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

Northeast Fisheries Science Center Reference Document 08-03a

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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
St. Petersburg, Florida 33701-5020
Email: Mike.Murphy@MyFWC.com

SARC Panelists (CIE):

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E-mail: chris.darby@cefas.co.uk

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

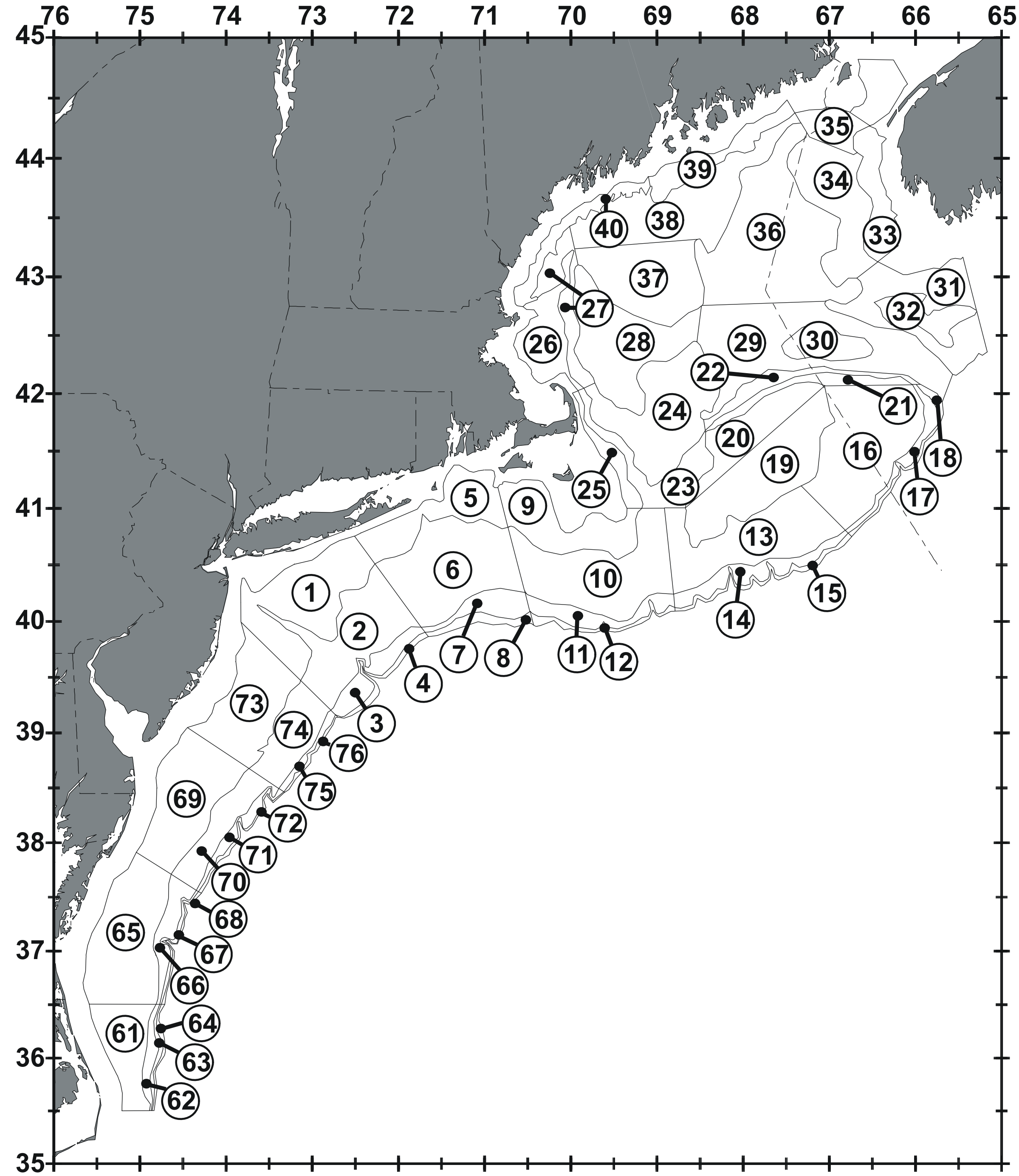

Figure 1. Offshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

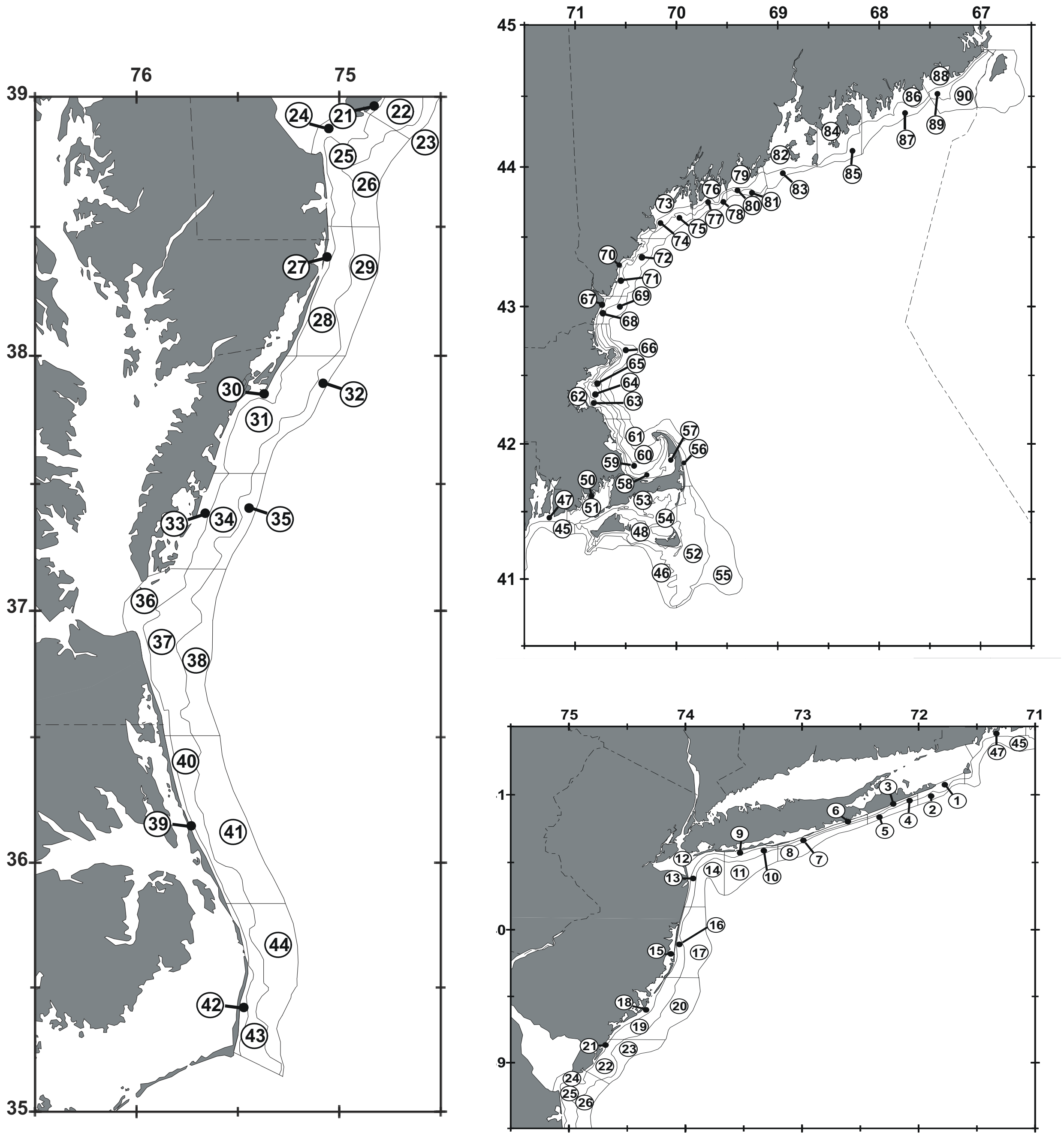

Figure 2. Inshore depth strata sampled during Northeast Fisheries Science Center bottom trawl research surveys.

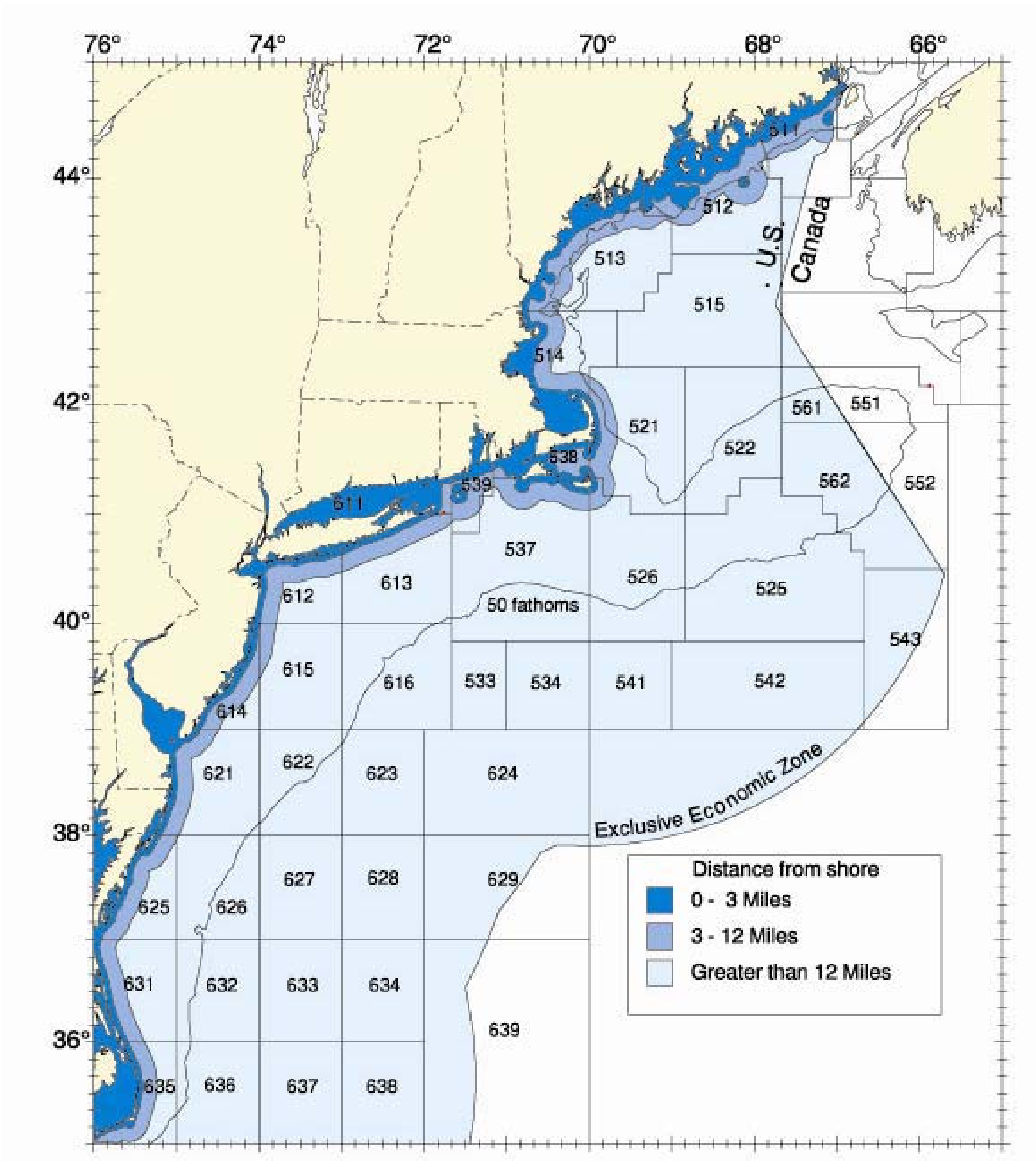

Figure 3. Statistical areas used for reporting commercial catches.

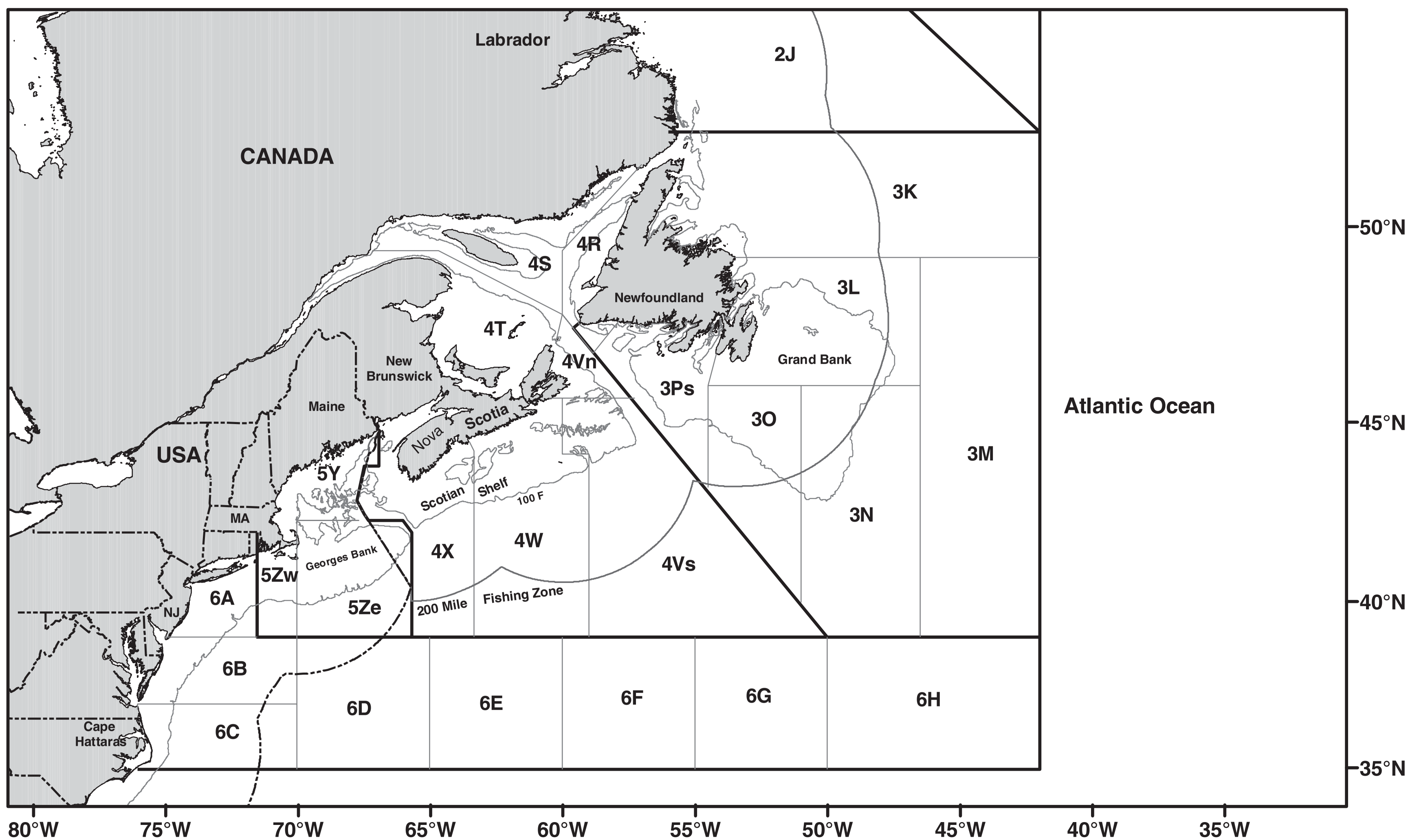

Figure 4. Catch reporting areas of the Northwest Atlantic Fisheries Organization (NAFO) for Subareas 3-6.

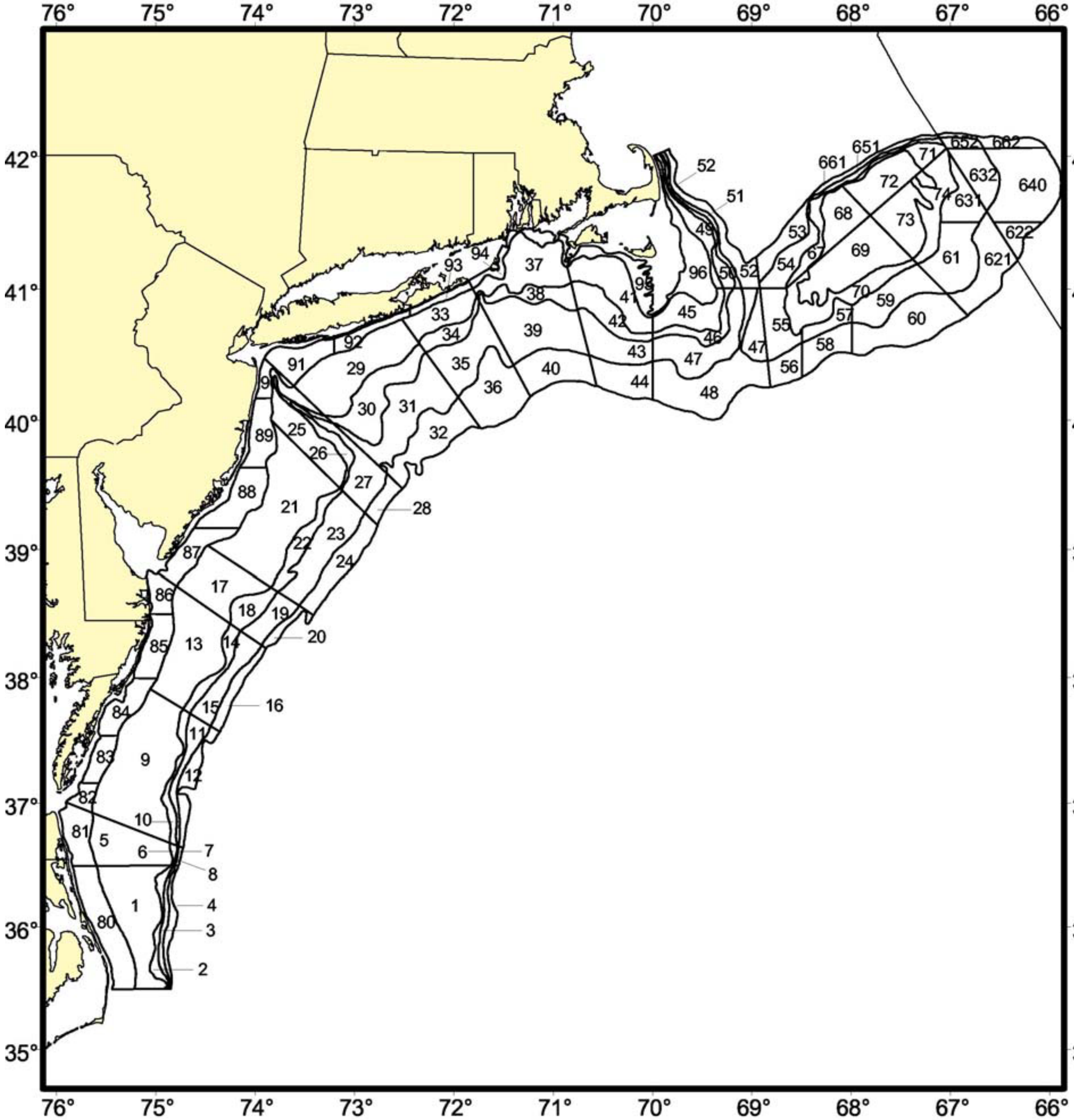

Figure 5. Shellfish strata for NEFSC resource surveys.

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 20th 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 μ 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, β_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, β_i ,and X_i are the same symbols as defined earlier, and ε is the normal error term. Any variable not significant at α=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 σ^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 λ_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 λ 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:

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

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

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

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 of 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 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

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

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

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

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):

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

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

$$\hat{C}_y = \sum_a \hat{C}_{y,a} \tag{15}$$

Predicted Proportions of Catch-At-Age

$$\hat{P}_{y,a} = \frac{\hat{C}_{y,a}}{\sum_a \hat{C}_{y,a}} \tag{16}$$

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

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

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 λ_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

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

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:

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

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 qs 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 1st (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):

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

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:

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

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:

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

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 ≥ 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

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

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

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

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

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

and predicted age composition is calculated as

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

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 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):

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

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

$$f = -L_l - L_p - L_{NYOHS}^U - L_{NTrawl}^U - L_{NYOHS}^U - L_{MDSSN}^U + P_{rdev} + P_{fdev} + P_{fadd} \quad (29)$$

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 $\pm$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 $\pm$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:

θ = 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

λ = 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;
θ = release survival rate (0.92)
M = the number of fish tagged or marked at the beginning of the year; and
λ = 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:

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

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 ≥ 18 inches TL, corresponding roughly to 3-year-old and older striped bass, and for fish ≥ 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 ≥ 28 inches) and Table A9.7 (fish ≥ 18 inches).

The 2006 IRCR estimates of F for fish ≥ 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 ≥ 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 ≥ 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 ≥ 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 ≥ 28 inches, approximating age 7+ and fish ≥ 18 inches, approximating age 3+). The stock size estimates for fish ≥ 28 inches also exhibit 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 ≥ 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 λ_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:

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

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

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

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 λ_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

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

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:

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

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 qs 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:

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

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:

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

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:

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

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 ≥ 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

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

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

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

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

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

and predicted age composition is calculated as

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

The age composition negative log-likelihood for survey t is

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

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):

$$\hat{\bar{t}} = \frac{\sum_y \hat{t}_y}{d_y} \tag{28}$$

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

$$\hat{R}_{i,y} = N_i \hat{P}_{i,y} \tag{29}$$

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

$$\hat{R}'_{i,y} = N_i \hat{P}'_{i,y} \tag{30}$$

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

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

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 $\geq$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 λ=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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A13.0 REFERENCES

Akaike H. 1973. Information theory as an extension of the maximum likelihood principle. In: Petrov BN, Csaki F, editors. 2nd International Symposium on Information Theory. Budapest: Akademiai Kiado; p 267–281.

Anderson DR, Burnham KP, White GC. 1994. AIC model selection in overdispersed capture-recapture data. Ecology 75:1780–1793.

Atlantic States Marine Fisheries Commission (ASMFC). 1987. Interstate Fisheries Management Plan for the Striped Bass of the Atlantic Coast from Maine to North Carolina. Washington (DC): ASMFC Fish Manage Rep. #1.

ASMFC. 1990. Source document for the supplement to the Striped Bass FMP - Amendment #4. Washington (DC): ASMFC Fish Manage Rep No.16; 244 p.

ASMFC. 1996. Report of the Juvenile Abundance Indices Workshop. Washington (DC): ASMFC Spec Rep No.48; 83 p.

ASMFC. 1998. Amendment #5 to the Interstate Fishery Management Plan for Atlantic Striped Bass. Washington (DC): ASMFC Fish Manage Rep No. 24; 31 p.

ASMFC. 2003. Amendment #6 to the Interstate Fishery Management Plan for Atlantic Striped Bass. Washington (DC): ASMFC Fish Manage Rep No. 41; 63 p.

ASMFC 2003b. 2003 stock assessment report for Atlantic striped bass: catch-at-age based VPA & tag release/recovery based survival estimation. ASMFC Rep. SBTC-2003-3; 85 p.

ASMFC. 2004. Summary of the USFWS Cooperative Tagging Program Results. Washington (DC): ASMFC. Report by Striped Bass Tag WG to Striped Bass Techn Comm; 27 p.

ASMFC. 2005. 2005 stock assessment report for Atlantic striped bass: catch-at-age based VPA & tag release/recovery based survival estimation. Washington (DC): ASMFC. Report by Striped Bass Techn Comm for Atlantic Striped Bass Management Board; 131 p.

Bain MB, Bain JL. 1982. Habitat suitability index models: coastal stocks of striped bass. Washington (DC): USFWS, Div Biol Serv, Rep. FWS/OBS-82/10.1; 29 p.

Bigelow HB, Schroeder WC. 1953. Fishes of the Gulf of Maine. US Fish and Wildl Serv Fish Bull 74(53):1-577.

Brodziak JKT. 2002. An age-structured assessment model for Georges Bank winter flounder. Woods Hole (MA): NEFSC Ref Doc 02-03; 54 p.

Brownie C, Anderson DR, Burnham KP, Robson DR. 1985. Statistical inference from band recovery - a handbook. 2nd ed. Washington (DC): USFWS Res Publ No. 156; 305 p.

Burnham KP, Anderson DR. 1992. Data-based selection of an appropriate biological model: the key to modern data analysis. In: McCullogh DR, Barrett RH, eds. Wildlife 2001: Populations. London (UK): Elsevier Science Publications; p 16–30.

Burnham KP, Anderson DR. 2002. Model selection and multi-model inference: a practical information-theoretic approach. 2nd ed. New York (NY): Springer-Verlag; 488 p.

Burnham KP, Anderson DR. 2003. Model selection and multi-model inference: a practical information-theoretical approach. 3rd ed. New York (NY): Springer-Verlag; 496 p.

Buckland ST, Burnham KP, Augustin NH. 1997. Model selection: an integral part of inference. Biometrics 53:603–618.

Buckel JA, Fogarty MJ, Conover DO. 1999. Mutual prey of fish and humans: a comparison of biomass consumed by bluefish, *Pomatomus saltatrix*, with that harvested by fisheries. Fish Bull 97: 776–785.

Clark JH, Kahn DM. [in revision.] Amount and disposition of striped bass discarded in Delaware's spring striped bass gill net fishery during 2001 through 2003: effects of regulations and fishing strategies. Submitted to N Amer J Fish Manage.

Clark JR. 1968. Seasonal movements of striped bass contingents of Long Island Sound and the New York Bight. Trans Am Fish Soc. 97:320–343.

Crecco V. 2003. Method of estimating fishing (F) and natural (M) mortality rates from total mortality (Z) and exploitation (u) rates for striped bass. Old Lyme (CT): A Report to the ASMFC Striped Bass Technical Committee. 40 p.

Crecco V. 2004. Further analyses on the 2003 fishing mortality (F) on striped bass based on landings and effort data from Connecticut. Old Lyme (CT): A Report to the ASMFC Striped Bass Technical Committee; 23 p.

Deriso RB, Maunder MN, Skalski JR. 2007. Variance estimation in integrated assessment models and its importance for hypothesis test. Can J Fish Aquat Sci 64:187–197.

Diodati PJ, Richards AR. 1996. Mortality of striped bass hooked and released in salt water. Trans Amer Fish Soc. 125:300–307.

Dorazio RM, Hattala KA, McCollough CB, Skjeveland JE. 1994. Tag recovery estimates of migration of striped bass from spawning areas of the Chesapeake Bay. Trans Am Fish Soc 123(6):950–963.

Dunning DJ, Ross QE, Waldman JR, Mattson MT. 1987. Tag retention by, and tagging mortality of, Hudson River striped bass. N Am J Fish Manage. 7:535–538.

Fabrizio MC. 1987. Contribution of Chesapeake Bay and Hudson River stocks of striped bass to Rhode Island coastal waters as estimated by isoelectric focusing of eye lens protein. Trans Am Fish Soc 116:588–593.

Goodyear CP, Cohen JE, Christensen S. 1985. Maryland striped bass: recruitment declining below replacement. Trans Am Fish Soc 114:146–151.

Goshorn C, Smith D, Rodgers B, Warner L. 1998. Estimates of the 1996 striped bass rate of fishing mortality in Chesapeake Bay. Annapolis (MD) and Kearneysville (WV): Maryland Dep Nat Res. A report to the ASMFC Striped Bass Technical Committee; 31 p.

Grant GC. 1974. The Age Composition of Striped Bass Catches in Virginia Rivers, 1967–1971, and a Description of the Fishery. Fish Bull 72(1):193–199.

Hartman K, Brandt S. 1995a. Trophic resource partitioning, diets, and growth of sympatric estuarine predators. Trans Am Fish Soc. 124: 520–537

Hartman K, Brandt S. 1995b. Predatory demand and impact of striped bass, bluefish, and weakfish in the Chesapeake Bay: applications of bioenergetics models. Can J Fish Aquat Sci. 52: 1667–1687.

Helser TE, Geaghan JP, Condrey RE. 1998. Estimating gillnet selectivity using nonlinear response surface regression. Can J Fish Aquat Sci. 55:1328–1337.

Hill J, Evans JW, Van Den Avyle MJ. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic) – striped bass. Washington (DC), Vicksburg (MS): USFWS Div Biol Serv Biol Rep. 82(11.118), US Army Corps Engineers Waterways Exp Sta Coastal Ecol Group TR EL-82-4. 35 p.

Hilborn R, Walters CJ. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics, and Uncertainty. New York (NY): Chapman and Hall, Inc. 570 p.

Hoenig JM, Barrowman NJ, Hearn WS, Pollock KH. 1998. Multiyear tagging studies incorporating fishing effort data. Can J Fish Aquat Sci. 55:1466–1476.

Hoenig JM, Hepworth D, Latour R, Sadler P. 2004. Fishing mortality in the Chesapeake. Gloucester Point (VA): Virginia Institute of Marine Science. A report to the ASMFC Striped Bass Technical Committee; 18 p.

Holland Jr BF, Yelverton GF. 1973. Distribution and biological studies of anadromous fishes offshore North Carolina. Morehead City (NC): NCDMF Div Commer Sportfish. NC Dep Nat Econ Resour Spec Sci Rep 24. 132p.

Hornick HT, Rodgers BA, Harris RE, Zhou JA. 2000. Estimate of the 1999 Striped Bass Rate of Fishing Mortality in Chesapeake Bay. Annapolis (MD), Gloucester Point (VA): MD MDR, VMRC; 11 p.

Jackson HW, Tiller RE. 1952. Preliminary observations on spawning potential in the striped bass. Solomons (MD): Chesapeake Bay Laboratory. CBL Pub No. 93; 16 p.

Jiang H. 2005. Age-dependent tag return models for estimating fishing mortality, natural mortality and selectivity [dissertation]. Raleigh (NC): NC State Univ.; 124 p.

Jiang H, Pollock KH, Brownie C, Hoenig JM, Latour RJ, Wells BK, Hightower JE. 2007. Tag return models allowing for harvest and catch and release: evidence of environmental and management impacts on striped bass fishing and natural mortality rates. N Amer J Fish Manage 27:387–396.

Kahn DM, Crecco V. 2006. Tag recapture data from Chesapeake Bay striped bass indicate that natural mortality has increased. In: Ottinger CA, Jacobs JM, editors. USGS/NOAA Workshop on Mycobacteriosis in Striped Bass, May 7–10, 2006, Annapolis, Maryland. Reston (VA): USGS. p 25–26.

Kahn DM, Miller RW, Shirey CA,Grabowski S. 1998. Restoration of the Delaware River Spawning Stock of Striped Bass. Dover (DE): Delaware Division of Fish and Wildlife.

Kahn DM, Shirey CA. 2000. Estimation of Reporting Rate for the USFWS Cooperative Striped Bass Tagging Program for 1999. Dover (DE): Division of Fish and Wildlife. A Report to the ASMFC Technical Committee; 5 p.

Kohlenstein LC. 1980. Aspects of the population dynamics of striped bass spawning in Maryland tributaries of the Chesapeake Bay [dissertation]. Laurel (MD): Johns Hopkins Univ; 143 p.

Lo NC, Jacobson LD, Squire JL. 1992. Indices of relative abundance from fish spotter data based on the delta-lognormal models. Can J Fish Aquat Sci 49:2525–2526.

McAllister MK, Ianelli JN. 1997. Bayesian stock assessment using catch-age and the sampling-importance resampling algorithm. Can J Fish Aquat Sci 54: 284–300.

McCullagh P, Nelder JA. 1989. Generalized linear models. London (UK): Chapman and Hall; 511 p.

Merriman D. 1941. Studies on the striped bass *Roccus saxatilis* of the Atlantic coast. USFWS Fish Bull 50(35):1–77.

Morris JA Jr, Rulifson RA, Toburen LH. 2003. Genetics, demographics, and life history strategies of striped bass, *Morone saxatilis*, inferred from otolith microchemistry. Fish Res. 62:53–63.

Musick JA, Murdy EO, Birdsong RS. 1997. Striped Bass. In: Fishes of Chesapeake Bay. Washington (DC): Smithsonian Institution Press; p 218–220.

Nelson GA, Chase BC, Stockwell J. 2003. Food habits of striped bass (*Morone saxatilis*) in coastal waters of Massachusetts. J Northw Atl Fish Sci. 32:1–25.

Nelson G. 2007. A forward-projecting Statistical Catch-at-Age model for striped bass. Gloucester (MA): MA Division of Marine Fisheries. A Report to the Striped Bass Stock Assessment Subcommittee; 45 p.

Nichols JD, Blohm RJ, Reynolds RE, Trost RE, Hines JE, Bladen JP. 1991. Band reporting rates for mallards with reward bands of different dollar values. J Wildlife Manage. 55:119–126.

Nichols PR, Miller RV. 1967. Seasonal movements of striped bass tagged and released in the Potomac River, Maryland, 1959–1961. Chesapeake Sci 8:102–124.

Nicholson WR. 1964. Growth compensation in four year classes of striped bass from Albemarle Sound, NC. Chesapeake Sci 5:145–149.

Northeast Fisheries Science Center (NEFSC). 1998. 26th Northeast Regional Stock Assessment Workshop (26th SAW): SARC Consensus Summary of Assessments. Northeast Fish Sci Cent Ref Doc. 98-03; 283 p.

Old Dominion University Center for Quantitative Fisheries Ecology (ODU CQFE). Striped Bass, *Morone Saxatilis* [Internet]. 2006 [cited 2007 June 6]. Available from: http://www.odu.edu/sci/cqfe/

Ottinger CA. 2006. Mycobacterial infections in striped bass (*Morone saxatilis*) from upper and lower Chesapeake Bay: 2002 and 2003 pound net studies. In: Ottinger CA, Jacobs JM, editors. USGS/NOAA Workshop on Mycobacteriosis in Striped Bass, May 7–10, 2006, Annapolis, Maryland. Reston (VA): USGS; p. 15–16.

Panek FM, Bobo T. 2006. Striped bass mycobacteriosis: a zoonotic disease of concern in Chesapeake Bay. In: Ottinger CA, Jacobs JM, editors. USGS/NOAA Workshop on Mycobacteriosis in Striped Bass, May 7–10, 2006, Annapolis, Maryland. Reston (VA): USGS; p 9–10.

Parma A. 2002. Bayesian approaches to the analysis of uncertainty in the stock assessment of Pacific halibut. Am Fish Soc Symp. 27:113–136.

Pennington M, Burmeister L, Hjellvik V. 2002. Assessing the precision of frequency distributions estimated from trawl-survey samples. Fish Bull 100: 74–80.

Pennington M, Volstad JH. 1994. Assessing the effect of intra-haul correlation and variable density on estimates of population characteristics from marine surveys. Biometrics 50:725–732.

Pieper L. 2006. Striped bass disease overview for the past ten year plus. In: Ottinger CA, Jacobs JM, editors. USGS/NOAA Workshop on Mycobacteriosis in Striped Bass, May 7–10, 2006, Annapolis, Maryland. Reston (VA): USGS; p. 10–11.

Pollock KH, Hoenig JM, Jones CM. 1991. Estimation of fishing and natural mortality when a tagging study is combined with a creel survey or port sampling. Am Fish Soc Symp 12:423–434.

Raney EC. 1952. The life history of the striped bass, *Roccus saxatilis* (Walbaum). Bull Bingham Oceanogr Collect 14(1):5–97.

Reynolds JB. 1983. Electrofishing. In: Nielsen LA, Johnson DL, editors. Fisheries Techniques. Bethesda (MD): Am Fish Soc.; 147–163.

Richards RA, Rago PJ. 1999. A Case History of Effective Fishery Management: Chesapeake Bay Striped Bass. N Am J Fish Manage 19(2): 356–375.

Ricker WE. 1975. Computation and interpretation of biological statistics of fish populations. Can J Fish Aquat Sci Bull 191: 382 p.

Rugolo LJ, Crecco VA, Gibson MR. 1994. Modeling stock status and the effectiveness of alternative management strategies for Atlantic coast striped bass. Washington (DC): ASMFC. A Report to the ASMFC Striped Bass Management Board. 30 p.

Rugolo LJ, Jones PW. 1989. A recruitment based interseason harvest control model for Chesapeake Bay striped bass. Annapolis (MD): Maryland Department of Natural Resources. A Report to the ASMFC Striped Bass Technical Committee. 51 p.

Rugolo LJ, Lange AM. 1993. Estimation of exploitation rate and population abundance for the 1993 striped bass stock. Annapolis (MD): Maryland Department of Natural Resources. A Report to the ASMFC Striped Bass Technical Committee. 38 p.

Scofield EC. 1931. The striped bass of California (*Roccus lineatus*). Sacramento (CA): Calif Dept Fish and Game. Fish Bull 29. 84 p.

Searle SR, Speed FM, Milliken GA. 1980. Population marginal means in the linear model: an alternative to least-squares means. Am Stat 34: 216–221.

Secor DH. 2000. Longevity and resilience of Chesapeake Bay striped bass. ICES J Mar Sci.: J Cons. 57(4): 808–815.

Setzler-Hamilton E, Boynton WR, Wood KV, Zion HH, Lubbers L, Mountford NK, Frere P, Tucker L, Mihursky JA. 1980. Synopsis of Biological Data on Striped Bass, *Morone saxatilis* (Walbaum). Washington (DC): NOAA Nat Mar Fish Serv. FAO Synopsis No. 121; 74 p.

Shepherd G. Striped bass (*Morone saxatilis*). Status of fishery resources off the Northeastern United States [Internet]. 2007 [cited 2007 Jun 6]. Available from: http://www.nefsc.noaa.gov/sos/spsyn/af/sbass/

Sinclair AF. 1998. Estimating trends in fishing mortality at age and length directly from research survey and commercial catch data. Can J Fish Aquat Sci 55:1248–1263.

Sissenwine MP, Bowman E. 1978. An analysis of some factors affecting the catchability of fish by bottom trawls. ICNAF Res Bull 13:81–87.

Sissenwine MP, Shepherd JG. 1987. An alternative perspective on recruitment overfishing and biological reference points. Can J Fish Aquat Sci. 44:913–918.

Smith DR, Burnham KP, Kahn DM, He X, Goshorn CJ, Hattala KA, Kahnle AW. 2000. Bias in survival estimates from tag recovery models where catch-and-release is common, with an example from Atlantic striped bass (*Morone saxatilis*). Can J Fish Aquat Sci 57:886–897.

Smith LD. 1970. Life history studies of striped bass. Brunswick (GA): GA Dept Nat Res Fish Sec. Final Report AFS-2; 134 p.

Smith WG, Wells A. 1977. Biological and fisheries data on striped bass, *Morone saxatilis*. Highlands (NJ): NOAA Northeast Fisheries Science Center. Sandy Hook Lab Tech Ser Rep No. 4; 42 p.

Sprankle K, Boreman J, Hestbeck JB. 1996. Loss rates for dorsal loop and internal anchor tags applied to striped bass. N Am J Fish Manage 16:461–464.

Terceiro M. 2003. The statistical properties of recreational catch rate data for some fish stocks off the northeast US coast. Fish Bull 101:653–672.

Thompson GG. 1994. Confounding of gear selectivity and natural mortality rates in cases where the former is a nonmonotone function of age. Can J Fish Aquat Sci 51:2654–2664.

Tiller RE. 1942. Indications of Compensatory Growth in the Striped Bass *Roccus saxatilis*, Walbaum, as Revealed by a Study of the Scales. Solomon Island (MD): Chesapeake Biological Laboratory. CBL Pub No. 57; 16 p.

Trent L, Hassler WH. 1966. Feeding behavior of adult striped bass in relation to stages of sexual maturity. Chesapeake Sci 7:189–192.

Tresselt EF. 1952. Spawning Grounds of the Striped Bass or Rock, *Roccus Saxatililis* (Walbaum), in Virginia. Bull Bingham Ocean Coll 14(1):98–110.

Vogelbein WK, Hoenig JM, Gauthier DT. 2006. Epizootic mycobacteriosis in Chesapeake Bay striped bass: What is the fate of infected fish? In: Ottinger CA, Jacobs JM, editors. USGS/NOAA Workshop on Mycobacteriosis in Striped Bass, May 7–10, 2006, Annapolis, Maryland. Reston (VA): USGS; p 26–27.

Welsh SA. 2004. Overestimation of tag-based fishing mortality rates by linear trend models: examples from simulated and real data. Morgantown (WV): USGS West Virginia University. Report submitted to the ASMFC Striped Bass Tagging Subcommittee; 28 p.

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. Tran Am Fish Soc 136:34–42.

White GC, Burnham KP. 1999. Program MARK - survival estimation from populations of marked animals. Bird Study 46:120–138.

Zlokovitz ER, Secor DH, Piccoli PM. 2003. Patterns of migration in Hudson River striped bass as determined by otolith microchemistry. Fish Res. 63:245–259.

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													
		Beach haul seine							Ocean Gillnet						
			Harvest			Length	Samples			Harvest			Length	Samples
State	Year	Quarter	Pounds	Number	Effort	Samples	Aged	Year	Quarter	Pounds	Number	Effort	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

			Ocean Trawl					
				Harvest			Length	Samples
State	Year	Year	Quarter	Pounds	Number	Effort	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 MA compliance report—2005 & 2006	age structure	
	Pound Net	Trap net discards 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 VA compliance report—2005 & 2006	age structure	
	Drift Gill Net	Drift gill net harvest MD compliance report—2005 & 2006	age structure	
	Hook & Line	Hook & line and pound net harvest MD compliance report—2005 & 2006	age structure	
	Pound Net	Fishery-independent sampling, Rappahannock River VA compliance report—2005 & 2006	age structure	
Delaware Bay	Gill Net	NJ Delaware Bay tagging program 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 1^{st})
NJ YOY	0	1 (January 1^{st})
MD YOY	0	1 (January 1^{st})
VA YOY	0	1 (January 1^{st})
MD Age 1	0	2 (January 1^{st})
NY (WLI) Age 1	0	2 (January 1^{st})
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

		No. Hauls	No. Bass	SRS		Cluster Sampling		Effective
Survey	Year	With Bass	Measured	Mean Length	s2	Mean Length	Var(Mean)	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

		No. Runs	No. Bass	SRS		Cluster Sampling		Effective
Survey	Year	With Bass	Measured	Mean Length	s2	Mean Length	Var(Mean)	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

		No. of Sets	No. Bass	SRS		Cluster Sampling		Effective
Survey	Year	With Bass	Measured	Mean Length	s2	Mean Length	Var(Mean)	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

		No. of Sets	No. Bass	SRS		Cluster Sampling		Effective
Survey	Year	With Bass	Measured	Mean Length	s2	Mean Length	Var(Mean)	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

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

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

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.

Parameters	Phase 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		
	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
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

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

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

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

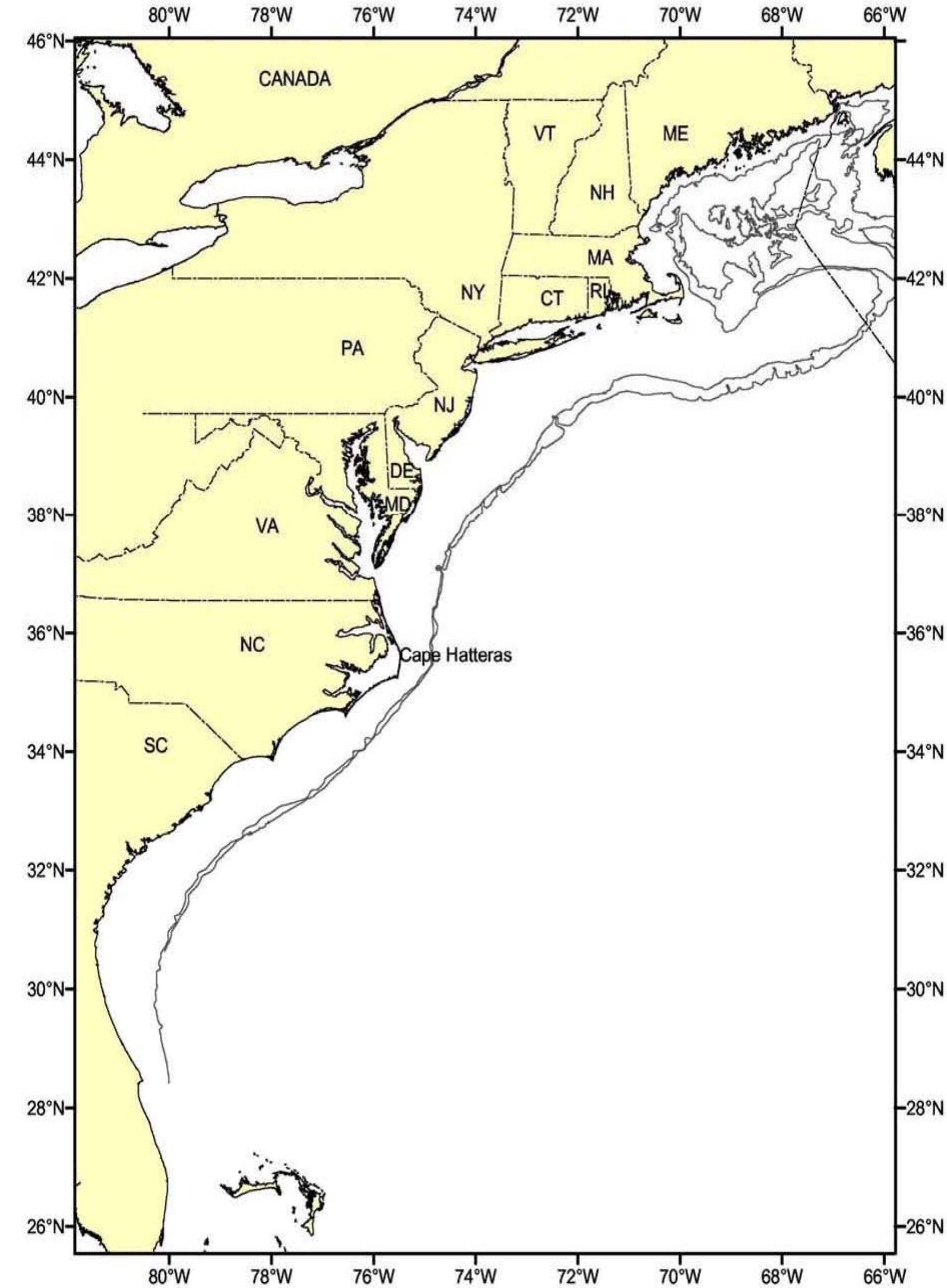


Figure A4.1 Map of the east coast of the United States.

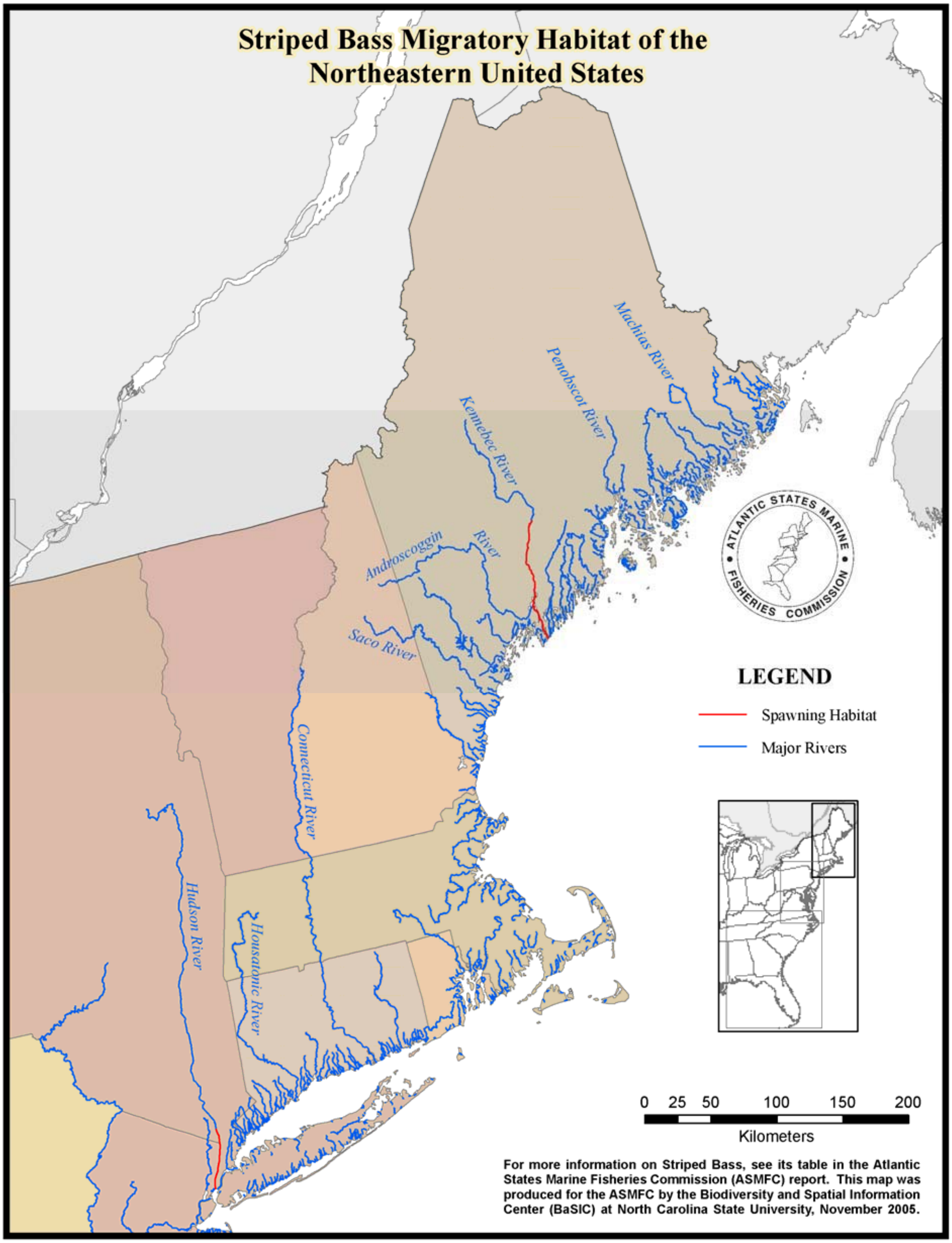


Figure A4.2. Striped Bass Spawning Habitat of Northeastern United States

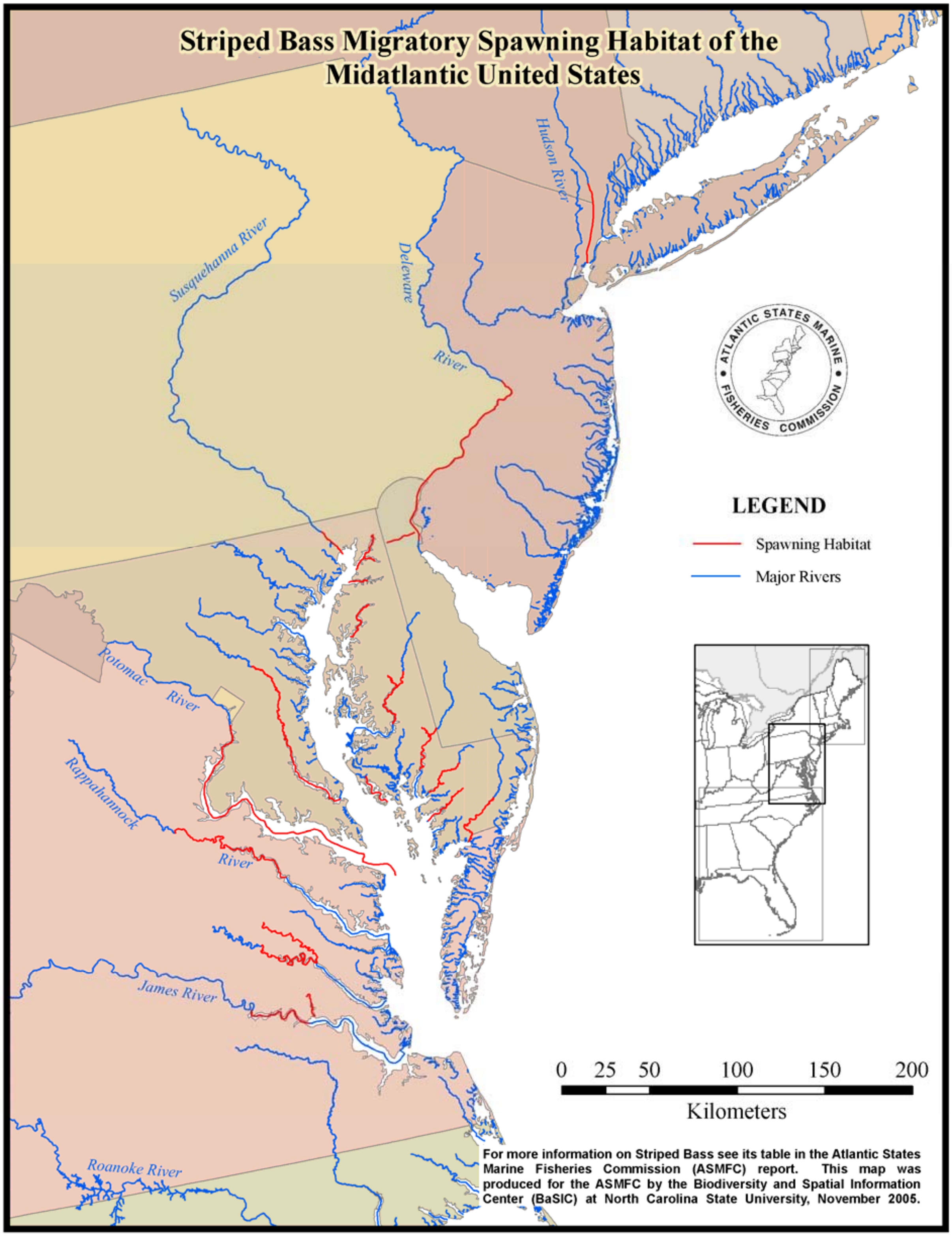


Figure A4.3. Striped Bass Spawning Habitat of Mid-Atlantic United States

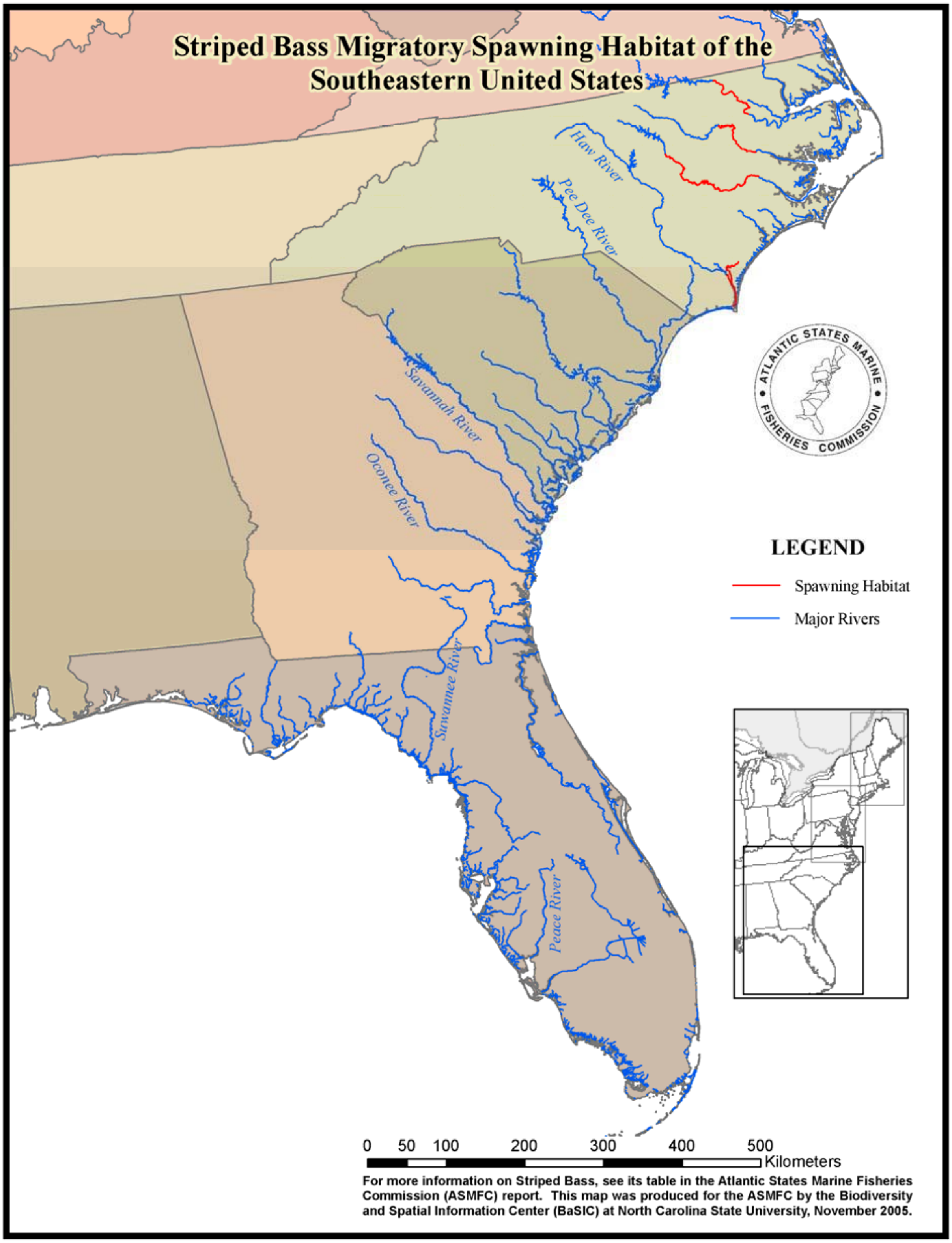


Figure A4.4 Striped Bass Spawning Habitat of Southeastern United States

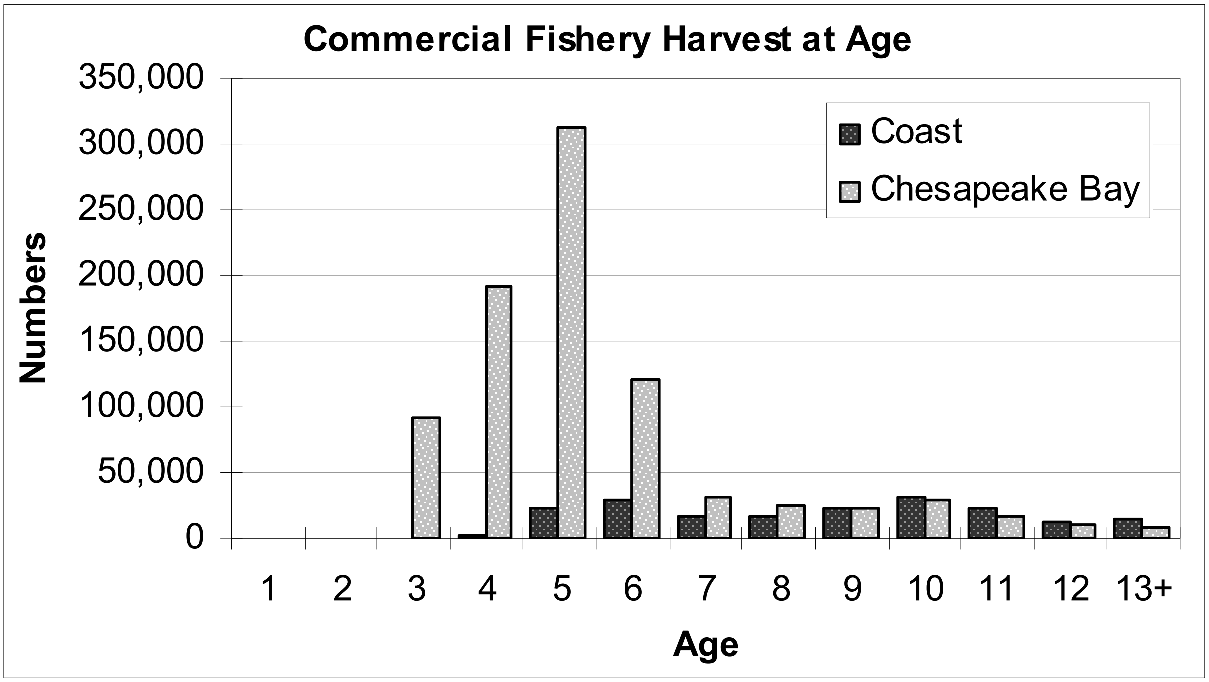


Figure A5.1. Age structure of 2006 commercial harvest by region

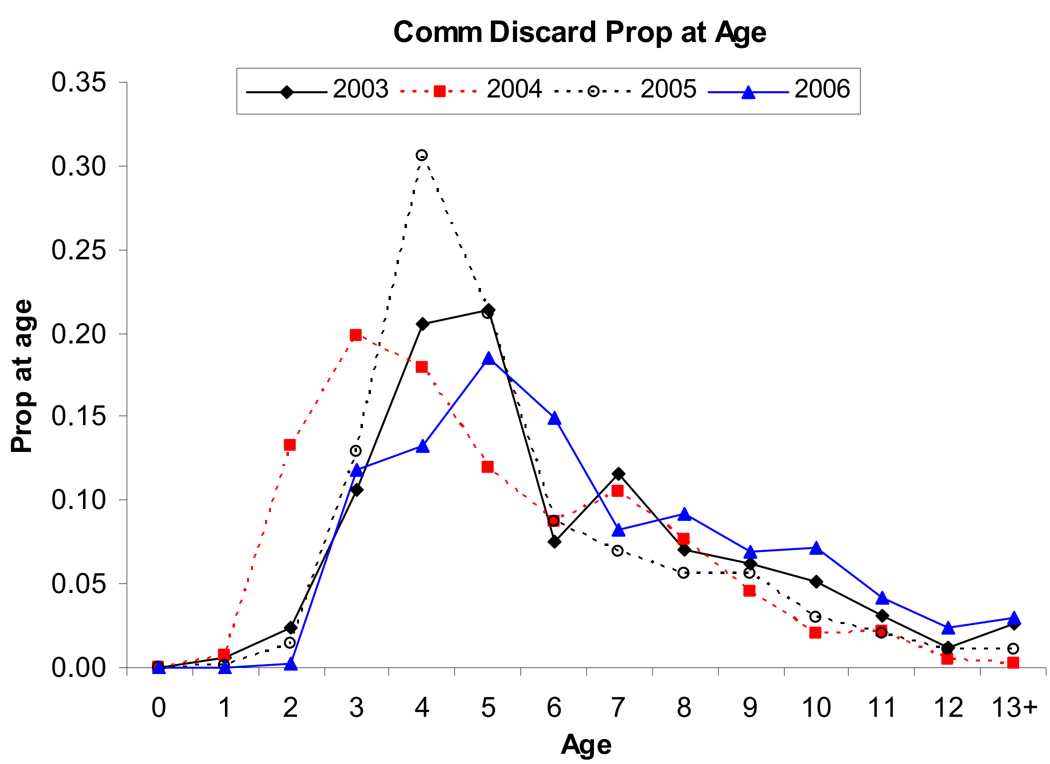


Figure A5.2. Commercial discard proportions at age, 2003-2006

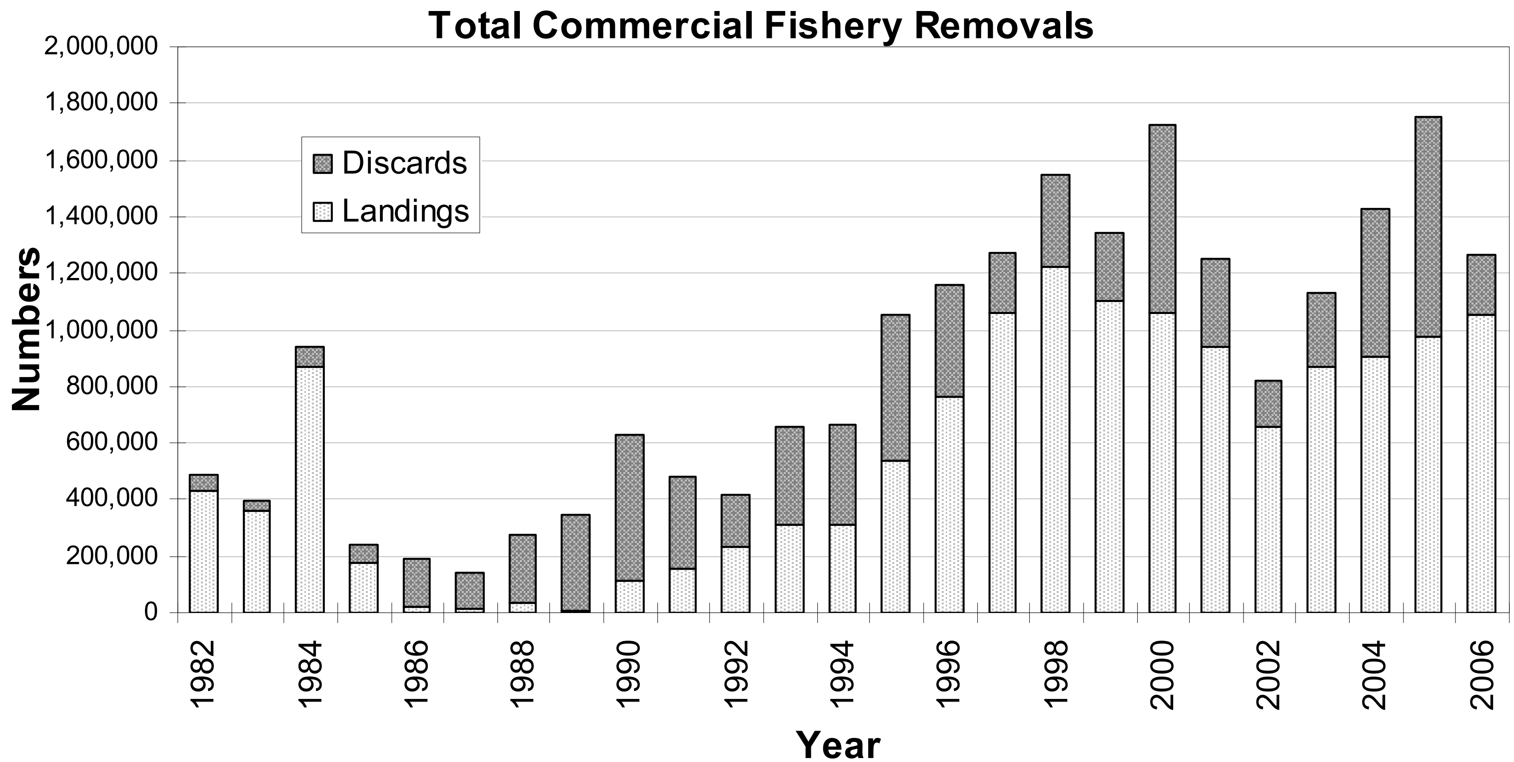


Figure A5.3. Total commercial removals (harvest and dead discards) of Atlantic striped bass, 1982-2006

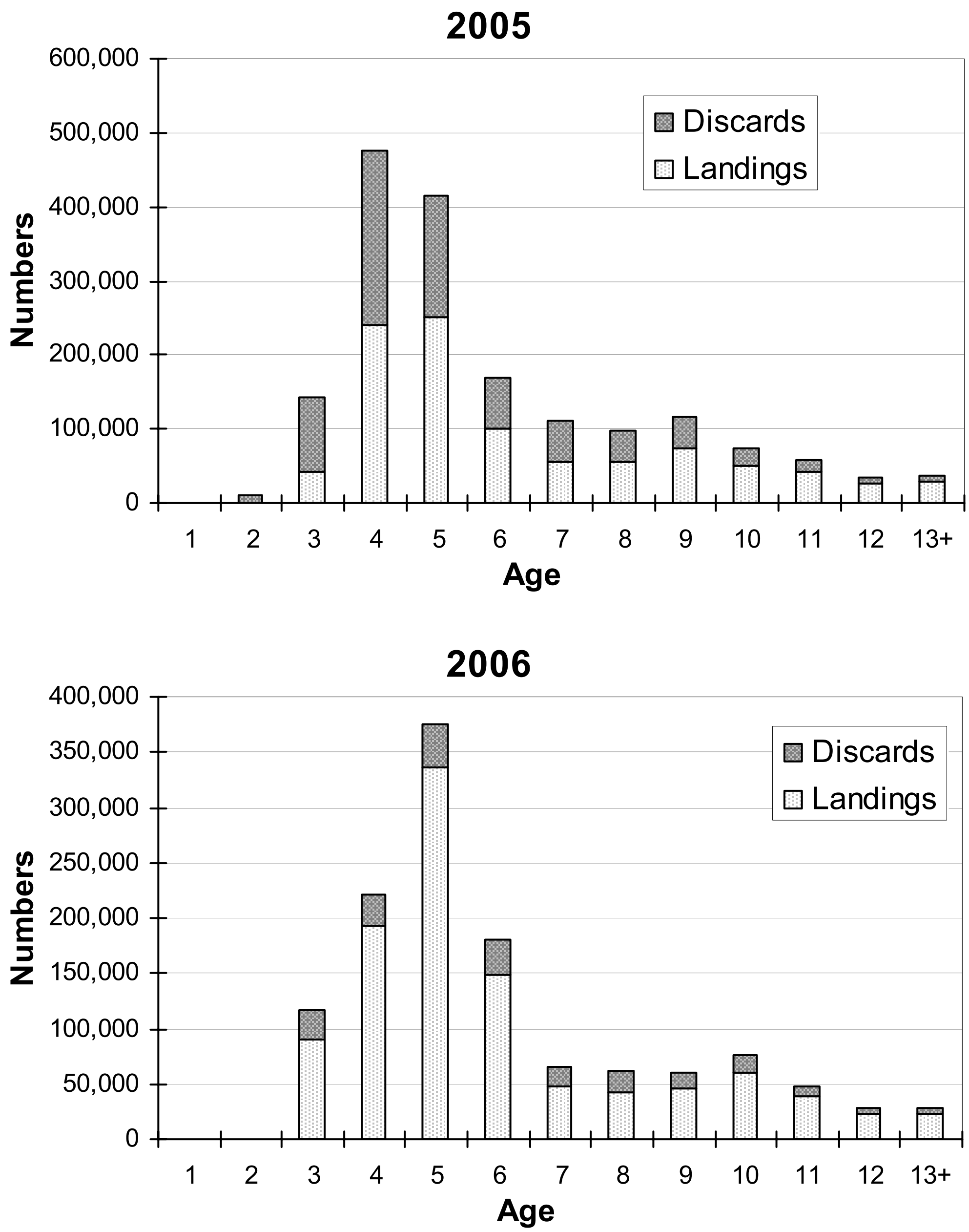


Figure A5.4. Total commercial removals (harvest and dead discards) by age of the Atlantic striped bass, 2005 and 2006

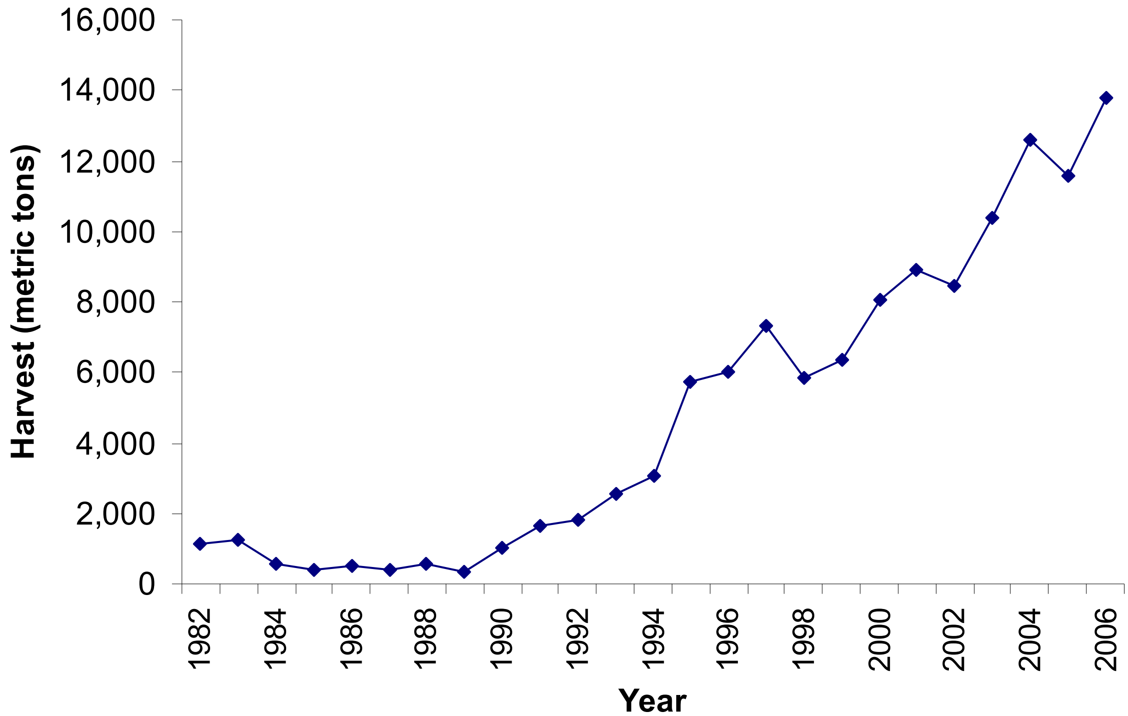


Figure A5.5. Total recreational harvest (metric tons) of striped bass along the US Atlantic coast (ME-NC), 1982-2006.

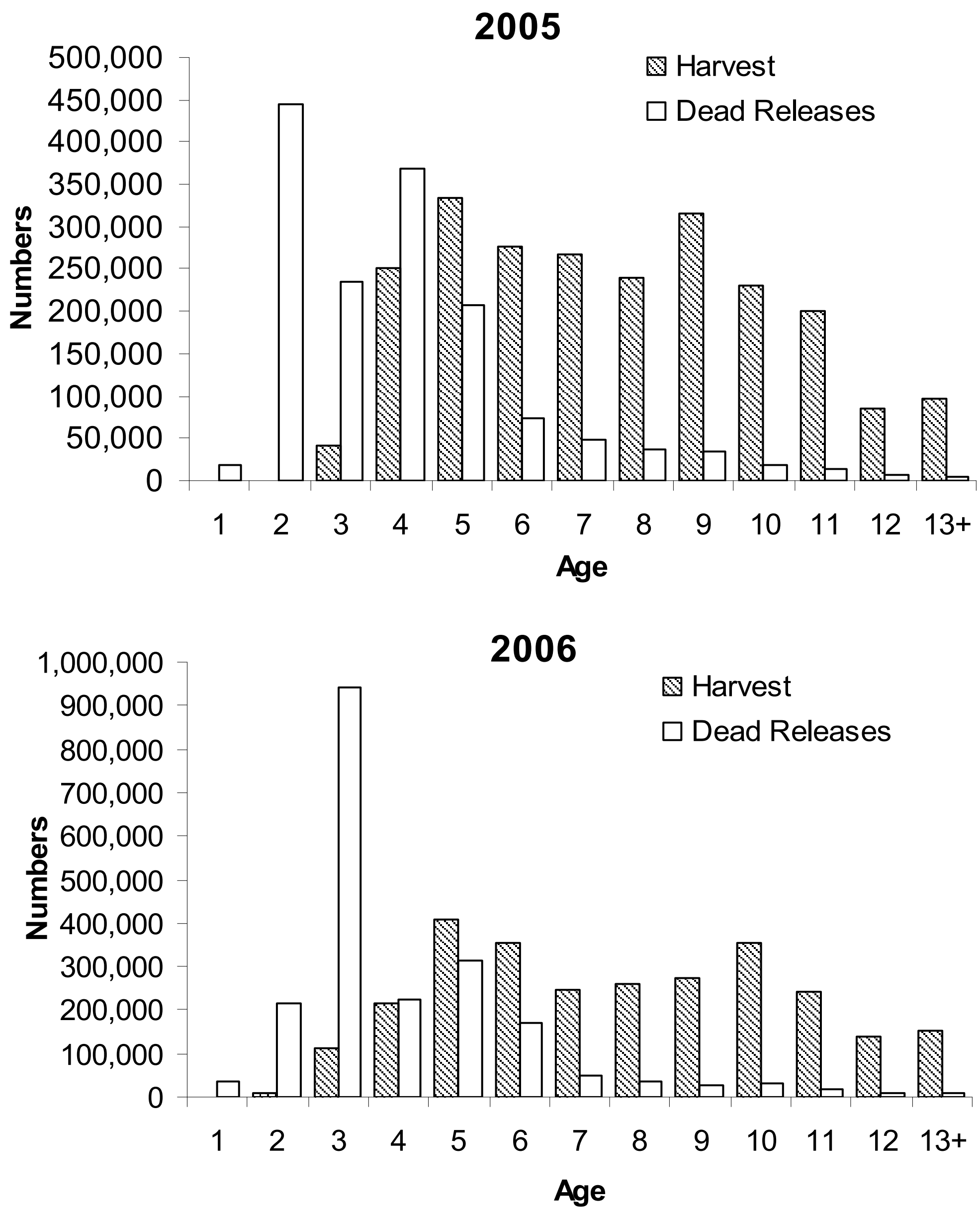
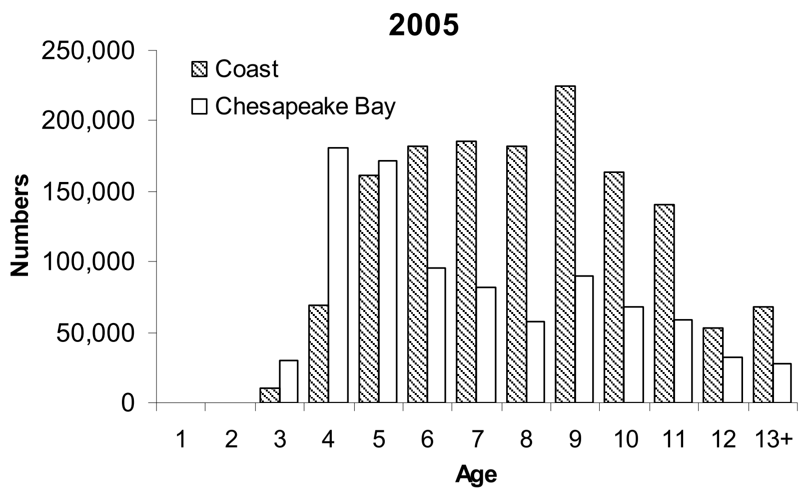
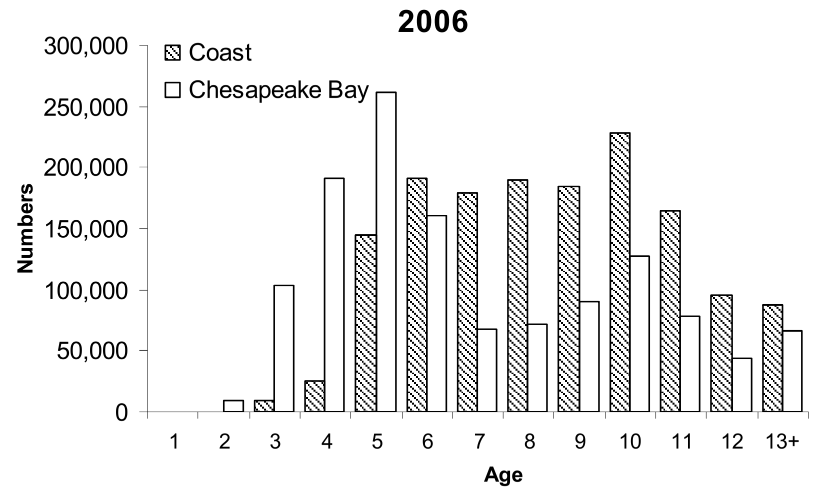


Figure A5.6. Comparison of age compositions from recreational harvest and dead release, 2005 and 2006.

A.





B.

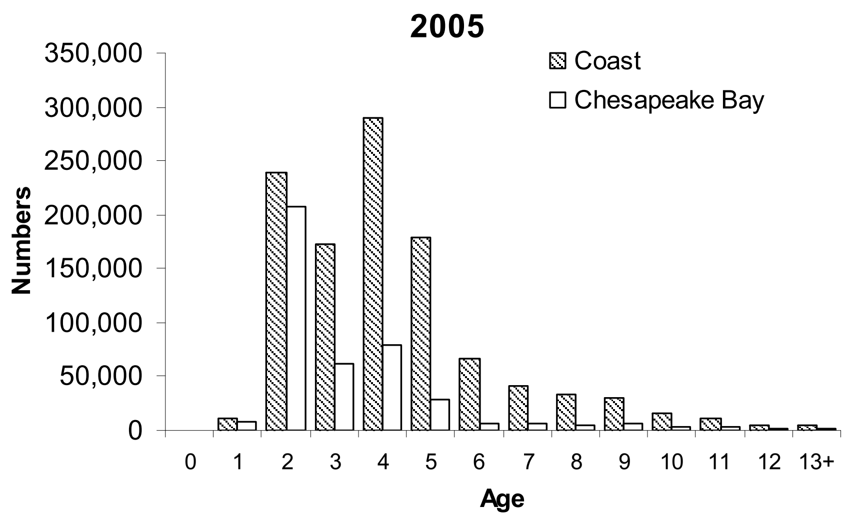


Figure A5.7. Comparison of age compositions between coast and Chesapeake Bay for A) harvested fish and B) dead releases in 2005 and 2006

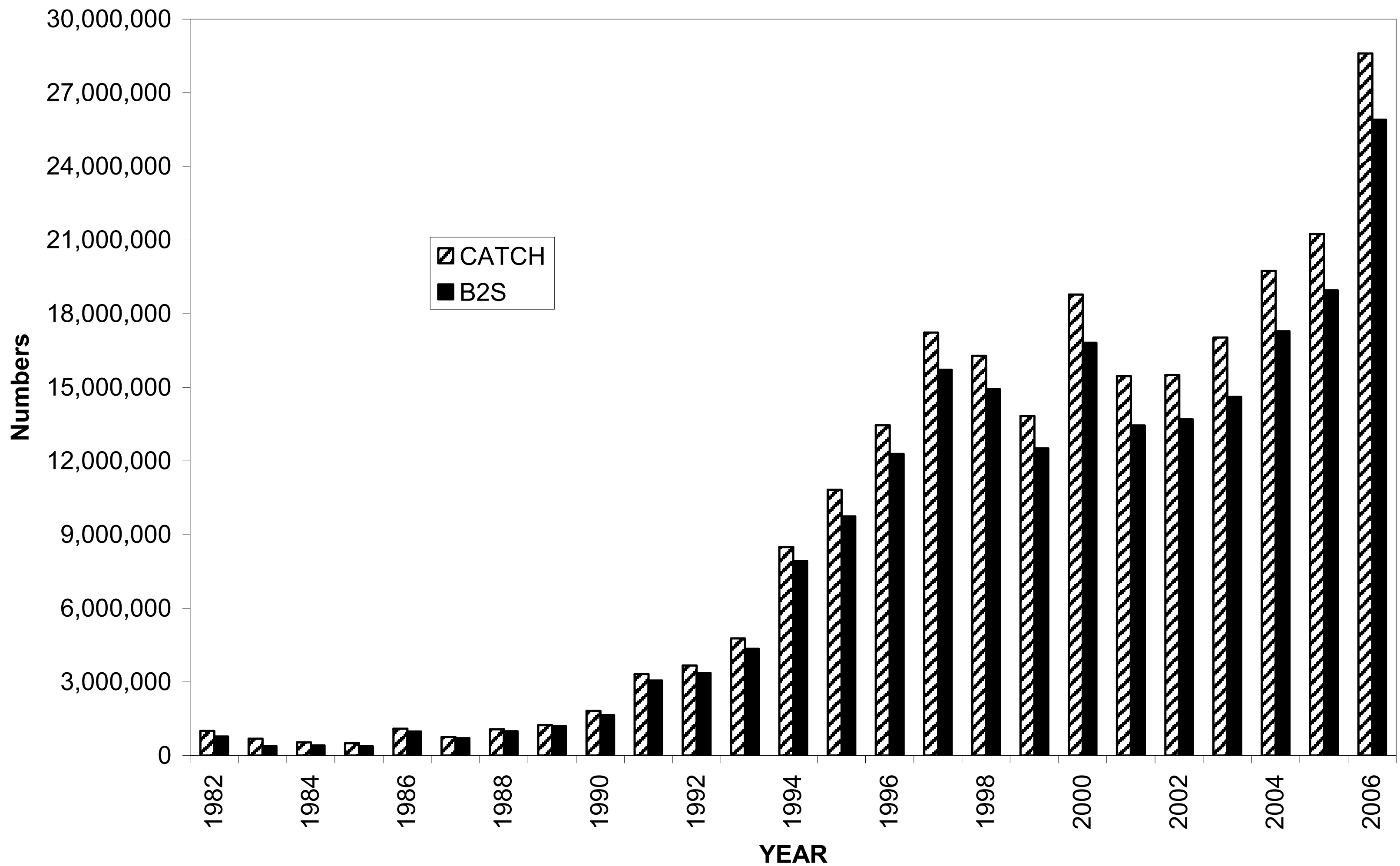


Figure A5.8. MRFSS estimates of catch and live releases (B2) for the US Atlantic coast (ME-NC), 1982-2006.

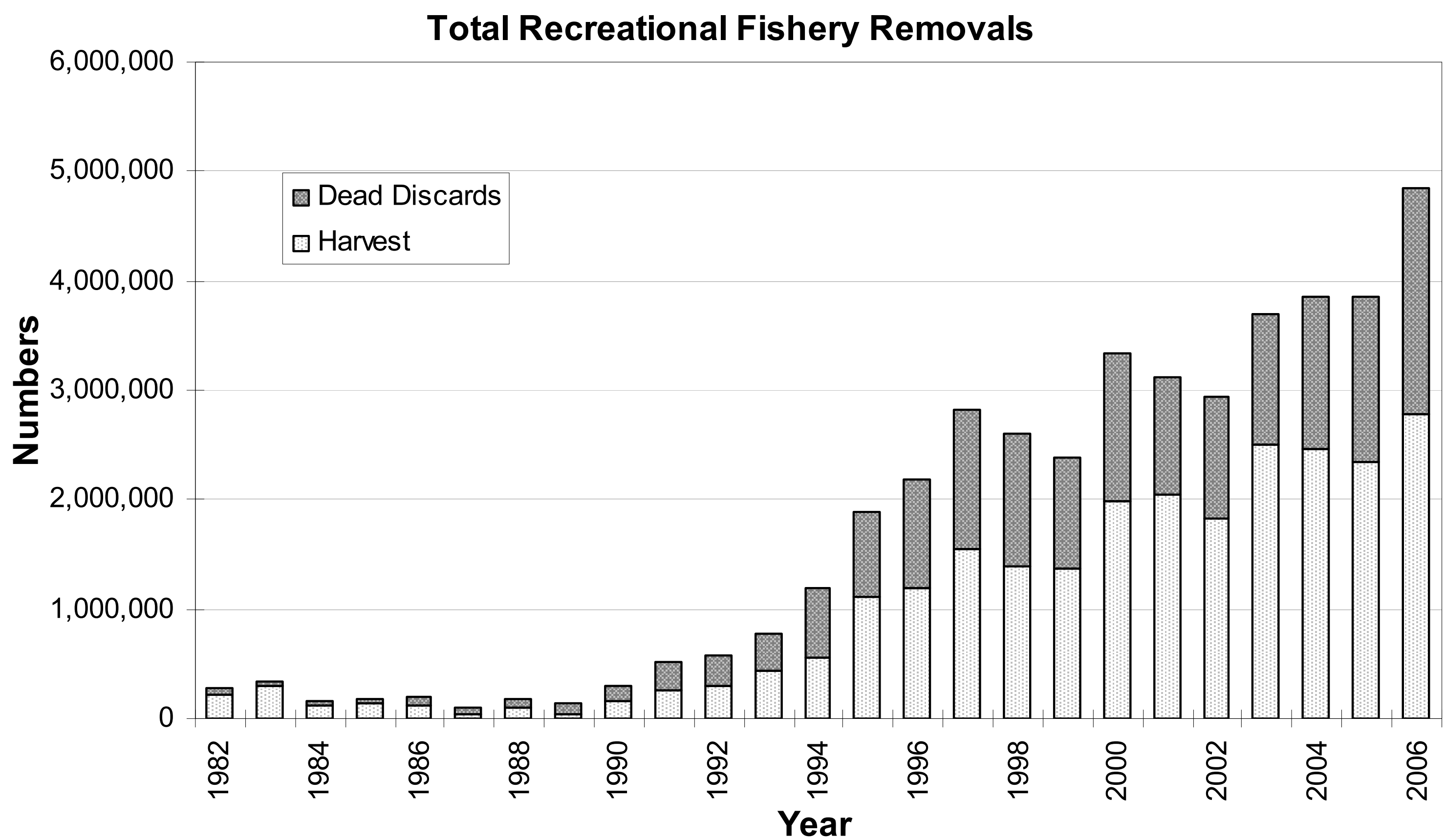


Figure A5.9. Total removals (harvest and dead discards) by the recreational fishery for striped bass, 1982-2006

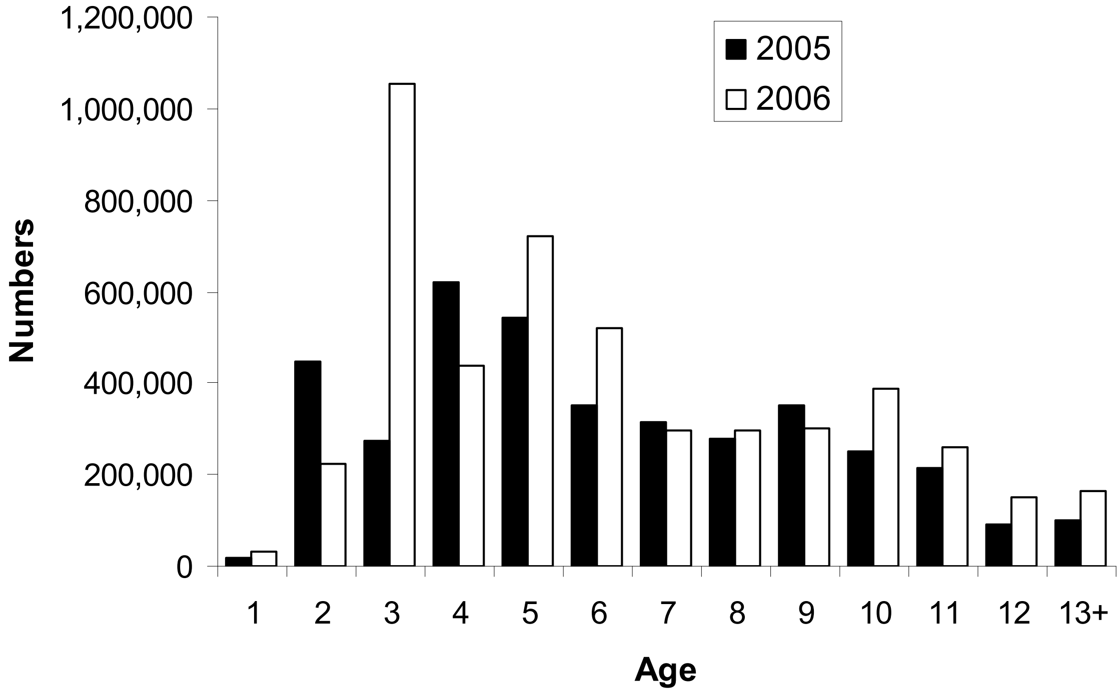


Figure A5.10. Total recreational removals (harvest and dead discards) by age, 2005-2006.

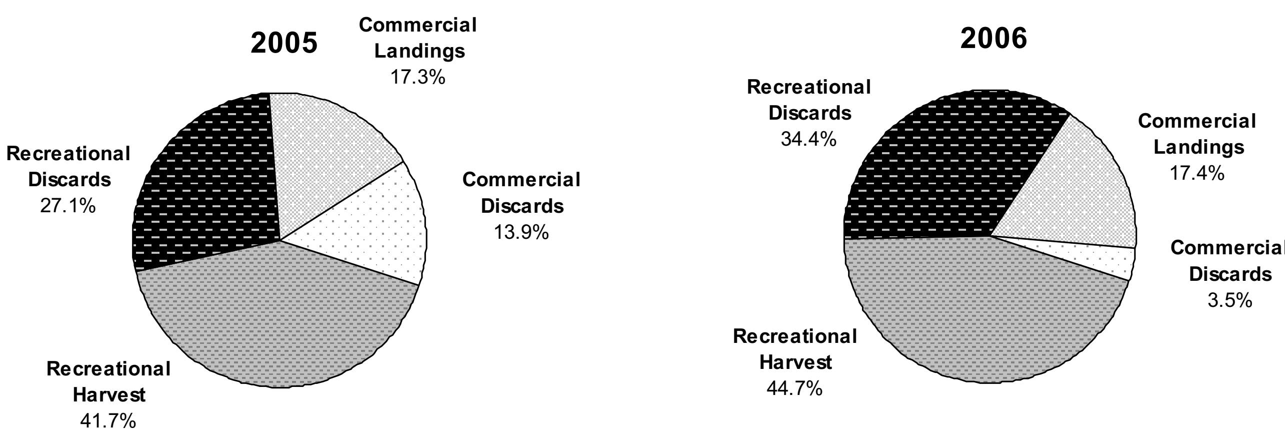


Figure A5.11. Percentage of 2005 and 2006 striped bass mortality by fishery component

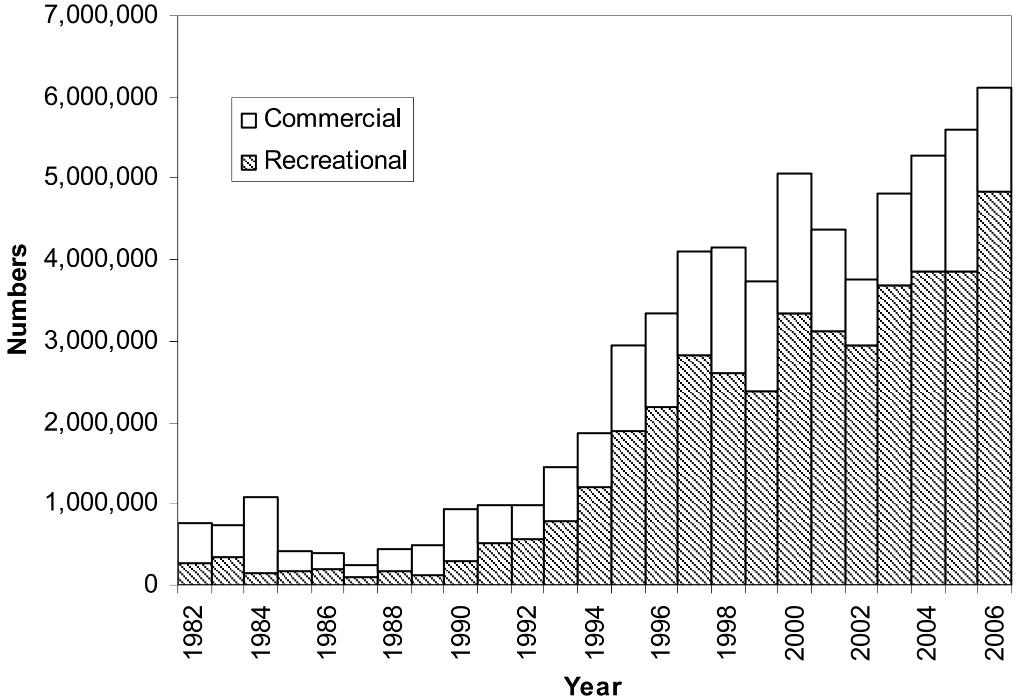


Figure A5.12. Total removals of striped bass partitioned into commercial and recreational contributions, 1982-2006.

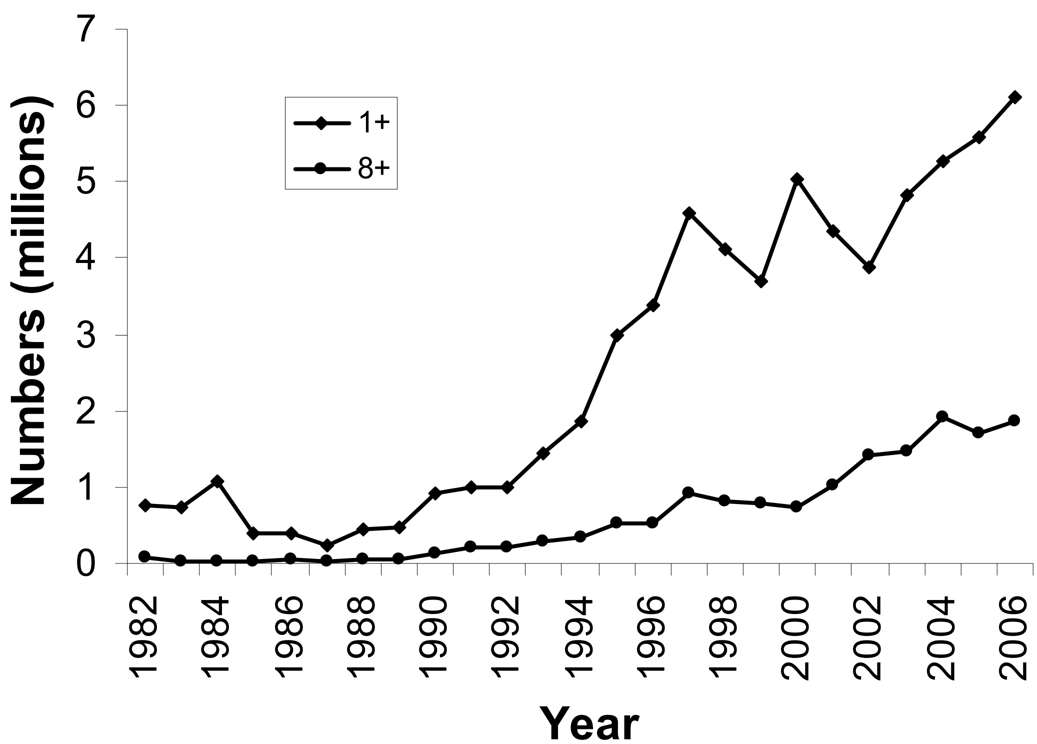


Figure A5.13. Total removals of striped bass by age group, 1982-2006

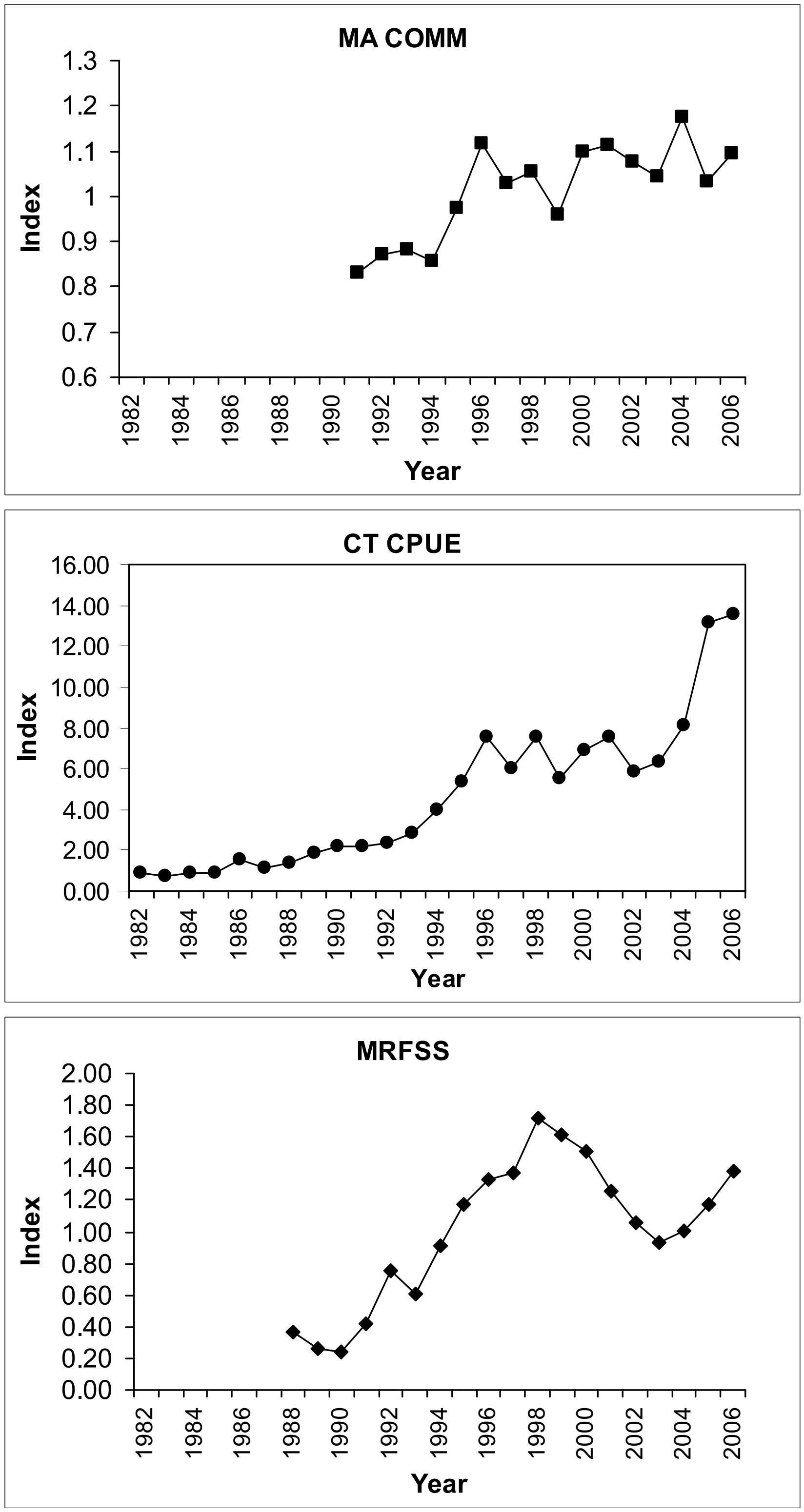


Figure A6.1. Fishery-dependent indices of relative abundance (aggregated), 1982-2006

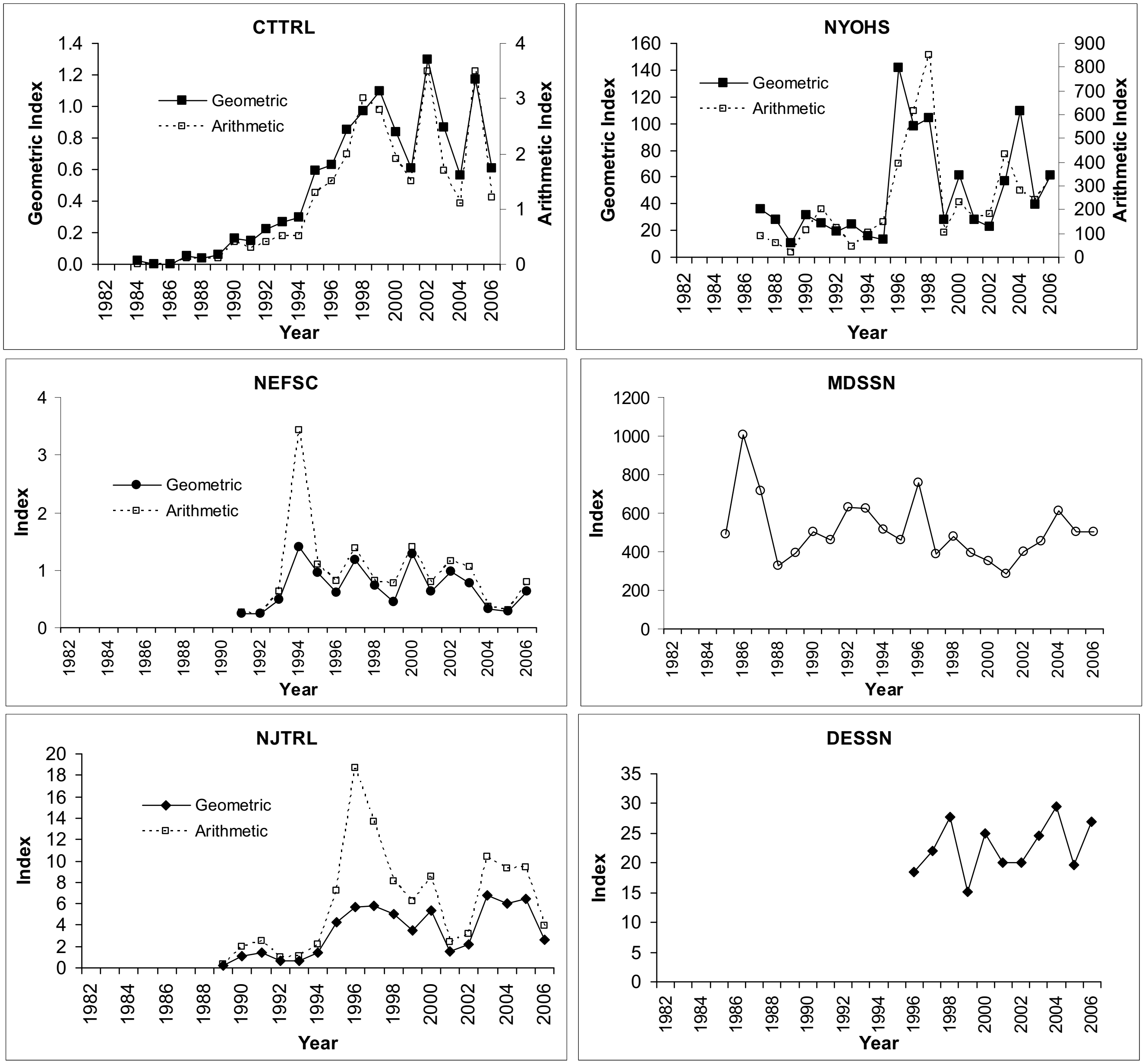


Figure A6.2. Fisheries-independent indices of relative abundance for ages 2-13+(aggregated), 1982-2006.

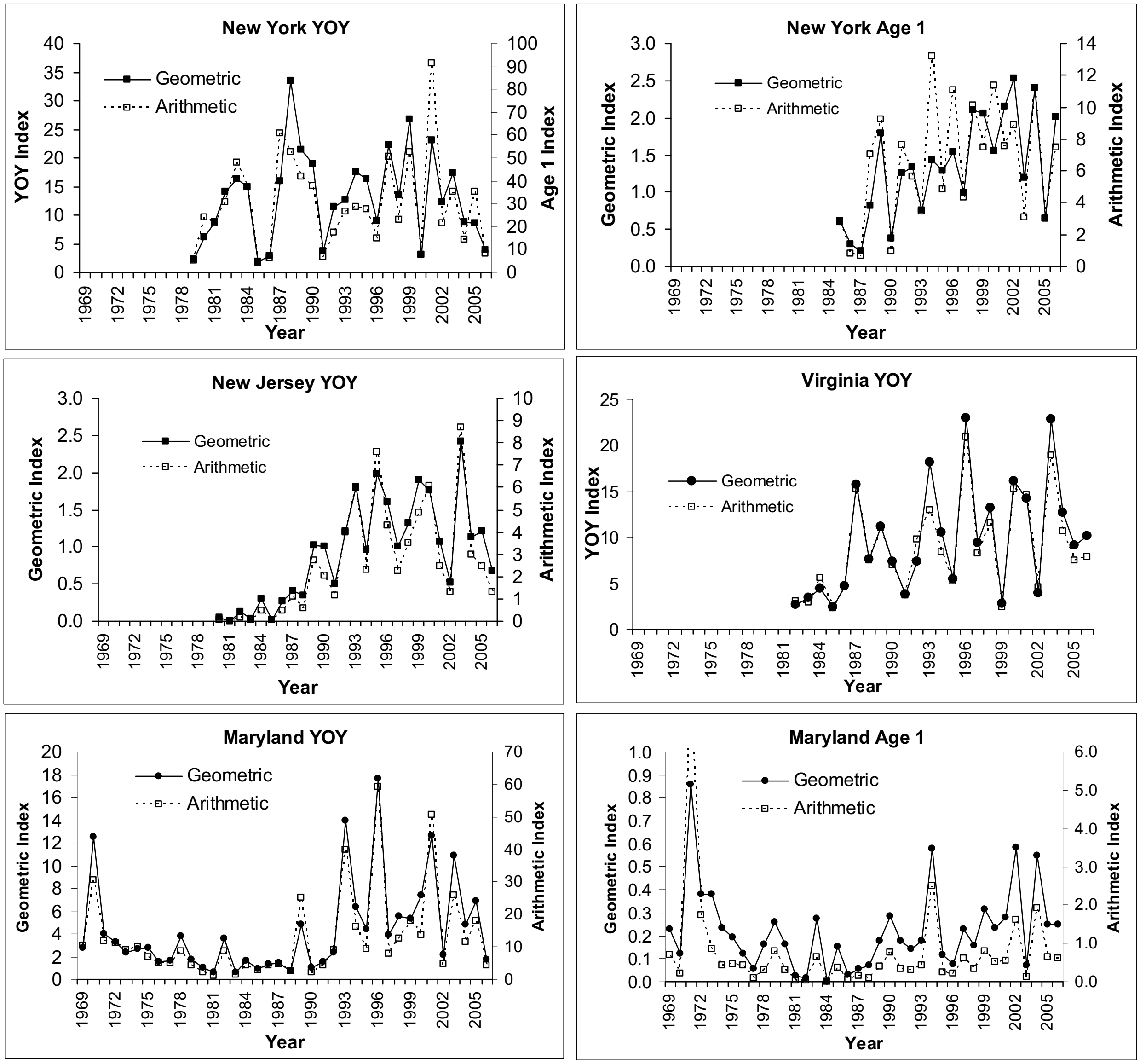


Figure A6.3. Young-of-the-year and age 1 indices of striped bass relative abundance

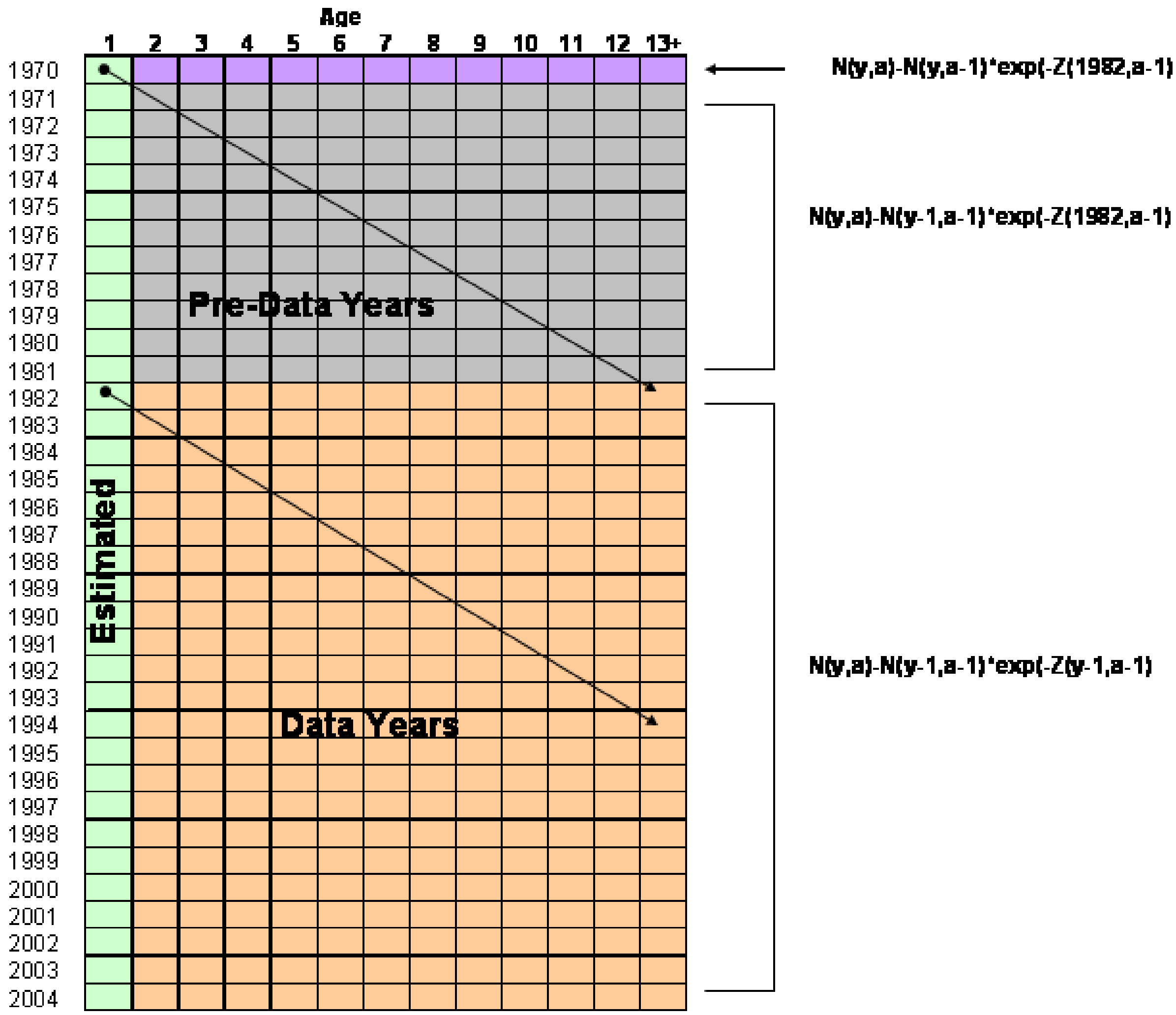


Figure A7.1. Schematic of population abundance-at-age

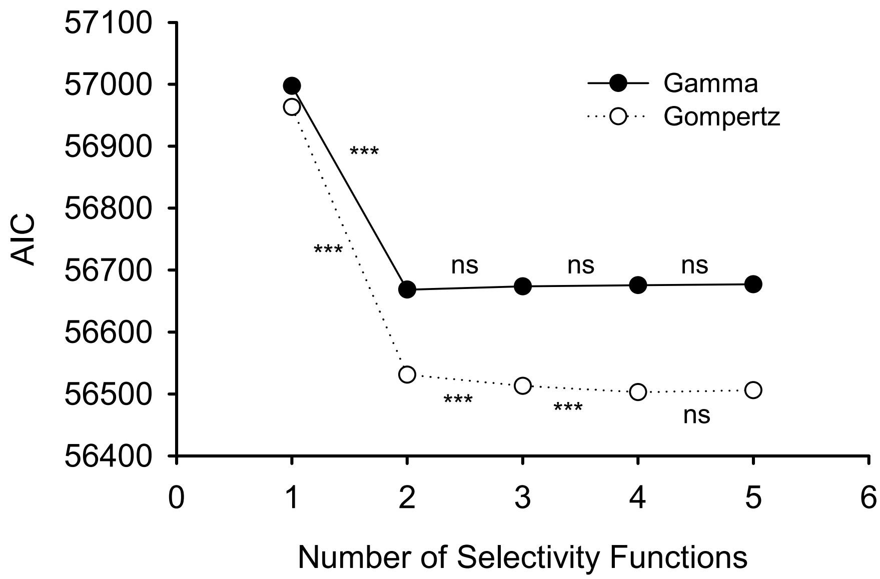


Figure A7.2. Plot of resulting AIC values from SCA model runs in which the number and type of selectivity function varied. Asterisks indicate the likelihood ratio tests' level of significance (*** p<=0.001) of comparisons between successive models.

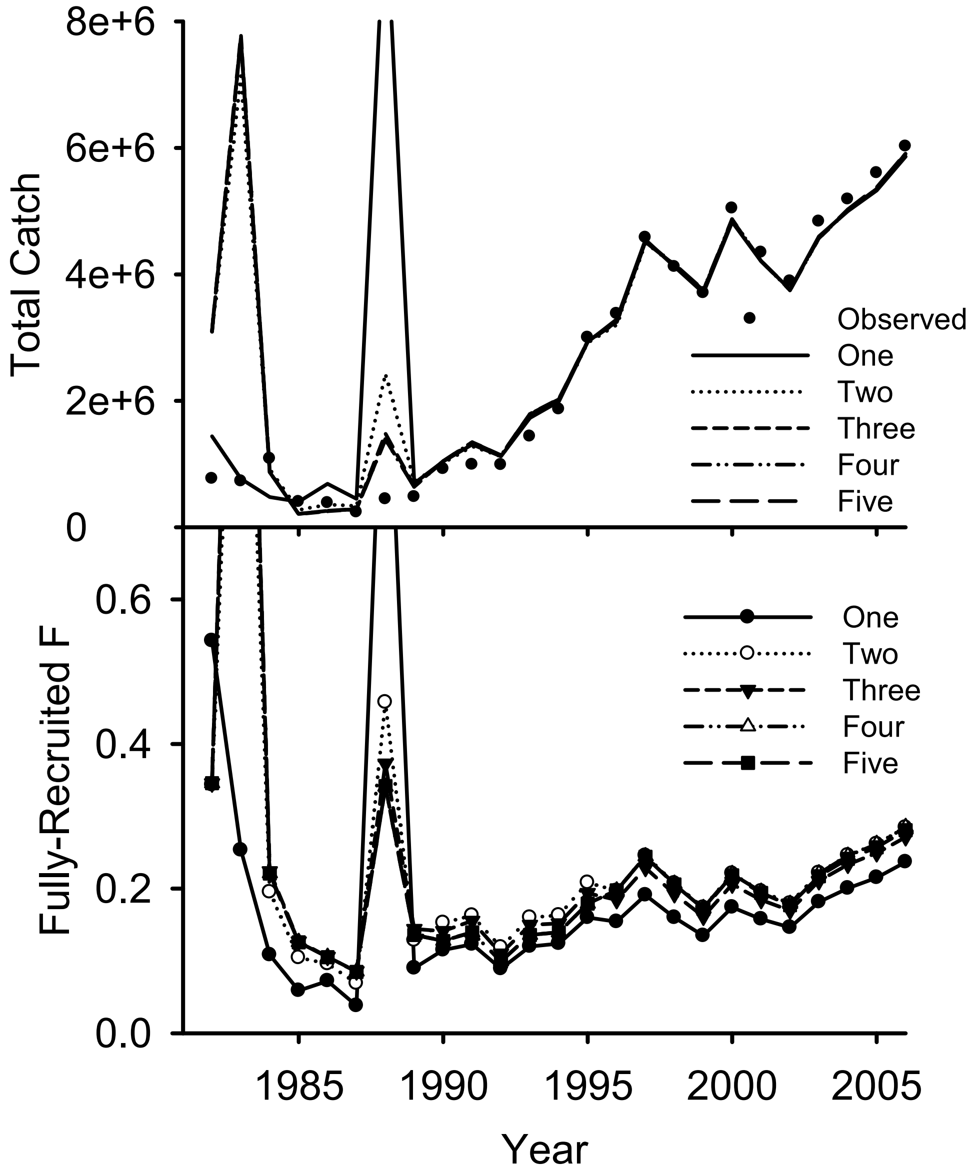


Figure A7.3. Observed and predicted total catch predictions from SCA and estimated fully-recruited fishing mortality by number of selectivity periods under equal weighting of all components.

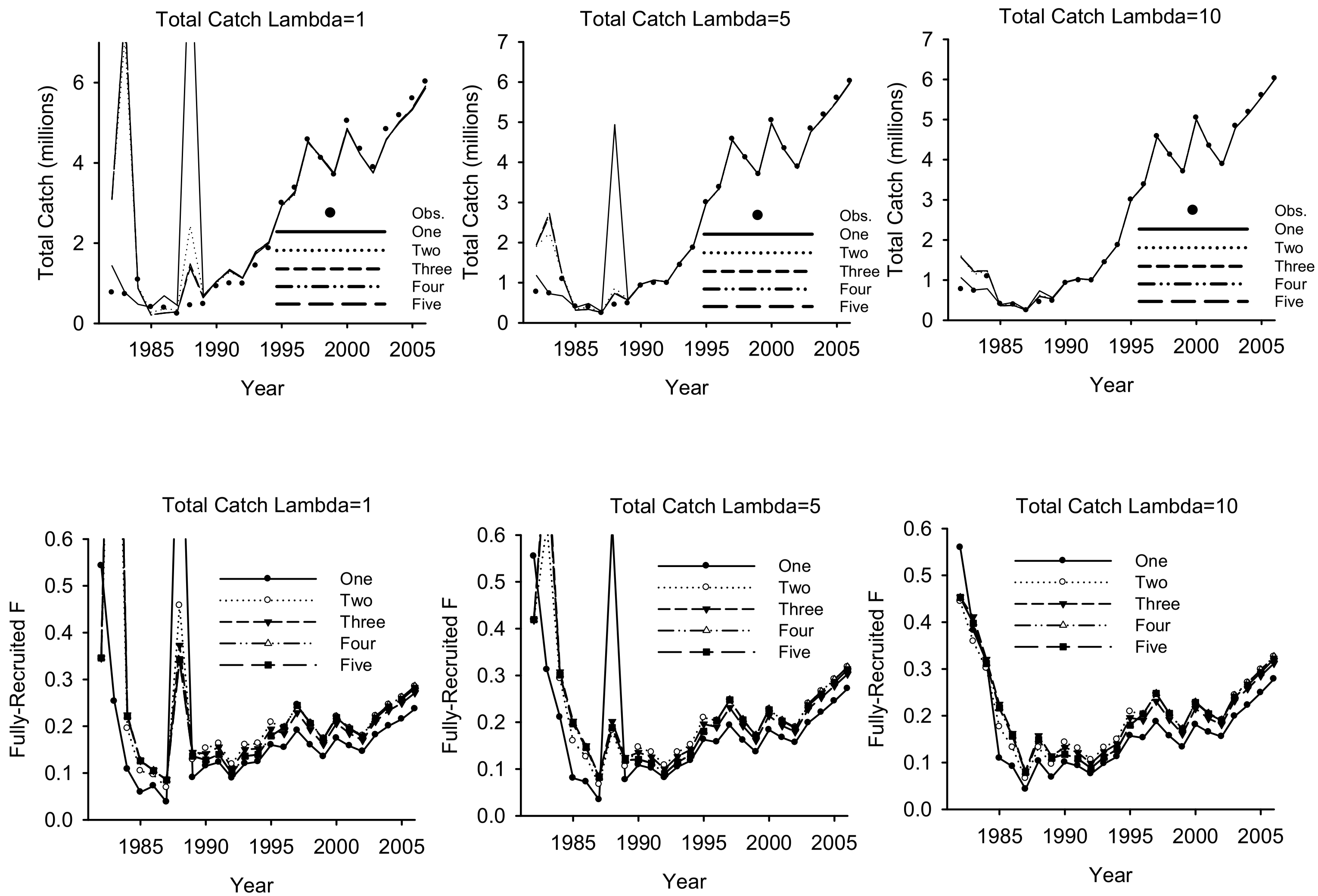
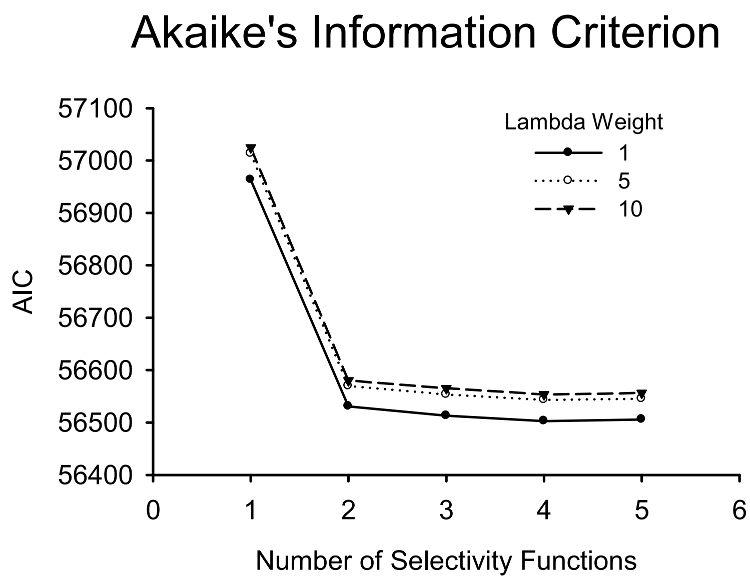


Figure A7.4. Comparison of observed and predicted total catch and fully-recruited F estimates from SCA model runs in which total catch lambda weights and number of selectivity periods (with Gompertz functions) were varied.



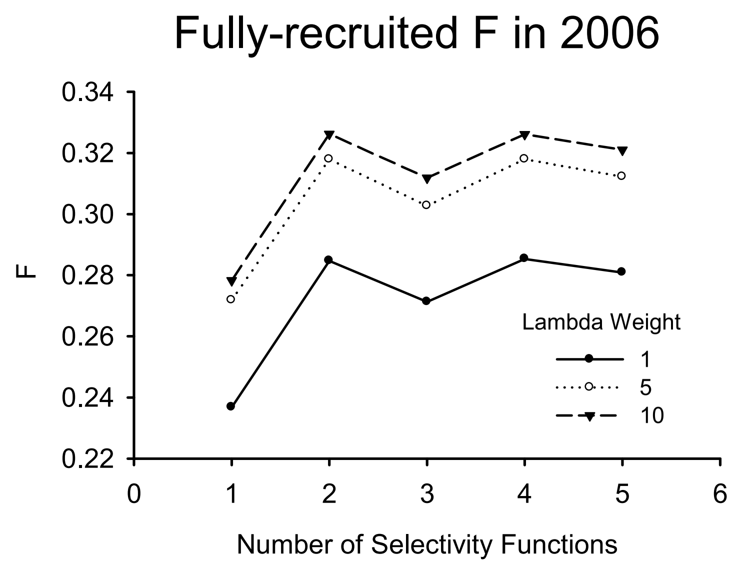


Figure A7.5. Comparison of Akaike's Information Criterion and fully-recruited F in 2006 from SCA model runs in which total catch lambda weights and number of selectivity periods (with Gompertz functions) were varied.

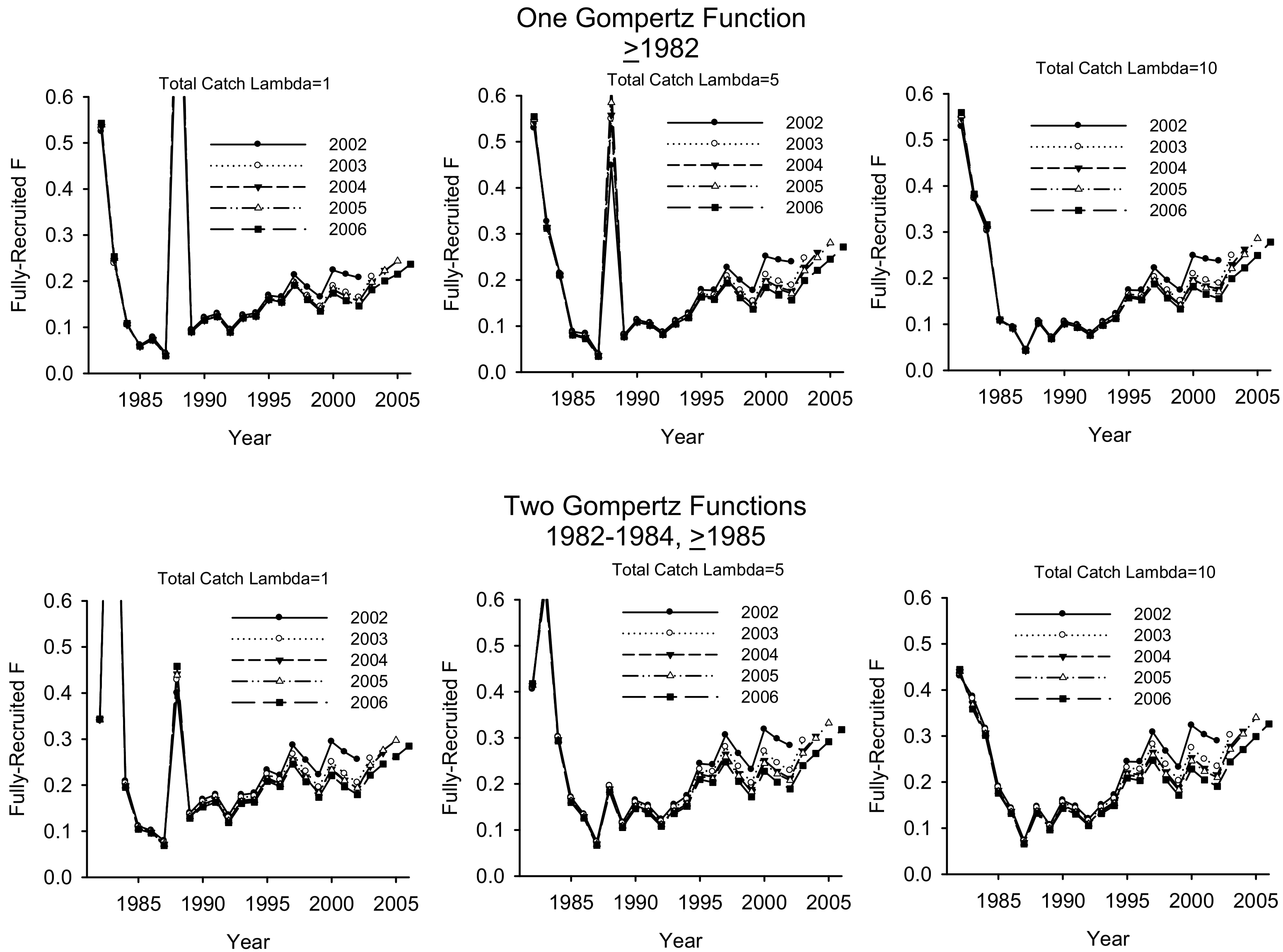


Figure A7.6. Retrospective plots for SCA model runs in which the number of selectivity periods and total catch lambda weights were varied.

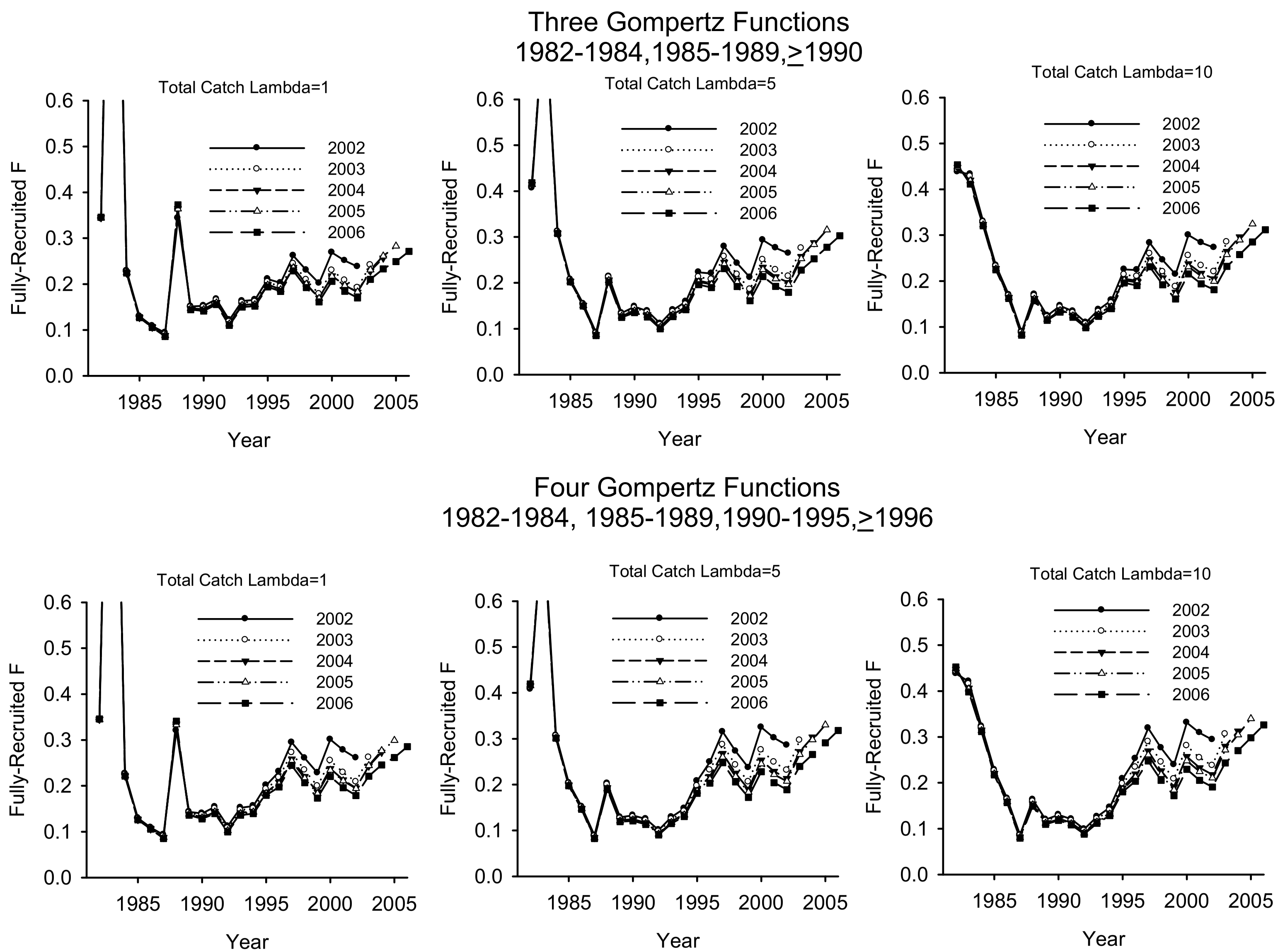


Figure A7.6 cont.

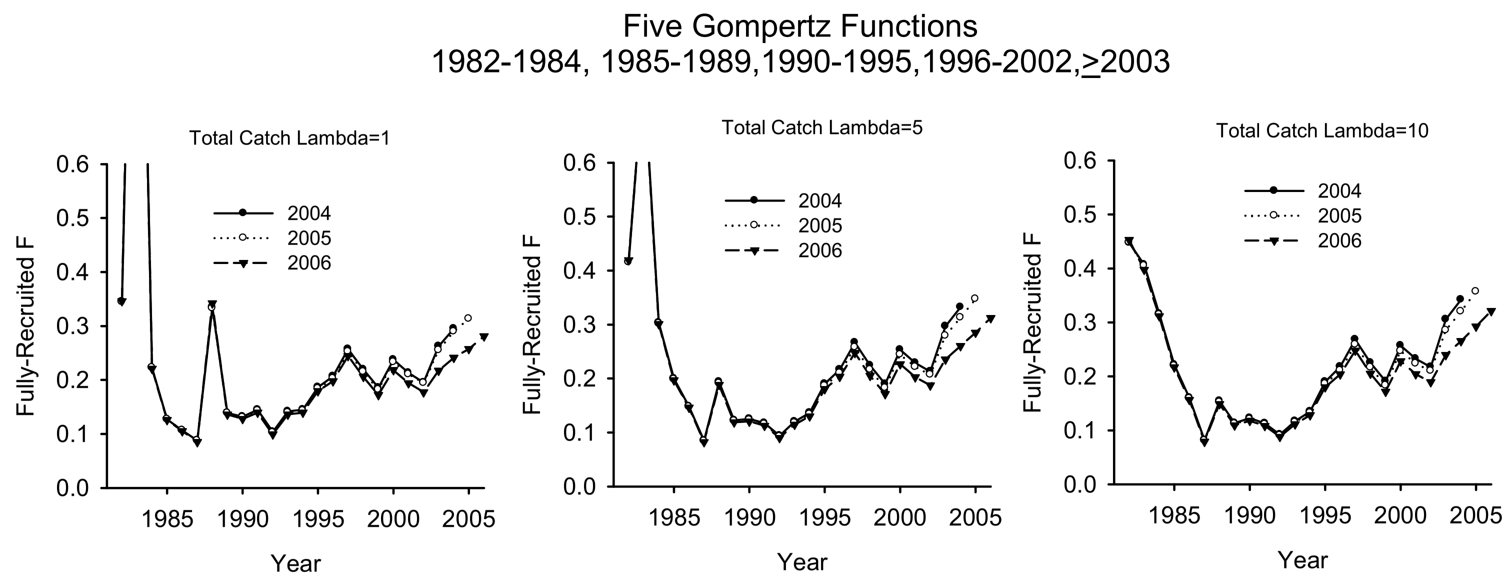


Figure A7.6 cont.

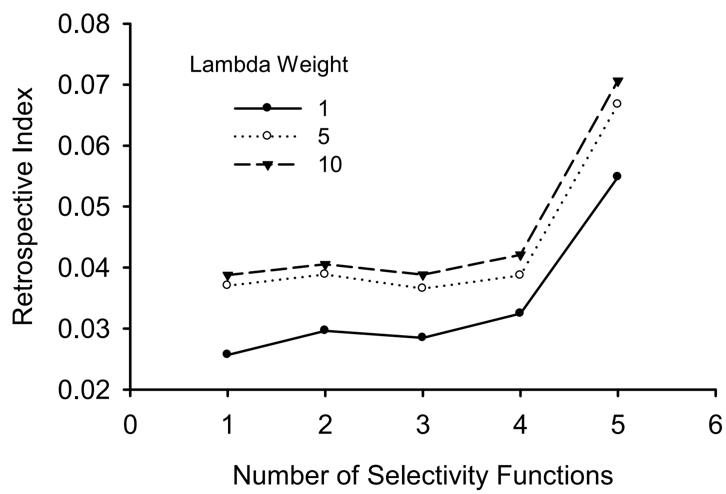


Figure A7.7. Comparison of the retrospective index among SCA model runs.

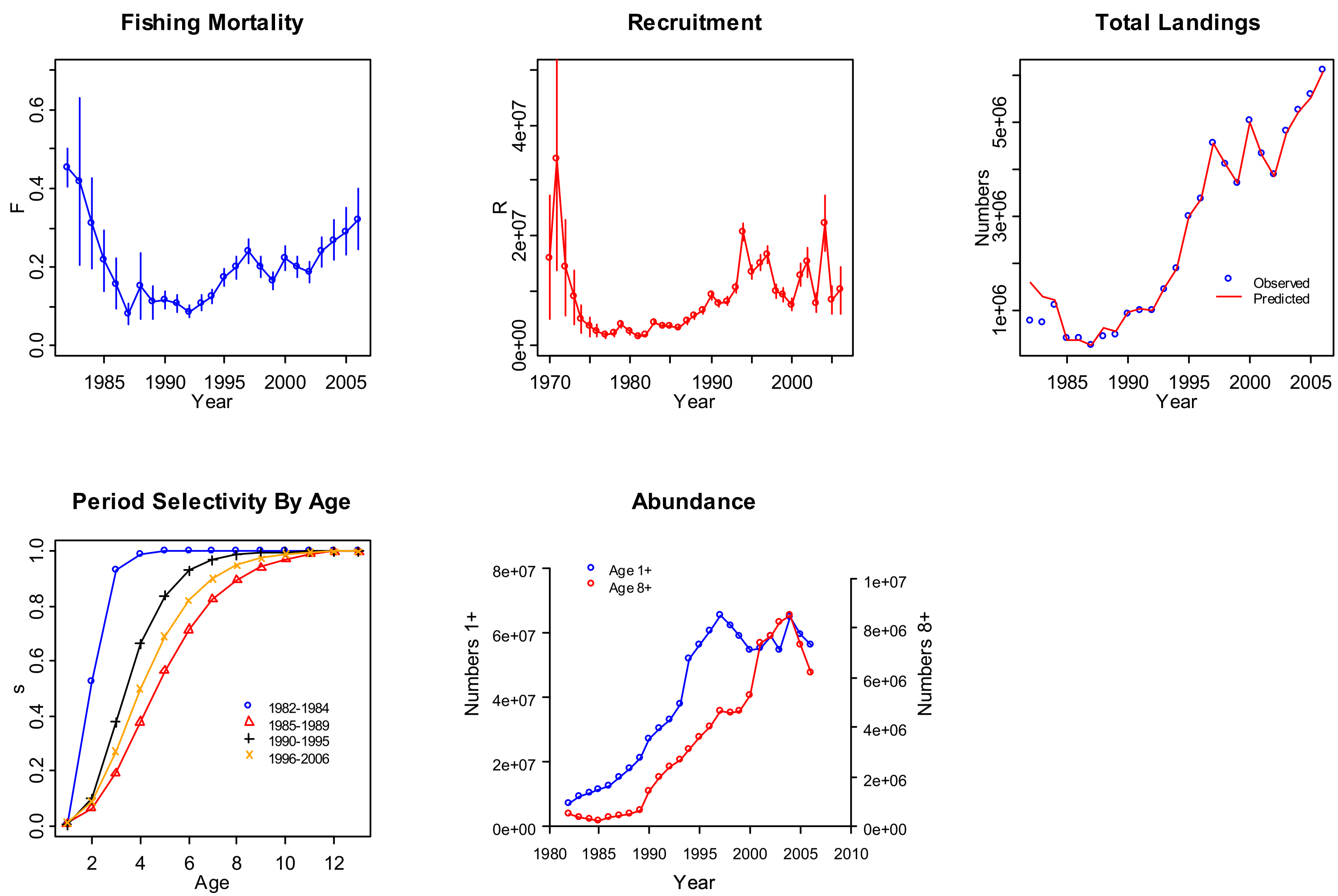


Figure A7.8. Estimates of fishing mortality (±95%CI), recruitment (±95%CI), total landings, period selectivity patterns, and abundance of ages 1+ and 8+ from the final configuration SCA model run.

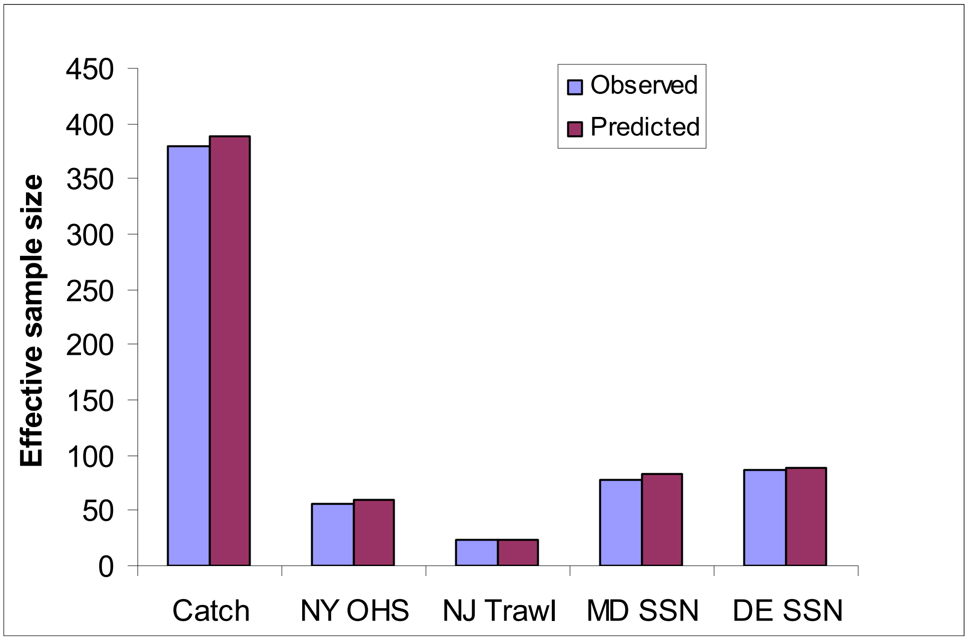


Figure A7.9. Comparison of observed (from equal weighting) and predicted effective sample sizes under the SCA final model run with total catch lambda=10.

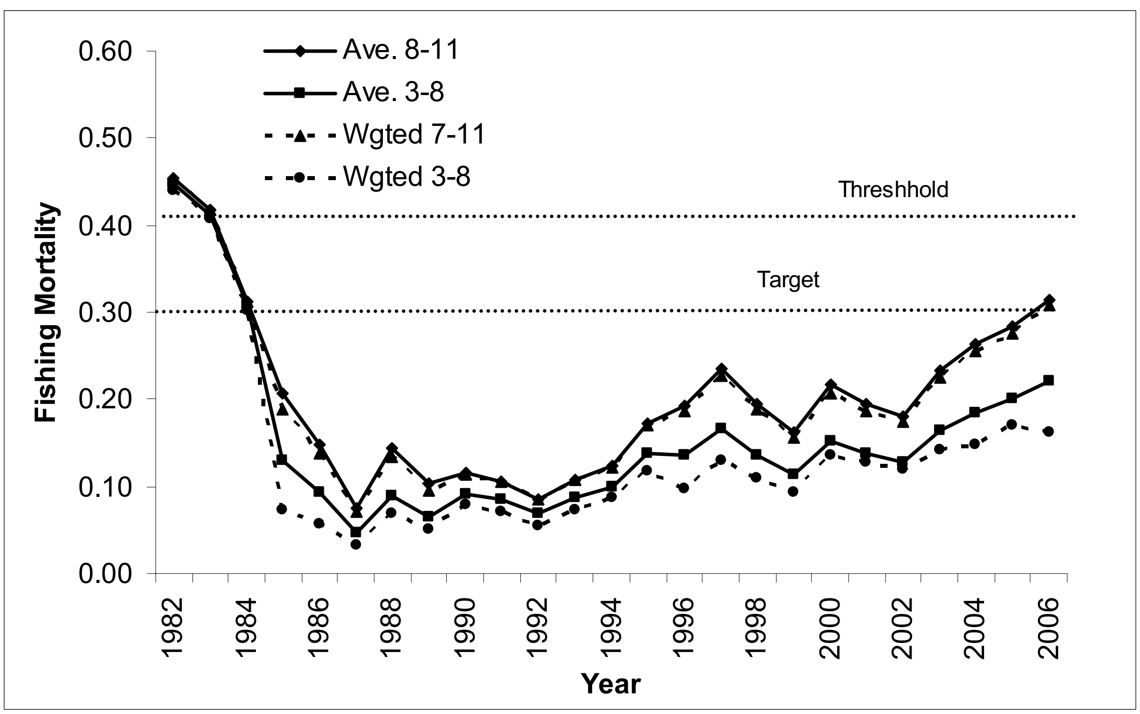


Figure A7.10. Comparison of fishing mortality estimates from the SCA model.

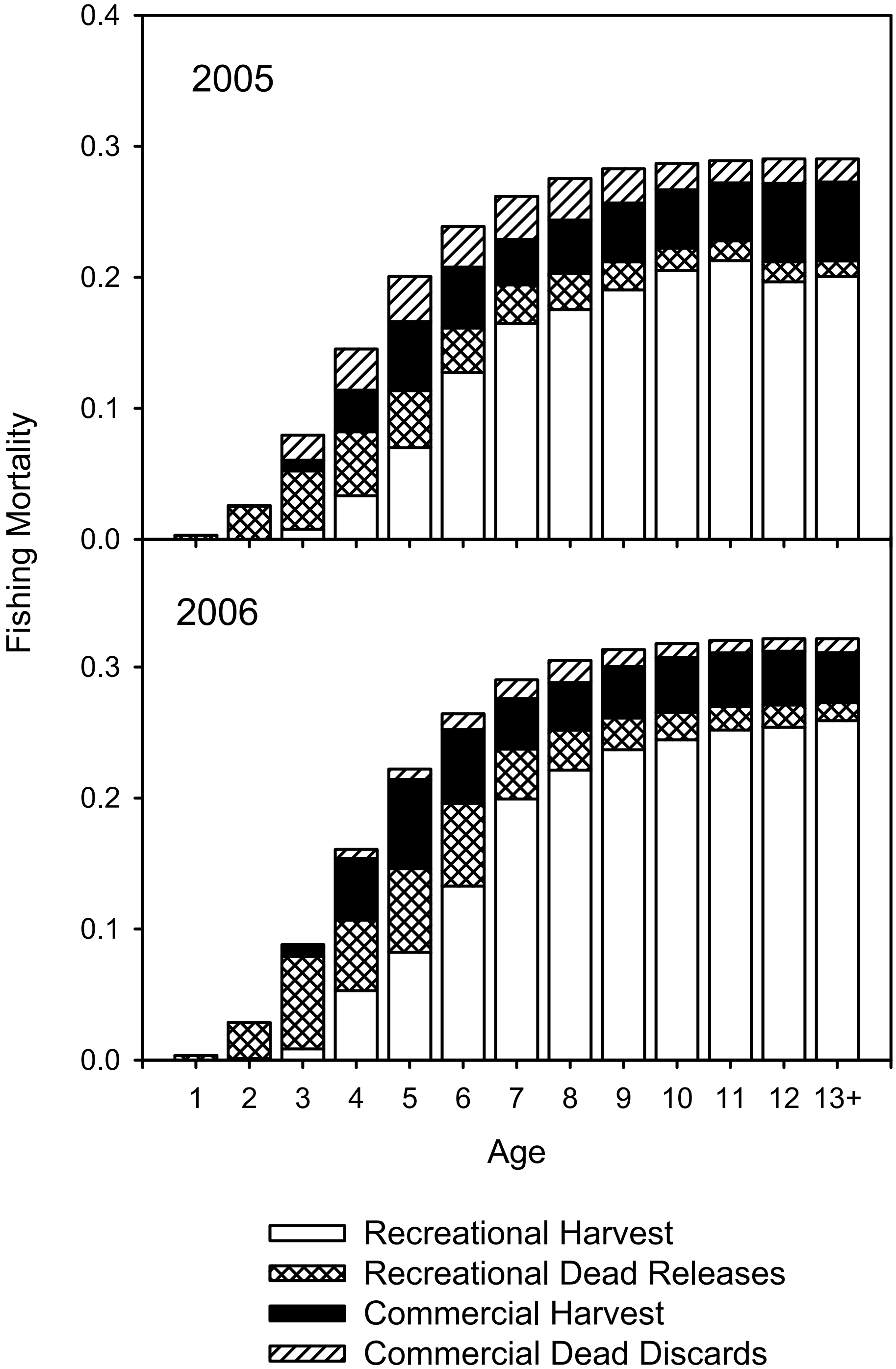


Figure A7.11. Comparison of fishing mortality in 2005 and 2006 from the SCA model partitioned into fishery components

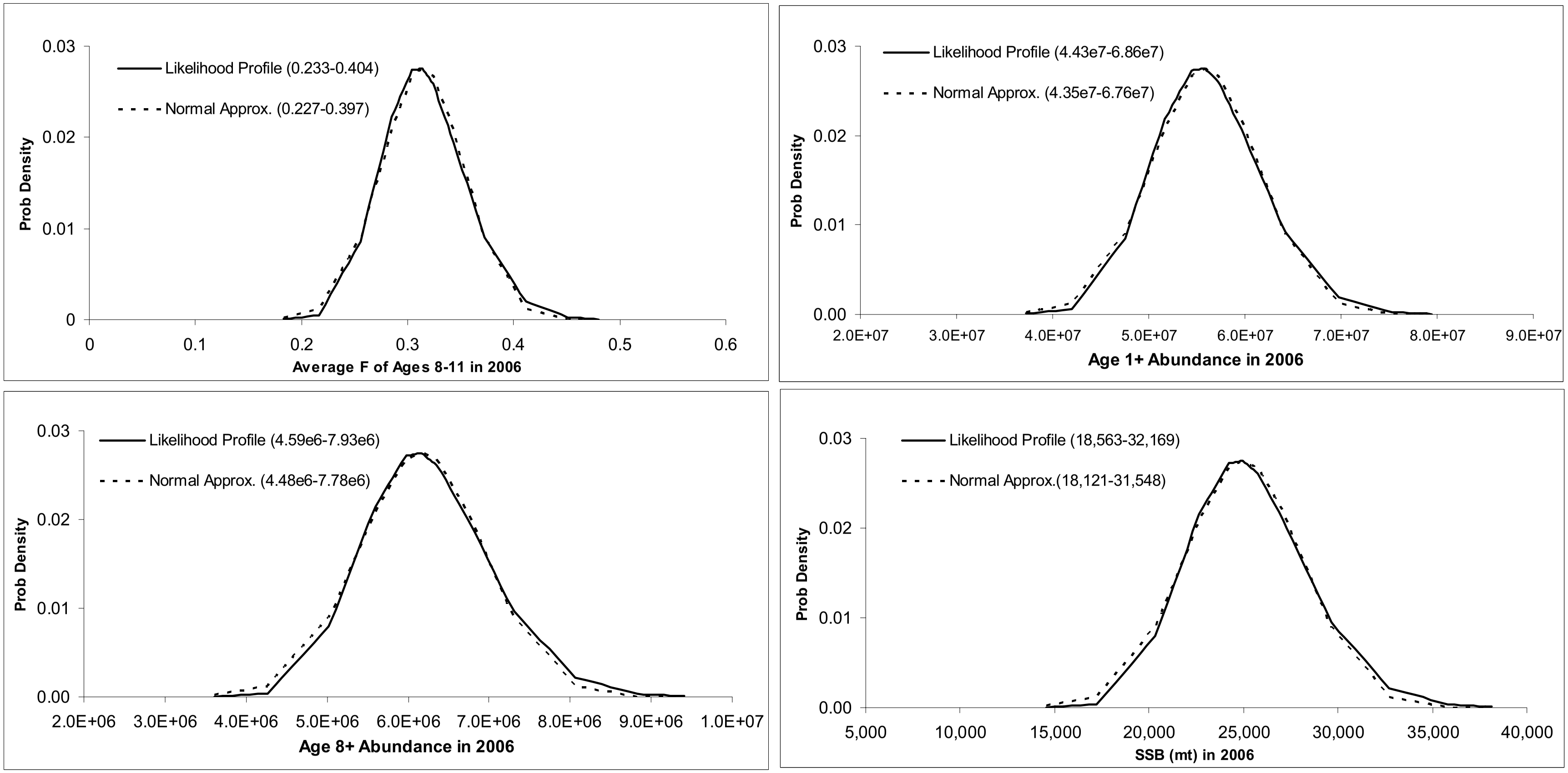


Figure A7.12. Comparison of likelihood profile and normal approximation methods for determining confidence intervals of estimates of average F of ages 8-11, age 1+ abundance, age 8+ abundance, and spawning stock biomass in 2006 from the SCA model. Lower and upper 95% confidence limits are shown in parentheses.

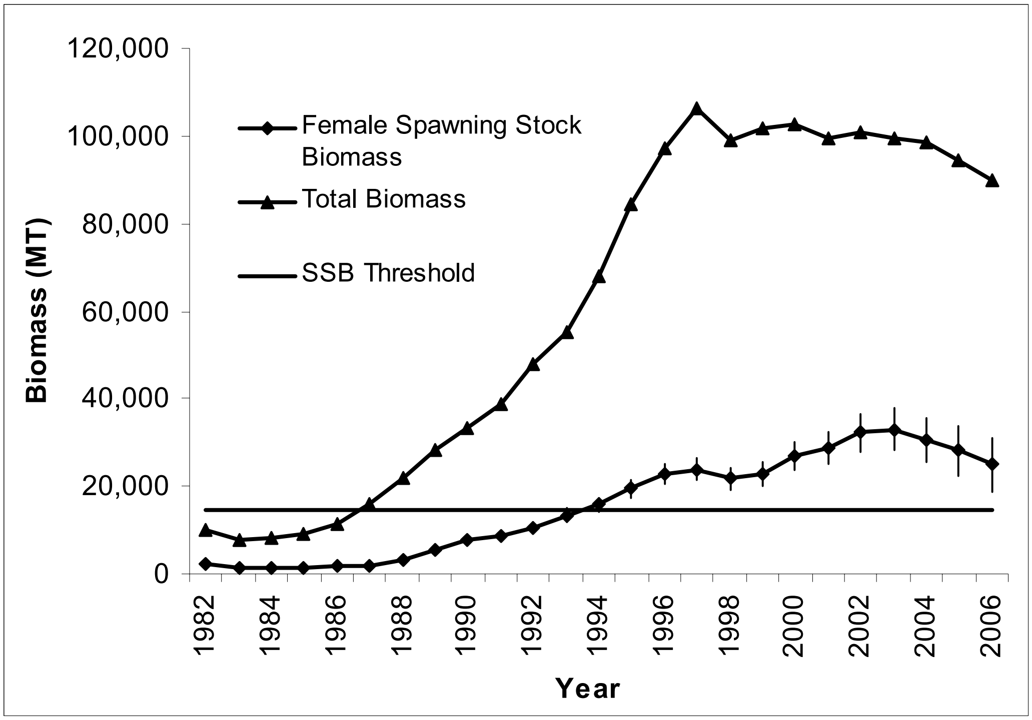


Figure A7.13. Striped bass female spawning stock biomass (mt) and Jan. 1 total biomass (mt) from the SCA model. 95% confidence intervals are shown for female spawning stock biomass.

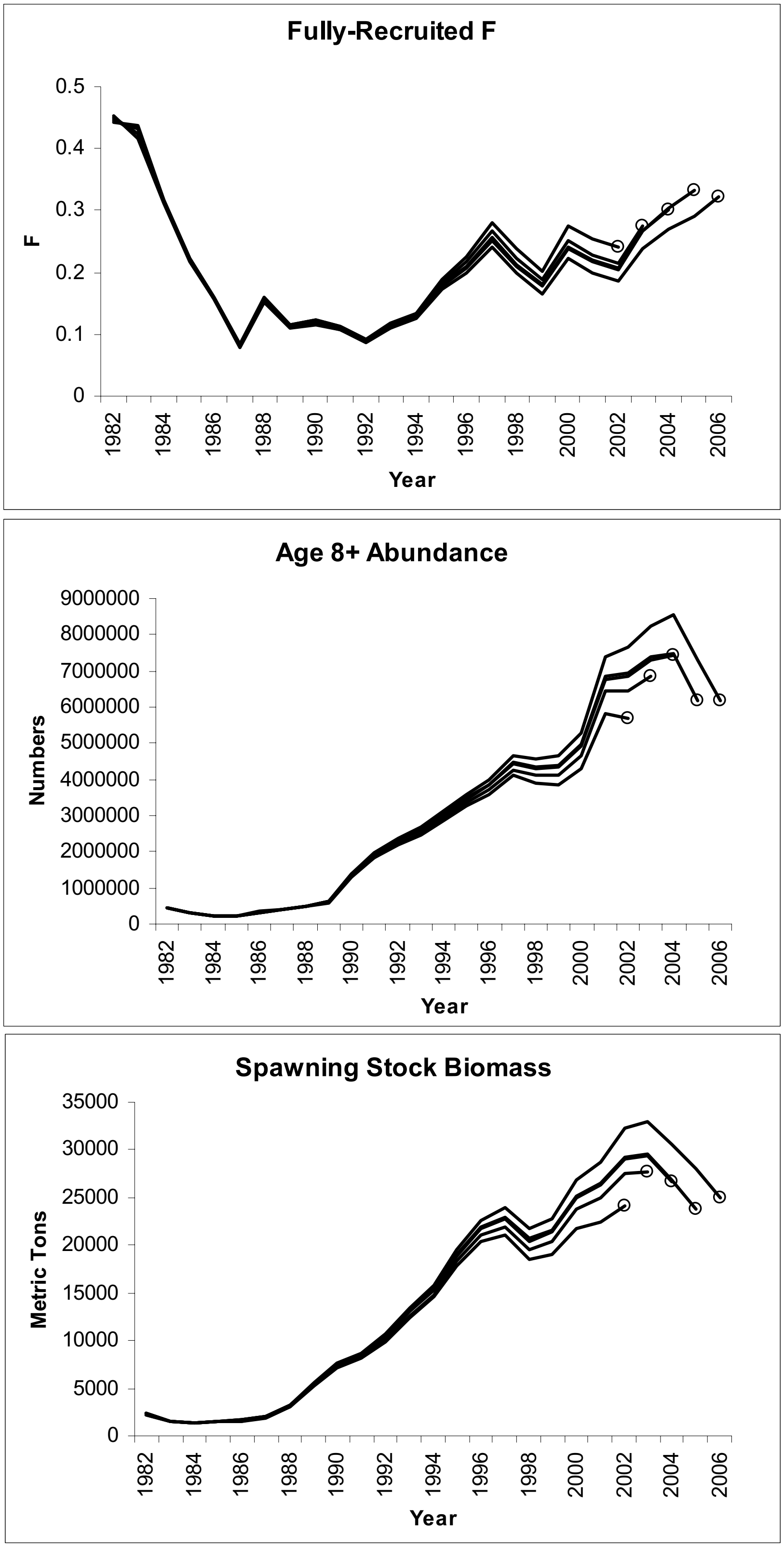


Figure A7.14. Retrospective analysis of fully-recruited fishing mortality, 8+ abundance, and spawning stock biomass from the SCA model.

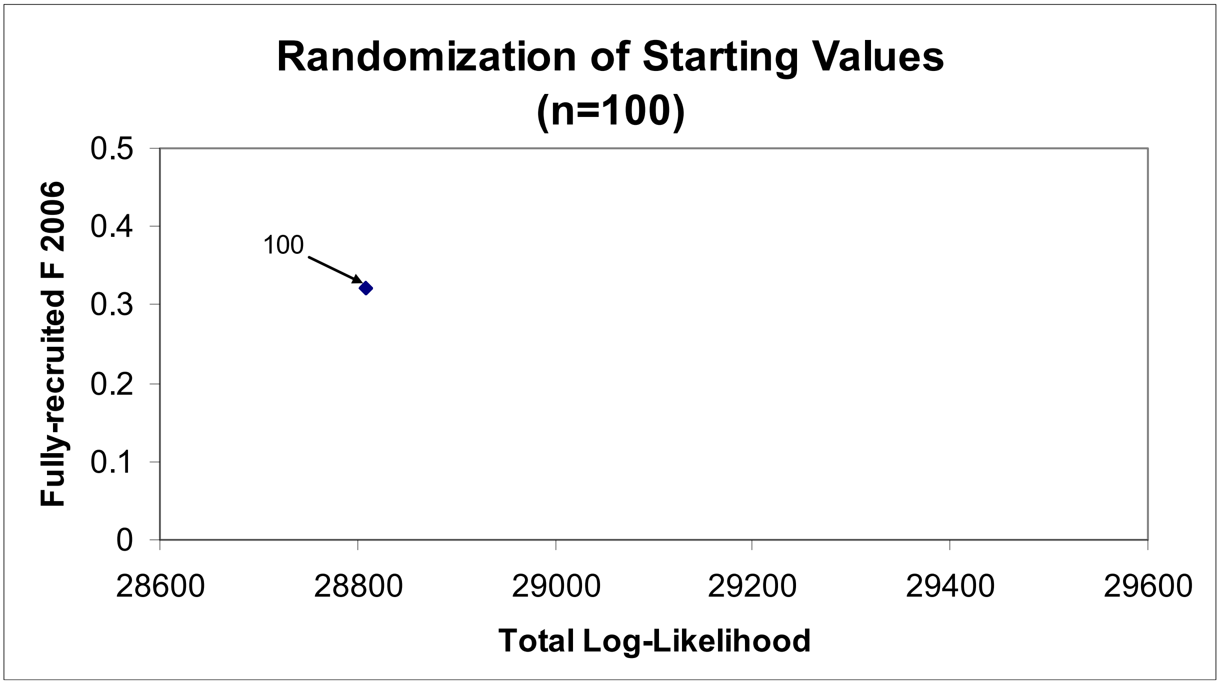


Figure A7.15. Results from 100 SCA model runs in which starting values were randomly permuted by +50%.

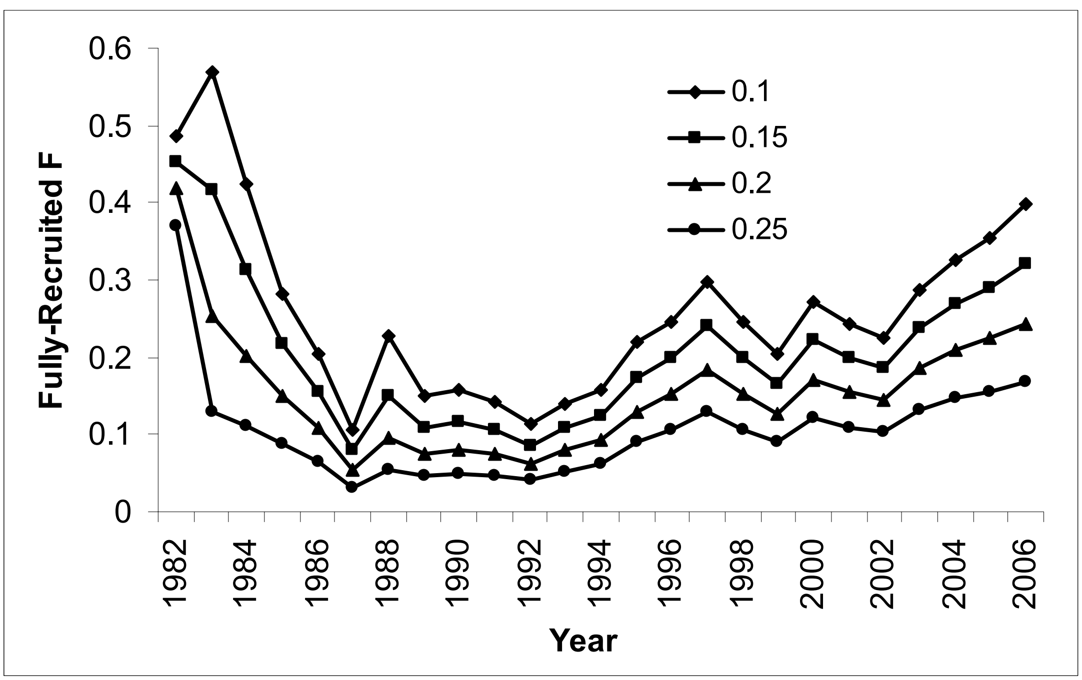
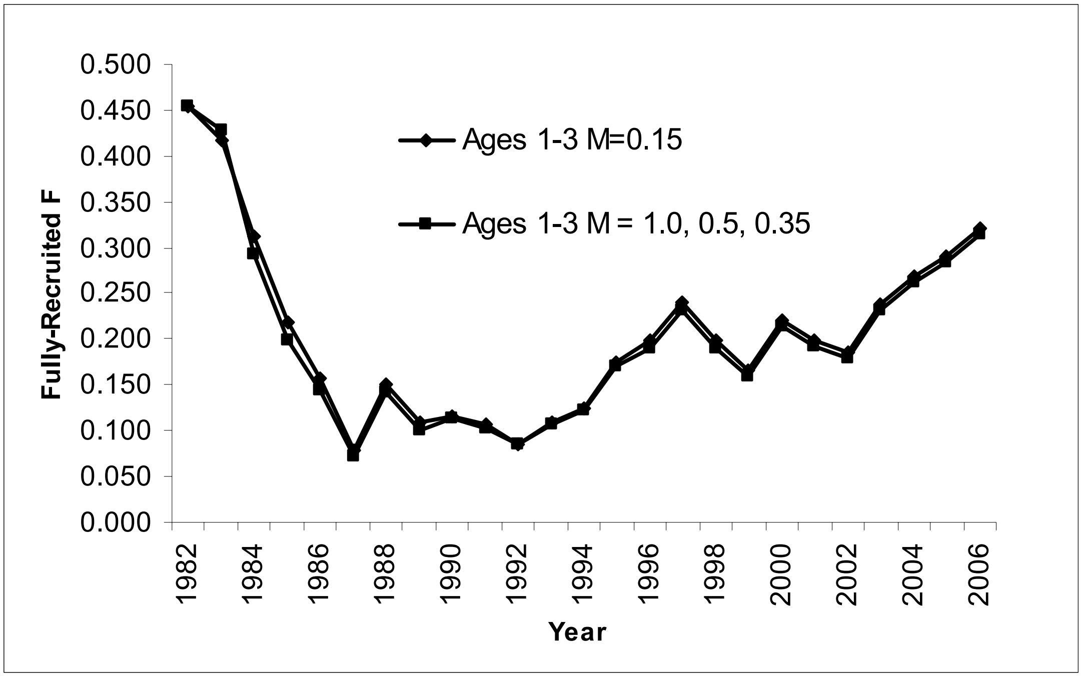


Figure A7.16. Effects of varying M on estimates of fully-recruited fishing mortality from the SCA model



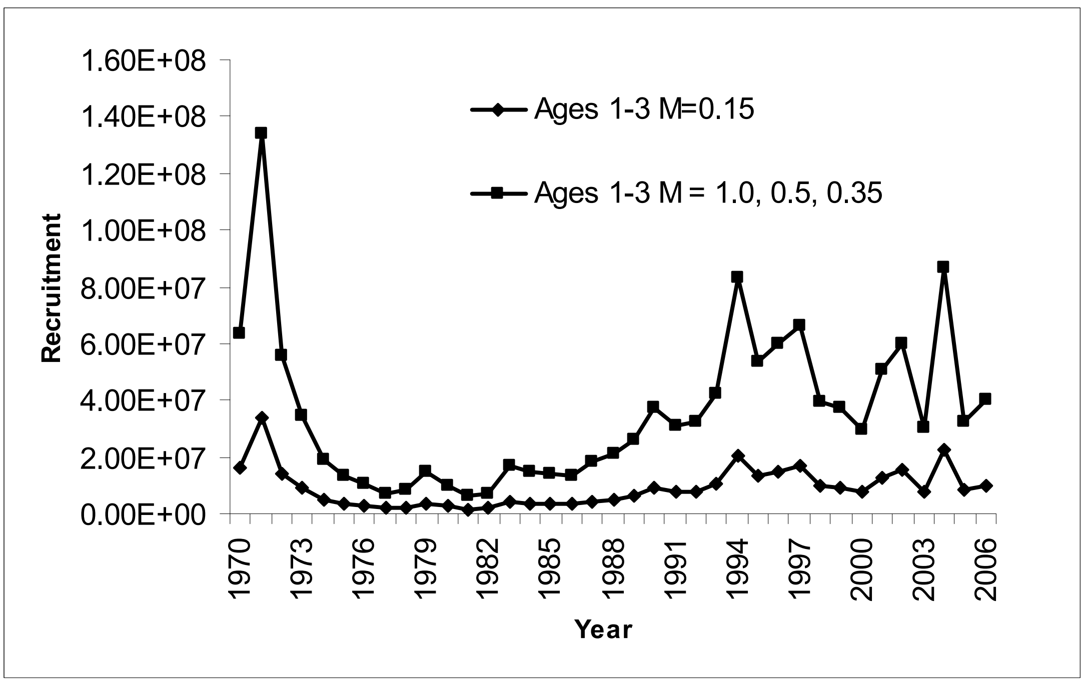


Figure A7.17. Effects of higher M for ages 1-3 on estimates of fully-recruited fishing mortality and recruitment from the SCA model.

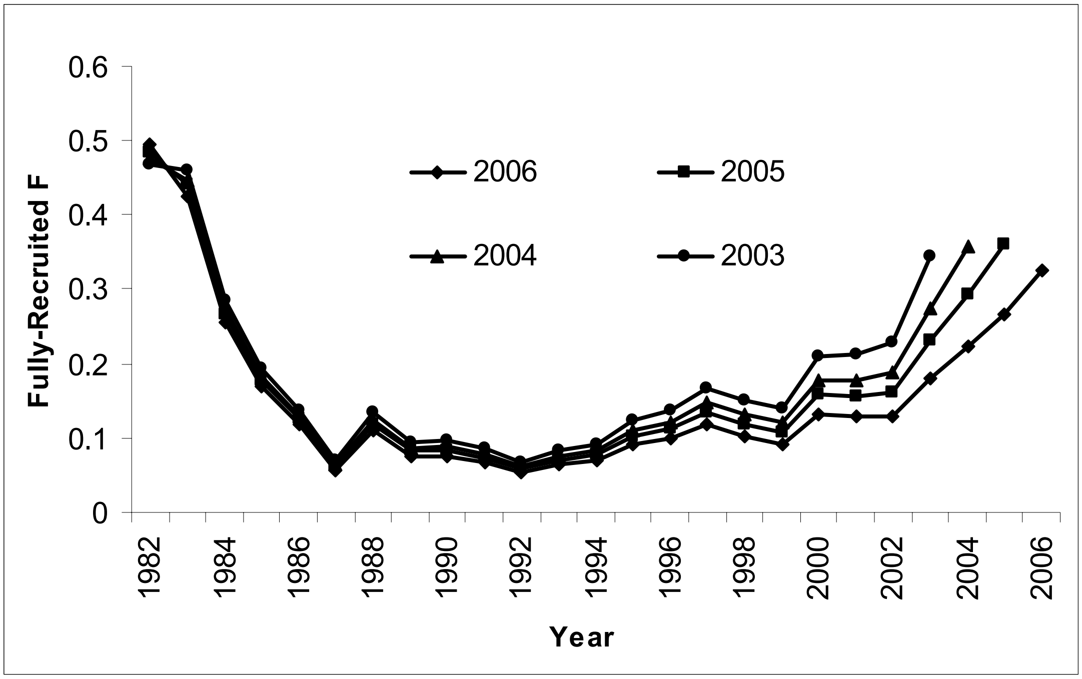


Figure A7.18. Comparison of retrospective pattern in fully-recruited F when M=0.30 after 1996

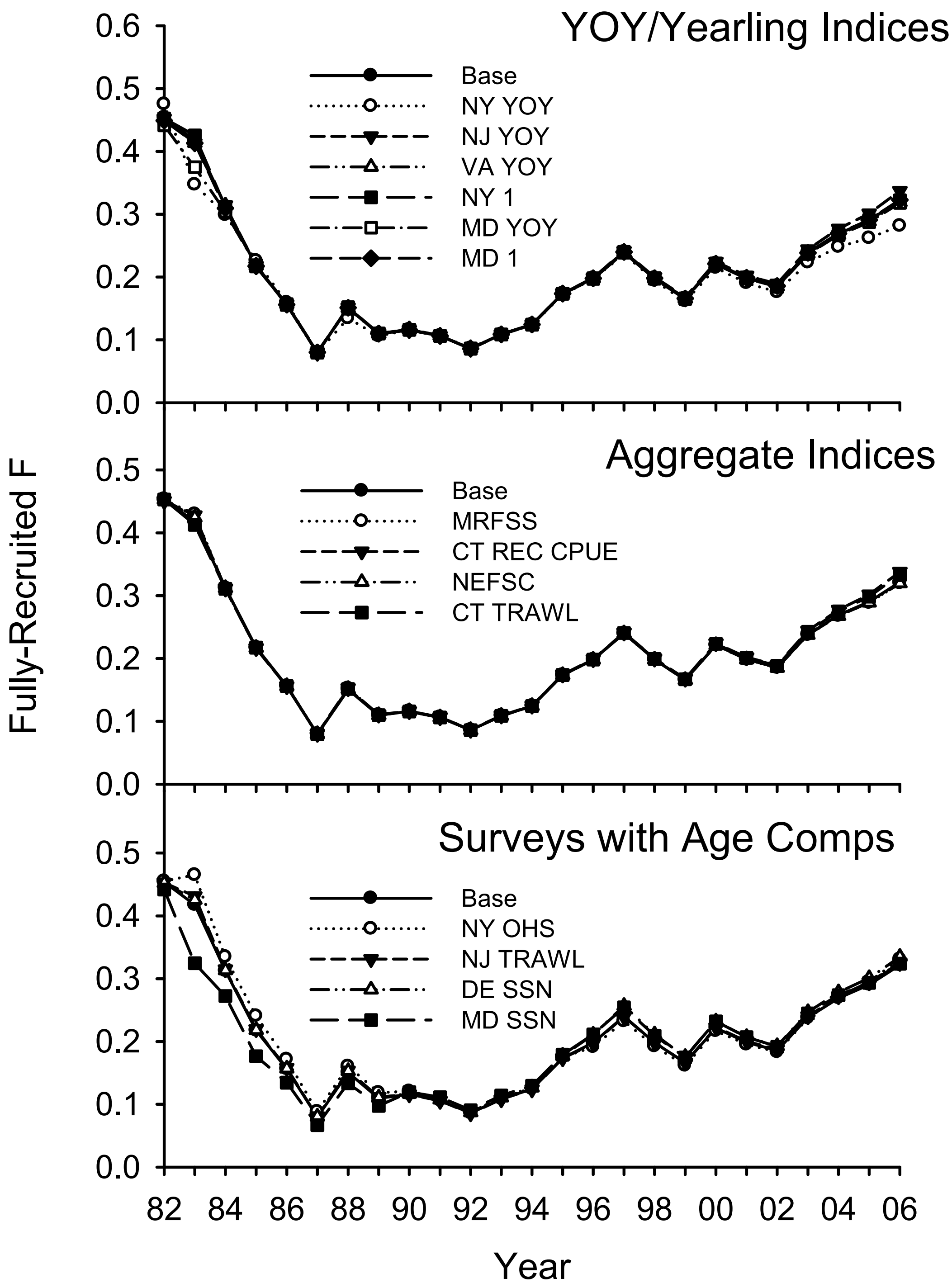
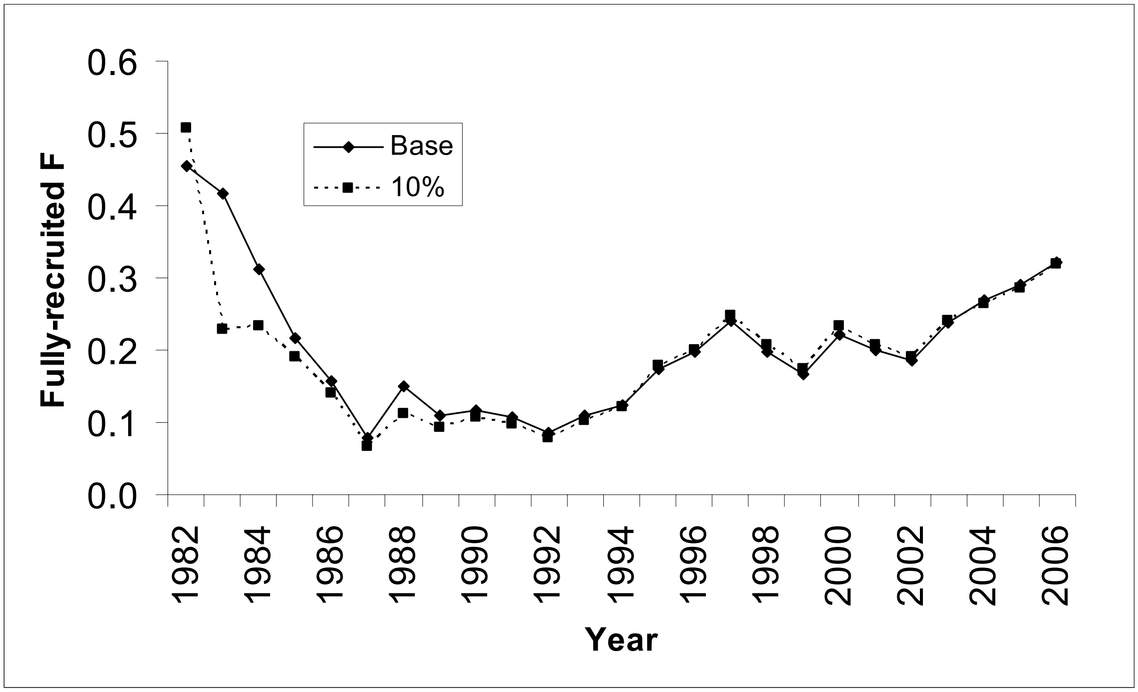


Figure A7.19. Comparison of fully-recruited F estimates when data from each survey were deleted one-at-a-time from the final SCA model configuration.

A.



B.

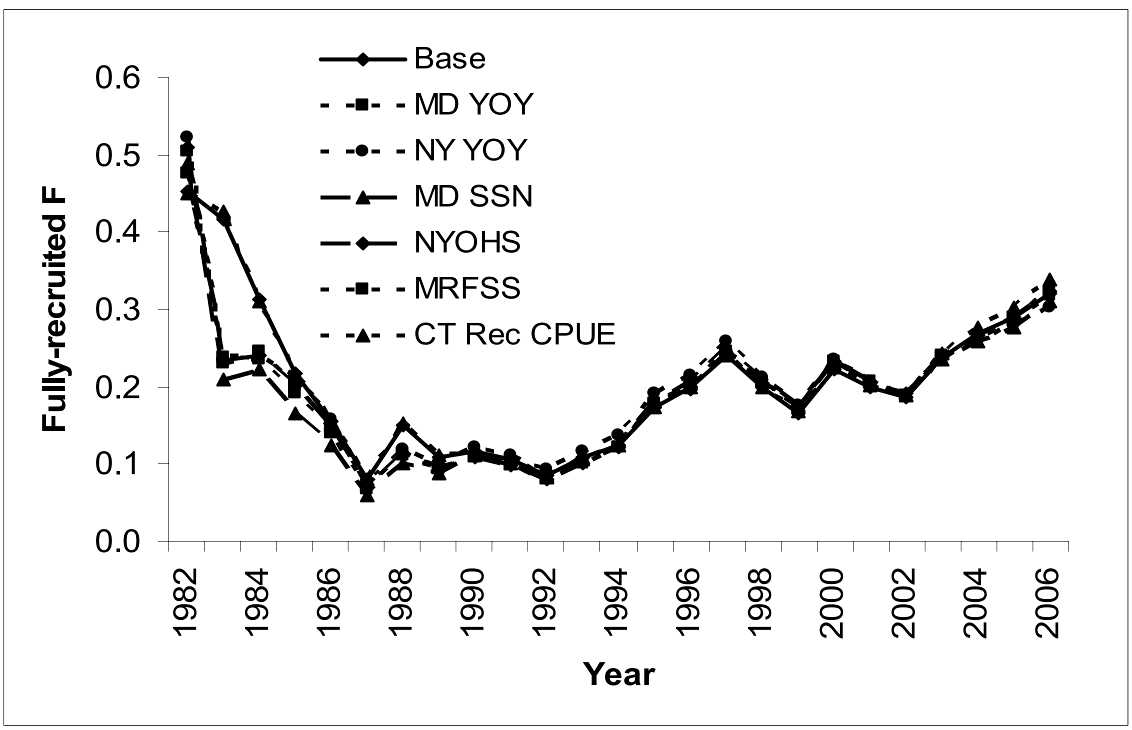
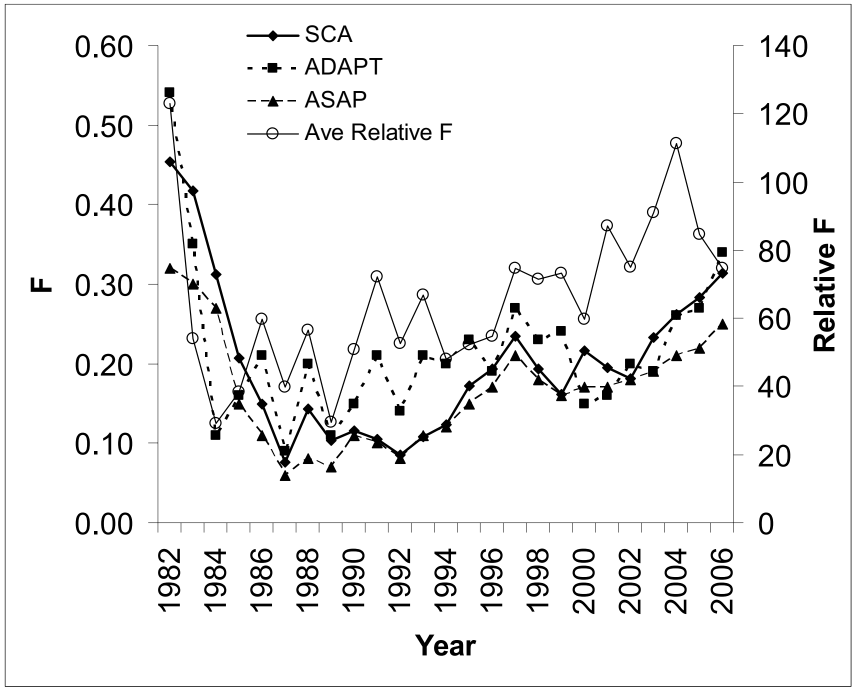


Figure A7.20. Comparison of fully-recruited F estimates from the SCA model when A) average effective sample sizes for the catch and survey multinomials were decreased to 10% of the original values and B) select surveys were deleted one-at-a-time when all average effective sample sizes were decreased to 10% of original values .

A.



B.

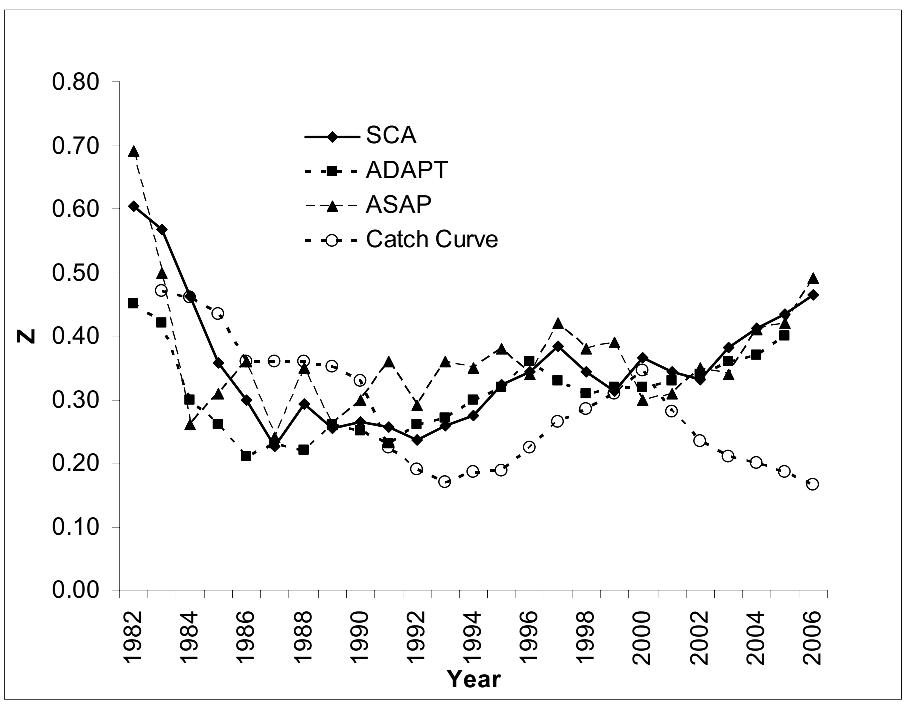


Figure A7.21. A) Comparison of SCA, ADAPT, ASAP, and relative F estimates of average fishing mortality of ages 8-11, and B) SCA, ADAPT, ASAP and catch curve analysis fully-recruited total mortality.

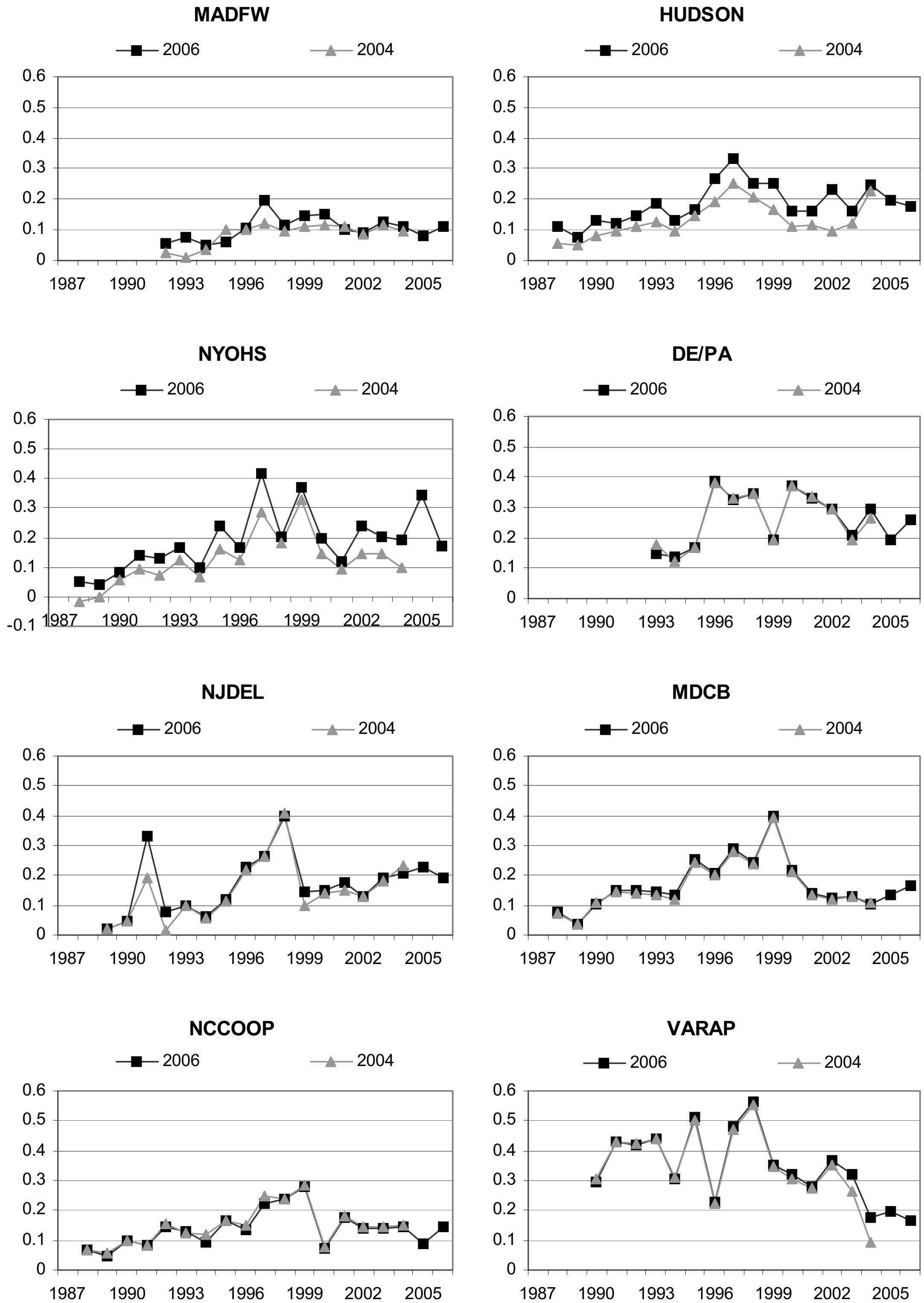


Figure A8.1. Retrospective analysis of fishing mortality estimates generated by the catch equation method for fish >28". Data shown are from the previous stock assessment in 2004 and the current in 2006.

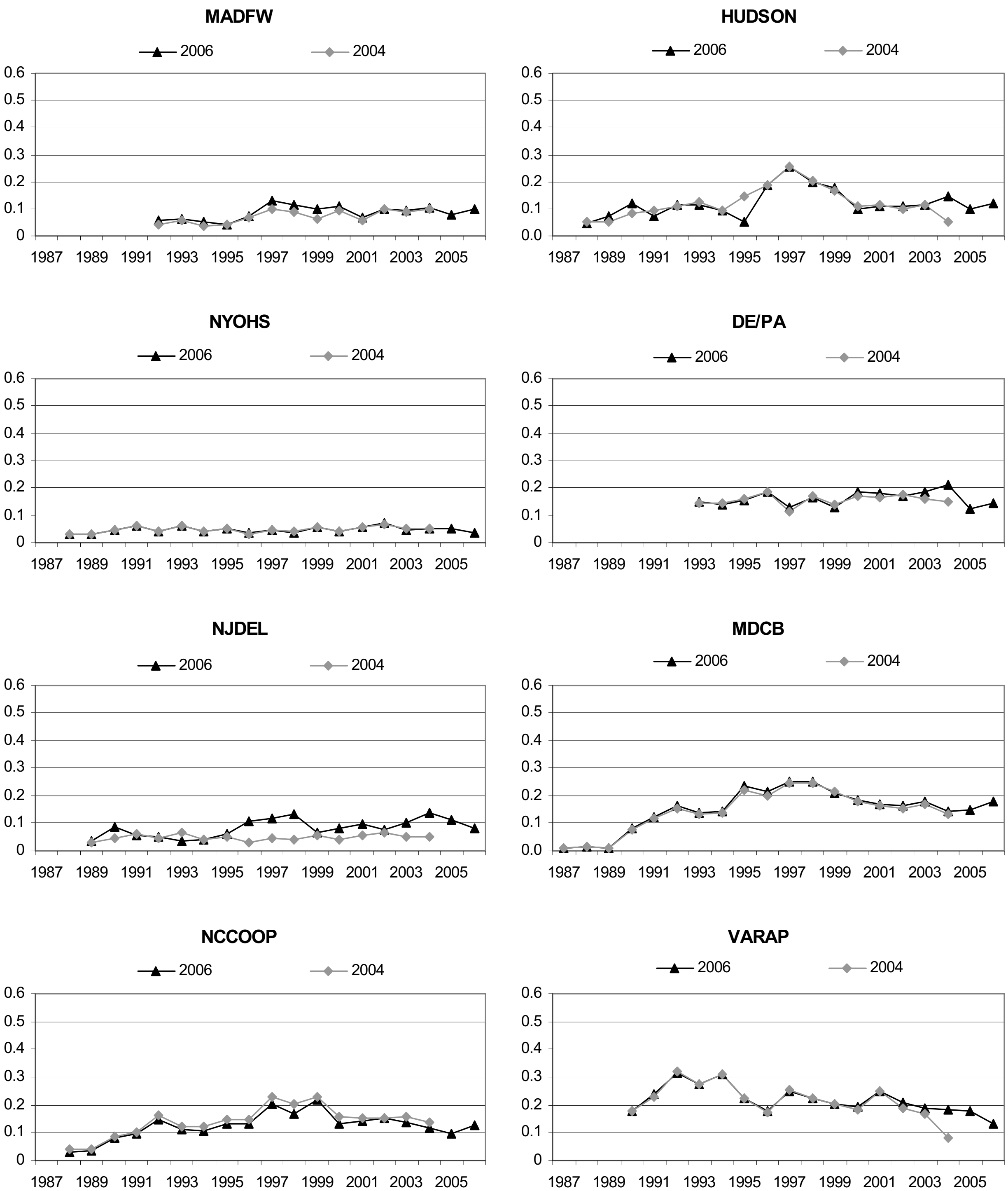


Figure A8.2. Retrospective analysis of fishing mortality estimates generated by the catch equation method for fish >18”. Data shown are from the previous stock assessment in 2004 and the current in 2006.

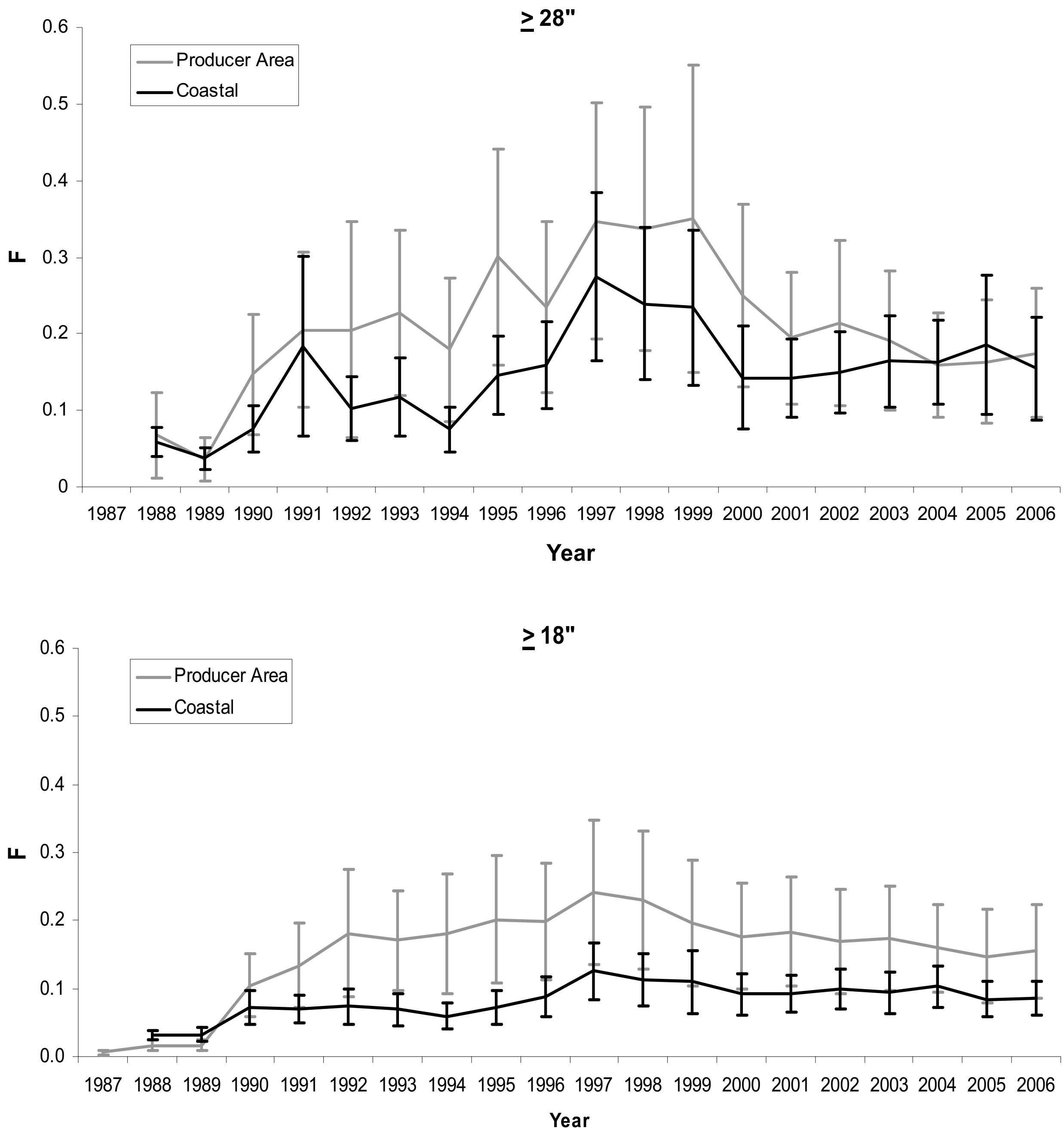
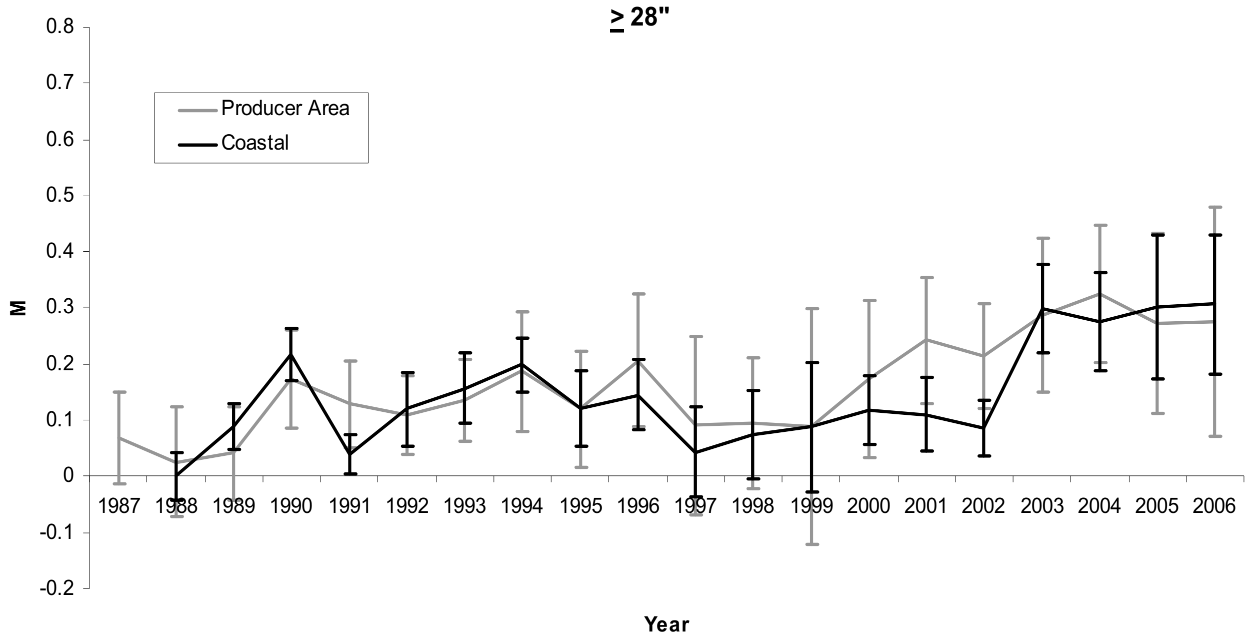


Figure A8.3. Coastal and producer area mean fishing mortality estimates and their 95% confidence intervals generated from the catch equation method for striped bass ≥ 28” and ≥ 18”.



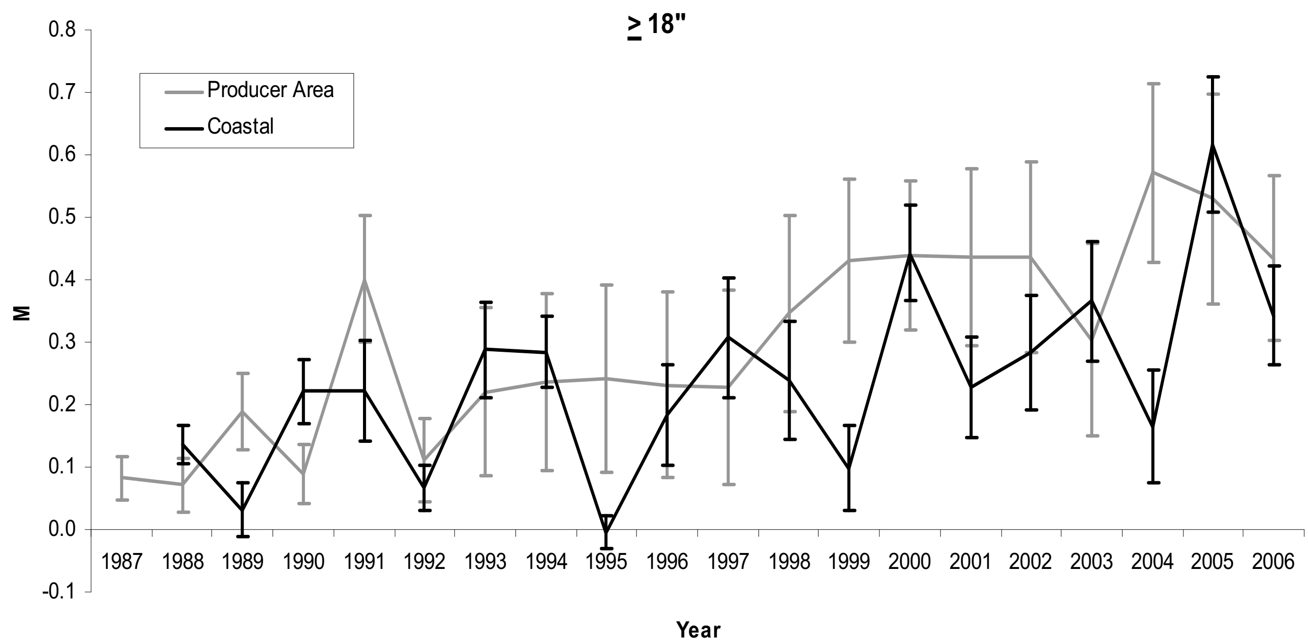


Figure A8.4. Coastal and producer area mean natural mortality estimates and their 95% confidence interval, generated from the catch equation method for striped bass ≥ 28” and ≥ 18”.

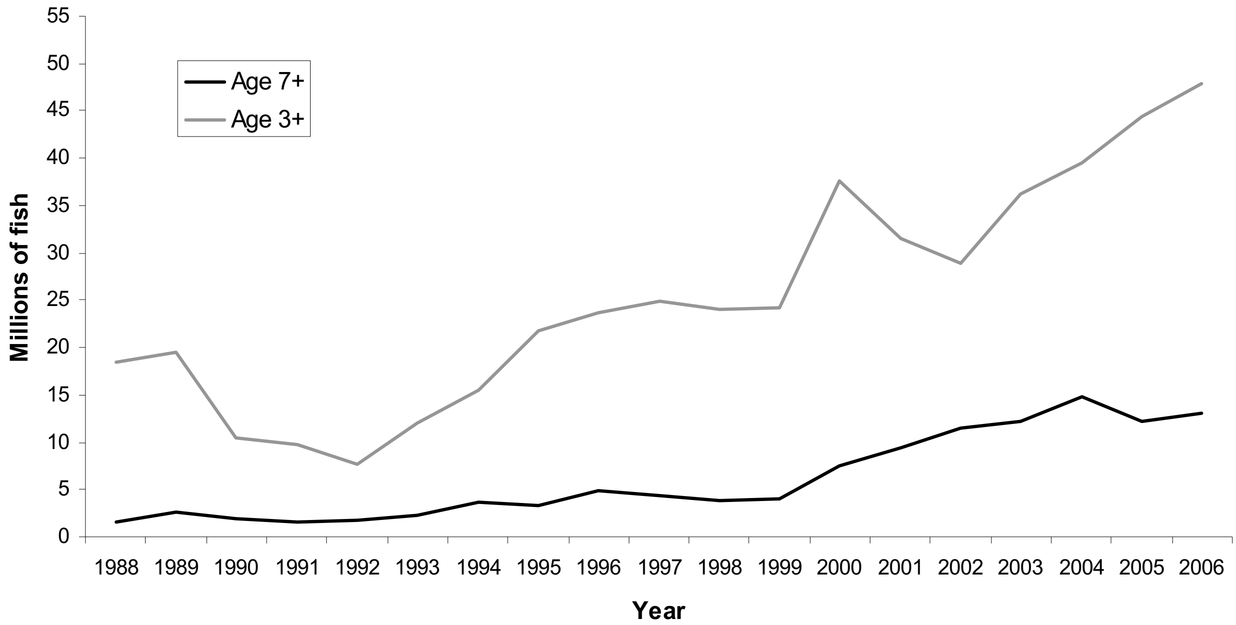


Figure A8.5. Stock size estimates generated from the catch equation method for fish age seven and older (comparable to fish > 28 inches) and fish age three and older (comparable to fish > 18 inches). Stock size obtained via "Kill (in numbers of fish) = F * Stock Size".

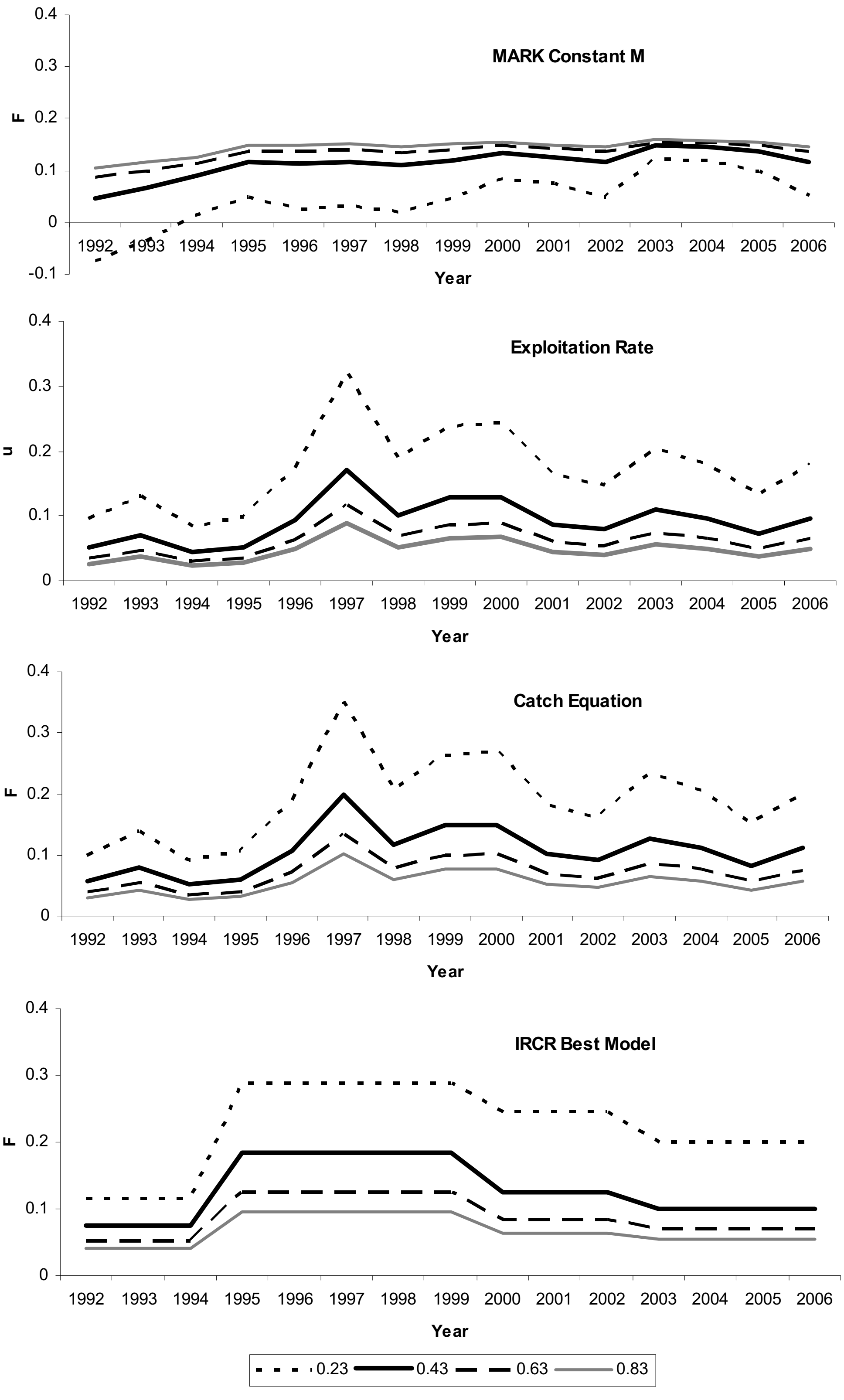


Figure A8.6. Sensitivity analysis showing effects of reporting rate values on exploitation rate and fishing mortality from different methods. Data shown are from MADFW.

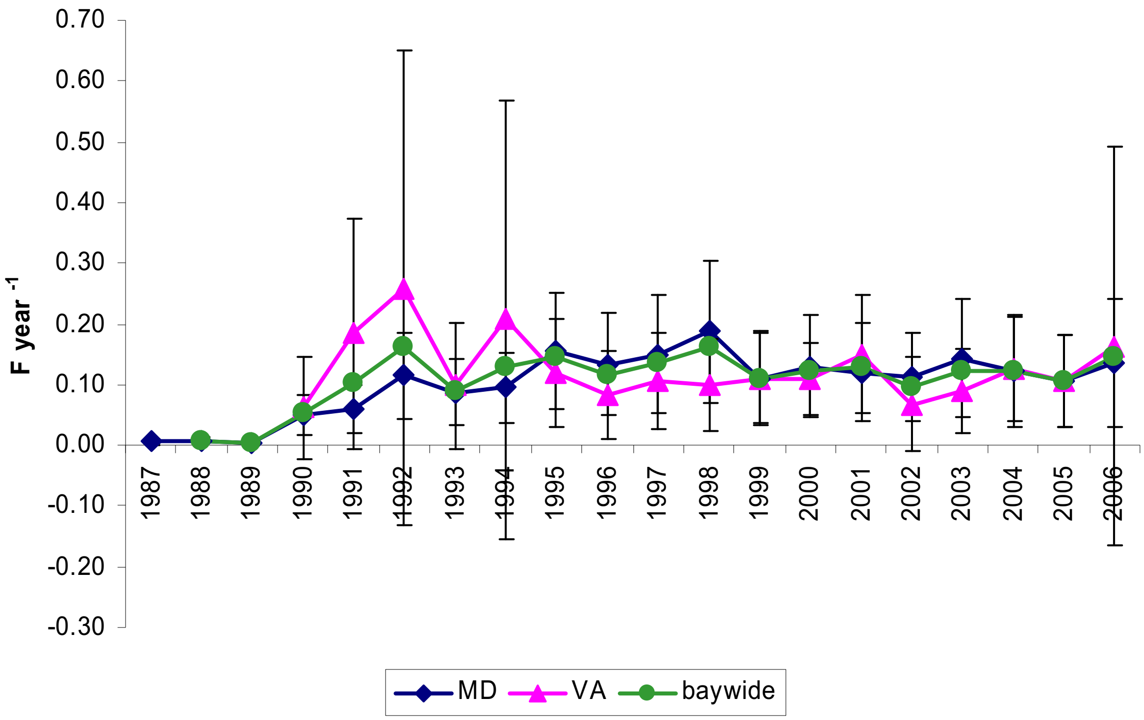


Figure A8.7. Fishing mortality of resident striped bass estimated using catch equation approach from MD and VA tagging data. Vertical bars represent 95% confidence limit intervals.

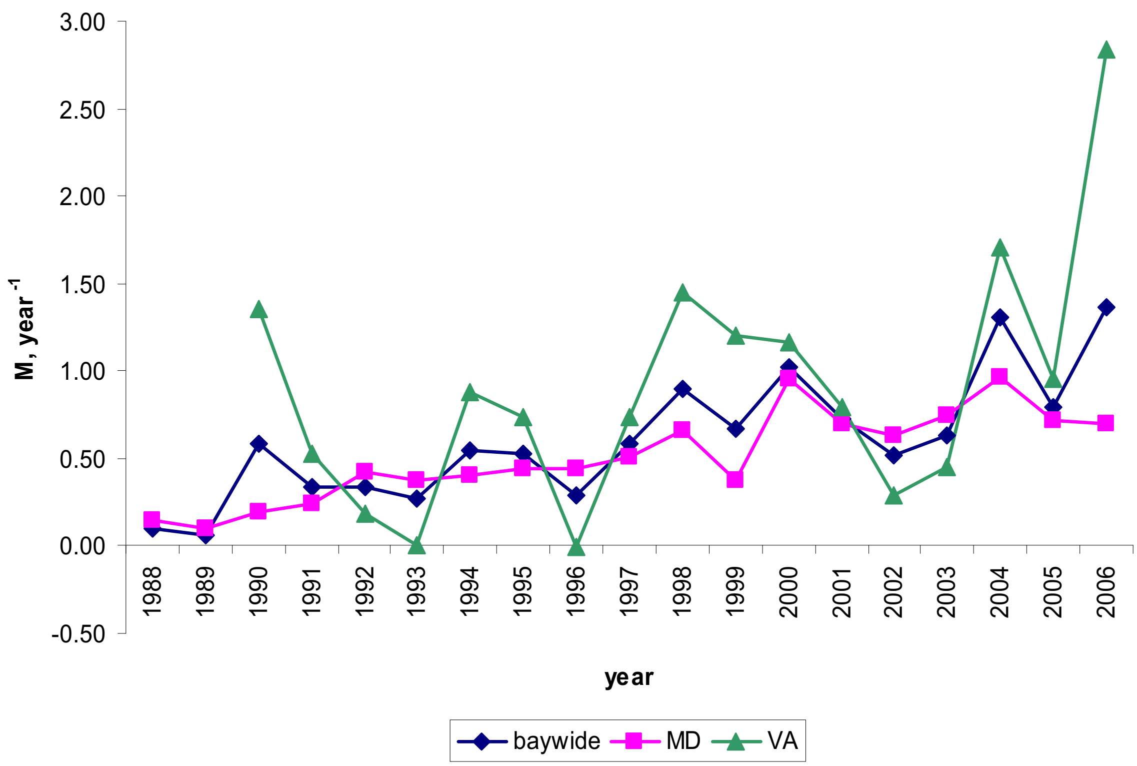


Figure A8.8. Natural mortality of resident striped bass estimated using catch equation approach from MD and VA tagging data.

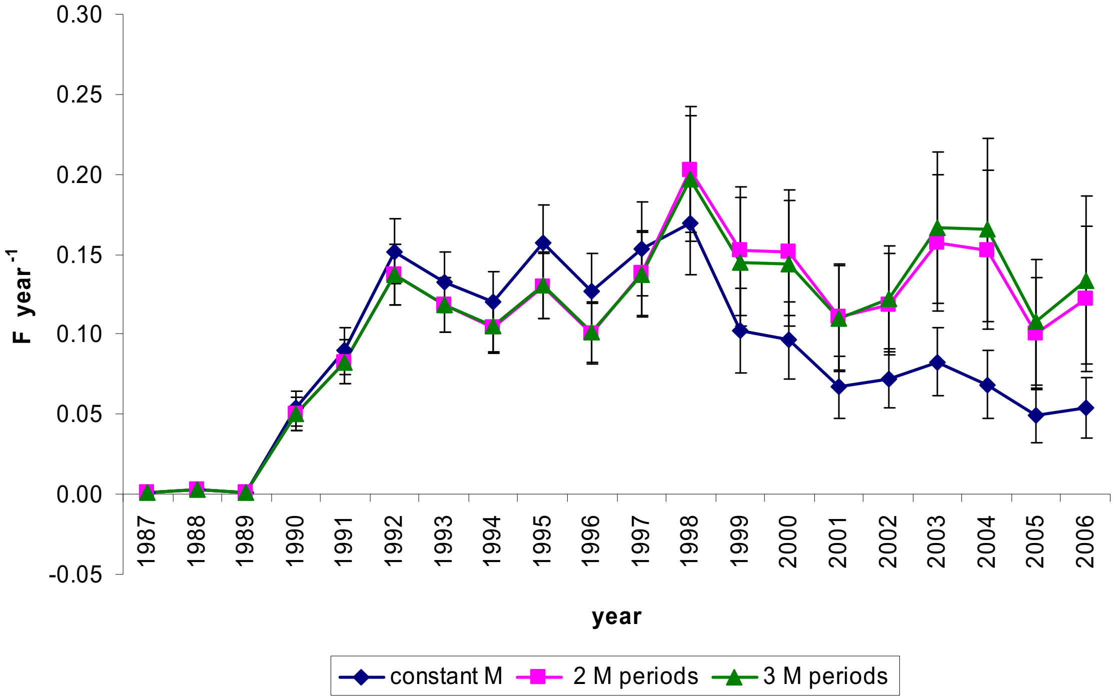


Figure A9.1. Fishing mortality of resident striped bass estimated from MD data using instantaneous rates model, assuming one, two and three different periods of natural mortality. Vertical bars represent 95% confidence limit intervals.

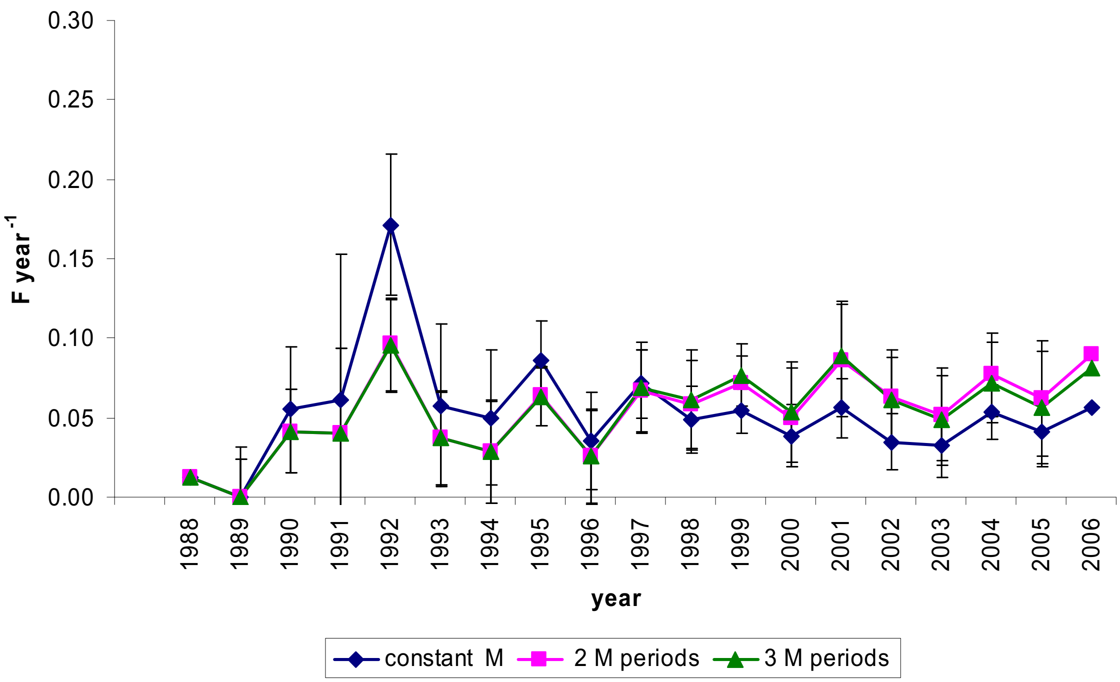


Figure A9.2. Fishing mortality of resident striped bass estimated from VA data using instantaneous rates model, assuming one, two and three different periods of natural mortality. Vertical bars represent 95% confidence limit intervals.

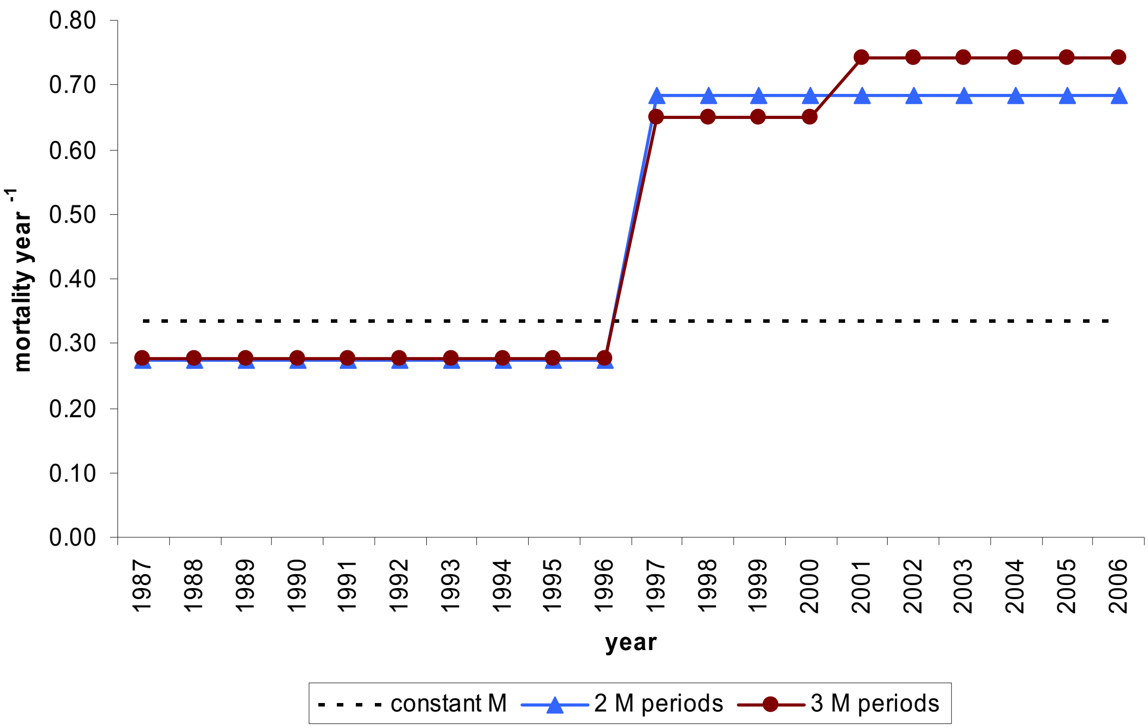


Figure A9.3. Instantaneous rates model estimates of natural mortality from MD data assuming constant M, two and three periods of different M.

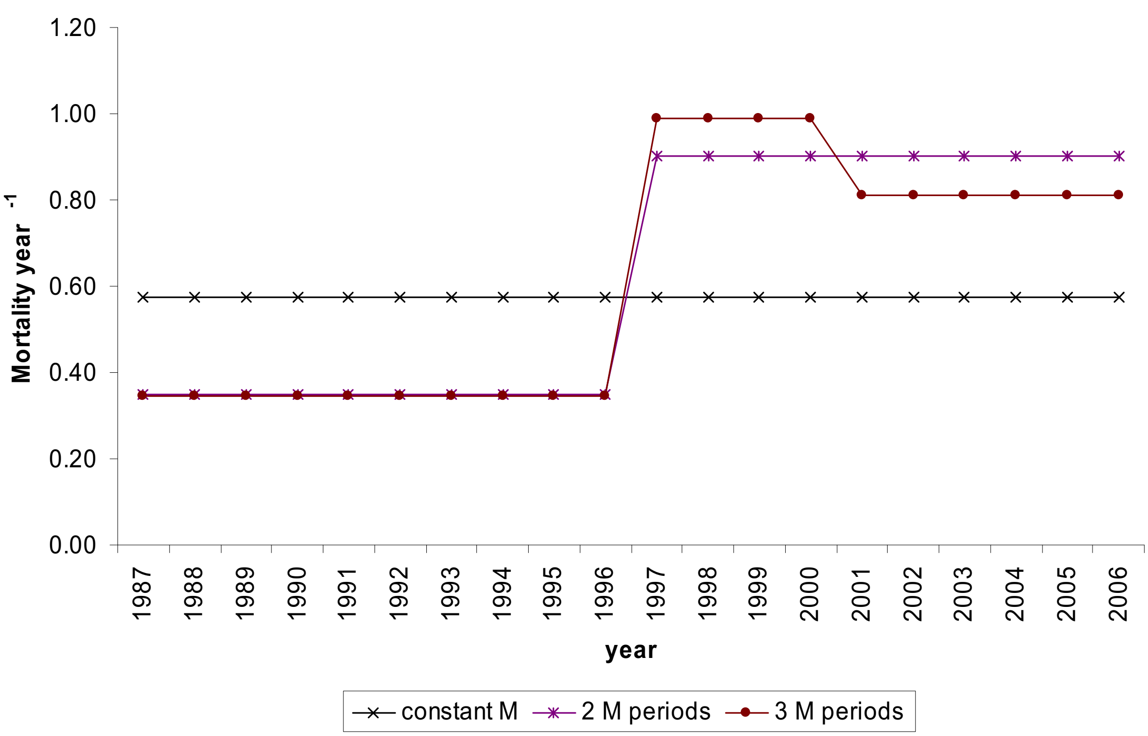


Figure A9.4. Instantaneous rates model estimates of natural mortality from VA data assuming constant M, two and three periods of different M.

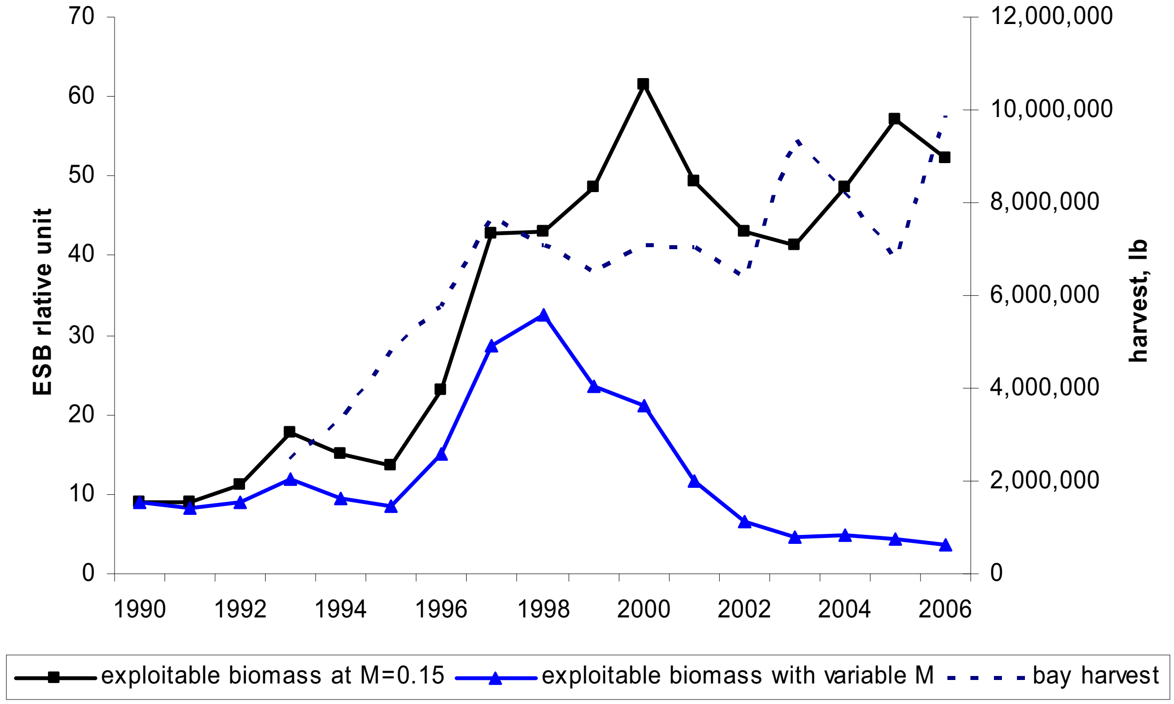
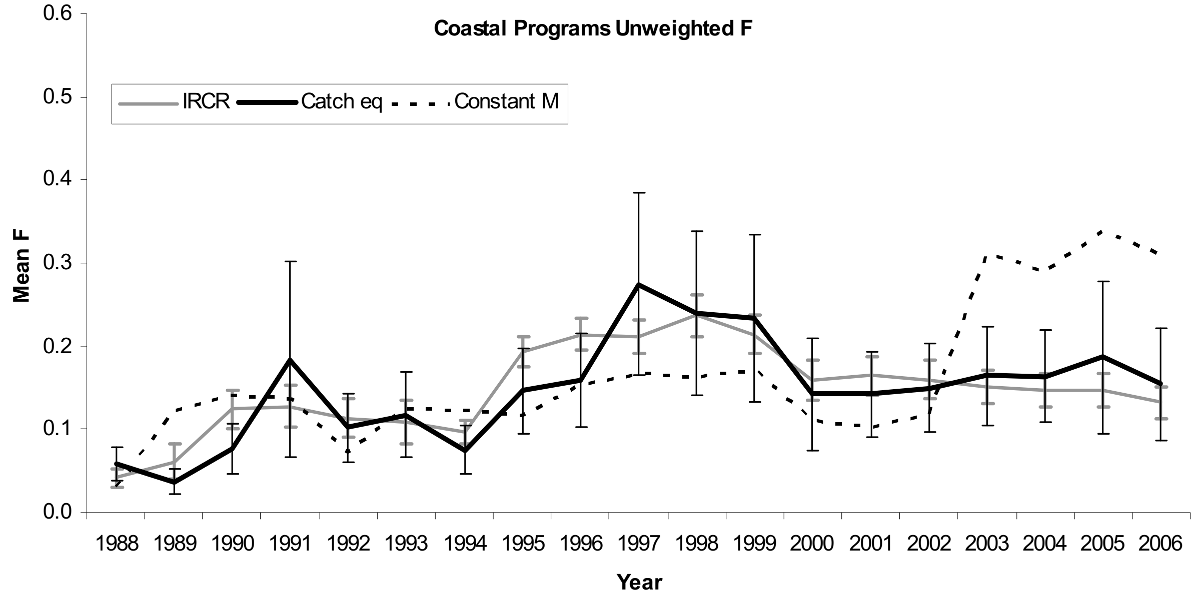


Figure A9.5. Projected Chesapeake bay exploited biomass assuming constant natural mortality M=0.15, period specific natural mortality from instantaneous model and bay-wide harvest.



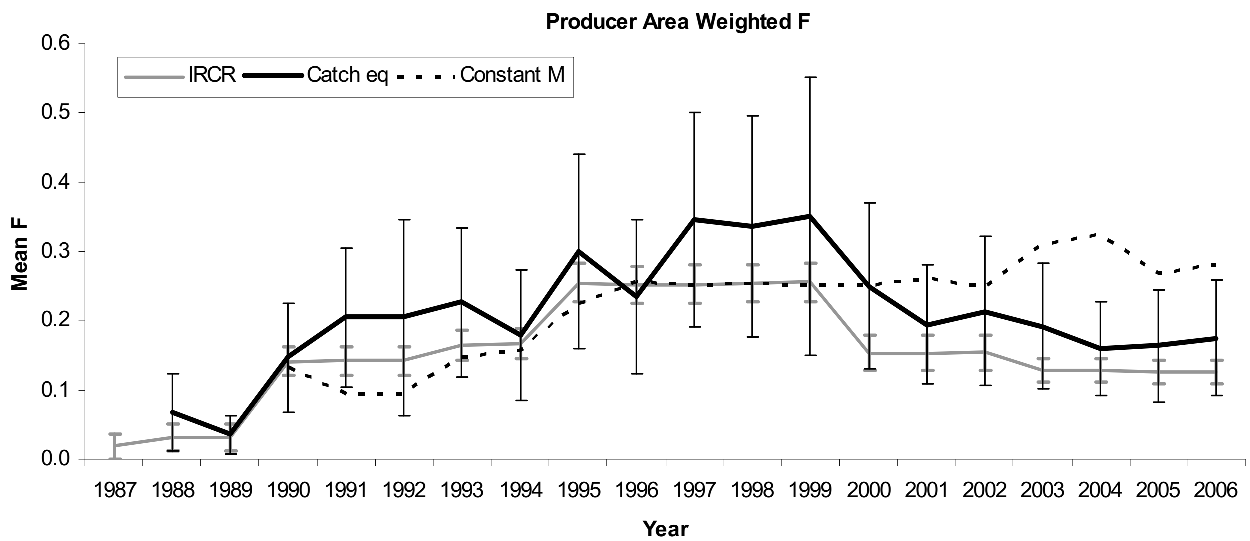
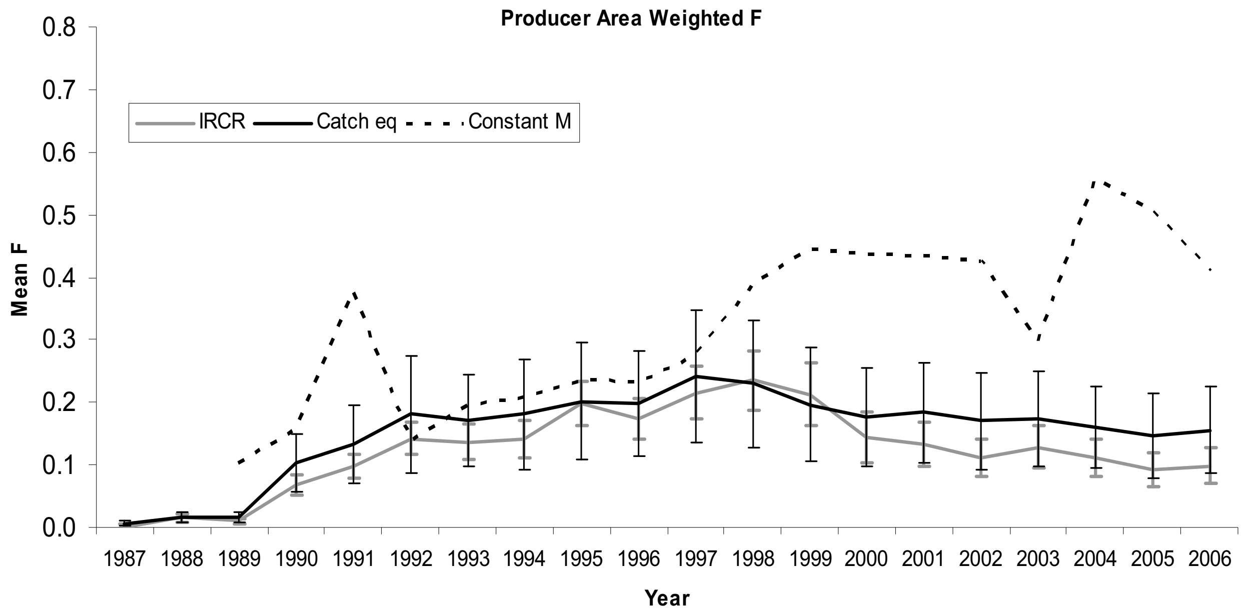


Figure A9.6. Comparison of coast program and producer area mean fishing mortality estimates from the IRCR model to the current and previous methods, for fish > 28 inches. 95% confidence intervals are shown for the catch equation and IRCR methods.



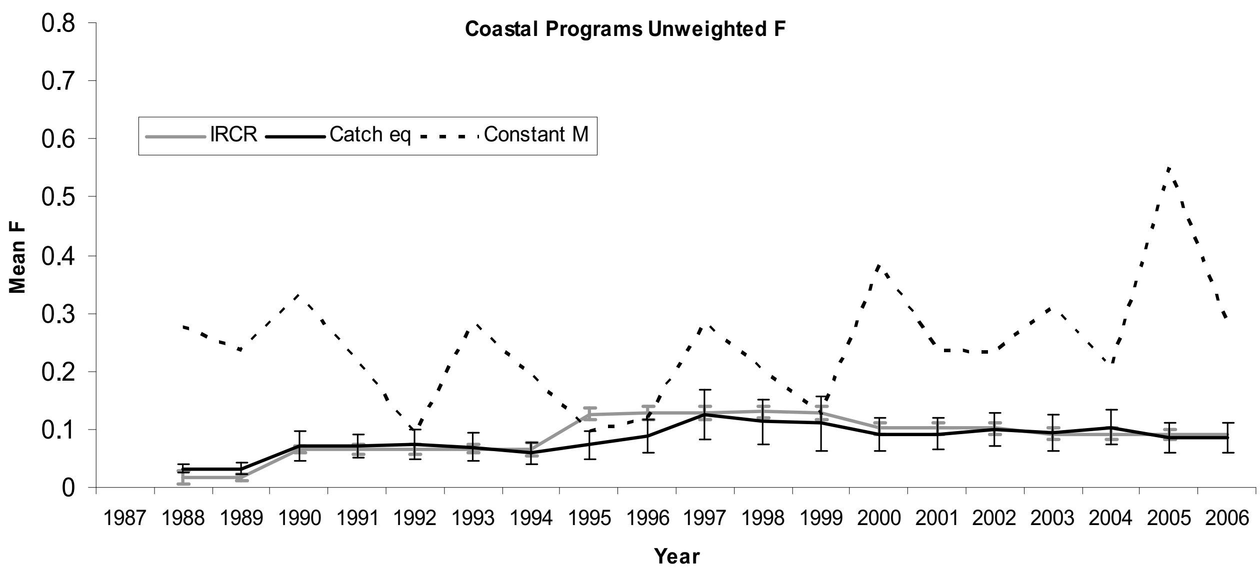


Figure A9.7. Comparison of coast program and producer area mean fishing mortality estimates from the IRCR model to the current and previous methods, for fish > 18 inches. 95% confidence intervals are shown for the catch equation and IRCR methods.

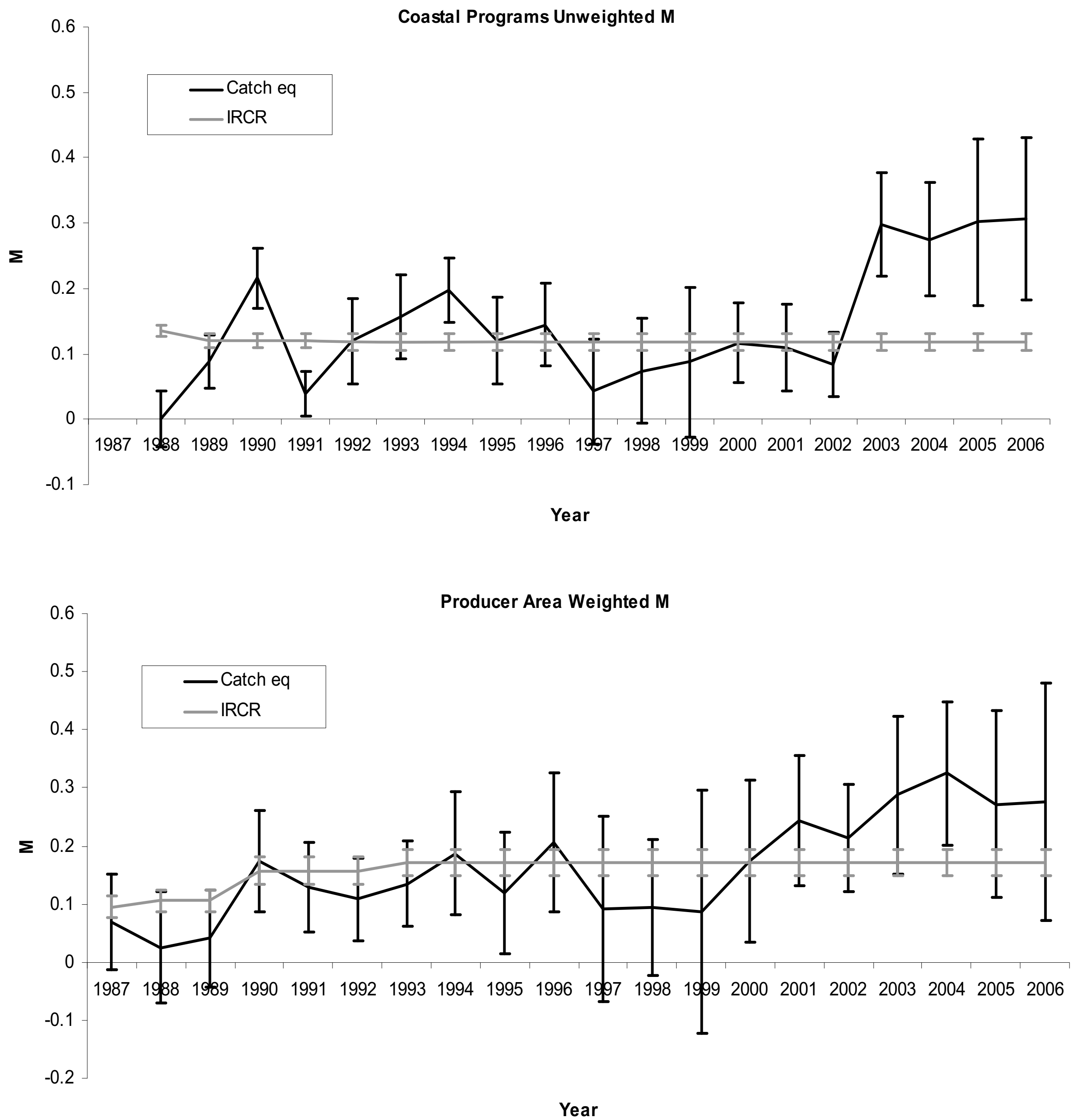
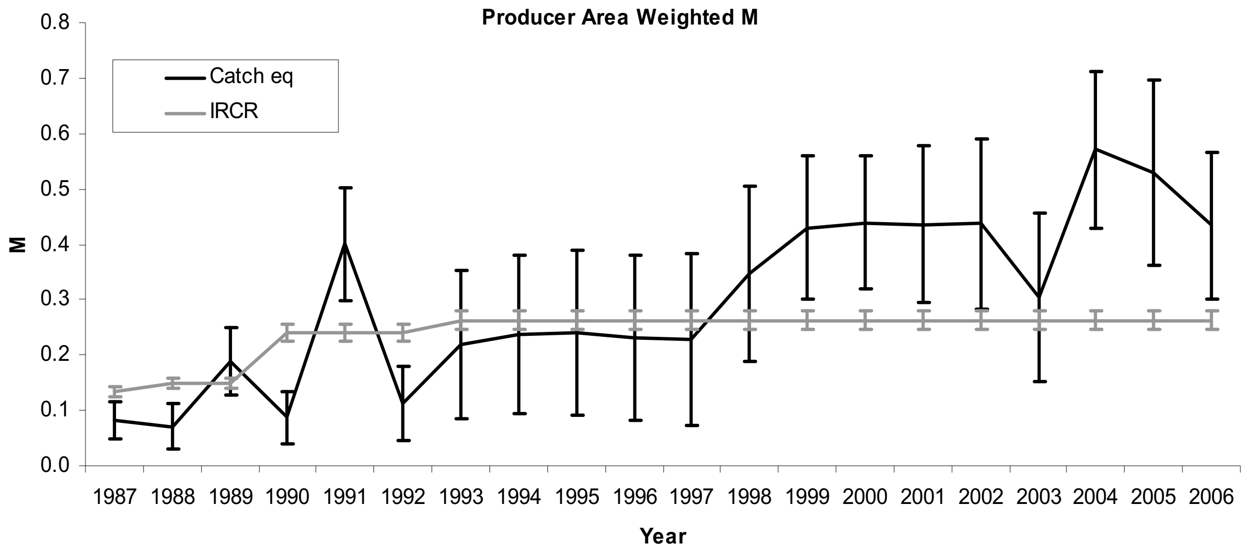


Figure A9.8. Comparison of coast program and producer area mean natural mortality estimates from the IRCR model the catch equation method, for fish > 28 inches. 95% confidence intervals are shown for both methods.



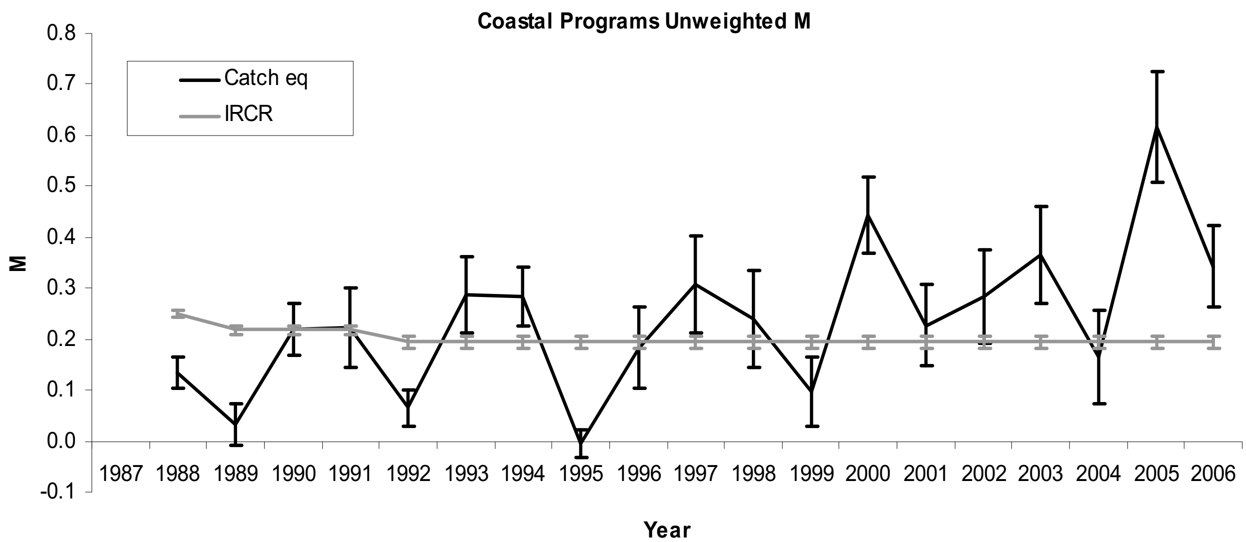
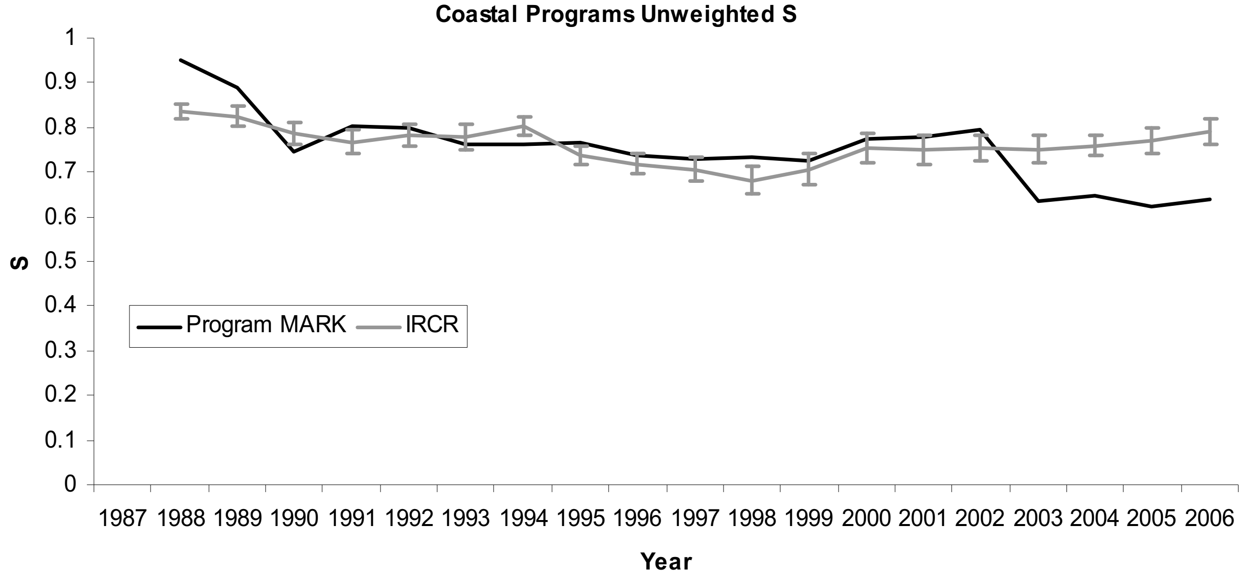


Figure A9.9. Comparison of coast program and producer area mean natural mortality estimates from the IRCR model and the catch equation method, for fish > 18 inches. 95% confidence intervals are shown for both methods.



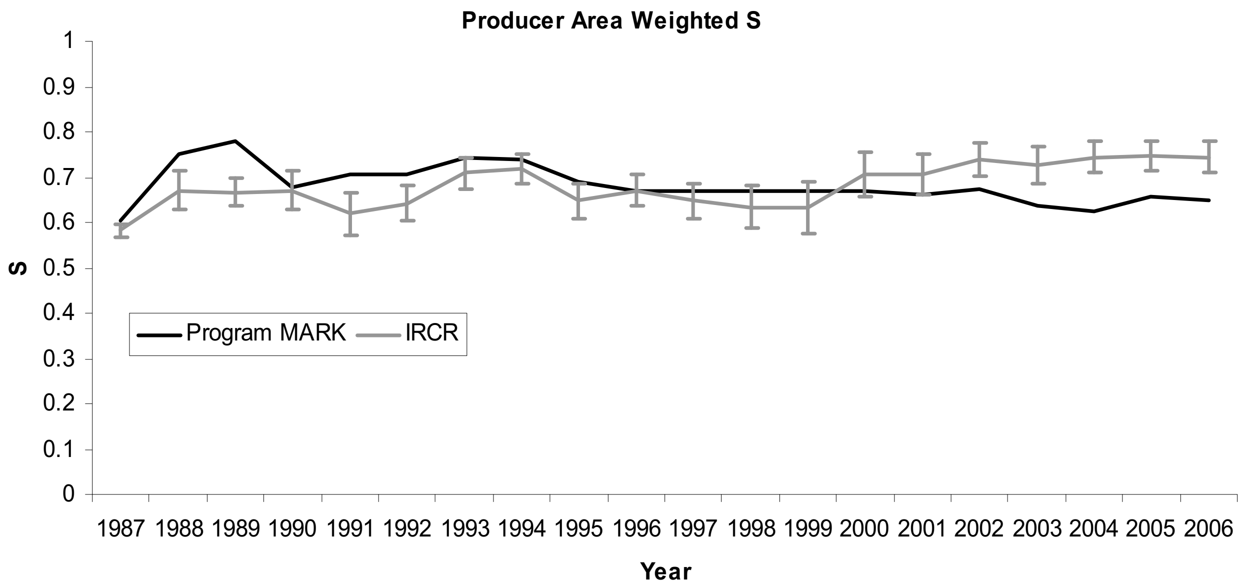


Figure A9.10. Comparison of coast program and producer area mean survival estimates from the IRCR model and Program MARK, for fish > 28 inches. 95% confidence intervals are shown for the IRCR model.

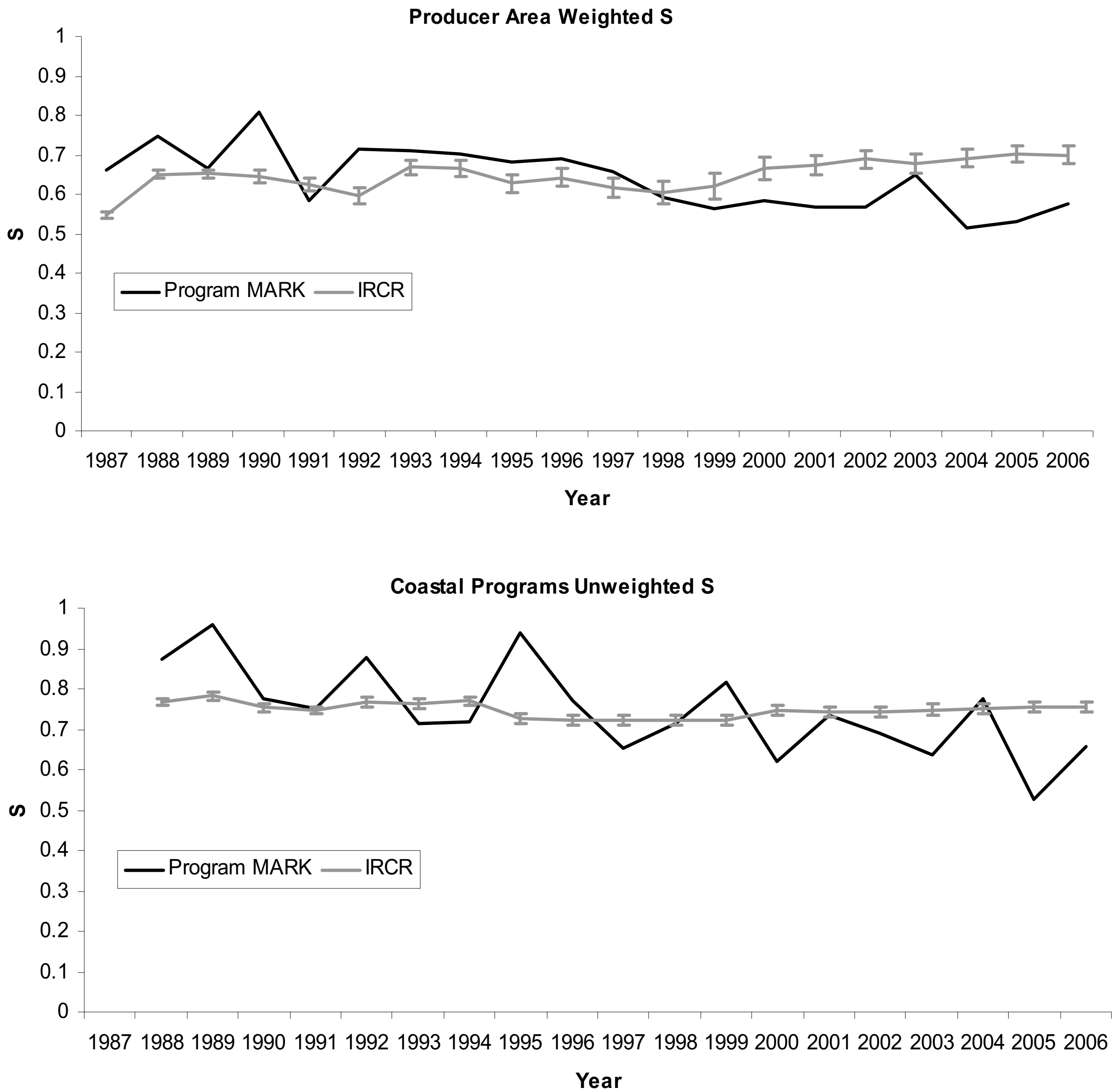
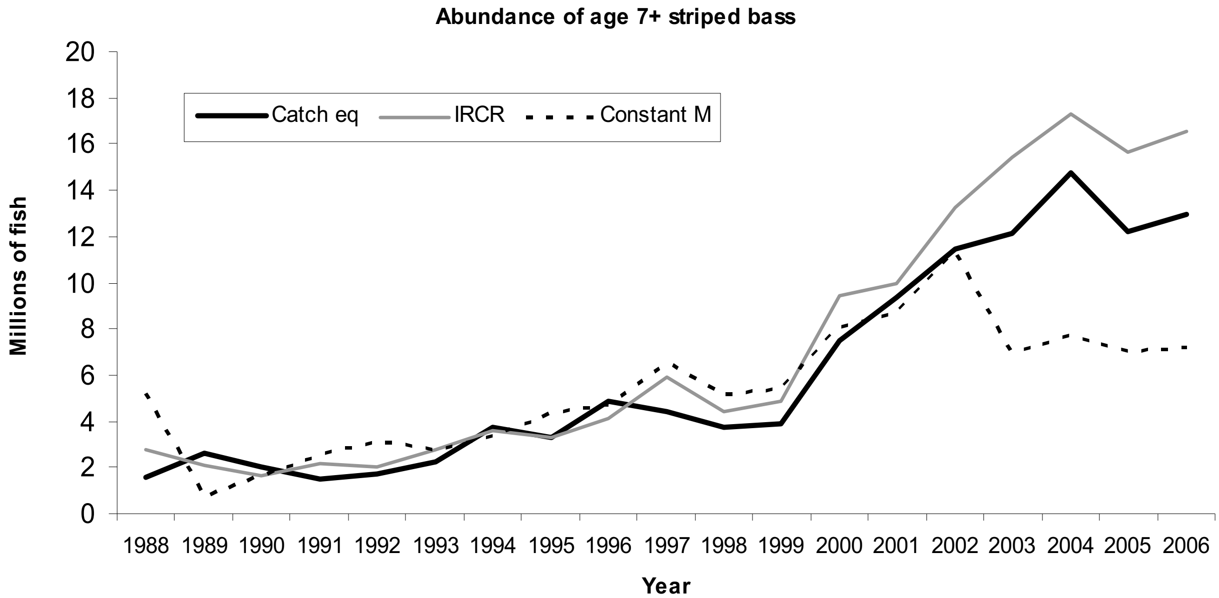


Figure A9.11. Comparison of coast program and producer area mean survival estimates from the IRCR model and Program MARK, for fish > 18 inches. 95% confidence intervals are shown for the IRCR model.



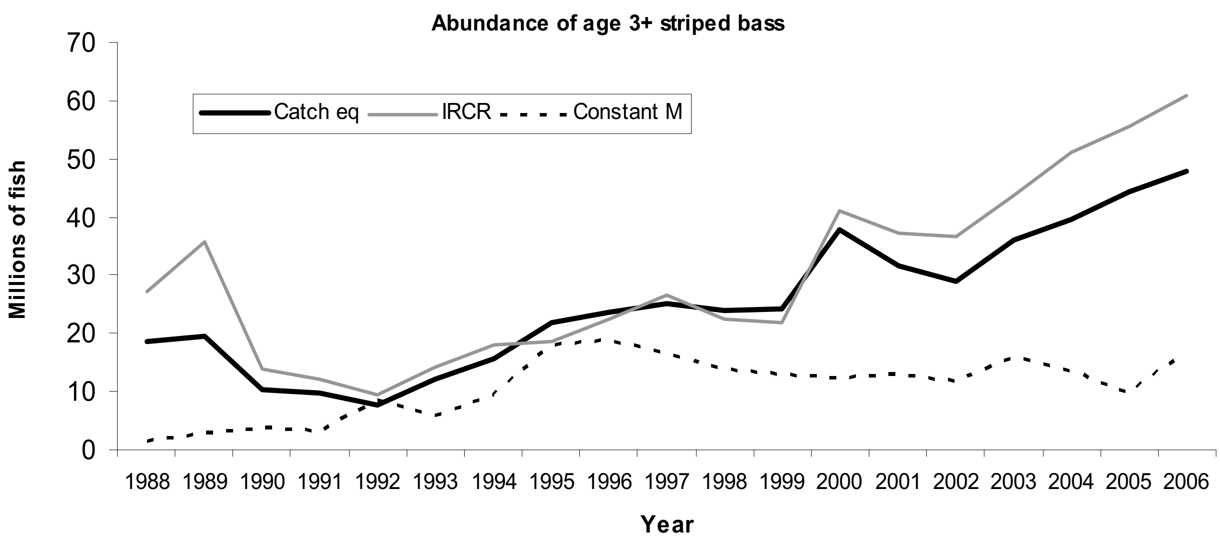


Figure A9.12. Stock size estimates generated from the IRCR model compared to the catch equation method, for fish age seven and older (comparable to fish > 28 inches) and fish age three and older (comparable to fish > 18 inches). Stock size obtained via "Kill (in numbers of fish) = F * Stock Size".

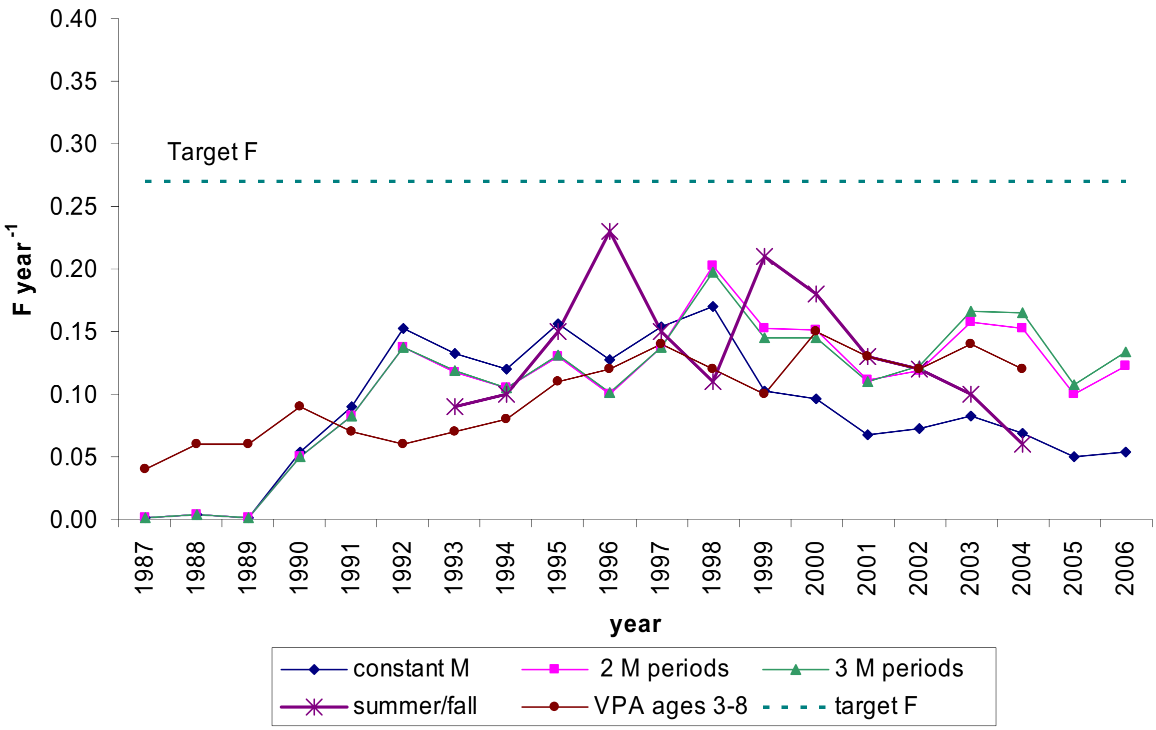


Figure A9.13. Comparison of fishing mortality estimates for MD data set from instantaneous rates model assuming constant M, two periods of M and three periods of M, with F estimates from bay-wide summer fall tagging study and coastwide VPA weighted by number F for ages 3-8.

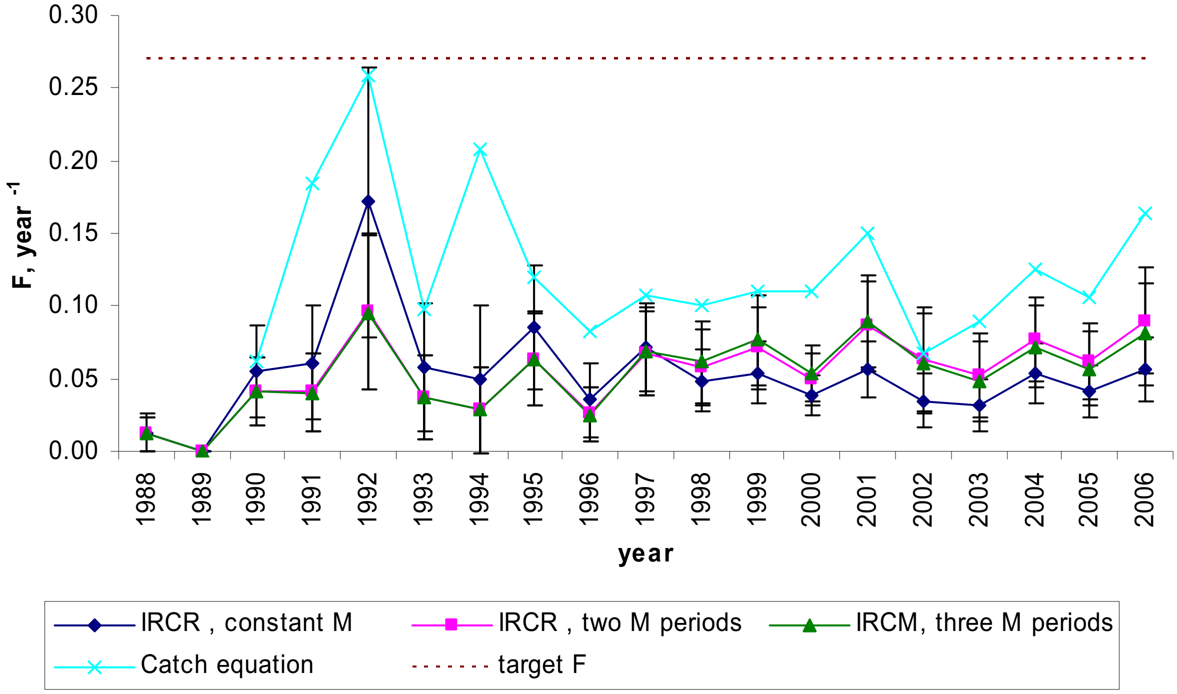


Figure A9.14. Fishing mortality estimates for VA data set from instantaneous rates model, summer fall tagging study and VPA weighted by number fishing mortality for ages 3-8.

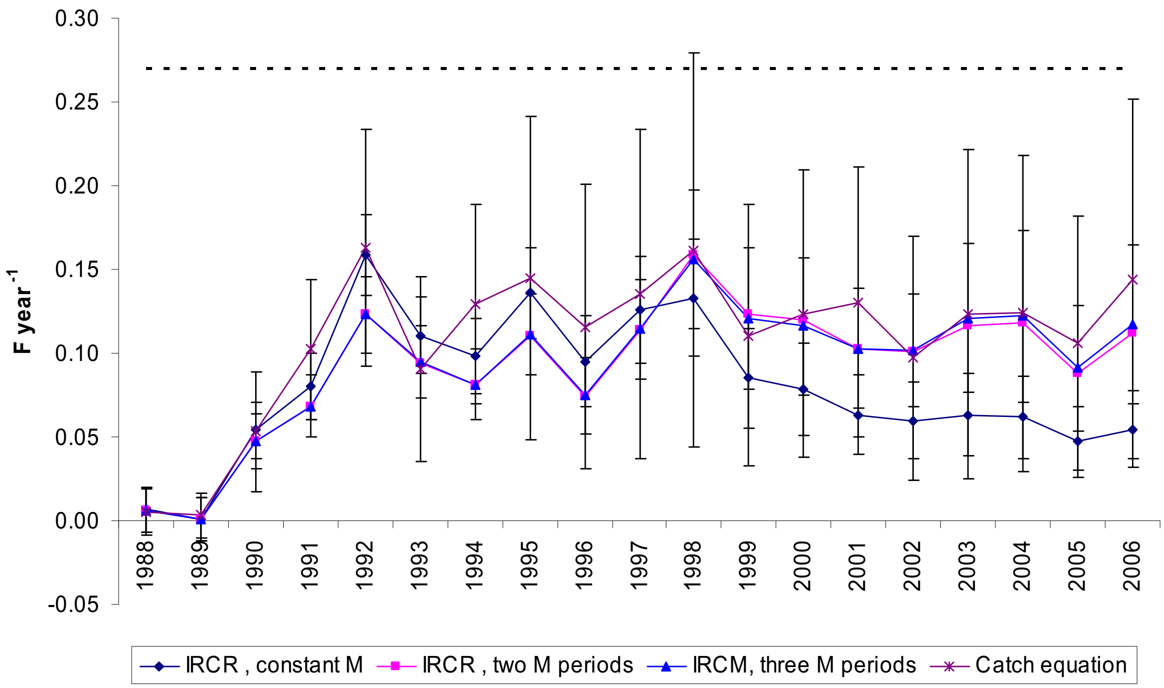


Figure A9.15. Comparison of bay-wide fishing mortality estimates from catch equation model and instantaneous rates model assuming constant M, two and three periods of M.

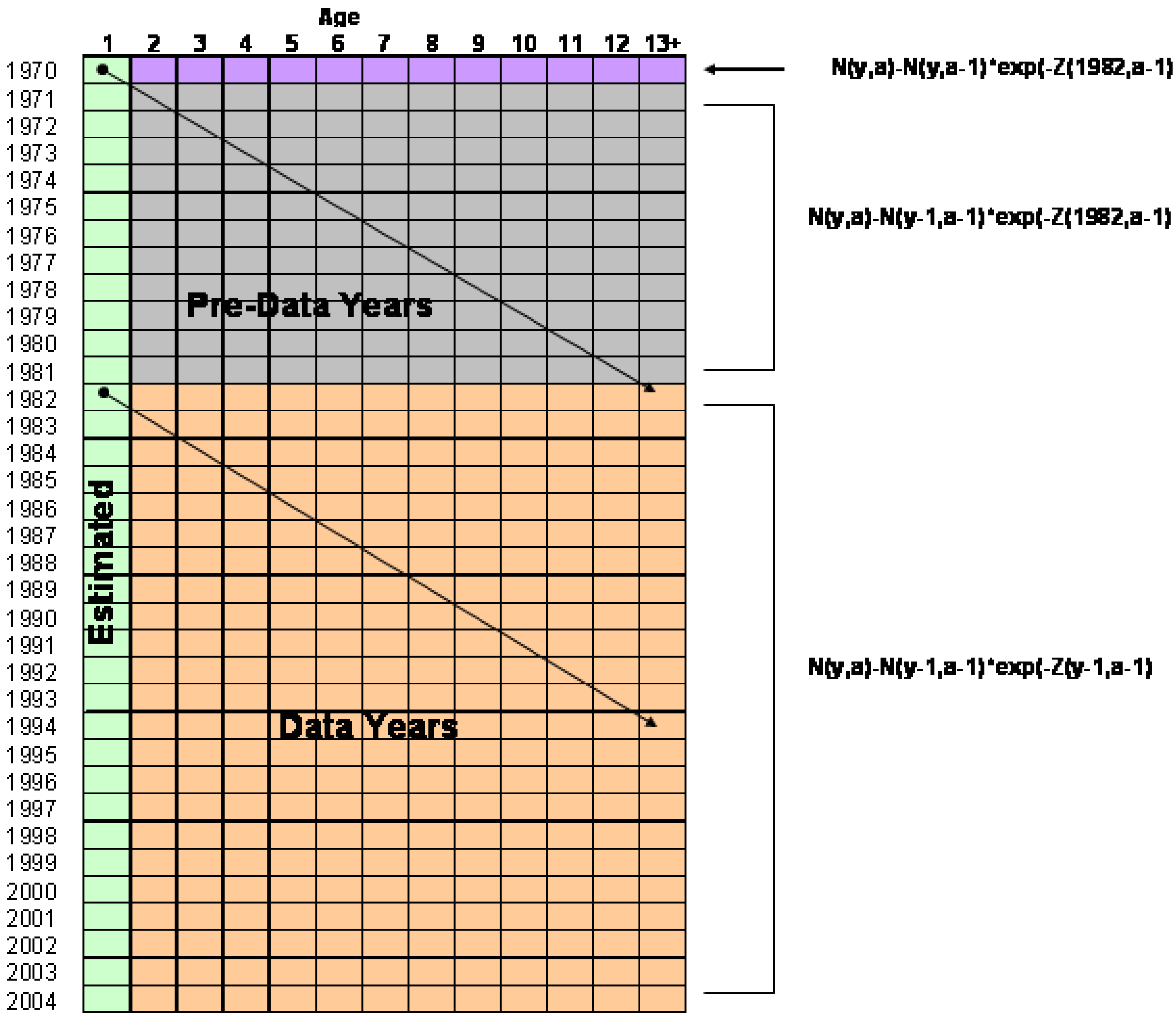


Figure A10.1. Schematic of population abundance-at-age

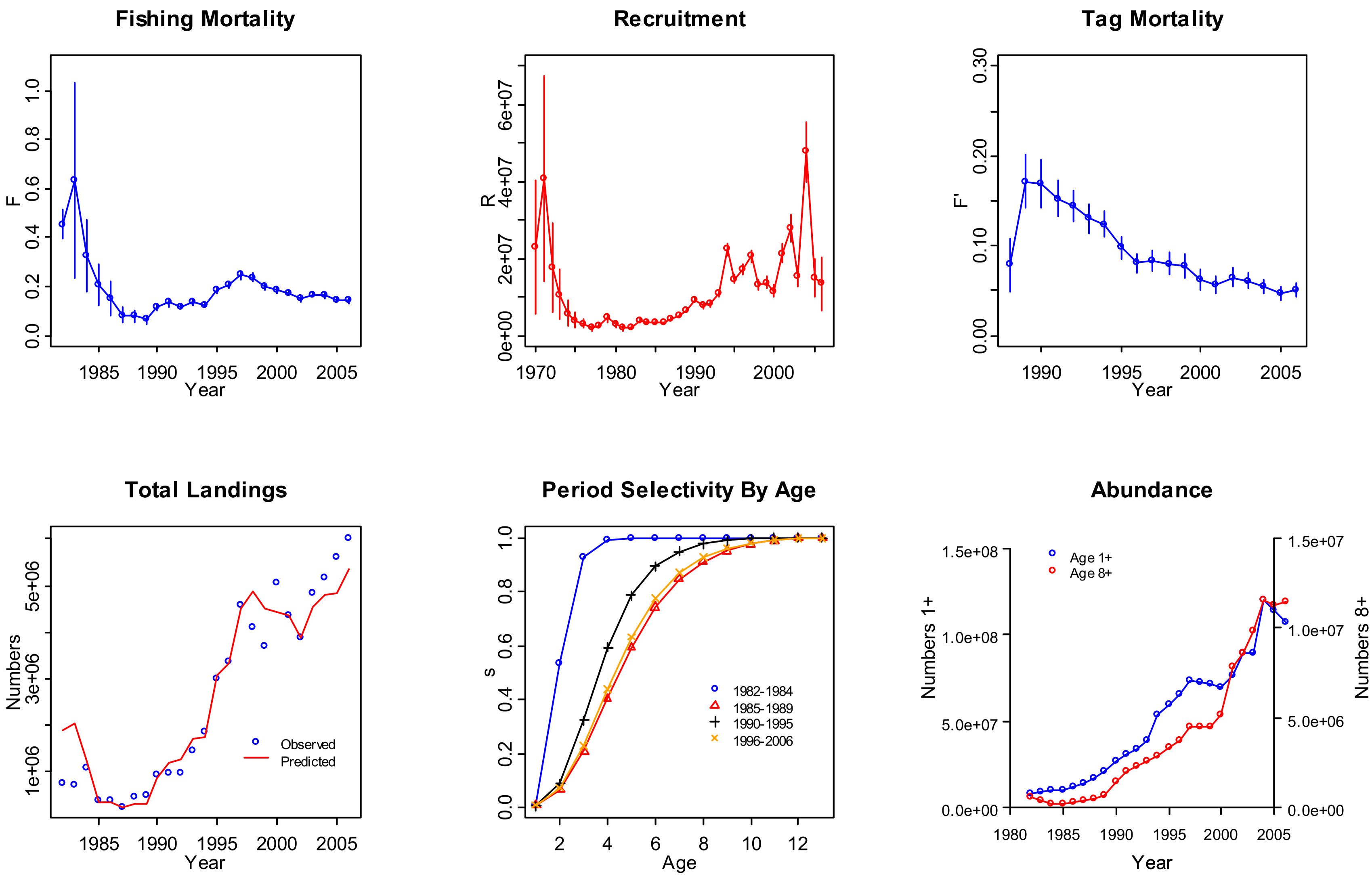


Figure A10.2. Estimates of fishing mortality (±95%CI), recruitment (±95%CI), fishing mortality on the tags, total landings, period selectivity patterns, and abundance of ages 1+ and 8+ from the SCATAG model run with equal weighting across all components.

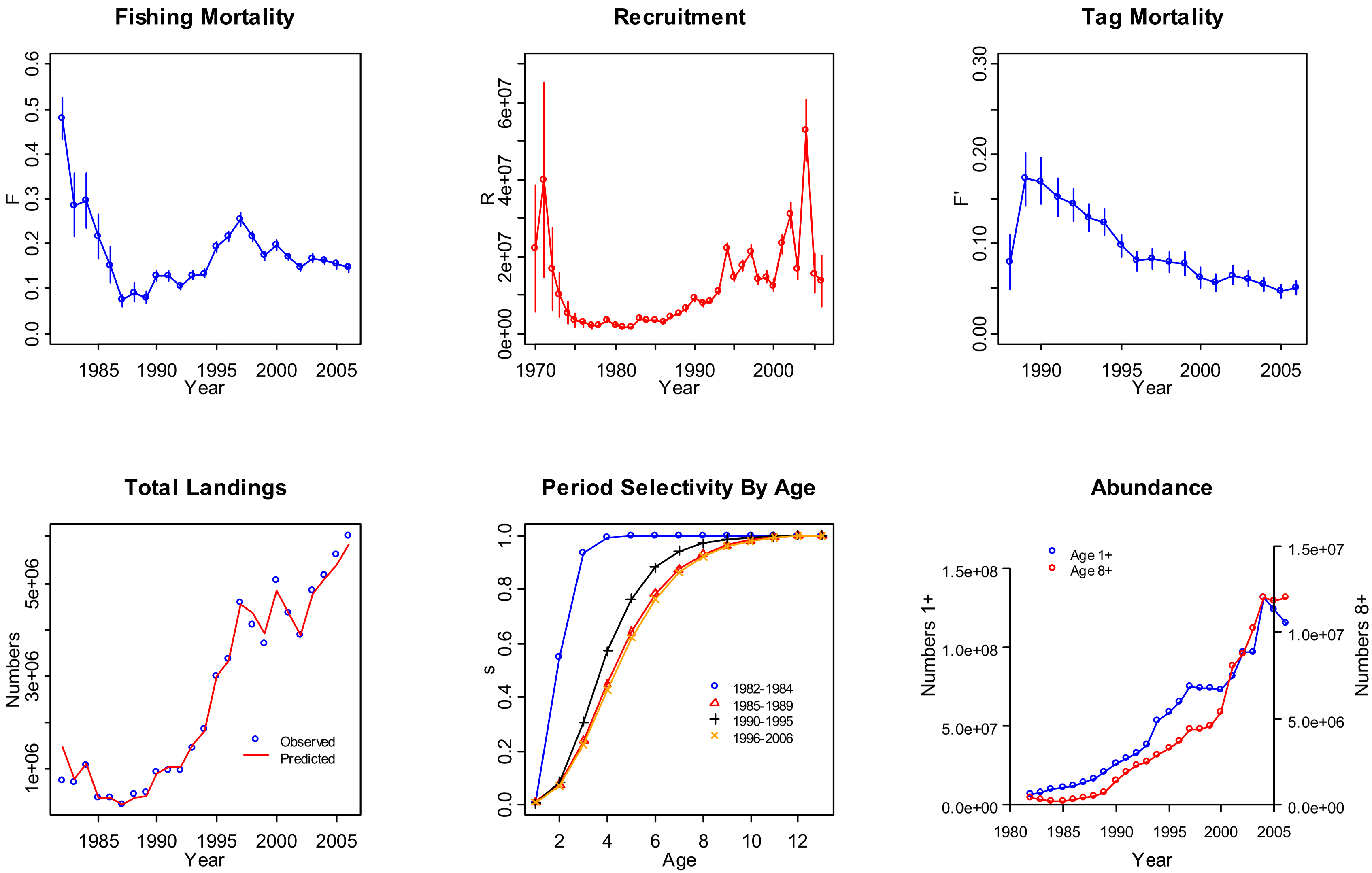


Figure A10.3. Estimates of fishing mortality ($\pm$95%CI), recruitment ($\pm$95%CI), total landings, period selectivity patterns, and abundance of ages 1+ and 8+ from SCATAG model run with total catch lambda =50.

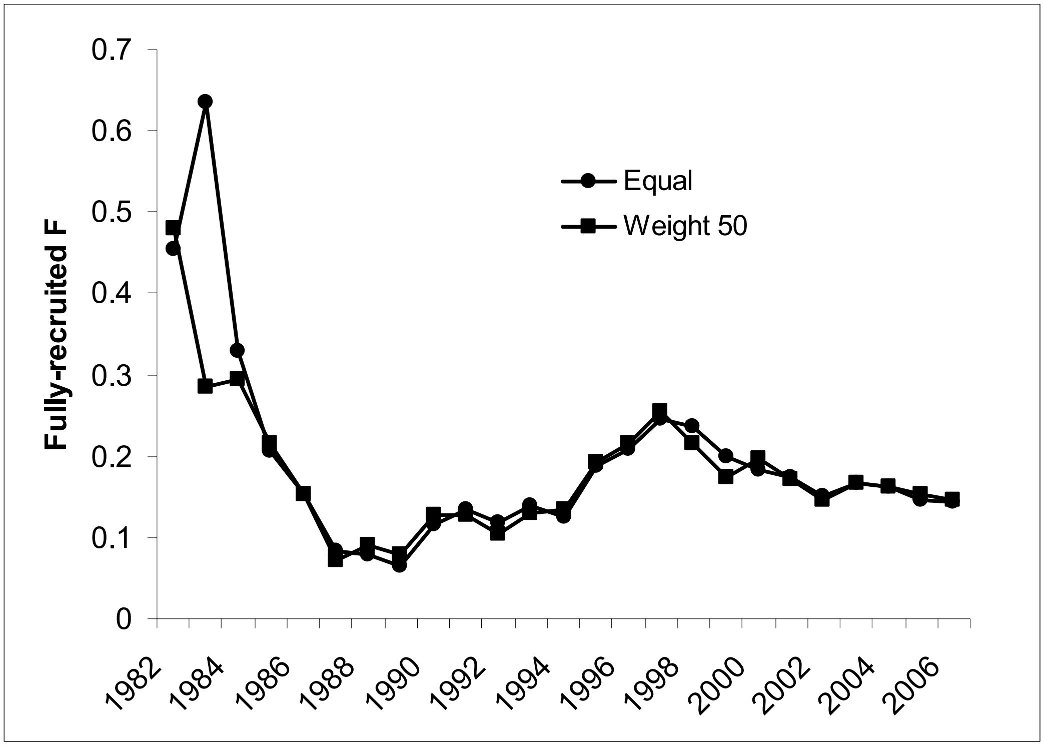


Figure A10.4. Comparison of fully-recruited fishing mortality estimates from the SCATAG model runs with equal weighting across all components and with total catch weight =50.

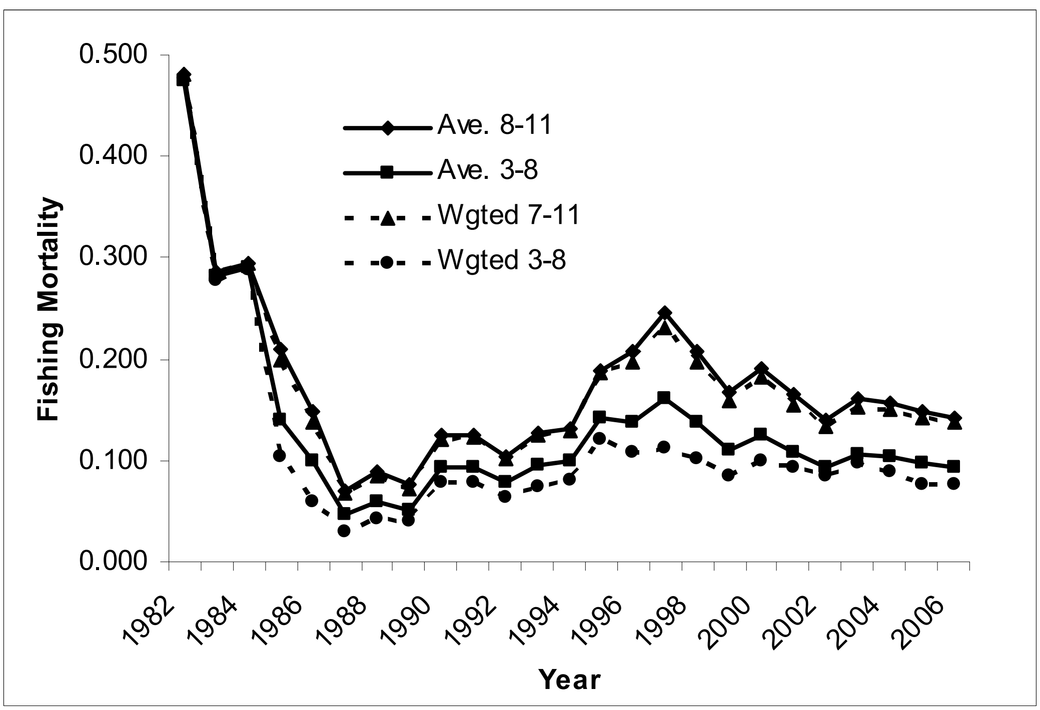


Figure A10.5. Estimates of average and abundance weighted fishing mortality from the SCATAG model under the total catch weight lambda=50.

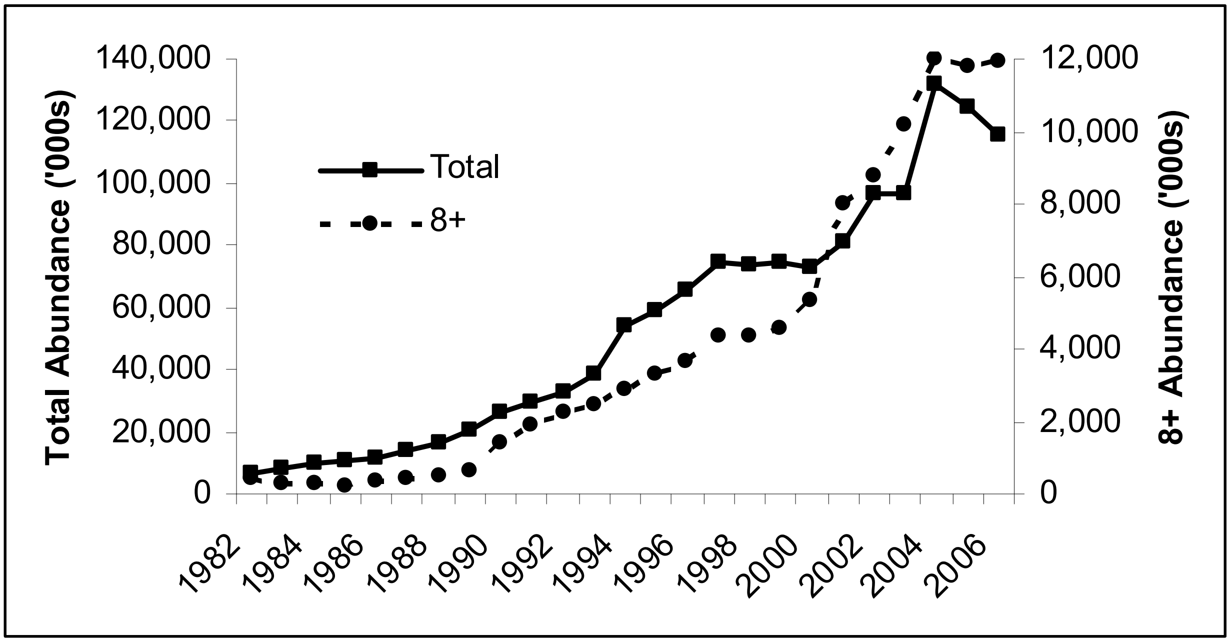


Figure A10.6. Estimates of total and 8+ abundance from the SCATAG model.

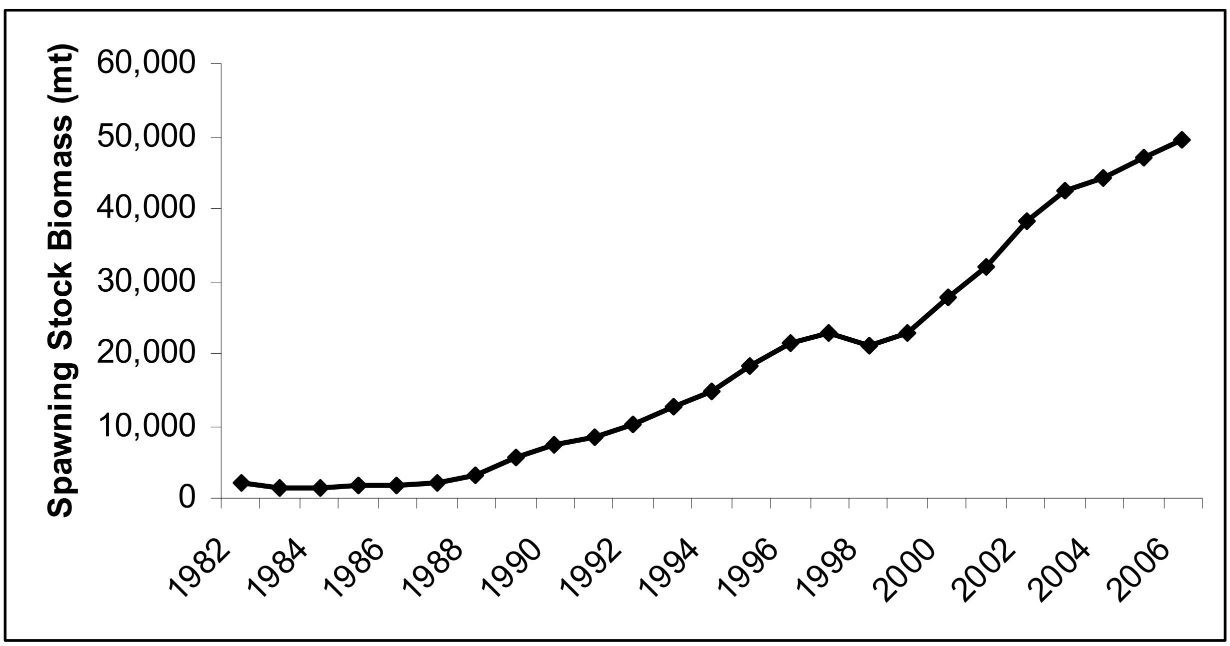
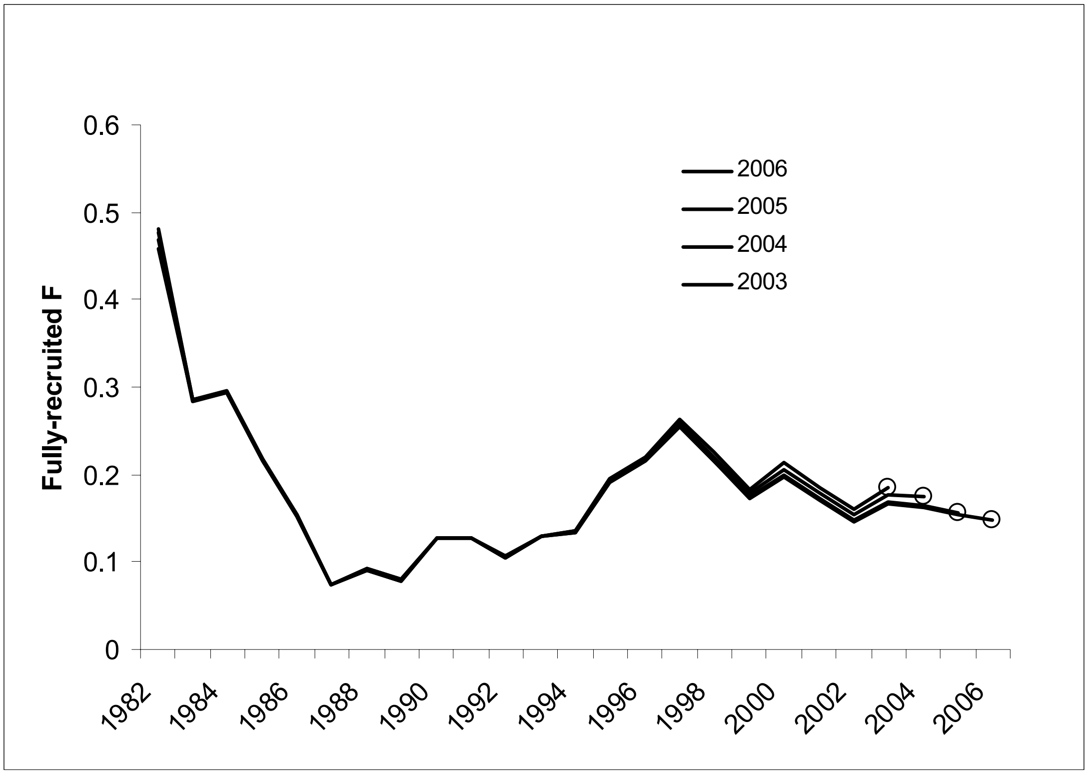


Figure A10.7. Estimates of female spawning stock biomass from the SCATAG model.



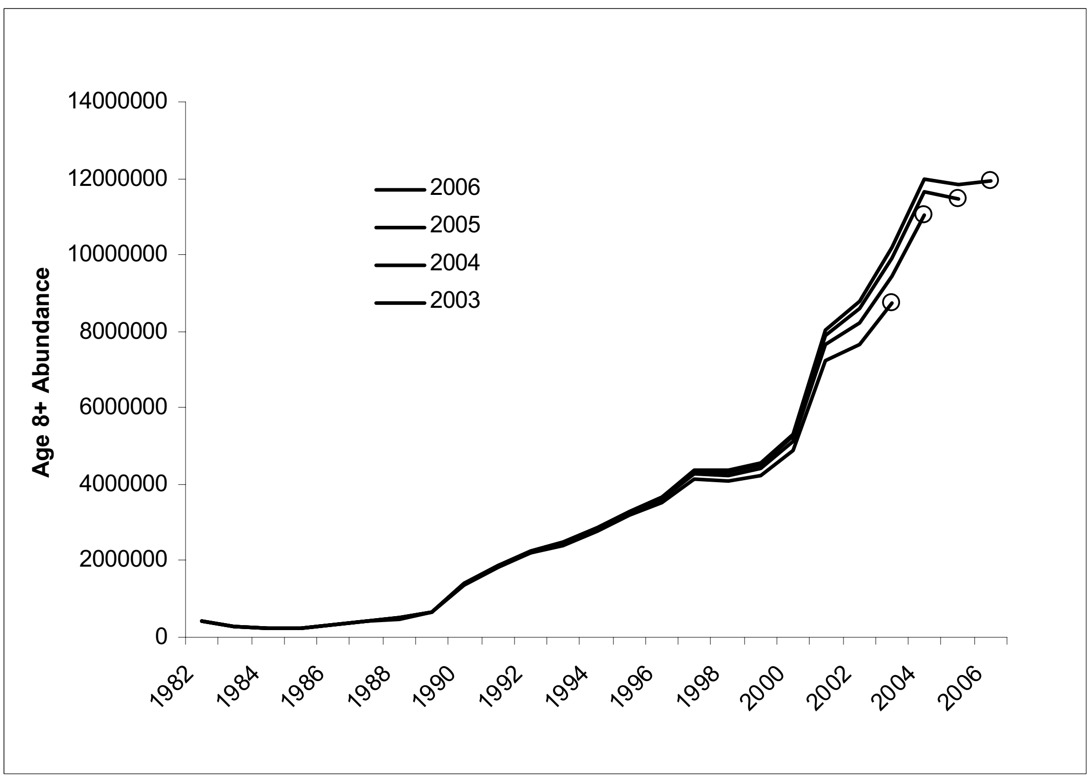


Figure A10.8. Retrospective analysis of fully-recruited fishing mortality and 8+ abundance from the SCATAG model.

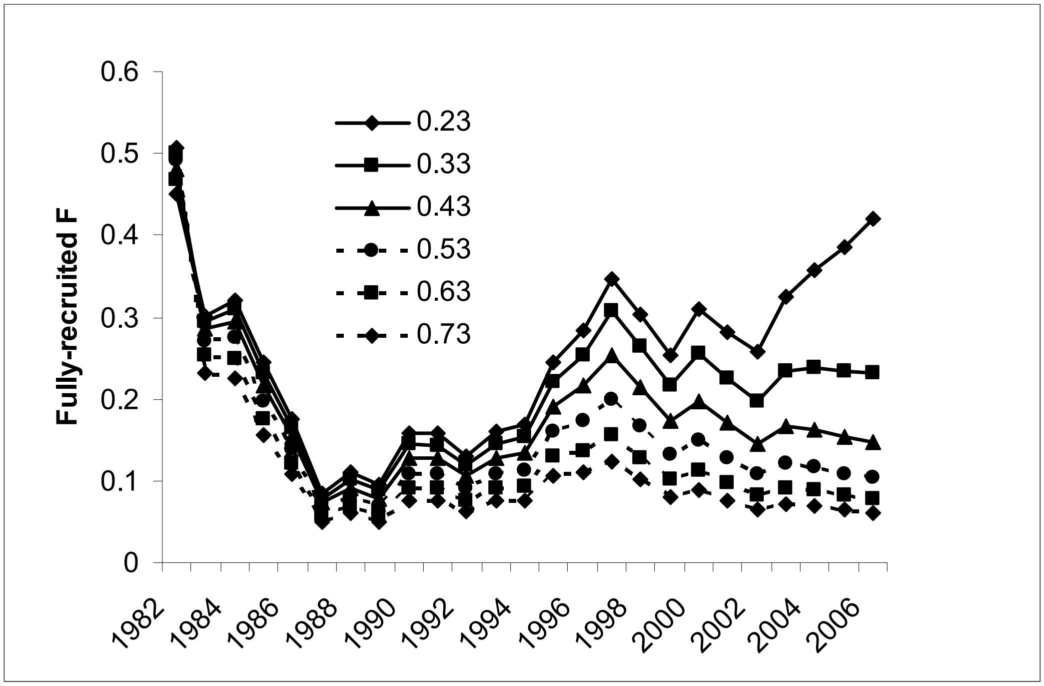


Figure A10.9. Effects of varying reporting rate on the estimates of fishing mortality from the SCATAG model.

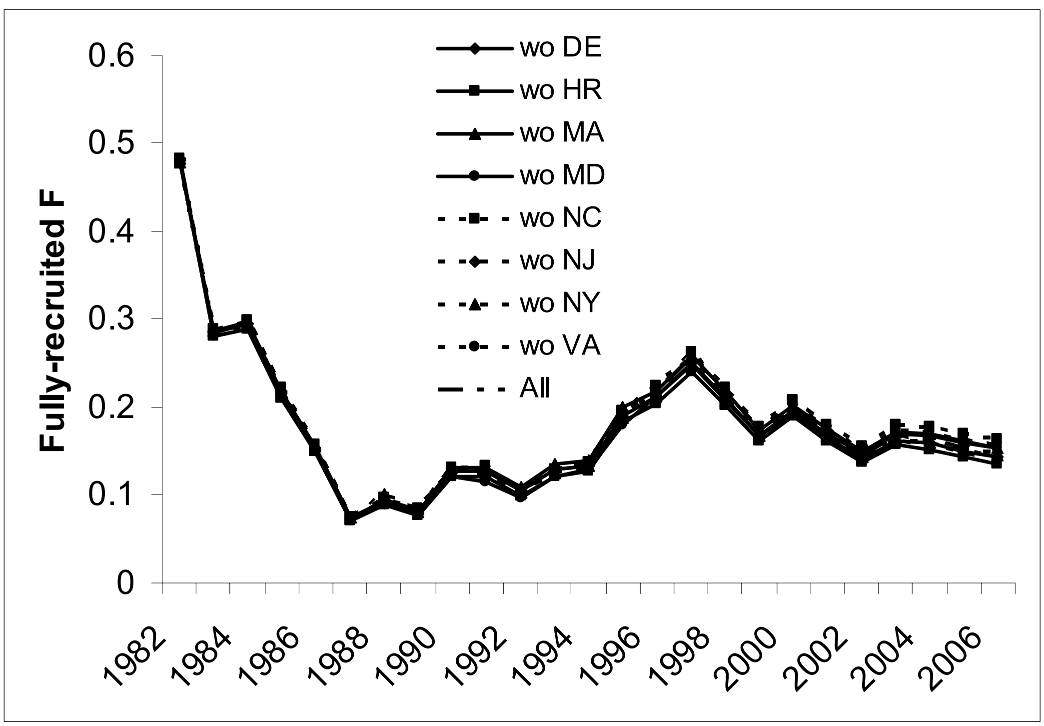


Figure A10.10. Estimates of fishing mortality when data from each tagging program are deleted from the SCATAG model.

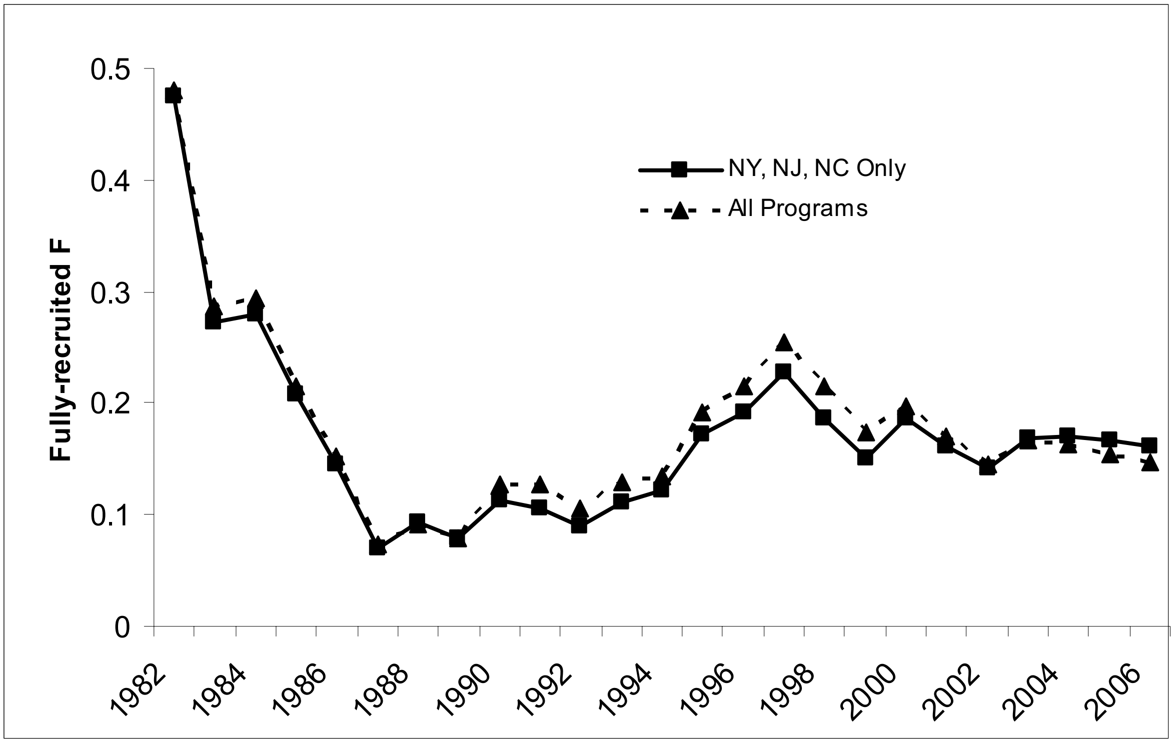


Figure A10.11. Comparison of estimates of fully-recruited fishing mortality from the SCATAG model with all programs and when only data from NYOHS, NJ, and NC COOP were used.

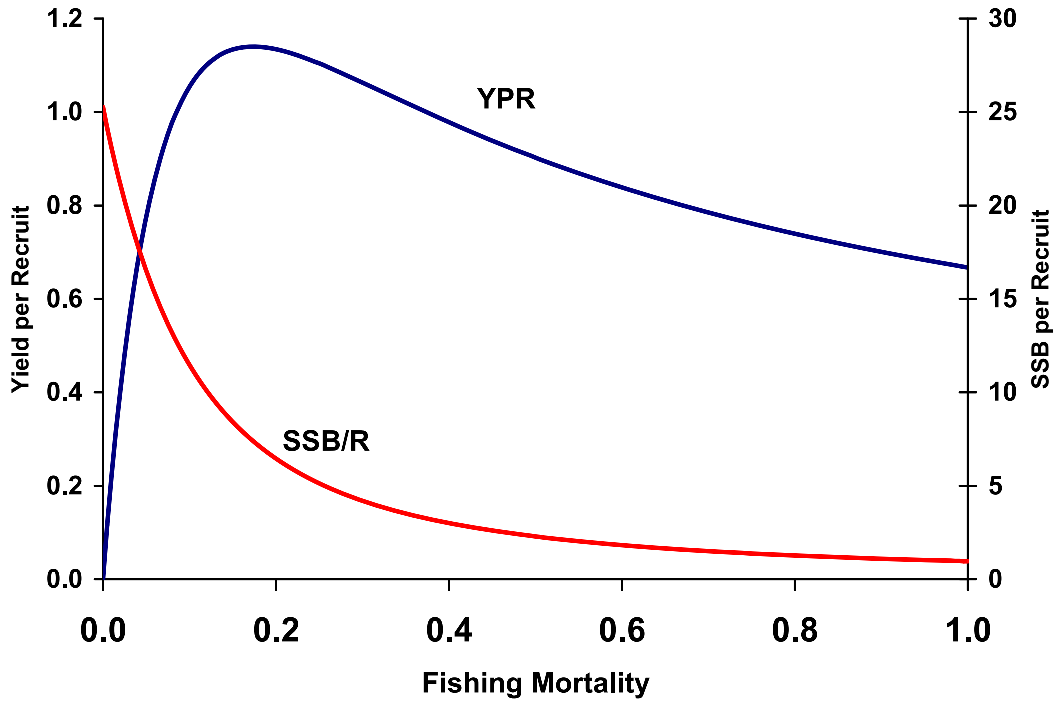


Figure A11.1. Thompson-Bell yield per recruit model for Atlantic striped bass fitted with a natural mortality equal to 0.15 and a maximum age of 25.

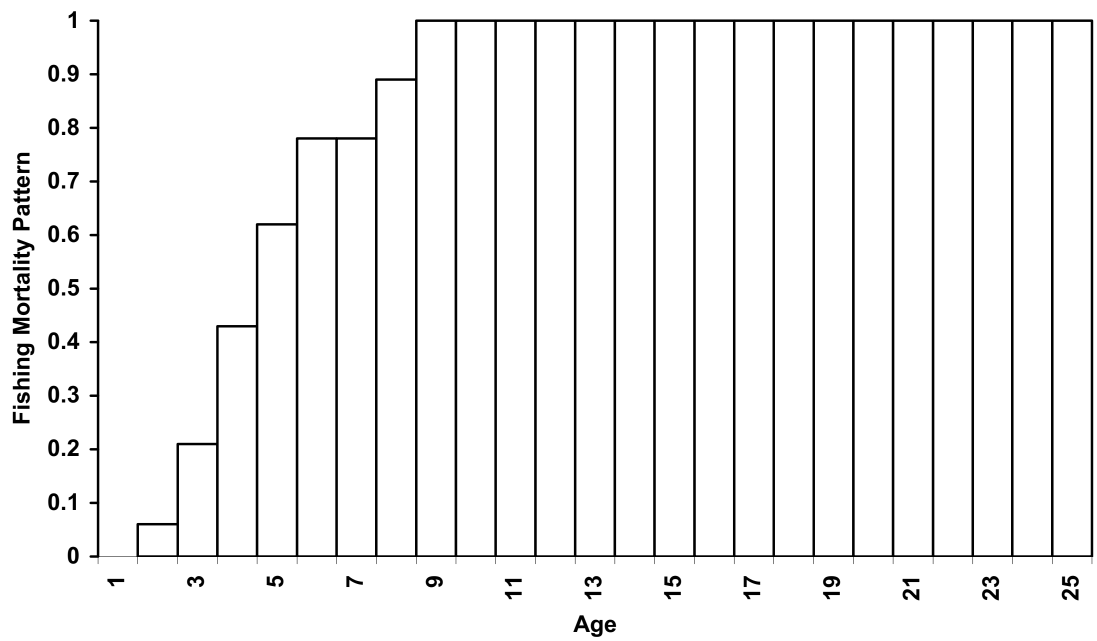


Figure A11.2. Age specific partial recruitments for Atlantic striped bass assuming a 50:50 sex ratio.

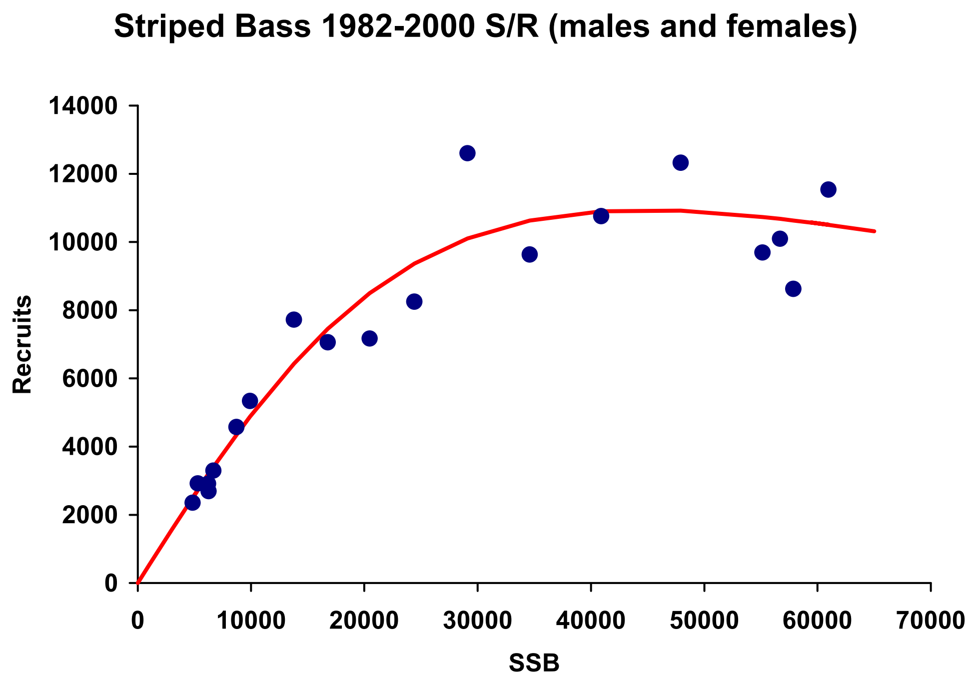


Figure A11.3. Shepherd stock-recruitment curve for Atlantic striped bass using data from the years 1982-1999

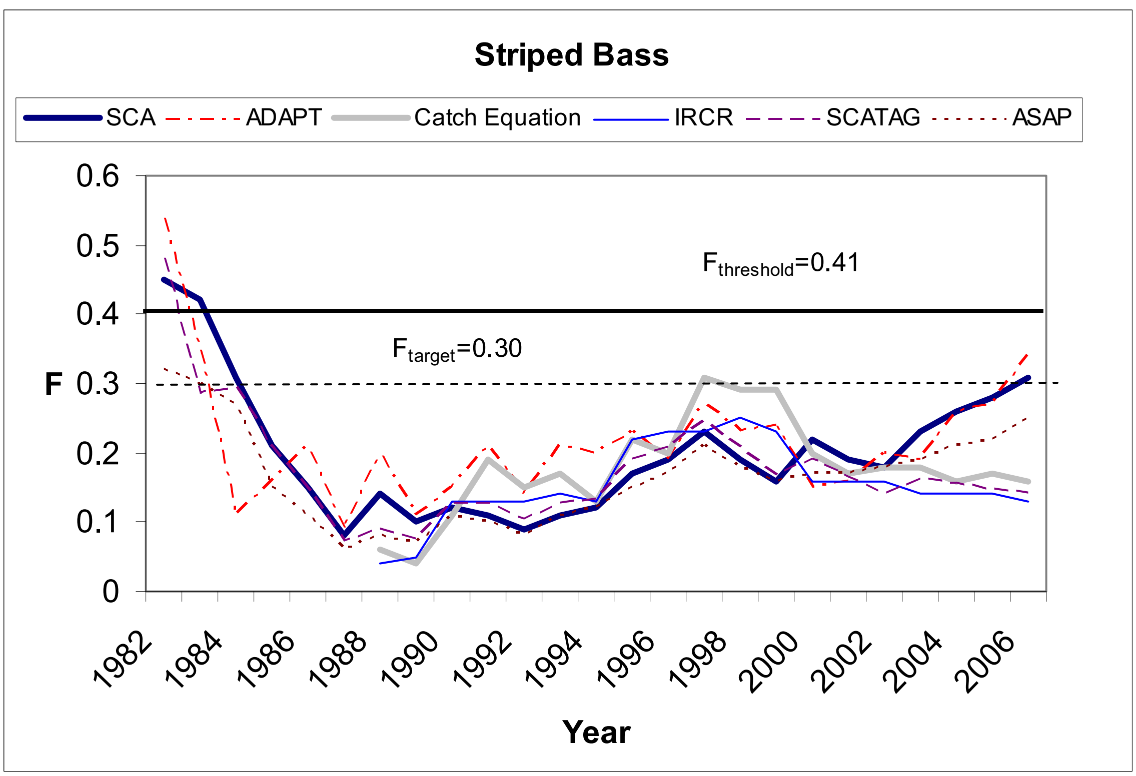


Figure A11.4. Estimates of instantaneous fishing mortality (F) from Catch Equation method, SCA, and supporting models

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

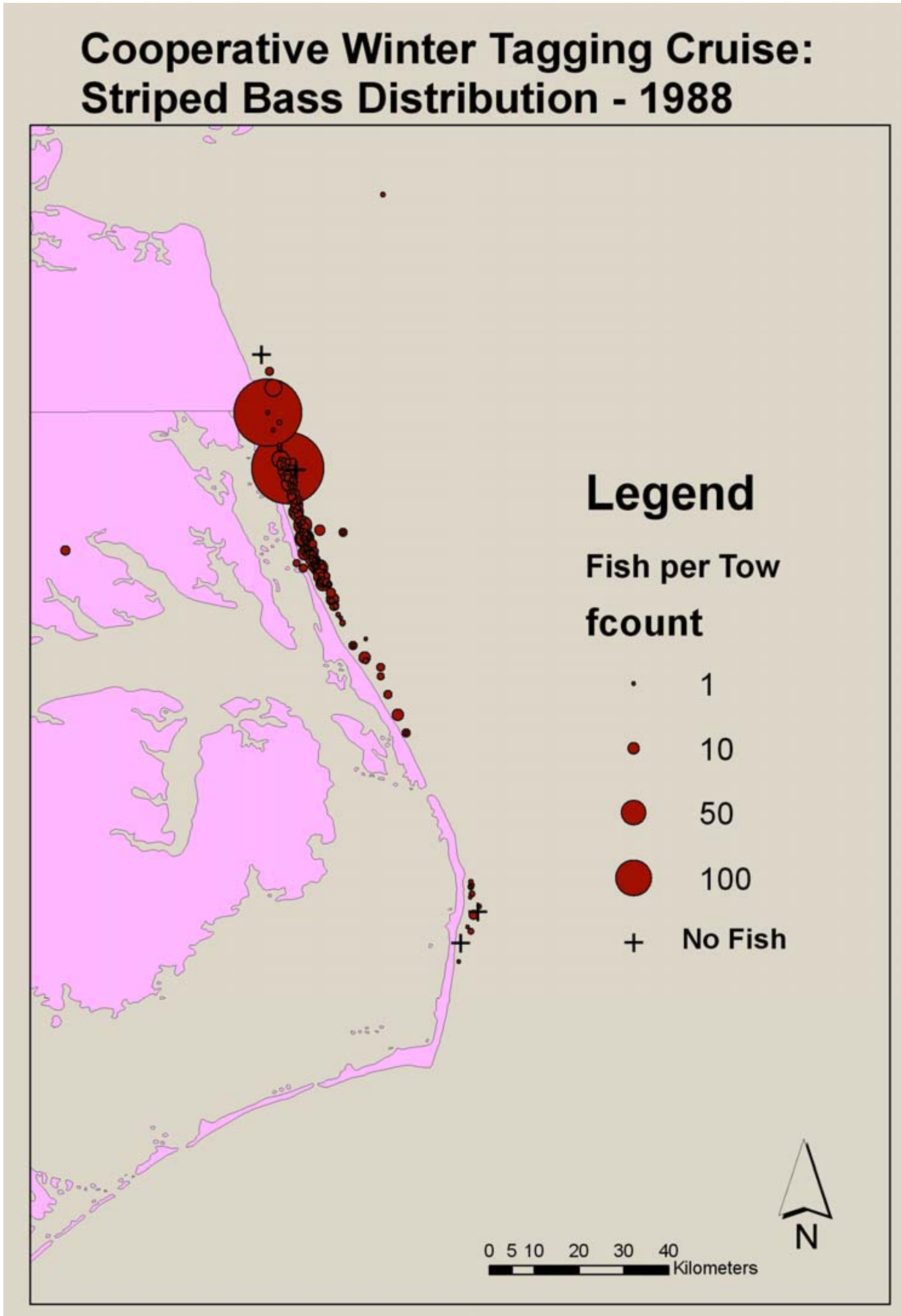

Figure 1. Distribution of striped bass captured on the wintering grounds during the 1988 Cooperative Winter Tagging Cruise

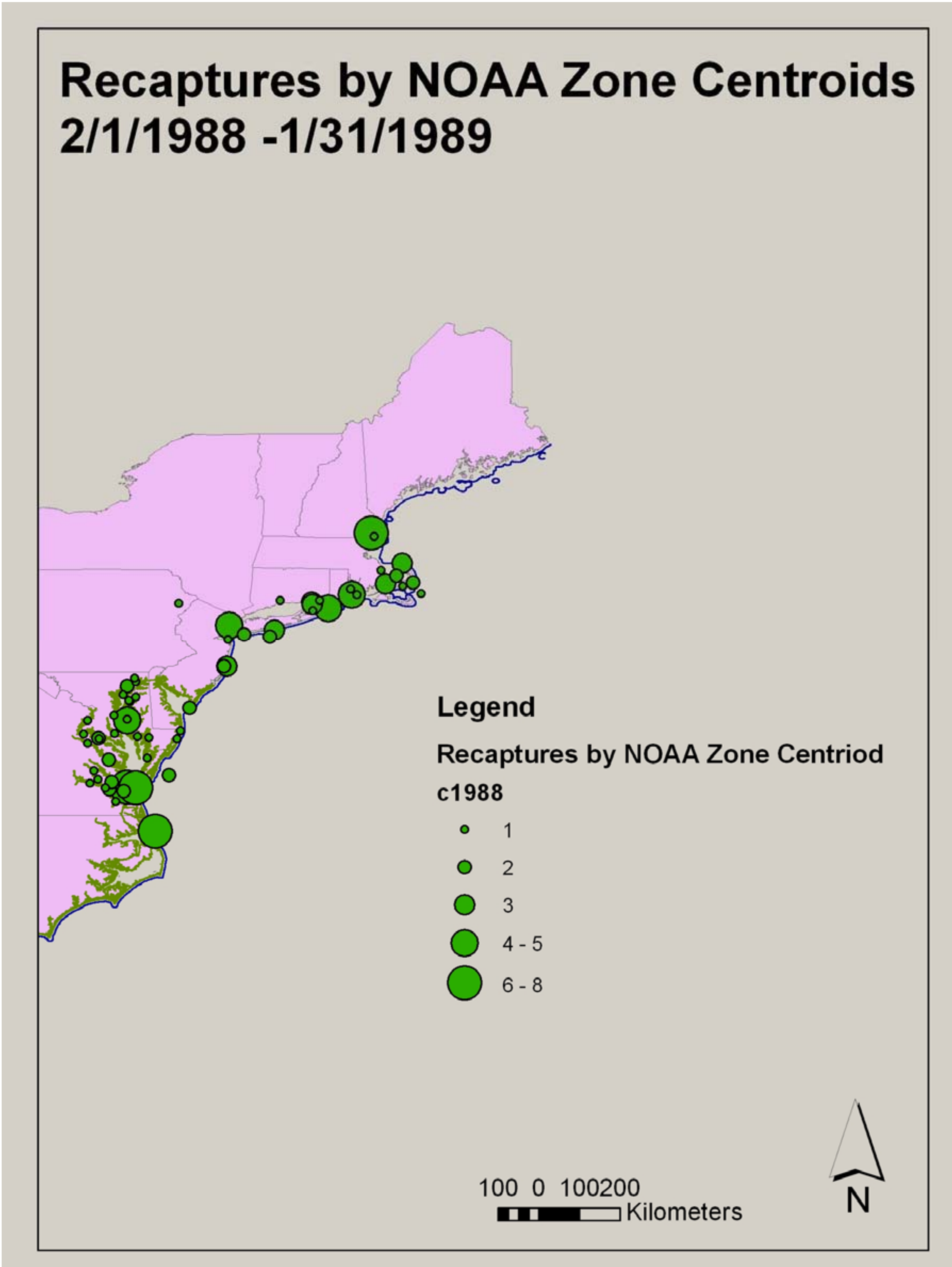

Figure 2. Distribution of all striped bass recaptures from 2/1/1988 – 1/31/1989 tagged during the 1988 Cooperative Winter Tagging Cruise

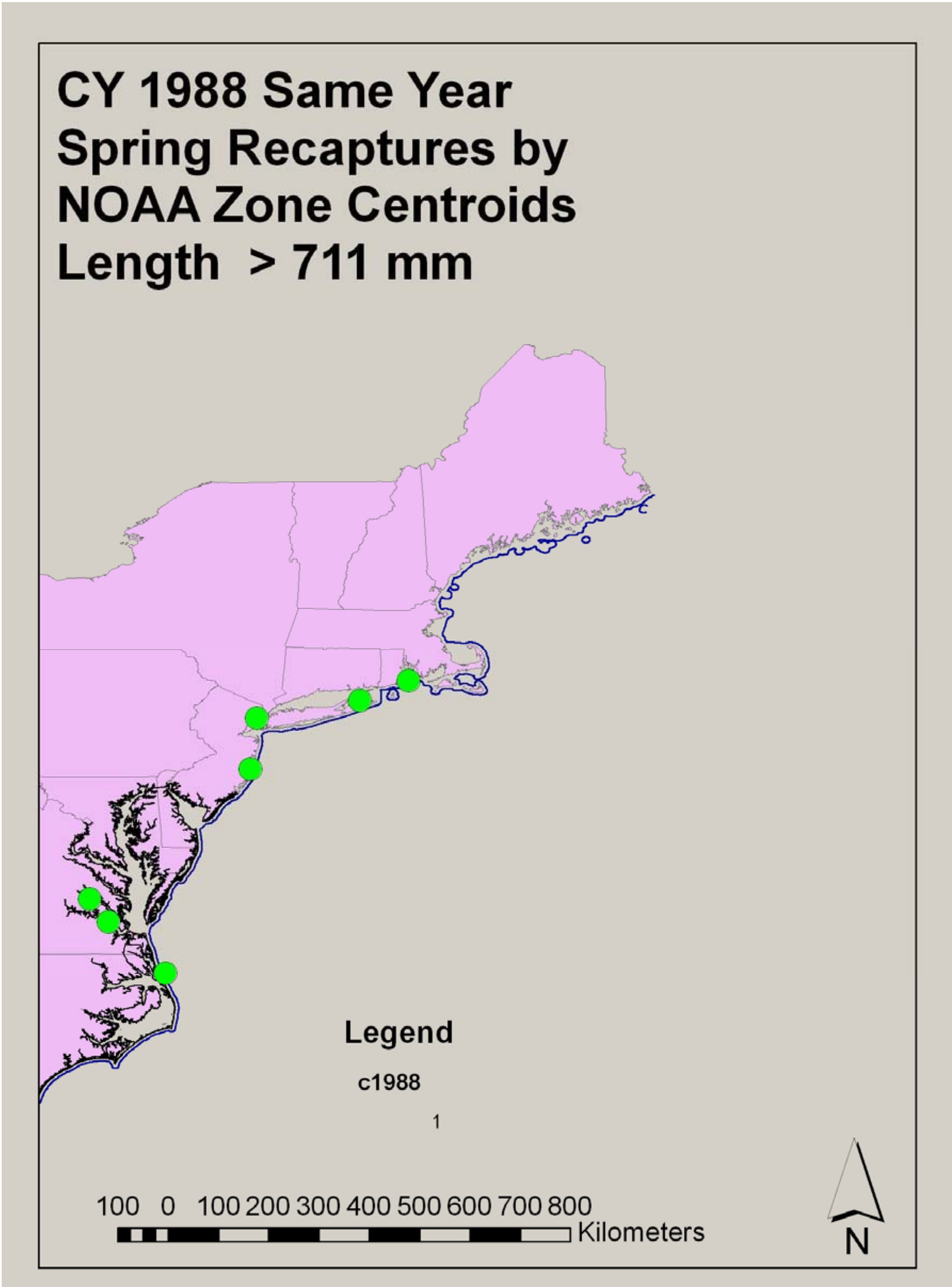

Figure 3. Distribution of 1988 spring recaptures of striped bass >711 mm and tagged during the 1988 Cooperative Winter Tagging Cruise

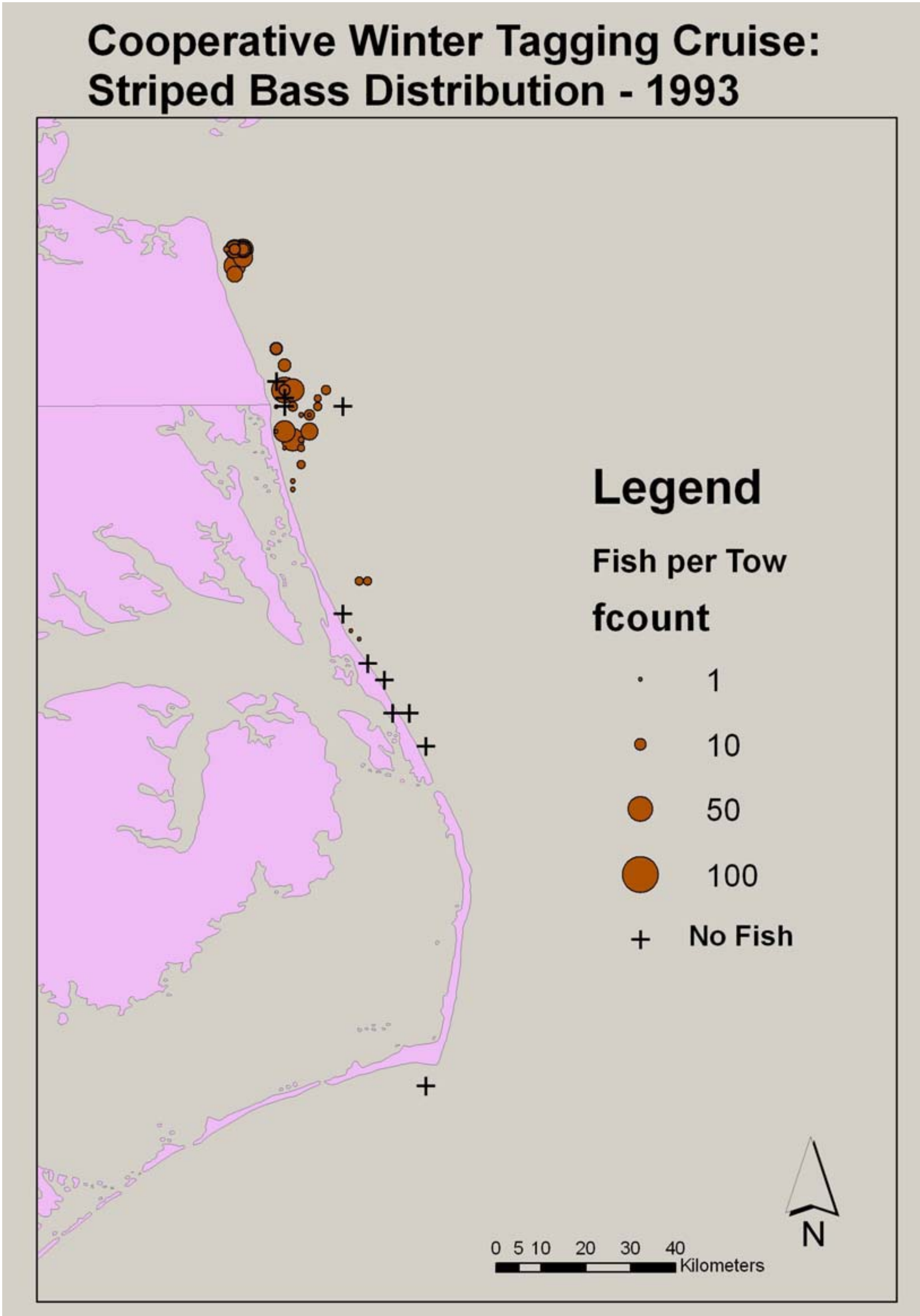

Figure 4. Distribution of striped bass captured on the wintering grounds during the 1993 Cooperative Winter Tagging Cruise

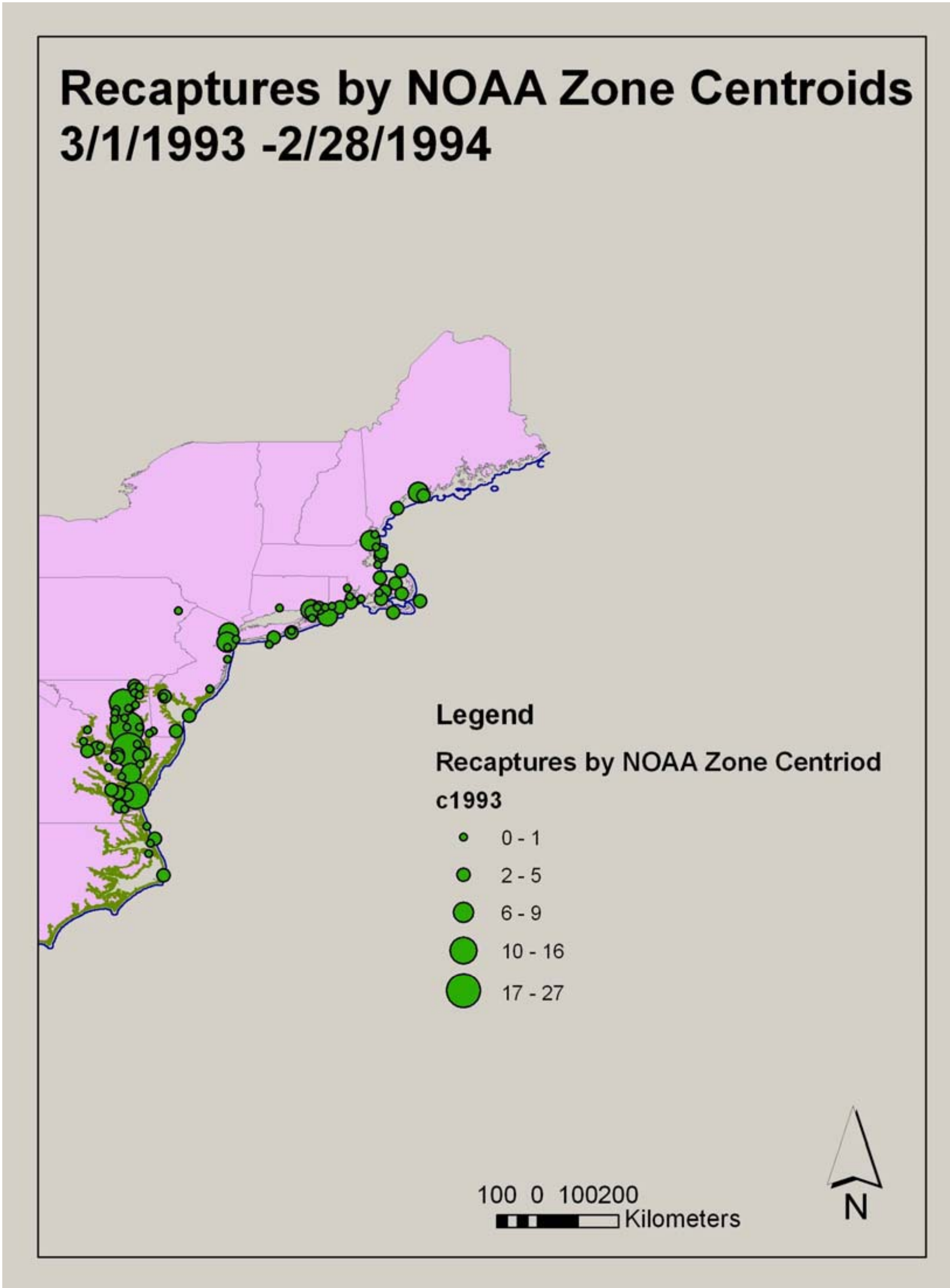

Figure 5. Distribution of all striped bass recaptures from 3/1/1993 – 2/28/1994 tagged during the 1993 Cooperative Winter Tagging Cruise

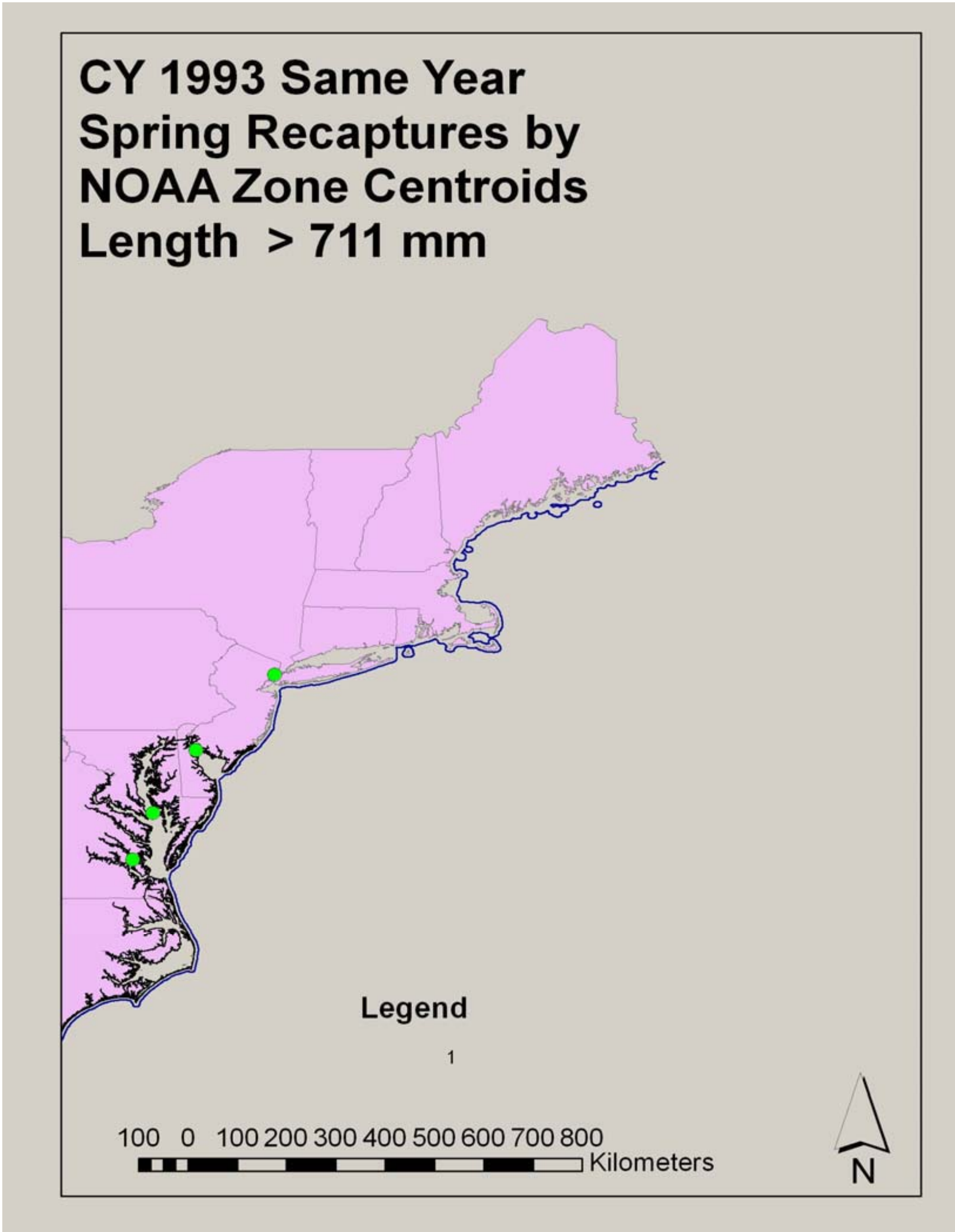

Figure 6. Distribution of 1993 spring recaptures of striped bass >711 mm and tagged during the 1993 Cooperative Winter Tagging Cruise

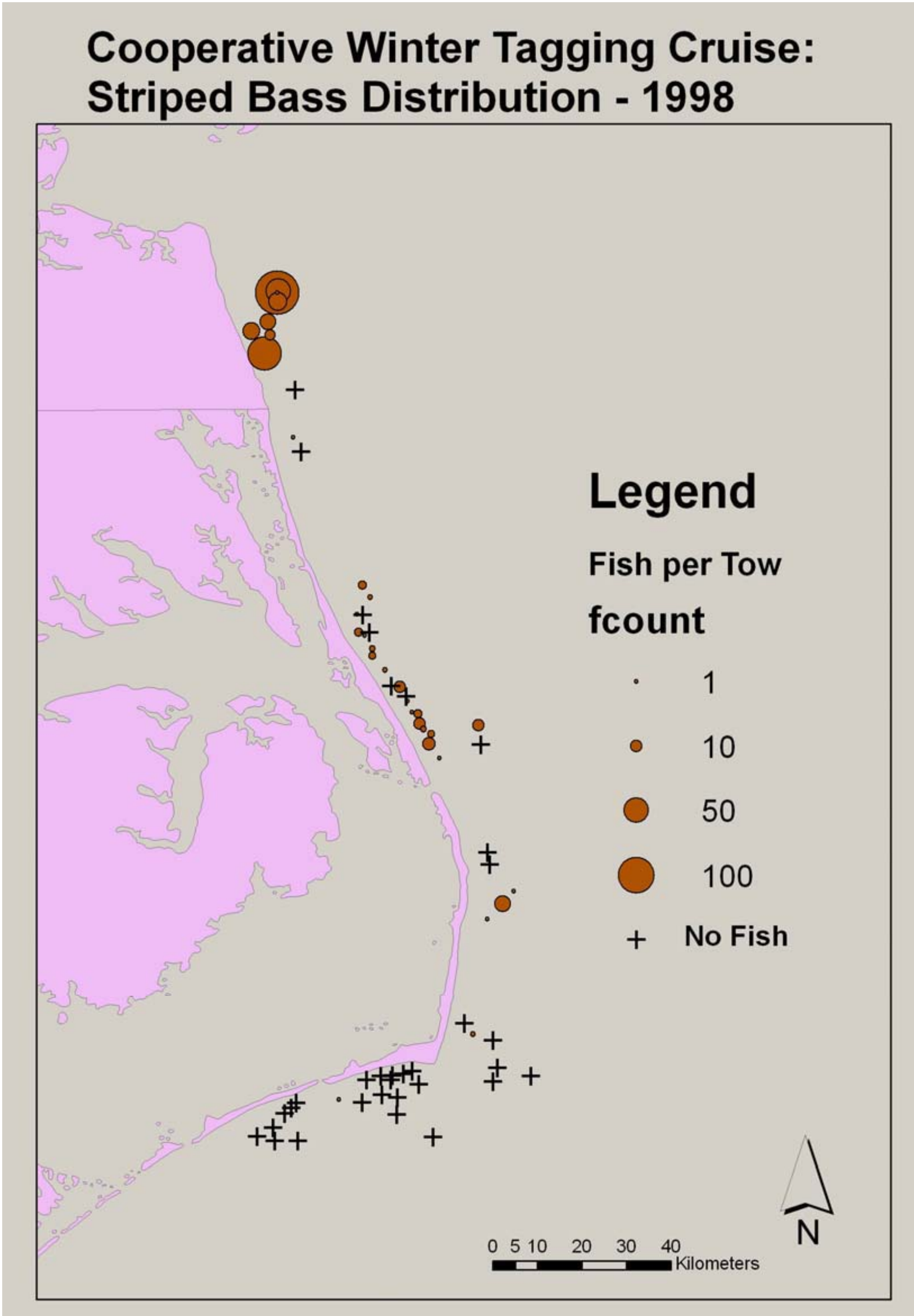

Figure 7. Distribution of striped bass captured on the wintering grounds during the 1998 Cooperative Winter Tagging Cruise

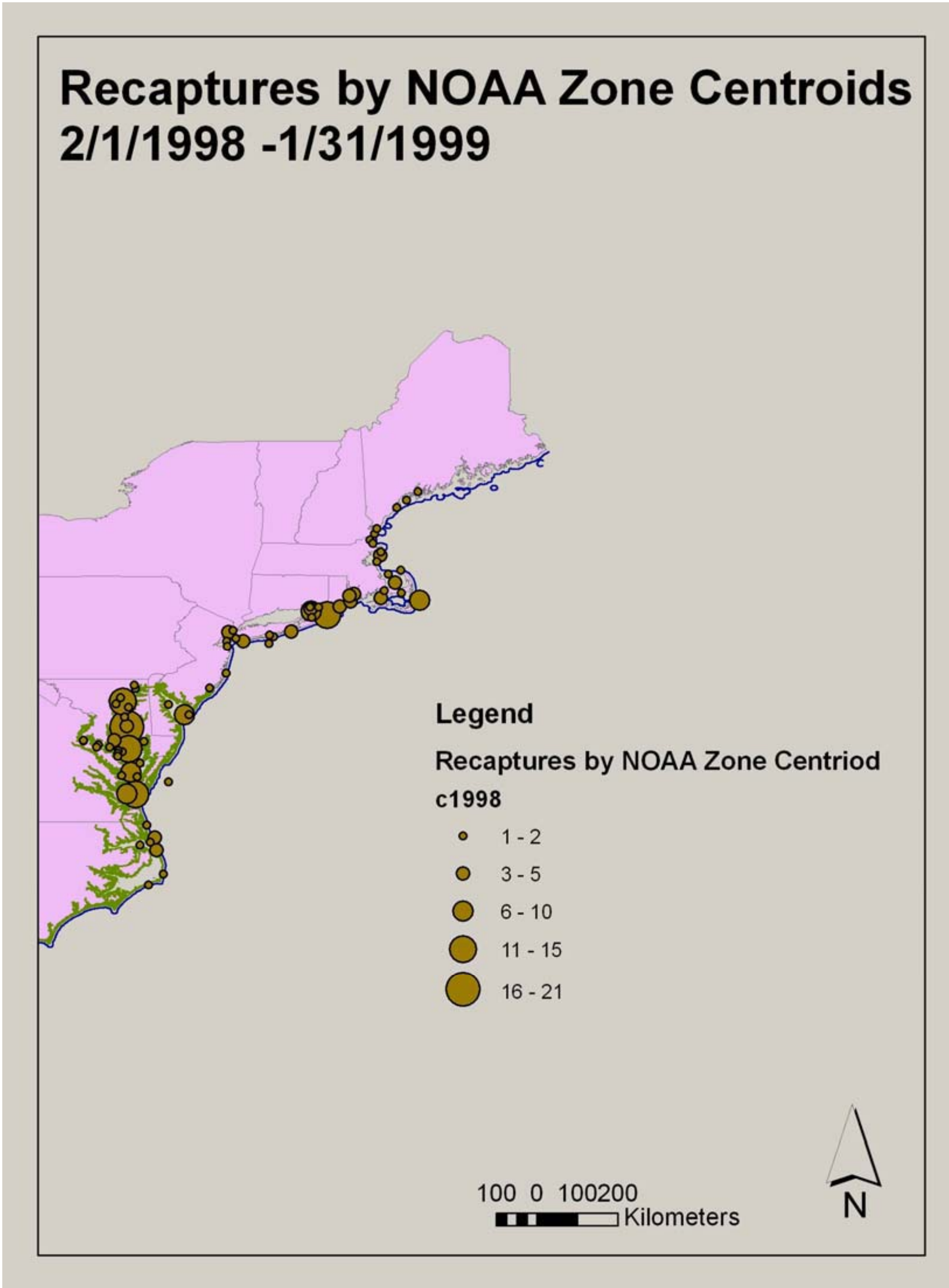

Figure 8. Distribution of all striped bass recaptures from 2/1/1998 – 1/31/1999 tagged during the 1998 Cooperative Winter Tagging Cruise

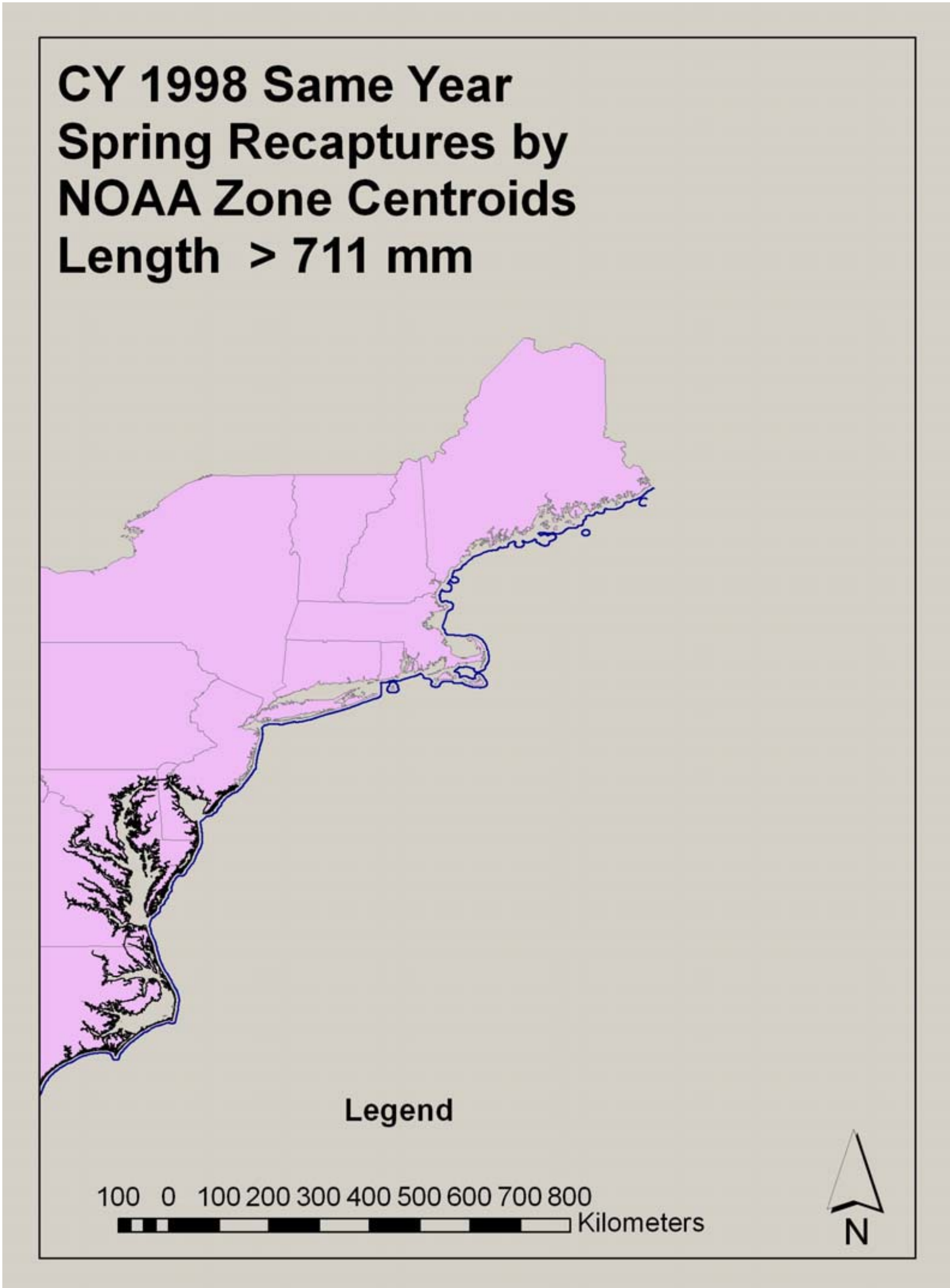

Figure 9. Distribution of 1998 spring recaptures of striped bass >711 mm and tagged during the 1998 Cooperative Winter Tagging Cruise

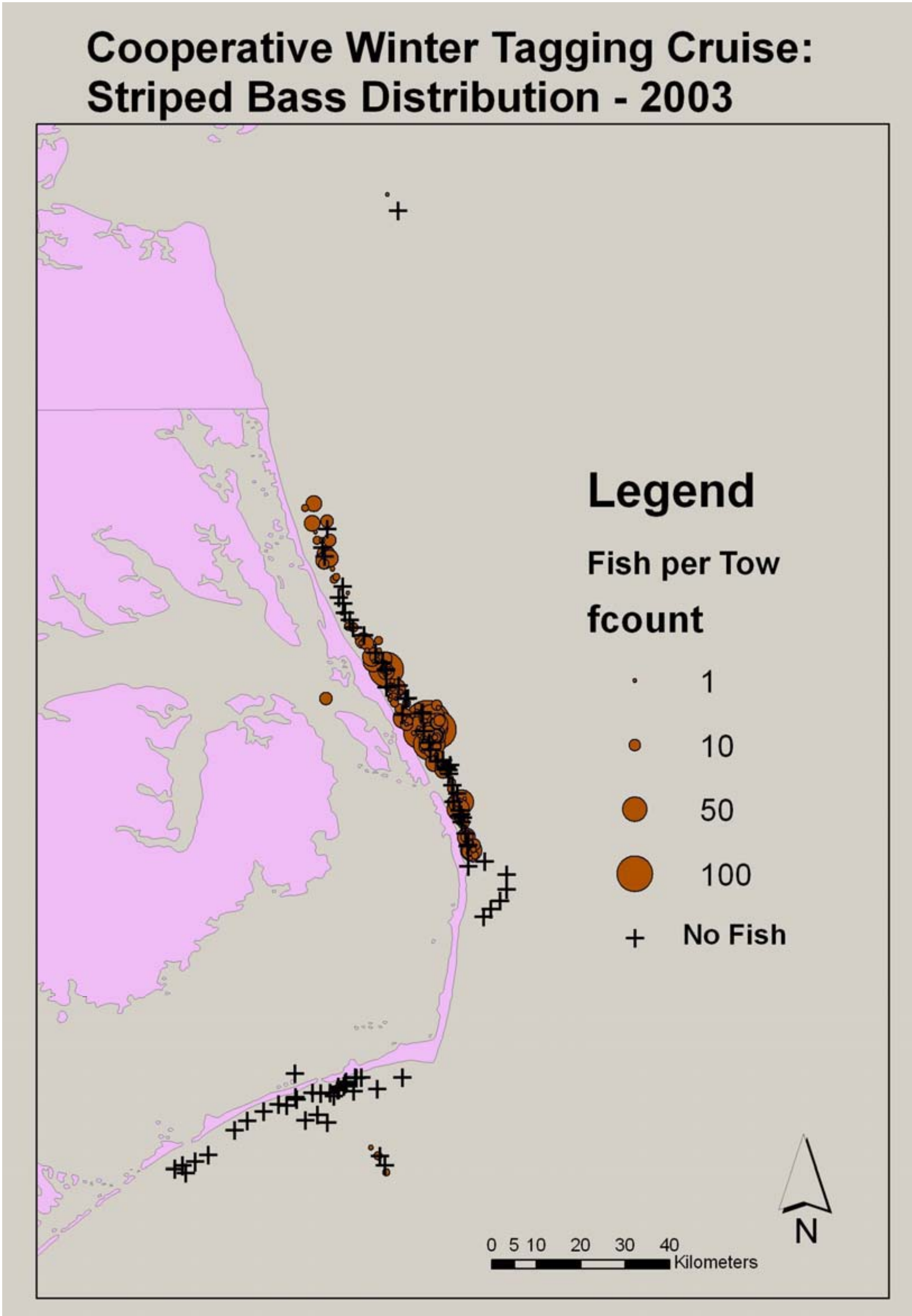

Figure 10. Distribution of striped bass captured on the wintering grounds during the 2003 Cooperative Winter Tagging Cruise

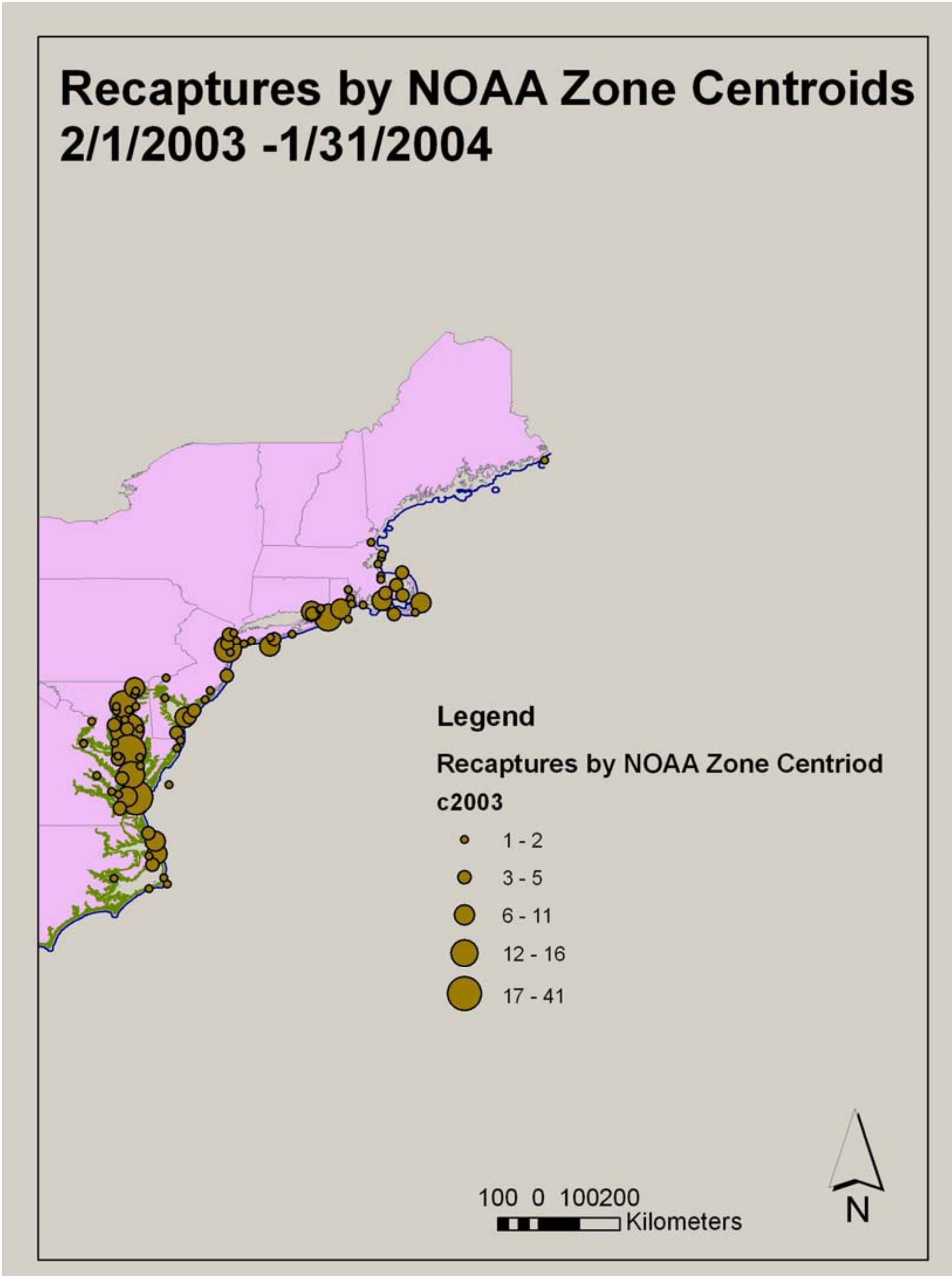

Figure 11. Distribution of all striped bass recaptures from 2/1/2003 – 1/31/2004 tagged during the 2003 Cooperative Winter Tagging Cruise

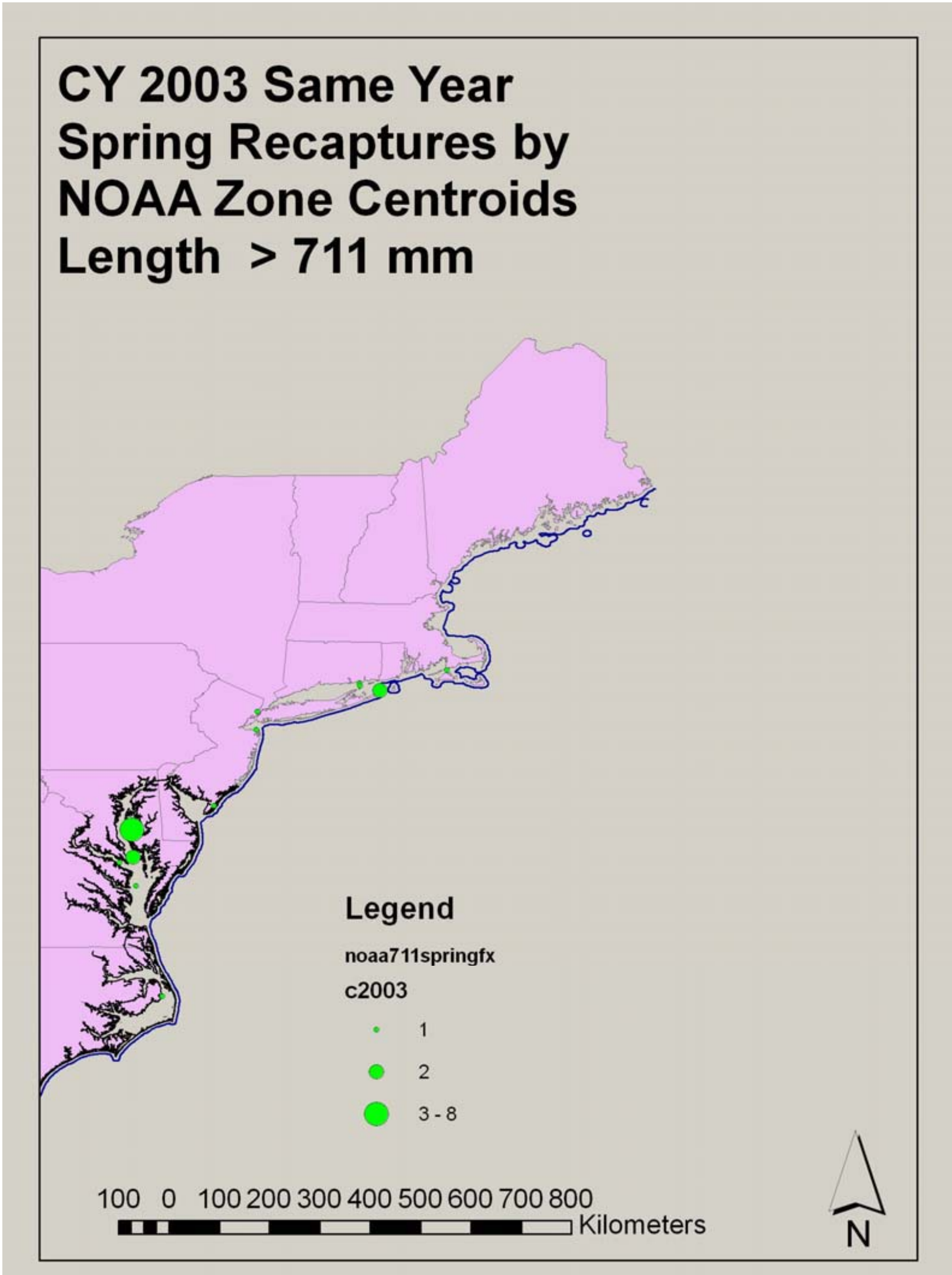

Figure 12. Distribution of 2003 spring recaptures of striped bass >711 mm and tagged during the 2003 Cooperative Winter Tagging Cruise

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 5th 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 α= 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 α= 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

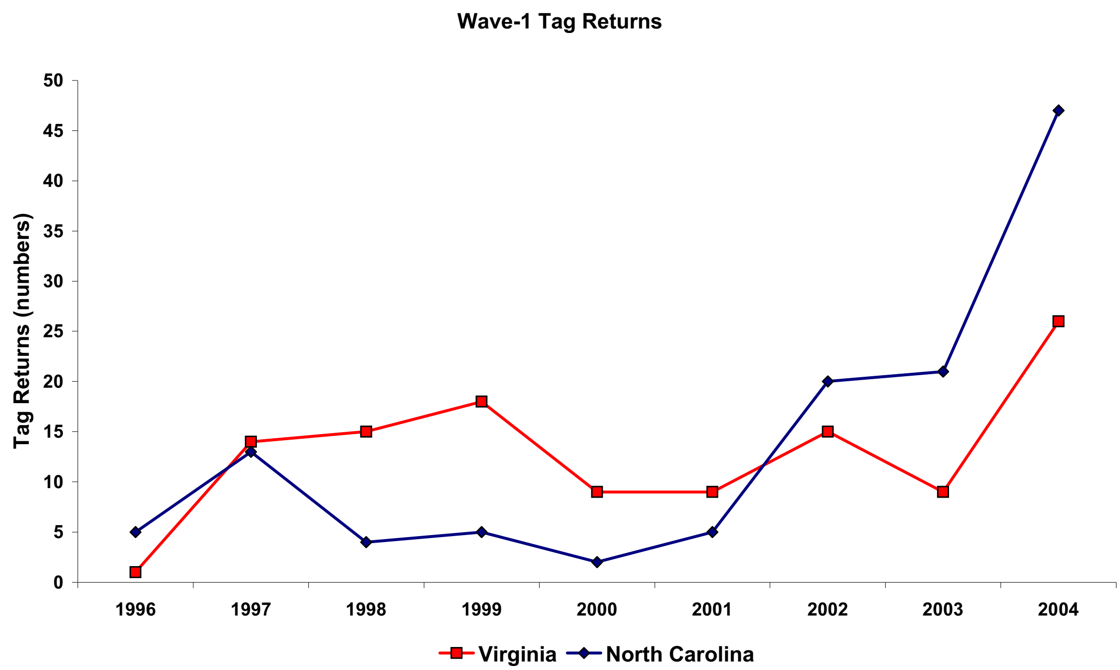

Figure 1. Wave-1 tag returns for Virginia and North Carolina

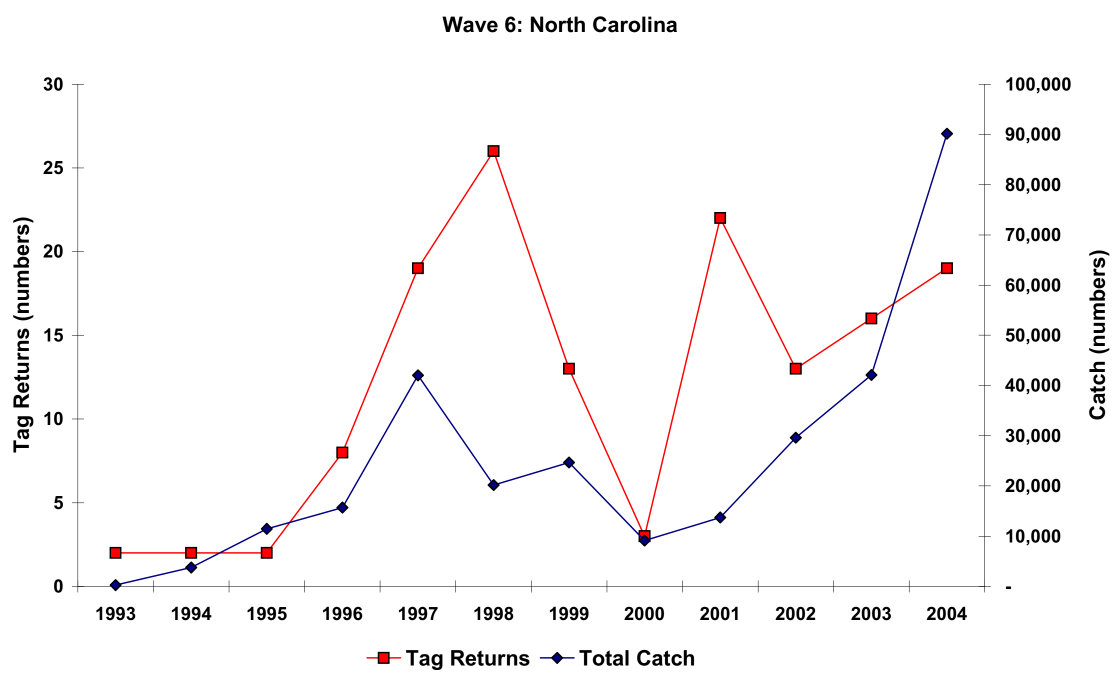

Figure 2. Wave-6 tag returns versus total harvest for North Carolina

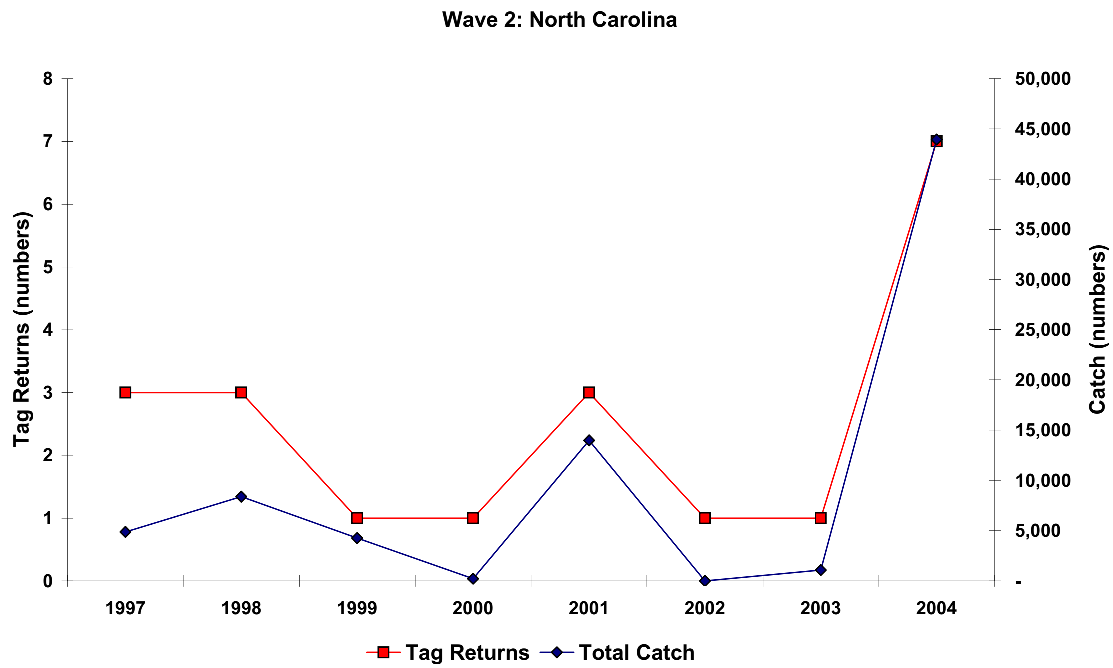

Figure 3. Wave-2 tag returns versus total harvest for North Carolina

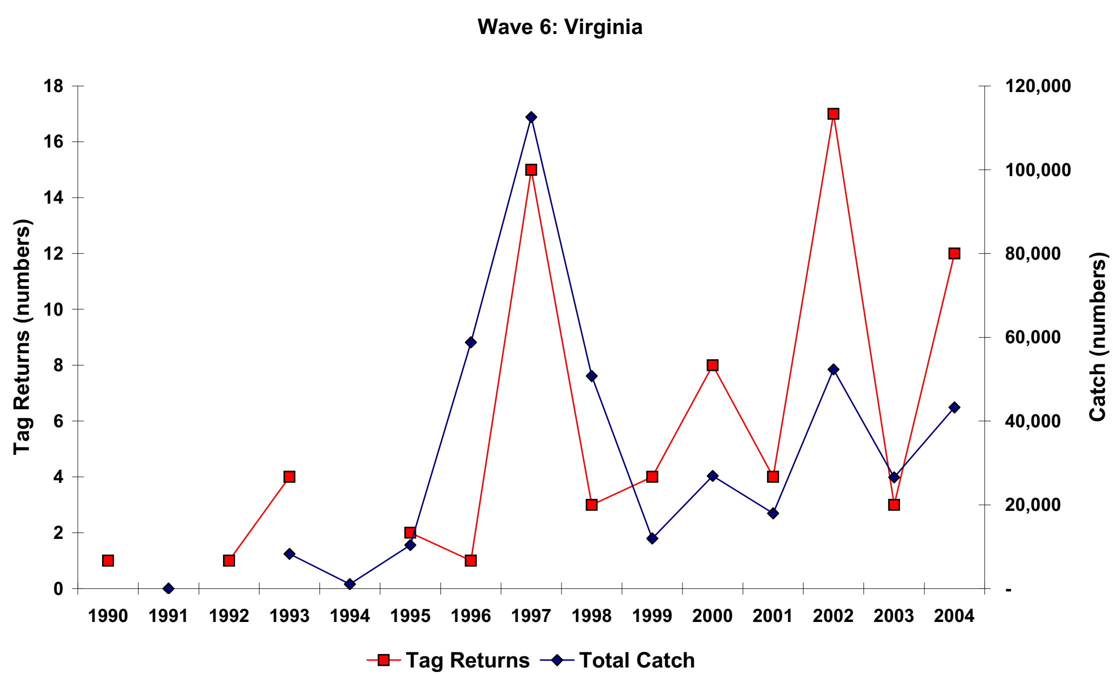

Figure 4. Wave-6 tag returns versus total harvest for Virginia.

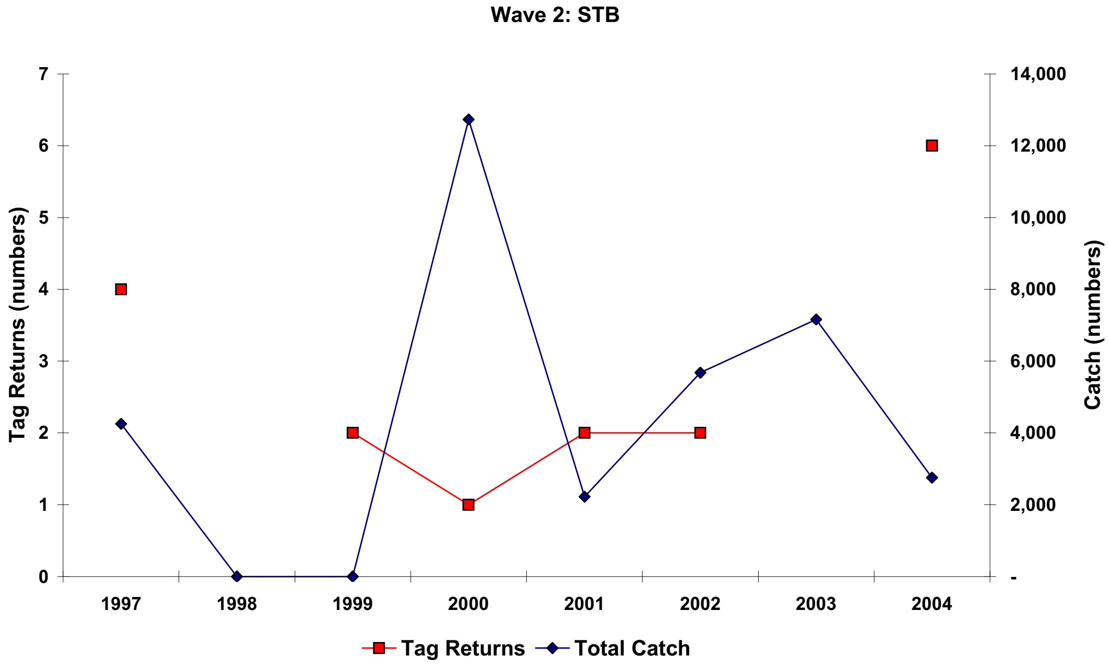

Figure 5. Wave-2 tag returns versus total harvest for Virginia

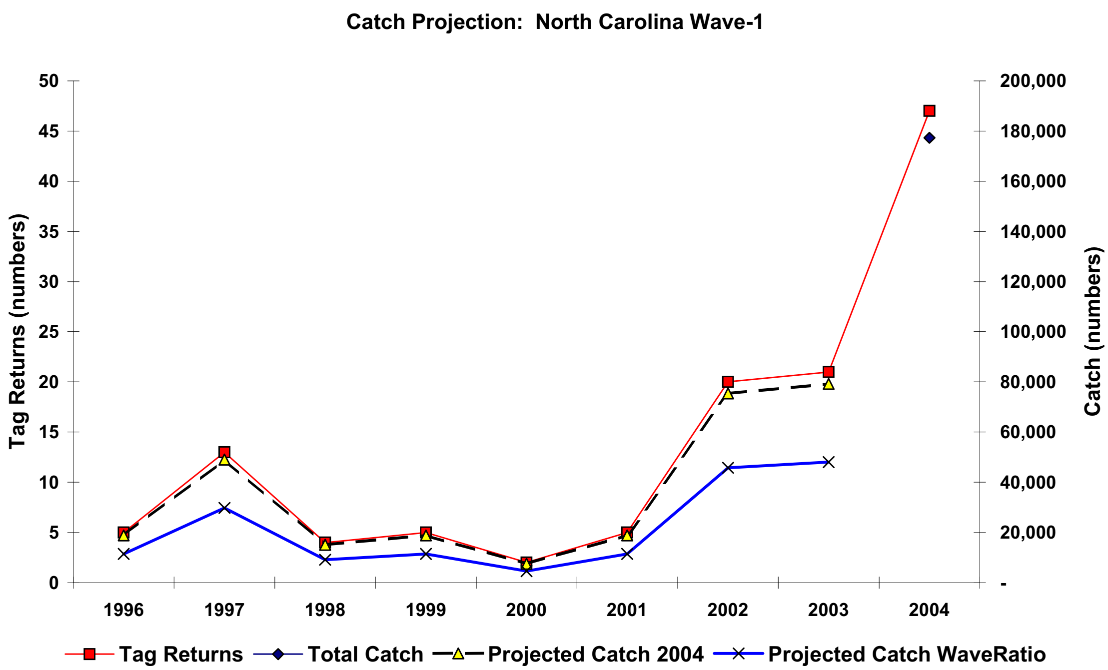

Figure 6. Comparison of harvest projections for North Carolina wave-1

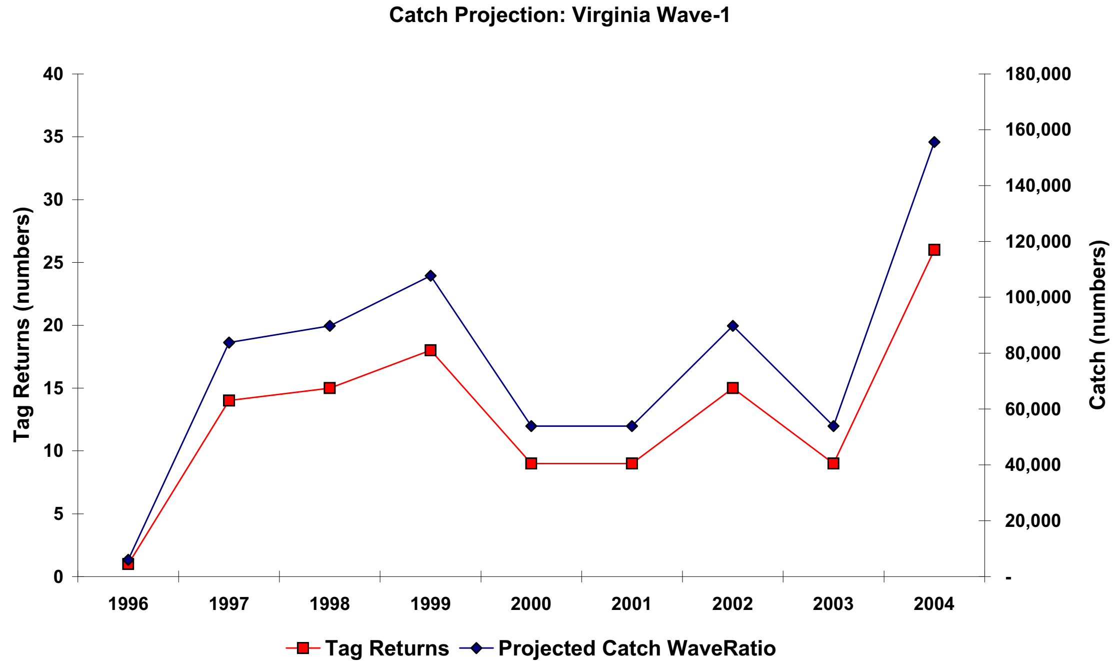

Figure 7. Harvest projection for Virginia wave-1

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

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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:

$$\text{State WAA} = \Sigma \text{ (state WAA * \% state CAA by numbers)} \qquad \text{Eqn. 1}$$

$$\text{Coastwide WAA} = \Sigma \text{ (State WAA * state \% coastwide CAA)} \qquad \text{Eqn. 2}$$

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

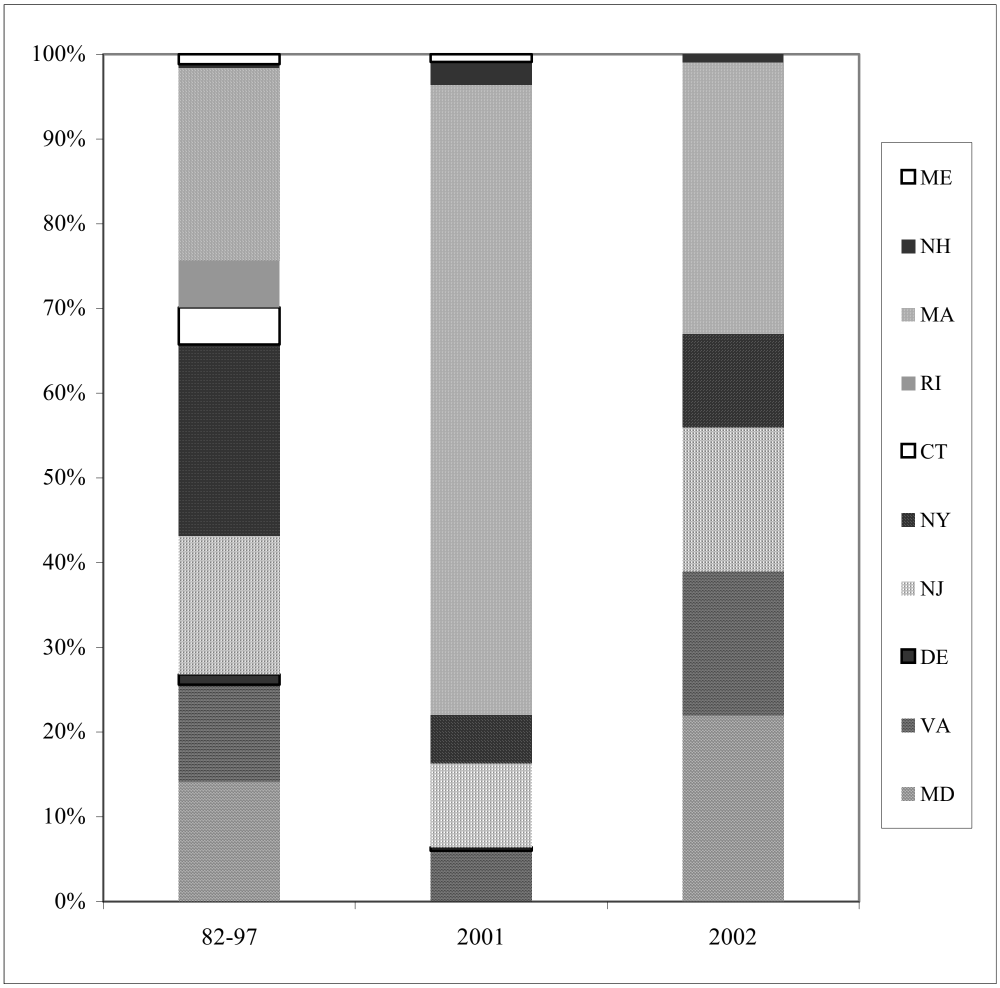


Figure 1. Composition of Striped Bass Coastwide WAA by State. 1982-1997 coastwide WAA shows a fairly even distribution from the 5 major harvest (by numbers) states (MA, NY, NJ, MD, VA). 2001 WAA is dominated by MA. 2002 WAA shows a strong contribution from MD and VA (Chesapeake Bay harvest states).

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 discards	NH Rec landings NH Rec discards	NH Rec landings NH Rec discards	NH Rec landings NH Rec discards	NH Rec landings NH Rec discards
MA Rec landings MA Rec discards MA Com landings MA Com discards	MA Rec landings MA Rec discards MA Com landings MA Com discards	MA Rec landings MA Rec discards MA Com landings MA Com discards	MA Rec landings MA Rec discards MA Com landings MA Com discards	MA Rec landings MA Rec discards MA Com landings MA Com discards
				RI Com landings RI Rec landings RI Rec discards
CT Rec landings CT Rec discards	CT Rec landings CT Rec discards	CT Rec landings CT Rec discards	CT Rec landings	CT Rec landings CT Rec discards
NY all	NY all	NY ALL	NY Com landings NY Rec landings NY Rec discards	NY Com landings NY Rec landings NY Rec discards
NJ Rec landings NJ Rec discards	NJ Rec landings NJ Rec discards	NJ Rec landings NJ Rec discards	NJ Rec landings NJ Rec discards	NJ ALL
				Del Com landings Del Rec landings
MD Com landings MD Rec landings MD Rec discards	MD Com landings MD Rec landings MD Rec discards	MD Com landings MD Rec landings MD Rec discards	MD Com landings MD Rec landings MD Rec discards	MD Com landings MD Rec landings MD Rec discards
VA Com landings VA Rec landings VA Rec discards	VA Com landings VA Rec landings VA Rec discards	VA Com landings VA Rec landings VA Rec discards	VA ALL	VA Com landings VA Rec landings 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 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 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 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 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 DISC	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

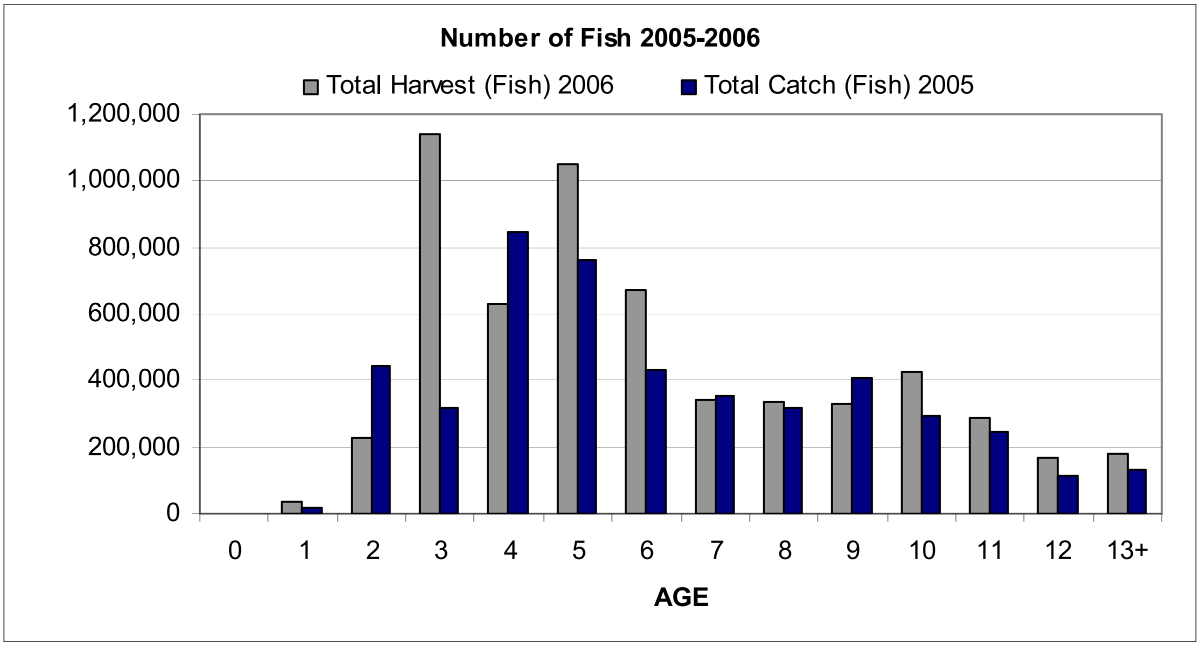


Figure 1. 2005-2006 Atlantic coastwide mean catch-at-age in numbers of striped bass.

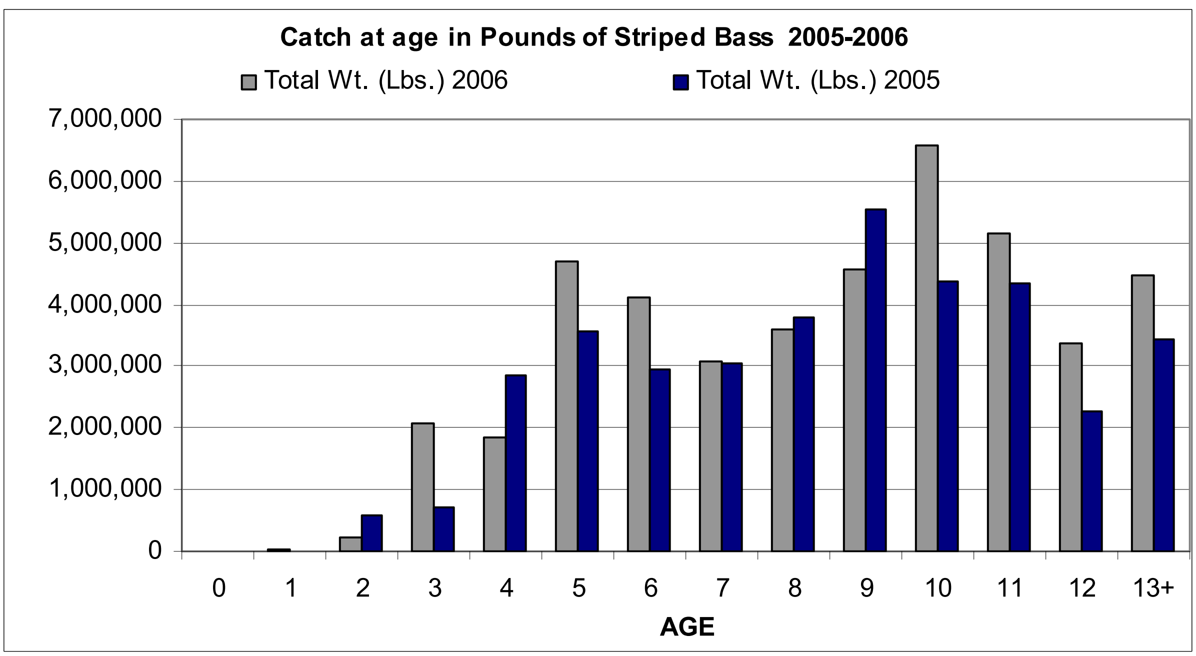


Figure 2. 2005-2006 Atlantic coastwide mean catch-at-age in pounds of striped bass.

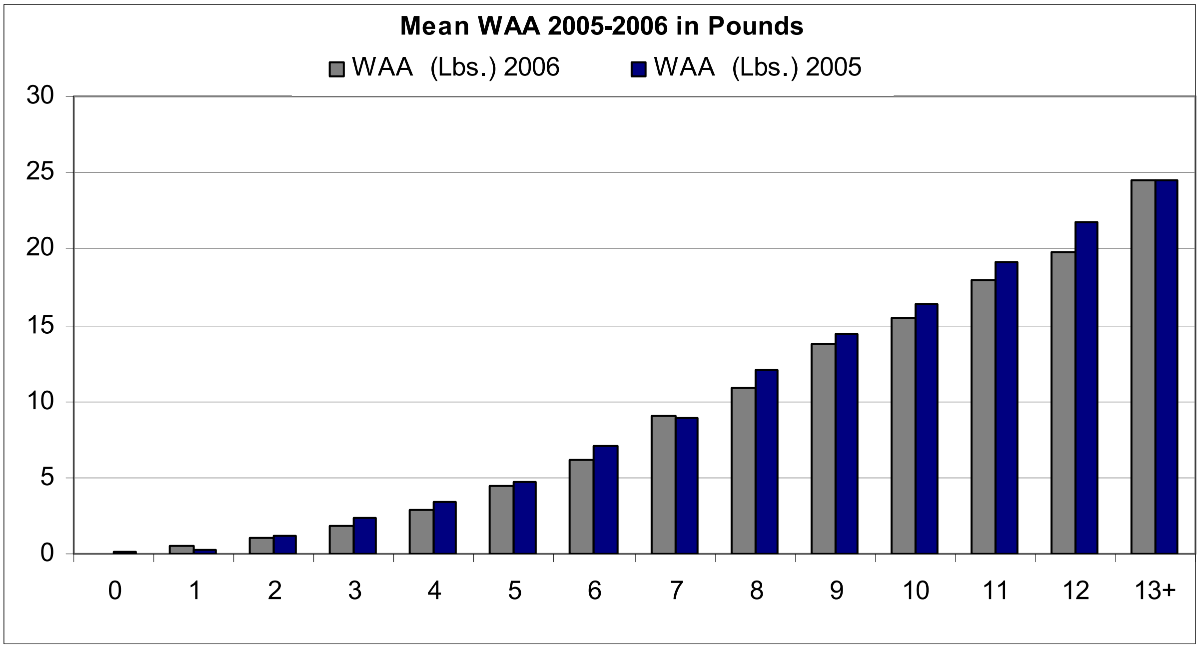


Figure 3. 2005 and 2006 Atlantic coastwide mean weight-at-age in pounds.

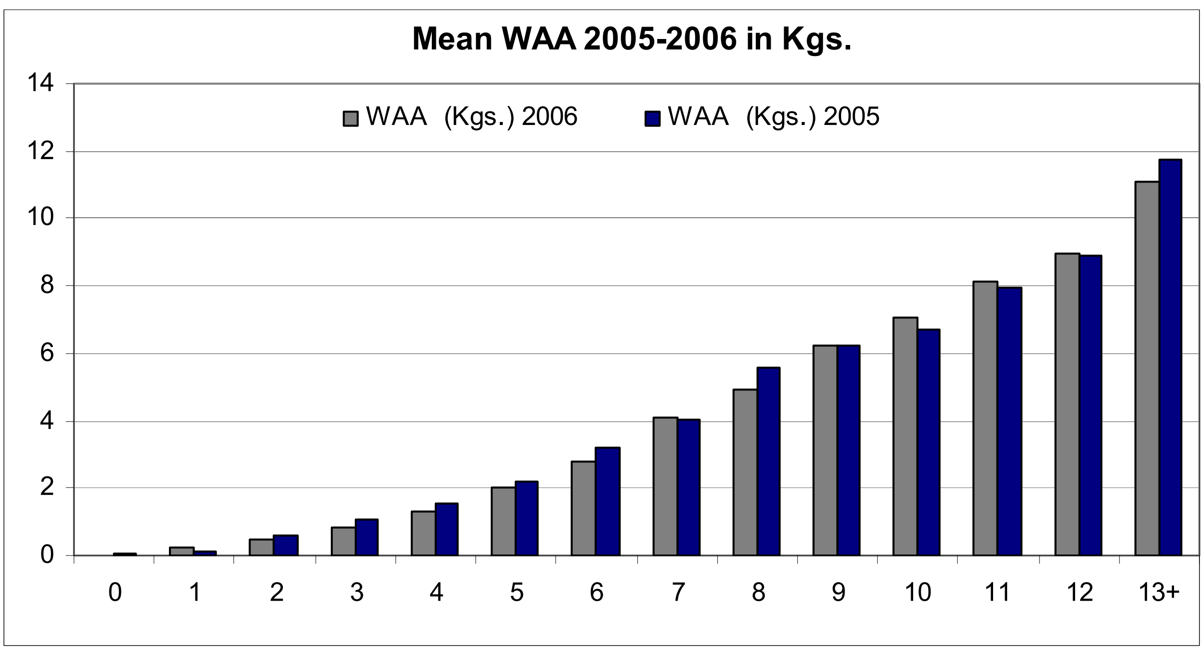
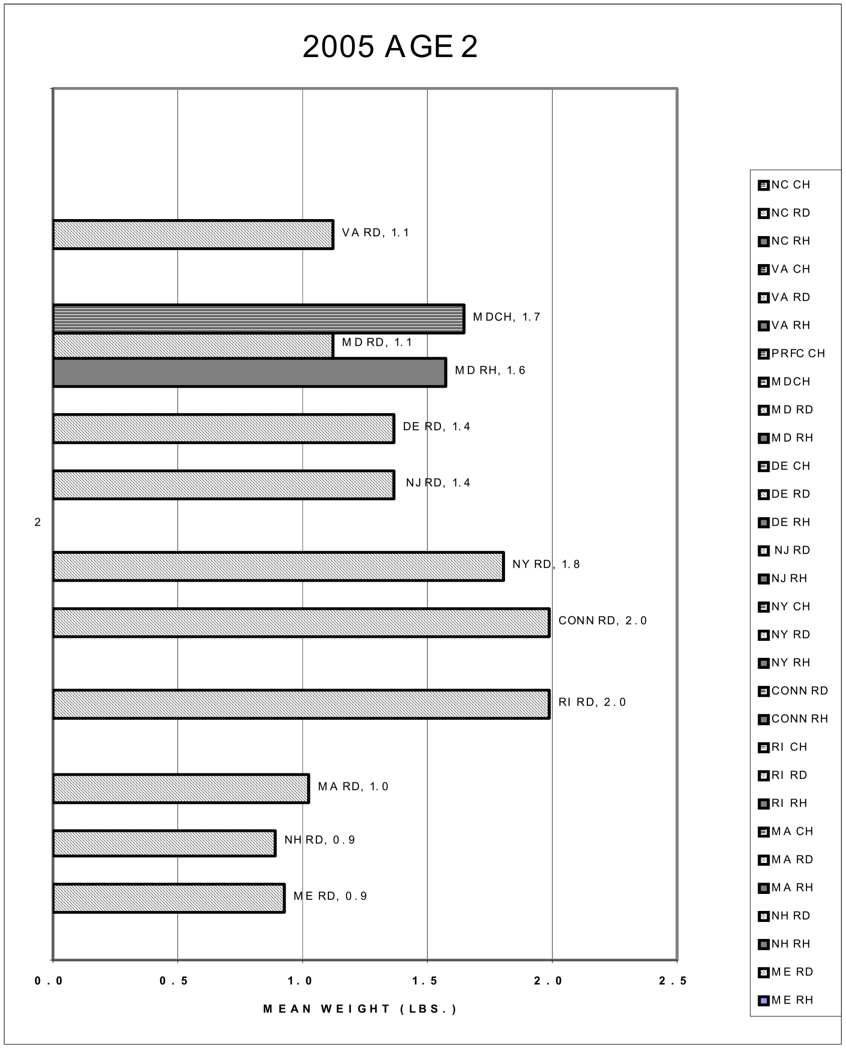


Figure 4. 2005 and 2006 Atlantic coastwide mean weight-at-age in kilograms.



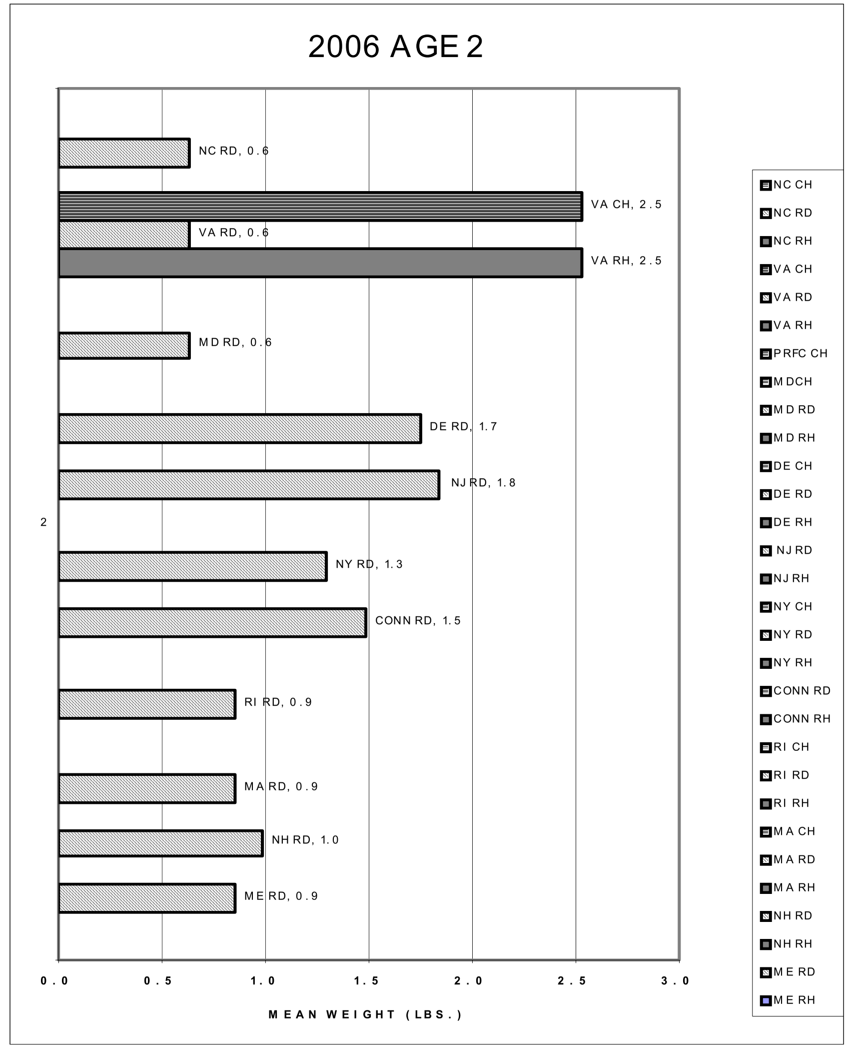


Figure 5A. 2005 and 2006 weight at age 2 by state and fishery.

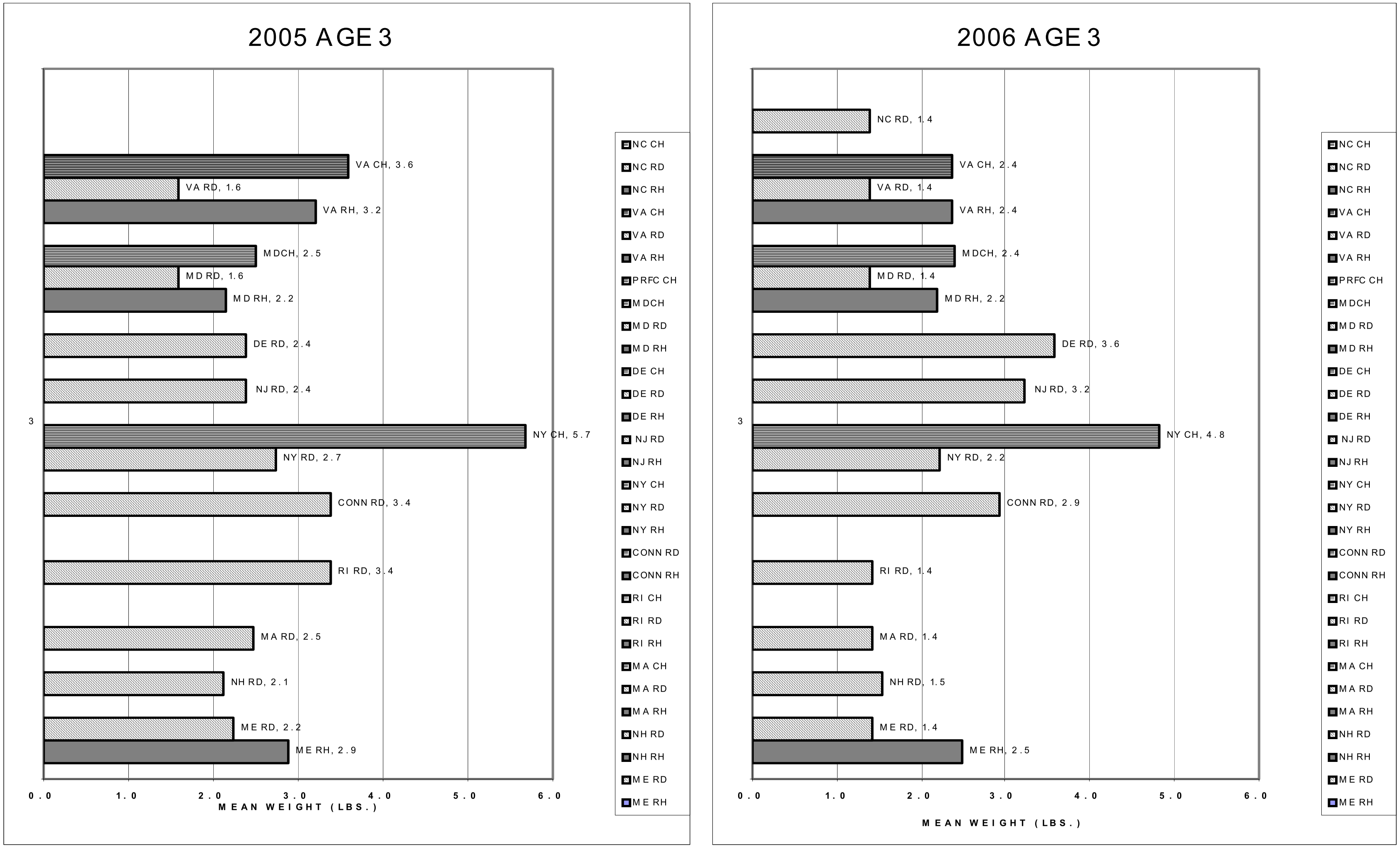
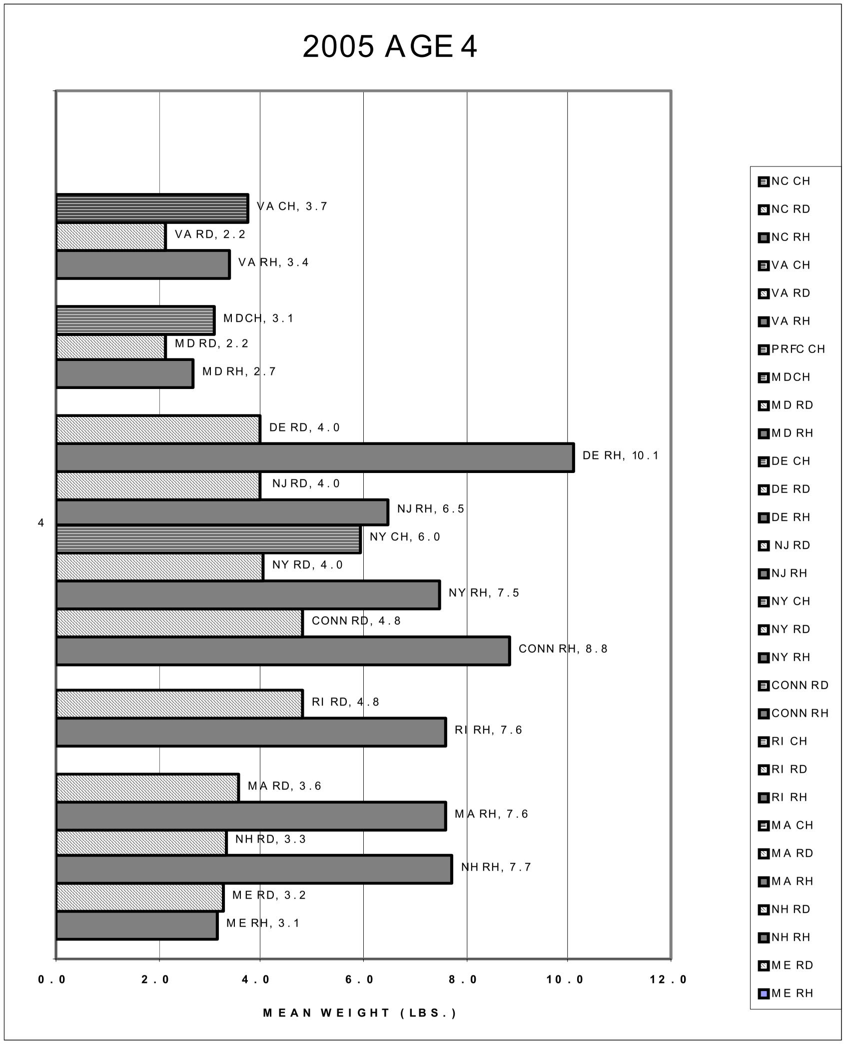


Figure 5B.2005 and 2006 weight at age 3 by state and fishery.



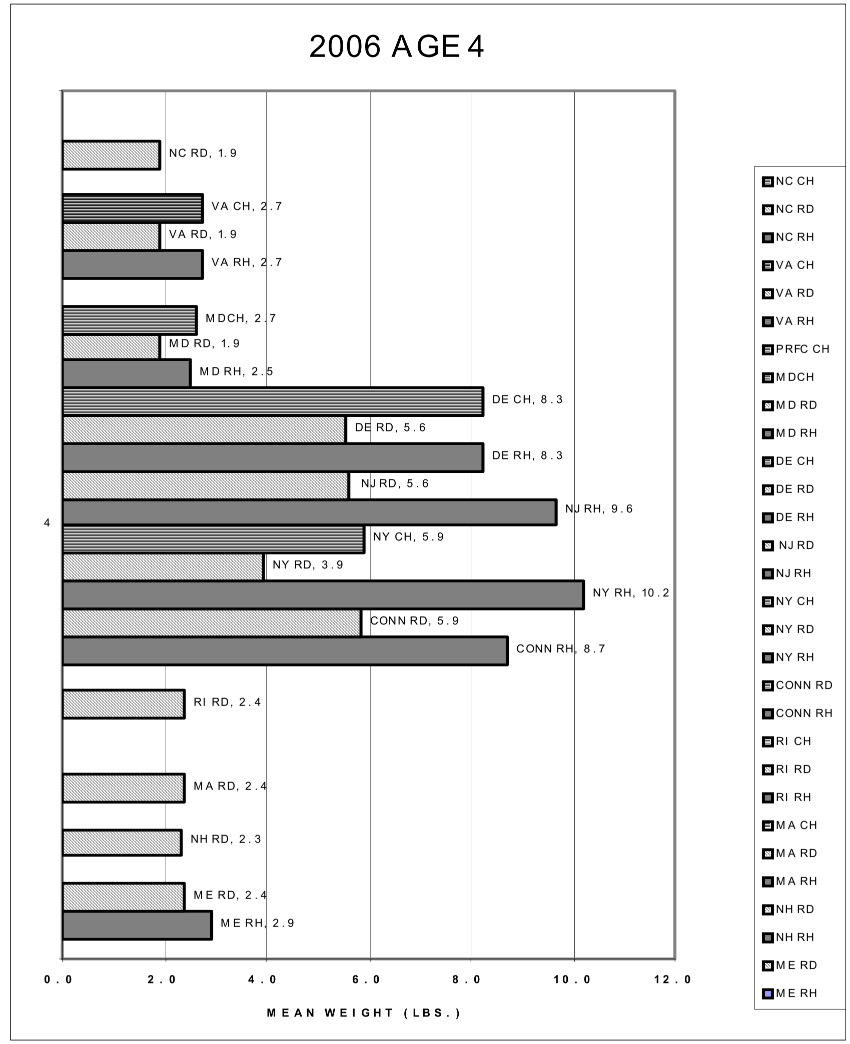


Figure 5C. 2005 and 2006 weight at age 4 by state and fishery.

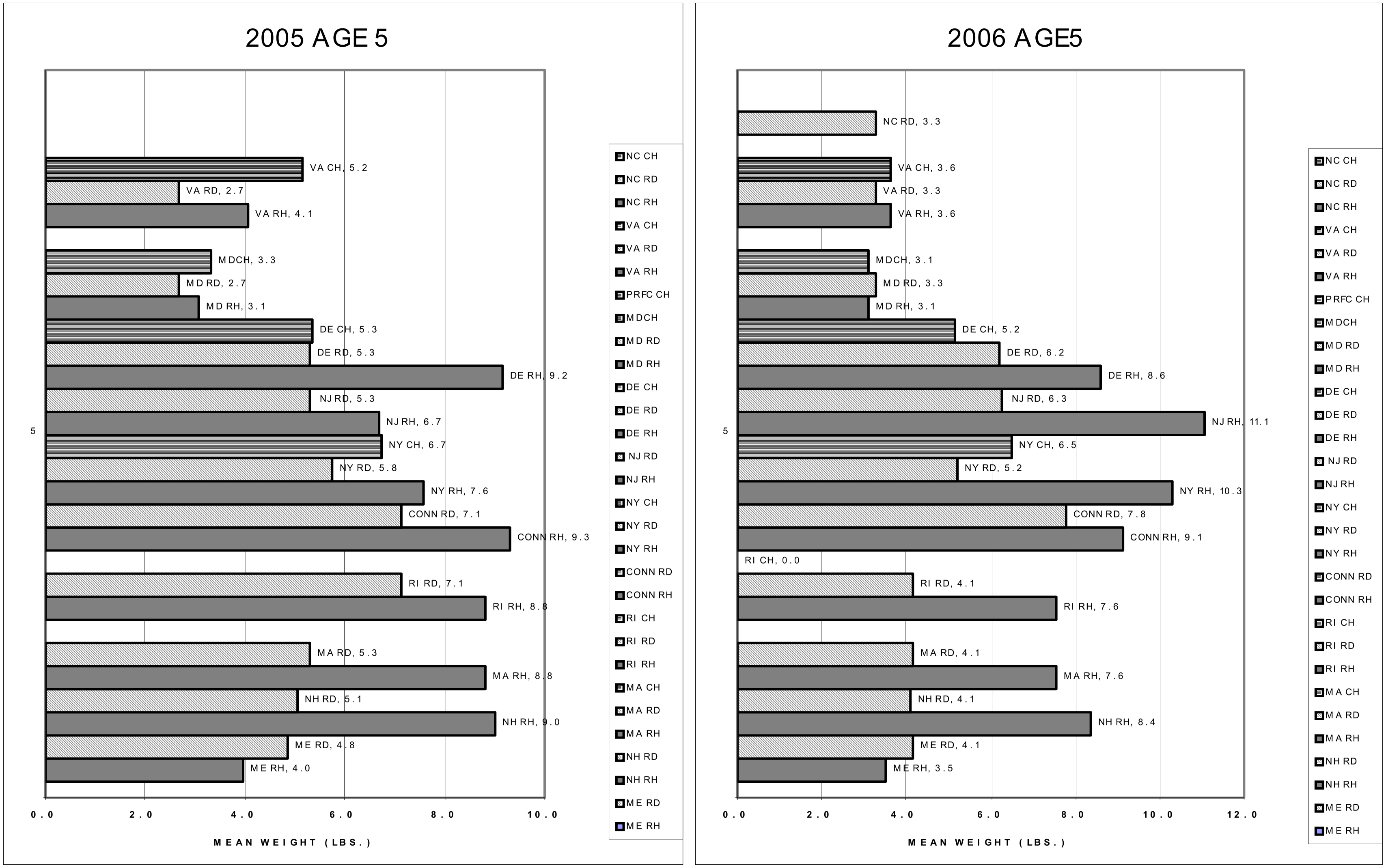


Figure 5D. 2005 and 2006 weight at age 5 by state and fishery.

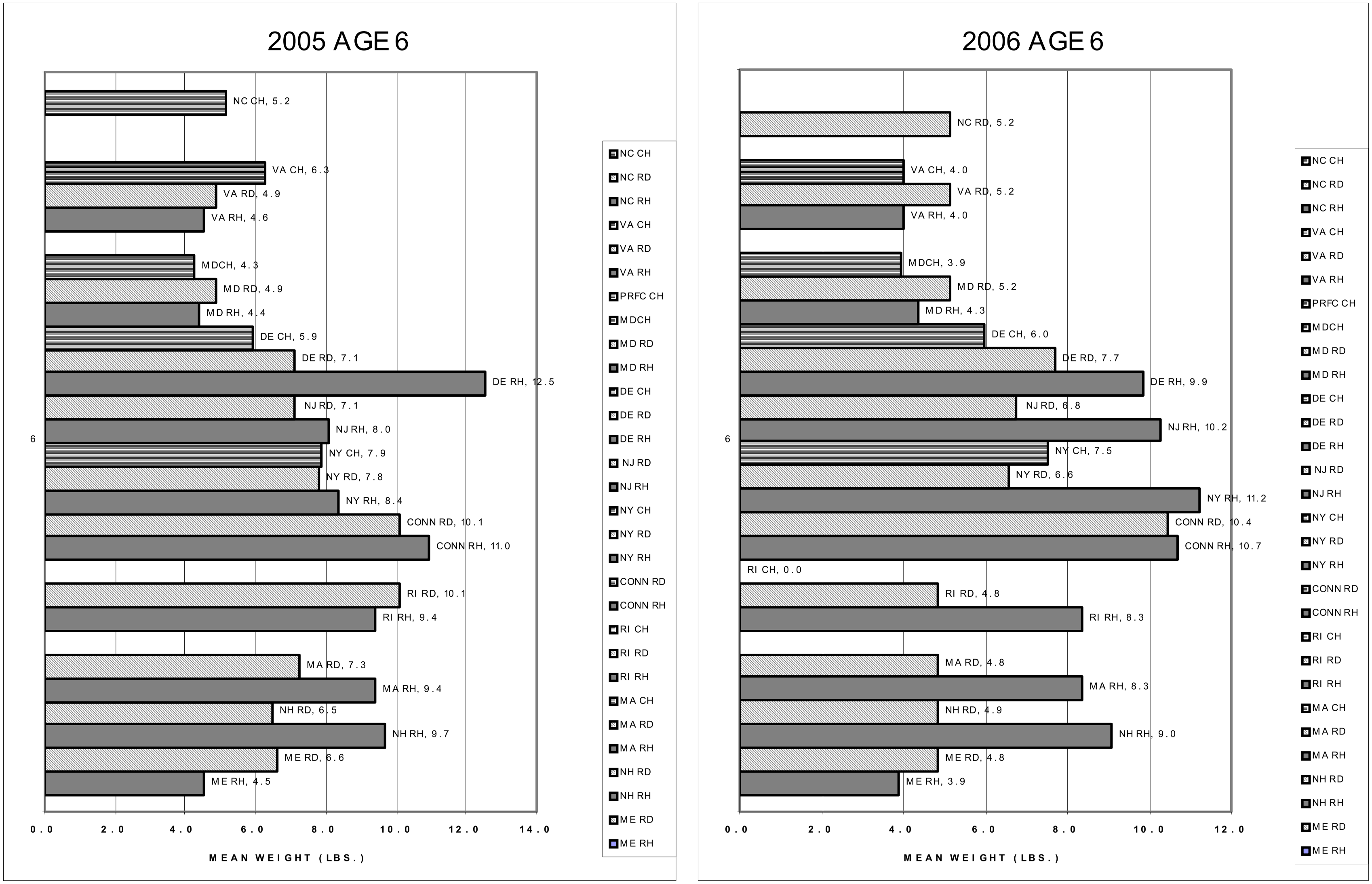
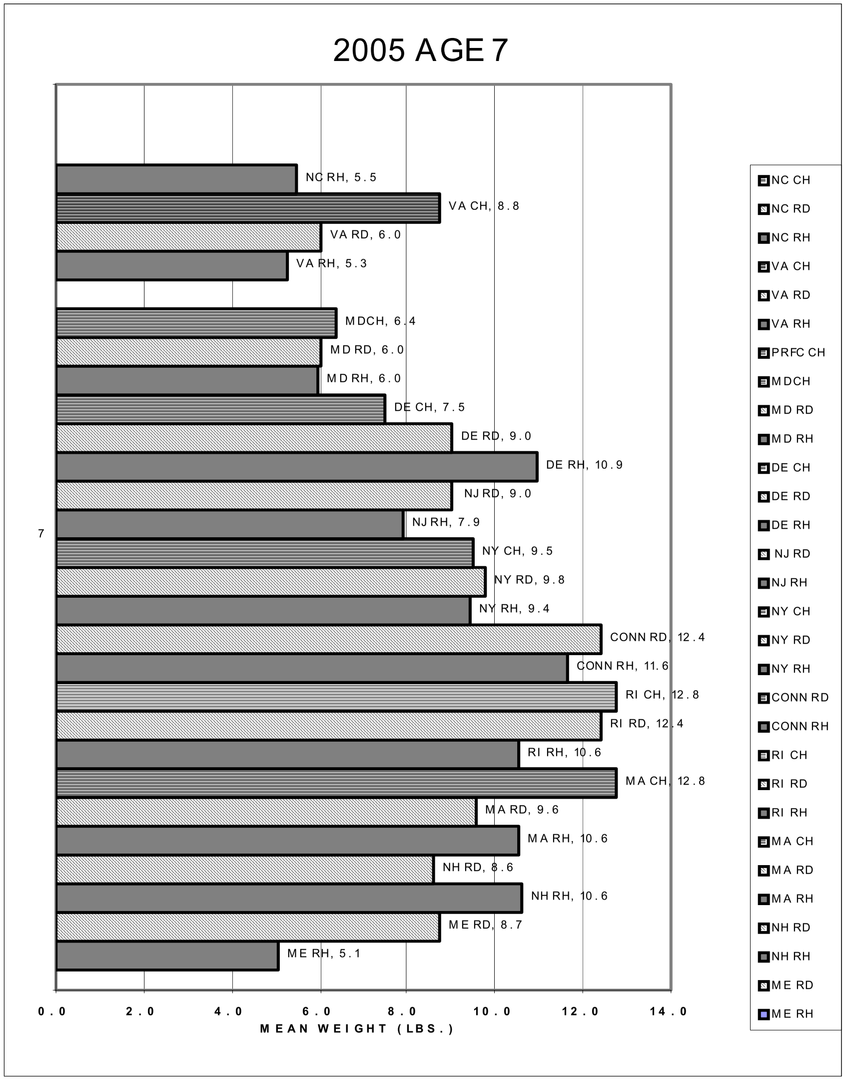


Figure 5E. 2005 and 2006 weight at age 6 by state and fishery.



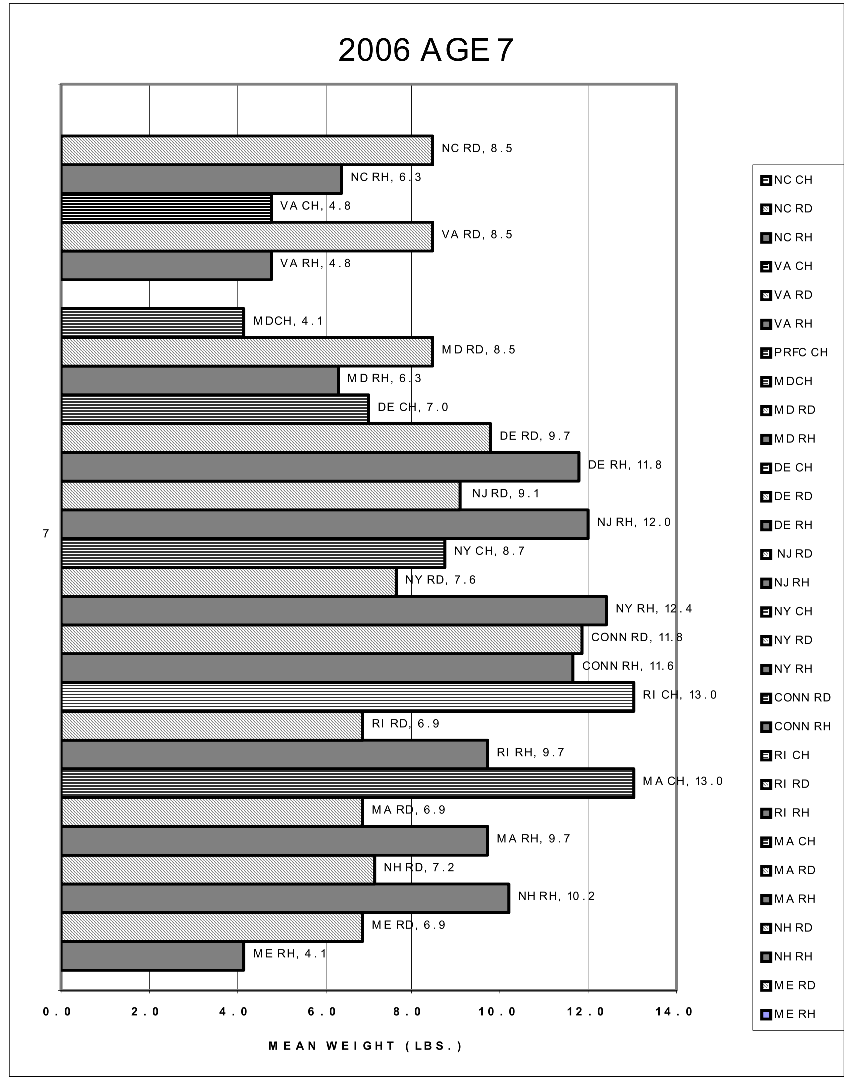
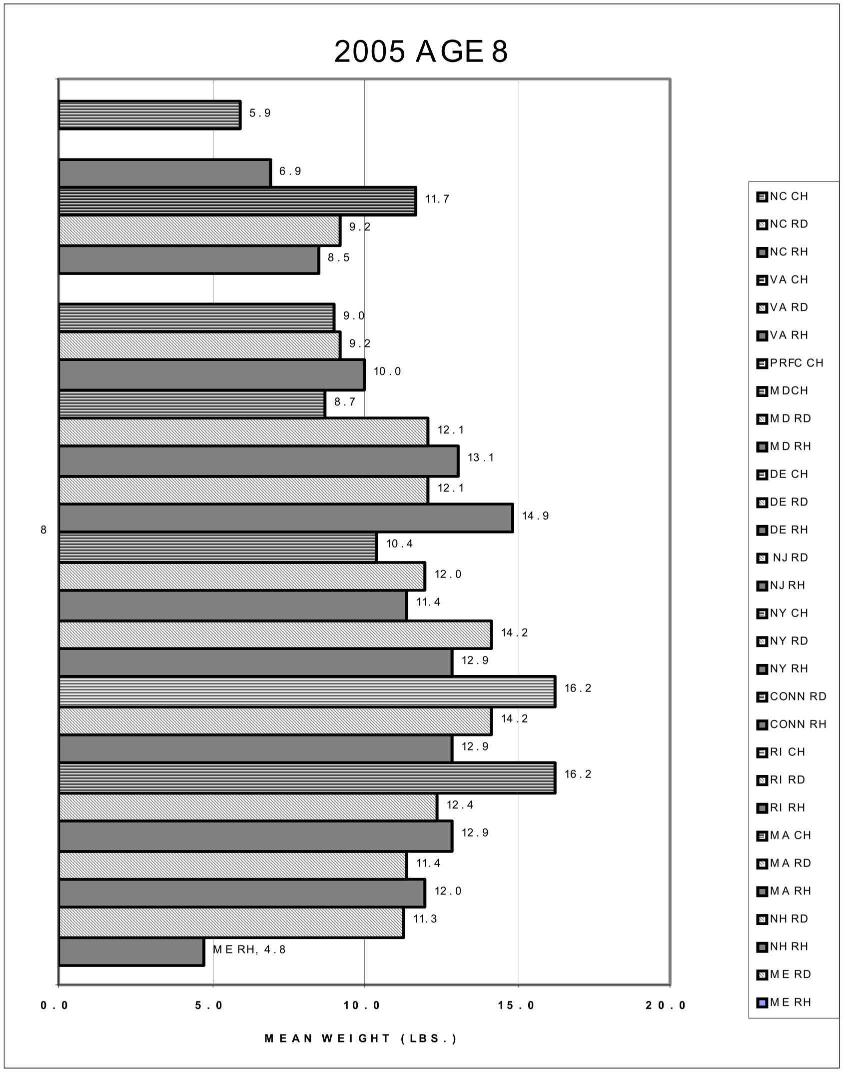


Figure 5F. 2005 and 2006 weight at age 7 by state and fishery.



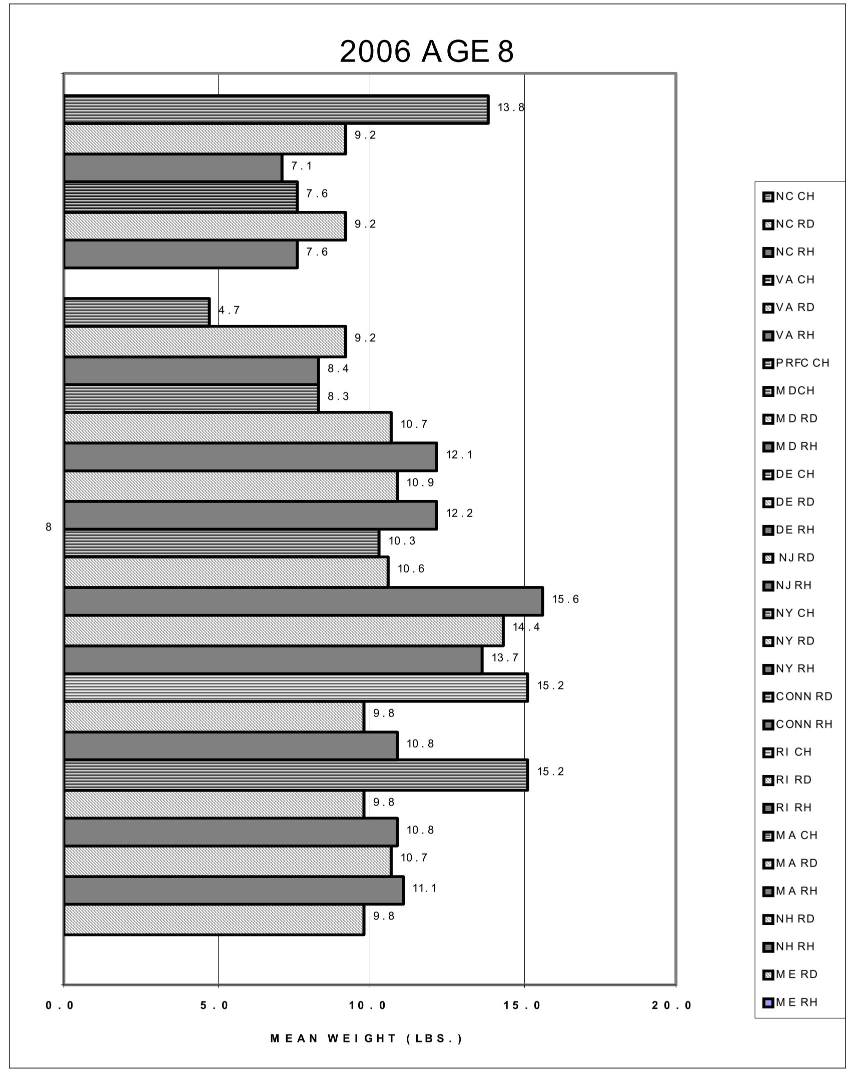


Figure 5G. 2005 and 2006 weight at age 8 by state and fishery.

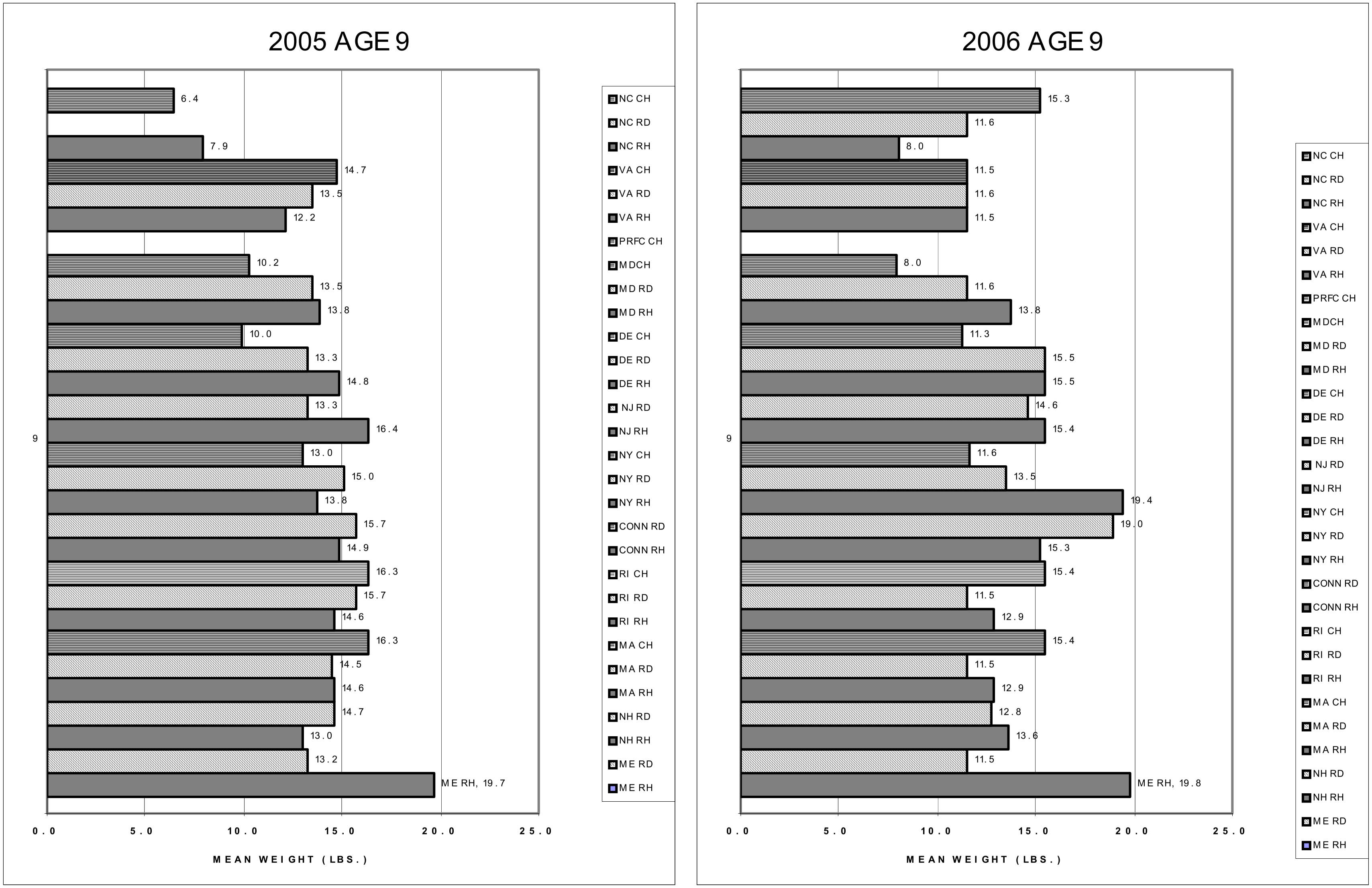


Figure 5H. 2005 and 2006 weight at age 9 by state and fishery.

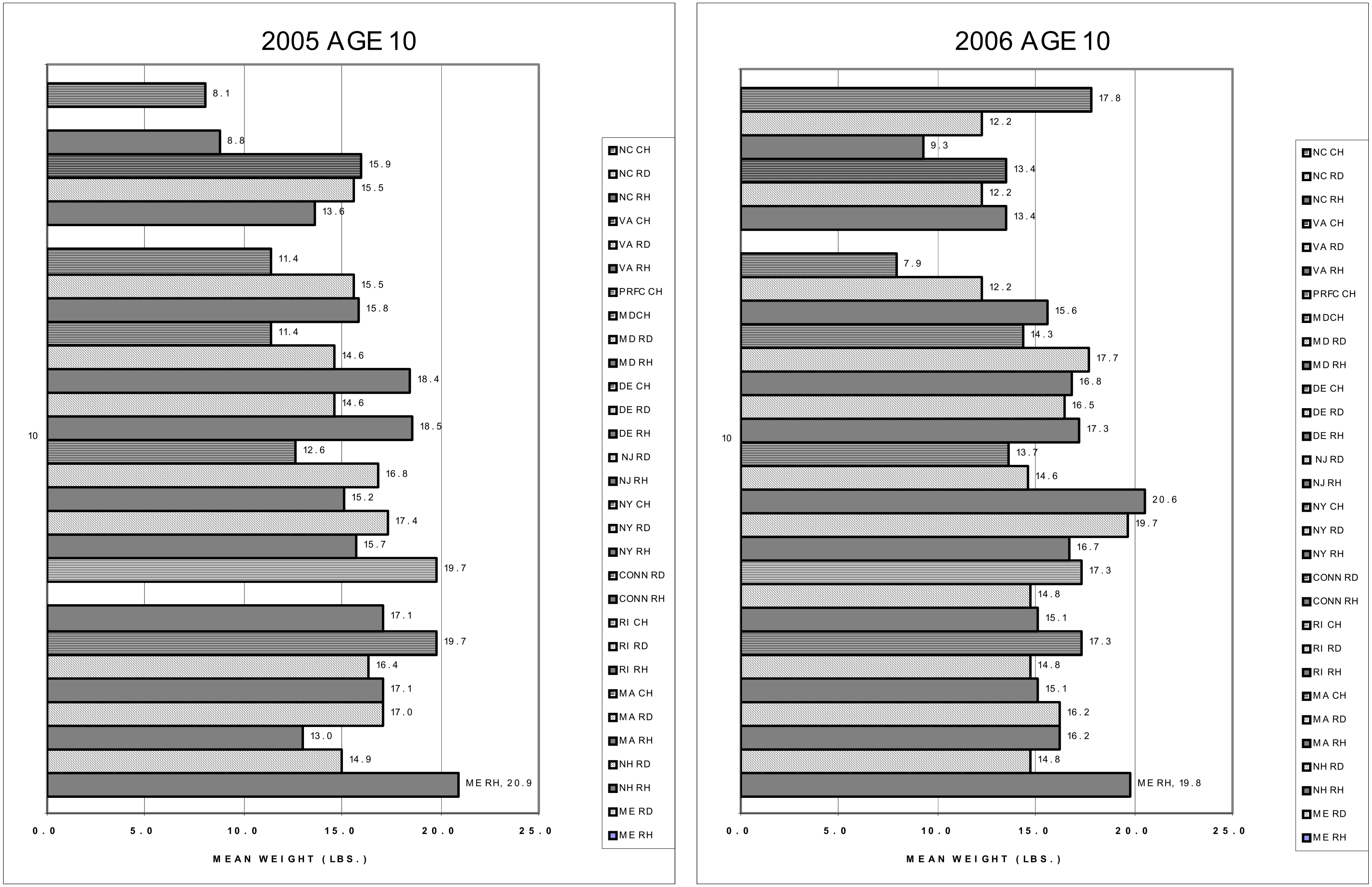
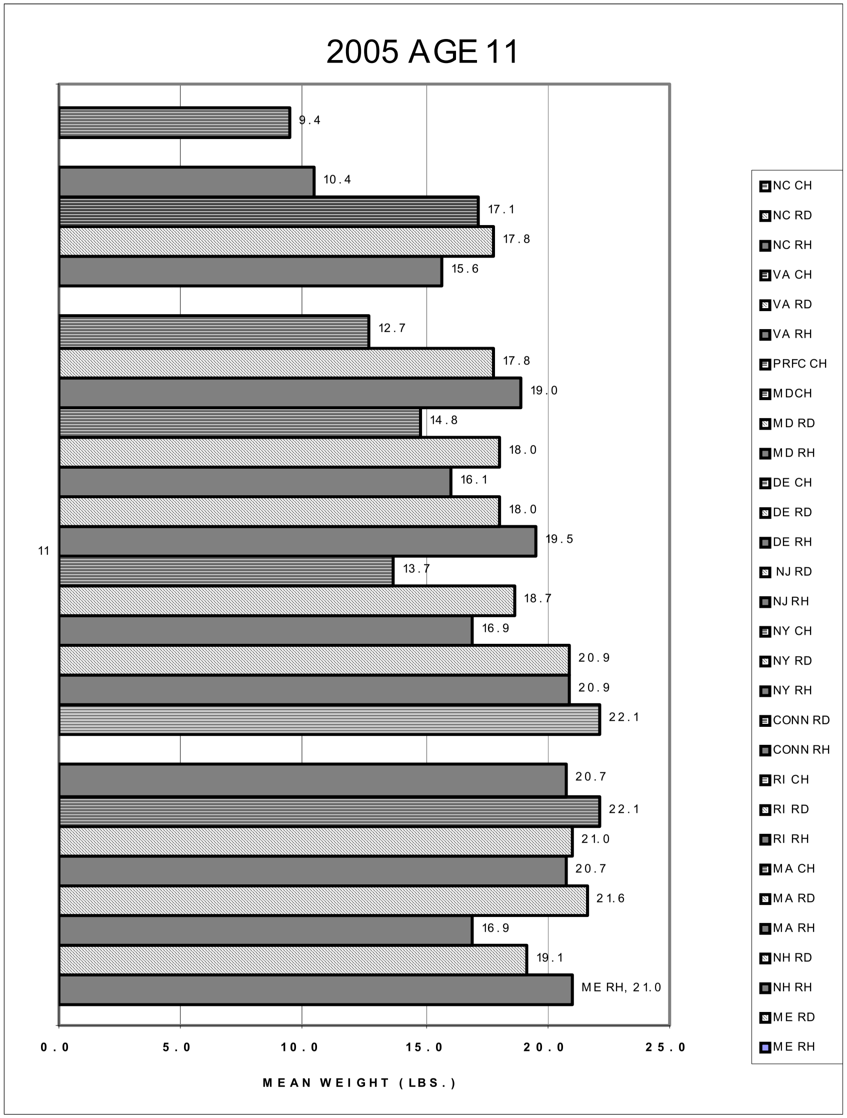


Figure 5I. 2005 and 2006 weight at age 10 by state and fishery.



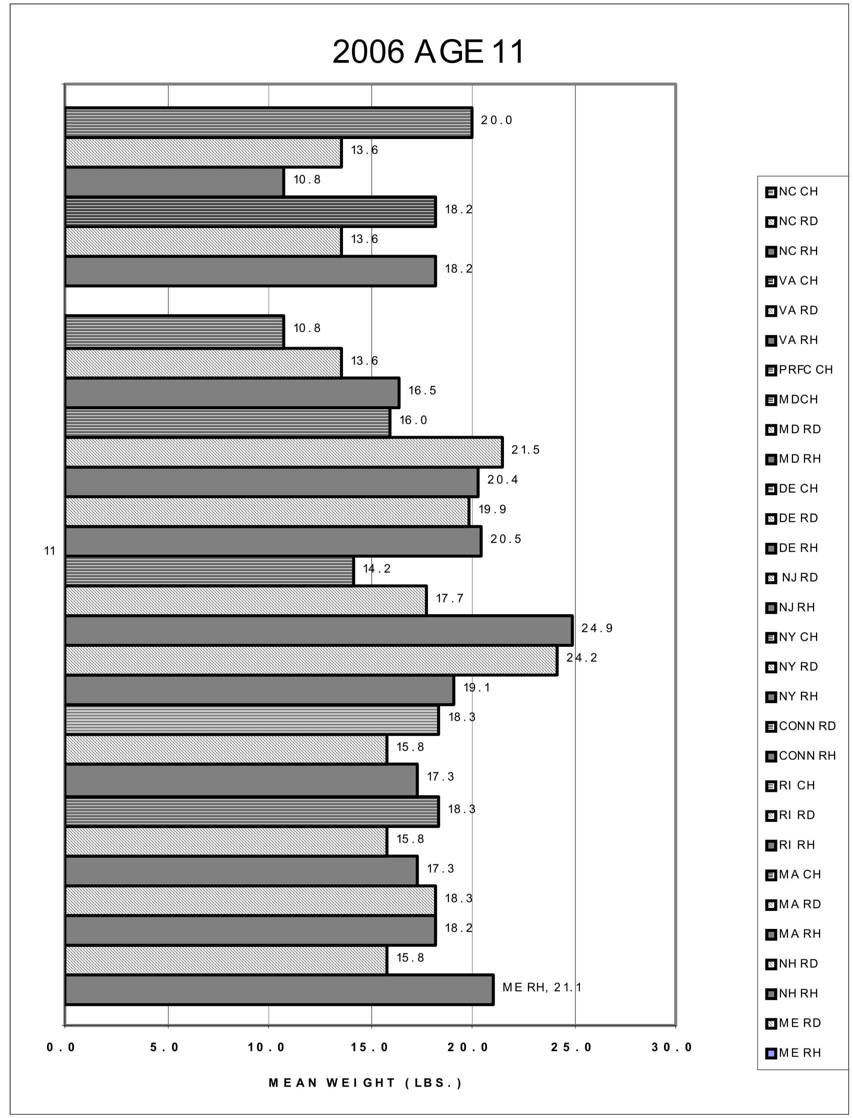
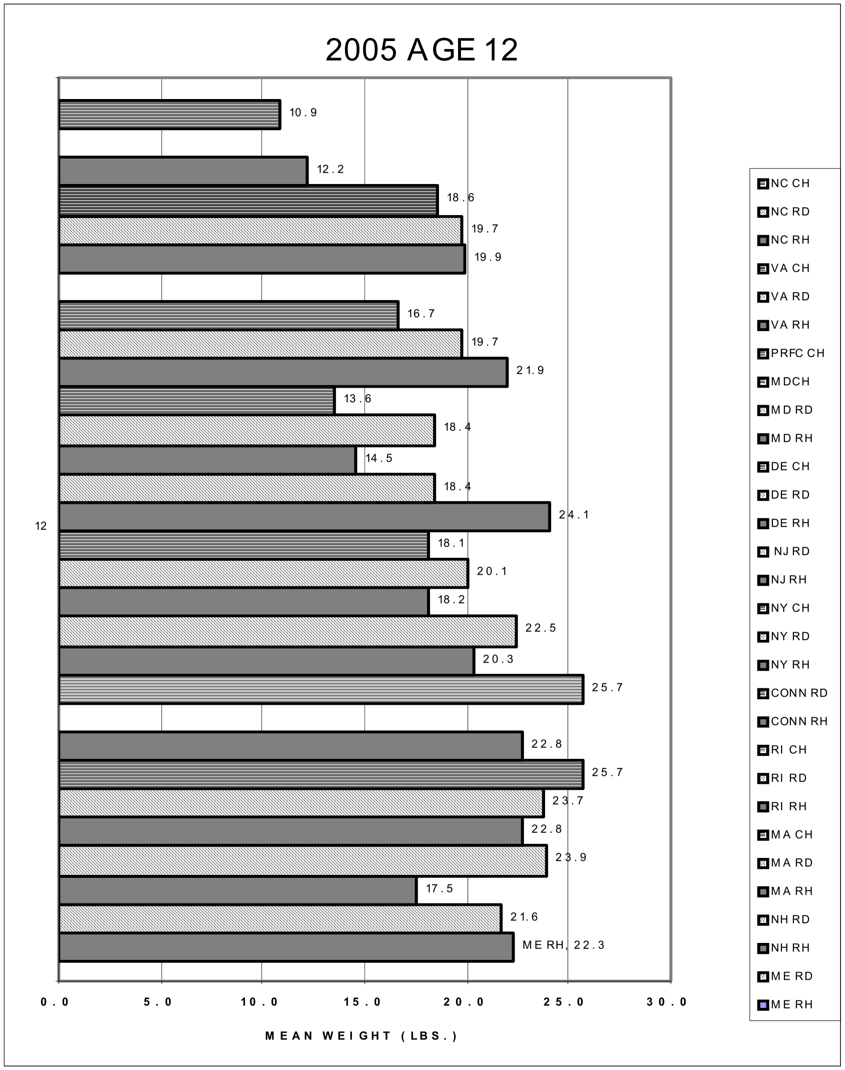


Figure 5J. 2005 and 2006 weight at age 11 by state and fishery.



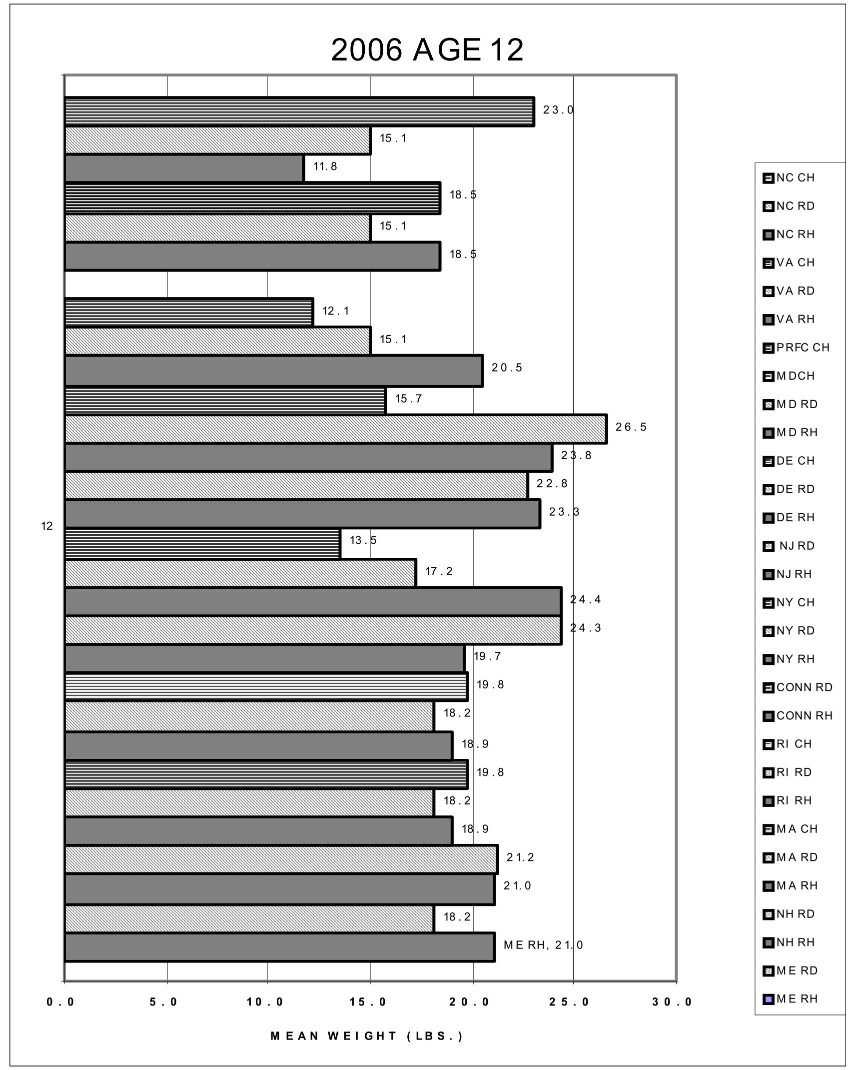
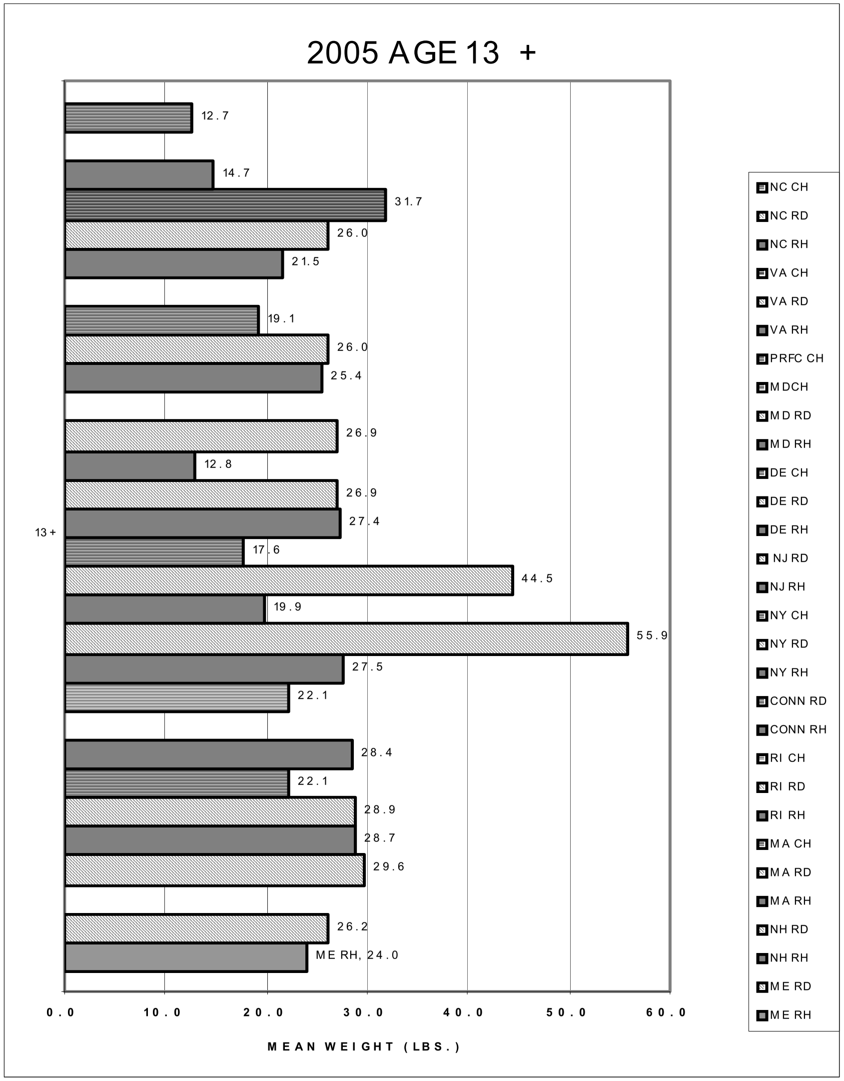


Figure 5K. 2005 and 2006 weight at age 12 by state and fishery.



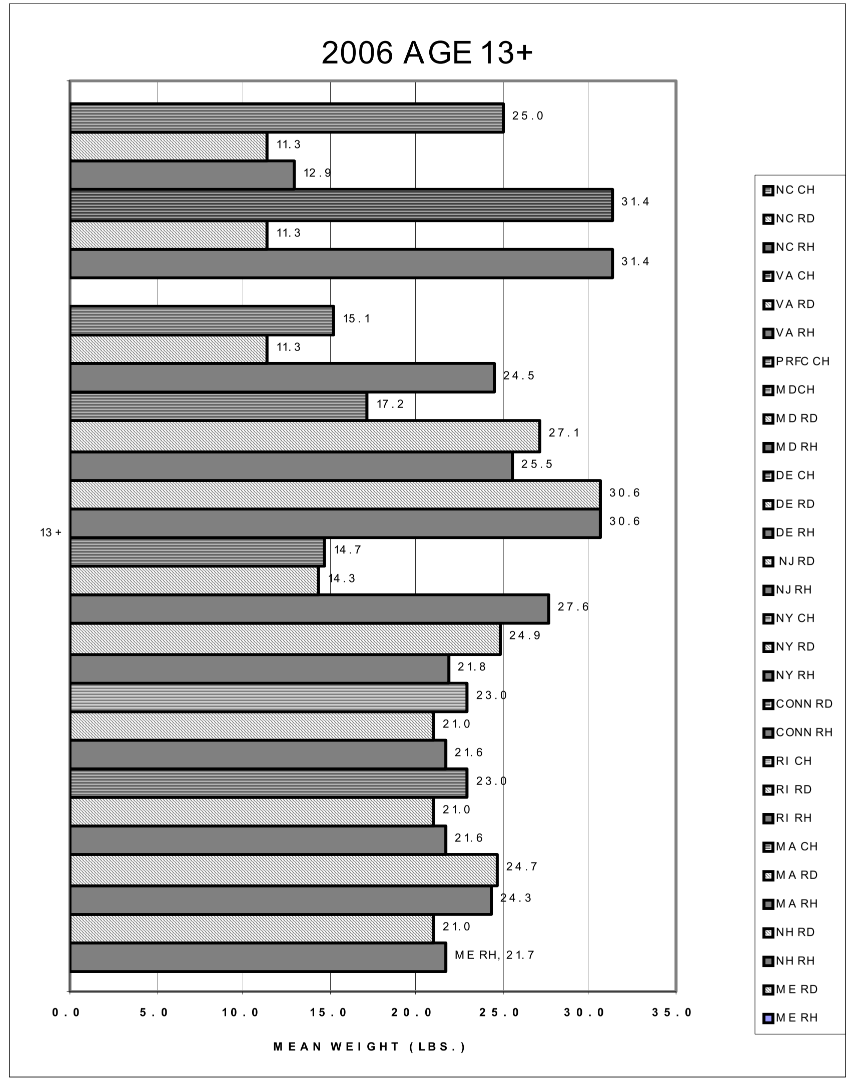


Figure 5L. 2005 and 2006 weight at ages 13+ by state and fishery.

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 Alexei Sharov	Maryland Department of Natural Resources	Tawes State Office Building 580 Taylor Avenue Annapolis, MD 21401
Tom Baum	New Jersey Department of Environmental Protection – Bureau of Marine Fisheries	P.O. Box 418 Port Republic, NJ 08241
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Megan Gamble Patrick Kilduff	Atlantic States Marine Fisheries Commission	1444 I Street, NW 6th Floor Washington, DC 20005
Bob Harris John Hoenig Phil Sadler	Virginia Institute of Marine Science	P.O. Box 1346 Gloucester Point, VA 23062-1346
Des Kahn Greg Murphy	Delaware Department of Natural Resources & Environmental Control, Fisheries	254 Maine Street P.O. Box 330 Little Creek, DE 19961
Andy Kahnle	New York Department of Environmental Conservation – Bureau of Marine Fisheries	21 South Putts Corner Road New Paltz, NY 12561
Laura Lee	Atlantic States Marine Fisheries Commission/ RI DEM	3 fort Wetherill Road Jamestown, RI 02835
Gary Nelson	Massachusetts Division of Marine Fisheries	30 Emerson Avenue Gloucester, MA 01930
Gary Shepherd	Northeast Fisheries Science Center	166 Water Street Woods Hole, MA 02543
Clif Tipton	United State Fish & Wildlife Service	177 Admiral Cochrane Annapolis, MD 21401
Vic Vecchio	New York Department of Environmental Conservation – Bureau of Marine Fisheries	205 North Belle Mead Road 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." 36^{th} SAW Advisory
- ***Goal***: Develop criteria for the inclusion/exclusion of current and future indices for aggregate or age-specific ($\geq$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
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-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
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-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
```

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-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
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-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################################################
```

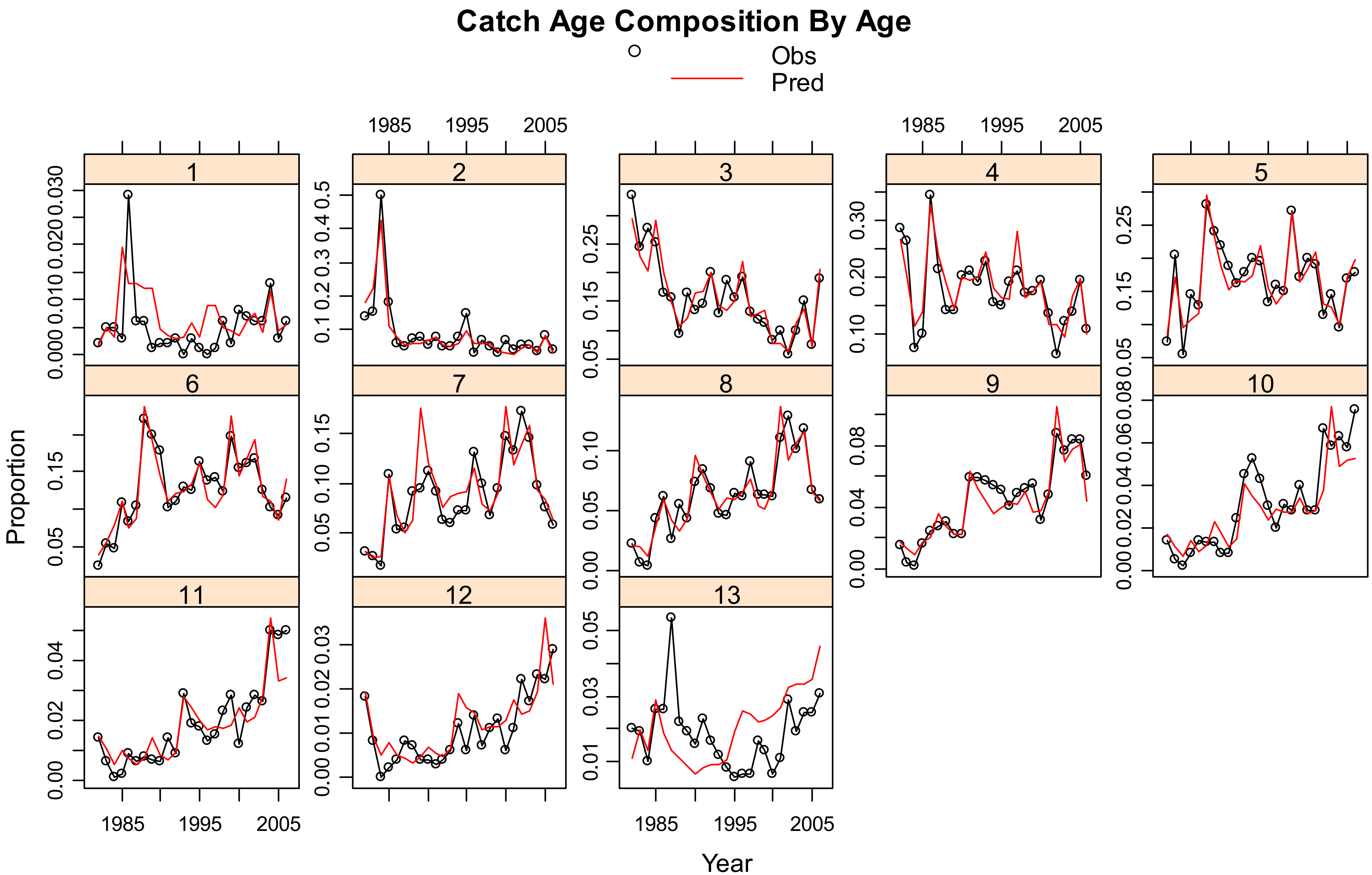


Figure 1. Plots of observed and predicted catch proportions-at-age by age

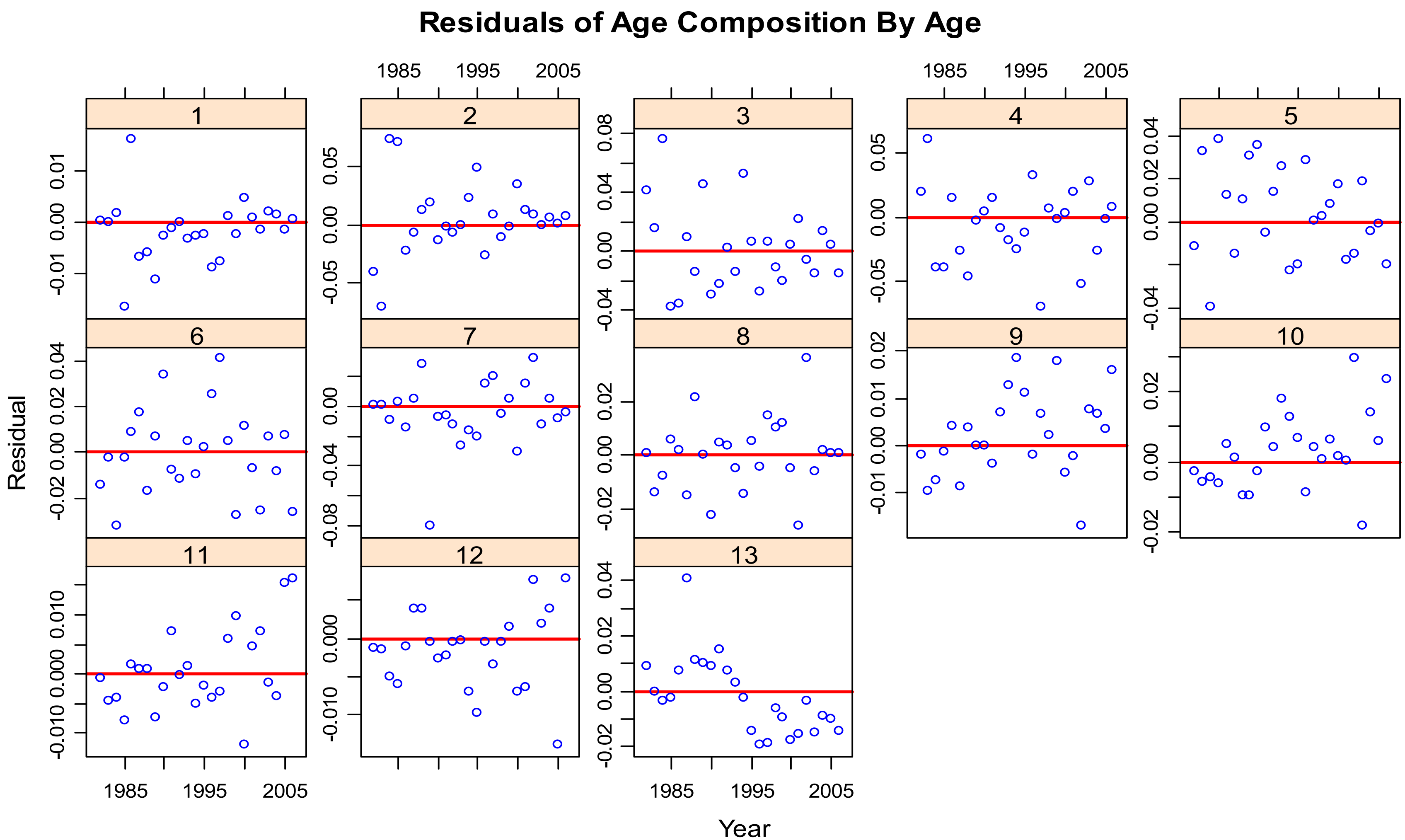


Figure 2. Residuals of catch proportions-at-age by age.

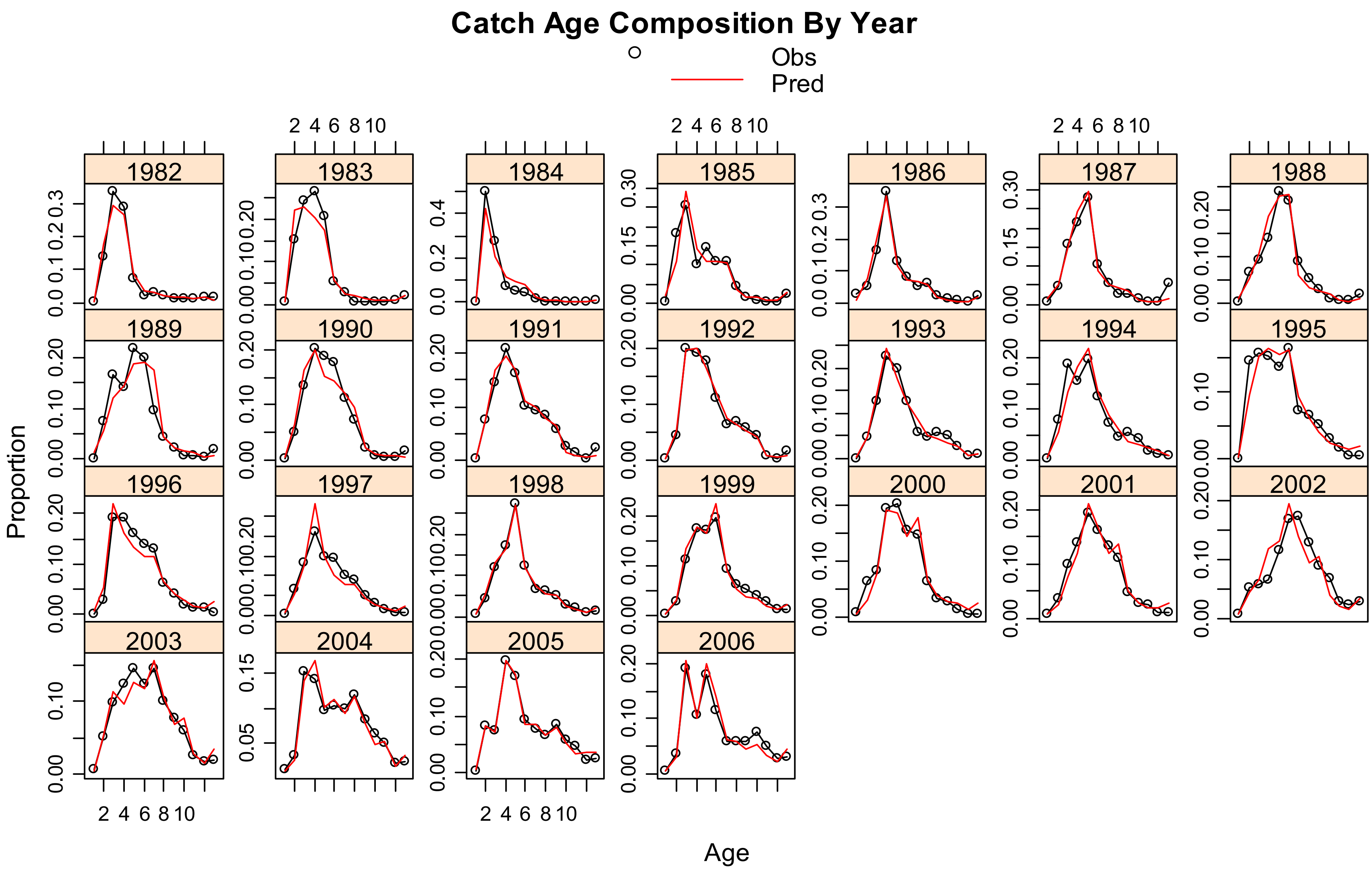


Figure 3. Observed and predicted catch proportions-at-age by year.

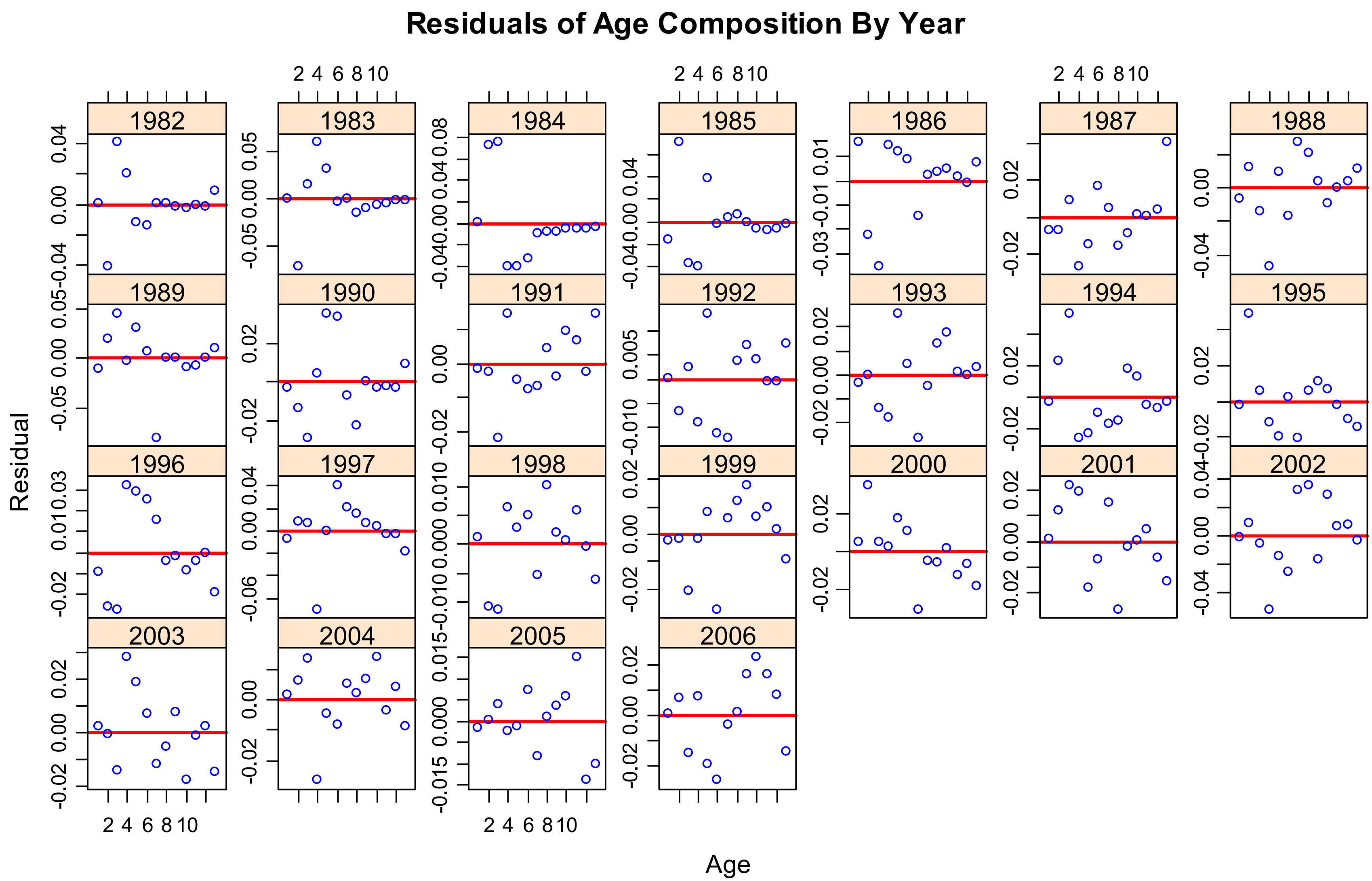


Figure 4. Residuals of catch proportions-at-age by year.

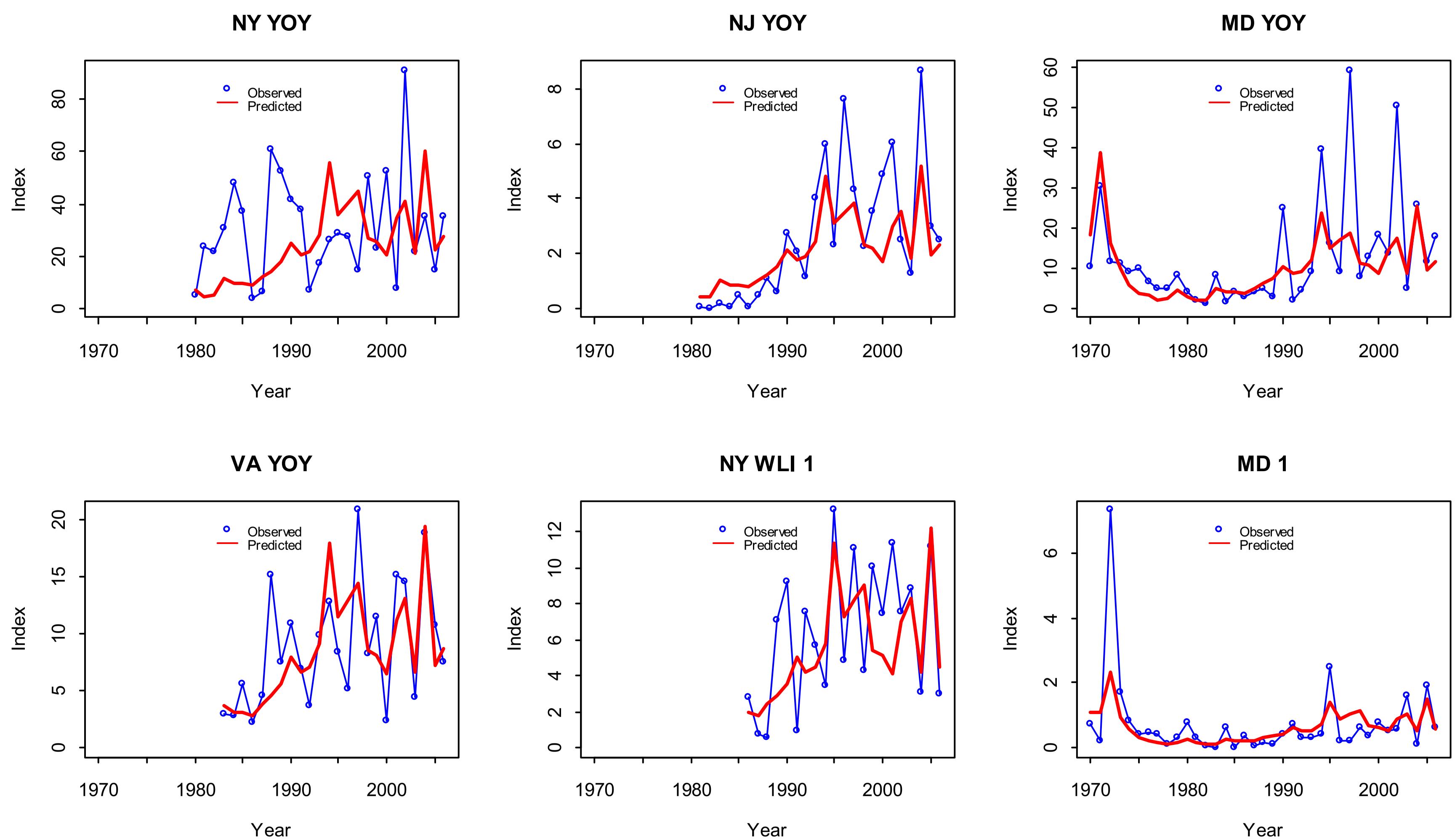


Figure 5. Young-of-the-year and yearling surveys tuned to Age 1 and 2, respectively.

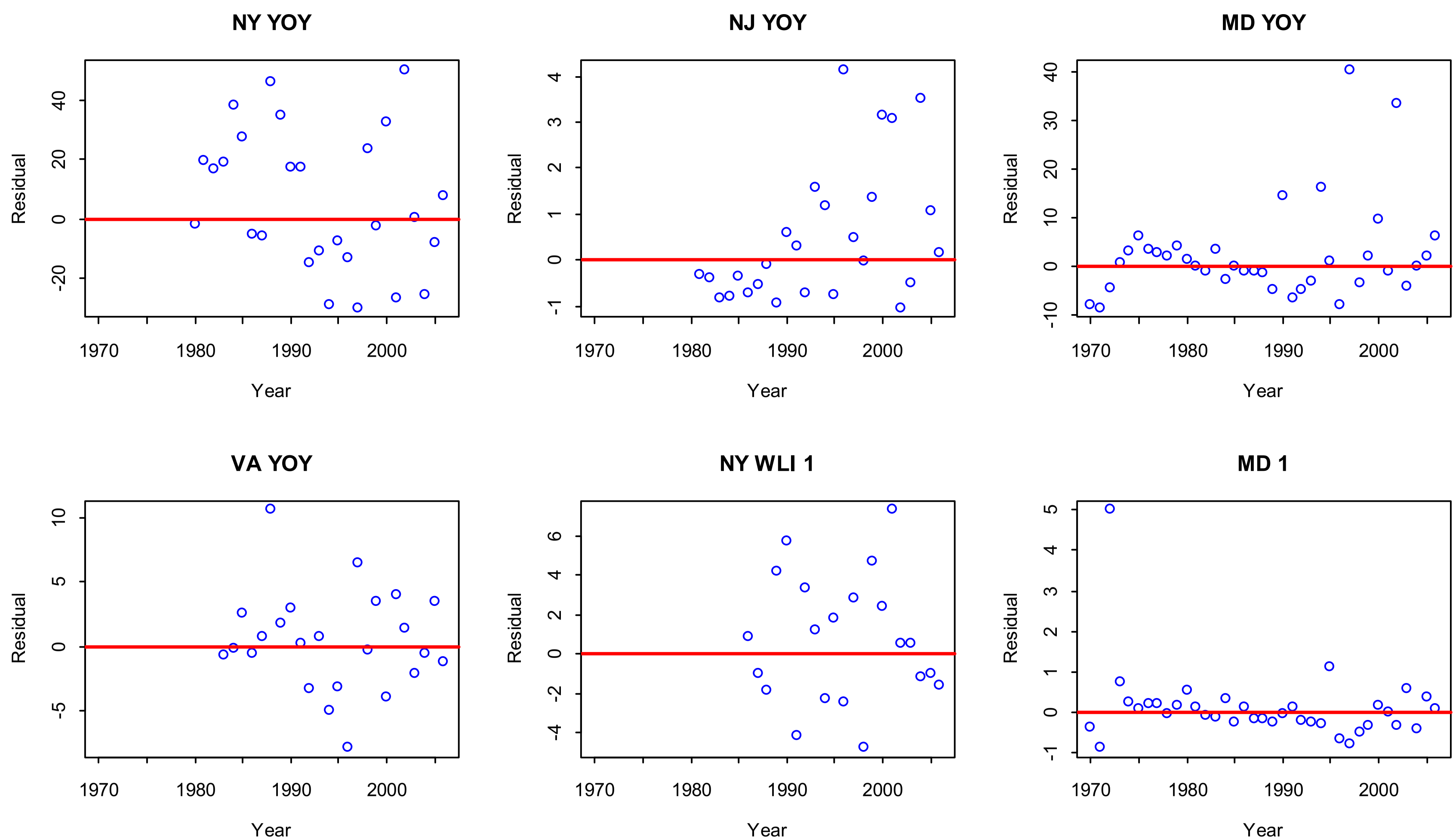


Figure 6. Residuals (observed-predicted) for young-of-the-year and yearling surveys.

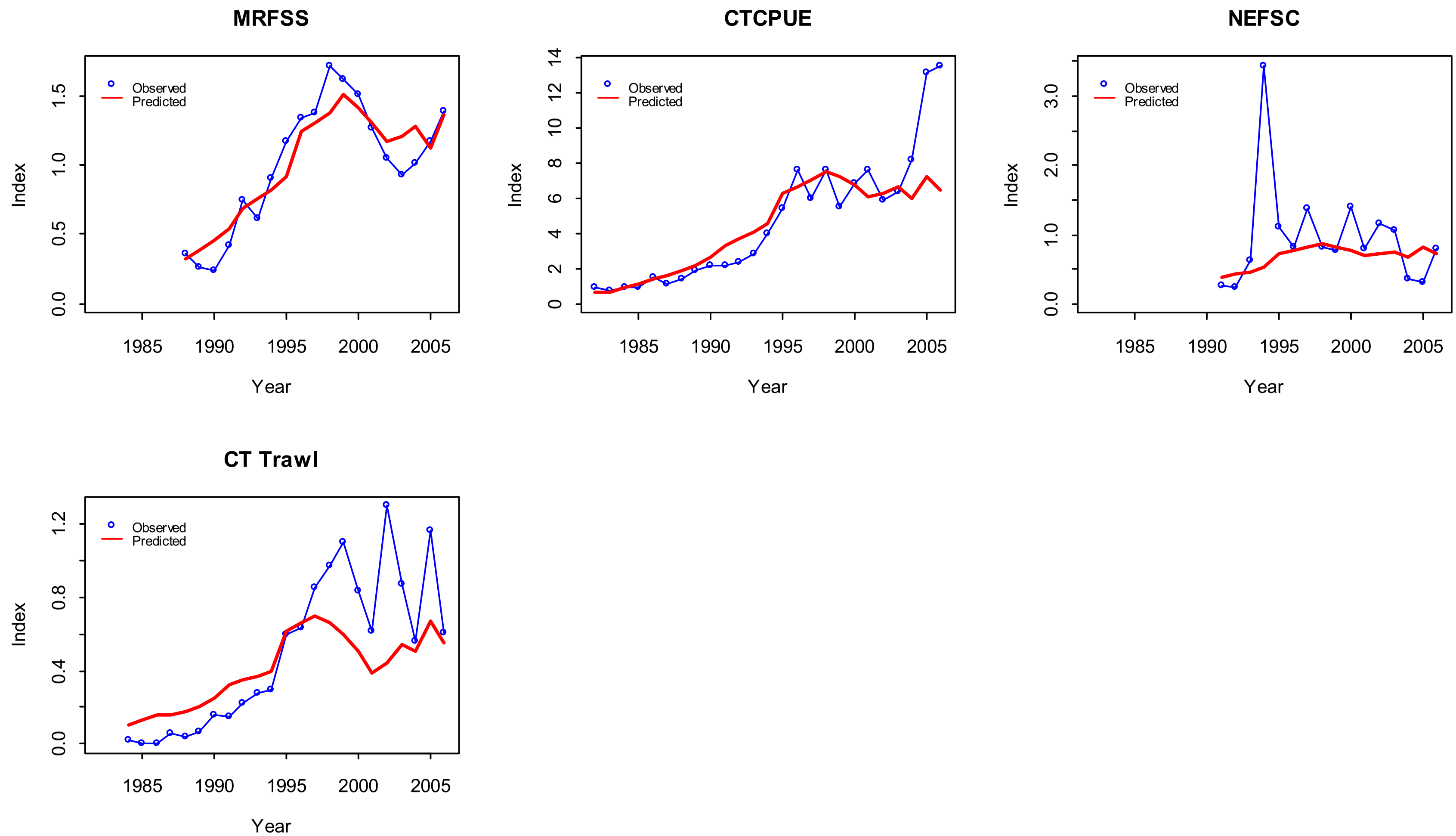


Figure 7. Observed and predicted aggregate indices.

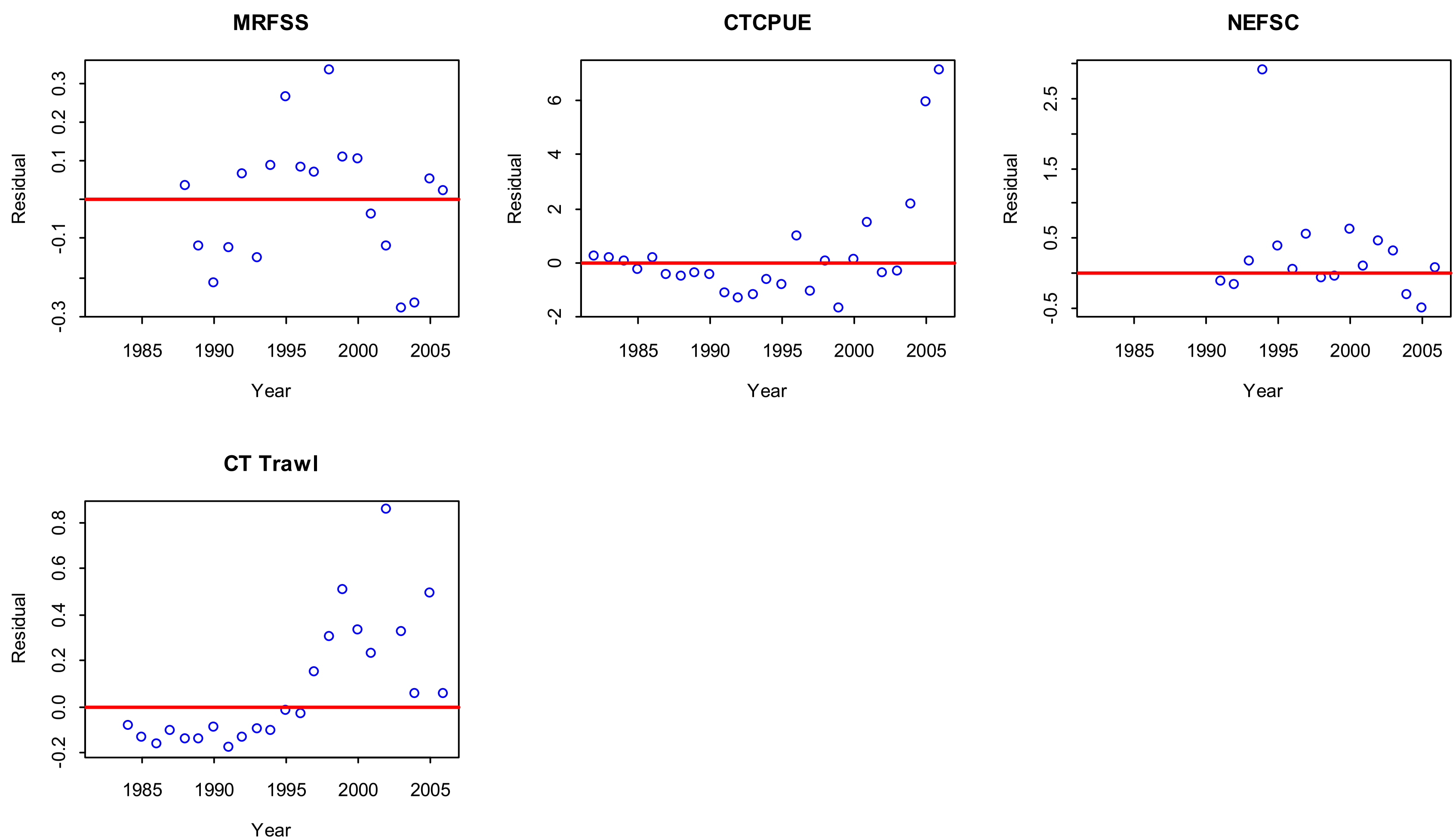


Figure 8. Residuals for aggregate indices.

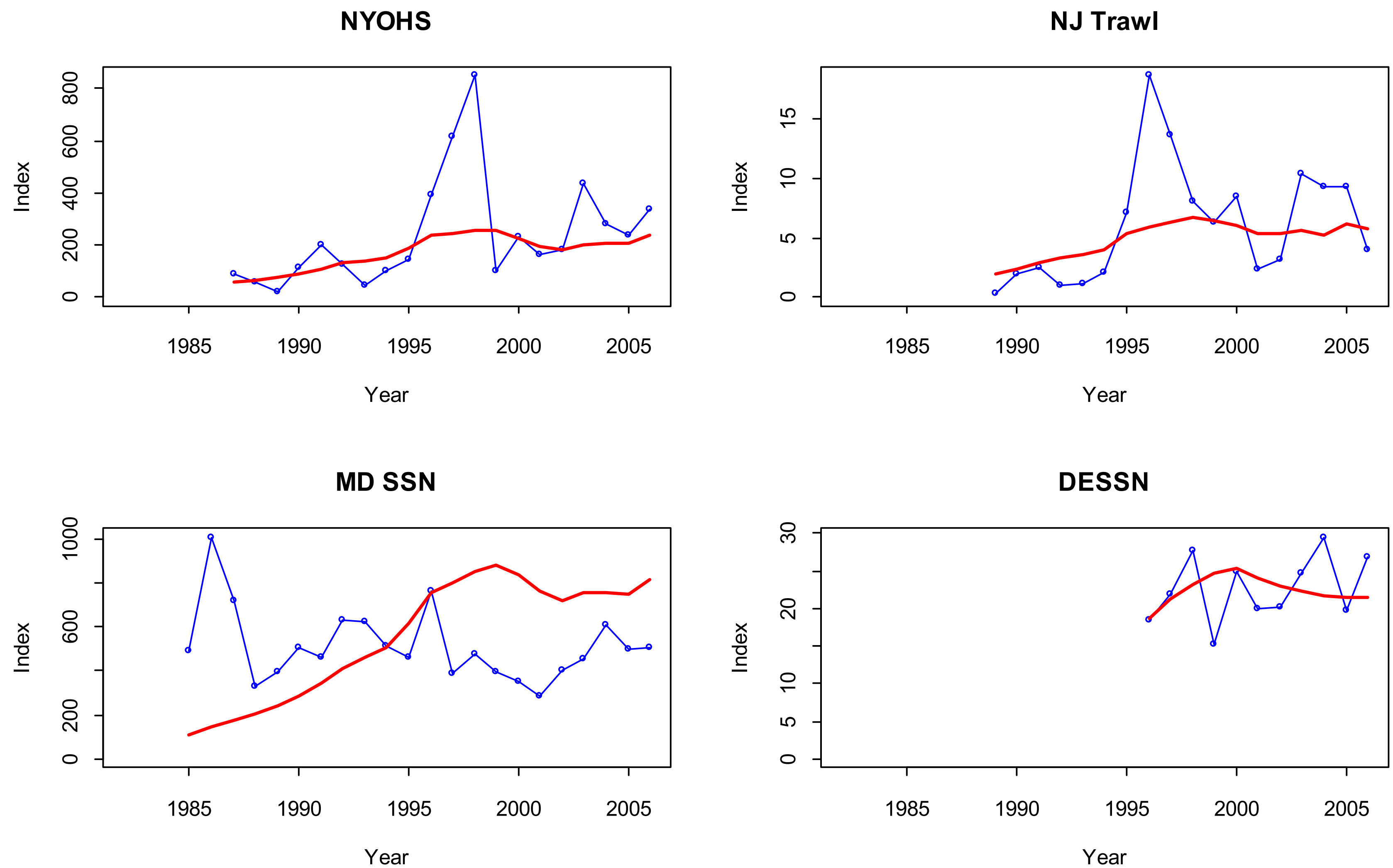


Figure 9. Observed (blue) and predicted (red) aggregate indices for surveys with age composition data.

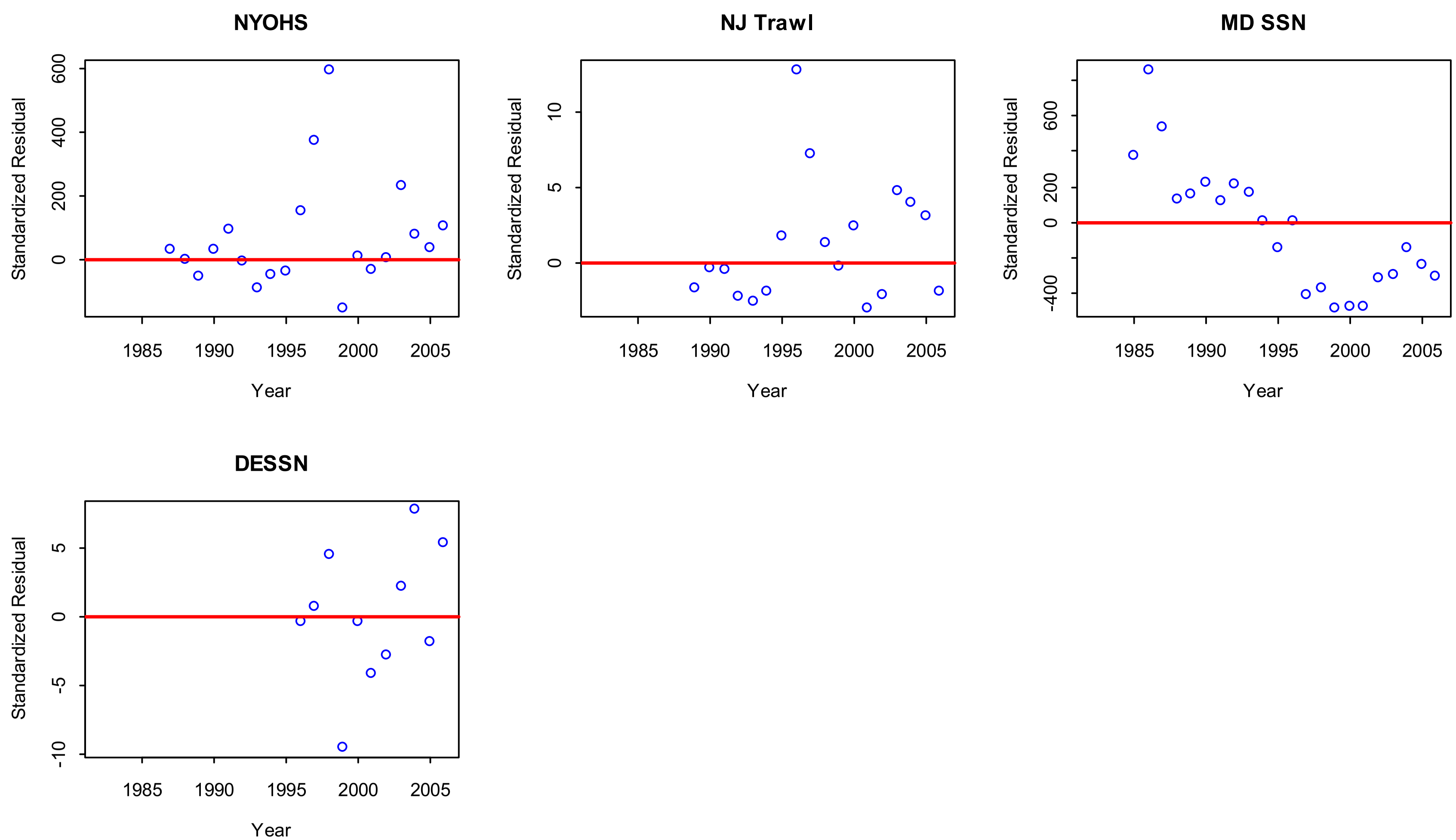


Figure 10. Residuals for aggregate indices with age composition data.

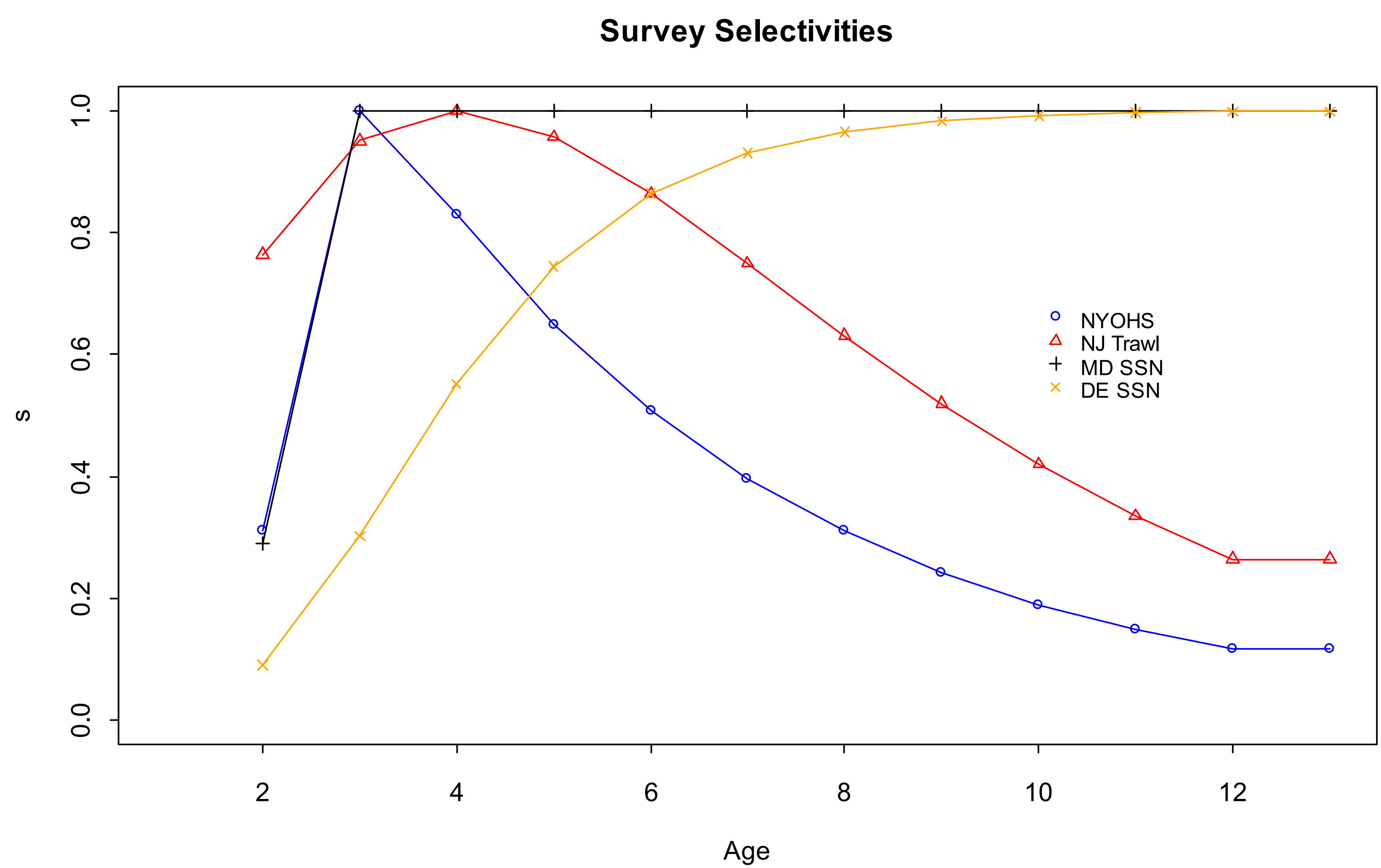


Figure 11. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD SSN, and DE SSN surveys.

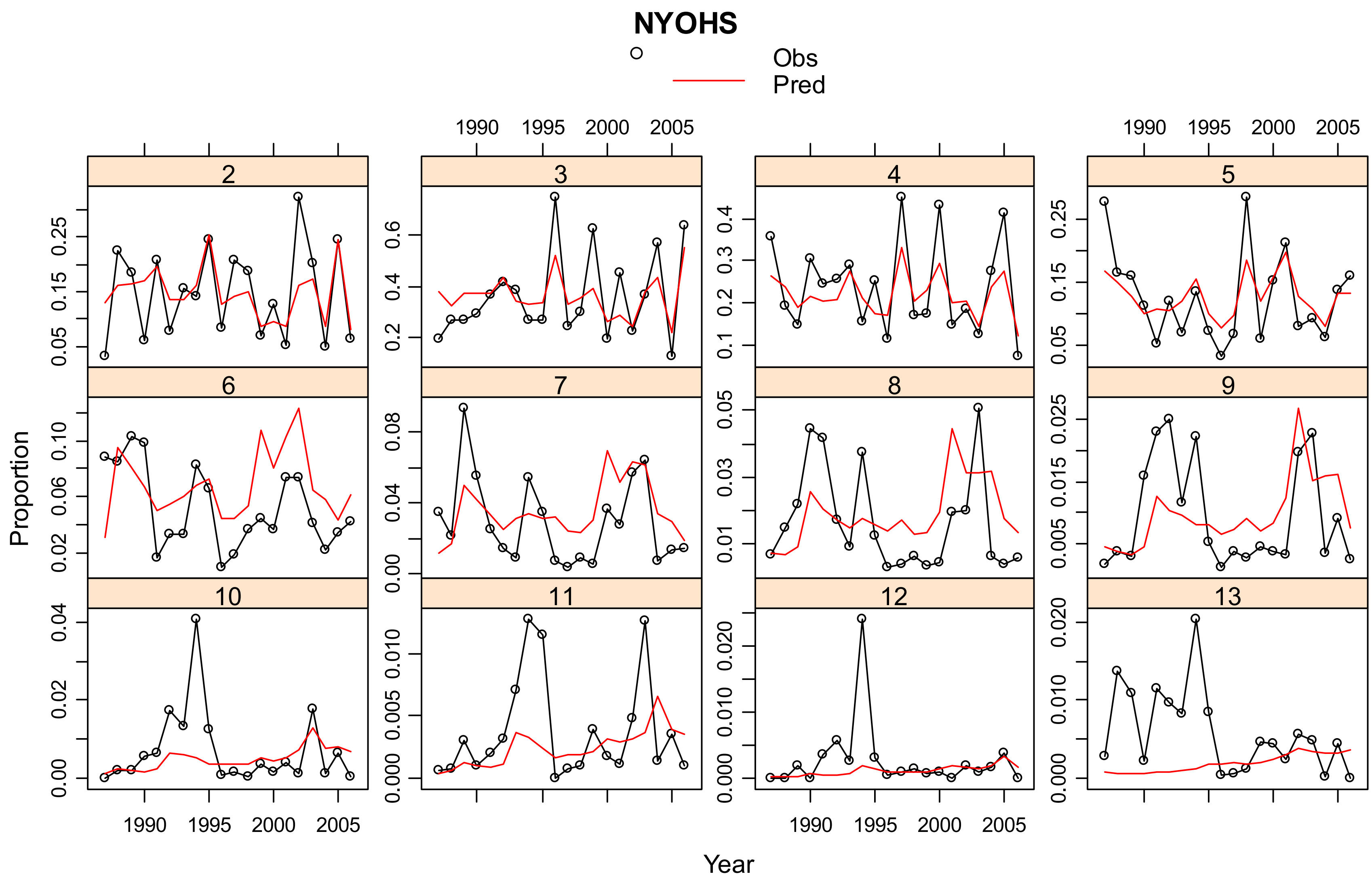


Figure 12. Observed and predicted proportions-at-age for each year by age for the NYOHS survey.

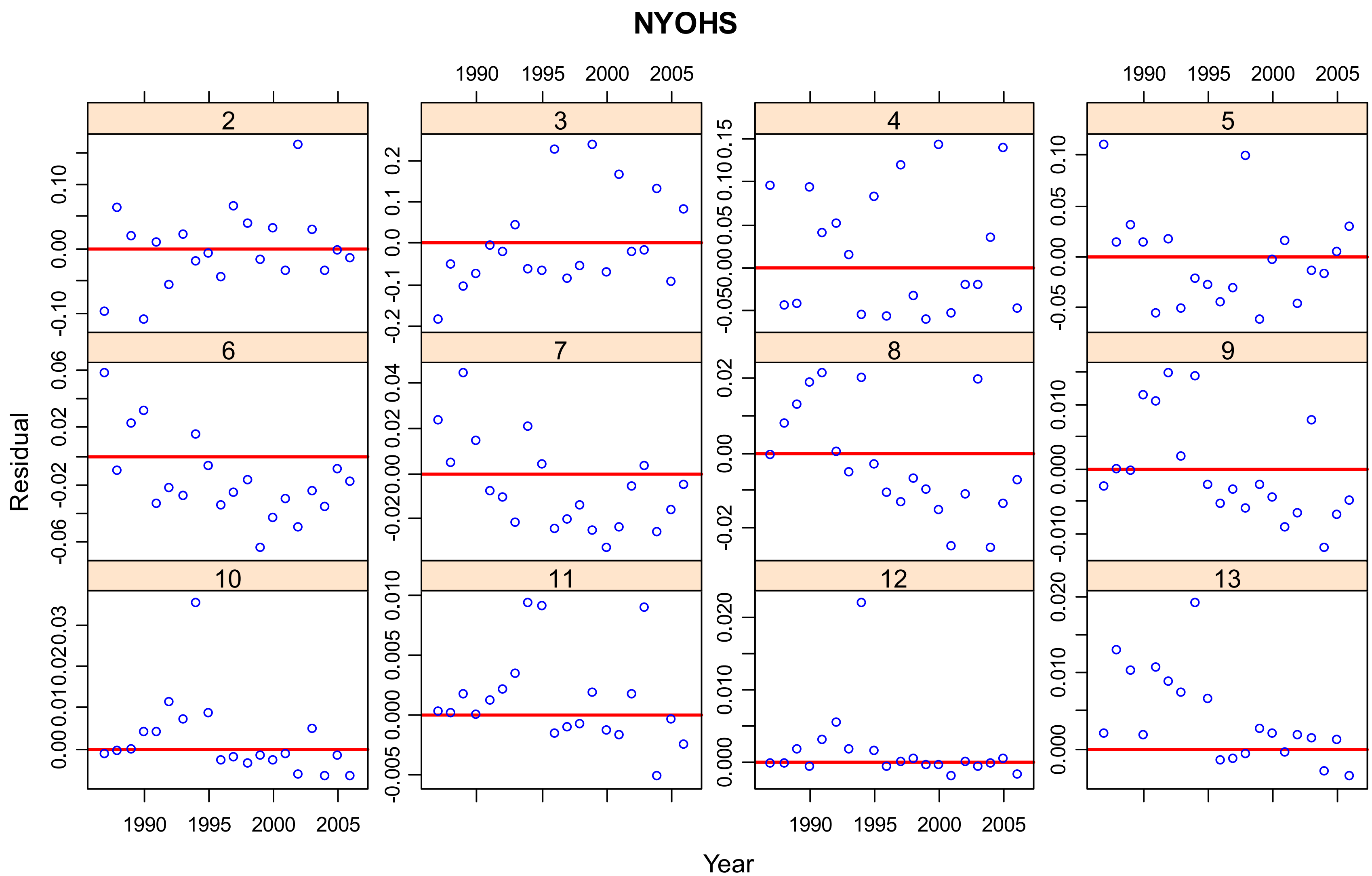


Figure 13. Residuals of proportions-at-age in each year by age for the NYOHS survey.

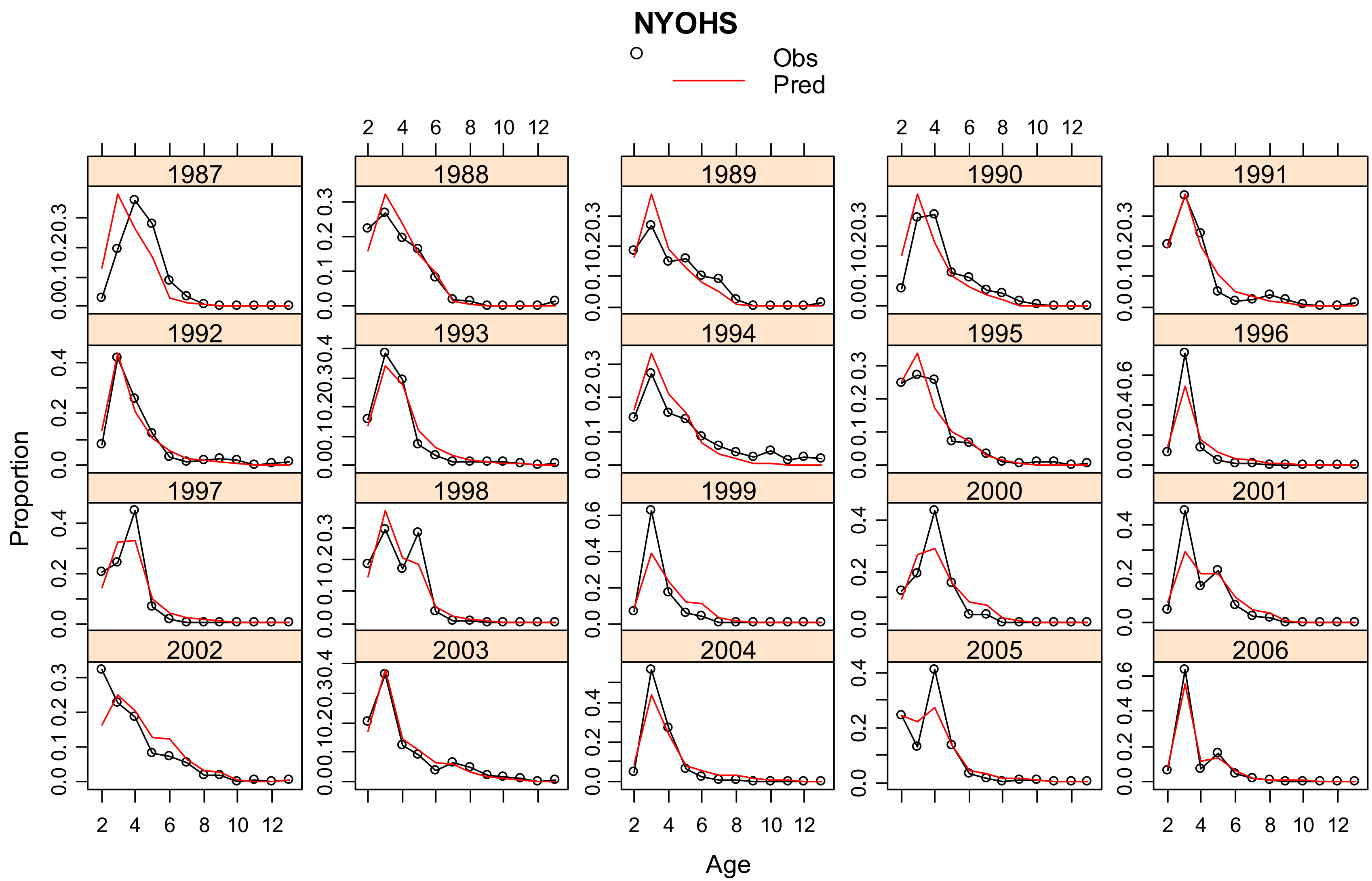


Figure 14. Observed and predicted proportions-at-age for each age by year for the NYOHS survey.

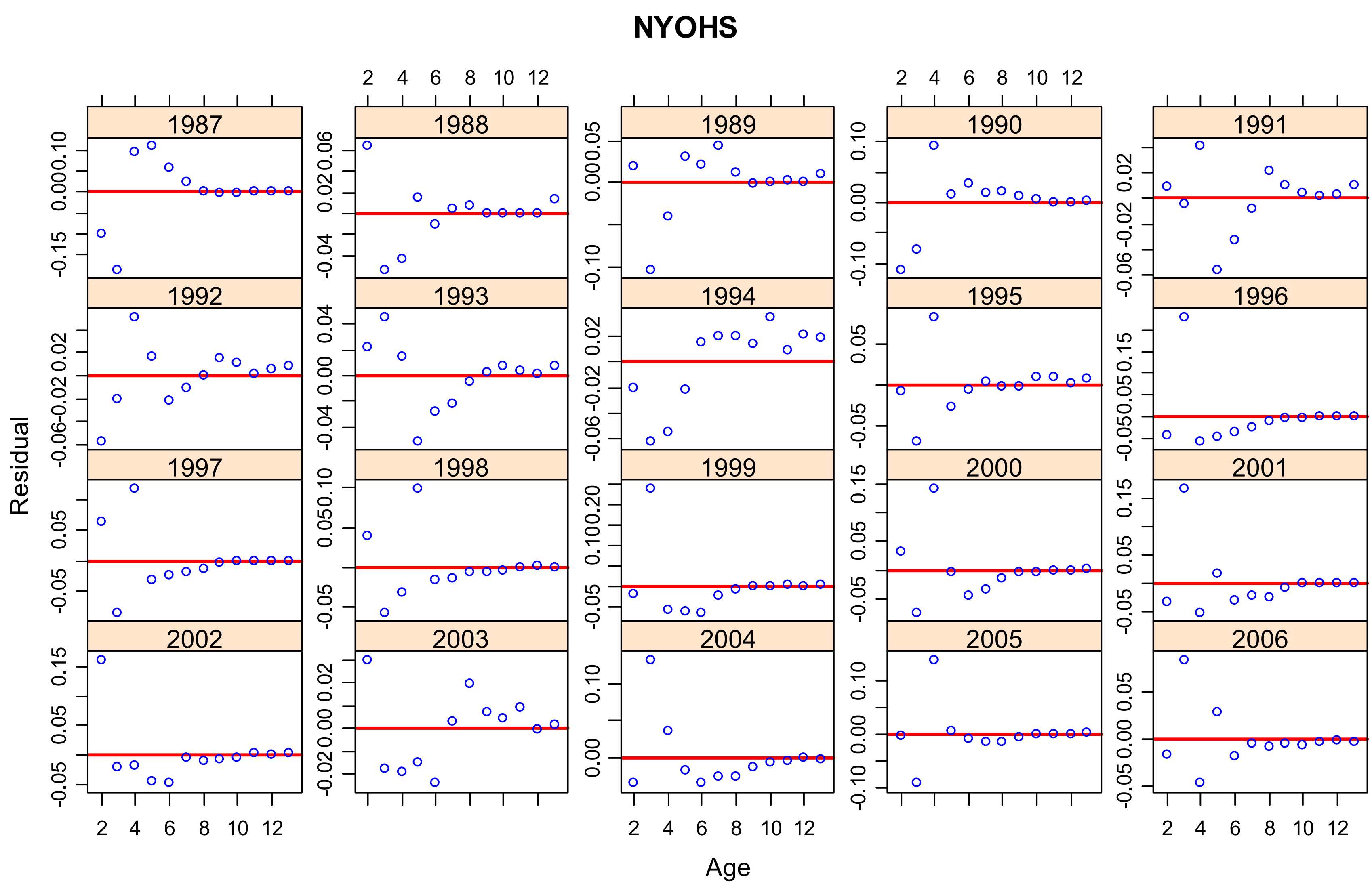


Figure 15. Residuals of proportions-at-age for each age by year for the NYOHS survey.

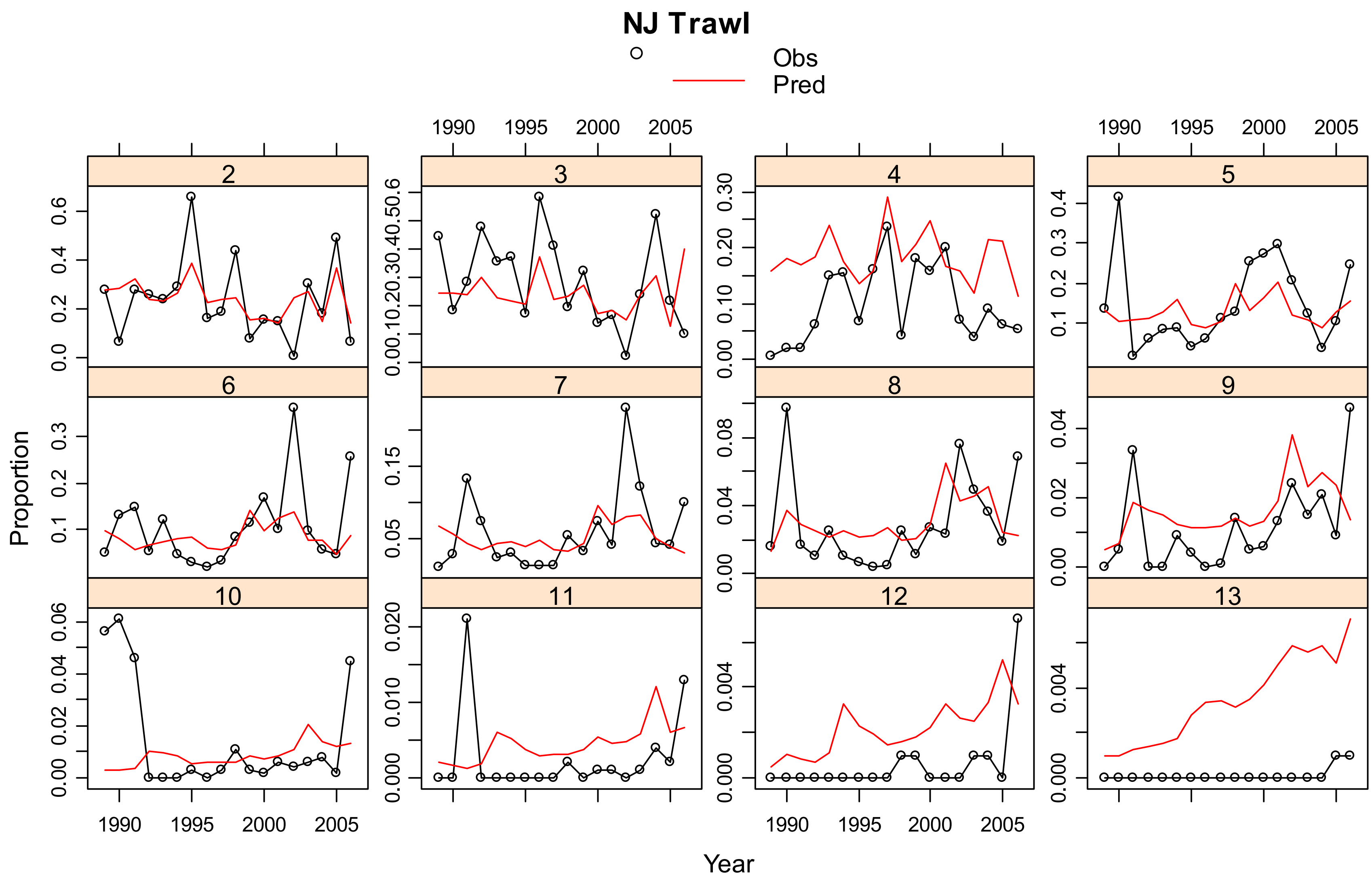


Figure 16. Observed and predicted proportions-at-age for each year by age for the NJ Trawl survey.

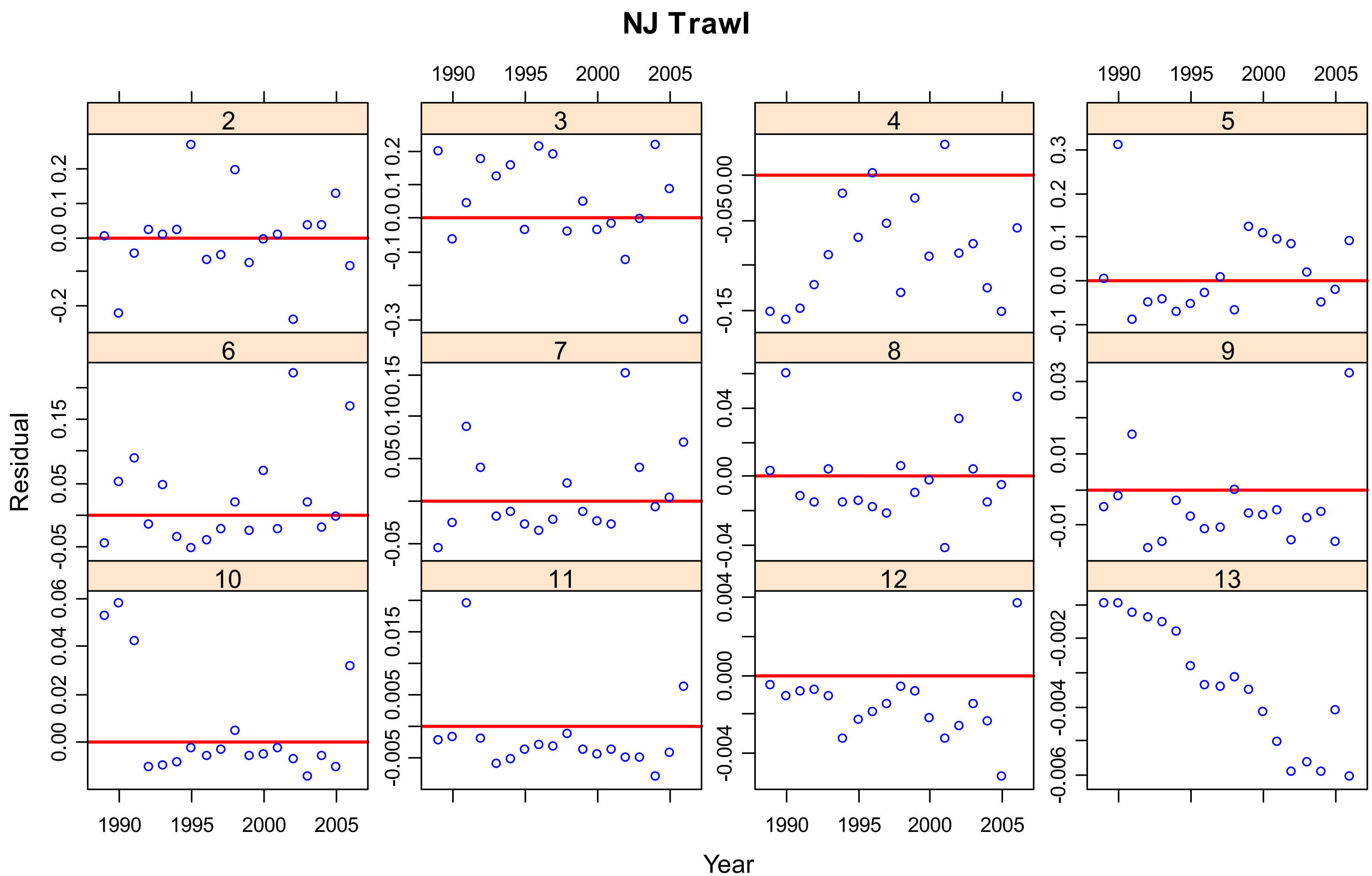


Figure 17. Residuals of proportions-at-age for each year by age for the NJ Trawl survey.

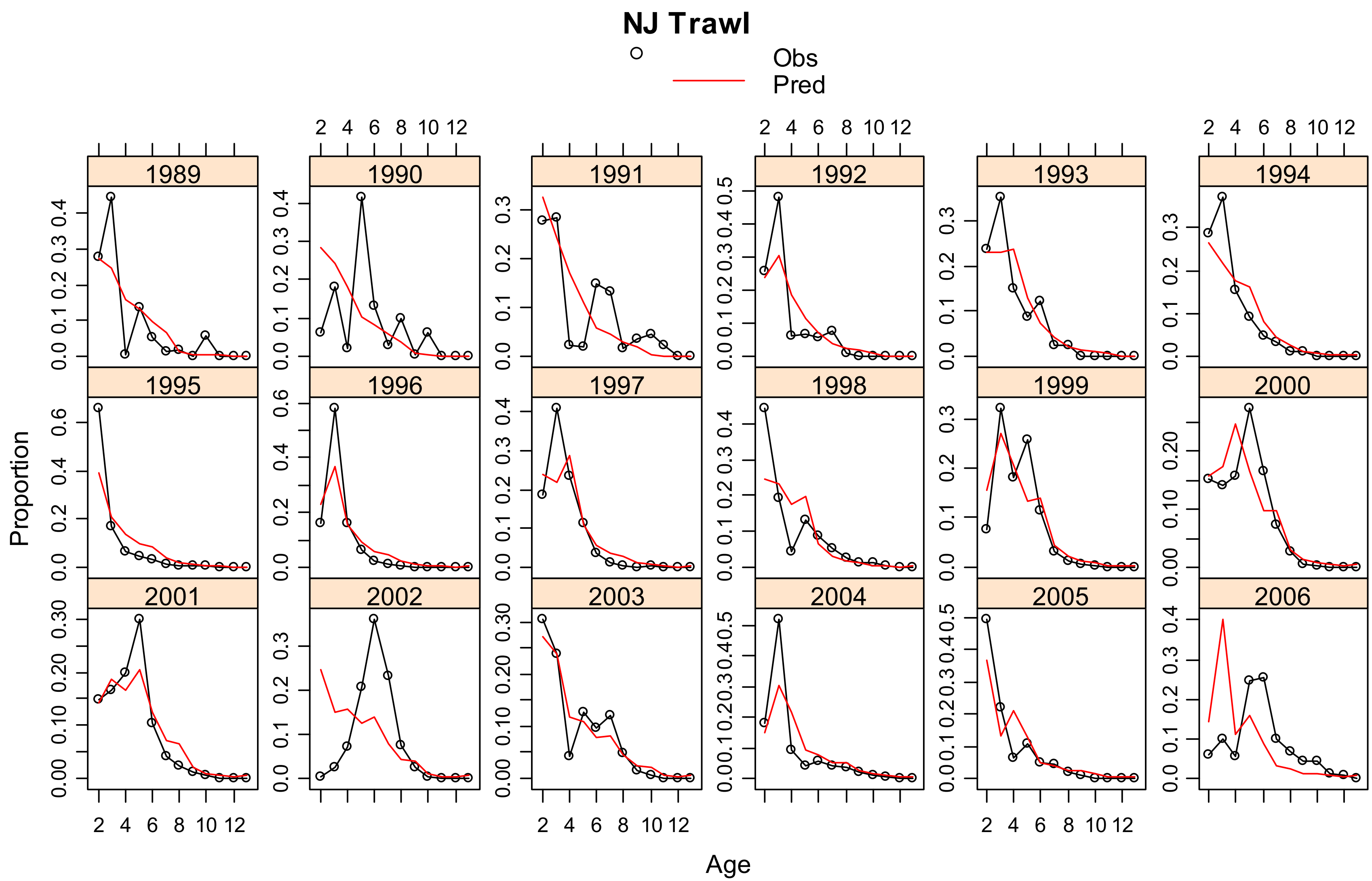


Figure 18. Observed and predicted proportions-at-age for each age by year for the NJ Trawl survey.

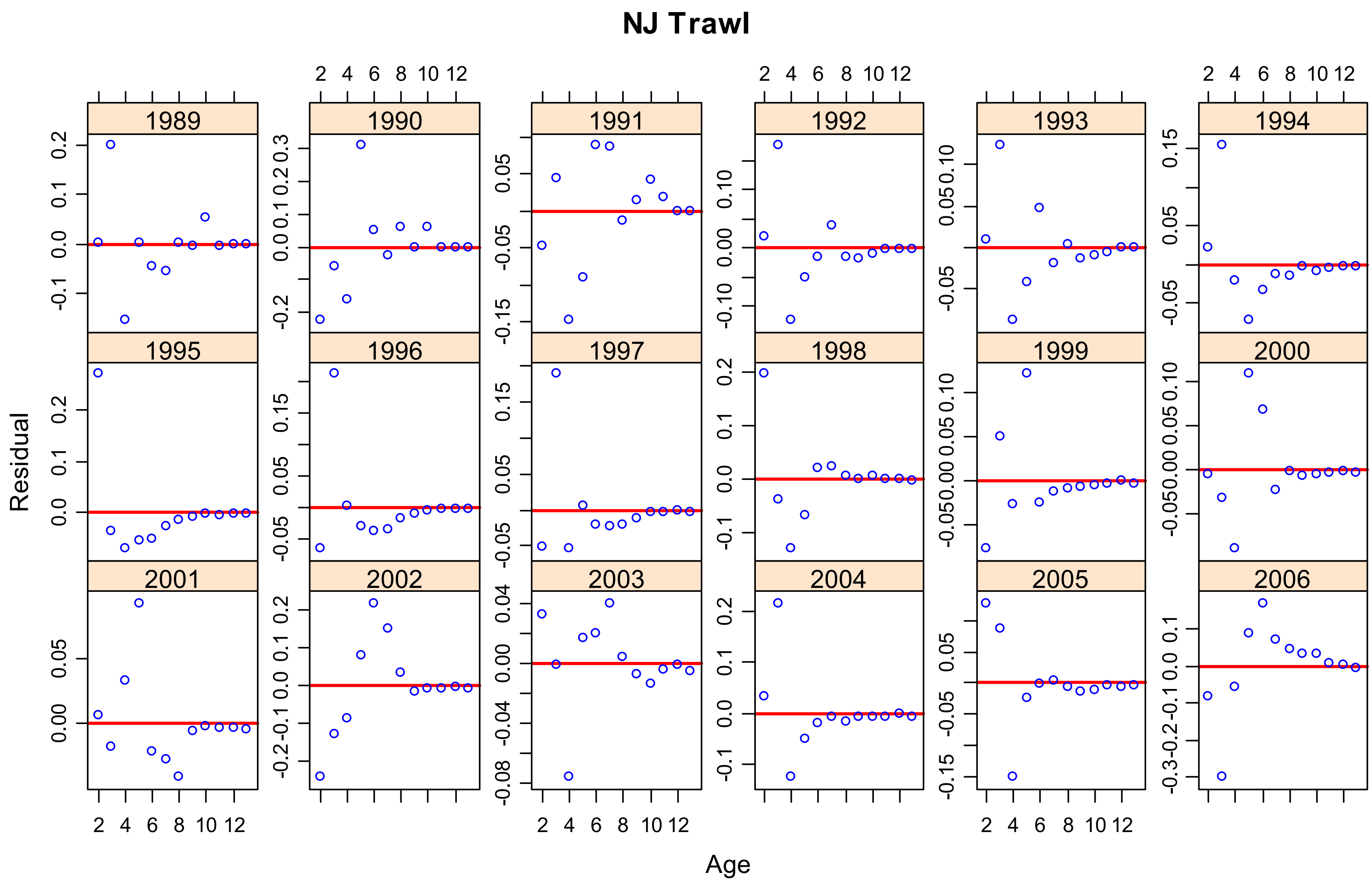


Figure 19. Residuals of proportions-at-age for each age by year for the NJ Trawl survey.

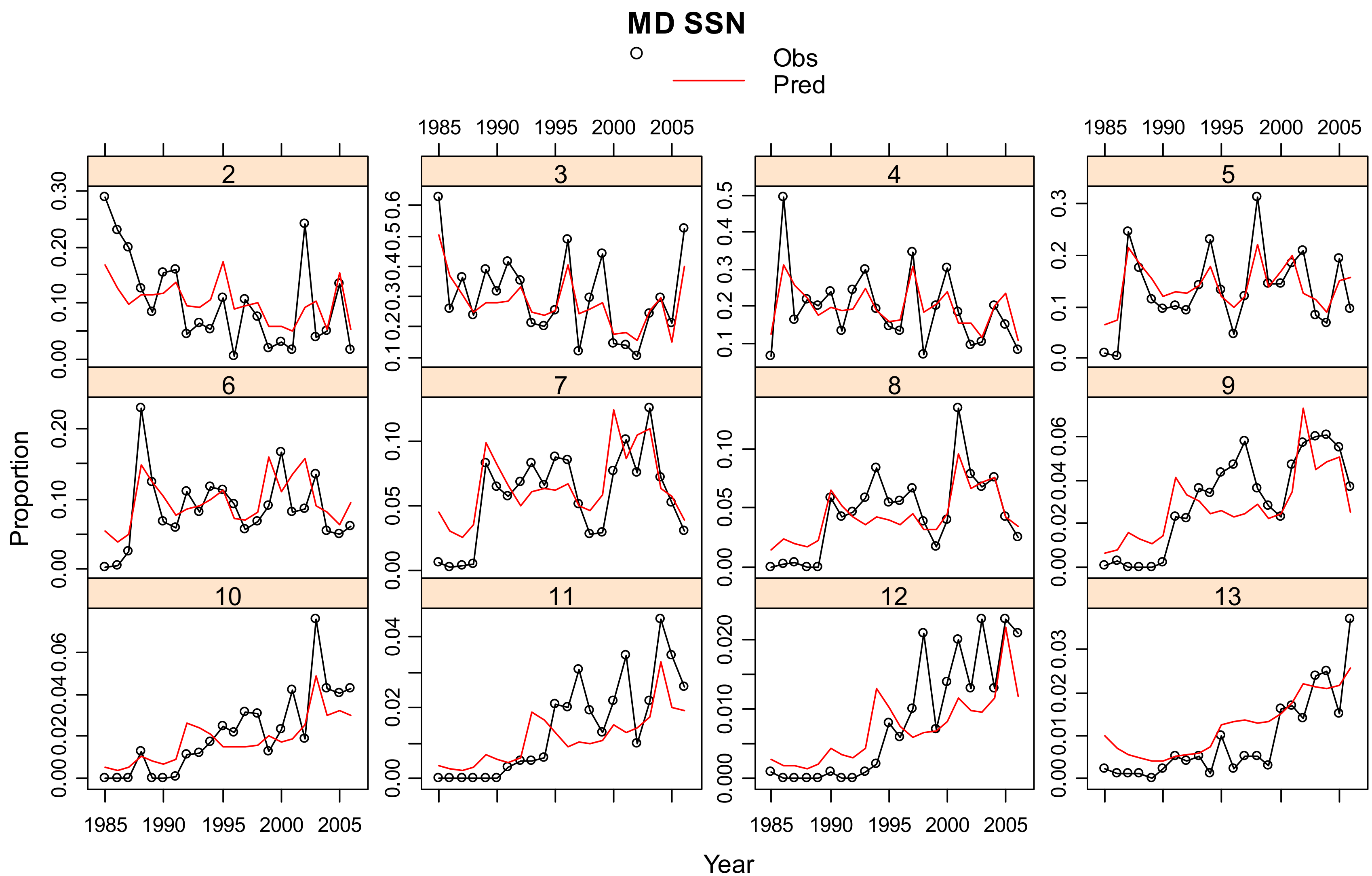


Figure 20. Observed and predicted proportions-at-age for each year by age for the MD SSN gillnet survey.

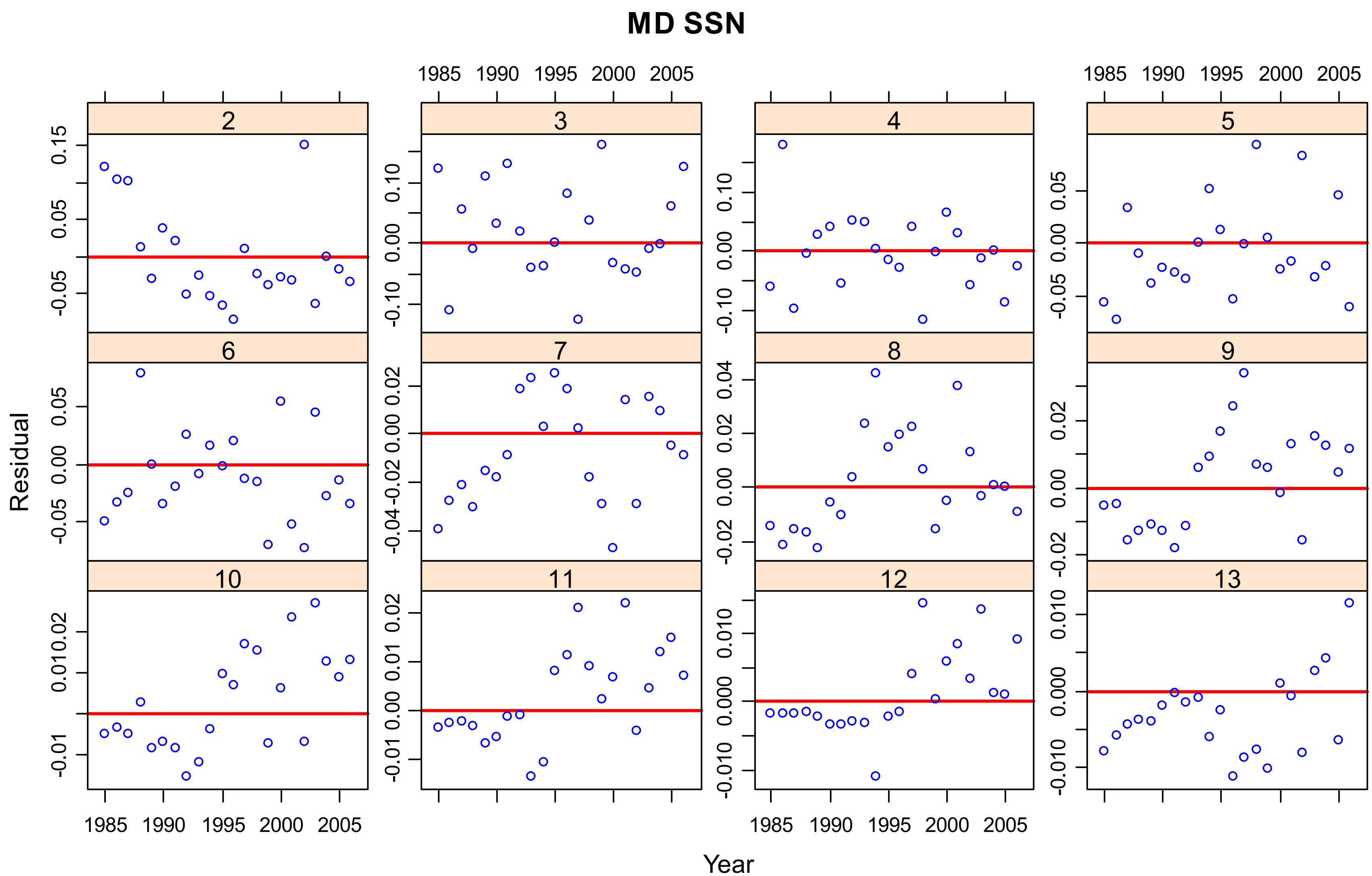


Figure 21. Residuals of proportions-at-age for each age by year for the MD SSN gillnet survey.

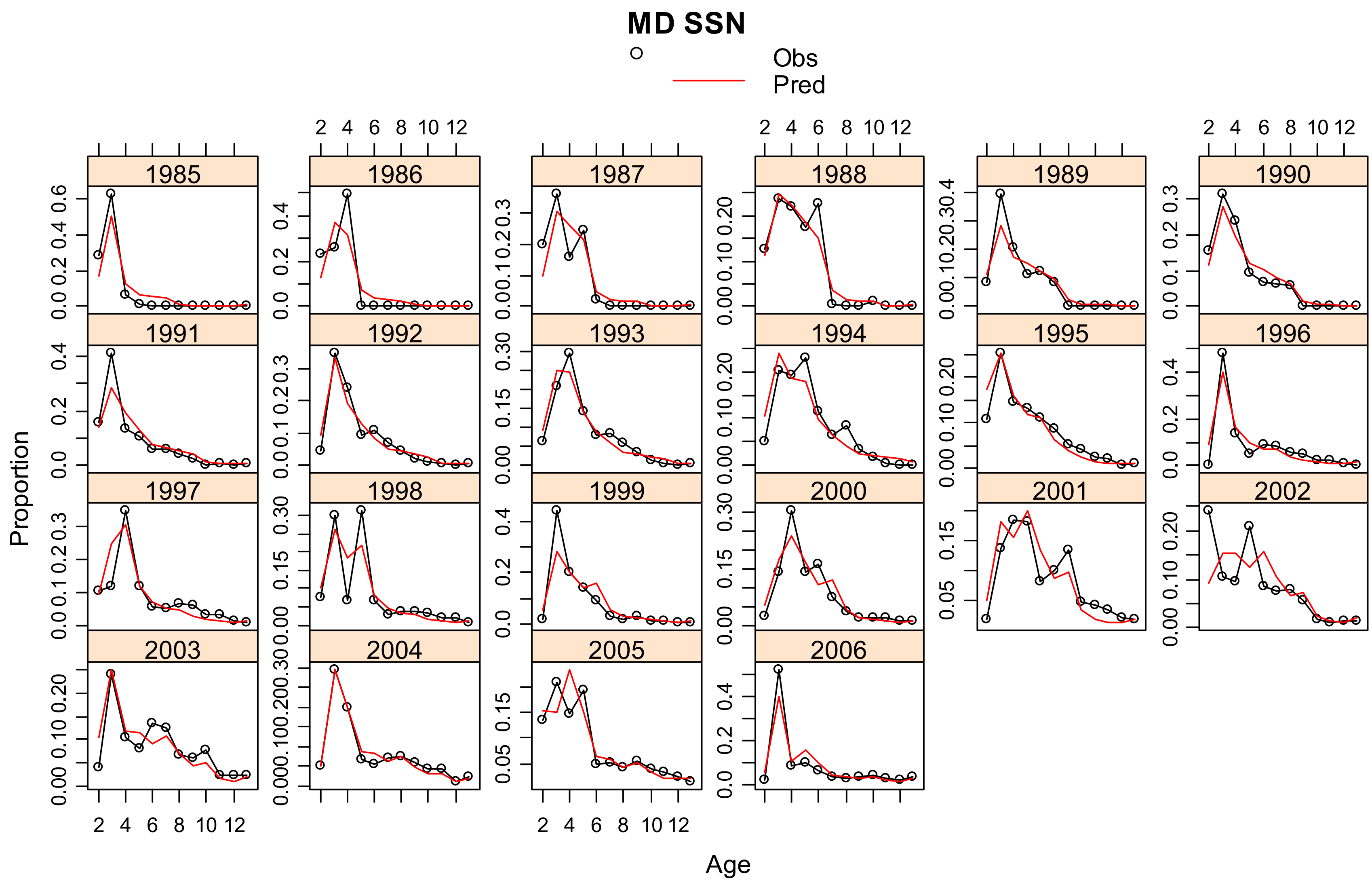


Figure 22. Observed and predicted proportions-at-age for each age by year for the MD SSN gillnet survey.

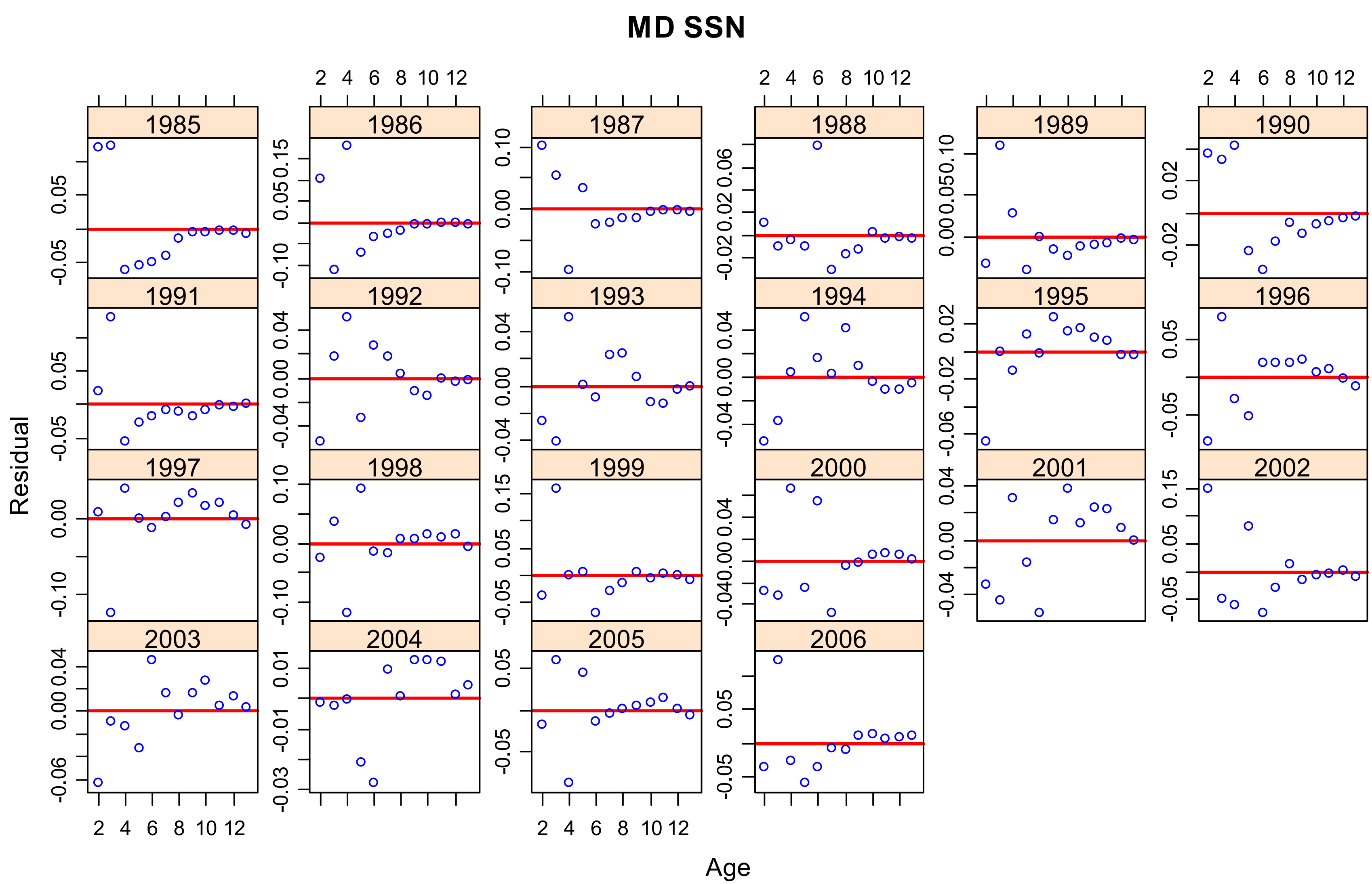


Figure 23. Residuals of proportions-at-age for each age by year for the MD SSN gillnet survey.

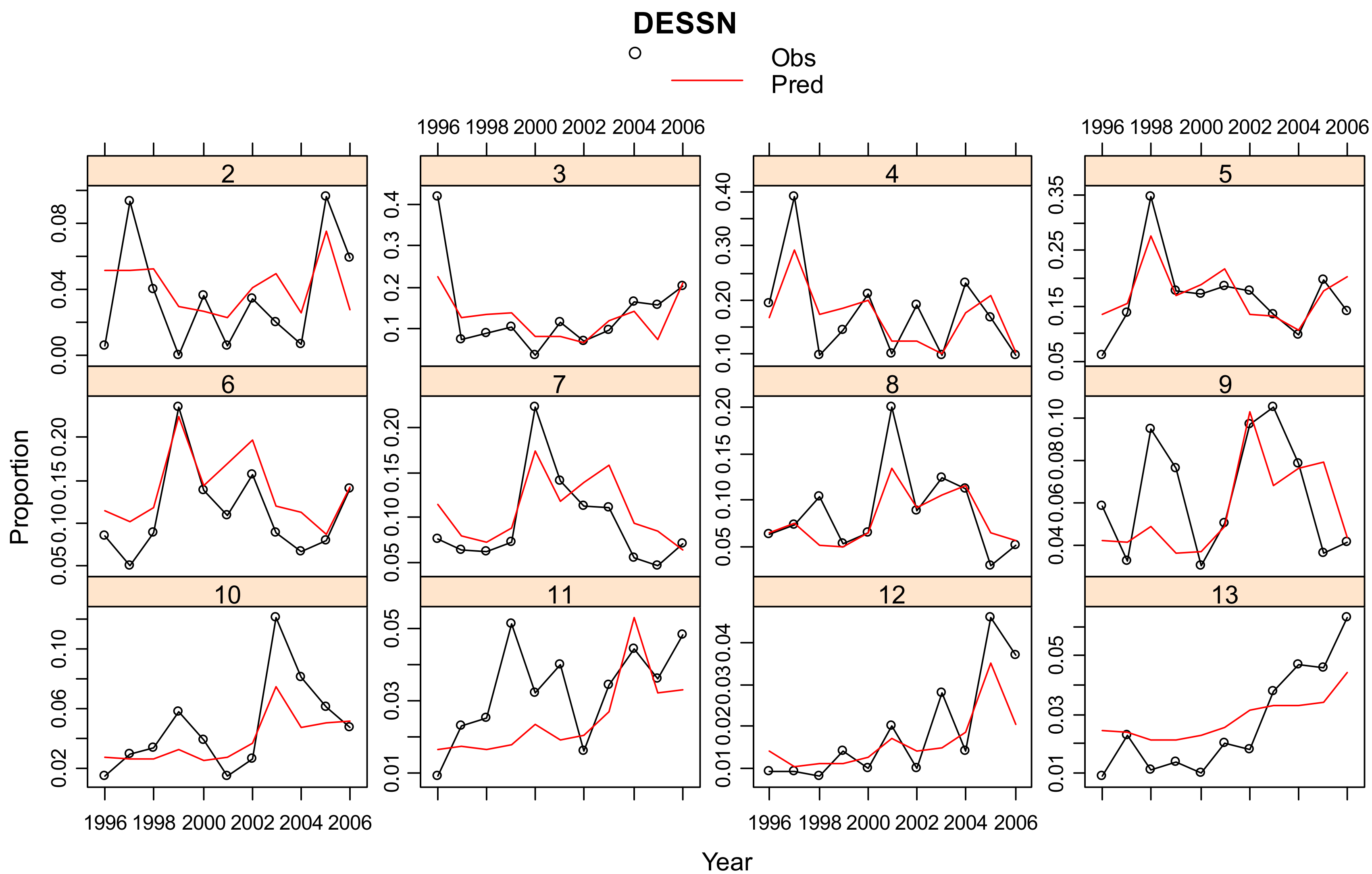


Figure 24. Observed and predicted proportions-at-age for each year by age for the DE SSN electrofishing survey.

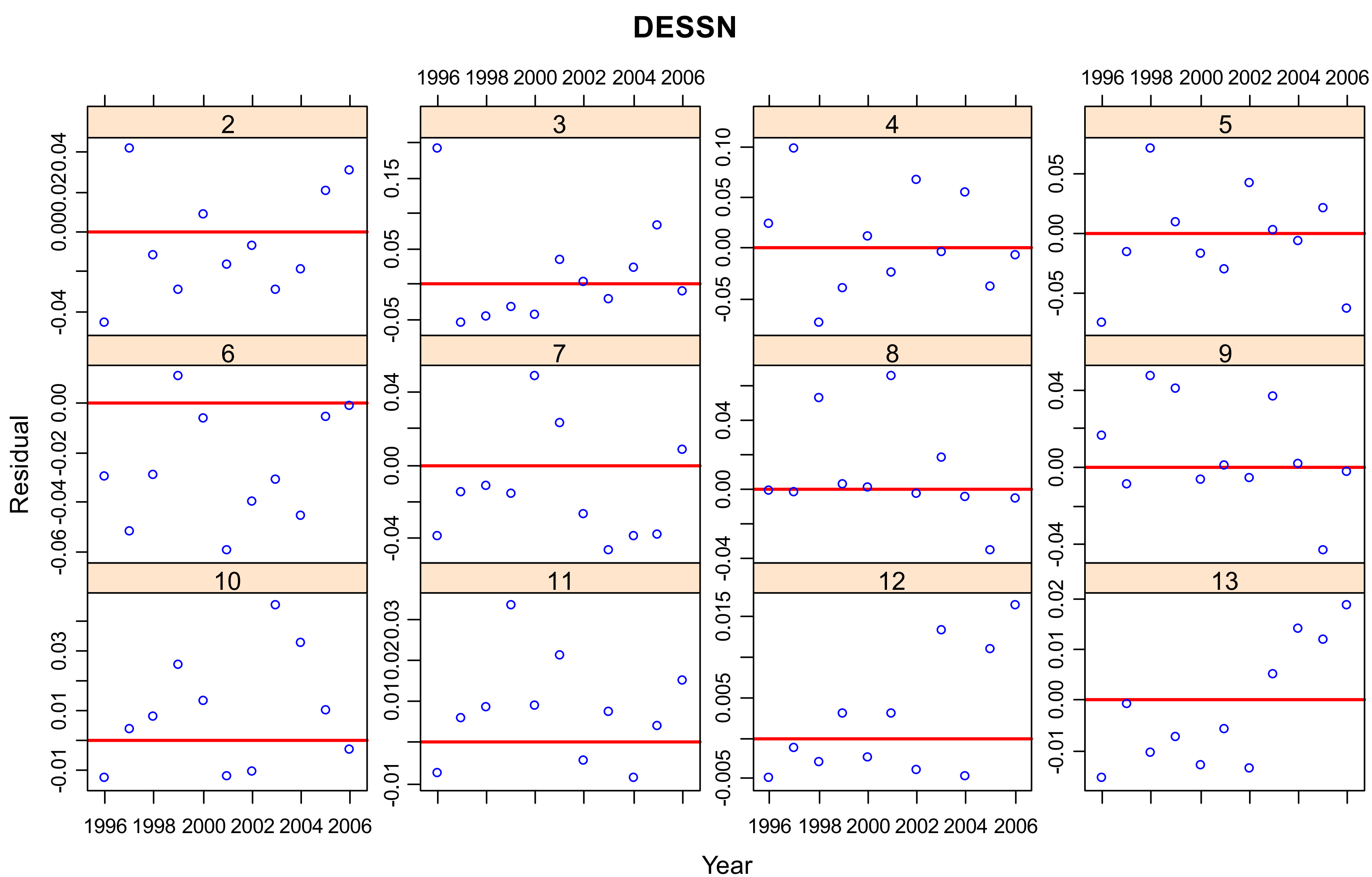


Figure 25. Residuals of proportions-at-age for each year by age for the DE SSN electrofishing survey.

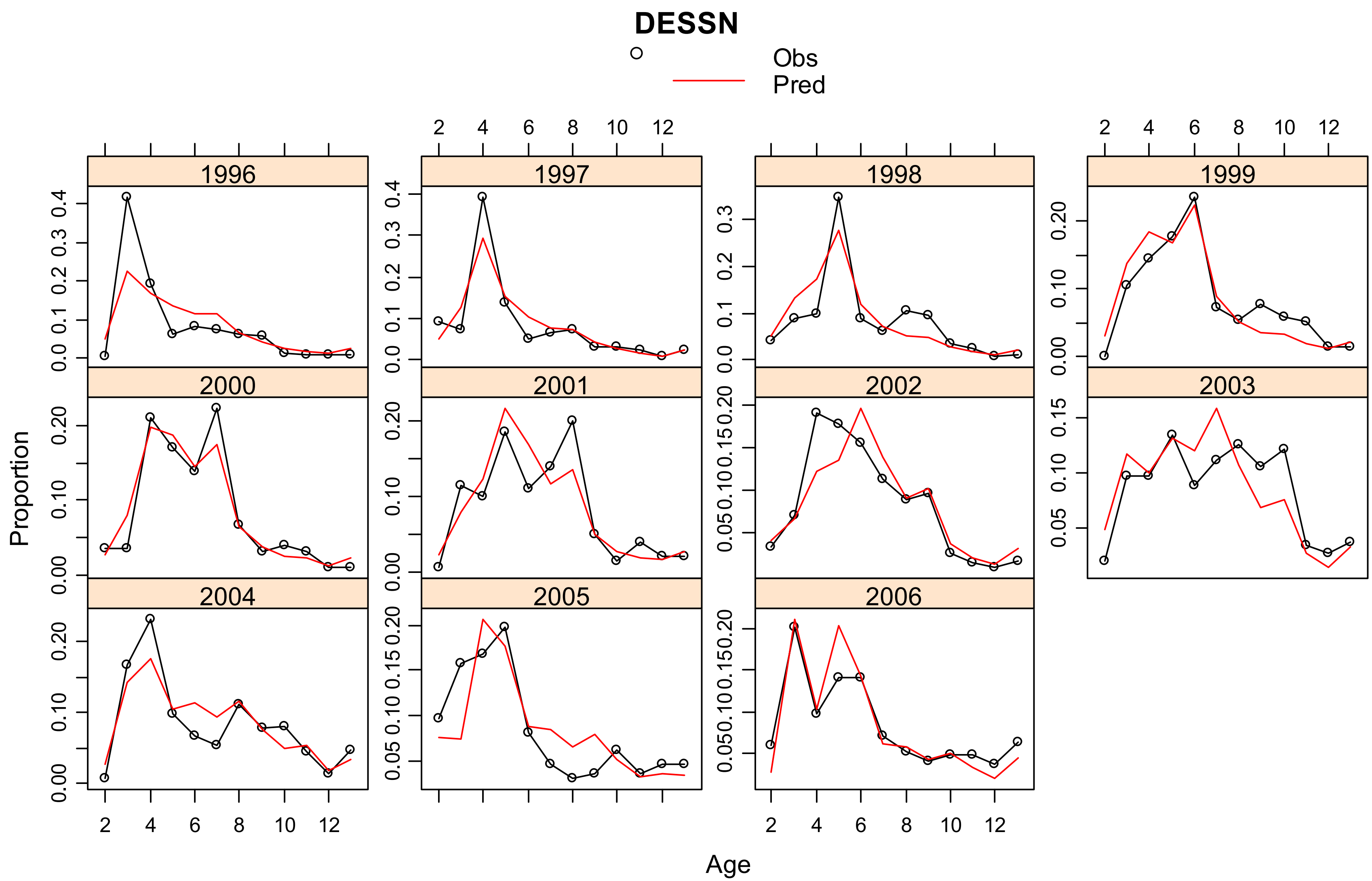


Figure 26. Observed and predicted proportions-at-age for each age by year for the DE SSN electrofishing survey.

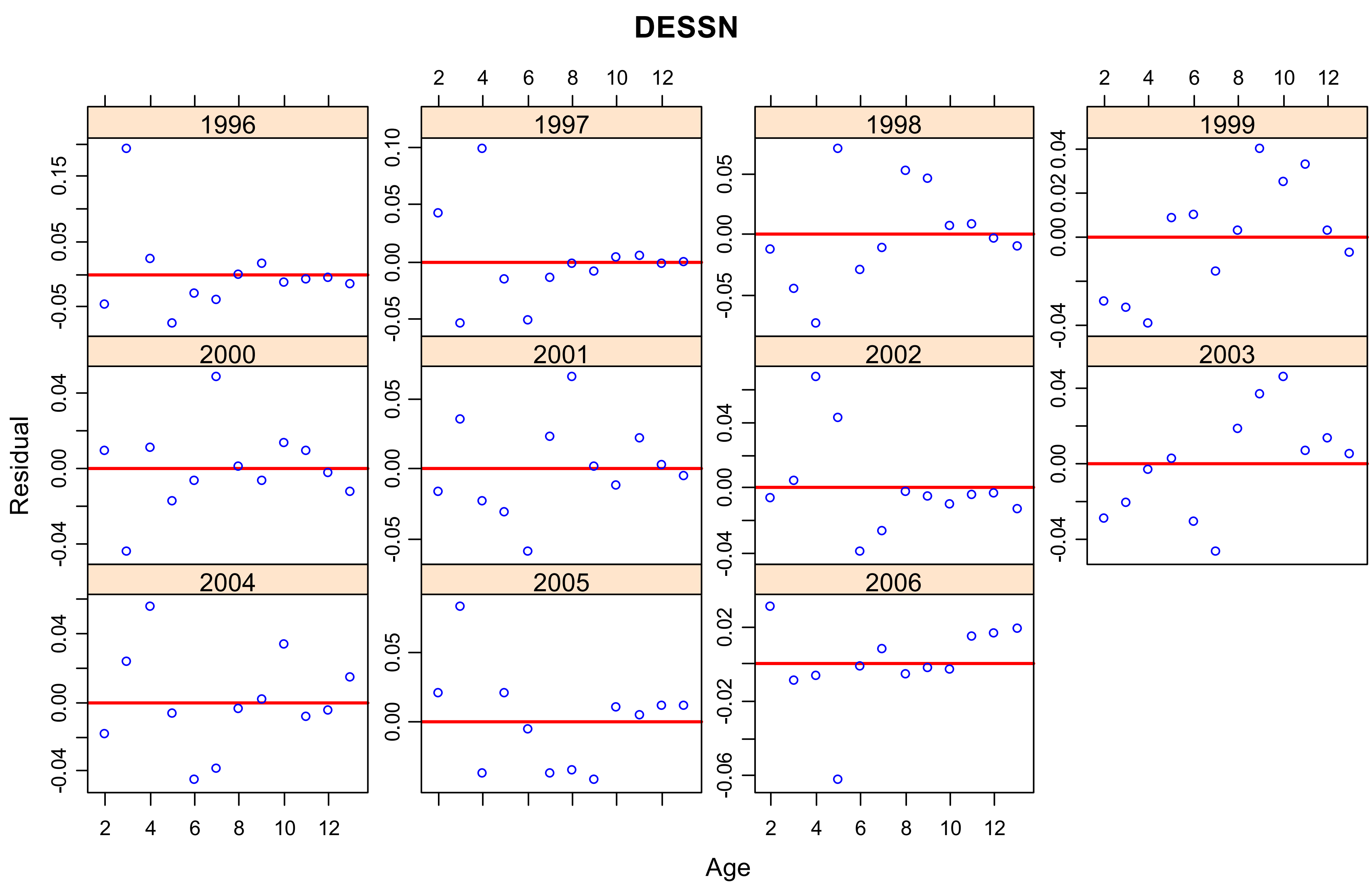


Figure 27. Residuals of proportions-at-age for each year by age for the DE SSN electrofishing survey.

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

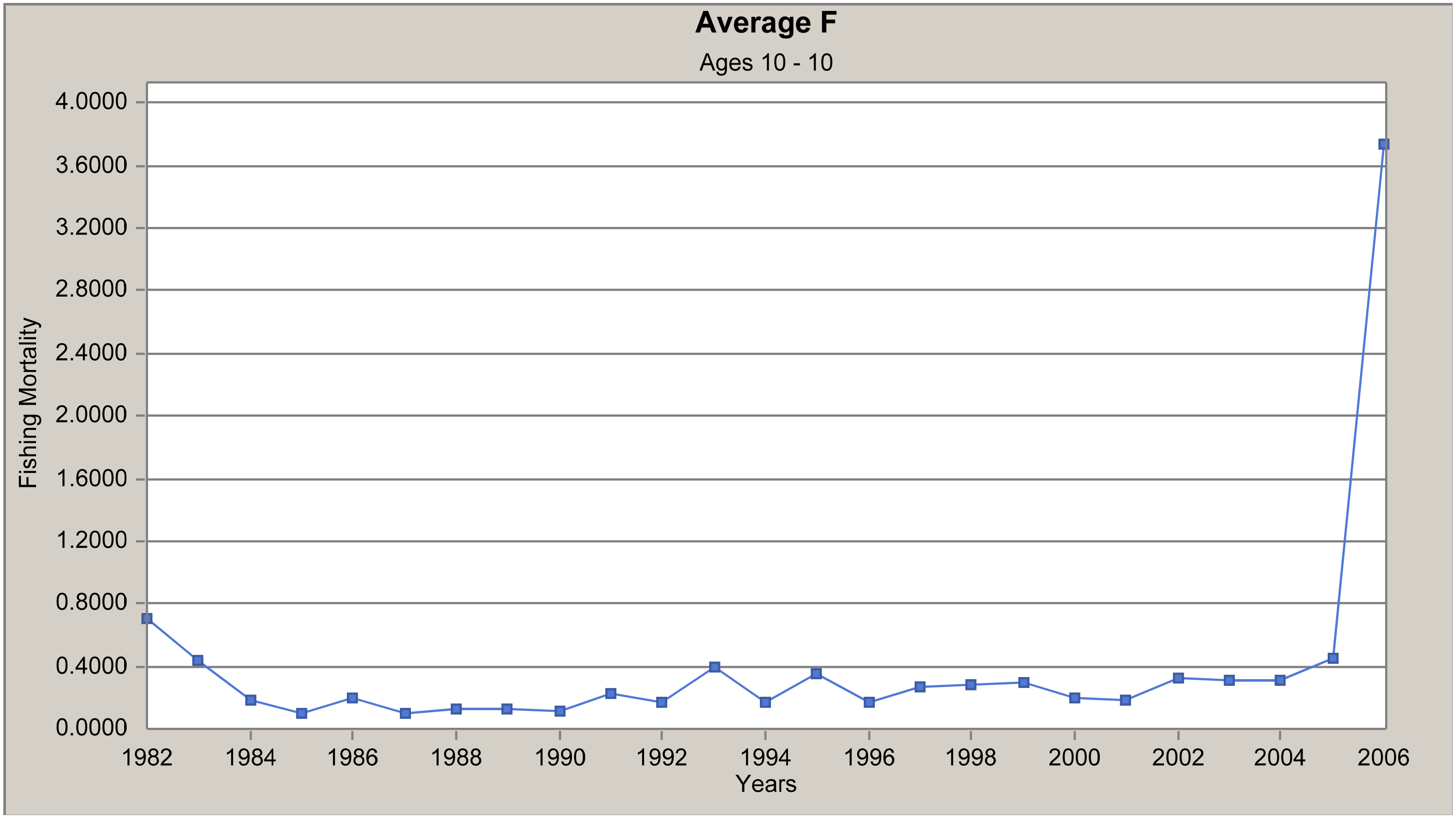


Figure 1. Age 10 fishing mortality from full ADAPT model with index selection comparable to previous assessment.

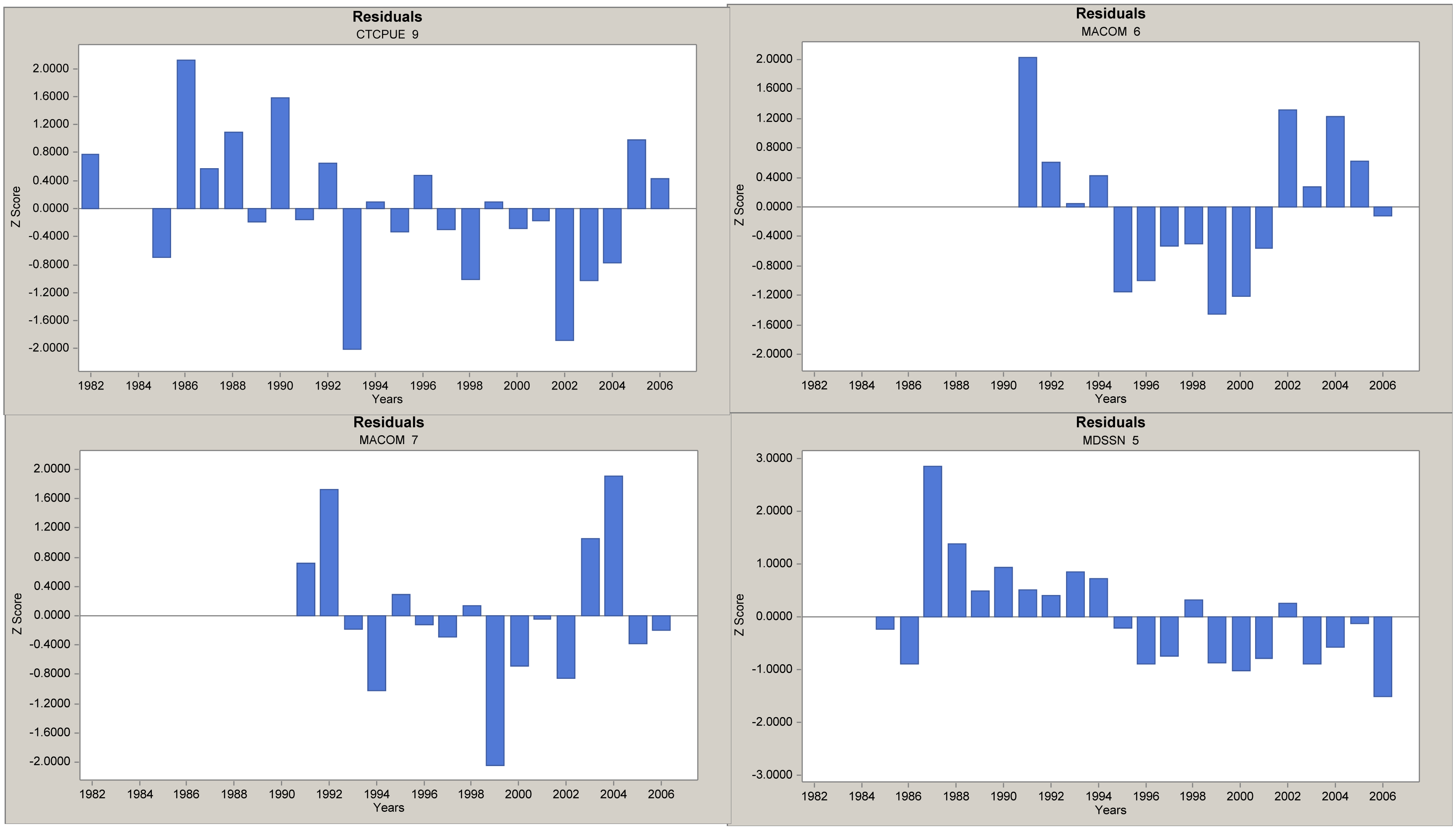
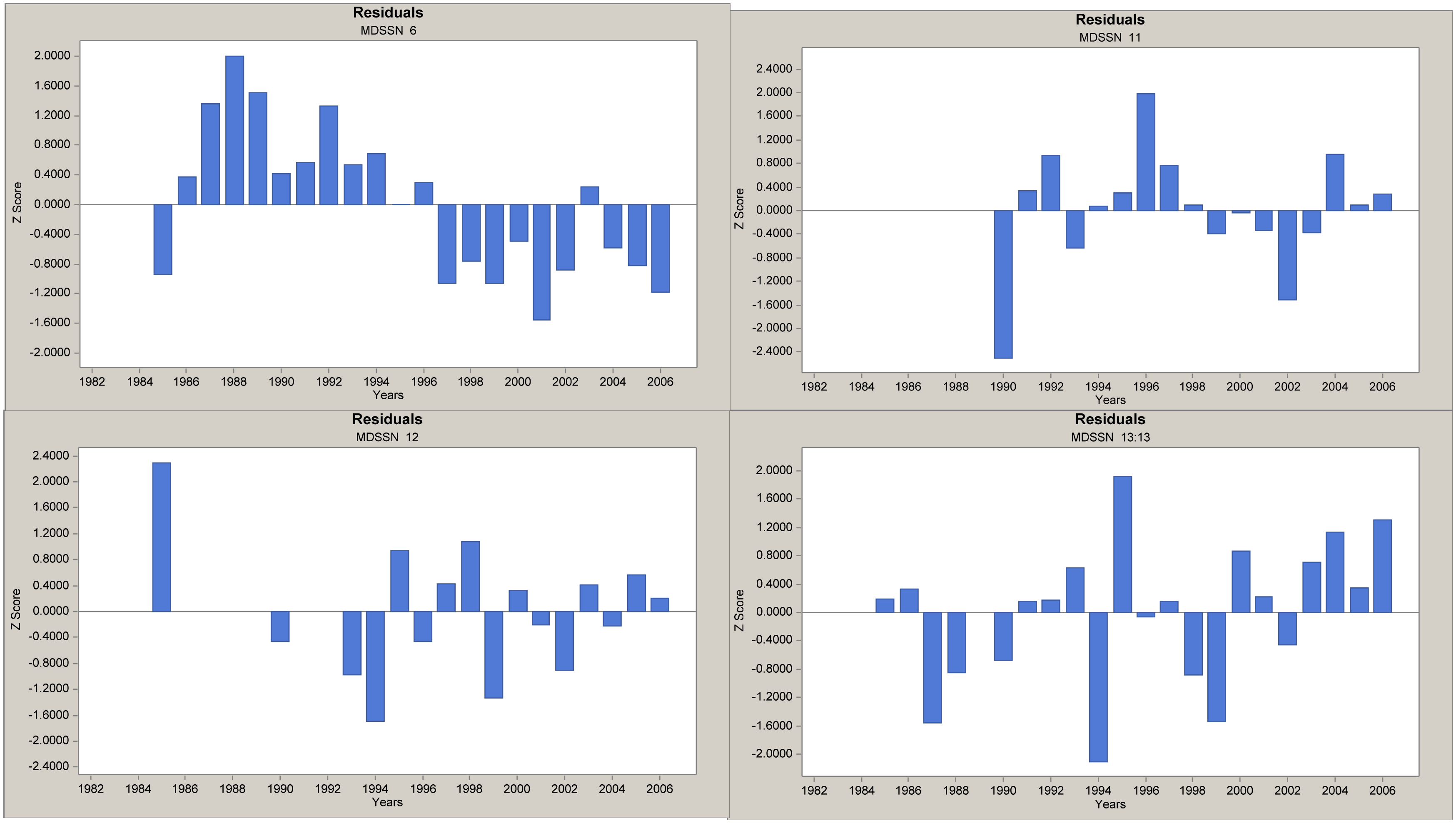


Figure 2. Residual plots from ADAPT model using index selection from previous assessment.



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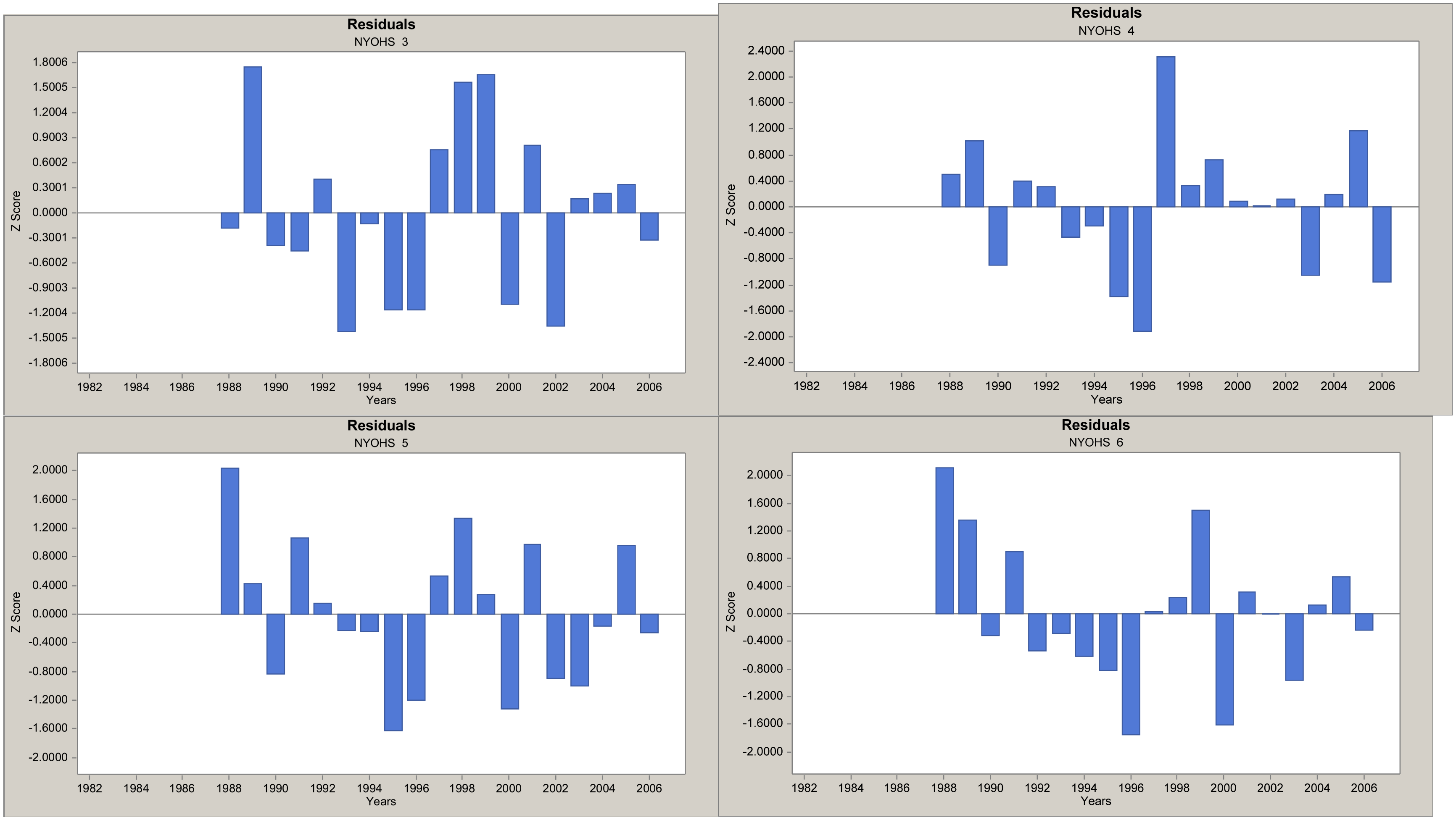

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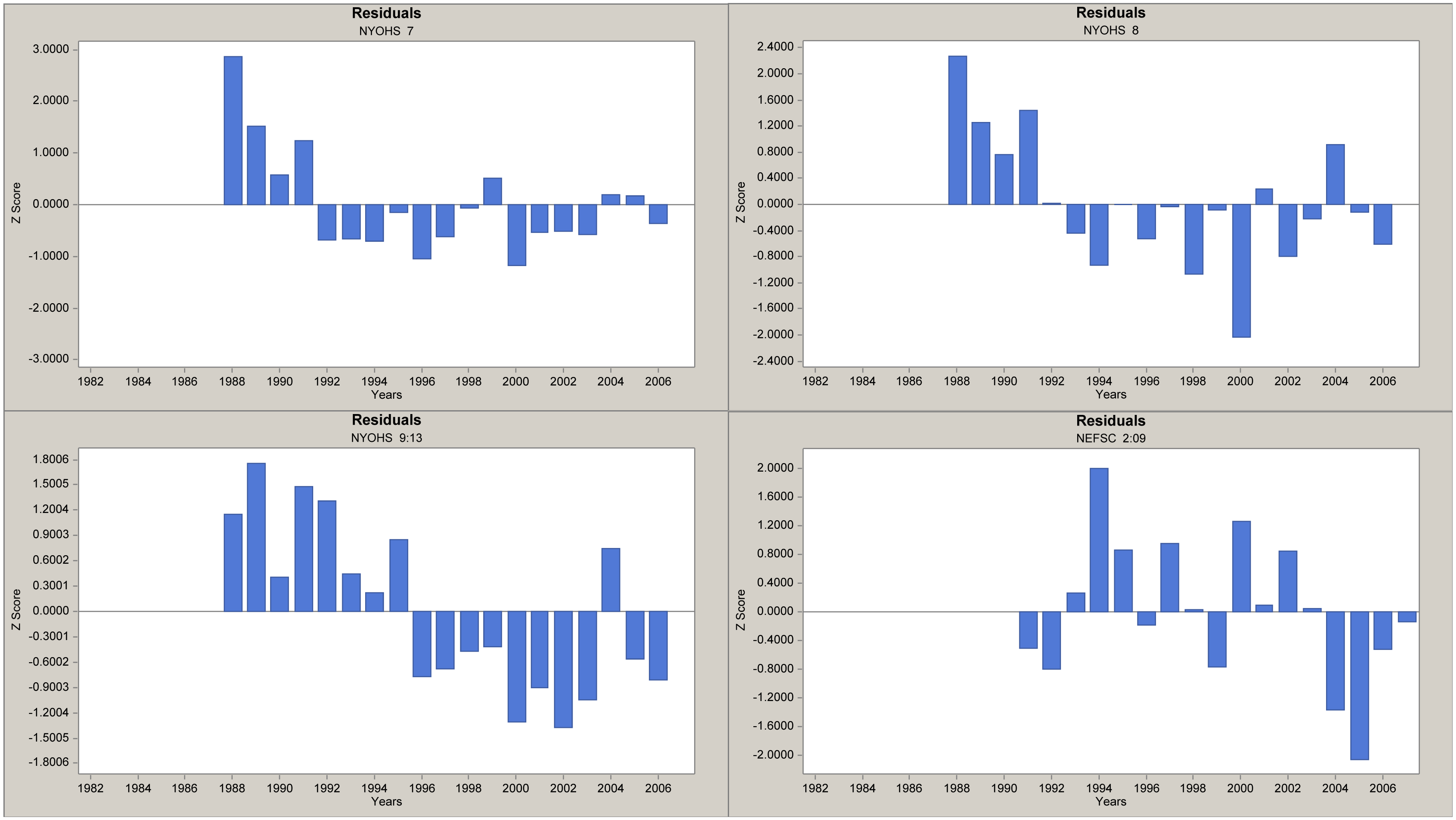

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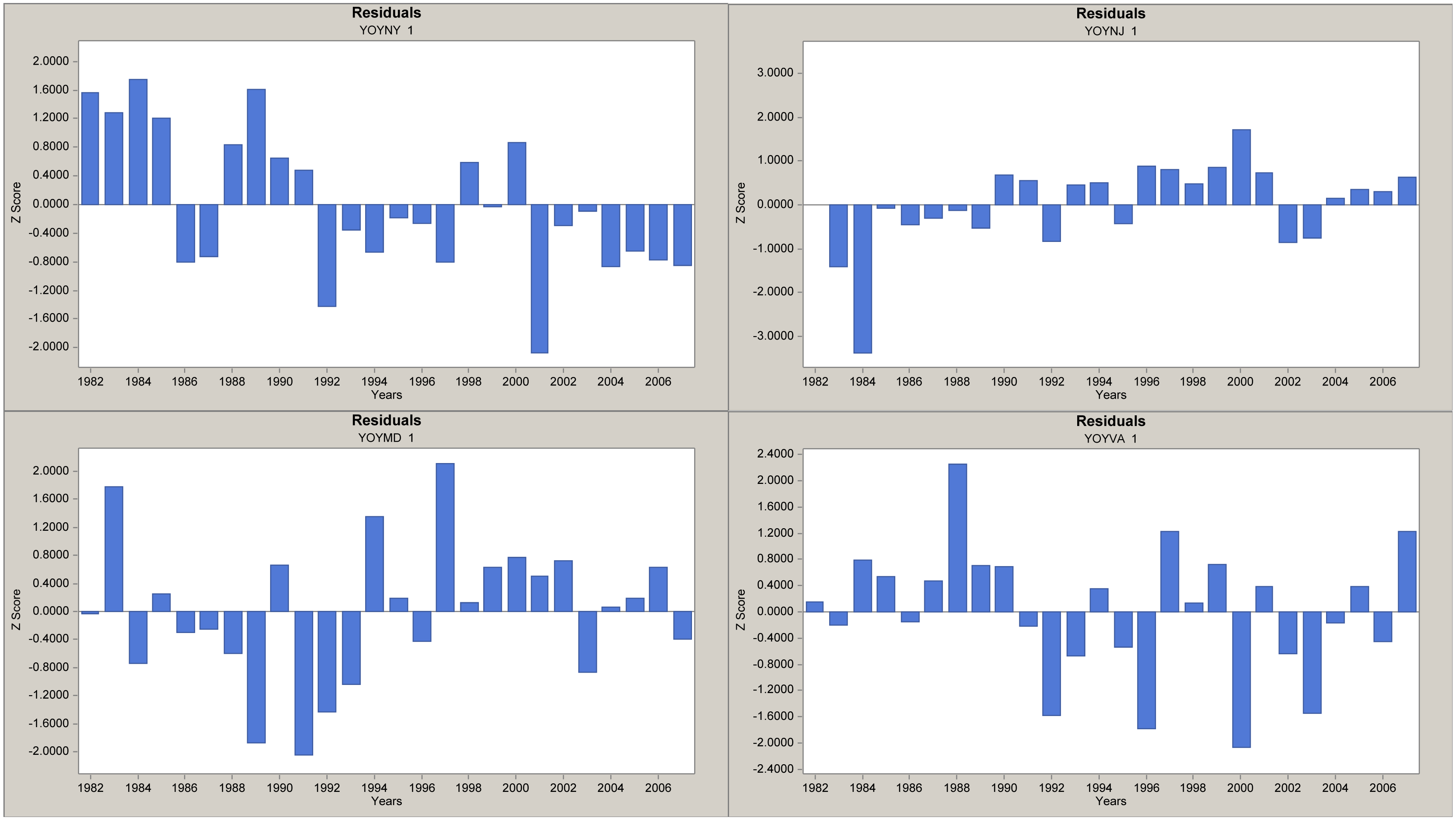

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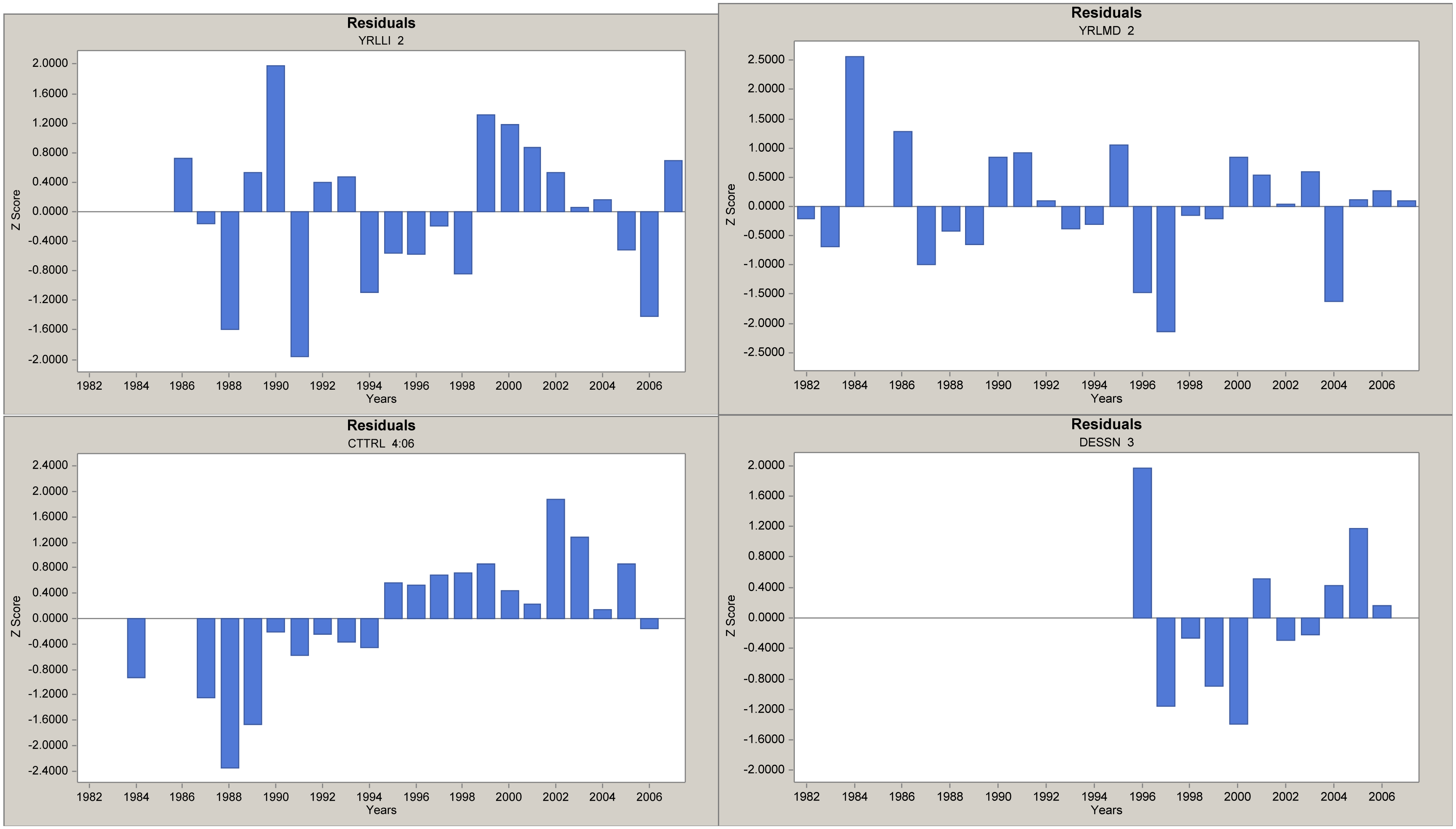

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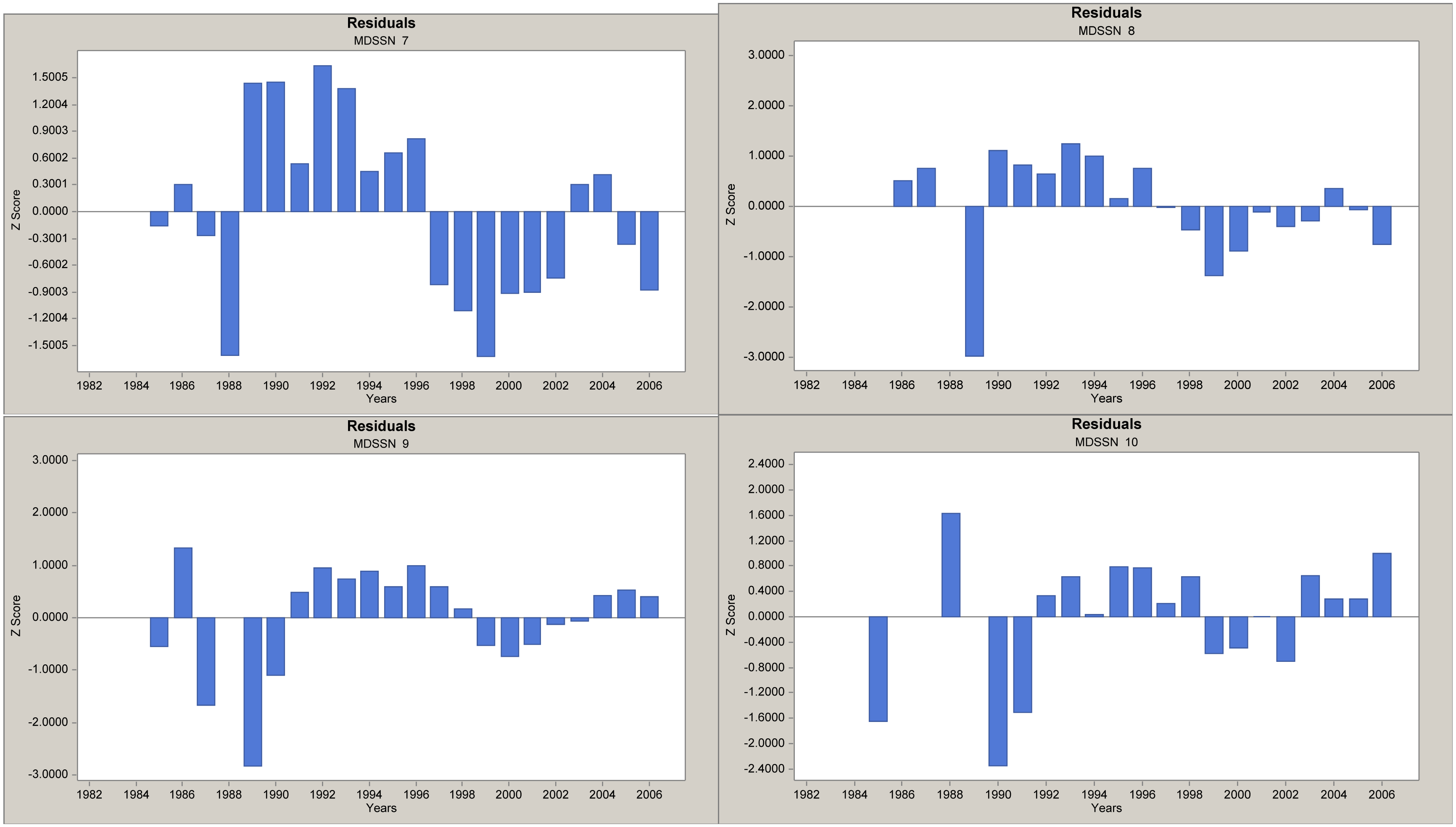

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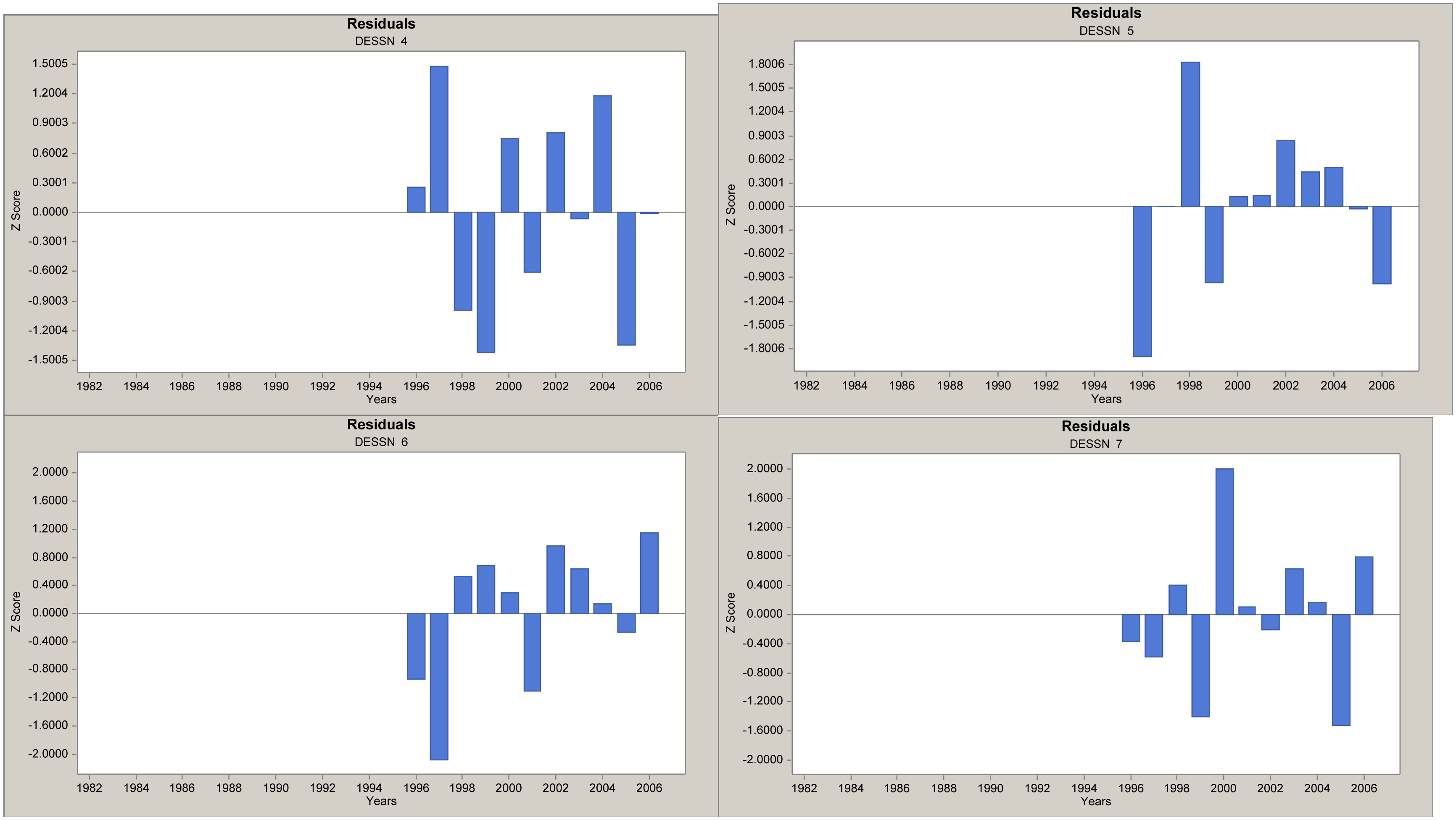

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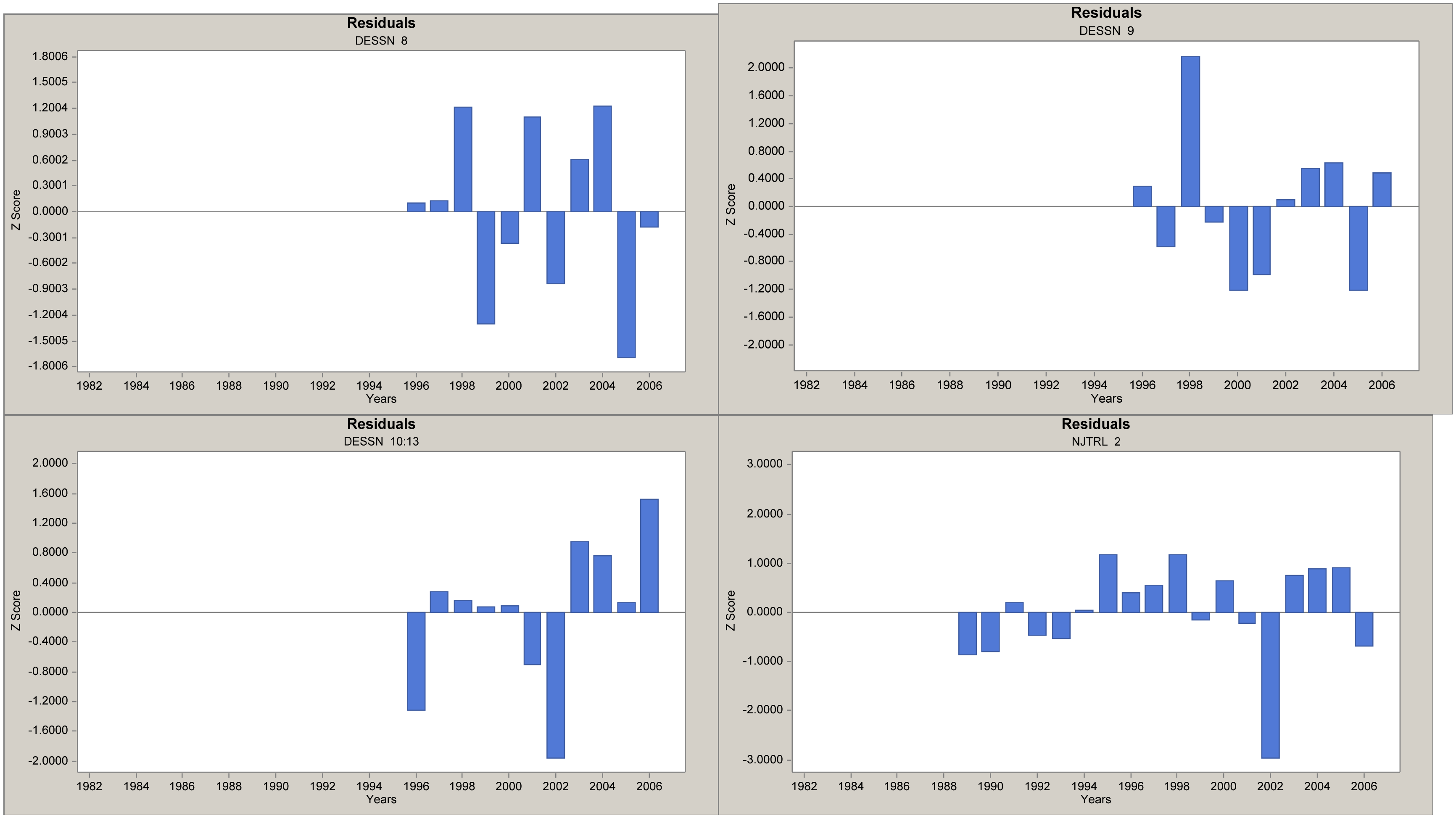

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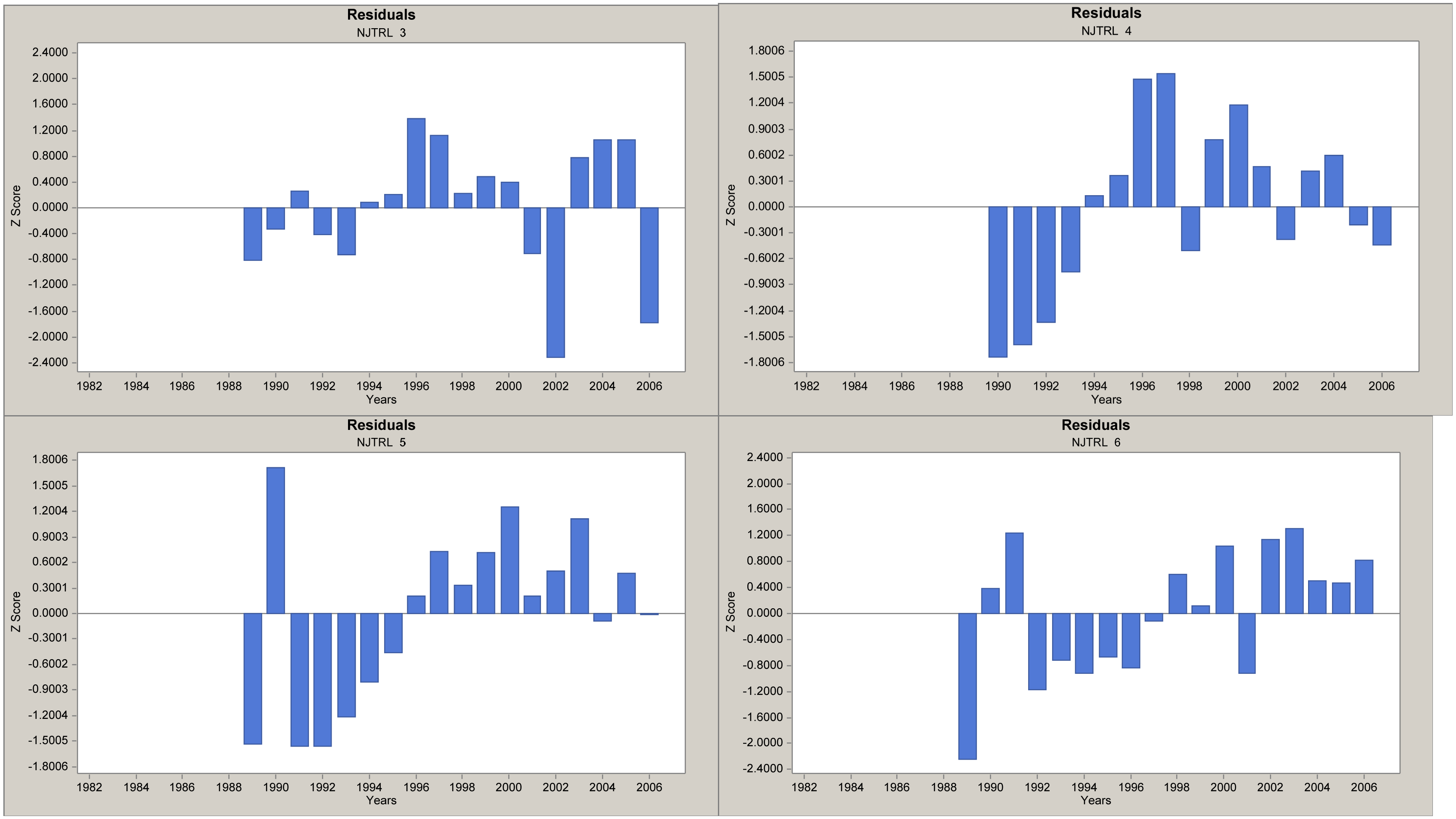

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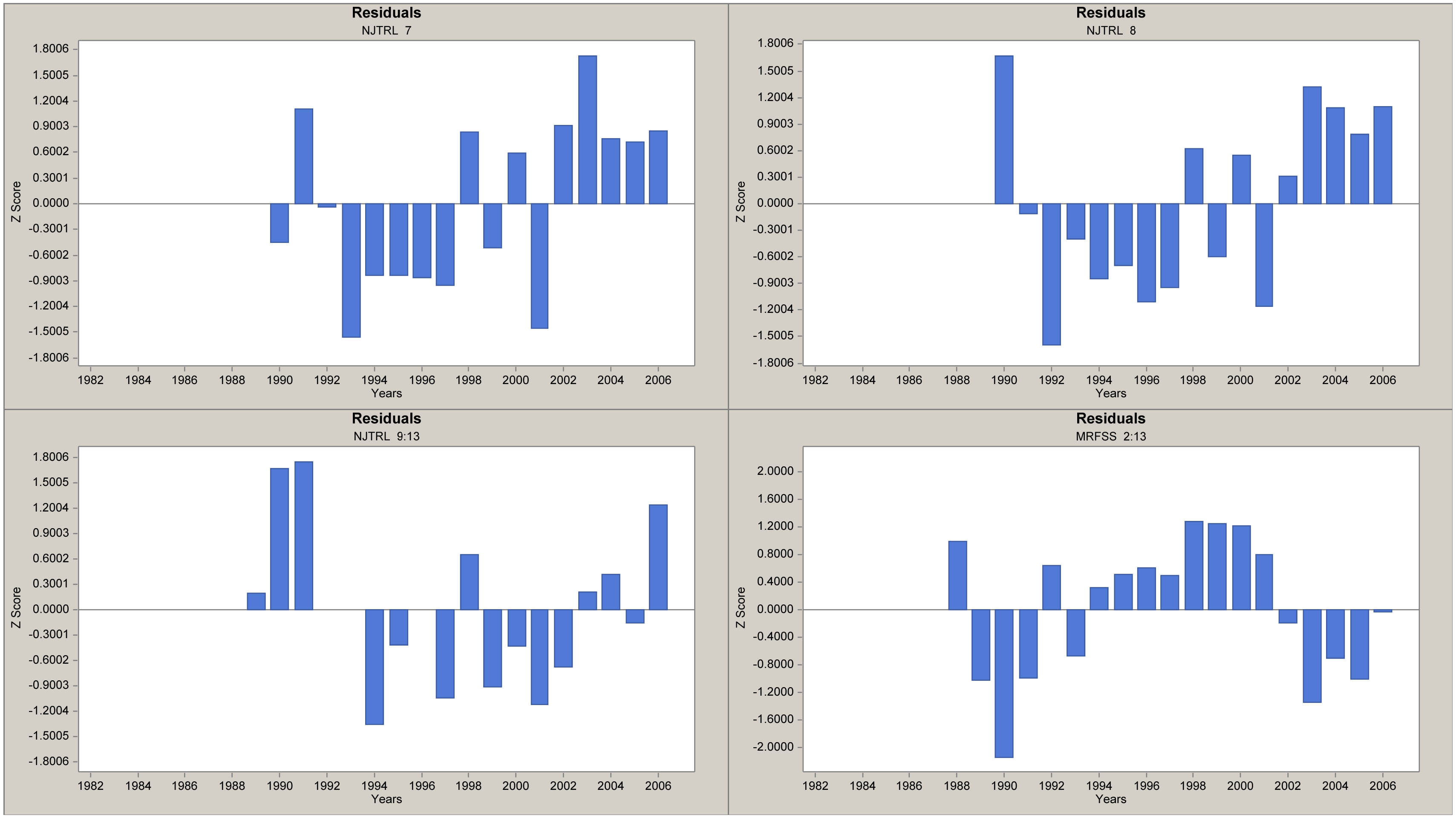

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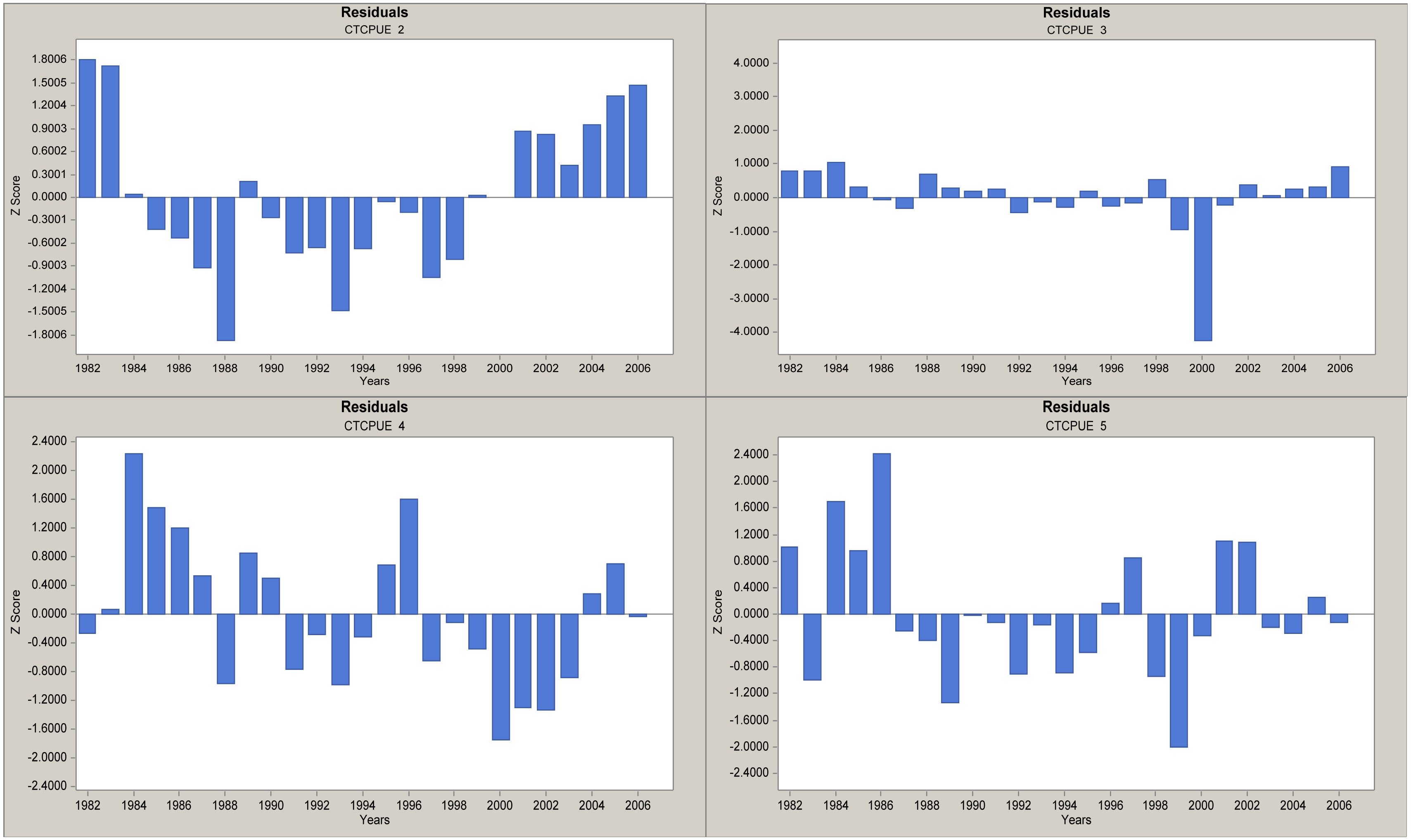

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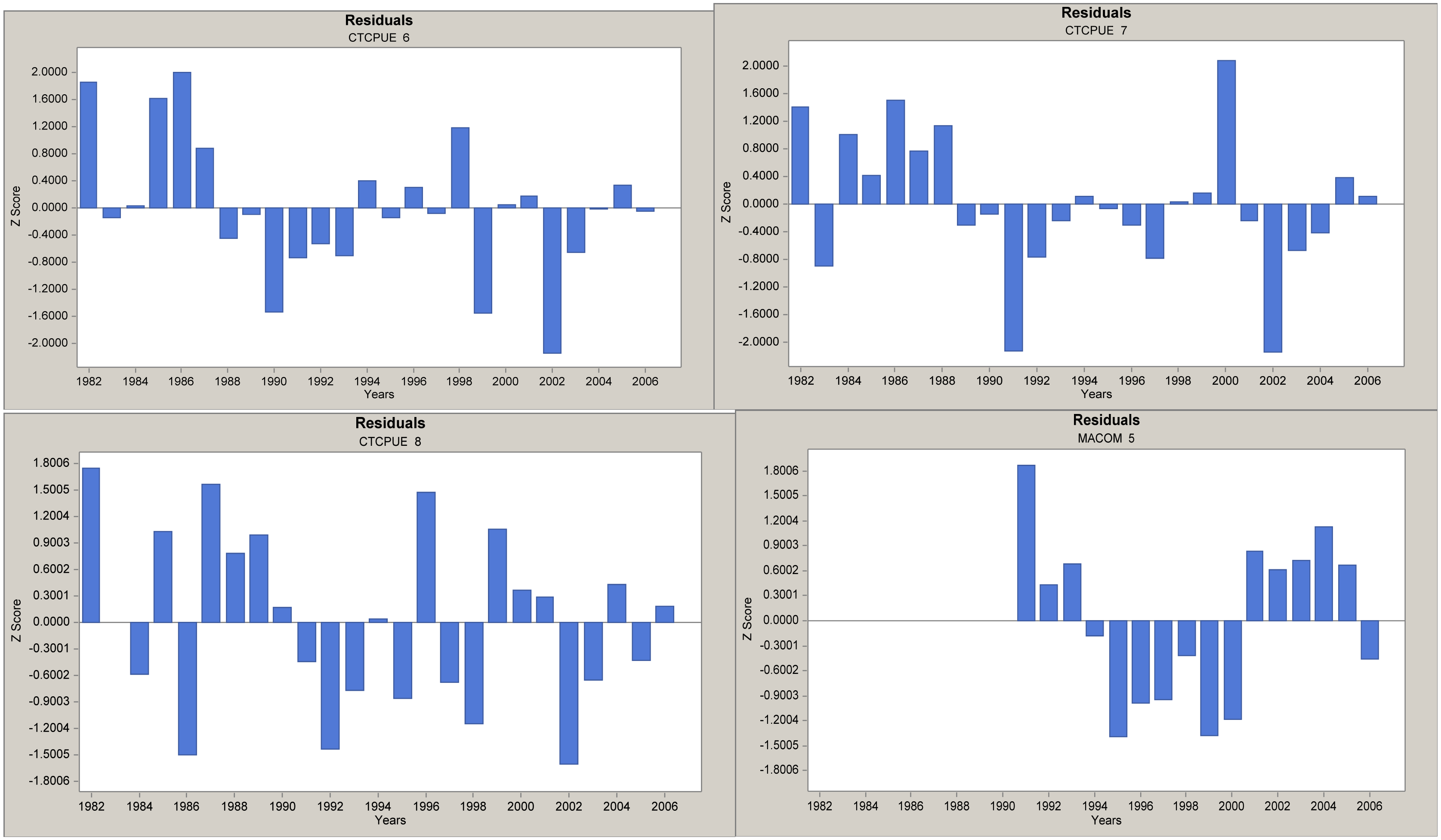

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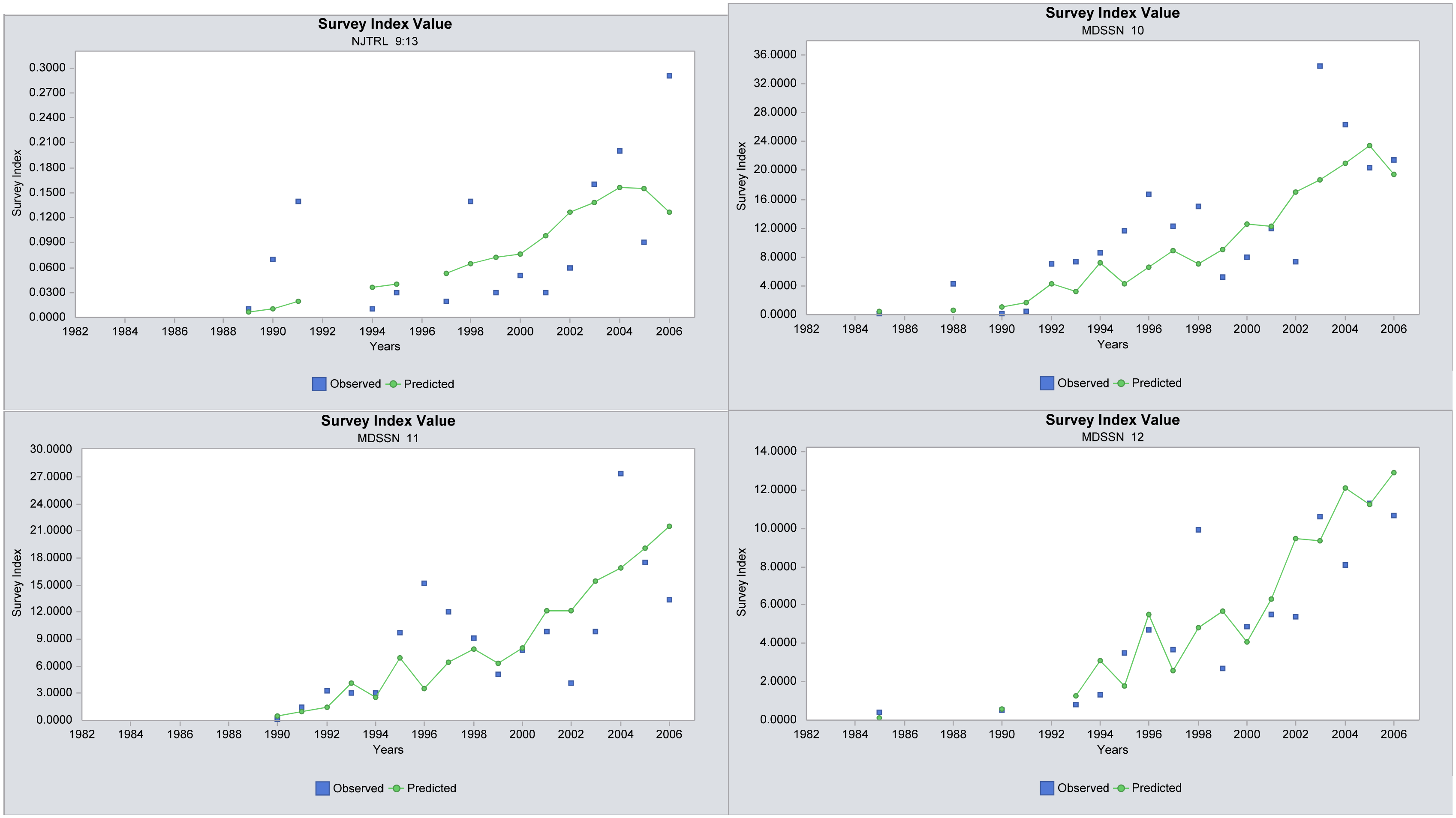
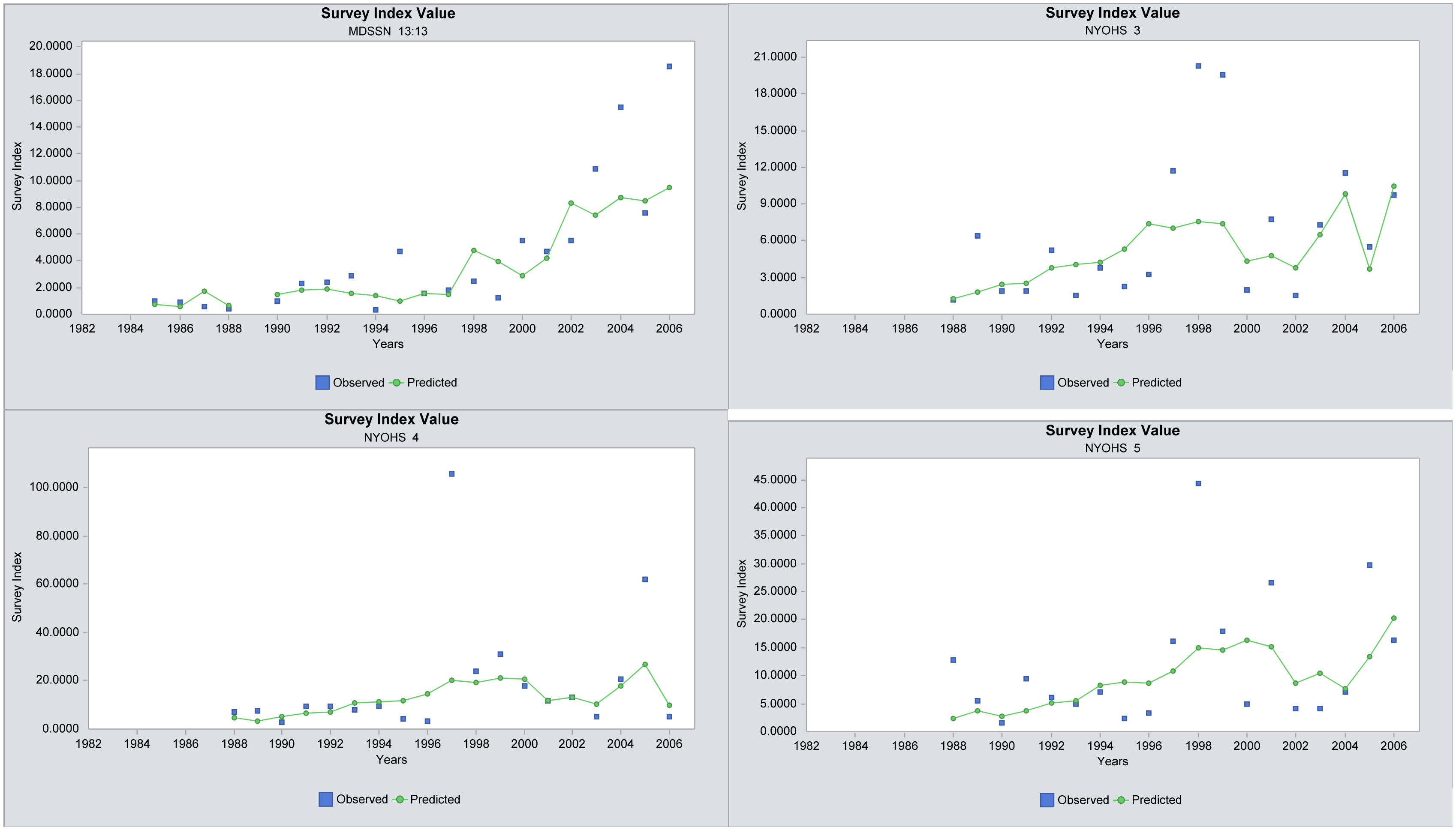


Figure 3. Observed vs. predicted indices from ADAPT model with reduced suite of indices



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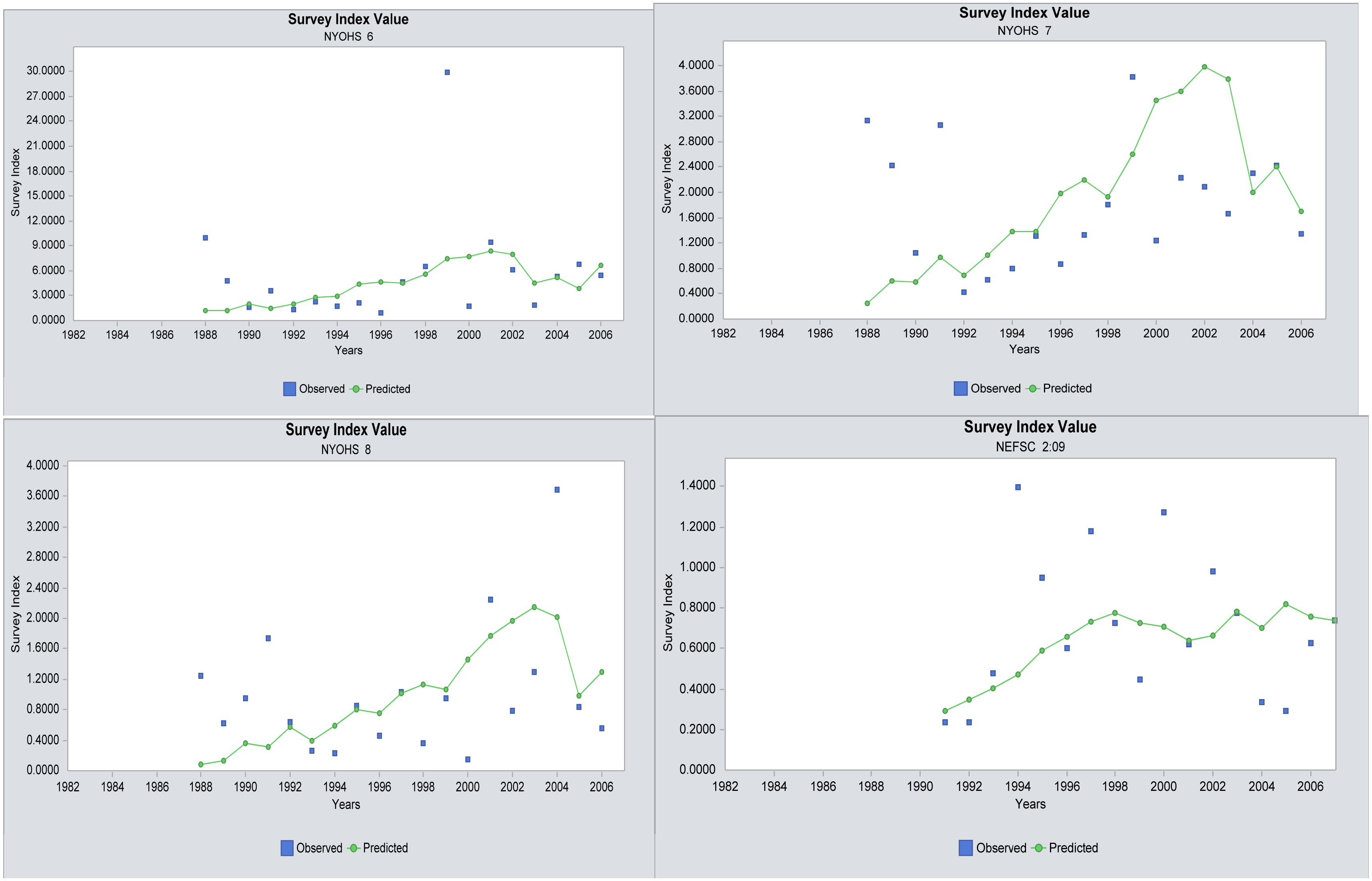

Figure 3 continued.

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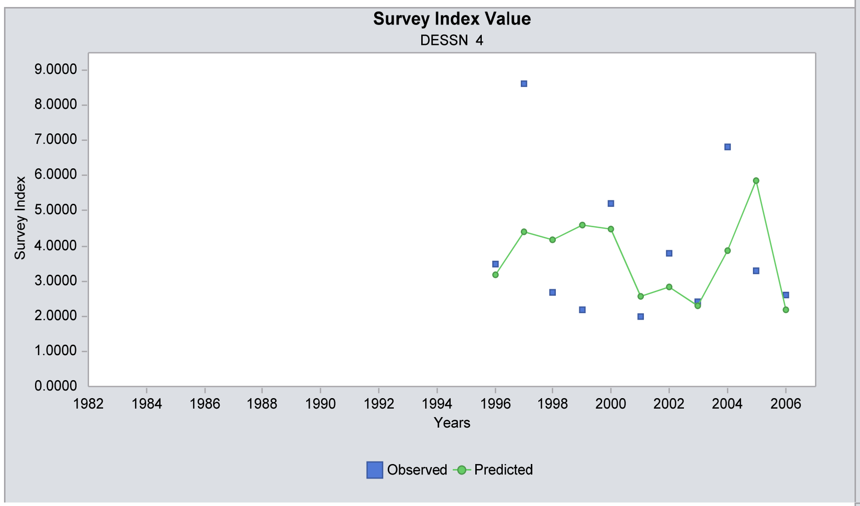

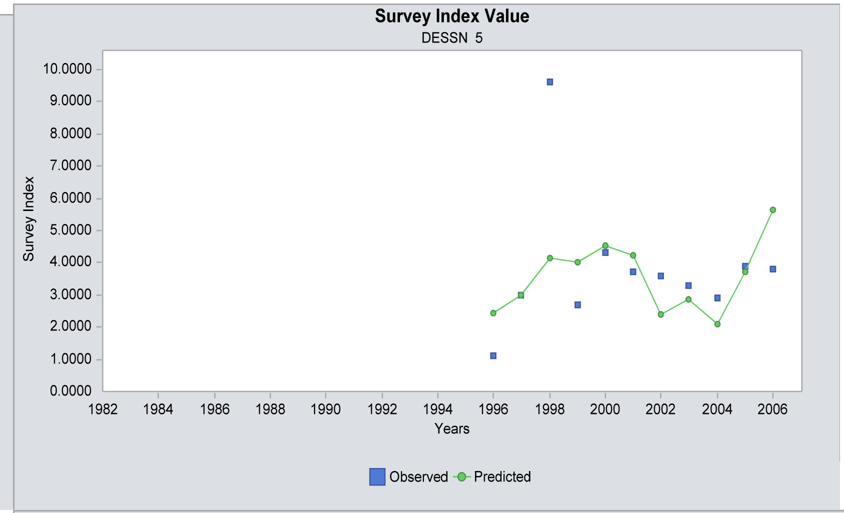

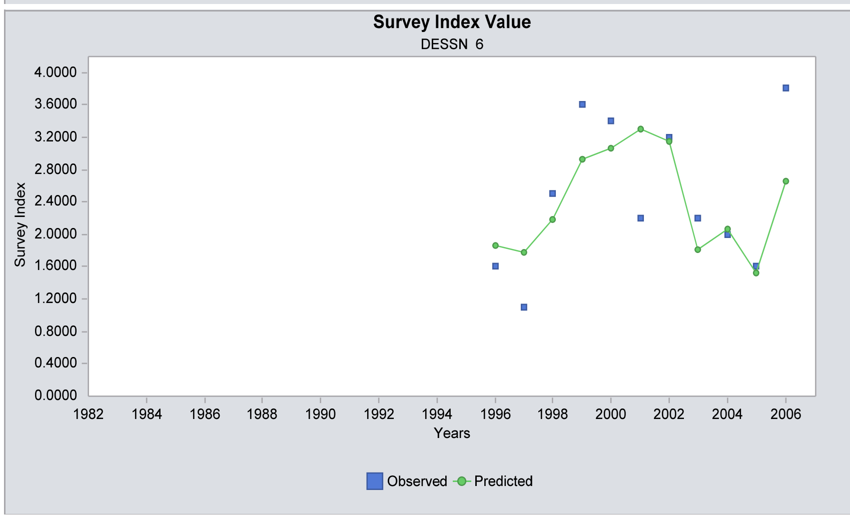

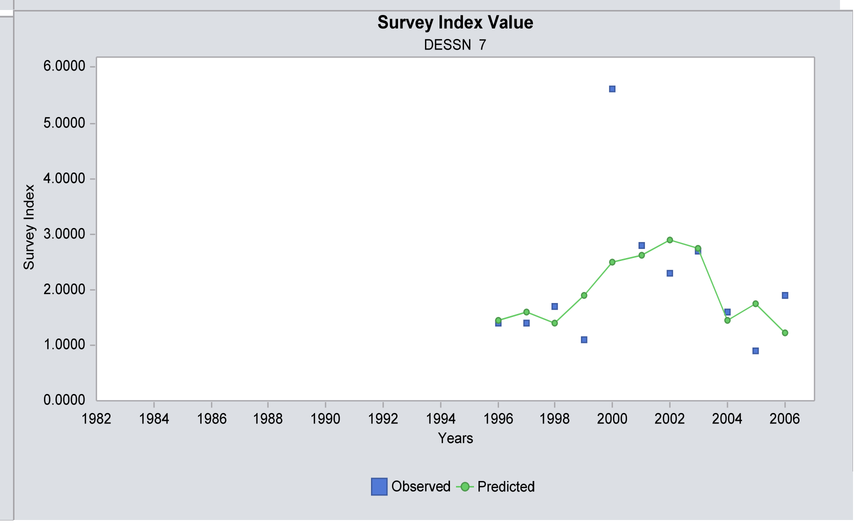

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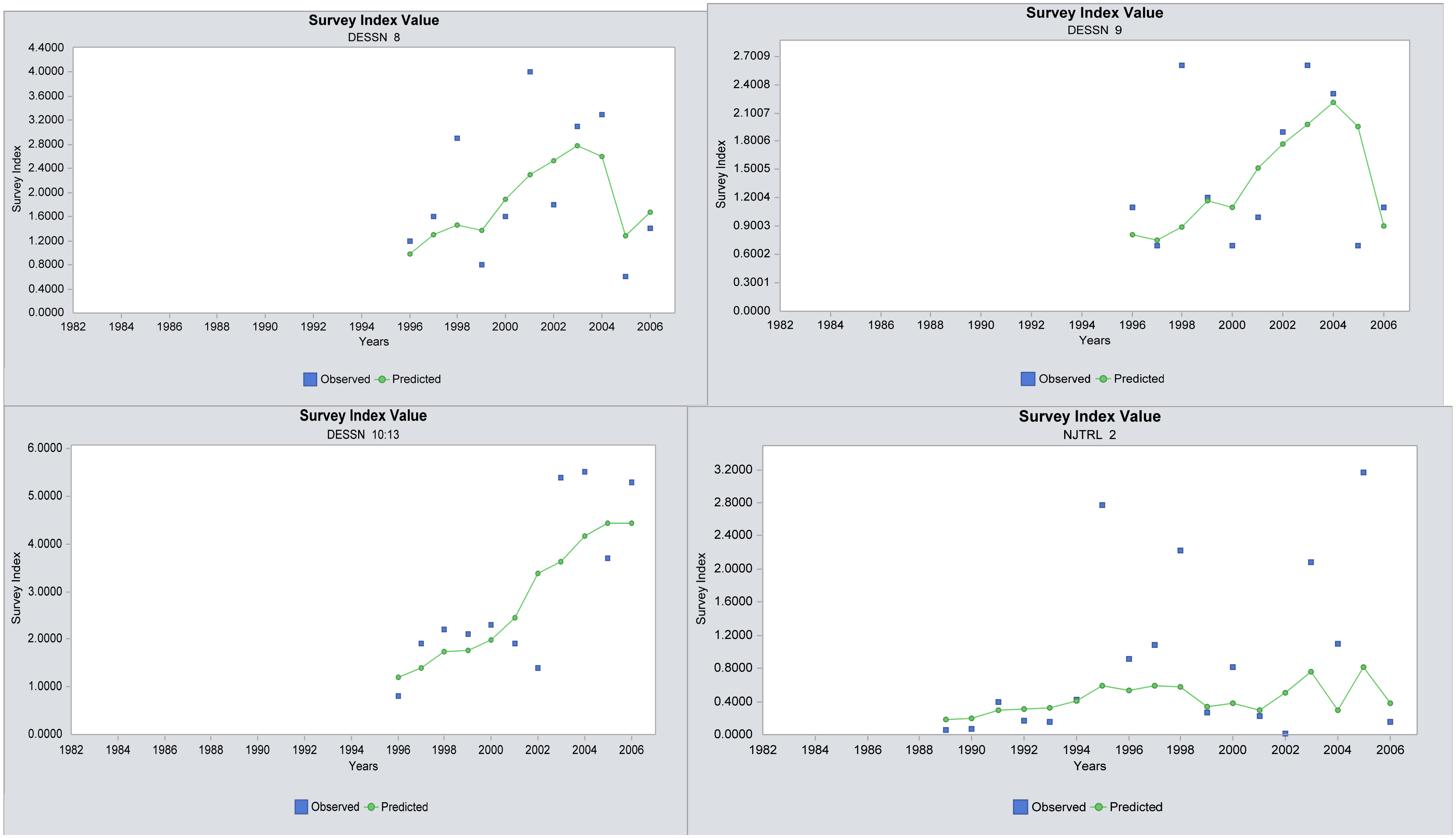

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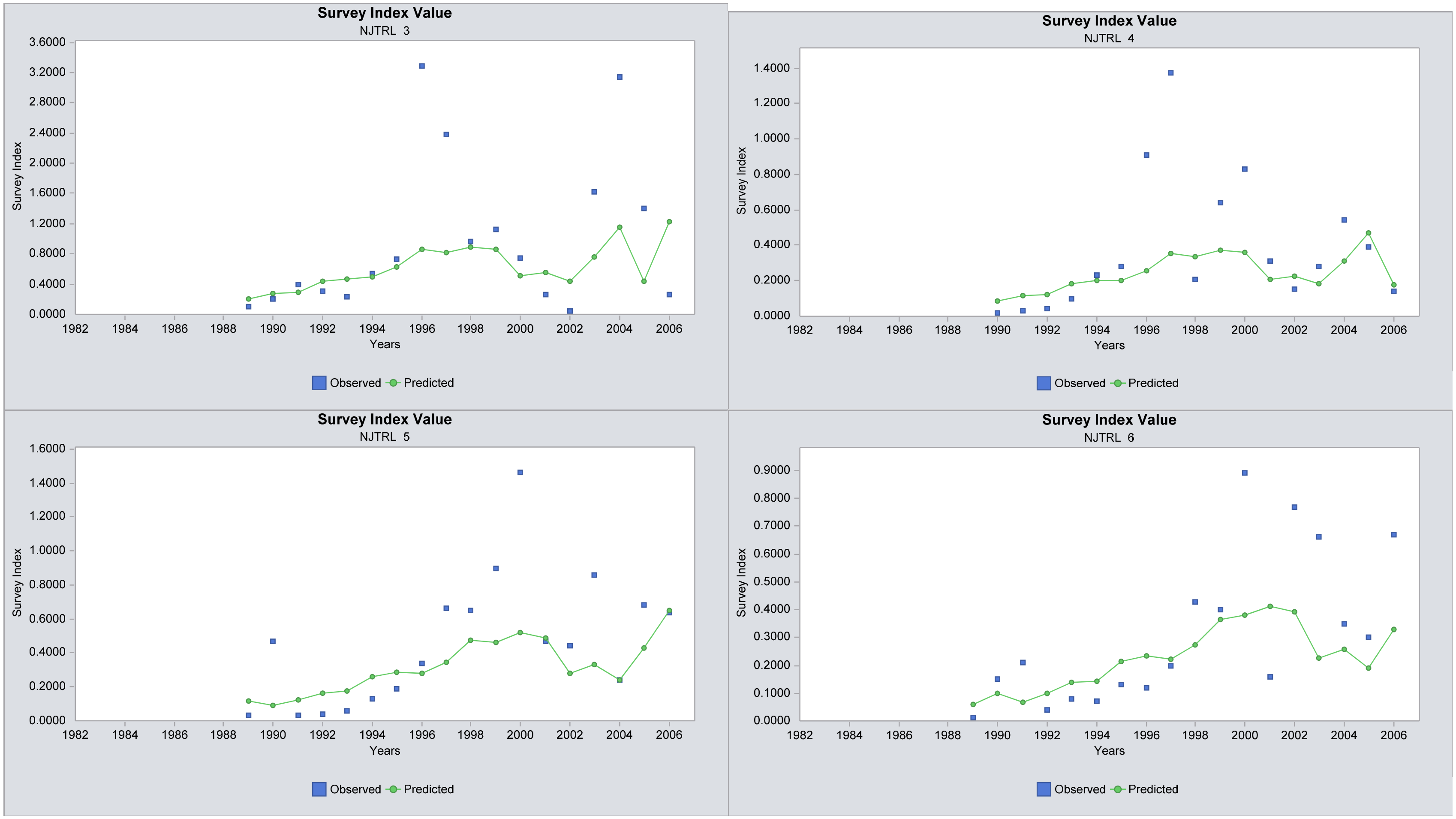

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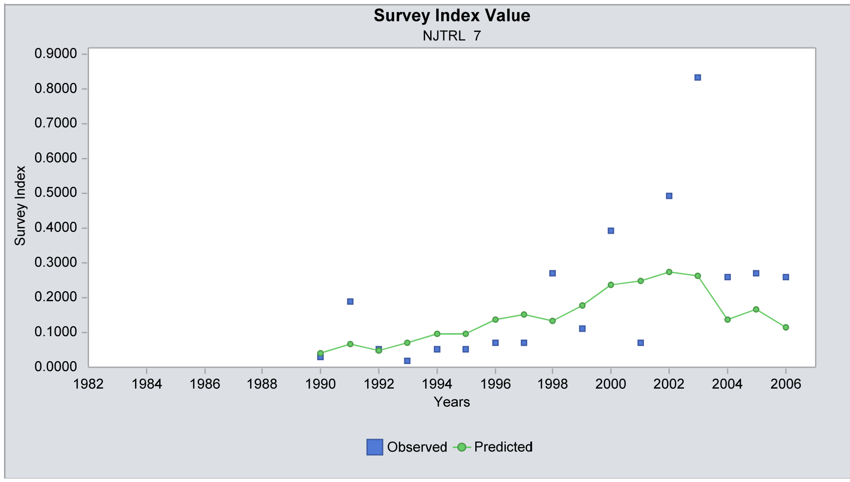

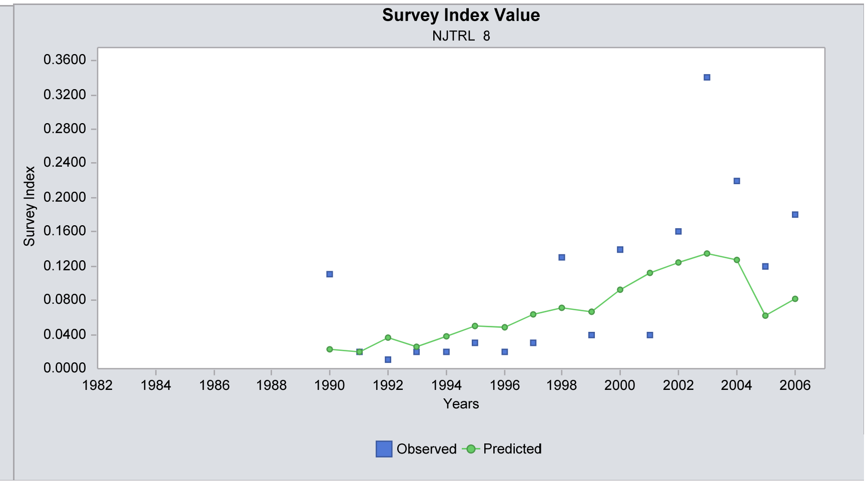

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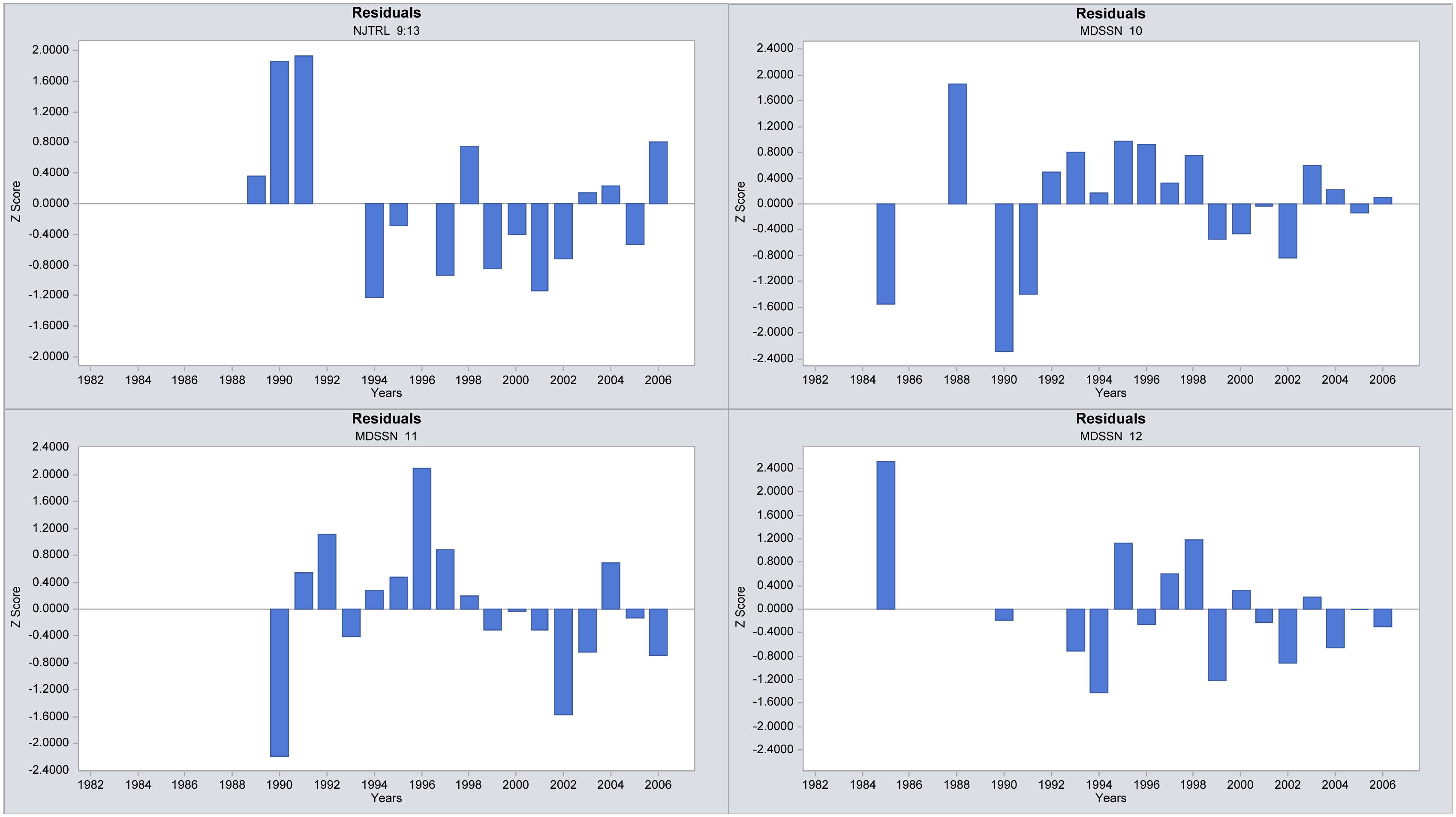
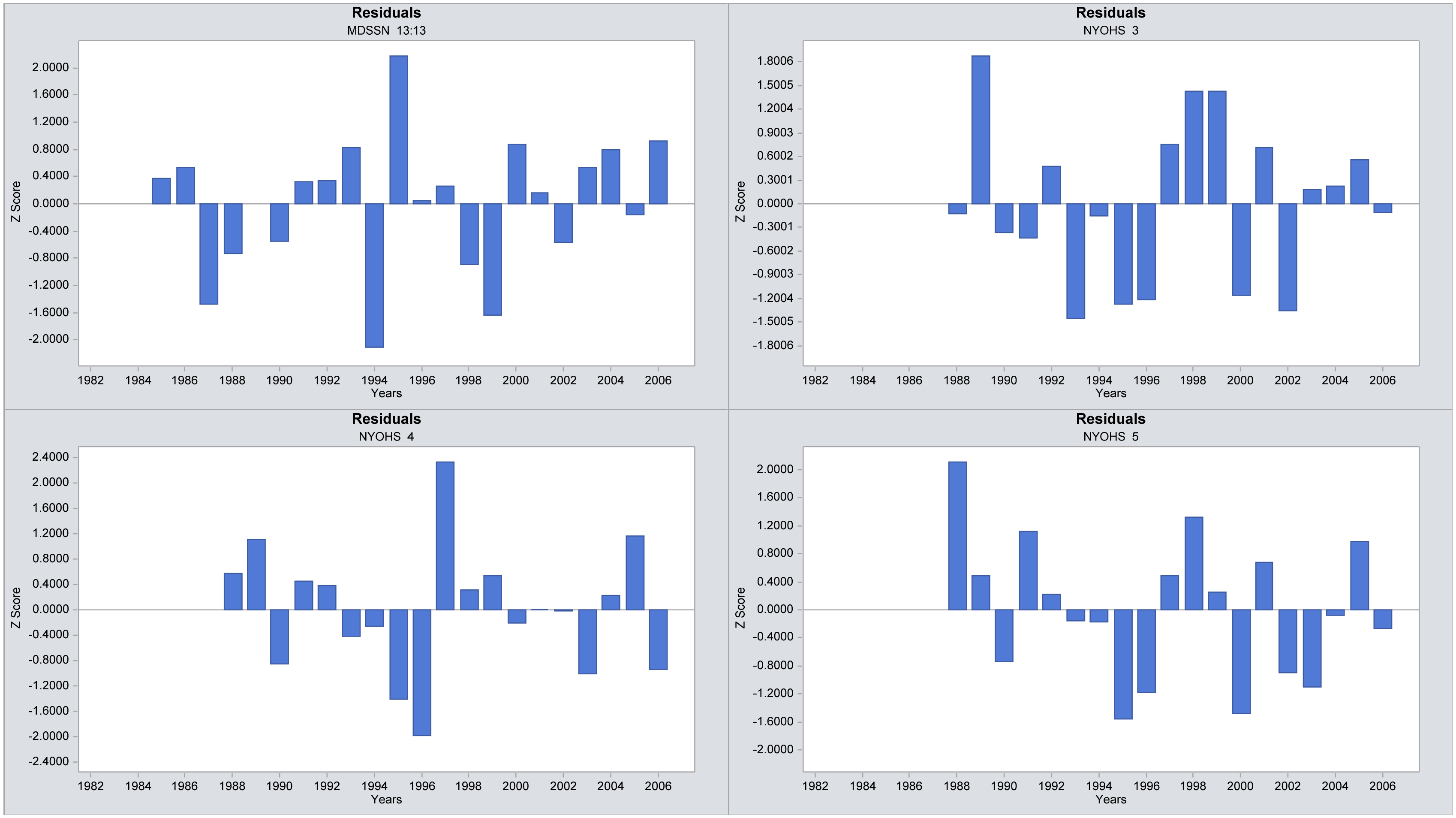


Figure 4. Residual plots from ADAPT model using reduced suite of indices.



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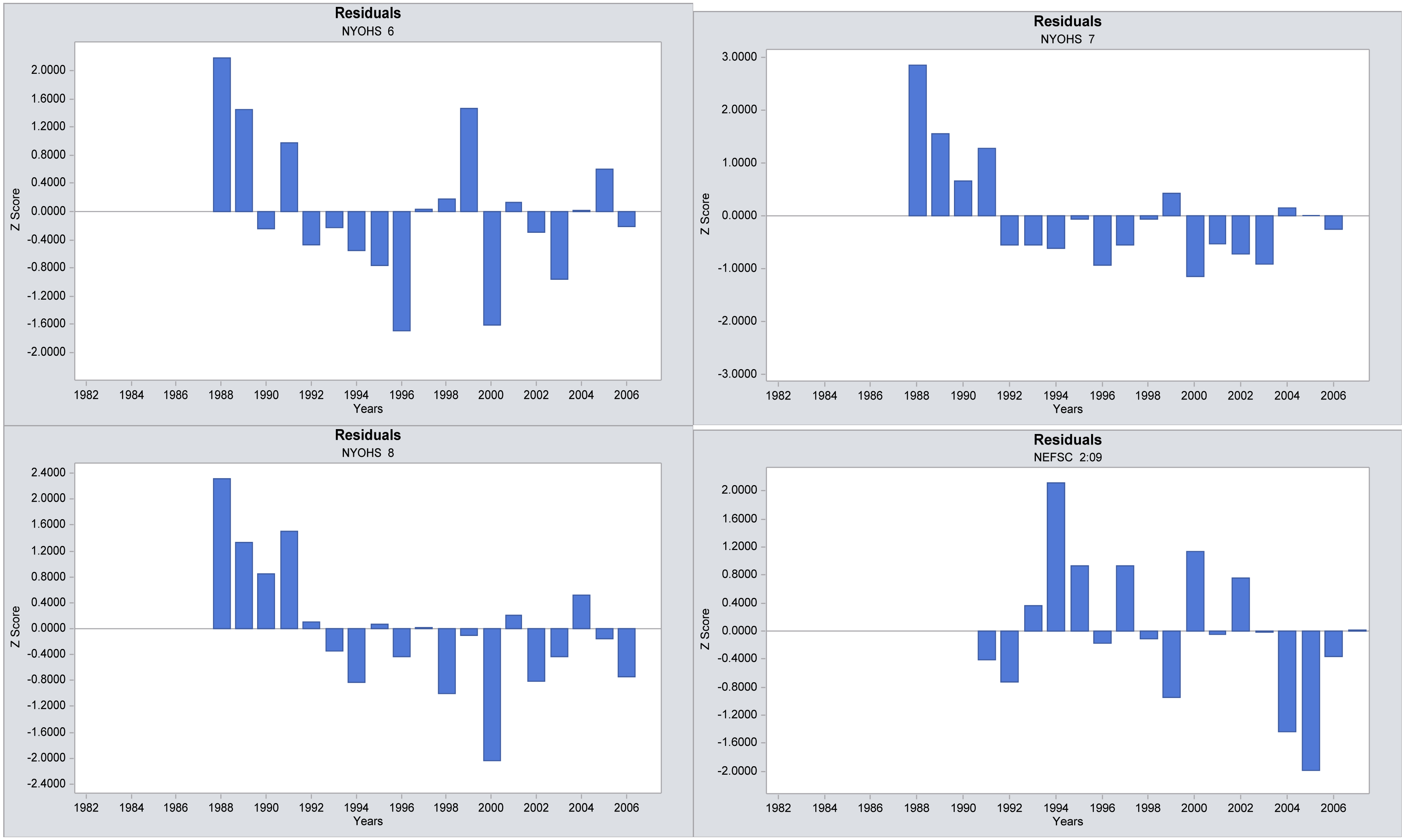

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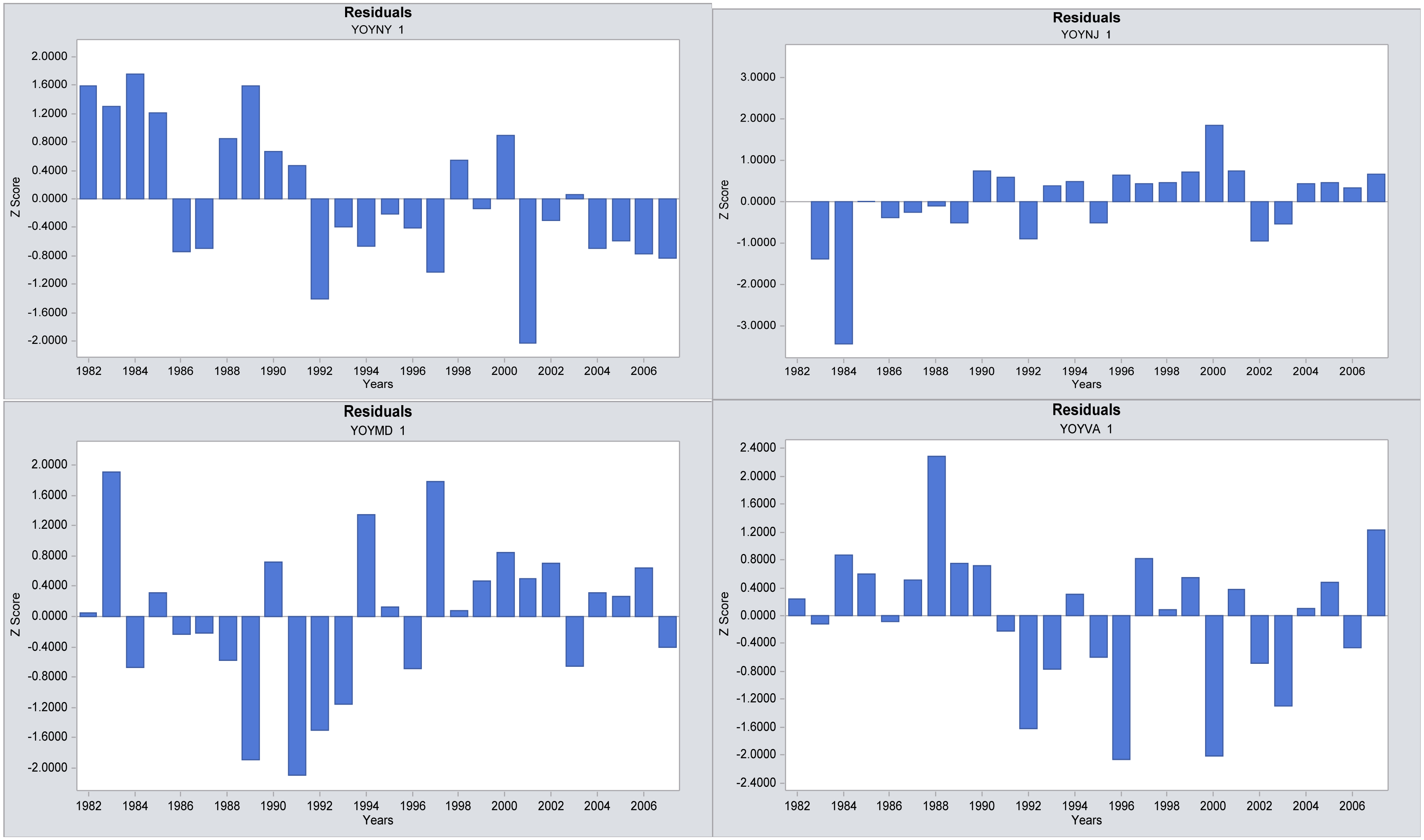

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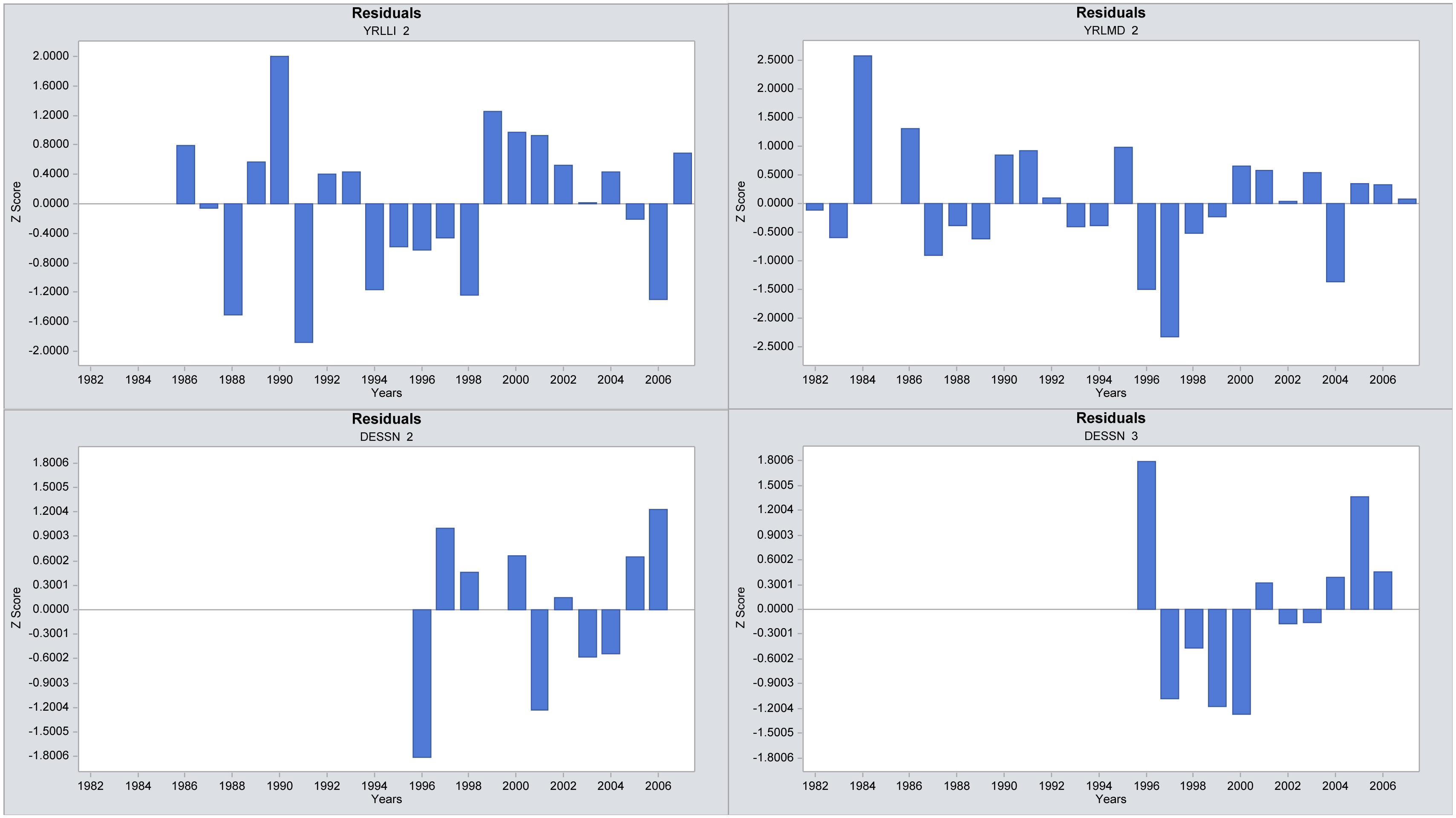

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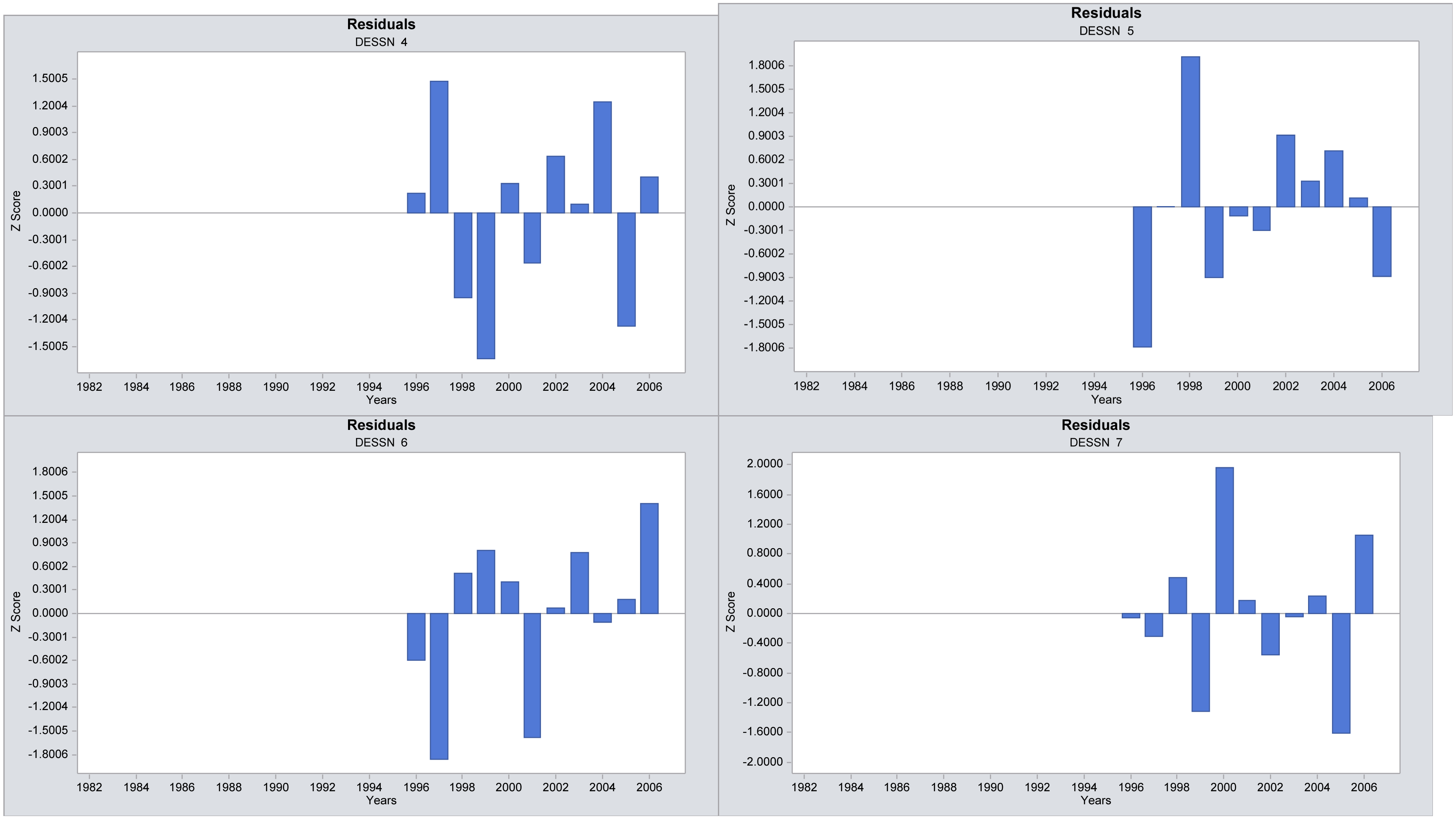

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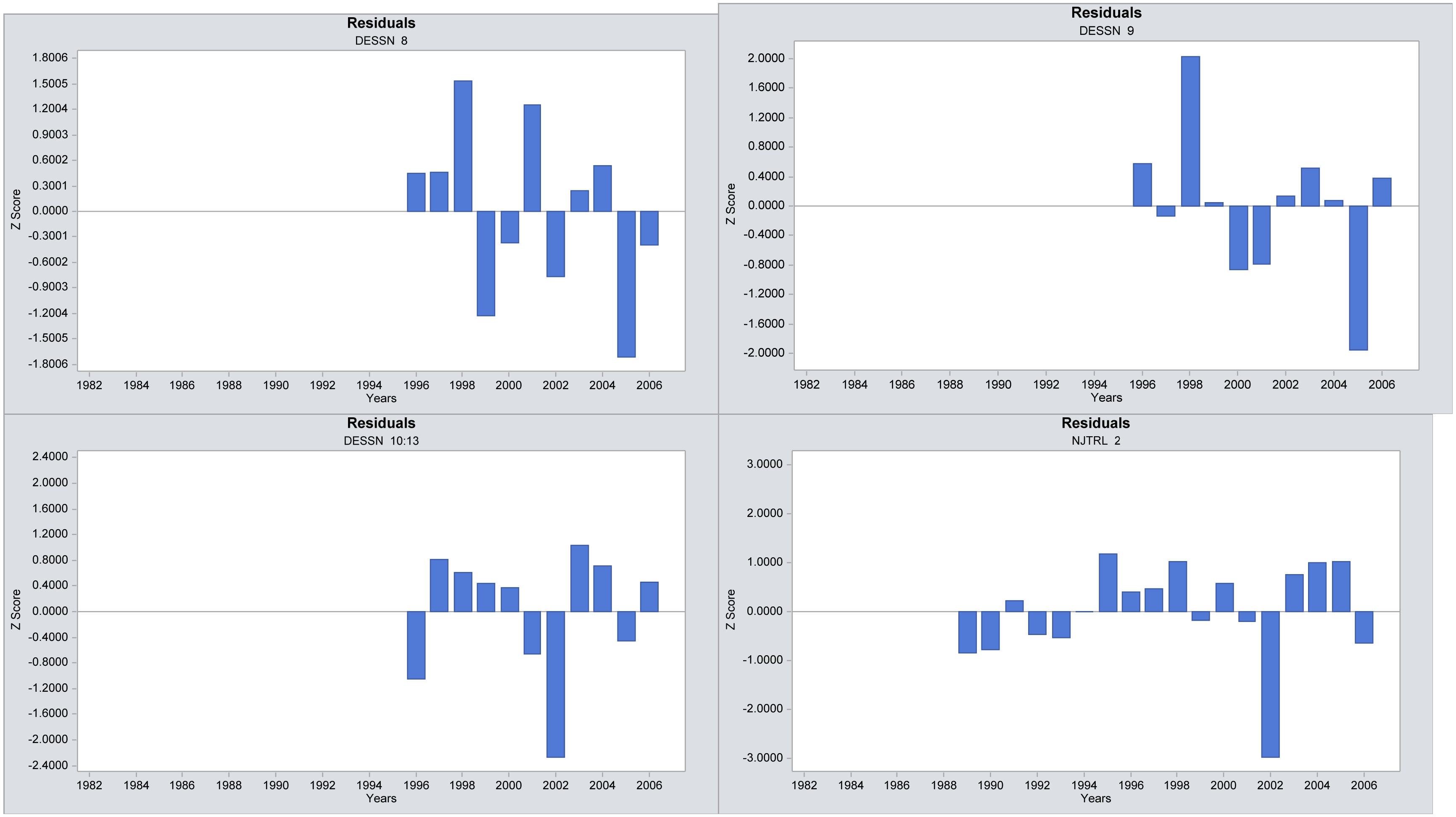

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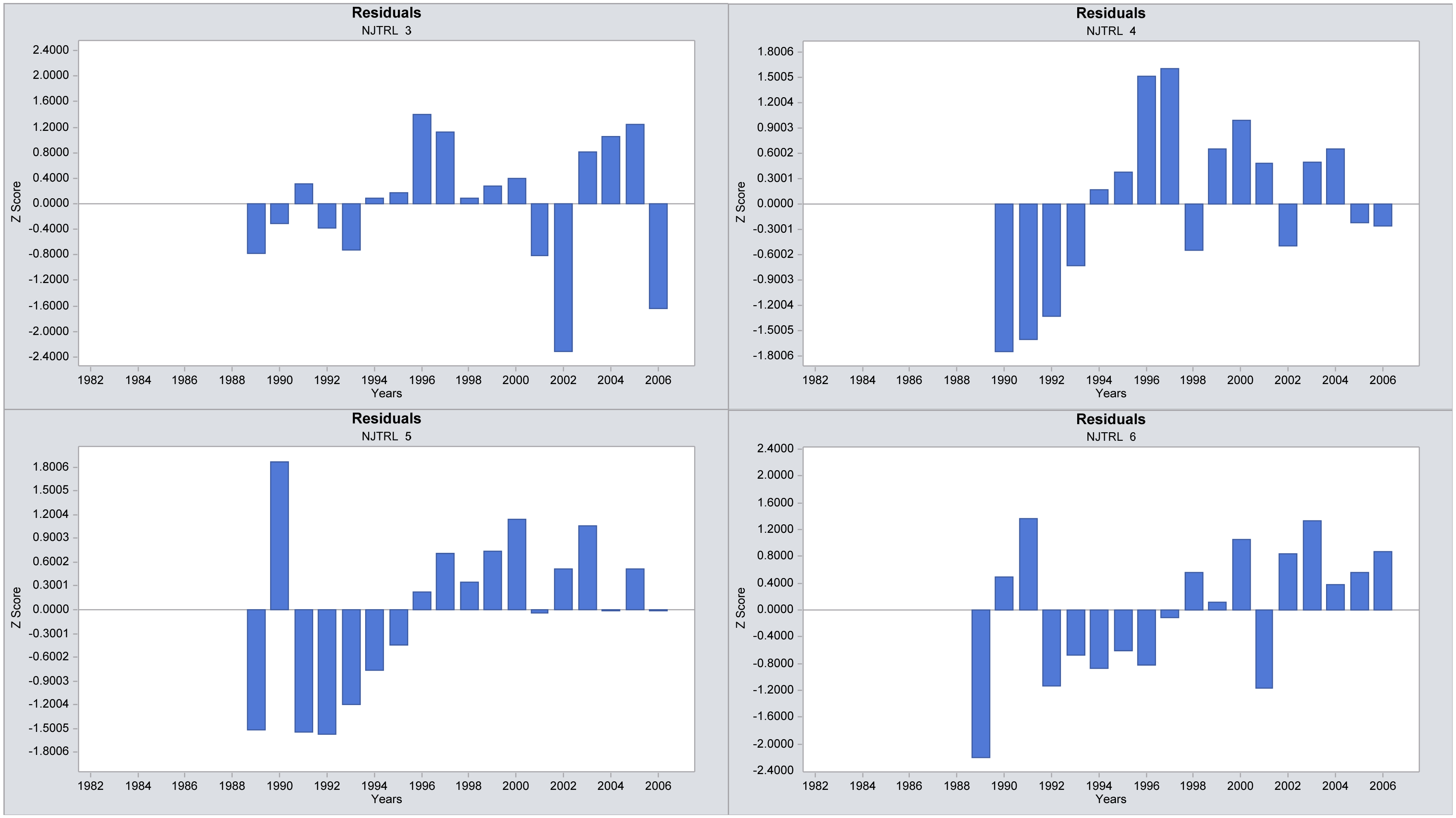

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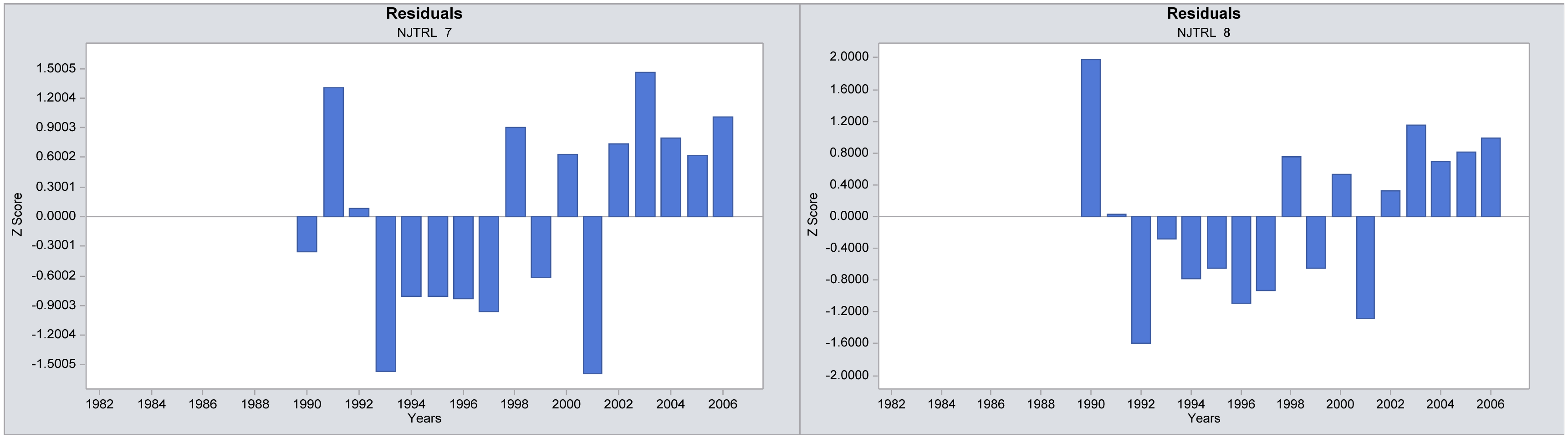

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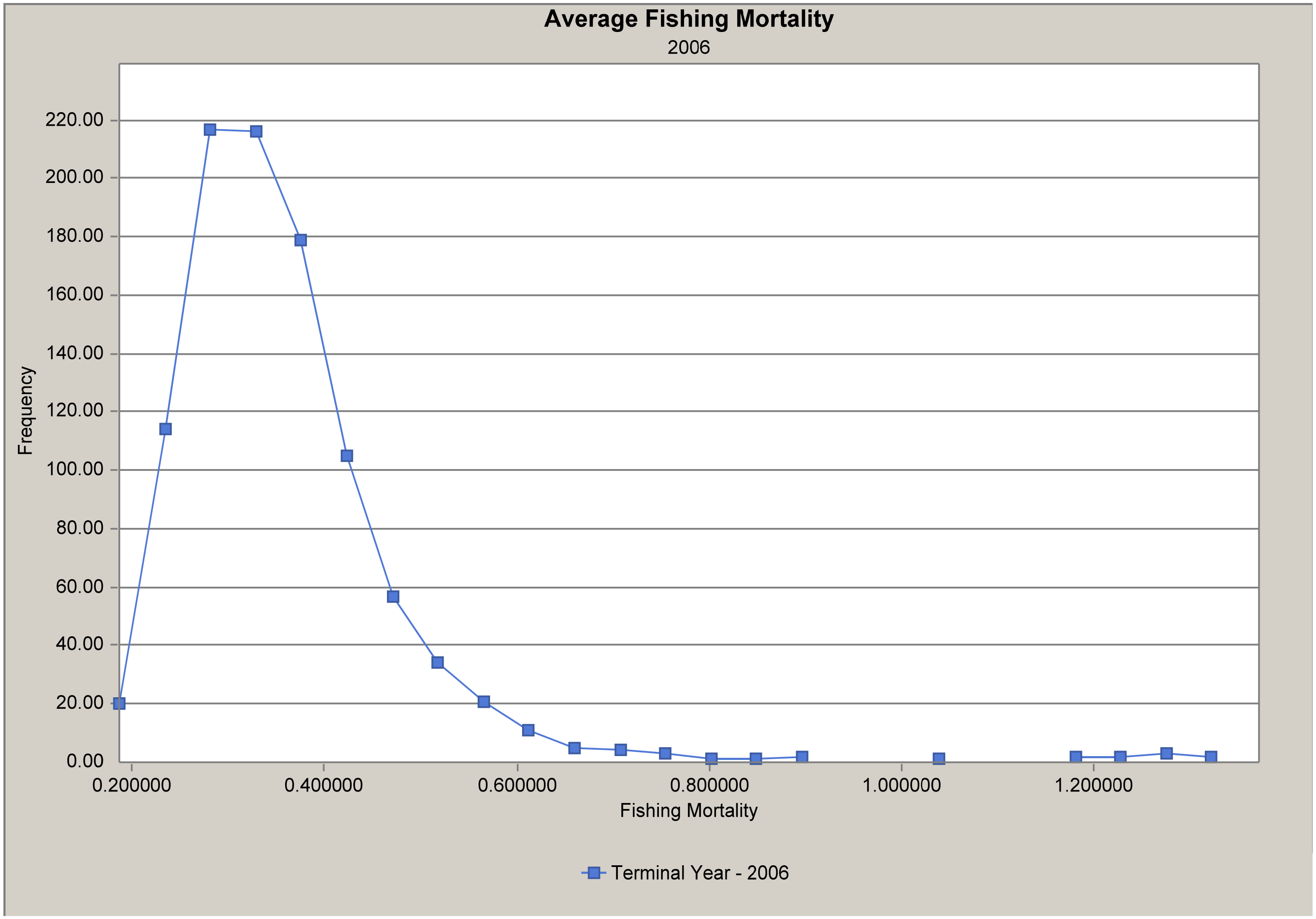


Figure 5. Bootstrap plot of fishing mortality from ADAPT model using reduced suite of indices

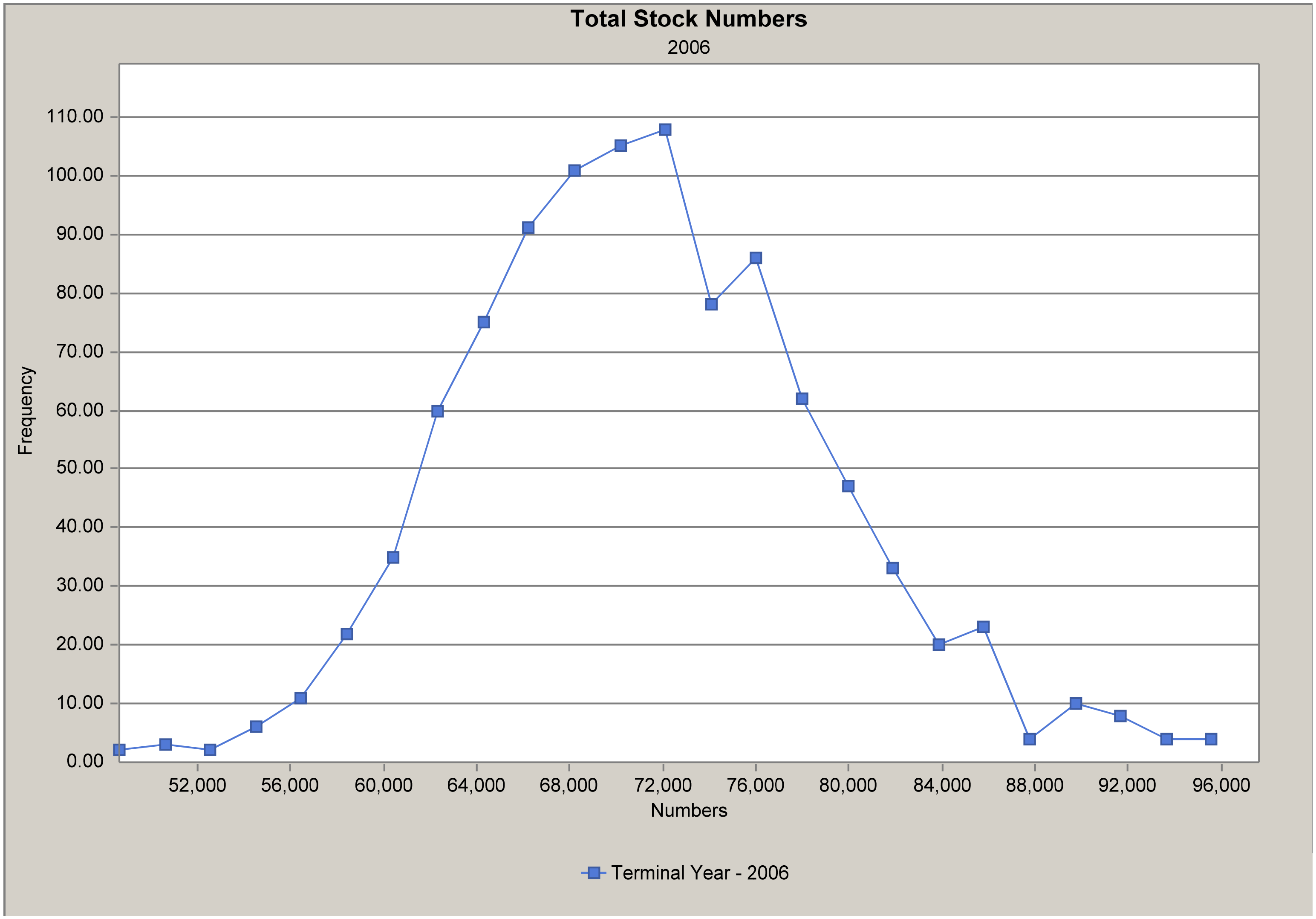


Figure 6. Bootstrap plot of stock numbers from ADAPT model using reduced suite of indices.

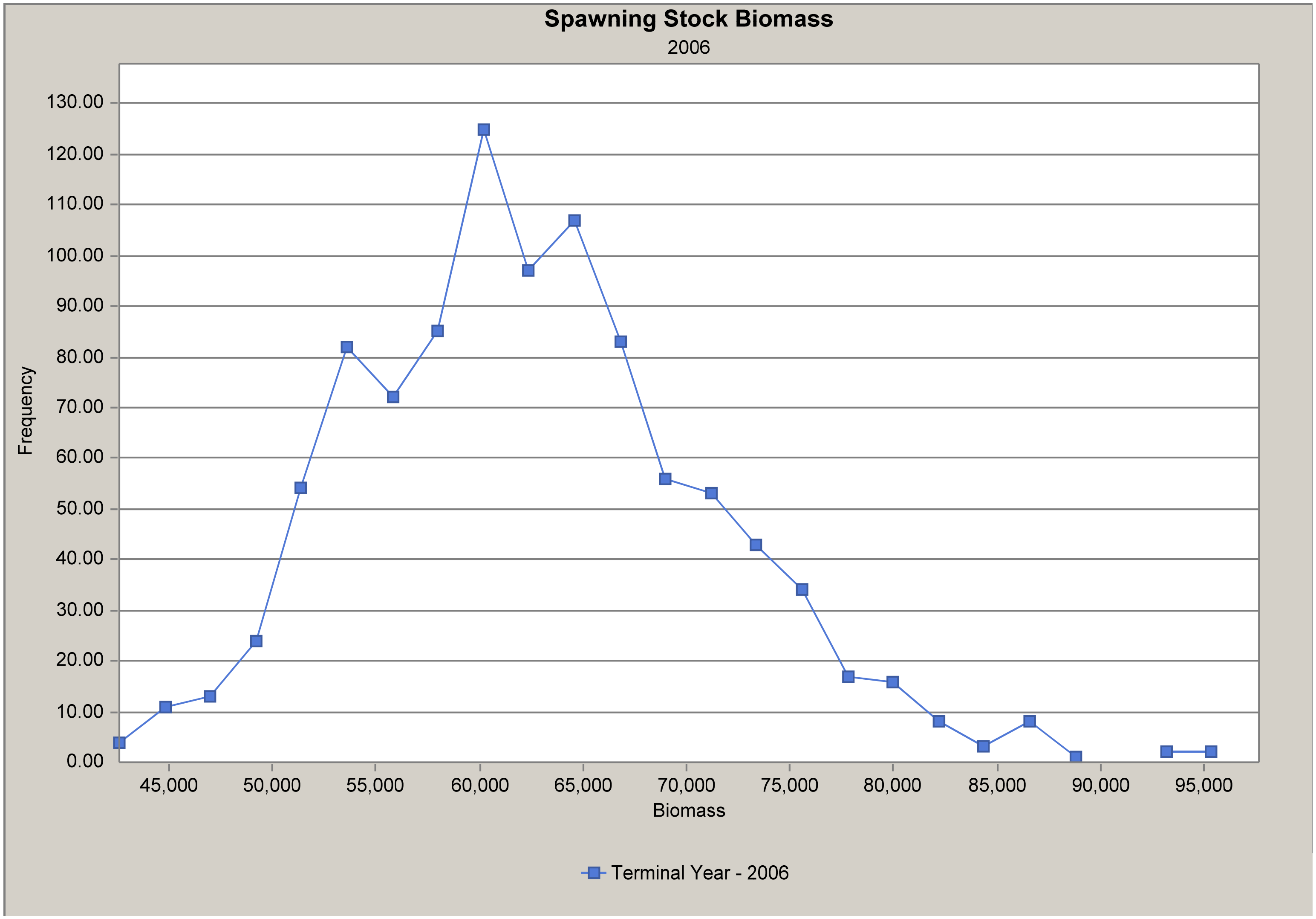
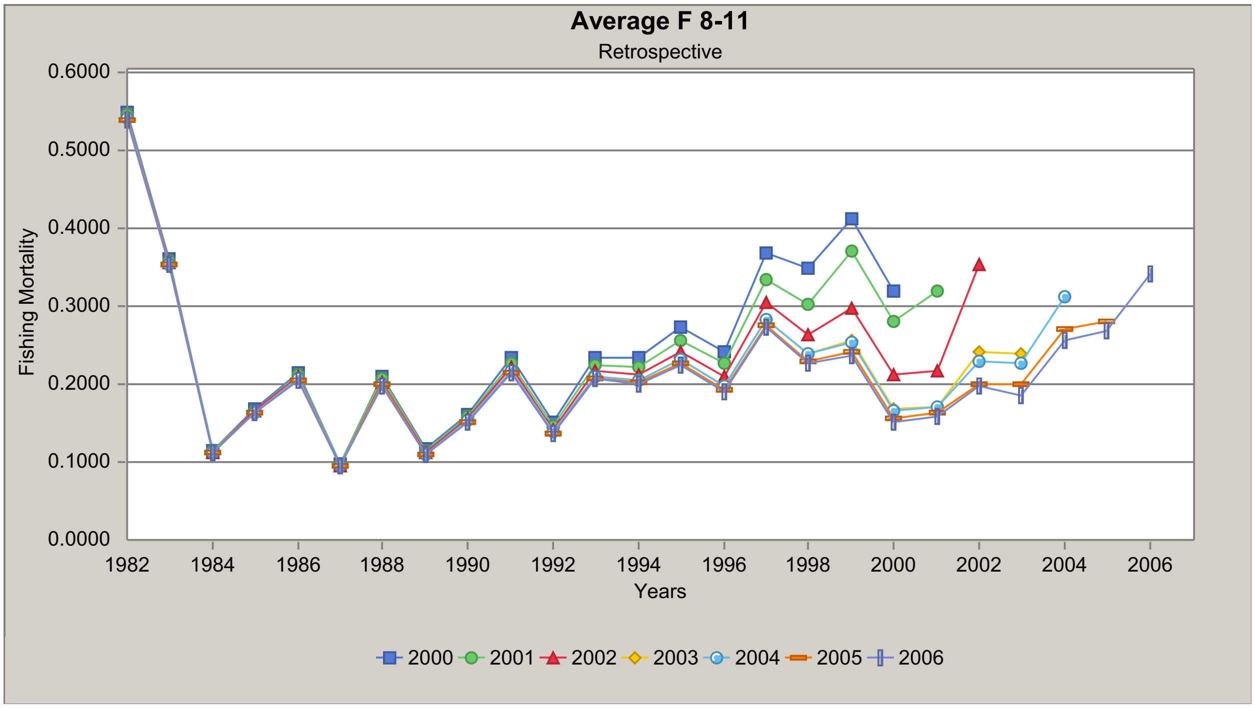


Figure 7. Bootstrap plot of spawning stock biomass from ADAPT model using reduced suite of indices.



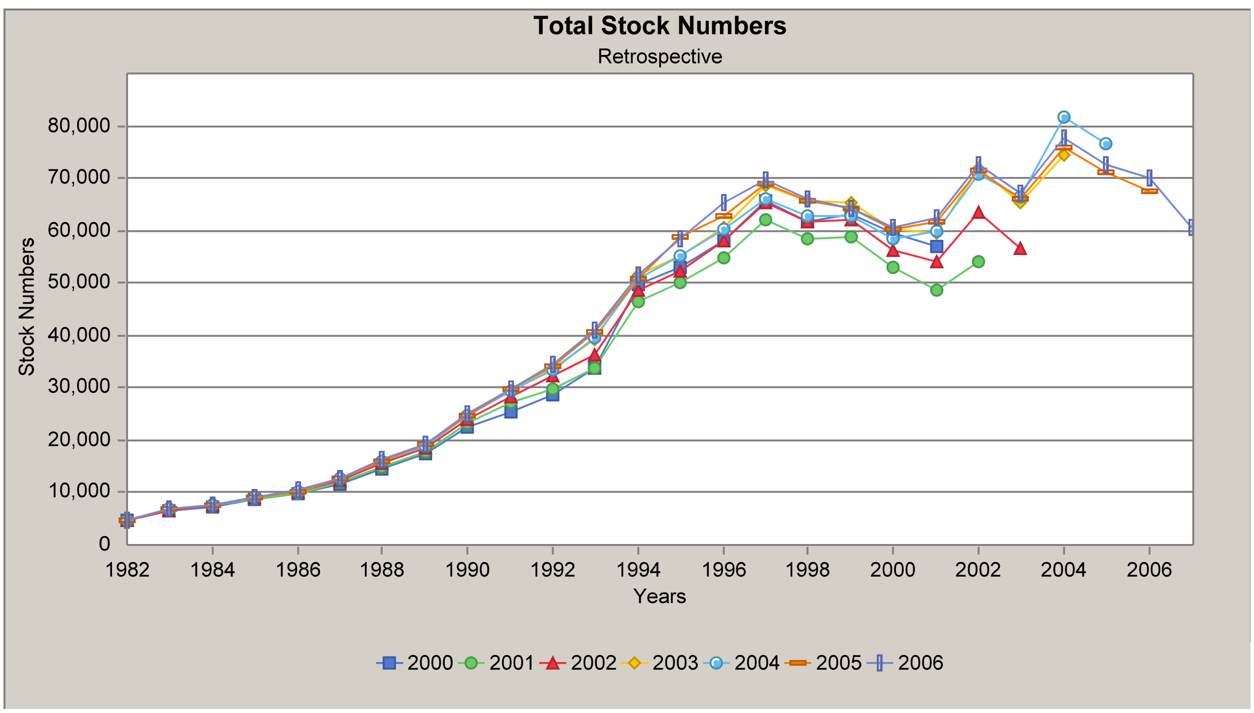
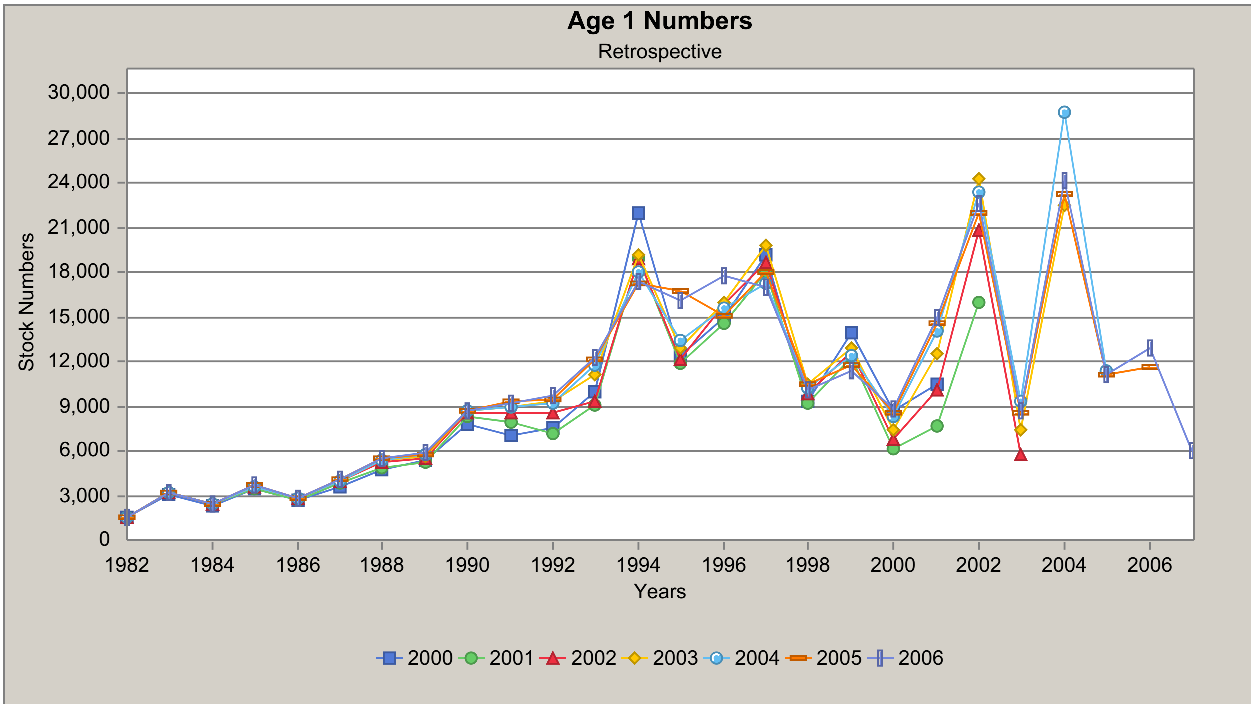


Figure 8. Retrospective plot of average fishing mortality and total stock abundance from ADAPT model using reduced suite of indices



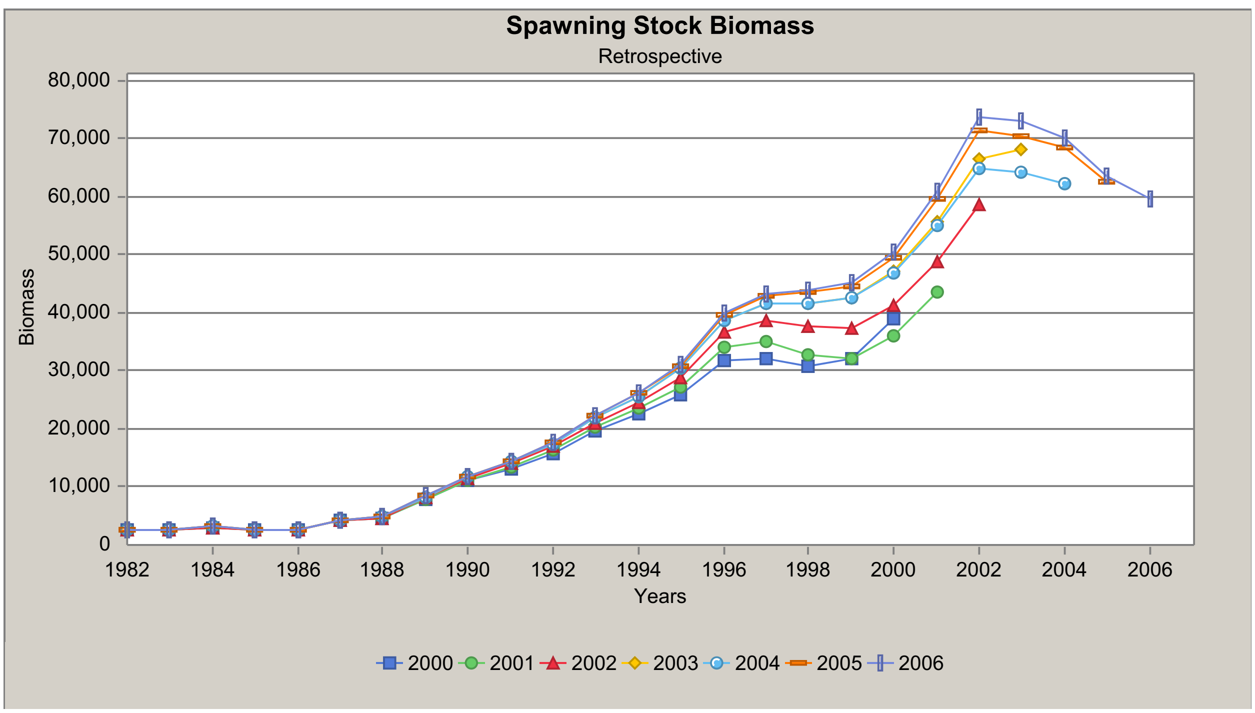


Figure 8 continued.

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

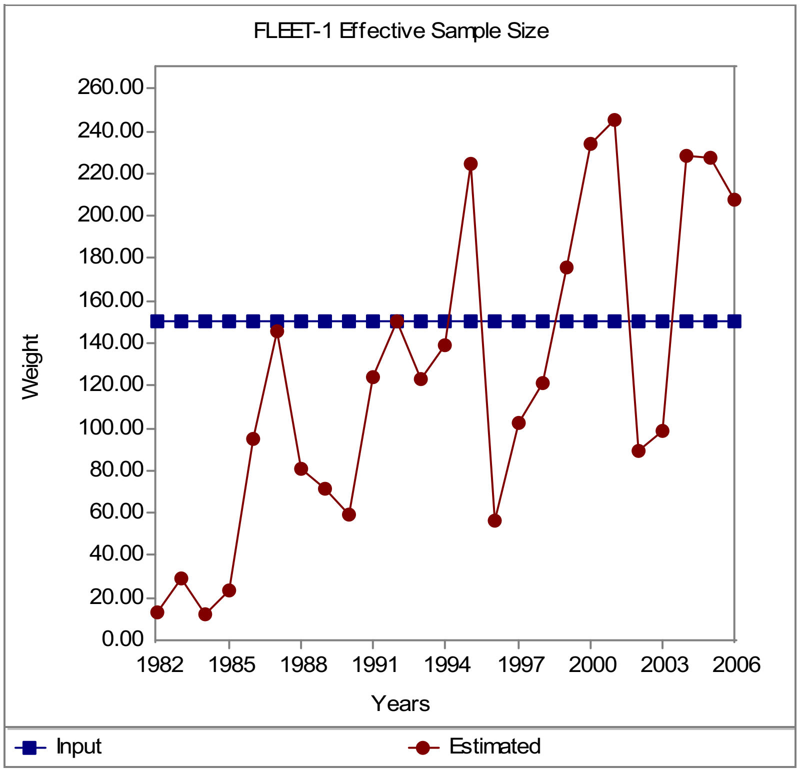
Table 5. Average biomass (MT) from ASAP catch at age model.

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.



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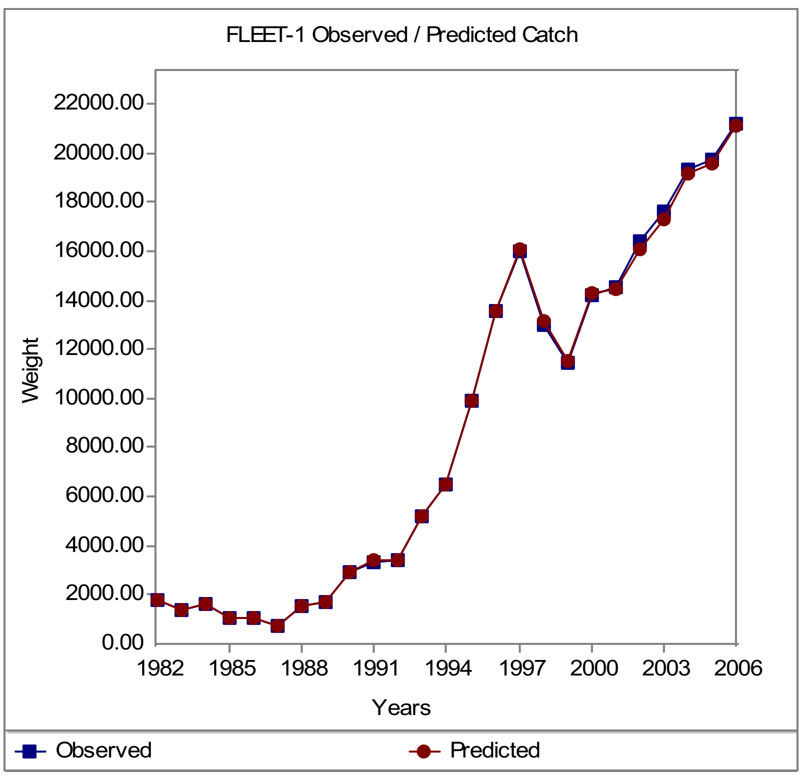


Figure 1. (A) Effective sample size and (B) observed and predicted catch biomass from ASAP catch at age model.

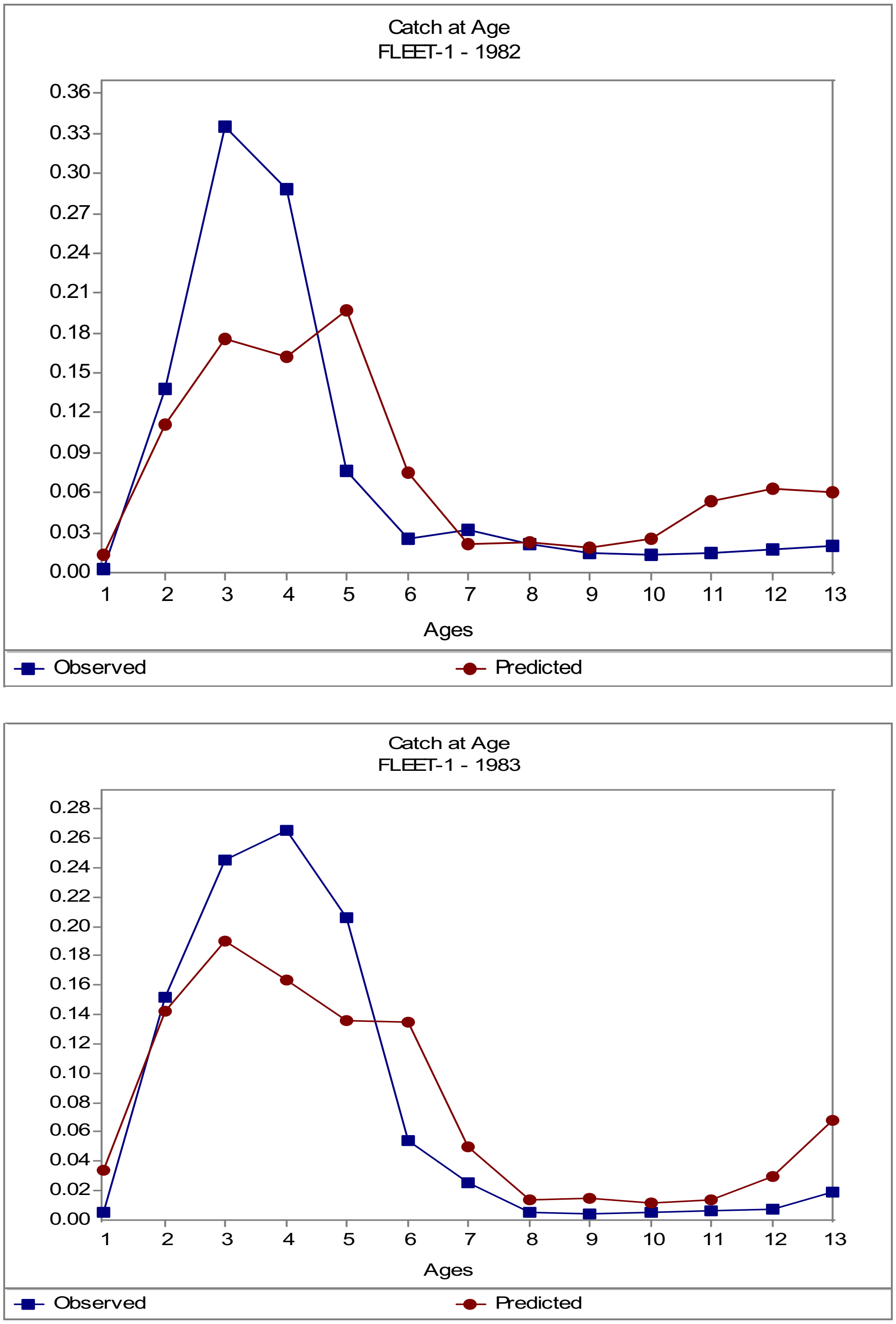
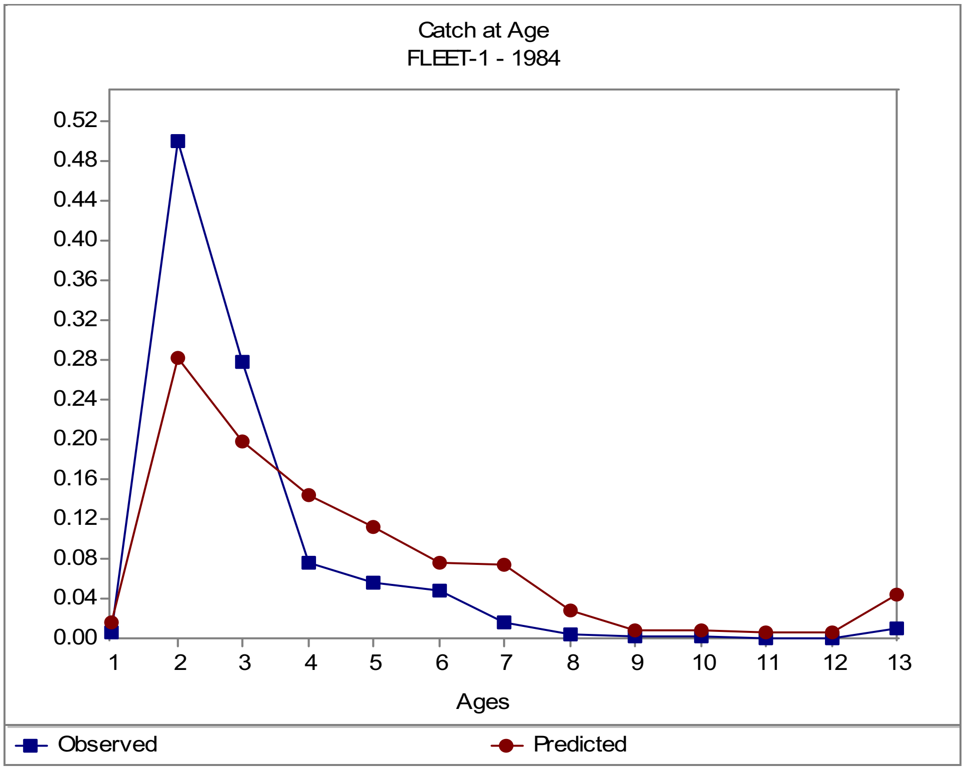
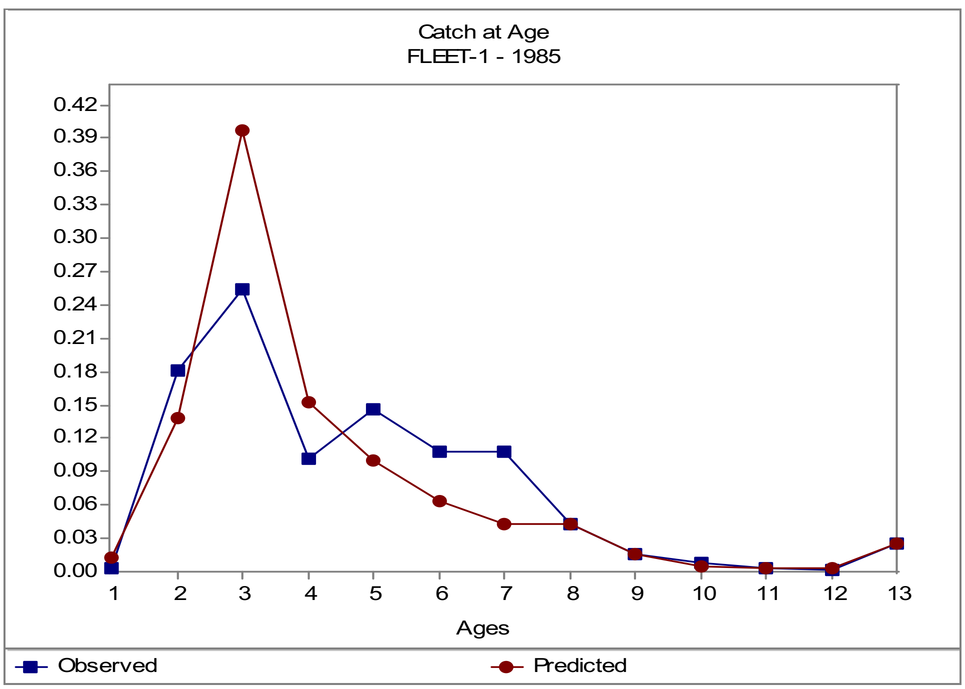


Figure 2. Comparison of observed and predicted proportions-at-age from the ASAP model.





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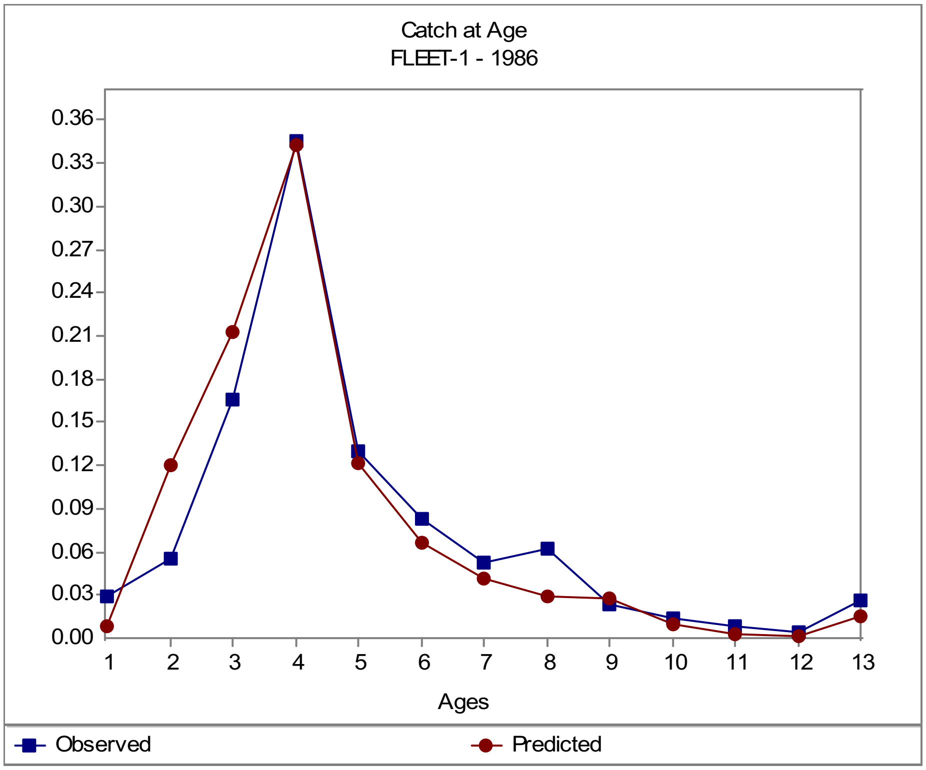

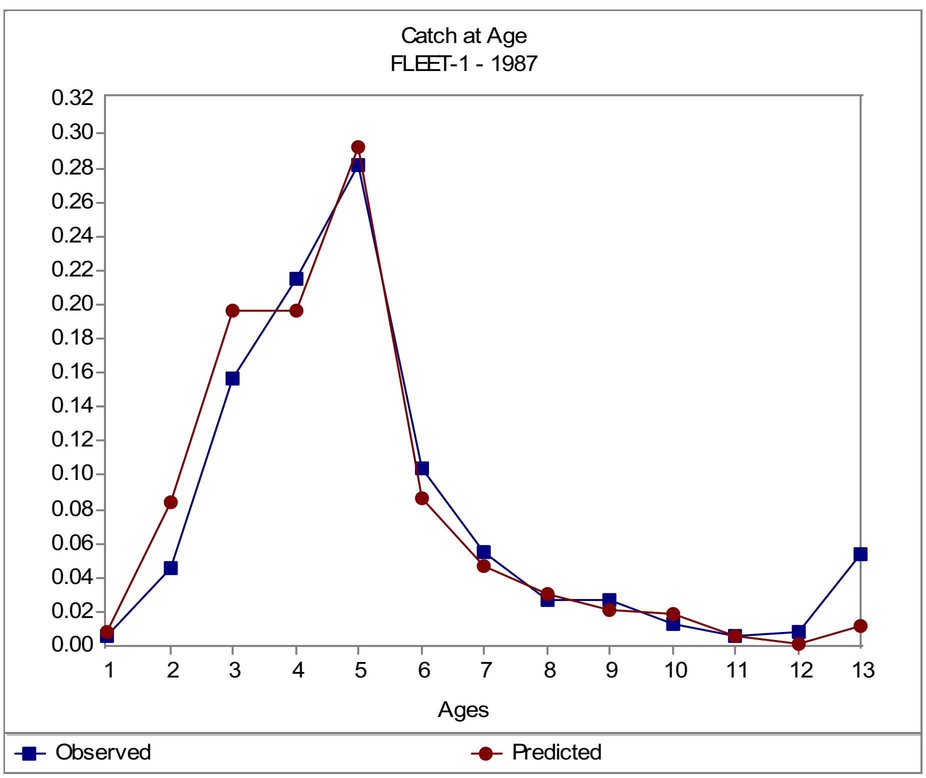

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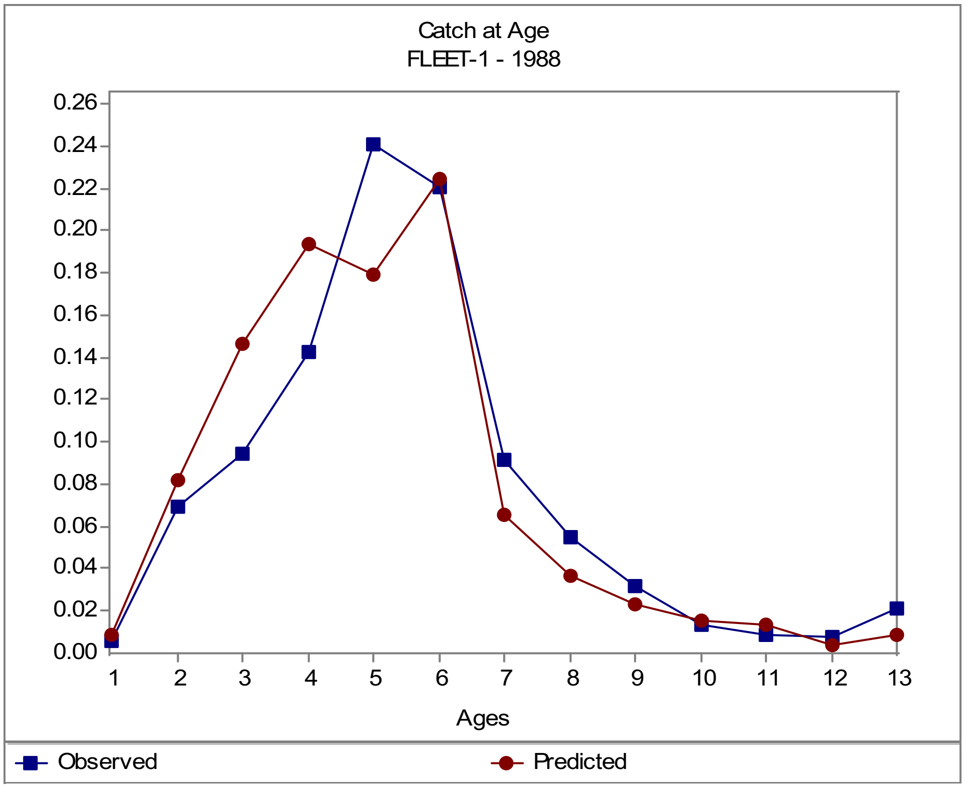

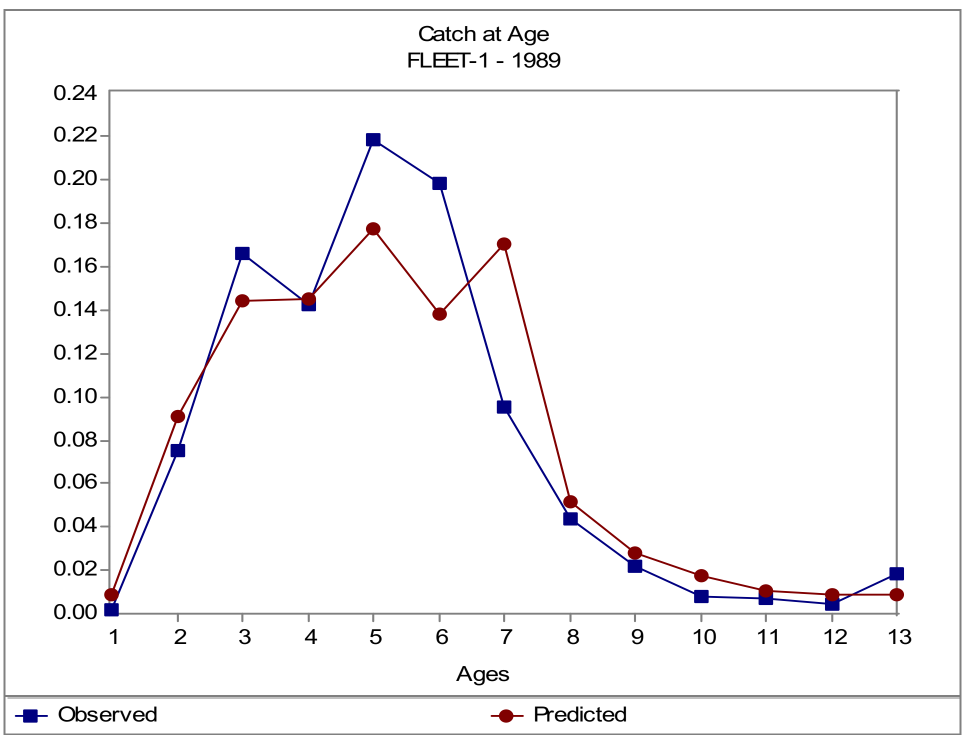

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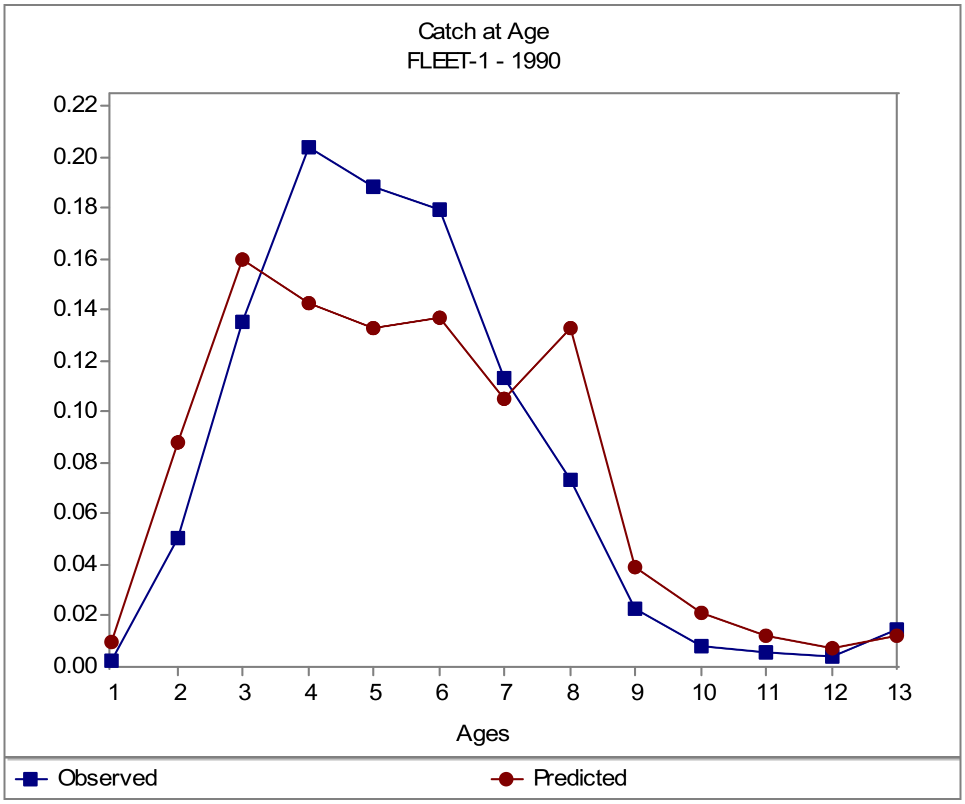

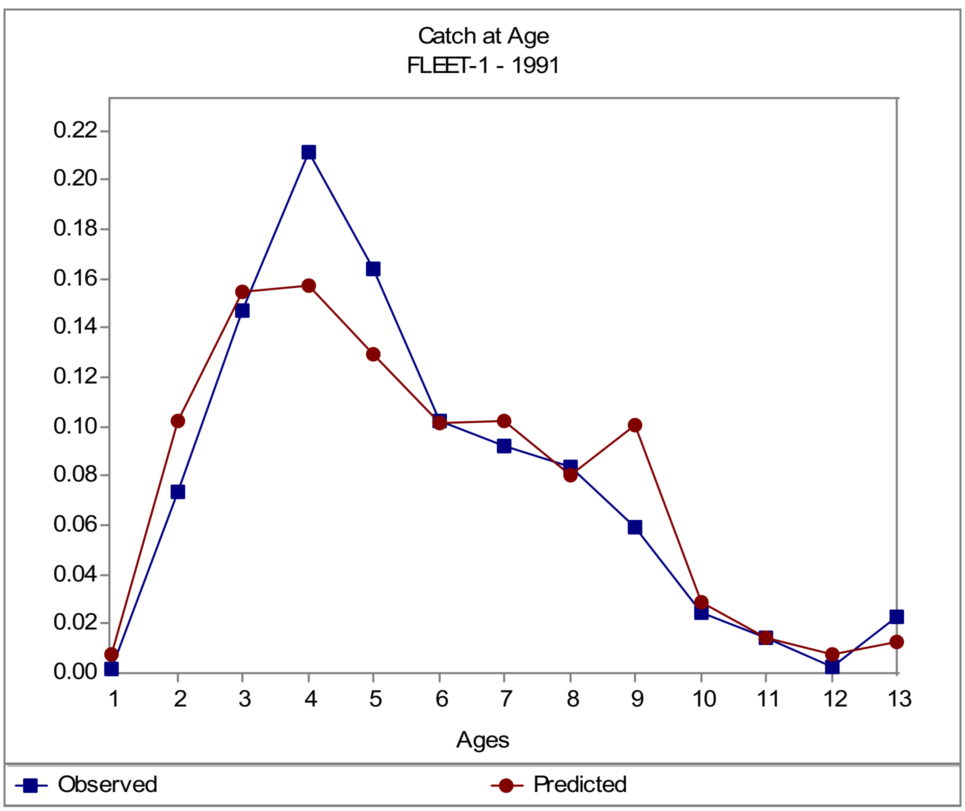

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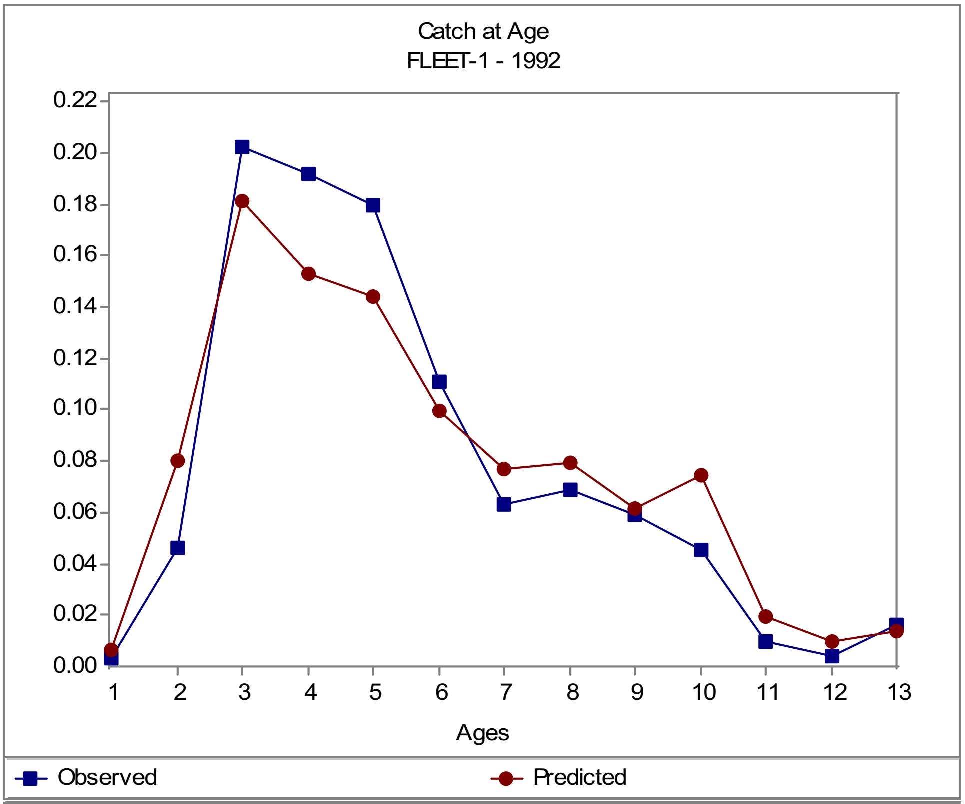

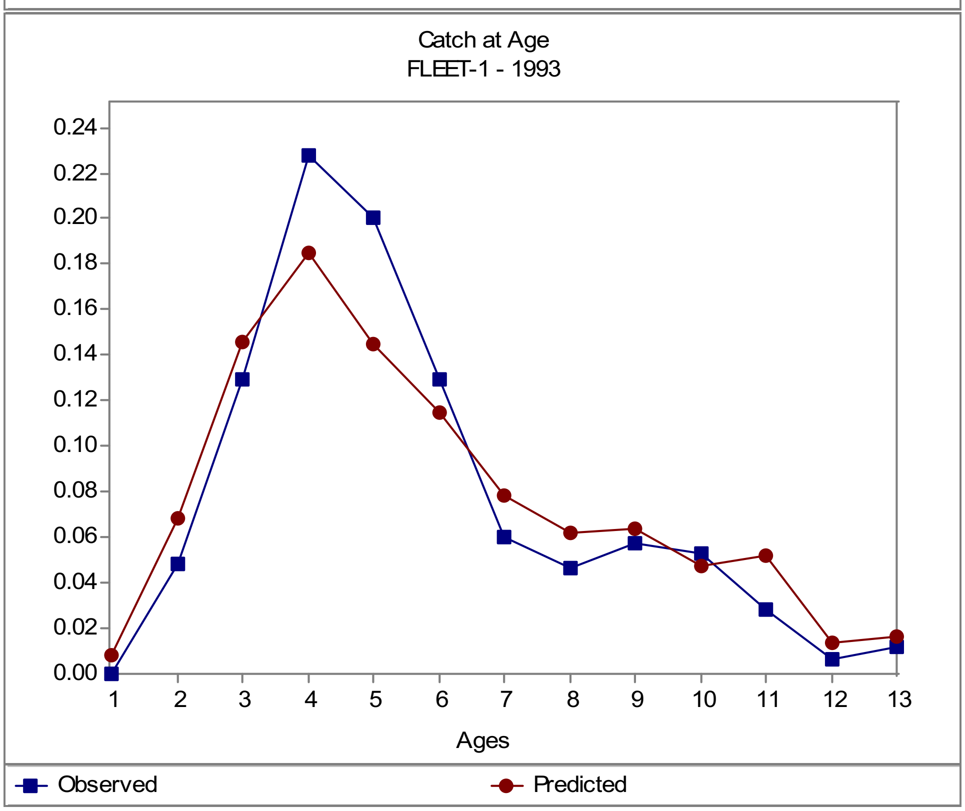

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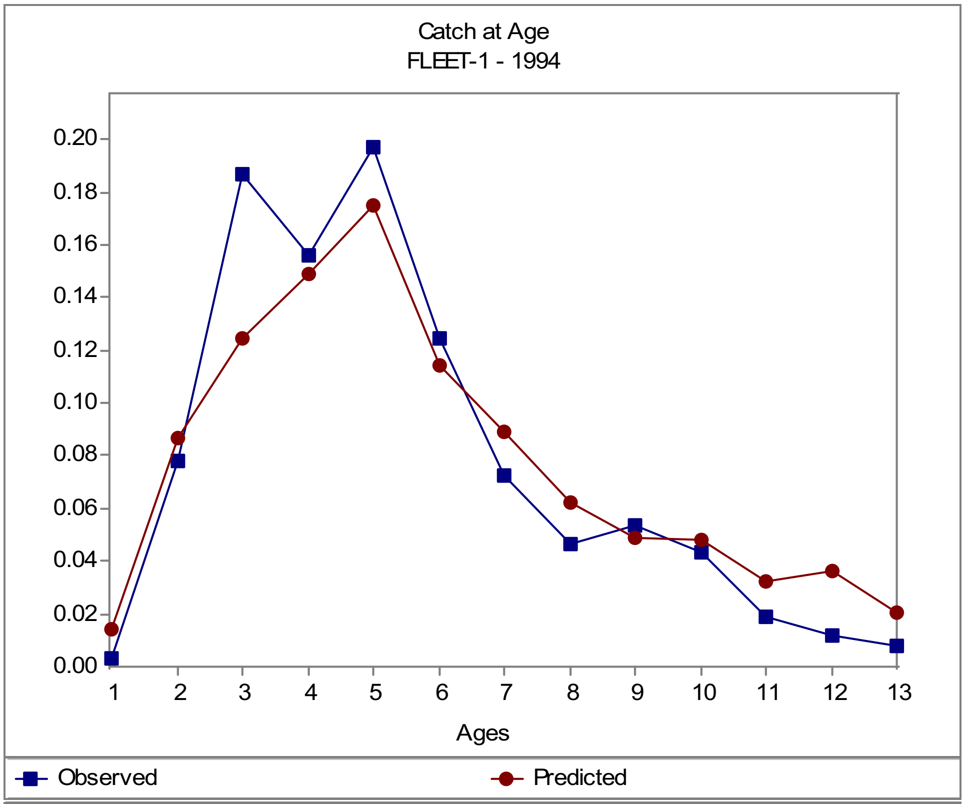

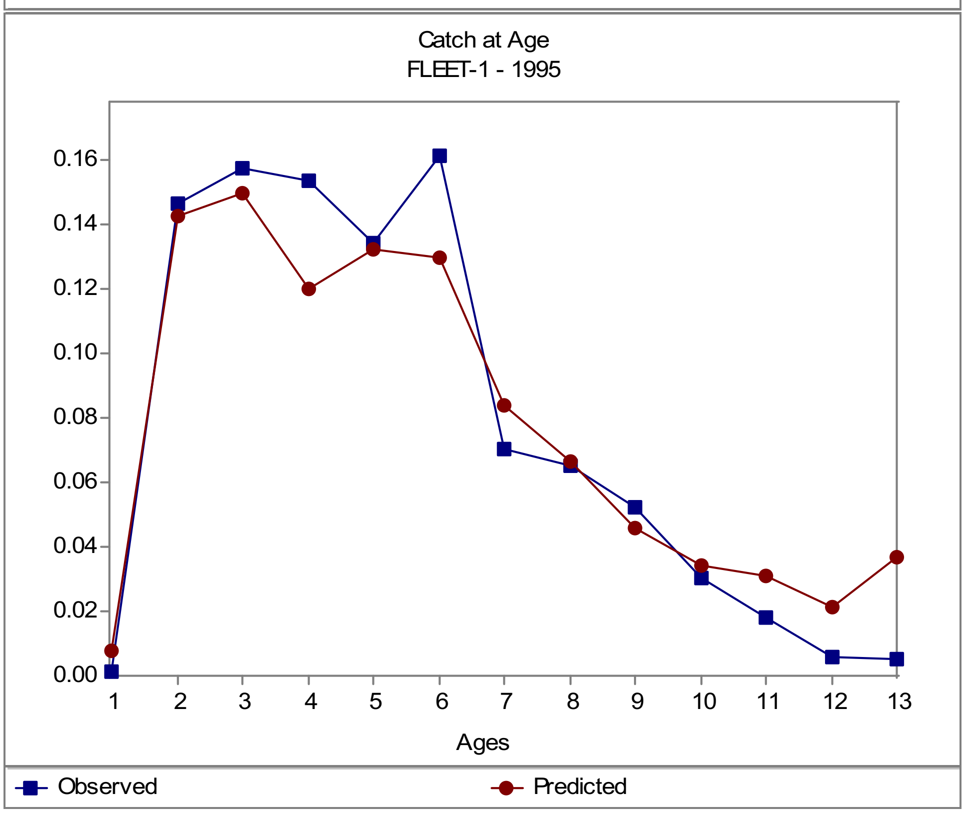

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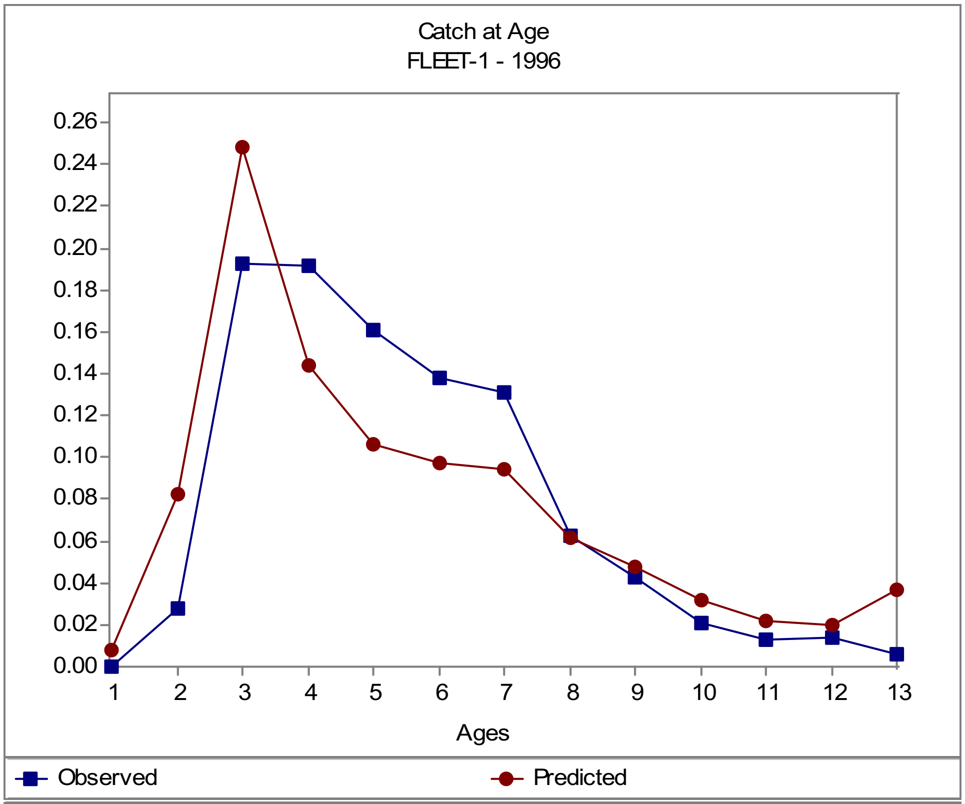

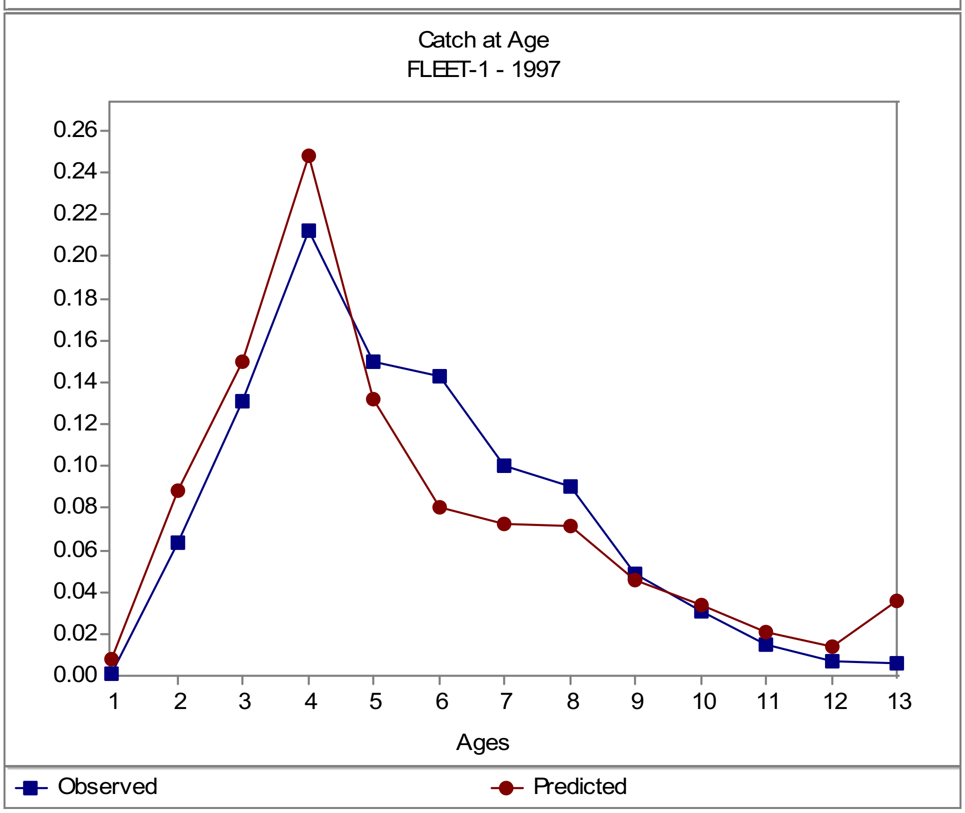

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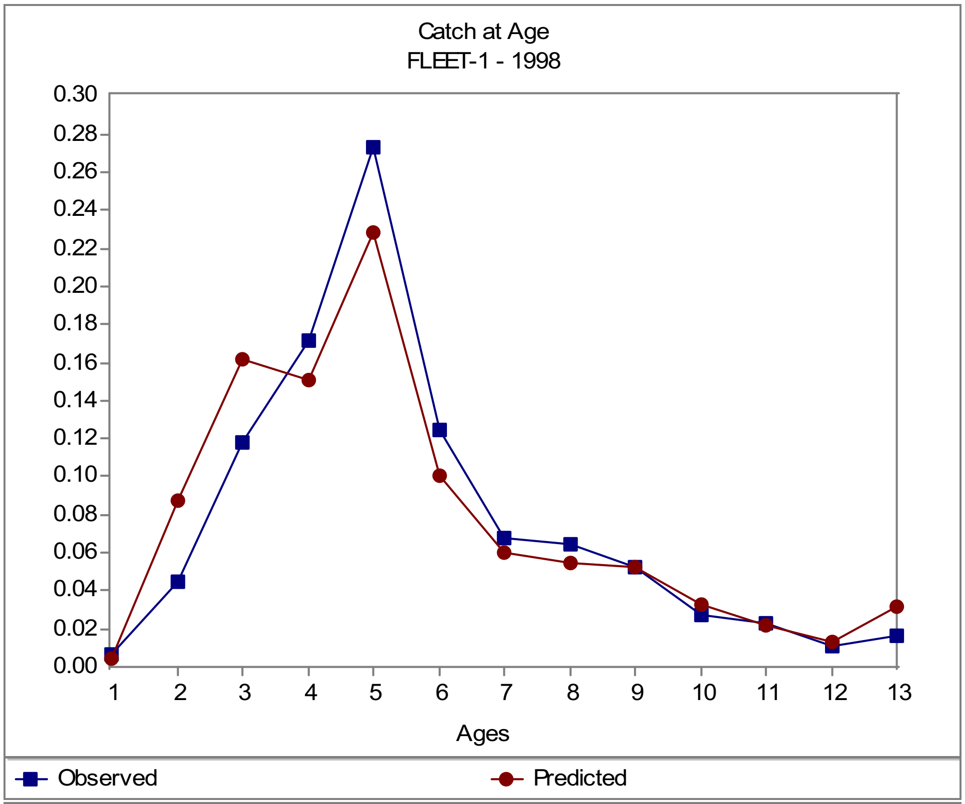

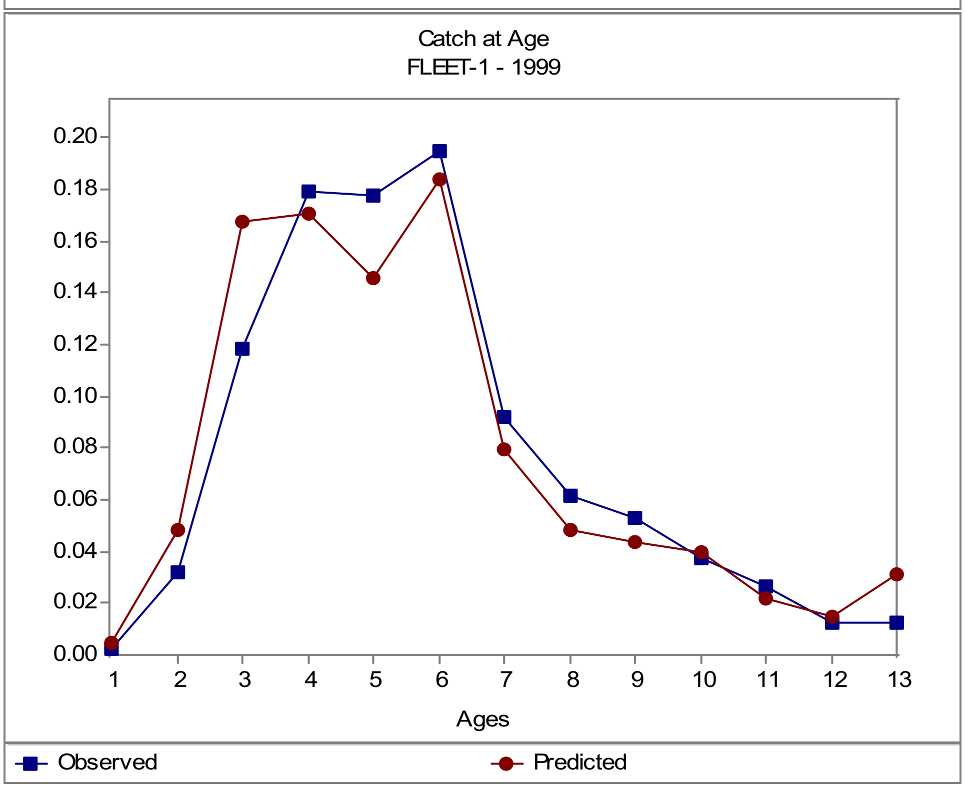

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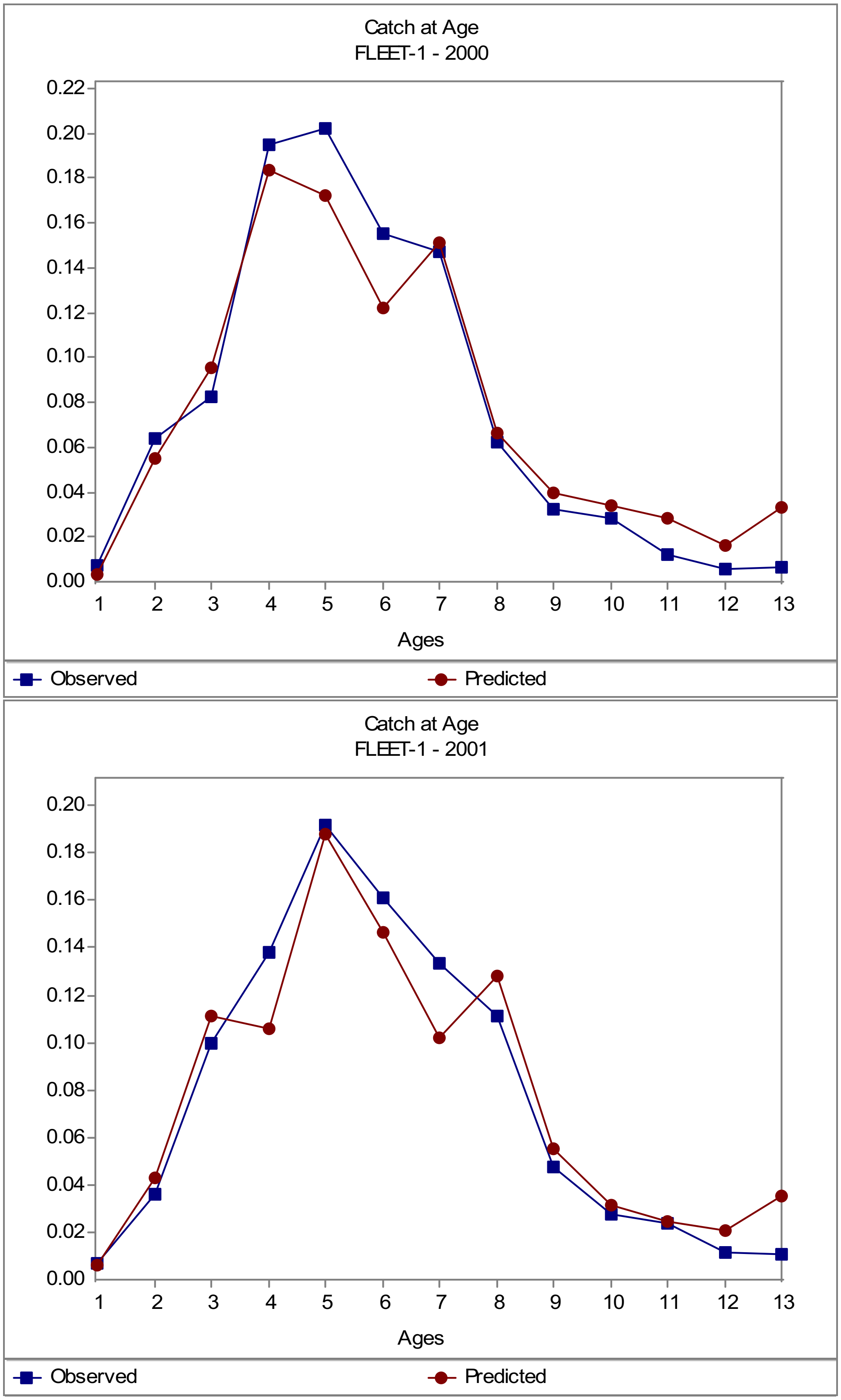

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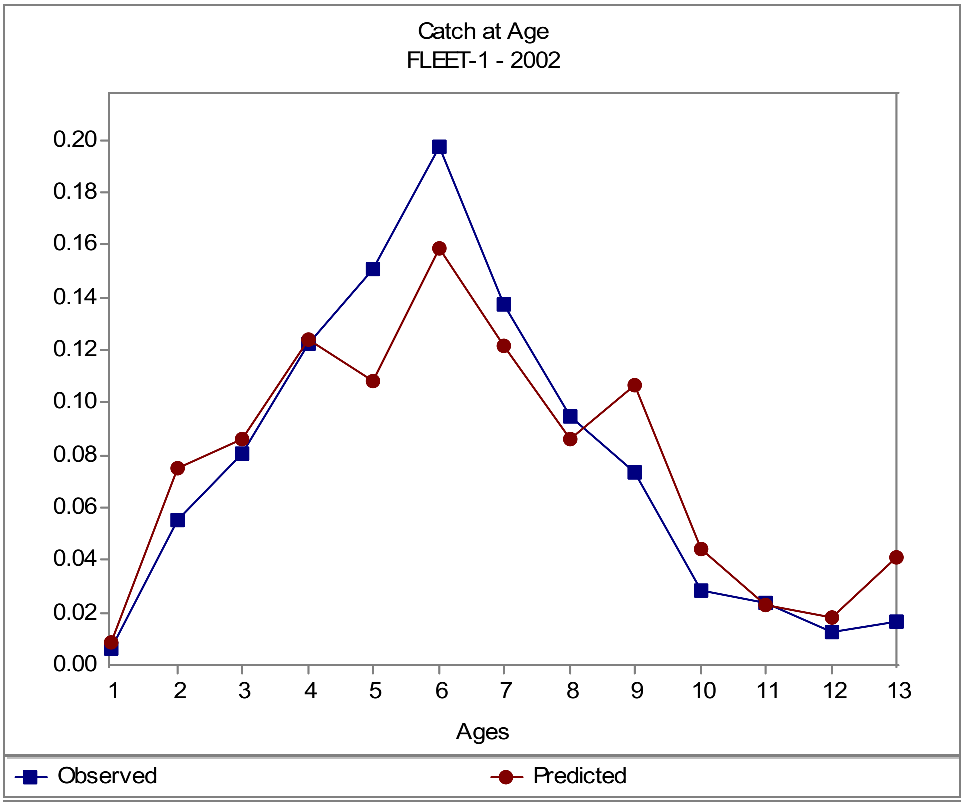

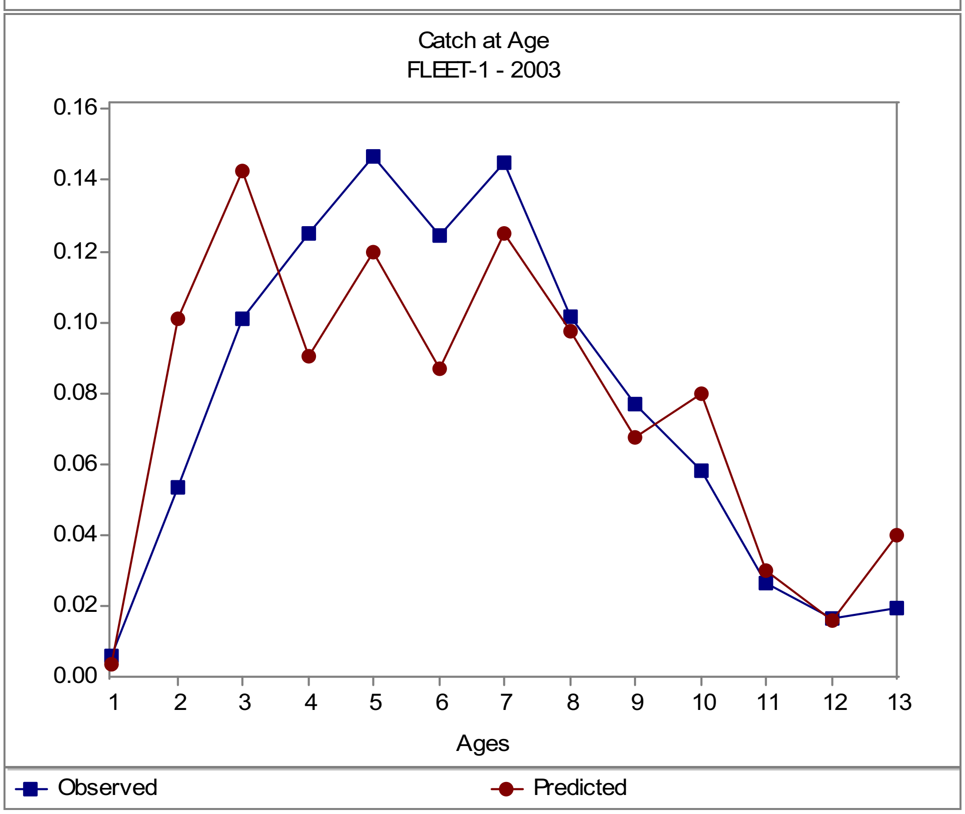

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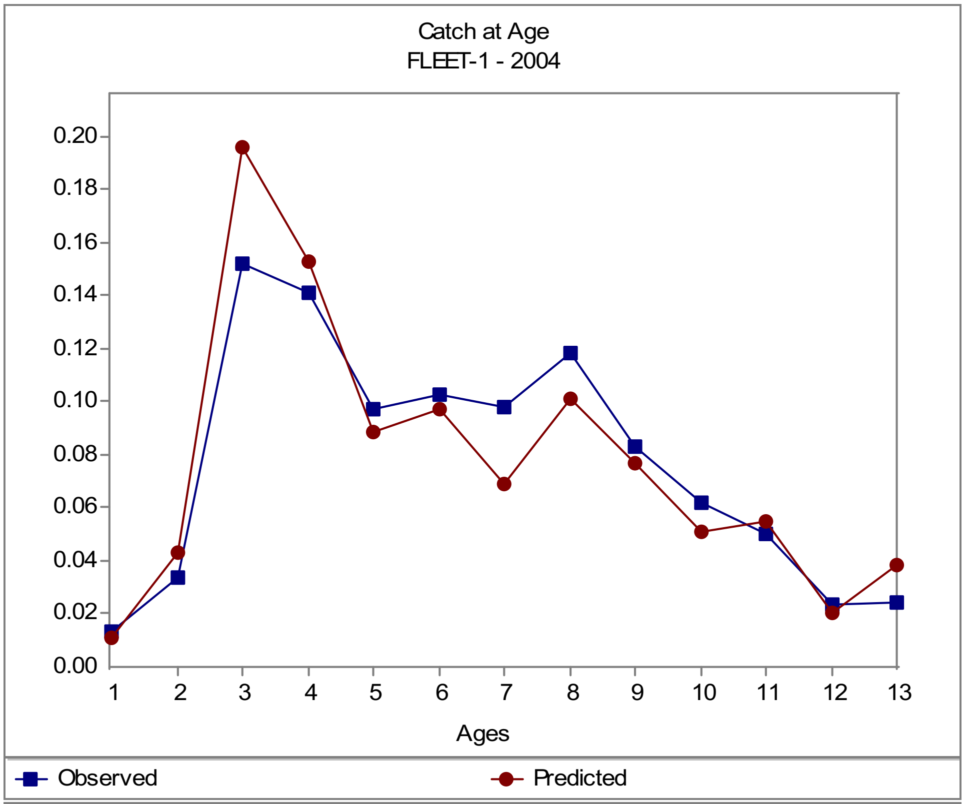

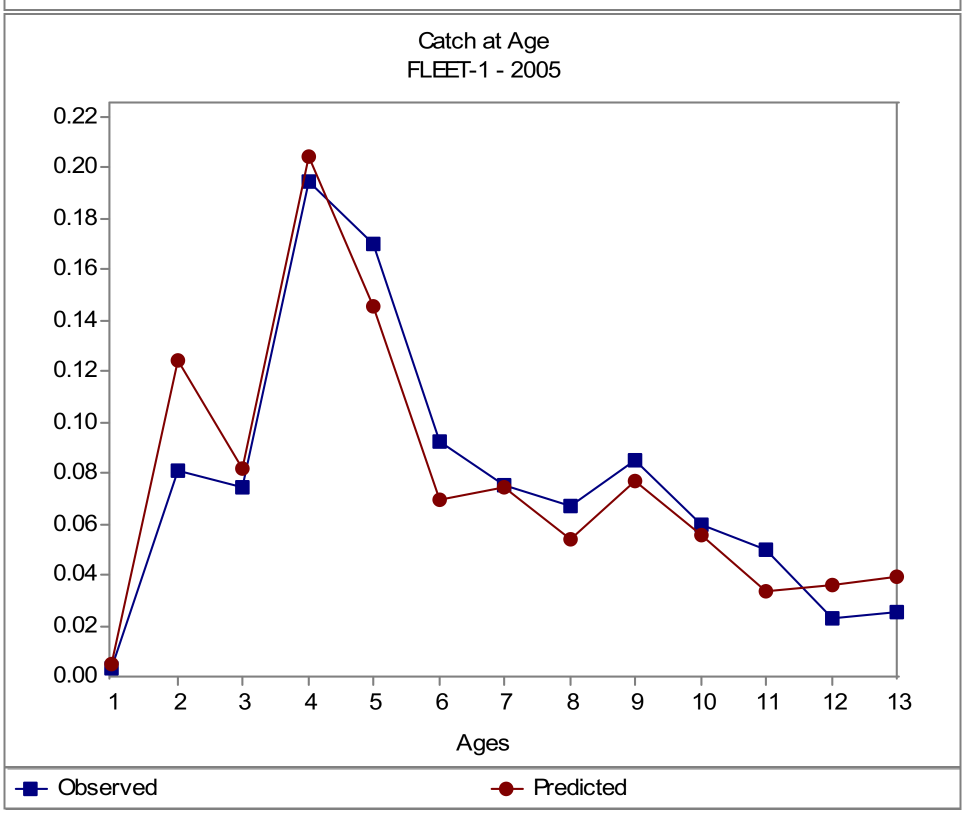

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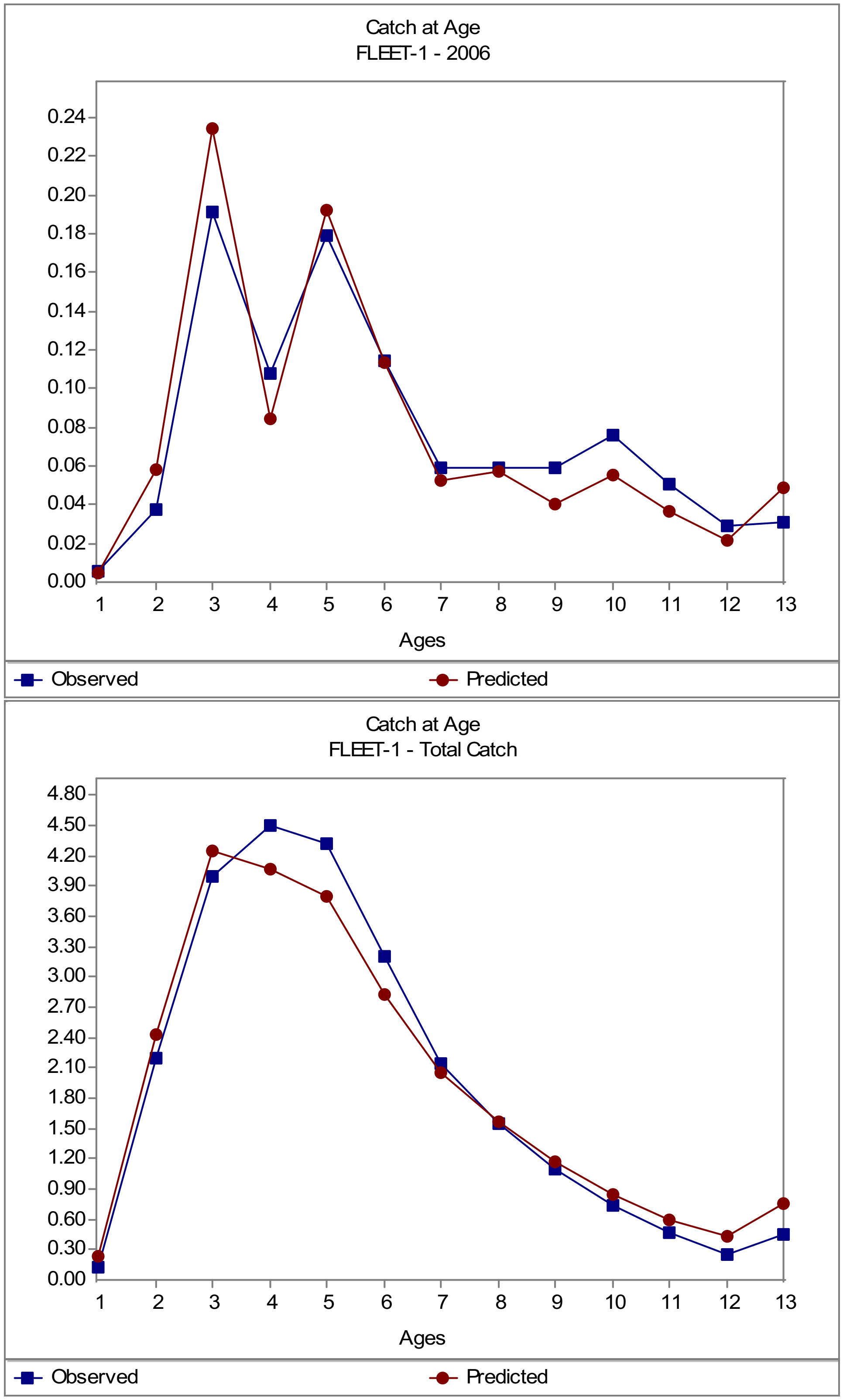

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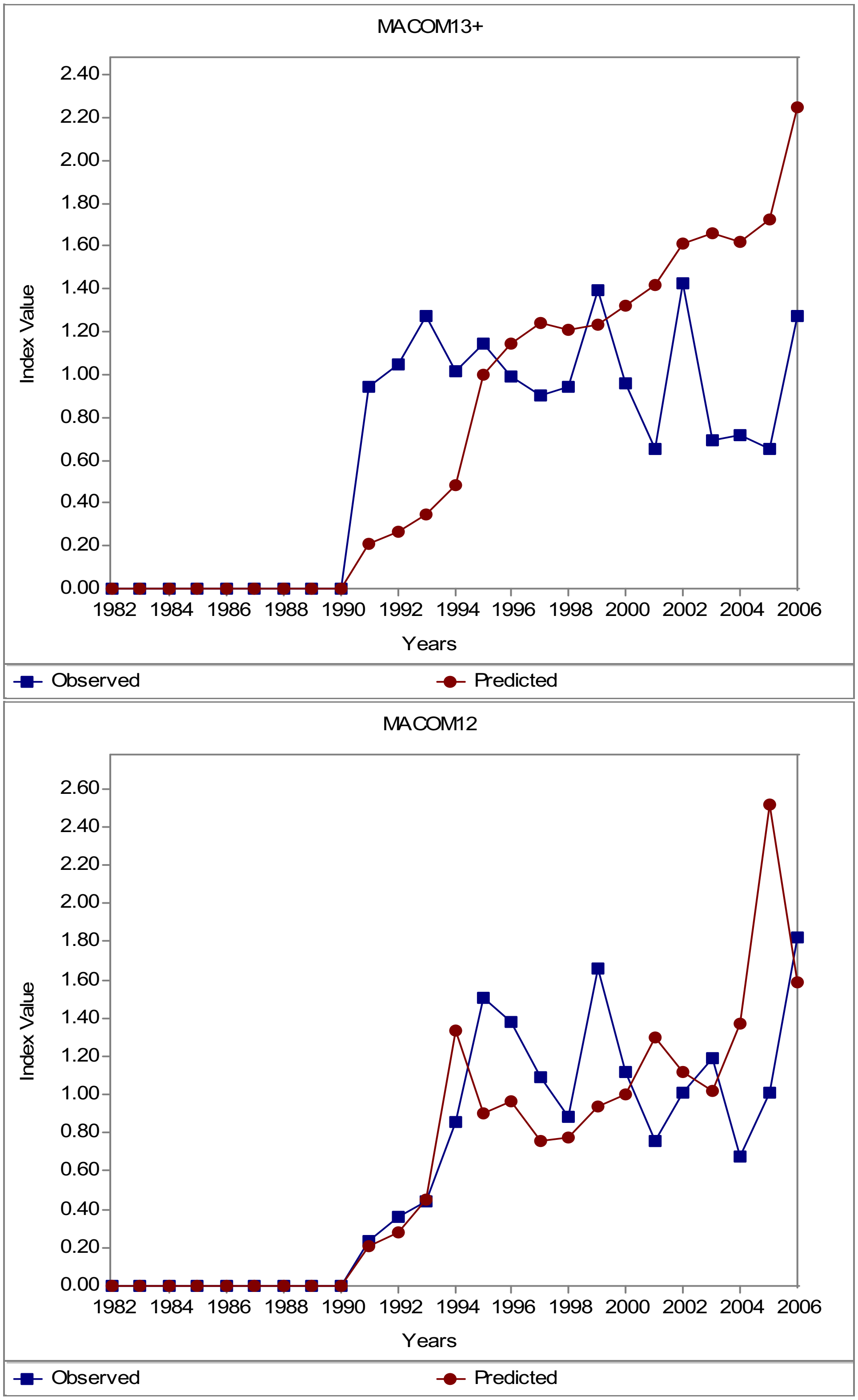
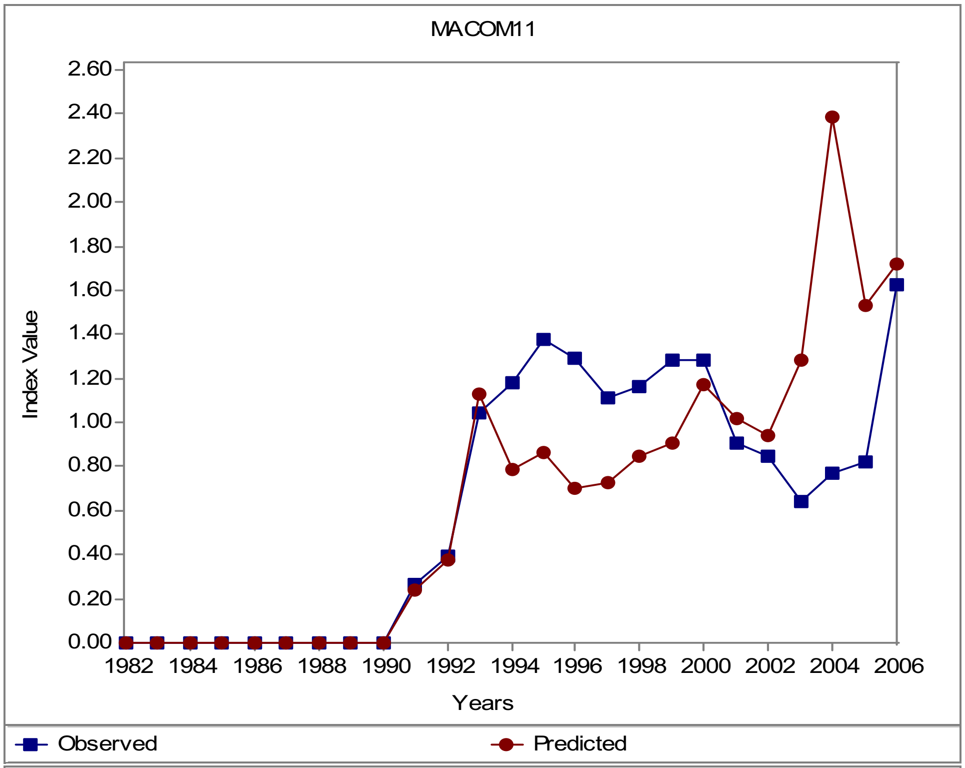
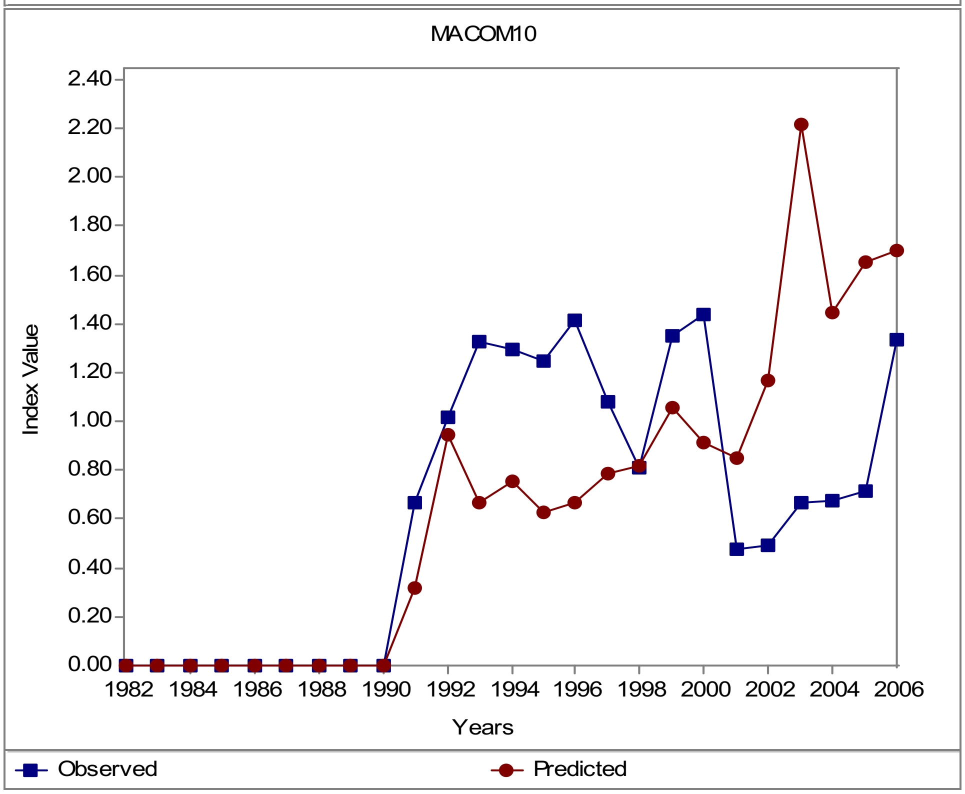


Figure 3. Observed and predicted indices used in ASAP catch at age model.





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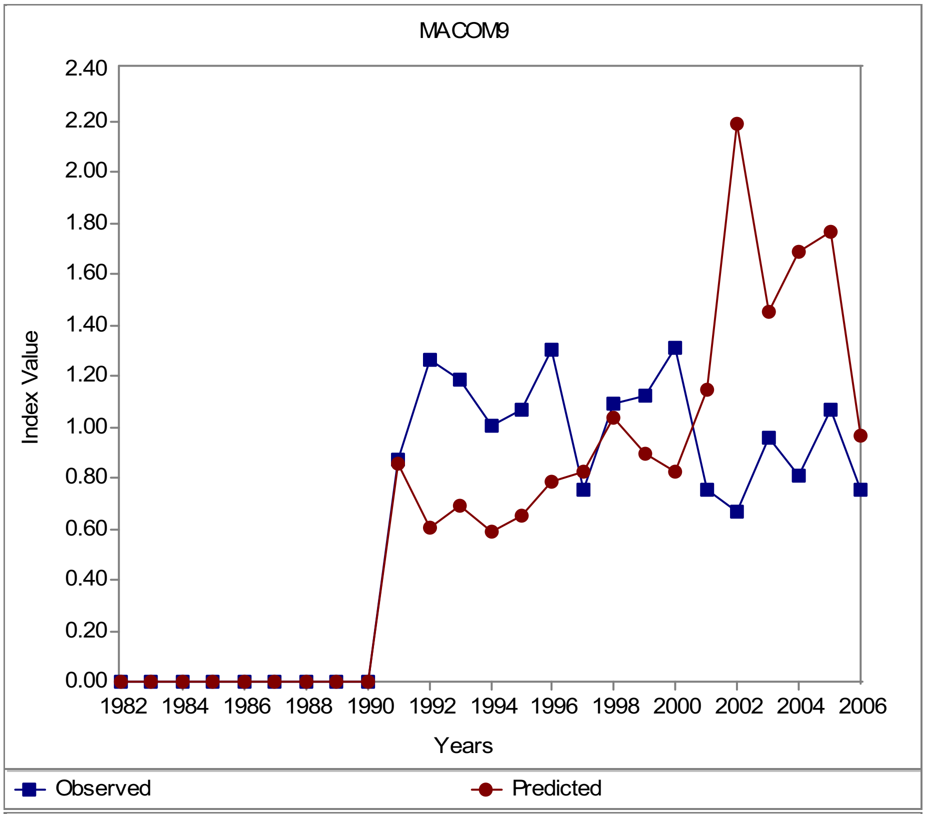

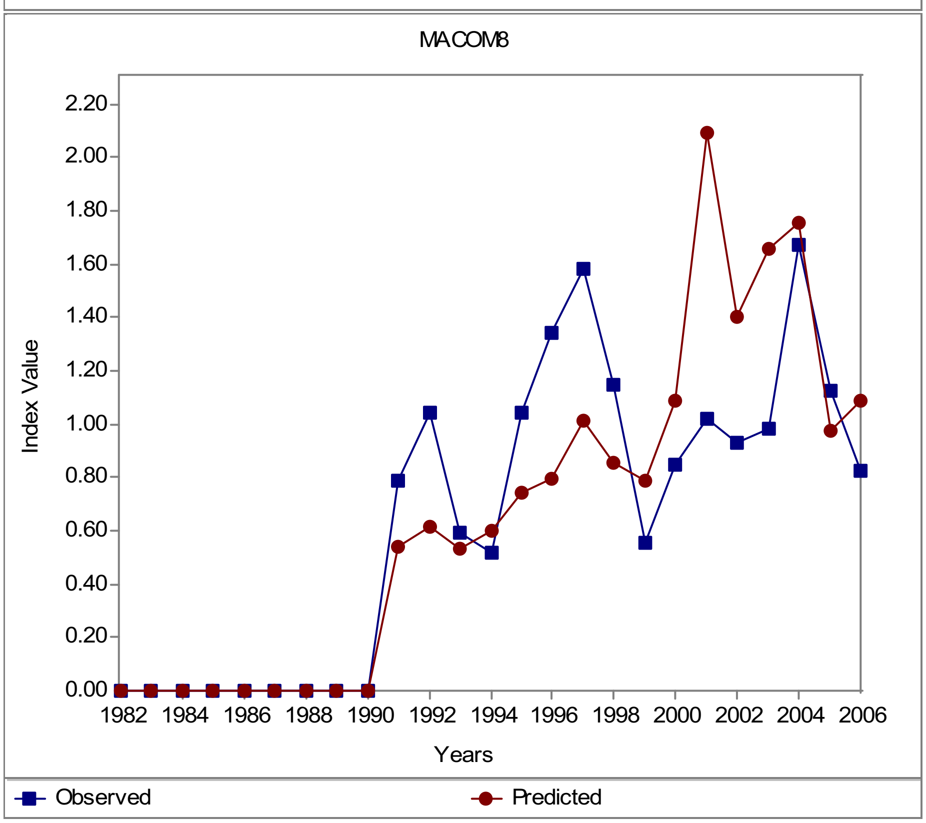

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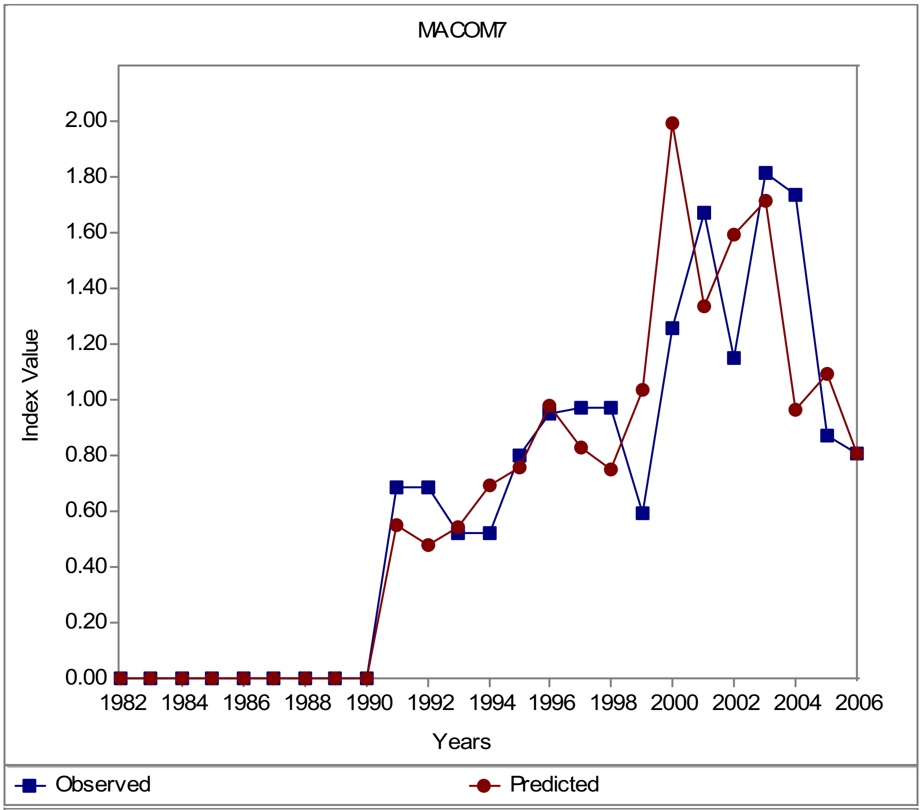

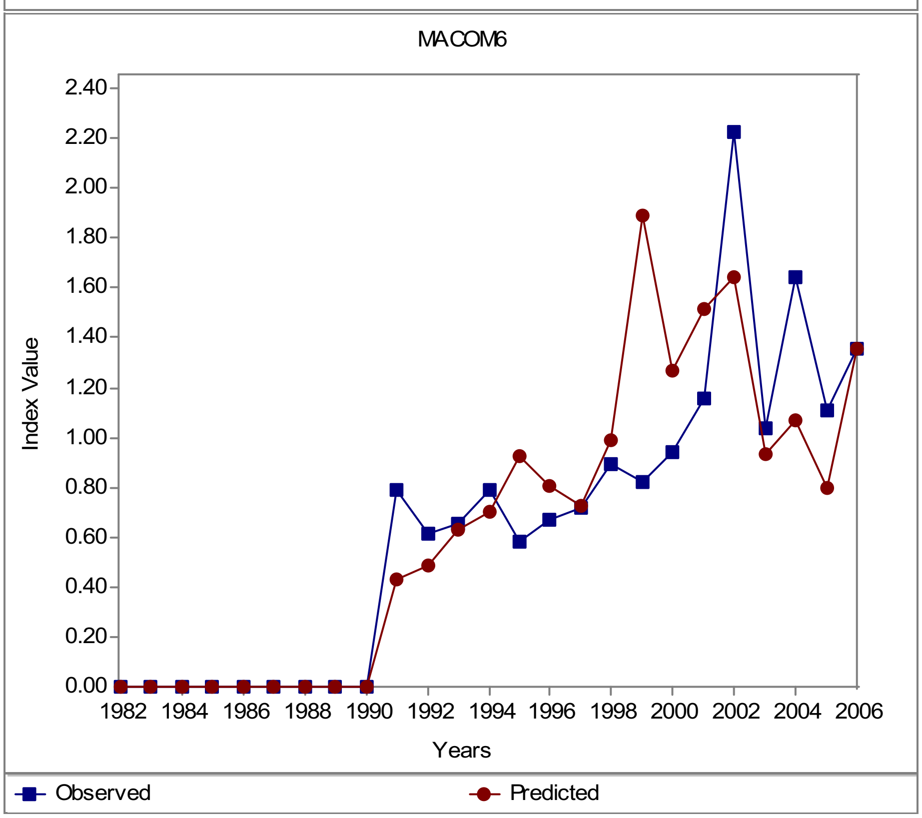

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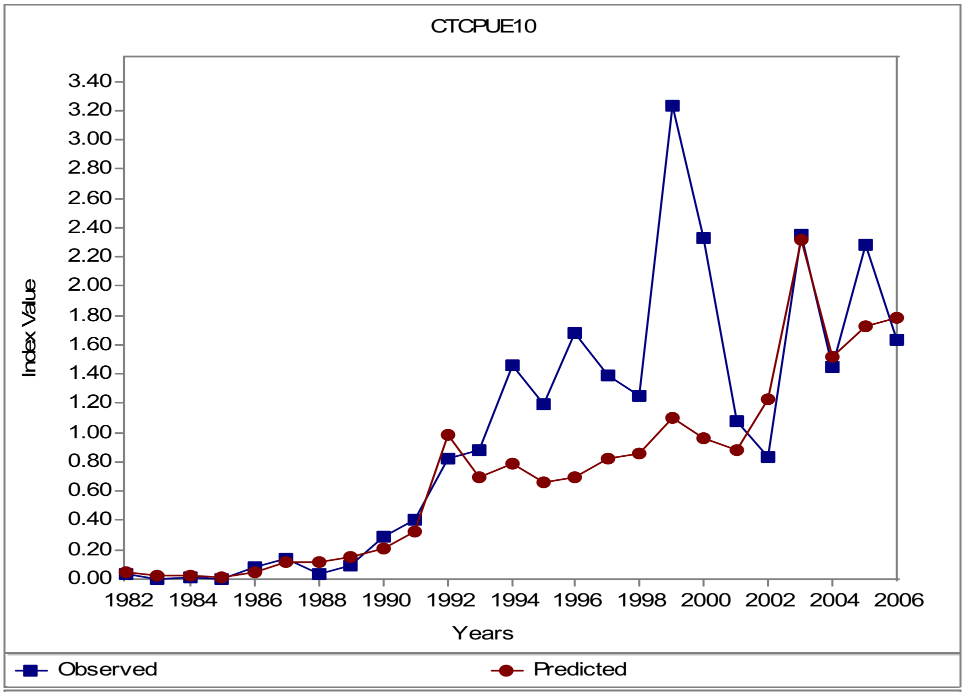

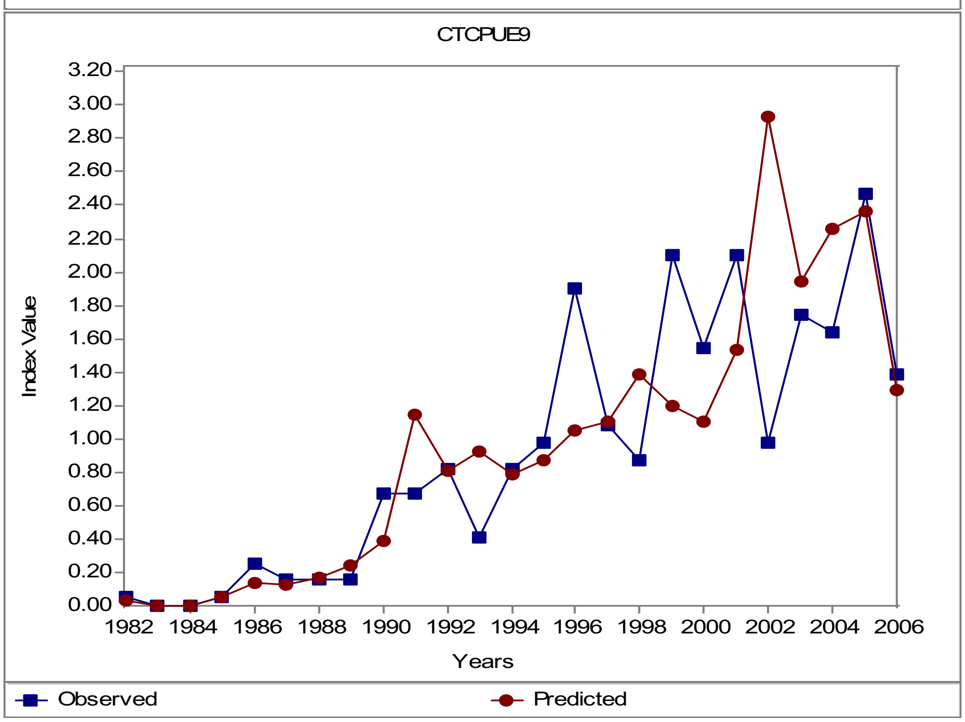

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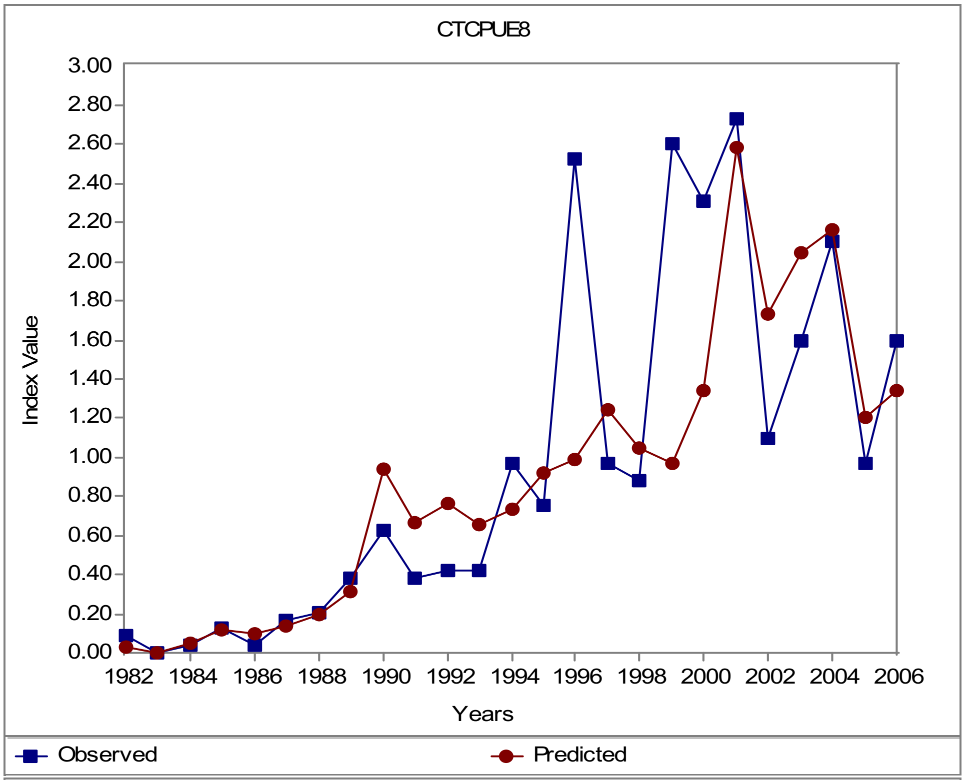

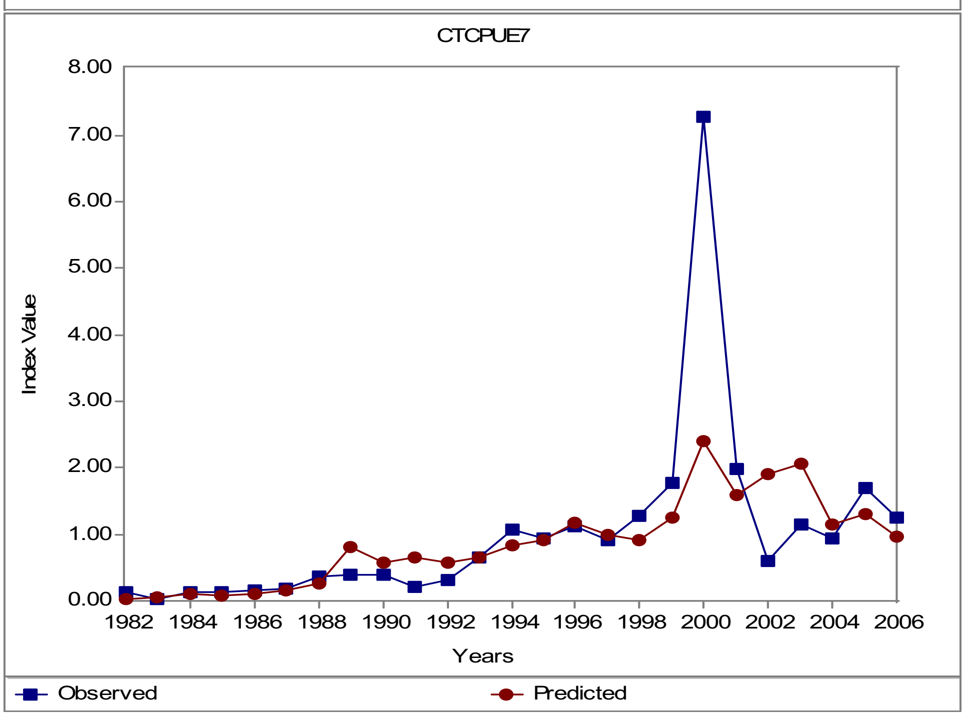

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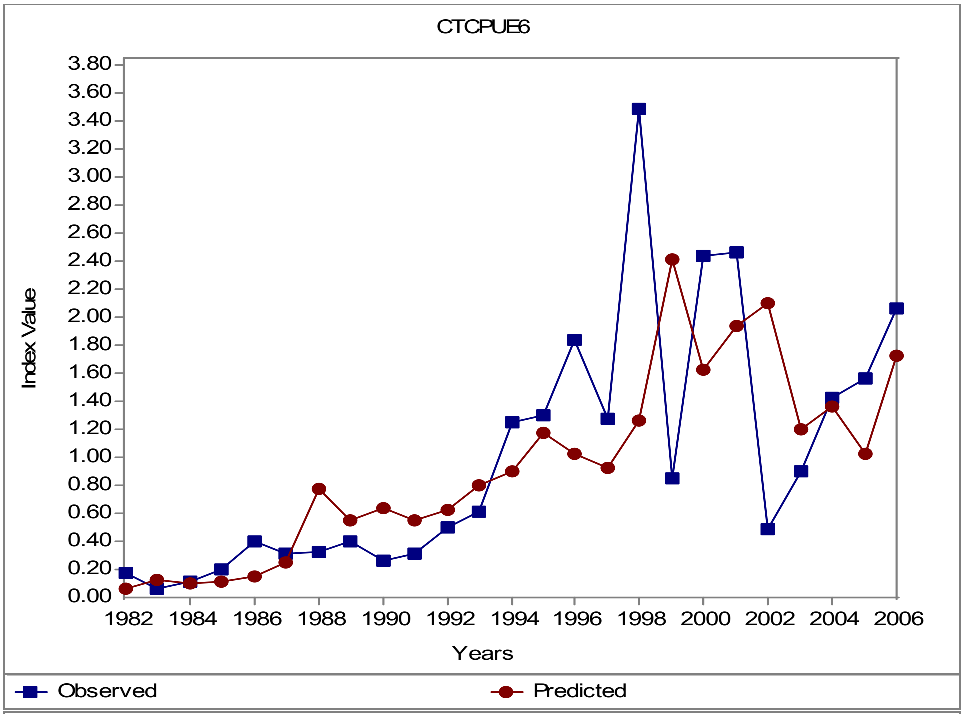

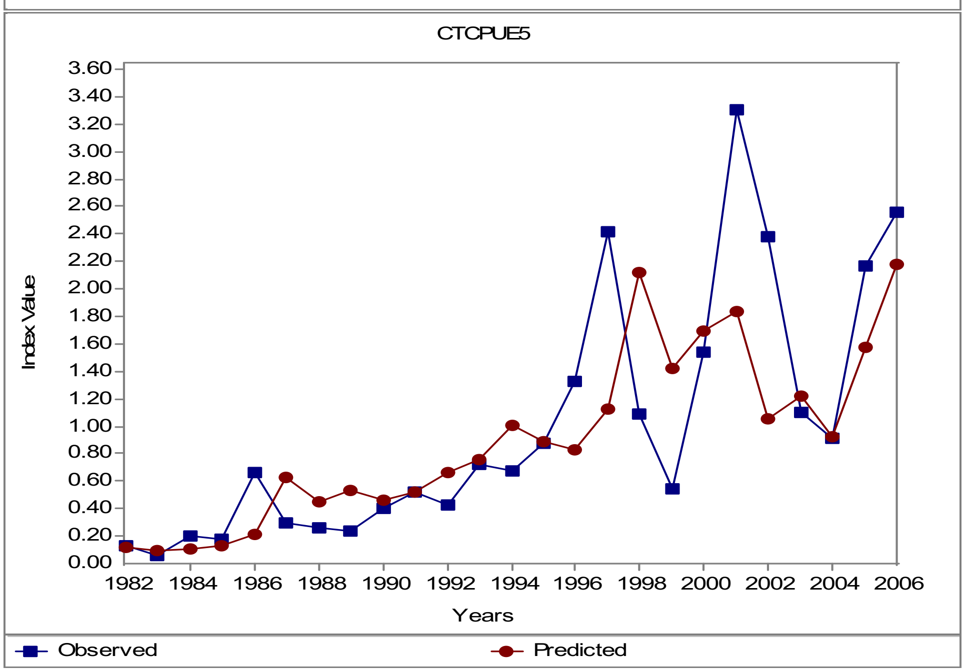

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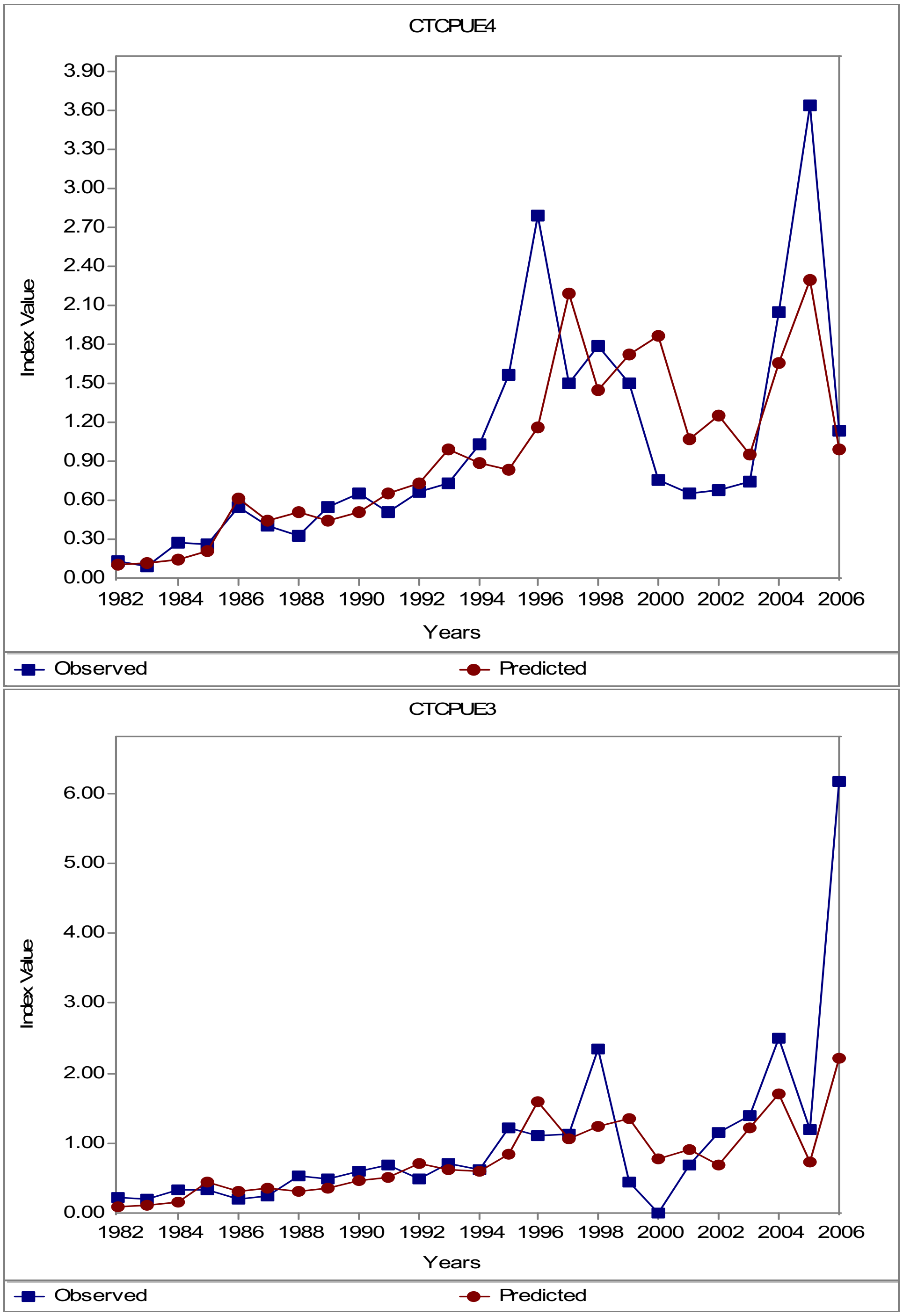

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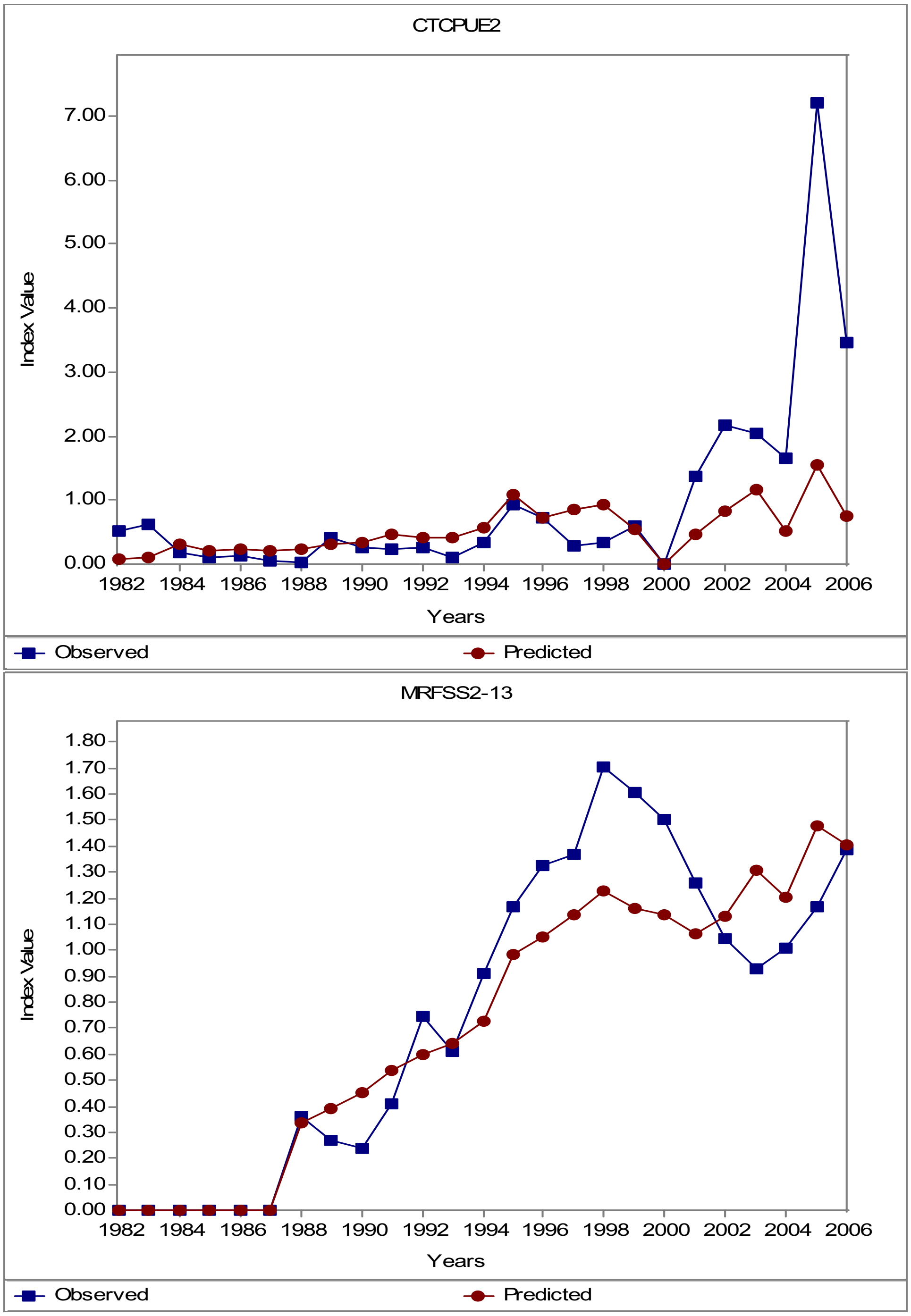

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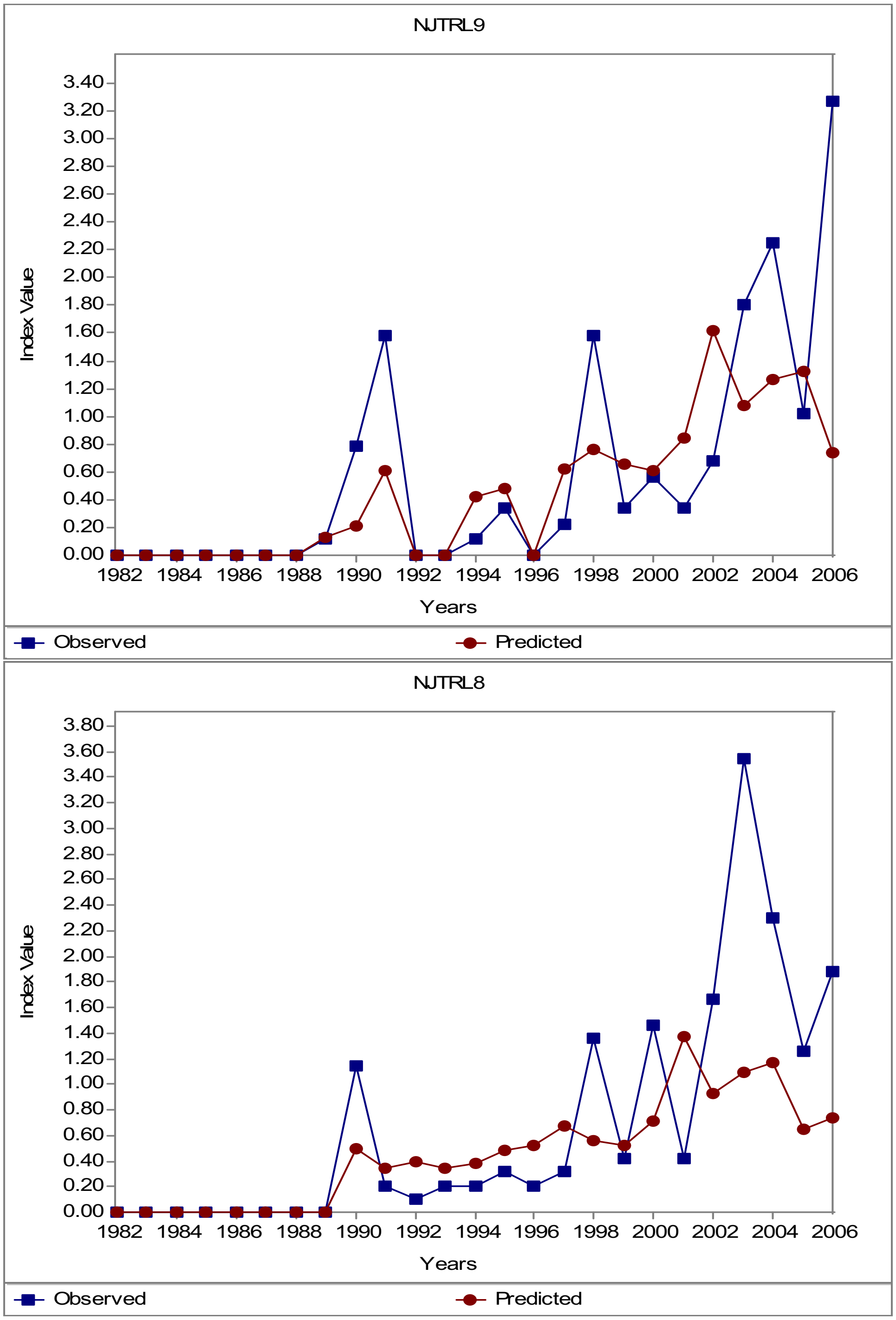

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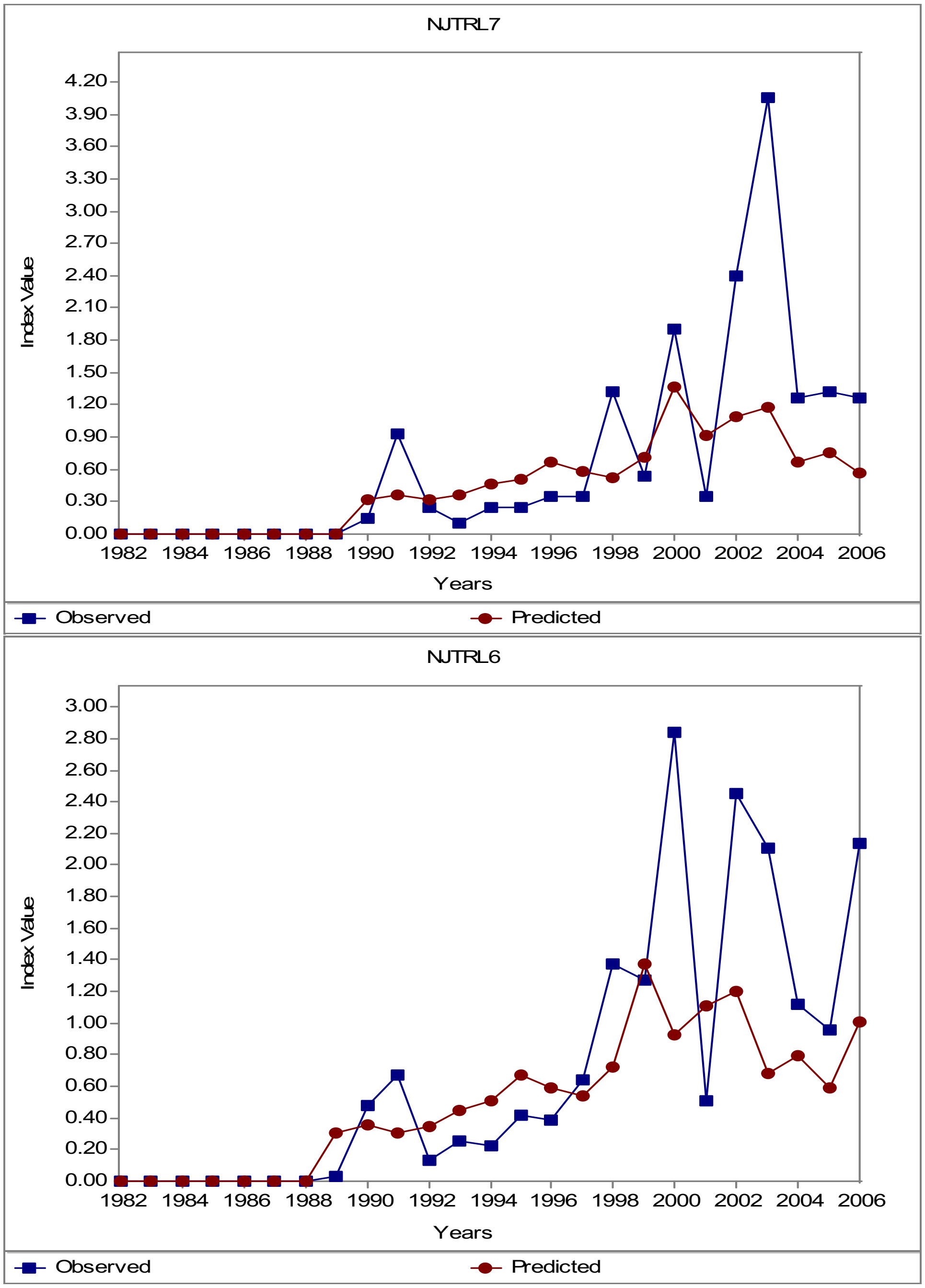

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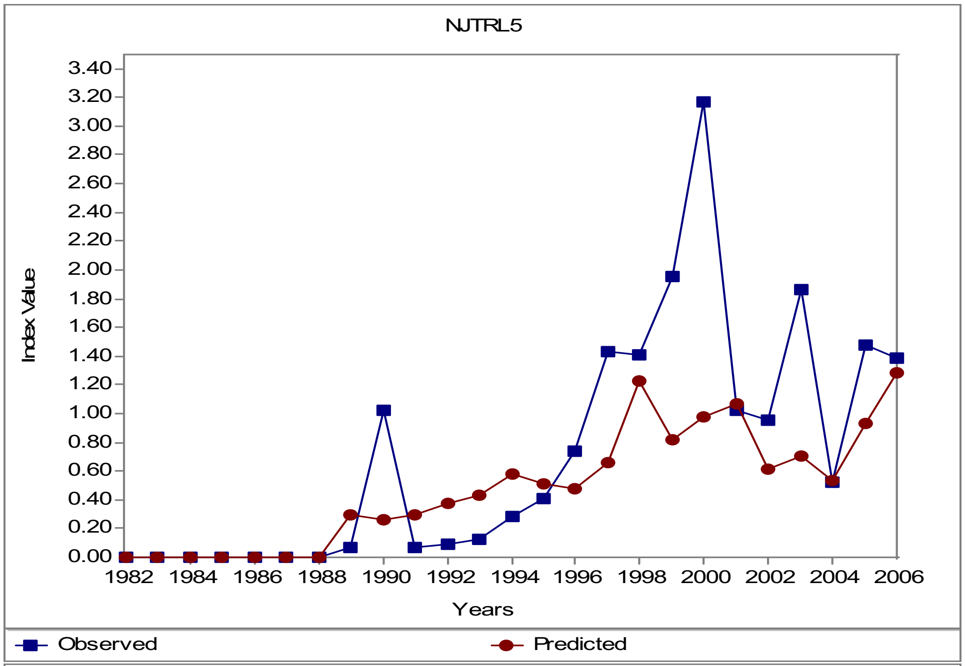

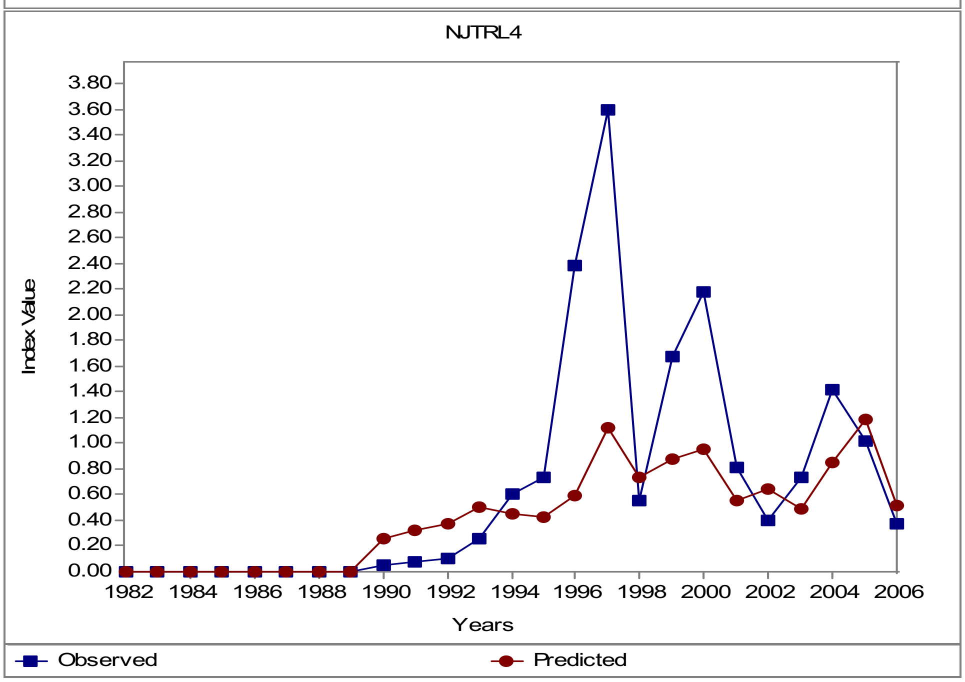

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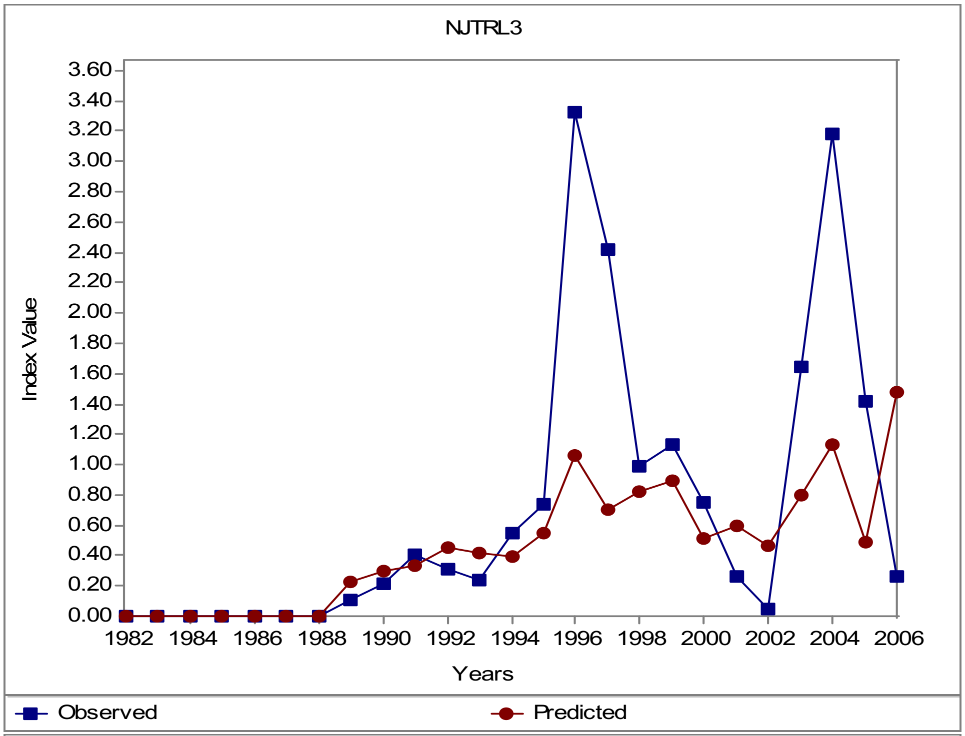

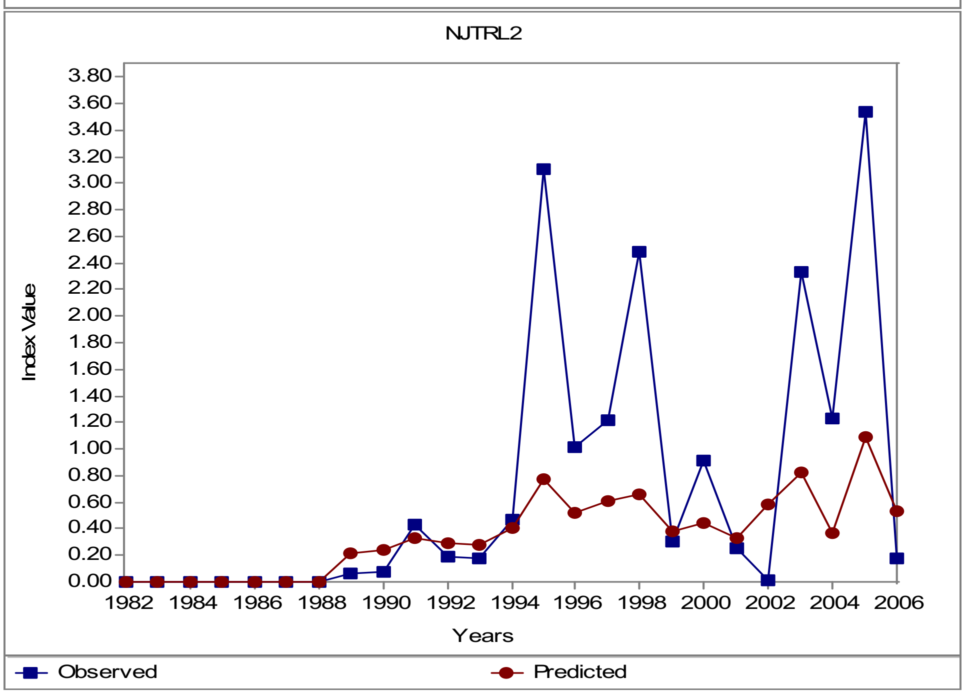

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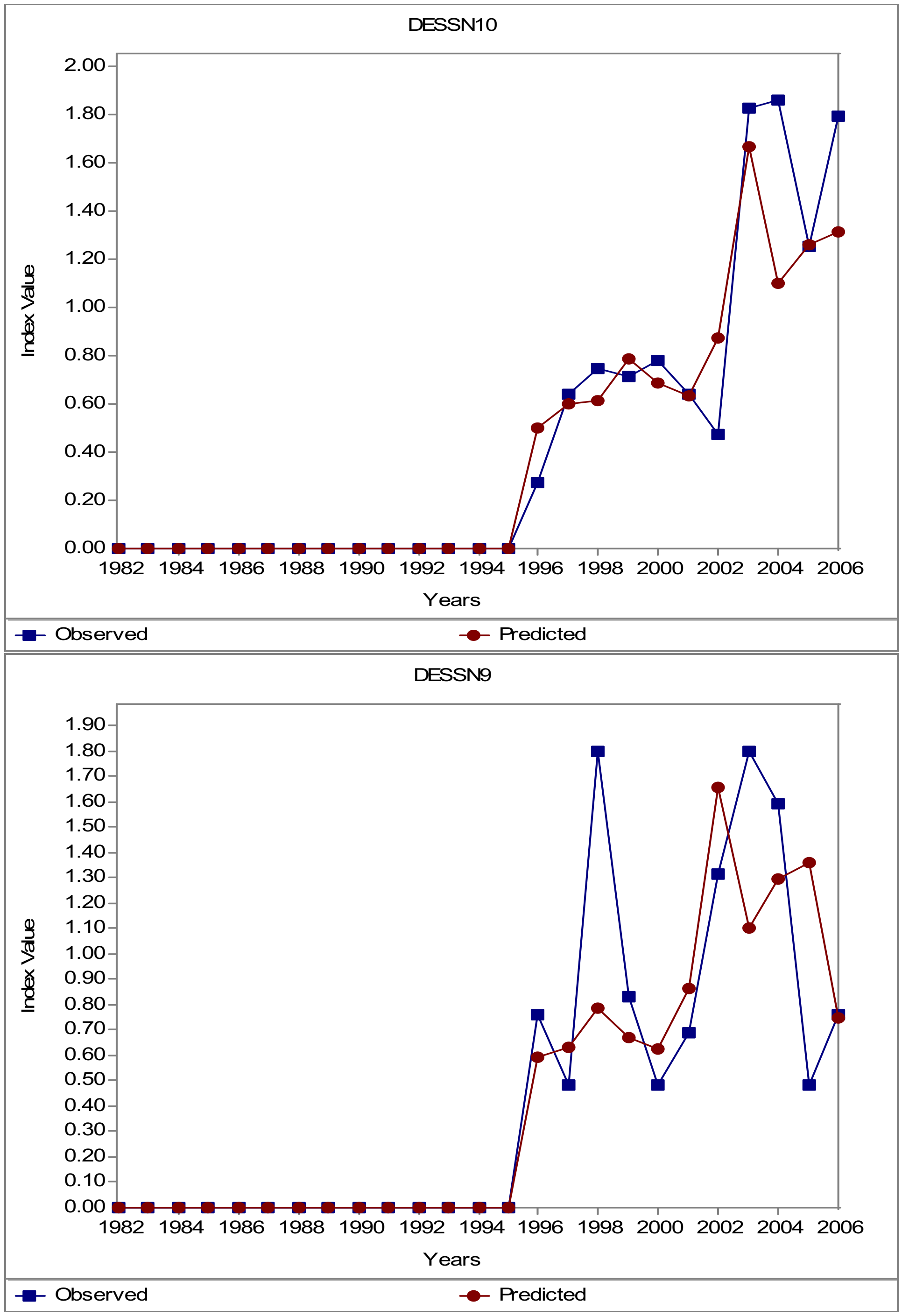

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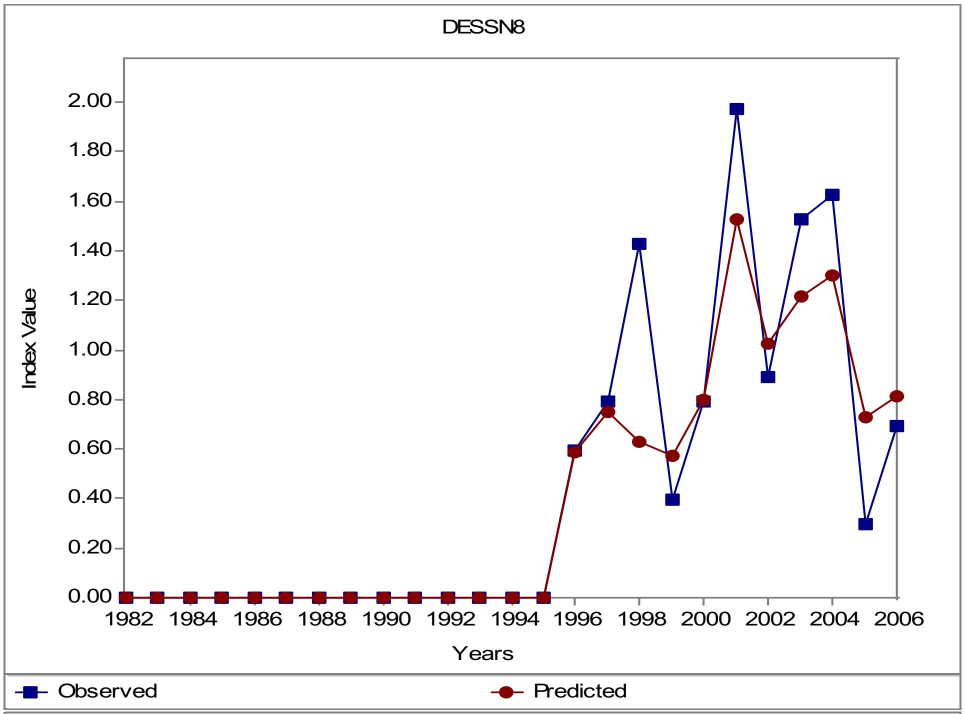

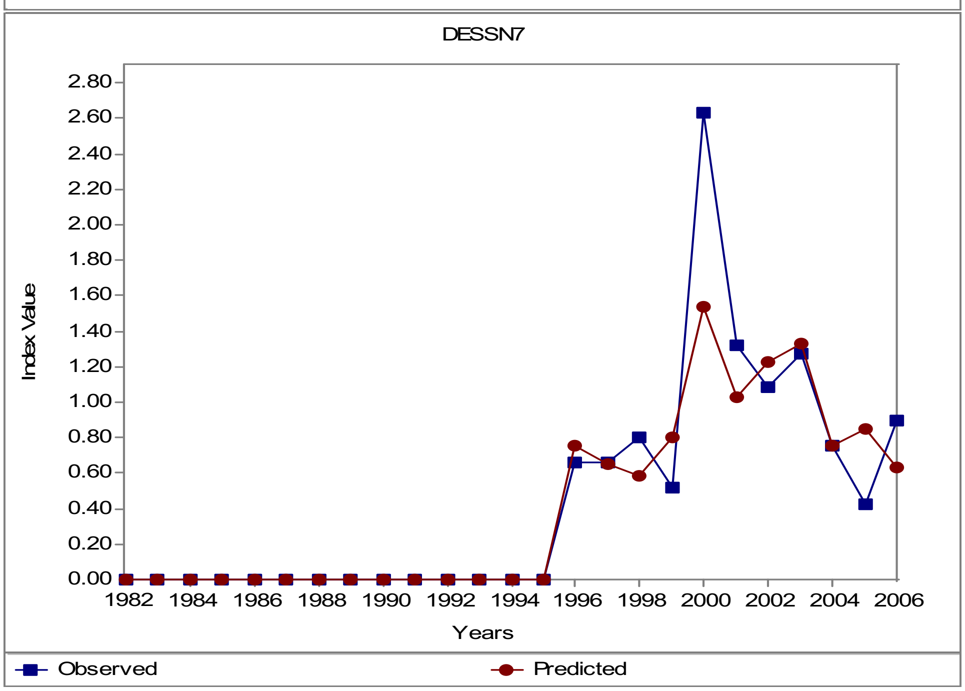

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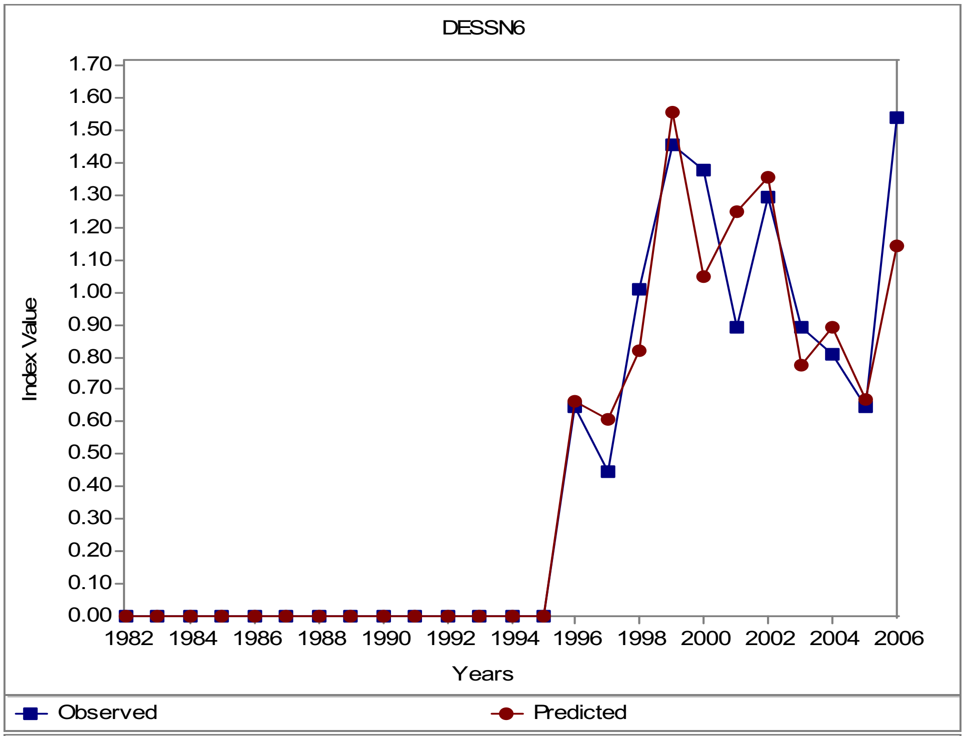

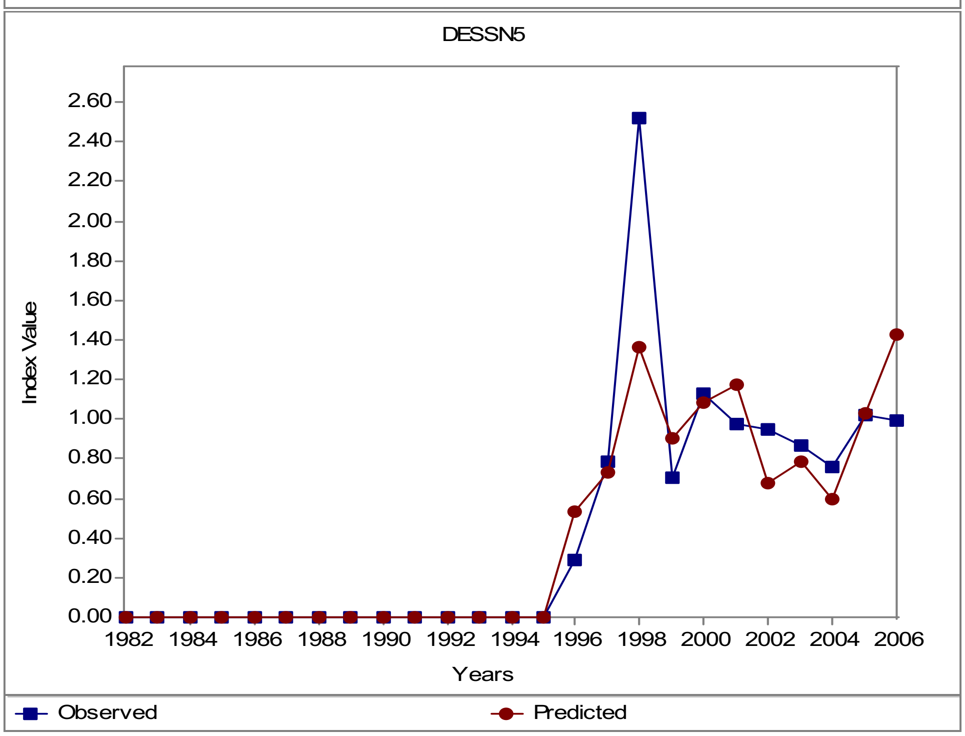

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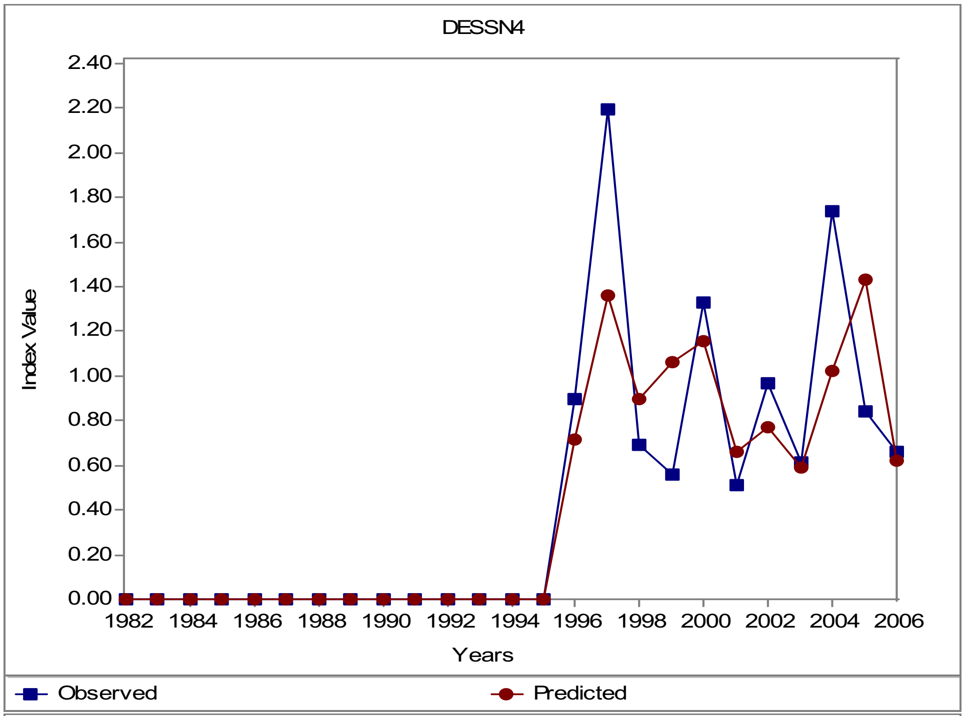

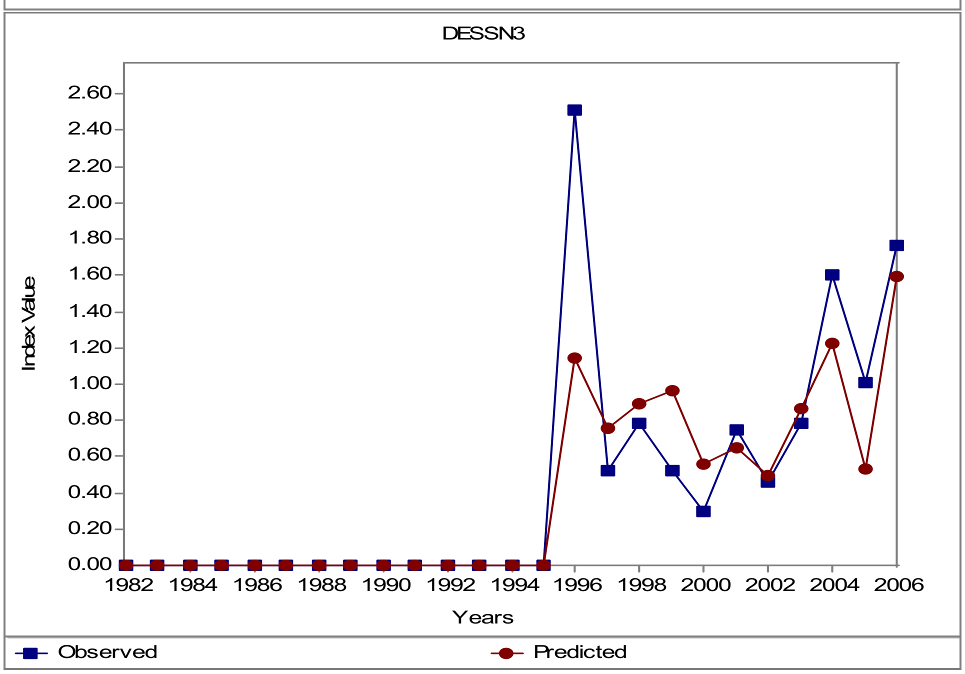

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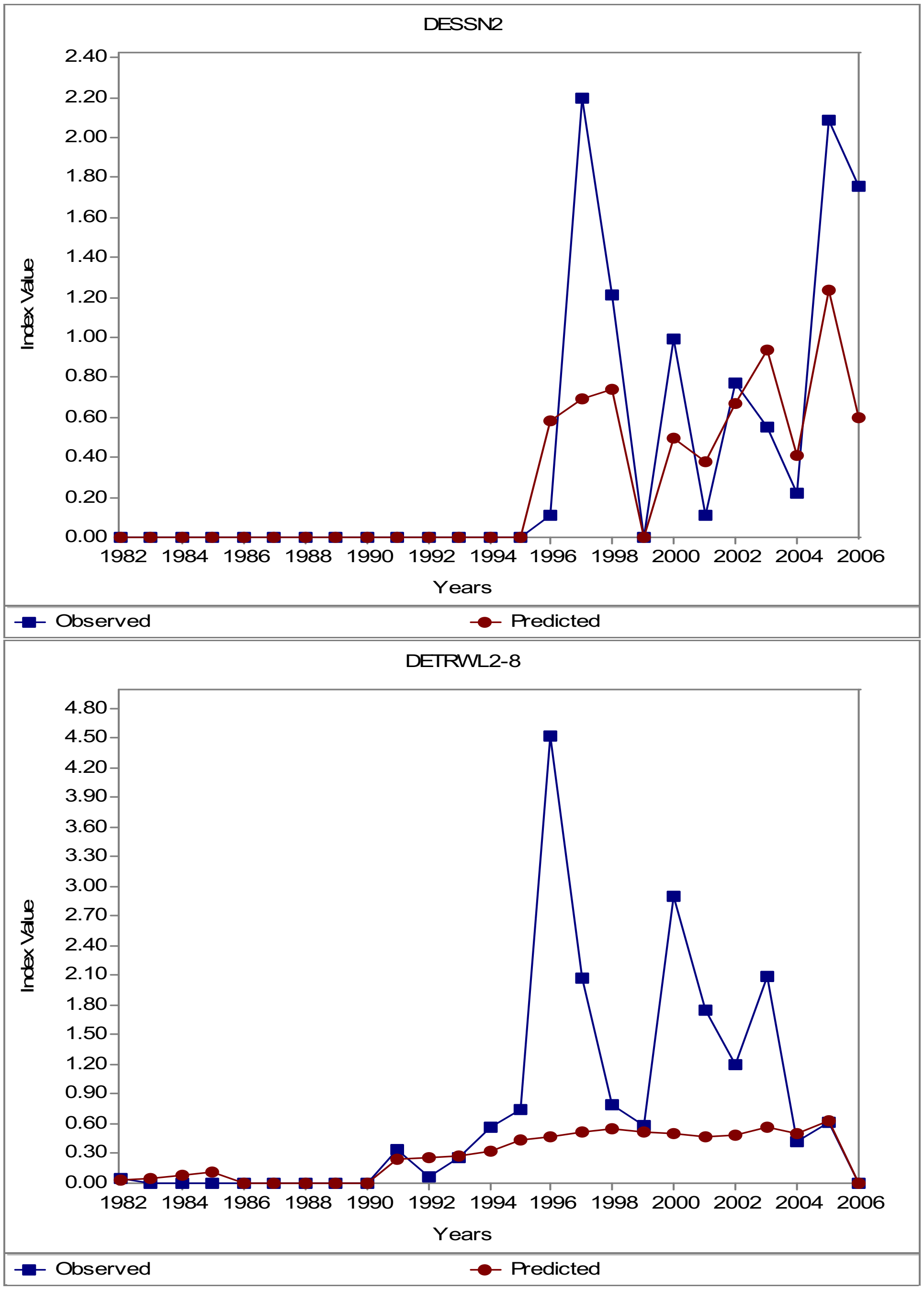

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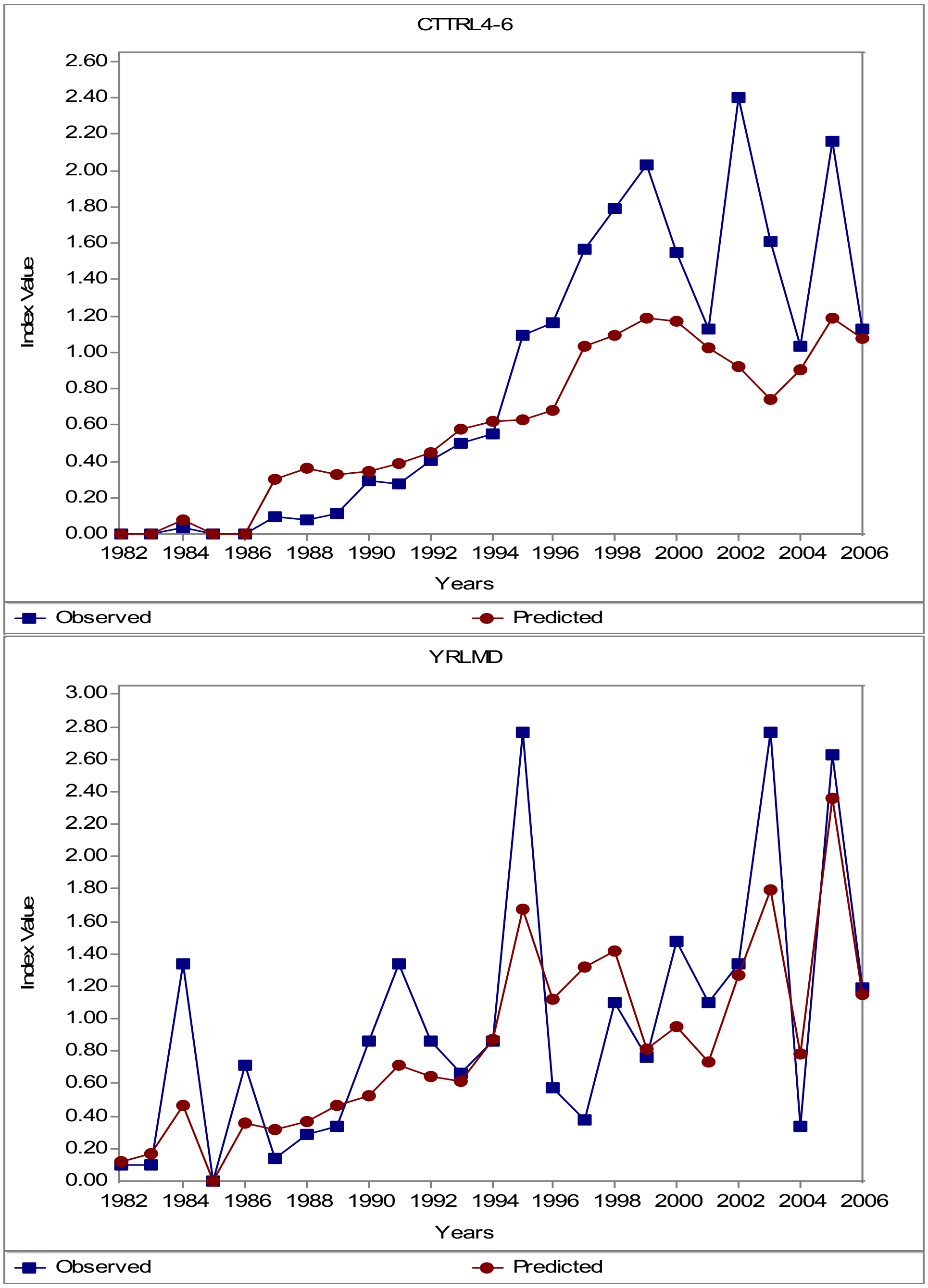

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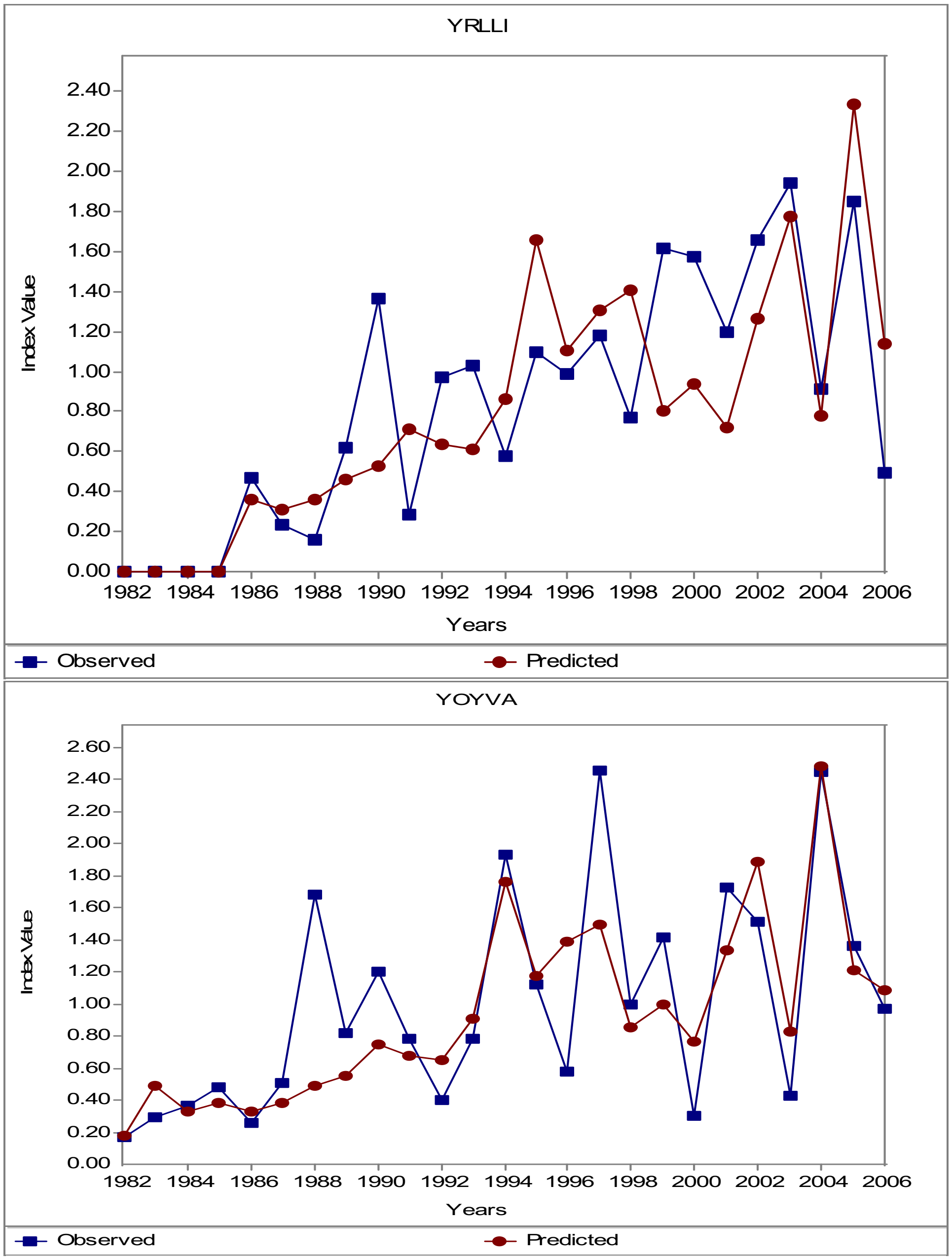

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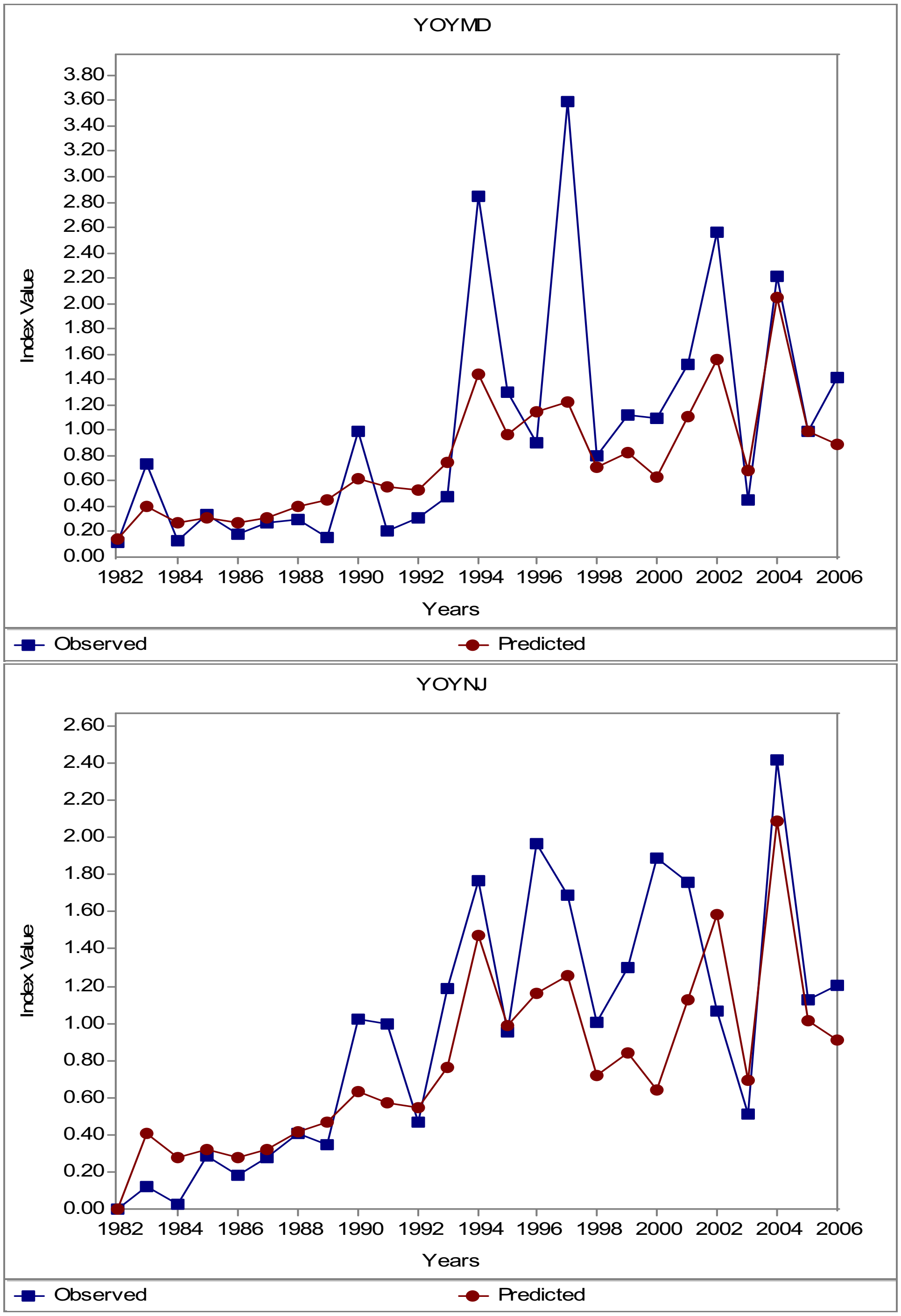

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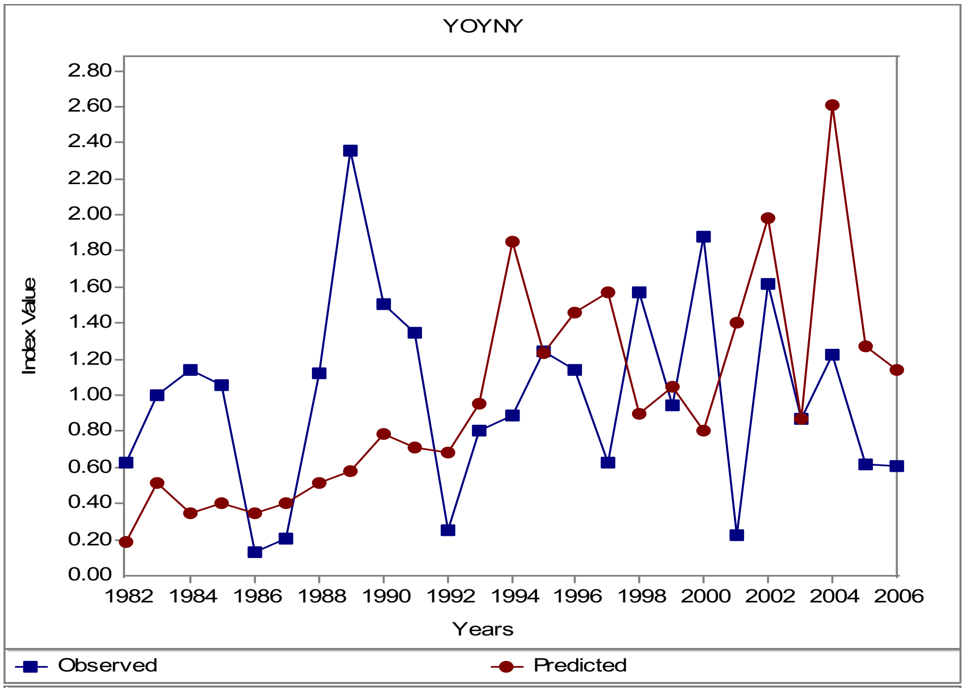

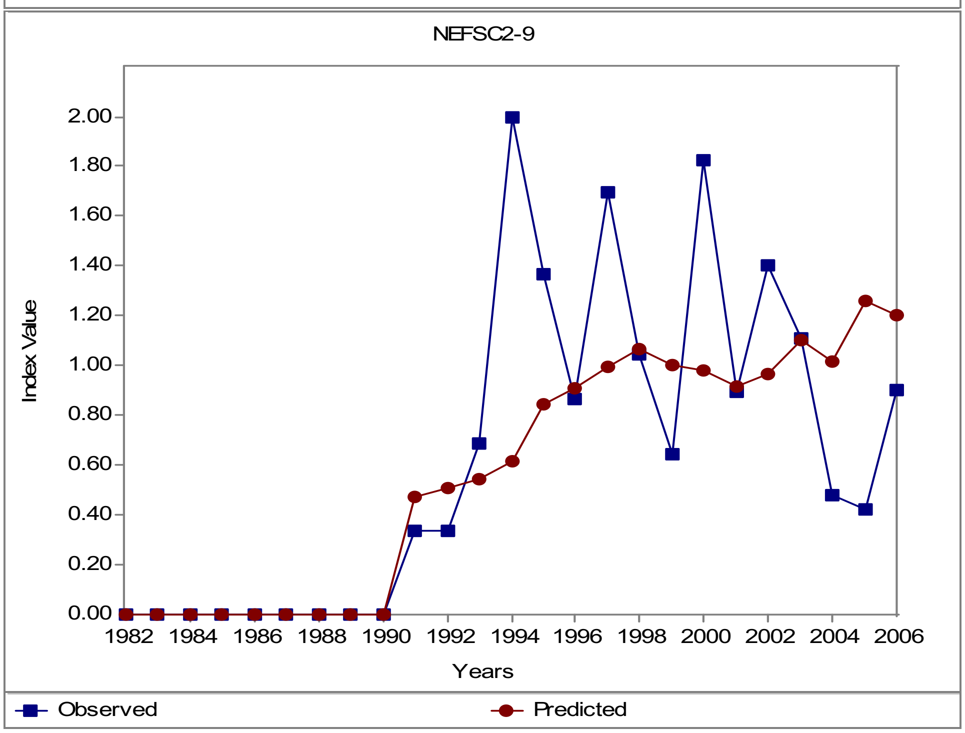

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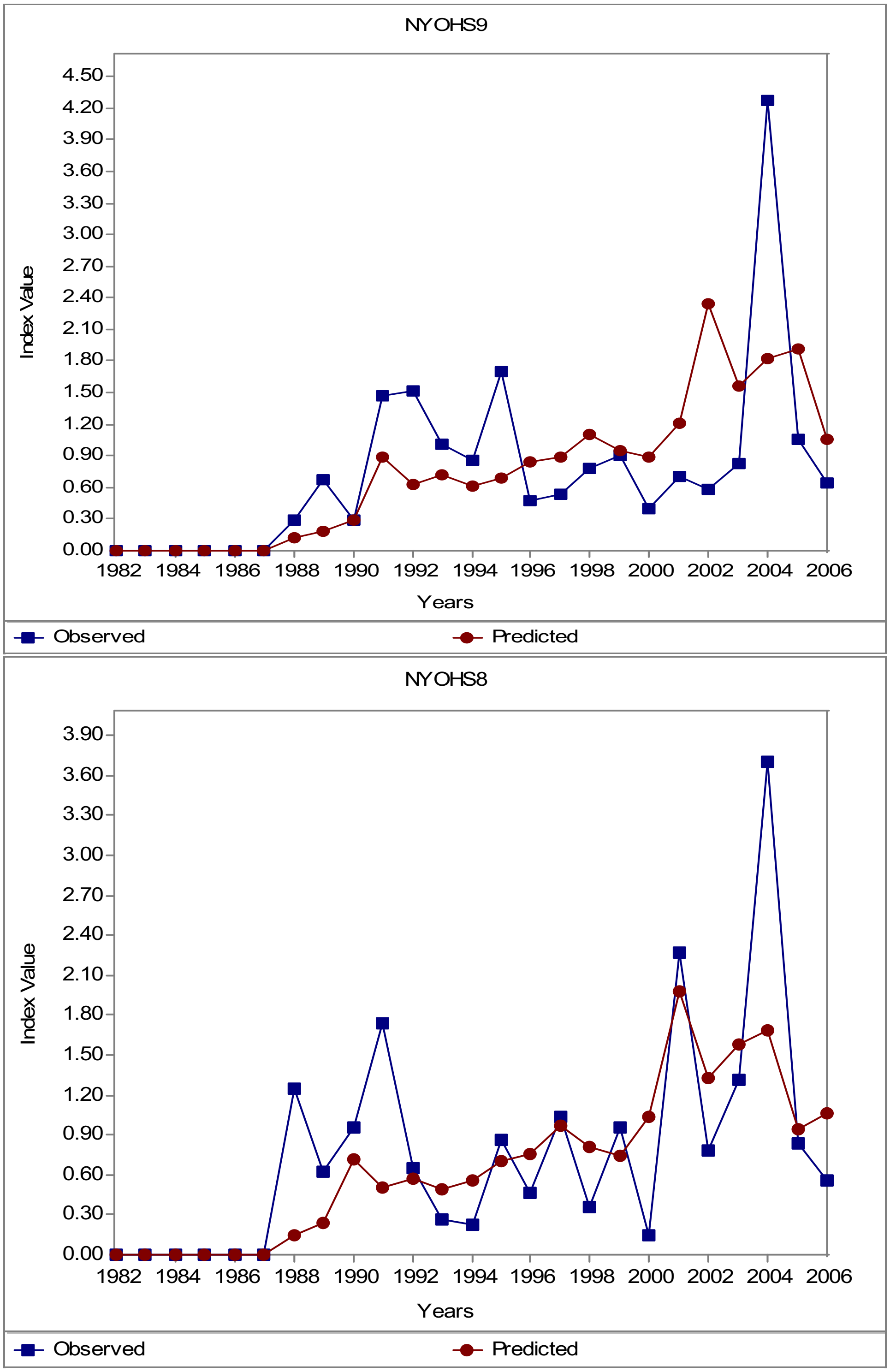

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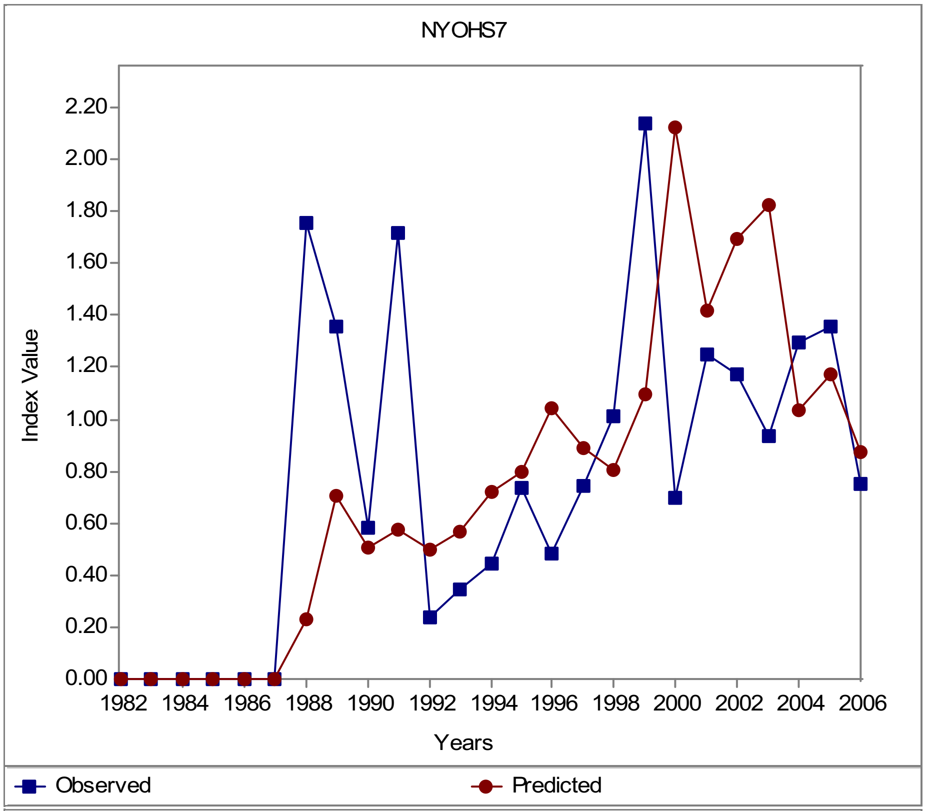

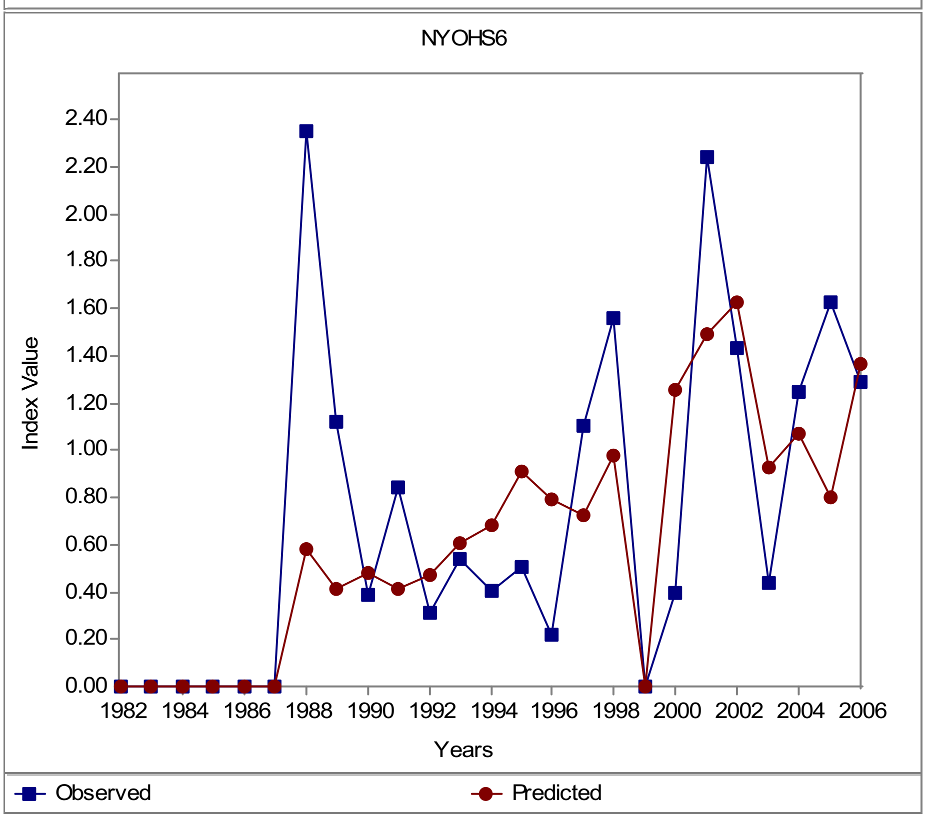

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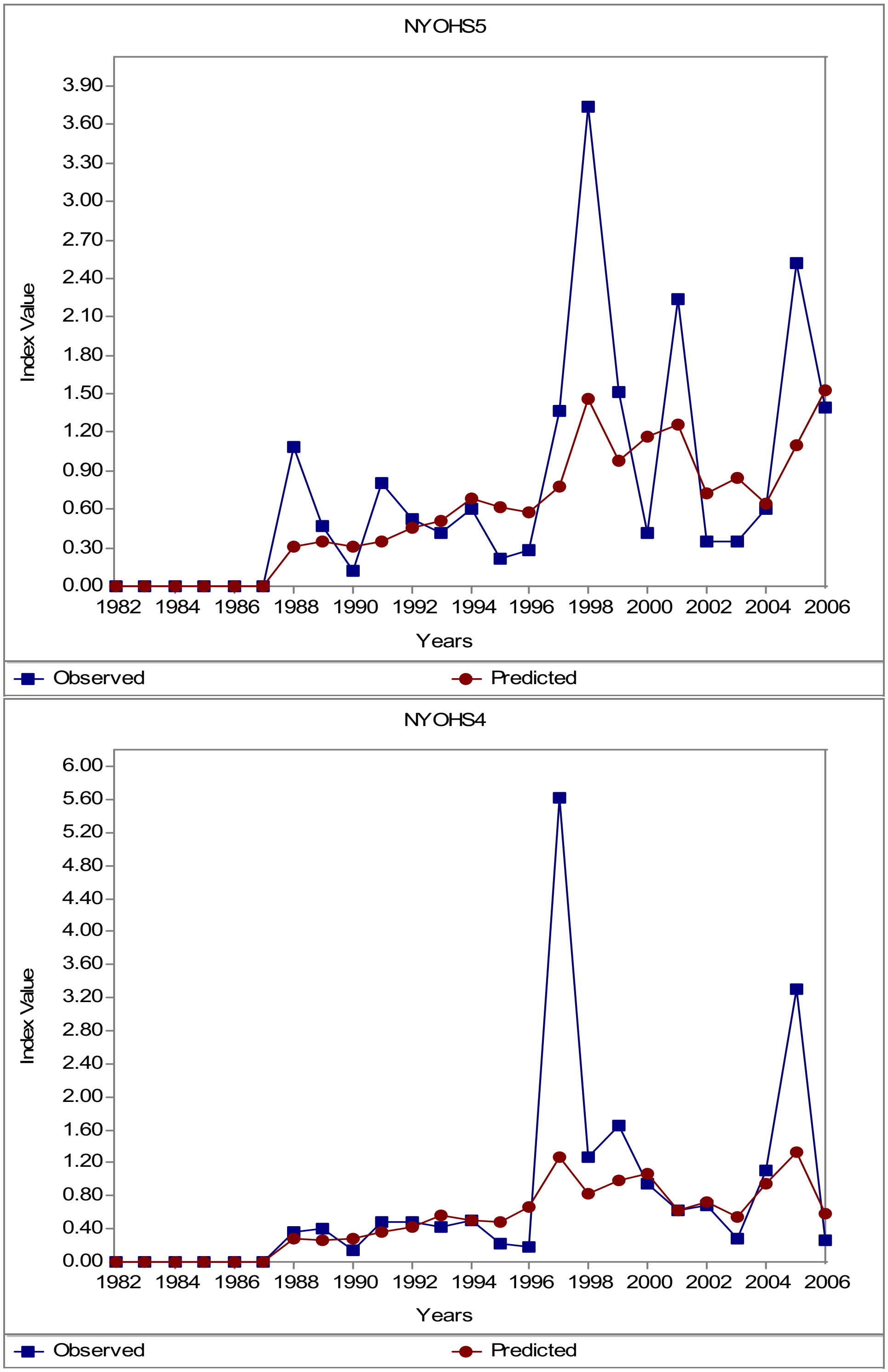

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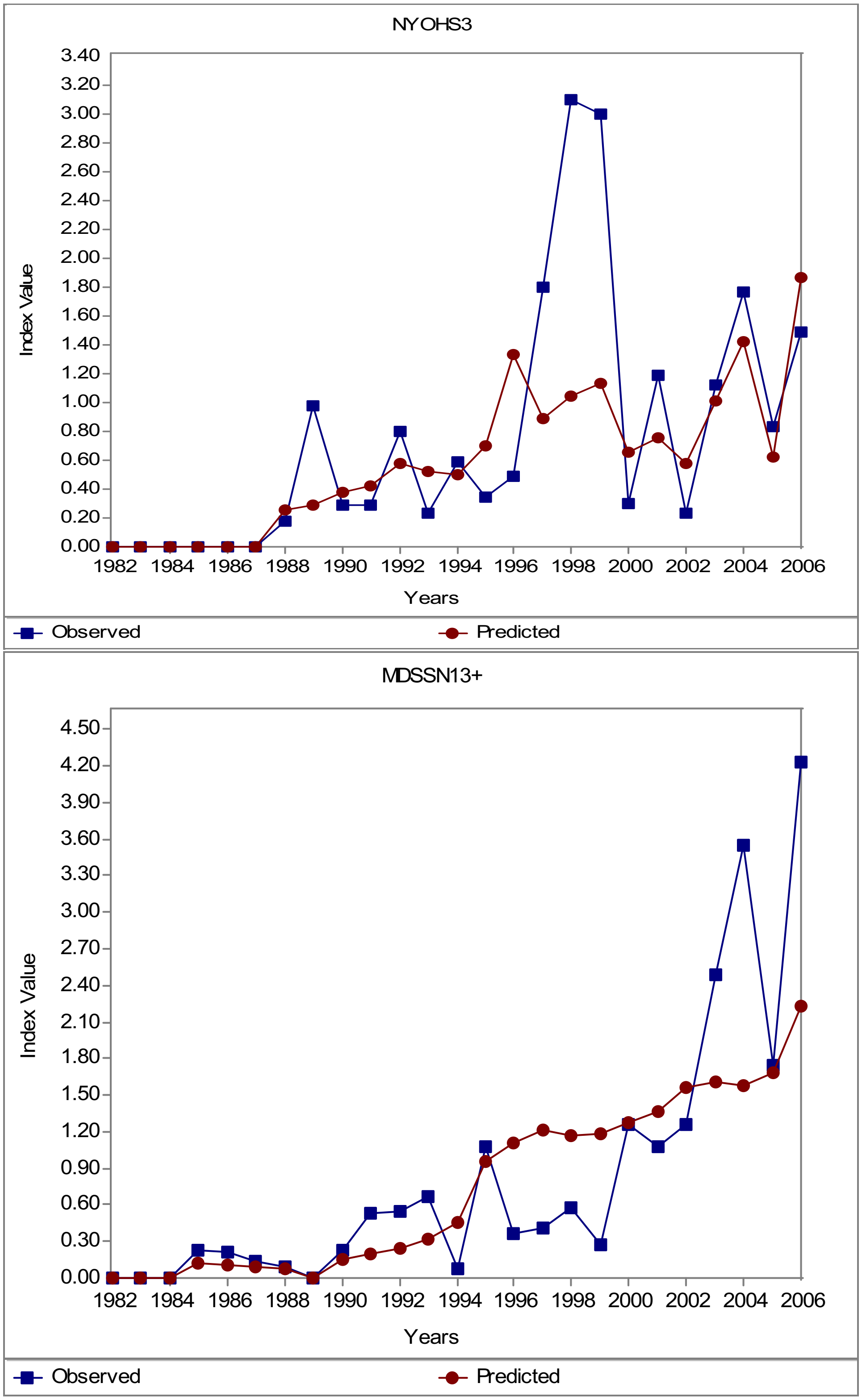

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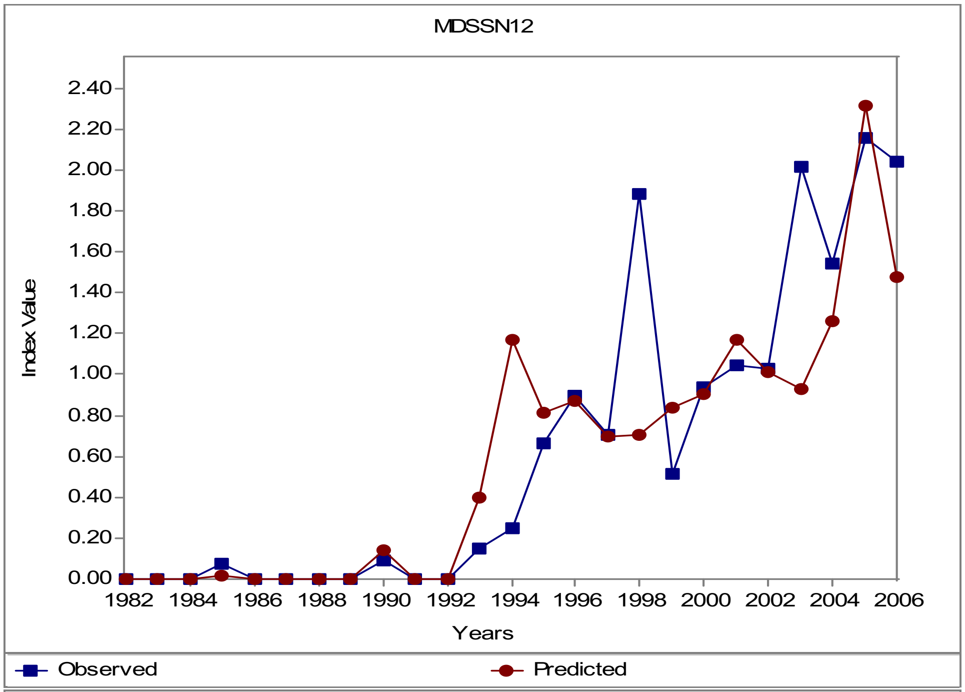

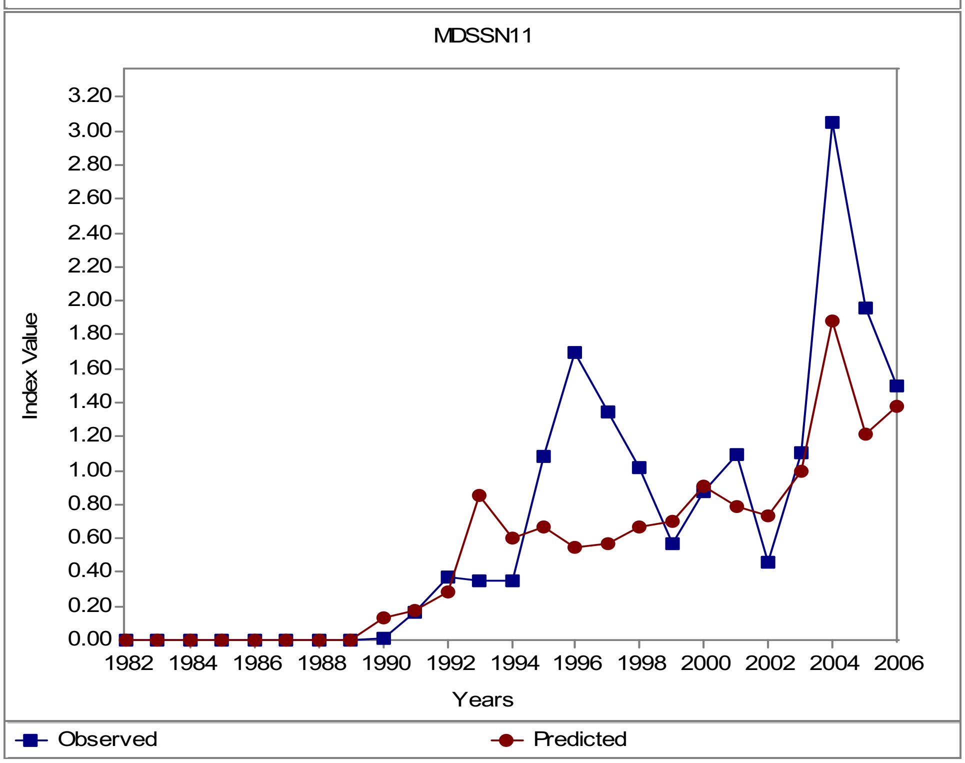

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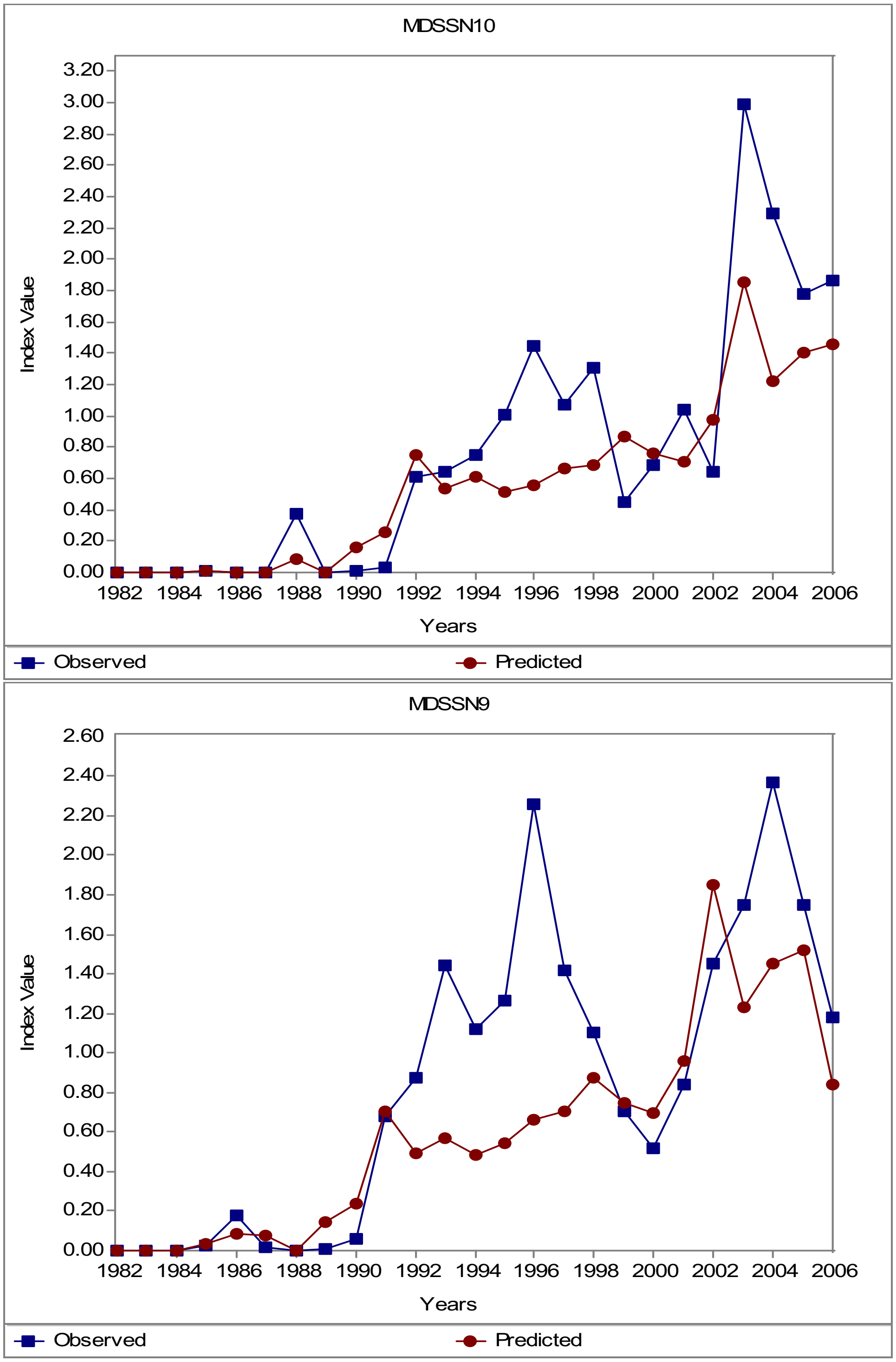

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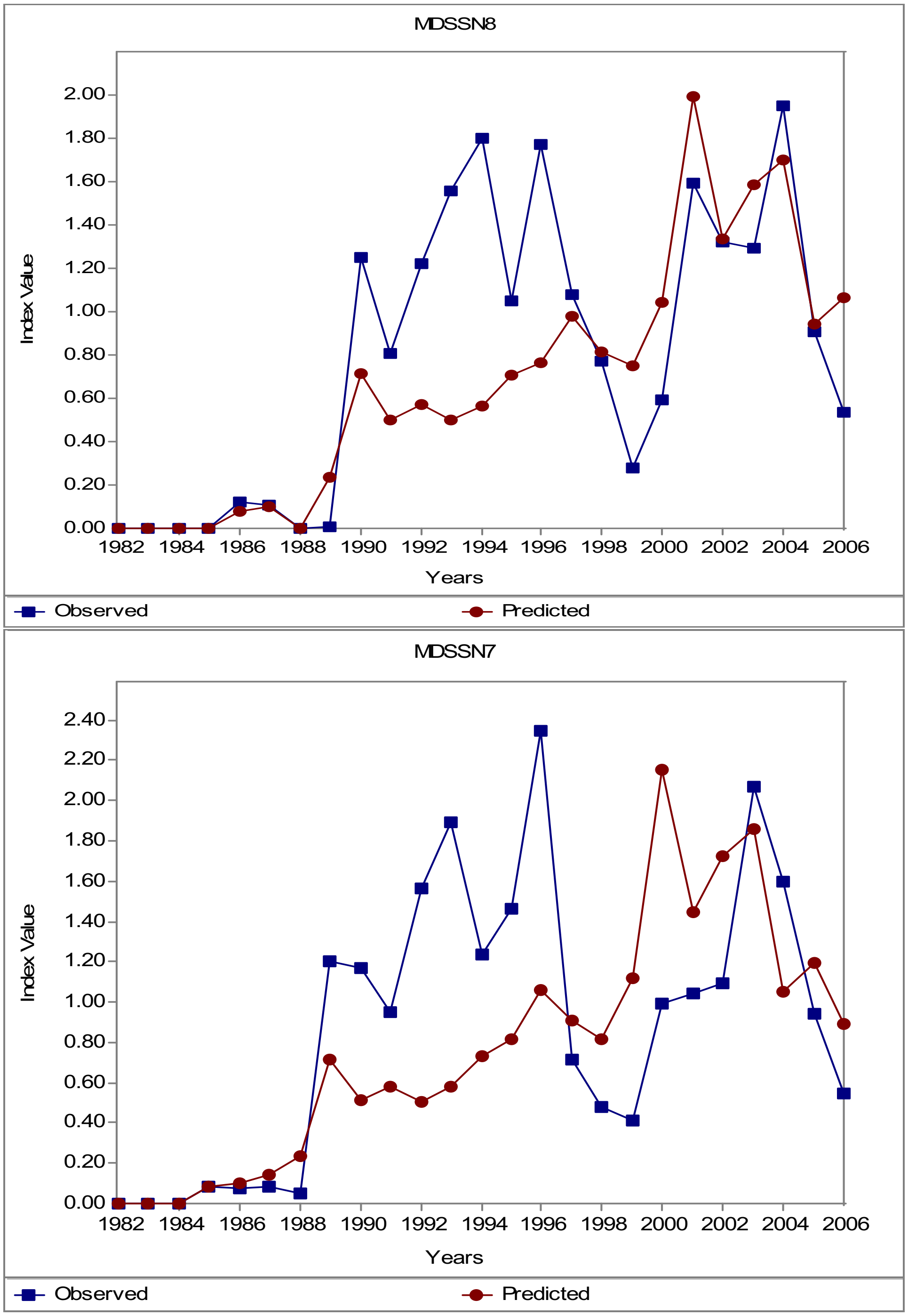

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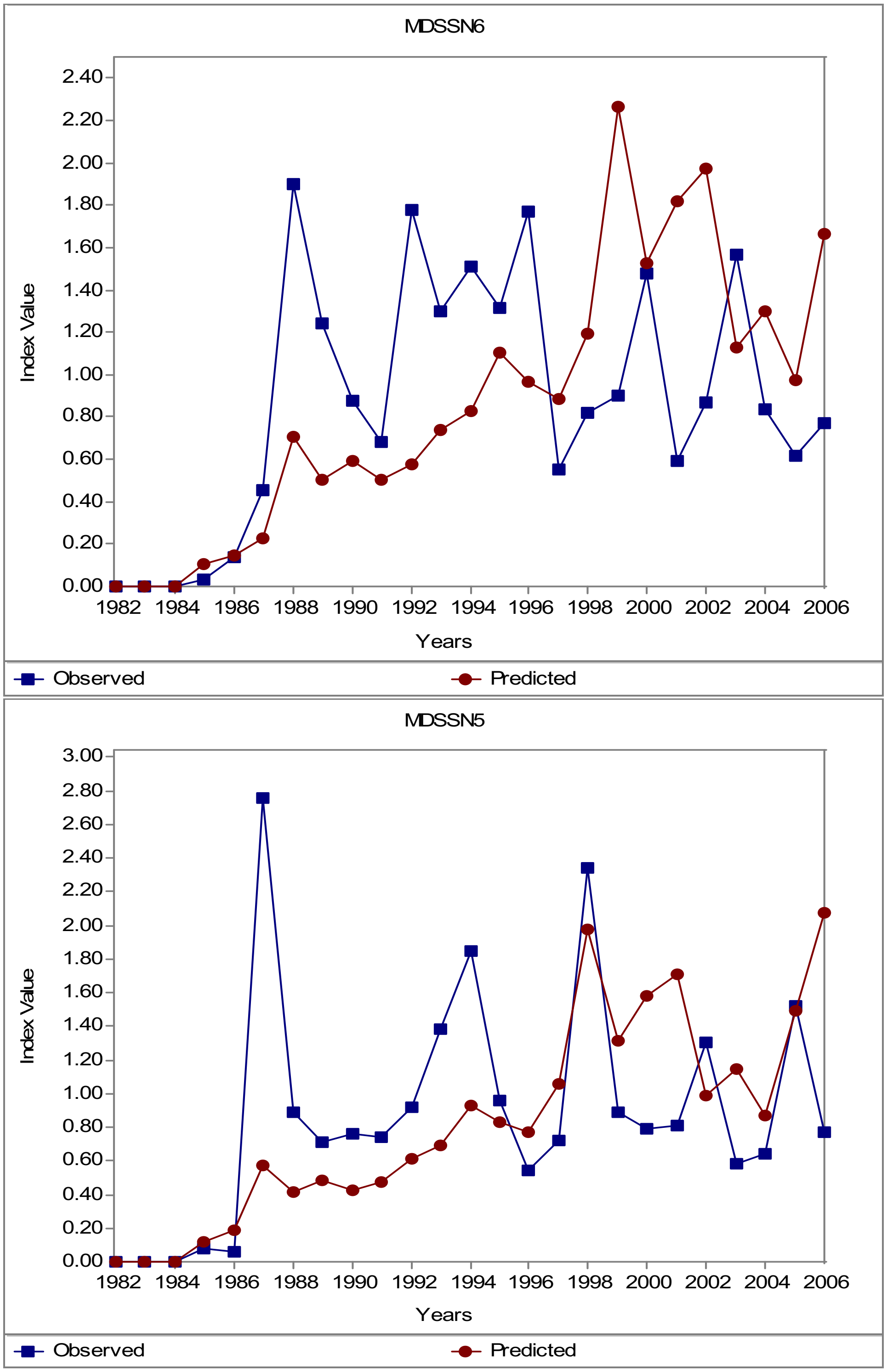

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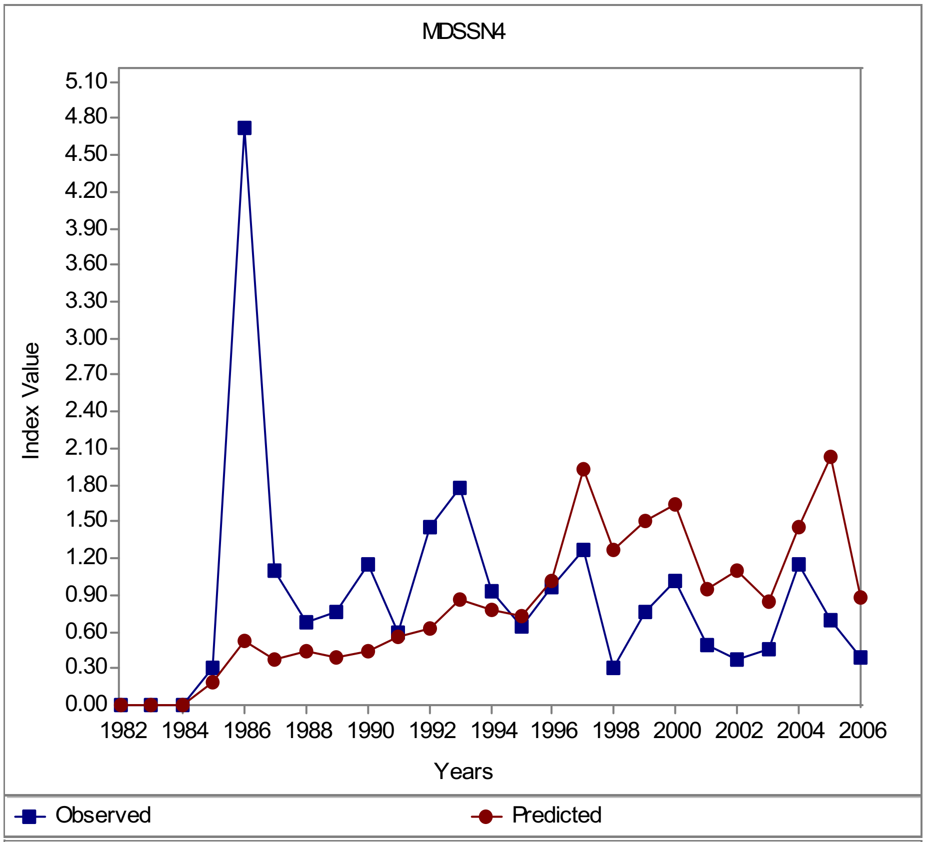

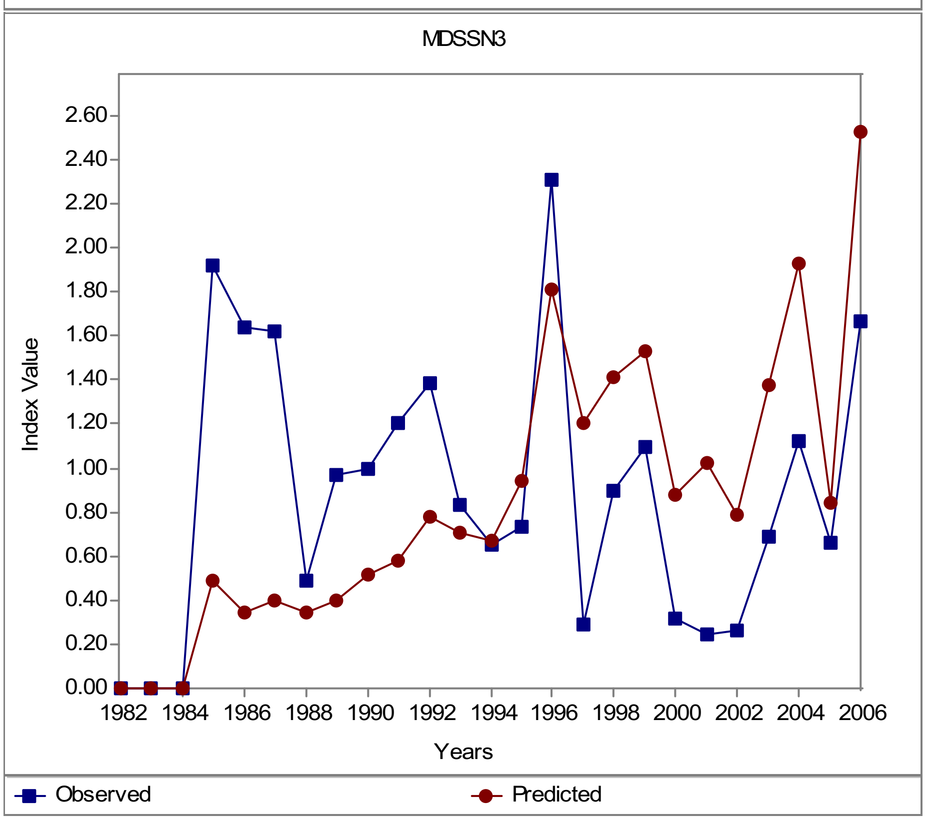

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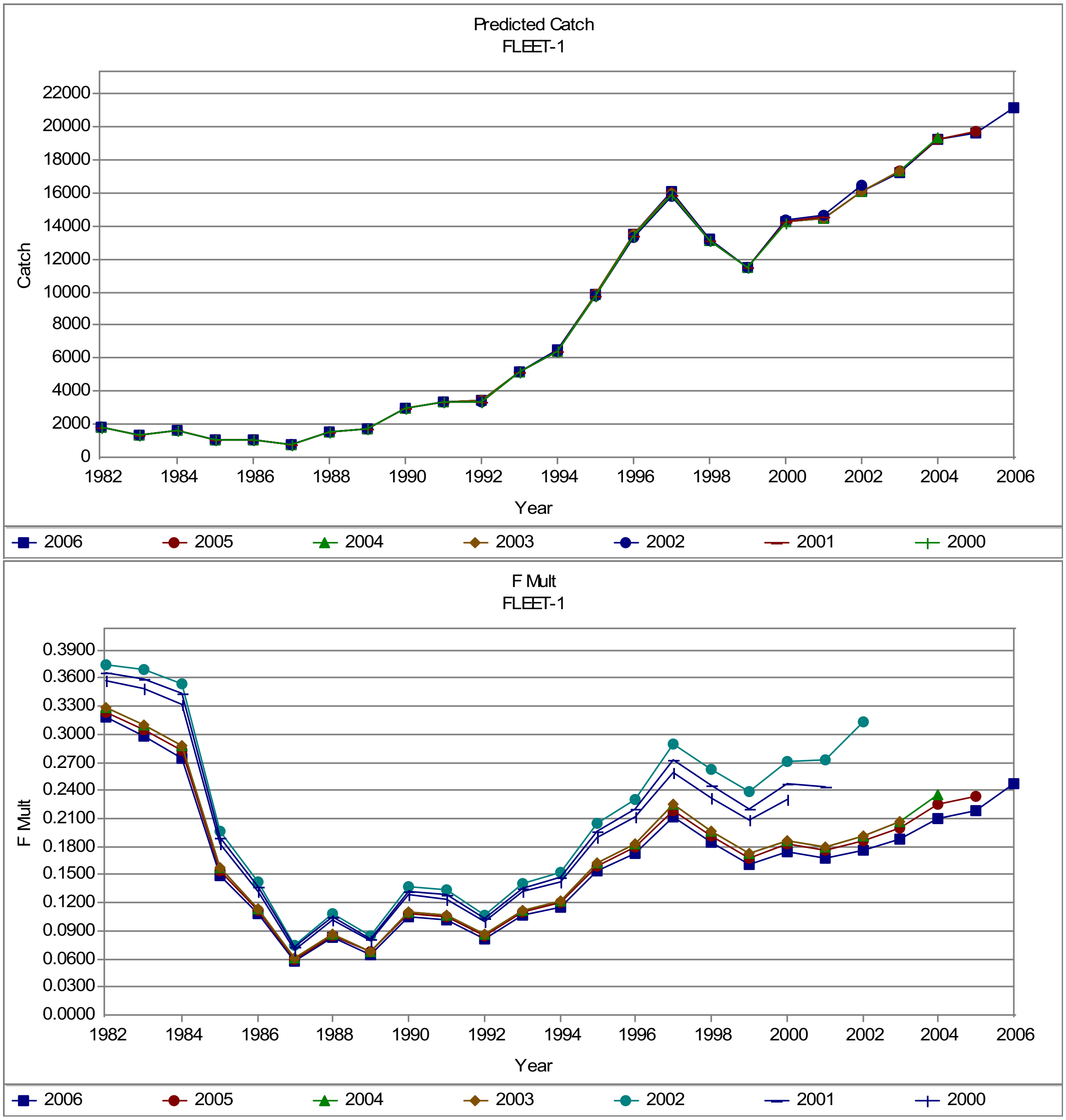

Figure 4. Retrospective patterns of catch and F estimates from ASAP model.

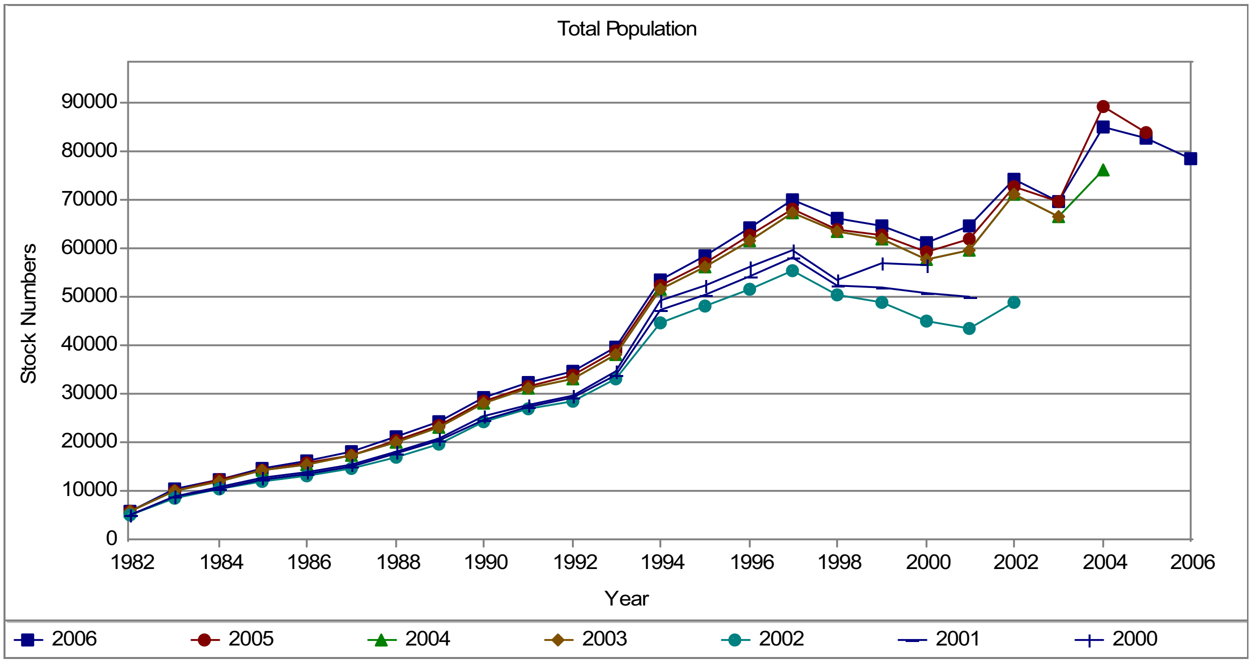

Figure 5. Retrospective patterns of total abundance from ASAP model.

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

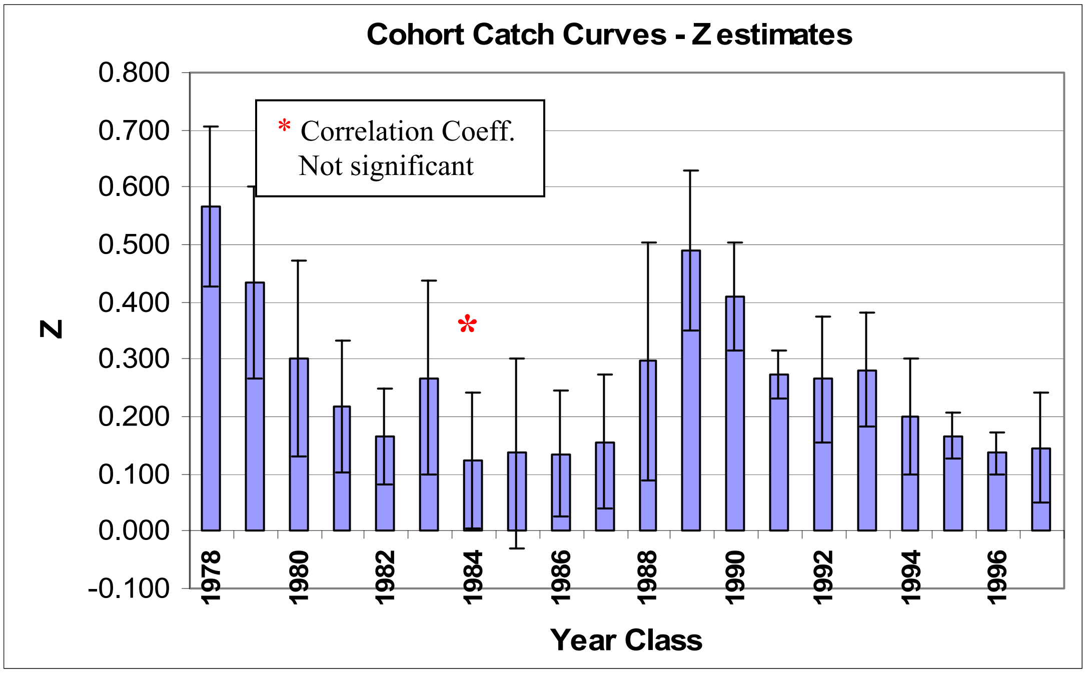

Figure 1. Catch Curve Z estimates (95% confidence intervals) - Parametric analysis

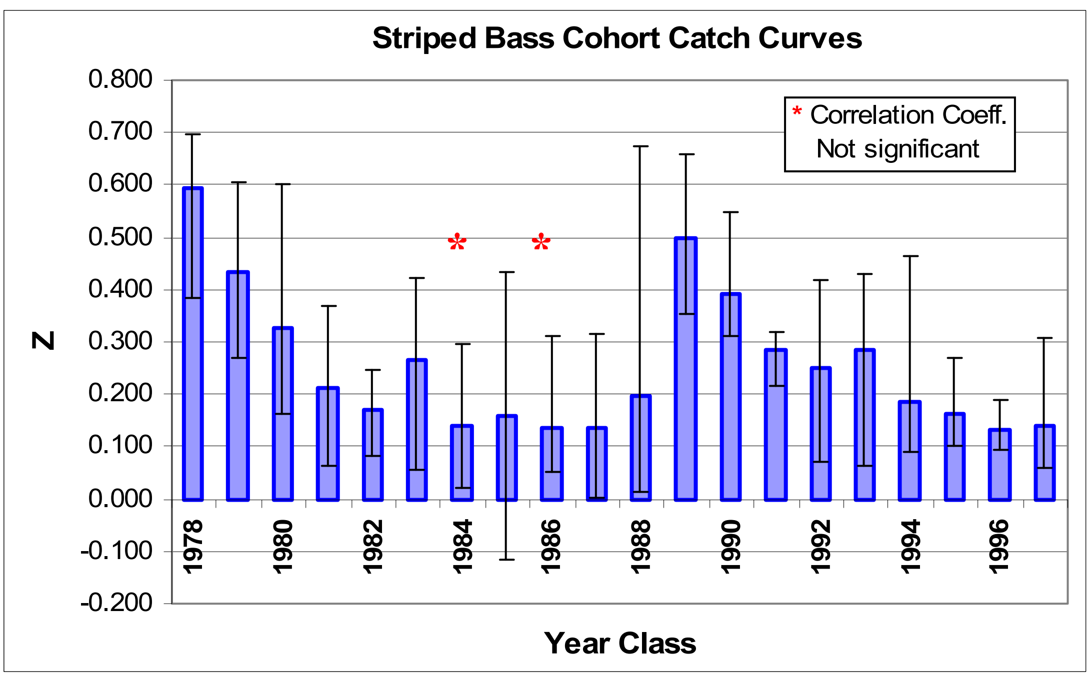

Figure 2. Catch Curve Z estimates (95% confidence intervals) – Nonparametric estimates

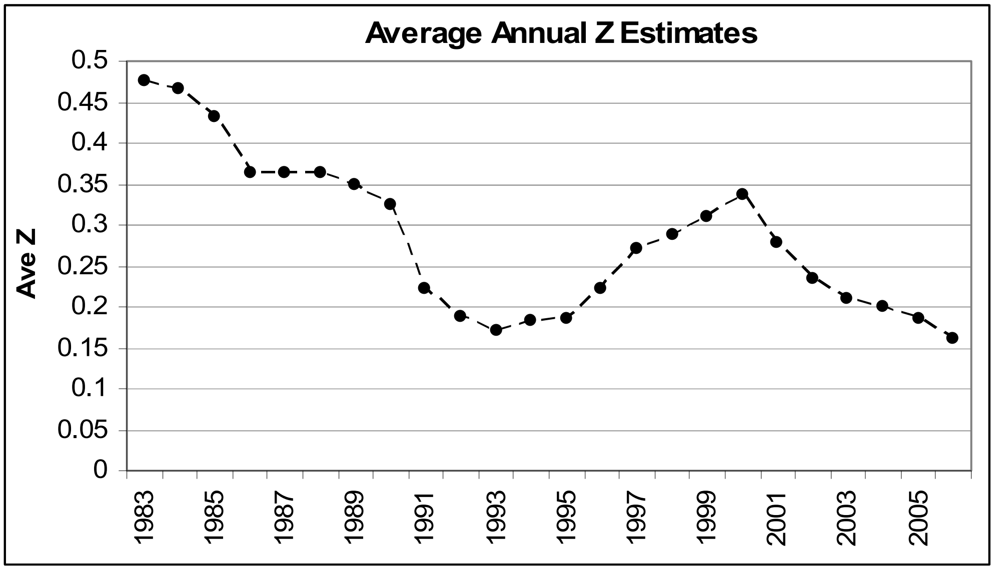

Figure 3. Average total mortality of striped bass by year using cohort specific catch curve estimates.

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:

$$\mathbf{RelFt = Catcht / [(RelNt + RelNt{+}1)/2].} \quad \mathbf{(2)}$$

Equation (2) is very similar to the equation introduced earlier by Sinclair (1998) except that he used relative exploitation:

$$\mathbf{Relu = Catch / RelNt} \qquad \mathbf{(3)}$$

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.

References

Cotter AJR, Burt L, Paxton CGM, Fernandez C, Buckland ST, Pan JX. 2004. Are stock assessment methods too complicated? Fish and Fisheries 2004, %, 235-254.

CreccoVA. 2004. Further analyses on the 2003 fishing mortality (F) on striped bass based on landings and effort data from Connecticut. Report to the ASMFC Striped Bass Technical Committee. September 2004. 23 p.

Nelson G. 2007. A forward-projecting Statistical Catch-at-Age model for striped bass. Report to the Striped Bass Stock Assessment Subcommittee. August, 2007. 45 p.

Ricker WE. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. J Fish Res Bd Can Bull. 191:382 p.

Statistical Analysis System (SAS). 2002. Users Guide to Syntax, Procedures and Concepts: Section on Methods of Bayesian Confidence Intervals. 425 p.

Sinclair AF. 1998. Estimating trends in fishing mortality at age and length directly from research survey and commercial catch data. Can J Fish Aquat Sci. 55:1248-1263.

Versak B. 2007. ASMFC Striped Bass Tagging Subcommittee summary of USFWS Cooperative Tagging results. Report to the Striped Bass Stock Assessment. Subcommittee. August, 2007. 56 p.

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

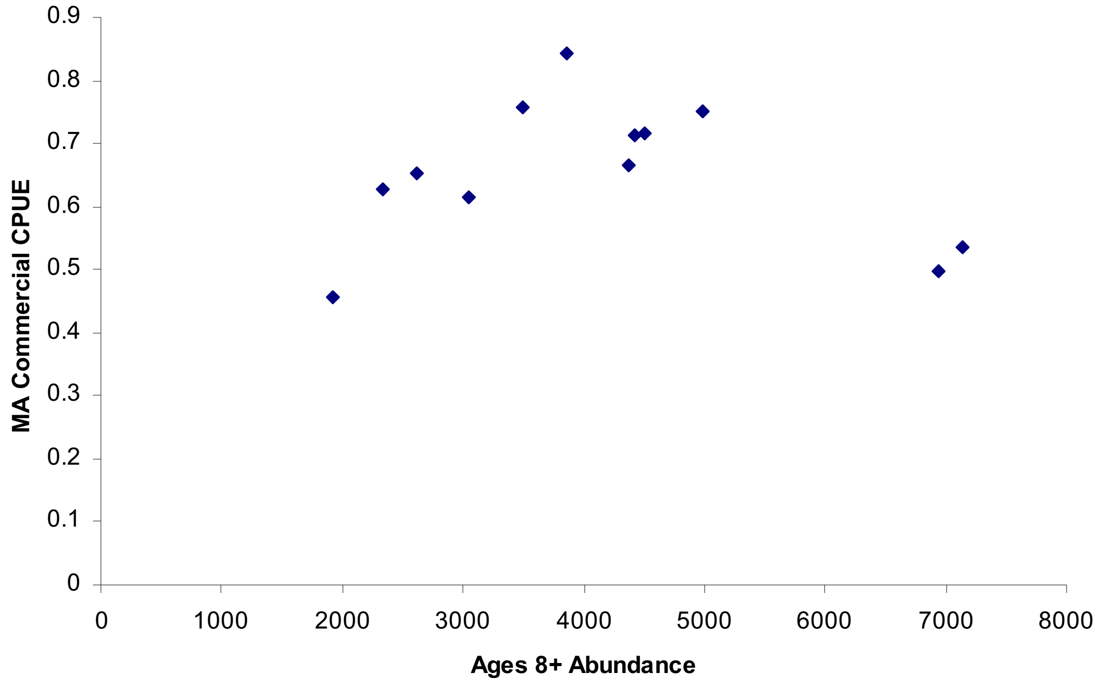


Figure 1. MA Commercial CPUE (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

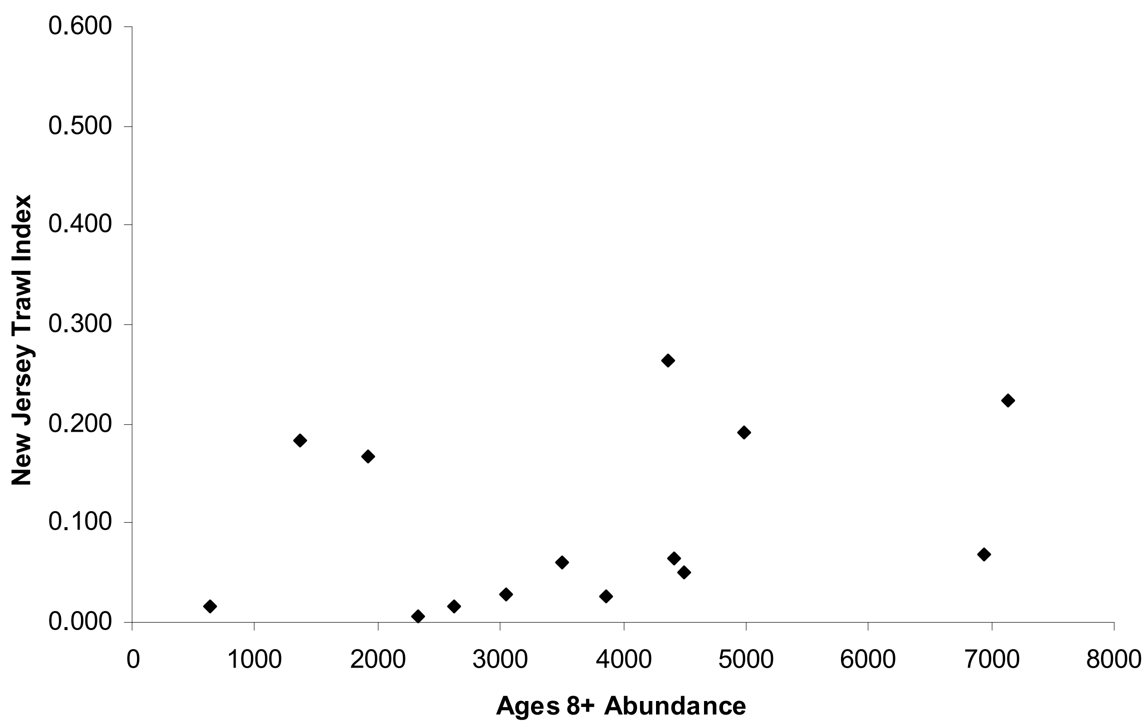


Figure 2. New Jersey Trawl Index (Ages 8+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

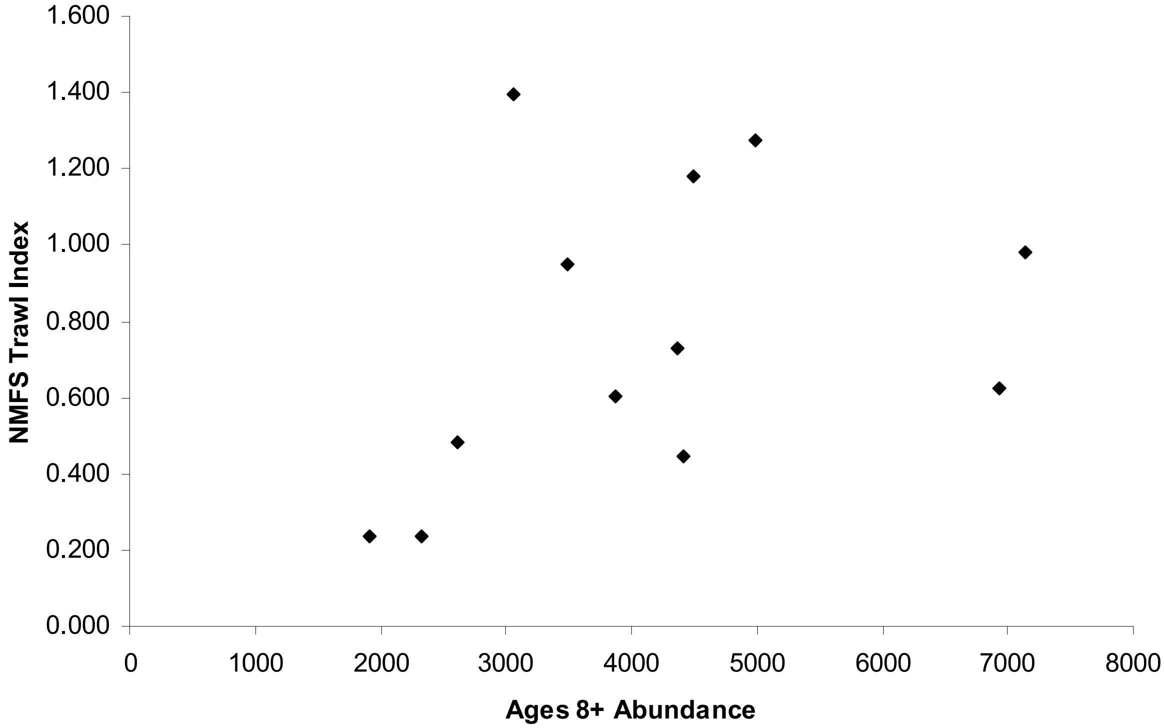


Figure 3. Delaware Spawning Stock Index (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

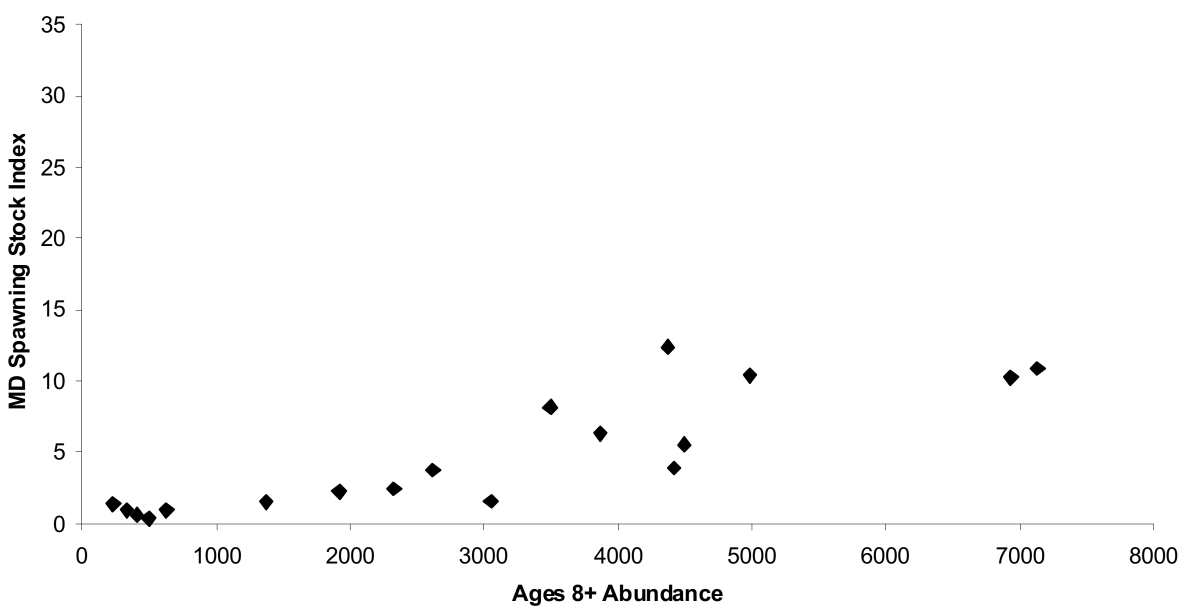


Figure 4. NMFS Trawl Index (Ages 2+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

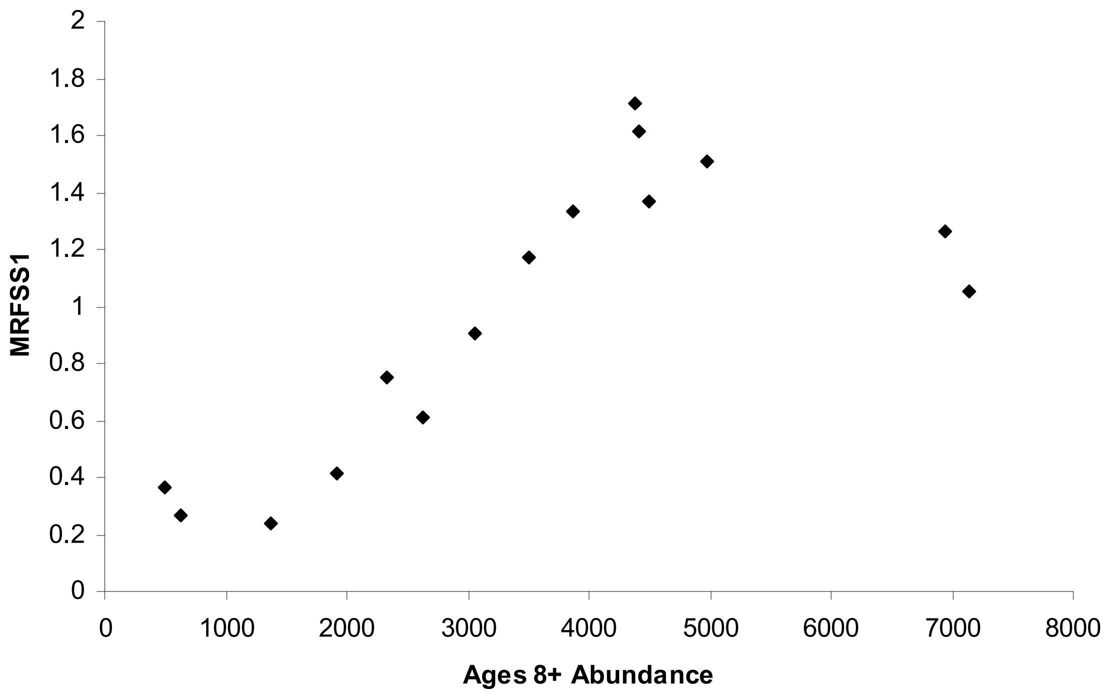


Figure 5. Maryland Spawning Stock Index (Ages 8+) plotted against age 8+ abundance based on SCAM model1982-2002

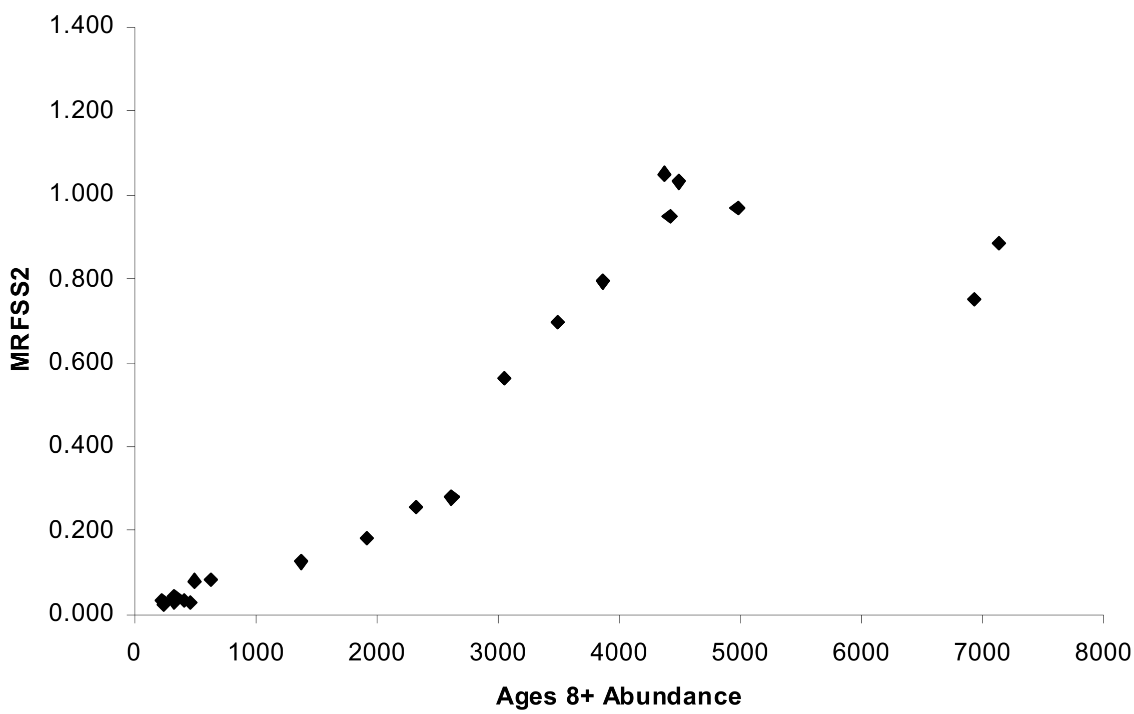


Figure 6.Sport1 CPUE Index based (ages 2+) on private boat intercepts plotted against ages 8+ abundance based on SCAM model, 1982-2002

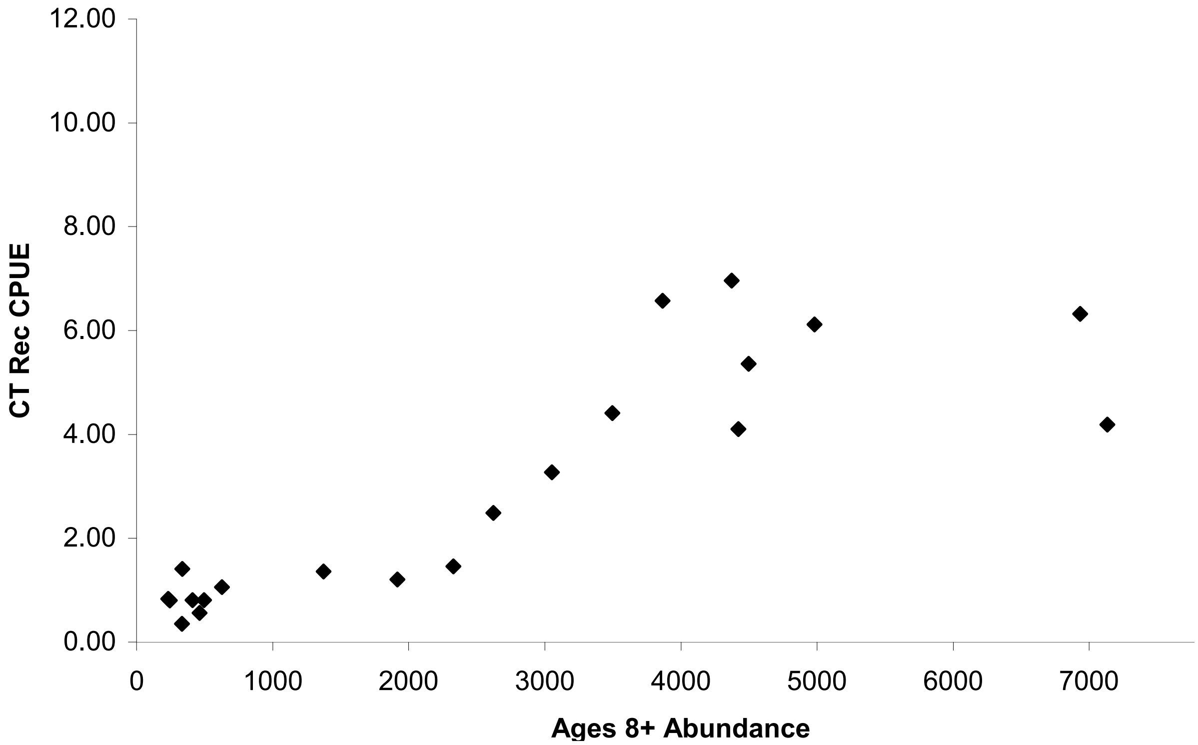


Figure 7. Sport2 CPUE Index based (ages 2+) on private boat data from north and mid-Atlantic combined plotted against ages 8+ abundance based on SCAM model, 1982-2002

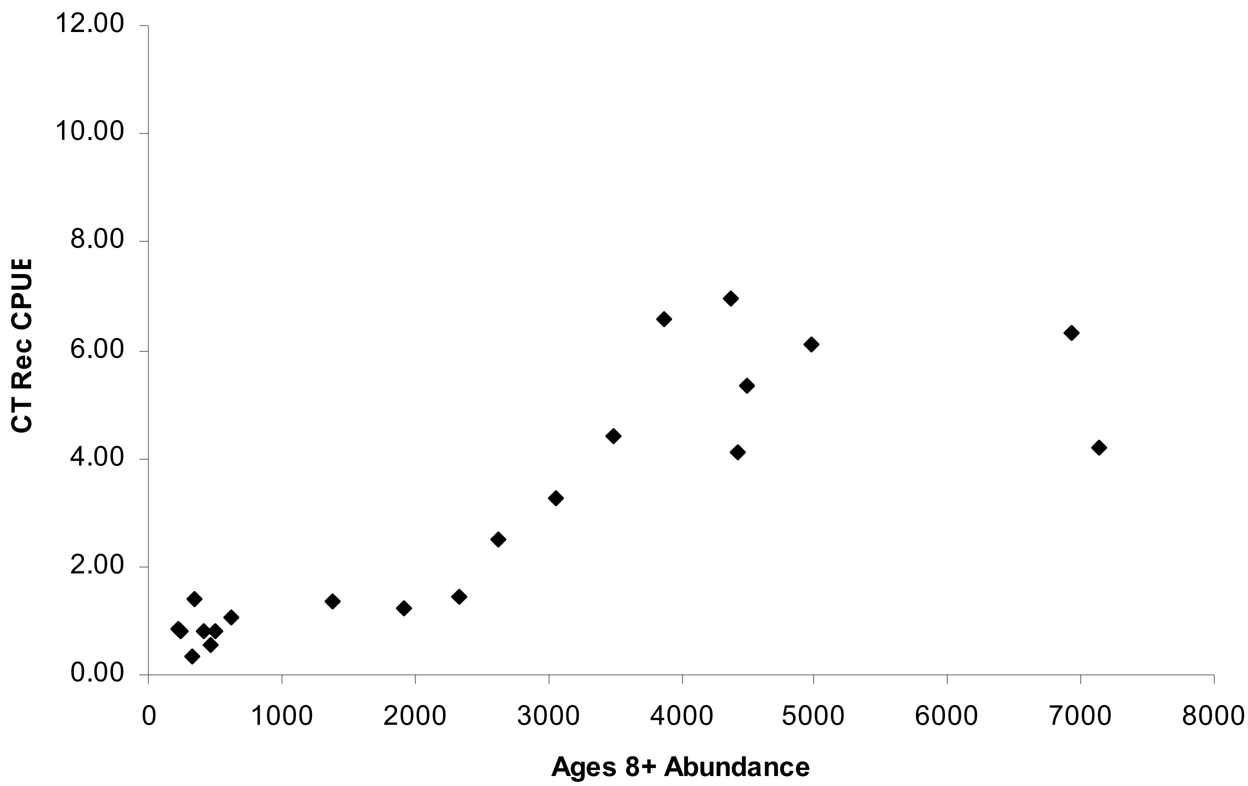


Figure 8. Connecticut Recreational CPUE (ages 3+) based on volunteer angler survey plotted against ages 8+ abundance based on SCAM model, 1982-2002

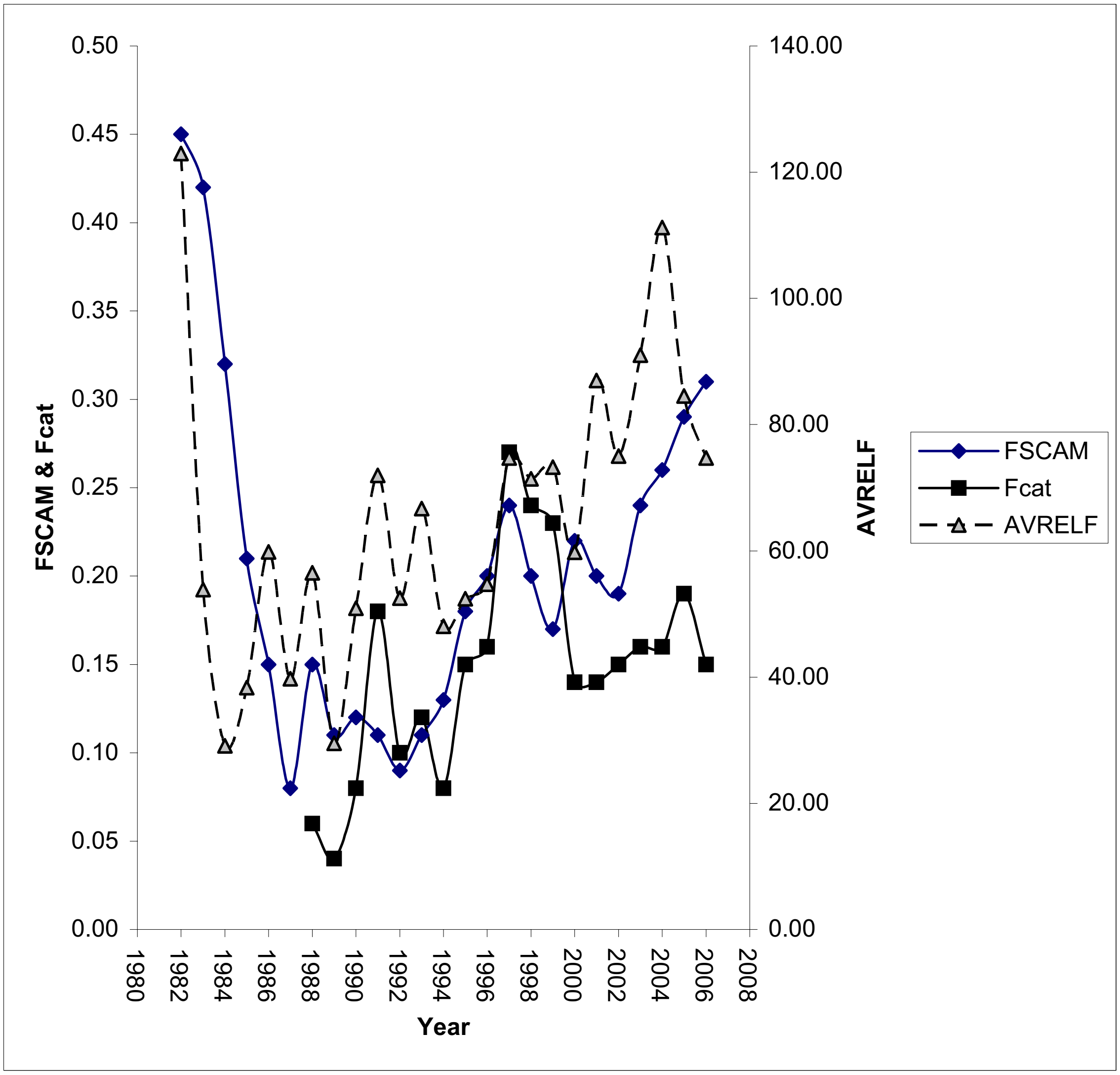


Figure 9. Comparison among the blended relative F (AVRELF), F from SCAM (FSCAM) and the F from the catch equation (Fcat) from 1982 to 2006

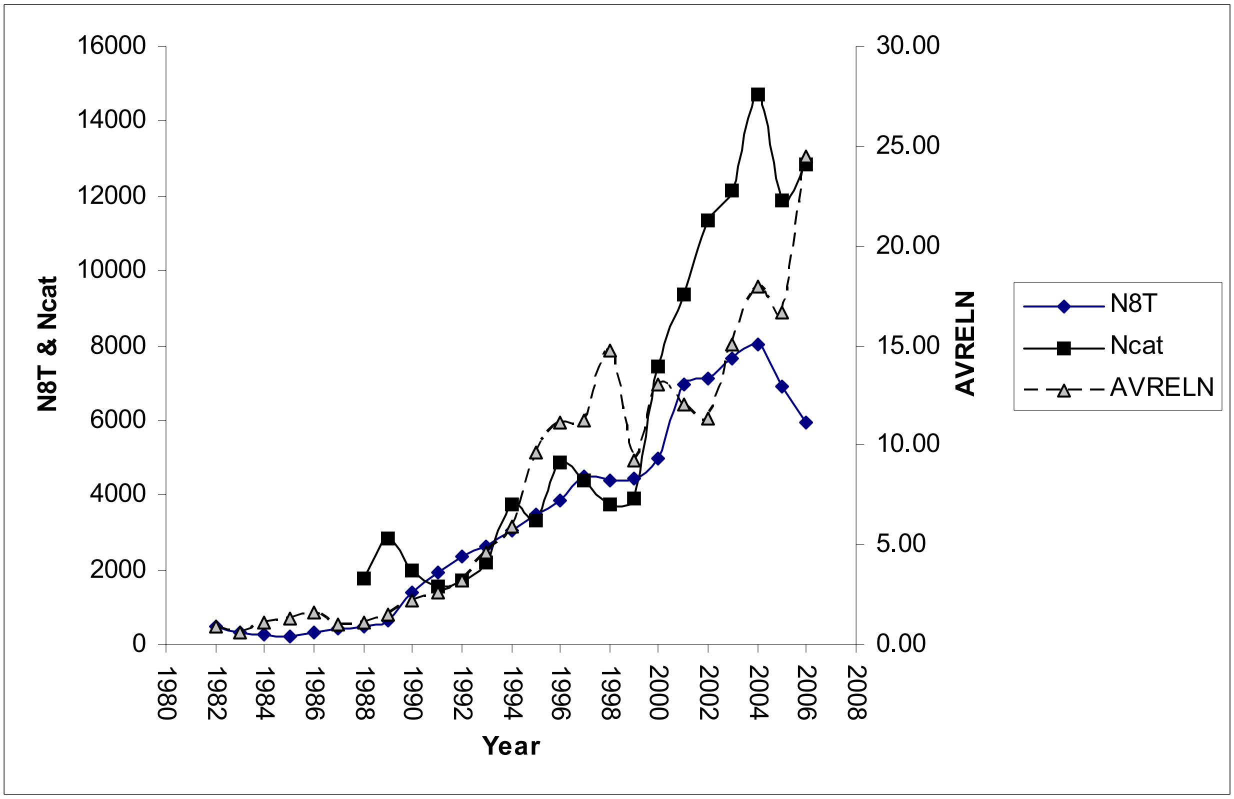


Figure 10. Comparison among the blended relative stock size (AVRELN), stock size from SCAM (N8T) and stock size from the catch equation (Ncat) from 1982-2006.

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	Release	Recaptures																		
releases	year	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	Release	Recaptures													
releases	year	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	Release	Recaptures																			
releases	year	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 $\geq$ 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 releases	Release year	Harvested Recaptures																		
		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 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
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 releases	Release year	Harvested Recaptures 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 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
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 $\geq$ 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 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 (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	Release	Harvested Recaptures																			
releases	year	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	Release	Released with Tag Removed																			
releases	year	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.

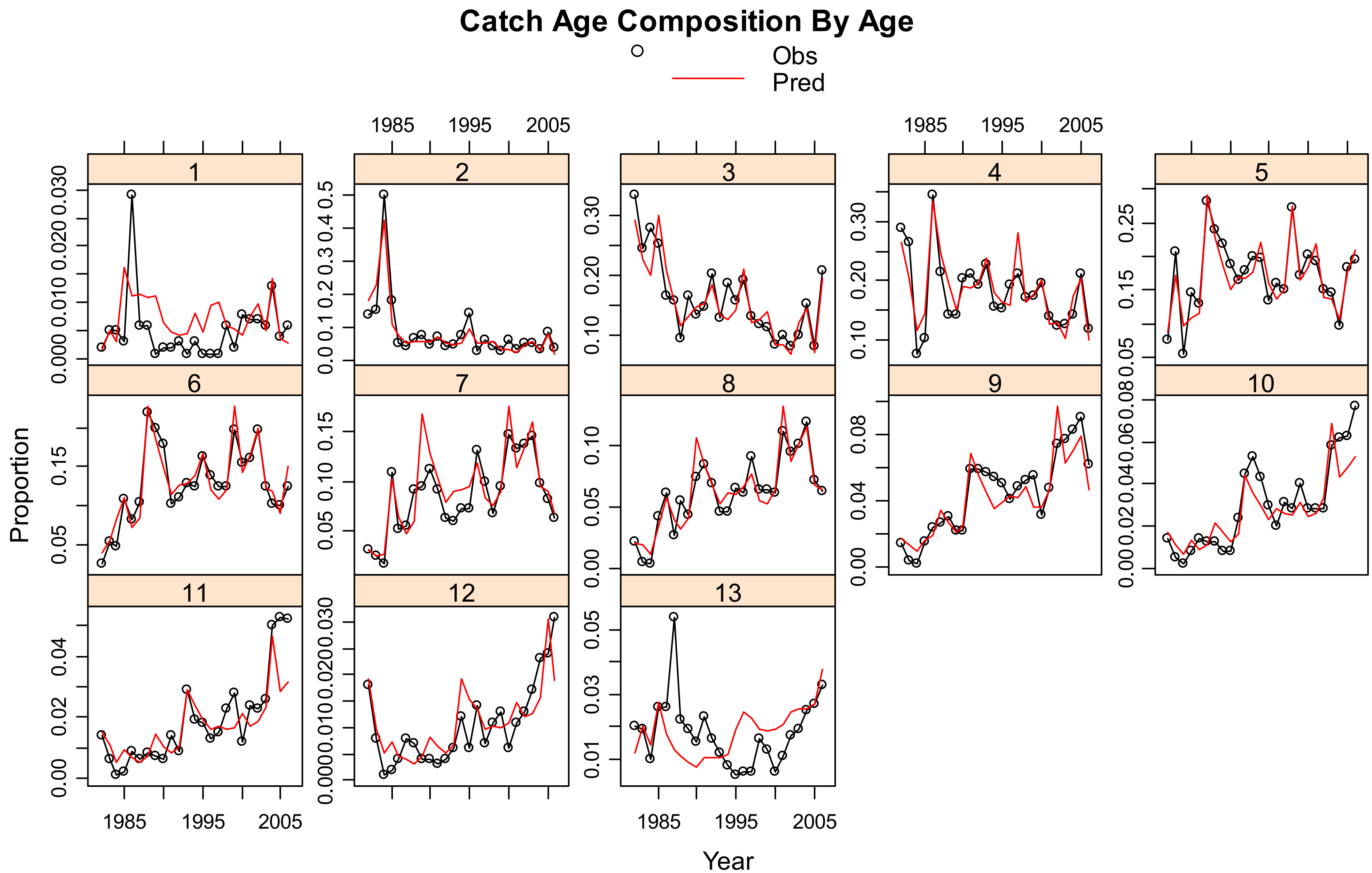


Figure 1. Comparison between observed and predicted annual catch age composition by age

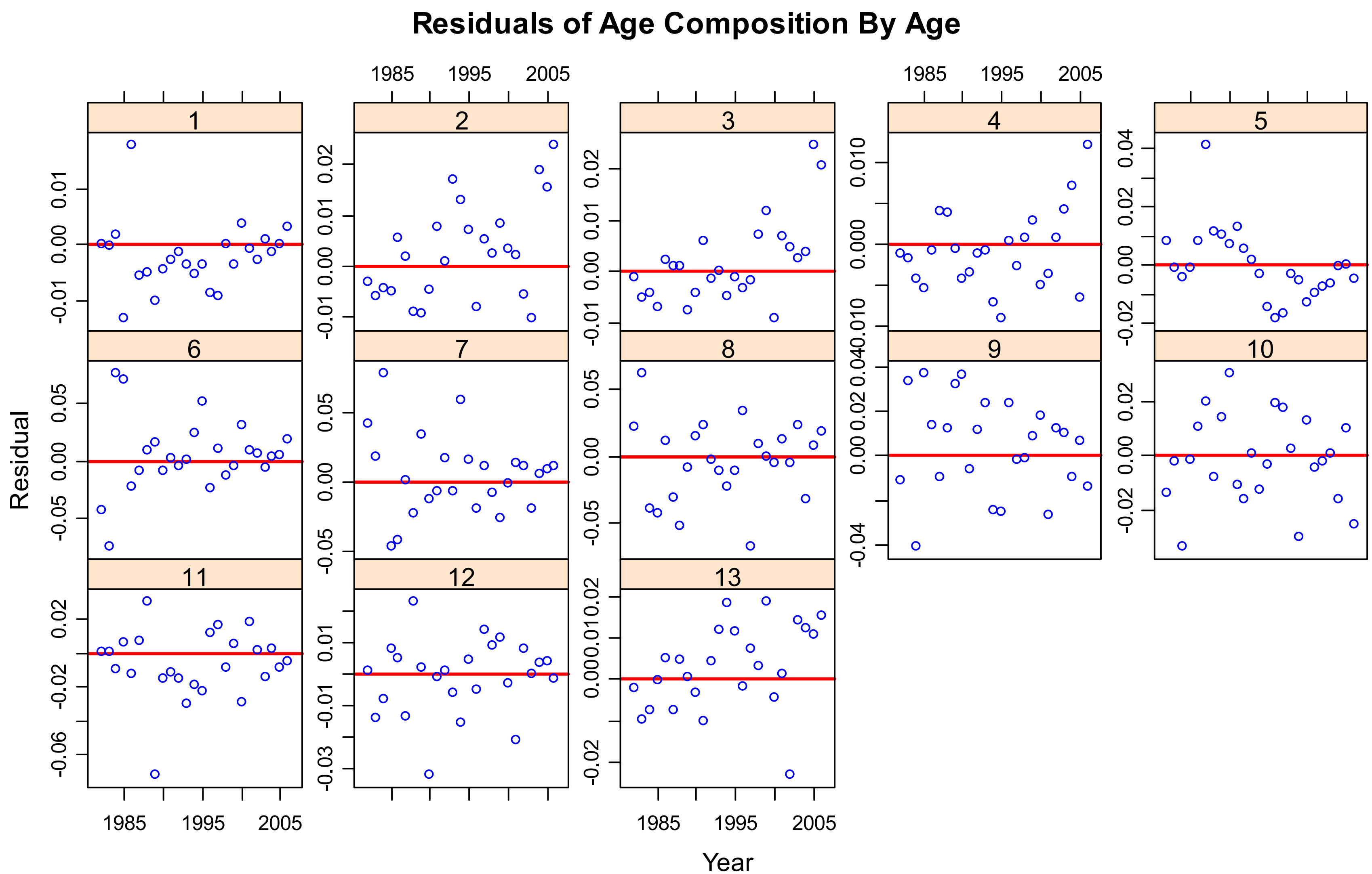


Figure 2. Residuals of annual catch age composition by age.

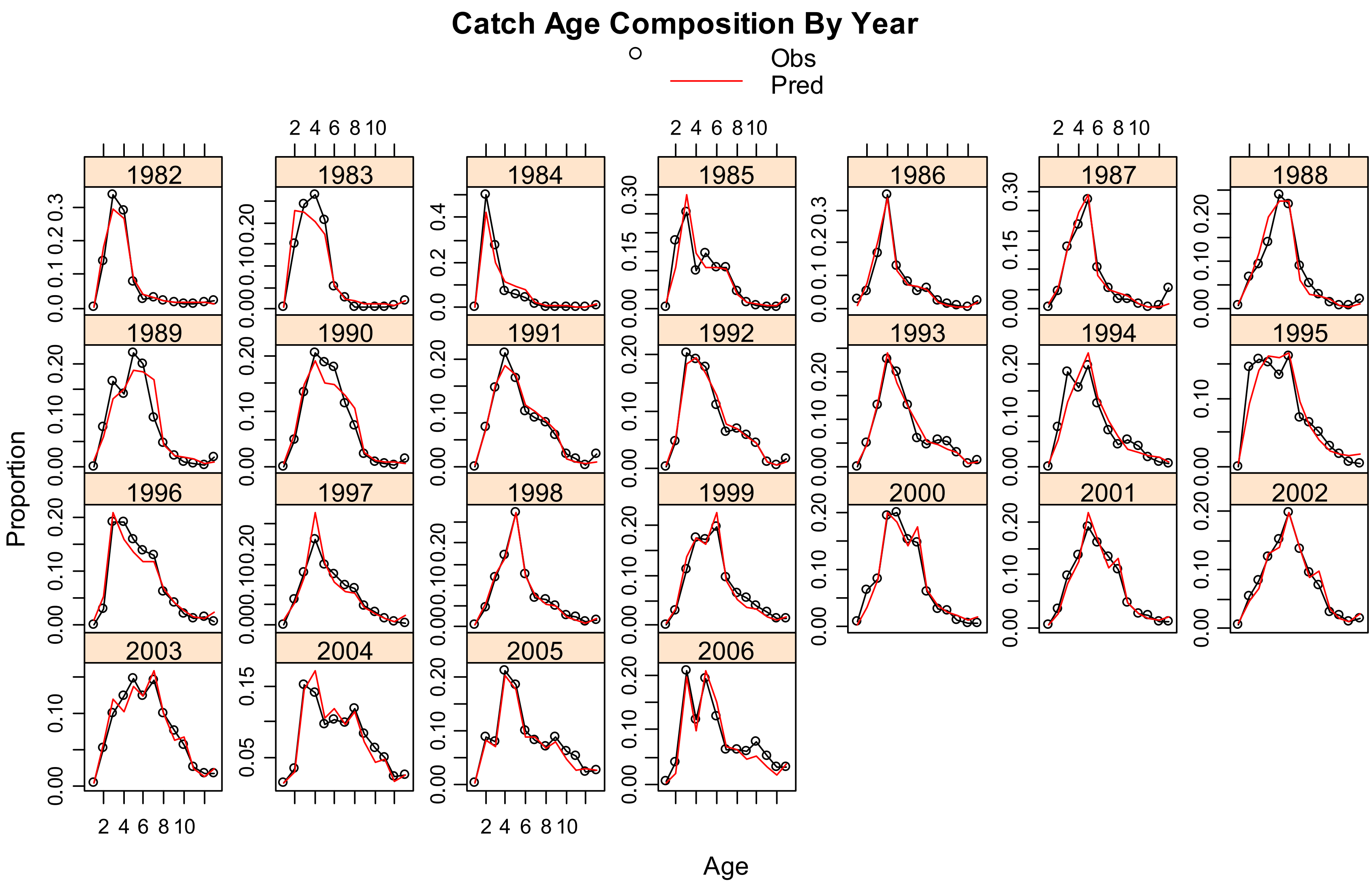


Figure 3. Comparison between observed and predicted catch age composition by year

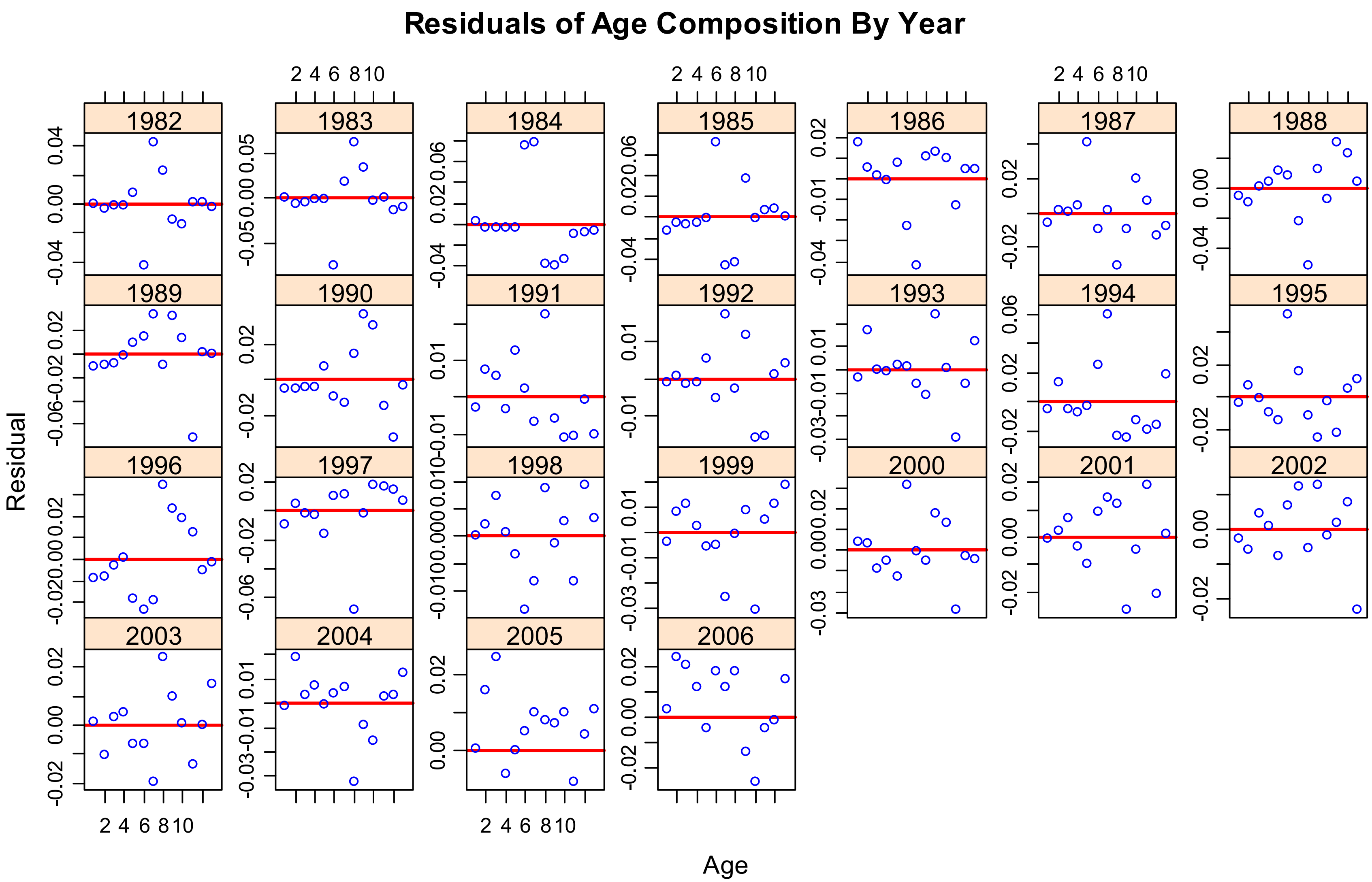


Figure 4. Residuals of annual catch age composition by age

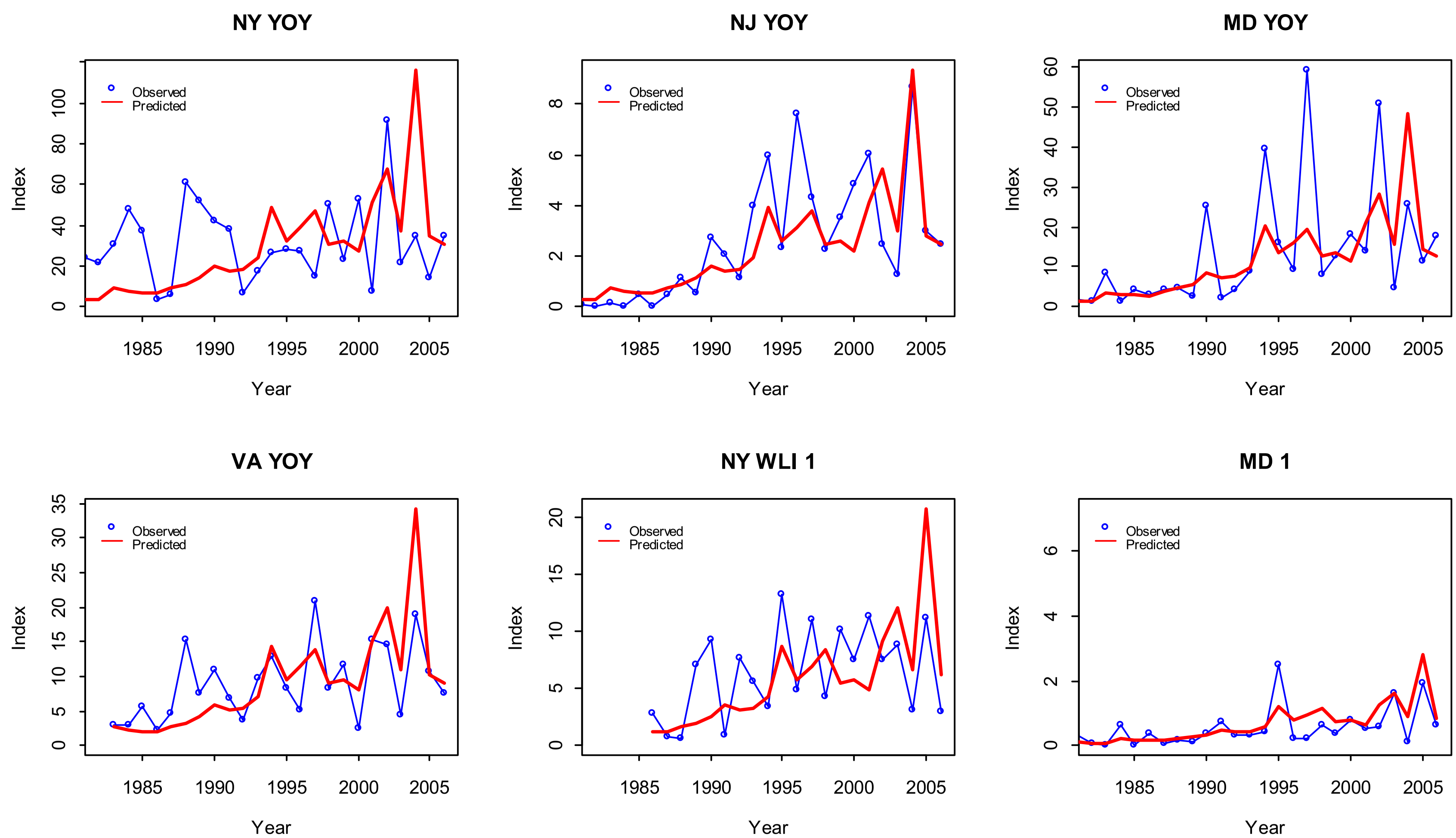


Figure 5. Observed and predicted YOY and Age 1 Indices

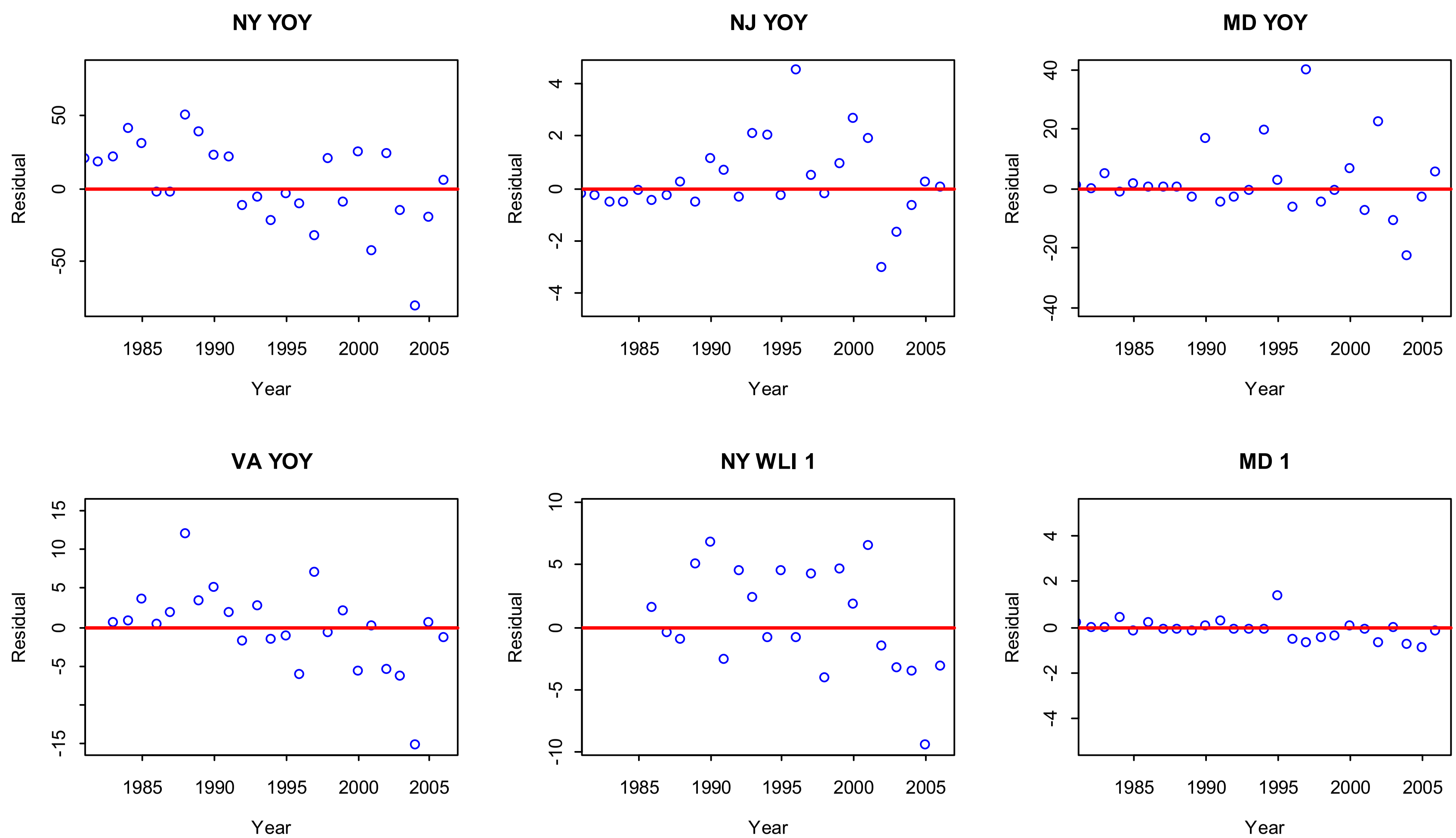


Figure 6. Residuals of YOY and Age 1 Indices

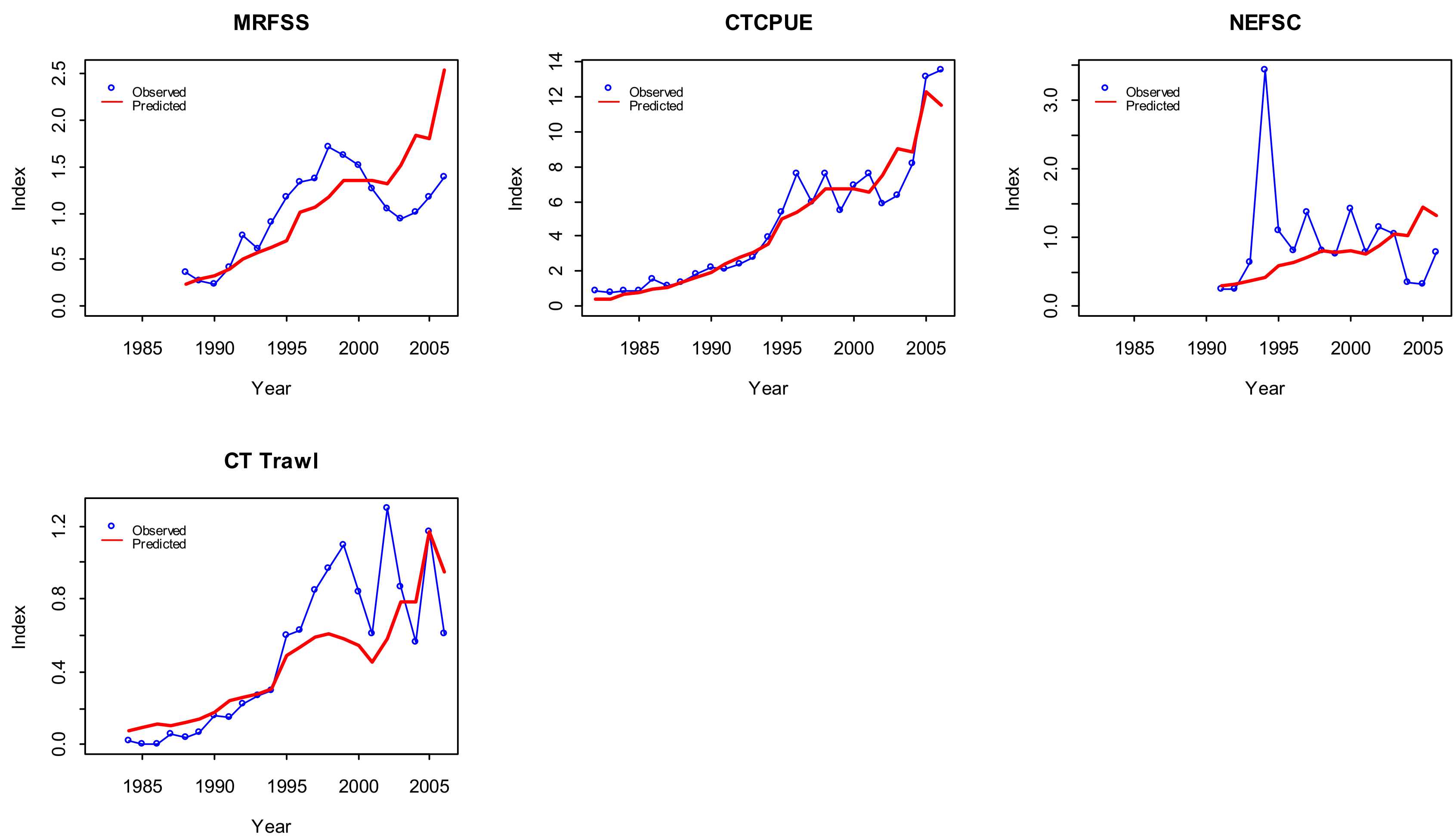


Figure 7. Observed and predicted aggregate indices

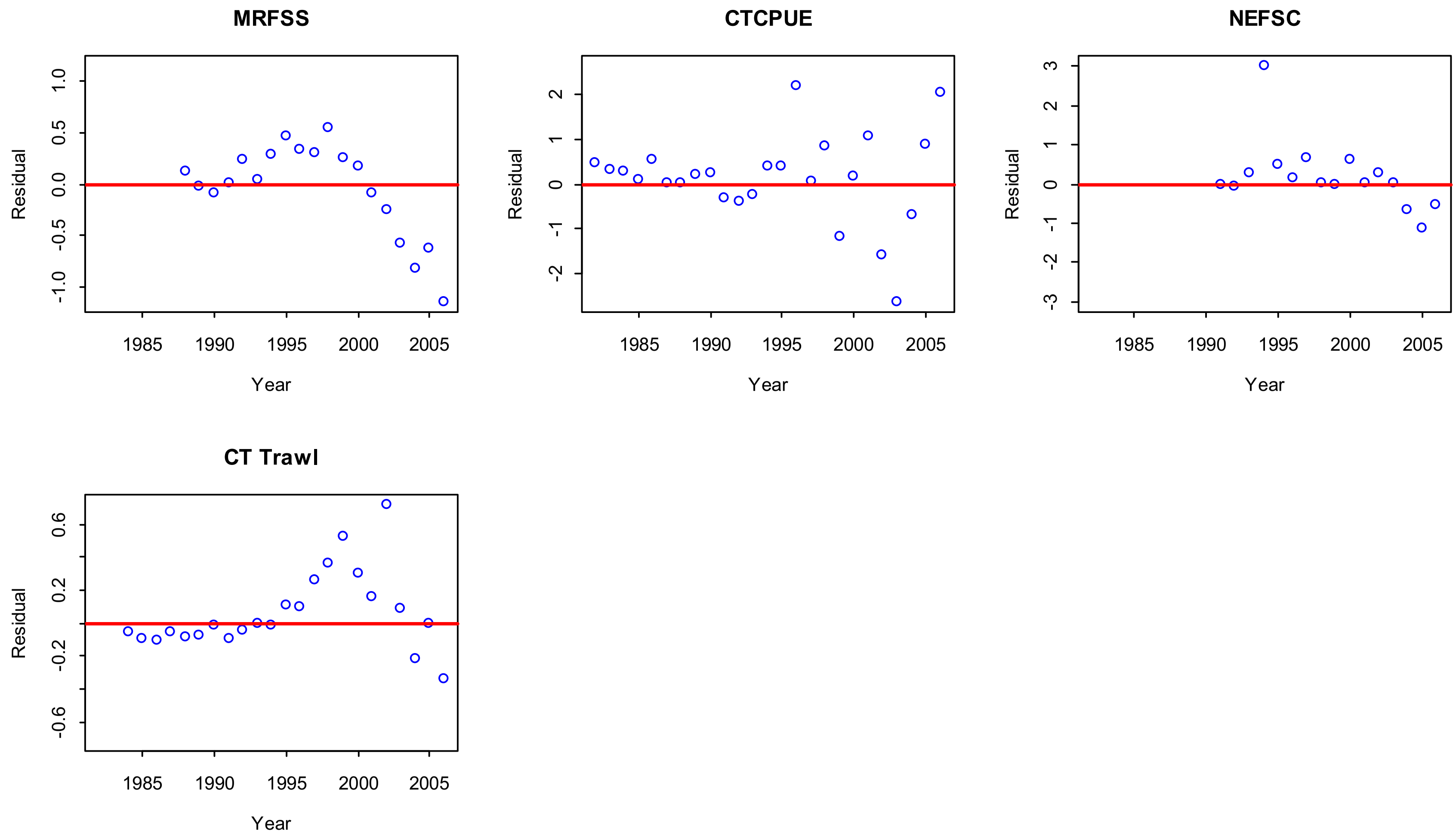


Figure 8. Residuals of aggregates indices

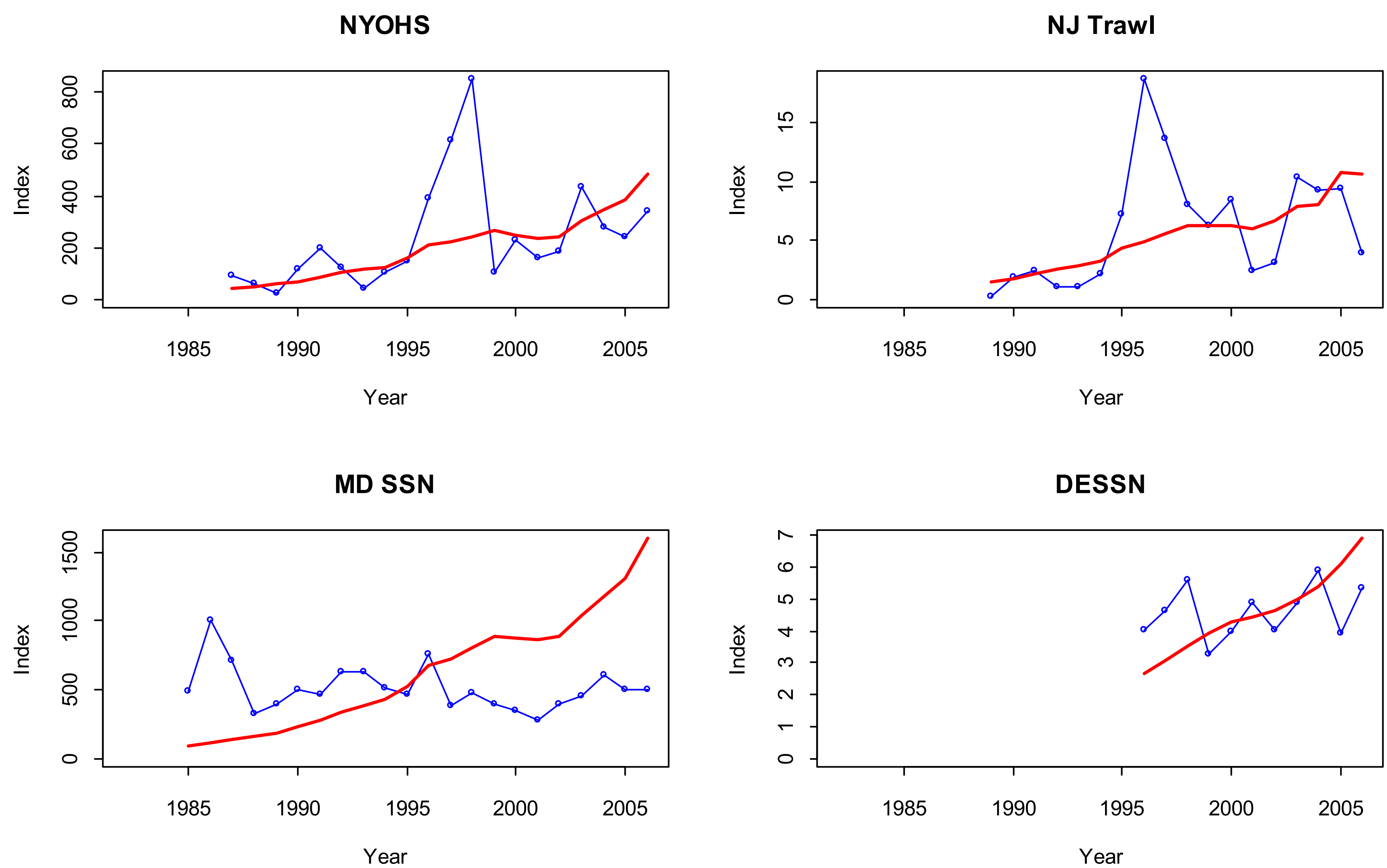


Figure 9. Observed and predicted survey indices with age composition data. Blue=observed, red=predicted

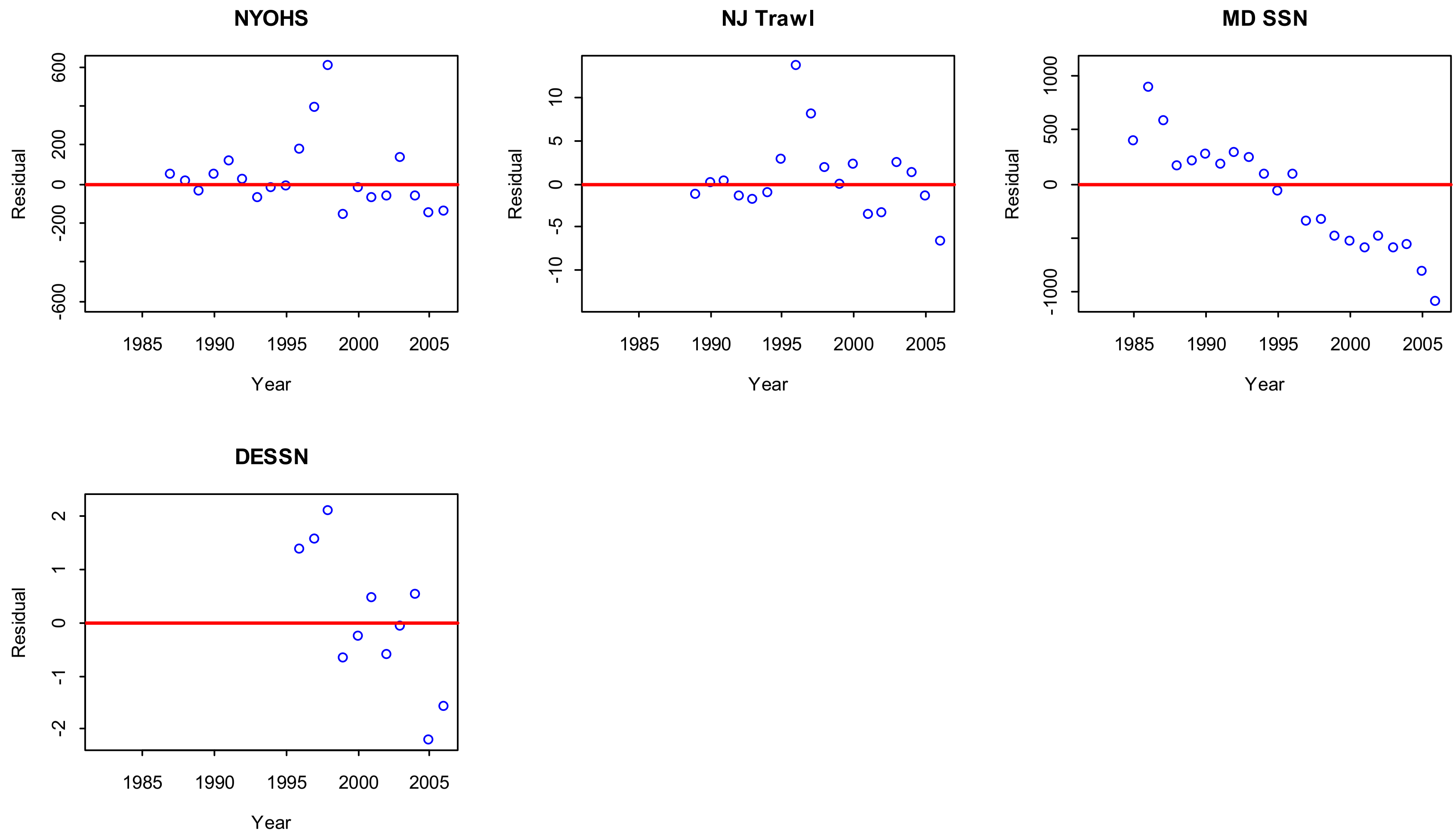


Figure 10. Residuals of survey indices with age composition data

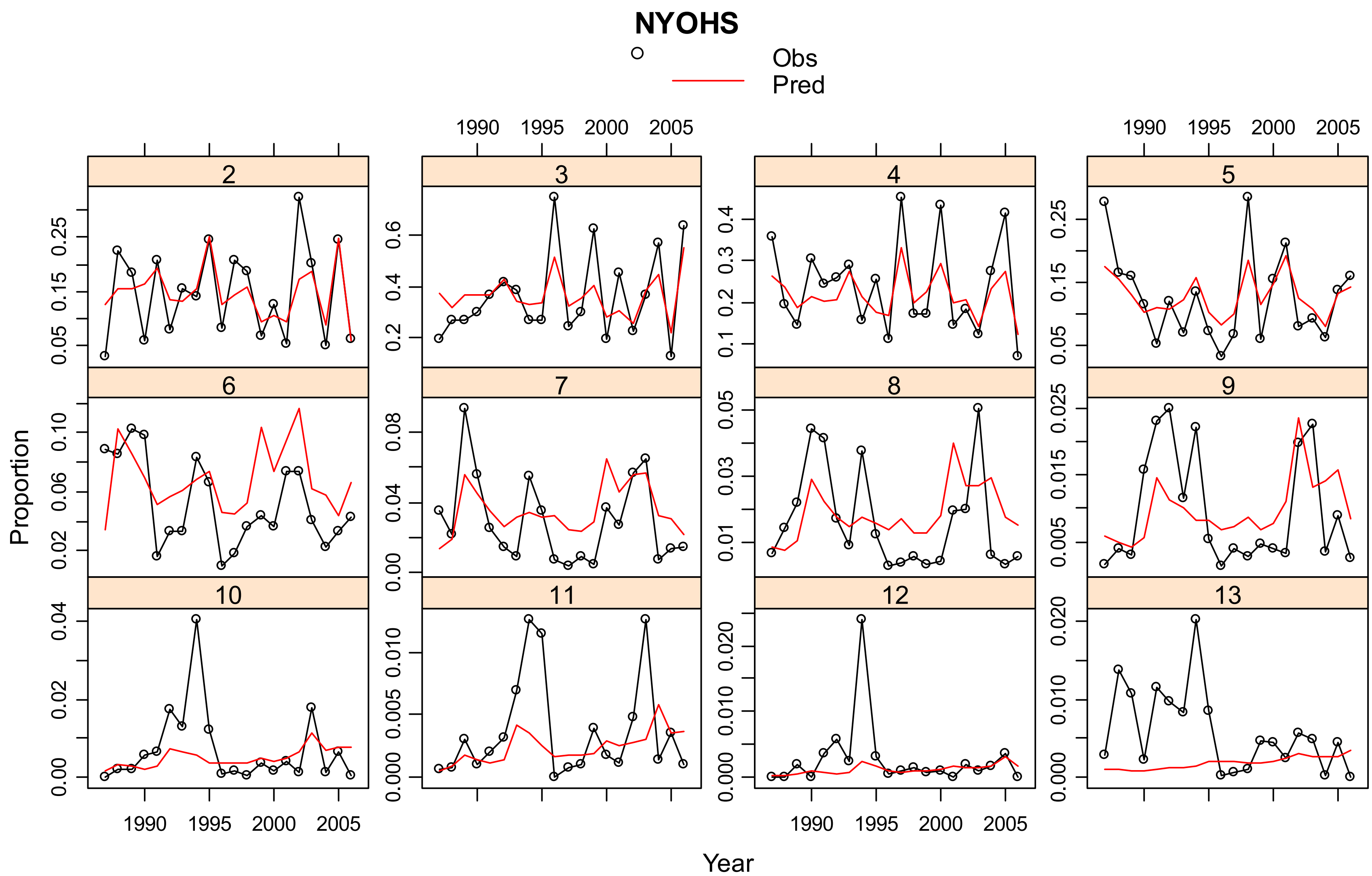


Figure 11. Observed and predicted annual survey age compositions by age for the NY Ocean Haul Seine survey

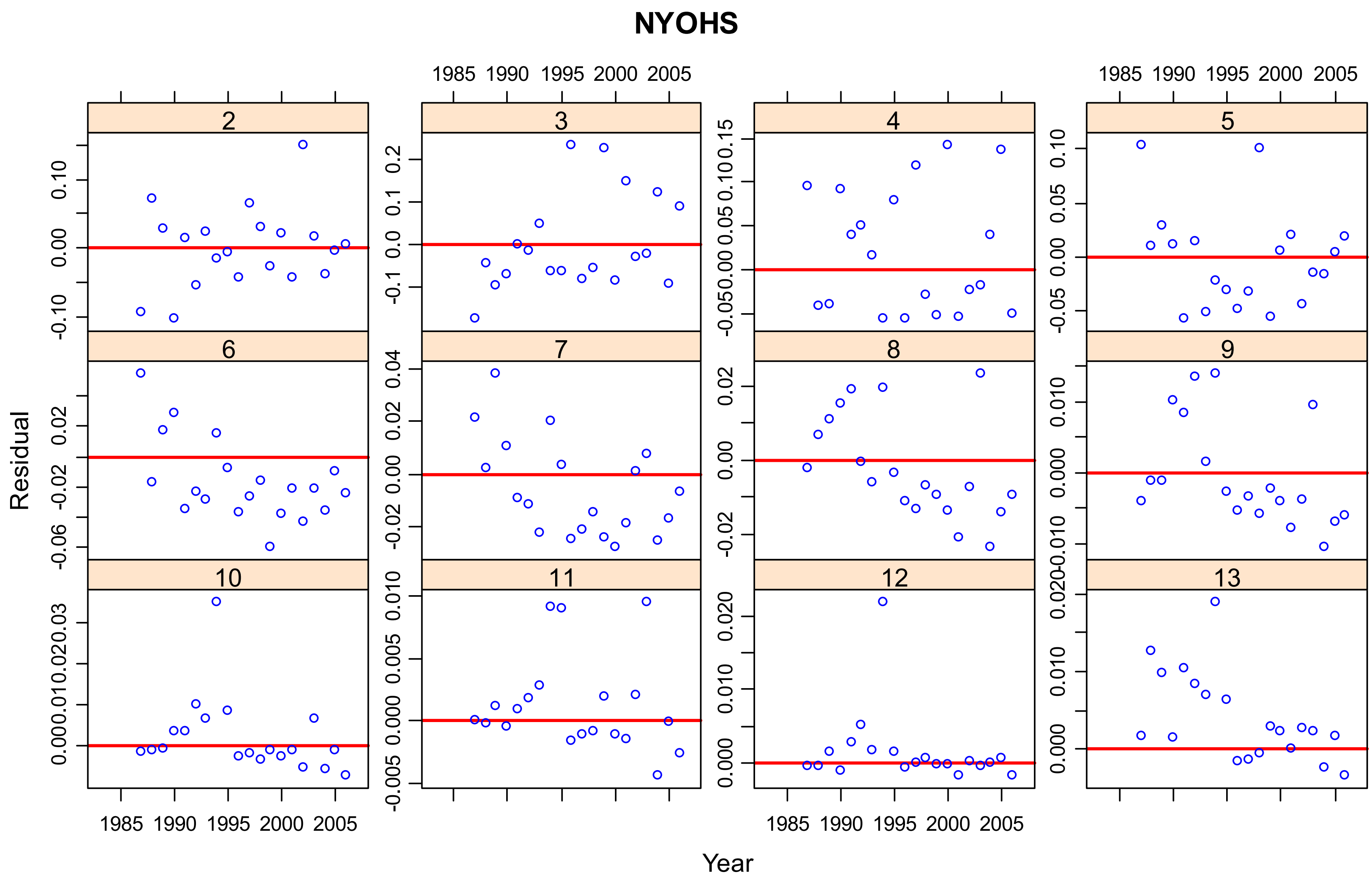


Figure 12. Residuals of annual survey age compositions by age for the NY Ocean Haul Seine survey

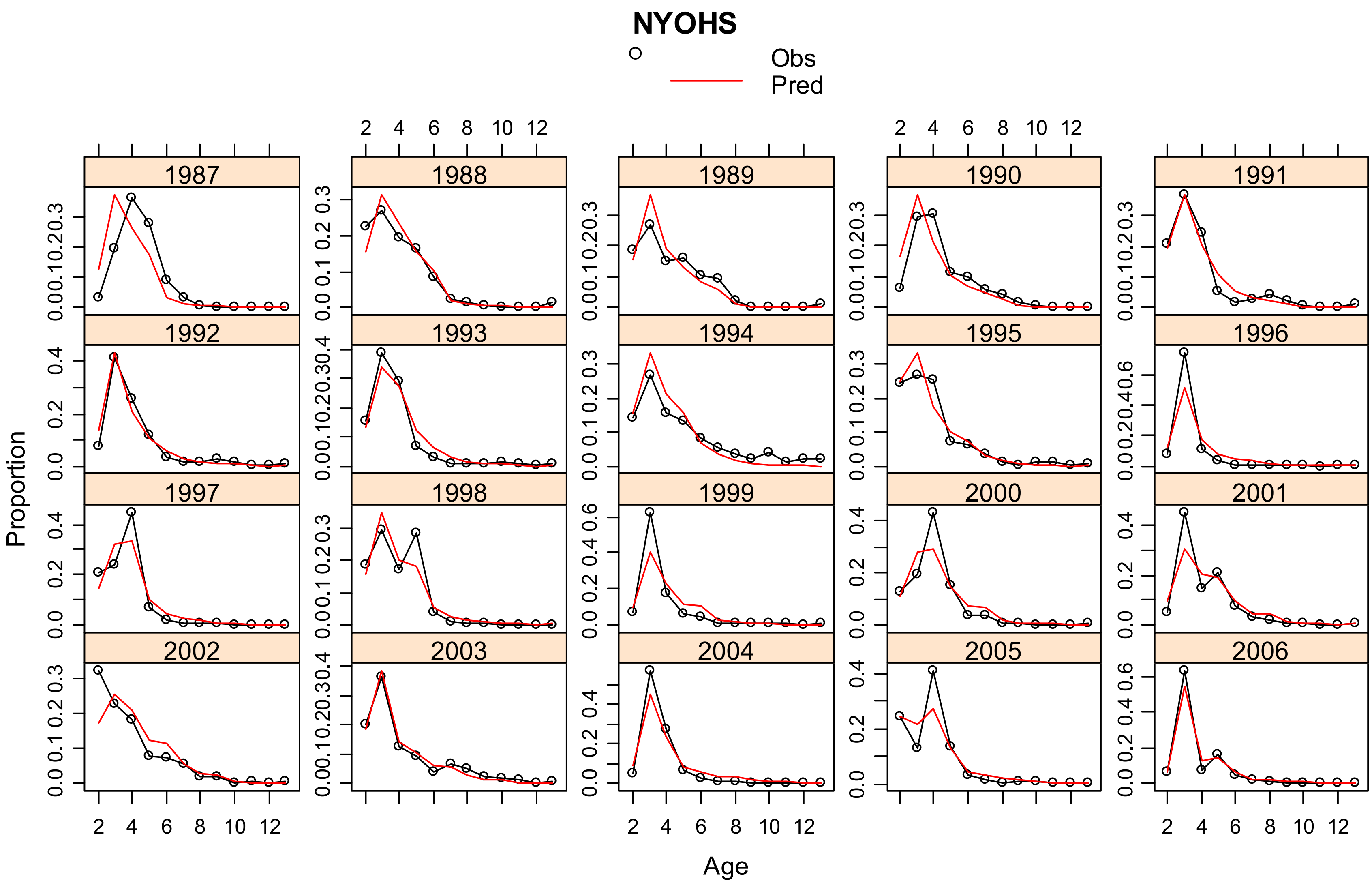


Figure 13. Observed and predicted survey age compositions by year for the NY Ocean Haul Seine survey

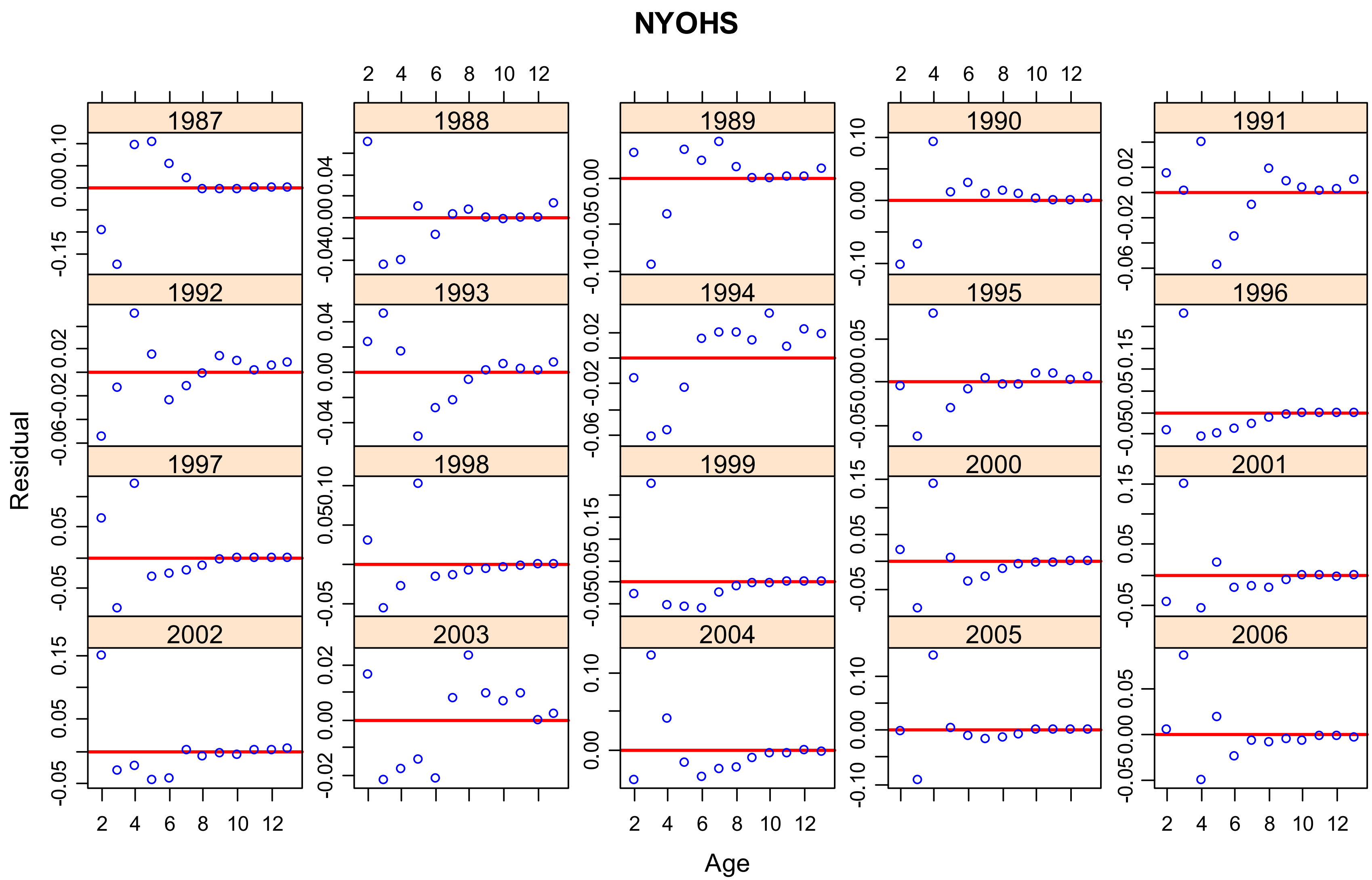


Figure 14. Residuals of survey age compositions by year for the NY Ocean Haul Seine survey

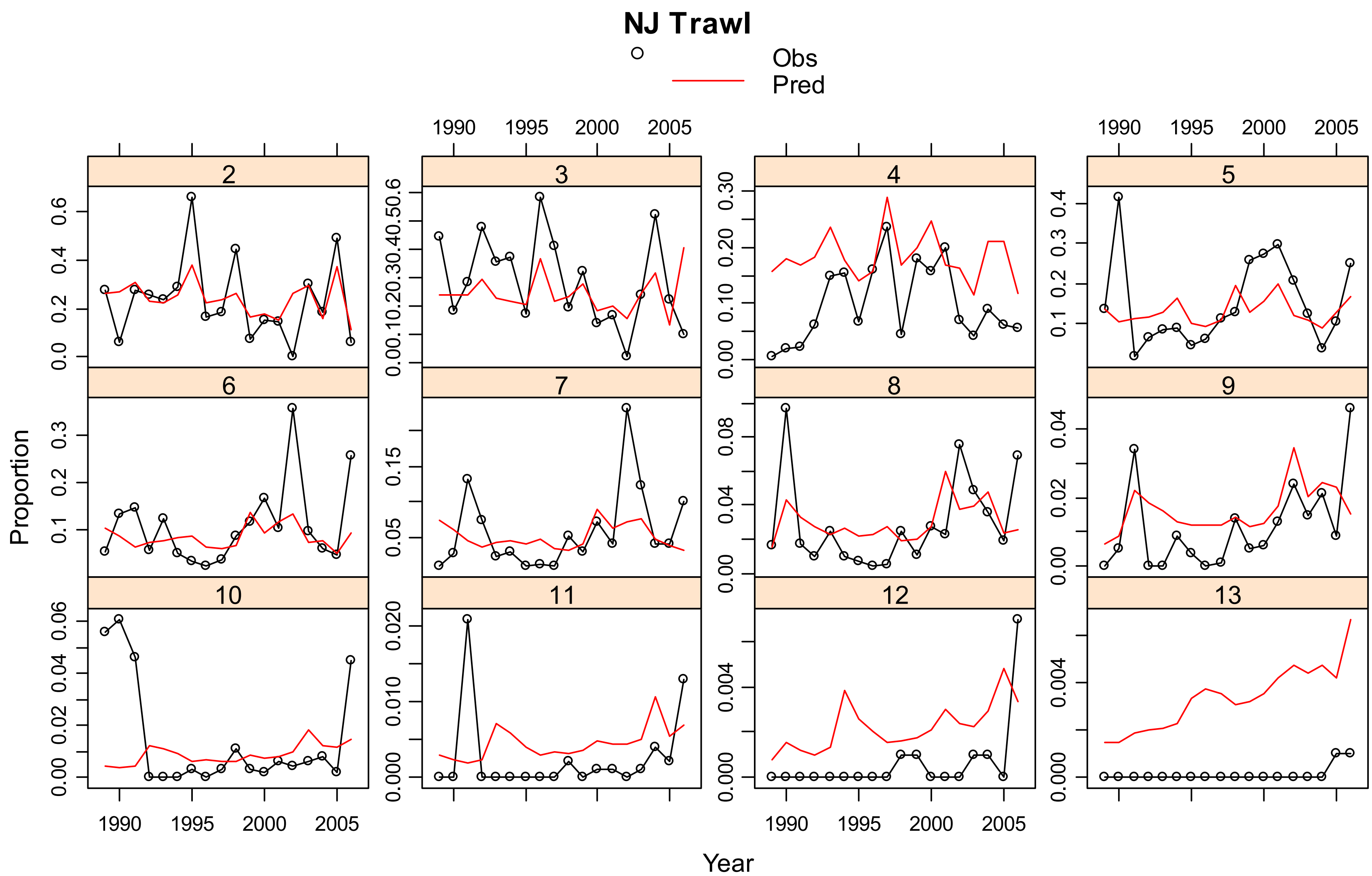


Figure 15. Observed and predicted annual survey age compositions by age for the New Jersey Trawl survey

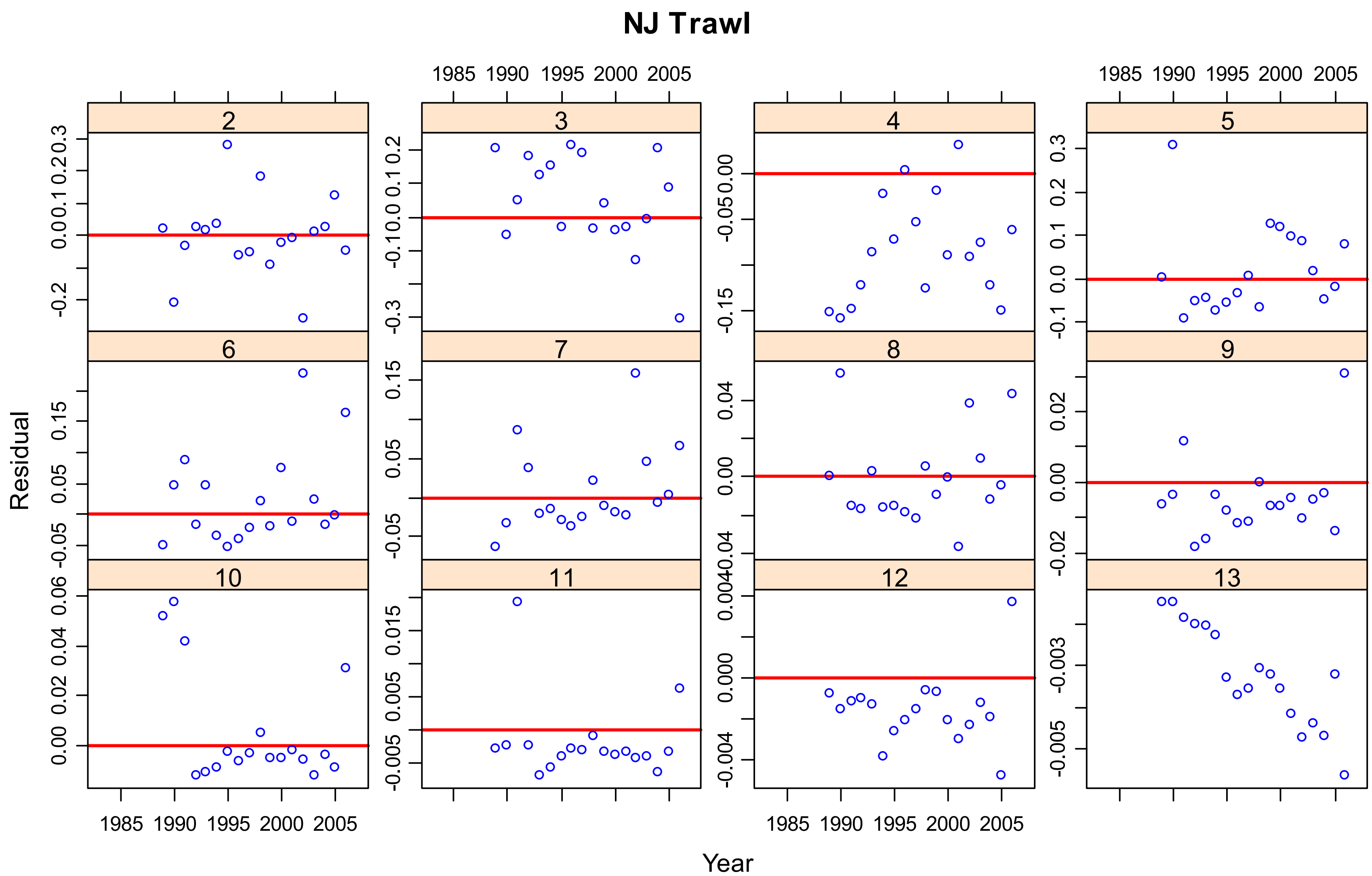


Figure 16. Residuals of annual survey age compositions by age for the New Jersey trawl survey

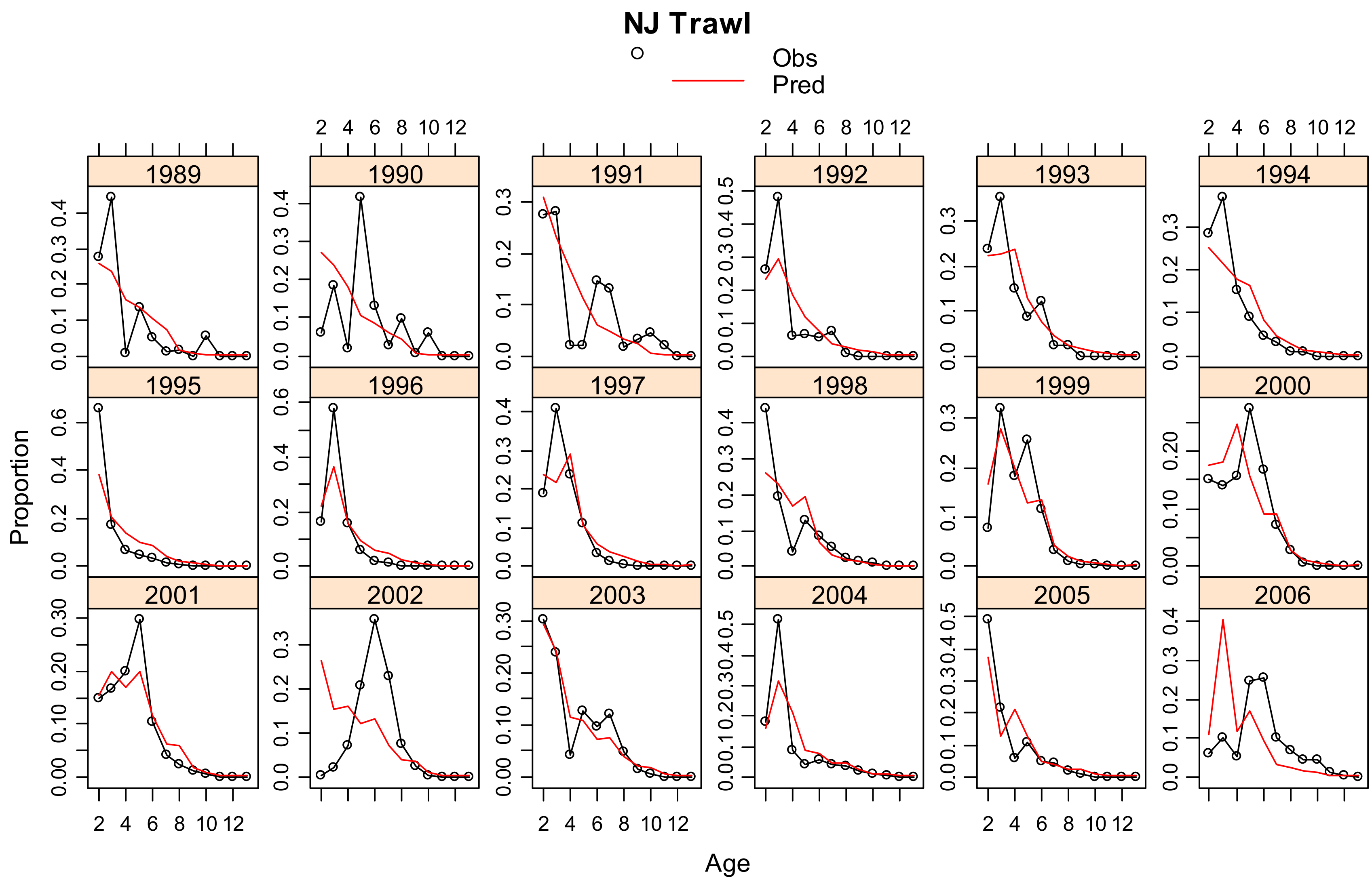


Figure 17. Observed and predicted survey age compositions by year for the New Jersey trawl survey

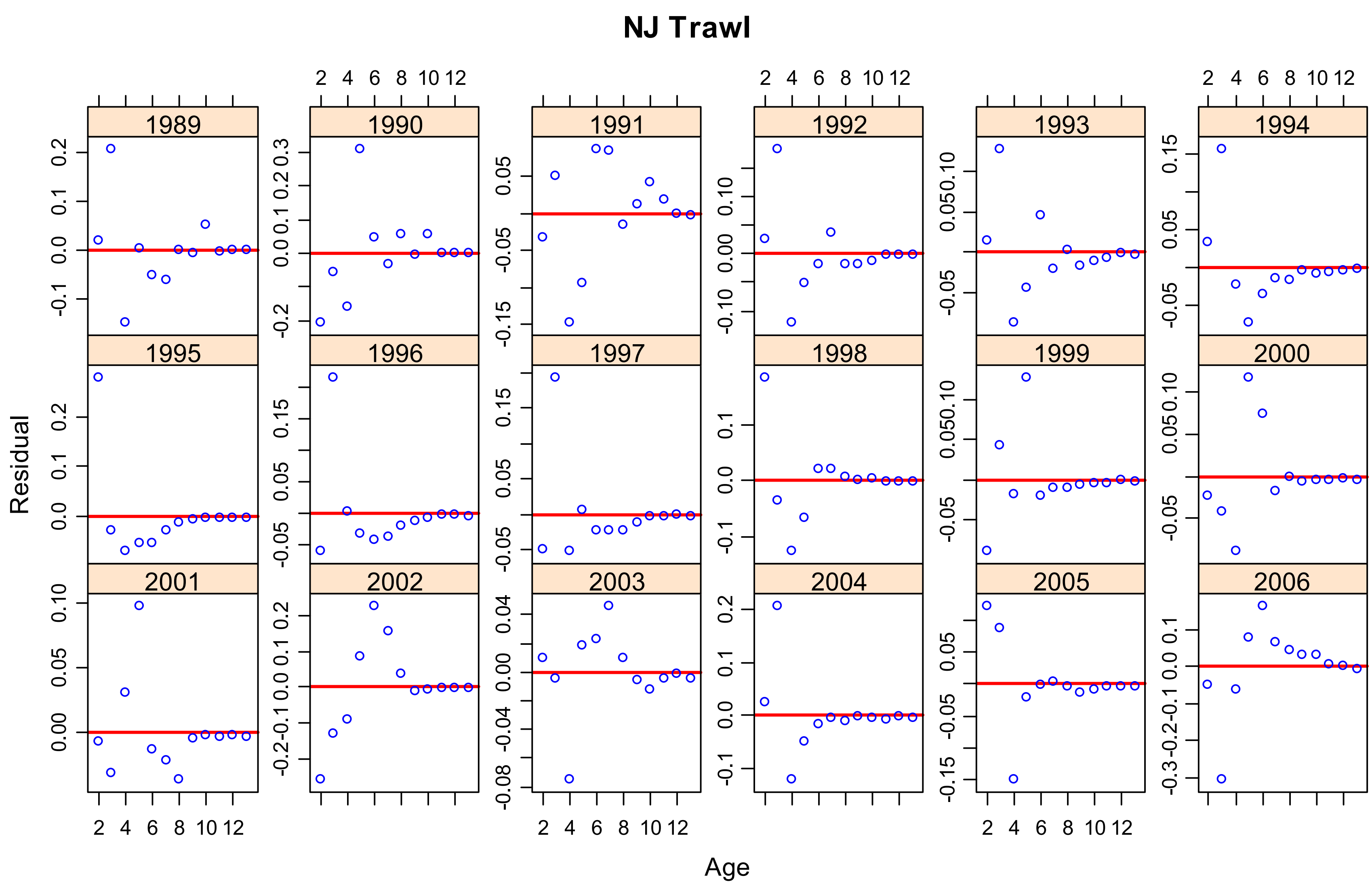


Figure 18. Residuals of survey age compositions by year for the New Jersey trawl survey

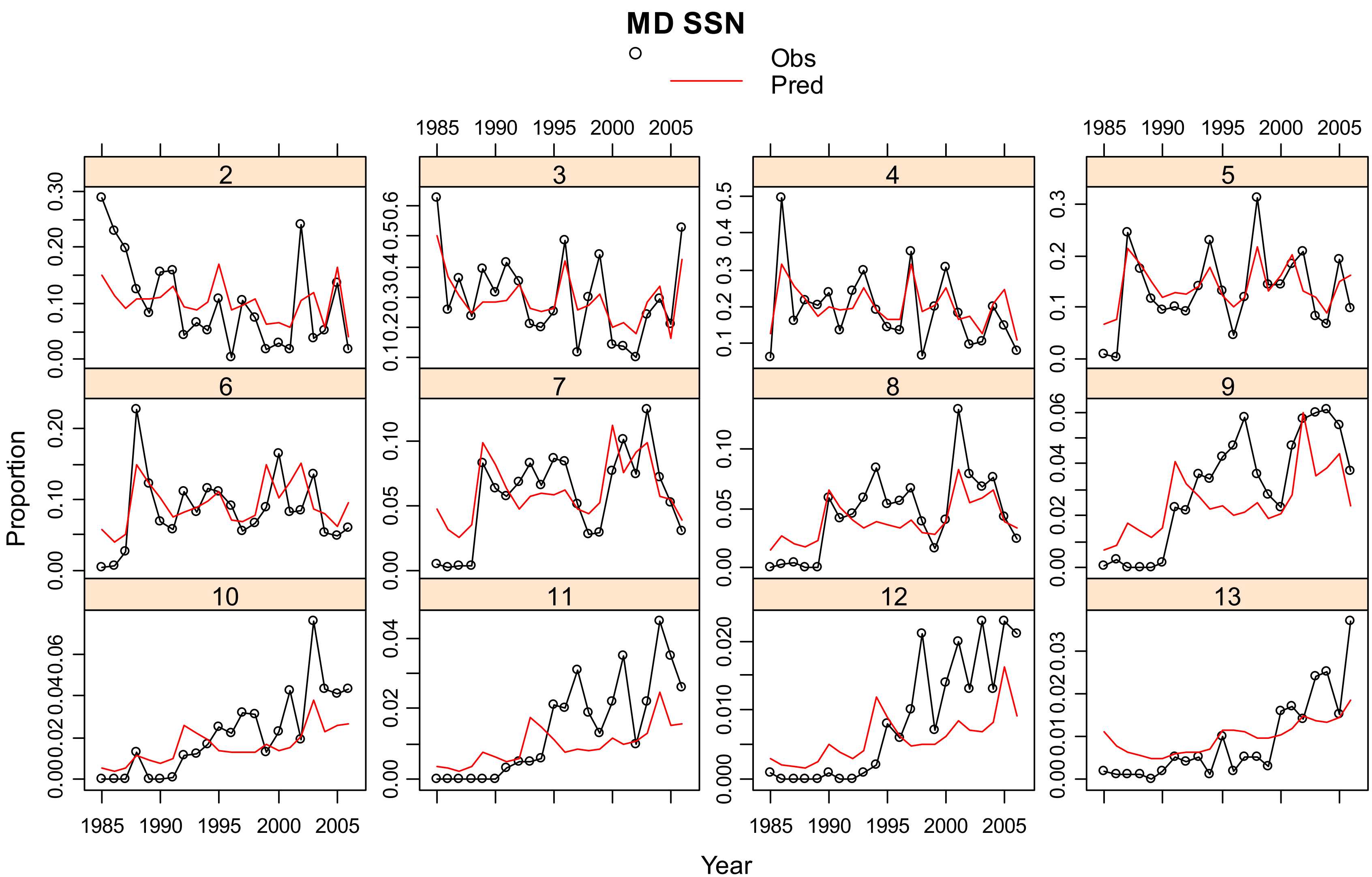


Figure 19. Observed and predicted annual survey age compositions by age for the Maryland gillnet survey

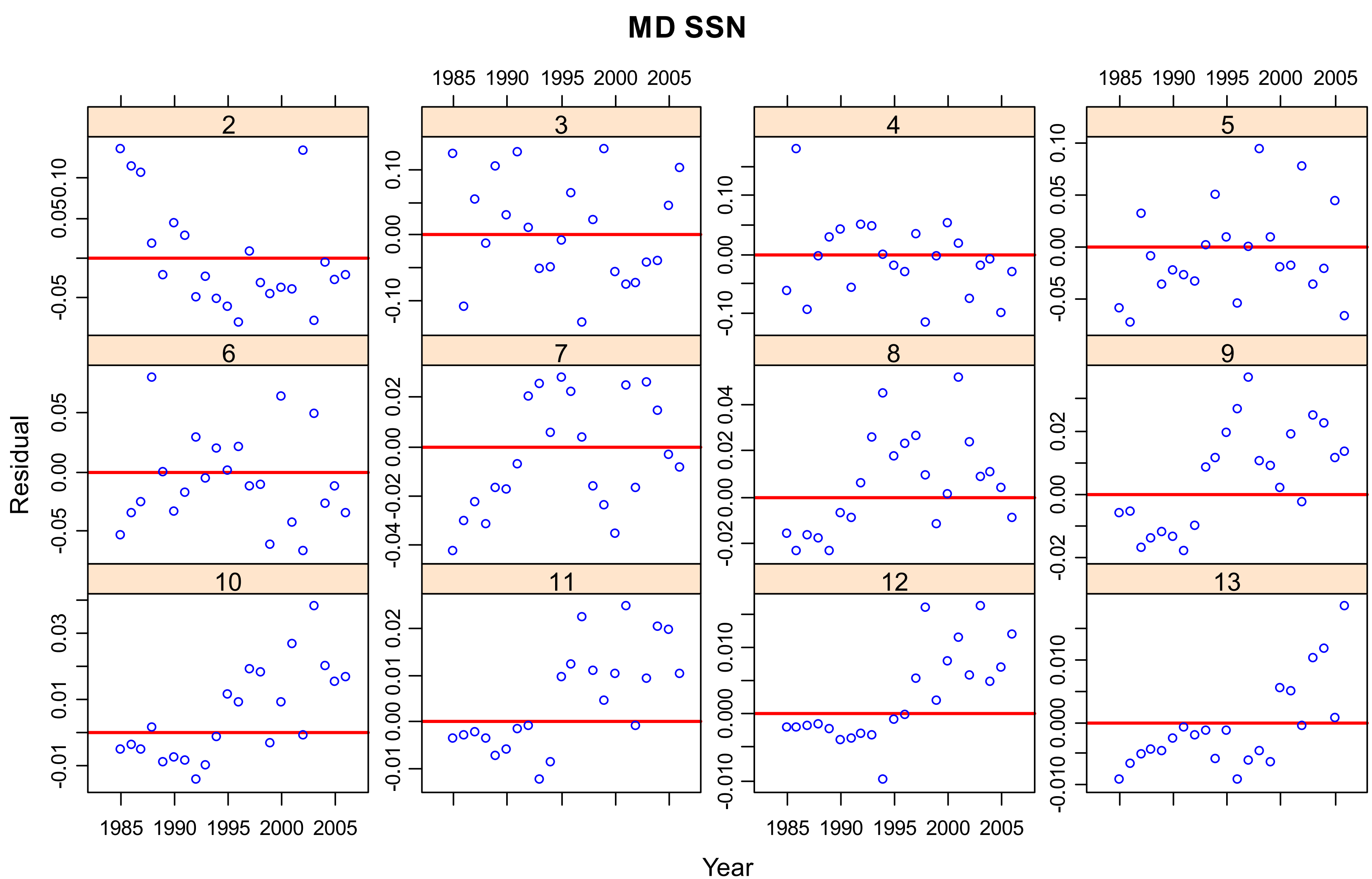


Figure 20. Residuals of annual survey age compositions by age for the Maryland gillnet survey

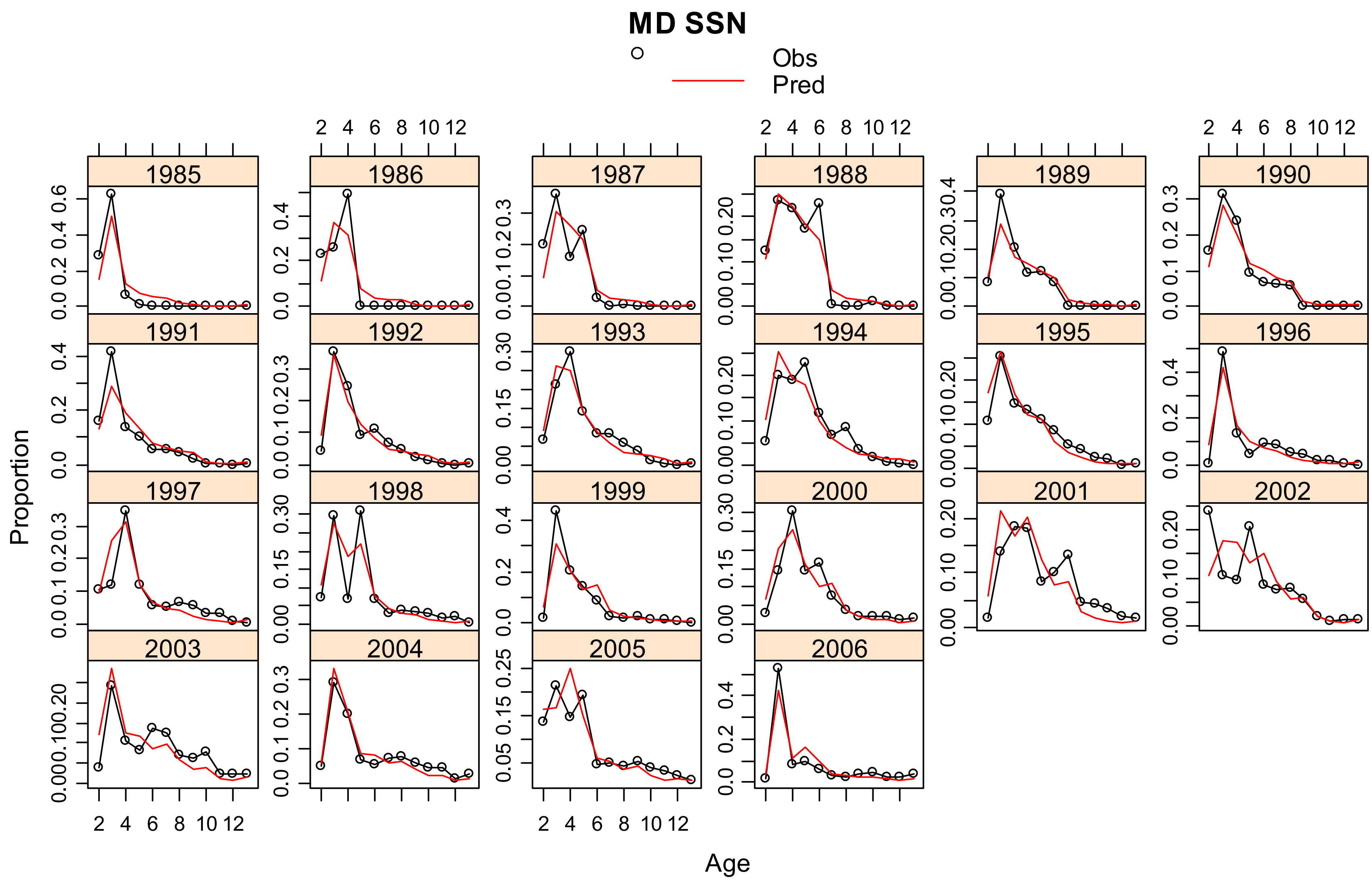


Figure 21. Observed and predicted survey age compositions by year for the Maryland gillnet survey

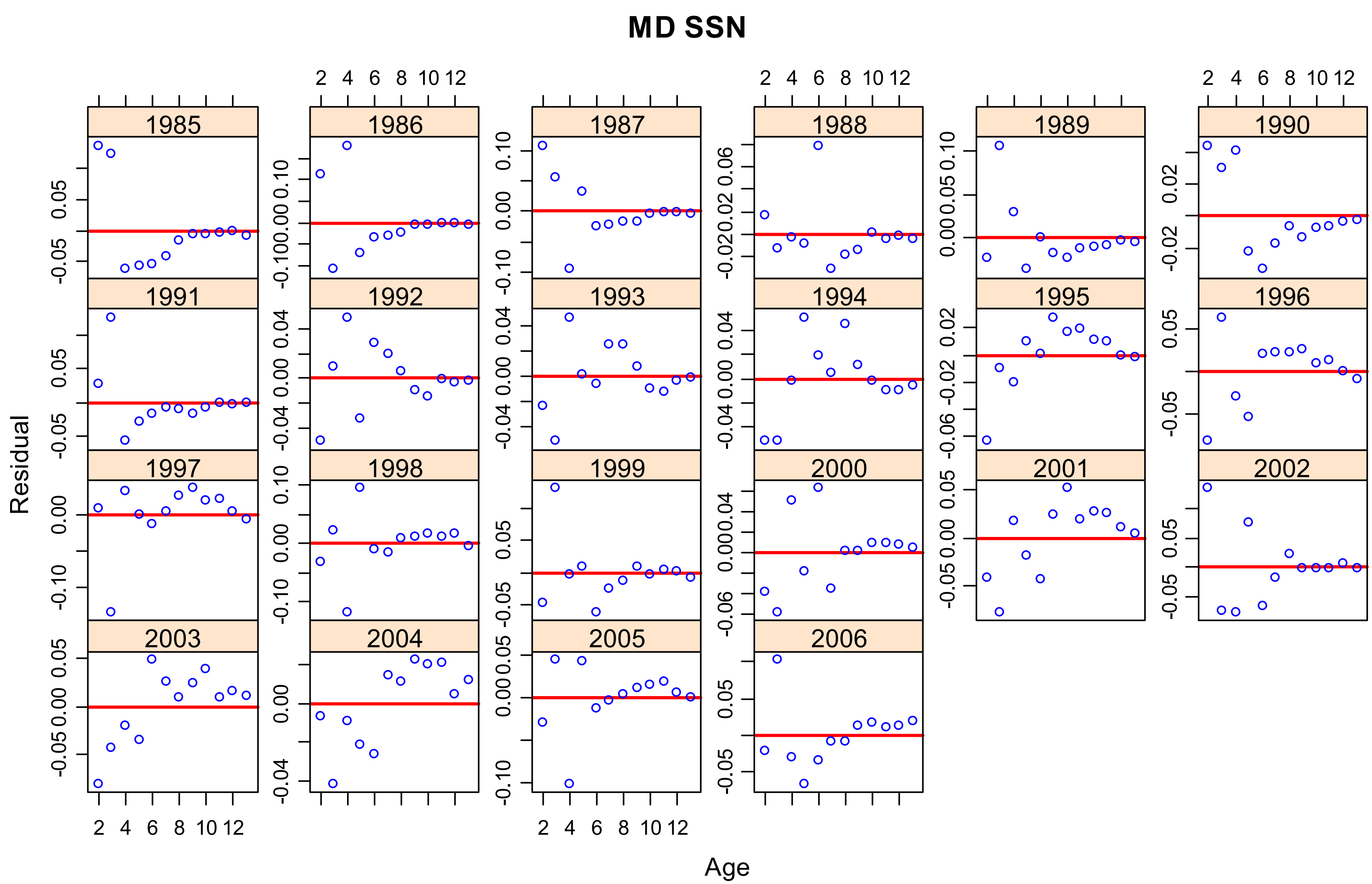


Figure 22. Residuals of survey age compositions by year for the Maryland gillnet survey

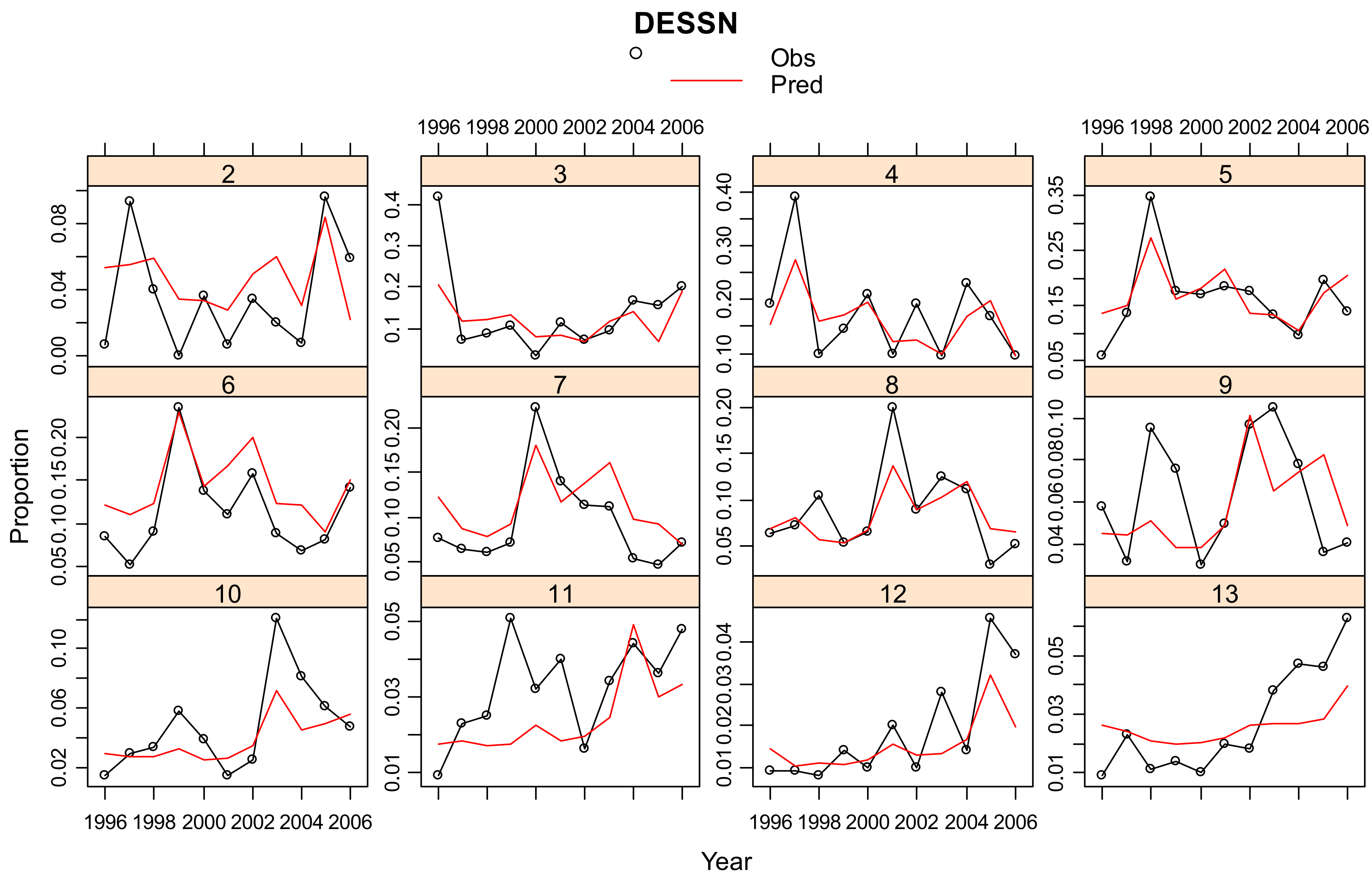


Figure 23. Observed and predicted annual survey age compositions by age for the Delaware electrofishing survey

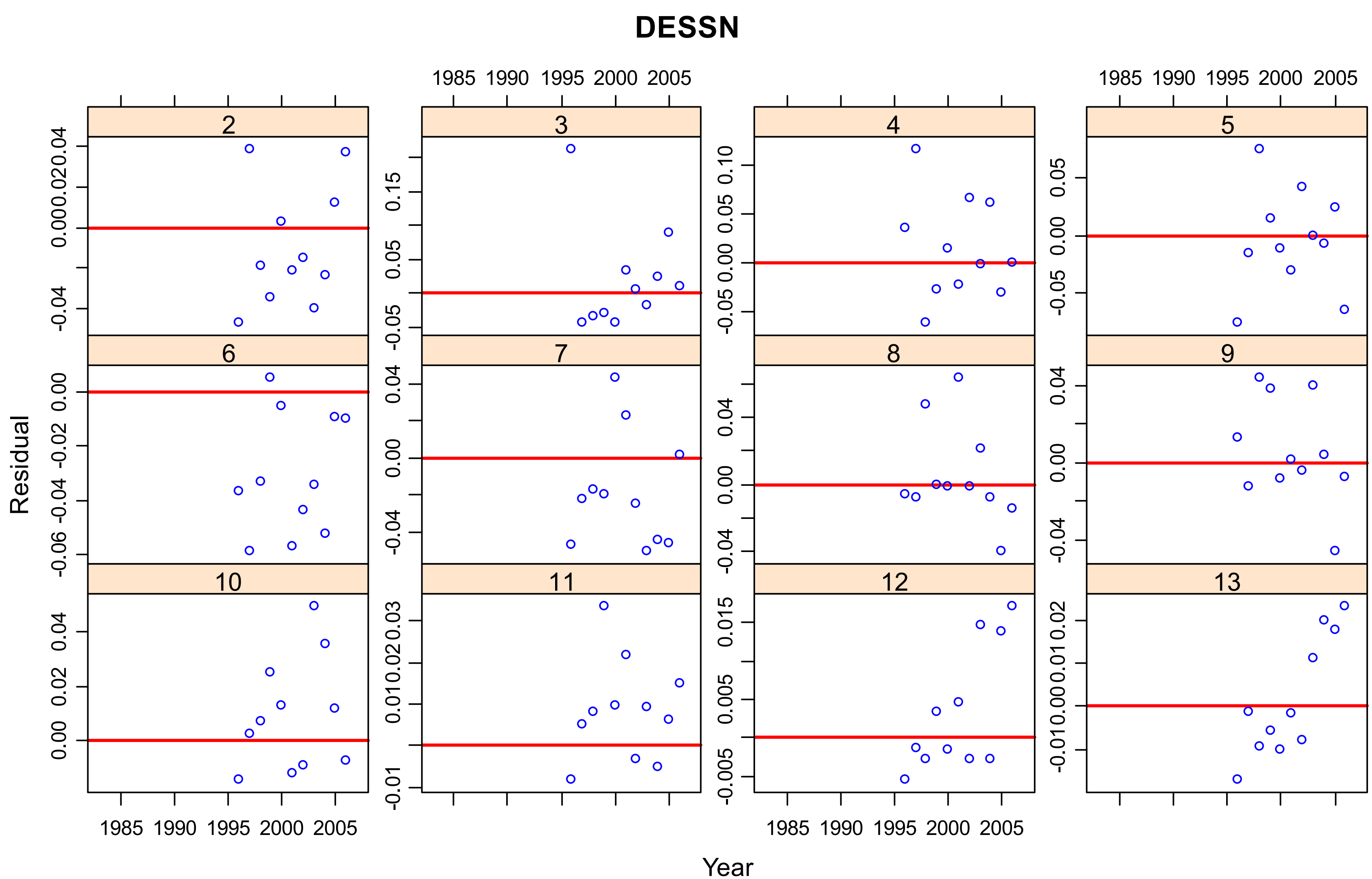


Figure 24. Residuals of annual survey age compositions by age for the Delaware electrofishing survey

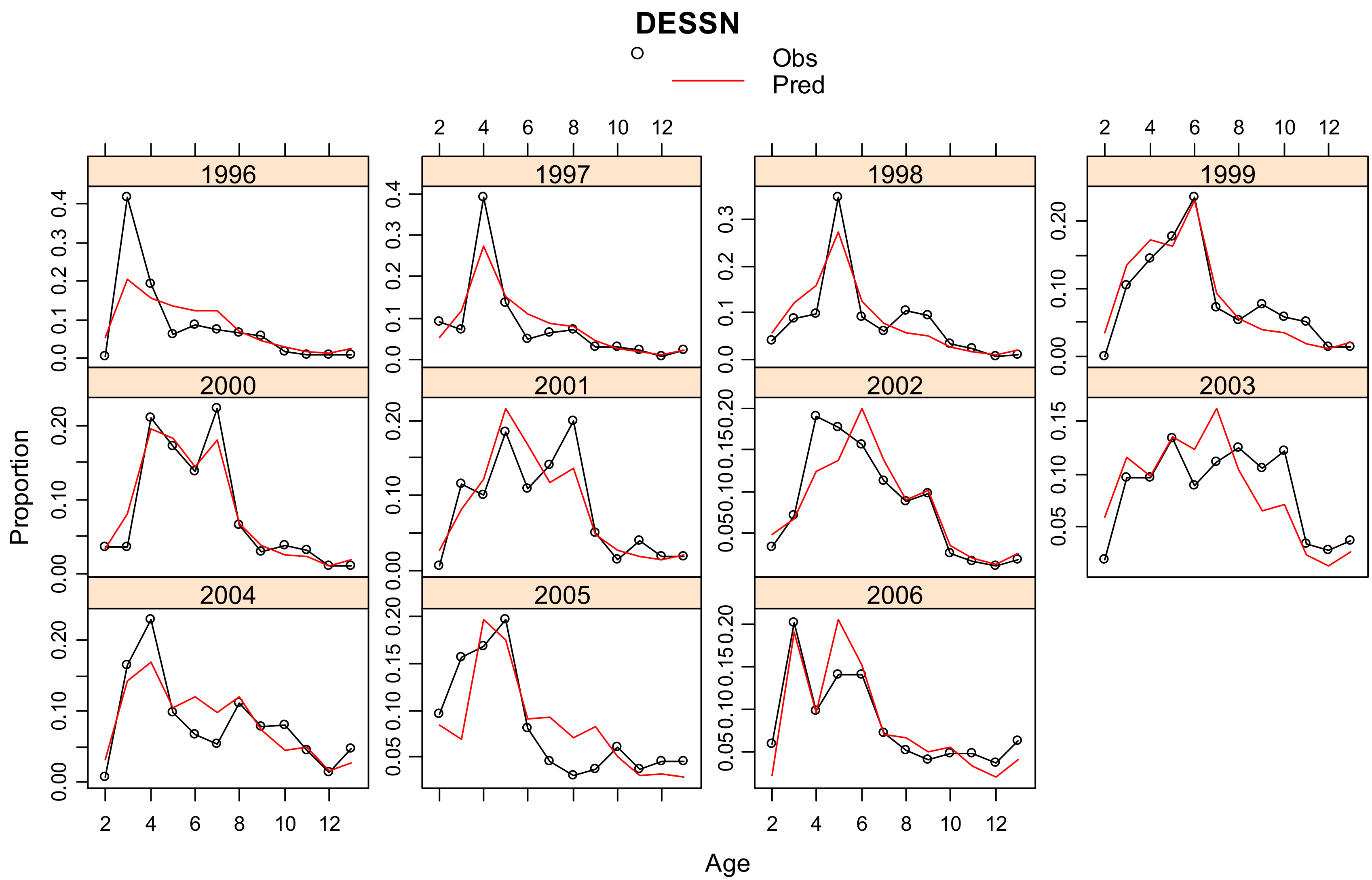


Figure 25. Observed and predicted survey age compositions by year for the Delaware electrofishing survey

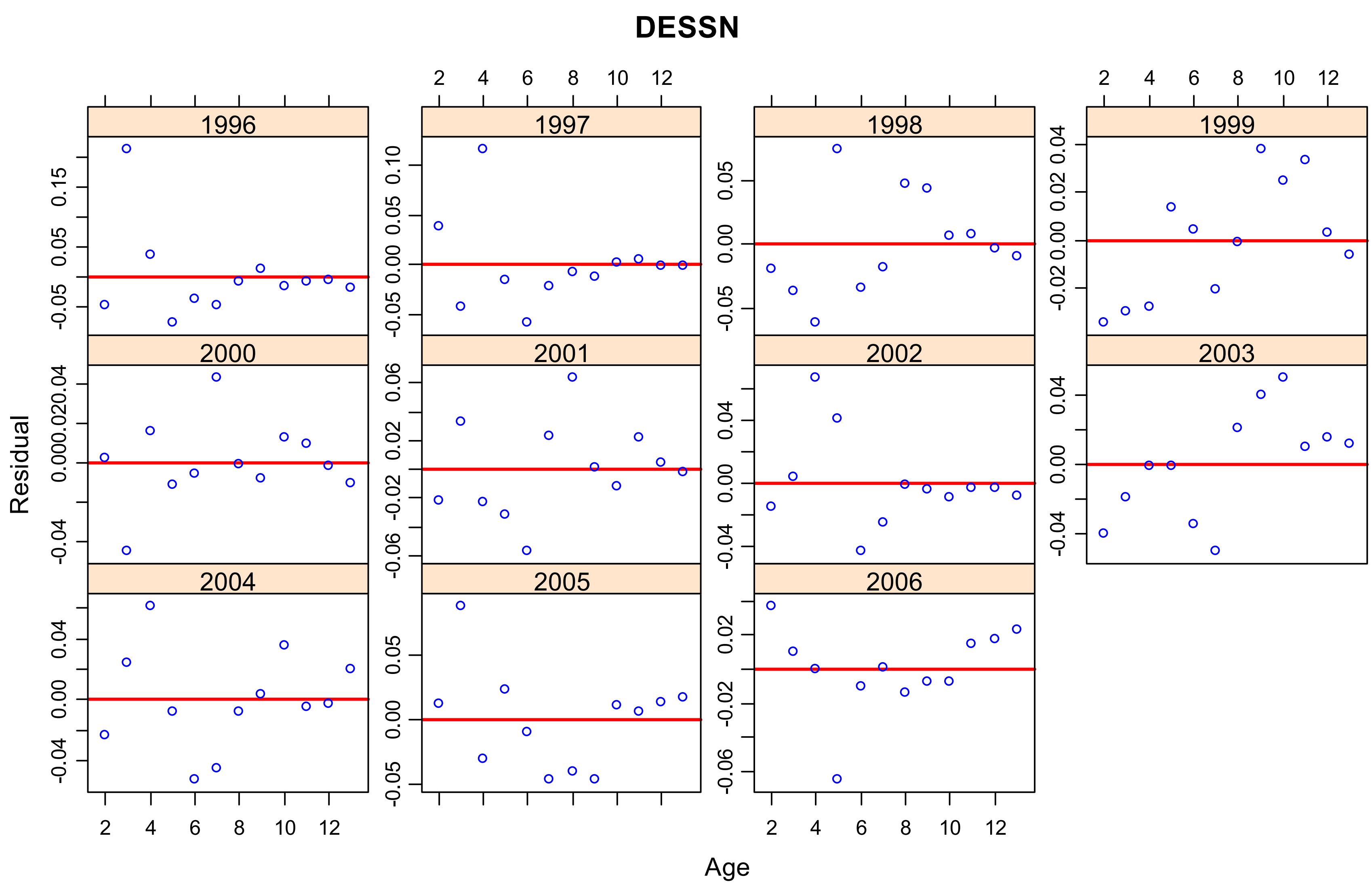


Figure 26. Residuals of survey age compositions by year for the Delaware electrofishing survey

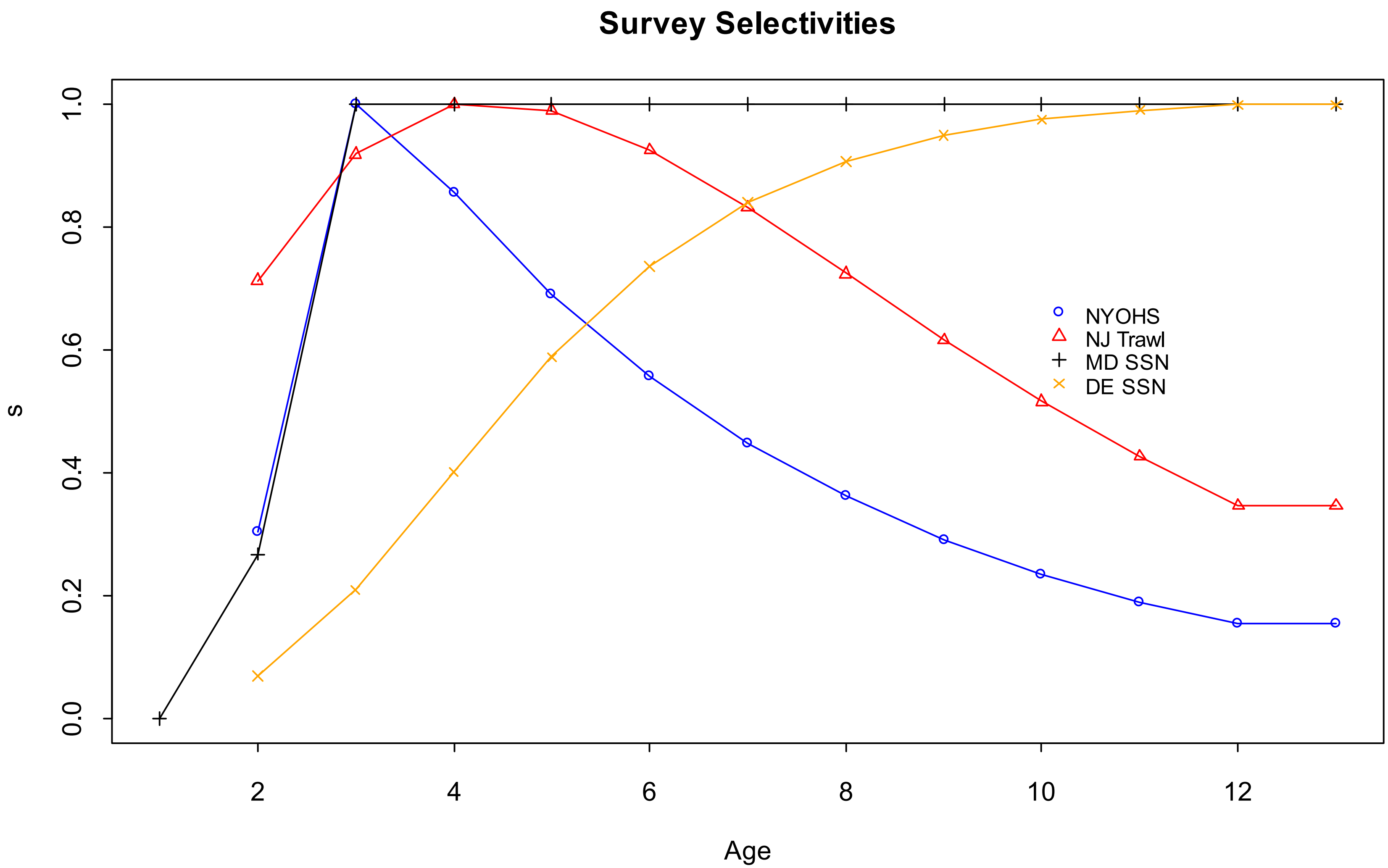


Figure 27. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD gillnet, and DE electrofishing surveys

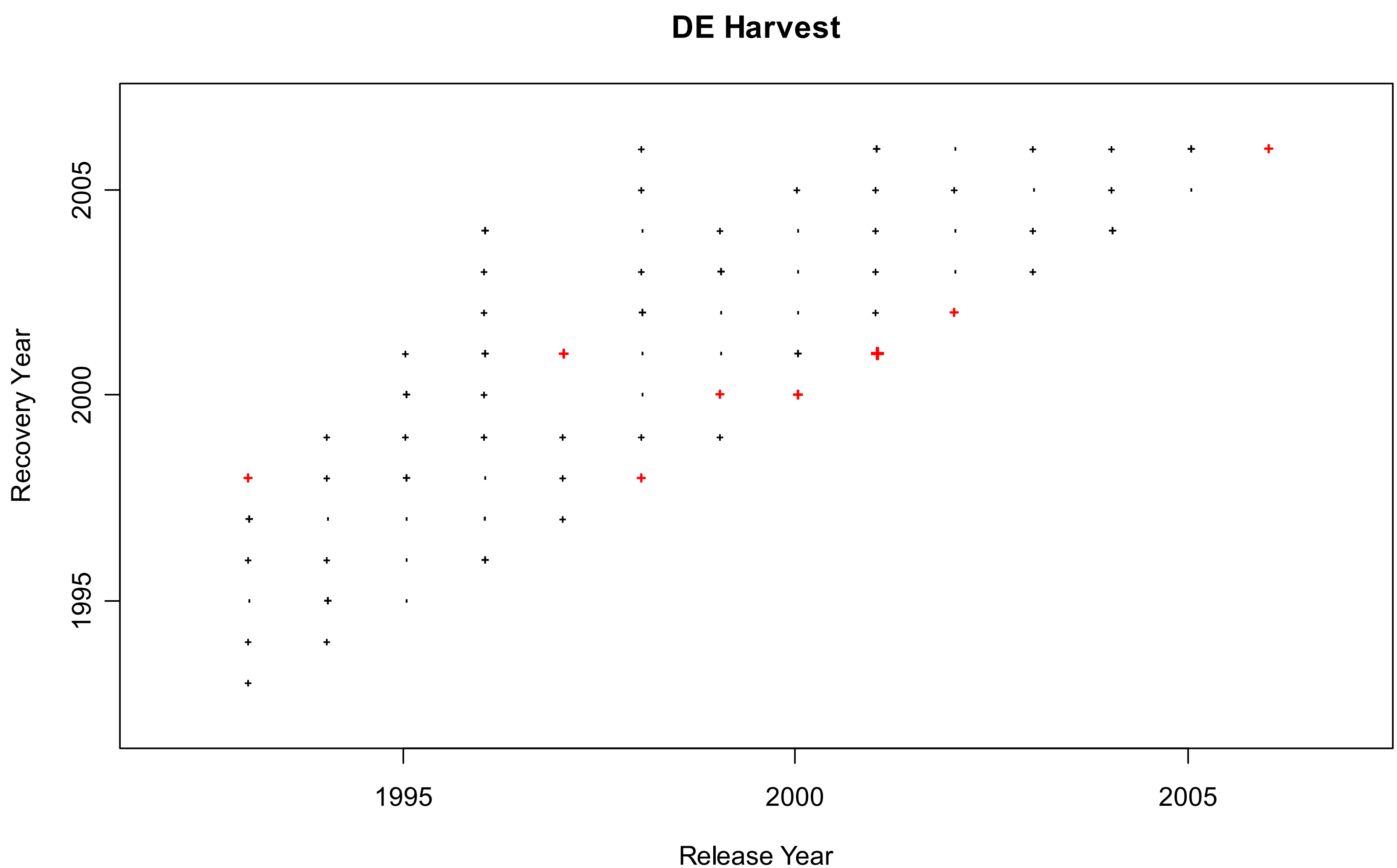
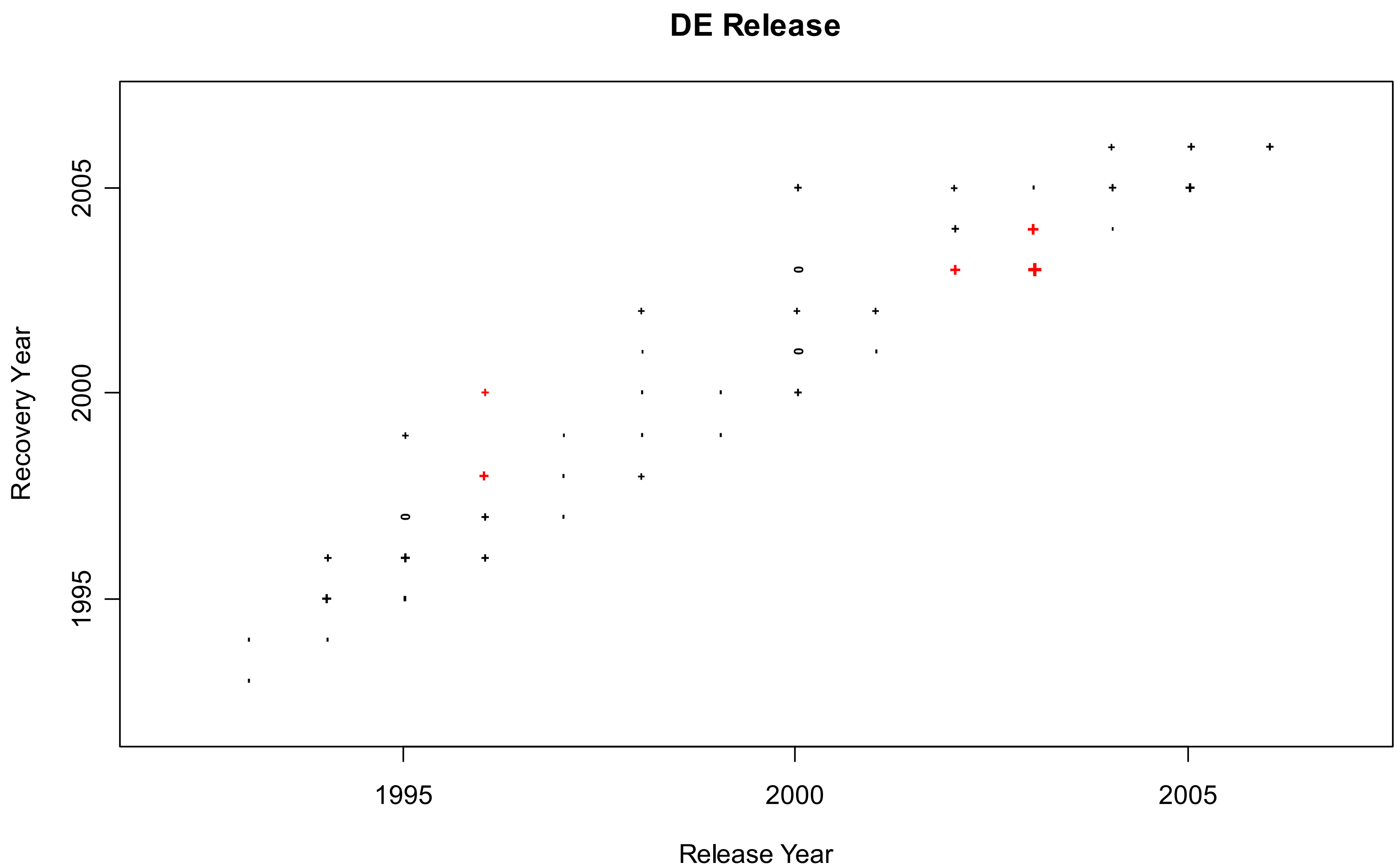


Figure 28. Residuals plots for the harvest and catch/release tag returns. The symbols represent negative (-) or positive (+) residuals, the size of the symbol represents the magnitude of the chi-square value, and the color red signifies that the cell chi-square value is significant at p<=0.05, df=1.



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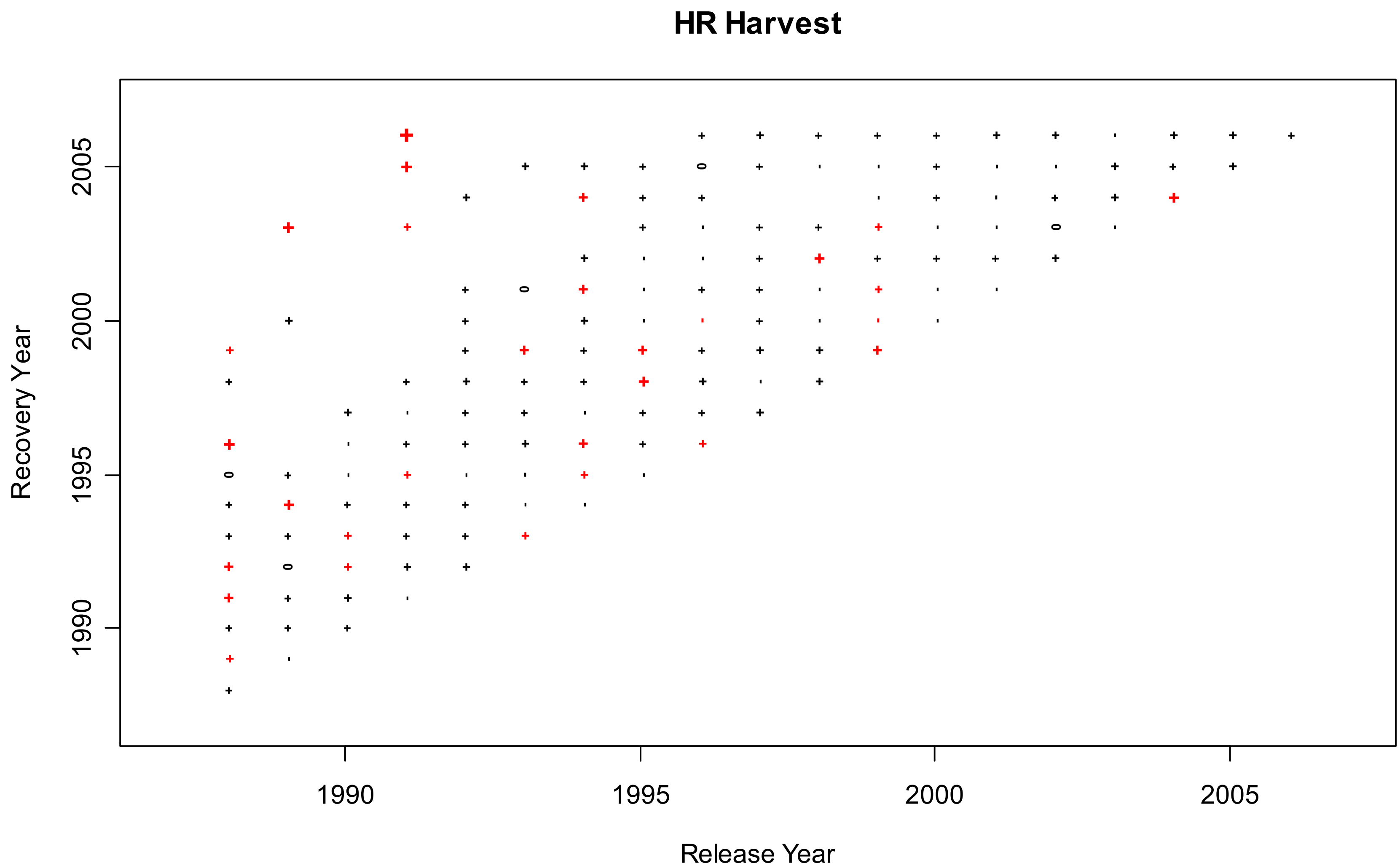

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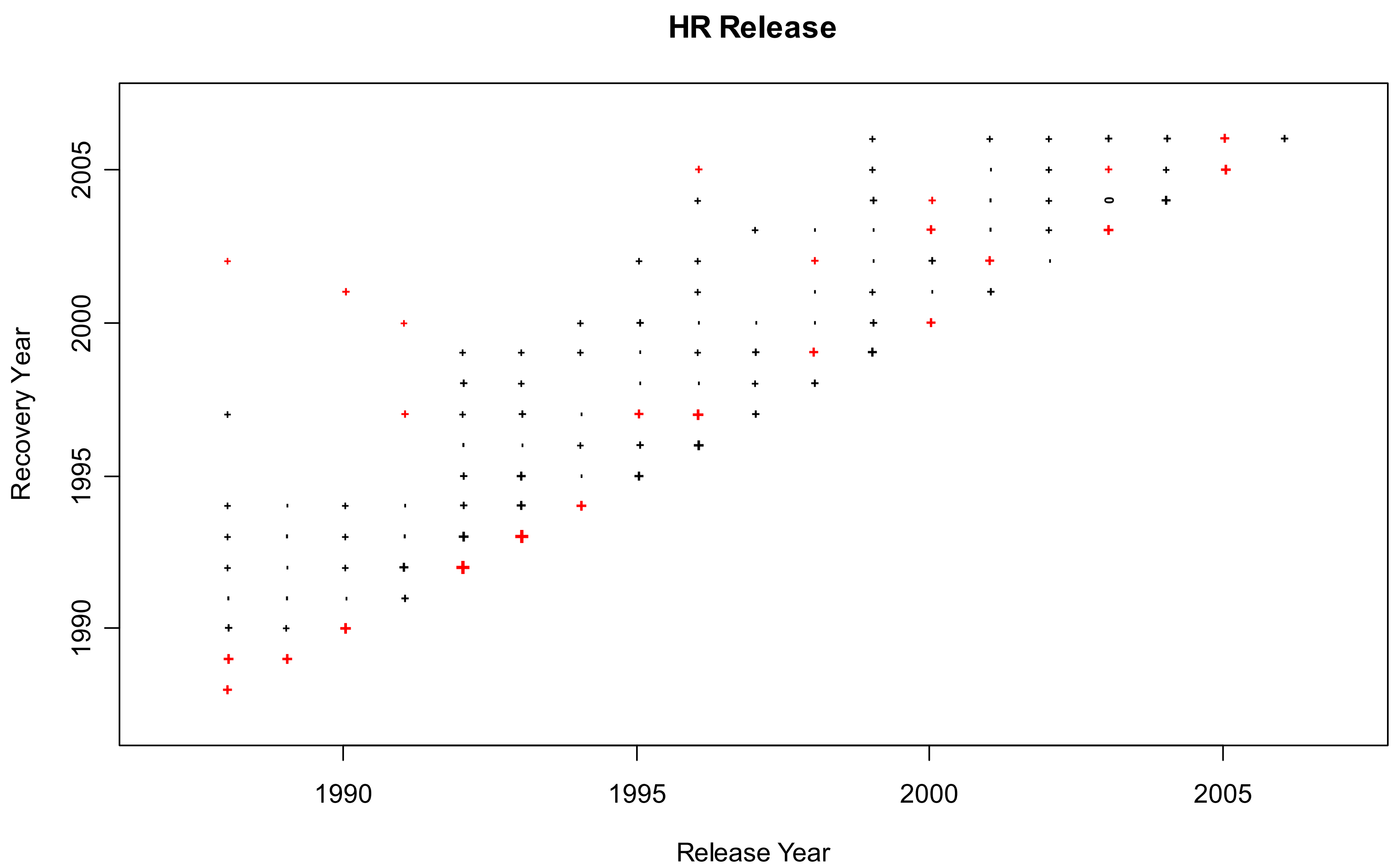

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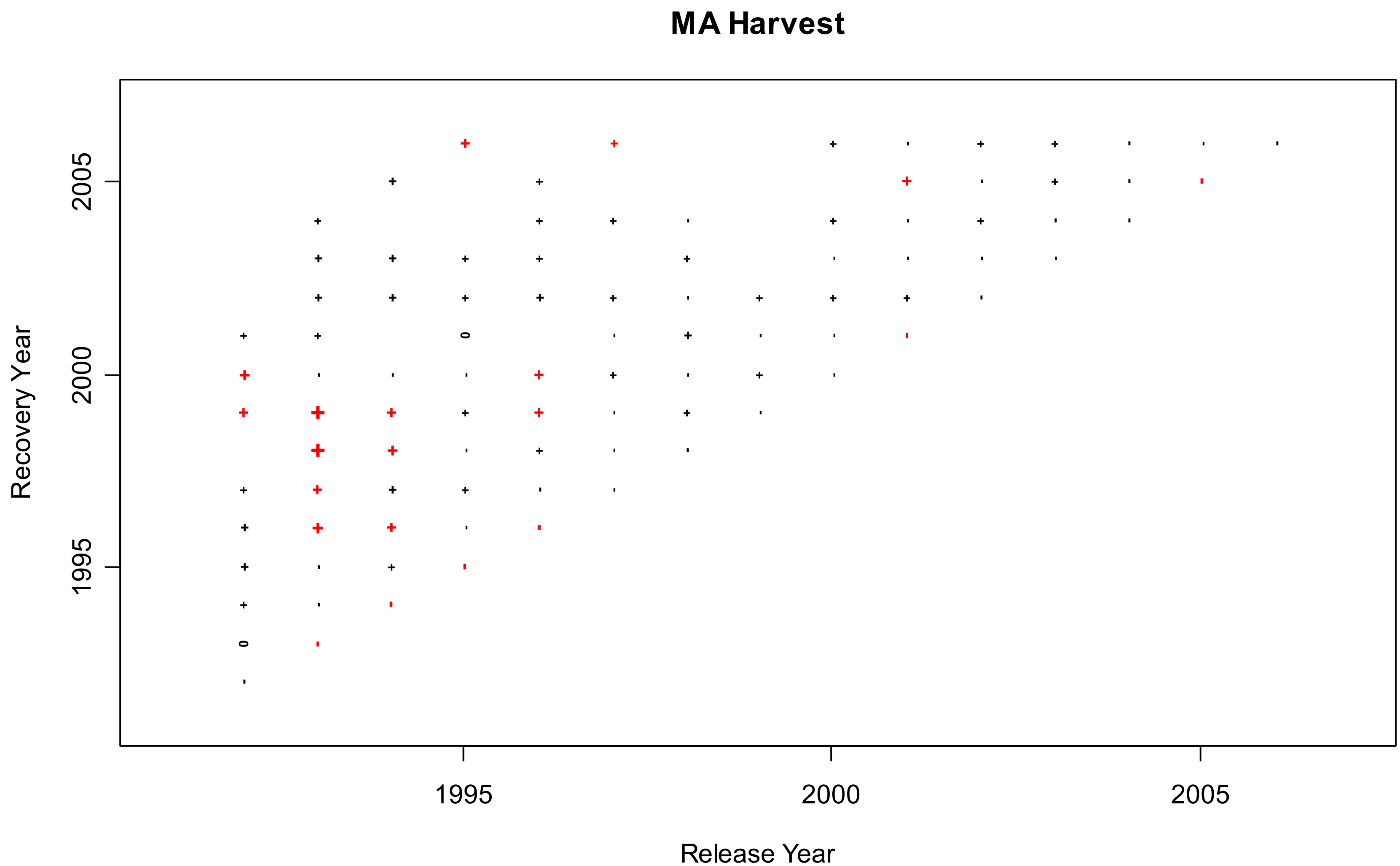

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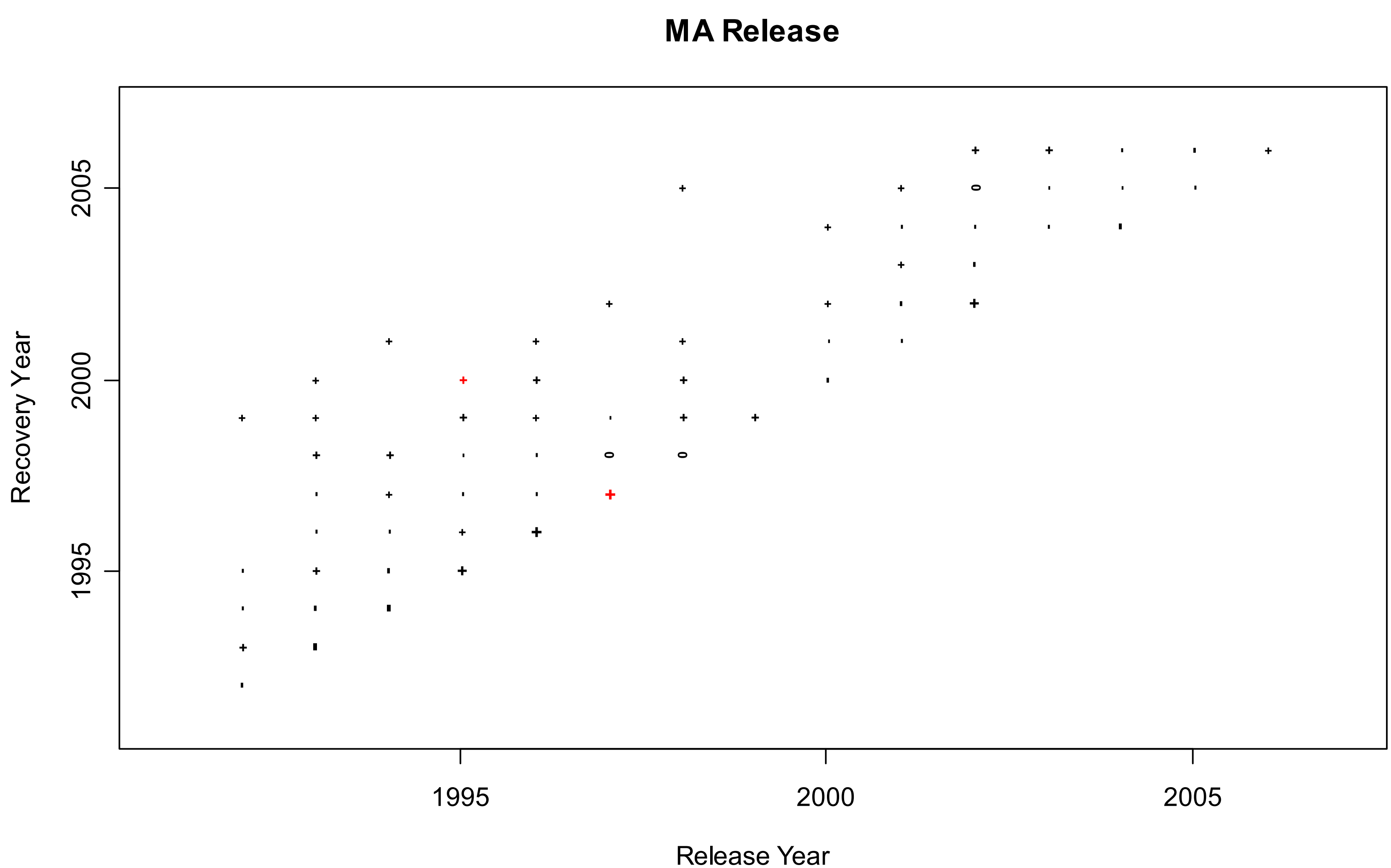

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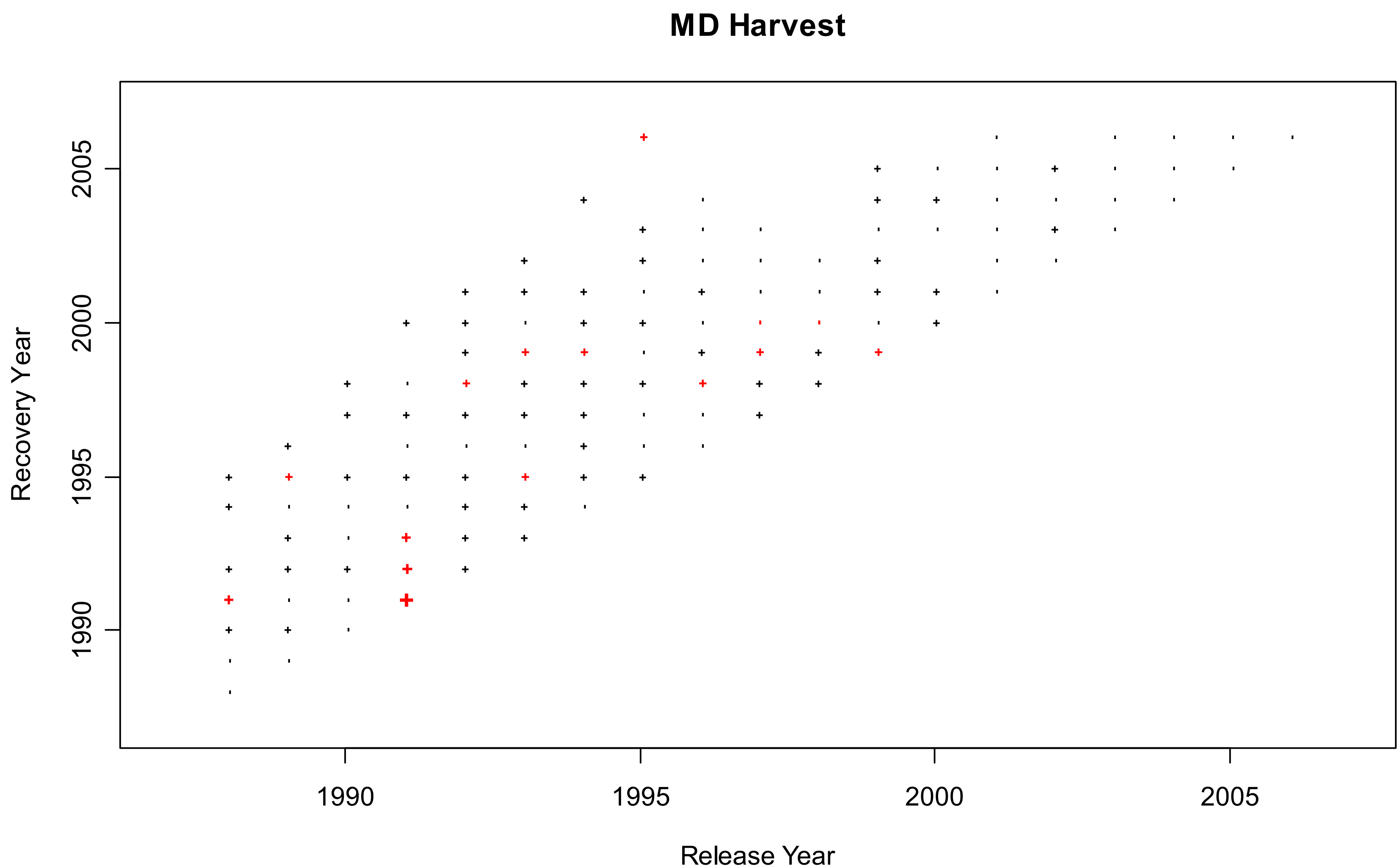

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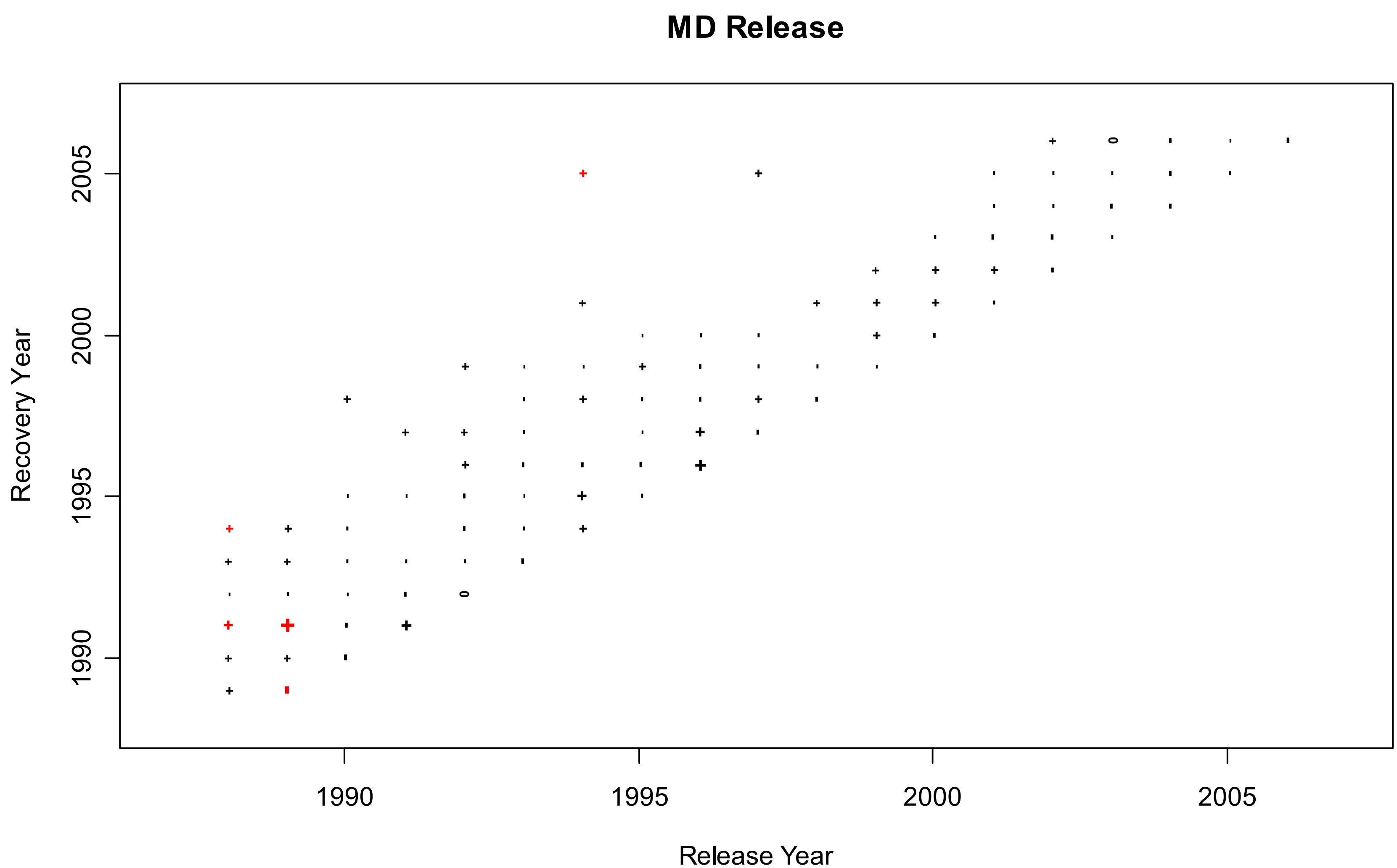

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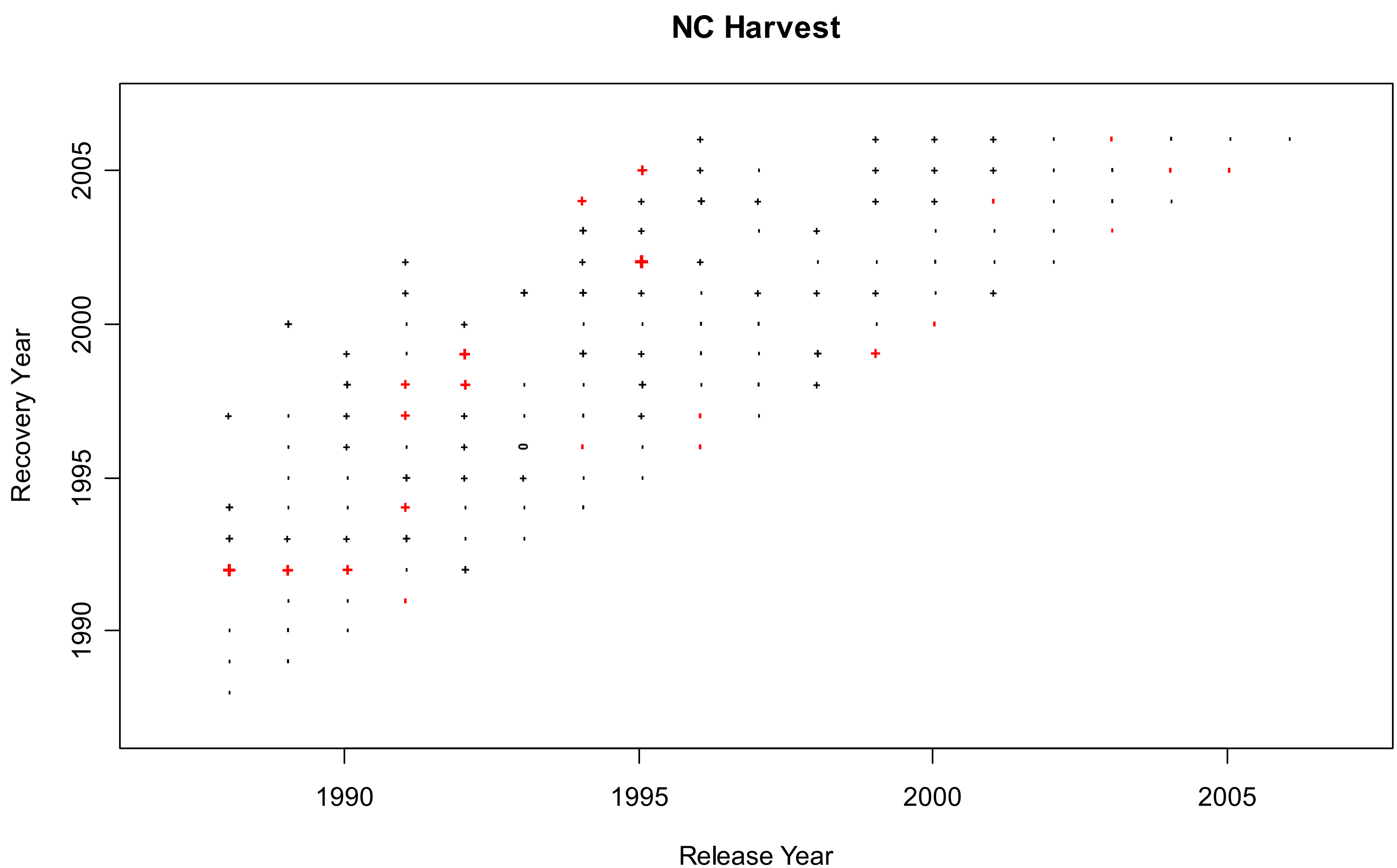

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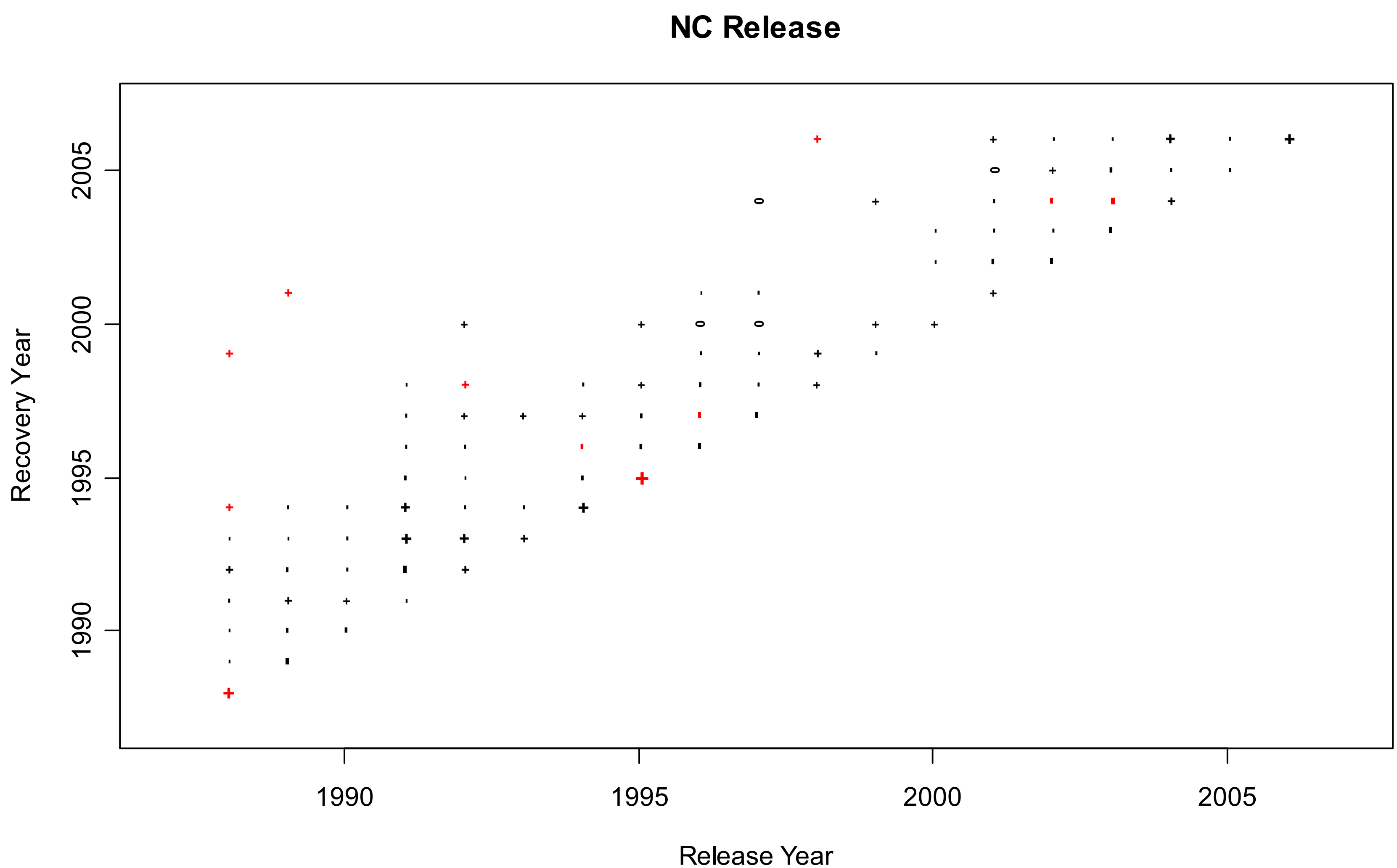

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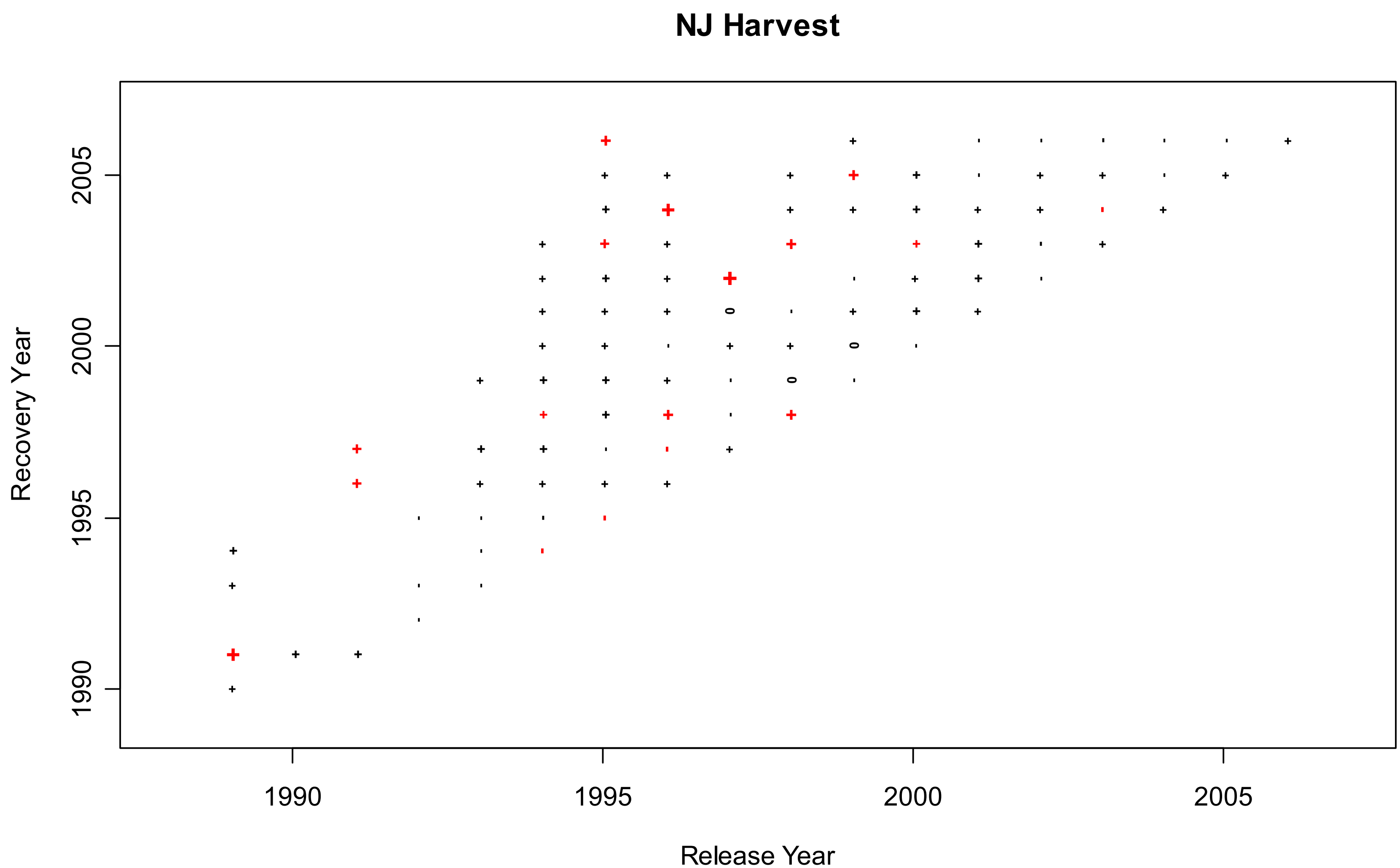

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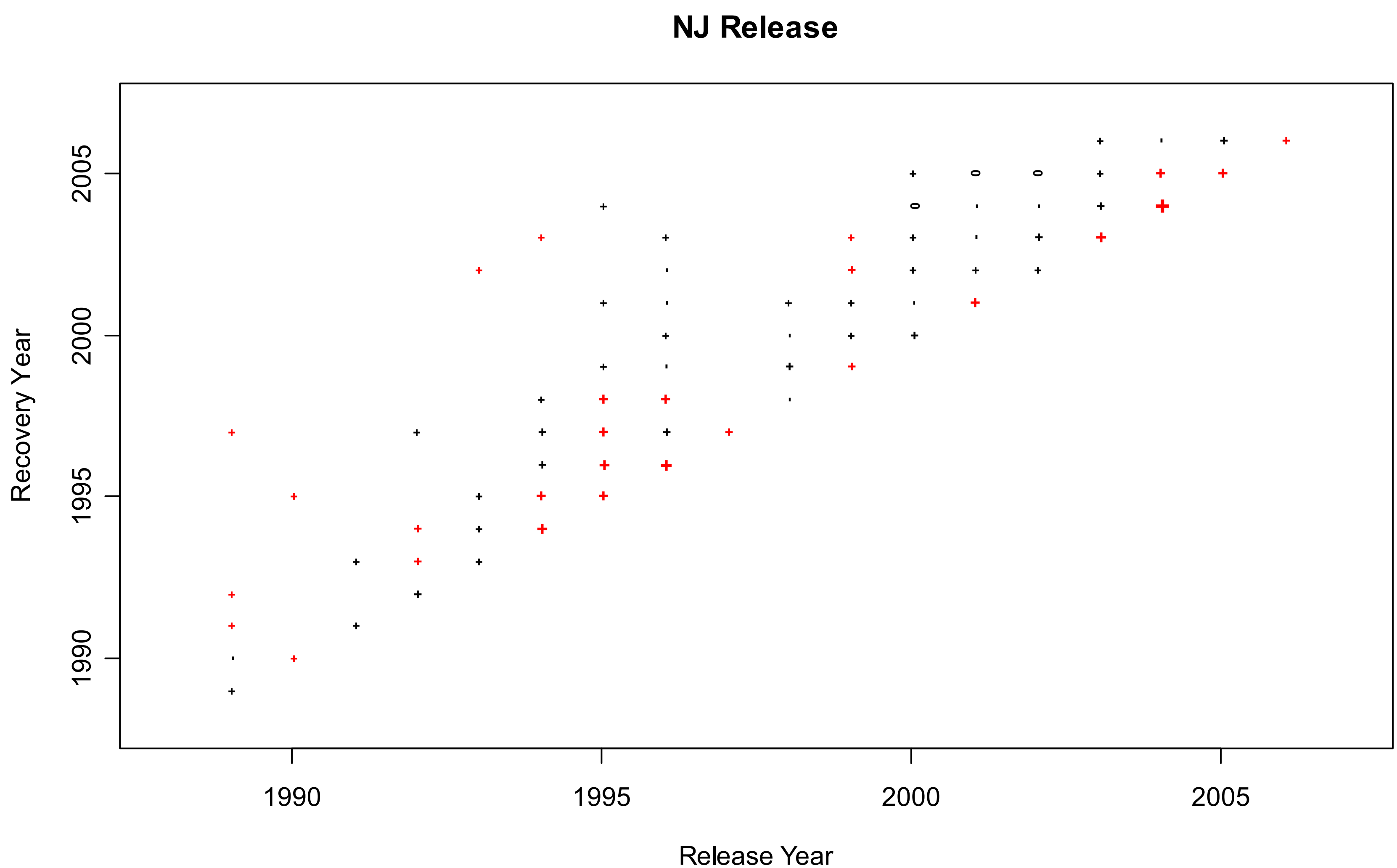

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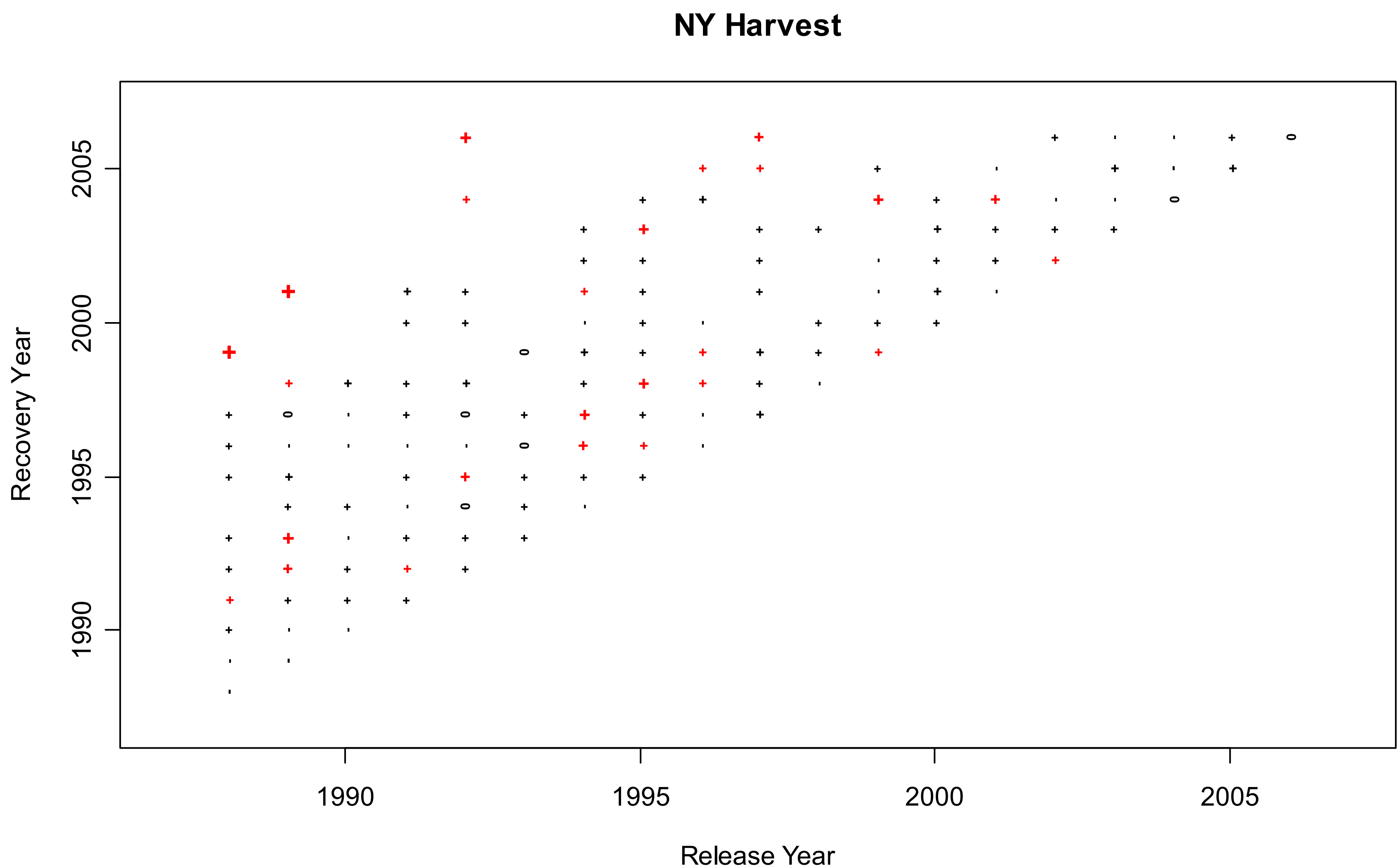

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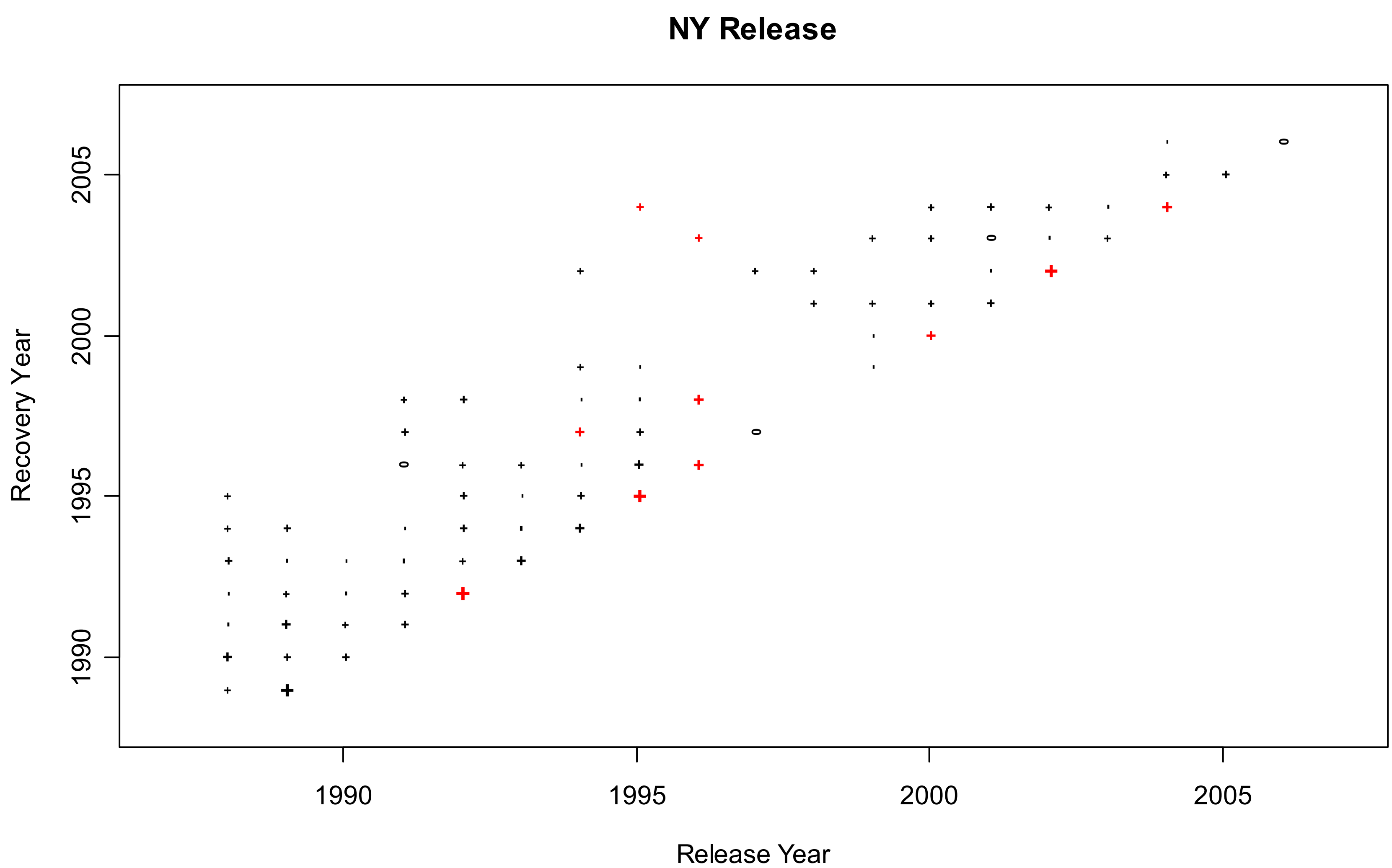

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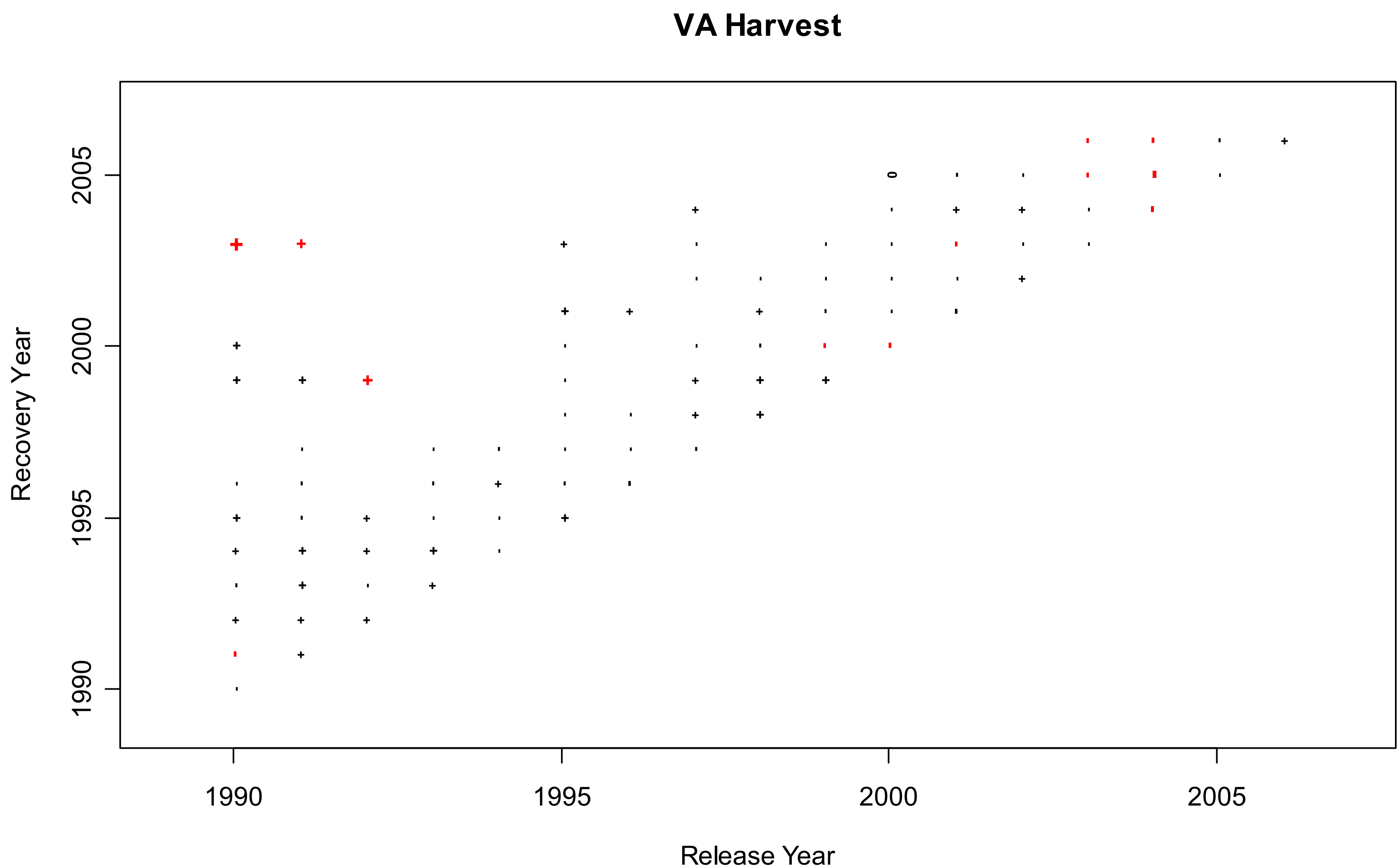

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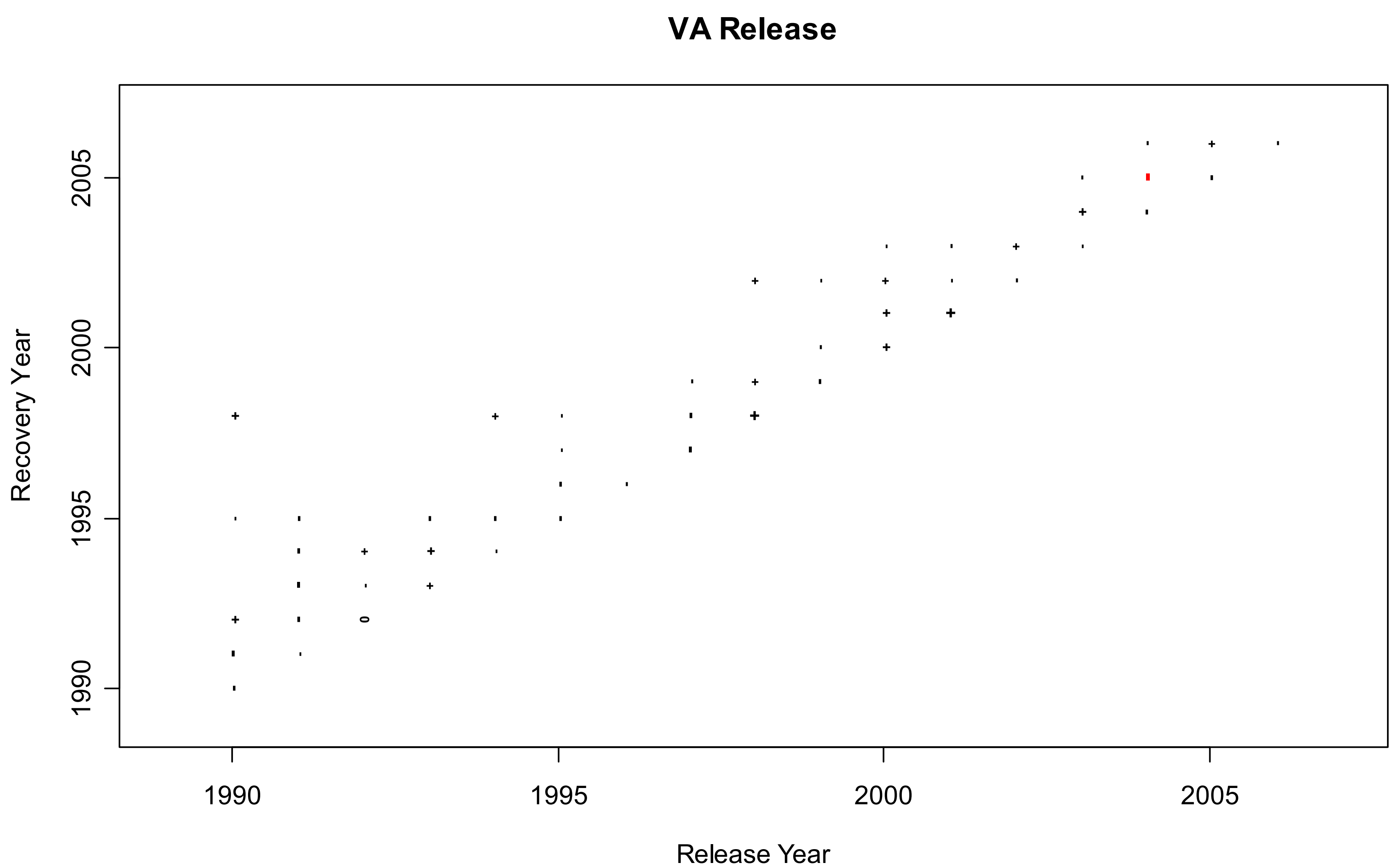

Figure 28 continued.

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