SEDAR

Southeast Data, Assessment, and Review

Stock Assessment Report
of
SEDAR 9

Gulf of Mexico Vermilion Snapper

SEDAR 9
Assessment Report 3

2006

SEDAR
One Southpark Circle #306
Charleston, SC 29414
(843) 571-4366

Table of Contents

SEDAR 9

Stock Assessment Report 3

Gulf of Mexico Vermilion Snapper

SECTION I. Introduction

SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

1. SEDAR Overview

SEDAR (Southeast Data, Assessment and Review) was initially developed by the Southeast Fisheries Science Center and the South Atlantic Fishery Management Council to improve the quality and reliability of stock assessments and to ensure a robust and independent peer review of stock assessment products. SEDAR was expanded in 2003 to address the assessment needs of all three Fishery Management Council in the Southeast Region (South Atlantic, Gulf of Mexico, and Caribbean) and to provide a platform for reviewing assessments developed through the Atlantic and Gulf States Marine Fisheries Commissions and state agencies within the southeast.

SEDAR strives to improve the quality of assessment advice provided for managing fisheries resources in the Southeast US by increasing and expanding participation in the assessment process, ensuring the assessment process is transparent and open, and providing a robust and independent review of assessment products. SEDAR is overseen by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: the Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commissions: the Executive Directors of the Atlantic States and Gulf States Marine Fisheries Commissions.

SEDAR is organized around three workshops. First is the Data Workshop, during which fisheries, monitoring, and life history data are reviewed and compiled. Second is the Assessment workshop, during which assessment models are developed and population parameters are estimated using the information provided from the Data Workshop. Third and final is the Review Workshop, during which independent experts review the input data, assessment methods, and assessment products.

SEDAR workshops are organized by SEDAR staff and the lead Council. Data and Assessment Workshops are chaired by the SEDAR coordinator. Participants are drawn from state and federal agencies, non-government organizations, Council members, Council advisors, and the fishing industry with a goal of including a broad range of disciplines and perspectives. All participants are expected to contribute to the process by preparing working papers, contributing, providing assessment analyses, and completing the workshop report.

SEDAR Review Workshop Panels consist of a chair and 3 reviewers appointed by the Center for Independent Experts (CIE), an independent organization that provides independent, expert reviews of stock assessments and related work. The Review Workshop Chair is appointed by the SEFSC director and is usually selected from a NOAA Fisheries regional science center. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers to the review workshop.

SEDAR 9 was charged with assessing 3 stocks under the jurisdiction of the Gulf of Mexico Fishery Management Council: greater amberjack, gray triggerfish, and vermilion snapper.

2. Management Overview

2.1 Management Unit Definition

Vermilion snapper is one of 14 snappers of 40 species of reef fish in the management unit for the Gulf of Mexico Reef Fish FMP. Two are not managed, leaving 15 groupers, 14 snappers, five tilefishes, four jacks, one triggerfish and one wrasse. The jurisdiction of the Gulf of Mexico Reef Fish FMP includes all waters of the GOM bounded outside by 200 nautical miles (nm) and inside by the state's territorial waters which are 3 nm in Alabama, Mississippi and Louisiana and 3 leagues or about 9 nm in Florida and Texas.

2.2 History of Management Relating to Vermilion Snapper

The following history of management only pertains to vermilion snapper management or regulations that could secondarily affect vermilion snapper so some reef fish amendments may not be listed. Management objectives are listed in Table 2.1 and reference the FMP or amendment establishing the respective objectives. Please contact the Gulf of Mexico Fishery Management Council for a complete history of reef fish management in the Gulf of Mexico.

2.2.1 Fishery management plan and regulatory amendments

The Reef Fish FMP (with its associated EIS) was implemented in November 1984. It established four management objectives for the reef fish fishery (Table 2.1). The FMP established the list of species in the management unit, which included vermilion snapper, and an inshore stressed area within which certain gear was prohibited, including fish traps and roller trawls [49FR 39548].

Amendment 1 (with its associated environmental assessment [EA], regulatory impact review [RIR], and initial regulatory flexibility analysis [IRFA]) to the Reef Fish Fishery Management Plan, was implemented in January, 1990. It revised and added seven objectives to the FMP (Table 2.1).

Amendment 1 set a vermilion snapper minimum size limit of 8 inches TL; however, vermilion snapper were excluded from the 10-snapper recreational bag limit. A framework procedure for specification of total allowable catch (TAC) was created to allow for annual management changes. The procedure included subdividing TAC into commercial and recreational allocations of 67 percent and 33 percent respectively. This amendment required a commercial vessel reef fish permit for harvest in excess of the bag limit, and for the sale of reef fish. In addition, this amendment prohibited the use of longline and buoy gear for the directed harvest of reef fish inside of the 50-fathom isobath west of Cape San Blas, Florida (85E30'W) and inside of the 20-fathom isobath east of Cape San Blas, Florida (85E30'W) [55 FR 2078].

Amendment 4 (with its associated EA and RIR), implemented in May 1992, established a moratorium on the issuance of new commercial reef fish vessel permits for a maximum period of three years [57 FR 11914].

Amendment 5 (with its associated SEIS, RIR, and IRFA), implemented in February 1994, required that all finfish, except for oceanic migratory species, be landed with head and fins attached, and closed the region of Riley's Hump (near Dry Tortugas, Florida) to all fishing during May and June to protect mutton snapper spawning aggregations [59 FR 966].

Amendment 8 (with its associated EA and RIR) was implemented in July 1995. This amendment proposed to establish a red snapper individual transferable quota system; however, the regulatory portions of the amendment were disapproved through Congressional action. Amendment 8 added and revised five management objectives of the FMP (Table 2.1) [60 FR 61200].

Amendment 11 (with its associated EA and RIR) was partially approved by NOAA Fisheries and implemented in January 1996. It implemented a new reef fish permit moratorium for no more than five years or until December 31, 2000, during which time the Council was to consider limited access for the reef fish fishery [60 FR 64356].

Amendment 12 (with its associated EA and RIR), submitted in December 1995 and implemented in January 1997. It created an aggregate bag limit of 20 reef fish for all reef fish species (including vermilion snapper) not having a bag limit [61 FR 65983].

Amendment 14 (with its associated EA, RIR, and IRFA), implemented in March and April, 1997, provided for a ten-year phase-out for the fish trap fishery; allowed transfer of fish trap endorsements for the first two years and thereafter only upon death or disability of the endorsement holder, to another vessel owned by the same entity, or to any of the 56 individuals who were fishing traps after November 19, 1992, and were excluded by the moratorium; and prohibited the use of fish traps west of Cape San Blas, Florida.

Amendment 15 (with its associated EA, RIR, and IRFA), implemented in January 1998, permanently increased the vermilion snapper size limit from 8 to 10 inches TL; prohibited harvest of reef fish from traps other than permitted reef fish traps, stone crab traps, or spiny lobster traps; removed black sea bass, rock sea bass, bank sea bass, and all species of grunts and porgies from the Reef Fish FMP; and removed sand perch and dwarf sand perch from the recreational 20-reef fish aggregate bag limit. [62 FR 67714].

An August 1999 regulatory amendment (with its associated EA, RIR, and IRFA) closed two areas (i.e., created two marine reserves), known as Steamboat Lumps and Madison-Swanson (104 and 115 square nautical miles respectively), year-round to all fishing under the jurisdiction of the Council with a four-year sunset closure [65 FR 31827].

Generic Sustainable Fisheries Act Amendment (with its associated EA, RIR, and IRFA), partially approved and implemented in November 1999, set MFMT for vermilion snapper at $F_{30\%\ SPR}$. Estimates of MSY, MSST, and OY were disapproved because they were based on SPR proxies rather than biomass-based estimates [67 FR 47967].

Amendment 17 (with its associated EA), implemented by NOAA Fisheries in August 2000, extended the commercial reef fish permit moratorium for another five years, from December 31, 2000 to December 31, 2005, unless replaced sooner by a comprehensive controlled access system [65 FR 41016].

Proposed Amendment 18 is being developed as an options paper and contains several actions that could impact the vermilion snapper fishery. There are proposed measures to reduce bycatch in the reef fish fishery, add new closed areas to protect grouper spawning aggregations, and change framework procedures for developing and managing TACs.

Amendment 19, also known as the **Generic Amendment Addressing the Establishment of the Tortugas Marine Reserves** (with its associated EIS, RIR, and IRFA), was submitted to NOAA Fisheries in March 2001, and implemented on August 19, 2002. This amendment, affecting all FMPs for Gulf fisheries, establishes two marine reserve areas off the Tortugas and prohibits fishing for any species and anchoring by fishing vessels inside the two marine reserves [67 FR 47467].

Amendment 20, also known as the **Charter/Headboat Moratorium Amendment** (with its associated EA and RIR), amended the Reef Fish FMP and the Coastal Migratory Pelagic FMP (Amendment 14) and was implemented by NOAA Fisheries on July 29, 2002, except for some provisions which became effective on December 26, 2002. This amendment establishes a three-year moratorium on the issuance of new charter and headboat vessel permits in the recreational for-hire fisheries in the Gulf exclusive economic zone (EEZ). The moratorium expires June 16, 2006. The purpose of this moratorium is to limit future expansion in the recreational for-hire fishery while the Council monitors the impact of the moratorium and considers the need for a more comprehensive effort management system [67 FR 43558].

Amendment 21 (with its EA, RIR and IRFA) was implemented on June 3, 2004, and extended the Madison-Swanson and Steamboat Lumps closures for an additional six years. Additionally, surface trolling is to be allowed during the months of May through October; whereas, the original regulatory amendment did not allow any fishing [69 FR 24532].

Amendment 22 (with its SEIS) was submitted to NOAA Fisheries on May 25, 2004, for implementation. Besides setting biological reference points and a rebuilding plan for red snapper, it provides alternatives to improve bycatch monitoring in the reef fish fishery. When implemented, these monitoring requirements will improve future stock assessments for vermilion snapper.

Amendment 23 (with SEIS, RIR and IRFA) implemented in May 2005 set biological reference points and a rebuilding plan for vermilion snapper MSY for vermilion snapper is the yield associated with F_{MSY} when the stock is at equilibrium. OY is the yield corresponding to a fishing mortality rate (F_{OY}) defined as 0.75*F_{MSY} (or F_{MSY} proxy) when the stock is at equilibrium. Maximum Fishing Mortality Threshold (MFMT) is set equal to F_{MSY}. Minimum Stock Size Threshold (MSST) is set equal to (1-M)*B_{MSY} (or B_{MSY} proxy). The ten-year rebuilding plan used a stepped approach, setting the TAC for 2004 -2007 at 1.475 million pounds, 2008-2010 at 2.058 million pounds and 2011-2013 at 2.641 million pounds. The minimum size for recreationally and commercially caught vermilion snapper was increased from 10 inches TL to 11 inches TL and the recreational bag limit was set at 10 fish within the 20-reef fish aggregate bag limit. Additionally, a commercial closed season was established from April 22 through May 31.

2.2.2 Control date notices

Control date notices are used to inform fishermen that a license limitation system or other method of limiting access to a particular fishery or fishing gear is under consideration. If a program to limit access is established, anyone not participating in the fishery or using the fishing gear by the published control date may be ineligible for initial access to participate in the fishery or to use that fishing method. However, a person who does not receive an initial eligibility may be able to enter the fishery or fishing method after the limited access system is established by transfer of the eligibility from a current participant, provided the limited access system allows such transfer. Publication of a control date does not obligate the Council to use that date as an initial eligibility criteria. A different date could be used, and additional qualification criteria could be established. The announcement of a control date is primarily intended to discourage entry into the fishery or use of the gear based on economic speculation during the Council's deliberation on the issues. The following summarizes control dates that have been established for the Reef Fish FMP.

November 18, 1998 - The Council is considering whether there is a need to impose additional management measures limiting entry into the recreational-for-hire (i.e., charter vessel and headboat) fisheries for reef fish and coastal migratory pelagic fish in the EEZ of the Gulf of Mexico and, if there is a need, what management measures should be imposed. Possible measures include the establishment of a limited entry program to control participation or effort in the recreational for-hire fishery for reef fish and coastal migratory pelagics. [63 FR 64031]. (In the Charter/Headboat Moratorium Amendment, approved by the Council for submission to NOAA Fisheries in March 2001, a qualifying date of March 29, 2001 was adopted.)

November 1, 1989 - Anyone entering the commercial reef fish fishery in the Gulf of Mexico and South Atlantic after November 1, 1989, may not be assured of future access to the reef fish resource if a management regime is developed and implemented that limits the number of participants in the fishery [54 FR 46755].

July 12, 2000 - The Council is considering whether there is a need to limit participation by gear type in the commercial reef fish fisheries in the EEZ of the Gulf of Mexico and, if there is a need, what management measures should be imposed to accomplish this. Possible measures include modifications to the existing limited entry program to control fishery participation, or effort, based on gear type, such as a requirement for a gear endorsement on the commercial reef fish vessel permit for the appropriate gear. Gear types which may be included are longlines, buoy gear, handlines, rod-and-reel, bandit gear, spearfishing gear, and powerheads used with spears [65 FR 42978].

March 29, 2001 - The Council is considering whether there is a need to limit participation in the reef fish and coastal migratory pelagics charter and headboat fisheries. The intent of this notice is to inform the public that entrants into the charter vessel/headboat fisheries after this date may not be assured of a future access to the reef fish and/or coastal migratory pelagics resources if: 1) an effort limitation management regime is developed and implemented that limits the number of vessels or participants in the fishery; and 2) if the control date notice is used as criterion for eligibility [67 FR 32312].

2.3 Current Management Criteria and Stock Benchmarks

As established by Amendment 23 to the Reef Fish FMP, MSY for vermilion snapper is the yield associated with F_{MSY} when the stock is at equilibrium. OY is the yield corresponding to a fishing mortality rate (F_{OY}) defined as $0.75*F_{MSY}$ (or F_{MSY} proxy) when the stock is at equilibrium. Maximum Fishing Mortality Threshold (MFMT) is set equal to F_{MSY}. Minimum Stock Size Threshold (MSST) is set equal to $(1\text{-}M)*B_{MSY}$ (or B_{MSY} proxy).

The ten-year rebuilding plan used a stepped approach, setting the TAC for 2004 -2007 at 1.475 million pounds, 2008-2010 at 2.058 million pounds and 2011-2013 at 2.641 million pounds.

The current minimum size for recreationally and commercially caught vermilion snapper is 11 inches TL; the recreational bag limit is 10 fish within the 20-reef fish aggregate bag limit; and a commercial closed season is established from April 22 through May 31.

SEDAR

SouthEast Data, Assessment, and Review

SEDAR 9

Stock Assessment Report 3

Gulf of Mexico

Vermilion Snapper

SECTION 2. Data Workshop

Results of the SEDAR 9 Data Workshop

June 20-24 2005

New Orleans, LA

TABLE OF CONTENTS

1. Introduction

1.1 Workshop Time and Place

The SEDAR 9 Data Workshop was held June 20 – 24, 2006, at the Hotel Monteleone in New Orleans, LA.

1.2 Terms of Reference

1. Characterize stock structure and develop a unit stock definition.
2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics). Provide models to describe growth, maturation, and fecundity by age, sex, or length as appropriate; recommend life history parameters (or ranges of parameters) for use in population modeling; evaluate the adequacy of life-history information for conducting stock assessments.
3. Provide indices of population abundance. Consider fishery dependent and independent data sources; develop index values for appropriate strata (e.g., age, size, area, and fishery); provide measures of precision; conduct analyses evaluating the degree to which available indices adequately represent fishery and population conditions. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics.
4. Characterize commercial and recreational catches, including both landings and discard removals, in weight and numbers. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible.
5. Evaluate the adequacy of available data for estimating the impacts of current management actions.
6. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements.
7. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity and coverage where possible.
8. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report).

1.3 Participants

Name	Affiliation
Workshop Participants:	
Robert Allman	NMFS/SEFSC Panama City, FL
Luiz Barbieri	FWC St. Petersburg, FL
Craig Brown	NMFS/SEFSC Miami, FL
Shannon Calay	NMFS/SEFSC Miami, FL
Alan Collins	NMFS/SEFSC Panama City, FL
Marianne Cufone	Environment Matters
Guy Davenport	NMFS/SEFSC Miami, FL
Guillermo Diaz	NMFS/SEFSC Miami, FL
Bob Dixon	NMFS/SEFSC Beaufort, NC
Dave Donaldson	GSFMC
Chris Dorsett	Nature Conservancy
Chris Gledhill	NMFS/SEFSC Pensacola FL
Terry Henwood	NMFS/SEFSC, Pascagoula MS
David Hamisko	NOAA Fisheries Pensacola, FL
Walter Ingram	NMFS/SEFSC Pascagoula MS
Joanne Lyczkowski-Shultz	NMFS.SEFSC Pascagoula, MS
Kevin McCarthy	NMFS/SEFSC Miami FL
Debra Murie	University of Florida
Josh Sladek Nowlis	NMFS/SEFSC Miami, FL
Scott Nichols	NMFS/SEFSC Pascagoula MS
Dennis O'Hearn	GMFMC Advisory Panel
Butch Pellegrin	NMFS/SEFSC Pascagoula MS
Larry Perruso	NMFS/SEFSC Pascagoula MS
Jennifer Potts	NMFS/SEFSC Beaufort, NC
Jay Rooker	Texas A&M University
Steven Saul	RSMAS/University of Miami
Jerry Scott	NMFS/SEFSC Miami, FL
Bob Shipp	University of South Alabama
Tom Turke	GMFMC Advisory Panel
Steve Turner	NMFS/SEFSC Miami, FL
Russell Underwood	GMFMC Advisory Panel
Glenn Zapfe	NOAA Fisheries Pascagoula, MS
Observers:	
Bobbi Walker	GMFMC
Donald Waters	Fisherman
Bob Zales II	Panama City Boatmens Assoc.
Staff:	
John Carmichael	SEDAR
Stu Kennedy	GMFMC
Dawn Aring	GMFMC
Patrick Gilles	NMFS/SEFSC Miami FL

1.4 Document List

Document #	Title	Authors
Documents Prepared for the SEDR 9 Data Workshop		
SEDAR9-DW1	History of vermillion snapper, greater amberjack, and gray triggerfish management in Federal waters of the US Gulf of Mexico, 1984-2005	Hood, P
SEDAR9-DW2	Vermillion Snapper Otolith Aging: 2001-2004 Data Summary	Allman, R J., J. A. Tunnell. B. K. Barnett
SEDAR9-DW3	Reproduction of vermillion snapper from the Northern and Eastern Gulf of Mexico, 1991-2002.	Collins, L. A., R. J. Allman, and H. M Lyon
SEDAR9-DW4	Standardized catch rate indices for vermilion snapper landed by the US recreational fishery in the Gulf of Mexico, 1986-2004	Cass-Calay, S. L.
SEDAR9-DW5	Standardized catch rate indices for vermilion snapper landed by the US commercial handline fishery in the Gulf of Mexico, 1990-2004	Kevin J. McCarthy and Shannon L. Cass-Calay
SEDAR9-DW6	Standardized catch rates of vermilion snapper from the US headboat fishery in the Gulf of Mexico, 1986-2004	Craig A. Brown
SEDAR9-DW7	Estimated Gulf of Mexico greater amberjack recreational landings (MRFSS, Headboat, TXPW) for 1981-2004	Guillermo Diaz
SEDAR9-DW8	Size frequency distribution of greater amberjack from dockside sampling of recreational landings in the Gulf of Mexico 1986-2003	Guillermo Diaz
SEDAR9-DW9	Size frequency distribution of greater amberjack from dockside sampling of commercial landings in the Gulf of Mexico 1986-2003	Guillermo Diaz
SEDAR9-DW10	Standardized catch rates of gulf of Mexico greater amberjack for the commercial longline and handline fishery 1990-2004	Guillermo Diaz
SEDAR9-DW11	Length Frequency Analysis and Calculated Catch at Age Estimations for Commercially Landed Gray Triggerfish (*Balistes capriscus*) From the Gulf of Mexico	Steven Saul
SEDAR9-DW12	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Gulf of Mexico Headboat Fishery	Steven Saul
SEDAR9-DW13	Estimated Gray Triggerfish (*Balistes capriscus*) Commercial Landings and Price Information for the Gulf of Mexico Fishery	Steven Saul
SEDAR9-DW14	Estimated Gray Triggerfish (*Balistes capriscus*) Recreational Landings for the State of Texas	Steven Saul
SEDAR9-DW15	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Marine Recreational Fishery Statistics Survey (MRFSS) In the Gulf of Mexico	Steven Saul and Patty Phares
SEDAR9-DW16	Length Frequency Analysis for the Gray Triggerfish (*Balistes capriscus*) Recreational Fishery In the Gulf of Mexico	Steven Saul
SEDAR9-DW17	Estimates of Vermilion Snapper, Greater Amberjack, and Gray Triggerfish Discards by Vessels with Federal Permits in the Gulf of Mexico	Kevin J. McCarthy

SEDAR9-DW18	Size Composition Data from the SEAMAP Trawl Surveys	Scott Nichols
SEDAR9-DW19	Species Composition of the various amberjack species in the Gulf of Mexico	Ching-Ping Chih
SEDAR9-DW20	Standardized Catch rates of Gulf of Mexico greater amberjack catch rates for the recreational fishery (MRFSS, Headboat) 1981-2004	Guillermo Diaz
SEDAR9-DW21	SEAMAP Reef Fish Survey of Offshore Banks: Yearly indices of Abundance for Vermilion Snapper, Greater Amberjack, and Gray Triggerfish	Gledhill, et. al.
SEDAR9-DW22	Data Summary of Gray Triggerfish (*Balistes capriscus),*Vermilion Snapper (*Rhomboplites aurorubens)*, and Greater Amberjack (*Seriola dumerili)* Collected During Small Pelagic Trawl Surveys, 1988 – 1996	G. Walter Ingram, Jr.
SEDAR9-DW23	Abundance Indices of Gray Triggerfish and Vermilion Snapper Collected in Summer and Fall SEAMAP Groundfish Surveys (1987 – 2004)	G. Walter Ingram, Jr.
SEDAR9-DW24	Review of the Early Life History of Vermilion Snapper, *Rhomboplites auroubens,* With a Summary of Data from SEAMAP plankton surveys in the Gulf of Mexico: 1982 – 2002	Lyczkowski-Shultz, J. and Hanisko, D.
SEDAR9-DW25	Review of the early life history of gray triggerfish, *Balistes capriscus,* with a summary of data from SEAMAP plankton surveys in the Gulf of Mexico: 1982, 1984 – 2002	Lyczkowski-Shultz, J., Hanisko, D. and Zapfe, G.
SEDAR9-DW26	Shrimp Fleet Bycatch Estimates for the SEDAR9 Species	Scott Nichols
SEDAR9-DW27	SEAMAP Trawl Indexes for the SEDAR9 Species	Scott Nichols
SEDAR9-DW-28	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured by the Marine Recreational Fisheries Statistics Survey (MRFSS)	Josh Sladek Nowlis
SEDAR9-DW-29	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured by the NMFS Southeast Zone Headboat Survey	Josh Sladek Nowlis
SEDAR9-DW-30	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured from commercial logbook entries with handline gear	Josh Sladek Nowlis
SEDAR9-DW-31	Estimated Gulf of Mexico vermillion snapper recreational landings (MRFSS, headboat, TPWD) for 1981-2004	Shannon & Guillermo

2. Life History

2.1 Stock Definitions

A preliminary report (Swartz and Bert, 2003) on the stock structure of vermilion snapper based on genetic information from samples taken from the eastern and western Gulf of Mexico, Florida Keys, east coast of Florida, North Carolina and Venezuela indicated some differences between areas. Samples from Venezuela were different than U.S. samples and Western gulf samples were different than those from other U.S. locations. However sample size was too small (<10) to derive any definitive conclusions. Differences in vermilion snapper age structure have been apparent over the last decade with western gulf fish older on average than eastern gulf fish (Allman et al., 2001; Allman et al. 2005). It was noted that Florida Fish and Wildlife Conservation Commission expected to have a report on results of additional studies of vermilion snapper genetics in the Gulf of Mexico and the Atlantic by mid July. The committee recommended that the results be sent to assessment scientists working on vermilion snapper for the SEDAR9 Assessment Workshop and that the report be submitted to that workshop for review.

2.2 Habitat

In the South Atlantic Bight, vermilion snapper are associated with live bottom habitat, rock rubble and outcroppings (Grimes 1978). Diver surveys and video data from the NMFS Panama City laboratory indicate that vermilion snapper are generally associated with low profile hard bottom habitat in the Gulf of Mexico. Unlike young-of- the-year (YOY) red snapper, YOY vermilion snapper appear to be associated with reef sites, often schooling above the reef.

2.3 Morphometrics and Conversion Factors

Conversions for length and weight were presented to the data workshop. Vermilion snapper lengths are generally recorded as either total length (TL) or fork length (FL). When necessary, fork length was converted to total length using Equation 1 (n=1413).

$$TL(mm) = 1.11 * FL(mm) - 0.16 \qquad \text{(Eq. 1)}$$

The length weight relationship was estimated using 1333 vermilion snapper for which both total length (TL) and whole weight (WW) were recorded (Equation 2).

$$TW\ (kg) = 2E\text{-}08 * TL(mm)^{2.98} \qquad \text{(Eq. 2)}$$

2.4 Age and Growth

Previous studies have examined the age and growth of vermilion snapper from the Gulf of Mexico using scales (Nelson, 1988; Zastrow, 1984; Barber, 1989) and otoliths (Barber, 1989; Hood and Johnson, 1999; Allman et al., 2001). Otoliths are believed to be more readable, and provide greater reader agreement than scales for aging vermilion snapper. Also, the annual formation of otolith increments has been verified for vermilion snapper (Hood and Johnson, 1998).

Since the last full assessment in 2001 (Porch and Cass-Calay, 2001), 9,998 vermilion snapper otoliths were collected along with corresponding morphological data. These were collected from 2001 through 2004. Most samples were collected off Florida (82%). A summary of the number of vermilion snapper age estimates from 1994 through 2004 is given by state and fishing sector in Table 1.1. To estimate reader precision, a reference set of 200 otoliths was used to compare reader precision between two groups of readers and ages compared using average percent error (APE; Beamish and Fournier, 1981). Fifty-seven percent of age readings were in agreement and 94% were within ± 1 year. Average percent reader error (APE) was 5.17% (CV = 7.14%). Production aging laboratories generally consider an APE ≤5% as a target for moderately long-lived species with relatively difficult to read otoliths (Morison et al., 1998; Campana, 2001). Precision estimates for vermilion snapper age estimates have improved since the last reported comparison of vermilion ages in which APE was 8.4% (Allman et al., 2001). Typically most of the disagreement between readers is due to difficulty establishing the first or core ring, which seems to be a common problem for many reef fish (Fowler 1995). Opaque zones near the core often make distinguishing the first annulus difficult. A total of 8,776 vermilion snapper otoliths were processed for aging from 2001 to 2004; of these, 9% were rejected due to preparation flaws or indistinguishable annuli.

Vermilion snapper collected from 2001 to 2004 ranged from 1 to 26 years for the commercial hand-line fishery, 2 to 13 years for the charter boat and headboat fisheries and 1 to 25 years for the fishery-independent survey (Fig.1.1). Age distributions from the commercial hand-line and recreational fisheries indicated that fish recruit by age 4 and age 5 respectively. Charter boat, headboat and commercial ages were significantly different (ANOVA, $p<0.001$). A Tukey's pairwise comparison indicated that means were different between the headboat and commercial fisheries and the charter boat and commercial fisheries. This was contrary to the findings of the previous reporting period (1994 to 2000) in which commercially caught vermilion snapper were on average slightly older than those from the recreational fishery (Allman et al., 2001). Few individuals beyond 10 years were recorded from any sector (2-4%).

Regional differences were apparent in both the commercial and recreational age distributions (Fig. 1.2 A&B). Commercial hand-line vermilion snapper from the western gulf were significantly older than those from the eastern gulf (ANOVA, $p<0.001$). On average western gulf fish were 1 year older than eastern gulf fish for the commercial fishery and 0.3 years older for the recreational fishery. A similar pattern was noted for the commercial fishery during 1994 to 2000 (Allman, et al. 2001) and as in previous years, few ages were available from the western gulf recreational fishery. Separate von Bertalanffy growth equations were calculated for the recreational and commercial fisheries and the east and west commercial fisheries (Table 1.2; Fig. 1.3).

An examination of the commercial hand-line age distribution by year suggested the influence of a strong 1999 year class which was visible beginning in 2002 as age 3 fish, in 2003 as age 4 fish and in 2004 as age 5 fish (SEDAR9 DW3). This strong year class was also noted in the recreational fishery with large number of age 4 fish in 2003 and age 5 fish in 2004.

Total length at age plots indicated large variation in size-at-age (Fig. 1.4). This was consistent with previous studies on vermilion snapper (Allman et al., 2001; Hood and Johnson, 1999; Zhao et al., 1997). Due in part to the large variation in size-at-age of vermilion snapper, the last stock assessment (Porch and Cass-Calay, 2001) used a non-age-based production model.

2.5 Natural Mortality

Vermilion snapper live to at least 26 years, based on age samples available (see SEDAR9 DW2). Based upon this information, and using the method of Hoenig (1983) results in a value for M of 0.16. This value is below those previously applied in vermilion snapper assessments and the general beliefs about vermilion snapper life history. Based upon these considerations, the DW suggested using a value of M of 0.25 for base line evaluations, and agreed with the range of M= 0.15 and 0.35 for sensitivity evaluations.

SEDAR 9 data workgroup recommended exploring other methods of determining natural mortality at the stock assessment workshop.

2.6 Relative Productivity and Resilience (Steepness)

The classification scheme developed at the FAO second technical consultation on the suitability of the CITES criteria for listing commercially-exploited aquatic species (Windhoek, Namibia, 22-25 October 2001; FAO 2001) was used to characterize the relative productivity of vermilion snapper. This information is provided in Table 1.3. A productivity rank was assigned to each life-history characteristic (a value of 1 was assigned for low, 2 for medium, and 3 for high productivity characteristics) and the ranks were averaged to produce an overall productivity score. This score was then used to prescribe a prior density function on steepness in the stock-recruitment relationship from the Periodic Life History strategists distribution of steepness values as summarized by Rose et. al. (2001). The dominant portion of the steepness values from these analogous species range from 0.6-0.8 with 90% of the values less than 0.9. As the vermilion snapper productivity score from this exercise is somewhat below the medium category, the data work group recommends that the prior probability density function on steepness for this species be lognormal with a mode of 0.6 and a CV such that there is no greater than a 10% probability of steepness values greater than 0.9.

2.7 Reproduction

In the last decade, two histological studies of reproduction were published on this gonochoristic and multiple-spawning species with indeterminate fecundity. A one-year study published on vermilion snapper from South Carolina by Cuellar et al. (1996) included the first estimates of batch fecundity and spawning frequency on fish <300 mm TL. Hood and Johnson (1999) also conducted a one-year study and provided information on age, growth and reproduction including the first published batch fecundity estimates for vermilion snapper <300 mm TL from the eastern Gulf of Mexico.

Another study of reproduction is being prepared for publication by NMFS-Panama City and preliminary results of this study are found in Collins et al. (2001). Results of this study are in SEDAR9 Working Document 3 (SEDAR9-DW3). The results of this most recent histological study with expanded temporal/spatial coverage of vermilion snapper reproduction will be given first in each sub-section of this section, followed by results of previous studies in each sub-section.

2.7.1 Sex ratio

Sex ratio was somewhat variable in the SEDAR9-DW3 study. Overall female:male sex ratio from all fishery sources and areas in that study was significantly female-dominated (1.48:1;

X^2=107 with critical value = 3.8, n = 2833, df = 1, and alpha = 0.05). Sex ratio was usually > 1:1 for recreational (1.72:1) and fishery-independent (1.87:1) samples and 1:1 for commercial samples (1.08:1).

Females generally seemed to decrease in dominance from the northern half of the vermilion snapper's range (North Carolina, South Carolina and northwest Florida) to the southern half (west-central Florida and Trinidad). Both Grimes (1976) and Cuellar et al. (1996) found that females off North Carolina and South Carolina made up 63 % of the total sampled (female:male sex ratio = 1.70:1). Fishery-independent samples from North Carolina were similar with 67 % female (sex ratio = 2.03:1), and commercial samples from the same area were also significantly different from 1:1 at 57 % female (sex ratio = 1.33:1) (Cuellar et al. 1996). Random samples from SEDAR9-DW3 were 60 % female (sex ratio = 1.5:1) which was significantly different than 1:1, although some individual locations did have sex ratios =1:1 or significantly < 1:1. Hood and Johnson (1999) found that the sex ratio off west-central Florida was not significantly different from 1:1 and SEDAR9-DW3 sex ratio for two locations (Homosassa and Fort Myers) near the area covered by Hood and Johnson was also 1:1. Vermilion snapper sex ratio from Trinidad was also 1:1 (Manickchand-Heileman and Phillip, 1999). It is also interesting to note that combined random samples from the commercial fishery, usually collected from deeper water than samples from the recreational fishery, were also 1:1 (SEDAR9-DW3).

2.7.2 Spawning Season/Area

The spawning season for Gulf vermilion snapper during 1991-2002 determined by histology was mid-April through mid-September (SEDAR9-WD3). Both late hydrated oocytes and ripe testes occurred during this 150 day period. The spawning period off North and South Carolina (Cuellar et al. 1996) and west-central Florida (Hood and Johnson 1999) was the same or very similar to the SEDAR9-WD3 results.

Spawning occurred all along the continental shelf of the U.S. Gulf (SEDAR9-DW3; per. comm. Joanne Lyczkowski-Shultz; SEDAR9-DW24). Catch-location data and histology allowed some spawning sites to be identified, mostly off Panama City, Florida, but sampling was opportunistic and not equal throughout the Gulf (SEDAR9-DW3).

2.7.3 Sexual Maturity

Histology indicated that both sexes of vermilion snapper were mature at all lengths sampled (153–555 mm; 1,384 females and 391 males) (SEDAR9-DW3). Only one female was immature. Relatively few fish < 200 mm were collected (n=33), but four out of five females and all three males at 150-174 mm were mature, and all 17 females and all 8 males at 175-199 mm were mature. The smallest female that we sampled (153 mm) was spent; no females with undeveloped ovaries and few females with early developing ovaries were found during the spawning season. The smallest male (161 mm) was ready to spawn and no males with undeveloped or early developing testes were found during the spawning season. Vermilion snapper were mature by age 1.

The SEDAR9-DW3 study and the two previous studies (Cuellar et al. 1996 and Hood and Johnson 1999) all found that vermilion snapper mature at < 200 mm TL and possibly as early as < 150 mm TL. Preliminary data in Collins and Pinckney (1988) showed that 60% of females and 90% of males from North Carolina, South Carolina, Georgia and northeast Florida were mature at 160 mm.

2.7.4 Fecundity

Batch fecundity from all fishery sources and areas combined was estimated as 7,385 to 407,570 hydrated oocytes (mean=73,388, SE=6,968, median=47,098) from 123 females collected in 1993-1994 and 2000-2001 (SEDAR9-DW3). Total length was an effective predictor of batch fecundity for all fish, with an exponential function explaining 66% of the variation in batch fecundity. Dates of catch on all fish ranged from late April to early September. Batch fecundity was significantly greater in large (>299 mm) fish (SEDAR9-DW3). Mean batch fecundity for small (<300 mm) fish was 41,051 (n=83, SE=1,764, median=39,941) and for large fish was 152,788 (n=40, SE=15,408, median=103,606). Batch fecundity was variable for both small and large females. Age was not an effective predictor of batch fecundity for fish which ranged from 2 to 14 yr (n=80, SEDAR9-DW3). Ages were not available for 1993 fish. SEDAR9-DW3 contains information on our spawning frequency estimate (87 spawns per year) and annual fecundity estimates (range of 0.64 to 35.5 million).

The SEDAR9 plenary group decided that four fish from off Fort Myers should be excluded from consideration in estimating fecundity because they were larger than all other fish (SEDAR9-DW3) from a site that was much deeper and further away than the area where most other samples were collected. It was also decided that TW should be analyzed as a predictor of fecundity because of the great variation in length at age (Allman et al. 2001, 2005; Hood and Johnson 1999) and the poor ability of age to predict fecundity (SEDAR9-DW3).

The four largest fish were excluded from SEDAR9-DW3 fecundity analysis during SEDAR9, and the results of this change follow. This change had no effect on the range of batch fecundity but it did slightly change the mean of batch fecundity both for all sizes of fish (189 - 395 mm TL) to 70,231 and for the large fish (> 299 mm TL) to 137,507. The new mean for the large fish (with n = 36) was still significantly greater than the mean for the small fish (<300 mm TL).

Total weight ranged from 0.09 to 0.79 kg and was regressed on annual fecundity (n = 114; Fig. 1.5). TW was an effective predictor of annual fecundity, which ranged from 0.64 to 35.5 million hydrated oocytes using a constant of 87 for spawning frequency (SEDAR9-DW3).

Batch fecundity estimates for small fish (< 300 mm TL) were similar for this report (SEDAR9-DW3), Cuellar et al. (1996) and Hood and Johnson (1999), but spawning frequency differed considerably between this report and Cuellar et al. (1996). The latter two studies estimated batch fecundity on few large fish (> 299 mm TL) whereas this report contains 40 such estimates. The difference in spawning frequency estimates of 87 in this report and 35 in Cuellar et al. (1996) is probably due to differences in estimation-methodology, areas, years and time-of-day sampled between the two studies.

2.8 Literature Cited

Allman, R. J., G. R. Fitzhugh, and W. A. Fable. 2001. Report of vermilion snapper otolith aging: 1994-2001 Data Summary. NMFS Panama City Laboratory Contribution Series 01- 01. 25 p.

Allman, R. J., J. A. Tunnell, and B. K. Barnett. 2005. Vermilion snapper otolith aging: 2001- 2004 Data Summary. NMFS Panama City Laboratory Contribution Series 05-02. 20 p.

Barber, R.C. 1989. Age and growth of vermilion snapper (Rhomboplites aurorubens) in the northern Gulf of Mexico. M.S. thesis. Texas A&M University. 87 pp.

Beamish, R.J. and D.A. Fournier. 1981. A method for comparing the precision of a set of age determinations. Can. J. Fish. Aquat. Sci. 38: 982-983.

Campana, S.E. 2001. Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. Jour. Fish Bio. 59: 197-242.

Collins, M. R., and J. L. Pinckney. 1988. Size and age at maturity for vermilion snapper (Rhomboplites aurorubens) (Lutjanidae) in the South Atlantic Bight. Northeast Gulf Science 10: 51-53.

Collins, L. A., W. T. Walling, Jr., J. H. Brusher, M. G. Remy, J. J. Mikulas, G. M.Chandler, and D. M. La Fond. 2003. Preliminary results from a study of reproduction in the vermilion snapper (Lutjanidae: Rhomboplites aurorubens) from the eastern U. S. Gulf of Mexico. Gulf and Caribbean Fisheries Institute 54: 580-591.

Cuellar, N., G. R. Sedberry and D.M. Wyanski. 1996. Reproductive seasonality, maturation, fecundity, and spawning frequency of the vermilion snapper, Rhomboplites aurorubens, off the southeastern United States. Fishery Bulletin 94: 635-653.

Fowler, A.J. 1995. Annulus formation in otoliths of coral reef fish-a review. pages 45-63. In Secor, D.H., J.M. Dean, and S.E. Campana (eds.), Recent developments in fish otoliths research. The Belle W. Baruch Library in Marine Science No. 19. University of South Carolina Press, Columbia, SC.

Grimes, C. B. 1976. Certain aspects of the life history of the vermilion snapper Rhomboplites aurorubens (Cuvier) from North and South Carolina waters. Philosophy Doctoral Dissertation, University of North Carolina at Chapel Hill. 240 p.

Grimes, C.B. 1978. Age, growth, and length-weight relationship of vermilion snapper, Rhomboplites aurorubens from North and South Carolina waters. Trans. Am. Fish. Soc. 107 (3): 454-456.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. U.S. 82: 898-902.

Hood, P.B. and A.K. Johnson. 1999. Age, growth, mortality, and reproduction of vermilion snapper, Rhomboplites aurorubens, from the eastern Gulf of Mexico. Fish. Bull. 97: 828-841.

Morison, A.K., S.G. Robertson, and D.G. Smith. 1998. An integrated system for production fish aging: image analysis and quality assurance. North American Journal of Fish. Manage. 18: 587-598.

Nelson, R.S. 1988. A study of the life history, ecology and population dynamics of four sympatric reef predators (Rhomboplites aurorubens, Lutjanus campechanus, Lutjanidae, Haemulon melanurum, Haemulidae, and Pagrus pagrus, Sparidae) on the east and west Flower Garden Banks, northwestern Gulf of Mexico. Ph.D. thesis. North Carolina State University. 197 pp.

Manickchand-Heileman, S. C., and D. A. T. Phillip. 1999. Contribution to the biology of the vermilion snapper, Rhomboplites aurorubens, in Trinidad and Tobago, West Indies, Environmental Biology of Fishes 55: 413-421.

Porch, C.E., and S.L. Cass-Calay. 2001. Status of the vermilion snapper fishery in the Gulf of Mexico assessment 5.0. NOAA/NOAA Fisheries/SEFSC/Sustainable Fisheries Division Contrib. NO. SFD-01/02-129 p.

Rose, K.A.,J.H. Cowan, K.O. Winemiller, R.A. Myers and R. Hilborn. 2001. Compensatory density dependence in fish populations: importance controversy, understanding and prognosis. Fish and Fisheries (2) 293-327.

Tringali, M.D. and M. Higham. 2005. Genetic stock structure of vermilion snapper (Rhomboplites aurorubens) in the Gulf of Mexico and Southeastern United States. Florida Fish and Wildlife Institute report number IHR2005-3. 21 pp.

Zastrow, C.E. 1984. Age and growth of the red snapper, Lutjanus campechanus, and the vermilion snapper, Rhomboplites aurorubens, from the northwestern Gulf of Mexico. M.S. thesis. Texas A&M University. 77 pp.

Zhao, B., J.C. McGovern, and P.J. Harris. 1997. Age, growth, and temporal change in size at age of the vermilion snapper from the South Atlantic Bight. Trans. Am. Fish. Soc. 126: 181-193.

Table 1.1. Number of vermilion snapper otolith ages by state and sector 1994-2004.

	AL	FL	MS	LA	TX
1994					
Commercial		28		73	
Charter boat		125		8	
Headboat		21			
Private					
Fishery-indep.					
1995					
Commercial		6		75	
Charter boat		10			
Headboat		169		13	
Private					
Fishery-indep.		5			
1996					
Commercial		6		71	
Charter boat		83			
Headboat		166		21	10
Private					
Fishery-indep.		4			
1997					
Commercial		2			
Charter boat		2			
Headboat		40			
Private		4			
Fishery-indep.					
1998					
Commercial		4	134		
Charter boat					
Headboat		12			
Private		2			
Fishery-indep.		1			
1999					
Commercial					
Charter boat	87	57	10		
Headboat	4	4			
Private	64		20		
Fishery-indep.		20	3		

Table 1.1 continued

2000					
Commercial		45		81	
Charter boat		85			

Headboat	12	110			23
Private					
Fishery-indep.		79	6		
2001					
Commercial	34	1154	67	98	
Charter boat		21			
Headboat	1	94		1	24
Private					
Fishery-indep.	6	506		16	
2002					
Commercial		1207	53	68	
Charter boat		174			
Headboat		84			
Private					
Fishery-indep.	4	198		4	
2003					
Commercial	7	2103	41	440	120
Charter boat		41			
Headboat	12	25		1	
Private		12			
Fishery-indep.		52			
2004					
Commercial	647			364	147
Charter boat	75				
Headboat	9			24	16
Private	5				
Fishery-indep.	24				

Table 1.2. Von Bertalanffy growth equations for vermilion snapper from 2001-2004.

All fishing sectors combined	TL= 426 $[1-e^{-0.2(Age + -3.9)}]$, n= 7980
Recreational	TL= 377 $[1-e^{-0.5(Age + -0.5)}]$, n= 619
Commercial	TL= 465 $[1-e^{-0.15 (Age + -5.0)}]$, n= 6498
Commercial East	TL= 459 $[1-e^{-0.15(Age+ -5.2)}]$, n= 5279
Commercial West	TL= 467 $[1-e^{-0.18(Age= -4.1)}]$, n= 1219

Table 1.3. Proposed guideline indices of productivity for exploited fish species.

Parameter	**Productivity**			Species
	Low	**Medium**	**High**	Vermilion Snapper
M	**<0.2**	**0.2 - 0.5**	**>0.5**	0.15, **0.25**, 0.35
K	**<0.15**	**0.15 - 0.33**	**> 0.33**	**0.20**
t_{mat} (years)	**> 8**	**3.3 - 8**	**< 3.3**	**1**
t_{max} (years)	**>25**	**14 - 25**	**<14**	**26**
Examples	orange roughy, many sharks	cod, hake	sardine, anchovy	Vermilion Snapper Productivity Score = 1.88 (Low Medium)

Figure 1.1. Vermilion snapper length frequency distribution of age samples by fishing mode 2001-2004.

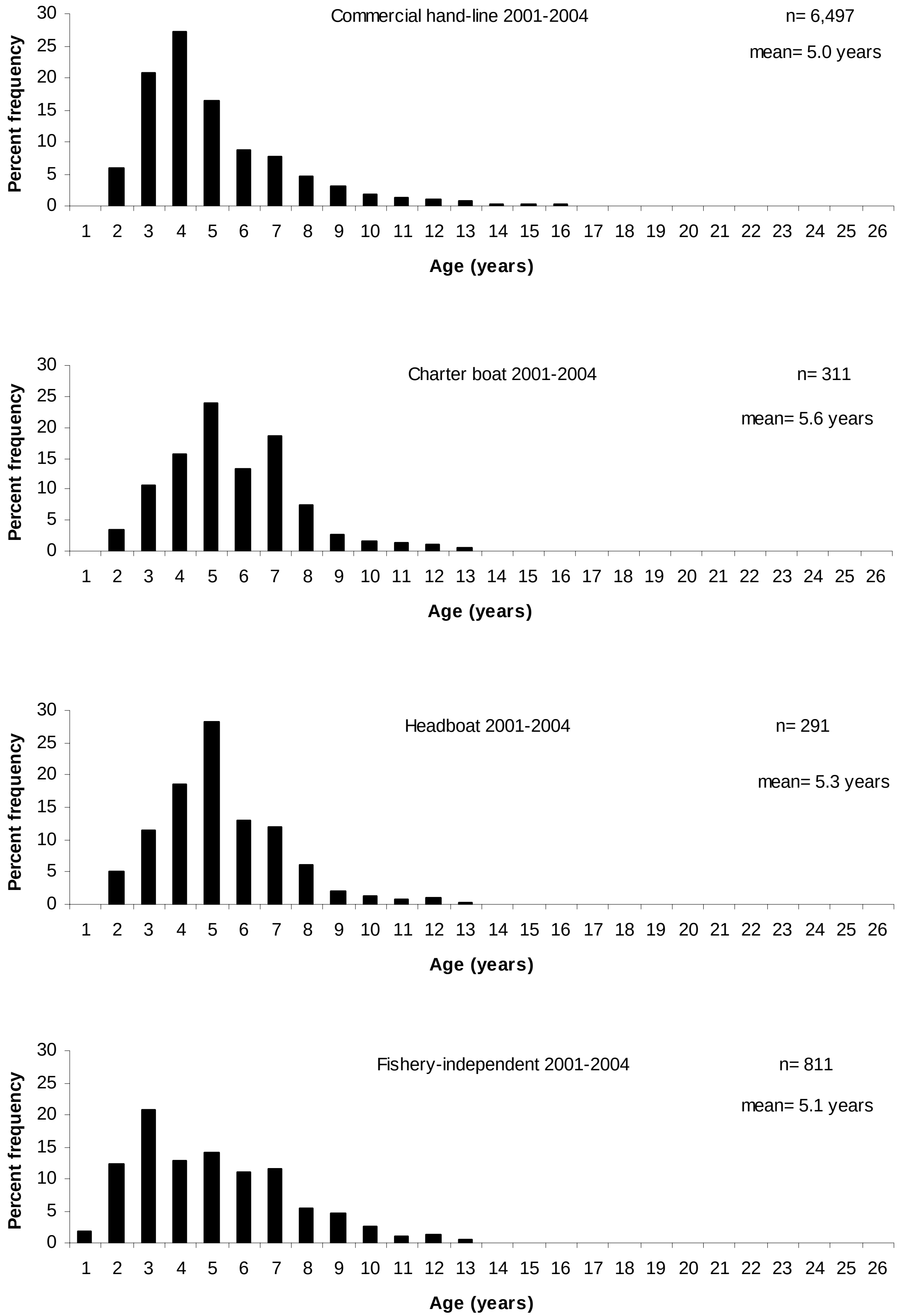


Figure 1.2. Vermilion snapper age frequency distribution of age samples by fishing mode and region 2001-2004.

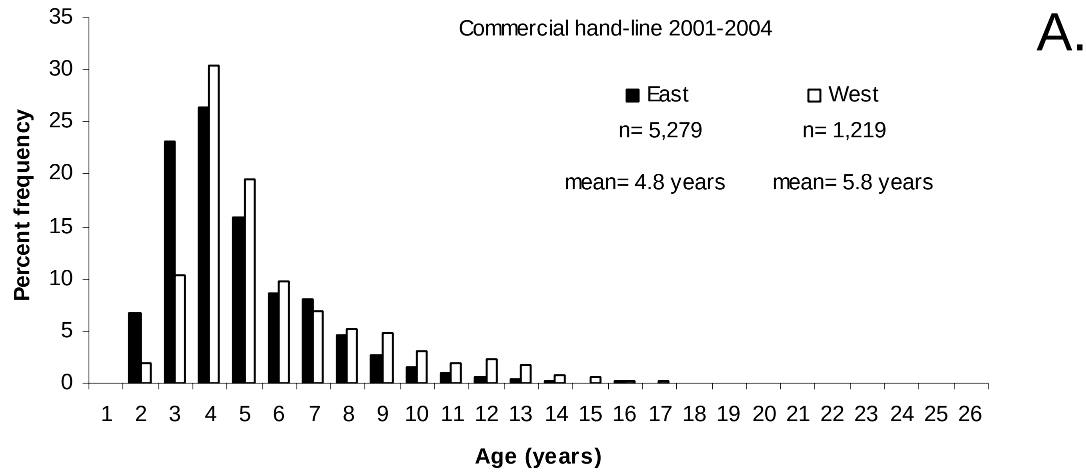


Figure 1.3. Von Bertalanffy growth curves from vermilion snapper 2001-2004.

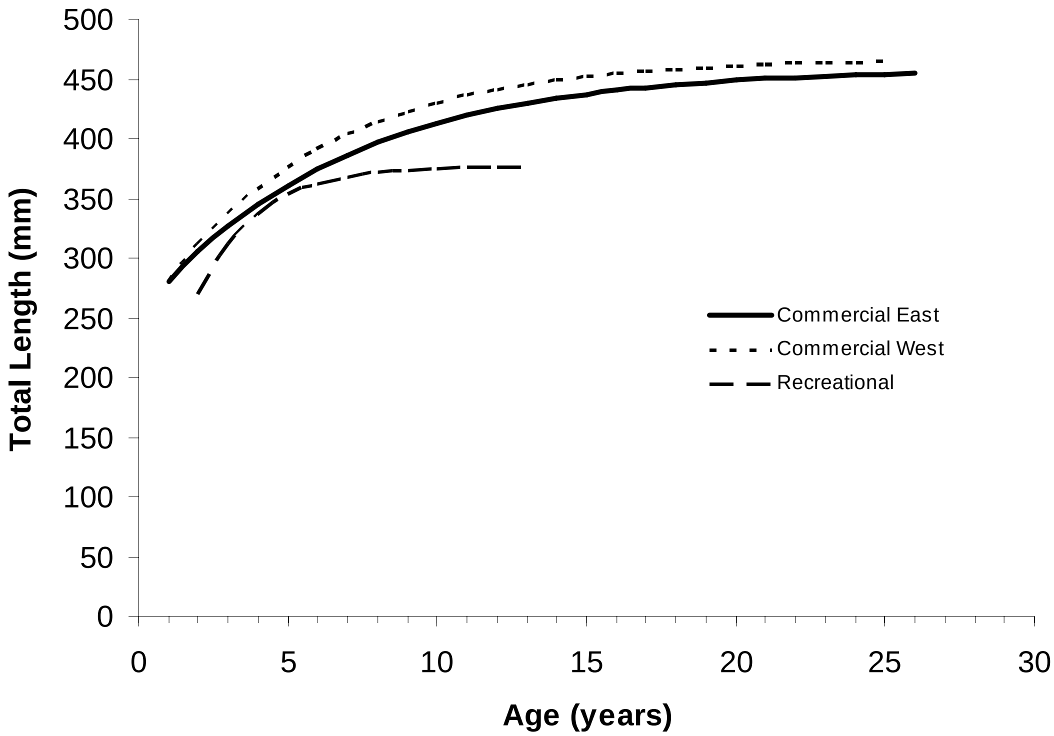


Figure 1.4. Vermilion snapper total length by age and fishing mode.

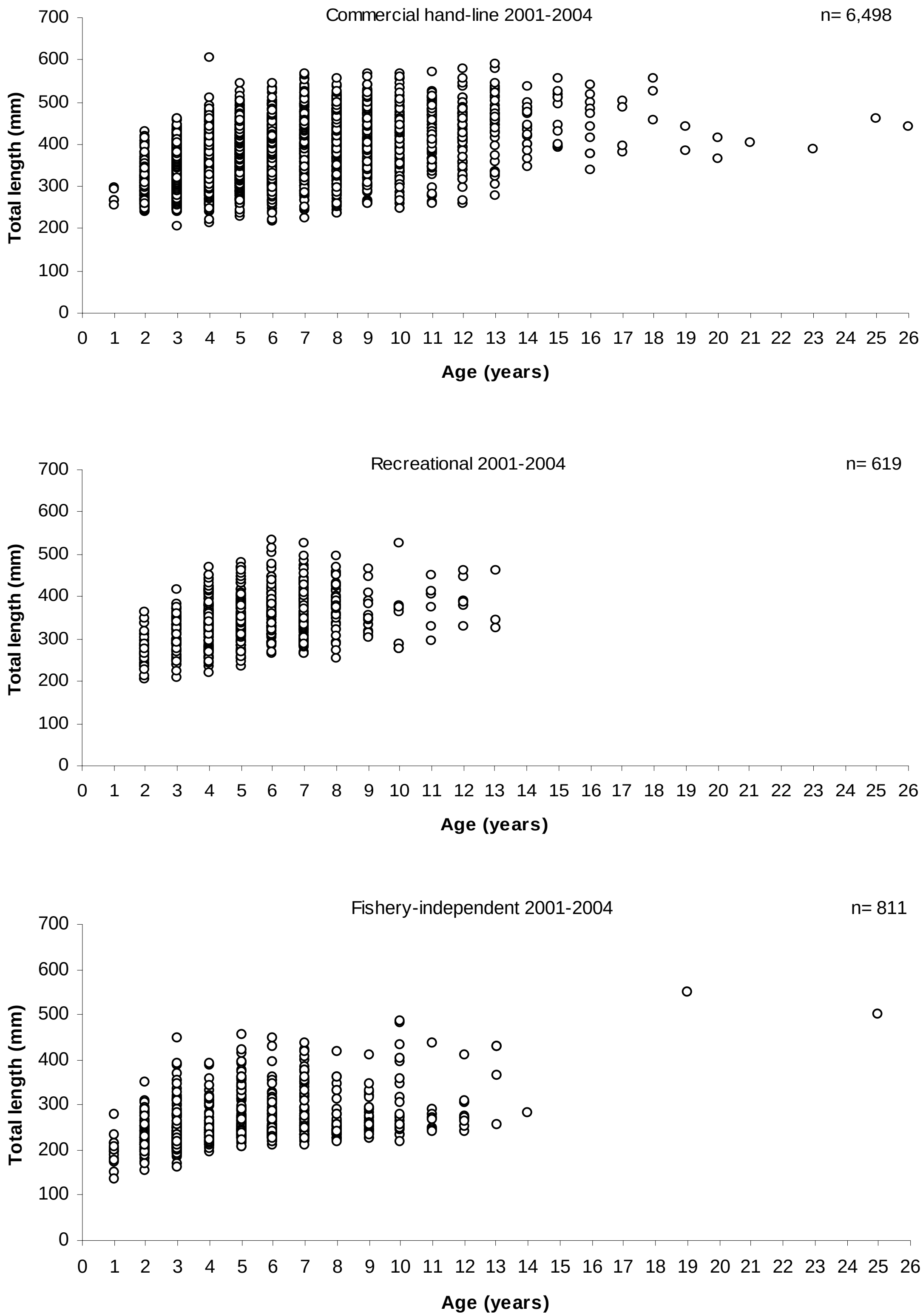
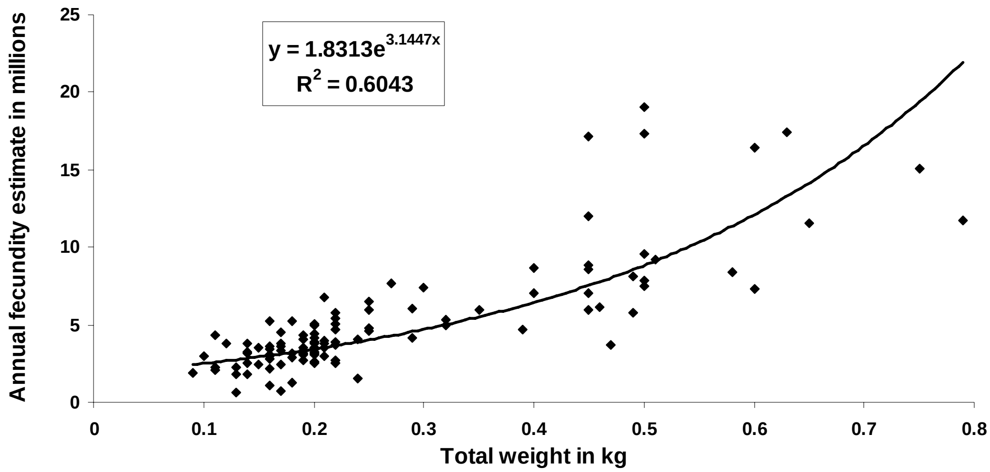


Figure 1.5 Vermilion snapper annual fecundity estimate regressed on total weight – assuming a spawning frequency estimate of 87 for all fish



3. Commercial Fishery Statistics

3.1 Commercial Landings

Commercial fishery statistics include information on landings of seafood products, fishing effort, and biological characteristics of the catch. A variety of sources of information are used to obtain these statistics.

The quantity (usually weight) and value of seafood products sold to licensed seafood dealers have been collected through various state and federal programs overtime. Currently these landing statistics are collected by state fisheries agencies in Alabama, Florida, and Louisiana on each fishing trip (trip ticket programs). In Mississippi and Texas, monthly dealer reports of landings are either sent in by the dealer or collected by state and federal port agents. Prior to the implementation of trip ticket programs landings were collected from seafood dealers each month by NMFS and state agents. Trip ticket programs generally provide information on the gear used and the fishing area. For the historical landings obtained from dealers each month, fishing gear and area were assigned by the agents on an annual basis.

At the National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (SEFSC) commercial landings statistics from North Carolina through Texas from 1962 to present are maintained in a data base referred to as the Accumulated Landings System (ALS). Statistics on all seafood products other than shrimp are maintained in that data base. Landings statistics from before 1962 are maintained by NMFS in Silver Springs, MD.

3.1.1 Commercial Data Collection Overview

Florida

Prior to 1986, commercial landings statistics were collected by a combination of monthly mail submissions and port agent visits. These procedures provided quantity and value, but did not provide information on gear, area or distance from shore. Because of the large number of dealers, port agents were not able to provide the gear, area and distance information for monthly data. Gear, area and distance from shore, however, are provided for annual summaries of the quantity and value and known as the Florida Annual Canvas data.

Beginning in 1986, mandatory reporting by all seafood dealers was implemented by the State of Florida. The state requires that a report (ticket) be completed and submitted to the state for every trip from which seafood was sold. Dealers have to report the type of gear as well as the quantity (pounds) purchased for each species. Information on the area of catch can also be provided on the tickets for individual trips (I did not think that this was correct for before about 1990). As of 1986 the ALS system relies solely on the Florida trip ticket data to create the ALS landings data for all species other than shrimp.

Alabama

Until the year 2000 data collection in Alabama was voluntary and was conducted by state and federal port agents that visit dealers and docks monthly. Summaries of the total landings (pounds) and value for species or market category were recorded. Port agents provided information on gear and fishing area from their knowledge of the fisheries and interaction with fishermen and dealers. As of mid- 2000 the State of Alabama required fishermen and dealers to report all commercial landings data through a trip ticket system. As of 2001 the ALS system relies solely on the Alabama trip ticket data to create the ALS landings data for Alabama.

Mississippi

Data collection in Mississippi is voluntary and is conducted by state and federal port agents that visit dealers and docks monthly. Summaries of the total landings (pounds) and value for species or market category are recorded. Port agents provide information on gear and fishing area from their knowledge of the fisheries and interaction with fishermen and dealers.

Louisiana

Prior to 1993, commercial landings statistics were collected in Louisiana by federal port agents following the traditional procedures established by the NMFS. Monthly summaries of the quantity and value were collected from each dealer in the state. The information on gear, area and distance from shore were added by the individual port agents.

Beginning in January 1993, the Department of Wildlife and Fisheries, State of Louisiana began to enforce the states' mandatory reporting requirement. Dealers have to be licensed by the state and are required to submit monthly summaries of the purchases that were made for individual species or market categories. With the implementation of the state statute, federal port agents did not participate in the collection of commercial fishery statistics.

After the implementation of the state program, information on the gear used, the area of catch and the distance from shore has not been added to the landings statistics (1992-1999). In 1998 the State of Louisiana required fishermen and dealers to report all commercial landings data through a trip ticket system. This data contains detailed landings information by trip including gear, area of capture and vessel information. As of 2000 the ALS system relies solely on the Louisiana trip ticket data to create the ALS landings data for Louisiana.

Texas

The state has mandatory reporting requirement for dealers licensed by the state. Dealers are required to submit monthly summaries of the quantities (pounds) and value of the purchases that were made for individual species or market categories. Information on gear, area and distance from shore are added to the state data by SEFSC personnel.

Interstate Transport

Often seafood products are landed in one state and transported by the purchasing dealer to another state; such landings may be recorded both in the state of landing and where the purchasing dealer is located. State and SEFSC personnel track these landings to assure that double counting does not occur and assign them to the state of landing.

3.1.2 Commercial Landings Data Base Organization and Data Handling

The data are organized into three primary components: historical annual data (1962-1976), monthly data (1977-present) and Florida annual data (1976-1996). The monthly 1977-present data for Florida does not have gear or fishing area for the period 1977-1996, while the annual Florida data (1976-1996) has gear and fishing area information which was provided by port agents based on their knowledge of the fisheries.

Accumulated Landings System (ALS)

1962-1976: Annual Landings by Year, State, County, Area, Gear, and Species for Florida West Coast through Texas.

1977-present: Monthly Landings by Year, Month, State, County, Area, Gear, and Species for Florida West Coast through Texas. Data reported from some states do not have information on the area and gear of capture particularly during the 1990s.

Historically the state and county recorded in the ALS indicates where the marine resource was landed. However in recent years (with the advent of trip tickets as the source of the landings data) in some states the state and county reflect the location of the main office of the purchasing dealer..

Fishing takes place in many different regions including United States waters of the Gulf of Mexico, the South Atlantic and in foreign waters. For the years 1976-present the area codes assigned to those regions are:

1. South Atlantic catch in the ALS is considered all area codes 0010, 0019, and 7xxx and higher.
2. Foreign Waters are area codes 022x- 060x and 186x.

In order to define the area of capture for Florida West coast for years 1976-1996 previous assessments use the Florida Annual Canvass data set. (Note* -The State of Florida implemented their trip ticket program in 1985 with more complete reporting starting in 1986. This data set was to contain area of capture information, but due to the nature of a public reporting, some fields on the ticket (such as area) may not have been reported consistently or completely in the early implementation years.)

Florida Annual Canvas Landings

1976-1996: Florida Annual Canvass for area and gear estimates by county which are not in the Monthly Landings for Florida West Coast.

The Florida Annual Data files from 1976 – 1996 represent annual landings by county (from dealer reports) which are broken out on a percentage estimate by species, gear, area of capture, and distance from shore. These estimates are submitted by Port agents, which were assigned responsibility for the particular county, from interviews and discussions with dealers and fishermen collected through out the year. The estimates are processed against the annual landings totals by county on a percentage basis to create the estimated proportions of catch by the gear, area and distance from shore. (The sum of percentages for a given Year, State, County, Species combination will equal 100.)

Florida Annual Canvass 1976-1996 considerations:

1. 1976-1985 Data is recorded as landed weight which for vermilion snapper was normally landed in a gutted condition. In order to convert to whole weight a factor of 1.11 was used.
2. All Area codes 0010, 0019, and 7xxx and higher are considered South Atlantic catch

3. State 00 and Grid 0000 in the data set are marine product landed else where and trucked into the State of Florida and are considered duplicated else where because they are theoretically reported back to the state of landing and are not included in the Florida totals.
4. State 12 is in the data set which represent Florida interior counties which were landed on Florida East Coast and not included in the Gulf catches.

Assignment of gear and area of capture 1990-present

The gear and fishing area designations in the landings data base has been provided by a variety of sources including port agents (annual and/or monthly landing reports), dealers (some trip ticket reports) and permit applications (some trip ticket reports, used only for gear). For some states the fishing gear and area were not reported when trip ticket programs were initiated. Beginning in 1990 fishermen have provided log books which indicate fishing gear, and area as well as catch and effort. The working group recommended that starting in 1990, landings be classified by gear and area using year and state specific information from logbooks.

3.1.3 Species composition

Species composition for vermillion snapper was reviewed for red snapper SEDAR7-DW 44. According to this report, there was no basis to infer that the species coding for vermilion snapper in the commercial landings data set was inaccurate.

3.1.4 Commercial landings by State

Commercial landings in pounds by state and year are shown in Table 2.1 and Fig 2.1. The largest quantities of vermilion snapper have been landed in Florida followed by Louisiana. The other states have accounted for comparatively smaller quantities.

3.1.5 Commercial Landings for Assessment by Gear and Area

Table 2.2 and Figure 2.2 show commercial landings by gear and region. For landings from 1990-2004 gear and statistical area were assigned from log books by year and state. The eastern and western regions were separated at approximately the Mississippi River with east including statistical areas 1-12 and the west including areas 13-21. Longline included vertical longline, trap included all pot and trap gears and handline included all other gears.

3.2 Bycatch

3.2.1 Commercial Finfish Fishery Discards

Estimates of vermilion snapper commercial discards were presented in SEDAR 9 DW 17. A 20% sample of the vessels with a Gulf of Mexico reef fish, king mackerel, Spanish mackerel or shark permit were selected to report discards. Data were available for the period August, 2001 through December, 2004. There were about 300 that reported vermilion snapper. Generalized linear model (GLM) analyses were used to determine those variables with significant effects on the proportion of trips reporting discards of the species of interest and on the catch rates (in number of fish) of trips reporting discards. Multiple factors were found to influence discard rates by species, but sampling period (August-December and January-July each year) and the number of hooks fished per line were consistently identified as the most important factors influencing discard rates

The estimated number of discards was calculated by multiplying the number of trips in a stratum by the average catch rate in the stratum with the strata defined by the results of the general linear models and by the amount of available data (a minimum of 30 observations per stratum). Estimates were made only for the handline fishery (included electric reel and hydraulic 'bandit rig' gear) due to small sample sizes of discards reported from other gears. Discard estimates were made for each of the seven sampling periods (each about a half year) and for species specific levels of hooks per handline. Additionally estimates were calculated for years before the discard program was initiated. These were made using the 2001-2004 average discard rates for each stratum. These pre-July 2001 estimates were made only for periods when the size limit was the same as the size limit in 2001-2004.

Annual estimated discards are summarized in Table 2.3. The time series for vermilion snapper was truncated at the point when size regulations went into effect (September 14, 1997). Therefore estimates for vermilion were made only for part of 1997 and 1998-2004. The committee reviewed the discard estimates of vermilion snapper in detail because of the magnitude of the estimates for 2002 (SEDAR 9 DW 17). That review found no obvious difference in the frequency of trips reporting high numbers of discards during 2002 and showed patterns of frequency distributions which were similar to adjacent sampling periods throughout the years covered by the survey.

The committee reviewed the average weight of discarded vermilion snapper estimated from the discard reports and the raw data used to make those estimates. Many of the reported weights were as large or larger than the weight of landed fish. The committee concluded that the reported weights might be a mixture of the average weight of individual fish, the average weight of all vermilion snapper discarded per day and possible other statistics. The committee therefore recommended that the average weight data from the discard reports not be used.

3.2.2 Shrimp Fishery Bycatch

The Bayesian techniques used to estimate shrimp fleet bycatch for red snapper during SEDAR7 (SEDAR7-DW-3 and -54) were applied to vermilion snapper, gray triggerfish, and greater amberjack in SEDAR9-DW-26. Results for all three species do not appear to be as reliable as the results for red snapper, probably in large part due to their lower abundances, but also due to reasons unique for each species. Vermilion snapper are extremely patchy, to the point that the negative binomial error adequate for red snapper may not be appropriate for vermilion. Because of doubts about the reliability of the annual estimates for these species from the SEDAR7 model, a delta distribution-based version of the Bayesian approach was introduced, and a fully mixed effects model ("Model 3") considered but not ultimately not used for red snapper was resurrected. There is some evidence that the delta implementation may be underestimating bycatch, and the frequencies of occurrence of for vermilion and greater amberjack are so low that one has to be suspicious about results of the CPUE portion of the delta distribution analysis. Model 3 central tendencies tended to be intermediate between the SEDAR7 and delta results, but the uncertainty estimates were enormous. Table Cf 2.2.1 provides some summary statistics of the performances of the models when applied to the SEDAR9 species, and compare them with the more successful situation for red snapper. In view of the unrealistic results that cropped up for all three SEDAR9 species, the DW recommends setting aside the estimates of inter-annual variation in favor of estimating an overall average, and then constructing wide uncertainty intervals to incorporate estimation error within models, variation among model choices, and inter-annual variation. Working at a resolution below an annual time step is not recommended.

The simplest statistic from SEDAR9-DW-26 (average CPUE in all observer trips times an approximate recent effort level) is recommended as the estimate of central tendency. It was not possible to partition the bycatch estimates by age as per SEDAR7-AW-20, as only a handful of fish for these 3 species have been measured across all the observer studies.

There are a number of options to be considered for providing estimates of central tendency and variation. These options will be developed, along with further exploration of why the SEDAR7 model performed as poorly as it did for these less abundant species. Results will be reported in a paper for the Assessment Workshop.

3.2.3 Size composition

The committee did not review the size composition of vermilion snapper, because the 2001 assessment (Porch and Cass-Calay 2001) concluded that there was little relationship between size and age, and therefore, the data are not useful to construct catch-at-age tables.

Table 2.1 Commercial landings (pounds whole weight) of vermilion snapper from Gulf of Mexico waters

	TX	LA	MS	AL	wFL	eFL	total
1963					53,280		53,280
1964					57,165		57,165
1965					54,168		54,168
1966					24,087		24,087
1967					51,060		51,060
1968					120,435		120,435
1969					116,439		116,439
1970					127,761		127,761
1971					139,083		139,083
1972					126,873		126,873
1973					190,476		190,476
1974					195,471		195,471
1975					389,277		389,277
1976					306,471		306,471
1977					528,500		528,500
1978					449,813		449,813
1979					438,884		438,884
1980					308,557		308,557
1981					361,864		361,864
1982					397,707		397,707
1983				8,756	561,748		570,504
1984		394,672	297,071	52,040	694,406		1,438,189
1985	38,546	304,502	171,965	128,567	834,952		1,478,532
1986	120,954	450,460	192,447	111,986	873,600		1,749,447
1987	42,386	611,823	188,833	61,106	701,257		1,605,405
1988	59,901	634,313	152,775	9,471	697,945	137	1,554,542
1989	62,129	577,849	99,364	10,434	908,932	114	1,658,822
1990	115,204	812,918	141,804	20,048	1,070,546	294,352	2,454,872
1991	40,130	603,017	116,970	6,629	1,028,279		1,795,025
1992	140,660	652,377	165,103	18,855	1,290,863	59	2,267,916
1993	304,283	646,397	116,005	22,373	1,630,247	235	2,719,540
1994	272,331	748,391	129,676	23,326	1,465,430	79	2,639,233
1995	221,885	376,400	104,614	3,766	1,471,368	8	2,178,040
1996	160,990	430,133	92,527	4,961	1,138,579	93	1,827,282
1997	296,266	614,185	130,116	6,841	1,078,230	176	2,125,814
1998	332,869	457,830	137,926	5,040	798,767	206	1,732,638
1999	313,901	740,949	60,264	16,113	851,105		1,982,332
2000	245,972	503,541	36,055	12,663	661,708	5	1,459,944
2001	236,721	600,561	37,781	26,710	813,310		1,715,084
2002	216,225	755,593	38,726	28,060	969,974		2,008,578
2003	188,873	1,052,991	47,052	35,765	1,091,067		2,415,748
2004	313,276	918,813	17,543	65,920	818,831		2,134,383

Table 2.2 Commercial landings (pounds whole weight) of vermilion snapper by gear and region.

	handline+		longline		
	west US Gulf	east US Gulf	west US Gulf	east US Gulf	total
1963	22,533	30,747			53,280
1964	23,532	33,633			57,165
1965	20,757	33,411			54,168
1966	6,660	17,427			24,087
1967	15,762	35,298			51,060
1968	50,283	70,152			120,435
1969	27,084	89,355			116,439
1970	44,400	83,361			127,761
1971	48,063	91,020			139,083
1972	46,509	80,364			126,873
1973	54,945	135,531			190,476
1974	66,822	128,649			195,471
1975	109,335	279,942			389,277
1976	60,495	245,976			306,471
1977	195,126	333,375			528,500
1978	163,261	286,552			449,813
1979	220,445	218,438			438,884
1980	148,455	159,658		444	308,557
1981	115,663	231,522	4,549	10,131	361,864
1982	146,490	239,367	4,662	7,188	397,707
1983	161,754	377,712	7,102	23,936	570,504
1984	848,288	532,675	41,392	15,834	1,438,189
1985	737,600	672,257	53,910	14,765	1,478,532
1986	939,041	689,625	119,597	1,184	1,749,447
1987	1,003,433	534,518	62,662	4,792	1,605,405
1988	991,713	492,997	54,372	15,460	1,554,542
1989	1,002,816	481,705	59,609	114,692	1,658,822
1990	962,643	1,489,581	613	2,035	2,454,872
1991	808,348	969,399	1,683	15,594	1,795,025
1992	1,036,278	1,217,900	12,352	1,386	2,267,916
1993	1,024,203	1,667,549	24,197	3,591	2,719,540
1994	1,040,183	1,582,072	13,494	3,485	2,639,233
1995	654,242	1,506,085	14,700	3,013	2,178,040
1996	651,873	1,166,437	5,545	3,426	1,827,282
1997	1,072,584	1,040,331	8,120	4,779	2,125,814
1998	895,269	807,987	6,422	22,959	1,732,638
1999	1,098,219	866,821	6,959	10,333	1,982,332
2000	758,230	699,209	709	1,796	1,459,944
2001	915,733	791,599	1,314	6,437	1,715,084
2002	997,300	1,008,662	432	2,183	2,008,578
2003	1,260,897	1,153,574	660	618	2,415,748
2004	1,218,992	903,434	11,004	953	2,134,383

Table 2.3. Annual estimates of vermilion snapper total discards for the Gulf of Mexico handline fishery.

YEAR	Estimate of Total Number of Discards
1997	16,994
1998	75,589
1999	80,293
2000	80,451
2001	77,930
2002	152,694
2003	38,479
2004	71,370

Table 2.4 Summary of unexpected levels and ranges for shrimp fleet bycatch estimates for the SEDAR9 species from SEDAR9-DW-26, compared with similar analyses for red snapper, and some supporting statistics.

	Vermilion Snapper	**Gray Triggerfish**	**Greater Amberjack**	**Red Snapper**
average CPUE x approx effort	7.7M	3.8M	1.9k	27.6M
SEDAR7 model results				
median of annual medians	36M	8.3M	140k	26.3M
range of annual medians	530x	130x	88x	15x
range of annual 95% ci ranges	18x-1200x	4.9x-67x	18x-100x	1.7x-29x
Delta model results				
median of annuals	1.6M	2.2m	24k	13M
range of annual medians	160x	140x	78x	6x
range of annual 95% ci ranges	2.5x-700x	3.9x-360x	53x-1100x	1.4x-6.7x
Model 3 results				
median of annuals	3.8M	1.7M	73k	14M
range of annual medians	93x	160x	70x	19x
range of annual 95% ci ranges	23000x-38000x	810x-1300x	660x-1200x	190x-270x
frequency of occurrence in C	4%	9%	0.07%	43%
frequency of occurrence in R	2%	8%	0.50%	30%
frequency of occurrence in B	5%	0	0	55%
number of stations				
C	8460	2863	2866	9943
R	26487	26983	26487	26486
B	4920	402	402	8130

C refers to observer data for commercial shrimp tows without BRDs
B refers to observer data for commercial shrimp tows with BRDs
R refers to research vessel (Oregon II) tows

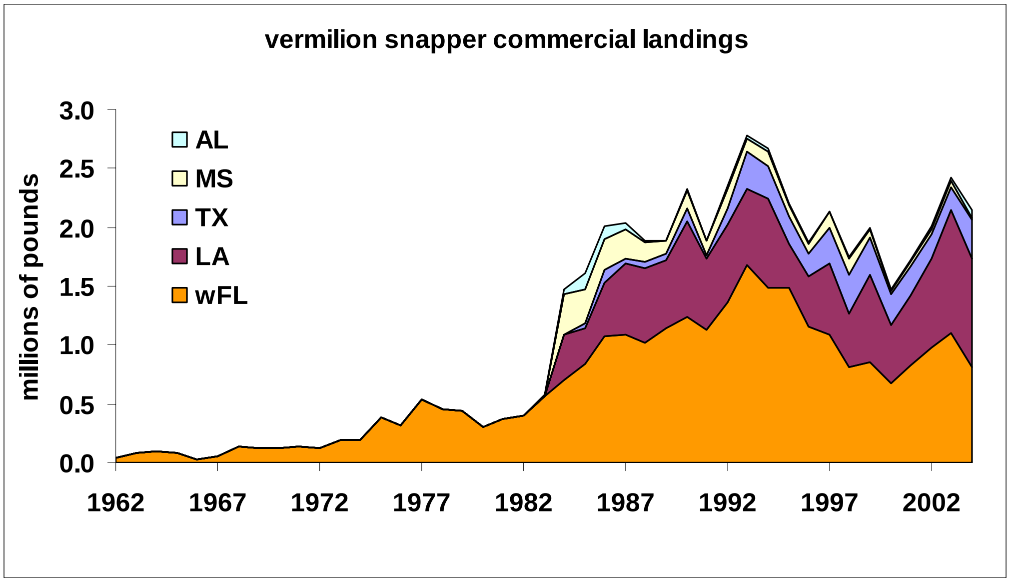


Figure 2.1 Commercial landings of vermilion snapper by state from 1962-2004.

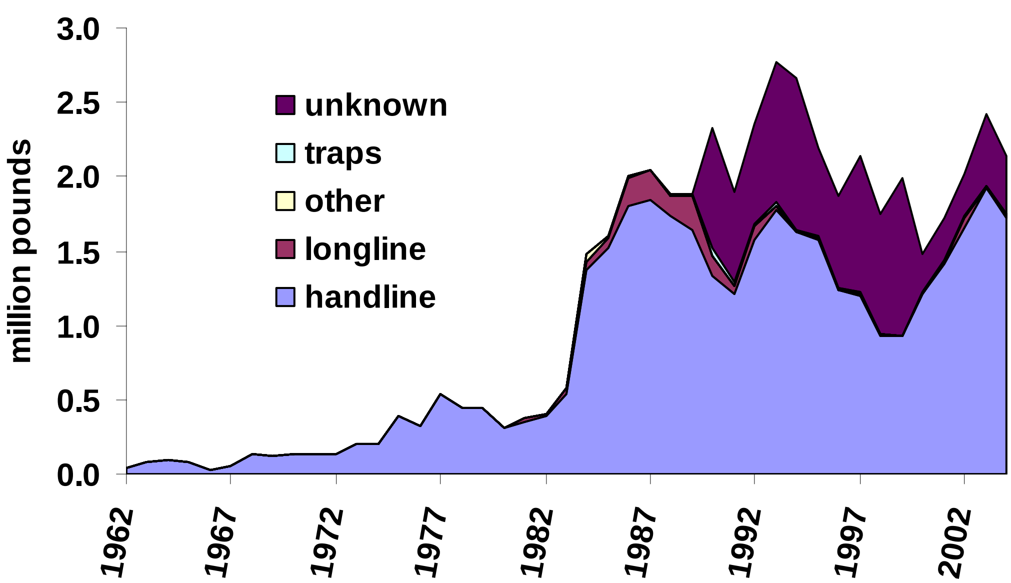


Figure 2.2 Commercial landings of vermilion snapper by gear.

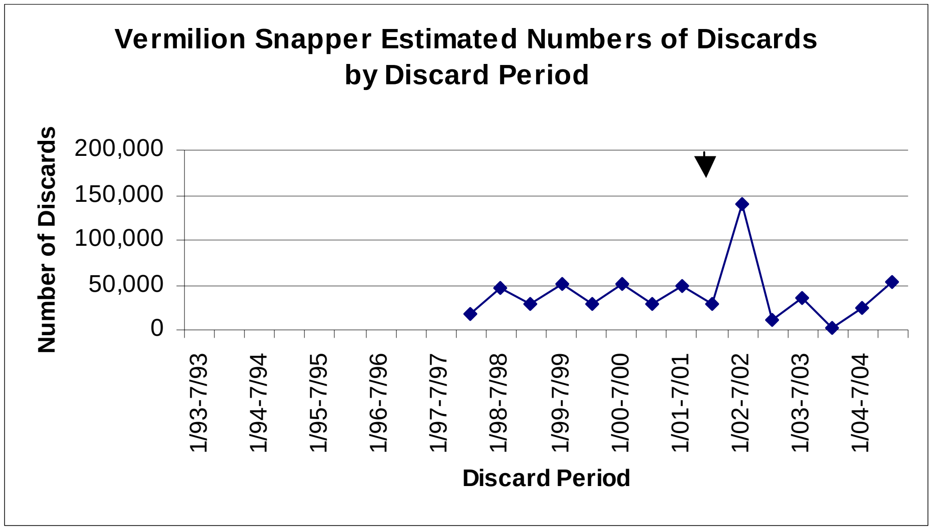


Figure 2.3. Estimated numbers of vermilion snapper discard, by discard period.

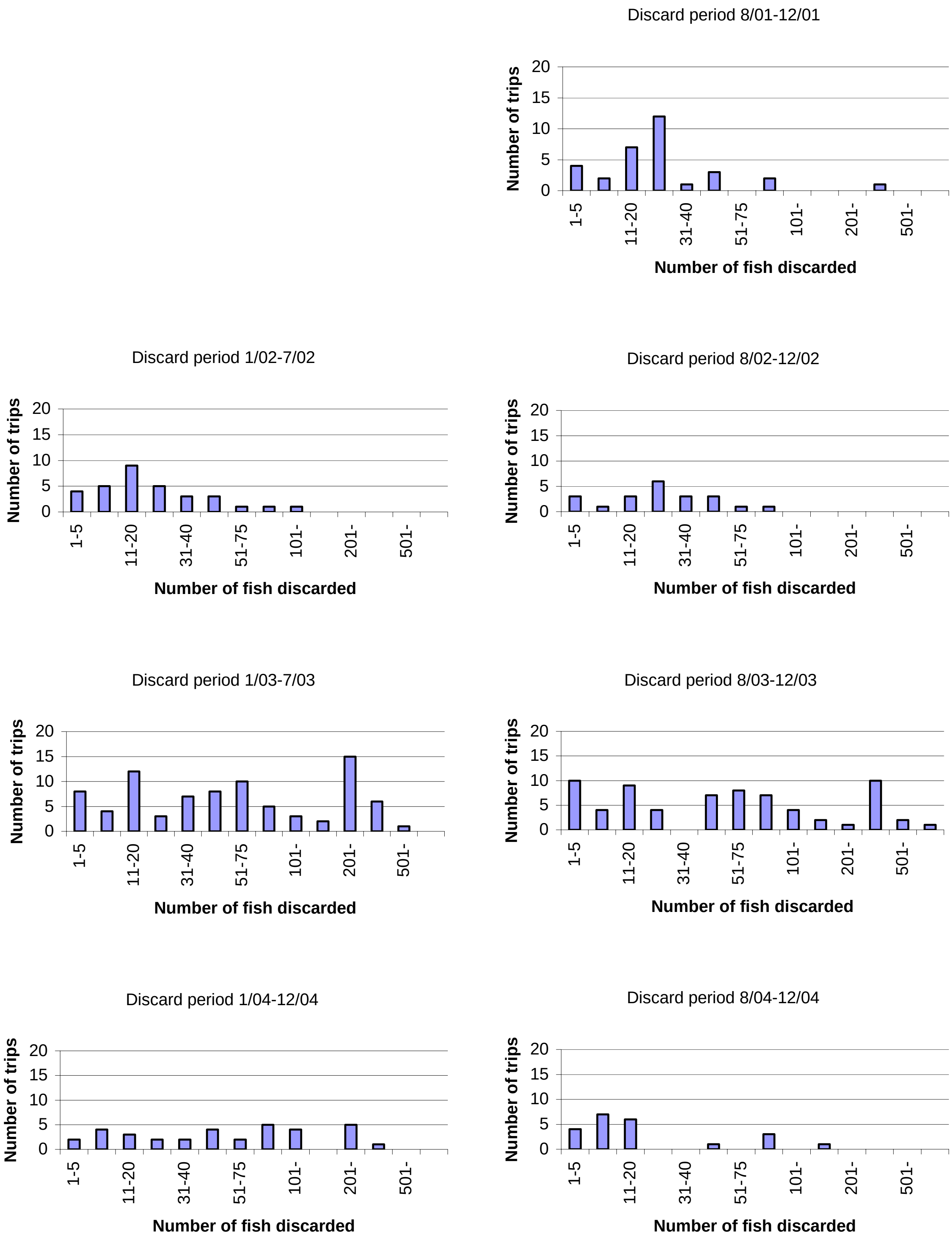


Figure 2.4. Frequency of vermilion snapper trips that reported discards by number of fish discarded and discard period.

4. Recreational Statistics

The recreational fishery statistics for vermilion snapper are collected by three separate surveys: Marine Recreational Fishing Statistical Survey (MRFSS), Texas Parks and Wildlife Department (TPWD) and the NMFS Beaufort Headboat Survey (HB). MRFSS has captured statistics on shore based, charter boat and private/rental boat fishing since 1981 from Florida through Louisiana. MRFSS included headboats in the survey from 1981-1985. In the Gulf of Mexico the HB began in 1986 covering the west coast of Florida through Texas. TPWD has collected recreational fishing statistics from 1981 – 1985 and since 1986 for all fishing modes except "offshore" headboats in the state of Texas.

The Recreational Statistics working group, henceforth referred to as "the group", expressed concern over the accuracy of the MRFSS data for the reef fish species, but the group agrees that for this species the recreational fishery landings contribute a large proportion of the overall catch. The group's concern centers on the low number of intercepted fish that is used in conjunction with the fishing effort estimates from the phone survey to estimate total catch (e.g., small anomalies in the data can be expanded to large anomalies). Another concern is over species identification of the B1 and B2 (not seen by interviewer) catches. Many fishermen are known to call vermilion snapper "red snapper", which in turn may cause problems with species assignation for the B1 and B2 catches.

DW Recommendation: The MRFSS and TPWD data are the best available data and cannot be ignored. The landings have CVs associated with them that will capture the high level of uncertainty and be incorporated into the assessment model. The previous assessment used data from 1986-1999, although recreational statistics are available back through 1981. The group recommends the use of all available data 1981-2004.

DW Recommendation: Staff of NMFS SEFSC are developing methodology by which to fill missing recreational landings information. The missing landings are most commonly from the first wave in 1981 and Texas for all years. The group decided to accept the methodology from the SEFSC staff (see Appendix 1). The group was not able to review the methodology at the time of the data workshop.

4.1 Recreational landings

4.1.1 MRFSS

The MRFSS program reports fish landed and observed (A), landed but not observed, used for bait, filleted, or discarded dead. (B1) and released alive (B2). Estimated vermilion snapper landed (dead fish; A+B1) by the recreational sector are shown in Table 3.1(a-d). Landings are summarized by year, state and mode. Most vermilion snapper were landed by private boats and charter boats operating off Florida and Alabama. Very few vermilion snapper are landed by recreational fishers operating off Louisiana and Texas.

Landings from shore-based fishing mode have been reported (Table 3.1d), but the group felt the estimates from shore mode were not likely to be valid.

DW Recommendation*:* Omit shore based landings, because it was felt that the fishing mode may have been misidentified, and vermilion snapper being caught from the shore is highly unlikely. If the fishing mode was misidentified the expansion factor for fishing effort from shore mode would greatly inflate any landings of vermilion snapper classified as shore mode.

DW Recommendation*:* The group felt that identification of vermilion snapper is relatively easy and the landings of unidentified snapper would most likely be other species of snapper. The group decided to disregard the unidentified snapper landings.

4.1.2 TPWD

Texas Parks and Wildlife Department (TPWD) provides estimates of recreational landings off the state of Texas. These are summarized by year and mode in Table 3.2. The largest reported landings are from headboats prior to 1986. No landings by headboats are reported after 1985 because the NMFS Beaufort Headboat Survey took over the headboat sampling program at that time. Other TPWD landings estimates are very small. This is likely due to the predominance of near-shore samples in the TPWD data. TPWD does not provide estimates of fish discarded dead or released alive.

4.1.3 Headboat Survey

Since 1986, the NMFS Beaufort Headboat Survey has provided estimates of fish landed by headboats. These are summarized by year and region in Table 3.3. The majority of vermilion snapper landed by headboats were landed off NW Florida and Alabama. A smaller, but substantial fraction, were landed off Texas. Headboat landings off Louisiana and Mississippi are negligible. The HB Survey does not currently provide estimates of fish discarded dead or released alive, although discards will be estimated in the near future.

DW Recommendation: The landings of areas 12 and 17 should not be included in the Gulf of Mexico analysis. The group felt that better than 99% of the trips in area 12 and 17 occur in Atlantic jurisdiction waters. There was no evidence of mixing of the Atlantic and Gulf of Mexico stocks in that area. Table 4 includes the Headboat Survey landings to be used in the assessment.

4.2 Recreational discards

Only the MFRSS program reports fish discarded or released by the recreational sector. (although HB discards are being compiled as of 2005). Discard estimates from the MRFSS program are summarized in Table 3.4(a-c).

DW Recommendation: To estimate the discard fraction, the group recommends the use of the ratio of releases (B2) to total catch (A+B1+B2) be calculated for the MRFSS charter boat mode only. The group felt that charter boat and headboat fishing are most similar and the rate of released fish would be most alike. Private boat fishing would not be the same as the “for-hire” sector (Tables 3a-c).

4.3 Length samples

Although numerous recreational length samples are available for vermilion snapper, the group did not review the length samples available from the different data sources because of the lack of relationship between size and age of the fish. However, this data will be used to estimate the average weight of vermilion snapper by year, mode and area to convert landings estimates in numbers to landings in weight.

Table 3.1a MRFSS A+B1 landings (numbers of fish) for the charter boat mode by year and state.

CHARTER BOAT MODE (MODE 3)

YEAR	AL	CV		FL	CV		LA	CV		MS	CV
1981	0	0.00		0	0.00		0	0.00		0	0.00
1982	0	0.00		0	0.00		0	0.00		0	0.00
1983	0	0.00		0	0.00		0	0.00		0	0.00
1984	0	0.00		0	0.00		0	0.00		0	0.00
1985	0	0.00		0	0.00		0	0.00		0	0.00
1986	66,037	1.00		281,844	0.31		1,228	0.98		0	0.00
1987	51,369	1.29		305,963	0.45		2,317	1.33		0	0.00
1988	32,897	0.88		335,622	0.22		0	0.00		0	0.00
1989	58,848	0.90		167,315	0.25		0	0.00		0	0.00
1990	299,703	0.77		217,646	0.32		1,970	1.35		621	1.46
1991	209,947	0.73		382,884	0.23		6,377	1.01		0	0.00
1992	220,718	0.84		217,331	0.19		1,337	0.93		0	0.00
1993	236,741	0.67		267,908	0.13		49	1.36		158	1.41
1994	118,611	0.76		283,341	0.15		4,031	1.14		432	1.29
1995	181,589	0.72		481,653	0.26		1,842	1.20		0	0.00
1996	158,674	0.71		94,421	0.27		380	1.60		0	0.00
1997	175,040	0.73		100,715	0.27		271	1.54		67	1.62
1998	95,782	0.24		44,251	0.08		36	0.96		0	0.00
1999	63,476	0.19		99,206	0.07		384	0.41		0	0.00
2000	19,000	0.25		111,117	0.08		0	0.00		0	0.00
2001	52,196	0.22		113,454	0.08		0	0.00		0	0.00
2002	26,640	0.20		83,744	0.07		3,777	0.74		0	0.00
2003	32,986	0.22		84,644	0.07		1,611	0.36		0	0.00
2004	83,639	0.21		159,500	0.05		16,356	0.76		0	0.00

Table 3.1b MRFSS A+B1 landings (numbers of fish) for the private boat mode by year and state.

PRIVATE BOAT MODE (MODE 4)

YEAR	AL	CV		FL	CV		LA	CV		MS	CV
1981	24,082	0.42		60,142	0.34		23,793	0.51		0	0.00
1982	0	0.00		954	0.47		11,749	0.76		0	0.00
1983	0	0.00		0	0.00		17,909	0.50		0	0.00
1984	22,056	0.74		0	0.00		489	0.75		0	0.00
1985	0	0.00		241,938	0.47		22,940	0.53		0	0.00
1986	0	0.00		78,393	0.33		0	0.00		0	0.00
1987	11,071	0.46		133,831	0.36		0	0.00		0	0.00
1988	72,824	0.51		226,466	0.32		0	0.00		0	0.00
1989	48,224	0.44		132,724	0.34		0	0.00		0	0.00
1990	96,682	0.43		18,930	0.60		0	0.00		0	0.00
1991	20,608	0.38		28,262	0.51		0	0.00		10,646	1.00
1992	142,882	0.16		117,903	0.23		17,095	0.41		431	0.60
1993	105,624	0.21		69,894	0.32		1,056	0.15		914	0.49
1994	50,747	0.21		39,131	0.39		0	0.00		0	0.00
1995	67,719	0.28		59,440	0.24		763	1.01		0	0.00
1996	4,611	0.57		31,924	0.37		1,656	0.64		0	0.00
1997	55,523	0.46		719	1.00		3,952	0.62		841	0.98
1998	9,031	0.34		3,121	0.64		2,461	0.71		0	0.00
1999	57,278	0.30		18,567	0.34		1,868	0.67		688	0.75
2000	5,582	0.44		22,561	0.42		0	0.00		0	0.00
2001	81,179	0.30		149,384	0.32		6,150	0.70		0	0.00
2002	55,589	0.32		122,814	0.31		0	0.00		0	0.00
2003	31,621	0.44		138,735	0.24		5,426	0.49		693	0.77
2004	69,493	0.45		142,697	0.22		2,520	0.68		3,755	0.90

Table 3.1c MRFSS A+B1 landings (numbers of fish) for the combined charterboat/headboat mode by year and state.

COMBINED CHARTER+HEAD BOAT MODE (MODE 5)

YEAR	AL	CV	FL	CV	LA	CV	MS	CV
1981	6,144	1.15	27,727	0.78	0	0.00	0	0.00
1982	74,259	1.24	668,552	0.76	38,352	1.20	0	0.00
1983	31,917	1.05	122,617	0.44	0	0.00	0	0.00
1984	185,302	0.85	88,863	0.76	0	0.00	0	0.00
1985	0	0.00	119,781	0.72	13,740	1.16	0	0.00
1986	0	0.00	0	0.00	0	0.00	0	0.00
1987	0	0.00	0	0.00	0	0.00	0	0.00
1988	0	0.00	0	0.00	0	0.00	0	0.00
1989	0	0.00	0	0.00	0	0.00	0	0.00
1990	0	0.00	0	0.00	0	0.00	0	0.00
1991	0	0.00	0	0.00	0	0.00	0	0.00
1992	0	0.00	0	0.00	0	0.00	0	0.00
1993	0	0.00	0	0.00	0	0.00	0	0.00
1994	0	0.00	0	0.00	0	0.00	0	0.00
1995	0	0.00	0	0.00	0	0.00	0	0.00
1996	0	0.00	0	0.00	0	0.00	0	0.00
1997	0	0.00	0	0.00	0	0.00	0	0.00
1998	0	0.00	0	0.00	0	0.00	0	0.00
1999	0	0.00	0	0.00	0	0.00	0	0.00
2000	0	0.00	0	0.00	0	0.00	0	0.00
2001	0	0.00	0	0.00	0	0.00	0	0.00
2002	0	0.00	0	0.00	0	0.00	0	0.00
2003	0	0.00	0	0.00	0	0.00	0	0.00
2004	0	0.00	0	0.00	0	0.00	0	0.00

Table 3.1d. MRFSS A+B1 landings (numbers of fish) for the shore mode by year and state.

SHORE MODE (MODE 1)

YEAR	AL	CV		FL	CV		LA	CV		MS	CV
1981	0	0.00		0	0.00		0	0.00		0	0.00
1982	0	0.00		0	0.00		0	0.00		0	0.00
1983	0	0.00		0	0.00		0	0.00		0	0.00
1984	0	0.00		0	0.00		0	0.00		0	0.00
1985	0	0.00		903	1.00		0	0.00		0	0.00
1986	0	0.00		0	0.00		0	0.00		0	0.00
1987	0	0.00		0	0.00		0	0.00		0	0.00
1988	0	0.00		0	0.00		0	0.00		0	0.00
1989	0	0.00		0	0.00		0	0.00		0	0.00
1990	5,916	0.54		0	0.00		0	0.00		0	0.00
1991	2,665	0.61		131,286	0.59		0	0.00		0	0.00
1992	0	0.00		0	0.00		0	0.00		0	0.00
1993	0	0.00		0	0.00		0	0.00		0	0.00
1994	0	0.00		0	0.00		0	0.00		0	0.00
1995	0	0.00		0	0.00		0	0.00		0	0.00
1996	0	0.00		0	0.00		0	0.00		0	0.00
1997	0	0.00		0	0.00		0	0.00		0	0.00
1998	0	0.00		0	0.00		0	0.00		0	0.00
1999	0	0.00		0	0.00		0	0.00		0	0.00
2000	0	0.00		0	0.00		0	0.00		0	0.00
2001	0	0.00		0	0.00		0	0.00		0	0.00
2002	0	0.00		0	0.00		0	0.00		0	0.00
2003	0	0.00		0	0.00		0	0.00		0	0.00
2004	0	0.00		0	0.00		0	0.00		0	0.00

Table 3.2 TPWD landings in numbers by mode. HB mode was not samples after 1985

YEAR	HB	MODE CB	PB	TOTAL
1983	53,141		6	53,147
1984	70,271		86	70,357
1985				
1986			56	56
1987			292	292
1988			749	749
1989			229	229
1990		16		16
1992			42	42
1993			731	731
1994		18	238	256
1995			517	517
1996			249	249
1997		556	3,062	3,618
1998		236	654	890
1999		302	1,212	1,514
2000		384	953	1,337
2001		4,729	627	5,356
2002			2,092	2,092
2003		116	1,482	1,598

Table 3.3. Headboat landings (number of fish) by area.

	AREA								
	Dry Tortugas Gulf Vessels	SW FL	FL Middle Grounds	NW FL & AL	LA	NE TX	Central TX	South TX	Total
YEAR	18	21	22	23	24	25	26	27	ALL
1986	28	2,645	26,279	488,750	792	36,729	13,555	2,215	570,993
1987		3,921	11,289	458,594	54	36,052	16,343	4,212	530,465
1988		5,984	9,111	641,962	1,591	34,985	13,027	1,121	707,781
1989		8,967	14,588	355,736	308	31,344	32,293	10,646	453,882
1990	308	8,052	15,058	411,767	1,272	30,122	46,526	25,547	538,652
1991		5,093	8,844	409,086	787	15,802	50,564	16,182	506,358
1992	10	11,424	8,741	545,357	3,960	31,778	40,167	1,098	642,535
1993	22	15,442	16,480	411,036	3,502	49,257	20,367	3,480	519,586
1994	22	11,354	18,783	344,653	3,165	75,280	32,791	6,684	492,732
1995	22	6,028	6,632	320,827	1,097	59,236	37,978	3,947	435,767
1996		9,775		209,416	1,546	40,740	28,129	4,540	294,146
1997		850	436	200,182	183	42,791	32,094	1,437	277,973
1998		2,720	6,000	87,633	80	36,450	23,350	1,920	158,153
1999		1,986	5,679	130,005	544	17,249	23,218	289	178,970
2000		717	1,347	129,563	323	26,057	16,132	5	174,144
2001		2,315	1,239	145,148	355	26,742	37,815	2,179	215,793
2002		2,944	2,448	141,498	355	31,580	37,117	1,366	217,308
2003		5,912	1,432	208,341	389	37,171	41,122	4,852	299,219
2004		4,671	894	230,608	N/A**	55,340	42,137	3,922	337,572

Table 3.4a. Numbers of fish released alive (B2) for the charter boat mode by year and state.

CHARTER BOAT MODE (MODE 3)

YEAR	AL	CV	FL	CV	LA	CV	MS	CV
1981	0	0.00	0	0.00	0	0.00	0	0.00
1982	0	0.00	0	0.00	0	0.00	0	0.00
1983	0	0.00	0	0.00	0	0.00	0	0.00
1984	0	0.00	0	0.00	0	0.00	0	0.00
1985	0	0.00	0	0.00	0	0.00	0	0.00
1986	0	0.00	8,399	0.57	0	0.00	0	0.00
1987	2,166	1.47	843	0.73	0	0.00	0	0.00
1988	0	0.00	84,076	0.35	0	0.00	0	0.00
1989	0	0.00	16,429	0.54	0	0.00	0	0.00
1990	13,282	1.19	16,061	0.59	0	0.00	0	0.00
1991	4,017	0.91	15,232	0.47	0	0.00	0	0.00
1992	15,252	0.95	37,914	0.37	0	0.00	0	0.00
1993	68,445	0.82	61,286	0.33	0	0.00	236	1.62
1994	12,323	0.90	18,968	0.46	0	0.00	884	1.39
1995	28,271	0.95	124,043	0.24	0	0.00	0	0.00
1996	25,229	0.81	3,683	0.49	0	0.00	0	0.00
1997	6,150	0.90	14,708	0.73	0	0.00	0	0.00
1998	9,485	0.41	4,553	0.34	0	0.00	0	0.00
1999	904	0.60	8,847	0.22	0	0.00	0	0.00
2000	569	0.50	7,516	0.25	0	0.00	0	0.00
2001	919	0.80	9,508	0.33	0	0.00	0	0.00
2002	1,450	0.62	1,659	0.32	0	0.00	0	0.00
2003	189	1.00	3,646	0.27	0	0.00	0	0.00
2004	10,477	0.40	17,990	0.12	0	0.00	0	0.00

Table 3.4b. Numbers of fish released alive (B2) for the private boat mode by year and state.

PRIVATE BOAT MODE (MODE 4)

YEAR	AL	CV	FL	CV	LA	CV	MS	CV
1981	0	0.00	0	0.00	0	0.00	0	0.00
1982	0	0.00	0	0.00	0	0.00	0	0.00
1983	0	0.00	0	0.00	0	0.00	0	0.00
1984	0	0.00	0	0.00	0	0.00	0	0.00
1985	0	0.00	0	0.00	5,066	1.00	0	0.00
1986	0	0.00	54,123	0.37	0	0.00	0	0.00
1987	0	0.00	15,772	0.59	0	0.00	0	0.00
1988	0	0.00	25,277	0.39	0	0.00	0	0.00
1989	0	0.00	36,365	0.51	0	0.00	0	0.00
1990	0	0.00	2,561	1.00	0	0.00	0	0.00
1991	12,838	0.55	112,878	0.35	0	0.00	0	0.00
1992	5,197	0.42	104,702	0.28	0	0.00	1,092	0.59
1993	41,650	0.39	115,756	0.27	0	0.00	18,171	0.60
1994	29,950	0.46	31,831	0.31	0	0.00	0	0.00
1995	10,274	0.52	84,522	0.31	10,890	1.00	0	0.00
1996	2,793	0.62	53,730	0.29	0	0.00	1,340	0.90
1997	8,972	0.72	3,592	0.61	774	1.00	0	0.00
1998	3,863	0.44	6,597	0.53	0	0.00	0	0.00
1999	23,530	0.79	13,050	0.36	6,669	0.67	76	1.00
2000	3,543	0.69	10,712	0.44	2,405	1.00	0	0.00
2001	6,080	0.54	33,003	0.38	0	0.00	0	0.00
2002	4,859	0.90	71,475	0.27	0	0.00	462	1.00
2003	548	1.00	67,176	0.23	0	0.00	0	0.00
2004	12,688	0.76	74,775	0.29	0	0.00	0	0.00

Table 3.4c. Numbers of fish released alive (B2) for the combined charter/head boat modes by year and state.

COMBINED CHARTER+HEAD BOAT MODE (MODE 5)

YEAR	AL	CV		FL	CV		LA	CV		MS	CV
1981	0	0.00		0	0.00		0	0.00		0	0.00
1982	0	0.00		3,968	1.49		0	0.00		0	0.00
1983	592	1.46		27,902	0.63		0	0.00		0	0.00
1984	724	1.36		13,598	0.72		0	0.00		0	0.00
1985	0	0.00		17,068	0.94		0	0.00		0	0.00
1986	0	0.00		0	0.00		0	0.00		0	0.00
1987	0	0.00		0	0.00		0	0.00		0	0.00
1988	0	0.00		0	0.00		0	0.00		0	0.00
1989	0	0.00		0	0.00		0	0.00		0	0.00
1990	0	0.00		0	0.00		0	0.00		0	0.00
1991	0	0.00		0	0.00		0	0.00		0	0.00
1992	0	0.00		0	0.00		0	0.00		0	0.00
1993	0	0.00		0	0.00		0	0.00		0	0.00
1994	0	0.00		0	0.00		0	0.00		0	0.00
1995	0	0.00		0	0.00		0	0.00		0	0.00
1996	0	0.00		0	0.00		0	0.00		0	0.00
1997	0	0.00		0	0.00		0	0.00		0	0.00
1998	0	0.00		0	0.00		0	0.00		0	0.00
1999	0	0.00		0	0.00		0	0.00		0	0.00
2000	0	0.00		0	0.00		0	0.00		0	0.00
2001	0	0.00		0	0.00		0	0.00		0	0.00
2002	0	0.00		0	0.00		0	0.00		0	0.00
2003	0	0.00		0	0.00		0	0.00		0	0.00
2004	0	0.00		0	0.00		0	0.00		0	0.00

5. Fishery-Dependent Indices

5.1 Commercial Fishery Catch Rates

The three fisheries independent catch rate indices are summarized in Figure 4.1.

5.1.1 Commercial Handline

Several abundance indices were developed for Gulf of Mexico vermilion snapper using data from commercial logbooks (SEDAR9-DW-05). Trips were limited to those that fished in a single statistical area within the Gulf of Mexico using handlines or electric reels (151,655 trips). The two gear types were considered equivalent. The indices were constructed for the period 1993-2004 because all permitted commercial vessels were required to report during this period. Vermilion snapper occurred on 27% of the 151,655 trips. The Stephens and MacCall (2004) species association approach was used to limit the input data to those trips that were more likely to catch vermilion snapper based on the species composition of the trip. This approach selected 41,255 trips for consideration, and vermilion snapper were landed on 30,471 (74%). Using these trips, delta-lognormal indices were constructed for the Gulf of Mexico, and the eastern and western regions. All indices indicated declining catch rates from 1993-2000. However, the index results differ during the period 2000-2004. The gulf-wide index indicates a slow increase in catch rates from 2000-2004. The eastern index indicates that catch rates have not improved off FL, AL and MS since 2000, while the western index suggests substantial improvement in catch rates of LA and TX.. A second set of indices were constructed that did not exclude trips based on species composition. These indices are very similar to those constructed using the species composition approach. None of the commercial indices directly considered the effect of the increase in minimum legal size that occurred in January 1998 (8" to 10"). Since the commercial data does not include discards, the group recommended that the indices be reconstructed breaking the data into two time periods at the date of the increase in the minimum size limit.

5.2 Recreational Fishery Catch Rates

5.2.1 Marine Recreational Fisheries Statistics Survey Catch Rates

Abundance indices were developed for Gulf of Mexico vermilion snapper (SEDAR9-DW-04) using data from the Marine Recreational Fisheries Statistics Survey (MRFSS). The dataset constructed for these analyses contained all hook and line trips from FL and AL that fished in areas >3 miles offshore. Other trips were excluded because they very rarely observe vermilion snapper. The MRFSS indices were constructed for the period 1986 to 2004. Trips before 1986 were excluded because vermilion snapper were very rarely reported, and as a result, the GLM sample designs were unbalanced with regard to the factors (YEAR, STATE, Red Snapper REC_SEASON and MODE (CB, PB)). Vermilion snapper occurred on 3.8% of 118,725 trips (as either landed or discarded animals A+B1+B2). Therefore there was concern that inclusion of all fishing trips would contaminate the CPUE series by including trips that fished outside of vermilion snapper "habitat" and by violating the statistical assumptions of the binomial component of the delta-lognormal model. Therefore, the Stephens and MacCall (2004) species association approach was used to identify trips that were more likely to observe vermilion snapper based on the composition of other species observed. This approach selected 4,480 trips for consideration of which 2,788 observed vermilion snapper (62%) Using these trips, a delta-lognormal model was constructed. The resulting standardized index indicates catch rates were relatively high during 1990-1995, but declined substantially thereafter, and remain low throughout 1997-2004. A second index was constructed that did not exclude trips based on species composition. This index is very similar one constructed using the species composition approach. Neither index directly considered the effect of the increase in minimum legal size that occurred in January 1998 (8” to 10”), or the 1997 implementation of an aggregate bag limit. However, the group agreed that because the MRFSS dataset includes discarded and released vermilion snapper, management decisions should not adversely affect the quality of the index.

5.2.2 Headboat Survey Catch Rates

An abundance index was developed (SEDAR9-DW-29) for Gulf of Mexico vermilion snapper using data from the NMFS Southeast Zone Headboat Survey. This index spanned from 1986 to 2004, with large sample sizes each year. Additionally, vessels could be tracked individually. Vermilion snapper was the most common species in the Gulf of Mexico headboat dataset and occurred in 38% of trips. Based upon the geographic distribution of average vermilion snapper catch rates, two zones (EAST and WEST, Figure INDEX-??) having relatively high catch rates were defined. The analysis was restricted to data from these two zones in order to reduce variance and to minimize the potential biases of year-to-year fluctuations in the proportion of total effort occurring within these zones. For similar reasons, the Stephens and MacCall (2004) species association approach was used to identify trips that were likely to catch vermilion snapper based on the composition of other species landed. Furthermore, the data were restricted to include only records from vessels making at least 30 of these trips during the time period. Based upon headboat data size frequency distributions, it appeared likely that the imposition of a 10 inch TL minimum size limit in January 1990 likely influenced discard rates, which are not recorded in the headboat survey data. Also, the aggregate 20 fish bag limit was instituted in January 1997, although the impact of this was expected to be lower. As a consequence, the EAST and WEST zone data sets were each split into two time periods (1986-1997 and 1998-2004) within which discard rates were expected to be relative consistent from year to year. For each set of data, a delta-lognormal model was constructed considering the following factors: year, month, season, area, vessel, time of day, trip duration, and whether or not the red snapper season was open (since this could influence fisher behavior). The Working Group recommended that the indices could be considered for use in the assessment, subject to revisions described in section 4.3.

5.3 Recommendations

5.3.1 Indices to be considered for use in the assessment

As a general recommendation, the indices recommended for use from each fishery (pending the expected revisions to the analyses) are those indices which employed the

Stephens and MacCall (2004) approach to subsetting the data, calculated separately for the Eastern and Western Gulf of Mexico. Gulf-wide indices should also be provided.

5.3.2 Data and/or analysis revisions

Due to the expected effect on discard rates caused by changing minimum legal size limits, the commercial handline indices should be constructed separately for the periods before and after the implementation of the 10” minimum size limit.

5.4 References:

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research 70 (2004), 299–310.

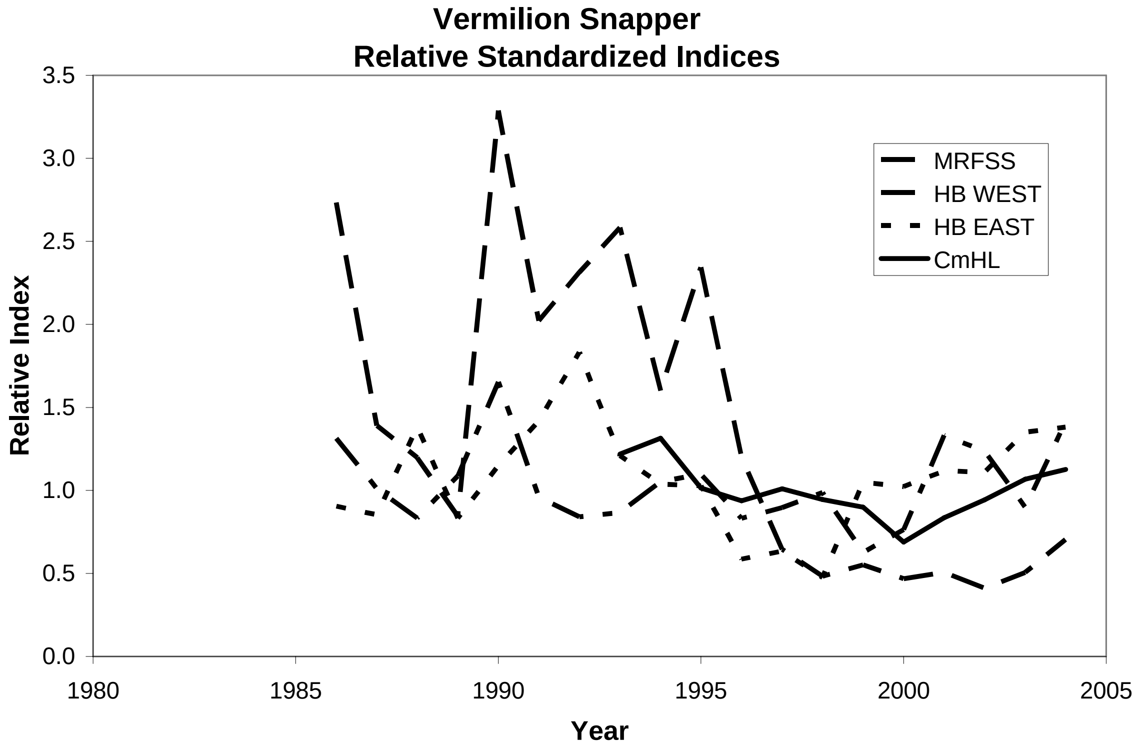


Figure 4.1 Relative standardized catch rate indices constructed using fisheries-dependent data.

6. Fishery-Independent Indices

In preparation for the SEDAR, four fishery independent surveys were analyzed and indices of relative abundance developed. These were the Southeast Area Monitoring and Assessment Program (SEAMAP) shrimp/bottomfish surveys and their predecessors, the SEAMAP ichthyoplankton surveys, the SEAMAP reef fish survey, and the small pelagics trawl survey. The small pelagics data may be useful for extended distributional information, but is not a rigorous time series, and is not considered further here. The ichthyoplankton and reef fish surveys are intended to index spawning stock size. The trawl indexes are intended to index new recruitment.

The three fisheries independent catch rate indices are summarized in Figure 5.1.

6.1 SEAMAP Ichthyoplankton Surveys:

Examination of proportion occurrence and nominal mean abundance of vermilion snapper larvae captured during all SEAMAP surveys indicated that larvae consistently occurred most frequently and in highest abundance in bongo net samples during the annual Fall Plankton survey. This survey coincides with both the time and location of peak vermilion snapper spawning Gulf-wide (in U.S. waters), namely late summer months over the continental shelf. The time series of larval data available for the upcoming assessment includes the years, 1986-2002 with 1998 observations excluded due to curtailed sampling that year. Geographic coverage during the fall plankton survey includes the west Florida shelf where vermilion snapper larvae are present in moderate to high abundances. Catches of vermilion snapper larvae from sampling during the summer and fall shrimp/bottomfish surveys were not included in estimates of annual abundance because these surveys do not extend east of Mobile Bay, Alabama and, therefore, do not adequately sample a large portion of the vermilion snapper spawning stock. It is evident from a comparison of mean annual abundances, coefficients of variation of mean abundance (CV), and annual proportion occurrence in the two plankton gear types that vermilion snapper larvae are taken more consistently in bongo than in neuston samples. CV's over the time series for bongo net catches are lower and relatively more stable than for neuston net catches. We recommend that the vermilion snapper index of larval abundance be based on bongo net samples from the SEAMAP Fall Plankton survey. This index, as reported in working document SEDAR9-DW-24, should be considered a nominal or raw index only.

Two sampling issues were discussed by the workgroup that need addressing before standardized larval indices are constructed and evaluated. The first was duplicate and/or multiple sampling at some SEAMAP systematic grid sites, and the second, was gaps in spatial coverage over the survey area. Two methods to mitigate any potential bias in survey indices caused by variable spatial coverage were discussed. First was a two step process to filter sample sites used to estimate larval abundance. Step one deletes duplicate samples at a systematic grid site, retaining a single sample at each grid site in accordance with SEAMAP sample design. Priority is given to samples collected by NMFS vessels since these vessels generally collect the majority of survey samples overall, and then to the sample nearest the actual grid site. The second step deletes any sites on the systematic grid not sampled during at least 75% of years in the time series resulting in a more consistent area of coverage over the time series.

The workgroup also briefly discussed the need to construct an age or size corrected index due to inter-annual differences in size (age) composition of vermilion snapper larvae over the index time series. It was decided that both adjusted (as described in Hanisko et al. SEDAR7-RW 7) and unadjusted indices will be constructed and compared. The final step will be construction of a model based larval abundance index using the delta-lognormal approach (Lo et al., 1992). Joanne Lyczkowski-Shultz will provide the final indexes prior to the August stock assessment. Separate east and west larval indexes have been requested. These will also be available prior to the assessment.

6.2 SEAMAP Reef Fish Survey:

The SEAMAP reef fish survey employs video cameras to estimate the abundance of fish associated with reefs and banks located on the continental shelf of the Gulf of Mexico. Fish traps are also employed to capture fish for aging. Details of survey design and estimates of abundance for vermilion snapper are in the working paper. We recommend the use of design-based estimates of abundance for vermilion snapper, gray triggerfish and greater amberjack. There was no advantage to using the model-based estimates because no gaps were present in the survey time series that could be accounted for using a GLM approach. The size of the fish observed during the survey come from two sources, fish captured in traps and fish measured on video tape with lasers. Lasers were first introduced in 1995. However, since both the capture of fish in traps, and the instances where fish are hit by lasers was infrequent, size distributions were not estimated. We report only the average size and size range of fish. Survey indices are presented in working paper SEDAR9-DW21. The size of vermilion snapper observed ranged from 135 mm to 586 mm FL. Therefore the video survey observes fish age 0+. Information from commercial and recreational catch of vermilion snapper indicates the largest catches of adults are from the Texas-Louisiana and Florida panhandle area of the Gulf of Mexico. However, the vermilion snapper larval catch data indicate large catches off of southwest Florida. The video data will be re-examined to tease out adult vermilion snapper abundance off southwest Florida. Additionally, the results of a 2004 survey will be added. These will be provided prior to the August stock assessment by Chris Gledhill, NMFS Pascagoula, MS. Separate east and west indexes have been requested. These will also be available prior to the assessment.

6.3 SEAMAP Trawl Surveys:

The procedures used in SEDAR7 to derive trawl survey indexes of abundance for red snapper (SEDAR7-DW- 1, 2; and the age composition portion of AW-15) were applied to vermilion snapper, and reported in SEDAR9-DW-27. A Bayesian modeling procedure is used to combine different survey designs from different time series to create a Fall index for 1972-2004, and a summer index for 1981-2004 based on the SEAMAP standard. Standard SEAMAP surveys are conducted between 5 and 50 fm, from Mobile Bay to the Mexican border. Vermilion snapper appear to be abundant enough to get useful indexes. However, we know from sporadic research vessel trawling and bycatch observer work that vermilion catch rates in the eastern Gulf are often much higher than they are in the SEAMAP trawl survey areas. Therefore, the SEAMAP trawl surveys may not be indexing a suitably large fraction of the total population. Vermilion snapper appear to have the most intense patchiness of any species examined to date, leading to large interannual fluctuations that may reflect more or fewer chance encounters with high density patches than real changes in overall abundance. Size composition data are available for 1987 forward. There often appear to be at least two peaks in the size frequencies consistent with two year classes. However, compared to red snapper, the separations are not as clean, and there are far fewer fish in the samples.

A temporary working group consisting of age / growth, larval index, and trawl index specialists met during the Data Workshop to interpret the size compositions from the SEAMAP trawl surveys collected in SEDAR9-DW-18, concentrating on the plots made from fish from all years, combined.

For vermilion snapper in the summer survey, there is a contribution of fish below 80mm that are clearly young of the year. However, as much of the annual recruitment has yet to occur, interannual variations in this peak cannot be expected to index year class strength. There is a much broad peak from 80 mm, dropping off above 200 mm, but continuing to 400 mm. This peak is almost certainly numerically dominated by age 1's, but based on the known large variations in age at size, could likely contain sizeable numbers of 2+s. The pattern of any possible exit from trawl vulnerability with increasing size or age is not known, but age 1's >200 mm are captured by hook and line on reefs. Therefore, it is possible that trawl surveys might favor capture of smaller 1's over larger 1's. At present, there has been no direct ageing of vermilion snapper from the trawl surveys, and we recommend starting that project. Until a time series of aged catches is established for the trawl surveys , the recommend interpretation of the summer survey index is to use the catch rate of fish >80mm as an index for 1+, with selectivity among ages unspecifiable from the survey alone.

In the fall survey, vermilion snapper show two peaks, with some overlap. Imposing a boundary between the peaks at 150mm would appear to be a reasonable approximation. The peak of smaller fish are clearly young of the year. The concern is whether recruitment is complete enough every year by the time of the fall survey such that year to year variations do index year class strength. Examination of larval survey catch rates (tables 2 & 3 of SEDAR9-DW-24) suggested that a substantial fraction of annual larval production might extend into October (perhaps 25%), but closer examination showed most October occurrences came from early October. Thus, there may be some contribution from spawning season variation to the interannual variation of the age 0 component of the trawl survey index, but it was felt that variation would usually be dominated by variation in year class strength, and thus should be considered in the assessment. The interpretation recommended for the peak of larger fish followed the same reasoning as the summer discussion – that fraction should be presently be treated as an index of 1+, without specifying a selectivity vector for ages from the trawl data at this time.

In red snapper (SEDAR7-AW-15), it was possible to establish age 0 / age 1 boundaries that varied over years. (The annual size compositions were not ambiguous for that more abundant species.) There are some cases of apparent shifting in the annual plots in SEDAR9-DW-18, but on an annual basis, the data become quite sparse. We decided to recommend against changing age 0 / age 1 boundaries among years. Such a procedure would probably add more noise than signal.

Scott Nichols will provide the age composition vectors prior to the August stock assessment. Separate east and west indexes have also been request. A west index will be provided for the assessment. An index from the easternmost sampling in the SEAMAP surveys will also be developed, but it may not be useful because so little of the eastern range is covered.

6.4 Summary of Outstanding Items:

In summary, fishery independent index items still outstanding, but slated for completion prior to the SEDAR9-AW in August are: final larval indexes: total, east, and west (Lyczkowski-Shultz); updated reef fish indexes (total), plus east / west breakouts (Gledhill), and trawl index age compositions and east / west breakouts (Nichols). In addition, the Reef Fish video data will be checked for the abundances in SW Florida (Gledhill).

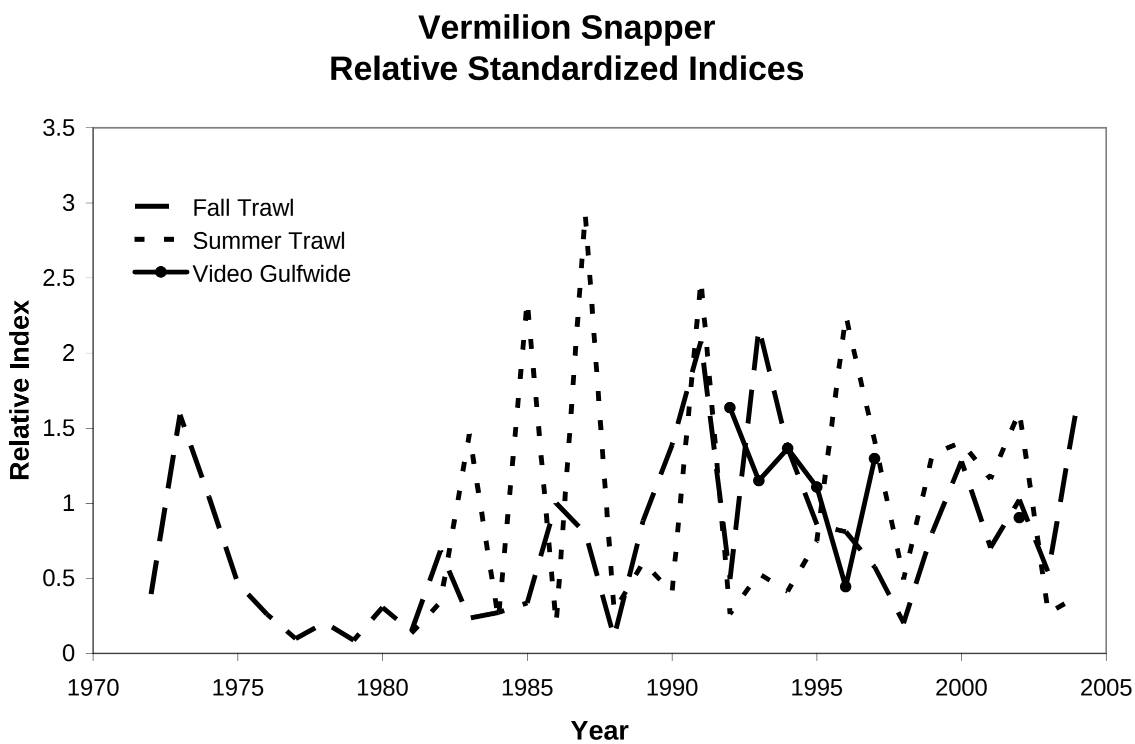


Figure 5.1 Relative standardized catch rate indices constructed using fisheries-independent data.

7. Release mortality

Limited information exists on catch and release mortality of vermilion snapper in the Gulf of Mexico. The only directed study (Burns et al. 2002) concluded that vermilion snapper are more susceptible to release mortality than red snapper, gag, and red grouper, but a mortality rate was not provided. Control fish, which were held in cages at depth of capture (up to 60 m) for 2 weeks had no significant mortality and showed little or no signs of decompression stress (e.g., everted stomachs, over-expanded swimbladders, protruding eyes). Based on low tag recaptures (0.7%) and the behavior of released fish held in tanks (all fish remained on the bottom of the tank until their vented swimbladders healed) the authors hypothesized that the main cause of release mortality for vermilion snapper is bottom predation.

In contrast, unpublished data provided by Bob Shipp at the SEDAR 9 Data Workshop suggest very low release mortality (5.5%) for vermilion snapper caught by the recreational fishery off of Alabama. Of the 72 vermilion snapper caught, tagged, and released as part of a MARFIN study, 68 swam vigorously towards the bottom (i.e., showed no significant signs of stress at the time of release) and were expected to survive. If we consider that the 4 fish that showed signs of stress at the time of release (i.e., oriented towards the bottom but swam erratically, or swam erratically and remained at the surface) would subsequently die, the estimated release mortality rate would be 5.5% (4/72).

Release mortality for vermilion snapper in the South Atlantic has been estimated at 17% for fish caught at depths of 43–55 m (Collins et al. 1999) and 27% for headboat catches (Dixon and Huntsman, unpublished data). The commercial fishery typically operates at greater depths than the headboat fishery, which the group believes would result in higher mortality rates. For that reason and based on the previous estimates, release mortality rates of 40% and 25% were recommended by the SEDAR 2 Data Workshop Life History Working Group for the South Atlantic commercial hook-and-line and headboat fisheries, respectively.

7.1 Recommended ranges

Given the lack of solid information on release mortality of vermilion snapper in the Gulf of Mexico, the Life History Working Group recommended that a range of values be used for sensitivity analysis. After discussion during the plenary session (including input by commercial and recreational fishers) the group decided that sensitivity runs be based on the following range of values:

(1) Private recreational: 10-40%

(2) Headboat: 40-60%

(3) Commercial hand-line: 40-75%.

The logic was to add 0.1 to the observed acute, immediate, at the surface mortality to provide a minimum for the range with the upper bounds set substantially above the minimum in order to provide a reasonable range of response. Typically upper bounds were set 0.3 or more above the lower bound.

7.2 Literature cited

Burns, K.M., C.C. Koenig, and F.C. Coleman. 2002. Evaluation of multiple factors involved in release mortality of undersized red grouper, gag, red snapper, and vermilion snapper. Mote Marine Laboratory Technical Report No. 790.

Collins, M.R. J.C. McGovern, G.R. Sedberry, H.S. Meister, and R. Pardieck. 1999. Swim bladder deflation in black sea bass and vermilion snapper: potential for increasing post release survival. N. Am. J. Fish. Manage. 19:828-832.

Dixon, R. L. and G.R. Huntsman. Unpublished. Survival rates of released undersized fishes. NMFS Beaufort.

8. APPENDICES

8.1 APPENDIX 1. TEXAS RECREATIONAL LANDINGS

Recreational landings estimates for TX, 1981-1985.

Prepared June 21, 2005, Patty Phares

I. Available estimates for gray triggerfish, greater amberjack and vermilion snapper in TX

A. TPWD Management Data Series 204 – Private and charterboat only (no headboat).

Annual landings estimates, with a year defined as May 15 - May 14, for 1983/84 through 1997/98.

(Estimates for 1998-99 and later years have not been received yet.)

These annual estimates are what TPWD uses and are based on the same survey data they use to compute the TPWD wave estimates sent to us. If landings by wave are not needed, these annual estimates may be best, at least until the wave estimates for 1983-1997 are replaced (see notes below).

Notes:

(1) The annual estimates were recomputed in the mid-1990s using a revision to the "pressure files", thus eliminating some extreme estimates.

The wave estimates for the 1980s and early 1990s have not yet been recomputed to use the revised pressure files and still contain outliers which may disappear when the wave estimates are recomputed.

(2) The annual estimates are based on 2 fishing seasons (high use and low use) and may be more precise than the sum of the 6 wave estimates.

(3) The annual estimates incorporate data entry corrections not yet made to the wave estimates.

(4) TPWD makes species-specific estimates for selected "target species". The rest of the species are combined in to "other". A "substitute" estimate can be derived for the species in "other" based on the counts of species observed, but these may not be very reliable estimates.

The annual estimates have species-specific estimates for each of these 3 species in gulf areas (not bays) in all years.

Before 1994, the wave estimates have species-specific estimates for vermilion snapper in gulf areas but not for gray triggerfish and vermilion snapper.

B. TPWD Management Data Series 29 and 58 – gulf headboats, through May 1983.

(#29) Annual landings estimates (use gulf headboats):

Sept 1978 - Aug 1979

Sept 1980 -- Aug 1981

Sept 1981 -- Aug 1982

(#58) Landings estimates for a partial year (use gulf headboats):

Sept 1 1982 -- May 14 1983

Notes:

(1) These MDSs were published in 1984 and may not incorporate needed revisions as do those in MDS 204 (no confirmation from TPWD on this yet).

(2) The Sept-Aug years are not comparable to either the May 15-May 14 years or to calendar years.

(3) According to the MDS, not all headboat in the survey areas were found and contacted (apparently a census was attempted) and possibly not all regions were covered (survey areas listed do not include the current "major areas" of gulf waters off Sabine Lake, Matagorda, San Antonio). **The MDS 29 states "Harvest estimates in this study should be considered minimum estimates...".**

C. TPWD wave estimates (estimates made for NMFS) – summed into May-April.

Summed to be comparable to TPWD annual estimates in A (May 1 - April 30, 1983/84 -- 2002/03).

Private and charterboats all years, headboats only in May 1983 - Aug 1984.

D. TPWD wave estimate (estimates made for NMFS) – same as C. but summed into annual Jan-Dec

Summed into annual estimates (Jan-Dec) as would be used in assessments.

Private and charterboats (wave 3-6 only in 1983), headboats only in May 1983 - Aug 1984.

F. MRFSS 1981- 1985. The only estimates are:

1981 waves 2, 3, 5, 6 (waves 1 and 4 are missing). All modes, charterboat and headboat combined.

1982-1984 waves 1-3, 5-6 (wave 4 is missing). Only shore mode.

1985 waves 1-2, 5-6 (wave 4 is missing). All modes, charterboat and headboat combined.

G. NMFS HEADBOAT SURVEY, 1986-1989

Use these estimates to evaluate magnitude and trends in pre-1986 headboat landings in TX.

Before 1997, TX landings were combined for Jan-May and for Sept-Dec.

Area (TTS, EEZ is not known), but all can be assigned to EEZ (area=4) for this purpose. These are gulf headboats (not in the bays).

II. Summary of “holes”

If both MRFSS and TPWD wave estimates are used:

* charter and headboat are combined in MRFSS (are bay headboats included in MRFSS?) .

x = “hole” (no survey or MRFSS estimate lost)

		Shore	Private	Charter	Headboat (gulf)	Headboat (bay)
1981	wave 1	x	x	x	x	x
	wave 2	MR	MR	MR*	MR*	with gulf?
	wave 3	MR	MR	MR*	MR*	with gulf?
	wave 4	x	x	x	x	x
	wave 5	MR	MR	MR*	MR*	with gulf?
	wave 6	MR	MR	MR*	MR*	with gulf?
1982	wave 1	MR	x	x	x	x
	wave 2	MR	x	x	x	x
	wave 3	MR	x	x	x	x
	wave 4	x	x	x	x	x
	wave 5	MR	x	x	x	x
	wave 6	MR	x	x	x	x
1983	wave 1	MR	x	x	x	x
	wave 2	MR	x	x	x	x
	wave 3	MR	TX	TX	TX	TX
	wave 4	X	TX	TX	TX	TX
	wave 5	MR	TX	TX	TX	TX
	wave 6	MR	TX	TX	TX	TX
1984	wave 1	MR	TX	TX	TX	TX
	wave 2	MR	TX	TX	TX	TX
	wave 3	MR	TX	TX	TX	TX
	wave 4	X	TX	TX	TX	TX
	wave 5	MR	TX	TX	x	TX
	wave 6	MR	TX	TX	x	TX
1985	wave 1	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 2	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 3	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 4	x	TX/x	TX/x	x/x	TX/x
	wave 5	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 6	MR	TX/MR	TX/MR*	x/MR*	TX/MR*

III. DISCUSSION

Comparing data sources in Tables 1 and 2, there is not appearance of comparability among data sources. For instance, in Table 1(a) for gray triggerfish, the TPWD Management Data Series estimates (based on May15-May14 year) and TPWD wave estimates made for NMFS are very different in many years. For MRFSS, there are almost no gray triggerfish estimates, but the leatherjacket family (Table 1(d) bears slight resemblance to the estimates from other sources.

This is true for private and charter (including MRFSS charter + headboat) for all three species (gray triggerfish, greater amberjack, vermilion snapper).

For headboats (without charterboats) compared between TPWD and the NMFS Headboat Survey, the comparisons cannot be made in the same year, but the general magnitude of TPWD estimates before 1985 is not like that of Headboat Survey estimates in 1986+ except for vermilion snapper.

Comparisons are destined to be faulty because of the abundance of “holes” and the different time periods for estimates (not the same 12-month period), different grouping of modes (charterboat and headboat alone vs. separate), and poor quality of some of the estimates. The TPWD wave estimates for these years do not have the benefit of revisions slated to be done, and the sampling levels are especially low for charterboats. The MRFSS estimates before 1986 also are considered less reliable – the charterboat component uses the “old” method for charterboats, and there are weaknesses in the estimates for all modes (early years of survey, less thorough editing of data when all estimates were revised in early 1990s, some procedural or methodological differences?).

In short, it’s too messy to try to consolidate the different estimates and fill in the holes. My suggestions are:

(1) Use MDS private and charterboat estimates for 1983-1997 (and use then as though they are calendar year estimates)

(2) Use TPWD wave estimates for 1998+ (these use the calculation procedures that will be applied to the earlier years when time allows for TPWD to do replace the old estimates).

(3) Use the average of the Headboat Survey for 1986-1989 for all years 1981-1985 (perhaps modified by Bob Dixon and TPWD if they believe the fleet was smaller or different).

If this is unsatisfactory, anyone’s procedure may be just as good. But there will never be more data, just re-hashing of the same data presented here.

SEDAR 9
SOUTHEAST DATA, ASSESSMENT AND REVIEW

Assessment of Vermilion Snapper, *Rhomboplites aurorubens*,
in the U.S. Gulf of Mexico

Stock Assessment Report 3

Section III. Assessment Workshop Report

Prepared by

SEDAR 9 Stock Assessment Panel

10 March 2006

Table of Contents

III. Stock Assessment Workshop Report
(Developed by Assessment Workshop Panel)

1. Introduction

1.1. Workshop Time and Place

The SEDAR 9 Assessment Workshop was held in Miami, FL, August 22 – 26, 2005.
A follow-up Assessment Workshop was held in Atlanta, GA, December 19-20, 2005

1.2. Terms of Reference

1. Select several appropriate modeling approaches, based on available data sources, parameters and values required to manage the stock, and recommendations of the Data Workshop.
2. Provide justification for the chosen data sources and for any deviations from Data Workshop recommendations.
3. Estimate stock parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates and measures of model 'goodness of fit'.
4. Characterize uncertainty in the assessment, considering components such as input data, modeling approach, and model configuration.
5. Provide yield-per-recruit and stock-recruitment analyses.
6. Provide complete SFA criteria. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT). Develop stock control rules.
7. Provide declarations of stock status relative to SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT.
8. Estimate Allowable Biological Catch (ABC) and provide an appropriate confidence interval.
9. Project future stock conditions and develop rebuilding schedules if warranted; include estimated generation time. Projections shall be developed in accordance with the following:
    - A) If stock is overfished:
        - F=0, F=current, F=Fmsy, Ftarget (OY),
        - F=Frebuild (max that rebuild in allowed time)
    - B) If stock is overfishing
        - F=Fcurrent, F=Fmsy, F= Ftarget (OY)
    - C) If stock is neither overfished nor overfishing
        - F=Fcurrent, F=Fmsy, F=Ftarget (OY)
10. Evaluate the results of past management actions and probable impacts of current management actions with emphasis on determining progress toward stated management goals.
11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and

sampling intensity. Prioritize recommendations based on their likelihood for improving stock assessment.

12. Fully document all activities: Draft Section III of the SEDAR Stock Assessment Report and provide complete tables of estimated values.
    - Reports are to be finalized and distributed to the panel for review by September 30.
    - Comments due to editors by October 14.
    - Final version due to Coordinator by October 28.

1.3. List of Participants

1.3.1. Assessment Workshop I, August 22-26 2005

Workshop Participants:

Harry Blanchet ....LA DWF/ GMFMC FSAP
Liz Brooks..NMFS/SEFSC Miami, FL
Craig Brown...NMFS/SEFSC Miami, FL
Shannon Calay ....NMFS/SEFSC Miami, FL
Guillermo Diaz...NMFS/SEFSC Miami, FL
Bob Dixon..NMFS/SEFSC Beaufort, NC
Bob Gill..GMFMC Advisory Panel
George Guillen...Univ. Houston Clear Lake/GMFMC SSC
David Hanisko ....NMFS/SEFSC, Pascagoula MS
Walter Ingram ....NMFS/SEFSC Pascagoula MS
Bob Muller..FL FWCC/GMFMC SSC
Debra Murie ....University of Florida/GMFMC FSAP
Josh Sladek Nowlis.......................................NMFS/SEFSC Miami, FL
Scott Nichols...NMFS/SEFSC Pascagoula MS
Dennis O'Hern..GMFMC Advisory Panel
Larry Perruso ....NMFS/SEFSC Pascagoula MS
Steven Saul..RSMAS/ SEFSC Miami FL
Jerry Scott ....NMFS/SEFSC Miami, FL
Steve Turner...NMFS/SEFSC Miami, FL

Observers:

Kay Williams ....GMFMC
Elizabeth Fetherston.....................................Ocean Conservancy
Albert Jones ....GMFMC SSC

Staff:

John Carmichael..SEDAR
Stu Kennedy..GMFMC
Dawn Aring...GMFMC
Patrick Gilles..NMFS/SEFSC Miami FL

1.3.2. Assessment Workshop II, December 19-20 2005

Workshop Participants:

Liz Brooks..NMFS/SEFSC Miami, FL
Craig Brown..NMFS/SEFSC Miami, FL
Shannon Calay ....NMFS/SEFSC Miami, FL
Guillermo Diaz..NMFS/SEFSC Miami, FL
George Guillen...Univ. Houston Clear Lake/GMFMC SSC
Walter Ingram ....NMFS/SEFSC Pascagoula MS
Bob Muller ....FL FWCC/GMFMC SSC
Debra Murie ....University of Florida/GMFMC FSAP
Josh Sladek Nowlis.......................................NMFS/SEFSC Miami, FL
Dennis O'Hern...GMFMC Advisory Panel
Jerry Scott ....NMFS/SEFSC Miami, FL
Steve Turner..NMFS/SEFSC Miami, FL
Clay Porch...NMFS/SEFSC Miami, FL

Observers:

Roy Williams ....GMFMC

Staff:

John Carmichael..SEDAR
Stu Kennedy..GMFMC
Dawn Aring...GMFMC
Patrick Gilles...NMFS/SEFSC Miami FL

1.4. List of Assessment Workshop Working Papers, Assessment Workshop I & II

SEDAR9-AW1	Incorporating age information into SEAMAP trawl indices for SEDAR9 species	Nicholls, S.
SEDAR9-AW2	Separating Vermilion Snapper Trawl Indexes into East and West Components	Nicholls, S
SEDAR9-AW3	Modeling Shrimp Fleet Bycatch for the SEDAR9 Assessments	Nicholls, S
SEDAR9-AW4	Status of the Vermilion Snapper (*Rhomboplites Aurorubens)* Fisheries of the Gulf of Mexico	Cass-Calay, S.
SEDAR9-AW5	Gulf of Mexico Greater Amberjack Stock Assessment	Diaz, Guillermo A., and Elizabeth Brooks
SEDAR9-AW6	A Categorical Approach to Modeling Catch at Age for Various Sectors of the Gray Triggerfish (*Balistes Capriscus)* Fishery in the Gulf of Mexico	Saul, Steven and G. Walter Ingram, Jr.
SEDAR9-AW7	Updated Fishery-Dependent Indices of Abundance for Gulf of Mexico Gray Triggerfish (*Balistes Capriscus)*	Nowlis, Joshua Sladek
SEDAR9-AW8	An Aggregated Production Model for the Gulf of Mexico Gray Triggerfish (*Balistes Capriscus)* Stock	Nowlis, Joshua Sladek and Steven Saul
SEDAR9-AW9	Age-Based Analyses of the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock	Nowlis, J. S.
SEDAR9-AW10	Gulf of Mexico greater amberjack virtual population analysis assessment	Brown, C. A.,C. E. Porch, and G. P. Scott
SEDAR9-AW11	Rebuilding Projections for the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock.	Nowlis, J. S.

2. Data Review and Update

Input data are discussed and tabulated within the detailed sections for each model (Sections 3.1 and 3.2). Deviations from SEDAR9-DW recommendations are noted.

3. Stock Assessment Models and Results

Two types of models were used to assess the status of vermilion snapper in the U.S. Gulf of Mexico, a state-space implementation of the Pella-Tomlinson (P-T) non-equilibrium surplus production model (Porch, 2001), and a state spaced age-structured production model (Porch, 2002a). The P-T production model is presented as a continuity case, and is intended to replicate the previous assessment (Porch and Cass-Calay, 2001).

3.1. Model 1: Continuity Case-Pella-Tomlinson Production Model

3.1.1. Pella-Tomlinson Production Model Methods

3.1.1.1. Overview

The P-T production model was used to replicate the previous assessment (Porch and Cass-Calay, 2001), and requires the following assumptions: 1) that there is a single unit stock, 2) that all age classes have the same average fecundity, and 3) that all age classes are equally vulnerable to fishing. These assumptions seem plausible for vermilion snapper of reproductive age (age 1 and older) because the growth curve is relatively flat and the variance in size-at-age is large.

The base model of the previous assessment (2001) used the P-T production model to obtain estimates of population abundance and mortality rates using data from 1986 - 1999.

3.1.1.2. Data Sources

Available data inputs were used as provided by the SEDAR9 Data Workshop (SEDAR 9: Vermilion Snapper Data Workshop Report). Three catch series (Commercial, Recreational and Shrimp Bycatch), one effort series (Shrimp Bycatch) and two indices of abundance (Commercial-Handline and Headboat East) were considered. The catch and effort series are summarized in Table 3.1.1.2.1. Indices of abundance are summarized in Table 3.1.1.2.2.
The effort series for the shrimp fleet was provided by the SEDAR7 (Red Snapper) data workshop, and is discussed in document SEDAR7-DW-24.

No attempt was made to model the dead discards of the recreational and commercial fisheries. In other words, release mortality was assumed to be negligible.

3.1.1.3. Model Configuration and Equations

The following description of the Pella-Tomlinson production model is excised (with permission of the author) from the description by Porch (2001).

The Pella-Tomlinson (1969) generalized production model may be written in the form

$$\frac{dB}{dt} = rB\left(1-\left(B/k\right)^{m-1}\right)-FB \tag{1}$$

where B denotes biomass, r is the intrinsic rate of increase, k is the carrying capacity, F is the fishing mortality rate, and m is the exponent controlling the inflection point of the production curve. There is no general analytical solution for this differential equation, although analytic solutions exist for specific values of m (e.g., the classic Schaeffer model with m=2). The present algorithm uses the semi-implicit difference approximation suggested by Otter Research Ltd. (2000),

$$B_{t+\delta} = \frac{B_t(1+r\delta)}{1+(r(B_t/k)^{m-1}+F_t)\delta} \tag{2}$$

Tests comparing this approximation with the exact solution for m=2 indicate it is accurate to several significant digits with δ = 1/16 yr.

The process and observation equations are summarized in Table 3.1.1.3.1. Process errors in the state variables and observation errors in the data variables were accommodated using the first-order autoregressive (AR1) model

$$\begin{aligned} g_{t+1} &= \mathrm{E}[g_{t+1}]\, e^{\varepsilon_{t+1}} \\ \varepsilon_{t+1} &= \rho\varepsilon_t + a_{t+1} \end{aligned}, \tag{3}$$

where g represents any given state or observation variable, a is a normal-distributed random error with mean 0 and standard deviation σ_g, and E[g] denotes the expected value of g given by the deterministic components of the process or observation equations in Table 3.1.1.3.1. In the case of data, the g_t in Eq. 3 correspond to observed quantities, but in the case of states the g_t are unobserved and must be estimated along with the parameter vector. For stability reasons, it is assumed that ε_0 = 0, leading to the negative log-density

$$-\log \mathrm{P}(g\,|\,\Theta,\mathbf{X}) = \frac{1}{2\sigma_g^2}\left[(\ln g_1 - \ln \mathrm{E}[g_1])^2 + \sum_{t=1}^{N-1}(\ln g_{t+1} - \ln \mathrm{E}[g_{t+1}] - \rho \ln g_t + \rho \ln \mathrm{E}[g_t])^2\right] + N\log\sigma_g\,, \tag{4}$$

where ρ_g is the correlation coefficient and σ_g^2 is the variance of log(a). In the present model, variances of the process and observation errors are parameterized as multiples of an overall variance parameter σ^2, i.e., $\sigma_g^2 = V_g\sigma^2$. Note that the 'random walk' model of Fournier et al. (1998) is merely a special case of Eq. 4 with $\rho = 1$ and $E[g_t] = g_0$ (a time-invariant parameter).

Catch and effort series were assumed to be lognormally distributed. The shrimp bycatch is poorly known and was assigned a relatively high coefficient of variation (CV) of 1.0, whereas the shrimp effort was assumed to be somewhat better known and assigned a CV of 0.5 The recreational catches were assigned CV's equal to the MRFSS estimates ($CV \cong 0.15$). The commercial catch, which is based on a census, was assumed to have relatively low CV of 0.1.

Estimates of the CVs of the two CPUE series are available from GLM results, but are unrealistically small as they reflect only the uncertainty in measuring CPUE rather than the uncertainty that CPUE reflects abundance. Accordingly, the two indices were assigned equal CVs in each year, and that value was estimated within the production model. In effect, this is equivalent to equally weighting the indices.

The model was implemented using the nonlinear optimization package AD Model Builder (Otter Research Ltd., 2000).

3.1.1.4. Parameters Estimated

The parameters estimated in P-T production model include three catchability coefficients (q_f, one for each fishery, f), three sets of effort parameters (E_{fy}), the initial biomass (B_{1986}), carrying capacity (k) and the intrinsic rate of increase (r). For the continuity case, the production exponent was fixed at m = 2 (Schaeffer type model). The state variables r, k and q_f were estimated as described in Table 3.1.1.4.1; no inter-annual variability was allowed. The annual effort parameters were assumed to be lognormally distributed about the overall mean of the series with a relatively large process error (CV = 0.5). A penalty was also incorporated that prevented MSY from being greater than the largest catch in the series.

3.1.1.5. Uncertainty and Measures of Precision

Parameter uncertainty was addressed by estimating process and observation errors. A complete description of the equations used can be found in a previous section, Section 3.1.1.3.

3.1.1.6. Benchmark / Reference points methods

Reference points and benchmarks were calculated with regard to maximum sustainable yield (MSY). Since the production exponent was fixed at 2.0, the model is a Schaeffer type model, and B_{MSY} occurs at k/2.

3.1.1.7. Projection methods

Projections were run replicating the methods of the 2001 assessment base model projections. Each projection was calculated from 2005 to 2016. Fishing mortality during 2005 and 2006 was assumed to be equal to the 2004 level. Four types of projections are presented; (1) constant fishing mortality (F_{2004}) projected through 2016, (2) fishing at F_{MSY} from 2007-2016, (3) fishing at the constant F that allows recovery in 2014, and (4) fishing at the constant yield that allows recovery in 2014. Projections 3 and 4 were intended to address the recovery plan imposed by Amendment 23 which stipulates recovery of the Gulf stock of vermilion snapper by 2014.

These projections are identical to those run during the 2001 assessment, except the recovery target year was 2011, and F_{2000} and F_{2001} were assumed equal to F_{1999} for the 2001 projections.

3.1.2. Pella-Tomlinson Production Model Results

3.1.2.1. Measures of Overall Model Fit

The likelihood statistics of the P-T model are as follows:

AIC:	-1.64e+02
AICc (small sample):	2.35e+01
Objective Function:	-1.45e+02

Generally, the performance of the P-T production model was adequate. Fits to the catch series and summarized in Fig. 3.1.2.1.1 and Table 3.1.2.1.1. For the directed fleets, predicted values rarely deviated from the observations by more than 20%. The fits to the shrimp bycatch were poor; deviations averaged 20-50%. However, this was not unexpected since a CV of 1.0 was used for the shrimp bycatch and CVs of 0.1 were used for the other catch series.

Fits to the shrimp effort series (Fig. 3.1.2.1.2 and Table 3.1.2.1.2), and indices of abundance (Fig. 3.1.2.1.3 and Table 3.1.2.1.3) were acceptable, although deviations were generally larger than those of the catch series. The recent improvement in catch rates implied by the commercial handline index was not reflected in the fit of the P-T model (Fig. 3.1.2.1.3).

3.1.2.2. Parameter estimates

The parameter estimates obtained from the P-T model continuity case are summarized in Table. 3.1.2.2.1.

3.1.2.3. Stock Biomass

The continuity run of the P-T production model estimated B_{MSY} at 10.8 million pounds. Results indicate that the biomass of vermilion snapper was below B_{MSY} during the initial year (1986), and remained so throughout the time series. In 1986, B/B_{MSY} was 0.74. The population status improved somewhat between 1986 and 1992, and then generally declined to a series minimum of 0.40 in 2004 (Fig. 3.1.2.3.1 and Table 3.1.2.3.1).

To facilitate comparison, the results of the 2001 base case and 2005 continuity case are overlaid in Figure 3.1.2.3.1. The population biomass estimates of the continuity case are very similar to the base case used during the previous assessment.

3.1.2.4. Fishing Mortality

The annual estimates of fishing mortality are summarized in Figure 3.1.2.4.1 and Table 3.1.2.4.1. The continuity run of the P-T production model estimated F_{MSY} at 0.33. According to the continuity run, F in the initial year was above F_{MSY} (F_{1986}/F_{MSY} = 1.2), then declined to a level near F_{MSY} until 1989. After 1989, F increased rapidly to values substantially above F_{MSY}. The fishing mortality rate remains above F_{MSY} through 2004. In 2004, F is estimated at 0.90 (F_{2004}/F_{MSY} = 2.7), the highest value in the time series.

The estimated fishing mortality rates from the continuity case are very similar to the base case used during the previous assessment (Figure 3.1.2.4.1.)

3.1.2.5. Measures of Parameter Uncertainty

Parameter uncertainty was addressed by estimating process and observation errors. The standard deviations of the estimated parameters are summarized in a previously cited table, Table 3.1.2.2.1.

3.1.2.6. Retrospective and Sensitivity Analyses

As this was intended to be a continuity case, no retrospective or sensitivity analyses were preformed. This model was intended to determine the effect of 5 additional years of data and updated data series on the estimated population benchmarks and reference points. This model was also constructed for comparison with a new age-structured approach (SSASPM) to be discussed in subsequent sections.

3.1.2.7. Benchmarks / Reference Points

The benchmarks and reference points estimated by the P-T production model continuity case and the 2001 base model are summarized in Table 3.1.2.7.1. According to the P-T production model continuity case, the 2004 population status is overfished (B_{2004}/B_{MSY} = 0.40) and overfishing is ongoing (F_{2004}/F_{MSY} = 2.7). This result is similar to the previous assessment (B_{1999}/B_{MSY} = 0.36; F_{1999}/F_{MSY} = 2.0).

3.1.2.8. Projections

Four projection scenarios were considered for the continuity case. These replicated the projections run for the 2001 vermilion snapper assessment, and are summarized in Figure 3.1.2.8.1 and Table 3.1.2.8.1.

If F_{2004} (0.90) is projected through 2016, the population declines steeply, reaching 1.8% of B_{MSY} in 2016. Projected yield declines as well, dropping to less than 200,000 lbs by 2016.

If the population is projected at $F = F_{MSY}$ during 2007-2016, the population biomass recovers to 79% of B_{MSY} by 2016. Yield initially declines (Y_{2004} = 3.4 million pounds while Y_{2007} is projected to equal 677,000 lbs), but recovers to 81% of MSY (2.9 million lbs) by 2016.

Amendment 23 stipulates that vermilion snapper are overfished, and mandates a 10 year recovery plan. Two projections were run to examine this recovery scenario. For the first, fishing mortality was held constant from 2007-2014, at the value predicted to achieve recovery by 2014 (F = 0.222). This strategy achieves recovery, but requires substantial reductions in yield, particularly during 2007 and 2008. By 2016, yield has recovered to 80% of MSY (2.9 million pounds). Another method to achieve recovery to B_{MSY} by 2014 is to restrict yield. The final projection demonstrates that dramatic reductions in yield are required. A constant yield of 887,000 lbs from 2007 to 2014 allows recovery to B_{MSY} in 2014.

The projections from the 2001 assessment of vermilion snapper are also summarized in Figure 3.1.2.8.1. The results of the continuity case are quite consistent with the previous model, although more pessimistic. According to the continuity case, fishing at F_{2004} (0.9) will cause the extinction of the population by ~2020. The less favorable projections are primarily due to the high fishing mortality rates observed during 2000-2004. They are the highest on record.

3.2. Model 2: State-Space Age-Structured Production Model (SSASPM)

3.2.1. SSASPM Methods

3.2.1.1. Overview

The state-space age-structured production model (SSASPM) is thoroughly described by Porch (2002). SSASPM has several advantages over a non-equilibrium production model, such as the Pella-Tomlinson. SSASPM accommodates age-varying fecundity, natural mortality and selectivity functions. In addition, age composition data can be used to provide additional information to minimize the objective function, and to estimate the selectivity of the directed fleets. The current version of SSASPM assumes a single unit stock.

3.2.1.2. Data Sources

SSASPM runs specified four directed fleets (Commercial-East, Commercial-West, Recreational and Shrimp-Bycatch) and five indices of abundance (Commercial-Handline-East, Commercial-Handline-West, Headboat-East, Headboat-West, and MRFSS-East). Three age composition matrices (number-at-age by year) were used (Commercial-East, Commercial-West and Recreational) to allow estimation of selectivity vectors. Age composition was determined from otolith observations made by the NOAA Fisheries, Panama City Laboratory, and reported in SEDAR9-DW-02.

Available data inputs were used as provided by the SEDAR9 Data Workshop (SEDAR 9: Vermilion Snapper Data Workshop Report) with the exception of the length-weight equation. The SEDAR9 length-weight equation (5):

$$TW\ (kg) = 2E\text{-}08 * TL(mm)^{2.98} \qquad (5)$$

was found to differ substantially from the relationship predicted using TIP data (Figure 3.2.1.2.1). Therefore, the length-weight equation reported by Hood and Johnson (1999) was substituted (rewritten as a power function in mm and kg),

$$W(kg) = 2.51E\text{-}08 * TL^{2.87} \qquad (6)$$

where W is whole weight in kg and TL is the total length in mm. The Hood and Johnson (1999) equation was also used during the 2001 vermilion snapper assessment, and was found to be more consistent with the available TIP observations (Figure 3.2.1.2.1).

The growth (Figure 3.2.1.2.2) and fecundity (Figure 3.2.1.2.3) functions were fixed at the values described in the SEDAR9 Data Workshop Report. Natural Mortality was fixed at 0.25 for all ages.

As suggested by the Data Workshop panel, steepness was estimated using a lognormal prior (mean = 0.6; variance = 0.85) such that there is a <10% chance than steepness exceeds 0.9.

The most recent estimate of shrimp trawl bycatch of vermilion snapper is 9.2 million fish annually[1]. According to Porch and Cass-Calay (2001), the length-distribution obtained from the NMFS observer program is bimodal, and suggests that approximately 25 % of the vermilion snapper landed by the shrimp fleet are age-0 and the remainder are at least age-1. Because SSASPM does not accommodate age-0, the shrimp bycatch estimate was multiplied by the proportion of fish expected to be at least age-1 (9.2 million * 0.75 = 6.9 million fish). Shrimp bycatch was modeled using a fixed selectivity (100% vulnerability at age-1, 30% at age-2, 3% at age-3 and 0% at ages 4-14+).

Input data for the SSASPM model are summarized in Table 3.2.1.2.1 (catch series), Table 3.2.1.2.2 (indices) and Table 3.2.1.2.3. (age composition).

[1] Nichols, S. Personal Communication. NOAA Fisheries, Pascagoula Laboratory. Scott.Nichols@noaa.gov

The data input file for the SSASPM base model is included as Table. 3.2.1.2.4

3.2.1.3. Model Equations

Model equations are excised (with permission of the author) from the SEDAR-9-RW supplementary document Porch (2003).

The abundance of each age class is computed at monthly intervals according to the formula

$$N_{a,y,m+1} = N_{a,y,m}\, e^{-M_a \delta} - \sum_{i} C_{a,y,m,i} \tag{7}$$

where $N_{a,y,m}$ is the number of fish in age class a at the beginning of month m in year y, $C_{a,y,m,i}$ is the catch in numbers of fleet i, M is the natural mortality rate coefficient (yr^{-1})and d is the duration of the time step in years (= 1/12).

The abundance at the beginning of the first month is modeled as

$$N_{a,y+1,1} = \begin{cases} \dfrac{4hS_{y-\alpha}}{\theta_0(1-h) + S_{y-\alpha}(5h-1)/R_0} & a = \alpha \\ N_{a-1,y,13} & \alpha < a < A \\ N_{A-1,y,13} + N_{A,y,13} & a = A \end{cases} \tag{8}$$

where the subscript 13 denotes the end of the 12th month (beginning of the next year). Note that the initial abundance of the youngest age class (a) is modeled by the Beverton and Holt (1957) function of spawning biomass (S) recast in terms of virgin recruitment R_0, virgin spawning biomass per recruit q_0, and steepness h. Steepness is defined as the proportion of virgin recruitment expected when S is 20% of the virgin level (where $0.2 < h < 1$).

Spawning biomass (aggregate fecundity) S is expressed

$$S_y = \sum_{a} p_a E_a N_{a,y,t} \tag{9}$$

where p is the proportion of each age class that is sexually mature and E_a is the average fecundity of mature individuals during the month t when spawning takes place. Similarly, the equilibrium spawning biomass per recruit for a given vector of fishing mortality rates at age (F) is computed

$$\theta_F = \sum_{a=\alpha}^{A-1} p_a E_a\, e^{-(Z_a \tau + \sum_{j=\alpha}^{a-1} Z_j)} + \frac{p_A E_A}{1-e^{-Z_A}}\, e^{-(Z_A \tau + \sum_{j=\alpha}^{A-1} Z_j)} \tag{10}$$

where $Z_a = M_a + F_a$, t is the fraction of the year elapsed at the time of spawning (= t/12). The virgin level (q_0), which is used in equation (8) above, is obtained by setting $F_a = 0$.

The age structure of the population at the start of the first year in the analysis (y=1) is assumed to be a virgin (unfished) condition. In that case the expected spawning biomass per recruit is computed by Eq. 10. Rearranging the spawner-recruit relationship then gives a value for the corresponding equilibrium recruitment.

$$R_\phi = R_0 \frac{4h\theta_\phi - (1-h)\theta_0}{\theta_\phi(5h-1)}. \tag{11}$$

The monthly catch of the i'th fishing entity (fleet) is computed as though it occurred as a pulse at the end of the month, after natural mortality and after the catch of fleets 1 through i-1:

$$C_{a,y,m,i} = F_{a,y,i}\left(N_{a,y,m}e^{-M_a\delta} - \sum_{k=1}^{i-1} C_{a,y,m,k}\right)\frac{\delta}{\tau_i} \tag{12}$$

where *ti* is the duration of the fishing season in years. The corresponding catch in weight is computed by multiplying the result of Eq. 12 by the average weight at age $w_{a,y}$. Note that this formulation is only approximate when the fleets actually fish simultaneously rather than sequentially, but with monthly time steps the error is negligible.

The fishing mortality rate F is separated into components representing the age-specific relative vulnerability v, annual effort expended f, and a catchability coefficient q:

$$F_{a,y,i} = q_{y,i} f_{y,i} v_{a,i} \tag{13}$$

The catchability coefficient q is the fraction of the most vulnerable age class that is taken per unit effort. Note that q may be allowed to vary from year to year rather than remain fixed in order to accommodate variations in the efficiency of the fishing process (see discussion of process errors below). The relative vulnerability coefficients v implicitly include factors such as gear selectivity, size limit regulations, and the fraction of the stock exposed to the fishery. They can be modeled by a logistic selection curve (other options include gamma and double logistic):

$$v_{a,i} = \frac{1}{1 + e^{-(a - a_{50,i})/d_i}}$$

(14)

where $a_{50,i}$ is the age of 50% relative vulnerability for fleet i and d_i is the dispersion coefficient controlling the slope of the curve at $a_{50,i}$ (values of 0.2 or less effectively imply knife-edge selection).

Time series of catch per unit effort (CPUE) or fishery-independent abundance surveys are modeled as though the observations were made just before the catch of the fleet with the corresponding index i:

$$I_{y,m,i} = q_{y,i} \sum_a v_{a,i} \left(N_{a,y,m} e^{-M_{a,y}\delta} - \sum_{k=1}^{i-1} C_{a,y,m,k} \right) \frac{\delta}{\tau_i} \tag{15}$$

As for catch, the corresponding CPUE in weight is computed by multiplying (15) by $w_{a,y}$. Average weight is computed as a power function of length, which in turn is computed as a von Bertalanffy function of age:

$$w_{ay} = \gamma \left[L_\infty (1 - e^{-k(a-t_0)}) \right]^\beta \tag{16}$$

The average weight for the plus-group depends on the age composition of the plus-group. However, to the extent that growth after the plus-age is approximately linear, the average weight may be calculated from the average age of the plus-group. Initially, it is assumed that the age composition of the plus-group is in equilibrium consistent with equation (10), in which case the average age of the plus-group at the beginning of the first year is

$$\bar{a}_{A,1} = A + \frac{e^{-(M_A + \phi_A)}}{(1 - e^{-(M_A + \phi_A)})} \tag{17}$$

Subsequently, the age of the plus-group is updated as

$$\bar{a}_{A,y+1} = \frac{A N_{A-1,y,13} + (\bar{a}_{A,y} + 1) N_{A,y,13}}{N_{A,y+1,1}} \tag{18}$$

3.2.1.4. Model Configuration

Several SSASPM model configurations were presented for consideration by the SEDAR-9-AW working group. These models are described in detail in SEDAR-9-AW-04. The working group chose a single base model. The following is a description of the configuration of the SSASPM base model.

Catch and CPUE observations were assumed to be unbiased, but imprecise. The annual catches from each fleet were assumed to be equally uncertain with constant coefficient of variation, *CV*, estimated by the model. The annual CPUE values for each fleet were assumed to be less certain than the catches, and were assigned coefficients of variation twice as large as the values estimated for the catch (i.e., 2*CV*). The fleet-specific CPUE series were equally weighted.
Effort and recruitment process errors were estimated independently. Recruitment was allowed to vary inter-annually as an essentially free parameter by allowing a coefficient of variation equal to 0.4 without autocorrelation. The annual effort of the directed fleets (COM-E, COM-W and REC) were allowed to vary with a moderate variance (CV=0.5) and correlation (r = 0.5). The annual effort of the Shrimp-Bycatch fleet was allowed to vary with small deviations (CV=0.2) and correlation (r = 0.5). The catchability coefficients, q, were estimated as time-independent constants.

3.2.1.5. Parameters Estimated

Since SSASPM is an age-structured model, tens to hundreds of parameters are estimated, making it impractical to discuss them all. The parameter input file for the SSASPM base model is included as Table. 3.2.1.4.1. For each estimated parameter, this table contains the initial estimates and parameter constraints (or priors).

3.2.1.6. Uncertainty and Measures of Precision

Like the P-T production model, SSASPM accommodates parameter uncertainty by estimating process and observation errors. A complete description of the equations used to estimate process error can be found in Table 3.2.1.5.1.

3.2.1.7. Benchmark / Reference points methods

Reference points and benchmarks were calculated with regard to maximum sustainable yield (MSY) and spawning potential ratio (SPR30%).

3.2.1.8. Projection methods

Projections were run to 2016 using the projection software PRO-2BOX (Porch, 2002b). Two types of base projections were run. The first, at 74.5% of Current Yield (0.745 * geometric mean yield from 2002 to 2004) beginning in 2006. For 2005, the geometric mean yield from 2002 to 2004 was applied without reduction. This projection was intended to account for the expected 25.5% reduction in shrimp trawl bycatch after 2005. The reduction was applied to all the directed fisheries because it is not possible to apply a fleet-specific F-multiplier in SSASPM. The second base projection applies current F (F_{2004}) to 2005-2016

To estimate the variance of the projection, 500 bootstraps were run off the deterministic results of SSASPM. This method does not take into account the inherent variability in the parameter estimated. Instead, the bootstrap variable was simply the recruitment deviations.

3.2.2. SSASPM Results

3.2.2.1. Measures of Overall Model Fit

The likelihood statistics of the SSASPM base model are as follows:

AIC	1.01e+03
data points	213
estimated parameters	138
AICc (small sample)	1.53e+03
Objective Function:	3.67e+02

Fits the catch series of the directed fleets are shown in Figure 3.2.2.1.1 and Table 3.2.2.1.1. Note that the period from 1950-1980 is presumed to be “prehistoric”, and is used only as a “burn-in” period to scale the estimates during historic period 1981-2004. In general, fits the catch series are quite good. The shrimp bycatch fits are the most variable. The model cannot properly accommodate a constant annual shrimp bycatch estimate, nor should this assumption be regarded as biologically realistic.

Fits to the indices of abundance are summarized in Figure 3.2.2.1.2 and Table 3.2.2.1.2. The fits to the CMHL-EAST and HB-WEST indices are similar to the observed trends, but the model fits to the HB-EAST and MRFSS-EAST indices are quite flat compared to the observed values. The recent (2000-2004) increasing trend of the CMHL-WEST index is not fit by the Set 1 SSASPM model runs.

The fits to the observed age composition are summarized in Figures 3.2.2.1.3 to 3.2.2.1.5. In general, the estimated age composition closely resembles the observations from otolith samples.

3.2.2.2. Parameter estimates

Selected parameter estimates, including B_0, B_{2004}, F_{2004}, the Beverton and Holt recruitment parameters, recruitment deviation estimates, and the biomass trajectory are summarized in Table. 3.2.2.2.1. Estimates of standard deviation are also tabulated.

The selectivity parameters for the directed fisheries were estimated using a logistic equation. The results are illustrated in Figure 3.2.2.2.1. Selectivity for the directed fleets is near 0 for Age 1 animals. For the eastern commercial fishery, a50 occurs at approximately age 2, while in the other sectors (commercial west and recreational), a50 is about age 3. For all directed fleets, all individuals age 5+ are fully vulnerable to fishing.

3.2.2.3. Stock Biomass and Recruitment

Annual trends in spawning stock biomass (SSB) and SSB relative to virgin (SSB/S_{1950}), MSY and SPR30% levels are summarized in Figure 3.2.2.3.1. All annual biomass estimates are summarized in Table 3.2.2.3.1. Estimates prior to 1981 are considered "prehistoric", and are used as a burn in to scale the model results. SSB statistics varied without obvious trend during 1981-1990, but generally declined thereafter. However, according the base run SSASPM results, the population is never below SSB_{MSY} and $SSB_{SPR30\%}$. In 2004, SSB was 44% of SSB_{1950}, SSB/SSB_{MSY} was 1.8 and $SSB/SSB_{SPR30\%}$ was 1.75, indicating a population that is not currently overfished.

3.2.2.4. Fishing Mortality

Annual trends in fishing mortality (F), and F relative to MSY and SPR30% levels are summarized in Figure 3.2.2.4.1 and Table 3.2.2.4.1. In 1950, F was assumed to be negligible. The linear increase during the "prehistoric" period (1950-1981) is dictated by the model structure (SSASPM-linear). F statistics varied without obvious trend during 1981-2000, but a general increase in F is notable during 2001-2004.

According to the SSASPM base run, F is less than F_{MSY} and $F_{SPR30\%}$ throughout the time series. In 2004, F/F_{MSY} was 0.65 and, $F/F_{SPR30\%}$ was 0.67, indicating a population that is not currently undergoing overfishing.

3.2.2.5. Recruitment

Annual estimates of recruitment (Age 1) are summarized in Figure 3.2.2.5.1 and Table 3.2.2.5.1. "Prehistoric" (1950-1980) recruitment estimates are considered as a burn in to scale the SSASPM model results. During the "historical" period (1981-2004), recruitment varies without obvious trend. However, it is important to note that the average recruitment during 2002-2004 (geometric mean = 1.0E+07) is substantially lower than the average during the period 1981-2004 (geometric mean = 1.7E+07).

The predicted spawner-recruit relationship and the estimated values during the "historic" period (1981-2004) are shown in Figure 3.2.2.5.2. There appears to be little relationship between the spawning stock biomass and recruitment at age 1.

3.2.2.6. Measures of Parameter Uncertainty

Parameter uncertainty was addressed by estimating process and observation errors. The standard deviations of the estimated parameters are summarized in the previously cited Table 3.2.2.2.1.

3.2.2.7. Retrospective and Sensitivity Analyses

No retrospective analyses were preformed. However, several sensitivity analyses were presented to the SEDAR9-AW working group. Models were presented that estimated steepness, fixed steepness at 0.60 (the mean value suggested by the data workshop), used larger effort deviation for the shrimp bycatch fleet (50%CV), and allowed or did not allow recruitment deviations. These sensitivity runs were not preferred by the AW working group, and were subsequently not pursued. They are described in detail in document SEDAR9-AW-04.

3.2.2.8. Benchmarks / Reference Points

The benchmarks and reference points estimated for the SSASPM base run are summarized in Table 3.2.2.8.1. Unlike the P-T production model, the SSASPM base model suggests that vermilion snapper are not overfished (SSB_{2004}/SSB_{MSY} = 1.80; ($SSB_{2004}/SSB_{SPR30\%}$ = 1.76), nor was overfishing occurring (F_{2004}/F_{MSY} = 0.65; ($F_{2004}/F_{SPR30\%}$ = 0.67) as of 2004.

3.2.2.9. Projections

Base Projections

Figure 3.2.2.9.1.1 and Table 3.2.2.9.1.1 summarize the “Current Yield” projection results. Recall that this projection employs a 25.5% reduction in yield beginning in 2006. Using this projection scenario, yield is, by definition, constant at 4.35 million pounds during 2006-2016, and this yield is sustainable. The spawning stock biomass increases during the “Current Yield” projection, implying that fishing at “Current Yield”, which is below MSY (5.5 million pounds) will allow the population status to improve. The projected recruitment estimates appear to be lower than the mean of the observed recruitments (1986-2004).

Figure 3.2.2.9.1.2 and Table 3.2.2.9.1.2 summarize the “Current F” projection results. Using this projection scenario, yield gradually decreases to about 5.2 million pounds in 2016. This value is slightly below MSY. The spawning stock biomass decreases slowly throughout the projection interval, although it remains above SSB_{MSY} and $SSB_{SPR30\%}$. The projected recruitment estimates appear to be lower than the mean of the observed recruitments (1986-2004).

Additional Projections (Sensitivity Analysis)

Because the recruitment estimates from the base projections are lower than the mean of the observed recruitment series (1986-2004), the AW working group requested an additional set of projections to examine the sensitivity of the results to higher recruitment estimated.

For these projections, the recruitment parameters were re-estimated using only the recent data (1986-2004), and these parameters were entered into the projection. This procedure required the use of a fixed steepness. The working group selected a steepness value of 0.8, which was close to the value estimated for the SSASPM base run.

Figure 3.2.2.9.2.1 and Table 3.2.2.9.2.1 summarize the “Current Yield” projection results for the sensitivity case. Recall that this projection employs a 25.5% reduction in yield beginning in 2006. Using this projection scenario, yield is, by definition, constant at 4.35 million pounds during 2006-2016, and this yield is sustainable. The spawning stock biomass increases during the “Current Yield” projection, implying that fishing at “Current Yield”, which is below MSY (5.5 million pounds) will allow the population status to improve. The projected recruitment estimates are close to the mean of the observed recruitments (1986-2004), as expected.

Figure 3.2.2.9.2.2 and Table 3.2.2.9.2.2 summarize the “Current F” projection results for the sensitivity case. Using this projection scenario, yield remains steady at about 6.5 million pounds throughout the time series. This value is slightly below MSY. The spawning stock biomass also remains virtually unchanged throughout the projection interval. SSB is above SSB_{MSY} and $SSB_{SPR30\%}$ through 2016. The projected recruitment estimates are close to the mean of the observed recruitments (1986-2004), as expected.

4. Panel Recommendations and Comment

4.1. Critique and review of models considered

4.1.1. Pella-Tomlinson production model (PT)

The Pella-Tomlinson production model with the shape parameter held constant at 2.0 is a logistic or Schaefer production model that uses landings and effort or catch per unit effort to estimate the rate of growth of the population, r, and a population carrying capacity, K. Since the curve of landings on effort is dome shaped, there is a maximum level and if we assume that the curve represents sustainable conditions then that value becomes the maximum sustainable yield (MSY).

The PT model is very straight forward and this implementation (Porch, 2001) allows uncertainty in the input data. The lack of biological flexibility in the model prevents the model from comparing maturity with selectivity or having higher steepness in the stock-recruit curve, i.e., this model cannot capture resiliency. The model was used to provide continuity with the earlier in 2001. The model preformed well as a continuity run with similar r values (0.64 in the 2001 assessment and 0.67 in this assessment), K values (21.2 million lb in 2001 assessment and 21.5 million lb in this assessment, and MSY values (3.4 million lb in 2001 assessment and 3.6 million lb in this assessment (Table 3.1.2.7.1). The fishing mortality ratio in 2004 was 2.70 and the biomass ratio was 0.40 indicating that the stock is overfished and undergoing overfishing.

4.1.2. State-space age-structured production model (SSASPM)

The majority of the Stock Assessment Workshop participants thought that a model that incorporated age specific population dynamics (i.e. fecundity, maturity, size-at-age, selectivity), would be more informative about stock status. In the case of vermilion snapper, all of the age data is from recent years (1994-2004, with most from 2000-2004) but the participants felt the data were sufficient to develop selectivity curves for the commercial and recreational fisheries. Selectivity is important because vermilion snapper likely mature before becoming fully vulnerable to fishing pressure (Figure 3.2.2.2.1) which increases their resiliency. The SSASPM model also allows autocorrelated effort estimates and CVs on the input data. Unlike the P-T production model, the SSASPM .base run indicates that during the period 1981-2004, GOM vermilion snapper have never been overfished, not has overfishing occurred. In every year, SSB/SSB_{MSY} has exceeded 1.80 and F/F_{MSY} is less than or equal to 0.7. . In 2004, the benchmarks statistics were $SSB/SSB_{MSY} = 1.80$, $SSB/SSB_{SPR30\%} = 1.75$, $F/F_{MSY} = 0.65$ and $F/F_{SPR30\%} = 0.67$. Although the SSAPSM base model indicates that the status of the stock is healthy, it is important to note the spawning stock biomass has generally decreased throughout the time series (Figure 3.2.2.3.1) while fishing mortality has increased (Figure 3.2.2.4.1).

4.2. Preferred model and configuration recommendations

The AW participants preferred the SSASPM model on the basis of its considering more of the age-structured biology and fishery characteristics of vermilion snapper. At the time of the recommendation (AW1, August 2005, Miami FL), we did not know what the model would estimate for the stock condition. SSASPM base and sensitivity runs were presented and discussed in detail at the second assessment workshop (AW2, December 2005, Atlanta GA). The AW panel did not recommend any further revisions to the base run configuration. In other species, the stock condition changes depending upon whether the model is allowed to estimate steepness or whether steepness is fixed but in vermilion snapper the model solved for the same 0.8 value that the assessment workshop recommended so the stock-recruit relationship was not an issue.

4.3. Status of stock declarations

Based on the SSASPM model, the stock was not overfished (F/F_{MSY} = 0.65 and $F/F_{SPR30\%}$ = 0.67) nor undergoing overfishing (SSB/SSB_{MSY} = 1.80, $SSB/SSB_{SPR30\%}$ = 1.75) at the end of 2004; however, the increasing fishing mortality rates and the associated decreasing spawning biomass indicates that the stock could become overfished if fishing mortality continues to increase.

It is estimated that shrimp effort has decreased recently (equivalent to a 25.5% reduction applied fleet-wide). If this is so, the status of vermilion snapper would benefit, as the fishing mortality on ages 0 and 1 would decline, and some of these animals would survive to maturity, and enter the directed fisheries at later ages.

4.4. Management evaluation

As established by Amendment 23 to the Reef Fish FMP implemented in May 2005, MSY for vermilion snapper is the yield associated with F_{MSY} when the stock is at equilibrium. MSY was estimated to be 3.37 mp based on the last stock assessment (range 3.18 to 4.03 mp) (Porch and Cass-Calay, 2001). OY is the yield corresponding to a fishing mortality rate (F_{OY}) defined as 0.75*F_{MSY} (or F_{MSY} proxy) when the stock is at equilibrium. The last stock assessment estimated F_{MSY} as 0.32 (RFSAP, 2001). Maximum Fishing Mortality Threshold (MFMT) is set equal to F_{MSY}. Minimum Stock Size Threshold (MSST) is set equal to (1-M)*B_{MSY} (or B_{MSY} proxy). The last stock assessment estimated B_{MSY} as 10.6 mp (Porch and Cass-Calay, 2001). Based on this information, MSST would equal 7.95 mp.

The rebuilding plan for vermilion snapper specified that the stock be rebuilt in ten years using a stepped strategy that holds harvest constant for an initial four year interval consistent with the average of the same four years under a constant fishing mortality rate, then three-year intervals thereafter. The allowable harvest starting in 2004 was 1.475 mp and equated to a 25.5

percent reduction in directed harvest based on 2003 estimated landings. In 2008 allowable harvest would increase to 2.058 mp and in 2011 harvest would increase to 2.641 mp.

The current minimum size for recreationally and commercially caught vermilion snapper is 11 inches TL; the recreational bag limit is 10 fish within the 20-reef fish aggregate bag limit; and a commercial closed season was established from April 22 through May 31.

The current rebuilding plan was developed using the 2001 P-T production model. The SSASPM model provides very different results. According to the base model chosen by the SEDAR9-AW2 panel, the Gulf of Mexico stock of vermilion snapper has never been overfished, and has never undergone overfishing. Thus, it is not possible to evaluate the progress of the rebuilding plan, except to state that the stock exceeded B/B_{MSY} in 2004, and is projected to continue to exceed B/B_{MSY} throughout the ten-year rebuilding plan. $B_{2014}/B_{MSY} > 1.5$, even when current (2004) F is projected. Current yield projections are more optimistic.

4.5. Model Comparison

The results of the P-T production model and the SSASPM model are contrasted on a control rules plot in Figure 4.6.1. It is clear the models have very different outcomes. This is due to a variety of reasons:

1. The model is implemented with data from 1981-2004 with the assumption that the stock was at virgin conditions in 1950.
2. The model was implemented with an assumption of a constant annual catch of 6.9 million fish for the shrimp bycatch. The previous assessment used an annually varying shrimp bycatch series that was not supported by the data workshop panel.
3. SSASPM is an age-structured model which utilized maturity, fecundity, selectivity functions, size-at-age information and age composition. The previous assessment (P-T production model) was not age-structured and did not use age composition information.

SSASPM results appear to differ from the production model primarily due to the assumption of virgin condition in 1950. This assumption scales the 1950-1980 catches to low levels. This version of SSASM fits a linear increase from the virgin condition (zero catch) in 1950 to the first year of observed data (1981). The P-T production model results suggest the population was already overfished in 1986, implying high catches in the 1980s. This implication does not appear to be realistic given the reported catch series (Table 3.1.1.2.1)

The level of assumed shrimp bycatch also impacts the status of vermilion snapper (SEDAR9-AW-04). Lower levels of shrimp bycatch cause lower estimates of productivity (steepness), and consequently poorer status. Therefore, the stock status of vermilion snapper is predicted to be less optimistic if the assumed shrimp bycatch is overestimated.

5. Literature Cited

Fournier, D. A., Hampton, J. and Sibert, J. R. 1998. MULTIFAN-CL: a length based, age-structured model for fisheries stock assessment, with application to the South Pacific Albacore, *Thunnus alalunga*. Can. J. Fish. Aquat. Sci. 55: 2105-2116.

Hood, P. B., and A. K. Johnson. 1999. Age, growth, mortality, and reproduction of vermilion snapper, *Rhomboplites aurorubens*, from the eastern Gulf of Mexico. Fish.Bull. 97 (4): 828-841.

Otter Research Ltd. 2000. An introduction to AD MODEL BUILDER Version 4.5. Box 2040, Sidney B.C. V8L 3S3, Canada. 141 p.

Pella, J.J and P.K. Tomlinson. 1969. A generalized stock production model. Int. Amer. Trop. Tuna Comm. Bull. 13: 419-496.

Porch, C. E. 2001. Another assessment of gray triggerfish (*Balistes capriscus*) in the Gulf of Mexico using a state-space implementation of the Pella-Tomlinson production model. Sustainable Fisheries Division Contribution SFD-00/01-126. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL.

Porch, C. E. 2002a. Preliminary assessment of Atlantic white marlin (*Tetrapturus albidus*) using a state-space implementation ff an age-structured production model. Col. Vol. Sci. Pap. ICCAT 55(2): 559-577.

Porch, C. E. 2002b. PRO-2BOX user’s guide (version 2.01). NOAA Fisheries, Southeast Fisheries Science Center, Sustainable Fisheries Division Contribution SFD-02/03-182.

Porch C. E. and S.L Cass-Calay. 2001. Status of the vermilion snapper fishery in the Gulf of Mexico: Assessment 5.0.). NOAA Fisheries, Southeast Fisheries Science Center Sustainable Fisheries Division Contribution No. SFD-01/02-129

SEDAR7-DW-24	Estimation of Effort in the Offshore Shrimp Trawl Fishery of the Gulf of Mexico	Nance, J.

6. Tables

Table 3.1.1.2.1. Catch and effort series used for the continuity case.

Table 3.1.1.2.2. Indices of abundance used for the continuity case.

Table 3.1.1.3.1. Stochastic equations used to define the state space Pella-Tomlinson model.

Table 3.1.1.4.1. Parameter configuration file for the continuity case.

Table 3.1.2.1.1. Fits to the catch series (millions of pounds) used for the continuity case.

Table 3.1.2.1.2. Fit to the relative effort series used for the continuity case.

Table 3.1.2.1.3. Fits to the indices used for the continuity case.

Table 3.1.2.2.1. The parameter estimates from the continuity case.

Table 3.1.2.3.1. Annual population biomass (abundance) estimates for the continuity case.

Table 3.1.2.4.1. Annual fishing mortality estimates for the continuity case.

Table 3.1.2.7.1. Management and biomass status benchmarks for the 2001 base case and the continuity case.

Table 3.1.2.8.1. Projected F, yield (millions of lbs), and biomass (millions of lbs) trajectories for the four continuity case scenarios.

Table 3.2.1.2.1. Catch series used for the SSASPM runs.

Table 3.2.1.2.2. Indices of abundance used for the SSASPM runs.

Table 3.2.1.2.3. Age composition matrices used for the SSASPM runs. The maximum effective sample size (SAMPLES) was fixed at 200.

Table 3.2.1.2.4. The data input file used for the SSASPM base run.

Table 3.2.1.4.1. The parameter input file used for the SSASPM base run.

Table 3.2.1.5.1. Stochastic equations used to define the state space age-structured production model, where the notation E is used to denote the value computed from the deterministic components of the model.

Table 3.2.2.1.1. Model fits to the catch series for the SSASPM base model.

Table 3.2.2.1.2. Model fits to the indices of abundance for the SSASPM base model.

Table 3.2.2.2.1. Key parameter estimates from the SSASPM base model.

Table 3.2.2.3.1. Spawning stock biomass (SSB) and SSB relative to SSB_{MSY} and $SSB_{SPR30\%.}$

Table 3.2.2.4.1. Fishing mortality rate (F) and F relative to F_{MSY} and $F_{SPR30\%.}$

Table 3.2.2.5.1. Annual recruitment estimates.

Table 3.2.2.8.1. Management and biomass status benchmarks for the SSASPM base case and sensitivity analysis.

Table 3.2.2.9.1.1. Results of the "Current Yield" projection of the SSASPM base model.

Table 3.2.2.9.1.2. Results of the "Current F" projection of the SSASPM base model.

Table 3.2.2.9.2.1 Results of the "Current Yield" projection of the SSASPM sensitivity case. This projection uses recruitment parameters estimating using only recent data (1986-2004).

Table 3.2.2.9.2.2 Results of the "Current F" projection of the SSASPM sensitivity case. This projection uses recruitment parameters estimating using only recent data (1986-2004).

Table 3.1.1.2.1. Catch and effort series used for the continuity case.

	CATCH SERIES (1000s of POUNDS)			EFFORT (DAYS FISHED)
YEAR	COMMERCIAL	REC (HB+MRFSS+TPWD)	SHRIMP BYCATCH	SHRIMP FLEET
1986	1749.40	535.21	534.15	226798
1987	1605.40	601.70	534.15	241902
1988	1554.50	658.24	534.15	205812
1989	1658.80	423.70	534.15	221165
1990	2454.90	657.98	534.15	211860
1991	1795.00	695.63	534.15	223388
1992	2267.90	860.14	534.15	216669
1993	2719.50	740.50	534.15	204482
1994	2639.20	684.71	534.15	195742
1995	2178.00	750.47	534.15	176589
1996	1827.30	378.74	534.15	189653
1997	2125.80	440.98	534.15	207912
1998	1732.60	293.53	534.15	216999
1999	1982.30	391.78	534.15	200475
2000	1459.90	283.16	534.15	192073
2001	1715.10	551.01	534.15	197644
2002	2008.60	443.24	534.15	194186
2003	2415.70	557.42	534.15	168153
2004	2134.40	741.75	534.15	188014

Table 3.1.1.2.2. Indices of abundance used for the continuity case.

YEAR	Commercial HL	Headboat East
1986		1.0320
1987		0.9415
1988		2.0546
1989		1.0626
1990		1.6947
1991		1.9385
1992		2.2609
1993	1.2189	1.4096
1994	1.3143	1.1549
1995	1.0144	1.1296
1996	0.9378	0.6480
1997	1.0093	0.6969
1998	0.9449	0.2477
1999	0.8986	0.4683
2000	0.6895	0.3688
2001	0.8347	0.3638
2002	0.9428	0.5412
2003	1.0679	0.4629
2004	1.1269	0.5237

Table 3.1.1.3.1. Stochastic equations used to define the state space Pella-Tomlinson model.

Variables	Description
Process functions for state variables	
$m_t = m_0\, e^{-\varepsilon_{m,t}},\ \ \varepsilon_{m,t} = \rho_m\, \varepsilon_{m,t-1} + a_{m,t}$	exponent controlling inflection point of production curve
$r_t = r_0\, e^{-\varepsilon_{r,t}},\ \ \varepsilon_{r,t} = \rho_r\, \varepsilon_{r,t-1} + a_{r,t}$	intrinsic rate of production
$k_t = \dfrac{B_1}{\alpha}\, e^{-\varepsilon_{k,t}},\ \ \varepsilon_{k,t} = \rho_k\, \varepsilon_{k,t-1} + a_{k,t}$	carrying capacity of environment
$q_{f,t} = q_{f,0} e^{-\varepsilon_{q,f,t}},\ \ \varepsilon_{q,f,t} = \rho_{q,f}\, \varepsilon_{q,f,t-1} + a_{q,f,t}$	catchability for fishery f
$E_{f,t} = E_{f,0} e^{-\varepsilon_{E,f,t}},\ \ \varepsilon_{E,f,t} = \rho_{E,f}\, \varepsilon_{E,f,t-1} + a_{E,f,t}$	effort expended by fishery f
Observation functions for data variables	
$C_{ft} = \left(\delta q_{ft} E_{ft} \sum_{j=1}^{16} B_{t+j\delta}\right) e^{-\varepsilon_{C,f,t}},\ \ \varepsilon_{C,f,t} = \rho_{C,f}\, \varepsilon_{C,f,t-1} + a_{C,f,t}$	catch of fishery *f*
$I_{ft} = \left(\delta q_{ft} \sum_{j=1}^{16} B_{t+j\delta}\right) e^{-\varepsilon_{I,f,t}},\ \ \varepsilon_{I,f,t} = \rho_{I,f}\, \varepsilon_{I,f,t-1} + a_{I,f,t}$	CPUE of fishery *f*
State moments	
$B_{t+\delta} = \dfrac{B_t(1+r_t\delta)}{1+(r_t(B_t/k_t)^{m_t-1}+F_t)\delta}$	biomass
$F_t = \sum_{f=1}^{n} q_{ft} E_{ft}$	fishing mortality rate

Table 3.1.1.4.1 . Parameter configuration file for the continuity case.

```
# INPUT FILE FOR PROGRAM PT-MODEL
# CLASS
#  |       SET (corresponds to pointers in data series.
#  |        |     NATURE specifies deterministic and stochastic parts of parameter class)
#  |        |     |        METHOD OF ESTIMATION (either 'FIXED' or 'ESTIMATED')
#  |        |     |        |                PHASE (immaterial if method = 'FIXED')
#  |        |     |        |                |    BEST ESTIMATE
#  |        |     |        |                |    |             LOWER BOUND
#  |        |     |        |                |    |             |             UPPER BOUND
#  |        |     |        |                |    |             |             |      (-)CV or (+)VARIANCE OF PRIOR
#  |        |     |        |                |    |             |             |             |         PDF OF PRIOR
#  |        |     |        |                |    |             |             |             |            |
 'M'       1    'CONST'  'FIXED'          4    0.2000E+01    0.1000E+00    0.9000E+01    0.2231E+00  'FREQUENTIST'
 'M'       1    'RHO'    'FIXED'          4    0.0000E+00    0.0000E+00    0.1000E+13    0.1000E+01  'FREQUENTIST'
 'M'       1    'VAR'    'FIXED'          3    0.0000E+00    0.0000E+00    0.1000E+13    0.1000E+01  'FREQUENTIST'
#
 'R'       1    'CONST'  'ESTIMATED'      3    0.6400E+00    0.1000E+00    1.0000E+00    0.5000E+01  'FREQUENTIST'
 'R'       1    'RHO'    'FIXED'          4    0.0000E+00    0.0000E+00    0.1000E+13    0.1000E+01  'FREQUENTIST'
 'R'       1    'VAR'    'FIXED'          3    0.0000E+00    0.0000E+00    0.1000E+13    0.1000E+01  'FREQUENTIST'
#
 'K'       1    'CONST'  'ESTIMATED'      2    0.5000E+00    0.1000E+00    0.1000E+01    0.5000E+01  'FREQUENTIST'
 'K'       1    'RHO'    'FIXED'          4    0.0000E+00    0.0000E+00    0.1000E+13    0.1000E+01  'FREQUENTIST'
 'K'       1    'VAR'    'FIXED'          3    0.0000E+00    0.0000E+00    0.1000E+13    0.1000E+01  'FREQUENTIST'
#
 'Q'       1    'CONST'  'ESTIMATED'      1    0.1000E+00    0.0000E+00    0.1000E+01    0.5000E+01  'FREQUENTIST'
 'Q'       1    'RHO'    'FIXED'          5    0.0000E+00    0.0000E+00    0.1000E+01    0.1000E+01  'FREQUENTIST'
 'Q'       1    'VAR'    'FIXED'          4    0.0000E+00    0.0000E+00    0.1000E+21    0.1000E+01  'FREQUENTIST'
 'Q'       2    'CONST'  'ESTIMATED'      1    0.1000E+00    0.0000E+00    0.1000E+01    0.5000E+01  'FREQUENTIST'
 'Q'       2    'RHO'    'FIXED'          5    0.0000E+00    0.0000E+00    0.1000E+01    0.1000E+01  'FREQUENTIST'
 'Q'       2    'VAR'    'FIXED'          4    0.0000E+00    0.0000E+00    0.1000E+21    0.1000E+01  'FREQUENTIST'
 'Q'       3    'CONST'  'ESTIMATED'      1    0.1000E+00    0.0000E+00    0.1000E+01    0.5000E+01  'FREQUENTIST'
 'Q'       3    'RHO'    'FIXED'          5    0.0000E+00    0.0000E+00    0.1000E+01    0.1000E+01  'FREQUENTIST'
 'Q'       3    'VAR'    'FIXED'          4    0.0000E+00    0.0000E+00    0.1000E+21    0.1000E+01  'FREQUENTIST'
#
 'E'       1    'CONST'  'ESTIMATED'      1    0.2400E+04    0.1000E+03    0.1000E+07    0.5000E+01  'FREQUENTIST'
 'E'       1    'RHO'    'FIXED'          5    0.5000E+00    0.0000E+00    0.9900E+00    0.1000E+01  'FREQUENTIST'
 'E'       1    'VAR'    'FIXED'          4    0.2231E+00    0.0000E+00    0.1000E+22    0.1000E+01  'FREQUENTIST'
 'E'       1    'DEVS1'  'ESTIMATED'      2    0.0000E+00   -0.5000E+01    0.5000E+01    0.1000E+00  'LOGNORMAL'
 'E'       2    'CONST'  'ESTIMATED'      1    0.5186E+03    0.1000E+02    0.1000E+07    0.5000E+01  'FREQUENTIST'
 'E'       2    'RHO'    'FIXED'          5    0.5000E+00    0.0000E+00    0.9900E+00    0.1000E+01  'FREQUENTIST'
 'E'       2    'VAR'    'FIXED'          4    0.2231E+00    0.0000E+00    0.1000E+22    0.1000E+01  'FREQUENTIST'
 'E'       2    'DEVS1'  'ESTIMATED'      2    0.0000E+00   -0.5000E+01    0.5000E+01    0.1000E+01  'LOGNORMAL'
 'E'       3    'CONST'  'FIXED'          1    0.1000E+01    0.1000E+00    0.1000E+03    0.1000E+01  'FREQUENTIST'
 'E'       3    'RHO'    'FIXED'          5    0.5000E+00    0.0000E+00    0.9900E+00    0.1000E+01  'FREQUENTIST'
 'E'       3    'VAR'    'FIXED'          4    0.2231E+00    0.0000E+00    0.1000E+22    0.1000E+01  'FREQUENTIST'
 'E'       3    'DEVS'   'ESTIMATED'      2    0.0000E+00   -0.5000E+01    0.5000E+01    0.1000E+01  'LOGNORMAL'
#
 'C_D'     1    'VAR'    'FIXED'          4    0.1000E+01    0.1000E+00    0.5000E+01    0.1000E+01  'FREQUENTIST'
 'I_D'     1    'VAR'    'FIXED'          5    0.1028E+00    0.1000E-01    0.1000E+01    0.1000E+01  'FREQUENTIST'
 'E_D'     1    'VAR'    'FIXED'          4    0.1000E+01    0.1000E-03    0.1000E+01    0.1000E+01  'FREQUENTIST'
 'V'       1    'CONST'  'FIXED'          6    0.1000E+01    0.1000E-02    0.1000E+02    0.1000E+01  'FREQUENTIST'
```

Table 3.1.2.1.1. Fits to the catch series (millions of pounds) used for the continuity case.

	COMMERCIAL			RECREATIONAL			SHRIMP BYCATCH		
YEAR	OBS	PRED	% DIFF	OBS	PRED	% DIFF	OBS	PRED	% DIFF
1986	1.749	2.034	16.27%	0.535	0.638	19.21%	0.534	0.534	-0.06%
1987	1.605	1.673	4.21%	0.602	0.594	-1.23%	0.534	0.577	7.93%
1988	1.554	1.645	5.83%	0.658	0.637	-3.29%	0.534	0.637	19.27%
1989	1.659	1.756	5.88%	0.424	0.439	3.66%	0.534	0.720	34.88%
1990	2.455	2.464	0.39%	0.658	0.652	-0.92%	0.534	0.757	41.71%
1991	1.795	1.963	9.36%	0.696	0.712	2.39%	0.534	0.802	50.07%
1992	2.268	2.490	9.80%	0.860	0.881	2.39%	0.534	0.815	52.62%
1993	2.720	3.190	17.28%	0.740	0.769	3.84%	0.534	0.741	38.76%
1994	2.639	3.183	20.62%	0.685	0.689	0.66%	0.534	0.606	13.41%
1995	2.178	2.536	16.46%	0.750	0.707	-5.81%	0.534	0.492	-7.91%
1996	1.827	1.940	6.17%	0.379	0.366	-3.36%	0.534	0.445	-16.71%
1997	2.126	2.199	3.44%	0.441	0.415	-5.91%	0.534	0.415	-22.29%
1998	1.733	1.857	7.16%	0.294	0.293	-0.21%	0.534	0.378	-29.16%
1999	1.982	1.938	-2.24%	0.392	0.375	-4.19%	0.534	0.348	-34.80%
2000	1.460	1.537	5.26%	0.283	0.295	4.17%	0.534	0.335	-37.28%
2001	1.715	1.740	1.44%	0.551	0.523	-5.08%	0.534	0.345	-35.36%
2002	2.009	2.083	3.68%	0.443	0.447	0.82%	0.534	0.338	-36.80%
2003	2.416	2.405	-0.43%	0.557	0.557	-0.09%	0.534	0.310	-41.89%
2004	2.134	2.276	6.62%	0.742	0.723	-2.47%	0.534	0.276	-48.39%

Table 3.1.2.1.2. Fit to the relative effort series used for the continuity case.

	RELATIVE EFFORT (SHRIMP FLEET)		
YEAR	OBS	PRED	% DIFF
1986	1.111	0.827	-25.55%
1987	1.185	0.853	-27.97%
1988	1.008	0.884	-12.30%
1989	1.083	0.938	-13.43%
1990	1.038	0.975	-6.07%
1991	1.094	1.043	-4.67%
1992	1.061	1.099	3.61%
1993	1.002	1.123	12.17%
1994	0.959	1.093	13.96%
1995	0.865	1.050	21.43%
1996	0.929	1.023	10.18%
1997	1.018	1.000	-1.77%
1998	1.063	0.942	-11.33%
1999	0.982	0.877	-10.67%
2000	0.941	0.816	-13.25%
2001	0.968	0.805	-16.82%
2002	0.951	0.801	-15.78%
2003	0.824	0.822	-0.14%
2004	0.921	0.942	2.27%

Table 3.1.2.1.3. Fits to the indices used for the continuity case.

	COMMERCIAL HANDLINE			HEADBOAT EAST		
YEAR	OBS	PRED	% DIFF	OBS	PRED	% DIFF
1986	-	-	-	1.032	1.333	29.20%
1987	-	-	-	0.942	1.395	48.20%
1988	-	-	-	2.055	1.488	-27.56%
1989	-	-	-	1.063	1.587	49.32%
1990	-	-	-	1.695	1.604	-5.36%
1991	-	-	-	1.939	1.587	-18.12%
1992	-	-	-	2.261	1.531	-32.27%
1993	1.219	1.338	9.80%	1.410	1.363	-3.34%
1994	1.314	1.125	-14.42%	1.155	1.145	-0.85%
1995	1.014	0.950	-6.33%	1.130	0.967	-14.37%
1996	0.938	0.882	-5.96%	0.648	0.898	38.56%
1997	1.009	0.842	-16.59%	0.697	0.857	22.97%
1998	0.945	0.815	-13.80%	0.248	0.829	234.78%
1999	0.899	0.806	-10.35%	0.468	0.820	75.13%
2000	0.689	0.833	20.81%	0.369	0.848	129.93%
2001	0.835	0.870	4.22%	0.364	0.886	143.44%
2002	0.943	0.855	-9.30%	0.541	0.871	60.84%
2003	1.068	0.766	-28.30%	0.463	0.779	68.41%
2004	1.127	0.594	-47.30%	0.524	0.605	15.44%

Table. 3.1.2.2.1. The parameter estimates from the continuity case.

Parameter Estimate		Value	Standard Deviation
Initial biomass (lbs)	B1986	7.916E+06	2.09E+03
Intrinsic rate of growth	r	6.681E-01	2.61E-02
Carrying Capacity (lbs)	k	2.152E+07	1.41E+03
Catchability (q)			
Commercial	q1	1.638E-04	3.43E-05
Recreational	q2	1.667E-04	4.15E-05
Shrimp Bycatch	q3	8.073E-02	2.38E-02

Relative Effort (unitless)		Fishery	
Year	Commercial	Recreational	Shrimp Bycatch
1986	1.553E+03	4.785E+02	8.269E-01
1987	1.221E+03	4.259E+02	8.533E-01
1988	1.125E+03	4.277E+02	8.840E-01
1989	1.127E+03	2.768E+02	9.377E-01
1990	1.564E+03	4.065E+02	9.747E-01
1991	1.259E+03	4.487E+02	1.043E+00
1992	1.655E+03	5.751E+02	1.099E+00
1993	2.383E+03	5.644E+02	1.123E+00
1994	2.830E+03	6.019E+02	1.093E+00
1995	2.669E+03	7.308E+02	1.050E+00
1996	2.200E+03	4.076E+02	1.023E+00
1997	2.612E+03	4.841E+02	1.000E+00
1998	2.280E+03	3.533E+02	9.423E-01
1999	2.406E+03	4.577E+02	8.771E-01
2000	1.845E+03	3.479E+02	8.160E-01
2001	2.000E+03	5.905E+02	8.051E-01
2002	2.436E+03	5.133E+02	8.009E-01
2003	3.141E+03	7.145E+02	8.224E-01
2004	3.832E+03	1.197E+03	9.417E-01

Table 3.1.2.3.1. Annual population biomass (abundance) estimates for the continuity case.

YEAR	BIOMASS (millions of lbs)	B/B_{MSY}
1986	7.916	0.736
1987	8.064	0.749
1988	8.622	0.801
1989	9.179	0.853
1990	9.795	0.910
1991	9.483	0.881
1992	9.551	0.888
1993	8.898	0.827
1994	7.614	0.708
1995	6.293	0.585
1996	5.414	0.503
1997	5.362	0.498
1998	4.960	0.461
1999	4.986	0.463
2000	4.863	0.452
2001	5.278	0.490
2002	5.341	0.496
2003	5.123	0.476
2004	4.320	0.401

Table 3.1.2.4.1. Annual fishing mortality estimates for the continuity case.

YEAR	F	F/F_{MSY}
1986	0.401	1.200
1987	0.340	1.017
1988	0.327	0.979
1989	0.306	0.917
1990	0.403	1.205
1991	0.365	1.093
1992	0.456	1.364
1993	0.575	1.721
1994	0.652	1.952
1995	0.644	1.927
1996	0.511	1.529
1997	0.589	1.764
1998	0.508	1.522
1999	0.541	1.620
2000	0.426	1.275
2001	0.491	1.470
2002	0.549	1.644
2003	0.700	2.095
2004	0.903	2.703

Table 3.1.2.7.1. Management and biomass status benchmarks for the 2001 base case and the continuity case.

Benchmark	2001 Base Run	2005 Continuity Case
B1986 (LBS)	6.18E+06	7.92E+06
B1999 (LBS)	3.77E+06	4.99E+06
B2004 (LBS)	-	4.32E+06
BMSY (LBS)	1.06E+07	1.08E+07
B1986/BMSY	0.584	0.736
B1999/BMSY	0.356	0.463
B2004/BMSY	-	0.401
F1986	0.443	0.401
F1999	0.632	0.541
F2004	-	0.903
FMSY	0.318	0.334
F1986/FMSY	1.39	1.20
F1999/FMSY	1.99	1.62
F2004/FMSY	-	2.70
R	0.637	0.668
K (LBS)	2.12E+07	2.15E+07
MSY (LBS)	3.37E+06	3.59E+06

*** R is the intrinsic rate of growth; K is the carrying capacity

Table 3.1.2.8.1. Projected F, yield (millions of lbs), and biomass (millions of lbs) trajectories for the four continuity case scenarios.

		F2004		FMSY		F Recovery		Yield Recovery	
Year	FMSY	F	F/FMSY	F	F/FMSY	F	F/FMSY	F	F/FMSY
2004	0.334	0.903	2.703	0.903	2.703	0.903	2.703	0.903	2.703
2005	0.334	0.903	2.703	0.903	2.703	0.903	2.703	0.903	2.703
2006	0.334	0.903	2.703	0.903	2.703	0.903	2.703	0.903	2.703
2007	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.444	1.328
2008	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.367	1.098
2009	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.285	0.853
2010	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.211	0.630
2011	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.152	0.455
2012	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.110	0.331
2013	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.084	0.251
2014	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.067	0.201
2015	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.057	0.172
2016	0.334	0.903	2.703	0.334	1.000	0.222	0.665	0.052	0.155
Year	BMSY	Biomass	B/BMSY	Biomass	B/BMSY	Biomass	B/BMSY	Biomass	B/BMSY
2004	10.761	4.320	0.401	4.320	0.401	4.320	0.401	4.320	0.401
2005	10.761	3.098	0.288	3.098	0.288	3.098	0.288	3.098	0.288
2006	10.761	2.288	0.213	2.288	0.213	2.288	0.213	2.288	0.213
2007	10.761	1.725	0.160	1.784	0.166	1.797	0.167	1.765	0.164
2008	10.761	1.318	0.122	2.320	0.216	2.597	0.241	2.020	0.188
2009	10.761	1.018	0.095	2.963	0.275	3.649	0.339	2.452	0.228
2010	10.761	0.792	0.074	3.706	0.344	4.950	0.460	3.167	0.294
2011	10.761	0.620	0.058	4.527	0.421	6.435	0.598	4.296	0.399
2012	10.761	0.488	0.045	5.391	0.501	7.988	0.742	5.961	0.554
2013	10.761	0.385	0.036	6.255	0.581	9.469	0.880	8.177	0.760
2014	10.761	0.305	0.028	7.075	0.657	10.761	1.000	10.761	1.000
2015	10.761	0.241	0.022	7.815	0.726	11.805	1.097	13.345	1.240
2016	10.761	0.192	0.018	8.456	0.786	12.597	1.171	15.562	1.446
Year	MSY	Yield	Y/MSY	Yield	Y/MSY	Yield	Y/MSY	Yield	Y/MSY
2004	3.595	3.410	0.949	3.410	0.949	3.410	0.949	3.410	0.949
2005	3.595	2.432	0.677	2.432	0.677	2.432	0.677	2.432	0.677
2006	3.595	1.814	0.504	1.814	0.504	1.814	0.504	1.814	0.504
2007	3.595	1.376	0.383	0.677	0.188	0.478	0.133	0.887	0.247
2008	3.595	1.057	0.294	0.873	0.243	0.681	0.190	0.887	0.247
2009	3.595	0.819	0.228	1.104	0.307	0.941	0.262	0.887	0.247
2010	3.595	0.639	0.178	1.365	0.380	1.251	0.348	0.887	0.247
2011	3.595	0.502	0.140	1.647	0.458	1.590	0.442	0.887	0.247
2012	3.595	0.395	0.110	1.937	0.539	1.930	0.537	0.887	0.247
2013	3.595	0.312	0.087	2.220	0.617	2.241	0.623	0.887	0.247
2014	3.595	0.247	0.069	2.482	0.690	2.503	0.696	0.887	0.247
2015	3.595	0.196	0.055	2.714	0.755	2.708	0.753	0.887	0.247
2016	3.595	0.156	0.043	2.911	0.810	2.860	0.796	0.887	0.247

Table 3.2.1.2.1. Catch series used for the SSASPM runs.

YEAR	Commercial East (LBS)	Commercial West (LBS)	Recreational (Numbers)	Shrimp Bycatch (Numbers)
1950-1962	-1	-1	-1	-1
1963	27700	20300	-1	-1
1964	30300	21200	-1	-1
1965	30100	18700	-1	-1
1966	15700	6000	-1	-1
1967	31800	14200	-1	-1
1968	63200	45300	-1	-1
1969	80500	24400	-1	-1
1970	75100	40000	-1	-1
1971	82000	43300	-1	-1
1972	72400	41900	-1	-1
1973	122100	49500	-1	-1
1974	115900	60200	-1	-1
1975	252200	98500	-1	-1
1976	221600	54500	-1	-1
1977	300337	175789	-1	-1
1978	258155	147082	-1	-1
1979	196791	198599	-1	-1
1980	143836	133743	-1	-1
1981	208578	104201	141888	6900000
1982	215646	131973	833154	6900000
1983	340912	145961	231710	6900000
1984	483215	832017	367066	6900000
1985	607023	722886	398400	6900000
1986	689625	939041	998551	6900000
1987	534518	1003433	1035306	6900000
1988	492997	991713	1375143	6900000
1989	481705	1002816	861223	6900000
1990	1489581	962643	1170574	6900000
1991	969399	808348	1165083	6900000
1992	1217900	1036278	1359566	6900000
1993	1667549	1024203	1202661	6900000
1994	1582072	1040183	989280	6900000
1995	1506085	654242	1229289	6900000
1996	1166437	651873	586062	6900000
1997	1040331	1072584	617878	6900000
1998	807987	895269	313724	6900000
1999	866821	1098219	421950	6900000
2000	699209	758230	333741	6900000
2001	791599	915733	623512	6900000
2002	1008662	997300	511965	6900000
2003	1153574	1260897	596534	6900000
2004	903434	1218992	815530	6900000

Table 3.2.1.2.2. Indices of abundance used for the SSASPM runs.

YEAR	CMHL-E	CMHL-W	HB-E	HB-W	MRFSS
1950-1985	-1	-1	-1	-1	-1
1986	-1	-1	1.032	1.3384	2.0146
1987	-1	-1	0.9415	1.0085	1.0238
1988	-1	-1	2.0546	0.8242	0.8825
1989	-1	-1	1.0626	1.1914	0.6223
1990	-1	-1	1.6947	1.6901	2.4221
1991	-1	-1	1.9385	1.0368	1.4895
1992	-1	-1	2.2609	0.9378	1.7052
1993	1.3672	0.9743	1.4096	0.9196	1.9029
1994	1.4585	1.0884	1.1549	1.105	1.178
1995	1.1465	0.8371	1.1296	1.1262	1.7258
1996	1.0401	0.8129	0.648	0.8599	0.8839
1997	0.9461	1.0744	0.6969	0.9198	0.4752
1998	0.8455	1.0737	0.2477	0.8737	0.3558
1999	0.9007	0.9372	0.4683	0.6062	0.406
2000	0.7258	0.6425	0.3688	0.6771	0.3447
2001	0.8776	0.7942	0.3638	1.1784	0.3744
2002	0.8899	1.0319	0.5412	0.8844	0.3027
2003	0.9232	1.2665	0.4629	0.6573	0.3733
2004	0.8787	1.4669	0.5237	1.1653	0.5176

Table 3.2.1.2.3. Age composition matrices used for the SSASPM runs. The maximum effective sample size (SAMPLES) was fixed at 200.

A) COMMERCIAL EAST		Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age
YEAR	SAMPLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1994	28	0	0	4	9	5	5	1	1	1	0	0	1	1	0
1995	6	0	0	0	0	2	2	1	0	1	0	0	0	0	0
1996	6	0	0	0	1	1	0	4	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	138	9	42	67	6	7	4	0	0	0	1	1	1	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	45	0	0	9	10	2	4	4	4	2	3	1	3	2	1
2001	200	0	47	165	256	266	177	121	74	40	44	19	17	9	15
2002	200	4	211	473	169	130	82	64	45	22	17	21	4	6	10
2003	200	1	76	435	800	310	141	188	90	57	13	13	11	6	4
2004	200	0	21	144	164	128	53	47	34	20	7	2	3	2	1

B) COMMERCIAL WEST		Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age
YEAR	SAMPLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1994	64	0	0	6	9	20	9	7	4	0	2	2	3	1	1
1995	75	0	11	5	14	20	9	8	0	3	3	0	1	0	1
1996	71	0	1	21	9	10	11	5	3	3	4	1	1	2	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	81	0	1	7	8	13	10	3	5	6	14	7	0	2	5
2001	102	0	1	10	15	14	12	7	6	9	8	4	2	7	7
2002	69	0	6	15	7	5	6	8	8	0	2	0	6	1	5
2003	200	0	9	51	245	74	44	30	28	19	9	14	10	4	5
2004	200	1	8	50	104	144	58	39	22	31	18	5	11	8	12

C) RECREATIONAL		Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age	Age
YEAR	SAMPLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14+
1994	154	0	0	27	39	30	26	7	12	9	2	1	0	1	0
1995	192	2	18	41	40	44	17	13	4	8	3	0	0	1	1
1996	200	1	17	44	57	53	54	21	17	6	8	1	1	0	0
1997	46	0	8	3	12	6	8	5	2	2	0	0	0	0	0
1998	14	0	1	3	2	4	1	2	1	0	0	0	0	0	0
1999	200	3	33	74	41	29	19	16	16	8	4	1	1	1	0
2000	200	0	6	34	51	53	26	16	19	12	7	1	3	1	1
2001	141	0	2	5	19	46	24	22	9	4	3	2	4	1	0
2002	200	0	15	45	24	55	36	42	26	5	3	3	2	2	0
2003	91	0	9	10	29	10	12	13	3	4	1	0	0	0	0
2004	129	0	0	7	41	48	10	16	3	1	2	1	0	0	0

Table 3.2.1.2.4. The data input file used for the SSASPM base run.

```
# GENERAL INFORMATION
# first and last year of data
  1950 2004
# number of years of prehistorical period
  31
# Enter 1 to calculate an average historic effort, 2 for a linear trend in historic effort, or 2 for exponential trend in historic
effort
  2
# first and last age of data
  1    14
# number of seasons (months) per year
  12
# type of overall variance parameter (1 = log scale variance, 2 = observation scale variance, 0=force equal weighting)
  1
# spawning season (integer representing season/month of year when spawning occurs)
  6
# maturity schedue (fraction of each age class that is sexually mature
  1 1 1 1 1 1 1 1 1 1 1 1 1 1
# fecundity schedule (index of per capita fecundity of each age class)
# MILLIONS OF EGGS (Batch Fecundity at age * 87) 87=Spawning Frequency
  3.16 3.33 3.51 3.69 3.87 4.05 4.23 4.41 4.59 4.77 4.94 5.12 5.30 5.48

# CATCH INFORMATION
# number of catch data series (if there are no series, there should be no entries after the next line below)
  4
# pdf of observation error for each series (1) lognormal, (2) normal
  1 1 1 1
# units (1=numbers, 2=weight)
  2 2 1 1
# season (month) when fishing begins for each series
  1 1 1 1
# season (month) when fishing ends for each series
  12 12 12 12
# set of catch variance parameters each series is linked to
  1 1 1 1
# set of q parameters each series is linked to
  1 2 3 4
# set of s parameters each series is linked to
  1 2 3 4
# set of e parameters each series is linked to
  1 2 3 4
```

Table 3.2.1.2.4. (continued) The data input file used for the SSASPM base run.

#observed catches by set (column for year required)

#CM-E	CM-W	REC	SHRMP-BYC	YEAR
-1	-1	-1	-1	1950
#### REPEAT THE CATCH SERIES FOR EACH YEAR 1951-1962 ###				
27700	20300	-1	-1	1963
30300	21200	-1	-1	1964
30100	18700	-1	-1	1965
15700	6000	-1	-1	1966
31800	14200	-1	-1	1967
63200	45300	-1	-1	1968
80500	24400	-1	-1	1969
75100	40000	-1	-1	1970
82000	43300	-1	-1	1971
72400	41900	-1	-1	1972
122100	49500	-1	-1	1973
115900	60200	-1	-1	1974
252200	98500	-1	-1	1975
221600	54500	-1	-1	1976
300337	175789	-1	-1	1977
258155	147082	-1	-1	1978
196791	198599	-1	-1	1979
143836	133743	-1	-1	1980
208578	104201	141888	***6900000***	1981
215646	131973	833154	***6900000***	1982
340912	145961	231710	***6900000***	1983
483215	832017	367066	***6900000***	1984
607023	722886	398400	***6900000***	1985
689625	939041	998551	***6900000***	1986
534518	1003433	1035306	***6900000***	1987
492997	991713	1375143	***6900000***	1988
481705	1002816	861223	***6900000***	1989
1489581	962643	1170574	***6900000***	1990
969399	808348	1165083	***6900000***	1991
1217900	1036278	1359566	***6900000***	1992
1667549	1024203	1202661	***6900000***	1993
1582072	1040183	989280	***6900000***	1994
1506085	654242	1229289	***6900000***	1995
1166437	651873	586062	***6900000***	1996
1040331	1072584	617878	***6900000***	1997
807987	895269	313724	***6900000***	1998
866821	1098219	421950	***6900000***	1999
699209	758230	333741	***6900000***	2000
791599	915733	623512	***6900000***	2001
1008662	997300	511965	***6900000***	2002
1153574	1260897	596534	***6900000***	2003
903434	1218992	815530	***6900000***	2004

Table 3.2.1.2.4. (continued) The data input file used for the SSASPM base run.

```
# annual scaling factors for observation variance (use this option to scale up the variance for observations based on very little (or
estimated) data) (column for year required)
#CM-E   CM-W    REC SHRMP-BYC  YEAR
1      1      1      1      1950
#### REPEAT THE SCALING FACTORS FOR EACH YEAR 1951-2004 ###
# INDICES OF ABUNDANCE (e.g., CPUE) If there are no series, there should be no entries between the comment lines.
# number of index data series
  5
# pdf of observation error for each series (1) lognormal, (2) normal
  1 1 1 1 1
# units (1=numbers, 2=weight)
  2 2 1 1 1
# season (month) when index begins for each series
  1 1 1 1 1
# season (month) when index ends for each series
  12 12 12 12 12
# option to (1) scale or (0) not to scale index observations
  0 0 0 0 0
# set of index variance parameters each series is linked to
  1 1 1 1 1
# set of q parameters each series is linked to
  5 6 7 8 9
# set of s parameters each series is linked to
  1 2 3 3 3
# observed indices by series (no column for year allowed)
#CMHL_E        CMHL_W         HB_E           HB_W           MRFSS          YEAR
-1.0000        -1.0000        -1.0000        -1.0000        -1.0000        1950
#### REPEAT PREVIOUS LINE FOR EACH YEAR 1951-1985 ###
-1.0000        -1.0000        1.0320         1.3384         2.0146         1986
-1.0000        -1.0000        0.9415         1.0085         1.0238         1987
-1.0000        -1.0000        2.0546         0.8242         0.8825         1988
-1.0000        -1.0000        1.0626         1.1914         0.6223         1989
-1.0000        -1.0000        1.6947         1.6901         2.4221         1990
-1.0000        -1.0000        1.9385         1.0368         1.4895         1991
-1.0000        -1.0000        2.2609         0.9378         1.7052         1992
1.3672         0.9743         1.4096         0.9196         1.9029         1993
1.4585         1.0884         1.1549         1.1050         1.1780         1994
1.1465         0.8371         1.1296         1.1262         1.7258         1995
1.0401         0.8129         0.6480         0.8599         0.8839         1996
0.9461         1.0744         0.6969         0.9198         0.4752         1997
0.8455         1.0737         0.2477         0.8737         0.3558         1998
0.9007         0.9372         0.4683         0.6062         0.4060         1999
0.7258         0.6425         0.3688         0.6771         0.3447         2000
0.8776         0.7942         0.3638         1.1784         0.3744         2001
0.8899         1.0319         0.5412         0.8844         0.3027         2002
0.9232         1.2665         0.4629         0.6573         0.3733         2003
0.8787         1.4669         0.5237         1.1653         0.5176         2004
```

Table 3.2.1.2.4. (continued) The data input file used for the SSASPM base run.

```
# annual scaling factors for observation variance (use this option to scale up the variance for obs based on very little data)
#CMHL_E        CMHL_W        HB_E          HB_W          MRFSS
1.0000  1.0000  1.0000  1.0000  1.0000  1950
```
REPEAT THESE SCALING FACTORS FOR EACH YEAR 1951-2004

```
# EFFORT OBSERVATIONS If there are no series, there should be no entries between the comment lines.
# number of effort data series
   0
# AGE COMPOSITION OBSERVATIONS If there are no series, there should be no entries between the comment lines.
# number of age-composition series (If there are no series, there should be no more entries in this section)
  3
# first year in age-composition series
  1994
# probability densities used for age-comp. series (0 = ignore, 3 = multinomial, 8 = robustified normal)
  3 3 3
# units (only 1=numbers, no other options at this time)
  1 1 1
# season (month) when age collections begin for each series
  1 1 1
# season (month) when age collections end for each series
  12 12 12
```
age composition data (***MAXIMUM SAMPLE SIZE = 200***)

#CM HL EAST

#FLEET	YEAR	SAMPLES	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14+
1	1994	28	0	0	4	9	5	5	1	1	1	0	0	1	1	0
1	1995	6	0	0	0	0	2	2	1	0	1	0	0	0	0	0
1	1996	6	0	0	0	1	1	0	4	0	0	0	0	0	0	0
1	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1998	138	9	42	67	6	7	4	0	0	0	1	1	1	0	0
1	1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2000	45	0	0	9	10	2	4	4	4	2	3	1	3	2	1
1	2001	200	0	47	165	256	266	177	121	74	40	44	19	17	9	15
1	2002	200	4	211	473	169	130	82	64	45	22	17	21	4	6	10
1	2003	200	1	76	435	800	310	141	188	90	57	13	13	11	6	4
1	2004	200	0	21	144	164	128	53	47	34	20	7	2	3	2	1

#CM HL WEST

#FLEET	YEAR	SAMPLES	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14+
2	1994	64	0	0	6	9	20	9	7	4	0	2	2	3	1	1
2	1995	75	0	11	5	14	20	9	8	0	3	3	0	1	0	1
2	1996	71	0	1	21	9	10	11	5	3	3	4	1	1	2	0
2	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2000	81	0	1	7	8	13	10	3	5	6	14	7	0	2	5
2	2001	102	0	1	10	15	14	12	7	6	9	8	4	2	7	7
2	2002	69	0	6	15	7	5	6	8	8	0	2	0	6	1	5
2	2003	200	0	9	51	245	74	44	30	28	19	9	14	10	4	5
2	2004	200	1	8	50	104	144	58	39	22	31	18	5	11	8	12

Table 3.2.1.2.4. (continued) The data input file used for the SSASPM base run.

#REC

#FLEET	YEAR	SAMPLES	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14+
3	1994	154	0	0	27	39	30	26	7	12	9	2	1	0	1	0
3	1995	192	2	18	41	40	44	17	13	4	8	3	0	0	1	1
3	1996	200	1	17	44	57	53	54	21	17	6	8	1	1	0	0
3	1997	46	0	8	3	12	6	8	5	2	2	0	0	0	0	0
3	1998	14	0	1	3	2	4	1	2	1	0	0	0	0	0	0
3	1999	200	3	33	74	41	29	19	16	16	8	4	1	1	1	0
3	2000	200	0	6	34	51	53	26	16	19	12	7	1	3	1	1
3	2001	141	0	2	5	19	46	24	22	9	4	3	2	4	1	0
3	2002	200	0	15	45	24	55	36	42	26	5	3	3	2	2	0
3	2003	91	0	9	10	29	10	12	13	3	4	1	0	0	0	0
3	2004	129	0	0	7	41	48	10	16	3	1	2	1	0	0	0

Table. 3.2.1.4.1.. Parameter inputs for SSASPM base run.

```
# Total number of process parameters (must match number of entries in 'Specifications 1' section)
40
# Number of sets of each class of parameters (must be atleast 1)
# q (catchability)
# |     Effort
# |     |     Vulnerability (selectivity)
# |     |     |     catch observation variance scalar
# |     |     |     |     index variance scalar
# |     |     |     |     |     effort variance scalar
# |     |     |     |     |     |
  9     4     4     1     1     1
# Specifications 1: process parameters and observation error parameters
#===============================================================================================
#class (nature) of parameter (1=constant, 2-4 = polynom of degree x, 5=knife edge, 6=logistic, 7=gamma)
#  |        best estimate (or central tendency of prior)
#  |       |                lower bound    upper bound
#  |       |                |                |              phase to estimate (-1 = don't estimate)
#  |       |                |                |              | prior density (1= lognorm, 2=norm, 3=uniform)
#  |       |                |                |              |     |       prior variance
#  |       |                |                |              |     |       |
#-----------------------------------------------------------------------------------------------
# Natural mortality rate
   1       0.2500E+00       0.1000E-01       0.5000E+00    -1     1       0.2500E+00
# Recruitment (10=Beverton/Holt, 11=Ricker)
  10       0.1000E+07       0.1000E+04       0.1000E+10     1     3       0.1000E+01
  10       0.6000E+01       0.1100E+01       1.0000E+02     2     1      -0.8500E+00
# Growth (type 8 = von Bertalanfy/Richards, Linf, K, t0, m, a, b (weight=al^b)
   8       0.1699E+02       0.1000E-03       0.1000E+06    -1     0       0.1000E+01
   8       0.2000E+00       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
   8      -0.3900E+01      -0.5000E+01       0.1000E+13    -1     0       0.1000E+01
   8       0.1000E+01       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
   8       0.5957E-03       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
   8       0.2870E+01       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
```

Table. 3.2.1.4.1.(continued). Parameter inputs for SSASPM base run.

```
# catchability
   #Catches (fix at 1 if E assumes Fishing Mortality)
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   #Indices
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
# effort for 'prehistoric' period when data is sparse
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
# effort for period with useful data (Set at assumed F va lues if q =1)
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
# vulnerability (selectivity)
#CM-EAST
   6       0.4046E+00       0.0000E-10       0.2000E+01     1     0       0.1000E+01
   6       2.6600E+00       0.5000E+00       0.4000E+01     3     0       0.6250E-01
#CM-WEST
   6       0.4046E+00       0.0000E-10       0.2000E+01     1     0       0.1000E+01
   6       2.6600E+00       0.5000E+00       0.4000E+01     3     0       0.6250E-01
#REC
   6       0.6329E+00       0.0000E-10       0.2000E+01     1     0       0.1000E+01
   6       3.0000E+00       0.5000E+00       0.4000E+01     3     0       0.6250E-01
#SHRIMP
   15       0.5000E+00       0.1000E-06       0.2000E+01   -4     0       0.1000E+01
   15       0.0100E+00       0.1000E-06       0.2000E+01   -4     0       0.1000E+01
   15       1.5000E+00       0.3000E+00       0.3000E+01   -3     0       0.6250E-01
   15       0.4150E+00       0.1000E-06       0.2000E+01   -4     0       0.1000E+01
   15       0.76938E+00      0.3000E+00       0.3000E+01   -3     0       0.6250E-01
```

Table. 3.2.1.4.1.(continued). Parameter inputs for SSASPM base run.

```
# catch observation error variance scalar
   1       1.0000E+00       0.1000E+00       0.5000E+01    -1     0       0.1000E+01
# index observation error variance scalar
   1       2.0000E+00       0.1000E+00       0.5000E+01    -1     0       0.1000E+01
# effort observation error variance scalar
   1       1.0000E+00       0.1000E+00       0.5000E+01    -1     0       0.1000E+01
#===============================================================================================
# Specifications 2: process ERROR parameters
#===============================================================================================
#    best estimate (or central tendency of prior)
#    |                lower bound    upper bound
#    |                |                |              phase to estimate (-1 = don't estimate)
#    |                |                |              |  prior density (1= lognormal, 2=normal, 3=uniform)
#    |                |                |              |     |       prior variance
#    |                |                |              |     |       |
#------------------------------------------------------------------------------------------------
# overall variance (negative value indicates a CV)
    -0.2000E+00      -0.2000E+01      -0.1000E-01     2     0       0.1000E+01
# recruitment process variation parameters (allows year to year fluctuations)
#    correlation coefficient
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
#    variance scalar (multiplied by overall variance)
     0.14820E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01(
#    annual deviation parameters (last entry is arbitrary for deviations)
     0.0000E+00      -0.5000E+01       0.5000E+01     4     1       0.1000E+01
# catchability process variation parameters (allows year to year fluctuations)
#    correlation coefficients
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
```

Table. 3.2.1.4.1.(continued). Parameter inputs for SSASPM base run.

```
#    variance scalars (multiplied by overall variance)
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
#    annual deviation parameters (last entry is arbitrary for deviations)
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
# effort process variation parameters (allows year to year fluctuations)
#    correlation coefficients
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
#    variance scalars (multiplied by overall variance)
     0.22300E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
     0.22300E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
     0.22300E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
     0.040000+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
#    annual deviation parameters (last entry is arbitrary for deviations)
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
```

Table 3.2.1.5.1. Stochastic equations used to define the state space age-structured production model, where the notation E is used to denote the value computed from the deterministic components of the model.

Variables	Description
Process functions for state variables	
$M_{ay} = E[M_a]\, e^{-\varepsilon_{M,y}}, \quad \varepsilon_{M,y} = \rho_{M,y}\, \varepsilon_{M,y-1} + \eta_{M,y}$	natural mortality rate
$N_{\alpha y} = E[N_{\alpha y}]\, e^{-\varepsilon_{R,y}}, \quad \varepsilon_{R,y} = \rho_R\, \varepsilon_{R,y-1} + \eta_{R,y}$	recruitment of youngest age
$q_{iy} = E[q_{iy}]\, e^{-\varepsilon_{q,i,y}}, \quad \varepsilon_{q,i,y} = \rho_{q,i}\, \varepsilon_{q,i,y-1} + \eta_{q,i,y}$	catchability for fleet *i*
$f_{iy} = E[f_{iy}]\, e^{-\varepsilon_{f,i,y}}, \quad \varepsilon_{f,i,y} = \rho_{f,i}\, \varepsilon_{f,i,y-1} + \eta_{f,i,y}$	effort expended by fishery f
Observation functions for data variables	
$C_{ft} = \left(\delta\, q_{ft}\, E_{ft} \sum_{j=1}^{16} B_{t+j\delta} \right) e^{-\varepsilon_{C,f,t}}, \quad \varepsilon_{C,f,t} = \rho_{C,f}\, \varepsilon_{C,f,t-1} + \eta_{C,f,t}$	catch of fleet *i*
$I_{ft} = \left(\delta q_{ft} \sum_{j=1}^{16} B_{t+j\delta} \right) e^{-\varepsilon_{I,f,t}}, \quad \varepsilon_{I,f,t} = \rho_{I,f}\, \varepsilon_{I,f,t-1} + \eta_{I,f,t}$	CPUE of fleet *i*

Table 3.2.2.1.1 Fits to catches for the SSASPM model.

	Commercial East (lbs)			Commercial West (lbs)			Recreational (Numbers)			Shrimp Bycatch (Numbers)		
YEAR	**OBS**	**PRED**	**%DIFF**	**OBS**	**PRED**	**%DIFF**	**OBS**	**PRED**	**%DIFF**	**OBS**	**PRED**	**%DIFF**
1981	208,580	114,370	-45.17%	104,200	61,615	-40.87%	141,890	272,030	91.72%	6,900,000	4,866,500	-29.47%
1982	215,650	238,420	10.56%	131,970	148,250	12.34%	833,150	585,220	-29.76%	6,900,000	6,031,900	-12.58%
1983	340,910	369,790	8.47%	145,960	221,060	51.45%	231,710	338,070	45.90%	6,900,000	6,389,400	-7.40%
1984	483,220	502,730	4.04%	832,020	640,110	-23.07%	367,070	408,310	11.23%	6,900,000	6,287,900	-8.87%
1985	607,020	610,380	0.55%	722,890	740,130	2.38%	398,400	489,990	22.99%	6,900,000	5,424,100	-21.39%
1986	689,620	656,660	-4.78%	939,040	889,610	-5.26%	998,550	868,330	-13.04%	6,900,000	6,296,000	-8.75%
1987	534,520	563,810	5.48%	1,003,400	952,860	-5.04%	1,035,300	1,010,900	-2.36%	6,900,000	7,893,800	14.40%
1988	493,000	537,360	9.00%	991,710	951,780	-4.03%	1,375,100	1,181,400	-14.09%	6,900,000	5,593,000	-18.94%
1989	481,700	597,950	24.13%	1,002,800	959,240	-4.34%	861,220	967,310	12.32%	6,900,000	7,105,800	2.98%
1990	1,489,600	1,114,800	-25.16%	962,640	934,370	-2.94%	1,170,600	1,122,100	-4.14%	6,900,000	6,674,700	-3.27%
1991	969,400	1,027,200	5.96%	808,350	863,920	6.87%	1,165,100	1,186,400	1.83%	6,900,000	7,359,800	6.66%
1992	1,217,900	1,203,400	-1.19%	1,036,300	996,810	-3.81%	1,359,600	1,311,500	-3.54%	6,900,000	6,471,800	-6.21%
1993	1,667,500	1,506,700	-9.64%	1,024,200	1,022,000	-0.21%	1,202,700	1,232,800	2.50%	6,900,000	5,837,800	-15.39%
1994	1,582,100	1,536,400	-2.89%	1,040,200	1,020,700	-1.87%	989,280	1,133,100	14.54%	6,900,000	5,829,200	-15.52%
1995	1,506,100	1,380,400	-8.35%	654,240	733,820	12.16%	1,229,300	1,072,300	-12.77%	6,900,000	5,937,900	-13.94%
1996	1,166,400	1,158,400	-0.69%	651,870	692,060	6.17%	586,060	657,300	12.16%	6,900,000	6,768,500	-1.91%
1997	1,040,300	1,002,800	-3.60%	1,072,600	912,090	-14.96%	617,880	585,280	-5.28%	6,900,000	7,368,700	6.79%
1998	807,990	797,300	-1.32%	895,270	780,500	-12.82%	313,720	374,070	19.24%	6,900,000	7,514,600	8.91%
1999	866,820	784,450	-9.50%	1,098,200	787,690	-28.27%	421,950	397,550	-5.78%	6,900,000	5,572,700	-19.24%
2000	699,210	726,010	3.83%	758,230	739,880	-2.42%	333,740	400,100	19.88%	6,900,000	7,735,200	12.10%
2001	791,600	808,570	2.14%	915,730	985,420	7.61%	623,510	616,550	-1.12%	6,900,000	6,117,500	-11.34%
2002	1,008,700	905,260	-10.25%	997,300	1,082,100	8.50%	511,960	582,520	13.78%	6,900,000	5,540,100	-19.71%
2003	1,153,600	952,820	-17.40%	1,260,900	1,089,400	-13.60%	596,530	609,450	2.17%	6,900,000	4,188,300	-39.30%
2004	903,430	787,160	-12.87%	1,219,000	979,170	-19.67%	815,530	688,120	-15.62%	6,900,000	4,918,500	-28.72%

Table 3.2.2.1.2 Fits to indices for the SSASPM model.

	Commercial HL East			Commercial HL West			Headboat East			Headboat West			MRFSS		
YEAR	OBS	PRED	%DIFF	OBS	PRED	%DIFF	OBS	PRED	%DIFF	OBS	PRED	%DIFF	OBS	PRED	%DIFF
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	1.03	0.92	-11.0%	1.34	1.08	-19.47%	2.01	0.88	-56.2%
1987	-	-	-	-	-	-	0.94	0.86	-8.9%	1.01	1.01	-0.32%	1.02	0.82	-19.7%
1988	-	-	-	-	-	-	2.05	0.83	-59.6%	0.82	0.97	18.07%	0.88	0.80	-9.8%
1989	-	-	-	-	-	-	1.06	0.87	-18.4%	1.19	1.02	-14.59%	0.62	0.83	33.7%
1990	-	-	-	-	-	-	1.69	0.88	-48.2%	1.69	1.03	-39.05%	2.42	0.84	-65.2%
1991	-	-	-	-	-	-	1.94	0.88	-54.6%	1.04	1.03	-0.40%	1.49	0.85	-43.3%
1992	-	-	-	-	-	-	2.26	0.90	-60.2%	0.94	1.05	12.38%	1.71	0.86	-49.4%
1993	1.37	1.12	-18.5%	0.97	1.06	9.2%	1.41	0.90	-36.2%	0.92	1.05	14.64%	1.90	0.86	-54.7%
1994	1.46	1.05	-28.3%	1.09	1.04	-4.2%	1.16	0.86	-25.3%	1.11	1.01	-8.52%	1.18	0.83	-29.8%
1995	1.15	0.96	-16.0%	0.84	0.98	17.3%	1.13	0.80	-29.6%	1.13	0.93	-17.27%	1.73	0.76	-55.8%
1996	1.04	0.92	-12.0%	0.81	0.93	14.0%	0.65	0.75	15.5%	0.86	0.88	2.18%	0.88	0.72	-18.7%
1997	0.95	0.91	-4.0%	1.08	0.90	-16.3%	0.70	0.73	5.4%	0.92	0.86	-6.23%	0.48	0.71	48.4%
1998	0.85	0.96	13.3%	1.07	0.91	-15.0%	0.25	0.76	207.9%	0.87	0.90	2.75%	0.36	0.73	106.2%
1999	0.90	1.00	11.4%	0.94	0.97	3.5%	0.47	0.81	73.0%	0.61	0.95	57.14%	0.41	0.78	91.9%
2000	0.73	0.99	36.2%	0.64	1.01	57.7%	0.37	0.82	123.4%	0.68	0.97	43.10%	0.35	0.79	129.9%
2001	0.88	0.97	10.6%	0.79	1.00	25.6%	0.36	0.80	119.0%	1.18	0.94	-20.53%	0.37	0.77	104.5%
2002	0.89	1.03	15.5%	1.03	0.98	-5.5%	0.54	0.81	49.1%	0.89	0.95	7.25%	0.30	0.78	156.2%
2003	0.92	1.00	8.0%	1.27	1.00	-21.2%	0.46	0.82	76.1%	0.66	0.96	45.67%	0.37	0.78	109.8%
2004	0.88	0.89	0.8%	1.47	0.96	-34.7%	0.52	0.75	42.2%	1.17	0.87	-24.96%	0.52	0.72	38.2%

Table. 3.2.2.2.1. Selected parameter estimates and error from the SSASPM base model.

	B/B0		Recruitment Devs	
YEAR	Value	Std Dev	Value	Std Dev
1950	1.000	0.000	0	0
1951	0.999	0.000	0	0
1952	0.995	0.001	0	0
1953	0.988	0.002	0	0
1954	0.980	0.003	0	0
1955	0.971	0.004	0	0
1956	0.961	0.006	0	0
1957	0.949	0.007	0	0
1958	0.937	0.009	0	0
1959	0.925	0.011	0	0
1960	0.912	0.013	0	0
1961	0.898	0.014	0	0
1962	0.885	0.016	0	0
1963	0.872	0.018	0	0
1964	0.858	0.020	0	0
1965	0.845	0.022	0	0
1966	0.831	0.023	0	0
1967	0.818	0.025	0	0
1968	0.805	0.026	0	0
1969	0.792	0.028	0	0
1970	0.779	0.030	0	0
1971	0.767	0.031	0	0
1972	0.754	0.032	0	0
1973	0.742	0.034	0	0
1974	0.730	0.035	0	0
1975	0.718	0.036	0	0
1976	0.706	0.038	0	0
1977	0.694	0.039	0	0
1978	0.683	0.040	0	0
1979	0.672	0.041	0	0
1980	0.661	0.042	0	0
1981	0.662	0.068	0.076	0.285
1982	0.679	0.074	0.223	0.272
1983	0.686	0.075	0.248	0.258
1984	0.674	0.072	0.193	0.249
1985	0.625	0.065	-0.013	0.241
1986	0.639	0.065	0.293	0.199
1987	0.720	0.071	0.612	0.164
1988	0.649	0.063	0.051	0.171
1989	0.708	0.067	0.520	0.134
1990	0.711	0.067	0.389	0.126
1991	0.748	0.070	0.531	0.117
1992	0.708	0.067	0.268	0.119
1993	0.646	0.061	0.121	0.123
1994	0.606	0.058	0.161	0.121
1995	0.573	0.056	0.151	0.122
1996	0.603	0.060	0.390	0.114
1997	0.637	0.065	0.433	0.114
1998	0.621	0.065	0.265	0.125
1999	0.551	0.061	-0.116	0.131
2000	0.658	0.078	0.609	0.118
2001	0.646	0.083	0.247	0.129
2002	0.581	0.081	-0.065	0.153
2003	0.476	0.073	-0.527	0.216
2004	0.440	0.075	-0.148	0.269

Parameter	***Value***	***Standard Deviation***
Virgin Biomass	2.15E+14	2.05E+13
Alpha	15.15	7.85
r_0	1.41e+07	1.34+06
F_{2004}	0.57	0.14
SSB_{2004}	9.47E+13	1.80E+13
Overall Variance (CV)	0.395	2.4184e-02

Table 3.2.2.3.1. Spawing stock biomass (SSB) and SSB relative to SSB_{MSY} and $SSB_{SPR30\%}$.

YEAR	SSB	SSB/SSB_{MSY}	$SSB/SSB_{SPR30\%}$	SSB/SSB_{VIRGIN}
1981	1.43E+08	2.707	2.640	0.662
1982	1.46E+08	2.776	2.707	0.679
1983	1.48E+08	2.804	2.735	0.686
1984	1.45E+08	2.758	2.690	0.674
1985	1.34E+08	2.554	2.491	0.625
1986	1.38E+08	2.613	2.548	0.639
1987	1.55E+08	2.944	2.871	0.720
1988	1.40E+08	2.656	2.590	0.649
1989	1.52E+08	2.895	2.823	0.708
1990	1.53E+08	2.908	2.835	0.711
1991	1.61E+08	3.060	2.984	0.748
1992	1.52E+08	2.893	2.822	0.708
1993	1.39E+08	2.641	2.576	0.646
1994	1.30E+08	2.476	2.415	0.606
1995	1.23E+08	2.342	2.284	0.573
1996	1.30E+08	2.467	2.405	0.603
1997	1.37E+08	2.604	2.539	0.637
1998	1.34E+08	2.541	2.478	0.621
1999	1.19E+08	2.255	2.199	0.551
2000	1.42E+08	2.693	2.626	0.658
2001	1.39E+08	2.640	2.575	0.646
2002	1.25E+08	2.376	2.317	0.581
2003	1.03E+08	1.948	1.899	0.476
2004	9.47E+07	1.800	1.755	0.440

Table 3.2.2.4.1. Fishing mortality rate (F) and F relative to F_{MSY} and $F_{SPR30\%}$..

YEAR	F	F/F_{MSY}	$F/F_{SPR30\%}$
1981	3.77E-01	4.33E-01	4.42E-01
1982	4.16E-01	4.78E-01	4.88E-01
1983	4.25E-01	4.89E-01	4.99E-01
1984	4.39E-01	5.05E-01	5.15E-01
1985	4.58E-01	5.26E-01	5.37E-01
1986	4.20E-01	4.83E-01	4.93E-01
1987	3.77E-01	4.34E-01	4.43E-01
1988	3.98E-01	4.58E-01	4.68E-01
1989	3.72E-01	4.28E-01	4.37E-01
1990	3.67E-01	4.22E-01	4.31E-01
1991	3.63E-01	4.18E-01	4.26E-01
1992	3.92E-01	4.50E-01	4.60E-01
1993	4.25E-01	4.89E-01	4.99E-01
1994	4.28E-01	4.92E-01	5.02E-01
1995	4.44E-01	5.10E-01	5.21E-01
1996	4.10E-01	4.71E-01	4.81E-01
1997	4.14E-01	4.76E-01	4.86E-01
1998	4.93E-01	5.66E-01	5.78E-01
1999	5.25E-01	6.03E-01	6.16E-01
2000	3.95E-01	4.54E-01	4.63E-01
2001	3.78E-01	4.35E-01	4.44E-01
2002	4.81E-01	5.53E-01	5.65E-01
2003	6.00E-01	6.90E-01	7.04E-01
2004	5.69E-01	6.54E-01	6.68E-01

Table 3.2.2.5.1. Annual recruitment estimates.

YEAR	RECRUITMENT (Age 1)
1981	1.47E+07
1982	1.70E+07
1983	1.75E+07
1984	1.65E+07
1985	1.34E+07
1986	1.81E+07
1987	2.50E+07
1988	1.44E+07
1989	2.28E+07
1990	2.02E+07
1991	2.33E+07
1992	1.80E+07
1993	1.54E+07
1994	1.59E+07
1995	1.57E+07
1996	1.98E+07
1997	2.08E+07
1998	1.77E+07
1999	1.20E+07
2000	2.45E+07
2001	1.74E+07
2002	1.27E+07
2003	7.92E+06
2004	1.13E+07

Table 3.2.2.8.1. Management and biomass status benchmarks for the SSASPM base case.

Benchmark	Value
SSB_{MSY}	5.26E+07
$SSB_{30\%SPR}$	5.40E+07
SSB_{1962}/SSB_{MSY}	2.71
SSB_{1999}/SSB_{MSY}	2.25
SSB_{2004}/SSB_{MSY}	1.80
$SSB_{1962}/SSB_{30\%SPR}$	2.64
$SSB_{1999}/SSB_{30\%SPR}$	2.20
$SSB_{2004}/SSB_{30\%SPR}$	1.75
F_{MSY}	0.87
$F_{30\%SPR}$	0.85
F_{1962}/F_{MSY}	0.43
F_{1999}/F_{MSY}	0.60
F_{2004}/F_{MSY}	0.65
$F_{1962}/F_{30\%SPR}$	0.44
$F_{1999}/F_{30\%SPR}$	0.62
$F_{2004}/F_{30\%SPR}$	0.67
STEEPNESS	0.79
MSY (LBS)	5.54E+06
F0.1	0.85
Virgin Recruitment (R_0)	1.41E+07

Table 3.2.2.9.1.1 Results of the "Current Yield" projection of the SSASPM base model.

SSB_{MSY} = 5.26E+14 $SSB_{SPR30\%}$ = 5.40E+14 MSY = 5.52E+06 F_{MSY} = 0.865 F_{2004} = 0.569

YEAR	YIELD	LCI	UCI	SSB/SSB_{MSY}	LCI	UCI	$SSB/SSB_{SPR30\%}$	LCI	UCI	Recuitment	LCI	UCI
2005	5.84E+06	5.84E+06	5.84E+06	1.75	1.44	2.37	1.70	1.40	2.31	1.46E+07	6.95E+06	2.47E+07
2006	4.35E+06	4.35E+06	4.35E+06	1.75	1.32	2.64	1.70	1.29	2.57	1.45E+07	6.75E+06	2.43E+07
2007	4.35E+06	4.35E+06	4.35E+06	1.79	1.33	2.83	1.75	1.30	2.75	1.46E+07	6.81E+06	2.44E+07
2008	4.35E+06	4.35E+06	4.35E+06	1.83	1.37	3.05	1.79	1.33	2.97	1.50E+07	7.36E+06	2.56E+07
2009	4.35E+06	4.35E+06	4.35E+06	1.87	1.38	3.25	1.82	1.34	3.17	1.50E+07	7.04E+06	2.65E+07
2010	4.35E+06	4.35E+06	4.35E+06	1.90	1.39	3.35	1.85	1.36	3.26	1.50E+07	6.97E+06	2.43E+07
2011	4.35E+06	4.35E+06	4.35E+06	1.93	1.49	3.44	1.88	1.45	3.35	1.53E+07	7.38E+06	2.48E+07
2012	4.35E+06	4.35E+06	4.35E+06	1.95	1.56	3.43	1.90	1.52	3.34	1.52E+07	7.37E+06	2.51E+07
2013	4.35E+06	4.35E+06	4.35E+06	1.97	1.58	3.61	1.92	1.54	3.51	1.55E+07	6.75E+06	2.65E+07
2014	4.35E+06	4.35E+06	4.35E+06	1.99	1.67	3.58	1.94	1.62	3.49	1.51E+07	7.14E+06	2.61E+07
2015	4.35E+06	4.35E+06	4.35E+06	2.01	1.65	3.52	1.96	1.60	3.43	1.49E+07	6.75E+06	2.54E+07
2016	4.35E+06	4.35E+06	4.35E+06	2.02	1.64	3.75	1.97	1.60	3.65	1.57E+07	7.24E+06	2.62E+07

Table 3.2.2.9.1.2. Results of the "Current F" projection of the SSASPM base model.

SSB_{MSY} = 5.26E+14 $SSB_{SPR30\%}$ = 5.40E+14 MSY = 5,52E+06 F_{MSY} = 0.865 F_{2004} = 0.569

YEAR	YIELD	LCI	UCI	SSB/SSB_{MSY}	LCI	UCI	$SSB/SSB_{SPR30\%}$	LCI	UCI	Recuitment	LCI	UCI
2005	5.94E+06	4.54E+06	8.69E+06	1.74	1.49	2.24	1.70	1.45	2.19	1.46E+07	6.95E+06	2.47E+07
2006	5.72E+06	4.27E+06	8.75E+06	1.68	1.37	2.28	1.64	1.34	2.22	1.45E+07	6.71E+06	2.42E+07
2007	5.54E+06	4.14E+06	8.45E+06	1.64	1.34	2.33	1.60	1.31	2.27	1.45E+07	6.78E+06	2.45E+07
2008	5.44E+06	4.08E+06	8.55E+06	1.61	1.31	2.37	1.57	1.28	2.31	1.48E+07	7.26E+06	2.55E+07
2009	5.37E+06	3.99E+06	8.71E+06	1.59	1.28	2.37	1.55	1.25	2.31	1.47E+07	6.92E+06	2.61E+07
2010	5.32E+06	4.01E+06	8.27E+06	1.58	1.29	2.37	1.53	1.25	2.31	1.47E+07	6.86E+06	2.37E+07
2011	5.29E+06	4.12E+06	8.57E+06	1.56	1.32	2.38	1.52	1.29	2.32	1.49E+07	7.17E+06	2.41E+07
2012	5.26E+06	4.19E+06	8.49E+06	1.56	1.32	2.31	1.52	1.28	2.25	1.47E+07	7.10E+06	2.44E+07
2013	5.25E+06	4.03E+06	8.72E+06	1.55	1.31	2.40	1.51	1.28	2.34	1.50E+07	6.54E+06	2.54E+07
2014	5.23E+06	4.08E+06	8.52E+06	1.55	1.32	2.35	1.51	1.28	2.29	1.45E+07	6.81E+06	2.50E+07
2015	5.22E+06	3.95E+06	8.39E+06	1.54	1.27	2.32	1.50	1.24	2.26	1.43E+07	6.53E+06	2.43E+07
2016	5.22E+06	4.07E+06	8.60E+06	1.54	1.31	2.38	1.50	1.28	2.32	1.50E+07	7.01E+06	2.51E+07

Table 3.2.2.9.2.1 Results of the "Current Yield" projection of the SSASPM sensitivity case. This projection uses recruitment parameters estimating using only recent data (1986-2004).

SSB_{MSY} = 6.54E+14 $SSB_{SPR30\%}$ = 6.91E+14 MSY = 7.07E+06 F_{MSY} = 0.886 F_{2004} = 0.569

YEAR	YIELD	LCI	UCI	SSB/SSB_{MSY}	LCI	UCI	$SSB/SSB_{SPR30\%}$	LCI	UCI	Recuitment	LCI	UCI
2005	5.84E+06	5.84E+06	5.84E+06	1.53	1.22	2.15	1.45	1.15	2.04	1.79E+07	8.53E+06	3.04E+07
2006	4.35E+06	4.35E+06	4.35E+06	1.64	1.21	2.53	1.55	1.14	2.39	1.80E+07	8.36E+06	3.02E+07
2007	4.35E+06	4.35E+06	4.35E+06	1.77	1.30	2.82	1.68	1.23	2.66	1.83E+07	8.52E+06	3.05E+07
2008	4.35E+06	4.35E+06	4.35E+06	1.89	1.41	3.12	1.79	1.34	2.95	1.90E+07	9.32E+06	3.23E+07
2009	4.35E+06	4.35E+06	4.35E+06	1.99	1.49	3.40	1.89	1.41	3.22	1.91E+07	8.95E+06	3.37E+07
2010	4.35E+06	4.35E+06	4.35E+06	2.09	1.57	3.56	1.97	1.49	3.37	1.91E+07	8.89E+06	3.11E+07
2011	4.35E+06	4.35E+06	4.35E+06	2.17	1.72	3.68	2.05	1.63	3.48	1.96E+07	9.45E+06	3.17E+07
2012	4.35E+06	4.35E+06	4.35E+06	2.24	1.83	3.76	2.12	1.73	3.55	1.95E+07	9.44E+06	3.22E+07
2013	4.35E+06	4.35E+06	4.35E+06	2.30	1.91	3.93	2.18	1.81	3.72	1.99E+07	8.69E+06	3.39E+07
2014	4.35E+06	4.35E+06	4.35E+06	2.35	2.02	3.98	2.23	1.91	3.76	1.94E+07	9.15E+06	3.35E+07
2015	4.35E+06	4.35E+06	4.35E+06	2.40	2.03	3.95	2.27	1.92	3.73	1.91E+07	8.67E+06	3.26E+07
2016	4.35E+06	4.35E+06	4.35E+06	2.44	2.06	4.17	2.31	1.94	3.94	2.02E+07	9.25E+06	3.37E+07

Table 3.2.2.9.2.2 Results of the "Current F" projection of the SSASPM sensitivity case. This projection uses recruitment parameters estimating using only recent data (1986-2004).

SSB_{MSY} = 6.54E+14 $SSB_{SPR30\%}$ = 6.91E+14 MSY = 7.07E+06 F_{MSY} = 0.886 F_{2004} = 0.569

YEAR	YIELD	LCI	UCI	SSB/SSB_{MSY}	LCI	UCI	$SSB/SSB_{SPR30\%}$	LCI	UCI	Recuitment	LCI	UCI
2005	6.62E+06	4.91E+06	1.00E+07	1.50	1.25	2.00	1.42	1.18	1.89	1.79E+07	8.53E+06	3.04E+07
2006	6.60E+06	4.80E+06	1.04E+07	1.52	1.20	2.11	1.43	1.14	2.00	1.79E+07	8.38E+06	3.02E+07
2007	6.52E+06	4.76E+06	1.02E+07	1.53	1.23	2.22	1.44	1.16	2.10	1.81E+07	8.45E+06	3.03E+07
2008	6.51E+06	4.79E+06	1.04E+07	1.54	1.24	2.30	1.45	1.17	2.18	1.86E+07	9.10E+06	3.19E+07
2009	6.53E+06	4.79E+06	1.07E+07	1.55	1.23	2.33	1.46	1.17	2.21	1.86E+07	8.71E+06	3.28E+07
2010	6.55E+06	4.89E+06	1.03E+07	1.55	1.26	2.36	1.47	1.19	2.23	1.85E+07	8.65E+06	2.99E+07
2011	6.56E+06	5.08E+06	1.07E+07	1.56	1.31	2.39	1.47	1.24	2.26	1.89E+07	9.07E+06	3.05E+07
2012	6.58E+06	5.21E+06	1.07E+07	1.56	1.32	2.33	1.48	1.25	2.20	1.87E+07	8.99E+06	3.09E+07
2013	6.59E+06	5.04E+06	1.10E+07	1.56	1.32	2.43	1.48	1.25	2.30	1.90E+07	8.31E+06	3.22E+07
2014	6.60E+06	5.13E+06	1.08E+07	1.57	1.33	2.39	1.48	1.26	2.26	1.85E+07	8.63E+06	3.17E+07
2015	6.60E+06	4.98E+06	1.06E+07	1.57	1.29	2.36	1.48	1.22	2.23	1.82E+07	8.28E+06	3.10E+07
2016	6.61E+06	5.16E+06	1.09E+07	1.57	1.34	2.42	1.48	1.26	2.29	1.91E+07	8.91E+06	3.20E+07

7. Figures

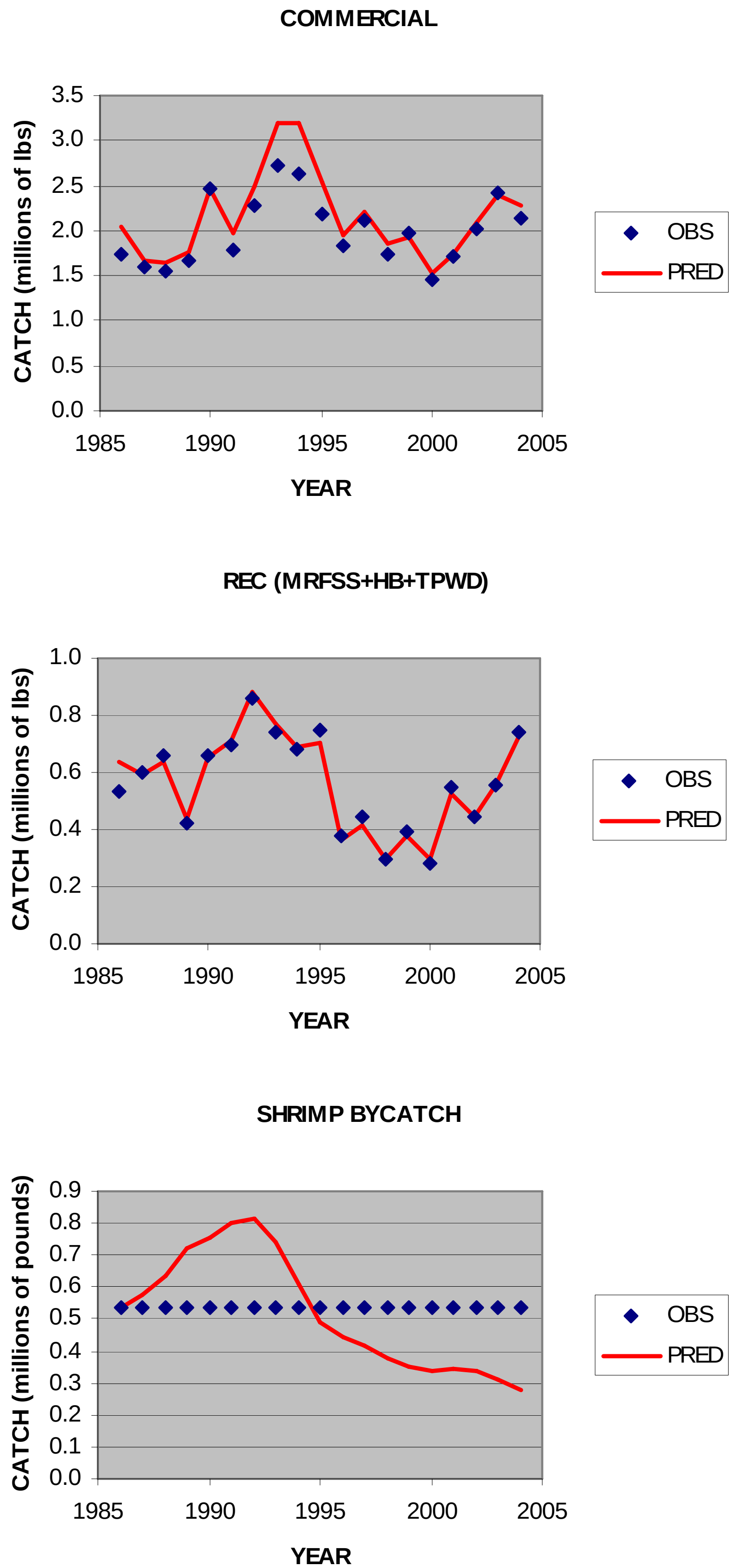


Figure 3.1.2.1.1. Model fits to the catch series for the continuity case.

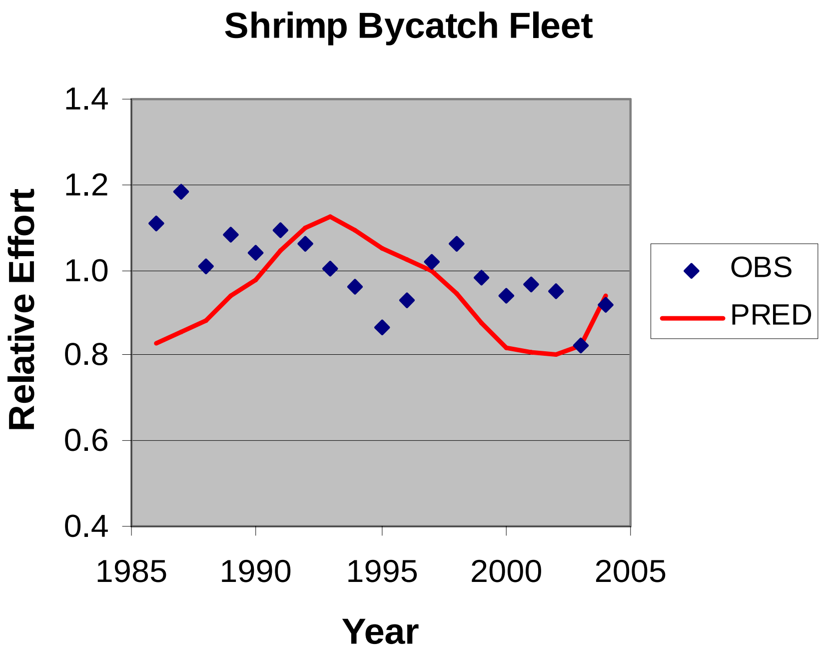


Figure 3.1.2.1.2. Model fits to the effort series for the continuity case.

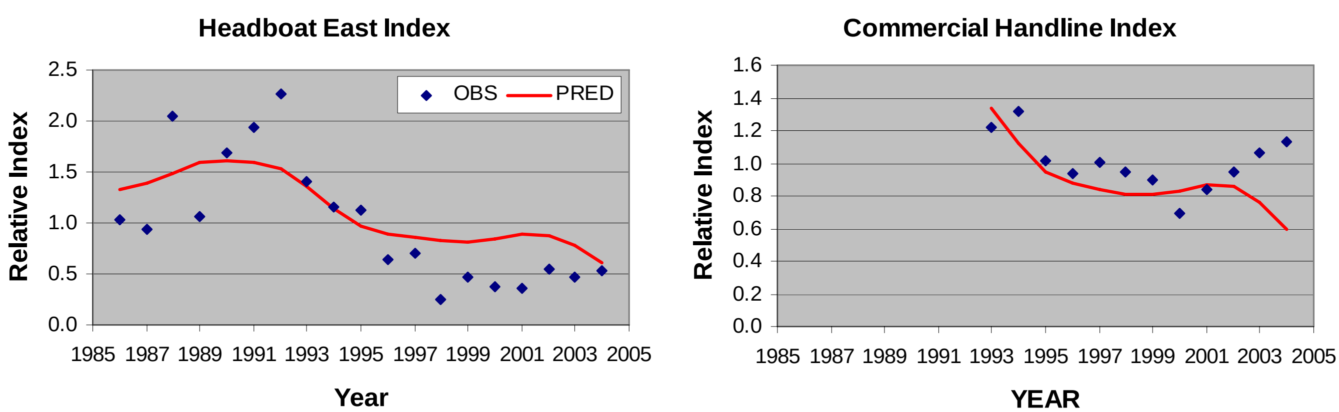


Figure 3.1.2.1.3. Model fits to the indices of abundance for the continuity case.

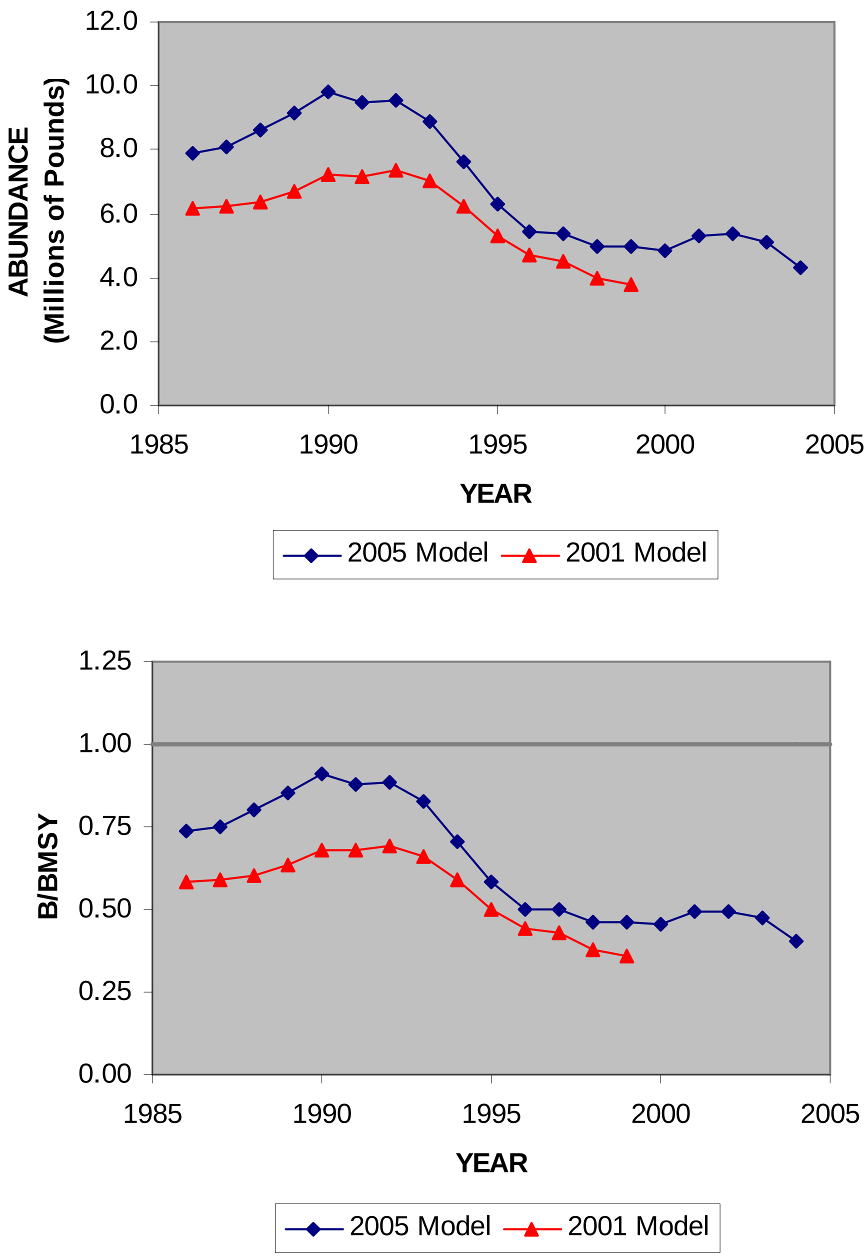
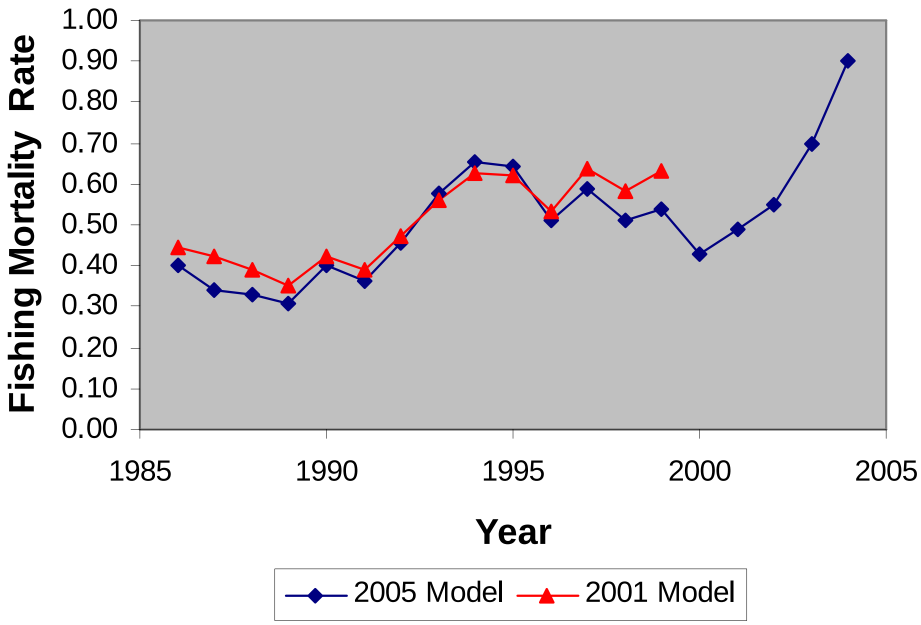


Figure 3.1.2.3.1. Comparison of the population biomass trajectories for the continuity case (2005) and the 2001 assessment base run.



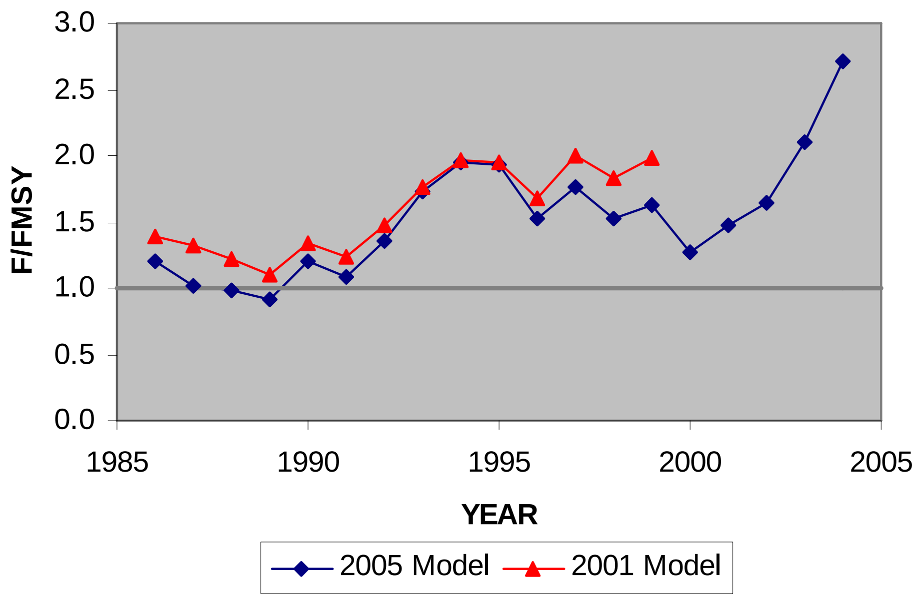


Figure 3.1.2.4.1. Comparison of the trend in fishing mortality rates for the continuity case (2005) and the 2001 assessment base run.

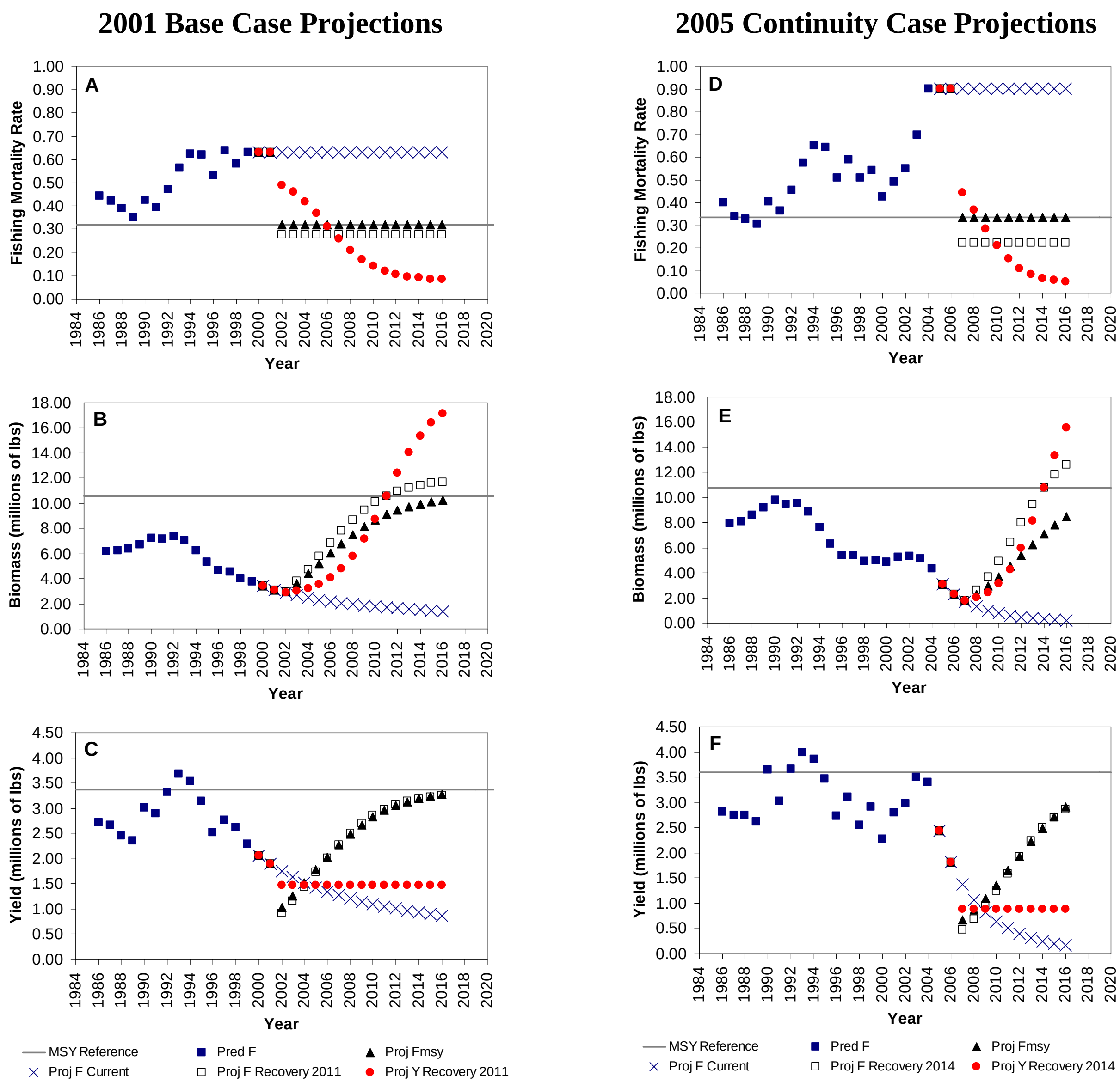


Figure 3.1.2.8.1. Projected fishing mortality, yield, and biomass trajectories for the four projection scenarios. Panels A-C are the 2001 base model projections. Panels D-F are the 2005 continuity case projections. Symbol Key: estimated value= blue square; current F projection = blue X; F_{MSY} projection = black triangle; F-recovery projection = open square; Yield-recovery projection = red circle.

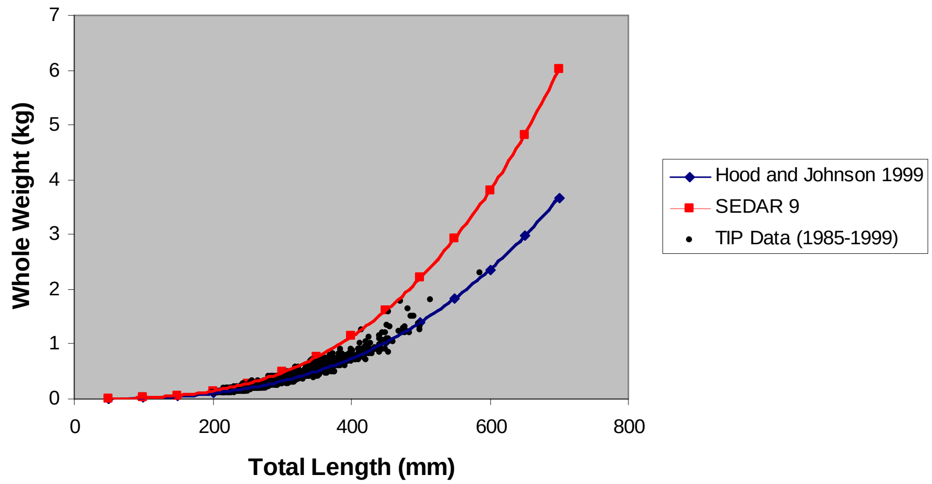


Figure 3.2.1.2.1. Comparison of length-weight relationships.

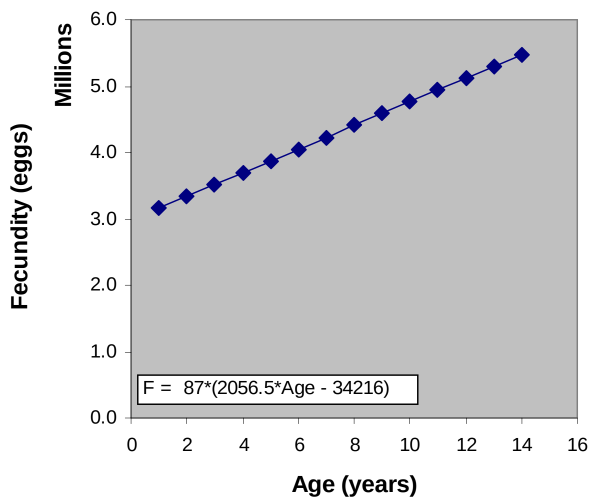


Figure 3.2.1.2.2. Annual fecundity at age.

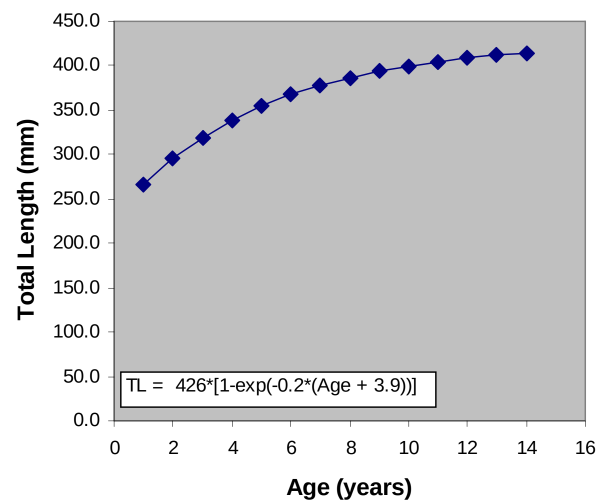


Figure 3.2.1.2.3 Length at age relationship.

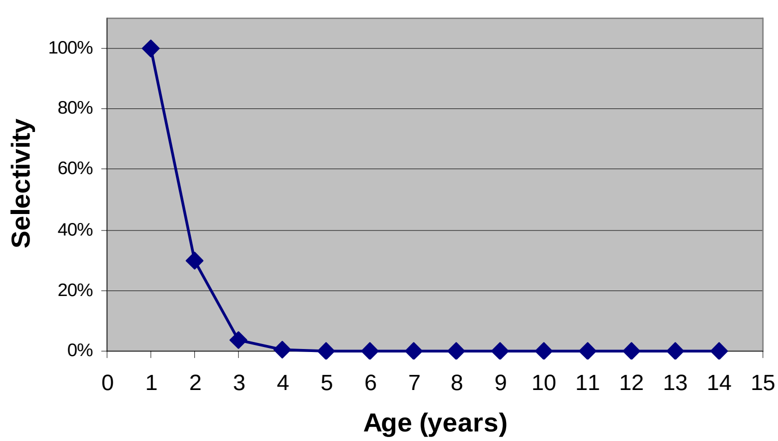


Figure 3.2.1.2.4. Fixed selectivity function used for shrimp bycatch fleet.

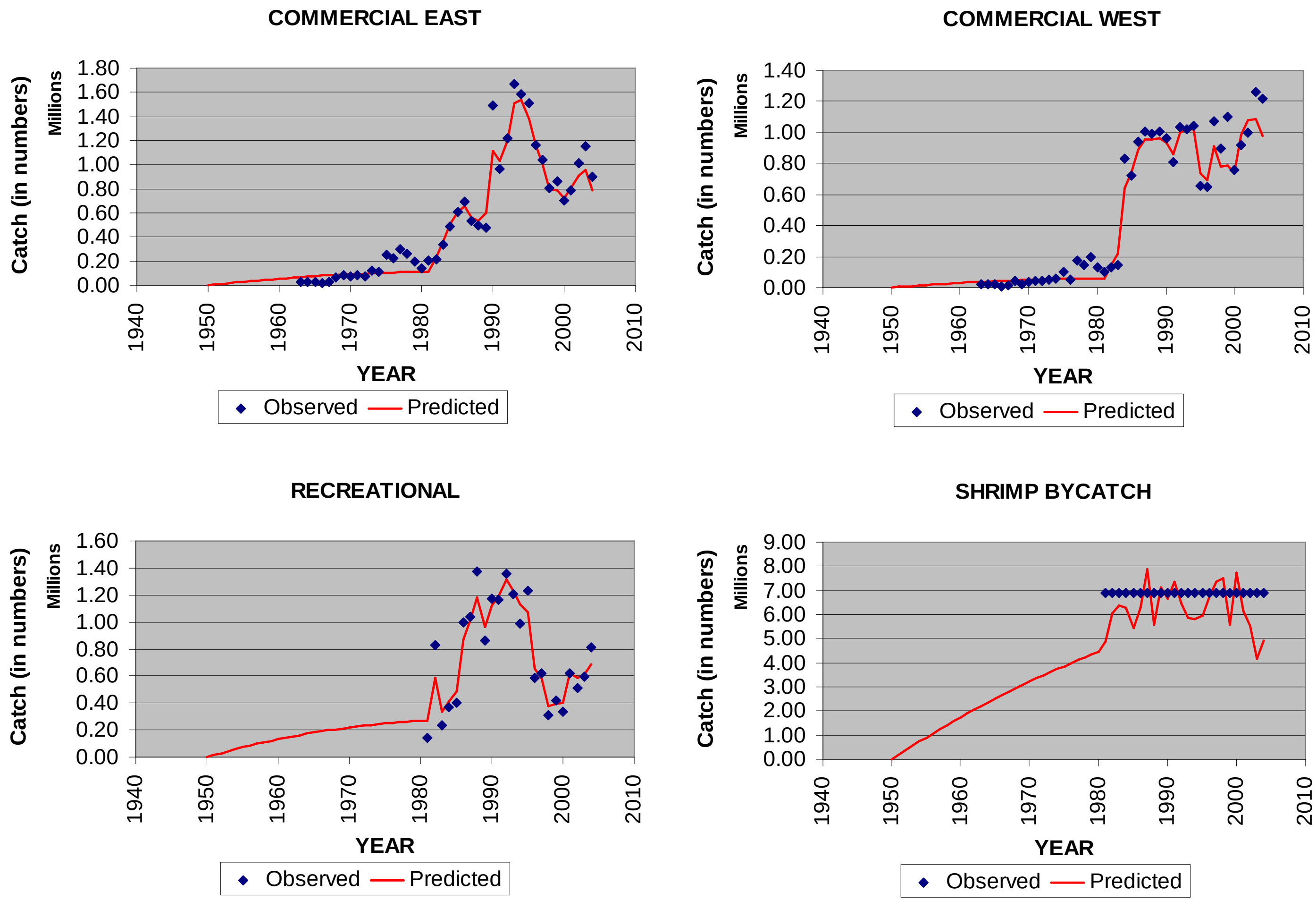


Figure 3.2.2.1.1 Model fits to the catch series for the SSASPM base model.

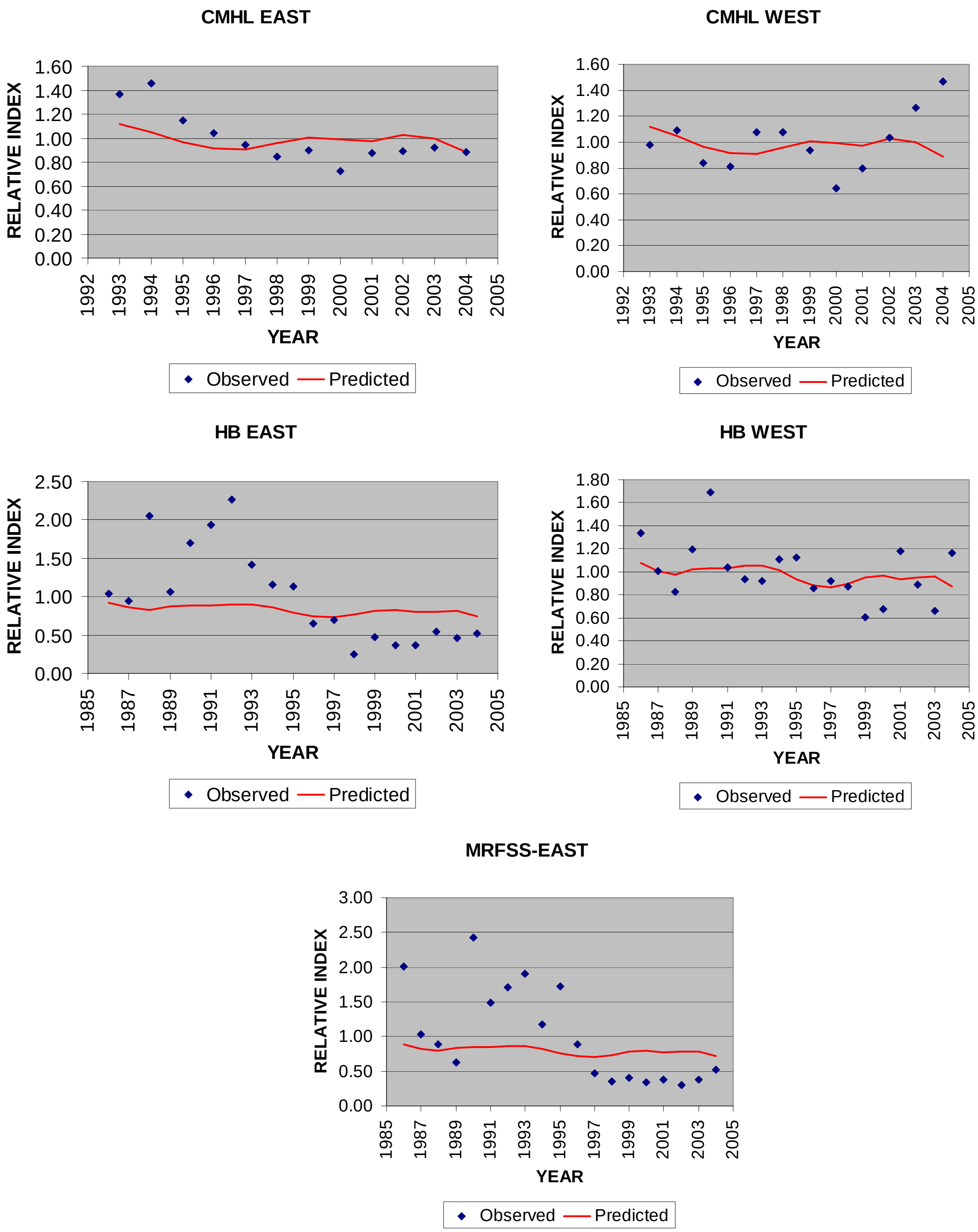


Figure 3.2.2.1.2 Model fits to the indices of abundance for the SSASPM base model.

AGE COMPOSTION COMMERCIAL EAST FISHERY

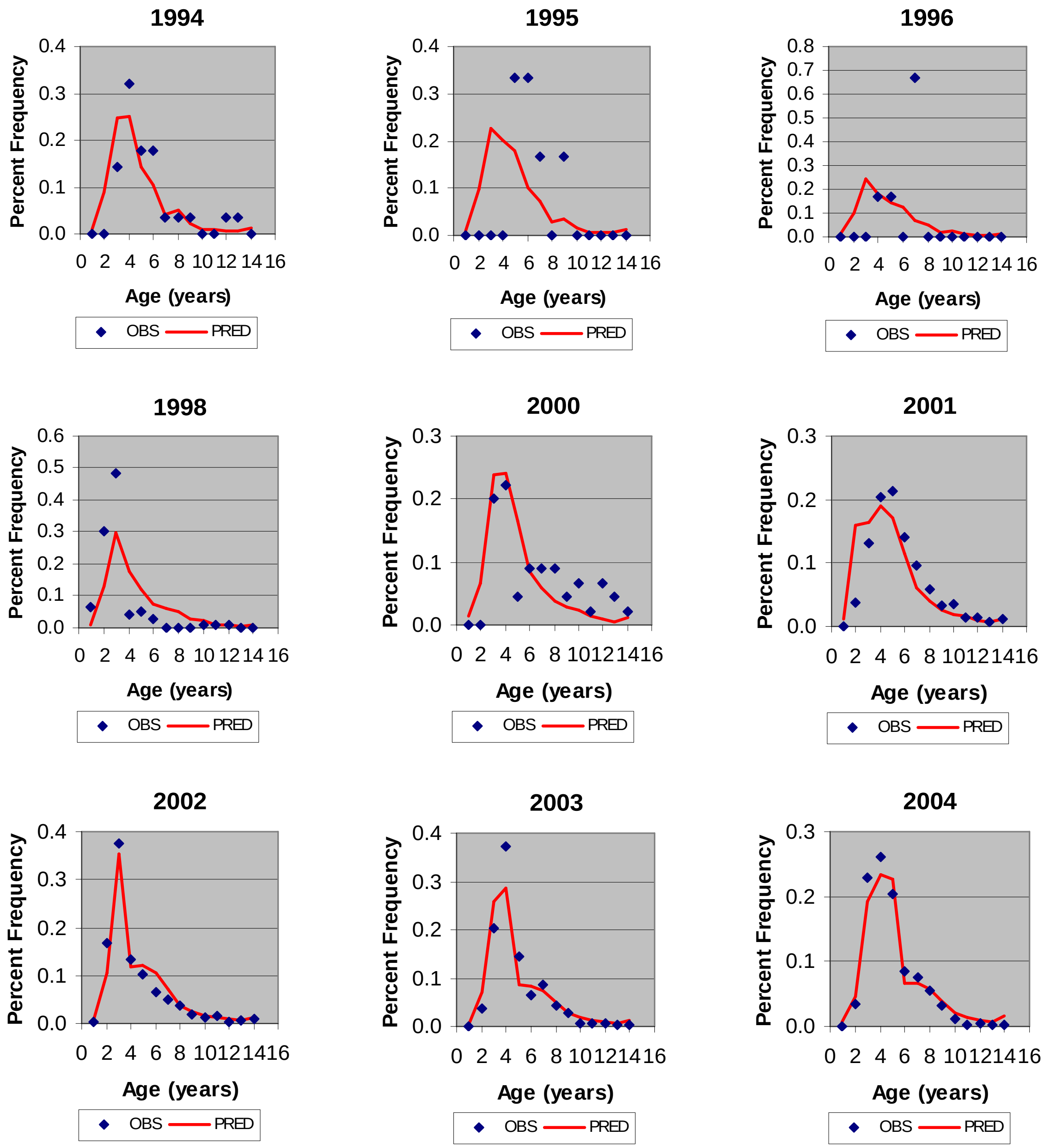


Figure 3.2.2.1.3 SSASPM base model fits to the age composition of the eastern commercial fishery.

AGE COMPOSTION COMMERCIAL WEST FISHERY

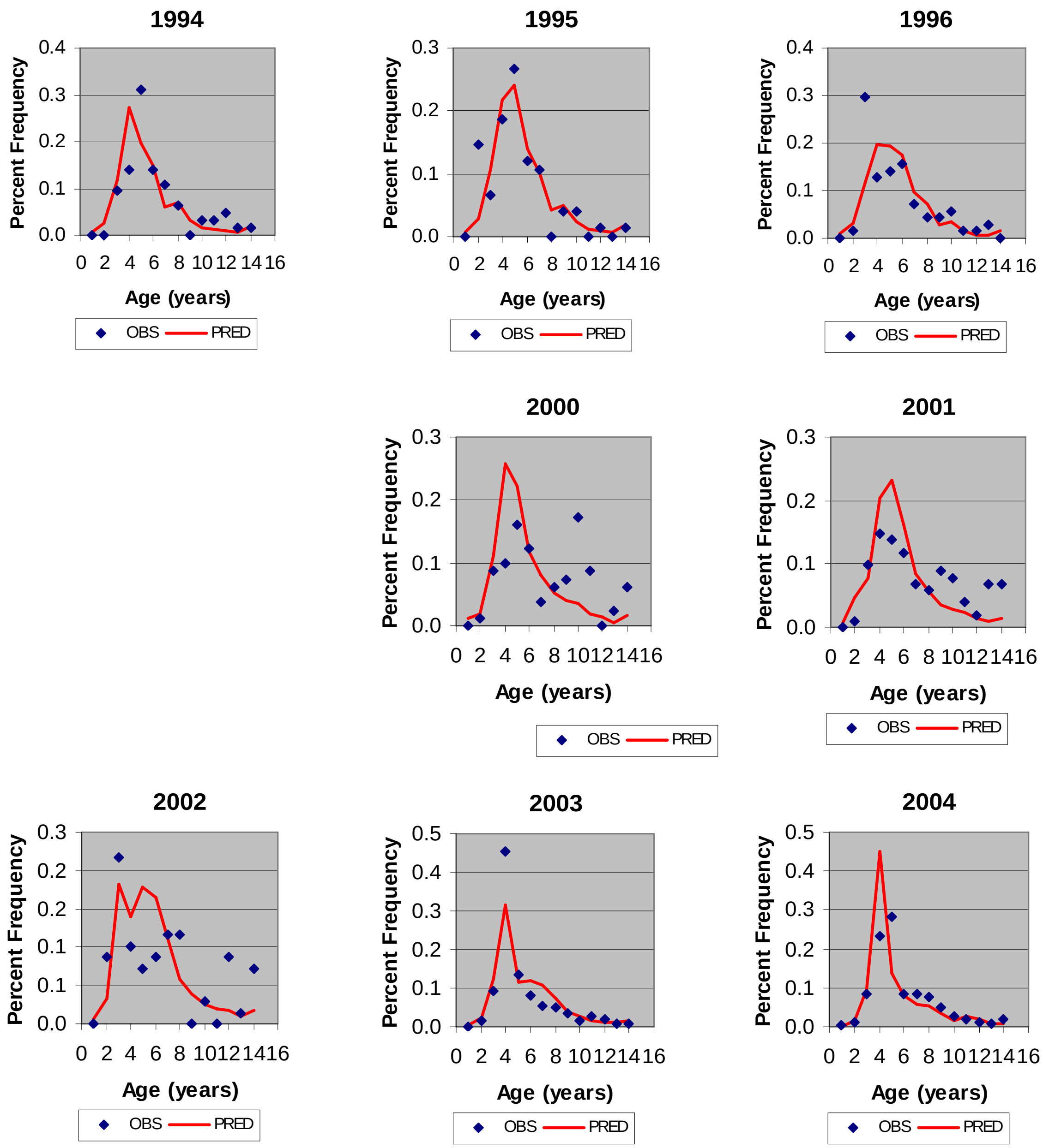


Figure 3.2.2.1.4 SSASPM base model fits to the age composition of the western commercial fishery.

AGE COMPOSTION RECREATIONAL FISHERY

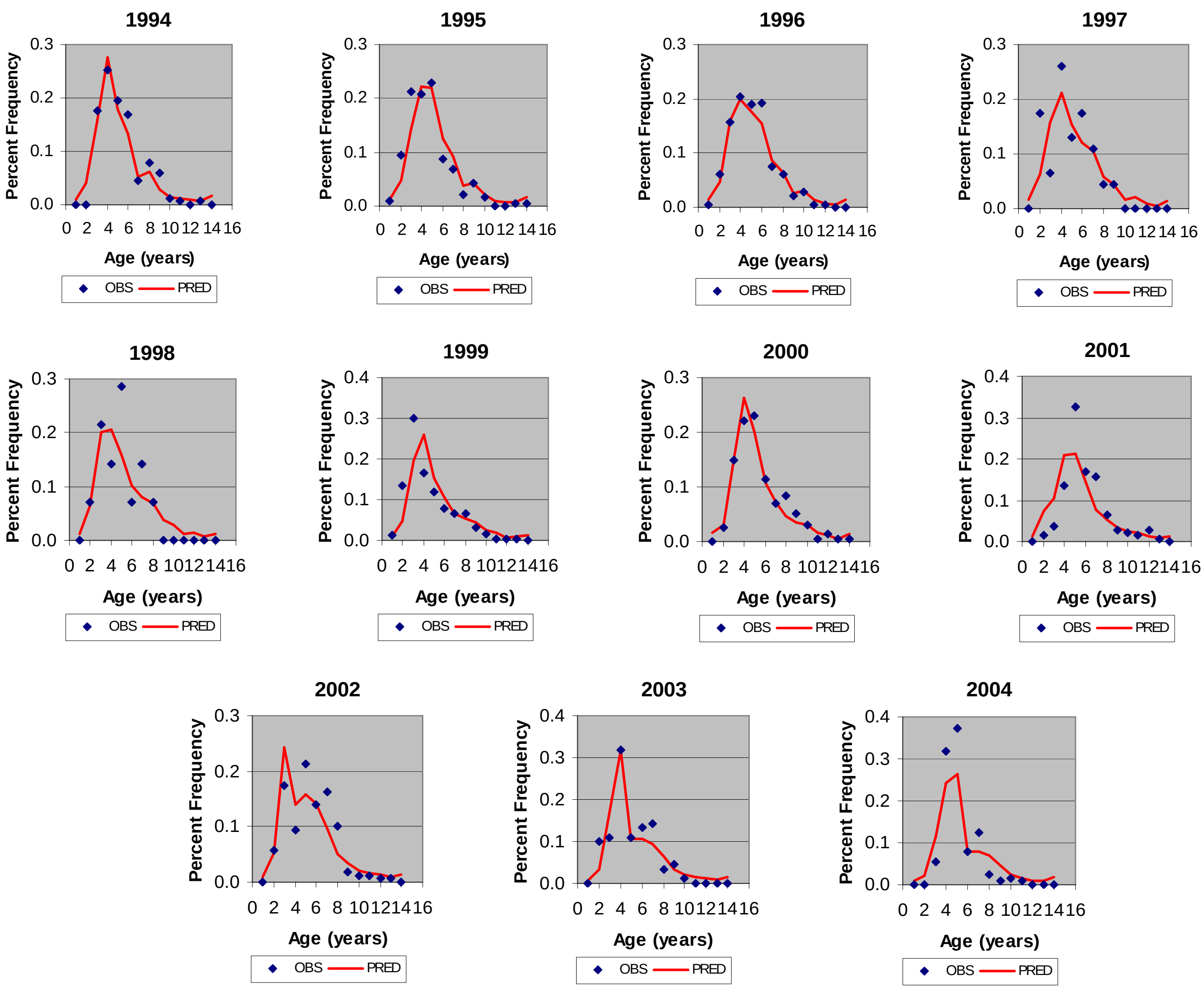


Figure 3.2.2.1.5 SSASPM base model fits to the age composition of the recreational fishery.

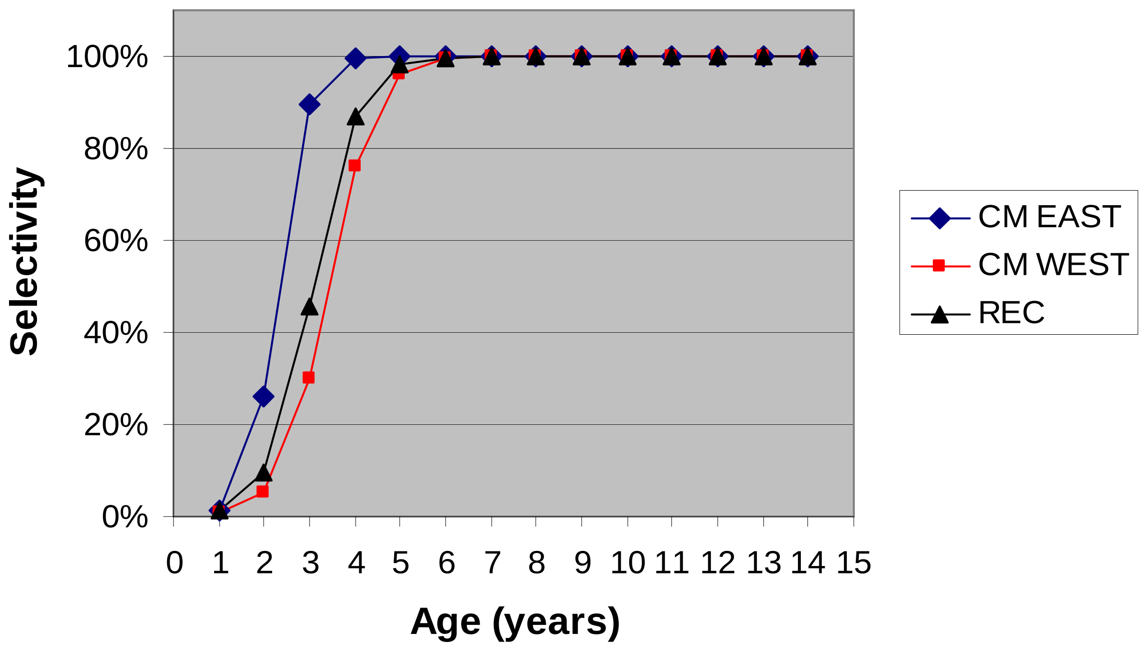


Figure 3.2.2.2.1. Estimated selectivity functions for the directed fisheries.

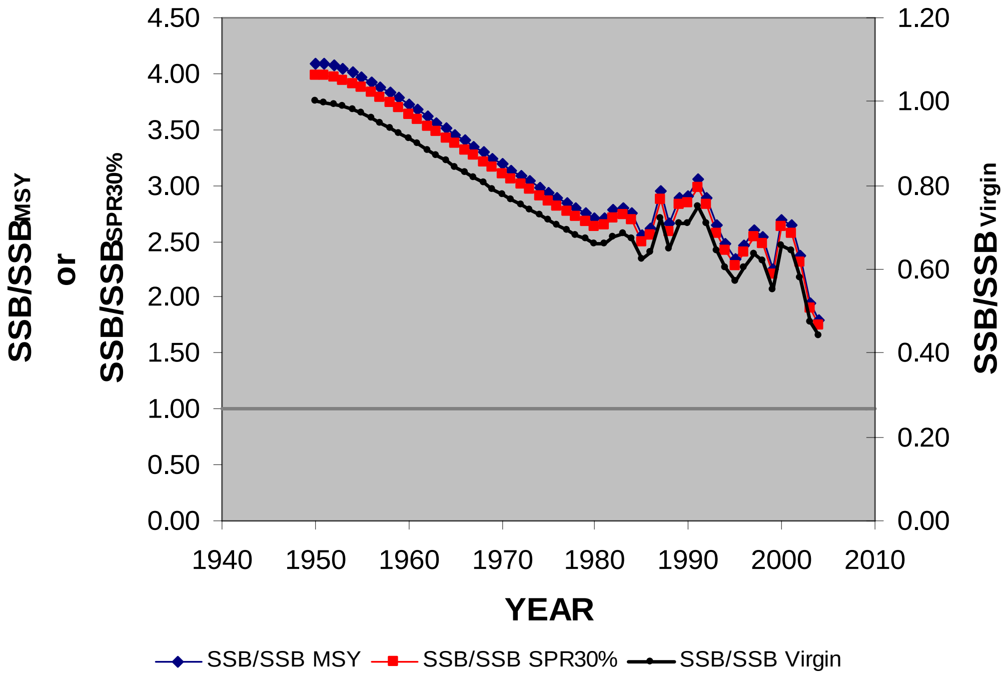


Figure 3.2.2.3.1. Spawning stock biomass (SSB) relative to SSB at MSY, SPR30% and virgin condition.

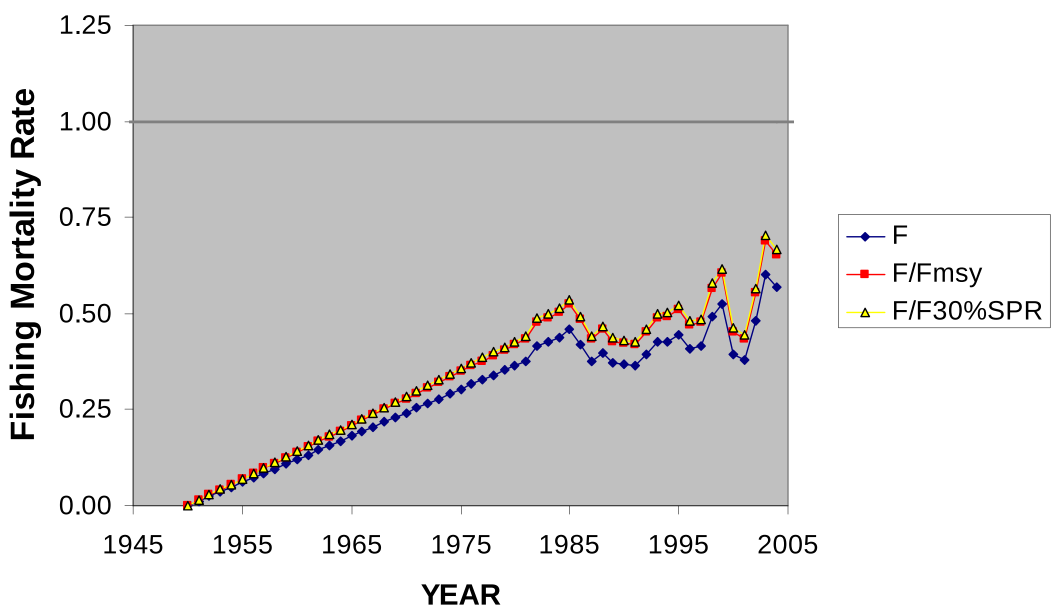


Figure 3.2.2.4.1. Fishing mortality rate (F) and F relative to F_{MSY} and $F_{SPR30\%}$..

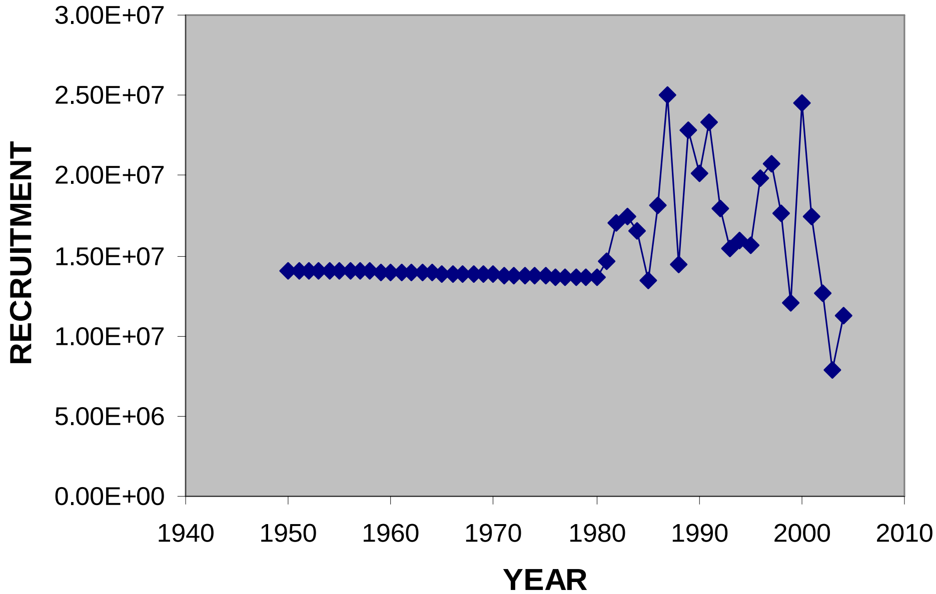


Figure 3.2.2.5.1. Annual recruitment (Age 1) estimates.

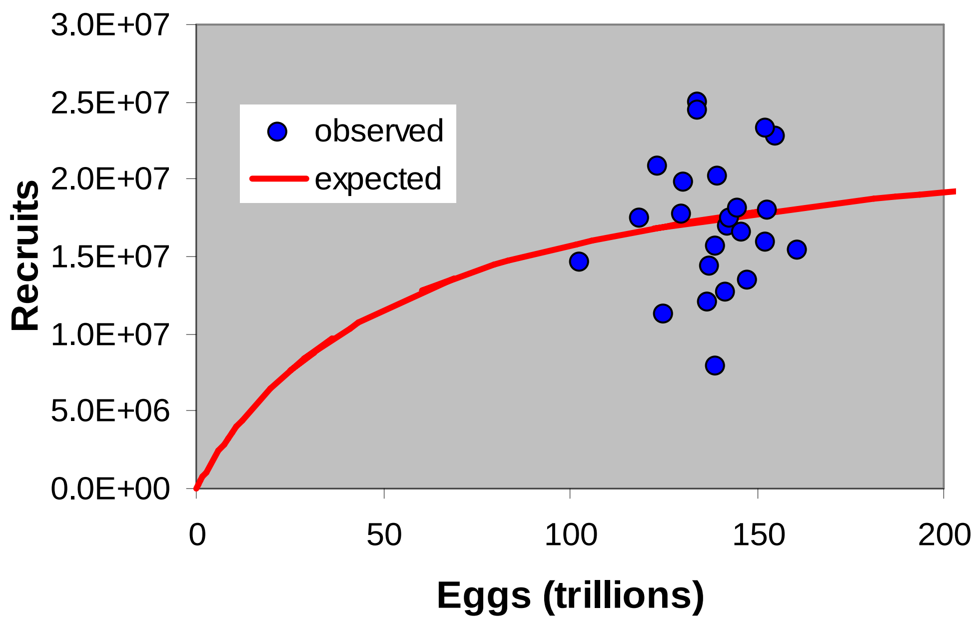


Figure 3.2.2.5.2. Spawner-Recruit relationship.

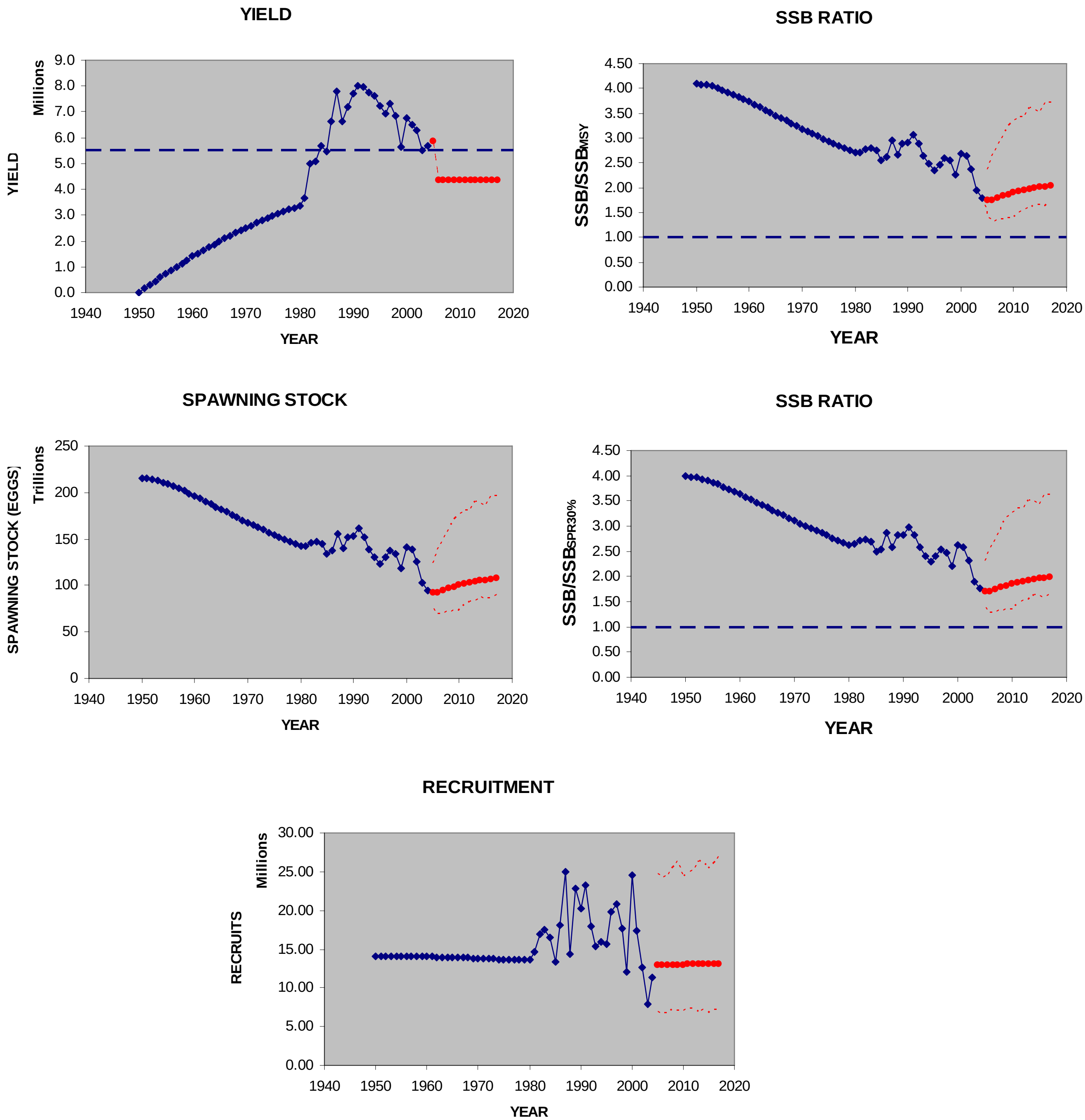


Figure 3.2.2.9.1.1. Results of the “Current Yield” projection of the SSASPM base model.

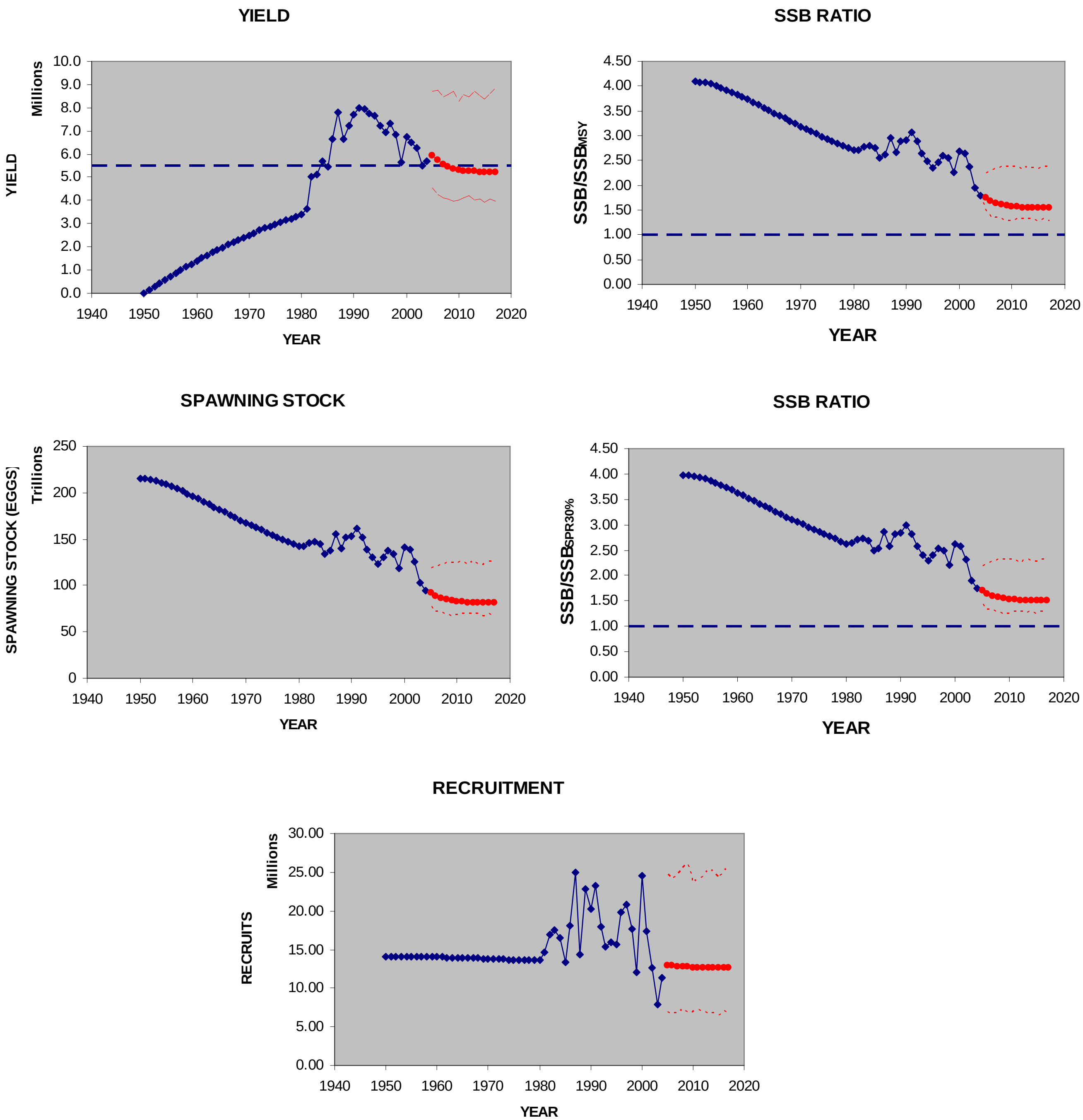


Figure 3.2.2.9.1.2. Results of the “Current F” projection of the SSASPM base model.

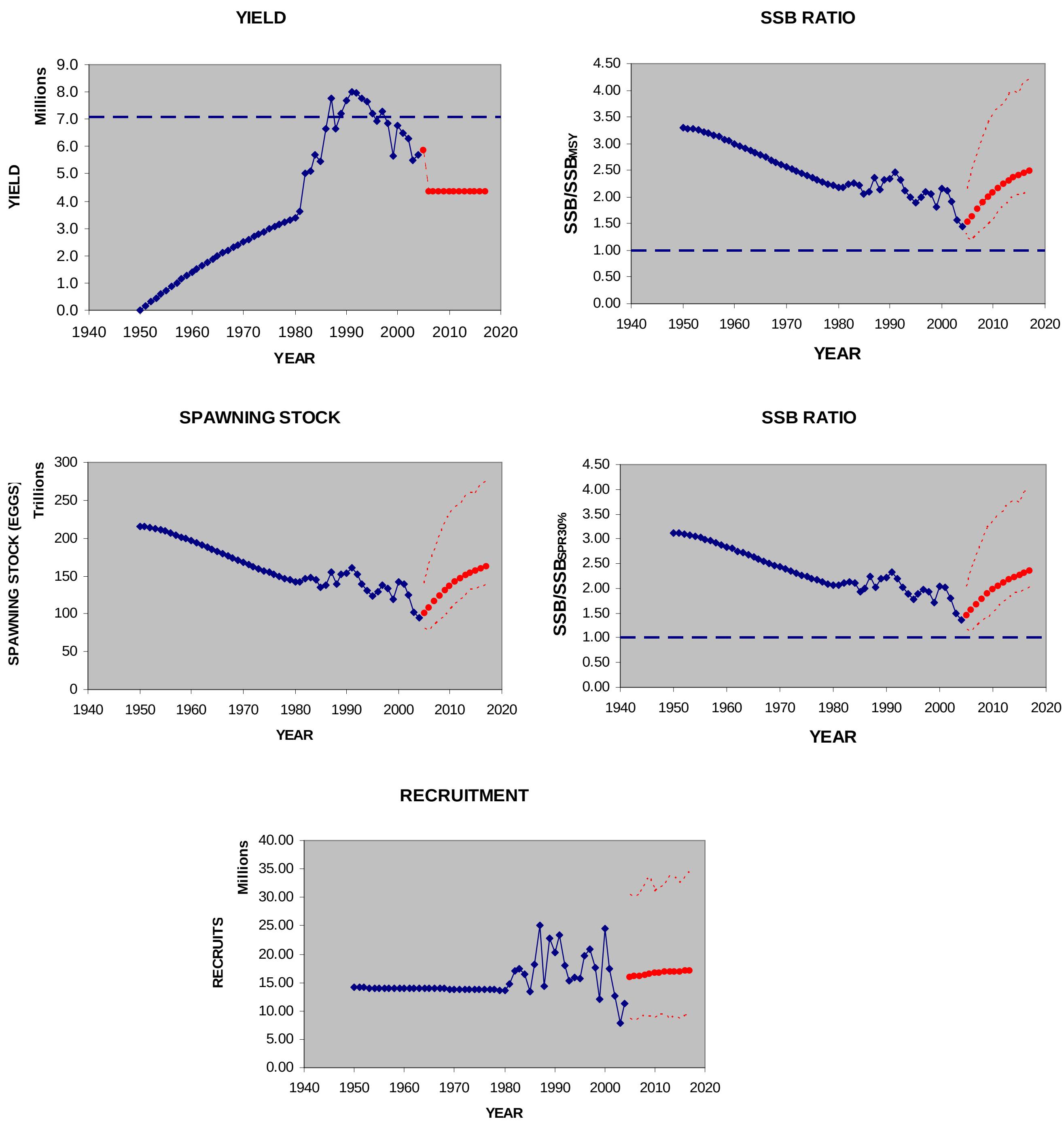


Figure 3.2.2.9.2.1 Results of the "Current Yield" projection of the SSASPM sensitivity case. This projection uses recruitment parameters estimating using only recent data (1986-2004).

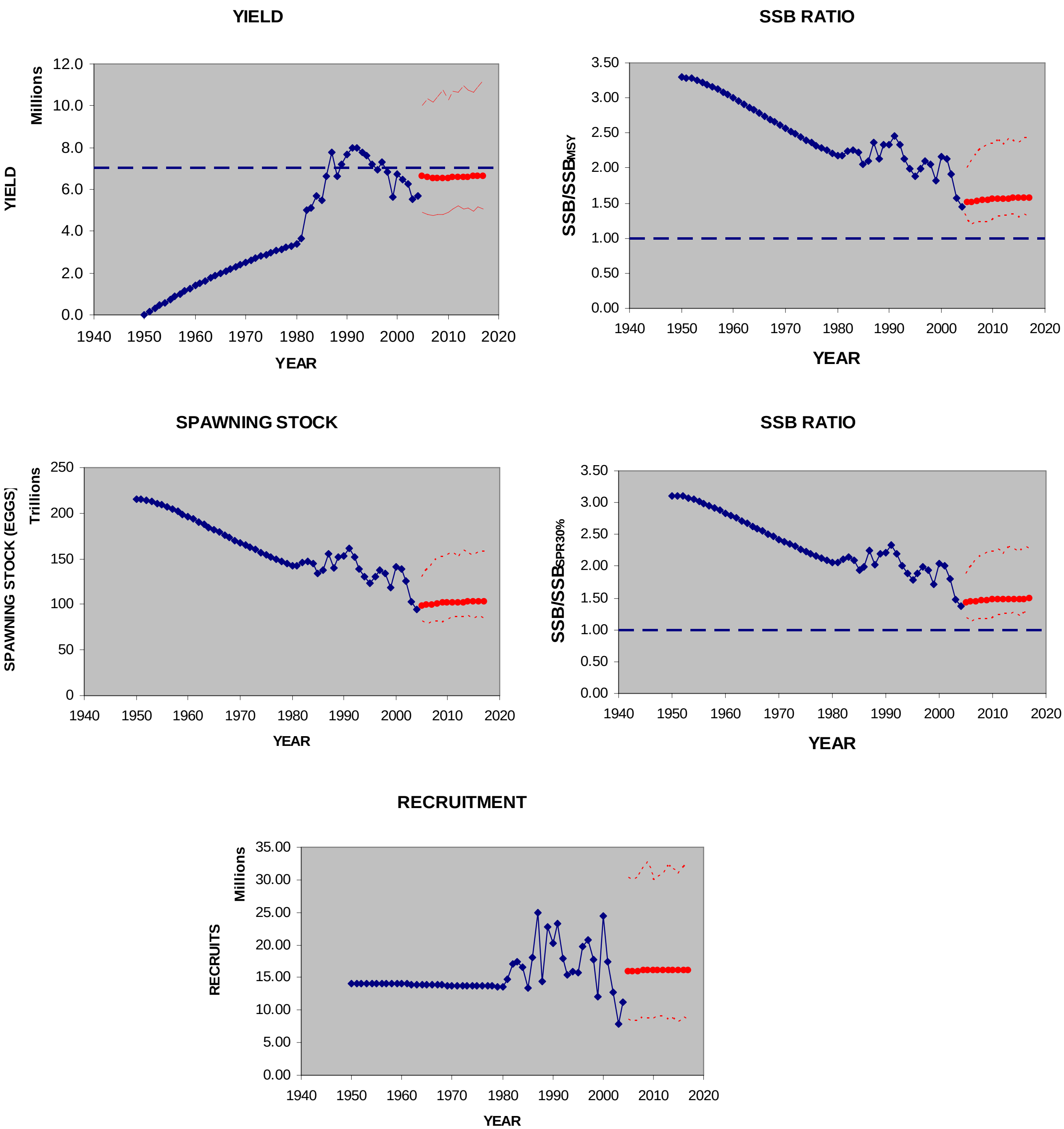


Figure 3.2.2.9.2.2 Results of the “Current F” projection of the SSASPM sensitivity case. This projection uses recruitment parameters estimating using only recent data (1986-2004).

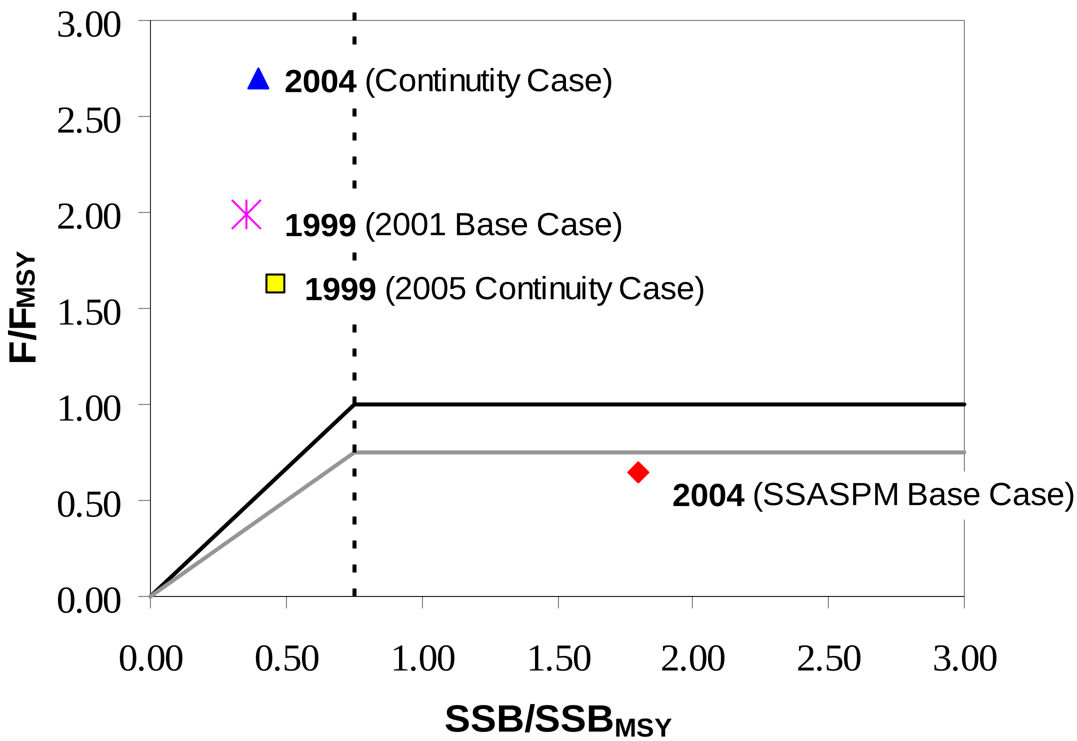


Figure 4.6.1 Comparison of P-T production and SSASPM model results.

SEDAR

SouthEast Data, Assessment, and Review

SEDAR 9
Stock Assessment Report 3

Gulf of Mexico Vermilion Snapper

SECTION 4. Review Workshop

Section 4 Contents

Consensus Summary Report

Gulf of Mexico Vermilion Snapper (*Rhomboplites aurorubens*)

Prepared by the SEDAR 9 Review Panel

Edited by M. Elizabeth Clarke for
SEDAR 9, March 27- 31, 2006
New Orleans, Louisiana

Executive summary

The SEDAR 9 Review Workshop met in New Orleans, LA from March 27 to 31, 2006 to review the stock assessment of Vermilion snapper in the Gulf of Mexico. The first day consisted primarily of presentations by the Assessment Team covering the Data Workshop, the two Assessment Workshop, and their preferred base case assessment. During the second and third days, the workshop reviewed the assessment by addressing the terms of reference for the Review Workshop, including the consideration of additional model runs. On the final day, preliminary drafts of the Consensus Summary Report and the Advisory Report were reviewed.

The SEDAR for vermilion snapper has extended over more than 12 months and was interrupted by Hurricane Katrina in New Orleans. During this time the Assessment Team and other Data Workshop and Assessment Workshop participants have worked towards producing a credible and reliable stock assessment. The previous stock was conducted in 2001 and a Pella-Tomlinson Production model was used.

The preferred model initially presented to the panel were State-Space Age-Structured Production Model (SSASPM). The panel agreed that the State-Space Age-Structured Production Model (SSASPM) was the most appropriate method for the base case model. The panel did recommend some changes to the base model. The assessment using the suggested base case model is documented in an Addendum to the Stock Assessment document. The final assessment using this method indicates that the stock is neither overfished nor undergoing overfishing. However, the stock is overexploited with respect to the optimum fishing mortality. Furthermore, a substantial but unmeasured mortality is exerted as a bycatch in the shrimp fishery, which is substantially reducing the yield in the directed fisheries.

The Review Panel was impressed by the quantity of the work that had gone into the assessment. Several changes to the base case assessment were requested during the Review Workshop. The final base case model will be documented in a final stock assessment report produced by the assessment author.

The panel felt that overall the assessment is adequate to provide management advice. However, the data used had serious weaknesses but were adequate given several caveats, including that management agencies are clear that there is high uncertainty attached to this assessment. The assessment methods provided adequately reliable estimate of the state of the stock with respect to benchmarks used currently for fisheries management in the Gulf of Mexico. However, the methods are not adequate for forecasting the effects of management measures that involve changing selection patterns, such as changes to minimum landing sizes. The assessment methods are considered to be appropriate for analyzing the available data and the methods are appropriate for management over medium-term timescales, but the benchmarks should be updated periodically. In addition the methods used to characterize the uncertainty were appropriate. Many of the judgments on the methods used were made primarily on theoretical grounds since the performance of the model could not be assessed during the workshop.

1. Introduction

1.1 Time and Place

The SEDAR 9 Review Workshop met in New Orleans, Louisiana, from 27 to 31 March 2006.

1.2 Terms of Reference for the Review Workshop

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.

2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stocks.

3. Recommend appropriate estimates of stock abundance, biomass, and exploitation*.

4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status*.

5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition* (e.g., exploitation, abundance, biomass).

6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters*. Ensure the implications of uncertainty in technical conclusions are clearly stated.

7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations. (In the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above, ensure that corrected estimates are provided by addenda to the assessment report)

8. Evaluate the performance of the Data and Assessment Workshops with regard to their respective Terms of Reference; state whether or not the Terms of Reference for those previous workshops were met and are adequately addressed in the Stock Assessment Report.

9. Review research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments.

10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Prepare an Advisory Report summarizing key assessment results. (Reports to be drafted by the Panel during the review workshop with a final report due two weeks after the workshop ends.)

1.3 List of Participants

- Participants Affiliation

Panel Chair:

M. Elizabeth Clarke	NOAA Fisheries/NWFSC

Review Panel:

Haddon, Malcolm	CIE Reviewer
Patterson, Kenneth	CIE Reviewer
Chen, Din	CIE Reviewer

Presenters:

Craig Brown	NMFS/SEFSC Miami
Shannon Cass-Calay	NMFS/SEFSC Miami
Guillermo Diaz	NMFS/SEFSC Miami
Josh Sladek-Nowlis	NMFS/SEFSC Miami
Steve Turner	NMFS/SEFSC Miami
Jerry Scott `	SEFSC

Observers:

Chris Dorsett	The Ocean Conservancy/GMFMC AP
Myron Fischer	GMFMC
Mike Nugent	GMFMC AP
Andy Strelcheck	NMFS/SERO
Wayne Werner	GMFMC AP
Joseph Powers	NMFS/SEFSC Miami

Staff support:

John Carmichael	SEDAR
Dawn Aring	GMFMC Staff
Patrick Gilles	NMFS/SEFSC Miami
Stu Kennedy	GMFMC Staff
Joseph Powers	NMFS/SEFSC Miami
Jerry Scott `	SEFSC

1.4 Review Workshop Documents

The following documents were available to the Review Panel during SEDAR 9.

Document #	Title	Authors
Documents Prepared for the Data Workshop		

SEDAR9-DW1	History of vermillion snapper, greater amberjack, and gray triggerfish management in Federal waters of the US Gulf of Mexico, 1984-2005	Hood, P.
SEDAR9-DW2	Vermillion Snapper Otolith Aging: 2001-2004 Data Summary	Allman, R J., J. A. Tunnell. B. K. Barnett
SEDAR9-DW3	Reproduction of vermillion snapper from the Northern and Eastern Gulf of Mexico, 1991-2002.	Collins, L. A., R. J. Allman, and H. M Lyon
SEDAR9-DW4	Standardized catch rate indices for vermilion snapper landed by the US recreational fishery in the Gulf of Mexico, 1986-2004	Cass-Calay, S. L.
SEDAR9-DW5	Standardized catch rate indices for vermilion snapper landed by the US commercial handline fishery in the Gulf of Mexico, 1990-2004	McCarthy, Kevin J., and Shannon L. Cass-Calay
SEDAR9-DW6	Standardized catch rates of vermilion snapper from the US headboat fishery in the Gulf of Mexico, 1986-2004	Brown, Craig A.
SEDAR9-DW7	Estimated Gulf of Mexico greater amberjack recreational landings (MRFSS, Headboat, TXPW) for 1981-2004	Diaz, Guillermo
SEDAR9-DW8	Size frequency distribution of greater amberjack from dockside sampling of recreational landings in the Gulf of Mexico 1986-2003	Diaz, Guillermo
SEDAR9-DW9	Size frequency distribution of greater amberjack from dockside sampling of commercial landings in the Gulf of Mexico 1986-2003	Diaz, Guillermo
SEDAR9-DW10	Standardized catch rates of gulf of Mexico greater amberjack for the commercial longline and handline fishery 1990-2004	Diaz, Guillermo
SEDAR9-DW11	Length Frequency Analysis and Calculated Catch at Age Estimations for Commercially Landed Gray Triggerfish (*Balistes capriscus*) From the Gulf of Mexico	Saul, Steven
SEDAR9-DW12	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Gulf of Mexico Headboat Fishery	Saul, Steven
SEDAR9-DW13	Estimated Gray Triggerfish (*Balistes capriscus*) Commercial Landings and Price Information for the Gulf of Mexico Fishery	Saul, Steven
SEDAR9-DW14	Estimated Gray Triggerfish (*Balistes capriscus*) Recreational Landings for the State of Texas	Saul, Steven
SEDAR9-DW15	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Marine Recreational Fishery Statistics Survey	Saul, Steven, and Patty Phares

	(MRFSS) In the Gulf of Mexico	
SEDAR9-DW16	Length Frequency Analysis for the Gray Triggerfish (*Balistes capriscus*) Recreational Fishery In the Gulf of Mexico	Saul, Steven
SEDAR9-DW17	Estimates of Vermilion Snapper, Greater Amberjack, and Gray Triggerfish Discards by Vessels with Federal Permits in the Gulf of Mexico	McCarthy, Kevin J.
SEDAR9-DW18	Size Composition Data from the SEAMAP Trawl Surveys	Nichols, Scott
SEDAR9-DW19	Species Composition of the various amberjack species in the Gulf of Mexico	Chih, Ching-Ping
SEDAR9-DW20	Standardized Catch rates of Gulf of Mexico greater amberjack catch rates for the recreational fishery (MRFSS, Headboat) 1981-2004	Diaz, Guillermo
SEDAR9-DW21	SEAMAP Reef Fish Survey of Offshore Banks: Yearly indices of Abundance for Vermilion Snapper, Greater Amberjack, and Gray Triggerfish	Gledhill, et. al.
SEDAR9-DW22	Data Summary of Gray Triggerfish (*Balistes capriscus),*Vermilion Snapper (*Rhomboplites aurorubens)*, and Greater Amberjack (*Seriola dumerili)* Collected During Small Pelagic Trawl Surveys, 1988 – 1996	Ingram, Jr., G. Walter
SEDAR9-DW23	Abundance Indices of Gray Triggerfish and Vermilion Snapper Collected in Summer and Fall SEAMAP Groundfish Surveys (1987 – 2004)	Ingram, Jr., G. Walter
SEDAR9-DW24	Review of the Early Life History of Vermilion Snapper, *Rhomboplites auroubens,* With a Summary of Data from SEAMAP plankton surveys in the Gulf of Mexico: 1982 – 2002	Lyczkowski-Shultz, J. and Hanisko, D.
SEDAR9-DW25	Review of the early life history of gray triggerfish, *Balistes capriscus,* with a summary of data from SEAMAP plankton surveys in the Gulf of Mexico: 1982, 1984 – 2002	Lyczkowski-Shultz, J., Hanisko, D. and Zapfe, G.
SEDAR9-DW26	Shrimp Fleet Bycatch Estimates for the SEDAR9 Species	Nichols, Scott
SEDAR9-DW27	SEAMAP Trawl Indexes for the SEDAR9 Species	Nichols, Scott
SEDAR9-DW-28	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured by the Marine Recreational Fisheries Statistics Survey (MRFSS)	Nowlis, Josh Sladek
SEDAR9-DW-29	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)*	Nowlis, Josh Sladek

	based on catch rates as measured by the NMFS Southeast Zone Headboat Survey	
SEDAR9-DW-30	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured from commercial logbook entries with handline gear	Nowlis, Josh Sladek
SEDAR9-DW-31	Estimated Gulf of Mexico vermillion snapper recreational landings (MRFSS, headboat, TPWD) for 1981-2004	Cass-Calay, Shannon, & Guillermo Diaz
Documents Prepared for the Assessment Workshop		
SEDAR9-AW1	Incorporating age information into SEAMAP trawl indices for SEDAR9 species	Nicholls, S.
SEDAR9-AW2	Separating Vermilion Snapper Trawl Indexes into East and West Components	Nicholls, S
SEDAR9-AW3	Modeling Shrimp Fleet Bycatch for the SEDAR9 Assessments	Nicholls, S
SEDAR9-AW4	Status of the Vermilion Snapper (*Rhomboplites Aurorubens)* Fisheries of the Gulf of Mexico	Cass-Calay, S.
SEDAR9-AW5	Gulf of Mexico Greater Amberjack Stock Assessment	Diaz, Guillermo A., and Elizabeth Brooks
SEDAR9-AW6	A Categorical Approach to Modeling Catch at Age for Various Sectors of the Gray Triggerfish (*Balistes Capriscus)* Fishery in the Gulf of Mexico	Saul, Steven and G. Walter Ingram, Jr.
SEDAR9-AW7	Updated Fishery-Dependent Indices of Abundance for Gulf of Mexico Gray Triggerfish (*Balistes Capriscus)*	Nowlis, Joshua Sladek
SEDAR9-AW8	An Aggregated Production Model for the Gulf of Mexico Gray Triggerfish (Balistes Capriscus) Stock	Nowlis, Joshua Sladek and Steven Saul
SEDAR9-AW9	Age-Based Analyses of the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock	Nowlis, J. S.
SEDAR9-AW10	Gulf of Mexico greater amberjack virtual population analysis assessment	Brown, C. A.,C. E. Porch, and G. P. Scott
SEDAR9-AW11	Rebuilding Projections for the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock.	Nowlis, J. S.
Documents Provided for the Review Workshop		
SEDAR9-RW01	Performance of production models on simulated data. (Presentation for NMFS National SAW 8, 2006)	Brooks, E. N. et al
Reference Documents Provided at Workshops		
SEDAR9-RD01	Stock structure of gray triggerfish on multiple spatial scales in the Gulf of Mexico.	Ingram, W.G.

Univ. South AL. PhD Thesis		
SEDAR9 RD02 2002. Proc. 53rd GCFI	Indirect estimation of red snapper and gray triggerfish release mortality	Patterson, W. F. et al.
SEDAR9-RD03 1997 Proc. 49th GCFI	Preliminary Analysis of Tag and Recapture Data of the Greater Amberjack, *Seriola dumerili,* in the Southeastern United States	McClellan, D. and Cummings, N.
SEDAR9 RD04 SEFSC Doc. No. SFD-99/00-99	Trends in Gulf of Mexico Greater Amberjack Fishery through 1998: Commercial landings, Recreational Catches, Observed length Frequencies, Estimates of Landed and Discarded Catch at Age, and Selectivity at Age.	Cummings, N. J., and D. B McClellan
SEDAR9-RD05 Fish. Res. 70 (2004) 299-310	A multispecies approach to subsetting logbook data for purposes of estimating CPUE	Stephens, A. and A. MacCall.
S9-RD06 SFD 99/00-100	Stock assessments of Gulf of Mexico greater amberjack using data through 1998.	Turner, S. C, N.J. Cummings, and C. E. Porch
S9-RD07 SFD 99/00-92	Catch rates of greater amberjack caught in the handline fishery in the Gulf of Mexico in 1990-1998	Turner, S. C.
S9-RD08 SFD 99/00-107	Catch rates of greater amberjack caught in the headboat fishery in the Gulf of Mexico, 1986-1998.	Turner, S. C.
S9-RD09 SFD 01/02-150	Projections of Gulf of Mexico greater amberjack from 2003-2012	Tuner, S. C. and G. P. Scott
S9-RD10 SFD 99/00-98	Gulf of Mexico greater amberjack abundance from recreational charter and private boat anglers from 1981-1998.	Cummings, N. J.
S9-RD11 SFD00/01-124	A stock assessment for gray triggerfish in the Gulf of Mexico.	Valle, M, C. Legault, and M. Ortiz.
S9-RD12 SFD00/01-126	Another assessment of gray triggerfish in the Gulf of Mexico using a space-state implementation of the Pella-Tomlinson production Model	Porch, C. E.
S9-RD13 SFD01/02-129	Status of the vermilion snapper fishery in the Gulf of Mexico. Assessment 5.0	Porch, C. E. and S. Cass-Calay.
S9-RD14 Panama City 01-1	Report of vermilion snapper otolith aging; 1994-2000 data summary	Allman, R. J., G. R. Fitzhugh, and W. A. Fable
S9-RD15 FWRI IHR2005-3	Genetic stock structure of vermilion snapper in the Gulf of Mexico and southeastern United States	Tringali, M. D. and M. Higham

S9-RD16 SCDNR	Age, growth, and reproduction of greater amberjack in the Southwestern North Atlantic. December 2004 Analytical Report	Harris, P. J.
S9-RD17	Preliminary Assessment of Atlantic white marlin using a state-space implementation of an age-structured production model	Porch, C. E.
S9-RD18	VPA-2BOX Program Documentation, Version 2.01. 2003. ICCAT Assessment Program Documentation.	Porch, C. E.
S9-RD19	VPA-2BOX Program Documentation, Version 3.01. 2003. ICCAT Assessment Program Documentation.	Porch, C. E.
Final Assessment Reports		
SEDAR9-AR1	Gray Triggerfish	
SEDAR9-AR2	Greater Amberjack	
SEDAR9-AR3	Vermillion Snapper	

2. Response to Terms of Reference

2.1 Background

The panel conducted a review of the documents "Assessment of Vermilion Snapper, *Rhomboplites aurorubens*, in the Gulf of Mexico", "SEDAR 9: Stock Assessment Report 3, Gulf of Mexico Vermilion Snapper. Section 2. Data Workshop", and the series of working documents cited in those reports.

Based on this review, the panel identified a number of key concerns about the assessment and raised these during the meeting. Some of the concerns were addressed by further explanation, but others were addressed by additional calculations to identify sensitivities. After this exploration, some revisions to the assessment were agreed as being appropriate. The concerns raised, the sensitivity tests made and the conclusions drawn there from are identified in Addendum 1 to this report, which also lists the panel's internally-adopted guidelines for assessing assessments. The revised assessment arising from this review is documented in Addendum 2 to this report.

2.2 Review of the Panel's deliberations

The deliberations on each species are presented in the form of responses to the terms of reference questions specifically, followed by relevant comments on the discussions.

2.2.1. Evaluate the adequacy, appropriateness and application of the data used in the assessment.

The data contained serious weaknesses.

- Most important of these was the lack of adequate sampling of the shrimp by-catch, which is a major source of anthropogenic mortality on this stock: removals by this fishery are about 40% of the incoming recruitments. Subsidiary issues were:
  1. the high variability in the MRFSS estimates of recreational catch, which is due to low proportion of positive replies in the telephone survey component of this sampling system;
  2. the absence of reliable fishery-independent information requires the careful interpretation of fishery-dependent indices of abundance;
  3. the absence of complete catch-at-age information substantially limits the precision of the analysis and the accuracy of the forecasts.

Overall, the data are considered adequate only subject to the following:

1. forecasts of stock status and yields will depend on the shrimp fishery discards continuing at current levels - yield improvements of up to 40% in the directed fisheries may be possible if this source of mortality were removed;
2. forecasts are predicated on the assumption that selection pattern remains unchanged;
3. management agencies are aware that high uncertainty is attached to this assessment.

2.2.2. Evaluate the adequacy, appropriateness and application of methods used to assess the stocks.

The assessment methods are considered to be appropriate for analysing the available data.

The Stephens and MacCall (2004) approach to identifying appropriate sub-sets of trip data for estimating CPUE was not reviewed in detail and its performance is not known. However, the method is considered appropriate on theoretical grounds alone. In particular, the restriction of this modeling approach to separate model fits for each year is considered appropriate.

The assessment methodologies used were State-Space Age-Structured Production Models (SSASPM), and biomass-dynamic production models. These methods are appropriate in situations, as here, where age-structured information is limited or absent. In particular, the SSASPM model structure has the advantage of utilising most of the relevant available information inside a formal likelihood-based structure. It is preferable on theoretical grounds if informative age-structured data are available. However, the performance of the ASPM method in estimating management-related parameters has not been fully tested by simulation in comparable circumstances. Although the outcome of a simulation exercise was made available, the conclusions were not unambiguous.

Absolute levels of **adequacy** of the methods cannot be assessed at present. In order to assess adequacy for management purposes, performance criteria for the system of data collection, assessment and management should be established *a priori*. In addition, simulation testing of the assessment methods would have to be performed under conditions approximating those believed to pertain to vermilion snapper. Such simulations were not available to the review panel.

In the absence of a defined acceptable level of precision, it is the expert opinion of the review panel that the "preferred case model", when applied to the vermilion snapper, results in an **adequately reliable** estimate of the state of the stock with respect to benchmarks in the context of the framework of current fisheries management in the Gulf of Mexico. This assessment is robust to reasonable alternative model structures and alternative interpretations of the data.

The methods are **not adequate** for forecasting the effects of management measures that involve changing selection patterns, such as changes to minimum landing sizes. They are however adequate for exploring the information content and management implications of small and incomplete data sets such as that available for vermilion snapper. It is noted that data collection in the Gulf of Mexico fisheries is a difficult and challenging task (see Recommendations, section 2.9.)

The **application** of the methods was considered to be appropriate. Continuity runs were established in order to identify the change in perception of stock status in response to new information. Methods were chosen in order to reflect the availability of data and the way in which it was collected. However, it was clear that insufficient time and resources had been made available to consider fully the model constraints and parameterisations. In this context, further model and data explorations at the review workshop were a helpful step in the process.

The practice of testing the sensitivity of model interest parameters (e.g. current F/F msy) to the use of alternative data series, and to the fixing of structural parameters and constraints is essential in the application of stock assessment models and should be developed and continued.

Model documentation should be improved (Recommendations, section 2.9.).

2.2.3. Recommend appropriate estimates of stock abundance, biomass and exploitation

The review panel recommends the adoption of population parameter estimates as listed in Addendum 2.

2.2.4. Evaluate the methods used to estimate population benchmarks and management parameters (e.g. MSY, Fmsy, Bmsy, MSST, MFMT or their proxies); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status.

The methods are appropriate for management over medium-term timescales, but the benchmarks should be updated periodically.

The methods used are transformations of maximum-likelihood parameter estimates from the final stock assessment. For the SSASPM base model, the reference points are calculated numerically with reference to maximum of the product of the equilibrium fecundity-per-recruit and recruitment-per-fecundity functions. This provides a calculation of the following population parameters:

- the fishing mortality corresponding to maximum sustainable yield (F_{msy}) or proxy thereof;
- the biomass at which maximum sustainable yield can be taken (B_{msy});
- the maximum sustainable yield.

The methods used are considered to be appropriate. However, improved methods based on stochastic modelling of the fishery, the stock, and the sampling from the stock could be developed that would give greater insight into the dynamics of the assessment and management process if more resources were available.

Density-dependence in growth and fecundity was not modelled. As growth and fecundity are likely to change over time and when stock abundance changes, the panel recommends that the benchmarks should be updated when new life history parameters become available.

The F_{msy} parameter estimate depends on quantifying both the stock-recruit relationship and quantifying the life-history parameters. In contrast, a $F_{30\%SPR}$ proxy for F_{msy} can be calculated using life-history parameters alone. Typically, much greater uncertainty is attached to the estimation of stock-recruit parameters than to life history parameters. In order to help provide more stable management (at the possible cost of some bias) it is recommended to use a yield-per recruit criterion as the proxy for F_{msy} until stock-recruit parameters can be estimated reliably. The $F_{30\%SPR}$ is appropriate for this purpose.

Management benchmarks are therefore calculated with reference to these population parameters as follows:

MFMT, the Maximum Fishing Mortality Threshold, is set = $F_{30\%SPR}$.
MSST, the Minimum Stock Size Threshold, is set = $(1\text{-}M).SSB_{30\%SPR}$.
F_{OY}, the optimum yield is defined as $0.75.F_{30\%SPR}$.

The parameters relevant to management are estimated as follows:

Parameter	***Value***
Population parameters and management benchmarks	
$F_{20\%SPR}$	1.19
$F_{30\%SPR}$	0.79
$F_{40\%SPR}$	0.55
F_{msy}	0.81
SSB_{msy}	6.88×10^{13} eggs
MFMT	0.79
MSST (@M=0.25)	5.35×10^{13} eggs
F_{OY}	0.59

Parameter	*Value*
Stocks parameters in 2004	
F_{2004}	0.49
F_{2004}/MFMT	0.62
SSB_{2004}	1.05×10^{14} eggs
SSB_{2004}/MSST	1.95
F_{2004}/FOY	0.82

Declarations of Stock Status:

- the stock is not overfished.
- the stock is not undergoing overfishing.
- the stock is not overexploited with respect to the optimum fishing mortality.
- a substantial but unmeasured mortality is exerted as a by-catch in the shrimp fishery, which is substantially reducing the yield in the directed fisheries.

2.2.5. Evaluate the adequacy, appropriateness and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g. exploitation, abundance, biomass).

The programme to calculate projections with uncertainty estimates is "VPA2box". The methods implemented and the performance of this method were not assessed at the meeting. Revised estimates of future population status are to be provided in Addendum 2.

2.2.6. Evaluate the adequacy, appropriateness and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure the implications of uncertainty in technical conclusions are clearly stated.

The primary tool for evaluating uncertainty is the calculation of sensitivity analyses, by investigating the robustness of interest parameter estimates to alternative choices about data usage, to specification of structural parameters. Numerous trial runs are calculated in order to identify key sensitivities and develop appropriate relevant treatments. This is considered highly **appropriate**. However, improved documentation of these trials at an earlier stage in the process would be helpful.

Model-conditioned estimates of the standard errors in the most important parameter estimates were calculated. The method is based on using automatically-calculated derivatives of the interest parameter with respect to the inverse hessian matrix of the likelihood at the solution (the method is specific to the software used, "AD model builder"). Improvement in the documentation of the method would be welcomed (see recommendation 2.9.5). These uncertainty estimates are considered to be more useful as diagnostics of model fitting rather than as reflecting the "real" uncertainty in the assessment.

2.2.7. Ensure that stock assessment results are clearly and accurately presented in the stock assessment report and that the reported results are consistent with Review Panel recommendations.

An addendum to this report is to be produced after the meeting, which documents the results of the assessment exercise.

2.2.8. Evaluate the performance of the data and assessment workshops with regard to their respective Terms of Reference; state whether or not the Terms of Reference for those previous workshops were met and are adequately addressed in the Stock Assessment Report.

2.2.8.1 Evaluation of Data Workshop terms of reference

The terms of reference of the Vermilion Snapper Data Workshop are evaluated by the review panel in Table 8.1. The workshop completed a thorough preparation of the available data and made helpful recommendations concerning the analysis. However, ToRs 5, 6 and 7 referring to assessing the impacts of management actions, the choice of assessment methods and research recommendations were not addressed. The Review Panel considers that these terms of reference were outside the reasonable scope of requests to a data preparation meeting, and recommends that such requests should be addressed in a different meeting.

The review panel commends the data workshop for the detailed and thorough analyses undertaken in preparation of the assessment meeting. However, it is recommended that data workshop reports should contain in printed tables all the data used to fit the assessment models. However, the provision of the data on the SEDAR website is commended.

Specific recommendations relevant to data collection are collected in Section 9.

2.8.2. Evaluation of Assessment Workshop

The workshop completed its principal terms of reference and achieved an assessment of the vermilion snapper assessment despite considerable challenges of limited information. The workshop did not complete all of its terms of reference, which were unrealistically ambitious given the available resources, and extended substantially beyond the stock assessment remit. The level of documentation was good and thorough. However, provision of the final parameter estimates and their standard errors would have been a helpful additional model diagnostic.

This assessment work sets a high standard for the assessment of fisheries with data of this type.

Additional technical issues were addressed during the review meeting (Addendum 1) and corresponding recommendations are made in section 2.9.

Table 2.8.1. Synopsis of the results of the Data Workshop

Term of Reference	***Outcome***	***Reviewers' Conclusion***
1. Characterise stock structure and develop a unit stock definition.	Some differentiation in stock structure and genetic composition is reported. A further report was sent to the Assessment Workshop. This did not show any significant stock differentiation.	ToR met by correspondence after the meeting.
2.1. Tabulate available life history information	Various life history parameters are tabulated and plotted.	ToR was unclear. It would have been helpful to identify exactly which data were required.
2.2 Provide models of growth, maturation and fecundity by age and sex or length as appropriate	Length-weight, growth and fecundity-weight relationships provided. Sex ratios and maturity-at-age are estimated. A long spawning period is identified, but spawning area was widespread.	ToR met. However, the assessment workshop did not support the proposed length-weight relationship.
2.3 Recommend life history parameters for assessments.	Suggested M =0.25 but test the range 0.15 to 0.30; Recommended further work. Steepness lognormal with mode 0.6 and P(steepness >0.9) <=10%.	ToR met (taking account of 2.2)
2.4 Evaluate adequacy of life history information for assessments	Life history parameters were evaluated with due regard for data quality.	Not directly addressed, but implicit in 2.3

Term of Reference	*Outcome*	*Reviewers' Conclusion*
3.1. Provide indices of population abundance with estimates of precision	Indices provided together with uncertainty estimates.	ToR met.
3.2. Conduct analyses evaluating the degree to which available indices adequately represent fishery and population conditions.	Partially achieved, but on an "expert opinion" basis rather than by analysis.	ToR not fully met, but this task is better addressed to a meeting focusing on analysis. The comments provided were very helpful. More clarity in formulating ToRs would be helpful.
3.2. Document programs, methods, coverage, sampling intensities.	Sampling intensities were documented. Other documentation was generally tackled by reference to earlier work	A more complete documentation would be helpful in making the information accessible to a wider audience.
4.1 Characterise commercial and recreational catches, including landings in weight and numbers.	Available data on commercial and recreational landings, discards and by-catches are presented.	ToR met.
4.2.Evaluate adequacy of data for estimating removals by sector.	Some features of the data sets are discussed, but clear evaluations of adequacy are not made. Substantial data problems were identified, particularly in the MRFSS catch data.	ToR was partially met. A full review of the data collection programmes is outside the plausible scope of a single-species workshop.
4.3. Provide length and age distributions if feasible	Age-distributions are plotted graphically	ToR partially met.
5. Evaluate the adequacy of	Not addressed	ToR not met.

Term of Reference	***Outcome***	***Reviewers' Conclusion***
available data for estimating the impacts of current management actions.		
6. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements	Not addressed.	ToR not met. This is outside the reasonable scope of competence of a data evaluation meeting.
7. Provide recommendations for future research in areas such as sampling, fishery monitoring and stock assessment. Include specific guidance on sampling intensity and coverage where possible.	Not addressed.	ToR not met.
8. Prepare complete documentation of workshop actions and decisions (Section II of the SEDAR assessment report)	Report is prepared.	ToR met.

Table 2.8.2. Synopsis of the results of the Assessment Workshop.

Term of reference	*Outcome*	*Reviewers' Conclusion*
1. Select several appropriate modelling approaches, based on available data sources, parameters and values required to manage the stock, and recommendations of the Data Workshop.	The workshop used both biomass-dynamic and SSASPM models.	These are the most appropriate methods. However, some additional insight might be gained by using simple approaches such as catch curves and yield-per recruit calculations in data screening. However, some further robustness testing and model adjustments as documented in Addendum 1 were found useful.
2. Provide justification for the chosen data sources and for any deviations from Data Workshop recommendations.	The only major deviation from the Data Workshop recommendations was the use of a different length-weigh relationship.	ToR met.
3. Estimate stock parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates and measures of model 'goodness of fit'.	Parameter estimates provided.	ToR met.
4. Characterize uncertainty in the assessment, considering components such as input data, modeling approach, and model	Uncertainty characterised principally through investigation of sensitivity of model estimates to model choice, model structure and parameterisation, but also	ToR met. This approach is considered highly appropriate.

Term of reference	*Outcome*	*Reviewers' Conclusion*
configuration.	by delta-estimates of standard errors of interest parameters at the solution.	
5. Provide yield-per-recruit and stock-recruitment analyses.	Not calculated separately – these are incorporated in the SSASPM model fits.	ToR met, but it would be informative to provide a separate yield-per recruit analysis based on the selection pattern and life-history characteristics.
6. Provide complete SFA criteria. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT). Develop stock control rules.	Population parameters and benchmarks are calculated. No stock control rules were developed.	ToR partially met, because no stock control rules were developed. A more specific term of reference may have been required. Scientific groups usually require clearer definitions of control rules to be evaluated.
7. Provide declarations of stock status relative to SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT.	Statements are provided (but subject to revision in Addendum 1).	ToR was met.
8. Estimate Allowable Biological Catch (ABC) and provide an appropriate confidence interval.	Not achieved	ToR not met.
9. Project future stock conditions and develop rebuilding schedules if warranted; include estimated generation time. Projections shall be developed in accordance with the following: A) If stock is overfished: F=0, F=current, F=Fmsy,	Projections are calculated based on current yield and fishing mortality scenarios.	ToR met.

Term of reference	*Outcome*	*Reviewers' Conclusion*
Ftarget (OY), F=Frebuild (max that rebuild in allowed time) B) If stock is overfishing F=Fcurrent, F=Fmsy, F= Ftarget (OY) C) If stock is neither overfished nor overfishing F=Fcurrent, F=Fmsy, F=Ftarget (OY)		
10. Evaluate the results of past management actions and probable impacts of current management actions with emphasis on determining progress toward stated management goals.	New assessment suggests rebuilding trajectory is at a higher level than was anticipated.	ToR is met.
11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity. Prioritize recommendations based on their likelihood for improving stock assessment.	Not achieved.	ToR not met.
12. Fully document all activities.	Achieved	ToR is met, though improved documentation would be helpful.

2.9 Recommendations

2.9.1. Establish an obligatory, randomised observer scheme to estimate levels of shrimp by-catches.

2.9.2. Establish a comprehensive age-reading programme for vermilion snapper in the major sectors, especially the shrimp by-catches.

2.9.3. Consider further reinforcing the MRFSS programme so that more precise and accurate estimations of recreational catches can be obtained.

2.9.4. Methods should preferably be simulation-tested prior to their use in an advisory context.

2.9.5. Methods should be documented more fully, including the structural model equations, the observation-error models, process-error models (if appropriate), values of constants, constraints and priors, and description of the fitting algorithm including the uncertainty-estimation method. This documentation, together with the input data, should be included in the stock assessment reports.

2.9.6. More detailed model diagnostics should be provided, such as complete lists of estimated parameters together with their estimated standard errors.

2.9.7. Significant increases in the resources available to the data collection, processing and modelling teams would be required in order to allow the foregoing recommendations to be implemented.

2.9.8. The benchmarks should be updated when new life history parameters become available.

2.9.9. In future assessments the SSASPM should be modified to take account of bias-correction in the length-weight prediction.

Addendum 1. Detailed review of the Vermilion Snapper Assessment.

A1.1 Panel's approach to evaluating stock assessments: Basic Principles

The review panel considered the characteristics that would ideally be desirable in a stock assessment process used for advisory purposes. In order to guide its deliberations relevant to the terms of reference, the panel considered the following attributes to be desirable. Specific issues of concern addressed for each stock are addressed in this framework. Overall conclusions are summarised in section 2.2.

1. All relevant data should be used, unless there is an *a priori* reason to exclude a data series, or a sound *a posteriori* reason can be identified. Data should be real observations, not “filled-in” using assumptions or other criteria, to the extent possible. Fish stock assessment depends on having reasonably long time-series of catch, effort and fishery-independent abundance estimates.

2. Conclusions about stock status with respect to reference points should be robust to underlying assumptions about data and structural model, e.g. reliance on filling-in assumptions, dependence on most contested parts of the data sets.

3. Assessments should include the following:

> 3.1 Data screening, to check assumptions in 1 and 2.
> 3.2 Model screening, to see if broadly similar conclusions are drawn from different models, including sensitivity to constraints etc.
> 3.3 Residual pattern screening: Does the model replicate the trends in the data?
> 3.4 Credibility check: are the estimated model parameters reasonable (e.g. selection pattern, r, B_0/B_{msy}, trends in F etc. in the context of biological knowledge about the stock and the fishery?
> 3.5 Variance estimates (or posteriors) for the estimated interest parameters, and *a priori* model testing, using simulated data, which should demonstrate that the model has useful precision in predicting interest parameters when presented with data.

4. Assessment documentation should include:

4.1. Data used to fit the assessment model.
4.2. Structural model equations, including process-error model if applicable
4.3. Observation-error model
4.4. Description of estimating algorithm
4.5. List of final parameter estimates and their s.d.s
4.6. Computational validation, including simulation testing
4.7. Source code (and ideally documentation) of the programs used should be made available.

A1.2 Vermilion Snapper: Summary of issues of concern identified by the review panel, sensitivity tests calculated by assessment staff, and conclusions drawn therefrom.

Criterion	*Concern*	*Sensitivities*	*Sensitivity test*	*Conclusion*
1. Data screening	Catch reporting changed from voluntary to obligatory in LA and FL during the time-series; impact of trip limit in recreational fishery	- to possible change in reporting efficiency	Not needed.	Change from voluntary to obligatory reporting is believed to have had little effect on reporting efficiency. MRFSS includes discards data (proportion is small).
1. Data screening	Change in minimum landing size was expected to alter reduce CPUE by ca. 11%.	- to step-change in q for commercial indices, several changes over time. 10” limit introduced in 1997.	Computationally intractable	In future assessments, consider a numerical simplification that allows a sensitivity test to be made.
1. Data screening	MRFSS data reported as very uncertain but ‘the best that we have’	- to biases and gaps in the MRFSS catch data	Low priority	Concerns on MRFSS centre on CV of about 20% due to low response rate in telephone survey.
1. Data screening	MRFSS data reported as very uncertain but ‘the best that we have’	- biases in the MRFSS data used as CPUE index	- Are the same trends in the assessment persistent if the MRFSS data (used as cpue) are excluded?	CPUE index from MRFSS believed reliable because is based on dockside sampling by independent observers.
1. Data screening	CPUE estimates are calculated by selecting a subset of data, based on fish assemblages, where VS are expected to occur.	- depletion of several fish species at the same time could mask a trend in absolute fish stock abundance.	Not needed	Subset selection done on an annual basis, hence bias in time-series is not a problem

Criterion	*Concern*	*Sensitivities*	*Sensitivity test*	*Conclusion*
1. Data screening	Index divergence, use of all relevant data (Larvae survey was not received in time)	- do the abundance indices, when fitted separately, lead to similar conclusions about stock status?	- Recalculate fitting each index series separately, including the SEAMAP video survey.	F04/Fmsy values: CHL-E: 0.43 CHL-W:0.14 HB-E: 0.75 HB-W: 0.4 MRFSS:0.8 Perception of stock status wrt MSY benchmarks is robust to choice of commercial cpue index or fishery-independent index
1. Data screening	Uncertainty about origin of length-weight data	Bias-correction for lognormal distribution should be applied	- Recalculate SSASPM with bias-correction in length-weight	Recommendation for future work
3.2 Model Screening (P-T continuity run)	MSY constrained to <= largest catch (equivalent to assuming all catches were sustainable).	Is the constraint limiting?	- If constraint is limiting, what is the effect of its removal?	The evaluation had been made but was not reported to the review panel.
3.2 Model Screening (P-T continuity run)	Is constraint to Schaefer form limiting?		Estimate exponent in PT model	Estimate of exponent =2.1, model is robust to this.
3.2 Model Screening (P-T continuity run)	Continuity run	- to new data gathered since 2001	- Recalculate model with 5 years of new data.	r =0.67 (0.64 previously) K=2.2e7 (2.1e7) msy=3.6e6 3.4e6) trends are similar F_{04}/F_{msy}=2.7 B_{04}/F_{msy}=0.4
3.2 SSASPM runs, set 1		- to allowing recruitment deviations, estimating or fixing steepness, and 3 levels of shrimp by-catch	- 6 Model fits	F04/Fmsy in range 0.52 to 1.62; B_{04}/B_{msy} in range 0.68 to 1.8

Criterion	*Concern*	*Sensitivities*	*Sensitivity test*	*Conclusion*
3.2 SSASPM runs, set 1		- as above, but allowing greater deviation from shrimp fleet effort data.	- 6 Model fits	F04/Fmsy in range 0.82 to 2.05; B_{04}/B_{msy} in range 0.64 to 1.55
3.2 SSASPM Model screening	Is the model sensitive to assumptions about starting conditions?	Sensitivity to assumptions made in the 'pre-historic' period	re-run with assumed starting conditions in a much earlier year	Catch data in directed fisheries are low prior to 1960s – but the shrimp by-catch may have been high since 1950s.
3.2 SSASPM Model screening	Is model sensitive to weighting?	- to increasing the relative weighting on the survey indices	- re-fit with assumed sample size for age-distributions = 25 instead of 200, survey CV = 0.3 instead of 0.8, catch CV = 0.1 instead of 0.4	- Residual trends are substantially improved. F_{04}/F_{msy} changed from 0.67 to 0.59 and B_{04}/B_{msy} changed from 1.8 to 1.93
3.2 SSASPM Model screening	Is mode sensitive to estimating the autocorrelation in process error?	- to estimating this parameter rather than fixing it equal to 0.2.	- re-fit estimating this parameter	- Estimate is bound limited at rho =1, only very small impact on interest parameters.
3.3 Residual pattern screening	Appropriateness of SSASPM fit	- does model describe trends in data?	- test of appropriateness of model fit.	Model does not capture large decrease in HB-east and MRFSS-east around 1995, nor rapid increase in CMHL-west since 2000.
3.3 Residual pattern screening	Appropriateness of P-T model fit	-does model describe trends in data?	- test of appropriateness of model fit (LOW PRORITY)	Model does not capture the increase in CM HL index after 2000.

Criterion	***Concern***	***Sensitivities***	***Sensitivity test***	***Conclusion***
3.4 Credibility check	Compare with trends in red snapper fishery : F increasing to 1 in 1983, then high but variable	- are trends inverse or complementary in this linked fishery?	Compare F trends in red snapper and vermilion snapper. Compare F trend with deployed effort.	It was noted that F increases between two and three times since early 1980s. This could be due to increased targeting on this species. Industry confirms a greater tendency to switch to VS in the CMHL fleet.
3.4 Credibility check	Selection pattern looks reasonable?	50% selection at ages 2-4, fully selected at ages 4- 5, about 300mm; flat-topped thereafter.	Is this reasonable given knowledge about hook selection and MLS? Is selectivity of shrimp by-catch reasonable?	It should be a high research priority to estimate selection and catches at age, especially in the shrimp fishery.
3.4 Credibility check	Model parameters consistent with known life-history (PT model)	r= 0.7 for small, fast-growing tropical species; M assumed = 0.25. Seems in the right range – or perhaps a bit high?		PT model inappropriate
3.4 Credibility check	Age-distribution consistent with perception of stock status	Many fish above age 10 not consistent with overfished status.		PT model inappropriate
3.4 Credibility check	M of 0.25 seems very high given the reported age-structure of catches.	Consider M=0.15	Run SSASPM with M=0.15	Not discussed in detail.
3.5 Performance of the estimators	Are the parameters estimated with reasonable precision ?	Precision of the estimators from the PT model	Estimate variances of interest parameters	r estimated with CV of 4% and K estimated with CV of 0.01% - Something is constraining this model fit.

Criterion	***Concern***	***Sensitivities***	***Sensitivity test***	***Conclusion***
3.5 Performance of the estimators	Are the parameters estimated with reasonable precision?	Precision of the estimators from the PT model	Estimate variances of interest parameters	F estimated with CV 25%; SSB estimated with CV 10%, seems reasonable.

Documentation Issues

Criterion	*Requirement*	*Provided*	*Adequacy*
4.1 Data	P-T : all input data printed in report	p. 30 of SAR 3	Yes
4.1 Data	SSASPM - all input data printed in report	pp. 44-46 of SAR 3	Not clear how the age-distributions are calculated, otherwise ok.
4.2 Structural model	PT: Write down all the equations	Table 3.1.1.3.1 and p. 10 of SAR 3	Yes, except definitions of ρ and a are implicit. ρ values not given.
4.2 Structural model	SSASPM: Write down the structural equations	p. 16 of SAR 3	Yes, except definition of τ, α and A
4.3 Observation model	PT: Write down the observation model	Eqn. 4, p.10 of SAR 3	Yes, except definitions of $\boldsymbol{\Theta}$ and **X** are implicit.
4.3 Observation model	SSASPM: Write down the observation model	Table 3.2.1.5.1 of SAR 3	Yes
4.4 Estimating algorithm	PT: Describe the estimating method and constraints (if any)	Reference to AD Model Builder, Otter Research	Preferable to describe the mathematical method than to refer to a software package.
4.4 Estimating algorithm	SSASPM :Describe the estimating method and constraints (if any)	Not fully	No
4.5 Parameter estimates and s.e.	PT	Table 3.1.2.2.1.	Yes
4.5 Parameter estimates and s.e.	SSASPM	Selected estimates in Table 3.2.2.2.1	Partial. s.e.s provided for forecasts.
4.6 Computational validation	PT, SSASPM : Demonstration that the code implements the equations correctly	No	No

Criterion	***Requirement***	***Provided***	***Adequacy***
4.6. Simulation testing	PT, SSASPM : Demonstration of the statistical properties of the estimators under plausible conditions.	A paper was provided but this did not unambiguously support the use of SSASPM over PT models in the current situation.	More simulation studies would be helpful here.
4.6 Transparency	Source code availability	Will be posted on website.	Yes

SEDAR Review Panel Advisory Report
Gulf of Mexico Vermilion Snapper
SEDAR 9 Review Workshop

Stock Distribution and Identification

This assessment covers the vermilion snapper distributed in the US waters of the Gulf of Mexico. There is no information available suggesting that this definition is an inappropriate one as a unit stock for management purposes.

Assessment methods

The assessment method used is an age-structured production model assuming constant selection and a stock-recruit relationship of Beverton-Holt form. The assessment used previously (a biomass-dynamic model of Schaefer type) shows similar tendencies.

Assessment data

The data sources used were:

Estimates of by-catches in the shrimp fishery
MRFSS estimates of catches and discards
Estimates of commercial catches
Estimates of catches in the charterboat and headboat recreational sectors
SEAMAP video survey indices of abundance
MRFSS estimates of catch rates
Commercial handline catch rates
Age, growth and fecundity estimates.

Catch trends

Catches before 1986 are not known with usable precision.

A large part – about 40% - of the removals from this stock are made as by-catches in the shrimp fishery. Very little information is available about the trends in these by-catches, and the absolute level is not known accurately.

In the non-shrimp fishery sectors, catches increased steadily from 1986 to 1994, decreased again until 2000, then increased from 2000 until 2004.

Fishing mortality trends

Fishing mortality shows an irregular but generally increasing trend from the mid 1980s to 2004, though fishing mortality may have been lower around 2000. This trend may be associated to an increased targeting of this species as the commercial handline fleet may be changing away from targeting red snapper.

Stock abundance and biomass trends

Stock biomass followed an irregular but declining trend in the time series. The estimated abundance in 2004 is the lowest in the time series. There are two periods of higher recruitment, around 2000 and around 1990.

Status determination criteria

The overall perception of trends in the stock are that fishing mortality is increasing, biomass is declining, and the stock has been sustained in recent years by a high recruitment in 2000. Furthermore, a substantial mortality is exerted, mostly on juvenile fish, by the shrimp fleet as a by-catch. These trends are robust to the various plausible assessment models and data series that were explored, and are considered to be reliably estimated.

However, the exact location of stock status in 2004 relative to the benchmarks is more uncertain.

Stock Status

Declarations of Stock Status:

- the stock was not overfished in 2004;
- the stock was not undergoing overfishing in 2004;
- the stock was not overexploited with respect to the optimum fishing mortality;
- a substantial but unmeasured mortality is exerted as a by-catch in the shrimp fishery, which is greatly reducing the yield in the directed fisheries;
- fishing mortality is tending increasing and biomass is decreasing. A further decrease in the size of the stock is likely if present conditions continue.

Projections

Quantitative projections are not yet available (See Addendum 2 to the Consensus Summary).

Allowable biological catch

Quantitative projections are not yet available (See Addendum 2 to the Consensus Summary).

Special Comments

The change of assessment model from the base case used previously maintains the same broad perception of a declining stock with increasing fishing mortality. However, on including life-history information, the estimated productivity of the stock at small stock size has been revised upwards. It is stressed that:

(a) while allowing the trend to smaller stock size and higher fishing mortalities to continue is not forecast to cause overfishing in the short term, it will do so in the medium term and will lead to conditions which are outside those seen historically – and predictions of stock dynamics in such conditions have not been validated by observation;

(b) increasing fishing mortality rates will lead to a smaller average size of fish in the catches.

Additional scientific and technical resources need to be made available in order that the requests for scientific advice can be fully met.

Sources of information

The primary source of information for this report includes the reports of the SEDAR 9 Data and Assessment Workshops (SEDAR 9 Stock Assessment Report for Gulf of Mexico Vermilion Snapper. SEDAR9-AR3.) and the compiled SEDAR working papers. Final assessment results reviewed at the workshop and referenced here are documented in an addendum to the stock assessment report included with the Review Workshop Consensus Report for Vermilion Snapper

SEDAR

SouthEast Data, Assessment, and Review

Gulf of Mexico Vermilion Snapper
SEDAR 9
Stock Assessment Report 3

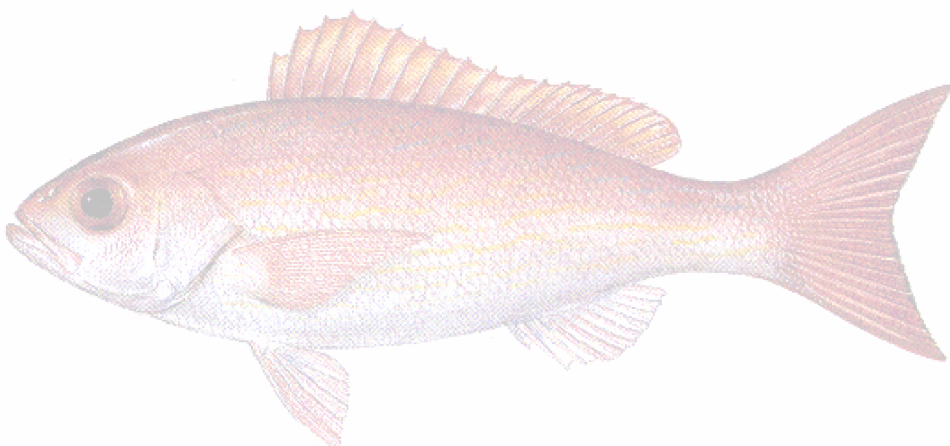
SECTION 5. Post Review Addendums

Contents

Consists of updated production model output file based on the model configuration recommended by the review workshop panel. Also includes updated benchmark estimates based on review panel recommendation to base reference point calculations on recent recruitment.

Appendix 1: A revised base case used to assess vermilion snapper in the U.S. Gulf of Mexico

Shannon L. Cass-Calay



May 5, 2006

Southeast Fisheries Science Center
Sustainable Fisheries Division
75 Virginia Beach Drive
Miami, FL 33149-1099

Sustainable Fisheries Division Contribution SFD-2006-XXX

A1. Introduction

The base case developed during the SEDAR9 assessment workshops (AW1-August 2005, Miami FL and AW2-December, Atlanta GA) was presented to the SEDAR9 review panel in March 2006 (New Orleans, LA). The review panel expressed concerns regarding the pronounced lack of fit to the indices of abundance. A detailed examination of the issue led the group to conclude that the relative weighting of three model components, the variance of the catches, indices of abundance and age composition, was not appropriate. An alternative weighting strategy was developed which resulted in model fits that were more satisfactory.

The review panel also recommended that benchmark statistics be calculated using the S-R parameters obtained from the recent time period (1986-2004). Earlier SSASPM runs used the entire time period (1950-2004).

The PRO2-Box base projection was updated using the revised SSASPM results. The review workshop recommended the use of the "Current F" projection as the base case. SPR based benchmarks were recommended by the review workshop. However, MSY based benchmarks are also provided in this document.

A2. Methods

An age structured production model (SSASPM) was used to assess population status of vermilion snapper. The assessment model is described in Section 3.2.1.3 of the SEDAR9 Vermilion Snapper Assessment Report. No changes were made to the SSASPM model formulation.

The input data is described in detail in tables 3.2.1.2.1, to 3.2.1.2.4 of the SEDAR9-Vermilion Snapper Assessment Report. No changes were made to the input data itself. However, the effective annual sample sizes of the age composition were downweighted to allow the model to fit the age composition with higher variance. Specifically, all effective sample sizes greater than 25 were set to 25 (λ=25 is equivalent to a CV of ~20%). Initially, all sample sizes greater than 200 had been fixed at 200 (CV~5%). Table A2.1 summarizes the changes to the effective sample sizes. Table A2.2 is the data input file used for the revised SSASPM base case.

Changes were also made to the relative weighting of the catch series and indices of abundance. Initially, the variance of the catch was estimated, and the indices were assigned a variance equal to 2X the catch variance. The revised base case used an alternative weighting strategy recommended by the review panel. The revised weightings are:

1) Variance of each catch series fixed at CV = 30%.
2) Variance of indices of abundance fixed at CV = 10%

3) Weight of annual age composition fixed using a maximum effective sample size, λ, of 25 (CV=20%).

The revised SSASPM parameter file is included (Table A2.3).

A3. Results and Discussion

A3.1 Measures of Overall Model Fit

The likelihood statistics of the SSASPM base model are as follows:

AIC	9.15e+02
data points	213
estimated parameters	137
AICc (small sample)	1.42e+03
Objective Function:	3.21e+02

Fits the catch series of the directed fleets are shown in Figure A3.1.1 and A3.1.2. Note that the period from 1950-1980 is presumed to be “pre-data”, and is used only as a “burn-in” period to scale the estimates during historic period 1981-2004. The revised base case is comparable to the original model, with only minor deterioration of the fits to the catch series. This deterioration is expected since the ***relative*** weighting of the catch series and age composition was reduced to better fit the indices of abundance. In general, fits the catch series were adequate. The shrimp bycatch fit is the most variable. The model cannot properly accommodate a constant annual shrimp bycatch estimate, nor should this assumption be regarded as biologically realistic.

Fits to the indices of abundance are summarized in Figure A3.1.3 and Figure A3.1.4. In general, the fits to the indices of abundance are improved for the revised base case, particularly for the Commercial Handline-East, Headboat-East and MRFSS indices, which show a similar trend.

The fits to the observed age composition are summarized in Figures A3.1.5 to A3.1.7. In general, the estimated age composition resembles the observations from otolith analysis. Although the revised base model fits are generally less precise than the original model, the fits do not deteriorate substantially. In the recreational sector the predicted age composition often shifts to older ages with the revised model weightings; whereas an opposite pattern is frequently present in the western commercial sector. The reason for this behavior is not entirely clear, but it may be due to a conflict in the information regarding population trend and age composition imparted by the indices of abundance, selectivity estimates and otolith age composition.

A3.2 Parameter estimates

Selected parameter estimates, including B_0, B_{2004}, F_{2004}, the Beverton and Holt stock-recruitment parameters and the selectivity parameters are summarized in Table A3.2.1. Estimates of variability are also tabulated.

The selectivity parameters for the directed fisheries were estimated using logistic functions. The results are shown in Figure A3.2.1. Selectivity is near zero at Age-1 and all individuals Age-5 and older are fully vulnerable to fishing. The age at 50% selectivity varies between ages 2-4. Compared to the previous base model, the estimated age at 50% selectivity is younger for the western commercial fleet, and older for the other fleets. These changes are consistent with the revised fits to the observed age composition (Figs. A3.1.5-A3.1.7),

A3.3 Stock Biomass

Annual trends in spawning stock biomass (SSB) and SSB relative to MSY and SPR30% levels are summarized in Figures A3.3.1, A3.3.2 and Table A3.3.1. Estimates prior to 1981 are considered “pre-data”, and are used as a burn in to scale the model results. SSB statistics varied without obvious trend during 1981-1987, but generally declined thereafter. According the revised base run results, the population was never below SSB_{MSY} or $SSB_{SPR30\%}$. In 2004, SSB was 48% of virgin (SSB_{1950}), SSB/SSB_{MSY} was 1.52 and $SSB/SSB_{SPR30\%}$ was 1.47, indicating a population that is not currently overfished.

These results are similar to the original base case (SSB/SSB_{1950} = 0.44; SSB/SSB_{MSY} = 1.80; $SSB/SSB_{SPR30\%}$ = 1.75).

A3.4 Fishing Mortality

Annual trends in fishing mortality (F), and F relative to MSY and SPR30% levels are summarized in Figures A3.4.1, A3.4.2 and Table 3.4.1. In 1950, F was assumed to be negligible. The linear increase during the “prehistoric” period (1950-1981) is dictated by the model structure (SSASPM-linear). Fishing mortality varied with a generally increasing trend during 1986-1999, and then decreased during 2000-2002. A slight increase in F is observed after 2002. According to the revised base run, F is less than F_{MSY} and $F_{SPR30\%}$ throughout the time series. In 2004, F/F_{MSY} was 0.60 and, $F/F_{SPR30\%}$ was 0.62, indicating a population that is not currently undergoing overfishing.

These results are similar to the original base case (F/F_{MSY} = 0.65 and $F/F_{SPR30\%}$ = 0.67).

A3.5 Recruitment

Annual estimates of recruitment (Age 1) are summarized in Figure A3.5.1 and Table A3.5.1. “Prehistoric” (1950-1980) recruitment estimates are considered as a burn in to scale the SSASPM model results. During the "historical" period (1981-2004), recruitment varies without obvious trend. For the revised base case, a notable peak in recruitment is apparent in 1987.

A3.6 Measures of Parameter Uncertainty

Parameter uncertainty was addressed by estimating process and observation errors. The standard deviations of the estimated parameters are summarized in the previously cited Table A3.2.1.

A3.7 Retrospective and Sensitivity Analyses

No retrospective analyses were preformed. However, numerous sensitivity analyses were presented to the SEDAR9-AW and RW working groups. Models were presented that estimated steepness, fixed steepness at 0.60 (the mean value suggested by the data workshop), used larger effort deviations for the shrimp bycatch fleet (50%CV), assumed various levels of shrimp bycatch, allowed or did not allow recruitment deviations, included/excluded various indices of abundance and assumed various levels of natural mortality (0.15-0.3). These sensitivity runs were not preferred by the RW working group. However many are described in detail in document SEDAR9-AW-04.

A3.8 Benchmarks / Reference Points

The benchmarks and reference points are summarized in Table A3.8.1. The revised model suggests that vermilion snapper are not overfished (SSB_{2004}/SSB_{MSY} = 1.52; ($SSB_{2004}/SSB_{SPR30\%}$ = 1.47), nor was overfishing occurring (F_{2004}/F_{MSY} = 0.60; ($F_{2004}/F_{SPR30\%}$ = 0.62) as of 2004. This result does not differ substantially from the original SSASPM base case developed during the assessment workshops.

A3.9 Base Projection

Figures A3.9.1 to A3.9.3 and Tables A3.9.1 to A3.9.3 summarize the "Current F" projection results. This projection was favored by the review workshop panel. The projected fishing mortality is held constant at F_{2004} (0.49) through 2016. This level is below the overfishing threshold throughout the projection interval (F_{2016}/F_{MSY} = 0.60; $F_{2016}/F_{SPR30\%}$= 0.62).

The effect of this fishing mortality rate on SSB is summarized in Figure A3.9.2 and Table A3.9.2. Under the "Current F" scenario, SSB, SSB/SSB_{MSY} and SSB/SSB_{SPR30} remain nearly constant, or slightly increasing, throughout the projection interval, and the population never experiences an overfished condition (SSB_{2016}/SSB_{MSY} = 1.6; SSB_{2016}/SSB_{SPR30} = 1.54)

Projected yield and recruitment also continue at nearly constant levels (Figure A3.9.3, Table A3.9.3). Yield is projected at 6.8 to 6.9 million pounds throughout the projection interval. These values are slightly below MSY (7.44 million pounds). The projected recruitment estimates 2005-2016 remain constant at about 17 million age-1 fish.

Table A2.1 The original and revised effective sample sizes used to weight the annual age composition.

Fleet	Year	Original Effective Sample Size	Revised Effective Sample Size
Commercial East	1994	28	25
	1995	6	6
	1996	6	6
	1997	0	0
	1998	138	25
	1999	0	0
	2000	45	25
	2001	200	25
	2002	200	25
	2003	200	25
	2004	200	25
Commercial West	1994	64	25
	1995	75	25
	1996	71	25
	1997	0	0
	1998	0	0
	1999	0	0
	2000	81	25
	2001	102	25
	2002	69	25
	2003	200	25
	2004	200	25
Recreational	1994	154	25
	1995	192	25
	1996	200	25
	1997	46	25
	1998	14	25
	1999	200	25
	2000	200	25
	2001	141	25
	2002	200	25
	2003	91	25
	2004	129	25

Table A2.2 The SSASPM data input file used for the ***revised*** base run.

```
#observed catches by set (column for year required)
#CM-E          CM-W           REC         SHRMP-BYC          YEAR
-1             -1             -1             -1              1950
#### REPEAT THE CATCH SERIES FOR EACH YEAR 1951-1962 ###
27700          20300          -1             -1              1963
30300          21200          -1             -1              1964
30100          18700          -1             -1              1965
15700          6000           -1             -1              1966
31800          14200          -1             -1              1967
63200          45300          -1             -1              1968
80500          24400          -1             -1              1969
75100          40000          -1             -1              1970
82000          43300          -1             -1              1971
72400          41900          -1             -1              1972
122100         49500          -1             -1              1973
115900         60200          -1             -1              1974
252200         98500          -1             -1              1975
221600         54500          -1             -1              1976
300337         175789         -1             -1              1977
258155         147082         -1             -1              1978
196791         198599         -1             -1              1979
143836         133743         -1             -1              1980
208578         104201         141888         6900000         1981
215646         131973         833154         6900000         1982
340912         145961         231710         6900000         1983
483215         832017         367066         6900000         1984
607023         722886         398400         6900000         1985
689625         939041         998551         6900000         1986
534518         1003433        1035306        6900000         1987
492997         991713         1375143        6900000         1988
481705         1002816        861223         6900000         1989
1489581        962643         1170574        6900000         1990
969399         808348         1165083        6900000         1991
1217900        1036278        1359566        6900000         1992
1667549        1024203        1202661        6900000         1993
1582072        1040183        989280         6900000         1994
1506085        654242         1229289        6900000         1995
1166437        651873         586062         6900000         1996
1040331        1072584        617878         6900000         1997
807987         895269         313724         6900000         1998
866821         1098219        421950         6900000         1999
699209         758230         333741         6900000         2000
791599         915733         623512         6900000         2001
1008662        997300         511965         6900000         2002
1153574        1260897        596534         6900000         2003
903434         1218992        815530         6900000         2004
```

Table A2.2 (continued) The SSASPM data input file used for the ***revised*** base run.

```
# annual scaling factors for observation variance (use this option to scale up the variance for observations based on very little (or
estimated) data) (column for year required)
#CM-E   CM-W    REC SHRMP-BYC  YEAR
1       1       1       1      1950
#### REPEAT THE SCALING FACTORS FOR EACH YEAR 1951-2004 ###
# INDICES OF ABUNDANCE (e.g., CPUE) If there are no series, there should be no entries between the comment lines.
# number of index data series
  5
# pdf of observation error for each series (1) lognormal, (2) normal
  1 1 1 1 1
# units (1=numbers, 2=weight)
  2 2 1 1 1
# season (month) when index begins for each series
  1 1 1 1 1
# season (month) when index ends for each series
  12 12 12 12 12
# option to (1) scale or (0) not to scale index observations
  0 0 0 0 0
# set of index variance parameters each series is linked to
  1 1 1 1 1
# set of q parameters each series is linked to
  5 6 7 8 9
# set of s parameters each series is linked to
  1 2 3 3 3
# observed indices by series (no column for year allowed)
#CMHL_E         CMHL_W          HB_E            HB_W            MRFSS           YEAR
-1.0000         -1.0000         -1.0000         -1.0000         -1.0000         1950
#### REPEAT PREVIOUS LINE FOR EACH YEAR 1951-1985 ###
-1.0000         -1.0000         1.0320          1.3384          2.0146          1986
-1.0000         -1.0000         0.9415          1.0085          1.0238          1987
-1.0000         -1.0000         2.0546          0.8242          0.8825          1988
-1.0000         -1.0000         1.0626          1.1914          0.6223          1989
-1.0000         -1.0000         1.6947          1.6901          2.4221          1990
-1.0000         -1.0000         1.9385          1.0368          1.4895          1991
-1.0000         -1.0000         2.2609          0.9378          1.7052          1992
1.3672          0.9743          1.4096          0.9196          1.9029          1993
1.4585          1.0884          1.1549          1.1050          1.1780          1994
1.1465          0.8371          1.1296          1.1262          1.7258          1995
1.0401          0.8129          0.6480          0.8599          0.8839          1996
0.9461          1.0744          0.6969          0.9198          0.4752          1997
0.8455          1.0737          0.2477          0.8737          0.3558          1998
0.9007          0.9372          0.4683          0.6062          0.4060          1999
0.7258          0.6425          0.3688          0.6771          0.3447          2000
0.8776          0.7942          0.3638          1.1784          0.3744          2001
0.8899          1.0319          0.5412          0.8844          0.3027          2002
0.9232          1.2665          0.4629          0.6573          0.3733          2003
0.8787          1.4669          0.5237          1.1653          0.5176          2004
```

Table A2.2 (continued) The SSASPM data input file used for the ***revised*** base run.

```
# annual scaling factors for observation variance (use this option to scale up the variance for obs based on very little data)
#CMHL_E        CMHL_W        HB_E          HB_W          MRFSS
1.0000  1.0000  1.0000  1.0000  1.0000  1950
#### REPEAT THESE SCALING FACTORS FOR EACH YEAR 1951-2004 ###

# EFFORT OBSERVATIONS If there are no series, there should be no entries between the comment lines.
# number of effort data series
   0
# AGE COMPOSITION OBSERVATIONS If there are no series, there should be no entries between the comment lines.
# number of age-composition series (If there are no series, there should be no more entries in this section)
  3
# first year in age-composition series
  1994
# probability densities used for age-comp. series (0 = ignore, 3 = multinomial, 8 = robustified normal)
  3 3 3
# units (only 1=numbers, no other options at this time)
  1 1 1
# season (month) when age collections begin for each series
  1 1 1
# season (month) when age collections end for each series
  12 12 12
# age composition data (MAXIMUM SAMPLE SIZE = 25)
#CM HL EAST
```

#FLEET	YEAR	SAMPLES	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14+
1	1994	25	0	0	4	9	5	5	1	1	1	0	0	1	1	0
1	1995	6	0	0	0	0	2	2	1	0	1	0	0	0	0	0
1	1996	6	0	0	0	1	1	0	4	0	0	0	0	0	0	0
1	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1998	25	9	42	67	6	7	4	0	0	0	1	1	1	0	0
1	1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2000	25	0	0	9	10	2	4	4	4	2	3	1	3	2	1
1	2001	25	0	47	165	256	266	177	121	74	40	44	19	17	9	15
1	2002	25	4	211	473	169	130	82	64	45	22	17	21	4	6	10
1	2003	25	1	76	435	800	310	141	188	90	57	13	13	11	6	4
1	2004	25	0	21	144	164	128	53	47	34	20	7	2	3	2	1

#CM HL WEST

#FLEET	YEAR	SAMPLES	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14+
2	1994	25	0	0	6	9	20	9	7	4	0	2	2	3	1	1
2	1995	25	0	11	5	14	20	9	8	0	3	3	0	1	0	1
2	1996	25	0	1	21	9	10	11	5	3	3	4	1	1	2	0
2	1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2000	25	0	1	7	8	13	10	3	5	6	14	7	0	2	5
2	2001	25	0	1	10	15	14	12	7	6	9	8	4	2	7	7
2	2002	25	0	6	15	7	5	6	8	8	0	2	0	6	1	5
2	2003	25	0	9	51	245	74	44	30	28	19	9	14	10	4	5
2	2004	25	1	8	50	104	144	58	39	22	31	18	5	11	8	12

Table A2.2 (continued) The SSASPM data input file used for the ***revised*** base run.

#FLEET #REC	YEAR	SAMPLES	AGE1	AGE2	AGE3	AGE4	AGE5	AGE6	AGE7	AGE8	AGE9	AGE10	AGE11	AGE12	AGE13	AGE14+
3	1994	25	0	0	27	39	30	26	7	12	9	2	1	0	1	0
3	1995	25	2	18	41	40	44	17	13	4	8	3	0	0	1	1
3	1996	25	1	17	44	57	53	54	21	17	6	8	1	1	0	0
3	1997	25	0	8	3	12	6	8	5	2	2	0	0	0	0	0
3	1998	25	0	1	3	2	4	1	2	1	0	0	0	0	0	0
3	1999	25	3	33	74	41	29	19	16	16	8	4	1	1	1	0
3	2000	25	0	6	34	51	53	26	16	19	12	7	1	3	1	1
3	2001	25	0	2	5	19	46	24	22	9	4	3	2	4	1	0
3	2002	25	0	15	45	24	55	36	42	26	5	3	3	2	2	0
3	2003	25	0	9	10	29	10	12	13	3	4	1	0	0	0	0
3	2004	25	0	0	7	41	48	10	16	3	1	2	1	0	0	0

Table A2.3. Parameter inputs for ***revised*** SSASPM base run. Changes are highlighted with bold italics and shading.

```
# Total number of process parameters (must match number of entries in 'Specifications 1' section)
40
# Number of sets of each class of parameters (must be atleast 1)
# q (catchability)
# |     Effort
# |     |     Vulnerability (selectivity)
# |     |     |     catch observation variance scalar
# |     |     |     |     index variance scalar
# |     |     |     |     |     effort variance scalar
# |     |     |     |     |     |
  9     4     4     1     1     1
# Specifications 1: process parameters and observation error parameters
#===============================================================================================
#class (nature) of parameter (1=constant, 2-4 = polynom of degree x, 5=knife edge, 6=logistic, 7=gamma)
#  |        best estimate (or central tendency of prior)
#  |       |                lower bound    upper bound
#  |       |                |                |              phase to estimate (-1 = don't estimate)
#  |       |                |                |              | prior density (1= lognorm, 2=norm, 3=uniform)
#  |       |                |                |              |     |       prior variance
#  |       |                |                |              |     |       |
#-----------------------------------------------------------------------------------------------
# Natural mortality rate
   1       0.2500E+00       0.1000E-01       0.5000E+00    -1     1       0.2500E+00
# Recruitment (10=Beverton/Holt, 11=Ricker)
  10       0.1000E+07       0.1000E+04       0.1000E+10     1     3       0.1000E+01
  10       0.6000E+01       0.1100E+01       1.0000E+02     2     1      -0.8500E+00
# Growth (type 8 = von Bertalanfy/Richards, Linf, K, t0, m, a, b (weight=al^b)
   8       0.1699E+02       0.1000E-03       0.1000E+06    -1     0       0.1000E+01
   8       0.2000E+00       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
   8      -0.3900E+01      -0.5000E+01       0.1000E+13    -1     0       0.1000E+01
   8       0.1000E+01       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
   8       0.5957E-03       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
   8       0.2870E+01       0.0000E+00       0.1000E+13    -1     0       0.1000E+01
```

Table A2.3 (continued). Parameter inputs for ***revised*** SSASPM base run. Changes are highlighted with bold italics and shading.

```
# catchability
   #Catches (fix at 1 if E assumes Fishing Mortality)
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   1       1.0000E+00       0.1000E-01       0.1000E+02    -1     0       0.1000E+01
   #Indices
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
   1       0.1000E-06       0.1000E-09       0.1000E+00     1     0       0.1000E+01
# effort for 'prehistoric' period when data is sparse
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
   1       0.00001E+00     -0.1000E-31       0.1000E+02    -1     0       0.1000E+01
# effort for period with useful data (Set at assumed F values if q =1)
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
   1       0.01000E+00      0.1000E-02       5.000E+00      1     0       0.1000E+01
# vulnerability (selectivity)
#CM-EAST
   6       0.4046E+00       0.0000E-10       0.2000E+01     1     0       0.1000E+01
   6       2.6600E+00       0.5000E+00       0.4000E+01     3     0       0.6250E-01
#CM-WEST
   6       0.4046E+00       0.0000E-10       0.2000E+01     1     0       0.1000E+01
   6       2.6600E+00       0.5000E+00       0.4000E+01     3     0       0.6250E-01
#REC
   6       0.6329E+00       0.0000E-10       0.2000E+01     1     0       0.1000E+01
   6       3.0000E+00       0.5000E+00       0.4000E+01     3     0       0.6250E-01
#SHRIMP
   15       0.5000E+00       0.1000E-06       0.2000E+01   -4     0       0.1000E+01
   15       0.0100E+00       0.1000E-06       0.2000E+01   -4     0       0.1000E+01
   15       1.5000E+00       0.3000E+00       0.3000E+01   -3     0       0.6250E-01
   15       0.4150E+00       0.1000E-06       0.2000E+01   -4     0       0.1000E+01
   15       0.76938E+00      0.3000E+00       0.3000E+01   -3     0       0.6250E-01
```

Table A2.3 (continued). Parameter inputs for ***revised*** SSASPM base run. Changes are highlighted with bold italics and shading.

```
# catch observation error variance scalar
   1       1.0000E+00       0.1000E+00       0.5000E+01    -1     0       0.1000E+01
# index observation error variance scalar
   1       0.3330E+00       0.1000E+00       0.5000E+01    -1     0       0.1000E+01
# effort observation error variance scalar
   1       1.0000E+00       0.1000E+00       0.5000E+01    -1     0       0.1000E+01
#================================================================================================
# Specifications 2: process ERROR parameters
#================================================================================================
#    best estimate (or central tendency of prior)
#    |                lower bound    upper bound
#    |                |                |              phase to estimate (-1 = don't estimate)
#    |                |                |              |  prior density (1= lognormal, 2=normal, 3=uniform)
#    |                |                |              |     |       prior variance
#    |                |                |              |     |       |
#-------------------------------------------------------------------------------------------------
# overall variance (negative value indicates a CV fixed at 30%)
    -0.3000E+00      -0.2000E+01      -0.1000E-01     -2     0       0.1000E+01
# recruitment process variation parameters (allows year to year fluctuations)
#    correlation coefficient
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
#    variance scalar
     0.14820E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01(
#    annual deviation parameters (last entry is arbitrary for deviations)
     0.0000E+00      -0.5000E+01       0.5000E+01     4     1       0.1000E+01
# catchability process variation parameters (allows year to year fluctuations)
#    correlation coefficients
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.9900E+00    -1     0       0.1000E+01
```

Table A2.3 (continued). Parameter inputs for ***revised*** SSASPM base run. Changes are highlighted with bold italics and shading.

```
#    variance scalars
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
     0.0000E+00      -0.1000E-31       0.1000E+21    -1     0       0.1000E+01
#    annual deviation parameters (last entry is arbitrary for deviations)
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
     0.0000E+00      -0.5000E+01       0.5000E+01    -1     0       0.1000E+01
# effort process variation parameters (allows year to year fluctuations)
#    correlation coefficients
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
     0.5000E+00       0.0000E+00       0.9900E+00    -1     0       0.1000E+01
#    variance scalars
     0.22300E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
     0.22300E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
     0.22300E+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
     0.040000+00      0.0000E+00       0.1000E+21    -1     0       0.1000E+01
#    annual deviation parameters (last entry is arbitrary for deviations)
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
     0.1000E-03      -0.5000E+01       0.5000E+01     2     1       0.1000E+01
```

Table A3.1.1. Selected parameter estimates and error from the SSASPM base models. ***Fixed values are indicated by shaded cells.***

	Original Model		***Revised Base Model***	
Parameter	***Value***	***Std Dev***	***Value***	***Std Dev***
Virgin Biomass	2.15E+14	2.05E+13	2.20e+14	1.94e+13
Alpha	15.15	7.85	16.74	8.38
r_0	1.41e+07	1.34+06	1.44e+07	1.26e+06
F_{2004}	0.57	0.14	0.49	0.11
SSB_{2004}	9.47E+13	1.80E+13	1.05e+14	1.44e+13
Overall Variance (CV)	0.395*	2.4184e-02	0.3	0.0
Catch Variance (CV)	0.395**	0.0	0.3	0.0
Index Variance (CV)	0.80 ***	0.0	0.1	0.0

* Estimated by model.
** Fixed equal to the overall variance estimated by the model.
*** Fixed at 2 times the catch variance.

Table A3.3.1 Spawning stock biomass (SSB) and SSB relative to SSB_{MSY} and $SSB_{SPR30\%}$. and SSB_{Virgin} for the revised base case.

YEAR	SSB	SSB/SSB_{MSY}	$SSB/SSB_{SPR30\%}$	SSB/SSB_{VIRGIN}
1981	1.72E+14	2.499	2.408	0.779
1982	1.75E+14	2.539	2.447	0.792
1983	1.69E+14	2.451	2.362	0.765
1984	1.56E+14	2.264	2.182	0.706
1985	1.46E+14	2.118	2.041	0.661
1986	1.47E+14	2.138	2.060	0.667
1987	2.12E+14	3.085	2.973	0.962
1988	1.94E+14	2.817	2.715	0.879
1989	1.93E+14	2.807	2.705	0.876
1990	1.85E+14	2.689	2.591	0.839
1991	1.80E+14	2.614	2.519	0.815
1992	1.62E+14	2.350	2.265	0.733
1993	1.35E+14	1.966	1.895	0.613
1994	1.21E+14	1.754	1.690	0.547
1995	1.03E+14	1.499	1.445	0.468
1996	9.97E+13	1.450	1.397	0.452
1997	9.64E+13	1.403	1.352	0.438
1998	8.95E+13	1.301	1.254	0.406
1999	8.04E+13	1.170	1.127	0.365
2000	1.02E+14	1.478	1.424	0.461
2001	1.11E+14	1.619	1.560	0.505
2002	1.12E+14	1.626	1.567	0.507
2003	1.05E+14	1.530	1.474	0.477
2004	1.05E+14	1.521	1.466	0.475

Table A3.4.1 Fishing mortality rate (F) and F relative to F_{MSY} and $F_{SPR30\%}$..

YEAR	F	F/F_{MSY}	$F/F_{SPR30\%}$
1981	0.296	0.365	0.378
1982	0.375	0.461	0.477
1983	0.429	0.528	0.547
1984	0.480	0.591	0.611
1985	0.477	0.587	0.608
1986	0.398	0.491	0.507
1987	0.288	0.355	0.367
1988	0.322	0.396	0.410
1989	0.346	0.426	0.441
1990	0.376	0.462	0.478
1991	0.395	0.486	0.503
1992	0.454	0.559	0.578
1993	0.544	0.670	0.693
1994	0.572	0.704	0.728
1995	0.619	0.762	0.788
1996	0.566	0.697	0.721
1997	0.553	0.681	0.704
1998	0.587	0.723	0.748
1999	0.602	0.741	0.766
2000	0.449	0.553	0.572
2001	0.419	0.516	0.534
2002	0.452	0.557	0.576
2003	0.493	0.607	0.627
2004	0.488	0.601	0.622

Table A3.5.1 Annual recruitment estimates.

YEAR	RECRUITMENT (Age 1)
1981	1.99E+07
1982	1.90E+07
1983	1.69E+07
1984	1.42E+07
1985	1.44E+07
1986	1.84E+07
1987	4.37E+07
1988	1.89E+07
1989	2.21E+07
1990	1.96E+07
1991	2.07E+07
1992	1.65E+07
1993	1.21E+07
1994	1.41E+07
1995	1.16E+07
1996	1.52E+07
1997	1.52E+07
1998	1.32E+07
1999	1.08E+07
2000	2.11E+07
2001	1.90E+07
2002	1.63E+07
2003	1.36E+07
2004	1.52E+07

Table A3.8.1. Management and biomass status benchmarks for the original SSASPM model and the revised base case. ***Note: the review workshop recommended the use of the revised base case and SPR30% based benchmarks.***

Benchmark	**Original Base Case** (Note: Benchmarks calculated using S/R relationship during 1950-2004)	**Revised Base Case** (Note: Reweighted model components; Benchmarks calculated using S/R relationship during 1986-2004)
F_{2004}	0.57	0.49
F_{MSY}	0.87	0.81
$F_{SPR20\%}$	1.25	1.19
$F_{SPR30\%}$	0.85	0.79
$F_{SPR40\%}$	0.60	0.55
$SSB_{2004\ (eggs)}$	9.47E+13	1.05E+14
$SSB_{MSY\ (eggs)}$	5.26E+13	6.88E+13
$SSB_{SPR20\%\ (eggs)}$	3.10E+13	4.17E+13
$SSB_{SPR30\%\ (eggs)}$	5.40E+13	7.14E+13
$SSB_{SPR40\%\ (eggs)}$	7.69E+13	1.01E+14
MSY	5.54E+06	7.44E+06
SPR_{MSY}	0.29	0.29
Steepness	0.79	0.8
Lifetime Reproductive Rate (alpha)	15.14	16
M fixed at	0.25	0.25
MFMT [= $F_{SPR30\%}$[		0.79
MSST [= (1-M)*$SSB_{SPR30\%}$)]		5.35E+13
F_{OY} [= 0.75 * $F_{SPR30\%}$]		0.59
F Ratios		
F_{2004}/F_{MSY}	0.65	0.60
F_{2004}/F_{SPR30}	0.67	0.62
Biomass Ratios		
SSB_{2004}/SSB_{MSY}	1.80	1.52
SSB_{2004}/SSB_{SPR30}	1.75	1.47

Table A3.9.1 Projected fishing mortality rates from the "Current F" projection. This projection uses a fixed F (F_{2004} = 0.49) from 2005 to 2016.

YEAR	F	F/F_{MSY}	F/F_{SPR30}
2005	0.49	0.60	0.62
2006	0.49	0.60	0.62
2007	0.49	0.60	0.62
2008	0.49	0.60	0.62
2009	0.49	0.60	0.62
2010	0.49	0.60	0.62
2011	0.49	0.60	0.62
2012	0.49	0.60	0.62
2013	0.49	0.60	0.62
2014	0.49	0.60	0.62
2015	0.49	0.60	0.62
2016	0.49	0.60	0.62

Table A3.9.2 Projected SSB estimates from the "Current F" projection.

YEAR	SSB	LCI	UCI	SSB/SSB_{MSY}	LCI	UCI	SSB/SSB_{SPR30}	LCI	UCI
2005	1.07E+14	9.28E+13	1.27E+14	1.55	1.35	1.84	1.49	1.30	1.77
2006	1.07E+14	8.86E+13	1.40E+14	1.56	1.29	2.03	1.51	1.24	1.96
2007	1.08E+14	8.97E+13	1.50E+14	1.57	1.30	2.18	1.52	1.26	2.10
2008	1.09E+14	9.46E+13	1.51E+14	1.58	1.38	2.19	1.52	1.33	2.11
2009	1.09E+14	9.00E+13	1.61E+14	1.59	1.31	2.33	1.53	1.26	2.25
2010	1.09E+14	9.27E+13	1.63E+14	1.59	1.35	2.37	1.53	1.30	2.29
2011	1.10E+14	9.20E+13	1.57E+14	1.60	1.34	2.28	1.54	1.29	2.19
2012	1.10E+14	9.55E+13	1.56E+14	1.60	1.39	2.27	1.54	1.34	2.19
2013	1.10E+14	9.63E+13	1.64E+14	1.60	1.40	2.38	1.54	1.35	2.30
2014	1.10E+14	9.51E+13	1.56E+14	1.60	1.38	2.26	1.54	1.33	2.18
2015	1.10E+14	9.84E+13	1.50E+14	1.60	1.43	2.19	1.54	1.38	2.11
2016	1.10E+14	9.95E+13	1.47E+14	1.60	1.45	2.14	1.54	1.39	2.06

Table A3.9.3 Projected yield (lbs) and recruitment from the "Current F" projection.

YEAR	Yield	LCI	UCI	Recruitment	LCI	UCI
2005	6.81E+06	5.58E+06	8.60E+06	1.65E+07	1.06E+07	2.51E+07
2006	6.81E+06	5.37E+06	9.56E+06	1.66E+07	9.78E+06	2.80E+07
2007	6.80E+06	5.47E+06	1.00E+07	1.66E+07	1.01E+07	2.83E+07
2008	6.83E+06	5.41E+06	9.44E+06	1.66E+07	1.05E+07	2.89E+07
2009	6.85E+06	5.58E+06	1.07E+07	1.66E+07	1.04E+07	3.15E+07
2010	6.87E+06	5.55E+06	1.01E+07	1.66E+07	9.78E+06	2.93E+07
2011	6.88E+06	5.52E+06	1.01E+07	1.66E+07	1.05E+07	2.94E+07
2012	6.89E+06	5.97E+06	1.02E+07	1.66E+07	1.07E+07	3.08E+07
2013	6.90E+06	5.98E+06	1.10E+07	1.66E+07	1.11E+07	3.16E+07
2014	6.91E+06	5.55E+06	9.69E+06	1.66E+07	1.05E+07	2.49E+07
2015	6.91E+06	5.92E+06	9.90E+06	1.66E+07	1.02E+07	2.95E+07
2016	6.91E+06	5.75E+06	1.00E+07	1.66E+07	9.41E+06	2.92E+07

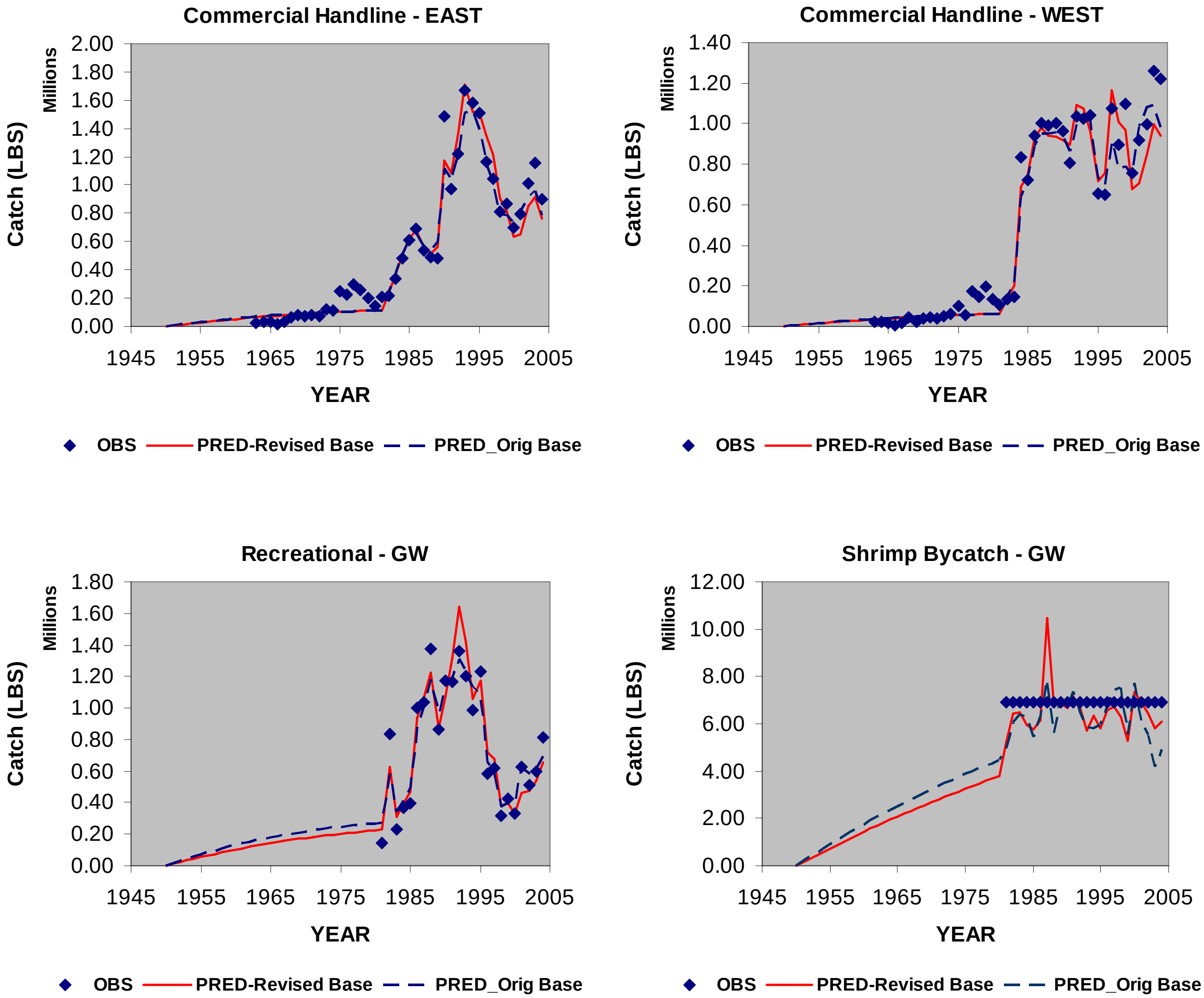


Figure A3.1.1 Comparison of the fits to the catch series for the original base case (dotted blue line) and the revised base case (red).

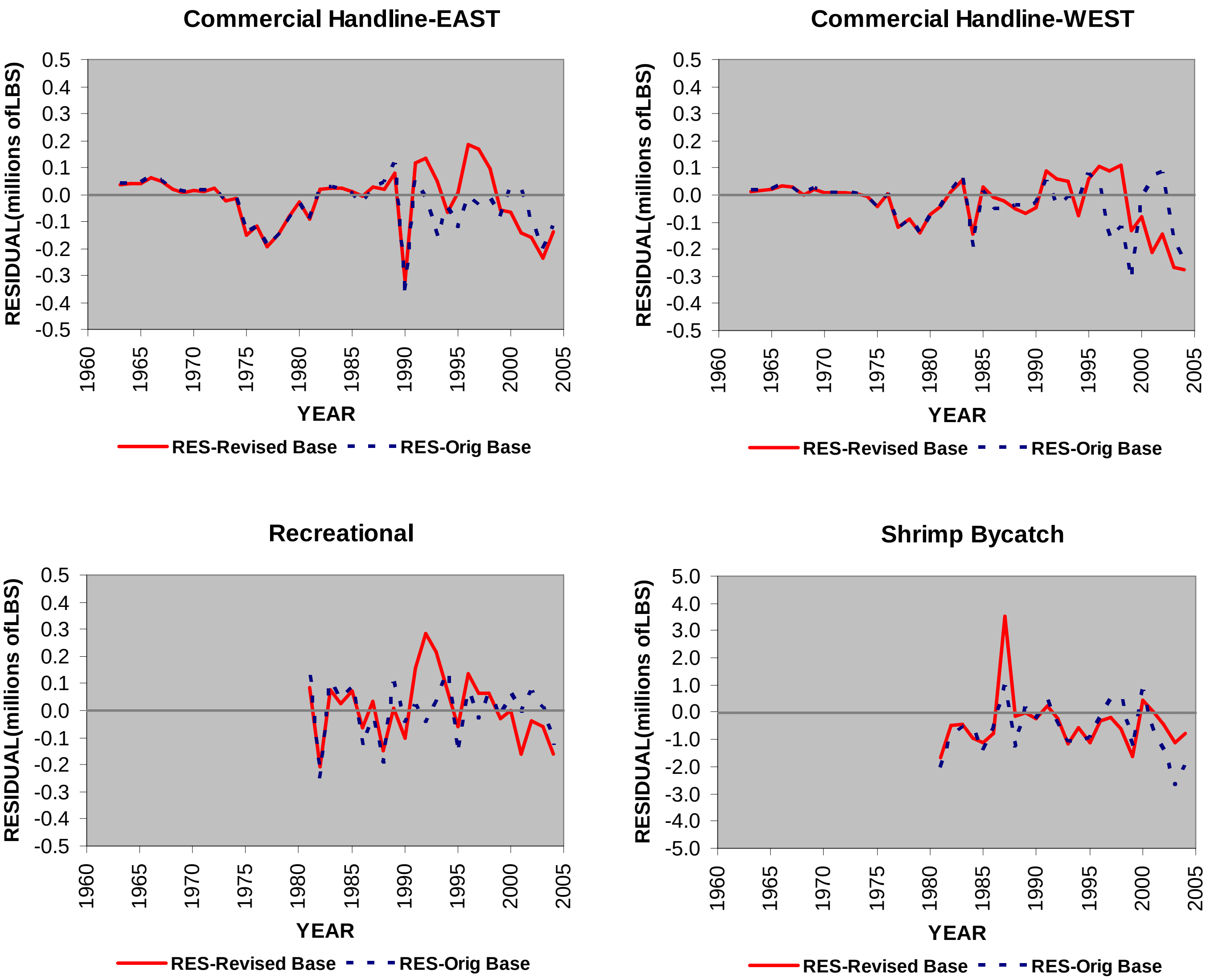


Figure A3.1.2. Comparison of the residuals for the fits to the catch series for the original base case (dotted blue line) and the revised base case (red). ***Note the different scale of the residuals for the shrimp bycatch.***

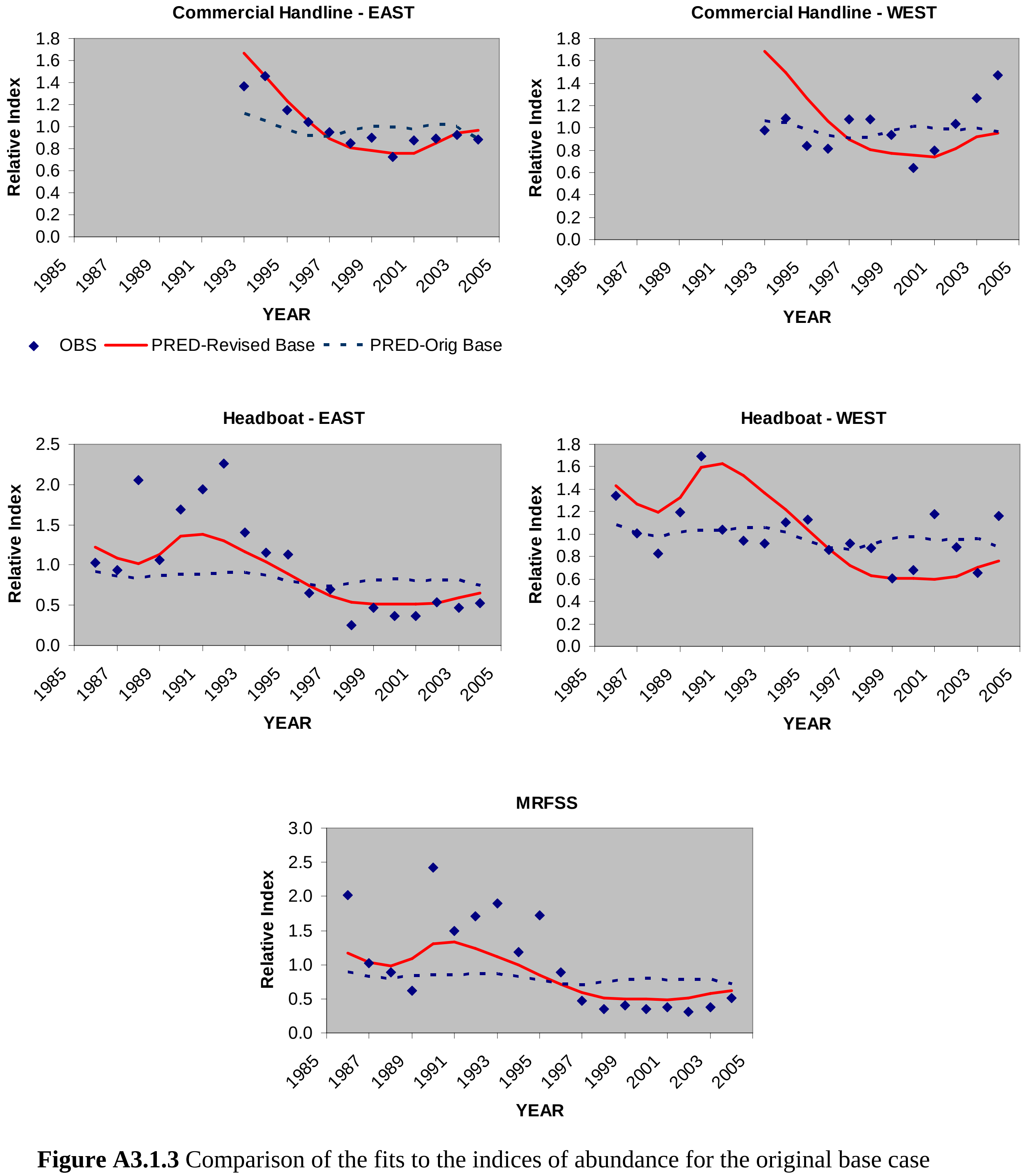


Figure A3.1.3 Comparison of the fits to the indices of abundance for the original base case (dotted blue line) and the revised base case (red).

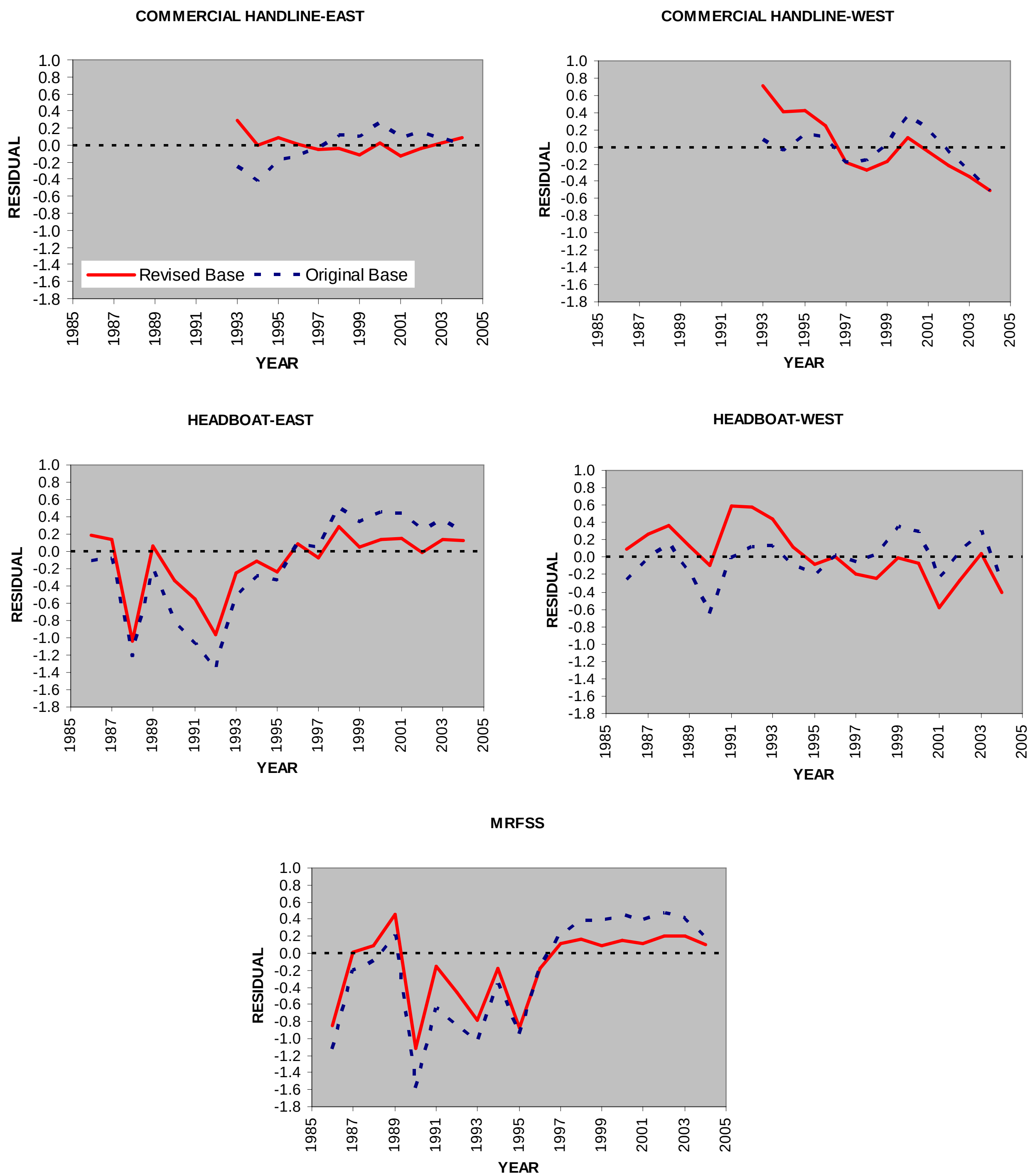


Figure A3.1.4. Comparison of the residuals of the fits to the indices of abundance for the original base case (dotted blue line) and the revised base case (red).

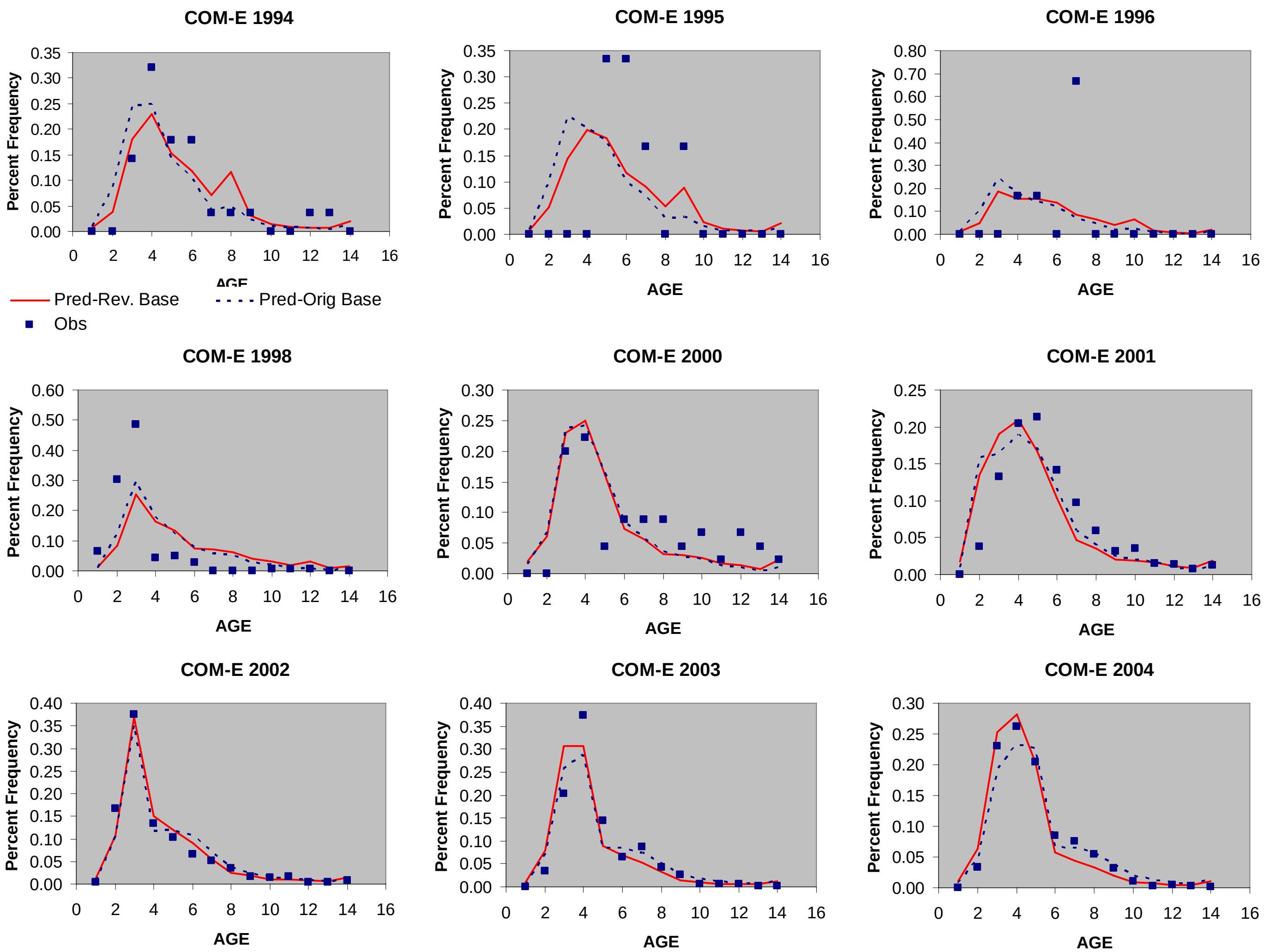


Figure A3.1.5. Fits to the observed age composition of the eastern commercial fishery for the original base case (dotted blue line) and the revised base case (red).

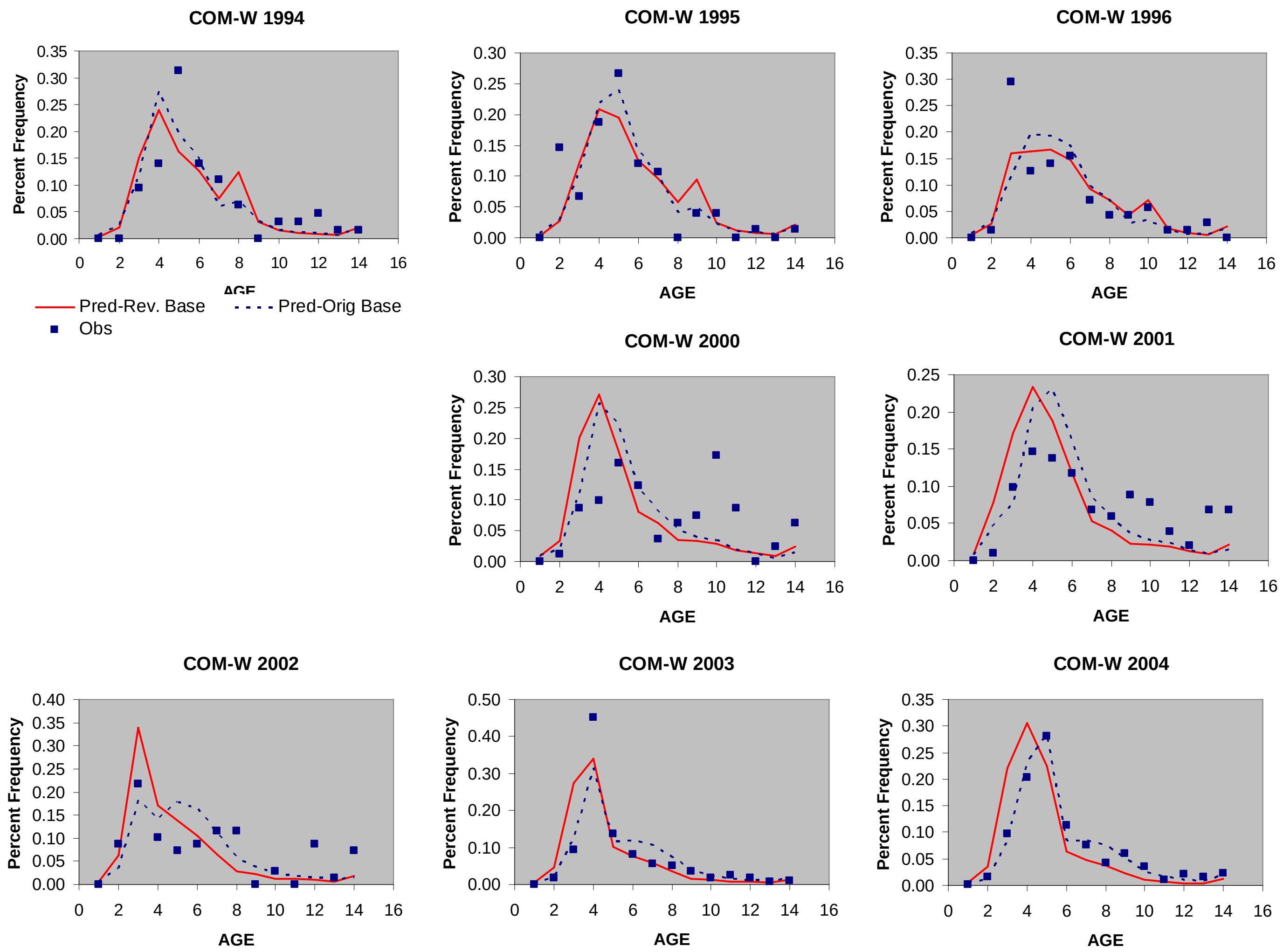


Figure A3.1.6. Fits to the observed age composition of the western commercial fishery for the original base case (dotted blue line) and the revised base case (red).

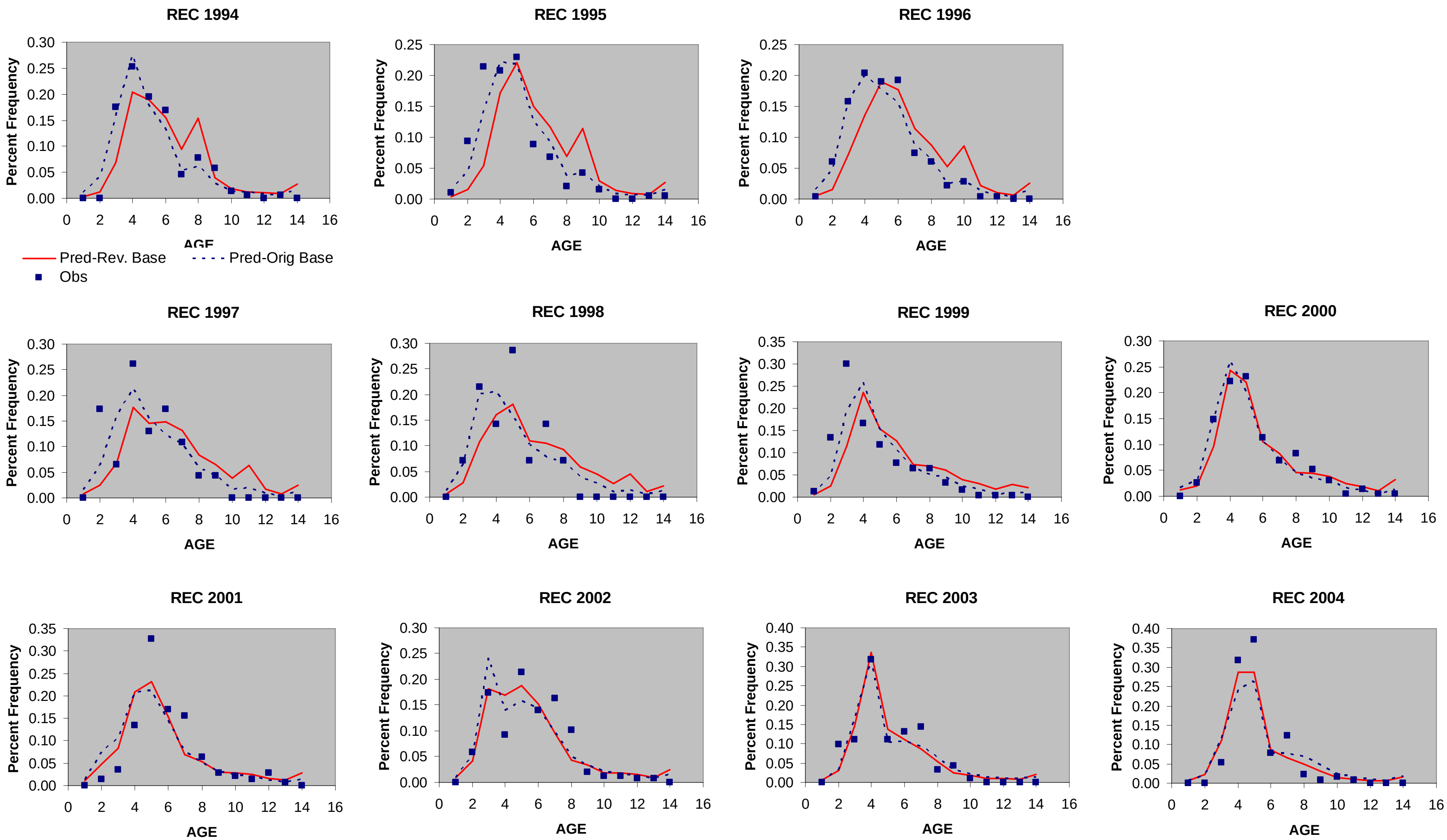


Figure A3.1.7. Fits to the observed age composition of the recreational fishery for the original base case (dotted blue line) and the revised base case (red).

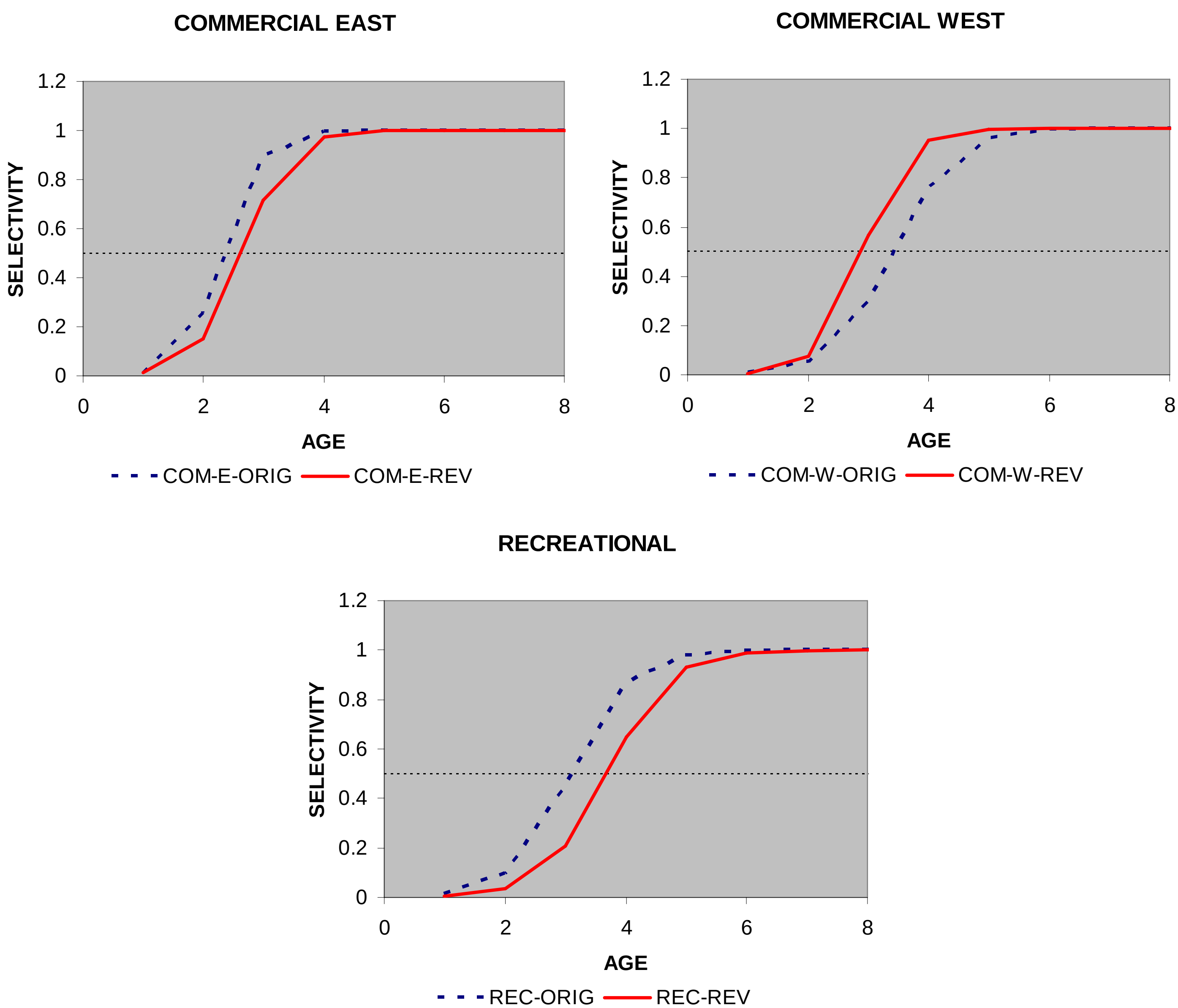


Figure A3.2.1. Comparison of relative selectivity for the original base case (dotted blue line) and the revised base case (red).

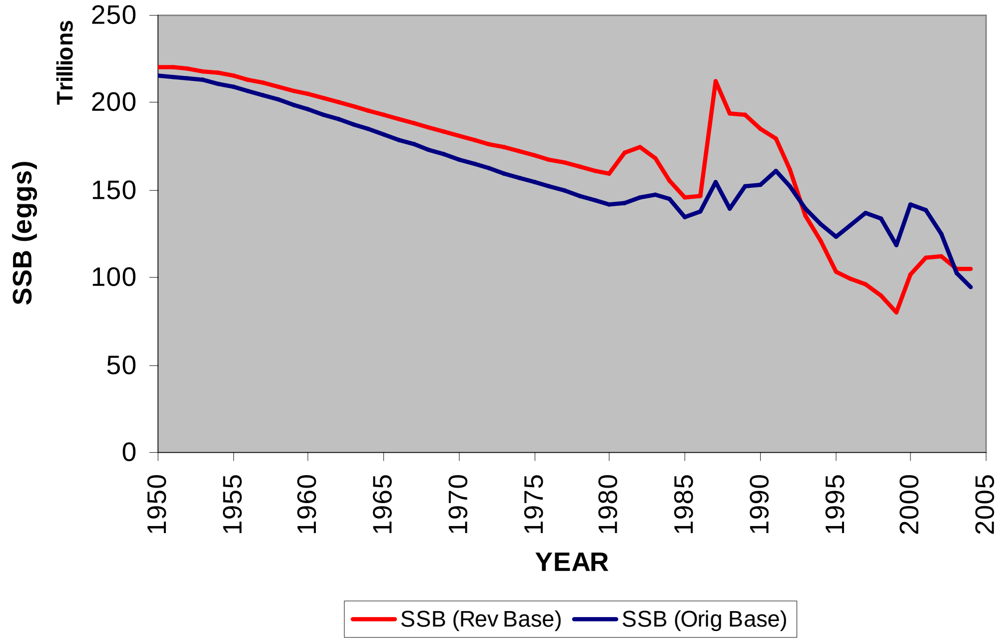


Figure A3.3.1. Comparison of the spawning stock biomass estimates for the original base case (blue) and the revised base case (red).

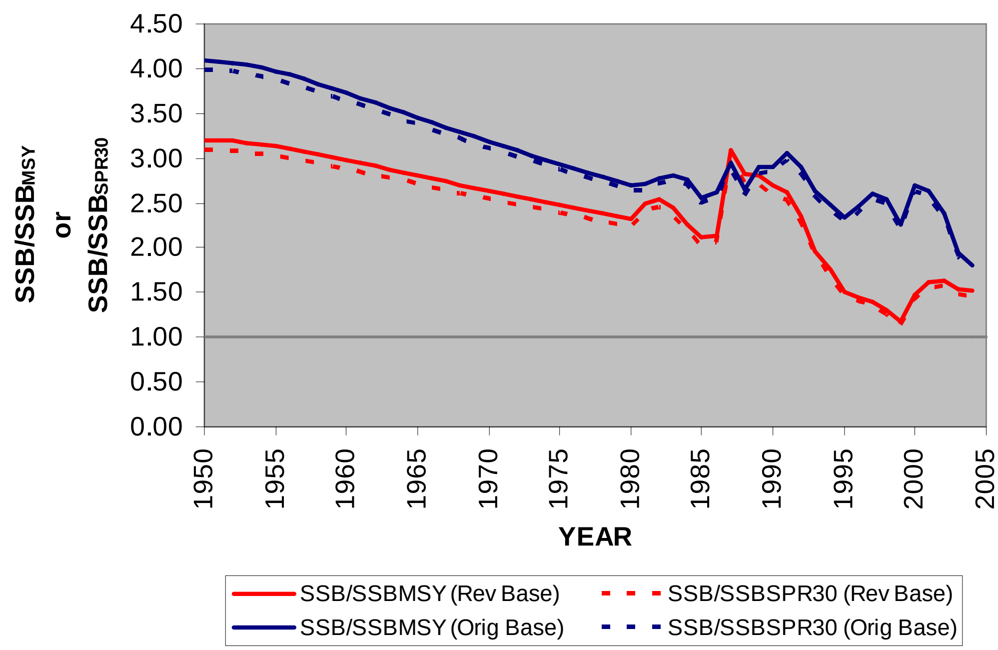


Figure A3.3.2. Comparison of the stock biomass trajectory, expressed relative to SSB_{MSY} (dotted) and SSB_{SPR30} (solid) for the original base case (blue series) and the revised base case (red series).

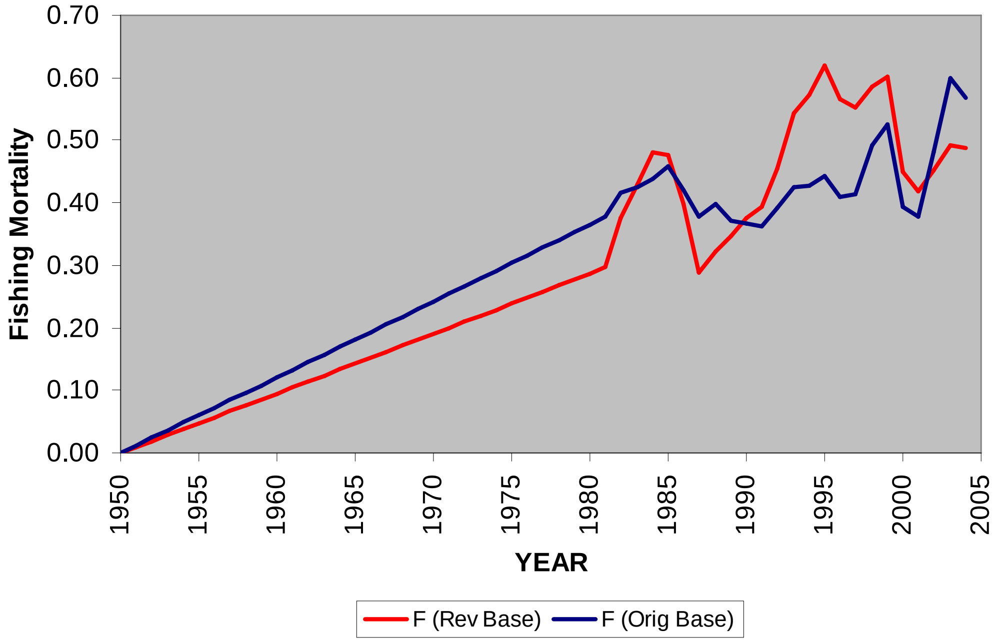


Figure A3.4.1. Comparison of the fishing mortality estimates for the original base case (blue) and the revised base case (red).

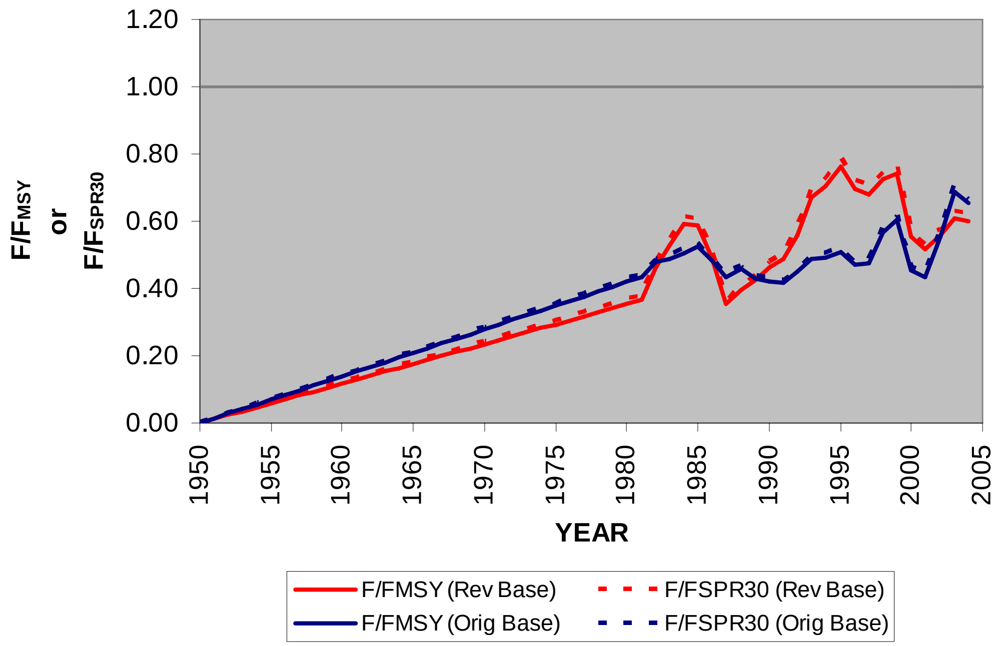


Figure A3.4.2. Comparison of the fishing mortality trajectory, expressed relative to F_{MSY} (dotted) and F_{SPR30} (solid) for the original base case (blue series) and the revised base case (red series).

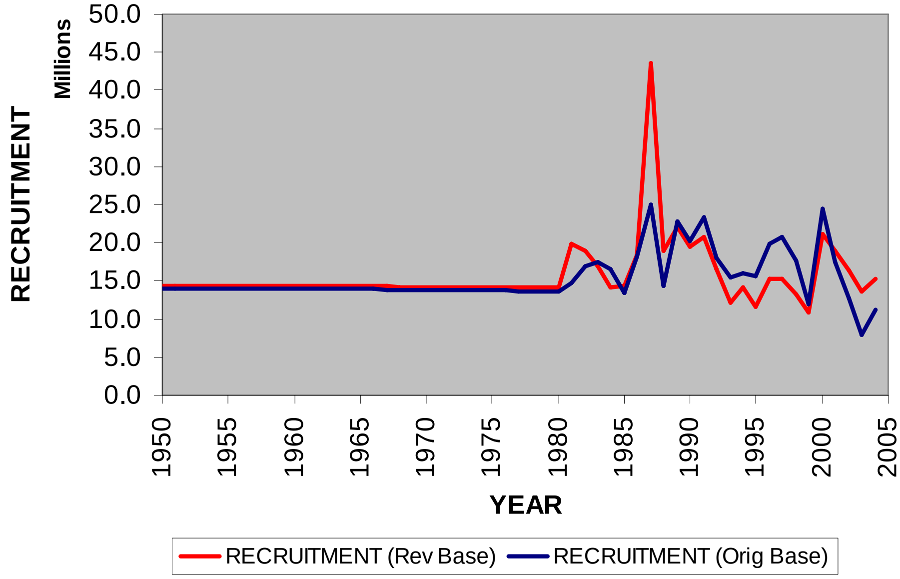


Figure A3.5.1. Comparison of the recruitment estimates for the original base case (blue) and the revised base case (red).

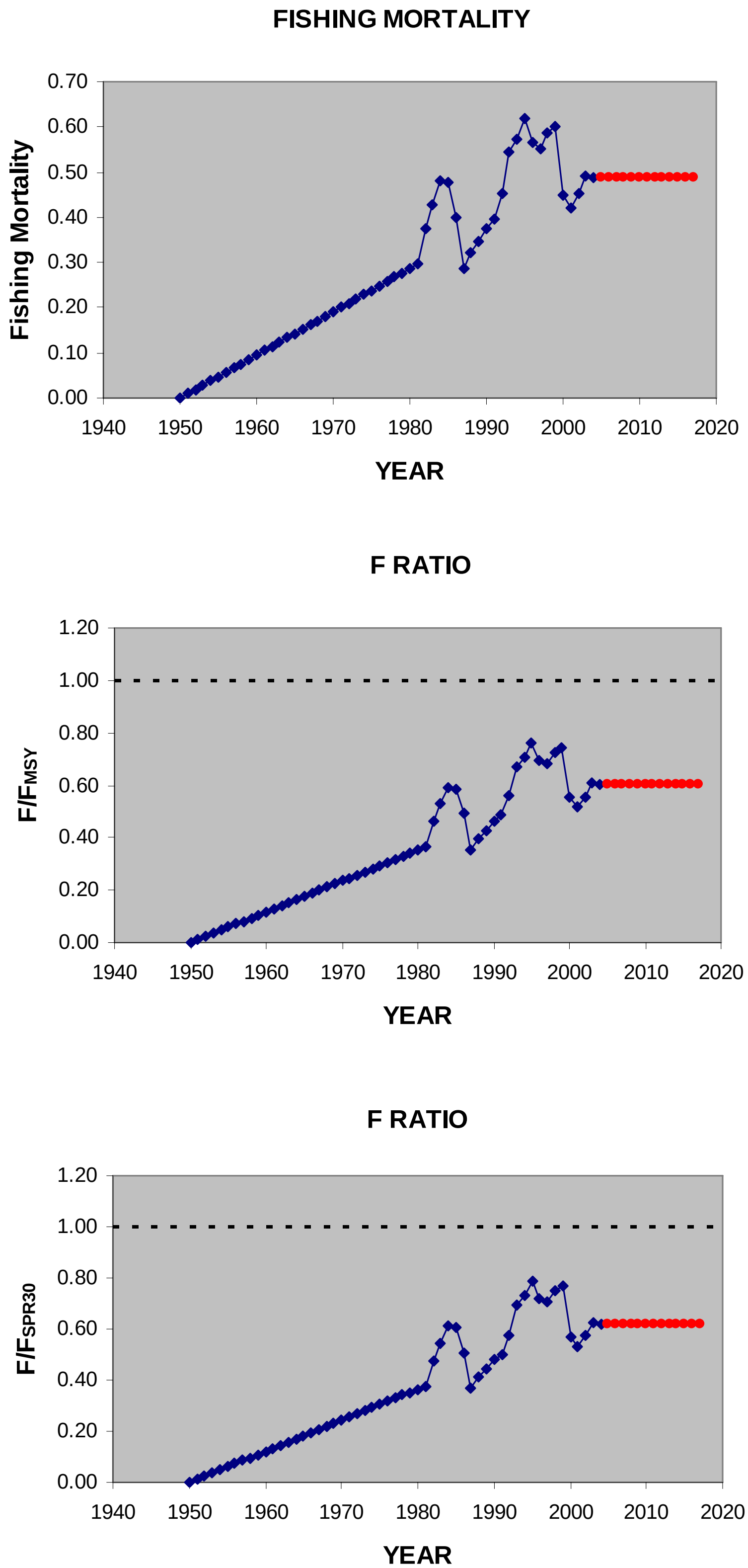


Figure A3.9.1 Projected fishing mortality (F), F/F_{MSY} and F/F_{SPR30} during 2005-2016 under the "Current F" scenario.

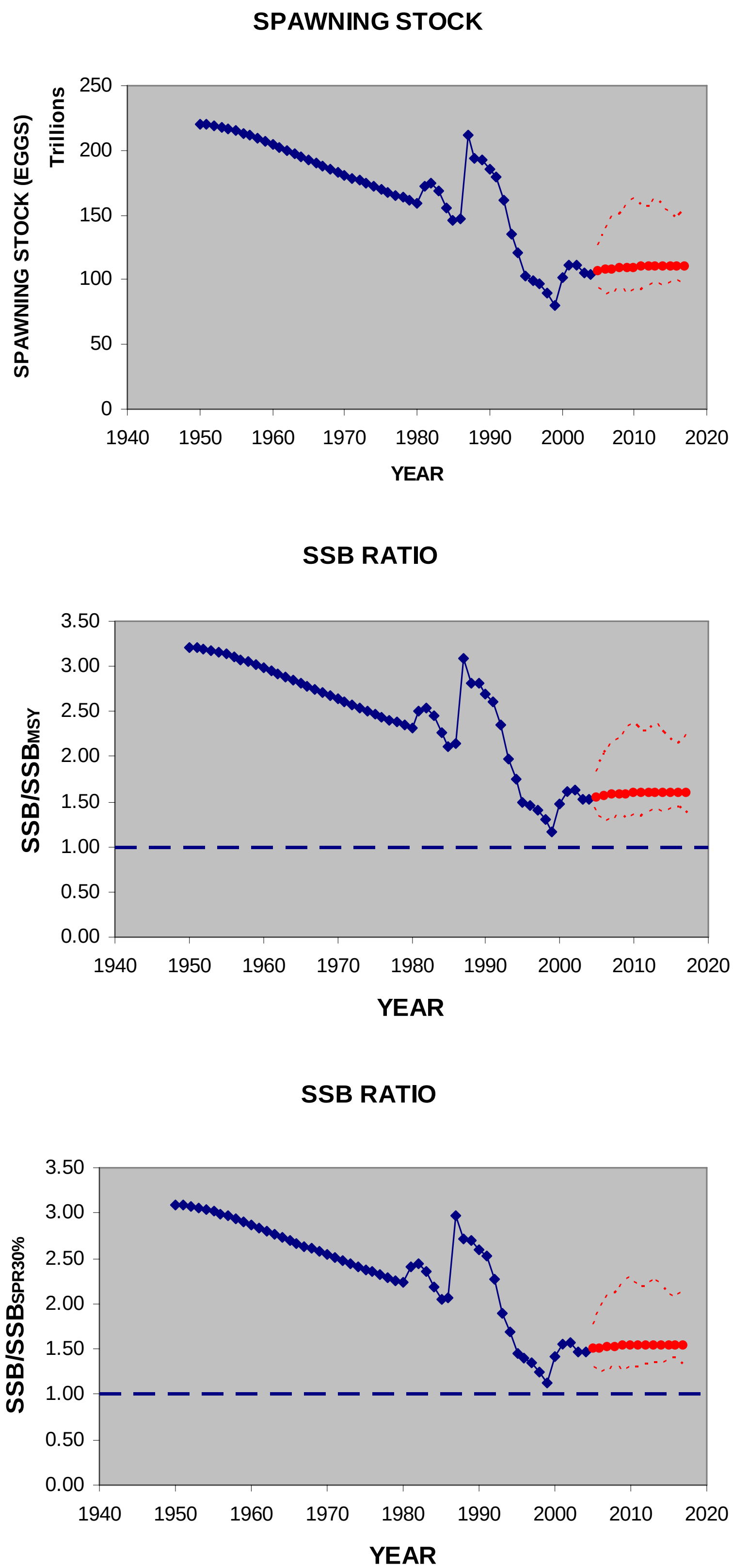
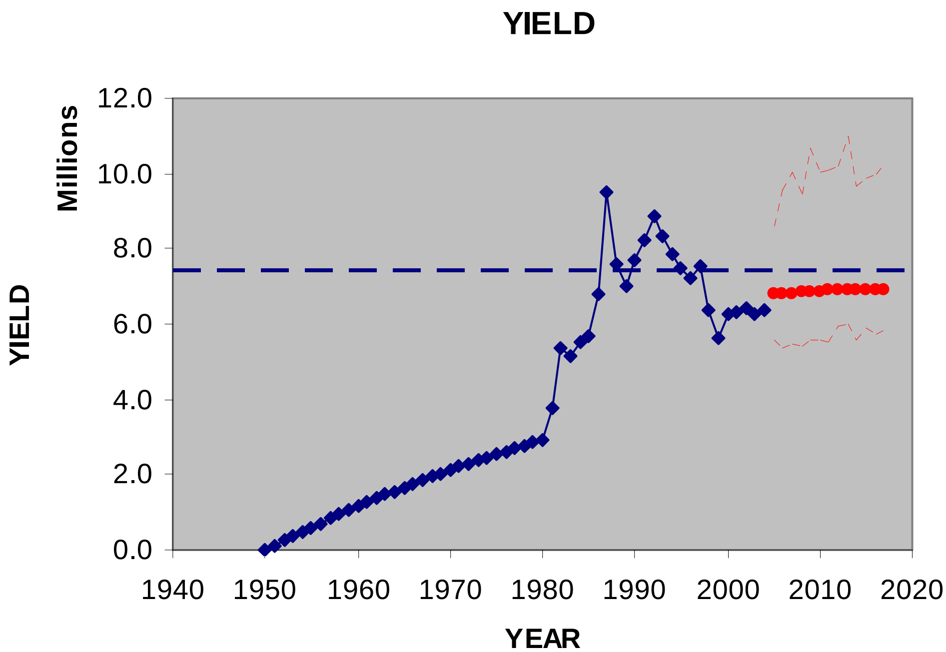


Figure A3.9.2 Projected spawning stock biomass (SSB), SSB/SSB_{MSY} and SSB/SSB_{SPR30} during 2005-2016 under the “Current F” scenario.



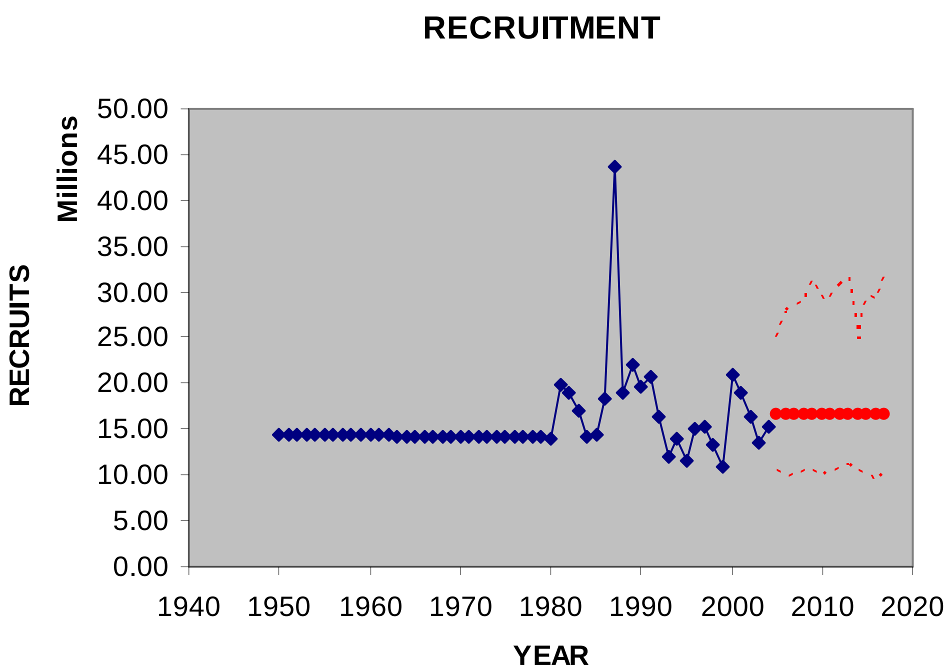


Figure A3.9.3 Projected yield (lbs) and recruitment (Age-1) during 2005-2016 under the "Current F" scenario.