Fishing mortality declined slightly to 0.16 rising above 0.2 only since 2004.

January 1st population sizes show a general increase in overall abundance since 1982 (Table 4). Predicted age 1+ abundance estimates in 1982 were 5.9 million fish increasing to 84.9 million in 2004 and declining to 78.4 million in 2006 (Table 4).

A retrospective analysis back to 2002 showed no retrospective pattern in the estimates of predicted total catch (Figure 4). A retrospective pattern in fishing mortality was apparent in 2002 and to a lesser extent in 2003, with both years overestimating F (Figure 4). However the F estimates for 2004 to 2006 were similar. Similarly, there was an under-estimation of abundance in 2002 and 2003 but negligible thereafter (Figure 5).

**ASAP Summary**

The catch at age model produced similar results as the ADAPT model within the constraints of the selected parameters. Fishing mortality has increased in recent years but remains below the target F, total abundance generally continues to increase although the 8+ abundance has decreased since 2004. The production of large cohorts continues on a regular frequency similar to the pattern seen in the MD juvenile indices from the 1960s.

The ASAP model fits observed data with mixed results. Fixing the selectivity pattern reduces the fit to catch at age in the early years but improves the fit in the latter years. Predicted indices generally captured the trend in observed indices but not the magnitude, particularly with young of year indices. This is in part due to fitting age one abundance to indices from multiple stocks/spawning areas. The trend in abundance and fishing mortality are relatively robust to starting values with the exception of fixed selectivity pattern.

**Appendix A10 Tables**

Table 1. Selectivity at age used as a fix input to ASAP catch at age model.

| Age | Selectivity |
|---|---|
| 1 | 0.01 |
| 2 | 0.14 |
| 3 | 0.34 |
| 4 | 0.47 |
| 5 | 0.61 |
| 6 | 0.67 |
| 7 | 0.73 |
| 8 | 0.82 |
| 9 | 0.92 |
| 10 | 1.00 |
| 11 | 1.00 |
| 12 | 1.00 |
| 13 | 1.00 |

Table 2. Residual sum of squares, number of years, lambda, and log likelihood values of indices used is ASAP catch at age model. Values weighted by lambda, consequently the likelihoods of low weighted values are smaller.

| Index | RSS | N | lambda | likelihood |
|---|---|---|---|---|
| MACOM5 | 3.646 | 16 | 5 | 9.11 |
| MACOM6 | 1.960 | 16 | 5 | 4.90 |
| MACOM7 | 1.443 | 16 | 5 | 3.61 |
| MACOM8 | 2.379 | 16 | 5 | 5.95 |
| MACOM9 | 4.538 | 16 | 5 | 11.35 |
| MACOM10 | 6.675 | 16 | 5 | 16.69 |
| MACOM11 | 3.406 | 16 | 5 | 8.51 |
| MACOM12 | 2.880 | 16 | 5 | 7.20 |
| MACOM13+ | 10.242 | 16 | 5 | 25.60 |
| MDSSN3 | 16.159 | 22 | 25 | 201.99 |
| MDSSN4 | 15.620 | 22 | 25 | 195.25 |
| MDSSN5 | 9.464 | 22 | 25 | 118.30 |
| MDSSN6 | 10.464 | 22 | 25 | 130.80 |
| MDSSN7 | 10.897 | 22 | 25 | 136.22 |
| MDSSN8 | 17.777 | 20 | 25 | 222.21 |
| MDSSN9 | 20.794 | 21 | 25 | 259.92 |
| MDSSN10 | 18.279 | 19 | 25 | 228.48 |
| MDSSN11 | 10.416 | 17 | 25 | 130.20 |
| MDSSN12 | 7.298 | 16 | 25 | 91.23 |
| MDSSN13+ | 13.222 | 21 | 25 | 165.27 |
| NYOHS3 | 8.685 | 19 | 25 | 108.57 |
| NYOHS4 | 7.720 | 19 | 25 | 96.50 |
| NYOHS5 | 9.637 | 19 | 25 | 120.46 |
| NYOHS6 | 8.853 | 18 | 25 | 110.67 |
| NYOHS7 | 9.833 | 19 | 25 | 122.91 |
| NYOHS8 | 14.846 | 19 | 25 | 185.57 |
| NYOHS9 | 9.808 | 19 | 25 | 122.59 |
| YOYNY | 17.354 | 25 | 25 | 216.93 |
| YOYNJ | 10.080 | 24 | 25 | 126.01 |
| YOYMD | 7.169 | 25 | 25 | 89.62 |
| YOYVA | 5.249 | 25 | 25 | 65.61 |
| YRLLI | 5.701 | 21 | 25 | 71.26 |

| Index | RSS | N | lambda | likelihood |
|---|---|---|---|---|
| YRLMD | 7.054 | 24 | 25 | 88.17 |
| NEFSC2-9 | 4.808 | 16 | 25 | 60.10 |
| CTTRL4-6 | 9.176 | 21 | 25 | 114.71 |
| DETRWL2-8 | 49.128 | 19 | 5 | 122.82 |
| DESSN2 | 8.526 | 10 | 25 | 106.58 |
| DESSN3 | 2.086 | 11 | 25 | 26.08 |
| DESSN4 | 1.461 | 11 | 25 | 18.26 |
| DESSN5 | 1.166 | 11 | 25 | 14.57 |
| DESSN6 | 0.452 | 11 | 25 | 5.65 |
| DESSN7 | 1.273 | 11 | 25 | 15.92 |
| DESSN8 | 1.836 | 11 | 25 | 22.95 |
| DESSN9 | 2.371 | 11 | 25 | 29.64 |
| DESSN10 | 1.201 | 11 | 25 | 15.01 |
| NJTRL2 | 29.238 | 18 | 25 | 365.47 |
| NJTRL3 | 15.698 | 18 | 25 | 196.22 |
| NJTRL4 | 12.392 | 17 | 25 | 154.90 |
| NJTRL5 | 14.918 | 18 | 25 | 186.48 |
| NJTRL6 | 13.220 | 18 | 25 | 165.25 |
| NJTRL7 | 10.568 | 17 | 25 | 132.10 |
| NJTRL8 | 11.215 | 17 | 25 | 140.19 |
| NJTRL9 | 11.056 | 15 | 25 | 138.20 |
| MRFSS2-13 | 1.378 | 19 | 25 | 17.22 |
| CTCPUE2 | 27.601 | 24 | 25 | 345.01 |
| CTCPUE3 | 25.242 | 25 | 25 | 315.52 |
| CTCPUE4 | 4.224 | 25 | 25 | 52.79 |
| CTCPUE5 | 7.319 | 25 | 25 | 91.48 |
| CTCPUE6 | 10.155 | 25 | 25 | 126.94 |
| CTCPUE7 | 9.601 | 25 | 25 | 120.02 |
| CTCPUE8 | 5.944 | 24 | 25 | 74.30 |
| CTCPUE9 | 4.606 | 23 | 25 | 57.57 |
| CTCPUE10 | 13.838 | 25 | 25 | 172.97 |
| Total | 621.242 | 1176 | 1375 | 6902.57 |

Table 3. Fishing mortality estimates from ASAP catch at age model. $F_{mult}$ equals F at age 10.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 0.00 | 0.04 | 0.11 | 0.15 | 0.19 | 0.21 | 0.23 | 0.26 | 0.29 | 0.32 | 0.32 | 0.32 | 0.32 |
| **1983** | 0.00 | 0.04 | 0.10 | 0.14 | 0.18 | 0.20 | 0.22 | 0.24 | 0.27 | 0.30 | 0.30 | 0.30 | 0.30 |
| **1984** | 0.00 | 0.04 | 0.09 | 0.13 | 0.17 | 0.18 | 0.20 | 0.23 | 0.25 | 0.27 | 0.27 | 0.27 | 0.27 |
| **1985** | 0.00 | 0.02 | 0.05 | 0.07 | 0.09 | 0.10 | 0.11 | 0.12 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 |
| **1986** | 0.00 | 0.02 | 0.04 | 0.05 | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 |
| **1987** | 0.00 | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 |
| **1988** | 0.00 | 0.01 | 0.03 | 0.04 | 0.05 | 0.06 | 0.06 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| **1989** | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| **1990** | 0.00 | 0.01 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 |
| **1991** | 0.00 | 0.01 | 0.03 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 |
| **1992** | 0.00 | 0.01 | 0.03 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 |
| **1993** | 0.00 | 0.01 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 |
| **1994** | 0.00 | 0.02 | 0.04 | 0.05 | 0.07 | 0.08 | 0.08 | 0.09 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 |
| **1995** | 0.00 | 0.02 | 0.05 | 0.07 | 0.09 | 0.10 | 0.11 | 0.13 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 |
| **1996** | 0.00 | 0.02 | 0.06 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 |
| **1997** | 0.00 | 0.03 | 0.07 | 0.10 | 0.13 | 0.14 | 0.15 | 0.17 | 0.19 | 0.21 | 0.21 | 0.21 | 0.21 |
| **1998** | 0.00 | 0.03 | 0.06 | 0.09 | 0.11 | 0.12 | 0.13 | 0.15 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 |
| **1999** | 0.00 | 0.02 | 0.05 | 0.08 | 0.10 | 0.11 | 0.12 | 0.13 | 0.15 | 0.16 | 0.16 | 0.16 | 0.16 |
| **2000** | 0.00 | 0.02 | 0.06 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 |
| **2001** | 0.00 | 0.02 | 0.06 | 0.08 | 0.10 | 0.11 | 0.12 | 0.14 | 0.15 | 0.17 | 0.17 | 0.17 | 0.17 |
| **2002** | 0.00 | 0.02 | 0.06 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.16 | 0.18 | 0.18 | 0.18 | 0.18 |
| **2003** | 0.00 | 0.03 | 0.06 | 0.09 | 0.11 | 0.13 | 0.14 | 0.15 | 0.17 | 0.19 | 0.19 | 0.19 | 0.19 |
| **2004** | 0.00 | 0.03 | 0.07 | 0.10 | 0.13 | 0.14 | 0.15 | 0.17 | 0.19 | 0.21 | 0.21 | 0.21 | 0.21 |
| **2005** | 0.00 | 0.03 | 0.07 | 0.10 | 0.13 | 0.15 | 0.16 | 0.18 | 0.20 | 0.22 | 0.22 | 0.22 | 0.22 |
| **2006** | 0.00 | 0.03 | 0.08 | 0.12 | 0.15 | 0.17 | 0.18 | 0.20 | 0.23 | 0.25 | 0.25 | 0.25 | 0.25 |

Table 4. Population estimates (000s) from ASAP catch at age model.

Jan. 1 Abundance estimates

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | total | 8+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 2,059 | 1,217 | 821 | 560 | 535 | 187 | 49 | 47 | 36 | 46 | 94 | 111 | 106 | 5,869 | 441 |
| **1983** | 5,745 | 1,766 | 1,002 | 634 | 415 | 379 | 130 | 33 | 31 | 23 | 29 | 59 | 136 | 10,383 | 311 |
| **1984** | 3,937 | 4,930 | 1,458 | 779 | 475 | 297 | 267 | 90 | 23 | 21 | 15 | 18 | 124 | 12,434 | 291 |
| **1985** | 4,483 | 3,380 | 4,083 | 1,143 | 589 | 345 | 213 | 188 | 62 | 15 | 13 | 10 | 93 | 14,618 | 381 |
| **1986** | 3,918 | 3,853 | 2,849 | 3,341 | 917 | 463 | 269 | 164 | 143 | 46 | 11 | 10 | 76 | 16,062 | 452 |
| **1987** | 4,492 | 3,369 | 3,267 | 2,363 | 2,733 | 739 | 371 | 214 | 129 | 112 | 36 | 9 | 67 | 17,899 | 566 |
| **1988** | 5,801 | 3,864 | 2,876 | 2,757 | 1,980 | 2,271 | 612 | 306 | 176 | 106 | 91 | 29 | 61 | 20,931 | 769 |
| **1989** | 6,543 | 4,989 | 3,287 | 2,407 | 2,283 | 1,620 | 1,850 | 496 | 246 | 140 | 84 | 72 | 72 | 24,088 | 1,109 |
| **1990** | 8,844 | 5,628 | 4,255 | 2,767 | 2,009 | 1,888 | 1,335 | 1,518 | 405 | 200 | 113 | 68 | 116 | 29,146 | 2,419 |
| **1991** | 7,978 | 7,604 | 4,774 | 3,534 | 2,267 | 1,622 | 1,515 | 1,064 | 1,199 | 316 | 155 | 88 | 142 | 32,256 | 2,964 |
| **1992** | 7,605 | 6,859 | 6,453 | 3,970 | 2,900 | 1,835 | 1,305 | 1,211 | 843 | 940 | 246 | 120 | 179 | 34,466 | 3,539 |
| **1993** | 10,758 | 6,540 | 5,837 | 5,403 | 3,289 | 2,376 | 1,496 | 1,058 | 975 | 674 | 746 | 195 | 237 | 39,583 | 3,885 |
| **1994** | 20,660 | 9,250 | 5,546 | 4,846 | 4,423 | 2,653 | 1,904 | 1,191 | 835 | 761 | 521 | 577 | 335 | 53,501 | 4,220 |
| **1995** | 13,814 | 17,762 | 7,833 | 4,589 | 3,950 | 3,548 | 2,113 | 1,506 | 932 | 646 | 584 | 400 | 699 | 58,376 | 4,767 |
| **1996** | 16,315 | 11,871 | 14,962 | 6,399 | 3,675 | 3,095 | 2,755 | 1,626 | 1,143 | 697 | 477 | 431 | 811 | 64,255 | 5,183 |
| **1997** | 17,437 | 14,018 | 9,973 | 12,142 | 5,077 | 2,846 | 2,373 | 2,090 | 1,214 | 839 | 504 | 345 | 899 | 69,756 | 5,891 |
| **1998** | 10,002 | 14,976 | 11,713 | 7,989 | 9,462 | 3,841 | 2,126 | 1,750 | 1,512 | 860 | 584 | 351 | 867 | 66,035 | 5,925 |
| **1999** | 11,614 | 8,593 | 12,562 | 9,469 | 6,305 | 7,278 | 2,922 | 1,599 | 1,295 | 1,099 | 616 | 418 | 872 | 64,642 | 5,899 |
| **2000** | 8,955 | 9,980 | 7,231 | 10,238 | 7,558 | 4,921 | 5,626 | 2,237 | 1,207 | 962 | 805 | 451 | 946 | 61,116 | 6,608 |
| **2001** | 15,695 | 7,694 | 8,384 | 5,867 | 8,121 | 5,852 | 3,770 | 4,266 | 1,670 | 885 | 696 | 583 | 1,011 | 64,494 | 9,110 |
| **2002** | 22,175 | 13,486 | 6,469 | 6,818 | 4,669 | 6,313 | 4,503 | 2,873 | 3,202 | 1,233 | 645 | 507 | 1,161 | 74,053 | 9,619 |
| **2003** | 9,717 | 19,053 | 11,325 | 5,245 | 5,402 | 3,609 | 4,829 | 3,408 | 2,140 | 2,343 | 890 | 465 | 1,203 | 69,629 | 10,450 |
| **2004** | 29,220 | 8,348 | 15,974 | 9,146 | 4,133 | 4,147 | 2,740 | 3,625 | 2,516 | 1,550 | 1,672 | 635 | 1,191 | 84,896 | 11,189 |
| **2005** | 14,204 | 25,097 | 6,976 | 12,798 | 7,129 | 3,128 | 3,099 | 2,022 | 2,625 | 1,784 | 1,081 | 1,166 | 1,273 | 82,382 | 9,950 |
| **2006** | 12,743 | 12,199 | 20,952 | 5,575 | 9,943 | 5,373 | 2,327 | 2,275 | 1,456 | 1,849 | 1,235 | 748 | 1,688 | 78,361 | 9,250 |

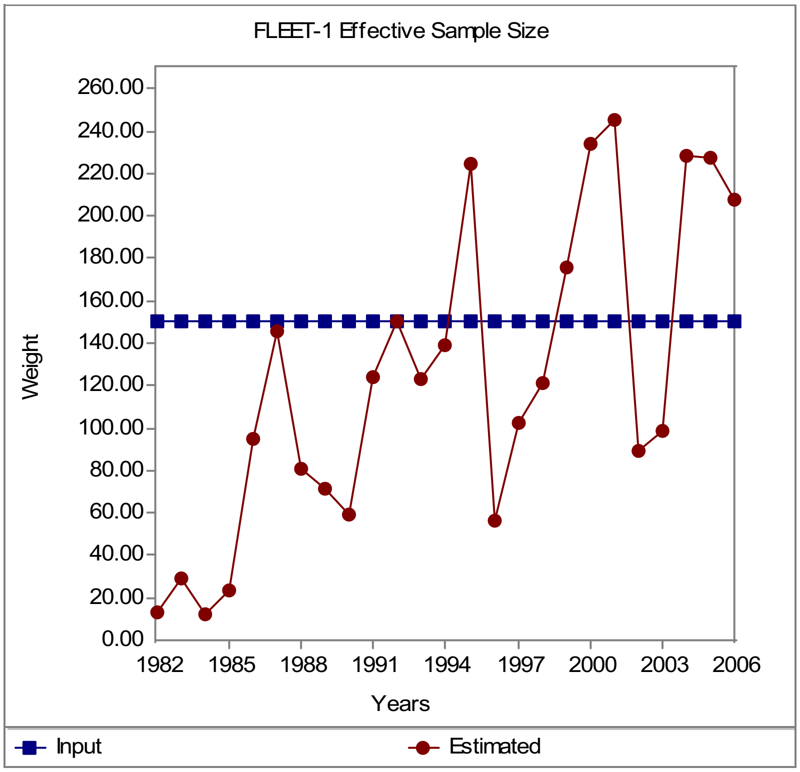
Table 5. Average biomass (MT) from ASAP catch at age model.

Average Biomass (mt)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 268 | 779 | 895 | 862 | 1,295 | 702 | 237 | 274 | 222 | 397 | 1,019 | 1,245 | 1,491 |
| **1983** | 1,149 | 971 | 942 | 869 | 983 | 1,247 | 491 | 179 | 189 | 186 | 274 | 613 | 1,510 |
| **1984** | 945 | 2,958 | 2,464 | 1,262 | 1,267 | 1,008 | 1,354 | 509 | 152 | 159 | 123 | 231 | 1,541 |
| **1985** | 269 | 2,062 | 4,369 | 1,897 | 1,291 | 1,240 | 1,046 | 1,027 | 419 | 112 | 121 | 103 | 1,298 |
| **1986** | 549 | 2,196 | 3,618 | 8,018 | 2,238 | 1,445 | 1,063 | 830 | 780 | 283 | 87 | 91 | 976 |
| **1987** | 898 | 2,594 | 4,606 | 4,987 | 6,832 | 2,151 | 1,338 | 1,014 | 715 | 725 | 279 | 84 | 877 |
| **1988** | 1,798 | 3,516 | 3,164 | 5,460 | 6,178 | 9,131 | 2,681 | 1,438 | 921 | 594 | 779 | 303 | 812 |
| **1989** | 1,047 | 4,141 | 4,010 | 5,367 | 6,985 | 7,340 | 9,932 | 3,090 | 1,487 | 1,216 | 749 | 700 | 956 |
| **1990** | 707 | 5,009 | 4,851 | 5,673 | 4,722 | 7,232 | 6,556 | 9,048 | 2,307 | 1,191 | 841 | 613 | 1,458 |
| **1991** | 1,675 | 6,996 | 6,158 | 7,668 | 5,940 | 5,142 | 7,286 | 6,003 | 7,744 | 1,973 | 1,463 | 727 | 2,019 |
| **1992** | 760 | 4,733 | 8,453 | 7,662 | 8,150 | 6,733 | 6,393 | 7,012 | 5,869 | 7,662 | 2,404 | 1,496 | 2,495 |
| **1993** | 753 | 4,970 | 7,647 | 10,751 | 9,110 | 8,505 | 7,178 | 6,466 | 6,856 | 5,395 | 7,110 | 2,101 | 3,451 |
| **1994** | 4,958 | 9,712 | 9,372 | 10,709 | 12,606 | 9,285 | 9,406 | 7,384 | 5,676 | 5,731 | 5,071 | 6,171 | 4,259 |
| **1995** | 3,868 | 12,433 | 10,575 | 10,005 | 10,941 | 12,949 | 11,368 | 9,278 | 6,778 | 5,723 | 4,417 | 3,888 | 11,648 |
| **1996** | 2,284 | 12,465 | 21,994 | 14,845 | 11,869 | 13,991 | 17,602 | 11,558 | 8,925 | 6,409 | 4,438 | 4,350 | 11,110 |
| **1997** | 2,267 | 8,691 | 11,768 | 29,870 | 14,267 | 10,359 | 10,700 | 10,594 | 8,170 | 7,692 | 5,013 | 3,534 | 13,284 |
| **1998** | 3,901 | 11,532 | 14,056 | 12,942 | 21,290 | 11,332 | 9,971 | 9,905 | 10,314 | 6,048 | 4,535 | 3,468 | 10,287 |
| **1999** | 7,201 | 7,733 | 13,944 | 13,636 | 12,043 | 18,268 | 9,818 | 8,045 | 8,495 | 8,624 | 5,351 | 4,083 | 10,444 |
| **2000** | 3,313 | 5,489 | 7,955 | 14,845 | 14,814 | 13,729 | 21,883 | 11,386 | 8,581 | 7,087 | 7,811 | 4,830 | 12,815 |
| **2001** | 2,511 | 2,924 | 9,390 | 10,268 | 17,948 | 19,017 | 15,533 | 21,413 | 10,621 | 6,897 | 6,018 | 4,830 | 10,988 |
| **2002** | 2,661 | 4,181 | 6,858 | 10,295 | 10,178 | 20,013 | 18,869 | 15,742 | 19,306 | 9,319 | 5,862 | 4,940 | 13,371 |
| **2003** | 972 | 11,432 | 11,325 | 7,342 | 11,884 | 11,549 | 19,798 | 17,724 | 13,054 | 16,873 | 7,561 | 4,375 | 13,237 |
| **2004** | 6,721 | 2,755 | 13,418 | 12,804 | 10,044 | 12,898 | 11,343 | 18,740 | 15,270 | 11,037 | 13,679 | 5,732 | 12,754 |
| **2005** | 1,830 | 11,816 | 7,009 | 19,111 | 14,915 | 9,607 | 12,047 | 10,911 | 16,083 | 11,862 | 8,514 | 10,364 | 13,674 |
| **2006** | 1,511 | 4,270 | 13,869 | 6,462 | 18,592 | 14,510 | 9,393 | 11,005 | 8,977 | 12,906 | 9,981 | 6,692 | 18,689 |

**Appendix A10 Figures**

A.




B.

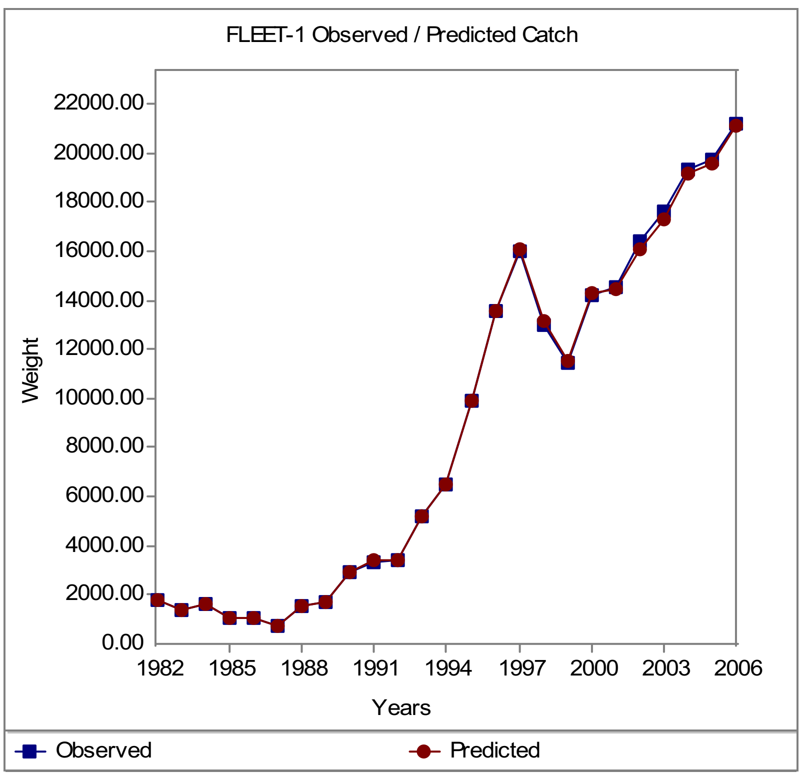
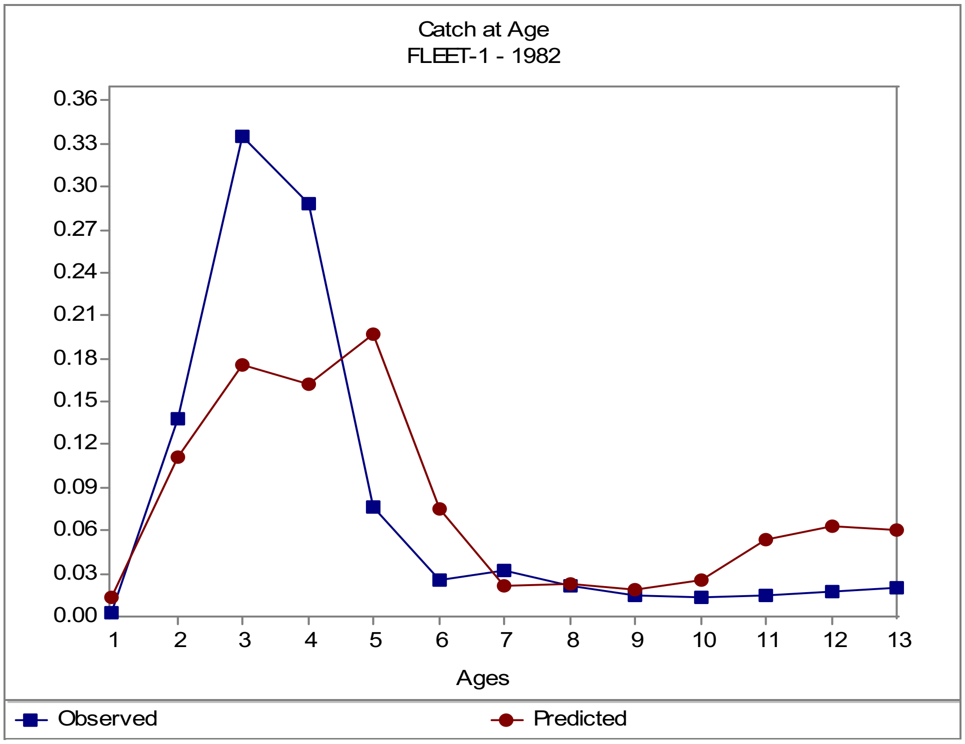



Figure 1. (A) Effective sample size and (B) observed and predicted catch biomass from ASAP catch at age model.



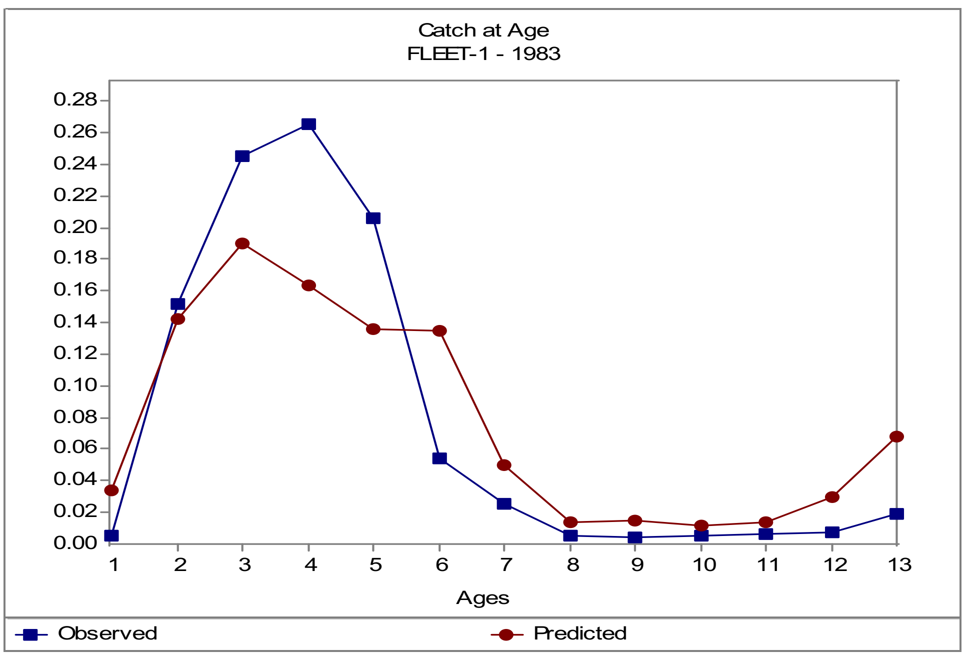
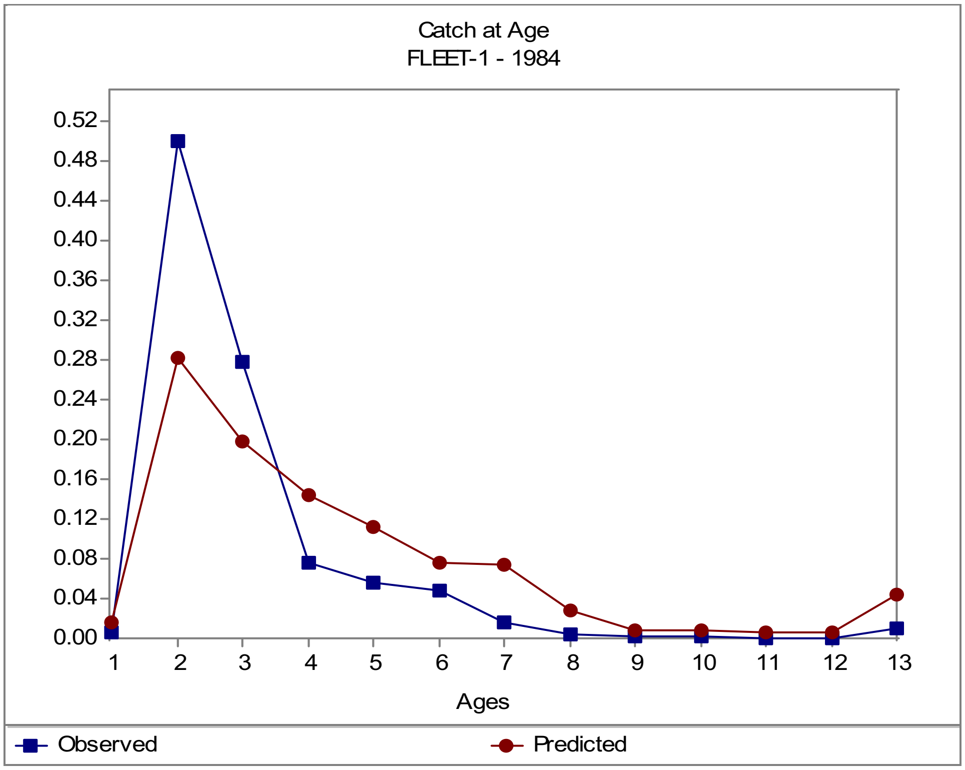




Figure 2. Comparison of observed and predicted proportions-at-age from the ASAP model.



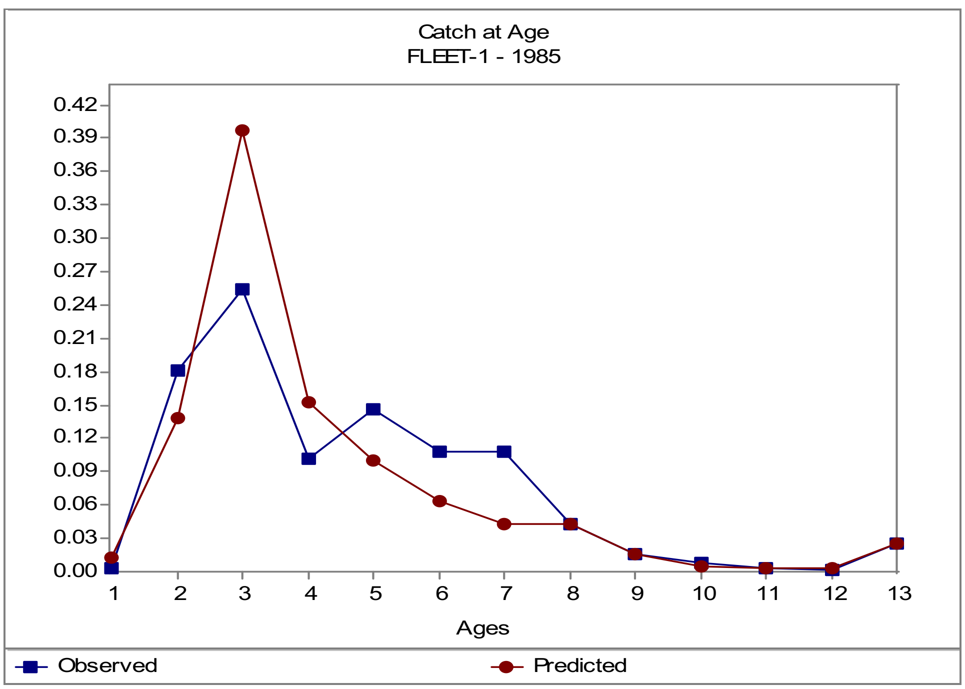
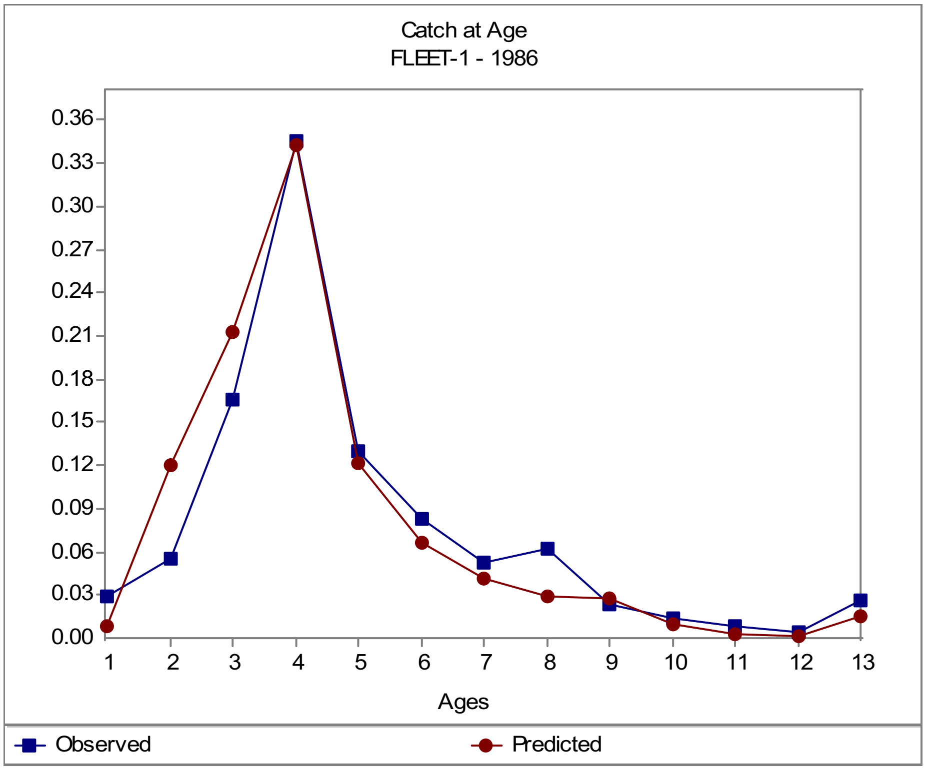




Figure 2 continued.



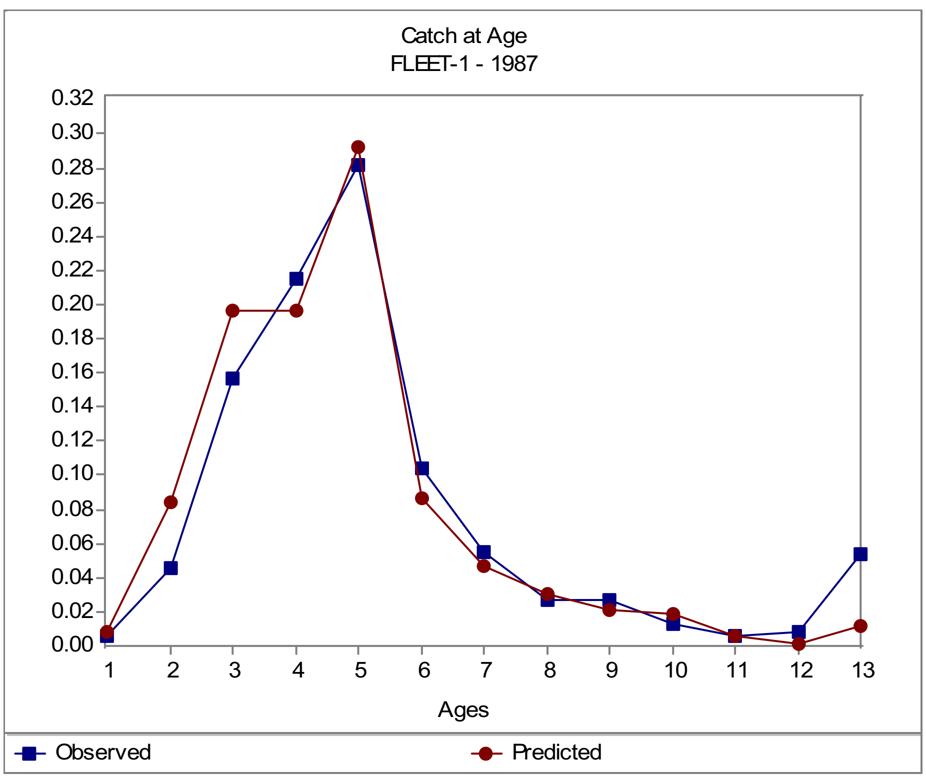
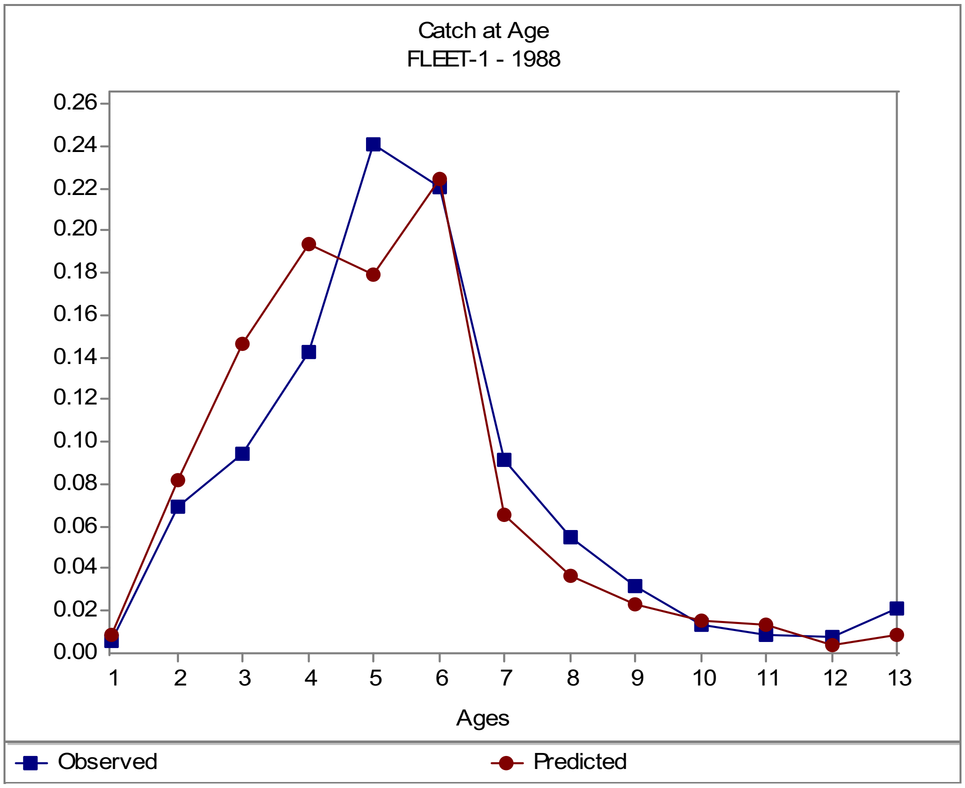




Figure 2 continued.



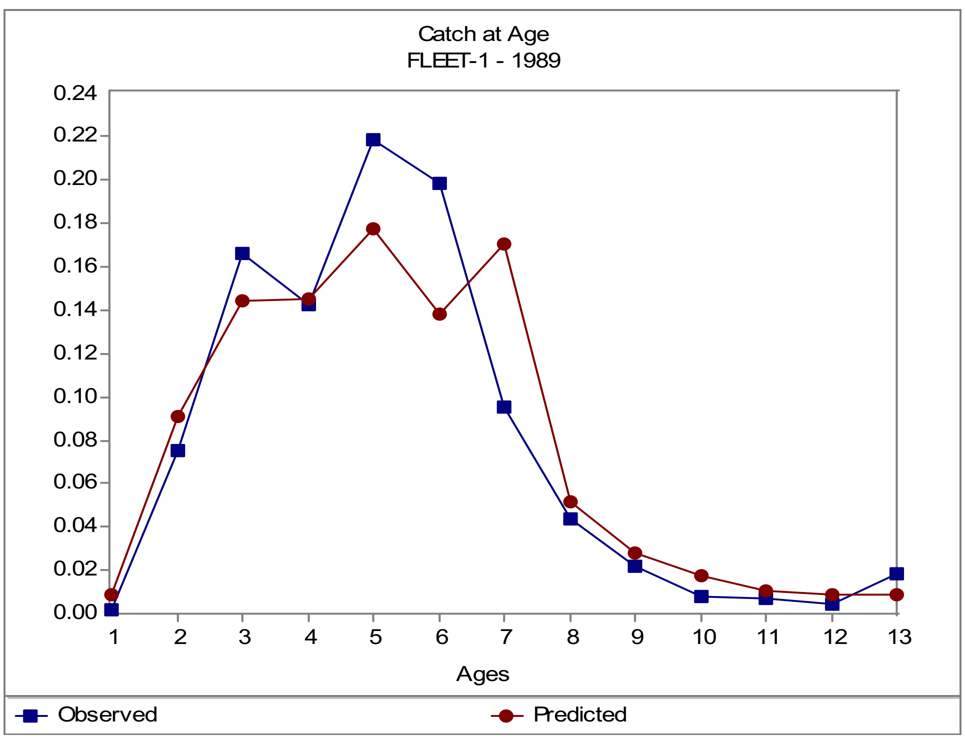
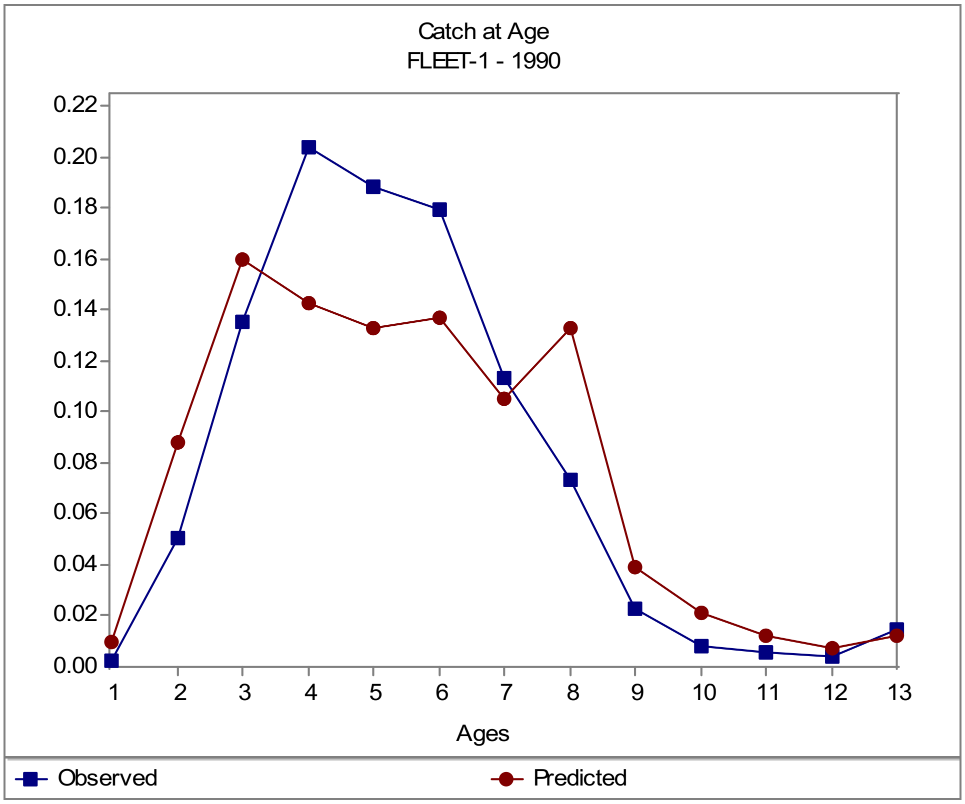




Figure 2 continued.



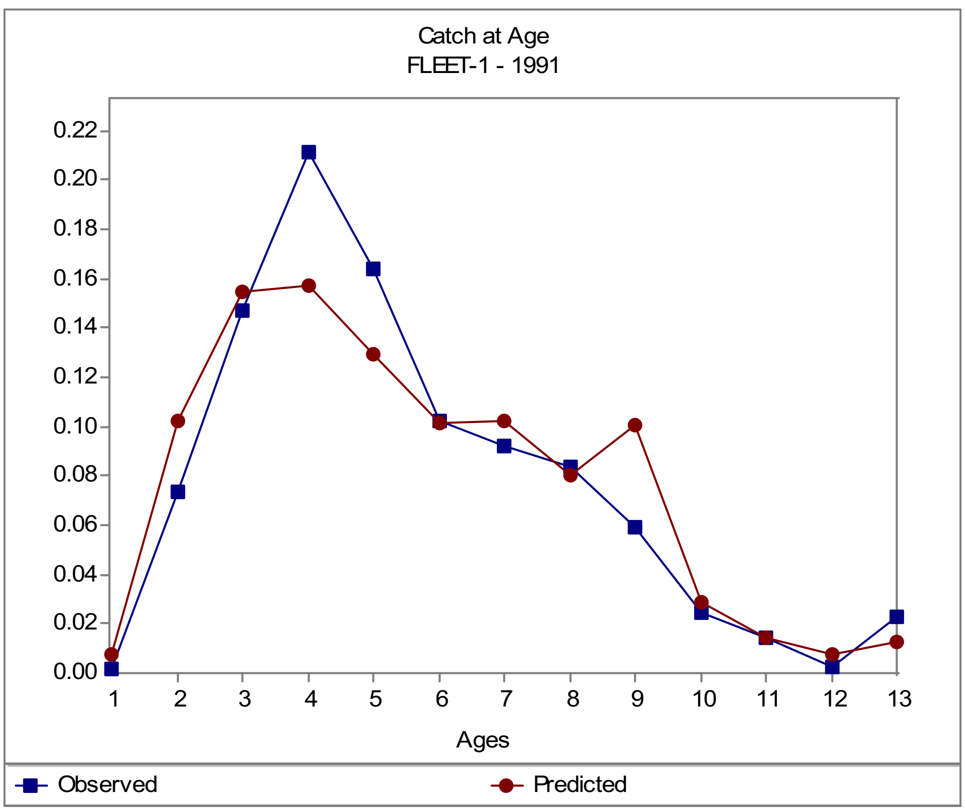
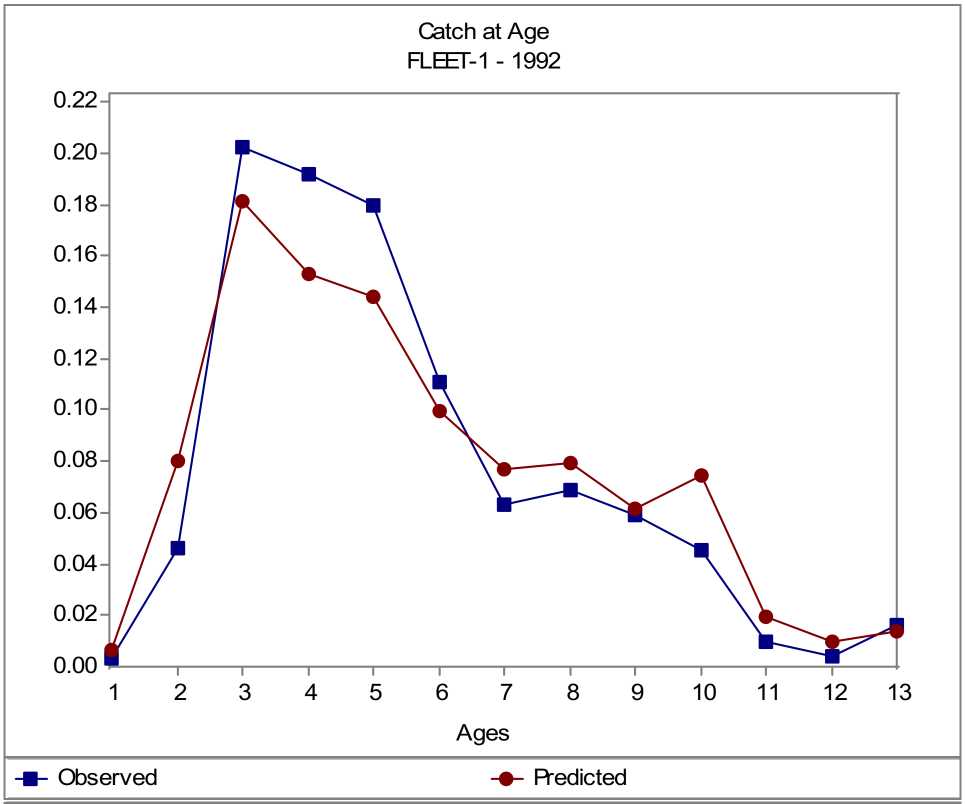




Figure 2 continued.



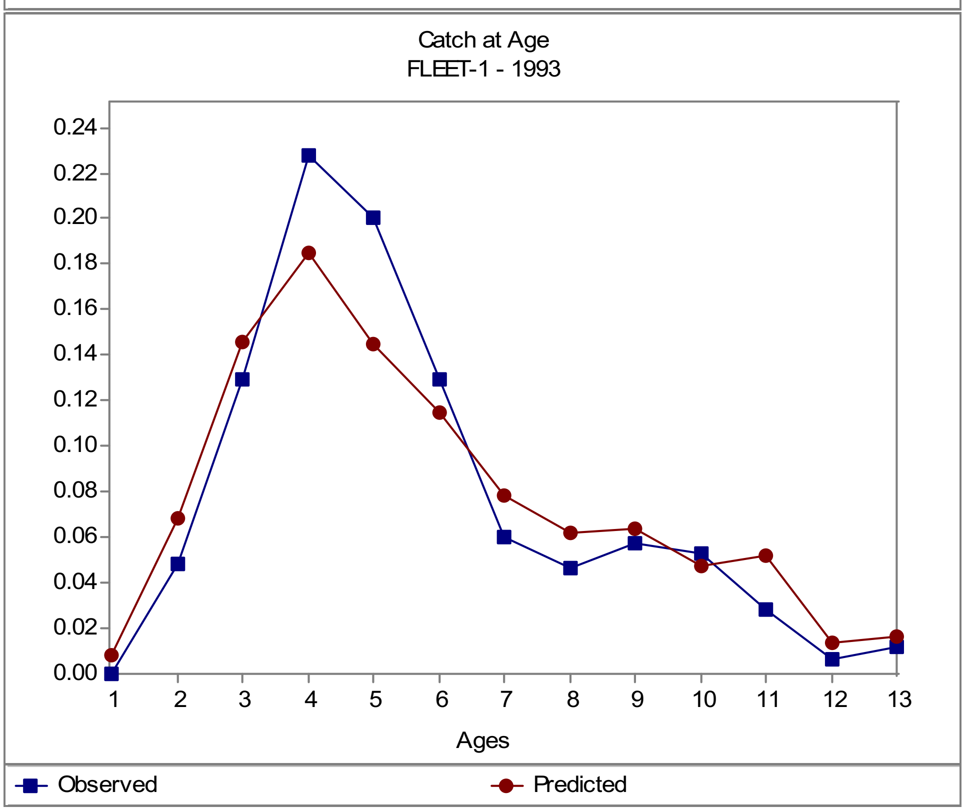
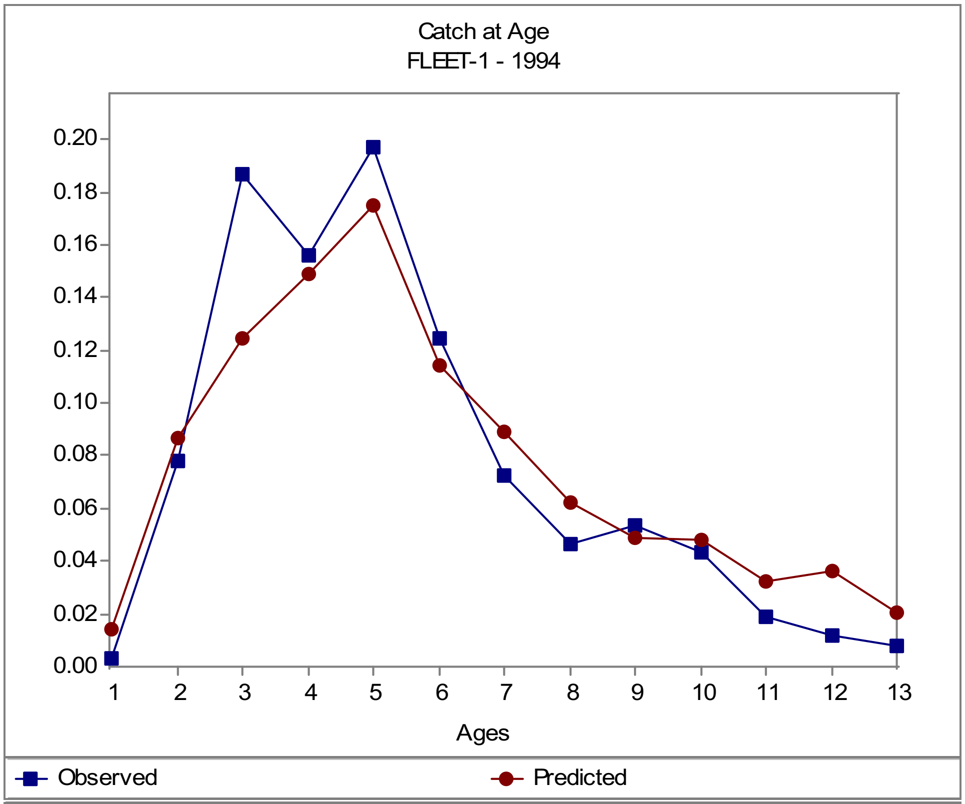




Figure 2 continued.



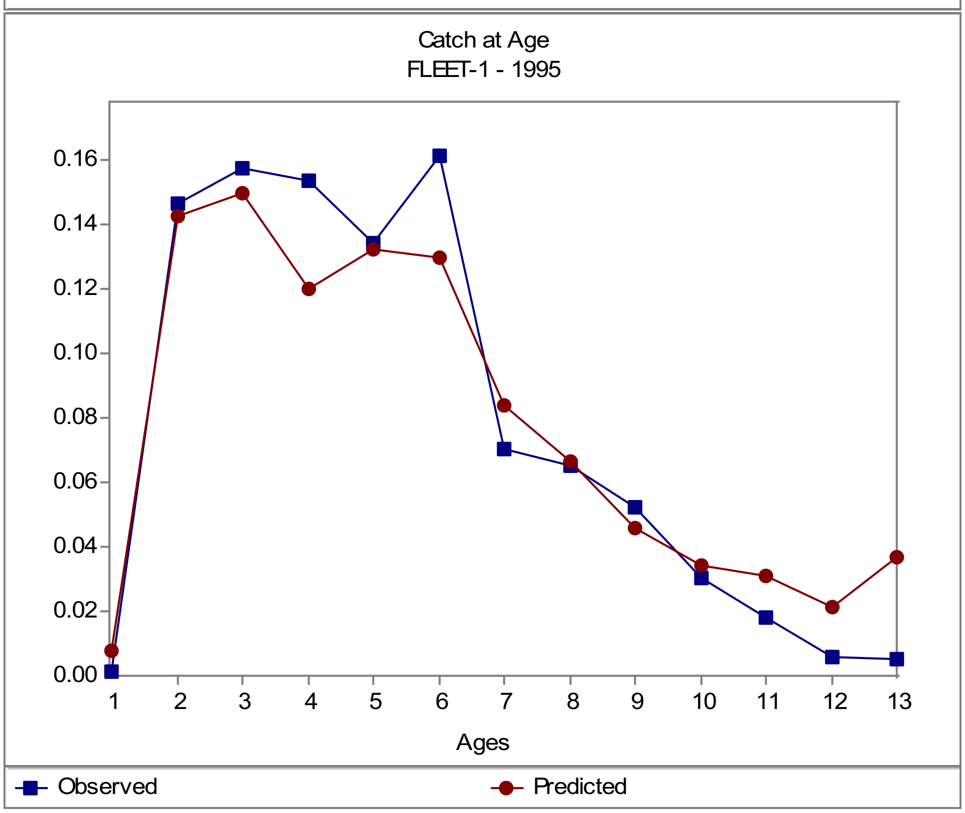




Figure 2 continued.

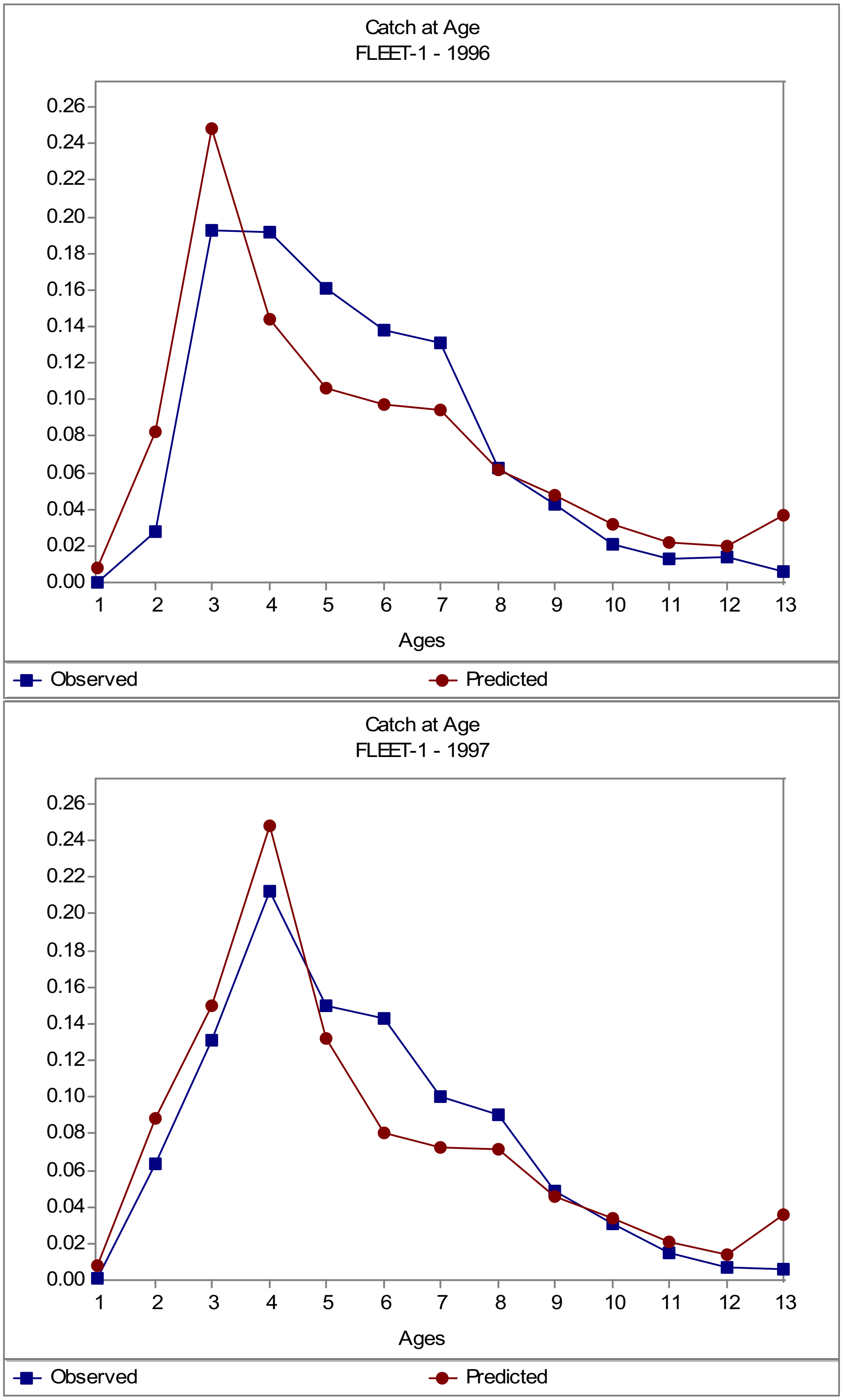
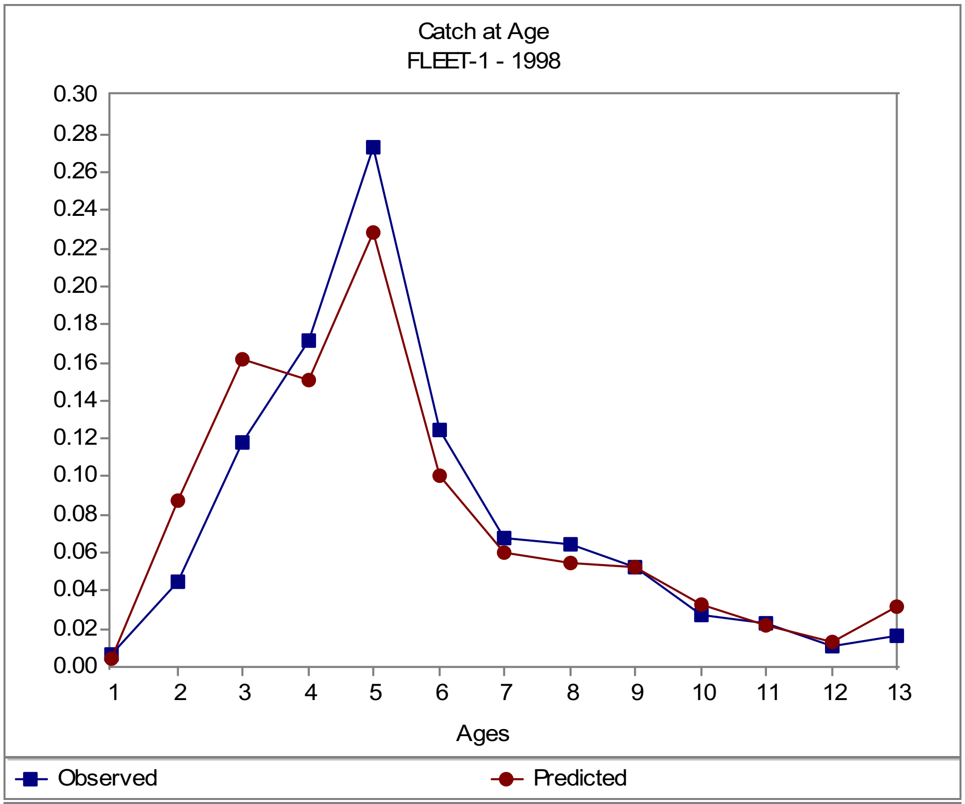



Figure 2 continued.



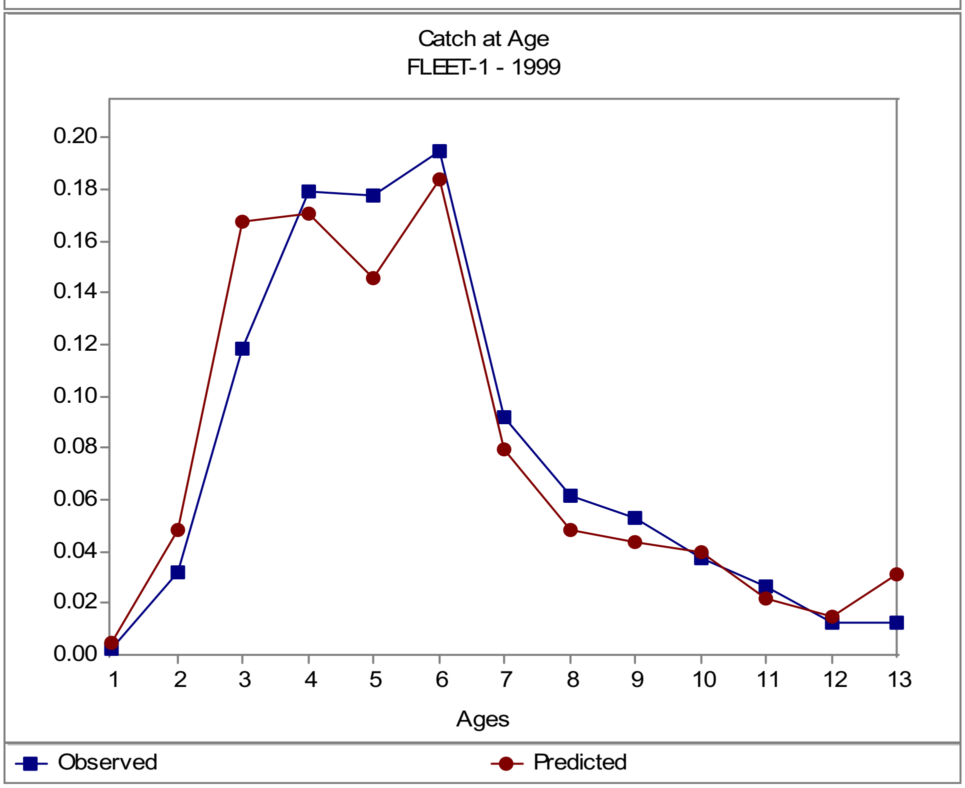
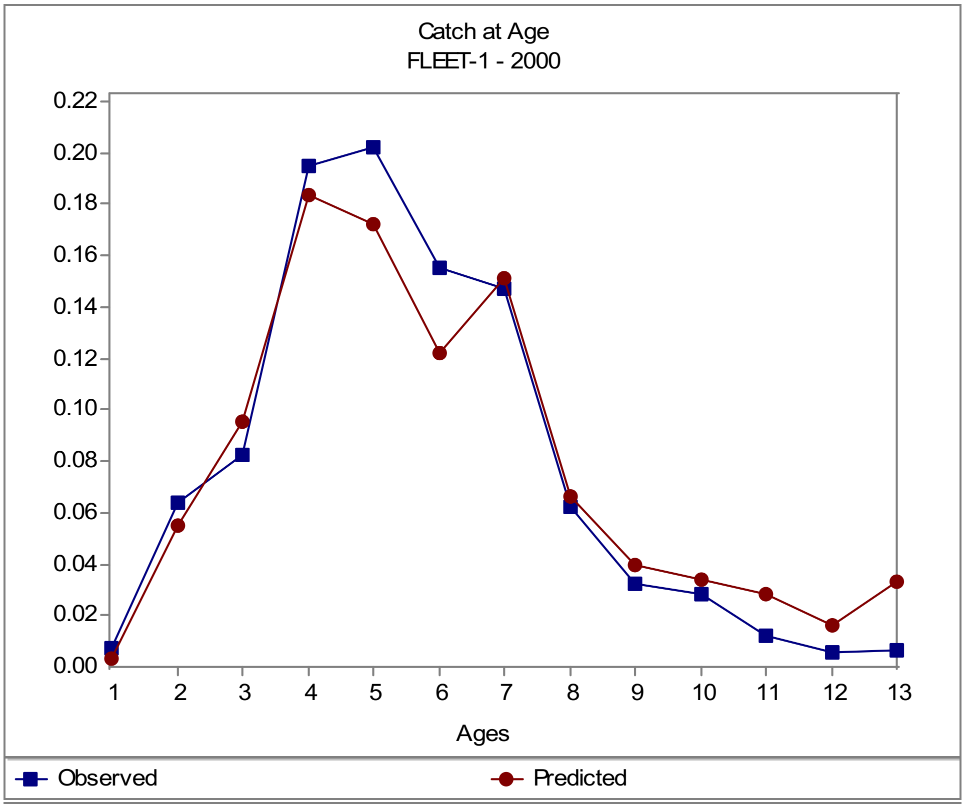
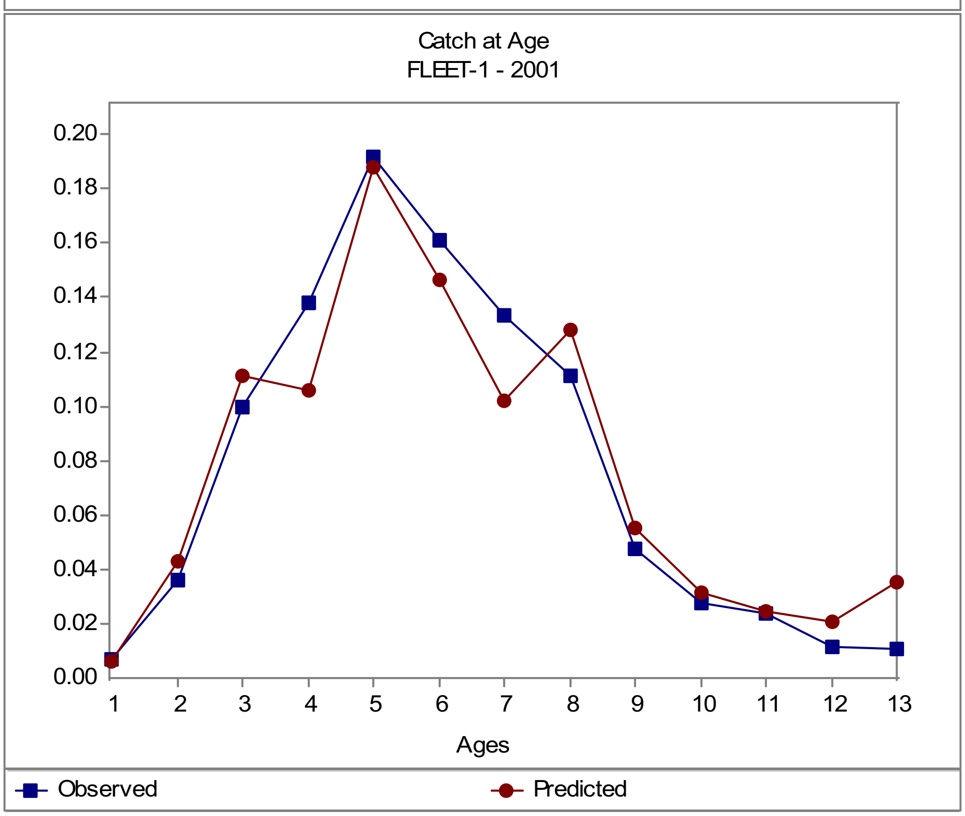




Figure 2 continued.

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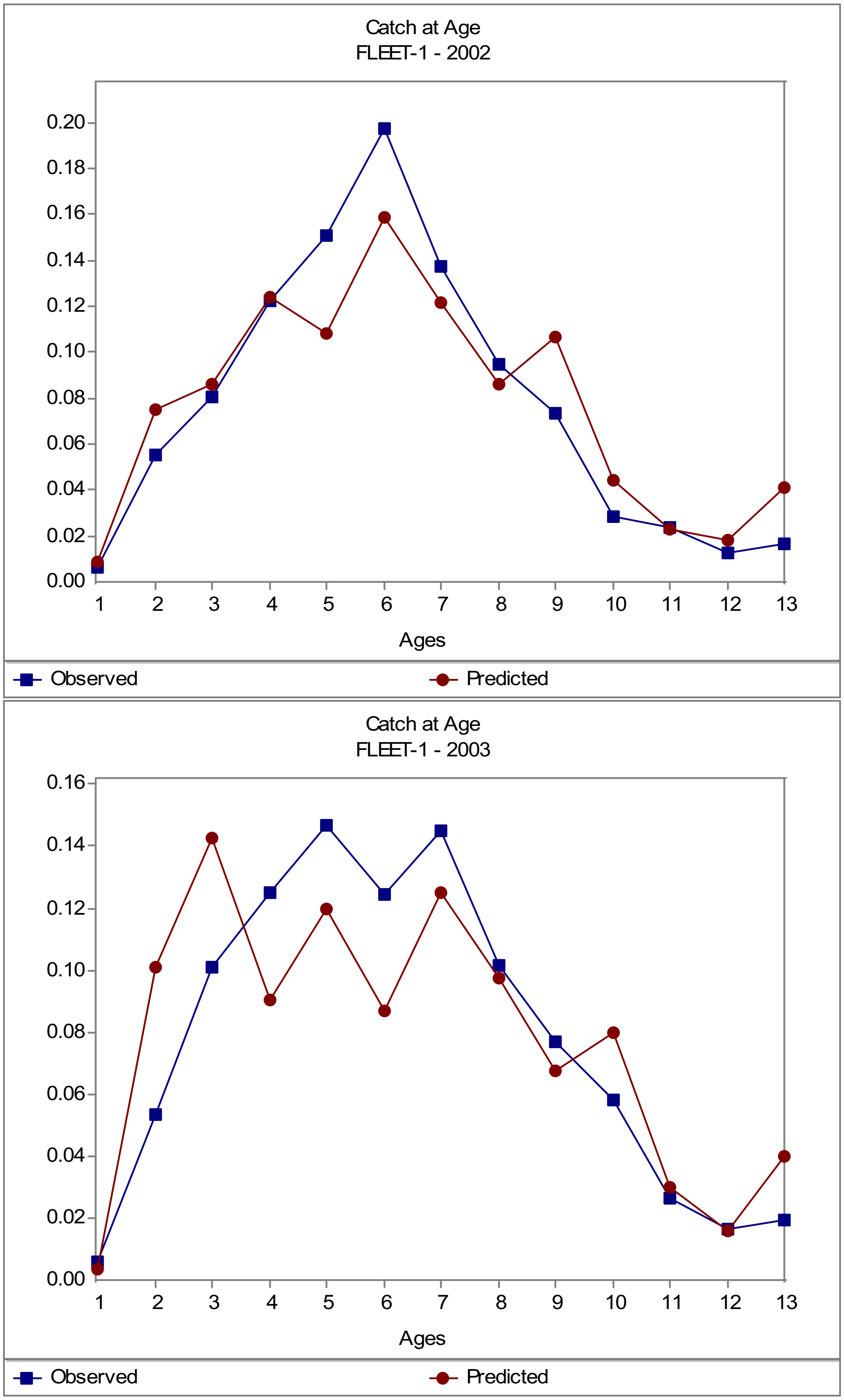
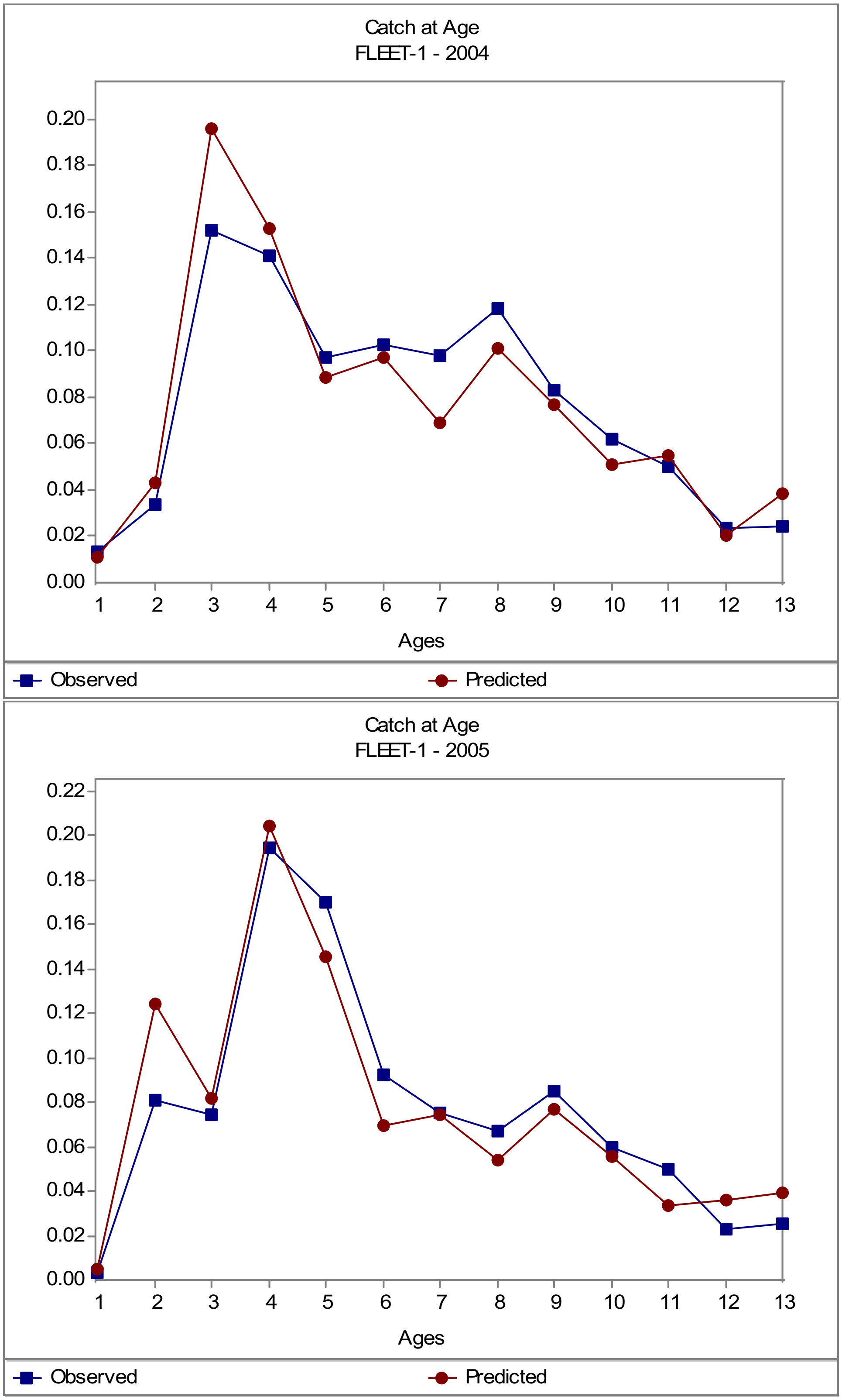



Figure 2 continued.

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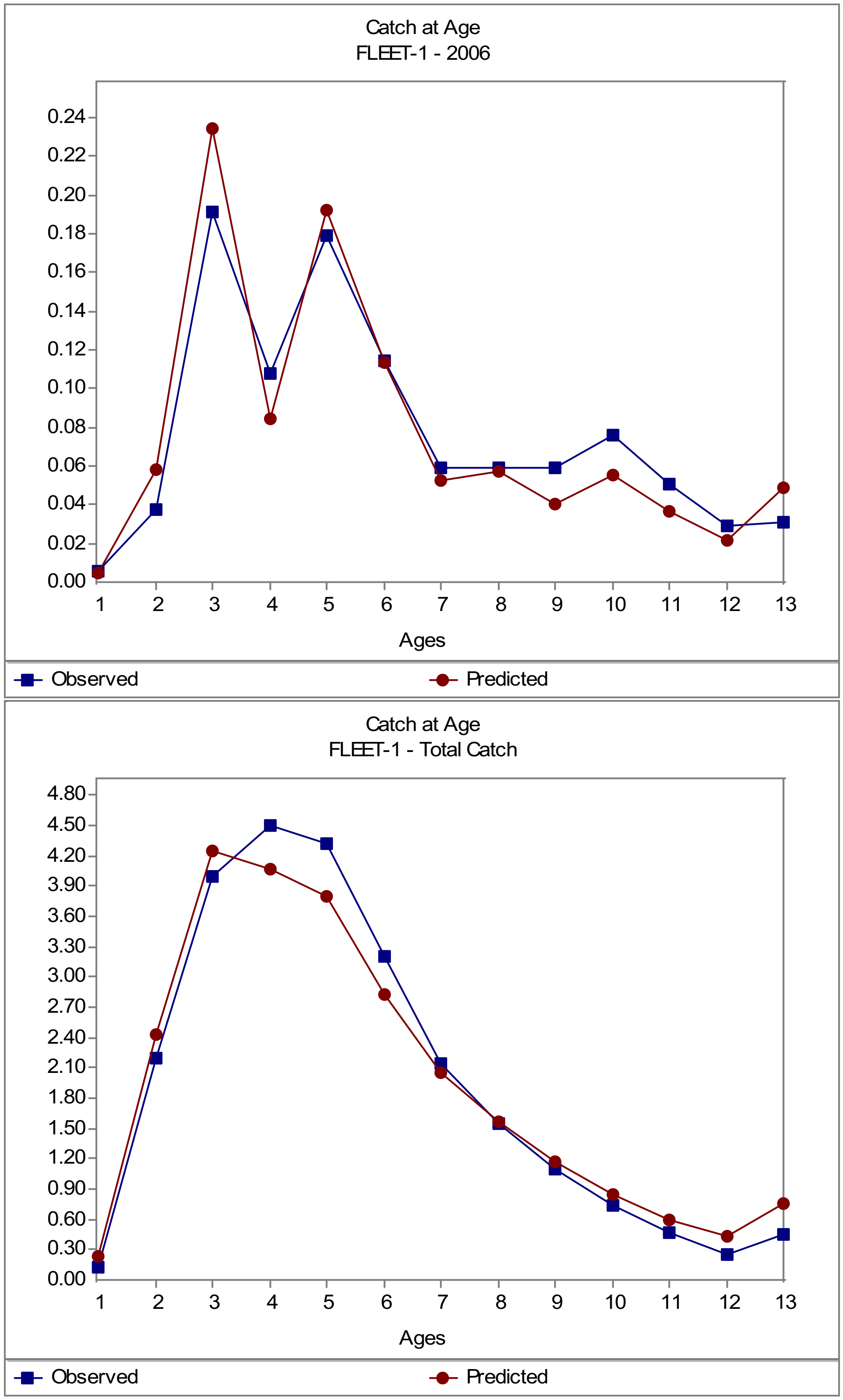


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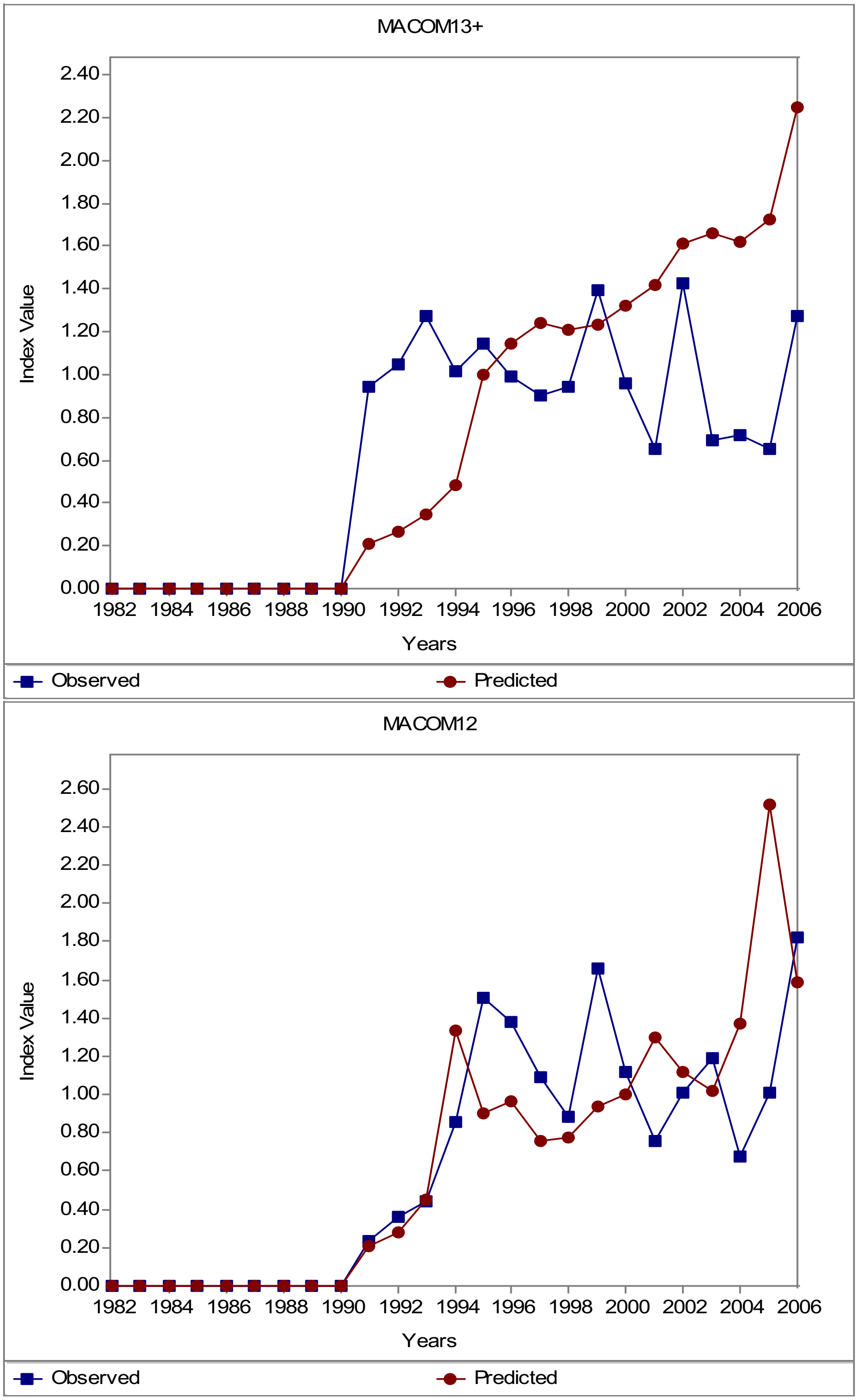



Figure 3. Observed and predicted indices used in ASAP catch at age model.

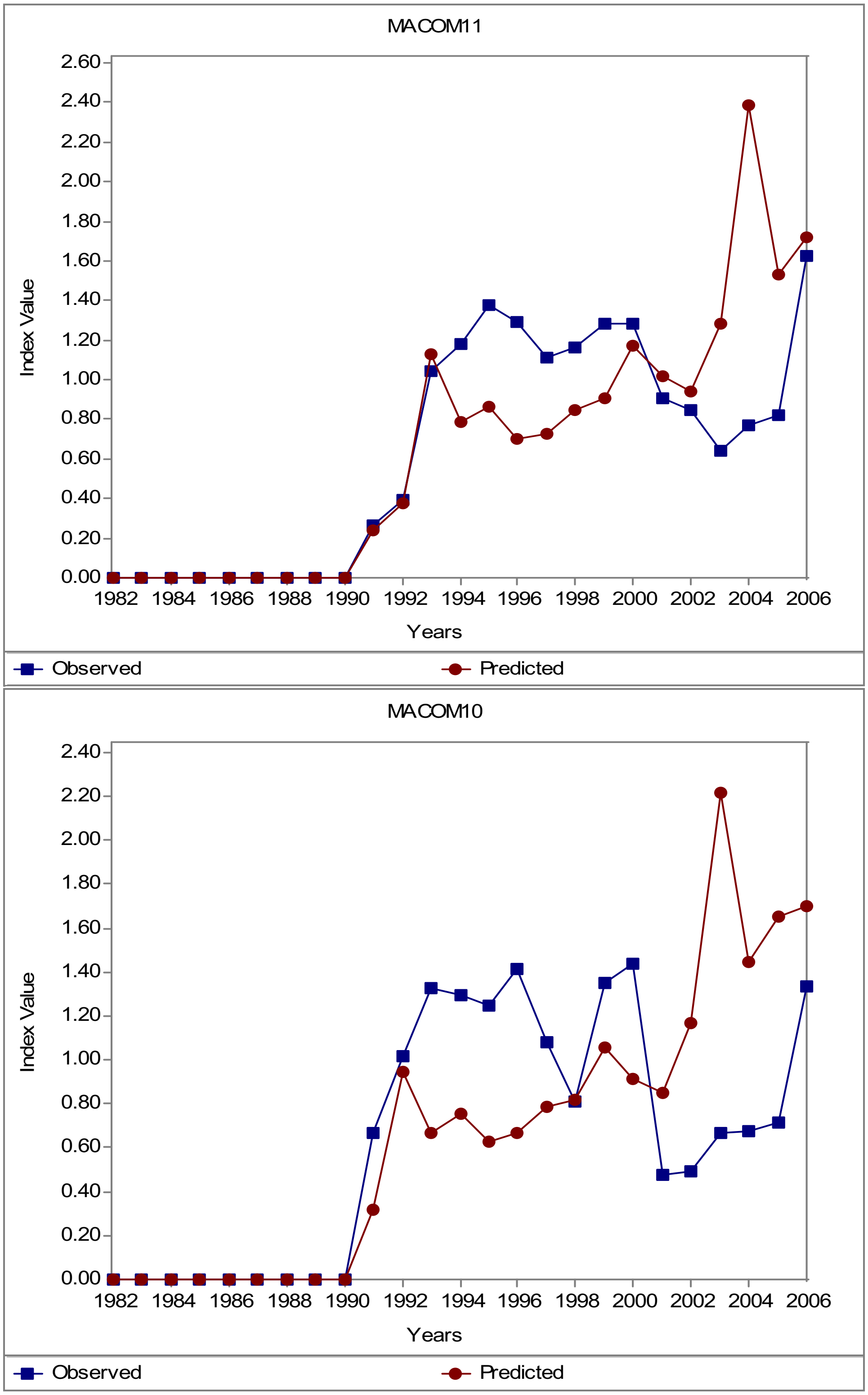
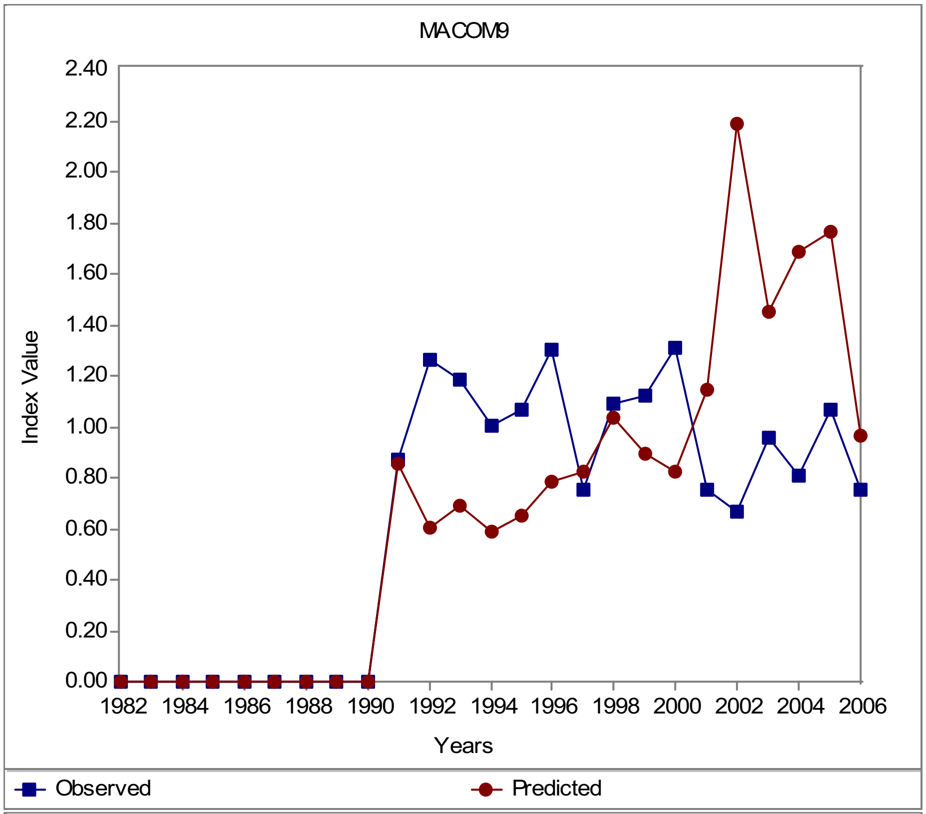
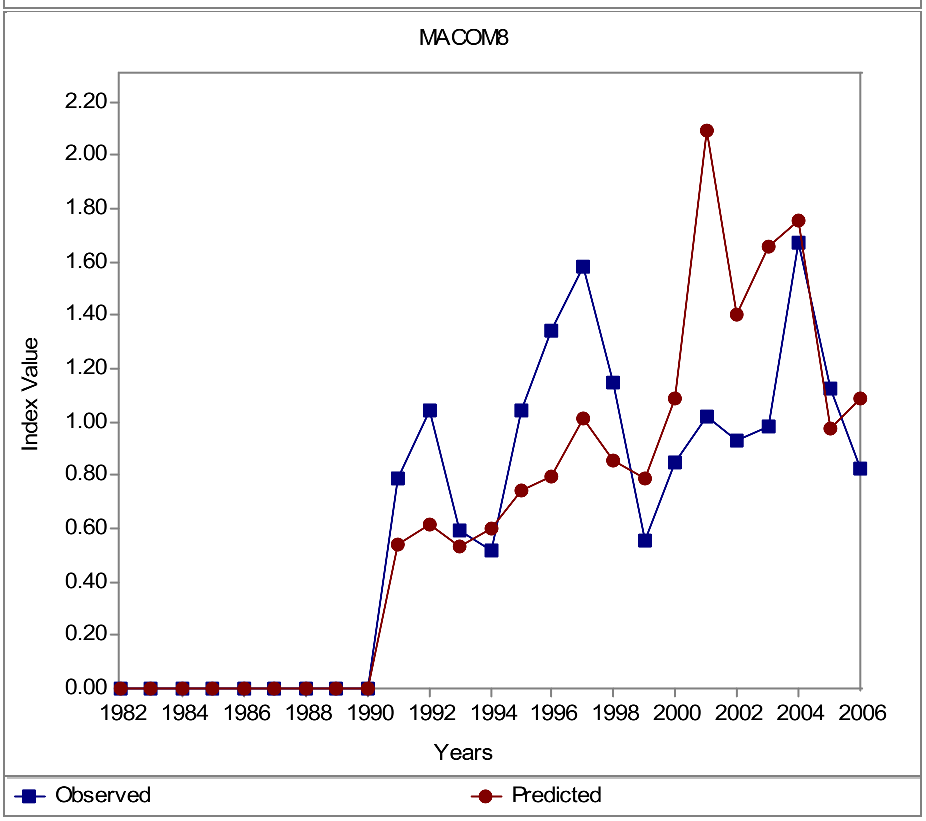



Figure 3 Continued.

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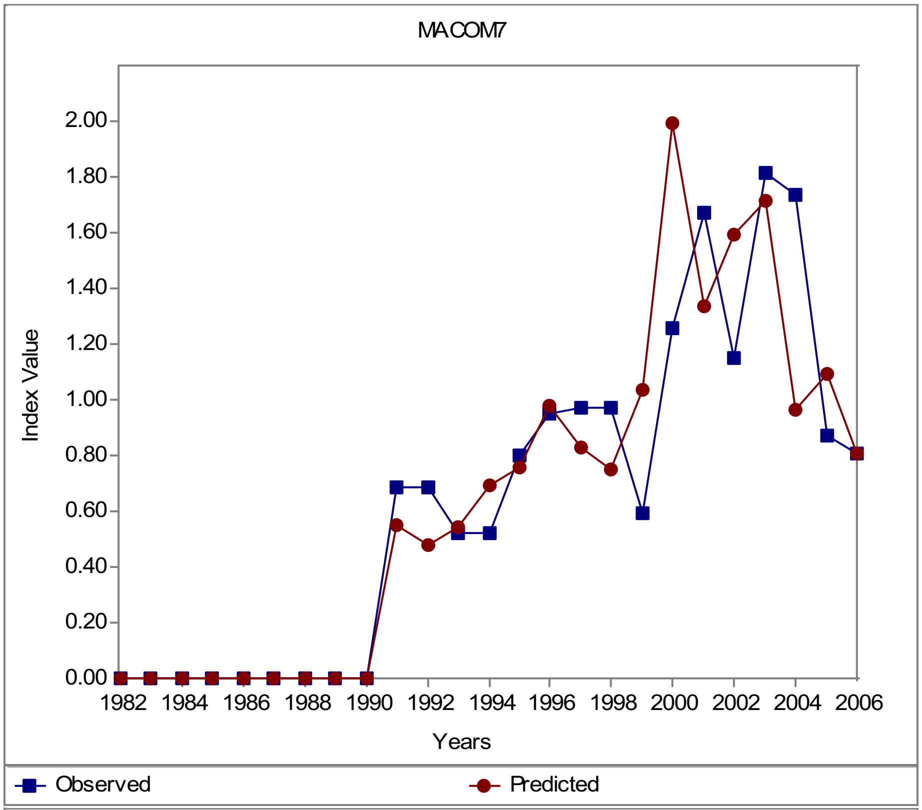


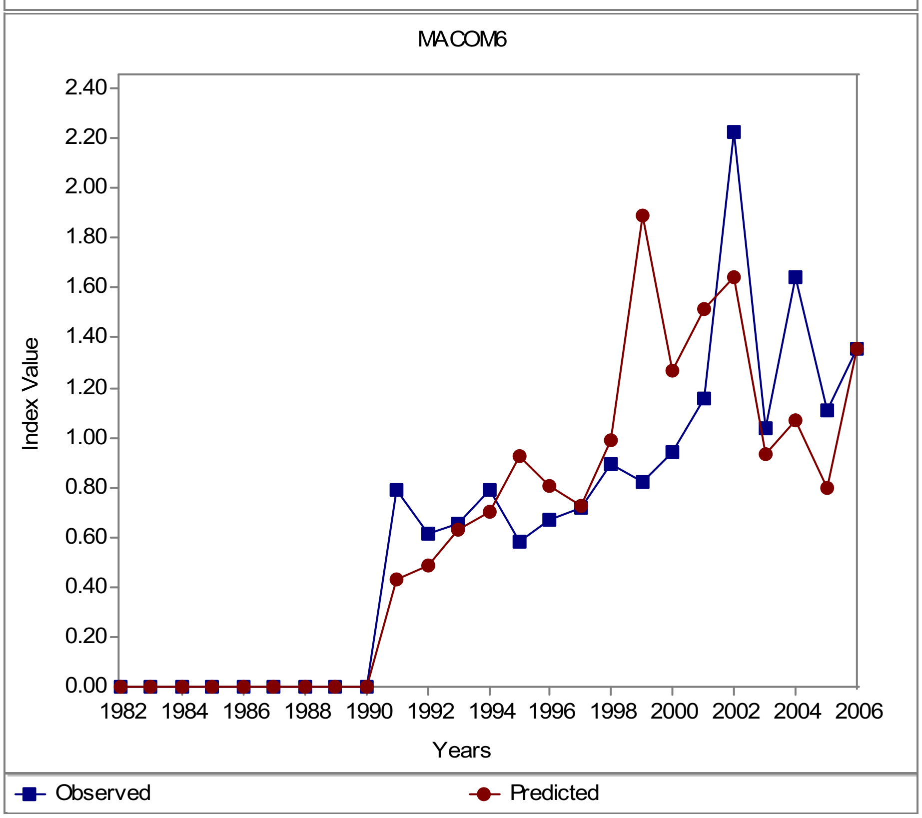


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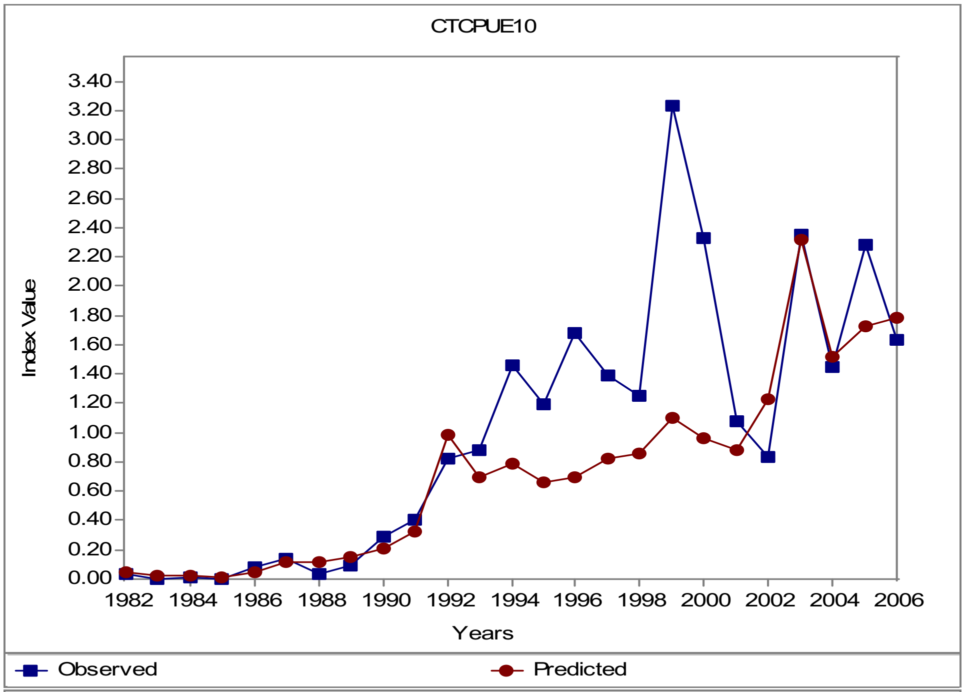


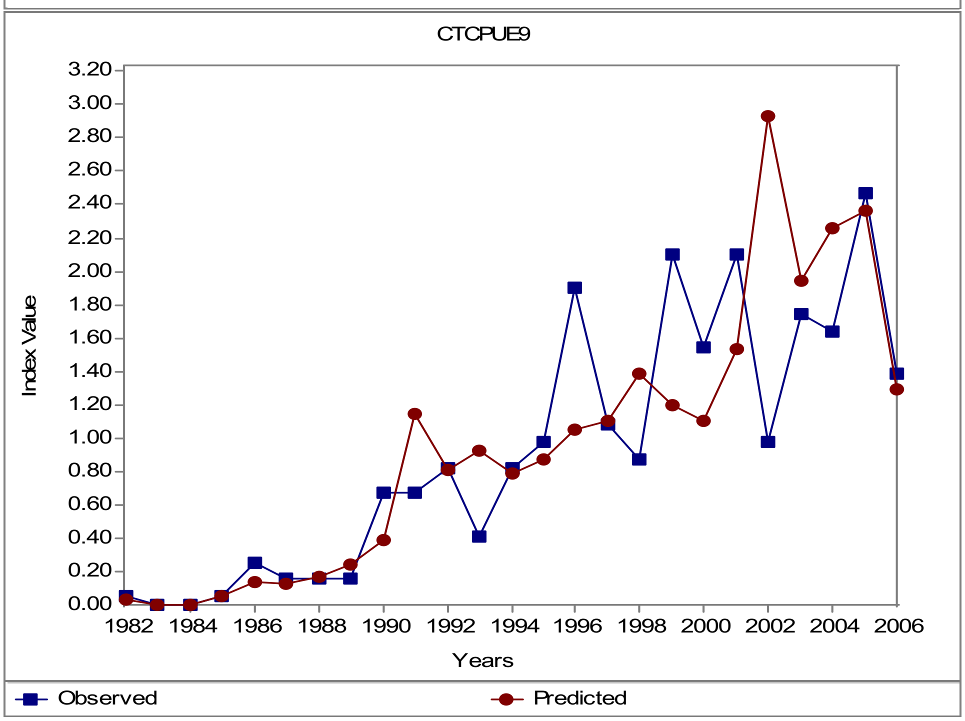


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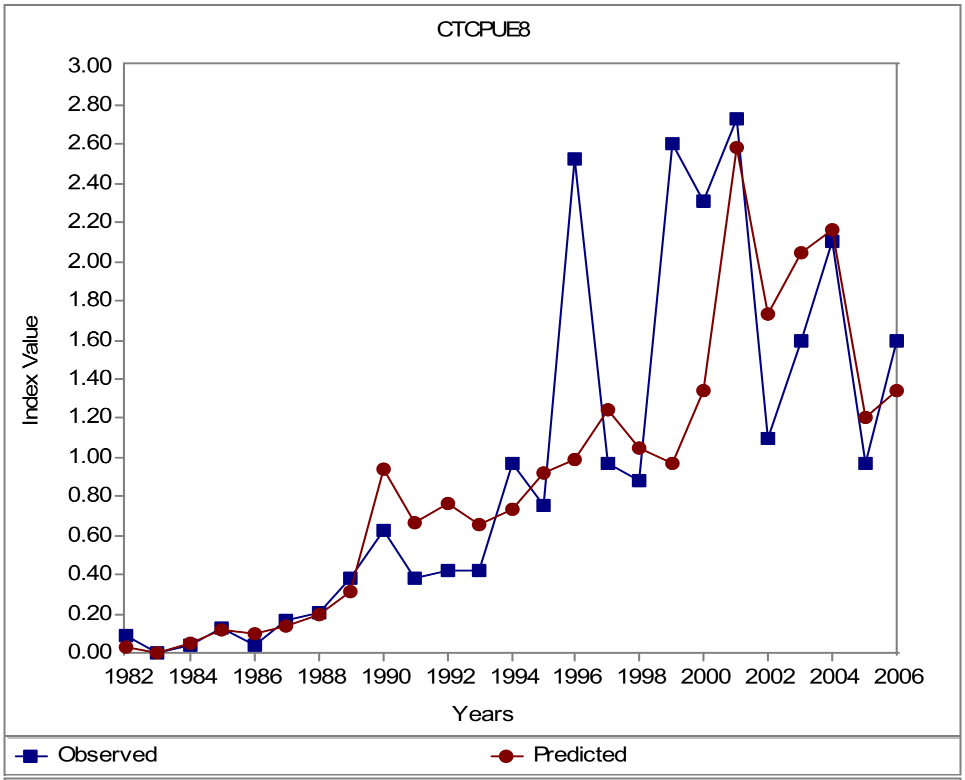


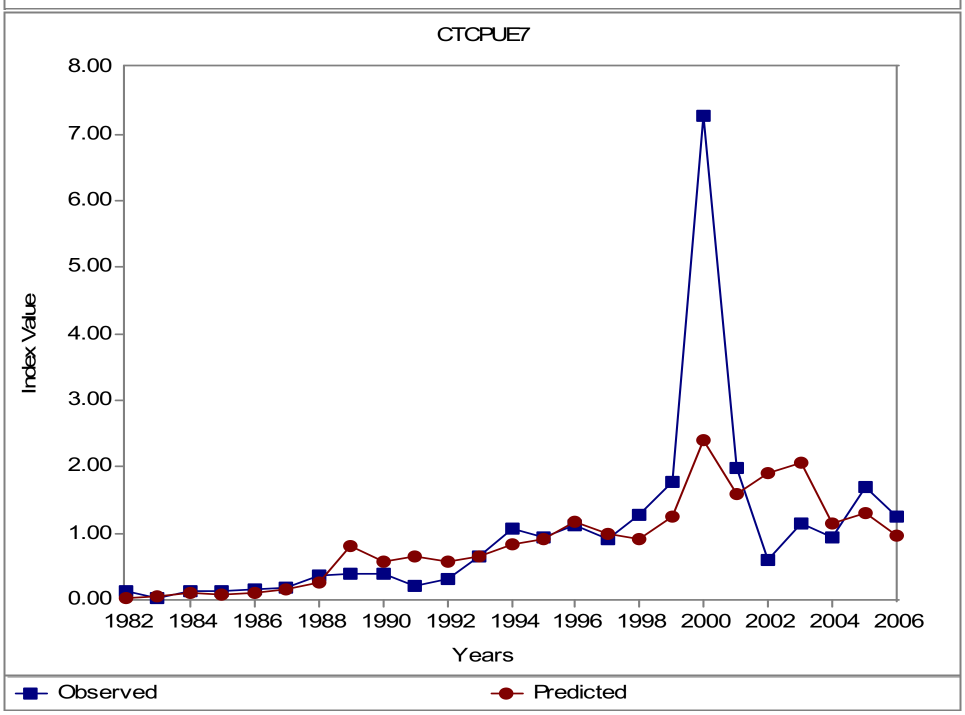


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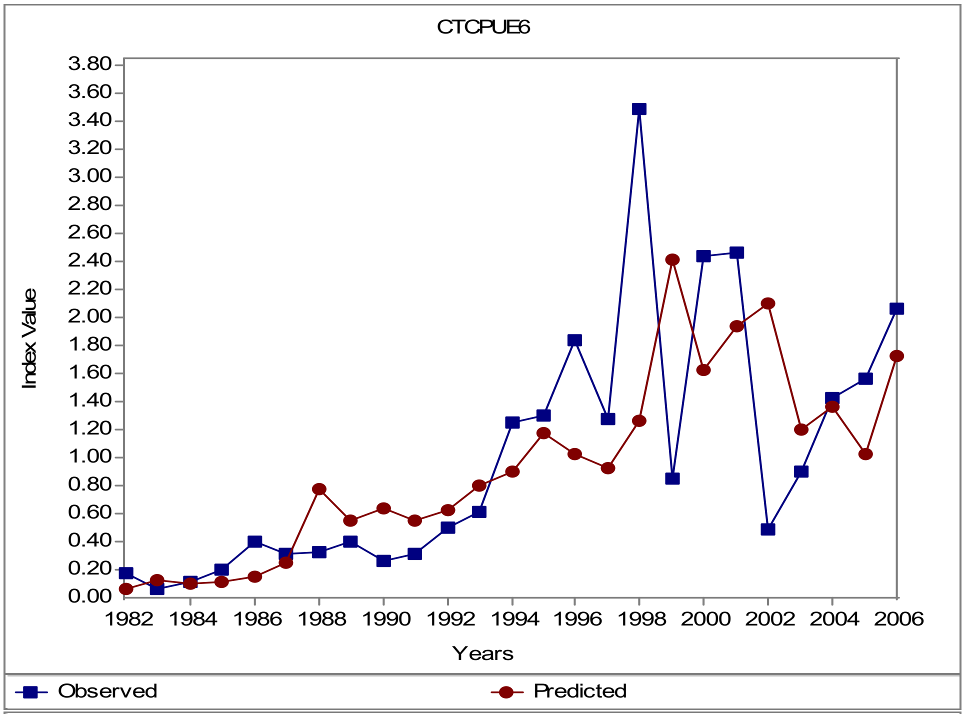


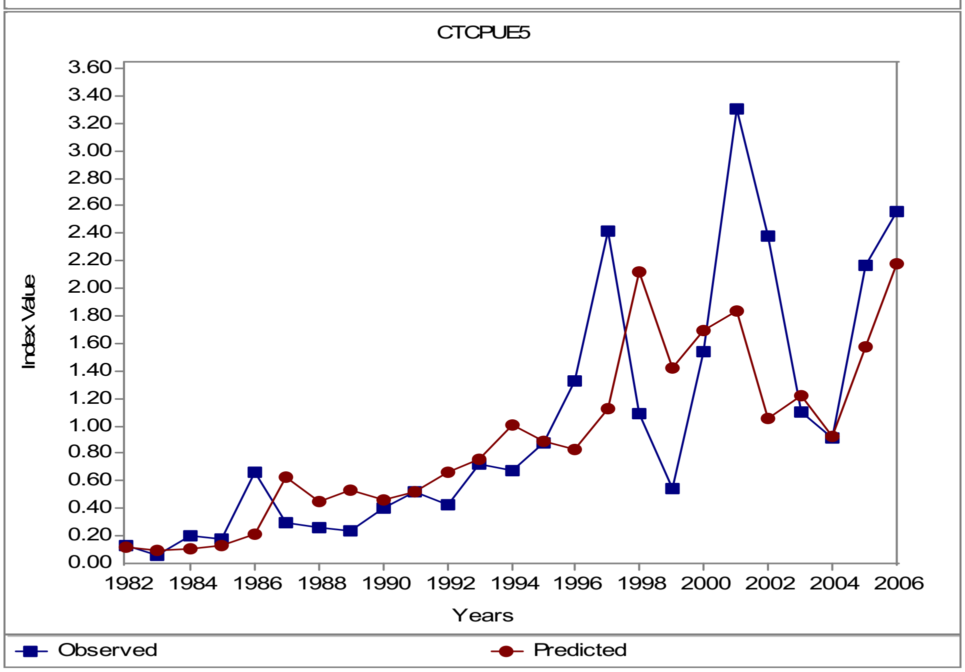


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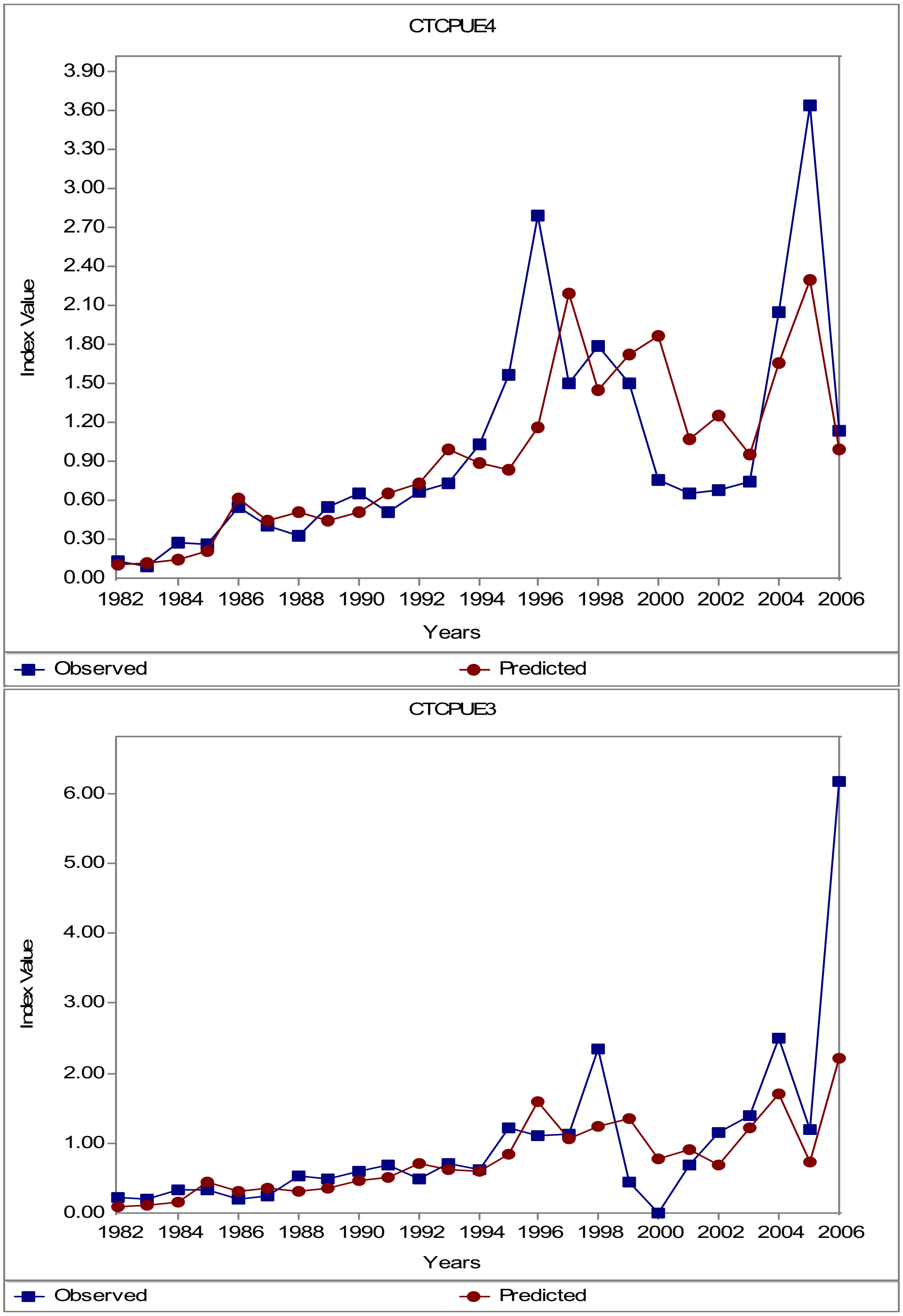


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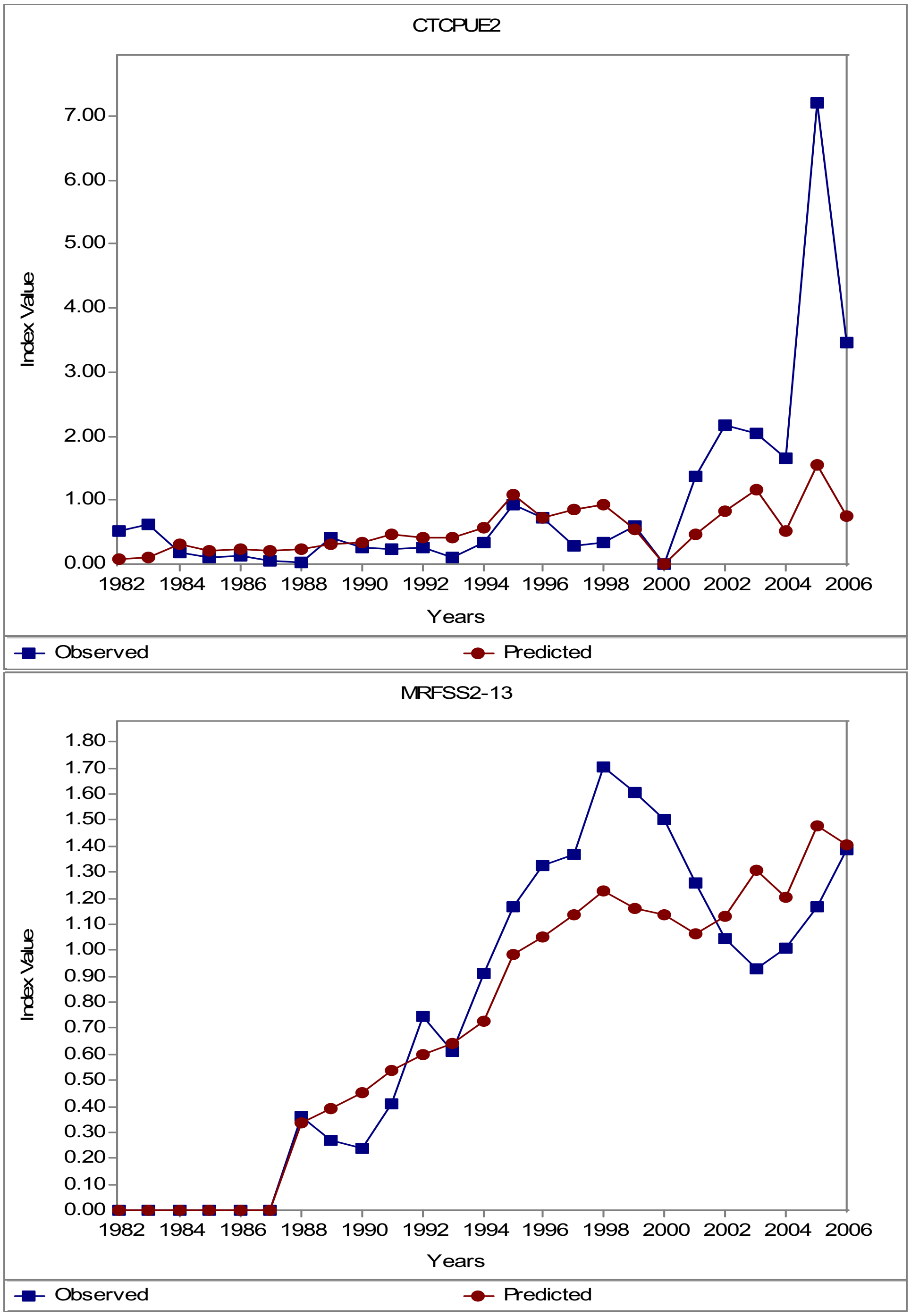


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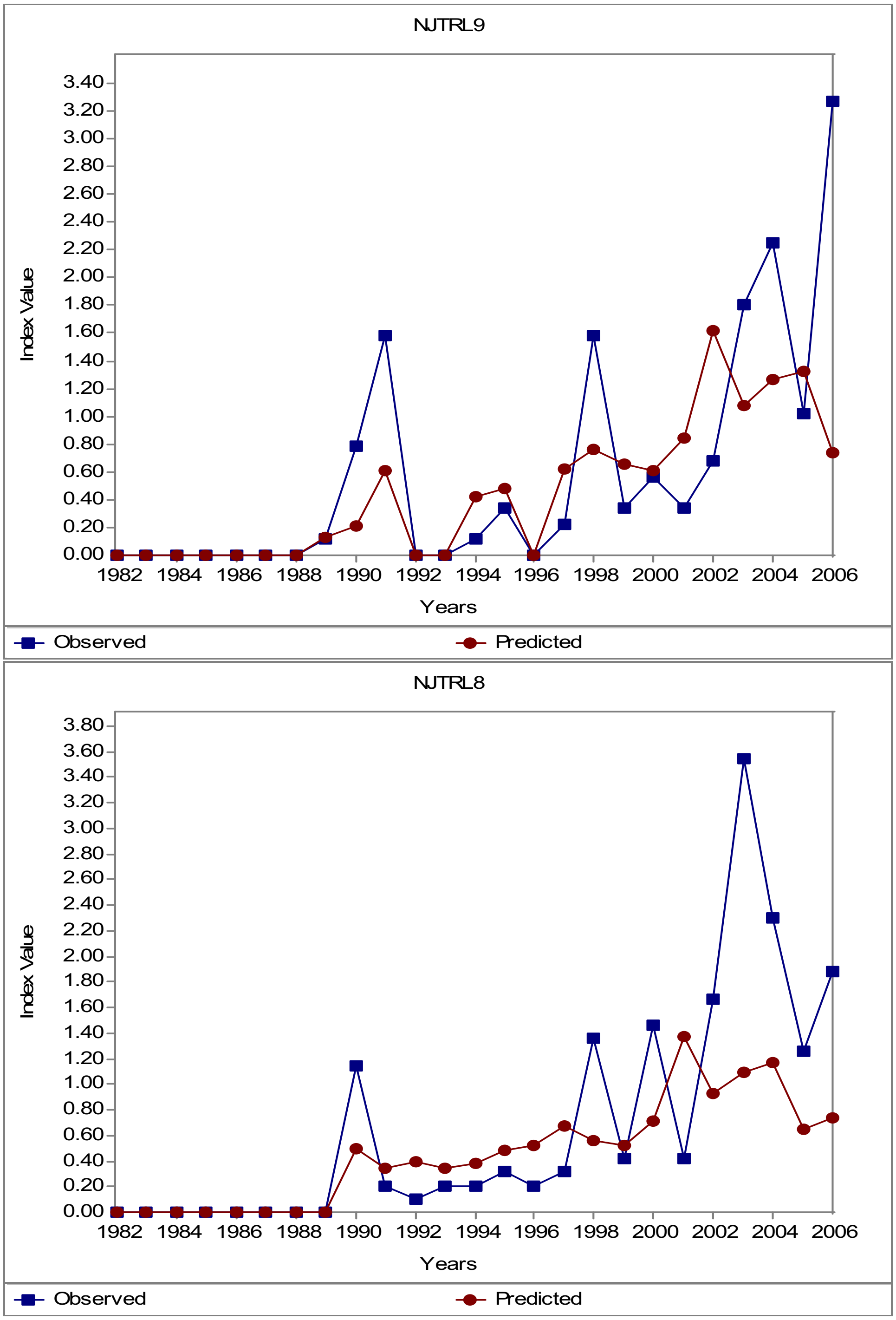


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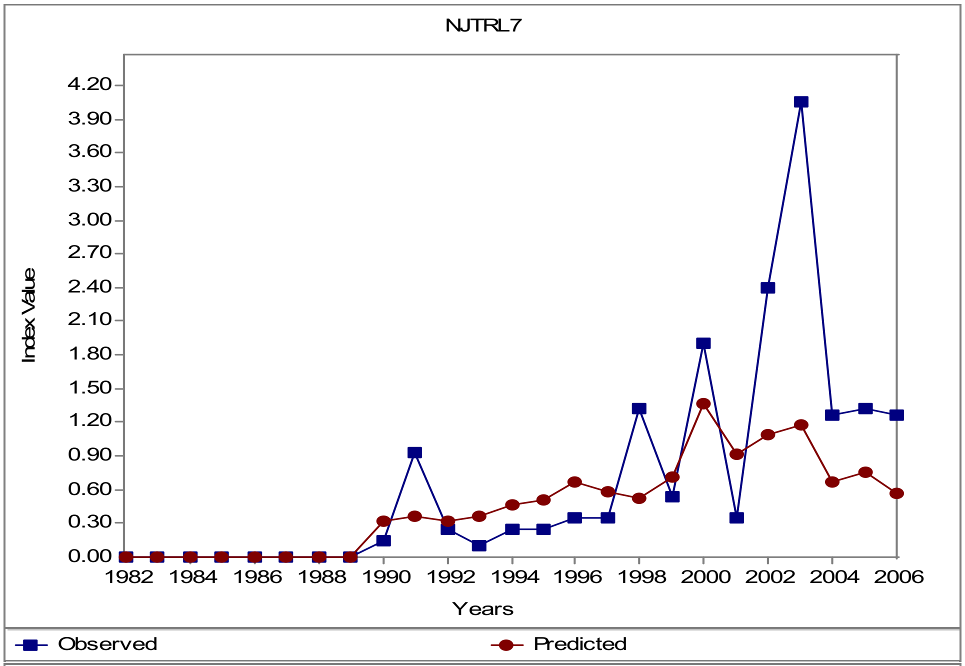


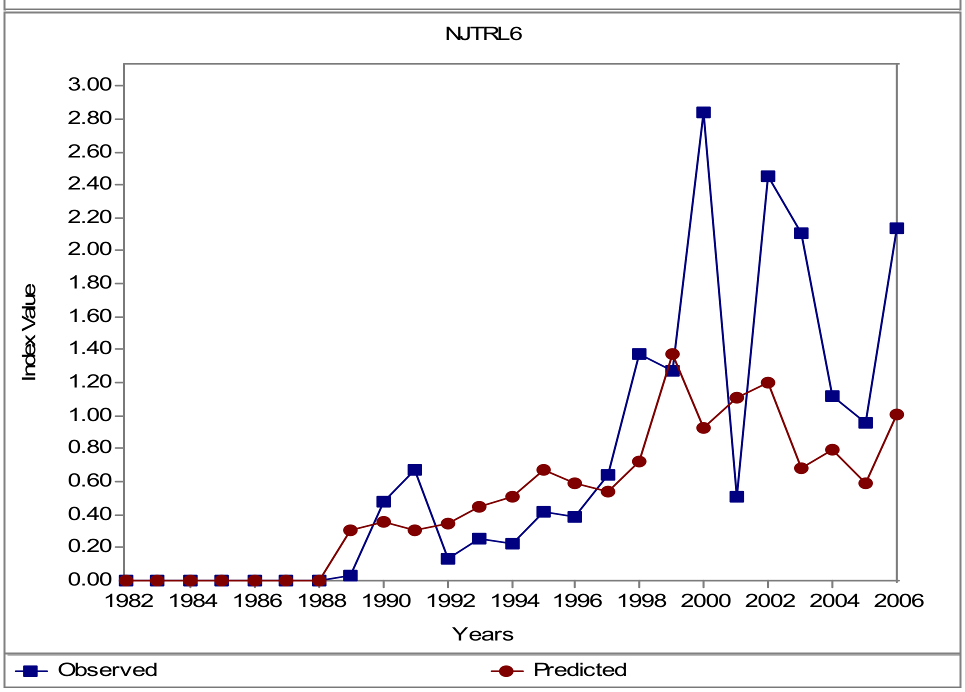


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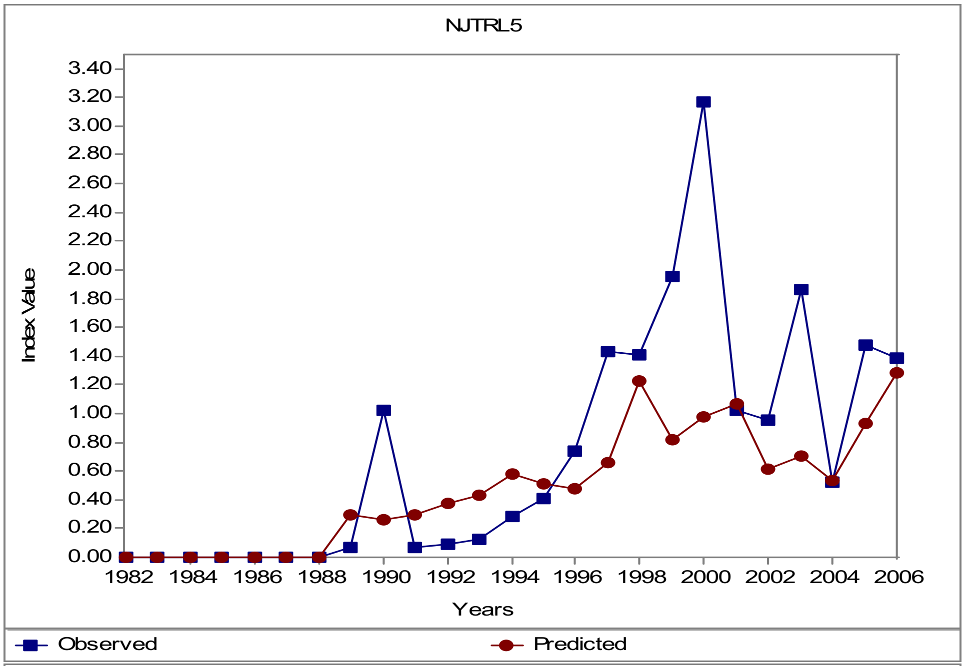


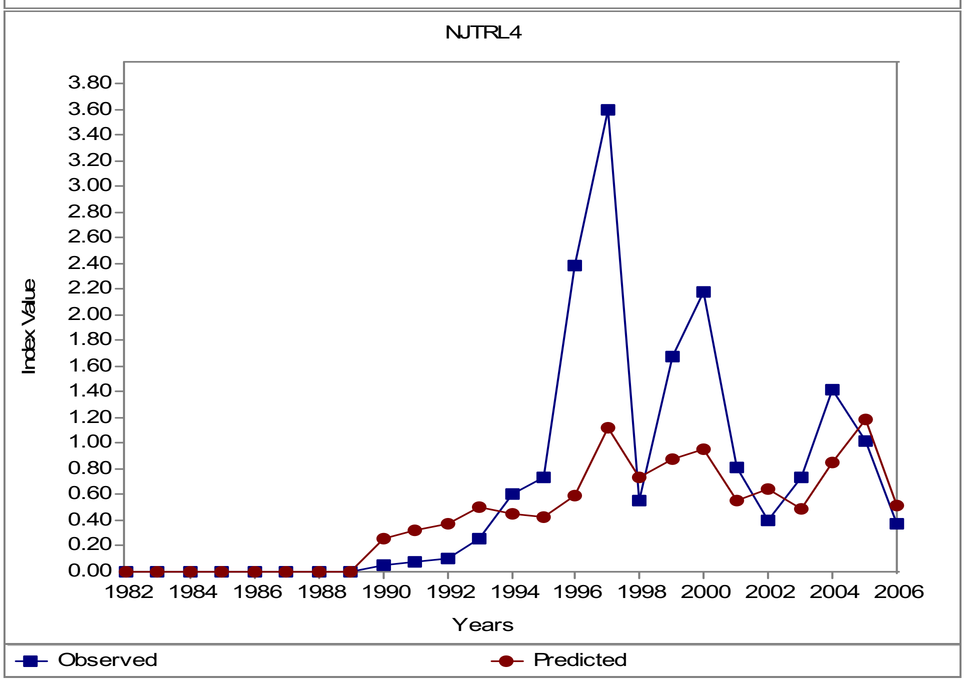


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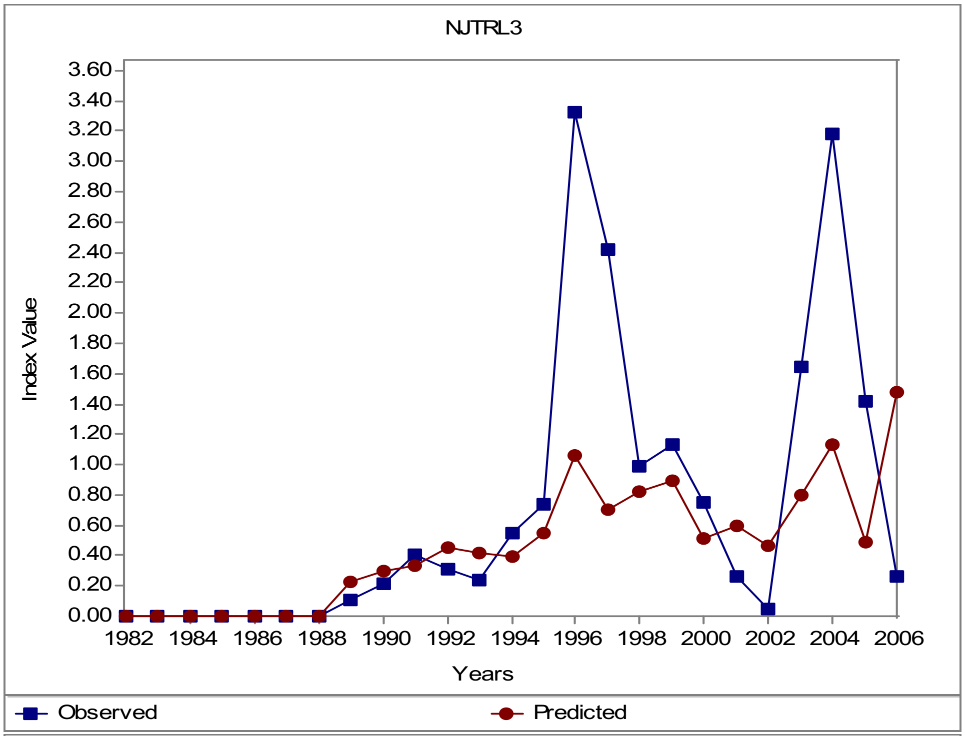


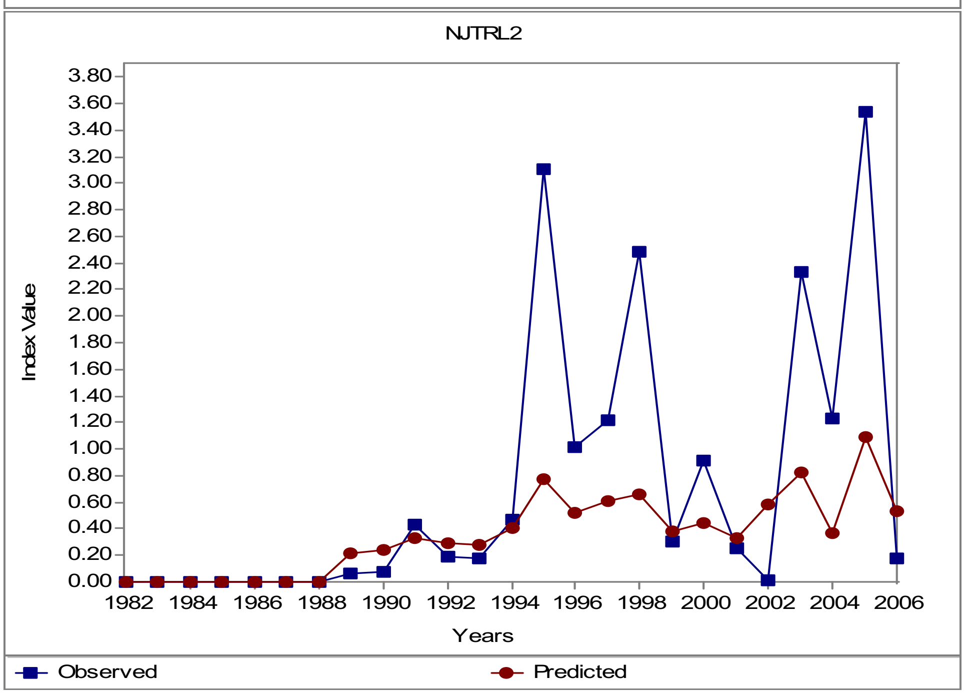


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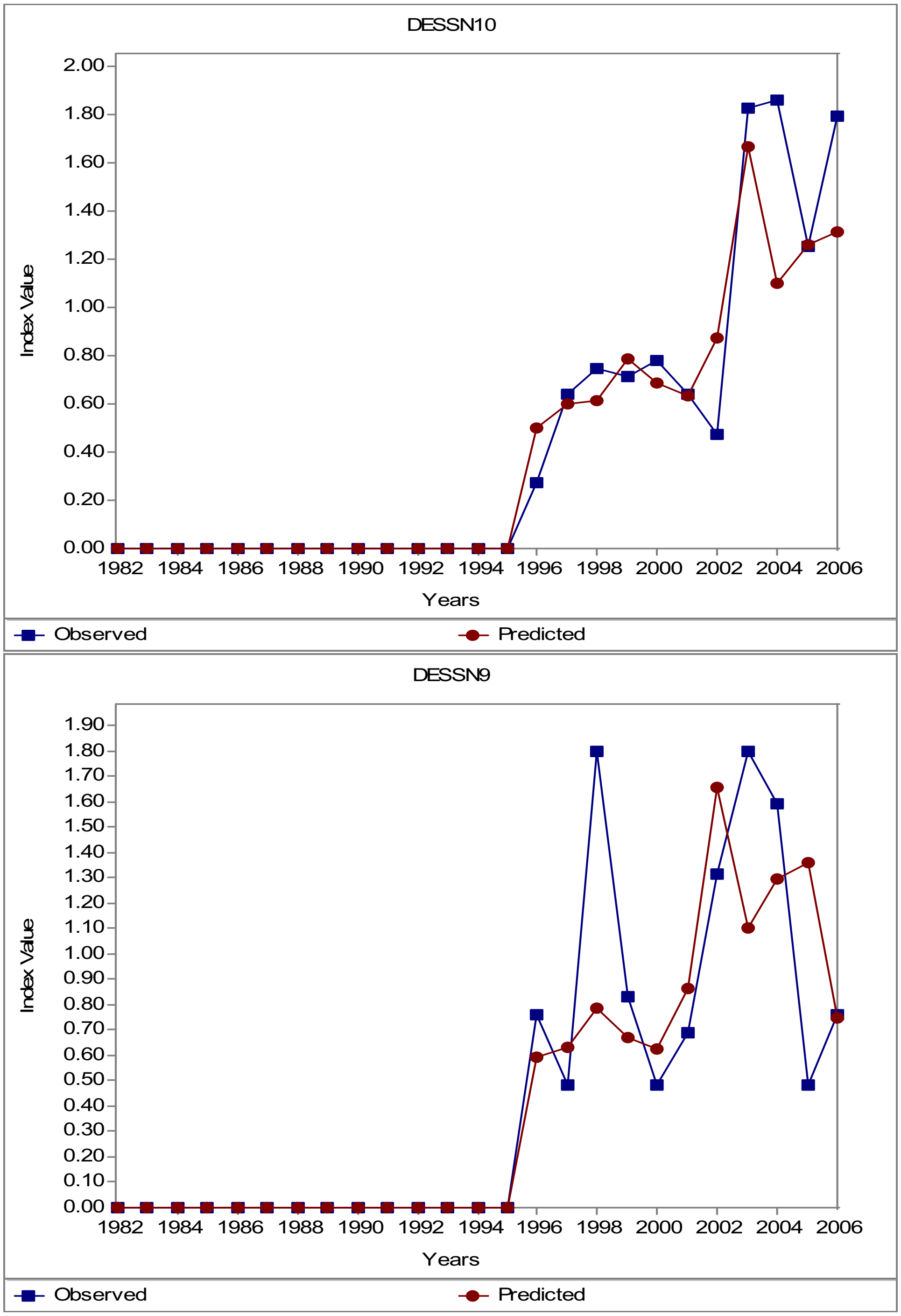


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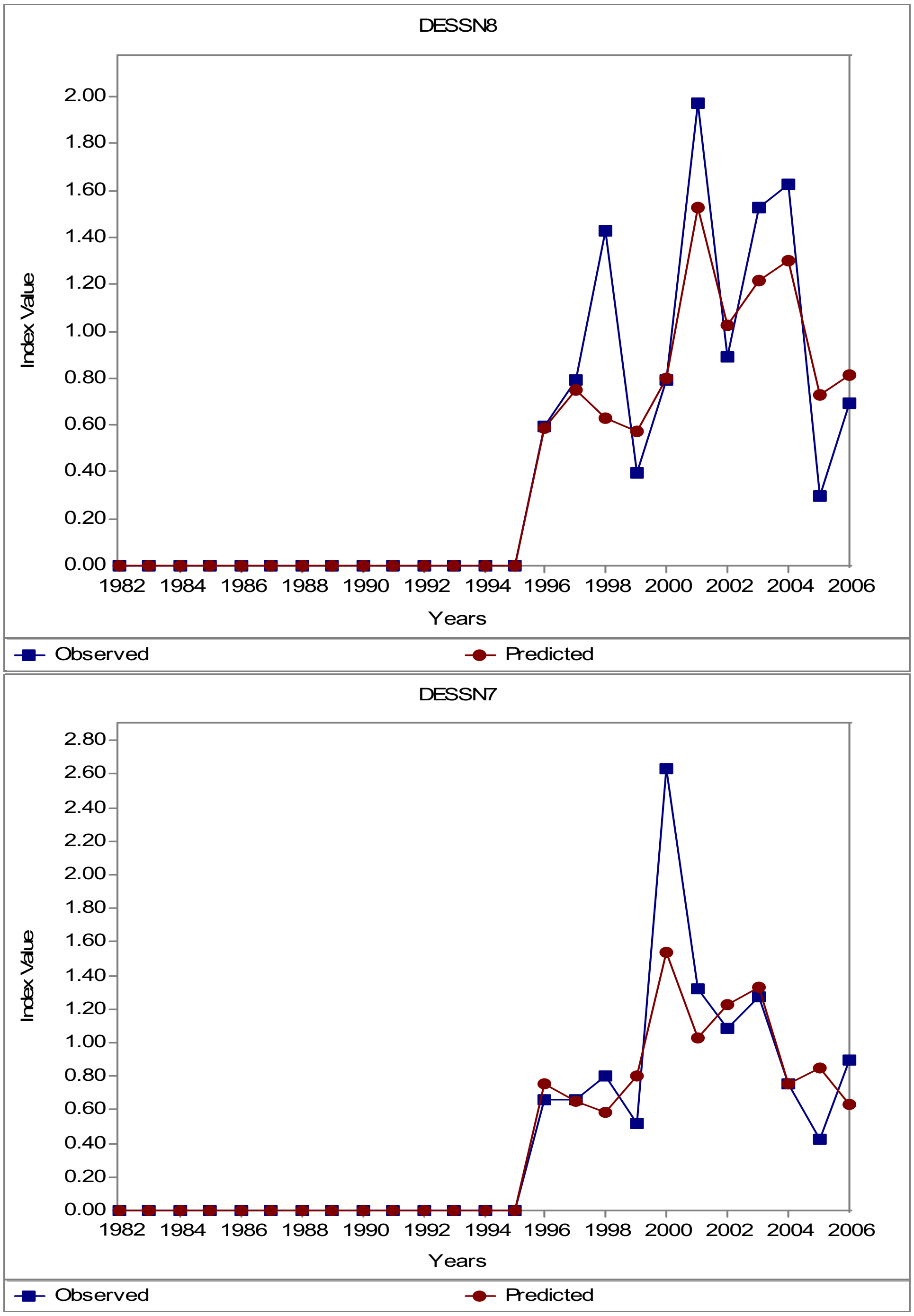


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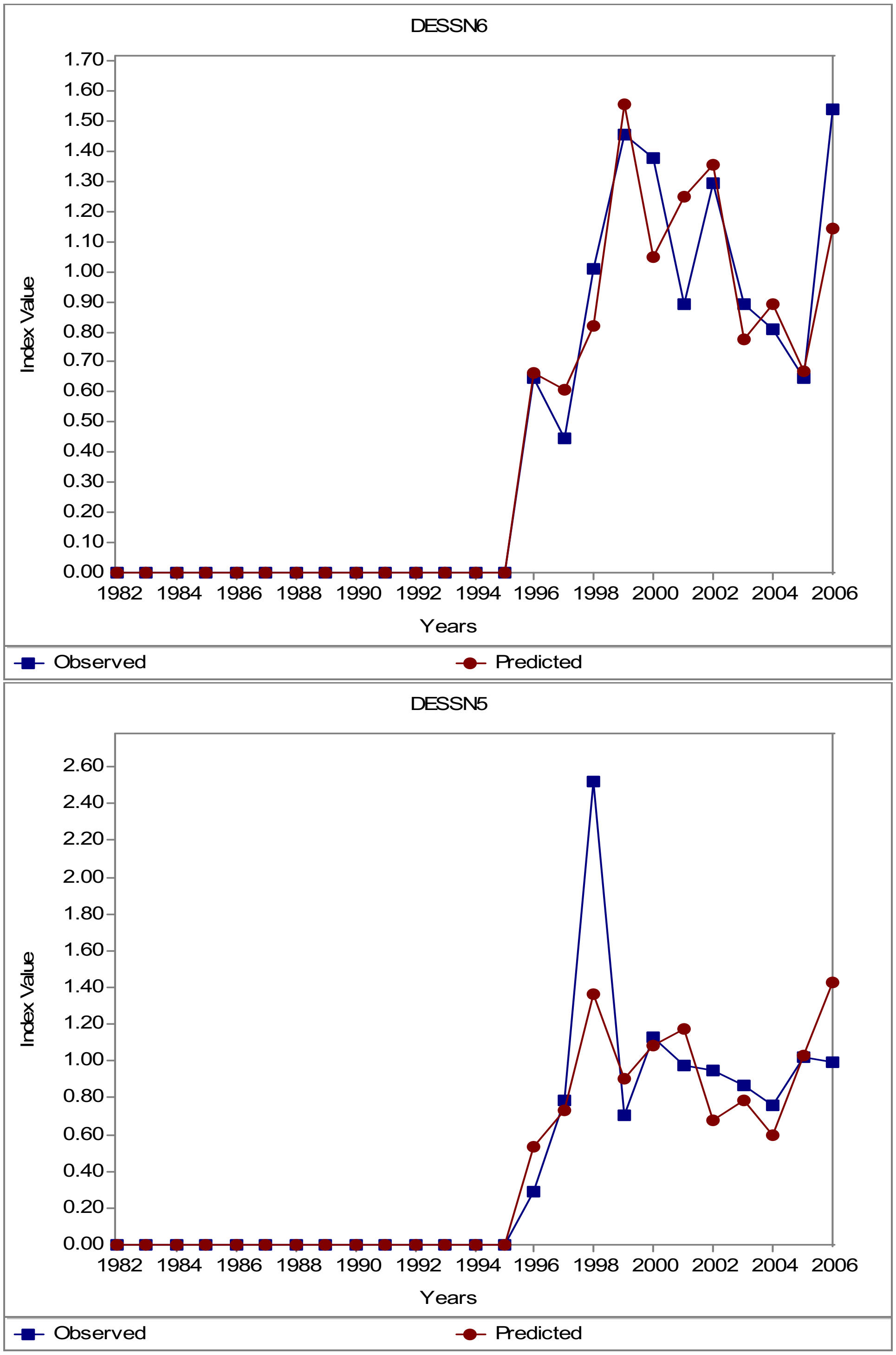


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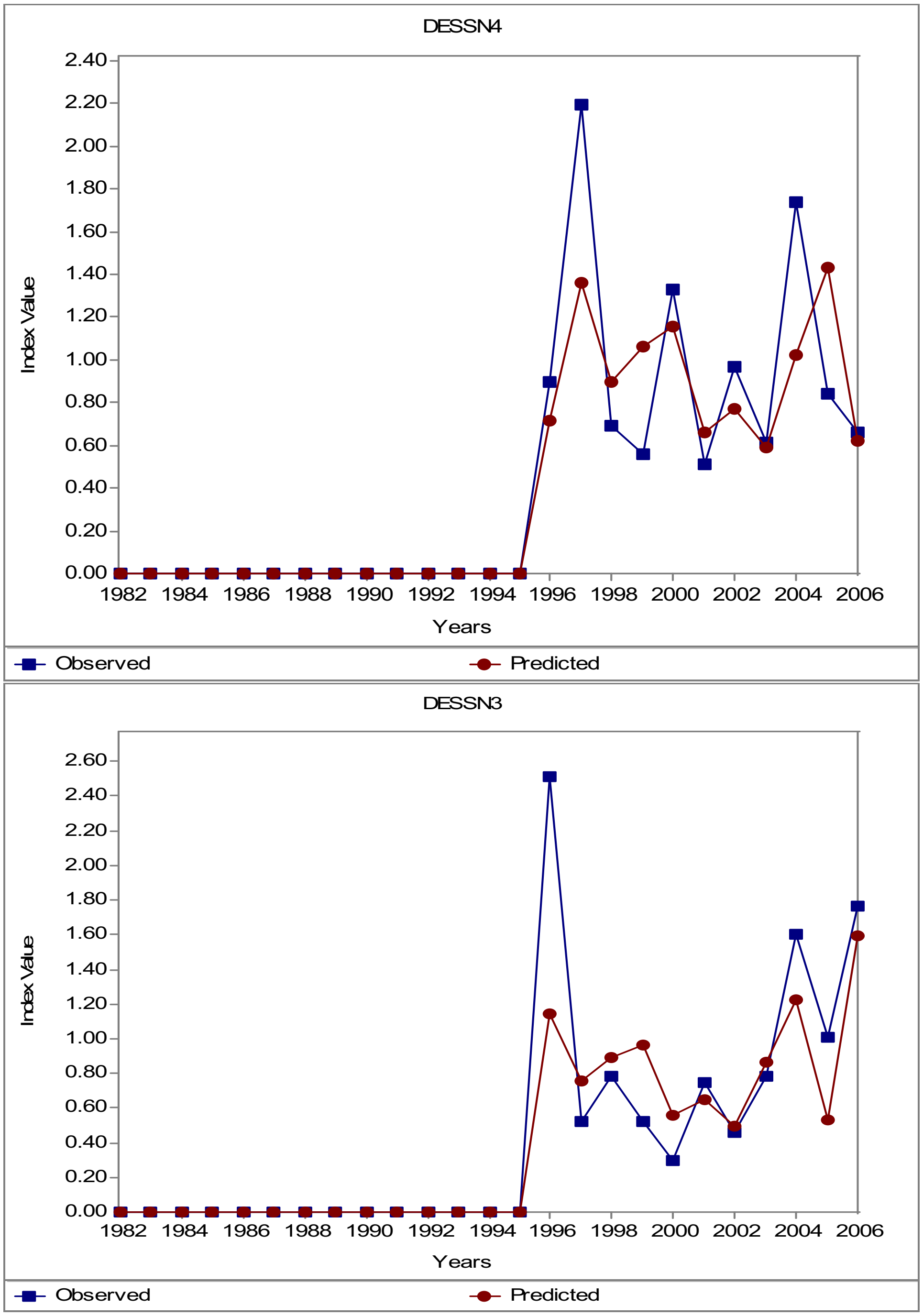


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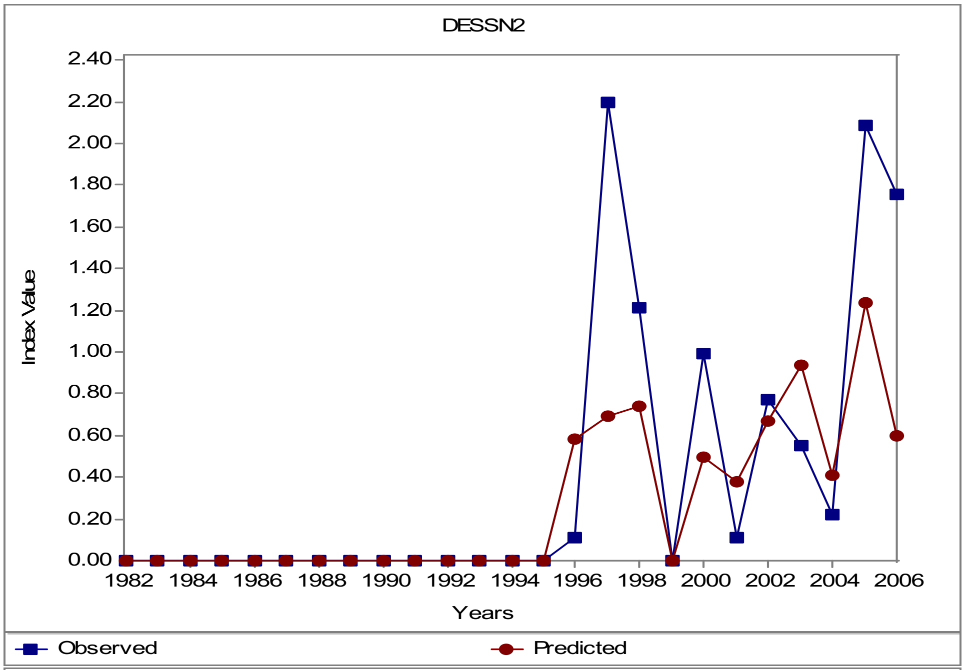


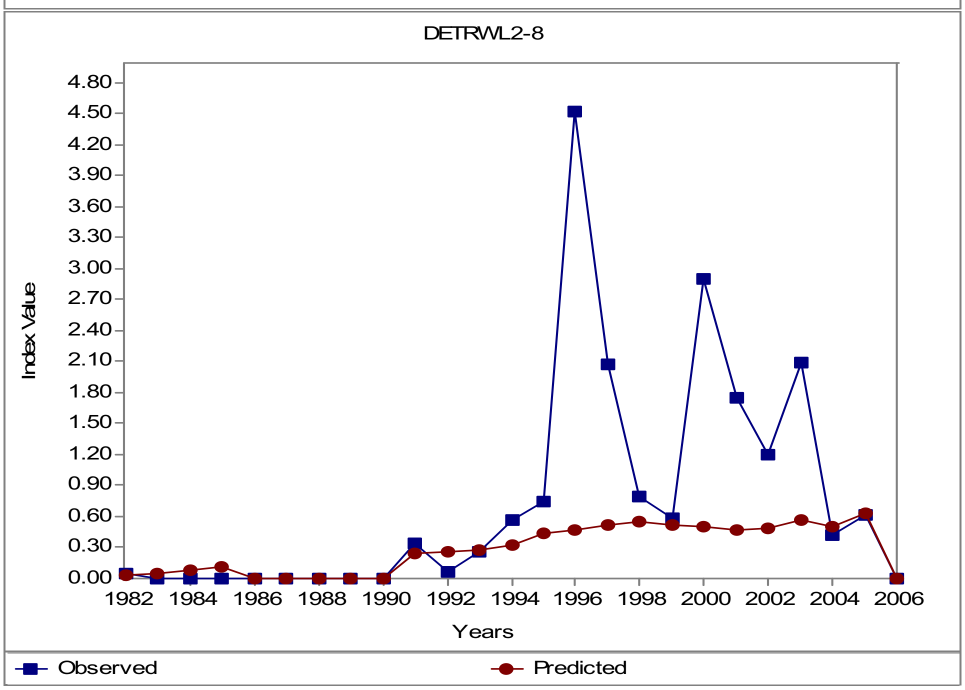


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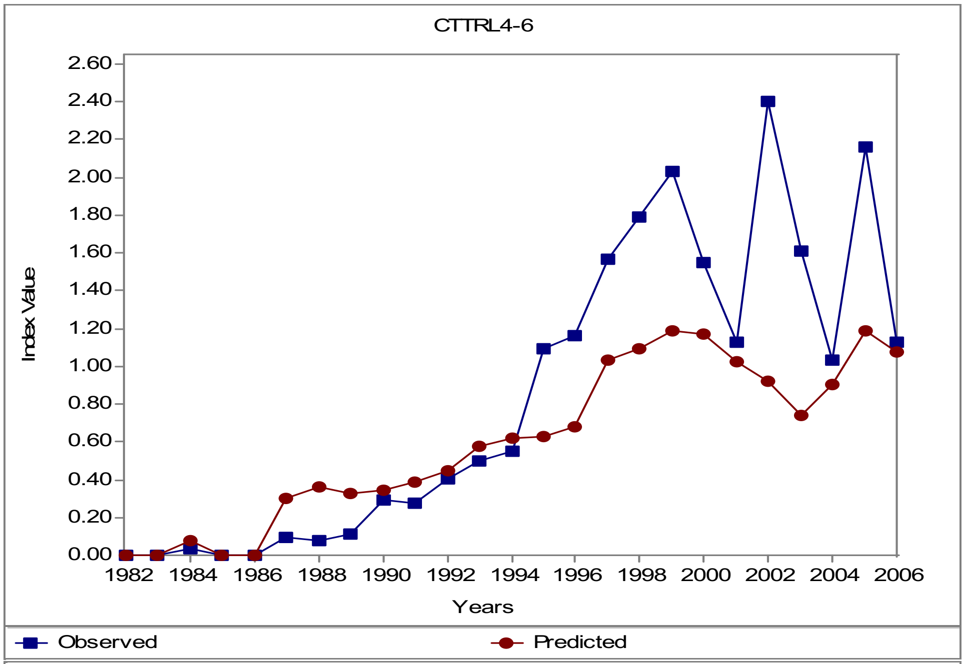


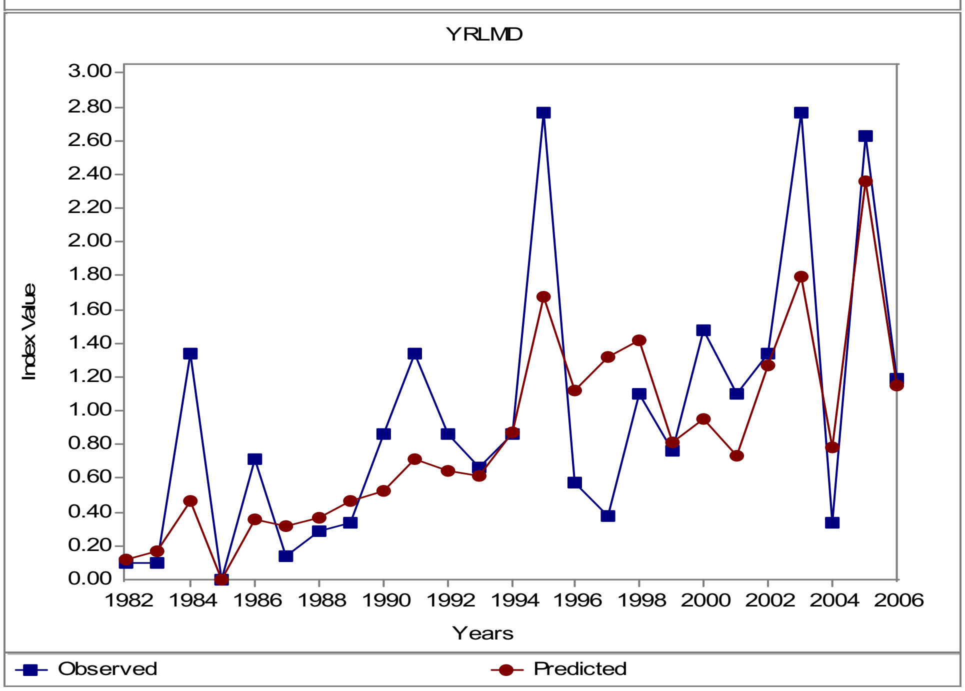


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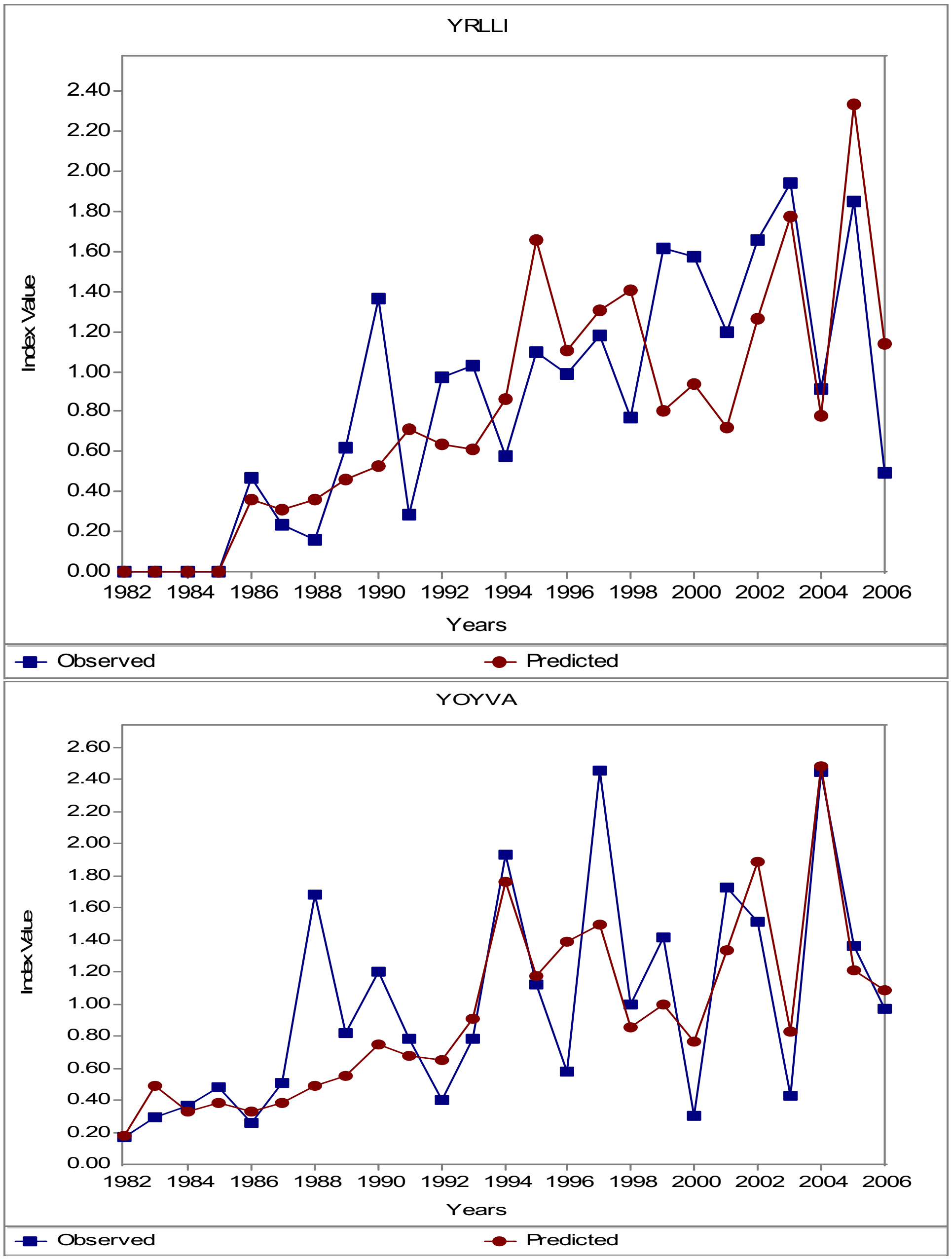


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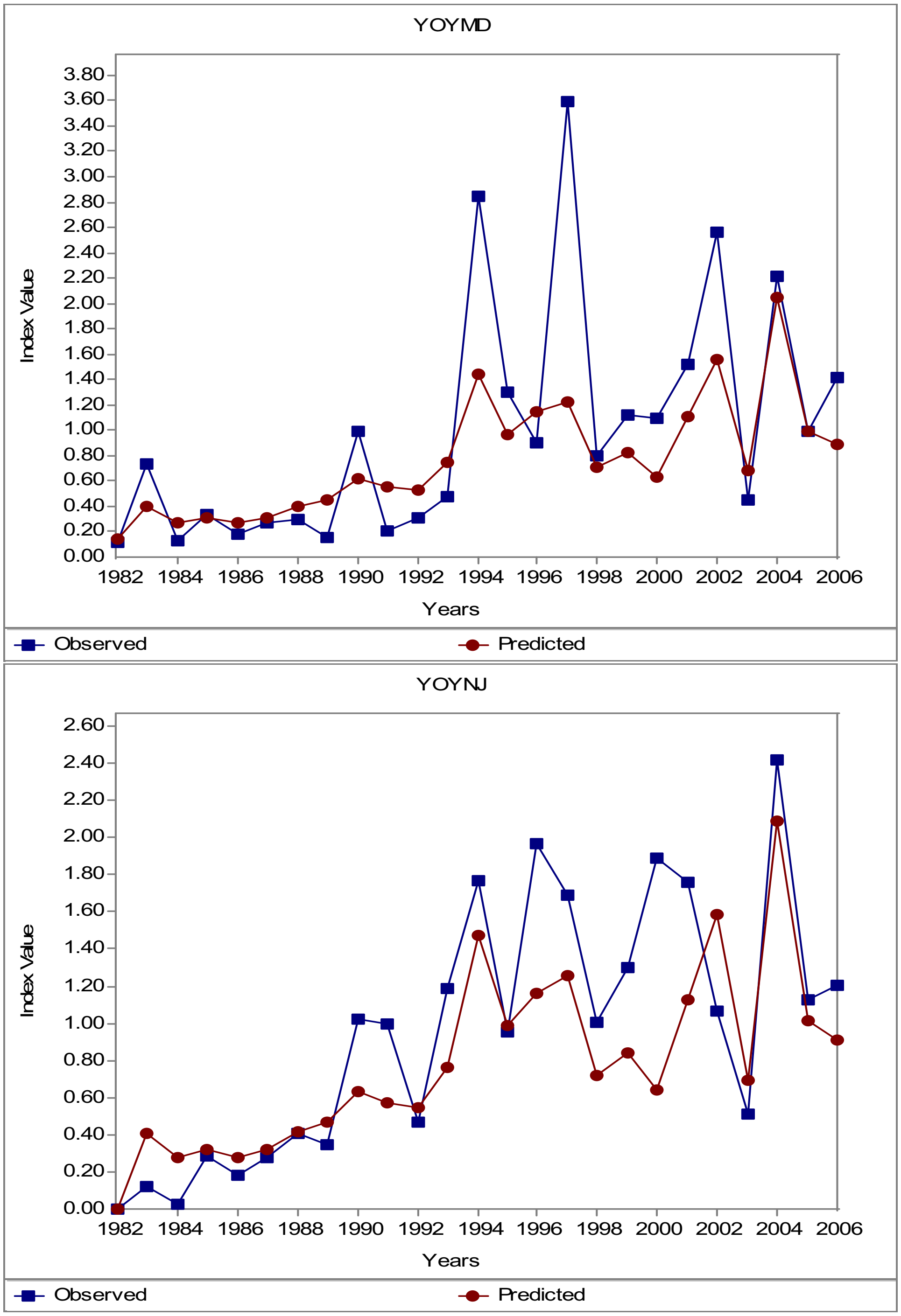


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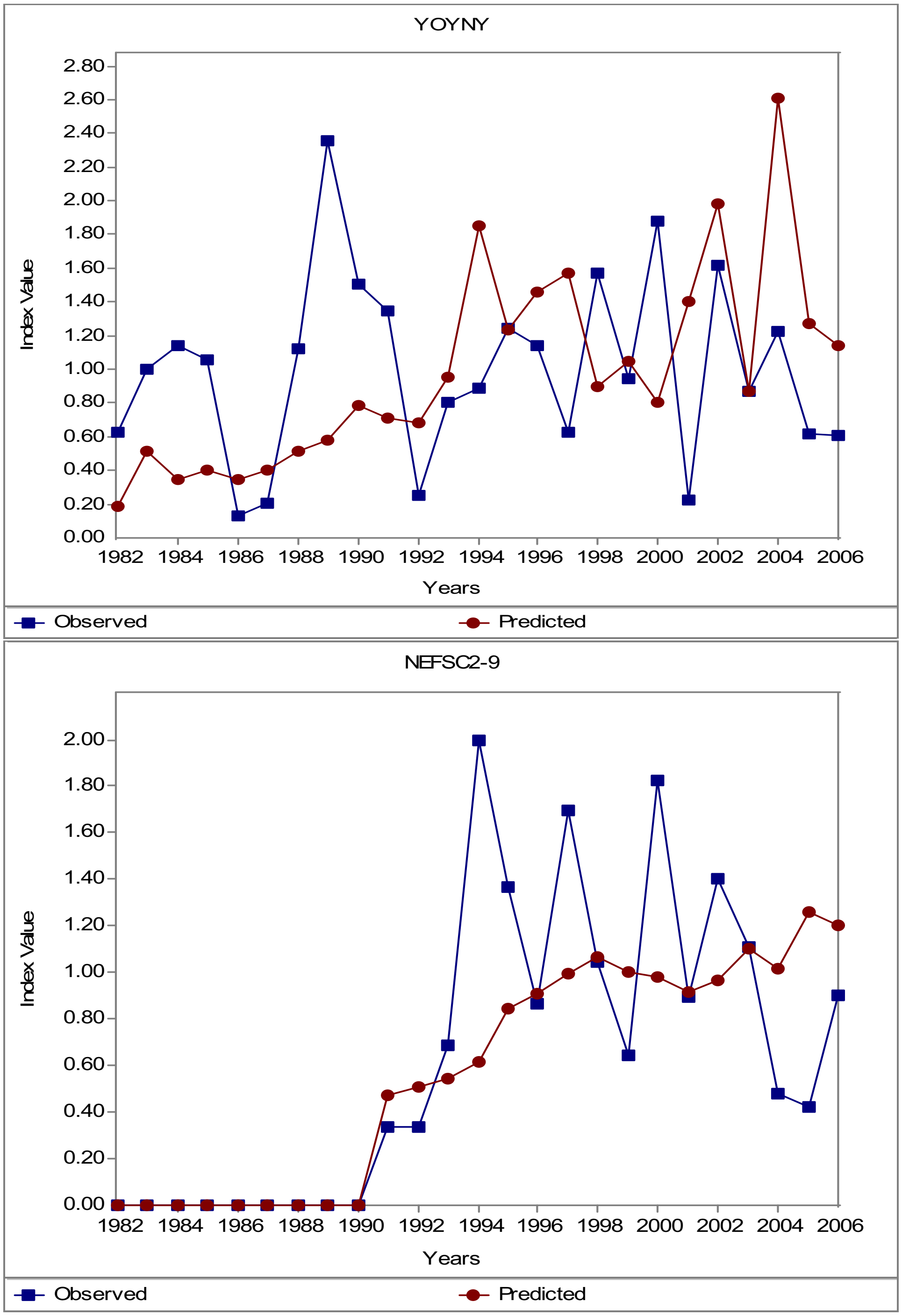


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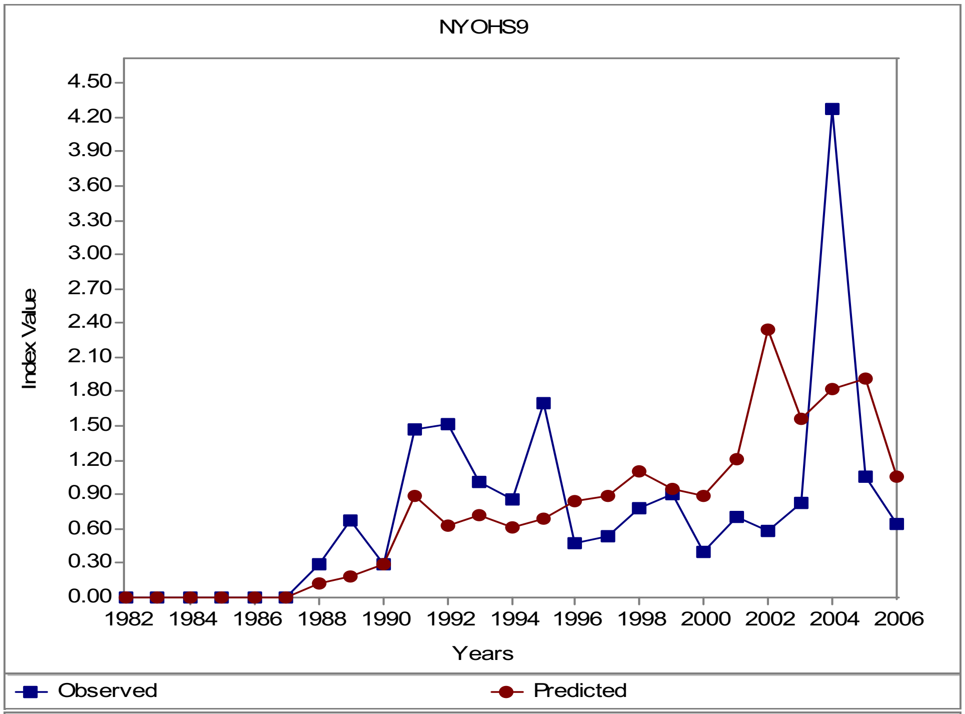


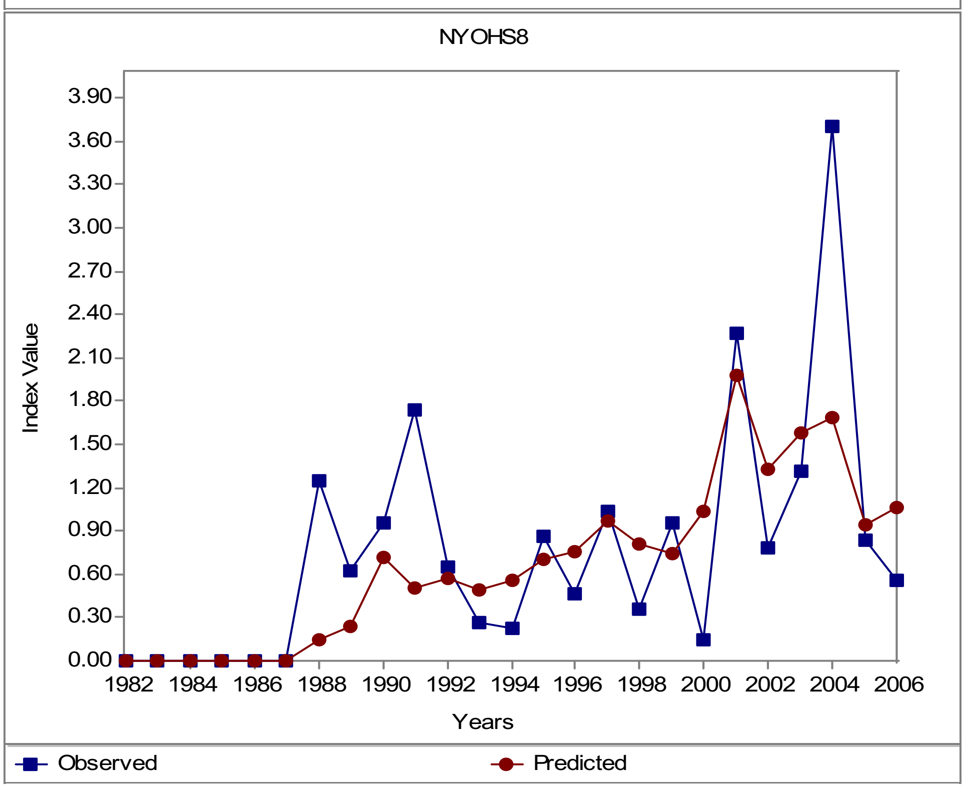


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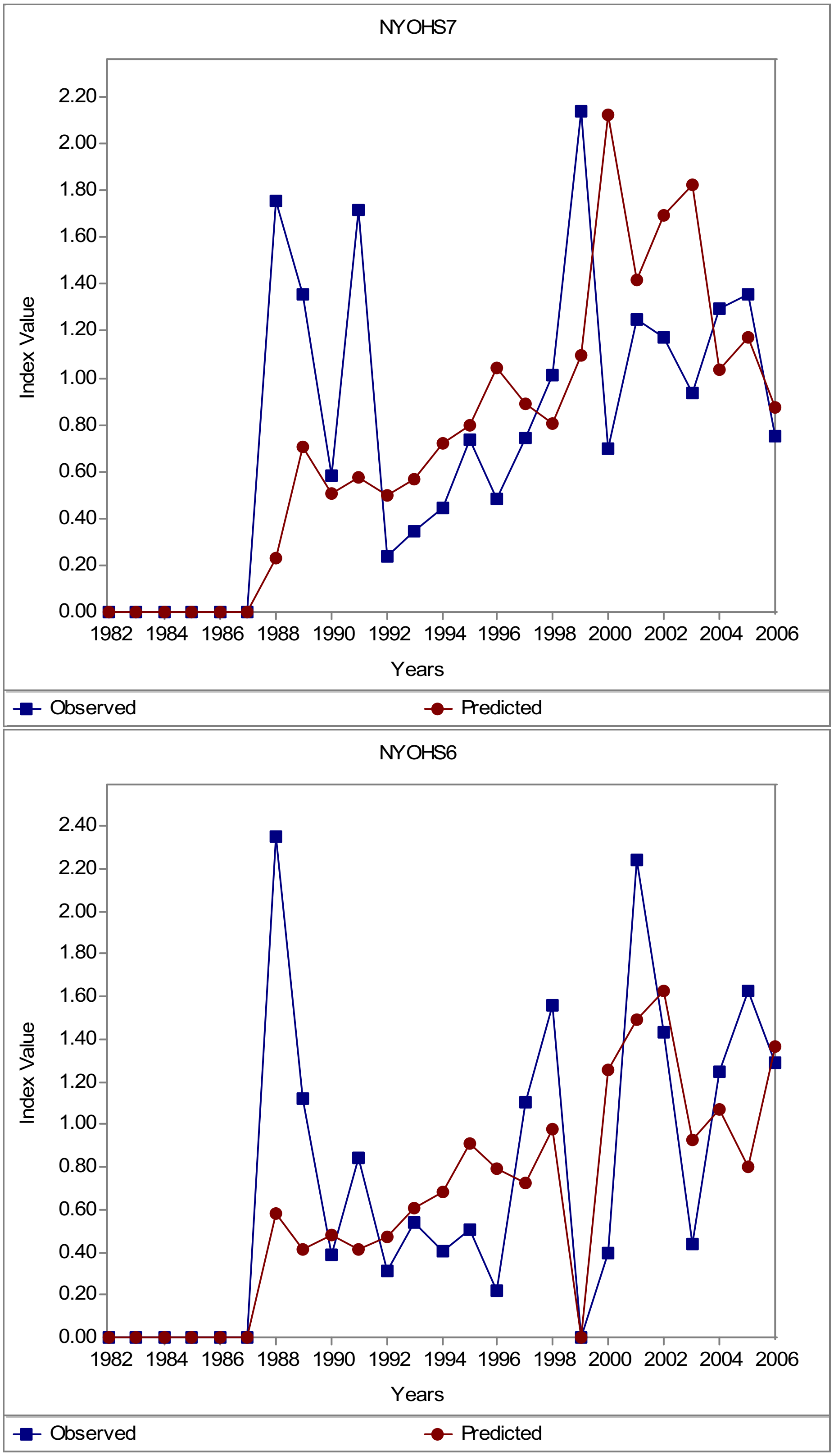


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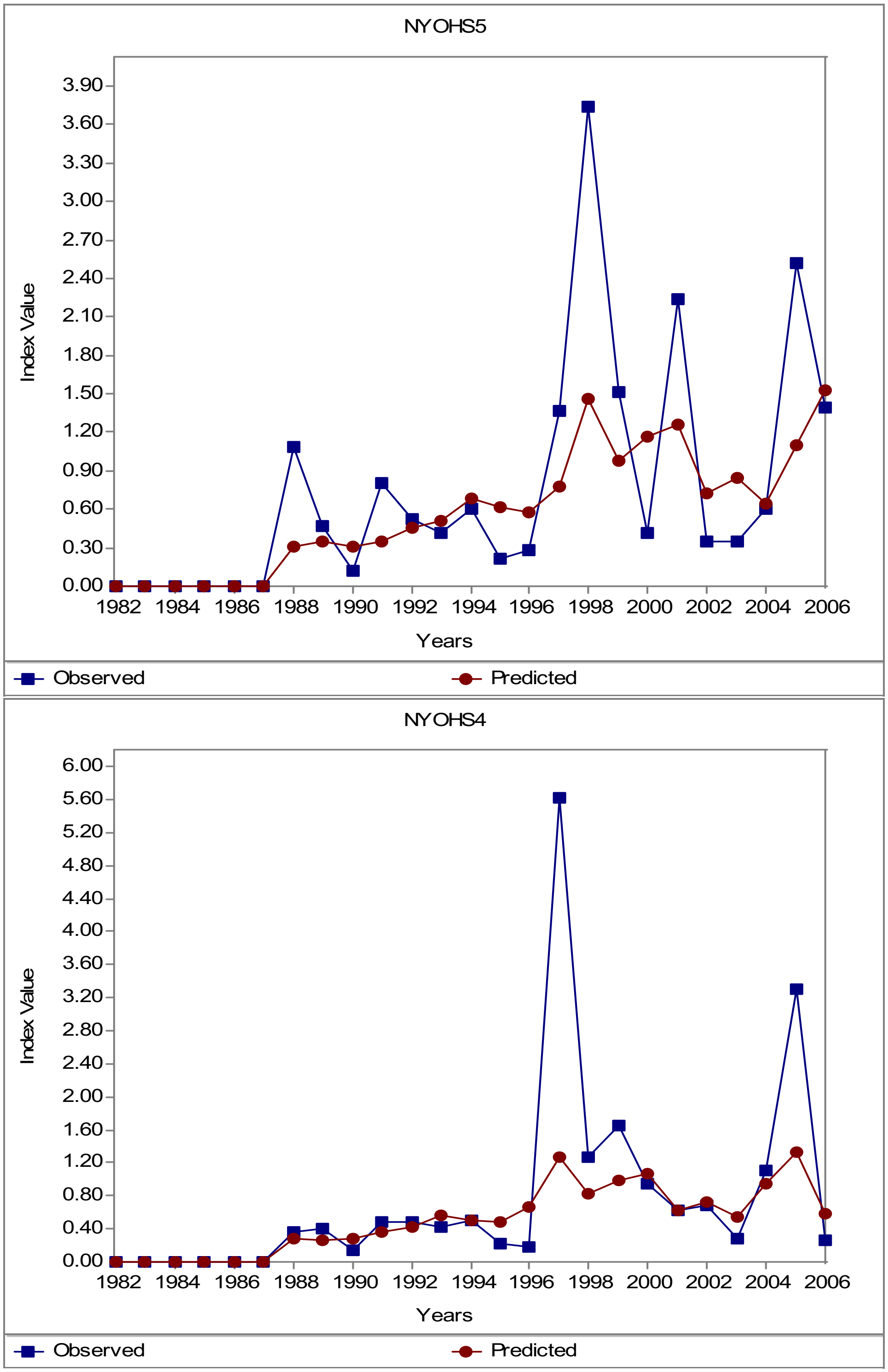


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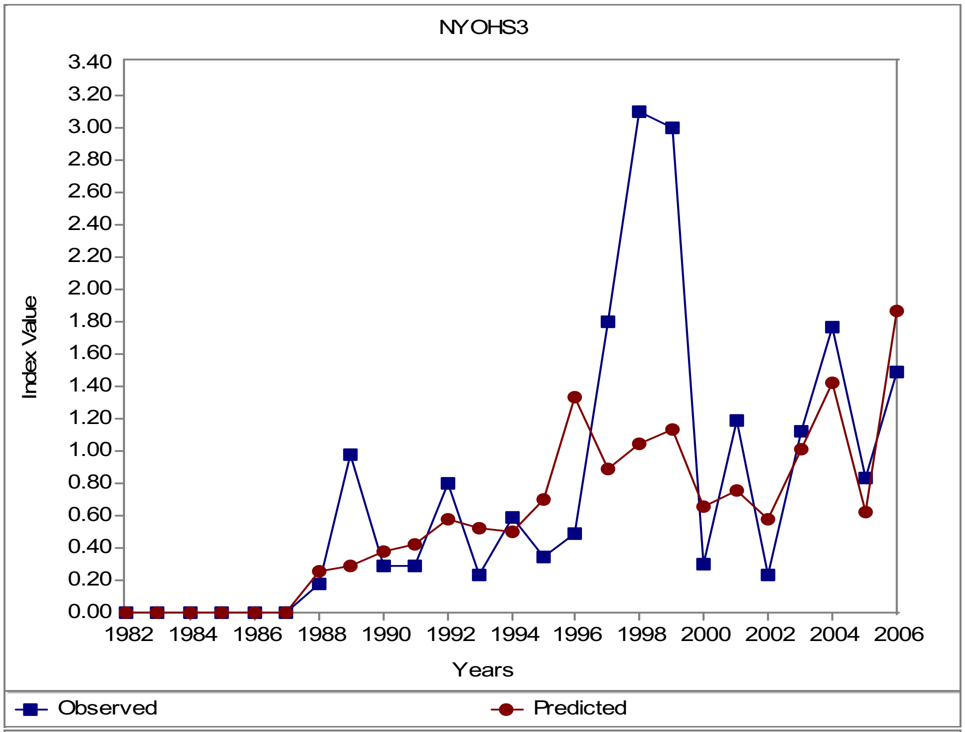


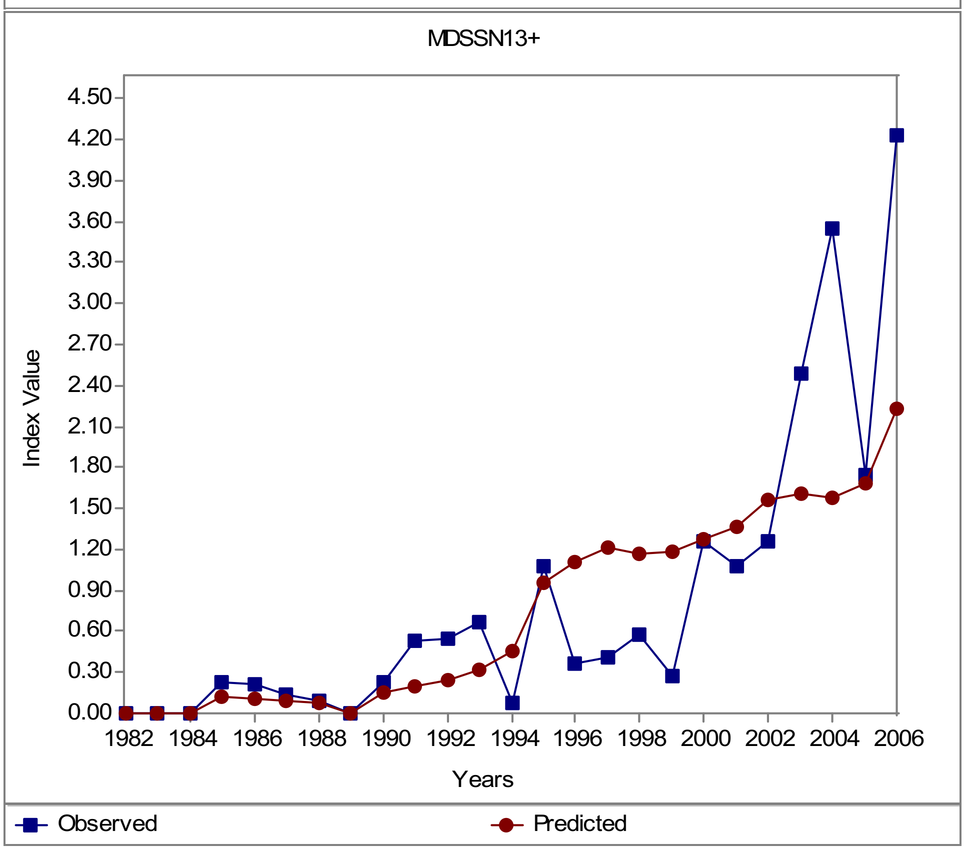


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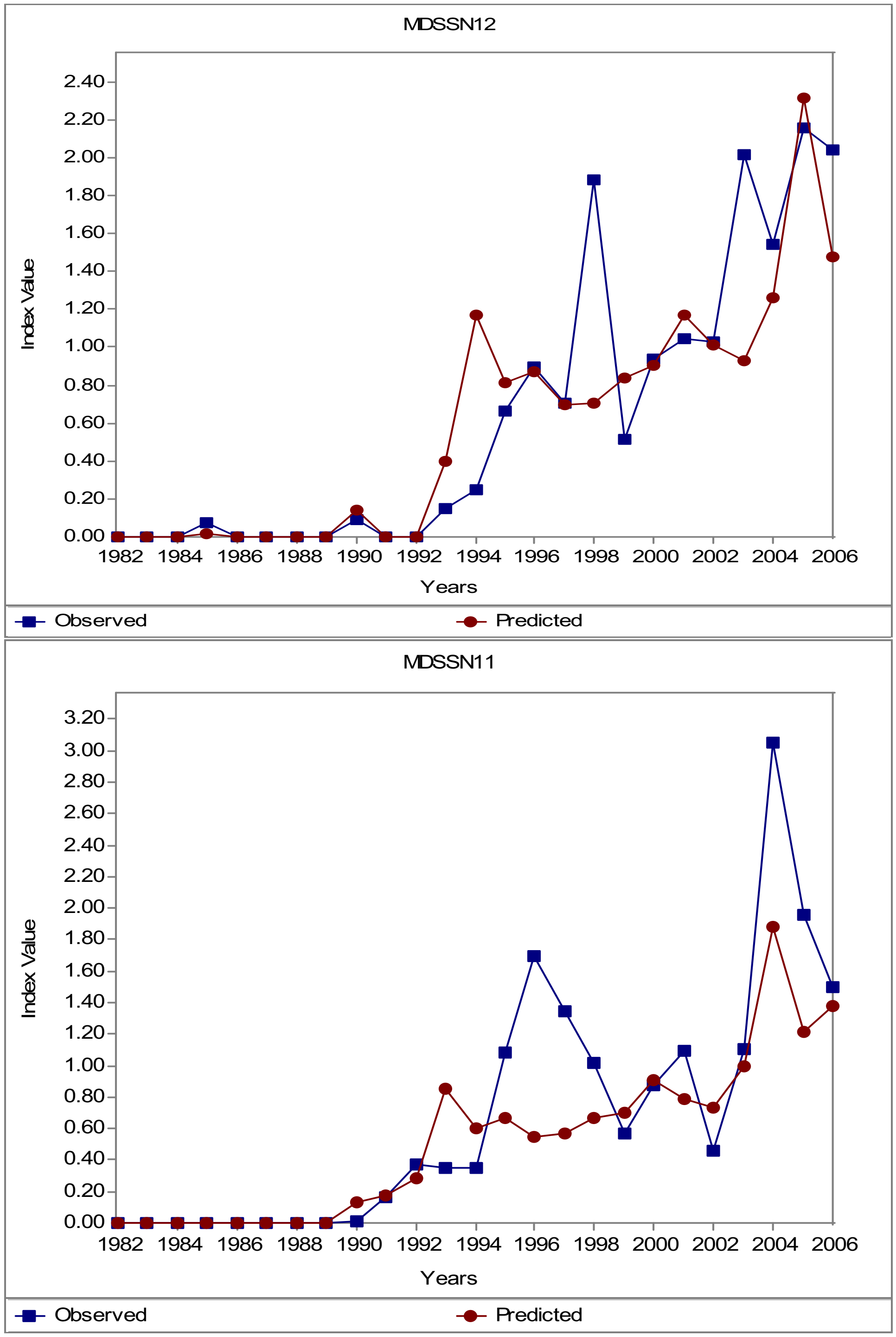


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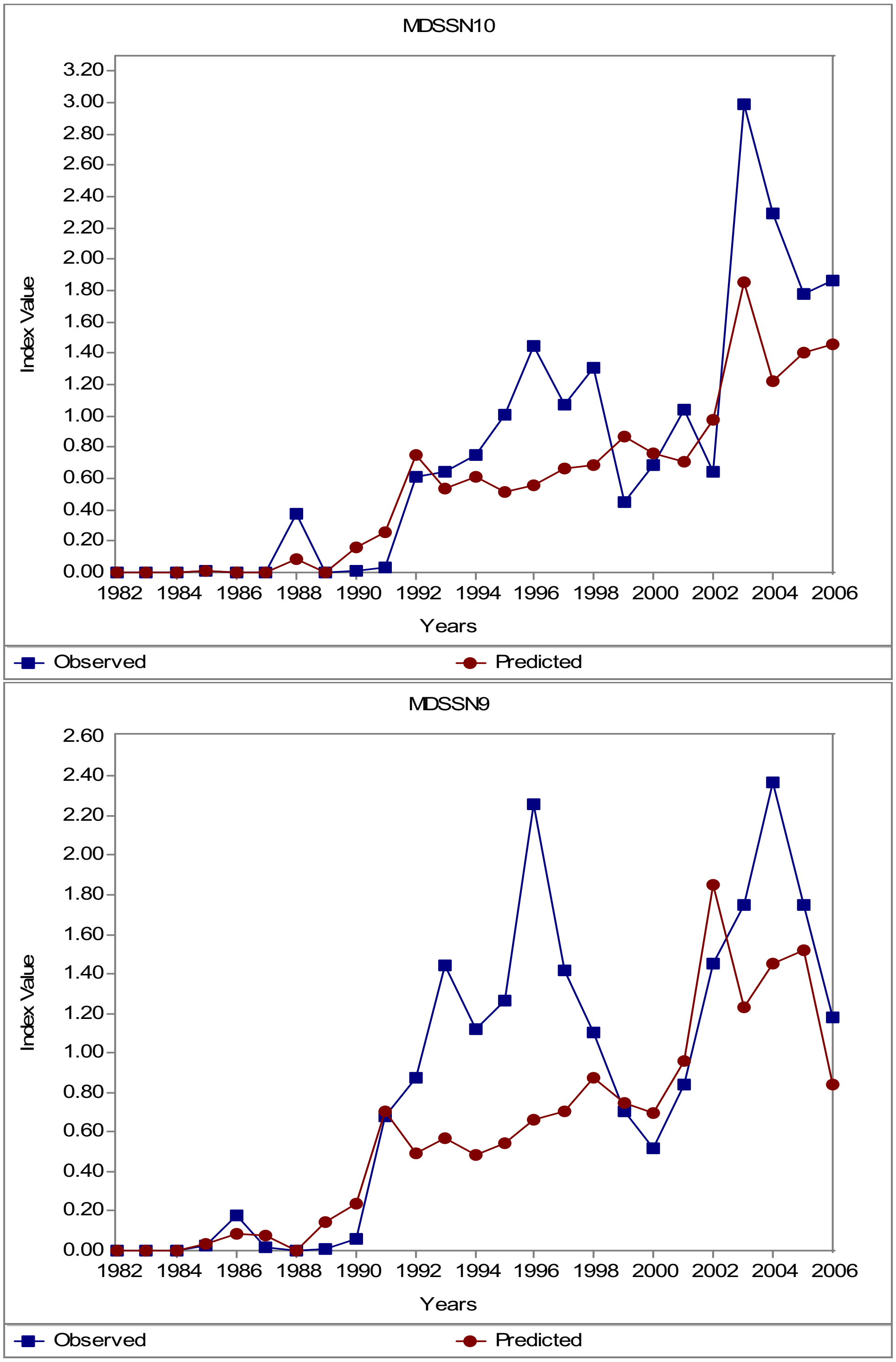


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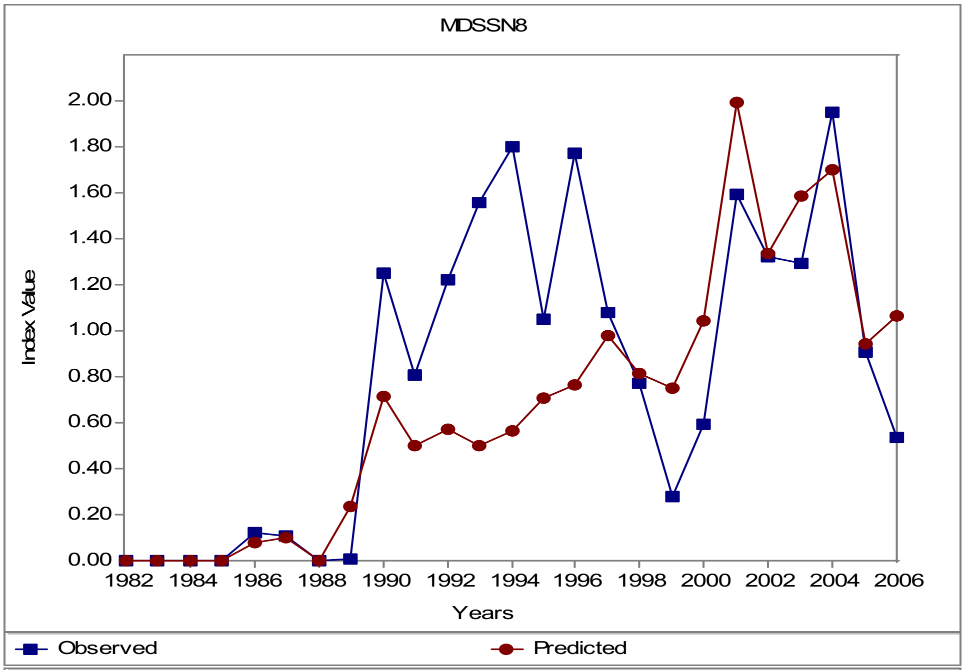


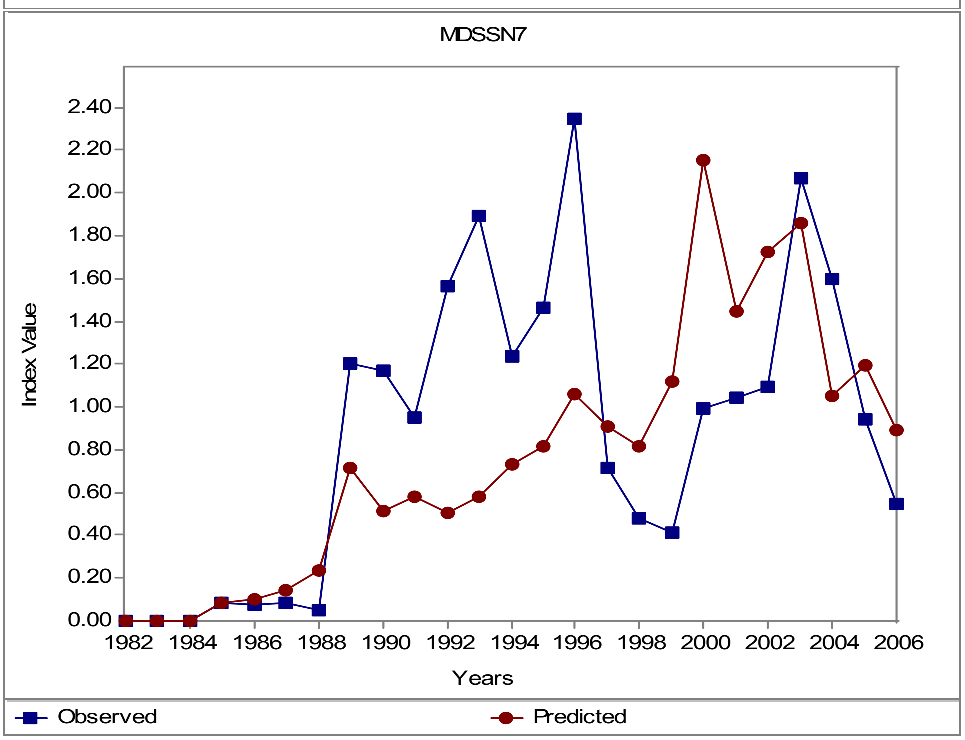


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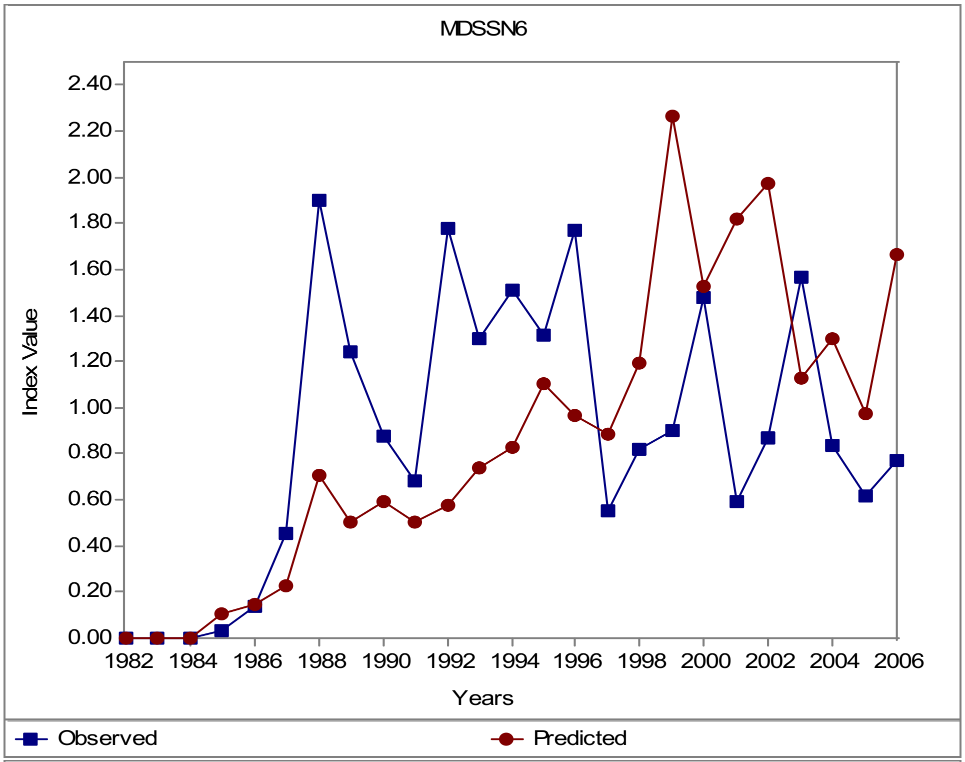


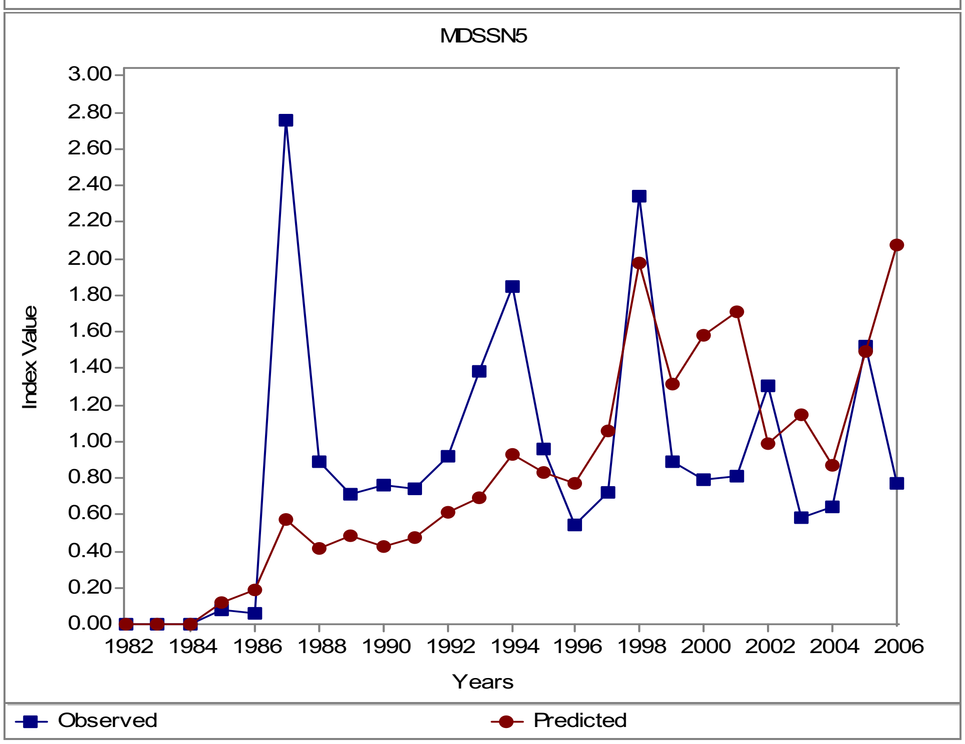


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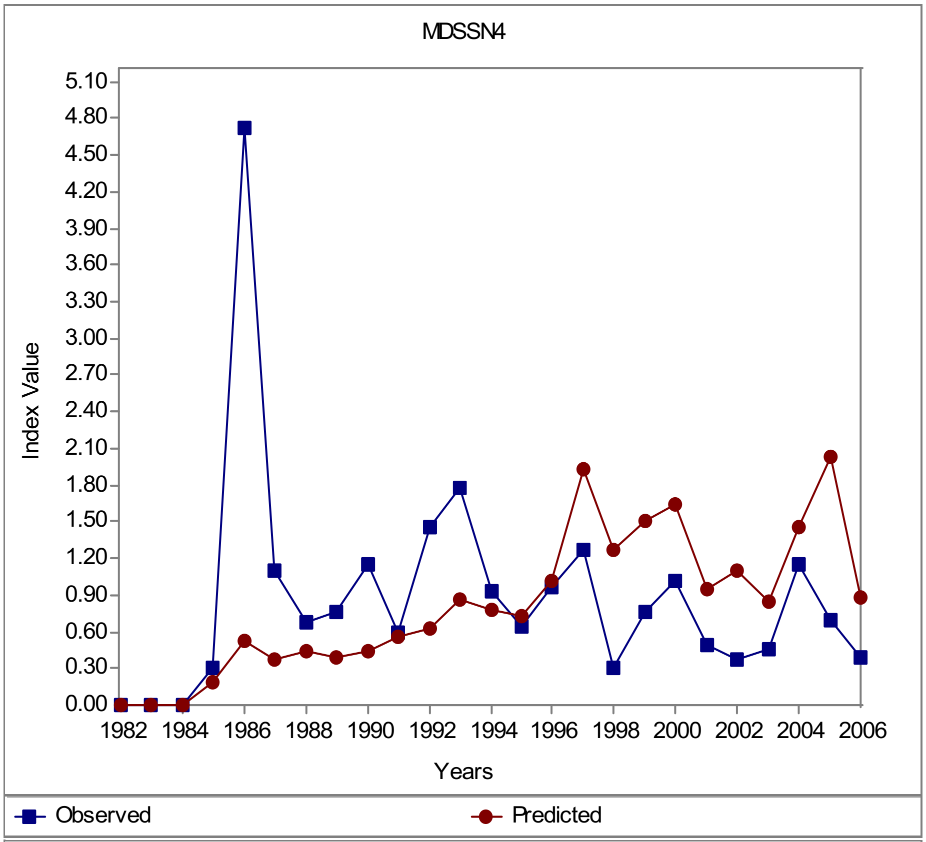


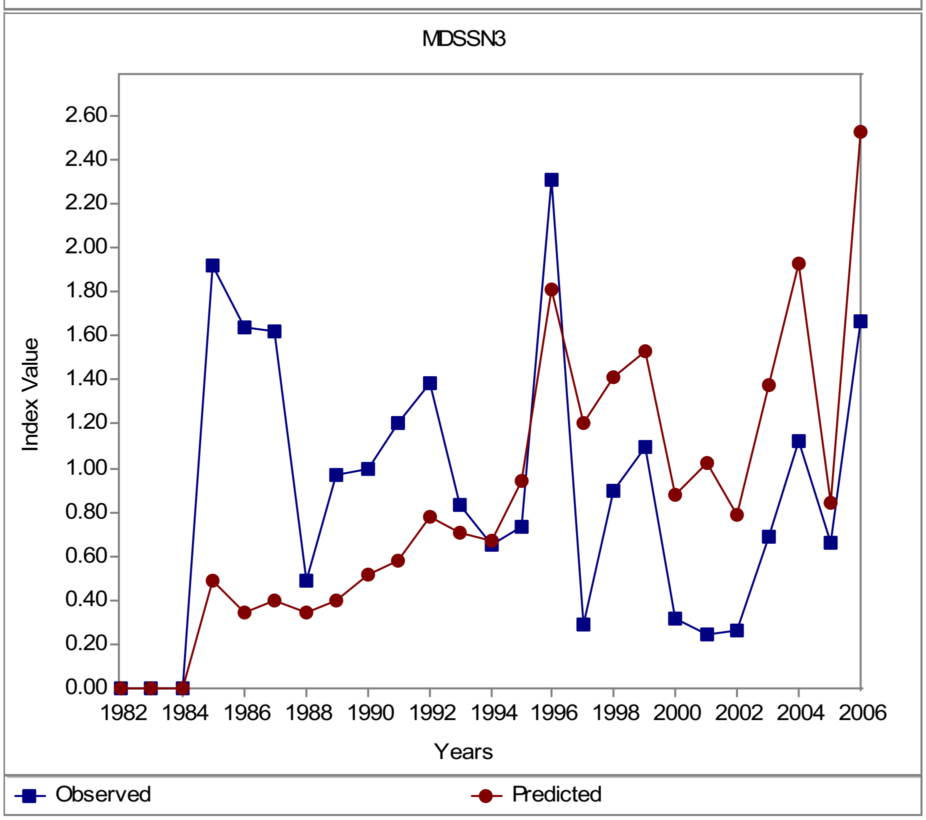


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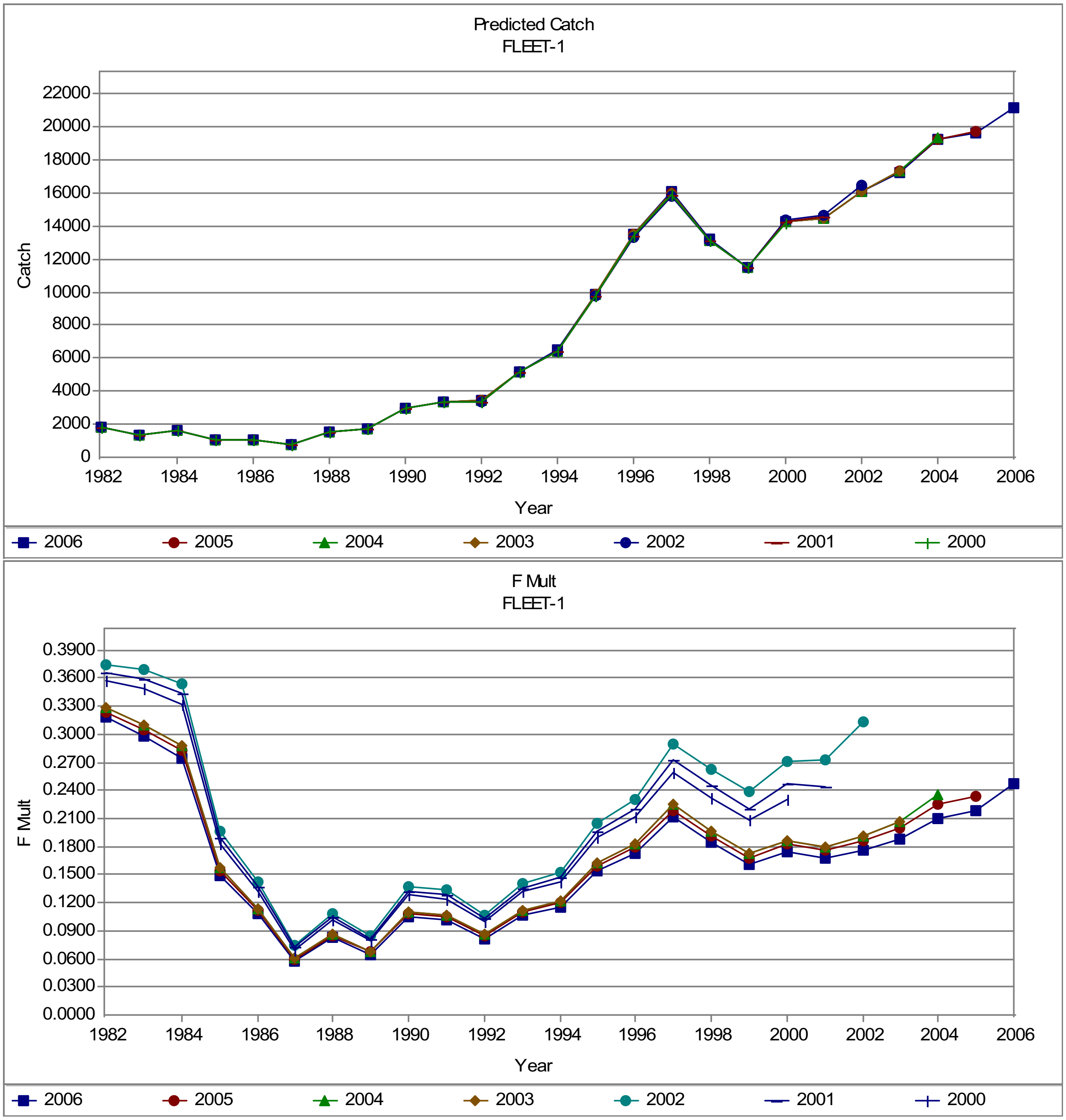


Figure 4. Retrospective patterns of catch and F estimates from ASAP model.

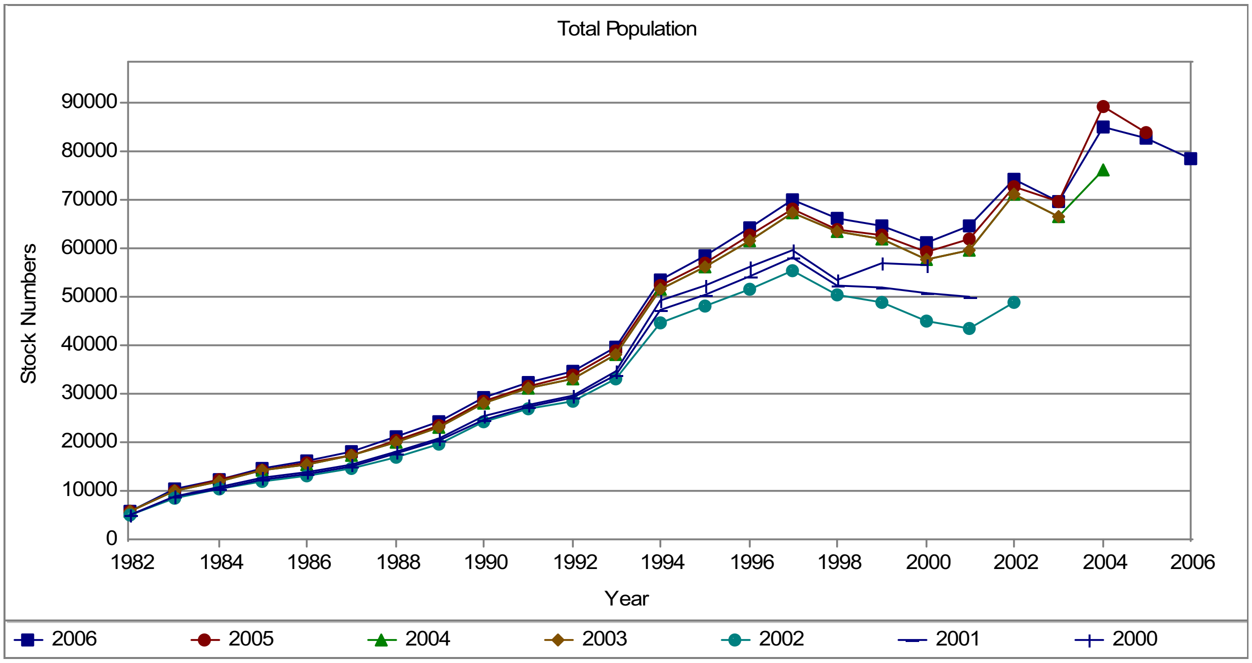


Figure 5. Retrospective patterns of total abundance from ASAP model.

## Appendix A11: Striped Bass Catch Curve Analysis

The coastwide 1982 – 2006 striped bass catch-at-age data was used to conduct a series of cohort catch curves (i.e. following the fate of a single cohort through time). For any given cohort, all age specific data available were analyzed to determine the age at full recruitment. The catch data from the age of full recruitment, plus one age group, through age-12 were used to conduct the cohort catch curves (i.e. the 13+ group was not used in the analysis). Ages-6 or 7 were usually the starting ages for the catch curve; however age-5 was typically the starting point for older cohorts, most likely due to smaller size limits during that time period resulting in earlier recruitment to the fishery.

Two different regression techniques were employed. The first analysis was a standard parametric linear regression analysis using the Proc Reg procedure in SAS software (SAS Institute Inc., v. 8e, 2001). The analysis determined the regression coefficient (estimate of total mortality, Z) for each cohort, the associated standard error and 95% confidence intervals and p-value to determine if the regression coefficient was significantly different from zero (Table 1, Figure 1). In an effort to develop more robust estimates of total mortality, a nonparametric regression analysis was also conducted in R 2.4 software. This analysis used a distribution-free test for the slope estimator using the Theil Statistic (Hollander and Wolfe, 1999). This analysis produced regression coefficients for each cohort, the associated 95% confidence intervals and p-vales (Table 2).

The two methods produced similar results in terms of total mortality estimates (on a per cohort basis), confidence intervals for those estimates, and determining significance for those estimates (Figures 1 and 2). The relationship between the two methods total mortality estimates is quite strong – i.e. similar regression coefficient estimates ($R^2$ = 0.960). The 1988 cohort was the only substantial difference between the two methods, in terms of total mortality estimates, with the nonparametric method producing lower estimates than the parametric method, 0.196 and 0.296 respectively. Also, there was one difference between the two methods when calculation significance for the regression coefficient. The nonparametric method determined the regression coefficient for the 1987 cohort was not significantly different from zero (p-value = 0.054), where the parametric test showed that is was (p-value = 0.025).

An alternate analysis was also conducted in order to create a timeseries of total mortality estimates that are more in line with the 1982 – 2006 catch information and other modeling techniques. A year specific total mortality estimate was derived using the cohort specific catch curve data, described above, in which the total mortality estimates of a cohort were aligned by years in which that cohort would have been harvested. For example, the 1980 cohort catch curve was estimated with catch data that began in 1985 (5 year olds) through 1992 (12 year olds); the 1981 cohort catch curve was estimated with data that began in 1986 through 1993. Those cohorts were then used, along with other cohorts with estimates in the same year, to calculate an average total mortality in 1986 for example. A minimum of three cohorts within a given year were used to calculate the average total mortality for that year. The average total mortality estimates were the highest in the early 1980's, followed by a decline to the mid 1990's and a subsequent rise through 2000; since 2000 there has been a steady decline in total mortality (Figure 3).

### References

Hollander M, Wolfe D. 1999. Nonparametric Statistical Methods. John Wiley and Sons, Inc. p 416 – 420.

**Appendix A11 Tables**

Table 1.

| Cohort (Year Class) | Regression Coefficient - **Z** | S.E. | Upper 95% C.I. | Lower 95% C.I. | P - value |
|---|---|---|---|---|---|
| 1978 | 0.566 | 0.058 | 0.707 | 0.426 | **0.0001** |
| 1979 | 0.434 | 0.068 | 0.600 | 0.268 | **0.0007** |
| 1980 | 0.301 | 0.069 | 0.471 | 0.132 | **0.0048** |
| 1981 | 0.218 | 0.047 | 0.334 | 0.102 | **0.0037** |
| 1982 | 0.166 | 0.035 | 0.249 | 0.082 | **0.0022** |
| 1983 | 0.267 | 0.066 | 0.436 | 0.098 | **0.0098** |
| 1984 | 0.125 | 0.043 | 0.243 | 0.006 | **0.0430** |
| 1985 | 0.136 | 0.064 | 0.301 | -0.029 | 0.0883 |
| 1986 | 0.135 | 0.045 | 0.245 | 0.025 | **0.0239** |
| 1987 | 0.156 | 0.048 | 0.273 | 0.039 | **0.0250** |
| 1988 | 0.296 | 0.081 | 0.504 | 0.088 | **0.0145** |
| 1989 | 0.489 | 0.050 | 0.628 | 0.350 | **0.0006** |
| 1990 | 0.410 | 0.034 | 0.504 | 0.316 | **0.0003** |
| 1991 | 0.272 | 0.015 | 0.313 | 0.230 | **0.0001** |
| 1992 | 0.265 | 0.043 | 0.375 | 0.155 | **0.0016** |
| 1993 | 0.281 | 0.039 | 0.380 | 0.182 | **0.0008** |
| 1994 | 0.200 | 0.036 | 0.301 | 0.099 | **0.0053** |
| 1995 | 0.167 | 0.015 | 0.208 | 0.125 | **0.0004** |
| 1996 | 0.136 | 0.013 | 0.173 | 0.099 | **0.0005** |
| 1997 | 0.145 | 0.030 | 0.242 | 0.049 | **0.0174** |

Ages 4 - 12 used for analysis (if all available and depending upon age of full recruitment)
Used standard parametric linerar regression techniques in SAS
Bold P-values indicate significance - reg. coeff. sig. diff. from zero
Took the absolute value of the regression coefficient for Z estimate

Table 2.

| Cohort (Year Class) | Regression Coefficient - **Z** | Upper 95% C.I. | Lower 95% C.I. | P - value |
|---|---|---|---|---|
| 1978 | 0.595 | 0.696 | 0.384 | **0.0000** |
| 1979 | 0.433 | 0.607 | 0.268 | **0.0010** |
| 1980 | 0.326 | 0.603 | 0.162 | **0.0070** |
| 1981 | 0.212 | 0.368 | 0.063 | **0.0045** |
| 1982 | 0.169 | 0.247 | 0.082 | **0.0010** |
| 1983 | 0.265 | 0.421 | 0.056 | **0.0130** |
| 1984 | 0.139 | 0.298 | 0.020 | **0.0340** |
| 1985 | 0.157 | 0.433 | -0.117 | 0.0700 |
| 1986 | 0.135 | 0.313 | 0.053 | **0.0160** |
| 1987 | 0.134 | 0.314 | 0.004 | 0.0540 |
| 1988 | 0.196 | 0.675 | 0.013 | **0.0250** |
| 1989 | 0.497 | 0.657 | 0.353 | **0.0100** |
| 1990 | 0.391 | 0.548 | 0.313 | **0.0100** |
| 1991 | 0.283 | 0.318 | 0.215 | **0.0100** |
| 1992 | 0.251 | 0.417 | 0.071 | **0.0130** |
| 1993 | 0.284 | 0.430 | 0.062 | **0.0060** |
| 1994 | 0.187 | 0.466 | 0.089 | **0.0180** |
| 1995 | 0.163 | 0.269 | 0.103 | **0.0100** |
| 1996 | 0.131 | 0.189 | 0.095 | **0.0100** |
| 1997 | 0.141 | 0.306 | 0.058 | **0.0420** |

Ages 4 - 12 used for analysis (if all available and depending upon age of full recruitment)
Used nonparametric regression techniques in R - Distribution-Free Test for the Slope, the Theil Statistic method described in Hollander, M. and Wolfe, D. (1999) - Nonparametrci Statistical Methods

Bold P-values indicate significance - reg. coeff. sig. diff. from zero

Took the absolute value of the regression coefficient for Z estimate

## Appendix A11 Figures

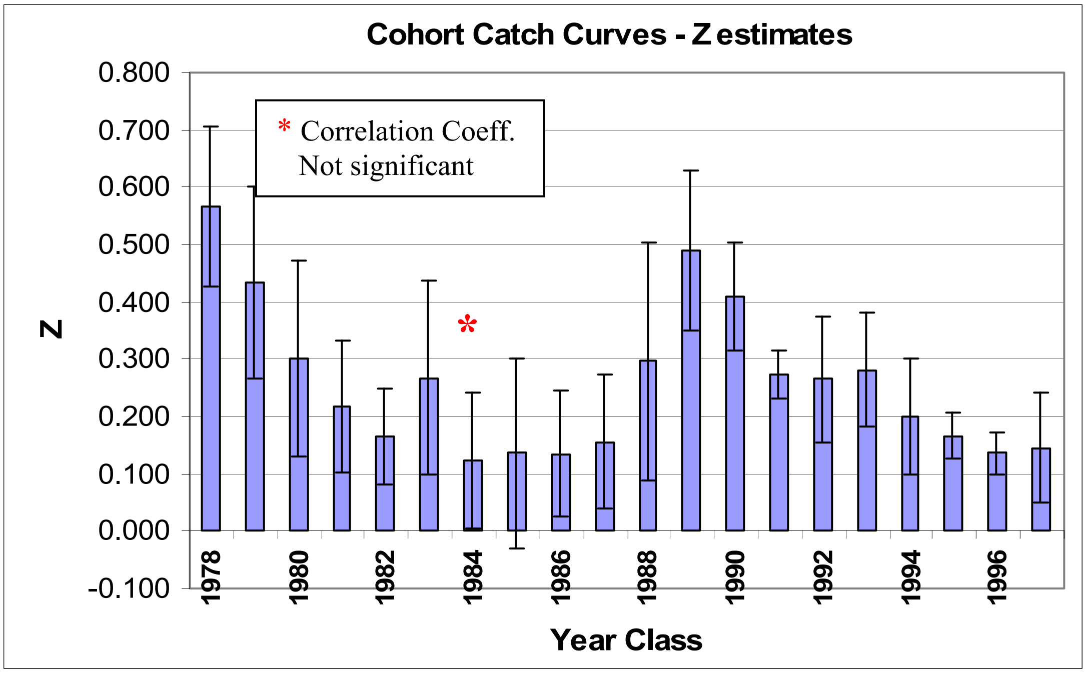


**Figure 1.** Catch Curve Z estimates (95% confidence intervals) - Parametric analysis

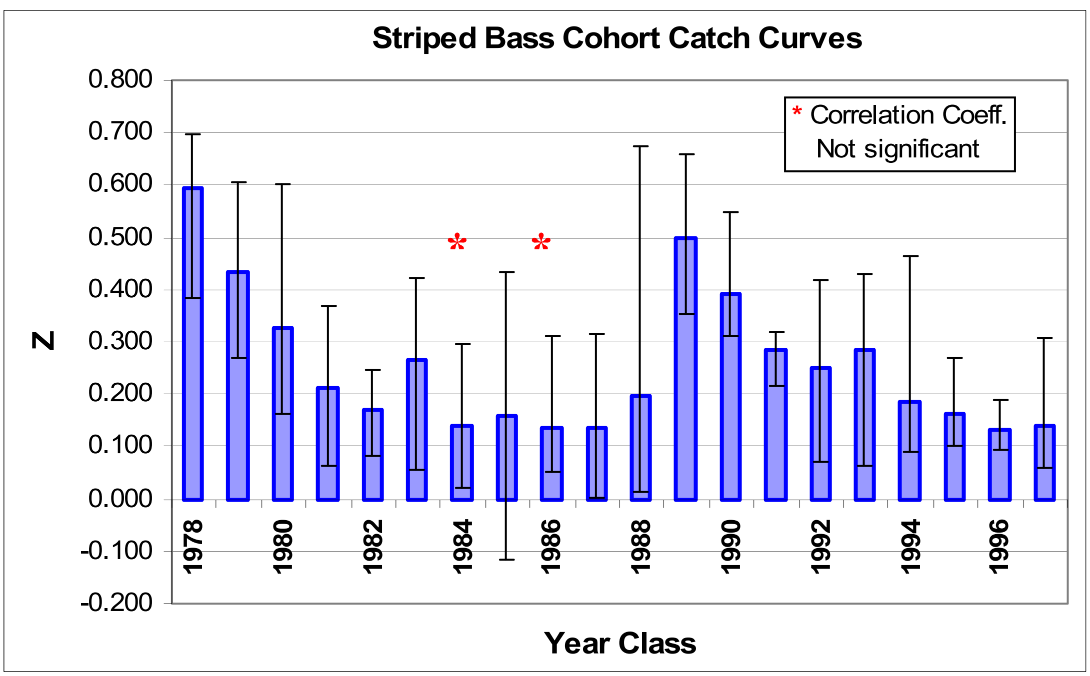


**Figure 2.** Catch Curve Z estimates (95% confidence intervals) – Nonparametric estimates

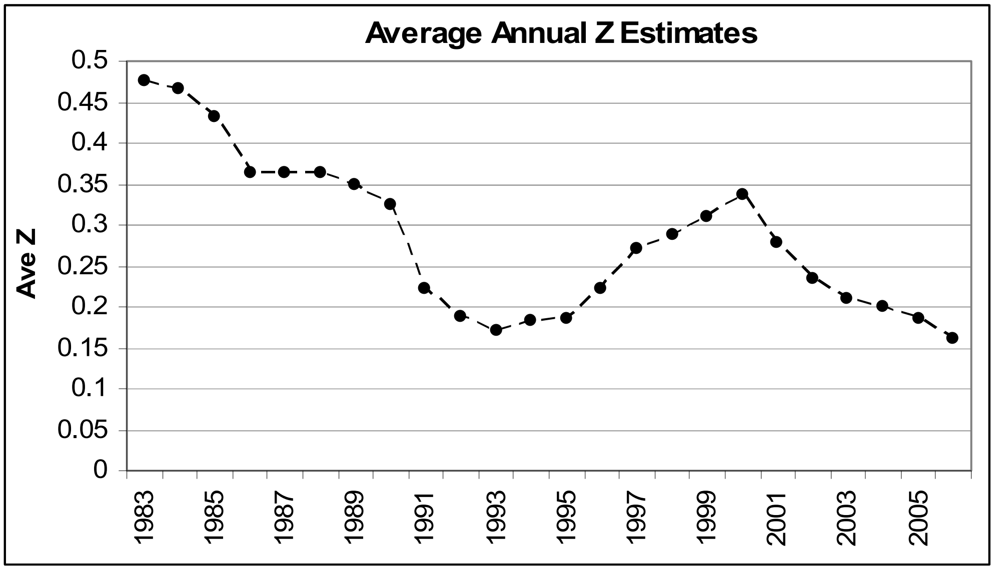


**Figure 3.** Average total mortality of striped bass by year using cohort specific catch curve estimates.

**Appendix A12: Estimating Fishing Mortality (F) on Ages 8+ Striped Bass Based on Landings and Survey Indices from 1982 to 2006**

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October 19, 2007

## Introduction

Our ability to assess the current status of Atlantic coast striped bass has been continually plagued by a pronounced discrepancy between fully recruited (ages 8+) F and stock size estimates from tagging and the ADAPT VPA. Recent fishing mortality (F) estimates on fully recruited stripers based on tagging and the catch equation have remained relatively low (F < 0.22) (Versak 2007), whereas the 2005 and 2006 F estimates on ages 8+ based on ADAPT have exceeded 0.35. All ADAPT model runs conducted thus far have exhibited a pronounced retrospective bias for the terminal (most recent year) age 8+ F and stock size estimates. The ADAPT model almost always overestimated F and underestimated stock size for fully recruited fish in the last three to five years by as much as 50%. Such a large systematic bias in recent F and stock size estimates greatly confounds our ability to determine whether or not striped bass are currently overfished. Due to shortcomings in the ADAPT model, the Statistical Catch-At-Age (SCAM) model has been recently proposed (Nelson 2007) to replace ADAPT in an effort to reduce the magnitude of retrospective bias in F and stock size for fully recruited striped bass. Recent (2007) model runs with SCAM indicate that the degree of retrospective was lower than that from ADAPT, but the SCAM model still overestimated F and underestimated stock size for ages 8+ stripers in recent years (2003-2006) of the time series by 20% to 30%.

Given the uncertainty and controversy surrounding current F estimates on larger striped bass based on tagging (Versak 2007), ADAPT and SCAM, index based approaches (Sinclair 1998; Cotter et al 2004; Crecco 2004) may be needed to corroborate the 2005 and 2006 F, and perhaps provide more stable and reliable terminal F and stock size estimates for fully recruited striped bass. The Striped Bass Stock Assessment Subcommittee (SBSAS) has recommended that annual trends (year effects) in fishing mortality (F) and stock biomass from 1990 to 2006 be examined independently from the VPA.

In this report, an index based approach using relative F (RelFt) and relative stock size (RelNt) estimates was used on fully recruited (ages 8+) striped bass from 1982 to 2006. Relative F and stock size estimates were derived as a ratio of landings to several selected tuning indices that were considered informative about changes in fully recruited (ages 8+) stock size. The objectives of this report were: 1) compare the trends in the RelFt estimates from 1982 to 2006 to corresponding trends in average annual F estimates derived from both SCAM and the catch equation method, and 2) compare the trend in relative stock size estimates (RelNt) to ages 8+ stock sizes from SCAM (Nelson 2007) and the catch equation method (Versak 2007).

## Methods

*Approach*

In this analysis, relative fishing mortality estimates (RelFt) were derived on fully recruited (ages 8+) striped bass from 1982 to 2006. The theoretical underpinnings of this approach is based on a simple re-arrangement of the Baranov catch equation (Ricker 1975, page 13, equation 1.17) with respect to F:

$$F = \text{Catch} / \text{Mean Stock Size}, \quad (1)$$

where: mean stock size is typically expressed as the average stock size in years t and t+1. RelFt estimates were based on the ratio of coast-wide annual (commercial and sport plus discards) landings (numbers) of ages 8+ stripers in year t (Catcht) to the corresponding average relative abundance index (RelNt, RelNt+1) in year t and t+1:

$$\mathbf{RelFt = Catcht / [(RelNt + RelNt{+}1)/2]. \quad (2)}$$

Equation (2) is very similar to the equation introduced earlier by Sinclair (1998) except that he used relative exploitation:

$$\mathbf{Relu = Catch / RelNt \qquad (3)}$$

rather than relative F. Because the 2007 RelNt index is not yet available, the RelNt+1 value ayear later in 2006 was assumed to be the same as the 2006 RelNt index. Relative F estimates via equation (2) do not consider temporal and spatial shifts in the age structure, so this approach is designed only to address relative changes in F across time (1982-2006). Thus, the RelFt values are uninformative about year-class and age-specific changes in F over the time series. The strength of the relative F method, however, is in its simplicity and intuitive appeal, allowing scientists to evaluate the relative accuracy of tuning indices and how they might affect the trend in F estimates. Most importantly, since RelFt estimates are expressed as a ratio of annual harvest to mean relative abundance, the trends in relative F are not confounded by the assumption of constant natural mortality (M = 0.15) used explicitly to derive F estimates (F = Z – 0.15) in the MARK, ADAPT and SCAM models.

The time series of landings and discards (Catcht, n*1000) of ages 8+ stripers (Table 2)in the numerator of equations (1-3) was taken from the 2007 stock assessment (see page). The tuning indices, used to measure striped bass relative abundance in the denominator of equations (2 and 3), were based one or more of the seven tuning indices used in SCAM (Nelson 2007). These indices (Table 1) include the 1991-2006 Massachusetts commercial cpue (ages 8+), 1982-2006 Connecticut **r**ecreational cpue (ages 3+) based on catch-effort from the MRFSS and annual Volunteer Angler Surveys, 1989-2006 New Jersey trawl cpue (ages 8+), 1996-2006 Delaware River cpue (ages 8+), 1985-2006 Maryland spring cpue (ages 8+), 1982-2006 Northeast Fisheries Science Center (NEFSC) trawl cpue (ages 2+), 1982-2006 MRFSS (sport1) cpue (ages 2+) of the coast-wide private boat fishery based on intercept data. One additional tuning index introduced by Des Kahn was also used. This consisted of the 1982-2006 coast-wide MRFSS cpue index (ages 2+) for the private boat fishery (sport2) using the expanded total catch and effort estimates (trips) rather than intercept data. An extensive description of these eight tuning indices is found elsewhere in the assessment report.

*Selection of Informative Tuning Indices*

Except for the sport2 data set derived recently by Des Kahn, all of the other abundance indices (Table 1) were used to tune SCAM. Many of the tuning indices, however, were poorly correlated to the catch-at-age matrix used in SCAM and therefore were not considered as informative indices of ages 8+abundance. Only four of the eight indices (Maryland cpue, Connecticut cpue and sport1 cpue and sport2 cpue) were linearly correlated ($P < 0.05$) to the 1982-2002 ages 8+ abundance (N8) estimates from SCAM (Table 3, Figures 1-8). Of the four, only the fisheries independent Maryland cpue time series was truly linearly related to ages 8+ abundance on the basis of residual patterns (Figure 5). The other three fisheries dependent indices (Connecticut cpue, sport1 cpue and sport2 cpue) were positively related to ages 8+ abundance from SCAM, but were curvilinear with respect to abundance after 2000 (Figures 6-8), suggesting that these fishery dependent indices are less reliable measures of relative abundance at high stock size.

As previously noted, high and persistent retrospective bias was clearly evident from SCAM (see Nelson 2007, Figures 12 and 13) particularly on recent (2003-2006) age 8+ F and abundance estimates. The degree of retrospective bias in SCAM appeared to decline for ages 8+ abundance prior to 2003. For this reason the assumption was made here that the 1982-2002 ages 8+ abundance estimates (N8) from SCAM were our best estimates of ages 8+ abundance, and therefore could be used as an objective basis to eliminate tuning indices that were not linearly correlated to ages 8+ abundance. It is clear that this regression approach to define informative indices using SCAM results is somewhat tainted by the fact that seven of the eight candidate indices were used to some extent to derive ages 8+ abundance from SCAM. Nevertheless, the magnitude and trend in ages 8+ abundance from SCAM are fairly robust to the choice of tuning indices (Gary Nelson MADMF pers comm.).

The choice of the 1982-2002 time series of ages 8+ abundance (N8) from SCAM (Table 2) as a time frame with which to ground truth the tuning indices is arbitrary. Moreover, retrospective bias in ages 8+ F and stock size was discernible as far back as the year 1999 (Nelson 2007). As a result, to further examine the sensitivity of the choice of tuning indices to the 1982-2002 time frame, the correlation analyses (Table 3) between tuning indices and ages 8+ abundance (N8) from SCAM were extended to include abundance estimates (N8) for the periods 1982-1999, 1982-2000 and 1982-2001.

Results of the correlation analyses that included tuning indices from the three additional time frames (1982-1999, 1982-2000 and 1982-2001) were similar to those from the previous analysis on the 1982-2002 time frame (Table 3). The same four indices, namely the Connecticut recreational cpue, both sport cpue indices (sport1 and sport2), and the Maryland spring cpue remained highly ($P < 0.0001$) correlated to ages 8+ abundance (N8) from SCAM for the periods 1982-1999, 1982-2000, 1982-2001 and 1982-2002. The results for the Massachusetts commercial index were sensitive to the chosen time frame of ages 8+ abundance (Table 3). The time series of Massachusetts commercial cpue indices was a poor indicator ($P <0.78$) of ages 8+ abundance for the periods 1982-2002 and 1982-2001, but were significantly correlated ($P <0.02$) to abundance from SCAM for the periods 1982-2000 and 1982-1999. This rapid shift in the correlation coefficient among time frames occurred because the relationship between the Massachusetts indices and ages 8+ abundance was strongly parabolic (Figure 1).

Based on the correlation results (Table 3), three tuning indices were chosen separately to express relative N (RelNt). They included the Connecticut cpue, the Maryland spring cpue and the sport2 cpue. The sport1 index based directly on intercept catch and directed fishing effort was, in most cases, less strongly correlated to ages 8+ abundance than the sport2 index across the four time periods (Table 3). There were also clear periods of nonlinearity between sport1 and sport2 cpue and ages 8+ abundance after 2002 (Figures 6 and 7). The time series trends of sport1 and sport2 cpue are somewhat redundant since they were both derived from basically the same MRFSS catch and effort data. Thus only one of the MRFSS indices should be selected as an informative index of ages 8+ fish. For this reason, the time series of sport2 tuning indices was selected over the sport1 data set based on the overall strength of the correlation with ages 8+ abundance from SCAM (Table 3).

*Ages 8+ Relative Abundance (RelNt) and Relative F (RelFt)*

In this analysis, relative stock size (RelNt) of fully recruited stripers (ages 8+) was estimated from 1982 to 2006 based on the CT cpue, the MD cpue and the MRFSS cpue (sport2). The final RelFt and RelNt estimates were derived from 1982 to 2006 as the blended average relative F and N values from the three tuning indices. The relative abundance indices from the Connecticut, Maryland and sport2 data sets differed in magnitude across the time series (Table 1). For this reason, the Connecticut and sport2 indices were scaled to units of the Maryland indices in order to facilitate blending the indices. Since the time series of Maryland cpue indices began in 1985, the blended estimates of relative F and N from 1982-1984 were based solely on the scaled Connecticut and Sport2 cpue.

**Results and Discussion**

*Relative Fishing Mortality (RelF) and Stock Size (RelN)*

Relative fishing mortality estimates (RelFt) based on the ratio of landings to the Connecticut cpue index (Table 4) were derived from 1982-2006 (Table 4). These RelFt estimates declined steadily from 1982 to 1989, rose to a peak level in 2004 then relative F declined to pre-2002 levels in 2005 and 2006. When the Connecticut cpue data were used to index relative abundance (Table 4), RelNt estimates rose steadily from low levels in 1983 to peak levels in 2006.

Using the Maryland spring cpue index, relative fishing mortality and stock size estimates (Table 5) were derived from 1982-2006. Relative fishing mortality (RelF) estimates generally rose after 1989 but varied without trend thereafter (Table 5). When the Maryland spring cpue data were used to index relative ages 8+ abundance (Table 5), ages 8+ relative abundance rose steadily from low levels prior to 1995 to peak levels in 2006.

When sport 2 indices were used to express relative F and stock size (Table 6) from 1982 to 2006, the trends were very similar to those based on the Connecticut cpue (Table 4). Relative fishing mortality (RelF) estimates based on the sport2 indices rose to peak levels in 2004 then relative F declined slightly thereafter. When Sport2 cpue data were used to index relative abundance (Table 6), relative stock size generally rose from low levels prior to 1994 to peak levels in 2006.

*Blended Ages 8+ Relative F and Abundance*

Ages 8+ relative F and stock size estimates were derived as a blended average across the three indices (Table 7, Figure 9 and 10). Blended relative F estimates from 1982 to 2004 generally followed the same trend as absolute F estimates based on SCAM (Figure 9), although the trend in the blended relative F estimates diverged substantially from SCAM F estimates in 2005 and 2006 (Table 7, Figure 9). The ages 8+ F estimates from SCAM continued to rise steadily from 2003 to a peak level of 0.31 in 2006, whereas the blended relative F estimates peaked in 2004 then dropped by 15 to 20% in 2005 and 2006.

Both the blended ages 8+ abundance and SCAM-based absolute abundance estimates rose steadily from about 1988 to 2004 (Table 7, Figure 10). After 2004, however, the trends in abundance changed dramatically between the two methods (Figure 10). The blended relative abundance estimates continued to rise beyond 2004 to peak levels in 2006, whereas the absolute abundance estimates from SCAM peaked in 2004 then fell by 15 to 20% in 2005 and 2006 (Figure 10). The results from this analysis suggest that the degree of retrospective bias in F and stock abundance from SCAM is largely confined to the most recent two (2005-2006) years of the time series.

The blended relative F and corresponding abundance estimates were also compared to tag-based F and abundance of ages 7+ fish based on the catch equation method (Versak 2007) from 1988 to 2006 (Table 7, Figures 9 and 10). Like the trend in the blended relative F values, the tag-based F estimates did not exhibit a steady rise in F beyond 2004 (Figure 9) as was clearly reflected by the SCAM F estimates (Figure 9). Moreover, ages 7+ abundance from tagging also rose fairly steadily from 1998 to peak levels in 2006 in a similar pattern as that exhibited by the blended relative stock estimates (Figure 10). The trends in relative F and stock size after 2002 are more consistent with trends in F and stock size from the catch equation method than those from SCAM.

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**Appendix A12 Tables**

Table 1. Time Series of Tuning Indices Used to Index Ages 8+ Stripers. Indices Include the MA Commercial (Ages 8+) CPUE, Connecticut (Ages 3+) Rec CPUE, New Jersey (Ages 8+) Trawl index, Delaware River Spawning (Ages 8+) Index, Maryland Spawning (Ages 8+) Index, Sport1 Ocean (Ages 2+) CPUE, Sport2 Coast-Wide (Ages 2+) CPUE and NMFS Trawl (Ages 2+) Index.

| YEAR | MACOMM | CT3 | NJTRWL | DESSN | MDSSN | Sport1 | Sport2 | NEFSC |
|---|---|---|---|---|---|---|---|---|
| 1982 | | 0.56 | | | | | 0.030 | |
| 1983 | | 0.35 | | | | | 0.031 | |
| 1984 | | 0.80 | | | | | 0.024 | |
| 1985 | | 0.83 | | | 1.38 | | 0.034 | |
| 1986 | | 1.41 | | | 0.95 | | 0.043 | |
| 1987 | | 0.81 | | | 0.63 | | 0.034 | |
| 1988 | | 0.81 | | | 0.37 | 0.362 | 0.080 | |
| 1989 | | 1.06 | 0.017 | | 0.95 | 0.266 | 0.082 | |
| 1990 | | 1.36 | 0.183 | | 1.53 | 0.241 | 0.125 | |
| 1991 | 0.455 | 1.21 | 0.167 | | 2.26 | 0.414 | 0.182 | 0.235 |
| 1992 | 0.628 | 1.46 | 0.007 | | 2.43 | 0.749 | 0.257 | 0.237 |
| 1993 | 0.652 | 2.49 | 0.016 | | 3.80 | 0.611 | 0.279 | 0.481 |
| 1994 | 0.614 | 3.27 | 0.028 | | 1.56 | 0.908 | 0.562 | 1.394 |
| 1995 | 0.756 | 4.41 | 0.060 | | 8.18 | 1.175 | 0.697 | 0.952 |
| 1996 | 0.842 | 6.57 | 0.026 | 3.01 | 6.32 | 1.333 | 0.794 | 0.602 |
| 1997 | 0.717 | 5.36 | 0.051 | 4.20 | 5.55 | 1.370 | 1.031 | 1.182 |
| 1998 | 0.665 | 6.96 | 0.263 | 7.67 | 12.38 | 1.715 | 1.050 | 0.729 |
| 1999 | 0.712 | 4.10 | 0.065 | 4.07 | 3.88 | 1.615 | 0.948 | 0.448 |
| 2000 | 0.751 | 6.12 | 0.192 | 4.65 | 10.39 | 1.511 | 0.969 | 1.274 |
| 2001 | 0.499 | 6.32 | 0.069 | 6.90 | 10.25 | 1.262 | 0.750 | 0.623 |
| 2002 | 0.535 | 4.19 | 0.224 | 5.16 | 10.90 | 1.053 | 0.885 | 0.981 |
| 2003 | 0.548 | 4.26 | 0.497 | 11.13 | 21.51 | 0.929 | 0.898 | 0.774 |
| 2004 | 0.634 | 6.61 | 0.417 | 11.10 | 23.60 | 1.009 | 0.985 | 0.335 |
| 2005 | 0.603 | 6.57 | 0.216 | 5.00 | 18.90 | 1.168 | 1.040 | 0.293 |
| 2006 | 0.719 | 10.76 | 0.471 | 7.80 | 29.20 | 1.387 | 1.282 | 0.628 |

Table 2. time series of ages 8+ fishing mortality (FSCAM) and stock size (N8T*1000) of stripers based on the SCAM model, ages 8+ landings (Catch*1000) in number and ages 7+ fishing mortality (FCAT) and stock size (NCAT) from the catch equation, 1982-2006.

| YEAR | CATCH | FSCAM | N8 | N8T | Fcat | Ncat |
|---|---|---|---|---|---|---|
| 1982 | 79.5 | 0.45 | 463 | 463 | | |
| 1983 | 34.5 | 0.42 | 333 | 333 | | |
| 1984 | 21.0 | 0.32 | 245 | 245 | | |
| 1985 | 39.2 | 0.21 | 232 | 232 | | |
| 1986 | 53.6 | 0.15 | 337 | 337 | | |
| 1987 | 32.3 | 0.08 | 412 | 412 | | |
| 1988 | 60.8 | 0.15 | 495 | 495 | 0.06 | 1770 |
| 1989 | 49.3 | 0.11 | 628 | 628 | 0.04 | 2830 |
| 1990 | 118.2 | 0.12 | 1375 | 1375 | 0.08 | 1996 |
| 1991 | 205.1 | 0.11 | 1918 | 1918 | 0.18 | 1526 |
| 1992 | 200.3 | 0.09 | 2329 | 2329 | 0.10 | 1715 |
| 1993 | 294.0 | 0.11 | 2621 | 2621 | 0.12 | 2177 |
| 1994 | 340.5 | 0.13 | 3052 | 3052 | 0.08 | 3728 |
| 1995 | 514.8 | 0.18 | 3496 | 3496 | 0.15 | 3308 |
| 1996 | 523.5 | 0.20 | 3865 | 3865 | 0.16 | 4869 |
| 1997 | 912.6 | 0.24 | 4498 | 4498 | 0.27 | 4397 |
| 1998 | 800.1 | 0.20 | 4372 | 4372 | 0.24 | 3739 |
| 1999 | 747.2 | 0.17 | 4421 | 4421 | 0.23 | 3921 |
| 2000 | 737.1 | 0.22 | 4982 | 4982 | 0.14 | 7454 |
| 2001 | 1012.1 | 0.20 | 6934 | 6934 | 0.14 | 9339 |
| 2002 | 941.6 | 0.19 | 7133 | 7133 | 0.15 | 11371 |
| 2003 | 1404.2 | 0.24 | | 7669 | 0.16 | 12168 |
| 2004 | 1873.7 | 0.26 | | 8028 | 0.16 | 14727 |
| 2005 | 1708.9 | 0.29 | | 6927 | 0.19 | 11865 |
| 2006 | 1781.3 | 0.31 | | 5915 | 0.15 | 12852 |

Table 3. Pearson Correlation (r) Analyses between relative abundance (cpue) of each of the eight candidate tuning indices and ages 8+ abundance from SCAM. This analysis was conducted on ages 8+ abundance over four time periods (1982-2002, 1982-2001, 1982-2000, 1982-1999). An asterisk (*) indicates a statistically significant ($P < 0.05$) correlation between the tuning index and ages 8+ abundance.

| Index | Time Periods (Years) | | | |
|---|---|---|---|---|
| | 82-02 | 82-01 | 82-00 | 82-99 |
| MaCOMM | -0.12 | 0.08 | 0.70* | 0.69* |
| NJtrwl | 0.32 | 0.13 | 0.22 | 0.08 |
| DESSN | 0.42 | 0.54 | 0.26 | 0.44 |
| MDSSN | 0.87* | 0.84* | 0.81* | 0.77* |
| Sport1 | 0.76* | 0.85* | 0.95* | 0.95* |
| Sport2 | 0.90* | 0.91* | 0.97* | 0.96* |
| NEFSC | 0.36 | 0.32 | 0.56 | 0.44 |
| CT cpue | 0.87* | 0.92* | 0.92* | 0.91* |

Table 4. Time series of relative fishing mortality (RefF1) and relative stock size (CTsc) on ages 8+ stripers based on landings and the Connecticut CPUE index from 1982-2006.

| YEAR | CATCH | ctsc | ctscl | RelF1 |
|---|---|---|---|---|
| 1982 | 79.50 | 1.27 | 0.79 | 77.31 |
| 1983 | 34.50 | 0.79 | 1.81 | 26.55 |
| 1984 | 21.00 | 1.81 | 1.88 | 11.40 |
| 1985 | 39.20 | 1.88 | 3.19 | 15.49 |
| 1986 | 53.60 | 3.19 | 1.83 | 21.37 |
| 1987 | 32.30 | 1.83 | 1.83 | 17.64 |
| 1988 | 60.80 | 1.83 | 2.40 | 28.77 |
| 1989 | 49.30 | 2.40 | 3.07 | 18.03 |
| 1990 | 118.20 | 3.07 | 2.73 | 40.70 |
| 1991 | 205.10 | 2.73 | 3.30 | 67.98 |
| 1992 | 200.30 | 3.30 | 5.63 | 44.88 |
| 1993 | 294.00 | 5.63 | 7.39 | 45.17 |
| 1994 | 340.50 | 7.39 | 9.97 | 39.24 |
| 1995 | 514.80 | 9.97 | 14.85 | 41.49 |
| 1996 | 523.50 | 14.85 | 12.11 | 38.83 |
| 1997 | 912.59 | 12.11 | 15.73 | 65.55 |
| 1998 | 800.10 | 15.73 | 9.27 | 64.02 |
| 1999 | 747.20 | 9.27 | 13.83 | 64.70 |
| 2000 | 737.10 | 13.83 | 14.28 | 52.44 |
| 2001 | 1012.10 | 14.28 | 9.47 | 85.22 |
| 2002 | 941.55 | 9.47 | 9.63 | 98.61 |
| 2003 | 1404.19 | 9.63 | 14.94 | 114.32 |
| 2004 | 1873.69 | 14.94 | 14.85 | 125.81 |
| 2005 | 1708.88 | 14.85 | 24.32 | 87.26 |
| 2006 | 1781.32 | 24.32 | 24.30 | 73.28 |

Table 5. Time series of relative fishing mortality (RelF2) and relative stock size (MDSNN) on ages 8+ stripers based on landings and the Maryland CPUE index from 1985-2006.

| YEAR | CATCH | MDSSN | mdSsnl | RelF2 |
|---|---|---|---|---|
| 1982 | 79.50 | | | |
| 1983 | 34.50 | | | |
| 1984 | 21.00 | | 1.38 | |
| 1985 | 39.20 | 1.38 | 0.95 | 33.66 |
| 1986 | 53.60 | 0.95 | 0.63 | 68.11 |
| 1987 | 32.30 | 0.63 | 0.37 | 64.93 |
| 1988 | 60.80 | 0.37 | 0.95 | 92.26 |
| 1989 | 49.30 | 0.95 | 1.53 | 39.69 |
| 1990 | 118.20 | 1.53 | 2.26 | 62.29 |
| 1991 | 205.10 | 2.26 | 2.43 | 87.50 |
| 1992 | 200.30 | 2.43 | 3.80 | 64.35 |
| 1993 | 294.00 | 3.80 | 1.56 | 109.68 |
| 1994 | 340.50 | 1.56 | 8.18 | 69.90 |
| 1995 | 514.80 | 8.18 | 6.32 | 71.01 |
| 1996 | 523.50 | 6.32 | 5.55 | 88.24 |
| 1997 | 912.59 | 5.55 | 12.38 | 101.82 |
| 1998 | 800.10 | 12.38 | 3.88 | 98.41 |
| 1999 | 747.20 | 3.88 | 10.39 | 104.69 |
| 2000 | 737.10 | 10.39 | 10.25 | 71.40 |
| 2001 | 1012.10 | 10.25 | 10.90 | 95.69 |
| 2002 | 941.55 | 10.90 | 21.51 | 58.11 |
| 2003 | 1404.19 | 21.51 | 23.60 | 62.26 |
| 2004 | 1873.69 | 23.60 | 18.90 | 88.17 |
| 2005 | 1708.88 | 18.90 | 29.20 | 71.06 |
| 2006 | 1781.32 | 29.20 | 29.20 | 61.00 |

Table 6. Time series of relative fishing mortality (RelF3) and relative stock size (SPORT2sc) on ages 8+ stripers based on landings and the sport2 CPUE index from 1982-2006.

| YEAR | CATCH | SPORT2SC | sport2scl | RelF3 |
|---|---|---|---|---|
| 1982 | 79.50 | 0.46 | 0.48 | 168.60 |
| 1983 | 34.50 | 0.48 | 0.37 | 81.15 |
| 1984 | 21.00 | 0.37 | 0.53 | 46.84 |
| 1985 | 39.20 | 0.53 | 0.66 | 65.86 |
| 1986 | 53.60 | 0.66 | 0.53 | 90.05 |
| 1987 | 32.30 | 0.53 | 1.24 | 36.65 |
| 1988 | 60.80 | 1.24 | 1.27 | 48.55 |
| 1989 | 49.30 | 1.27 | 1.93 | 30.81 |
| 1990 | 118.20 | 1.93 | 2.81 | 49.81 |
| 1991 | 205.10 | 2.81 | 3.97 | 60.44 |
| 1992 | 200.30 | 3.97 | 4.31 | 48.34 |
| 1993 | 294.00 | 4.31 | 8.69 | 45.22 |
| 1994 | 340.50 | 8.69 | 10.78 | 34.99 |
| 1995 | 514.80 | 10.78 | 12.28 | 44.67 |
| 1996 | 523.50 | 12.28 | 15.94 | 37.11 |
| 1997 | 912.59 | 15.94 | 16.23 | 56.73 |
| 1998 | 800.10 | 16.23 | 14.66 | 51.81 |
| 1999 | 747.20 | 14.66 | 14.98 | 50.42 |
| 2000 | 737.10 | 14.98 | 11.60 | 55.47 |
| 2001 | 1012.10 | 11.60 | 13.68 | 80.08 |
| 2002 | 941.55 | 13.68 | 13.88 | 68.31 |
| 2003 | 1404.19 | 13.88 | 15.23 | 96.47 |
| 2004 | 1873.69 | 15.23 | 16.08 | 119.70 |
| 2005 | 1708.88 | 16.08 | 19.82 | 95.21 |
| 2006 | 1781.32 | 19.82 | 19.82 | 89.88 |

Table 7. Overall average fishing mortality and stock abundance (n*1000) ages 8+ stripers based on SCAM (FSCAM, N8T) and the catch equation (FCAT, NCAT) compared to average RELF (AVRELF) and stock size (AVRELN) by the three blended tuning indices, 1982-2006.

| YEAR | AVRELF | FSCAM | Fcat | AVRELN | N8T | Ncat |
|---|---|---|---|---|---|---|
| 1982 | 122.96 | 0.45 | | 0.86 | 463 | |
| 1983 | 53.85 | 0.42 | | 0.64 | 333 | |
| 1984 | 29.12 | 0.32 | | 1.09 | 245 | |
| 1985 | 38.34 | 0.21 | | 1.26 | 232 | |
| 1986 | 59.84 | 0.15 | | 1.60 | 337 | |
| 1987 | 39.74 | 0.08 | | 0.99 | 412 | |
| 1988 | 56.53 | 0.15 | 0.06 | 1.15 | 495 | 1770 |
| 1989 | 29.51 | 0.11 | 0.04 | 1.54 | 628 | 2830 |
| 1990 | 50.93 | 0.12 | 0.08 | 2.18 | 1375 | 1996 |
| 1991 | 71.97 | 0.11 | 0.18 | 2.60 | 1918 | 1526 |
| 1992 | 52.52 | 0.09 | 0.10 | 3.23 | 2329 | 1715 |
| 1993 | 66.69 | 0.11 | 0.12 | 4.58 | 2621 | 2177 |
| 1994 | 48.04 | 0.13 | 0.08 | 5.88 | 3052 | 3728 |
| 1995 | 52.39 | 0.18 | 0.15 | 9.64 | 3496 | 3308 |
| 1996 | 54.73 | 0.20 | 0.16 | 11.15 | 3865 | 4869 |
| 1997 | 74.70 | 0.24 | 0.27 | 11.20 | 4498 | 4397 |
| 1998 | 71.41 | 0.20 | 0.24 | 14.78 | 4372 | 3739 |
| 1999 | 73.27 | 0.17 | 0.23 | 9.27 | 4421 | 3921 |
| 2000 | 59.77 | 0.22 | 0.14 | 13.07 | 4982 | 7454 |
| 2001 | 87.00 | 0.20 | 0.14 | 12.04 | 6934 | 9339 |
| 2002 | 75.01 | 0.19 | 0.15 | 11.35 | 7133 | 11371 |
| 2003 | 91.02 | 0.24 | 0.16 | 15.01 | 7669 | 12168 |
| 2004 | 111.23 | 0.26 | 0.16 | 17.92 | 8028 | 14727 |
| 2005 | 84.51 | 0.29 | 0.19 | 16.61 | 6927 | 11865 |
| 2006 | 74.72 | 0.31 | 0.15 | 24.45 | 5915 | 12852 |

## Appendix A12 Figures

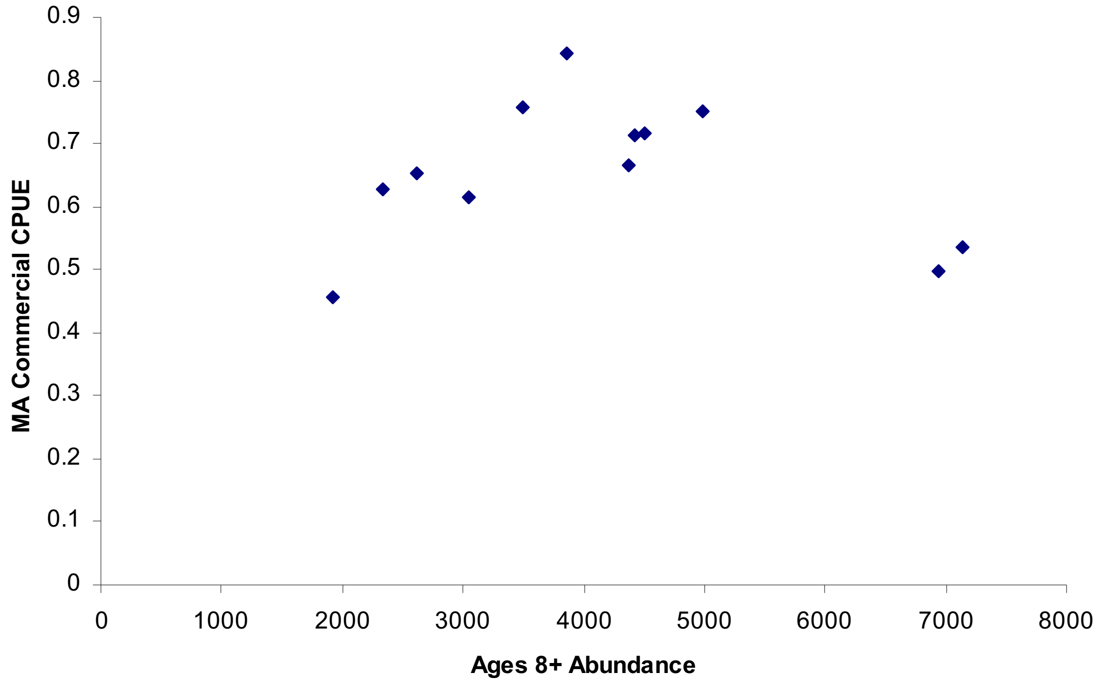



Figure 1. MA Commercial CPUE (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

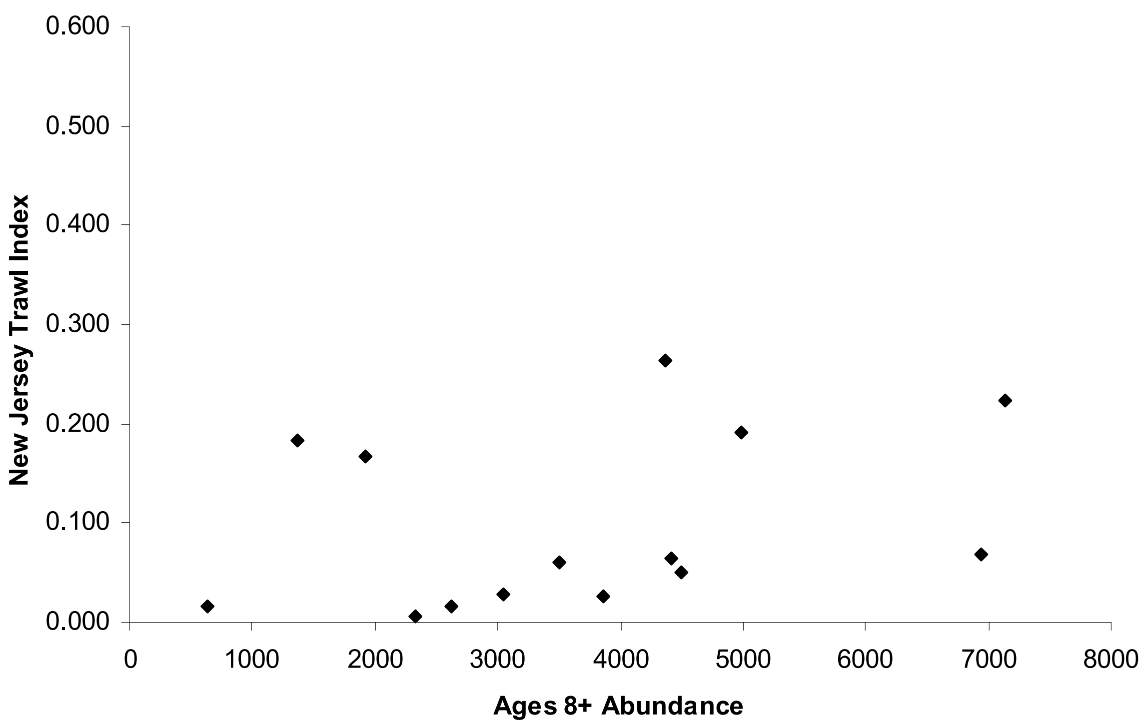



Figure 2. New Jersey Trawl Index (Ages 8+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

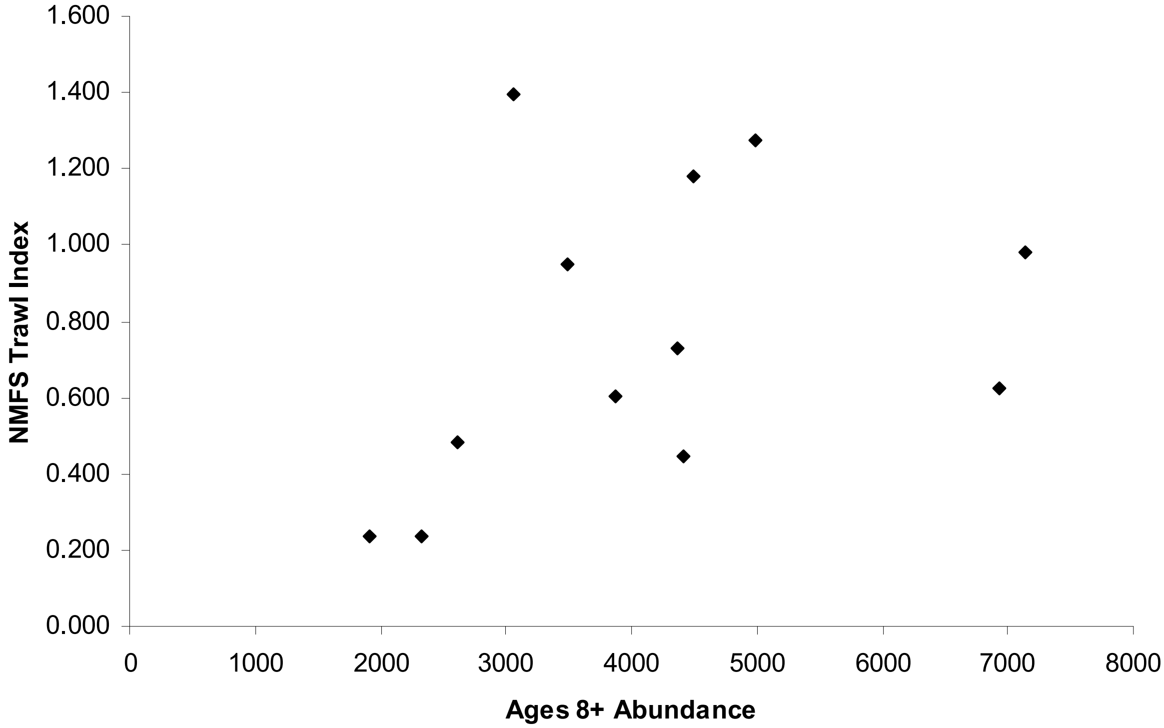



Figure 3. Delaware Spawning Stock Index (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

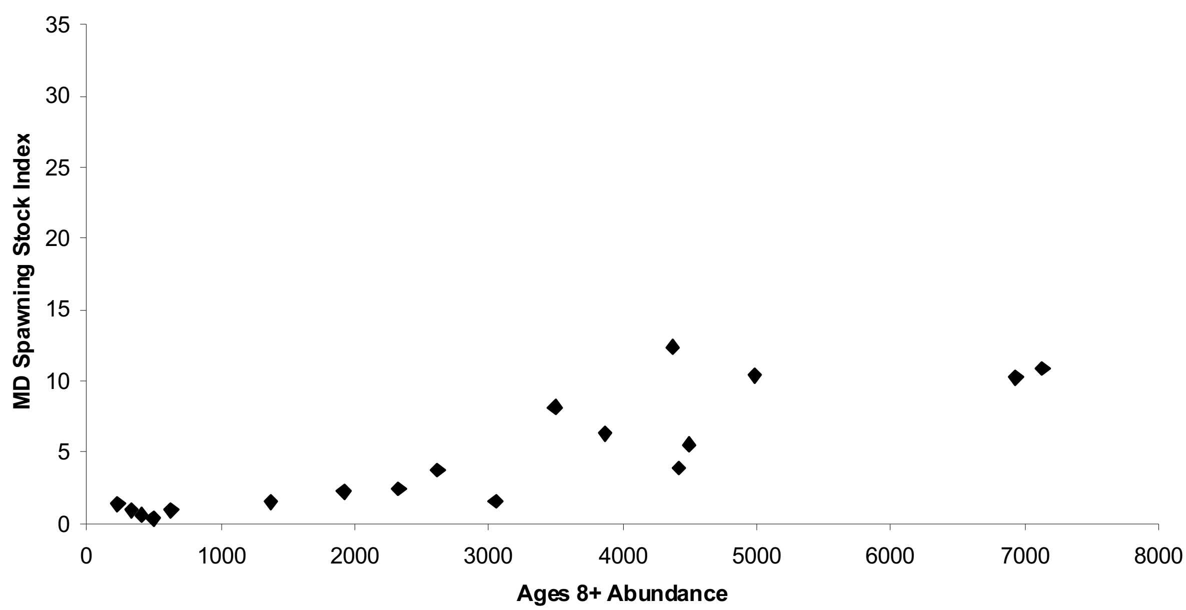



Figure 4. NMFS Trawl Index (Ages 2+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

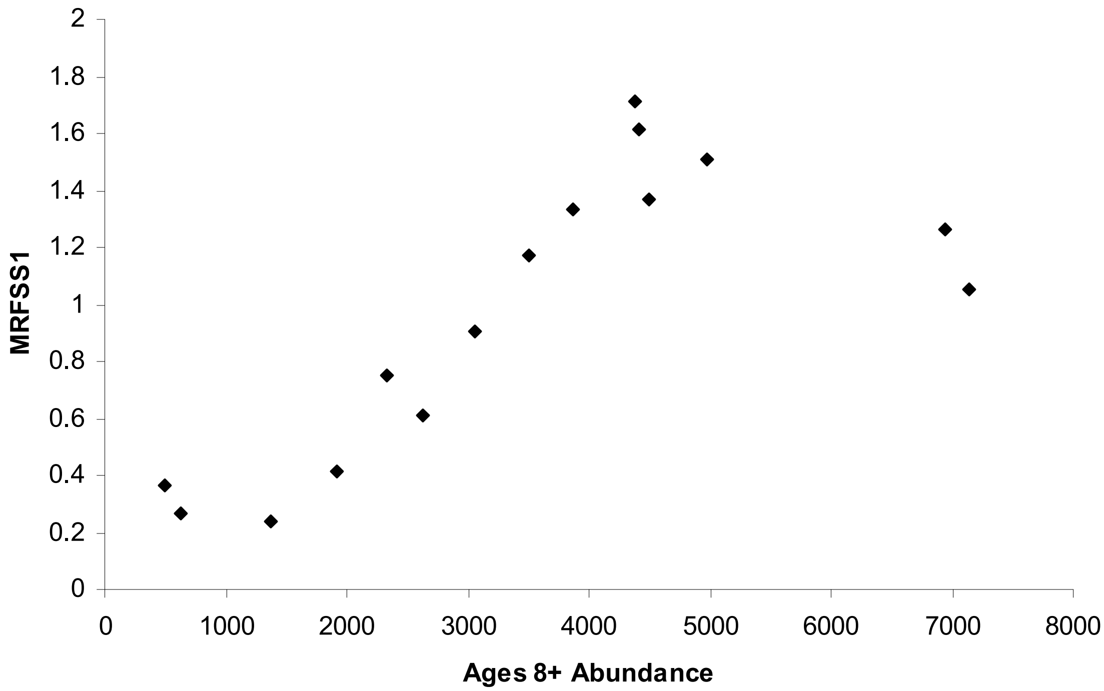



Figure 5. Maryland Spawning Stock Index (Ages 8+) plotted against age 8+ abundance based on SCAM model1982-2002

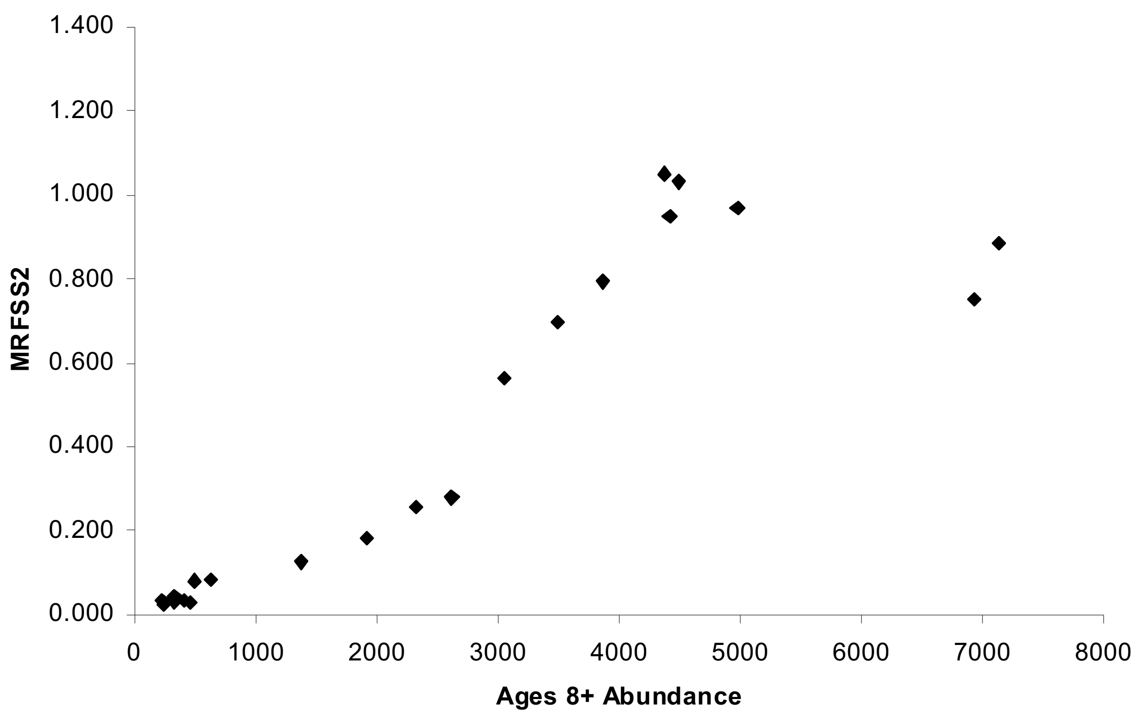



Figure 6.Sport1 CPUE Index based (ages 2+) on private boat intercepts plotted against ages 8+ abundance based on SCAM model, 1982-2002

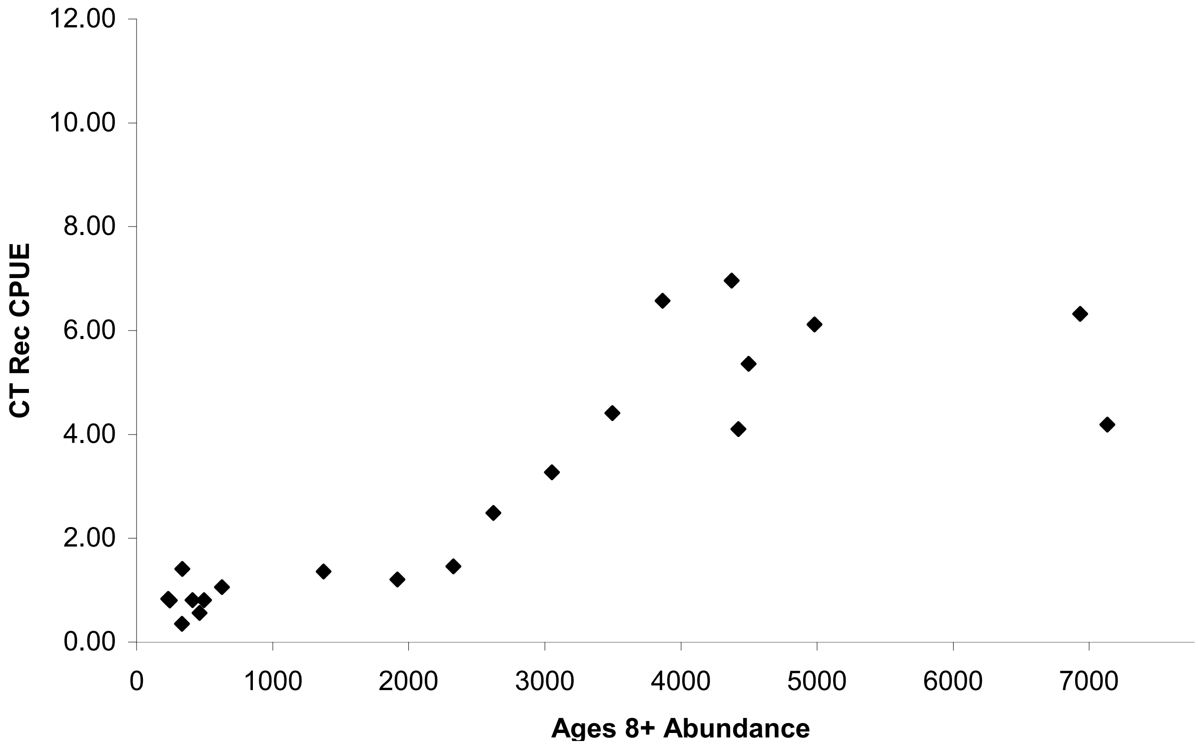



Figure 7. Sport2 CPUE Index based (ages 2+) on private boat data from north and mid-Atlantic combined plotted against ages 8+ abundance based on SCAM model, 1982-2002

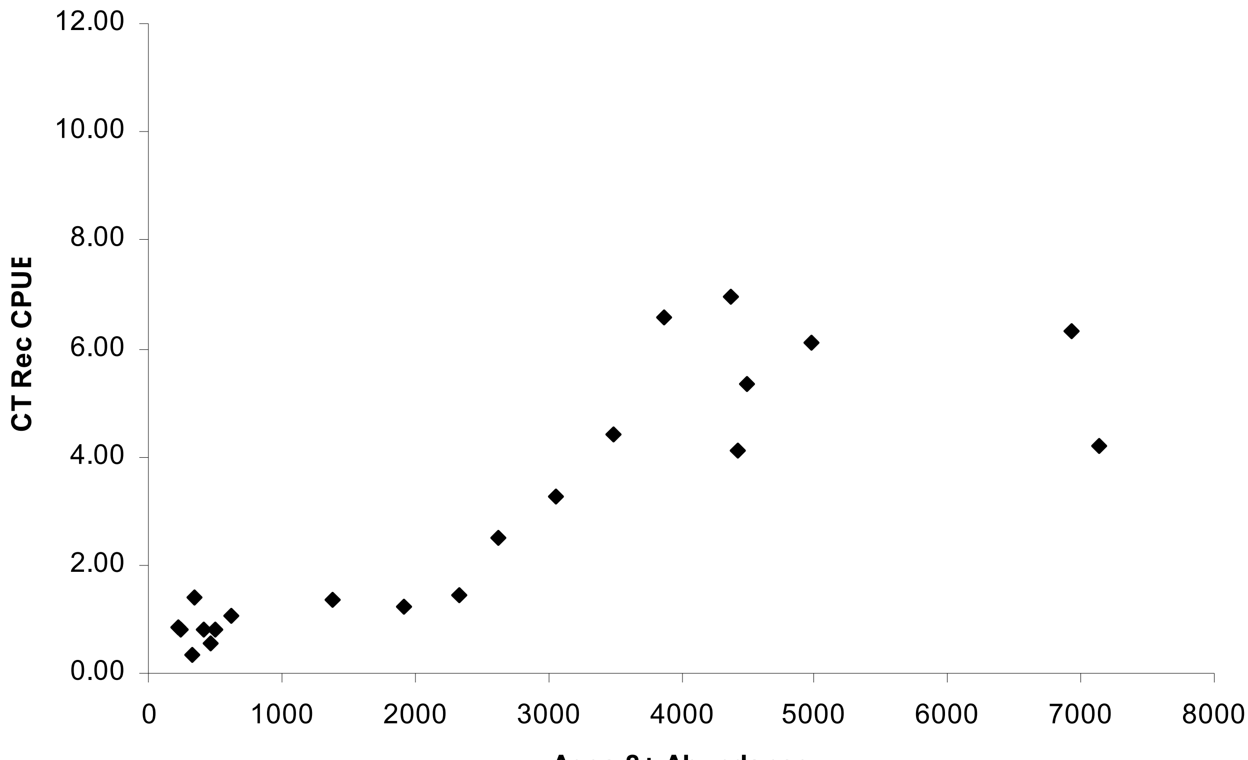



Figure 8. Connecticut Recreational CPUE (ages 3+) based on volunteer angler survey plotted against ages 8+ abundance based on SCAM model, 1982-2002

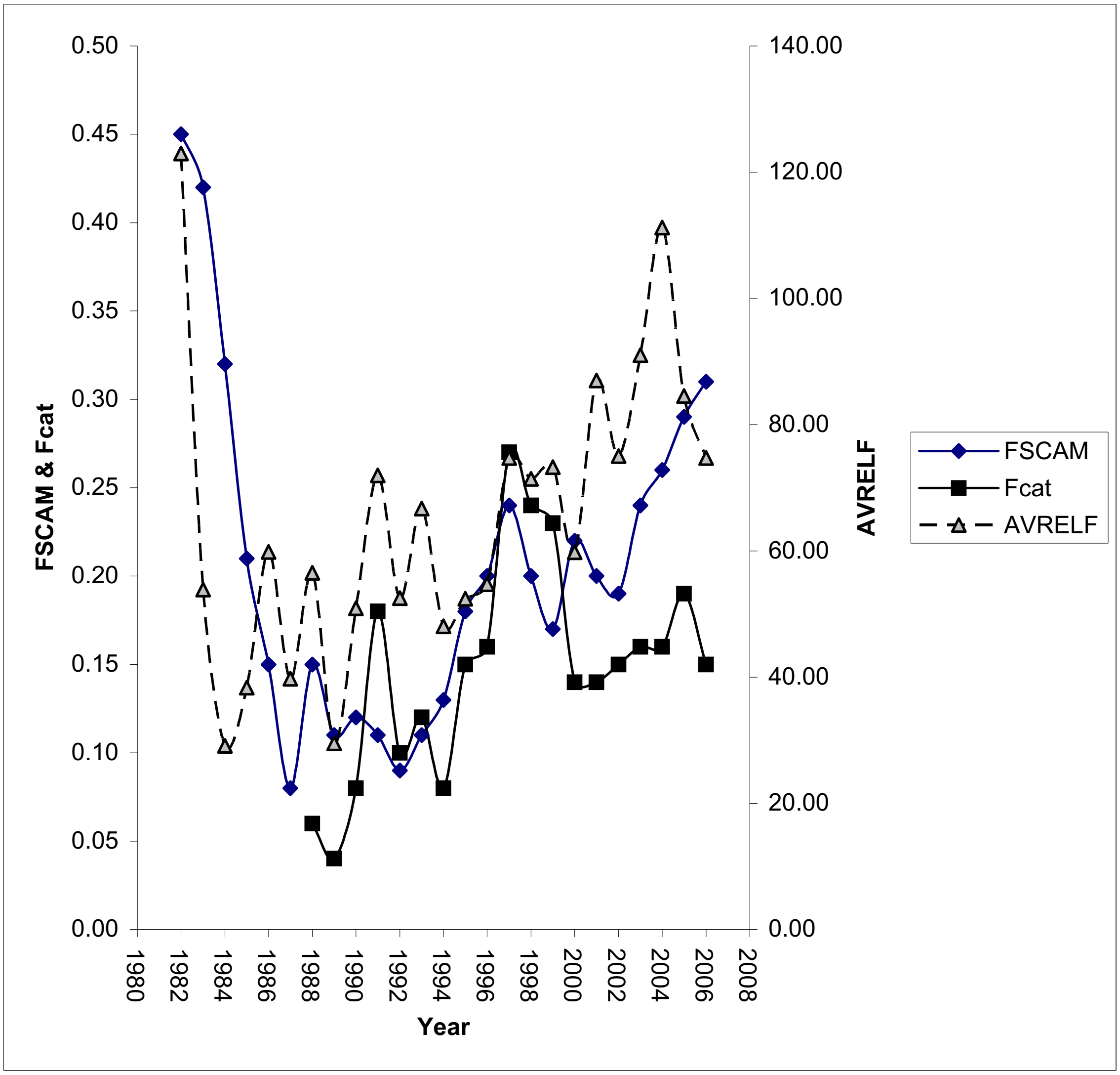



Figure 9. Comparison among the blended relative F (AVRELF), F from SCAM (FSCAM) and the F from the catch equation (Fcat) from 1982 to 2006

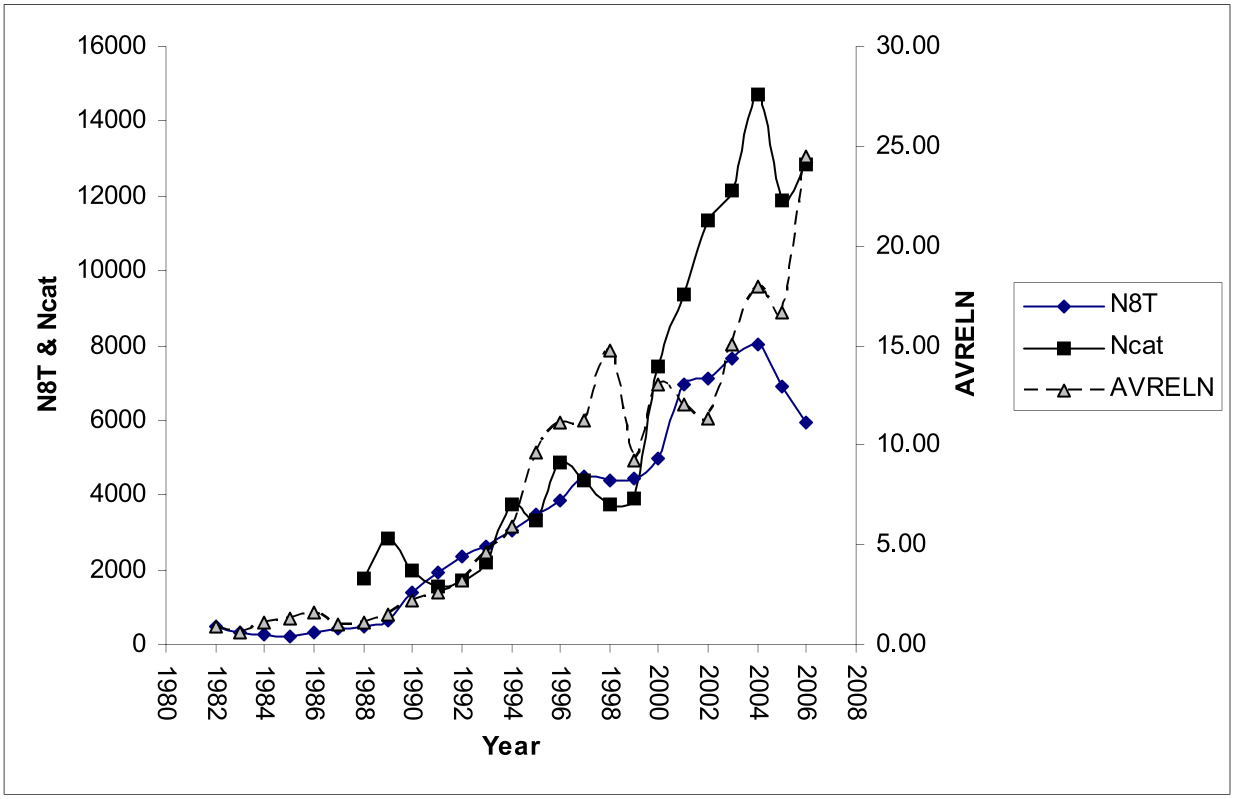



Figure 10. Comparison among the blended relative stock size (AVRELN), stock size from SCAM (N8T) and stock size from the catch equation (Ncat) from 1982-2006.

# Appendix A13. Input Tagging Matrices for Program MARK/Catch Equation Method and Instantaneous Rates - Catch and Release Model, for Coastwide and Chesapeake Bay Tagging Assessments.

## Appendix A13 Tables

Table 1. Program MARK input matrices for the coastal tagging programs, for fish ≥ 28”.

Massachusetts

| Number of releases | Release year | Recaptures 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 329 | 1992 | 21 | 22 | 12 | 12 | 8 | 4 | 0 | 4 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 611 | 1993 | | 35 | 32 | 26 | 29 | 17 | 17 | 11 | 2 | 2 | 2 | 2 | 1 | 0 | 0 |
| 462 | 1994 | | | 21 | 28 | 27 | 19 | 17 | 7 | 2 | 1 | 2 | 2 | 0 | 1 | 0 |
| 218 | 1995 | | | | 15 | 12 | 10 | 4 | 5 | 3 | 1 | 1 | 1 | 0 | 0 | 1 |
| 274 | 1996 | | | | | 22 | 15 | 13 | 11 | 9 | 1 | 3 | 1 | 1 | 1 | 0 |
| 118 | 1997 | | | | | | 17 | 6 | 3 | 3 | 1 | 2 | 0 | 1 | 0 | 1 |
| 219 | 1998 | | | | | | | 16 | 16 | 9 | 8 | 2 | 4 | 1 | 1 | 0 |
| 59 | 1999 | | | | | | | | 6 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| 163 | 2000 | | | | | | | | | 10 | 6 | 7 | 3 | 4 | 0 | 1 |
| 411 | 2001 | | | | | | | | | | 21 | 23 | 16 | 9 | 11 | 3 |
| 353 | 2002 | | | | | | | | | | | 23 | 13 | 14 | 9 | 8 |
| 172 | 2003 | | | | | | | | | | | | 9 | 3 | 6 | 6 |
| 615 | 2004 | | | | | | | | | | | | | 31 | 24 | 13 |
| 542 | 2005 | | | | | | | | | | | | | | 25 | 25 |
| 510 | 2006 | | | | | | | | | | | | | | | 33 |

Table 1 continued.

New York – Ocean Haul Seine

| Number of releases | Release year | Recaptures 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 214 | 1988 | 25 | 14 | 14 | 9 | 5 | 6 | 1 | 3 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 342 | 1989 | | 35 | 28 | 24 | 14 | 13 | 7 | 4 | 1 | 1 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 246 | 1990 | | | 23 | 17 | 10 | 6 | 3 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 281 | 1991 | | | | 30 | 25 | 10 | 6 | 5 | 2 | 6 | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 287 | 1992 | | | | | 41 | 24 | 14 | 17 | 6 | 3 | 6 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 236 | 1993 | | | | | | 28 | 13 | 13 | 7 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 254 | 1994 | | | | | | | 24 | 20 | 20 | 20 | 6 | 5 | 1 | 3 | 2 | 1 | 0 | 0 | 0 |
| 353 | 1995 | | | | | | | | 53 | 37 | 22 | 18 | 6 | 4 | 3 | 1 | 4 | 3 | 0 | 0 |
| 110 | 1996 | | | | | | | | | 15 | 5 | 14 | 5 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 67 | 1997 | | | | | | | | | | 13 | 5 | 4 | 0 | 1 | 2 | 1 | 1 | 1 | 1 |
| 82 | 1998 | | | | | | | | | | | 6 | 4 | 3 | 1 | 1 | 1 | 0 | 0 | 0 |
| 85 | 1999 | | | | | | | | | | | | 13 | 7 | 3 | 1 | 1 | 4 | 1 | 0 |
| 56 | 2000 | | | | | | | | | | | | | 8 | 6 | 2 | 4 | 2 | 0 | 0 |
| 93 | 2001 | | | | | | | | | | | | | | 8 | 6 | 5 | 8 | 1 | 0 |
| 176 | 2002 | | | | | | | | | | | | | | | 29 | 11 | 5 | 0 | 3 |
| 145 | 2003 | | | | | | | | | | | | | | | | 13 | 5 | 7 | 1 |
| 156 | 2004 | | | | | | | | | | | | | | | | | 17 | 4 | 3 |
| 64 | 2005 | | | | | | | | | | | | | | | | | | 9 | 3 |
| 57 | 2006 | | | | | | | | | | | | | | | | | | | 5 |

Table 1 continued.

New Jersey – Delaware Bay

| Number of releases | Release year | Recaptures 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | 1989 | 4 | 3 | 7 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 1990 | | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 1991 | | | 4 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 84 | 1992 | | | | 9 | 7 | 5 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 1993 | | | | | 8 | 4 | 5 | 2 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 308 | 1994 | | | | | | 32 | 24 | 17 | 16 | 11 | 4 | 3 | 2 | 1 | 2 | 0 | 0 | 0 |
| 552 | 1995 | | | | | | | 56 | 51 | 32 | 27 | 14 | 5 | 6 | 3 | 4 | 3 | 1 | 2 |
| 600 | 1996 | | | | | | | | 88 | 35 | 45 | 14 | 10 | 6 | 4 | 5 | 6 | 2 | 0 |
| 96 | 1997 | | | | | | | | | 15 | 2 | 2 | 2 | 1 | 4 | 0 | 0 | 0 | 0 |
| 128 | 1998 | | | | | | | | | | 21 | 10 | 6 | 3 | 0 | 4 | 1 | 1 | 0 |
| 106 | 1999 | | | | | | | | | | | 13 | 8 | 6 | 5 | 2 | 1 | 3 | 1 |
| 233 | 2000 | | | | | | | | | | | | 22 | 18 | 12 | 12 | 7 | 5 | 0 |
| 522 | 2001 | | | | | | | | | | | | | 53 | 38 | 24 | 15 | 8 | 4 |
| 359 | 2002 | | | | | | | | | | | | | | 28 | 21 | 14 | 11 | 2 |
| 564 | 2003 | | | | | | | | | | | | | | | 58 | 27 | 26 | 9 |
| 847 | 2004 | | | | | | | | | | | | | | | | 100 | 49 | 21 |
| 180 | 2005 | | | | | | | | | | | | | | | | | 23 | 9 |
| 225 | 2006 | | | | | | | | | | | | | | | | | | 24 |

Table 1 continued.

North Carolina – Cooperative Trawl Cruise

| Number of releases | Release year | Recaptures 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 191 | 1988 | 18 | 11 | 9 | 3 | 10 | 4 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 411 | 1989 | | 24 | 20 | 18 | 14 | 7 | 3 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 322 | 1990 | | | 25 | 19 | 16 | 8 | 3 | 2 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 856 | 1991 | | | | 74 | 39 | 48 | 34 | 18 | 7 | 12 | 8 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 433 | 1992 | | | | | 46 | 29 | 14 | 14 | 8 | 8 | 10 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 142 | 1993 | | | | | | 17 | 5 | 5 | 3 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 480 | 1994 | | | | | | | 41 | 25 | 9 | 10 | 6 | 6 | 1 | 3 | 1 | 2 | 2 | 0 | 0 |
| 372 | 1995 | | | | | | | | 43 | 16 | 17 | 14 | 5 | 3 | 2 | 5 | 1 | 1 | 2 | 0 |
| 557 | 1996 | | | | | | | | | 35 | 20 | 15 | 6 | 5 | 4 | 4 | 0 | 3 | 1 | 1 |
| 869 | 1997 | | | | | | | | | | 88 | 44 | 25 | 14 | 13 | 0 | 3 | 4 | 1 | 0 |
| 106 | 1998 | | | | | | | | | | | 12 | 11 | 0 | 2 | 1 | 1 | 0 | 0 | 1 |
| 179 | 1999 | | | | | | | | | | | | 21 | 8 | 5 | 2 | 0 | 3 | 2 | 1 |
| 164 | 2000 | | | | | | | | | | | | | 9 | 6 | 2 | 3 | 3 | 2 | 1 |
| 515 | 2001 | | | | | | | | | | | | | | 46 | 23 | 15 | 5 | 11 | 9 |
| 789 | 2002 | | | | | | | | | | | | | | | 51 | 43 | 22 | 18 | 10 |
| 1578 | 2003 | | | | | | | | | | | | | | | | 107 | 65 | 38 | 25 |
| 784 | 2004 | | | | | | | | | | | | | | | | | 58 | 26 | 26 |
| 557 | 2005 | | | | | | | | | | | | | | | | | | 25 | 21 |
| 2113 | 2006 | | | | | | | | | | | | | | | | | | | 153 |

Table 2. Program MARK input matrices for the producer area tagging programs, for fish ≥ 28”.

New York – Hudson River

| Number of releases | Release year | Recaptures 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 277 | 1988 | 25 | 31 | 18 | 11 | 10 | 5 | 4 | 1 | 4 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 387 | 1989 | | 42 | 29 | 17 | 9 | 6 | 9 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 297 | 1990 | | | 42 | 22 | 16 | 12 | 7 | 2 | 1 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 364 | 1991 | | | | 38 | 31 | 13 | 10 | 9 | 5 | 5 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 702 | 1992 | | | | | 90 | 58 | 34 | 22 | 14 | 13 | 10 | 5 | 2 | 1 | 0 | 0 | 1 | 0 | 0 |
| 539 | 1993 | | | | | | 77 | 36 | 23 | 21 | 15 | 7 | 8 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 383 | 1994 | | | | | | | 43 | 34 | 27 | 10 | 6 | 6 | 5 | 4 | 2 | 0 | 2 | 1 | 0 |
| 462 | 1995 | | | | | | | | 52 | 34 | 30 | 21 | 11 | 4 | 1 | 2 | 1 | 1 | 1 | 0 |
| 684 | 1996 | | | | | | | | | 92 | 68 | 33 | 18 | 3 | 9 | 4 | 2 | 4 | 3 | 1 |
| 184 | 1997 | | | | | | | | | | 29 | 11 | 12 | 6 | 3 | 2 | 2 | 0 | 1 | 1 |
| 530 | 1998 | | | | | | | | | | | 67 | 45 | 18 | 9 | 20 | 6 | 0 | 1 | 2 |
| 503 | 1999 | | | | | | | | | | | | 65 | 22 | 27 | 12 | 14 | 7 | 3 | 4 |
| 486 | 2000 | | | | | | | | | | | | | 45 | 25 | 23 | 18 | 13 | 6 | 3 |
| 577 | 2001 | | | | | | | | | | | | | | 49 | 39 | 14 | 6 | 6 | 10 |
| 196 | 2002 | | | | | | | | | | | | | | | 20 | 11 | 9 | 4 | 7 |
| 677 | 2003 | | | | | | | | | | | | | | | | 63 | 44 | 35 | 17 |
| 648 | 2004 | | | | | | | | | | | | | | | | | 76 | 34 | 34 |
| 576 | 2005 | | | | | | | | | | | | | | | | | | 59 | 44 |
| 707 | 2006 | | | | | | | | | | | | | | | | | | | 61 |

Table 2 continued.

Delaware/Pennsylvania – Delaware River

| Number of releases | Release year | Recaptures 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 | 1993 | 6 | 8 | 1 | 4 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 82 | 1994 | | 7 | 10 | 6 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 174 | 1995 | | | 21 | 12 | 8 | 6 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 112 | 1996 | | | | 17 | 5 | 6 | 1 | 2 | 2 | 1 | 1 | 1 | 0 | 0 |
| 113 | 1997 | | | | | 15 | 7 | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| 204 | 1998 | | | | | | 30 | 10 | 5 | 4 | 5 | 3 | 1 | 1 | 1 |
| 108 | 1999 | | | | | | | 9 | 11 | 2 | 1 | 3 | 1 | 0 | 0 |
| 150 | 2000 | | | | | | | | 24 | 12 | 4 | 3 | 1 | 3 | 0 |
| 222 | 2001 | | | | | | | | | 31 | 14 | 9 | 6 | 3 | 4 |
| 138 | 2002 | | | | | | | | | | 13 | 11 | 4 | 4 | 1 |
| 286 | 2003 | | | | | | | | | | | 32 | 21 | 8 | 7 |
| 167 | 2004 | | | | | | | | | | | | 18 | 10 | 7 |
| 110 | 2005 | | | | | | | | | | | | | 10 | 10 |
| 181 | 2006 | | | | | | | | | | | | | | 20 |

Table 2 continued.

Maryland – Chesapeake Bay

| Number of releases | Release year | Recaptures 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 1987 | 1 | 0 | 2 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 129 | 1988 | | 6 | 8 | 7 | 14 | 6 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 220 | 1989 | | | 9 | 17 | 17 | 6 | 4 | 3 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 305 | 1990 | | | | 23 | 16 | 12 | 5 | 2 | 4 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 396 | 1991 | | | | | 47 | 24 | 20 | 5 | 9 | 3 | 5 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 436 | 1992 | | | | | | 45 | 30 | 19 | 17 | 7 | 10 | 6 | 5 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 629 | 1993 | | | | | | | 58 | 44 | 42 | 15 | 16 | 8 | 9 | 1 | 3 | 2 | 0 | 0 | 0 | 0 |
| 548 | 1994 | | | | | | | | 52 | 43 | 26 | 16 | 15 | 10 | 4 | 3 | 0 | 1 | 1 | 1 | 0 |
| 528 | 1995 | | | | | | | | | 61 | 32 | 24 | 16 | 7 | 6 | 2 | 2 | 3 | 0 | 0 | 2 |
| 862 | 1996 | | | | | | | | | | 92 | 54 | 44 | 18 | 9 | 7 | 2 | 1 | 1 | 0 | 0 |
| 336 | 1997 | | | | | | | | | | | 41 | 26 | 18 | 2 | 2 | 1 | 1 | 0 | 1 | 0 |
| 264 | 1998 | | | | | | | | | | | | 26 | 16 | 3 | 5 | 2 | 0 | 0 | 0 | 0 |
| 117 | 1999 | | | | | | | | | | | | | 19 | 8 | 8 | 3 | 1 | 2 | 1 | 0 |
| 248 | 2000 | | | | | | | | | | | | | | 21 | 16 | 4 | 5 | 4 | 1 | 0 |
| 469 | 2001 | | | | | | | | | | | | | | | 31 | 19 | 11 | 6 | 3 | 3 |
| 324 | 2002 | | | | | | | | | | | | | | | | 18 | 20 | 6 | 7 | 2 |
| 325 | 2003 | | | | | | | | | | | | | | | | | 22 | 11 | 9 | 7 |
| 367 | 2004 | | | | | | | | | | | | | | | | | | 17 | 9 | 11 |
| 334 | 2005 | | | | | | | | | | | | | | | | | | | 20 | 14 |
| 277 | 2006 | | | | | | | | | | | | | | | | | | | | 16 |

Table 2 continued.

Virginia – Rappahannock River

| Number of | Release | Recaptures | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 301 | 1990 | 26 | 9 | 15 | 2 | 4 | 6 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 390 | 1991 | | 41 | 24 | 16 | 11 | 3 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 40 | 1992 | | | 4 | 3 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 212 | 1993 | | | | 22 | 18 | 7 | 4 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 123 | 1994 | | | | | 9 | 7 | 5 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 210 | 1995 | | | | | | 29 | 11 | 8 | 3 | 3 | 2 | 3 | 0 | 1 | 0 | 1 | 0 |
| 67 | 1996 | | | | | | | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 212 | 1997 | | | | | | | | 15 | 13 | 8 | 3 | 0 | 1 | 2 | 1 | 0 | 0 |
| 158 | 1998 | | | | | | | | | 24 | 13 | 2 | 3 | 2 | 0 | 0 | 0 | 0 |
| 162 | 1999 | | | | | | | | | | 17 | 6 | 2 | 3 | 2 | 0 | 0 | 0 |
| 365 | 2000 | | | | | | | | | | | 28 | 19 | 14 | 9 | 4 | 3 | 0 |
| 269 | 2001 | | | | | | | | | | | | 19 | 14 | 4 | 6 | 2 | 1 |
| 122 | 2002 | | | | | | | | | | | | | 10 | 6 | 7 | 1 | 0 |
| 400 | 2003 | | | | | | | | | | | | | | 35 | 24 | 7 | 1 |
| 686 | 2004 | | | | | | | | | | | | | | | 39 | 12 | 13 |
| 284 | 2005 | | | | | | | | | | | | | | | | 16 | 11 |
| 175 | 2006 | | | | | | | | | | | | | | | | | 12 |

Table 3. Instantaneous Rates – Catch and Release Model input matrices for the coastal tagging programs, for fish ≥ 28”. The first matrix contains all harvested recaptures and the second matrix contains released fish with their tag removed.

Massachusetts

| Number of | Release | Harvested Recaptures | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 327 | 1992 | 6 | 10 | 7 | 11 | 8 | 4 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 610 | 1993 | | 17 | 18 | 15 | 25 | 16 | 14 | 9 | 1 | 2 | 2 | 2 | 1 | 0 | 0 |
| 461 | 1994 | | | 8 | 23 | 23 | 15 | 13 | 7 | 2 | 0 | 2 | 2 | 0 | 1 | 0 |
| 218 | 1995 | | | | 4 | 8 | 9 | 3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 273 | 1996 | | | | | 10 | 10 | 11 | 9 | 7 | 0 | 3 | 1 | 1 | 1 | 0 |
| 118 | 1997 | | | | | | 8 | 4 | 2 | 3 | 1 | 1 | 0 | 1 | 0 | 1 |
| 217 | 1998 | | | | | | | 9 | 11 | 6 | 6 | 2 | 3 | 1 | 0 | 0 |
| 59 | 1999 | | | | | | | | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| 162 | 2000 | | | | | | | | | 9 | 4 | 4 | 3 | 3 | 0 | 1 |
| 408 | 2001 | | | | | | | | | | 15 | 18 | 10 | 7 | 10 | 3 |
| 350 | 2002 | | | | | | | | | | | 11 | 11 | 11 | 5 | 5 |
| 171 | 2003 | | | | | | | | | | | | 8 | 2 | 5 | 4 |
| 615 | 2004 | | | | | | | | | | | | | 25 | 17 | 9 |
| 540 | 2005 | | | | | | | | | | | | | | 16 | 20 |
| 509 | 2006 | | | | | | | | | | | | | | | 20 |

| Number of | Release | Released with Tag Removed | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 327 | 1992 | 14 | 11 | 5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 610 | 1993 | | 18 | 13 | 11 | 4 | 1 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 461 | 1994 | | | 12 | 5 | 4 | 4 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 218 | 1995 | | | | 11 | 4 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 273 | 1996 | | | | | 12 | 4 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 118 | 1997 | | | | | | 9 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 217 | 1998 | | | | | | | 6 | 5 | 3 | 2 | 0 | 0 | 0 | 1 | 0 |
| 59 | 1999 | | | | | | | | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 162 | 2000 | | | | | | | | | 1 | 2 | 2 | 0 | 1 | 0 | 0 |
| 408 | 2001 | | | | | | | | | | 6 | 4 | 5 | 1 | 2 | 0 |
| 350 | 2002 | | | | | | | | | | | 11 | 2 | 2 | 2 | 3 |
| 171 | 2003 | | | | | | | | | | | | 0 | 1 | 1 | 2 |
| 615 | 2004 | | | | | | | | | | | | | 6 | 7 | 4 |
| 540 | 2005 | | | | | | | | | | | | | | 7 | 4 |
| 509 | 2006 | | | | | | | | | | | | | | | 10 |

Table 3 continued – New York – Ocean Haul Seine

| Number of | Release | Harvested Recaptures | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 221 | 1988 | 3 | 3 | 5 | 7 | 3 | 3 | 0 | 2 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 342 | 1989 | | 4 | 10 | 9 | 9 | 10 | 3 | 4 | 1 | 1 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 249 | 1990 | | | 6 | 8 | 6 | 3 | 3 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 280 | 1991 | | | | 13 | 12 | 6 | 3 | 4 | 1 | 4 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 285 | 1992 | | | | | 12 | 12 | 6 | 13 | 4 | 3 | 4 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 235 | 1993 | | | | | | 13 | 9 | 10 | 5 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 258 | 1994 | | | | | | | 8 | 13 | 17 | 15 | 5 | 4 | 1 | 3 | 1 | 1 | 0 | 0 | 0 |
| 352 | 1995 | | | | | | | | 30 | 26 | 16 | 16 | 5 | 4 | 3 | 1 | 4 | 1 | 0 | 0 |
| 109 | 1996 | | | | | | | | | 6 | 5 | 7 | 5 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| 69 | 1997 | | | | | | | | | | 10 | 5 | 4 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 82 | 1998 | | | | | | | | | | | 6 | 4 | 3 | 0 | 0 | 1 | 0 | 0 | 0 |
| 85 | 1999 | | | | | | | | | | | | 11 | 6 | 2 | 1 | 0 | 4 | 1 | 0 |
| 56 | 2000 | | | | | | | | | | | | | 4 | 5 | 2 | 3 | 1 | 0 | 0 |
| 94 | 2001 | | | | | | | | | | | | | | 4 | 5 | 4 | 6 | 1 | 0 |
| 175 | 2002 | | | | | | | | | | | | | | | 16 | 10 | 3 | 0 | 3 |
| 146 | 2003 | | | | | | | | | | | | | | | | 9 | 4 | 7 | 1 |
| 154 | 2004 | | | | | | | | | | | | | | | | | 9 | 2 | 2 |
| 64 | 2005 | | | | | | | | | | | | | | | | | | 7 | 3 |
| 56 | 2006 | | | | | | | | | | | | | | | | | | | 3 |

| Number of | Release | Released with Tag Removed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 221 | 1988 | 0 | 10 | 9 | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 342 | 1989 | | 29 | 16 | 12 | 5 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 249 | 1990 | | | 16 | 9 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 280 | 1991 | | | | 16 | 11 | 2 | 3 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 285 | 1992 | | | | | 25 | 9 | 8 | 4 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 235 | 1993 | | | | | | 14 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 258 | 1994 | | | | | | | 15 | 7 | 3 | 5 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 352 | 1995 | | | | | | | | 21 | 9 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| 109 | 1996 | | | | | | | | | 8 | 0 | 6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 69 | 1997 | | | | | | | | | | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 82 | 1998 | | | | | | | | | | | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 85 | 1999 | | | | | | | | | | | | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 56 | 2000 | | | | | | | | | | | | | 4 | 1 | 0 | 1 | 1 | 0 | 0 |
| 94 | 2001 | | | | | | | | | | | | | | 4 | 1 | 1 | 2 | 0 | 0 |
| 175 | 2002 | | | | | | | | | | | | | | | 12 | 1 | 2 | 0 | 0 |
| 146 | 2003 | | | | | | | | | | | | | | | | 4 | 1 | 0 | 0 |
| 154 | 2004 | | | | | | | | | | | | | | | | | 8 | 2 | 1 |
| 64 | 2005 | | | | | | | | | | | | | | | | | | 2 | 0 |
| 56 | 2006 | | | | | | | | | | | | | | | | | | | 1 |

Table 3 continued – New Jersey – Delaware Bay

| Number of releases | Release year | Harvested Recaptures 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | 1989 | 0 | 2 | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 1990 | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 1991 | | | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 84 | 1992 | | | | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 1993 | | | | | 3 | 1 | 2 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 308 | 1994 | | | | | | 5 | 9 | 10 | 11 | 8 | 4 | 3 | 2 | 1 | 1 | 0 | 0 | 0 |
| 552 | 1995 | | | | | | | 23 | 30 | 18 | 16 | 10 | 5 | 3 | 3 | 4 | 2 | 1 | 2 |
| 600 | 1996 | | | | | | | | 49 | 18 | 30 | 13 | 6 | 5 | 3 | 3 | 6 | 2 | 0 |
| 96 | 1997 | | | | | | | | | 9 | 2 | 2 | 2 | 1 | 4 | 0 | 0 | 0 | 0 |
| 128 | 1998 | | | | | | | | | | 19 | 5 | 5 | 2 | 0 | 4 | 1 | 1 | 0 |
| 106 | 1999 | | | | | | | | | | | 5 | 5 | 5 | 1 | 0 | 1 | 3 | 1 |
| 233 | 2000 | | | | | | | | | | | | 13 | 15 | 8 | 9 | 6 | 4 | 0 |
| 522 | 2001 | | | | | | | | | | | | | 33 | 26 | 21 | 13 | 6 | 4 |
| 359 | 2002 | | | | | | | | | | | | | | 17 | 10 | 11 | 9 | 2 |
| 564 | 2003 | | | | | | | | | | | | | | | 34 | 12 | 18 | 5 |
| 847 | 2004 | | | | | | | | | | | | | | | | 55 | 31 | 17 |
| 180 | 2005 | | | | | | | | | | | | | | | | | 12 | 4 |
| 225 | 2006 | | | | | | | | | | | | | | | | | | 13 |

| Number of releases | Release year | Released with Tag Removed 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | 1989 | 3 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 1990 | | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 1991 | | | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 84 | 1992 | | | | 7 | 6 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 1993 | | | | | 5 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 308 | 1994 | | | | | | 26 | 15 | 7 | 5 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 552 | 1995 | | | | | | | 29 | 21 | 13 | 11 | 4 | 0 | 2 | 0 | 0 | 1 | 0 | 0 |
| 600 | 1996 | | | | | | | | 35 | 17 | 15 | 1 | 4 | 1 | 1 | 2 | 0 | 0 | 0 |
| 96 | 1997 | | | | | | | | | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 128 | 1998 | | | | | | | | | | 2 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1999 | | | | | | | | | | | 7 | 3 | 1 | 4 | 2 | 0 | 0 | 0 |
| 233 | 2000 | | | | | | | | | | | | 9 | 3 | 3 | 2 | 1 | 1 | 0 |
| 522 | 2001 | | | | | | | | | | | | | 19 | 9 | 2 | 2 | 2 | 0 |
| 359 | 2002 | | | | | | | | | | | | | | 9 | 10 | 3 | 2 | 0 |
| 564 | 2003 | | | | | | | | | | | | | | | 23 | 12 | 5 | 4 |
| 847 | 2004 | | | | | | | | | | | | | | | | 42 | 17 | 4 |
| 180 | 2005 | | | | | | | | | | | | | | | | | 10 | 5 |
| 225 | 2006 | | | | | | | | | | | | | | | | | | 10 |

Table 3 continued – North Carolina – Cooperative Trawl Cruise

| Number of | Release | | | | | | | | | Harvested Recaptures | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 191 | 1988 | 4 | 3 | 4 | 0 | 6 | 3 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 411 | 1989 | | 6 | 7 | 7 | 11 | 4 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 322 | 1990 | | | 11 | 6 | 11 | 5 | 1 | 2 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 856 | 1991 | | | | 23 | 19 | 23 | 20 | 16 | 5 | 11 | 7 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 433 | 1992 | | | | | 22 | 11 | 7 | 10 | 7 | 6 | 7 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 142 | 1993 | | | | | | 6 | 3 | 5 | 3 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 480 | 1994 | | | | | | | 14 | 16 | 7 | 6 | 5 | 6 | 1 | 3 | 1 | 2 | 2 | 0 | 0 |
| 372 | 1995 | | | | | | | | 21 | 13 | 16 | 11 | 5 | 2 | 2 | 5 | 1 | 1 | 2 | 0 |
| 557 | 1996 | | | | | | | | | 26 | 17 | 12 | 3 | 3 | 3 | 4 | 0 | 3 | 1 | 1 |
| 869 | 1997 | | | | | | | | | | 67 | 31 | 16 | 9 | 11 | 0 | 3 | 3 | 1 | 0 |
| 106 | 1998 | | | | | | | | | | | 9 | 7 | 0 | 2 | 1 | 1 | 0 | 0 | 0 |
| 179 | 1999 | | | | | | | | | | | | 18 | 5 | 5 | 2 | 0 | 2 | 2 | 1 |
| 164 | 2000 | | | | | | | | | | | | | 4 | 6 | 1 | 2 | 3 | 2 | 1 |
| 515 | 2001 | | | | | | | | | | | | | | 32 | 18 | 11 | 3 | 9 | 6 |
| 789 | 2002 | | | | | | | | | | | | | | | 39 | 31 | 20 | 13 | 7 |
| 1578 | 2003 | | | | | | | | | | | | | | | | 75 | 53 | 29 | 16 |
| 784 | 2004 | | | | | | | | | | | | | | | | | 40 | 18 | 15 |
| 557 | 2005 | | | | | | | | | | | | | | | | | | 17 | 16 |
| 2113 | 2006 | | | | | | | | | | | | | | | | | | | 107 |

| Number of | Release | | | | | | | | | Released with Tag Removed | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 191 | 1988 | 13 | 8 | 5 | 2 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 411 | 1989 | | 17 | 13 | 11 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 322 | 1990 | | | 14 | 11 | 5 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 856 | 1991 | | | | 45 | 18 | 23 | 14 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 433 | 1992 | | | | | 23 | 17 | 7 | 4 | 1 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 142 | 1993 | | | | | | 8 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 480 | 1994 | | | | | | | 26 | 8 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 372 | 1995 | | | | | | | | 22 | 2 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 557 | 1996 | | | | | | | | | 8 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 869 | 1997 | | | | | | | | | | 18 | 13 | 9 | 5 | 1 | 0 | 0 | 1 | 0 | 0 |
| 106 | 1998 | | | | | | | | | | | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 179 | 1999 | | | | | | | | | | | | 3 | 3 | 0 | 0 | 0 | 1 | 0 | 0 |
| 164 | 2000 | | | | | | | | | | | | | 4 | 0 | 1 | 1 | 0 | 0 | 0 |
| 515 | 2001 | | | | | | | | | | | | | | 11 | 3 | 4 | 1 | 2 | 2 |
| 789 | 2002 | | | | | | | | | | | | | | | 12 | 11 | 1 | 5 | 3 |
| 1578 | 2003 | | | | | | | | | | | | | | | | 27 | 12 | 8 | 9 |
| 784 | 2004 | | | | | | | | | | | | | | | | | 17 | 8 | 10 |
| 557 | 2005 | | | | | | | | | | | | | | | | | | 8 | 5 |
| 2113 | 2006 | | | | | | | | | | | | | | | | | | | 44 |

Table 4. Instantaneous Rates – Catch and Release Model input matrices for the producer area tagging programs, for fish ≥ 28”. The first matrix contains all harvested recaptures and the second matrix contains released fish with their tag removed

New York – Hudson River

| Number of | Release | Released with Tag Removed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 261 | 1988 | 14 | 21 | 11 | 2 | 4 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 380 | 1989 | | 33 | 16 | 7 | 5 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 291 | 1990 | | | 29 | 9 | 7 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 361 | 1991 | | | | 23 | 17 | 5 | 4 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 693 | 1992 | | | | | 54 | 30 | 18 | 11 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 527 | 1993 | | | | | | 42 | 20 | 13 | 4 | 5 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 379 | 1994 | | | | | | | 26 | 8 | 5 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 457 | 1995 | | | | | | | | 23 | 11 | 10 | 3 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 |
| 678 | 1996 | | | | | | | | | 27 | 24 | 6 | 6 | 1 | 2 | 2 | 0 | 1 | 2 | 0 |
| 183 | 1997 | | | | | | | | | | 7 | 4 | 4 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 523 | 1998 | | | | | | | | | | | 19 | 16 | 4 | 2 | 7 | 1 | 0 | 0 | 0 |
| 499 | 1999 | | | | | | | | | | | | 20 | 9 | 6 | 3 | 2 | 3 | 1 | 1 |
| 479 | 2000 | | | | | | | | | | | | | 18 | 6 | 9 | 10 | 5 | 0 | 0 |
| 570 | 2001 | | | | | | | | | | | | | | 16 | 16 | 2 | 1 | 1 | 2 |
| 191 | 2002 | | | | | | | | | | | | | | | 4 | 3 | 2 | 2 | 2 |
| 667 | 2003 | | | | | | | | | | | | | | | | 25 | 9 | 10 | 7 |
| 645 | 2004 | | | | | | | | | | | | | | | | | 19 | 9 | 10 |
| 569 | 2005 | | | | | | | | | | | | | | | | | | 19 | 15 |
| 699 | 2006 | | | | | | | | | | | | | | | | | | | 17 |

Table 4 continued (New York – Hudson River)

| Number of releases | Release year | Harvested Recaptures 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 261 | 1988 | 11 | 10 | 7 | 9 | 6 | 3 | 2 | 1 | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 380 | 1989 | | 9 | 13 | 10 | 4 | 5 | 7 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 291 | 1990 | | | 13 | 13 | 9 | 8 | 4 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 361 | 1991 | | | | 15 | 14 | 8 | 6 | 9 | 5 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| 693 | 1992 | | | | | 35 | 27 | 16 | 11 | 12 | 10 | 7 | 3 | 2 | 1 | 0 | 0 | 1 | 0 | 0 |
| 527 | 1993 | | | | | | 35 | 16 | 10 | 17 | 10 | 5 | 6 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 379 | 1994 | | | | | | | 17 | 25 | 21 | 8 | 6 | 4 | 4 | 4 | 2 | 0 | 2 | 1 | 0 |
| 457 | 1995 | | | | | | | | 27 | 23 | 20 | 18 | 10 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 678 | 1996 | | | | | | | | | 65 | 44 | 27 | 12 | 2 | 7 | 2 | 2 | 3 | 1 | 1 |
| 183 | 1997 | | | | | | | | | | 22 | 7 | 8 | 5 | 3 | 2 | 1 | 0 | 1 | 1 |
| 523 | 1998 | | | | | | | | | | | 48 | 29 | 14 | 7 | 13 | 5 | 0 | 1 | 2 |
| 499 | 1999 | | | | | | | | | | | | 45 | 13 | 21 | 9 | 12 | 4 | 2 | 3 |
| 479 | 2000 | | | | | | | | | | | | | 27 | 19 | 13 | 8 | 8 | 6 | 3 |
| 570 | 2001 | | | | | | | | | | | | | | 33 | 23 | 12 | 5 | 5 | 8 |
| 191 | 2002 | | | | | | | | | | | | | | | 16 | 8 | 7 | 2 | 5 |
| 667 | 2003 | | | | | | | | | | | | | | | | 38 | 35 | 25 | 10 |
| 645 | 2004 | | | | | | | | | | | | | | | | | 57 | 25 | 24 |
| 569 | 2005 | | | | | | | | | | | | | | | | | | 40 | 29 |
| 699 | 2006 | | | | | | | | | | | | | | | | | | | 44 |

Table 4 continued.

Delaware/Pennsylvania – Delaware River

| Number of | Release | Harvested Recaptures | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 57 | 1993 | 3 | 3 | 1 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 82 | 1994 | | 4 | 6 | 4 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 174 | 1995 | | | 11 | 7 | 5 | 6 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 112 | 1996 | | | | 14 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 0 |
| 113 | 1997 | | | | | 13 | 6 | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| 204 | 1998 | | | | | | 24 | 9 | 4 | 3 | 4 | 3 | 1 | 1 | 1 |
| 108 | 1999 | | | | | | | 7 | 10 | 2 | 1 | 3 | 1 | 0 | 0 |
| 150 | 2000 | | | | | | | | 20 | 10 | 2 | 2 | 1 | 2 | 0 |
| 222 | 2001 | | | | | | | | | 28 | 10 | 9 | 6 | 3 | 4 |
| 138 | 2002 | | | | | | | | | | 13 | 5 | 2 | 3 | 1 |
| 286 | 2003 | | | | | | | | | | | 19 | 13 | 7 | 7 |
| 167 | 2004 | | | | | | | | | | | | 14 | 7 | 5 |
| 110 | 2005 | | | | | | | | | | | | | 6 | 7 |
| 181 | 2006 | | | | | | | | | | | | | | 16 |

| Number of | Release | Released with Tag Removed | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 57 | 1993 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 82 | 1994 | | 3 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 174 | 1995 | | | 2 | 5 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 112 | 1996 | | | | 4 | 3 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 113 | 1997 | | | | | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 204 | 1998 | | | | | | 6 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 108 | 1999 | | | | | | | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 | 2000 | | | | | | | | 4 | 2 | 2 | 1 | 0 | 1 | 0 |
| 222 | 2001 | | | | | | | | | 3 | 4 | 0 | 0 | 0 | 0 |
| 138 | 2002 | | | | | | | | | | 0 | 6 | 2 | 1 | 0 |
| 286 | 2003 | | | | | | | | | | | 13 | 8 | 1 | 0 |
| 167 | 2004 | | | | | | | | | | | | 3 | 3 | 2 |
| 110 | 2005 | | | | | | | | | | | | | 4 | 3 |
| 181 | 2006 | | | | | | | | | | | | | | 4 |

Table 4 continued – Maryland – Chesapeake Bay

| Number of releases | Release year | Harvested Recaptures 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 1987 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 124 | 1988 | | 2 | 1 | 3 | 7 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 216 | 1989 | | | 3 | 7 | 3 | 3 | 2 | 1 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 303 | 1990 | | | | 10 | 8 | 5 | 3 | 1 | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 390 | 1991 | | | | | 47 | 24 | 20 | 5 | 9 | 3 | 5 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 431 | 1992 | | | | | | 21 | 15 | 11 | 14 | 4 | 8 | 6 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 621 | 1993 | | | | | | | 30 | 25 | 30 | 13 | 14 | 7 | 8 | 1 | 3 | 2 | 0 | 0 | 0 | 0 |
| 543 | 1994 | | | | | | | | 24 | 27 | 20 | 16 | 10 | 8 | 4 | 2 | 0 | 0 | 1 | 0 | 0 |
| 527 | 1995 | | | | | | | | | 45 | 24 | 18 | 12 | 4 | 5 | 2 | 2 | 3 | 0 | 0 | 2 |
| 859 | 1996 | | | | | | | | | | 59 | 35 | 36 | 14 | 6 | 7 | 2 | 1 | 1 | 0 | 0 |
| 335 | 1997 | | | | | | | | | | | 33 | 19 | 15 | 1 | 2 | 1 | 1 | 0 | 0 | 0 |
| 263 | 1998 | | | | | | | | | | | | 22 | 13 | 2 | 3 | 2 | 0 | 0 | 0 | 0 |
| 117 | 1999 | | | | | | | | | | | | | 16 | 5 | 6 | 2 | 1 | 2 | 1 | 0 |
| 248 | 2000 | | | | | | | | | | | | | | 18 | 12 | 0 | 4 | 4 | 1 | 0 |
| 467 | 2001 | | | | | | | | | | | | | | | 21 | 10 | 10 | 5 | 2 | 3 |
| 323 | 2002 | | | | | | | | | | | | | | | | 13 | 18 | 5 | 6 | 0 |
| 322 | 2003 | | | | | | | | | | | | | | | | | 14 | 9 | 8 | 5 |
| 366 | 2004 | | | | | | | | | | | | | | | | | | 13 | 7 | 9 |
| 333 | 2005 | | | | | | | | | | | | | | | | | | | 15 | 10 |
| 275 | 2006 | | | | | | | | | | | | | | | | | | | | 13 |

| Number of releases | Release year | Released with Tag Removed 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 1987 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 124 | 1988 | | 0 | 7 | 4 | 5 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 216 | 1989 | | | 5 | 9 | 13 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 303 | 1990 | | | | 13 | 7 | 6 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 390 | 1991 | | | | | 25 | 10 | 7 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 431 | 1992 | | | | | | 22 | 12 | 6 | 2 | 3 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 621 | 1993 | | | | | | | 24 | 16 | 9 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 543 | 1994 | | | | | | | | 25 | 15 | 4 | 0 | 4 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 527 | 1995 | | | | | | | | | 16 | 6 | 6 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 859 | 1996 | | | | | | | | | | 30 | 19 | 7 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 335 | 1997 | | | | | | | | | | | 7 | 7 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 263 | 1998 | | | | | | | | | | | | 4 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 117 | 1999 | | | | | | | | | | | | | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 |
| 248 | 2000 | | | | | | | | | | | | | | 3 | 4 | 4 | 1 | 0 | 0 | 0 |
| 467 | 2001 | | | | | | | | | | | | | | | 8 | 9 | 1 | 1 | 1 | 0 |
| 323 | 2002 | | | | | | | | | | | | | | | | 5 | 1 | 1 | 1 | 2 |
| 322 | 2003 | | | | | | | | | | | | | | | | | 6 | 1 | 1 | 2 |
| 366 | 2004 | | | | | | | | | | | | | | | | | | 4 | 2 | 1 |
| 333 | 2005 | | | | | | | | | | | | | | | | | | | 4 | 4 |
| 275 | 2006 | | | | | | | | | | | | | | | | | | | | 1 |

Table 4 continued – Virginia – Rappahannock River

| Number of | Release | Harvested Recaptures | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 297 | 1990 | 10 | 1 | 6 | 1 | 3 | 5 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 386 | 1991 | | 19 | 10 | 12 | 9 | 2 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 40 | 1992 | | | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 209 | 1993 | | | | 11 | 11 | 5 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 123 | 1994 | | | | | 4 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 205 | 1995 | | | | | | 18 | 6 | 5 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 0 |
| 67 | 1996 | | | | | | | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 210 | 1997 | | | | | | | | 11 | 12 | 6 | 2 | 0 | 1 | 1 | 1 | 0 | 0 |
| 156 | 1998 | | | | | | | | | 16 | 9 | 1 | 3 | 1 | 0 | 0 | 0 | 0 |
| 159 | 1999 | | | | | | | | | | 13 | 2 | 1 | 2 | 1 | 0 | 0 | 0 |
| 362 | 2000 | | | | | | | | | | | 13 | 11 | 6 | 5 | 3 | 3 | 0 |
| 268 | 2001 | | | | | | | | | | | | 9 | 8 | 2 | 6 | 1 | 0 |
| 122 | 2002 | | | | | | | | | | | | | 7 | 3 | 5 | 1 | 0 |
| 392 | 2003 | | | | | | | | | | | | | | 23 | 13 | 3 | 1 |
| 680 | 2004 | | | | | | | | | | | | | | | 21 | 8 | 8 |
| 281 | 2005 | | | | | | | | | | | | | | | | 12 | 7 |
| 175 | 2006 | | | | | | | | | | | | | | | | | 10 |

| Number of | Release | Released with Tag Removed | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 297 | 1990 | 15 | 6 | 7 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 386 | 1991 | | 20 | 10 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 1992 | | | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 209 | 1993 | | | | 10 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 123 | 1994 | | | | | 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 205 | 1995 | | | | | | 5 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 1996 | | | | | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 210 | 1997 | | | | | | | | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 156 | 1998 | | | | | | | | | 6 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 159 | 1999 | | | | | | | | | | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 362 | 2000 | | | | | | | | | | | 9 | 6 | 4 | 2 | 0 | 0 | 0 |
| 268 | 2001 | | | | | | | | | | | | 7 | 4 | 2 | 0 | 0 | 0 |
| 122 | 2002 | | | | | | | | | | | | | 2 | 2 | 0 | 0 | 0 |
| 392 | 2003 | | | | | | | | | | | | | | 8 | 6 | 2 | 0 |
| 680 | 2004 | | | | | | | | | | | | | | | 11 | 2 | 5 |
| 281 | 2005 | | | | | | | | | | | | | | | | 3 | 4 |
| 175 | 2006 | | | | | | | | | | | | | | | | | 2 |

Table 5. Program MARK input matrices for the Chesapeake Bay specific tagging programs, for male fish 18 - 28".

Virginia

| Number of releases | Release year | Recaptures 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 189 | 1990 | 20 | 7 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 107 | 1991 | | 18 | 6 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 166 | 1993 | | | | 12 | 8 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 1994 | | | | | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 361 | 1995 | | | | | | 37 | 10 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 258 | 1996 | | | | | | | 20 | 12 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 458 | 1997 | | | | | | | | 27 | 9 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 601 | 1998 | | | | | | | | | 26 | 12 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 666 | 1999 | | | | | | | | | | 48 | 15 | 6 | 2 | 1 | 0 | 0 | 0 |
| 1352 | 2000 | | | | | | | | | | | 113 | 30 | 7 | 7 | 1 | 1 | 0 |
| 496 | 2001 | | | | | | | | | | | | 50 | 8 | 9 | 0 | 0 | 1 |
| 189 | 2002 | | | | | | | | | | | | | 12 | 2 | 7 | 0 | 1 |
| 443 | 2003 | | | | | | | | | | | | | | 24 | 11 | 2 | 2 |
| 757 | 2004 | | | | | | | | | | | | | | | 38 | 6 | 0 |
| 597 | 2005 | | | | | | | | | | | | | | | | 26 | 15 |
| 461 | 2006 | | | | | | | | | | | | | | | | | 33 |

Table 5 continued.

Maryland

| Number of releases | Release year | Recaptures 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1314 | 1987 | 90 | 40 | 19 | 37 | 36 | 42 | 25 | 8 | 7 | 4 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1834 | 1988 | | 74 | 45 | 60 | 53 | 56 | 34 | 15 | 15 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0; | 0 | 0 |
| 1876 | 1989 | | | 58 | 91 | 77 | 82 | 38 | 30 | 16 | 9 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 848 | 1990 | | | | 53 | 44 | 42 | 17 | 13 | 4 | 5 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 991 | 1991 | | | | | 60 | 69 | 43 | 21 | 14 | 5 | 5 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1120 | 1992 | | | | | | 118 | 59 | 38 | 22 | 9 | 5 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1468 | 1993 | | | | | | | 98 | 92 | 51 | 31 | 20 | 13 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1215 | 1994 | | | | | | | | 106 | 87 | 35 | 20 | 19 | 10 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 773 | 1995 | | | | | | | | | 94 | 46 | 19 | 10 | 6 | 2 | 3 | 0 | 1 | 0 | 0 | 0 |
| 724 | 1996 | | | | | | | | | | 86 | 39 | 29 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 |
| 500 | 1997 | | | | | | | | | | | 61 | 29 | 7 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 673 | 1998 | | | | | | | | | | | | 85 | 23 | 13 | 4 | 2 | 1 | 1 | 0 | 0 |
| 410 | 1999 | | | | | | | | | | | | | 35 | 25 | 6 | 3 | 0 | 0 | 0 | 0 |
| 683 | 2000 | | | | | | | | | | | | | | 67 | 11 | 13 | 4 | 3 | 1 | 0 |
| 624 | 2001 | | | | | | | | | | | | | | | 54 | 13 | 10 | 4 | 1 | 0 |
| 808 | 2002 | | | | | | | | | | | | | | | | 60 | 33 | 14 | 1 | 0 |
| 457 | 2003 | | | | | | | | | | | | | | | | | 38 | 18 | 7 | 4 |
| 313 | 2004 | | | | | | | | | | | | | | | | | | 26 | 10 | 2 |
| 539 | 2005 | | | | | | | | | | | | | | | | | | | 35 | 16 |
| 286 | 2006 | | | | | | | | | | | | | | | | | | | | 26 |

Table 6. Instantaneous Rates – Catch and Release Model input matrices for the Chesapeake Bay specific tagging programs, for male fish 18-28”. The first matrix contains all harvested recaptures and the second matrix contains released fish with their tag removed.

Virginia

| Number of | Release | Harvested Recaptures | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 615 | 1988 | 4 | 0 | 9 | 5 | 5 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217 | 1989 | | 0 | 3 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1990 | | | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1991 | | | | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | | | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1993 | | | | | | 2 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1994 | | | | | | | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 344 | 1995 | | | | | | | | 6 | 5 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 256 | 1996 | | | | | | | | | 2 | 6 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 452 | 1997 | | | | | | | | | | 12 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 596 | 1998 | | | | | | | | | | | 11 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 660 | 1999 | | | | | | | | | | | | 16 | 4 | 3 | 0 | 1 | 0 | 0 | 0 |
| 1326 | 2000 | | | | | | | | | | | | | 29 | 12 | 5 | 2 | 0 | 1 | 1 |
| 484 | 2001 | | | | | | | | | | | | | | 23 | 6 | 1 | 1 | 0 | 0 |
| 184 | 2002 | | | | | | | | | | | | | | | 3 | 1 | 1 | 0 | 1 |
| 438 | 2003 | | | | | | | | | | | | | | | | 9 | 7 | 2 | 2 |
| 756 | 2004 | | | | | | | | | | | | | | | | | 22 | 6 | 0 |
| 595 | 2005 | | | | | | | | | | | | | | | | | | 14 | 10 |
| 456 | 2006 | | | | | | | | | | | | | | | | | | | 15 |

| Number of | Release | Released with tag removed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 615 | 1988 | 3 | 7 | 17 | 6 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217 | 1989 | | 4 | 6 | 2 | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1990 | | | 8 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1991 | | | | 10 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | | | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1993 | | | | | | 5 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1994 | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 344 | 1995 | | | | | | | | 7 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 256 | 1996 | | | | | | | | | 6 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 452 | 1997 | | | | | | | | | | 6 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 596 | 1998 | | | | | | | | | | | 13 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 660 | 1999 | | | | | | | | | | | | 15 | 5 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1326 | 2000 | | | | | | | | | | | | | 28 | 12 | 2 | 1 | 0 | 0 | 0 |
| 484 | 2001 | | | | | | | | | | | | | | 10 | 2 | 1 | 0 | 0 | 0 |
| 184 | 2002 | | | | | | | | | | | | | | | 4 | 1 | 2 | 0 | 0 |
| 438 | 2003 | | | | | | | | | | | | | | | | 3 | 2 | 0 | 1 |
| 756 | 2004 | | | | | | | | | | | | | | | | | 10 | 3 | 0 |
| 595 | 2005 | | | | | | | | | | | | | | | | | | 8 | 4 |
| 456 | 2006 | | | | | | | | | | | | | | | | | | | 13 |

Table 6 continued (Virginia)

| Number of releases | Release year | Harvested Recaptures 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 615 | 1988 | 4 | 0 | 9 | 5 | 5 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217 | 1989 | | 0 | 3 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1990 | | | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1991 | | | | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | | | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1993 | | | | | | 2 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1994 | | | | | | | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 344 | 1995 | | | | | | | | 6 | 5 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 256 | 1996 | | | | | | | | | 2 | 6 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 452 | 1997 | | | | | | | | | | 12 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 596 | 1998 | | | | | | | | | | | 11 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 660 | 1999 | | | | | | | | | | | | 16 | 4 | 3 | 0 | 1 | 0 | 0 | 0 |
| 1326 | 2000 | | | | | | | | | | | | | 29 | 12 | 5 | 2 | 0 | 1 | 1 |
| 484 | 2001 | | | | | | | | | | | | | | 23 | 6 | 1 | 1 | 0 | 0 |
| 184 | 2002 | | | | | | | | | | | | | | | 3 | 1 | 1 | 0 | 1 |
| 438 | 2003 | | | | | | | | | | | | | | | | 9 | 7 | 2 | 2 |
| 756 | 2004 | | | | | | | | | | | | | | | | | 22 | 6 | 0 |
| 595 | 2005 | | | | | | | | | | | | | | | | | | 14 | 10 |
| 456 | 2006 | | | | | | | | | | | | | | | | | | | 15 |

| Number of releases | Release year | Released with tag removed 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 615 | 1988 | 3 | 7 | 17 | 6 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217 | 1989 | | 4 | 6 | 2 | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1990 | | | 8 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1991 | | | | 10 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | | | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1993 | | | | | | 5 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1994 | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 344 | 1995 | | | | | | | | 7 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 256 | 1996 | | | | | | | | | 6 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 452 | 1997 | | | | | | | | | | 6 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 596 | 1998 | | | | | | | | | | | 13 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 660 | 1999 | | | | | | | | | | | | 15 | 5 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1326 | 2000 | | | | | | | | | | | | | 28 | 12 | 2 | 1 | 0 | 0 | 0 |
| 484 | 2001 | | | | | | | | | | | | | | 10 | 2 | 1 | 0 | 0 | 0 |
| 184 | 2002 | | | | | | | | | | | | | | | 4 | 1 | 2 | 0 | 0 |
| 438 | 2003 | | | | | | | | | | | | | | | | 3 | 2 | 0 | 1 |
| 756 | 2004 | | | | | | | | | | | | | | | | | 10 | 3 | 0 |
| 595 | 2005 | | | | | | | | | | | | | | | | | | 8 | 4 |
| 456 | 2006 | | | | | | | | | | | | | | | | | | | 13 |

Table 6 continued.

Maryland

| Number of releases | Release year | Harvested Recaptures 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1293 | 1987 | 1 | 6 | 0 | 18 | 19 | 21 | 17 | 6 | 7 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1802 | 1988 | | 4 | 2 | 23 | 26 | 37 | 23 | 10 | 12 | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1830 | 1989 | | | 1 | 39 | 51 | 57 | 30 | 19 | 9 | 6 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 831 | 1990 | | | | 21 | 27 | 26 | 11 | 10 | 3 | 3 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 974 | 1991 | | | | | 31 | 38 | 29 | 9 | 10 | 4 | 5 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1107 | 1992 | | | | | | 59 | 41 | 26 | 8 | 4 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1458 | 1993 | | | | | | | 63 | 51 | 31 | 17 | 15 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1204 | 1994 | | | | | | | | 54 | 60 | 19 | 16 | 15 | 8 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 769 | 1995 | | | | | | | | | 55 | 26 | 13 | 5 | 5 | 2 | 1 | 0 | 1 | 0 | 0 | 0 |
| 720 | 1996 | | | | | | | | | | 44 | 25 | 22 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 |
| 488 | 1997 | | | | | | | | | | | 33 | 20 | 7 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 668 | 1998 | | | | | | | | | | | | 52 | 15 | 6 | 4 | 2 | 1 | 1 | 0 | 0 |
| 406 | 1999 | | | | | | | | | | | | | 22 | 16 | 4 | 1 | 0 | 0 | 0 | 0 |
| 676 | 2000 | | | | | | | | | | | | | | 32 | 9 | 11 | 3 | 3 | 1 | 0 |
| 617 | 2001 | | | | | | | | | | | | | | | 31 | 11 | 9 | 3 | 0 | 0 |
| 806 | 2002 | | | | | | | | | | | | | | | | 39 | 25 | 11 | 1 | 0 |
| 454 | 2003 | | | | | | | | | | | | | | | | | 27 | 14 | 3 | 3 |
| 311 | 2004 | | | | | | | | | | | | | | | | | | 14 | 7 | 0 |
| 537 | 2005 | | | | | | | | | | | | | | | | | | | 24 | 15 |
| 282 | 2006 | | | | | | | | | | | | | | | | | | | | 16 |

| Number of releases | Release year | Released with Tag Removed 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1293 | 1987 | 28 | 2 | 11 | 15 | 14 | 17 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1802 | 1988 | | 13 | 32 | 31 | 21 | 15 | 10 | 5 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1830 | 1989 | | | 40 | 37 | 19 | 17 | 7 | 6 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 831 | 1990 | | | | 21 | 14 | 14 | 5 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 974 | 1991 | | | | | 24 | 25 | 9 | 9 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1107 | 1992 | | | | | | 48 | 17 | 10 | 12 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1458 | 1993 | | | | | | | 32 | 34 | 16 | 10 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1204 | 1994 | | | | | | | | 47 | 25 | 12 | 4 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 769 | 1995 | | | | | | | | | 33 | 18 | 3 | 3 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 720 | 1996 | | | | | | | | | | 37 | 12 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 488 | 1997 | | | | | | | | | | | 20 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 668 | 1998 | | | | | | | | | | | | 29 | 8 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 406 | 1999 | | | | | | | | | | | | | 10 | 8 | 2 | 2 | 0 | 0 | 0 | 0 |
| 676 | 2000 | | | | | | | | | | | | | | 29 | 2 | 2 | 1 | 0 | 0 | 0 |
| 617 | 2001 | | | | | | | | | | | | | | | 19 | 1 | 1 | 1 | 0 | 0 |
| 806 | 2002 | | | | | | | | | | | | | | | | 20 | 6 | 3 | 0 | 0 |
| 454 | 2003 | | | | | | | | | | | | | | | | | 9 | 3 | 2 | 1 |
| 311 | 2004 | | | | | | | | | | | | | | | | | | 10 | 3 | 1 |
| 537 | 2005 | | | | | | | | | | | | | | | | | | | 9 | 1 |
| 282 | 2006 | | | | | | | | | | | | | | | | | | | | 8 |

## Appendix A14. Miscellaneous Tables Pertaining to Tagging Data

Tag release and recapture data are exchanged between the USFWS office in Annapolis, MD, and the cooperating tagging agencies. The USFWS maintains the tag release/recovery database and provides rewards to fishermen who report the recapture of tagged fish. From 1985 through July 2007, a total of 469,896 striped bass have been tagged and released, with 84,544 recaptures reported and recorded in the USFWS database (Tina McCrobie, personal communication).

These data were used to develop the following descriptive statistics of reported fish:

- length frequency distributions of releases, measured as total length (TL);
- age frequency distributions of recaptures; and
- annual catch rates.

Annual catch rates were developed for both $\geq$ 18 inch fish and $\geq$ 28 inch fish and were estimated as follows:

$$(R / 0.43) / M \qquad \textit{Eqn 1.}$$

where:

R = number of fish recovered;
0.43 = reporting rate; and
M = number of fish marked.

The data are used in both Program MARK and the IRCR model as program-specific matrices of releases and recaptures occurring in each year over the time series (Appendix 11). The number of twice-recaptured fish was examined to ensure that this phenomenon did not cause a bias in model results. Of 84,544 recaptured fish in the database, only 3,542 fish were recorded as twice recaptured. Since this was less than 5%, it was considered inconsequential.

Length frequencies (total length) of fish tagged in 2006 were tabulated by program (Table 1). Length represents the length of fish at the time of tagging.

Age distributions of fish recaptured in 2006 were tabulated by program (Table 2). Age distributions are based on a subsample of the total number of tagged fish (all programs do not age all tagged fish). Ages are read from scales taken at time of tagging and are adjusted to the recovery date.

Geographic distributions of 2006 recaptures (from fish tagged and released during the full time series) were organized by state and month for each tagging program (Table 3).

Annual catch rates for fish $\geq$ 28 inches show more variability among the programs over the time series, with values for most programs between 0.1 and 0.4 since the late 1990's. In particular, VARAP shows high (up to 0.6) and erratic values. There is no clear trend (Table 4).

Annual catch rates for $\geq$ 18 inch fish have shown a very slight steady decrease since the mid 1990's, with all values for all programs between 0.1 and 0.3 except for one. The 2006 values were unusually closely grouped from 0.14 to 0.20 (Table 5).

Catch rate for both length groups ($\geq$ 18 inches and $\geq$ 28 inches) peaked in late 1990's and values for the past few years are similar to values seen in the earliest part of the time series.

The difference between the total catch rate and the exploitation rate suggests that the live release rate was approximately 5 %. This rate has been fairly constant since the mid-1990's. This estimate could be biased low because anglers may be less likely to notice tags on fish they have released. They could also be less likely to recover tags they do notice, since they are releasing the fish.

## Appendix A14 Tables

Table 1. Total length frequencies of fish tagged in 2006 by program.

| | Coast Programs | | | | Producer Area Programs | | | |
|---|---|---|---|---|---|---|---|---|
| TL | MADFW | NYOHS | NJDEP | NCCOOP | DE/PA | MDCB | VARAP | HUDSON |
| 199 | | | | | | | | |
| 249 | | | | | | | | |
| 299 | | | | | | 3 | | |
| 349 | | | | 1 | | 36 | | |
| 399 | | 25 | | 0 | 1 | 98 | | |
| 449 | | 204 | 1 | 4 | 139 | 141 | | |
| 499 | | 307 | 2 | 48 | 126 | 147 | 211 | 55 |
| 549 | | 281 | 25 | 319 | 134 | 104 | 178 | 76 |
| 599 | 1 | 145 | 190 | 632 | 79 | 56 | 80 | 97 |
| 649 | 15 | 109 | 495 | 646 | 61 | 35 | 15 | 96 |
| 699 | 35 | 47 | 469 | 544 | 20 | 25 | 4 | 76 |
| 749 | 53 | 20 | 153 | 535 | 20 | 24 | 16 | 114 |
| 799 | 60 | 6 | 65 | 431 | 21 | 33 | 19 | 143 |
| 849 | 83 | 1 | 37 | 492 | 29 | 54 | 35 | 147 |
| 899 | 69 | 2 | 18 | 430 | 36 | 48 | 36 | 148 |
| 949 | 48 | 2 | 10 | 222 | 33 | 39 | 41 | 94 |
| 999 | 19 | 1 | 2 | 93 | 21 | 45 | 25 | 43 |
| 1049 | 4 | | | 46 | 14 | 16 | 6 | 28 |
| 1099 | 2 | | | 7 | 4 | 12 | 1 | 14 |
| >1099 | 1 | | | 9 | 9 | 8 | 1 | 3 |
| Total | 390 | 1150 | 1467 | 4459 | 747 | 924 | 668 | 1134 |

Table 2. Age frequencies of tagged fish recaptured in 2006 by program.

| | **Coast Programs** | | | | **Producer Area Programs** | | | |
|---|---|---|---|---|---|---|---|---|
| AGE | MADFW | NYOHS | NJDEP | NCCOOP | DE/PA | MDCB | VARAP | HUDSON |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | 1 | 19 | 1 | | 1 | | | |
| 4 | 0 | 11 | 2 | | 5 | | 21 | |
| 5 | 0 | 28 | 46 | | 9 | | 19 | |
| 6 | 2 | 38 | 69 | | 19 | | 8 | |
| 7 | 4 | 8 | 31 | | 9 | | 4 | |
| 8 | 9 | 10 | 46 | | 7 | | 6 | 1 |
| 9 | 8 | 3 | 37 | | 7 | 1 | 9 | 0 |
| 10 | 17 | 10 | 29 | | 11 | 1 | 8 | 0 |
| 11 | 10 | 9 | 12 | | 9 | 2 | 7 | 3 |
| 12 | 2 | 4 | 12 | | 6 | 5 | 4 | 2 |
| 13 | 6 | 4 | 7 | | 7 | 8 | 3 | 4 |
| 14 | 2 | 3 | 5 | | 3 | 3 | 5 | 1 |
| 15 | 4 | 0 | 2 | | 4 | 0 | | 5 |
| 16 | 1 | 0 | 4 | | 3 | 0 | | 6 |
| 17 | 0 | 1 | 2 | | 3 | 0 | | 3 |
| 18 | 1 | 1 | 1 | | 2 | 0 | | 3 |
| 19 | 0 | 1 | 1 | | | 0 | | 0 |
| 20 | 0 | | | | | 1 | | 0 |
| 21 | 0 | | | | | | | 0 |
| 22 | 1 | | | | | | | 0 |
| 23 | | | | | | | | 1 |
| Total | 68 | 150 | 307 | | 105 | 21 | 94 | 29 |

Table 3. Distribution of tag recaptures by state (program) and month.

**Coast Programs**

Massachusetts (recaptures in 2006 from fish tagged and released during 1992-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | | | | | | | | | 0 |
| NH | | | | | | | | | | | | | 0 |
| MA | | | | | 1 | 6 | 13 | 5 | 2 | | | | 27 |
| RI | | | | | 1 | 1 | | | | | | | 2 |
| CT | | | | | 1 | | 1 | | | 1 | | | 3 |
| NY | | | 1 | | 15 | 2 | 2 | | 2 | | 2 | | 24 |
| NJ | | | 1 | 1 | 6 | 5 | 1 | | | 3 | 5 | | 22 |
| DE | | | | 1 | | | | | | | | | 1 |
| MD | | | 1 | 12 | 5 | 1 | | | | | | | 19 |
| VA | 7 | 4 | 3 | | | | | | | | | 4 | 18 |
| NC | 3 | | | | | | | | | | | 1 | 4 |
| PA | | | | 1 | | | | | | | | | 1 |
| Total | 10 | 4 | 6 | 15 | 29 | 15 | 17 | 5 | 4 | 4 | 7 | 5 | 121 |

New York - Ocean Haul Seine (recaptures in 2006 from fish tagged/release during 1988-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | | | 2 | | | | | | 2 |
| NH | | | | | | 1 | 1 | | | | | | 2 |
| MA | | | | | 4 | 9 | 8 | 5 | 1 | | | | 27 |
| RI | | | | 1 | 3 | 2 | 3 | 3 | 4 | | | | 16 |
| CT | | | | | 3 | 1 | 2 | 2 | 2 | | 1 | | 11 |
| NY | 1 | | | 3 | 13 | 5 | 4 | 3 | 6 | 5 | 4 | 1 | 45 |
| NJ | | | 1 | 9 | 6 | 4 | 1 | 1 | 1 | 1 | 3 | 8 | 35 |
| PA | | | | | | | | | | | | | 0 |
| DE | 1 | | | 1 | 1 | | | | | | | | 3 |
| MD | | 1 | | 1 | 2 | | | | | | 1 | | 5 |
| VA | 2 | | | | | | | | | | | 2 | 4 |
| NC | 3 | | | | 1 | | | | | | | 1 | 5 |
| Total | 7 | 1 | 1 | 15 | 33 | 22 | 21 | 14 | 14 | 6 | 9 | 12 | 155 |

Table 3 continued.

New Jersey - Delaware Bay (recaptures in 2006 from fish tagged/release during 1989-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | 1 | 2 | 2 | | | | | | 5 |
| NH | | | | | | 1 | | | 1 | | | | 2 |
| MA | | | | | 4 | 13 | 25 | 17 | 15 | 4 | | | 78 |
| RI | | | | | 7 | 9 | 10 | 5 | 3 | 3 | | | 37 |
| CT | | | | | 2 | 4 | 4 | 2 | 2 | 1 | | | 15 |
| NY | | | | 1 | 15 | 23 | 10 | 2 | 4 | 12 | 4 | 4 | 75 |
| NJ | 1 | 1 | | 3 | 18 | 10 | 5 | | 2 | 9 | 10 | 1 | 60 |
| PA | | | | | 1 | | | | | | | | 1 |
| DE | 1 | | | 1 | | | | | | | 1 | 1 | 4 |
| MD | 1 | 1 | | 4 | 6 | | | | | | 1 | 1 | 14 |
| VA | 2 | 6 | 1 | | | | | | | | | 10 | 19 |
| NC | | | 1 | | | | | | | | | 1 | 2 |
| Total | 5 | 8 | 2 | 9 | 54 | 62 | 56 | 26 | 27 | 29 | 16 | 18 | 312 |

North Carolina - Winter Trawl Survey (recaptures in 2006 from fish tagged and released during 1992-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | | | 2 | 1 | 1 | | | | 4 |
| NH | | | | | | 1 | 1 | | | | | | 2 |
| MA | | | | 1 | 7 | 19 | 20 | 14 | 9 | 2 | | | 72 |
| RI | | | | | 1 | 5 | 5 | 4 | 2 | 1 | | | 18 |
| CT | | | | | 5 | 1 | 2 | 2 | 2 | 1 | | | 13 |
| NY | | | | 4 | 28 | 19 | 12 | | 9 | 12 | 5 | | 89 |
| NJ | | | | 4 | 11 | 10 | 2 | | | 7 | 12 | | 46 |
| PA | | | | | | | | | | | | | 0 |
| DE | | | | | | | | | 1 | | | | 1 |
| MD | | 2 | 3 | 40 | 16 | 30 | 19 | 8 | 12 | 10 | 3 | 3 | 146 |
| VA | 4 | 10 | 6 | 5 | 8 | 3 | 3 | | 1 | 5 | 20 | 23 | 88 |
| NC | 7 | 2 | 4 | 1 | | | | | | | | | 14 |
| Total | 11 | 14 | 13 | 55 | 76 | 88 | 66 | 29 | 37 | 38 | 40 | 26 | 493 |

Table 3 continued.

## **Producer Areas**

Delaware / Pennsylvania - Delaware River (recaptures in 2006 from fish tagged and released during 1992-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | | | 1 | | | | | | 1 |
| NH | | | | | | | 1 | | | | | | 1 |
| MA | | | | | 1 | 3 | 2 | 2 | | | | | 8 |
| RI | | | | | | 1 | | 1 | | | | | 2 |
| CT | | | | | | 1 | | | | | | | 1 |
| NY | | | | | 2 | 1 | 1 | 2 | | 1 | 1 | | 8 |
| NJ | | | | | 8 | 14 | 6 | 1 | 2 | | 11 | 1 | 43 |
| PA | | | | 1 | 3 | 2 | | | | | | | 6 |
| DE | | | | | 4 | 3 | 2 | | 1 | 3 | 2 | | 15 |
| MD | | | | 4 | 2 | 3 | 2 | 2 | 3 | 2 | 4 | | 22 |
| VA | | | | | | | | | 1 | | | 6 | 7 |
| NC | | | | | | | | | | | | | 0 |
| Total | 0 | 0 | 0 | 5 | 20 | 28 | 15 | 8 | 7 | 6 | 18 | 7 | 114 |

Maryland - Chesapeake Bay Spring Spawning Stock (recaptures in 2006 from fish tagged and released during 1992-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | | | | | | | | | 0 |
| NH | | | | | | | | | | | | | 0 |
| MA | | | | | 1 | 2 | 3 | 1 | 2 | 1 | | | 10 |
| RI | | | | | | 1 | 1 | 2 | 2 | 1 | | | 7 |
| CT | | | | | | 1 | | 1 | 1 | | | | 3 |
| NY | | | | | 4 | 3 | 1 | 2 | 2 | | | | 12 |
| NJ | | | | | 2 | 1 | | | | 3 | | | 6 |
| PA | | | | | | | | | | | | | 0 |
| DE | | | | | | | | | 2 | 1 | 1 | | 4 |
| MD | 1 | 3 | 2 | 6 | 8 | 19 | 14 | 5 | 6 | 6 | 8 | | 78 |
| DC | | | | | 3 | | | | | | | | 3 |
| VA | 5 | | 1 | | 3 | 4 | 1 | 1 | | 2 | 5 | 9 | 31 |
| NC | 1 | | 1 | | | | | | | | | | 2 |
| Total | 7 | 3 | 4 | 6 | 21 | 31 | 20 | 12 | 15 | 14 | 14 | 9 | 156 |

Table 3 continued.

Virginia - Rappahannock River (recaptures in 2006 from fish tagged and released during 1990-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | | | | | | | | | 0 |
| NH | | | | | | | | | | | | | 0 |
| MA | | | | | 1 | 4 | 3 | 3 | 1 | 1 | | | 13 |
| RI | | | | | | | | | | | | | 0 |
| CT | | | | | 1 | 1 | 1 | | | | | | 3 |
| NY | | | | | 4 | 2 | | 1 | 1 | 1 | | | 9 |
| NJ | | | | | 1 | 6 | | | | 1 | | | 8 |
| PA | | | | | | | | | | | | | 0 |
| DE | | | | | | | | | | | | | 0 |
| MD | | | | 1 | 2 | 7 | 3 | 2 | 3 | 2 | | | 20 |
| VA | 2 | 2 | | 5 | 3 | 1 | 3 | | 3 | 8 | 6 | 13 | 46 |
| NC | 3 | | 1 | | | | | | | | 1 | | 5 |
| Total | 5 | 2 | 1 | 6 | 12 | 21 | 10 | 6 | 8 | 13 | 7 | 13 | 104 |

Hudson River (recaptures in 2006 from fish tagged and released during 1992-2006)

| State | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME | | | | | | | | | | | | | 0 |
| NH | | | | | | | | | | | | | 0 |
| MA | | | | | | 3 | 11 | 8 | 3 | 3 | | | 28 |
| RI | | | | | | 5 | 3 | 2 | 1 | 1 | | | 12 |
| CT | | | | | 2 | 9 | 7 | 1 | 5 | 2 | 2 | | 28 |
| NY | | | | 13 | 44 | 33 | 14 | 3 | 11 | 5 | 5 | 6 | 134 |
| NJ | 1 | | | 3 | 1 | 14 | 4 | 2 | 2 | | 14 | 5 | 46 |
| PA | | | | | | | | | | | | | 0 |
| DE | | | | | | | | | | | | | 0 |
| MD | | | | 1 | | | | | | | | 2 | 3 |
| VA | 2 | 2 | 1 | | | | | | | | | 6 | 11 |
| NC | | | | | | | | | | | 1 | | 1 |
| Total | 3 | 2 | 1 | 17 | 47 | 64 | 39 | 16 | 22 | 11 | 22 | 19 | 263 |

Table 4. R/M estimates of catch rates of ≥28 inch striped bass from tagging programs. Catch rate is the proportion of tagged striped bass that were caught, but may have been released (with reporting rate adjustment of 0.43).

| Year | NJDEL | NYOHS | NCCOOP | MADFW | VARAP | MDCB | DE/PA | HUDSON | MEAN |
|---|---|---|---|---|---|---|---|---|---|
| 1987 | * | * | * | * | * | 0.08 | * | * | **0.08** |
| 1988 | * | 0.27 | 0.21 | * | * | 0.11 | * | 0.21 | **0.20** |
| 1989 | 0.24 | 0.24 | 0.13 | * | * | 0.10 | * | 0.25 | **0.19** |
| 1990 | 0.52 | 0.22 | 0.18 | * | 0.49 | 0.18 | * | 0.33 | **0.32** |
| 1991 | 0.58 | 0.25 | 0.20 | * | 0.58 | 0.28 | * | 0.24 | **0.36** |
| 1992 | 0.25 | 0.33 | 0.25 | 0.15 | 0.58 | 0.24 | * | 0.29 | **0.30** |
| 1993 | 0.20 | 0.28 | 0.28 | 0.13 | 0.57 | 0.21 | 0.24 | 0.33 | **0.28** |
| 1994 | 0.24 | 0.22 | 0.20 | 0.11 | 0.36 | 0.22 | 0.20 | 0.26 | **0.23** |
| 1995 | 0.24 | 0.35 | 0.27 | 0.16 | 0.55 | 0.27 | 0.21 | 0.25 | **0.29** |
| 1996 | 0.34 | 0.32 | 0.15 | 0.19 | 0.21 | 0.25 | 0.41 | 0.31 | **0.27** |
| 1997 | 0.36 | 0.45 | 0.24 | 0.34 | 0.44 | 0.28 | 0.29 | 0.37 | **0.34** |
| 1998 | 0.38 | 0.17 | 0.26 | 0.17 | 0.60 | 0.23 | 0.34 | 0.29 | **0.31** |
| 1999 | 0.29 | 0.36 | 0.27 | 0.24 | 0.37 | 0.38 | 0.19 | 0.30 | **0.30** |
| 2000 | 0.22 | 0.33 | 0.13 | 0.14 | 0.41 | 0.20 | 0.36 | 0.22 | **0.25** |
| 2001 | 0.24 | 0.20 | 0.21 | 0.12 | 0.35 | 0.15 | 0.28 | 0.20 | **0.22** |
| 2002 | 0.18 | 0.38 | 0.15 | 0.15 | 0.38 | 0.13 | 0.24 | 0.24 | **0.23** |
| 2003 | 0.24 | 0.21 | 0.16 | 0.12 | 0.36 | 0.16 | 0.26 | 0.22 | **0.22** |
| 2004 | 0.27 | 0.25 | 0.17 | 0.12 | 0.20 | 0.11 | 0.28 | 0.27 | **0.21** |
| 2005 | 0.30 | 0.33 | 0.10 | 0.11 | 0.22 | 0.14 | 0.23 | 0.24 | **0.21** |
| 2006 | 0.25 | 0.20 | 0.17 | 0.15 | 0.16 | 0.16 | 0.26 | 0.20 | **0.19** |

* Years when few or no striped bass were tagged and released.

Table 5. R/M estimates of catch rates of ≥18" inch striped bass from tagging programs. Catch rate is the proportion of tagged striped bass that were caught, but may have been released (with reporting rate adjustment of 0.43).

| Year | NJDEL | NYOHS | NCCOOP | MADFW | VARAP | MDCB | DE/PA | HUDSON | MEAN |
|---|---|---|---|---|---|---|---|---|---|
| 1987 | * | * | * | * | * | 0.16 | * | * | **0.16** |
| 1988 | * | 0.18 | 0.19 | * | * | 0.10 | * | 0.15 | **0.16** |
| 1989 | 0.28 | 0.23 | 0.11 | * | * | 0.08 | * | 0.20 | **0.18** |
| 1990 | 0.44 | 0.21 | 0.16 | * | 0.38 | 0.15 | * | 0.59 | **0.32** |
| 1991 | 0.23 | 0.17 | 0.19 | * | 0.28 | 0.19 | * | 0.24 | **0.22** |
| 1992 | 0.21 | 0.19 | 0.25 | 0.16 | 0.54 | 0.25 | * | 0.24 | **0.26** |
| 1993 | 0.19 | 0.14 | 0.21 | 0.12 | 0.40 | 0.18 | 0.23 | 0.25 | **0.21** |
| 1994 | 0.19 | 0.17 | 0.17 | 0.12 | 0.37 | 0.22 | 0.25 | 0.21 | **0.21** |
| 1995 | 0.21 | 0.15 | 0.23 | 0.14 | 0.30 | 0.28 | 0.28 | 0.15 | **0.22** |
| 1996 | 0.26 | 0.18 | 0.14 | 0.18 | 0.26 | 0.27 | 0.26 | 0.27 | **0.23** |
| 1997 | 0.27 | 0.16 | 0.21 | 0.28 | 0.27 | 0.29 | 0.19 | 0.31 | **0.25** |
| 1998 | 0.29 | 0.15 | 0.24 | 0.18 | 0.24 | 0.28 | 0.26 | 0.25 | **0.24** |
| 1999 | 0.19 | 0.14 | 0.27 | 0.16 | 0.23 | 0.23 | 0.20 | 0.22 | **0.20** |
| 2000 | 0.20 | 0.14 | 0.15 | 0.11 | 0.24 | 0.23 | 0.24 | 0.20 | **0.19** |
| 2001 | 0.23 | 0.14 | 0.17 | 0.10 | 0.28 | 0.19 | 0.22 | 0.19 | **0.19** |
| 2002 | 0.14 | 0.18 | 0.18 | 0.15 | 0.27 | 0.17 | 0.19 | 0.18 | **0.18** |
| 2003 | 0.21 | 0.11 | 0.15 | 0.12 | 0.25 | 0.19 | 0.25 | 0.20 | **0.18** |
| 2004 | 0.26 | 0.14 | 0.17 | 0.11 | 0.16 | 0.16 | 0.18 | 0.22 | **0.18** |
| 2005 | 0.23 | 0.14 | 0.08 | 0.11 | 0.17 | 0.15 | 0.27 | 0.18 | **0.17** |
| 2006 | 0.19 | 0.16 | 0.16 | 0.14 | 0.16 | 0.20 | 0.21 | 0.17 | **0.17** |

* Years when few or no striped bass were tagged and released.

## Appendix A15. AD Model Builder code for the instantaneous rates catch/release model (IRCR).

```
//--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--
//                                                                                     //
//  Jiang et. al (2007) Age-independent instantaneous rates model for catch and release
//
//  Gary Nelson
//  Massachusetts Division of Marine Fisheries
//  Gloucester, MA 01930
//  gary.nelson@state.ma.us                                                            //
//  Version 1.2                                                                        //
//--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><><>--><>--
```

### DATA_SECTION

```
// Starting and ending year of the release year
 init_int styrR;
 init_int endyrR;

//Starting and ending year of recovery years
 init_int styr;
 init_int endyr;

 //Total Releases by Year
 init_vector N(styrR,endyrR);

//Recapture Matrix for harvest fish
 init_imatrix rh(styrR,endyrR,styr,endyr);

//Recapture Matrix for releases fish
 init_imatrix rr(styrR,endyrR,styr,endyr);

//---Reporting Rate for harvested fish----------
 init_number lh;

 //---Initial probability of tag shedding and tag-induced mortality for harvested fish--
 init_number phih;

 //---Reporting Rate for released fish----------
 init_number lr;

 //---Initial probability of tag shedding and tag-induced mortality for released fish--
 init_number phir;

//Hooking Mortality
 init_number h;

//Number of Natural Mortality Periods and Beginnng Years
 init_int mp;
 init_ivector mp_int(1,mp);
 int pp;

//Number of Fishing  Mortality Periods and Beginning Years
 init_int fp;
 init_ivector fp_int(1,fp);
 int qq;

//Number of Tag Mortality Periods
 init_int fap;
 init_ivector fap_int(1,fap);
 int ss;
 int tp;
```

### LOCAL_CALCS

```
  pp=mp+1;
  qq=fp+1;
```

```
  ss=fap+1;
  tp=mp+fp+fap+(4*(endyr-styr+1));
 END_CALCS
 matrix sigma(1,tp,1,tp+1);
 !! set_covariance_matrix(sigma);
 //looping variables
 int y;
 int t;
 int a;
 int d;
 int cnt;
 int total;
 int Ntags;
 int looper;
 int df_r;
 int df_h;
 int hless;
 int rless;

PARAMETER_SECTION
 number dodo;
 number dodo1;
 number probs;
 number AIC;
 number AICc;
 number K;
 number up_df;
 number up_count;
 number up_chi;
 number up_chat;
 number p_chi;
 number p_df;
 number p_chat;

 //-------------F estimates-------------------------------
 init_bounded_vector e_F(1,fp,-30.,1.6,1);
 vector F(styr,endyr);
 vector fp_yr(1,qq);

  //-------------M estimates-------------------------------
 init_bounded_vector e_M(1,mp,-30,1.6,1);
 vector M(styr,endyr);
 vector mp_yr(1,pp);

 //--------------Tag Mortality----------------------------
 init_bounded_vector e_FA(1,fap,-30.,1.6,1);
 vector FA(styr,endyr);
 vector fap_yr(1,ss);

 //------------------Tag Number of Tags-------------------
 vector tags(styrR,endyrR);

 //----------------Mortality Calculations------------
 matrix s(styrR,endyrR,styr,endyr);
 matrix u_h(styrR,endyrR,styr,endyr);
 matrix u_r(styrR,endyrR,styr,endyr);
 vector S_fish(styr,endyr);

 //---------Predicted Cell recoveries-------------
 vector sum_prob_h(styrR,endyrR);
 vector sum_prob_r(styrR,endyrR);
 matrix s_prob(styrR,endyrR,styr,endyr);
 matrix exp_prob_h(styrR,endyrR,styr,endyr);
 matrix ll_h(styrR,endyrR,styr,endyr);
 matrix exp_prob_r(styrR,endyrR,styr,endyr);
 matrix ll_r(styrR,endyrR,styr,endyr);
 vector ll_ns(styrR,endyrR);
 matrix exp_r_h(styrR,endyrR,styr,endyr);
 matrix exp_r_r(styrR,endyrR,styr,endyr);
 matrix pool_r(styrR,endyrR,styr,endyr);
 matrix pool_h(styrR,endyrR,styr,endyr);
```

```
 matrix pool_r_e(styrR,endyrR,styr,endyr);
 matrix pool_h_e(styrR,endyrR,styr,endyr);
 matrix chi_r(styrR,endyrR,styr,endyr);
 matrix chi_h(styrR,endyrR,styr,endyr);
 matrix p_chi_r(styrR,endyrR,styr,endyr);
 matrix p_chi_h(styrR,endyrR,styr,endyr);
 matrix pear_r(styrR,endyrR,styr,endyr);
 matrix pear_h(styrR,endyrR,styr,endyr);
 vector exp_ns(styrR,endyrR);
 vector chi_ns(styrR,endyrR);
 vector pear_ns(styrR,endyrR);
 sdreport_vector S(styr,endyr);
 sdreport_vector FM(styr,endyr);
 sdreport_vector FT(styr,endyr);
 sdreport_vector NM(styr,endyr);

 //----------Likelihood Values------------------------------------------
 number f_tag;
 objective_function_value f;

INITIALIZATION_SECTION
 e_F -1.6;
 e_FA -1.6;
 e_M -1.6;

RUNTIME_SECTION
 maximum_function_evaluations 100, 500, 5000;
 convergence_criteria 1e-5, 1e-7, 1e-16;

PRELIMINARY_CALCS_SECTION
 F.initialize();
 FA.initialize();
 M.initialize();
PROCEDURE_SECTION
 calc_number_tags();
 calc_M_vector();
 calc_F_vector();
 calc_FA_vector();
 calc_fish_surv();
 calc_s();
 calc_s_prob();
 calc_u_h();
 calc_u_r();
 calc_exp_prob_h();
 calc_exp_prob_r();
 calc_LL();
 calc_Chisquare();
 calc_pooled_cells();
 evaluate_the_objective_function();

FUNCTION calc_number_tags
  cnt=0;
  for(t=styrR;t<=endyrR;t++){
    Ntags=0;
    for(y=styr+cnt;y<=endyr;y++){
      Ntags+=rh(t,y)+rr(t,y);
      }
      tags(t)=Ntags;
      cnt+=1;
   }

FUNCTION calc_M_vector
 for(t=1;t<=mp;t++){
       mp_yr(t)=mp_int(t);
   }
   mp_yr(pp)=endyr+1;

 for(t=styr;t<=endyr;t++){
     for(d=1;d<=mp;d++){
         if(t>=mp_yr(d) && t<mp_yr(d+1)){
           M(t)=mfexp(e_M(d));
```

```
          NM(t)=M(t);
         }
     }
  }

FUNCTION calc_F_vector
 for(t=1;t<=fp;t++){
   fp_yr(t)=fp_int(t);
   }
   fp_yr(qq)=endyr+1;

 for(t=styr;t<=endyr;t++){
     for(d=1;d<=fp;d++){
         if(t>=fp_yr(d) && t<fp_yr(d+1)){
          F(t)=mfexp(e_F(d));
          FM(t)=F(t);
         }
      }
  }

FUNCTION calc_FA_vector
  for(t=1;t<=fap;t++){
    fap_yr(t)=fap_int(t);
   }
    fap_yr(ss)=endyr+1;

 for(t=styr;t<=endyr;t++){
   for(d=1;d<=fap;d++){
     if(t>=fap_yr(d) && t<fap_yr(d+1)){
       FA(t)=mfexp(e_FA(d));
       FT(t)=FA(t);
      }
    }
  }

FUNCTION calc_fish_surv
  for (t=styr;t<=endyr;t++){
     S_fish(t)=mfexp(-1*(F(t)+h*FA(t)+M(t)));
     S(t)=S_fish(t);
   }

FUNCTION calc_s
 cnt=0;
 for(t=styrR;t<=endyrR;t++){
    for(y=styr+cnt;y<=endyr;y++) {
       if(t==y){s(t,y)=1;}
       if(t!=y){s(t,y)=mfexp(-F(y-1)-FA(y-1)-M(y-1));}
      }
      cnt+=1;
   }

FUNCTION calc_u_h
  cnt=0;
  for(t=styrR;t<=endyrR;t++){
    for(y=styr+cnt;y<=endyr;y++) {
       u_h(t,y)=(F(y)/(F(y)+FA(y)+M(y)))*(1-mfexp(-F(y)-FA(y)-M(y)));
      }
      cnt+=1;
   }

FUNCTION calc_u_r
 cnt=0;
 for (t=styrR;t<=endyrR;t++){
    for (y=styr+cnt;y<=endyr;y++) {
       u_r(t,y)=(FA(y)/(F(y)+FA(y)+M(y)))*(1-mfexp(-F(y)-FA(y)-M(y)));
      }
      cnt+=1;
   }

FUNCTION calc_s_prob
 cnt=0;
```

```
 for(t=styrR;t<=endyrR;t++){
    looper=0;
    for(y=styr+cnt;y<=endyr;y++){
        probs=1;
        for(a=y-looper;a<=y;a++){
            probs=probs*s(t,a);
         }
         s_prob(t,y)=probs;
         looper+=1;
     }
     cnt+=1;
   }

FUNCTION calc_exp_prob_h
 cnt=0;
 for(t=styrR;t<=endyrR;t++){
    dodo=0;
    for(y=styr+cnt;y<=endyr;y++){
       exp_prob_h(t,y)=lh*phih*s_prob(t,y)*u_h(t,y);
         dodo+=exp_prob_h(t,y);
      }
    sum_prob_h(t)=dodo;
    cnt+=1;
  }

FUNCTION calc_exp_prob_r
 cnt=0;
 for(t=styrR;t<=endyrR;t++){
    dodo=0;
    for(y=styr+cnt;y<=endyr;y++) {
      exp_prob_r(t,y)=lr*phir*s_prob(t,y)*u_r(t,y);
        dodo+=exp_prob_r(t,y);
      }
    sum_prob_r(t)=dodo;
    cnt+=1;
  }

FUNCTION calc_LL
 cnt=0;
 for(t=styrR;t<=endyrR;t++){
   for(y=styr+cnt;y<=endyr;y++) {
      ll_h(t,y)=0;
      ll_r(t,y)=0;
      if(rh(t,y)!=0){
        ll_h(t,y)=rh(t,y)*log(exp_prob_h(t,y));
       }
      if(rr(t,y)!=0){
        ll_r(t,y)=rr(t,y)*log(exp_prob_r(t,y));
       }
    }
    cnt+=1;
  }
 for (t=styrR;t<=endyrR;t++){
     ll_ns(t)=(N(t)-tags(t))*log(1-(sum_prob_h(t)+sum_prob_r(t)));
   }

FUNCTION evaluate_the_objective_function
 f_tag=0;
 cnt=0;
 for(t=styrR;t<=endyrR;t++){
    for(y=styr+cnt;y<=endyr;y++){
       f_tag+=ll_h(t,y)+ll_r(t,y);
      }
      cnt+=1;
   }

   for(t=styrR;t<=endyrR;t++){
      f_tag+=ll_ns(t);
      }
   f=f_tag*-1.;
```

```
FUNCTION calc_Chisquare
 cnt=0;
 up_count=0;
 for(t=styrR;t<=endyrR;t++){
    for(y=styr+cnt;y<=endyr;y++){
       up_count+=1;
      }
      cnt+=1;
   }

 cnt=0;
 for(t=styrR;t<=endyrR;t++) {
    for(y=styr+cnt;y<=endyr;y++) {
       exp_r_r(t,y)=exp_prob_r(t,y)*N(t);
       exp_r_h(t,y)=exp_prob_h(t,y)*N(t);
      }
    cnt+=1;
   }

  cnt=0;
  for(t=styrR;t<=endyrR;t++) {
    for(y=styr+cnt;y<=endyr;y++){
        chi_r(t,y)=square(rr(t,y)-exp_r_r(t,y))/exp_r_r(t,y);
        chi_h(t,y)=square(rh(t,y)-exp_r_h(t,y))/exp_r_h(t,y);
        pear_r(t,y)=(rr(t,y)-exp_r_r(t,y))/sqrt(exp_r_r(t,y));
        pear_h(t,y)=(rh(t,y)-exp_r_h(t,y))/sqrt(exp_r_h(t,y));
      }
      cnt+=1;
    }
  for (t=styrR;t<=endyrR;t++){
        exp_ns(t)=N(t)*(1-(sum_prob_h(t)+sum_prob_r(t)));
   }

  //Not seen chi
  for(t=styrR;t<=endyrR;t++){
      chi_ns(t)=0;
      chi_ns(t)=square((N(t)-tags(t))-exp_ns(t))/exp_ns(t);
      pear_ns(t)=((N(t)-tags(t))-exp_ns(t))/sqrt(exp_ns(t));
   }

 //total chi square
 up_chi=sum(chi_r)+sum(chi_h)+sum(chi_ns);
 K=fap+mp+fp;
 up_df=up_count*2-K;
 up_chat=up_chi/up_df;
 AIC=-1.*2*f_tag+2*K;
 AICc=AIC+(2*K*(K+1))/(sum(N)-K-1);

FUNCTION calc_pooled_cells
// Pool harvested cells
  cnt=0;
  for(t=styrR;t<=endyrR;t++){
     for(y=styr+cnt;y<=endyr;y++) {
       pool_h_e(t,y)=0;
       pool_h(t,y)=0;
       pool_h_e(t,y)=exp_r_h(t,y);
       pool_h(t,y)=rh(t,y);
       }
      cnt+=1;
   }
  cnt=0;
  hless=0;
  for(t=styrR;t<=endyrR;t++){
    for(y=endyr;y>=styr+cnt;y--){
          if(pool_h_e(t,y)>=1){
             pool_h(t,y)=pool_h(t,y);
             pool_h_e(t,y)=pool_h_e(t,y);
            }
          if(pool_h_e(t,y)>=0 && pool_h_e(t,y)<1){
             if(y!=styr+cnt)
               {
```

```
                 hless+=1;
                 pool_h_e(t,y-1)=pool_h_e(t,y-1)+pool_h_e(t,y);
                 pool_h(t,y-1)=pool_h(t,y-1)+pool_h(t,y);
                 pool_h(t,y)=0;
                 pool_h_e(t,y)=0;
                }
                if (y==styr+cnt) break;
             }
          }//for
          cnt+=1;
      }//for

// Pool released cells
  cnt=0;
  for(t=styrR;t<=endyrR;t++){
      for(y=styr+cnt;y<=endyr;y++){
            pool_r_e(t,y)=0;
            pool_r(t,y)=0;
            pool_r_e(t,y)=exp_r_r(t,y);
            pool_r(t,y)=rr(t,y);
        }
      cnt+=1;
   }
  cnt=0;
  rless=0;
  for(t=styrR;t<=endyrR;t++){
    for(y=endyr;y>=styr+cnt;y--){
          if(pool_r_e(t,y)>=1){
             pool_r(t,y)=pool_r(t,y);
             pool_r_e(t,y)=pool_r_e(t,y);
            }
          if(pool_r_e(t,y)>=0 && pool_r_e(t,y)<1){
            if (y!=styr+cnt){
                 rless+=1;
                 pool_r_e(t,y-1)=pool_r_e(t,y-1)+pool_r_e(t,y);
                 pool_r(t,y-1)=pool_r(t,y-1)+pool_r(t,y);
                 pool_r(t,y)=0;
                 pool_r_e(t,y)=0;
                }
                if (y==styr+cnt) break;
             }
          }//for
          cnt+=1;
      }//for
  p_df=up_count*2-hless-rless-K;

 //Pooled Chi-square
  cnt=0;
  for(t=styrR;t<=endyrR;t++) {
    for(y=styr+cnt;y<=endyr;y++) {
        p_chi_h(t,y)=0;
        p_chi_r(t,y)=0;
        if(pool_h_e(t,y)!=0){
          p_chi_h(t,y)=square(pool_h(t,y)-pool_h_e(t,y))/pool_h_e(t,y);
         }
        if(pool_r_e(t,y)!=0){
          p_chi_r(t,y)=square(pool_r(t,y)-pool_r_e(t,y))/pool_r_e(t,y);
         }
      }
      cnt+=1;
   }
  p_chi=sum(p_chi_h)+sum(p_chi_r)+sum(chi_ns);
  p_chat=p_chi/p_df;

REPORT_SECTION
 report<<"Log-L"<<"  "<<"\t"<<"K"<<"\t"<<"AIC"<<"         "<<"AICc"<<"       "<<"Eff. Sample 
Size"<<endl;
 report<<f_tag<<"   "<<"\t"<<K<<"\t"<<AIC<<"\t"<<AICc<<"\t"<<sum(N)<<endl;
 report<<" "<<endl;
 report<<" "<<endl;
 report<<"*******Model Statistics******************"<<endl;
```

```
 report<<"Unpooled Chi-square     "<<"  "<<up_chi<<endl;
 report<<"Upooled df              "<<"  "<<up_df<<endl;
 report<<"Unpooled c-hat          "<<"  "<<up_chat<<endl;
 report<<"Pooled Chi-square       "<<"  "<<p_chi<<endl;
 report<<"Pooled df               "<<"  "<<p_df<<endl;
 report<<"Pooled c-hat            "<<"  "<<p_chat<<endl;
 report <<"****************************************"<<endl;
 report<<"  "<<endl;
 report<<"  "<<endl;
 report << "S for fish" << endl;
 report << S_fish << endl;
 report<<" "<<endl;
 report<<"*******************Observed and Calculated
Data***********************************"<<endl;
 report << "Obs Recoveries of harvest fish "<< endl;
 report<<rh<<endl;
 report <<" "<<endl;
 report << "Obs Recoveries of release fish "<< endl;
 report<<rr<<endl;
 report <<" "<<endl;

 report << "Total Released "<< endl;
 report<<N<<endl;
 report <<" "<<endl;

 report <<"Total Recovered Tags"<<endl;
 report <<tags<<endl;
 report<<" "<<endl;

 report << "s matrix" << endl;
 report <<s<<endl;
 report<<" "<<endl;

 report << "S_prob matrix" << endl;
 report <<s_prob<<endl;
 report<<" "<<endl;

 report << "Exploitation Rate of harvested fish" << endl;
 report <<u_h<<endl;
 report<<" "<<endl;

 report << "Exploitation Rate of released fish" << endl;
 report <<u_r<<endl;
 report<<" "<<endl;

 report <<"Expected Probability of harvested fish"<<endl;
 report<<exp_prob_h<<endl;
 report <<" "<<endl;

 report <<"Expected Probability of released fish"<<endl;
 report<<exp_prob_r<<endl;
 report <<" "<<endl;

 report<<"Not Seen Probability"<<endl;
 report<<1-(sum_prob_h+sum_prob_r)<<endl;
 report<<" "<<endl;

 report <<"Expected Number of harvested fish"<<endl;
 report<<exp_r_h<<endl;
 report <<" "<<endl;

 report <<"Expected Number of released fish"<<endl;
 report<<exp_r_r<<endl;
 report <<" "<<endl;

 report <<"Expected Number of not seen"<<endl;
 report<<exp_ns<<endl;
 report <<" "<<endl;

 report <<"Cell Likelihoods of harvested fish"<<endl;
 report<<ll_h<<endl;
```

```
 report <<" "<<endl;

 report <<"Cell Likelihoods of released fish"<<endl;
 report<<ll_r<<endl;
 report <<" "<<endl;

 report <<"Cell Likelihoods of unseen"<<endl;
 report<<ll_ns<<endl;
 report <<" "<<endl;

 report <<"Unpooled Chi-squares of Harvested Fish"<<endl;
 report<<chi_h<<endl;
 report <<" "<<endl;

 report <<"Unpooled Chi-squares of Released Fish"<<endl;
 report<<chi_r<<endl;
 report <<" "<<endl;

 report <<"Chi-squares of Not Seen"<<endl;
 report<<chi_ns<<endl;
 report <<" "<<endl;

 report <<"Pooled Cells of Harvested Fish"<<endl;
 report<<pool_h<<endl;
 report <<" "<<endl;

 report <<"Pooled Expected Cells of Harvested Fish"<<endl;
 report<<pool_h_e<<endl;
 report <<" "<<endl;

 report <<"Pooled Cells of Released Fish"<<endl;
 report<<pool_r<<endl;
 report <<" "<<endl;
 report <<"Pooled Expected Cells of Harvested Fish"<<endl;
 report<<pool_r_e<<endl;
 report <<" "<<endl;

 report <<"Pooled Chi-squares of Harvested Fish"<<endl;
 report<<p_chi_h<<endl;
 report <<" "<<endl;

 report <<"Pooled Chi-squares of Released Fish"<<endl;
 report<<p_chi_r<<endl;
 report <<" "<<endl;
 report <<"Pearson Residuals for released fish"<<endl;
 report<<pear_r<<endl;
 report <<" "<<endl;

 report <<"Pearson Residuals for harvested fish"<<endl;
 report<<pear_h<<endl;
 report <<" "<<endl;

 report <<"Pearson Residuals for not seen"<<endl;
 report<<pear_ns<<endl;
 report <<" "<<endl;

FINAL_SECTION
 //Ouput F and sd
  ofstream ofs1("F.std");
   d=mp+fp+fap+(endyr-styr+1);
   for(y=styr;y<=endyr;y++){
        d+=1;
       ofs1<<FM(y)<<"\t"<<sigma(d,1)<<endl;
     }
 //Output FA and sd
   ofstream ofs2("FA.std");
   for(y=styr;y<=endyr;y++){
        d+=1;
       ofs2<<FT(y)<<"\t"<<sigma(d,1)<<endl;
     }
```

```
//Output M and Sd
 ofstream ofs3("M.std");
for(y=styr;y<=endyr;y++){
        d+=1;
      ofs3<<NM(y)<<"\t"<<sigma(d,1)<<endl;
    }
```

**Appendix A16. Plots of results from SCATAG model run with total catch lambda weight=50.**

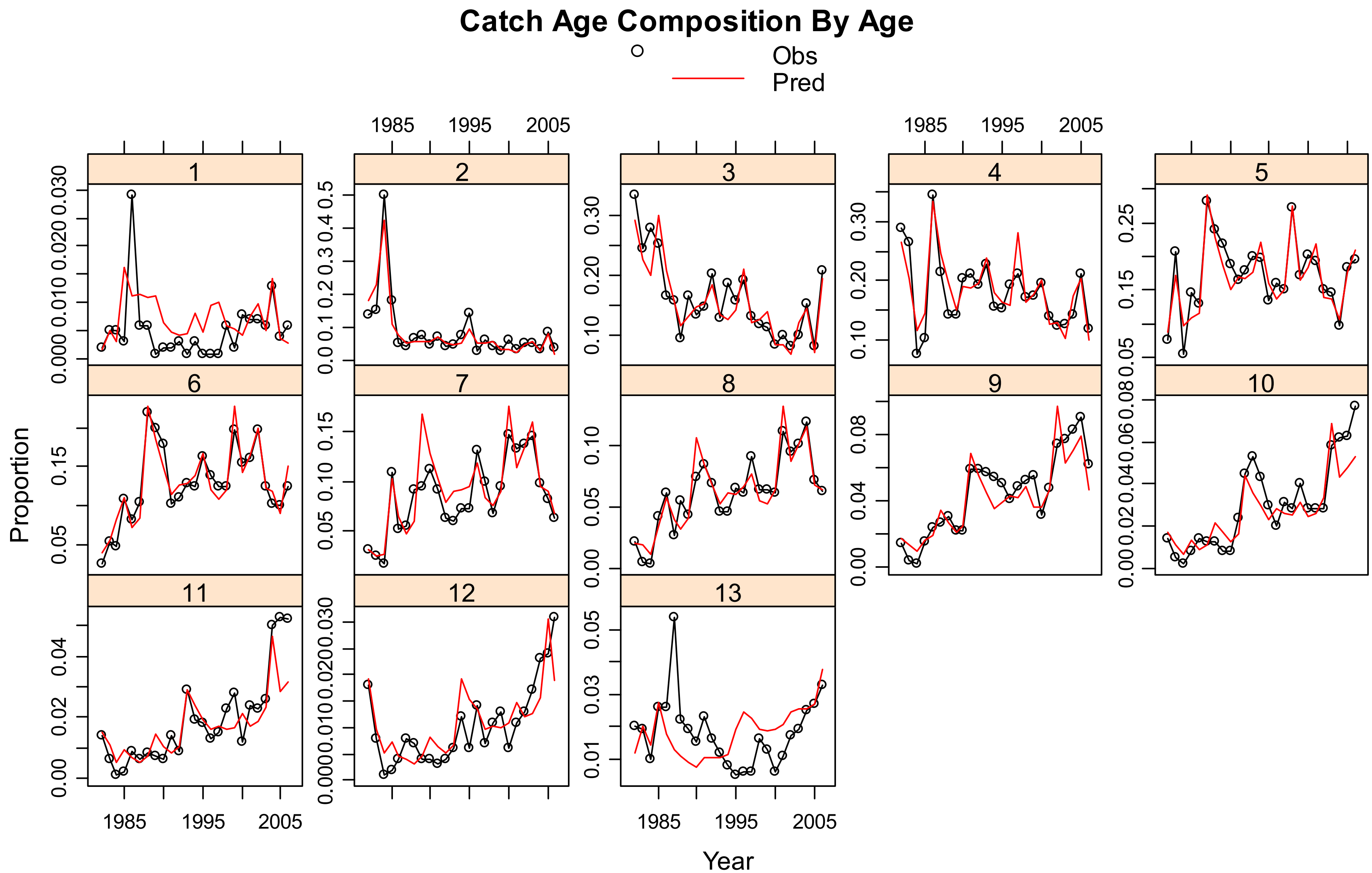



Figure 1. Comparison between observed and predicted annual catch age composition by age

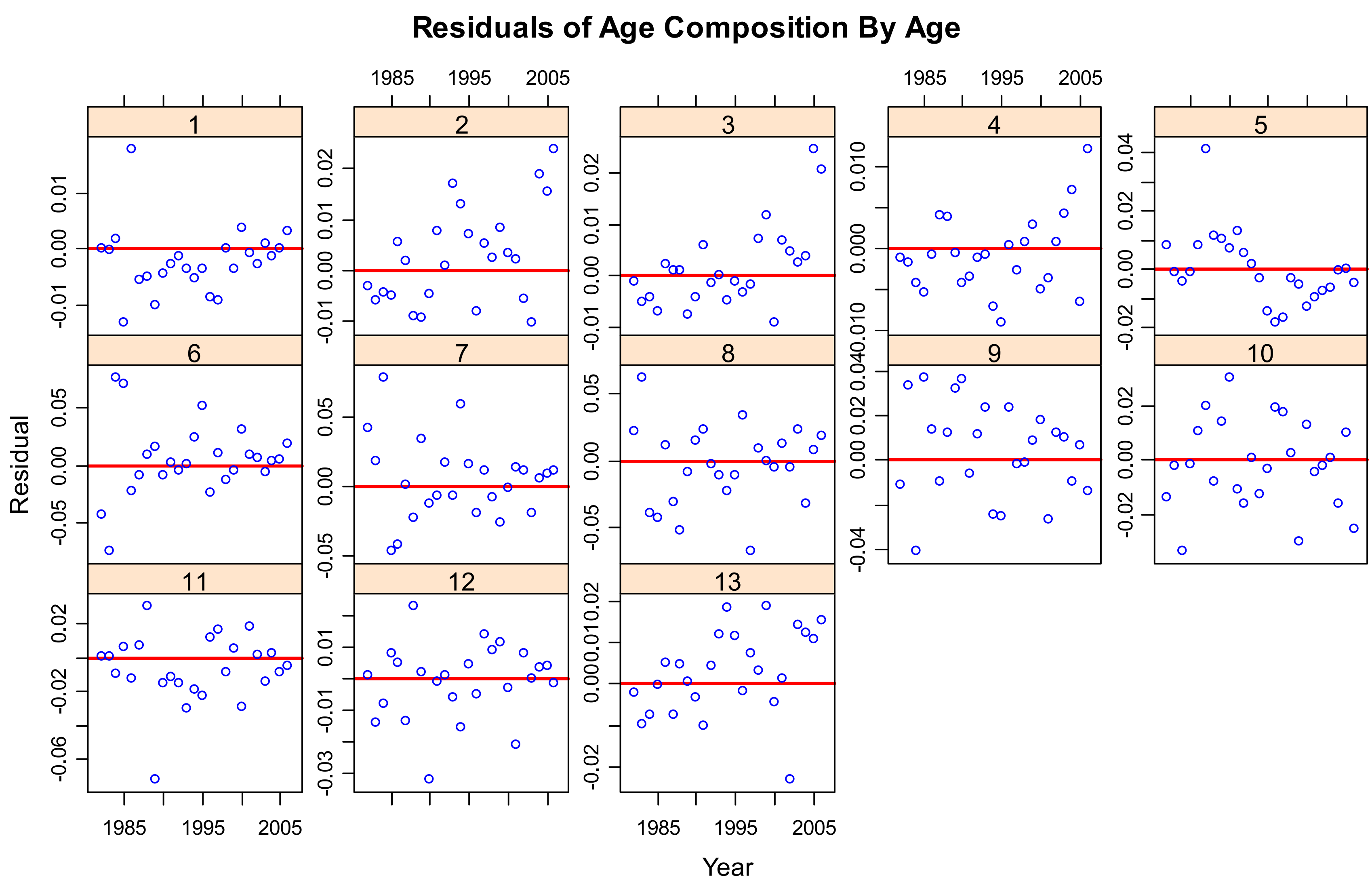



Figure 2. Residuals of annual catch age composition by age.

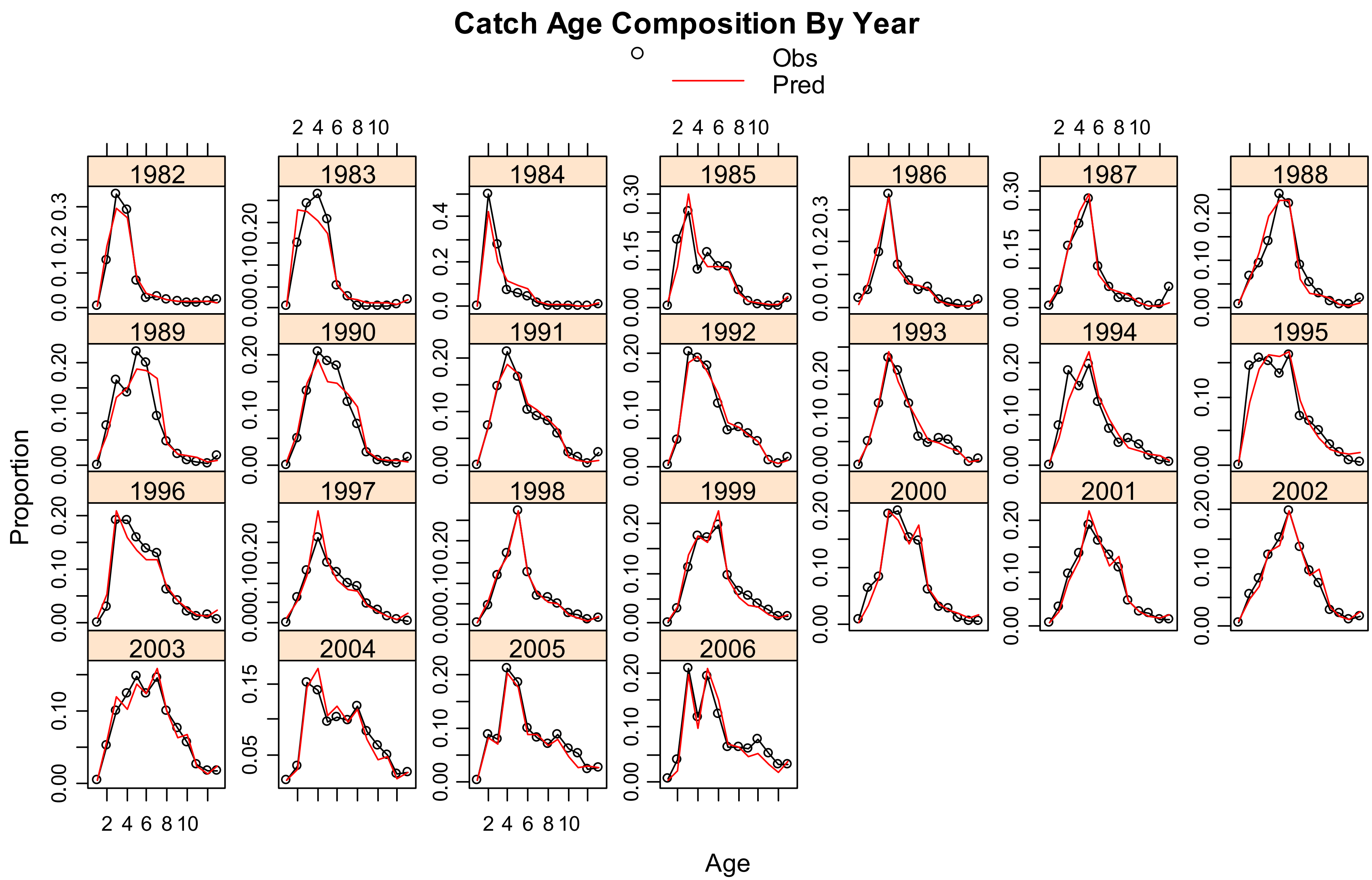



Figure 3. Comparison between observed and predicted catch age composition by year

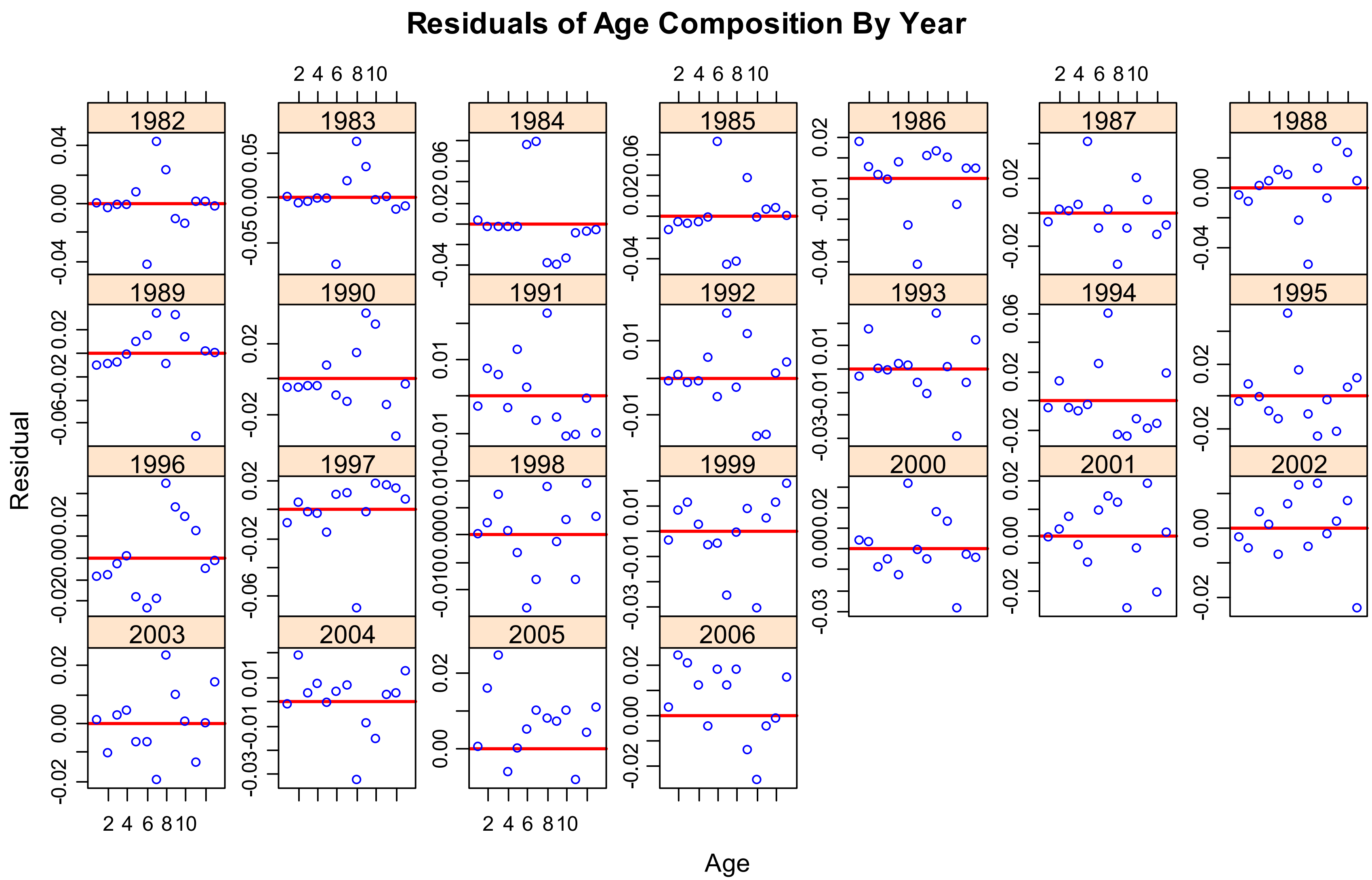



Figure 4. Residuals of annual catch age composition by age

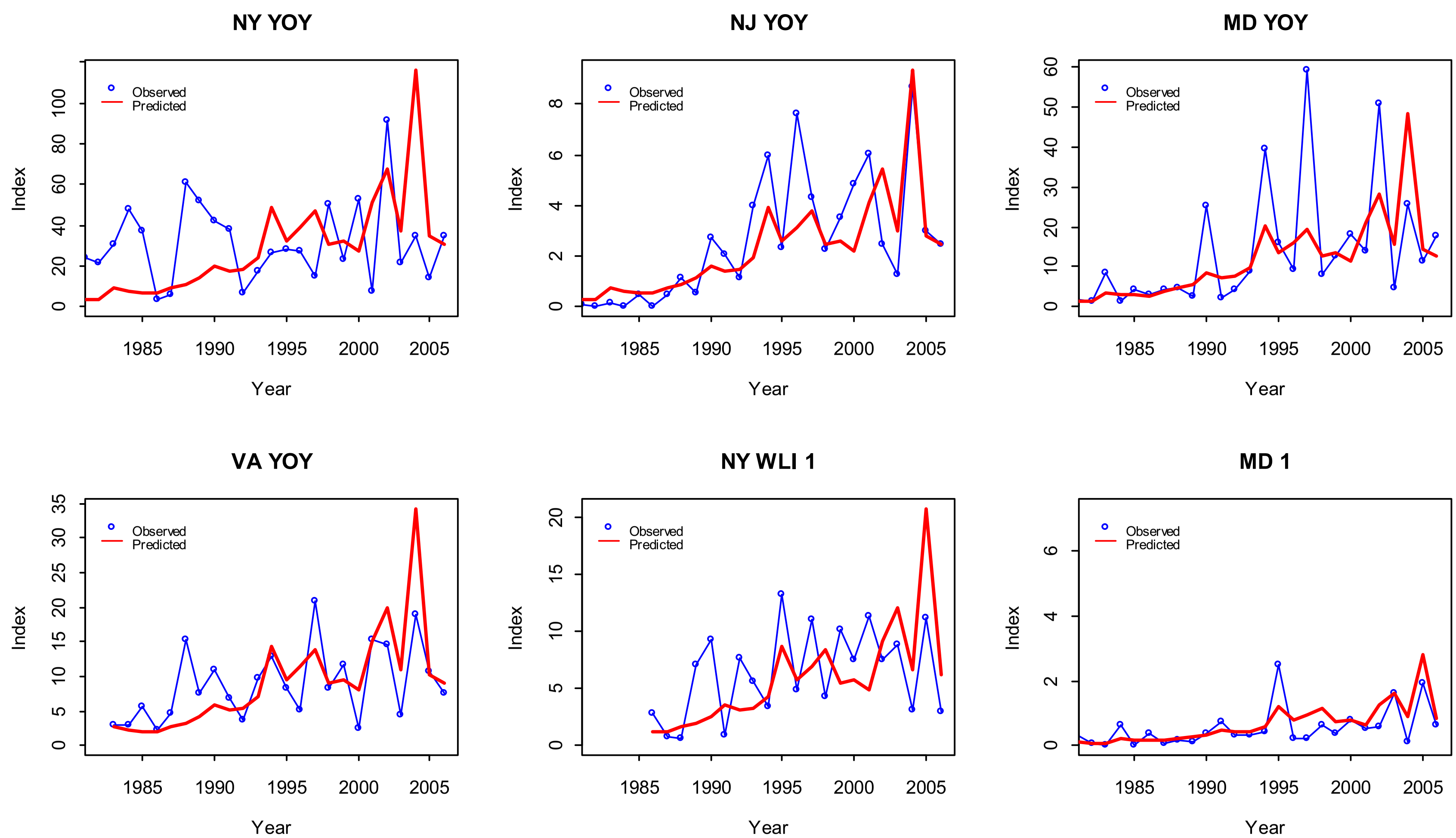



Figure 5. Observed and predicted YOY and Age 1 Indices

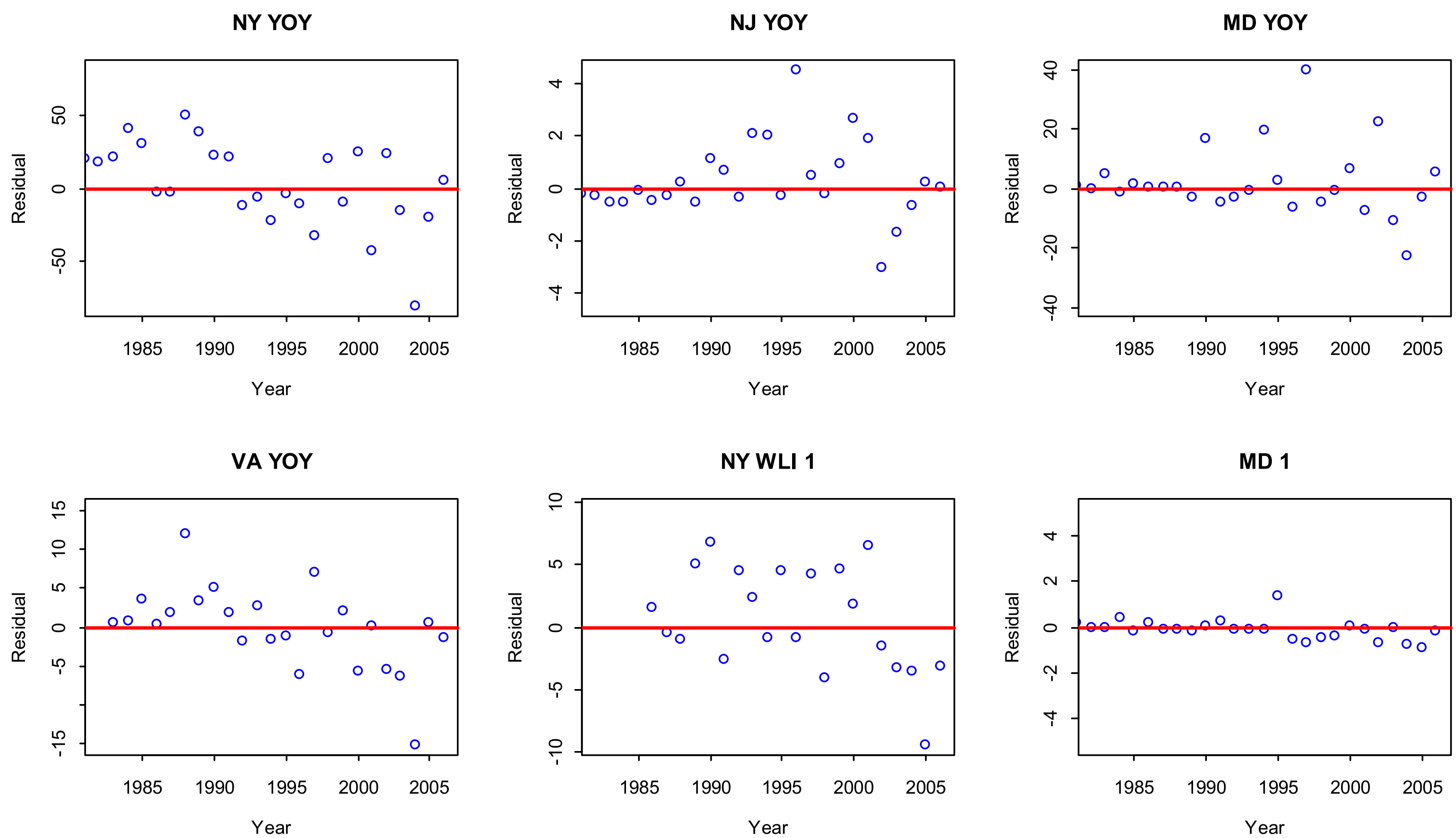



Figure 6. Residuals of YOY and Age 1 Indices

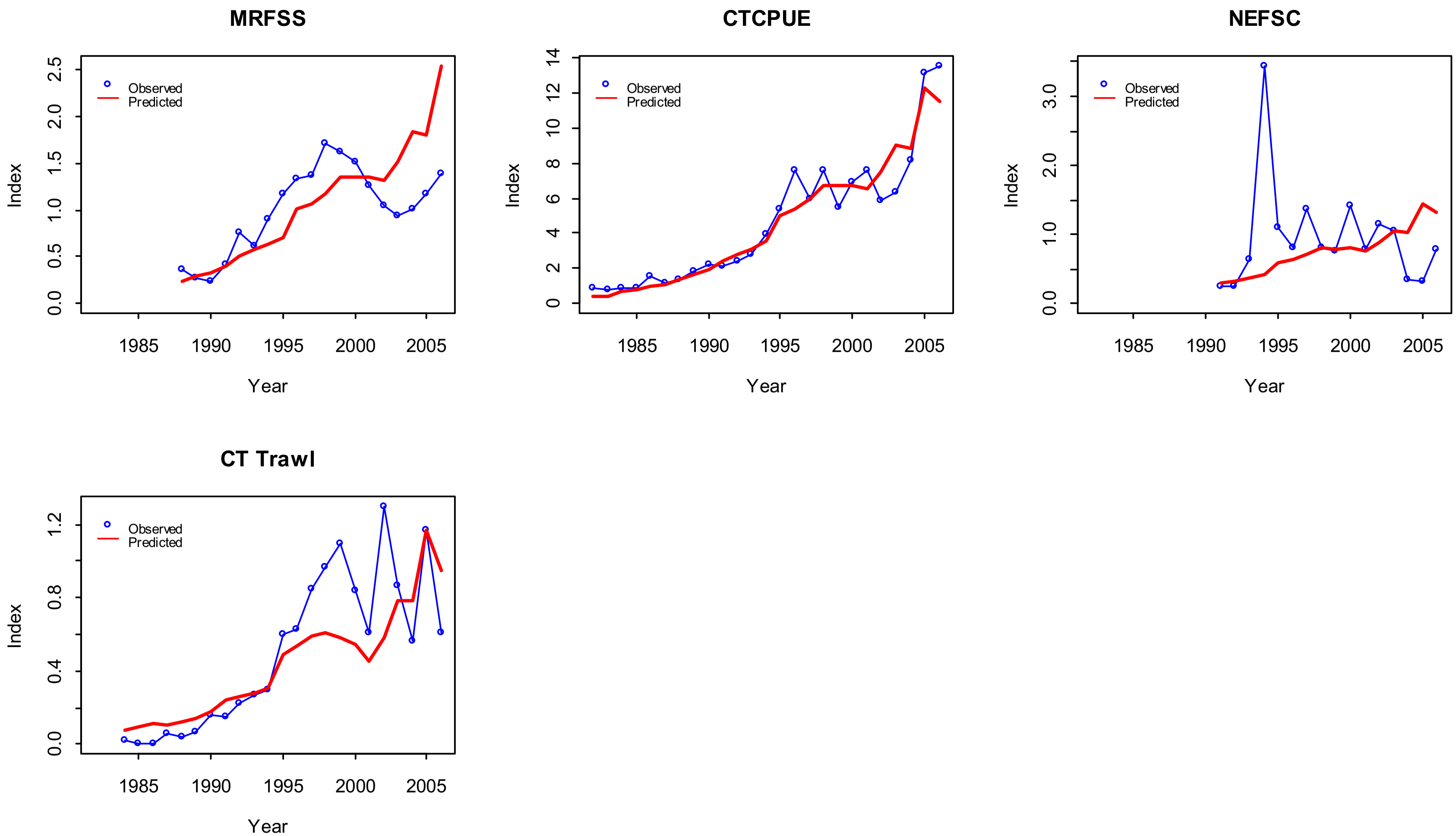



Figure 7. Observed and predicted aggregate indices

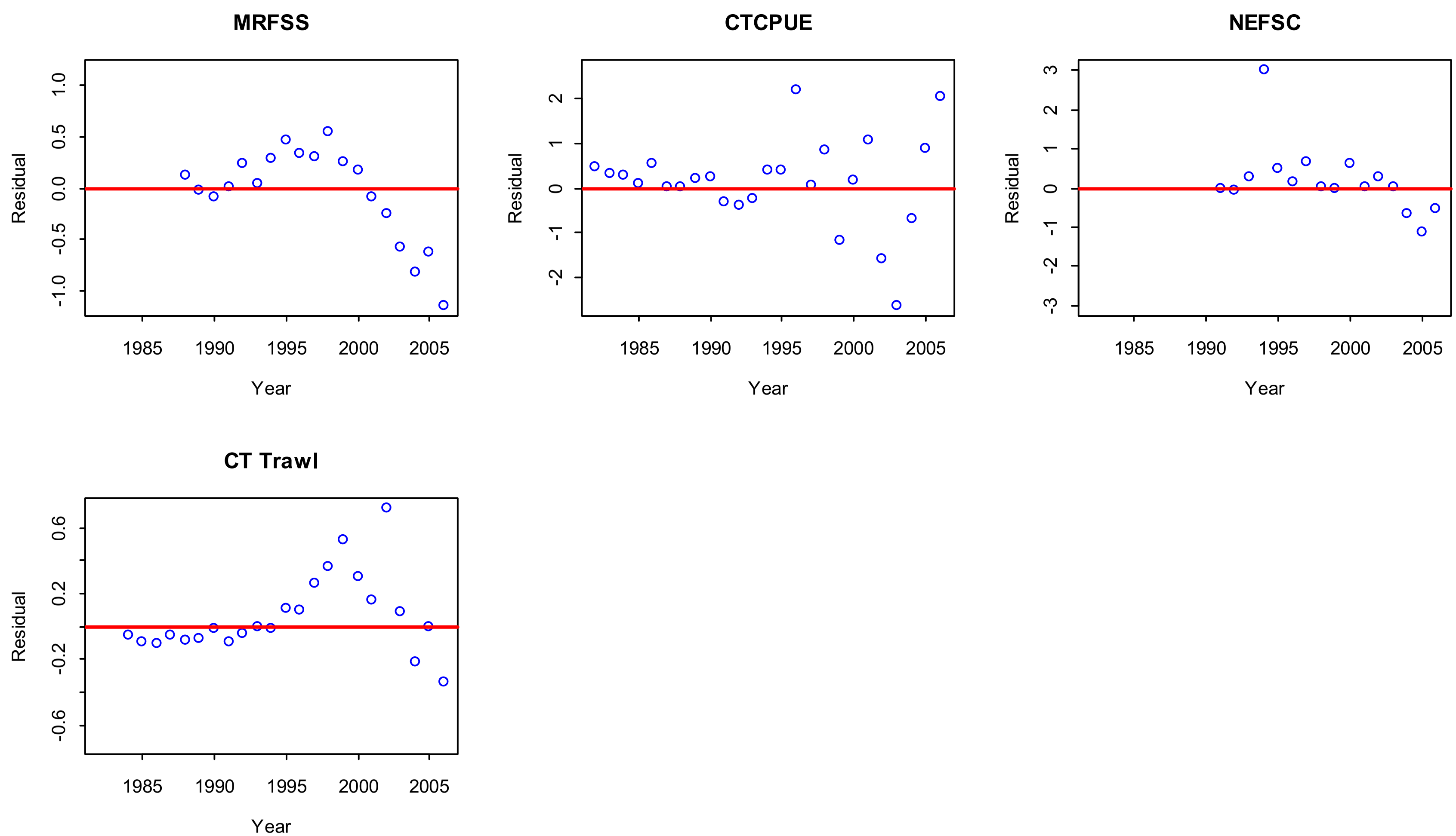



Figure 8. Residuals of aggregates indices

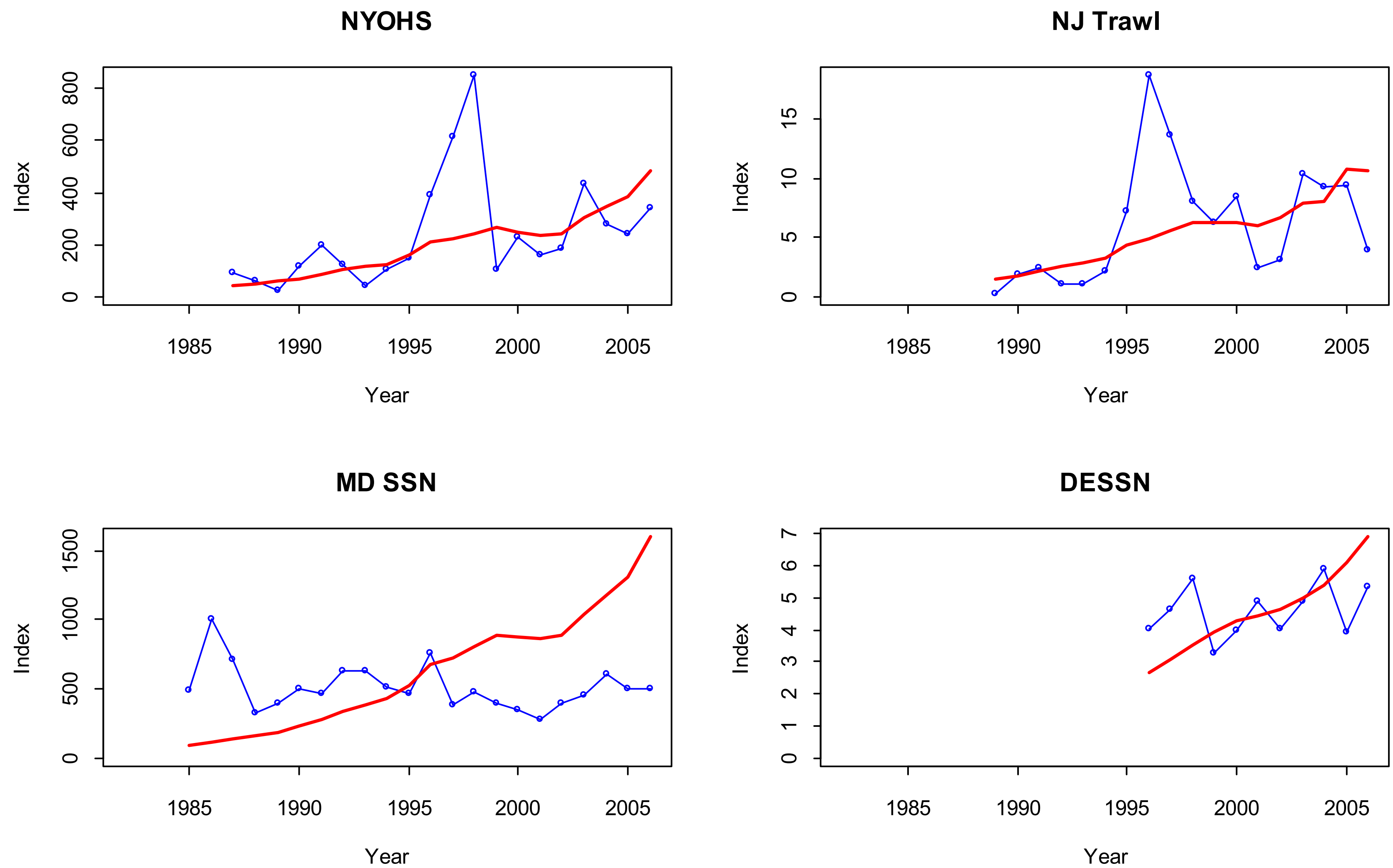



Figure 9. Observed and predicted survey indices with age composition data. Blue=observed, red=predicted

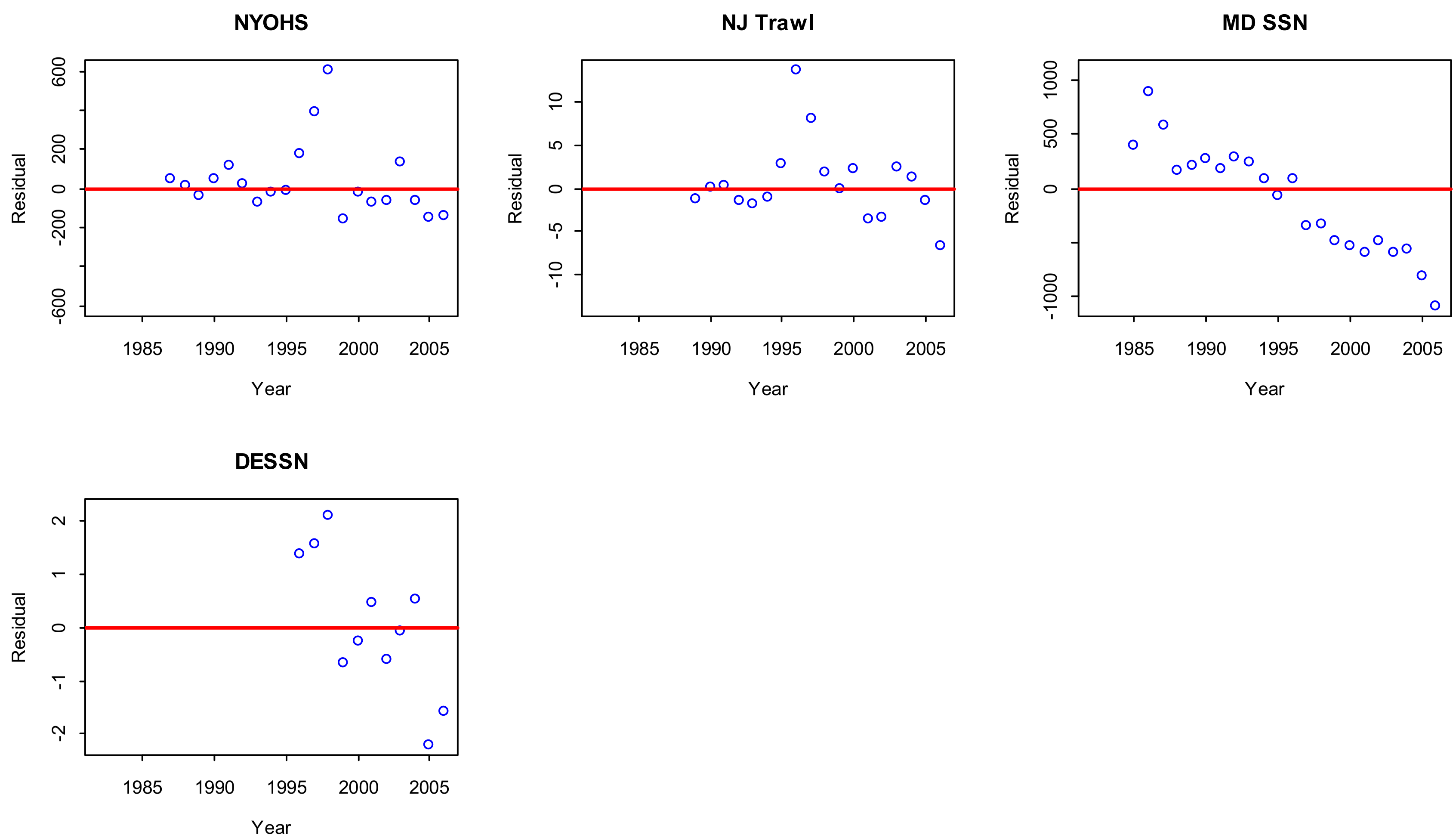



Figure 10. Residuals of survey indices with age composition data

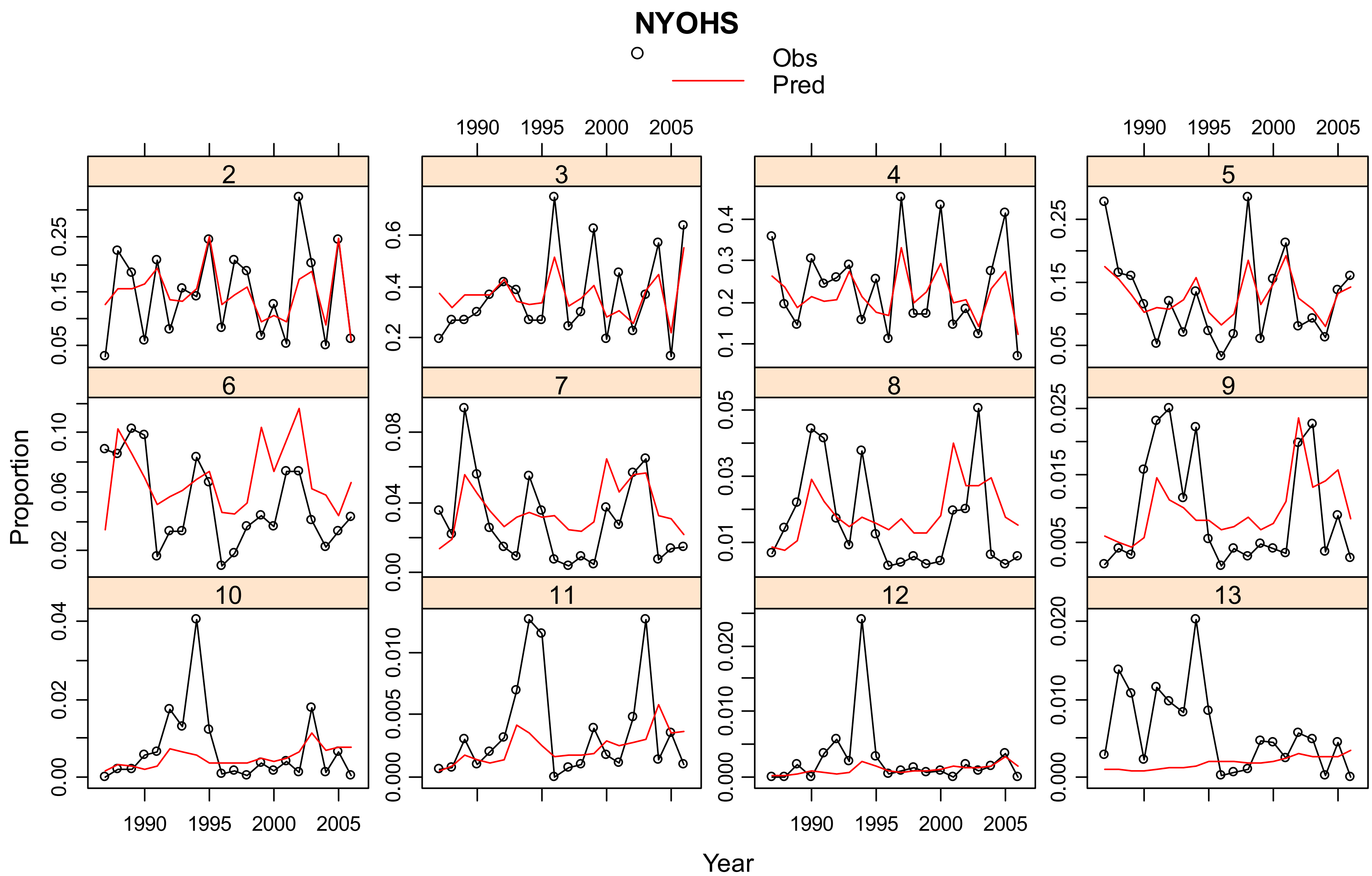



Figure 11. Observed and predicted annual survey age compositions by age for the NY Ocean Haul Seine survey

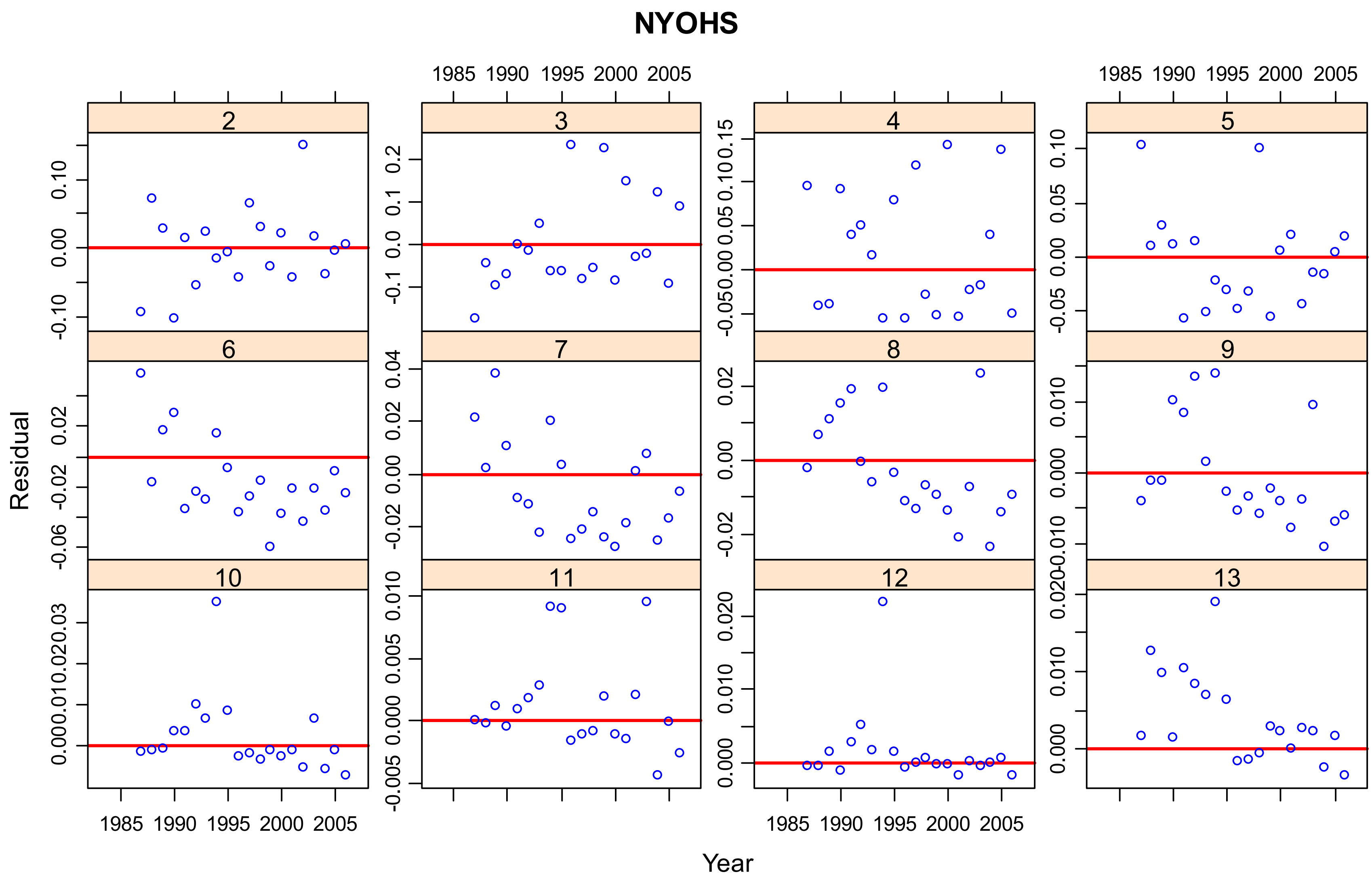



Figure 12. Residuals of annual survey age compositions by age for the NY Ocean Haul Seine survey

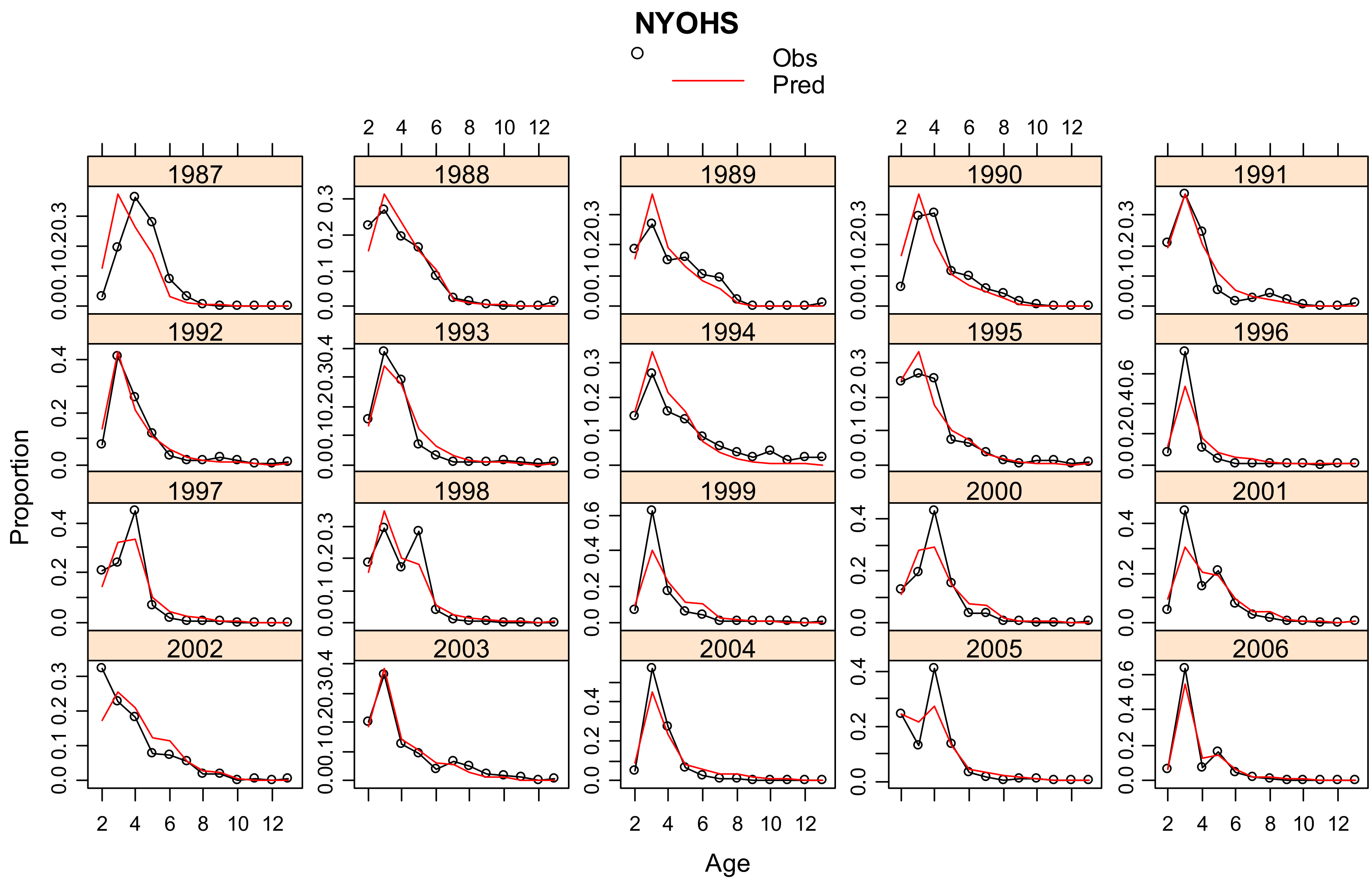



Figure 13. Observed and predicted survey age compositions by year for the NY Ocean Haul Seine survey

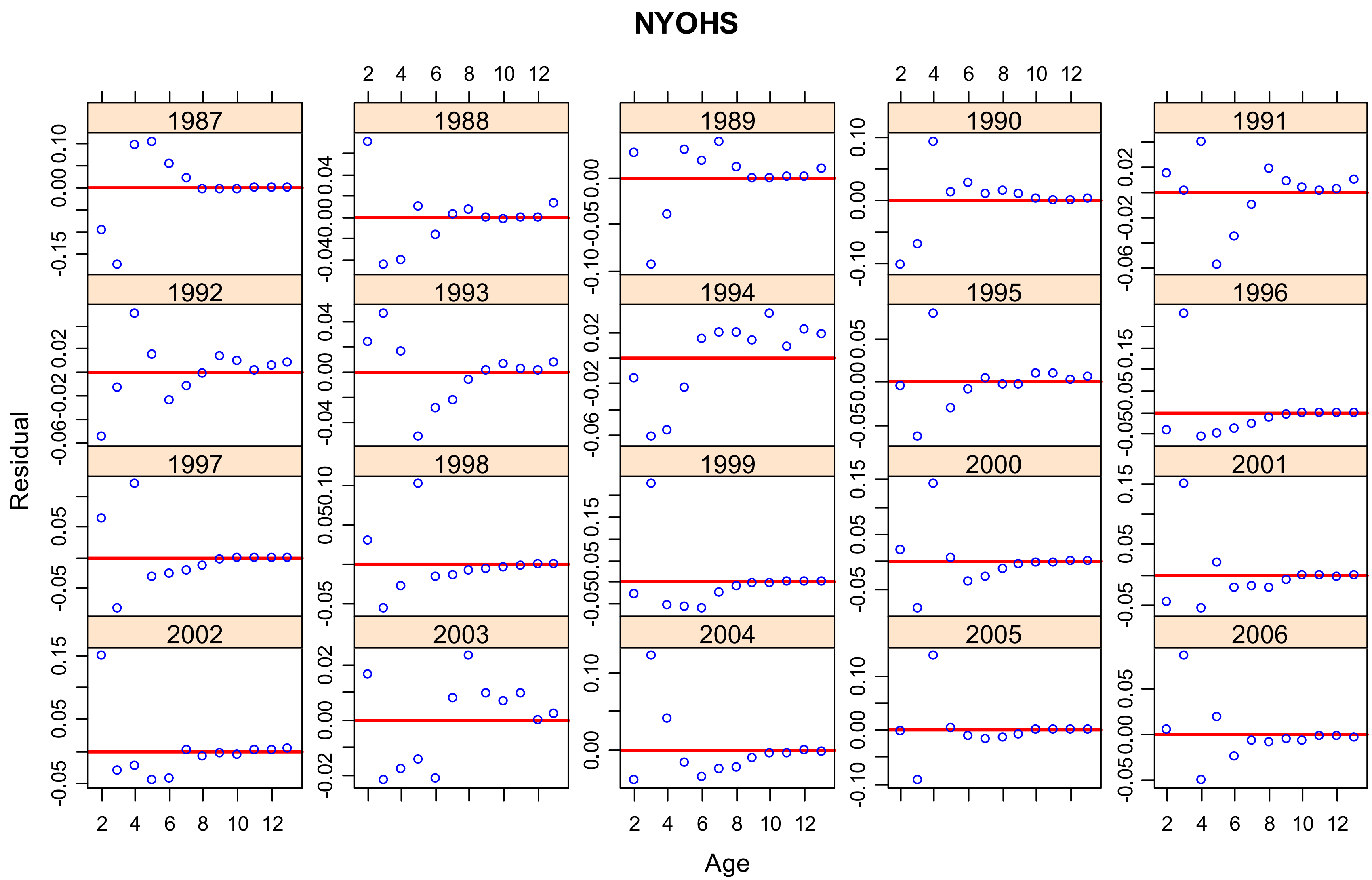



Figure 14. Residuals of survey age compositions by year for the NY Ocean Haul Seine survey

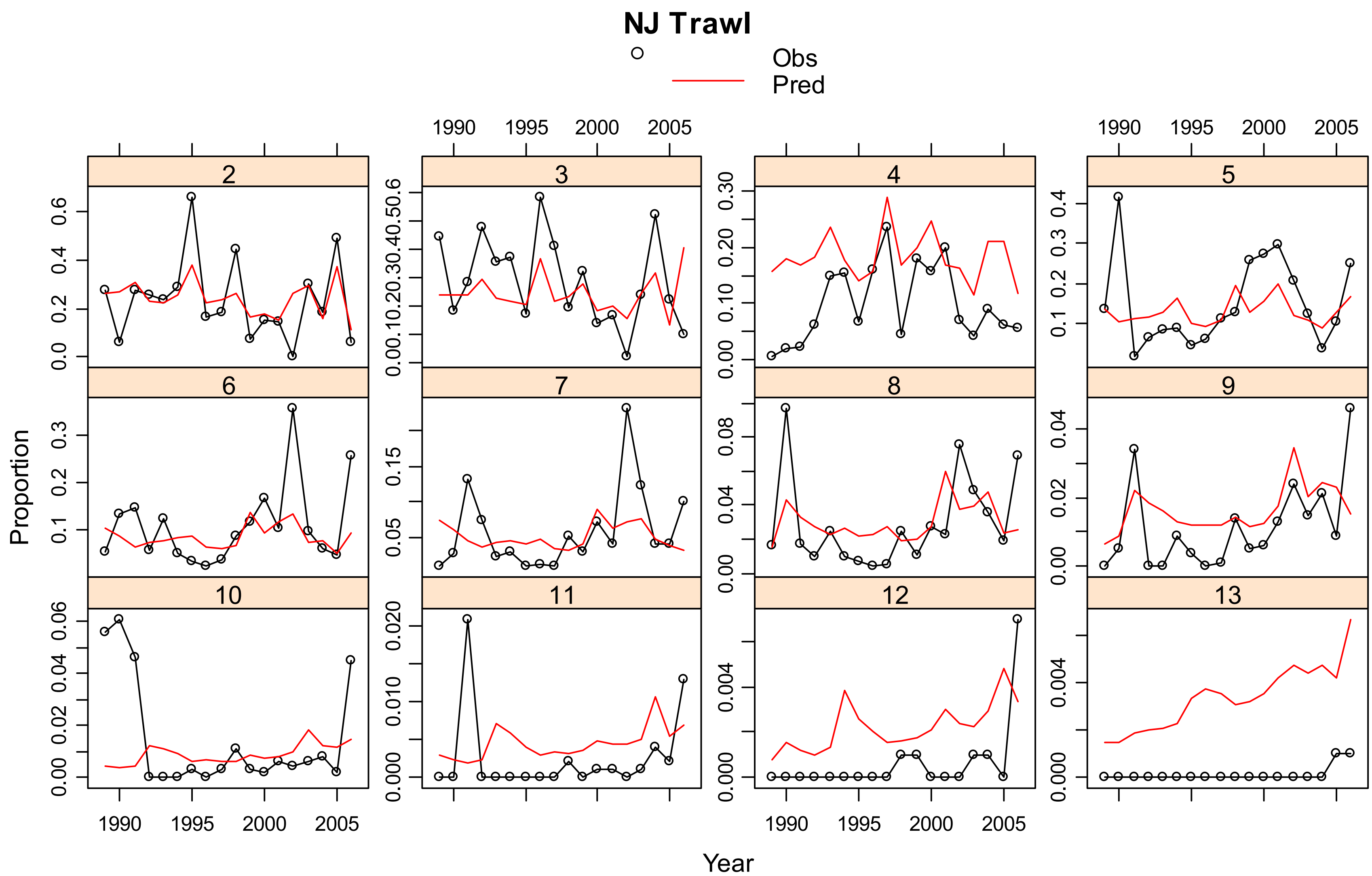



Figure 15. Observed and predicted annual survey age compositions by age for the New Jersey Trawl survey

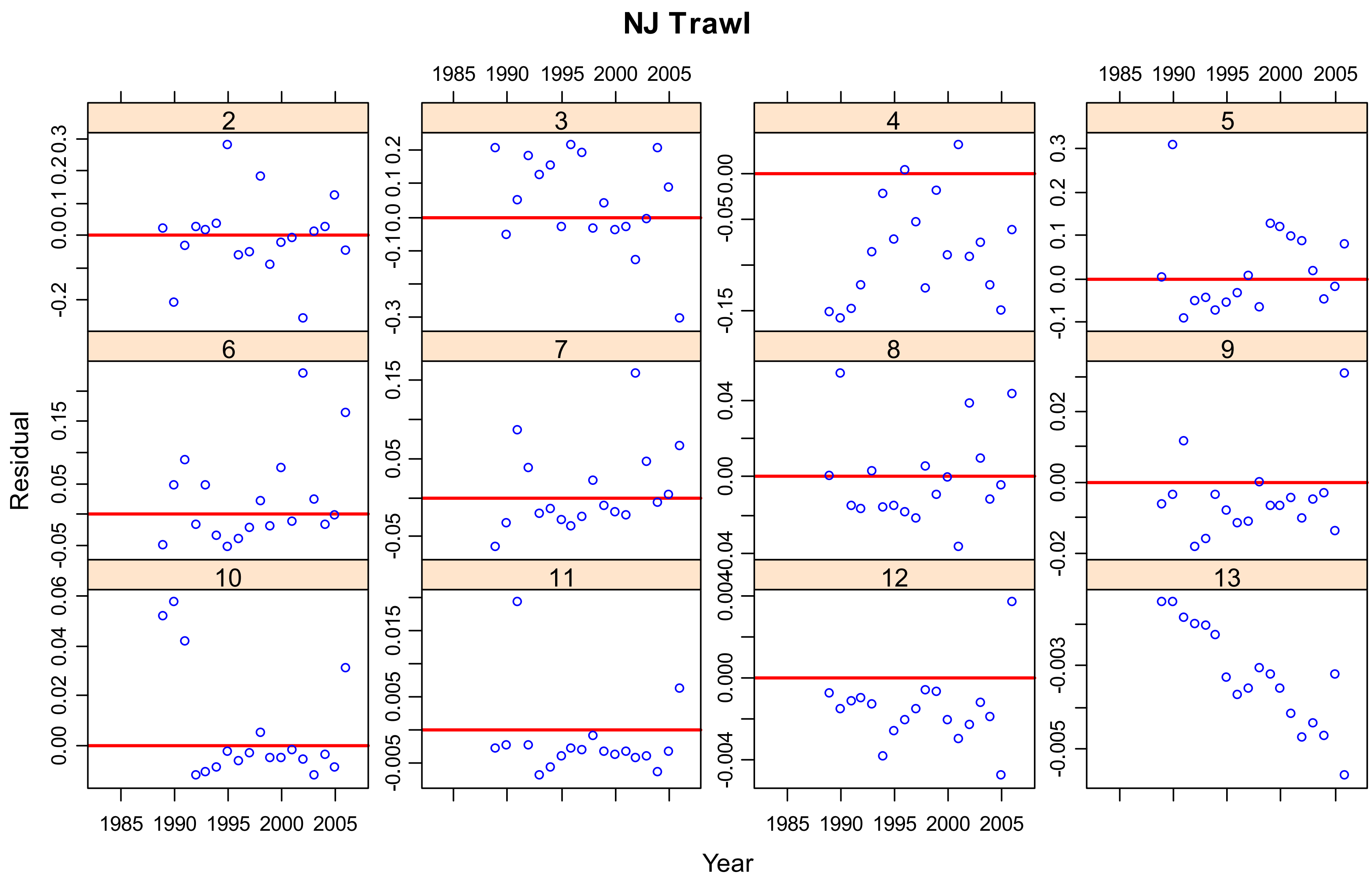



Figure 16. Residuals of annual survey age compositions by age for the New Jersey trawl survey

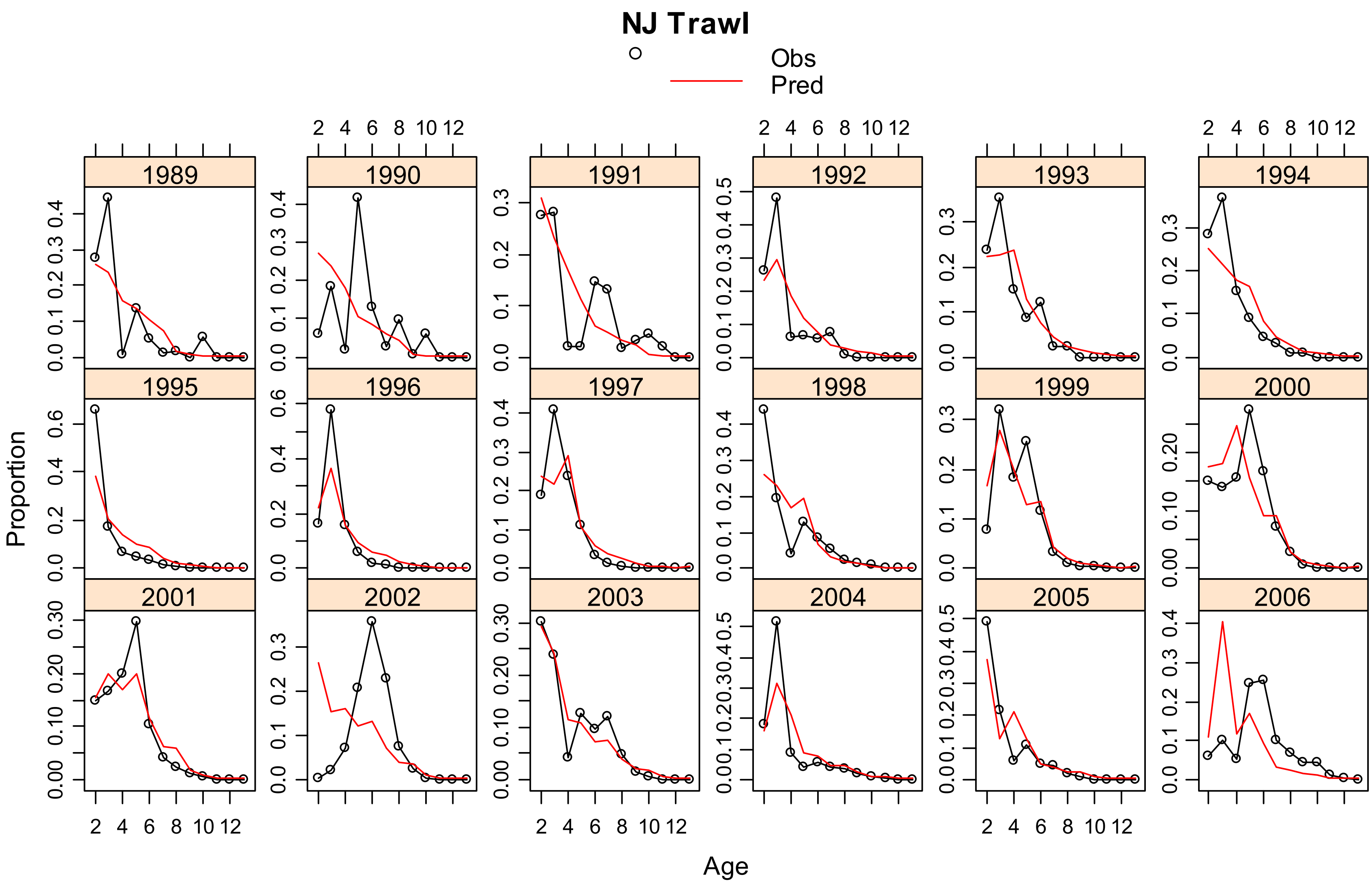



Figure 17. Observed and predicted survey age compositions by year for the New Jersey trawl survey

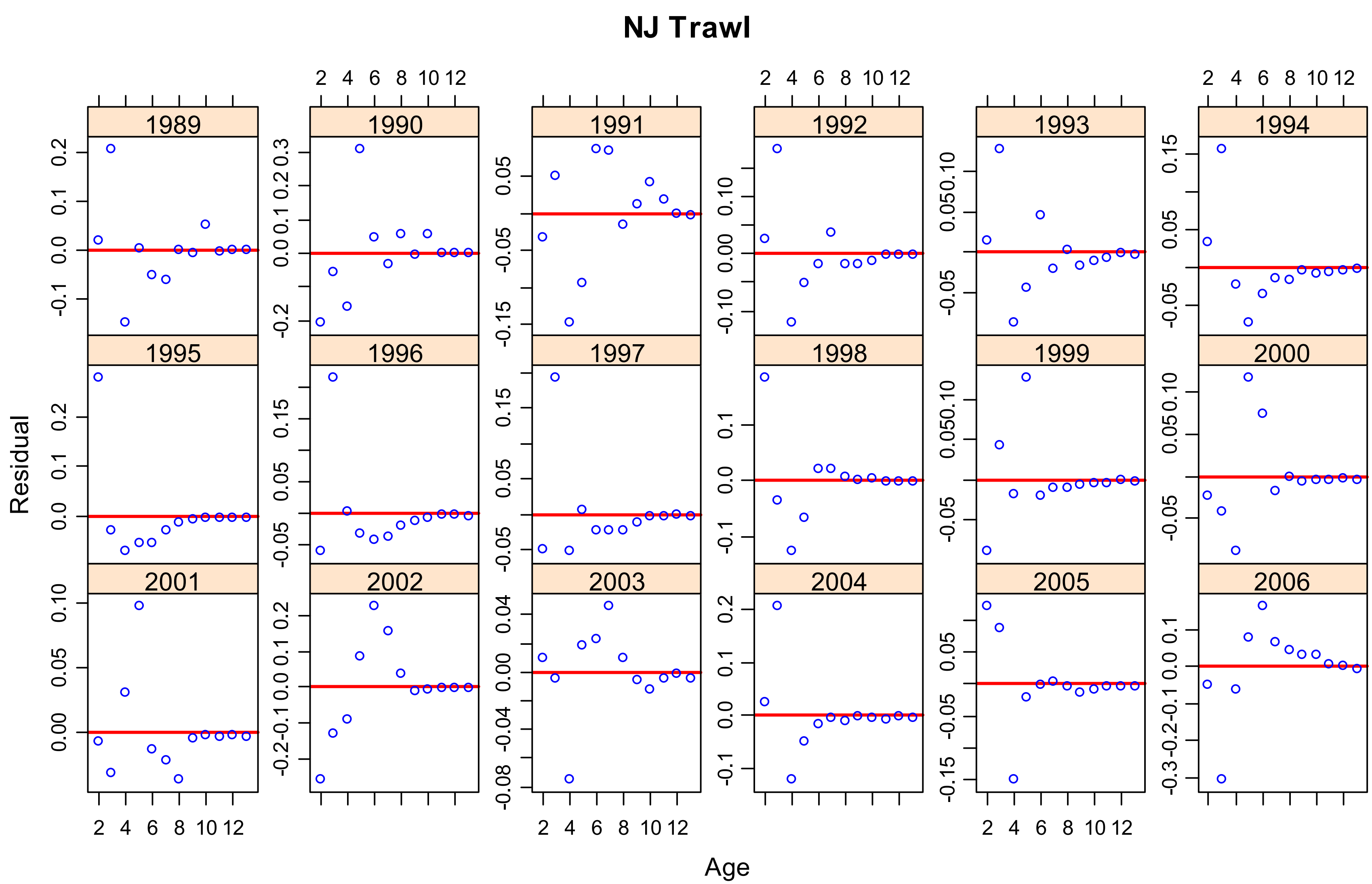



Figure 18. Residuals of survey age compositions by year for the New Jersey trawl survey

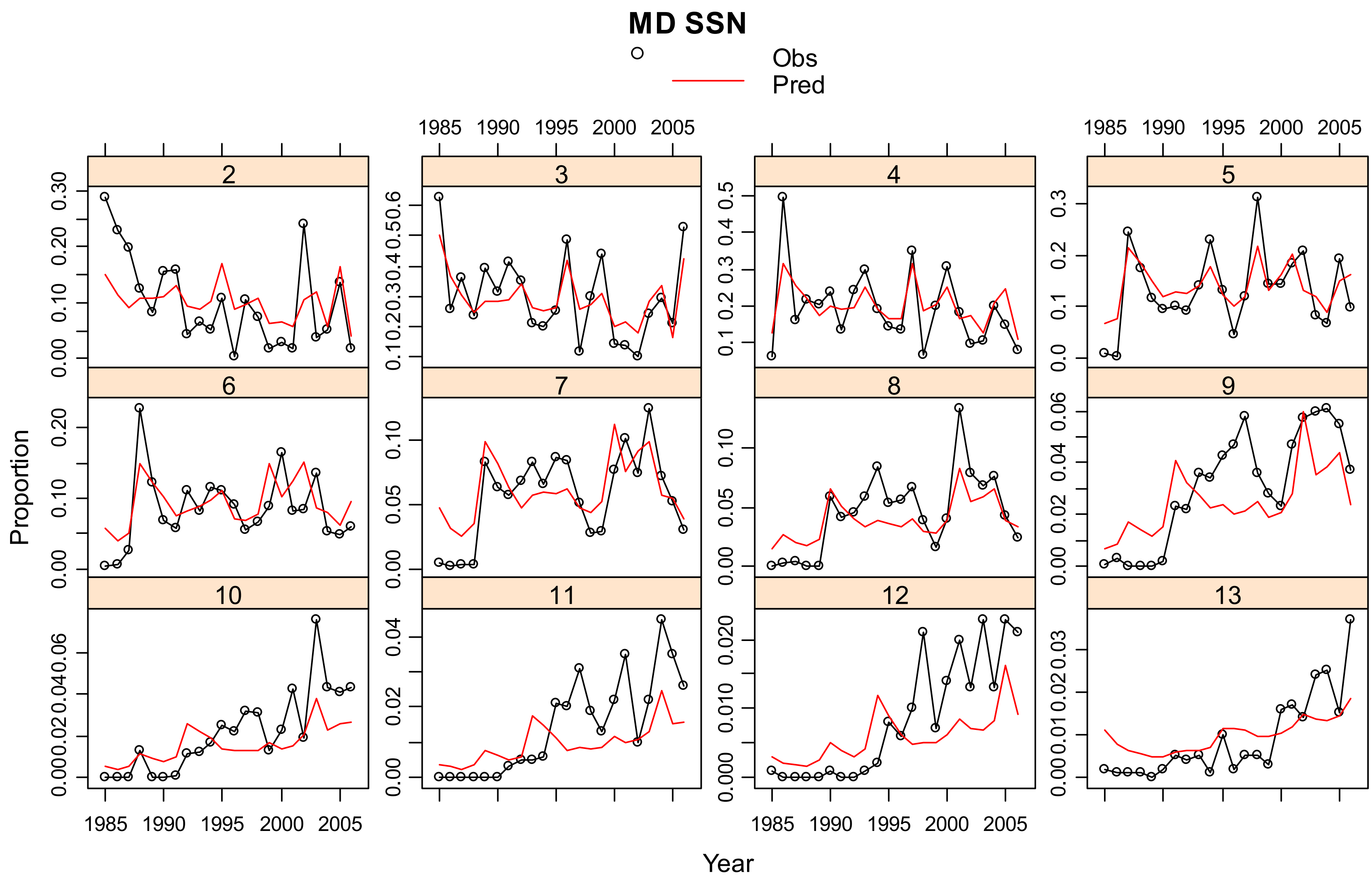



Figure 19. Observed and predicted annual survey age compositions by age for the Maryland gillnet survey

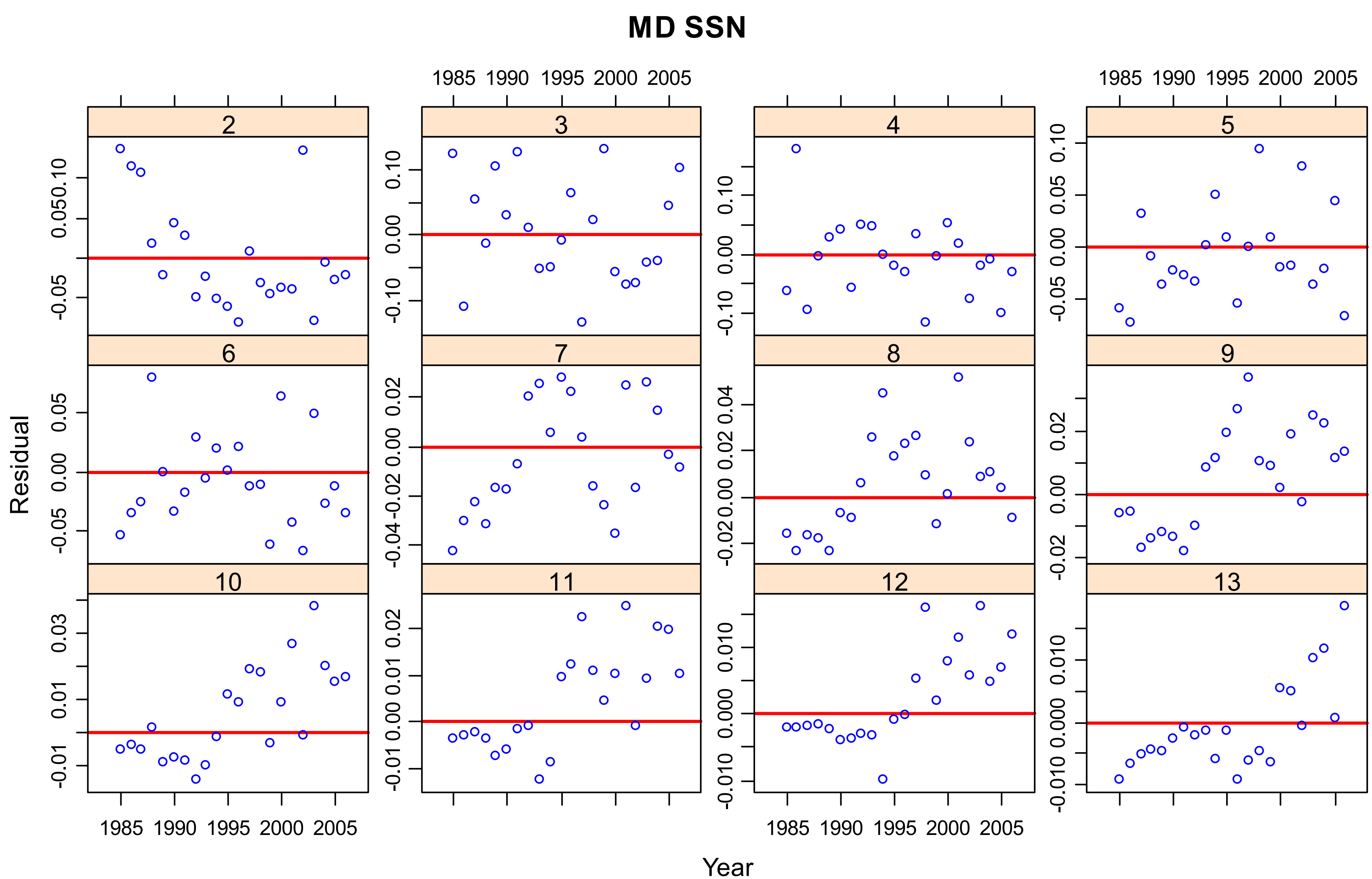



Figure 20. Residuals of annual survey age compositions by age for the Maryland gillnet survey

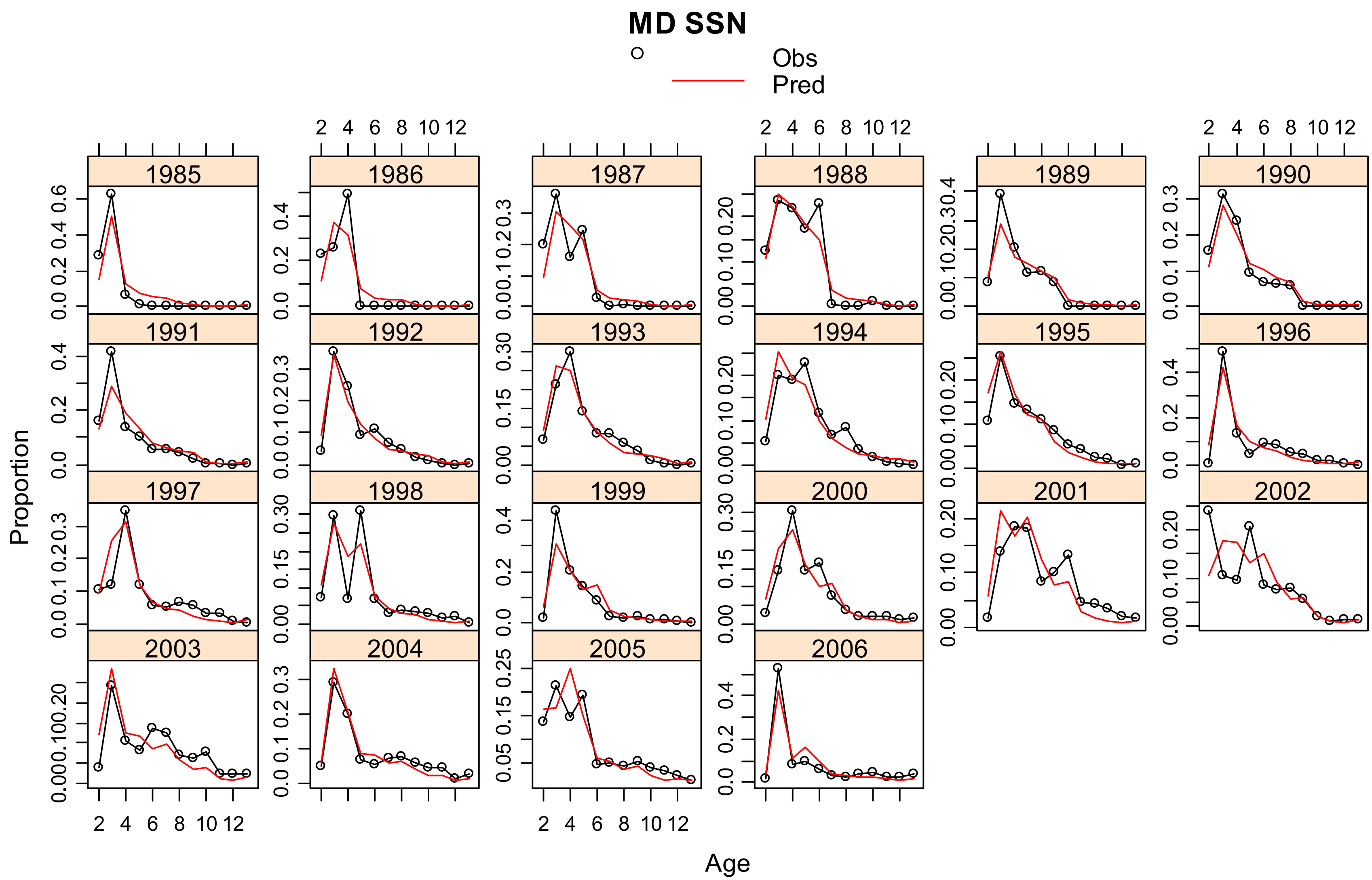



Figure 21. Observed and predicted survey age compositions by year for the Maryland gillnet survey

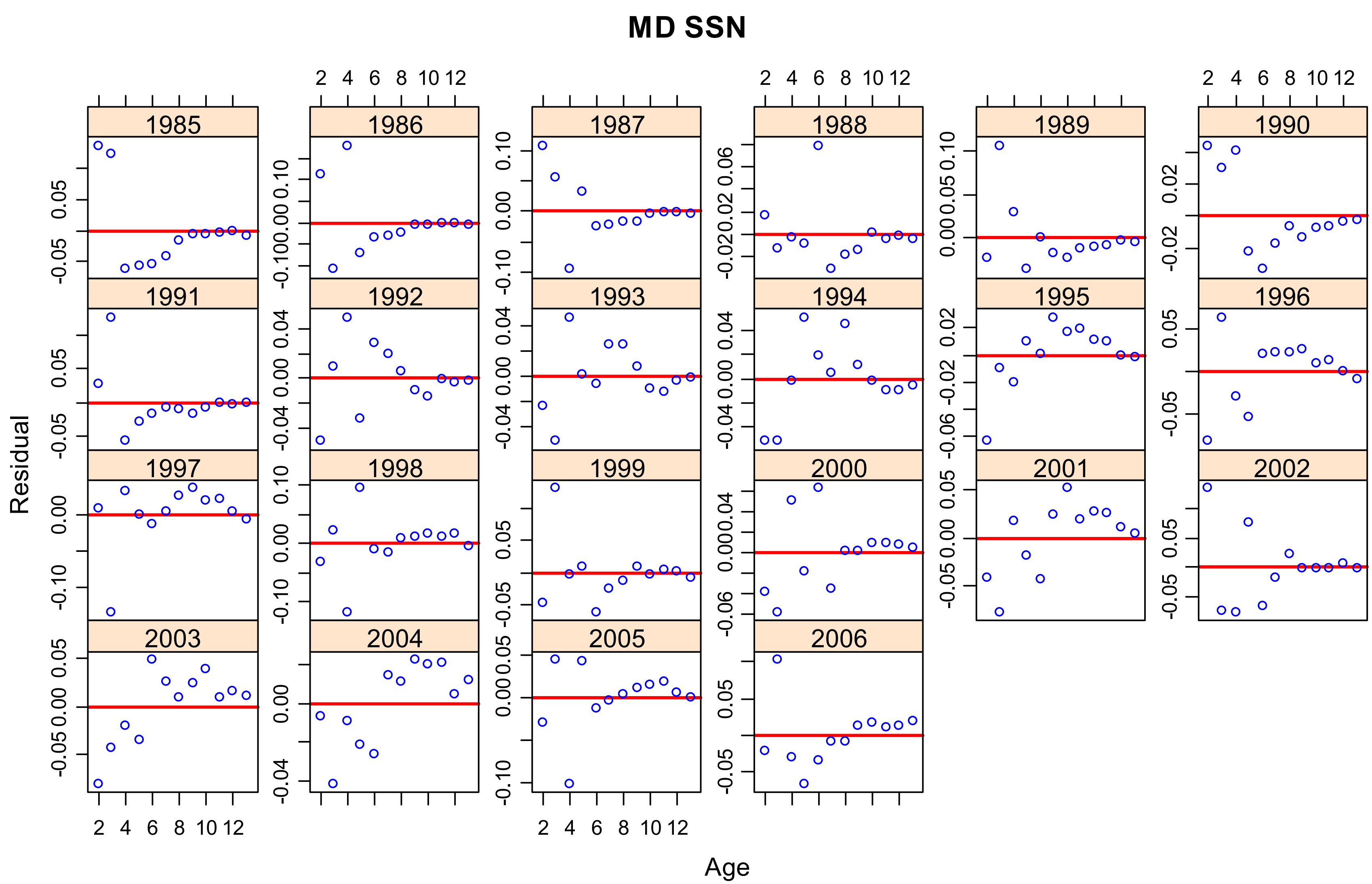



Figure 22. Residuals of survey age compositions by year for the Maryland gillnet survey

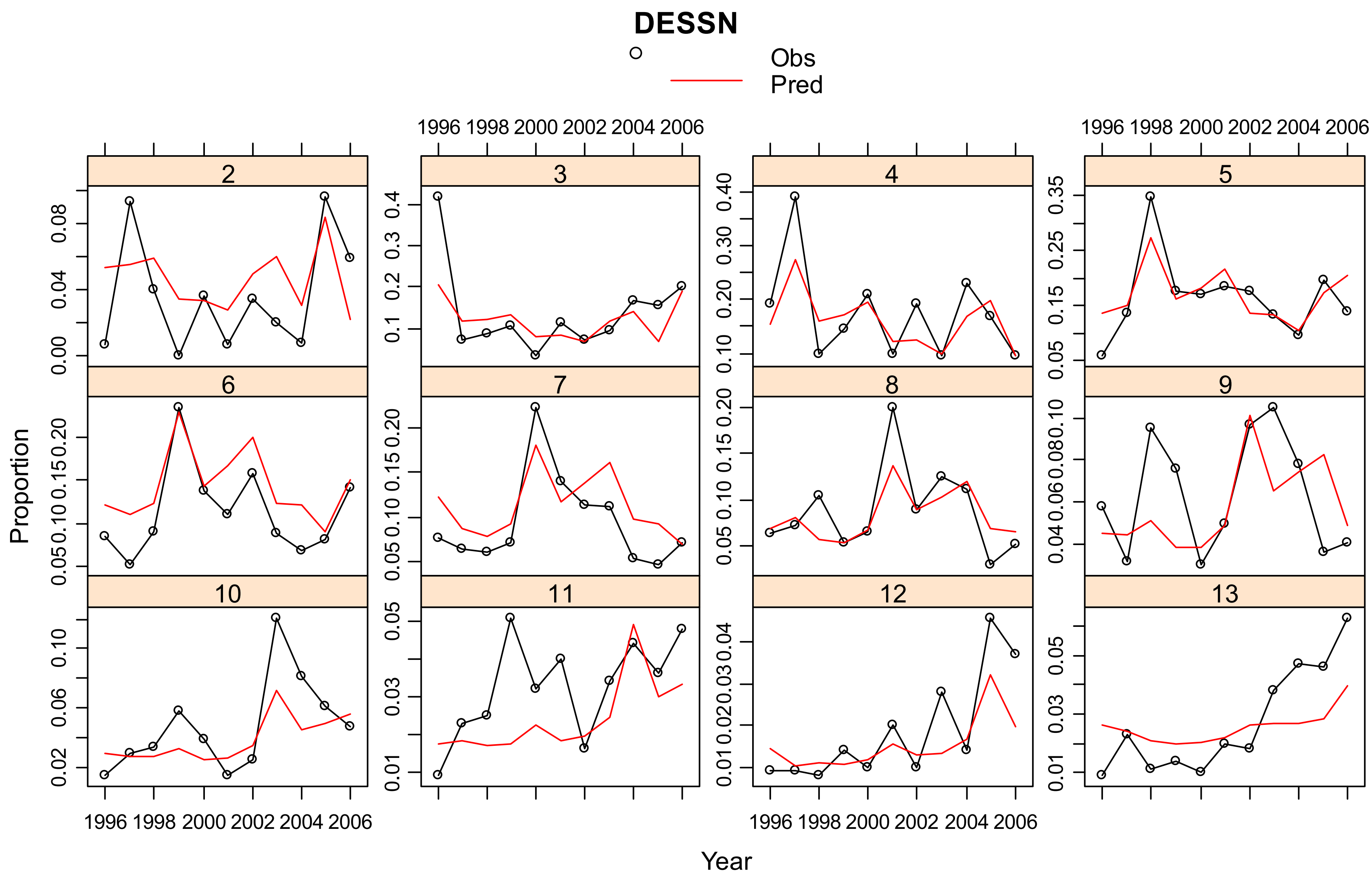



Figure 23. Observed and predicted annual survey age compositions by age for the Delaware electrofishing survey

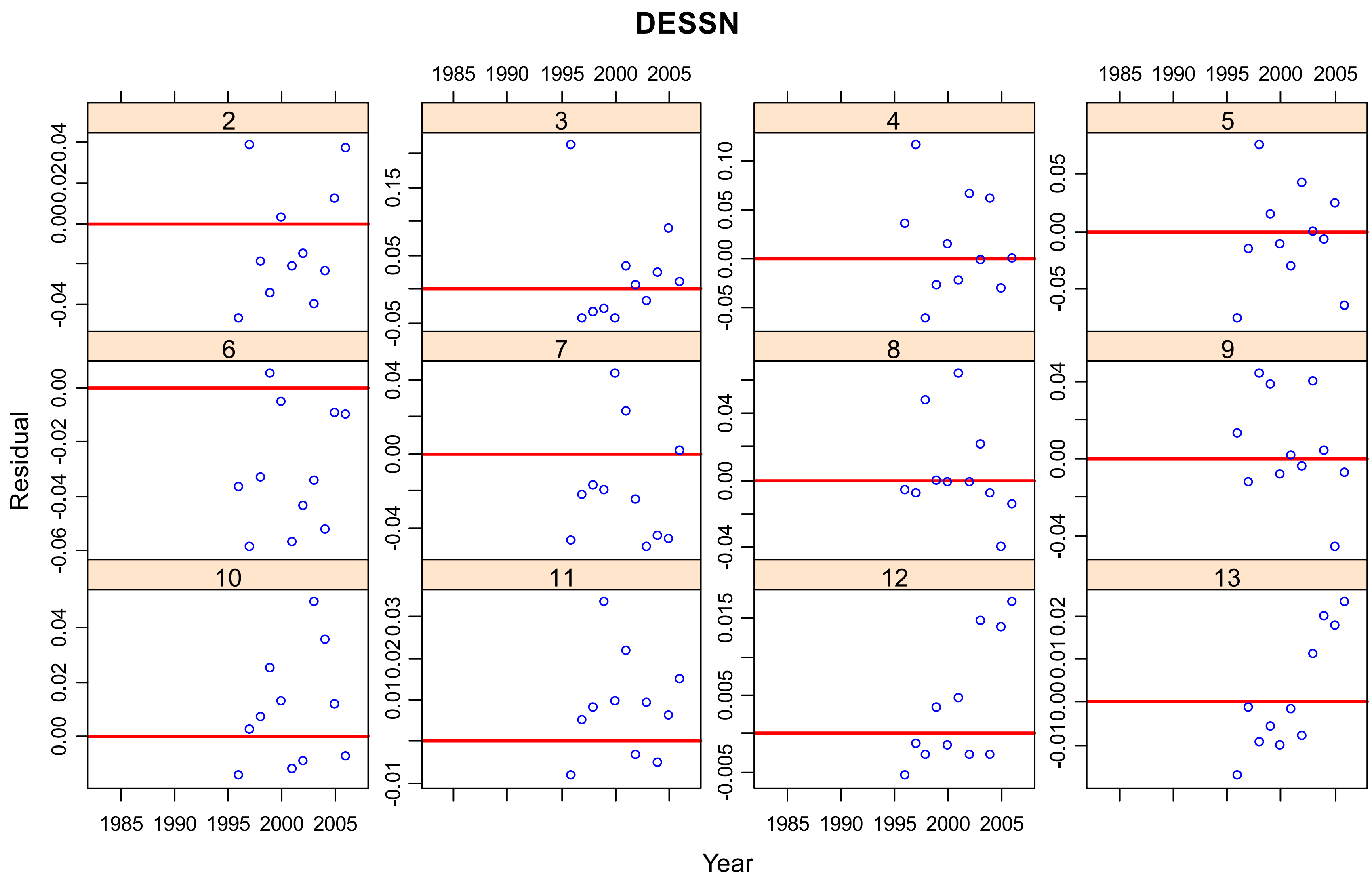



Figure 24. Residuals of annual survey age compositions by age for the Delaware electrofishing survey

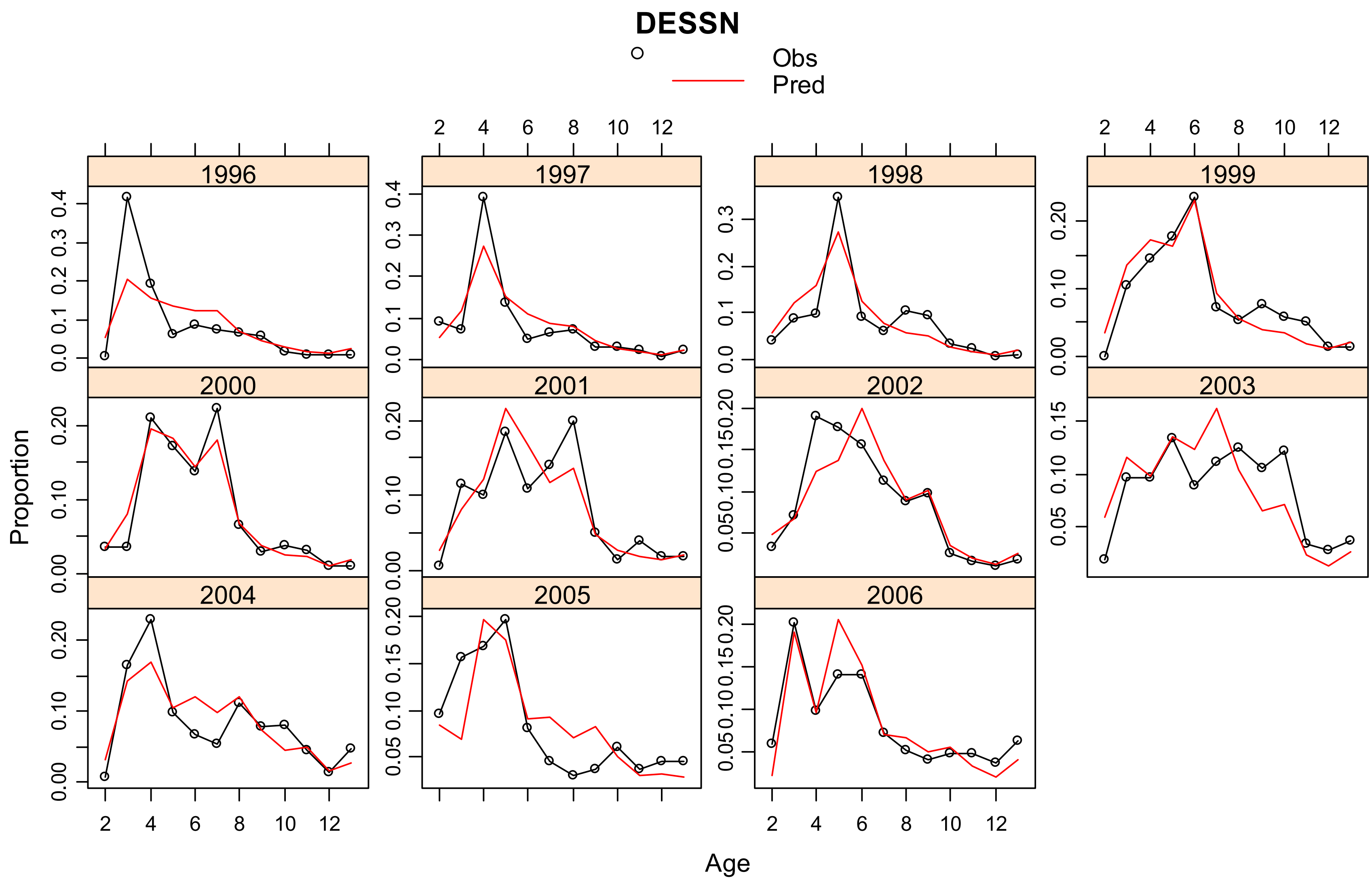



Figure 25. Observed and predicted survey age compositions by year for the Delaware electrofishing survey

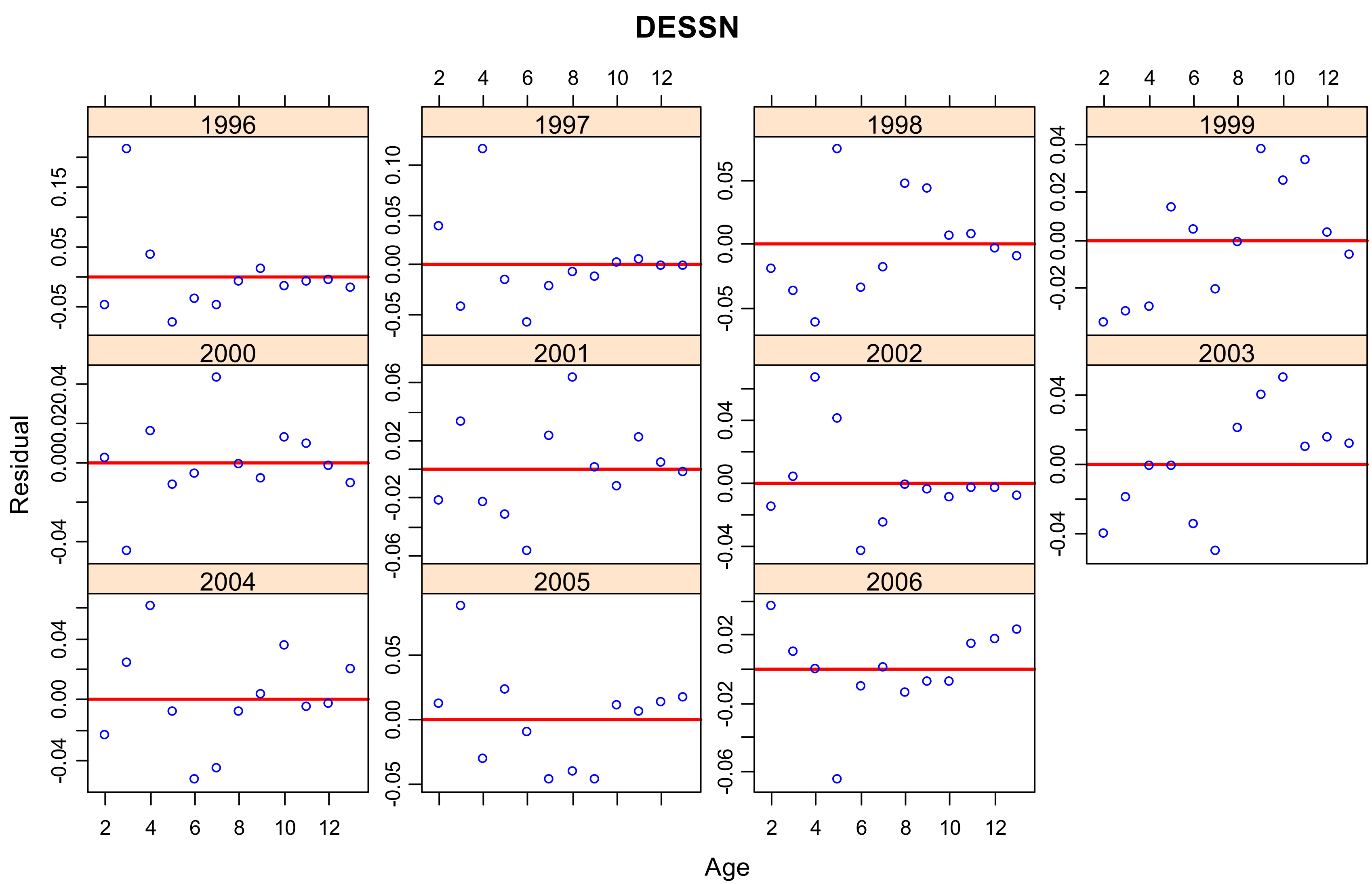



Figure 26. Residuals of survey age compositions by year for the Delaware electrofishing survey

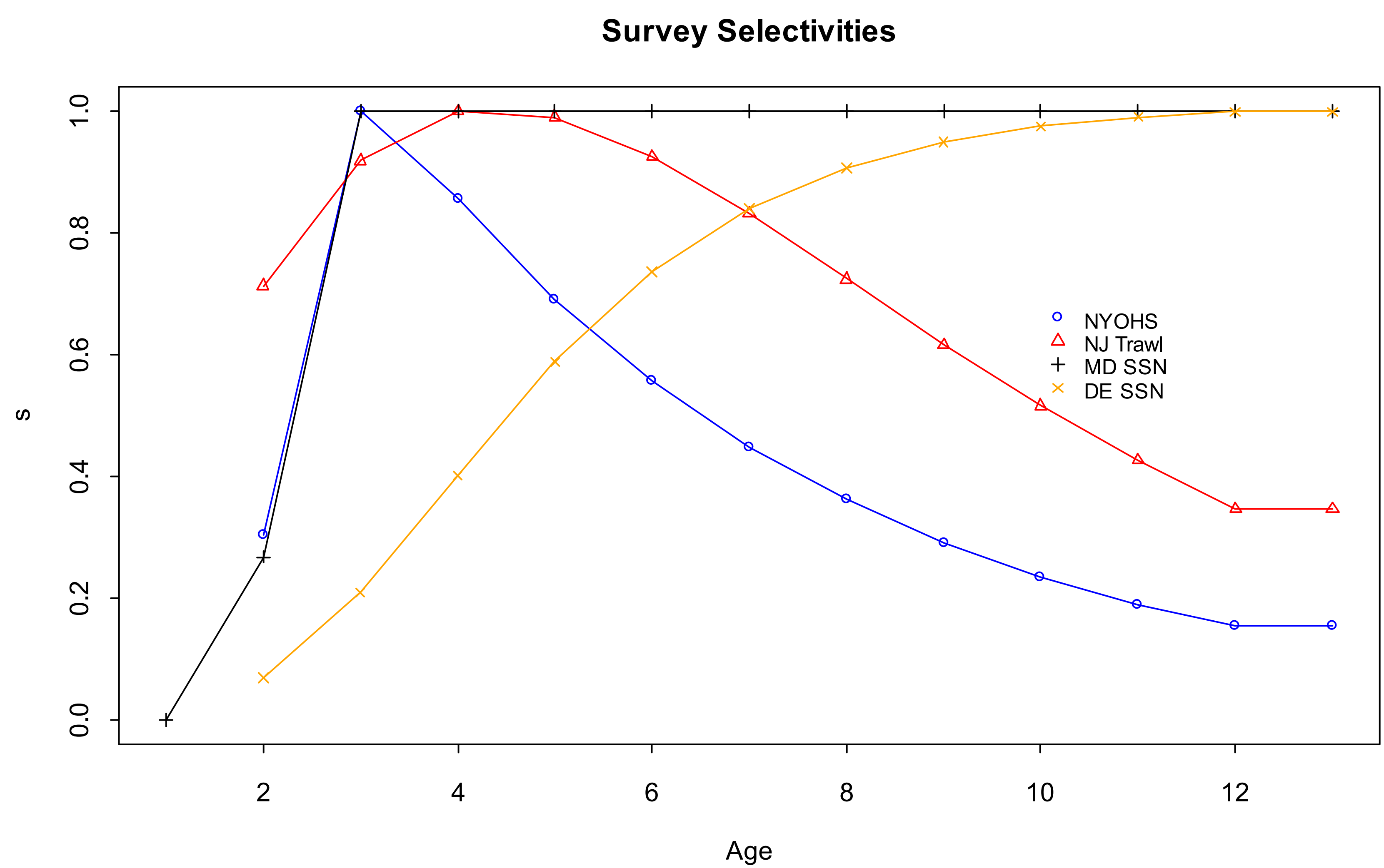



Figure 27. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD gillnet, and DE electrofishing surveys

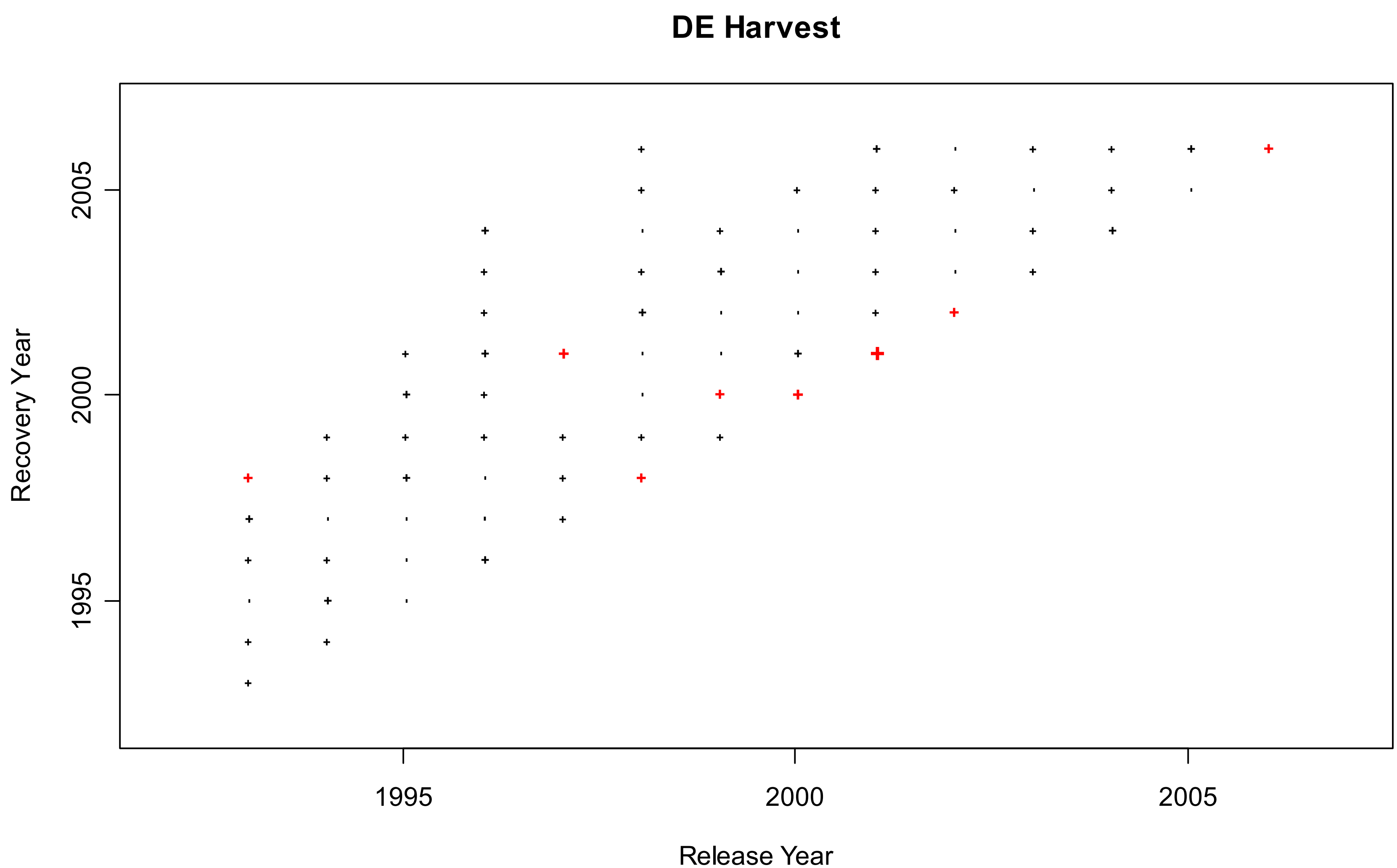
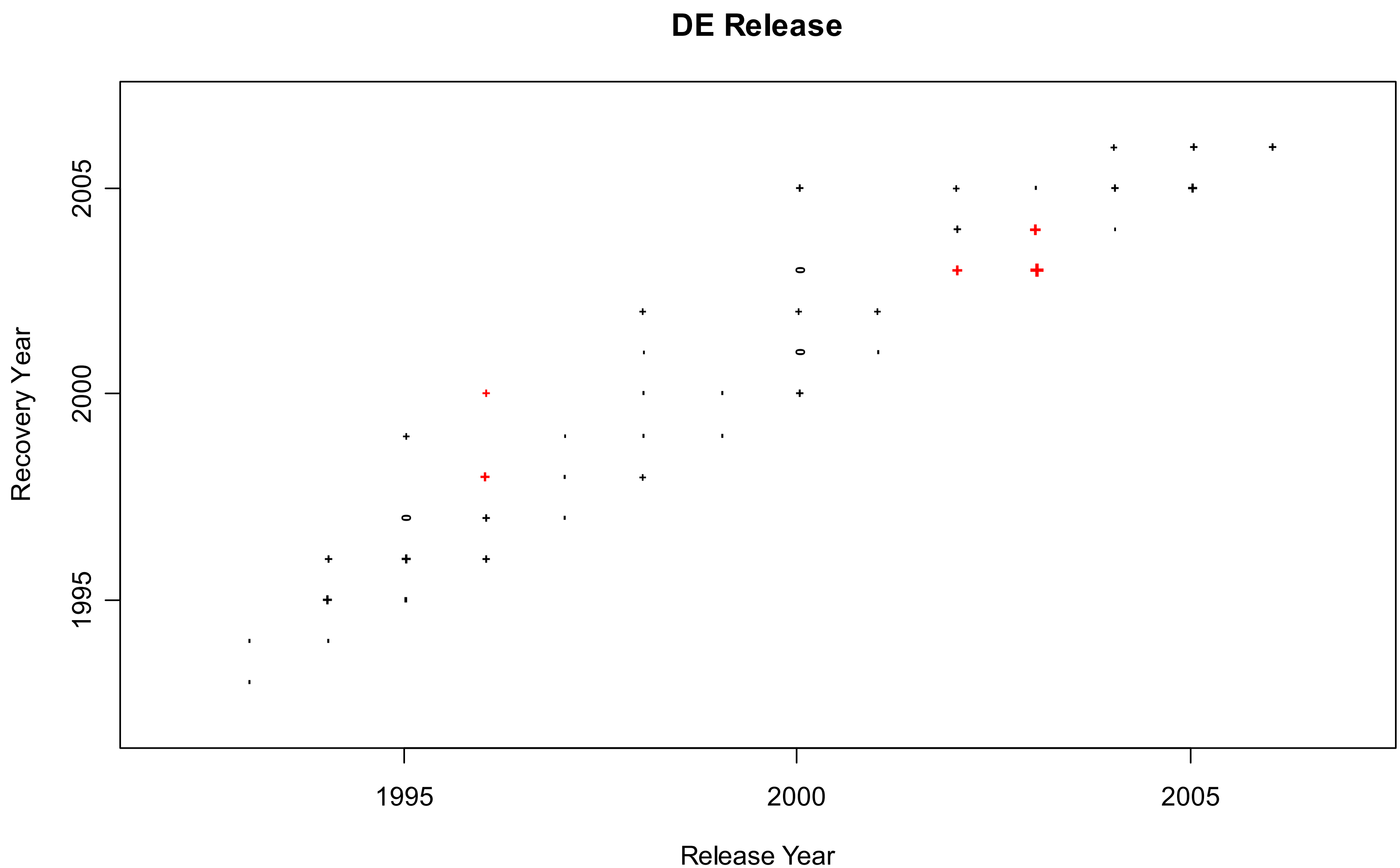



Figure 28. Residuals plots for the harvest and catch/release tag returns. The symbols represent negative (-) or positive (+) residuals, the size of the symbol represents the magnitude of the chi-square value, and the color red signifies that the cell chi-square value is significant at p<=0.05, df=1.

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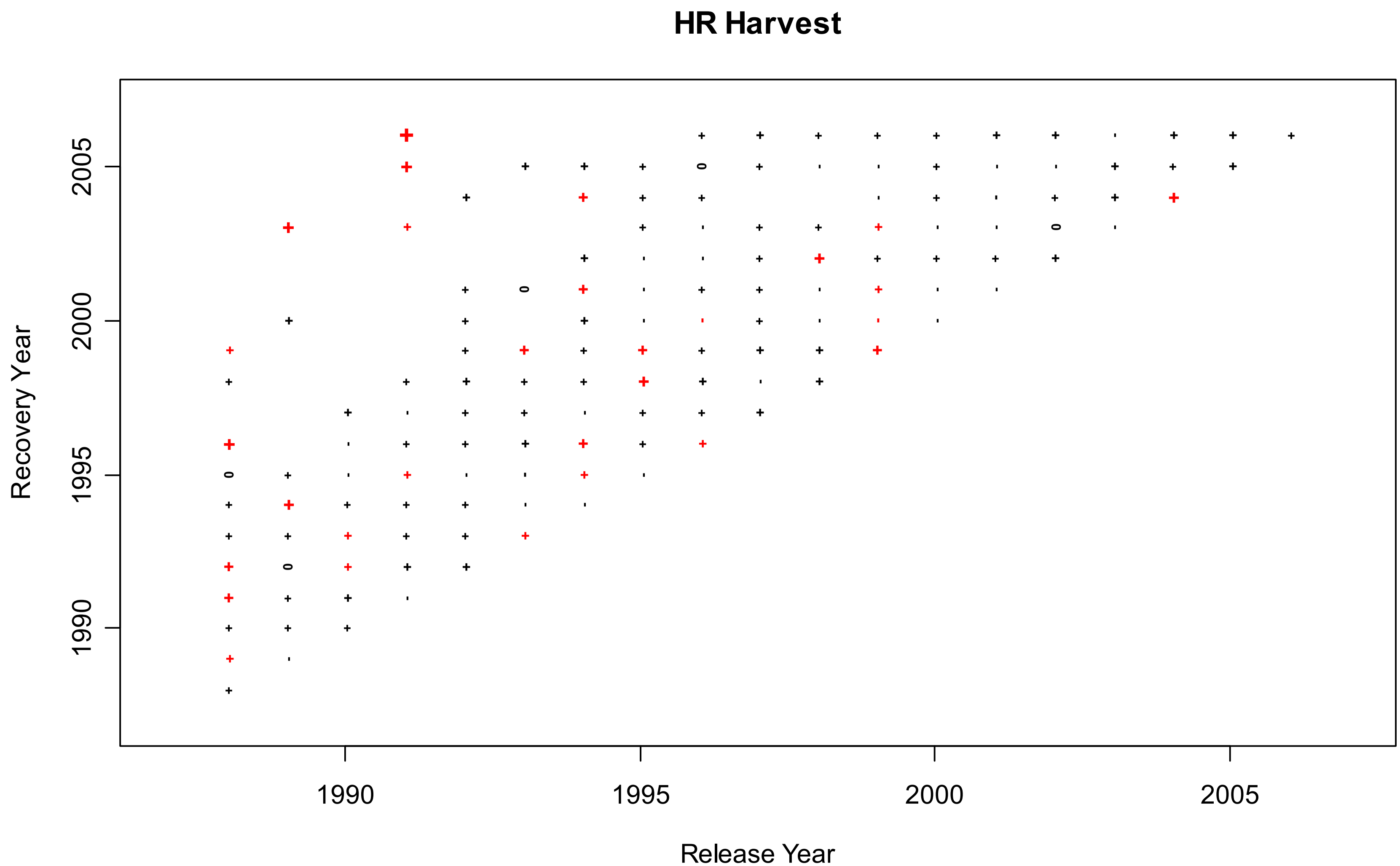


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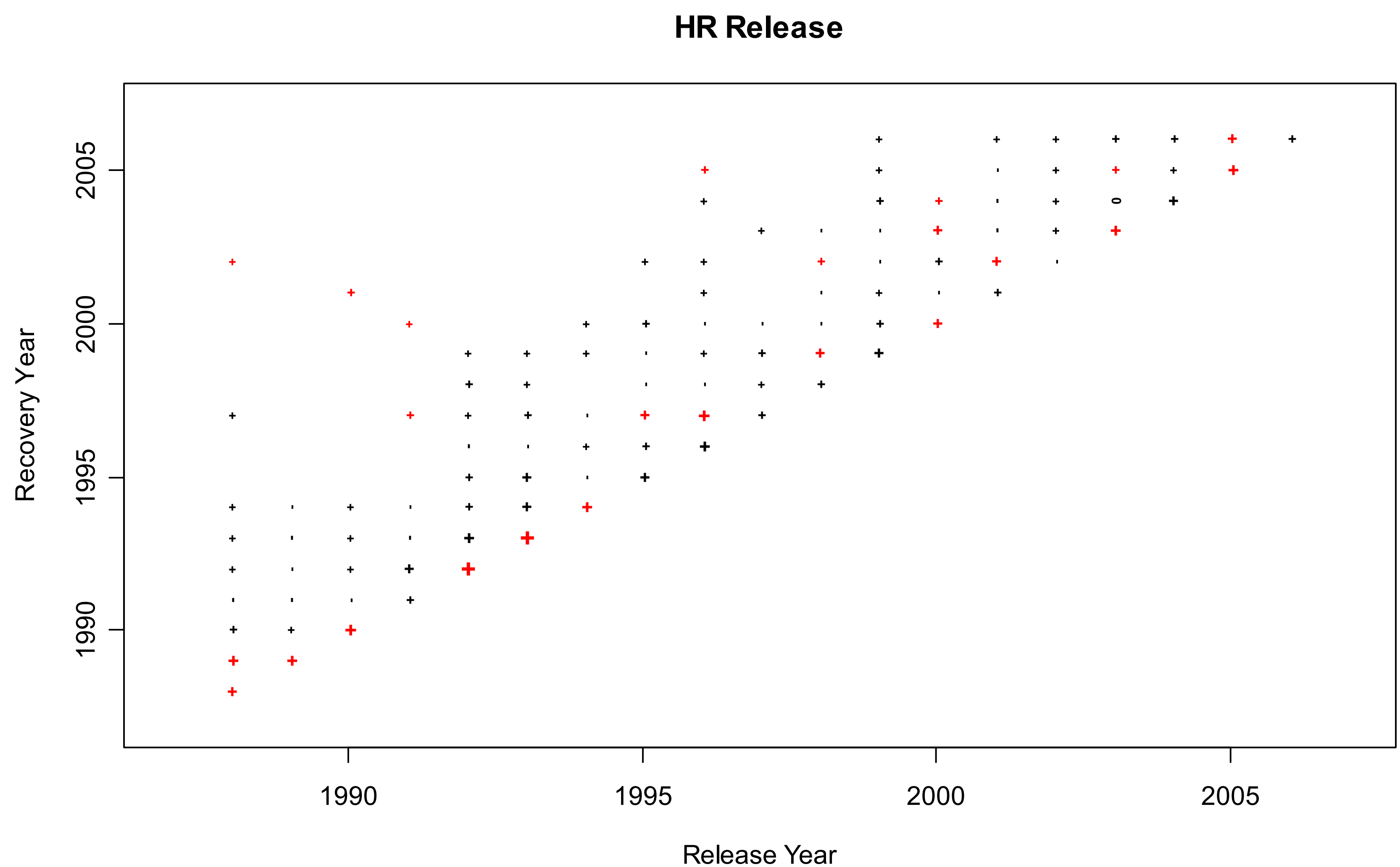


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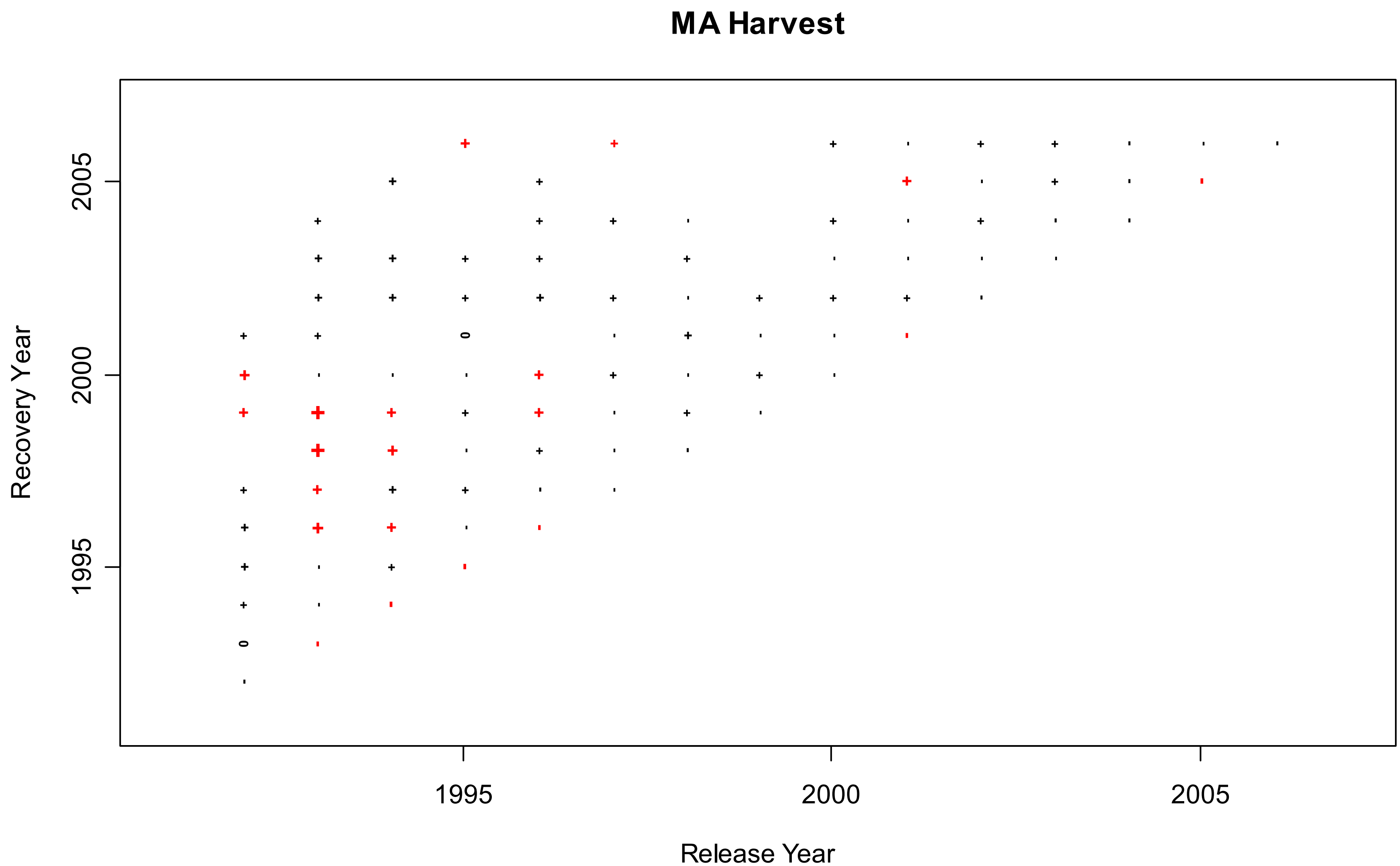


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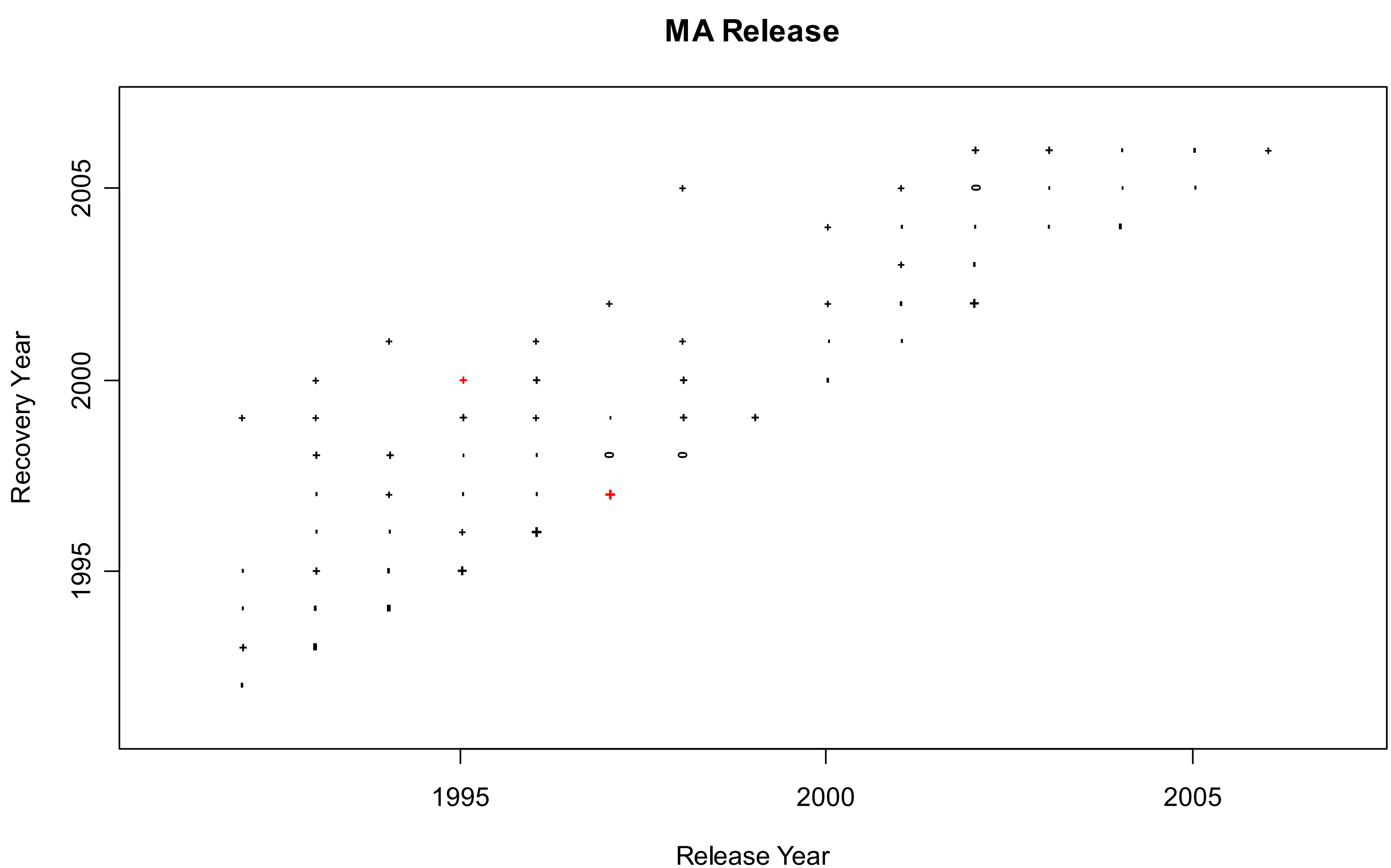


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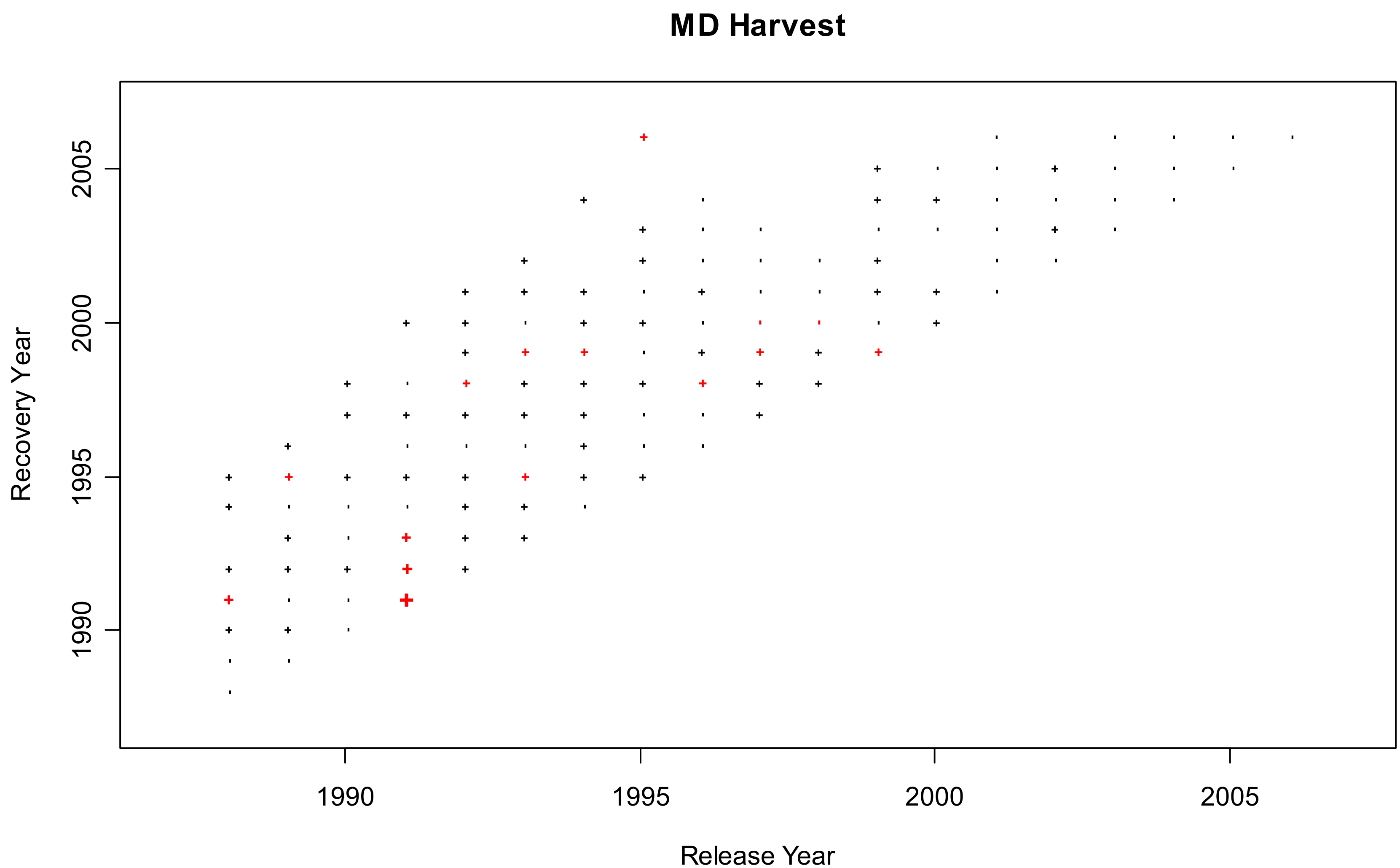


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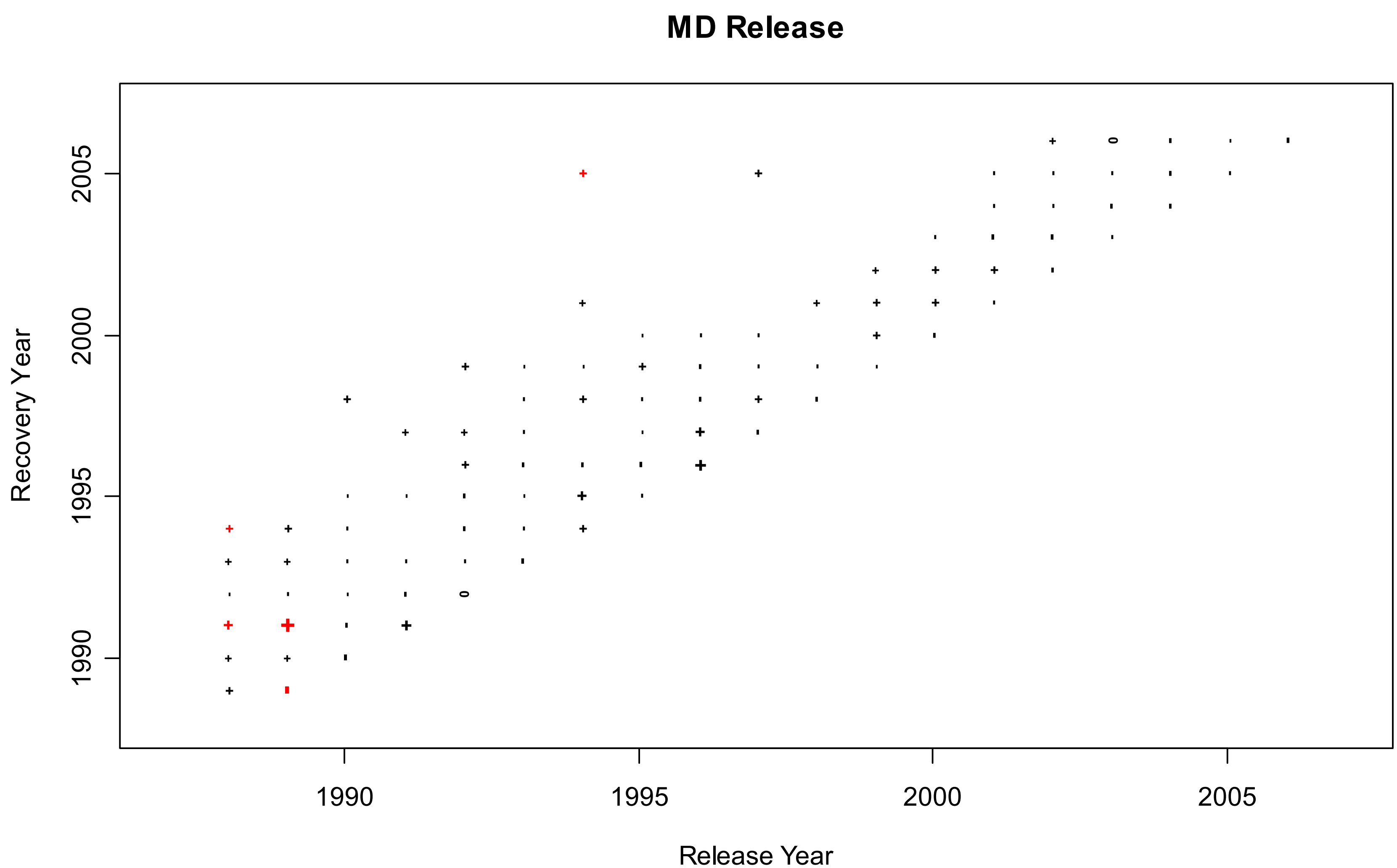


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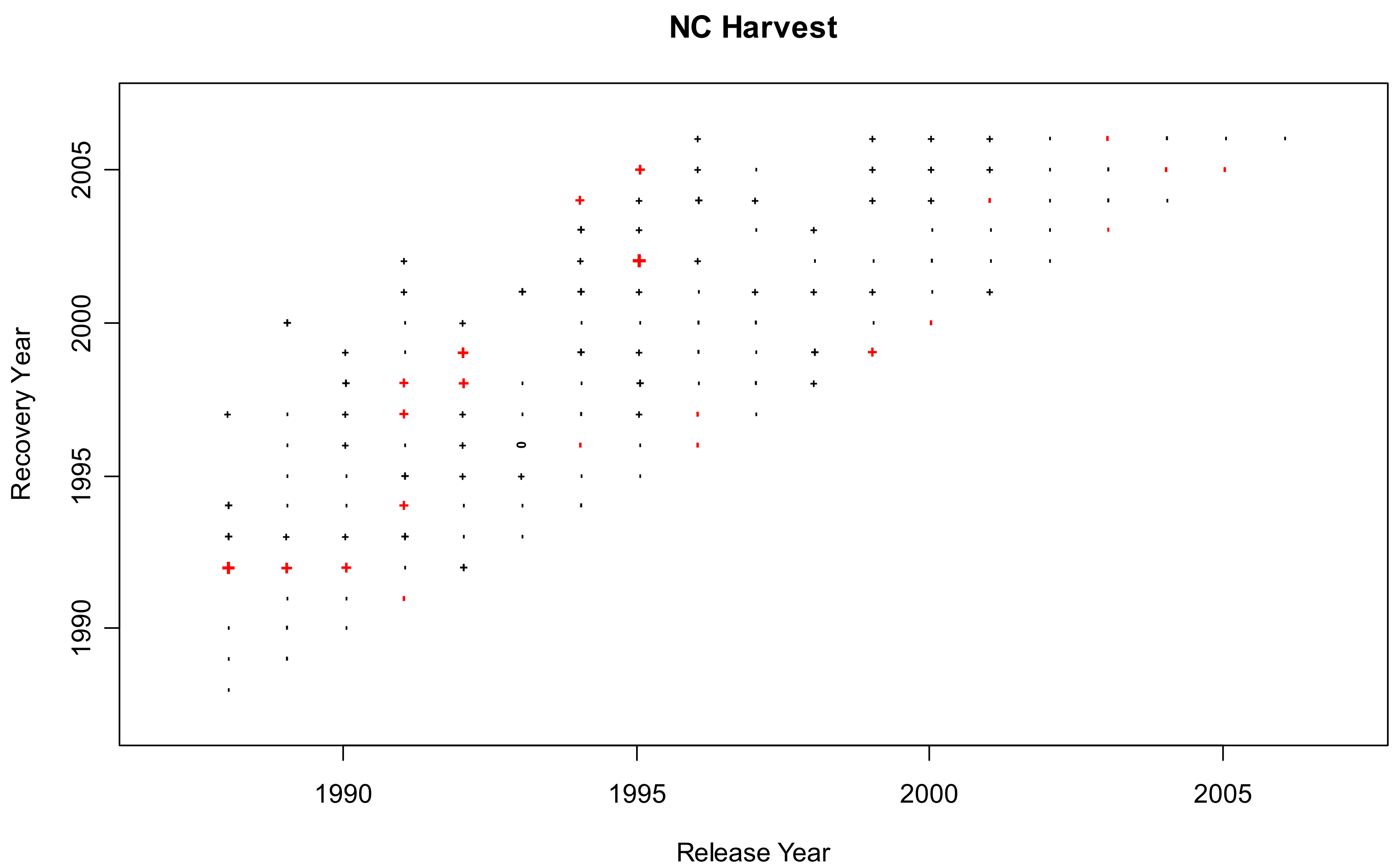


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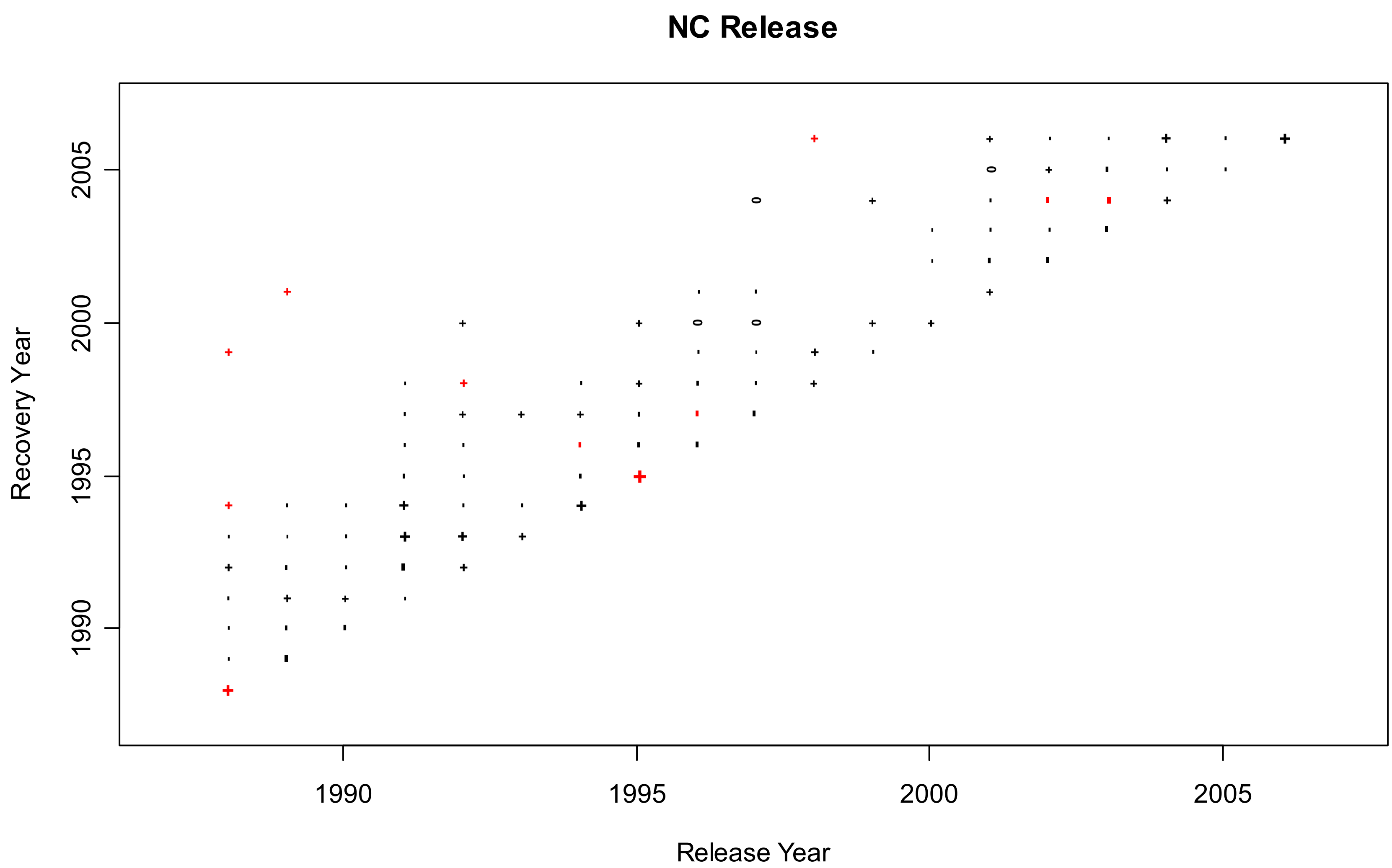


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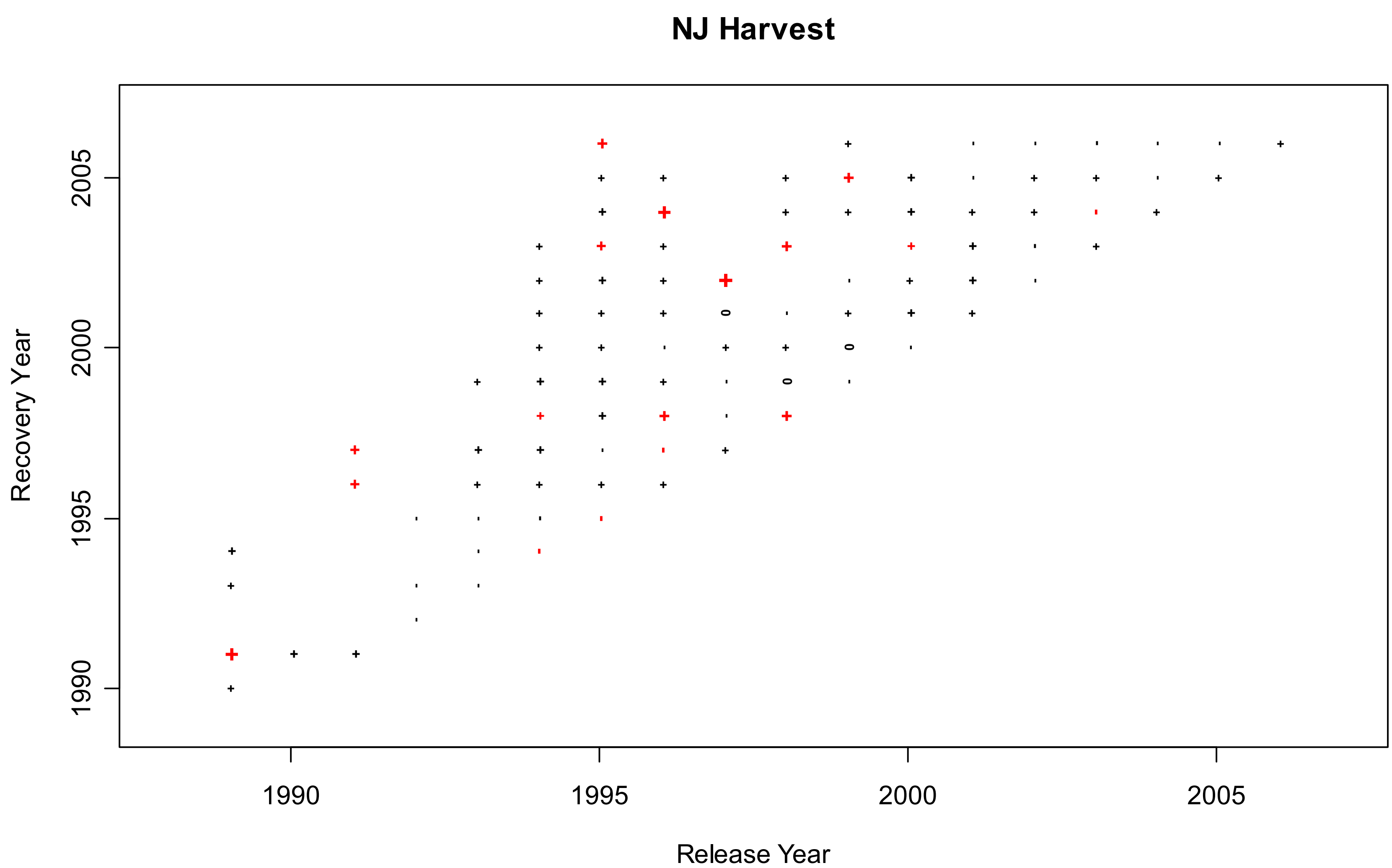


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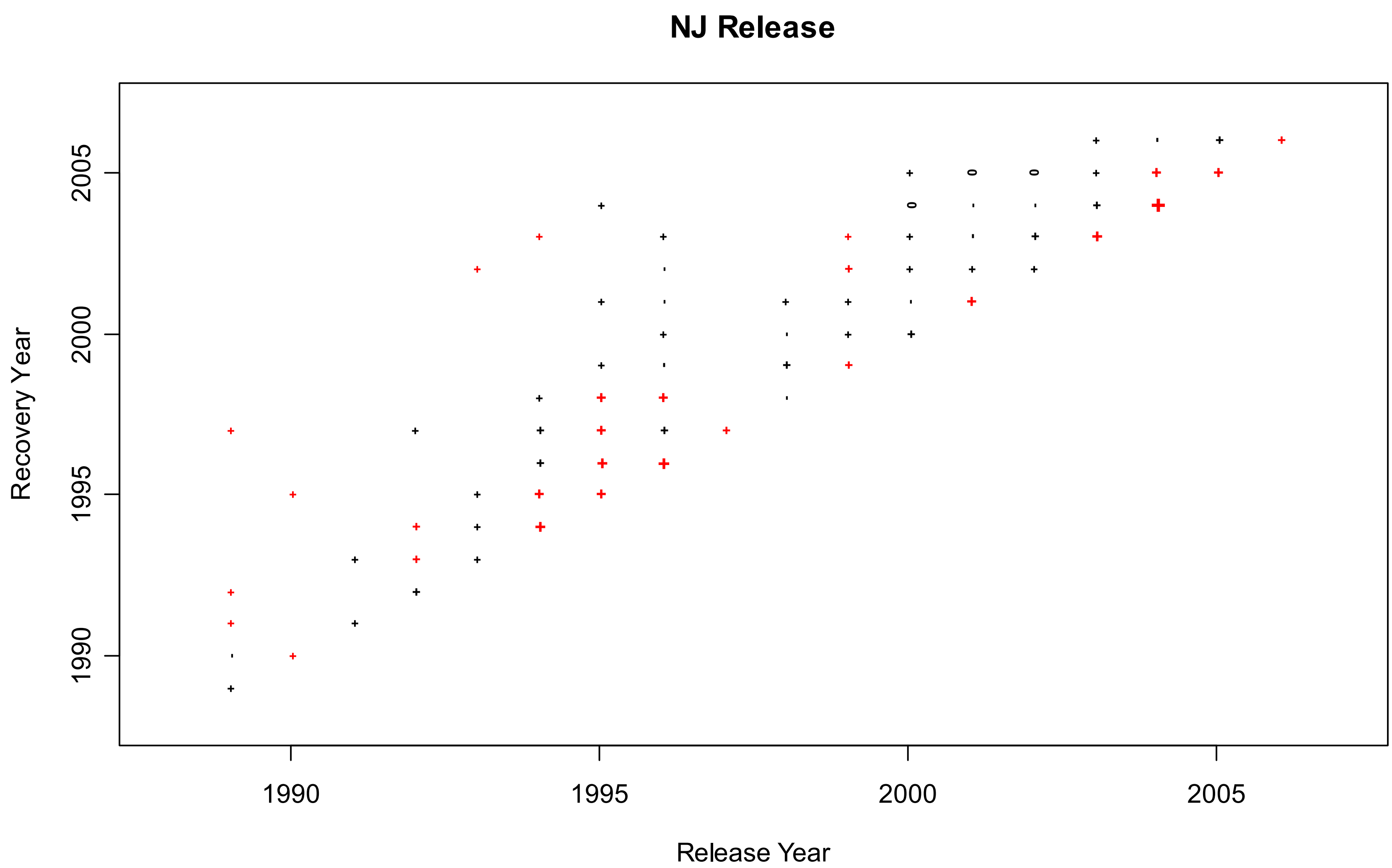


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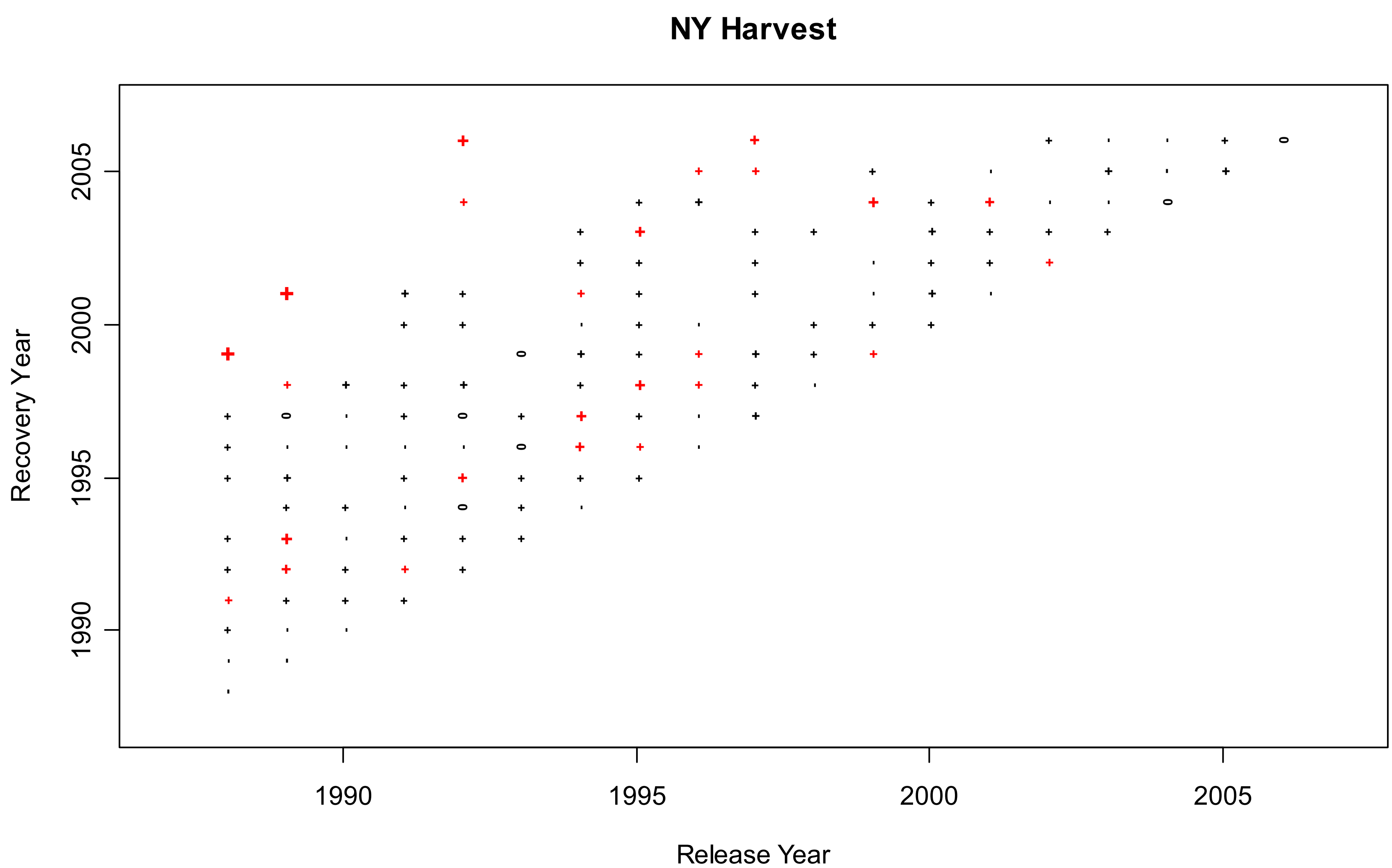


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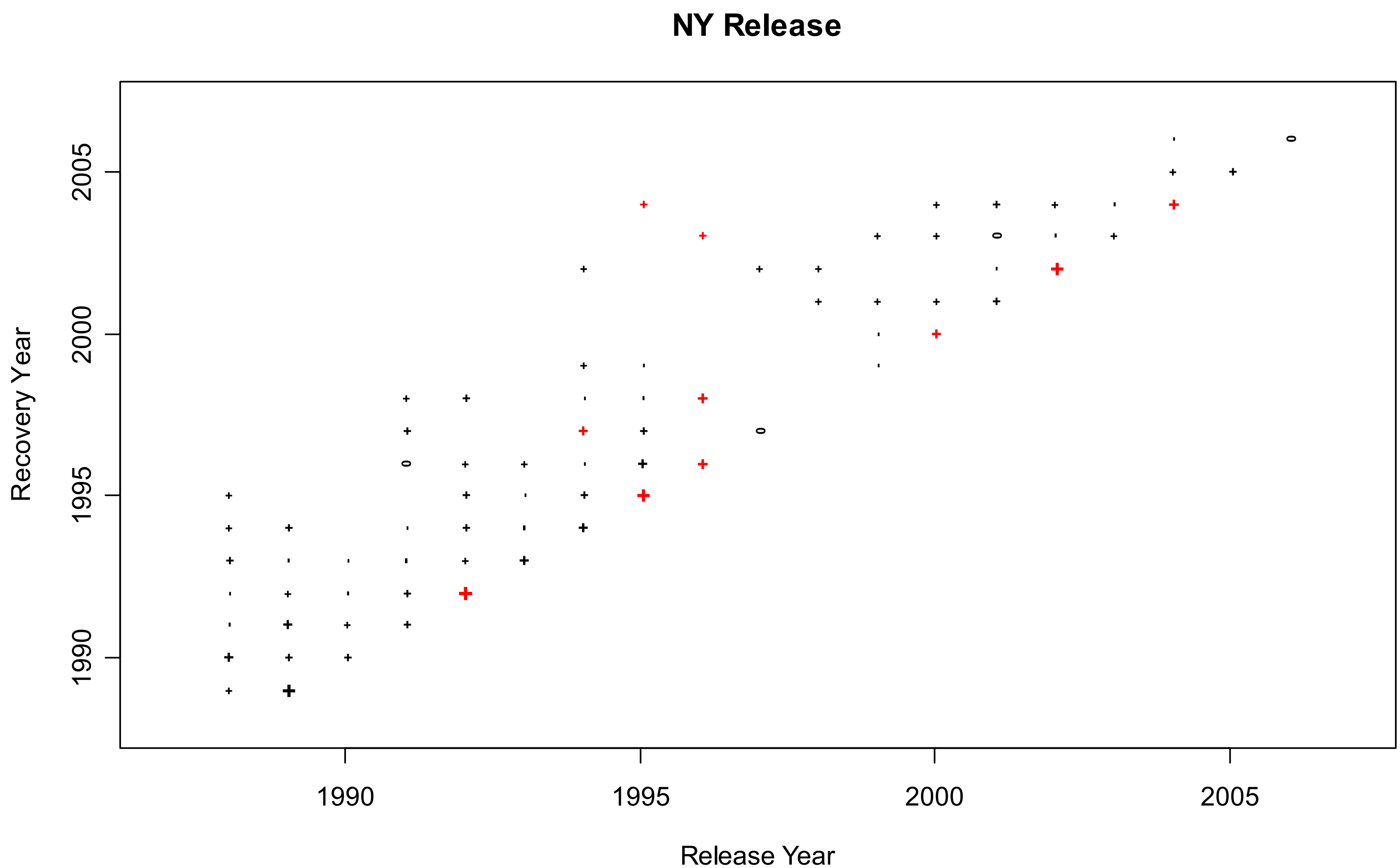


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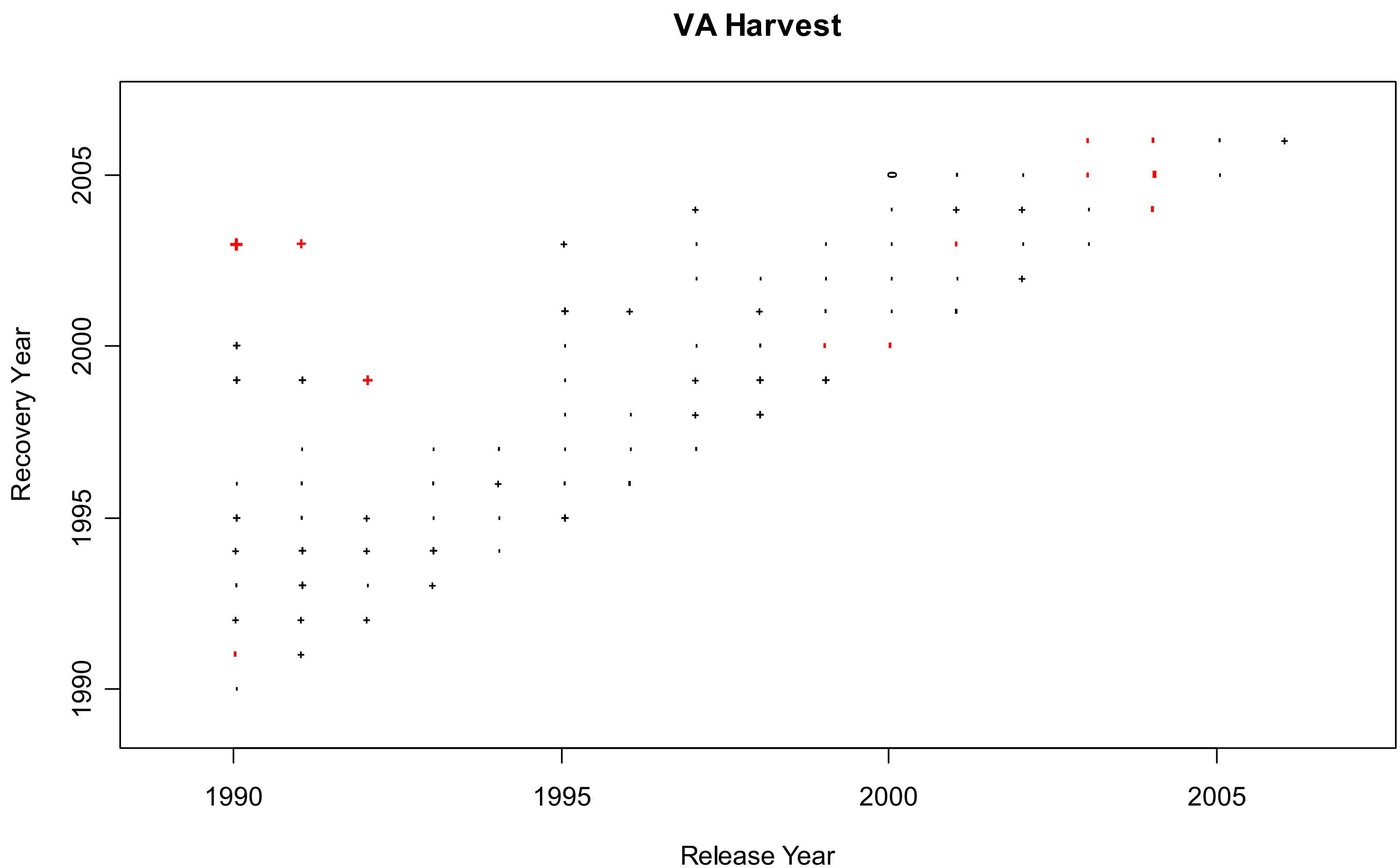


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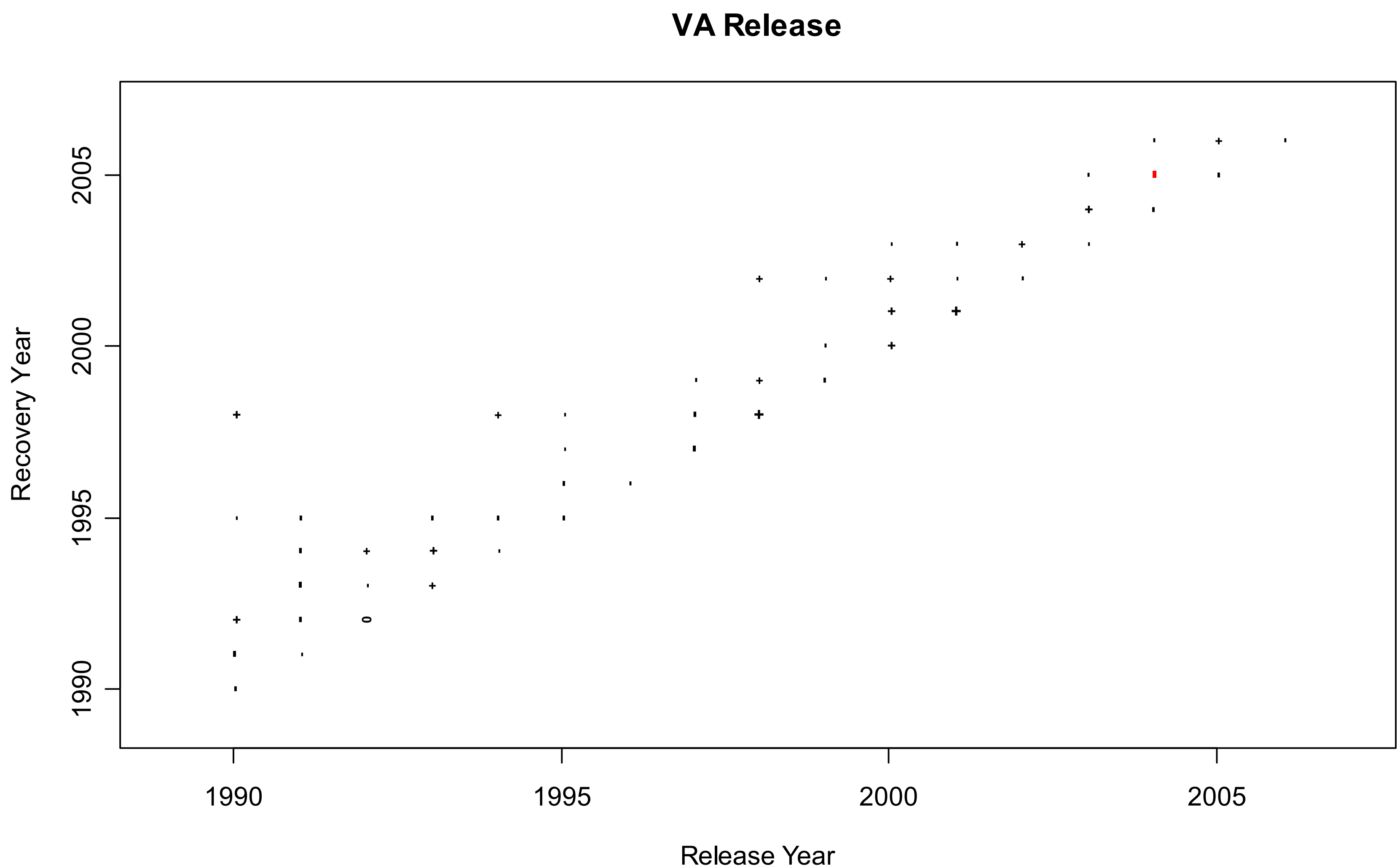


Figure 28 continued.

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