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

**This series is a secondary scientific series** designed to assure the long-term documentation and to enable the timely transmission of research results by Center and/or non-Center researchers, where such results bear upon the research mission of the Center (see the outside back cover for the mission statement). These documents receive internal scientific review, and most receive copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these documents.

All documents issued in this series since April 2001, and several documents issued prior to that date, have been copublished in both paper and electronic versions. To access the electronic version of a document in this series, go to *http://www.nefsc.noaa.gov/nefsc/publications/*. The electronic version is available in PDF format to permit printing of a paper copy directly from the Internet. If you do not have Internet access, or if a desired document is one of the pre-April 2001 documents available only in the paper version, you can obtain a paper copy by contacting the senior Center author of the desired document. Refer to the title page of the document for the senior Center author's name and mailing address. If there is no Center author, or if there is corporate (*i.e.*, non-individualized) authorship, then contact the Center's Woods Hole Laboratory Library (166 Water St., Woods Hole, MA 02543-1026).

**This document's publication history is as follows**: manuscript submitted for review January 28, 2008; manuscript accepted through technical review February 1, 2008; manuscript accepted through policy review January 29, 2008; and final copy submitted for publication January 28, 2008. Pursuant to section 515 of Public Law 106-554 (the Information Quality Act), this information product has undergone a pre-dissemination review by the Northeast Fisheries Science Center, completed on February 1, 2008. The signed pre-dissemination review and documentation is on file at the NEFSC Editorial Office. This document may be cited as:

Northeast Fisheries Science Center. 2008. 46th Northeast Regional Stock Assessment Workshop (46th SAW) Assessment Report Appendixes. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 08-03b; 343 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Table of Contents

***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**

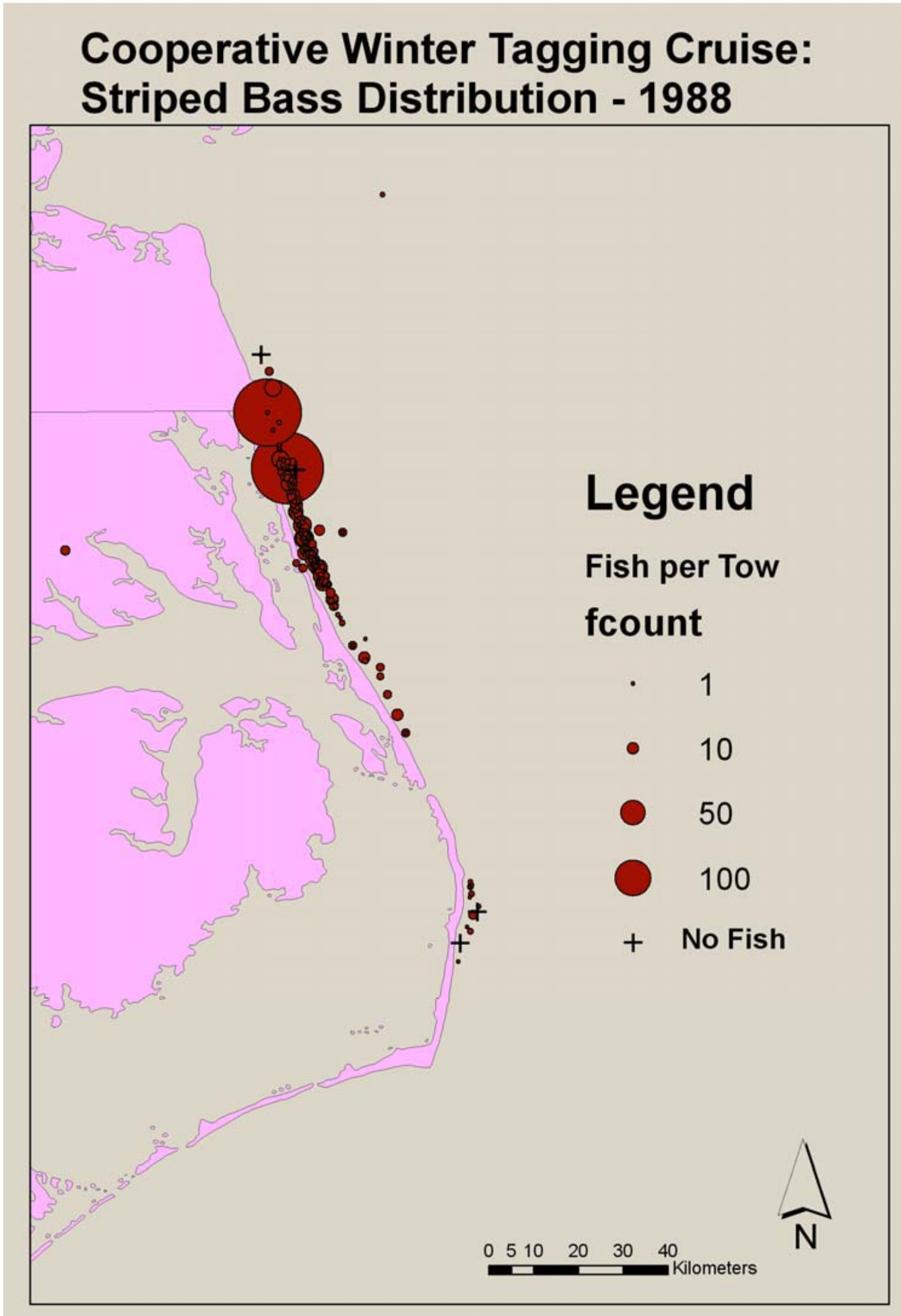



Figure 1. Distribution of striped bass captured on the wintering grounds during the 1988 Cooperative Winter Tagging Cruise

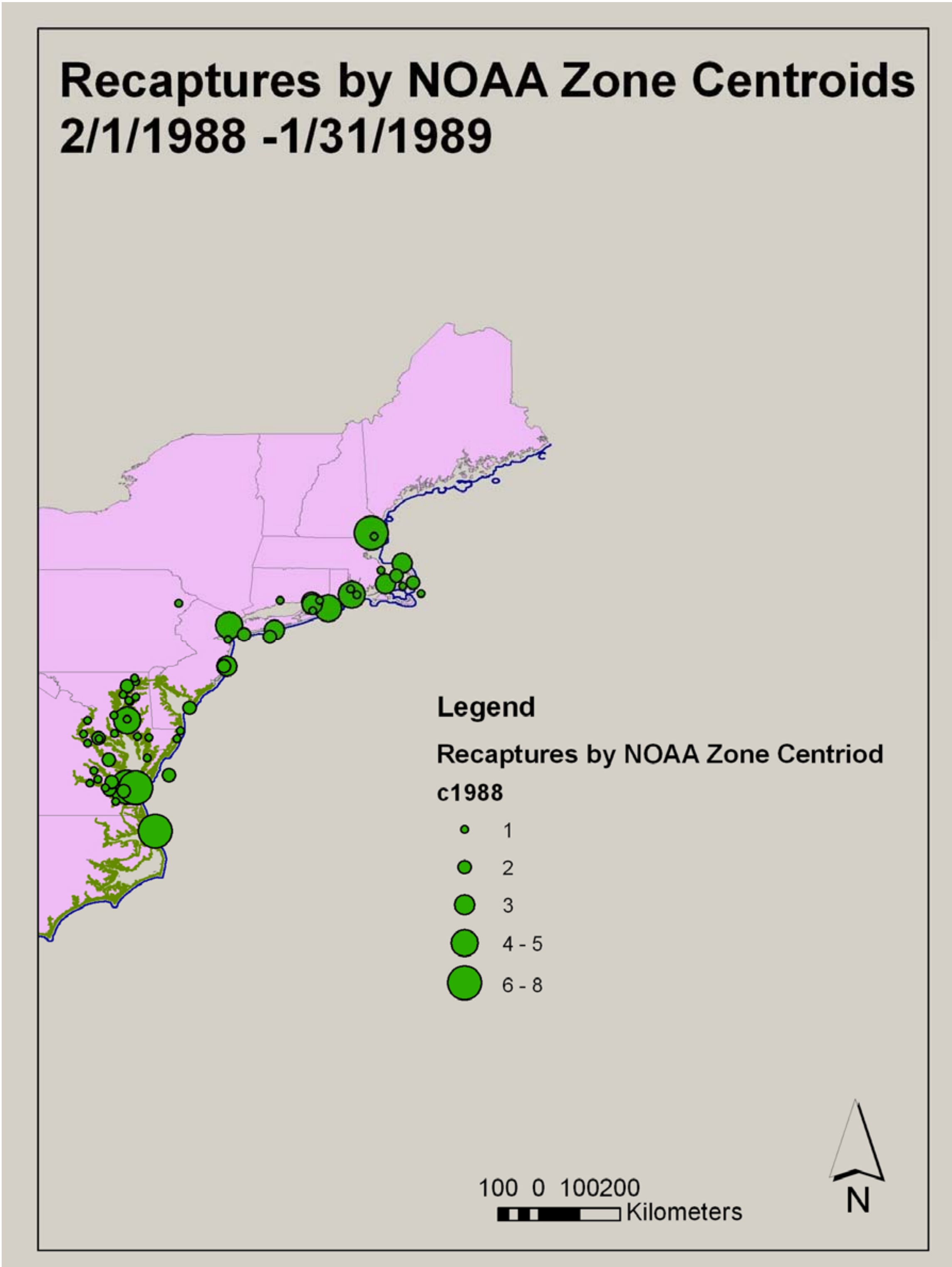



Figure 2. Distribution of all striped bass recaptures from 2/1/1988 – 1/31/1989 tagged during the 1988 Cooperative Winter Tagging Cruise

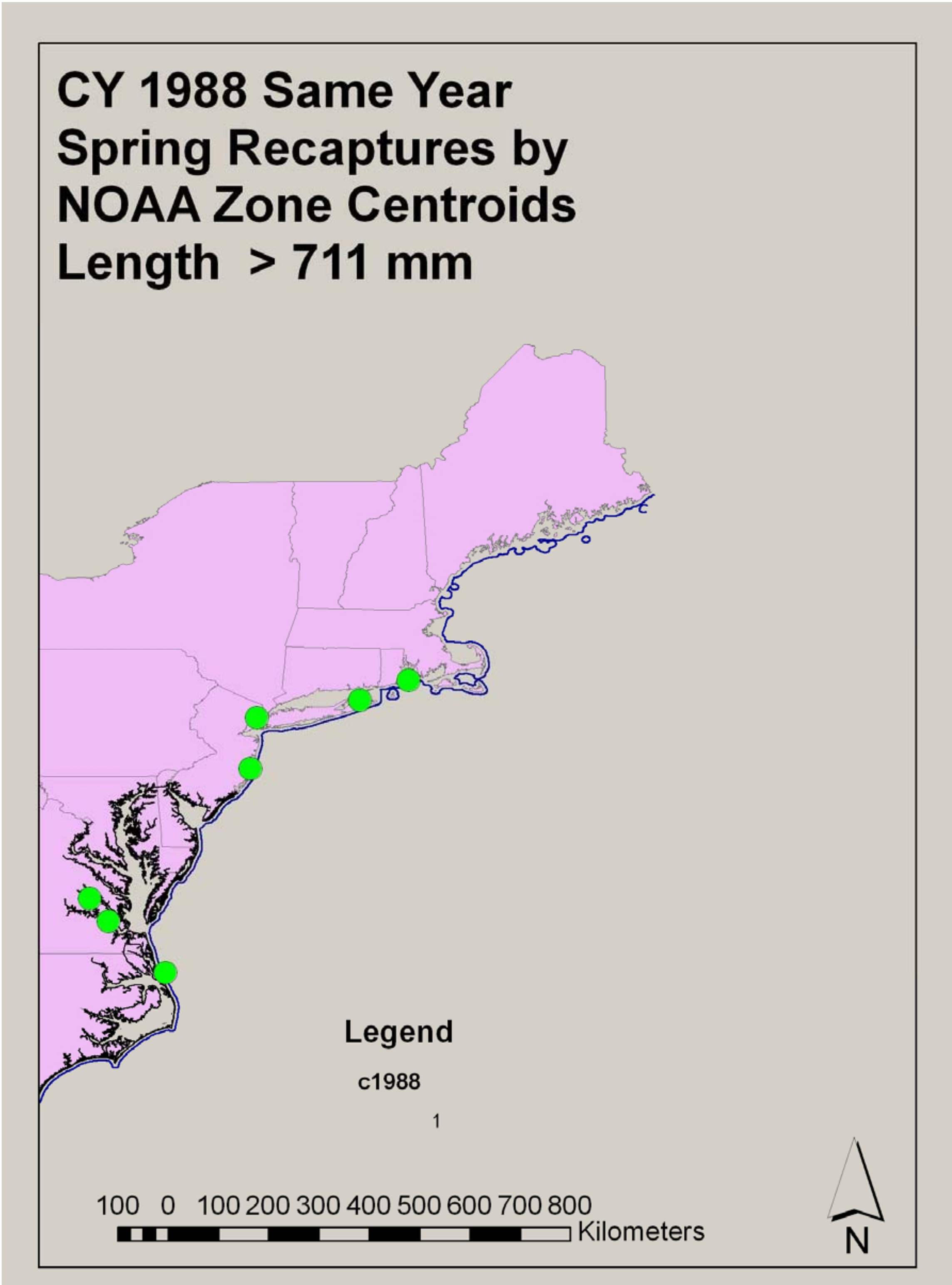



Figure 3. Distribution of 1988 spring recaptures of striped bass >711 mm and tagged during the 1988 Cooperative Winter Tagging Cruise

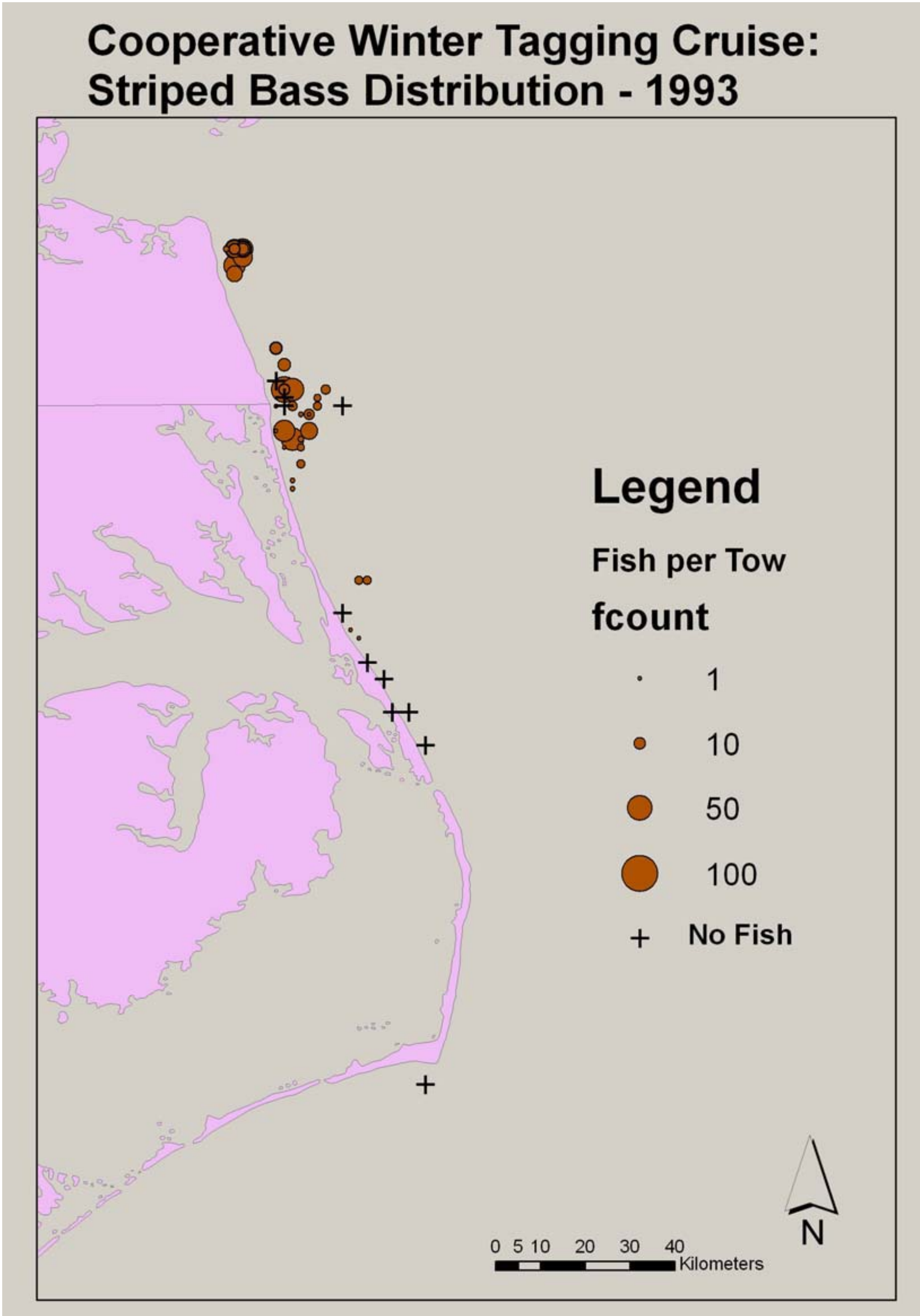



Figure 4. Distribution of striped bass captured on the wintering grounds during the 1993 Cooperative Winter Tagging Cruise

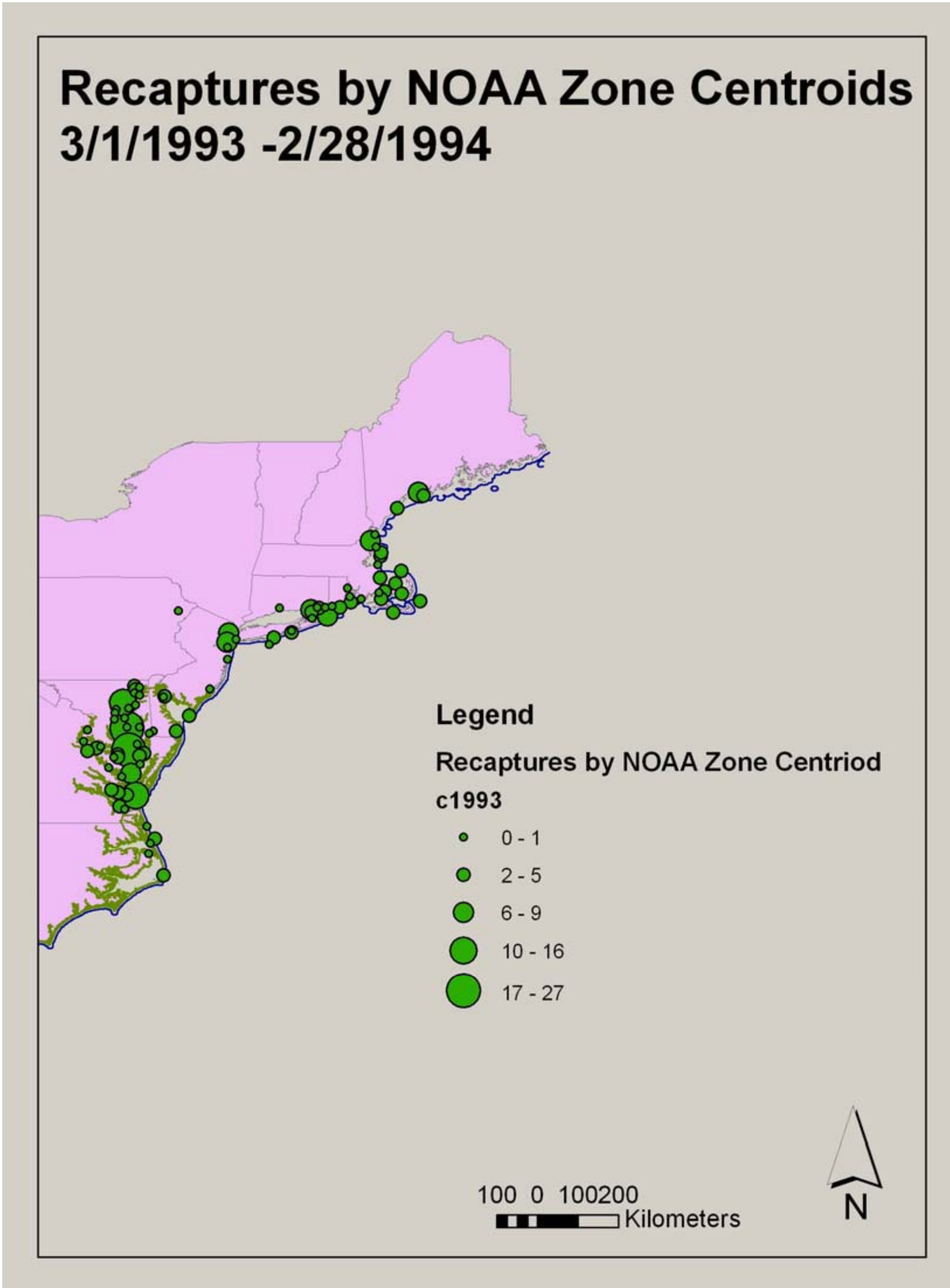



Figure 5. Distribution of all striped bass recaptures from 3/1/1993 – 2/28/1994 tagged during the 1993 Cooperative Winter Tagging Cruise

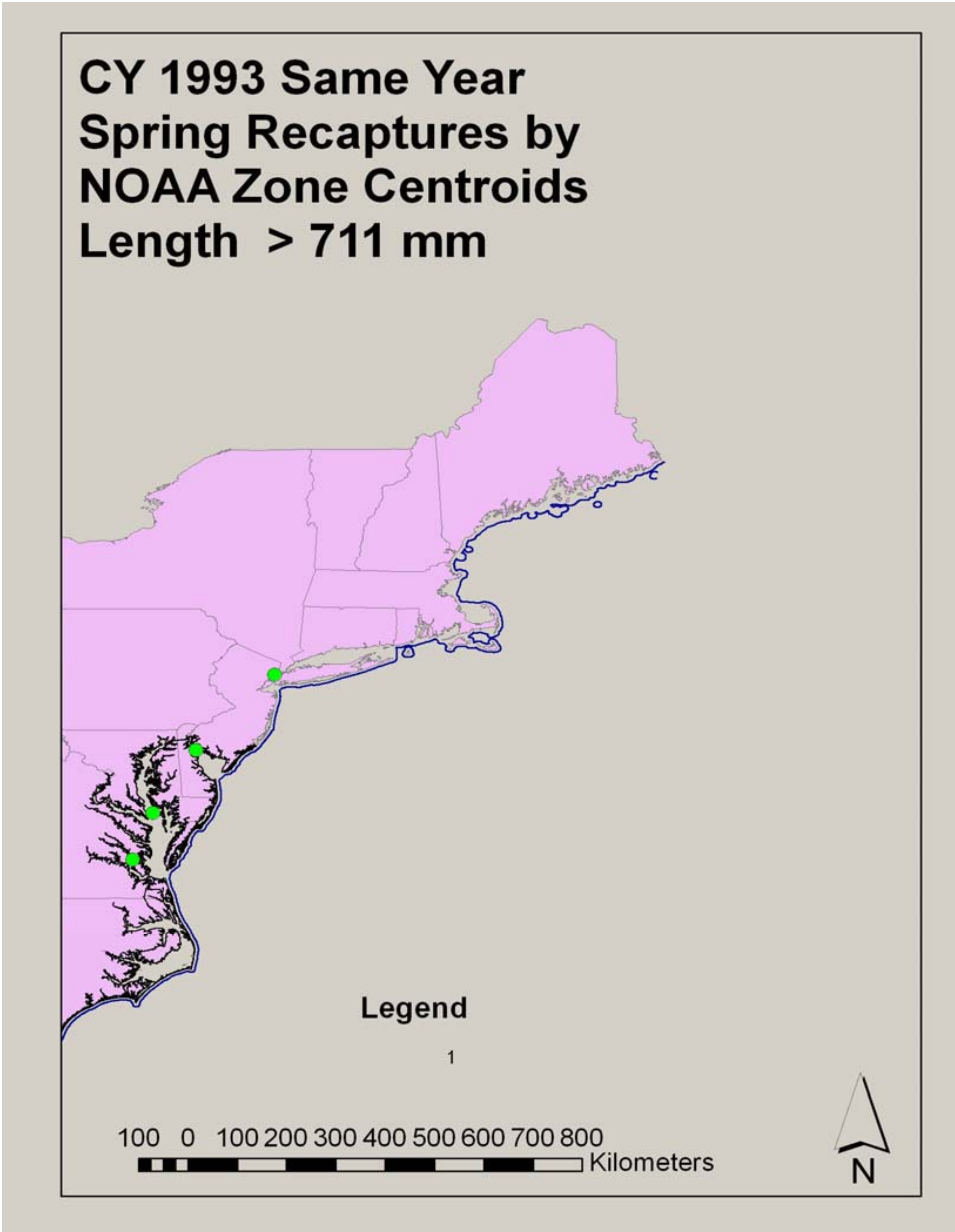



Figure 6. Distribution of 1993 spring recaptures of striped bass >711 mm and tagged during the 1993 Cooperative Winter Tagging Cruise

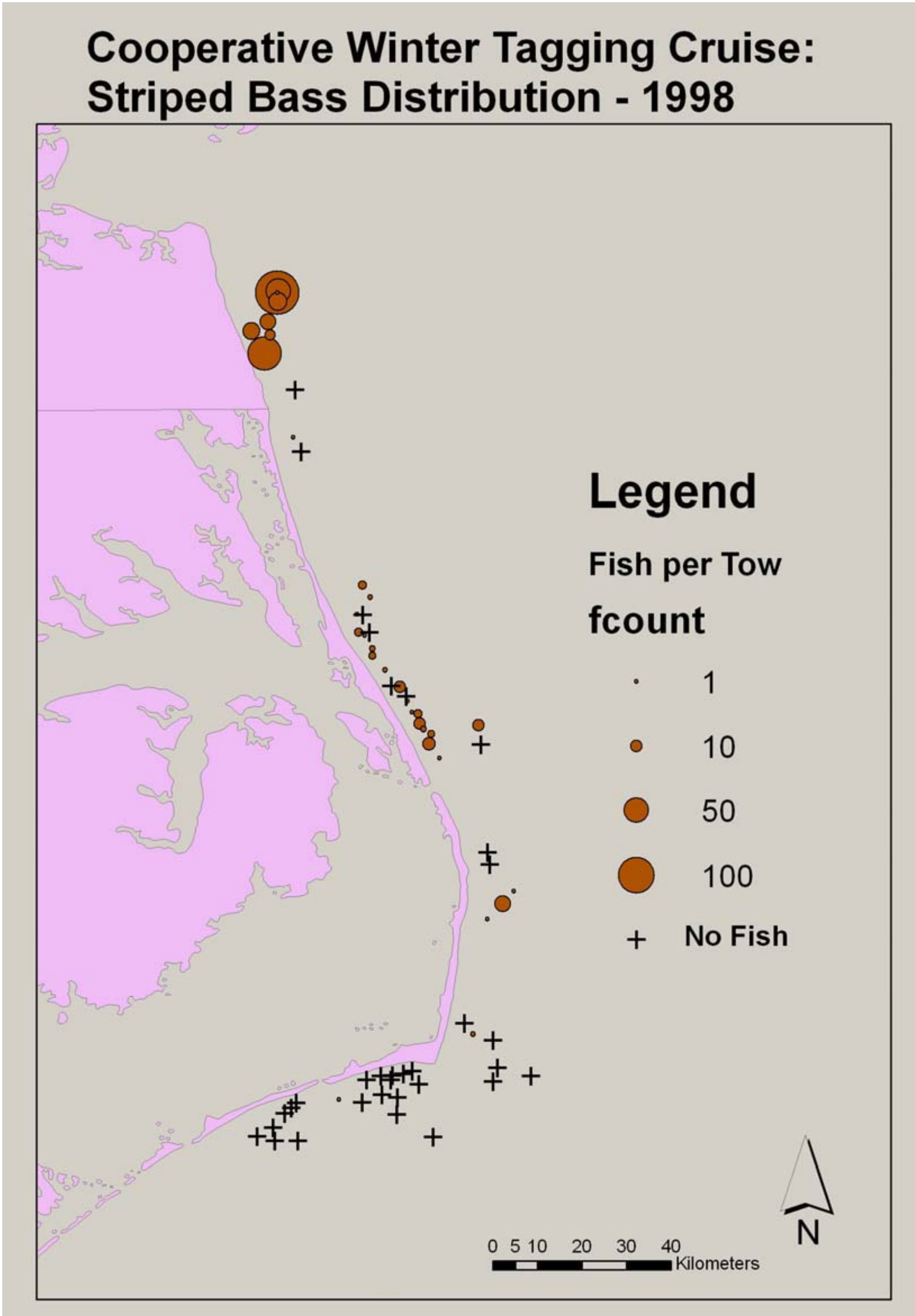



Figure 7. Distribution of striped bass captured on the wintering grounds during the 1998 Cooperative Winter Tagging Cruise

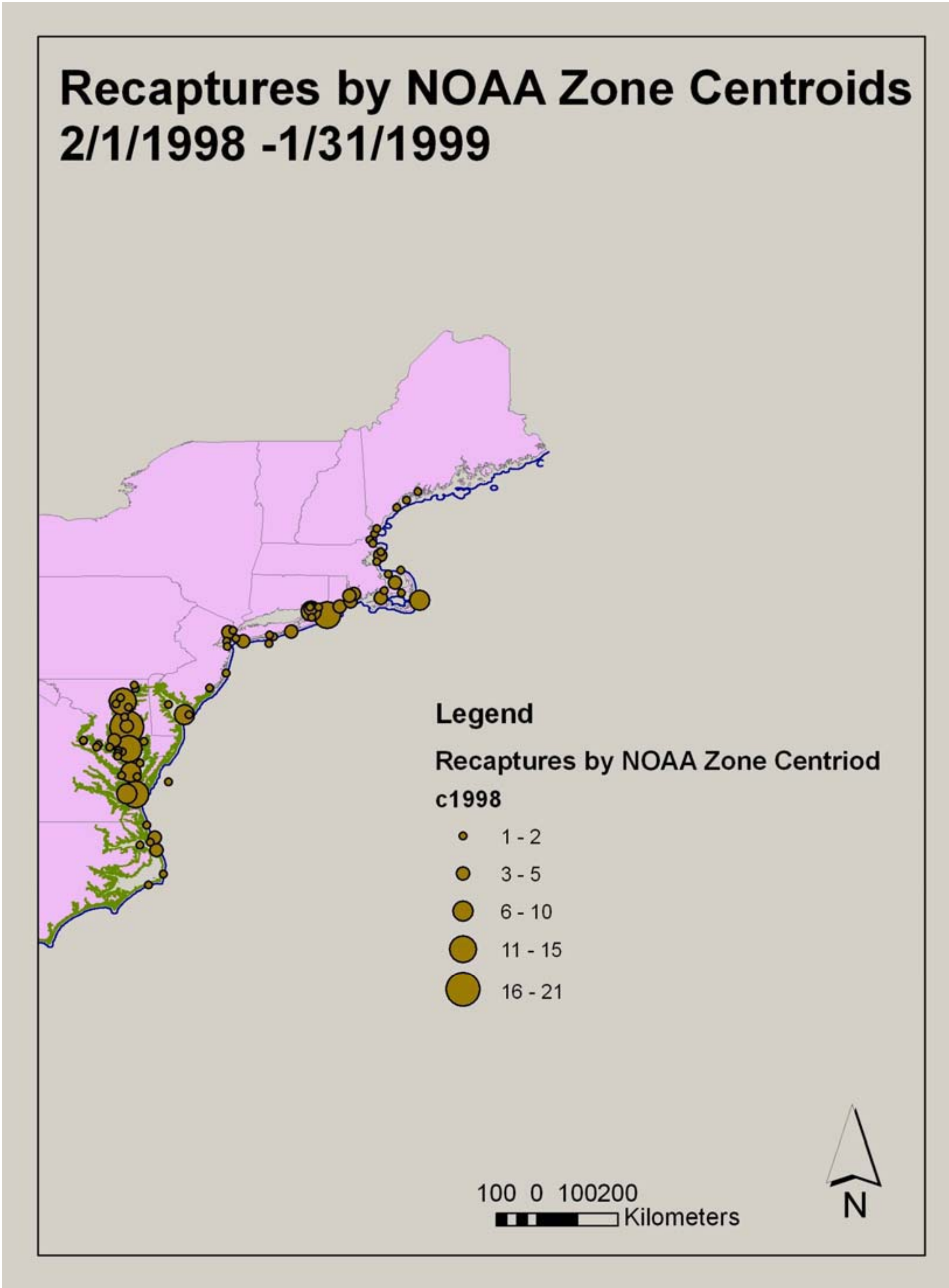



Figure 8. Distribution of all striped bass recaptures from 2/1/1998 – 1/31/1999 tagged during the 1998 Cooperative Winter Tagging Cruise

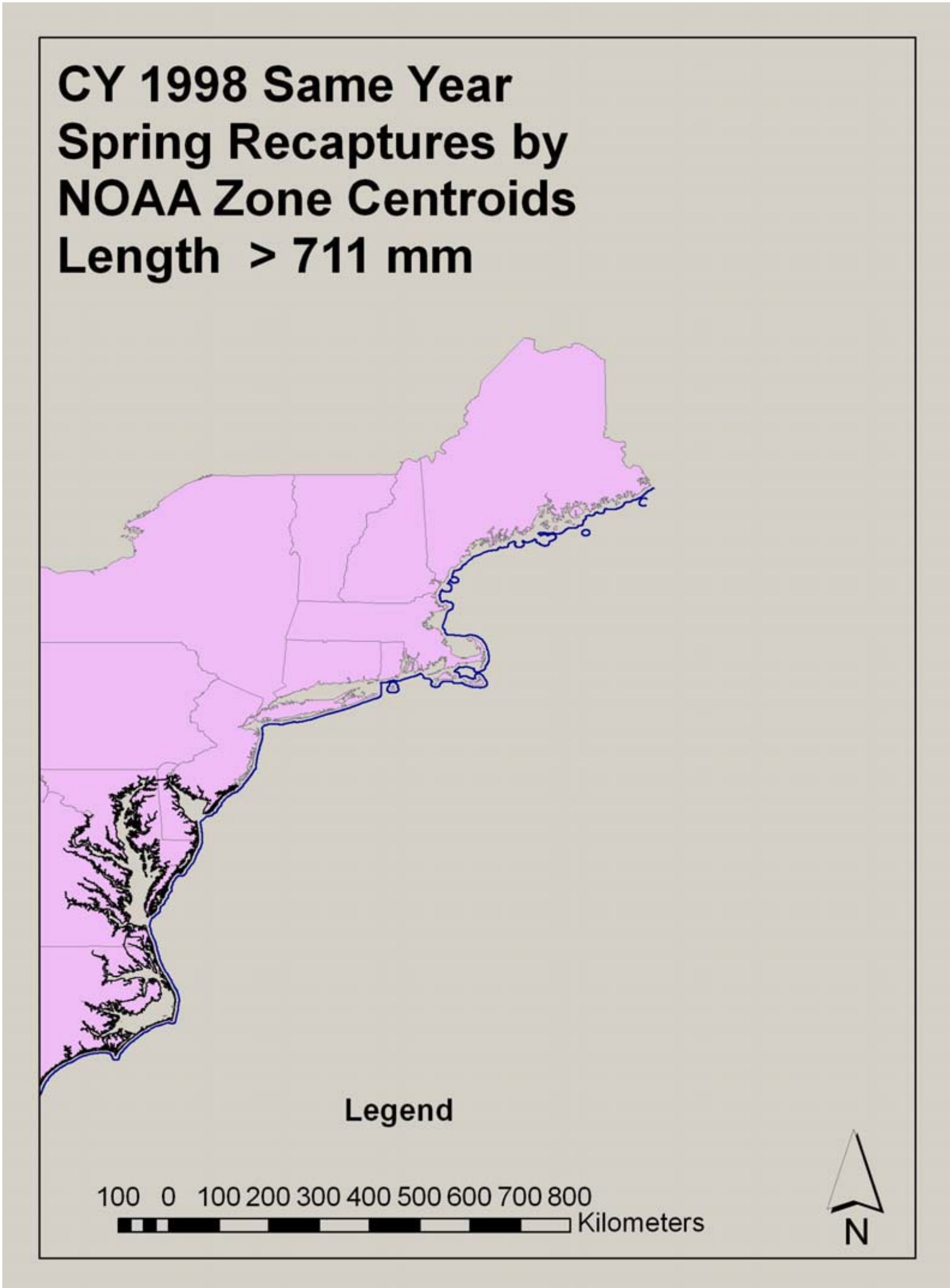



Figure 9. Distribution of 1998 spring recaptures of striped bass >711 mm and tagged during the 1998 Cooperative Winter Tagging Cruise

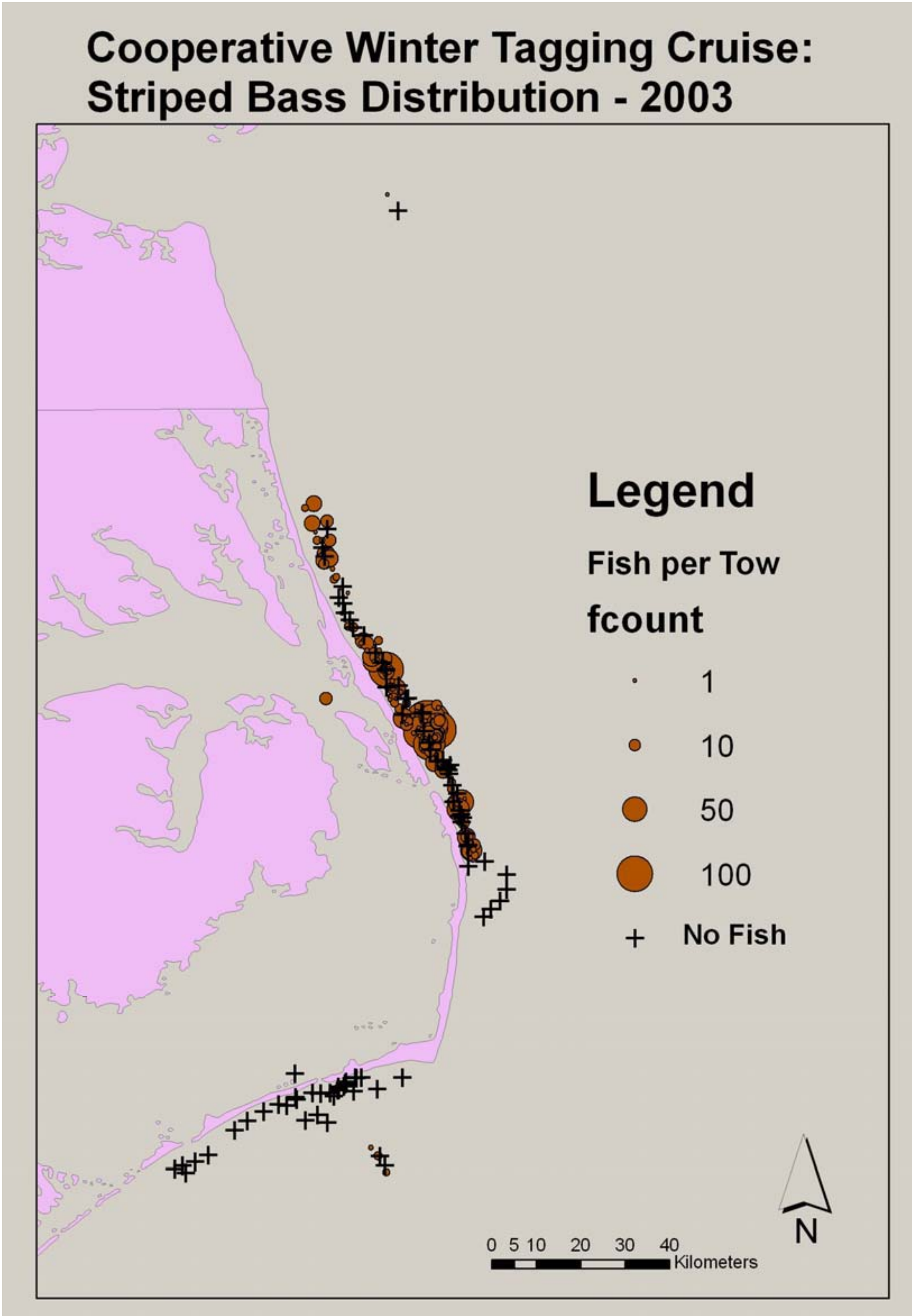



Figure 10. Distribution of striped bass captured on the wintering grounds during the 2003 Cooperative Winter Tagging Cruise

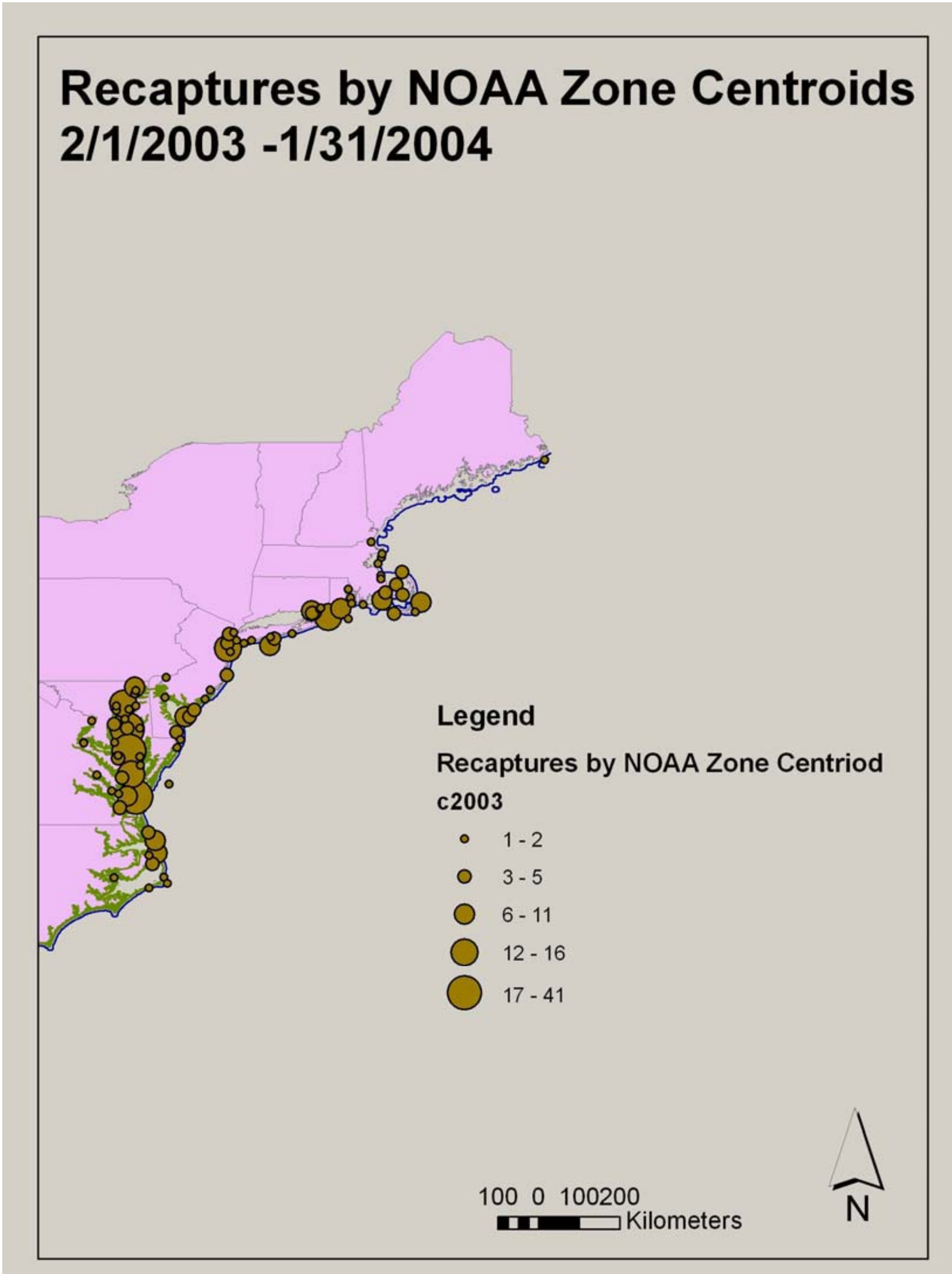



Figure 11. Distribution of all striped bass recaptures from 2/1/2003 – 1/31/2004 tagged during the 2003 Cooperative Winter Tagging Cruise

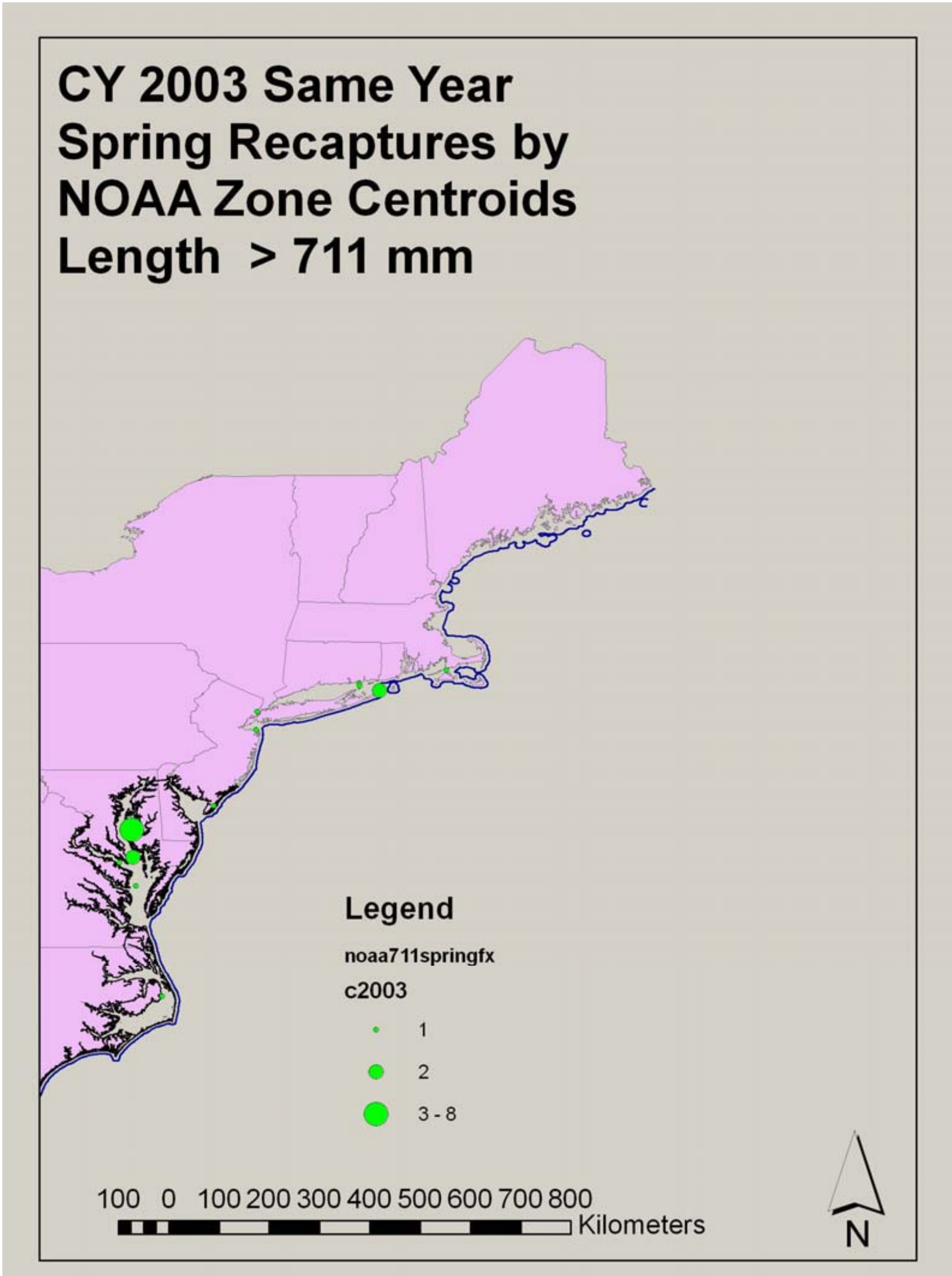



Figure 12. Distribution of 2003 spring recaptures of striped bass >711 mm and tagged during the 2003 Cooperative Winter Tagging Cruise

## 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 $\alpha$= 0.05. Weighted proportions at age are generated by weighting the age proportions sampled in each county by county harvest. Scales are impressed in plastic using a heated press and aged by projecting impressions on a microfiche machine.

*Rhode Island*

Scales are removed from each striped bass that is weighed and measured in the commercial dockside sampling program. A sample of scales (typically seven or more) is removed from the area behind the pectoral fin and then cataloged for ageing. The number of age samples taken range from 185 to 492 per year per gear type.

*New York*

A sample of scales is collected from each fish sampled by staff from the Bureau of Marine Resources (as described in the previous New York section). Each year, approximately 1,000 age samples are collected. Scales are pressed into clear acetate and age assignment is completed by a minimum of two readers. Age assignments are compared for agreement. Disagreements are settled by a group reading or repress of the sample. Samples for which no agreement can be reached are often discarded from the set.

*Delaware*

Commercial harvest is sampled primarily at fish houses, but sometimes samples are obtained prior to arrival at fish houses. DFW personnel are not always available to sample due to other responsibilities. No formal sampling scheme exists due to the fact that samples are often difficult to obtain because harvest can be sporadic in space and time. There is often also a problem getting access to all fish in a fish house if they have been boxed up prior to DFW personnel arrival. Usually in the two-month spring gill net season, DFW obtains 8-15 samples, totaling a few hundred fish. Each fish is measured and weighed, sex is determined if possible, and scale samples are taken.

**Potomac River Fisheries Commission (DC)**

A random sample (weekly or monthly) is purchased from local fish buyers. The samples are transported to VIMS, where length, weight, sex and age (scales) are recorded. The recent average monthly harvest are used to establish a target sampling frequency and sample sizes. The sample is ‘worked-up’ by professionally trained people at VIMS.

*Maryland*

Age composition of the pound net and hook-and-line fisheries is estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). The first stage refers to total length samples taken during the surveys, which was assumed to be a random sample of the commercial harvest. In this case, the length frequencies from hook-and-line and pound net check stations were combined with the pound net tagging length frequency. In stage 2, a random sub-sample of scales was aged which were selected in proportion to the length frequency of the initial sample. The total number of scales to be aged was determined using a Vartot analysis which is a derived index measuring the precision of an age-length key (Kimura 1977, Lai 1987). Regardless of the sample size indicated by the Vartot analysis, 10 fish in each length category over 700 mm TL were aged. Year-class was determined by reading acetate impressions of the scales placed in microfiche readers, and age was calculated by subtracting year-class from collection year. The resulting ages were used to construct an age-length key.

*Virginia*

VMRC has been collecting striped bass biological data since 1988. The field sampling program is designed to sample striped bass harvests, in general proportion to the extent and timing of these harvests within specific water areas. Since 2003, Virginia has managed its

Coastal Area and Chesapeake Area harvests by two different ITQ systems, and data collections procedures are intended to ensure adequate representation of both harvest areas. Samples of biological data are collected from seafood buyers' place of business or dockside from offloaded striped bass caught by pound nets or haul seines. Infrequently, some gill net or commercial hook-and-line fisherman's harvests may be sampled directly. At a majority of the sites, striped bass are sampled from a 50-pound box that was previously boxed and iced. At other sites, recently landed fish are randomly sampled directly from the culling table. For each specimen, length is measured using an electronic fish measuring board (FMB), with the accuracy of +/- 2.5 millimeters, and weight is recorded directly to the FMB, from an Ohaus scale, accurate to the nearest 0.01 pound. A sub-sample of fork lengths are taken, but all striped bass are measured for total length (natural) from the tip of the fish snout to the end of its caudal fin. Sub-samples of sex information and fish hard parts (scales and otoliths) are also collected, on a 1-inch interval basis. Generally, only 40-50% of striped bass sampled for scales are also sampled for otoliths. Supplementary data is collected for each biological sample, such as date of collection, harvest location, market grade, harvest area, and gear type.

*North Carolina*

Scales are obtained from striped bass above the lateral line and below the dorsal fin, pressed on acetate sheets using a Carver heated hydraulic press and read by DMF personnel on a microfiche reader. Age is assigned using ASMFC striped bass ageing guidelines. A sub-sample of 15 fish per sex per 25 mm size group are aged. Year class is then assigned to the remainder of the sample.

**Commercial Harvest-At-Age**

Commercial harvest at age are usually estimated by applying corresponding length-frequency distributions and age-length keys to the reported number of fish landed by the commercial fisheries in each state. State-specific descriptions of the estimation procedures are below.

*Massachusetts*

The proportion that each age comprises the total samples of harvested fish is estimated from a sub-sample of 250-350 fish which guarantees a precision of $\pm$10% at $\alpha$= 0.05. Weighted proportions at age are generated by weighting the age proportions sampled in each county by county harvest. The number of fish harvested is then multiplied by the proportions-at-age to get numbers harvested-at-age.

*Rhode Island*

Gear-specific age-length keys are computed based on the length and age samples collected from the commercial dockside sampling program. The keys are applied to the commercial length frequencies to estimate the catch-at-age for each gear. The numbers at age are summed over gear types to provide an estimate of the total commercial catch-at-age for the year.

*New York*

Since sampling is conducted weekly throughout the open season and open geographic area, it is assumed that the annual sample is representative of the harvest. The number of fish harvested is disaggregated by the length and age frequency of the monitoring samples. No effort has been made to apportion the release data to length or age classes because no physical samples are collected.

*Delaware*

The DFW develops keys from age-length samples. In lesser fisheries, such as the commercial hook and line, personnel often does not obtain adequate samples and has to borrow from other sources, because harvest are quite sporadic and scarce (~5,000 lbs landed over several months).

**Potomac River Fisheries Commission (DC)**

Harvest is apportioned via ageing of the commercial samples. No age data (except fish < 18") are collected for released fish. Also included is information on the For-Hire fisheries, as the PRFC considers party, charter, guide and other such boats as commercial operations that carry recreational fishermen. PRFC requires a commercial license for the captain and requires him to have a sport fishing decal (license) for his boat that exempts his passengers from needing to be individually licensed. Captains use a logbook system to report their boats' catch and estimates of the released fish. PRFC also cooperates with the NMFS "For-Hire" Survey by providing a monthly list of boats and captains licensed to carry fee-paying passengers in the Potomac. This allows NMFS to include the PRFC boats in their database and to survey them. At present, NMFS is unable to produce a separate catch and release estimate for the Potomac, but the information on the total harvest is included in the MD and VA estimate. Since, the PRFC, MD and VA all share in one overall Chesapeake Bay F-base management system, there is no immediate need for a Potomac River sub-total for the "For-Hire" fishery.

*Maryland*

The harvest-at-age for each fishery is calculated by applying the age-length key developed from the hook-and-line and pound net data to the length frequencies observed in each fisheries and expanding the resulting age distribution to the harvest.

*Virginia*

Harvest data are apportioned to age classes by using an area-specific (Chesapeake Area or Coastal Area), seasonal age-length key (if possible) or annual key. Collected lengths and the age-length key are inputs, along with the harvest weight, into the template that has been used for 3 years to determine catch at age.

*North Carolina*

Total pounds landed is obtained from trip ticket program. Then year classes are apportioned to harvest based on the percentage of pounds per year class as observed in the sample taken from fish houses. Numbers of fish per year class are then assigned using the average weight per fish per year class as observed in the sample.

## Appendix A3: Estimation of Virginia and North Carolina Wave-1 Harvest, 1996-2004

DT: 7/11/2005

TO: ASMFC Striped Bass Technical Committee

FR: Joseph Grist, ASMFC

RE: MRFSS North Carolina Wave-1 2004 harvest

### Introduction

During the March 2005 Striped Bass Technical Committee (STB TC) meeting, the results for the 2004 wave-1 North Carolina (NC) harvest were reported. This was the first time wave-1 was directly sampled by the Marine Recreational Fisheries Statistics Survey (MRFSS), and the results were both predictable and a cause for concern. A total of 177,288 striped bass (equivalent to 3,615,670 lb) were harvested during wave-1 in North Carolina.

Anecdotal knowledge has suggested that North Carolina, Virginia, and possibly other states had a sizeable wave-1 fishery. The 2004 wave-1 harvest values for North Carolina and the wave-1 tag return data (Figure 1) for North Carolina and Virginia support this suggestion. However, information is still lacking on what the previous annual harvest rates were, as well as the level of exploitation in Virginia and elsewhere during wave-1. The STB TC requested an examination of the data that included suggestions for how to incorporate these data efficiently into the coastwide STB assessment.

The goal of this analysis is to determine if tag return data during wave-6 and wave-2 are correlated with the reported total harvest and, if so, if a proxy ratio may be utilized to back-calculate wave-1 data for North Carolina and Virginia.

### Data

Striped bass tag return data from North Carolina and Virginia were provided by the U.S. Fish and Wildlife Service (USFWS). Data were queried from the MRFSS website (http://www.st.nmfs.gov/st1/recreational/queries/effort/effort_time_series.html) on July 11, 2005 for North Carolina and Virginia, having selected variables by harvest (A+B1), all oceans combined, and all modes combined.

### Methods

Tag return and MRFSS data were merged by wave and by year and were analyzed for each state. SAS 9.1 was utilized to calculate Pearson's correlation coefficient (PROC CORR), generate linear regressions, and conduct ANOVA or analysis of variance (PROC REG) to test for similarities between tag return and total harvest data by wave. Only wave-6 (November and December) and Wave-2 (March and April) data were analyzed.

## Results

*North Carolina*

Tag returns were positively correlated with total harvest (0.5828) during wave-6 (Figure 2). ANOVA indicated significant evidence ($p$-value = 0.0366) that total harvest could explain the proportion of tag returns during wave-6.

Tag returns were positively correlated with total harvest (0.9518) during wave-2 (Figure 3). ANOVA indicated significant evidence ($p$-value < 0.0001) that total harvest could explain the proportion of tag returns during wave-2.

*Virginia*

Tag returns were positively correlated with total harvest (0.5827) during wave-6 (Figure 4). Although ANOVA did not indicate statistically significant evidence ($p$-value = 0.0599) that total harvest could explain the proportion of tag returns during wave 6, the given p-value indicates suggestive, but inconclusive, evidence that the null hypothesis is false, possibly representing biological significance.

Tag returns were slightly negatively correlated with total harvest (-0.4007) during wave-2 (Figure 5). ANOVA did not indicate significant evidence ($p$-value = 0.4311) that total harvest could explain the proportion of tag returns during wave-2. However, the tag return data were not consistent from year to year and a negative correlation was expected.

## Estimates of Wave-1 Harvest 1996-2004

Based on the above analyses and suggestion from the Striped Bass TC, Table 1 contains estimates for total harvest for each state.

*North Carolina*

Wave-1 total harvest for 1996-2003 is based on the NC specific 2004 wave-1 ratio of tag returns to MRFSS total harvest numbers. There were 47 tags returned during the wave-1 fishery period for the ocean fishery. The MRFSS reported harvest (A+B1) was 177,288 striped bass during the same period. This resulted in a 2004 ratio tags to harvest of 0.000265. This ratio was applied to the wave-1 tag returns for the NC ocean fishery to provide a back-calculated total harvest for wave-1 in NC.

*Virginia*

Unlike NC, a 2004 wave-1 total harvest was not reported. However, analysis of the tag returns suggested that a winter fishery similar to that of North Carolina occurred off VA during 2004. The July 11th report to the TC did indicate that VA wave-6 tag returns were positively correlated to harvest and implied biological significance, though wave-2 analysis did not. Personal communication with Sara Winslow (NCDMF) confirmed that the winter fishery begins in the latter half of wave-6 and continues into wave-1 in northeastern NC, and similar trends would be expected for southeastern VA. Anecdotally, this suggested that wave-6 and wave-1 harvest would show some level of correlation in fishing activity. Using known wave-1 tag returns, a mean ratio (0.000167) of tag returns to harvest for VA wave-6, 1996-2004, was utilized to back-calculate the total wave-1 harvest.

**Summary**

The 2004 wave-1 total harvest for North Carolina corresponds with observed recreational effort that begins during wave-6 and continues into wave-1 throughout the coastal waters of northeastern North Carolina and southeastern Virginia (Sara Winslow, NCDMF, personal communication).

Analysis indicates that tag return data can be used to explain total harvest in wave-6 and wave-2 in North Carolina. If the assumption that wave-1 follows a similar trend is acceptable by the STB TC, then wave-1 data before 2004 could be back-calculated for North Carolina striped bass harvest. There are two possible methods for back-calculation (Figure 6). One would be using the direct 2004 ratio of tag returns to reported total harvest. The other would be to use the combined ratio of tag returns to total harvest for both wave-6 and wave-2.

Correlation analysis for Virginia did indicate total harvest could be explained by tag returns, although ANOVA did not provide strong evidence for or against the reported correlation. However, tag return evidence does show a wave-1 striped bass fishery is occurring in Virginia (Figure 1), and using the wave-6 mean ratio of tag returns to reported total harvest for 1996-2004 could be utilized to back-calculate the wave-1 striped bass recreational fishery (Figure 7).

**Appendix A3 Tables**

Table 1. Estimates of wave-1 harvest by the winter striped bass recreational fisheries off Virginia and North Carolina.

| Year | Total harvest values (projected) | |
|---|---|---|
| | NC | VA |
| 1996 | 18,860 | 5,985 |
| 1997 | 49,037 | 83,793 |
| 1998 | 15,088 | 89,778 |
| 1999 | 18,860 | 107,734 |
| 2000 | 7,544 | 53,867 |
| 2001 | 18,860 | 53,867 |
| 2002 | 75,442 | 89,778 |
| 2003 | 79,214 | 53,867 |
| 2004 | 177,288* | 155,616 |

*actual harvest

## Appendix A3 Figures

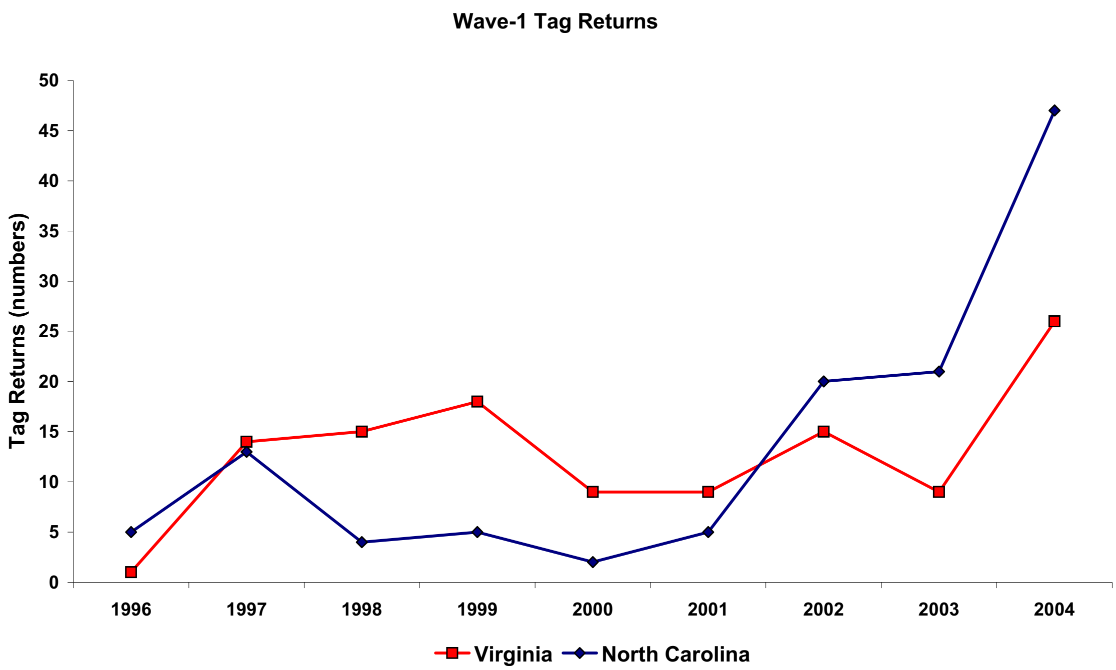



Figure 1. Wave-1 tag returns for Virginia and North Carolina

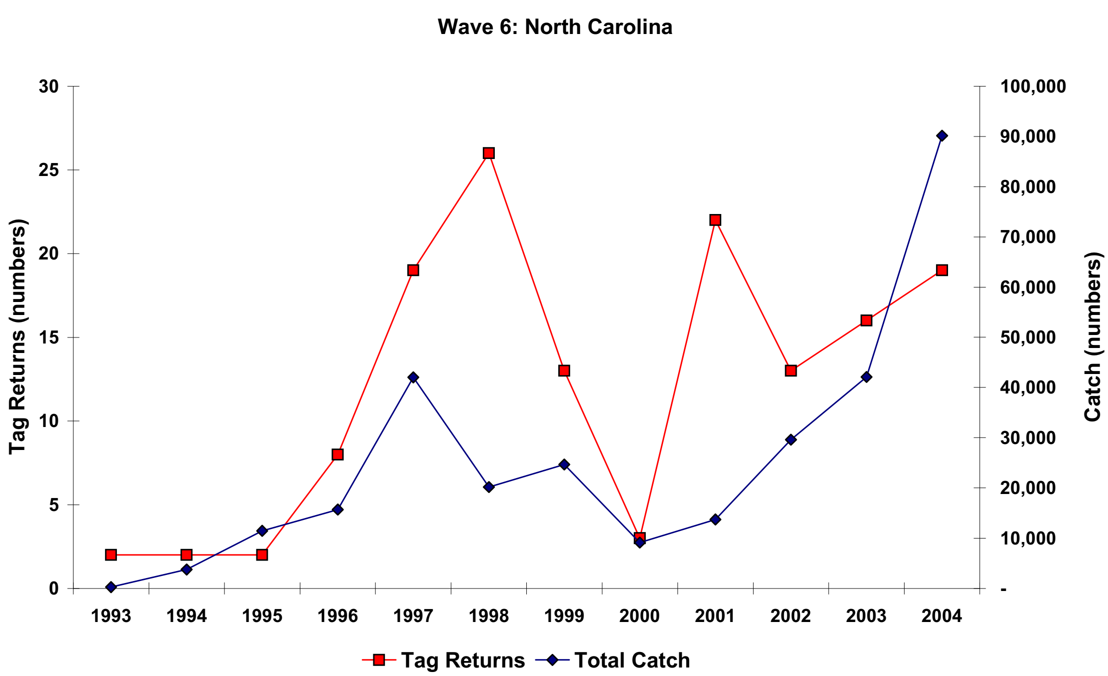



Figure 2. Wave-6 tag returns versus total harvest for North Carolina

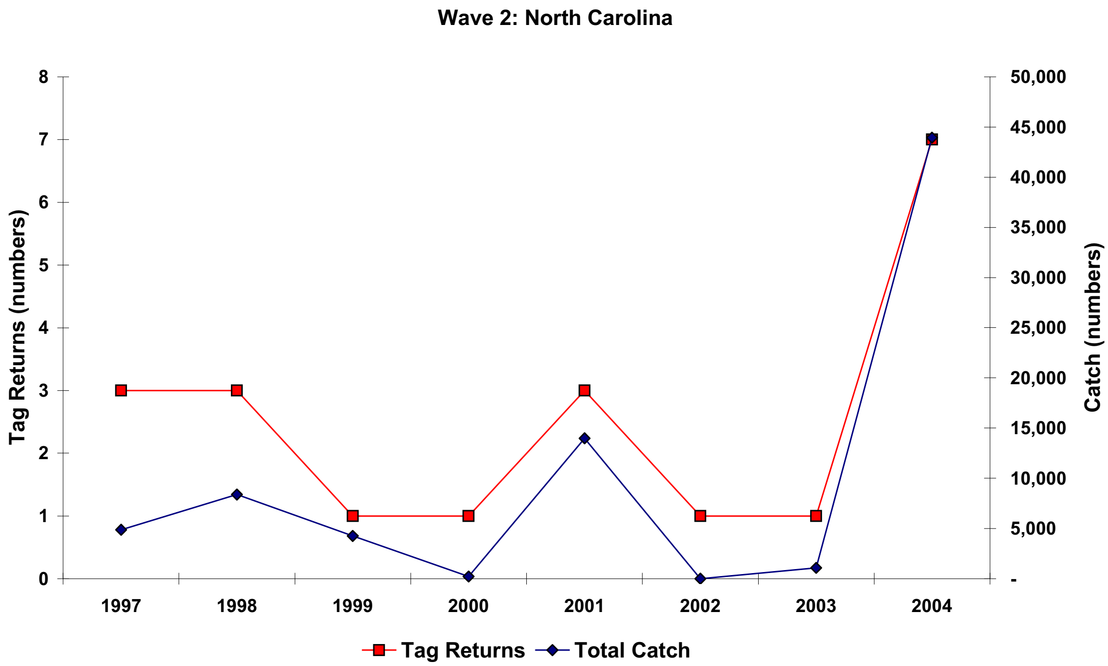



Figure 3. Wave-2 tag returns versus total harvest for North Carolina

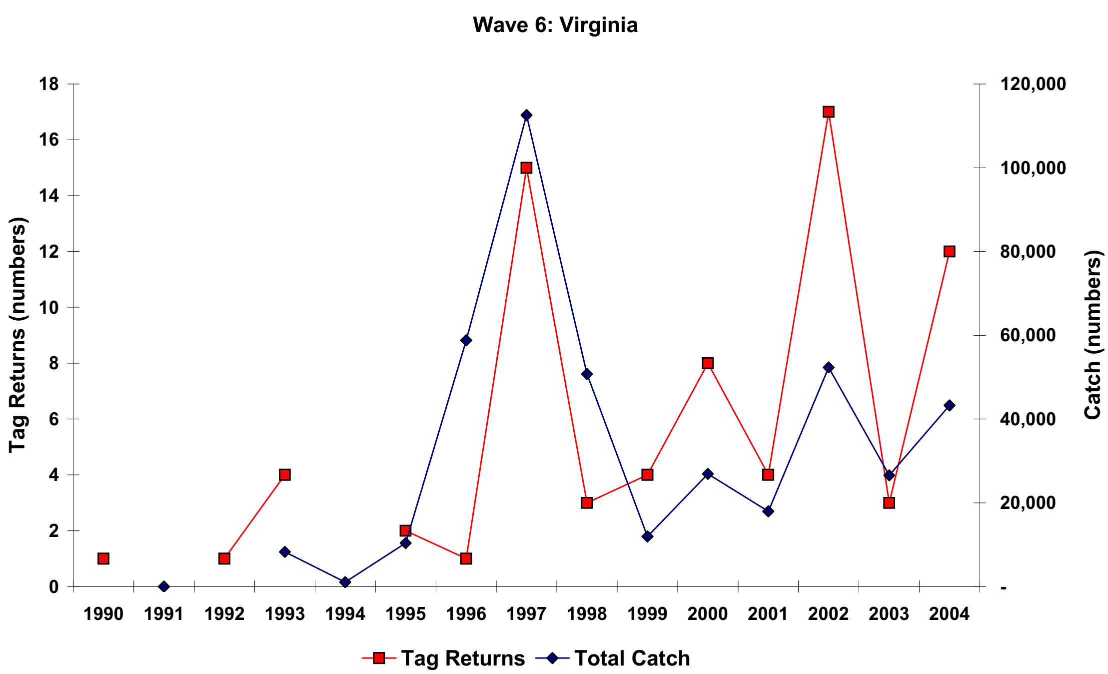



Figure 4. Wave-6 tag returns versus total harvest for Virginia.

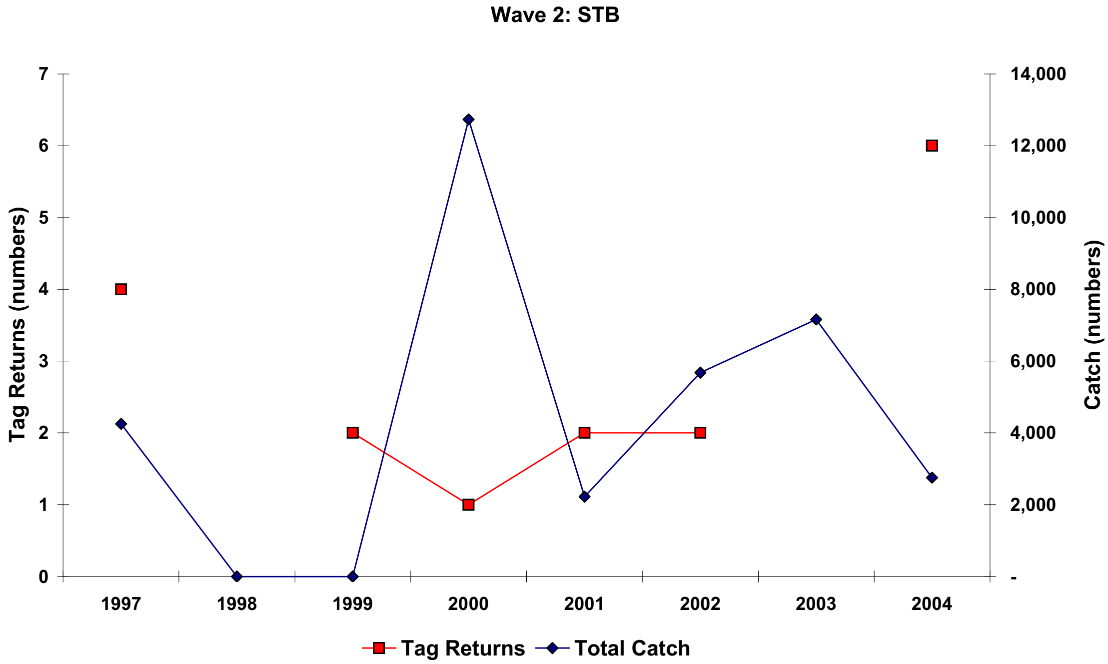



Figure 5. Wave-2 tag returns versus total harvest for Virginia

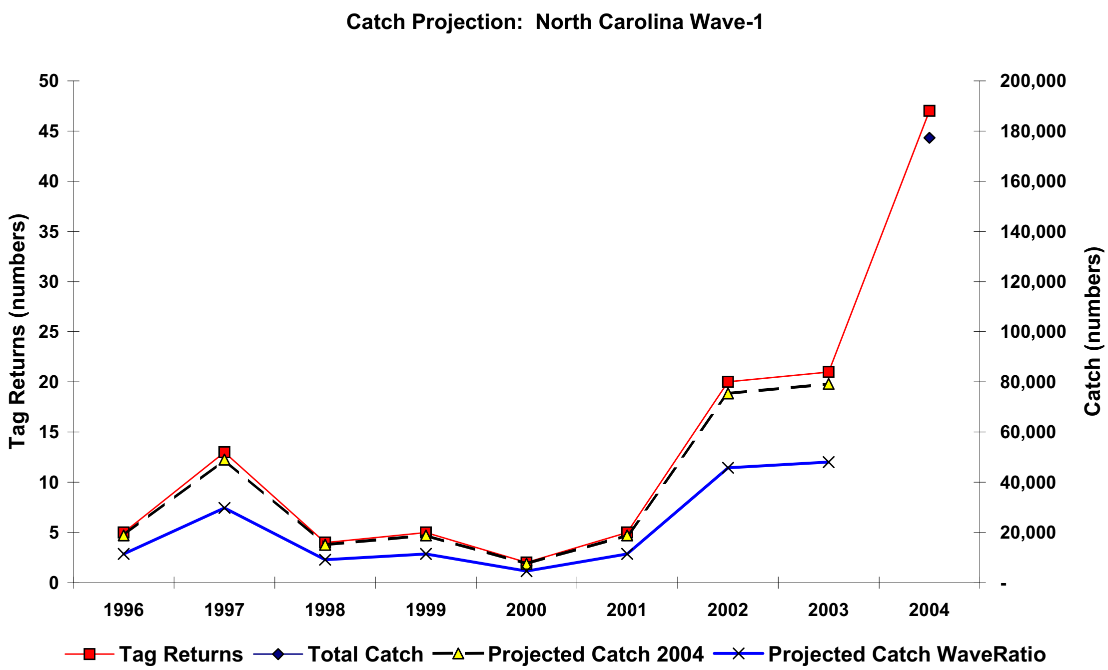



Figure 6. Comparison of harvest projections for North Carolina wave-1

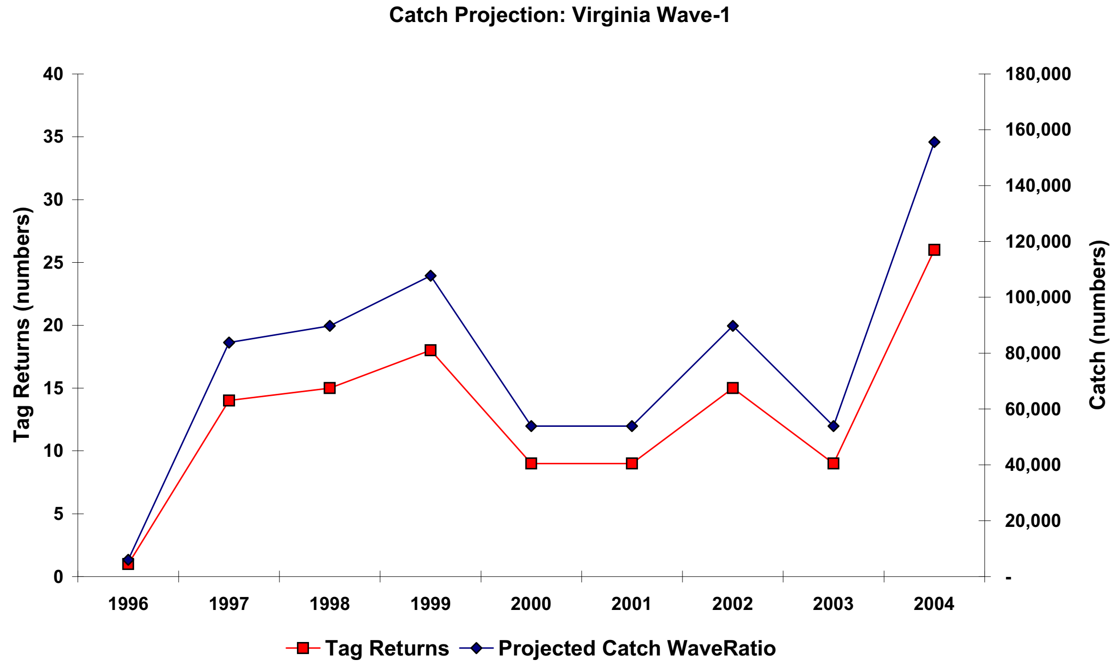



Figure 7. Harvest projection for Virginia wave-1

**Estimation of Virginia Wave 1 Harvest in 2005 and 2006**

In Appendix C of the 2005 stock assessment, a memo from Joe Grist states "Personal communication with Sara Winslow (NCDMF) confirmed that the winter fishery begins in the latter half of wave-6 and continues into wave-1 in northeastern NC, and similar trends would be expected for southeastern VA." If the fisheries are similar because of their close proximity, it follows that complete information on harvest from NC in 2005 and 2006 could be used to provide more realistic estimates of harvest in Virginia during wave 1.

If it is assumed that the number of tags returned from killed fish is proportional to the numbers of fish harvested regardless of location, the ratio of the NC harvest in wave 1 to tag returns from NC harvested fish will provide a means by which harvest in Virginia can be estimated in the same wave using Virginia wave 1 tag returns:

VA harvest = NC harvest/NC tag returns*VA tag returns

"Killed" tag numbers from only recreational anglers fishing were extracted from the USFWS tag database using the following codes:

Region = "COAST",
disposition="K"
recapturertype="H" or "S",
event=1
capmonth =1 or 2
capyear=2005 or 2006
State = "NC" (or "VA")

To match the tag data, estimates of wave 1 NC harvest from charter/private boats in the state territorial seas for 2005 and 2006 were extracted from the MRFSS website.

Estimates of harvest are given below

| | Wave 1 | | | | Wave 1 | |
|---|---|---|---|---|---|---|
| | NC | NC | Ratio | | VA | Est. |
| Year | Harvest | Tag Returns | (har/tags) | | Tag Returns | Harvest |
| 2005 | 71981 | 14 | 5141.50 | | 7 | 35991 |
| 2006 | 84144 | 23 | 3658.43 | | 23 | 84144 |

## Appendix A4: Recreational Fishery Monitoring Programs

### Recreational Harvest and Releases

Information on harvest and release numbers, harvest weights, and sizes of harvested bass come from the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS). The MRFSS data collection consists of a stratified intercept survey of anglers at fishing access sites that obtains numbers of fish harvested and released per angler trip, and a telephone survey that derives numbers of angler trips. Estimates of harvest and release numbers are derived on a bi-monthly basis. For detailed descriptions of the MRFSS program, see http://www.st.nmfs.gov/st1/recreational/overview/overview.html.

### Recreational Length-Frequencies of Harvested Fish

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

*Maine*

A volunteer angler program targets avid striped bass fishermen as a means of collecting additional length data. Though this has increased the sample size of the MRFSS, it still overlooks lengths and weights on sub-legal or released stripers. Because many anglers opt for catch and release, field interviewers actually see limited numbers of fish. An angler using the Volunteer Angler Logbook (VAL) records information about fish harvested or released during each trip for themselves and any fishing companions. Information about each trip is also recorded, including time spent fishing, area fished, number of anglers, and target species. At the end of the season each angler mails his/her logbook to the Department of Marine Resources (DMR), which is then copied and sent back to the angler.

*Massachusetts*

For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month, place the scales in marked coin envelopes, and record the disposition of each fish (released or harvested), fishing mode (boat or shore-based fishing), and location. Over 2,200 samples are received each year from over 100 anglers. Starting in 2005, DMF began using the MRFSS length data and the volunteer angler harvest length data to estimate the length structure of harvested fish. This is done by first generating the percentages-at–length from MRFSS and volunteer program by fishing mode and then averaging the proportions-at-length across programs. DMF then estimates the harvest by fishing mode and applies the numbers to the correct proportions-at-length to get harvest numbers at length and fishing mode, and then sums across modes to get total numbers harvested-at-length. The volunteer angler data adds about 200-400 extra measurements to estimate harvest length distributions.

*Connecticut*

The Volunteer Angler Survey (VAS) is designed to collect fishing trip and catch information from marine recreational (hook and line) anglers who volunteer to record their angling activities via a logbook. VAS anglers contribute valuable fisheries-specific information concerning striped bass, fluke, bluefish, scup, tautog, and other important finfish species used in monitoring and assessing fish populations inhabiting Connecticut marine waters. The survey logbook is easy to fill out. Each participating angler is assigned a personal code number for confidentiality. Recording instructions are provided on the inside cover of the logbook. Upon completion, anglers tape the pre-postage paid logbook shut and drop it off in the mail. Anglers that send in logbooks are rewarded with a VAS cooler and updated results of the program. After all the logbooks are computer entered and error checked, the logbooks are returned to each participant for their own records. The CT Fisheries Division has annually supplemented the MRFSS survey with about 2,000-3,000 length measurements from the angler survey.

*New York*

The MRFSS length data are not used in any fashion. Instead, the American Littoral Society's (ALS) release data are used to estimate length distribution of both harvested fish (>28") and released fish (B2 sub-legal <28"). The sample sizes are about 5,000 fish each year.

*New Jersey*

New Jersey collects information on harvested fish through the Striped Bass Bonus Program (SBBP). NJ's historical commercial quota forms the basis of this program where a recreational angler can harvest one additional striped bass per day measuring not less than 28 inches. Any striped bass taken under the provision of the SBBP are to be transported to the nearest authorized fish checking station by the person who caught the fish on the day it was harvested. The angler is also required to fill out a non-transferable card to be filled out immediately upon harvesting the fish with the following information: date, location caught, and length. Once the fish is taken to a check station, the check stations may also record the weight (lbs) and take scale samples. Party and charter boat captains who participate in the program (this allows for a patron of the boat to harvest a 3rd fish) will also record the data mentioned above and collect scale samples from all harvested Bonus fish. All of this information, both individual and P/C boats harvest, is turned in (mandatory harvest reporting) to the NJ Bureau of Marine Fisheries for monitoring, entry, and analysis.

*Maryland*

There are two additional sources for size frequency data: a volunteer angler survey and the DNR creel survey during the spring trophy season. Neither of the additional surveys employ statistical design. The volunteer angler survey is described in the next MD section. The DNR creel survey was initiated in 2002. The survey samples access sites (docks and marinas) with the largest volume of recreational angler traffic during the spring trophy season (mid-April to mid-May). The number of intercepted boats has varied from 137 to 181, number of anglers from 180 to 461, and the number of examined fish from 460 to 510. Biological data collected during the survey includes total length, weight, sex, spawning condition, and age (both scales and otoliths are collected). Other fishing statistics are collected, such as number of hours fished, number of lines fished, boat type, number of anglers per boat, number of fish kept, and number of fish released.

**Recreational Length-Frequencies of Released Fish**

Data on sizes of released striped bass come mostly from state-specific sampling programs. Proportions-at-length are calculated and multiplied by the MRFSS dead discard numbers to obtain total number released dead-at-length. Descriptions of these programs are below.

*Maine*

Release data are collected through the Volunteer Angler Survey, as described in the previous Maine section. DMR has annually supplemented the MRFSS survey with about 5000-8000 length measurements from the Volunteer Angler Survey.

*New Hampshire*

The Fish and Game Department (FGD) uses a striped bass volunteer angler survey for anglers fishing in New Hampshire. Roughly 45-50 volunteer anglers per year report information about each striped bass fishing trip they take that originates in NH. They are asked to measure every striped bass they catch (both harvested and released fish) to the nearest inch. Volunteers report on roughly 1000-1700 trips each year and provide usable measurements on 3500-7000 fish each year. About 95% of the measured fish are released (87% sub-legal size and 8% legal size).

*Massachusetts*

For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month, place the scales in marked coin envelopes, and record the disposition of the each fish (released or harvested), and fishing mode. Over 2,200 samples are received each year from over 100 anglers. Approximately 1,000-1,500 lengths of released striped bass are reported each year.

*Rhode Island*

The size structure of striped bass released from Rhode Island's recreational fishery is based on the American Littoral Society's (ALS) release data for Rhode Island by year.

*Connecticut*

Release data come from the Volunteer Angler Survey, as described in the previous Connecticut section. About 2000-3000 length measurements of released fishes are obtained each year.

*New York*

The ALS release data are used to estimate length distribution. The ALS tags are released all around the marine district of New York all year long. Because fish can be tagged at any size, the Bureau of Marine Resources gets both legal and sub-legal length distributions, both within and outside NY's open recreational season. Thus, the length distribution for harvested fish is from the fish >28 in, and the length distribution for the released fish is from the sub-legal (i.e., <28).

*New Jersey*

Lengths of released striped bass are collected through a volunteer angler survey (VAS), as described in the previous New Jersey section. It is important to note that, although the VAS is primarily administered trough the SBBP, the VAS and the SBBP are independent data sources.

Someone does not need to harvest a Bonus fish or have the Bonus cards in order to participate in, fill out, and submit their logbooks. There is a broad range of participant avidity and apparent skill level – from someone that fishes once or twice a year and does not catch/harvest a single bass to someone that fishes 100 days of the year. The only 'screening/removal' of logbooks for analysis the Bureau of Marine Fisheries conducts is to ensure the logbooks are filled out correctly and contain the proper information. Information on the size composition of harvested and released fish as well as effort (by trip and even hours), CPUE and fishing mode are available by region. (The state is broken down into 30 different regions and each location provided by the fisherman is assigned to one of those areas.) The VAS survey was initiated in 1990 when the NJ Fish and Wildlife initiated the SBBP. VAS provides about 500-1500 length measurements on released fish per year.

In addition to the VAS, length information is also collected through Party/Charter Boat Logbooks, administered through the SBBBP. Each boat that signs up to participate in the SBBP is mailed a logbook as well as the instructions on how to fill it out properly. A Private/Charter boat does not need to use or harvest any SBBP fish to fill out or participate in the logbook survey but they do need to be a participant in the SBBP. Boat owners are asked to fill out a daily trip logbook for each trip they take when targeting striped bass, even if no striped bass are caught; they are not asked to record striped bass information when they are making trips targeting other species. They are asked to record the date, location fished, number of patrons, number of hours fished, lengths of released fish (longest length to the nearest inch), number of released fish, lengths of harvested fish, and number of harvested fish. Logbooks must be completed even if no Bonus Cards are used or all bonus cards have been used for the year. All logbooks are returned by the end of the season. Private/Charter Boat Logbooks were first collected in 1997 and have continued ever since. Much of this data has never been looked at closely or analyzed but all of the information has been entered, checked, and screened for incorrect information.

*Delaware*

The American Littoral Society's release length data for New Jersey are used. About 50 to 300 length measurements are available each year.

*Maryland*

There are two additional sources for size frequency data: a volunteer angler survey and the DNR creel survey during the spring trophy season. Neither of the additional surveys employs statistical design. The DNR creel survey is described in the previous MD section. Maryland DNR has conducted a volunteer angler survey to obtain information on size structure of kept and released striped bass in the recreational fishery since 2000. The areas and time periods covered are defined by the number of responses received from anglers. Anglers are asked to provide information on the date of fishing, number of hours fished, number of anglers in the party, and method of fishing. Anglers also record the total number of striped bass kept and the total number of striped bass released and measure and record the length for the first twenty striped bass caught. A separate form is filled for each trip even if no fish are caught. If more than one survey participant is fishing on the same boat, only one designated individual is asked to fill out the survey form for the group for that day to avoid duplication. The data are submitted to MD DNR either on paper forms or via internet entry. Participation varies from year to year, which is reflected in the total number of entries. The number of reported trips varies between 200 and 300 and the total number of measured fish varies approximately from 600 to 2000 per year. Volunteer angler survey data are combined with the MRFSS information and MD DNR Spring Trophy Survey to characterize size frequency distribution of recreational harvest by wave. Volunteer survey data are the only source for the characterization of the discards. The volunteer survey does not provide age information.

*Virginia*

Data on releases are derived from the MD DNR Volunteer Logbook Survey described above.

*North Carolina*

North Carolina does not collect information on size of releases. Usually, release length frequency data that reflect the release sizes in NC are borrowed from other states.

**Recreational Age Data**

Many states collect scale samples during state sampling programs designed to collect information on harvest and released striped bass from the recreational fishery (described above). For those states that do not collect scale samples, age-length keys are usually borrowed from neighboring states. Detailed descriptions of how age samples are collected are given below.

*Massachusetts*

For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they capture each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month and record the disposition of the each fish (released or harvested) and fishing mode. Over 2,200 samples are received each year from over 100 anglers. The size frequency of released fishes by mode are used to allocate MRFSS release numbers by mode among size classes. A sub-sample of all scale samples collected (about 450-520 fish/yr) are aged and combined with commercial samples (250 fish/yr) and tagging samples (about 150-300 fish/yr) to produce an age-length key used to convert the MRFSS size distribution into age classes. Recreational scale samples are selected using a weighted random design based on the total number of striped bass caught in each wave and mode stratum (as determined by MRFSS).

*New York*

An age-length key is created using data from NY's combined projects: the cooperative angler survey, western Long Island beach seine survey, and a Fall ocean haul seine survey. The cooperative angler (fishery-dependent) data is from both kept and released fish, but the geographical distribution of the samples are biased towards the Western Long Island Sound. Samples are at the pleasure of the cooperating fishers, collected pretty much all year long. Each year, anglers contribute anywhere from 500 to 5,000 samples, over a fairly wide range of sizes. The beach seine survey is a multi-species, fishery-independent survey conducted at fixed sampling sites in bays around the north and south shores of Long Island. Most of the samples are of small juvenile fish, but some larger adult fish are caught. Each year the beach seine survey contributes approximately 1,000 length/age samples collected over the months of April through November. The Fall ocean haul seine survey is a fishery-independent survey conducted at fixed survey sites. The geographic distribution of sampling is biased towards the eastern South Shore of Long Island, during the months of September through December. Each year, about 1,000 to 2,500 samples are collected. The survey samples the adult coastal migratory mixed striped bass stocks. The age-length key created is applied to both legal and sub-legal fish (assumed harvest and discards), broken down into two six-month seasonal keys.

*New Jersey*

New Jersey collects age (scale) samples from harvested fish through the Striped Bass Bonus Program (SBBP), described in previous NJ sections. Once a harvested fish taken under the provision of the SBBP is taken to the nearest authorized check station, the check station may record the weight (lbs) and take scale samples, to augment the non-transferable card, which collects date, location caught, and length information, filed out immediately after harvest by the angler. Party and charter boat captains who participate in the program, allowing for a patron of the boat to harvest a 3rd fish, will also record the data mentioned above and collect scale samples from all harvested Bonus fish. All of this information, both individual and Party/Charter boat harvest, is turned in (mandatory harvest reporting) to the NJ Bureau of Marine Fisheries for monitoring, entry, and analysis.

*Maryland*

Direct age data are available from the creel survey of the trophy fishery only. Both scales and otoliths are collected from the fish examined in creel survey. For periods not covered by the creel survey, an age-length key developed from the samples of commercially harvested fish is applied to recreational length frequency to characterize age structure of the recreational harvest.

*Virginia*

Most age data are collected from the commercial fishery. The sampling group will sometimes sample from one or more recreational tournaments, but not in every year. In 2004, there were two length and age samples; no sampling of tournaments occurred in 2005.

**Recreational Harvest-At-Age**

Recreational harvest-at-age is usually estimated by applying corresponding length-frequency distributions expanded to total numbers of harvest-at-length and age-length keys to the MRFSS number of fish harvested by the recreational anglers in each state. State-specific descriptions of the estimation procedures are below.

*Maine*

DMR uses age-length data collected by MA DMF. The age-length key is applied to the Volunteer Angler Survey lengths, which is then applied to MRFSS estimates of harvested fish.

*New Hampshire*

FGD uses age-length data collected by MA DMF. The age-length key is applied to the Volunteer Angler Survey lengths, which is then applied to MRFSS estimates of harvested fish.

*Massachusetts*

Harvest numbers-at-age are generated by applying total numbers of harvested fish by length to the age-length key as described above.

*Rhode Island*

Age-length data collected by NY DEC and MA DMF are combined to create annual age-length keys. The combined NY-MA age-length key is applied to the expanded length frequencies from RI's recreational fishery to estimate recreational harvest-at-age on an annual basis.

*Connecticut*

The Fisheries Division uses age-length keys from Long Island Sound provided by NY DEC and applies the numbers-at-length obtained from the volunteer angler survey.

*New York*

The MRFSS numbers of harvest and releases by wave are disaggregated by the ALS length frequency distribution (calculated by wave). The numbers at length are added by wave together into two seasonal length distributions. The seasonal length distributions are multiplied by the seasonal length/age keys created (see above) for legal (i.e., >28 inches, harvest) and sub-legal (i.e., <28 inches, releases) fish. The length distributions are adjusted, due to the conversion of ALS data from fork length to total length and the "gaps" which result, by averaging the values before and after the interval with no observed frequency. Next, the numbers are added for each season. Occasionally there is a need to re-adjust for the actual numbers of harvest or releases from MRFSS due to the adjustments and rounding.

*New Jersey*

New Jersey uses the length frequency information gained from the Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational harvest of striped bass and the MRFSS harvest data by season (fall and spring) to expand the length frequency data. A variety of age sources are then used to develop NJ's age-length key by season. For the spring key, age data from NJ's Delaware Bay Striped Bass Tagging Survey (occurs in March – May), NJ's April cruise of the Ocean Trawl Survey, and spring harvested striped bass from the SBBP are used. To develop NJ's fall age-length key, age data from the October cruise of the Ocean Trawl Survey and fall harvested fish from the SBBP are utilized. The appropriate seasonal age-length key is then expanded to the length frequency information to develop NJ's striped bass harvest by age and season.

*Delaware*

For the first half of the year, DFW uses age-length data from the spring spawning stock survey on the Delaware River (electrofishing), plus age-length data from the sample of commercial harvest in spring (gill net). This sums to several hundred fish. For the second half of year, data are limited to a small sample from the fall commercial fishery, plus a score or so of research survey catches, thus New Jersey's age-length data from the SBBP is used.

**Potomac River Fisheries Commission (DC)**

Length and age data collected from the commercial fisheries are used to generate recreational numbers-at-age.

*Maryland*

Length frequency of recreational harvest is characterized using MRFSS, VAS, and creel survey length data. The age-length key derived from the spring spawning survey is applied to length frequency for waves 2 and 3. For waves 4–6, an age length key derived from samples of commercial harvest is used.

*Virginia*

A catch-at-age matrix is developed, starting with an age-length key from the commercial samples of length and weight and proportions of harvested striped bass at length from MRFSS.

*North Carolina*

The NY age-length key is used along with length frequencies to apportion harvest numbers into age classes.

**Recreational Dead Discards-at-Age**

The number of dead discards-at-age is usually estimated by applying corresponding total numbers of dead discards-at-length to age-length keys. State-specific descriptions of the estimation procedures are below.

*Maine*

DMR uses age-length data collected by MA DMF. These data are applied to the Volunteer Angler Survey lengths, which is then applied to the dead discard estimates.

*New Hampshire*

FGD uses age-length data collected by MA DMF. These data are applied to the Volunteer Angler Survey lengths, which is then applied to the dead discard estimates.

*Massachusetts*

Dead discards-at-age are generated by applying total numbers of discards-at-length to the age-length key described above.

*Rhode Island*

Age-length data collected by NY DEC and MA DMF are combined to create annual age-length keys. The combined NY-MA age-length key is applied to the expanded length frequencies from Rhode Island's recreational fishery to estimate recreational releases-at-age on an annual basis.

*Connecticut*

The Fisheries Division uses age-length keys from Long Island Sound provided by NY DEC and applies the dead discards numbers-at-length.

*New York*

The MRFSS numbers of harvest and releases by wave are disaggregate by the ALS length frequency distribution (calculated by wave). The numbers at length are added by wave together into two seasonal length distributions. The seasonal length distributions are multiplied by the seasonal age-length keys created (see previous NY section) for legal (i.e., >28 inches, harvest) and sub-legal (i.e., <28 inches, releases) fish. The length distributions are adjusted, due to the conversion of ALS data from fork length to total length and the "gaps" which result, by averaging the values before and after the interval with no observed frequency. Once complete, the numbers are added for each season. Occasionally there is a need to re-adjust for the actual numbers of harvest or releases from MRFSS due to the adjustments and rounding.

*New Jersey*

New Jersey uses the length frequency information gained from the Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational released striped bass and the MRFSS release data by season (fall and spring) to expand the length frequency data. A variety of age sources are used to develop NJ's age-length key by season. For the spring key, age data from NJ's Delaware Bay Striped Bass Tagging Survey (occurs in March – May), NJ's April cruise of the Ocean Trawl Survey, and spring harvested striped bass from the SBBP are used. To develop NJ's fall age-length key, age data from the October cruise of the Ocean Trawl Survey and fall harvested fish from the SBBP are utilized. The appropriate seasonal age-length key is then expanded to the length frequency information to develop NJ's striped bass dead discards by age and season.

*Delaware*

For the first half of the year, DFW uses the age-length data from the spring spawning stock survey on the Delaware River (electrofishing), plus age-length data from the sample of commercial harvest in spring (gill net). This sums to several hundred fish. For the second half of year, data are limited to a small sample from the fall commercial fishery, plus a score or so of research survey catches, thus New Jersey's age-length data from the SBBP are used.

**Potomac River Fisheries Commission (DC)**

Length and age data collected from the commercial fisheries are used to generate recreational numbers-at-age.

*Maryland*

Length frequency of recreational releases is characterized using MRFSS, VAS, and creel survey length data. The age-length key derived from the spring spawning survey is applied to length frequency for waves 2 and 3. For waves 4–6, an age-length key derived from samples of commercial harvest is used.

*Virginia*

Release numbers (discards from the recreational fishery by spring (Waves 2,3) and summer-fall (Waves 4,5,6)) are apportioned to age classes, using the MD DNR Volunteer Angler Survey proportion of discards-at-age and proportion of discards-at-length, expanded according to seasonal harvest in numbers.

*North Carolina*

The NY age-length key is used, along with length frequencies, to apportion release numbers into age classes.

## Appendix A5a: Analysis and Discussion of the 1998-2002 Striped Bass Coastwide Weight-at-Age

Prepared for the Striped Bass Stock Assessment Sub-Committee Meeting
August 9 – 11, 2005

**Linda S. Barker**
**Maryland DNR Fisheries Service**

### Introduction

A crucial element of the yearly catch-age based virtual population analyses (VPA) of Atlantic striped bass is the calculation of biomass of the mixed coastal stock. This calculation requires coastwide weight-at-age (WAA). The coastwide WAA has consistently been calculated as a weighted mean:

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

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

The current VPA analysis uses a time series dating back to 1982. The yearly values were not calculated on a yearly basis, however. In 1997, the values for 1982-1997 were developed. These values were developed using data from all states, subdividing each year into quarterly time periods to account for growth, and weighting by numbers of fish. (Details of developing weights at age for 1982 to 1996 can be found in NEFSC Lab Ref. 98-03.) Coastwide WAA was not re-calculated in 1998 or 1999. Instead, the 1997 values were used as these years' values. The 2000, 2001 and 2002 coastwide WAA were developed at the Stock Assessment Subcommittee Workshops, weighted by total weight of fish, using readily available data sets. Therefore, the methodology and data sets used for these calculations were not consistent, either with the methodology used for the 1982-1997 WAA or with each other. The 2000-2002 values showed an apparent decline in WAA, but it was impossible to determine if this apparent trend was due to the change in method or a true change in WAA.

In 2004, a standardized report format was developed that calculated WAA as part of the CAA calculations. The 2003 coastwide WAA was developed using all states' data:

- Maine and New Hampshire recreational harvest and discards,
- Massachusetts recreational and commercial catch,
- Rhode Island recreational and commercial catch,
- Connecticut recreational catch,
- New York recreational catch and commercial landings,
- New Jersey recreational catch,
- Delaware recreational and commercial catch,
- Maryland recreational and commercial catch,
- Virginia recreational and commercial catch, and
- North Carolina recreational and commercial catch.

An apparent decline was observed between the 2001and 2002 coastwide WAA – only 2 of 13 age-classes of harvested fish did not show a reduction in WAA (Table 1). Due to concerns about this apparent decrease in coastwide WAA and the inability to compare 1998-2002 with the rest of the time series, the subcommittee decided to re-calculate these coastwide WAA values.

**Methods: Recalculation of the 1998-2002 values.**

All states were requested to provide the 1998-2002 time series of WAA, landings and discards. Because information was not received from all states, it was decided to develop the coastwide WAA from information for states with greatest catch. For 1998-2001, the coastwide WAA was calculated using the 5 major harvester states (MA, NY, NJ, MD, VA), NH and CT (Table 2). For 2002, data were available to include RI and DE (Table 3). WAA was calculated as the weighted mean, weighted by numbers for commercial harvest, recreational harvest, and recreational discard. Annual state removals were taken from the time series tables for commercial harvest, recreational harvest and recreational discard numbers in the 2004 coastwide compliance report summary prepared by Gary Sheppard if not provided by state. WAA for the nearest neighboring state was used if that state's WAA was not available. The oldest age group was designated "13+", and 1982-1997 "13+" values were recalculated as the arithmetic averages of 13- to 15-year-old age class values. A constraint imposed by the 1998-2002 data was that an annual time frame was used for all calculations, as opposed to the finer time frame used in the 1982-1997 and 2003 calculations. The time series matrix of WAA including re-calculated values is presented in Table 4.

**Discussion**

The apparent decrease in WAA from 2000 - 2002 within the "old" WAA time series. Most age classes showed a decrease between 2000 and 2002 (14 of 15 age-classes) (Table 2). However, examination of the development of the WAA revealed that this decrease was due to differences in the development of the values. Because average WAA is greater for coastal than Chesapeake Bay states for all harvested age classes, calculations are skewed if the harvest proportion is not used in the WAA calculations.

**Evaluation of the apparent decline between 2001-2002 values**

The 1982-1997 coastwide WAA time series was developed using all states' data. In contrast, the 2001 coastwide WAA was developed without data from RI, CT, MD and NC. Due to comparatively low harvest, RI, CT and NC do not contribute strongly to the coastwide WAA. However, the exclusion of MD data from the 2001 calculation had a major influence on the coastwide value. Without the MD numbers factoring in to the average, the coastwide WAA was disproportionately weighted by MA (Figure 1, Table 5). This is significant because MD is a Chesapeake Bay harvest state and MA is a coastal harvest state. Based on data from 1982-1997, the majority of fish harvested in Chesapeake Bay (ages 3–11) were, on average, 2.6 kg (5.7 lb) smaller than coastal fish (Table 6). The unnaturally strong contribution of MA in the 2001 WAA, followed by the strong contribution of MD fish in the 2002 WAA, certainly contributed to the observed decline in the coastwide WAA.

**Patterns in WAA from 2000–2003 within the recalculated WAA time series**

Coastwide WAA values for 2000 to 2002 were recalculated using a consistent method that was considered functionally equivalent to the method used for earlier calculations. Although a subset of states was used, these states constitute the majority of the harvest and therefore maintained the overall harvest proportion throughout the WAA calculations. In contrast to the earlier values, these values showed a consistent increase across the 2000–2003 time frame (Table 4). Between 2000 and 2001, 11 of the 13 age classes showed an increase in WAA, between 2002 and 2003, 12 of the 13 age classes showed an increase in WAA. The 2003 WAA was developed from information provided by all states for the 2003 stock assessment. Comparison of the 2003 WAA against the mean values for 2000-2002 showed an increase in 11 of 13 age classes.

Comparison of "old" vs. recalculated WAA values from 2000 – 2002. Although the recalculated WAA values showed an increase across the 2000-2003 time frame, these values were lower than the mean of the 1982-1996 time series (Table 7).

**Future Work**

Future years' WAA will be calculated from information provided in stock assessment "Compliance Report Template", and will therefore include all states' data. No recommendations are suggested to improve calculation methodology for future years.

It would be useful to determine if there truly was a decrease between the 1982-96 WAA and the 1998-2003 WAA. However, data are not available to recalculate 1982-2002 WAA using the current method, nor are data available to recalculate 2000-03 using the earlier method.

**Appendix A5a Figures**

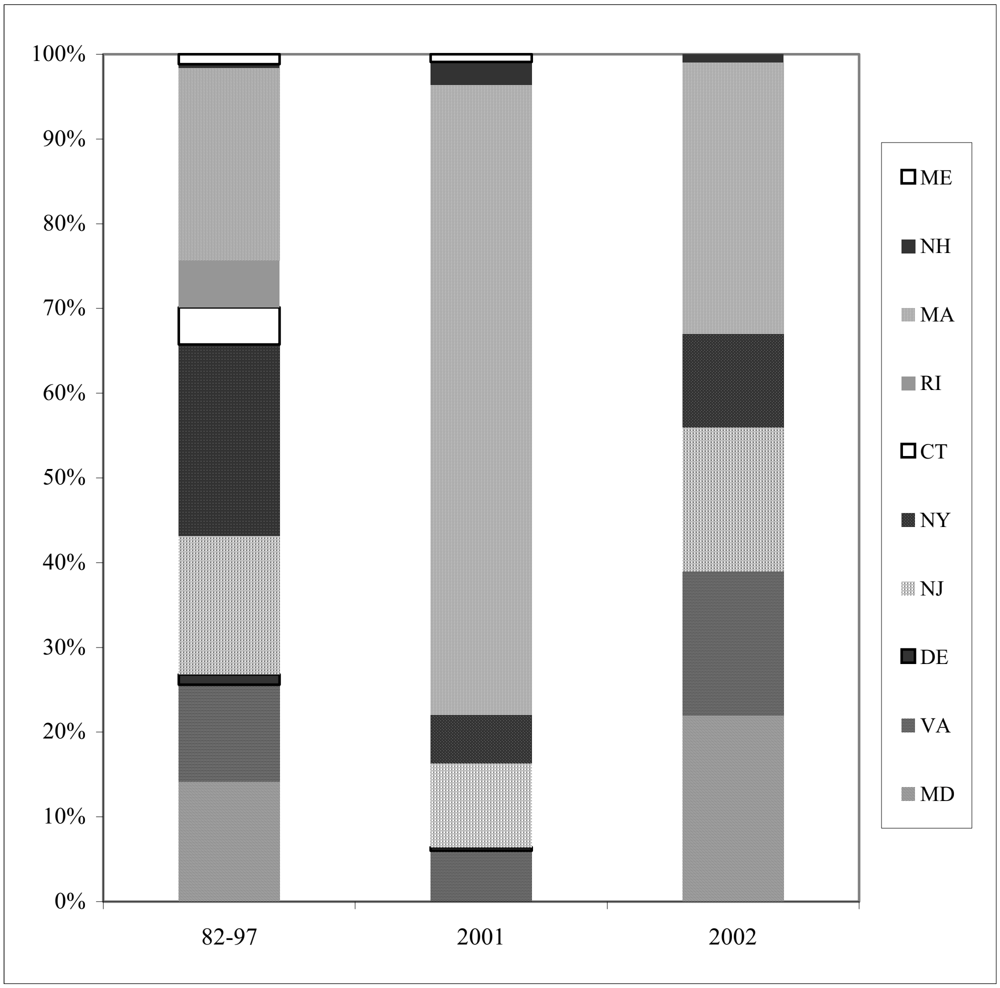



Figure 1. Composition of Striped Bass Coastwide WAA by State. 1982-1997 coastwide WAA shows a fairly even distribution from the 5 major harvest (by numbers) states (MA, NY, NJ, MD, VA). 2001 WAA is dominated by MA. 2002 WAA shows a strong contribution from MD and VA (Chesapeake Bay harvest states).

## Appendix A5a Tables

Table 1. Striped Bass Coastwide WAA (kg) Time Series Used for the 2002 Stock Assessment. 1997-1999 values are identical. Note the apparent decline in WAA between 2001-2002.

| | | | | | | | | Age | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1982 | 0.13 | 0.64 | 1.09 | 1.54 | 2.42 | 3.75 | 4.83 | 5.79 | 6.20 | 8.68 | 10.80 | 11.20 | 12.97 | 13.26 | 15.91 |
| 1983 | 0.20 | 0.55 | 0.94 | 1.37 | 2.37 | 3.29 | 3.77 | 5.36 | 6.01 | 8.10 | 9.57 | 10.39 | 11.11 | 11.10 | 11.12 |
| 1984 | 0.24 | 0.60 | 1.69 | 1.62 | 2.67 | 3.39 | 5.07 | 5.65 | 6.76 | 7.76 | 8.41 | 12.65 | 10.65 | 11.75 | 14.75 |
| 1985 | 0.06 | 0.61 | 1.07 | 1.66 | 2.19 | 3.59 | 4.91 | 5.46 | 6.77 | 7.45 | 9.00 | 10.69 | 11.42 | 14.34 | 15.98 |
| 1986 | 0.14 | 0.57 | 1.27 | 2.40 | 2.44 | 3.12 | 3.95 | 5.05 | 5.44 | 6.09 | 7.75 | 9.16 | 10.97 | 11.55 | 15.83 |
| 1987 | 0.20 | 0.77 | 1.41 | 2.11 | 2.50 | 2.91 | 3.61 | 4.74 | 5.52 | 6.49 | 7.77 | 9.78 | 11.38 | 11.62 | 16.46 |
| 1988 | 0.31 | 0.91 | 1.10 | 1.98 | 3.12 | 4.02 | 4.38 | 4.70 | 5.24 | 5.62 | 8.58 | 10.40 | 11.50 | 11.31 | 17.00 |
| 1989 | 0.16 | 0.83 | 1.22 | 2.23 | 3.06 | 4.53 | 5.37 | 6.23 | 6.04 | 8.68 | 8.94 | 9.74 | 13.04 | 9.93 | 17.11 |
| 1990 | 0.08 | 0.89 | 1.14 | 2.05 | 2.35 | 3.83 | 4.91 | 5.96 | 5.70 | 5.97 | 7.44 | 9.08 | 9.36 | 10.80 | 17.65 |
| 1991 | 0.21 | 0.92 | 1.29 | 2.17 | 2.62 | 3.17 | 4.81 | 5.64 | 6.46 | 6.24 | 9.46 | 8.30 | 9.62 | 15.96 | 17.09 |
| 1992 | 0.10 | 0.69 | 1.31 | 1.93 | 2.81 | 3.67 | 4.90 | 5.79 | 6.96 | 8.15 | 9.77 | 12.44 | 13.10 | 11.15 | 17.65 |
| 1993 | 0.07 | 0.76 | 1.31 | 1.99 | 2.77 | 3.58 | 4.80 | 6.11 | 7.03 | 8.01 | 9.53 | 10.76 | 14.45 | 13.85 | 15.36 |
| 1994 | 0.24 | 1.05 | 1.69 | 2.21 | 2.85 | 3.50 | 4.94 | 6.20 | 6.80 | 7.53 | 9.73 | 10.69 | 11.38 | 9.06 | 17.75 |
| 1995 | 0.28 | 0.70 | 1.35 | 2.18 | 2.77 | 3.65 | 5.38 | 6.16 | 7.27 | 8.86 | 7.57 | 9.73 | 13.97 | 15.65 | 20.37 |
| 1996 | 0.14 | 1.05 | 1.47 | 2.32 | 3.23 | 4.52 | 6.39 | 7.11 | 7.81 | 9.20 | 9.31 | 10.10 | 11.36 | 12.45 | 17.30 |
| 1997 | 0.13 | 0.62 | 1.18 | 2.46 | 2.81 | 3.64 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 1998 | 0.13 | 0.62 | 1.18 | 2.46 | 2.81 | 3.64 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 1999 | 0.13 | 0.62 | 1.18 | 2.46 | 2.81 | 3.64 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 2000 | 0.14 | 1.05 | 1.47 | 2.32 | 3.23 | 4.52 | 6.39 | 7.11 | 7.81 | 9.20 | 9.31 | 10.10 | 11.36 | 12.45 | 17.30 |
| 2001 | 0.13 | 0.62 | 1.17 | 2.46 | 2.81 | 3.63 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| 2002 | 0.82 | 0.81 | 1.25 | 1.75 | 2.47 | 3.30 | 4.16 | 5.48 | 6.36 | 7.45 | 8.75 | 8.89 | 9.99 | 11.03 | 13.95 |

Table 2. Revised Time Series of Striped Bass Coastwide WAA (kg).

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

Table 3. Comparison of 2001& 2002 Data Used to Develop Striped Bass Coastwide WAA.

| STATE | 2001 | | | 2002 | | |
|---|---|---|---|---|---|---|
| | SURVEYS | % WAA | % HARVEST | SURVEYS | % WAA | % HARVEST |
| ME | COMM (harv, discards) | 1 | 1 | X | 0 | 2 |
| NH | COMM (harv, discards) | 3 | 1 | REC | 1 | 1 |
| MA | COMBINED | 74 | 16 | COMBINED | 32 | 20 |
| RI | X | 0 | 5 | X | 0 | 5 |
| CT | X | 0 | 3 | X | 0 | 3 |
| NY | COMM & REC | 6 | 13 | COMM & REC | 11 | 13 |
| NJ | REC | 10 | 23 | REC | 17 | 19 |
| DE | COMM | <1 | 2 | X | 0 | 1 |
| MD | X | 0 | 17 | COMM (C.BAY) | 22 | 15 |
| VA | COMM & REC | 6 | 17 | COMM & REC | 17 | 19 |
| NC | X | 0 | 3 | X | 0 | 3 |

Table 4. Comparison of Average Striped Bass WAA (lb) for "Coastal" (MA, NY, NJ) and "Chesapeake Bay" (MD and VA) States, based 1982-1997 Values.

| Age | Coastal | CBay | Δ |
|---|---|---|---|
| **1** | 1.8 | | |
| **2** | 1.9 | 2.3 | -0.4 |
| **3** | 3.3 | 2.4 | 0.9 |
| **4** | 4.7 | 2.7 | 2.0 |
| **5** | 6.7 | 3.5 | 3.2 |
| **6** | 8.3 | 5.5 | 2.8 |
| **7** | 10.1 | 7.4 | 2.8 |
| **8** | 12.9 | 10.4 | 2.5 |
| **9** | 14.9 | 12.3 | 2.6 |
| **10** | 17.4 | 14.1 | 3.4 |
| **11** | 20.4 | 17.3 | 3.0 |
| **12** | 22.8 | 14.9 | 7.8 |
| **13** | 24.9 | 17.7 | 7.2 |
| **14** | 27.9 | 19.4 | 8.5 |
| **15** | 35.1 | 15.8 | 19.4 |

Table 5. Information Used to Calculate 1998-2002 Striped Bass Coastwide WAA.

| REMOVAL | YEARS | HARVEST-AT-AGE | Pre-calculated WAA |
|---|---|---|---|
| NH Rec landings | 98-02 | supplied | used MA |
| NH Rec discards | 98-02 | supplied | used MA |
| MA Rec landings | 98-02 | supplied | supplied |
| MA Rec discards | 98-02 | supplied | supplied |
| MA Com landings | 98-02 | supplied | supplied |
| MA Com discards | 98-02 | supplied | supplied |
| RI Com landings | 2002 | supplied | used MA |
| RI Rec landings | 2002 | supplied | used MA |
| RI Rec discards | 2002 | supplied | used MA |
| CT Rec landings | 98-02 | GaryN CAA[3] | used MA |
| CT Rec discards | 98-00,02 | GaryN CAA[3] | used MA |
| NY all | 98-00 | | |
| NY Com landings | 01-02 | 01,02 Ann. Rpts. | 01,02 Ann. Rpts. |
| NY Rec landings | 01-02 | 01,02 Ann. Rpts. | 01,02 Ann. Rpts. |
| NY Rec discards | 01-02 | 01,02 Ann. Rpts. | 01,02 Ann. Rpts. |
| NJ Rec landings | 98-01 | | |
| NJ Rec discards | 98-01 | % of harvest #s[1] | % of harvest WAA[2] |
| NJ ALL | 2002 | supplied | supplied |
| Del Com landings | 2002 | GaryN CAA[3] | used NY |
| Del Rec landings | 2002 | GaryN CAA[3] | used NJ |
| MD Com landings | 98-02 | supplied | supplied |
| MD Rec landings | 98-02 | | |
| MD Rec discards | 98-02 | | |
| VA Com landings | 98-00,02 | GaryN CAA[3] | used MD |
| VA Rec landings | 98-00,02 | GaryN CAA[3] | used MD |
| VA Rec discards | 98-00,02 | GaryN CAA[3] | used MD |
| VA ALL | 2001 | GaryN CAA[3] | used MD |

[1] (rec harvest-at-age)*(rec discard-at-age)/(total harvest)
[2] Ages 2-5: discard WAA = 0.8*harvest WAA, Ages 6+: discard WAA = 0.9*harvest WAA
[3] Coastwide summary CAA document supplied by Gary Nelson

Table 6. Removals Used to Calculate 1998-2002 Striped Bass Coastwide WAA.

| 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|
| NH Rec landings<br>NH Rec discards | NH Rec landings<br>NH Rec discards | NH Rec landings<br>NH Rec discards | NH Rec landings<br>NH Rec discards | NH Rec landings<br>NH Rec discards |
| MA Rec landings<br>MA Rec discards<br>MA Com landings<br>MA Com discards | MA Rec landings<br>MA Rec discards<br>MA Com landings<br>MA Com discards | MA Rec landings<br>MA Rec discards<br>MA Com landings<br>MA Com discards | MA Rec landings<br>MA Rec discards<br>MA Com landings<br>MA Com discards | MA Rec landings<br>MA Rec discards<br>MA Com landings<br>MA Com discards |
| | | | | RI Com landings<br>RI Rec landings<br>RI Rec discards |
| CT Rec landings<br>CT Rec discards | CT Rec landings<br>CT Rec discards | CT Rec landings<br>CT Rec discards | CT Rec landings | CT Rec landings<br>CT Rec discards |
| NY all | NY all | NY ALL | NY Com landings<br>NY Rec landings<br>NY Rec discards | NY Com landings<br>NY Rec landings<br>NY Rec discards |
| NJ Rec landings<br>NJ Rec discards | NJ Rec landings<br>NJ Rec discards | NJ Rec landings<br>NJ Rec discards | NJ Rec landings<br>NJ Rec discards | NJ ALL |
| | | | | Del Com landings<br>Del Rec landings |
| MD Com landings<br>MD Rec landings<br>MD Rec discards | MD Com landings<br>MD Rec landings<br>MD Rec discards | MD Com landings<br>MD Rec landings<br>MD Rec discards | MD Com landings<br>MD Rec landings<br>MD Rec discards | MD Com landings<br>MD Rec landings<br>MD Rec discards |
| VA Com landings<br>VA Rec landings<br>VA Rec discards | VA Com landings<br>VA Rec landings<br>VA Rec discards | VA Com landings<br>VA Rec landings<br>VA Rec discards | VA ALL | VA Com landings<br>VA Rec landings<br>VA Rec discards |

[1] (rec harvest-at-age)*(rec discard-at-age)/(total harvest)
[2] Ages 2-5: discard WAA = 0.8*harvest WAA, Ages 6+: discard WAA = 0.9*harvest WAA
[3] Coastwide summary CAA document supplied by Gary Nelson

Table 7. Comparison of "Old" and "New", or Recalculated Striped Bass Coastwide WAA (kg) for 2000-2003.

| | YEAR AGE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13/13+ | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OLD | **2000** | 0.14 | 1.05 | 1.47 | 2.32 | 3.23 | 4.52 | 6.39 | 7.11 | 7.81 | 9.2 | 9.31 | 10.1 | 11.36 | 12.45 | 17.3 |
| | **2001** | 0.13 | 0.62 | 1.17 | 2.46 | 2.81 | 3.63 | 4.51 | 5.07 | 6.73 | 9.17 | 9.94 | 10.24 | 11.94 | 14.49 | 17.92 |
| | **2002** | 0.82 | 0.81 | 1.25 | 1.75 | 2.47 | 3.3 | 4.16 | 5.48 | 6.36 | 7.45 | 8.75 | 8.89 | 9.99 | 11.03 | 13.95 |
| | **MEAN 00-02** | 0.36 | 0.83 | 1.30 | 2.18 | 2.84 | 3.82 | 5.02 | 5.89 | 6.97 | 8.61 | 9.33 | 9.74 | 11.10 | 12.66 | 16.39 |
| | **Δ 2002 - 2001** | 0.69 | 0.19 | 0.08 | *-0.71* | *-0.34* | *-0.33* | *-0.35* | 0.41 | *-0.37* | *-1.72* | *-1.19* | *-1.35* | *-1.95* | *-3.46* | *-3.97* |
| | **Δ 2002 - 2000** | 0.68 | *-0.24* | *-0.22* | *-0.57* | *-0.76* | *-1.22* | *-2.23* | *-1.63* | *-1.45* | *-1.75* | *-0.56* | *-1.21* | *-1.37* | *-1.42* | *-3.35* |
| NEW | **2000** | 0.2 | 0.6 | 0.9 | 1.4 | 1.9 | 2.8 | 4 | 4.9 | 6.1 | 6 | 8.8 | 9.8 | 12.8 | | |
| | **2001** | 0.1 | 0.4 | 0.8 | 1.7 | 2.2 | 3.2 | 4 | 5 | 5.9 | 7.2 | 8.1 | 7.4 | 10.6 | | |
| | **2002** | 0.1 | 0.3 | 1.1 | 1.5 | 2.2 | 3.2 | 4.2 | 5.5 | 6.0 | 7.6 | 9.1 | 9.7 | 11.5 | | |
| | **2003** | 0.1 | 0.6 | 1.0 | 1.4 | 2.2 | 3.2 | 4.1 | 5.2 | 6.1 | 7.2 | 8.5 | 9.4 | 11 | | |
| NEW VS. OLD | **Δ 2000(N) - 2000(O)** | 0.06 | *-0.45* | *-0.57* | *-0.92* | *-1.33* | *-1.72* | *-2.39* | *-2.21* | *-1.71* | *-3.2* | *-0.51* | *-0.3* | 1.44 | | |
| | **Δ 2001(N) - 2001(O)** | *-0.03* | *-0.22* | *-0.37* | *-0.76* | *-0.61* | *-0.43* | *-0.51* | *-0.07* | *-0.83* | *-1.97* | *-1.84* | *-2.84* | *-1.34* | | |
| | **Δ 2002(N) - 2002(O)** | *-0.72* | *-0.51* | *-0.15* | *-0.25* | *-0.27* | *-0.10* | 0.04 | 0.02 | *-0.36* | 0.15 | 0.35 | 0.81 | *-0.16* | | |
| | **MEAN 82-96** | 0.2 | 0.8 | 1.3 | 2.0 | 2.7 | 3.6 | 4.8 | 5.7 | 6.4 | 7.5 | 8.9 | 10.3 | 13.5 | | |
| | **Δ 2003 - MEAN 82-96** | *-0.07* | *-0.17* | *-0.29* | *-0.58* | *-0.48* | *-0.43* | *-0.7* | *-0.53* | *-0.3* | *-0.32* | *-0.41* | *-0.94* | *-2.5* | | |

Negative values emphasized by italics.

**Appendix 5b: Analysis of the 2005-2006 Striped Bass Coastwide Weight-at-Age**

**Prepared for the**
**Striped Bass Stock Assessment Sub-Committee**
**by**
**Linda S. Barker and Lisa Warner**
**Maryland DNR Fisheries Service**

**FINAL**

*September 7, 2007*

## Introduction

This report presents the results of the 2005-2006 update of the Atlantic coastwide weight-at-age (WAA) analysis for striped bass. This analysis followed the procedure outlined in "Analysis and Discussion of the 1998-2002 Striped Bass Coastwide Weight-at-Age", prepared for the Striped Bass Stock Assessment Sub-Committee meeting August 9 – 11, 2005 by Linda S. Barker of Maryland DNR Fisheries Service. The data for these calculations were provided through the annual compliance report's catch-at-age (CAA) spreadsheet. This standardized template has been in use since 2004.

## Methods

It should be noted that although these calculations were performed exactly the same as those in 2005, the equation provided in the 2005 document was incorrect. The coastwide WAA was calculated as the ratio of (total weight of fish caught) to (total number of fish caught) for each age.

Subsequent analyses were performed on the WAA for the individual state fishery elements. WAA for a fishery element was calculated as the ratio of the total weight of fish harvested or discarded by that fishery element to the total number of fish harvested or discarded by that fishery element for each age. The following fishery elements were included in the calculation of the 2005 and 2006 coastwide WAA:

- Maine recreational harvest and discards,
- New Hampshire recreational harvest and discards,
- Massachusetts recreational harvest and discards and commercial harvest and discards,
- Rhode Island recreational harvest and discards and commercial harvest and discards,
- Connecticut recreational harvest and discards,
- New York recreational catch and commercial landings,
- New Jersey recreational harvest and discards,
- Delaware recreational harvest and discards and commercial harvest and discards,
- Maryland recreational harvest and discards and commercial harvest and discards,
- PRFC recreational harvest and commercial harvest,
- Virginia recreational harvest and discards and commercial harvest and discards, and
- North Carolina recreational harvest and discards and commercial harvest and discards.

## Results and Discussion

Summary information for the coastwide CAA and WAA are shown in the attached tables and figures. Tables 1 - 4 provide the values used in the calculation of coastwide WAA – the total catch at age, the total weight of catch at age, and the ratio WAA value. The 2006 and 2005 coastwide values are provided in both pounds (Tables 1 and 3) and kilograms (Tables 2 and 4). The distributions of the 2005 and 2006 coastwide mean CAA are presented in both numbers of fish (Fig 1) and pounds (Fig 2). The distributions of the 2005 and 2006 coastwide mean WAA are presented in both pounds (Fig 3) and kg (Fig 4).

The WAA time series is provided in Table 5, but the 2003 and 2004 values are missing. These values need to be checked and updated and will be added later.

The 2005 and 2006 fishery-based tables demonstrate details of analysis. The coastwide CAA is divided into the fishery elements (recreational harvest, recreational discards, and commercial harvest in each state) in Tables 6A and 6B (numbers of fish) and Tables 7A and 7B (pounds of fish). Commercial discard data were not included in this analysis. Tables 8A and 8B present the proportional contribution of each fishery element to the coastwide CAA in 2006 and 2005.

The 2006 coastwide CAA by fishery (Table 8A) shows a shift in the proportional contribution to the coastwide catch at approximately age 6. The catch of younger fish (ages 2-6) was dominated by recreational discards. The ranges of contribution to the coastwide catch for ages 2-6 were: MD (2-51%), VA (0-36%), MA (14-25%) and ME (9-18%). The range in recreational harvest of the Bay states was also significant: MD (0-17%) and VA (0-14%). MD's commercial harvest (8-24%) was the third significant contributor to the catch for the younger ages. The catch of older fish (ages 6+) was dominated by recreational harvest. Most of the recreational harvest at each of the older ages was in the northern states: MA (13-18%), NY and NJ (both 10-13%) and CT (8-10%). The exception was MD (8-26%). 2005 numbers are shown in Table 8B.

These shifts in proportional contribution to the coastwide catch show a differential effect on the coastwide WAA. This emphasizes the importance of the accuracy of age assignments and age-length keys (ALK) among the states. In addition, some states use the ALK from a neighboring state, so the coastwide effect of those states' information is compounded. The tools and information supplied by MD, MA, NY and NJ account for the greatest overall contribution to the WAA calculations.

Figures 5A-5L show mean WAA (2-13+ years) by state and fishery element. These figures clearly show that most fisheries reported similar WAA for each age, but there were exceptions. Some fishery values were not biologically reasonable (Appendix A). Because the growth equations supplied in the state spreadsheets indicated that striped bass all along the coast are growing at similar rates, these outliers indicate possible age-related errors.

There was an apparent difference in WAA for coastal and Chesapeake Bay states in 2005 and 2006, but this did not appear to be a biological difference. 2006 WAA show wide ranges among the younger ages: age 3 (1.4 – 4.8 lbs., Figure 5B), age 4 (1.9 - 10.2 lbs., Figure 5C) and age 5 (3.1 - 11.1 lbs., Figure 5D), between states and years. This does not appear to be due to an actual difference in growth rates (i.e., females on the coast growing much faster) because growth curves indicate similar growth patterns between all states. A specific example using age 4 fish in 2006 illustrates the difference: mean weight of a NY recreational harvest fish is 10 lbs., while a ME fish of the same age weighs 2.9 lbs., and a fish from MD or VA weighs approximately 2.5 lbs. (Figure 5C). A comparison was made of coastal ALKs for recreational discards against the

MD spring ALK. The MD spring ALK should represent the complete stock on the spawning ground and should therefore contain the majority of the coastal fish. The WAA for DE, CT, NY and NJ were shifted outside of the MD minimum and maximum values for younger ages. While the young females are not encountered on the MD spawning grounds, they are sampled during a spring/early summer recreational creel survey. Mean WAAs from these data are much lower than those seen on the coast. Again, since each state's growth curves show similar patterns, these large differences in mean weight at age may be due to ageing error and should be further evaluated to provide an explanation of the differences between states.

These differences in WAA among fisheries prompted further investigation into the compliance report spreadsheets. Several errors were discovered in age-length keys and cell entries that required adjustment. Even after these corrections, the final results indicate that there may be some effects from ageing errors. See Appendix A for further details.

## Appendix 5b Tables

Table 1. 2006 Atlantic coastwide striped bass weights at age (pounds). * calculated from total numbers and total weights

| 2006<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Harvest (Fish) 2006 | 15 | 33,806 | 226,091 | 1,142,739 | 632,900 | 1,052,055 | 670,060 | 341,169 | 333,025 | 332,892 | 424,426 | 288,268 | 169,550 | 182,478 | **5,829,474** |
| Total Wt. (Lbs.) 2006 | 0 | 16,522 | 242,467 | 2,079,375 | 1,965,837 | 4,877,206 | 4,155,669 | 3,083,536 | 3,613,561 | 4,570,353 | 6,588,685 | 5,163,478 | 3,356,854 | 4,463,092 | **44,176,635** |
| WAA (Lbs.) 2006 | 0.01 | 0.49 | 1.07 | 1.82 | 3.11 | 4.64 | 6.20 | 9.04 | 10.85 | 13.73 | 15.52 | 17.91 | 19.80 | 24.46 | |

Table 2. 2006 Atlantic coastwide striped bass weights at age (kg). * calculated from total numbers and total weights

| 2006<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Catch (Fish) 2006 | 15 | 33,806 | 226,091 | 1,142,739 | 632,900 | 1,052,055 | 670,060 | 341,169 | 333,025 | 332,892 | 424,426 | 288,268 | 169,550 | 182,478 | **5,829,474** |
| Total Wt. (Kgs.) 2006 | 0 | 7,494 | 109,981 | 943,189 | 891,689 | 2,212,263 | 1,884,980 | 1,398,668 | 1,639,084 | 2,073,077 | 2,988,577 | 2,342,114 | 1,522,643 | 2,024,425 | **20,038,185** |
| WAA (Kgs.) 2006 | 0.01 | 0.22 | 0.49 | 0.83 | 1.33 | 2.02 | 2.80 | 4.10 | 4.91 | 6.22 | 7.03 | 8.12 | 8.98 | 11.09 | |

Table 3. 2005 Atlantic coastwide striped bass weights at age (pounds). * calculated from total numbers and total weights

| 2005<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Catch (Fish) 2005 | 75 | 18,261 | 446,254 | 317,592 | 859,555 | 787,390 | 444,234 | 361,636 | 328,166 | 412,818 | 296,104 | 248,357 | 115,046 | 132,895 | **4,768,383** |
| Total Wt. (Lbs.) 2005 | 8 | 5,815 | 572,054 | 727,494 | 2,911,356 | 3,691,836 | 3,034,246 | 3,119,694 | 3,897,877 | 5,600,426 | 4,376,674 | 4,350,654 | 2,260,358 | 3,436,972 | **37,985,465** |
| WAA (Lbs.) 2005 | 0.09 | 0.30 | 1.13 | 2.31 | 3.29 | 4.52 | 6.78 | 8.63 | 11.73 | 14.17 | 16.40 | 19.13 | 21.72 | 24.56 | |

Table 4. 2005 Atlantic coastwide striped bass weights at age (kg). * calculated from total numbers and total weights

| 2005<br>AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | COAST WIDE TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Catch (Fish) 2005 | 75 | 18,261 | 446,254 | 317,592 | 845,159 | 760,655 | 429,839 | 352,587 | 317,883 | 407,471 | 295,693 | 248,357 | 115,046 | 132,895 | **4,687,768** |
| Total Wt. (Kgs.) 2005 | 4 | 2,637 | 259,479 | 329,986 | 1,320,569 | 1,674,589 | 1,376,311 | 1,415,069 | 1,768,047 | 2,540,310 | 1,985,226 | 1,973,424 | 1,025,281 | 1,558,984 | **17,229,917** |
| WAA (Kgs.) 2005 | 0.05 | 0.14 | 0.58 | 1.04 | 1.56 | 2.20 | 3.20 | 4.01 | 5.56 | 6.23 | 6.71 | 7.95 | 8.91 | 11.73 | |

Table 5. 1982-2006 striped bass Atlantic coastwide weights at age (kg) time series (less 2003 and 2004).

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

Table 6A. 2006 striped bass catch at age (numbers of fish) by state and fishery.

| 2006 STATE FISHERY | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0 | 0 | 0 | 8,709 | 11,722 | 35,478 | 14,798 | 1,760 | 0 | 13 | 13 | 275 | 186 | 430 | **73,385** |
| ME RECREATIONAL DISCARDS | 0 | 0 | 19,839 | 200,717 | 42,932 | 36,686 | 16,820 | 2,959 | 1,849 | 1,147 | 1,184 | 771 | 342 | 379 | **325,624** |
| NEW HAMPSHIRE RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 0 | 1,467 | 3,114 | 1,799 | 2,199 | 1,528 | 1,969 | 1,250 | 664 | 770 | **14,760** |
| NEW HAMPSHIRE RECREATIONALDISCARDS | 0 | 0 | 3,407 | 26,485 | 5,138 | 6,078 | 3,006 | 476 | 229 | 165 | 184 | 117 | 63 | 86 | **45,434** |
| MASS RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 11,558 | 32,235 | 26,771 | 43,404 | 44,581 | 69,177 | 50,245 | 30,376 | 36,757 | **345,104** |
| MASS RECREATIONAL DISCARDS | 0 | 0 | 30,649 | 291,125 | 79,370 | 138,094 | 89,946 | 18,457 | 12,147 | 9,464 | 11,359 | 6,486 | 3,330 | 2,594 | **693,021** |
| MASS COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 460 | 2,868 | 11,125 | 19,766 | 15,563 | 9,697 | 10,506 | **69,985** |
| RI RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 806 | 9,085 | 11,997 | 9,364 | 12,382 | 8,657 | 9,750 | 7,099 | 3,452 | 2,688 | **75,279** |
| RI RECREATIONAL DISCARDS | 0 | 852 | 17,704 | 53,907 | 7,680 | 16,082 | 6,798 | 2,529 | 1,431 | 743 | 388 | 250 | 104 | 97 | **108,567** |
| RI COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 50 | 46 | 1,319 | 3,325 | 4,016 | 2,832 | 1,878 | 970 | 993 | **15,429** |
| CON RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 658 | 4,616 | 10,937 | 15,151 | 6,345 | 15,676 | 11,860 | 9,306 | 3,163 | 6,064 | **83,776** |
| CON RECREATIONAL DISCARDS | 0 | 3,050 | 25,993 | 62,401 | 8,039 | 15,567 | 7,408 | 3,028 | 2,776 | 1,984 | 1,136 | 1,227 | 693 | 1,360 | **134,659** |
| NY RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 7,530 | 55,500 | 64,912 | 37,289 | 42,998 | 26,998 | 34,832 | 21,297 | 13,128 | 5,955 | **310,441** |
| NY RECREATIONAL DISCARDS | 0 | 213 | 8,757 | 58,721 | 12,237 | 23,589 | 8,374 | 3,827 | 3,236 | 1,940 | 2,411 | 1,481 | 903 | 554 | **126,246** |
| N Y COMMERCIAL HARVEST | 0 | 0 | 0 | 127 | 1,411 | 18,155 | 14,102 | 9,681 | 8,671 | 6,587 | 7,623 | 4,568 | 1,186 | 1,418 | **73,528** |
| NJ RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 4,615 | 25,037 | 51,241 | 82,538 | 71,059 | 68,644 | 76,010 | 53,236 | 32,312 | 24,818 | **489,510** |
| NJ RECREATIONALDISCARDS | 15 | 340 | 6,632 | 44,840 | 25,896 | 49,021 | 19,584 | 7,049 | 4,371 | 3,061 | 3,293 | 2,006 | 1,150 | 788 | **168,045** |
| DEL RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 406 | 2,044 | 2,284 | 2,895 | 2,190 | 2,016 | 2,884 | 1,786 | 1,361 | 815 | **18,680** |
| DEL RECREATIONAL DISCARDS | 0 | 65 | 1,023 | 5,455 | 3,716 | 5,560 | 1,760 | 719 | 397 | 225 | 268 | 193 | 112 | 132 | **19,624** |
| DEL COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 13 | 4,755 | 14,373 | 4,281 | 2,548 | 1,157 | 1,099 | 332 | 840 | 813 | **30,212** |
| MD RECREATIONAL HARVEST | 0 | 0 | 0 | 69,790 | 102,755 | 174,591 | 68,894 | 28,592 | 31,184 | 40,461 | 49,265 | 34,615 | 23,490 | 36,825 | **660,462** |
| MD RECREATIONAL DISCARDS | 0 | 17,232 | 65,843 | 131,574 | 26,917 | 16,711 | 12,000 | 7,257 | 8,698 | 8,630 | 9,672 | 3,998 | 2,300 | 1,584 | **312,417** |
| MD COMMERCIAL HARVEST | 0 | 0 | 0 | 90,171 | 154,029 | 254,656 | 104,954 | 25,365 | 14,508 | 5,655 | 3,488 | 2,194 | 187 | 743 | **655,951** |
| PRFC COMMERCIAL HARVEST | | | | 185 | 35,808 | 49,282 | 4,522 | 369 | 1,015 | 554 | 554 | 0 | 0 | 0 | **92,288** |
| VA RECREATIONAL HARVEST | 0 | 0 | 9,430 | 33,943 | 88,366 | 86,000 | 90,715 | 37,697 | 31,866 | 30,416 | 50,052 | 28,442 | 15,383 | 25,882 | **528,191** |
| VA RECREATIONAL DISCARDS | 0 | 12,003 | 36,426 | 62,893 | 11,219 | 3,244 | 3,718 | 1,411 | 1,236 | 795 | 1,301 | 664 | 512 | 253 | **135,677** |
| VA COMMERCIAL HARVEST | 0 | 0 | 81 | 336 | 1,303 | 8,694 | 11,275 | 6,097 | 9,713 | 16,389 | 25,124 | 14,064 | 9,195 | 7,123 | **109,395** |
| NC RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,959 | 10,309 | 20,137 | 26,562 | 24,214 | 13,780 | 11,007 | **107,966** |
| NC RECREATIONAL DISCARDS | 0 | 51 | 307 | 1,360 | 333 | 454 | 247 | 70 | 54 | 43 | 47 | 27 | 14 | 12 | **3,019** |
| NC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 85 | 326 | 684 | 656 | 1,031 | **2,798** |
| TOTAL AT AGE | **15** | **33,806** | **226,091** | **1,142,739** | **632,900** | **1,052,055** | **670,060** | **341,169** | **333,025** | **332,892** | **424,426** | **288,268** | **169,550** | **182,478** | **5,829,474** |

Table 6B. 2005 striped bass catch at age (numbers of fish) by state and fishery.

| 2005 STATE FISHERY | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0 | 0 | 0 | 9,872 | 30,581 | 19,338 | 3,666 | 647 | 323 | 45 | 136 | 207 | 176 | 190 | **65,179** |
| ME RECREATIONAL DISCARDS | 0 | 0 | 43,368 | 65,239 | 78,653 | 33,280 | 9,269 | 4,165 | 3,756 | 2,367 | 1,005 | 435 | 208 | 198 | **241,943** |
| NEW HAMPSHIRE RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 312 | 3,129 | 5,875 | 6,599 | 6,415 | 3,751 | 1,182 | 162 | 42 | 8 | **27,476** |
| NEW HAMPSHIRE RECREATIONALDISCARDS | 0 | 0 | 13,278 | 7,133 | 10,027 | 6,484 | 2,038 | 715 | 551 | 342 | 184 | 104 | 66 | 99 | **41,022** |
| MASS RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 2,505 | 36,790 | 56,750 | 61,896 | 80,240 | 67,697 | 34,916 | 22,525 | 11,932 | 17,533 | **392,784** |
| MASS RECREATIONAL DISCARDS | 0 | 0 | 63,042 | 58,533 | 99,799 | 79,088 | 31,005 | 15,771 | 16,133 | 11,524 | 5,517 | 2,857 | 1,657 | 2,253 | **387,180** |
| MASS COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,888 | 12,372 | 15,613 | 9,585 | 7,073 | 4,281 | 5,915 | **57,728** |
| RI RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 442 | 3,669 | 8,086 | 11,401 | 17,730 | 20,884 | 14,023 | 11,978 | 7,714 | 11,365 | **107,293** |
| RI RECREATIONAL DISCARDS | 0 | 182 | 25,261 | 4,806 | 9,788 | 7,837 | 3,982 | 2,514 | 1,649 | 1,315 | 694 | 512 | 267 | 477 | **59,282** |
| RI COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 27 | 172 | 632 | 1,337 | 3,019 | 2,896 | 2,790 | 1,880 | 1,002 | 1,194 | **14,949** |
| CON RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 814 | 5,929 | 14,327 | 19,341 | 9,041 | 18,146 | 13,849 | 11,439 | 3,233 | 6,957 | **103,075** |
| CON RECREATIONAL DISCARDS | 69 | 2,310 | 47,579 | 12,246 | 32,133 | 14,856 | 7,454 | 5,992 | 2,419 | 4,826 | 3,365 | 2,544 | 703 | 589 | **137,083** |
| NY RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 3,103 | 18,287 | 33,787 | 40,845 | 20,598 | 40,406 | 31,489 | 27,666 | 13,925 | 10,014 | **240,119** |
| NY RECREATIONAL DISCARDS | 0 | 110 | 34,834 | 10,287 | 30,485 | 13,421 | 4,691 | 3,569 | 1,672 | 3,049 | 2,321 | 2,040 | 1,027 | 365 | **107,870** |
| N Y COMMERCIAL HARVEST | 0 | 0 | 0 | 417 | 6,635 | 11,375 | 12,764 | 11,959 | 4,124 | 10,307 | 7,814 | 2,786 | 2,061 | 317 | **70,560** |
| NJ RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 28,734 | 67,361 | 49,101 | 30,180 | 33,573 | 34,238 | 21,829 | 33,239 | 3,587 | 17,600 | **319,444** |
| NJ RECREATIONALDISCARDS | 6 | 208 | 7,975 | 11,409 | 25,597 | 19,483 | 7,635 | 7,991 | 5,767 | 5,153 | 1,797 | 1,969 | 122 | 682 | **95,795** |
| DEL RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 137 | 1,120 | 1,925 | 3,184 | 1,619 | 2,227 | 2,720 | 4,755 | 572 | 237 | **18,496** |
| DEL RECREATIONAL DISCARDS | 0 | 8,132 | 580 | 1,488 | 1,692 | 2,823 | 410 | 580 | 544 | 591 | 595 | 270 | 179 | 104 | **17,987** |
| DEL COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 525 | 4,332 | 5,395 | 4,096 | 4,726 | 4,143 | 2,690 | 280 | 150 | 0 | **26,336** |
| MD RECREATIONAL HARVEST | 0 | 0 | 326 | 25,251 | 96,875 | 107,248 | 45,922 | 38,932 | 26,339 | 42,500 | 34,665 | 36,337 | 21,909 | 17,660 | **493,964** |
| MD RECREATIONAL DISCARDS | 0 | 7,193 | 135,950 | 48,116 | 58,836 | 23,165 | 5,573 | 4,906 | 3,760 | 4,742 | 3,039 | 2,539 | 1,738 | 708 | **300,266** |
| MD COMMERCIAL HARVEST | 0 | 0 | 144 | 42,952 | 214,726 | 203,839 | 62,171 | 21,599 | 11,773 | 7,424 | 2,928 | 2,164 | 105 | 139 | **569,964** |
| PRFC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 14,396 | 26,735 | 14,396 | 9,049 | 10,283 | 5,347 | 411 | 0 | 0 | 0 | **80,615** |
| VA RECREATIONAL HARVEST | 0 | 0 | 0 | 3,738 | 86,193 | 65,312 | 49,664 | 41,334 | 26,665 | 37,613 | 25,939 | 18,078 | 8,433 | 8,882 | **371,853** |
| VA RECREATIONAL DISCARDS | 0 | 0 | 70,853 | 14,396 | 20,607 | 5,813 | 1,447 | 1,541 | 823 | 1,101 | 566 | 875 | 544 | 197 | **118,763** |
| VA COMMERCIAL HARVEST | 0 | 0 | 0 | 90 | 3,387 | 5,078 | 5,710 | 6,791 | 8,975 | 24,725 | 19,079 | 19,509 | 12,624 | 13,277 | **119,244** |
| NC RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,481 | 12,260 | 36,963 | 47,240 | 27,291 | 10,857 | 8,892 | **144,983** |
| NC RECREATIONAL DISCARDS | 1 | 126 | 3,066 | 1,618 | 2,546 | 1,428 | 509 | 331 | 257 | 242 | 132 | 98 | 45 | 39 | **10,437** |
| NC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 0 | 761 | 2,639 | 3,603 | 6,749 | 5,887 | 7,003 | **26,693** |
| TOTAL AT AGE | **75** | **18,261** | **446,254** | **317,592** | **859,555** | **787,390** | **444,234** | **361,636** | **328,166** | **412,818** | **296,104** | **248,357** | **115,046** | **132,895** | **4,768,383** |

Table 7A. 2006 striped bass catch at age (pounds of fish) by state and fishery.

| AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0.0 | 0 | 0 | 21,514 | 34,430 | 124,619 | 56,994 | 7,287 | 0 | 256 | 256 | 5,785 | 3,917 | 10,170 | **265,227** |
| ME RECREATIONAL DISCARDS | 0.0 | 0 | 16,928 | 287,155 | 101,295 | 152,002 | 80,923 | 20,355 | 18,061 | 13,222 | 17,469 | 12,183 | 6,221 | 8,216 | **734,033** |
| NEW HAMPSHIRE RECREATIONAL HAR | 0.0 | 0 | 0 | 0 | 0 | 12,271 | 28,162 | 18,332 | 24,336 | 20,814 | 31,917 | 22,707 | 13,974 | 19,808 | **192,321** |
| NEW HAMPSHIRE RECREATIONAL DIS | 0.0 | 0 | 3,381 | 40,432 | 11,945 | 24,735 | 14,593 | 3,416 | 2,455 | 2,105 | 2,975 | 2,147 | 1,327 | 2,323 | **111,834** |
| MASS RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 87,267 | 268,770 | 259,791 | 470,642 | 575,749 | 1,045,473 | 868,369 | 575,194 | 838,651 | **4,989,907** |
| MASS RECREATIONAL DISCARDS | 0.0 | 0 | 26,152 | 416,497 | 187,269 | 572,171 | 432,744 | 126,965 | 118,655 | 109,118 | 167,563 | 102,537 | 60,535 | 54,741 | **2,374,948** |
| MASS COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 5,980 | 43,574 | 171,426 | 342,627 | 285,253 | 191,736 | 265,034 | **1,305,631** |
| RI RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 68,592 | 100,033 | 90,870 | 134,261 | 111,801 | 147,347 | 122,690 | 65,358 | 59,420 | **900,372** |
| RI RECREATIONAL DISCARDS | 0.0 | 0 | 15,107 | 77,122 | 18,120 | 66,635 | 32,706 | 17,398 | 13,983 | 8,571 | 5,721 | 3,948 | 1,898 | 2,040 | **263,250** |
| RI COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 17,149 | 50,515 | 61,886 | 49,089 | 34,414 | 19,177 | 24,130 | **256,359** |
| CON RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 5,722 | 42,234 | 116,914 | 176,163 | 86,894 | 239,270 | 198,417 | 178,130 | 62,165 | 57,980 | **1,163,889** |
| CON RECREATIONAL DISCARDS | 0.0 | 1,725 | 38,477 | 182,118 | 47,061 | 121,239 | 77,352 | 35,824 | 39,896 | 37,599 | 22,320 | 29,659 | 16,840 | 25,334 | **675,443** |
| NY RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 76,886 | 571,442 | 729,836 | 462,657 | 671,208 | 524,172 | 717,637 | 530,507 | 319,763 | 164,165 | **4,768,272** |
| NY RECREATIONAL DISCARDS | 0.0 | 121 | 11,287 | 131,011 | 48,048 | 122,448 | 55,178 | 29,132 | 34,210 | 26,114 | 35,200 | 26,226 | 15,576 | 7,910 | **542,461** |
| N Y COMMERCIAL HARVEST | 0.0 | 0 | 0 | 612 | 8,340 | 117,620 | 105,681 | 84,683 | 89,114 | 76,415 | 104,220 | 64,925 | 15,952 | 20,883 | **688,446** |
| NJ RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 44,528 | 277,502 | 525,181 | 990,231 | 865,097 | 1,058,911 | 1,311,301 | 1,089,025 | 754,127 | 759,299 | **7,675,201** |
| NJ RECREATIONAL DISCARDS | 0.2 | 207 | 12,186 | 145,044 | 144,991 | 307,580 | 132,238 | 63,825 | 47,473 | 44,638 | 54,318 | 39,949 | 26,222 | 24,119 | **1,042,790** |
| DEL RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 3,353 | 17,620 | 22,498 | 34,129 | 26,588 | 31,214 | 48,433 | 36,361 | 32,440 | 25,522 | **278,159** |
| DEL RECREATIONAL DISCARDS | 0.0 | 40 | 1,783 | 19,460 | 20,629 | 34,521 | 13,547 | 7,004 | 4,252 | 3,487 | 4,745 | 4,152 | 2,975 | 4,104 | **120,700** |
| DEL COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 110 | 24,597 | 85,863 | 29,926 | 21,098 | 13,049 | 15,738 | 5,308 | 13,166 | 17,804 | **226,660** |
| MD RECREATIONAL HARVEST | 0.0 | 0 | 0 | 152,714 | 259,006 | 543,865 | 298,811 | 179,661 | 260,756 | 556,947 | 770,982 | 570,715 | 482,536 | 903,855 | **4,979,847** |
| MD RECREATIONAL DISCARDS | 0.0 | 6,746 | 42,037 | 183,660 | 51,909 | 54,419 | 61,867 | 61,324 | 80,373 | 99,760 | 118,252 | 54,404 | 34,655 | 17,977 | **867,382** |
| MD COMMERCIAL HARVEST | 0.0 | 0 | 0 | 216,857 | 408,321 | 790,627 | 410,439 | 105,075 | 68,639 | 45,124 | 27,669 | 23,729 | 2,265 | 11,257 | **2,110,003** |
| PRFC COMMERCIAL HARVEST | 0.0 | 0 | 0 | 1,081 | 209,717 | 365,599 | 44,141 | 4,684 | 18,233 | 13,513 | 16,540 | 0 | 0 | 0 | **673,508** |
| VA RECREATIONAL HARVEST | 0.0 | 0 | 23,868 | 80,076 | 242,820 | 313,674 | 362,632 | 180,648 | 242,468 | 348,852 | 672,590 | 517,157 | 284,023 | 812,252 | **4,081,059** |
| VA RECREATIONAL DISCARDS | 0.0 | 7,663 | 50,846 | 121,288 | 36,535 | 16,725 | 31,419 | 13,036 | 14,287 | 9,721 | 17,708 | 10,002 | 5,812 | 0 | **335,042** |
| VA COMMERCIAL HARVEST | 0.0 | 0 | 218 | 837 | 4,159 | 45,723 | 65,868 | 44,977 | 92,462 | 202,844 | 389,193 | 247,526 | 171,510 | 148,201 | **1,413,518** |
| NC RECREATIONAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 12,424 | 73,299 | 161,988 | 246,621 | 261,607 | 162,211 | 150,380 | **1,068,530** |
| NC RECREATIONAL DISCARDS | 0.0 | 20 | 196 | 1,898 | 643 | 1,478 | 1,275 | 588 | 502 | 492 | 572 | 363 | 217 | 140 | **8,384** |
| NC COMMERCIAL HARVEST | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 229 | 1,296 | 5,792 | 13,701 | 15,062 | 27,378 | **63,458** |
| TOTAL POUNDS AT AGE | **0.169** | **16,522** | **242,467** | **2,079,375** | **1,965,837** | **4,877,206** | **4,155,669** | **3,083,536** | **3,613,561** | **4,570,353** | **6,588,685** | **5,163,478** | **3,356,854** | **4,463,092** | 44,176,635 |

Table 7B. 2005 striped bass catch at age (pounds of fish) by state and fishery.

| AGE | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0 | 0 | 0 | 28,592 | 95,495 | 76,799 | 16,651 | 3,270 | 1,534 | 880 | 2,831 | 4,352 | 3,918 | 4,560 | **238,883** |
| ME RECREATIONAL DISCARDS | 0 | 0 | 40,424 | 146,596 | 255,392 | 161,151 | 61,405 | 36,327 | 42,288 | 31,327 | 15,014 | 8,303 | 4,501 | 5,189 | **807,917** |
| NEW HAMPSHIRE RECREATIONALHAI | 0 | 0 | 0 | 0 | 2,413 | 28,254 | 56,804 | 70,167 | 76,736 | 48,886 | 15,374 | 2,730 | 735 | 159 | **302,258** |
| NEW HAMPSHIRE RECREATIONALDIS | 0 | 0 | 11,807 | 15,187 | 33,377 | 32,780 | 13,263 | 6,156 | 6,302 | 5,010 | 3,138 | 2,243 | 1,574 | 2,934 | **133,771** |
| MASS RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 18,994 | 324,730 | 532,423 | 653,852 | 1,032,335 | 985,776 | 596,283 | 466,984 | 271,713 | 503,136 | **5,386,226** |
| MASS RECREATIONAL DISCARDS | 0 | 0 | 64,497 | 144,362 | 355,676 | 420,342 | 225,433 | 150,995 | 199,363 | 167,409 | 90,448 | 59,895 | 39,349 | 65,169 | **1,982,939** |
| MASS COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36,831 | 200,321 | 254,870 | 189,264 | 156,587 | 109,818 | 223,114 | **1,170,806** |
| RI RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 3,355 | 32,386 | 75,863 | 120,442 | 228,103 | 304,109 | 239,485 | 248,328 | 175,650 | 322,897 | **1,750,619** |
| RI RECREATIONAL DISCARDS | 0 | 78 | 50,326 | 16,265 | 47,131 | 55,769 | 40,231 | 31,261 | 23,369 | 20,672 | 12,070 | 10,672 | 5,994 | 26,619 | **340,458** |
| RI COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17,055 | 48,886 | 47,278 | 55,084 | 41,614 | 25,705 | 26,331 | **261,953** |
| CON RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 7,198 | 55,114 | 157,122 | 224,791 | 116,294 | 270,406 | 217,411 | 239,601 | 65,616 | 191,465 | **1,545,018** |
| CON RECREATIONAL DISCARDS | 8 | 994 | 94,789 | 41,444 | 154,730 | 105,708 | 75,314 | 74,519 | 34,287 | 75,870 | 58,481 | 53,063 | 15,799 | 32,910 | **817,916** |
| NY RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 23,156 | 138,541 | 283,382 | 384,562 | 234,458 | 557,434 | 477,337 | 467,642 | 253,232 | 198,906 | **3,018,651** |
| NY RECREATIONAL DISCARDS | 0 | 70 | 63,062 | 28,050 | 122,449 | 77,364 | 36,628 | 34,911 | 20,100 | 45,867 | 38,935 | 38,145 | 20,656 | 16,224 | **542,460** |
| N Y COMMERCIAL HARVEST | 0 | 0 | 0 | 2,363 | 39,509 | 76,375 | 100,414 | 113,736 | 43,041 | 134,493 | 98,810 | 38,261 | 37,241 | 5,577 | **689,821** |
| NJ RECREATIONALHARVEST | 0 | 0 | 0 | 0 | 185,861 | 450,300 | 395,262 | 239,208 | 499,724 | 560,852 | 404,665 | 649,690 | 86,392 | 481,640 | **3,953,594** |
| NJ RECREATIONALDISCARDS | 0 | 68 | 10,893 | 27,233 | 101,935 | 103,587 | 54,006 | 72,232 | 69,705 | 68,449 | 26,322 | 35,450 | 2,240 | 18,352 | **590,472** |
| DEL RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 1,385 | 10,252 | 24,088 | 34,787 | 21,131 | 32,990 | 49,991 | 76,570 | 8,320 | 3,040 | **262,553** |
| DEL RECREATIONAL DISCARDS | 0 | 2,679 | 792 | 3,552 | 6,739 | 15,008 | 2,901 | 5,242 | 6,569 | 7,855 | 8,707 | 4,851 | 3,289 | 2,795 | **70,979** |
| DEL COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 2,164 | 23,076 | 31,796 | 30,634 | 41,335 | 41,255 | 30,549 | 4,139 | 2,034 | 0 | **206,981** |
| MD RECREATIONAL HARVEST | 0 | 0 | 514 | 54,397 | 260,066 | 329,920 | 200,112 | 233,241 | 263,227 | 586,891 | 548,640 | 689,157 | 480,651 | 448,705 | **4,095,520** |
| MD RECREATIONAL DISCARDS | 0 | 1,799 | 152,281 | 75,991 | 127,063 | 61,616 | 27,198 | 29,645 | 34,573 | 63,822 | 47,213 | 45,267 | 34,245 | 18,370 | **719,083** |
| MD COMMERCIAL HARVEST | 0 | 0 | 237 | 106,830 | 663,723 | 680,922 | 264,326 | 138,359 | 106,082 | 75,947 | 33,308 | 27,446 | 1,749 | 2,656 | **2,101,586** |
| PRFC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 49,536 | 123,467 | 89,947 | 81,120 | 118,253 | 65,849 | 5,289 | 0 | 0 | 0 | **533,461** |
| VA RECREATIONAL HARVEST | 0 | 0 | 0 | 11,954 | 294,362 | 265,298 | 226,062 | 219,113 | 227,754 | 458,439 | 353,368 | 282,691 | 167,681 | 191,024 | **2,697,747** |
| VA RECREATIONAL DISCARDS | 0 | 0 | 79,364 | 22,736 | 44,503 | 15,463 | 7,062 | 9,309 | 7,563 | 14,816 | 8,787 | 15,610 | 10,721 | 5,116 | **241,050** |
| VA COMMERCIAL HARVEST | 0 | 0 | 0 | 322 | 12,595 | 26,179 | 35,774 | 59,484 | 104,930 | 363,931 | 303,556 | 334,141 | 235,075 | 420,771 | **1,896,757** |
| NC RECREATIONAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8,107 | 84,857 | 291,930 | 417,063 | 283,549 | 132,425 | 130,500 | **1,348,432** |
| NC RECREATIONAL DISCARDS | 1 | 126 | 3,067 | 1,620 | 2,550 | 1,434 | 516 | 340 | 269 | 256 | 147 | 116 | 63 | 66 | **10,570** |
| NC COMMERCIAL HARVEST | 0 | 0 | 0 | 0 | 0 | 0 | 262 | 0 | 4,488 | 16,858 | 29,103 | 63,556 | 63,972 | 88,746 | **266,985** |
| TOTAL POUNDS AT AGE | **8.150** | **5,815** | **572,054** | **727,494** | **2,911,356** | **3,691,836** | **3,034,246** | **3,119,694** | **3,897,877** | **5,600,426** | **4,376,674** | **4,350,654** | **2,260,358** | **3,436,972** | **37,985,465** |

Table 8A. Proportional contributions by fishery to the 2006 coastwide CAA (by numbers of fish).

| PROP OF HARVEST BY NUMBER | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.008 | 0.019 | 0.034 | 0.022 | 0.005 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 |
| ME RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.088 | 0.176 | 0.068 | 0.035 | 0.025 | 0.009 | 0.006 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 |
| NEW HAMPSHIRE RECREATIONAL HARVE | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.005 | 0.007 | 0.005 | 0.005 | 0.004 | 0.004 | 0.004 |
| NEW HAMPSHIRE RECREATIONAL DISCA | 0.000 | 0.000 | 0.015 | 0.023 | 0.008 | 0.006 | 0.004 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| MASS RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.011 | 0.048 | 0.078 | 0.130 | 0.134 | 0.163 | 0.174 | 0.179 | 0.201 |
| MASS RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.136 | 0.255 | 0.125 | 0.131 | 0.134 | 0.054 | 0.036 | 0.028 | 0.027 | 0.022 | 0.020 | 0.014 |
| MASS COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.009 | 0.033 | 0.047 | 0.054 | 0.057 | 0.058 |
| RI RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.009 | 0.018 | 0.027 | 0.037 | 0.026 | 0.023 | 0.025 | 0.020 | 0.015 |
| RI RECREATIONAL DISCARDS | 0.000 | 0.025 | 0.078 | 0.047 | 0.012 | 0.015 | 0.010 | 0.007 | 0.004 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 |
| RI COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.010 | 0.012 | 0.007 | 0.007 | 0.006 | 0.005 |
| CON RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.016 | 0.044 | 0.019 | 0.047 | 0.028 | 0.032 | 0.019 | 0.033 |
| CON RECREATIONAL DISCARDS | 0.000 | 0.090 | 0.115 | 0.055 | 0.013 | 0.015 | 0.011 | 0.009 | 0.008 | 0.006 | 0.003 | 0.004 | 0.004 | 0.007 |
| NY RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.012 | 0.053 | 0.097 | 0.109 | 0.129 | 0.081 | 0.082 | 0.074 | 0.077 | 0.033 |
| NY RECREATIONAL DISCARDS | 0.000 | 0.006 | 0.039 | 0.051 | 0.019 | 0.022 | 0.012 | 0.011 | 0.010 | 0.006 | 0.006 | 0.005 | 0.005 | 0.003 |
| N Y COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.017 | 0.021 | 0.028 | 0.026 | 0.020 | 0.018 | 0.016 | 0.007 | 0.008 |
| NJ RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.024 | 0.076 | 0.242 | 0.213 | 0.206 | 0.179 | 0.185 | 0.191 | 0.136 |
| NJ RECREATIONAL DISCARDS | 0.998 | 0.010 | 0.029 | 0.039 | 0.041 | 0.047 | 0.029 | 0.021 | 0.013 | 0.009 | 0.008 | 0.007 | 0.007 | 0.004 |
| DEL RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 | 0.008 | 0.007 | 0.006 | 0.007 | 0.006 | 0.008 | 0.004 |
| DEL RECREATIONAL DISCARDS | 0.000 | 0.002 | 0.005 | 0.005 | 0.006 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| DEL COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.021 | 0.013 | 0.008 | 0.003 | 0.003 | 0.001 | 0.005 | 0.004 |
| MD RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.061 | 0.162 | 0.166 | 0.103 | 0.084 | 0.094 | 0.122 | 0.116 | 0.120 | 0.139 | 0.202 |
| MD RECREATIONAL DISCARDS | 0.000 | 0.510 | 0.291 | 0.115 | 0.043 | 0.016 | 0.018 | 0.021 | 0.026 | 0.026 | 0.023 | 0.014 | 0.014 | 0.009 |
| MD COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.079 | 0.243 | 0.242 | 0.157 | 0.074 | 0.044 | 0.017 | 0.008 | 0.008 | 0.001 | 0.004 |
| PRFC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.057 | 0.047 | 0.007 | 0.001 | 0.003 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 |
| VA RECREATIONAL HARVEST | 0.000 | 0.000 | 0.042 | 0.030 | 0.140 | 0.082 | 0.135 | 0.110 | 0.096 | 0.091 | 0.118 | 0.099 | 0.091 | 0.142 |
| VA RECREATIONAL DISCARDS | 0.000 | 0.355 | 0.161 | 0.055 | 0.018 | 0.003 | 0.006 | 0.004 | 0.004 | 0.002 | 0.003 | 0.002 | 0.003 | 0.001 |
| VA COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.008 | 0.017 | 0.018 | 0.029 | 0.049 | 0.059 | 0.049 | 0.054 | 0.039 |
| NC RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.031 | 0.060 | 0.063 | 0.084 | 0.081 | 0.060 |
| NC RECREATIONAL DISCARDS | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| NC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.004 | 0.006 |
| PROP OF HARVEST BY # | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table 8B. Proportional contributions by fishery to the 2005 coastwide CAA (by numbers of fish).

| PROP OF HARVEST BY NUMBER | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ME RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.031 | 0.036 | 0.025 | 0.008 | 0.002 | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| ME RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.097 | 0.205 | 0.092 | 0.042 | 0.021 | 0.012 | 0.011 | 0.006 | 0.003 | 0.002 | 0.002 | 0.001 |
| NEW HAMPSHIRE RECREATIONALHARVE | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.013 | 0.018 | 0.020 | 0.009 | 0.004 | 0.001 | 0.000 | 0.000 |
| NEW HAMPSHIRE RECREATIONALDISCA | 0.000 | 0.000 | 0.030 | 0.022 | 0.012 | 0.008 | 0.005 | 0.002 | 0.002 | 0.001 | 0.001 | 0.000 | 0.001 | 0.001 |
| MASS RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.047 | 0.128 | 0.171 | 0.245 | 0.164 | 0.118 | 0.091 | 0.104 | 0.132 |
| MASS RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.141 | 0.184 | 0.116 | 0.100 | 0.070 | 0.044 | 0.049 | 0.028 | 0.019 | 0.012 | 0.014 | 0.017 |
| MASS COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.008 | 0.038 | 0.038 | 0.032 | 0.028 | 0.037 | 0.045 |
| RI RECREATIONALHARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.018 | 0.032 | 0.054 | 0.051 | 0.047 | 0.048 | 0.067 | 0.086 |
| RI RECREATIONAL DISCARDS | 0.000 | 0.010 | 0.057 | 0.015 | 0.011 | 0.010 | 0.009 | 0.007 | 0.005 | 0.003 | 0.002 | 0.002 | 0.002 | 0.004 |
| RI COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.009 | 0.007 | 0.009 | 0.008 | 0.009 | 0.009 |
| CON RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.008 | 0.032 | 0.053 | 0.028 | 0.044 | 0.047 | 0.046 | 0.028 | 0.052 |
| CON RECREATIONAL DISCARDS | 0.919 | 0.126 | 0.107 | 0.039 | 0.037 | 0.019 | 0.017 | 0.017 | 0.007 | 0.012 | 0.011 | 0.010 | 0.006 | 0.004 |
| NY RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.023 | 0.076 | 0.113 | 0.063 | 0.098 | 0.106 | 0.111 | 0.121 | 0.075 |
| NY RECREATIONAL DISCARDS | 0.000 | 0.006 | 0.078 | 0.032 | 0.035 | 0.017 | 0.011 | 0.010 | 0.005 | 0.007 | 0.008 | 0.008 | 0.009 | 0.003 |
| N Y COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.001 | 0.008 | 0.014 | 0.029 | 0.033 | 0.013 | 0.025 | 0.026 | 0.011 | 0.018 | 0.002 |
| NJ RECREATIONALHARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.033 | 0.086 | 0.111 | 0.083 | 0.102 | 0.083 | 0.074 | 0.134 | 0.031 | 0.132 |
| NJ RECREATIONALDISCARDS | 0.074 | 0.011 | 0.018 | 0.036 | 0.030 | 0.025 | 0.017 | 0.022 | 0.018 | 0.012 | 0.006 | 0.008 | 0.001 | 0.005 |
| DEL RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.009 | 0.005 | 0.005 | 0.009 | 0.019 | 0.005 | 0.002 |
| DEL RECREATIONAL DISCARDS | 0.000 | 0.445 | 0.001 | 0.005 | 0.002 | 0.004 | 0.001 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.002 | 0.001 |
| DEL COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.006 | 0.012 | 0.011 | 0.014 | 0.010 | 0.009 | 0.001 | 0.001 | 0.000 |
| MD RECREATIONAL HARVEST | 0.000 | 0.000 | 0.001 | 0.080 | 0.113 | 0.136 | 0.103 | 0.108 | 0.080 | 0.103 | 0.117 | 0.146 | 0.190 | 0.133 |
| MD RECREATIONAL DISCARDS | 0.000 | 0.394 | 0.305 | 0.152 | 0.068 | 0.029 | 0.013 | 0.014 | 0.011 | 0.011 | 0.010 | 0.010 | 0.015 | 0.005 |
| MD COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.135 | 0.250 | 0.259 | 0.140 | 0.060 | 0.036 | 0.018 | 0.010 | 0.009 | 0.001 | 0.001 |
| PRFC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.017 | 0.034 | 0.032 | 0.025 | 0.031 | 0.013 | 0.001 | 0.000 | 0.000 | 0.000 |
| VA RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.012 | 0.100 | 0.083 | 0.112 | 0.114 | 0.081 | 0.091 | 0.088 | 0.073 | 0.073 | 0.067 |
| VA RECREATIONAL DISCARDS | 0.000 | 0.000 | 0.159 | 0.045 | 0.024 | 0.007 | 0.003 | 0.004 | 0.003 | 0.003 | 0.002 | 0.004 | 0.005 | 0.001 |
| VA COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.006 | 0.013 | 0.019 | 0.027 | 0.060 | 0.064 | 0.079 | 0.110 | 0.100 |
| NC RECREATIONAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.037 | 0.090 | 0.160 | 0.110 | 0.094 | 0.067 |
| NC RECREATIONAL DISCARDS | 0.007 | 0.007 | 0.007 | 0.005 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| NC COMMERCIAL HARVEST | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.006 | 0.012 | 0.027 | 0.051 | 0.053 |
| PROP OF HARVEST BY # | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

## Appendix 5b Figures

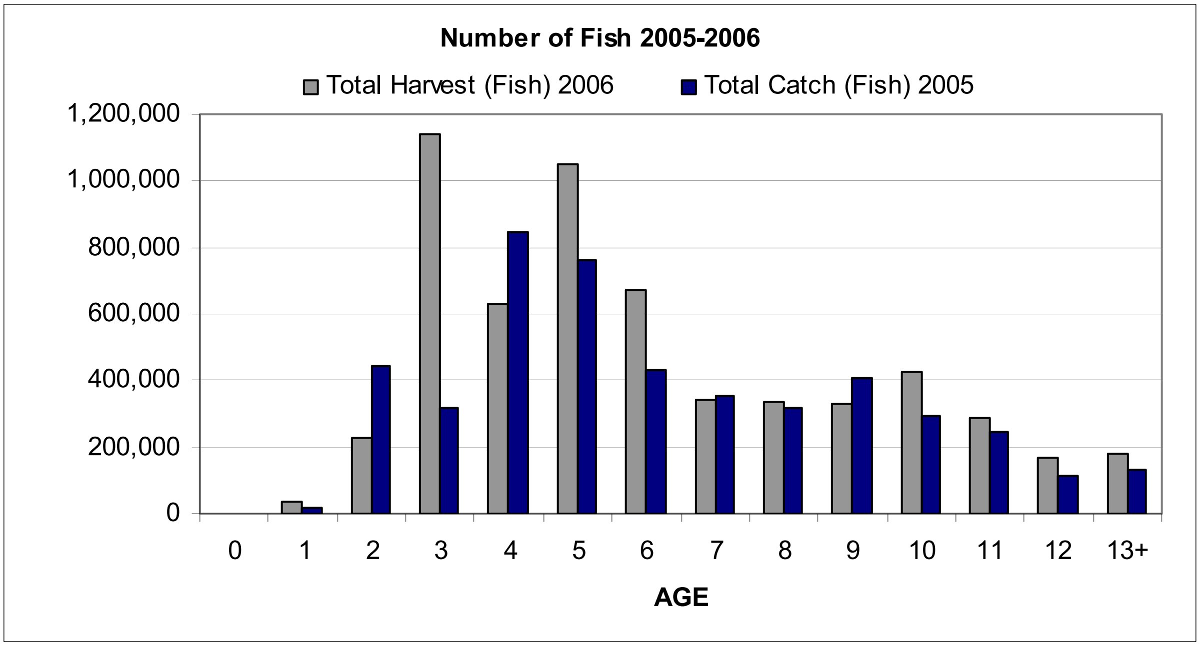



Figure 1. 2005-2006 Atlantic coastwide mean catch-at-age in numbers of striped bass.

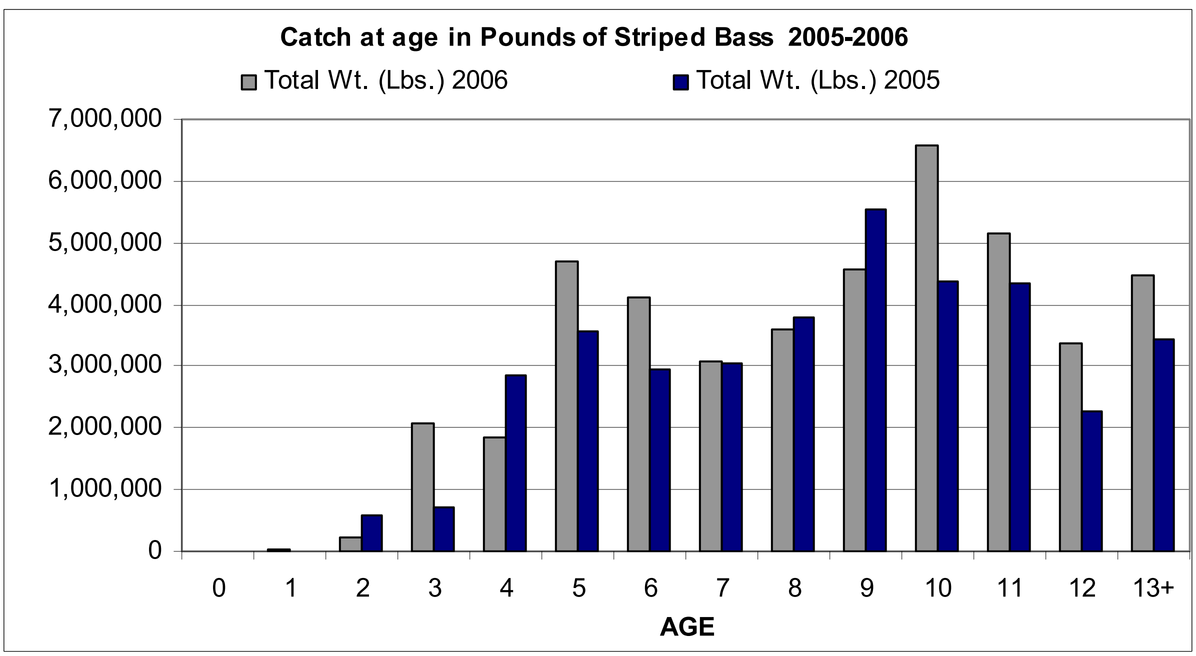



Figure 2. 2005-2006 Atlantic coastwide mean catch-at-age in pounds of striped bass.

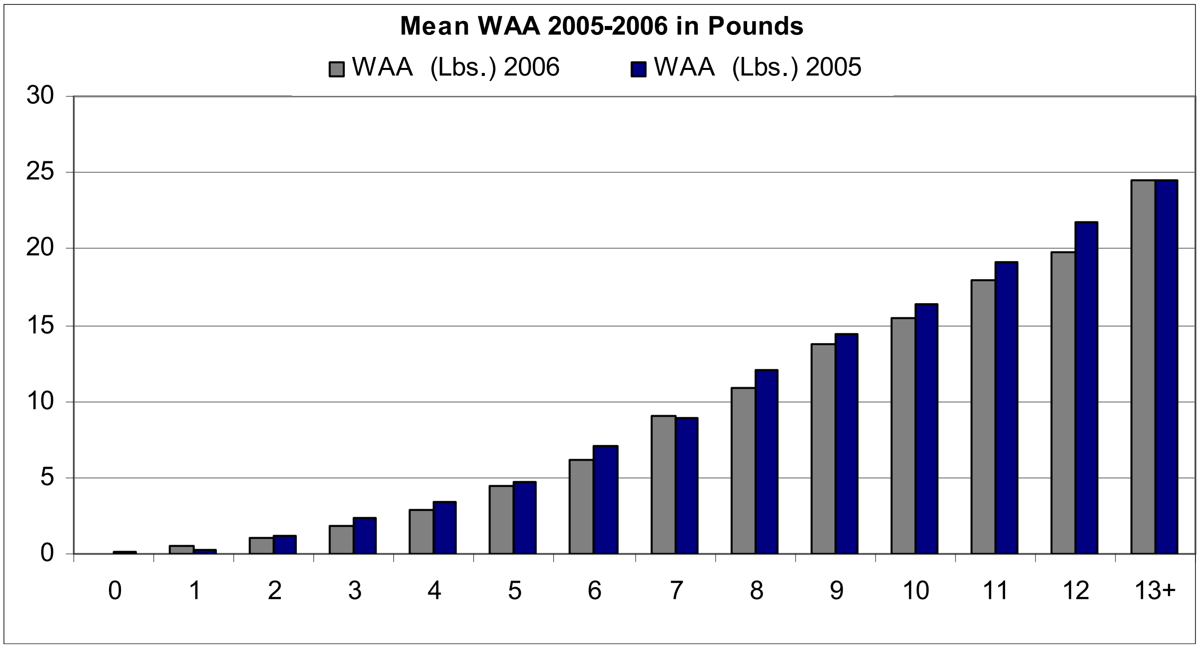



Figure 3. 2005 and 2006 Atlantic coastwide mean weight-at-age in pounds.

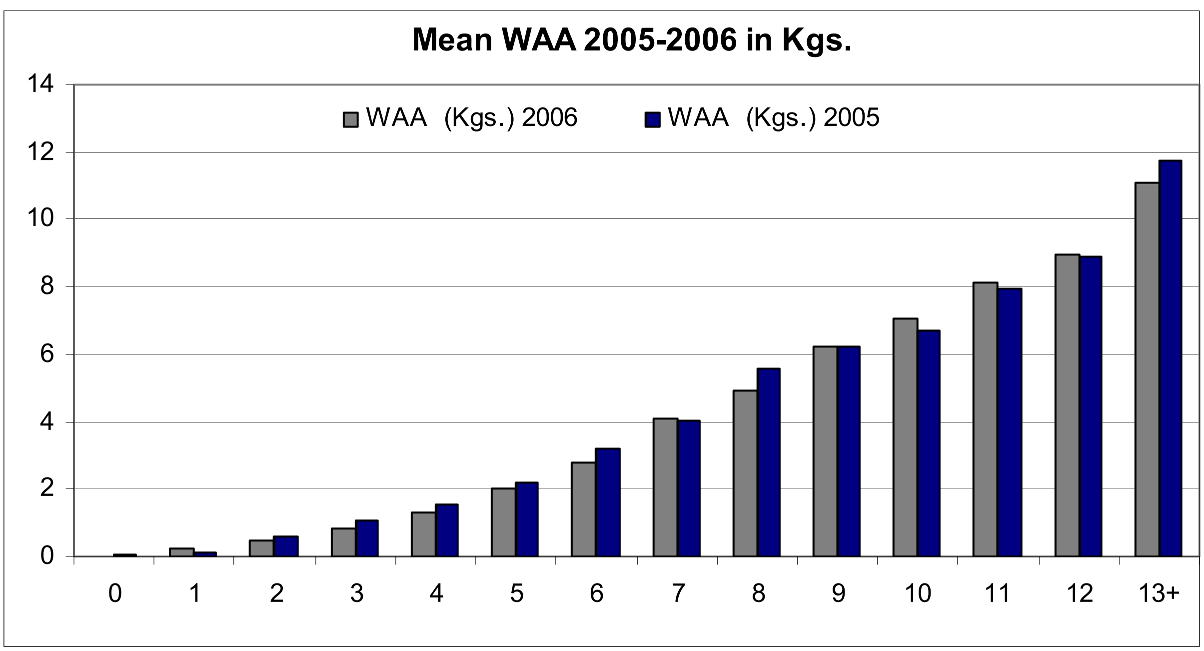



Figure 4. 2005 and 2006 Atlantic coastwide mean weight-at-age in kilograms.

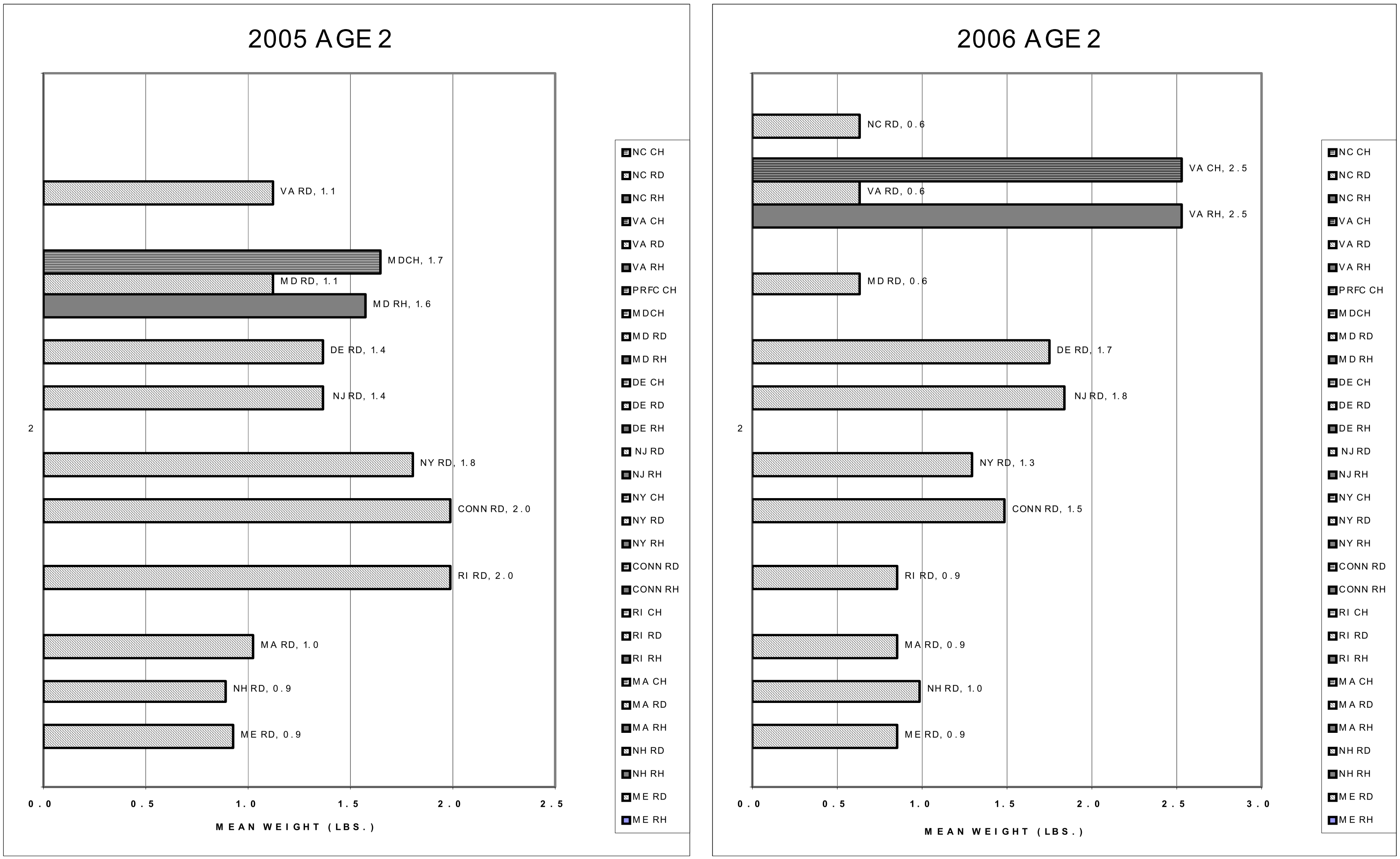
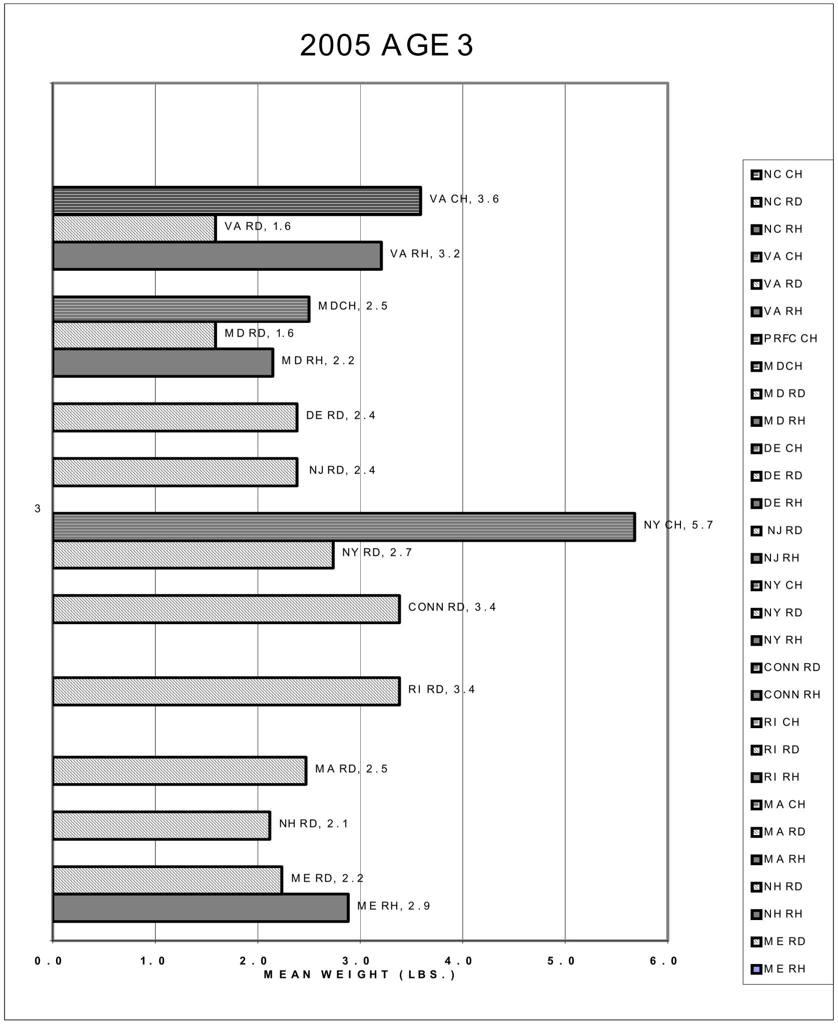



Figure 5A. 2005 and 2006 weight at age 2 by state and fishery.



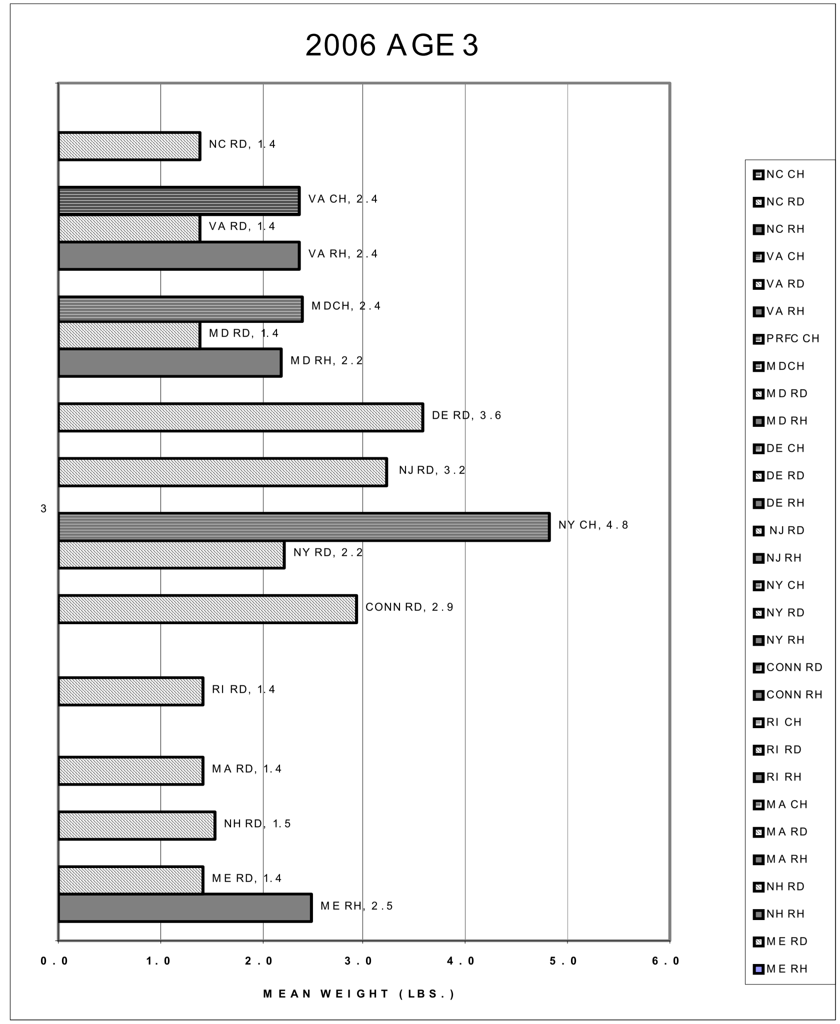
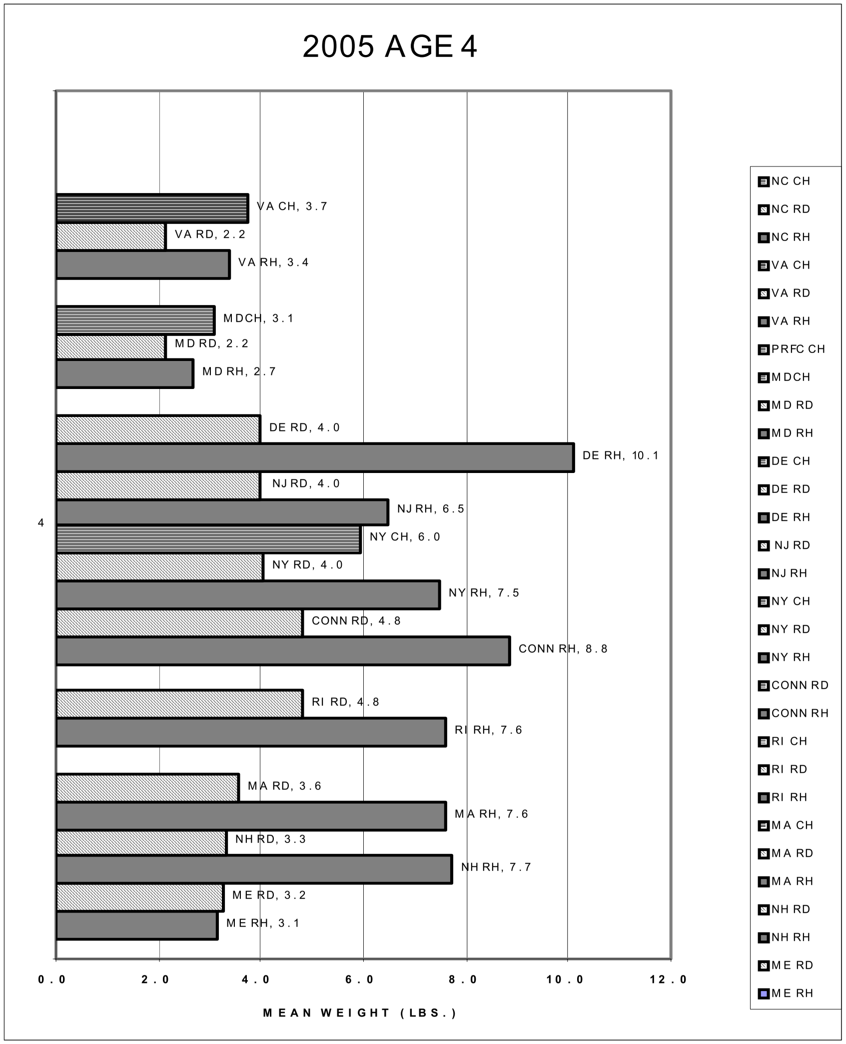




Figure 5B.2005 and 2006 weight at age 3 by state and fishery.



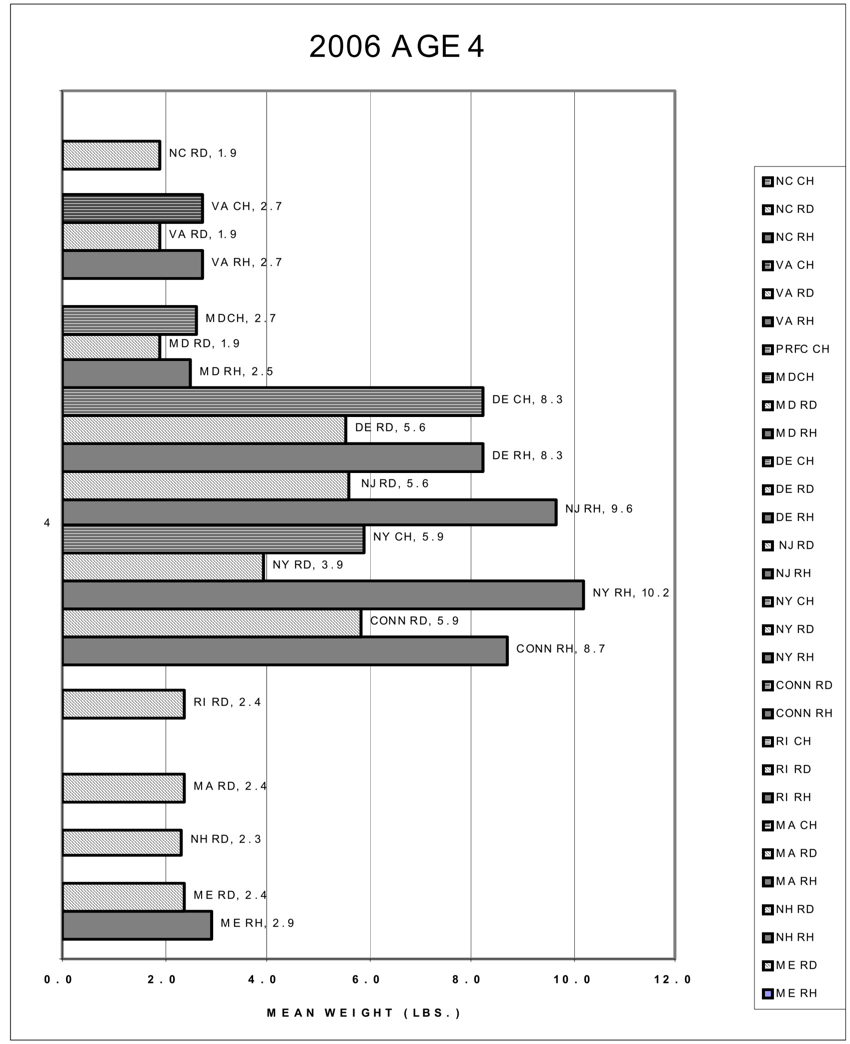




Figure 5C. 2005 and 2006 weight at age 4 by state and fishery.

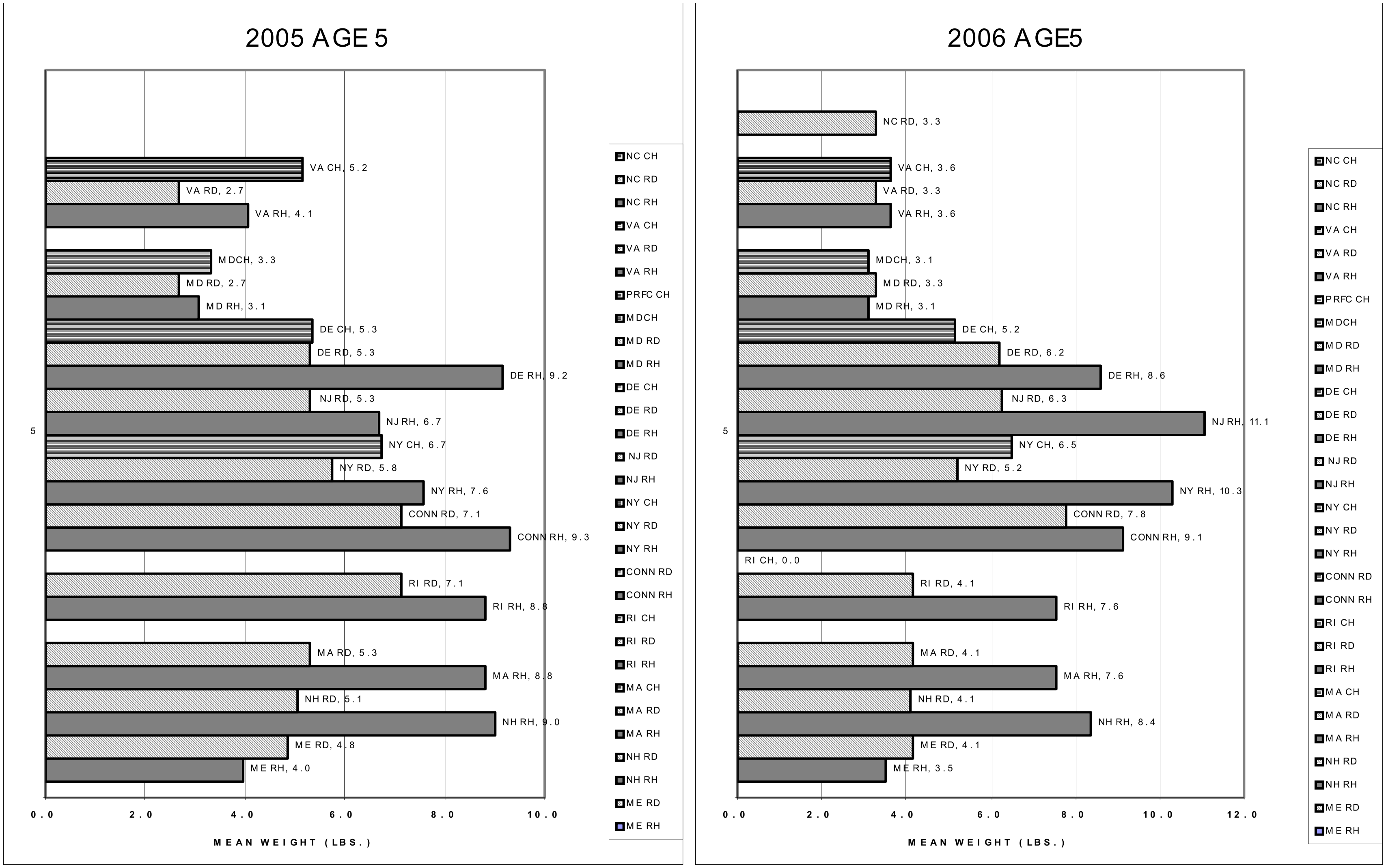



Figure 5D. 2005 and 2006 weight at age 5 by state and fishery.

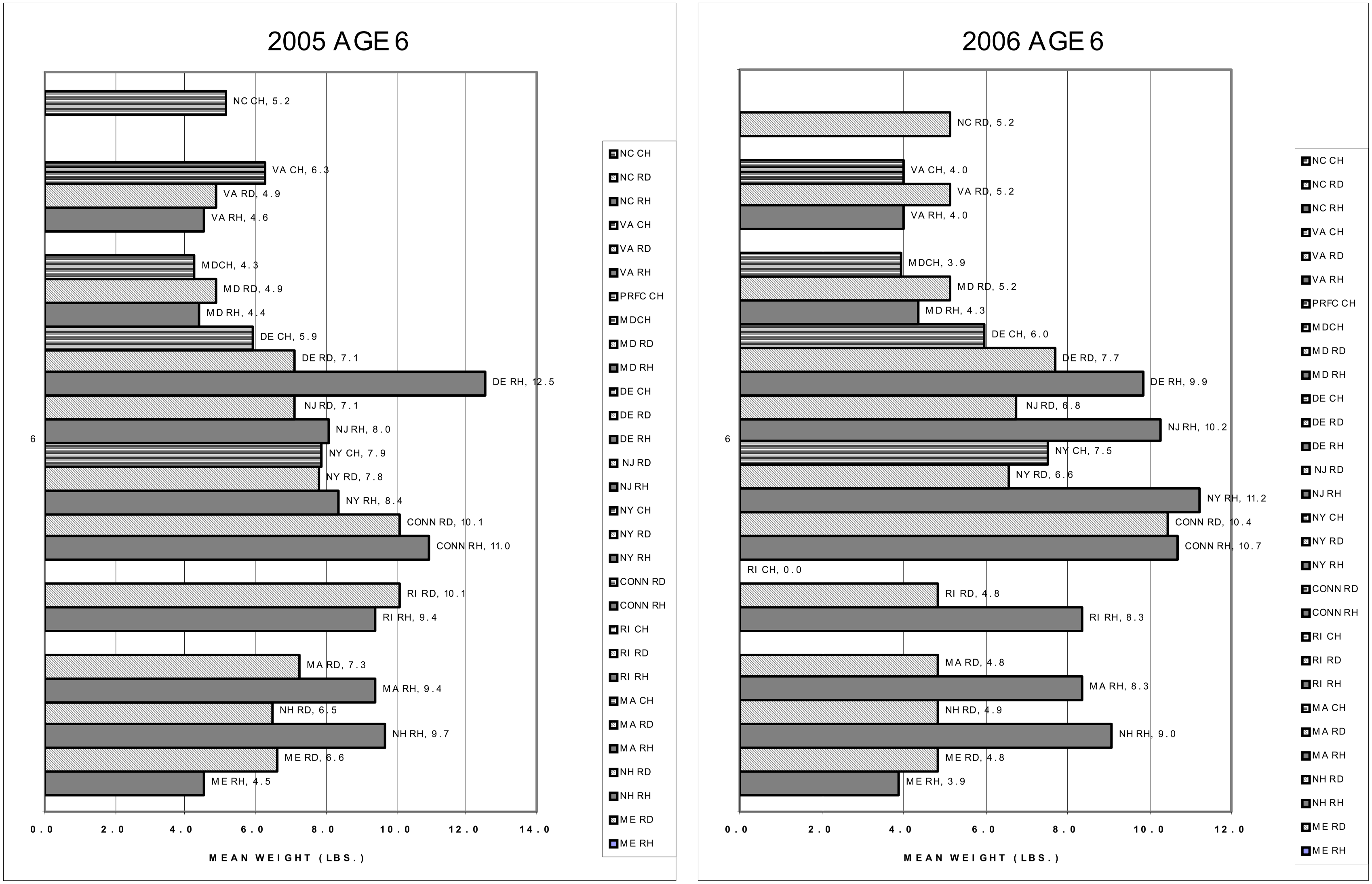



Figure 5E. 2005 and 2006 weight at age 6 by state and fishery.

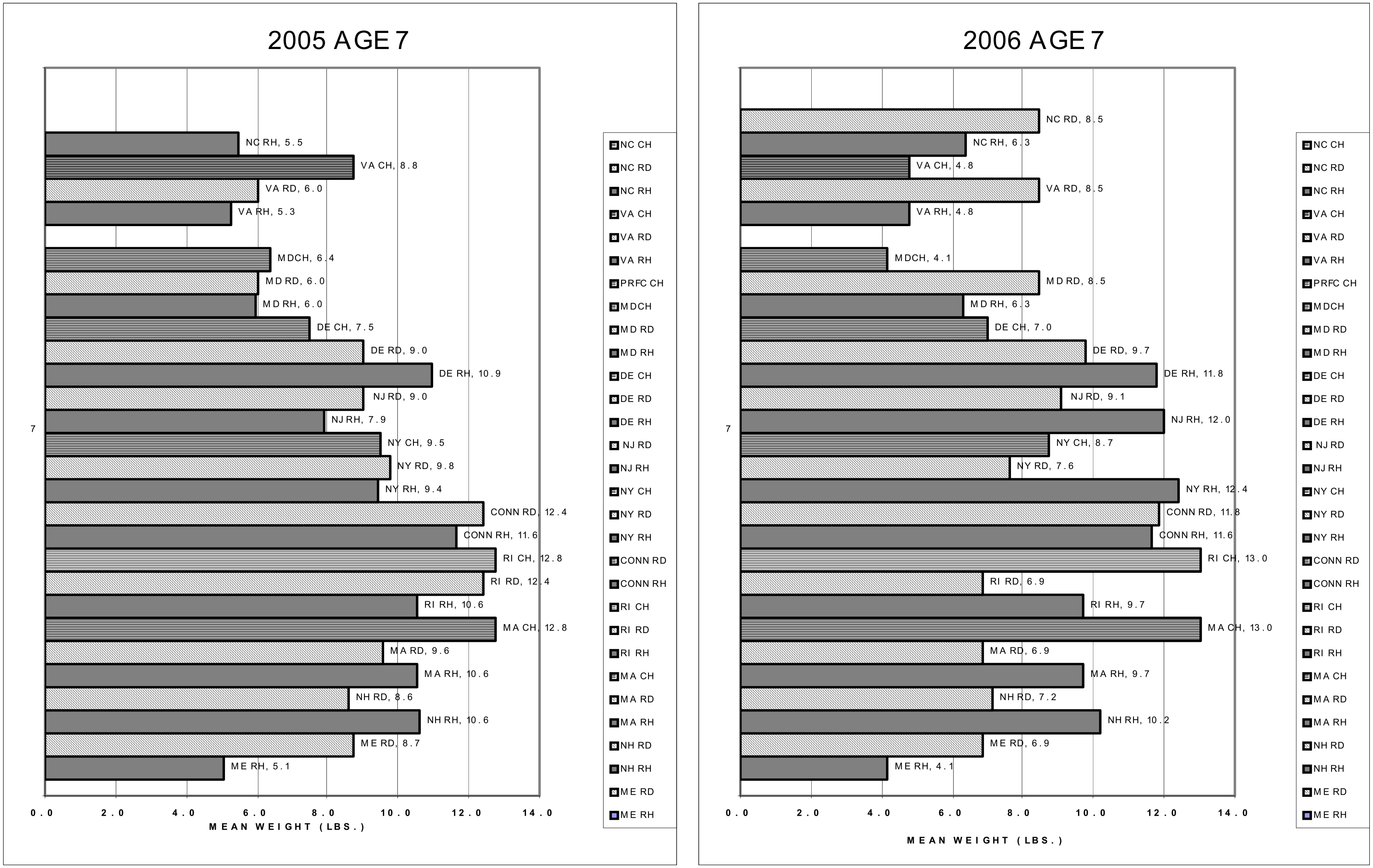



Figure 5F. 2005 and 2006 weight at age 7 by state and fishery.

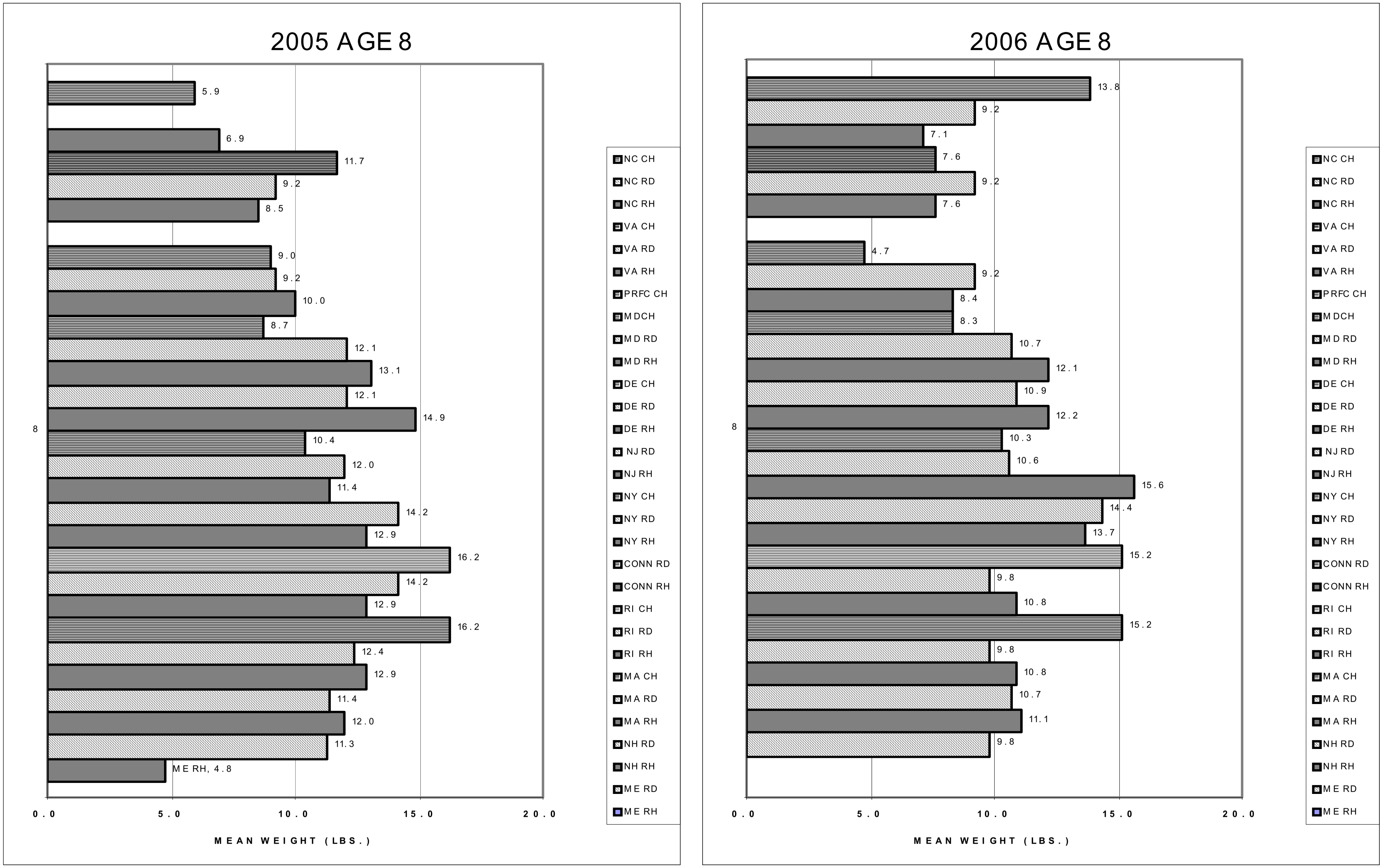



Figure 5G. 2005 and 2006 weight at age 8 by state and fishery.

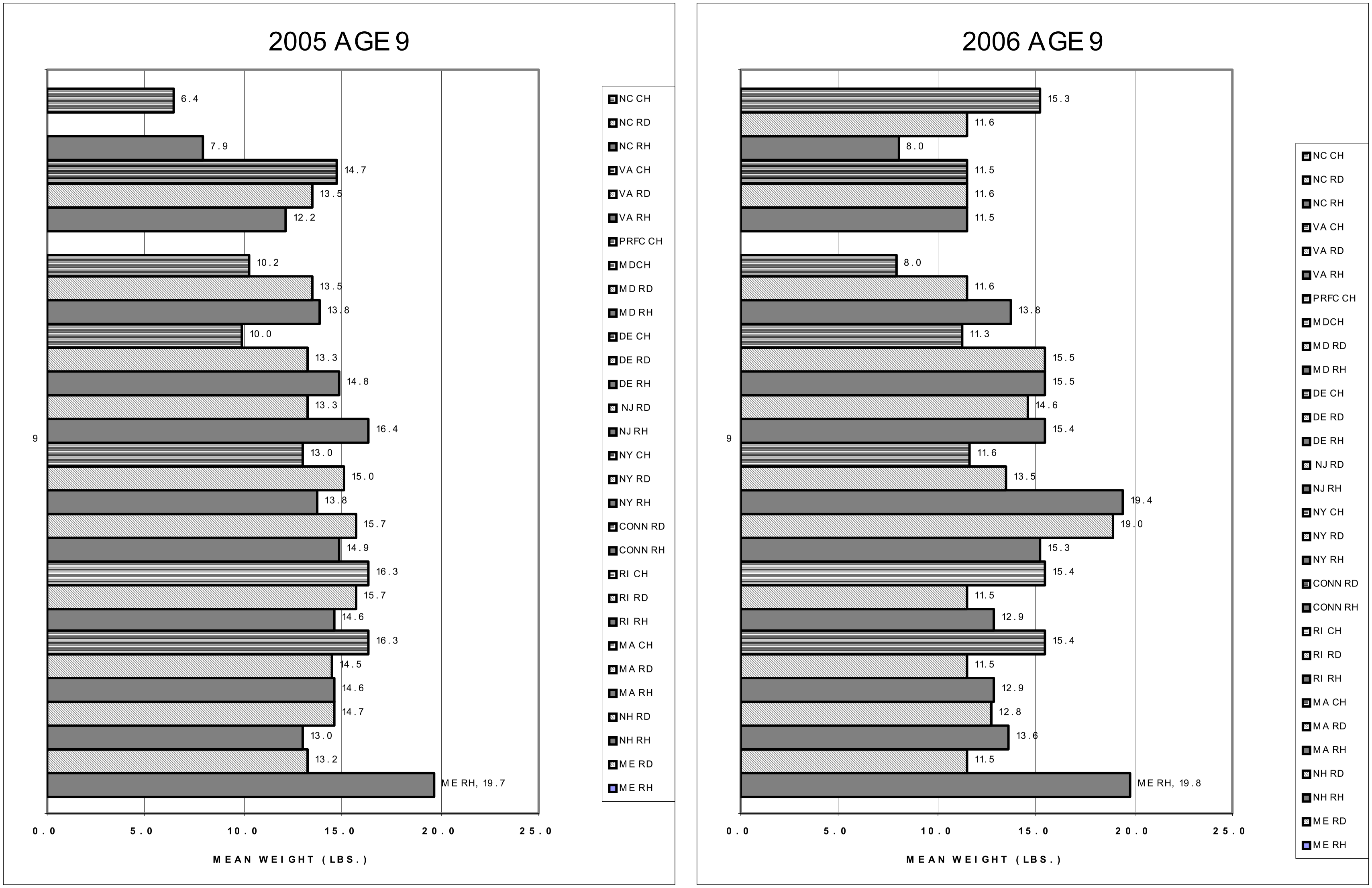



Figure 5H. 2005 and 2006 weight at age 9 by state and fishery.

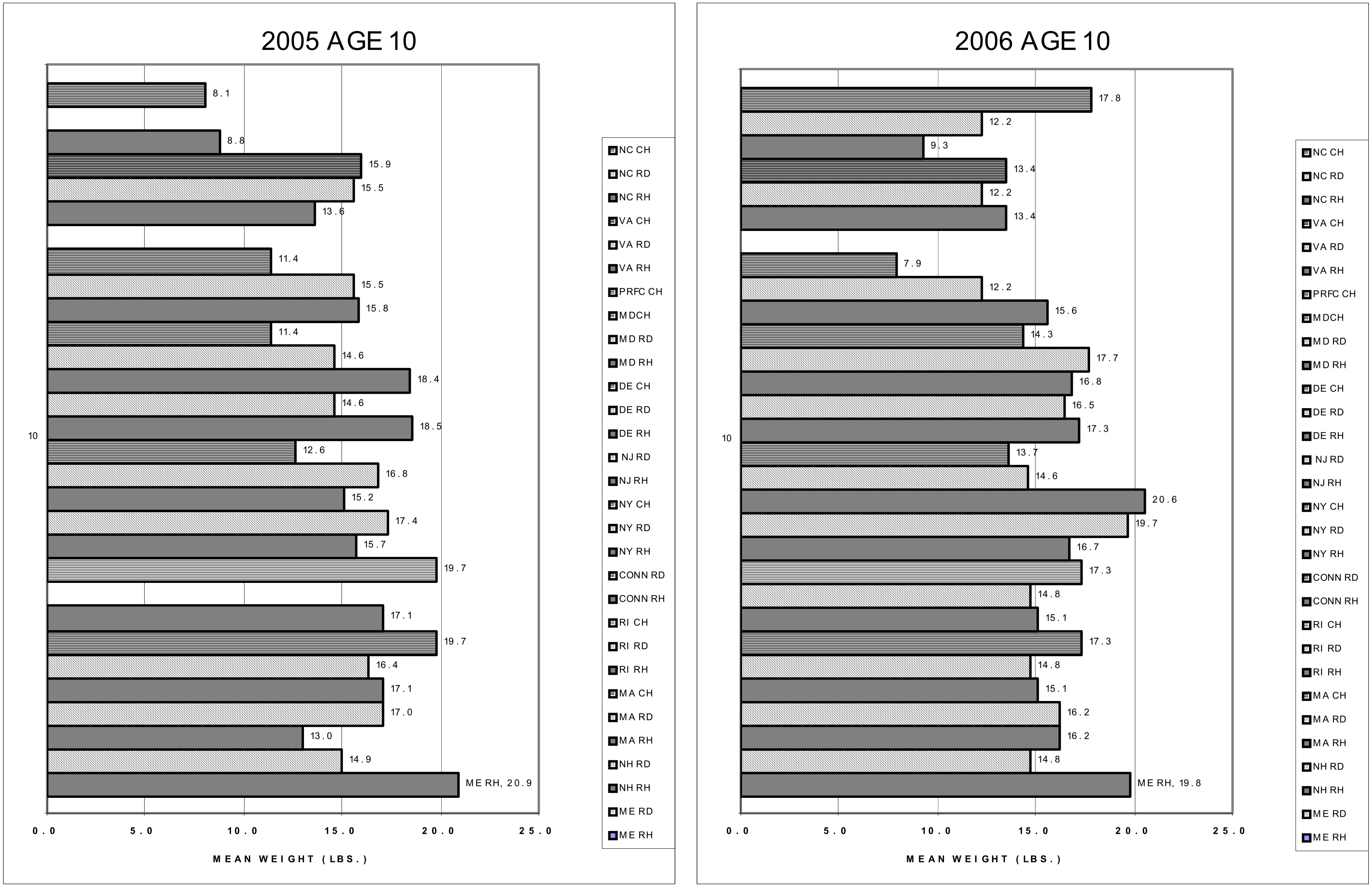



Figure 5I. 2005 and 2006 weight at age 10 by state and fishery.

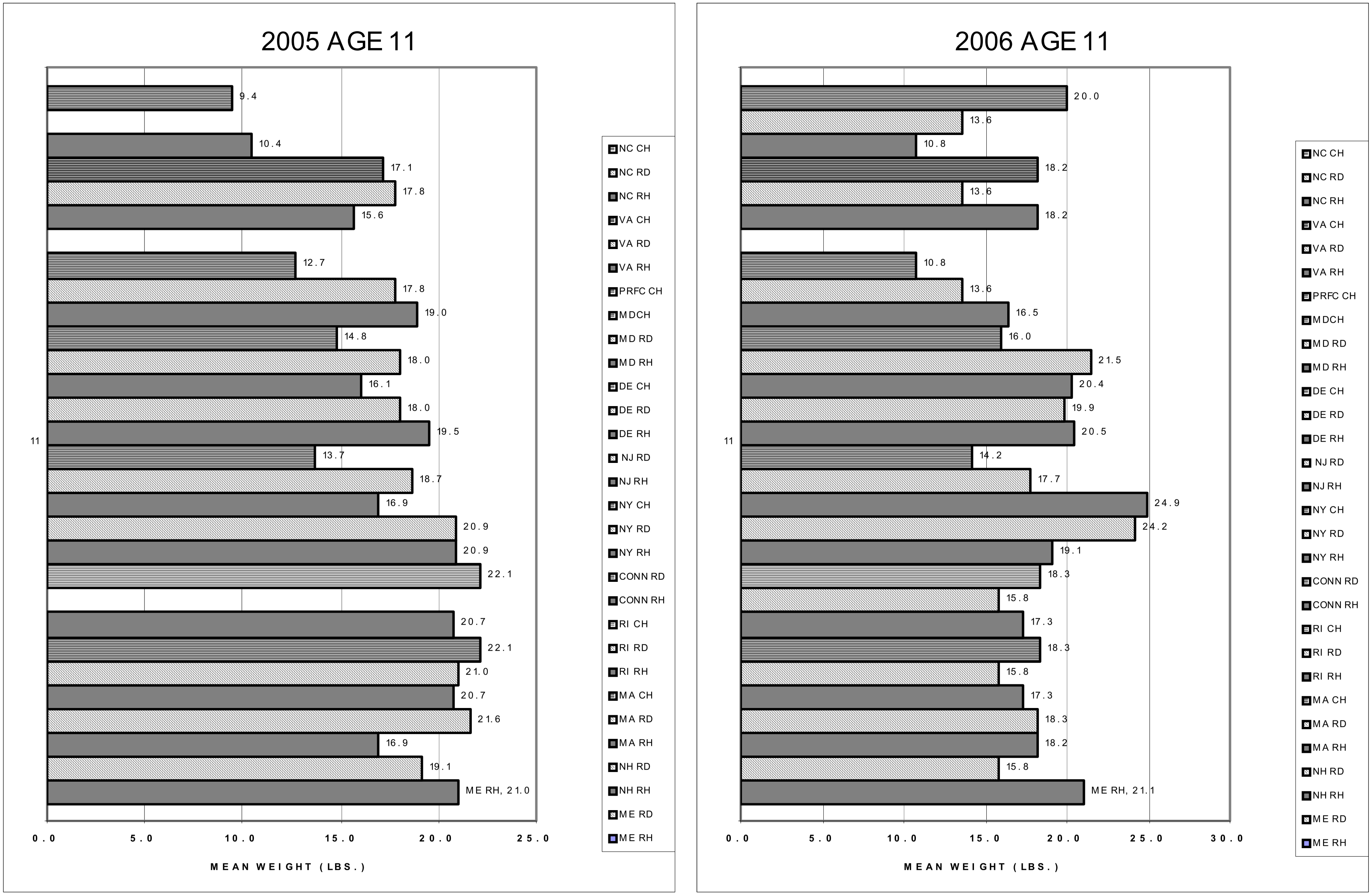
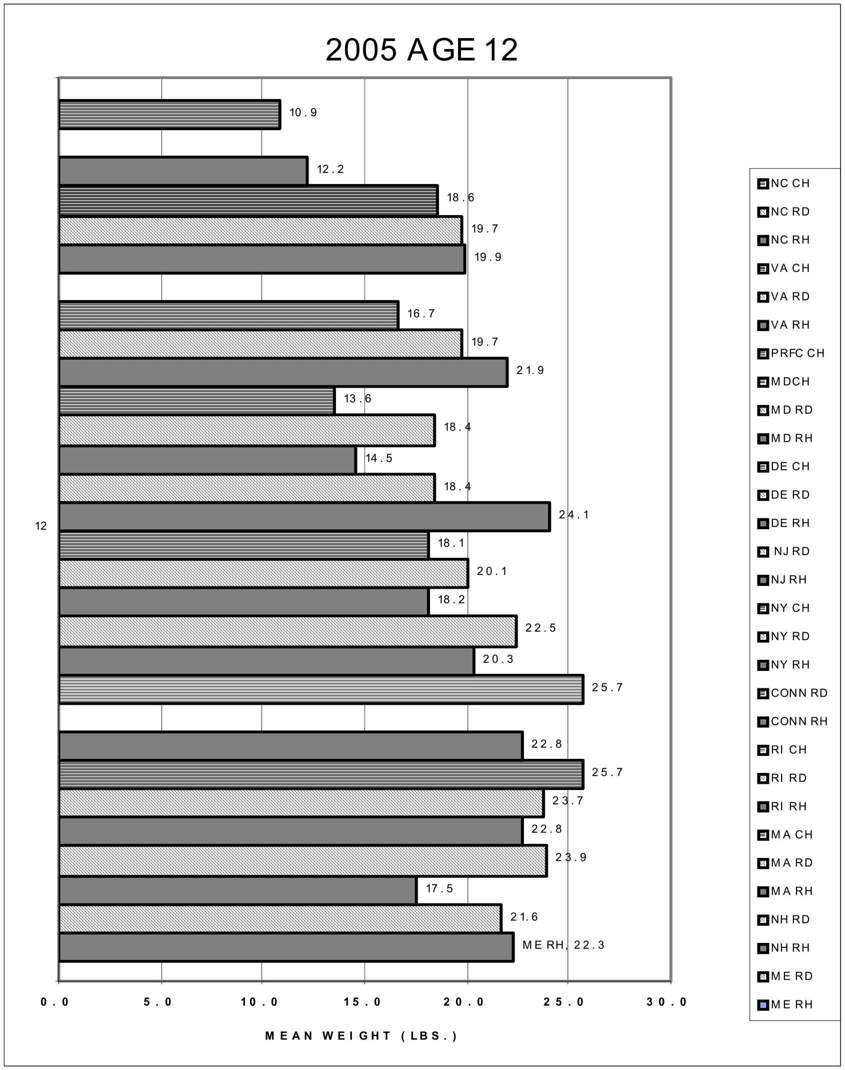



Figure 5J. 2005 and 2006 weight at age 11 by state and fishery.



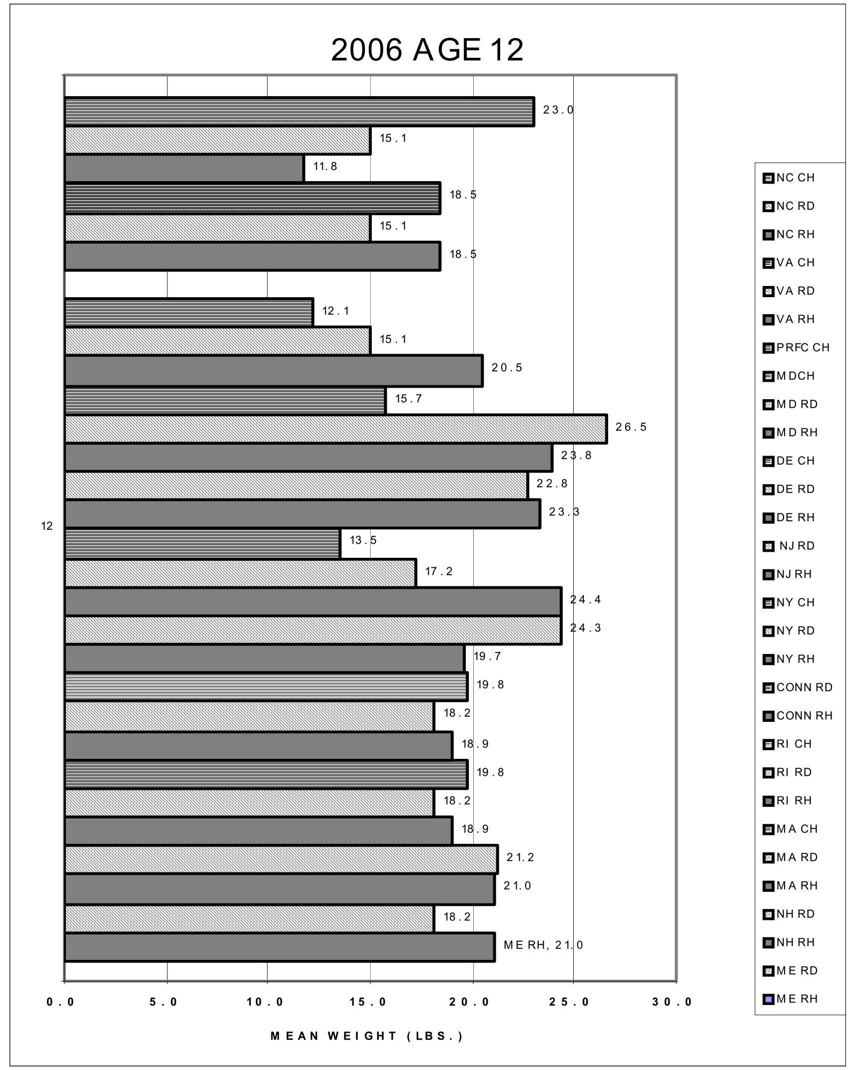




Figure 5K. 2005 and 2006 weight at age 12 by state and fishery.

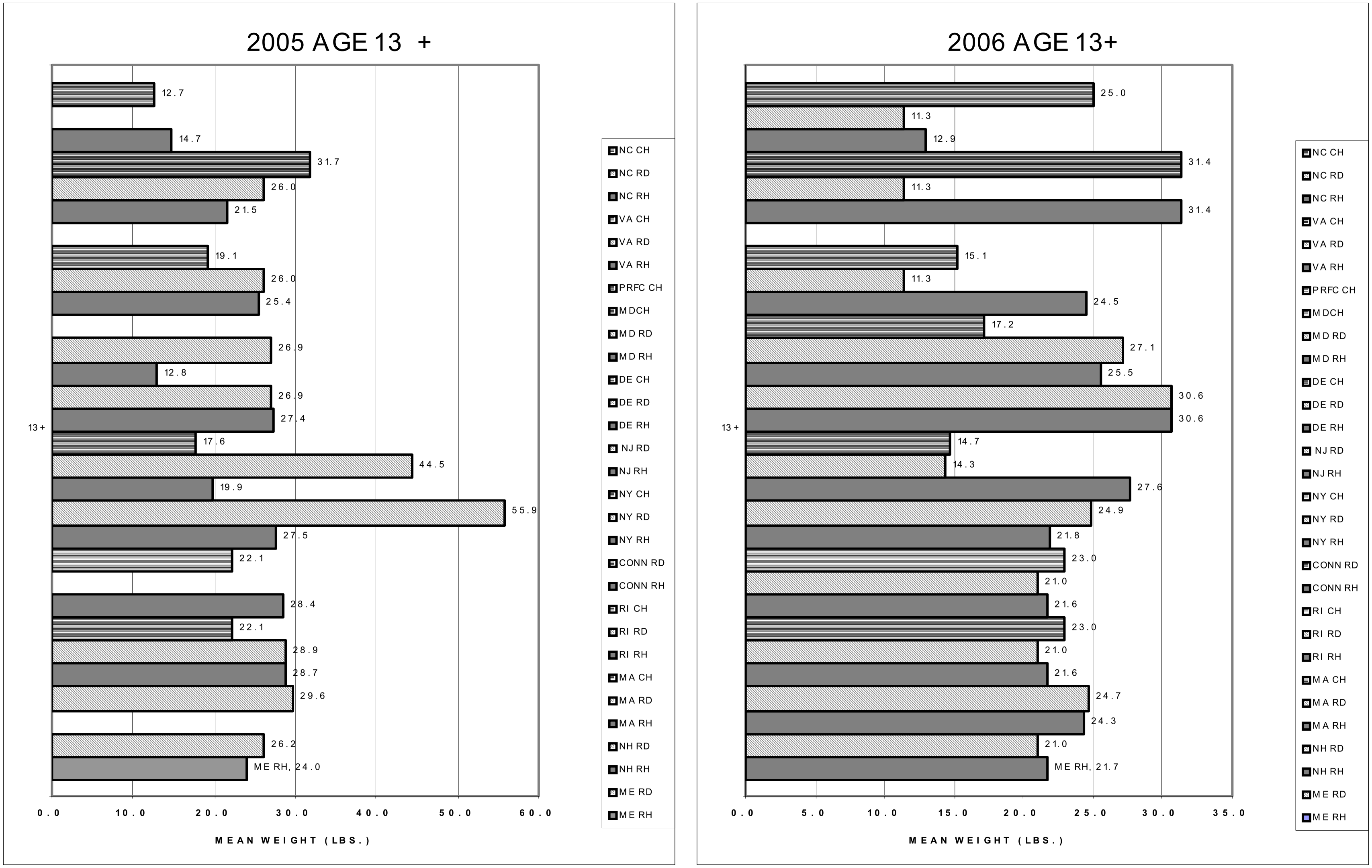



Figure 5L. 2005 and 2006 weight at ages 13+ by state and fishery.

## Appendix 5b Appendix

### Problems encountered in this analysis

Lisa Warner, a striped bass biologist with extensive experience with striped bass biology and working with age-length keys, performed these calculations. Several problems were found with the compliance report spreadsheets that required adjustment before accurate WAA calculations could be performed.

### General Comments

1. Apparent difference in weights at age between states, and Bay and coast needs to be further investigated. Weights range in younger ages – age 3 ranged from 1.4 lbs to 4.8 lbs., age 4 ranged from 1.9-10.2 lbs. and age 5 ranged from 3.1-11.1 lbs... Is it a biological difference – i.e. females on the coast grow really, really fast (age length keys contained 28" age 4 fish)? Growth curves from annual compliance reports indicate similar growth patterns between all states, therefore differences may stem from ageing error.

2. Data standardization – we need to utilize standard units for the compliance report. For example, data was in kg and pounds; total length and fork length.
Care needs to be taken to make sure there are no missing formulas or ages, especially when length groups have been collapsed. Maybe a template with locked cells would help.

3. The summary page in the compliance report needs to be re-evaluated. The way it is currently set up makes it extremely easy to make an error in the statewide summary due to sum product errors, making it unusable.( Example- ages 1-3 below) It might be easier to omit this step and save the weighting for the coastal WAA process and not have these state combined fisheries WAA. Unless there are mean weights in every cell of each age for each fishery, the weighted mean weight at age for the state will be incorrect

| Fishery: | Total # | Total wt | | Mean weight at age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Rec Harvest | 310441 | 4768272 | | - | - | - | - | 10.21 | 10.30 | 11.24 | 12.41 | 15.61 | 19.42 | 20.60 | 24.91 | 24.36 |
| Comm. | 73528 | 688446 | | - | - | - | 4.83 | 5.91 | 6.48 | 7.49 | 8.75 | 10.28 | 11.60 | 13.67 | 14.21 | 13.45 |
| Rec Discard | 142027 | 542461 | | - | 0.50 | 1.14 | 1.98 | 3.49 | 4.61 | 5.85 | 6.76 | 9.38 | 11.95 | 12.96 | 15.72 | 15.31 |
| TOTAL | 525996 | 5999179 | wt'd by wt | 0.00 | 0.05 | 0.10 | 0.73 | 9.11 | 9.34 | 10.33 | 11.48 | 14.44 | 17.84 | 19.12 | 22.85 | 22.29 |
| | | | wt'd by # | 0.00 | 0.14 | 0.31 | 1.21 | 7.79 | 8.23 | 9.26 | 10.37 | 13.18 | 16.31 | 17.57 | 20.93 | 20.39 |

## Appendix A6: VPA Indices Workshop

## Striped Bass VPA Indices Workshop – Baltimore, July 28 & 29, 2004

**List of Participants**

| NAME | AGENCY | ADDRESS |
|---|---|---|
| Linda Barker<br>Alexei Sharov | Maryland Department of Natural Resources | Tawes State Office Building<br>580 Taylor Avenue<br>Annapolis, MD 21401 |
| Tom Baum | New Jersey Department of Environmental Protection – Bureau of Marine Fisheries | P.O. Box 418<br>Port Republic, NJ 08241 |
| Peter Fricke | National Marine Fisheries Service – NOAA F/SF5 | 1315 East West Highway #3221<br>Silver Spring, MD 20910 |
| Megan Gamble<br>Patrick Kilduff | Atlantic States Marine Fisheries Commission | 1444 I Street, NW 6th Floor<br>Washington, DC 20005 |
| Bob Harris<br>John Hoenig<br>Phil Sadler | Virginia Institute of Marine Science | P.O. Box 1346<br>Gloucester Point, VA 23062-1346 |
| Des Kahn<br>Greg Murphy | Delaware Department of Natural Resources & Environmental Control, Fisheries | 254 Maine Street<br>P.O. Box 330<br>Little Creek, DE 19961 |
| Andy Kahnle | New York Department of Environmental Conservation – Bureau of Marine Fisheries | 21 South Putts Corner Road<br>New Paltz, NY 12561 |
| Laura Lee | Atlantic States Marine Fisheries Commission/ RI DEM | 3 fort Wetherill Road<br>Jamestown, RI 02835 |
| Gary Nelson | Massachusetts Division of Marine Fisheries | 30 Emerson Avenue<br>Gloucester, MA 01930 |
| Gary Shepherd | Northeast Fisheries Science Center | 166 Water Street<br>Woods Hole, MA 02543 |
| Clif Tipton | United State Fish & Wildlife Service | 177 Admiral Cochrane<br>Annapolis, MD 21401 |
| Vic Vecchio | New York Department of Environmental Conservation – Bureau of Marine Fisheries | 205 North Belle Mead Road<br>East Setauket, NY 11733 |

**Workshop Purposes**

- ***Impetus***: "An objective discrimination of which tuning indices to include or withhold from the model should be integrated in the next assessment." 36th SAW Advisory
- ***Goal***: Develop criteria for the inclusion/exclusion of current and future indices for aggregate or age-specific (≥age 2+) used in the striped bass virtual population model.
- ***Objectives***: Critically evaluate the survey design and precision of the index, and validate each index by comparing it to other area indices. If applicable, determine how the survey design should be modified to be more valuable.

**Background: The Role of Indices in the VPA**

Indices are used in the tuning process as a relative index of abundance (abundance at age). Some surveys provide an aggregrate index and others provide an age specific index. Some may be appropriate for aggregation due to precision; others are more precise as an age-specific index.

ADAPT uses the entire time series to determine relative abundance of the cohort in the terminal year. The longer the time series the more information the model has to produce an estimate. After the model produces the estimate, the stock assessment subcommittee evaluates the correlation of the index to the known abundance as the VPA has estimated it.

**Evaluation Criteria**

The Workshop participants began the discussion with the some suggested guidelines provided by Gary Nelson prior to the meeting. The guidelines are as follows:

a. Have a sampling design
b. Have an acceptable level of precision (if applicable)
c. Has it been validated? (i.e., is it correlated with indices of abundance of other life stages, etc.)

The sampling design should be appropriate to achieve the objectives of the survey. Additionally, the sampling design should produce a precise estimate. Further indication of a good index is the validation of the survey, comparing it to another index that shows similar trends. There should be a correlation between indices sampling similar portions of the coastwide stock. If an age class can be followed through time, it is also indicative of a good survey.

Taking Gary's suggestions a step further, John Hoenig developed a set of discussion points regarding the index. The following list includes the John points plus additional comments from other participants.

1) Correlation of an index with the VPA is not an appropriate evaluation criterion unless the index pertains to the whole stock. (If substocks in the North go up, as reflected in three indices, and substocks in the South go down, as reflected in one index, you'd get a biased picture if you eliminated the southern index just because it disagreed with the average (which is dominated by the North)).
2) Validity of sampling design can be used to determine inclusion. An index should not be evaluated based on an inappropriate variance. The appropriate variance can be determined based on the survey's sampling design. For example, if one site is sampled repeatedly (e.g., a pound net) the sample size is one (i.e., one site).

3) The number of sites and the number of days sampled may be useful criteria; a minimum number of fish sampled might be appropriate *in combination* with other factors (number of sites, etc.)

4) All indices should be treated "equally" to be "fair".
    a. If you evaluate one index you should evaluate all of them.
    b. You can kick out indices but there must be a way to reinstate them and there must be a way to introduce new indices that is "fair" in the sense of holding the index to the same standards as other indices.

5) If you want to make a change to the set of indices, it is important to do two assessments in parallel – one the old way and one the new way for several (e.g., 3) years. Otherwise, you can't distinguish between changes in stock perception due to methodology and changes due to stock dynamics.

6) If an index represents only a portion of the stock complex then it should receive a weight less than one. The stock assessment subcommittee has typically weighted the indices according to how well they fit the VPA, e.g., using iteratively reweighted least squares.

7) If an index is unique in representing a particular portion of the stock complex, then it may be desirable to retain the index even if it is not perfect.

8) The primary criterion thus would appear to be whether an index tracks weak and strong year classes well. An index can be considered poor if year-to-year changes in catchability obscure abundance trends.
    a. In looking for year effects, it is not appropriate to look at the residuals from the VPA unless the index being evaluated pertains to the whole stock.
    b. If one plots age-specific indices versus time, then synchronous peaks and valleys (all indices going up and down together) is problematic.

9) If age-specific indices are problematic, the program might still provide an aggregate index

10) Validation of one index against another index from the area provides support for the two indices.

Some of the indices used in the VPA assessment are age-specific and some are age-aggregated indices. It might be necessary to develop different criteria for the two kinds of indices. Before eliminating an age-specific index, the survey should be considered as an aggregated index. The problem with the index may be the ageing. It could still track the stock appropriately as an aggregate.

The Stock Assessment Subcommittee currently uses iterative reweighting for the surveys, meaning the survey weighting is based on how well the index fits the estimate produced by the VPA. The VPA is currently used to derive a single estimate of the fishing mortality on the coastal migratory stock. Ideally, there would be stock specific VPAs that are combined into one coastwide assessment.

If you believe that the particular index gives you reliable representation of the dynamics and abundance of the species in the particular area, then an estimate of variability of the index is needed. Also, you need to know if the same index is representative of the stock coastwide because we are looking for an ideal index of relative abundance that would be truly representative of the stock coastwide. An alternative to the VPA's iterative reweighting would be to assign weights to each index based on an assumed contribution to the overall coastwide migratory stock.

There is some concern about apriori weighting because an index may represent the local stock accurately. Also, as the stocks have rebuilt over time the contribution to the coastal stock has increased. There is uncertainty as to how this can be accounted for in the apriori weighting.

**Review of Sampling Program and Indices**

The participant agreed to many of the points in John Hoenig's list, but not all. The group decided to continue with a review of the sampling programs. The evaluation criteria would be further refined as the surveys are reviewed.

*Massachusetts – Commercial CPUE Index (Gary Nelson)*

The Massachusetts Commercial catch per unit effort index has been used in the VPA assessment since the Striped Bass Stock Assessment Subcommittee has used the VPA. The unit of effort has changed over the course of the time series. The method for calculating the CPUE has changed over time with different MA DMF personnel. The time series has been recalculated using a consistent methodology.

The index is really a measure of commercial harvest per effort or an estimate of the number of fish sold per trip. It uses the weight of the fish reported by the dealer and the average weight of the fish measured in the fish house. The average is then weighted by the total fish (whole fish) landed in each county. The total weight reported is an absolute (no variance), but the average weight is estimated so the variance is included. The number of trips comes from the required catch reports. Fishermen must submit catch reports to receive a license for the following year. Catch reports include information such as hours fished, number of fish sold and released by month, and dealer transactions. This survey is used as an age aggregated index and age-specific index.

The sampling design is not ideal for this index because the sampling is dependent on which fish house lands striped bass. Three counties in Massachusetts make up about 80% of the total landings. The information gathered in the fish house does not provide information about the trip, whether it was landed as a direct or indirect take. Most of the Massachusetts striped bass fishermen are weekend warriors.

There are a few problems with the survey design. Permits are issued to the boat, not individuals. Therefore, an average trip per boat is estimated not per fishermen. The number of fishermen is not collected. In Massachusetts, this fishery is hook and line only and has a trip limit of 40 fish per day. There could be five guys on a boat for one hour catching 40 fish or one guy out there all day catching 40 fish.

The catch per effort per trip is not well defined because the information is not collected. There are over 4,300 people permitted but Massachusetts only receives 100-200 voluntary logs with trip dates, numbers caught, hours fished per trip. The average hours fished is estimate from the logbooks. Average hours fished contributes to variability in the survey. There can be hours fished with zero catch. Even though commercial fishermen are required to submit catch reports, not all submit the report despite the penalty of losing the permit in the next year. So Gary has to impute the fish caught using the information he does have. Additional information may be available through the VTR data for commercial fishermen holding a federal permit.

This survey has a multiple stage sampling design, meaning it needs a randomly sample a fish house and then randomly sample the fish. The variance estimate is conditional on assumption of random sample, but sample may not be representative. The fish that end up in the fish houses are random, but the selection of which fish house is sampled is not random. Therefore, we do not know if the sample is representative of all the catch because it is not random. Bootstrapping does not confer validity on an index.

The group discussed the difficulty of setting one standard for all the surveys – the protocol for variation estimation will depend on the survey design, therefore will not be consistent across all surveys. The index should not be thrown out because it's not perfect, especially if there is not another index to replace it and its representative of the area.

The number of trips is declining because the quota is filling more quickly. There is a jump in the CPUE from 1994-1995 because there was a change in the minimum size and the commercial quota also increased. The group is not confident that the CPUE represents the population, particularly the fishery has capped out the quota since 2000. Also, in a representative catch, the cohorts can be followed through the samples. The 1993 yearclass was strong and it cannot be followed through the MA CPUE. One suggestion was to apply a length frequency to the ageing samples for a more representative sample.

For an age-specific index, Massachusetts could randomly pick a fish box to collect samples. The proportion of ages in a sample could be applied to the aggregate index. Massachusetts had to cut down on the sizes of age samples from the fish house due to personnel cut backs.

*Connecticut Recreational CPUE and Trawl Survey*

Connecticut submitted information regarding the trawl survey, but did not provide information on the recreational catch per unit effort. Additionally, there was no representative from Connecticut in attendance at the Workshop. The Connecticut surveys were not reviewed at this time.

*New York Long Island Ocean Haul Seine Survey (Vic Vecchio)*

Originally, the survey had 10 sampling locations that consisted of inshore sandy sites. The locations were randomly sampled from October to November. After the commercial striped bass fishery reopened, commercial trawls were prohibited from state waters. Some localities prohibit NY DEC from accessing traditional sampling sites. In New York, fishermen are not allowed to use ocean haul seine survey to commercially catch striped bass, but can use to fish for other species. The estimates derived from 10 sampling locations were compared to the results with fewer sampling locations. There was no difference in the ages in the catch. Additionally, funding has been reduced impacting the sampling dates and actual survey catch. The dates of the older survey have been standardized.

In reviewing the time series, it is interesting to note that the catch jumped in 1996-1998 due to the 1993 and 1996 yearclasses. Also, in some cases the coefficient of variance exceeded the catch. Bootstrapping would be appropriate for the New York data.

Age samples are taken from every fish measured in the survey. New York is able to produce an estimate of geometric mean catch at age for each survey year. The CV is then calculated for the catch at age and an averaged from 1997-2003 is produced. The survey is not very good at catching the larger fish, so the sample sizes for the older fish are pretty small.

The survey samples a mixed stock. To evaluate the survey, the ocean haul seine survey was correlated to the YOY index. Out of 13 age groups, 11 had positive correlation, but only 6 had a significant correlation.

*New Jersey Trawl Survey (Tom Baum)*

The New Jersey trawl survey has a stratified random sampling design. The survey occurs in April and October. Decreases in funding have led to reductions in annual sampling effort, from 60 to 45 seine hauls. New Jersey's survey was not designed to sample striped bass survey; it was originally for sampling groundfish. Striped bass are tagged when feasible.

In a typical year, there are 30-40 tows in 18 strata, which comes out to about 2 tows per site. The CVs are pretty low in the later half of the time series. The high CVs in the latter half of the time series could be attributed to low sample sizes at each stratum. The standard error should be checked to determine if it was calculated for a stratified random design.

The survey is used as an age aggregated index, aggregating ages from 2-13. April and October are used as separate age aggregated indices because the length frequencies differ significantly, representing different stock composition. April survey is more consistent and therefore probably the better candidate for an age-specific index. New Jersey has an age-length key for every year, so most of the information is available for switching over to an age-specific index. If the survey measures all of the fish caught, then it could be used as an age-aggregated index. It is possible to get age specific data, but New Jersey is not likely to produce the data.

To reduce the variance, some of the strata should be thrown out because no striped bass were caught in that location. The strata should only be removed from the index if there were no striped bass throughout the time series. The variance can be a problem with fixed station trawl surveys because there is no random element to the survey.

*Delaware Trawl Survey (Des Kahn)*

The Delaware trawl survey began during the 1960's, but the exact start date is not well documented. The survey collects weight rather than numbers of fish (kilograms per tow of striped bass). The time series is disjointed because a different vessel was used in the first two segments of the time series. In 2002, the survey began using a new custom-built stern rig trawler. Comparative tows were conducted to get a handle on the catchability of the two vessels.

The trawl survey uses a fixed sampling scheme. It was selected due to the lack of towable bottom in Delaware Bay. The index was conducted the whole year. Due to the number of zero tows, the data was jackknifed – used for situations were the distribution assumptions may not be true. Jackknife does not deal with the lack of distribution of the data; it does assume that the sample is representative of the population from which it is drawn.

The sample size is the number of months that were sampled. In some years, the trawl survey did not operate in March. In each month, the fixed sites were sample nine times.

The trawl survey is used as an aggregate index in the VPA (age 2-7). There is age data available from 1998 forward. To validate the index, it should be compared to another mixed stock index. The lagged juvenile index is often used to confirm trends.

*Delaware Spawning Stock Survey (Greg Murphy)*

The Delaware River spawning stock survey collects age, size, sex, and abundance estimates for striped bass. The survey began in 1991 experimenting with three different collection methods and has continued using electrofishing since 1994. The survey divided the

Delaware River into two zones based on river access. There are twelve Delaware stations and fourteen Pennsylvania stations. Over time, some of the stations have been lost due to development.

The stations cannot be considered random, but the observations at each station are random. The survey has a multistage lattice design. The strata are sampled independently of another (i.e. sampling does not affect other sites). The lattice survey design imposes a structure to control the number of times each area sampled.

Another challenge that confronts the survey has been the moving salt line, which can restrict the sample areas upstream where electrofishing is effective. Reviewing its correlation to other life stages, such as a juvenile survey, could validate this survey.

*Maryland Spawning Stock Survey (Linda Barker)*

The objective of the Maryland's spring gillnet survey is to characterize the Chesapeake Bay portion of the spawning stock biomass and provide a relative abundance at age. The survey area at one time covered the Chesapeake Bay, Choptank River and Potomac River, but the Choptank River has since been dropped from the survey. A stratified random design is used to sample the spawning areas.

The group discussed the survey's sampling design to determine if it was truly randomly stratified. Because Maryland DNR samples the same site twice in some days, the design can be referred to as two-stage cluster sampling. It is important to correctly identify the sampling design to properly calculate the variance.

For each sample, all of the striped bass are measured, all females are aged, but only males greater than 700 mm are aged and smaller males are subsampled. Since 2000, approximately 500 fish are aged per year. The group recommended developing area and sex specific age length keys. MD DNR should also look into applying selectivity coefficients.

The survey has revealed that it does not accurately capture the spawning stock biomass as it collects samples of fish ages 2-8. There is a very low variance for ages less than 8 years old and higher variable estimates for ages greater than 8 years old. The number of age 8+ appearing in the survey has increased since the moratorium. The fish caught in the survey are mostly males (age 2-8) and the ages 10 and greater are mostly females. The data is representative of the behavior of the fish, capturing mostly males. The CPUE provides a decent relative abundance at age, but it is not doing a good job of characterizing the spawning stock survey.

*Virginia Pound Net Survey (Phil Sadler)*

Since 1991, Virginia Marine Institute of Science has conducted the Viginia pound net survey. The pound net survey takes place on the striped bass spawning grounds in the Rappahannock River between river miles 44-47. VIMS has the option of sampling up to four commercial nets. The upper and lower nets are used for this survey and the middle nets are used for tagging. VIMS alternates sampling between the upper and lower nets. The sampling occurs from March 30 to May 3, when the females are on the spawning ground. The pound nets are checked twice a week, but are fishing constantly. When the samples are collected, the fish are sexed and measured, scales are taken from every fish, and a subsample of otoliths.

The sex ratio in the catch tends to be two males to every female. The females captured in the survey are generally ages 4 and older and males are age 3 and older. There appears to be no bias in net catchability.

There are several periods where no fish were caught. By averaging the CPUE data, the estimate is low. To eliminate the zero effect, VIMS could graph CPUE by date and determine the area under the curve.

The Workshop participants had a lengthy discussion on the Virginia pound net survey because it is an example of a survey that was removed in recent stock assessment due to poor performance in the VPA. The Virginia pound net survey provides an estimate of catch in the commercial fishery. If a variance is estimated, it is not an estimate of the striped bass abundance rather it is the variance for the commercial catch. The workshop participants suggested several ways to evaluate the survey. Local juvenile surveys can be used for validation. A longitudinal catch curve can also be applied to investigate year effects, specifically to detect downward trends. The catch curves explain how often the striped bass are seen and if the patterns are explainable. VIMS should also examine the temporal window and the spatial window to evaluate the survey design.

*NEFSC Trawl Survey (Gary Shepherd)*

The NEFSC trawl survey uses a stratified random design and assumes that time is irrelevant. The index samples fish from Nova Scotia to North Carolina. It is an eight-week cruise, completed in four two-week legs. Fishing occurs 24 hours per day. The survey did not really start to encounter striped bass until 1991. The survey has shown a general upward trend since 1990. The catch distribution tends to very from year to year and the sizes encountered are also variable.

The NEFSC trawl survey data would be a good candidate for an age-specific index. An age-length key from the New Jersey March-April gillnet survey could be applied to the NEFSC samples. The NEFSC survey is important because it is the only survey to cover the range of the coastal migratory stock. For a good index, the NEFSC would need 400 ageing samples. The fish are encountered in different locations in different years. So the appropriate key needs to applied to the samples. For the fish encountered in the southern range, an age-length key could be derived from the North Carolina Cooperative Cruise.

**VPA Output Compared to the Indices**

The group reviewed the ADAPT VPA output from last year's assessment to each of the indices reviewed during the workshop. The VPA predicted the indices very well when there weren't many striped bass. As the stock increased, the variance went up with the mean. If one of the criteria for inclusion was the index must follow the same trend as the VPA, then none of the indices would be used. The coastal indices should carry the same signal as the VPA output because they characterize the coastal migratory stock. Some of the indices may not align with the VPA because they were down weighted.

Several of the indices show spikes. The spikes should be compared to other indices to determine if there is correlation. The coastal indices should be reviewed to determine if there are spikes that correlate with one another or the VPA output. To determine the validation of the indices, it would be helpful to know how the VPA weighs the indices.

The stock assessment subcommittee has typically used the bootstrap estimates to determine the variation in the surveys. All of the surveys are entered into the VPA and the bootstrap estimates determine if it is appropriate to include each index.

On the other hand, the VPA produces an estimate of the overall stock complex abundance. To use the VPA to evaluate the indices may mean eliminating an index that does not track the overall stock complex, but tracks local trends accurately. An index should not be removed without a legitimate reason for removing the index. The effect of each index on the VPA should be analyzed.

**General Overview of Survey Issues**

The sampling design of each survey was a common theme for discussion during the review of the indices. There tends to be two separate types of programs. The first group includes the NEFSC trawl survey and the Maryland Spawning Stock Survey. These two surveys are randomized over space. The second group includes other programs such as MA CPUE, which is a census of commercial catch rates, but fishermen are not fishing over random fish. The New York ocean haul seine survey is not randomized over space. The Virginia pound net survey uses two nets over fixed locations. Delaware is randomized, but only 30% can be sampled.

There is confidence that the Maryland spawning stock survey and the NEFSC trawl survey are catching a representative sample of the population because both surveys are randomized over space. Both surveys can get a valid variance. The sampling design of the other surveys may not be randomized; therefore it cannot be assumed that the surveys are a good representation of the stock. Without randomization, the estimate of variance for each survey may not be appropriate.

The Virginia pound provides a good estimate of the fishermen's catch rate, but the variance is not very useful. The NEFSC survey is not designed to catch striped bass and does catch a lot of striped bass. The variance is only useful for qualitative purposes. Variance estimates are for the survey index.

In addition to variance, age information is collected through the indices, despite some of the ageing error issues. Another important measure for the indices is the ability to track cohorts over time. There needs to be confidence that the survey is tracking cohort abundance in a logical trend. Catchability can influence the ability of a survey to track a cohort over time. If the design of the survey changes, the catchability can change.

A survey could reflect logical trends for 8 of the 10 years, straying from the trend in the remaining two years. Those two years could be eliminated if there was adequate evidence that is was due to abnormal climatic conditions influencing fish abundance.

To verify a cohort trend, the survey can be compared to a local young of the year index. States would need to be careful about using the index to validate the juvenile survey and vice versa. In some areas, a young of the year index may not be available for comparison. In these situations, a catch curve could be applied to the cohort. Longitudinal catch curves could be used, not to estimate mortality rates, but to see if there is trend that is useful.

Ideally, the stock assessment will include the same indices as in previous years and then a separate run is made to remove more questionable indices. There should be some guidelines for removing an index from the model run or at the very least an explanation provided in the assessment report. To evaluate an index for inclusion, one could plot the indices by year for each cohort. If one of the indices has a dramatically different trend, the index is not tracking things well. It is important to remember that an index can be valid for a local area, but not for the stock complex. It may track a different trend or a local stock. For example, Chesapeake Bay recruitment correlates well with the Delaware River recruitment, but not the Hudson River.

Striped bass is a stock complex measured by local indices, but the stock complex abundance is supposed to be annually evaluated.

**Recommendations for criteria to evaluate the VPA indices**

The Workshop participants developed a list of evaluation steps that should be applied to each index. The state agencies should use the evaluation list for each state survey. Each program should be analyzed to determine if the survey is conducted at the appropriate time of year, i.e. bracketing the correct spawning period. Similarly, the survey design should be reviewed by the state to determine if the sampling area is correct. If the state determines there is a lot of noise in the data, the state should attempt to refine the data. For instance, if some of the stations catch striped bass consistently and others do not, can something be done to refine these data? The states should identify if the indices are sex-specific indices or age-specific due to survey design. Because a self-evaluation by each state could be subjective, the Technical Committee should evaluate the state's program evaluation and make a recommendation to the Striped Bass Stock Assessment Subcommittee.

1. Evaluate design and best method to evaluate uncertainty of index.
2. Assess the index and/or improve the index to get the best signal.
3. Validate the index before use in the VPA.
    a. Sensitivity of the VPA results to the influence each index.
    b. Validate an index to a JAI, where possible.
    c. Longitudinal catch curves, to determine the cohort trends.
    d. Plots of age specific index v. year to see if cohorts are moving in a specific direction.
4. Evaluation by the agency conducting the survey
    a. Rank (weight) index
    b. Criticisms/Supporting Evidence
5. Evaluate by the Striped Bass Technical Committee
    a. Evaluate index based on survey design, precision, and ability to track cohorts or portion of the stock targeted.
    b. Provide recommendations to the Striped Bass Stock Assessment Subcommittee on which indices should be used in the assessment.

The Workshop participants developed a matrix in Excel that includes the important components for evaluating each index (sampling design, time of year, tracking stock or catch, etc.). Also included in the matrix are recommendations to improve and evaluate the survey.

**PURPOSE: TO ESTIMATE FINAL YEAR ABUNDANCE**

| SURVEY | SINCE | SAMPLING DESIGN | TIME OF YEAR | STOCK OR CATCH | WHAT STOCK? | AGES | VARIANCE? |
|---|---|---|---|---|---|---|---|
| NMFS (TOTAL, REC HARVEST) | | SURVEY | ALL | CATCH | MIXED | | YES?? |
| NEFSC CRUISE | | STRAT RANDOM | SPRING/FALL | STOCK | MIXED | | YES |
| MASS COMM CATCH | | NONE | ALL | CATCH/HARVEST | MIXED | | |
| RI - FLOATING TRAPS? | | | | | | | |
| CONN TRAWL SURVEY | | | | STOCK | MIXED | | |
| CONN REC CATCH | | | | CATCH | MIXED | | |
| NY HAUL SEINE | | FIXED STATION | FALL | STOCK | MIXED | | |
| NY HUDSON SPAWN SURVEY | | STRAT RANDOM | | STOCK | HUDSON | 5-10 | YES |
| PA RIVER SURVEY | | | | | | | |
| NJ TRAWL SURVEY | | STRAT RANDOM | SPRING | STOCK | MIXED | | YES? |
| NJ REC CATCH | | NONE | ALL | CATCH | MIXED | | NO |
| DEL RIVER SURVEY | | CLUSTER?? | SPRING | STOCK | DEL | | |
| DEL TRAWL SURVEY | | FIXED STATION | ALL | STOCK | MIXED | | |
| MD JI | | FIXED STATIONS | SUMMER | STOCK | CBAY | | |
| MD SPRING GILLNET SURVEY | 1985 | STRAT RANDOM | SPRING | STOCK | CBAY | | |
| VA POUND NETS | 1991 | FIXED STATIONS | | CATCH | RAPP | 3+ | YES/NO |

| SURVEY | EVALUATION/CRITERIA | RECOMMENDATIONS |
|---|---|---|
| NMFS (TOTAL, REC HARVEST) | | Define what an index would be using total catch and effort |
| NEFSC CRUISE | | Age fish samples from trawls; review strata choices |
| MASS COMM CATCH | | Standardize minimum length numbers; compare lengths of subsamples to length of all; examine applying age-length keys;develop index with total catch; adjust index for covariates; examine whether change in week-end warrior composition |
| RI - FLOATING TRAPS? | | see if data is available for development of an index |
| CONN TRAWL SURVEY | | segregate into age-specific indices; use age-length key instead of VB equation |
| CONN REC CATCH | | Describe and evaluate |
| NY HAUL SEINE | AGAINST TOTAL JI? NY JI? | resestimate precision using bootstrap; compare index at age to Jis individually |
| NY HUDSON SPAWN SURVEY | | Describe and evaluate; generate age-specific indices with appropriate variance |
| PA RIVER SURVEY | | Describe and evaluate |
| NJ TRAWL SURVEY | | Examine strata choices; generate age-specific indices using April data |
| NJ REC CATCH | | determine if development of an index is possible |
| DEL RIVER SURVEY | | investigate area under curve method for possible spatial distribution issues; examine temporal disitribution within strata; compare upper river index to PA survey |
| DEL TRAWL SURVEY | | change biomass index to numbers; generate age-specific indices; compare indices to VPA for age 1 |
| MD JI | AGAINST LAGGED CATCH | |
| MD SPRING GILLNET SURVEY | | examine first vs second set;review impact of sex-specific catchabilities |
| VA POUND NETS | AGAINST JI, LONG CATCH CURVES, YEAR EFFECTS, CATCH VS. TEMPORAL WINDOW | AGAINST JI, LONG CATCH CURVES, YEAR EFFECTS, CATCH VS. TEMPORAL WINDOW; examine flow regimes; compare index to MDs |

Summary of Responses to Workshop Recommendation

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| NEFSC | Age-specific: ages 3-11 | Yes | Age fish samples in trawl;review strata choices | No | No PSEs provided for age-specific indices. Untransformed, aggregate index PSEs (91-04): range= 0.13-0.58, mean=0.29 | No |
| MA Comm Catch | Aggregate and age-specific commercial Index | Yes | Standardize min. length numbers; compare lengths of subsamples to length of all; examine applying age-length keys; develop index with total catch; adjust covariate; examine week-end warrior composition | Yes A total catch index was developed using covariates, making most recommendations moot. | Old index age 7-12 average PSE: 7-0.51,8-0.23,9-0.13, 10-0.13,11-0.18,12-0.23. New Index age7-12 PSE (for 2000): 7- 0.05, 8-0.08, 9-0.10,10-0.11,11-0.15,12-0.22 | Yes, correlation of aggregate indices to other aggregate indices (MRFSS, NYOHS, NJ, CT) but no significant correlations of new age indices to other programs; only 1996 YC could be tracked over only three years; influence of age-specific and aggregate index on VPA results increased. |
| RI – Floating Traps | ? | No | See if data is available for development of an index | No | None | No |
| CT Trawl Survey | Aggregate Index (spring) | Yes | Segregate into age-specific indices using age-length keys instead of VB equation | No | Ln transformed, aggregate index PSEs: range=0.1-0.5, mean=0.20 | No |

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| CT Rec Catch | Age-specific: ages 2-11 | Yes | Describe and evaluate | No | None | No |
| NY Ocean Haul Seine | Age-specific Index: ages: 3-13+ | Yes | Re-estimate precision using bootstrap; compare index at age to juvenile indices individually | Yes | Aggregate PSEs:mean=0.08; Age-specific PSEs: 2-0.17,3-0.11,4-0.13,5-0.16,6-0.22,7-0.23,8-0.39,9-0.51 | Yes, strong correlations between CB juvenile index and indices for ages 2-5; not so for older ages. |
| NY Hudson Spawn Survey | ? | No | Describe and evaluate; generate age-specific indices | No, but survey would be inappropriate | None | No |
| PA River Survey | Electrofishing survey | No | Describe and evaluate | No | None | No |
| NJ Trawl Survey | Aggregate Index | Yes | Examine strata choices; generate age-specific indices using April data | No | Aggregate index PSEs (91-03): range 0.18-0.69, average 0.38 | No |
| NJ Rec Catch | RecCatch/Effort | No | Determine if development of an index is possible | No | None | No |

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| DE Spawning stock River Survey | Electrofishing aggregate and age-specific: ages 2-15 | No | Investigate area under the curve method for possible spatial distribution issues; examine temporal distribution within strata; compare upper river index to PA survey | Yes – claims multistage lattice design addresses spatial and temporal distribution issues. | Aggregate PSEs (96-03): mean=0.20. Age-specific mean PSEs: 2-0.52,3-0.3,4-0.31,5-0.29,6-0.27,7-0.27,8-0.26,9-0.27,10-0.36,11-0.34,12-0.47, 13-0.46 | Yes, compared age-specific indices to NJ juvenile fish index and found 6 out of 14 were significantly correlated. However, only 3 of nine comparisons between DE and PA surveys were significantly correlated. |
| DE Trawl Survey | Aggregate Index | No | Change biomass index to number; generate age-specific indices; compare indices to VPA for age 1 | Some – developed numbers index using GLM | Aggregate mean PSE (91-04): 0.29 (I calculated from Table 3) | No |
| MD Spring Gillnet Survey | Age-specific 2-13+ | Yes | Examine first vs second set;review impact of sex-specific catchabilities | In progress, showed differences in catchability and visibility | Age-specific mean PSEs (91-04):2-0.11, 3-0.02, 4-0.02,5-0.03,6-0.03,7-0.03,8-0.04,9-0.06,10-0.14,11-0.10,12-0.10,13-0.71 | No |

| Survey | Index Type | In VPA? | Workshop Recommendations | Recommendations Addressed? | PSE Range | Attempted Validation? |
|---|---|---|---|---|---|---|
| VA Pound Net Survey | Fixed Pounds Net | No | Validate Index against MD and VA juveniles indices; examine year effects,; use longitudinal catch curves; examine catch versus temporal window, flow regimes. | Yes – no relationship between river flow and index; Mar 30-3May window better for inter-annual assessment of stock | Can't be calculated due to fixed sites | Yes, compared age-specific indices for age 3 8 to VA JI index but found poor correlation; weak correlation for age 9-10; high correlation between age 11-12 index and JI; there were no correlations between index and MD juvenile indices. |

## Appendix A7. AD Model Builder Code for the Striped Bass Statistical Catch-At-Age Model

```
//--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--
//
//        Striped bass Statistical Catch-At-Age Model
//        Gary Nelson
//        Massachusetts Division of Marine Fisheries
//        Gloucester, MA 01930
//
//   Some Code Adapted from Erik H. Williams' Menhaden Statistical Catch-At-Age Model
//
//
//
//--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--><>--
TOP_OF_MAIN_SECTION
 arrmblsize=1000000;

DATA_SECTION
 !! ad_comm::change_datafile_name("scamdata.dat");

// STARTING AND ENDING YEAR OF MODEL
 init_int styr;
 init_int endyr;

// NUMBER OF AGES
 init_int nages;

// VECTOR OF AGES FOR AGE BINS
 init_ivector agebins(1,nages);

//CALCULATE RECRUITMENT YEARS
 int styrR;
 LOCAL_CALCS
  styrR=styr-(nages-1);
 END_CALCS

//TOTAL CATCH CVs
 init_vector total_catch_CV(styr,endyr);

//TOTAL CATCH LIKELIHOOD WEIGHTS
 init_number l_wgt;

//REC & COM HARVEST AND RELEASE AND DISCARDS MORTALITY NUMBERS
 init_vector obs_total_catch(styr,endyr);

//CATCH AGE COMPOSITION
 init_vector ss_age_comp(styr,endyr);
 init_number caa_wgt;
 init_matrix obs_age_comp(styr,endyr,1,nages);

// YOY AND YEARLING SURVEYS
 init_int age_surv_num;
 init_vector age_surv_flag(1,age_surv_num);
 init_vector age_surv_ages(1,age_surv_num);
 init_vector yoy_wgt(1,age_surv_num);
 init_matrix age_surv_CV(styrR,endyr,1,age_surv_num);
 init_matrix age_obs_surv_indices(styrR,endyr,1,age_surv_num);

// AGGREGATE SURVEYS
 init_int agg_surv_num;
 init_vector agg_surv_flag(1,agg_surv_num);
 init_vector agg_surv_ages(1,agg_surv_num);
 init_vector agg_wgt(1,agg_surv_num);
 init_matrix agg_surv_CV(styrR,endyr,1,agg_surv_num);
 init_matrix agg_obs_surv_indices(styrR,endyr,1,agg_surv_num);

//SURVEYS WITH AGE COMPOSITION
 init_int ac_surv_num;
 init_vector ac_surv_flag(1,ac_surv_num);
 init_vector ac_surv_wgt(1,ac_surv_num);
 init_vector ac_age_wgt(1,ac_surv_num);
 init_matrix ac_surv_CV(styrR,endyr,1,ac_surv_num);
```

```
 init_matrix ac_obs_surv_indices(styrR,endyr,1,ac_surv_num);

//SAMPLE SIZES OF SURVEY AGE COMPOSITIONS
 init_matrix ac_ss(styrR,endyr,1,ac_surv_num);

//SURVEY AGE COMPOSITION IN PROPORTIONS
 init_3darray surv_comps(1,ac_surv_num,styrR,endyr,1,nages);

//SPAWNING STOCK WEIGHTS-AT-AGE
 init_matrix ssw(styr,endyr,1,nages);
 init_vector mat(1,nages);
 init_number pM;
 init_number pF;

//INPUT CONSTANT M
 init_number M;
 init_number R_lam;
 init_number F_lam;

 int cnt;
 int y;
 int a;
 int t;
 int realage;
 int d;
 int total;
 int n_parms;
 int df;

 LOCAL_CALCS
  n_parms=1+(endyr-styrR+1)+1+(endyr-styr+1)+2+2+2+2+2+2+2+1+age_surv_num+agg_surv_num+ac_surv_num+1;
  df=n_parms+(endyr-styr+1)+(endyr-styrR+1)+age_surv_num+agg_surv_num+ac_surv_num;
 END_CALCS
 matrix sigma(1,df,1,df+1);
 !! set_covariance_matrix(sigma);

PARAMETER_SECTION
//TEMPORARY VARIABLES
 number adds;
 number pgroup;
 number diff;
 number diff2;
 number sel;
 number aveN;
 number sump;
 number sumage;
 number maxs;
 number dodo;
 number dodo1;
 number sumdo;
 number sumdo1;
 number fpen;

//--------------------INITIATE SCAM ARRAYS-------------------------//
//AVERAGE RECRUITMENT
 init_number log_avg_R(1);

//RECRUITMENT DEVIATIONS
 init_bounded_dev_vector log_R_dev(styrR,endyr,-20.,20.,3);//Age 1 recruitment values from styr to endyr

//AVERAGE FISHING MORTALITY
 init_number log_avg_F(2);

//FISHING MORTALITY DEVIATIONS
 init_bounded_dev_vector log_F_dev(styr,endyr,-15.,15.,2);//

//NUMBERS,F,Z MATRICES
 matrix N(styrR,endyr,1,nages);//Population numbers by year and age
 matrix F(styr,endyr,1,nages);
 matrix Z(styrR,endyr,1,nages);

//CATCH SELECTIVITIES
 init_bounded_number p1_A50(0,150,4);
 init_bounded_number p1_slope(0,150,4);
 init_bounded_number p2_A50(0,150,4);
 init_bounded_number p2_slope(0,150,4);
 init_bounded_number p3_A50(0,150,4);
 init_bounded_number p3_slope(0,150,4);
 init_bounded_number p4_A50(0,150,4);
 init_bounded_number p4_slope(0,150,4);
```

```
 vector p1_sel(1,nages);
 vector p2_sel(1,nages);
 vector p3_sel(1,nages);
 vector p4_sel(1,nages);

//SURVEY SELECTIVITIES
 init_bounded_vector DE_surv(1,2,0,150,9);
 init_number MD_surv(10);
 init_vector NY_surv(1,2,7);
 init_bounded_number NY_e(1e-22,0.9999,7)
 init_vector NJ_surv(1,2,8);
 matrix surv_sel(1,nages,1,ac_surv_num);

//STARTING VALUES FOR SURVEY SELECTIVITY PARAMETERS
 LOCAL_CALCS
  NY_e=0.95;
  NY_surv(1)=-1;
  NY_surv(2)=1;
  NJ_surv(1)=3;
  NJ_surv(2)=1;
  MD_surv=0.3;
  DE_surv(1)=3;
  DE_surv(2)=1;
 END_CALCS

//SURVEY CATCHABILITY COEEFFICIENTS AND PREDICTED INDICES
 init_bounded_vector age_qs(1,age_surv_num,-50.,0.,5);
 matrix age_pred_surv_indices(styrR,endyr,1,age_surv_num);
 init_bounded_vector agg_qs(1,agg_surv_num,-50.,0.,5);
 matrix agg_pred_surv_indices(styrR,endyr,1,agg_surv_num);
 init_bounded_vector ac_qs(1,ac_surv_num,-50.,0.,6);
 matrix ac_pred_surv_indices(styrR,endyr,1,ac_surv_num);

//PREDICTED SURVEY AGE COMPOSITIONS
 3darray calc_comps(1,ac_surv_num,styrR,endyr,1,nages);
 3darray surv_pred_comps(1,ac_surv_num,styrR,endyr,1,nages);

//INDIVIDUAL LIKELIHOOD SAVE VECTORS
 vector like_age(1,age_surv_num);
 vector like_agg(1,agg_surv_num);
 vector like_ac_surv(1,ac_surv_num);
 vector like_ac_age(1,ac_surv_num);

//CATCH-AT-AGE,PREDICTED TOTAL CATCH, PREDICTED CATCH AGE COMPOSITION, AND SSB
 matrix C(styr,endyr,1,nages);
 vector pred_total_catch(styr,endyr);
 matrix pred_age_comp(styr,endyr,1,nages);
 number f_total_catch;
 number f_age_comp;
 matrix SSB(styr,endyr,1,nages);
 matrix rwgts(styr,endyr,1,nages);
 matrix W2(styr,endyr,1,nages);
 matrix jan1bio(styr,endyr,1,nages);
 matrix catchbio(styr,endyr,1,nages);
 vector tSSB(styr,endyr);

//REPORT STANDARD DEVIATIONS FOR ANNUAL FS,RS, AND CATCHABILITY COEFFICIENTS
 sdreport_vector F_ann(styr,endyr);
 sdreport_vector R(styrR,endyr);
 sdreport_vector q_YOY(1,age_surv_num);
 sdreport_vector q_Agg(1,agg_surv_num);
 sdreport_vector q_AC(1,ac_surv_num)

 objective_function_value f;

INITIALIZATION_SECTION
 //STARTING VALUES FOR REMAINING PARAMETERS
 log_avg_R 10.6;
 log_avg_F -2.6;
 p1_A50 3;
 p1_slope 1;
 p2_A50 3;
 p2_slope 1;
 p3_A50  3;
 p3_slope 1;
 p4_A50 3;
 p4_slope 1;
 age_qs -20.4;
 agg_qs -19.7;
 ac_qs  -20.2;
```

```
RUNTIME_SECTION
 maximum_function_evaluations 10000, 10000, 10000;
 convergence_criteria 1e-5, 1e-7, 1e-16;

PRELIMINARY_CALCS_SECTION
 F.initialize();
 C.initialize();
 calc_comps.initialize();

PROCEDURE_SECTION
 calc_selectivity();
 calc_F_mortality();
 calc_Z_matrix();
 calc_numbers_at_age();
 calc_catch_at_age();
 calc_pred_age_comp();
 calc_indices_selectivity();
 calc_predict_indices_age();
 calc_predict_indices_agg();
 calc_predict_indices_ac();
 scam_likelihood();
 calc_biomass();
 evaluate_the_objective_function();

//CALCULATE CATCH SELECTIVITIES VALUES FOR CURRENT PARAMETER ESTIMATES
FUNCTION calc_selectivity //gompertz function
 for (a=1;a<nages;a++){
   p1_sel(a)=exp(-1.*exp(-1.*p1_slope*(double(agebins(a))-p1_A50)));
   p2_sel(a)=exp(-1.*exp(-1.*p2_slope*(double(agebins(a))-p2_A50)));
   p3_sel(a)=exp(-1.*exp(-1.*p3_slope*(double(agebins(a))-p3_A50)));
   p4_sel(a)=exp(-1.*exp(-1.*p4_slope*(double(agebins(a))-p4_A50)));
 }
 p1_sel(nages)=p1_sel(nages-1);
 p2_sel(nages)=p2_sel(nages-1);
 p3_sel(nages)=p3_sel(nages-1);
 p4_sel(nages)=p4_sel(nages-1);

 p1_sel=p1_sel/max(p1_sel);
 p2_sel=p2_sel/max(p2_sel);
 p3_sel=p3_sel/max(p3_sel);
 p4_sel=p4_sel/max(p4_sel);

//MATCH PERIOD SELECTVITIES TO YEARS AND CALCULATE ANNUAL F AND F-AT-AGE
FUNCTION calc_F_mortality
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     if (y<1985) sel=p1_sel(a);
     if (y>=1985 && y<=1989) sel=p2_sel(a);
     if (y>=1990 && y<=1995) sel=p3_sel(a);
     if (y>=1996) sel=p4_sel(a);
     F(y,a)=sel*mfexp(log_avg_F+log_F_dev(y));
     F_ann(y)=mfexp(log_avg_F+log_F_dev(y));
   }
 }

//FILL Z MATRIX
FUNCTION calc_Z_matrix
 for(y=styrR;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     if(y<styr)Z(y,a)=F(styr,a)+M;
     if(y>=styr)Z(y,a)=F(y,a)+M;
   }
 }

//CALCULATE AND FILL NUMBERS-AT-AGE MATRIX
FUNCTION calc_numbers_at_age
 N(styrR,1)=mfexp(log_avg_R+log_R_dev(styrR));//Fill in Recruits in first year and age

 for(a=2;a<=nages;a++){
   N(styrR,a)=N(styrR,a-1)*mfexp(-1.*Z(styrR,a-1));//Fills in top row of matrix
 }
 N(styrR,nages)=N(styrR,nages-1)*mfexp(-1.*Z(styrR,nages-1))/(1.-mfexp(-1.*Z(styrR,nages)));

 for(y=styrR+1;y<=endyr;y++){  //Rest of pre-data years
   N(y,1)=mfexp(log_avg_R+log_R_dev(y));
   N(y)(2,nages)=++elem_prod(N(y-1)(1,nages-1),(mfexp(-1.*Z(y-1)(1,nages-1))));
   N(y,nages)+=N(y-1,nages)*mfexp(-1.*Z(y-1,nages));//plus  group
 }

 for(y=styrR;y<=endyr;y++){
   R(y)=mfexp(log_avg_R+log_R_dev(y));
```

```
 }

FUNCTION calc_biomass
 //Rivard weights

 for(a=2;a<=nages-1;a++){
   for(y=styr+1;y<=endyr;y++){
      W2(y,a)=(log(ssw(y,a))+log(ssw(y-1,a-1)))/2;
     }
    }
 for(y=styr;y<=endyr-1;y++){
      W2(y,1)=2.*log(ssw(y,1))-W2(y+1,2);
     }
 for(a=1;a<=nages-2;a++){
      W2(styr,a)=2.*log(ssw(styr,a))-W2(styr+1,a+1);
    }
 W2(styr,nages-1)=(W2(styr,nages-1)+W2(styr,nages-2))/2;
 W2(endyr,1)=2.*log(ssw(endyr,1))-W2(endyr,2);
 for(y=styr;y<=endyr;y++){
      W2(y,nages)=log(ssw(y,nages));
     }
 for(y=styr;y<=endyr;y++){
      for(a=1;a<=nages;a++){
      rwgts(y,a)=exp(W2(y,a));
      jan1bio(y,a)=rwgts(y,a)*N(y,a);
      catchbio(y,a)=ssw(y,a)*obs_total_catch(y)*obs_age_comp(y,a);
     }
    }
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     SSB(y,a)=(N(y,a)*rwgts(y,a)*mat(a)*mfexp(-1*(pF*F(y,a)+pM*M)))/2;
   }
 }
 tSSB=rowsum(SSB);

//CALCULATE CATCH-AT-AGE MATRIX
FUNCTION calc_catch_at_age
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     C(y,a)=N(y,a)*F(y,a)*(1.-mfexp(-1.*Z(y,a)))/Z(y,a);
   }
 }

//CALCULATE PREDICTED CATCH AGE COMPOSITION
FUNCTION calc_pred_age_comp
 for(y=styr;y<=endyr;y++){
   sumage=0;
   for(a=1;a<=nages;a++){
     sumage+=C(y,a);
   }
   pred_total_catch(y)=sumage;

   for(a=1;a<=nages;a++){
     pred_age_comp(y,a)=C(y,a)/(sumage+0.001);
   }
 }

//CALCULATE SURVEY SELECTIVITY INDICES
FUNCTION calc_indices_selectivity //NYOHS NJTRL MDAdults DESSN
 for(int s=1;s<=ac_surv_num;s++){
   maxs=0;
   for(a=1;a<nages;a++){
     surv_sel(a,s)=0;
     if(s==1){
       if(a>=2) surv_sel(a,s)=(1/(1-NY_e))*pow((1-NY_e)/NY_e,NY_e)*(exp(NY_surv(1)*NY_e*(NY_surv(2)-
double(a)))/(1+exp(NY_surv(1)*(NY_surv(2)-double(a)))));
     }

     if(s==2){
         if(a>=2) surv_sel(a,s)=pow(double(a),NJ_surv(1))*exp(-1.*NJ_surv(2)*double(a));
       }
     if(s==3){
       if (a==2) surv_sel(a,s)=MD_surv;
       if (a>=3) surv_sel(a,s)=1;
     }

     if(s==4){
       if(a>=2) surv_sel(a,s)=exp(-1.*exp(-1.*DE_surv(2)*(double(agebins(a))-DE_surv(1))));
      }
     if(surv_sel(a,s)>=maxs) maxs=surv_sel(a,s);
   }
```

```
   for(a=1;a<nages;a++){
     surv_sel(a,s)=surv_sel(a,s)/maxs;
     }
   surv_sel(nages,s)=surv_sel(nages-1,s);
 }


//CALCULATE PREDICTED YOY AND YEARLING INDICES
FUNCTION calc_predict_indices_age
 for(t=1;t<=age_surv_num;t++){
     realage=0;
     for(y=styrR;y<=endyr;y++){
       if (age_obs_surv_indices(y,t)>=0.)                              // Skip Missing Values (-1)
        {
          realage=(int)floor(age_surv_ages(t));
           age_pred_surv_indices(y,t)=mfexp(age_qs(t))*N(y,realage)*mfexp(-1.*age_surv_flag(t)*Z(y,realage));
         }
       if (age_obs_surv_indices(y,t)==-1) age_pred_surv_indices(y,t)=-1;
     }//y loop
     q_YOY(t)=mfexp(age_qs(t));
   }//t loop

//CALCULATE PREDICTED AGGREGATE INDICES
FUNCTION calc_predict_indices_agg
 for(t=1;t<=agg_surv_num;t++){
     cnt=0;
     adds=0;
     realage=0;
     diff2=0;
     for(y=styrR;y<=endyr;y++){
       if (agg_obs_surv_indices(y,t)>=0.)                              // Skip Missing Values (-1)
        {
           realage=(int)floor(agg_surv_ages(t));
           diff2=int(ceil(agg_surv_ages(t)*100.)-(floor(agg_surv_ages(t))*100.));
           pgroup=0;
           for (a=realage;a<=diff2;a++)
             {
              pgroup+=N(y,a)*mfexp(-1.*agg_surv_flag(t)*Z(y,a));
             }
             agg_pred_surv_indices(y,t)=mfexp(agg_qs(t))*pgroup;
        }//agg_surv_indices>=0
        if (agg_obs_surv_indices(y,t)==-1) agg_pred_surv_indices(y,t)=-1;
     }//y loop
     q_Agg(t)=mfexp(agg_qs(t));
  }//t loop

//CALCULATE PREDICTED SURVEY WITH AGE COMPOSITION INDICES
FUNCTION calc_predict_indices_ac
  for(int t=1;t<=ac_surv_num;t++){
       for(y=styrR;y<=endyr;y++){
          for(a=1;a<=nages;a++){
            calc_comps(t,y,a)=-1;
            if (surv_comps(t,y,a)>=0.)// Skip Missing Values (-1)
             {
               calc_comps(t,y,a)=surv_sel(a,t)*mfexp(ac_qs(t))*N(y,a)*mfexp(-1.*ac_surv_flag(t)*Z(y,a));
             }
           }//a loop
         }//y loop
      q_AC(t)=mfexp(ac_qs(t));
     }//t loop


  for(int t=1;t<=ac_surv_num;t++){
     for(y=styrR;y<=endyr;y++){
         sumage=0;
         for (a=1;a<=nages;a++){
            if(surv_comps(t,y,a)>=0.){sumage+=calc_comps(t,y,a);}
           }
            if(sumage>0.) {ac_pred_surv_indices(y,t)=sumage;}
            if(sumage<=0.){ac_pred_surv_indices(y,t)=-1;}

         for (a=1;a<=nages;a++){
            surv_pred_comps(t,y,a)=-1;
            if(sumage>0.){
              if(surv_comps(t,y,a)>=0.){surv_pred_comps(t,y,a)=calc_comps(t,y,a)/sumage;}
             }
            if(sumage<=0.){surv_pred_comps(t,y,a)=-1;}
           }
       }
    }
```

```
//CALCULATE LIKELIHOODS
FUNCTION scam_likelihood
 f_total_catch=0.;
 f_age_comp=0.;
 cnt=0;

 //CALCULATE TOTAL CATCH WEIGHTED RESIDUAL SUM OF SQUARES
    for(y=styr;y<=endyr;y++){
         f_total_catch+=square((log(obs_total_catch(y)+0.00001)-
log(pred_total_catch(y)+0.00001))/total_catch_CV(y));
      cnt+=1;
      }
     f_total_catch=f_total_catch*l_wgt;

//CALCULATE CATCH AGE COMP LIKELIHOOD
     for(y=styr;y<=endyr;y++){
       for(a=1;a<=nages;a++){
          f_age_comp-=ss_age_comp(y)*obs_age_comp(y,a)*log(pred_age_comp(y,a)+1e-7);
         }
       }
    f_age_comp=f_age_comp*caa_wgt;

//CALCULATE YOY AND YEARLING WEIGHTED RESIDUAL SUM OF SQUARES
   for(t=1;t<=age_surv_num;t++){
     like_age(t)=0;
     for(y=styrR;y<=endyr;y++){
         if(age_obs_surv_indices(y,t)>=0.){
        like_age(t)+=square((log(age_obs_surv_indices(y,t)+0.00001)-
log(age_pred_surv_indices(y,t)+0.00001))/age_surv_CV(y,t));
        cnt+=1;
           }
     }
     like_age(t)=like_age(t)*yoy_wgt(t);
   }

//CALCULATE AGGREGATE SURVEY WEIGHTED RESIDUAL SUM OF SQUARES
   for(t=1;t<=agg_surv_num;t++){
      like_agg(t)=0.;
      for(y=styrR;y<=endyr;y++){
           if(agg_obs_surv_indices(y,t)>=0.){
          like_agg(t)+=square((log(agg_obs_surv_indices(y,t)+0.00001)-
log(agg_pred_surv_indices(y,t)+0.00001))/agg_surv_CV(y,t));
          cnt+=1;
            }
      }
     like_agg(t)=like_agg(t)*agg_wgt(t);
   }

// CALCULATE SURVEY WITH AGE COMPOSITIONS WEIGHTED RESIDUAL SUM OF SQUARES
   for(t=1;t<=ac_surv_num;t++){
      like_ac_surv(t)=0;
      for(y=styrR;y<=endyr;y++){
        if(ac_obs_surv_indices(y,t)>=0.){
         like_ac_surv(t)+=square((log(ac_obs_surv_indices(y,t)+0.00001)-
log(ac_pred_surv_indices(y,t)+0.00001))/ac_surv_CV(y,t));
         cnt+=1;
        }
      }
      like_ac_surv(t)=like_ac_surv(t)*ac_surv_wgt(t);
   }

// CALCULATE SURVEY AGE COMPOSITIONS LIKELHOOD
   for(t=1;t<=ac_surv_num;t++){
      like_ac_age(t)=0.;
      for(y=styrR;y<=endyr;y++){
         for(a=1;a<=nages;a++){
           if(surv_comps(t,y,a)!=-1){
            like_ac_age(t)-=ac_ss(y,t)*surv_comps(t,y,a)*log(surv_pred_comps(t,y,a)+1e-7);
            }
         }
      }
        like_ac_age(t)=like_ac_age(t)*ac_age_wgt(t);
   }

FUNCTION evaluate_the_objective_function
  f=0;
 //CALCULATE CONCENTRATED LIKELIHOOD FOR ALL DATA WITH LOGNORMAL ERRORS
  f+=0.5*cnt*log((sum(like_age)+sum(like_agg)+sum(like_ac_surv)+f_total_catch)/cnt);
 //SUM REMAINING LIKELIHOODS
  f+=sum(like_ac_age);
```

```
  f+=f_age_comp;
  f+=R_lam*norm2(log_R_dev);

//CALCULATE PENALTY CONSTRAINT FOR F
    if(current_phase()<3){
     fpen=10.*norm2(mfexp(log_avg_F+log_F_dev)-0.15);
    }
    else{
     fpen=0.001*norm2(mfexp(log_avg_F+log_F_dev)-0.15);
    }
    if(active(log_F_dev)){
      fpen+=norm2(log_F_dev);
     }
  f+=F_lam*fpen;


REPORT_SECTION
 report <<"Likelihood Components" << endl;
 report <<" "<<endl;
 report <<"                       "<<"\t"<<"Weight"<<"   "<<"RSS"<<endl;
 report <<" Total Catch        : "<<"\t"<<l_wgt<<"\t"<<setw(10)<<f_total_catch<<endl;
 report <<" YOY/Yearl Surveys    " << endl;
 for(t=1;t<=age_surv_num;t++){
 report <<"   Survey "<<t<<"         : "<<"\t"<<yoy_wgt(t)<<"\t"<<setw(10)<<like_age(t)<<endl;
 }
 report <<" Aggregate Surveys    " << endl;
   for(t=1;t<=agg_surv_num;t++)
      {
 report <<"   Survey "<<t<<"         : "<<"\t"<<agg_wgt(t)<<"\t"<<setw(10)<<like_agg(t)<<endl;
      }
 report <<" Age Survey Indices   " << endl;

  for(t=1;t<=ac_surv_num;t++)
      {
 report <<"   Survey "<<t<<"         : "<<"\t"<<ac_surv_wgt(t)<<"\t"<<setw(10)<<like_ac_surv(t)<<endl;
      }
 report<<" "<<endl;
 report <<" Total RSS            "<<"\t"<<"
"<<"\t"<<setw(10)<<(sum(like_age)+sum(like_agg)+sum(like_ac_surv)+f_total_catch)<<endl;
 report <<" No. of Obs           "<<"\t"<<" "<<"\t"<<setw(10)<<cnt<<endl;
 report <<" Conc. Likelihood     "<<"\t"<<"  "<<"\t"<<setw(10)<<
           0.5*cnt*log((sum(like_age)+sum(like_agg)+sum(like_ac_surv)+f_total_catch)/cnt) <<endl;

 report<<" "<<endl;
 report <<" Catch Age Comps    : "<<"\t"<<caa_wgt <<"\t"<<setw(10)<<f_age_comp<<endl;
 report <<" Survey Age Comps       " <<endl;
  for(t=1;t<=ac_surv_num;t++)
      {
 report <<"   Survey "<<t<<"         : "<<"\t"<<ac_age_wgt(t)<<"\t"<<setw(10)<<like_ac_age(t)<<endl;
      }
 report <<" "<<endl;

 report <<"Recr Devs "<<"          : "<<"\t"<<R_lam<<"\t"<<setw(10)<<R_lam*norm2(log_R_dev)<<endl;
 report <<"F Devs    "<<"          : "<<"\t"<<F_lam<<"\t"<<setw(10)<<F_lam*norm2(log_F_dev)<<endl;

 report <<" "<<endl;
 report <<"Total Likelihood    : "<<"\t"<<"  "<<"\t"<<setw(10)<<f<<endl;
 report << " " << endl;
 report<<"*****************************************************************************************"<<endl;
 report<<"Mortality Rates "<<endl;
 report << "Natural" << endl;
 report << M << endl;
 report<<" "<<endl;
 report << "Fishing" << endl;
 report << mfexp(log_avg_F+log_F_dev)<< endl;
 report<<" "<<endl;
 report <<"*******************************************SCAM Output**********************"<<endl;
 report << "Total Catch" << endl;
 report << "Observed" << obs_total_catch << endl;
 report << "Predicted" << pred_total_catch <<endl;
 report <<" "<<endl;
 report << "Obs Catch Age Comp "<< endl;
 report<<obs_age_comp<<endl;
 report <<" "<<endl;
 report <<"Pred Catch Age comp"<<endl;
 report<<pred_age_comp<<endl;
 report <<" "<<endl;
 report << "Number-At-Age "<< endl;
 report << N<<endl;
 report << "Selectivity Period 1" << endl;
 report <<"Age " << agebins << endl;
```

```
report << "p1_sel" << p1_sel << endl;
report <<" "<<endl;
report << "Selectivity Period 2" << endl;
report <<"Age " << agebins << endl;
report << "p2_sel" << p2_sel << endl;
report <<" "<<endl;
report << "Selectivity Period 3" << endl;
report <<"Age " << agebins << endl;
report << "p3_sel" << p3_sel << endl;
report << "Selectivity  Period 4" << endl;
report <<"Age " << agebins << endl;
report << "p4_sel" << p4_sel << endl;
report <<" "<<endl;

report <<"Period Selectivity Parameters"<<endl;
report <<"P1: "<<p1_A50<<" "<<p1_slope<<endl;
report <<"P2: "<<p2_A50<<" "<<p2_slope<<endl;
report <<"P3: "<<p3_A50<<" "<<p3_slope<<endl;
report <<"P4: "<<p4_A50<<" "<<p4_slope<<endl;

report<<"Observed Age Indices"<<endl;
report<<age_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Age Indices"<<endl;
report<<age_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Age Survey qs"<<endl;
report<<mfexp(age_qs)<<endl;
report <<" "<<endl;
report<<"YOY/Yearling CVs"<<endl;
report<<age_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Aggregate Indices"<<endl;
report<<agg_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Aggregate Indices"<<endl;
report<<agg_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Aggregate Survey qs"<<endl;
report<<mfexp(agg_qs)<<endl;
report <<" "<<endl;
report<<"Aggregate Indices CVs"<<endl;
report<<agg_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Age Comp Indices"<<endl;
report<<ac_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Age Comps Indices"<<endl;
report<<ac_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Age Comps Survey qs"<<endl;
report<<mfexp(ac_qs)<<endl;
report <<" "<<endl;
report<<"Age Comps Indices CVs"<<endl;
report<<ac_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Survey Age Comps "<<endl;
report<<surv_comps<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps "<<endl;
report<<surv_pred_comps<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps Selectivities"<<endl;
report<<surv_sel<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps Selectivities Parameters"<<endl;
report<<NY_e<<NY_surv<<endl;
report<<NJ_surv<<endl;
report<<MD_surv<<endl;
report<<DE_surv<<endl;
report <<" "<<endl;
report<<"Fishing Mortality at age"<<endl;
report<<F<<endl;
report <<" "<<endl;
report<<"SSB at age"<<endl;
report<<SSB<<endl;
report <<" "<<endl;
report<<"Rivards Weights"<<endl;
report<<rwgts<<endl; report <<" "<<endl;
report<<"Catch Weights"<<endl;
report<<ssw<<endl; report <<" "<<endl;
```

```
 report<<"January-1 stock biomass"<<endl;
 report<<jan1bio<<endl; report <<" "<<endl;
 report<<"Catch biomass"<<endl;
 report<<catchbio<<endl; report <<" "<<endl;


FINAL_SECTION
 // Output data to files for import into R
  ofstream ofs28("effss.out");
      sumdo1=0;
      dodo1=0;
      for(y=styr;y<=endyr;y++)
        {
          sumdo=0;
          dodo=0;
          for(a=1;a<=nages;a++)
            {
               if(obs_age_comp(y,a)!=-1)
                {
                sumdo+=pred_age_comp(y,a)*(1-pred_age_comp(y,a));
                dodo+=square(obs_age_comp(y,a)-pred_age_comp(y,a));

               }
               if(obs_age_comp(y,a)==-1)
                {
                sumdo=0;
                dodo=0;
               }
            }
           if(sumdo>0 && dodo>0) sumdo1+=sumdo/dodo;
        }

     for(y=styr;y<=endyr;y++)
       {
        if (obs_total_catch(y)!=-1) dodo1+=1;
       }
     ofs28<<sumdo1/dodo1<<endl;
 //Survey age comps
   for(t=1;t<=ac_surv_num;t++)
     {
      sumdo1=0;
      dodo1=0;
      for(y=styrR;y<=endyr;y++)
        {

          sumdo=0;
          dodo=0;
          for(a=1;a<=nages;a++)
            {
               if(surv_comps(t,y,a)!=-1)
                {
                sumdo+=surv_pred_comps(t,y,a)*(1-surv_pred_comps(t,y,a));
                dodo+=square(surv_comps(t,y,a)-surv_pred_comps(t,y,a));

               }
               if(surv_comps(t,y,a)==-1)
                {
                sumdo=0;
                dodo=0;
               }
            }
           if(sumdo>0 && dodo>0) sumdo1+=sumdo/dodo;
       }

     for(y=styrR;y<=endyr;y++)
       {
        if (ac_obs_surv_indices(y,t)!=-1) dodo1+=1;
       }
     ofs28<<sumdo1/dodo1<<endl;

    }
 // Calculate F and sd
   ofstream ofs1("F.out");
   d=n_parms+1;
   for(t=styr;t<=endyr;t++)
     {
       ofs1<<F_ann(t)<<"\t"<<sigma(d,1)<<endl;
       d+=1;
     }
 //Calculate R and sd
  ofstream ofs2("R.out");
```

```
   for(t=styrR;t<=endyr;t++)
   {
       ofs2<<R(t)<<"\t"<<sigma(d,1)<<endl;
       d+=1;
   }
//Output Indices qs
  ofstream ofs13("YOYqs.out");
    for(t=1;t<=age_surv_num;t++)
   {
     ofs13<<mfexp(age_qs(t))<<"\t"<<sigma(d,1)<<endl;
     d+=1;
   }
   ofstream ofs14("Aggqs.out");
     for(t=1;t<=agg_surv_num;t++)
   {
    ofs14<<mfexp(agg_qs(t))<<"\t"<<sigma(d,1)<<endl;
    d+=1;
   }
  ofstream ofs15("ACqs.out");
    for(t=1;t<=ac_surv_num;t++)
   {
    ofs15<<mfexp(ac_qs(t))<<"\t"<<sigma(d,1)<<endl;
    d+=1;
   }
//Output N-at-age
  ofstream ofs4("N.out");
  ofs4<<N<<endl;
//Output Catch Age Comp
  ofstream ofs5("CACpred.out");
  ofs5<<pred_age_comp<<endl;
//Output Catch Age Comp
  ofstream ofs51("CACobs.out");
  ofs51<<obs_age_comp<<endl;
//Output Total Catch
  ofstream ofs6("CatPred.out");
  for(y=styr;y<=endyr;y++)
    {
     ofs6<<pred_total_catch(y)<<endl;
    }
 //Output Total Catch
  ofstream ofs61("CatObs.out");
  for(y=styr;y<=endyr;y++)
    {
     ofs61<<obs_total_catch(y)<<endl;
    }
//Output Total Catch
  ofstream ofs7("Fatage.out");
     ofs7<<F<<endl;
//Output Selectivity
  ofstream ofs8("Select.out");
  for(a=1;a<=nages;a++)
    {
    ofs8<<p1_sel(a)<<"\t"<<p2_sel(a)<<"\t"<<p3_sel(a)<<"\t"<<p4_sel(a)<<endl;
    }
//Output Selectivity Parameters
  ofstream ofs9("Selparms.out");
    ofs9<<p1_A50<<"\t"<<p1_slope<<endl;
    ofs9<<p2_A50<<"\t"<<p2_slope<<endl;
    ofs9<<p3_A50<<"\t"<<p3_slope<<endl;
    ofs9<<p4_A50<<"\t"<<p4_slope<<endl;
//Output Indices
  ofstream ofs10("YOYPred.out");
     ofs10<<age_pred_surv_indices<<endl;

   ofstream ofs101("YOYObs.out");
     ofs101<<age_obs_surv_indices<<endl;

   ofstream ofs11("AggPred.out");
     ofs11<<agg_pred_surv_indices<<endl;
   ofstream ofs111("AggObs.out");
     ofs111<<agg_obs_surv_indices<<endl;

  ofstream ofs12("ACPred.out");
     ofs12<<ac_pred_surv_indices<<endl;
  ofstream ofs121("ACObs.out");
     ofs121<<ac_obs_surv_indices<<endl;


//Output Sruvey age comps
  ofstream ofs16("survacpred.out");
     ofs16<<surv_pred_comps<<endl;
```

```
 ofstream ofs161("survacobs.out");
     ofs161<<surv_comps<<endl;
 ofstream ofs169("calccomps.out");
     ofs169<<calc_comps<<endl;


//Output Sruvey select
  ofstream ofs17("survsel.out");
     ofs17<<surv_sel<<endl;
//Output Sruvey select parms

 // ofstream ofs18("survparms.out");
 //    ofs18<<surv_A50<<endl;
  //   ofs18<<surv_slope<<endl;


//Output Total SSB
  ofstream ofs27("SSB.out");
     ofs27<<SSB<<endl;

//Output jani1biomass
  ofstream ofs29("jan1bio.out");
     ofs29<<jan1bio<<endl;
//Output catch biomass
  ofstream ofs30("catchbio.out");
     ofs30<<catchbio<<endl;
```

## Data used in the striped bass statistical catch-at-age model.

```
#Starting and ending year of catch data
1982
2006

#Number of ages
13

#Agebin vector
1 2 3 4 5 6 7 8 9 10 11 12 13

# CV of catch (harvest+dead discards)
0.40 0.23 0.19 0.17 0.21 0.14 0.27 0.18 0.08 0.09 0.06 0.07 0.06 0.05 0.05 0.04 0.04 0.04
0.04 0.03 0.03 0.04 0.04 0.04 0.04

# Total catch likelihood weight
10

#Total catch (numbers)
766200 727700 1084900 400800 384900 239100 444900 479900 921300 988400 986900 1437000 1866600 2999700 3376200
4580100
4118300 3704300 5044400 4344000 3889500 4836200 5272677 5596311 6113218
#Catch age comp samples sizes
380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380 380

#Catch age comp likelihood weight
1

#Fishery age comp data
0.002 0.138 0.335 0.288 0.076 0.025 0.032 0.022 0.015 0.014 0.014 0.018 0.020
0.005 0.152 0.245 0.265 0.206 0.054 0.026 0.006 0.004 0.005 0.006 0.008 0.019
0.005 0.500 0.279 0.076 0.056 0.048 0.017 0.004 0.002 0.002 0.001 0.001 0.010
0.003 0.181 0.254 0.101 0.146 0.108 0.109 0.043 0.016 0.008 0.002 0.002 0.026
0.029 0.055 0.166 0.345 0.130 0.083 0.053 0.062 0.024 0.014 0.009 0.004 0.026
0.006 0.046 0.157 0.215 0.281 0.105 0.055 0.027 0.027 0.013 0.006 0.008 0.054
0.006 0.069 0.094 0.142 0.241 0.220 0.091 0.055 0.031 0.013 0.008 0.007 0.022
0.001 0.075 0.166 0.142 0.219 0.199 0.095 0.044 0.022 0.008 0.007 0.004 0.019
0.002 0.050 0.135 0.204 0.188 0.179 0.113 0.074 0.022 0.008 0.006 0.004 0.015
0.002 0.074 0.147 0.211 0.164 0.103 0.092 0.084 0.059 0.024 0.014 0.003 0.023
0.003 0.046 0.202 0.192 0.179 0.111 0.063 0.069 0.059 0.045 0.009 0.004 0.016
0.001 0.048 0.129 0.228 0.201 0.129 0.060 0.047 0.057 0.053 0.029 0.006 0.012
0.003 0.078 0.187 0.156 0.197 0.125 0.073 0.046 0.054 0.043 0.019 0.012 0.008
0.001 0.145 0.157 0.152 0.135 0.163 0.072 0.065 0.051 0.030 0.018 0.006 0.005
0.001 0.029 0.192 0.193 0.161 0.139 0.131 0.062 0.041 0.020 0.013 0.014 0.006
0.001 0.064 0.131 0.212 0.150 0.125 0.100 0.091 0.049 0.031 0.015 0.007 0.006
0.006 0.045 0.118 0.172 0.273 0.124 0.068 0.064 0.052 0.028 0.023 0.011 0.016
0.002 0.029 0.113 0.175 0.173 0.197 0.095 0.064 0.055 0.040 0.028 0.013 0.013
0.008 0.064 0.083 0.195 0.202 0.155 0.147 0.062 0.032 0.028 0.012 0.006 0.006
0.007 0.036 0.099 0.138 0.192 0.161 0.133 0.111 0.048 0.028 0.024 0.011 0.011
0.007 0.055 0.081 0.122 0.151 0.197 0.137 0.095 0.074 0.028 0.023 0.013 0.017
0.006 0.053 0.101 0.125 0.147 0.124 0.145 0.101 0.077 0.058 0.026 0.017 0.019
0.013 0.034 0.151 0.141 0.097 0.103 0.098 0.119 0.084 0.063 0.050 0.023 0.025
0.003 0.082 0.075 0.196 0.171 0.093 0.076 0.067 0.084 0.058 0.048 0.022 0.025
0.006 0.037 0.191 0.108 0.179 0.115 0.059 0.059 0.060 0.076 0.050 0.029 0.031

##################################################################################
# YOY and Yearling Surveys - NY YOY, NJ YOY, MD YOY, VA YOY, NY 1, MD 1
###################################################################################
#Number of No age comp surveys
6

#Survey time of year fractions
0 0 0 0 0 0

# Survey ages
1 1 1 1 2 2

# YOY/Yearling Likelihood Weight
1 1 1 1 1 1

#Survey CVs
-1 -1 0.19 -1 -1 0.33
-1 -1 0.13 -1 -1 0.26
-1 -1 0.16 -1 -1 0.31
-1 -1 0.21 -1 -1 0.39
-1 -1 0.20 -1 -1 0.18
-1 -1 0.22 -1 -1 0.19
-1 -1 0.13 -1 -1 0.31
-1 -1 0.24 -1 -1 0.45
```

```
-1 -1 0.20 -1 -1 0.41
-1 -1 0.12 -1 -1 0.24
0.15 -1 0.16 -1 -1 0.36
0.20 0.714 0.15 -1 -1 0.26
0.172 1.000 0.193 -1 -1 0.52
0.132 0.353 0.136 0.215 -1 0.57
0.189 0.600 0.229 0.202 -1 0.21
0.200 0.255 0.194 0.299 -1 1.00
0.123 1.000 0.216 0.158 0.556 0.43
0.121 0.271 0.232 0.146 0.360 0.51
0.212 0.216 0.224 0.119 0.351 0.53
0.072 0.140 0.268 0.119 0.449 0.29
0.113 0.210 0.264 0.159 0.302 0.29
0.096 0.136 0.149 0.118 0.307 0.26
0.098 0.164 0.174 0.162 0.322 0.24
0.074 0.190 0.228 0.170 0.288 0.39
0.106 0.211 0.238 0.089 0.387 0.33
0.092 0.164 0.128 0.100 0.375 0.26
0.136 0.210 0.131 0.127 0.297 0.35
0.108 0.144 0.315 0.101 0.394 0.64
0.107 0.138 0.116 0.105 0.500 0.34
0.093 0.225 0.141 0.105 0.364 0.34
0.143 0.169 0.178 0.128 0.243 0.34
0.182 0.182 0.103 0.099 0.257 0.25
0.208 0.174 0.264 0.130 0.226 0.20
0.106 0.209 0.121 0.149 0.246 0.15
0.092 0.224 0.117 0.086 0.197 0.34
0.095 0.144 0.152 0.122 0.408 0.20
0.212 0.126 0.202 0.104 0.486 0.28

#Survey Indices, -1 for missing data
-1 -1 10.52 -1 -1 0.71
-1 -1 30.52 -1 -1 0.22
-1 -1 11.77 -1 -1 7.31
-1 -1 11.01 -1 -1 1.73
-1 -1 8.92 -1 -1 0.86
-1 -1 10.13 -1 -1 0.44
-1 -1 6.69 -1 -1 0.46
-1 -1 4.91 -1 -1 0.42
-1 -1 4.85 -1 -1 0.10
-1 -1 8.45 -1 -1 0.31
5.00 -1 4.24 -1 -1 0.80
23.91 0.07 1.98 -1 -1 0.30
21.44 0 1.22 -1 -1 0.04
30.50 0.17 8.45 3.05 -1 0.02
48.03 0.05 1.37 2.90 -1 0.63
37.11 0.47 4.21 5.63 -1 0.00
3.85 0.04 2.93 2.27 2.81 0.36
6.14 0.48 4.14 4.65 0.78 0.05
60.67 1.11 4.80 15.22 0.62 0.15
52.30 0.57 2.65 7.49 7.07 0.11
41.94 2.71 25.20 10.99 9.25 0.40
37.97 2.06 2.14 6.94 0.96 0.75
6.85 1.16 4.44 3.71 7.59 0.34
17.29 3.99 9.03 9.83 5.66 0.32
26.49 5.97 39.76 12.91 3.46 0.44
28.49 2.32 16.12 8.39 13.21 2.51
27.39 7.61 9.27 5.14 4.85 0.23
14.66 4.3 59.39 20.88 11.09 0.23
50.35 2.25 7.98 8.24 4.34 0.62
22.91 3.51 12.67 11.58 10.09 0.35
52.54 4.85 18.12 2.46 7.51 0.79
7.82 6.05 13.77 15.23 11.39 0.52
91.24 2.47 50.75 14.58 7.55 0.56
21.53 1.29 4.73 4.52 8.88 1.61
34.97 8.67 25.75 18.92 3.10 0.13
14.33 2.98 11.44 10.71 11.24 1.91
35.01 2.47 17.79 7.51 2.99 0.64

################################################################################
# Aggregate Surveys MRFSS CTCPUE NEFSC CTTRL
#################################################################################

#Number of No age comp surveys
4

#Survey time of year fractions
0.5 0.5 0.3333 0.3333

# Survey ages
3.13 2.13 2.09 2.04
```

```
#Aggregate Surveys Likelihood Weights
1 1 1 1

#Survey CVs
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 0.574 -1 -1
-1 0.453 -1 -1
-1 0.553 -1 1
-1 0.32 -1 1
-1 0.494 -1 1
-1 0.275 -1 0.40
0.79 0.268 -1 0.50
0.85 0.177 -1 0.33
0.77 0.165 -1 0.25
0.38 0.415 0.156 0.33
0.24 0.194 0.373 0.25
0.21 0.141 0.357 0.20
0.2 0.227 0.579 0.20
0.2 0.291 0.229 0.23
0.2 0.235 0.305 0.20
0.2 0.175 0.332 0.20
0.2 0.217 0.128 0.27
0.2 0.207 0.14 0.21
0.2 0.165 0.284 0.21
0.2 0.146 0.363 0.27
0.2 0.127 0.157 0.29
0.2 0.151 0.332 0.18
0.2 0.169 0.302 0.18
0.2 0.15 0.238 0.26
0.2 0.18 0.534 0.25

#Survey Indices, -1 for missing data
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 0.903 -1 -1
-1 0.751 -1 -1
-1 0.922 -1 0.022
-1 0.891 -1 0
-1 1.518 -1 0
-1 1.135 -1 0.053
0.362145961 1.361 -1 0.036
0.266005882 1.84 -1 0.063
0.24098429 2.203 -1 0.162
0.41409724 2.163 0.258 0.146
0.749170058 2.377 0.247 0.22
0.610929185 2.845 0.634 0.273
0.908054028 3.954 3.441 0.296
1.174633583 5.396 1.101 0.6
1.333341093 7.583 0.807 0.63
1.369797852 5.99 1.373 0.85
1.714551001 7.574 0.81 0.97
1.614670646 5.526 0.767 1.1
1.510928023 6.873 1.409 0.84
1.2616274 7.56 0.795 0.613
1.052792365 5.87 1.156 1.3
0.929391076 6.35 1.049 0.87
1.009113292 8.15 0.359 0.56
1.168405332 13.15470042 0.312 1.17
1.386671533 13.52818536 0.792 0.61
```

```
############################################################################
#Surveys with Age Data - NYOHS NJTRL MDAdults DESSN
############################################################################
#Number of Age surveys
4

#Survey time of year fractions
0.75 0.25 0.25 0.25

#Surveys Indices with Age Data Likelihood Weights
1 1 1 1

# Survey Age Comp Likelihood Weights
1 1 1 1

#Survey CVs
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 0.3 -1
-1 -1 0.3 -1
0.250804572 -1 0.25 -1
0.185277089 -1 0.25 -1
0.17721519 0.551 0.25 -1
0.285590278 0.607 0.25 -1
0.32486298 0.612 0.25 -1
0.407348243 0.449 0.25 -1
0.173025732 0.681 0.25 -1
0.73776908 0.482 0.25 -1
0.562797013 0.173 0.25 -1
0.184391737 0.752 0.25 0.190
0.260247235 0.327 0.25 0.232
0.25758645 0.229 0.25 0.250
0.4625 0.550 0.25 0.183
0.27466319 0.332 0.25 0.209
0.567319461 0.217 0.25 0.224
0.49045281 0.592 0.25 0.220
0.377706126 0.337 0.25 0.140
0.177619893 0.360 0.25 0.172
0.373695198 0.380 0.25 0.177
0.261588426 0.674 0.25 0.199

#Survey Indices, -1 for missing data
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 488.1 -1
-1 -1 1006.9 -1
90.11 -1 715.0 -1
60.45 -1 327.4 -1
21.33 0.280 395.9 -1
115.2 1.961 503.6 -1
200.7 2.461 460.8 -1
125.2 1.034 629.0 -1
45.08 1.083 625.3 -1
102.2 2.145 513.5 -1
147.3 7.165 461.8 -1
```

```
392.1 18.687 759.2 4.044
614.8 13.626 387.1 4.659
850.2 8.087 478.8 5.600
104 6.270 396.6 3.261
230.1 8.492 352.5 4.000
163.4 2.385 282.6 4.889
183.3 3.177 400.3 4.021
434.2 10.427 455.0 4.913
281.5 9.304 610.9 5.899
239.5 9.360 500.3 3.908
338.7 3.951 505.8 5.333

# Age Samples for Age Comps - (Survey (column) sample size (row))
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 -1 -1
-1 -1 77 -1
-1 -1 77 -1
56 -1 77 -1
56 -1 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 -1
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
56 23 77 87
# Age Comp Data for Surveys: Ages 1-13 must be present
#NYOHS
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.0318 0.1949 0.3591 0.2787 0.0883 0.0349 0.0067 0.0017 0 0.0006 0 0.0028
-1 0.2255 0.2687 0.1945 0.166 0.0851 0.0218 0.0144 0.0039 0.0021 0.0007 0 0.0137
-1 0.1833 0.269 0.1478 0.1596 0.1025 0.0936 0.0217 0.003 0.002 0.003 0.002 0.0108
-1 0.0608 0.2957 0.3063 0.1139 0.0985 0.0557 0.0444 0.0158 0.0058 0.001 0 0.0023
-1 0.207 0.3666 0.2439 0.0519 0.0166 0.0253 0.0416 0.023 0.0063 0.002 0.0036 0.0115
-1 0.0792 0.4166 0.2577 0.1211 0.0329 0.0143 0.017 0.025 0.0175 0.0032 0.0058 0.0096
-1 0.1563 0.3868 0.2908 0.0701 0.0328 0.0094 0.009 0.0115 0.0131 0.007 0.0025 0.0082
-1 0.141 0.2705 0.1562 0.1346 0.0832 0.0546 0.0375 0.0222 0.0406 0.0127 0.0241 0.0203
-1 0.245 0.2695 0.2542 0.072 0.0658 0.0352 0.0123 0.0054 0.0123 0.0115 0.0031 0.0084
-1 0.0832 0.7475 0.1142 0.0328 0.0094 0.0073 0.0027 0.0013 0.0007 0 0.0005 0.0003
-1 0.2063 0.2425 0.4508 0.0669 0.0184 0.0037 0.0037 0.0039 0.0017 0.0007 0.0009 0.0006
-1 0.1876 0.2969 0.1714 0.2855 0.0366 0.0091 0.0058 0.0029 0.0002 0.001 0.0015 0.0011
```

```
-1 0.0697 0.6277 0.1722 0.0594 0.0438 0.005 0.0032 0.0046 0.0035 0.0039 0.0007 0.0046
-1 0.1273 0.193 0.4338 0.1541 0.0364 0.0368 0.0041 0.0039 0.0016 0.0018 0.001 0.0044
-1 0.0524 0.4553 0.1474 0.2129 0.0735 0.0274 0.0194 0.0032 0.0039 0.0011 0 0.0025
-1 0.3225 0.2261 0.1843 0.0805 0.0735 0.0572 0.0198 0.0198 0.0013 0.0048 0.0018 0.0057
-1 0.2022 0.3647 0.1251 0.0922 0.0406 0.0646 0.0506 0.0227 0.0177 0.0126 0.0009 0.0049
-1 0.0501 0.5698 0.2734 0.0628 0.0222 0.0076 0.0061 0.0036 0.0011 0.0014 0.0017 0.0002
-1 0.2444 0.1280 0.4126 0.1370 0.0336 0.0138 0.0035 0.0090 0.0065 0.0035 0.0037 0.0045
-1 0.0639 0.6359 0.0728 0.1610 0.0424 0.0144 0.0057 0.0025 0.0003 0.0010 0.0000 0.0000
 #NJTRL
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.278 0.444 0.006 0.137 0.052 0.011 0.016 0 0.056 0 0 0
-1 0.061 0.182 0.02 0.414 0.132 0.029 0.097 0.005 0.061 0 0 0
-1 0.277 0.284 0.021 0.02 0.148 0.132 0.017 0.034 0.046 0.021 0 0
-1 0.258 0.478 0.061 0.064 0.055 0.074 0.01 0 0 0 0 0
-1 0.238 0.353 0.15 0.087 0.123 0.024 0.025 0 0 0 0 0
-1 0.287 0.37 0.155 0.09 0.048 0.031 0.01 0.009 0 0 0 0
-1 0.658 0.172 0.067 0.045 0.032 0.012 0.007 0.004 0.003 0 0 0
-1 0.162 0.58 0.16 0.061 0.021 0.013 0.004 0 0 0 0 0
-1 0.187 0.409 0.236 0.113 0.035 0.012 0.005 0.001 0.003 0 0 0
-1 0.442 0.193 0.043 0.13 0.086 0.054 0.025 0.014 0.011 0.002 0.001 0
-1 0.077 0.32 0.181 0.256 0.115 0.032 0.011 0.005 0.003 0 0.001 0
-1 0.152 0.14 0.157 0.274 0.167 0.073 0.027 0.006 0.002 0.001 0 0
-1 0.148 0.167 0.199 0.299 0.103 0.042 0.023 0.013 0.006 0.001 0 0
-1 0.005 0.023 0.071 0.206 0.359 0.23 0.076 0.024 0.004 0 0 0
-1 0.304 0.238 0.041 0.126 0.097 0.122 0.049 0.015 0.006 0.001 0.001 0
-1 0.182 0.519 0.09 0.04 0.058 0.043 0.036 0.021 0.008 0.004 0.001 0
-1 0.493 0.218 0.061 0.106 0.047 0.042 0.019 0.009 0.002 0.002 0.000 0.001
-1 0.061 0.100 0.055 0.248 0.256 0.100 0.069 0.046 0.045 0.013 0.007 0.001
#MD SSN
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.288 0.626 0.065 0.010 0.003 0.005 0.000 0.001 0.000 0.000 0.001 0.002
-1 0.229 0.259 0.494 0.004 0.005 0.002 0.003 0.003 0.000 0.000 0.000 0.001
-1 0.199 0.361 0.161 0.246 0.025 0.003 0.004 0.000 0.000 0.000 0.000 0.001
-1 0.125 0.237 0.218 0.174 0.228 0.004 0.000 0.000 0.013 0.000 0.000 0.001
-1 0.084 0.391 0.203 0.115 0.123 0.083 0.000 0.000 0.000 0.000 0.000 0.000
-1 0.155 0.314 0.239 0.096 0.068 0.064 0.059 0.002 0.000 0.000 0.001 0.002
-1 0.159 0.415 0.135 0.102 0.058 0.057 0.042 0.023 0.001 0.003 0.000 0.005
-1 0.043 0.352 0.244 0.093 0.111 0.068 0.046 0.022 0.011 0.005 0.000 0.004
-1 0.065 0.211 0.299 0.141 0.082 0.083 0.059 0.036 0.012 0.005 0.001 0.005
-1 0.052 0.202 0.191 0.230 0.116 0.066 0.084 0.034 0.017 0.006 0.002 0.001
-1 0.108 0.254 0.146 0.132 0.112 0.087 0.054 0.043 0.025 0.021 0.008 0.010
-1 0.005 0.485 0.135 0.046 0.092 0.085 0.056 0.047 0.022 0.020 0.006 0.002
-1 0.105 0.120 0.348 0.119 0.056 0.051 0.067 0.058 0.032 0.031 0.010 0.005
-1 0.075 0.298 0.068 0.312 0.067 0.028 0.039 0.036 0.031 0.019 0.021 0.005
-1 0.018 0.439 0.202 0.143 0.089 0.029 0.017 0.028 0.013 0.013 0.007 0.003
-1 0.029 0.144 0.305 0.143 0.165 0.077 0.040 0.023 0.023 0.022 0.014 0.016
-1 0.017 0.138 0.185 0.183 0.082 0.101 0.134 0.047 0.042 0.035 0.020 0.017
-1 0.241 0.104 0.096 0.208 0.085 0.075 0.079 0.057 0.019 0.010 0.013 0.014
-1 0.039 0.242 0.105 0.082 0.135 0.125 0.068 0.060 0.076 0.022 0.023 0.024
```

```
-1 0.051 0.293 0.199 0.067 0.054 0.072 0.076 0.061 0.043 0.045 0.013 0.025
-1 0.135 0.211 0.148 0.194 0.049 0.052 0.043 0.055 0.041 0.035 0.023 0.015
-1 0.017 0.526 0.082 0.097 0.060 0.030 0.025 0.037 0.043 0.026 0.021 0.037
 #DE SSN
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
-1 0.006 0.417 0.192 0.061 0.085 0.076 0.064 0.058 0.015 0.009 0.009 0.009
-1 0.093 0.074 0.391 0.137 0.051 0.064 0.073 0.032 0.03 0.023 0.009 0.023
-1 0.04 0.087 0.098 0.347 0.09 0.061 0.105 0.095 0.034 0.025 0.008 0.011
-1 0 0.105 0.144 0.177 0.235 0.072 0.054 0.076 0.058 0.051 0.014 0.014
-1 0.036 0.036 0.21 0.171 0.138 0.223 0.066 0.03 0.039 0.032 0.01 0.01
-1 0.006 0.115 0.1 0.185 0.11 0.14 0.2 0.05 0.015 0.04 0.02 0.02
-1 0.034 0.071 0.191 0.178 0.157 0.113 0.089 0.097 0.026 0.016 0.01 0.018
-1 0.02 0.097 0.097 0.134 0.089 0.111 0.125 0.105 0.121 0.034 0.028 0.038
-1 0.007 0.166 0.231 0.098 0.068 0.054 0.112 0.078 0.081 0.044 0.014 0.047
-1 0.096 0.157 0.168 0.198 0.081 0.046 0.03 0.036 0.061 0.036 0.046 0.046
-1 0.059 0.201 0.097 0.141 0.141 0.071 0.052 0.041 0.048 0.048 0.037 0.063
#########################Catch Weight-at-age############################################
0.13 0.64 1.09 1.54 2.42 3.75 4.83 5.79 6.2 8.68 10.8 11.2 14.05
0.2 0.55 0.94 1.37 2.37 3.29 3.77 5.36 6.01 8.1 9.57 10.39 11.11
0.24 0.6 1.69 1.62 2.67 3.39 5.07 5.65 6.76 7.76 8.41 12.65 12.38
0.06 0.61 1.07 1.66 2.19 3.59 4.91 5.46 6.77 7.45 9 10.69 13.91
0.14 0.57 1.27 2.4 2.44 3.12 3.95 5.05 5.44 6.09 7.75 9.16 12.78
0.2 0.77 1.41 2.11 2.5 2.91 3.61 4.74 5.52 6.49 7.77 9.78 13.15
0.31 0.91 1.1 1.98 3.12 4.02 4.38 4.7 5.24 5.62 8.58 10.4 13.27
0.16 0.83 1.22 2.23 3.06 4.53 5.37 6.23 6.04 8.68 8.94 9.74 13.36
0.08 0.89 1.14 2.05 2.35 3.83 4.91 5.96 5.7 5.97 7.44 9.08 12.6
0.21 0.92 1.29 2.17 2.62 3.17 4.81 5.64 6.46 6.24 9.46 8.3 14.22
0.1 0.69 1.31 1.93 2.81 3.67 4.9 5.79 6.96 8.15 9.77 12.44 13.97
0.07 0.76 1.31 1.99 2.77 3.58 4.8 6.11 7.03 8.01 9.53 10.76 14.55
0.24 1.05 1.69 2.21 2.85 3.5 4.94 6.2 6.8 7.53 9.73 10.69 12.73
0.28 0.7 1.35 2.18 2.77 3.65 5.38 6.16 7.27 8.86 7.57 9.73 16.66
0.14 1.05 1.47 2.32 3.23 4.52 6.39 7.11 7.81 9.2 9.31 10.1 13.7
0.13 0.62 1.18 2.46 2.81 3.64 4.51 5.07 6.73 9.17 9.94 10.24 14.78
0.39 0.77 1.2 1.62 2.25 2.95 4.69 5.66 6.82 7.03 7.76 9.87 11.87
0.62 0.9 1.11 1.44 1.91 2.51 3.36 5.03 6.56 7.85 8.69 9.76 11.98
0.37 0.55 1.1 1.45 1.96 2.79 3.89 5.09 7.11 7.37 9.7 10.7 13.55
0.16 0.38 1.12 1.75 2.21 3.25 4.12 5.02 6.36 7.79 8.65 8.29 10.87
0.12 0.31 1.06 1.51 2.18 3.17 4.19 5.48 6.03 7.56 9.09 9.75 11.52
0.1 0.6 1 1.4 2.2 3.2 4.1 5.2 6.1 7.2 8.5 9.4 11
0.23 0.33 0.84 1.4 2.43 3.11 4.14 5.17 6.07 7.12 8.18 9.03 10.71
0.1 0.6 1.0 1.6 2.2 3.2 4.0 5.6 6.2 6.7 8.0 8.9 11.7
0.2 0.5 0.8 1.3 2.0 2.8 4.1 4.9 6.2 7.0 8.1 9.0 11.1
#####Maturity-at-age###########################################
0 0 0 0.04 0.13 0.45 0.89 0.94 1 1 1 1 1
####Proportion of Natural Mortality Before Spawning############
0.33
####Proportion of Fishing Mortality Before Spawning############
0.1
####Natural Mortality##########################################
0.15
####Recruitment dev weight#####################################
1
####F dev weight###############################################
```

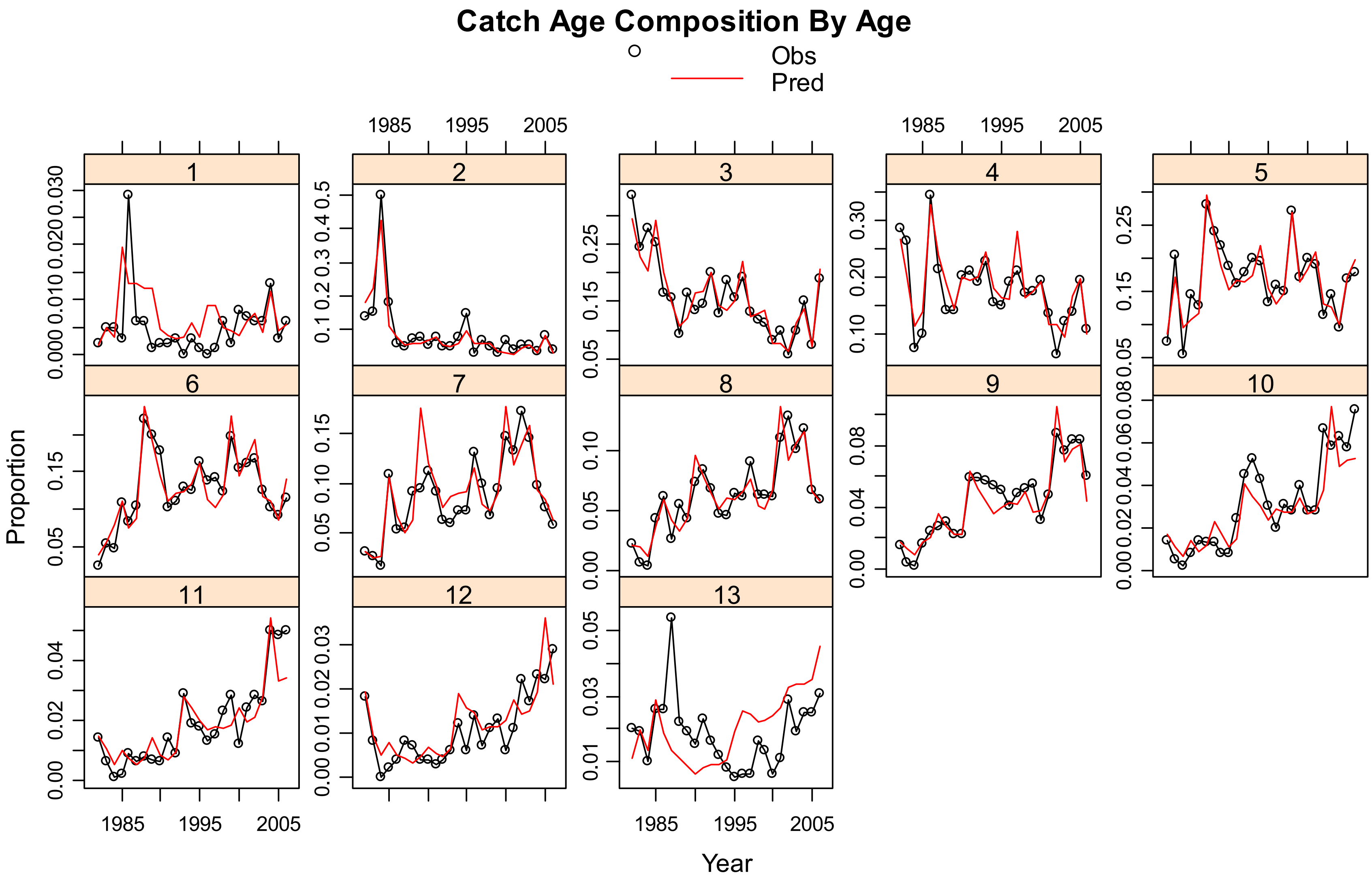



Figure 1. Plots of observed and predicted catch proportions-at-age by age

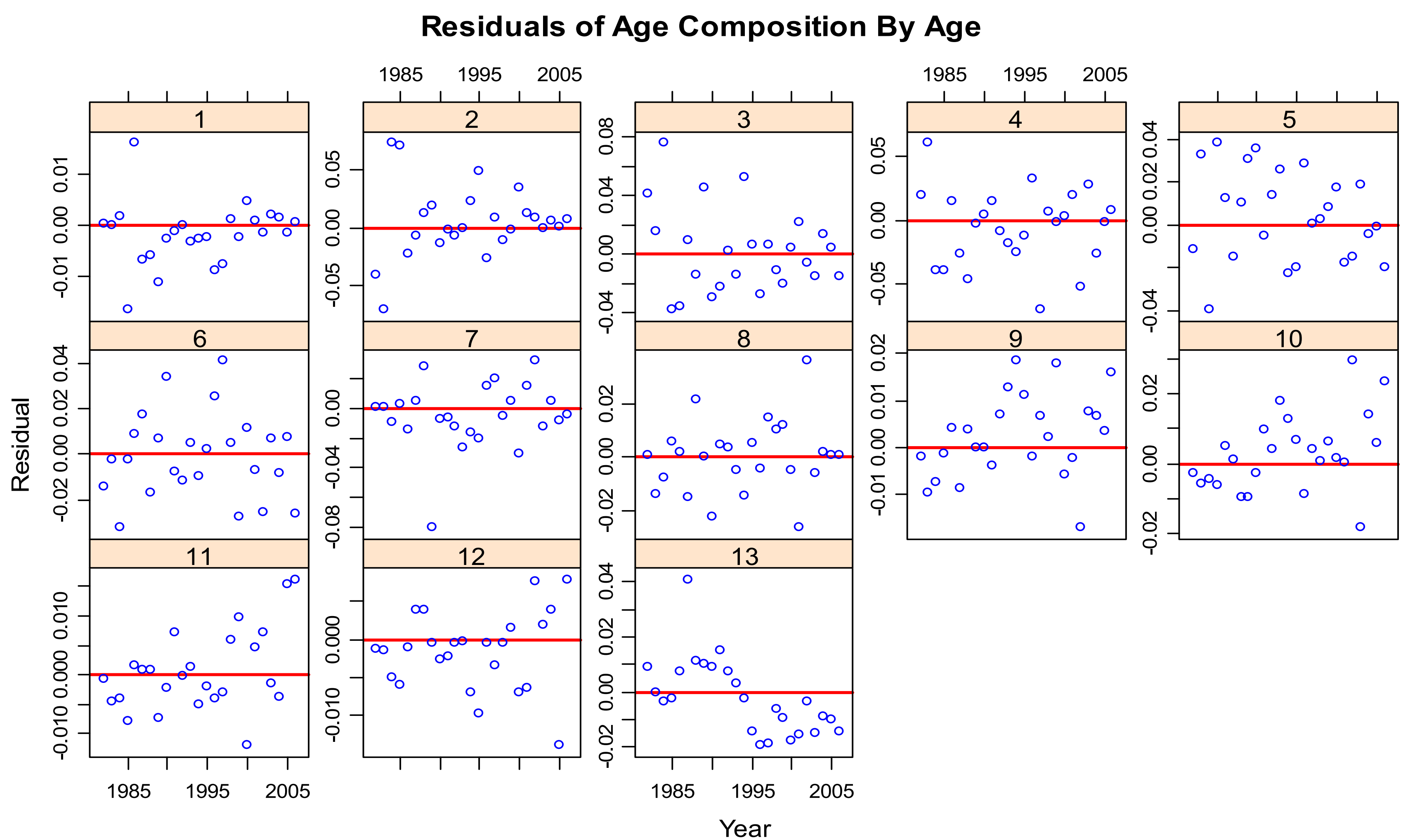



Figure 2. Residuals of catch proportions-at-age by age.

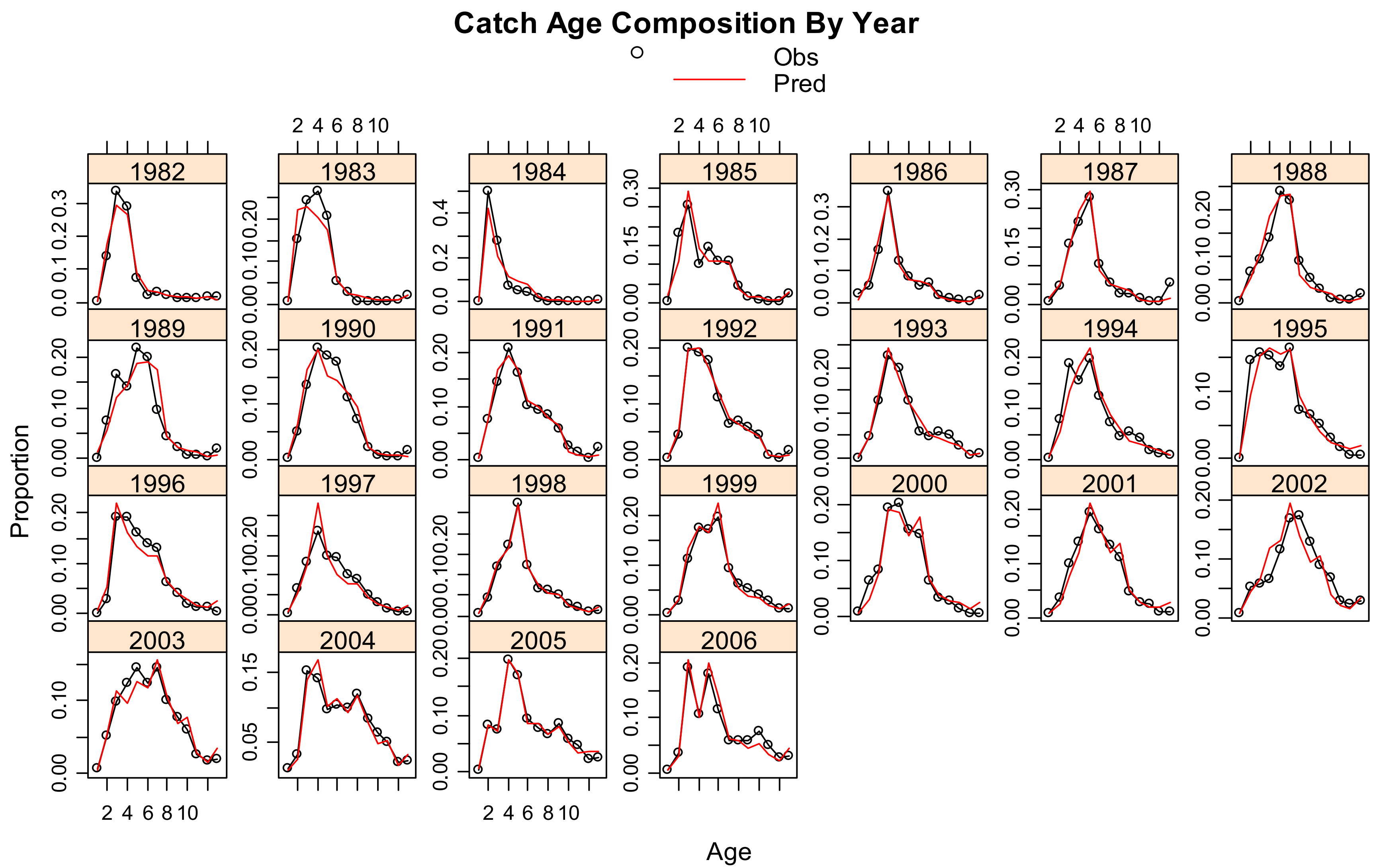



Figure 3. Observed and predicted catch proportions-at-age by year.

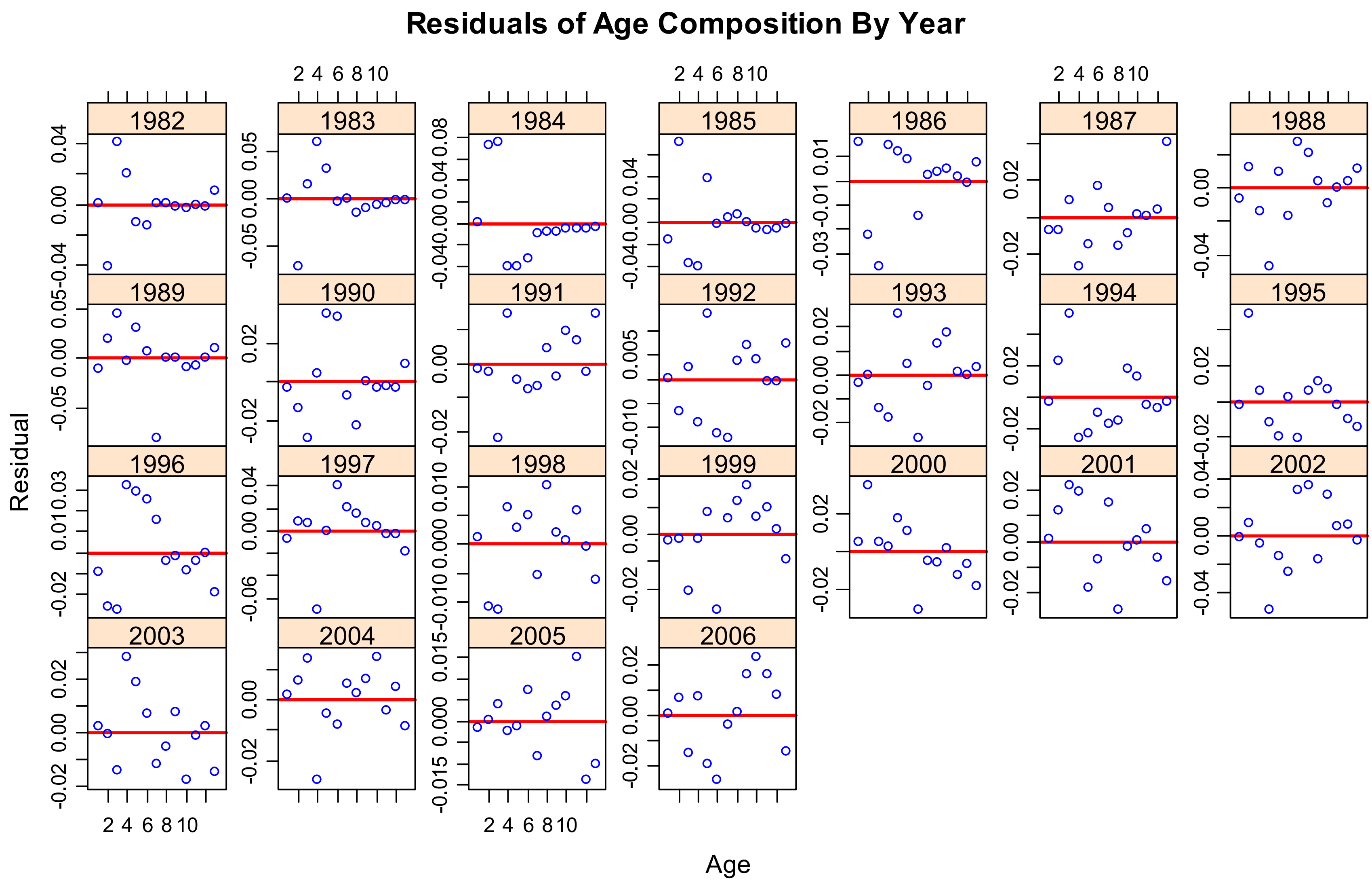



Figure 4. Residuals of catch proportions-at-age by year.

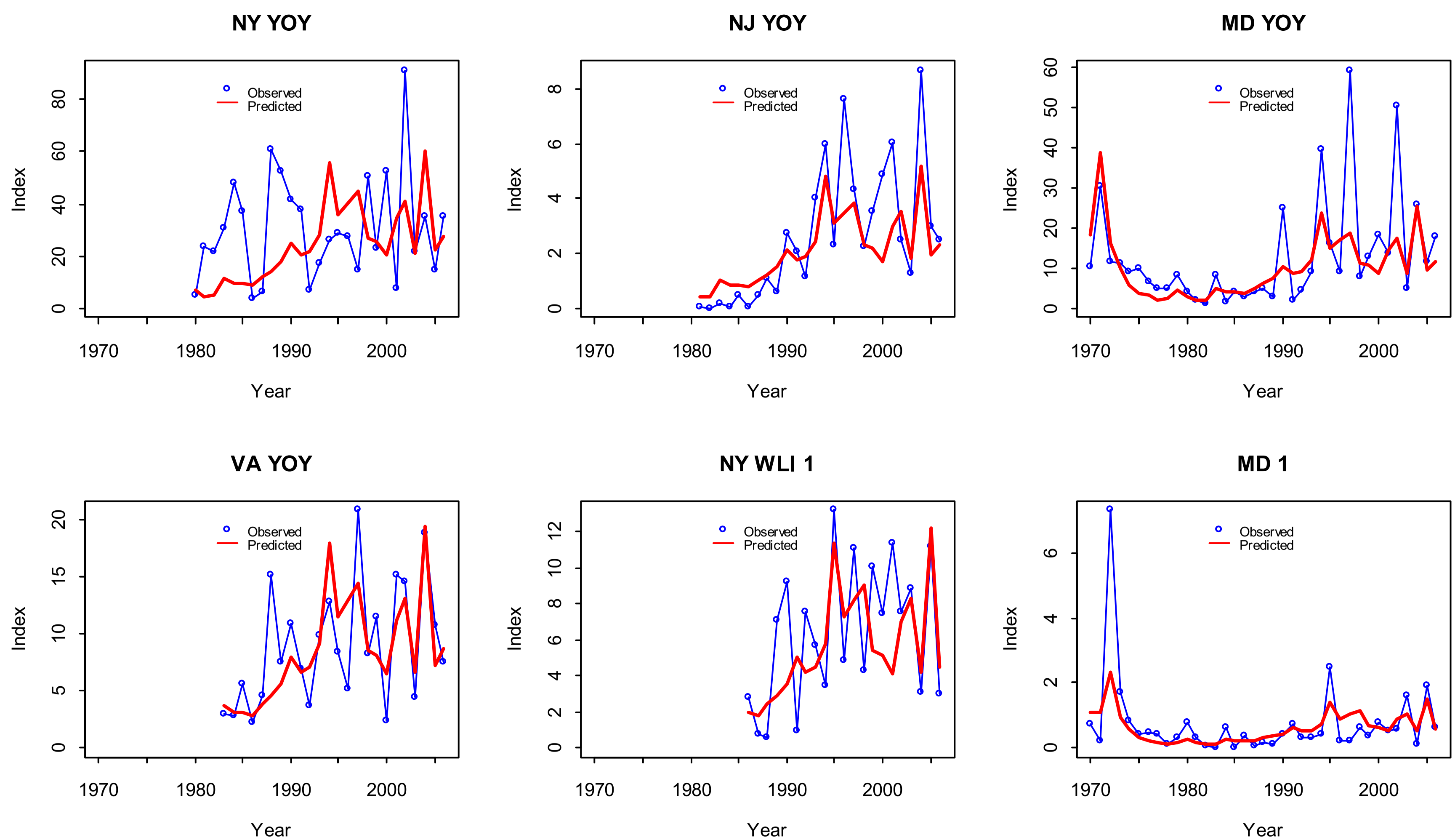



Figure 5. Young-of-the-year and yearling surveys tuned to Age 1 and 2, respectively.

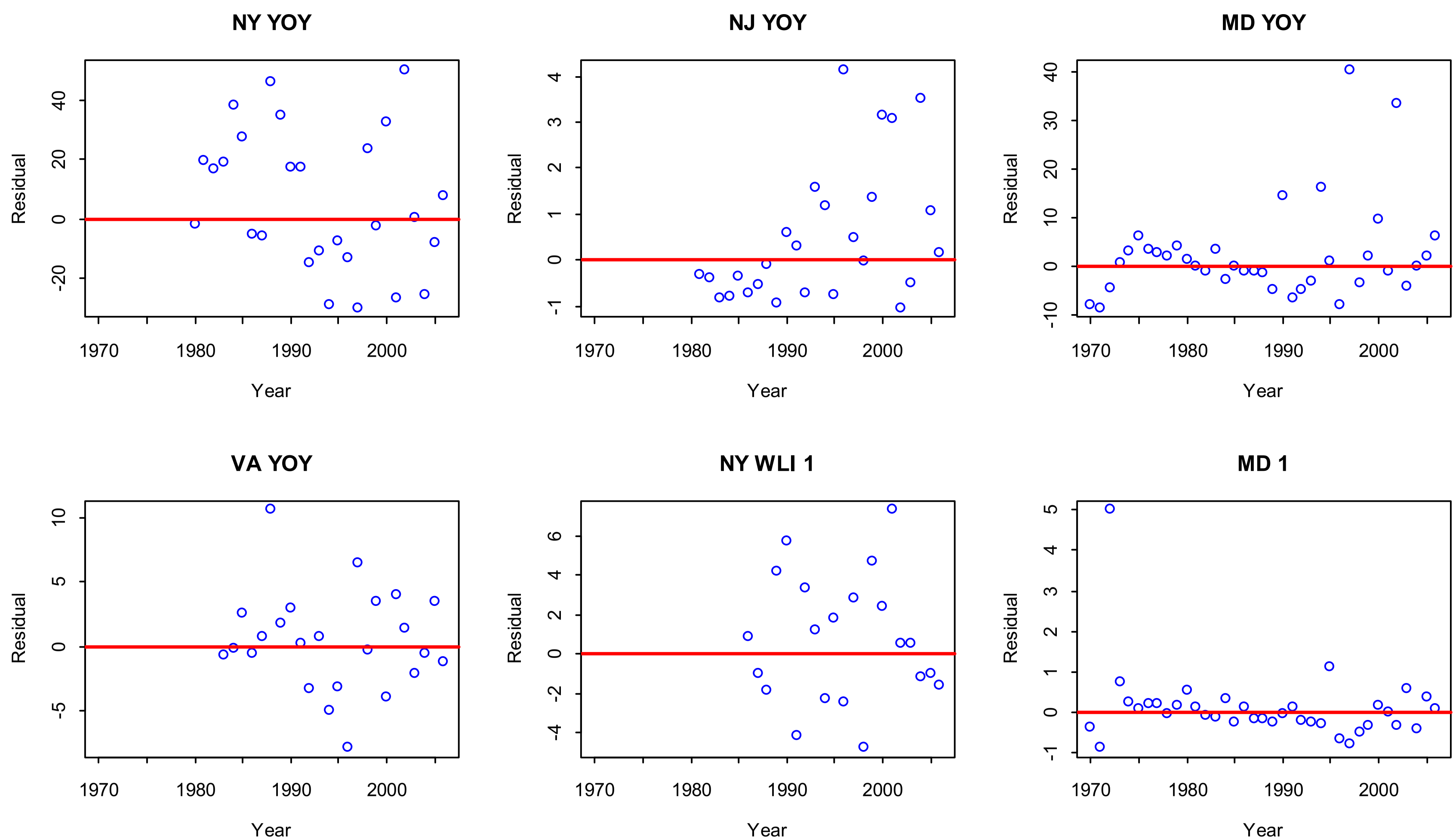



Figure 6. Residuals (observed-predicted) for young-of-the-year and yearling surveys.

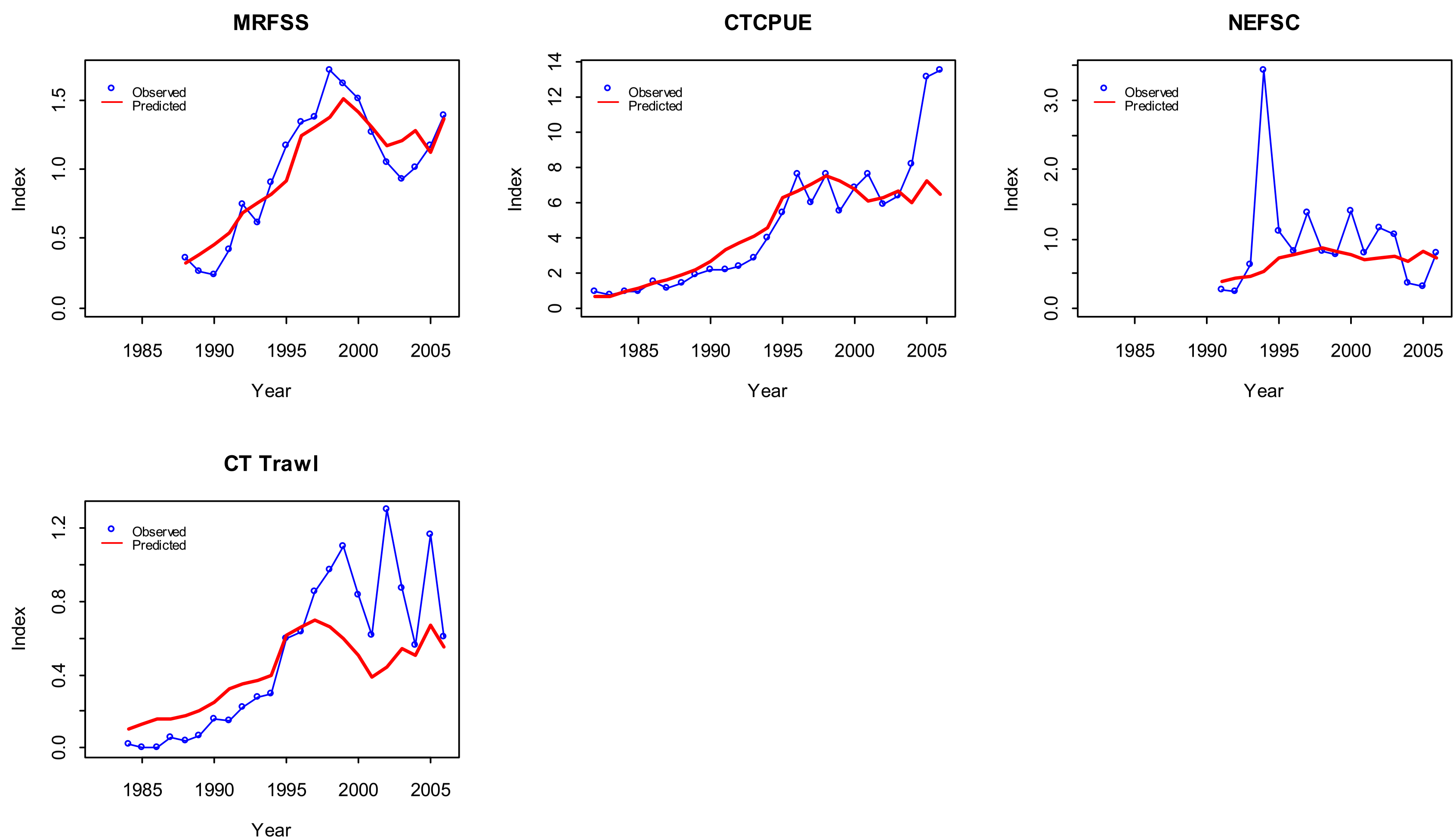



Figure 7. Observed and predicted aggregate indices.

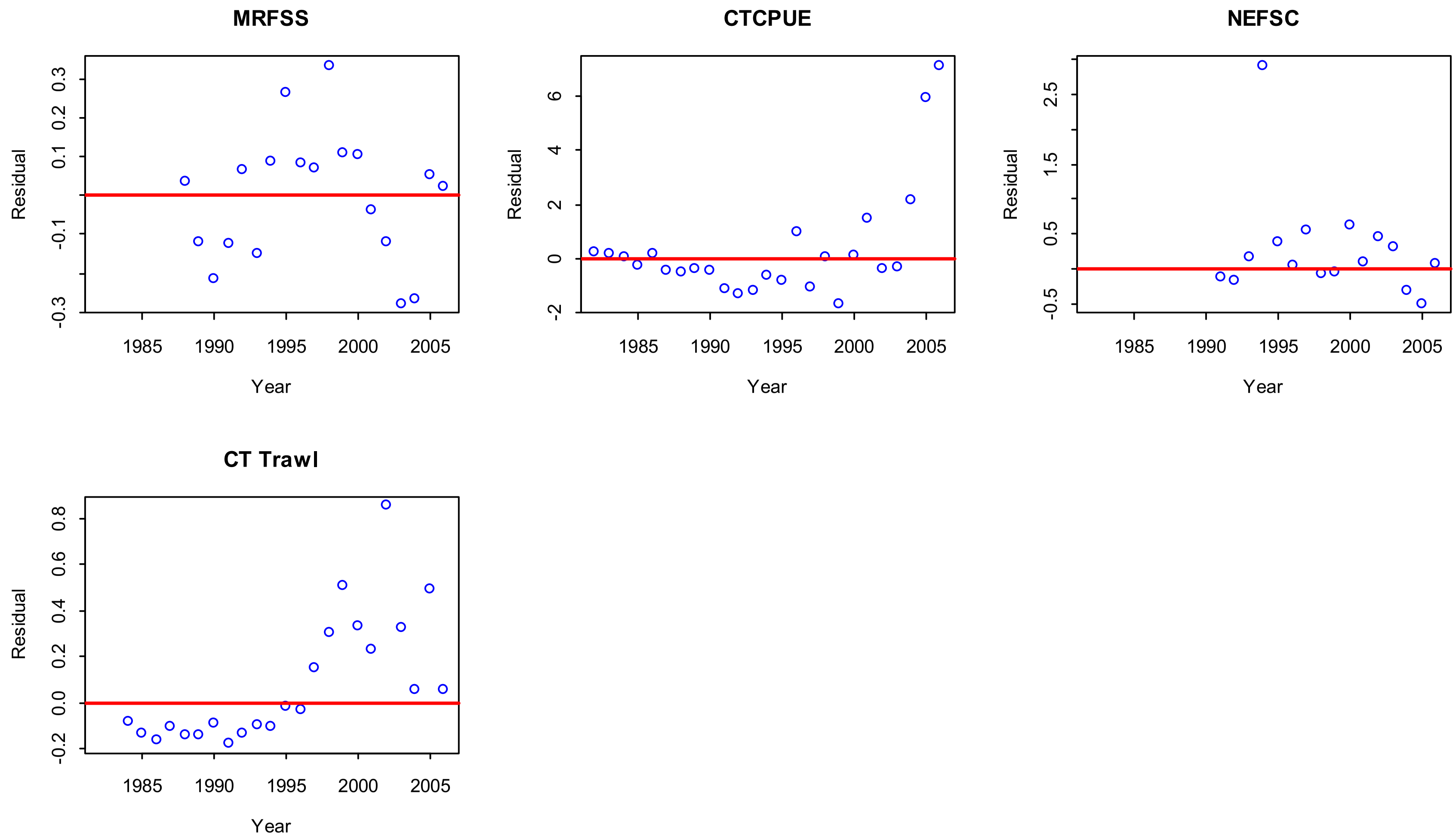



Figure 8. Residuals for aggregate indices.

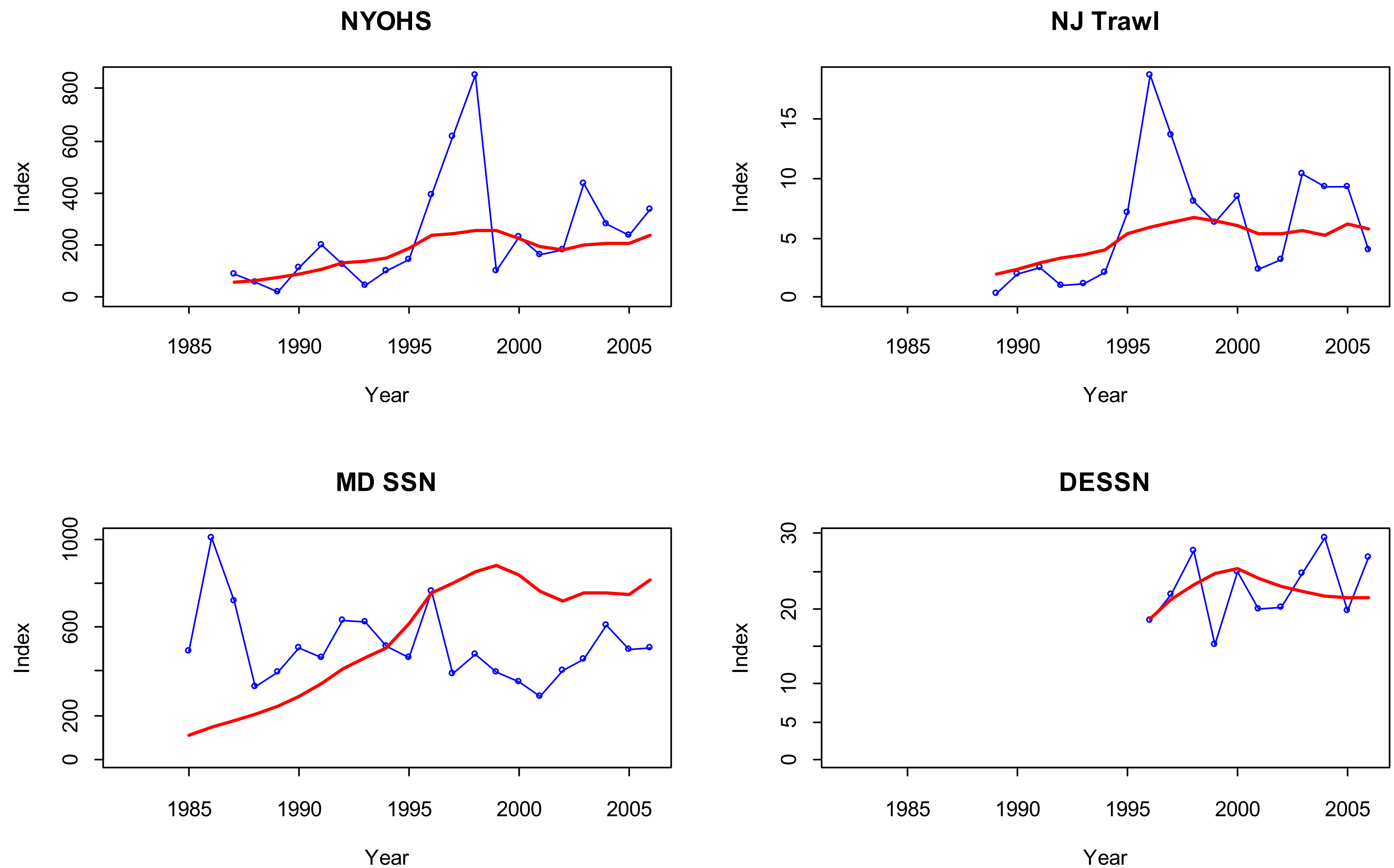



Figure 9. Observed (blue) and predicted (red) aggregate indices for surveys with age composition data.

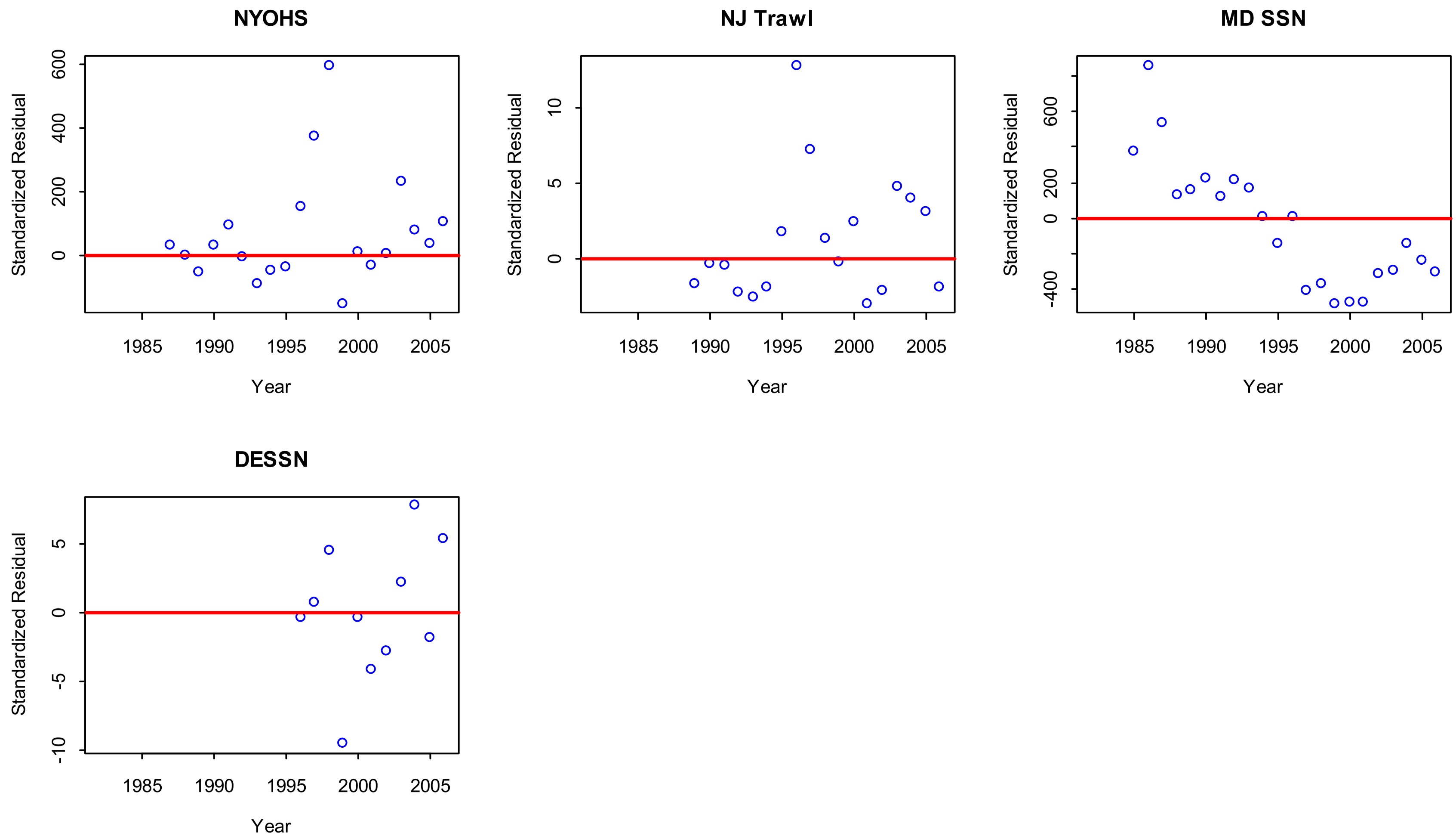



Figure 10. Residuals for aggregate indices with age composition data.

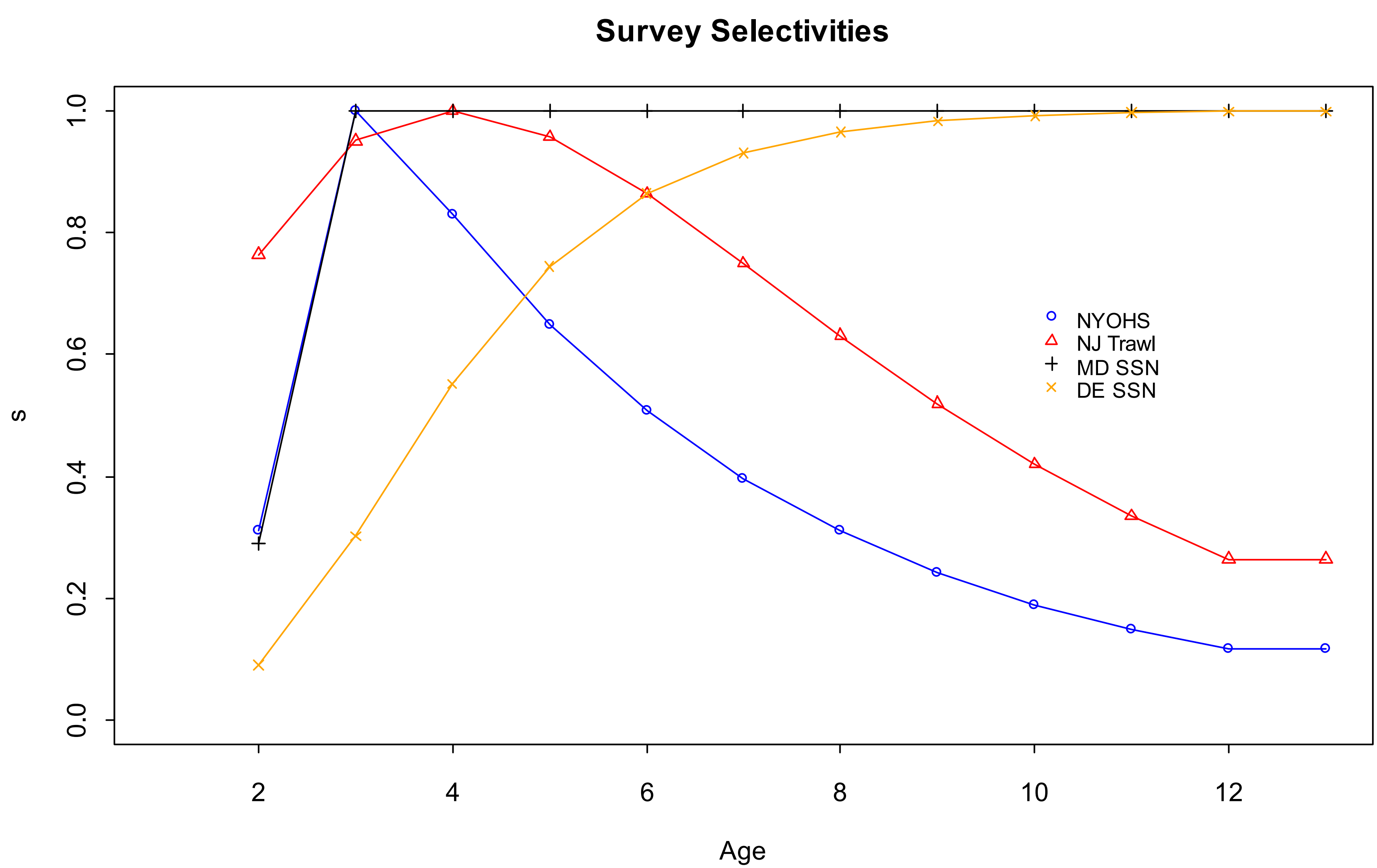



Figure 11. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD SSN, and DE SSN surveys.

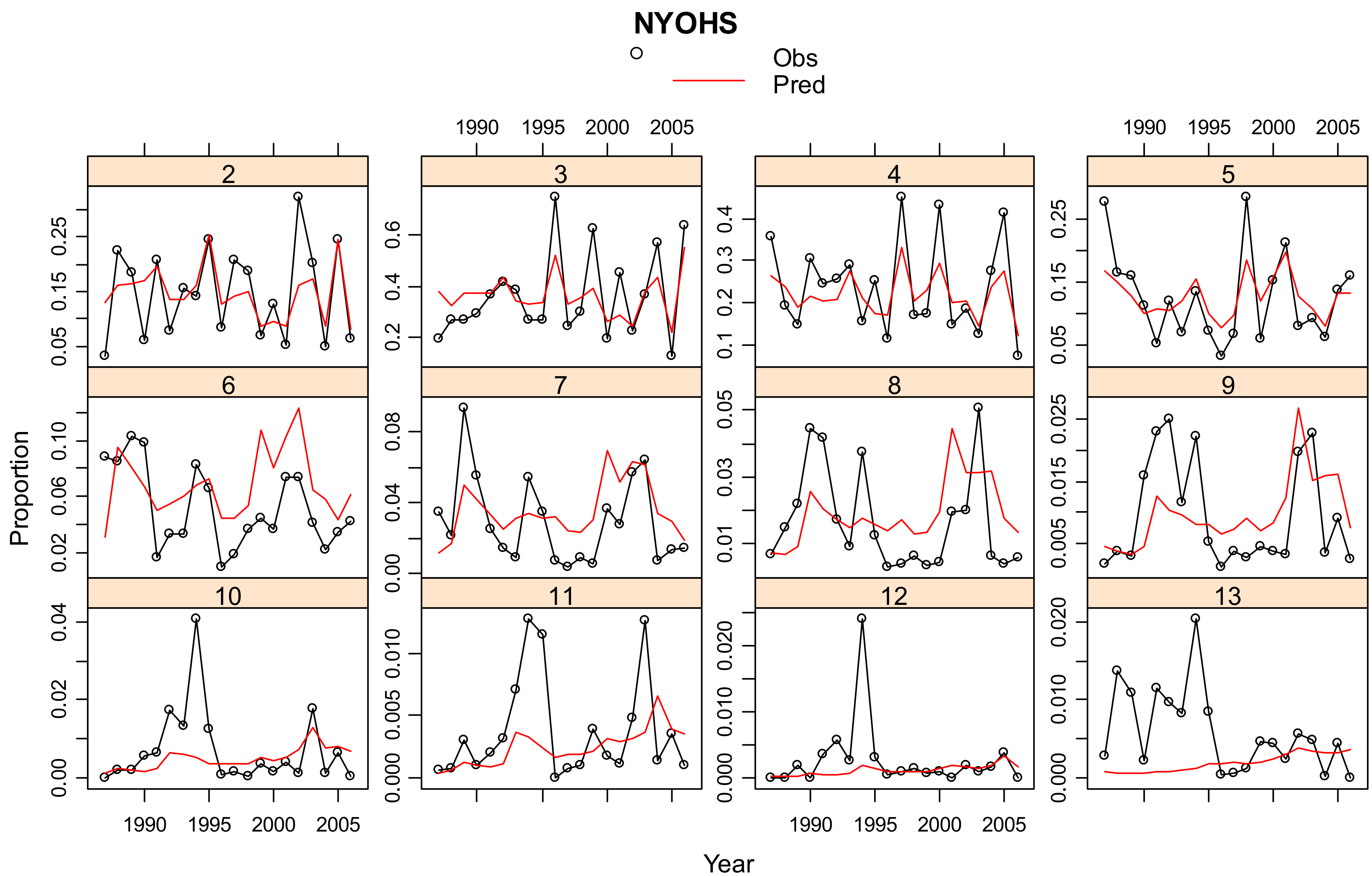



Figure 12. Observed and predicted proportions-at-age for each year by age for the NYOHS survey.

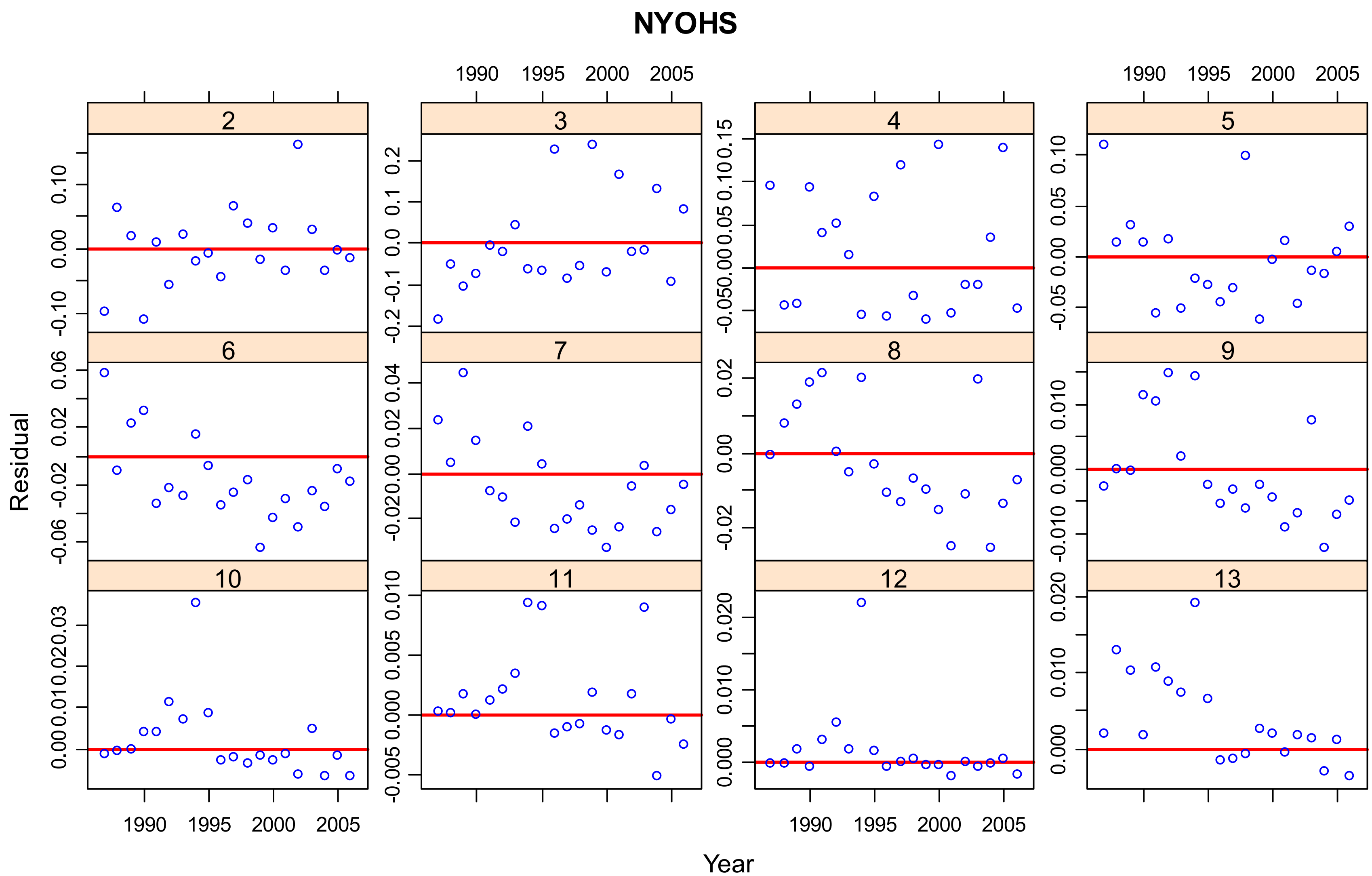


Figure 13. Residuals of proportions-at-age in each year by age for the NYOHS survey.

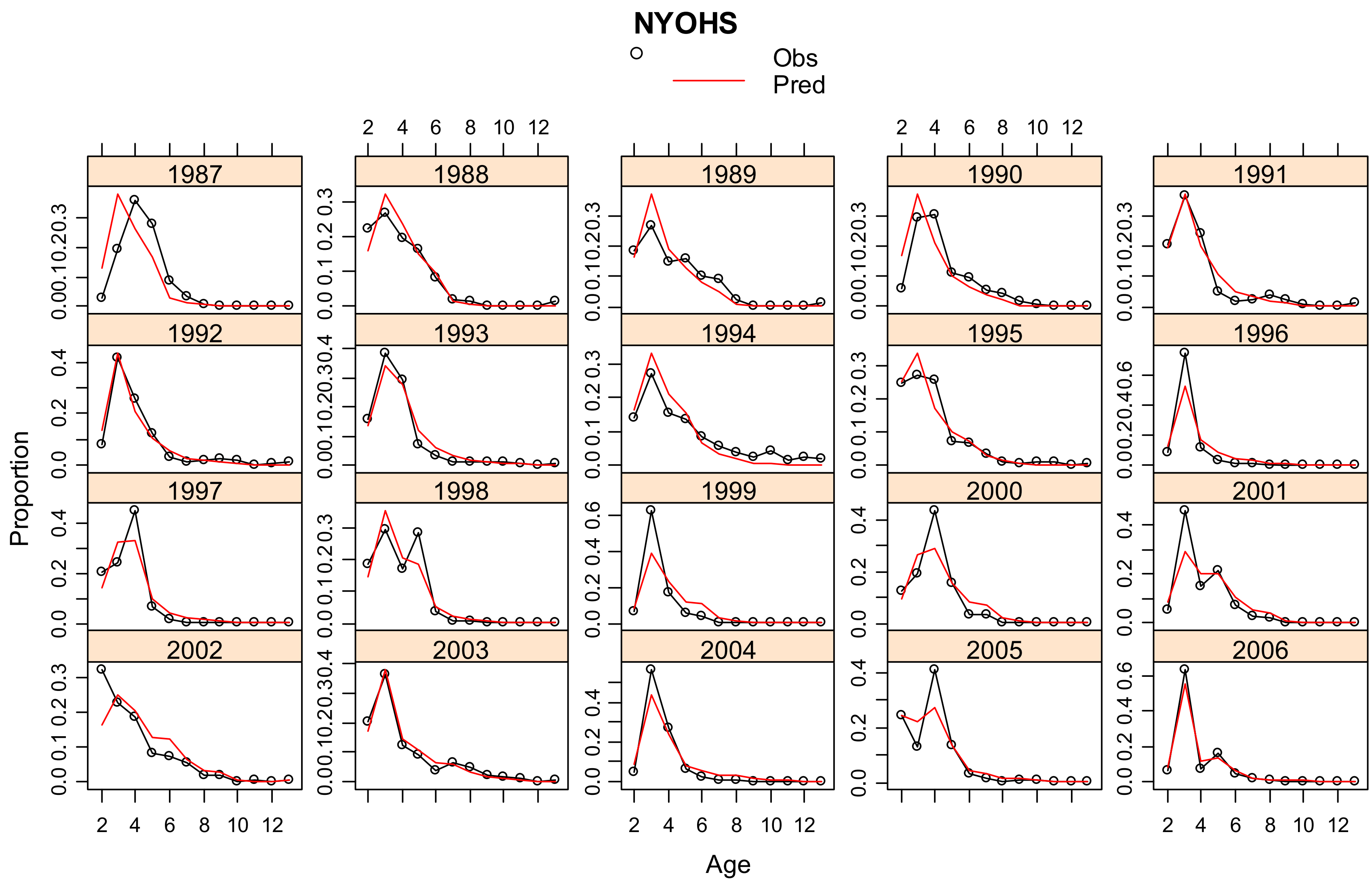



Figure 14. Observed and predicted proportions-at-age for each age by year for the NYOHS survey.

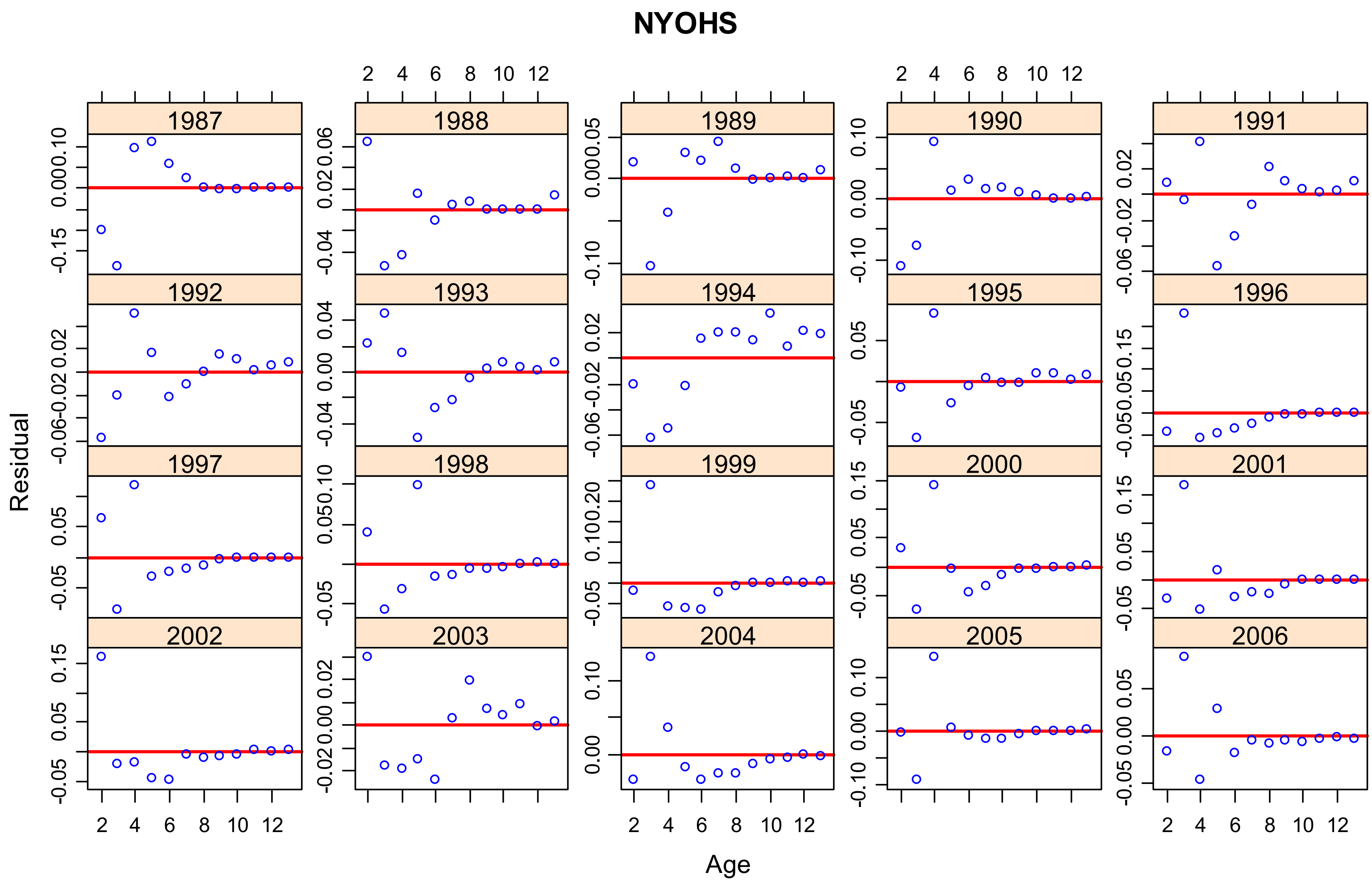



Figure 15. Residuals of proportions-at-age for each age by year for the NYOHS survey.

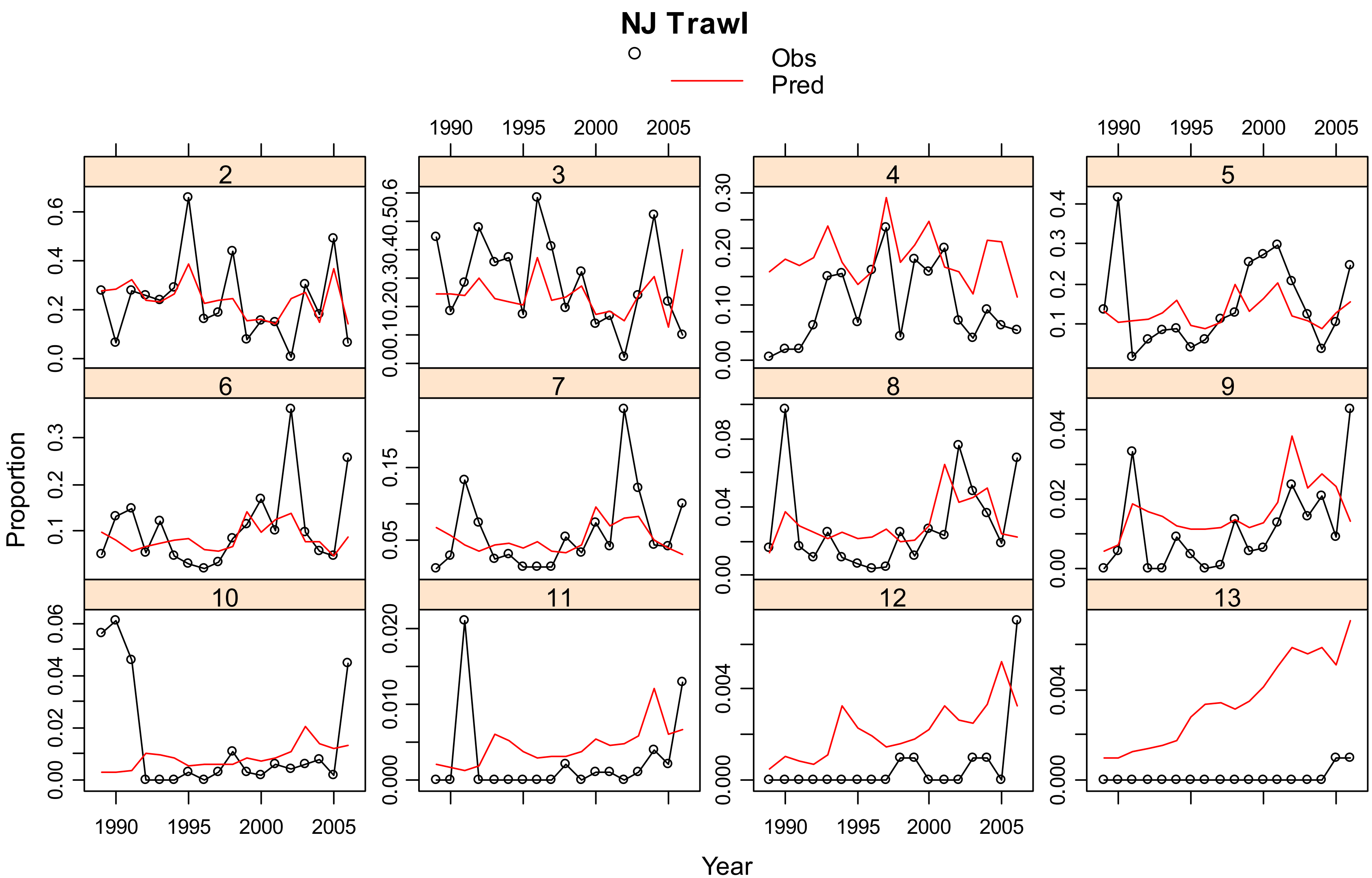



Figure 16. Observed and predicted proportions-at-age for each year by age for the NJ Trawl survey.

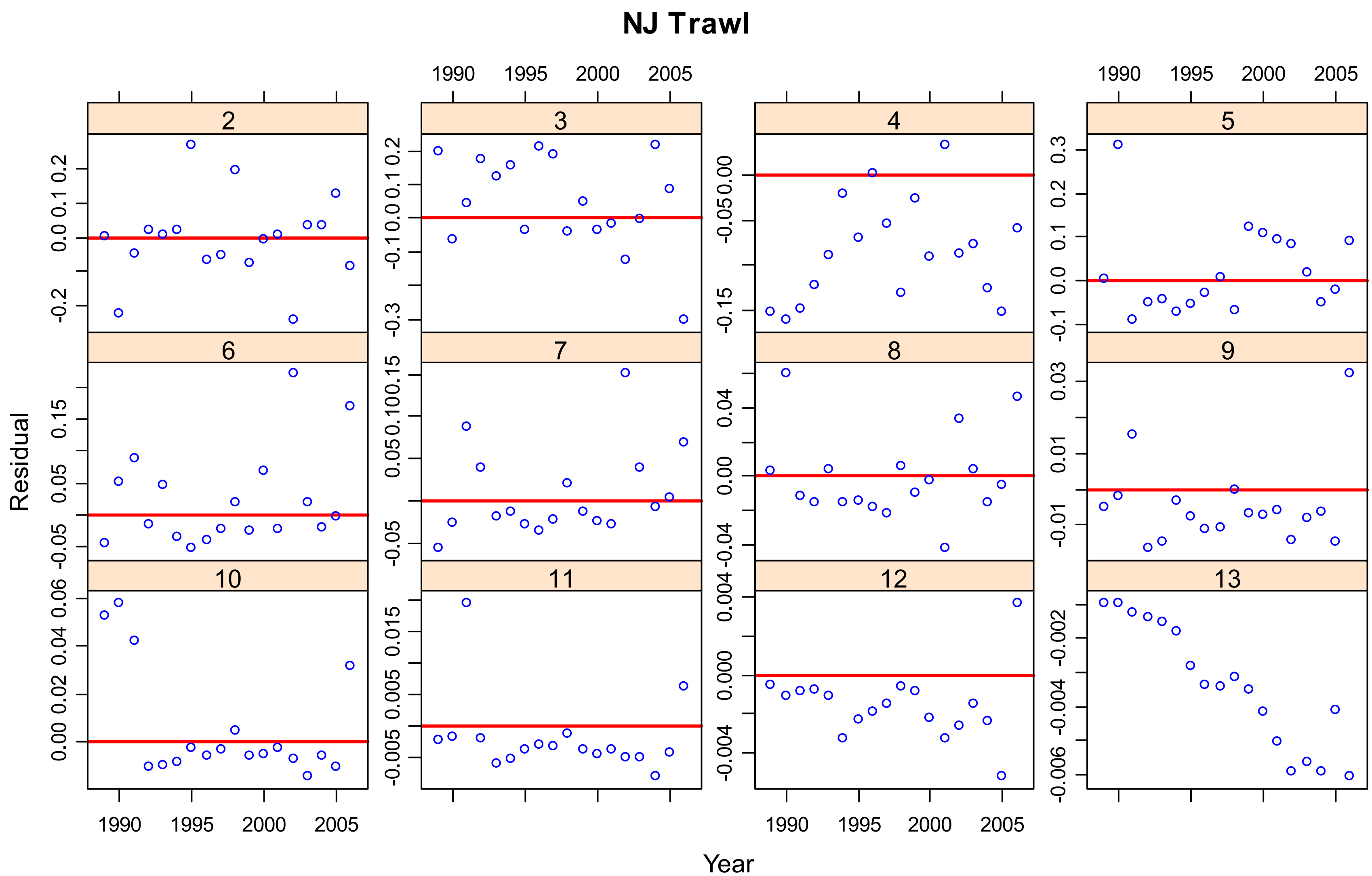



Figure 17. Residuals of proportions-at-age for each year by age for the NJ Trawl survey.

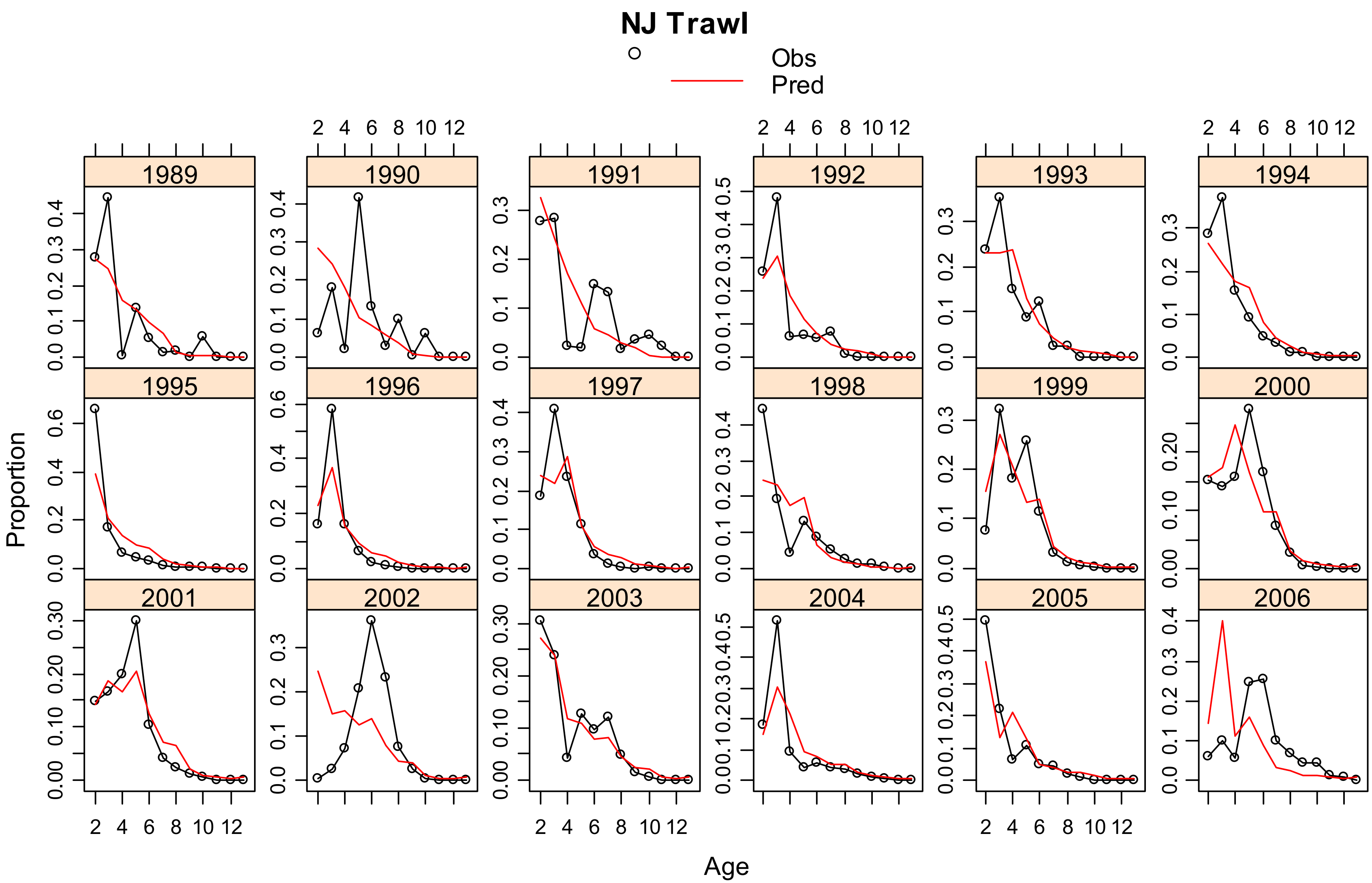


Figure 18. Observed and predicted proportions-at-age for each age by year for the NJ Trawl survey.

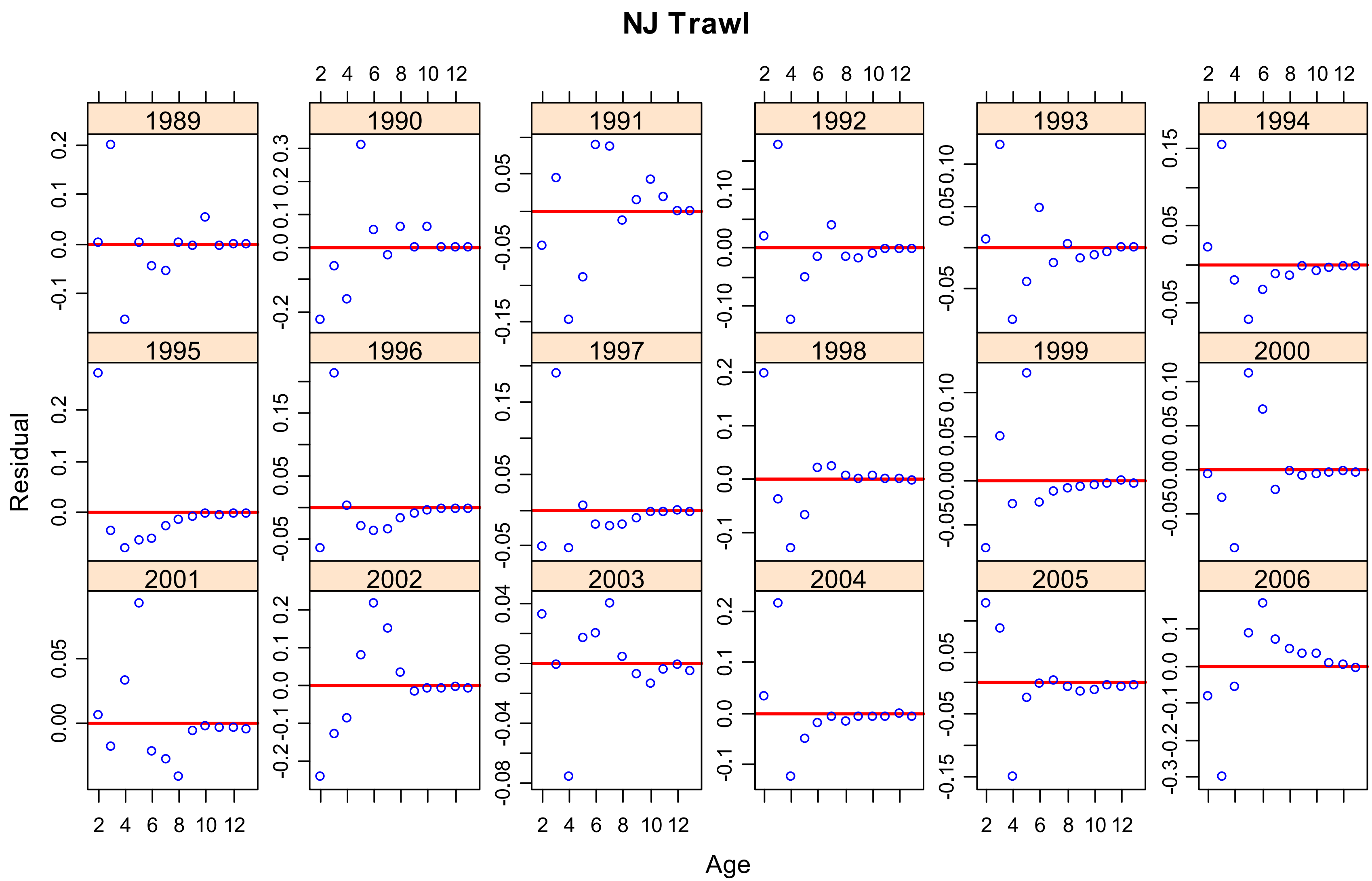



Figure 19. Residuals of proportions-at-age for each age by year for the NJ Trawl survey.

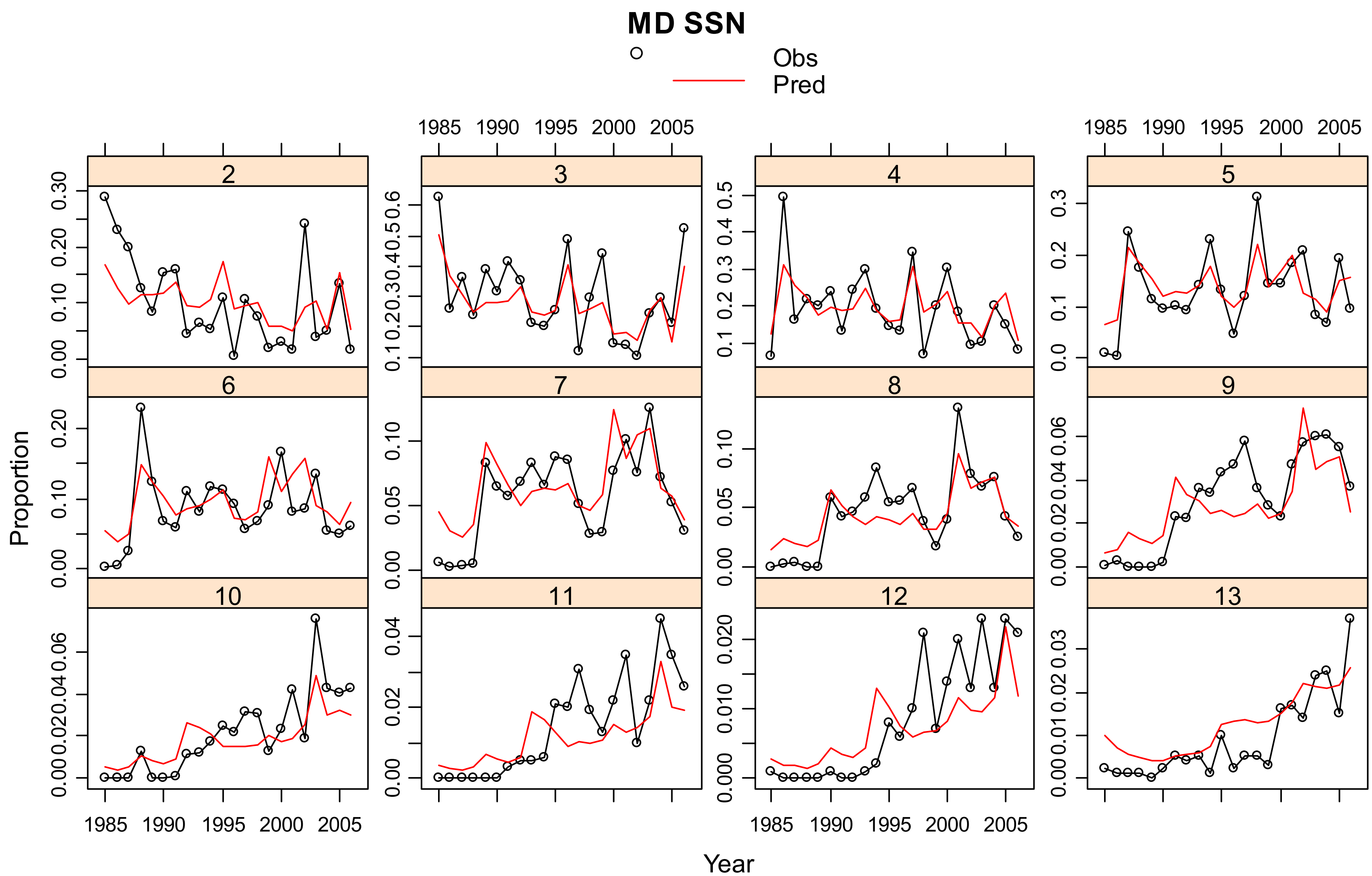



Figure 20. Observed and predicted proportions-at-age for each year by age for the MD SSN gillnet survey.

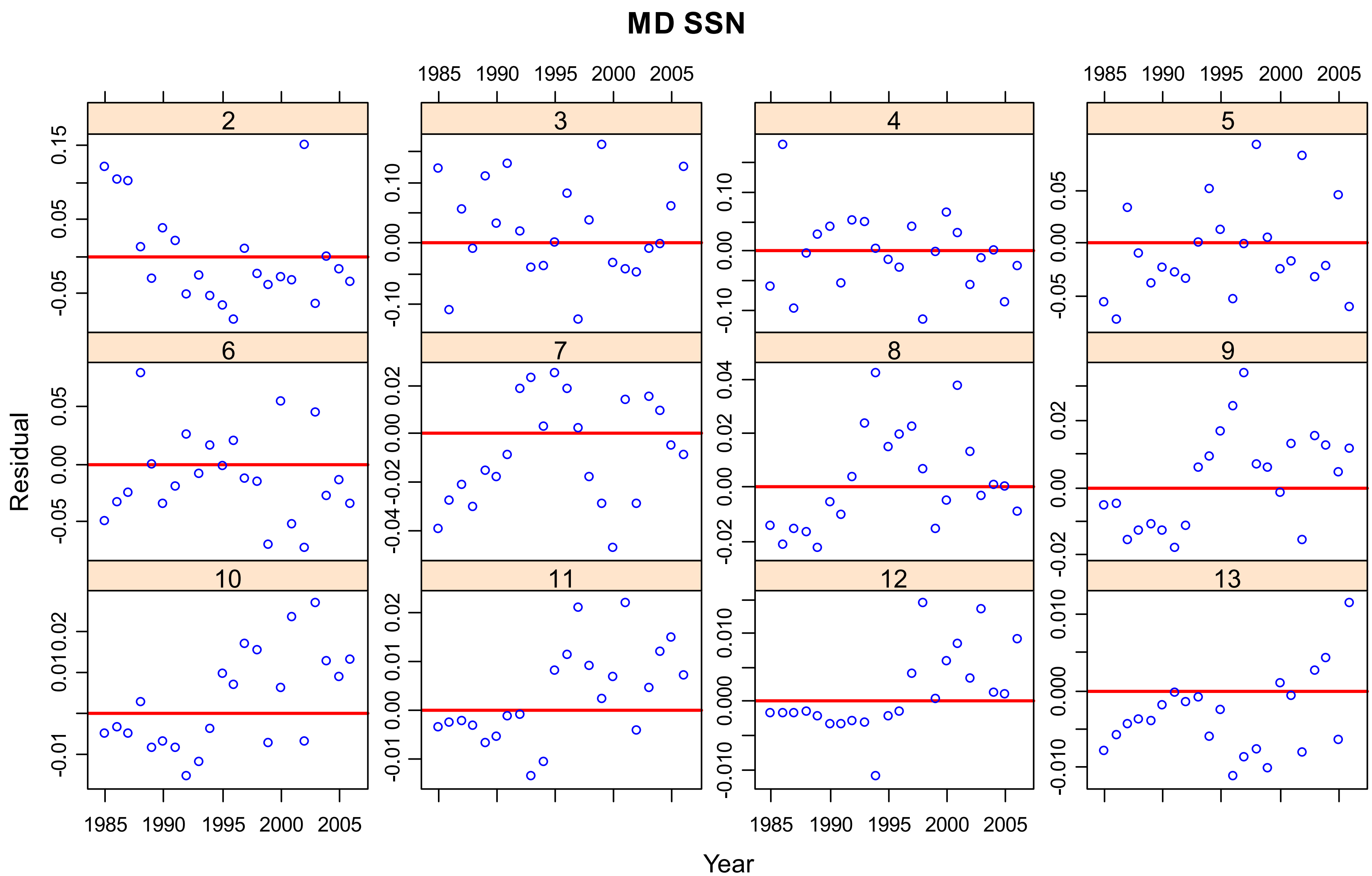



Figure 21. Residuals of proportions-at-age for each age by year for the MD SSN gillnet survey.

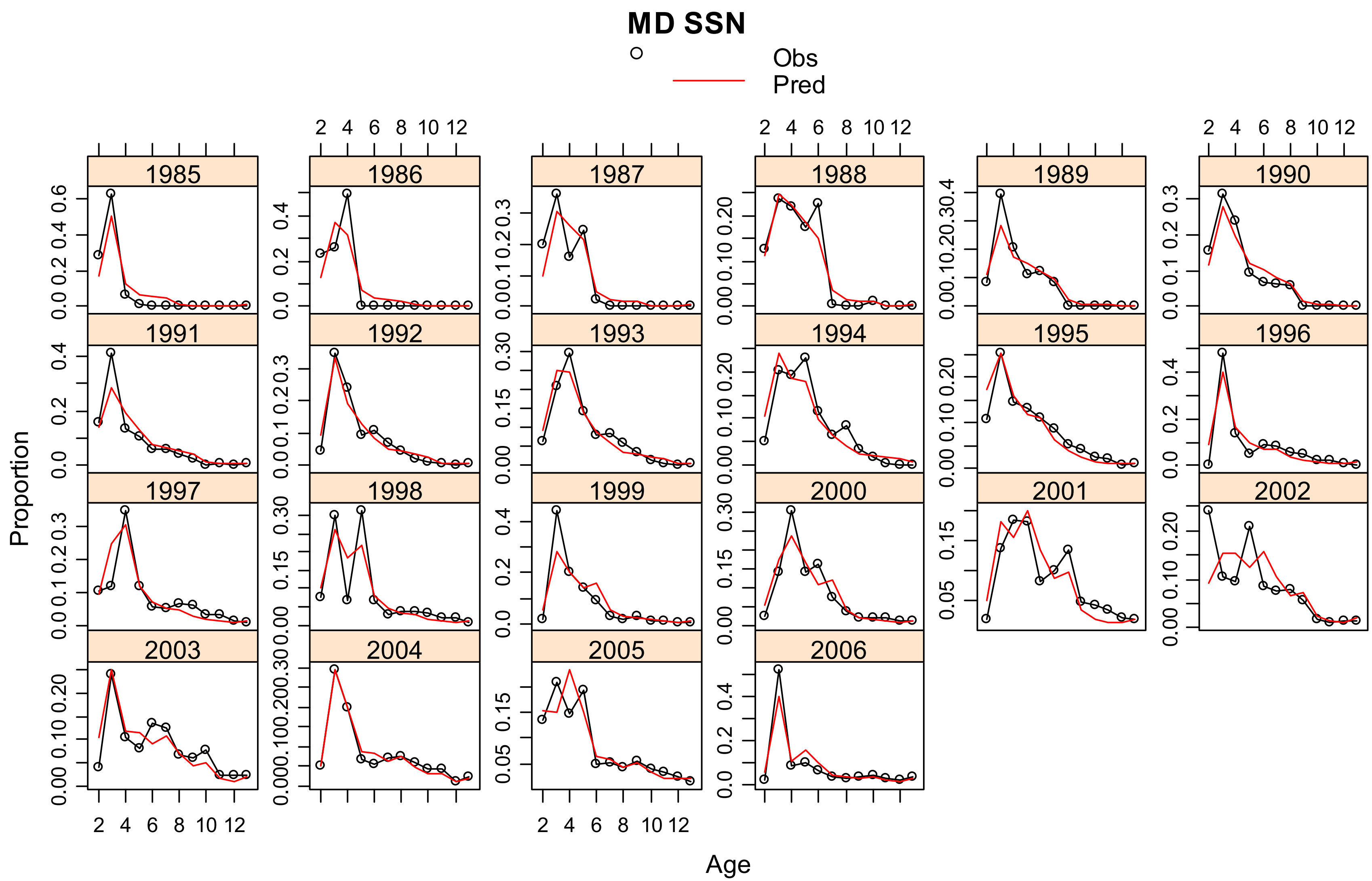



Figure 22. Observed and predicted proportions-at-age for each age by year for the MD SSN gillnet survey.

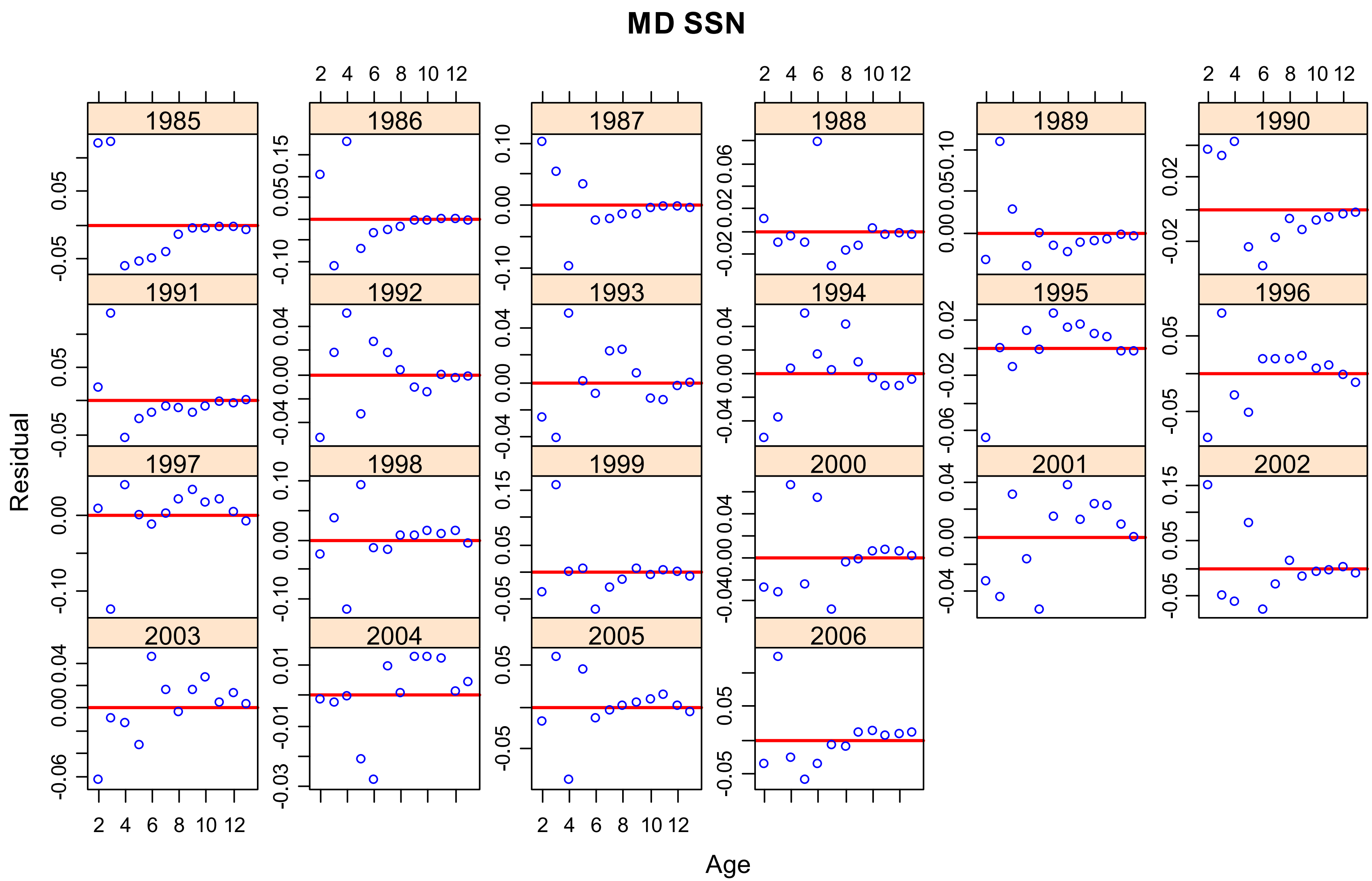



Figure 23. Residuals of proportions-at-age for each age by year for the MD SSN gillnet survey.

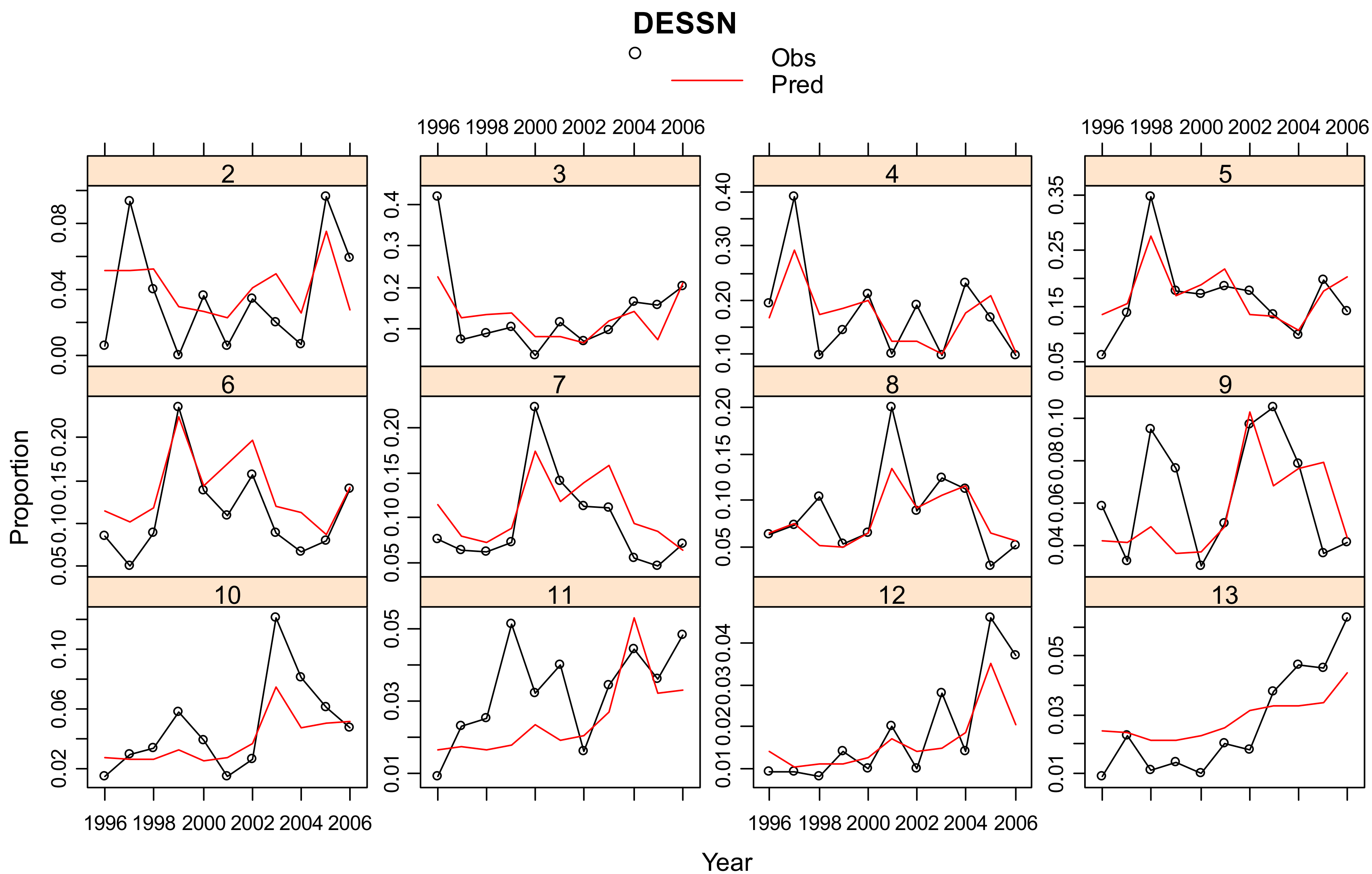



Figure 24. Observed and predicted proportions-at-age for each year by age for the DE SSN electrofishing survey.

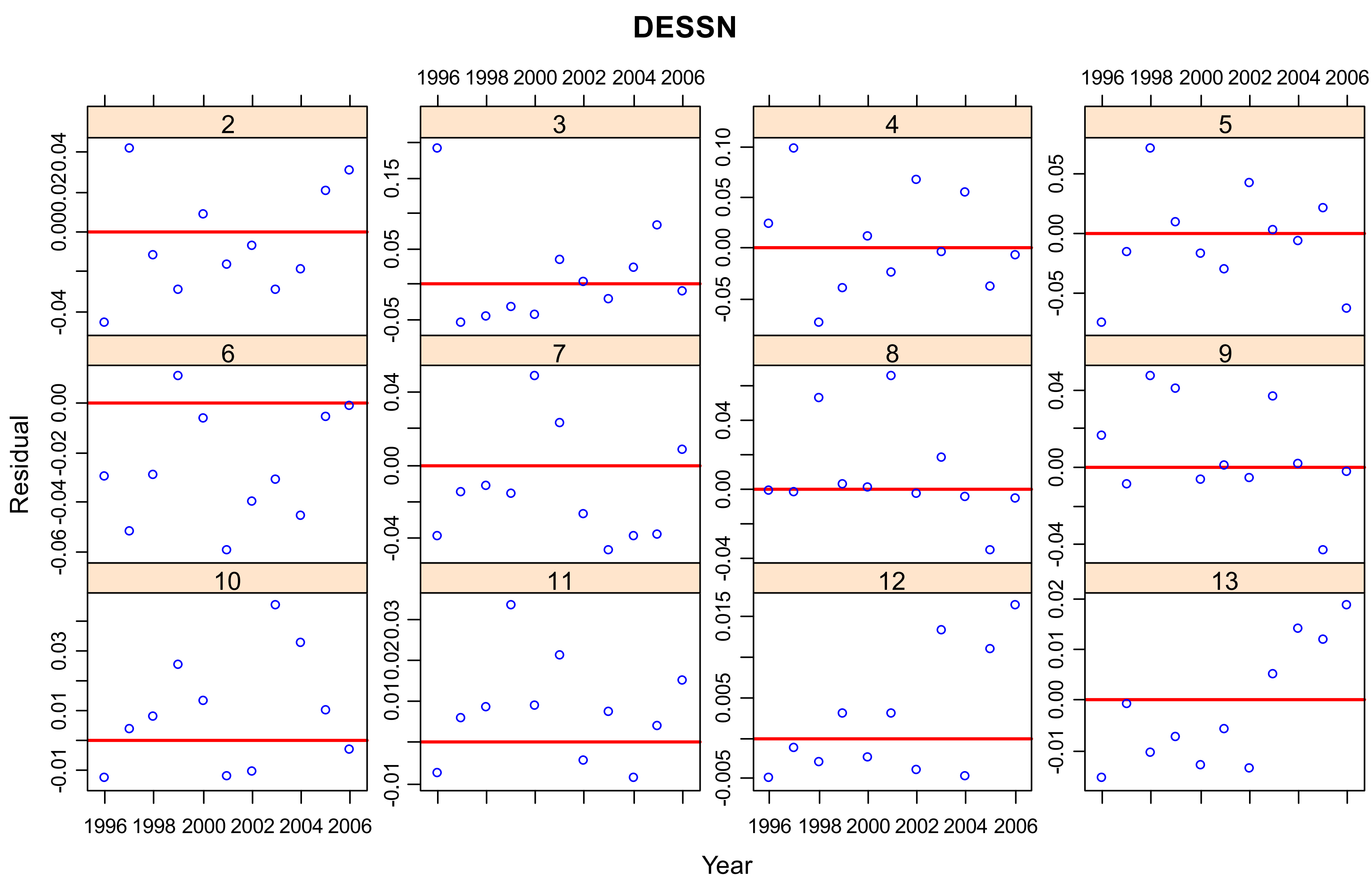



Figure 25. Residuals of proportions-at-age for each year by age for the DE SSN electrofishing survey.

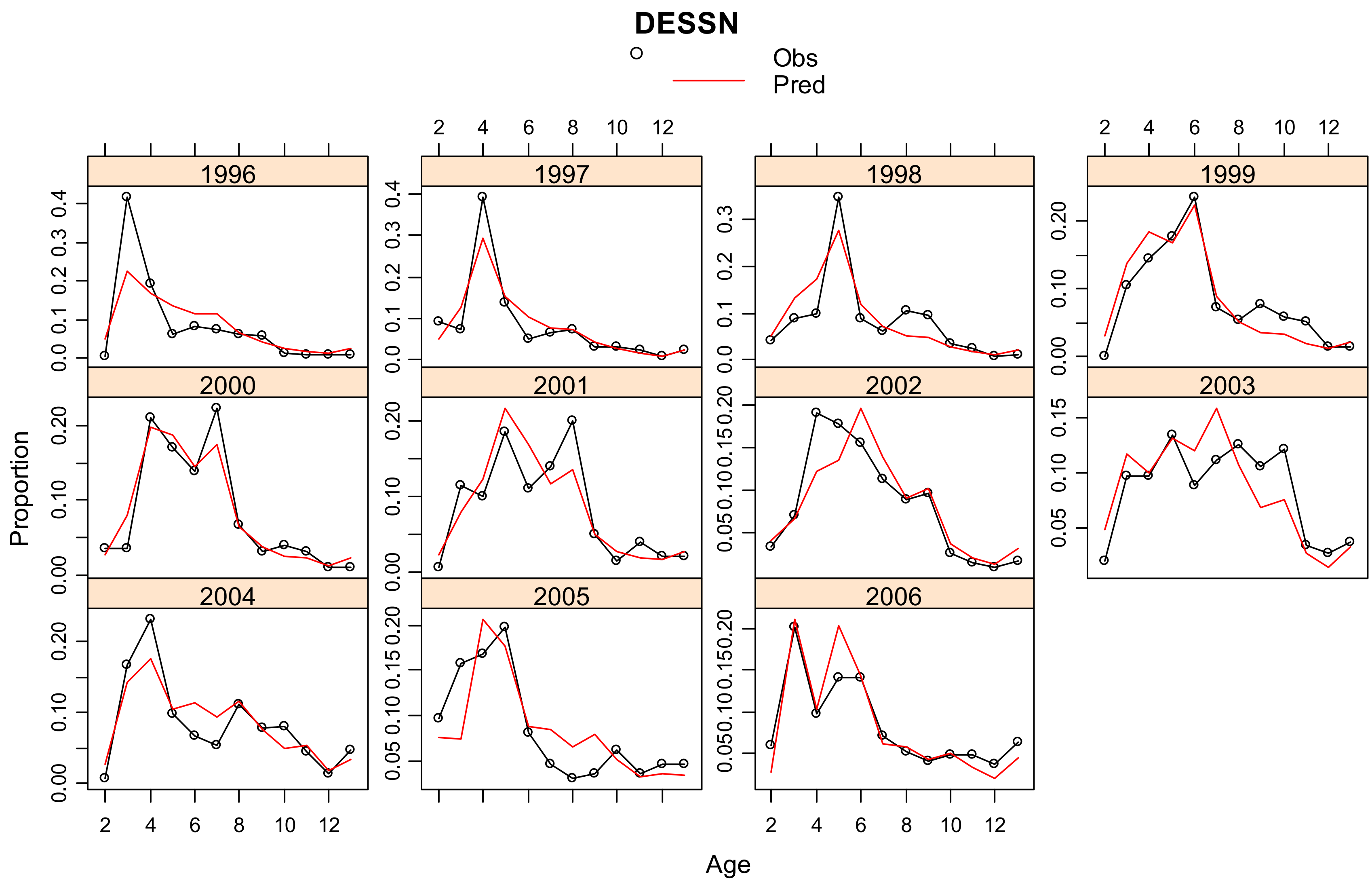



Figure 26. Observed and predicted proportions-at-age for each age by year for the DE SSN electrofishing survey.

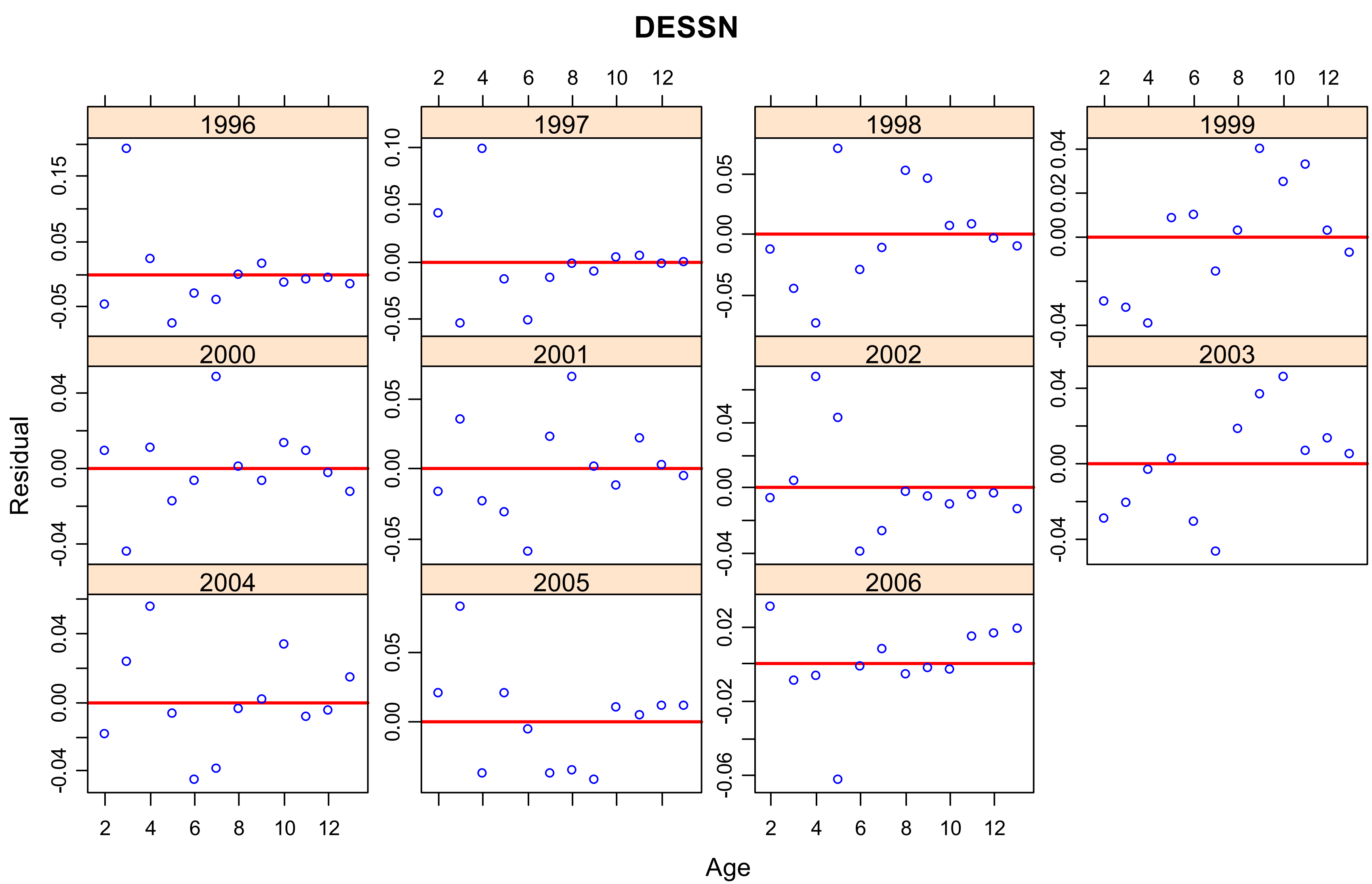



Figure 27. Residuals of proportions-at-age for each year by age for the DE SSN electrofishing survey.

## Appendix A9. ADAPT Virtual Population Analysis

### Catch at Age and Indices

Initial runs of ADAPT for the 2007 assessment used a combination of 62 age-specific and age aggregated fishery independent and fishery dependent indices under TOR 1 and 2. Model results indicated a significant increase in fishing mortality among 9-11 year old fish in the terminal year. The increases, particularly at age 10 from which increased from 0.5 in 2005 to 2.2 in 2006, were unrealistic and further evaluation of the chosen indices was warranted (Figure 1). Residual plots (Figure 2) showed systematic trends in residuals for some survey indices and suggests that the MD spawning stock indices for ages 3 to 9, the New York haul seine index for combined ages 9 to13, the CT trawl index and the DE trawl index should be removed from the updated analysis. Similarly, fishery dependent indices from MA commercial CPUE, MRFSS and CT recreational CPUE were also removed (the MA commercial indices failure to track strong year classes which provided additional justification for exclusion from analysis).

*Model Configuration*

The remaining 34 indices were used in the final run of ADAPT. Indices included the MD SSB index for ages 10-13+, NY Ocean Haul seine ages 3-8, NEFSC aggregated for ages 2-9, young-of-year (age 0) in Maryland, Virginia, New York and New Jersey, age 1 index for Maryland and Long Island, New York, DE spawning stock for ages 2-9, and aggregated for 10-13, and the NJ trawl index for ages 2-8 and aggregated for 9-13. The ADAPT run used the following input options: full F in terminal year was calculated using an averaging method; F at oldest true age for all years, including terminal year was calculated using Heincke's method and ages 8 through 11 were used to calculate the oldest true age. Plus group abundance was calculated using the backward method and the model assumed a flat topped partial recruitment. Natural mortality was fixed at M=0.15. In past assessments, an iterative re-weighting of the survey indices was applied to the model. Generally the result was an improvement in the CVs at age and the overall standard deviation. In the current model configuration, the CVs and standard deviation was better without re-weighting. Consequently the re-weighting is turned off and all indices given equal weighting.

*Partial Recruitment Vector*

A flat top partial recruitment vector was assumed for the ADAPT model. Initial PR values were calculated using the three year geometric mean fishing mortality for each age from the previous ADAPT model scaled to the highest value of F among all ages.

*Bootstrap*

The model was bootstrapped 1000 times to produce a distribution of F, SSB and abundance in the terminal year.

**ADAPT Results**

*Tuning Indices*

Plots of observed and predicted indices (Figure 3) and the residuals (Figure 4) for the 34 remaining indices suggested better fit with this model configuration.

*Fishing Mortality*

The 2006 average fishing mortality rate (F) for fully recruited ages 8 through 11 equaled 0.34 and was above the current target (0.30)(Table 1 and 2). This represents a decrease in F on fully recruited ages from that reported for 2003 (reported as F = 0.62 in 2004, SBSASC 2004). This may reflect the shift in model indices and a reduced in the retrospective effect on terminal year F. The 2003 value of F in the current run was 0.19. Fishing mortality in 2006 on ages 3-8, which are generally targeted in producer areas, was F = 0.15 (Table 2). Among the individual age groups, the highest value of F (0.46) was estimated for 9 year old fish (1997 year class) (Table 1). Estimates of age 8-11 F increased from 0.27 in 2005 to 0.34 in 2006 (Table 2). Bootstrap estimates of age 8-11 F, based on 1000 iterations, are presented in Figure 5; the distribution of Fs was characterized by a highly skewed distribution with values to 1.32.

*Population Abundance (January 1)*

Striped bass abundance increased steadily from 1982 through 1997 when it reached a level around 70 million fish (Table 3). Total abundance declined to 60 million fish in 2000, increased to 78 million fish in 2004 and has since declined to 61 million in 2007. The 2001 and 2003 cohort remained strong in 2007 and exceeded the size of the strong 1993 and 1996 year classes. Estimates of abundance obtained this year were higher than those reported in 2004 (SBSAC 2004). Bootstrap estimates for abundance at age are presented in Figure 6; the total abundance estimates followed near- normal distribution.

Abundance of striped bass age 8+ increased steadily from 1982 through 2004 to 5.6 million fish. It has since decreased to a 1 Jan 2007 estimate 6.1 million fish (Table 3).

*Spawning Stock Biomass*

Female spawning stock biomass (SSB) grew steadily from 1982 through 2002 when it peaked at about 36.7 thousand metric tons (Table 4). Female SSB has declined since then and was estimated at 29.8 thousand metric tons in 2006, assuming 1:1 male- female ratio. The estimated SSB remained above the threshold level of 1995. Bootstrap estimates for SSB are presented in Figure 7; the SSB estimates followed a near- normal distribution.

*Retrospective Patterns*

A retrospective analysis was conducted on the VPA results extending back to 2000 in order to determine trends in estimation of F, total abundance, female SSB and recruitment in the terminal year. The analysis revealed that average fishing mortality estimates for ages 8-11 were overestimated in 2000 but improved significantly in subsequent years (Figure 8). The terminal year estimate for 2005 was 0.28 compared to the 2005 estimate in the 2006 model of 0.27. There was limited bias in terminal year estimates of total abundance, recruitment or female SSB (Figure 8) which were all underestimated.

*Sensitivity Runs*

Natural mortality was changed to 1.0, 0.5, and 0.35 for ages 1, 2 and 3 respectively to determine the sensitivity to age specific values. As expected, the increase in M at age increased the estimates of population abundance for the corresponding ages.

*Additional Estimates*

Estimates of total and catch biomass are given in Tables 5 and 6.

*Sources of Uncertainty*

The ADAPT VPA abundance indices used this year's analysis were improved through a reasoned and objective evaluation process described in ASMFC 2004. The review reduced the number of indices and the number of indices at age, especially for fish age eight and older. This year's ADAPT VPA analysis was highly sensitive to the selection of indices, especially to those for the older ages. As the striped bass population abundance increased beginning in 1982, the indices produced a strong signal of trend. However, as abundance peaked and fluctuated around the recent level, the trends are less evident in the indices, as used by this model. There is clearly a need to develop additional fishery independent indices of abundance for older fish in the fished subset of the population.

*ADAPT Summary*

The striped bass population remains at high level of abundance due, in part, to strong incoming cohorts. The fully exploited population abundance (age 8+) has decreased since 2004, but remains above the abundance in 2000. Average fishing mortality for fully recruited ages (8-11) in 2006 was estimated at 0.35. The F estimate for 2003 was 0.19 which is much lower than the F for the same year (0.62) estimated in the 2004 assessment (SBSASC 2004). However, this difference is due primarily to the selection of tuning indices and the presence of a retrospective problem in the previous model. The 2006 fully recruited fishing mortality estimate is above the target of 0.3. However, the bootstrap distribution of F and suggests that the mean is not the appropriate metric and true F is likely less than 0.3. Spawning stock biomass has decreased from levels in 2002 but remains well above the 1995 threshold level.

## Appendix A9 Tables

Table 1. Fishing mortality estimates from ADAPT model using reduced suite of indices.

| | Fishing | Mortality | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AGE** | **1982** | **1983** | **1984** | **1985** | **1986** | **1987** | **1988** | **1989** | **1990** | **1991** | **1992** | **1993** |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.12 | 0.09 | 0.24 | 0.04 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 3 | 0.38 | 0.29 | 0.37 | 0.06 | 0.04 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 |
| 4 | 0.37 | 0.52 | 0.20 | 0.07 | 0.10 | 0.04 | 0.03 | 0.04 | 0.08 | 0.07 | 0.06 | 0.07 |
| 5 | 0.28 | 0.44 | 0.29 | 0.20 | 0.11 | 0.06 | 0.10 | 0.06 | 0.14 | 0.09 | 0.07 | 0.11 |
| 6 | 0.19 | 0.28 | 0.25 | 0.32 | 0.15 | 0.07 | 0.12 | 0.12 | 0.12 | 0.11 | 0.08 | 0.10 |
| 7 | 0.33 | 0.26 | 0.20 | 0.33 | 0.23 | 0.08 | 0.16 | 0.07 | 0.17 | 0.09 | 0.08 | 0.08 |
| 8 | 0.59 | 0.08 | 0.09 | 0.27 | 0.29 | 0.10 | 0.20 | 0.11 | 0.13 | 0.19 | 0.08 | 0.12 |
| 9 | 0.67 | 0.17 | 0.05 | 0.16 | 0.21 | 0.11 | 0.31 | 0.12 | 0.14 | 0.15 | 0.19 | 0.13 |
| 10 | 0.71 | 0.43 | 0.18 | 0.10 | 0.19 | 0.10 | 0.13 | 0.12 | 0.11 | 0.22 | 0.16 | 0.38 |
| 11 | 0.20 | 0.73 | 0.13 | 0.11 | 0.13 | 0.07 | 0.15 | 0.09 | 0.23 | 0.29 | 0.12 | 0.20 |
| 12 | 0.64 | 0.14 | 0.08 | 0.20 | 0.25 | 0.10 | 0.21 | 0.11 | 0.13 | 0.18 | 0.12 | 0.16 |
| 13 | 0.64 | 0.14 | 0.08 | 0.20 | 0.25 | 0.10 | 0.21 | 0.11 | 0.13 | 0.18 | 0.12 | 0.16 |
| 8 - 11 F | 0.54 | 0.35 | 0.11 | 0.16 | 0.21 | 0.09 | 0.20 | 0.11 | 0.15 | 0.21 | 0.14 | 0.21 |
| 3 - 8 F | 0.35 | 0.31 | 0.23 | 0.21 | 0.15 | 0.06 | 0.10 | 0.07 | 0.11 | 0.10 | 0.07 | 0.08 |

| **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.01 | 0.03 | 0.01 | 0.02 | 0.01 | 0.01 | 0.04 | 0.02 | 0.02 | 0.01 | 0.03 | 0.02 | 0.03 |
| 0.05 | 0.06 | 0.06 | 0.06 | 0.04 | 0.04 | 0.06 | 0.06 | 0.04 | 0.05 | 0.05 | 0.08 | 0.07 |
| 0.06 | 0.09 | 0.10 | 0.11 | 0.08 | 0.07 | 0.11 | 0.12 | 0.04 | 0.13 | 0.09 | 0.09 | 0.15 |
| 0.10 | 0.10 | 0.14 | 0.14 | 0.17 | 0.10 | 0.14 | 0.12 | 0.11 | 0.15 | 0.15 | 0.16 | 0.12 |
| 0.12 | 0.17 | 0.15 | 0.23 | 0.14 | 0.15 | 0.15 | 0.13 | 0.12 | 0.21 | 0.16 | 0.21 | 0.16 |
| 0.09 | 0.15 | 0.22 | 0.20 | 0.14 | 0.13 | 0.21 | 0.15 | 0.16 | 0.18 | 0.26 | 0.17 | 0.21 |
| 0.10 | 0.17 | 0.20 | 0.31 | 0.16 | 0.16 | 0.15 | 0.19 | 0.18 | 0.16 | 0.23 | 0.29 | 0.20 |
| 0.24 | 0.24 | 0.17 | 0.32 | 0.25 | 0.18 | 0.14 | 0.13 | 0.19 | 0.19 | 0.21 | 0.26 | 0.46 |
| 0.17 | 0.34 | 0.15 | 0.25 | 0.25 | 0.26 | 0.17 | 0.14 | 0.23 | 0.23 | 0.25 | 0.22 | 0.40 |
| 0.30 | 0.15 | 0.25 | 0.22 | 0.25 | 0.36 | 0.15 | 0.17 | 0.18 | 0.16 | 0.34 | 0.31 | 0.30 |
| 0.15 | 0.22 | 0.18 | 0.30 | 0.20 | 0.18 | 0.15 | 0.17 | 0.20 | 0.18 | 0.23 | 0.25 | 0.32 |
| 0.15 | 0.22 | 0.18 | 0.30 | 0.20 | 0.18 | 0.15 | 0.17 | 0.20 | 0.18 | 0.23 | 0.25 | 0.32 |
| 0.20 | 0.23 | 0.19 | 0.27 | 0.23 | 0.24 | 0.15 | 0.16 | 0.20 | 0.19 | 0.26 | 0.27 | 0.34 |
| 0.09 | 0.12 | 0.14 | 0.17 | 0.12 | 0.11 | 0.14 | 0.13 | 0.11 | 0.15 | 0.16 | 0.17 | 0.15 |

Table 2. Average fishing mortality for ages 8-11 estimated in ADAPT model.

| Year | 8-11 Average F | F wt'd by N | 3 - 8 average F |
|---|---|---|---|
| 1982 | 0.54 | 0.45 | 0.35 |
| 1983 | 0.35 | 0.20 | 0.31 |
| 1984 | 0.11 | 0.09 | 0.23 |
| 1985 | 0.16 | 0.20 | 0.21 |
| 1986 | 0.21 | 0.23 | 0.15 |
| 1987 | 0.09 | 0.10 | 0.06 |
| 1988 | 0.20 | 0.20 | 0.10 |
| 1989 | 0.11 | 0.11 | 0.07 |
| 1990 | 0.15 | 0.13 | 0.11 |
| 1991 | 0.21 | 0.19 | 0.10 |
| 1992 | 0.14 | 0.12 | 0.07 |
| 1993 | 0.21 | 0.17 | 0.08 |
| 1994 | 0.20 | 0.16 | 0.09 |
| 1995 | 0.23 | 0.21 | 0.12 |
| 1996 | 0.19 | 0.18 | 0.14 |
| 1997 | 0.27 | 0.29 | 0.17 |
| 1998 | 0.23 | 0.21 | 0.12 |
| 1999 | 0.24 | 0.20 | 0.11 |
| 2000 | 0.15 | 0.15 | 0.14 |
| 2001 | 0.16 | 0.17 | 0.13 |
| 2002 | 0.20 | 0.19 | 0.11 |
| 2003 | 0.19 | 0.18 | 0.15 |
| 2004 | 0.26 | 0.24 | 0.16 |
| 2005 | 0.27 | 0.26 | 0.17 |
| 2006 | 0.34 | 0.32 | 0.15 |

Table 3. Population abundance estimate (000s) from ADAPT model using reduced suite of indices.

1-Jan Population Numbers

| AGE | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1547 | 3222 | 2432 | 3690 | 2816 | 4085 | 5476 | 5828 | 8703 | 9254 | 9690 | 12287 |
| 2 | 1003 | 1329 | 2770 | 2088 | 3175 | 2413 | 3515 | 4711 | 5015 | 7489 | 7964 | 8338 |
| 3 | 867 | 766 | 1042 | 1883 | 1730 | 2713 | 2067 | 2997 | 4021 | 4274 | 6378 | 6812 |
| 4 | 760 | 510 | 494 | 618 | 1526 | 1430 | 2300 | 1740 | 2505 | 3346 | 3544 | 5305 |
| 5 | 261 | 451 | 261 | 349 | 494 | 1190 | 1183 | 1921 | 1435 | 1983 | 2686 | 2875 |
| 6 | 122 | 170 | 250 | 169 | 246 | 379 | 962 | 919 | 1557 | 1075 | 1556 | 2148 |
| 7 | 93 | 87 | 110 | 167 | 105 | 183 | 303 | 738 | 703 | 1187 | 831 | 1238 |
| 8 | 41 | 58 | 58 | 78 | 104 | 72 | 145 | 223 | 592 | 509 | 937 | 657 |
| 9 | 26 | 19 | 46 | 45 | 51 | 67 | 56 | 102 | 173 | 447 | 361 | 744 |
| 10 | 22 | 11 | 14 | 38 | 33 | 36 | 52 | 35 | 78 | 130 | 330 | 257 |
| 11 | 66 | 10 | 6 | 10 | 29 | 24 | 28 | 39 | 27 | 61 | 89 | 243 |
| 12 | 31 | 46 | 4 | 5 | 8 | 22 | 19 | 20 | 31 | 18 | 39 | 68 |
| 13 | 36 | 112 | 147 | 61 | 49 | 142 | 55 | 91 | 121 | 146 | 151 | 128 |
| Total | 4873 | 6792 | 7633 | 9200 | 10366 | 12755 | 16160 | 19365 | 24960 | 29917 | 34558 | 41100 |
| 8+ | 222 | 256 | 275 | 237 | 274 | 363 | 355 | 510 | 1022 | 1311 | 1907 | 2097 |

| 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17353 | 16043 | 17701 | 16997 | 10063 | 11310 | 8842 | 14968 | 22700 | 8684 | 24413 | 11195 | 12938 | 6050 |
| 10575 | 14931 | 13805 | 15234 | 14626 | 8637 | 9727 | 7575 | 12854 | 19516 | 7448 | 20947 | 9618 | 11104 |
| 7112 | 8967 | 12449 | 11790 | 12842 | 12419 | 7334 | 8074 | 6375 | 10877 | 16563 | 6246 | 17605 | 8069 |
| 5691 | 5798 | 7282 | 10114 | 9590 | 10603 | 10300 | 5925 | 6549 | 5279 | 8918 | 13510 | 4987 | 14071 |
| 4263 | 4629 | 4568 | 5666 | 7806 | 7600 | 8525 | 7954 | 4546 | 5403 | 3989 | 6981 | 10612 | 3682 |
| 2208 | 3328 | 3609 | 3429 | 4242 | 5678 | 5947 | 6394 | 6075 | 3496 | 3995 | 2954 | 5123 | 8120 |
| 1677 | 1685 | 2412 | 2673 | 2346 | 3179 | 4212 | 4396 | 4855 | 4624 | 2451 | 2930 | 2062 | 3761 |
| 986 | 1318 | 1252 | 1667 | 1877 | 1760 | 2410 | 2937 | 3247 | 3558 | 3326 | 1623 | 2128 | 1442 |
| 504 | 768 | 953 | 884 | 1051 | 1370 | 1293 | 1784 | 2081 | 2332 | 2605 | 2269 | 1048 | 1500 |
| 564 | 341 | 519 | 694 | 554 | 705 | 989 | 964 | 1345 | 1474 | 1661 | 1826 | 1512 | 567 |
| 151 | 410 | 210 | 383 | 468 | 372 | 470 | 720 | 719 | 917 | 1005 | 1117 | 1261 | 875 |
| 171 | 96 | 304 | 141 | 265 | 315 | 224 | 349 | 524 | 517 | 670 | 615 | 704 | 801 |
| 112 | 78 | 125 | 119 | 384 | 318 | 235 | 338 | 674 | 599 | 709 | 679 | 757 | 917 |
| 51365 | 58394 | 65188 | 69791 | 66114 | 64266 | 60509 | 62380 | 72545 | 67275 | 77754 | 72893 | 70355 | 60959 |
| 2488 | 3011 | 3363 | 3888 | 4599 | 4840 | 5621 | 7092 | 8590 | 9397 | 9976 | 8129 | 7410 | 6102 |

Table 4. Female spawning biomass (000s MT) from ADAPT model using a reduced suite of indices.

| | Female | Spawning | Stock | Biomass (000s mt) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AGE** | **1982** | **1983** | **1984** | **1985** | **1986** | **1987** | **1988** | **1989** | **1990** | **1991** | **1992** | **1993** | **1994** |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 17.5 | 11.5 | 11.5 | 19.5 | 46 | 44.5 | 73 | 51.5 | 75 | 99.5 | 106 | 162 | 183.5 |
| 5 | 32.5 | 51 | 30 | 40 | 61 | 179 | 186 | 291 | 200.5 | 281.5 | 407.5 | 406.5 | 622 |
| 6 | 95.5 | 100 | 148 | 108.5 | 136 | 215 | 645.5 | 731 | 1127.5 | 621.5 | 1025.5 | 1445 | 1454.5 |
| 7 | 175 | 135 | 187 | 279.5 | 164.5 | 257.5 | 451.5 | 1441 | 1379.5 | 2139 | 1375.5 | 2184 | 2960.5 |
| 8 | 97 | 130.5 | 118 | 178.5 | 224.5 | 138 | 261.5 | 516.5 | 1479.5 | 1174.5 | 2194 | 1590.5 | 2381 |
| 9 | 61.5 | 53.5 | 130.5 | 131 | 130 | 166.5 | 128.5 | 256 | 483.5 | 1300 | 1056 | 2229.5 | 1508 |
| 10 | 82 | 36.5 | 45 | 125.5 | 99 | 99.5 | 135.5 | 111.5 | 221.5 | 359.5 | 1123 | 878 | 1919 |
| 11 | 337 | 38.5 | 24.5 | 40 | 104 | 76.5 | 97 | 131 | 100 | 210.5 | 328 | 998.5 | 614.5 |
| 12 | 152 | 230 | 20.5 | 21 | 33 | 90 | 79 | 88 | 130.5 | 67.5 | 199 | 327.5 | 809.5 |
| 13 | 223 | 586.5 | 856.5 | 396.5 | 292.5 | 877 | 339.5 | 573.5 | 713 | 970 | 995 | 875 | 668.5 |
| Total | 1,273 | 1,373 | 1,572 | 1,340 | 1,291 | 2,144 | 2,397 | 4,191 | 5,911 | 7,224 | 8,810 | 11,097 | 13,121 |

| **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 210 | 243 | 362 | 250.5 | 263.5 | 246 | 154.5 | 161.5 | 121 | 199 | 276.5 | 101.5 |
| 701.5 | 739.5 | 882.5 | 1117 | 819 | 874 | 870.5 | 543 | 600 | 448.5 | 784 | 1196.5 |
| 2259.5 | 2694 | 2461 | 2579.5 | 2847 | 2895 | 3412.5 | 3401.5 | 1937 | 2202 | 1702.5 | 2968.5 |
| 3051.5 | 4825.5 | 5008 | 4048.5 | 4185 | 5457.5 | 6215.5 | 7466.5 | 6934 | 3680.5 | 4377 | 3068.5 |
| 3197 | 3395 | 4114 | 4172 | 3763 | 4392 | 5694 | 6777.5 | 7310 | 6691.5 | 3264.5 | 4316 |
| 2395 | 3094.5 | 2818 | 2868.5 | 3903.5 | 3628.5 | 4767.5 | 5342 | 6296.5 | 6822.5 | 5897 | 2667 |
| 1218.5 | 1988.5 | 2727.5 | 1769.5 | 2394 | 3219 | 3365.5 | 4335 | 4514.5 | 5081.5 | 5588 | 4546.5 |
| 1452 | 885.5 | 1704.5 | 1831 | 1334.5 | 1923.5 | 2691 | 2826.5 | 3440 | 3549 | 3931.5 | 4441 |
| 437 | 1241.5 | 638 | 1223.5 | 1279 | 1010.5 | 1466 | 2246.5 | 2232 | 2733 | 2454 | 2789 |
| 607.5 | 798 | 815 | 2124.5 | 1782.5 | 1492.5 | 1720 | 3624.5 | 3075.5 | 3531 | 3375.5 | 3739.5 |
| 15,530 | 19,905 | 21,531 | 21,985 | 22,571 | 25,139 | 30,357 | 36,725 | 36,461 | 34,939 | 31,651 | 29,834 |

Table 5. Biomass estimates (Jan. 1 000s MT) from ADAPT model using reduced suite of indices.

1-Jan Biomass (000s mt)

| AGE | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 98 | 372 | 366 | 72 | 168 | 383 | 1038 | 395 | 205 | 1073 | 352 | 222 | 2438 |
| 2 | 530 | 355 | 960 | 799 | 587 | 792 | 1499 | 2389 | 1893 | 2032 | 3032 | 2299 | 2867 |
| 3 | 843 | 594 | 1005 | 1508 | 1523 | 2432 | 1902 | 3158 | 3911 | 4579 | 7002 | 6476 | 8060 |
| 4 | 944 | 623 | 610 | 1035 | 2445 | 2340 | 3844 | 2726 | 3962 | 5262 | 5592 | 8565 | 9684 |
| 5 | 541 | 861 | 499 | 658 | 995 | 2916 | 3035 | 4729 | 3284 | 4594 | 6634 | 6648 | 10151 |
| 6 | 455 | 480 | 708 | 523 | 644 | 1010 | 3050 | 3455 | 5329 | 2933 | 4826 | 6813 | 6874 |
| 7 | 426 | 327 | 450 | 682 | 397 | 613 | 1082 | 3427 | 3314 | 5094 | 3275 | 5197 | 7054 |
| 8 | 230 | 294 | 266 | 410 | 516 | 311 | 597 | 1167 | 3352 | 2676 | 4945 | 3598 | 5376 |
| 9 | 139 | 115 | 276 | 280 | 279 | 354 | 279 | 544 | 1030 | 2774 | 2262 | 4745 | 3246 |
| 10 | 185 | 80 | 96 | 266 | 212 | 211 | 288 | 237 | 470 | 773 | 2398 | 1917 | 4101 |
| 11 | 723 | 87 | 52 | 85 | 222 | 162 | 207 | 278 | 215 | 456 | 697 | 2141 | 1331 |
| 12 | 341 | 491 | 44 | 45 | 71 | 191 | 170 | 187 | 277 | 144 | 424 | 700 | 1727 |
| 13 | 499 | 1249 | 1815 | 850 | 630 | 1862 | 728 | 1218 | 1518 | 2076 | 2116 | 1868 | 1426 |
| Total | 5,954 | 5,928 | 7,146 | 7,213 | 8,688 | 13,578 | 17,719 | 23,911 | 28,762 | 34,466 | 43,554 | 51,189 | 64,335 |

| 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2320 | 1177 | 908 | 2583 | 7445 | 3228 | 1720 | 1219 | 478 | 4687 | 2149 | 2484 | 1162 |
| 6120 | 7485 | 4488 | 4628 | 5117 | 5680 | 2841 | 2863 | 5236 | 1353 | 5771 | 2650 | 2712 |
| 10676 | 12629 | 13124 | 11077 | 11481 | 7297 | 6337 | 4046 | 6056 | 11758 | 3289 | 9269 | 4741 |
| 11129 | 12887 | 19232 | 13260 | 13938 | 13068 | 8221 | 8517 | 6431 | 10551 | 14650 | 5408 | 15723 |
| 11454 | 12122 | 14466 | 18365 | 13369 | 14323 | 14239 | 8879 | 9847 | 7358 | 12877 | 19574 | 6792 |
| 10735 | 12771 | 11759 | 12214 | 13494 | 13728 | 16138 | 16081 | 9234 | 10451 | 8120 | 14085 | 21960 |
| 7312 | 11647 | 12069 | 9692 | 10008 | 13160 | 14903 | 17916 | 16670 | 8922 | 10512 | 7397 | 13560 |
| 7273 | 7742 | 9488 | 9482 | 8546 | 9968 | 12980 | 15428 | 16609 | 15311 | 7511 | 9844 | 6660 |
| 5156 | 6613 | 6112 | 6180 | 8349 | 7735 | 10153 | 11447 | 13485 | 14634 | 12714 | 5871 | 8409 |
| 2648 | 4244 | 5874 | 3812 | 5162 | 6879 | 7175 | 9325 | 9710 | 10946 | 12005 | 9941 | 3733 |
| 3097 | 1907 | 3661 | 3944 | 2906 | 4102 | 5750 | 6048 | 7347 | 7716 | 8523 | 9621 | 6693 |
| 939 | 2656 | 1381 | 2623 | 2737 | 2156 | 3132 | 4814 | 4778 | 5874 | 5290 | 6049 | 6925 |
| 1304 | 1707 | 1765 | 4556 | 3814 | 3185 | 3675 | 7767 | 6584 | 7590 | 7275 | 8111 | 9821 |
| 80,163 | 95,587 | 104,329 | 102,416 | 106,367 | 104,511 | 107,263 | 114,350 | 112,466 | 117,153 | 110,685 | 110,304 | 108,889 |

Table 6. Catch biomass estimates (000s MT) from ADAPT model using reduced suite of indices.

| Catch AGE | Biomass 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | 1 | 1 | - | 2 | - | 1 | - | - | - | - | - | 1 |
| 2 | 68 | 61 | 326 | 44 | 12 | 8 | 28 | 30 | 41 | 67 | 32 | 53 | 153 |
| 3 | 280 | 168 | 512 | 109 | 81 | 53 | 46 | 97 | 142 | 187 | 262 | 243 | 589 |
| 4 | 340 | 265 | 133 | 67 | 319 | 108 | 125 | 152 | 385 | 453 | 365 | 651 | 642 |
| 5 | 141 | 356 | 161 | 129 | 122 | 168 | 334 | 321 | 407 | 424 | 498 | 799 | 1,048 |
| 6 | 72 | 129 | 175 | 155 | 100 | 73 | 394 | 432 | 633 | 321 | 402 | 664 | 813 |
| 7 | 117 | 70 | 93 | 214 | 81 | 48 | 178 | 245 | 511 | 439 | 306 | 416 | 669 |
| 8 | 97 | 22 | 27 | 94 | 121 | 31 | 115 | 131 | 405 | 468 | 393 | 411 | 538 |
| 9 | 73 | 17 | 14 | 43 | 50 | 35 | 73 | 63 | 118 | 380 | 406 | 581 | 679 |
| 10 | 92 | 30 | 16 | 25 | 32 | 19 | 33 | 33 | 44 | 150 | 365 | 610 | 610 |
| 11 | 119 | 44 | 6 | 9 | 26 | 12 | 32 | 29 | 38 | 134 | 91 | 392 | 350 |
| 12 | 153 | 58 | 4 | 9 | 15 | 20 | 34 | 19 | 32 | 23 | 51 | 100 | 238 |
| 13 | 221 | 151 | 137 | 143 | 129 | 170 | 127 | 119 | 173 | 317 | 222 | 255 | 186 |
| Total | 1,773 | 1,371 | 1,606 | 1,041 | 1,089 | 745 | 1,520 | 1,671 | 2,928 | 3,365 | 3,392 | 5,174 | 6,518 |

| 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | - | 10 | 5 | 14 | 5 | 3 | 3 | 16 | 2 | 4 |
| 303 | 104 | 181 | 141 | 97 | 177 | 59 | 62 | 152 | 59 | 215 | 79 |
| 636 | 955 | 710 | 582 | 466 | 459 | 484 | 238 | 480 | 677 | 420 | 771 |
| 994 | 1,508 | 2,389 | 1,145 | 934 | 1,428 | 1,047 | 381 | 839 | 1,050 | 1,636 | 766 |
| 1,123 | 1,754 | 1,926 | 2,531 | 1,227 | 1,999 | 1,841 | 981 | 1,558 | 1,260 | 2,001 | 2,049 |
| 1,788 | 2,119 | 2,387 | 1,507 | 1,833 | 2,181 | 2,277 | 2,073 | 1,932 | 1,712 | 1,596 | 1,894 |
| 1,154 | 2,826 | 2,068 | 1,315 | 1,182 | 2,894 | 2,388 | 2,811 | 2,900 | 2,179 | 1,656 | 1,454 |
| 1,207 | 1,490 | 2,108 | 1,500 | 1,202 | 1,597 | 2,430 | 2,739 | 2,573 | 3,317 | 2,043 | 1,738 |
| 1,118 | 1,068 | 1,504 | 1,470 | 1,347 | 1,147 | 1,313 | 2,068 | 2,286 | 2,731 | 2,927 | 2,240 |
| 803 | 634 | 1,289 | 800 | 1,165 | 1,047 | 936 | 1,971 | 2,048 | 2,410 | 2,237 | 3,225 |
| 404 | 396 | 696 | 738 | 908 | 580 | 894 | 1,000 | 1,088 | 2,215 | 2,197 | 2,490 |
| 170 | 468 | 348 | 446 | 474 | 315 | 413 | 845 | 761 | 1,140 | 1,141 | 1,590 |
| 237 | 260 | 424 | 777 | 589 | 419 | 524 | 1,284 | 1,032 | 1,430 | 1,521 | 2,117 |
| 9,939 | 13,581 | 16,031 | 12,964 | 11,430 | 14,255 | 14,612 | 16,457 | 17,653 | 20,195 | 19,591 | 20,417 |

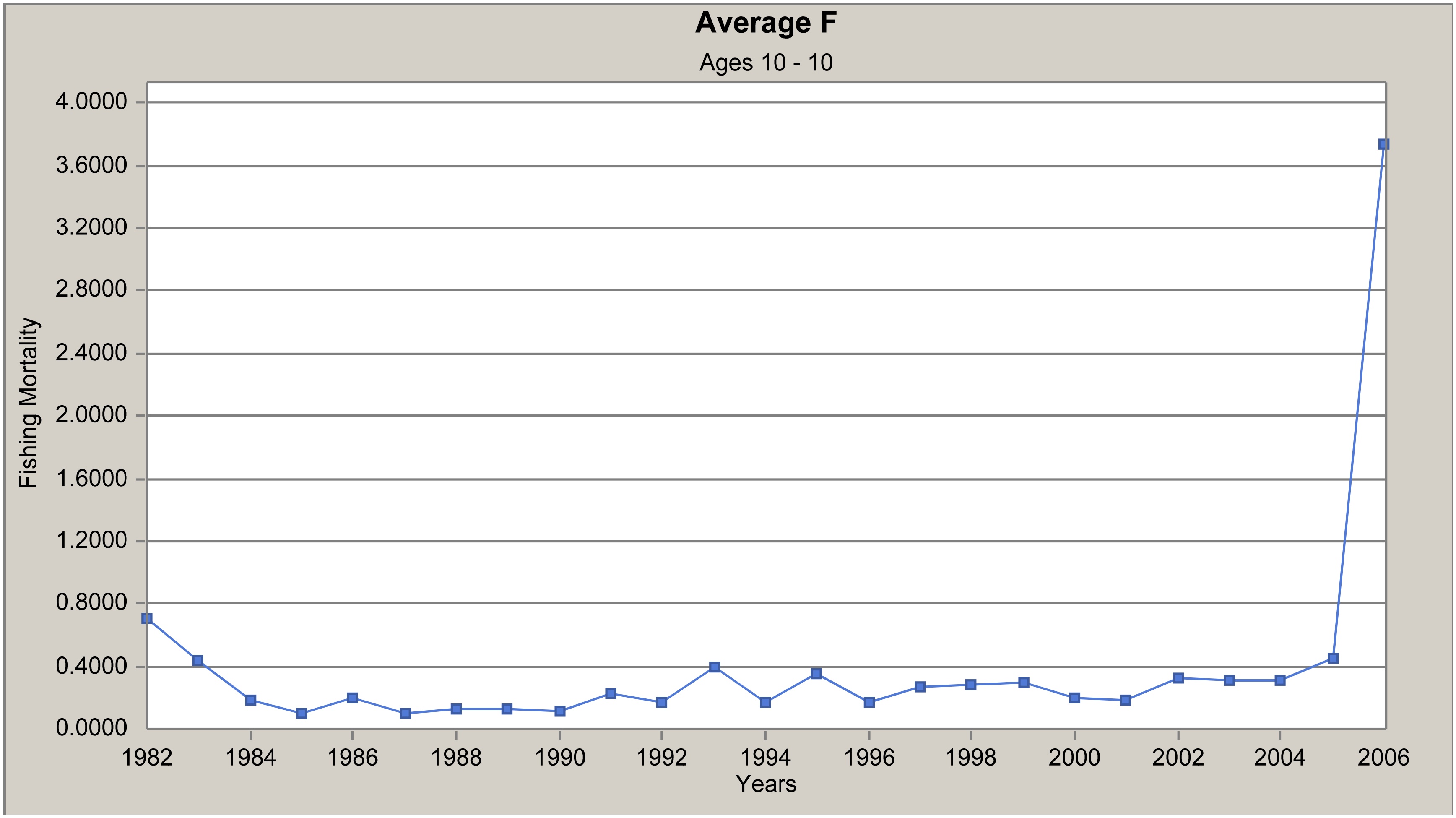



Figure 1. Age 10 fishing mortality from full ADAPT model with index selection comparable to previous assessment.

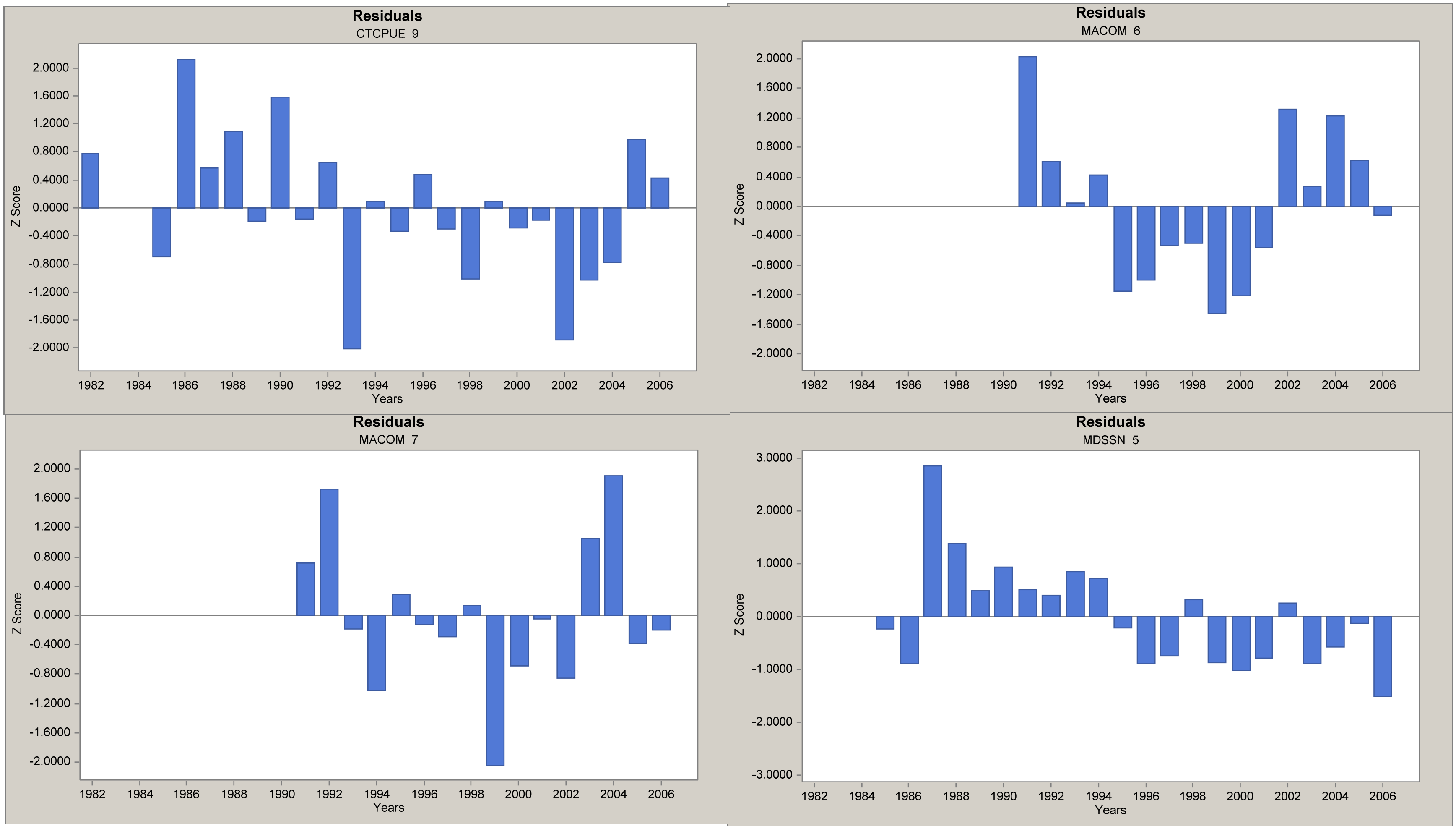



Figure 2. Residual plots from ADAPT model using index selection from previous assessment.

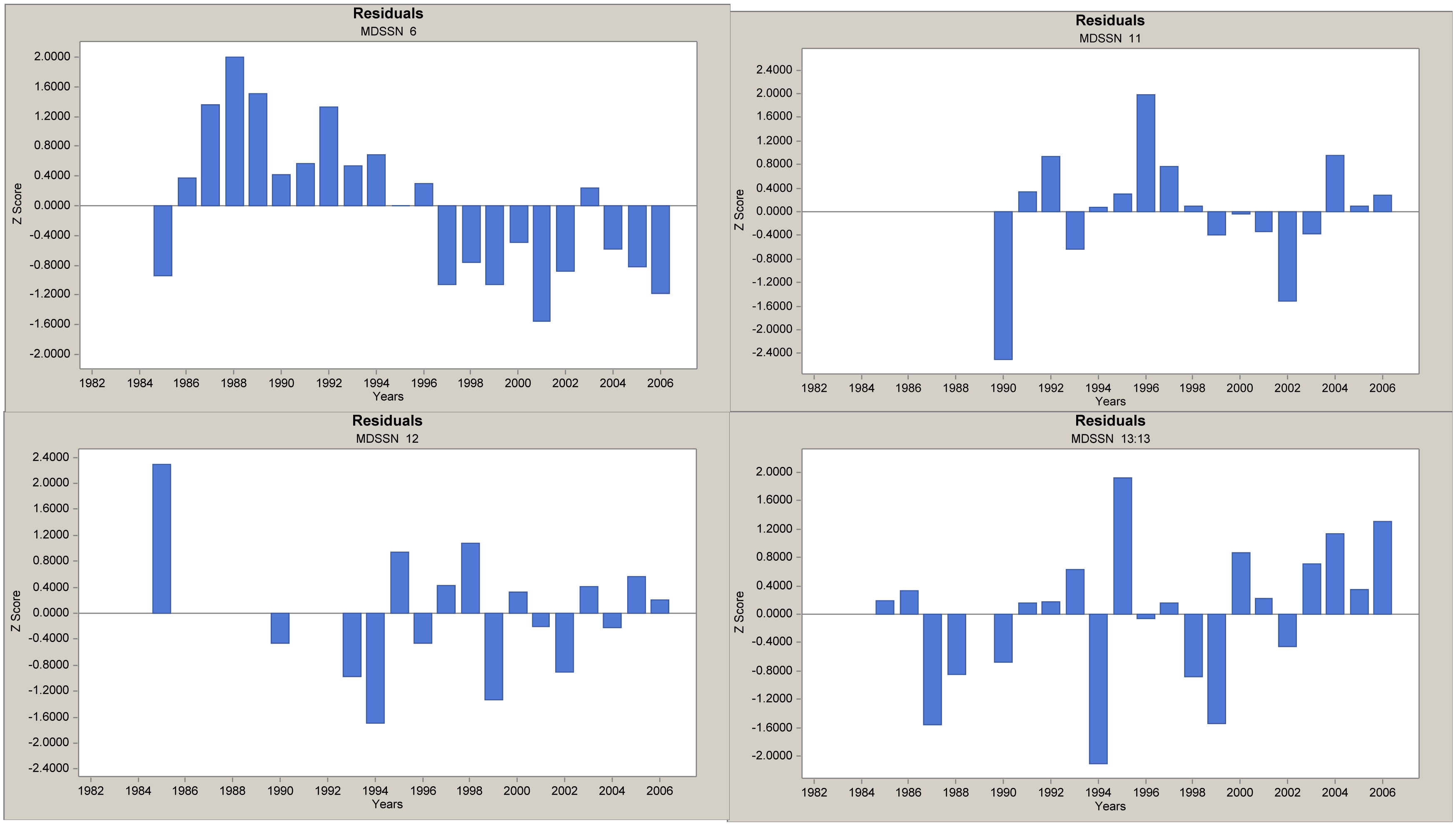



Figure 2 continued.

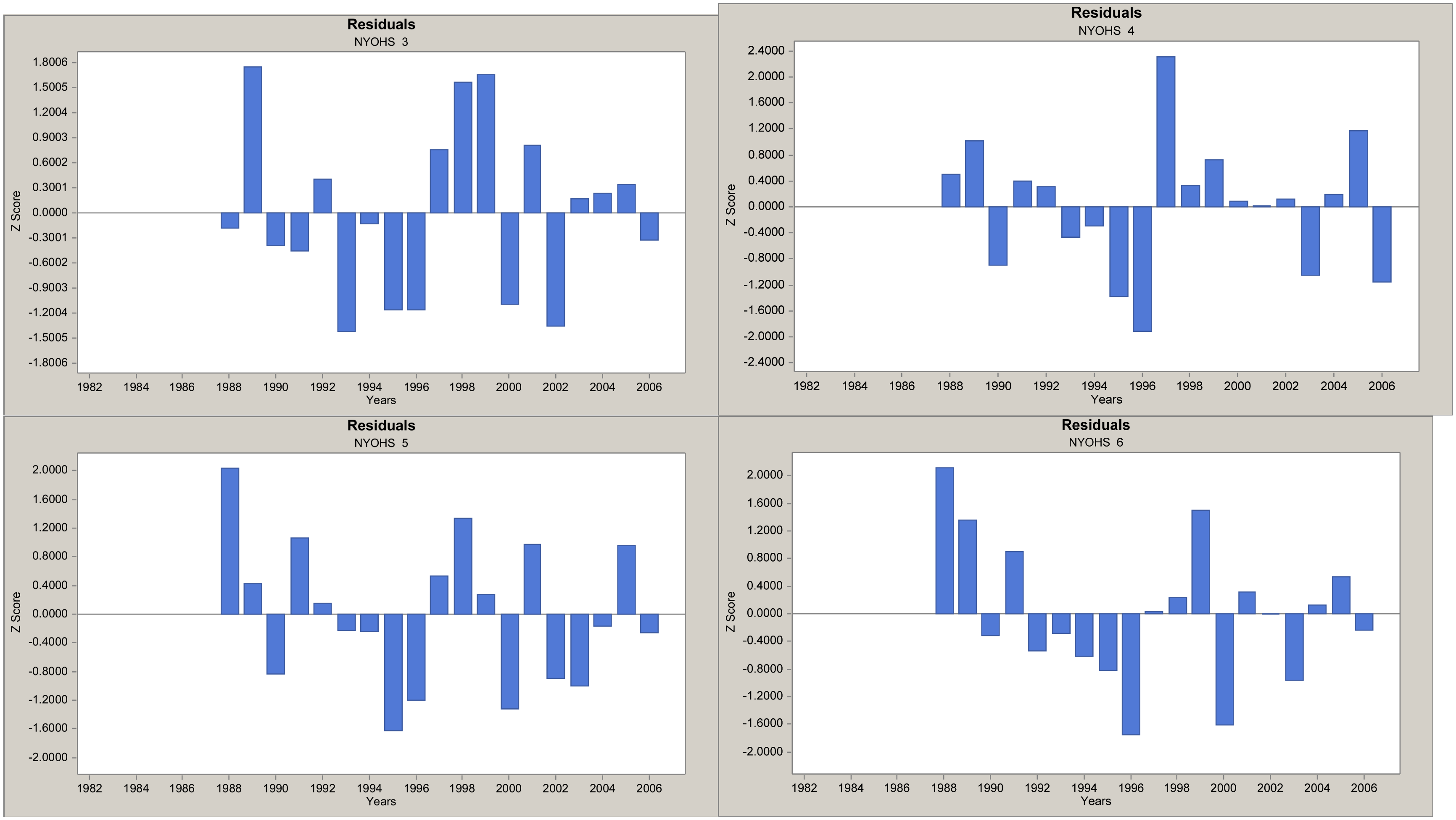



Figure 2 continued.

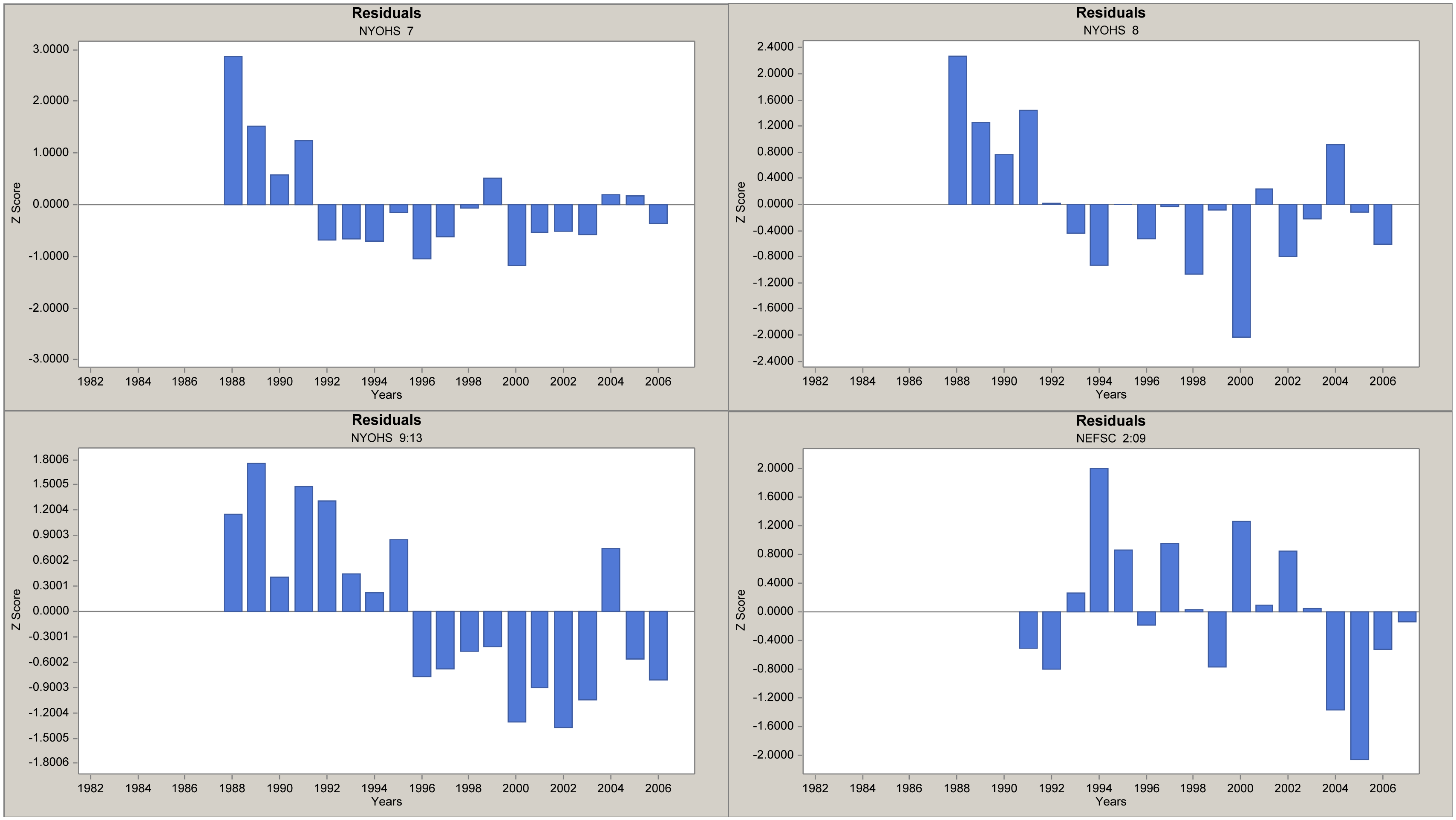



Figure 2 continued.

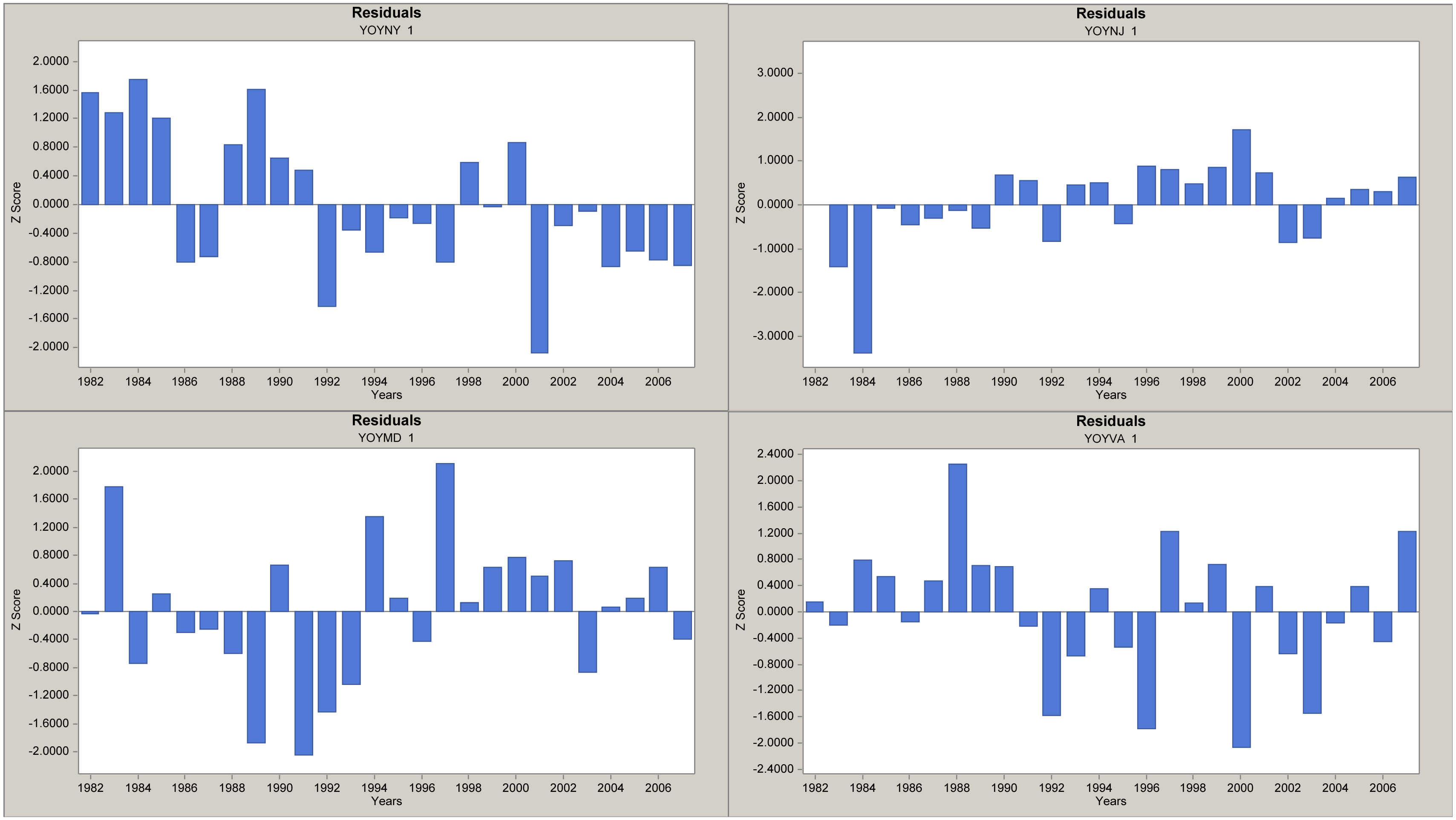



Figure 2 continued.

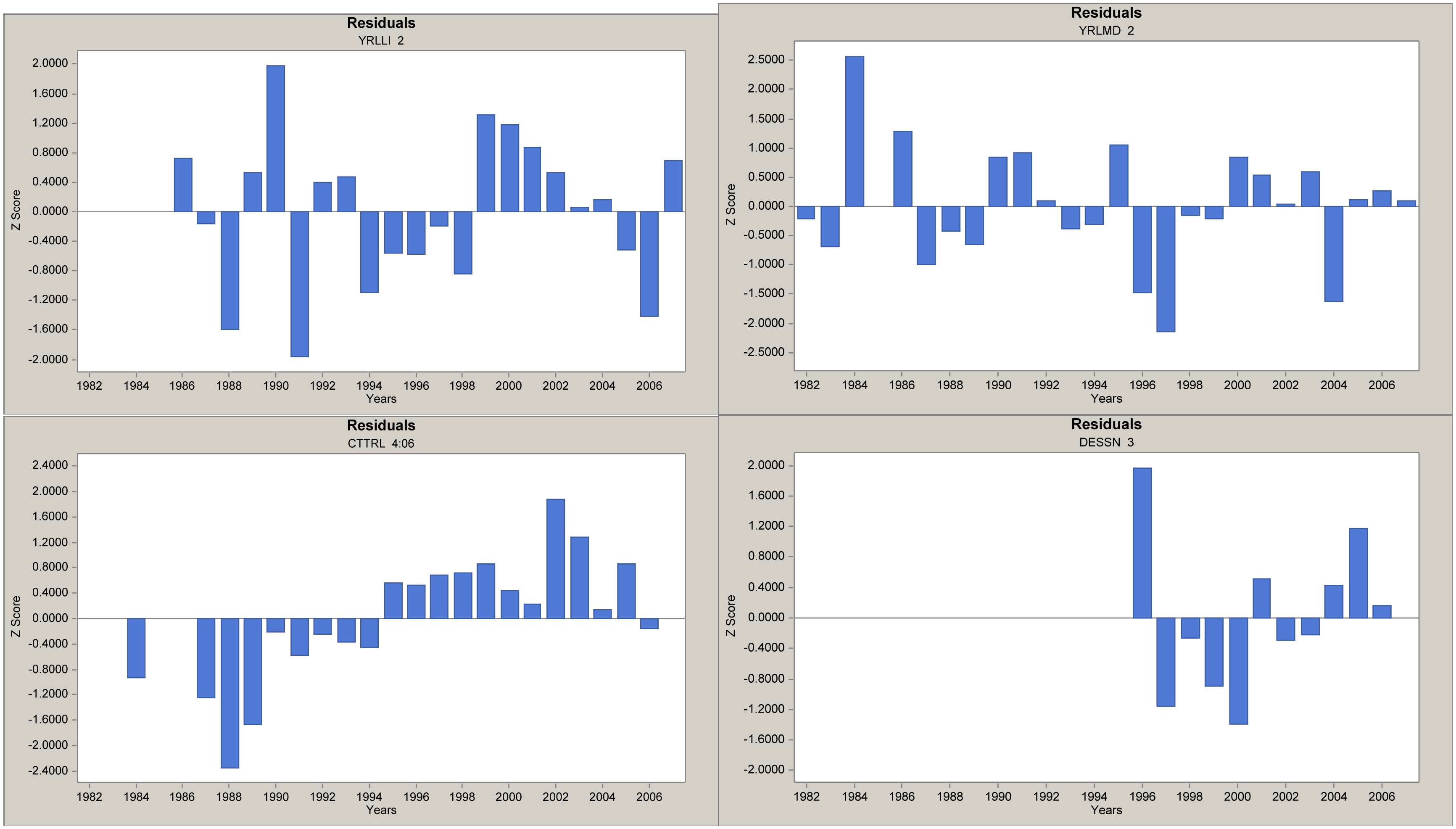



Figure 2 continued.

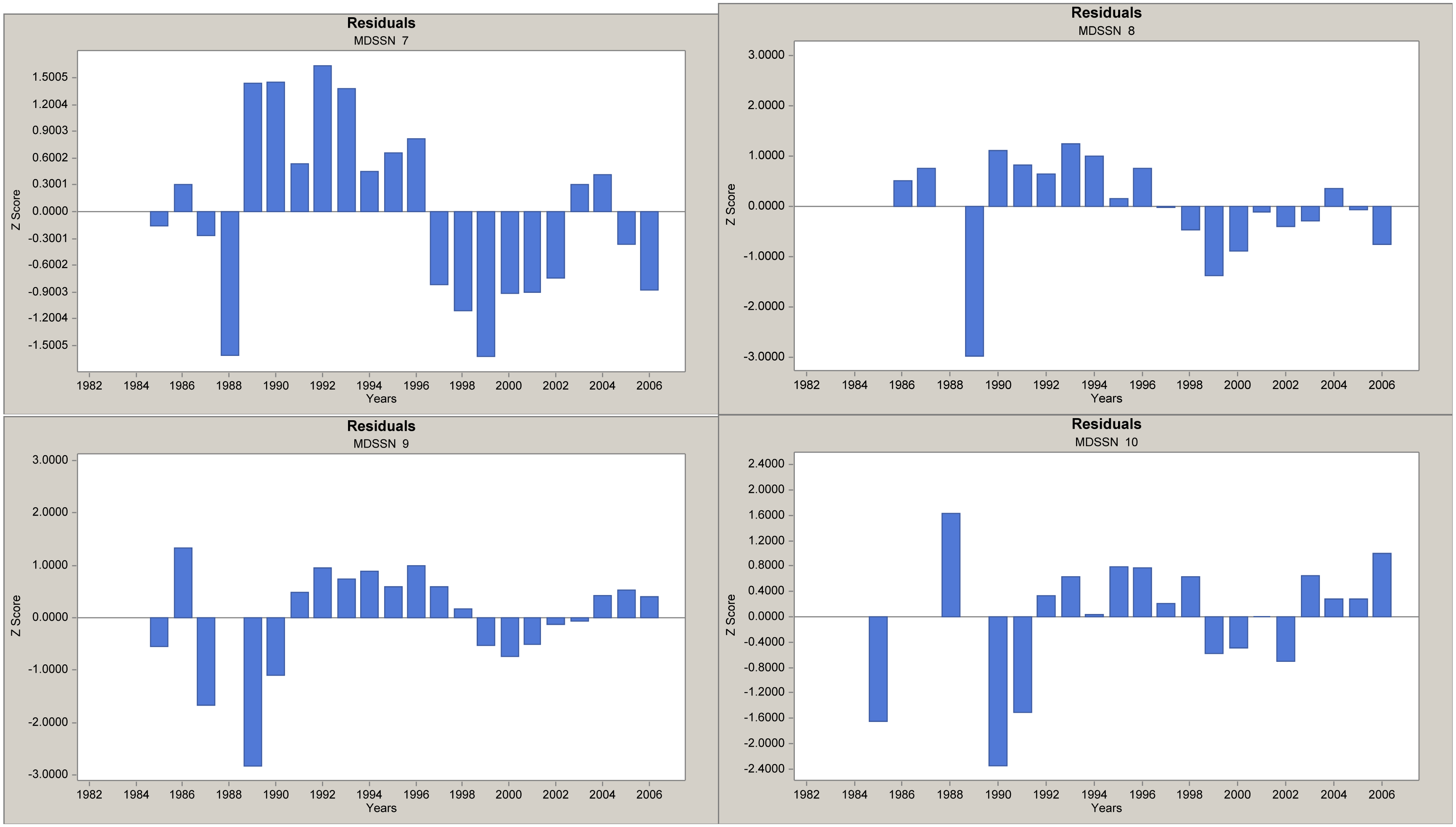



Figure 2 continued.

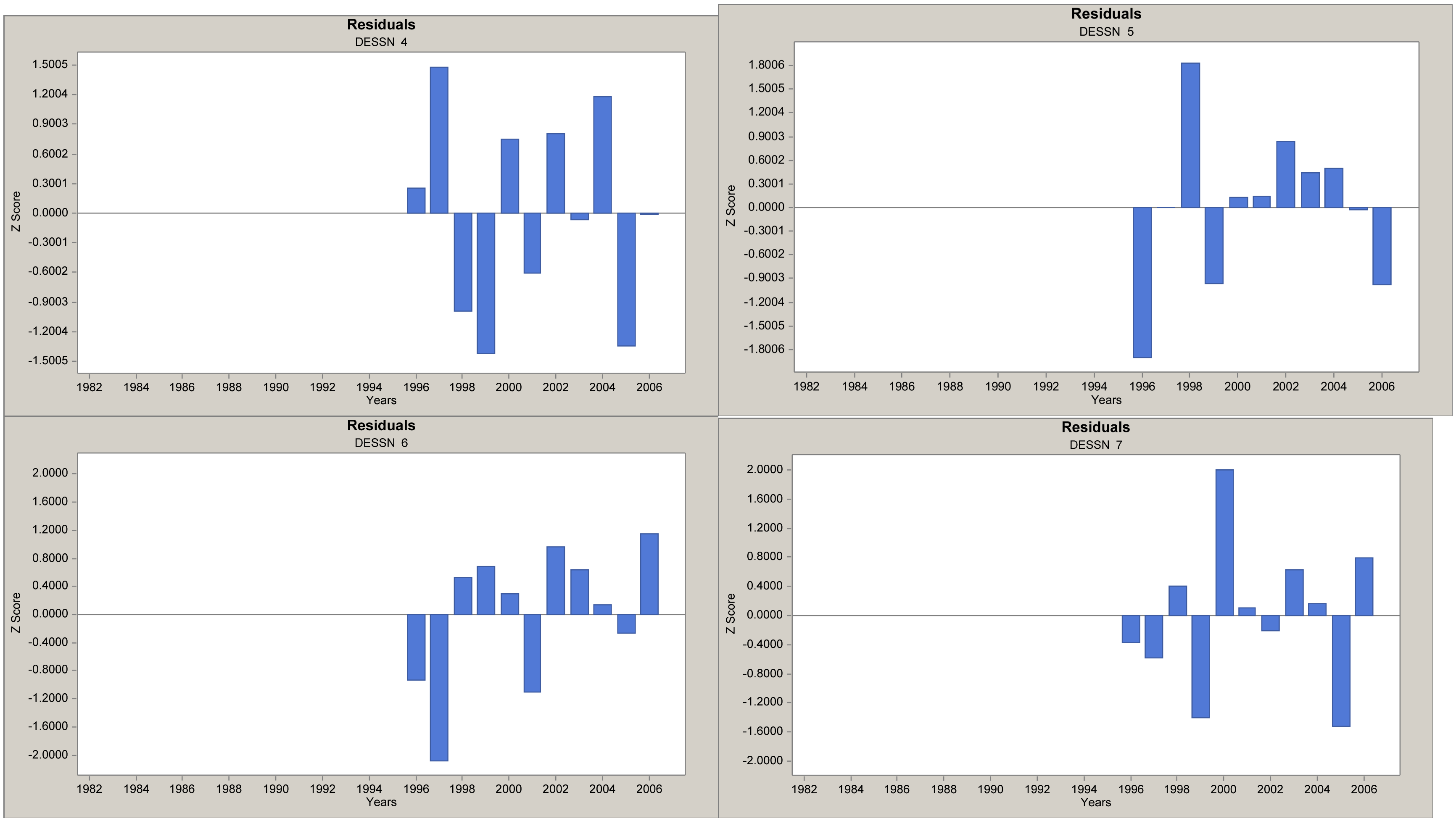



Figure 2 continued.

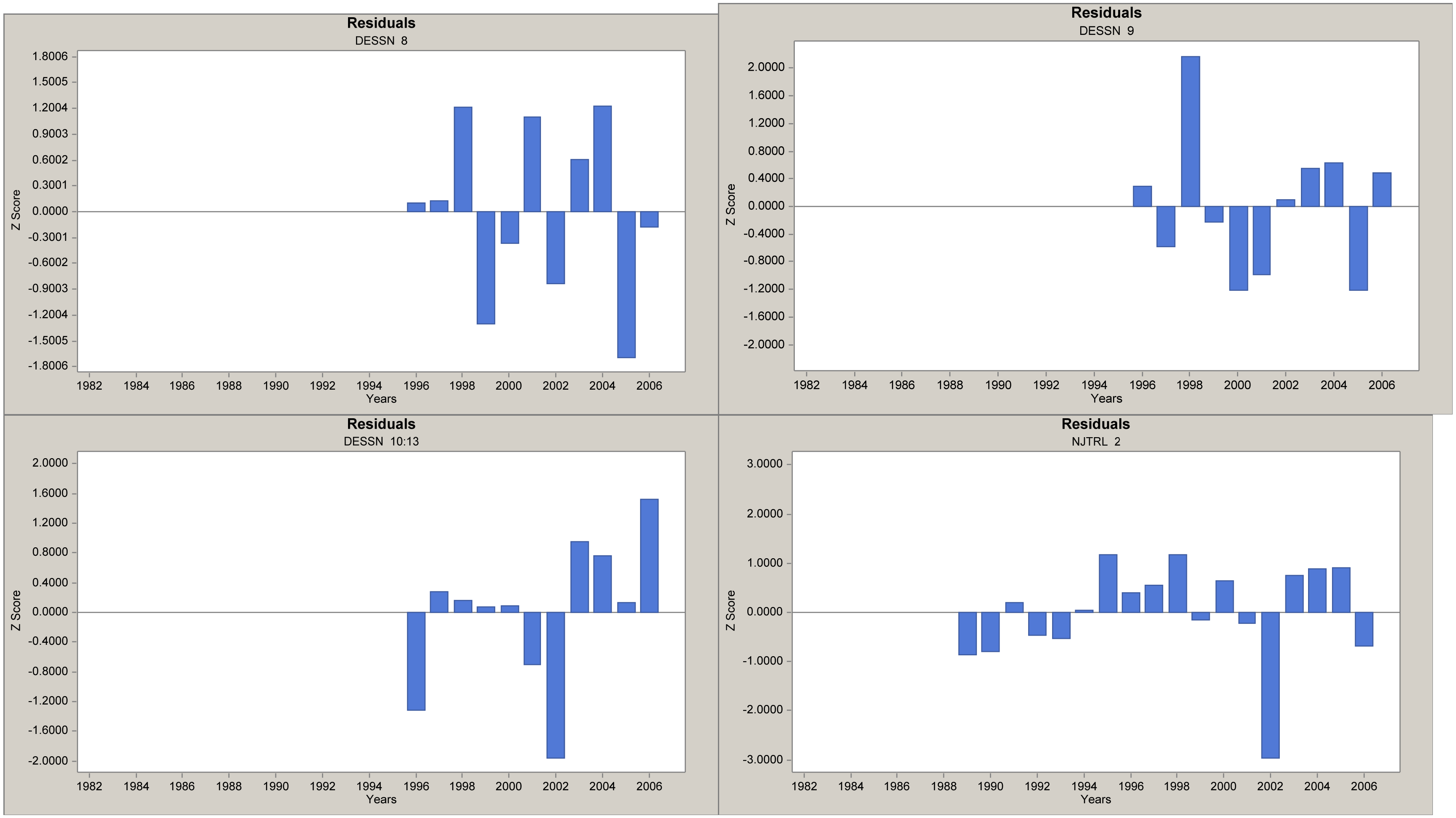



Figure 2 continued.

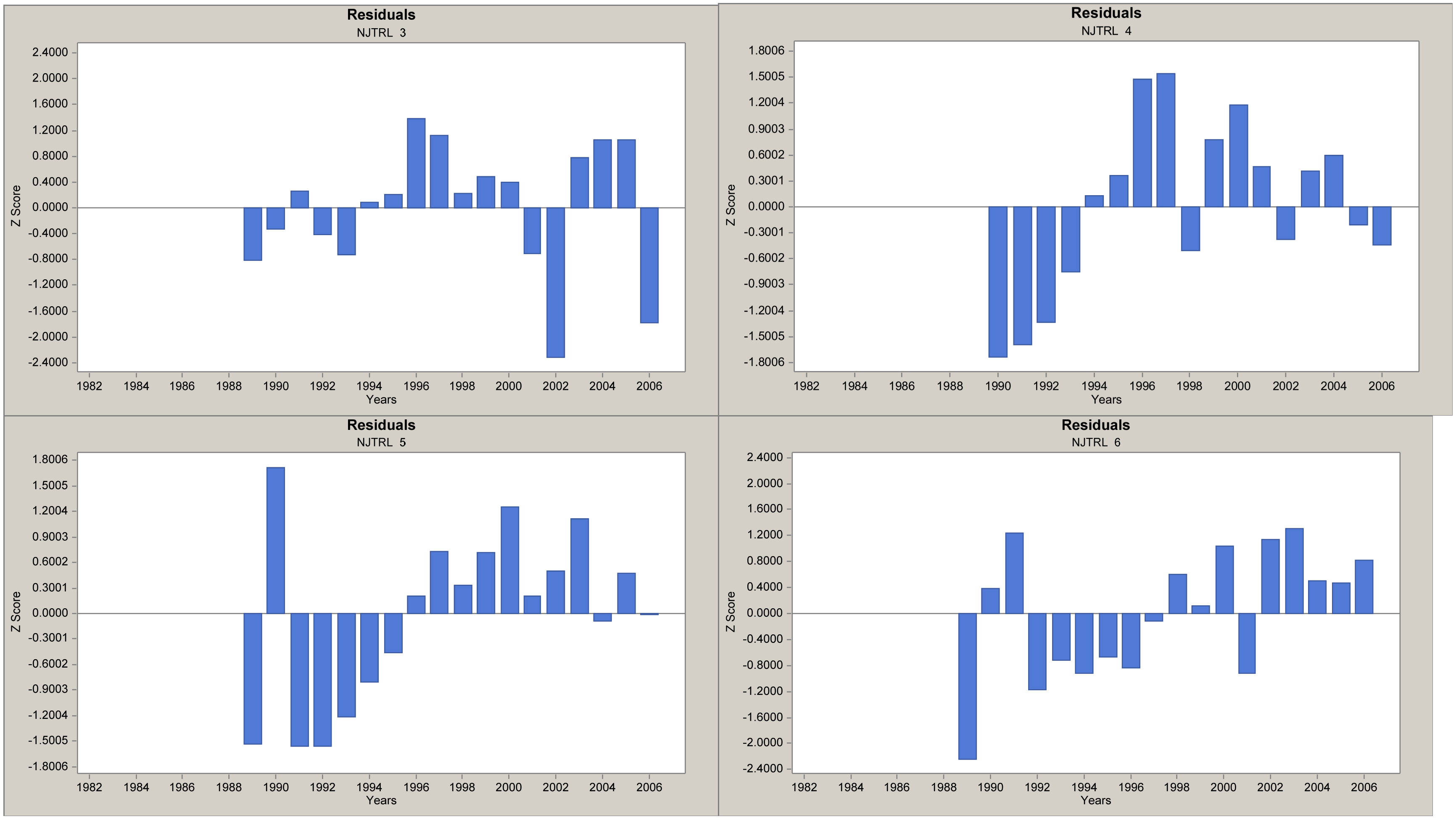



Figure 2 continued.

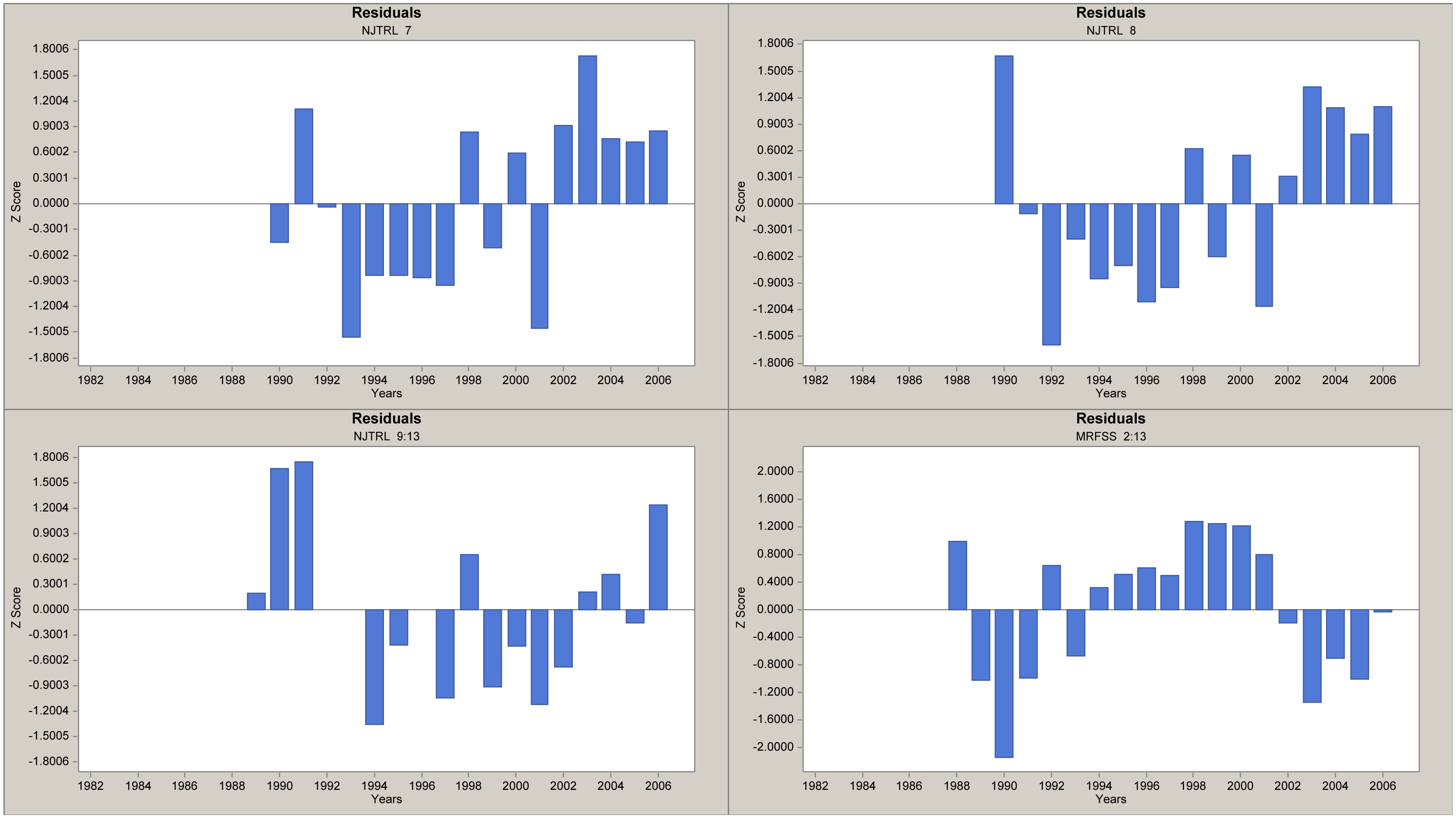



Figure 2 continued.

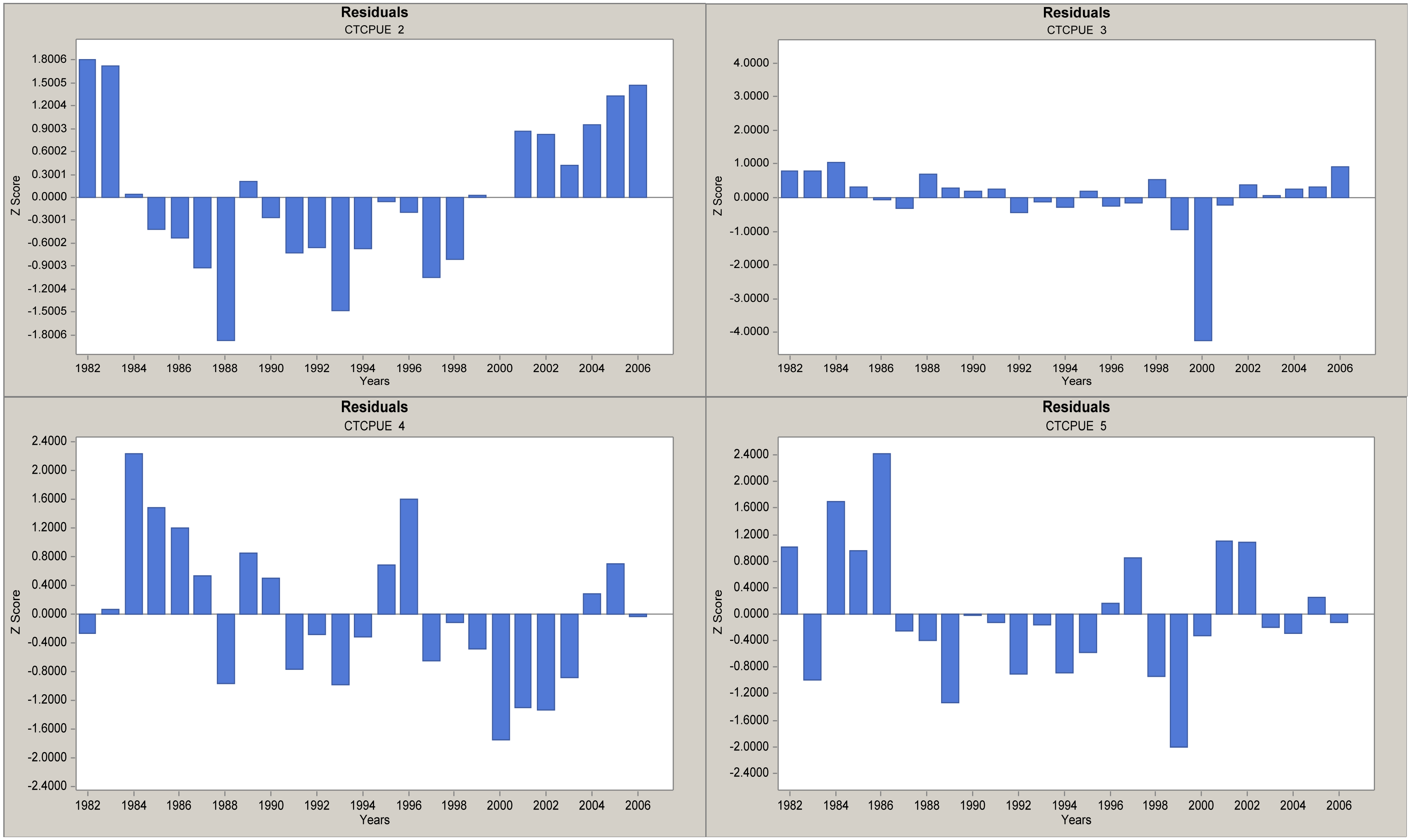



Figure 2 continued.

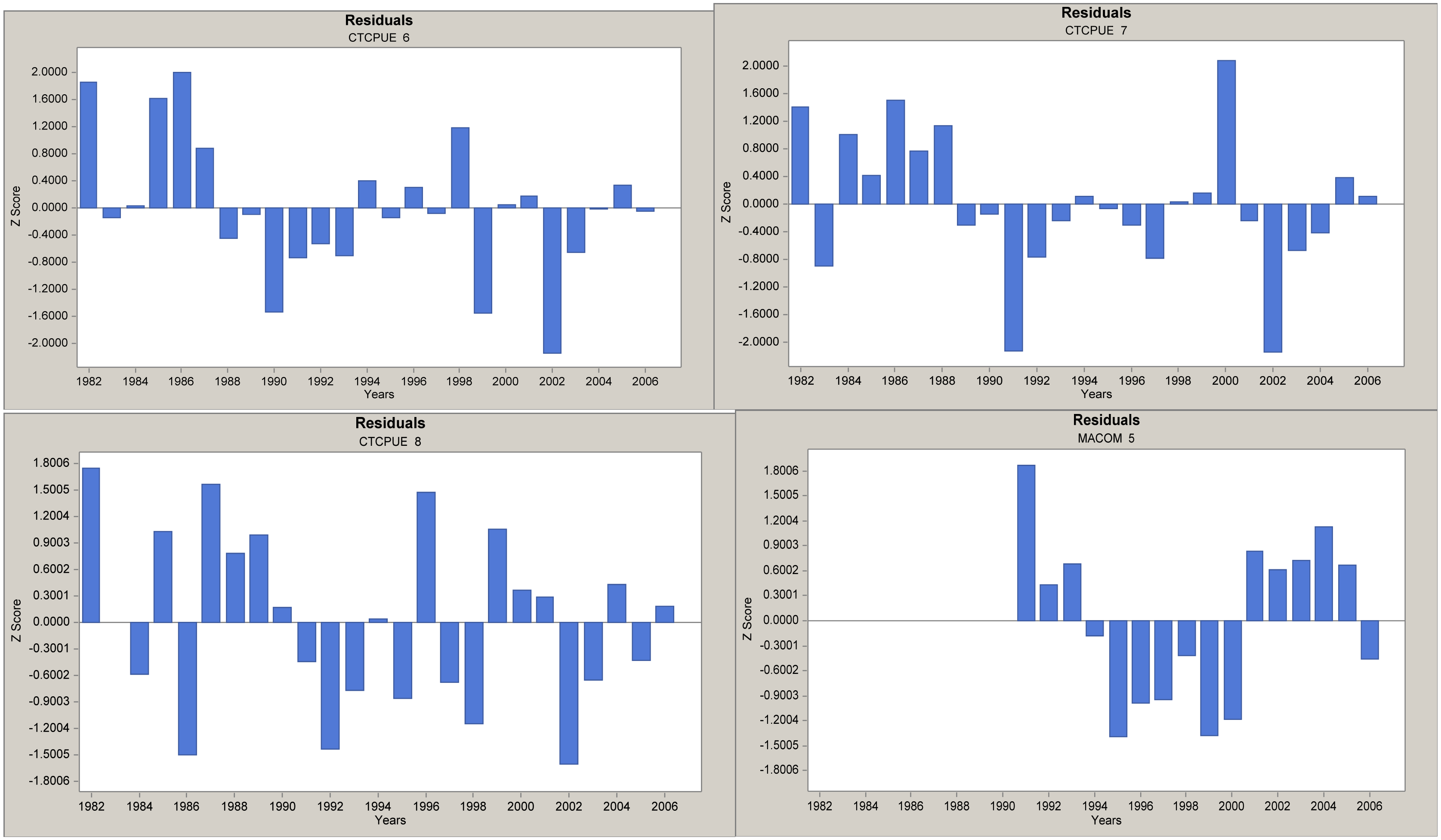



Figure 2 continued.

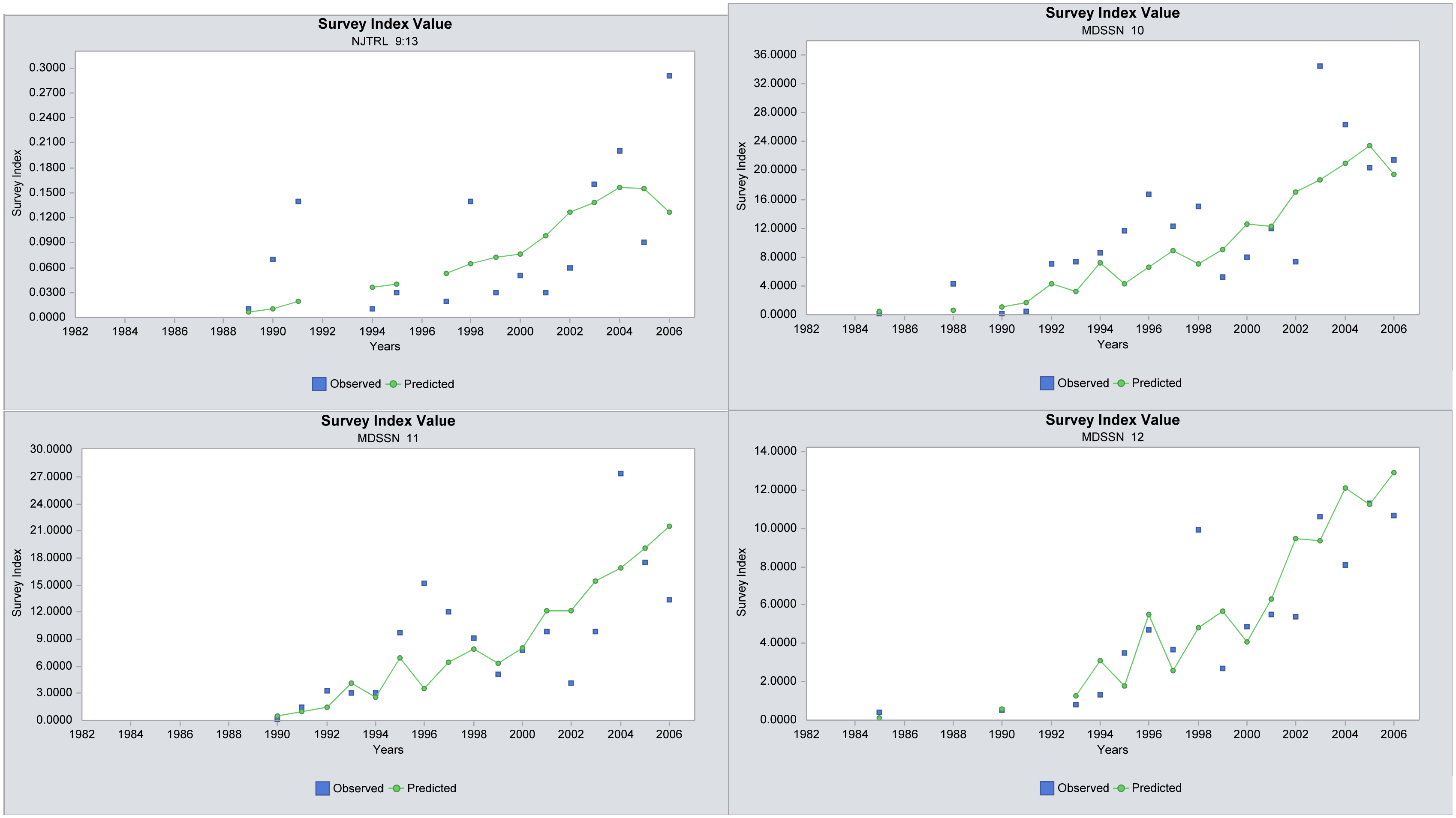



Figure 3. Observed vs. predicted indices from ADAPT model with reduced suite of indices

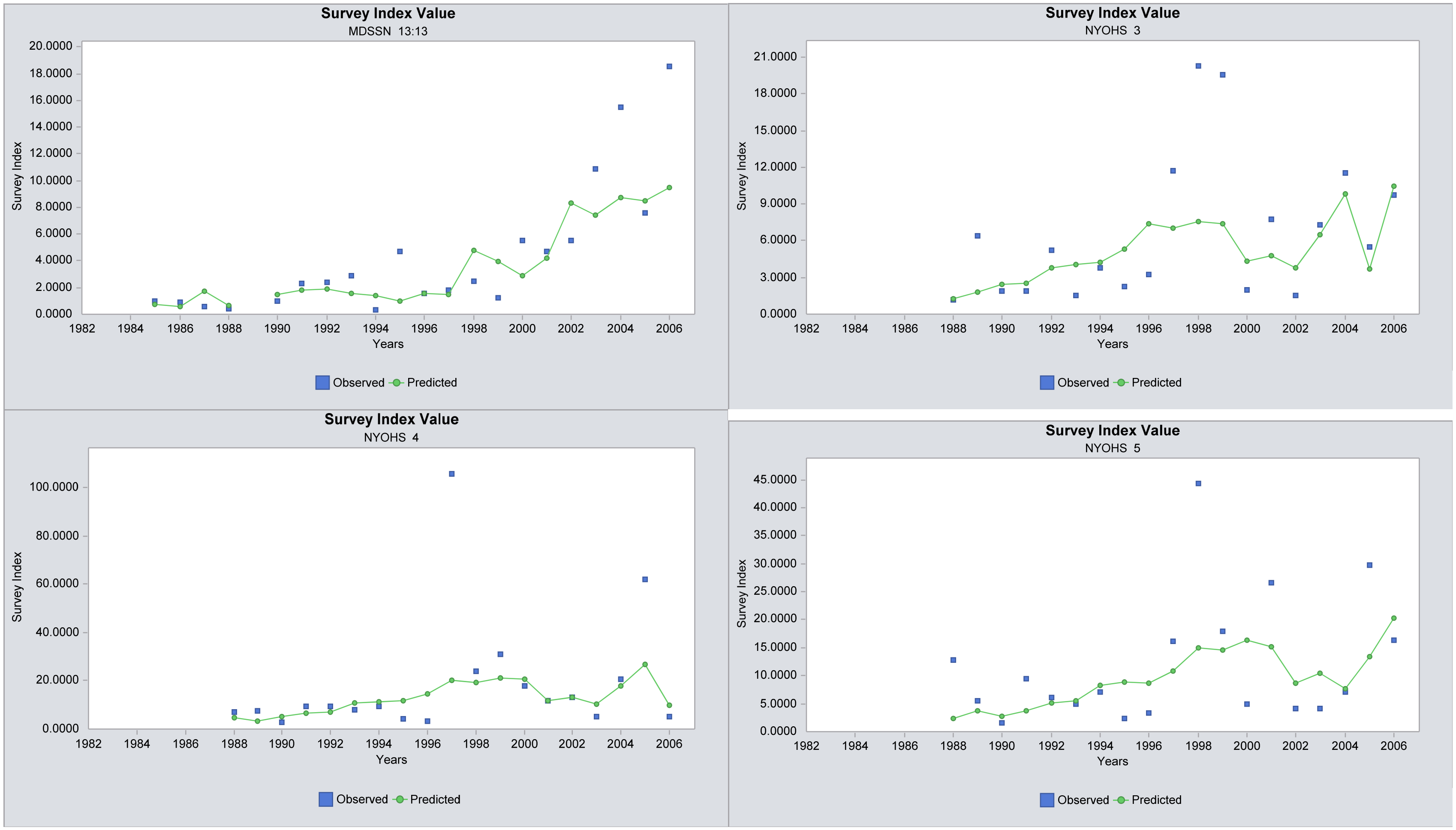



Figure 3 continued.

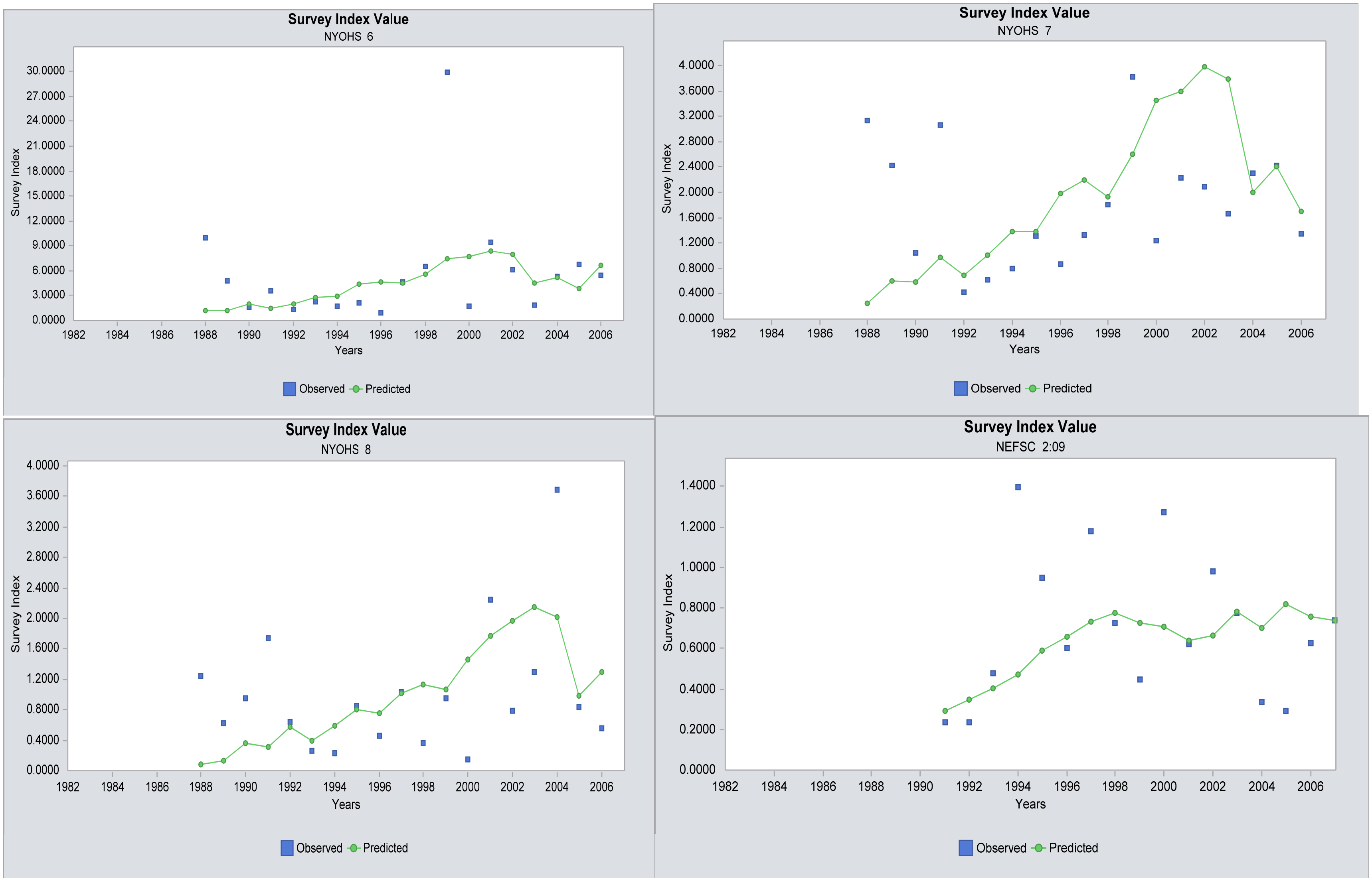



Figure 3 continued.


Figure 3 continued.


Figure 3 continued.

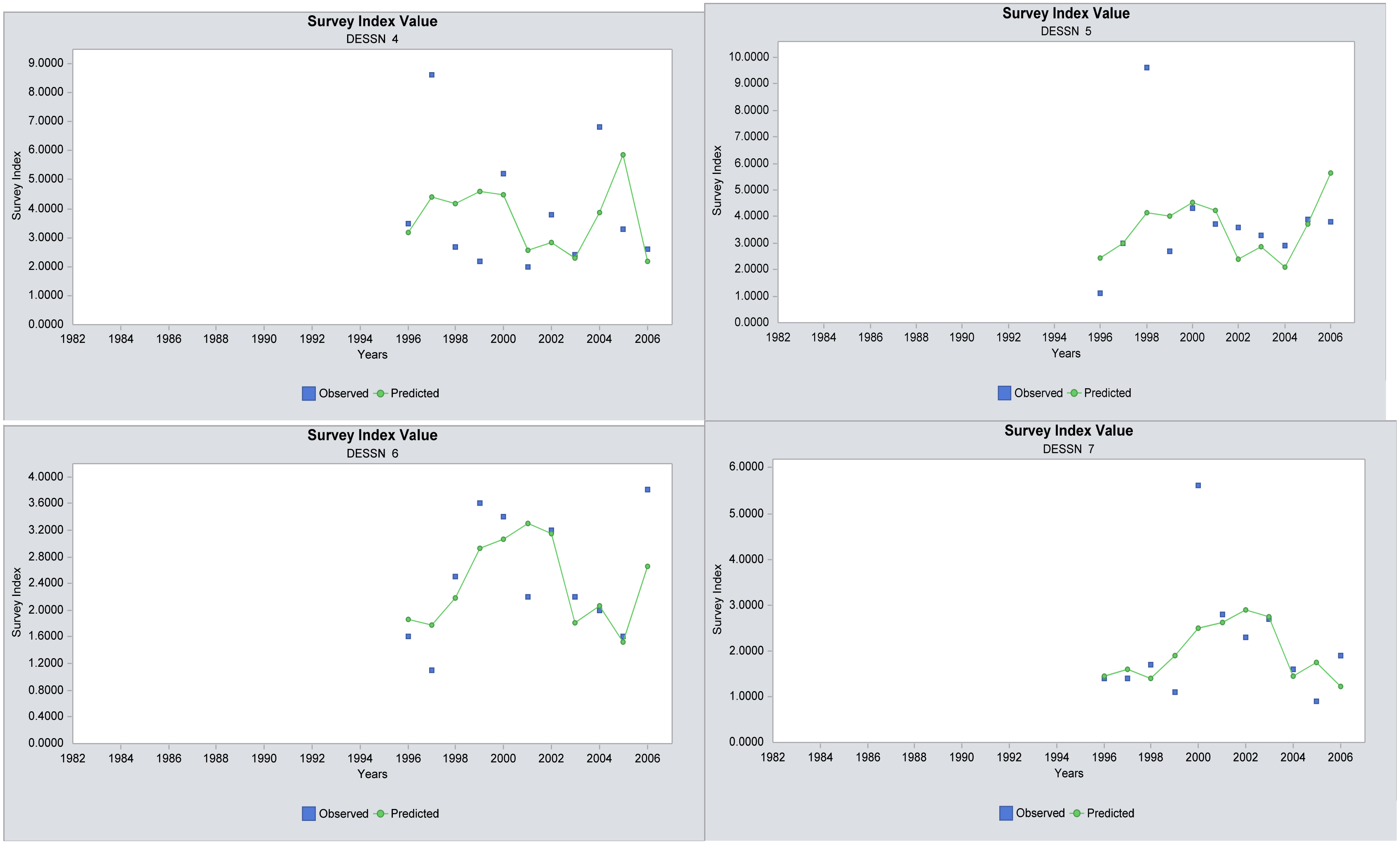



Figure 3 continued.

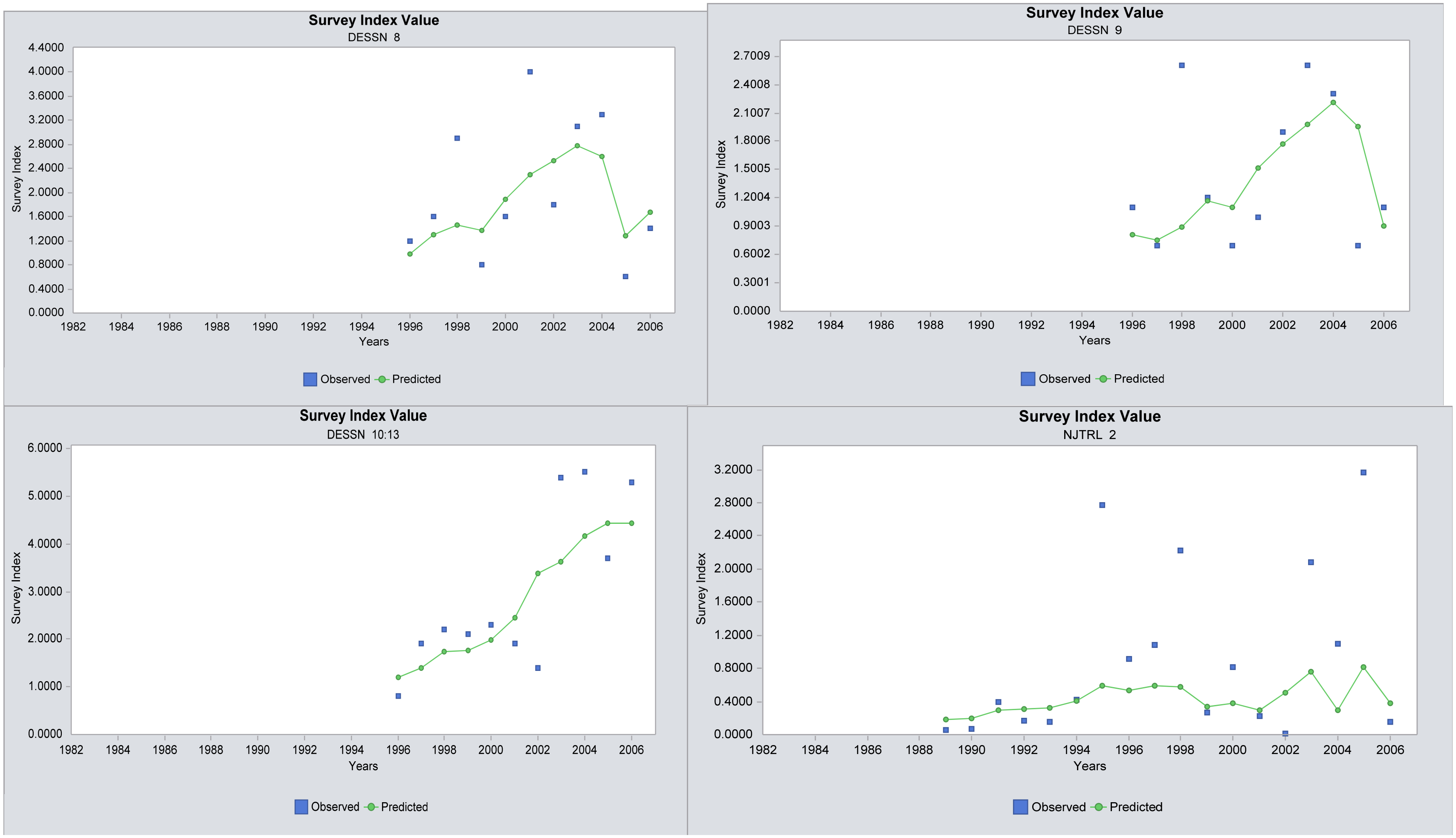



Figure 3 continued.

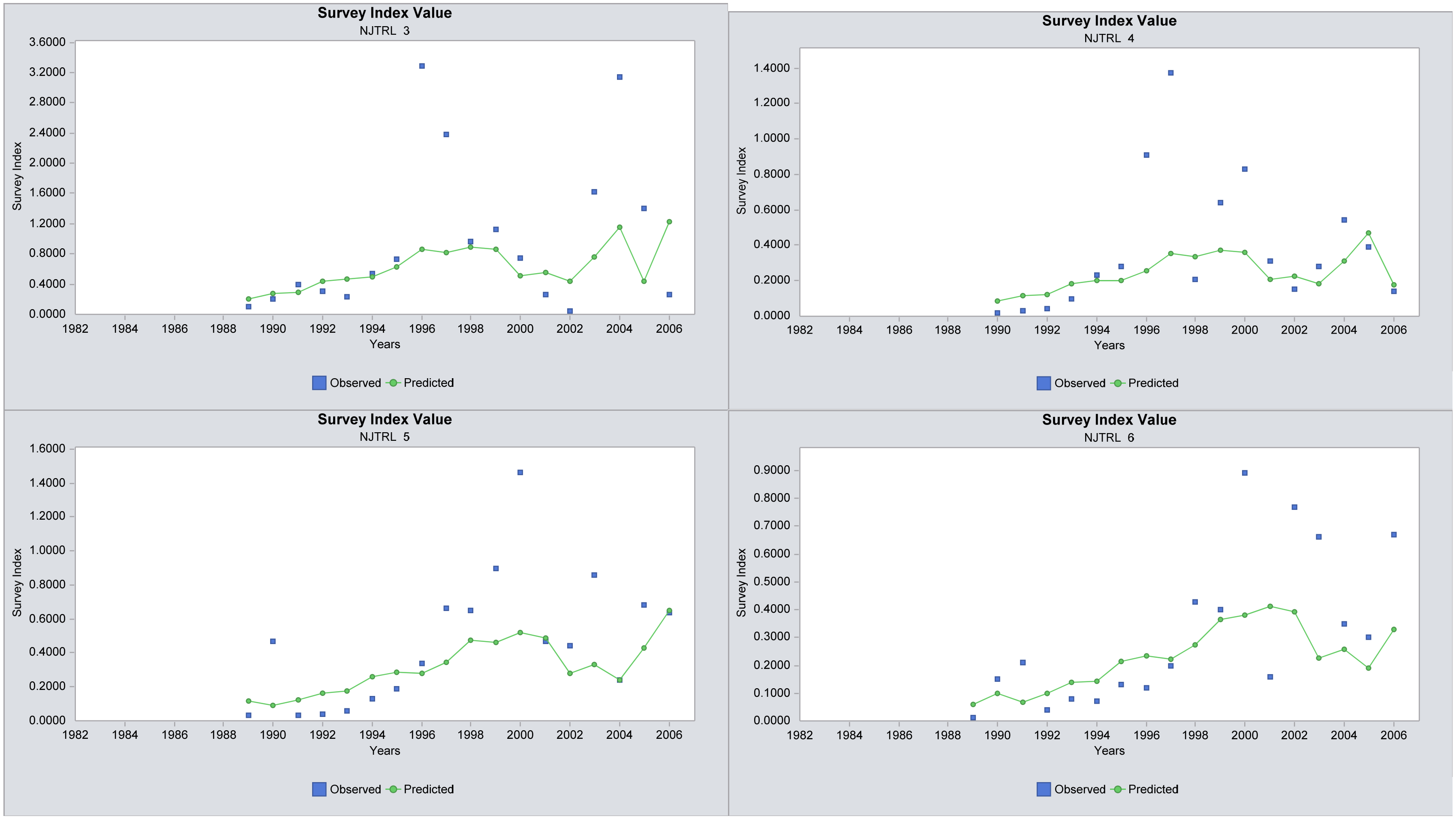
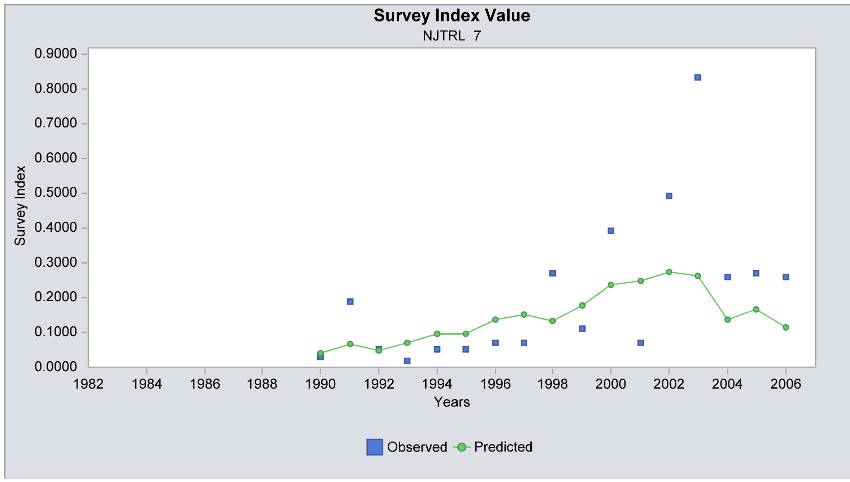



Figure 3 continued.



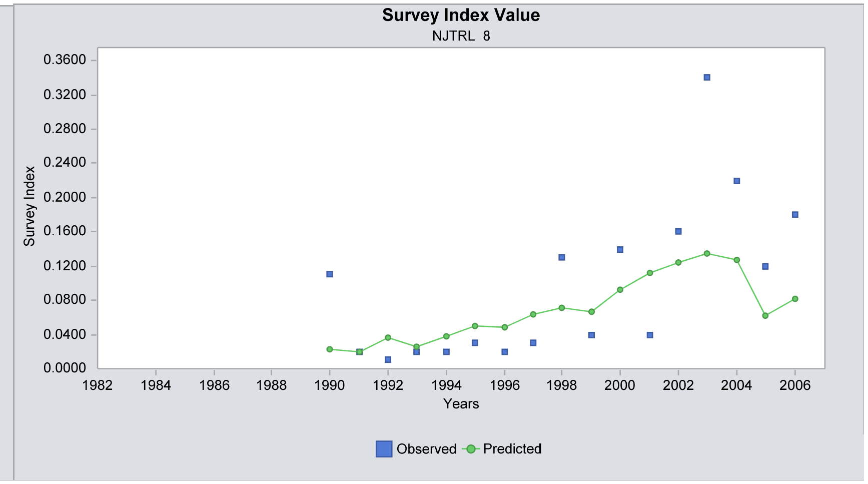




Figure 3 continued.

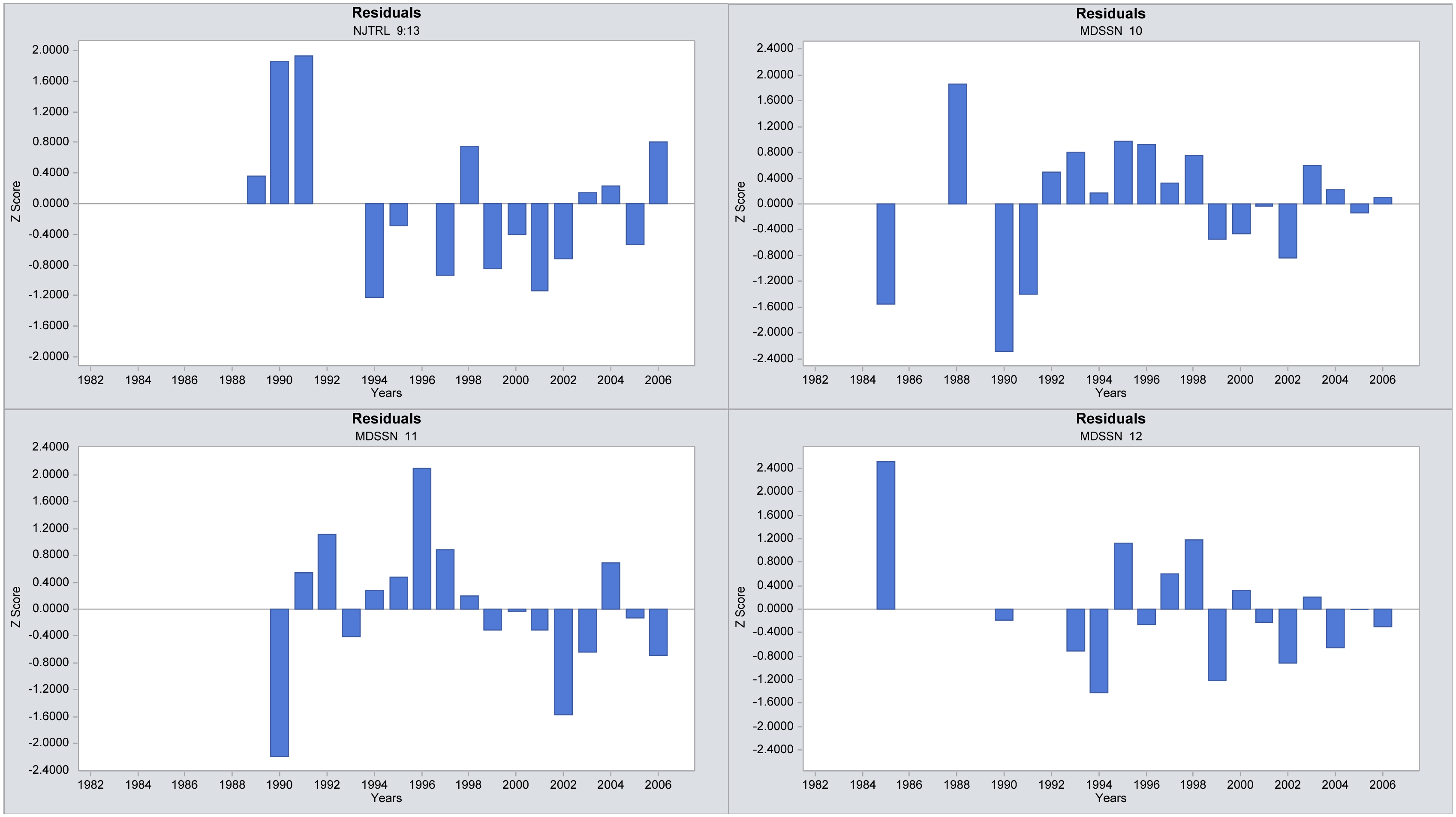



Figure 4. Residual plots from ADAPT model using reduced suite of indices.

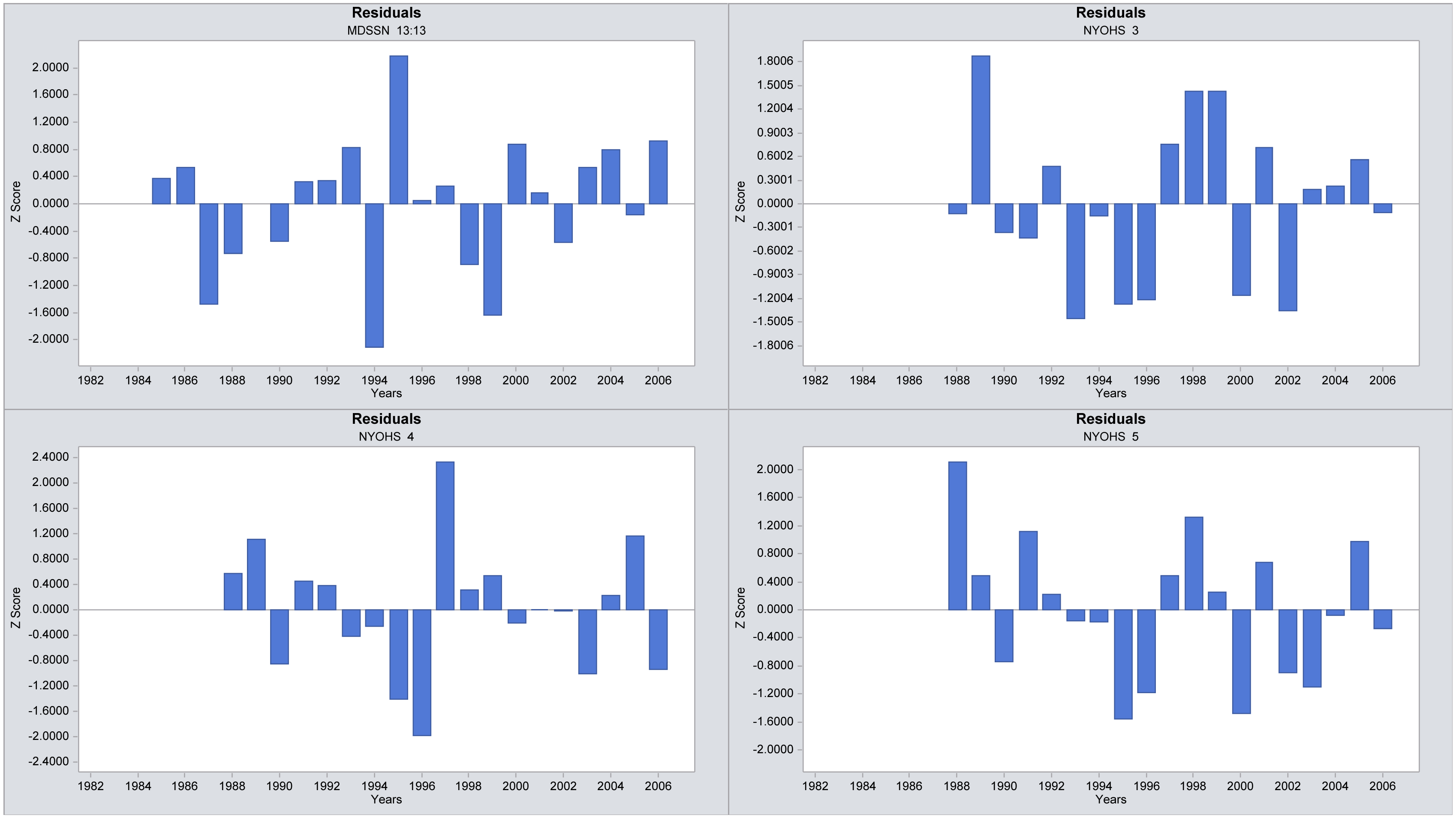



Figure 4 continued.

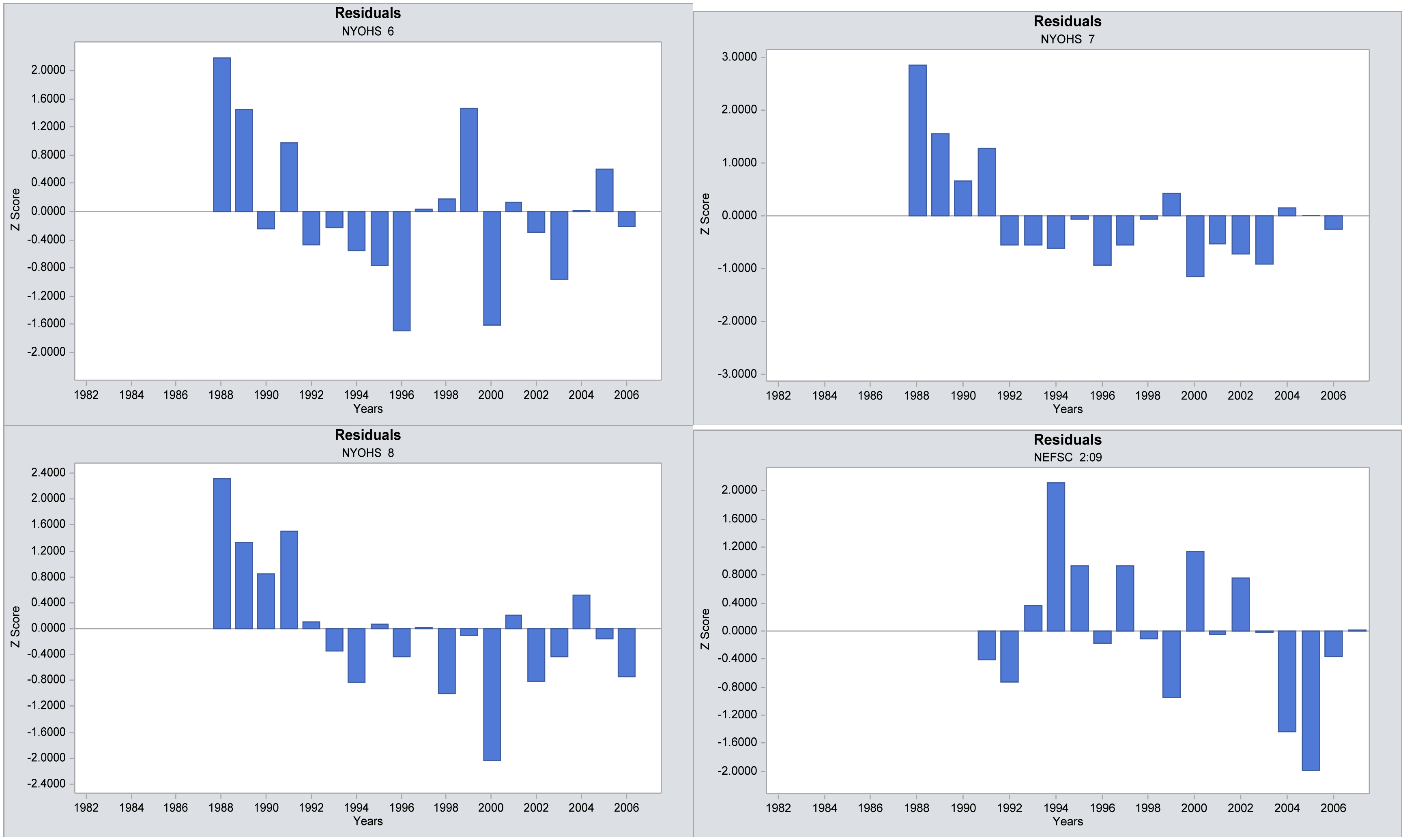



Figure 4 continued.

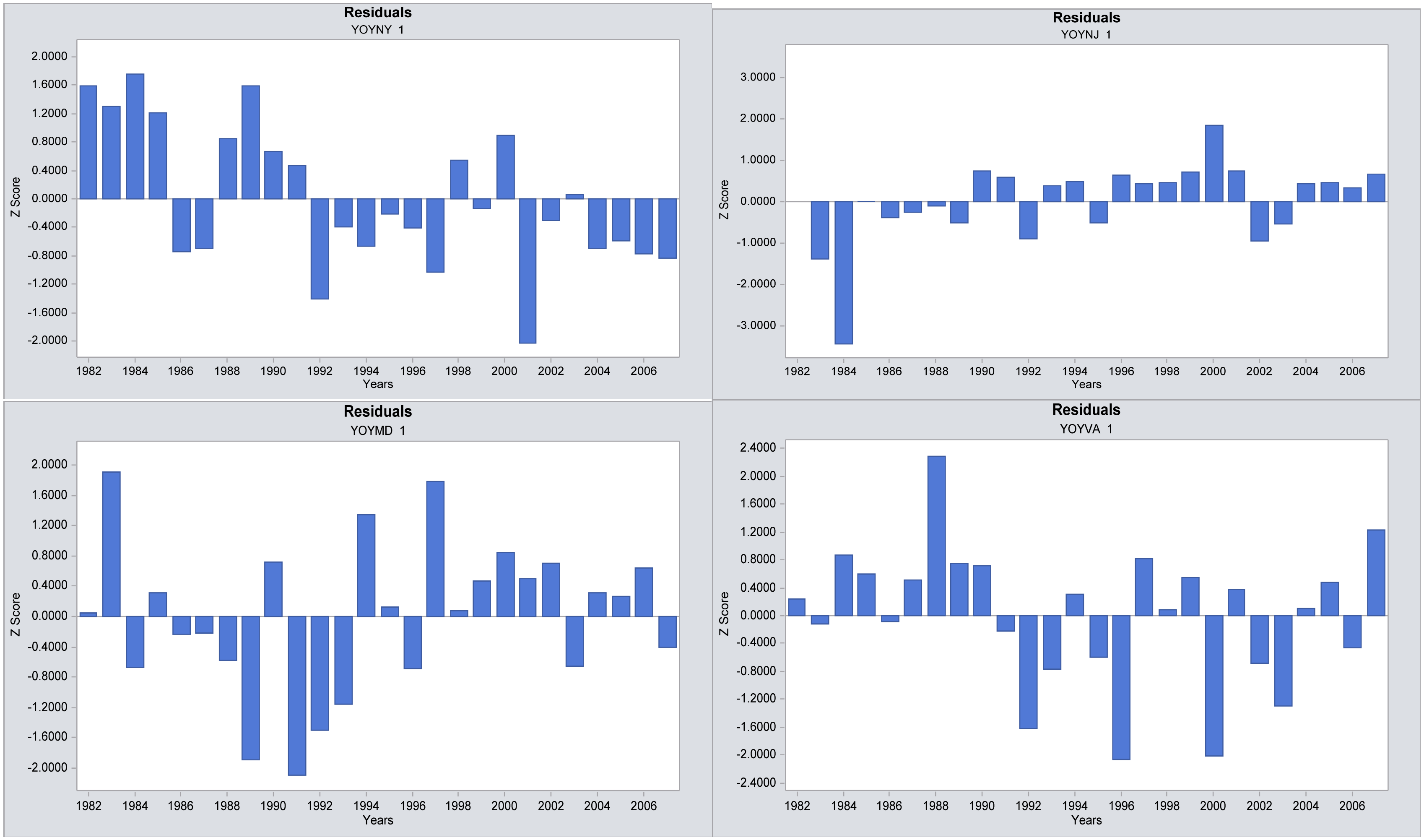



Figure 4 continued.

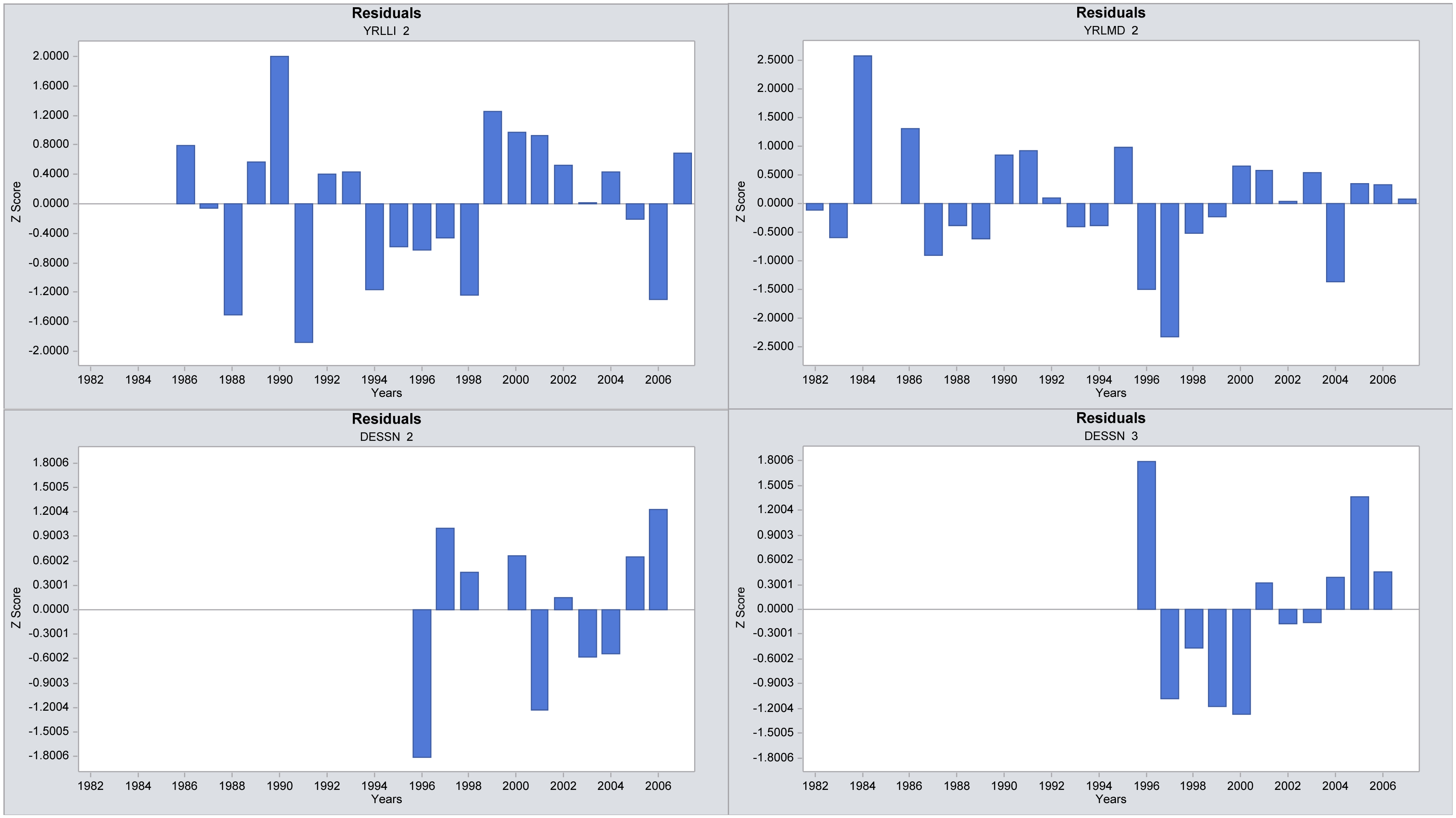



Figure 4 continued.

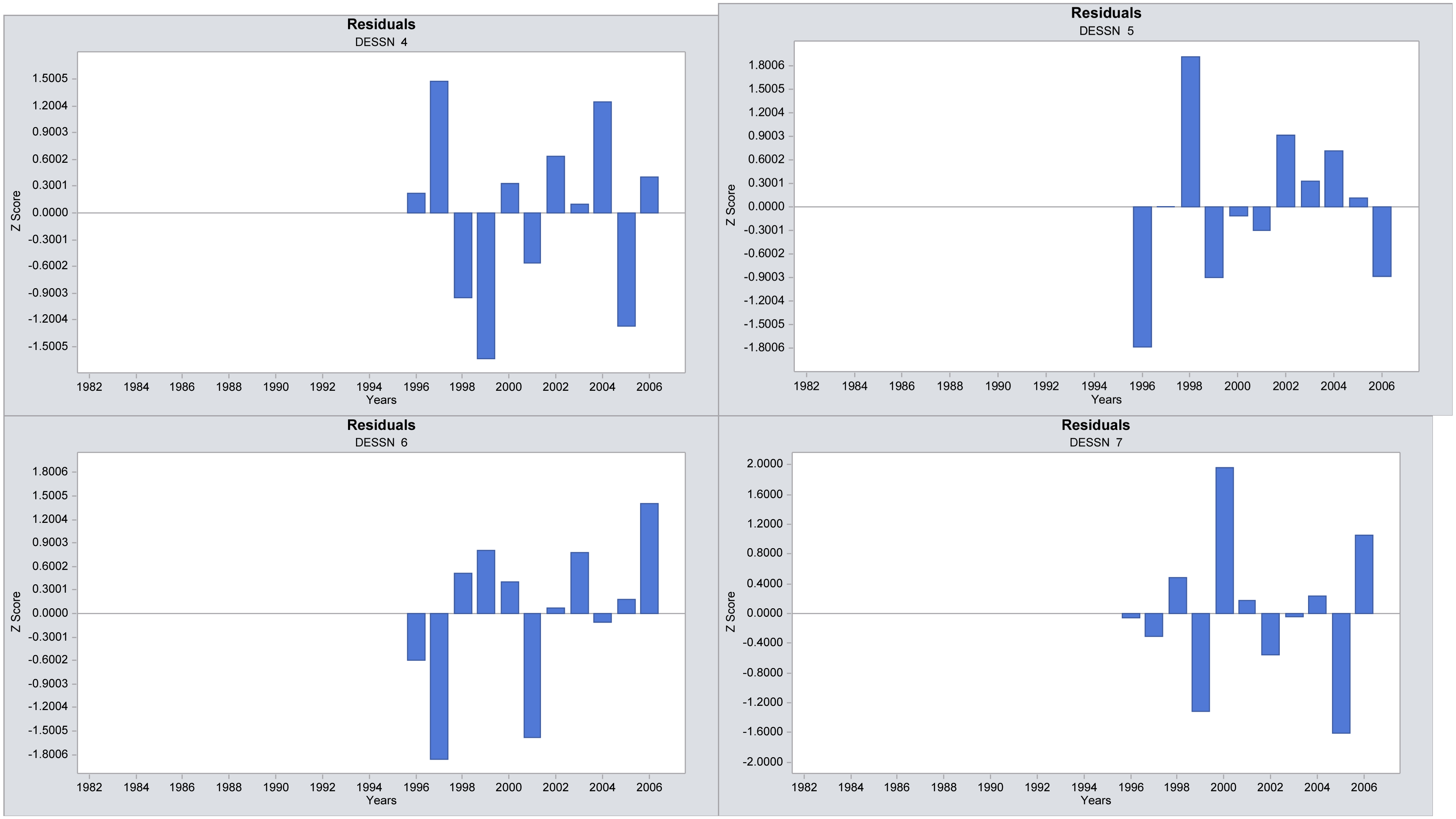



Figure 4 continued.

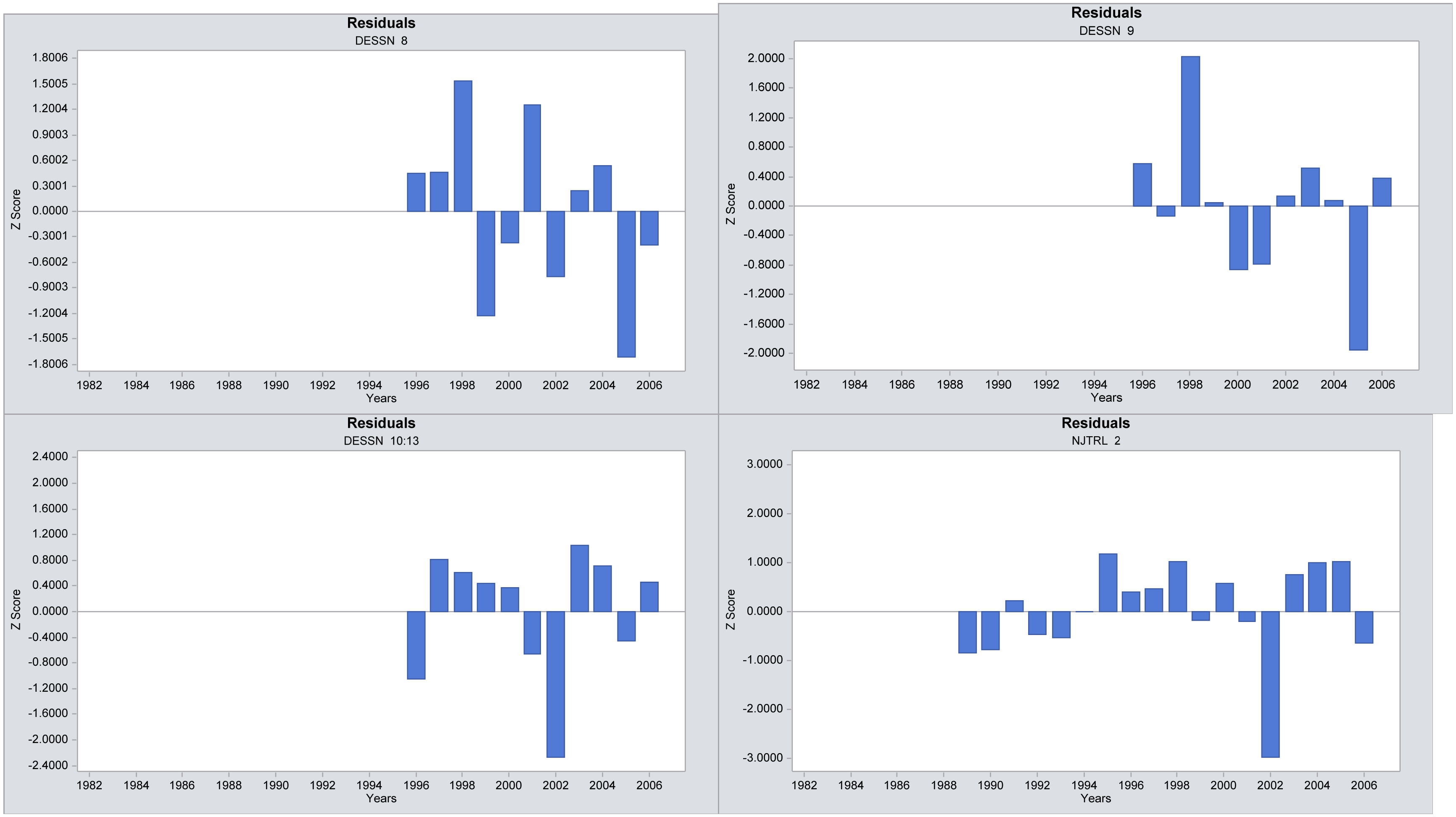



Figure 4 continued.

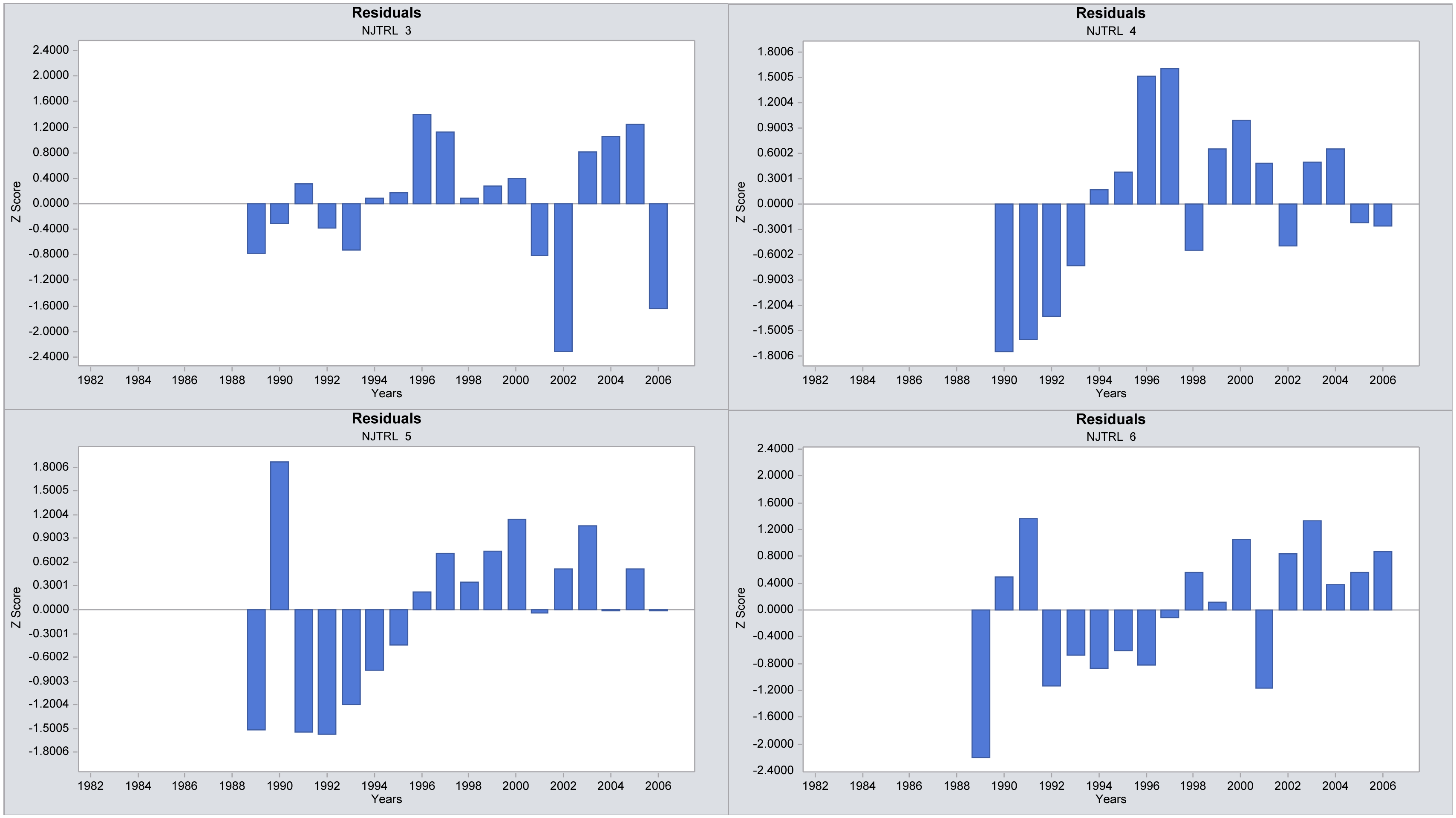
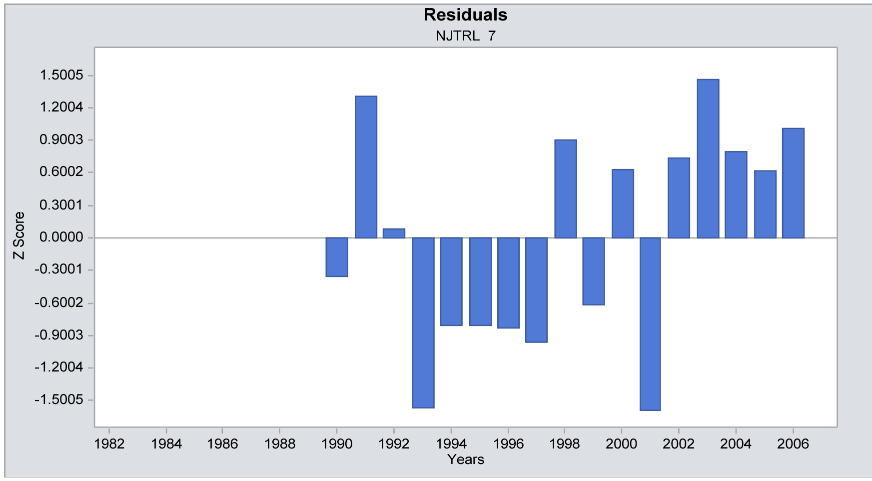



Figure 4 continued.



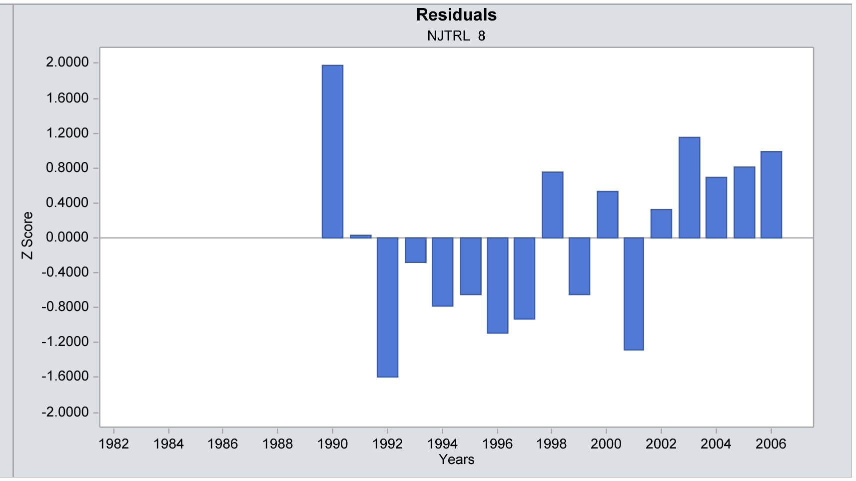




Figure 4 continued.

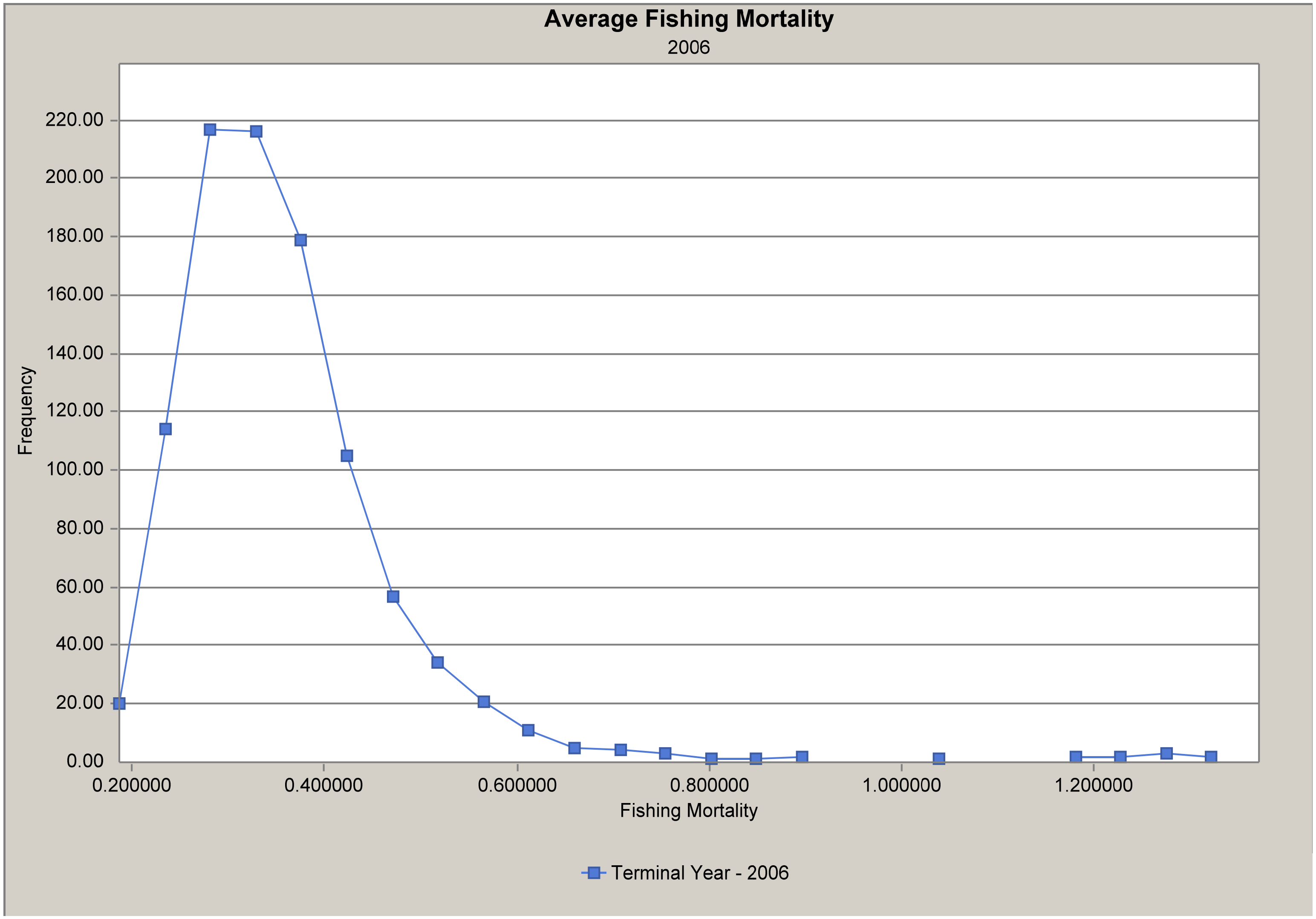



Figure 5. Bootstrap plot of fishing mortality from ADAPT model using reduced suite of indices

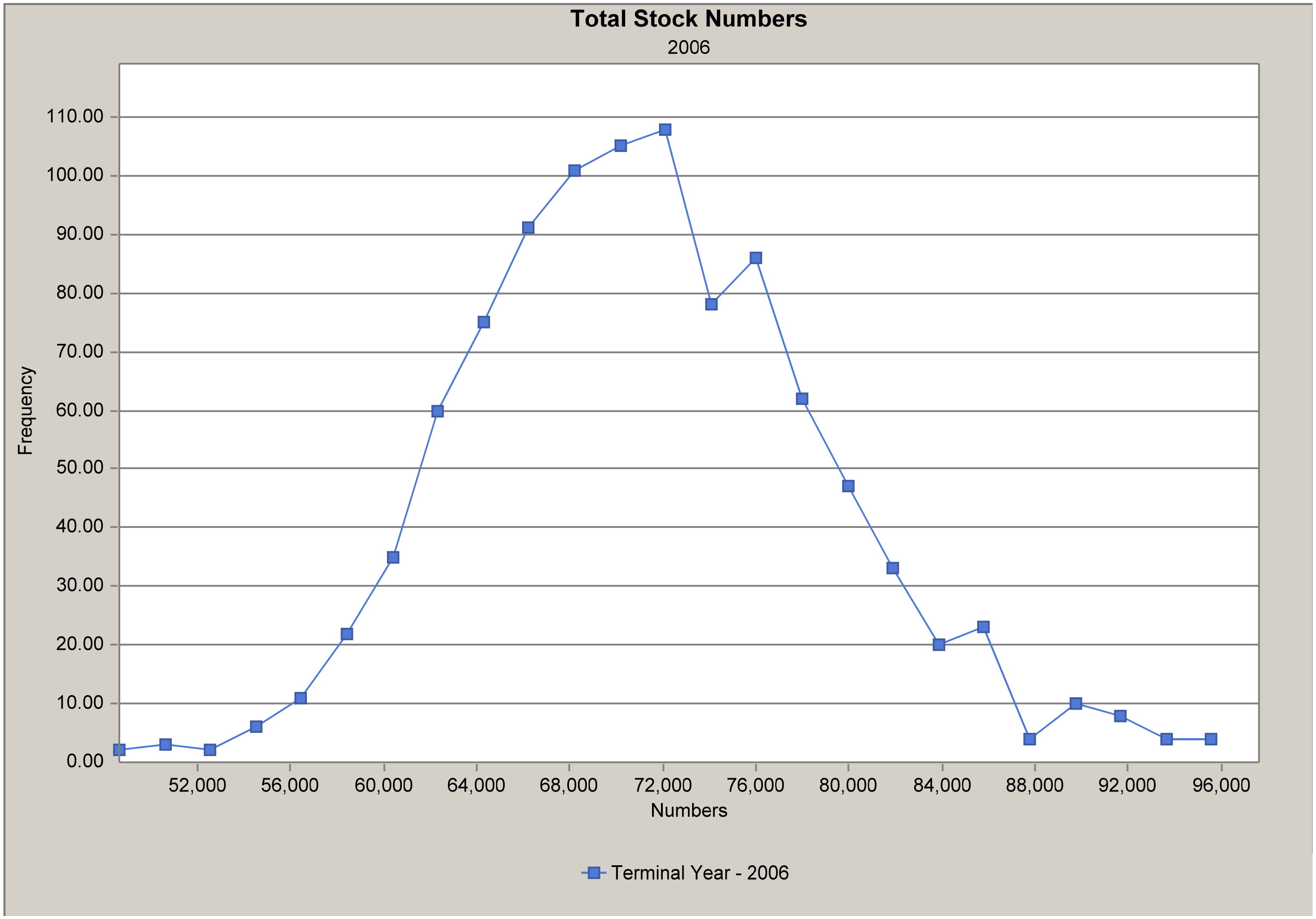



Figure 6. Bootstrap plot of stock numbers from ADAPT model using reduced suite of indices.

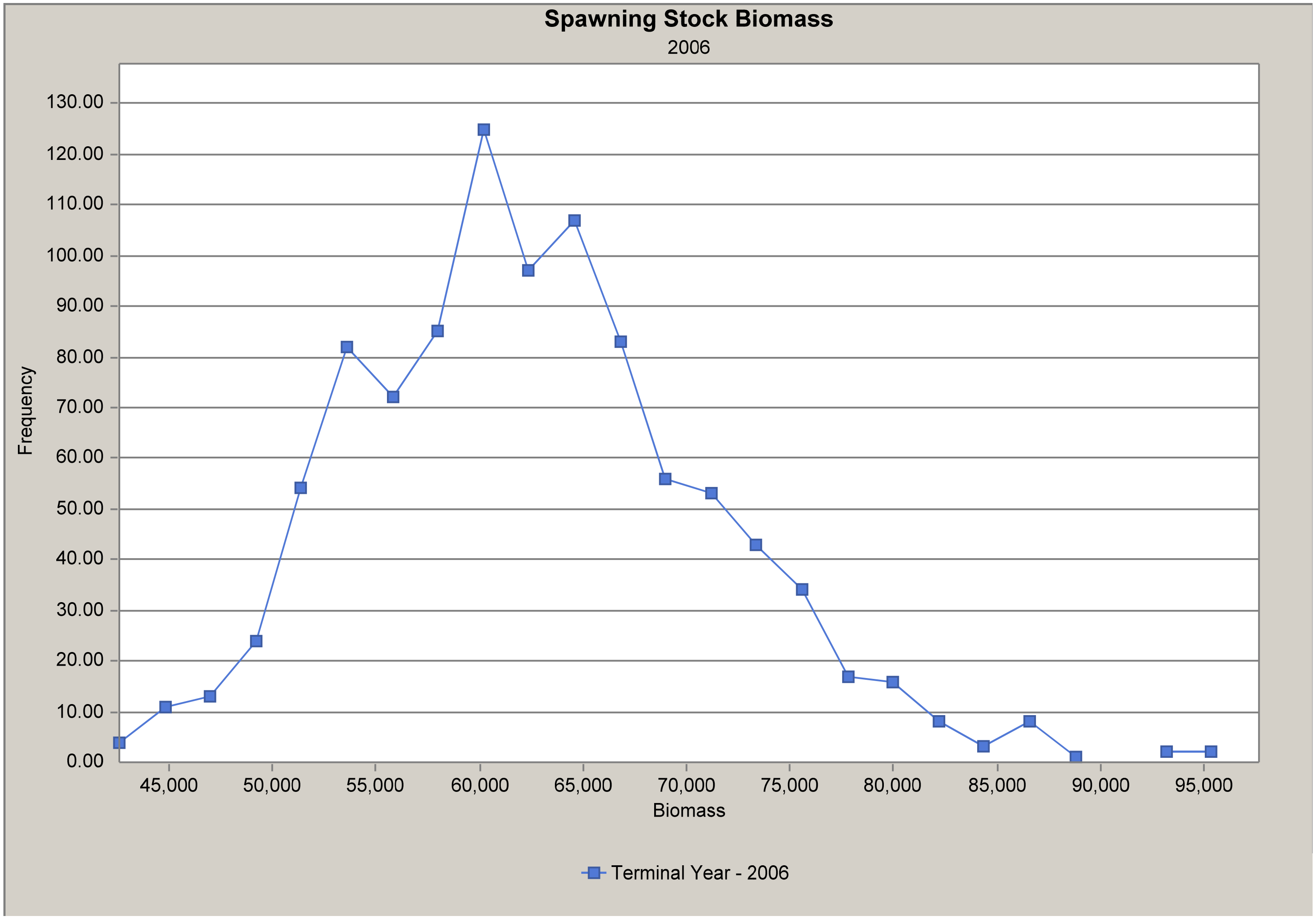
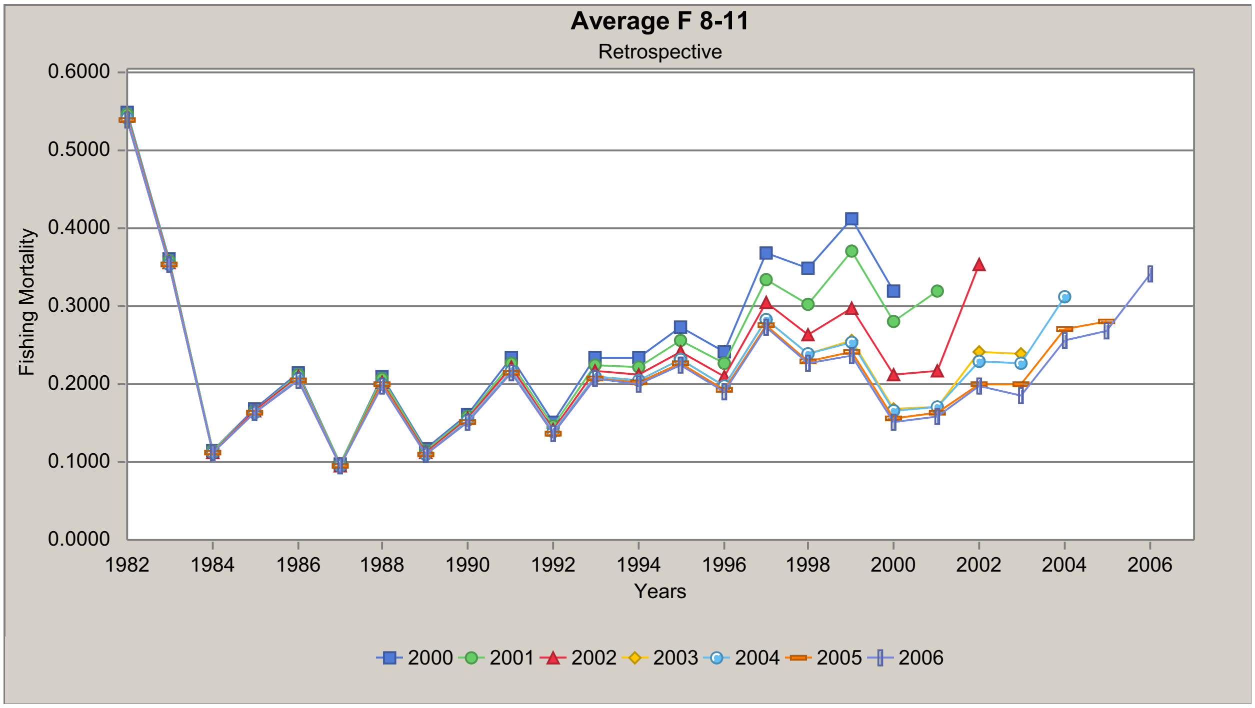



Figure 7. Bootstrap plot of spawning stock biomass from ADAPT model using reduced suite of indices.



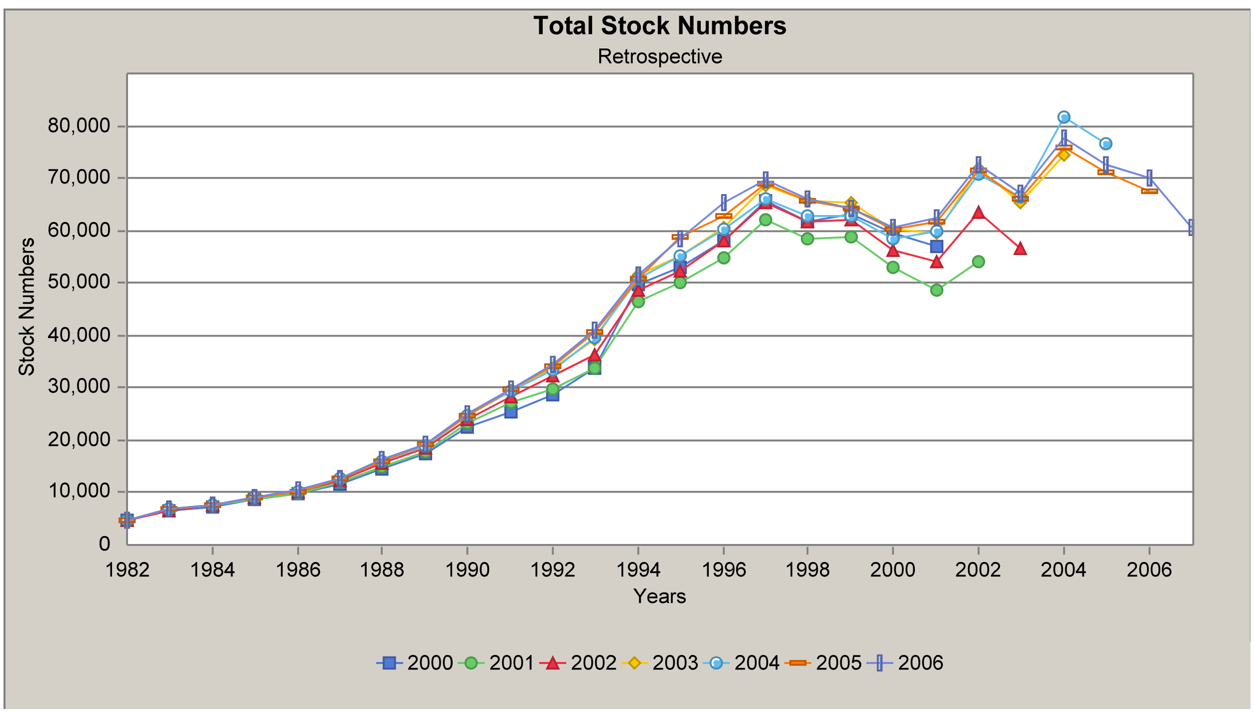
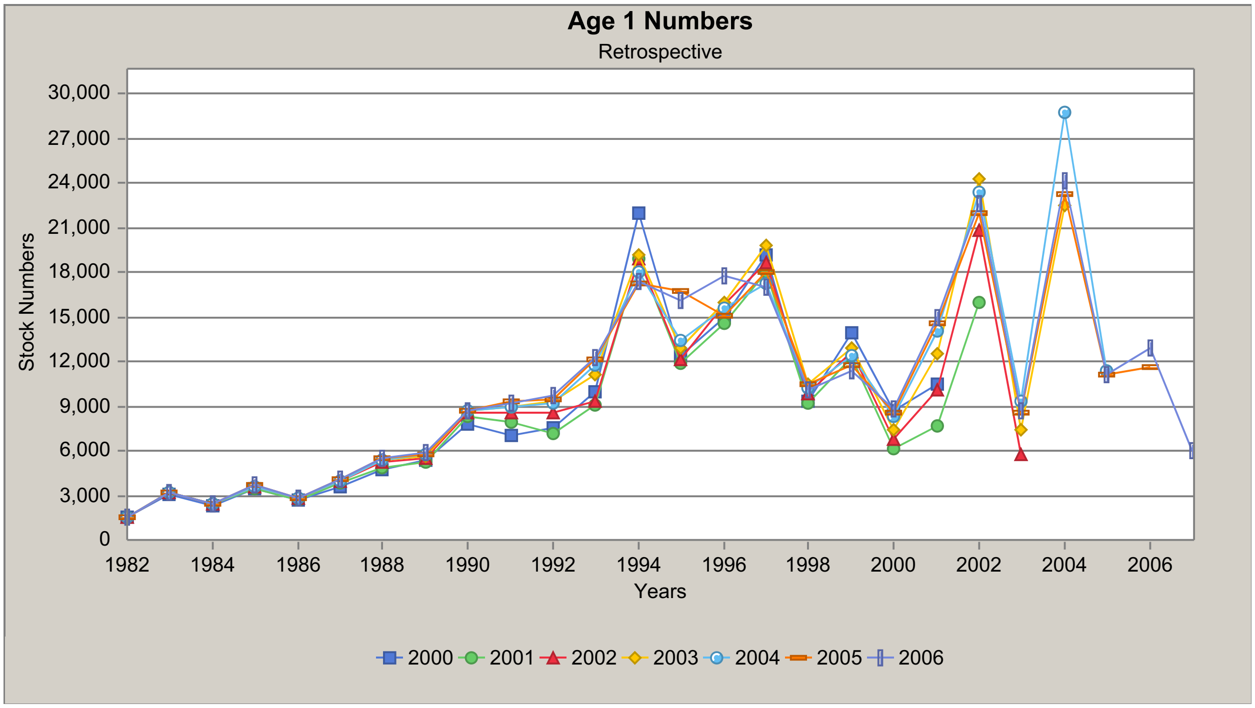




Figure 8. Retrospective plot of average fishing mortality and total stock abundance from ADAPT model using reduced suite of indices



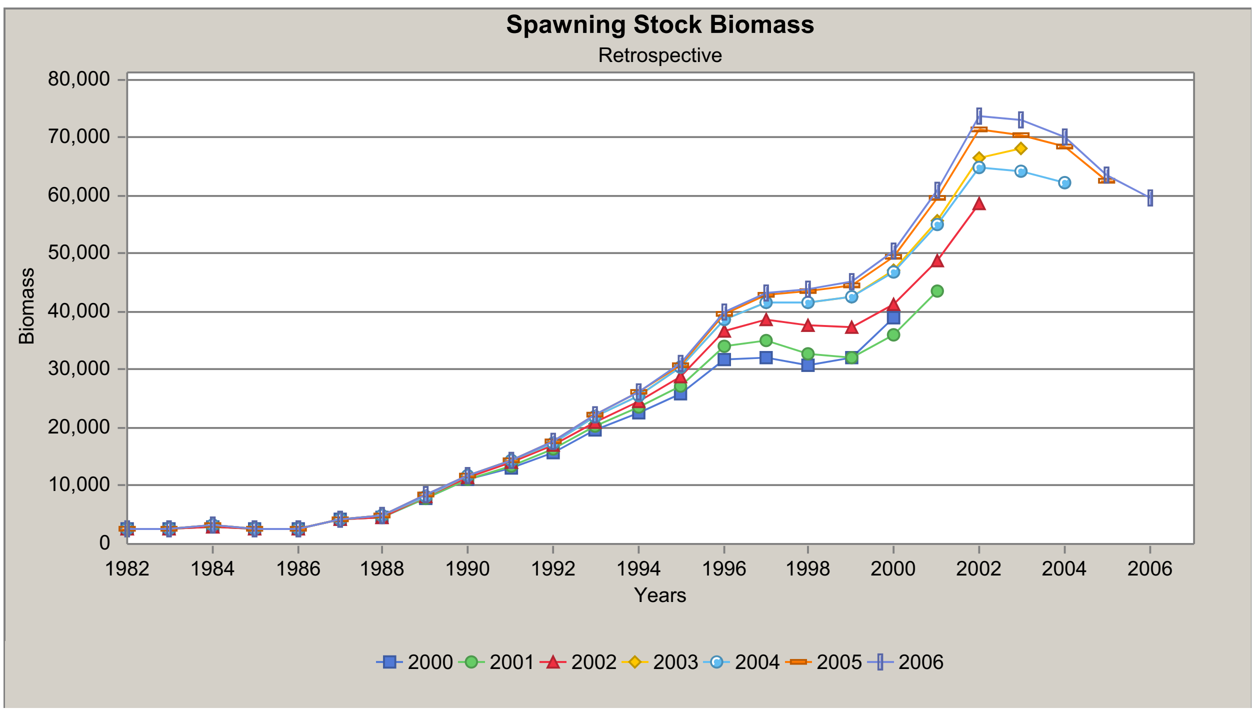




Figure 8 continued.

## Appendix A10. Age-Structured Assessment Program (ASAP)

### Catch at Age and Indices

As an alternative to the ADAPT VPA, a forward projecting catch at age model was evaluated. The model was developed by Legault and Restrepo (1998) and the corresponding software is available in the NMFS Fisheries toolbox as ASAP. The input values from ADAPT were used as initial values for the ASAP model. ASAP allows selectivity and catchability patterns to vary over time. The model was structured to allow greater deviations from the indices than from the catch-at-age data.

### Partial Recruitment Vector

Initial model runs indicated that estimation of selectivity parameters was not reasonable and therefore a selectivity pattern was fixed. Selectivity was calculated from the average F at age in the VPA model from 1982-2004 (PR relative to maximum average F). Full recruitment occurred at age 10 and was 1.0 through ages 13+ (Table 1).

### Model Configuration

$F_{mult}$, recruitment and abundance were allowed to deviate from the fitted model. Effective sample size was fixed at 150 for the time series (Figure 1A) and initial CV for recruitment was 0.5. All available indices were used with the MA commercial CPUE and DE trawl indices down weighted by a factor of 5.

### ASAP model results

The final model configuration produced a residual sum of squares of 0.00178. The model closely predicted catch at age for the combined time series and annual catch when compared to the observed catch (Figure 1B). Annual catch at age predictions were less accurate, particularly in the beginning of the time series (Figure 2). The fishery prior to 1985 produced a bimodal selectivity pattern because of intense fisheries of age 2 fish in Chesapeake Bay. The pattern changed following the closure of that fishery in 1985. Since the selectivity in the model was fixed at the long term average, those early years did not fit the predicted catch well. Similarly, the fixed selectivity pattern created problems when large cohorts dominated the fisheries in recent years (Figure 2).

Predicted indices varied from observed estimates in part due to the level of noise apparent in the index signal (Figure 3). Negative log-likelihood values were lowest for Delaware spawning stock indices at age, MRFSS CPUE and the young of year/age 1 indices (Table 2).

Fishing mortality estimates in ASAP are based on a separability assumption. $F_{MULT}$ is the product of $F$ at age and selectivity. The 2006 $F_{MULT}$ value equals 0.25 (Table 3). The trend in $F$ was a steady increase between 1987 at 0.06 to 1997 when F equaled 0.21 (Table 3). Fishing mortality declined slightly to 0.16 rising above 0.2 only since 2004.

January 1st population sizes show a general increase in overall abundance since 1982 (Table 4). Predicted age 1+ abundance estimates in 1982 were 5.9 million fish increasing to 84.9 million in 2004 and declining to 78.4 million in 2006 (Table 4).

A retrospective analysis back to 2002 showed no retrospective pattern in the estimates of predicted total catch (Figure 4). A retrospective pattern in fishing mortality was apparent in 2002 and to a lesser extent in 2003, with both years overestimating F (Figure 4). However the F estimates for 2004 to 2006 were similar. Similarly, there was an under-estimation of abundance in 2002 and 2003 but negligible thereafter (Figure 5).

**ASAP Summary**

The catch at age model produced similar results as the ADAPT model within the constraints of the selected parameters. Fishing mortality has increased in recent years but remains below the target F, total abundance generally continues to increase although the 8+ abundance has decreased since 2004. The production of large cohorts continues on a regular frequency similar to the pattern seen in the MD juvenile indices from the 1960s.

The ASAP model fits observed data with mixed results. Fixing the selectivity pattern reduces the fit to catch at age in the early years but improves the fit in the latter years. Predicted indices generally captured the trend in observed indices but not the magnitude, particularly with young of year indices. This is in part due to fitting age one abundance to indices from multiple stocks/spawning areas. The trend in abundance and fishing mortality are relatively robust to starting values with the exception of fixed selectivity pattern.

**Appendix A10 Tables**

Table 1. Selectivity at age used as a fix input to ASAP catch at age model.

| Age | Selectivity |
|---|---|
| 1 | 0.01 |
| 2 | 0.14 |
| 3 | 0.34 |
| 4 | 0.47 |
| 5 | 0.61 |
| 6 | 0.67 |
| 7 | 0.73 |
| 8 | 0.82 |
| 9 | 0.92 |
| 10 | 1.00 |
| 11 | 1.00 |
| 12 | 1.00 |
| 13 | 1.00 |

Table 2. Residual sum of squares, number of years, lambda, and log likelihood values of indices used is ASAP catch at age model. Values weighted by lambda, consequently the likelihoods of low weighted values are smaller.

| Index | RSS | N | lambda | likelihood |
|---|---|---|---|---|
| MACOM5 | 3.646 | 16 | 5 | 9.11 |
| MACOM6 | 1.960 | 16 | 5 | 4.90 |
| MACOM7 | 1.443 | 16 | 5 | 3.61 |
| MACOM8 | 2.379 | 16 | 5 | 5.95 |
| MACOM9 | 4.538 | 16 | 5 | 11.35 |
| MACOM10 | 6.675 | 16 | 5 | 16.69 |
| MACOM11 | 3.406 | 16 | 5 | 8.51 |
| MACOM12 | 2.880 | 16 | 5 | 7.20 |
| MACOM13+ | 10.242 | 16 | 5 | 25.60 |
| MDSSN3 | 16.159 | 22 | 25 | 201.99 |
| MDSSN4 | 15.620 | 22 | 25 | 195.25 |
| MDSSN5 | 9.464 | 22 | 25 | 118.30 |
| MDSSN6 | 10.464 | 22 | 25 | 130.80 |
| MDSSN7 | 10.897 | 22 | 25 | 136.22 |
| MDSSN8 | 17.777 | 20 | 25 | 222.21 |
| MDSSN9 | 20.794 | 21 | 25 | 259.92 |
| MDSSN10 | 18.279 | 19 | 25 | 228.48 |
| MDSSN11 | 10.416 | 17 | 25 | 130.20 |
| MDSSN12 | 7.298 | 16 | 25 | 91.23 |
| MDSSN13+ | 13.222 | 21 | 25 | 165.27 |
| NYOHS3 | 8.685 | 19 | 25 | 108.57 |
| NYOHS4 | 7.720 | 19 | 25 | 96.50 |
| NYOHS5 | 9.637 | 19 | 25 | 120.46 |
| NYOHS6 | 8.853 | 18 | 25 | 110.67 |
| NYOHS7 | 9.833 | 19 | 25 | 122.91 |
| NYOHS8 | 14.846 | 19 | 25 | 185.57 |
| NYOHS9 | 9.808 | 19 | 25 | 122.59 |
| YOYNY | 17.354 | 25 | 25 | 216.93 |
| YOYNJ | 10.080 | 24 | 25 | 126.01 |
| YOYMD | 7.169 | 25 | 25 | 89.62 |
| YOYVA | 5.249 | 25 | 25 | 65.61 |
| YRLLI | 5.701 | 21 | 25 | 71.26 |

| Index | RSS | N | lambda | likelihood |
|---|---|---|---|---|
| YRLMD | 7.054 | 24 | 25 | 88.17 |
| NEFSC2-9 | 4.808 | 16 | 25 | 60.10 |
| CTTRL4-6 | 9.176 | 21 | 25 | 114.71 |
| DETRWL2-8 | 49.128 | 19 | 5 | 122.82 |
| DESSN2 | 8.526 | 10 | 25 | 106.58 |
| DESSN3 | 2.086 | 11 | 25 | 26.08 |
| DESSN4 | 1.461 | 11 | 25 | 18.26 |
| DESSN5 | 1.166 | 11 | 25 | 14.57 |
| DESSN6 | 0.452 | 11 | 25 | 5.65 |
| DESSN7 | 1.273 | 11 | 25 | 15.92 |
| DESSN8 | 1.836 | 11 | 25 | 22.95 |
| DESSN9 | 2.371 | 11 | 25 | 29.64 |
| DESSN10 | 1.201 | 11 | 25 | 15.01 |
| NJTRL2 | 29.238 | 18 | 25 | 365.47 |
| NJTRL3 | 15.698 | 18 | 25 | 196.22 |
| NJTRL4 | 12.392 | 17 | 25 | 154.90 |
| NJTRL5 | 14.918 | 18 | 25 | 186.48 |
| NJTRL6 | 13.220 | 18 | 25 | 165.25 |
| NJTRL7 | 10.568 | 17 | 25 | 132.10 |
| NJTRL8 | 11.215 | 17 | 25 | 140.19 |
| NJTRL9 | 11.056 | 15 | 25 | 138.20 |
| MRFSS2-13 | 1.378 | 19 | 25 | 17.22 |
| CTCPUE2 | 27.601 | 24 | 25 | 345.01 |
| CTCPUE3 | 25.242 | 25 | 25 | 315.52 |
| CTCPUE4 | 4.224 | 25 | 25 | 52.79 |
| CTCPUE5 | 7.319 | 25 | 25 | 91.48 |
| CTCPUE6 | 10.155 | 25 | 25 | 126.94 |
| CTCPUE7 | 9.601 | 25 | 25 | 120.02 |
| CTCPUE8 | 5.944 | 24 | 25 | 74.30 |
| CTCPUE9 | 4.606 | 23 | 25 | 57.57 |
| CTCPUE10 | 13.838 | 25 | 25 | 172.97 |
| Total | 621.242 | 1176 | 1375 | 6902.57 |

Table 3. Fishing mortality estimates from ASAP catch at age model. $F_{mult}$ equals F at age 10.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 0.00 | 0.04 | 0.11 | 0.15 | 0.19 | 0.21 | 0.23 | 0.26 | 0.29 | 0.32 | 0.32 | 0.32 | 0.32 |
| **1983** | 0.00 | 0.04 | 0.10 | 0.14 | 0.18 | 0.20 | 0.22 | 0.24 | 0.27 | 0.30 | 0.30 | 0.30 | 0.30 |
| **1984** | 0.00 | 0.04 | 0.09 | 0.13 | 0.17 | 0.18 | 0.20 | 0.23 | 0.25 | 0.27 | 0.27 | 0.27 | 0.27 |
| **1985** | 0.00 | 0.02 | 0.05 | 0.07 | 0.09 | 0.10 | 0.11 | 0.12 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 |
| **1986** | 0.00 | 0.02 | 0.04 | 0.05 | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 |
| **1987** | 0.00 | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 |
| **1988** | 0.00 | 0.01 | 0.03 | 0.04 | 0.05 | 0.06 | 0.06 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| **1989** | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 |
| **1990** | 0.00 | 0.01 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 |
| **1991** | 0.00 | 0.01 | 0.03 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 |
| **1992** | 0.00 | 0.01 | 0.03 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 |
| **1993** | 0.00 | 0.01 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 |
| **1994** | 0.00 | 0.02 | 0.04 | 0.05 | 0.07 | 0.08 | 0.08 | 0.09 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 |
| **1995** | 0.00 | 0.02 | 0.05 | 0.07 | 0.09 | 0.10 | 0.11 | 0.13 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 |
| **1996** | 0.00 | 0.02 | 0.06 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 |
| **1997** | 0.00 | 0.03 | 0.07 | 0.10 | 0.13 | 0.14 | 0.15 | 0.17 | 0.19 | 0.21 | 0.21 | 0.21 | 0.21 |
| **1998** | 0.00 | 0.03 | 0.06 | 0.09 | 0.11 | 0.12 | 0.13 | 0.15 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 |
| **1999** | 0.00 | 0.02 | 0.05 | 0.08 | 0.10 | 0.11 | 0.12 | 0.13 | 0.15 | 0.16 | 0.16 | 0.16 | 0.16 |
| **2000** | 0.00 | 0.02 | 0.06 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 |
| **2001** | 0.00 | 0.02 | 0.06 | 0.08 | 0.10 | 0.11 | 0.12 | 0.14 | 0.15 | 0.17 | 0.17 | 0.17 | 0.17 |
| **2002** | 0.00 | 0.02 | 0.06 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.16 | 0.18 | 0.18 | 0.18 | 0.18 |
| **2003** | 0.00 | 0.03 | 0.06 | 0.09 | 0.11 | 0.13 | 0.14 | 0.15 | 0.17 | 0.19 | 0.19 | 0.19 | 0.19 |
| **2004** | 0.00 | 0.03 | 0.07 | 0.10 | 0.13 | 0.14 | 0.15 | 0.17 | 0.19 | 0.21 | 0.21 | 0.21 | 0.21 |
| **2005** | 0.00 | 0.03 | 0.07 | 0.10 | 0.13 | 0.15 | 0.16 | 0.18 | 0.20 | 0.22 | 0.22 | 0.22 | 0.22 |
| **2006** | 0.00 | 0.03 | 0.08 | 0.12 | 0.15 | 0.17 | 0.18 | 0.20 | 0.23 | 0.25 | 0.25 | 0.25 | 0.25 |

Table 4. Population estimates (000s) from ASAP catch at age model.

Jan. 1 Abundance estimates

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ | total | 8+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 2,059 | 1,217 | 821 | 560 | 535 | 187 | 49 | 47 | 36 | 46 | 94 | 111 | 106 | 5,869 | 441 |
| **1983** | 5,745 | 1,766 | 1,002 | 634 | 415 | 379 | 130 | 33 | 31 | 23 | 29 | 59 | 136 | 10,383 | 311 |
| **1984** | 3,937 | 4,930 | 1,458 | 779 | 475 | 297 | 267 | 90 | 23 | 21 | 15 | 18 | 124 | 12,434 | 291 |
| **1985** | 4,483 | 3,380 | 4,083 | 1,143 | 589 | 345 | 213 | 188 | 62 | 15 | 13 | 10 | 93 | 14,618 | 381 |
| **1986** | 3,918 | 3,853 | 2,849 | 3,341 | 917 | 463 | 269 | 164 | 143 | 46 | 11 | 10 | 76 | 16,062 | 452 |
| **1987** | 4,492 | 3,369 | 3,267 | 2,363 | 2,733 | 739 | 371 | 214 | 129 | 112 | 36 | 9 | 67 | 17,899 | 566 |
| **1988** | 5,801 | 3,864 | 2,876 | 2,757 | 1,980 | 2,271 | 612 | 306 | 176 | 106 | 91 | 29 | 61 | 20,931 | 769 |
| **1989** | 6,543 | 4,989 | 3,287 | 2,407 | 2,283 | 1,620 | 1,850 | 496 | 246 | 140 | 84 | 72 | 72 | 24,088 | 1,109 |
| **1990** | 8,844 | 5,628 | 4,255 | 2,767 | 2,009 | 1,888 | 1,335 | 1,518 | 405 | 200 | 113 | 68 | 116 | 29,146 | 2,419 |
| **1991** | 7,978 | 7,604 | 4,774 | 3,534 | 2,267 | 1,622 | 1,515 | 1,064 | 1,199 | 316 | 155 | 88 | 142 | 32,256 | 2,964 |
| **1992** | 7,605 | 6,859 | 6,453 | 3,970 | 2,900 | 1,835 | 1,305 | 1,211 | 843 | 940 | 246 | 120 | 179 | 34,466 | 3,539 |
| **1993** | 10,758 | 6,540 | 5,837 | 5,403 | 3,289 | 2,376 | 1,496 | 1,058 | 975 | 674 | 746 | 195 | 237 | 39,583 | 3,885 |
| **1994** | 20,660 | 9,250 | 5,546 | 4,846 | 4,423 | 2,653 | 1,904 | 1,191 | 835 | 761 | 521 | 577 | 335 | 53,501 | 4,220 |
| **1995** | 13,814 | 17,762 | 7,833 | 4,589 | 3,950 | 3,548 | 2,113 | 1,506 | 932 | 646 | 584 | 400 | 699 | 58,376 | 4,767 |
| **1996** | 16,315 | 11,871 | 14,962 | 6,399 | 3,675 | 3,095 | 2,755 | 1,626 | 1,143 | 697 | 477 | 431 | 811 | 64,255 | 5,183 |
| **1997** | 17,437 | 14,018 | 9,973 | 12,142 | 5,077 | 2,846 | 2,373 | 2,090 | 1,214 | 839 | 504 | 345 | 899 | 69,756 | 5,891 |
| **1998** | 10,002 | 14,976 | 11,713 | 7,989 | 9,462 | 3,841 | 2,126 | 1,750 | 1,512 | 860 | 584 | 351 | 867 | 66,035 | 5,925 |
| **1999** | 11,614 | 8,593 | 12,562 | 9,469 | 6,305 | 7,278 | 2,922 | 1,599 | 1,295 | 1,099 | 616 | 418 | 872 | 64,642 | 5,899 |
| **2000** | 8,955 | 9,980 | 7,231 | 10,238 | 7,558 | 4,921 | 5,626 | 2,237 | 1,207 | 962 | 805 | 451 | 946 | 61,116 | 6,608 |
| **2001** | 15,695 | 7,694 | 8,384 | 5,867 | 8,121 | 5,852 | 3,770 | 4,266 | 1,670 | 885 | 696 | 583 | 1,011 | 64,494 | 9,110 |
| **2002** | 22,175 | 13,486 | 6,469 | 6,818 | 4,669 | 6,313 | 4,503 | 2,873 | 3,202 | 1,233 | 645 | 507 | 1,161 | 74,053 | 9,619 |
| **2003** | 9,717 | 19,053 | 11,325 | 5,245 | 5,402 | 3,609 | 4,829 | 3,408 | 2,140 | 2,343 | 890 | 465 | 1,203 | 69,629 | 10,450 |
| **2004** | 29,220 | 8,348 | 15,974 | 9,146 | 4,133 | 4,147 | 2,740 | 3,625 | 2,516 | 1,550 | 1,672 | 635 | 1,191 | 84,896 | 11,189 |
| **2005** | 14,204 | 25,097 | 6,976 | 12,798 | 7,129 | 3,128 | 3,099 | 2,022 | 2,625 | 1,784 | 1,081 | 1,166 | 1,273 | 82,382 | 9,950 |
| **2006** | 12,743 | 12,199 | 20,952 | 5,575 | 9,943 | 5,373 | 2,327 | 2,275 | 1,456 | 1,849 | 1,235 | 748 | 1,688 | 78,361 | 9,250 |

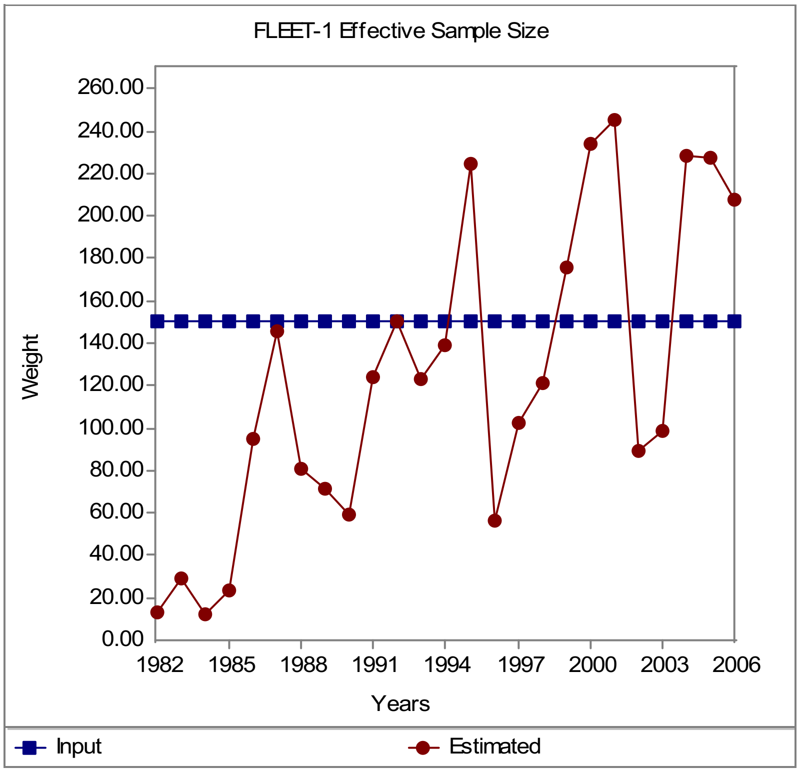
Table 5. Average biomass (MT) from ASAP catch at age model.

Average Biomass (mt)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 268 | 779 | 895 | 862 | 1,295 | 702 | 237 | 274 | 222 | 397 | 1,019 | 1,245 | 1,491 |
| **1983** | 1,149 | 971 | 942 | 869 | 983 | 1,247 | 491 | 179 | 189 | 186 | 274 | 613 | 1,510 |
| **1984** | 945 | 2,958 | 2,464 | 1,262 | 1,267 | 1,008 | 1,354 | 509 | 152 | 159 | 123 | 231 | 1,541 |
| **1985** | 269 | 2,062 | 4,369 | 1,897 | 1,291 | 1,240 | 1,046 | 1,027 | 419 | 112 | 121 | 103 | 1,298 |
| **1986** | 549 | 2,196 | 3,618 | 8,018 | 2,238 | 1,445 | 1,063 | 830 | 780 | 283 | 87 | 91 | 976 |
| **1987** | 898 | 2,594 | 4,606 | 4,987 | 6,832 | 2,151 | 1,338 | 1,014 | 715 | 725 | 279 | 84 | 877 |
| **1988** | 1,798 | 3,516 | 3,164 | 5,460 | 6,178 | 9,131 | 2,681 | 1,438 | 921 | 594 | 779 | 303 | 812 |
| **1989** | 1,047 | 4,141 | 4,010 | 5,367 | 6,985 | 7,340 | 9,932 | 3,090 | 1,487 | 1,216 | 749 | 700 | 956 |
| **1990** | 707 | 5,009 | 4,851 | 5,673 | 4,722 | 7,232 | 6,556 | 9,048 | 2,307 | 1,191 | 841 | 613 | 1,458 |
| **1991** | 1,675 | 6,996 | 6,158 | 7,668 | 5,940 | 5,142 | 7,286 | 6,003 | 7,744 | 1,973 | 1,463 | 727 | 2,019 |
| **1992** | 760 | 4,733 | 8,453 | 7,662 | 8,150 | 6,733 | 6,393 | 7,012 | 5,869 | 7,662 | 2,404 | 1,496 | 2,495 |
| **1993** | 753 | 4,970 | 7,647 | 10,751 | 9,110 | 8,505 | 7,178 | 6,466 | 6,856 | 5,395 | 7,110 | 2,101 | 3,451 |
| **1994** | 4,958 | 9,712 | 9,372 | 10,709 | 12,606 | 9,285 | 9,406 | 7,384 | 5,676 | 5,731 | 5,071 | 6,171 | 4,259 |
| **1995** | 3,868 | 12,433 | 10,575 | 10,005 | 10,941 | 12,949 | 11,368 | 9,278 | 6,778 | 5,723 | 4,417 | 3,888 | 11,648 |
| **1996** | 2,284 | 12,465 | 21,994 | 14,845 | 11,869 | 13,991 | 17,602 | 11,558 | 8,925 | 6,409 | 4,438 | 4,350 | 11,110 |
| **1997** | 2,267 | 8,691 | 11,768 | 29,870 | 14,267 | 10,359 | 10,700 | 10,594 | 8,170 | 7,692 | 5,013 | 3,534 | 13,284 |
| **1998** | 3,901 | 11,532 | 14,056 | 12,942 | 21,290 | 11,332 | 9,971 | 9,905 | 10,314 | 6,048 | 4,535 | 3,468 | 10,287 |
| **1999** | 7,201 | 7,733 | 13,944 | 13,636 | 12,043 | 18,268 | 9,818 | 8,045 | 8,495 | 8,624 | 5,351 | 4,083 | 10,444 |
| **2000** | 3,313 | 5,489 | 7,955 | 14,845 | 14,814 | 13,729 | 21,883 | 11,386 | 8,581 | 7,087 | 7,811 | 4,830 | 12,815 |
| **2001** | 2,511 | 2,924 | 9,390 | 10,268 | 17,948 | 19,017 | 15,533 | 21,413 | 10,621 | 6,897 | 6,018 | 4,830 | 10,988 |
| **2002** | 2,661 | 4,181 | 6,858 | 10,295 | 10,178 | 20,013 | 18,869 | 15,742 | 19,306 | 9,319 | 5,862 | 4,940 | 13,371 |
| **2003** | 972 | 11,432 | 11,325 | 7,342 | 11,884 | 11,549 | 19,798 | 17,724 | 13,054 | 16,873 | 7,561 | 4,375 | 13,237 |
| **2004** | 6,721 | 2,755 | 13,418 | 12,804 | 10,044 | 12,898 | 11,343 | 18,740 | 15,270 | 11,037 | 13,679 | 5,732 | 12,754 |
| **2005** | 1,830 | 11,816 | 7,009 | 19,111 | 14,915 | 9,607 | 12,047 | 10,911 | 16,083 | 11,862 | 8,514 | 10,364 | 13,674 |
| **2006** | 1,511 | 4,270 | 13,869 | 6,462 | 18,592 | 14,510 | 9,393 | 11,005 | 8,977 | 12,906 | 9,981 | 6,692 | 18,689 |

## Appendix A10 Figures

A.




B.

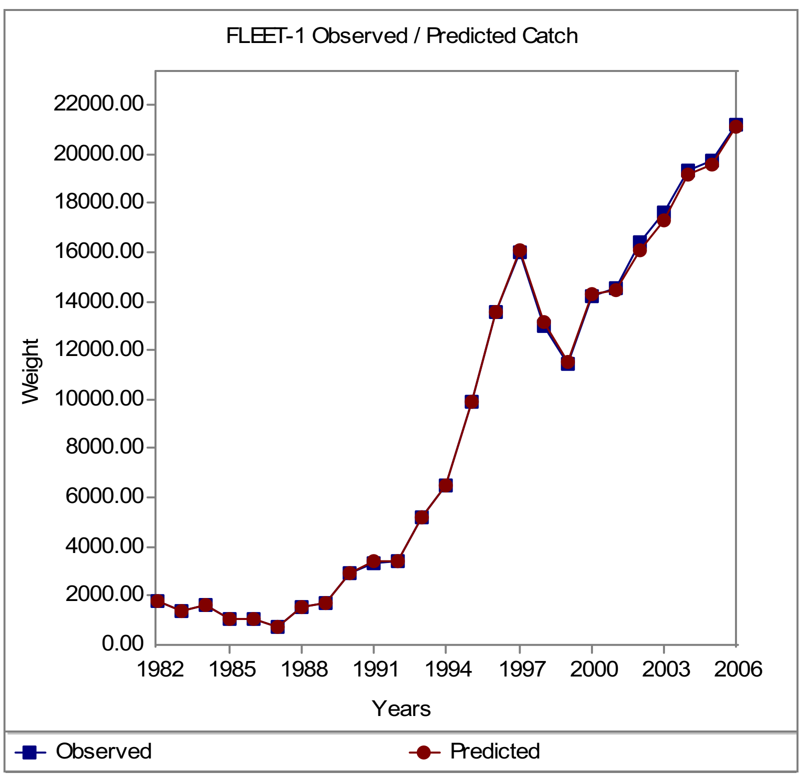



Figure 1. (A) Effective sample size and (B) observed and predicted catch biomass from ASAP catch at age model.

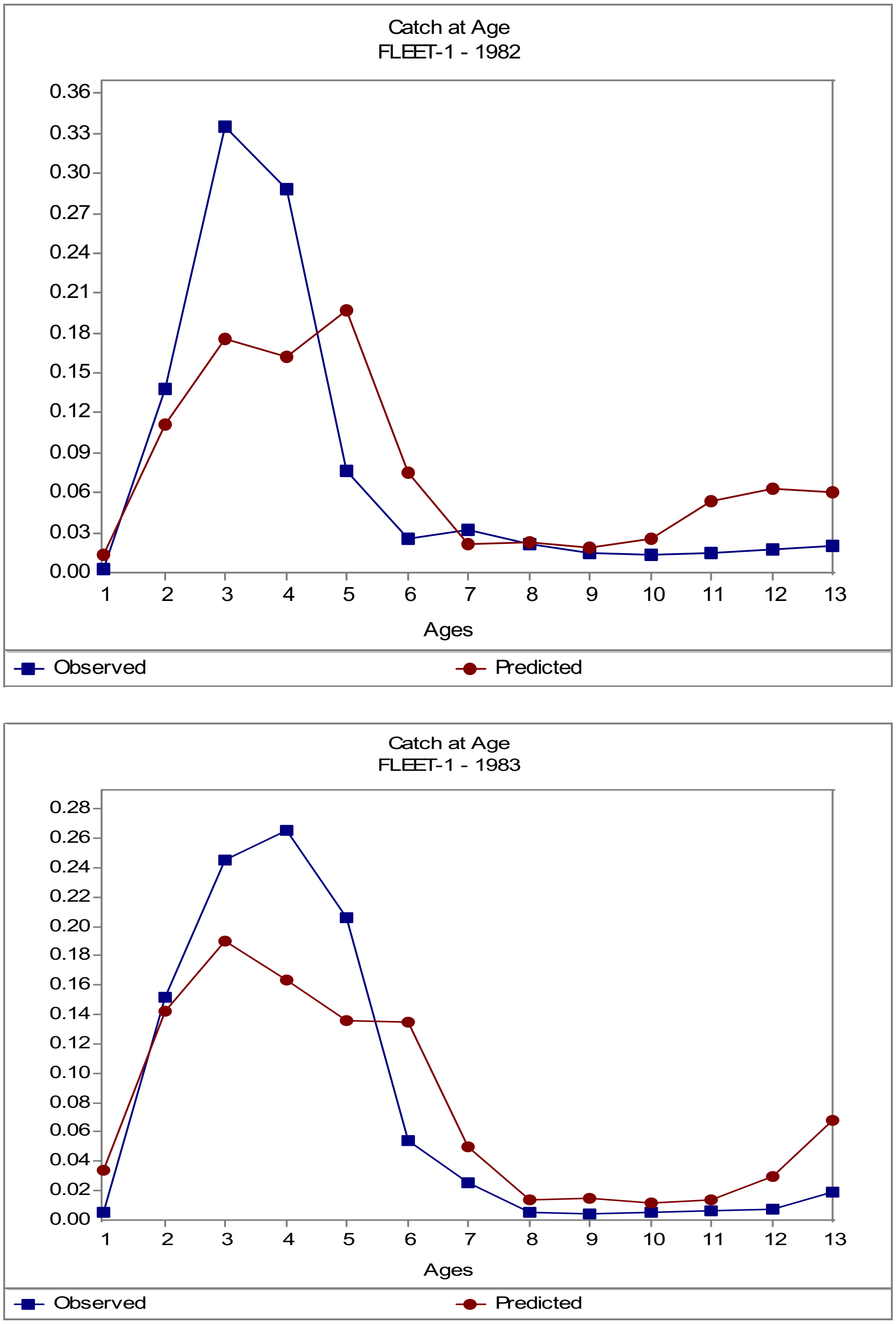
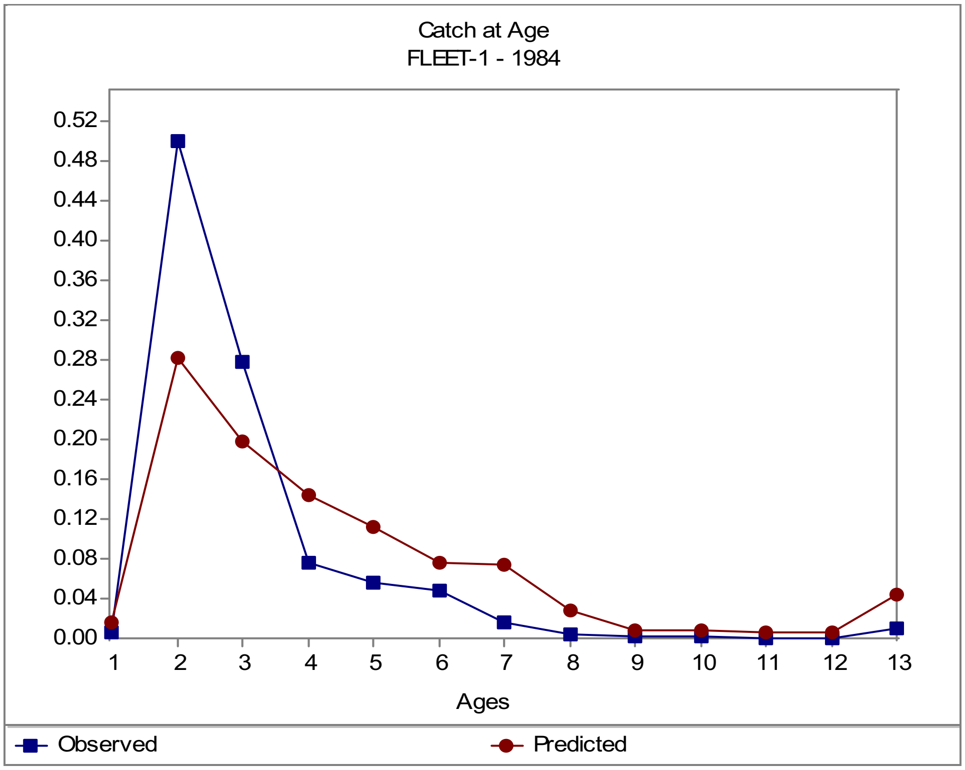



Figure 2. Comparison of observed and predicted proportions-at-age from the ASAP model.



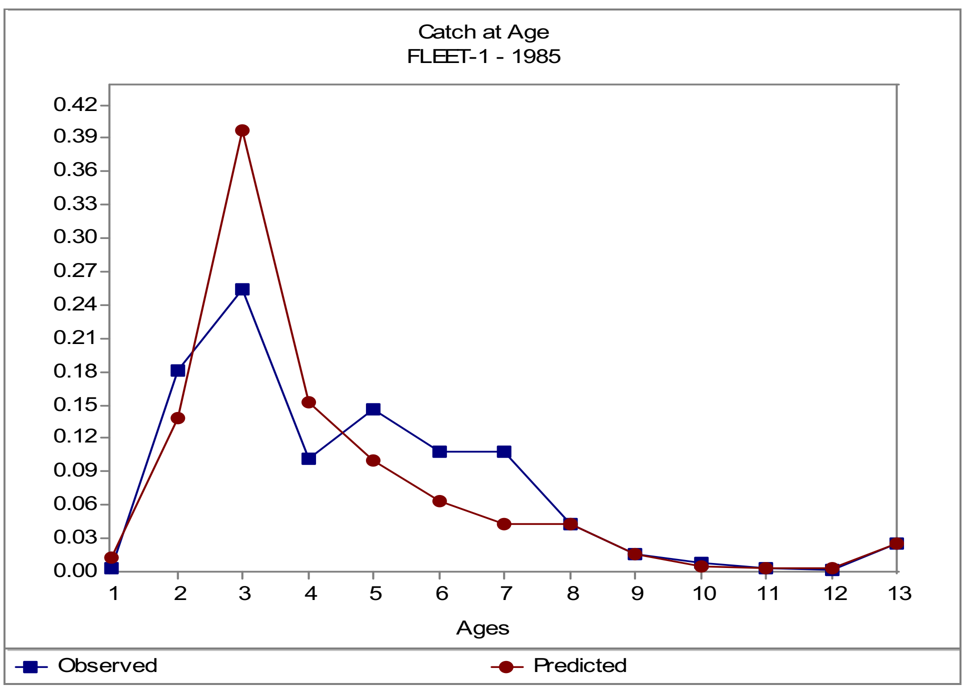
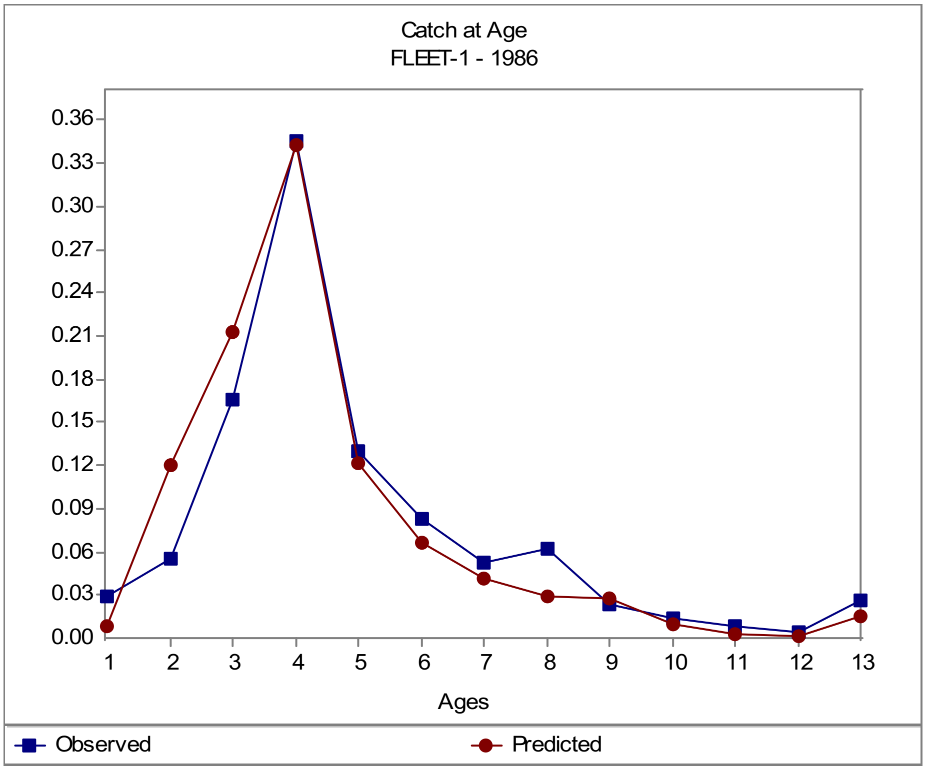




Figure 2 continued.



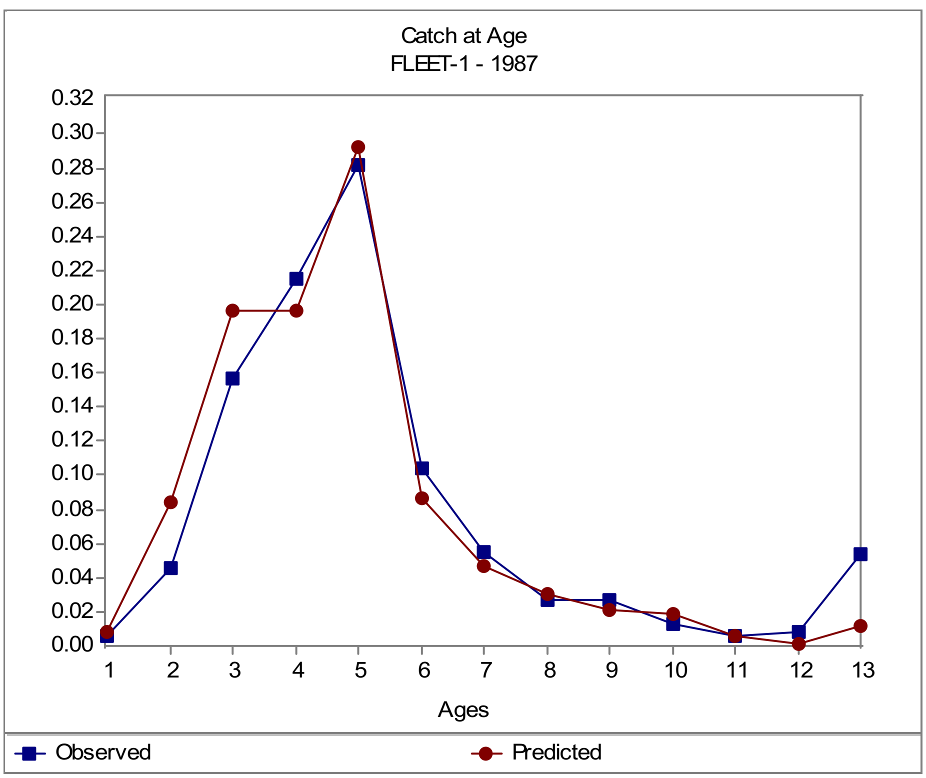
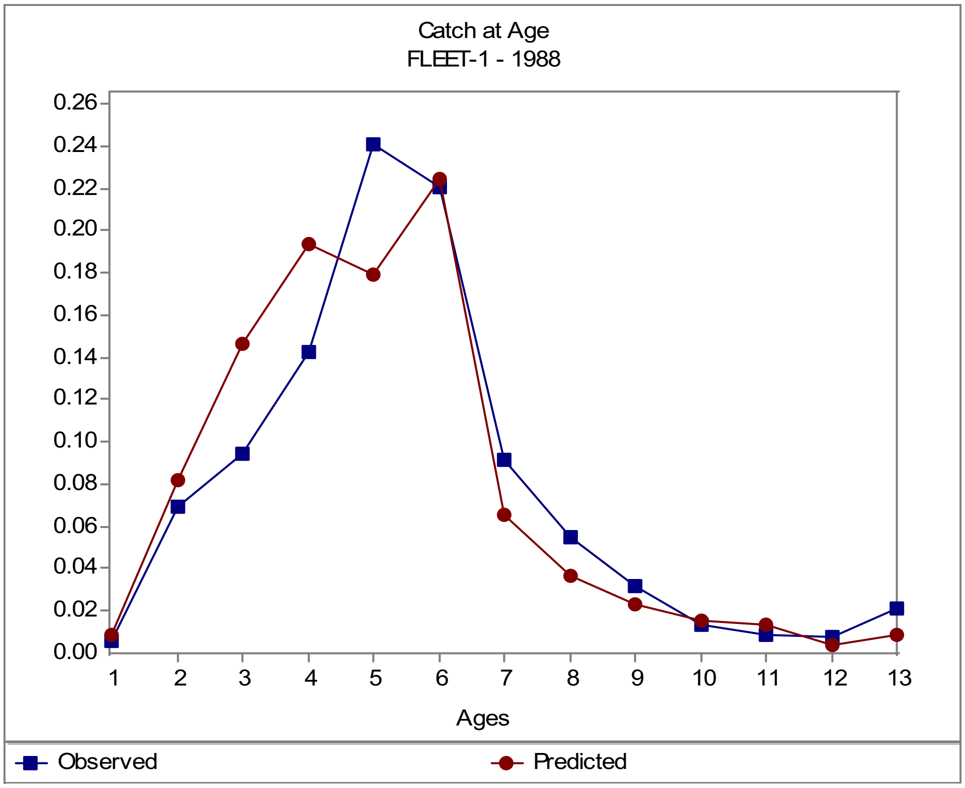




Figure 2 continued.



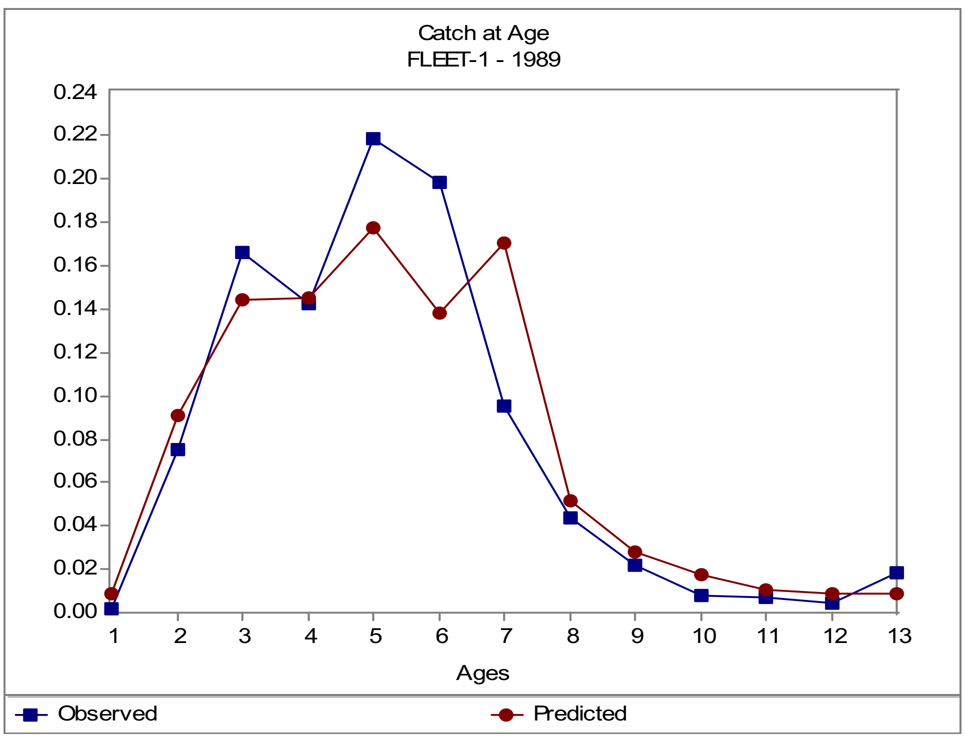
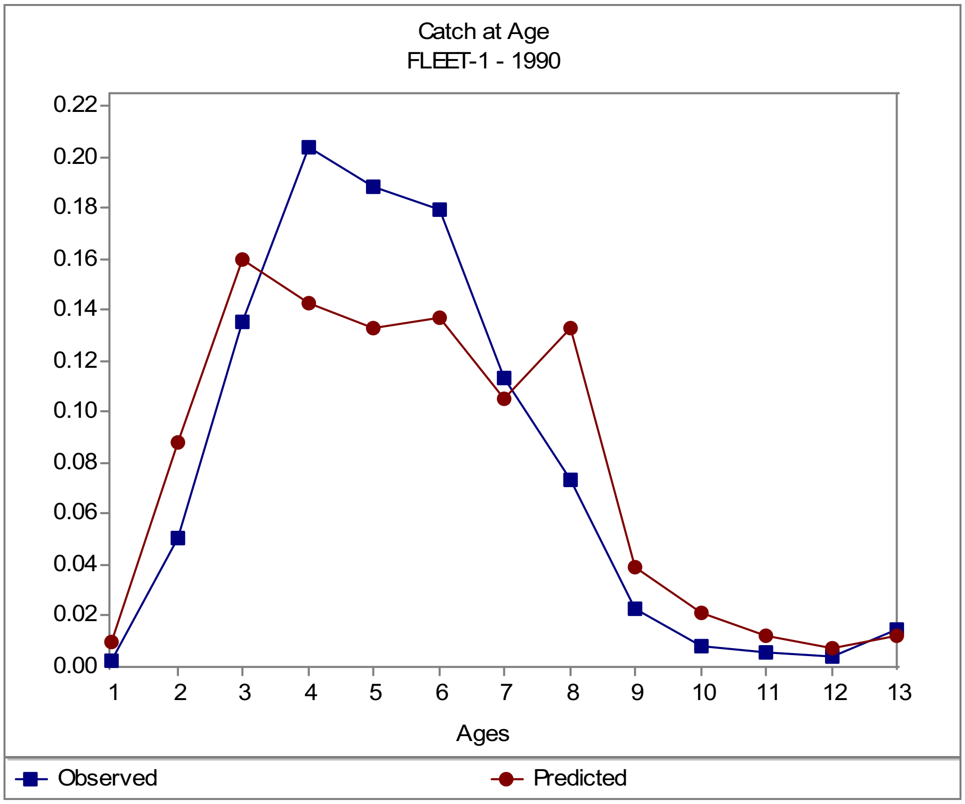




Figure 2 continued.



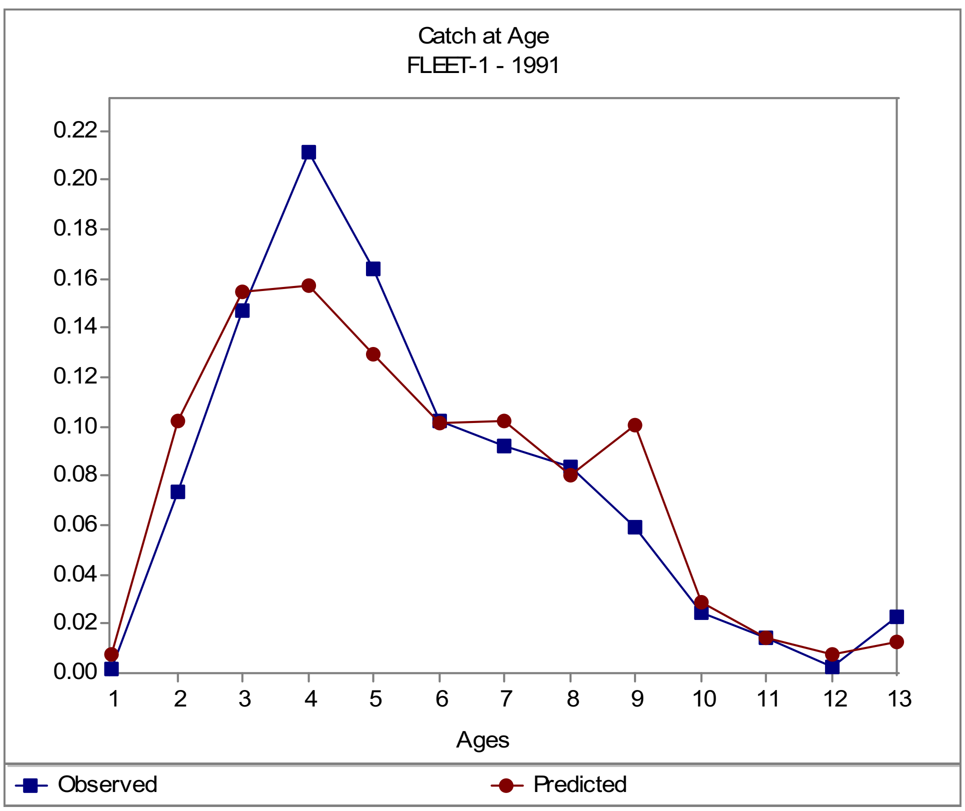
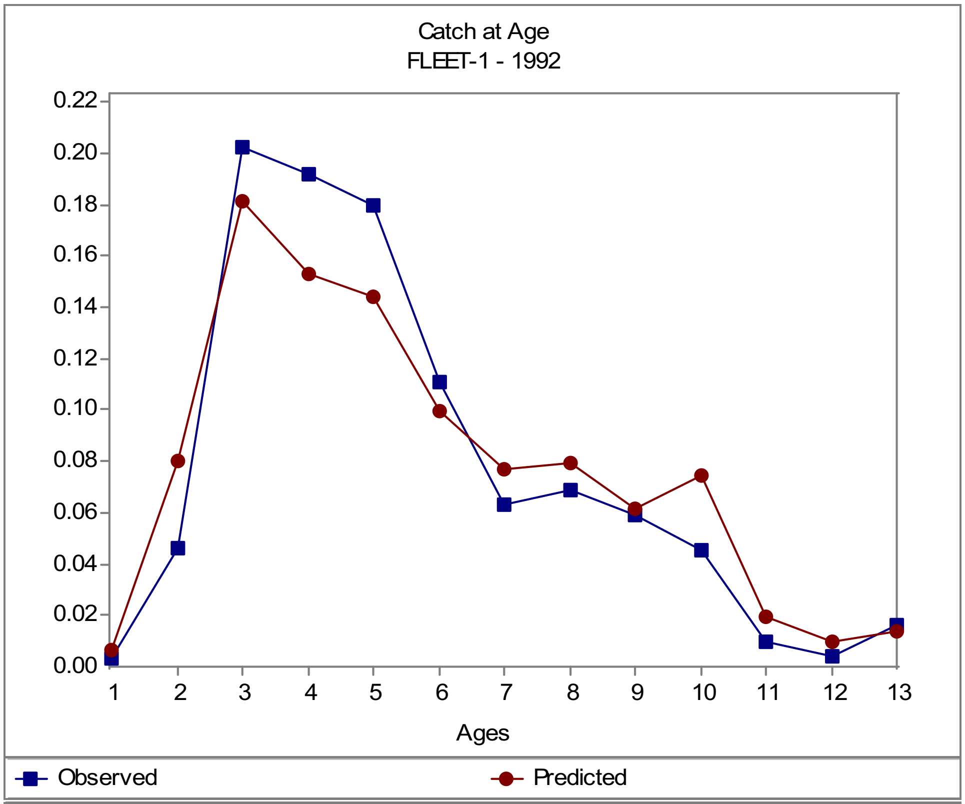




Figure 2 continued.



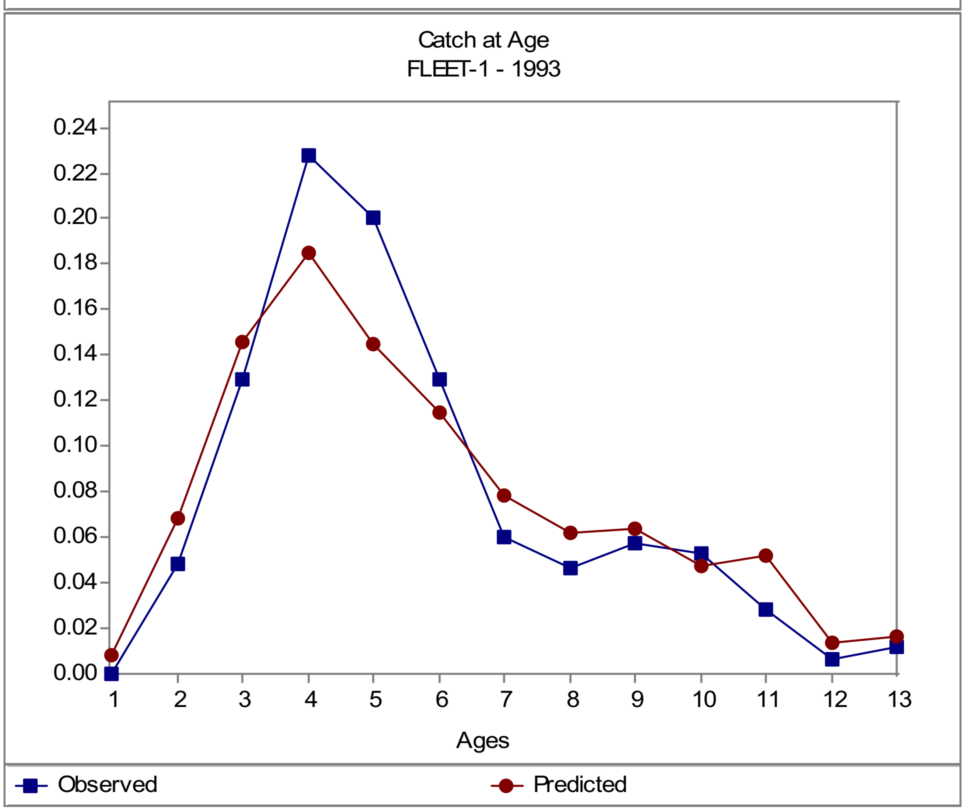
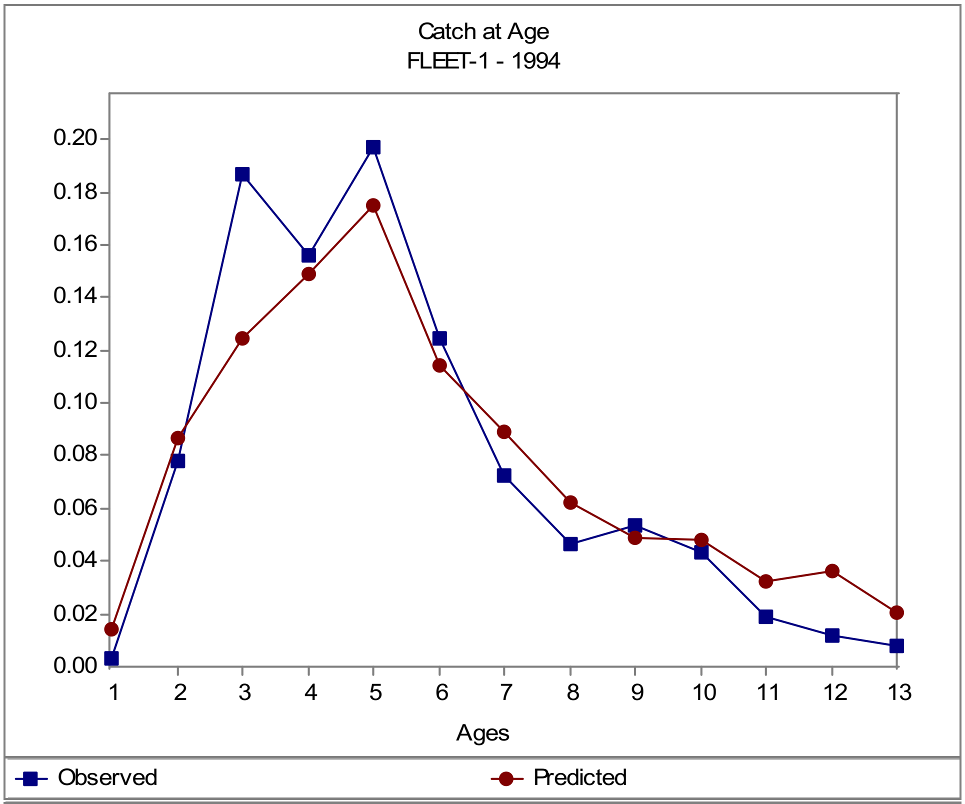




Figure 2 continued.



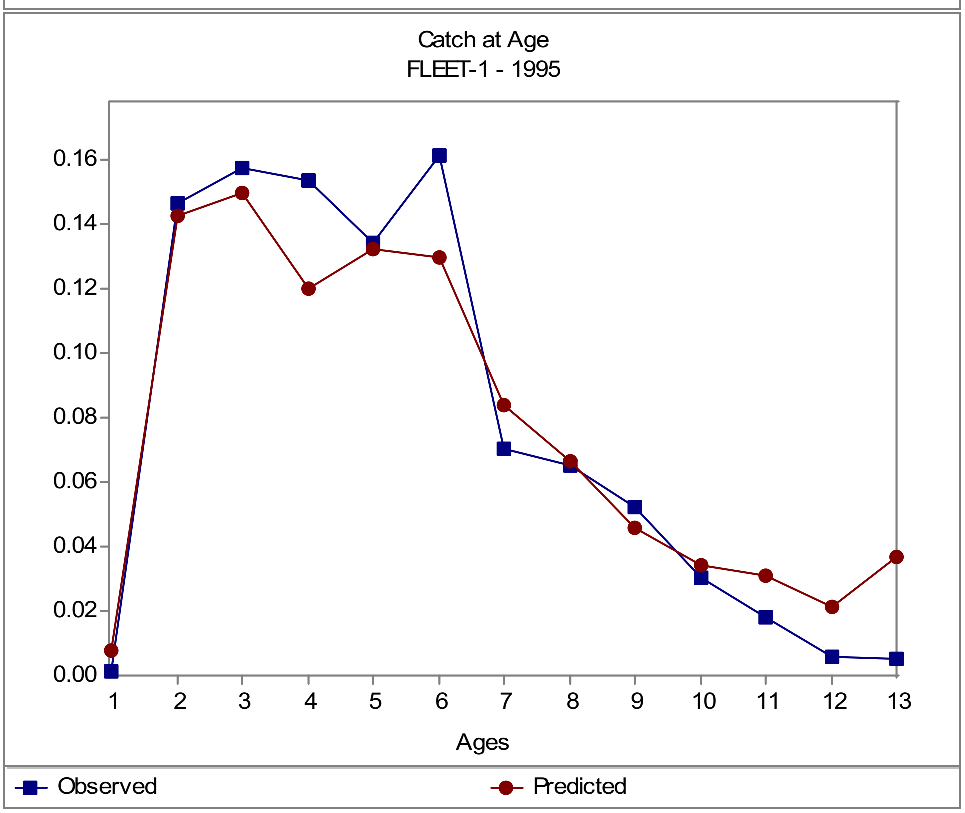




Figure 2 continued.

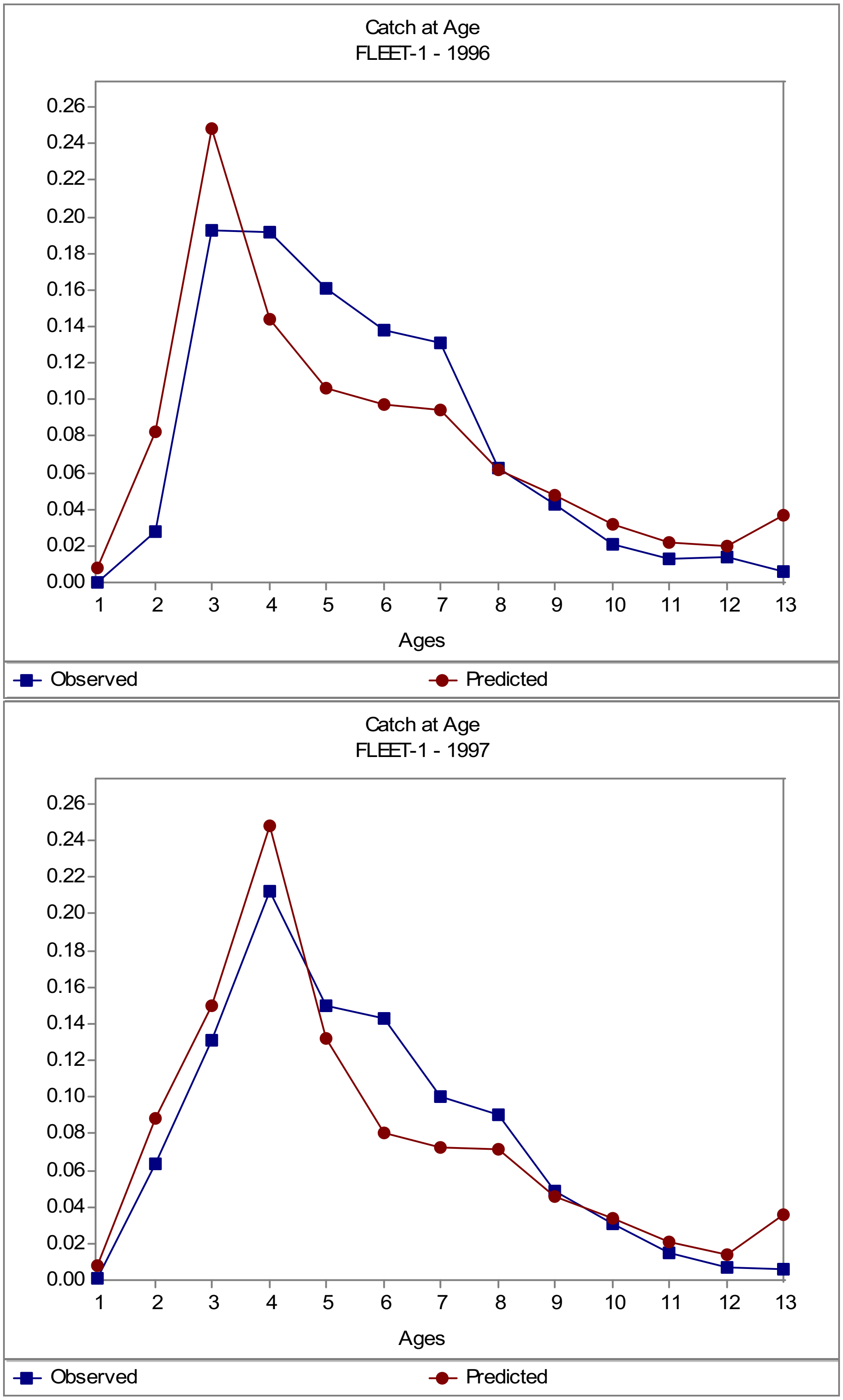



Figure 2 continued.

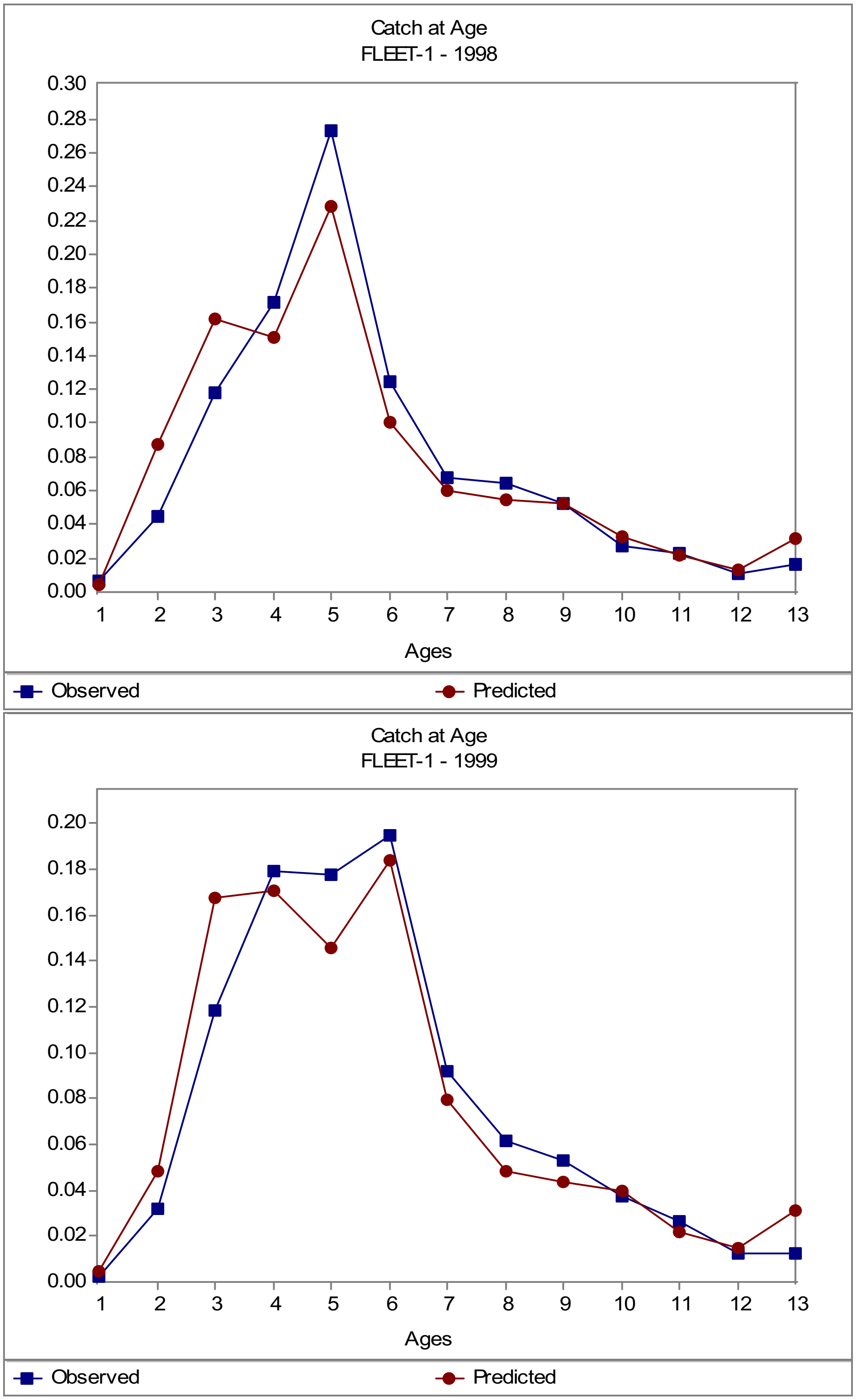



Figure 2 continued.

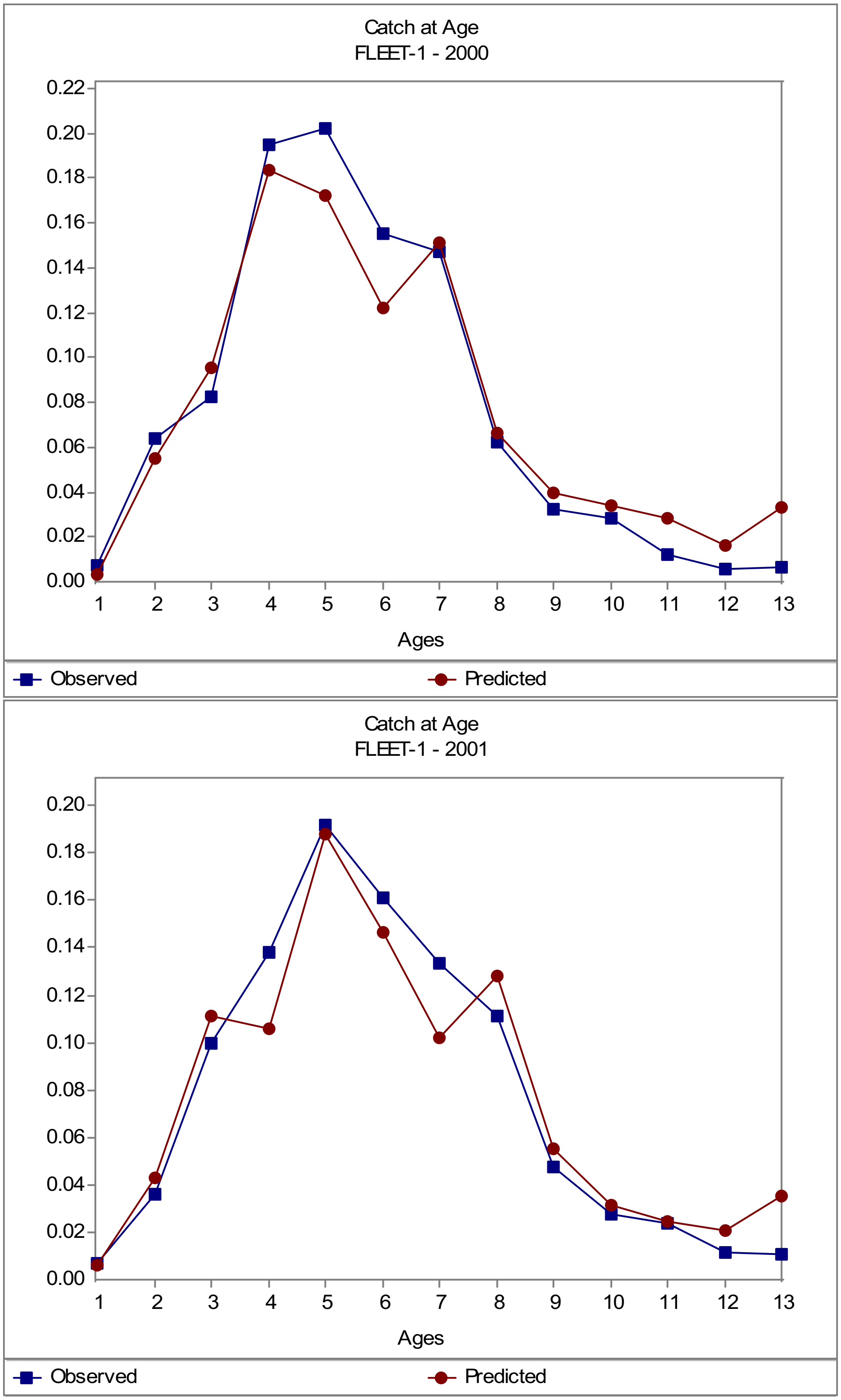
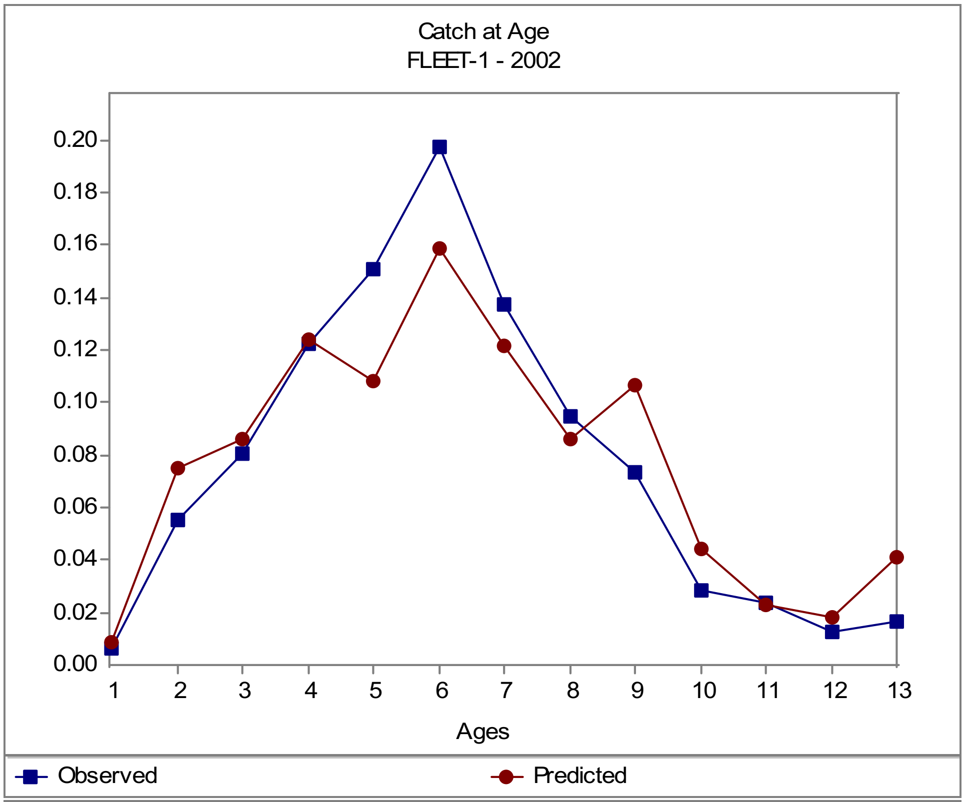



Figure 2 continued.



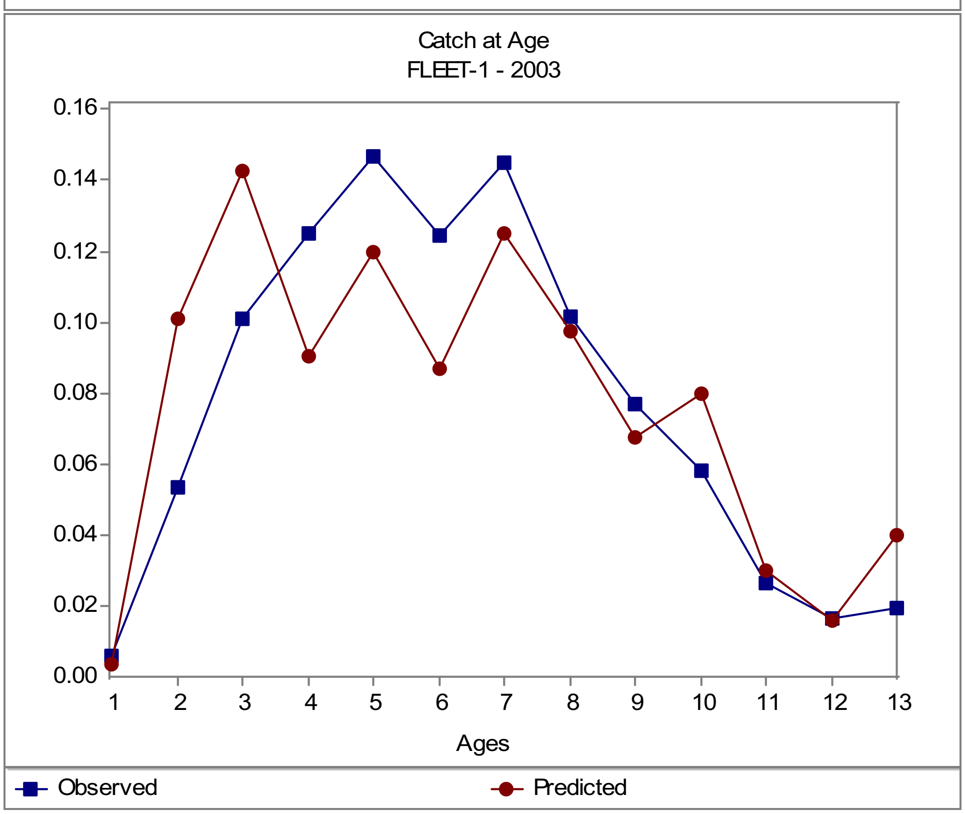
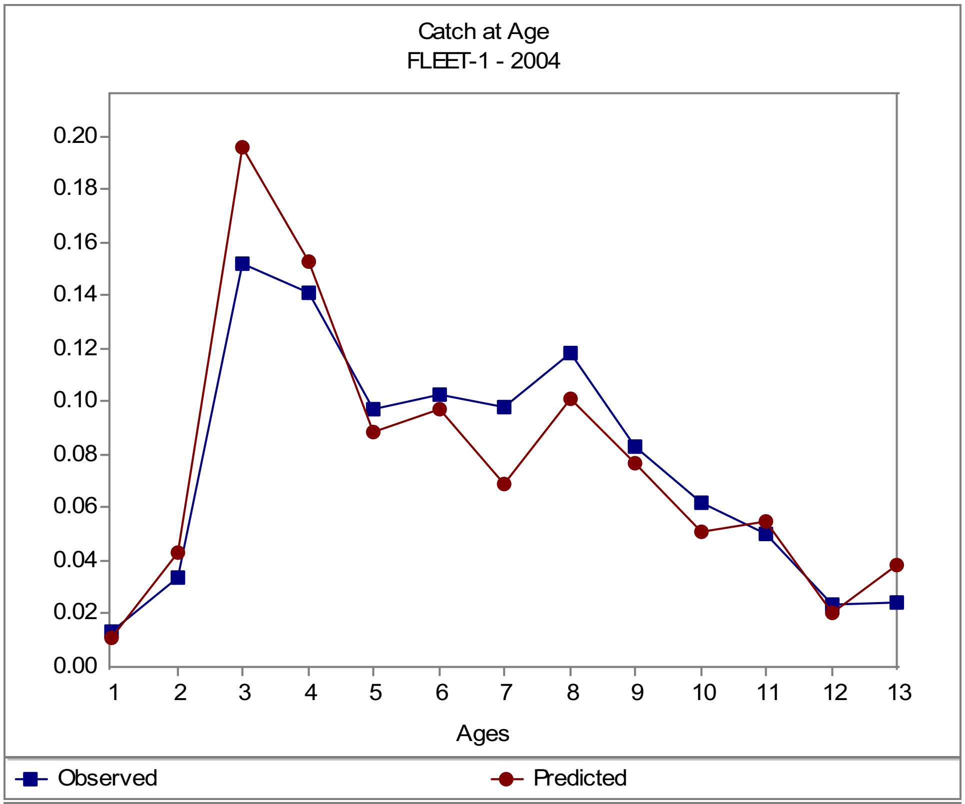




Figure 2 continued.



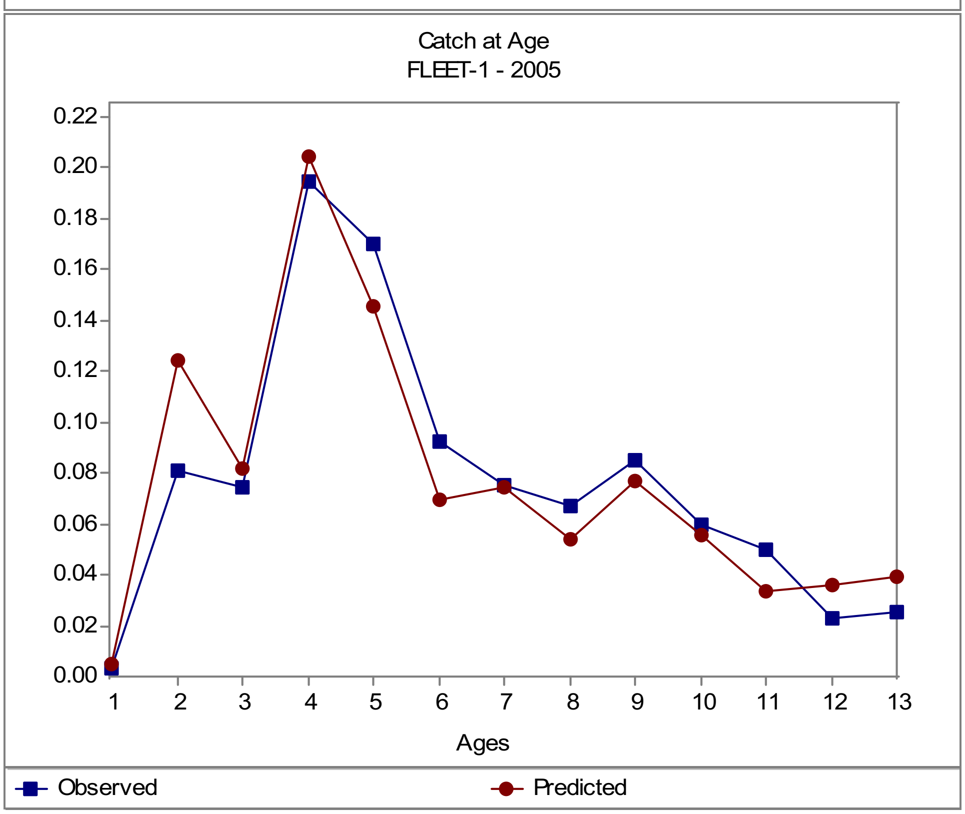
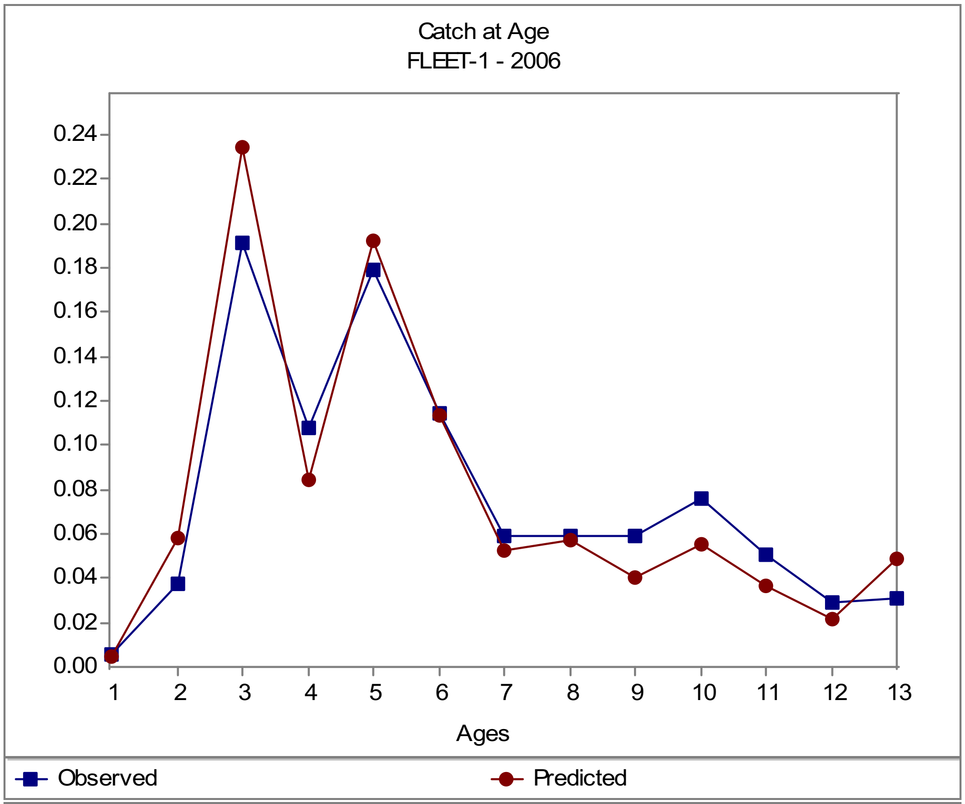




Figure 2 continued.



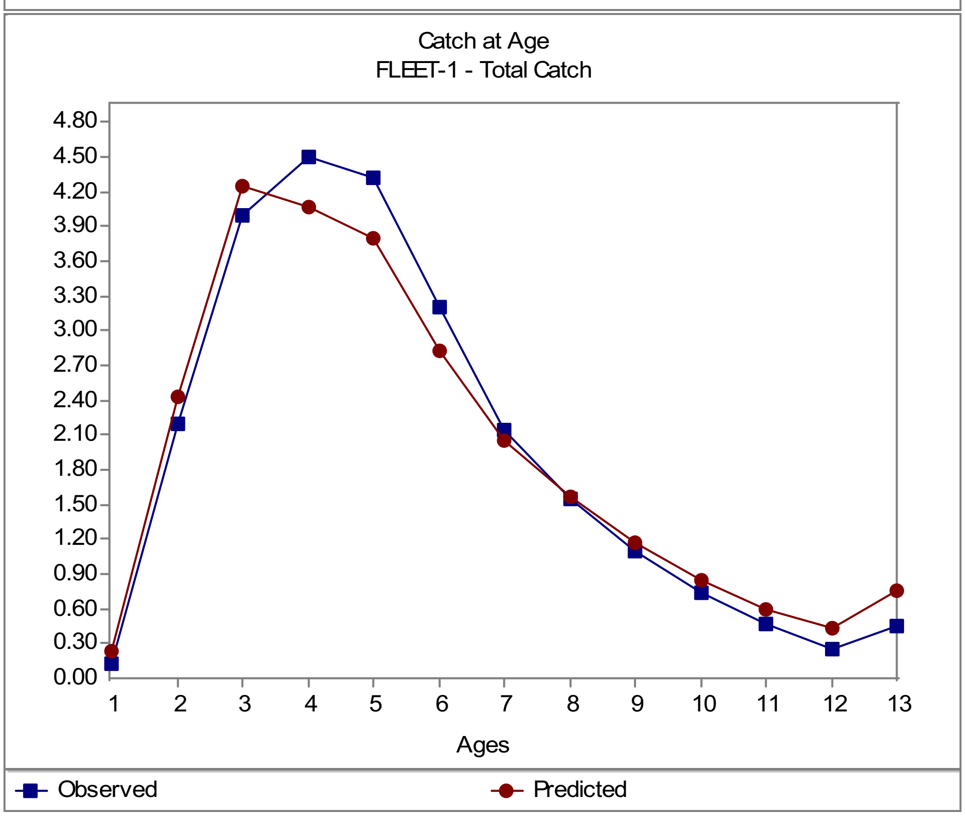




Figure 2 continued.

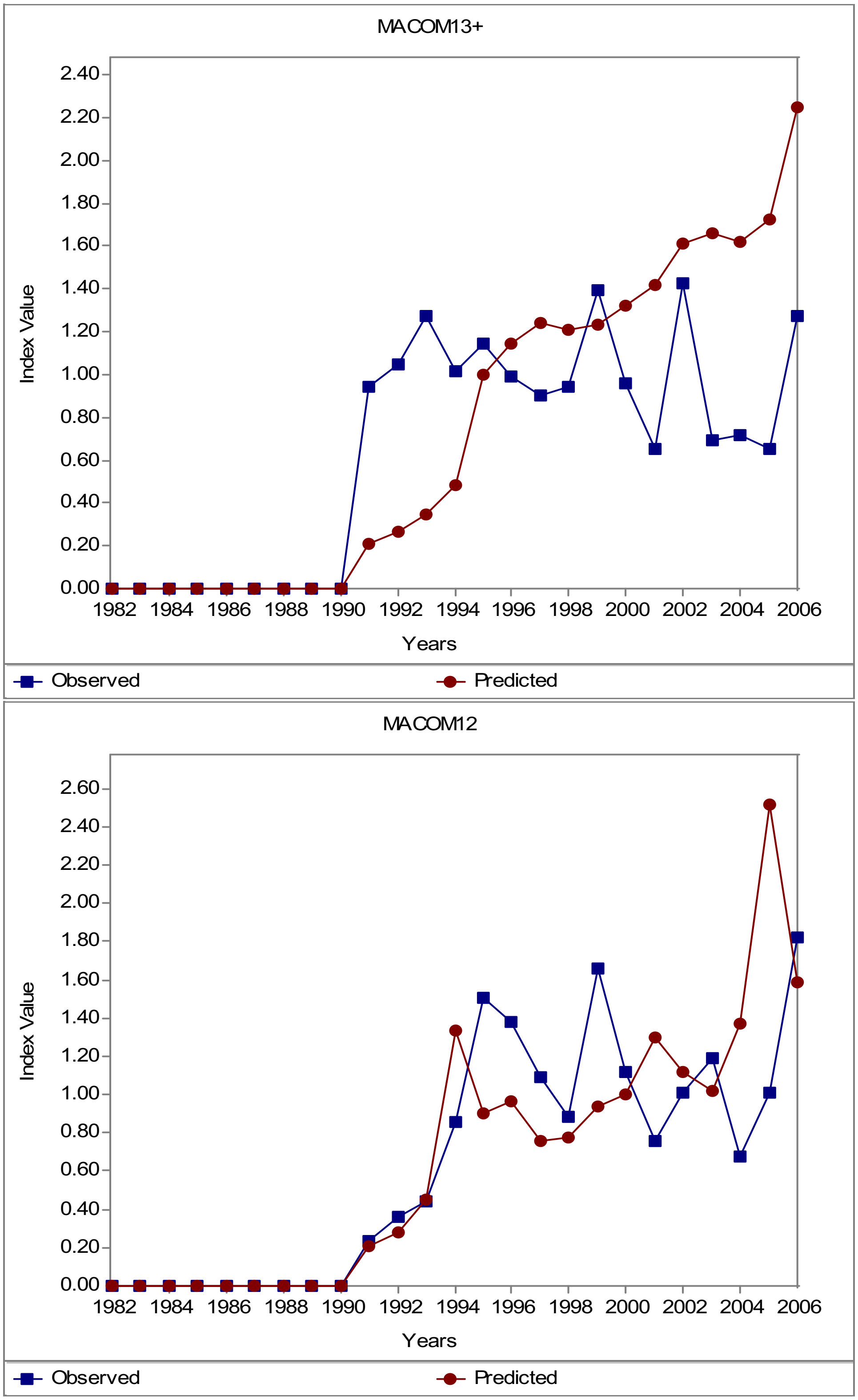
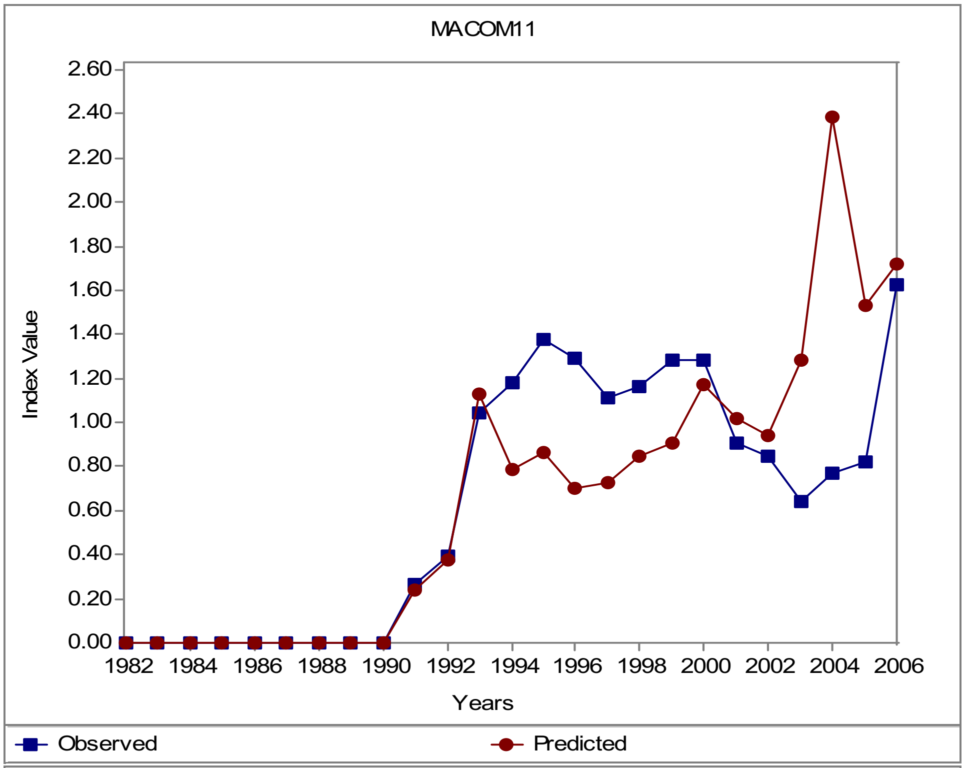



Figure 3. Observed and predicted indices used in ASAP catch at age model.



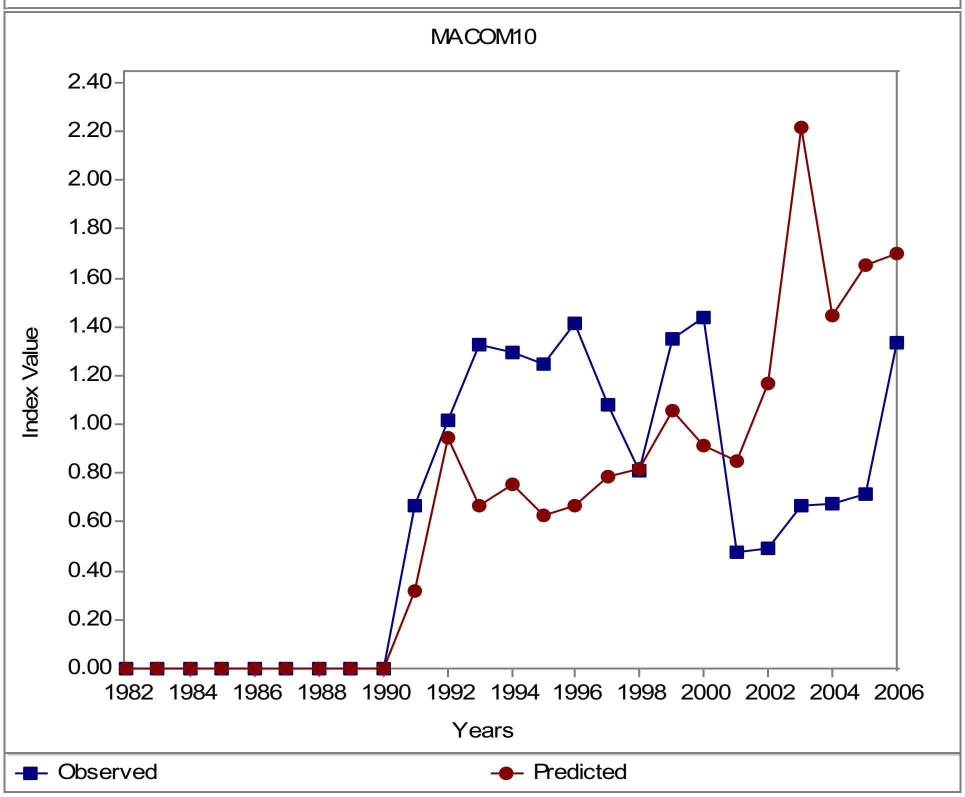
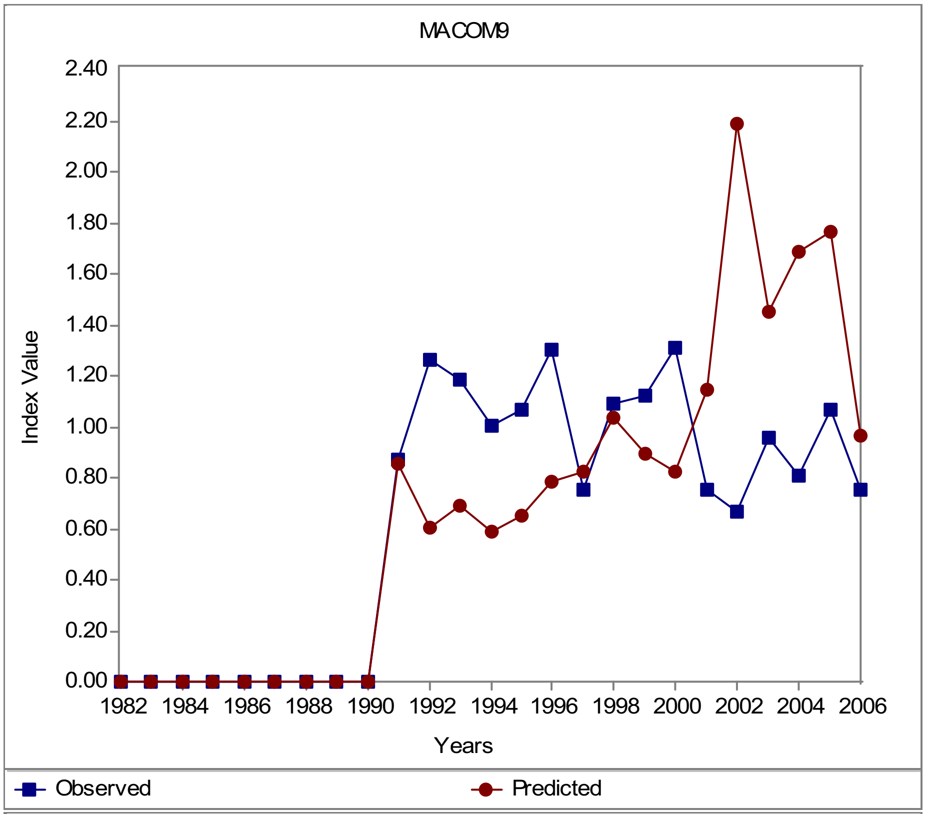




Figure 3 Continued.



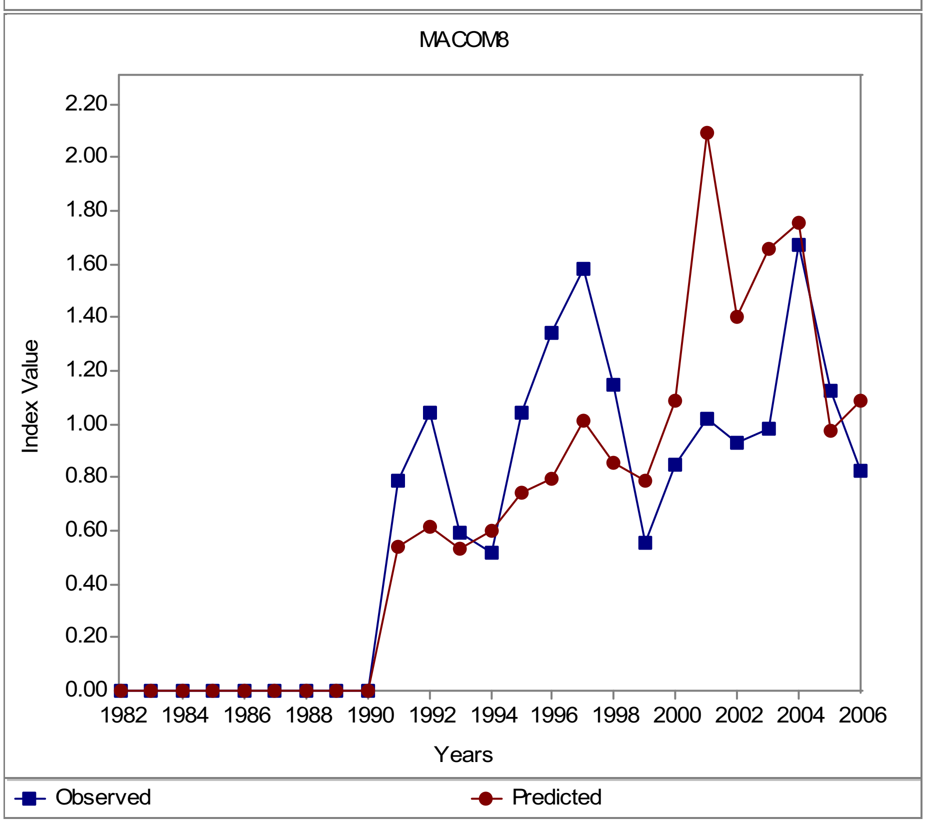
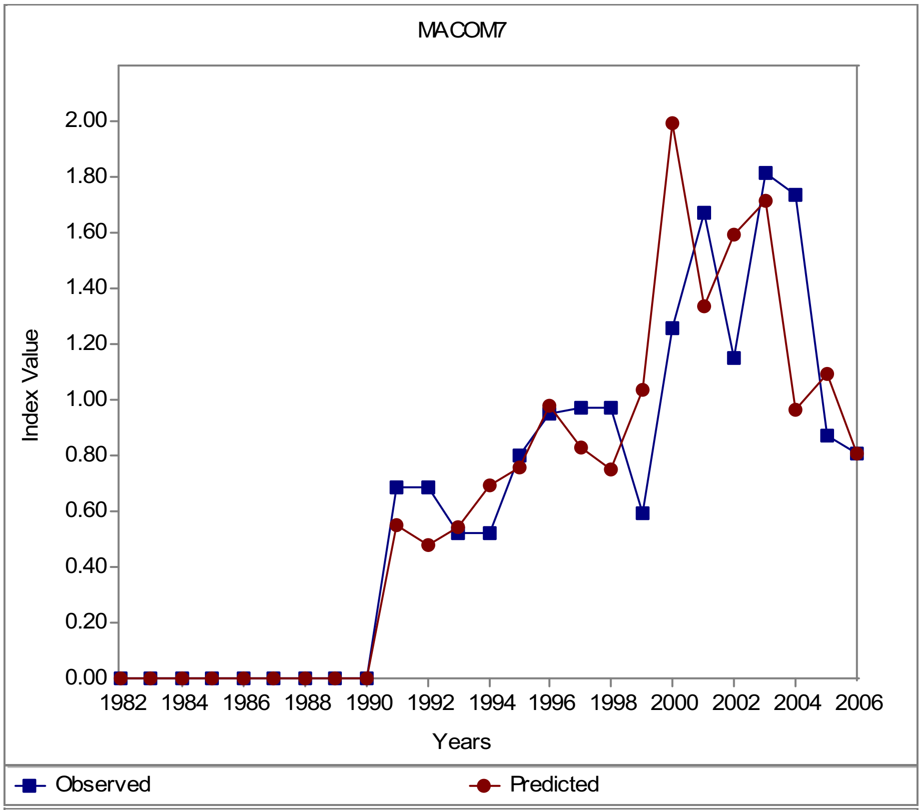




Figure 3 continued.



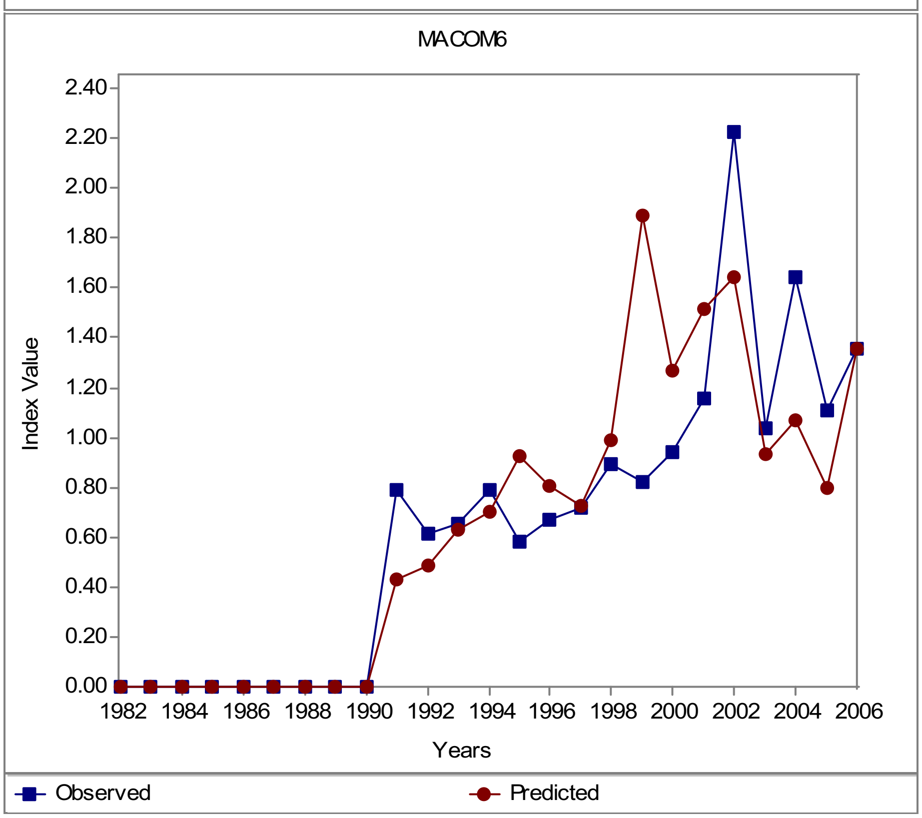
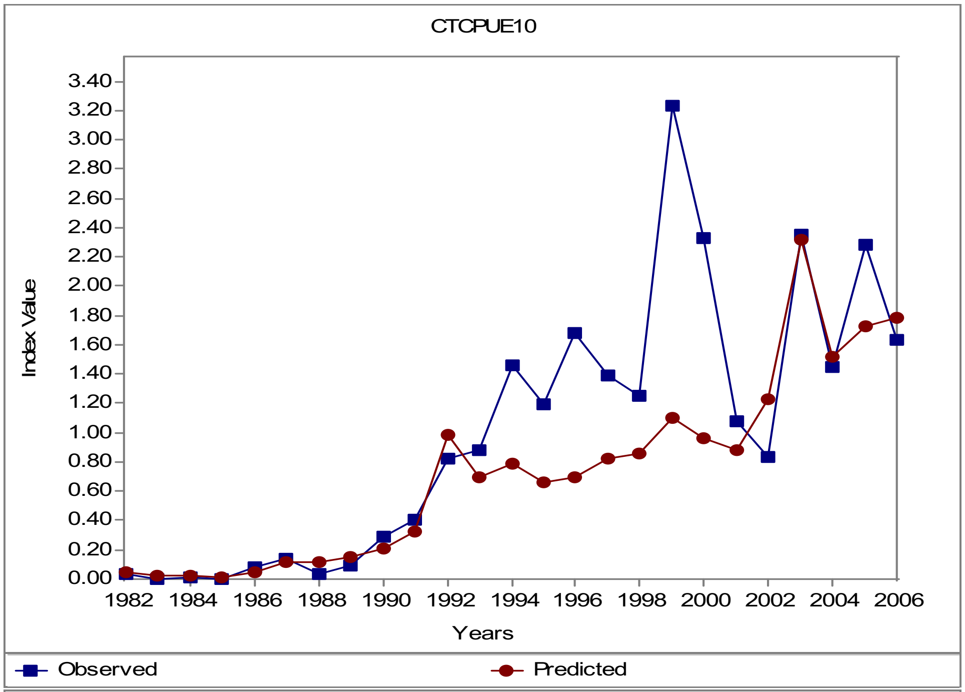




Figure 3 continued.



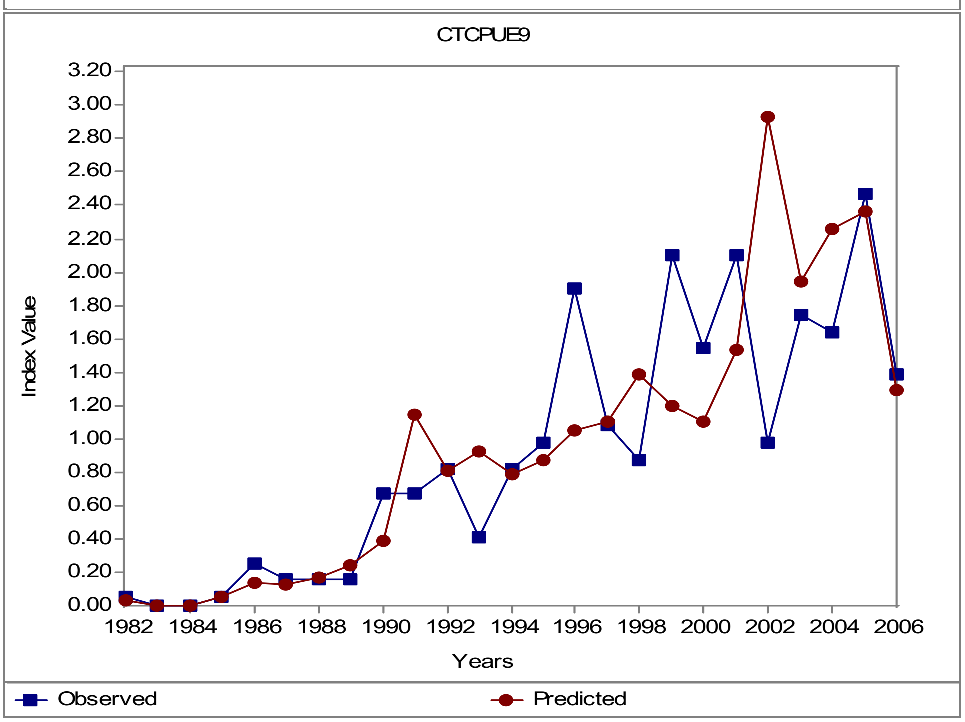




Figure 3 continued.

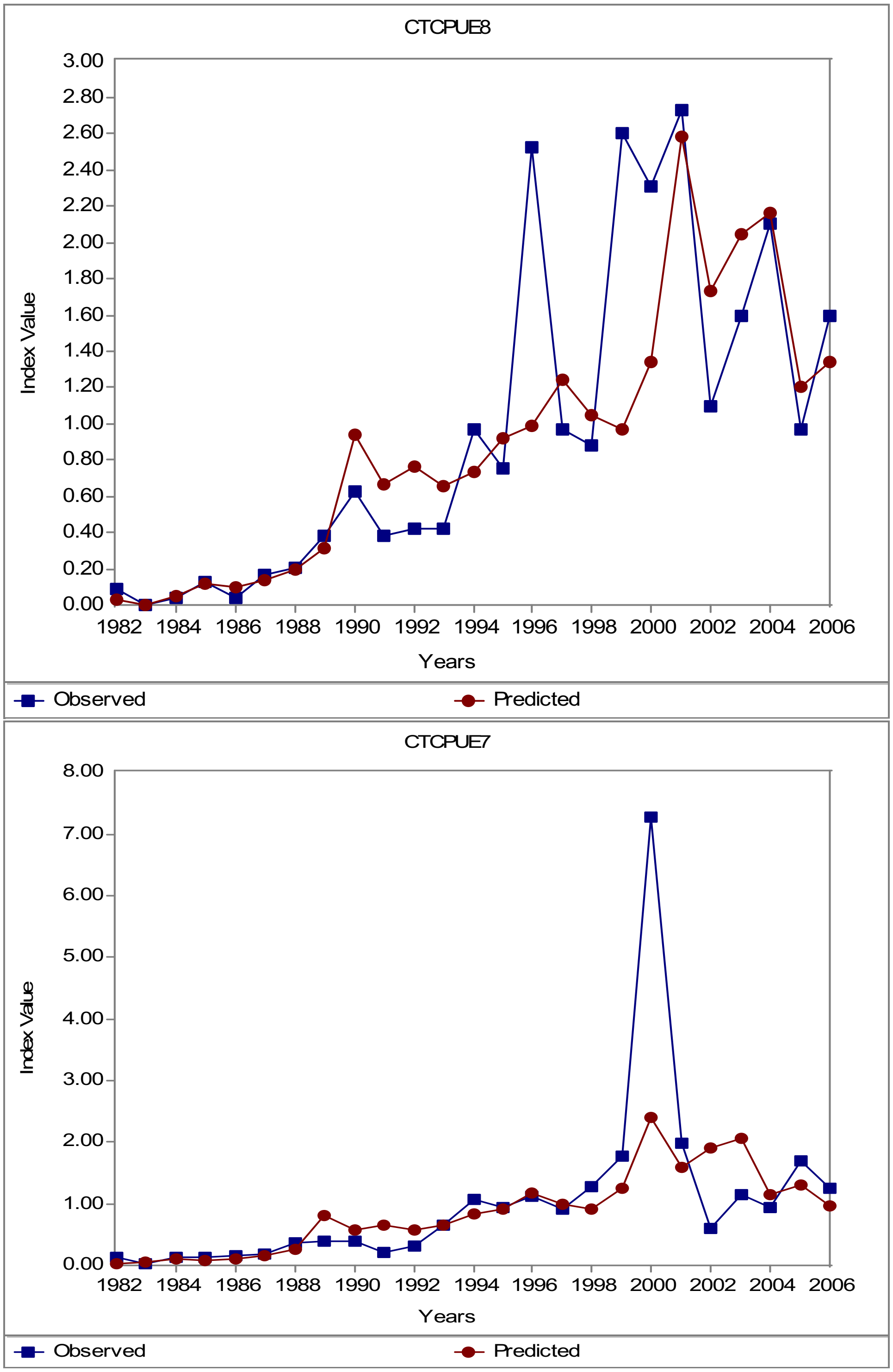
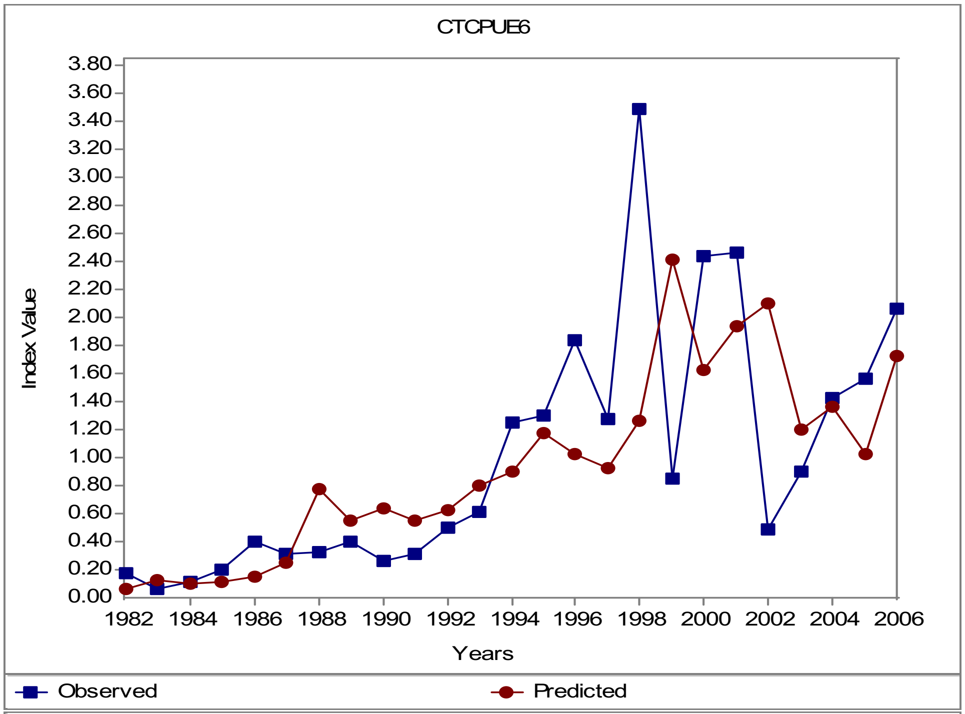



Figure 3 continued.



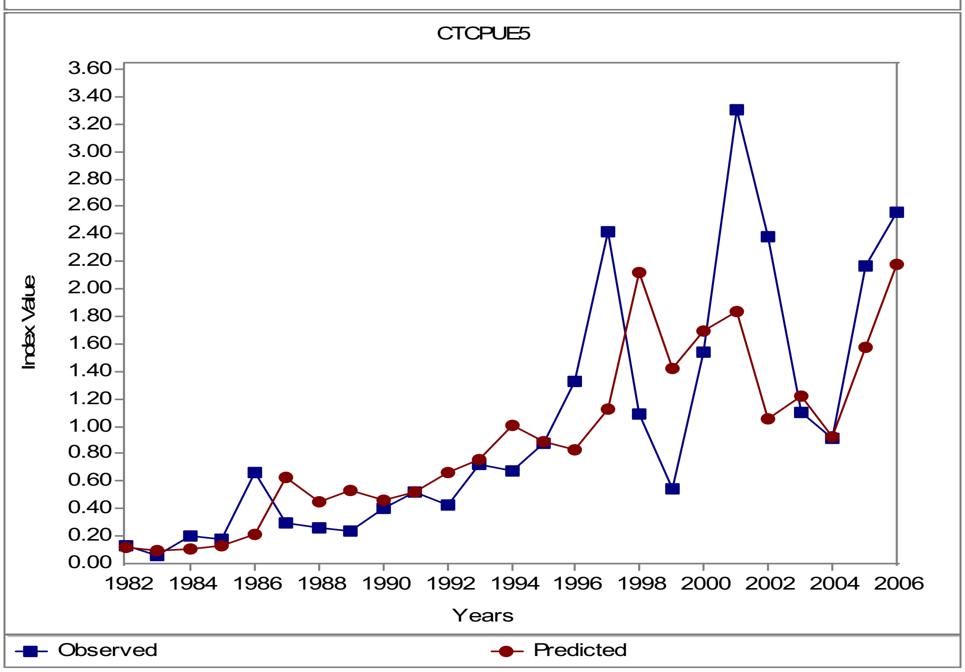




Figure 3 continued.

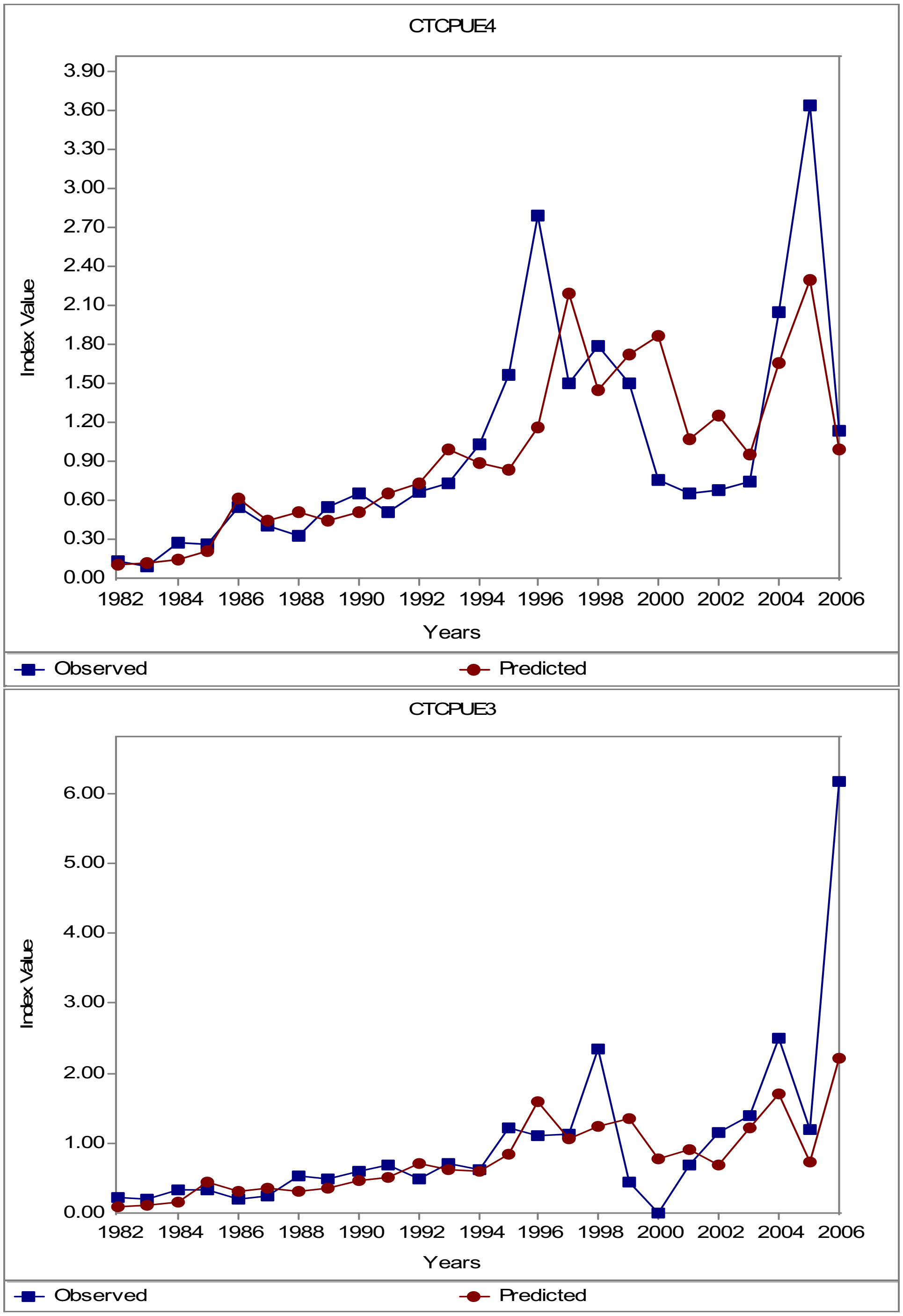



Figure 3 continued.

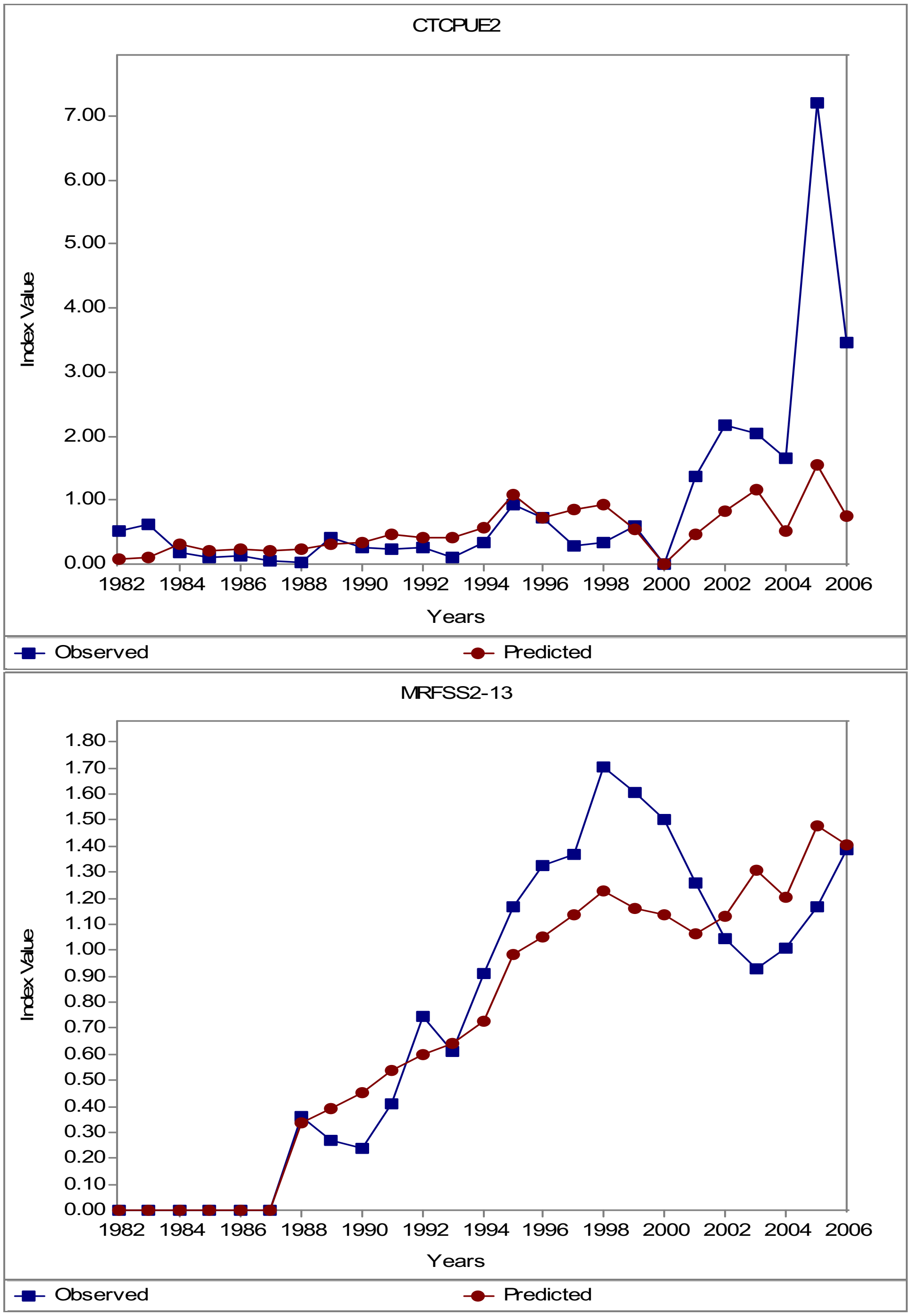



Figure 3 continued.

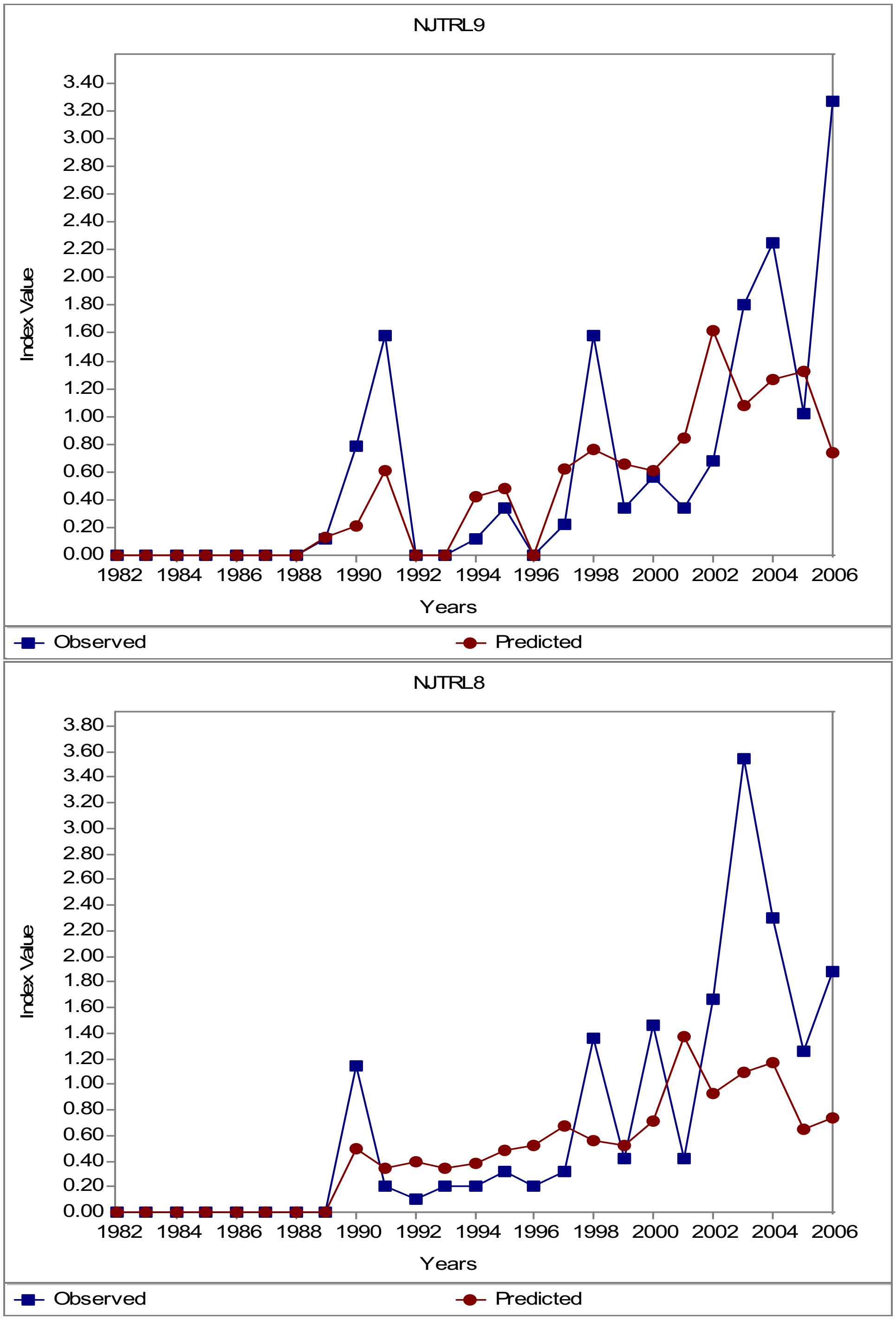
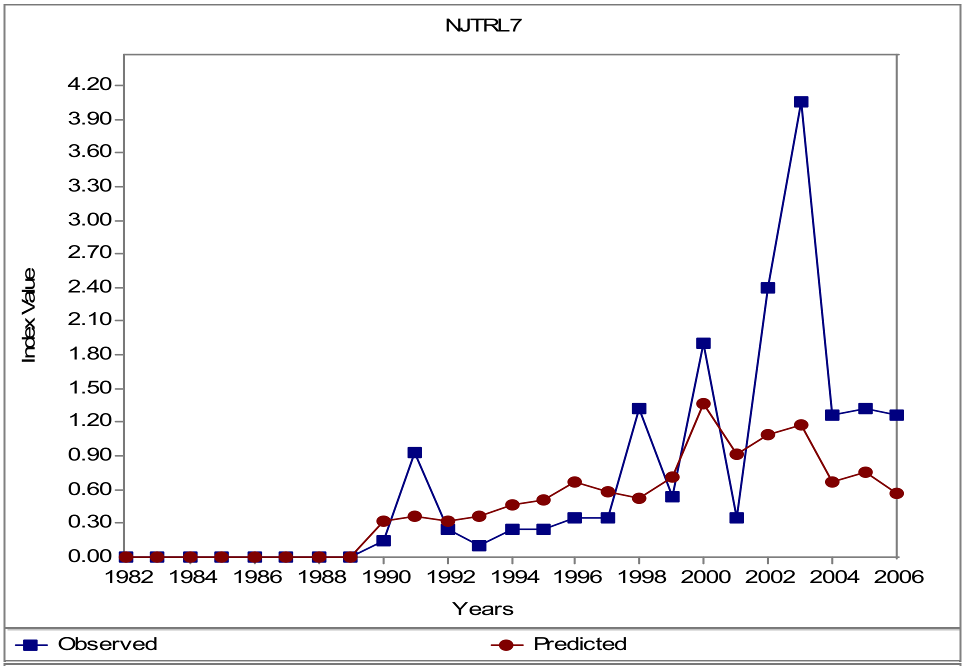



Figure 3 continued.



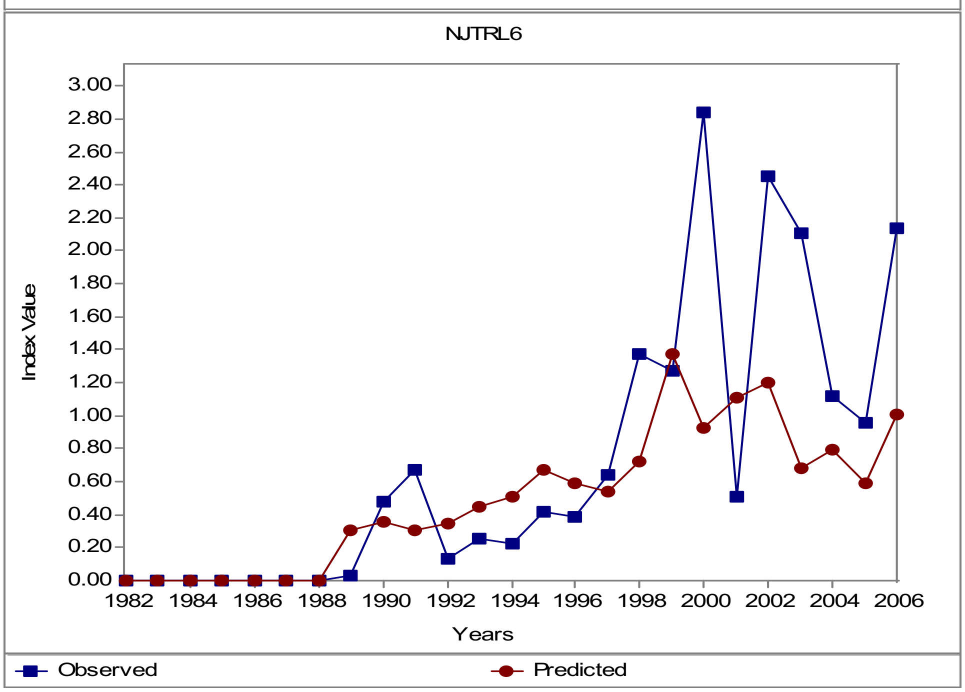




Figure 3 continued.

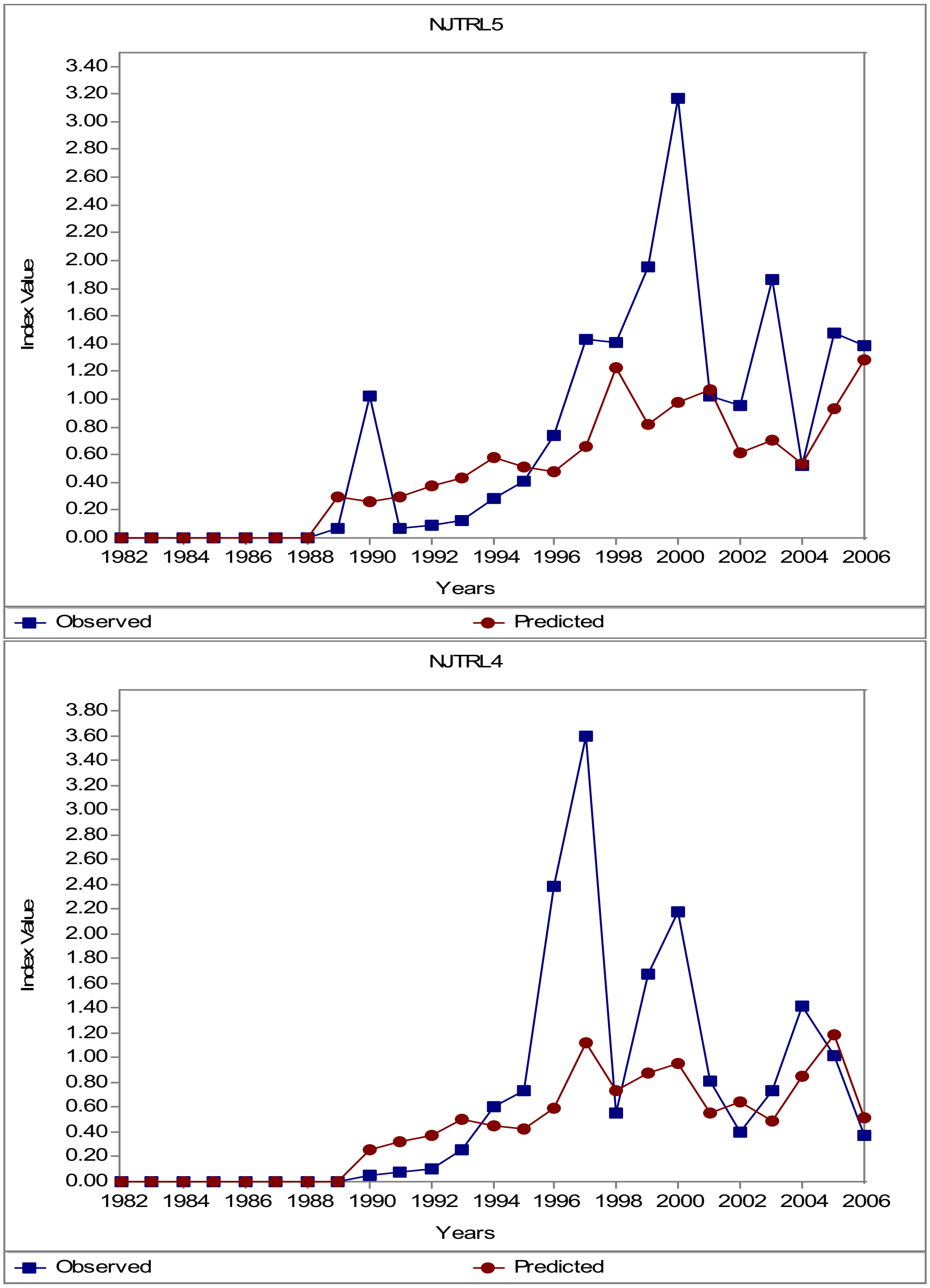
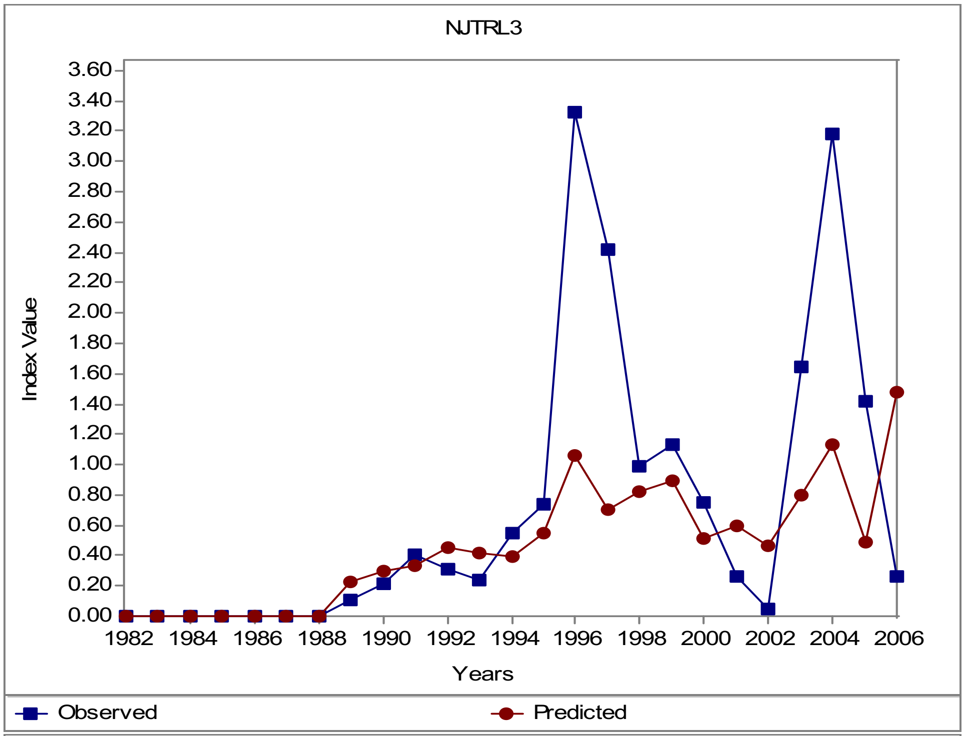



Figure 3 continued.



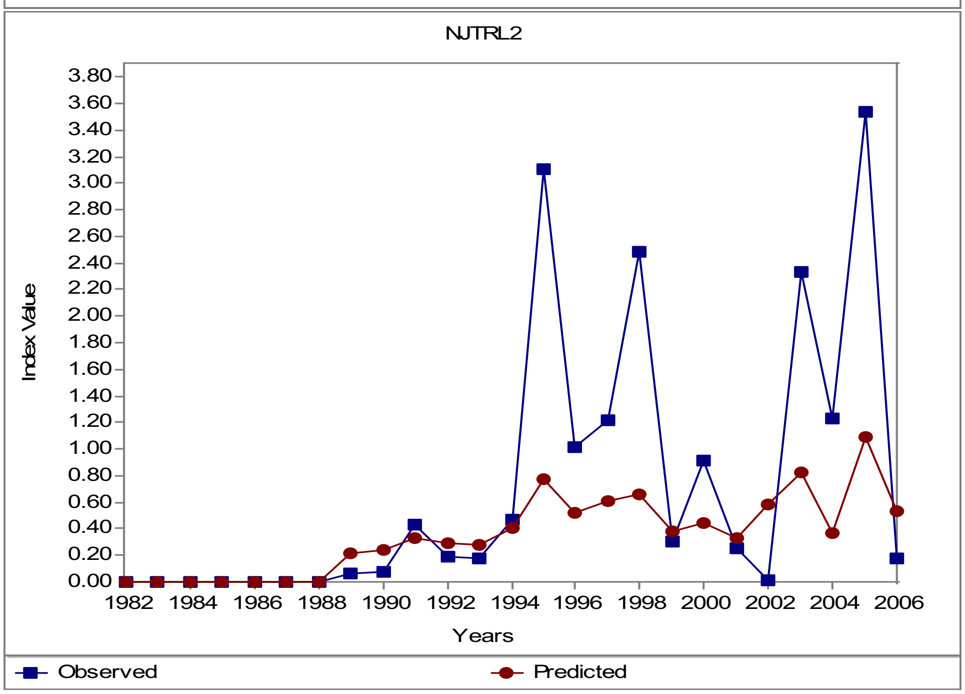




Figure 3 continued.

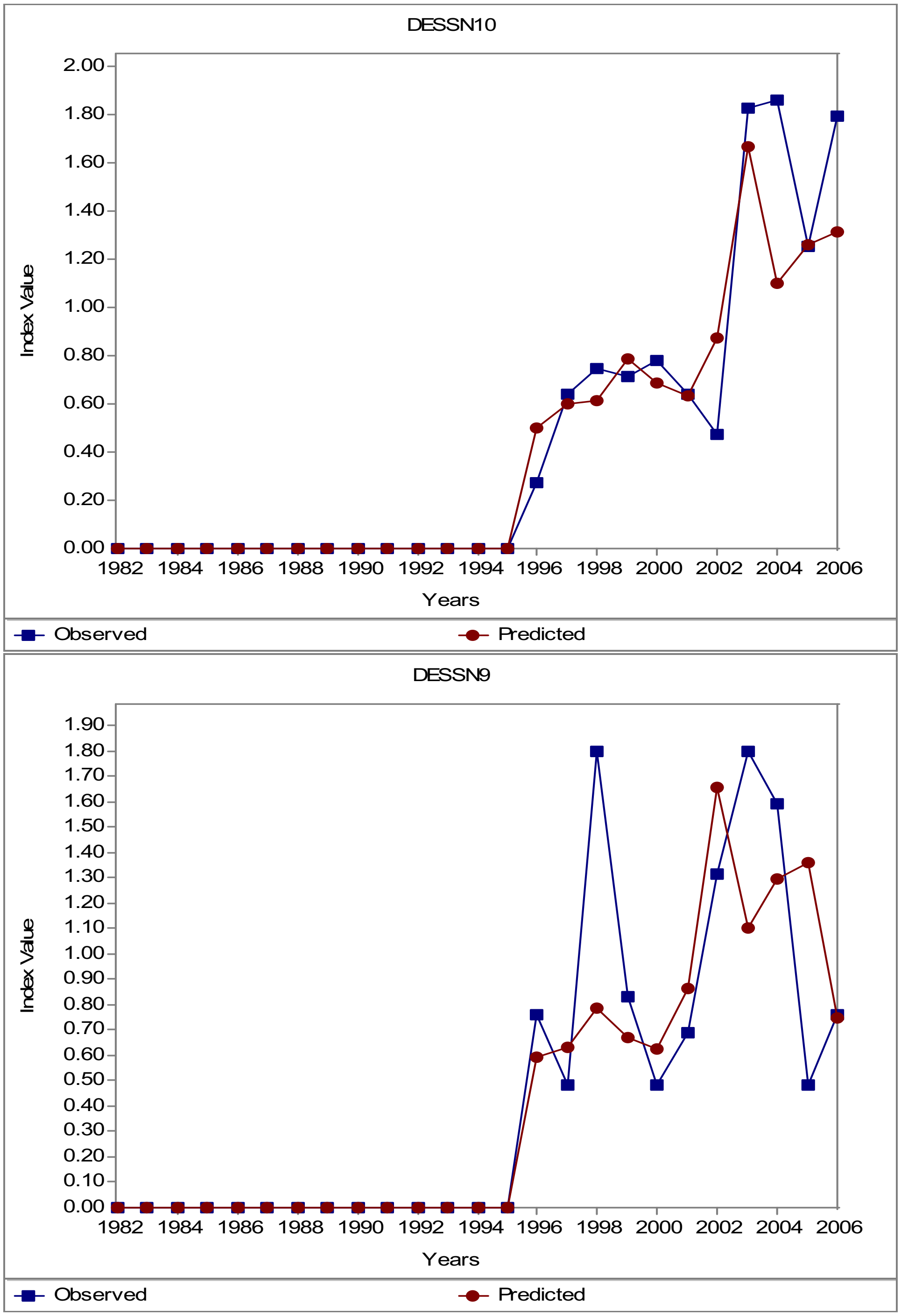



Figure 3 continued.

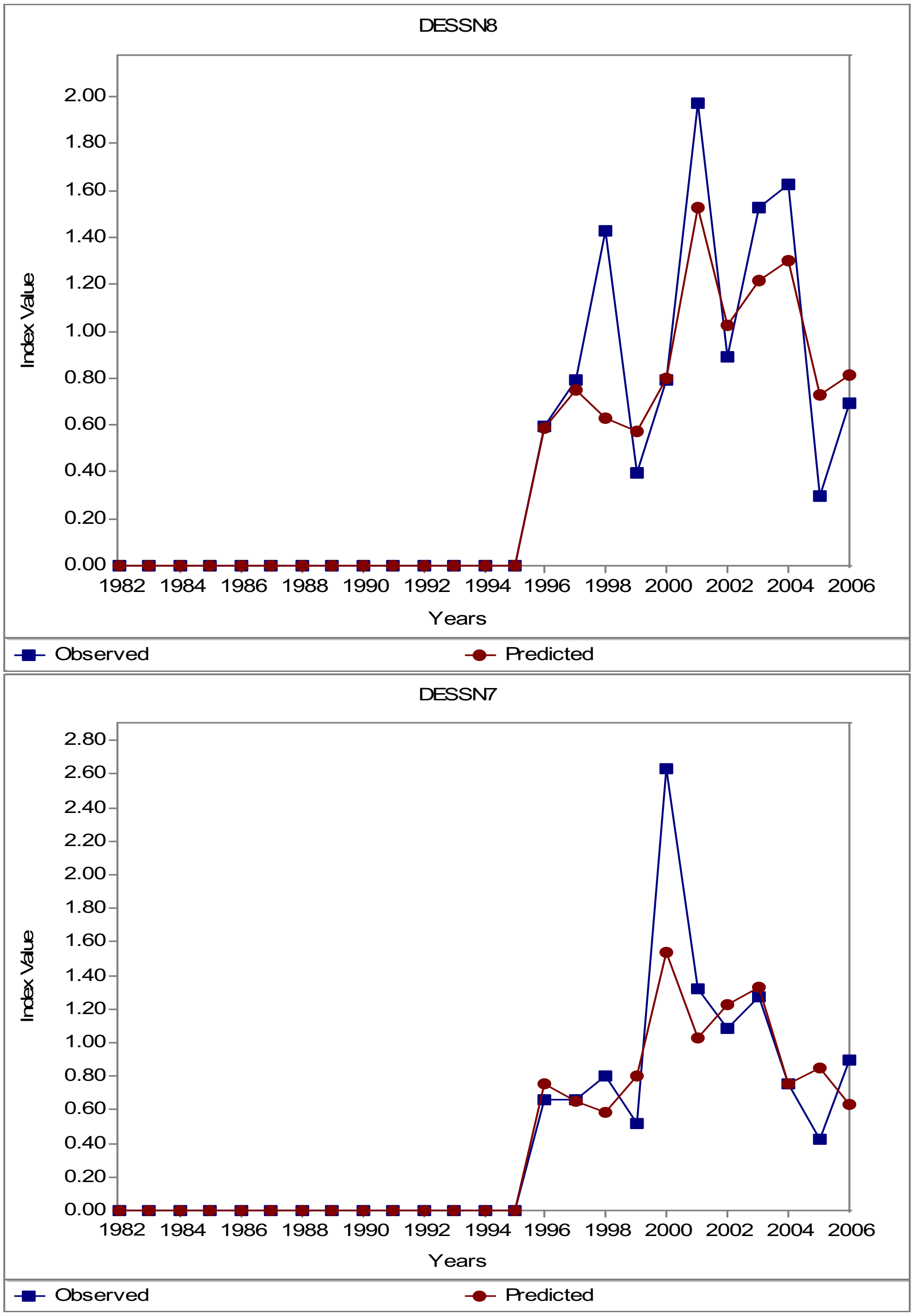
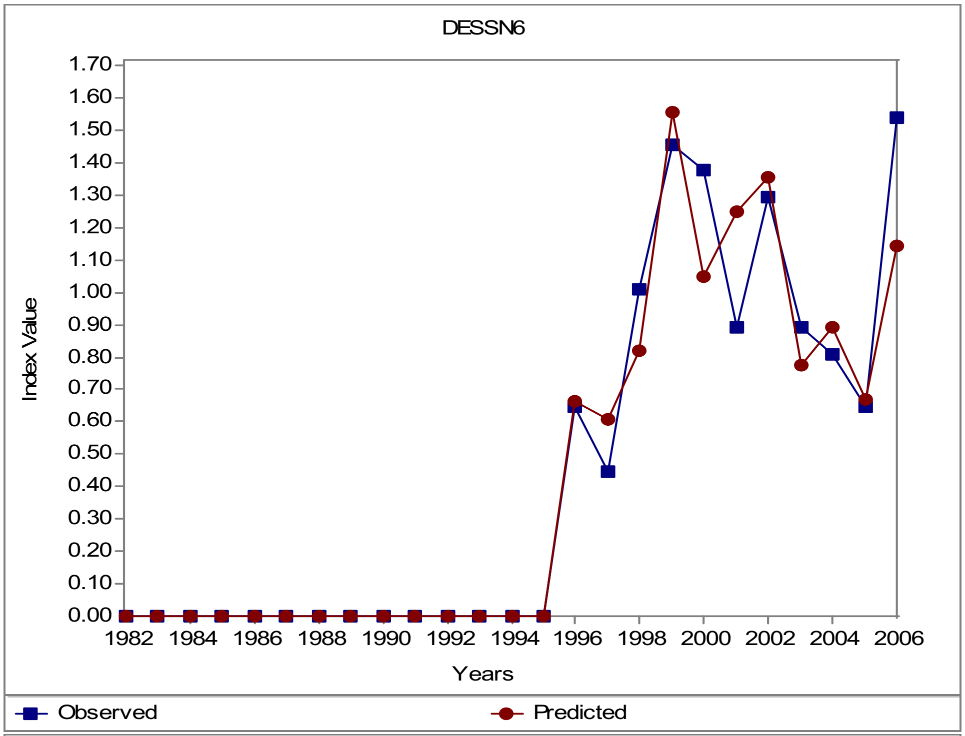



Figure 3 continued.



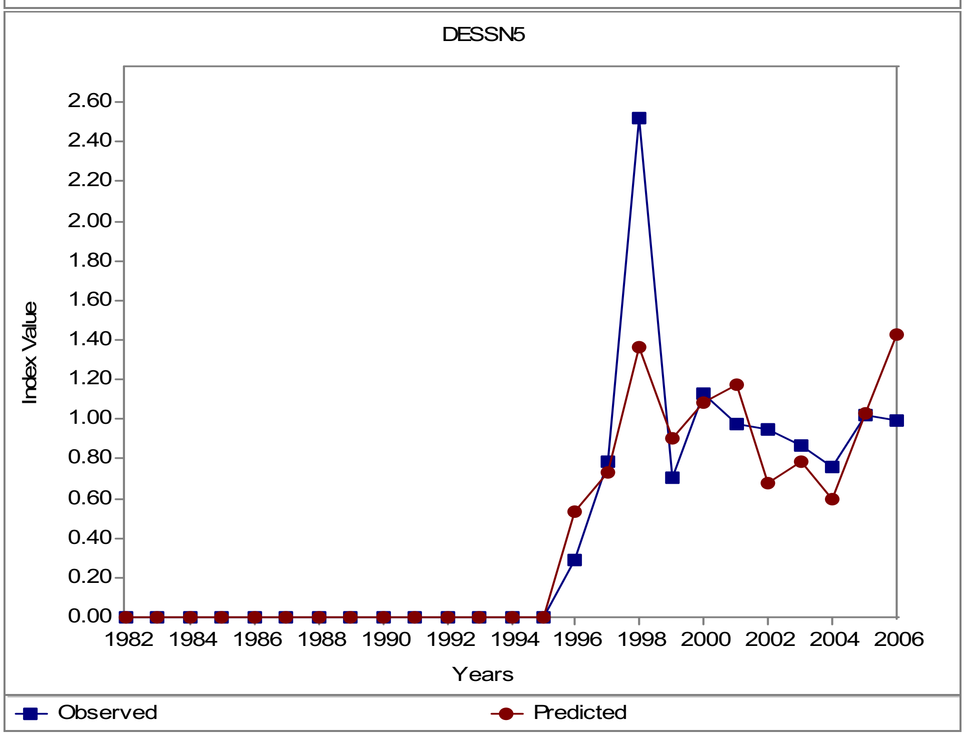
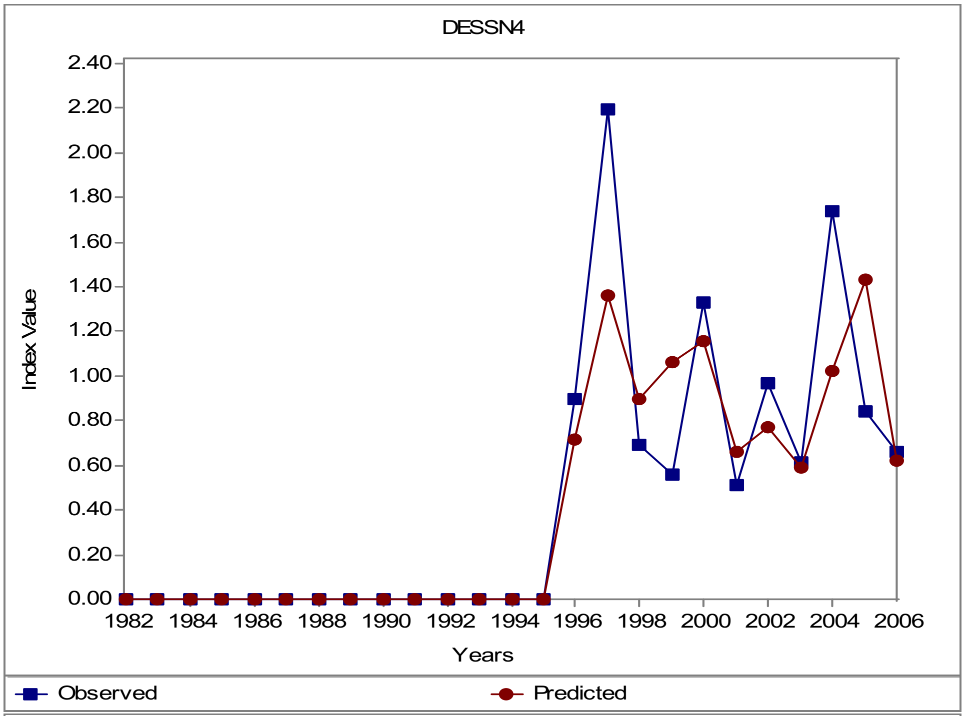




Figure 3 continued.



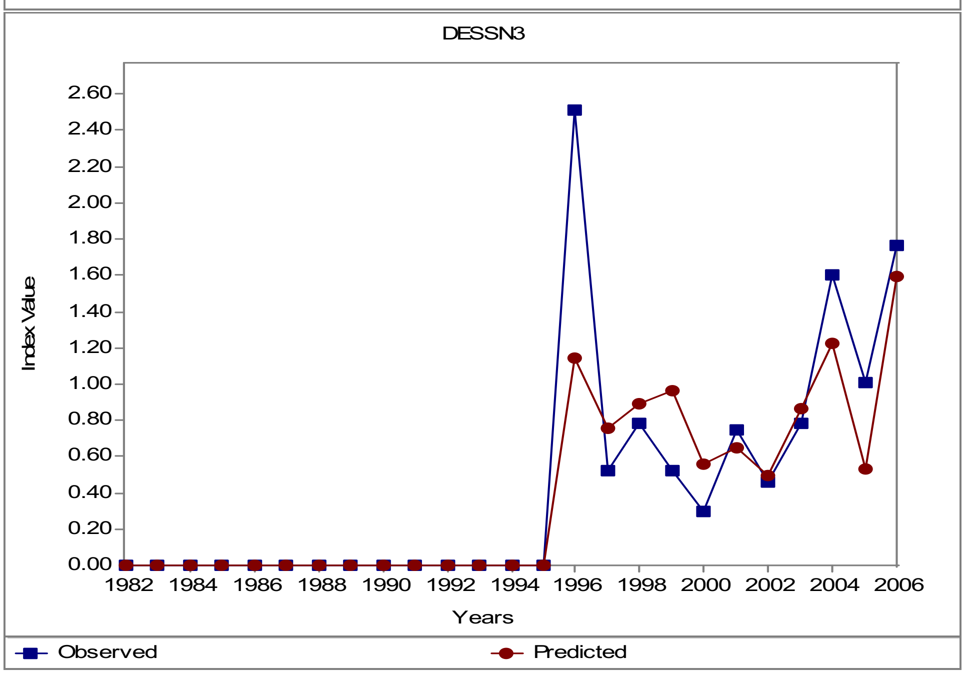




Figure 3 continued.

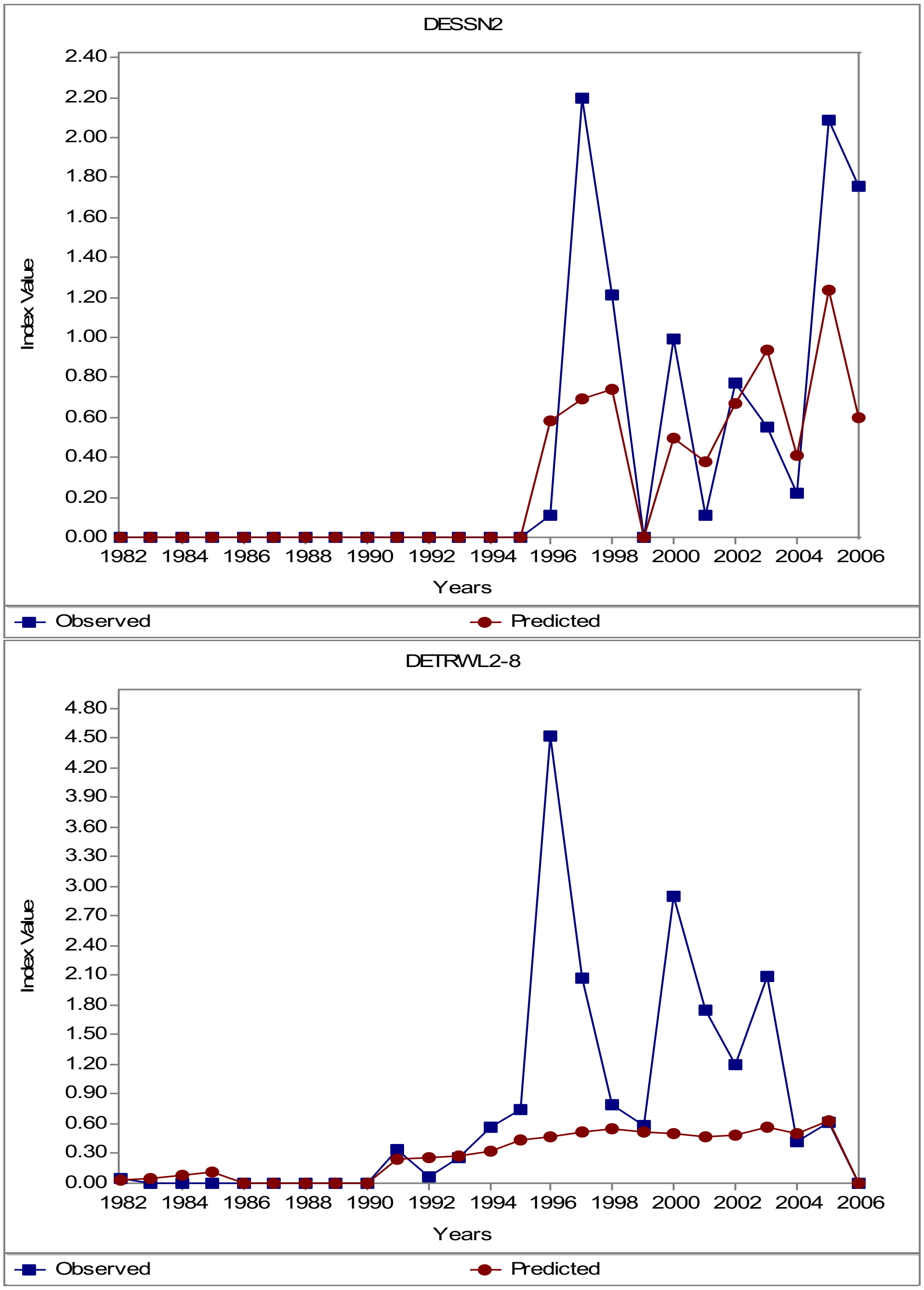



Figure 3 continued.

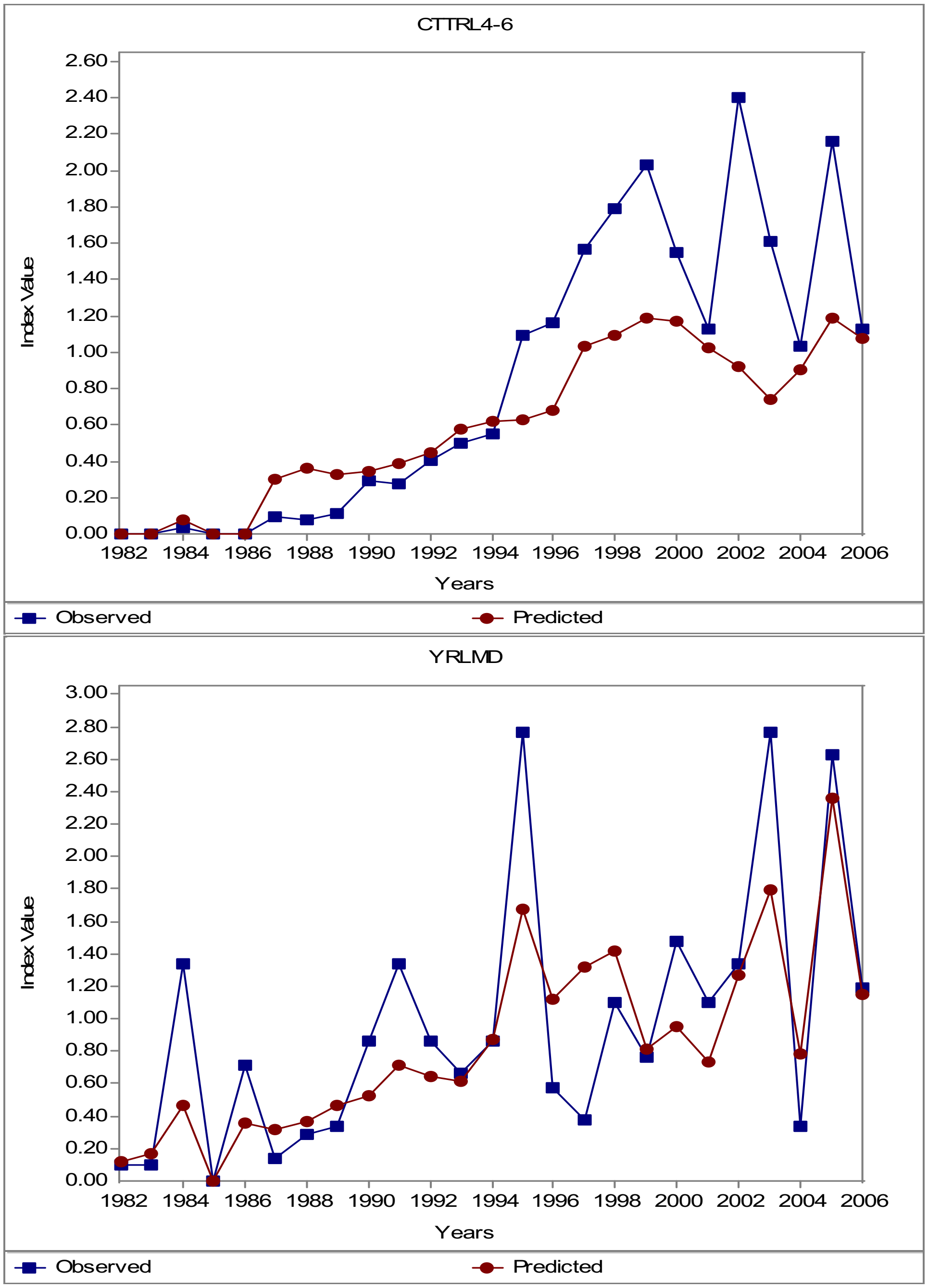



Figure 3 continued.

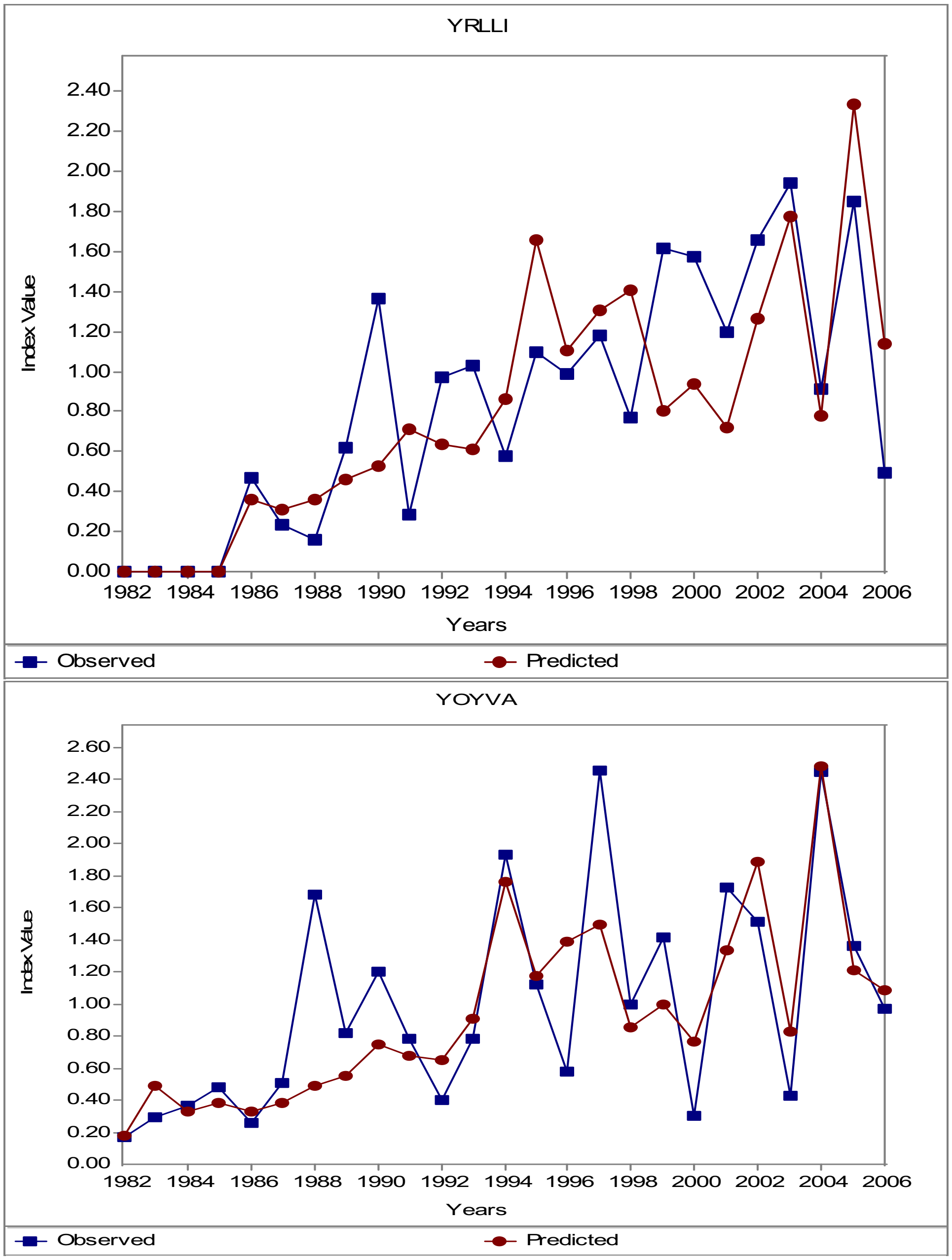



Figure 3 continued.

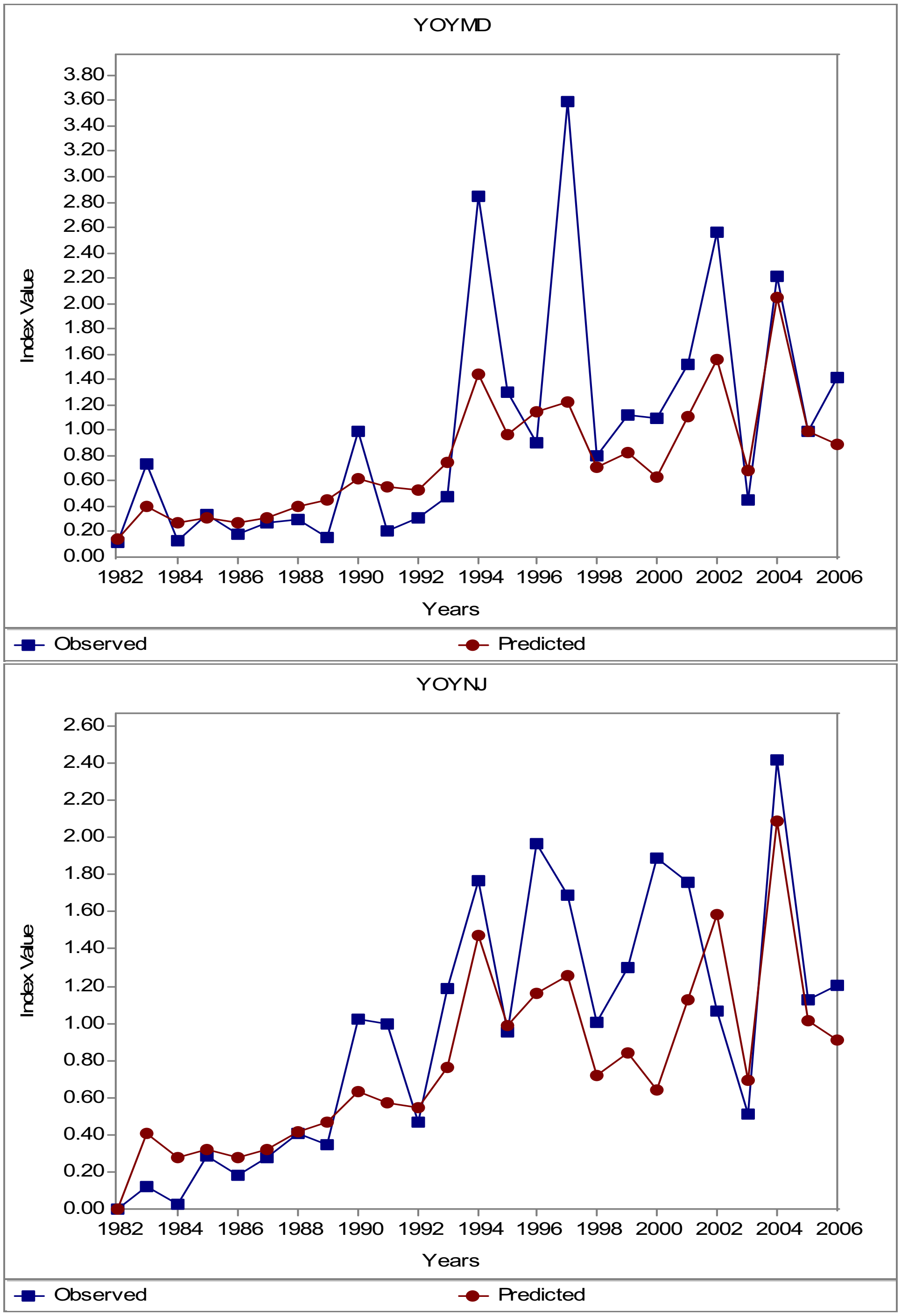



Figure 3 continued.

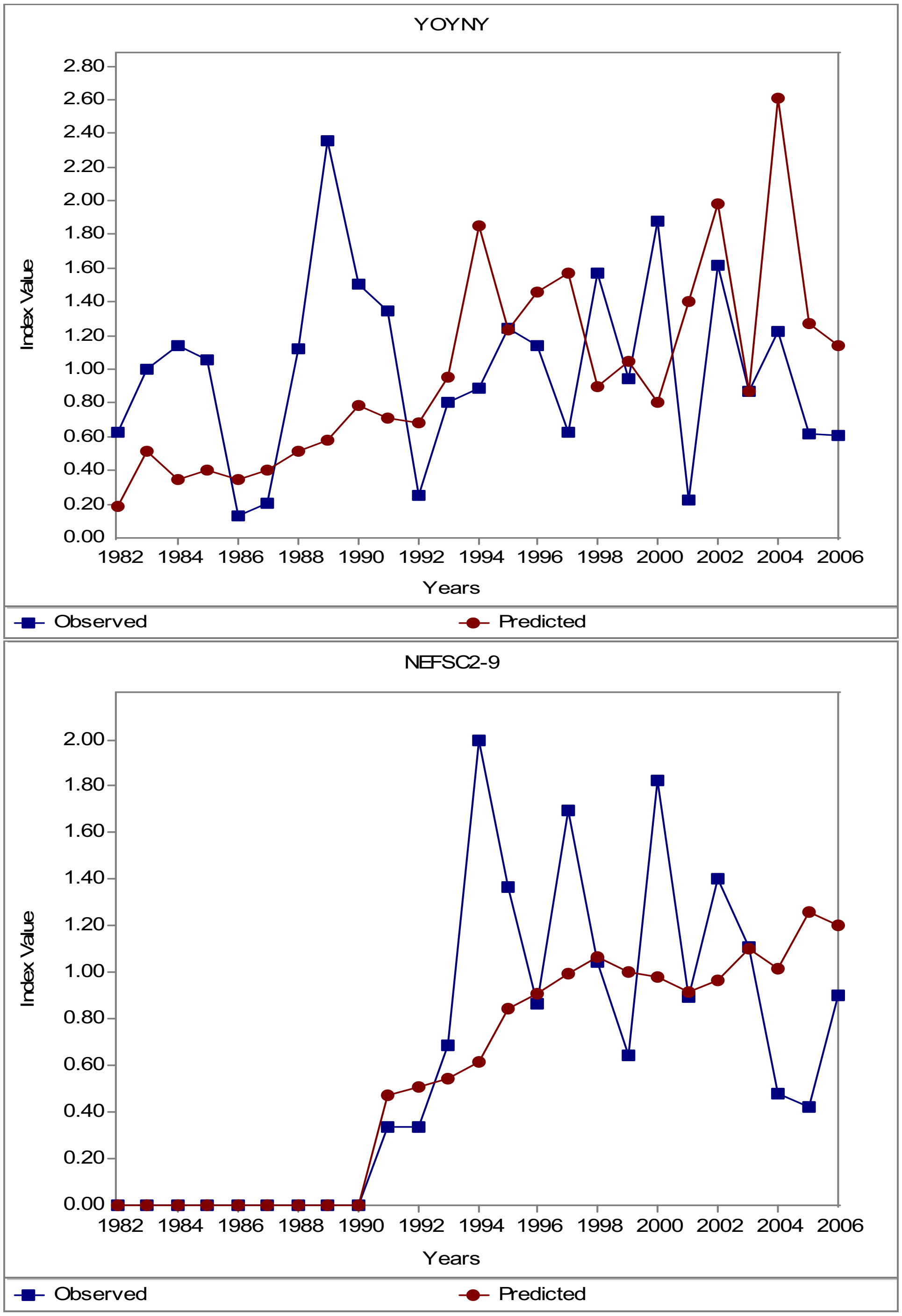



Figure 3 continued.

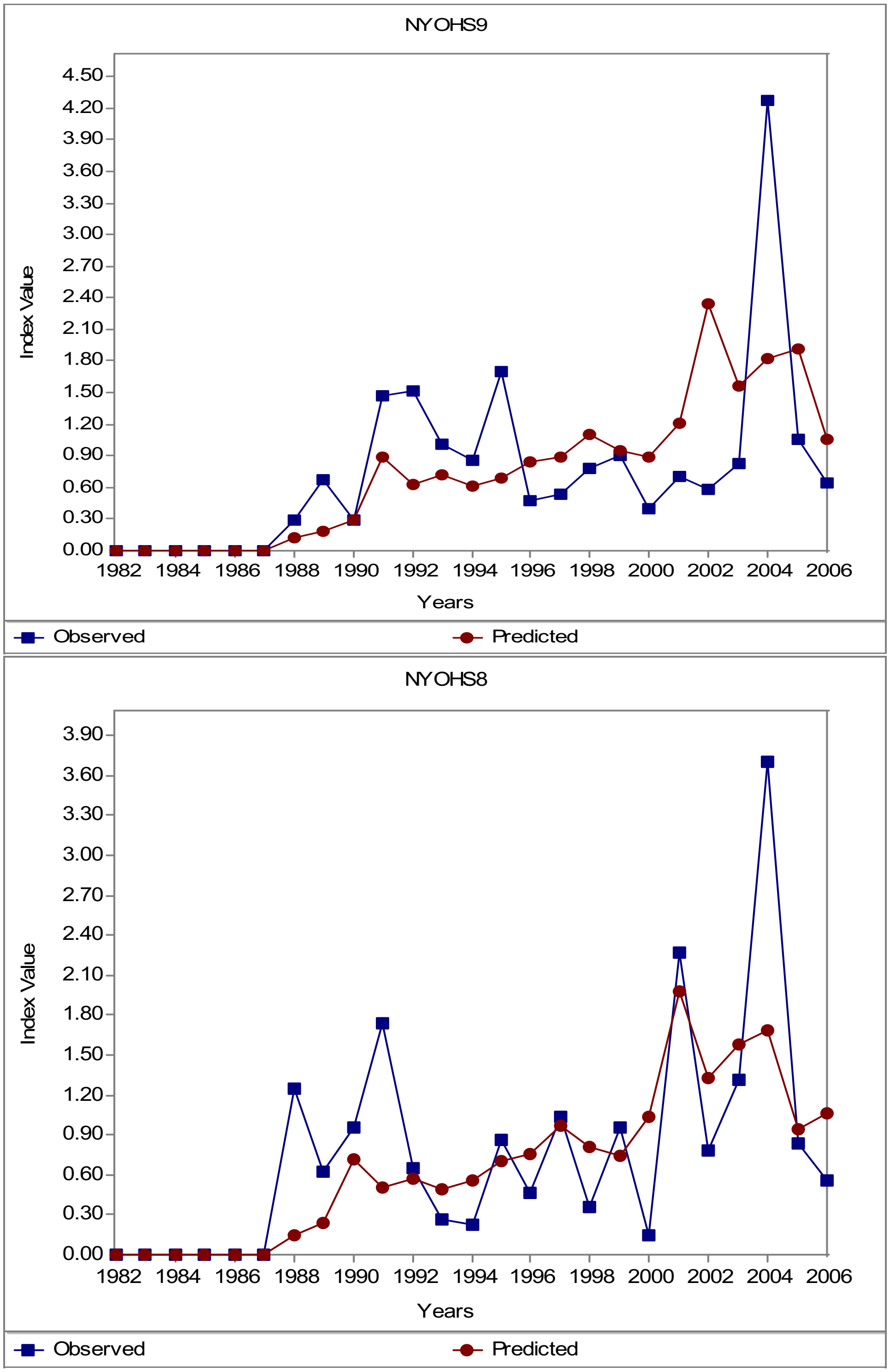
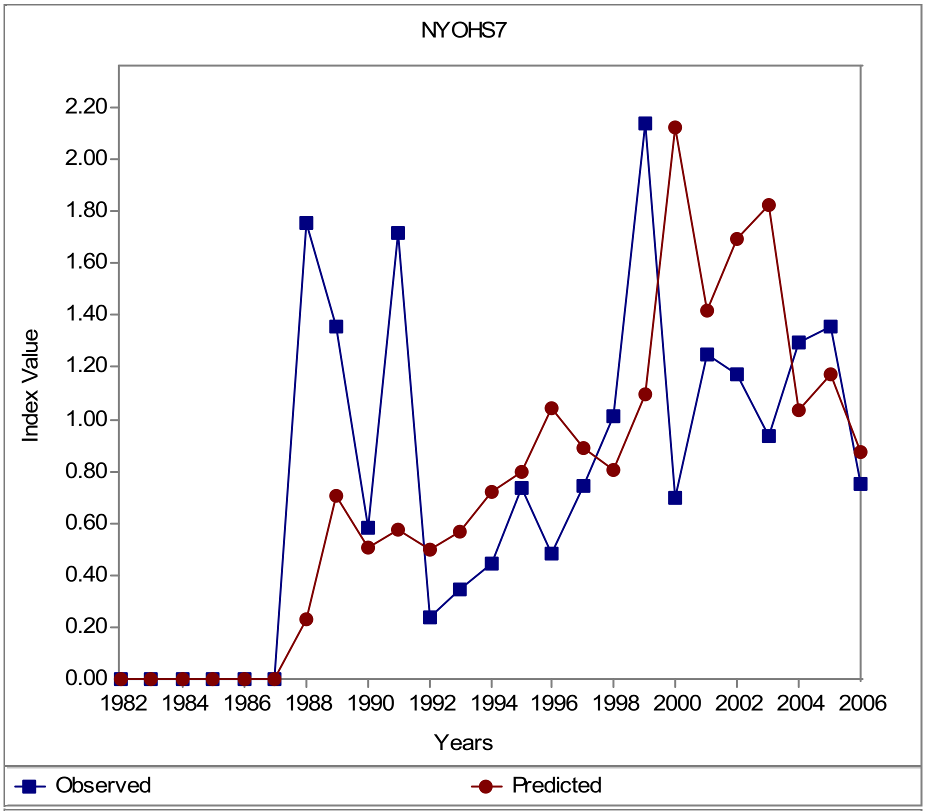



Figure 3 continued.



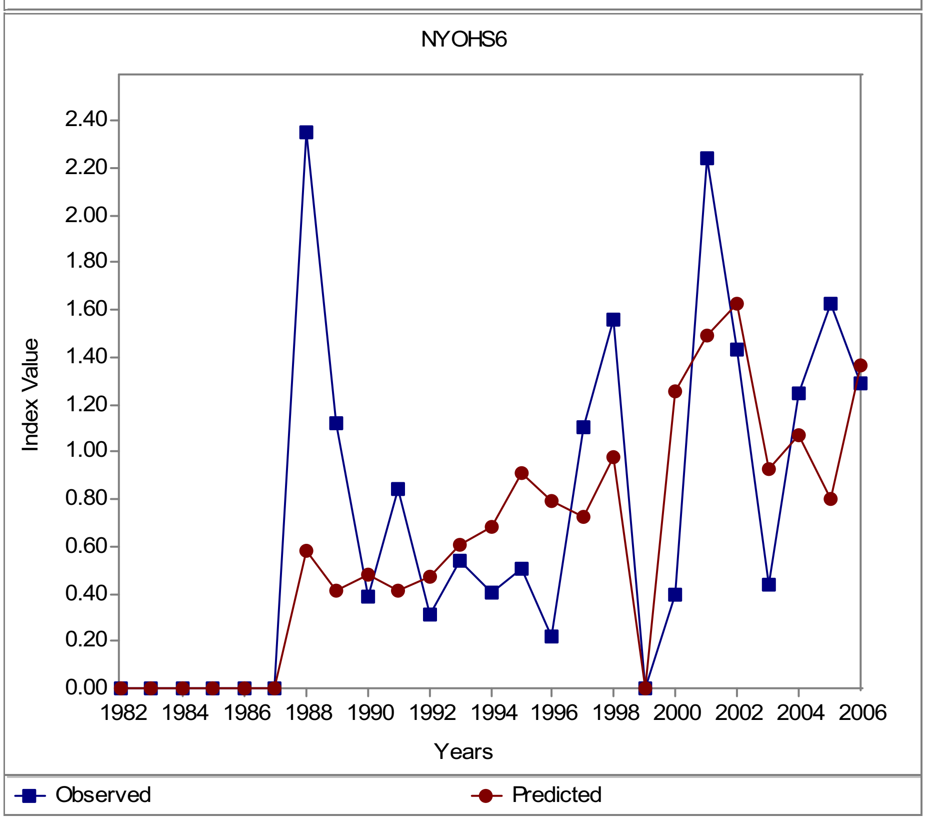




Figure 3 continued.

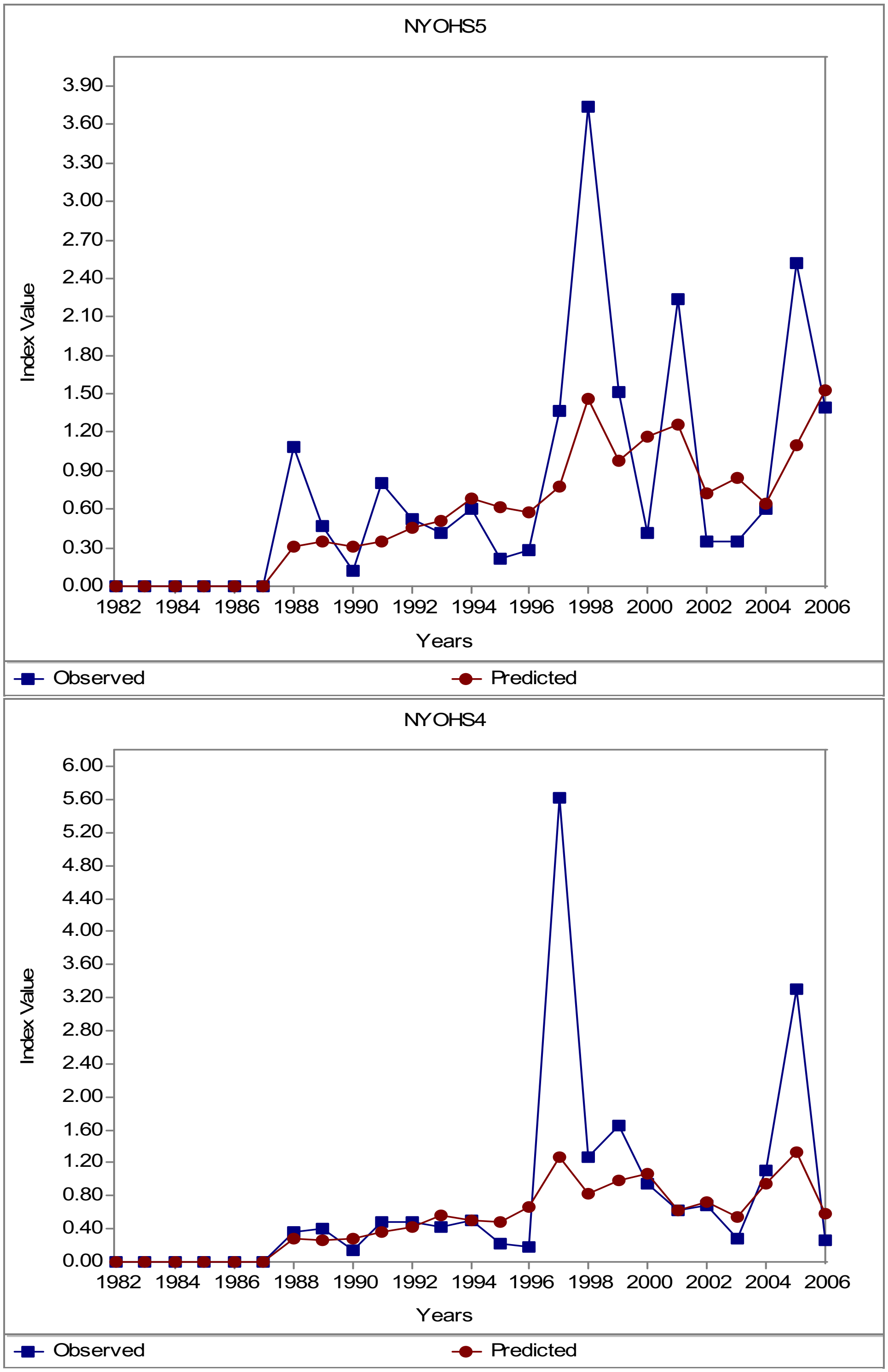



Figure 3 continued.

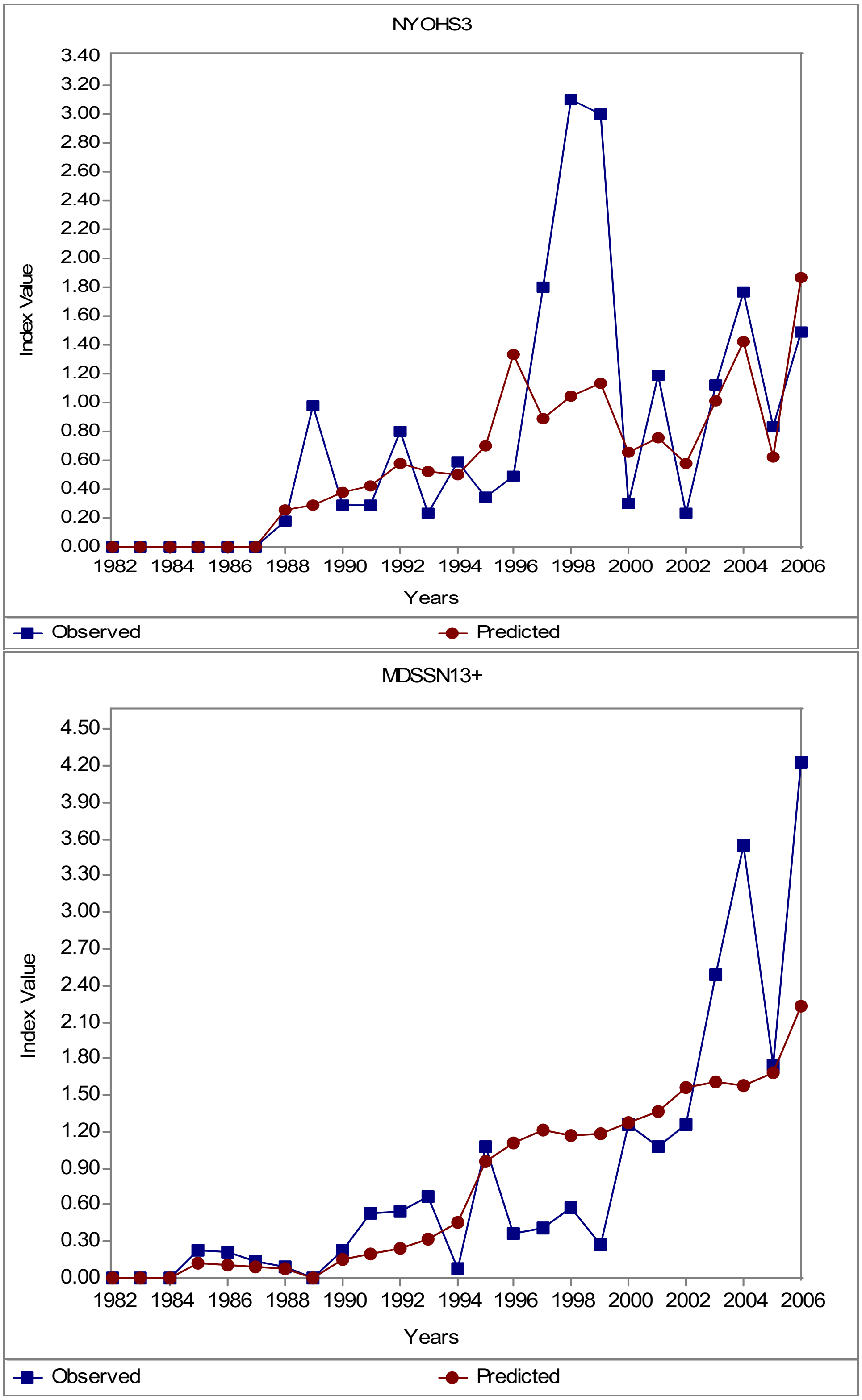
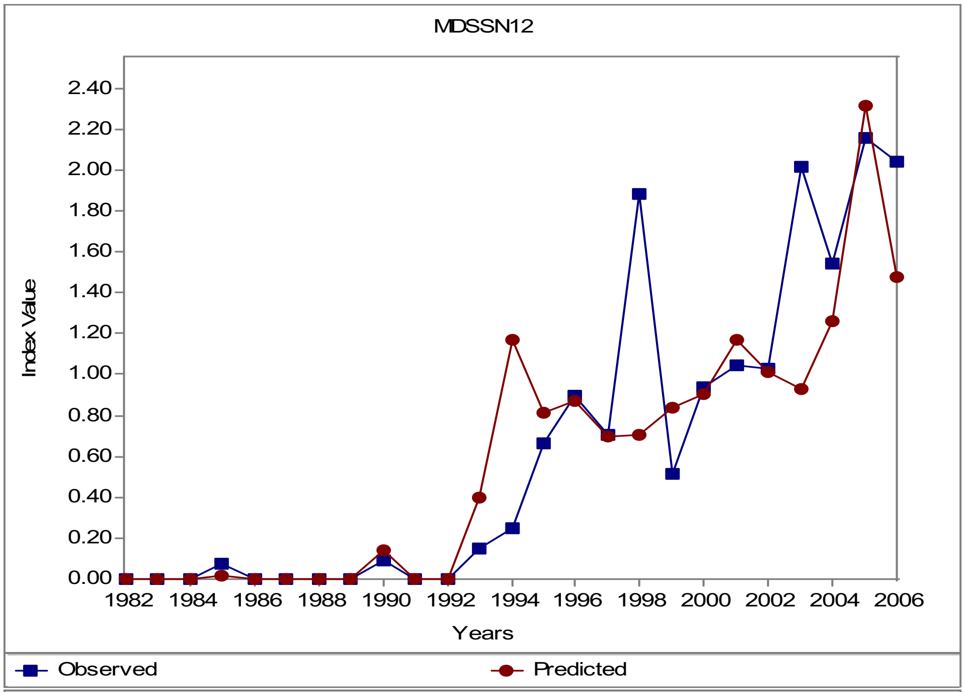



Figure 3 continued.



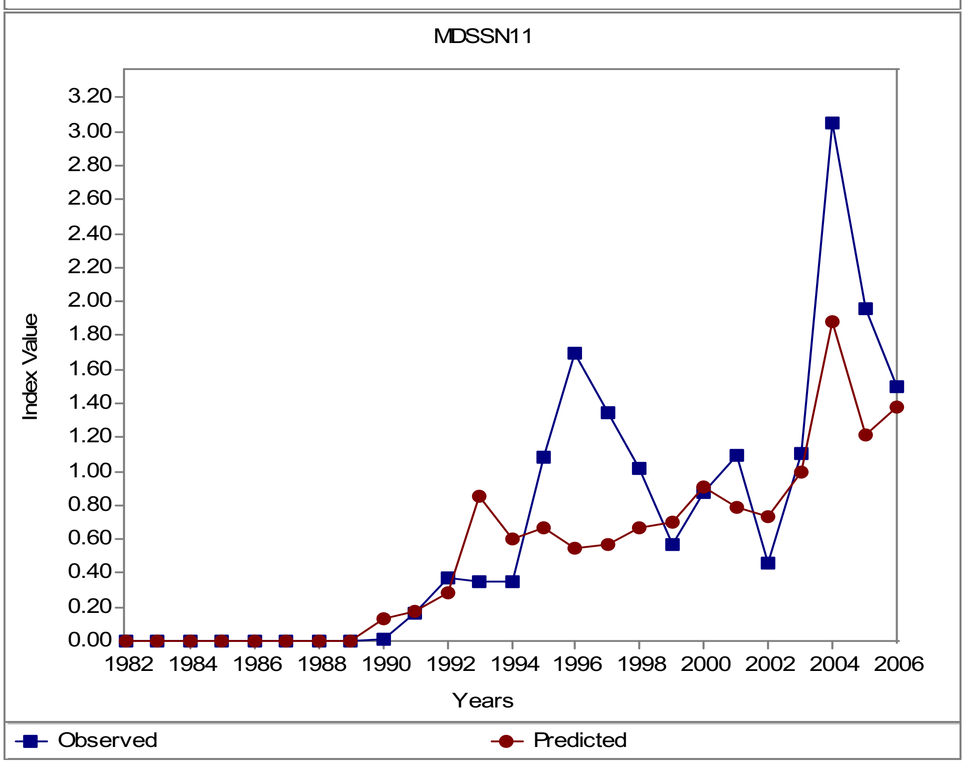
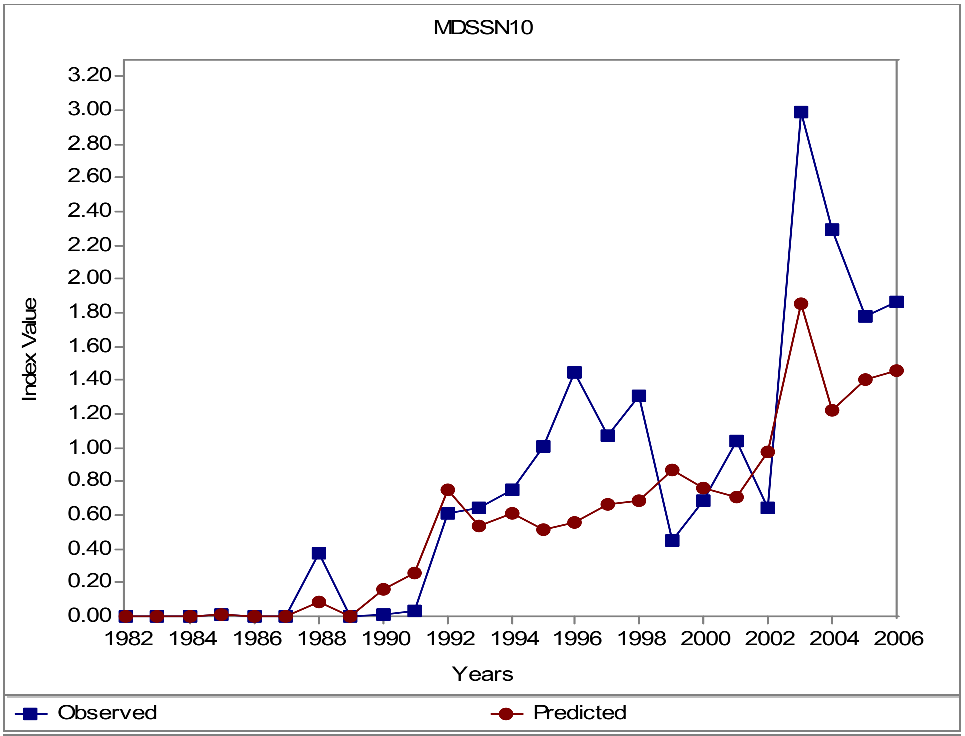




Figure 3 continued.



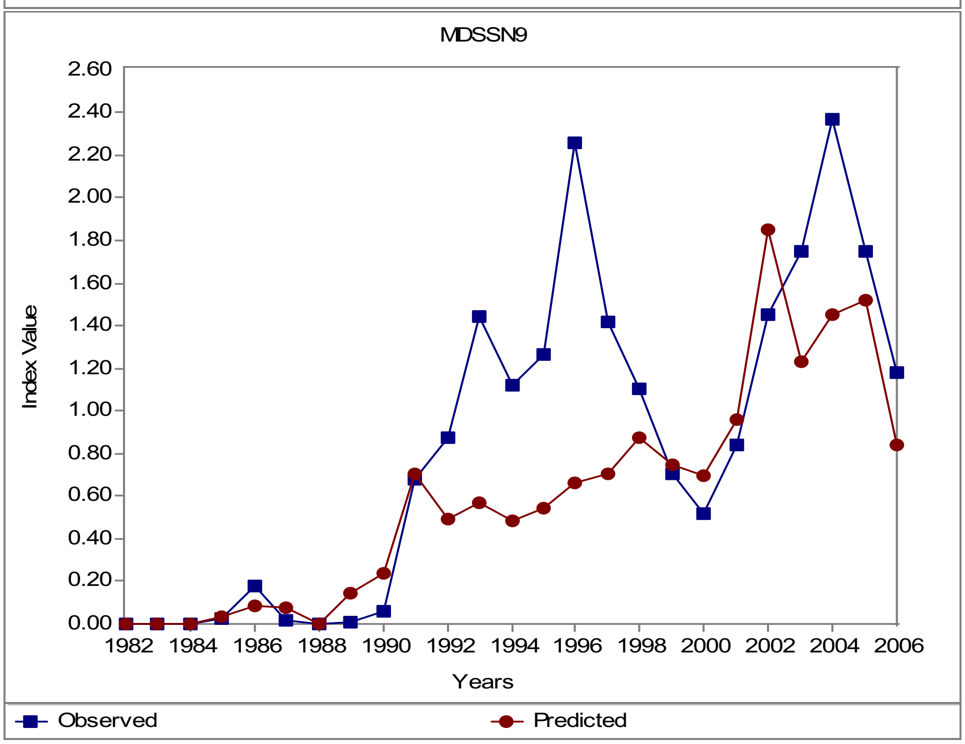
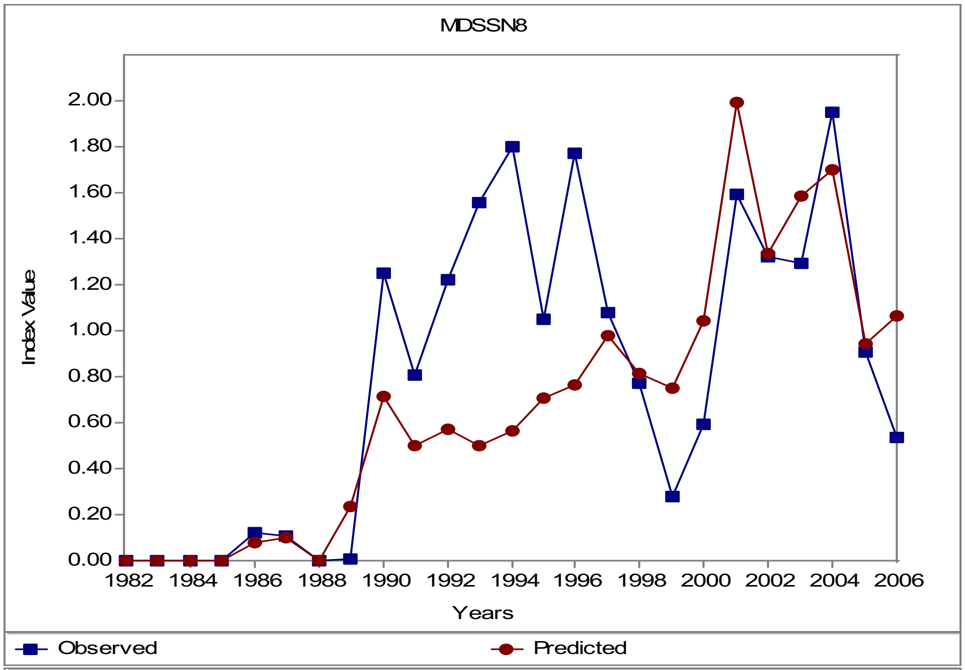




Figure 3 continued.



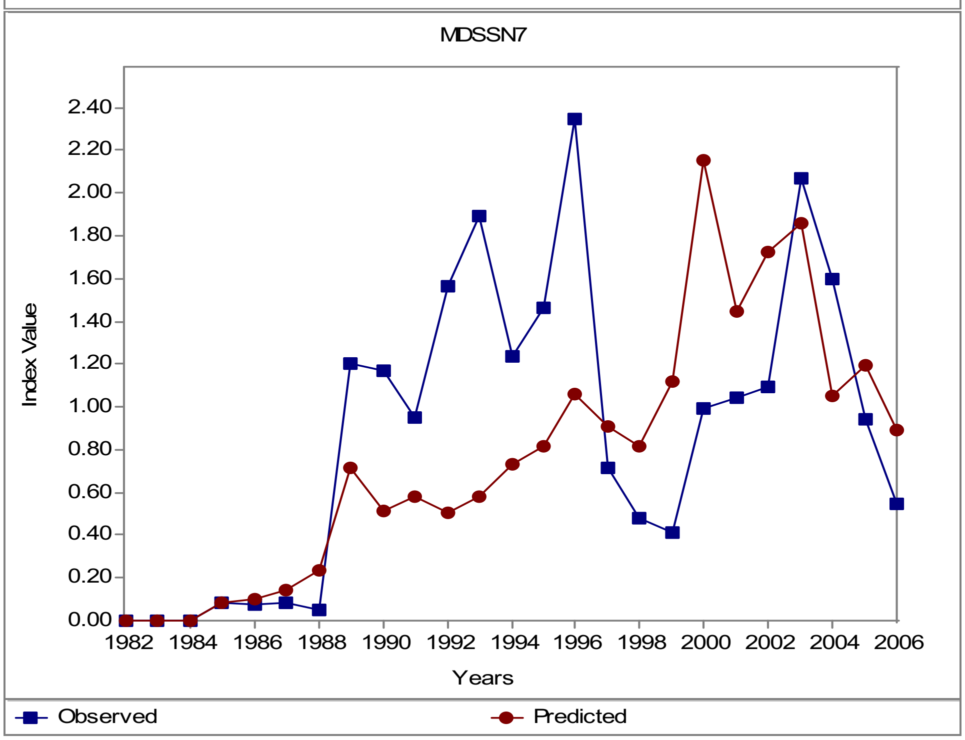
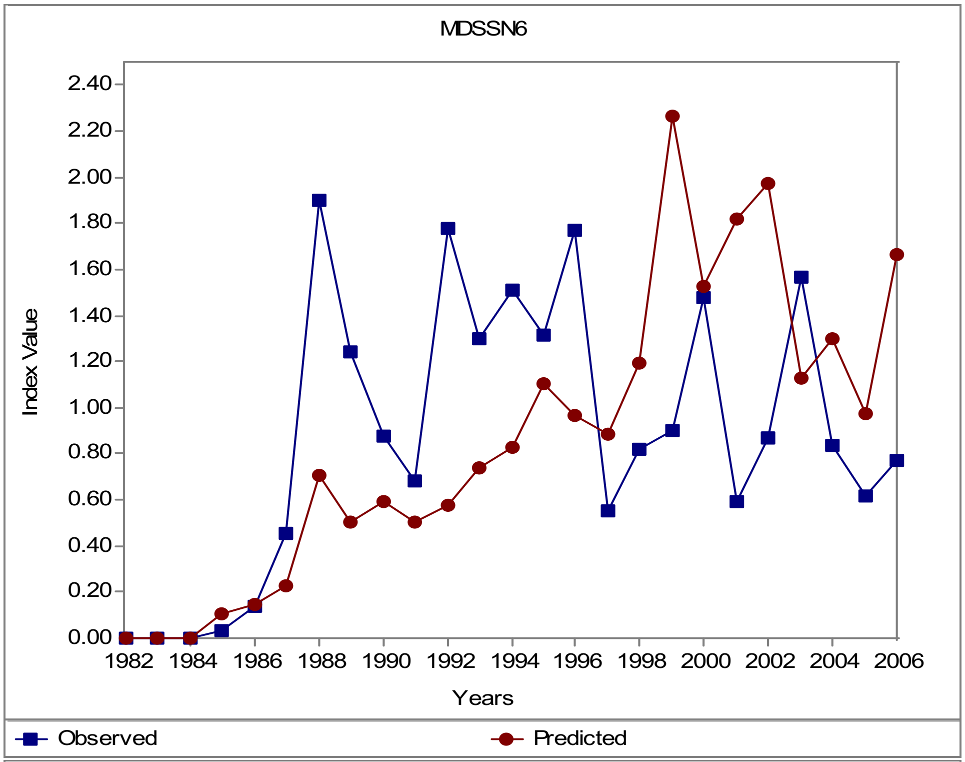




Figure 3 continued.



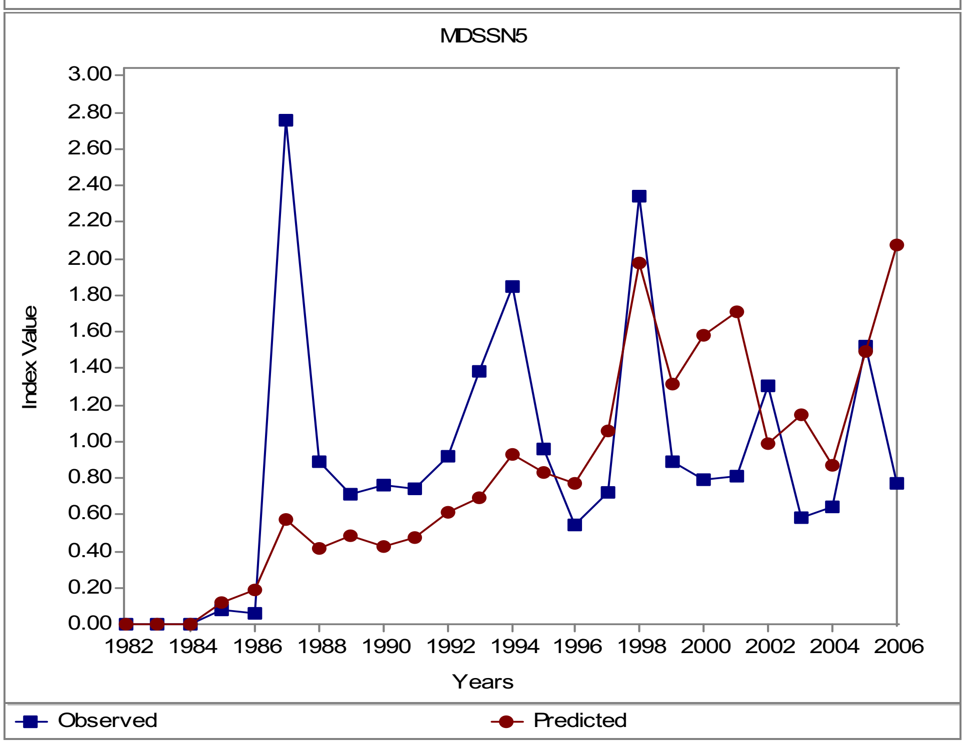
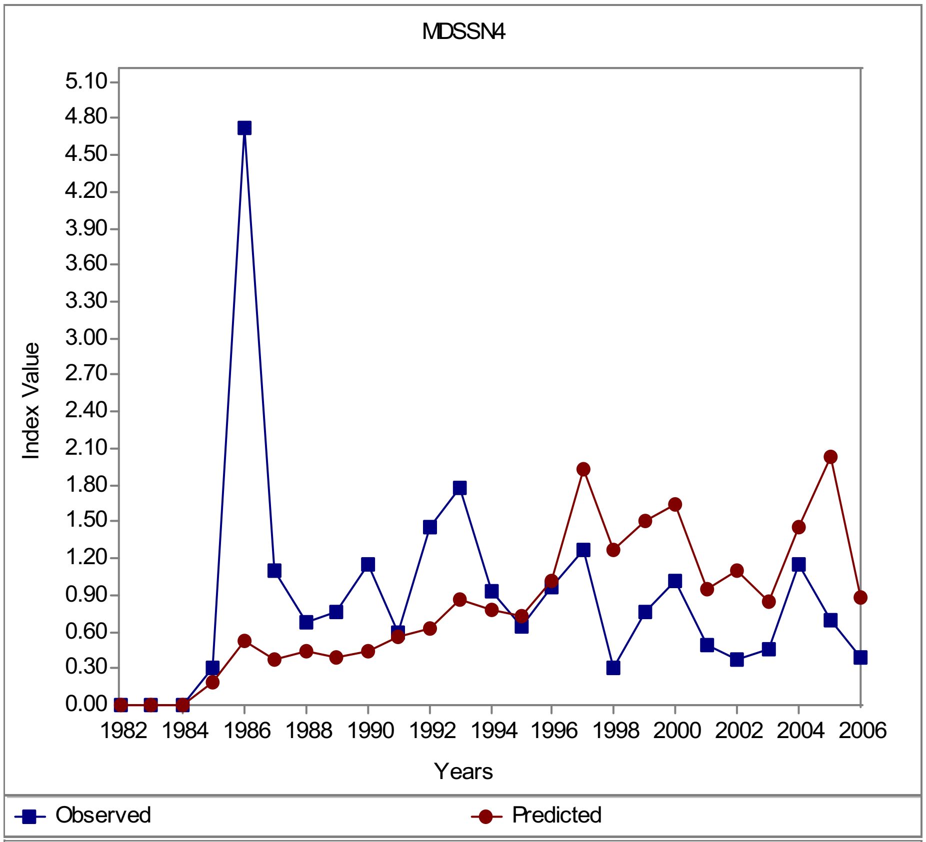




Figure 3 continued.



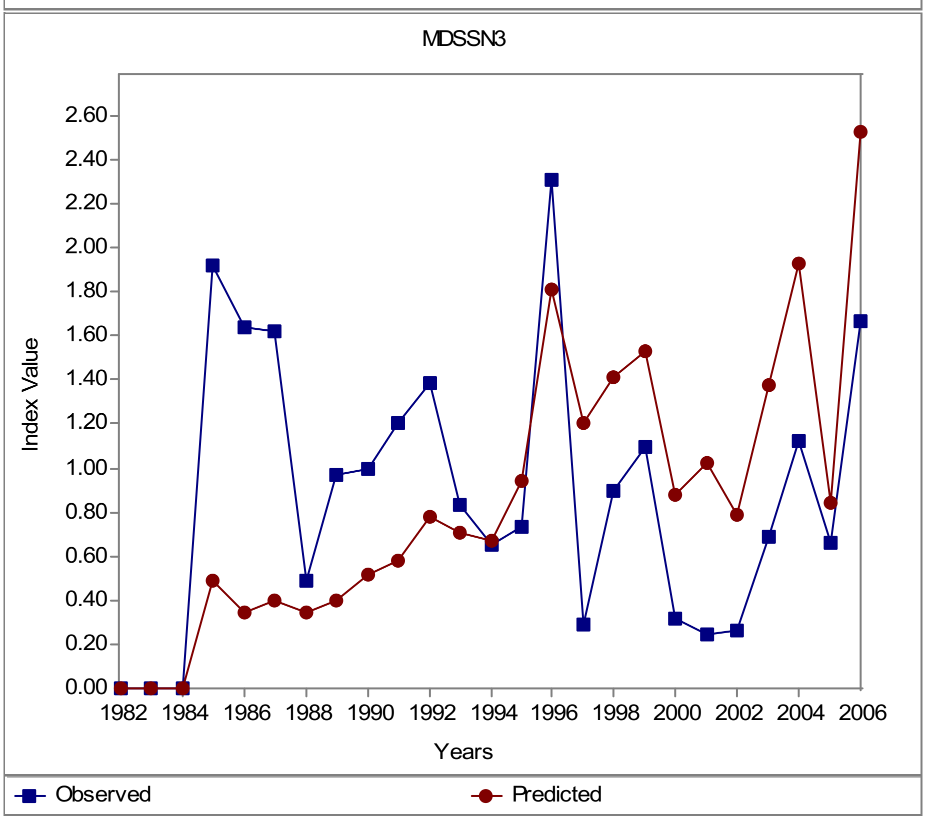
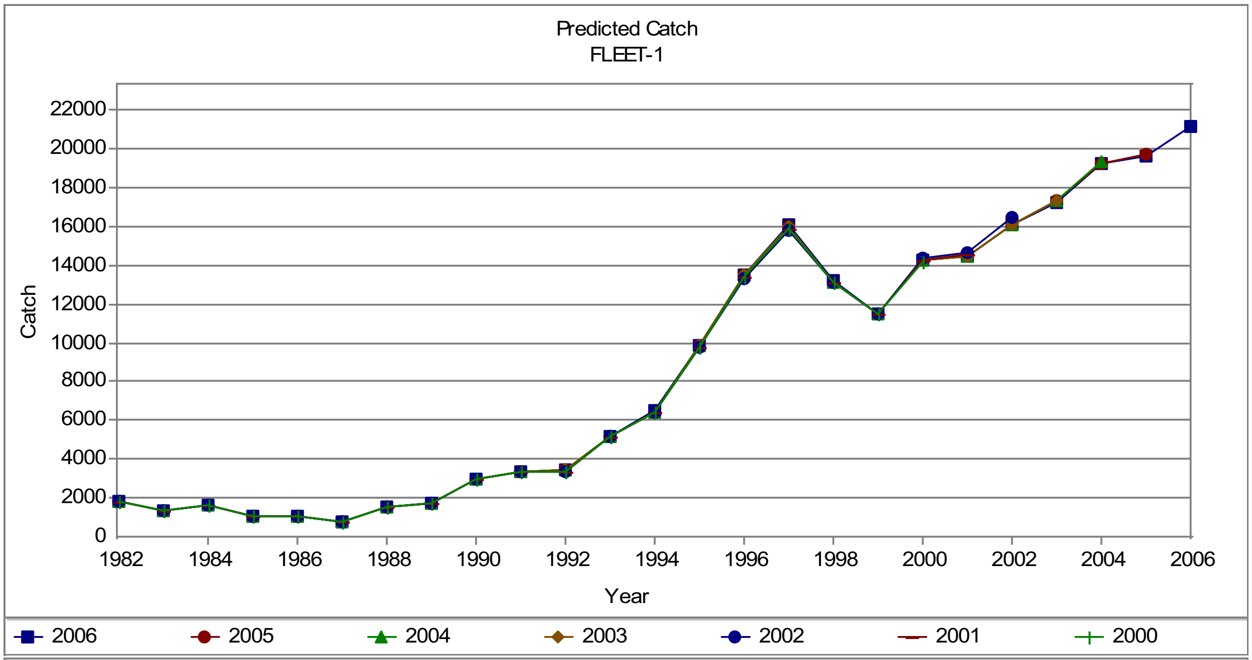




Figure 3 continued.



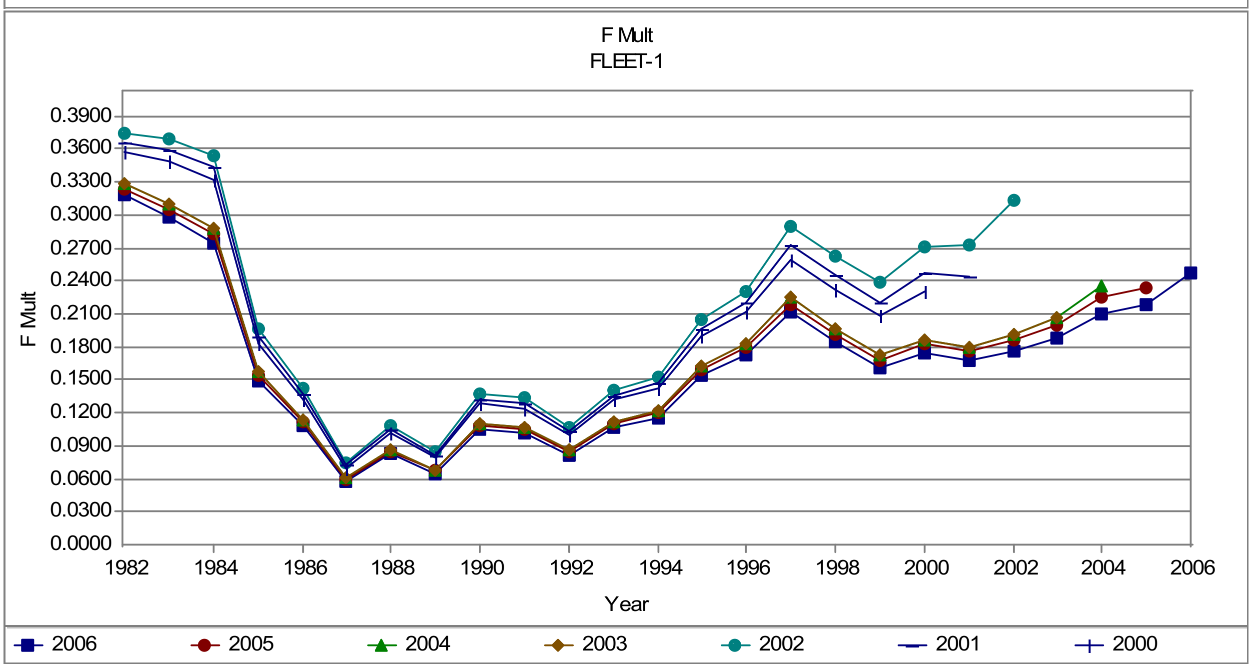




Figure 4. Retrospective patterns of catch and F estimates from ASAP model.

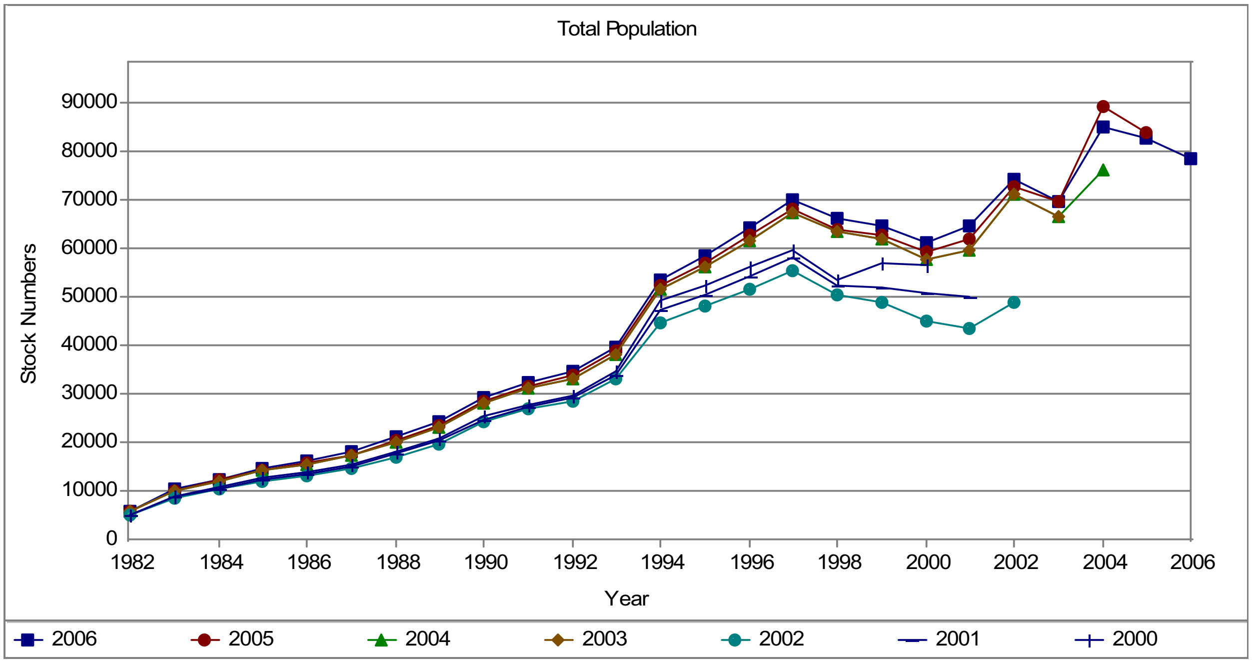



Figure 5. Retrospective patterns of total abundance from ASAP model.

## 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

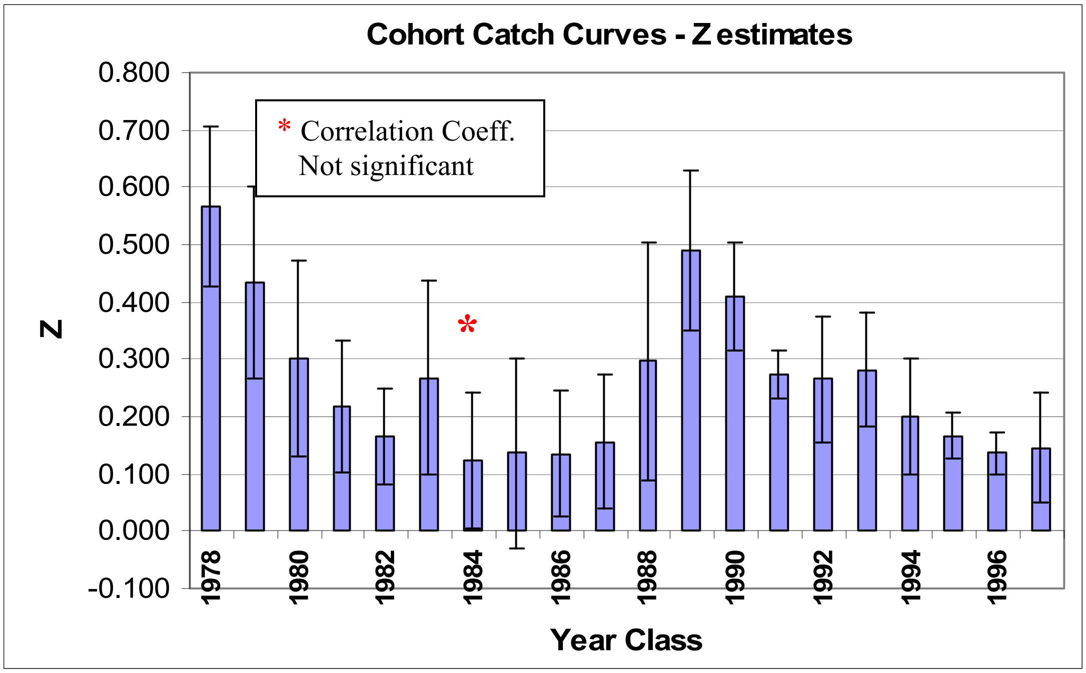



**Figure 1.** Catch Curve Z estimates (95% confidence intervals) - Parametric analysis

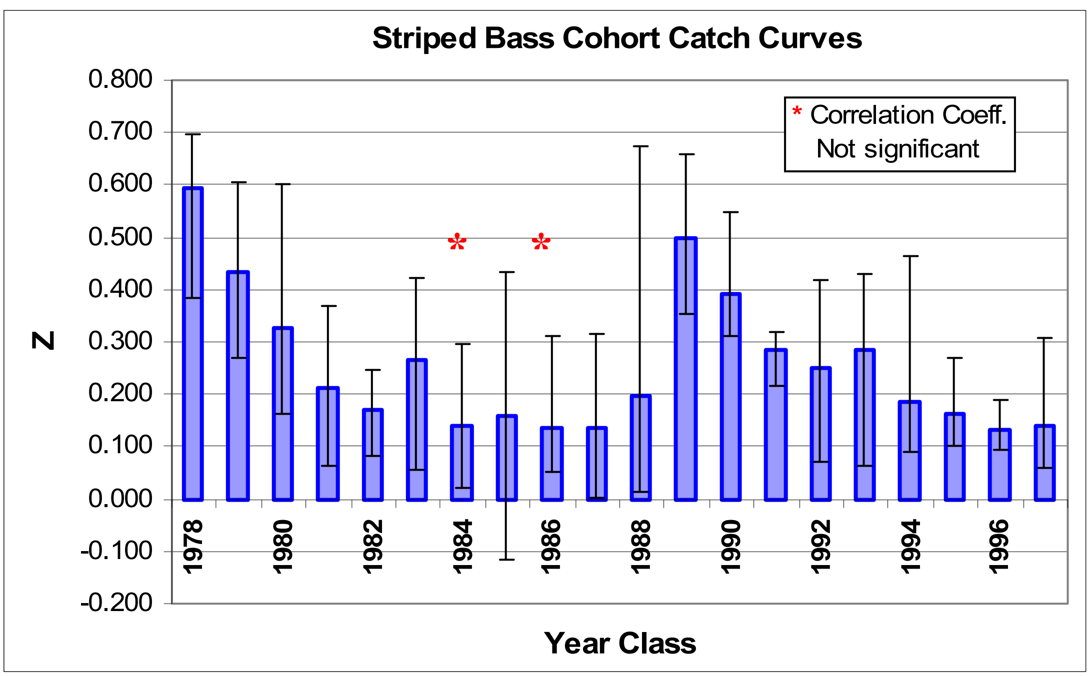



**Figure 2.** Catch Curve Z estimates (95% confidence intervals) – Nonparametric estimates

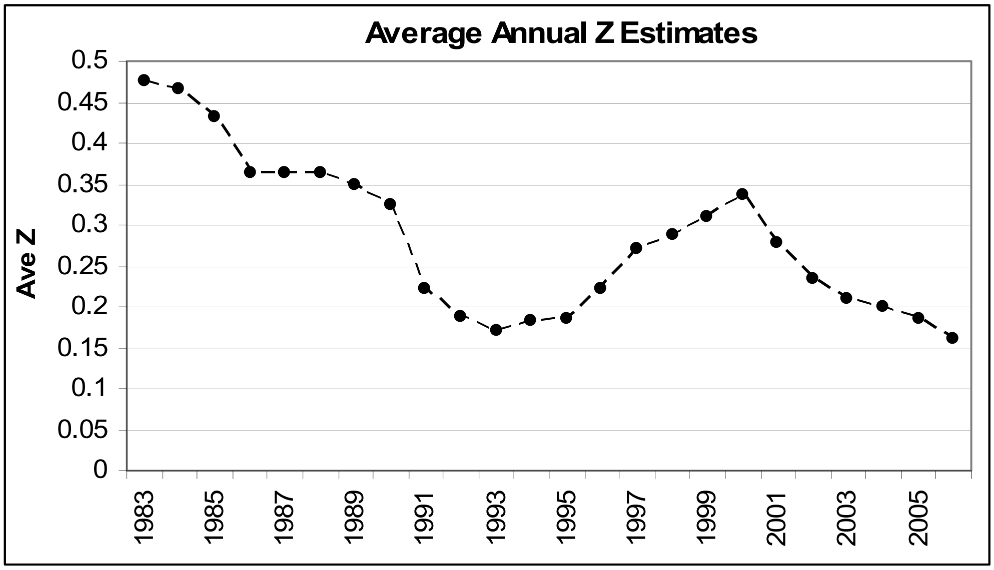



**Figure 3.** Average total mortality of striped bass by year using cohort specific catch curve estimates.

**Appendix A12: Estimating Fishing Mortality (F) on Ages 8+ Striped Bass Based on Landings and Survey Indices from 1982 to 2006**

Victor Crecco
Connecticut Marine Fisheries Division
333 Ferry Rd..
Old Lyme CT 06371

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

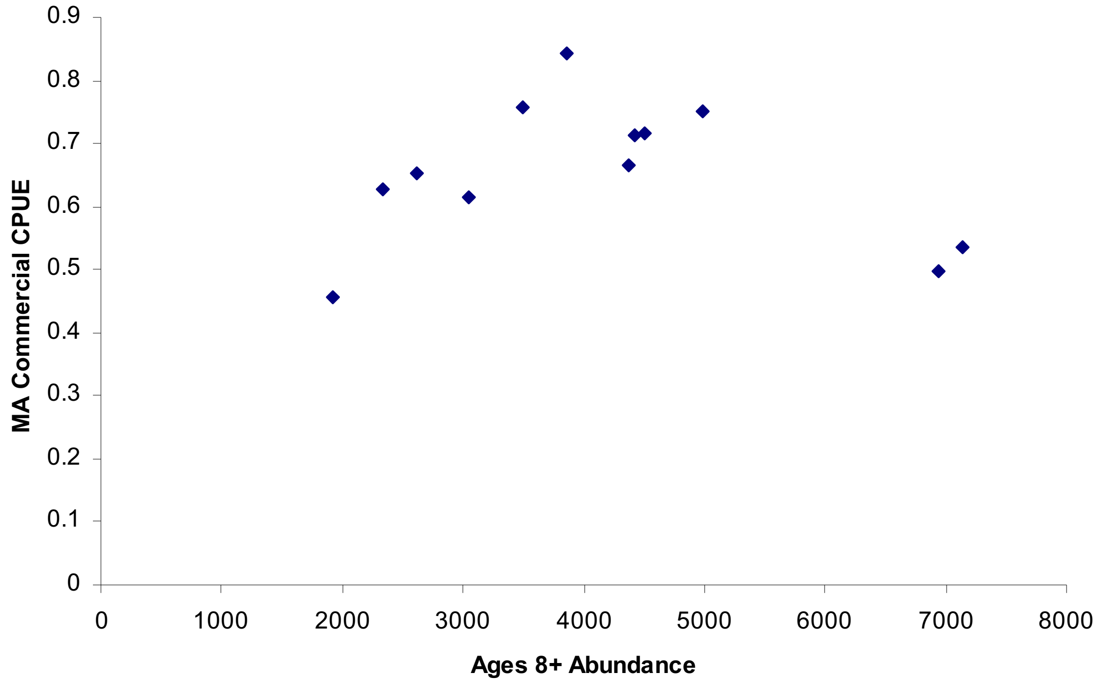



Figure 1. MA Commercial CPUE (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

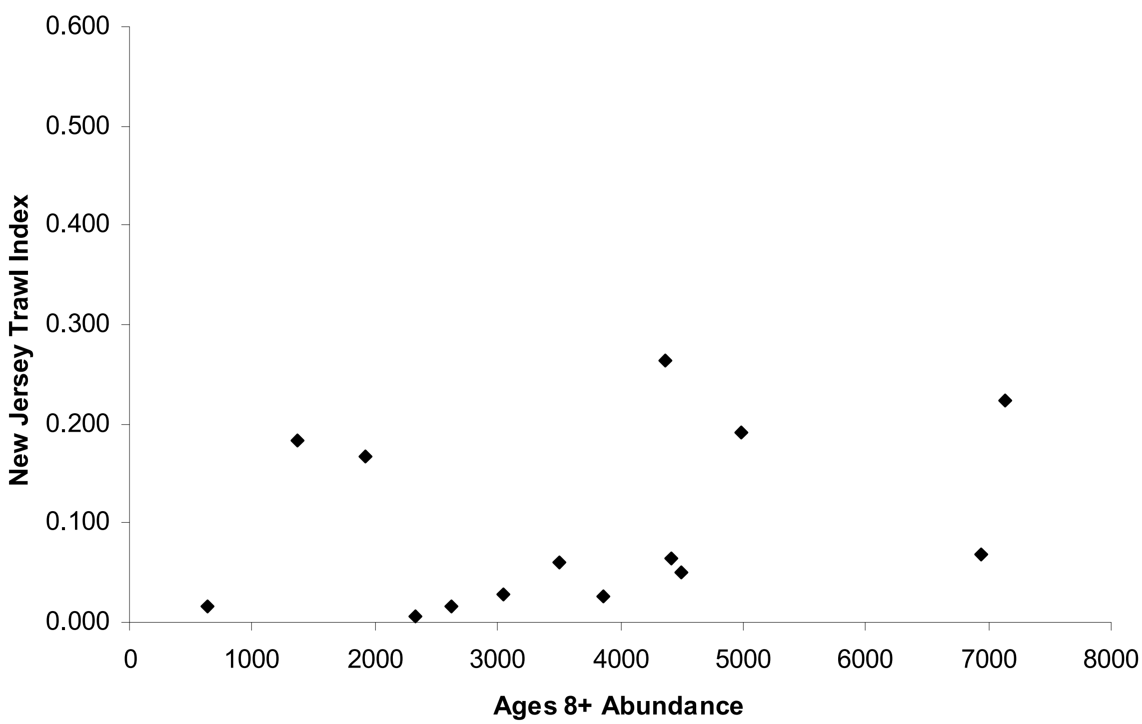



Figure 2. New Jersey Trawl Index (Ages 8+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

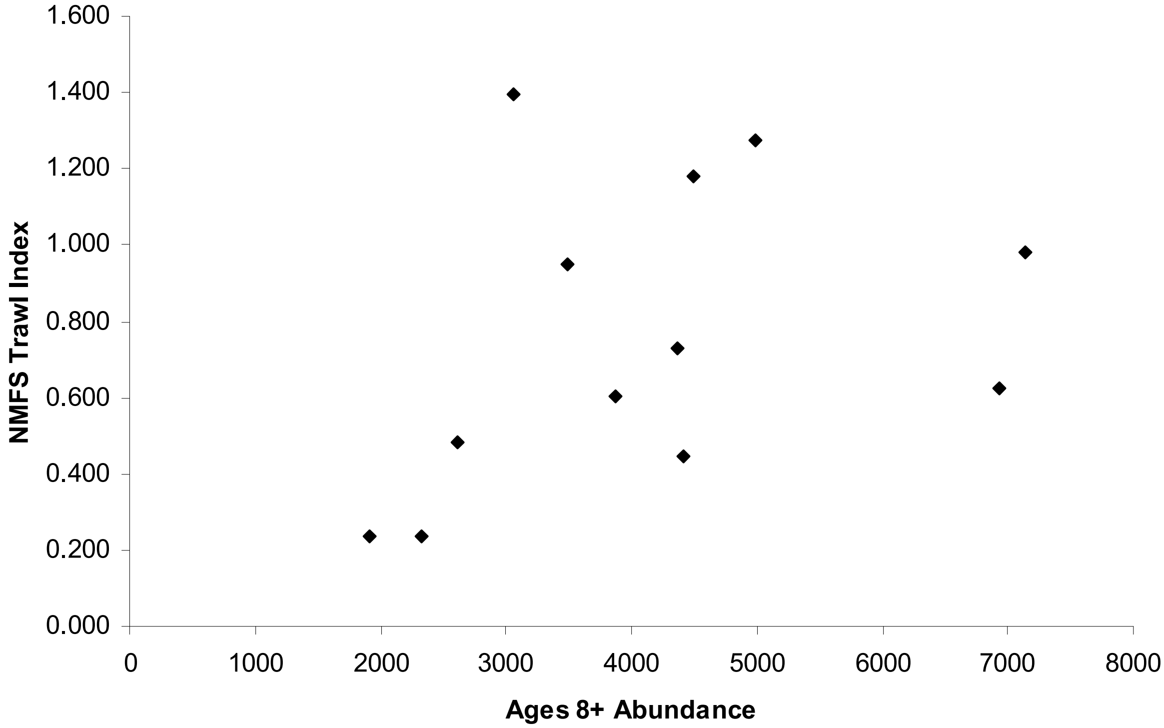



Figure 3. Delaware Spawning Stock Index (Ages 8+) plotted against ages 8+ abundance based on SCAM model, 1982-2002.

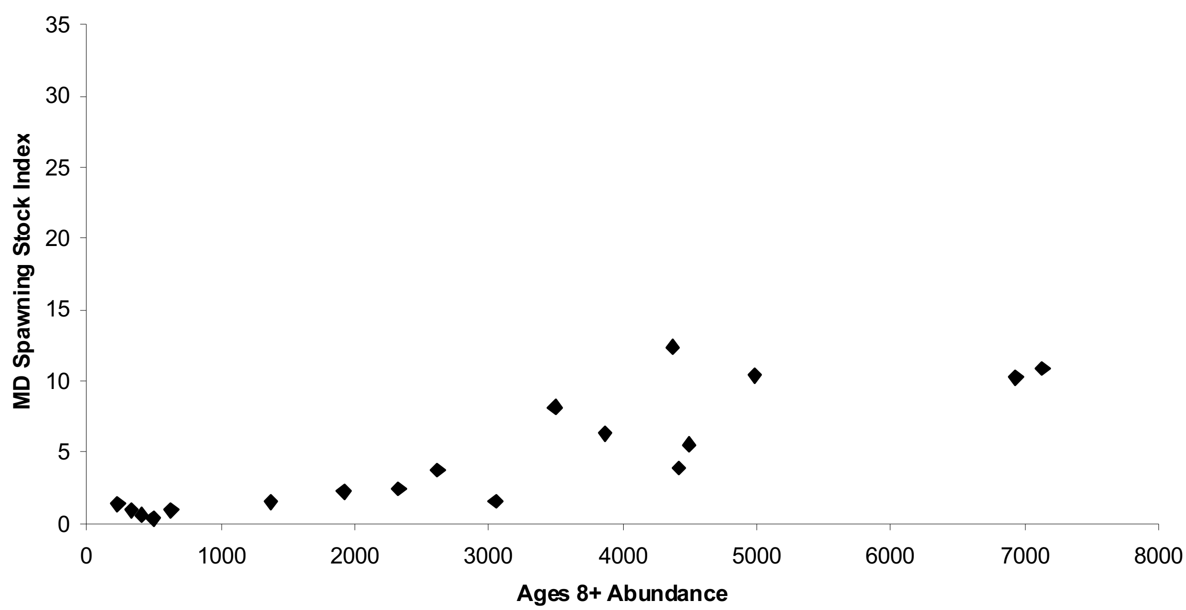



Figure 4. NMFS Trawl Index (Ages 2+) plotted against age 8+ abundance based on SCAM model, 1982-2002.

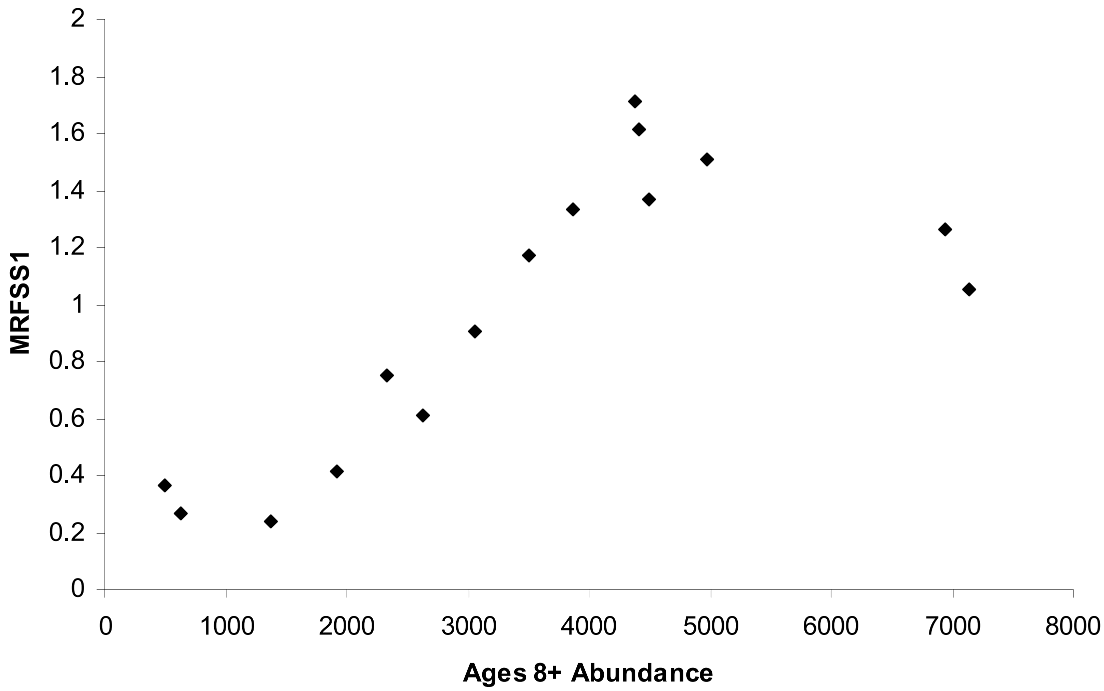



Figure 5. Maryland Spawning Stock Index (Ages 8+) plotted against age 8+ abundance based on SCAM model1982-2002

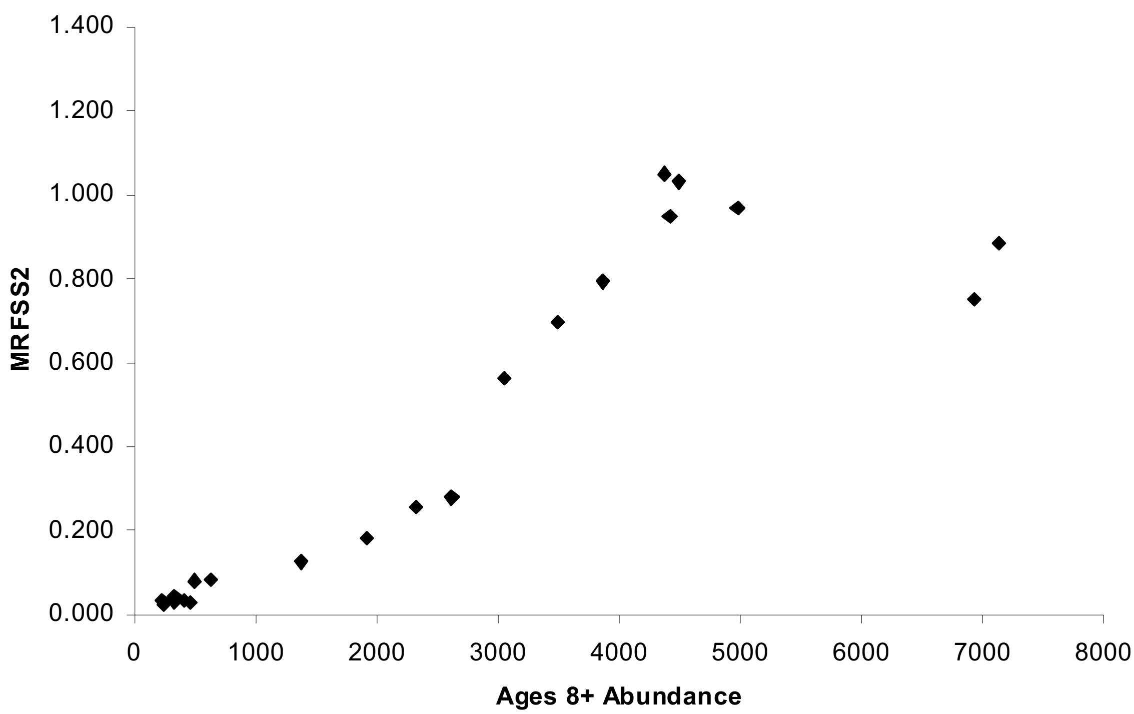



Figure 6.Sport1 CPUE Index based (ages 2+) on private boat intercepts plotted against ages 8+ abundance based on SCAM model, 1982-2002

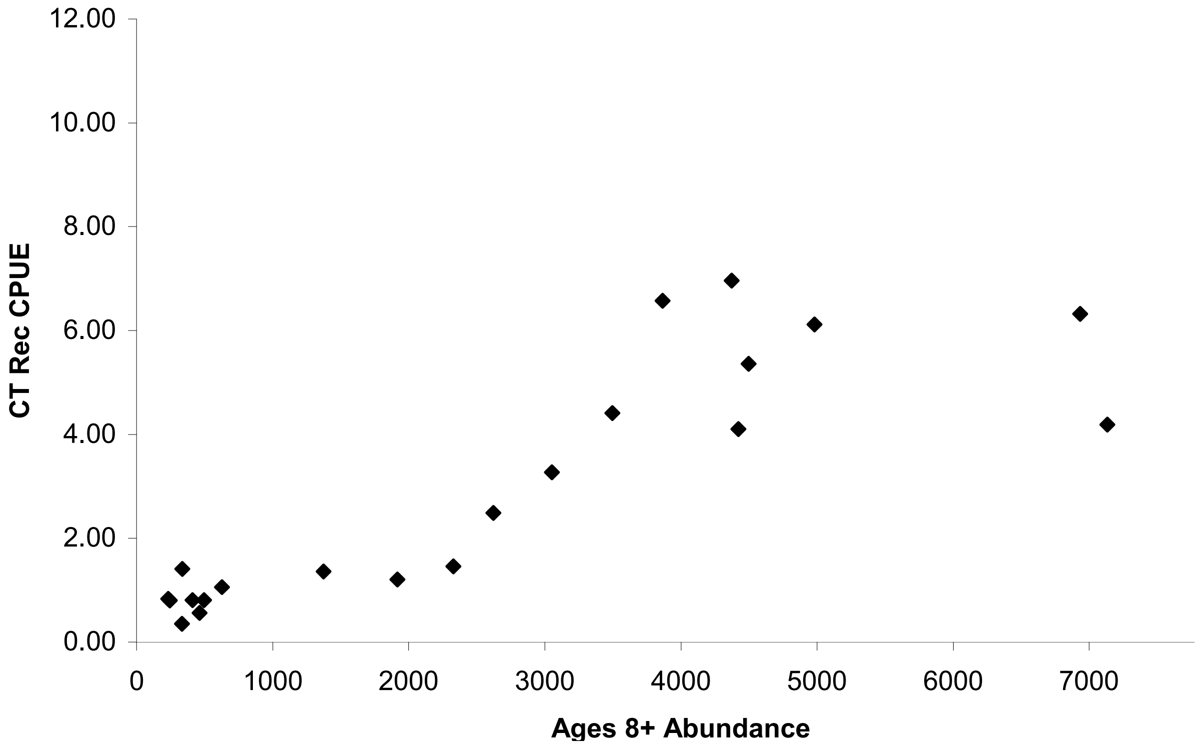



Figure 7. Sport2 CPUE Index based (ages 2+) on private boat data from north and mid-Atlantic combined plotted against ages 8+ abundance based on SCAM model, 1982-2002

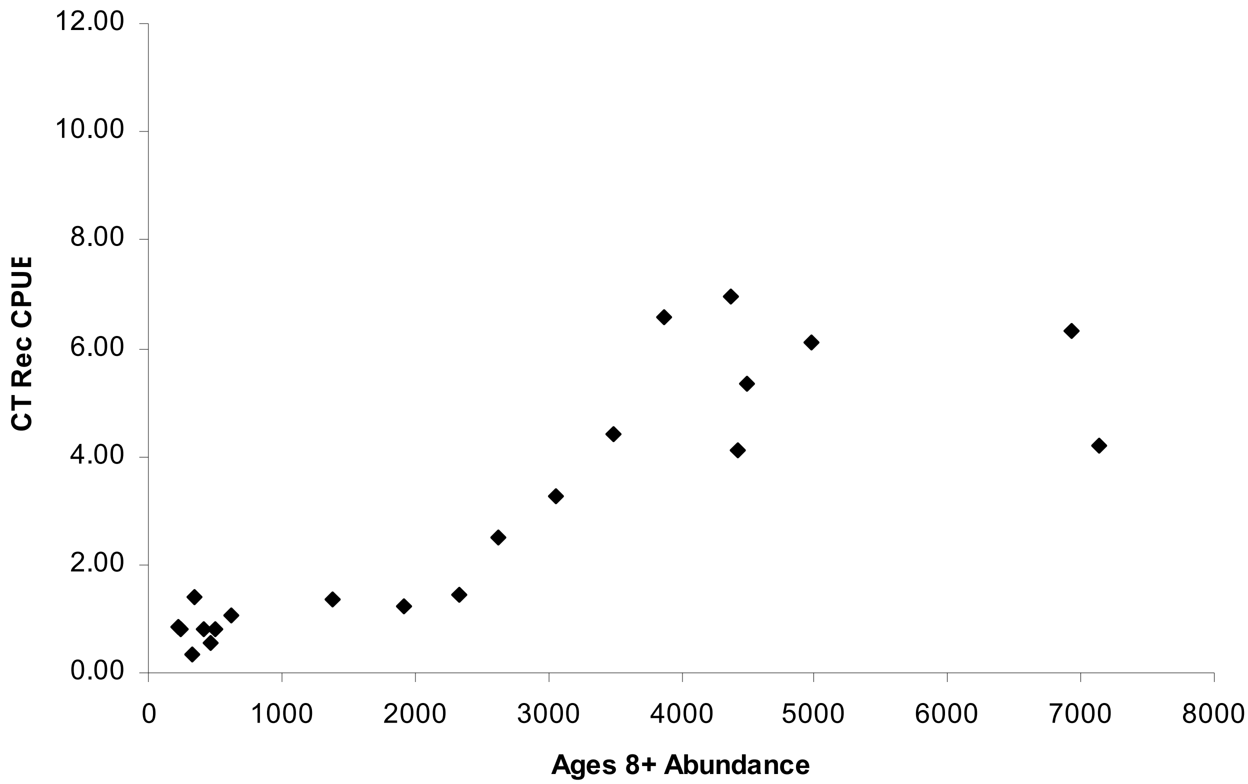



Figure 8. Connecticut Recreational CPUE (ages 3+) based on volunteer angler survey plotted against ages 8+ abundance based on SCAM model, 1982-2002

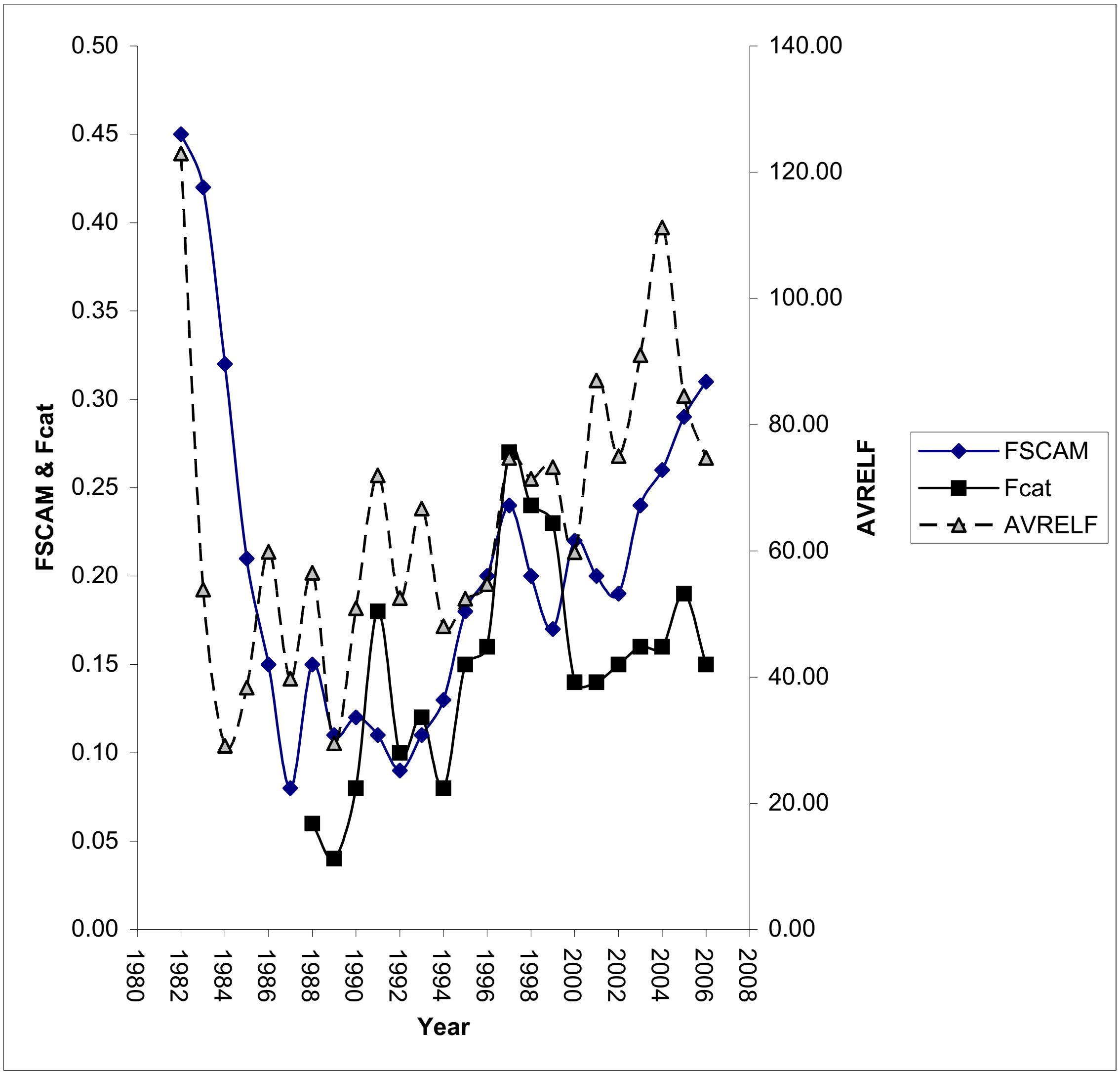



Figure 9. Comparison among the blended relative F (AVRELF), F from SCAM (FSCAM) and the F from the catch equation (Fcat) from 1982 to 2006

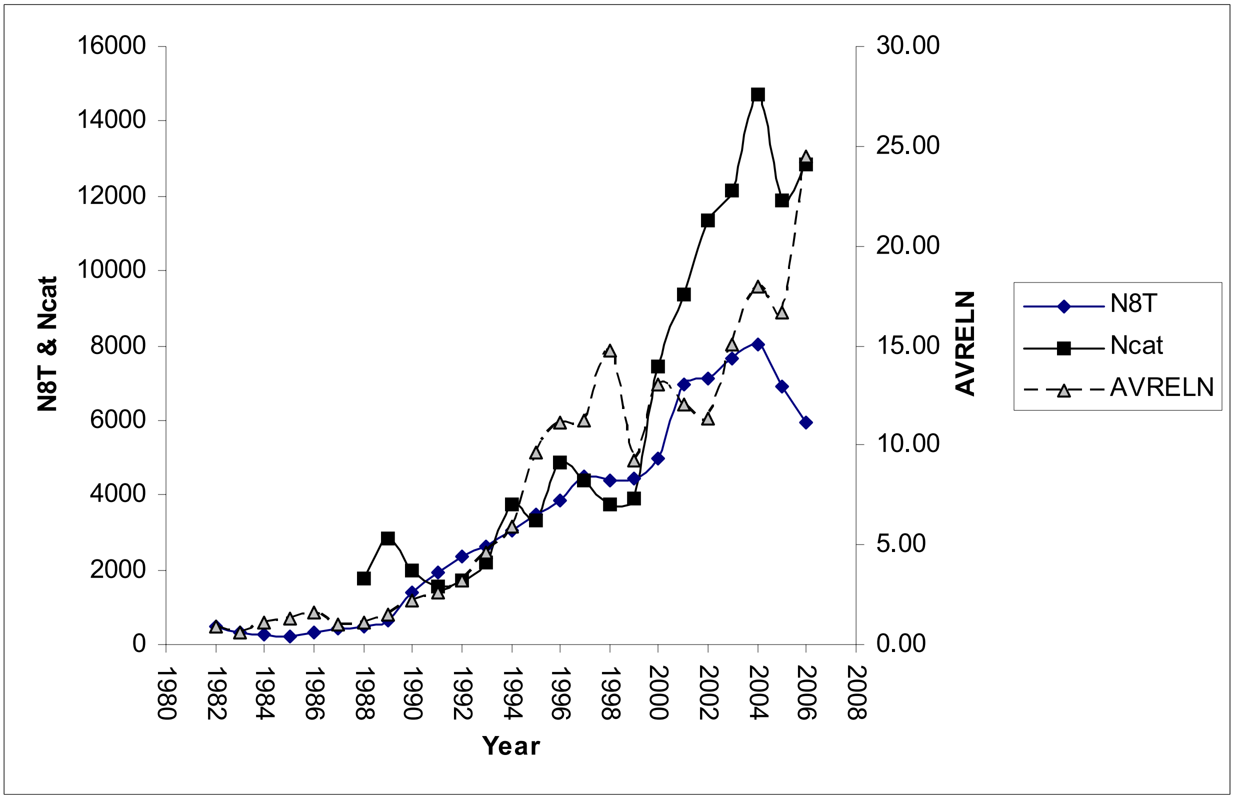



Figure 10. Comparison among the blended relative stock size (AVRELN), stock size from SCAM (N8T) and stock size from the catch equation (Ncat) from 1982-2006.

# 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 | Release | Recaptures | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 38 | 1989 | 4 | 3 | 7 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 1990 | | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 1991 | | | 4 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 84 | 1992 | | | | 9 | 7 | 5 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 1993 | | | | | 8 | 4 | 5 | 2 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 308 | 1994 | | | | | | 32 | 24 | 17 | 16 | 11 | 4 | 3 | 2 | 1 | 2 | 0 | 0 | 0 |
| 552 | 1995 | | | | | | | 56 | 51 | 32 | 27 | 14 | 5 | 6 | 3 | 4 | 3 | 1 | 2 |
| 600 | 1996 | | | | | | | | 88 | 35 | 45 | 14 | 10 | 6 | 4 | 5 | 6 | 2 | 0 |
| 96 | 1997 | | | | | | | | | 15 | 2 | 2 | 2 | 1 | 4 | 0 | 0 | 0 | 0 |
| 128 | 1998 | | | | | | | | | | 21 | 10 | 6 | 3 | 0 | 4 | 1 | 1 | 0 |
| 106 | 1999 | | | | | | | | | | | 13 | 8 | 6 | 5 | 2 | 1 | 3 | 1 |
| 233 | 2000 | | | | | | | | | | | | 22 | 18 | 12 | 12 | 7 | 5 | 0 |
| 522 | 2001 | | | | | | | | | | | | | 53 | 38 | 24 | 15 | 8 | 4 |
| 359 | 2002 | | | | | | | | | | | | | | 28 | 21 | 14 | 11 | 2 |
| 564 | 2003 | | | | | | | | | | | | | | | 58 | 27 | 26 | 9 |
| 847 | 2004 | | | | | | | | | | | | | | | | 100 | 49 | 21 |
| 180 | 2005 | | | | | | | | | | | | | | | | | 23 | 9 |
| 225 | 2006 | | | | | | | | | | | | | | | | | | 24 |

Table 1 continued.

North Carolina – Cooperative Trawl Cruise

| Number of releases | Release year | Recaptures | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 191 | 1988 | 18 | 11 | 9 | 3 | 10 | 4 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 411 | 1989 | | 24 | 20 | 18 | 14 | 7 | 3 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 322 | 1990 | | | 25 | 19 | 16 | 8 | 3 | 2 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 856 | 1991 | | | | 74 | 39 | 48 | 34 | 18 | 7 | 12 | 8 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 433 | 1992 | | | | | 46 | 29 | 14 | 14 | 8 | 8 | 10 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 142 | 1993 | | | | | | 17 | 5 | 5 | 3 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 480 | 1994 | | | | | | | 41 | 25 | 9 | 10 | 6 | 6 | 1 | 3 | 1 | 2 | 2 | 0 | 0 |
| 372 | 1995 | | | | | | | | 43 | 16 | 17 | 14 | 5 | 3 | 2 | 5 | 1 | 1 | 2 | 0 |
| 557 | 1996 | | | | | | | | | 35 | 20 | 15 | 6 | 5 | 4 | 4 | 0 | 3 | 1 | 1 |
| 869 | 1997 | | | | | | | | | | 88 | 44 | 25 | 14 | 13 | 0 | 3 | 4 | 1 | 0 |
| 106 | 1998 | | | | | | | | | | | 12 | 11 | 0 | 2 | 1 | 1 | 0 | 0 | 1 |
| 179 | 1999 | | | | | | | | | | | | 21 | 8 | 5 | 2 | 0 | 3 | 2 | 1 |
| 164 | 2000 | | | | | | | | | | | | | 9 | 6 | 2 | 3 | 3 | 2 | 1 |
| 515 | 2001 | | | | | | | | | | | | | | 46 | 23 | 15 | 5 | 11 | 9 |
| 789 | 2002 | | | | | | | | | | | | | | | 51 | 43 | 22 | 18 | 10 |
| 1578 | 2003 | | | | | | | | | | | | | | | | 107 | 65 | 38 | 25 |
| 784 | 2004 | | | | | | | | | | | | | | | | | 58 | 26 | 26 |
| 557 | 2005 | | | | | | | | | | | | | | | | | | 25 | 21 |
| 2113 | 2006 | | | | | | | | | | | | | | | | | | | 153 |

Table 2. Program MARK input matrices for the producer area tagging programs, for fish ≥ 28”.

New York – Hudson River

| Number of releases | Release year | Recaptures 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 277 | 1988 | 25 | 31 | 18 | 11 | 10 | 5 | 4 | 1 | 4 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 387 | 1989 | | 42 | 29 | 17 | 9 | 6 | 9 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 297 | 1990 | | | 42 | 22 | 16 | 12 | 7 | 2 | 1 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 364 | 1991 | | | | 38 | 31 | 13 | 10 | 9 | 5 | 5 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 702 | 1992 | | | | | 90 | 58 | 34 | 22 | 14 | 13 | 10 | 5 | 2 | 1 | 0 | 0 | 1 | 0 | 0 |
| 539 | 1993 | | | | | | 77 | 36 | 23 | 21 | 15 | 7 | 8 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 383 | 1994 | | | | | | | 43 | 34 | 27 | 10 | 6 | 6 | 5 | 4 | 2 | 0 | 2 | 1 | 0 |
| 462 | 1995 | | | | | | | | 52 | 34 | 30 | 21 | 11 | 4 | 1 | 2 | 1 | 1 | 1 | 0 |
| 684 | 1996 | | | | | | | | | 92 | 68 | 33 | 18 | 3 | 9 | 4 | 2 | 4 | 3 | 1 |
| 184 | 1997 | | | | | | | | | | 29 | 11 | 12 | 6 | 3 | 2 | 2 | 0 | 1 | 1 |
| 530 | 1998 | | | | | | | | | | | 67 | 45 | 18 | 9 | 20 | 6 | 0 | 1 | 2 |
| 503 | 1999 | | | | | | | | | | | | 65 | 22 | 27 | 12 | 14 | 7 | 3 | 4 |
| 486 | 2000 | | | | | | | | | | | | | 45 | 25 | 23 | 18 | 13 | 6 | 3 |
| 577 | 2001 | | | | | | | | | | | | | | 49 | 39 | 14 | 6 | 6 | 10 |
| 196 | 2002 | | | | | | | | | | | | | | | 20 | 11 | 9 | 4 | 7 |
| 677 | 2003 | | | | | | | | | | | | | | | | 63 | 44 | 35 | 17 |
| 648 | 2004 | | | | | | | | | | | | | | | | | 76 | 34 | 34 |
| 576 | 2005 | | | | | | | | | | | | | | | | | | 59 | 44 |
| 707 | 2006 | | | | | | | | | | | | | | | | | | | 61 |

Table 2 continued.

Delaware/Pennsylvania – Delaware River

| Number of | 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 releases | Release year | Recaptures 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | 1987 | 1 | 0 | 2 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 129 | 1988 | | 6 | 8 | 7 | 14 | 6 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 220 | 1989 | | | 9 | 17 | 17 | 6 | 4 | 3 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 305 | 1990 | | | | 23 | 16 | 12 | 5 | 2 | 4 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 396 | 1991 | | | | | 47 | 24 | 20 | 5 | 9 | 3 | 5 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 436 | 1992 | | | | | | 45 | 30 | 19 | 17 | 7 | 10 | 6 | 5 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 629 | 1993 | | | | | | | 58 | 44 | 42 | 15 | 16 | 8 | 9 | 1 | 3 | 2 | 0 | 0 | 0 | 0 |
| 548 | 1994 | | | | | | | | 52 | 43 | 26 | 16 | 15 | 10 | 4 | 3 | 0 | 1 | 1 | 1 | 0 |
| 528 | 1995 | | | | | | | | | 61 | 32 | 24 | 16 | 7 | 6 | 2 | 2 | 3 | 0 | 0 | 2 |
| 862 | 1996 | | | | | | | | | | 92 | 54 | 44 | 18 | 9 | 7 | 2 | 1 | 1 | 0 | 0 |
| 336 | 1997 | | | | | | | | | | | 41 | 26 | 18 | 2 | 2 | 1 | 1 | 0 | 1 | 0 |
| 264 | 1998 | | | | | | | | | | | | 26 | 16 | 3 | 5 | 2 | 0 | 0 | 0 | 0 |
| 117 | 1999 | | | | | | | | | | | | | 19 | 8 | 8 | 3 | 1 | 2 | 1 | 0 |
| 248 | 2000 | | | | | | | | | | | | | | 21 | 16 | 4 | 5 | 4 | 1 | 0 |
| 469 | 2001 | | | | | | | | | | | | | | | 31 | 19 | 11 | 6 | 3 | 3 |
| 324 | 2002 | | | | | | | | | | | | | | | | 18 | 20 | 6 | 7 | 2 |
| 325 | 2003 | | | | | | | | | | | | | | | | | 22 | 11 | 9 | 7 |
| 367 | 2004 | | | | | | | | | | | | | | | | | | 17 | 9 | 11 |
| 334 | 2005 | | | | | | | | | | | | | | | | | | | 20 | 14 |
| 277 | 2006 | | | | | | | | | | | | | | | | | | | | 16 |

Table 2 continued.

Virginia – Rappahannock River

| Number of releases | Release year | Recaptures 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 301 | 1990 | 26 | 9 | 15 | 2 | 4 | 6 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 390 | 1991 | | 41 | 24 | 16 | 11 | 3 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 40 | 1992 | | | 4 | 3 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 212 | 1993 | | | | 22 | 18 | 7 | 4 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 123 | 1994 | | | | | 9 | 7 | 5 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 210 | 1995 | | | | | | 29 | 11 | 8 | 3 | 3 | 2 | 3 | 0 | 1 | 0 | 1 | 0 |
| 67 | 1996 | | | | | | | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 212 | 1997 | | | | | | | | 15 | 13 | 8 | 3 | 0 | 1 | 2 | 1 | 0 | 0 |
| 158 | 1998 | | | | | | | | | 24 | 13 | 2 | 3 | 2 | 0 | 0 | 0 | 0 |
| 162 | 1999 | | | | | | | | | | 17 | 6 | 2 | 3 | 2 | 0 | 0 | 0 |
| 365 | 2000 | | | | | | | | | | | 28 | 19 | 14 | 9 | 4 | 3 | 0 |
| 269 | 2001 | | | | | | | | | | | | 19 | 14 | 4 | 6 | 2 | 1 |
| 122 | 2002 | | | | | | | | | | | | | 10 | 6 | 7 | 1 | 0 |
| 400 | 2003 | | | | | | | | | | | | | | 35 | 24 | 7 | 1 |
| 686 | 2004 | | | | | | | | | | | | | | | 39 | 12 | 13 |
| 284 | 2005 | | | | | | | | | | | | | | | | 16 | 11 |
| 175 | 2006 | | | | | | | | | | | | | | | | | 12 |

Table 3. Instantaneous Rates – Catch and Release Model input matrices for the coastal tagging programs, for fish ≥ 28”. The first matrix contains all harvested recaptures and the second matrix contains released fish with their tag removed.

Massachusetts

| Number of | Release | Harvested Recaptures | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 327 | 1992 | 6 | 10 | 7 | 11 | 8 | 4 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 610 | 1993 | | 17 | 18 | 15 | 25 | 16 | 14 | 9 | 1 | 2 | 2 | 2 | 1 | 0 | 0 |
| 461 | 1994 | | | 8 | 23 | 23 | 15 | 13 | 7 | 2 | 0 | 2 | 2 | 0 | 1 | 0 |
| 218 | 1995 | | | | 4 | 8 | 9 | 3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 273 | 1996 | | | | | 10 | 10 | 11 | 9 | 7 | 0 | 3 | 1 | 1 | 1 | 0 |
| 118 | 1997 | | | | | | 8 | 4 | 2 | 3 | 1 | 1 | 0 | 1 | 0 | 1 |
| 217 | 1998 | | | | | | | 9 | 11 | 6 | 6 | 2 | 3 | 1 | 0 | 0 |
| 59 | 1999 | | | | | | | | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| 162 | 2000 | | | | | | | | | 9 | 4 | 4 | 3 | 3 | 0 | 1 |
| 408 | 2001 | | | | | | | | | | 15 | 18 | 10 | 7 | 10 | 3 |
| 350 | 2002 | | | | | | | | | | | 11 | 11 | 11 | 5 | 5 |
| 171 | 2003 | | | | | | | | | | | | 8 | 2 | 5 | 4 |
| 615 | 2004 | | | | | | | | | | | | | 25 | 17 | 9 |
| 540 | 2005 | | | | | | | | | | | | | | 16 | 20 |
| 509 | 2006 | | | | | | | | | | | | | | | 20 |

| Number of | Release | Released with Tag Removed | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 327 | 1992 | 14 | 11 | 5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 610 | 1993 | | 18 | 13 | 11 | 4 | 1 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 461 | 1994 | | | 12 | 5 | 4 | 4 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 218 | 1995 | | | | 11 | 4 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 273 | 1996 | | | | | 12 | 4 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 118 | 1997 | | | | | | 9 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 217 | 1998 | | | | | | | 6 | 5 | 3 | 2 | 0 | 0 | 0 | 1 | 0 |
| 59 | 1999 | | | | | | | | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 162 | 2000 | | | | | | | | | 1 | 2 | 2 | 0 | 1 | 0 | 0 |
| 408 | 2001 | | | | | | | | | | 6 | 4 | 5 | 1 | 2 | 0 |
| 350 | 2002 | | | | | | | | | | | 11 | 2 | 2 | 2 | 3 |
| 171 | 2003 | | | | | | | | | | | | 0 | 1 | 1 | 2 |
| 615 | 2004 | | | | | | | | | | | | | 6 | 7 | 4 |
| 540 | 2005 | | | | | | | | | | | | | | 7 | 4 |
| 509 | 2006 | | | | | | | | | | | | | | | 10 |

Table 3 continued – New York – Ocean Haul Seine

| Number of 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 | Release | Harvested Recaptures | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 191 | 1988 | 4 | 3 | 4 | 0 | 6 | 3 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 411 | 1989 | | 6 | 7 | 7 | 11 | 4 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 322 | 1990 | | | 11 | 6 | 11 | 5 | 1 | 2 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 856 | 1991 | | | | 23 | 19 | 23 | 20 | 16 | 5 | 11 | 7 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 433 | 1992 | | | | | 22 | 11 | 7 | 10 | 7 | 6 | 7 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 142 | 1993 | | | | | | 6 | 3 | 5 | 3 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 480 | 1994 | | | | | | | 14 | 16 | 7 | 6 | 5 | 6 | 1 | 3 | 1 | 2 | 2 | 0 | 0 |
| 372 | 1995 | | | | | | | | 21 | 13 | 16 | 11 | 5 | 2 | 2 | 5 | 1 | 1 | 2 | 0 |
| 557 | 1996 | | | | | | | | | 26 | 17 | 12 | 3 | 3 | 3 | 4 | 0 | 3 | 1 | 1 |
| 869 | 1997 | | | | | | | | | | 67 | 31 | 16 | 9 | 11 | 0 | 3 | 3 | 1 | 0 |
| 106 | 1998 | | | | | | | | | | | 9 | 7 | 0 | 2 | 1 | 1 | 0 | 0 | 0 |
| 179 | 1999 | | | | | | | | | | | | 18 | 5 | 5 | 2 | 0 | 2 | 2 | 1 |
| 164 | 2000 | | | | | | | | | | | | | 4 | 6 | 1 | 2 | 3 | 2 | 1 |
| 515 | 2001 | | | | | | | | | | | | | | 32 | 18 | 11 | 3 | 9 | 6 |
| 789 | 2002 | | | | | | | | | | | | | | | 39 | 31 | 20 | 13 | 7 |
| 1578 | 2003 | | | | | | | | | | | | | | | | 75 | 53 | 29 | 16 |
| 784 | 2004 | | | | | | | | | | | | | | | | | 40 | 18 | 15 |
| 557 | 2005 | | | | | | | | | | | | | | | | | | 17 | 16 |
| 2113 | 2006 | | | | | | | | | | | | | | | | | | | 107 |

| Number of | Release | Released with Tag Removed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 191 | 1988 | 13 | 8 | 5 | 2 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 411 | 1989 | | 17 | 13 | 11 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 322 | 1990 | | | 14 | 11 | 5 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 856 | 1991 | | | | 45 | 18 | 23 | 14 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 433 | 1992 | | | | | 23 | 17 | 7 | 4 | 1 | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 142 | 1993 | | | | | | 8 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 480 | 1994 | | | | | | | 26 | 8 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 372 | 1995 | | | | | | | | 22 | 2 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 557 | 1996 | | | | | | | | | 8 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 869 | 1997 | | | | | | | | | | 18 | 13 | 9 | 5 | 1 | 0 | 0 | 1 | 0 | 0 |
| 106 | 1998 | | | | | | | | | | | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 179 | 1999 | | | | | | | | | | | | 3 | 3 | 0 | 0 | 0 | 1 | 0 | 0 |
| 164 | 2000 | | | | | | | | | | | | | 4 | 0 | 1 | 1 | 0 | 0 | 0 |
| 515 | 2001 | | | | | | | | | | | | | | 11 | 3 | 4 | 1 | 2 | 2 |
| 789 | 2002 | | | | | | | | | | | | | | | 12 | 11 | 1 | 5 | 3 |
| 1578 | 2003 | | | | | | | | | | | | | | | | 27 | 12 | 8 | 9 |
| 784 | 2004 | | | | | | | | | | | | | | | | | 17 | 8 | 10 |
| 557 | 2005 | | | | | | | | | | | | | | | | | | 8 | 5 |
| 2113 | 2006 | | | | | | | | | | | | | | | | | | | 44 |

Table 4. Instantaneous Rates – Catch and Release Model input matrices for the producer area tagging programs, for fish $\geq$ 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 releases | Release year | Harvested Recaptures 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 releases | Release year | Released with Tag Removed 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 releases | Release year | Harvested Recaptures 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 releases | Release year | Released with Tag Removed 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 297 | 1990 | 15 | 6 | 7 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 386 | 1991 | | 20 | 10 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 1992 | | | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 209 | 1993 | | | | 10 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 123 | 1994 | | | | | 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 205 | 1995 | | | | | | 5 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 67 | 1996 | | | | | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 210 | 1997 | | | | | | | | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 156 | 1998 | | | | | | | | | 6 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 159 | 1999 | | | | | | | | | | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 362 | 2000 | | | | | | | | | | | 9 | 6 | 4 | 2 | 0 | 0 | 0 |
| 268 | 2001 | | | | | | | | | | | | 7 | 4 | 2 | 0 | 0 | 0 |
| 122 | 2002 | | | | | | | | | | | | | 2 | 2 | 0 | 0 | 0 |
| 392 | 2003 | | | | | | | | | | | | | | 8 | 6 | 2 | 0 |
| 680 | 2004 | | | | | | | | | | | | | | | 11 | 2 | 5 |
| 281 | 2005 | | | | | | | | | | | | | | | | 3 | 4 |
| 175 | 2006 | | | | | | | | | | | | | | | | | 2 |

Table 5. Program MARK input matrices for the Chesapeake Bay specific tagging programs, for male fish 18 - 28".

Virginia

| Number of releases | Release year | Recaptures 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 189 | 1990 | 20 | 7 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 107 | 1991 | | 18 | 6 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 166 | 1993 | | | | 12 | 8 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 1994 | | | | | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 361 | 1995 | | | | | | 37 | 10 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 258 | 1996 | | | | | | | 20 | 12 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 458 | 1997 | | | | | | | | 27 | 9 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 601 | 1998 | | | | | | | | | 26 | 12 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 666 | 1999 | | | | | | | | | | 48 | 15 | 6 | 2 | 1 | 0 | 0 | 0 |
| 1352 | 2000 | | | | | | | | | | | 113 | 30 | 7 | 7 | 1 | 1 | 0 |
| 496 | 2001 | | | | | | | | | | | | 50 | 8 | 9 | 0 | 0 | 1 |
| 189 | 2002 | | | | | | | | | | | | | 12 | 2 | 7 | 0 | 1 |
| 443 | 2003 | | | | | | | | | | | | | | 24 | 11 | 2 | 2 |
| 757 | 2004 | | | | | | | | | | | | | | | 38 | 6 | 0 |
| 597 | 2005 | | | | | | | | | | | | | | | | 26 | 15 |
| 461 | 2006 | | | | | | | | | | | | | | | | | 33 |

Table 5 continued.

Maryland

| Number of releases | Release year | Recaptures 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1314 | 1987 | 90 | 40 | 19 | 37 | 36 | 42 | 25 | 8 | 7 | 4 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1834 | 1988 | | 74 | 45 | 60 | 53 | 56 | 34 | 15 | 15 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0; | 0 | 0 |
| 1876 | 1989 | | | 58 | 91 | 77 | 82 | 38 | 30 | 16 | 9 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 848 | 1990 | | | | 53 | 44 | 42 | 17 | 13 | 4 | 5 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 991 | 1991 | | | | | 60 | 69 | 43 | 21 | 14 | 5 | 5 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1120 | 1992 | | | | | | 118 | 59 | 38 | 22 | 9 | 5 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1468 | 1993 | | | | | | | 98 | 92 | 51 | 31 | 20 | 13 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1215 | 1994 | | | | | | | | 106 | 87 | 35 | 20 | 19 | 10 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 773 | 1995 | | | | | | | | | 94 | 46 | 19 | 10 | 6 | 2 | 3 | 0 | 1 | 0 | 0 | 0 |
| 724 | 1996 | | | | | | | | | | 86 | 39 | 29 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 |
| 500 | 1997 | | | | | | | | | | | 61 | 29 | 7 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 673 | 1998 | | | | | | | | | | | | 85 | 23 | 13 | 4 | 2 | 1 | 1 | 0 | 0 |
| 410 | 1999 | | | | | | | | | | | | | 35 | 25 | 6 | 3 | 0 | 0 | 0 | 0 |
| 683 | 2000 | | | | | | | | | | | | | | 67 | 11 | 13 | 4 | 3 | 1 | 0 |
| 624 | 2001 | | | | | | | | | | | | | | | 54 | 13 | 10 | 4 | 1 | 0 |
| 808 | 2002 | | | | | | | | | | | | | | | | 60 | 33 | 14 | 1 | 0 |
| 457 | 2003 | | | | | | | | | | | | | | | | | 38 | 18 | 7 | 4 |
| 313 | 2004 | | | | | | | | | | | | | | | | | | 26 | 10 | 2 |
| 539 | 2005 | | | | | | | | | | | | | | | | | | | 35 | 16 |
| 286 | 2006 | | | | | | | | | | | | | | | | | | | | 26 |

Table 6. Instantaneous Rates – Catch and Release Model input matrices for the Chesapeake Bay specific tagging programs, for male fish 18-28". The first matrix contains all harvested recaptures and the second matrix contains released fish with their tag removed.

Virginia

| Number of | Release | Harvested Recaptures | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 615 | 1988 | 4 | 0 | 9 | 5 | 5 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217 | 1989 | | 0 | 3 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1990 | | | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1991 | | | | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | | | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1993 | | | | | | 2 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1994 | | | | | | | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 344 | 1995 | | | | | | | | 6 | 5 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 256 | 1996 | | | | | | | | | 2 | 6 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 452 | 1997 | | | | | | | | | | 12 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 596 | 1998 | | | | | | | | | | | 11 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 660 | 1999 | | | | | | | | | | | | 16 | 4 | 3 | 0 | 1 | 0 | 0 | 0 |
| 1326 | 2000 | | | | | | | | | | | | | 29 | 12 | 5 | 2 | 0 | 1 | 1 |
| 484 | 2001 | | | | | | | | | | | | | | 23 | 6 | 1 | 1 | 0 | 0 |
| 184 | 2002 | | | | | | | | | | | | | | | 3 | 1 | 1 | 0 | 1 |
| 438 | 2003 | | | | | | | | | | | | | | | | 9 | 7 | 2 | 2 |
| 756 | 2004 | | | | | | | | | | | | | | | | | 22 | 6 | 0 |
| 595 | 2005 | | | | | | | | | | | | | | | | | | 14 | 10 |
| 456 | 2006 | | | | | | | | | | | | | | | | | | | 15 |

| Number of | Release | Released with tag removed | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| releases | year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 615 | 1988 | 3 | 7 | 17 | 6 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217 | 1989 | | 4 | 6 | 2 | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1990 | | | 8 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1991 | | | | 10 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | | | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1993 | | | | | | 5 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1994 | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 344 | 1995 | | | | | | | | 7 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 256 | 1996 | | | | | | | | | 6 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 452 | 1997 | | | | | | | | | | 6 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 596 | 1998 | | | | | | | | | | | 13 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 660 | 1999 | | | | | | | | | | | | 15 | 5 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1326 | 2000 | | | | | | | | | | | | | 28 | 12 | 2 | 1 | 0 | 0 | 0 |
| 484 | 2001 | | | | | | | | | | | | | | 10 | 2 | 1 | 0 | 0 | 0 |
| 184 | 2002 | | | | | | | | | | | | | | | 4 | 1 | 2 | 0 | 0 |
| 438 | 2003 | | | | | | | | | | | | | | | | 3 | 2 | 0 | 1 |
| 756 | 2004 | | | | | | | | | | | | | | | | | 10 | 3 | 0 |
| 595 | 2005 | | | | | | | | | | | | | | | | | | 8 | 4 |
| 456 | 2006 | | | | | | | | | | | | | | | | | | | 13 |

Table 6 continued (Virginia)

| Number of releases | Release year | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Harvested Recaptures | | | | | | | | | | | | | | | | | | |
| 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 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Released with tag removed | | | | | | | | | | | | | | | | | | |
| 615 | 1988 | 3 | 7 | 17 | 6 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 217 | 1989 | | 4 | 6 | 2 | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1990 | | | 8 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | 1991 | | | | 10 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1992 | | | | | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1993 | | | | | | 5 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1994 | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 344 | 1995 | | | | | | | | 7 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 256 | 1996 | | | | | | | | | 6 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 452 | 1997 | | | | | | | | | | 6 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 596 | 1998 | | | | | | | | | | | 13 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 660 | 1999 | | | | | | | | | | | | 15 | 5 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1326 | 2000 | | | | | | | | | | | | | 28 | 12 | 2 | 1 | 0 | 0 | 0 |
| 484 | 2001 | | | | | | | | | | | | | | 10 | 2 | 1 | 0 | 0 | 0 |
| 184 | 2002 | | | | | | | | | | | | | | | 4 | 1 | 2 | 0 | 0 |
| 438 | 2003 | | | | | | | | | | | | | | | | 3 | 2 | 0 | 1 |
| 756 | 2004 | | | | | | | | | | | | | | | | | 10 | 3 | 0 |
| 595 | 2005 | | | | | | | | | | | | | | | | | | 8 | 4 |
| 456 | 2006 | | | | | | | | | | | | | | | | | | | 13 |

Table 6 continued.

Maryland

| Number of releases | Release year | Harvested Recaptures 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1293 | 1987 | 1 | 6 | 0 | 18 | 19 | 21 | 17 | 6 | 7 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1802 | 1988 | | 4 | 2 | 23 | 26 | 37 | 23 | 10 | 12 | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1830 | 1989 | | | 1 | 39 | 51 | 57 | 30 | 19 | 9 | 6 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 831 | 1990 | | | | 21 | 27 | 26 | 11 | 10 | 3 | 3 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 974 | 1991 | | | | | 31 | 38 | 29 | 9 | 10 | 4 | 5 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1107 | 1992 | | | | | | 59 | 41 | 26 | 8 | 4 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1458 | 1993 | | | | | | | 63 | 51 | 31 | 17 | 15 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1204 | 1994 | | | | | | | | 54 | 60 | 19 | 16 | 15 | 8 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 769 | 1995 | | | | | | | | | 55 | 26 | 13 | 5 | 5 | 2 | 1 | 0 | 1 | 0 | 0 | 0 |
| 720 | 1996 | | | | | | | | | | 44 | 25 | 22 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 |
| 488 | 1997 | | | | | | | | | | | 33 | 20 | 7 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 668 | 1998 | | | | | | | | | | | | 52 | 15 | 6 | 4 | 2 | 1 | 1 | 0 | 0 |
| 406 | 1999 | | | | | | | | | | | | | 22 | 16 | 4 | 1 | 0 | 0 | 0 | 0 |
| 676 | 2000 | | | | | | | | | | | | | | 32 | 9 | 11 | 3 | 3 | 1 | 0 |
| 617 | 2001 | | | | | | | | | | | | | | | 31 | 11 | 9 | 3 | 0 | 0 |
| 806 | 2002 | | | | | | | | | | | | | | | | 39 | 25 | 11 | 1 | 0 |
| 454 | 2003 | | | | | | | | | | | | | | | | | 27 | 14 | 3 | 3 |
| 311 | 2004 | | | | | | | | | | | | | | | | | | 14 | 7 | 0 |
| 537 | 2005 | | | | | | | | | | | | | | | | | | | 24 | 15 |
| 282 | 2006 | | | | | | | | | | | | | | | | | | | | 16 |

| Number of releases | Release year | Released with Tag Removed 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1293 | 1987 | 28 | 2 | 11 | 15 | 14 | 17 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1802 | 1988 | | 13 | 32 | 31 | 21 | 15 | 10 | 5 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1830 | 1989 | | | 40 | 37 | 19 | 17 | 7 | 6 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 831 | 1990 | | | | 21 | 14 | 14 | 5 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 974 | 1991 | | | | | 24 | 25 | 9 | 9 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1107 | 1992 | | | | | | 48 | 17 | 10 | 12 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1458 | 1993 | | | | | | | 32 | 34 | 16 | 10 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1204 | 1994 | | | | | | | | 47 | 25 | 12 | 4 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 769 | 1995 | | | | | | | | | 33 | 18 | 3 | 3 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 720 | 1996 | | | | | | | | | | 37 | 12 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 488 | 1997 | | | | | | | | | | | 20 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 668 | 1998 | | | | | | | | | | | | 29 | 8 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 406 | 1999 | | | | | | | | | | | | | 10 | 8 | 2 | 2 | 0 | 0 | 0 | 0 |
| 676 | 2000 | | | | | | | | | | | | | | 29 | 2 | 2 | 1 | 0 | 0 | 0 |
| 617 | 2001 | | | | | | | | | | | | | | | 19 | 1 | 1 | 1 | 0 | 0 |
| 806 | 2002 | | | | | | | | | | | | | | | | 20 | 6 | 3 | 0 | 0 |
| 454 | 2003 | | | | | | | | | | | | | | | | | 9 | 3 | 2 | 1 |
| 311 | 2004 | | | | | | | | | | | | | | | | | | 10 | 3 | 1 |
| 537 | 2005 | | | | | | | | | | | | | | | | | | | 9 | 1 |
| 282 | 2006 | | | | | | | | | | | | | | | | | | | | 8 |

## Appendix A14. Miscellaneous Tables Pertaining to Tagging Data

Tag release and recapture data are exchanged between the USFWS office in Annapolis, MD, and the cooperating tagging agencies. The USFWS maintains the tag release/recovery database and provides rewards to fishermen who report the recapture of tagged fish. From 1985 through July 2007, a total of 469,896 striped bass have been tagged and released, with 84,544 recaptures reported and recorded in the USFWS database (Tina McCrobie, personal communication).

These data were used to develop the following descriptive statistics of reported fish:

- length frequency distributions of releases, measured as total length (TL);
- age frequency distributions of recaptures; and
- annual catch rates.

Annual catch rates were developed for both $\geq$ 18 inch fish and $\geq$ 28 inch fish and were estimated as follows:

$$(R / 0.43) / M \qquad \textit{Eqn 1.}$$

where:

R = number of fish recovered;
0.43 = reporting rate; and
M = number of fish marked.

The data are used in both Program MARK and the IRCR model as program-specific matrices of releases and recaptures occurring in each year over the time series (Appendix 11). The number of twice-recaptured fish was examined to ensure that this phenomenon did not cause a bias in model results. Of 84,544 recaptured fish in the database, only 3,542 fish were recorded as twice recaptured. Since this was less than 5%, it was considered inconsequential.

Length frequencies (total length) of fish tagged in 2006 were tabulated by program (Table 1). Length represents the length of fish at the time of tagging.

Age distributions of fish recaptured in 2006 were tabulated by program (Table 2). Age distributions are based on a subsample of the total number of tagged fish (all programs do not age all tagged fish). Ages are read from scales taken at time of tagging and are adjusted to the recovery date.

Geographic distributions of 2006 recaptures (from fish tagged and released during the full time series) were organized by state and month for each tagging program
(Table 3).

Annual catch rates for fish $\geq$ 28 inches show more variability among the programs over the time series, with values for most programs between 0.1 and 0.4 since the late 1990's. In particular, VARAP shows high (up to 0.6) and erratic values. There is no clear trend (Table 4).

Annual catch rates for $\geq$ 18 inch fish have shown a very slight steady decrease since the mid 1990's, with all values for all programs between 0.1 and 0.3 except for one. The 2006 values were unusually closely grouped from 0.14 to 0.20 (Table 5).

Catch rate for both length groups ($\geq$ 18 inches and $\geq$ 28 inches) peaked in late 1990's and values for the past few years are similar to values seen in the earliest part of the time series.

The difference between the total catch rate and the exploitation rate suggests that the live release rate was approximately 5 %. This rate has been fairly constant since the mid-1990's. This estimate could be biased low because anglers may be less likely to notice tags on fish they have released. They could also be less likely to recover tags they do notice, since they are releasing the fish.

**Appendix A14 Tables**

Table 1. Total length frequencies of fish tagged in 2006 by program.

| | Coast Programs | | | | Producer Area Programs | | | |
|---|---|---|---|---|---|---|---|---|
| TL | MADFW | NYOHS | NJDEP | NCCOOP | DE/PA | MDCB | VARAP | HUDSON |
| 199 | | | | | | | | |
| 249 | | | | | | | | |
| 299 | | | | | | 3 | | |
| 349 | | | | 1 | | 36 | | |
| 399 | | 25 | | 0 | 1 | 98 | | |
| 449 | | 204 | 1 | 4 | 139 | 141 | | |
| 499 | | 307 | 2 | 48 | 126 | 147 | 211 | 55 |
| 549 | | 281 | 25 | 319 | 134 | 104 | 178 | 76 |
| 599 | 1 | 145 | 190 | 632 | 79 | 56 | 80 | 97 |
| 649 | 15 | 109 | 495 | 646 | 61 | 35 | 15 | 96 |
| 699 | 35 | 47 | 469 | 544 | 20 | 25 | 4 | 76 |
| 749 | 53 | 20 | 153 | 535 | 20 | 24 | 16 | 114 |
| 799 | 60 | 6 | 65 | 431 | 21 | 33 | 19 | 143 |
| 849 | 83 | 1 | 37 | 492 | 29 | 54 | 35 | 147 |
| 899 | 69 | 2 | 18 | 430 | 36 | 48 | 36 | 148 |
| 949 | 48 | 2 | 10 | 222 | 33 | 39 | 41 | 94 |
| 999 | 19 | 1 | 2 | 93 | 21 | 45 | 25 | 43 |
| 1049 | 4 | | | 46 | 14 | 16 | 6 | 28 |
| 1099 | 2 | | | 7 | 4 | 12 | 1 | 14 |
| >1099 | 1 | | | 9 | 9 | 8 | 1 | 3 |
| Total | 390 | 1150 | 1467 | 4459 | 747 | 924 | 668 | 1134 |

Table 2. Age frequencies of tagged fish recaptured in 2006 by program.

| | **Coast Programs** | | | |
|---|---|---|---|---|
| AGE | MADFW | NYOHS | NJDEP | NCCOOP |
| 1 | | | | |
| 2 | | | | |
| 3 | 1 | 19 | 1 | |
| 4 | 0 | 11 | 2 | |
| 5 | 0 | 28 | 46 | |
| 6 | 2 | 38 | 69 | |
| 7 | 4 | 8 | 31 | |
| 8 | 9 | 10 | 46 | |
| 9 | 8 | 3 | 37 | |
| 10 | 17 | 10 | 29 | |
| 11 | 10 | 9 | 12 | |
| 12 | 2 | 4 | 12 | |
| 13 | 6 | 4 | 7 | |
| 14 | 2 | 3 | 5 | |
| 15 | 4 | 0 | 2 | |
| 16 | 1 | 0 | 4 | |
| 17 | 0 | 1 | 2 | |
| 18 | 1 | 1 | 1 | |
| 19 | 0 | 1 | 1 | |
| 20 | 0 | | | |
| 21 | 0 | | | |
| 22 | 1 | | | |
| 23 | | | | |
| Total | 68 | 150 | 307 | |

| **Producer Area Programs** | | | |
|---|---|---|---|
| DE/PA | MDCB | VARAP | HUDSON |
| | | | |
| | | | |
| 1 | | | |
| 5 | | 21 | |
| 9 | | 19 | |
| 19 | | 8 | |
| 9 | | 4 | |
| 7 | | 6 | 1 |
| 7 | 1 | 9 | 0 |
| 11 | 1 | 8 | 0 |
| 9 | 2 | 7 | 3 |
| 6 | 5 | 4 | 2 |
| 7 | 8 | 3 | 4 |
| 3 | 3 | 5 | 1 |
| 4 | 0 | | 5 |
| 3 | 0 | | 6 |
| 3 | 0 | | 3 |
| 2 | 0 | | 3 |
| | 0 | | 0 |
| | 1 | | 0 |
| | | | 0 |
| | | | 0 |
| | | | 1 |
| 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.**

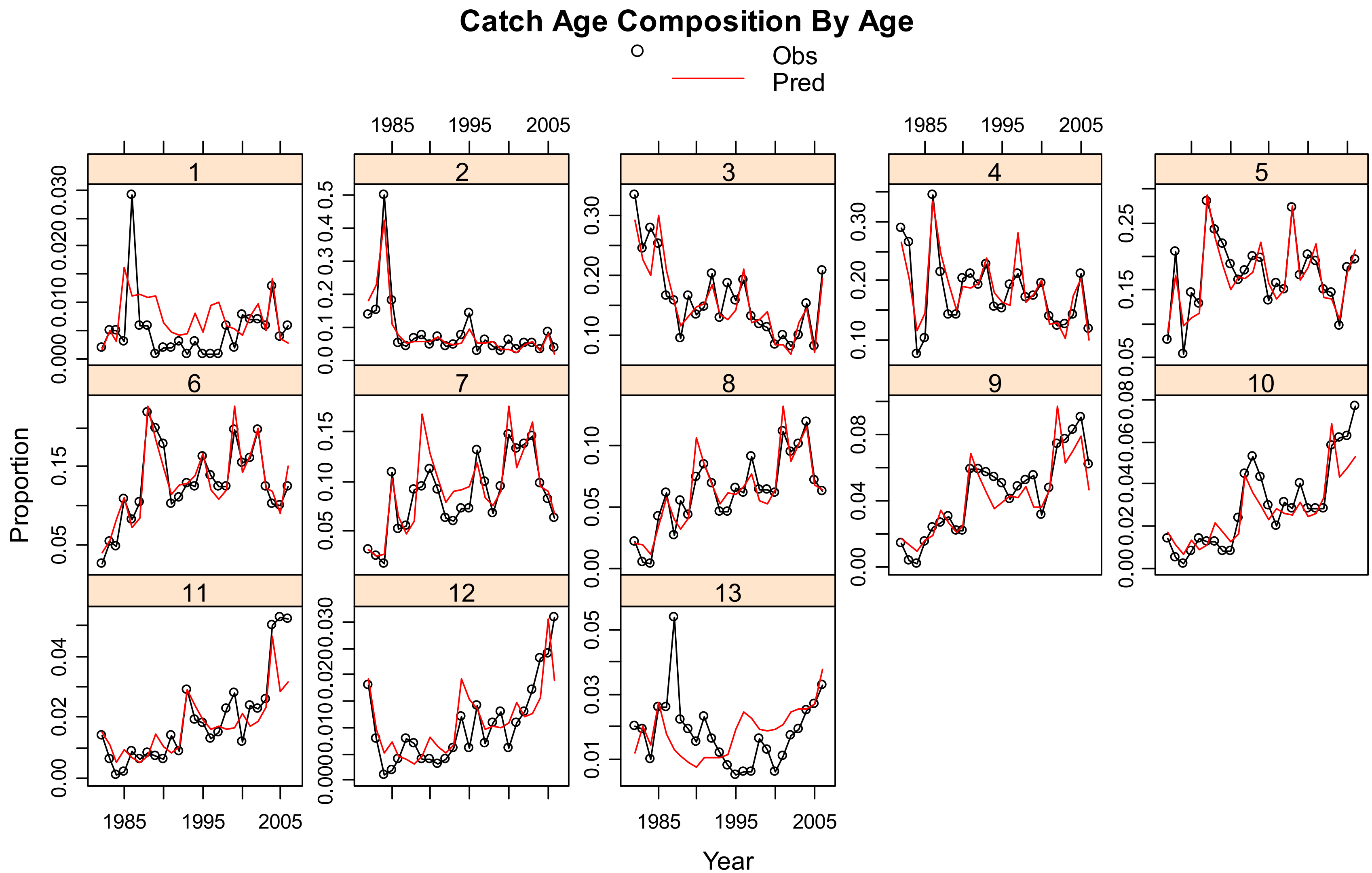



Figure 1. Comparison between observed and predicted annual catch age composition by age

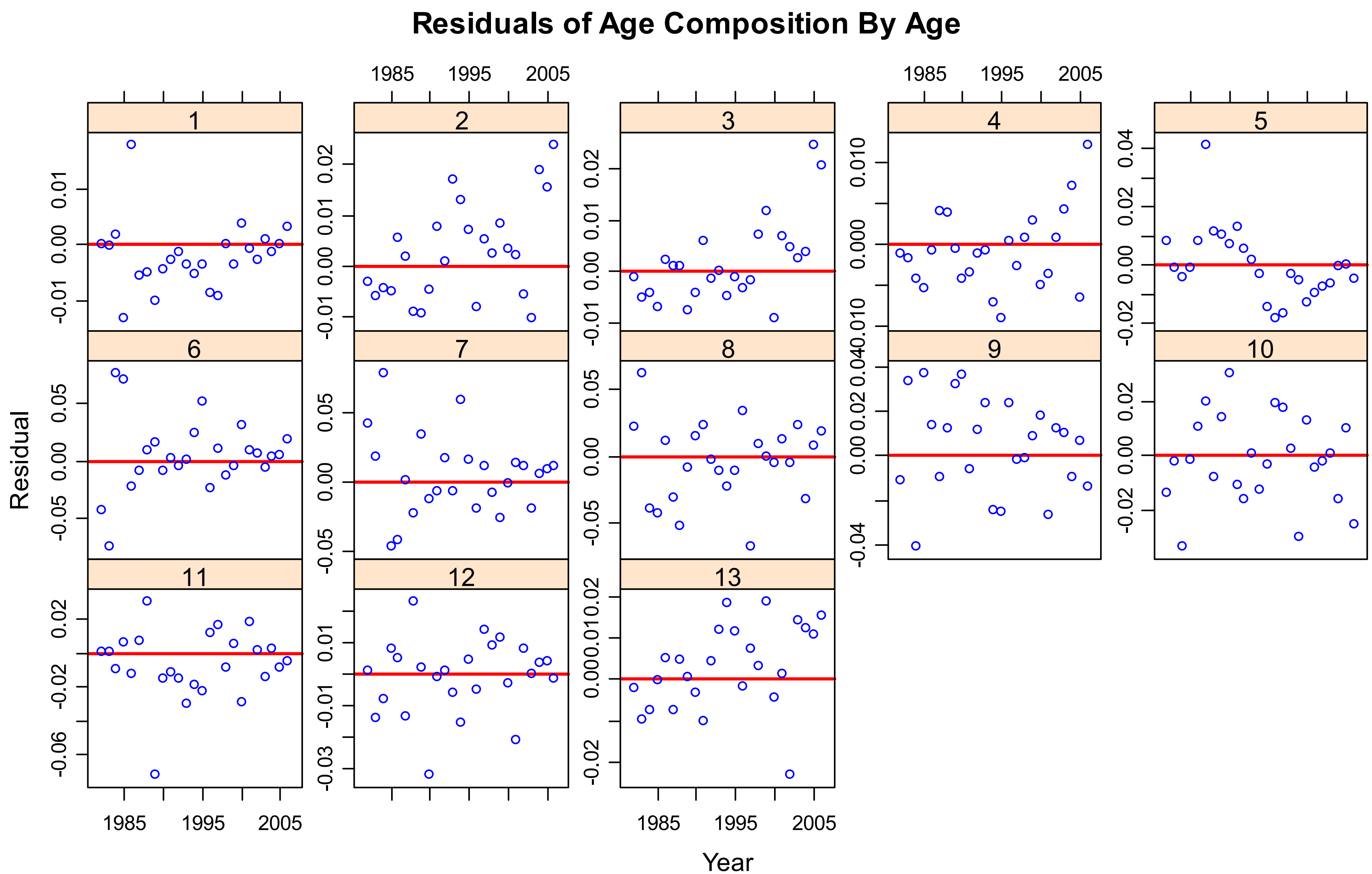



Figure 2. Residuals of annual catch age composition by age.

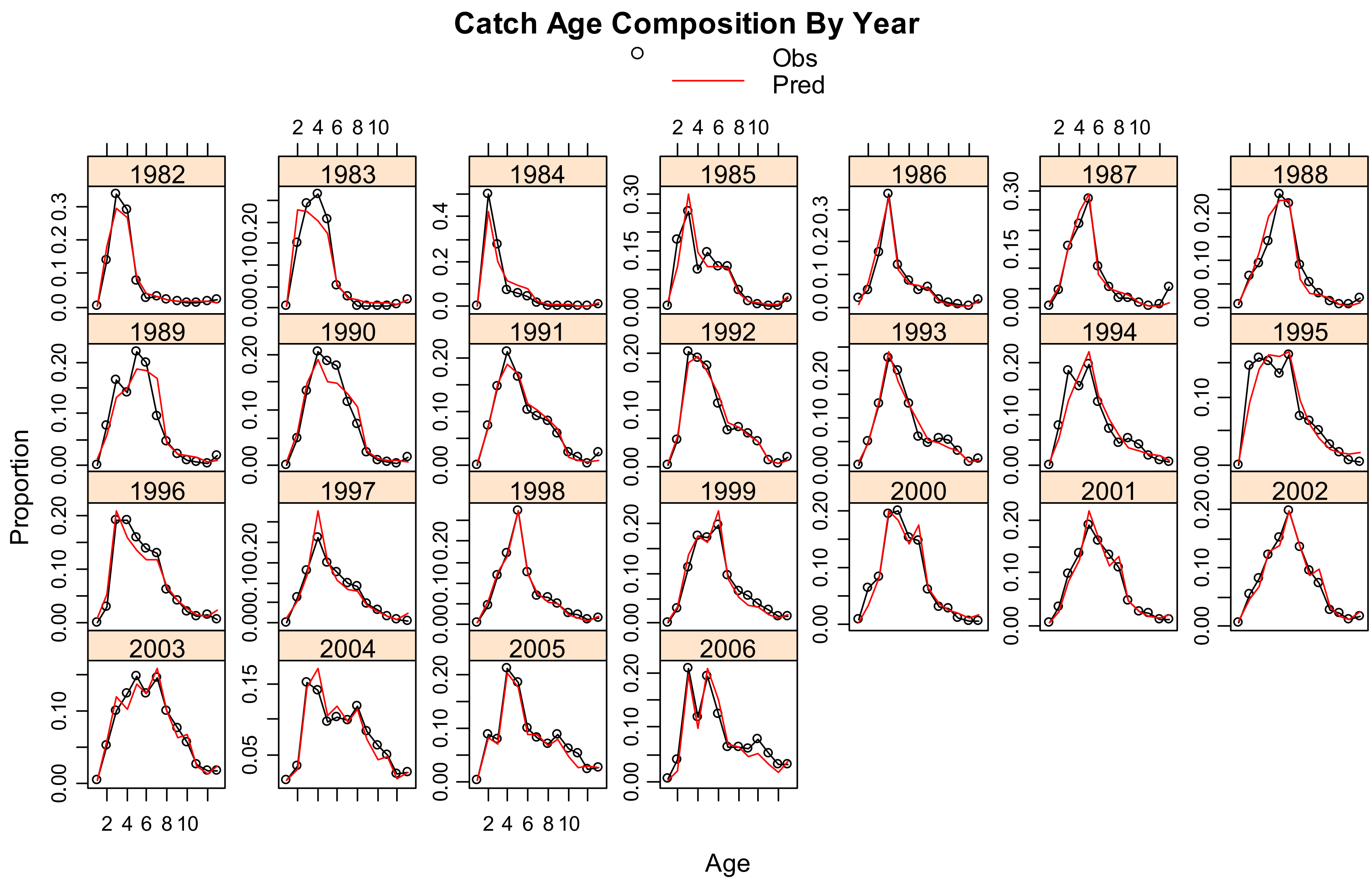



Figure 3. Comparison between observed and predicted catch age composition by year

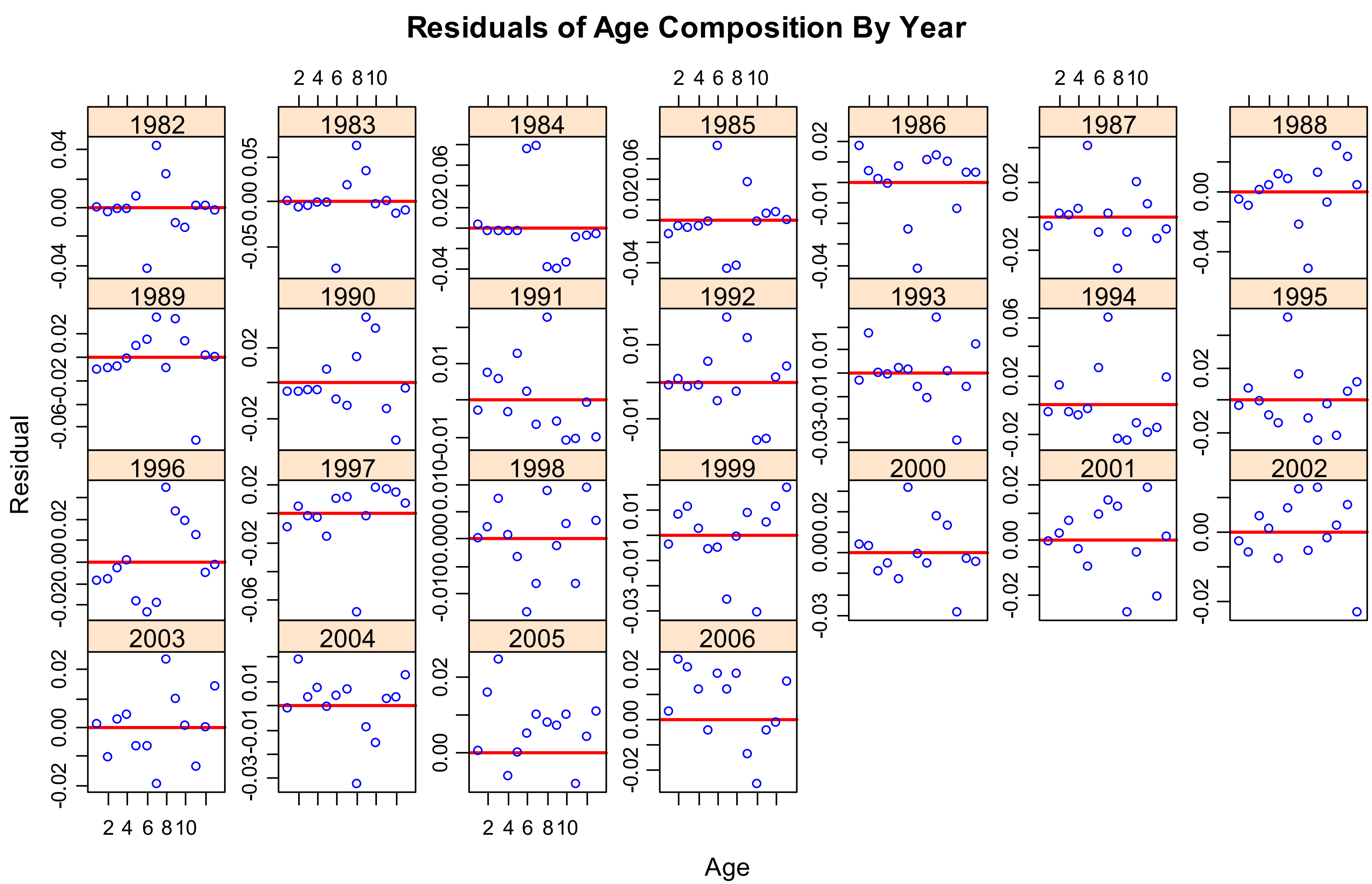



Figure 4. Residuals of annual catch age composition by age

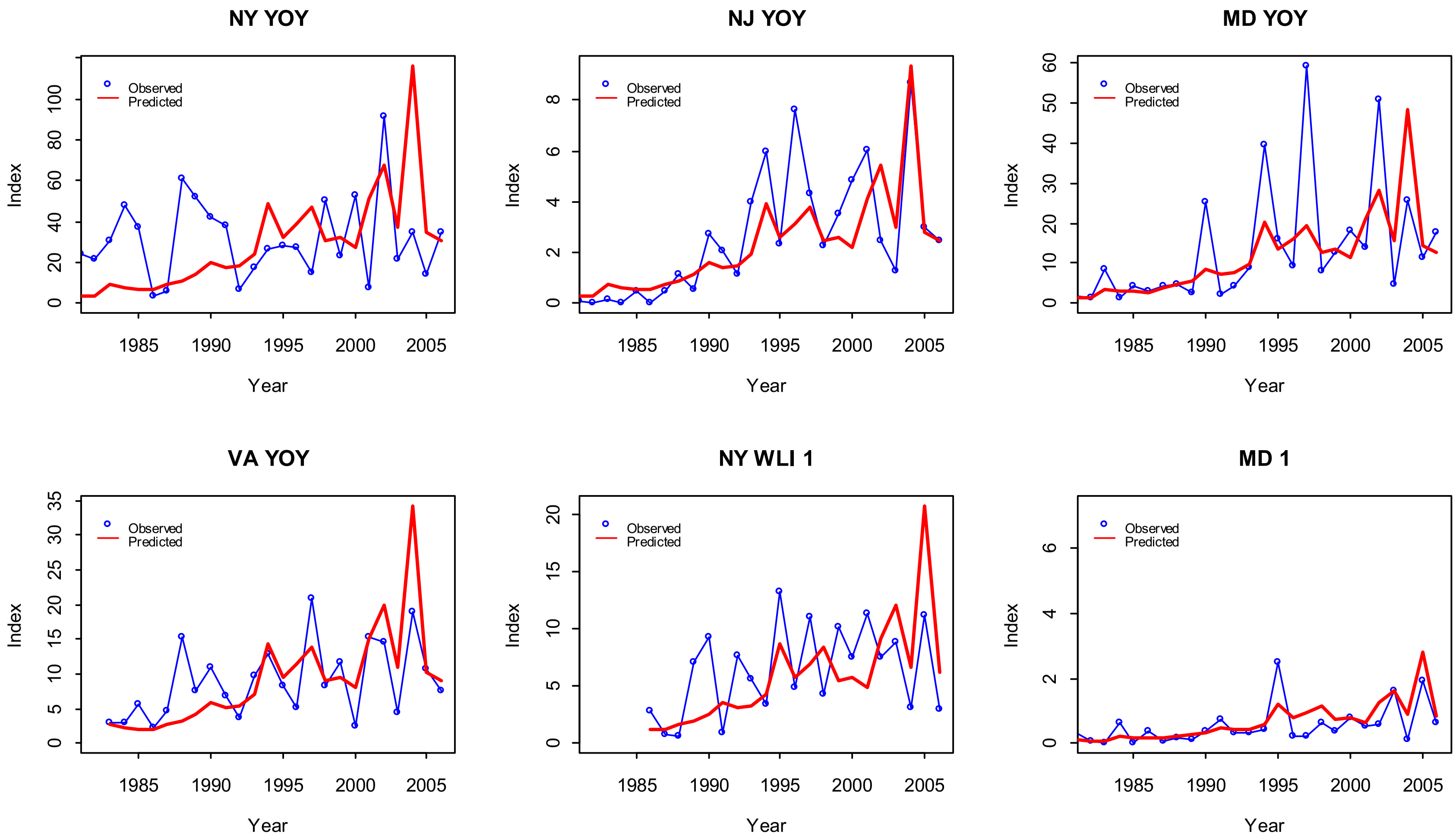



Figure 5. Observed and predicted YOY and Age 1 Indices

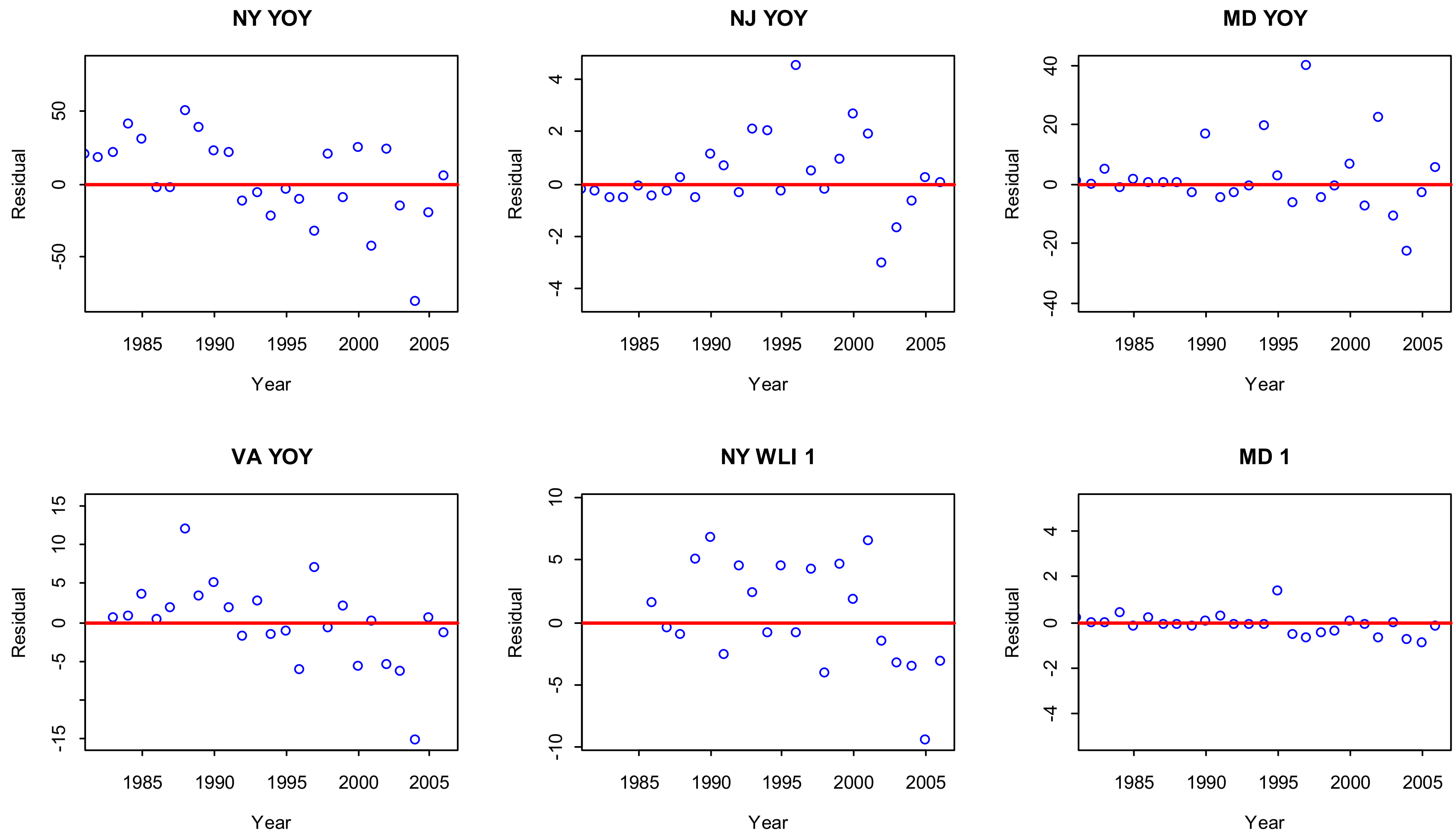



Figure 6. Residuals of YOY and Age 1 Indices

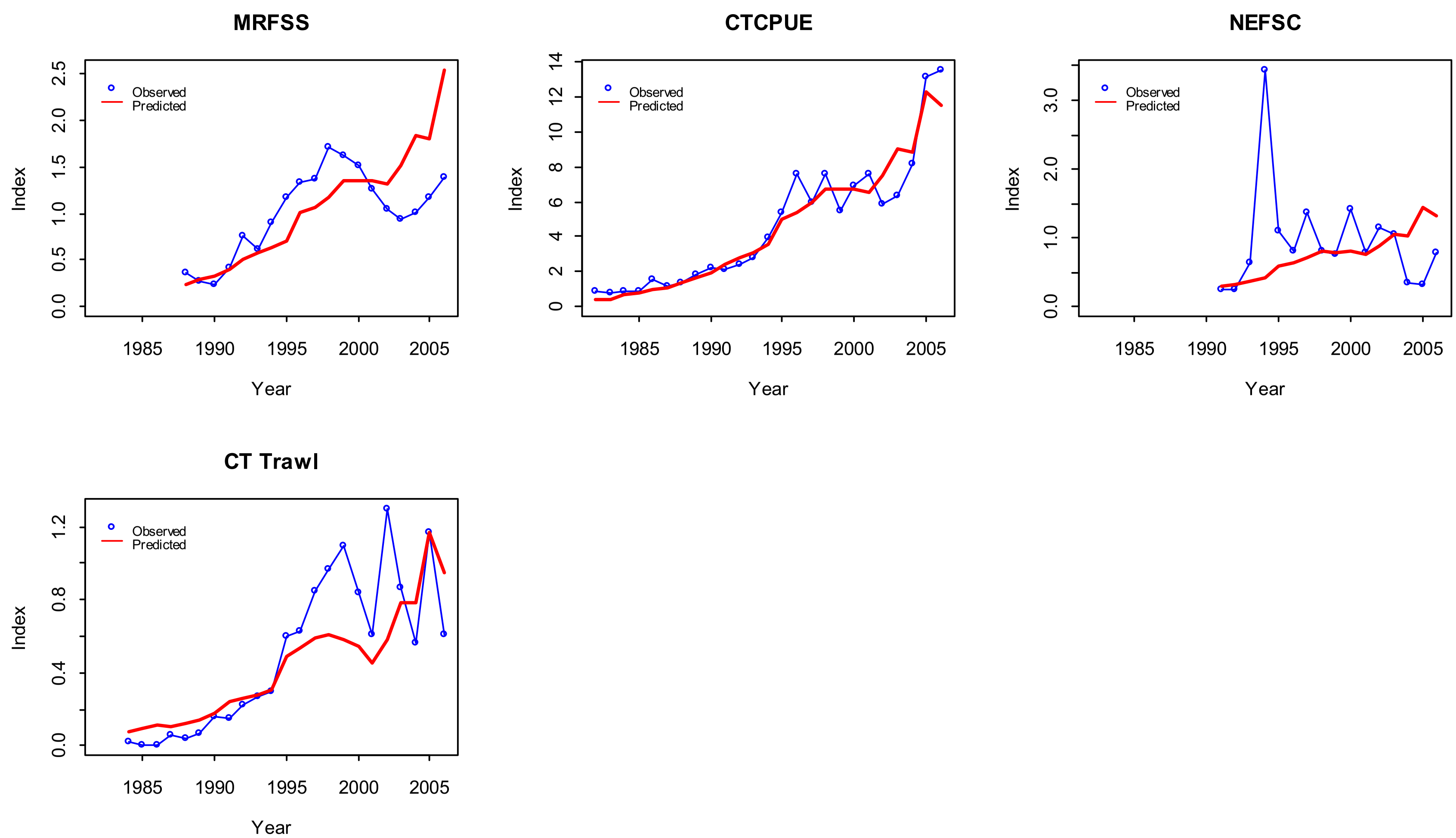



Figure 7. Observed and predicted aggregate indices

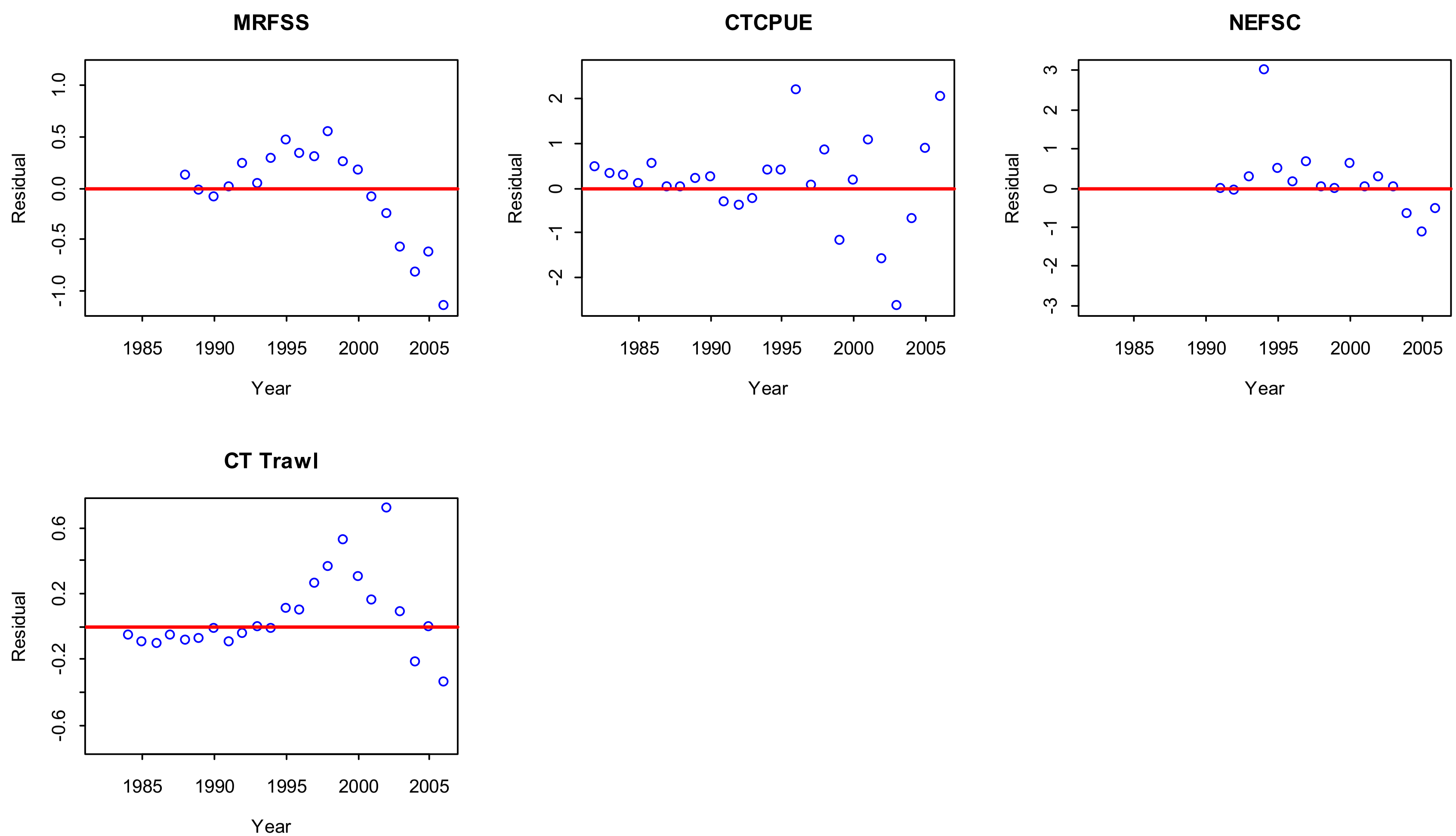



Figure 8. Residuals of aggregates indices

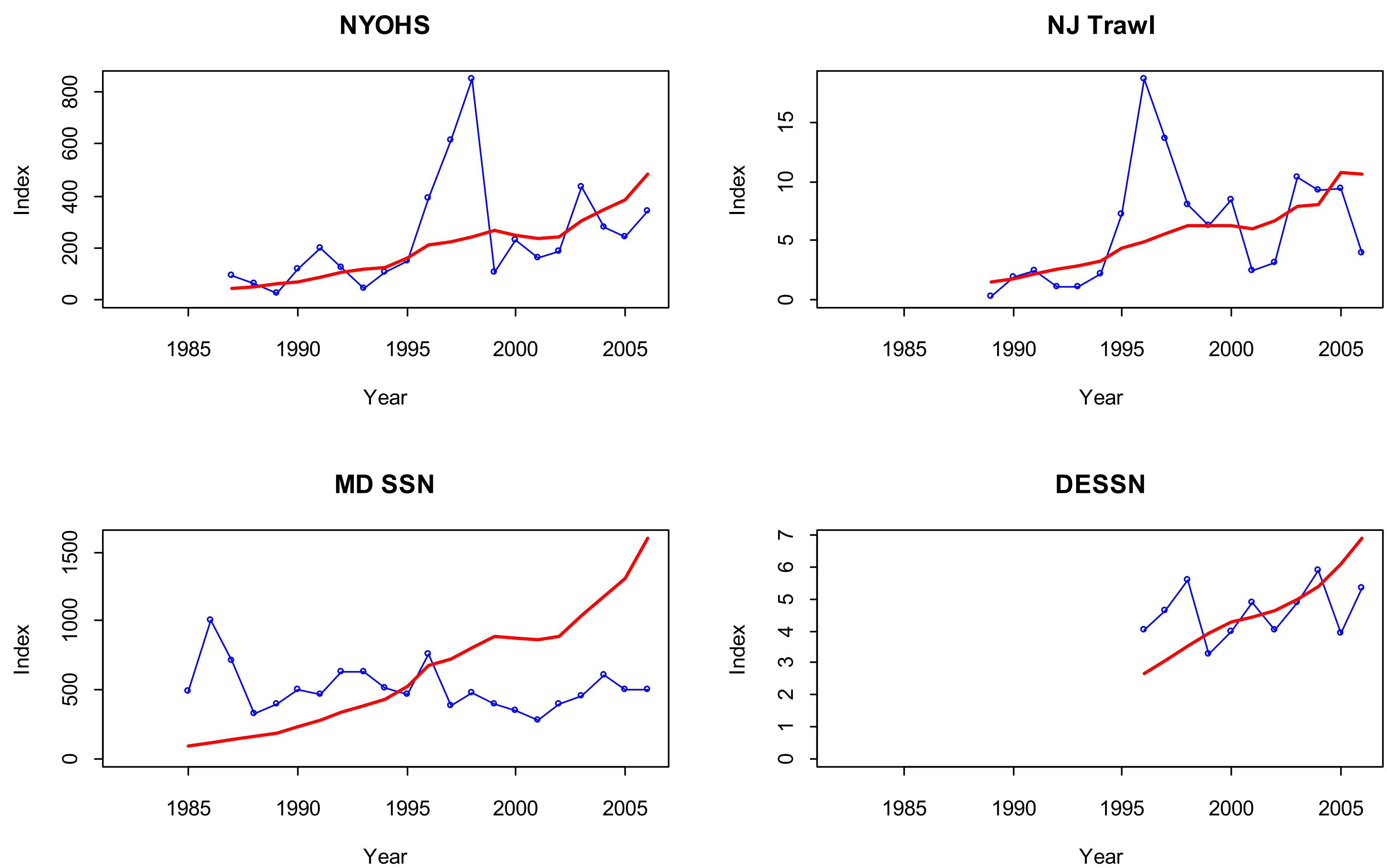



Figure 9. Observed and predicted survey indices with age composition data. Blue=observed, red=predicted

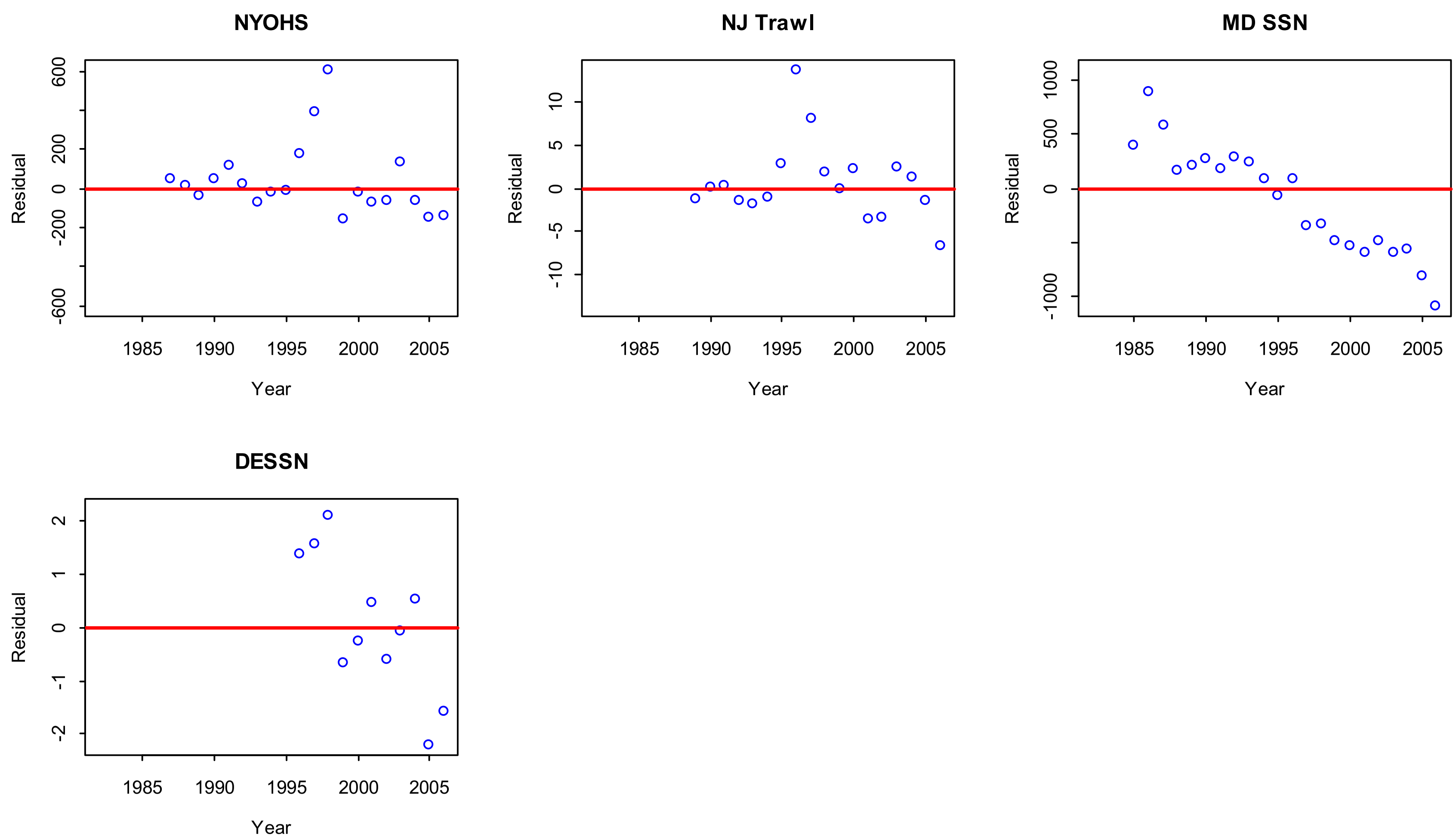



Figure 10. Residuals of survey indices with age composition data

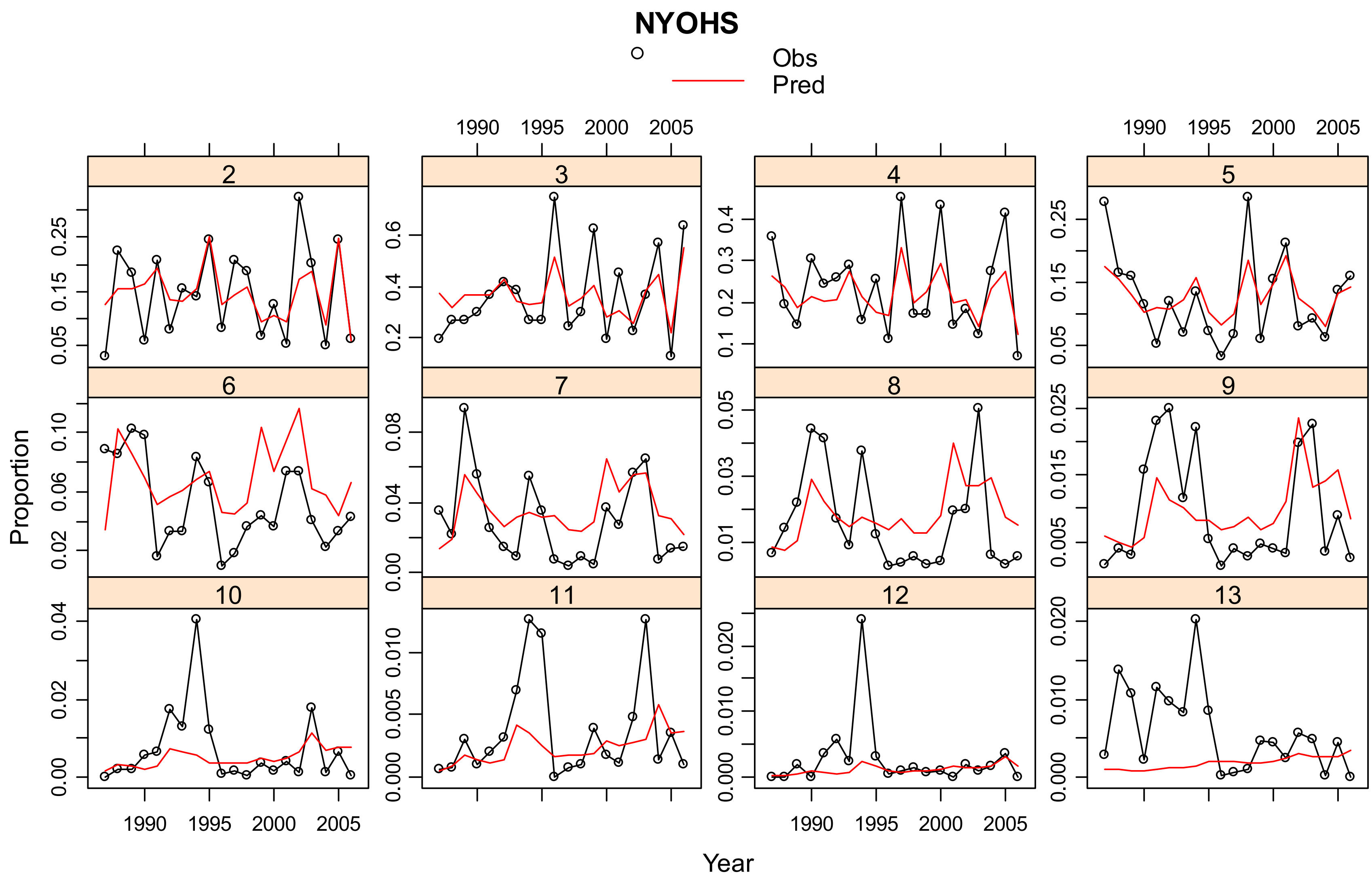



Figure 11. Observed and predicted annual survey age compositions by age for the NY Ocean Haul Seine survey

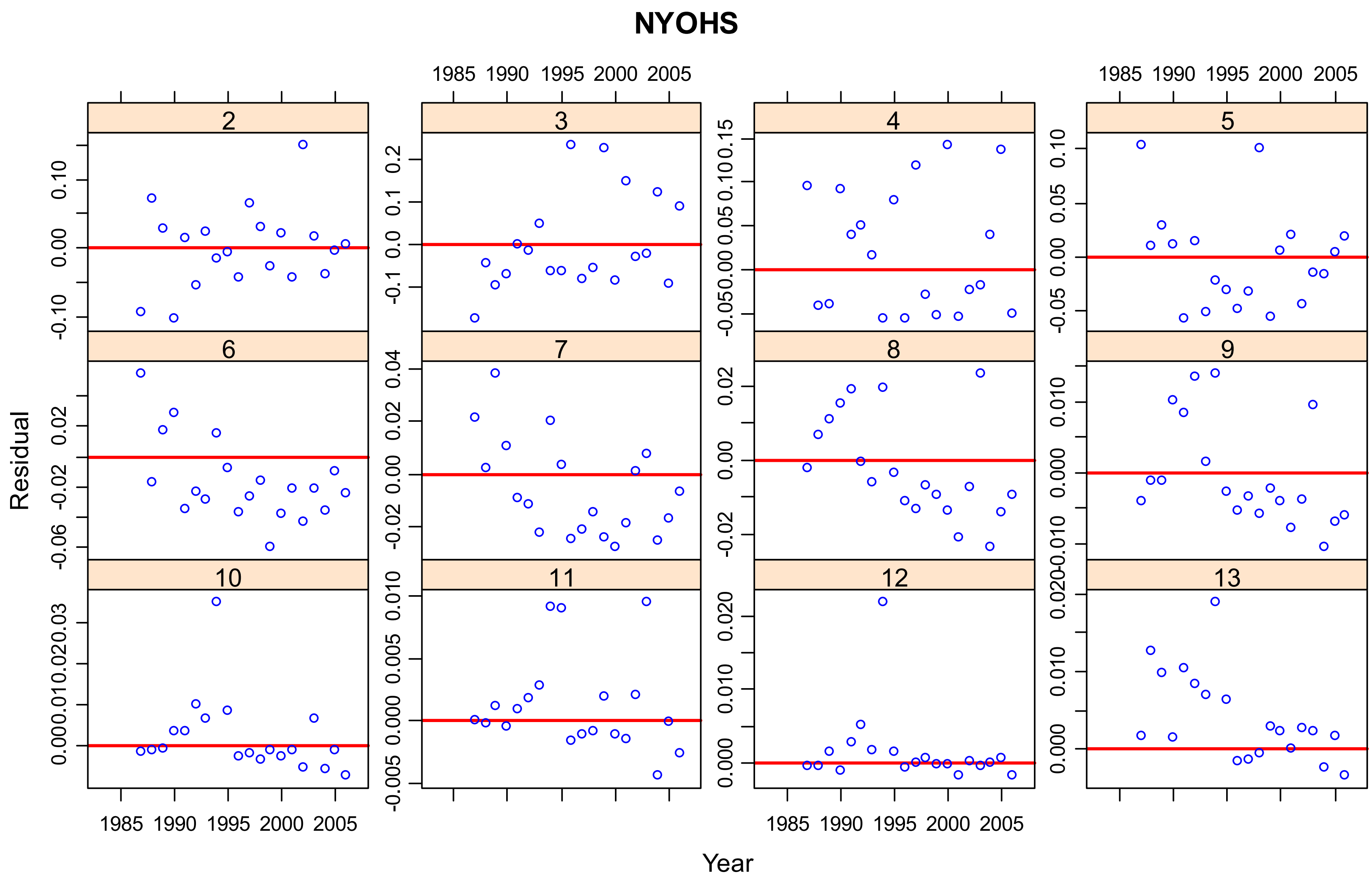



Figure 12. Residuals of annual survey age compositions by age for the NY Ocean Haul Seine survey

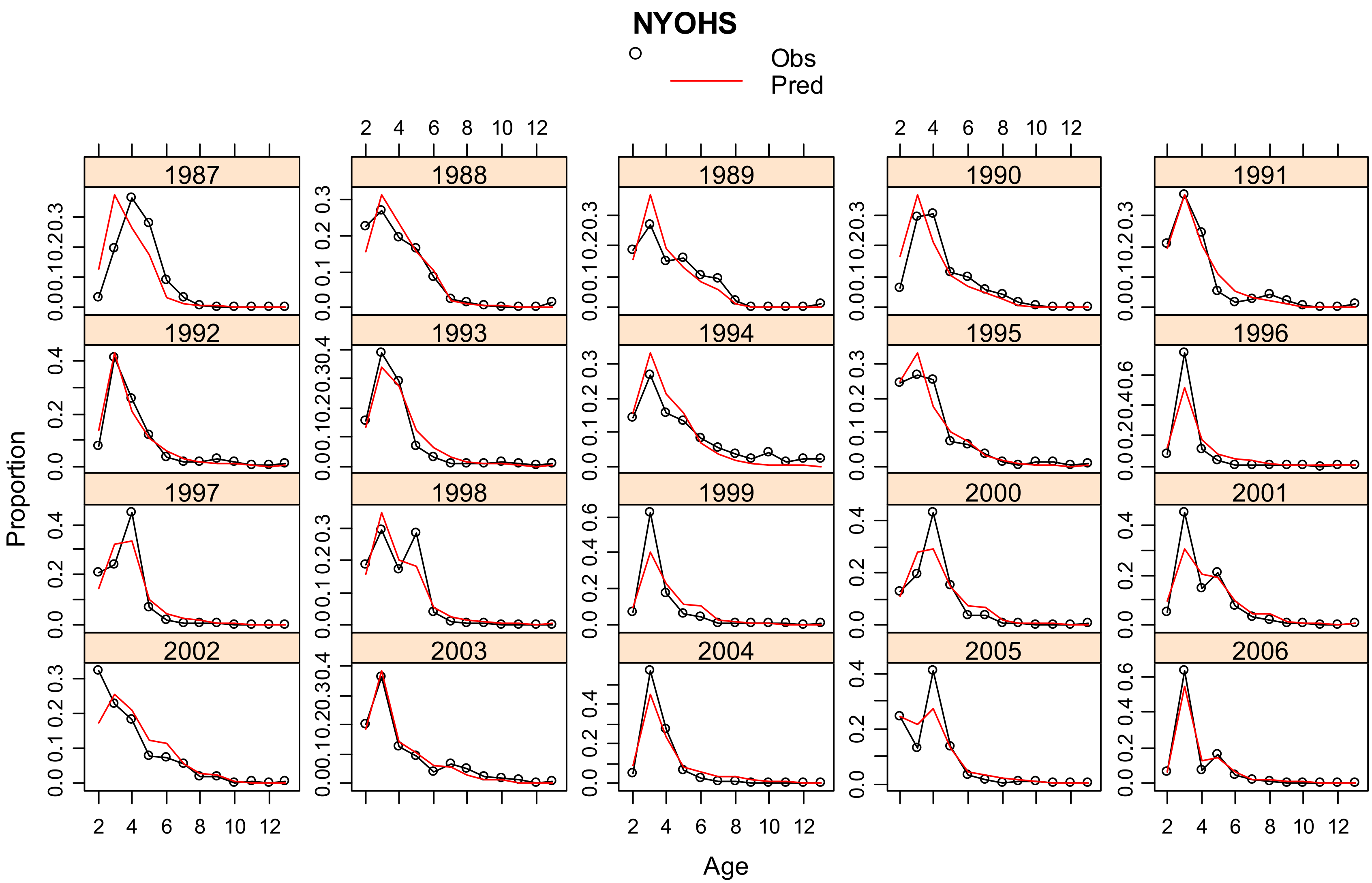



Figure 13. Observed and predicted survey age compositions by year for the NY Ocean Haul Seine survey

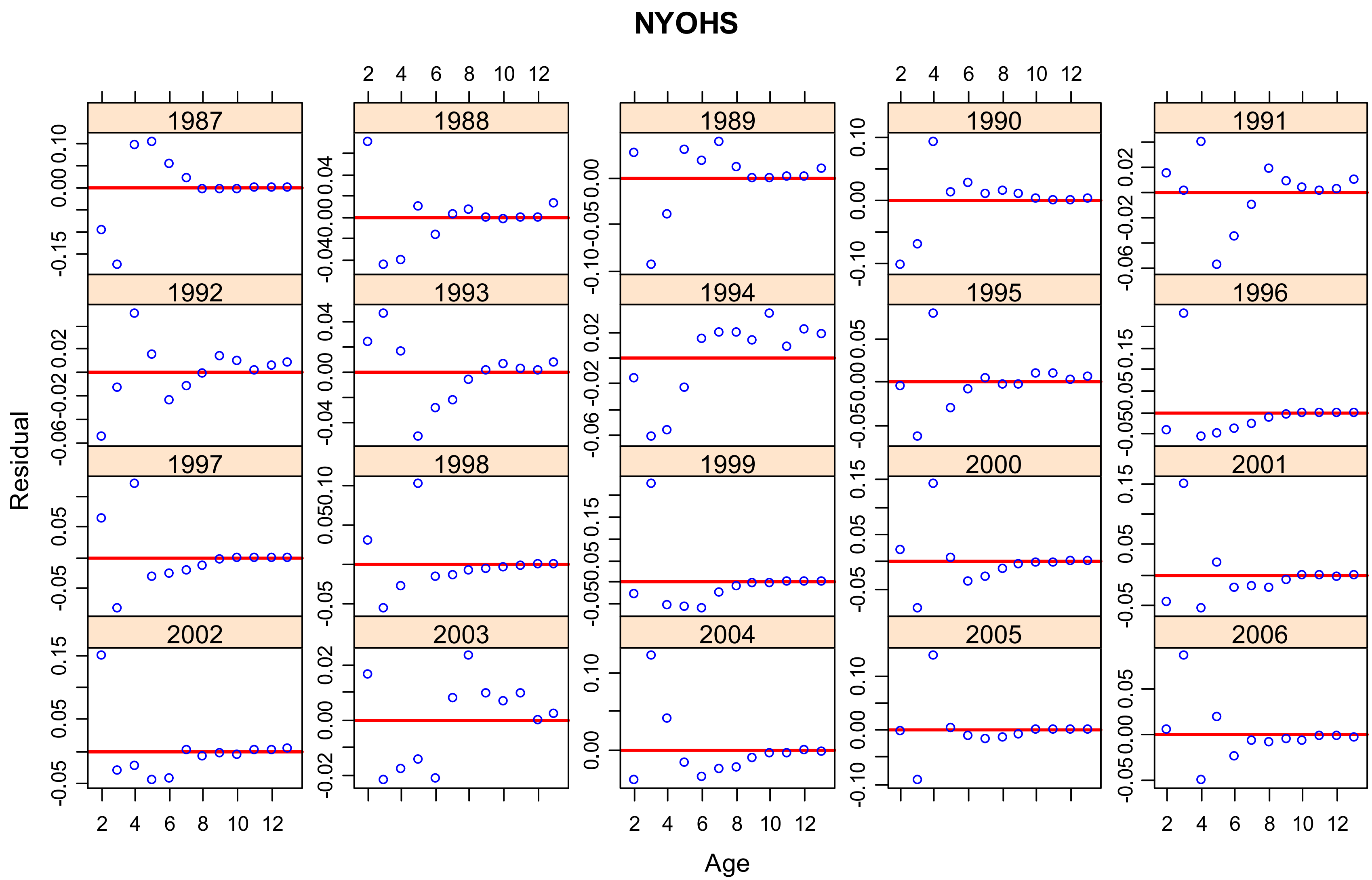



Figure 14. Residuals of survey age compositions by year for the NY Ocean Haul Seine survey

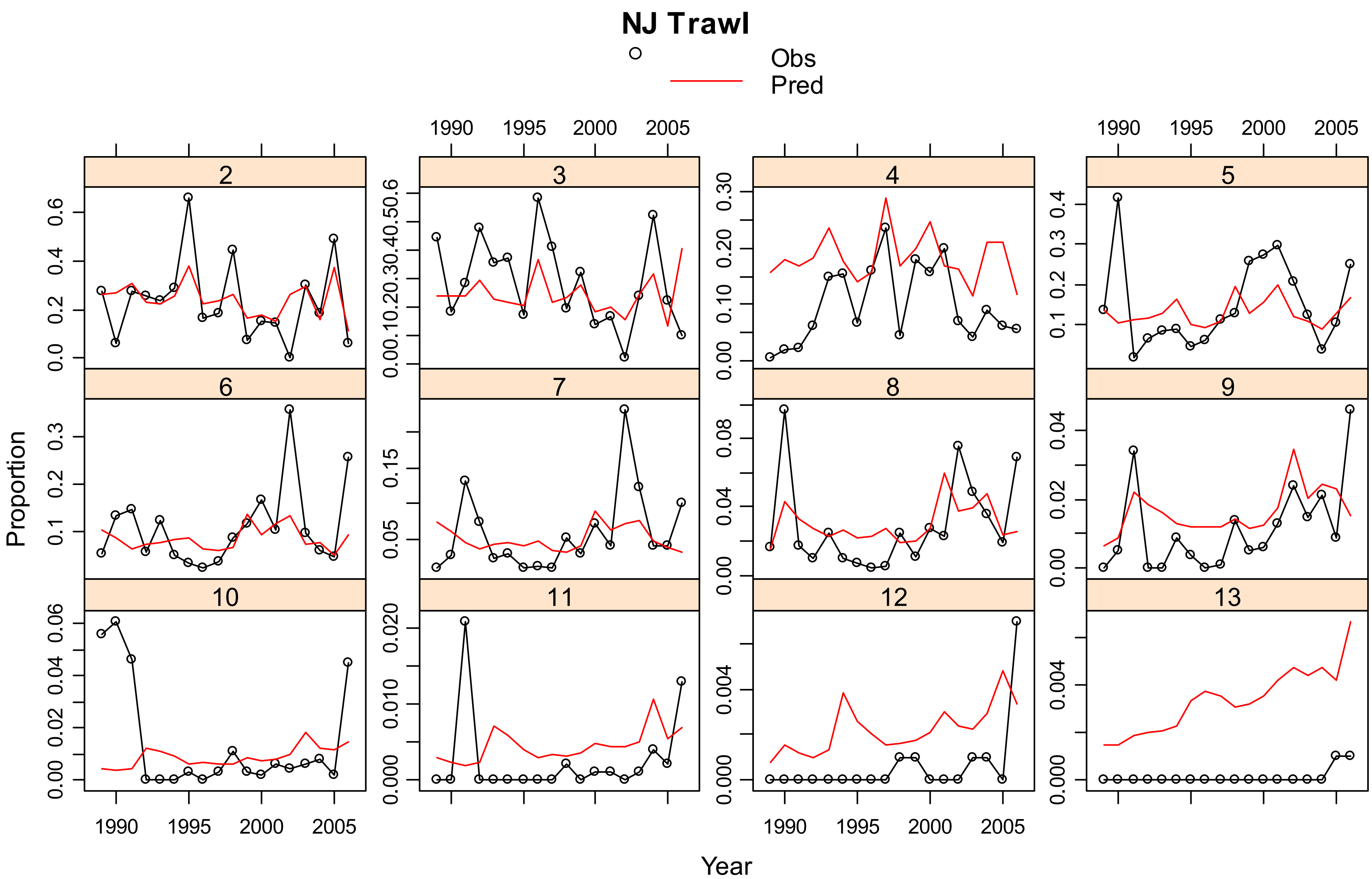



Figure 15. Observed and predicted annual survey age compositions by age for the New Jersey Trawl survey

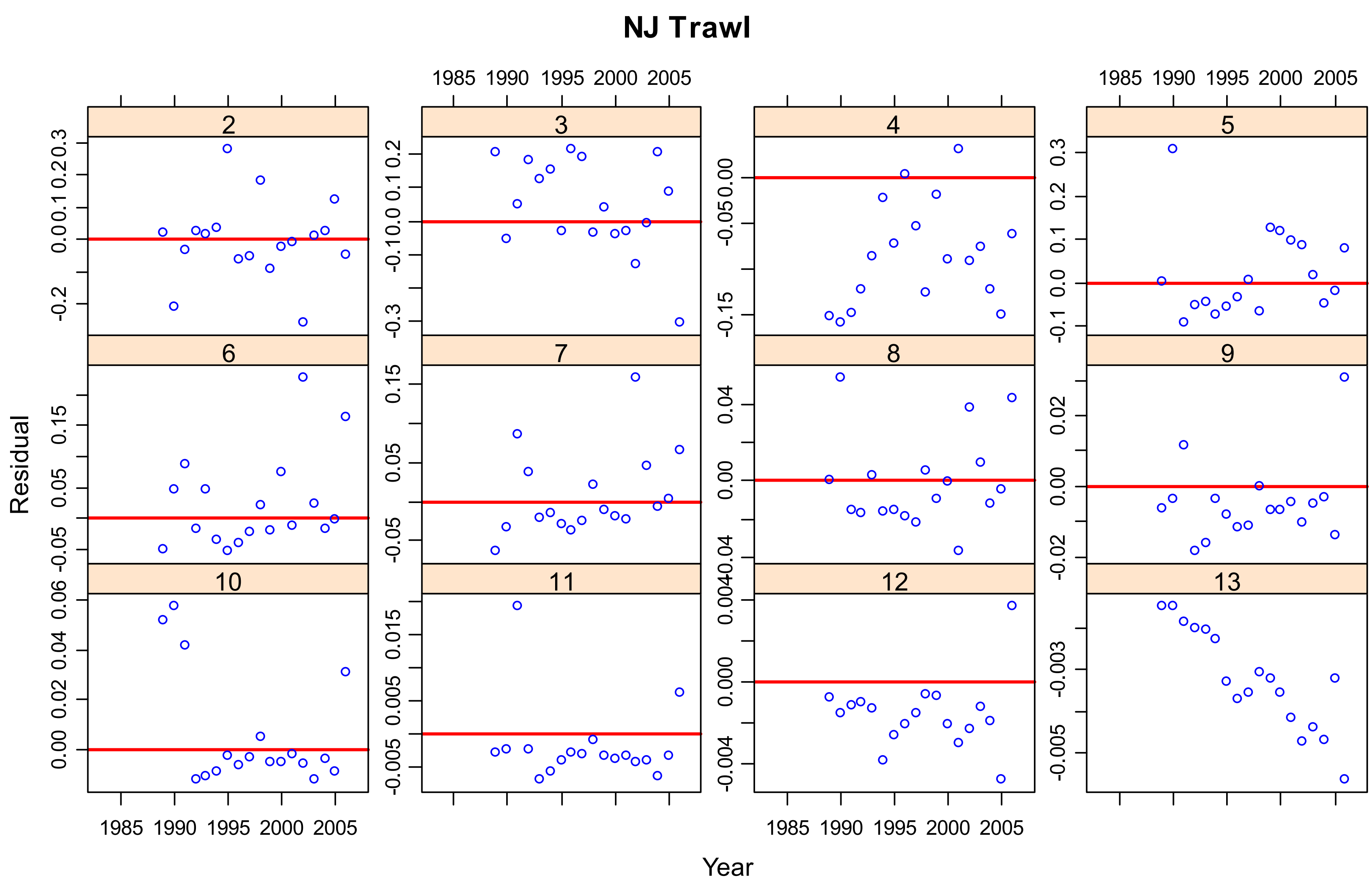



Figure 16. Residuals of annual survey age compositions by age for the New Jersey trawl survey

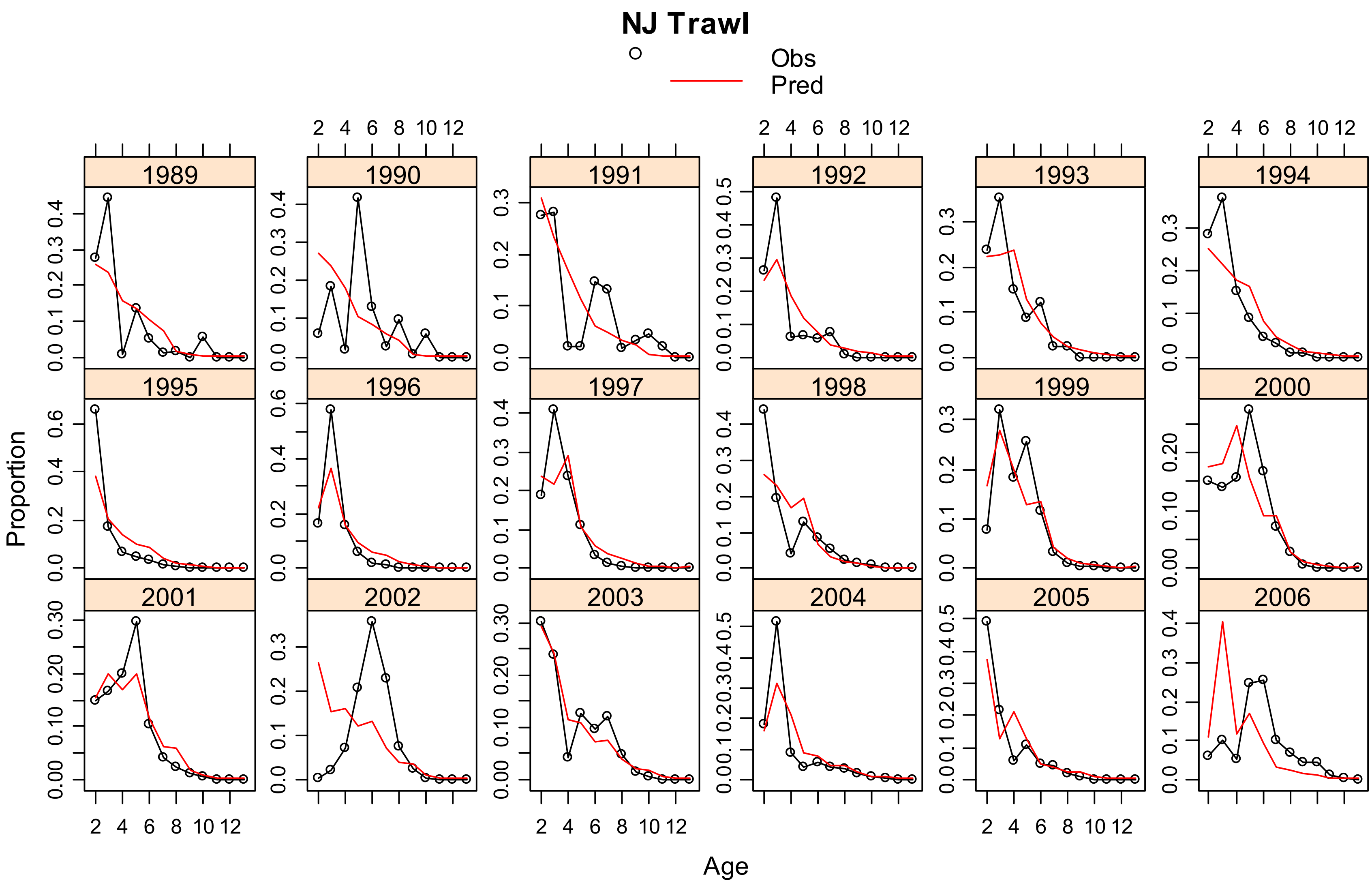



Figure 17. Observed and predicted survey age compositions by year for the New Jersey trawl survey

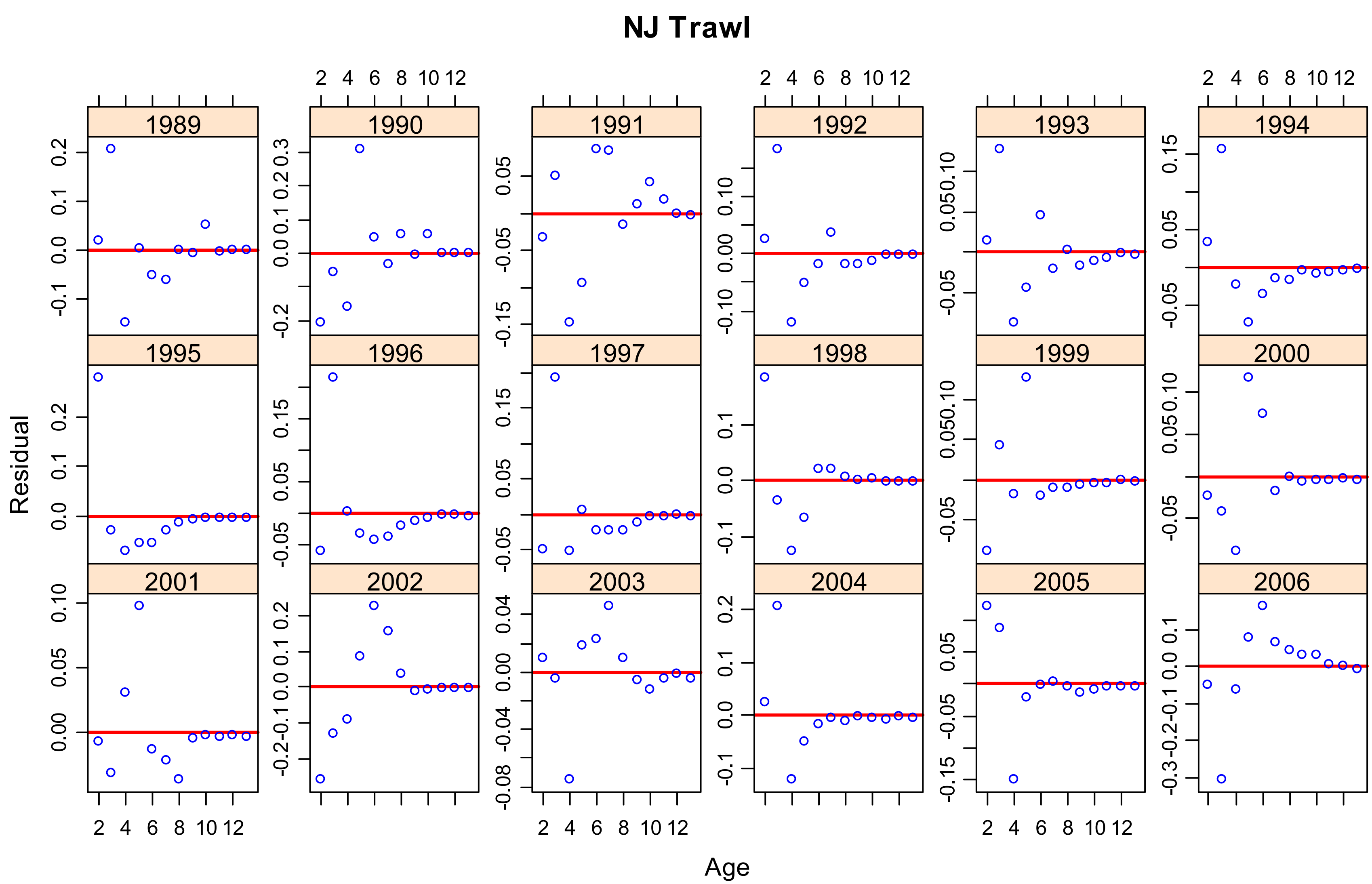



Figure 18. Residuals of survey age compositions by year for the New Jersey trawl survey

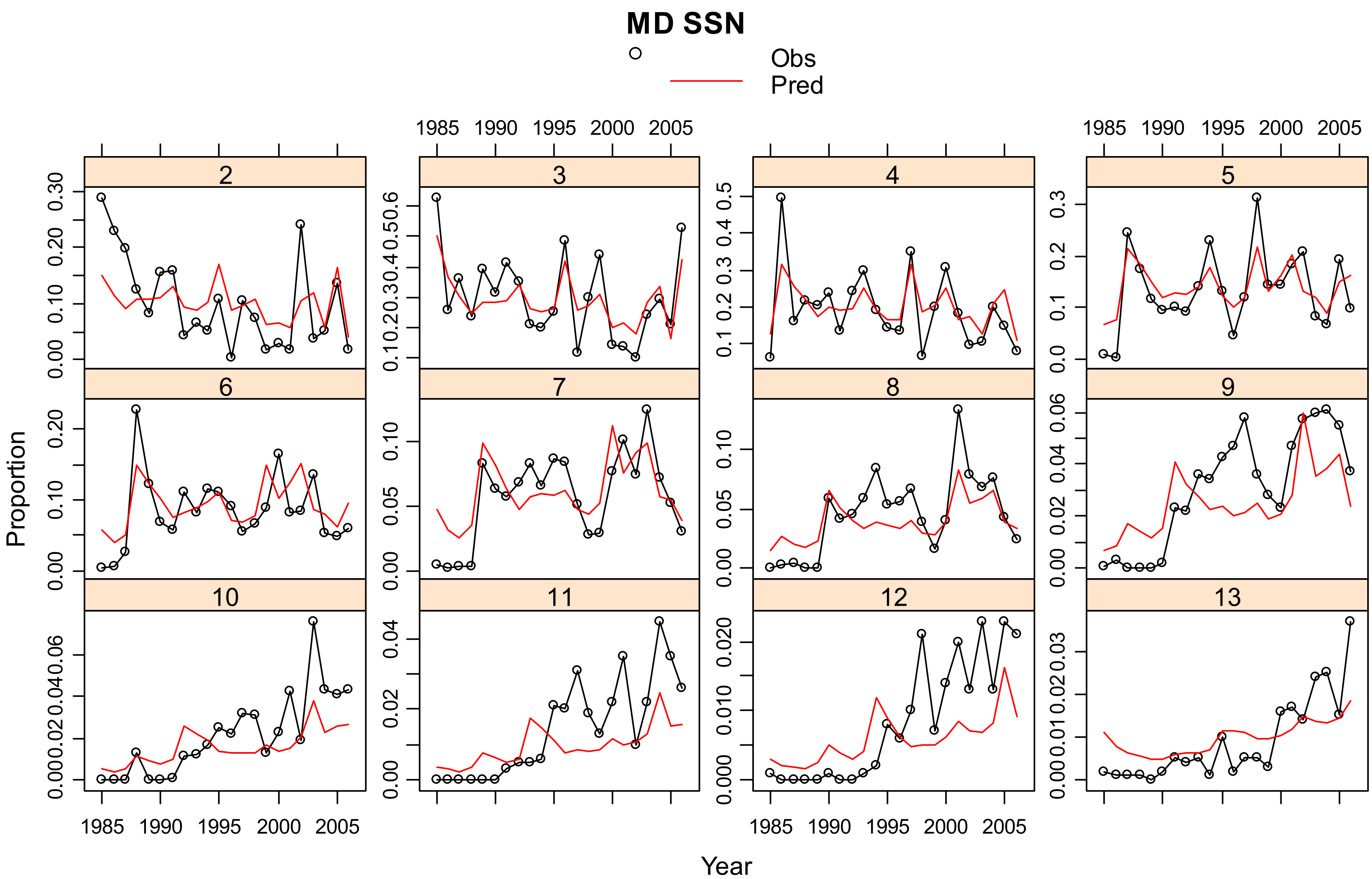



Figure 19. Observed and predicted annual survey age compositions by age for the Maryland gillnet survey

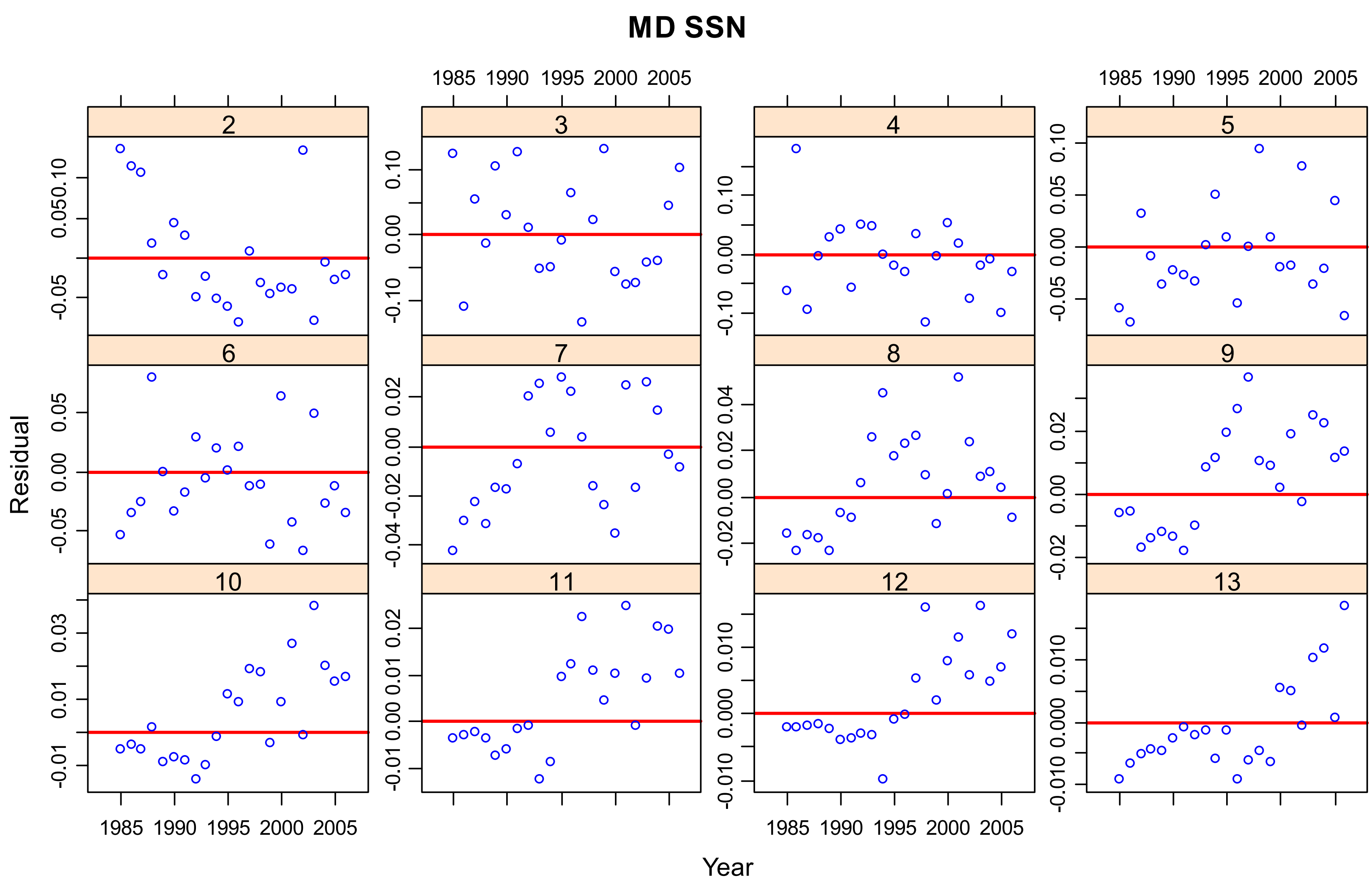



Figure 20. Residuals of annual survey age compositions by age for the Maryland gillnet survey

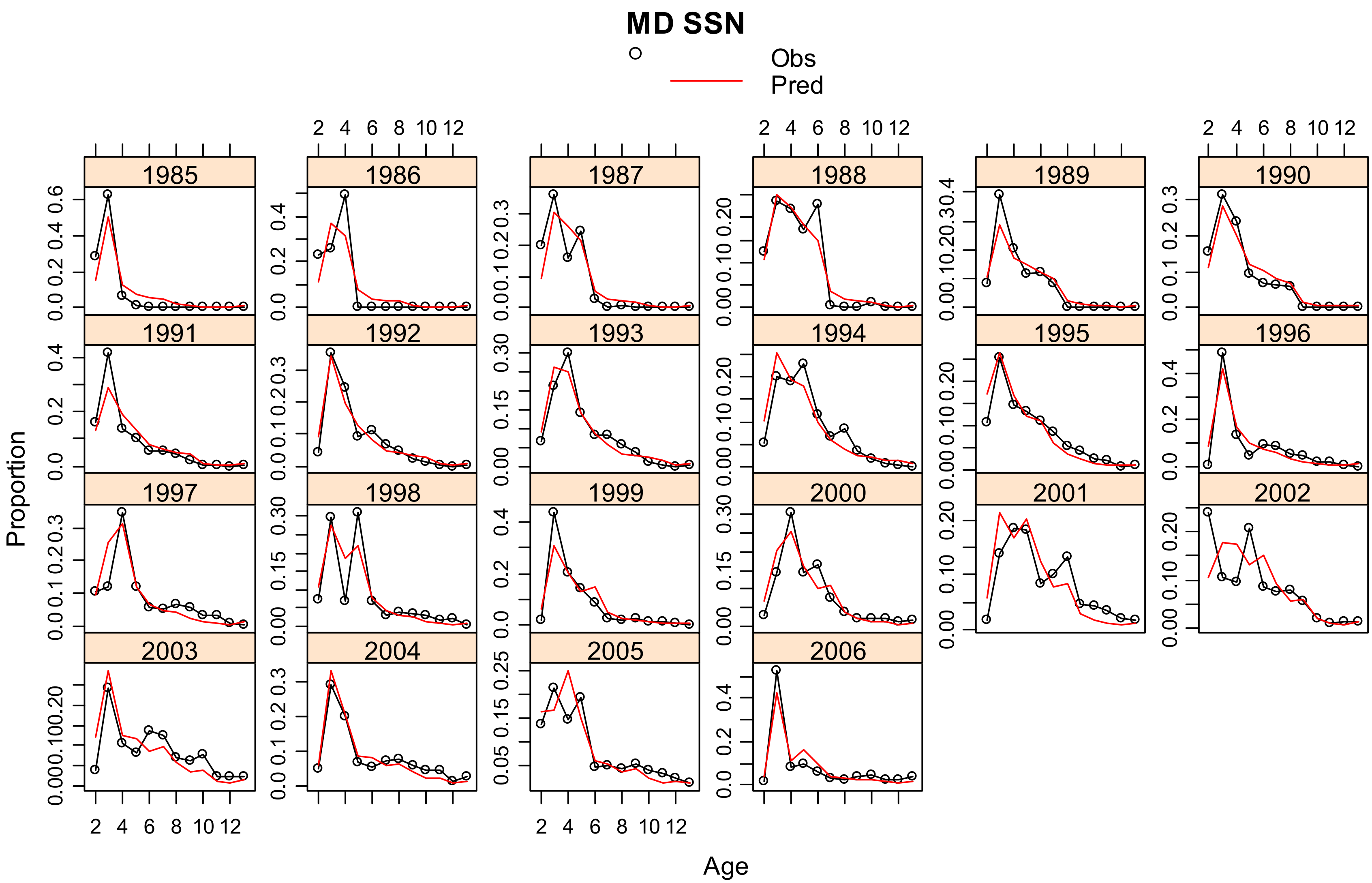



Figure 21. Observed and predicted survey age compositions by year for the Maryland gillnet survey

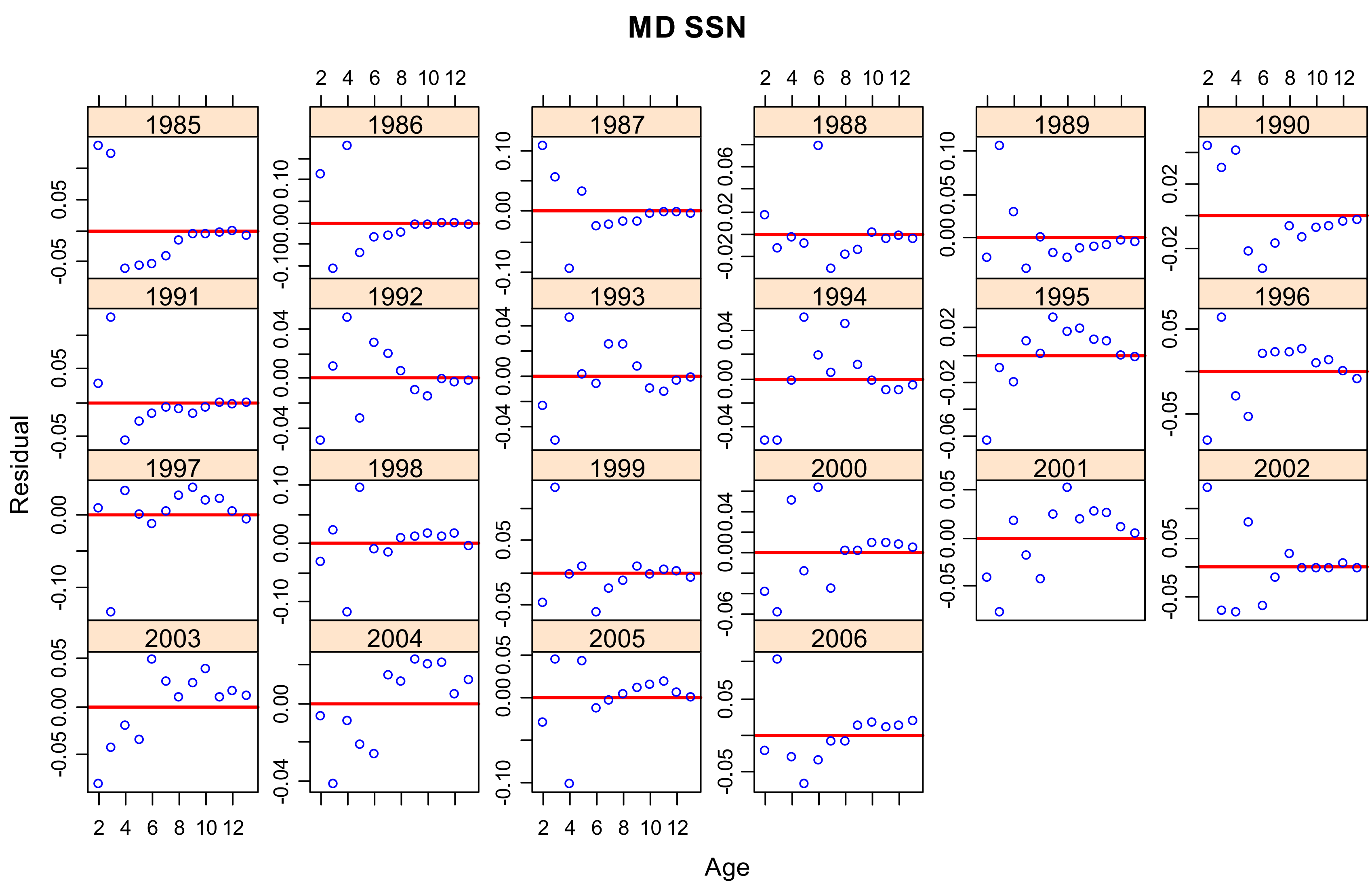



Figure 22. Residuals of survey age compositions by year for the Maryland gillnet survey

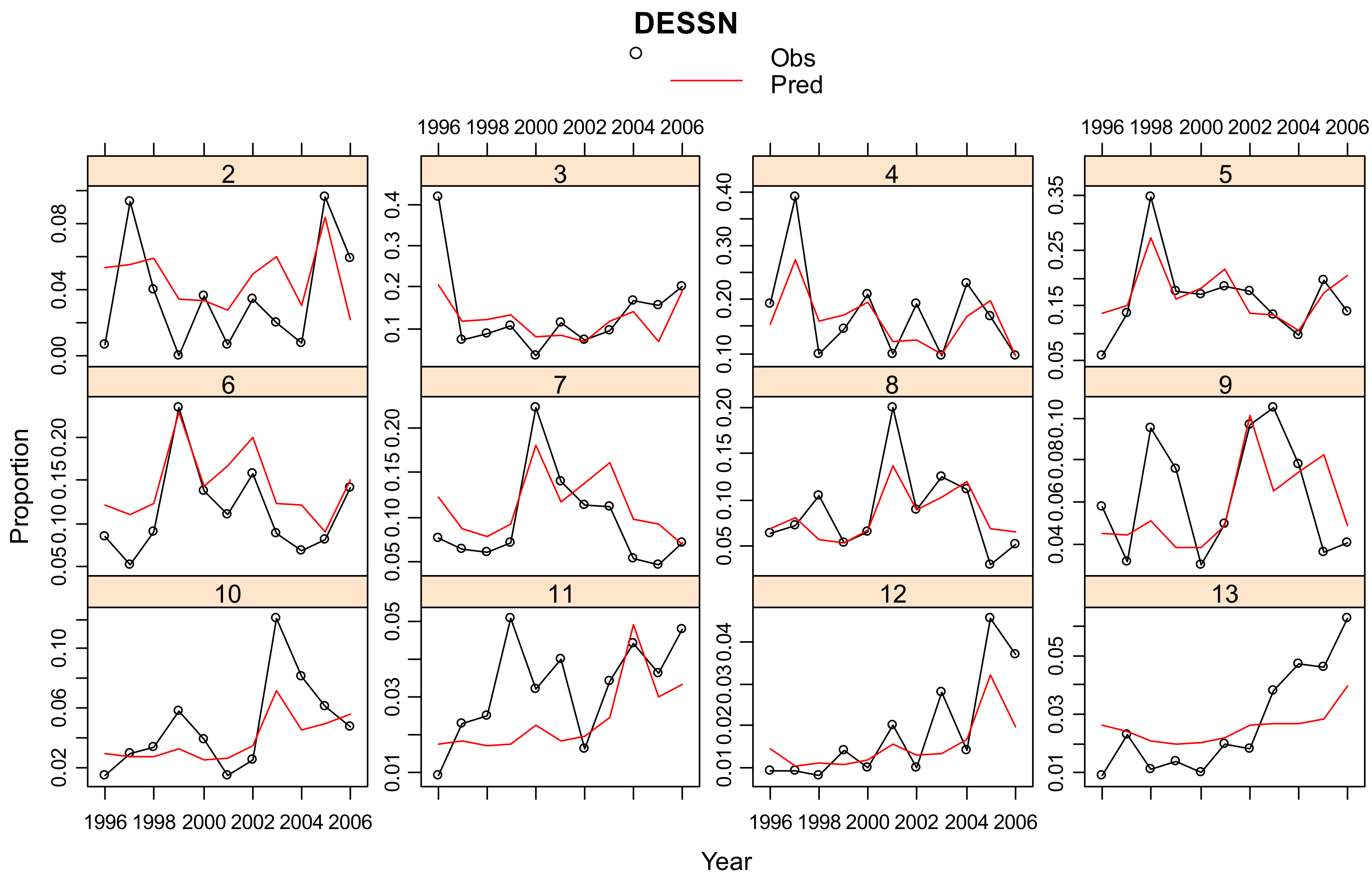



Figure 23. Observed and predicted annual survey age compositions by age for the Delaware electrofishing survey

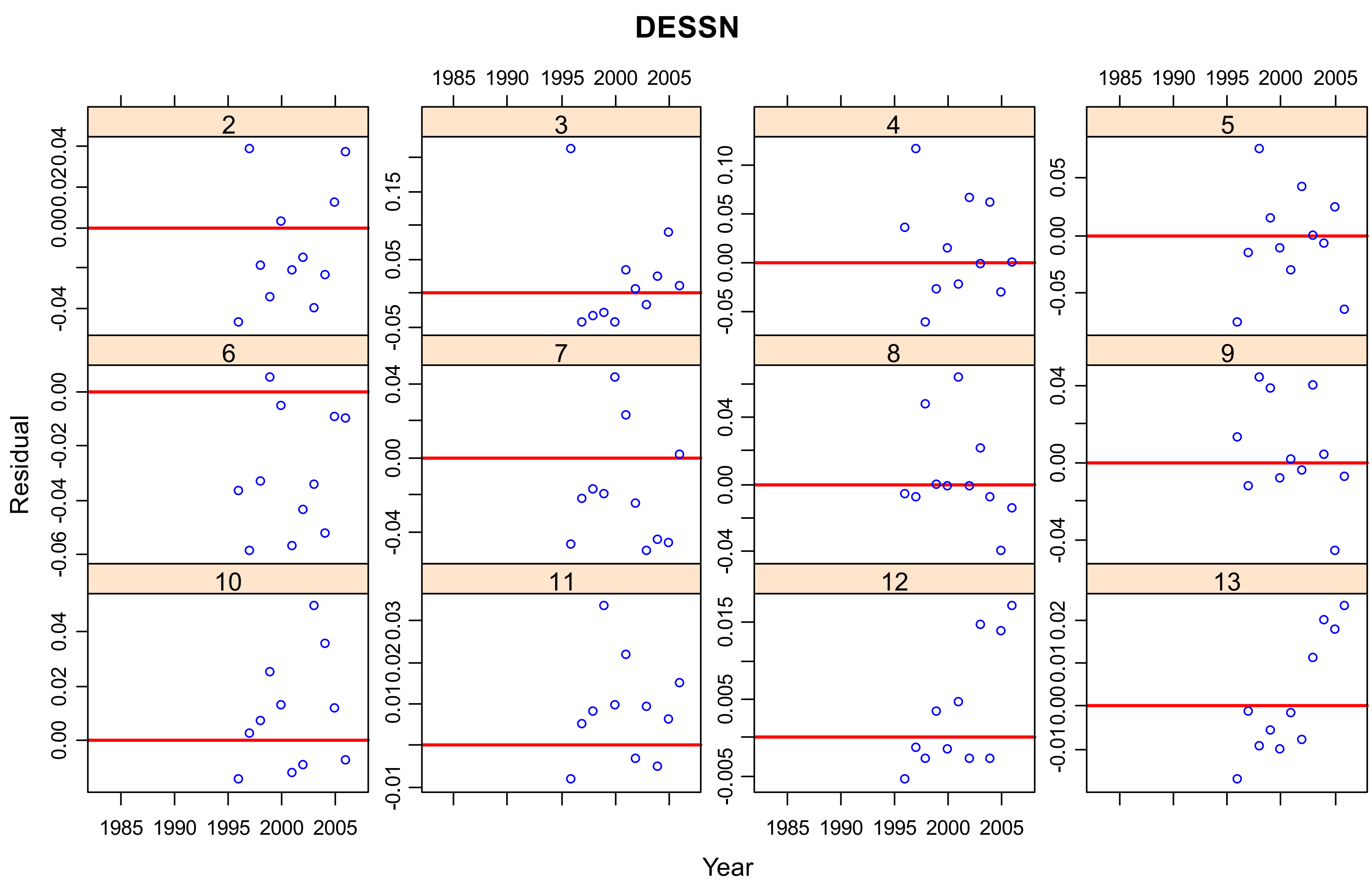



Figure 24. Residuals of annual survey age compositions by age for the Delaware electrofishing survey

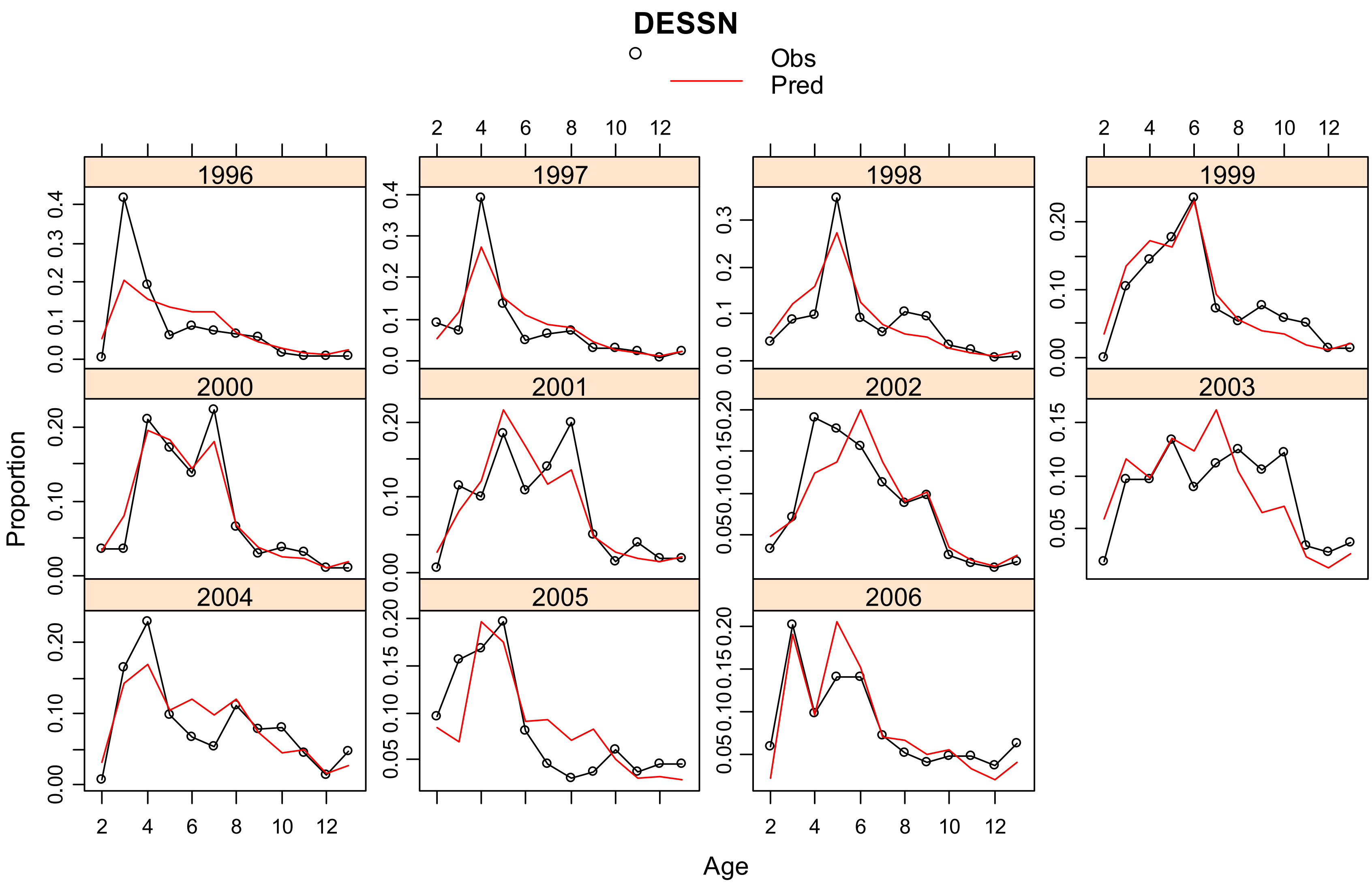



Figure 25. Observed and predicted survey age compositions by year for the Delaware electrofishing survey

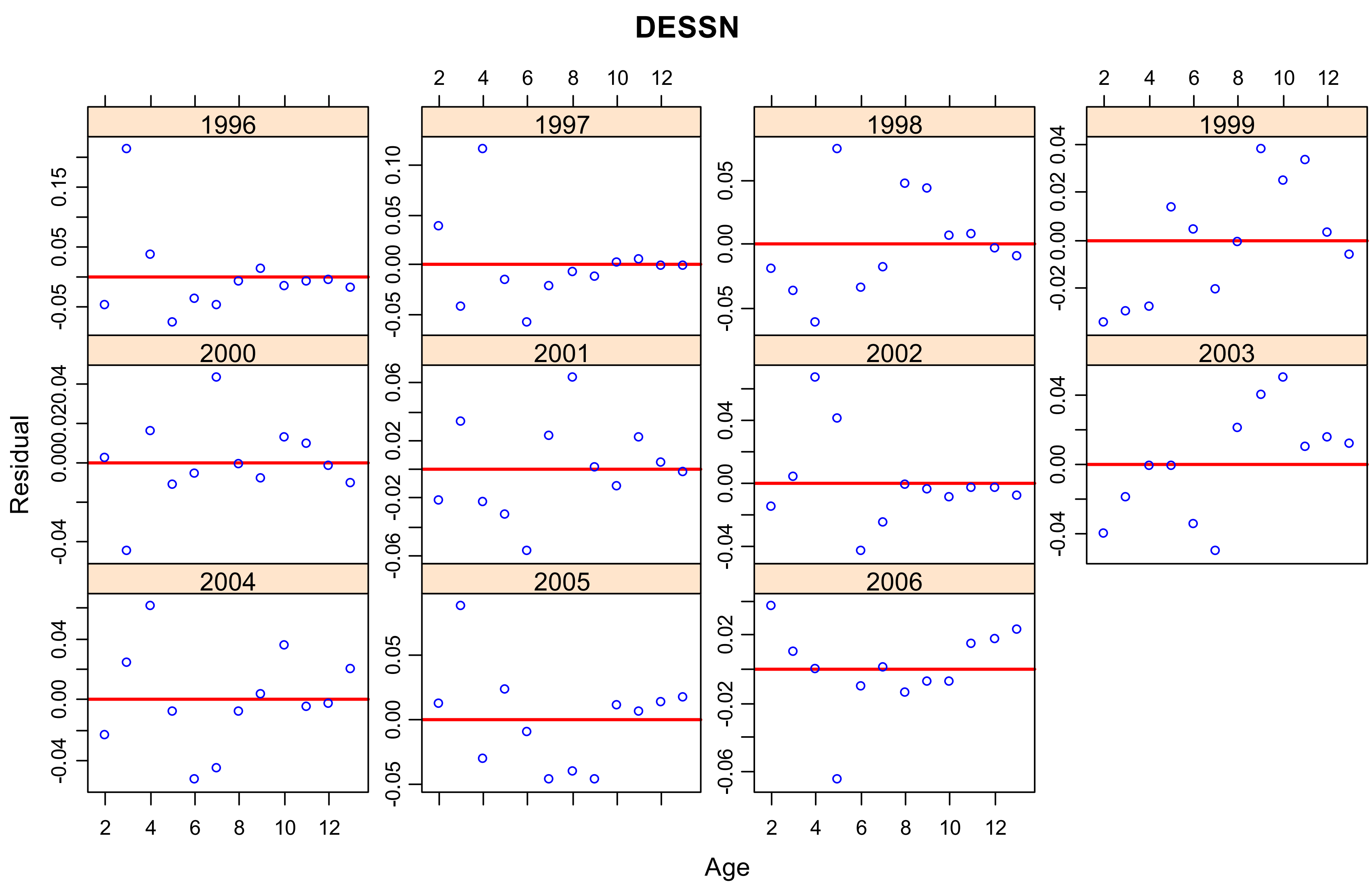



Figure 26. Residuals of survey age compositions by year for the Delaware electrofishing survey

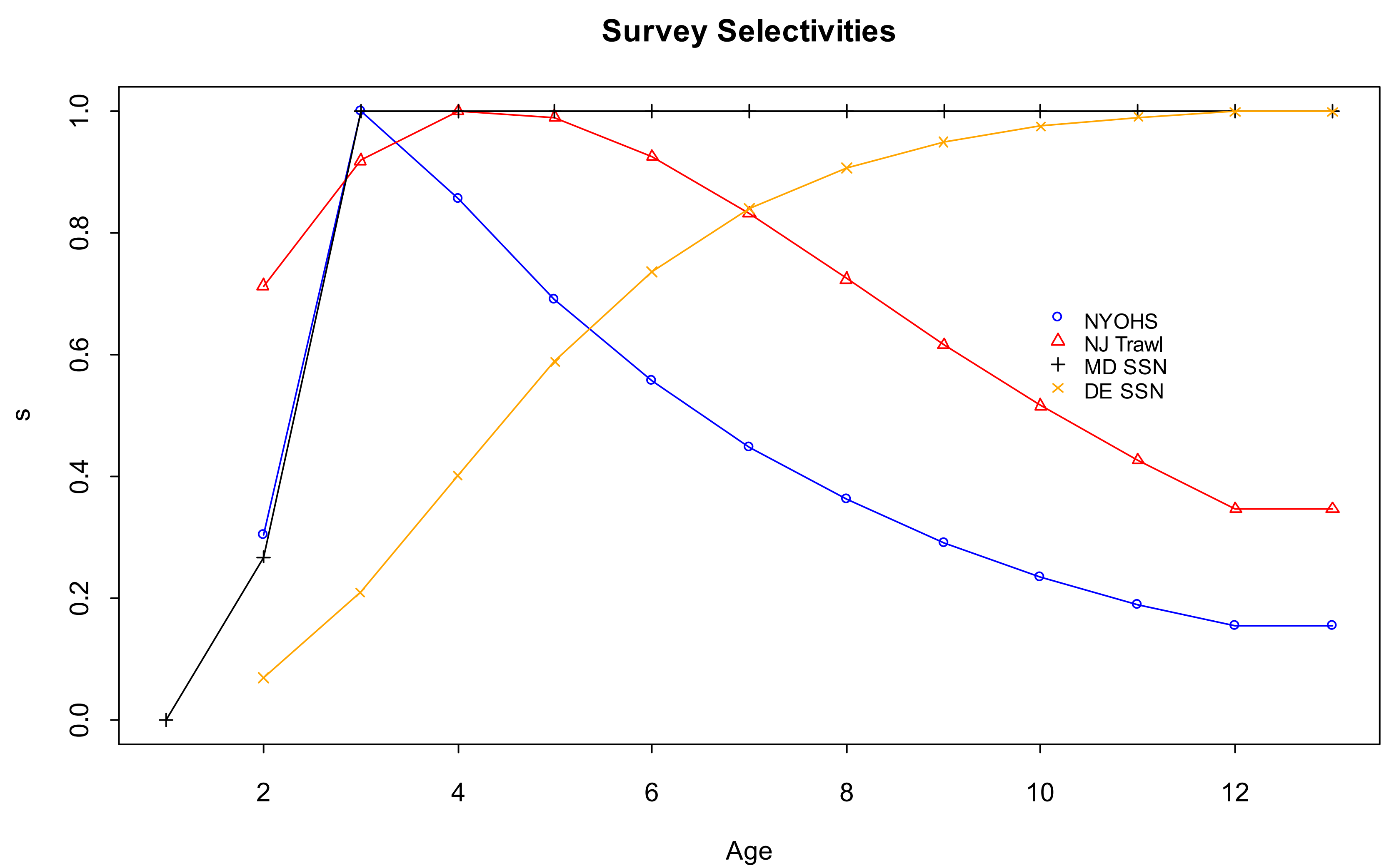



Figure 27. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD gillnet, and DE electrofishing surveys

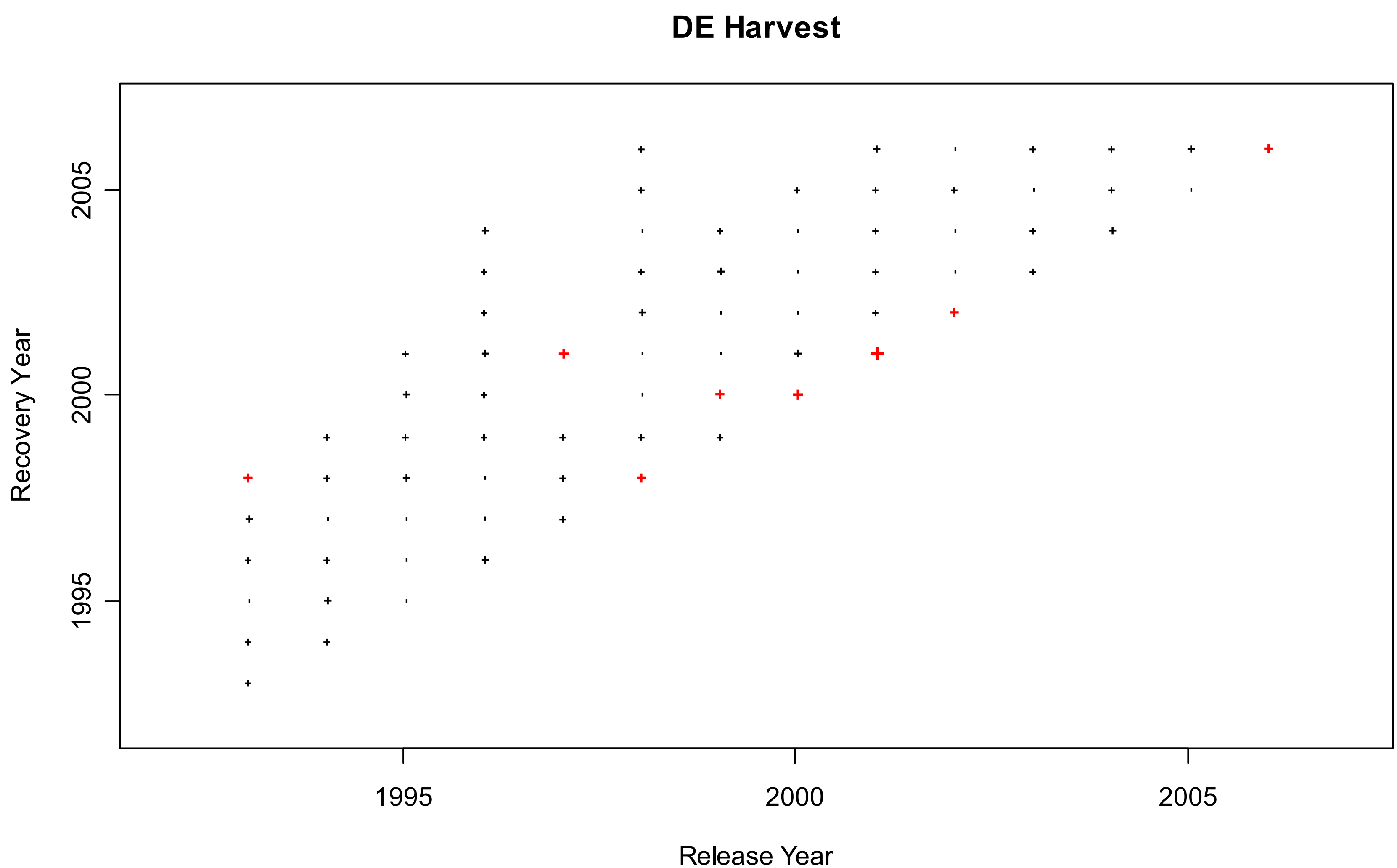



Figure 28. Residuals plots for the harvest and catch/release tag returns. The symbols represent negative (-) or positive (+) residuals, the size of the symbol represents the magnitude of the chi-square value, and the color red signifies that the cell chi-square value is significant at p<=0.05, df=1.

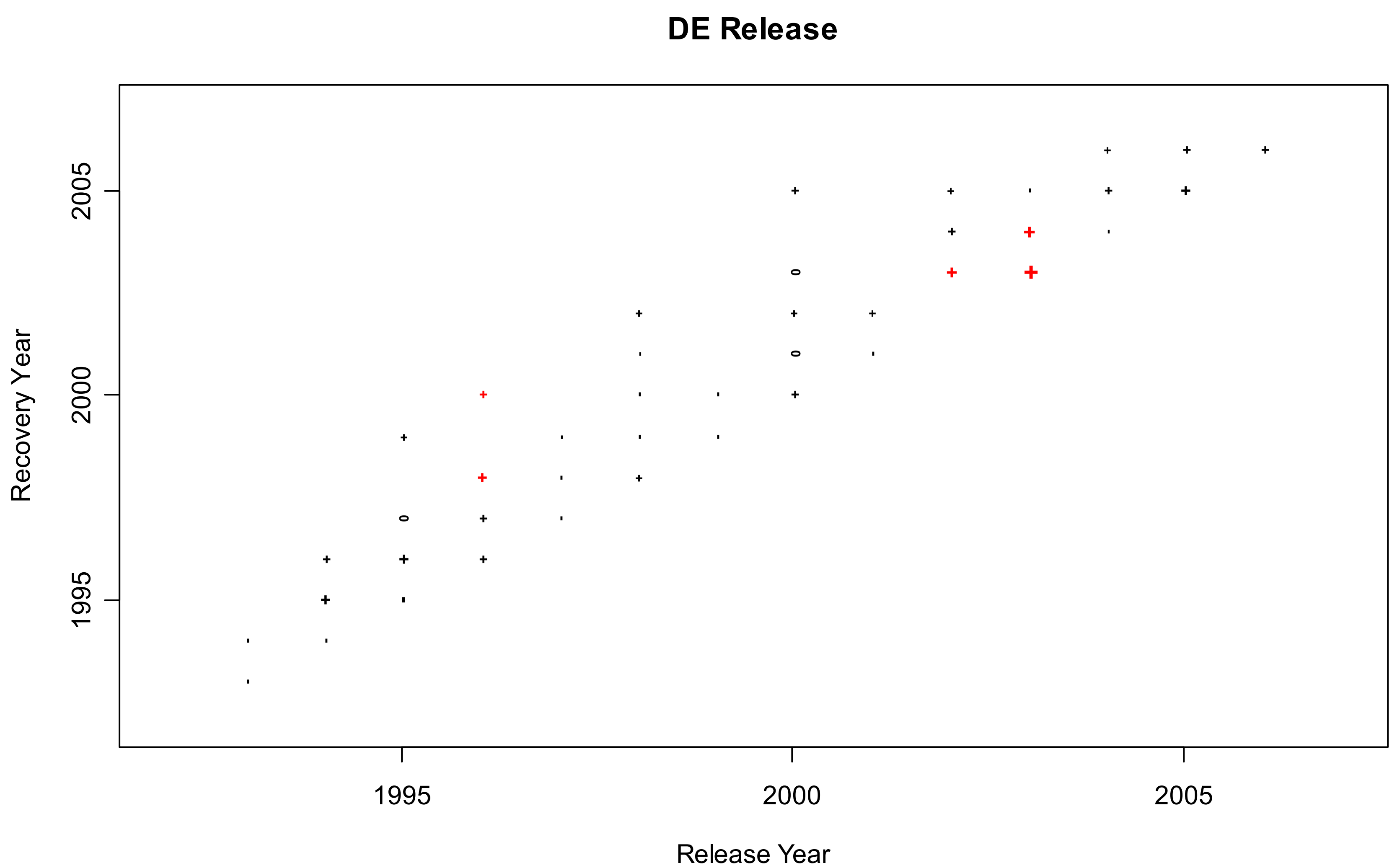



Figure 28 continued.

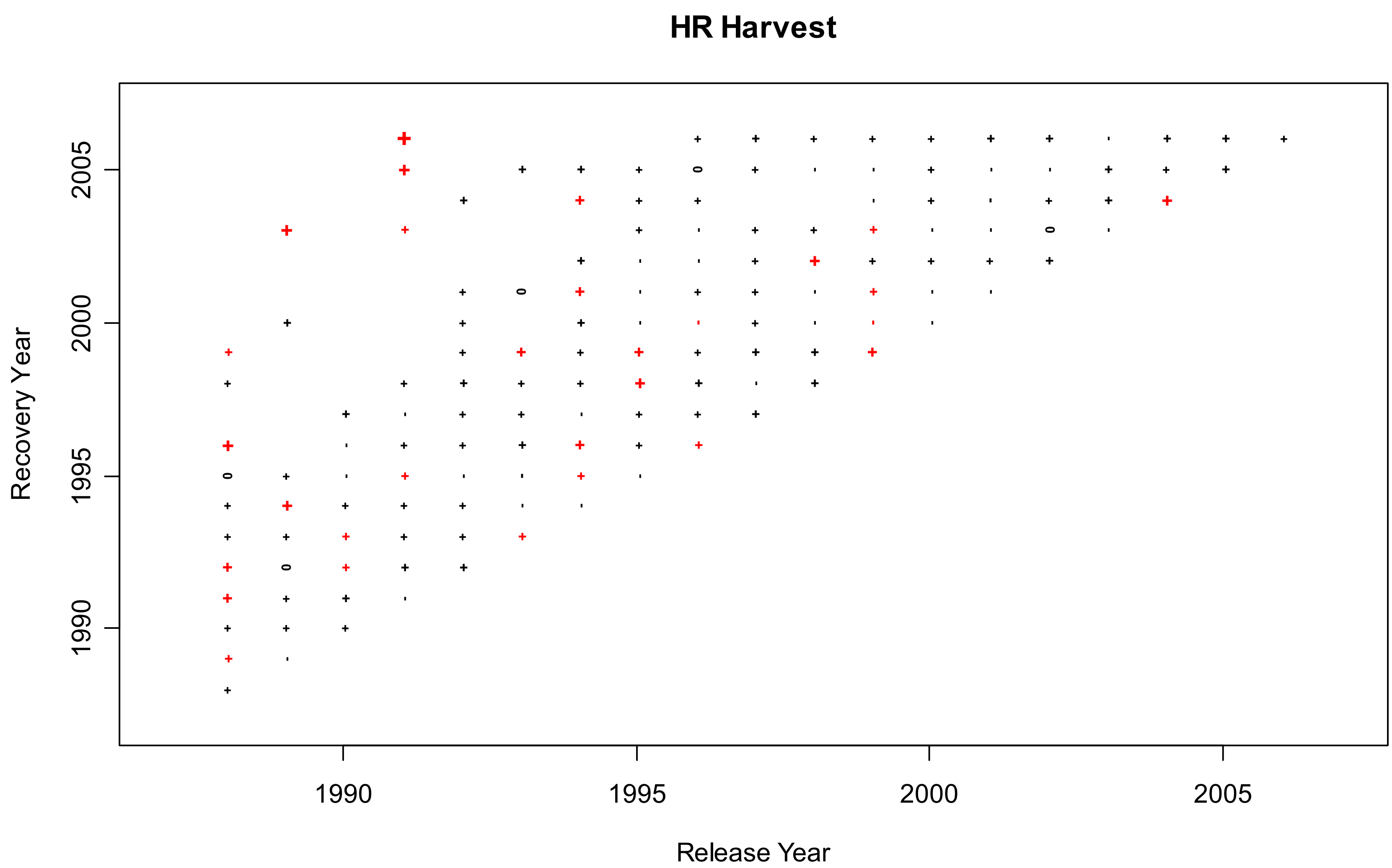



Figure 28 continued.

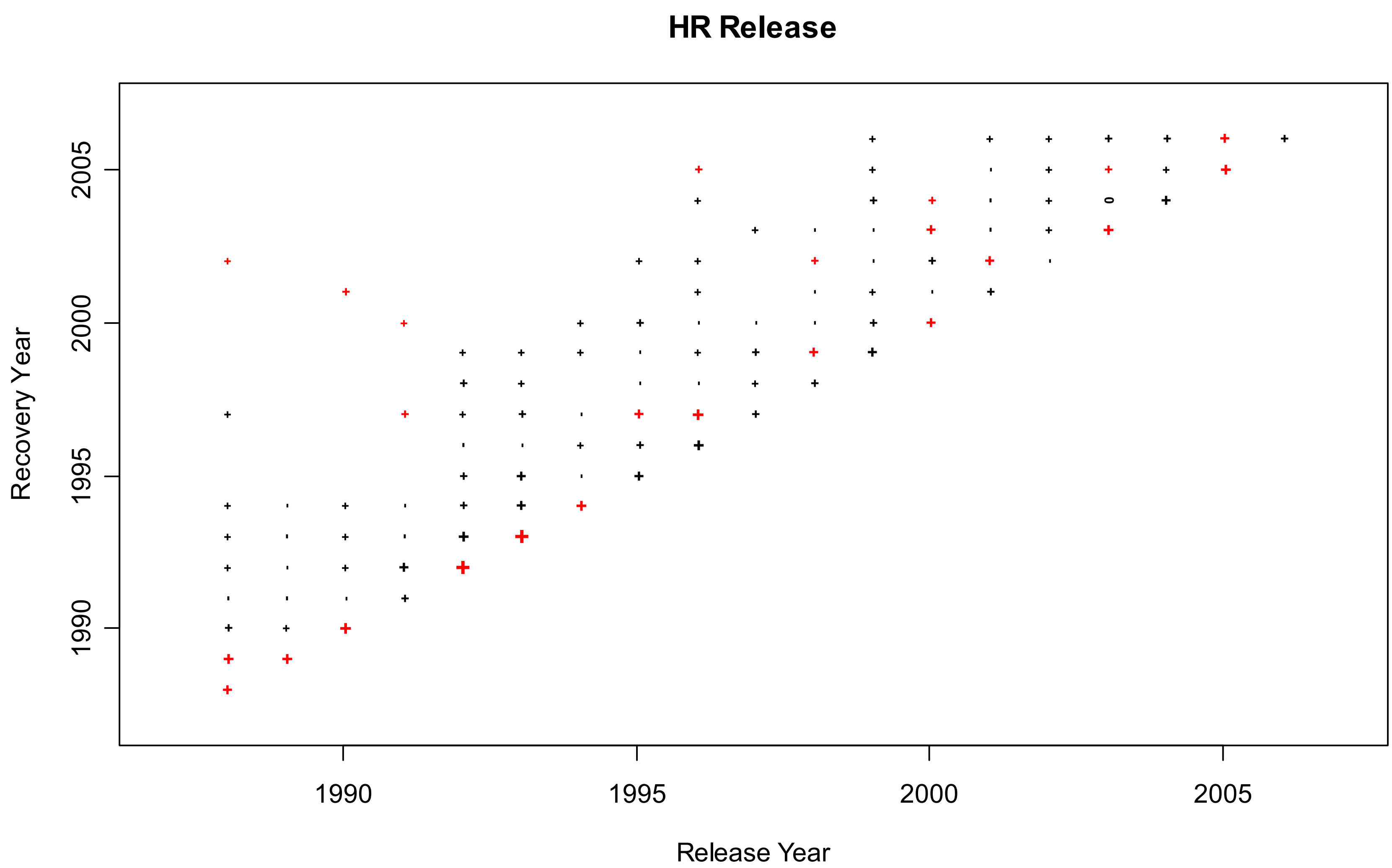



Figure 28 continued.

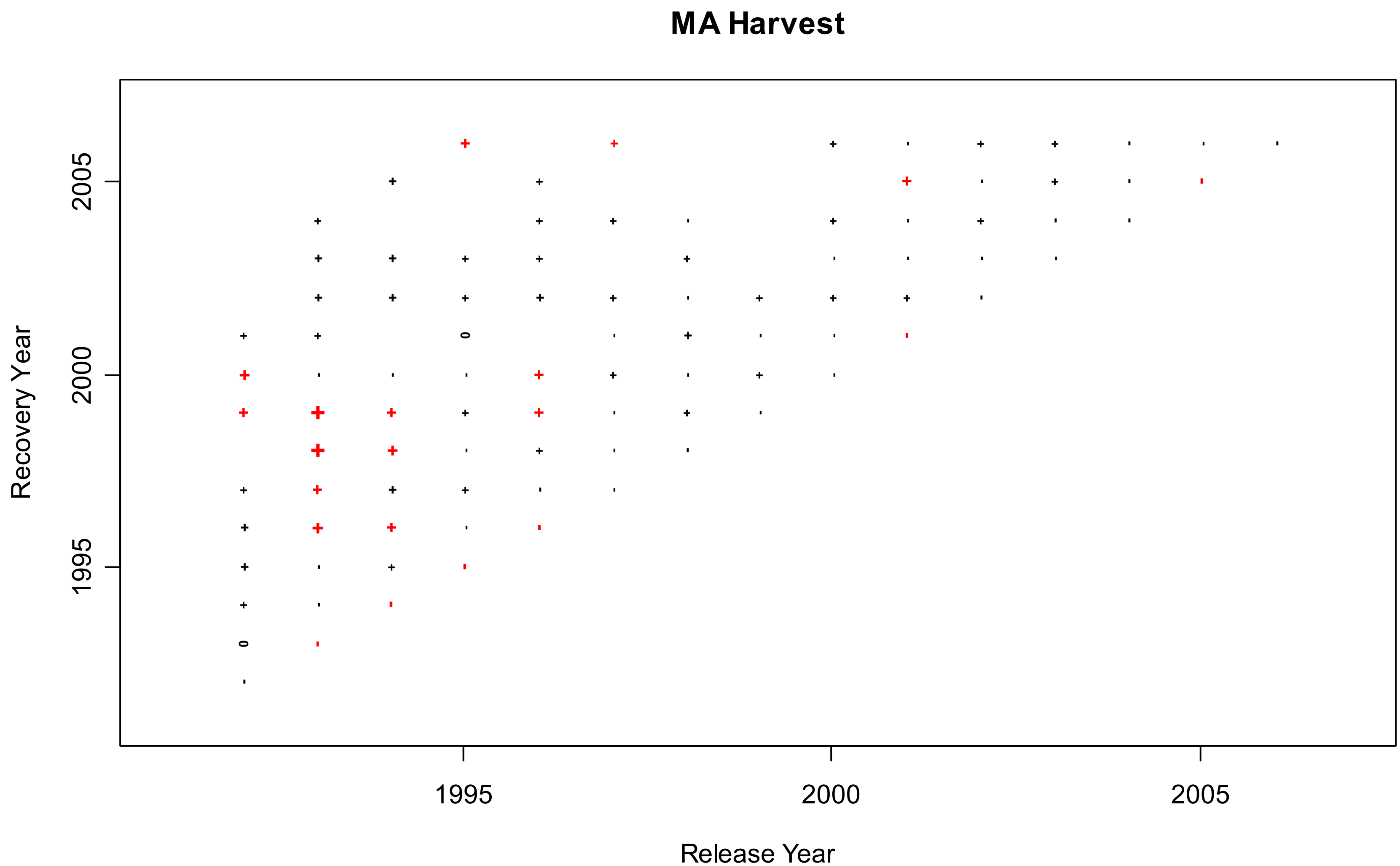


Figure 28 continued.

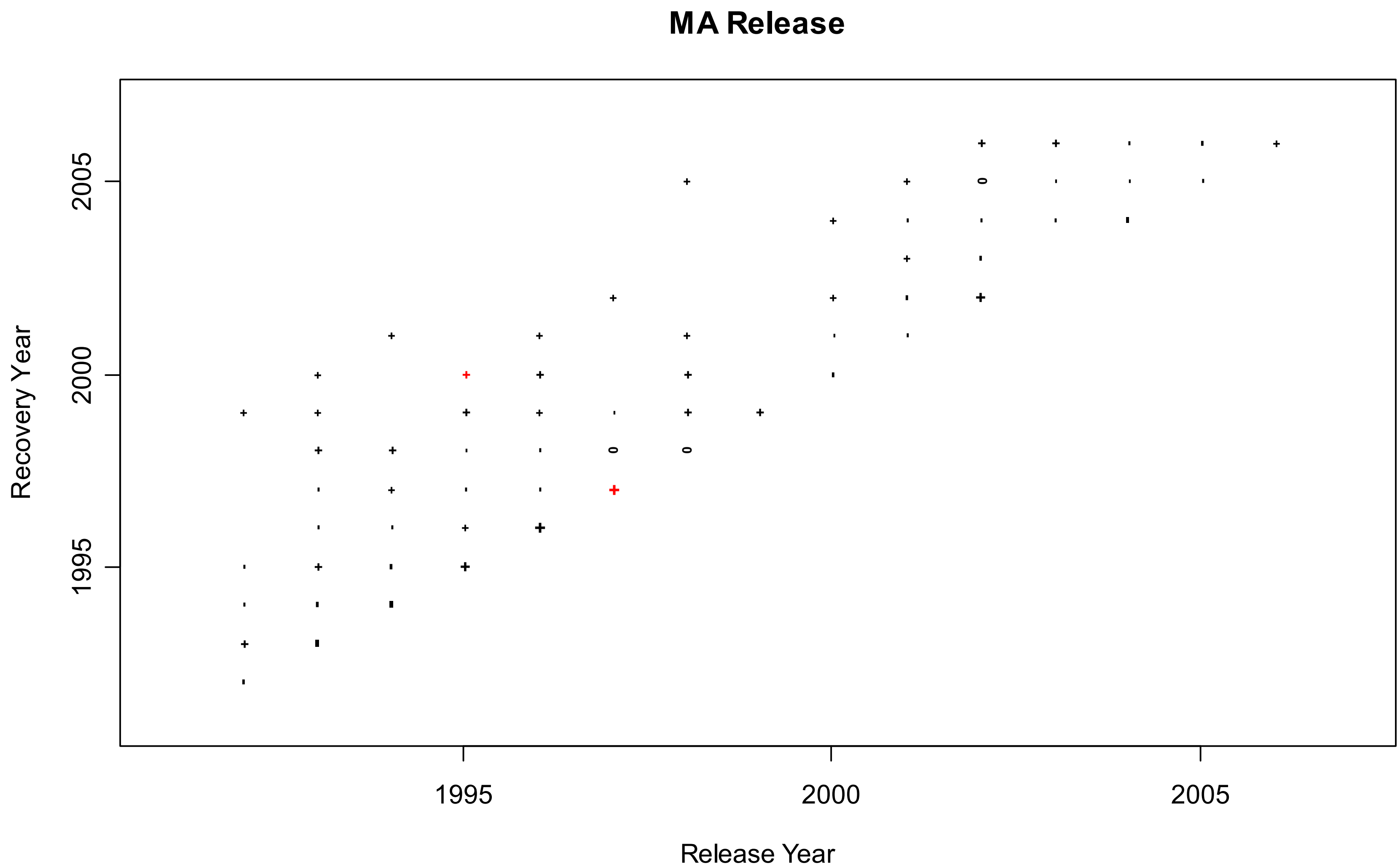



Figure 28 continued.

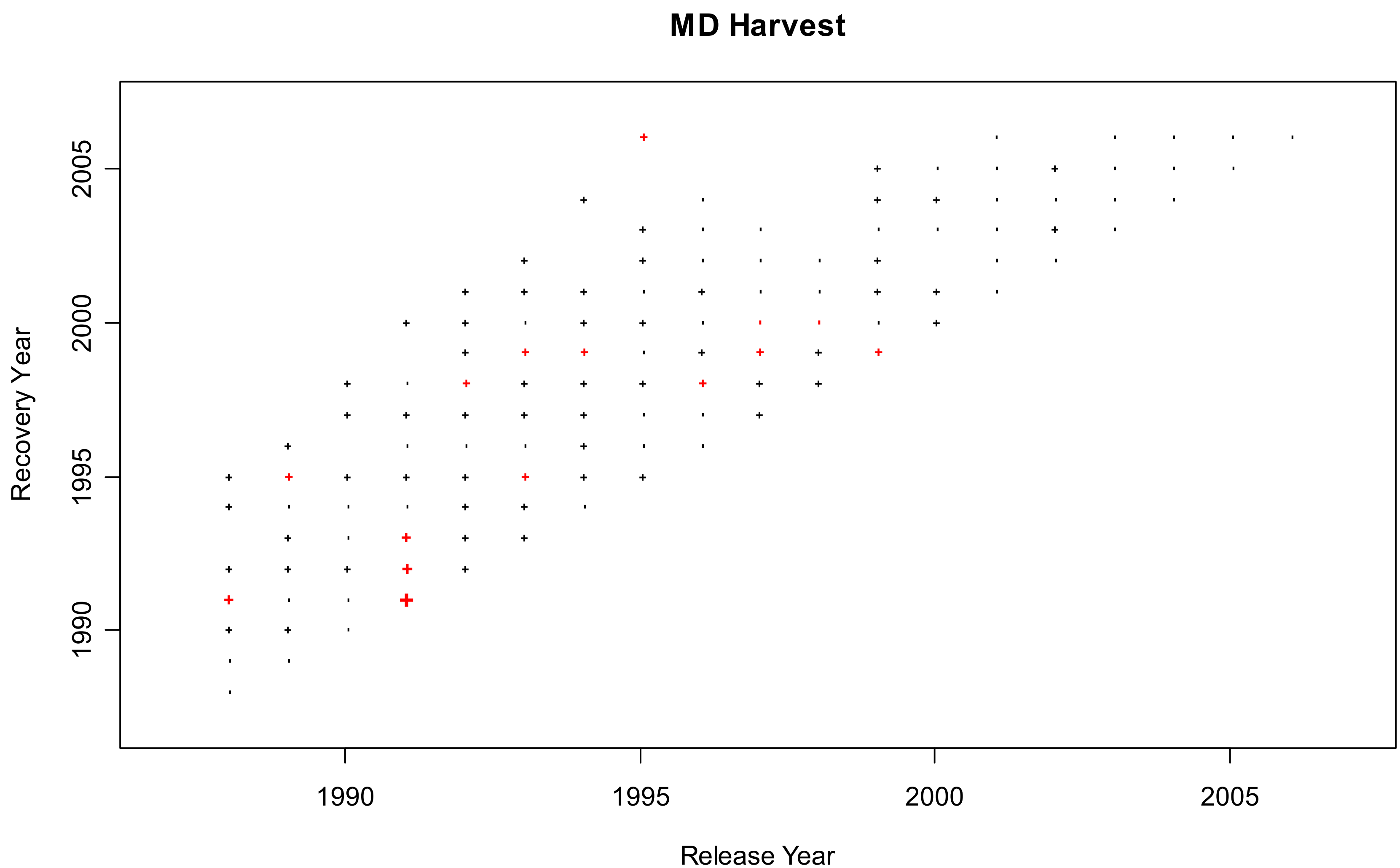



Figure 28 continued.

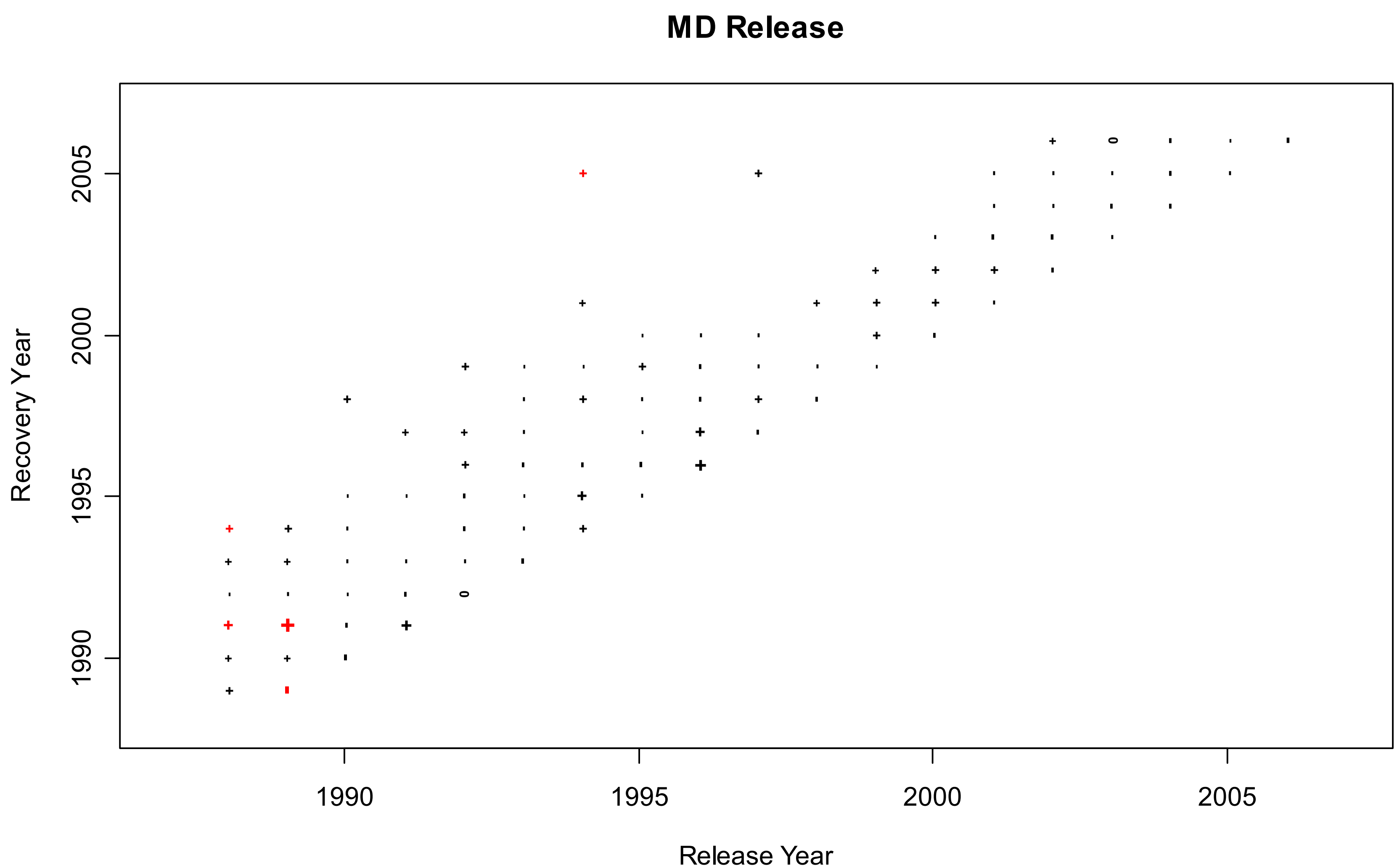



Figure 28 continued.

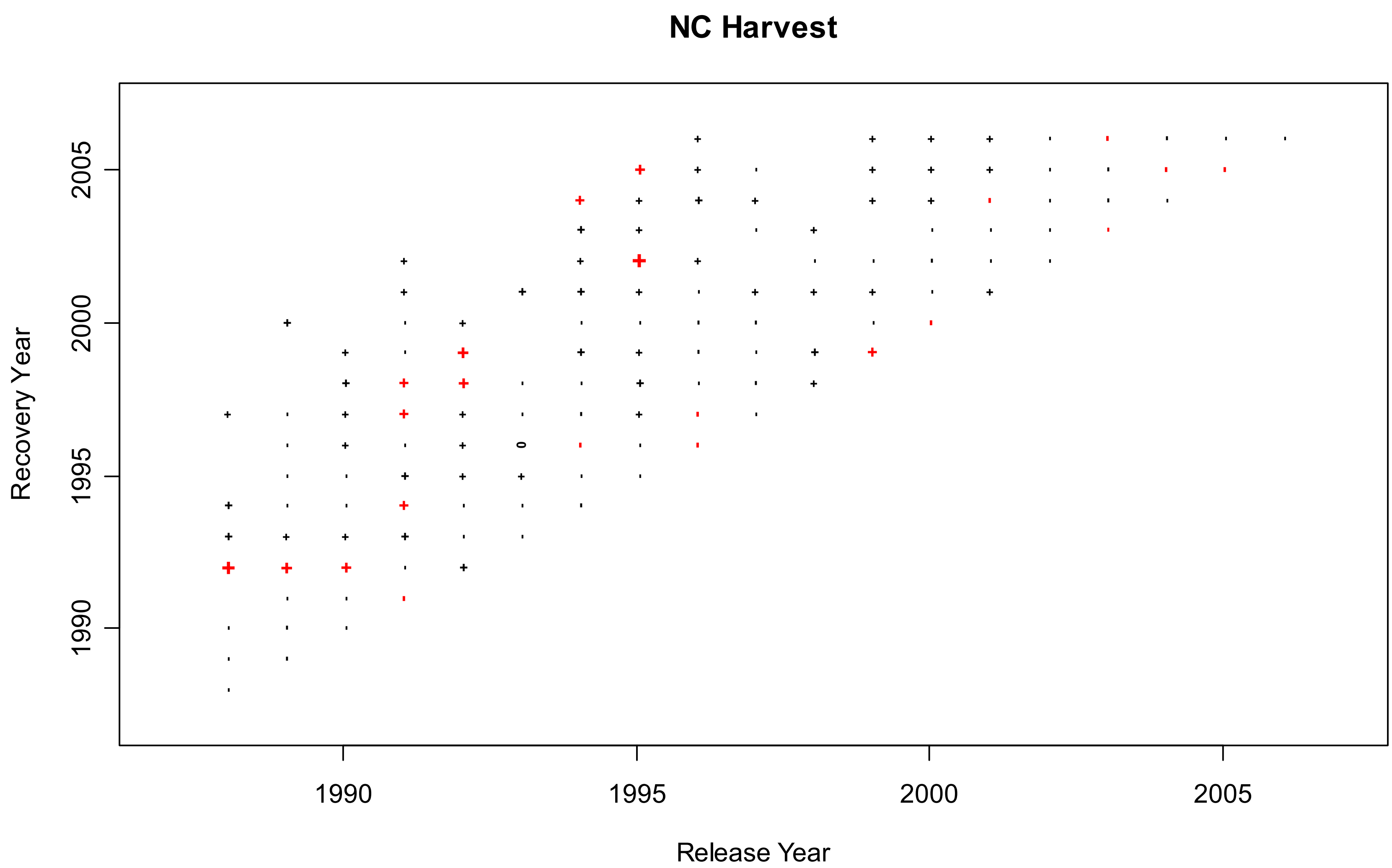



Figure 28 continued.

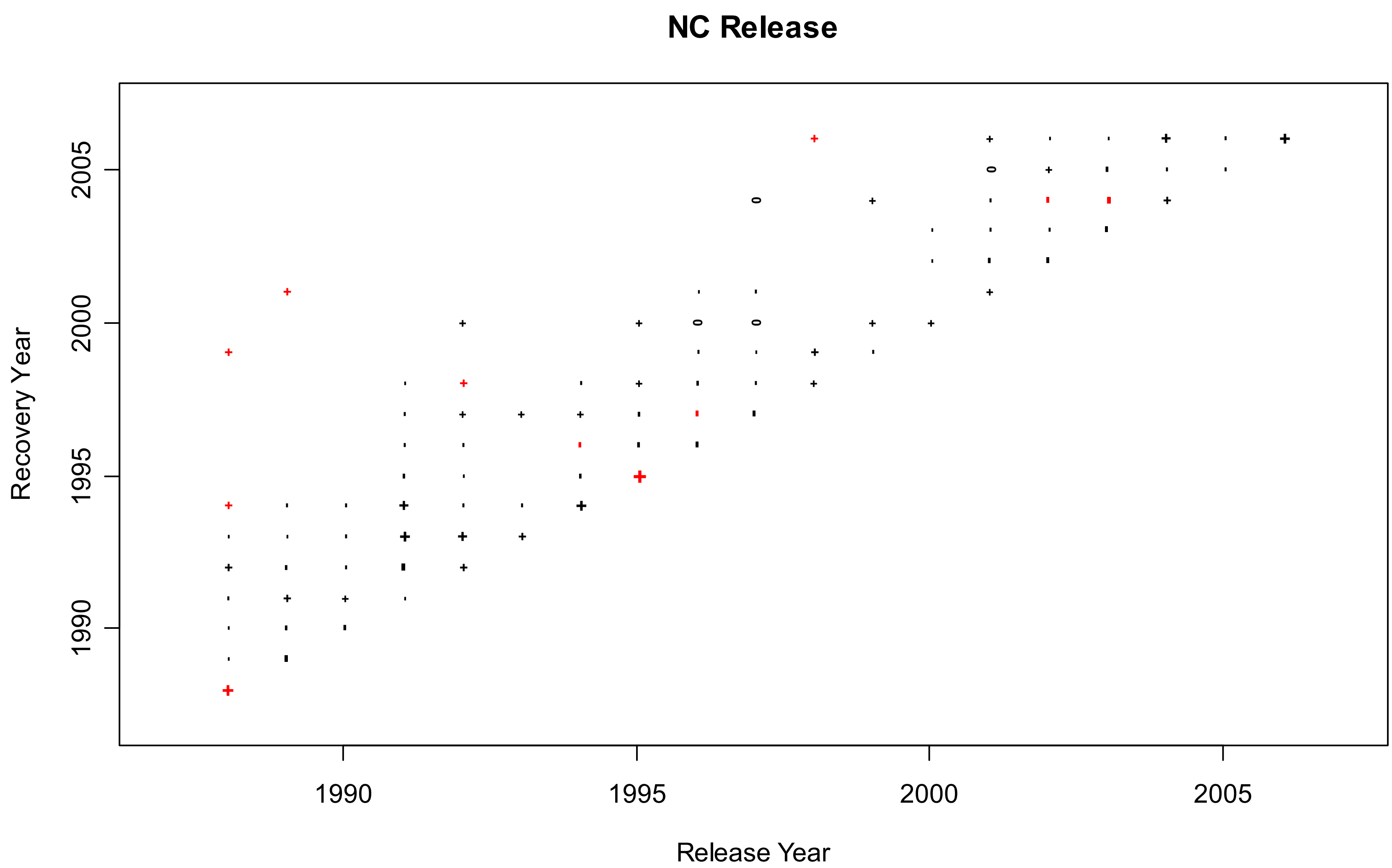



Figure 28 continued.

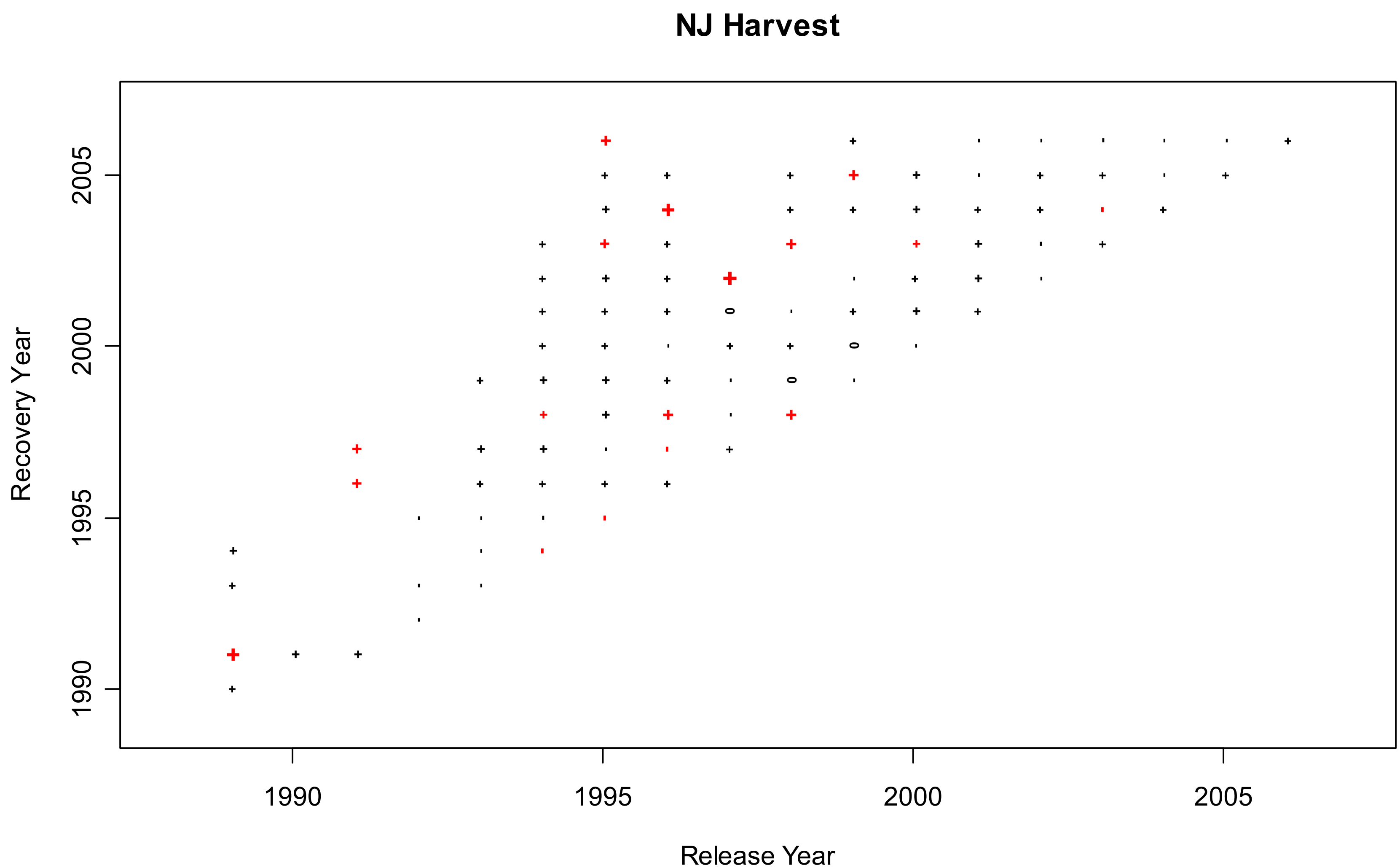



Figure 28 continued.

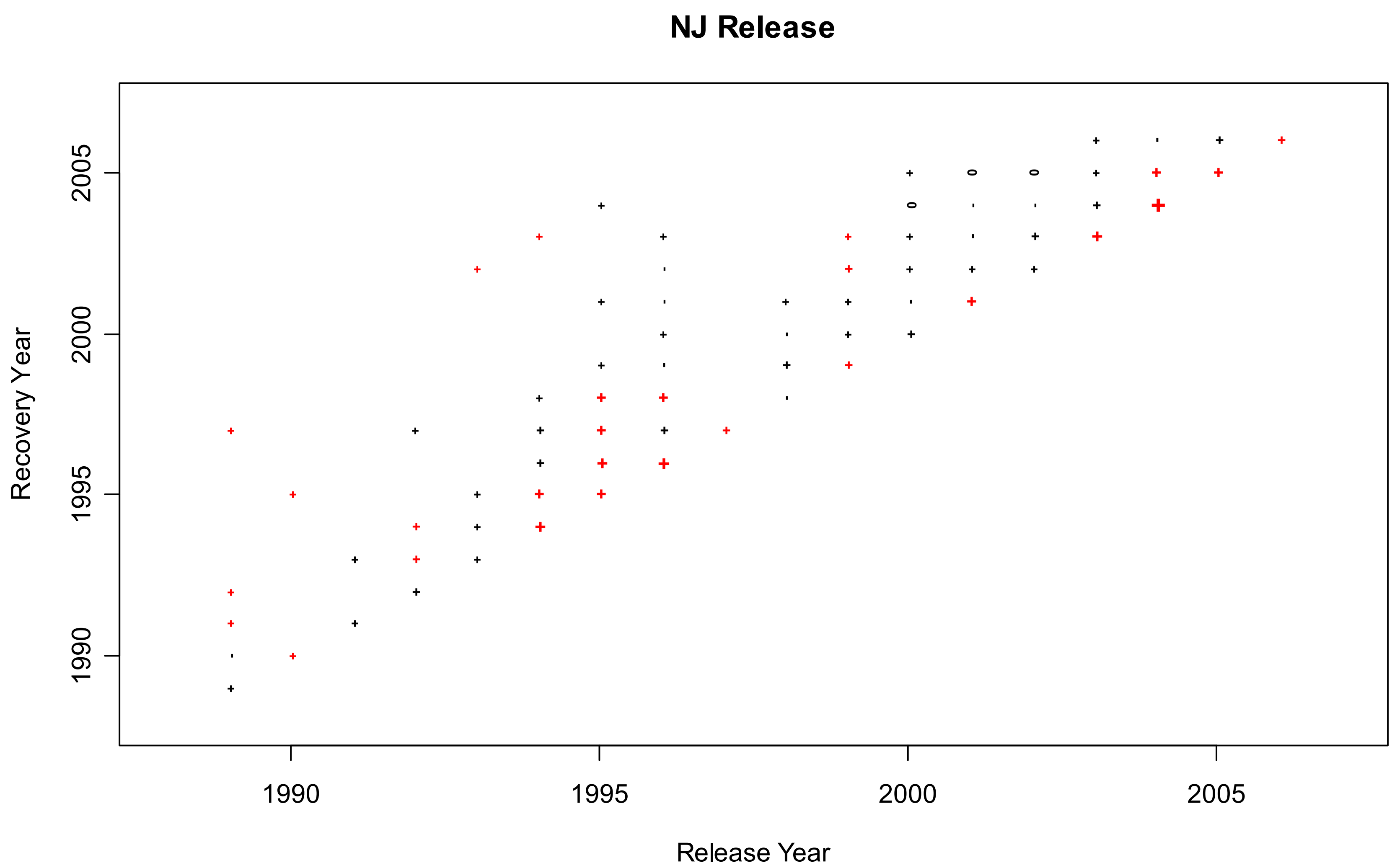



Figure 28 continued.

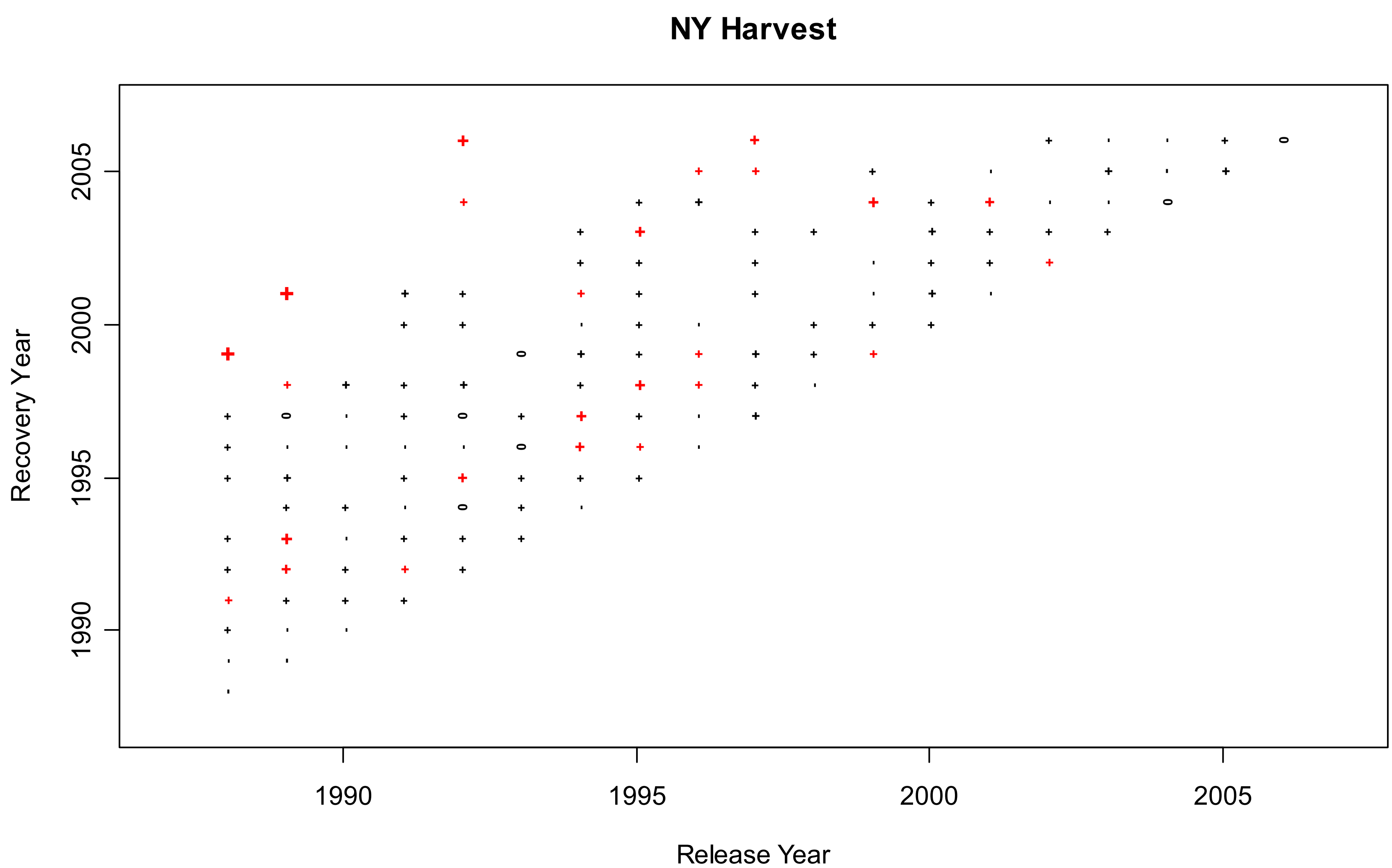



Figure 28 continued.

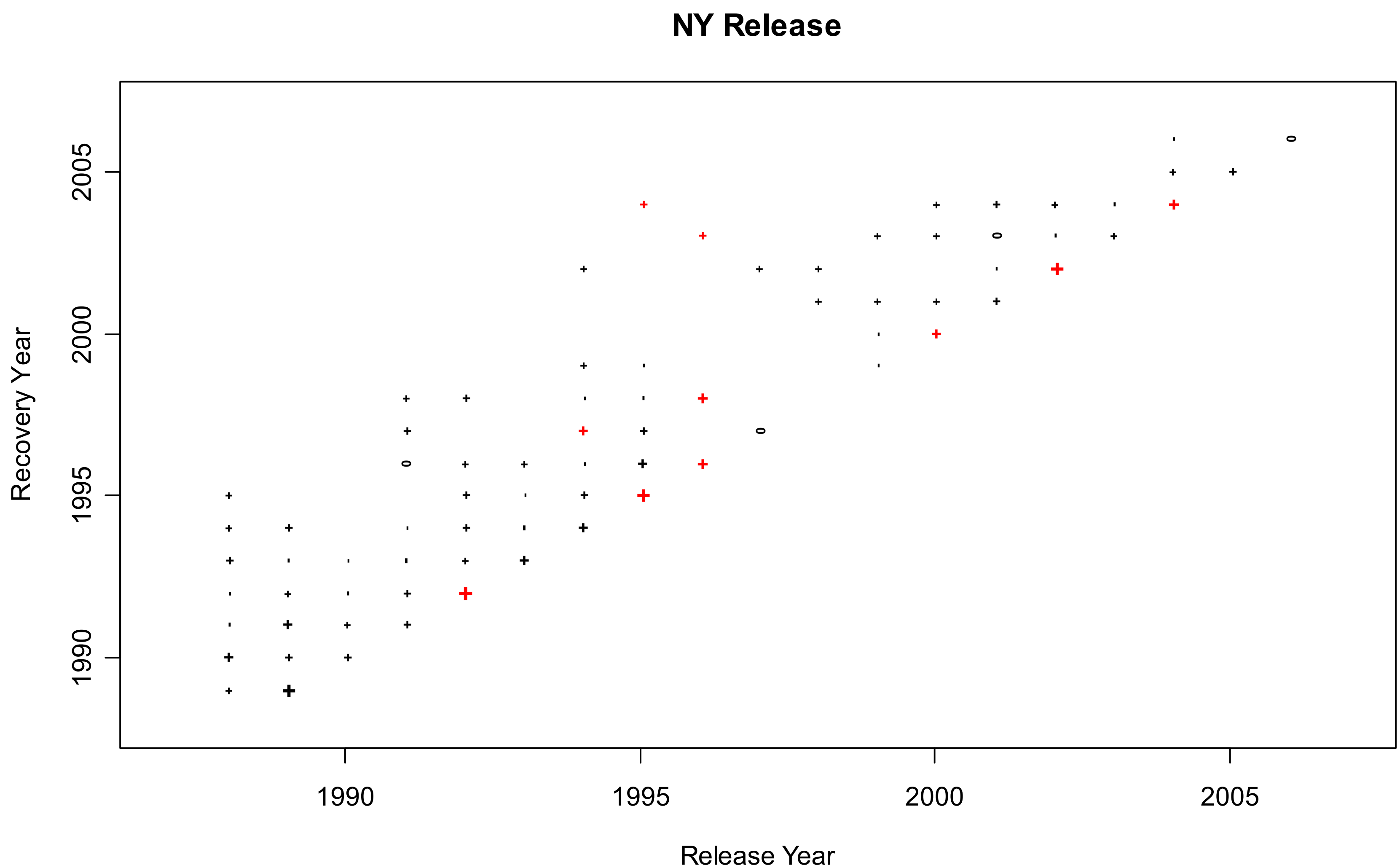



Figure 28 continued.

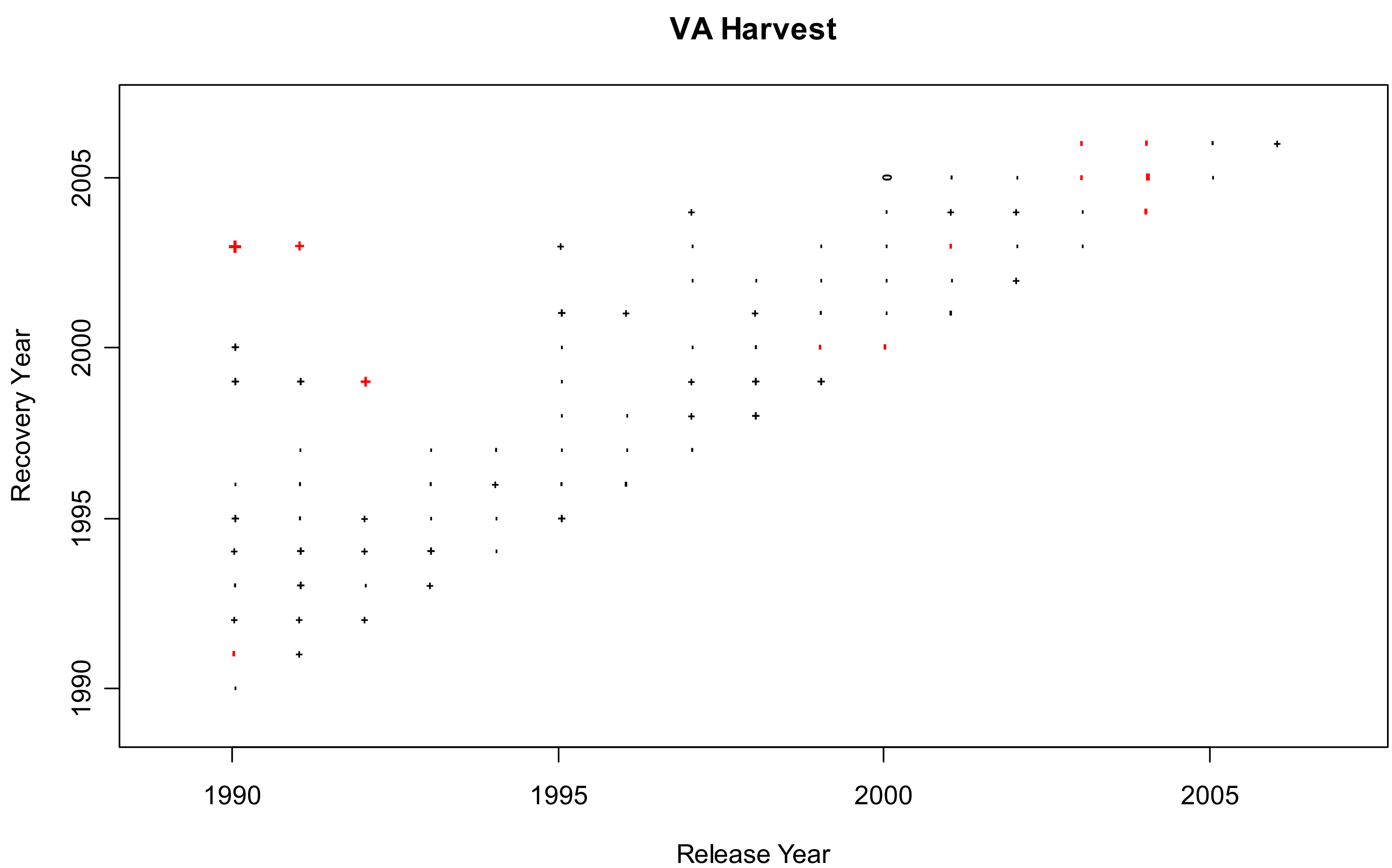



Figure 28 continued.

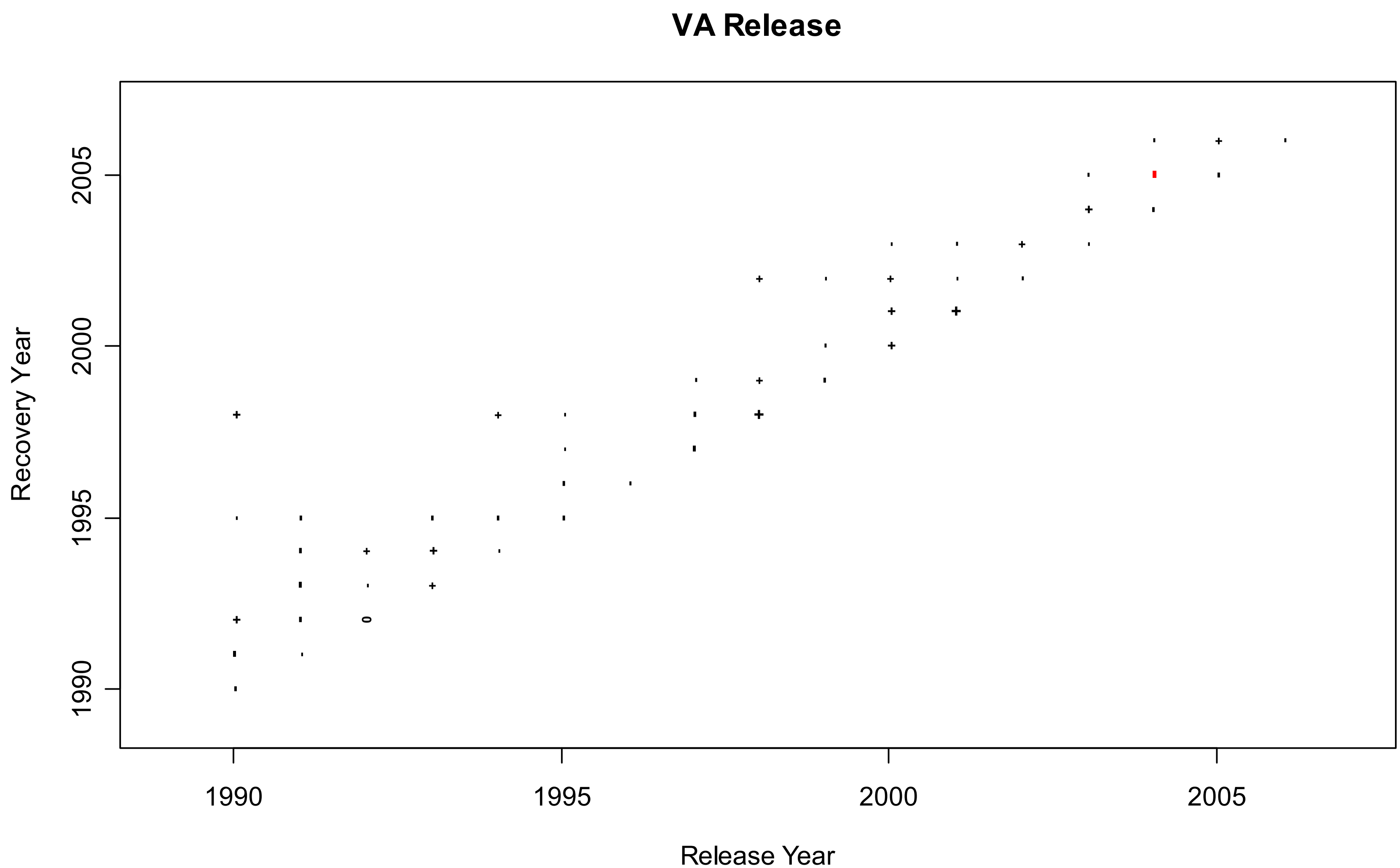



Figure 28 continued.