SEDAR

Southeast Data, Assessment, and Review

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SEDAR 16
Stock Assessment Report

# South Atlantic and Gulf of Mexico King Mackerel

**March 2009**

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, Sc 29405

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# SEDAR

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## SECTION I: Introduction

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## 1. SEDAR PROCESS DESCRIPTION

SouthEast Data, Assessment, and Review (**SEDAR**) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and US Caribbean. SEDAR seeks improvements in the scientific quality of stock assessments and the relevance of information available to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commission representatives: 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. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

SEDAR workshops are public meetings organized by SEDAR staff and the lead Council. Workshop 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, 3 reviewers appointed by the Center for Independent Experts (CIE), and one reviewer appointed by each council having jurisdiction over the stocks assessed. 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.

# 2. MANAGEMENT OVERVIEW

## 2.1 *FISHERY MANAGEMENT PLAN AND AMENDMENTS*

The following summary describes only those management actions that likely affect king mackerel fisheries and harvest

*Original SAMFC/GMFMC FMP*

The Fishery Management Plan for Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic and Environmental Assessment (EA), approved in 1982 and implemented in February of 1983, treats king and Spanish mackerel each as one U.S. stock. It establishes allocations for recreational and commercial fisheries, with the commercial allocation divided between net and hook-and-line fishermen.

*Plan Amendments affecting king mackerel*

**Amendment 1** - Amendment 1 and its Environmental Impact Statement (EIS), implemented in September of 1985, provides a framework procedure for pre-season adjustment of total allowable catch (TAC), revises king mackerel maximum sustainable yield (MSY) downward, recognizes separate Atlantic and Gulf migratory groups of king mackerel, and establishes fishing permits and bag limits for king mackerel. Commercial allocations among gear users are eliminated. The Gulf commercial allocation for king mackerel is divided into eastern and western zones for the purpose of regional allocation.

**Amendment 2 -** Amendment 2 with EA, implemented in July of 1987, revises Spanish mackerel MSY downward, recognizes two migratory groups, and sets commercial quotas and bag limits. Charterboat permits are required. The Amendment clarifies that TAC for overfished stocks must be set below the upper range of acceptable biological catch (ABC). The use of purse seines on overfished stocks is prohibited.

**Amendment 3 -** Amendment 3 with EA, was partially approved in 1989, revised, resubmitted, and approved in 1990. It prohibits drift gill nets for coastal pelagics and purse seines for the overfished groups of mackerels.

**Amendment 5 -** Amendment 5 with EA was implemented in August 1990. It extends the management area for Atlantic groups of mackerel through the Mid-Atlantic Fishery Management Council's (MAFMC) area of jurisdiction; revises problems in the fishery and plan objectives; revises the definition of "overfishing"; and provides that the South Atlantic Fishery Management

Council (SAFMC) will be responsible for pre-season adjustments of TACs and bag limits for the Atlantic migratory groups, while the Gulf Council will be responsible for Gulf migratory groups.

It also continues to manage the two recognized Gulf migratory groups of king mackerel as one until management measures appropriate to the eastern and western groups can be determined; redefines recreational bag limits as daily limits; deletes a provision that specified that bag limit catches of mackerel may be sold; provides guidelines for corporate commercial vessel permits; specifies that Gulf group king mackerel may be taken only by hook-and-line and run-around gill nets; establishes a minimum size of 12" FL or 14" TL for king mackerel and includes a definition of "conflict" to provide guidance to the Secretary.

**Amendment 6 -** Amendment 6, implemented in November 1992, identifies additional problems and an objective in the fishery; provides for rebuilding overfished stocks within specific periods; provides for biennial assessments and adjustments; provides for more seasonal adjustment actions, including size limits, vessel trip limits, closed seasons or areas, and gear restrictions; and allows Gulf group king mackerel stock identification and allocation when appropriate. It also changes commercial permit requirements to allow qualification in one of three preceding years; discontinues the reversion of the bag limit to zero when the recreational quota is filled; modifies the recreational fishing year to the calendar year; and changes the minimum size limit for king mackerel to 20" fork length, and changes all size limit measures to fork length only.

**Amendment 7 -** Amendment 7, implemented in September 1994, equally divides the Gulf commercial allocation in the Eastern Zone at the Dade-Monroe County line in Florida. The sub-allocation for the area from Monroe County through Western Florida is equally divided between commercial hook-and-line and net gear users.

**Amendment 8 -** Amendment 8, implemented in March 1998, makes the following changes to the management regime: Clarifies allowable gear specifications for the Gulf group king mackerel fishery by allowing only hook-and-line and run-around gill nets. Catch by permitted, multi-species vessels and bycatch allowances for purse seines are maintained; establishes the Council's intent to evaluate the impacts of permanent jurisdictional boundaries between the GMFMC and SAFMC and separate FMPs for coastal pelagics in these areas; establishes a moratorium on commercial king mackerel permits until no later than October 15, 2000, with a qualification date for initial participation of October 16, 1995; legalizes retention of up to 5 cut-off (damaged) king mackerel on vessels with commercial trip limits; sets an optimum yield (OY) target at 30% static SPR; provides the SAFMC with authority to set vessel trip limits, closes seasons or areas, and gear restrictions for Gulf group king mackerel in the North Area of the Eastern Zone (Dade/Monroe to Volusia/Flagler County lines); establishes various data consideration and reporting requirements under the Framework Procedure, and modifies the seasonal framework adjustment measures and specifications.

**Amendment 9 -** Amendment 9, implemented in April 2000, reallocates the percentage of the commercial allocation of TAC for the North Area (Florida east coast) and South/West Area (Florida west coast) of the Eastern Zone to 46.15% North and 53.85% South/West and retain the recreational and commercial allocations of TAC at 68% recreational and 32% commercial; subdivides the commercial hook-and-line king mackerel allocation for the Gulf group, Eastern

Zone, South/West Area (Florida west coast) by establishing 2 subzones with a dividing line between the 2 subzones at the Collier/Lee County line; establishes regional allocations for the west coast of Florida based on the 2 subzones with 7.7% of the Eastern Zone allocation of TAC being allowed from Subzone 2 and the remaining 92.3% being allocated as follows: 50% - Florida east coast; 50% - Florida west coast; 50% - Net Fishery; 50% - Hook-and-Line Fishery; and establishes a trip limit of 3,000 pounds per vessel per trip for the Western Zone.

Amendment 9 also establishes a moratorium on the issuance of commercial king mackerel gill-net endorsements and allows re-issuance of gill-net endorsements to only those vessels that: (1) had a commercial mackerel permit with a gill-net endorsement on or before the moratorium control date of October 16, 1995 (Amendment 8), and (2): had landings of king mackerel using a gill net in one of the two fishing years 1995-96 or 1996-97 as verified by NMFS or trip tickets from the FDEP; allows the transfer of gill net endorsements to immediate family members (son, daughter, father, mother, or spouse) only; and prohibits the use of gill nets or any other net gear for the harvest of Gulf group king mackerel south of an east/west line at the Collier/Lee County line. The Amendment also increases the minimum size limit for Gulf group king mackerel from 20" to 24" fork length and allows the retention and sale of cut-off (damaged) legal-sized king and Spanish mackerel.

**Amendment 10 -** Amendment 10, implemented on July 14, 2000, incorporates essential fish habitat (EFH) provision for the South Atlantic Fishery Management Council (SAFMC).

**Amendment 11 -** Amendment 11, implemented on December 2, 1999, includes proposals for mackerel in the SAFMC's Comprehensive Amendment Addressing Sustainable Fishery Act Definitions and other Provisions in Fishery Management Plans of the South Atlantic Region.

**Amendment 12 -** Amendment 12, implemented in October 2000, extends the commercial king mackerel permit moratorium from October 15, 2000 to October 15, 2005, or until replaced with a license limitation, limited access, and/or individual fishing quota or individual transferable quota system, whichever occurs first.

**Amendment 13 -** Amendment 13, implemented in August 2002, establishes two marine reserves in the EEZ in the vicinity of the Dry Tortugas, Florida, known as Tortugas North and Tortugas South, in which fishing for coastal migratory pelagic species is prohibited. This action complements previous actions taken under the National Marine Sanctuaries Act.

**Amendment 14 -** Amendment 14, implemented July 29, 2002, establishes a three-year moratorium on the issuance of charter vessel and headboat permits, unless replaced sooner by comprehensive effort limitation system. The control date for eligibility was established as March 29, 2001. The amendment includes provisions for eligibility, application, appeals, and transferability.

**Amendment 15 -** Amendment 15, implemented in 2005, to the CMP FMP in the Atlantic and Gulf of Mexico establishes two actions. Action 1 establishes an indefinite limited access program for the king mackerel fishery in the exclusive economic zone under the jurisdiction of the Gulf of

Mexico, South Atlantic, and Mid-Atlantic Fishery Management Councils. Action 2 changes the fishing season to March 1 through February 28/29 for the Atlantic groups of king and Spanish mackerel. Beginning the fishing year on March 1 ensures the mackerel fisheries in the Atlantic are open when other fisheries are closed.

**Amendment 17 –** Amendment 17, implemented in XXXX, establishes a limited access system on for-hire reef fish and CMP permits. Permits are renewable and transferable in the same manner as currently prescribed for such permits. The Council will have periodic review at least every 10 years on the effectiveness of the limited access system.

South Atlantic Council Regulatory Amendments

Letter from Gulf Council Chair to Andrew Kemmerer dated May 7, 1990 with Regulatory Impact Review prepared by GMFMC and NMFS (May 1990) attached: Atlantic migratory group king mackerel: ABC = 6.5 – 15.7 Mlb, TAC = 8.3 Mlb, commercial allocation (37.1%) = 3.08 Mlb, recreational allocation (62.9%) = 5.22 Mlb = 601,000 fish ; and bag limit of 2 per person per trip off FL and 3 fish per person per trip off GA, SC & NC. The definition of overfishing was set at 40% Spawning Stock Biomass for king mackerel.

Letter from Gulf and South Atlantic Council Chairs to Andrew Kemmerer dated May 17, 1991 with Regulatory Impact Review prepared by GMFMC and NMFS (May 1991) attached: Atlantic migratory group king mackerel: ABC = 9.6 – 15.5 Mlb, TAC = 10.5 Mlb, commercial allocation (37.1%) = 3.9 Mlb, recreational allocation (62.9%) = 6.6 Mlb = 735,000 fish ; and bag limit of 5 fish per person per day throughout the range.

*May 1994:* Framework Seasonal Adjustment of Harvest Levels and Procedures under the Fishery Management Plan for Coastal Pelagics in the Gulf of Mexico and South Atlantic includes Environmental Assessment and Regulatory Impact Review) - For the 1994/1995 season, Atlantic Migratory Group king mackerel: ABC = 7.6-10.3 Mlb; TAC is lowered from 10.5 to 10 Mlb; bag limit remains unchanged at 5/person/day off GA-NY and 2/person/day off FL; commercial allocation (37.1%) = 3.71 Mlb and recreational allocation (62.9%) = 6.29 Mlb/8.87 pounds per fish = 709,100 fish.

*February 1995*: Revised Final Regulatory Amendment (Including Regulatory Impact Review and Environmental Assessment) for the Fishery management Plan for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexico and South Atlantic Regions - Set trip limits for Atlantic Migratory Group King Mackerel: (a) 4/1 thru 3/31 from Volusia/Flagler to NY/CT = 3,500 pounds; (b) 4/1 thru 10/31 from Brevard/Volusia to Volusia/Flagler = 3,500 pounds; and (c) 4/1 thru 10/31 from Collier/Monroe to Brevard/Volusia = 50 fish.

*June 1995*: Framework Seasonal Adjustment of Harvest Levels and Procedures under the Fishery Management Plan for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexcio and South Atlantic Region (Including Regulatory Impact Review, Social Impact Assessment and Environmental Assessment) - For fishing year 1995/96 for Atlantic Migratory Group king mackerel: ABC = 7.3-15.5 Mlb; TAC is lowered from 10 to 7.3 Mlb; bag limit is reduced from 5 to 3 fish per person per day off NY through GA effective 1/1/96 while the bag limit remains unchanged at 2/person/day off FL; commercial allocation (37.1%) = 2.7 Mlb and recreational allocation (62.9%) = 4.6 Mlb/10.11 pounds per fish = 454,995 fish.

*September 1996:* Framework Seasonal Adjustment of Harvest Levels and Procedures under the Fishery Management Plan for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexcio and South Atlantic Region (Including Regulatory Impact Review, Social Impact Assessment and Environmental Assessment) - For fishing year 1996/97 for Atlantic Migratory Group king mackerel: ABC = 4.1-6.8 Mlb; TAC is lowered from 7.3 to 6.8 Mlb; bag limit remains unchanged at 3 fish per person per day off NY through GA and 2/person/day off FL; commercial allocation (37.1%) = 2.52 Mlb and recreational allocation (62.9%) = 4.28 Mlb/9.76 pounds per fish (from 1995 stock assessment) = 438,525 fish.

*May 1997*: Framework Seasonal Adjustment of Harvest Levels and Procedures under the Fishery Management Plan for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexcio and South Atlantic Region (Including Regulatory Impact Review, Social Impact Assessment and Environmental Assessment) - For fishing year 1997/98 for Atlantic Migratory Group king mackerel – NO CHANGE TO ABC, TAC OR BAG LIMITS: ABC = 4.1-6.8 Mlb; TAC is lowered from 7.3 to 6.8 Mlb; bag limit remains unchanged at 3 fish per person per day off NY through GA and 2/person/day off FL; commercial allocation (37.1%) = 2.52 Mlb and recreational allocation (62.9%) = 4.28 Mlb/9.76 pounds per fish (from 1995 stock assessment) = 438,525 fish. Revised trip limits for Atlantic migratory group king mackerel: (a) 4/1 thru 3/31 from Volusia/Flagler to NY/CT = 3,500 pounds (NO CHANGE); (b) 4/1 thru 10/31 from Brevard/Volusia to Volusia/Flagler = 3,500 pounds (NO CHANGE); (c) 4/1 thru 10/31 from DADE/Monroe to Brevard/Volusia = 50 fish; AND (d) 4/1 THRU 10/31 MONROE COUNTY = 125 FISH. (Note: new trip limits shown in all caps.)

*August 1998*: Framework Seasonal Adjustment of Harvest Levels and Procedures under the Fishery Management Plan for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexcio and South Atlantic Region (Including Regulatory Impact Review, Social Impact Assessment/Fishery Impact Statement and Environmental Assessment) - For fishing year 1998/99 for Atlantic Migratory Group king mackerel: ABC = 8.4-11.9 Mlb; TAC is increased from 6.8 to 8.4 Mlb; bag limit remains unchanged at 3 fish per person per day off NY through GA and 2/person/day off FL; commercial allocation (37.1%) = 3.12 Mlb and recreational allocation (62.9%) = 5.28 Mlb/10.46 pounds per fish (from 1998 stock assessment) = 504,780 fish. Atlantic migratory group king mackerel size limit increased from 20” FL to 24” FL. Revised trip limits for Gulf migratory group king mackerel in the northern area of the eastern subzone (Dade through Volusia Counties, Florida): the trip limit is increased from 50 fish to 75 fish throughout the entire season (Nov. – Mar. 31). Revised trip limits for Atlantic migratory group king mackerel: (a) 4/1 thru 3/31 from Volusia/Flagler to SC/NC = 3,500 pounds (NO CHANGE); (b) NORTH OF THE SC/NC LINE = 2,000 POUNDS YEAR-ROUND UNLESS 80% OF THE COMMERCIAL ALLOCATION IS TAKEN PRIOR TO FEBRUARY 1, THEN IT WOULD BR REDUCED TO 1,000 POUNDS; (c) 4/1 thru 10/31 from Brevard/Volusia to Volusia/Flagler = 3,500 pounds (NO CHANGE); (d) 4/1 thru 10/31 from DADE/Monroe to Brevard/Volusia = 50 fish; and (e) 4/1 thru 10/31 Monroe County = 125 fish. (Note: new trip limits shown in all caps.) NOTE: THIS FRAMEWORK SEASONAL ADJUSTMENT DID NOT TAKE PLACE. SEE BELOW (JULY 1999).

*January 2000*: South Atlantic Fishery Management Council Framework Seasonal Adjustment of Harvest Levels and Related Measures under the Fishery Management Plan for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexcio and South Atlantic Region (Including Regulatory Impact Review, Social Impact Assessment/Fishery Impact Statement and Environmental Assessment) - For fishing year 2000/2001 for Atlantic Migratory Group king mackerel: ABC = 8.9-13.3 Mlb; TAC is increased from 8.4 to 10.0 Mlb; bag limit remains unchanged at 3 fish per person per day off NY through GA and 2/person/day off FL; commercial allocation (37.1%) = 3.71 Mlb and recreational allocation (62.9%) = 6.29 Mlb/10.46 pounds per fish (from 1999 stock assessment) = 601,338 fish. Revised trip limits for Atlantic migratory group king mackerel: (a) 4/1 thru 3/31 from Volusia/Flagler to NY/CT = 3,500 pounds (NO CHANGE); (b) 4/1 thru 10/31 from Brevard/Volusia to Volusia/Flagler = 3,500 pounds (NO CHANGE); (c) 4/1 THRU 10/31 FROM DADE/MONROE TO BREVARD/VOLUSIA = 75 FISH; and (e) 4/1 thru 10/31 Monroe County = 125 fish. (Note: new trip limits shown in all caps.) MSY and status determination criteria were also revised to reflect the new biomass-based values.

<u>Gulf Council Regulatory Amendments:</u>

*May 1986*: Allowed charter boats to obtain commercial permits. For the 1986/87 season (July 1 - June 30), the amendment set TAC for Gulf group king mackerel at 2.9 MP with 0.93 MP commercial quota - 1.97 MP recreational allocation. The bag limit was set at two fish when fishing from boats without a captain and crew and three fish for when fishing from boats with a captain and crew - crew excluded. The commercial quota allocated 6% for purse seines, 64.5% for eastern zone (FL), and 29% for western zone (AL-TX).The recreational and commercial fisheries closed when the allocation is taken.

*May 1987*: For the 1987/88 season (July 1 - June 30), reduced TAC for Gulf group king mackerel to 2.2 MP with commercial quota of 0.7 MP and recreational allocation of 1.5 MP. The purse-seine allocation was set to zero.

*May 1988*: For the 1988/89 season set TAC for Gulf group king mackerel at 3.4 MP with commercial quota of 1.1 MP and recreational allocation 2.3 MP. The commercial quota was allocated 69% to eastern zone (FL) and 31% to western zone (AL-TX).

*May 1989*: For the 1989/1990 season increased TAC for Gulf group king mackerel to 4.25 MP with commercial quota 1.36 MP and recreational allocation 2.89 MP. The bag limit remained unchanged.

*May 1990*: For the 1990/1991 season the amendment left the TAC (4.25 MP) and bag limit for Gulf group king mackerel unchanged. The TAC (5.25 MP) for Gulf group Spanish mackerel also was unchanged.

*May 1991*: For the 1991/92 season increased TAC for Gulf group king mackerel to 5.75 MP with a 1.84 MP commercial quota and 3.91 MP recreational allocations. The king mackerel bag limit was modified to 2 fish off Florida and 2/3 AL-TX (See 1986/87 regulatory amendment for description). The amendment also set the overfishing thresholds at 30% SPR (SSBR).

*May 1992*: For the 1992/93 season increased TAC for Gulf group king mackerel to 7.8 MP with commercial quota of 2.50 MP and recreational allocation of 5.3 MP. The king mackerel bag limit was reduced to two fish per person including captain and crew of charter and head boats for the entire Gulf EEZ. The amendment deleted the requirement that bag limits for Gulf group king and Spanish mackerels revert to zero when allocations are projected to be harvested and the fisheries be closed. Emergency action added 259,000 pounds under 25-fish trip limit.

*July 1993*: Regulatory amendment for the 1993/94 season left the TAC and bag limits the same for Gulf group king mackerel. For the eastern zone (FL) commercial hook-and-line fisheries the trip limit for the FL east coast zone (FECZ) was set at 50 fish until 50% of the sub quota was taken and then reduced to 25 fish until the quota taken. For the FL west coast zone (FWCZ) there was no trip limit until 75% of the sub quota taken then reduced to 50 fish.

*May 1994*: For the 1994/95 season, left the TAC and bag limits unchanged for Gulf group king mackerel. Commercial gill net boats fishing king mackerel in the eastern zone were limited to 25,000 pounds per trip until 90 percent of the suballocation is taken; then 15,000 pound dail trip limit. FECZ modified to 50 fish until 25% of sub quota is taken then 25 fish per daily trip until the allocation is filled. Emergency action added 300,100 pounds under 125-fish trip limit.

*May 1995*: For the 1995/96 season, left TAC and bag limits for Gulf group king & Spanish mackerel. Hook-and-line trip limits for the FWCZ of the eastern zone set at 125 fish until 75% of the sub quota is taken, then it becomes 50 fish. If the 75 percent of quota is not taken by March 1, the =50 fish limit remains until the subquota is filled or the season end on March 31.

*July 1996*: For the 1996/97 season left TAC and bag limits unchanged for Gulf group king mackerel, except the bag limit for captain and crew of charter and head boats was changed to zero. The commercial hook-and-line trip limit for the FWCZ was 1,250 pounds per trip until 75% of the sub quota is taken, then it became 500 pounds per trip. FECZ was set at 750 pounds, then to 500 pounds when 75% taken.

*May 1997*: For the 1997/98 season increased TAC to 10.6 MP for Gulf group king mackerel. The zero bag limit for captain and crew of charter and head boats was rescinded. The commercial hook-and-line trip limit for the FECZ adjusted to 50 fish until the sub quota is taken.

*July 1998*: For the 1998/99 season, retained the TAC (10.6 Mlb) for the Gulf group king mackerel, but set the bag limit for captain and crew of charter and head boats at zero and retain the 2-fish bag limit for all other recreational fishermen.. The size limit for Gulf group king mackerel was increased from 20" to 24 inches (FL). The commercial king mackerel hook-and-line trip limit for the western zone (AL-TX) adjusted 3,000 pounds per trip. (Note: this is the first time trip limit established for king mackerel in the western zone).

*July 1999*: For the 1999-2000 season retained TAC for Gulf group king mackerel at 10.6 million pounds. It also established a 2-fish per person per day bag limit on Gulf group king mackerel for the captain and crew of for-hire vessels and retained this 2-fish bag limit for all other recreational fishermen. The fishing season for the commercial gill net fishery for Gulf group king mackerel opens at 6 a.m. eastern standard time (EST) on the Tuesday following the Martin Luther King, Jr. holiday, with the following weekend open as long as the quota has not been taken and all subsequent weekends and holidays are closed as long as the season remains open. Weekend and holiday closures will be from 6 a.m. Saturday to 6 a.m. Monday EST (or Tuesday if a Monday holiday is involved), and during this period boats with a net on board must be tied to the dock.

*July 2000*: Implemented on April 30, 2001, reduced TAC to 10.2 MP, provided a 2-fish bag limit for the captain and crew of for-hire vessels, and revised the trip limit for Gulf migratory group king mackerel in the northern area of the Eastern Zone (Miami-Dade through Volusia Counties, Florida) to remain at 50 fish until February 1. If the quota is not 75 percent filled as of February 1, the trip limit increases to 75 fish. If the quota is 75% filled or greater, the trip limit will remain at 50 fish.

*July 2003*: established definitions of maximum sustainable yield (MSY), optimum yield (OY), the overfishing threshold, and the overfished condition for Cobia and Gulf group king and Spanish mackerel.

NOTE: All plan amendments were approved by both Councils. Regulatory amendments were Council/migratory group specific.

## *2.2 EMERGENCY AND INTERIM RULES (IF ANY)*

<u>GMFMC</u>

An emergency rule in 1986 reduced TAC for Gulf group king mackerel from 14.4 million pounds to 5.2 million pounds.

An emergency rule in 1992 added 259,000 lbs. to the commercial Gulf group King mackerel TAC.

The Gulf Council requested emergency implementation (to be effective 11/1/93): The commercial quota for Eastern Zone Gulf group king mackerel (1.73 million pounds) be divided equally at the Dade-Monroe County line, with subquotas of 865,000 pound north, and the same amount south and west of the line.  NMFS approved and implemented for the fishing season begun in 11/93.

An emergency rule in 1994 added 300,000 lbs. to the commercial Gulf group King mackerel TAC.

## *2.3 CONTROL DATE NOTICES (IF ANY)*

SAFMC At the June 2006 SAFMC Council meeting, the SA Council approved a motion requesting establishment of June 15, 2004 as a control date for the Atlantic migratory group king mackerel fishery.

GMFMC October 16, 1995 – Date of requirement of having a commercial king mackerel permit in order to qualify for a moratorium permit.

## *2.4 MANAGEMENT PROGRAM SPECIFICATIONS*

**Table 2.4.1. General Management Information**

| | |
|---|---|
| Species | King Mackerel |
| Management Unit | King Mackerel |
| Management Unit Definition | Gulf and Atlantic Migratory Groups |
| Management Entity | SAFMC/GMFMC |
| Management Contacts<br>SERO / Council | SAFMC - Gregg Waugh<br>GMFMC - Rick Leard<br>SERO – Steve Branstetter |
| Current stock exploitation status | Not Overfishing – Gulf and Atlantic Groups |
| Current stock biomass status | Not Overfished - Gulf and Atlantic Groups |

**Table 2.4.2. Specific Management Criteria**

| Criteria | Gulf of Mexico - Current | | Gulf of Mexico - Alternative | |
|---|---|---|---|---|
| | Definition | Value | Definition | Value |
| MSST | 0.8(Bmsy) | | MSST = [(1-M) or 0.5 whichever is greater]*$B_{MSY}$ | SEDAR 16 |
| MFMT | Fmsy = F30%SPR | | $F_{MSY}$ | SEDAR 16 |
| MSY | Yield @30%SPR | 10.7 MP | Yield at $F_{MSY}$ | SEDAR 16 |
| $F_{MSY}$ | | | $F_{MSY}$ | SEDAR 16 |
| OY | Yield @ 0.85Fmsy | 10.2 MP | Yield at $F_{OY}$ | SEDAR 16 |
| $F_{OY}$ | 0.85Fmsy | | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$ | SEDAR 16 |
| M | -- | 0.2 | | SEDAR 16 |
| Probability value for evaluating status | 50% Fcurr> Fmsy = overfishing | 50% Bcurr < MSST = overfished | | |

| Criteria | South Atlantic – Current | | South Atlantic - Proposed | |
|---|---|---|---|---|
| | Definition | Value | Definition | Value |
| MSST | 0.85(Bmsy) | | MSST = [(1-M) or 0.5 whichever is greater]*$B_{MSY}$ | SEDAR 16 |
| MFMT | Fmsy = F30%SPR | | $F_{MSY}$ | SEDAR 16 |
| MSY | | 10.4 MP | Yield at $F_{MSY}$ | SEDAR 16 |
| $F_{MSY}$ | | | $F_{MSY}$ | SEDAR 16 |
| OY | Yield @ F40% SPR | | Yield at $F_{OY}$ | SEDAR 16 |
| $F_{OY}$ | F40% SPR | | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$ | SEDAR 16 |
| M | --- | 0.15 | | SEDAR 16 |
| Probability value for evaluating status | 50% Fcurr> Fmsy = overfishing | 50% Bcurr < MSST = overfished | | |

**Table 2.4.3. Stock projection information**

*(This provides the basic information necessary to bridge the gap between the terminal year of the assessment and the year in which any changes may take place or specific alternative exploitation rates should be evaluated)*

| Requested Information | Value |
|---|---|
| First Year of Management | 2010 |
| Projection Criteria during interim years should be based on (e.g., exploitation or harvest) | AW Panel determination |
| Projection criteria values for interim years should be determined from (e.g., terminal year, avg of X years) | AW Panel determination |

*First year of Management:* Earliest year in which management changes resulting from this assessment are expected to become effective

*interim years*: those between the terminal assessment year and the first year that any management could realistically become effective.

*Projection Criteria*: The parameter which should be used to determine population removals, typically either an exploitation rate or an average landings value or a pre-specified landings target.

**Table 2.4.4. Quota Calculation Details**

If the stock is managed by quota, please provide the following information

| Quota Detail | Gulf of Mexico Value | South Atlantic Value |
|---|---|---|
| Current ABC range ( million lbs) | 5.3 - 9.6 | 8.9-13.3 |
| Current TAC Value | 10.2 million lbs | 10.0 million lbs |
| Next Scheduled Quota Change | 2010/2011 | 2010/2011 |
| Commercial allocation | 3.26 | 3.7 |
| Recreational allocation | 6.94 | 6.3 |

The current quota is conditioned on exploitation and does not currently have a separate bycatch/discard allowance.

## *2.5 MANAGEMENT AND REGULATORY TIMELINE*

The following tables provide a timeline of management actions by fishery.

**Table 2.5.1. Annual Commercial King Mackerel Regulatory Summary**

| Year | Fishing Year | | Size Limit | Trip Limit | |
|---|---|---|---|---|---|
| | Atlantic | Gulf | | Atlantic | Gulf |
| 1983[1] | | | None | -- | -- |
| 1984[1] | | | None | -- | -- |
| 1985[2] | 4/1 - 3/31 | 7/1 - 6/30 | None | -- | -- |
| 1986 | 4/1 - 3/31 | 7/1 - 6/30 | None | -- | -- |
| 1987 | 4/1 - 3/31 | 7/1 - 6/30 | None | -- | -- |
| 1988 | 4/1 - 3/31 | 7/1 - 6/30 | None | -- | -- |
| 1989 | 4/1 - 3/31 | 7/1 - 6/30 | None | -- | -- |
| 1990[3] | 4/1 - 3/31 | 7/1 - 6/30 | 12 in FL or 14 in TL | -- | -- |
| 1991 | 4/1 - 3/31 | 7/1 - 6/30 | 12 in FL or 14 in TL | -- | -- |
| 1992 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | -- | -- |
| 1993 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | -- | i, j, k |
| 1994 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | -- | k, l, m, n |
| 1995 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | a, b | l, m, n, o |
| 1996 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | c, d, e | l, p, q |
| 1997 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | c, d, f, g | l, q, r |
| 1998 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | " | " |
| 1999 | 4/1 - 3/31 | 7/1 - 6/30 | 24 in FL | " | " |
| 2000 | 4/1 - 3/31 | 7/1 - 6/30 | 24 in FL | c, d, g, h | l, q, s, t |
| 2001 | 4/1 - 3/31 | 7/1 - 6/30 | 24 in FL | " | " |
| 2002 | 4/1 - 3/31 | 7/1 - 6/30 | 24 in FL | " | " |
| 2003 | 4/1 - 3/31 | 7/1 - 6/30 | 24 in FL | " | " |
| 2004 | 4/1 - 3/31 | 7/1 - 6/30 | 24 in FL | " | " |
| 2005 | 3/1 - 2/28-29 | 7/1 - 6/30 | 24 in FL | " | " |
| 2006 | 3/1 - 2/28-29 | 7/1 - 6/30 | 24 in FL | " | " |
| 2007 | 3/1 - 2/28-29 | 7/1 - 6/30 | 24 in FL | " | " |

[1]One stock

[2]Two management groups (Atlantic & Gulf migratory) from this point forward

[3]Management area expands from TX through NC to TX through NY

**Key to trip limit codes**

| | |
|---|---|
| a | Brevard/Volusia to NY -> 3,500 lb/trip (year round) |
| b | Brevard/Volusia to Monroe/Collier -> 50 fish/trip (4/1 - 10/31) |
| c | Volusia/Flagler to NY ->3,500lb/trip (year-round) |
| d | Volusia County -> 3,500lb/trip (4/1 - 10/31) |
| e | Brevard/Volusia to Collier/Monroe -> 50 fish/trip (4/1 - 10/31) |
| f | Brevard/Volusia to Miami-Dade/Monroe -> 50 fish/trip (4/1 - 10/31) |
| g | Monroe County -> 1,250 lb/trip (4/1 - 10/31) |
| h | Brevard/Volusia to Miami-Dade/Monroe -> 75 fish/trip (4/1 - 10/31) |
| i | FECZ -> 25 fish/trip limit under emergency addition of 259K lbs |
| j | FECZ -> 50 fish/vessel until 50% of suballocation, then 25 fish/vessel until quota taken (11/1-3/31) |
| k | FWCZ -> hook and line: no trip limit until 75% of subquota taken then 50 fish/trip |
| l | 25,000 lb trip limit for gillnets |
| m | FECZ -> hook and line: 50 fish/vessel until 25% of sub-allocation, then 25 fish/vessel until quota taken (11/1-3/31) |
| n | FWCZ -> 125 fish/trip (Emergency addition of 300,100 lbs - additional poundage was intended for the southern area) |
| o | FWCZ -> hook-and-line trip limit is 125 fish until 75% of subquota taken then 50 fish |
| p | FECZ -> hook and line: 750 lbs/trip until 75% of sub allocation taken, then 500 lbs/trip (11/1 - 3/31) |
| q | FWCZ -> hook and line: 1,250 lbs/trip until 75% of suballocation taken, then 500 lbs/trip |
| r | FECZ -> hook and line: 50 fish/trip (11/1 - 3/31) |
| s | FECZ -> 50 fish/trip until Feb 1; if quota not 75% filled by 2/1, then 75 fish; if quota 75% or greater, then stay at 50 fish |
| t | Gulf WZ -> 3,000 lb trip limit |

| | |
|---|---|
| FWCZ | Florida west coast subzone: AL/FL border to Collier/Monroe line (4/1-10/31) or Monroe/Miami-Dade line (11/1- 3/31) |
| FECZ | Florida east coast subzone: Monroe/Miami-Dade line to Volusia/Flagler line ((11/1 - 3/31) |
| Gulf WZ | Gulf western zone: US/Mexico border to Alabama/Florida border (7/1 - 6/30) |

## Table 2.5.2. Annual Recreational King Mackerel Regulatory Summary

| | Fishing Year | | | Bag Limit | | Closures | |
|---|---|---|---|---|---|---|---|
| **Year** | **Atlantic** | **Gulf** | **Size Limit** | **Atlantic** | **Gulf** | **Atlantic** | **Gulf** |
| 1983-1984[1] | | | -- | -- | -- | -- | -- |
| 1984-1985[1] | | | -- | -- | -- | -- | -- |
| 1985-1986[2] | | | | | | | |
| 1986-1987 | 4/1 - 3/31 | 7/1 - 6/30 | -- | Private = 2/person/trip; Charterboat = greater of 2/person incl capt&crew or 3/person excl capt&crew | | -- | -- |
| 1987-1988 | 4/1 - 3/31 | 7/1 - 6/30 | -- | 3/person/trip | " | | Closed 12/16/87 0001h |
| 1988-1989 | 4/1 - 3/31 | 7/1 - 6/30 | -- | 2/person/trip FL & 3 GA to SC | " | Closed 10/17/88 0001h | Closed 12/17/88 0001h |
| 1989-1990 | 4/1 - 3/31 | 7/1 - 6/30 | -- | 2/person/trip FL & 3 GA to SC | " | | |
| 1990-1991[3] | 4/1 - 3/31 | 7/1 - 6/30 | 12 in FL or 14 in TL | 2 FL; 3 GA-NY | Same as above[4] | | Closed 12/20/90 0001h |
| 1991-1992 | 4/1 - 3/31 | 7/1 - 6/30 | 12 in FL or 14 in TL | 5 FL-NY | " | | Closed 01/13/92 |
| 1992-1993 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | 2 FL; 5 GA-NY | 2 per person including captain & crew | | -- |
| 1993 | Calendar Year | | 20 in FL | " | " | | -- |
| 1994 | Calendar Year | | 20 in FL | " | " | | -- |
| 1995 | Calendar Year | | 20 in FL | 2 FL; 3 GA-NY | " | | -- |
| 1996 | Calendar Year | | 20 in FL | " | " | | -- |
| 1997 | Calendar Year | | 20 in FL | " | 2 per person, 0 capt&crew as of 6-97 | | -- |
| 1998 | Calendar Year | | 20 in FL | " | 2 per person, 2 capt&crew as of 2-98 | | -- |
| 1999 | Calendar Year | | 24 in FL | " | 2 per person, 0 capt&crew as of 9-99 | | -- |
| 2000 | Calendar Year | | 24 in FL | " | 2 per person, 2 capt&crew as of 6-00 | | -- |
| 2001 | Calendar Year | | 24 in FL | " | " | | -- |
| 2002 | Calendar Year | | 24 in FL | " | " | | -- |
| 2003 | Calendar Year | | 24 in FL | " | " | | -- |
| 2004 | Calendar Year | | 24 in FL | " | " | | -- |
| 2005 | Calendar Year | | 24 in FL | " | " | | -- |
| 2006 | Calendar Year | | 24 in FL | " | " | | -- |
| 2007 | Calendar Year | | 24 in FL | " | " | | -- |

[1]One stock  [2]Two management groups (Atl antic & Gulf migratory) from this point forward

[3]Management area expands from TX through NC to TX through NY

[4]Redefined as daily bag limits; 1-day possession except for-hire on multi-day can have 2-day possession

Table 2.5.3. Summary of quota management and harvest for the Gulf of Mexico migratory group of king mackerel.

| Fishing Year | ABC Range[1] (lbs) | TAC (lbs) | Recreational Allocation/Quota[2] (lbs. /numbers) | Commercial Allocation | East/West-EC/WC-North-South[3,4] | Annual Harvest Levels Com | Rec | Total[5] |
|---|---|---|---|---|---|---|---|---|
| 1986/87 | 1.2-2.9 | 2.9 | 1.97 | 0.93 | 0.60/0.27+PS=0.06 | 1.473 | 3.269 | 4.742 |
| 1987/88 | 0.6-2.7 | 2.2 | 1.5 | 0.70 | 0.48/0.22 | 0.868 | 2.145 | 3.013 |
| 1988/89 | 0.5-4.3 | 3.4 | 2.31 | 1.09 | 0.75/0.34 | 1.405 | 5.276 | 6.681 |
| 1989/90 | 2.7-5.8 | 4.25 | 2.89/298,000 | 1.36 | 0.94/0.42 | 1.954 | 3.36 | 5.314 |
| 1990/91 | 3.2-5.4 | 4.25 | 2.89/301,000 | 1.36 | 0.94/0.42 | 1.816 | 3.951 | 5.767 |
| 1991/92 | 4.0-7.0 | 5.75 | 3.91/574,000 | 1.84 | 1.27/0.57 | 2.117 | 4.773 | 6.89 |
| 1992/93 | 4.0-10.79 | 7.8 | 5.3/715,000 | 2.50+0.259 | 1.73+0.259/0.77[6] | 3.599 | 6.258 | 9.857 |
| 1993/94 | 1.9-8.1[7] | 7.8 | 5.3/759,000 | 2.5 | 1.73/0.77 | 2.572 | 6.146 | 8.718 |
| 1994/95 | 1.9-8.1[7] | 7.8 | 5.3/768,000 | 2.05+0.300 | 1.73+0.300/0.77[7] | 2.901 | 7.948 | 10.849 |
| 1995/96 | 1.9-8.1[7] | 7.8 | 5.3/629,000 | 2.5 | 1.73/0.77 | 2.645 | 6.265 | 8.91 |
| 1996/97 | 4.7-8.8 | 7.8 | 5.3/629,000 | 2.5 | 1.73/0.77 | 2.864 | 6.933 | 9.797 |
| 1997/98 | 6.0-13.7 | 10.6 | 7.21 | 3.39 | 2.34/1.05 | 3.445 | 6.6341 | 10.08 |
| 1998/99 | 7.1-10.8 | 10.6 | 7.21 | 3.39 | 2.34/1.05 | 3.895 | 5.235 | 9.13 |
| 1999/00 | 8.0-12.5 | 10.6 | 7.21 | 3.39 | 2.34/1.05 | 2.953 | 4.067 | 7.02 |
| 2000/01 | 5.5-8.8 | 10.2 | 6.94 | 3.26 | 3.25/1.01-1/04/1.21-0.169/1.04 | 3.079 | 5.061 | 8.14 |
| 2001/02 | 5.3 - 9.6 | 10.2 | 6.94 | 3.26 | 3.25/1.01-1/04/1.21-0.169/1.04 | 2.932 | 5.163 | 8.095 |
| 2002/03 | 5.3 - 9.6 | 10.2 | 6.94 | 3.26 | 3.25/1.01-1/04/1.21-0.169/1.04 | 3.126 | 4.764[8] | 7.89 |
| 2003/04 | 5.3 - 9.6 | 10.2 | 6.94 | 3.26 | 3.25/1.01-1/04/1.21-0.169/1.04 | 2.758 | 4.296 | 7.054 |
| 2004/05 | 5.3 - 9.6 | 10.2 | 6.94 | 3.26 | 3.25/1.01-1/04/1.21-0.169/1.04 | 2.904 | 3.26 | 6.164 |
| 2005/06 | 5.3 - 9.6 | 10.2 | 6.94 | 3.26 | 3.25/1.01-1/04/1.21-0.169/1.04 | 2.687 | 3.317 | 6.004 |

[1] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target: the Panel's best estimate of ABC has been intermediate to the end-point of this range. [2] Recreational quota in numbers is the allocation divided by an estimate of annual weight (not used prior to fishing year 1989). [3]East/West commercial allocations apply to all legal gears except purse seine in fishing year 1986 and are divided at the AL/FL border. [4]East zone allocations are divided into East Coast FL and West Coast FL, and West Coast FL is divided into North and South subzones. [5]Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing. [6]0.25 million pound allocation added to commercial allocation for L East only, opened 2/18/93-3/26/93.

[7]0.3 million pounds added to hook and line quota for Florida West Coast subzone.

[8]2002-03 recreational landings, in pounds, were estimated from the average of 1999-2001 landings.

Table 2.5.4. . Summary of quota management and harvest for the South Atlantic of Mexico migratory group of king mackerel.

| Fishing Year | ABC Range[1] (lbs) | TAC (lbs) | Recreational Allocation/Quota[2] (lbs. /numbers) | Commercial Allocation | Annual Harvest Levels Com | Rec | Total[3] |
|---|---|---|---|---|---|---|---|
| 1986/87 | 6.9-15.4 | 9.68 | | 3.59 (PS=0.40) | 2.84 | 5.98 | 8.82 |
| 1987/88 | 6.9-15.4 | 9.68 | 6.09 | 3.59 (PS=0.40) | 3.453 | 3.905 | 7.357 |
| 1988/89 | 5.5-10.7 | 7.00 | 4.4 | 2.6 (PS=0.40) | 3.091 | 4.881 | 7.972 |
| 1989/90 | 6.9-15.4 | 9.00 | 5.66/666,000 | 3.34 | 2.635 | 3.4 | 6.036 |
| 1990/91 | 6.5-15.7 | 8.30 | 5.22/601,000 | 3.08 | 2.676 | 3.718 | 6.394 |
| 1991/92 | 9.6-15.5 | 10.50 | 6.60/735,000 | 3.9 | 2.516 | 5.822 | 8.338 |
| 1992/93 | 8.6-12.0 | 10.50 | 6.60/834,000 | 3.9 | 2.227 | 6.251 | 8.477 |
| 1993/94 | 9.9-14.6 | 10.50 | 6.60/854,000 | 3.9 | 2.018 | 4.438 | 6.456 |
| 1994/95 | 7.6-10.3 | 10.00 | 6.29/709,000 | 3.71 | 2.197 | 3.728 | 5.925 |
| 1995/96 | 7.3-15.5 | 7.30 | 4.60/454,000 | 2.7 | 1.87 | 4.153 | 6.023 |
| 1996/97 | 4.1-6.8 | 6.80 | 4.28/438,525 | 2.52 | 2.702 | 3.99 | 6.692 |
| 1997/98 | 4.1-6.8 | 6.80 | 4.28/438,525 | 2.52 | 2.684 | 5.158 | 7.843 |
| 1998/99 | 8.4-11.9 | 8.40 | 5.28/504,780 | 3.12 | 2.549 | 4.268 | 6.816 |
| 1999/00 | 8.9-13.3 | 10.00 | 6.30/601,338 | 3.7 | 2.238 | 3.424 | 5.662 |
| 2000/01 | 8.9-13.3 | 10.00 | 6.30/601,338 | 3.7 | 2.073 | 5.338 | 7.411 |
| 2001/02 | 8.9-13.3 | 10.00 | 6.30/601,338 | 3.7 | 2.017 | 4.037 | 6.054 |
| 2002/03 | 8.9-13.3 | 10.00 | 6.30/601,338 | 3.7 | 1.712 | 4.266[4] | 5.978 |
| 2003/04 | 8.9-13.3 | 10.00 | 6.30/601,338 | 3.7 | 1.958 | 4.075 | 6.033 |
| 2004/05 | 8.9-13.3 | 10.00 | 6.30/601,338 | 3.7 | 2.549 | 3.313 | 5.862 |
| 2005/06 | 8.9-13.3 | 10.00 | 6.30/601,338 | 3.7 | 2.150 | 3.961 | 6.111 |

[1]The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target: the Panel's best estimate of ABC has been intermediate to the end-point of this range

[2]Recreational quota in numbers is the allocation divided by an estimate of annual average weight.

[3]Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.

[4]2002-03 recreational landings, in pounds, were estimated from the average of 1999-2001 landings.

## 3. ASSESSMENT HISTORY AND REVIEW

### *3.1 Introduction*

This document presents a brief history of the stock assessments of king mackerel, *Scomberomorus cavalla*, in the southeastern USA from the time that the first Coastal Migratory Pelagics Fishery Management Plan (FMP) was drafted and adopted (1980-1982/83), until the last assessment to-date (2004). This document does not pretend to carry out an analytical retrospective comparison of historical assessment results and it is certainly not exhaustive. Its intent is to provide an overview of the main methodological approaches and types of data that have been used. Readers that are interested in more detail will surely need to consult historical reports.

Stock assessments for king mackerel have been conducted very frequently, biannually or even annually for a period of time. For this document, I did not consult each assessment report. Instead, the literature sources are spaced more or less every two years. The sections below provide commentary particularly on analytical aspects. Table 1 presents an annotated history.

### *3.2 Stock structure*

From very early on, it was recognized that US fisheries exploited two groups or stocks of king mackerel, one from the Gulf of Mexico and the other from the Atlantic, but that there was considerable mixing between them, at least during part of the year in South Florida. Initially, in preparation for the FMP, the data were not informative enough to make a separation. Subsequently, two "migratory groups" were defined based on analyses of tagging data from the 1970s (Powers and Eldridge, 1983): A Gulf group and an Atlantic group. During the winter (November 1 to March 31) the Flagler-Volusia County line in Florida separated the two groups, and, in the summer (April 1 to October 31), the Monroe-Collier County line in Florida separated the two groups.

In the early 1990s, it was recognized that some of the fish caught in the moving winter-summer boundary were indeed fish that originated in the Atlantic group, instead of being from the Gulf. The 1994 assessment assumed two scenarios: (1) that 100% of these fish were from the Gulf (i.e., the *status quo*), or (2) that 80% and 20% of these were from the Atlantic and Gulf, respectively. The results from these two scenarios had substantially different management implications, especially for the Gulf in terms of recommended harvest levels. That year, a Panel was established to review the available information, but it was unable to decide on mixing proportions based on available tagging data. More data were needed. DeVries and Grimes (1998) provided additional information on mixing based on otolith shapes, but it did not appear to be sufficiently compelling to change the assumption that 100% of the fish in the mixing zone were from the Gulf. This uncertainty still remained as an unresolved issue with potentially important management implications in the last (2004) assessment.

In addition, electrophoretic data and spawning seasonality/location suggest some degree of stock structure within the Gulf of Mexico (Powers and Thompson, 1993) but this is not well understood and is not accounted for in assessment and management. It is also important to note that king mackerel are distributed beyond USA waters. King mackerel are caught in waters off many countries in the Continent and it is almost certain that the fish caught in the US EEZ in the western part of the Gulf of Mexico are related to fish caught in the Mexican EEZ in the Gulf. From 1985 until 1994, stock assessments included

Mexican catches, primarily in sensitivity runs labeled "Total Gulf". However, it was not possible to associate these catches to particular gears or particular size/age ranges, such that the results from such analyses were highly uncertain.

### *3.3 The assessment model*

As in most situations, the choice of model used to assess king mackerel has largely been conditioned by the types of available data.

The preliminary assessment work leading to the 1982 FMP (which actually began being drafted in 1979 or 1980) had catches for only a few years. There was an estimate of growth, a tagging study and a guess of the value of natural mortality, M. The tagging data and the value of M were used to estimate a value of total mortality, Z. The estimate of recruitment was approximated by $R = \frac{CZ}{F}$, assuming equilibrium. Using a yield-per-recruit vector, times recruitment, equilibrium yield was calculated for various F levels.

The simple equilibrium yield-per-recruit approach was used until 1985. In the interim, Powers and Eldridge (1983) also attempted a stock production model. It was based on very short time series of catch an effort data, much of which depended on assumptions made to reconstruct historical series (particularly for the recreational catches).

Subsequently, Nichols (1985) introduced virtual population analysis (VPA). By this time, the time series of catches were more complete and length frequency data from a variety of sources had been recovered. The model analyzed catch-at-age where sexes had been aged separately, and included Mexican catch data in some of the runs. The tuning of the VPA was an ad-hoc procedure, based on an initial guess for F in the terminal year, and regressing the declining catch part of cohorts (ages 4+ or 6+) against time. The results were particularly sensitive to the choice of M and starting F. This approach continued to be used until 1989.

Gavaris (1988) introduced ADAPT, a method for calibrating a VPA to relative abundance data in a least-squares framework. This rather more statistical treatment of the data has been applied to the king mackerel assessments since 1988 (Powers and Thompson, 1993) to-date in different computer language incarnations: In APL (Conser and Powers, 1989), Visual BASIC (Powers and Restrepo 1992) and FORTRAN (Restrepo, 1996). The basic algorithms in all of these are the same, but each version has incorporated additional options for more flexible treatments of the data (e.g., in how the various indices are weighted). SEDAR 5 (in 2004) highlighted the fact that this basic approach has been used throughout the existence of the rebuilding program for the Gulf migratory group, and that consistency in methods is a desirable property in such situations.

In 2004, another variant of ADAPT (Porch et al., 2001) was used to model simultaneously both migratory groups allowing for mixing between them. This model was not adopted, partly because it implied that mixing could occur anywhere throughout the Atlantic and Gulf regions, rather than being limited primarily to southern Florida.

### *3.4 The benchmarks*

The initial FMP estimated MSY for both migratory groups at 37 million lbs, using equilibrium yield-per-recruit. In 1983, a revised MSY value of 26.2 million lbs was adopted based on the mean from two values: one from a production model, and the other from the equilibrium yield-per-recruit approach, using a revised sex-specific growth curve. Until at least 1994, this value was used to define OY (optimum yield) = MSY.

During the period 1985-1994, much of the focus was not on how to estimate MSY, but rather on how to calculate Allowable Biological Catches (ABCs). Starting in 1987, ABC was calculated as the short-term projected catch fishing at a level of $F_{0.1}$ (this benchmark was adopted as a proxy for $F_{MSY}$). These projections were made separately based on the assessment results for the two migratory groups.

In the early 1990s, much thought was given throughout NMFS to the development of metrics that would allow analysts to quantify overfishing relative to various benchmarks. Much of this work in the Southeast centered on spawning stock biomass per recruit (SSBR, Goodyear, 1993). Depending on life-history characteristics different levels of SSBR (compared to the maximum attainable in the absence of fishing) could be used to measure when a stock is prone to recruitment overfishing, or higher values could be used as proxies for $F_{MSY}$. In 1991, the target used to calculate ABC changed from $F_{0.1}$ to $F_{30\%SSBR}$ ($F_{30\%}$). In the following years, ABC advice from the stock assessment was presented as high and low values, corresponding to the $50^{th}$ and $16^{th}$ percentiles of a distribution of ABCs that was generated from a mixed Monte Carlo-Bootstrap procedure.

By the mid-1990s, the thinking about biological reference points had become more refined and it was generally agreed that it would be convenient and prudent to think separately about targets (such as OY, or something one wants to achieve) and limits (such as recruitment overfishing, or something one wants to avoid). Starting in 1996, OY was defined for king mackerel as $F_{30\%}$, and the overfishing limit was defined as $F_{20\%}$. Much debate centered on how to measure SSBR (Mace et al., 1996) in terms of whether or not to account for year-class strength from the VPA results.

In 1998, NMFS published Guidelines on National Standard 1 (Optimum Yield) of the Magnuson-Stevens Fishery Conservation Management Act. These Guidelines required that FMPs adopt not only targets and limits, but also to consider both biomass and fishing mortality. By 2000, a Maximum Fishing Mortality Threshold (MFMT) and a Minimum Stock Size Threshold (MSST) were defined following default guidance provided in Restrepo et al. (1998). At high stock sizes, close to $B_{MSY}$ and higher, MFMT = $F_{MSY}$ = $F_{30\%}$. $B_{MSY}$ was calculated from the replacement line corresponding to $F_{30\%}$ that intersects the spawner-recruit data (Sissenwine and Shepherd, 1987). The MSST was calculated as (1-M)*$B_{MSY}$. Since the median assumed natural mortality differs for both migratory groups, this biomass limit differs between them: MSST = 0.80*$B_{MSY}$ for the Gulf and MMST = 0.85*$B_{MSY}$ for the Atlantic. In terms of targets, the Act suggested that OY ≤ MSY. For the purpose of computing ABC, a target of $F_{40\%}$ has been adopted.

In 2007, the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act was signed into law. NMFS is currently considering the necessary revisions to its National Standard 1 Guidelines and it is expected that benchmarks for king mackerel will be revisited again at a latter date.

### *3.5 Acknowledgments*

I would like to thank G. Scott and A. Tross for motivation to write this paper and for helpful discussion. Any mistakes in this document are, however, entirely my own.

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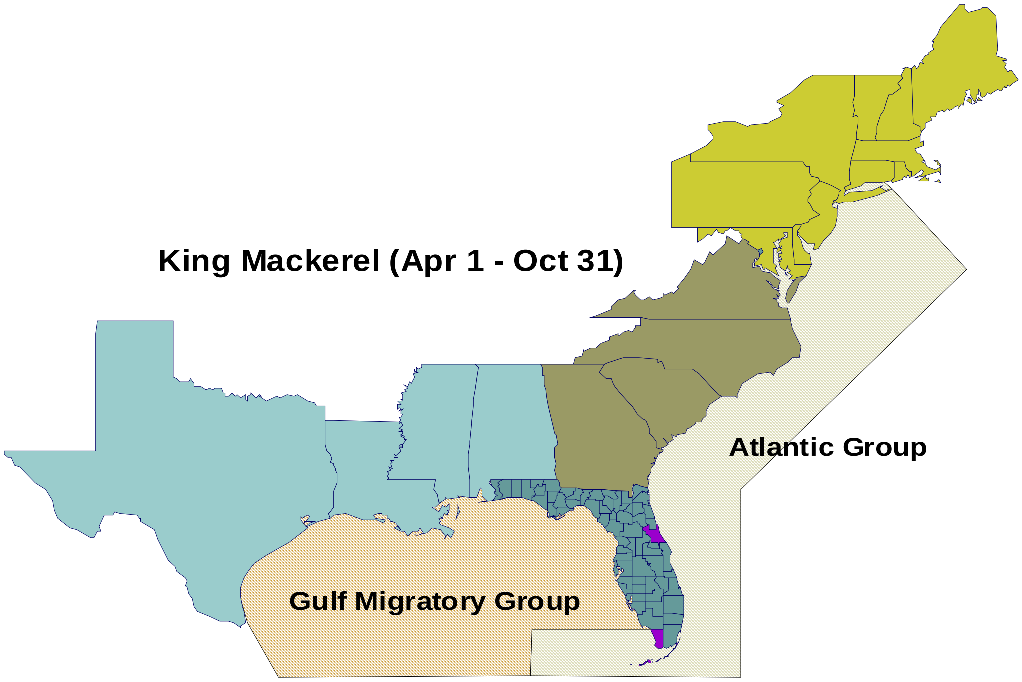
**Table 1**. An annotated timeline of king mackerel stock assessments in the Gulf of Mexico. Note: This table does not attempt to compile an exhaustive list of all the information that went into each assessment. It is intended to be indicative of some of the changes that have taken place over time.

| Years/Sources | Notes |
|---|---|
| **1980-1983**<br>FMP (1983) | - Two stocks possible but note defined<br>- Growth and length-weight data from Beaumariage (1973) combined to estimated unisex growth<br>- Limited length composition from two Florida fisheries<br>- Most assessment calculations probably made by Chittenden (unpublished work)<br>- M ~ 0.4<br>- Age at first capture ~ 1.5<br>- MSY ~ 36.8 million lbs overall<br>- Commercial catch statistics since 1970 by State available from NMFS<br>- Recreational catch statistics available from limited creel surveys conducted in different states in different years |
| **1983-1985**<br>FMP (1983); Powers & Eldridge (1983) | - Mackerel Stock Assessment Panel (MSAP) established<br>- Two seasonal migratory groups defined (Gulf and Atlantic)<br>- Changed growth to Johnson et al. (1983)<br>- MSY estimated with 3 methods. The average of 2 methods (production model, and assuming that average 1970-1976 catches were in equilibrium) gives MSY = 26.2 million lbs<br>- MSY divided as 14.225 million lbs for the Gulf and 11.812 million lbs for the Atlantic, based on catch ratios for 1975 to 1979 |
| **1985-1989**<br>MSAP (1986); Scott and Burn (1987) | - VPA used (Nichols, 1985)<br>- Growth from Johnson et al. (1983) for females and Nomura et al. (1967) for males<br>- Considered Mexican catches in a "Total Gulf Migratory Group" alternative<br>- Recreational catches from NMFS Recreational Catch Survey<br>- Several CPUE series developed: Charterboat; Marine recreational surveys; Texas Parks and Wildlife creel surveys; Louisiana commercial fisheries; individual fishermen logs<br>- Initiated tuned VPAs<br>- M ~ 0.3; Later revised to M ~[0.15 - 0.3]<br>- ABC (and TACs) calculated projecting at $F_{0.1}$ |
| **1990-1994**<br>MSAP (1990); MSAP (1992); | - Tuned VPAs (Conser and Powers, 1989)<br>- Uncertainty estimated from Monte-Carlo simulations<br>- Growth from Manooch et al. (1987) for the Gulf and Collins et al. (1988) for the Atlantic |

| | |
|---|---|
| MSAP (1994) | - Improved catch-at-size after 1989 Panama City workshop to match length samples to catch by migratory group, year, month, sector and gear<br>- Assigned ages to catch-at-size assuming variability in length-at-age (Shepherd, 1985)<br>- Introduced Generalized Linear Models (GLMs) for standardizing CPUE data<br>- Introduced fishery-independent indices of abundance (NMFS Fall Groundfish Survey in Gulf and SEAMAP survey in S. Atl. Bight)<br>- Introduced bycatch estimates from the Gulf of Mexico shrimp trawl fishery<br>- Revised M~0.15 range ~ [0.1 - 0.25]<br>- Maturity/spawning from Finucane et al. (1986)<br>- Established a Panel in 1994 to predict mixing proportions in the mixing zone<br>- Since 1991, ABC calculated projecting at $F_{30\%SSBR}$<br>- Defined "generation time" as 12 years |
| **1995-1998**<br>MSAP (1996)<br>MSAP (1998) | - Tuned VPAs (Powers and Restrepo, 1992; Restrepo 1996)<br>- Revised M~0.2 range ~ [0.15 - 0.25] for Gulf group<br>- Replaced Fall Groundfish Survey index by the NMFS Bycatch Index<br>- Changed method for estimating bycatch in GoM shrimp fishery<br>- Considered using otolith shape data (DeVries and Grimes 1998) to infer mixing proportions<br>- Stopped using catches from Mexico |
| **1999-2004**<br>MSAP (2000)<br>MSAP (2002)<br>MSAP (2003)<br>SEDAR (2004) | - SEDAR (Southeast Data, Assessment and Re view) process started in 2002<br>- Used 2 fishery-independent indices forage 0 in the Gulf: SEAMAP Icthyoplankton survey and NMFS bycatch estimates. Since 2002, assumed that icthyoplankton survey reflects SSB instead of age 0<br>- Developed MFMT control rule based on $F_{30\%}$ as a proxy for $F_{MSY}$<br>- OY target based on $F_{40\%}$<br>- In 2004 developed new growth curves (Brooks and Ortiz, 2004)<br>- Five indices used in last Atlantic assessment: SEAMAP shallow trawl survey; Fla. FWCC Marine Fish Trip Ticket; MRFSS; NMFS Headboat survey<br>- Nine indices used in last Gulf assessment: NMFS shrimp bycatch; SEAMAP Icthyoplankton Survey; S.E> Florida Headboat; Texas Parks & Wildlife survey (split into 2 periods); MRFSS; NW Florida charterboat; SW Florida charterboat; NW Florida commercial; SW Florida commercial |

## 4. REGIONAL MAPS



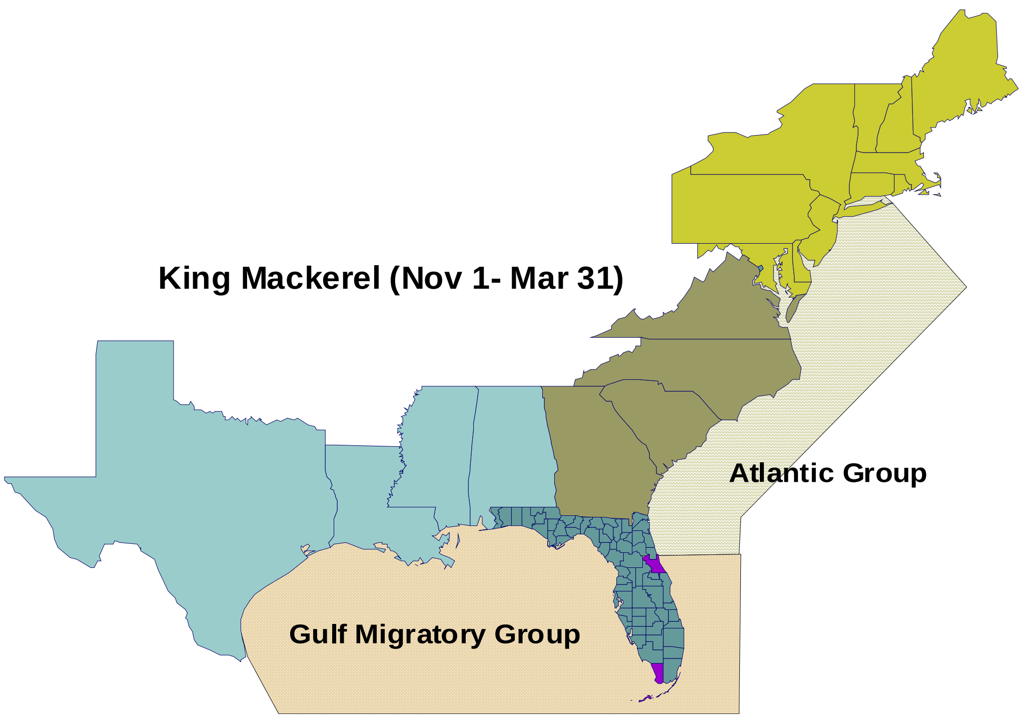




Figure 4.1. Current definitions of stock boundaries for Gulf and Atlantic king mackerel stocks.

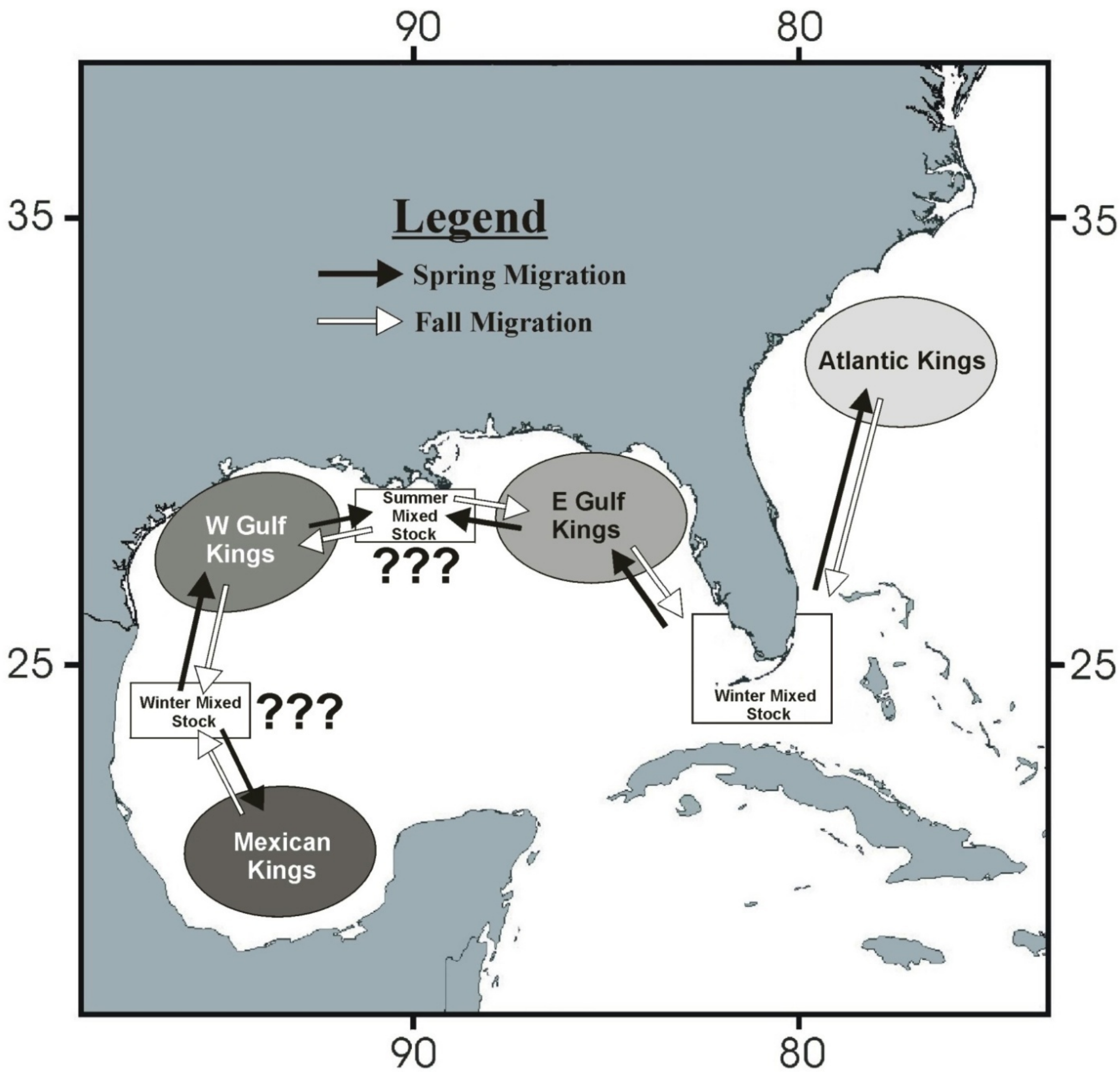



Figure 4.2. Hypothesized population structure and migratory pathways of king mackerel in U.S. waters and Mexican waters in the western and southern Gulf of Mexico. All migratory pathways have been documented with tagging data.

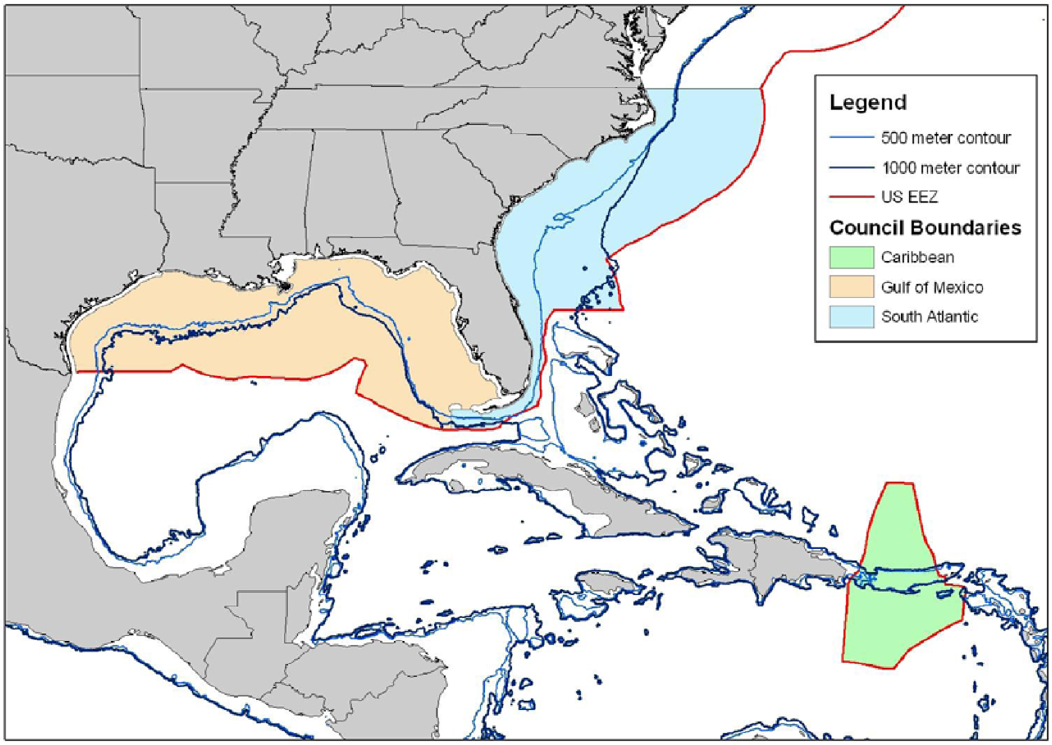



Figure 4.3. Southeast Region including Council and EEZ Boundaries

## 5. ASSESSMENT SUMMARY

The Summary Report provides a broad but concise view of the salient aspects of the stock assessment. It recapitulates: (a) the information available to and prepared by the Data Workshop; (b) the application of those data, development and execution of one or more assessment models, and identification of the most reliable model configuration as the base run by the Assessment Workshop (AW); and (c) the findings and advice determined during the Review Workshop. All contents of the Summary Report are also elsewhere in the Stock Assessment Report (SAR).

It is important to note that the Review Panel accepted the base cases provided by the Assessment Workshop as providing one of several plausible estimates of stock abundance, biomass and exploitation. However, the base cases alone do not provide sufficient information about the uncertainty of these estimates. The results reported herein are for those base cases (modified for the Gulf of Mexico migratory group as recommended by the Review Panel), as recommended by the two Councils' respective SSCs for providing management advice.

## SEDAR 16 Summary Report

South Atlantic and Gulf of Mexico King Mackerel

### Stock Distribution and Identification

This assessment applies to king mackerel within US waters of the South Atlantic and Gulf of Mexico. Current management defines two migratory units (Gulf of Mexico and South Atlantic) which mix in an area of south Florida during the winter months.

### Assessment Methods

Two modeling approaches were considered in this assessment: a virtual population analysis model (VPA-2Box), and a statistical catch-at-age model (Stock Synthesis version 3). Separate modeling runs for the VPA were computed for the two migratory units, while runs employing Stock Synthesis 3 analyzed the two migratory units simultaneously in three "zones": the Gulf no-mix zone, the Atlantic no-mix zone, and the mixing zone. A "continuity case" was also computed. To ensure continuity, Atlantic and Gulf "continuity runs" were run using both F-ADAPT and VPA-2BOX software programs with the same inputs and model specifications; both programs provided identical solutions and results

The virtual population analysis model using the VPA-2Box software was chosen for evaluating stock status and providing management advice. The Assessment Panel recommended VPA-base configuration is detailed in the Assessment Workshop Report. The Panel's recommended configuration includes 1) "50/50 mixing zone assumption" (i.e., that 50% of the fish caught in the mixing zone during Winter belong to the Gulf group and 50% to the Atlantic group; Mixing zone = catches from Monroe to Flagler Counties in Florida, from November to March); 2) Age-0 in the Atlantic and Gulf of Mexico models; 3) estimates all terminal-F (fishing mortality) parameters that had previously been fixed in the continuity run; 4) updated life history information and catch-at-age information developed for, and recommended by the SEDAR 16 data workshop panel; 5) use a different method to estimate index selectivity by age from partial catches (Butterworth and Geromont, 1999) than that of the continuity case; and, 6) use a different weighting scheme for the indices.

The Review Panel did not suggest an alternative base model configuration than the one suggested by the Assessment Panel for the South Atlantic migratory group, and only made one modification to the base model configuration for the Gulf of Mexico migratory group; removing the first three years of the SEAMAP Fall Groundfish index.

**Assessment Data Summary**

Due to management definitions, the king mackerel assessment used fishing year rather than calendar year. In the South Atlantic, the fishing year is April 1 – March 31 of the following year. Therefore, in the South Atlantic the 1981 fishing year (FY1981) began on 4/1/81 and ended 3/30/82. In the Gulf of Mexico, the fishing year is July 1-June 30 of the following year. Therefore, in the Gulf the 1981 fishing year (FY1981) began on 7/1/81 and ended 6/30/82. The FY nomenclature will be used throughout this document.

The base assessment includes data from FY1981-2006. Directed fisheries included Commercial (ALS) and Recreational landings (estimated from MRFSS, Headboat, and Texas Parks and Wildlife Division components). Other sources of removals that were accounted for included dead discards from the recreational fisheries, and bycatch from the shrimp fisheries. The population is modeled over ages 0 – 11+ with the final age (11) treated as a plus group. Specific data sources included in the VPA model and the years over which information is available are summarized as follows:

Landings (fleets):
- Commercial (all gears combined): 1981 - 2006
- Recreational – MRFSS: 1981 – 2006
- Recreational – Headboat: 1986 - 2006
- Recreational – Texas Parks & Wildlife: 1981 – 2006

Discards:
- Commercial: assumed to be negligible
- Recreational: 1981-2006

Shrimp Bycatch:
- Gulf of Mexico: 1972 - 2006
- South Atlantic: 1989 – 2006

Length & Age Composition:

Otoliths and size measurements collected since 1984 and 1980, respectively, were used to convert catch to catch-at size and for ageing the catch, using age-length keys. There were no size samples from discarded fish. Discards from the recreational fisheries surveyed by MRFSS were assumed to have the same size distribution as the retained catch. Discards from the Headboat fisheries were assumed to be below the minimum size.

Indices :

Gulf of Mexico:

Fisheries dependent indices:

- Commercial logbook (Gulf no-mix): 1993 - 2006
- MRFSS (Gulf no-mix): 1981 - 2006
- Headboat (Gulf no-mix): 1986 – 2006
- Trip ticket Florida: 1986-2006 (not included in base model configuration)

Fisheries independent

- SEAMAP Fall Groundfish: 1981 - 2006
- SEAMAP Fall Plankton: 1986 - 2006

South Atlantic:

Fisheries dependent indices:

- North Carolina Trip Ticket: 1994 – 2006
- MRFSS (Atl no-mix): 1981 – 2006
- Headboat (Atl no-mix): 1981-2006
- Commercial logbook (Atl no-mix): 1993-2006 (not included in base model configuration)
- Shark Gillnet: 1993 – 1995; 1998 – 2007 (not included in base model configuration)

Fisheries independent

- SEAMAP South Atlantic: 1989 – 2006

Life History:

Natural mortality is set at M=0.160 for the South Atlantic and M = 0.174 for the Gulf of Mexico. Specific values vary across ages based on a scaled Lorenzen curve.

Reproductive information was updated from previous assessments to incorporate results from several recent studies. The maturity series used for the VPA base runs was unchanged from SEDAR 5 however an updated fecundity-at-age vector was produced.

Discard mortality rates are updated from previous assessments to incorporate information provided by the discard mortality sub-working group at the Data Workshop. Estimated mortality on discards is 33% for live releases of the Headboat fishery and 20% for live releases of the MRFSS releases (B2).

No concerns were raised by the Review Panel about US data collection, but the absence of Mexican catch data from the assessment means that the absolute size of the stock cannot be estimated. Nevertheless, the assessments contain useful information about trends and relative stock sizes.

The Review Panel also noted that it is a problem that few fishery independent surveys cover this stock, and the existing ones are not complete in their spatial or temporal coverage. While much effort has been made to analyze the fishery data to cover for this lack, such analysis cannot be a full and proper substitute for fishery independent survey data concerning a pelagic fish stock. In such stocks, fishery catch rates are often poor estimators of stock abundance.

## Catch Trends

Total directed landings of the South Atlantic stock of king mackerel have declined over the assessment timeframe, with a peak of 10.474 mp in FY1982 to a low of 5.644 mp in FY2002 (Table 1, Fig. 1). In the Gulf of Mexico, total directed landings ranged from 1.956 mp in FY1987 to 9.432 mp in FY1982 (Table 2, Fig. 2). Total directed landings in the terminal year (FY2006) were 7.506 mp in the South Atlantic and 5.761 mp in the Gulf of Mexico.

Commercial landings in the South Atlantic displayed a general decrease over the assessment period, ranging from 5.597 mp in FY1982 to 2.623 mp in FY2003 (Table 1, Fig. 1). Commercial landings within the Gulf of Mexico were slightly more stable over the timeframe examined with a peak in commercial landings observed in FY1982 (2.981 mp), with a low in FY1987 of 0.591 mp (Table 2, Fig. 2). The average commercial landings for the last five years were 2.27 mp in the Gulf of Mexico and 3.21 mp in the South Atlantic.

Total recreational landings were comparable or larger than the commercial landings throughout the assessment timeframe. South Atlantic recreational landings ranged from 2.923 mp in FY2002 to a peak of 6.385 mp in FY1992 (Table 1, Fig. 1). Recreational landings in the Gulf of Mexico ranged from 1.364 mp in FY1987 to 6.450 mp in FY1982 (Table 2, Fig. 2). Average recreational landings in the South Atlantic over the last five years were 3.5 mp; the Gulf of Mexico average was 2.9 mp.

Recreational landings in weight by migratory group and fishing sector (i.e. HB, MRFSS) are summarized in Table 3. Incidental catches including shrimp bycatch and dead discards from the recreational fishery are summarized in Table 4. Commercial discards were assumed to be negligible.

## Fishing Mortality Trends

Annual estimates of fishing mortality were expressed either as “apical F” (the highest F-at-age value in any given year, as reported in prior assessments) or as “current F” (the highest value of the geometric mean by age of hat year and two prior years)[1]. Both measures are roughly comparable in that they index the fully-selected fishing mortality rate, but as expected, the measure referred to as “apical F” is more variable because it is often associated with different ages in different years. The “current F” measure changes more slowly because it is a running mean, and therefore, the age with which it is associated changes more gradually.

Fishing mortality estimates varied over the assessment timeframe (Table 5, Fig 3). For the South Atlantic, current F has ranged from 0.2 in FY1988 to 0.37 in FY1997, with a gradual increase since FY2000. Current F in FY 2006 was 0.32. For the Gulf of Mexico, current F generally increased from 0.36 in FY1983 to a peak of 0.52 in FY1995, followed by a gradual decrease. Current F in FY 2006 was 0.21.

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[1] Although the term “current F” was used by the review panel and appears elsewhere in SEDAR16 reports, it is more accurately described as simply a running average of the reference year and two prior years. Strictly speaking, the measure corresponds to current years only when the reference year is 2006.

**Stock Abundance and Biomass Trends**

Total stock abundance displayed very different trends between regions over the assessment timeframe. The abundance of king mackerel Age 1+ has declined in the South Atlantic region with a peak of 12.8 million fish in FY1981 to a low of 5.9 million fish in FY2001 (Table 6, Fig. 4). The estimated total stock abundance of Age 1+ fish in the terminal year of the assessment was 7.2 million fish. In the Gulf of Mexico, numbers of Age 1+ king mackerel has generally increased slowly over the assessment period with a low of 4.0 million fish in FY1984, to a peak of 17.2 million fish in FY2006 (Table 6, Fig. 4).

In the South Atlantic, estimated recruitment at age-0 varied without obvious trend, ranging from 2.2 million in FY2000 to 8.6 million in FY1989 (Table 6, Fig. 5). In the Gulf of Mexico, recruitment at age-0 has varied substantially, ranging from 2.0 million in FY1983 to 20 million in FY2004 (Table 6, Fig. 5). During recent years recruitment has been quite high, averaging 15 million since FY2003. These large recruitment estimates are driven by the steep increase in the SEAMAP Fall Groundfish Survey which indexes the abundance of Age-0 king mackerel and has increased more than 5-fold since the early 1980s.

The spawning stock biomass (measured by egg production) in the South Atlantic decreased about 45% since FY1981, while in the Gulf of Mexico, the spawning stock has shown a continued, steady increase from a low of 1502 in FY1985, to a peak of 3921 billion hydrated eggs in FY2006 (Table 7, Fig. 6).

**Status Determination Criteria**

Management benchmark recommendations are based on the “Base” model configuration for the South Atlantic and the “Corrected Base” model configuration for the Gulf of Mexico as selected by the Gulf of Mexico and South Atlantic Fishery Management Council’s respective Science and Statistics Committees. Full details are described in the Assessment and Review Workshop Reports and the associated Addenda.

The Review Panel recommended a revised protocol for reporting fishing mortality rates and F management reference points. Rather than using an apical F or current F (see above for definitions) measure, the RP recommended to use the average F on ages 2-8 and the current (2004-2006) selectivity pattern ($F_{avg2\text{-}8}$). This new measure restricts the calculations to the ages generally exploited by the directed commercial and recreational fisheries. In the table below, both methods are reported for clarity and ease of comprehension. This $F_{avg2\text{-}8}$ is only reported in the status determination table, for the F base reference points ($F_{MSY}$, $F_{OYs}$, MFMT) and 2006 fishing mortality rate.

**Status Determination Tables** (values given are the deterministic results): Yield is ***for landings only*** in millions of pounds; MSST is in ***billions of hydrated eggs***. Two methods of calculating annual F and the F management references are reported, Apical F of ages 0-11+ and Average F of ages 2-8. The latter method was recommended by the review panel.

| Criteria | South Atlantic Migratory Group | |
|---|---|---|
| | Definition | Recommended Value[2] |
| ***Biomass references*** | | |
| M (natural mortality rate) | Base of Lorenzen M | 0.1603 |
| MSY (millions of pounds) | Yield at $F_{MSY}$[1] | 8.64 |
| OY (millions of pounds) | Yield at $F_{OY}$[1] | OY (65% $F_{30SPR)}$= 7.70<br>OY (75% $F_{30SPR)}$= 8.07<br>OY (85% $F_{30SPR)}$= 8.35 |
| MSST | MSST = [(1-M) or 0.5 whichever is greater] *$B_{MSY}$[1] | 1826.4 |
| | | |
| ***F references calculated using Apical F of ages 0-11+*** | | |
| $F_{MSY}$ | $F_{MSY}$ | Unknown |
| $F_{30\%SPR}$ | $F_{30\%SPR}$[1] | 0.32 |
| MFMT | $F_{MSY}$[1] | 0.32 |
| $F_{OY}$ | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$[1] | 65% $F_{30SPR}$= 0.21<br>75% $F_{30SPR}$= 0.24<br>85% $F_{30SPR}$= 0.27 |
| | | |
| | | |
| ***F references calculated using Average F of ages 2-8 as per recommendation of RP*** | | |
| $F_{MSY}$ | $F_{MSY}$ | Unknown |
| $F_{30\%SPR}$ | $F_{30\%SPR}$[1] | 0.26 |
| $F_{OY}$ | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$[1] | 65% $F_{30SPR}$= 0.17<br>75% $F_{30SPR}$= 0.19<br>85% $F_{30SPR}$= 0.22 |
| MFMT | $F_{MSY}$[1] | 0.26 |
| | | |

[1]*As it was deemed inappropriate to estimate $F_{MSY}$ directly due to the lack of a strong stock-recruitment relationship,* ***$F_{30\%SPR}$ was used as a proxy for $F_{MSY}$*** *when necessary.*

| Criteria | Gulf of Mexico Migratory Group | |
|---|---|---|
| | Definition | Recommended Value[2] |
| ***Biomass references*** | | |
| M | Base of Lorenzen M | 0.174 |
| MSY (millions of pounds) | Yield at $F_{MSY}$[1] | 9.10 |
| OY (millions of pounds) | Yield at $F_{OY}$[1] | OY (65% $F_{30SPR)}$= 8.23<br>OY (75% $F_{30SPR)}$= 8.61<br>OY (85% $F_{30SPR)}$= 8.87 |
| MSST | MSST = [(1-M) or 0.5 whichever is greater] *$B_{MSY}$[1] | 2615.5 |
| | | |
| ***F references calculated using Apical F of ages 0-11+*** | | |
| $F_{MSY}$ | $F_{MSY}$ | Unknown |
| $F_{30\%SPR}$ | $F_{30\%SPR}$[1] | 0.25 |
| $F_{OY}$ | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$[1] | 65% $F_{30SPR}$= 0.16<br>75% $F_{30SPR}$= 0.19<br>85% $F_{30SPR}$= 0.21 |
| MFMT | $F_{MSY}$[1] | 0.25 |
| | | |
| ***F references calculated using Average F of ages 2-8 as per recommendation of RP*** | | |
| $F_{MSY}$ | $F_{MSY}$ | Unknown |
| $F_{30\%SPR}$ | $F_{30\%SPR}$[1] | 0.19 |
| $F_{OY}$ | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$[1] | 65% $F_{30SPR}$= 0.12<br>75% $F_{30SPR}$= 0.14<br>85% $F_{30SPR}$= 0.16 |
| MFMT | $F_{MSY}$[1] | 0.19 |

[1]*As it was deemed inappropriate to estimate $F_{MSY}$ directly due to the lack of a strong stock-recruitment relationship,* ***$F_{30\%SPR}$ was used as a proxy for $F_{MSY}$*** *when necessary.*

## Stock Status

Stock status determinations at the end of FY 2006 relative to current estimates for benchmark values are summarized in the *Status Summary Table* below.

**Status Summary Table** (values given are the deterministic estimates from the assessment model results presented in the addenda.) F references and Current F were calculated with using the average F of ages 2-8 and current selectivity (2004-2006), as per the recommendation of the RP.

| | Recommended Values | |
|---|---|---|
| Criteria | South Atlantic Migratory Group | Gulf of Mexico Migratory Group |
| $SSB_{F30\%SPR}$ [2] | 2175.0 | 3165.7 |
| $SSB_{2006}$ | 2443.0 | 3921.0 |
| $SSB_{2006}/SSB_{F30\%SPR}$ | 1.12 | 1.24 |
| $SSB_{2006}/MSST$ | 1.34 | 1.50 |
| MSST | 1826.4 | 2615.5 |
| MFMT | 0.26 | 0.19 |
| $F_{current}$ | 0.26 | 0.16 |
| $F_{current}/MFMT$ | 1.01 | 0.83 |

The Gulf of Mexico migratory group of king mackerel was not overfished and was not experiencing overfishing in FY2006 while the South Atlantic migratory group was also not overfished however fishing mortality rate in 2006 was at or slightly above MFMT. The Gulf of Mexico migratory group had been overfished as recently as FY1998.

Spawning stock trajectories relative to the status determination criterion MSST (where$MSST = (1\text{-}M) * SSB_{SPR30;}$ $M = 0.1603$ in the Atlantic and 0.1738 in the Gulf of Mexico) indicate the overfished status. The annual trajectories of SSB/MSST for each stock are summarized in Fig. 7. In the South Atlantic, SSB/MSST declined during the time series from 2.5 in FY1981 to 1.3 in FY2006; in the Gulf of Mexico, SSB/MSST generally increased during the time series, from 0.57 in FY1985 to about 1.5 in FY2006.

The status determination criterion MFMT is estimated by $F_{30\%SPR}$. Fishing mortality trajectories relative to MFMT (calculated on the basis of the average F of ages 2-8 and the selectivity corresponding to FY2004-2006) indicate the overfishing status of the migratory groups. The annual trajectories of Fcurrent/MFMT for each stock are summarized in Fig. 8. In the South Atlantic, F/MFMT has generally been below 1.0, but has increased recently. Currently F/MFMT is 1.01. In the Gulf of Mexico, F/MFMT suggests that overfishing was most severe in the late 1980s and early 1990s, and that overfishing ended for the Gulf stock unit in FY2002.

According to the base model results, overfishing is not occurring for the Gulf migratory unit. For the South Atlantic migratory unit, the point estimate of current F is the same magnitude as the point estimate of MFMT.

The Review Panel noted that standard methods had been used to calculate population benchmarks, and did not re-evaluate these methods. Rather, the panel identified what stock status

[2] SSB is defined in terms of numbers of hydrated eggs (billions).

declarations could reliably be made in the light of the uncertainties which had been identified. These declarations are provided.

Both the Gulf of Mexico (GOM) and Atlantic (ATL) spawning stock biomass levels in 2006 were above the MSST, and therefore not overfished. However, it is uncertain whether the GOM stock is currently experiencing overfishing. For the ATL stock, it is uncertain whether overfishing is occurring, but if it is, then this is at a low level.

### Projections

Projections of the population dynamics of each stock used a stock recruitment relationship estimated assuming a constant relative recruitment. The S-R relationship was defined using a fixed high steepness (0.95) and a Beverton-Holt S-R function. Maximum expected recruitment was set equal to the geometric mean of VPA estimated recruits over the years for which indices of stock and recruitment were both available (1981-2004 GOM and 1989-2004 ATL). These stock-recruitment relationships are summarized in Figure 9.

Short term projections (2007-2016) were prepared to evaluate a range of future fishing mortality ($F_{MSY}$, $F_{OY}$, $F_{current}$) strategies using the projection software PRO-2BOX (Porch, 2002b). To estimate the variance of the projection, 1000 bootstraps were made based on the VPA results. Although the alpha and beta parameters of the S-R relationship were fixed, the predicted recruitment of each bootstrap was allowed to vary with a CV calculated from the SSB-R observations. Projections were prepared assuming management changes could take place in 2008 FY, for 2007 FY it was assumed the same fishing rates as 2006, selectivity remains constant for all fisheries as the average of last three years (2004-06), and discard rates remain constant for all fisheries. Future recruitment is estimated from the S-R relationship stated above.

Six types of projections at constant F were made for the period 2008-2016:

Project at $F_{Current}$
Project at $F_{SPR40\%}$
Project at $F_{OY}$ (=75% $F_{SPR30\%}$)
Project at $F_{MSY}$ (= $F_{SPR30\%}$)
Project at $F_{OY}$ (=65% $F_{SPR30\%}$)
Project at $F_{OY}$ (=85% $F_{SPR30\%}$)

Projections for the Gulf are extremely optimistic, as a result of several very strong year-classes that are estimated in the VPA during the last few years. It is noted in the assessment workshop document that the choice of weighting of the indices has a substantial impact on the perception of stock status.

### Allowable Biological Catch

The AW terms of reference require the calculation of Allowable Biological Catches (ABCs). The selection of what constitutes an ABC amongst several candidates is a management choice, so the projection results presented in the assessment, addendum and annexes do not identify any particular ABCs. Instead, yields (landings only) are presented for the six scenarios mentioned above.

Projected yields (landings in million pounds) under different F strategies.

*South Atlantic migratory group*

| Year | F30%SPR | F40%SPR | Fcurrent | F 65% SPR30 | F 75% SPR30 | F 85% SPR30 |
|---|---|---|---|---|---|---|
| 2007 | 9.277 | 9.277 | 9.277 | 9.277 | 9.277 | 9.277 |
| 2008 | 9.453 | 6.669 | 9.504 | 6.391 | 7.291 | 8.170 |
| 2009 | 9.248 | 6.956 | 9.288 | 6.706 | 7.498 | 8.236 |
| 2010 | 9.154 | 7.240 | 9.184 | 7.017 | 7.718 | 8.344 |
| 2011 | 9.132 | 7.522 | 9.156 | 7.319 | 7.943 | 8.477 |
| 2012 | 8.860 | 7.476 | 8.880 | 7.295 | 7.851 | 8.314 |
| 2013 | 8.788 | 7.549 | 8.805 | 7.379 | 7.893 | 8.309 |
| 2014 | 8.794 | 7.665 | 8.810 | 7.507 | 7.985 | 8.369 |
| 2015 | 8.737 | 7.672 | 8.750 | 7.520 | 7.979 | 8.338 |
| 2016 | 8.704 | 7.685 | 8.717 | 7.538 | 7.981 | 8.327 |

*Gulf of Mexico migratory group*

| Year | F30%SPR | F40%SPR | Fcurrent | F 65% SPR30 | F 75% SPR30 | F 85% SPR30 |
|---|---|---|---|---|---|---|
| 2007 | 11.810 | 11.810 | 11.810 | 11.810 | 11.810 | 11.810 |
| 2008 | 17.130 | 12.610 | 14.394 | 11.513 | 13.162 | 14.778 |
| 2009 | 17.491 | 13.543 | 15.157 | 12.513 | 14.050 | 15.496 |
| 2010 | 16.286 | 13.223 | 14.526 | 12.357 | 13.640 | 14.791 |
| 2011 | 14.240 | 12.046 | 13.023 | 11.369 | 12.366 | 13.215 |
| 2012 | 12.432 | 10.834 | 11.576 | 10.300 | 11.080 | 11.715 |
| 2013 | 11.277 | 10.018 | 10.622 | 9.568 | 10.221 | 10.732 |
| 2014 | 10.503 | 9.438 | 9.958 | 9.041 | 9.614 | 10.053 |
| 2015 | 10.148 | 9.200 | 9.672 | 8.834 | 9.361 | 9.755 |
| 2016 | 9.886 | 9.015 | 9.456 | 8.669 | 9.165 | 9.533 |

## Uncertainty

Uncertainty in the estimates of quantities of interest was determined by running 1000 non-parametric bootstraps of the index residuals. These bootstraps allow computation of the maximum likelihood estimate (MLE), bootstrap average, bias, standard error and coefficients of variation (CVs) for each parameter. In addition, bootstrapping allows the computation of upper and lower 80% confidence range on the annual estimates of SSB, R and F.

Bootstrap analyses were run using the index residuals for both base and sensitivity models and the bootstrap results were used to estimate the proportion of the runs that resulted in an overfished condition ($SSB_{2006}$ < MSST) and current overfishing ($F_{current}$ > MFMT). If these proportions are used to infer probability, then for the South Atlantic migratory group the bootstrap analysis indicates that there is 4.2% chance[3] of the 2006 stock status being overfished, while the Gulf of Mexico migratory group has a 0.3% chance of being overfished. The results further indicate that there is a 5.9% chance of the Gulf of Mexico migratory group experiencing overfishing, while there is a 66.7% chance that the South Atlantic migratory group is experiencing overfishing. The current stock status and the results of the 1000 bootstraps analyses are shown in Fig. 10.

In terms of uncertainty, the choice of the indices weighting scheme selected also had a substantial impact on the perception of stock status, as examined by several sensitivity analyses that the review panel considered plausible (Fig. 11). In addition, retrospective patterns from the base run suggest that there may be additional structural uncertainty in the model estimates that is not necessarily captured by bootstrapping.

## Special Comments

The Review Panel highlighted the following points in the Executive Summary of their consensus Report:

The assessment was well carried out and used appropriate methods. However, because of uncertainties in stock structure and incomplete data series, a substantial uncertainty in the state of the stock exists. For practical purposes, the most important of these is that it is very uncertain whether good recruitments that appear in some indices means that the available stock biomass of catchable fish in the eastern Gulf will increase in the next years. It will take two to three years for these fish to enter the fishery, at which point an update assessment should be conducted to test whether the expected increase is indeed occurring.

The uncertainties around the stock assessments due to uncertainties in stock structure and the relationship of the data to the stock are such that considering only base-case assessments would not provide an adequate picture for management purposes. The RP has reviewed a wide range of interpretations of the data and could draw some firm conclusions about the state of the stocks, but other issues remain uncertain. In the face of this uncertainty the RP advocates that estimates be presented in the form of a decision table that illustrates the levels of risk associated with various catch levels.

[3] Determined from the cumulative probability distribution of 1000 bootstrap results.

The uncertainties in the assessments are so important that they cannot be estimated on the basis of a single assessment with stochastic projections. The RP recommends instead that the results of a number of plausible assessments be projected forward so that the results can be used for management purposes in the form of a decision table. The Assessment Team has been asked to prepare such tables (These were completed and can be found in Annex 3). The panel also advises on a closer assessment of the assumptions used concerning the shape of the stock-recruitment relationship at low stock sizes.

The RP had concerns as to the appropriateness of assessing a resource that is apparently migratory and trans-boundary in nature in a national assessment and management structure. This is relevant as the absence of Mexican catch data is a critical source of uncertainty in terms of stock levels and selectivity; better information of the Mexican catch is needed.

**Table 1.** Estimates of directed landings (million pounds*) for the king mackerel Atlantic stock including the 50% split of catch in the Mixing-winter area. Fishing year is April 1st through March 31th of following year, winter catches include from Nov 1st through March 31th.

| Fishing Year | Commercial million lbs | Recreational million lbs | Total wgt | Commercial numbers | Recreational numbers | Total numbers |
|---|---|---|---|---|---|---|
| 1981/82 | 5.142 | 4.754 | 9.896 | 480,266 | 672,661 | 1,152,928 |
| 1982/83 | 5.597 | 4.878 | 10.474 | 497,104 | 618,612 | 1,115,717 |
| 1983/84 | 3.627 | 6.353 | 9.980 | 329,327 | 828,373 | 1,157,700 |
| 1984/85 | 3.049 | 5.546 | 8.595 | 254,939 | 676,709 | 931,648 |
| 1985/86 | 3.781 | 6.215 | 9.996 | 285,533 | 876,422 | 1,161,954 |
| 1986/87 | 3.313 | 5.972 | 9.286 | 313,999 | 875,388 | 1,189,387 |
| 1987/88 | 3.730 | 3.572 | 7.301 | 392,905 | 627,079 | 1,019,983 |
| 1988/89 | 3.549 | 4.975 | 8.524 | 358,110 | 693,435 | 1,051,545 |
| 1989/90 | 3.247 | 3.404 | 6.651 | 303,412 | 477,546 | 780,959 |
| 1990/91 | 3.232 | 3.549 | 6.781 | 356,494 | 526,174 | 882,667 |
| 1991/92 | 3.186 | 6.310 | 9.496 | 337,728 | 831,938 | 1,169,667 |
| 1992/93 | 3.374 | 6.385 | 9.760 | 308,504 | 812,354 | 1,120,858 |
| 1993/94 | 2.766 | 4.245 | 7.011 | 260,266 | 427,433 | 687,698 |
| 1994/95 | 2.960 | 3.728 | 6.688 | 269,440 | 455,905 | 725,345 |
| 1995/96 | 2.675 | 4.551 | 7.225 | 223,112 | 592,380 | 815,492 |
| 1996/97 | 3.601 | 4.600 | 8.201 | 376,671 | 523,291 | 899,962 |
| 1997/98 | 3.636 | 5.490 | 9.126 | 361,157 | 664,584 | 1,025,741 |
| 1998/99 | 3.770 | 4.420 | 8.190 | 363,327 | 541,535 | 904,862 |
| 1999/00 | 2.933 | 3.149 | 6.082 | 299,869 | 409,295 | 709,165 |
| 2000/01 | 2.951 | 4.624 | 7.575 | 273,692 | 589,034 | 862,725 |
| 2001/02 | 2.853 | 3.786 | 6.638 | 236,627 | 383,171 | 619,798 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2002/03 | 2.721 | 2.923 | 5.644 | 245,148 | 385,442 | 630,591 |
| 2003/04 | 2.623 | 3.903 | 6.526 | 228,115 | 489,948 | 718,063 |
| 2004/05 | 3.765 | 3.870 | 7.635 | 356,888 | 409,594 | 766,482 |
| 2005/06 | 3.187 | 3.011 | 6.198 | 297,772 | 442,298 | 740,071 |
| 2006/07 | 3.731 | 3.775 | 7.506 | 357,494 | 497,313 | 854,807 |

*Estimates of whole weight (kg) for king mackerel stock were calculated from the Catch at Size by sex (CAS-Sex) files [numbers of fish by size bin 5 cm, by month, state, sector, gear, sex] times the expected weight at size by sex relationship at the mid-point of the size bin. The size-weight relationships were updated in 2008 by stock and sex using only observations from the no-mixing area respectively (SEDAR16-AW-08). Weights were converted to pounds for presentation.

**Table 2**. Estimates of directed landings (million pounds*) for the king mackerel GOM stock including the 50% split of catch in the Mixing-winter area. Fishing year is July 1st through June 30th of following year, winter catches include from Nov 1st through March 31th.

| Fishing Year | Commercial million lbs | Recreational million lbs | Total | Commercial numbers | Recreational numbers | Total numbers |
|---|---|---|---|---|---|---|
| 1981/82 | 2.894 | 2.124 | 5.018 | 449,537 | 254,017 | 703,554 |
| 1982/83 | 2.981 | 6.450 | 9.432 | 333,460 | 791,645 | 1,125,105 |
| 1983/84 | 1.786 | 1.969 | 3.755 | 294,527 | 332,643 | 627,171 |
| 1984/85 | 2.103 | 2.580 | 4.682 | 252,870 | 400,486 | 653,357 |
| 1985/86 | 2.265 | 1.668 | 3.933 | 324,790 | 195,390 | 520,179 |
| 1986/87 | 0.997 | 2.405 | 3.402 | 135,592 | 387,802 | 523,394 |
| 1987/88 | 0.591 | 1.364 | 1.956 | 73,968 | 228,302 | 302,270 |
| 1988/89 | 0.948 | 3.559 | 4.506 | 103,859 | 410,210 | 514,069 |
| 1989/90 | 1.343 | 2.254 | 3.596 | 163,674 | 420,556 | 584,230 |
| 1990/91 | 1.260 | 2.659 | 3.919 | 170,529 | 400,459 | 570,988 |
| 1991/92 | 1.448 | 2.902 | 4.350 | 180,768 | 571,667 | 752,435 |
| 1992/93 | 2.452 | 3.735 | 6.187 | 371,597 | 476,770 | 848,367 |
| 1993/94 | 1.824 | 3.657 | 5.480 | 231,819 | 511,105 | 742,923 |
| 1994/95 | 2.120 | 5.372 | 7.492 | 286,647 | 649,925 | 936,572 |
| 1995/96 | 1.840 | 3.576 | 5.416 | 247,401 | 482,121 | 729,522 |
| 1996/97 | 1.965 | 4.439 | 6.404 | 307,525 | 516,774 | 824,299 |
| 1997/98 | 2.469 | 3.662 | 6.132 | 322,152 | 477,714 | 799,866 |
| 1998/99 | 2.673 | 2.909 | 5.582 | 365,877 | 370,742 | 736,620 |
| 1999/00 | 2.271 | 2.312 | 4.583 | 283,018 | 323,146 | 606,164 |
| 2000/01 | 2.234 | 2.723 | 4.957 | 286,303 | 386,283 | 672,586 |
| 2001/02 | 2.103 | 2.827 | 4.929 | 283,148 | 400,567 | 683,715 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2002/03 | 2.253 | 2.752 | 5.005 | 347,289 | 407,184 | 754,473 |
| 2003/04 | 2.290 | 2.797 | 5.087 | 311,588 | 365,081 | 676,669 |
| 2004/05 | 2.284 | 2.628 | 4.913 | 355,707 | 361,502 | 717,209 |
| 2005/06 | 2.103 | 2.992 | 5.095 | 305,755 | 414,590 | 720,345 |
| 2006/07 | 2.417 | 3.343 | 5.761 | 325,725 | 508,393 | 834,118 |

*Estimates on weight (kg) for king mackerel stock were calculated from the Catch at Size by sex (CAS-Sex) files [numbers of fish by size bin 5 cm, by month, state, sector, gear, sex] times the expected weight at size by sex relationship at the mid-point of the size bin. The size-weight relationships were updated in 2008 by stock and sex using only observations from the no-mixing area respectively (SEDAR16-AW- 08). Weights were converted to pounds for presentation.

Table 3. Estimates of recreational landings by sector (million pounds whole weight) for king mackerel stock units including 50% split of catch in the mixing-winter area.

| Stock | Fishing Year | Headboat million lbs | MRFSS million lbs | Total | Stock | Fishing Year | Headboat million lbs | MRFSS million lbs | Total |
|---|---|---|---|---|---|---|---|---|---|
| **ATL** | 1981/82 | - | 4.754 | 4.754 | **GOM** | 1981/82 | 0.024 | 2.099 | 2.124 |
| | 1982/83 | - | 4.878 | 4.878 | | 1982/83 | 0.110 | 6.340 | 6.450 |
| | 1983/84 | - | 6.353 | 6.353 | | 1983/84 | 0.096 | 1.873 | 1.969 |
| | 1984/85 | - | 5.546 | 5.546 | | 1984/85 | 0.085 | 2.494 | 2.580 |
| | 1985/86 | 0.010 | 6.205 | 6.215 | | 1985/86 | 0.119 | 1.548 | 1.668 |
| | 1986/87 | 0.283 | 5.689 | 5.972 | | 1986/87 | 0.168 | 2.237 | 2.405 |
| | 1987/88 | 0.207 | 3.365 | 3.572 | | 1987/88 | 0.094 | 1.270 | 1.364 |
| | 1988/89 | 0.183 | 4.792 | 4.975 | | 1988/89 | 0.103 | 3.455 | 3.559 |
| | 1989/90 | 0.176 | 3.228 | 3.404 | | 1989/90 | 0.152 | 2.101 | 2.254 |
| | 1990/91 | 0.229 | 3.320 | 3.549 | | 1990/91 | 0.141 | 2.518 | 2.659 |
| | 1991/92 | 0.251 | 6.059 | 6.310 | | 1991/92 | 0.148 | 2.754 | 2.902 |
| | 1992/93 | 0.179 | 6.206 | 6.385 | | 1992/93 | 0.204 | 3.531 | 3.735 |
| | 1993/94 | 0.161 | 4.084 | 4.245 | | 1993/94 | 0.228 | 3.429 | 3.657 |
| | 1994/95 | 0.177 | 3.551 | 3.728 | | 1994/95 | 0.196 | 5.177 | 5.372 |
| | 1995/96 | 0.137 | 4.414 | 4.551 | | 1995/96 | 0.195 | 3.381 | 3.576 |
| | 1996/97 | 0.311 | 4.289 | 4.600 | | 1996/97 | 0.271 | 4.168 | 4.439 |
| | 1997/98 | 0.168 | 5.323 | 5.490 | | 1997/98 | 0.285 | 3.378 | 3.662 |
| | 1998/99 | 0.123 | 4.298 | 4.420 | | 1998/99 | 0.172 | 2.737 | 2.909 |
| | 1999/00 | 0.151 | 2.998 | 3.149 | | 1999/00 | 0.220 | 2.092 | 2.313 |
| | 2000/01 | 0.150 | 4.474 | 4.624 | | 2000/01 | 0.137 | 2.586 | 2.723 |
| | 2001/02 | 0.102 | 3.683 | 3.786 | | 2001/02 | 0.146 | 2.681 | 2.827 |
| | 2002/03 | 0.094 | 2.830 | 2.923 | | 2002/03 | 0.183 | 2.569 | 2.752 |
| | 2003/04 | 0.075 | 3.829 | 3.903 | | 2003/04 | 0.135 | 2.662 | 2.797 |

| | | | |
|---|---|---|---|
| 2004/05 | 0.141 | 3.728 | 3.869 |
| 2005/06 | 0.184 | 2.826 | 3.011 |
| 2006/07 | 0.154 | 3.621 | 3.775 |

| | | | |
|---|---|---|---|
| 2004/05 | 0.214 | 2.415 | 2.629 |
| 2005/06 | 0.221 | 2.771 | 2.992 |
| 2006/07 | 0.243 | 3.100 | 3.343 |

**Table 4.** Estimates of incidental removals and dead discards (numbers of fish) of king mackerel. Shrimp bycatch are all age 0 fish.

| Fishing Year | Shrimp Bycatch | | Recreational Dead Discards | |
|---|---|---|---|---|
| | Gulf | Atlantic | Gulf | Atlantic |
| 1981/82 | 560,714 | - | 2,002 | 494 |
| 1982/83 | 234,807 | - | 6,241 | 232 |
| 1983/84 | 447,285 | - | 26 | 52 |
| 1984/85 | 1,467,069 | - | 1,759 | 303 |
| 1985/86 | 725,460 | - | 1,999 | 2,617 |
| 1986/87 | 811,806 | - | 5,908 | 8,770 |
| 1987/88 | 1,476,385 | - | 7,366 | 9,324 |
| 1988/89 | 1,690,808 | - | 9,807 | 8,812 |
| 1989/90 | 2,742,900 | 23,369 | 26,236 | 6,103 |
| 1990/91 | 2,093,187 | 64,146 | 33,620 | 7,012 |
| 1991/92 | 2,014,732 | 25,742 | 31,141 | 16,604 |
| 1992/93 | 1,465,161 | 27,117 | 16,655 | 8,011 |
| 1993/94 | 2,789,829 | 13,497 | 21,886 | 7,471 |
| 1994/95 | 3,136,550 | 21,055 | 37,025 | 6,246 |
| 1995/96 | 2,739,787 | 40,141 | 32,092 | 14,357 |
| 1996/97 | 1,376,113 | 59,534 | 26,028 | 13,369 |
| 1997/98 | 1,348,322 | 15,744 | 21,158 | 19,585 |
| 1998/99 | 1,193,085 | 47,539 | 23,037 | 17,020 |
| 1999/00 | 1,210,741 | 32,003 | 20,088 | 20,356 |
| 2000/01 | 1,078,106 | 18,381 | 29,799 | 18,589 |

| | | | | |
|---|---|---|---|---|
| 2001/02 | 772,155 | 7,198 | 64,614 | 25,042 |
| 2002/03 | 641,061 | 8,479 | 53,170 | 19,826 |
| 2003/04 | 1,542,801 | 15,383 | 41,252 | 27,671 |
| 2004/05 | 2,888,086 | 8,185 | 53,527 | 27,253 |
| 2005/06 | 1,909,170 | 7,202 | 84,446 | 38,118 |
| 2006/07 | 923,292 | 13,120 | 63,644 | 32,020 |

**Table 5.** Annual trends in apical F, current F and current F/MFMT. MFMT is calculated with the 2006 current F selectivity vector.

| | SOUTH ATLANTIC | | | GULF OF MEXICO | | |
|---|---|---|---|---|---|---|
| | Apical F | Current F | Current F /MFMT | Apical F | Current F | Current F /MFMT |
| 1983/84 | 0.381 | 0.295 | 0.914 | 0.413 | 0.363 | 1.443 |
| 1984/85 | 0.287 | 0.240 | 0.744 | 0.427 | 0.360 | 1.431 |
| 1985/86 | 0.441 | 0.243 | 0.752 | 0.558 | 0.351 | 1.397 |
| 1986/87 | 0.288 | 0.326 | 1.010 | 0.556 | 0.337 | 1.342 |
| 1987/88 | 0.208 | 0.259 | 0.804 | 0.493 | 0.362 | 1.439 |
| 1988/89 | 0.287 | 0.198 | 0.614 | 0.368 | 0.405 | 1.611 |
| 1989/90 | 0.219 | 0.201 | 0.623 | 0.548 | 0.463 | 1.844 |
| 1990/91 | 0.331 | 0.216 | 0.670 | 0.422 | 0.440 | 1.750 |
| 1991/92 | 0.311 | 0.220 | 0.683 | 0.568 | 0.508 | 2.023 |
| 1992/93 | 0.345 | 0.263 | 0.815 | 0.713 | 0.468 | 1.863 |
| 1993/94 | 0.318 | 0.314 | 0.974 | 0.507 | 0.498 | 1.980 |
| 1994/95 | 0.252 | 0.302 | 0.937 | 0.681 | 0.487 | 1.939 |
| 1995/96 | 0.361 | 0.268 | 0.832 | 0.537 | 0.525 | 2.091 |
| 1996/97 | 0.366 | 0.292 | 0.906 | 0.377 | 0.476 | 1.895 |
| 1997/98 | 0.390 | 0.372 | 1.154 | 0.294 | 0.386 | 1.534 |
| 1998/99 | 0.315 | 0.331 | 1.025 | 0.313 | 0.318 | 1.265 |
| 1999/00 | 0.233 | 0.253 | 0.783 | 0.346 | 0.309 | 1.229 |
| 2000/01 | 0.263 | 0.228 | 0.706 | 0.313 | 0.319 | 1.271 |
| 2001/02 | 0.285 | 0.234 | 0.725 | 0.212 | 0.284 | 1.131 |
| 2002/03 | 0.269 | 0.232 | 0.719 | 0.177 | 0.214 | 0.852 |
| 2003/04 | 0.358 | 0.249 | 0.772 | 0.225 | 0.192 | 0.763 |
| 2004/05 | 0.377 | 0.288 | 0.893 | 0.223 | 0.195 | 0.776 |
| 2005/06 | 0.344 | 0.317 | 0.982 | 0.239 | 0.207 | 0.826 |
| 2006/07 | 0.359 | 0.325 | 1.007 | 0.287 | 0.207 | 0.825 |

**Table 6.** Recruitment (number at Age 0) and abundance (numbers at Age 1+) for the South Atlantic and Gulf of Mexico king mackerel migratory groups.

| | AGE 0 | | AGE 1+ | |
|---|---|---|---|---|
| Fishing Year | South Atlantic | Gulf of Mexico | South Atlantic | Gulf of Mexico |
| 1981/82 | 5.59E+06 | 4.49E+06 | 1.28E+07 | 5.09E+06 |
| 1982/83 | 4.61E+06 | 4.00E+06 | 1.21E+07 | 5.25E+06 |
| 1983/84 | 3.76E+06 | 1.96E+06 | 1.11E+07 | 4.94E+06 |
| 1984/85 | 5.52E+06 | 6.39E+06 | 9.92E+06 | 4.04E+06 |
| 1985/86 | 7.18E+06 | 4.47E+06 | 1.01E+07 | 4.72E+06 |
| 1986/87 | 4.90E+06 | 3.72E+06 | 1.08E+07 | 4.96E+06 |
| 1987/88 | 2.91E+06 | 5.27E+06 | 1.02E+07 | 4.68E+06 |
| 1988/89 | 3.90E+06 | 7.69E+06 | 8.81E+06 | 4.95E+06 |
| 1989/90 | 8.63E+06 | 8.99E+06 | 8.22E+06 | 5.97E+06 |
| 1990/91 | 5.73E+06 | 8.47E+06 | 1.04E+07 | 6.62E+06 |
| 1991/92 | 2.55E+06 | 6.43E+06 | 1.04E+07 | 7.29E+06 |
| 1992/93 | 3.12E+06 | 5.87E+06 | 8.60E+06 | 6.79E+06 |
| 1993/94 | 3.47E+06 | 9.80E+06 | 7.48E+06 | 6.49E+06 |
| 1994/95 | 5.26E+06 | 1.05E+07 | 7.20E+06 | 7.29E+06 |
| 1995/96 | 5.81E+06 | 9.13E+06 | 7.83E+06 | 7.82E+06 |
| 1996/97 | 5.29E+06 | 6.12E+06 | 8.49E+06 | 8.02E+06 |
| 1997/98 | 2.95E+06 | 7.69E+06 | 8.63E+06 | 7.59E+06 |
| 1998/99 | 5.31E+06 | 6.44E+06 | 7.48E+06 | 8.04E+06 |
| 1999/00 | 2.62E+06 | 5.80E+06 | 7.86E+06 | 7.97E+06 |

| | | | | |
|---|---|---|---|---|
| 2000/01 | 2.21E+06 | 5.63E+06 | 6.98E+06 | 7.71E+06 |
| 2001/02 | 4.58E+06 | 5.70E+06 | 5.95E+06 | 7.48E+06 |
| 2002/03 | 3.82E+06 | 6.59E+06 | 6.56E+06 | 7.50E+06 |
| 2003/04 | 6.98E+06 | 1.08E+07 | 6.61E+06 | 7.96E+06 |
| 2004/05 | 3.42E+06 | 2.04E+07 | 8.18E+06 | 9.73E+06 |
| 2005/06 | 3.63E+06 | 1.66E+07 | 7.52E+06 | 1.46E+07 |
| 2006/07 | 4.71E+06 | 1.34E+07 | 7.17E+06 | 1.73E+07 |

**Table 7.** Spawning stock (billions of hydrated eggs) and SSB/MSST ratios for the South Atlantic and Gulf of Mexico king mackerel migratory groups.

| | SSB | | SSB/MSST | |
|---|---|---|---|---|
| Fishing Year | South Atlantic | Gulf of Mexico | South Atlantic | Gulf of Mexico |
| 1981/82 | 4508 | 2123 | 2.47 | 0.81 |
| 1982/83 | 4568 | 2036 | 2.50 | 0.78 |
| 1983/84 | 4587 | 1555 | 2.51 | 0.59 |
| 1984/85 | 4498 | 1590 | 2.46 | 0.61 |
| 1985/86 | 4418 | 1502 | 2.42 | 0.57 |
| 1986/87 | 4275 | 1532 | 2.34 | 0.59 |
| 1987/88 | 4086 | 1590 | 2.24 | 0.61 |
| 1988/89 | 3873 | 1731 | 2.12 | 0.66 |
| 1989/90 | 3555 | 1748 | 1.95 | 0.67 |
| 1990/91 | 3545 | 1885 | 1.94 | 0.72 |
| 1991/92 | 3580 | 2040 | 1.96 | 0.78 |
| 1992/93 | 3369 | 2215 | 1.84 | 0.85 |
| 1993/94 | 3098 | 2245 | 1.70 | 0.86 |
| 1994/95 | 2962 | 2265 | 1.62 | 0.87 |
| 1995/96 | 2873 | 2210 | 1.57 | 0.84 |
| 1996/97 | 2847 | 2340 | 1.56 | 0.89 |
| 1997/98 | 2824 | 2443 | 1.55 | 0.93 |
| 1998/99 | 2701 | 2509 | 1.48 | 0.95 |
| 1999/00 | 2641 | 2658 | 1.45 | 1.02 |
| 2000/01 | 2640 | 2788 | 1.45 | 1.07 |
| 2001/02 | 2476 | 2876 | 1.36 | 1.10 |

| | | | | |
|---|---|---|---|---|
| 2002/03 | 2377 | 2873 | 1.3 | 1.10 |
| 2003/04 | 2341 | 2872 | 1.28 | 1.10 |
| 2004/05 | 2365 | 2955 | 1.29 | 1.13 |
| 2005/06 | 2433 | 3285 | 1.33 | 1.26 |
| 2006/07 | 2443 | 3921 | 1.34 | 1.50 |

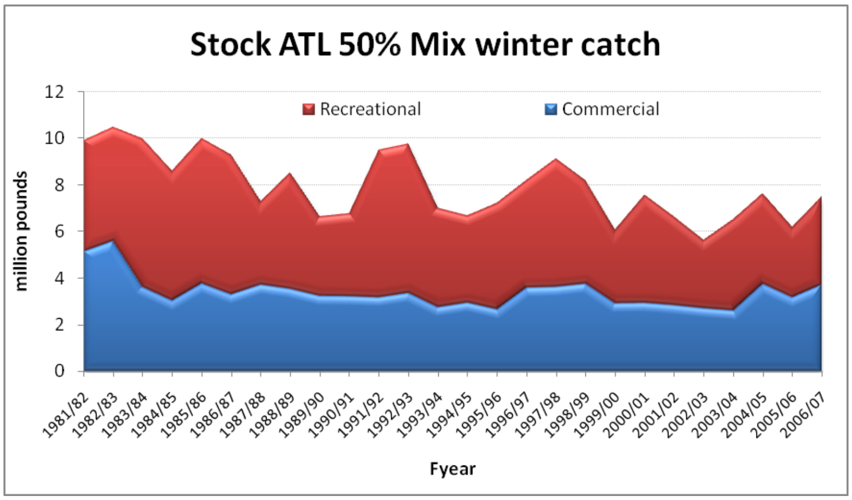


**Figure 1.** Estimated retained catch (million lbs) of Atlantic king mackerel by sector and fishing year (Apr-Mar) assuming a 50% split of the catch in the mixing-winter zone between stocks.

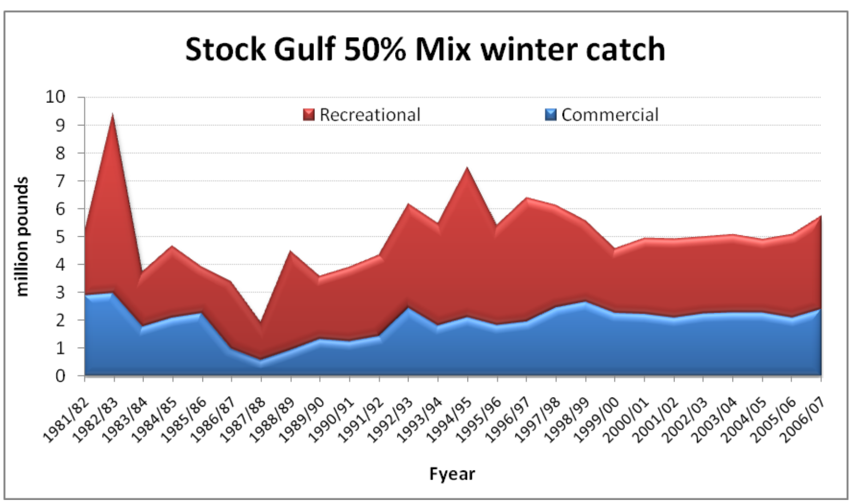


**Figure 2.** Estimated retained catch (million lbs) of Gulf king mackerel by sector and fishing year (Jul-Jun) assuming a 50% split of the catch in the mixing-winter zone between stocks.

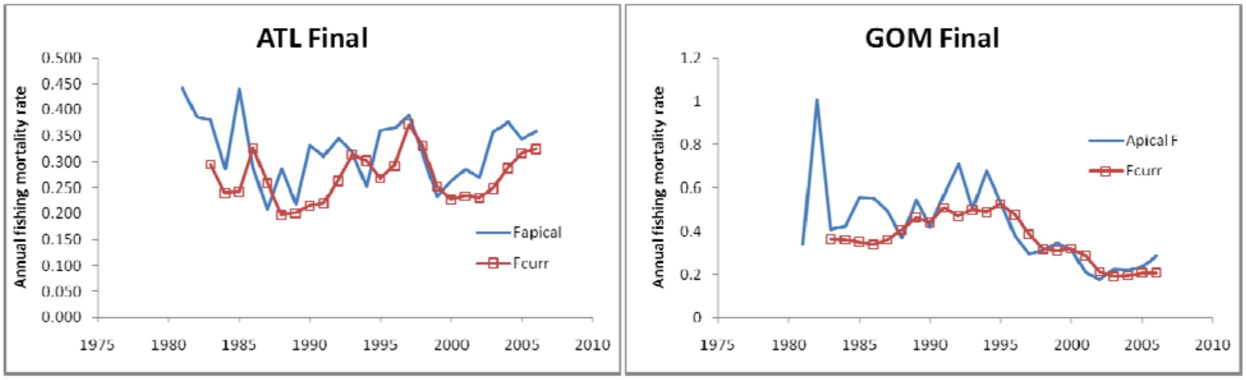


**Figure 3.** Annual trend in apical fishing mortality and current fishing mortality for base models.

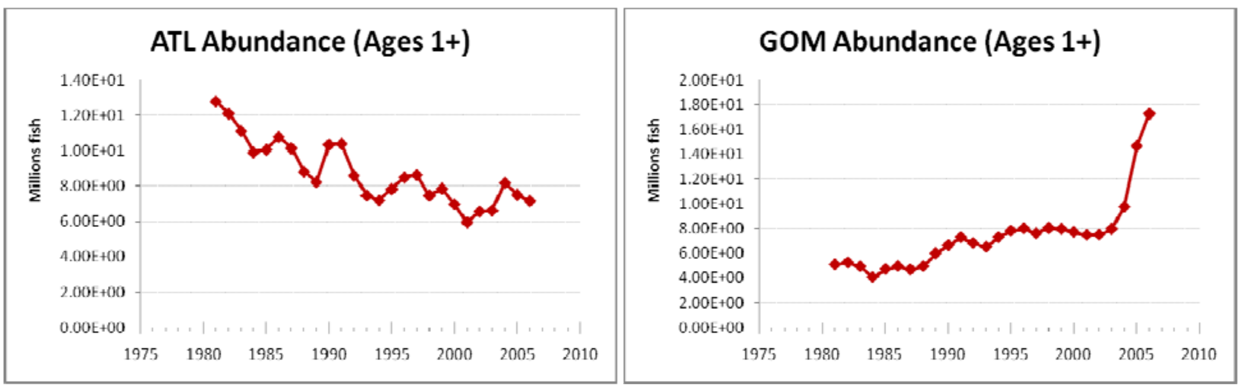


**Figure 4.** Annual trend in abundance (number of fish Ages 1+) for base models.

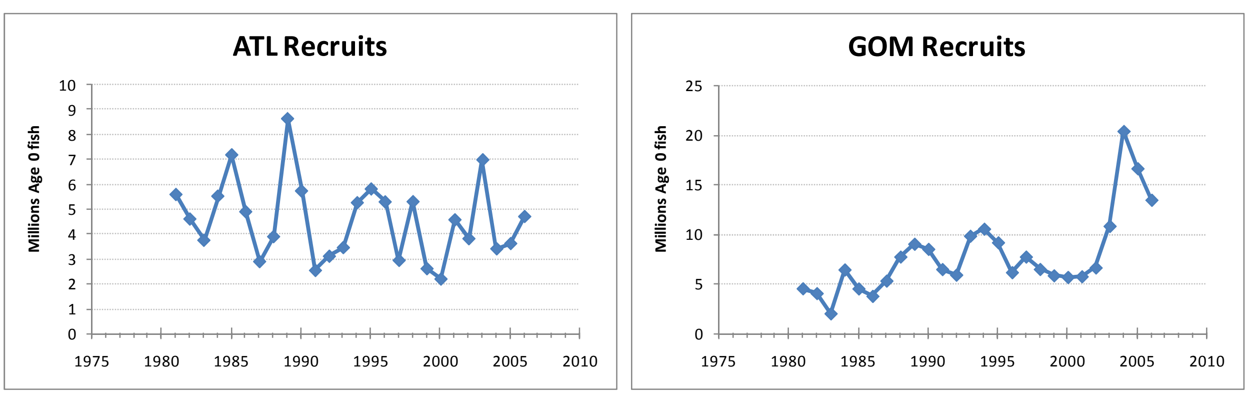


**Figure 5.** Annual trend in recruitment (Age-0) for base models.

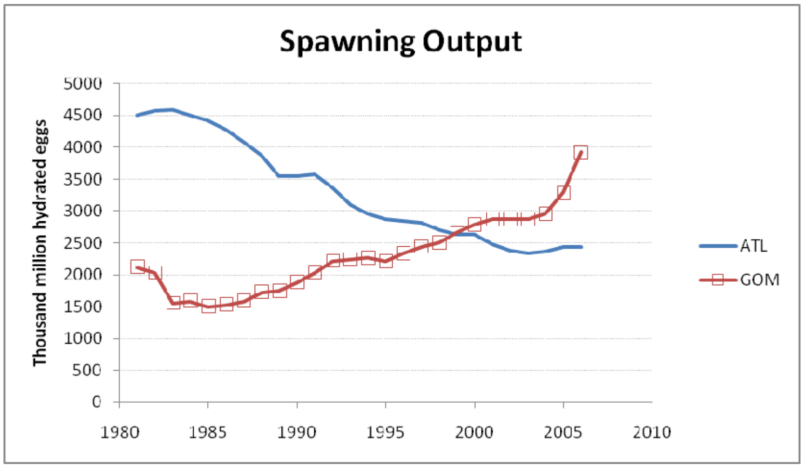


**Figure 6.** Annual trend in spawning stock (billions of hydrated eggs) for base models.

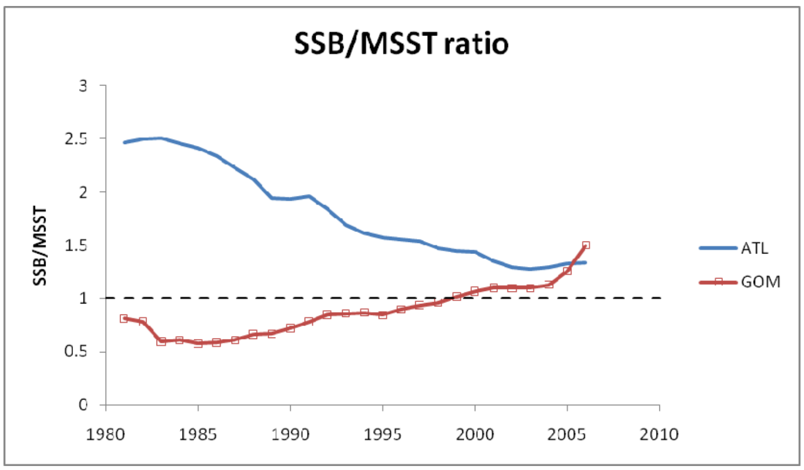


**Figure 7.** Annual trend in SSB/MSST for South Altantic and Gulf of Mexico base models.

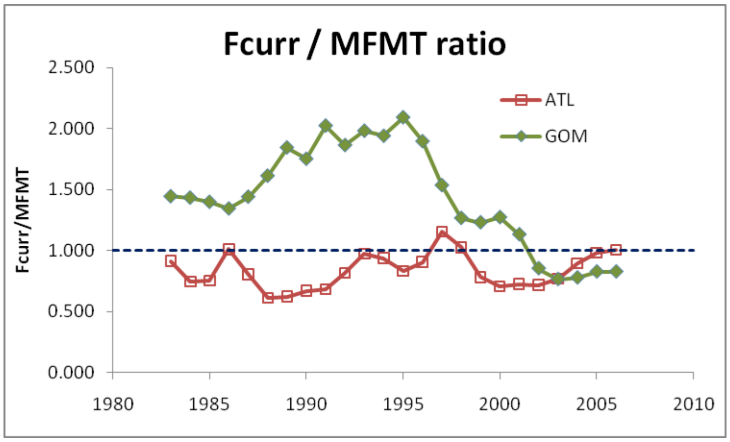


**Figure 8.** Annual trend in F/MFMT for base models. MFMT is calculated with the 2006 current F selectivity vector (based on F for years 2004-2006). .

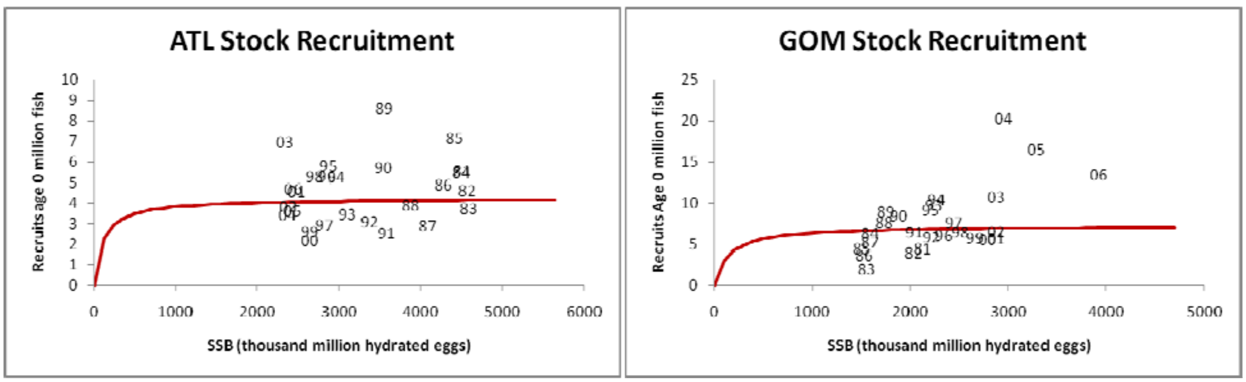


**Figure 9.** Recruits and SSB from VPA base models (numbers) and estimated Beverton and Holt S-R functions (solid line) used for projections of the base models. Numbers represent the year-class.

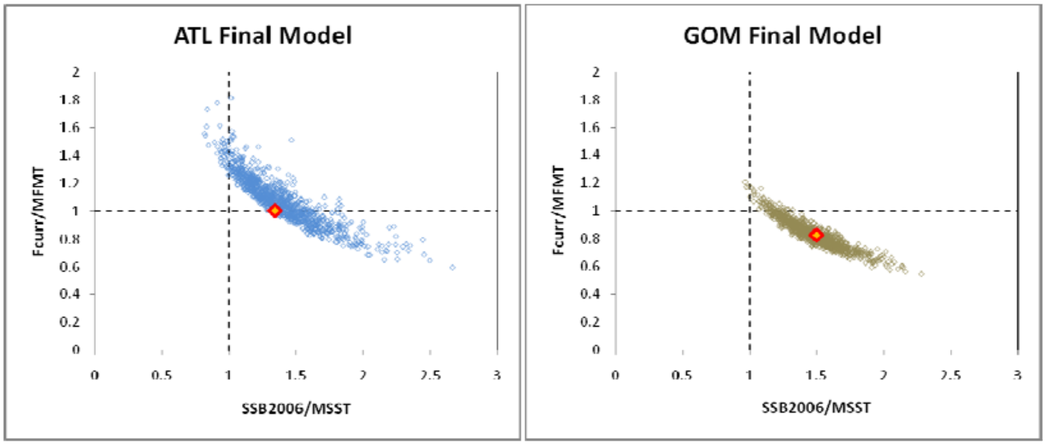


**Figure 10.** Phase plots of current stock status for Gulf of Mexico and South Atlantic king mackerel. The red large diamond is the deterministic result, small squares are bootstrap results.

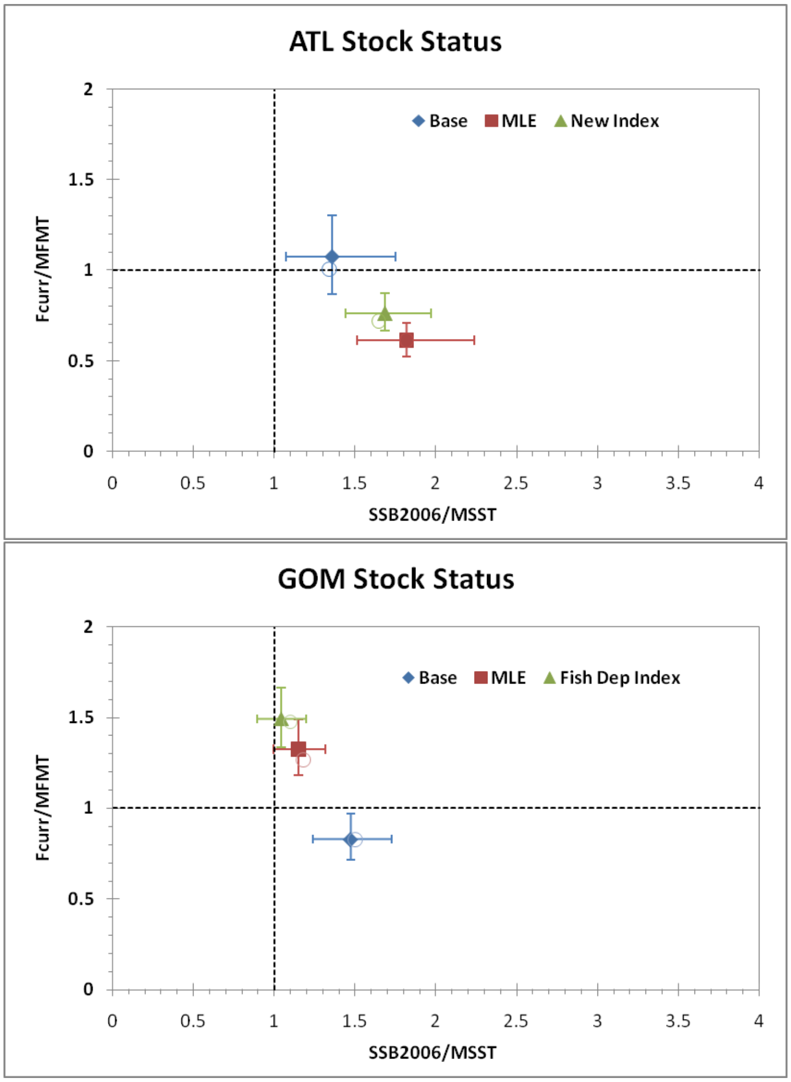


**Figure 11.** Phase plot showing 2006 stock status for final base runs and sensitivity analyses (Review Panel "States of Nature"). The error bars indicate the 10th and 90th percentiles. The open symbols indicate the deterministic run upon which management advice was based. The closed symbols indicate the median estimate.

## 6. STOCK ASSESSMENT IMPROVEMENT PROGRAM FORMS

# Data for NMFS Species Information System

## Gulf of Mexico King Mackerel

(Please see Table of FB Field Values below. Also, for Best F, F Year, F/Flimit, F/Fmsy, F/Ftarget, Best B Estimate, B Year, B/Blimit, and B/Bmsy, please provide end-year values. The min/max fields can be left empty—these were included to accommodate assessments that can only provide a range of values but no single best estimate.)

| Data Elements: | Workshop Data: |
|---|---|
| **Assessment Year** — The year the assessment completes its scientific review and is available for advice to management. | 2008 |
| **Assessment Month** — The month the assessment completes its scientific review and is available for advice to management. | August |
| **Last Data Year** — The most recent year of data included in the assessment. | 2006/7 Fishing Year |
| **Assessment Model** — Name of assessment model accepted by the scientific review process and used to complete the stock assessment. | VPA-2BOX |
| **Model Version** — Version of the assessment model accepted by the scientific review process and used to complete the stock assessment. | 3.01 |
| **Lead Lab** — NMFS Laboratory or outside agency with lead responsibility for the stock assessment. | SEFSC |
| **Point of Contact** — Full name of the person to contact with questions regarding the assessment. | Mauricio Ortiz, Shannon Cass-Calay |
| **Update Type** — New: The stock has never been assessed before; Benchmark: Assessments that are substantially different from the previous assessment (new/updated model, inclusion of new data source); Update: Assessments that have included the most recent catch and/or abundance index data to provide updated status determinations or quota recommendations (no substantial changes to the methods of interpretation). | Benchmark |
| **Review Type** — Accept: Assessment was accepted by the scientific review committee and is available for use as advice to management; Reject: Assessment was rejected by the scientific review committee and will not be used as advice for management; Remand: Assessment was sent back by the scientific review committee for changes or re-evaluation; Not Reviewed: Assessment was not reviewed by a scientific or technical review committee. | Accept |

| Data Elements: | Workshop Data: |
|---|---|
| **Life History** — 0: No life history data; 1: The size composition of harvested fish provides a simple index of a stock's growth potential and vulnerability to overharvesting; 2: Basic demographic parameters such as age, growth, and maturity rates provide information on productivity and natural mortality; 3: Seasonal and spatial patterns of mixing, migration, and variability in life history characteristics, especially growth and maturity, provides improved understanding of how a population responds to its environment; 4: Food habits information defines the predator-prey and competitive relationships within the fish community, thus providing a first step towards direct estimation of natural mortality rates and ecologically-based harvest recommendations. | 3 |
| **Frequency** — 0: Never-an assessment has never been conducted; 1: Infrequent-the most recent assessment was conducted more than three years ago; 2: Frequent or recent-the most recent assessment was conducted within the last three years but is not conducted annually; 3: Annual or more-assessments are conducted at least annually. | 2 |
| **Level** — 0: Although some data may have been collected on this species, these data have not been examined beyond simple time series plots or tabulations of catch; 1: Either a) time series of a (potentially imprecise) abundance index calculated as raw or standardized CPUE in commercial, recreational, or survey vessel data, or b) onetime estimation of absolute abundance made on the basis of tagging results, a depletion study, or some form of calibrated survey; 2: Simple equilibrium models applied to life history information; for example, yield per recruit or spawner per recruit functions based on mortality, growth, and maturity schedules; catch curve analysis; survival analysis; or length-based cohort analysis; 3: Equilibrium and non-equilibrium production models aggregated both spatially and over age and size; for example, the Schaefer model and the Pella-Tomlinson model; 4: Size, stage, or age structured models such as cohort analysis and untuned and tuned VPA analyses, age-structured production models, CAGEAN, stock synthesis, size or age-structured Bayesian models. modified DeLury methods, and size or age-based mark-recapture models; 5: Assessment models incorporating ecosystem considerations and spatial and seasonal analyses in addition to Levels 3 and 4. Ecosystem considerations include one or more of the following a) one or more time-varying parameters, either estimated as constrained series, or driven by environmental variables, b) multiple target species as state variables in the model, or c) living components of the ecosystem other than the target species included as state variables in the model. | 4 |
| **Catch** — 0: No catch data; 1: Landed catch provides a minimum estimate of fishery removals and is | 4 |

| Data Elements: | Workshop Data: |
|---|---|
| typically obtained from mandatory landing receipts. In some cases, particularly recreational fisheries, a statistical sampling program is used to expand estimates of sampled catch up to the total angling population; 2: Catch size composition provides a measure of the sizes of fish being impacted by the fishery, and when tracked over time can provide an index of recruitment to the fishery and total mortality rates; 3: Spatial data on catch from logbooks can provide information on range extensions and contractions, and other changes in stock or fleet distribution; 4: Catch age composition requires the development of age determination techniques and an investment in the collection and processing of appropriate samples. The result is much greater stock assessment accuracy than can be obtained with size composition alone; 5: Accurate and complete data on total removals (including landed catch, discards, bycatch in other fisheries, and cryptic mortality induced by fishing gear contact) will contribute to accurate stock assessment results. An at-sea observer program can monitor total removals, cross-check logbook data, and collect site-specific biological samples. In many fisheries, the relative merits of observer programs for collecting data on total removals and/or age composition data may warrant consideration before or instead of investing in a fishery logbook program. | |
| **Abundance** — 0: No abundance data; 1: Relative abundance index from fishery catch per unit effort or an imprecise, infrequent suervey. Another Level 1 situation would be a single survey from which an estimate of absolute abundance has been made. At this low level of information there will only be a limited ability to track changes in stock abundance because of uncertainties in the calibration of the index, or a high level of noise in the data relative to the magnitude of the expected changes in stock abundance; 2: Precise, frequent surveys with age composition will provide more accurate tracking of changes in stock abundance and the associated age composition data will enable better estimation of historical and current levels of recruitment; 3: Research surveys with known or estimated catchability, acoustic surveys with known or estimated target strengths, and statistically-designed tagging studies can provide estimates of absolute abundance. This is especially valuable when the time series of the survey is so short that no trend is detectable; 4: Habitat-specific surveys refine the concept of stratified random surveys so that survey results are more closely associated with particular habitats. The result is improved knowledge of the relationship between fish assemblages and habitat features. In addition, these surveys use alternative methodologies to extend survey coverage into all relevant habitats. | 1 |
| **Citation** — A complete citation for the assessment document so users can locate the source document if necessary. If the document is available in electronic format, include a web address in addition to the citation. | SEDAR 16 South Atlantic and Gulf of Mexico King Mackerel. Section V: Review Workshop Report |

| Data Elements: | Workshop Data: |
| --- | --- |
| | http://www.sefsc.noaa.gov/sedar/Sedar_Documents.jsp?WorkshopNum=16&FolderType=Review |
| **Minimum F Estimate** — Minimum estimate of fishing mortality or total catch used to determine the rate of fishing (used when ranges are available). | |
| **Maximum F Estimate** — Maximum estimate of fishing mortality or total catch used to determine the rate of fishing (used when ranges are available). | |
| **Best F Estimate** — Best available point estimate of fishing mortality rate or total catch used to determine the rate of fishing. | 0.155 |
| **F Unit** — Unit of measure for the fishing mortality-related fields. | Instantaneous F averaged across ages (2-8). |
| **F Year** — The year of the fishing mortality estimates. | "Current F" (Geomean FY2004-6) |
| **F Basis** — Basis for the fishing mortality estimate (F rate or total catch estimate). | Average F (across ages 2-8) |
| **Flimit** — Fishing mortality rate or total catch threshold, above which the stock is considered to be overfishing. | 0.187 |
| **Flimit Basis** — Basis for the Flimit estimate (F rate or total catch estimate). | FSPR30% |
| **Fmsy** — Fishing mortality rate that, on average, would produce the maximum sustainable yield from a stock that has a size of Bmsy. | 0.187 |
| **Fmsy Basis** — Basis for the Fmsy estimate (calculated, proxy, etc.) | FSPR30% as proxy |
| **Ftarget** — Fishing mortality rate or catch level associated with an annual target identified by the FMC. | |
| **Ftarget Basis** — Basis for the target fishing mortality rate (F rate or total catch estimate). | |
| **F/Flimit** — Ratio of current fishing mortality and the overfishing threshold or catch/catch level associated with Flimit. | 0.827 |
| **F/Fmsy** — Ratio of current fishing mortality and the fishing mortality that would produce the MSY or catch/catch level associated with Fmsy. | 0.827 |

| Data Elements: | Workshop Data: |
|---|---|
| **F/Ftarget** — Ratio of current fishing mortality and the target fishing mortality rate or catch/catch level associated with an annual target identified by the FMC. | |
| **Minimum B Estimate** — Minimum estimate of the stock size in terms of biomass from the assessment model (used when ranges are available). | 3224 Billion hydrated oocytes |
| **Maximum B Estimate** — Maximum estimate of stock size in terms of biomass from the assessment model (used when ranges are available). | 4512 Billion hydrated oocytes |
| **Best B Estimate** — Best available point estimate of stock size in terms of biomass from the assessment model. | 3921 Billion hydrated oocytes |
| **B Unit** — Units used for the biomass related fields. | Billion hydrated oocytes |
| **B Year** — Year of biomass estimate. | FY2006/7 |
| **B Basis** — Basis for the biomass estimate (calculated, survey) and type of estimate (total, spawning stock, summary). | Female reproductive output |
| **Blimit** — Stock size threshold, below which the stock is considered to be overfished. | 2615 |
| **Blimit Basis** — Basis for the Blimit estimate (calculate, B%, etc.) | (1-M) * BSPR30% |
| **Bmsy** — Stock size that, on average, would produce MSY when it is fished at a level equal to Fmsy. | 3166 Billion hydrated oocytes |
| **Bmsy Basis** — Basis for the Bmsy estimate (B%, proxy, etc.) | (1-M) * B30%SPR |
| **MSY** — Maximum Sustainable Yield- the maximum long-term average catch that can be achieved from the stock. | 9.10 million pounds |
| **Stock Level to Bmsy** — The current stock abundance level relative to the biomass level that would, on average, support the MSY. Below: B/Bmsy < 0.8 Near: 0.8 < B/Bmsy < 1.0 Above: B/Bmsy > 1.0 | Above |
| **B/Blimit** — Ratio of current biomass and the overfished level. | 1.499 |
| **B/Bmsy** — Ratio of current biomass and the biomass at MSY; measure of stock size. | 1.238 |
| **Comments** — Any additional information on the assessment. | |

## Table of FB Field Values

| F Unit | F Basis | Flimit Basis | Fmsy Basis | Ftarget Basis | B Unit | B Basis | Blimit Basis | Bmsy Basis |
|---|---|---|---|---|---|---|---|---|
| tons | apical F (max F at age) | $F_{30\%}$ | Direct estimate | $F_{30\%}$ | adult spawners (hatchery + natural) | Female reproductive output | $B_{20\%}$ | $B_{30\%}$ |
| spawners (natural only) | average F (F average across range of ages) | $F_{35\%}$ | $F_{30\%}$ as proxy | $F_{35\%}$ | individuals per hectare | Mature female biomass | $B_{25\%}$ | $B_{35\%}$ |
| pounds of tails | catch | $F_{35\%}$ adjusted for biomass | $F_{35\%}$ as proxy | $F_{35\%}$ adjusted for biomass | kg/tow | Spawning biomass | $B_{30\%}$ | $B_{40\%}$ |
| mt | effort | $F_{40\%}$ | $F_{40\%}$ as proxy | $F_{40\%}$ | lbs. | Survey CPUE | $B_{35\%}$ | Avg. survey CPUE |
| individuals per hectare | U (exploitation rate = catch/biomass) | $F_{40\%}$ adjusted for biomass | $F_{45\%}$ as proxy | $F_{40\%}$ adjusted for biomass | lbs. Head on (shrimp only) | Total stock biomass | $B_{40\%}$ | CPUE at MSY |
| catch/survey index | | $F_{45\%}$ | $F_{50\%}$ as proxy | $F_{45\%}$ | million lbs. | | $(1-M)*B_{30\%}$ | Escapement goal |
| adult spawners (hatchery + natural) | | $F_{45\%}$ adjusted for biomass | $F_{max}$ as proxy | $F_{45\%}$ adjusted for biomass | million lbs. Shucked meats | | $0.5*B_{35\%}$ | MSY/M |

| F Unit | F Basis | Flimit Basis | Fmsy Basis | Ftarget Basis | B Unit | B Basis | Blimit Basis | Bmsy Basis |
|---|---|---|---|---|---|---|---|---|
| Instantaneous annual F for age with maximum F | | $F_{50\%}$ | | $F_{50\%}$ | million shrimp | | $0.5*B_{msy}$ | |
| Instantaneous annual F averaged across ages | | $F_{50\%}$ adjusted for biomass | | $F_{50\%}$ adjusted for biomass | mt | | $0.6*B_{msy}$ | |
| annual exploitation rate | | $F_{msy}$ | | $F_{msy}$ | mt (eggs only) | | $0.7*B_{msy}$ | |
| | | $F_{msy}$ adjusted for $B<B_{msy}$ | | $F_{msy}*(F_{40\%}/F_{35\%})$ adjusted for biomass | mt (female biomass only) | | $0.8*B_{msy}$ | |
| | | $F_{max}$ | | $0.6*F_{msy}$ | mt (meat weight only) | | $(1-M)*B_{msy}$ | |
| | | $F_{rebuild}$ | | $0.75*F_{msy}$ | number of spawning fish | | 0.7*CPUE @ MSY | |
| | | M | | $0.85*F_{msy}$ | number of fish | | 50% Escapement goal | |
| | | $catch/(B_{msy}*0.2)$ | | $0.75*F_{limit}$ | spawners (natural only) | | | |

| F Unit | F Basis | Flimit Basis | Fmsy Basis | Ftarget Basis | B Unit | B Basis | Blimit Basis | Bmsy Basis |
|---|---|---|---|---|---|---|---|---|
| | | catch/($B_{msy}$*0.3) | | $F_{max}$ | trillion eggs | | | |
| | | $m_H$ (arithmetic mean of the pdf of $F_{msy}$) adjusted for biomass | | $F_{rebuild}$ | | | | |
| | | Effort at MSY | | 0.75*M | | | | |
| | | MSY | | $m_H$ (harmonic mean of the pdf of $F_{msy}$) adjusted for biomass | | | | |
| | | | | Effort at MSY | | | | |
| | | | | MSY | | | | |

## Data for NMFS Species Information System

## South Atlantic King Mackerel

(Please see Table of FB Field Values below. Also, for Best F, F Year, F/Flimit, F/Fmsy, F/Ftarget, Best B Estimate, B Year, B/Blimit, and B/Bmsy, please provide end-year values. The min/max fields can be left empty—these were included to accommodate assessments that can only provide a range of values but no single best estimate.)

| Data Elements: | Workshop Data: |
|---|---|
| **Assessment Year** — The year the assessment completes its scientific review and is available for advice to management. | 2008 |
| **Assessment Month** — The month the assessment completes its scientific review and is available for advice to management. | August |
| **Last Data Year** — The most recent year of data included in the assessment. | 2006/7 Fishing Year |
| **Assessment Model** — Name of assessment model accepted by the scientific review process and used to complete the stock assessment. | VPA-2BOX |
| **Model Version** — Version of the assessment model accepted by the scientific review process and used to complete the stock assessment. | 3.01 |
| **Lead Lab** — NMFS Laboratory or outside agency with lead responsibility for the stock assessment. | SEFSC |
| **Point of Contact** — Full name of the person to contact with questions regarding the assessment. | Mauricio Ortiz, Shannon Cass-Calay |
| **Update Type** — New: The stock has never been assessed before; Benchmark: Assessments that are substantially different from the previous assessment (new/updated model, inclusion of new data source); Update: Assessments that have included the most recent catch and/or abundance index data to provide updated status determinations or quota recommendations (no substantial changes to the methods of interpretation). | Benchmark |
| **Review Type** — Accept: Assessment was accepted by the scientific review committee and is available for use as advice to management; Reject: Assessment was rejected by the scientific review committee and will not be used as advice for management; Remand: Assessment was sent back by the scientific review committee for changes or re-evaluation; Not Reviewed: Assessment was not reviewed by a scientific or technical review committee. | Accept |

| Data Elements: | Workshop Data: |
|---|---|
| **Life History** — 0: No life history data; 1: The size composition of harvested fish provides a simple index of a stock's growth potential and vulnerability to overharvesting; 2: Basic demographic parameters such as age, growth, and maturity rates provide information on productivity and natural mortality; 3: Seasonal and spatial patterns of mixing, migration, and variability in life history characteristics, especially growth and maturity, provides improved understanding of how a population responds to its environment; 4: Food habits information defines the predator-prey and competitive relationships within the fish community, thus providing a first step towards direct estimation of natural mortality rates and ecologically-based harvest recommendations. | 3 |
| **Frequency** — 0: Never-an assessment has never been conducted; 1: Infrequent-the most recent assessment was conducted more than three years ago; 2: Frequent or recent-the most recent assessment was conducted within the last three years but is not conducted annually; 3: Annual or more-assessments are conducted at least annually. | 2 |
| **Level** — 0: Although some data may have been collected on this species, these data have not been examined beyond simple time series plots or tabulations of catch; 1: Either a) time series of a (potentially imprecise) abundance index calculated as raw or standardized CPUE in commercial, recreational, or survey vessel data, or b) onetime estimation of absolute abundance made on the basis of tagging results, a depletion study, or some form of calibrated survey; 2: Simple equilibrium models applied to life history information; for example, yield per recruit or spawner per recruit functions based on mortality, growth, and maturity schedules; catch curve analysis; survival analysis; or length-based cohort analysis; 3: Equilibrium and non-equilibrium production models aggregated both spatially and over age and size; for example, the Schaefer model and the Pella-Tomlinson model; 4: Size, stage, or age structured models such as cohort analysis and untuned and tuned VPA analyses, age-structured production models, CAGEAN, stock synthesis, size or age-structured Bayesian models. modified DeLury methods, and size or age-based mark-recapture models; 5: Assessment models incorporating ecosystem considerations and spatial and seasonal analyses in addition to Levels 3 and 4. Ecosystem considerations include one or more of the following a) one or more time-varying parameters, either estimated as constrained series, or driven by environmental variables, b) multiple target species as state variables in the model, or c) living components of the ecosystem other than the target species included as state variables in the model. | 4 |
| **Catch** — 0: No catch data; 1: Landed catch provides a minimum estimate of fishery removals and is | 4 |

| Data Elements: | Workshop Data: |
|---|---|
| typically obtained from mandatory landing receipts. In some cases, particularly recreational fisheries, a statistical sampling program is used to expand estimates of sampled catch up to the total angling population; 2: Catch size composition provides a measure of the sizes of fish being impacted by the fishery, and when tracked over time can provide an index of recruitment to the fishery and total mortality rates; 3: Spatial data on catch from logbooks can provide information on range extensions and contractions, and other changes in stock or fleet distribution; 4: Catch age composition requires the development of age determination techniques and an investment in the collection and processing of appropriate samples. The result is much greater stock assessment accuracy than can be obtained with size composition alone; 5: Accurate and complete data on total removals (including landed catch, discards, bycatch in other fisheries, and cryptic mortality induced by fishing gear contact) will contribute to accurate stock assessment results. An at-sea observer program can monitor total removals, cross-check logbook data, and collect site-specific biological samples. In many fisheries, the relative merits of observer programs for collecting data on total removals and/or age composition data may warrant consideration before or instead of investing in a fishery logbook program. | |
| **Abundance** — 0: No abundance data; 1: Relative abundance index from fishery catch per unit effort or an imprecise, infrequent suervey. Another Level 1 situation would be a single survey from which an estimate of absolute abundance has been made. At this low level of information there will only be a limited ability to track changes in stock abundance because of uncertainties in the calibration of the index, or a high level of noise in the data relative to the magnitude of the expected changes in stock abundance; 2: Precise, frequent surveys with age composition will provide more accurate tracking of changes in stock abundance and the associated age composition data will enable better estimation of historical and current levels of recruitment; 3: Research surveys with known or estimated catchability, acoustic surveys with known or estimated target strengths, and statistically-designed tagging studies can provide estimates of absolute abundance. This is especially valuable when the time series of the survey is so short that no trend is detectable; 4: Habitat-specific surveys refine the concept of stratified random surveys so that survey results are more closely associated with particular habitats. The result is improved knowledge of the relationship between fish assemblages and habitat features. In addition, these surveys use alternative methodologies to extend survey coverage into all relevant habitats. | 1 |
| **Citation** — A complete citation for the assessment document so users can locate the source document if necessary. If the document is available in electronic format, include a web address in addition to the citation. | SEDAR 16 South Atlantic and Gulf of Mexico King Mackerel. Section V: Review Workshop Report |

| Data Elements: | Workshop Data: |
|---|---|
| | http://www.sefsc.noaa.gov/sedar/Sedar_Documents.jsp?WorkshopNum=16&FolderType=Review |
| **Minimum F Estimate** — Minimum estimate of fishing mortality or total catch used to determine the rate of fishing (used when ranges are available). | |
| **Maximum F Estimate** — Maximum estimate of fishing mortality or total catch used to determine the rate of fishing (used when ranges are available). | |
| **Best F Estimate** — Best available point estimate of fishing mortality rate or total catch used to determine the rate of fishing. | 0.258 |
| **F Unit** — Unit of measure for the fishing mortality-related fields. | Instantaneous F averaged across ages (2-8). |
| **F Year** — The year of the fishing mortality estimates. | "Current F" (Geomean FY2004-6) |
| **F Basis** — Basis for the fishing mortality estimate (F rate or total catch estimate). | Average F (across ages 2-8) |
| **Flimit** — Fishing mortality rate or total catch threshold, above which the stock is considered to be overfishing. | 0.256 |
| **Flimit Basis** — Basis for the Flimit estimate (F rate or total catch estimate). | FSPR30% |
| **Fmsy** — Fishing mortality rate that, on average, would produce the maximum sustainable yield from a stock that has a size of Bmsy. | 0.256 |
| **Fmsy Basis** — Basis for the Fmsy estimate (calculated, proxy, etc.) | FSPR30% as proxy |
| **Ftarget** — Fishing mortality rate or catch level associated with an annual target identified by the FMC. | |
| **Ftarget Basis** — Basis for the target fishing mortality rate (F rate or total catch estimate). | |
| **F/Flimit** — Ratio of current fishing mortality and the overfishing threshold or catch/catch level associated with Flimit. | 1.008 |
| **F/Fmsy** — Ratio of current fishing mortality and the fishing mortality that would produce the MSY or catch/catch level associated with Fmsy. | 1.008 |

| Data Elements: | Workshop Data: |
|---|---|
| **F/Ftarget** — Ratio of current fishing mortality and the target fishing mortality rate or catch/catch level associated with an annual target identified by the FMC. | |
| **Minimum B Estimate** — Minimum estimate of the stock size in terms of biomass from the assessment model (used when ranges are available). | 1951 Billion hydrated oocytes |
| **Maximum B Estimate** — Maximum estimate of stock size in terms of biomass from the assessment model (used when ranges are available). | 3203 Billion hydrated oocytes |
| **Best B Estimate** — Best available point estimate of stock size in terms of biomass from the assessment model. | 2443 Billion hydrated oocytes |
| **B Unit** — Units used for the biomass related fields. | Billion hydrated oocytes |
| **B Year** — Year of biomass estimate. | FY2006/7 |
| **B Basis** — Basis for the biomass estimate (calculated, survey) and type of estimate (total, spawning stock, summary). | Female reproductive output |
| **Blimit** — Stock size threshold, below which the stock is considered to be overfished. | 1826.35 Billion hydrated oocytes |
| **Blimit Basis** — Basis for the Blimit estimate (calculate, B%, etc.) | (1-M) * BSPR30% |
| **Bmsy** — Stock size that, on average, would produce MSY when it is fished at a level equal to Fmsy. | 2175 Billion hydrated oocytes |
| **Bmsy Basis** — Basis for the Bmsy estimate (B%, proxy, etc.) | (1-M) * B30%SPR |
| **MSY** — Maximum Sustainable Yield- the maximum long-term average catch that can be achieved from the stock. | 8.64 million pounds |
| **Stock Level to Bmsy** — The current stock abundance level relative to the biomass level that would, on average, support the MSY. Below: B/Bmsy < 0.8 Near: 0.8 < B/Bmsy < 1.0 Above: B/Bmsy > 1.0 | Above |
| **B/Blimit** — Ratio of current biomass and the overfished level. | 1.338 |
| **B/Bmsy** — Ratio of current biomass and the biomass at MSY; measure of stock size. | 1.123 |
| **Comments** — Any additional information on the assessment. | |

# Table of FB Field Values

| F Unit | F Basis | Flimit Basis | Fmsy Basis | Ftarget Basis | B Unit | B Basis | Blimit Basis | Bmsy Basis |
|---|---|---|---|---|---|---|---|---|
| tons | apical F (max F at age) | $F_{30\%}$ | Direct estimate | $F_{30\%}$ | adult spawners (hatchery + natural) | Female reproductive output | $B_{20\%}$ | $B_{30\%}$ |
| spawners (natural only) | average F (F average across range of ages) | $F_{35\%}$ | $F_{30\%}$ as proxy | $F_{35\%}$ | individuals per hectare | Mature female biomass | $B_{25\%}$ | $B_{35\%}$ |
| pounds of tails | catch | $F_{35\%}$ adjusted for biomass | $F_{35\%}$ as proxy | $F_{35\%}$ adjusted for biomass | kg/tow | Spawning biomass | $B_{30\%}$ | $B_{40\%}$ |
| mt | effort | $F_{40\%}$ | $F_{40\%}$ as proxy | $F_{40\%}$ | lbs. | Survey CPUE | $B_{35\%}$ | Avg. survey CPUE |
| individuals per hectare | U (exploitation rate = catch/biomass) | $F_{40\%}$ adjusted for biomass | $F_{45\%}$ as proxy | $F_{40\%}$ adjusted for biomass | lbs. Head on (shrimp only) | Total stock biomass | $B_{40\%}$ | CPUE at MSY |
| catch/survey index | | $F_{45\%}$ | $F_{50\%}$ as proxy | $F_{45\%}$ | million lbs. | | $(1-M)*B_{30\%}$ | Escapement goal |
| adult spawners (hatchery + natural) | | $F_{45\%}$ adjusted for biomass | $F_{max}$ as proxy | $F_{45\%}$ adjusted for biomass | million lbs. Shucked meats | | $0.5*B_{35\%}$ | MSY/M |

| F Unit | F Basis | Flimit Basis | Fmsy Basis | Ftarget Basis | B Unit | B Basis | Blimit Basis | Bmsy Basis |
|---|---|---|---|---|---|---|---|---|
| Instantaneous annual F for age with maximum F | | $F_{50\%}$ | | $F_{50\%}$ | million shrimp | | $0.5*B_{msy}$ | |
| Instantaneous annual F averaged across ages | | $F_{50\%}$ adjusted for biomass | | $F_{50\%}$ adjusted for biomass | mt | | $0.6*B_{msy}$ | |
| annual exploitation rate | | $F_{msy}$ | | $F_{msy}$ | mt (eggs only) | | $0.7*B_{msy}$ | |
| | | $F_{msy}$ adjusted for $B<B_{msy}$ | | $F_{msy}*(F_{40\%}/F_{35\%})$ adjusted for biomass | mt (female biomass only) | | $0.8*B_{msy}$ | |
| | | $F_{max}$ | | $0.6*F_{msy}$ | mt (meat weight only) | | $(1-M)*B_{msy}$ | |
| | | $F_{rebuild}$ | | $0.75*F_{msy}$ | number of spawning fish | | 0.7*CPUE @ MSY | |
| | | M | | $0.85*F_{msy}$ | number of fish | | 50% Escapement goal | |
| | | catch/($B_{msy}$*0.2) | | $0.75*F_{limit}$ | spawners (natural only) | | | |

| F Unit | F Basis | Flimit Basis | Fmsy Basis | Ftarget Basis | B Unit | B Basis | Blimit Basis | Bmsy Basis |
|---|---|---|---|---|---|---|---|---|
| | | catch/($B_{msy}$*0.3) | | $F_{max}$ | trillion eggs | | | |
| | | $m_H$ (arithmetic mean of the pdf of $F_{msy}$) adjusted for biomass | | $F_{rebuild}$ | | | | |
| | | Effort at MSY | | 0.75*M | | | | |
| | | MSY | | $m_H$ (harmonic mean of the pdf of $F_{msy}$) adjusted for biomass | | | | |
| | | | | Effort at MSY | | | | |
| | | | | MSY | | | | |

# SEDAR

## Southeast Data, Assessment, and Review

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## SEDAR 16

# South Atlantic and Gulf of Mexico King Mackerel

## SECTION II: Data Workshop Report

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, Sc 29405

## Table of Contents

# 1. INTRODUCTION

## *1.1. WORKSHOP TIME AND PLACE*

The SEDAR 16 Data Workshop was held February 11 – 15, 2008 in Charleston, South Carolina.

## *1.2. TERMS OF REFERENCE*

1. Characterize stock structure and develop a unit stock definition. Provide maps of species and stock distribution.

2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling.

3. Provide measures of population abundance that are appropriate for stock assessment. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Consider relevant fishery dependent and independent data sources; develop values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision. Evaluate the degree to which available indices adequately represent fishery and population conditions. Recommend which data sources should be considered in assessment modeling.

4. Characterize commercial and recreational catch, including both landings and discard removals, in weight and number. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible. Provide maps of fishery effort and harvest.

5. 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. Provide discussion of progress on research and monitoring recommended by SEDAR 5.

6. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report).

## *1.3. LIST OF PARTICIPANTS*

***Workshop Panel***

Jason Adriance ........ GMFMC SSC/LDWF
Alan Bianchi ........ NC DMF
Dick Brame ........ SAFMC AP/CCA
Ken Brennan ........ NMFS Beaufort
Craig Brown ........ NMFS Miami
Shannon Cass-Calay ........ NMFS Miami
Mark Collins ........ SC DNR
Doug DeVries ........ GMFMC SSC/NMFS Panama City
Dave Donaldson ........ ASMFC
Richard Fulford ........ GMFMC SAP/Univ. of Southern MS
Dave Gloeckner ........ NMFS Beaufort
Randy Gregory ........ NC DMF
Pat Harris ........ SAFMC SSC/SC DNR
Ben Hartig ........ SAFMC AP
Frank Hester ........ DSF
Jack Holland ........ NC DMF
Walter Ingram ........ NMFS Pascagoula
Linda Lombardi-Carlson ........ NMFS Panama City
Vivian Matter ........ NMFS Miami
Kevin J. McCarthy ........ NMFS Miami
Refik Orhun ........ NMFS Miami
Mauricio Ortiz ........ NMFS Miami
Chris Palmer ........ NMFS Panama City
Will Patterson ........ GMFMC SSC/ Univ. of West FL
Patty Phares ........ NMFS SEFSC
Edward Presley ........ GMFMC AP
Clay Porch ........ NMFS Miami
Beverly Sauls ........ FL FWC
Katie Siegfried ........ NMFS Panama City
Tom Sminkey ........ NMFS Silver Spring
Steve Turner ........ NMFS Miami
Donald Waters ........ GMFMC AP
Geoff White ........ ACCSP
Bill Wickers ........ SAFMC AP
Bob Zales, II ........ GMFMC AP

***Council Representation***

David Cupka ........ SAFMC
George Geiger ........ SAFMC
Kay Williams ........ GMFMC

***Observers***

Julie Defilippi........................................................................................................ACCSP
Russell Hudson ........................................................................................................ DSF
Tom Ihde ........................................................................................................Univ. of MD
Kate Shepard ........................................................................................ Univ. of West FL
Mike Wilberg ...........................................................................................................CBL

***Staff***

Tyree Davis........................................................................................................NMFS Miami
Julie Neer ........................................................................................................ SEDAR
Rick Leard........................................................................................................GMFMC
Rachael Lindsay........................................................................................................ SEDAR
Andi Stephens ........................................................................................................SAFMC
Gregg Waugh ........................................................................................................SAFMC

## *1.4. LIST OF DATA WORKSHOP WORKING PAPERS*

| Document # | Title | Authors | Working Group |
|---|---|---|---|
| **Documents Prepared for the Data Workshop** | | | |
| SEDAR16-DW-01 | Standardized Catch Rates of King Mackerel from the Southeast Shark Drift Gillnet Fishery: 1993-2007 | Carlson, J.K., K. Siegfried, and I. Baremore | Indices |
| SEDAR16-DW-02 | Biological data collection and ageing procedures under the Fisheries Information Network (FIN) | Donaldson, D. and G. Bray | Life History |
| SEDAR16-DW-03 | Backcalculation of recreational catch of king mackerel from 1930 to 1980. SEFSC-SFD contribution. | Walter, J. F. | Recreational Statistics |
| SEDAR16-DW-04 | Standardized catch rates of king mackerel from Florida commercial trip ticket data for the Gulf and South Atlantic 1986-2007. | Walter, J. F. | Indices |
| SEDAR16-DW-05 | Estimating the king mackerel bycatch in the shrimp fisheries of the Gulf of Mexico and the south | Siegfried, K. | Commercial Statistics |

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| | Atlantic | | |
| SEDAR16-DW-06 | Batch fecundity and an attempt to estimate spawning frequency of king mackerel (*Scomberomorus cavalla*) in U.S. waters | Fitzhugh, G.R., C.F. Levins, W.T. Walling, M. Gamby, H. Lyon, and D.A. DeVries | Life History |
| SEDAR16-DW-07 | A review of Gulf of Mexico and Atlantic king mackerel (*Scomberomorus cavalla*) age data, 1986 – 2007, from the Panama City Laboratory, Southeast Fisheries Science Center, NOAA Fisheries Service | Palmer, C., D. DeVries, and L. Lombardi-Carlson | Life History |
| SEDAR16-DW-08 | Abundance Indices of King Mackerel, *Scomberomorus cavalla*, collected in Fall SEAMAP Groundfish Surveys in the Western U.S. Gulf of Mexico (1972-2007) | Ingram, Jr., G. Walter | Indices |
| SEDAR16-DW-09 | Abundance Indices of King Mackerel, *Scomberomorus cavalla*, collected during SEAMAP Shallow Water Trawl Surveys in the South Atlantic Bight (1989-2006) | Ingram, Jr., G. Walter | Indices |
| SEDAR16-DW-10 | Update analysis of king mackerel mark and recapture data from the NMFS SEFSC Cooperative Tagging Center | Ortiz, M. | Life History |
| SEDAR16-DW-11 | Standardized catch rates of Atlantic king mackerel (*Scomberomorus cavalla*) from the North Carolina Commercial fisheries trip ticket | Bianchi, A. and M. Ortiz | Indices |
| SEDAR16-DW-12 | Review and estimates of von Bertalanffy growth curves for king mackerel Atlantic and Gulf of Mexico stock units | Ortiz, M. and C. Palmer | Life History |

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| SEDAR16-DW-13 | Analysis of king mackerel size and size-frequency samples data available for use in stock assessment | Ortiz, M. | Life History |
| SEDAR16-DW-14 | Standardized catch rates of king mackerel, *Scomberomorus cavalla* from the Marine Recreational Fisheries Statistical Survey MRFSS | Ortiz, M. | Indices |
| SEDAR16-DW-15 | Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates from the Southeastern US (North Carolina to Florida-east coast) in 1981-2003 with For-Hire Survey estimates with application to King Mackerel landings | Sminkey, T. | Recreational Statistics |
| SEDAR16-DW-16 | Standardized catch rates of king mackerel (*Scomberomorus cavalla)* from the headboat fishery in the U.S. Gulf of Mexico and U.S. South Atlantic | Cass-Calay, S.L. | Indices |
| SEDAR16-DW-17 | Spatial and temporal variability in the relative contribution of U.S. king mackerel (*Scomberomorus cavalla*) stocks to winter mixed fisheries off South Florida | Clardy, T.R., W.F. Patterson, III, D.A. DeVries, and C. Palmer | Life History |
| SEDAR16-DW-18 | Age and Growth and Stock Mixing in Gulf of Mexico and Atlantic King Mackerel (*Scomberomorous cavalla*) | Shepard, K.W. F. Patterson, III, D. A. Devries, and C. Palmer | Life History |
| SEDAR16-DW-19 | King Mackerel Length Frequencies and Condition of Released Fish from Florida and Alabama At-Sea Headboat Observer Surveys in the Gulf of Mexico and Atlantic Ocean, 2005 to 2007 | Sauls, B. | Recreational Statistics |
| SEDAR16-DW-20 | Data Summary of King Mackerel | Ingram, Jr., G. | Indices |

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|---|---|---|---|
| | (*Scomberomorus cavalla*) Collected During Small Pelagic Trawl Surveys in the U.S. Gulf of Mexico, 1988 – 1996 and 2002-2007 | Walter | |
| SEDAR16-DW-21 | Recreational Survey Data for King Mackerel in the Atlantic and Gulf of Mexico | Matter, V. | Recreational Statistics |
| SEDAR16-DW-22 | Standardized catch rates of king mackerel from the United States Gulf of Mexico, south Atlantic, and Mixing Zone commercial hook and line fisheries, 1993-2006 | McCarthy, K. | Indices |
| SEDAR16-DW-23 | Calculated discards of king mackerel from commercial fishing vessels in the Gulf of Mexico, south Atlantic, and Mixing Zone | McCarthy, K. | Commercial Statistics |
| SEDAR16-DW-24 | Compilation of Historical Commercial Landings of King Mackerel, *Scomberomorus cavalla*, from US Coastal Waters in the Gulf of Mexico and Atlantic | Orhun, R. | Commercial Statistics |
| SEDAR16-DW-25 | Estimates of released king mackerel in the South Atlantic and Gulf of Mexico Headboat fishery, 2004-2006. | Brennan, K. | Recreational Statistics |
| SEDAR16-DW-26 | Estimation of the Stock Composition of Winter King Mackerel Fisheries off South Florida with Natural Tags Based on Otolith Stable Isotope Chemistry | Patterson, W.F., III, and Shepard, K. | Life History |
| SEDAR16-DW-27 | Additional ageing data for Gulf of Mexico king mackerel | Shepard, K, and W.F. Patterson, III | Life History |
| SEDAR16-DW-28 | Review of Catch, Catch at Size, Sex ratios and Catch at Age of king mackerel from U.S. Gulf of Mexico and South Atlantic fisheries | Ortiz, M. | Commercial and Recreational Statistics |

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| SEDAR16-DW-29 | King mackerel (*Scomberomorus cavalla*) larval indices of relative abundance from SEAMAP Fall plankton surveys, 1986 to 2006 | Hanisko, David S. and J. Lyczkowski-Shultz | Indices |
| SEDAR16-DW-30 | Discrimination Among U.S. South Atlantic and Gulf of Mexico King Mackerel Stocks With Otolith Shape Analysis and Otolith Microchemistry | Patterson, III, W.F., R.L. Shipp, T. R. Clardy, and Z. Chen | Life History |
| SEDAR16-DW-31 | Review of king mackerel sampling data provided by The Fisheries Research in the Gulf of Mexico and Caribbean Sea at the Instituto Nacional de Pesca in Mexico | Ortiz, M. | Commercial Statistics |
| | **Reference Documents** | | |
| SEDAR16-RD01 | Microsatellite variation suggests substantial gene flow between king mackerel (*Scomberomorus cavalla*) in the western Atlantic Ocean and Gulf of Mexico | Broughton, R.E., L.B. Stewart, and J.R. Gold | |
| SEDAR16-RD02 | Mitochondrial DNA variation in king mackerel (*Scomberomorus cavalla*) from the western Atlantic Ocean and Gulf of Mexico | Gold, J. R., Â. Y Kristmundsdottir, and L. R. Richardson | |
| SEDAR16-RD03 | Population structure of king mackerel (*Scomberomorus cavalla*) around peninsular Florida, as revealed by microsatellite DNA | Gold, J. R., E. Pak and D. A. DeVries | |
| SEDAR16-RD04 | Spatial and temporal variation in age composition and growth of king mackerel Scomberomorus cavalla from the southeastern U.S., 1986-1989;omplications for stock structure and recruitment variability | DeVries, D.A. and C. Grimes | |

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| SEDAR16-RD05 | BREVIARIO DE LA PESQUERÍA DE SIERRA Y PETO DEL GOLFO DE MEXICO | Provided by M. Ortiz | |
| SEDAR16-RD06 | Optimizing yields of king mackerel (*Scomberomorus cavalla*) fishery in the western and southern Gulf of Mexico | Chavez, E.A. and F. Arreguin-Sanchez | |
| SEDAR16-RD07 | Population dynamics of the king mackerel (*Scomberomorus cavalla*) of the Campeche Bank, Mexico | Arreguin-Sanchez, F., M.A. Cabrera, F.A. Aguilar | |

# 2. LIFE HISTORY

## *2.1. OVERVIEW*

The life history working group (LHG) reviewed information on stock structure and mixing, natural mortality, age, growth, reproduction, movements and migration, age sampling, and size and age composition of the fisheries. Discard mortality was partially addressed by the recreational fishery statistics working group.

Issues discussed by the LHG included mixing rates in the south Florida winter fishery; effects of stock mixing on growth parameter estimates; likely existence of a western Gulf stock or migratory group and the implications for stock assessment; the availability and reliability of data from Mexican fisheries; precision and accuracy of age data from the FIN program; impacts of minimum size limits on growth parameter estimates and the availability and advisability of using recently collected fishery-independent size and age data from young fish; new batch fecundity estimates; and the implications of the fact that most North Carolina age data were from tournaments and were non-random samples.

### 2.1.1. Group leader and membership

Doug DeVries (Leader, SSC) ............................................................NMFS-Panama City
Mark Collins ......................................................................................... SC DNR
Richard Fulford (SAP)............................................................. Gulf Coast Research Lab
Randy Gregory........................................................................................ NCDMF
Frank Hester........................................................................................ Consultant
Mauricio Ortiz.......................................................................................NMFS-Miami
Chris Palmer.......................................................................................NMFS-Panama City
Will Patterson (SSC)..........................................................................U. of West Florida
Clay Porch .........................................................................................NMFS-Miami
Kate Shepard.......................................................................................U. of West Florida

## *2.2. REVIEW OF WORKING PAPERS*

**SEDAR16-DW-02: Biological data collection and ageing procedures under the Fisheries Information Network (FIN)**

Initial sampling targets for age data were 5% of landings from the commercial and recreational sector. Starting in 2007 the targets were 500 age samples per key strata, and double the number of age samples for length samples. Key strata were defined as areas where one would expect to have differences in age of fish between strata, and were identified by the FIN Work Group as year, gear and region. For king mackerel, key strata are commercial and recreational, east Gulf, west Gulf, and S. Atlantic. Sampling is considered to be representative of the fisheries, i.e., it is not quota sampling. Unsorted commercial catches are randomly sampled. With sorted catches – every nth fish is sampled.

**SEDAR16-DW-06: Batch fecundity and an attempt to estimate spawning frequency of king mackerel (*Scomberomorus cavalla*) in U.S. waters.**

Fitzhugh et al. (2008) used the hydrated oocyte method to estimate batch fecundities for 178 king mackerel collected in the Gulf (n=32) and Atlantic (n= 146) during 2005-2007. In the Atlantic, the spawning season appeared to have a bimodal pattern, with hydrated females most common in May and June and again in August, with none found in July. In the Gulf, hydrated females were encountered over a shorter duration from May to July, with no bimodal pattern. The smallest hydrated female was 602 mm FL with most >700 mm. Fecundity-fork length relationships for the Gulf (all data available) and Atlantic (June-August data) using linear models were very similar, with slopes of 3220 and 3111 and $r^2$ 's of 0.68 and 0.70, respectively. In contrast the fecundity-FL relationship for Apr-May in the Atlantic had a much lower slope of 1459.

Spawning frequency was estimated from 13 Atlantic and 60 Gulf trips during May – August based on the average daily spawning fraction of mature females showing hydrated ova out of the total mature (active) females (determined macroscopically). Gulf fish were estimated to spawn every 2.9 da in 2006 and every 4.5 da in 2007, while the estimate for Atlantic fish in 2007 was every 5.7 da. Fecundity estimates from fish showing histological evidence of recent post-ovulatory follicles (POFs) were not excluded from the analyses because almost all (88%) hydrated females examined exhibited both old and recent POFs, suggesting high spawning frequency. Given this evidence, the small sample sizes, especially in the Atlantic, and the small spatial coverage of the study, these spawning frequencies should be considered only as rough estimates, and especially for the Atlantic, are very likely underestimates.

**SEDAR16-DW-07: A review of Gulf of Mexico and Atlantic king mackerel (*Scomberomorus cavalla)* age data, 1986 – 2007, from the Panama City Laboratory, Southeast Fisheries Science Center, NOAA Fisheries Service**

King mackerel, *Scomberomorus cavalla*, is a highly sought after species in the Gulf of Mexico (GOM) and the Atlantic Ocean (Atlantic) regions. Separate migratory groups, or stocks, migrate from the eastern GOM and southeastern U.S. Atlantic towards the south Florida area waters where the two stocks mix during the winter. In preparation for SEDAR16, sub-sampling of king mackerel otoliths occurred for the years 2005-2007 due in most part to rescheduling. Aged fish from these two regions (Atlantic n = 24,446, GOM n = 19,114) from 1986 - 2007 were compiled for the SEDAR16 data workshop for review. Ages ranged from 0 to 26 for the Atlantic and 0 to 24 for the GOM. Three readers aged otoliths with some overlap that resulted in high rates of precision with an average percent error (APE) between all three readers of less than 3.0%. Commercial and tournament samples made up 35% and 30% of all samples respectively followed by the recreational catch which contributed 28% of aged samples. North Carolina contributed 54% of the tournament samples. The vast majority of fish, over 90%, were collected with hook and line gear. Ages were evenly distributed between the Atlantic and GOM for both sexes.

**SEDAR16-DW-10: Updated analysis of the king mackerel mark and recapture data from the NMFS SEFSC Cooperative Tagging Center**

Conventional tagging data of king mackerel available at the SEFSC Cooperative Tagging Center were reviewed and summarized. Overall, 24,987 records of king mackerel releases were available since 1961 with a total of 1227 recaptures. Tagged kings from the Gulf of Mexico stock totaled 20,775 or 83%, and 4212 or 17%, from the Atlantic stock. In summary, available mark and recapture data supported the assumption of two main migratory groups; one from the Atlantic US coast and one from the Gulf of Mexico. Also, tag recaptures corroborated that the south Florida east coast and Florida Keys are an area of mixing for both stocks, particularly during the winter months. However, the data also showed that not all of the population migrates during the winter months, at least in the Gulf of Mexico. Data also support the conclusion that not all fish caught in the mixing zone between November and March are from the Gulf unit. Independent of the stock or region of the tagged fish, most of the tag recaptures were within the same area of release (60% or more) even when observations are restricted to fish at large for more than 30 days and recaptured during a different season. The lower percentages of recaptures corresponded to fish tagged in the mixing area and recovered in the opposing non-mixing region. In fact, no recaptures have been recorded from king tagged in the Gulf of Mexico and recovered in the Atlantic north of the Florida – Georgia border.

**SEDAR-DW-12: Review and estimates of von Bertalanffy growth curves for the king mackerel Atlantic and Gulf of Mexico stock units**

Aged king mackerel samples from 1986 – 2007 provided by the Panama City Laboratory, Southeast Fisheries Science Center, NOAA Fisheries Service and the Fisheries Information Network (FIN) were used to estimate von Bertalanffy growth models for the Atlantic and Gulf of Mexico populations. There were statistically different growth patterns between males and females by stock unit but no differences with or without aged samples from the mixing zone. Age-length scatter plots show females obtaining a larger size at age versus males from both regions. Estimates of the von Bertalanffy growth parameters show minor differences if the size-age observations from the mixing zone were included in the data set. Growth parameters were within ± two standard deviations with and without aged samples included in the analysis in most cases. The main differences were between sexes for both the Atlantic and Gulf of Mexico stocks where females always attained larger asymptotic sizes than males and males had greater estimated growth rates (K) versus females. Residual sum of squares (Chen et al. 1992) and likelihood ratio tests (Kimura 1980, Haddon 2001) both showed significant differences in growth curves by sex.

**SEDAR-16-DW-13: Analysis of the king mackerel size and size-frequency samples data available for use in stock assessment**

Between 1980 and 2007 approximately 490,000 king mackerel were measured (fork length), sexed, and assigned a collection region: Gulf of Mexico (GOM) non-mixing zone from Collier County Florida to the north, Atlantic Ocean (Atlantic) non-mixing zone from Flagler County Florida to the north, and the mixing zone including the Florida Keys from Monroe to Volusia County Florida. Aggregated size-frequency samples by region, fishery (commercial and recreational), year, and season show that the commercial hand line, MRFSS (Marine Recreational Fisheries Statistical Survey), and recreational head boat catch data are similar. Differences in size-frequency distributions show up in the private and charter boat sector, however the low number of size samples precluded further conclusions for these fisheries. The mixing zone represented smaller fish sampled for all fisheries with the larger samples coming from the GOM. Commercial samples made up more than 60% of the size samples with MRFSS contributing about 35%. The majority of samples were collected in the mid 1980's with July through October the peak sampling months for the Atlantic and GOM regions.

**SEDAR-16-DW-17: Spatial and temporal variability in the relative contribution of U. S. king mackerel *(Scomberomorus cavalla)* stocks to winter mixed fisheries off South Florida**

King mackerel, *Scomberomorus cavalla*, are ecologically and economically important scombrids that occur in U.S. waters of the Gulf of Mexico (GOM) and the Atlantic Ocean (Atlantic). Separate migratory groups, or stocks, migrate from eastern GOM and southeastern U.S. Atlantic waters to south Florida where the stocks mix during the winter. Currently, all winter landings from a management-defined south Florida mixing zone are attributed to the GOM stock. In this study the stock composition of winter landings across three south Florida sampling zones was estimated using stock-specific otolith morphology variables and Fourier harmonics. Mean jackknifed classification accuracies from stepwise linear discriminant function analysis of otolith shape variables ranged from 66 – 76% for sex-specific models. Estimates of the Atlantic stock's contribution of winter landings derived from maximum likelihood stock mixing models indicated that stock's contribution was highest off southeastern Florida (as high as 82.8% for females in winter 2001 – 2002) and lowest off southwestern Florida (as low as 14.5% for females in winter 2002 – 2003). Overall, results provide evidence that the Atlantic stock contributes some, and perhaps a significant (i.e., ≥ 50%), percentage of landings taken in the management-defined winter mixing zone off south Florida and the practice of assigning all winter mixing zone landings to the GOM stock should be reevaluated.

**SEDAR-16-DW-26: Estimation of the Stock Composition of Winter King Mackerel Fisheries off South Florida with Natural Tags Based on Otolith Stable Isotope Chemistry**

Otoliths can serve as ideal markers of fish populations or stocks and have characteristics that are unique to individual species or stocks and serve as ideal, permanent natural tags. Using otolith elemental and/or isotopic signatures as natural biogeochemical tags of fish from different water bodies, geographic areas, or stocks is another equally promising otolith based approach to estimate movement patterns or stock mixing of adult fishes (Begg et al. 1988; Thorrold et al. 1998, 2001; Patterson et al. 1998, 2002; Kennedy et al. 2000). Sampled fish for this study took place in the Atlantic and GOM in summer 2006 when stocks were separate and in three south Florida sampling zones during winter 2006/2007. Fish were measured to the nearest fork length (FL), weighed to the nearest 0.1 kg, sexed, and both sagittal otoliths were collected. Forty-five males and females were selected from each stock for chemical analysis after all fish were aged and shape analysis completed with stratified random sampling. The age and sex distribution of summer 2006 male and female king mackerel was similar between Atlantic and GOM samples. Multivariate analysis of variance (MANOVA) results indicated stock-specific stable isotope $\delta^{13}C$ and $\delta^{18}O$ differences between Atlantic and GOM fish ($p < 0.001$) but not between sexes ($p = 0.06$). Analysis of variance (ANOVA) results indicate differences in stable isotope delta values in $\delta^{13}C$ between stocks ($p < 0.001$) but not between sexes ($p = 0.212$), similarly with $\delta^{18}O$ differences (stock: $p < 0.001$; sex $p = 0.166$). Mean jackknifed classification accuracy was greater than 80% for sex-specific and combined sex models using LDF model results that indicated otolith stable isotope signatures are strong natural tags of king mackerel stocks. Winter-sampled king mackerel stable isotope signatures were indeterminate to $\delta^{13}C$ and $\delta^{18}O$ values of summer sampled fish. Maximum likelihood stock composition modeling indicates an east-west gradient in percent in percent Atlantic stock contribution to winter mixed-stock king mackerel fisheries existed for winter 2006-07 samples. Atlantic males were the lowest estimate of the Atlantic contribution with 21.4% in zone I sampled in mid to late January 2007, with the highest estimate of 93.6% for females sampled in zone III during February 2007. The trend in stock composition estimates of zone III landings during winter months was the lowest Atlantic contribution (i.e., highest GOM contribution) occurring in December and January and highest Atlantic contribution occurring in March.

**SEDAR-16-DW-27: Additional Ageing Data for Gulf of Mexico King Mackerel**

The 2004 SEDAR5 data workshop indicated the need to estimate growth functions for US king mackerel (*Scomberomorous cavalla*) populations as well as the landed catch. In the past, samples collected exclusively from fishery-dependent sources were used to calculate growth functions for each stock. This practice may bias estimates of growth by excluding individuals below the legal size limits. This study assesses age and growth in Gulf of Mexico king mackerel by including size-at-age data from fishery-dependent and -independent samples collected in the summers of 2006 and 2007. Von Bertalanffy growth functions (VBGFs) were fitted to fish size at age data for males (n=464) and females (n=1045) with juveniles included in both data sets. Three approaches were employed to fit the growth functions: juveniles that had not yet deposited the first annulus were included either as age zero years, as age-0.5 years, or as age-0.5 with $t_0$ fixed at the origin. The three methods employed to fit VBGFs resulted in distinct estimates for each von Bertalanffy parameter. The first approach produced the highest values for

$L_\infty$ and the lowest values for k and $t_0$. The second approach resulted in intermediate parameter estimates, and the final method produced the lowest estimates of $L_\infty$ and highest of k. This pattern was consistent between sexes. All six functions had high regression coefficients >0.98 with the highest coefficients resulting from the first method. The impact of fitting $t_0$ closer to the origin (or fixing it at the origin) on estimates of the other two von Bertalanffy parameters highlights the importance of including fish under the legal size limit. Also, plots of residuals versus age for all VBGF models demonstrated a sigmoidal pattern suggesting a simple VBGF may not be sufficient to describe the variation in size at age data.

**SEDAR-16-DW-28: Review of catch, catch at size, sex ratios, and catch at age of king mackerel from the U.S. Gulf of Mexico and South Atlantic fisheries.**

Commercial and recreational catch data were used to estimate catch at size (CAS) by sex tables. CAS data was converted to catch at age (CAA) by sex using age length keys (ALK) or stochastic ageing method (SAR). Catch data was obtained from three zones: Atlantic no mixing zone from Flagler County Florida north to the New England area, the Gulf of Mexico (GOM) no mixing zone from Collier County Florida north, and the mixing zone between Volusia and Monroe County Florida. Over 95% of the Atlantic stock is landed in Florida and North Carolina. In the GOM, 75% of the catch is landed in Florida with Louisiana contributing 23%. The Marine Fisheries Statistical Survey (MRFSS) estimates of discard rates (live fish) show an increase in releases in recent years in the Atlantic and GOM. Recently, the released catch (B2) has been about 35% of the retained catch in the Atlantic stock and 50% in the GOM stock. Catch at age data from commercial and recreational sectors from ALK show the majority of aged samples are from 1 to 7 years old with July – October months producing the greatest number of samples. Catch by age proportions varied in 2002 and 2005 when no ALK were available and the SAR model was used. CAA estimates and proportion by age was similar to the CAA base model of the last assessment (SEDAR-5 2003), using the same sex ratios at size and growth parameters in the 2003 stock assessment.

## *2.3. STOCK DEFINITION AND DESCRIPTION*

King mackerel range in the western Atlantic Ocean from the northeastern US to Brazil, including waters of the Gulf of Mexico and Caribbean Sea (Collette and Nauen 1983). King mackerel have been managed as a single stock in US waters since the inception of the Coastal Pelagics Management Plan (CPMP), which was jointly created by the Gulf of Mexico and South Atlantic Fishery Management Councils in 1983 (GMFMC and SAFMC 1983). While a single stock is still assumed, the first amendment to the CPMP instituted the premise that fish in US Atlantic and Gulf waters constitute two separate migratory groups (GMFMC and SAFMC 1985). The two migratory group approach was supported at the time by tag recapture data that indicated Gulf and Atlantic fish undertook separate seasonal migrations (Powers and Eldridge 1983; Sutter et al. 1991). While later genetic analyses confirmed Gulf and Atlantic fish are genetically distinct (Gold et al. 1997; Gold et al. 2002), other evidence exists that two distinct migratory groups may exist within the Gulf alone. That evidence, as well results from various studies examining broader issues of king mackerel population structure and connectivity, is reviewed in this section. Data sources from which population structure inference is drawn include tagging studies, analysis of regional differences in population demographics, population genetics analyses, and, most recently, estimates of population mixing computed from natural tags derived from otolith shape and chemistry.

Fishermen and scientists alike have long known that king mackerel, like many other scombrids, undertake seasonal migrations. For example, catch per unit of effort is correlated with water temperature in the eastern Gulf and Atlantic waters of the US southeast, and fishery-dependent data clearly demonstrate an increase in fish availability in winter off south Florida (Fable et al. 1981; Trent et al. 1987). Perhaps the greatest information on seasonal migrations has come from mark recapture studies conducted off the southeastern US in the Atlantic and Gulf of Mexico. While that information is reviewed in section 2.9 more extensively, some of it also will be discussed here in the context of king mackerel population structure.

Several tagging studies have been conducted to examine movement and mixing in king mackerel in US waters. Tagging studies conducted in the 1970s and 1980s demonstrated that king mackerel in the eastern GOM and Atlantic migrate along the Florida peninsula in late fall and overwinter off south Florida where large gillnet and troll fisheries are prosecuted on the mixed stock. As water temperatures warm in spring, fish migrate northward and return to summer spawning grounds (Powers and Eldridge 1983; Sutter et al. 1991; Schaefer and Fable 1994). Fishery-dependent data from winter fisheries off Louisiana, North Carolina, and Florida suggest most of the seasonal migrants are small, young fish (e.g., < 6 years old), an inference that also is supported by tagging data. Fable et al. (1987) reported larger fish tagged in summer off south Louisiana tended to remain resident in the northern Gulf in winter, while smaller individuals tended to be recaptured either off south Florida or in Mexican waters in winter. Fish tagged off Vera Cruz, Mexico in winter subsequently were mostly recaptured in the northern Gulf of Mexico. Therefore, not only do tagging data corroborate the inference that Gulf and Atlantic fish mix in winter off south Florida, but recaptures in the western Gulf indicate winter mixing may also occur between fish from the western US Gulf and fish resident in Mexican waters (Arreguin-Sanchez et al. 1995).

Differences in population demographics among regions in US waters provide further evidence that distinct Atlantic, eastern Gulf, and western Gulf populations (or migratory groups) of king mackerel exist. Little reproductive biology information is available with which to examine interpopulational differences (e.g., Finucane et al. 1986; Fitzhugh et al. 2008), but there is some evidence that spawning seasonality is distinct among regions (Collins et al. 1987; DeVries et al. 1990; Grimes et al.1990; Johnson et al. 1994). The most compelling evidence for interpopulational differences in demographic patterns comes from age and growth estimates derived from examination of otolith microstructure. DeVries et al. (1997) reported interregional differences existed in population growth rate estimates among fish sampled in the south Atlantic, eastern Gulf, and western Gulf, which they concluded supported the suggestion made by Johnson et al. (1994) that eastern and western Gulf fish constituted separate stocks.

Genetic differences reported between fish sampled in the eastern and western Gulf were among the evidence cited by Johnson et al. (1994) in their suggestion that fish in those regions constituted separate stocks. In their work on protein allozymes, they reported allelic variability of one polymorphic dipeptidase locus was significantly different between eastern and western Gulf fish. However, Gold et al. (1997) later showed that difference was confounded by correlations with age and sex. Furthermore, Gold et al. (1997, 2002) reported results from mitochondrial (mtDNA) and nuclear microsatellite DNA analyses did not indicate genetic differences existed between eastern and western Gulf fish. Results of Gold et al.'s (1997, 2002) studies did demonstrate that eastern Gulf and Atlantic fish are genetically distinct, although differences between the populations, while statistically significant, are weak. It should be noted, however, that any finding of significantly different genetic variability between king mackerel populations is remarkable given the amount of straying demonstrated among regions with tagging data. Furthermore, a lack of a significant genetic difference in selectively neutral markers, such as mtDNA or nuclear DNA microsatellites, is not definitive evidence that interregional population structure does not exist (Nolan et al. 1991; Pruett et al. 2005).

Gold et al. (2002) attempted to use the nuclear microsatellite library they developed for king mackerel to distinguish Gulf from Atlantic fish around the Florida peninsula, a feat that tagging data repeatedly have been found to be ill-suited to perform. They reported that estimates of the stock composition of their samples rarely deviated from a 50:50 split (± 10%) of Gulf to Atlantic fish regardless of where along the coast of Florida samples were collected. This finding may indicate equal proportions of Gulf and Atlantic fish were present, or that natural tags derived from interstock genetic variability were too weak to distinguish Gulf from Atlantic fish effectively.

Stock markers based on otolith shape and otolith chemistry have proven to be the most effective natural tags yet found to distinguish eastern Gulf from Atlantic king mackerel, with the principle goal being to distinguish the two stocks as they mix off south Florida in winter. DeVries et al. (2002) reported differences in sagittal otolith shape parameters were significant between Atlantic and Gulf females in summer 1996 (when stocks were separate), and that discriminant function analysis of shape data classified 71% of Atlantic and 78% of Gulf fish accurately. The authors then parameterized a maximum likelihood mixing model with the same set of variables to estimate the stock composition of females sampled during winter 1996/97 off southeast Florida. They estimated 99.8% (SE = 3.4%) of winter samples belonged to the Atlantic migratory group. Furthermore, the authors concluded that otolith shape analysis suggested the migratory groups effectively did not mix in their sampling area off southeast Florida in winter 1996/97. In a similar approach, Clardy et al. (in press) were able to distinguish female and male mackerel between Gulf and Atlantic groups sampled in summer 2001 and 2002 with between 65 and 82% accuracy with otolith shape characteristics. Maximum likelihood estimates of the stock identity of fish collected in three zones around southern Florida in winter

2001/02 and 2002/03 indicated fish off southwest Florida were up to 85% Gulf group, while fish off southeast Florida were up to 84% Atlantic group.

Patterson et al. (2004) examined differences in king mackerel migratory group-specific otolith elemental signatures with the same samples for which Clardy et al. (in press) examined otolith shape parameters. Classification accuracies computed from sex-specific linear discriminant functions (LDFs) with elemental concentrations (Ba, Mn, Mg, and Sr) as dependent variables ranged from 69 – 91%. Otolith chemistry-based maximum likelihood estimates of the stock identity of fish collected in the three south Florida winter zones mirrored results from otolith shape analysis: fish in the southwestern zone were mostly Gulf fish and fish in the southeastern zone were predominantly Atlantic fish. Doug DeVries noted that otoliths from Mexican and S. Texas king mackerel were typically much more difficult to age (i.e., had very diffuse annuli) than those from the northern and eastern Gulf. This observation is consistent with the hypothesis that there is a stock or migratory group in the western Gulf that spends much of its life in the warmer waters of the SW Gulf where there would be smaller seasonal differences in growth and therefore potentially less distinct annual marks laid down in the otoliths. Otolith shape and/or chemical analysis studies could be used for further analysis of a potential western Gulf stock unit.

Most recently, Shepard et al. (in press) and Patterson and Shepard (2008) examined stock mixing among winter sampling zones off south Florida with otolith shape and otolith stable isotope ($\delta^{13}C$ and $\delta^{18}O$) analysis, respectively. They reported successful discrimination between eastern Gulf and Atlantic fish sampled in summer 2006 (mean success of 66% with otolith shape data and 81% with stable isotopes). Estimates of the Atlantic migratory group's contribution to south Florida winter landings were consistent between otolith-based approaches, with a higher percentage of Gulf fish estimated to have been landed off southwestern Florida (as high as 73% for males) and a higher percentage of Atlantic fish estimated to have been landed off southeastern Florida (as high as 93% for females). Overall, results from all otolith-based (shape or chemistry) studies of king mackerel population mixing have suggested that mixing is spatially variable around the tip of southern Florida, as well as temporally variable within a given winter and among winters. However, a consistent pattern of greater estimates of Gulf group contribution off southwest Florida and greater estimates of Atlantic group contribution off southeastern Florida has been observed among studies.

In summary, a distinct picture of king mackerel population structure begins to come into focus when results of tagging, population demographic, population genetics, and otolith-based stock mixing studies are viewed in total. Figure 2.15.1 depicts the hypothesized population structure of king mackerel in U.S. waters, as the LHG sees it. Tagging data clearly show that relatively small, young fish from the eastern Gulf and Atlantic mix off south Florida in winter; fish from the eastern Gulf and western Gulf mix in the north central Gulf in summer; and at least some young migrants from the western Gulf migrate into Mexican waters in winter. Population demographic patterns, such as they are known, among eastern Gulf, western Gulf, and Atlantic regions are consistent with the interpretation that distinct migratory groups, or populations, exist among those regions. Genetics data confirm differences exist between eastern Gulf and Atlantic fish, but mixing between eastern and western Gulf populations during summer when spawning occurs likely precludes genetic divergence between those groups. Otolith-based analyses of stock mixing off south Florida in winter have consistently resulted in greater estimates of Gulf group contribution to winter southwest Florida landings, while the converse is true of estimates from southeastern Florida. To gain a more complete understanding of population structure, future work should be aimed at estimating mixing between eastern Gulf and western Gulf populations, as well as attempting to estimate the vulnerability of western Gulf fish to overfished Mexican fisheries in winter (Chavez and Arreguin-Sanchez 1995).

In regards to a possible western Gulf/Mexican migratory group, the LHG discussed the merits of conducting sensitivity runs to examine the potential impacts or the implications such a stock structure would have on the status of the migratory groups as currently defined. Two possible analyses were discussed. The one the group felt was worth pursuing was to examine the effect of removing data from west of the Mississippi River (i.e., west or northwest of Southwest Pass) under the assumption that these data reflect the dynamics of a distinct migratory unit that is shared with Mexico. The remaining data would then be considered to reflect the dynamics of the putative Atlantic migratory unit and an eastern Gulf migratory unit. Any management advice that proceeded from the corresponding stock assessment model would then be interpreted as applicable only to the Atlantic and eastern Gulf. The group realized, because of the lack of information, that this will be a simple approach, ignoring any sort of mixing zone. The group also did not consider it prudent at this time to conduct a separate assessment of the supposed western Gulf + Mexico migratory unit owing to the paucity of information on age structure and relative abundance for that region. However, a recent paper (Chavez and Arrenguin-Sanchez 1995) has suggested that the stock in Mexico may be overfished and is undergoing overfishing. Thus, if the fisheries operating west of the Mississippi River are in fact exploiting a single western Gulf + Mexico migratory unit, then additional catches from that region could contribute to further overfishing of that stock.

The second proposed sensitivity run discussed was to combine the data from Mexico with that for the entire U.S. Gulf of Mexico under the assumption that the king mackerel populations off Mexico are well-mixed with the populations in the U.S. Gulf of Mexico and effectively constitute a single stock. There was a strong consensus that the evidence for a single migratory unit occupying the entire range from West Florida through Mexico was much less compelling and such an analysis was unwarranted at this time. Moreover, the data obtained from Mexico to date is incomplete and has not undergone the same level of scrutiny as the U.S. data.

<u>LHG Recommendations for the AW:</u>

1) Attempt to address statistically the issue of the wide confidence intervals on estimates of Atlantic stock contribution to winter landings in south Florida derived from otolith shape and otolith chemistry analyses.

2) Conduct a sensitivity analysis which examines the effect of removing data for the western Gulf (defined as west or northwest of the mouth of the Mississippi River, i.e., Southwest Pass) under the assumption that these data reflect the dynamics of a distinct migratory unit that is shared with Mexico, and understanding that this is a simple approach which ignores any sort of mixing zone.

## *2.4. NATURAL MORTALITY*

The final estimates of natural mortality rate (M) used for during SEDAR5 were considered constant for all ages and set equal to 0.15 for the Atlantic migratory group and 0.20 for the Gulf migratory group. The SEDAR5 DW Panel had recommended a range of 0.15-0.25 (mean = 0.2) be used for both subgroups, however this recommendation was based primarily on observations of the maximum age of the Gulf group alone. The SEDAR5 RW Panel did not support the recommendation, citing insufficient evidence to warrant a change from previous values and thereby affecting the continuity of results between SEDAR5 and prior assessments. Subsequently, estimates of maximum age have been produced for both the Gulf and Atlantic migratory groups (**SEDAR16-DW-07**). Application of Hoenig's (1983) regression based on fish data only to these maximum age estimates (26 years for the Atlantic, 24 years for the Gulf) suggests average M values of 0.17 $yr^{-1}$ and 0.16 $yr^{-1}$ for the Gulf and Atlantic, respectively.

Consistent with the recommendations of previous SEDAR panels for other species, the group recommends modeling the natural mortality rate of king mackerel as a declining 'Lorenzen' function of size (translated to age by use of a growth curve) (Lorenzen 1996). The Lorenzen curve should be scaled such that the average value of M over the range of fully-selected ages (in this case age 2 up to the maximum age) is the same as the point estimate from Hoenig's (1983) regression – 0.17 for the Gulf and 0.16 for the Atlantic. Separate functions should be developed for the Gulf and Atlantic migratory units owing to differences in the observed maximum age and growth. Preliminary calculations of M based on the growth information available at the data workshop are shown in Figure 2.15.2. It should be noted that a consequence of scaling the Lorenzen curve to ages 2 and older is that the cumulative natural mortality rate on ages 1 and older is slightly higher than in previous assessments. However, inasmuch as Hoenig's paper was based primarily on catch curve analyses of fully-selected age classes, it would seem more appropriate to apply the resulting estimates of M only to fully selected ages. In any case, the impact of this change is likely to be small as age 1 fish constitute a small fraction of the catch.

The value of M for the plus-group should be computed as a weighted average of the natural mortality rates for the age classes from the first age in the plus-group to the maximum age. In principle, the weights should reflect the declining relative abundance of older age classes, but the results are usually relatively insensitive to the discount rate selected as long as the plus-group is reasonably large. It is considered sufficient to compute the weights based on the expected decline in abundance with age under equilibrium conditions without fishing. This exercise, however, does not address the larger question that natural mortality is poorly known.

LHG Recommendations for the AW:

1) Model the natural mortality rate of king mackerel as a declining Lorenzen function of size.

## *2.5. DISCARD MORTALITY*

A special "sub-working group" was held during the DW to discuss the issue of discard mortality within the commercial and recreational sectors. As such, the LHG did not discuss it further.

## *2.6. AGE*

The Panama City Laboratory of the Southeast Fisheries Science Center, NOAA Fisheries Service has conducted production ageing of king mackerel yearly since 1986, ageing over 43,000 during those years (Figures 2.15.3, 2.15.4, and 2.15.5). A description of the methods, information on quality control and sub-sampling procedures, and the distribution of age samples by year, geographical location, gear, fishery, and collecting agency or program are presented in SEDAR16-DW-07. The group discussed the absence of data from the western Gulf (in the Panama City database) since 1995 and agreed that would severely limit any assessment of a potential western Gulf stock. The paucity of age data from South Carolina and Georgia was also noted but the group did not feel that would cause any major problems given the large sample sizes from North Carolina and NE Florida.

The group discussed the sampling designs of the various programs contributing to the Panama City age database. It was pointed out that most of the TIP samples, which include virtually all commercial samples, were the result of quota sampling based on 10 cm size bins by sex. Quota sampling for king mackerel age data was instituted to optimize sampling and ageing efforts by reducing oversampling of young fish with minimal variation in age at size and to insure adequate sample sizes of larger, older fish in which the range in age at size is much greater than in the smaller, younger fish which dominate the landings.

Beginning in 2002, the state-federal cooperative Fisheries Information Network (FIN) program also began collecting and ageing king mackerel otoliths from the Gulf of Mexico. The goals, methods, sampling protocol, geographical coverage, qa/qc procedures and results, and temporal and spatial distribution of samples through 2006 are presented in SEDAR16-DW-02. Between 2002 and 2006 the FIN program collected and aged otoliths of 2325 king mackerel. Sample sizes from Florida's FWRI were very low (116 in 2003 and 9 in 2004) because they sent almost all of their samples directly to the NMFS Panama City laboratory. Virtually all FIN samples were from recreational sources, except in Louisiana, where commercial samples composed 93.0-97.0 % each year. FIN age sampling is designed to be representative of the fisheries it samples (i.e., are not quota samples), and for quality assurance, there is a group who meet annually to evaluate how well the program met that design goal.

Discussions of the FIN data centered on the potential effect on assessment models of including age data from states with marginal precision levels (higher APE's and lower percent agreement) from the reference collection (Table 2.14.1 (from S16-DW-02)). Whole otolith APE's >10% for MDMR, LDWF, and TPWD were of most concern. Given the paucity of age data from the western Gulf in recent years in the larger Panama City NMFS database, the group felt it was important to try to incorporate these FIN data if possible. It was recommended that the king mackerel stock assessment include the precision ageing measures as ageing error proportions, particularly for the Stock Synthesis 2 model.

The group discussed how removing biased age data (mostly tournament age samples) affects the growth curves used to age the catch but felt it was unlikely to have a major effect. This is directed towards the North Carolina aged samples that are mostly tournament fish that are quota sampled. North Carolina does have tournament length frequency data (n = 26,048) from 1984 to 1994 taken from individual boat surveys that is random and representative of the entire tournament catch.

<u>LHG Recommendations for the AW:</u>

1) Given the differences in ageing precision among laboratories, particularly within the FIN program, and to account for the wide range of APE estimates, APE information should be incorporated into the assessment models where possible.

## *2.7. GROWTH*

The following is from the SEDAR5 report and provides some information:

"Growth of king mackerel in the Gulf of Mexico and the Atlantic has been documented in several studies. Early studies utilized age determinations from whole otoliths to model growth (Beaumariage 1973, Johnson et al. 1983, Manooch et al. 1987). Subsequent studies documented the underageing of older fish (>80 cm FL males, 90 cm FL females) from whole otoliths (Collins et al. 1988, DeVries and Grimes 1997. The life history group considered a report, SEDAR Doc.-6, which was a literature review of the growth of king mackerel in the southeastern U.S. Information presented in this report included a summary of available formulae for transforming from individual length to weight, length to age and length to length.

The group noted that sexual dimorphism was very significant in the length to age relationship, in the weight to length relationship and also the body size – otolith size relationship, and should be taken into account when modeling growth of king mackerel. In addition DeVries and Grimes (1997) documented spatial differences. The group noted that the information on sex ratio at size used in the most recent assessment included observations available through 1994 (Restrepo 1996). The group recommended the sex ratio at length curves be updated to include data collected subsequent to the Restrepo (1996) study. Currently the assessment assumes that the sex ratio of fish size 50 cm FL and smaller is 1:1 however little data exist to verify this assumption. The group recommended as a long term research object to conduct a histological study to evaluate this assumption.

The group also reviewed a report providing a summary of the updated king mackerel otolith observations through fishing year 2002/2003 (SEDAR 5 Doc-7). The group reviewed the existing formulae for converting individual length to age and felt that the von Bertalanffy growth equations of DeVries and Grimes (1997) were most current. " – **End SEDAR5**

SEDAR16-DW-12 provided updated von Bertalanffy growth parameters by sex for Gulf and Atlantic migratory groups both with and without samples from the mixing zone as defined in the FMP. The group discussed which growth estimates should be used. Age-length keys are to be used to age most of the catch samples. Growth curves are to be used to age catch data for which no age length keys are available (1981 – 1985) and for specific cells in subsequent years for which there were no appropriate age data. The group also discussed the new age length key data provided by Dr. Will Patterson and Kate Shepard which includes significant numbers of age 0 and 1 fish collected in fishery independent surveys. These data help address the selectivity issues of fishery dependent samples subject to size limits.

<u>LHG Recommendations for the AW:</u>

1) Represent growth in the king mackerel population by sex and migratory group (required for the Stock Synthesis 2 assessment algorithm) following the methods of SEDAR16-DW-12. The size-age data used should combine the data used in SEDAR16-DW-12 with the new size-age data from Patterson and Shepard, including the fishery-independent samples of age 0 and age 1 fish, provided more accurate ages can be assigned (e.g., by counting daily rings). All data should come from outside the mixing zone to ensure that each curve uniquely represents either the Atlantic or Gulf migratory group.

2) Represent growth in the fraction of the king mackerel population that is vulnerable to fishing by sex and migratory group using:

   a) the growth curves developed in SEDAR 5; required for level 1 update (catches only) of the continuity VPA.

b) updated growth curves following recommendation (1) above, but excluding fishery-independent data ; required for level 2 update (catches and life-history parameters) of the continuity VPA.

### *2.8. REPRODUCTION*

Until very recently, few studies on reproduction of king mackerel in the U.S. have been conducted – one in the Gulf only (Beaumariage 1973), one in the Gulf and Atlantic (Finucane et al. 1986) and two in the Atlantic only (Waltz 1986; Noble et al. 1992). Only Finucane et al. (1986) provide fecundity estimates (by length, weight, and age). These estimates were derived from 65 fish 446-1,489 mm FL, 0.681-25.610 kg, and ages 1-13 yr. Fecundity samples came from North Carolina (n=12), Texas (n=12), Louisiana (n=24), and northwest Florida (n=17). One caveat with the Finucane et al. (1986) results is that the fish were all aged with whole otoliths, which have been shown to underage older fish (Collins et al. 1989; DeVries and Grimes 1997). Besides the ageing issue, the method Finucane et al. (1986) used presumed that king mackerel were determinate spawners, an approach known to underestimate fecundity in fishes that actually exhibit indeterminate oocyte development reflected in multiple spawnings over a season (Murua et al. 2003). They also estimated fecundity by counting yolked eggs >=0.20 mm (Hunter and Goldberg 1980) as opposed to the current widely used technique of counting hydrated oocytes.

To address these issues with the Finucane et al. (1986) study, and responding to SEDAR5 research recommendations to develop batch fecundity, spawning frequency, and age specific fecundity estimates, including size and age at maturity, Fitzhugh et al. (SEDAR16-DW-06) used the hydrated oocyte method to estimate batch fecundities for 178 king mackerel collected in the Gulf (n=32) and Atlantic (n= 146) during 2005-2007.

Because Finucane et al. (1986) included all vitellogenic eggs (which would certainly contribute to more than one batch) in their counts, those counts could not be considered estimates of batch fecundity, as they would be overestimates. Based upon the fecundity-length relationship for NW Florida (Table 4 in Finucane et al., 1986), the expected annual fecundity of an 800 mm FL female would be 1,644,805 ova. However, Fitzhugh et al. (SEDAR16-DW-06) estimated that a single batch for a female this size should equal 560,000 ova. Because of these differences in methods and the overestimation problem, the group concluded it would be inappropriate to merge the fecundity estimates of Finucane et al. (1986) with the new data presented in SEDAR16-DW-06. The group also concluded that the new fecundity data in SEDAR16-DW-06 should be used in the upcoming assessment, but that it should be fit with a power function and that all months (Apr-Aug) should be included for the Atlantic.

The group also agreed that given the high frequency (88%) of hydrated females exhibiting old and recent POFs, the small sample sizes, especially in the Atlantic, the small spatial coverage of the study, and the reliance on macro staging for spawning frequency estimates, spawning frequencies of Fitzhugh et al. (2008) should be considered only as rough estimates, and especially for the Atlantic, are very likely underestimates. There was also discussion regarding the need to determine if spawning frequency varies by age (currently the data are insufficient for this), in which case the use of batch fecundity alone may not adequately represent the relative reproductive contribution of each age class.

No new size or age at maturity data is available so the same relationships from Finucane et al. (1986) used in SEDAR5 will have to be used in SEDAR16.

LHG Recommendations for the AW:

1) Use the batch fecundity relationships, whether length or age-related, from Fitzhugh et al. (SEDAR16-DW-06) to estimate female reproductive potential until age-based spawning frequency estimates can be incorporated. The group recognizes the possibility that annual differences in population reproductive potential may occur even at equivalent levels of stock biomass (see Marshall et al. 2003), but the available data represent only a few years and therefore do not allow the detection of annual variations.

2) Use size or age at maturity data from Finucane et al. (1986).

## *2.9. MOVEMENTS AND MIGRATIONS INFERRED FROM TAGGING DATA*

This section addresses stock mixing and migration patterns that are apparent from the tagging data described in S16-DW-10. Additional data on stock mixing off Florida, based on otolith shape analysis and otolith isotope chemistry, contributed to the discussion below but are described in the report section on stock structure.

Working Group Consensus regarding migration and movement based on tagging data:

Two issues can be potentially addressed based on the tagging data summarized in S16-DW-10. The first is the issue of migration into and out of the mixing zone by fish from the two migratory units (Atlantic and Gulf of Mexico, hereafter GOM). The second is the issue of whether the GOM migratory unit is a single unit or comprised of two overlapping migratory units (eastern and western). The life history working group examined the tagging data for each of these issues.

The region delimited by the Flagler-Volusia and Monroe-Collier county lines on the Florida coast is commonly referred to as the mixing zone. Current allocation rules state that all king mackerel caught in this region between November and March are taken from the GOM migratory unit. Tagging data suggest that at least some of these fish are in fact from the Atlantic unit. Of the 12,896 fish tagged and released in the mixing zone between November and March (GOM fish), 527 were recaptured. Most of these recaptures occurred in the mixing zone, however 90 (17.1%) were recaptured somewhere on the Atlantic coast north of the Flagler-Volusia county line. In contrast, only 20 (3.8%) were recaptured in the Gulf of Mexico outside the mixing zone. Of the 1288 fish tagged and released in the mixing zone between April and

October (Atlantic fish), 116 were recaptured. All but three of these recaptures occurred in the mixing zone or along the Atlantic coast north of the Flagler-Volusia county line. These data strongly suggest that fish present in the mixing zone in the winter may be from either the GOM or Atlantic migratory unit. It was the consensus of the working group that tagging data are not sufficient to accurately quantify unit mixing in the Florida mixing zone, but they do suggest that 100% percent allocation of catch to the GOM unit in the winter is not supported by the data.

Of the 7878 fish tagged and released in the GOM no-mix zone that stretches from Florida's Monroe-Collier county line to the Texas-Mexican border, 460 were recaptured in that same zone. Figure 2.15.6 (from S16-DW-10) gives straight line distances between individual release and recapture locations for the subset of these 460 fish recaptured in a different season. These data suggest that migration pathways occur in an easterly direction towards Florida and in a westerly direction towards Mexico. These data are consistent with two possible scenarios: the GOM migratory unit is contiguous from Florida to Mexico or the existence of two migratory units in the Gulf of Mexico separated between eastern and western zones. Figure 1 below summarizes the hypothesized unit structure of the king mackerel stock that the working group considered most supported by the tagging data. The workgroup felt that limitations with these data outlined below make the exact structure of the GOM migratory unit inconclusive. Further study is needed to more clearly determine the existence of an east and west portion of the GOM unit, delineate these portions if they exist in terms of a dividing line, and measure the amount of mixing between eastern and western portions of the unit. It was also the consensus of the group that identification techniques currently being employed to characterize unit mixing in the Florida mixing zone may be useful for clarifying the east/west structure of the GOM unit and the level of connectivity between the US GOM unit and king mackerel stocks off the coast of Mexico. The magnitude of the Mexican landings in comparison to US landings from the GOM unit indicate clarification of this issue should be a priority for future assessments (see SEDAR16-DW-31).

It should be emphasized that the tagging programs conducted to date were not designed to evaluate levels of mixing. As noted by the SEDAR5 RW Panel, tagging fish in a concentrated area (as done in the tagging studies off southeast Florida) does not lend itself to estimation of mixing rates. Moreover, tag recoveries in these programs were fishery-dependent. Thus, the numbers of tags recovered in different locations were dependent not only on fish movements, but on local fishing effort and reporting rates as well. Finally, while the data set covers a period from 1961 to 2005, the vast majority of the releases and recaptures occurred between 1983 and 1996. This may limit the utility of these data for describing current conditions of the stock. Accordingly, even qualitative interpretations regarding stock definition and mixing must be viewed with some caution.

LHG Recommendations for the AW: none

## *2.10. MERISTICS AND CONVERSION FACTORS*

The LHG recommended updating the length-weight relationship for king mackerel stocks. It was suggested that this relationship be analyzed by stock unit and sex using observations collected outside of the so-called mixing zone. Size and weight data were obtained from the Panama City NOAA Fisheries Lab database and after preliminary evaluation, power functions were estimated for whole and gutted weight as function of fork-length by stock and sex. Table 2.14.2 shows the estimated parameters, and Figure 2.15.7 compares the results with the prior size-weight relationship from Johnson et al. (1983).

LHG Recommendations for the AW:

1) Update the length-weight relationship for king mackerel stocks by stock unit and sex using observations collected outside of the mixing zone.

## *2.11. COMMENTS ON ADEQUACY OF DATA FOR ASSESSMENT ANALYSES*

These issues were discussed in the individual sections above

## *2.12. RESEARCH RECOMMENDATIONS*

1) Examine population connectivity throughout the Gulf and S. Atlantic using otolith elemental and stable isotope signatures of age-0 fish as natural tags of various regions. Otolith signatures of juvenile king mackerel collected in various resource surveys should first be examined to determine if population- or region-specific differences exist in otolith signatures, although success seems likely given the degree of classification success seen in adult mackerel whose otolith chemical signatures are integrated over several years of life, thus adding greater variance to their signatures. Once signatures are determined, the chemistry of adult cores could be sampled to examine interregional mixing between purported migratory groups (populations) in the Atlantic, eastern Gulf, western Gulf, and even Mexico.

2) Investigate and quantify mixing between eastern Gulf and western Gulf populations. The magnitude of the Mexican landings in comparison to U.S. landings from the GOM unit indicate clarification of this issue should be a priority for future assessments (see SEDAR16-DW-31).

3) Investigate / estimate the vulnerability of western Gulf fish to overfished Mexican fisheries in winter (Chavez and Arreguin-Sanchez 1995).

4) Conduct studies and monitoring that will allow estimation of natural mortality.

5) Review sampling procedures for age, length, and weight of king mackerel for both commercial and recreational fisheries to identify possible sampling biases.

6) Determine the impact of the quota sampling methodology, typically used for king mackerel in the TIP program, on growth parameter and age composition estimates; and explore methodologies for removing this potential bias.

7) Investigate the feasibility of switching from the current quota sampling design to random sampling of major strata.

8) Establish uniform, clear, consistent age and size sampling protocols.

9) Continue holding ageing workshops and training to standardize techniques and increase the ageing precision among laboratories.

10) Increase age sampling in South Carolina and Georgia and length sampling north of Florida in the Atlantic.

11) Increase sampling effort in the western Gulf (Louisiana, Texas, and Mexico) for otoliths and lengths of landed catch. Currently, there are very few samples being collected for this important component of the fishery, thus there are few data to parameterize the king mackerel population and fishery in the western Gulf.

12) Try to recover and include age and size data from Collins et al. (1989) Atlantic age and growth study in the next stock assessment of Atlantic king mackerel.

13) For the sake of standardization, request the Texas Parks and Wildlife Department to measure fork length on king mackerel in the future.

14) Establish clear priorities for added reproductive information as expanded work would involve considerable costs for a long-term sampling program.

15) If made a priority, more precisely determine 1) the extent of hydration that can be determined via routine observations in the field and 2) the timing of this phase relative to final oocyte maturation and spawning and 3) calibration of the degeneration of post-ovulatory follicles. This is needed to account for and correct a likely bias in spawning frequency estimates.

16) If made a priority, design and implement a reproductive sampling program (in concert with age sampling) on an annual basis that expands and intensifies spatial and temporal coverage (particularly adding the western Gulf of Mexico). A goal would be to provide annual estimates of spawning frequency. This would include regular training of port agents and scientific observers in macroscopic methods and additionally include a quality control component of random sub-sampling for histological comparisons.

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### *2.14. TABLES*

Table 2.14.1 (Table 8 in S16-DW-02). Average Percent Error (APE) from the king mackerel reference set reading by agency: Florida Fish and Wildlife Research Institute (FWRI), Alabama Marine Resources and Wildlife Division (AMRD), Mississippi Department of Marine Resources (MDMR), Louisiana Department of Wildlife and Fisheries (LDWF), and Texas Parks and Wildlife Department (TPWD).

| | APE | | APE |
|---|---|---|---|
| | Whole | Sectioned | Overall |
| FWRI | 5.03% | 0.48% | 2.75% |
| AMRD | 5.82% | 2.30% | 4.06% |
| MDMR | 11.31% | 4.84% | 8.76% |
| LDWF | 14.35% | 5.93% | 7.75% |
| TPWD | 10.39% | 4.87% | 7.45% |

Table 2.14.2. Estimated size-weight relationship for king mackerel stock units by sex. Data include only observations collected outside of the mixing zone, units of regression are kg for weight and cm for size (fork length).

**gutted wgt (kg) = alpha * (FL size cm) ^ beta**

| Stock unit | sex | *parameter* | *Estimate* | *Stderror* | *LowCL* | *UppCL* |
|---|---|---|---|---|---|---|
| ATLnoMix | Fem | alpha | 6.51E-06 | 3.90E-07 | 5.80E-06 | 7.32E-06 |
| | | beta | 3.0334074 | 0.0127821 | 3.0085342 | 3.0583074 |
| | Mal | alpha | 6.39E-06 | 7.15E-07 | 5.14E-06 | 7.95E-06 |
| | | beta | 3.0303692 | 0.0247411 | 2.9820943 | 3.0785878 |
| GOMnoMix | Fem | alpha | 4.61E-06 | 2.61E-07 | 4.13E-06 | 5.15E-06 |
| | | beta | 3.0994531 | 0.0121849 | 3.0756165 | 3.1233133 |
| | Mal | alpha | 6.24E-06 | 4.72E-07 | 5.37E-06 | 7.25E-06 |
| | | beta | 3.0275893 | 0.0168221 | 2.9942853 | 3.0609122 |

**whole wgt (kg) = alpha * (FL size cm) ^ beta**

| Stock unit | sex | *parameter* | *Estimate* | *Stderror* | *LowCL* | *UppCL* |
|---|---|---|---|---|---|---|
| ATLnoMix | Fem | alpha | 6.18E-06 | 3.18E-07 | 5.59E-06 | 6.83E-06 |
| | | beta | 3.0492411 | 0.0108913 | 3.0280486 | 3.0704764 |
| | Mal | alpha | 5.27E-06 | 6.21E-07 | 4.18E-06 | 6.63E-06 |
| | | beta | 3.0850167 | 0.0258529 | 3.0344847 | 3.1355972 |
| GOMnoMix | Fem | alpha | 7.81E-06 | 6.62E-07 | 6.63E-06 | 9.20E-06 |
| | | beta | 2.9988011 | 0.0178936 | 2.9642011 | 3.0335487 |
| | Mal | alpha | 6.57E-06 | 6.29E-07 | 5.46E-06 | 7.91E-06 |
| | | beta | 3.0288173 | 0.0209352 | 2.9882854 | 3.0693161 |

## 2.15. FIGURES

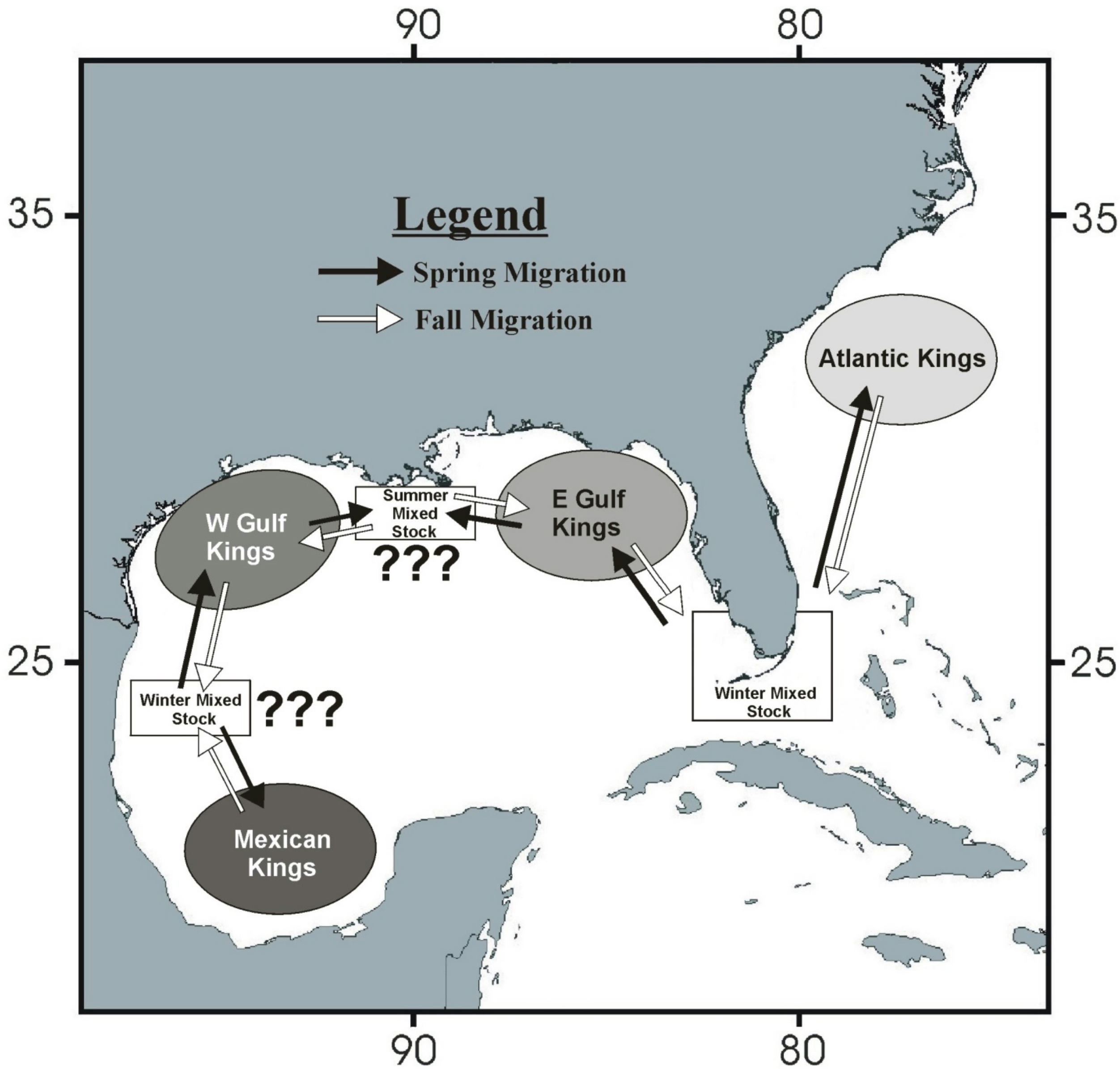


Figure 2.15.1. Hypothesized population structure and migratory pathways of king mackerel in U.S. waters and Mexican waters in the western and southern Gulf of Mexico. All migratory pathways have been documented with tagging data.

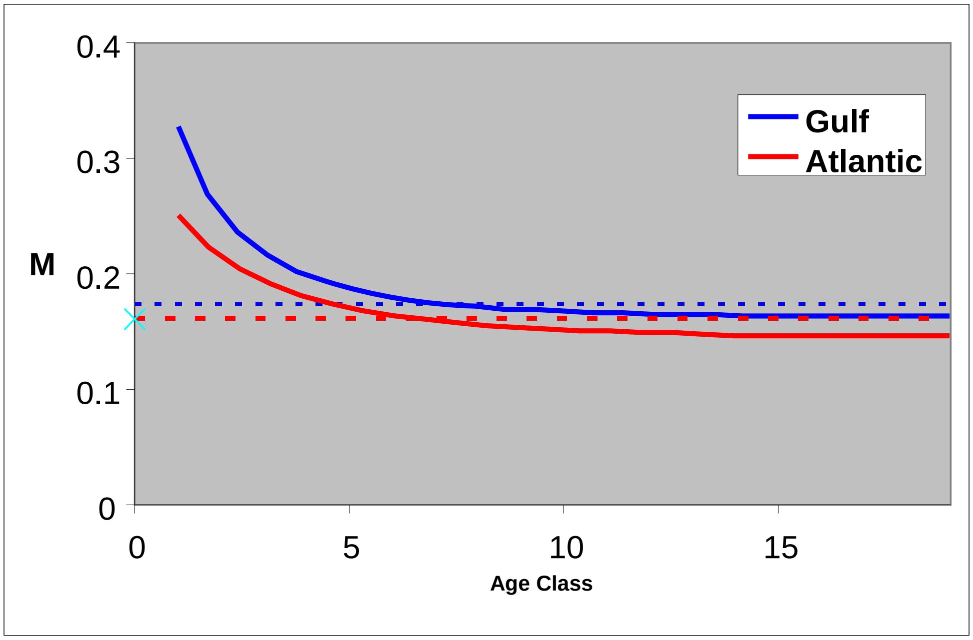


Figure 2.15.2. Age-varying M using the Lorenzen approach for the Gulf of Mexico (blue) and Atlantic (red). Point estimates of M (Hoenig method) are also indicated for the Gulf (dashed blue) and Atlantic (dotted red).

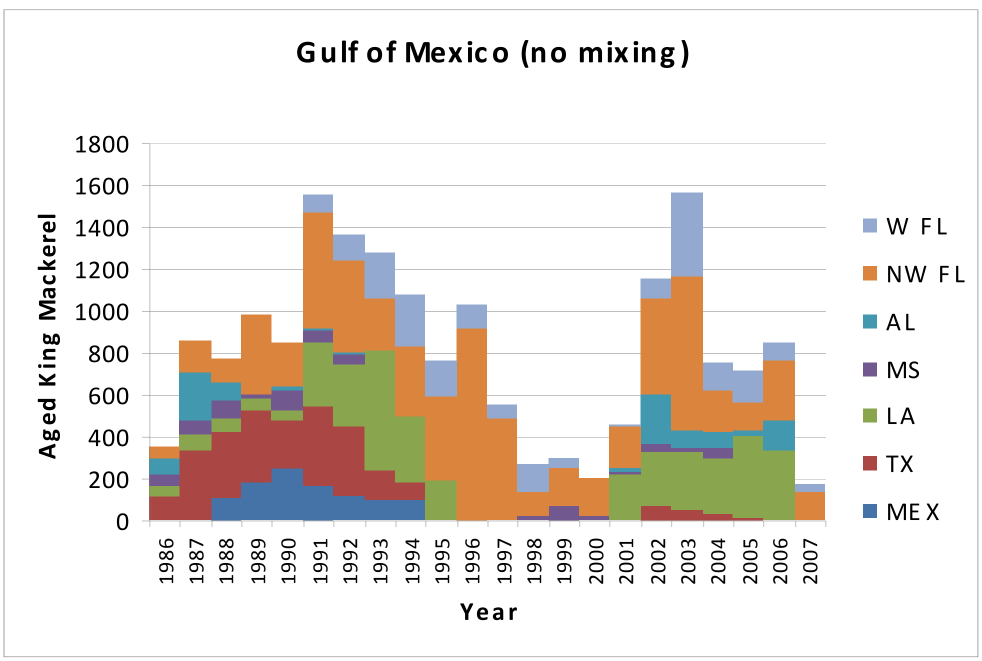


Figure 2.15.3. Aged king mackerel samples from the Gulf of Mexico no mixing zone: W FL (West Florida), NW FL (Northwest Florida), AL (Alabama), MS (Mississippi), LA (Louisiana), TX (Texas), MEX (Mexico).

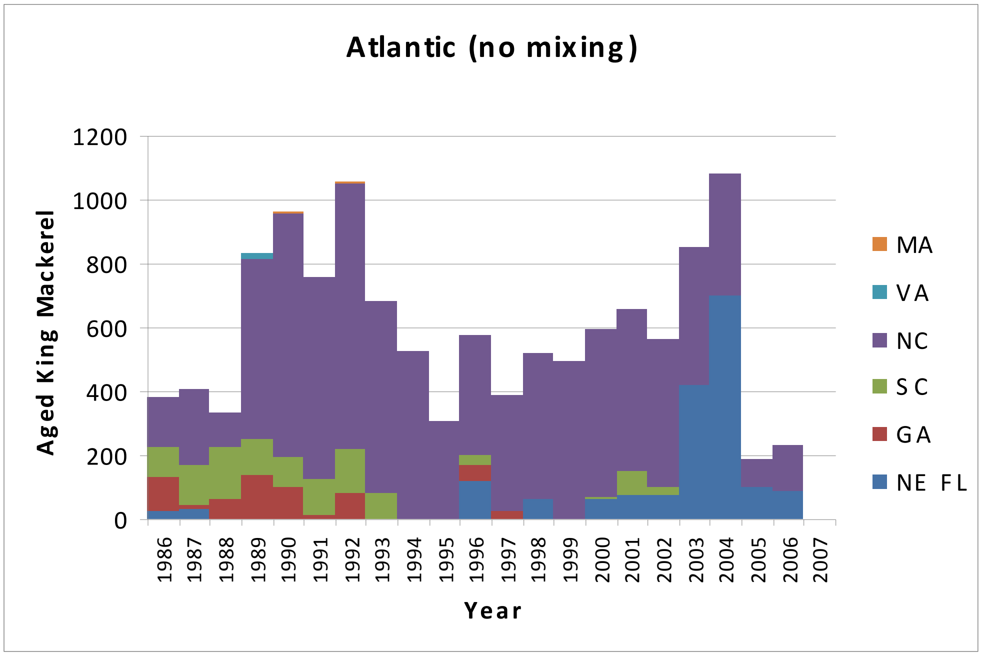


Figure 2.15.4. Aged king mackerel samples from the Atlantic no mixing zone: MA (Massachusetts), VA (Virginia), NC (North Carolina), SC (South Carolina), GA (Georgia), NE FL (Northeast Florida).

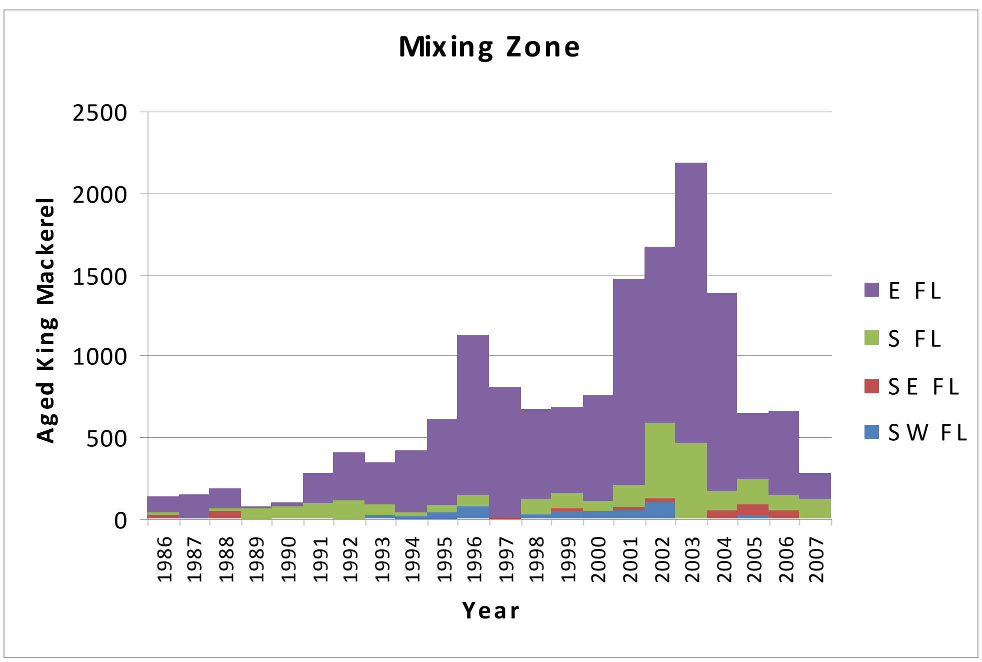


Figure 2.15.5. Aged king mackerel samples from the mixing zone: E FL (East Florida), S FL (South Florida), SE FL (Southeast Florida), SW FL (Southwest Florida).

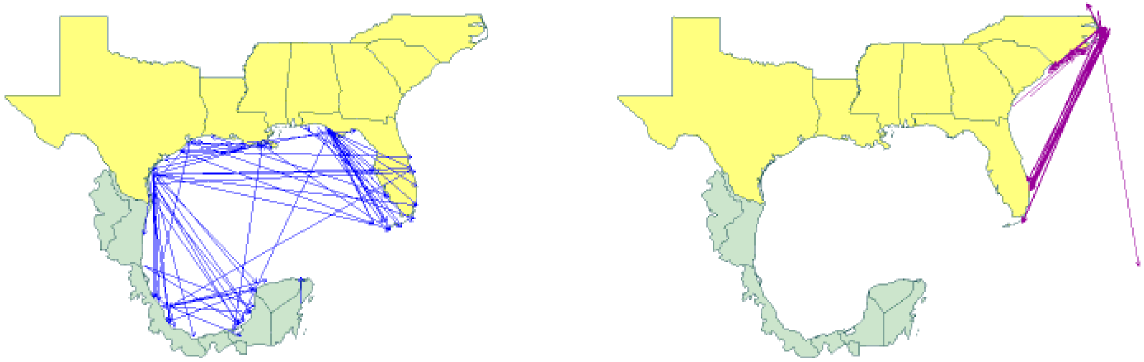

Figure 2.15.6 (Fig. 17 in S16-DW-10). Vector displacement maps of king mackerel tag recoveries from the non-mixing areas of the Gulf of Mexico (left) and Atlantic (right) regions.

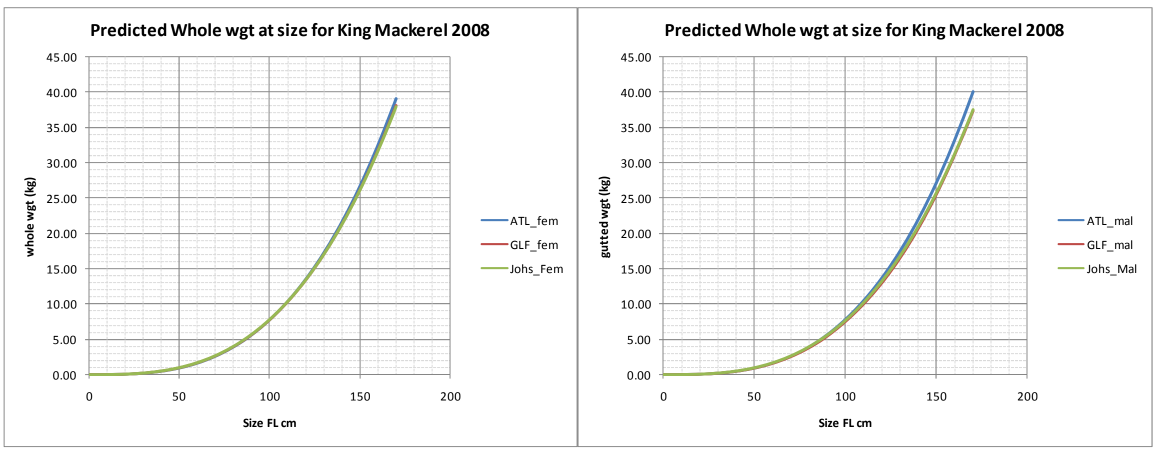


Figure 2.15.7. Estimates of weight at size for king mackerel by sex and stock unit (ATL, GLF) from fish collected outside the mixing zone only (Panama City NMFS database 1986-2007) and from study by Johnson et al. (1983).

# 3. COMMERCIAL FISHERY STATISTICS

## *3.1. OVERVIEW*

The commercial statistics working group reviewed information on commercial catches (landings and bycatch) and the size composition of those catches. Information on commercial catch rates were addressed by the indices working group and information on the age composition of the commercial catches was partially addressed by the life history working group.

The working group reviewed information on the size of fish landed in the commercial fishery by region and year and the size of discarded fish recorded by observers on shrimp vessels. Additionally the working group reviewed information on the sampling fractions for the commercial fishery.

### 3.1.1. Group leader and membership

Steve Turner (Data Leader) .......... NMFS-Miami
Alan Bianchi (Database) .......... NCDMF
Kevin McCarthy .......... NMFS-Miami
Dave Donaldson .......... GSMFC
Dave Gloeckner .......... NMFS-Beaufort
Ben Hartig (AP) .......... FL Commercial
Jack Holland (Port Sampler) .......... NCDMF
Rusty Hudson .......... Consultant
Rick Leard (Staff) .......... GMFMC
Refik Orhun .......... NMFS-Miami
Katie Siegfried .......... NMFS Panama City
Donald Waters (AP) .......... FL Commercial
Kay Williams. .......... GMFMC

## *3.2. REVIEW OF WORKING PAPERS*

Three working papers were presented, discussed and reviewed in the commercial fisheries working group meetings held during the data workshop. These documents were:

**Sedar-16-DW-24:** Compilation of Historical Commercial Landings of King Mackerel, *Scomberomorus cavalla*, from US waters in the US Gulf of Mexico and off the US South Atlantic States (Orhun, M.R. & Turner, S.C.)

**Sedar-16-DW-05:** A description of the discard estimates of the commercial shrimp fishery was presented, discussed and agreed upon in the commercial fisheries working group meeting utilizing the document, “Estimation of king mackerel bycatch in the shrimp trawl fishery in the US Gulf of Mexico and South Atlantic” (Siegfried, K.I.)

**Sedar-16-DW-23:** Calculated discards of king mackerel from commercial fishing vessels in the Gulf of Mexico, South Atlantic, and the Mixing Zone (McCarthy, K.)

The working group also reviewed information from SEDAR16-DW-13 (Ortiz, M) which presented information on the size composition of king mackerel landings by region and quarter.

Further information on the size composition and sampling of commercial landings was provided in "Commercial king mackerel sampling fractions for the South Atlantic and Gulf of Mexico" (Gloeckner, D. manuscript in preparation)

## *3.3. COMMERCIAL CATCHES*

### 3.3.1. U.S. Commercial Landings

The catches of king mackerel were aggregated into three regions for assessment: Gulf, Atlantic and the "Mixing Zone" (Figure 3.9.1.), and commercial statistics were handled in that manner. Commercial landings were assigned to one of those regions based on the county where the fish were landed. The NMFS fishing areas in the southeastern US are organized by a Latitude and longitude (Lat-Lon) grid on the Atlantic coast and the NMFS's historical shrimp grid (# 1-21) for the South Atlantic(SAFMC) and Gulf of Mexico Fisheries Management Councils (GMFMC), respectively (Figure 3.9.2). It is also possible to organize the Gulf of Mexico fishing areas into a "Lat-Lon" grid (Figure 3.9.3). Some of the most important fishing areas for King Mackerel are centered at the tip of South Florida and the Florida Keys (Figure 3.9.4a.). Another geographical representation of fishing areas is done via four-digit water body codes developed by NMFS and shown in Figure 3.9.4b for the Florida East Coast.

The landings were aggregated into three separate managed regions using the NMFS county codes for Florida and the NMFS state codes of the respective states of the Gulf and S. Atlantic. The three regions are the Gulf, the Mixing Zone, and the Atlantic using the following convention as the borders defining the "mixing zone" area as dynamic, seasonally shifting boundary area of the two fishery management of the GMFMC and the SAFMC:

1) South of Monroe/Collier county line on the Gulf of Mexico coast of Florida,
2) South of Volusia/Flagler county line on the Atlantic coast of Florida

These geographic strata reflected the general stock structure and movement patterns used in past assessments and described in the report of the life history working group: that separate management units exist in the Gulf of Mexico and in the Atlantic and that these management units overlap geographically in the mixing area.

#### *3.3.1.1. U.S. Commercial Fishing Areas and Landings for Assessment*

Commercial fisheries landings of King Mackerel were complied for this workshop beginning with landings in 1897 using historical databases of NOAA's Science and Technology division in Washington D.C., previously published NMFS fishery statistics data (Holiday and O'Bannon, 1990) and data of the Accumulated Landing System (ALS) database maintained by the National Marine Fisheries Service (NMFS) Southeast Fisheries Science Center (SEFSC) in Miami, Florida (Table 3.8.1 and Figure 3.9.5.).

Due data requirements of the Stock Synthesis model, that is also considered for use in the current King Mackerel for stock assessment for Sedar 16, missing data were generated using an averaging routine of the closest two neighboring year's landings, to linear interpolate values for the missing years (Figure 3.9.6.) These landings were aggregated by two management regions (south Atlantic and Gulf of Mexico) for possible later use in calculating allowable catches by management area (Table 3.8.2.).

An alternative way of assigning landings to the three regions was also investigated. With this method the three zones were assigned using water body (fishing area) information (Table 3.8.3.). When compared to the tabulations based on county of landing differences were observed. The tabulations based on county of landing were selected for use in the assessment to maintain continuity with historical treatment of the data.

#### *3.3.1.2. U.S. Commercial Landings by Gear*

Commercial landings by gear (Table 3.8.4) show that in the 1960s and 1970s gillnet landings usually accounted for more than half of the landings while since the mid 1980s gillnet landings have accounted for roughly 10-20% of the landings.

#### *3.3.1.3. U.S. Commercial Landings for Management*

The mixing area used for this assessment spans part of the area managed by the South Atlantic Fishery Management Council and part of the area managed by the Gulf of Mexico Management Council. For possible use in determining allowable catches, landings are presented by management area for two different ways of defining those areas. The first divides the Gulf of Mexico management area from the South Atlantic management area at the border between Monroe county and Miami-Dade county in Florida, i.e. at about 25$^{o}$ 48'08" N, while the second divides the Gulf of Mexico management area and South Atlantic management area along the Florida East Coast, i.e. at about 29$^{o}$ 25'38" N (Godcharles and Murphy 1986).

### 3.3.2. Mexican Commercial Landings (Sedar16-RD-05, RD-06 and RD-07)

Three reference documents (RD) regarding the Mexican commercial fishery on King Mackerel were made available at the workshop, i.e. Sedar16-RD-05, RD-06 and RD-07**,** and they are included in the literature cited of this document as Instituto Nacional De La Pesca (1999), Chavez & Arreguin-Sanchez (1995), and Arreguin-Sanchez et al. (1995)., respectively.

Commercial landings data of King Mackerel, i.e. “Peto” in Spanish, reported in Mexican waters (Instituto Nacional De La Pesca, 1999) were discussed during the commercial landing workgroup meeting. It was noted that distribution of King Mackerel shown in the document reached from Tamaulipas, the state bordering with the US and Texas and involved all states in Mexico surrounding the Gulf including the three states of the Yucatan peninsula, i.e. Campeche, Yucatan and Quintana Roo, the latter extending into the Caribbean region on the east side of the Yucatan Peninsula.

The commercial King Mackerel landings data presented in Fig. 2 of reference document (RD) SEDAR-16-RD-05 (Instituto Nacional De La Pesca 1999) covered the years from 1970 - 1999, with landings in 1970 being the lowest on record and little under 1,000 mt or 2,200,000 lbs (2.2 MP) and about 5,000 mt or 11.1 MP in 1999. The highest landings were recorded in 1983 at close to 6,000 mt or 13.2 MP. Going back further in time, Fig. 4 in the Sedar-16-RD-06 (Chavez and Arreguin-Sanchez 1995) document showed recorded landings of less than 500 mt or 1.1 MP from 1952 through 1960, and then landings steadily increasing to about 1,000 mt or 2.2 MP by 1965. Total combined Mexican and US commercial catches from 1952-2006 were calculated using the Mexican landings from the ICCAT database (Figure 3.9.7.)

There was a discussion regarding the hypothesis that the fish on the West side of the Mississippi Delta (W. Louisiana and Texas on the US side) might belong to a western Gulf stock (see the Life History working group report for information on assumed stock structure. Commercial landings occur in US waters during the summer (check the management effect of this observation). The landings in Tamaulipas (Mexican state bordering the US) were recorded mainly in June and August (Table 9 of Sedar-16-RD-05) suggesting a possible seasonal north to south movement pattern.

### 3.3.3. Adequacy of the Landings Data

The working group considered the landings data from the United States to be adequate for conducting stock assessments.

The working group was unable to evaluate the adequacy of the Mexican landings statistics because the absence of scientists and fishermen familiar with that fishery.

## *3.4. U.S. COMMERCIAL DISCARDS*

Historically the commercial discards have been divided up into two major categories for each regional fisheries management council, one each for the commercial finfish fishery fleet and one each for the shrimp fishing fleet. They are then analyzed separately for the South Atlantic Fisheries Management Council (SAFMC) and for the Gulf of Mexico Fisheries Management Council (GMFMC).

### 3.4.1. U.S. Finfish Fishery Discards

The data set for calculating commercial vessel king mackerel discards included trips from vessels that reported discards to the coastal discard logbook program between January 1, 2002 and December 31, 2006 in the US south Atlantic, Gulf of Mexico, and king mackerel mixing zone. Only discard reports from hook and line gear (handline, electric reel, and trolling gears) were included in the calculations. The available data for other gears were too few for discard rates to be calculated. Eight factors were examined with GLM analyses for their possible influences on the king mackerel discard rate within each region. The significant main effects were identified, and then mean discard rates (discards per hook hour fished) were calculated for all strata associated with the two most influential effects in each region, year was not one of those effects in any region. Those mean rate calculations included all hook and line discard trips within each stratum, i.e. trips with no king mackerel discards reported were included in the discard rate calculations to produce a mean nominal discard rate. Total hook and line effort (hook hours) was tabulated from the coastal logbook data set for each of those region specific strata for each year from 1998-2007. Total discards for each stratum were then calculated as: stratum mean discard rate*stratum specific annual effort. Yearly calculated king mackerel discards are reported for each region in Table 3.8.5. Discards were not calculated for years prior to 1998 because before that year no census of total effort was available (starting in 1998 it became mandatory to report all coastal pelagic effort to the coastal logbook program). Table 3.8.6. includes reported estimates of discard mortality.

## 3.4.2. Shrimp Fishery Bycatch

The working group reviewed SEDAR16-DW-05 which provided details on the development of the preliminary estimates of bycatch by region. An addendum to that report (SEDAR16-DW-05_addendum) presented after the meeting provided some additional information and final tables and figures.

### *3.4.2.1. Gulf of Mexico (GOM) Shrimp Fishery Bycatch*

Bycatch estimates were required from the shrimp fishery in the GOM. Observer data are available from 1972-2006. Effort data are available for the GOM from the NMFS-Galveston laboratory from 1981-2007 (Figure 3.9.8.). Estimates of king mackerel bycatch in the shrimp fishery were calculated using a delta-GLM model (Figures 3.9.9. and Table 3.8.7.) The catch rate derived from the delta-GLM was then scaled by the average number of nets per vessel used in the GOM and the effort differentiated by depth strata, year and region of the GOM (Figure 3.9.10 and Table 3.8.8.). The delta-lognormal model fit better than the delta-gamma method and bycatch estimates are provided.

### *3.4.2.2. South Atlantic (SA) Shrimp Fishery Bycatch*

Bycatch estimates were also required from the shrimp fishery in the SA. Observer data are available for the SA from 1972-2006, however the occurrences of king mackerel in the shrimp fishery are so low that we were not able to apply the GLM method. Effort data are available from each state for the SA, but the years for which the effort data are available differ from state to state (Table 3.8.9. and Figures 3.9.11. - 3.9.16.) . Because there were so few king mackerel recorded by observers it was not possible to develop a standardized discard rate index from the observer data. Using an alternative index as a proxy was considered. The SEAMAP shallow water trawl survey index (Table 3.8.10. and SEDAR16-DW-09) was deemed a good proxy for commercial shrimp vessel bycatch rates (Figure 3.9.17. and Table 3.8.11.) considering the trawl used was the same as used in most of the fishery, the similarities in the distribution of fishing effort and the size of the king mackerel caught.

#### *3.4.2.3 Mixing Zone Shrimp Fishery Bycatch*

The mixing zone for king mackerel included shrimp zones one and two in the GOM. Although the entire mixing zone has observer coverage, the occurrences of king mackerel in observed shrimping effort were almost zero in the entire region except zones one and two in the GOM. However, zones one and two still have very few occurrences. Applying the few occurrences observed in zones one and two to the entire mixing zone would produce a highly inflated, unsuitable estimate. Also, the SEAMAP survey does not gather data in this region. The working group therefore concluded that bycatch estimates for the mixing area were highly uncertain and recommended that they not be used.

#### *3.4.2.4. Recommendations on Discards and Bycatch*

The working group recommended that the calculated numbers of king mackerel discarded by the finfish fishery in the Gulf of Mexico (non-mixing) and the South Atlantic (non-mixing) were sufficiently low as to be negligible. The working group noted that the calculated discards for the mixing area ranged from about 35,000 to 60,000 fish annually; if the discard mortality rate is about 25%, then the calculated number of dead discards (roughly 10,000 to 15,000 fish annually) might be sufficiently low to be negligible.

All king mackerel bycatch from the shrimp fishery were thought to die; the impact of those losses would depend on the assumed natural mortality rate of age 0 fish. The bycatch levels for the shrimp fishery in the Gulf of Mexico (non-mixing) appeared to be relatively large (roughly 1-2.5 million fish annually since the early 1990s) and the working group recommended that the assessment workshop consider including those estimates in the assessment. The South Atlantic (non-mixing) shrimp fishery bycatch of king mackerel was substantially lower than in the Gulf of Mexico, though once again sufficiently large relative to total removals that the assessment working group should carefully consider including those estimates in the assessment.

### 3.4.3. Adequacy of the Discard and Bycatch Estimates

The working group considered that it would be preferred to have observer based estimates of finfish fishery discards rather than the self – reported estimates available from the SEFSC commercial log book program. The working group did not have a quantitative method of determining the adequacy of the discard estimates, but did consider that the relatively low calculated values were similar to their expectations that discards from the directed king mackerel fishery would likely be relatively low given the ability of the fishermen in most areas to target fish greater than the minimum size.

The working group considered the estimates of king mackerel bycatch from the shrimp fisheries to be of low precision for the Gulf of Mexico and the South Atlantic (non-mixing). For both areas the working group considered that effort estimates were likely to be reasonably accurate while the catch rate indices were likely of lower precision and accuracy relative to the true discard rates. For the Gulf shrimp fishery the probable low reliability was in due to the low numbers of king mackerel observed and the infrequency of encountering king mackerel. For the South Atlantic the SEAMAP index of trawl catch rates may have been a reasonable proxy because of gear and fishing area similarities, however the limited sampling, low king mackerel catch rates and the infrequency of catching king mackerel would mean that its precision would likely be quite low.

## *3.5. SIZE AND AGE SAMPLES AND SAMPLING FRACTIONS FROM THE COMMECIAL FISHERIES*

Age composition data from the commercial catches has been reviewed and discussed by the Life History working group (LHG). Please refer to their report on this subject.

### 3.5.1. Size Samples from the U.S. Commercial Finfish Fishery

The numbers of king mackerel sampled in each region by hook and line gears (including hook and line and trolling) and gillnet are shown in Figure 3.9.19. The majority of samples have been taken from hook and line fishing primarily in the mixing area where most of the landings are taken. Annual length composition for the hook and line fishery for each region is presented in Figures 3.9.19. - 3.9.21.

### 3.5.2. Size of the U.S. Commercial Finfish Fishery Discards

The Gulf of Mexico reef fish fishery observer program has recorded the size of two king mackerel released from one trolling trip and one trip using an unrecorded gear. The fish caught by trolling was 52 cm and the other was 70 cm. That observer program has been active since 2006 and since then the minimum size in the Gulf of Mexico was 24" (61 cm). It is likely that the 70 cm fish was discarded during a closed season while the 52 cm fish may have been discarded in either a closed or open season.

Commercial fishermen indicated that king mackerel discarded in the mixing area were likely smaller than in other areas because king mackerel caught in that area are generally smaller than other areas. The commercial fishermen stated that they believed that the majority of king mackerel released from the hook and line fisheries were below, but close to the minimum size.

### 3.5.3. Size of the Shrimp Fishery Bycatch

Observers aboard shrimp vessels have recorded the size of more than 1,000 king mackerel caught in the Gulf of Mexico and more than 200 caught in the South Atlantic (Figure 3.9.18). The average size in the Gulf of Mexico king mackerel bycatch was about 240mm and about 170mm in the South Atlantic.

### 3.5.4. Commercial King Mackerel Sampling Fractions for the South Atlantic and Gulf of Mexico

Commercial king mackerel sampling fractions were contributed to the report by David Gloeckner from the Southeast Fisheries Science Center (SEFSC) Beaufort Laboratory.

#### *3.5.4.1. Data for Sampling Fractions*

Length samples of king mackerel have been collected by the Trip Interview Program (TIP) and several state agencies since 1981. These samples are collected by port agents at docks where commercial landings are landed throughout the Atlantic and Gulf coasts. Trips are randomly sampled to obtain trip, effort, catch, length frequency and age information. Occasionally there has been quota sampling to obtain age structures on fish that are rare in the catch (extremely large and small fish). These non-random samples are identified in the data to allow removal from analyses where non-random samples are not appropriate. Commercial landings data has been collected by state and federal personnel as a cooperative data collection effort since the early 1970s. The National Marine Fisheries Service (NMFS) stores this data in the Accumulated Landings System (ALS), located on the Oracle server at the SEFSC in Miami. The ALS contains landings data for the Atlantic and Gulf States beginning in 1962.

### *3.5.4.2. Sampling Fraction Calculation Methods*

Sampling fractions are derived by dividing number of fish sampled by landings (in numbers or weight). The resulting number yields the proportion of landings that are sampled. For some stock assessment methods (such as VPA the method used in previous king mackerel assessments) this proportion is used to expand the length composition obtained from samples to the landings. The result is an estimate of the total number and size of fish landed. Sample data were obtained from the assessment sample data (NMFS/SEFSC), which is a data set of all sampling data from commercial, charter, headboat, MRFSS, and research programs. The data used where a subset of this data, which contained commercial samples that were identified as having no sampling bias. These data were further limited to those that could be assigned a year, gear, state and area. Those data that had unknown year sampled, gear used, sampling state or sampling area were deleted from the file. Further, only gears belonging to hook and line or gill net gear types were used. Sample data were joined with landings data from ALS by year, gear and area. ALS data were also limited to those data that could be assigned a year, gear, state and area. Data in the ALS and sample data were assigned a state and an area based on landing and sample location. Areas assigned to the data corresponded to the Atlantic area where no mixing occurs, the Gulf area where no mixing of occurs, and the area where mixing of Atlantic and Gulf stocks occurs.

### *3.5.4.3. Sampling Fraction Results*

The mean sampling fraction was 0.014 with a standard deviation of +/- 0.058 across all gears, states and year. Sampling fractions ranged from 0.000 to 1.000, with the largest sampling fraction (1.000) occurring in Alabama in 2005 for gill net gear. Landings in Al, MS and TX had infrequent years with sampling and numerous years had no sampling. SC had the highest mean sampling fraction across all years with a mean of 0.065 for hook and line (Table 3.8.12). Only AL, NC and FL had any years with a sampling fraction above 0.001 for gill net gear (Table 3.8.13) (Figure 3.9.19.). For sampling fractions broken down by area, the mean sampling fraction across areas, gears and years was 0.050 with a standard deviation of +/- 0.163 (Figure 3.9.20). The highest sampling fraction for hook and line gear was also from the Gulf, with a sampling fraction of 0.299 in 1984 (Table 3.8.14). The Gulf had the highest sampling fraction for a given year with a sampling fraction of 1.000 for gill net in 1996, 2001, 2002 and 2005 (Table 3.8.15). Across regions, year and gear the mean sampling frequency was 1875.70 with a standard deviation of +/- 2829.40.The Gulf had the highest sampling frequency with 17,898 in 1984 for hook and line (Table

3.8.16). For gill net gear, the highest sampling frequency occurred in 1981 in the mixing zone with 4,794 samples obtained (Table 3.8.17) (Figure 3.9.21). Length frequency distributions of the size of the sampled fish and number of fish sampled for the Atlantic, the Gulf and the mixing zone are presented in Figures 3.9.22 - 3.9.24.

### *3.5.4.4. Adequacy of Size Samples for Characterizing the Catch*

The working group considered the hook and line size samples to be generally adequate for characterizing the size composition of the commercial landings from 1981 to present for most years and regions. However on a state basis increased sampling is needed in some states which account for important components of the landings, such as North Carolina.

The working group considered the size information on the discards from the finfish fishery (2 fish observed, very likely not from the mixing zone where the largest number of discards was calculated to have occurred) to be inadequate for accurately characterizing that component of the catch.

The working group considered the size composition information on bycatch from the shrimp fisheries to be of limited value. Sufficient information was available to characterize the age composition of the bycatch (mostly age 0), but there was insufficient information to determine if annual patterns existed in the size of king mackerel bycatch in shrimp trawls.

## *3.6. RESEARCH RECOMMENDATIONS*

Consistent and sufficient levels of observers are needed aboard shrimp vessels in both the Gulf of Mexico and the South Atlantic. The South Atlantic shrimp fishery has been woefully under sampled.

The Mackerel Stock Assessment Panel reports should be reviewed for information on the Mexican fishery.

Cooperative research with Mexican scientists is needed to understand the relationships between king mackerel exploited in Mexican and U. S. waters. Additionally participation of Mexican scientists is needed in the assessment process (both accumulation and interpretation of data as well as assessment) to better understand the linkages and the Mexican fisheries.

## *3.7. LITERATUR CITED*

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## 3.8. TABLES

**Table 3.8.1.** US Commercial landings in metric tonnes (1mt= 2,203lb) of King Mackerel from 1897-2006. Number highlighted in light gray are interpolated.

**Table 3.8.2.** US commercial landings in metric tonnes (1mt= 2,203lb) by Gulf of Mexico and South Atlantic management regions.

**Table 3.8.3.** US commercial landings 1962-2006 in metric tonnes (1mt= 2,203lb), aggregated into three regions using water body code information as opposed to landing data shown in Table 1 (for 1962-2006) where county code information was used to generate region aggregations.

**Table 3.8.4.** U.S. Commercial Landings 1962-2006 in metric tonnes (1mt= 2,203lb); comparison of a) gillnet (GN) landings vs. b) all other gears combined (mostly hand line and trolling) and percentage of gillnet landings.

**Table 3.8.5.** Calculated yearly commercial hook and line vessel king mackerel discards by region. Discards are reported in number of fish.

**Table 3.8.6.** Estimated condition at release of king mackerel commercial hook and line discards. Numbers of fish and percent of total are reported by region.

**Table 3.8.7.** The bycatch index used to calculate estimates of king mackerel bycatch in the shrimp fishery in the Gulf of Mexico.

**Table 3.8.8.** Estimated number of king mackerel in the Gulf of Mexico shrimp fishery bycatch.

**Table 3.8.9.** The shrimp fishery effort (in numbers of trips) from the South Atlantic used in calculating king mackerel bycatch. Values highlighted in gray were tabulated from the South Atlantic Shrimp System. The remaining values were tabulated from state specific trip ticket systems.

**Table 3.8.10.** The bycatch index used to calculate estimates of king mackerel bycatch in the shrimp fishery in the south Atlantic.

**Table 3.8.11.** The estimates for king mackerel bycatch (in numbers of fish) in the south Atlantic shrimp trawl fishery. The italicized values (NC 1993 and SC 2006) were derived by taking the geometric mean of the previous 4 years.

**Table 3.8.12.** Sampling fractions for king mackerel by year and state for hook and line gear.

**Table 3.8.13.** Sampling fractions for king mackerel by year and state for gill net gear.

**Table 3.8.14.** Sampling fractions for king mackerel by year and area for hook and line gears.

**Table 3.8.15.** Sampling fractions for king mackerel by year and area for gill net gear.

**Table 3.8.16.** Sampling frequency (in number of samples) for king mackerel by year and area for hook and line gear.

**Table 3.8.17.** Sampling frequency (in number of samples) for king mackerel by year and area for gill net gear.

**Table 3.8.1.** US Commercial landings in metric tonnes (1mt= 2,203lb) of King Mackerel from 1897-2006. Number highlighted in light gray are interpolated.

| Year | Gulf | Mix Zone* | Atlantic | Total |
|---|---|---|---|---|
| 1897 | | 0.0 | 0.0 | 0.0 |
| 1898 | | 2.7 | 4.1 | 6.8 |
| 1899 | | 5.9 | 8.2 | 14.1 |
| 1900 | | 8.6 | 12.3 | 20.9 |
| 1901 | | 11.8 | 16.3 | 28.1 |
| 1902 | 0.0 | 14.5 | 20.4 | 35.0 |
| 1903 | 8.6 | 82.6 | 25.0 | 116.2 |
| 1904 | 17.2 | 150.7 | 30.0 | 197.9 |
| 1905 | 25.9 | 219.2 | 34.5 | 279.2 |
| 1906 | 34.5 | 287.3 | 39.5 | 361.3 |
| 1907 | 43.1 | 355.4 | 44.0 | 442.6 |
| 1908 | 51.7 | 423.5 | 49.0 | 524.3 |
| 1909 | 60.4 | 491.6 | 53.6 | 605.5 |
| 1910 | 68.5 | 560.1 | 58.6 | 687.2 |
| 1911 | 77.2 | 628.2 | 63.1 | 768.5 |
| 1912 | 85.8 | 696.3 | 67.6 | 849.7 |
| 1913 | 94.4 | 764.4 | 72.6 | 931.5 |
| 1914 | 103.0 | 832.5 | 77.2 | 1,013.2 |
| 1915 | 111.7 | 901.0 | 82.2 | 1,094.9 |
| 1916 | 120.3 | 969.1 | 86.7 | 1,176.1 |
| 1917 | 128.9 | 1,037.2 | 91.7 | 1,257.8 |
| 1918 | 137.5 | 1,105.4 | 96.2 | 1,339.1 |
| 1919 | 143.4 | 1,080.8 | 86.2 | 1,310.5 |
| 1920 | 148.9 | 1,055.8 | 76.7 | 1,281.4 |
| 1921 | 154.8 | 1,030.9 | 66.7 | 1,252.8 |
| 1922 | 160.7 | 1,006.3 | 56.7 | 1,223.3 |
| 1923 | 166.4 | 981.6 | 47.2 | 1,195.2 |
| 1924 | 220.6 | 1,126.6 | 37.2 | 1,384.5 |
| 1925 | 275.1 | 1,271.4 | 27.2 | 1,573.8 |
| 1926 | 329.1 | 1,416.7 | 23.9 | 1,769.6 |
| 1927 | 374.2 | 1,711.1 | 11.3 | 2,096.7 |
| 1928 | 393.0 | 1,412.3 | 14.1 | 1,819.3 |
| 1929 | 582.9 | 1,394.4 | 7.9 | 1,985.2 |
| 1930 | 415.3 | 1,258.8 | 13.2 | 1,687.2 |
| 1931 | 221.8 | 1,330.6 | 8.2 | 1,560.6 |
| 1932 | 176.5 | 1,321.9 | 5.9 | 1,504.3 |
| 1933 | 202.5 | 1,164.3 | 10.4 | 1,377.2 |
| 1934 | 205.5 | 1,002.4 | 14.5 | 1,222.4 |
| 1935 | 278.7 | 1,154.3 | 19.1 | 1,452.1 |

| Year | Gulf | Mix Zone* | Atlantic | Total |
|---|---|---|---|---|
| 1936 | 297.0 | 1,494.6 | 23.2 | 1,814.8 |
| 1937 | 406.5 | 1,118.3 | 27.7 | 1,552.4 |
| 1938 | 255.2 | 1,409.3 | 63.6 | 1,728.1 |
| 1939 | 485.5 | 1,369.4 | 0.0 | 1,854.9 |
| 1940 | 582.1 | 996.7 | 15.9 | 1,594.7 |
| 1941 | 511.1 | 1,235.1 | 0.0 | 1,746.2 |
| 1942 | 488.4 | 1,287.3 | 0.0 | 1,775.8 |
| 1943 | 465.3 | 1,339.1 | 0.0 | 1,804.3 |
| 1944 | 442.6 | 1,391.3 | 3.6 | 1,837.5 |
| 1945 | 345.8 | 1,443.2 | 7.3 | 1,796.2 |
| 1946 | 327.3 | 1,321.8 | 10.4 | 1,659.5 |
| 1947 | 308.7 | 1,200.6 | 14.1 | 1,523.4 |
| 1948 | 290.1 | 1,079.0 | 17.7 | 1,386.7 |
| 1949 | 420.0 | 957.8 | 15.6 | 1,393.4 |
| 1950 | 123.3 | 593.2 | 26.7 | 743.3 |
| 1951 | 340.3 | 1,079.8 | 7.8 | 1,427.9 |
| 1952 | 239.6 | 822.1 | 5.3 | 1,067.0 |
| 1953 | 377.5 | 795.1 | 4.8 | 1,177.3 |
| 1954 | 319.7 | 590.2 | 0.3 | 910.2 |
| 1955 | 350.6 | 820.1 | 5.9 | 1,176.6 |
| 1956 | 355.1 | 1,292.9 | 3.3 | 1,651.4 |
| 1957 | 262.9 | 1,256.7 | 21.0 | 1,540.5 |
| 1958 | 414.9 | 1,040.4 | 27.4 | 1,482.7 |
| 1959 | 365.5 | 1,193.5 | 16.3 | 1,575.3 |
| 1960 | 548.9 | 1,116.0 | 22.7 | 1,687.6 |
| 1961 | 496.7 | 1,209.8 | 29.3 | 1,735.8 |
| 1962 | 603.5 | 1,328.6 | 25.7 | 1,957.8 |
| 1963 | 765.2 | 1,585.7 | 31.1 | 2,382.0 |
| 1964 | 172.8 | 1,398.0 | 43.4 | 1,614.3 |
| 1965 | 770.1 | 1,324.2 | 68.2 | 2,162.5 |
| 1966 | 935.6 | 1,147.6 | 45.6 | 2,128.8 |
| 1967 | 1,009.5 | 1,856.1 | 11.7 | 2,877.3 |
| 1968 | 1,458.8 | 1,461.6 | 5.2 | 2,925.6 |
| 1969 | 764.9 | 2,154.0 | 8.9 | 2,927.7 |
| 1970 | 628.4 | 2,538.3 | 7.0 | 3,173.7 |
| 1971 | 992.1 | 1,665.5 | 14.1 | 2,671.7 |
| 1972 | 561.8 | 1,731.5 | 9.0 | 2,302.3 |
| 1973 | 366.5 | 2,417.8 | 31.0 | 2,815.3 |
| 1974 | 1,762.3 | 3,139.4 | 31.2 | 4,933.0 |
| 1975 | 914.1 | 2,054.1 | 64.4 | 3,032.6 |
| 1976 | 570.2 | 2,992.0 | 112.6 | 3,674.8 |

| Year | Gulf | Mix Zone* | Atlantic | Total |
|---|---|---|---|---|
| 1977 | 156.5 | 4,098.2 | 172.5 | 4,427.2 |
| 1978 | 197.0 | 2,216.8 | 116.1 | 2,529.9 |
| 1979 | 94.9 | 2,260.9 | 238.9 | 2,594.7 |
| 1980 | 384.5 | 2,453.3 | 483.2 | 3,321.0 |
| 1981 | 59.6 | 3,651.5 | 426.0 | 4,137.1 |
| 1982 | 165.7 | 3,017.4 | 677.5 | 3,860.6 |
| 1983 | 704.2 | 2,039.3 | 496.6 | 3,240.1 |
| 1984 | 371.8 | 1,612.8 | 445.0 | 2,429.5 |
| 1985 | 470.5 | 1,547.2 | 491.9 | 2,509.6 |
| 1986 | 201.0 | 1,797.3 | 621.7 | 2,620.1 |
| 1987 | 274.9 | 1,364.3 | 728.1 | 2,367.2 |
| 1988 | 229.7 | 1,336.1 | 502.6 | 2,068.4 |
| 1989 | 330.0 | 901.3 | 435.2 | 1,666.5 |
| 1990 | 321.8 | 1,243.0 | 640.8 | 2,205.6 |
| 1991 | 334.5 | 879.9 | 702.5 | 1,916.9 |
| 1992 | 598.4 | 1,033.0 | 637.6 | 2,269.1 |
| 1993 | 499.3 | 1,606.4 | 503.5 | 2,609.2 |
| 1994 | 609.9 | 857.2 | 448.3 | 1,915.3 |
| 1995 | 421.9 | 1,152.1 | 527.4 | 2,101.3 |
| 1996 | 513.2 | 1,376.6 | 432.6 | 2,322.4 |
| 1997 | 604.7 | 1,468.4 | 768.0 | 2,841.2 |
| 1998 | 661.4 | 1,378.1 | 585.5 | 2,625.0 |
| 1999 | 745.8 | 1,470.0 | 538.5 | 2,754.3 |
| 2000 | 654.7 | 1,150.2 | 532.9 | 2,337.8 |
| 2001 | 590.6 | 1,239.5 | 420.4 | 2,250.5 |
| 2002 | 576.6 | 1,151.0 | 386.7 | 2,114.3 |
| 2003 | 598.3 | 1,406.5 | 371.1 | 2,376.0 |
| 2004 | 622.3 | 1,429.5 | 460.2 | 2,512.0 |
| 2005 | 521.3 | 1,391.6 | 597.0 | 2,509.9 |
| 2006 | 646.2 | 1,626.1 | 566.6 | 2,838.9 |

* As a close approximation, mixing Zone prior to 1961 equals FL East plus 35% of FL West landings. The 35% of FL West was based on the average percentage of FL West landings from Monroe County for the time period from 1962 - 1971.

**Table 3.8.2.** US commercial landings in metric tonnes (1mt= 2,203lb) by Gulf of Mexico and South Atlantic management regions.

| Year | Gulf | Atlantic | Total |
|---|---|---|---|
| 1962 | 953.9 | 1,004.8 | 1,958.7 |
| 1963 | 1,329.8 | 1,053.2 | 2,383.0 |
| 1964 | 620.3 | 995.6 | 1,615.9 |
| 1965 | 896.1 | 1,269.0 | 2,165.1 |
| 1966 | 1,243.0 | 887.6 | 2,130.5 |
| 1967 | 1,455.9 | 1,421.9 | 2,877.8 |
| 1968 | 1,701.1 | 1,224.6 | 2,925.7 |
| 1969 | 1,530.5 | 1,397.5 | 2,928.0 |
| 1970 | 1,119.6 | 2,054.3 | 3,173.9 |
| 1971 | 1,292.3 | 1,379.7 | 2,672.0 |
| 1972 | 650.5 | 1,652.0 | 2,302.5 |
| 1973 | 1,046.5 | 1,769.5 | 2,816.0 |
| 1974 | 2,895.5 | 2,038.4 | 4,933.9 |
| 1975 | 1,237.9 | 1,796.7 | 3,034.6 |
| 1976 | 1,322.4 | 2,355.4 | 3,677.8 |
| 1977 | 2,462.8 | 1,969.0 | 4,431.8 |
| 1978 | 824.1 | 1,709.8 | 2,533.9 |
| 1979 | 798.4 | 1,805.2 | 2,603.6 |
| 1980 | 1,417.0 | 1,919.7 | 3,336.7 |
| 1981 | 1,450.7 | 2,709.5 | 4,160.2 |
| 1982 | 1,037.2 | 2,853.8 | 3,890.9 |
| 1983 | 1,336.7 | 1,950.4 | 3,287.2 |
| 1984 | 872.0 | 1,590.9 | 2,462.8 |
| 1985 | 823.5 | 1,721.8 | 2,545.4 |
| 1986 | 928.0 | 1,690.4 | 2,618.4 |
| 1987 | 489.2 | 1,870.7 | 2,359.9 |
| 1988 | 471.9 | 1,589.6 | 2,061.5 |
| 1989 | 428.2 | 1,227.8 | 1,656.0 |
| 1990 | 749.4 | 1,448.3 | 2,197.7 |
| 1991 | 451.9 | 1,377.3 | 1,829.2 |
| 1992 | 1,027.1 | 1,245.0 | 2,272.1 |
| 1993 | 1,358.0 | 1,214.0 | 2,572.0 |
| 1994 | 816.9 | 1,137.7 | 1,954.6 |
| 1995 | 878.2 | 1,237.0 | 2,115.2 |
| 1996 | 1,098.9 | 1,230.1 | 2,329.0 |
| 1997 | 900.2 | 1,888.8 | 2,789.0 |
| 1998 | 1,170.4 | 1,472.7 | 2,643.1 |
| 1999 | 1,341.3 | 1,453.4 | 2,794.7 |
| 2000 | 986.9 | 1,346.8 | 2,333.7 |
| 2001 | 1,032.5 | 1,214.1 | 2,246.6 |
| 2002 | 990.8 | 1,120.1 | 2,110.9 |
| 2003 | 1,081.6 | 1,291.8 | 2,373.4 |
| 2004 | 1,026.5 | 1,484.9 | 2,511.5 |
| 2005 | 1,093.0 | 1,412.8 | 2,505.8 |
| 2006 | 1,117.1 | 1,721.1 | 2,838.2 |

**Table 3.8.3.** US commercial landings 1962-2006 in metric tonnes (1mt= 2,203lb), aggregated into three regions using water body code information as opposed to landing data shown in Table 1 (for 1962-2006) where county code information was used to generate region aggregations.

| Year | Gulf | Mixed | Atlantic | Total |
|---|---|---|---|---|
| 1962 | 789.9 | 1,142.1 | 25.7 | 1,957.8 |
| 1963 | 439.5 | 1,911.4 | 31.1 | 2,382.0 |
| 1964 | 138.5 | 1,432.3 | 43.4 | 1,614.3 |
| 1965 | 280.8 | 1,813.5 | 68.2 | 2,162.5 |
| 1966 | 793.0 | 1,290.2 | 45.6 | 2,128.8 |
| 1967 | 592.1 | 2,273.5 | 11.7 | 2,877.3 |
| 1968 | 808.2 | 2,112.1 | 5.2 | 2,925.6 |
| 1969 | 516.9 | 2,401.9 | 8.9 | 2,927.7 |
| 1970 | 538.1 | 2,628.6 | 7.0 | 3,173.7 |
| 1971 | 687.6 | 1,970.0 | 14.1 | 2,671.7 |
| 1972 | 528.3 | 1,765.0 | 9.0 | 2,302.3 |
| 1973 | 363.5 | 2,408.9 | 42.8 | 2,815.3 |
| 1974 | 1,057.7 | 3,844.1 | 31.2 | 4,933.0 |
| 1975 | 640.7 | 2,327.5 | 64.4 | 3,032.6 |
| 1976 | 454.3 | 3,107.9 | 112.6 | 3,674.8 |
| 1977 | 143.5 | 4,111.2 | 172.5 | 4,427.2 |
| 1978 | 101.3 | 2,309.4 | 119.2 | 2,529.9 |
| 1979 | 87.0 | 2,267.5 | 240.4 | 2,594.9 |
| 1980 | 546.4 | 2,278.7 | 493.6 | 3,318.7 |
| 1981 | 52.8 | 3,622.3 | 469.2 | 4,144.2 |
| 1982 | 147.7 | 2,921.4 | 792.3 | 3,861.4 |
| 1983 | 701.0 | 1,955.2 | 585.4 | 3,241.5 |
| 1984 | 368.5 | 1,570.2 | 493.5 | 2,432.2 |
| 1985 | 464.3 | 1,435.0 | 610.0 | 2,509.3 |
| 1986 | 199.9 | 1,724.7 | 693.8 | 2,618.4 |
| 1987 | 274.2 | 1,306.1 | 779.5 | 2,359.9 |
| 1988 | 229.1 | 1,286.7 | 545.7 | 2,061.5 |
| 1989 | 329.7 | 870.1 | 456.2 | 1,656.0 |
| 1990 | 316.7 | 1,229.3 | 651.7 | 2,197.7 |
| 1991 | 325.1 | 793.7 | 710.3 | 1,829.2 |
| 1992 | 581.1 | 1,032.6 | 658.4 | 2,272.1 |
| 1993 | 484.9 | 1,584.2 | 502.8 | 2,572.0 |
| 1994 | 604.5 | 895.7 | 454.4 | 1,954.6 |
| 1995 | 395.4 | 1,188.0 | 531.8 | 2,115.2 |
| 1996 | 442.8 | 1,451.1 | 435.1 | 2,329.0 |
| 1997 | 564.7 | 1,440.9 | 783.5 | 2,789.0 |
| 1998 | 639.9 | 1,398.2 | 605.0 | 2,643.1 |
| 1999 | 673.1 | 1,550.9 | 570.7 | 2,794.7 |
| 2000 | 587.1 | 1,181.2 | 565.4 | 2,333.7 |
| 2001 | 522.7 | 1,273.1 | 450.9 | 2,246.6 |
| 2002 | 538.1 | 1,155.6 | 417.2 | 2,110.9 |
| 2003 | 553.2 | 1,409.5 | 410.7 | 2,373.4 |
| 2004 | 536.3 | 1,490.0 | 485.2 | 2,511.5 |
| 2005 | 451.7 | 1,425.7 | 628.5 | 2,505.8 |
| 2006 | 592.9 | 1,664.3 | 581.0 | 2,838.2 |

**Table 3.8.4.** U.S. Commercial Landings 1962-2006 in metric tonnes (1mt= 2,203lb); comparison of a) gillnet (GN) landings vs. b) all other gears combined (mostly hand line and trolling) and percentage of gillnet landings.

| | a) Gill Net | | | | b) Other | | |
|---|---|---|---|---|---|---|---|
| Year | Gulf | Mix+ATL | GN total | % | Gulf | Mix+ATL | Total |
| 1962 | 497.7 | 108.8 | 606.5 | 31% | 105.8 | 1,245.5 | 1,351.3 |
| 1963 | 353.6 | 904.2 | 1,257.9 | 53% | 411.6 | 712.5 | 1,124.1 |
| 1964 | 88.3 | 609.1 | 697.5 | 43% | 84.5 | 832.3 | 916.8 |
| 1965 | 194.1 | 959.5 | 1,153.6 | 53% | 576.0 | 433.0 | 1,009.0 |
| 1966 | 699.8 | 731.4 | 1,431.2 | 67% | 235.8 | 461.7 | 697.6 |
| 1967 | 509.8 | 1,519.5 | 2,029.4 | 71% | 499.7 | 348.2 | 847.9 |
| 1968 | 715.7 | 1,344.4 | 2,060.2 | 70% | 743.1 | 122.3 | 865.4 |
| 1969 | 407.4 | 1,549.6 | 1,957.0 | 67% | 357.5 | 613.2 | 970.8 |
| 1970 | 340.7 | 1,618.5 | 1,959.1 | 62% | 287.7 | 926.8 | 1,214.6 |
| 1971 | 559.7 | 1,292.6 | 1,852.4 | 69% | 432.4 | 387.0 | 819.3 |
| 1972 | 396.1 | 674.8 | 1,070.9 | 47% | 165.7 | 1,065.7 | 1,231.5 |
| 1973 | 265.8 | 1,114.0 | 1,379.8 | 49% | 100.6 | 1,334.8 | 1,435.5 |
| 1974 | 794.4 | 2,369.7 | 3,164.0 | 64% | 967.9 | 801.0 | 1,768.9 |
| 1975 | 490.8 | 969.3 | 1,460.1 | 48% | 423.3 | 1,149.2 | 1,572.5 |
| 1976 | 365.1 | 1,723.3 | 2,088.4 | 57% | 205.1 | 1,381.3 | 1,586.4 |
| 1977 | 126.8 | 2,654.1 | 2,780.9 | 63% | 29.6 | 1,616.6 | 1,646.2 |
| 1978 | 76.1 | 1,068.2 | 1,144.3 | 45% | 120.9 | 1,264.6 | 1,385.5 |
| 1979 | 20.2 | 983.5 | 1,003.7 | 39% | 74.7 | 1,516.4 | 1,591.0 |
| 1980 | 425.2 | 984.7 | 1,409.9 | 42% | 40.8 | 1,951.9 | 1,992.6 |
| 1981 | 23.4 | 1,595.2 | 1,618.5 | 39% | 36.2 | 2,482.4 | 2,518.6 |
| 1982 | 26.2 | 1,270.3 | 1,296.5 | 34% | 139.4 | 2,424.7 | 2,564.1 |
| 1983 | 15.4 | 947.0 | 962.4 | 30% | 688.8 | 1,588.9 | 2,277.7 |
| 1984 | 10.8 | 766.3 | 777.1 | 32% | 360.9 | 1,291.5 | 1,652.4 |
| 1985 | 13.1 | 588.7 | 601.8 | 24% | 457.3 | 1,450.4 | 1,907.7 |
| 1986 | 3.9 | 582.6 | 586.5 | 22% | 197.1 | 1,836.4 | 2,033.6 |
| 1987 | 21.5 | 101.2 | 122.7 | 5% | 253.4 | 1,991.1 | 2,244.5 |
| 1988 | 8.5 | 242.2 | 250.7 | 12% | 221.2 | 1,596.5 | 1,817.7 |
| 1989 | 19.6 | 4.2 | 23.8 | 1% | 310.4 | 1,332.4 | 1,642.7 |
| 1990 | 10.8 | 262.8 | 273.5 | 12% | 311.0 | 1,621.0 | 1,932.0 |
| 1991 | 3.3 | 29.6 | 32.8 | 2% | 331.2 | 1,552.9 | 1,884.1 |
| 1992 | 7.7 | 167.0 | 174.7 | 8% | 590.7 | 1,503.6 | 2,094.3 |
| 1993 | * | 641.7 | 643.7 | 25% | 497.4 | 1,468.1 | 1,965.5 |
| 1994 | * | 44.7 | 46.9 | 2% | 607.6 | 1,260.8 | 1,868.4 |
| 1995 | * | 242.8 | 243.0 | 12% | 421.7 | 1,436.6 | 1,858.3 |
| 1996 | * | 390.8 | 390.9 | 17% | 513.1 | 1,418.4 | 1,931.6 |
| 1997 | * | 276.3 | 276.9 | 10% | 604.2 | 1,960.2 | 2,564.3 |
| 1998 | * | 309.8 | 310.8 | 12% | 660.4 | 1,653.8 | 2,314.2 |
| 1999 | * | 465.7 | 467.8 | 17% | 743.7 | 1,542.8 | 2,286.5 |
| 2000 | * | 194.9 | 196.0 | 8% | 653.5 | 1,488.3 | 2,141.8 |
| 2001 | * | 218.2 | 218.4 | 10% | 590.4 | 1,441.7 | 2,032.1 |
| 2002 | - | 156.4 | 156.4 | 7% | 576.6 | 1,381.3 | 1,957.9 |
| 2003 | * | 182.3 | 182.6 | 8% | 598.1 | 1,595.4 | 2,193.4 |
| 2004 | * | 223.5 | 223.6 | 9% | 622.3 | 1,666.1 | 2,288.4 |
| 2005 | * | 316.1 | 316.1 | 13% | 521.3 | 1,672.5 | 2,193.8 |
| 2006 | - | 234.5 | 234.5 | 8% | 646.2 | 1,958.2 | 2,604.4 |

* Landings lower than 4.53 metric tonnes or 10,000 lbs.

**Table 3.8.5.** Calculated yearly commercial hook and line vessel king mackerel discards by region. Discards are reported in number of fish.

| Year | Mixing Zone Discards | Gulf of Mexico Discards | South Atlantic Discards | Yearly Total |
|---|---|---|---|---|
| 1998 | 48,831 | 5,423 | 6,080 | 60,335 |
| 1999 | 50,438 | 6,429 | 5,189 | 62,056 |
| 2000 | 50,216 | 5,269 | 5,232 | 60,716 |
| 2001 | 44,616 | 5,193 | 5,597 | 55,406 |
| 2002 | 40,651 | 5,260 | 4,718 | 50,628 |
| 2003 | 37,799 | 5,200 | 4,243 | 47,243 |
| 2004 | 30,694 | 4,300 | 4,181 | 39,176 |
| 2005 | 26,712 | 3,163 | 4,612 | 34,487 |
| 2006 | 27,607 | 4,264 | 4,949 | 36,820 |

**Table 3.8.6.** Estimated condition at release of king mackerel commercial hook and line discards. Numbers of fish and percent of total are reported by region.

| Region | Year | All Dead | Majority Dead | All Alive | Majority Alive | Kept | NA[1] | NR[2] | N Fish |
|---|---|---|---|---|---|---|---|---|---|
| Gulf of Mexico | 2002 | 2.6 | 2.6 | 42.7 | 52.2 | | | | 232 |
| | 2003 | 1.6 | | 50.0 | 48.4 | | | | 62 |
| | 2004 | | 7.9 | 92.1 | | | | | 38 |
| | 2005 | 58.7 | 4.8 | 3.2 | 22.2 | 1.6 | 9.5 | | 63 |
| | 2006 | 73.1 | | 4.5 | 20.9 | 1.5 | | | 67 |
| | **Total** | **20.1** | **2.6** | **36.8** | **38.7** | **0.4** | **1.3** | | **462** |
| Mixing Zone | 2002 | 3.6 | 2.9 | 68.3 | 19.6 | 5.7 | | | 419 |
| | 2003 | 4.3 | 5.1 | 65.1 | 19.8 | 5.4 | 0.3 | | 739 |
| | 2004 | 25.5 | 15.3 | 40.8 | 15.6 | 2.8 | | | 353 |
| | 2005 | 0.3 | 1.5 | 28.3 | 19.2 | 0.8 | | 49.9 | 661 |
| | 2006 | 1.1 | 3.2 | 43.8 | 47.2 | 0.2 | | 4.5 | 625 |
| | **Total** | **5.2** | **4.8** | **49.1** | **25.2** | **2.9** | **0.1** | **12.8** | **2,797** |
| South Atlantic | 2002 | 7.0 | 32.2 | 22.7 | 37.4 | 0.7 | | | 286 |
| | 2003 | 12.5 | | 87.5 | | | | | 16 |
| | 2004 | | | | | 100.0 | | | 12 |
| | 2005 | 5.3 | | 87.1 | 6.1 | 1.5 | | | 132 |
| | 2006 | 12.1 | | 75.8 | | 12.1 | | | 33 |
| | **Total** | **6.9** | **19.2** | **45.7** | **24.0** | **4.2** | | | **479** |

[1] Unknown
[2] Unreported

**Table 3.8.8.** Estimated number of king mackerel in the Gulf of Mexico shrimp fishery bycatch.

| Year | Numbers |
|---|---|
| 1981 | 148,925 |
| 1982 | 73,007 |
| 1983 | 0 |
| 1984 | 409,775 |
| 1985 | 286,260 |
| 1986 | 132,365 |
| 1987 | 645,067 |
| 1988 | 558,991 |
| 1989 | 1,643,210 |
| 1990 | 1,250,951 |
| 1991 | 1,453,860 |
| 1992 | 525,262 |
| 1993 | 1,653,275 |
| 1994 | 1,539,115 |
| 1995 | 1,858,265 |
| 1996 | 686,776 |
| 1997 | 1,009,554 |
| 1998 | 989,183 |
| 1999 | 853,640 |
| 2000 | 959,050 |
| 2001 | 1,795,203 |
| 2002 | 942,965 |
| 2003 | 2,584,018 |
| 2004 | 2,554,041 |
| 2005 | 488,343 |
| 2006 | 1,031,632 |

**Table 3.8.9.** The shrimp fishery effort (in numbers of trips) from the South Atlantic used in calculating king mackerel bycatch. Values highlighted in gray were tabulated from the South Atlantic Shrimp System. The remaining values were tabulated from state specific trip ticket systems.

| Year | FL | GA | NC | SC | Total |
|---|---|---|---|---|---|
| 1978 | | 10,666 | 2,211 | | 12,877 |
| 1979 | | 14,552 | 3,397 | 10,035 | 27,984 |
| 1980 | | 13,103 | 4,227 | 11,908 | 29,238 |
| 1981 | 4,766 | 6,541 | 3,684 | 7,288 | 22,279 |
| 1982 | 4,972 | 11,154 | 5,134 | 12,169 | 33,429 |
| 1983 | 4,989 | 11,580 | 5,615 | 8,962 | 31,146 |
| 1984 | 4,668 | 5,680 | 5,796 | 5,134 | 21,278 |
| 1985 | 4,946 | 6,958 | 3,055 | 4,724 | 19,684 |
| 1986 | 4,158 | 9,634 | 3,377 | 9,742 | 26,912 |
| 1987 | 4,069 | 9,164 | 3,325 | 11,384 | 27,942 |
| 1988 | 4,812 | 9,422 | 5,290 | 8,352 | 27,875 |
| 1989 | 5,112 | 7,580 | 5,982 | 10,296 | 28,970 |
| 1990 | 6,186 | 6,244 | 4,923 | 9,638 | 26,991 |
| 1991 | 5,802 | 10,125 | 5,231 | 15,431 | 36,589 |
| 1992 | 4,688 | 8,925 | 4,553 | 14,010 | 32,176 |
| 1993 | 3,462 | 8,977 | 4,553 | 13,245 | 30,237 |
| 1994 | 5,197 | 8,575 | 3,875 | 12,080 | 29,727 |
| 1995 | 4,665 | 9,893 | 4,027 | 14,152 | 32,737 |
| 1996 | 5,071 | 7,771 | 3,295 | 10,193 | 26,330 |
| 1997 | 5,309 | 8,960 | 3,316 | 12,725 | 30,310 |
| 1998 | 5,252 | 8,009 | 3,605 | 9,749 | 26,615 |
| 1999 | 4,624 | 7,276 | 4,228 | 10,257 | 26,385 |
| 2000 | 3,760 | 5,411 | 3,198 | 10,166 | 22,535 |
| 2001 | 2,995 | 3,411 | 2,748 | 6,903 | 16,057 |
| 2002 | 2,767 | 3,946 | 2,654 | 7,385 | 16,752 |
| 2003 | 2,474 | 3,064 | 2,994 | 7,026 | 15,558 |
| 2004 | 2,236 | 3,354 | 2,971 | 4,664 | 13,225 |
| 2005 | 2,042 | 2,772 | 1,625 | 3,476 | 9,915 |
| 2006 | 2,697 | 2,610 | 2,438 | 5,299 | 13,044 |

**Table 3.8.10.** The bycatch index used to calculate estimates of king mackerel bycatch in the shrimp fishery in the south Atlantic.

| Year | Index | CV |
|---|---|---|
| 1989 | 0.80665 | 0.21208 |
| 1990 | 2.37662 | 0.15817 |
| 1991 | 0.70355 | 0.22176 |
| 1992 | 0.84277 | 0.24134 |
| 1993 | 0.44636 | 0.24653 |
| 1994 | 0.70829 | 0.23165 |
| 1995 | 1.22616 | 0.19830 |
| 1996 | 2.26104 | 0.16814 |
| 1997 | 0.51945 | 0.24049 |
| 1998 | 1.78616 | 0.19990 |
| 1999 | 1.21292 | 0.18440 |
| 2000 | 0.81567 | 0.22108 |
| 2001 | 0.44828 | 0.23417 |
| 2002 | 0.50613 | 0.21131 |
| 2003 | 0.98880 | 0.19557 |
| 2004 | 0.61887 | 0.35744 |
| 2005 | 0.72637 | 0.49344 |
| 2006 | 1.00582 | 0.22129 |

**Table 3.8.11.** The estimates for king mackerel bycatch (in numbers of fish) in the south Atlantic shrimp trawl fishery. The italicized values (NC 1993 and SC 2006) were derived by taking the geometric mean of the previous 4 years.

| Year | SC | NC | FL no mix | GA | Total |
|---|---|---|---|---|---|
| 1989 | 55,336 | 25,547 | 26,894 | 88,398 | 196,175 |
| 1990 | 154,851 | 41,567 | 33,680 | 210,877 | 440,976 |
| 1991 | 54,455 | 12,530 | 23,860 | 85,348 | 176,193 |
| 1992 | 90,674 | 7,003 | 20,430 | 91,761 | 209,868 |
| 1993 | 59,294 | *17,472* | 4,014 | 49,403 | 130,184 |
| 1994 | 85,561 | 3,875 | 5,525 | 6,069 | 101,030 |
| 1995 | 172,680 | 4,027 | 10,124 | 12,176 | 199,007 |
| 1996 | 230,468 | 3,295 | 21,221 | 17,575 | 272,559 |
| 1997 | 65,643 | 3,316 | 4,520 | 4,767 | 78,246 |
| 1998 | 174,151 | 3,605 | 15,331 | 14,168 | 207,255 |
| 1999 | 13,049 | 4,228 | 9,522 | 8,727 | 35,526 |
| 2000 | 8,958 | 3,198 | 6,091 | 4,330 | 22,577 |
| 2001 | 3,142 | 2,748 | 3,201 | 1,401 | 10,492 |
| 2002 | 4,194 | 2,654 | 3,352 | 2,001 | 12,201 |
| 2003 | 7,438 | 2,994 | 5,473 | 3,485 | 19,389 |
| 2004 | 3,695 | 2,971 | 3,360 | 1,737 | 11,762 |
| 2005 | 3,027 | 1,625 | 3,729 | 1,815 | 10,196 |
| 2006 | *4,055* | 2,438 | 3,198 | 5,203 | 14,893 |

**Table 3.8.12.** Sampling fractions for king mackerel by year and state for hook and line gear.

| | STATE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| YEAR | FL | MS | AL | LA | TX | NC | SC | GA |
| 1981 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1982 | 0.006 | 0.000 | 0.000 | 0.039 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1983 | 0.012 | 0.000 | 0.000 | 0.075 | 0.000 | 0.005 | 0.000 | 0.000 |
| 1984 | 0.039 | 0.000 | 0.000 | 0.304 | 0.000 | 0.007 | 0.073 | 0.057 |
| 1985 | 0.029 | 0.000 | 0.000 | 0.068 | 0.000 | 0.015 | 0.000 | 0.000 |
| 1986 | 0.015 | 0.000 | 0.000 | 0.025 | 0.039 | 0.017 | 0.069 | 0.011 |
| 1987 | 0.010 | 0.000 | 0.000 | 0.080 | 0.000 | 0.010 | 0.069 | 0.014 |
| 1988 | 0.012 | 0.222 | 0.000 | 0.015 | 0.000 | 0.024 | 0.073 | 0.035 |
| 1989 | 0.027 | 0.000 | 0.000 | 0.036 | 0.000 | 0.012 | 0.020 | 0.096 |
| 1990 | 0.023 | 0.000 | 0.000 | 0.000 | 0.000 | 0.015 | 0.033 | 0.000 |
| 1991 | 0.041 | 0.062 | 0.000 | 0.000 | 0.000 | 0.008 | 0.024 | 0.101 |
| 1992 | 0.043 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.032 | 0.042 |
| 1993 | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.027 | 0.045 |
| 1994 | 0.032 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.018 | 0.055 |
| 1995 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.049 | 0.069 |
| 1996 | 0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.056 | 0.077 |
| 1997 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.117 | 0.020 |
| 1998 | 0.024 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.068 | 0.015 |
| 1999 | 0.034 | 0.008 | 0.000 | 0.000 | 0.000 | 0.006 | 0.090 | 0.048 |
| 2000 | 0.037 | 0.000 | 0.000 | 0.001 | 0.000 | 0.010 | 0.122 | 0.016 |
| 2001 | 0.029 | 0.000 | 0.012 | 0.000 | 0.000 | 0.009 | 0.290 | 0.041 |
| 2002 | 0.023 | 0.000 | 0.000 | 0.006 | 0.000 | 0.002 | 0.277 | 0.006 |
| 2003 | 0.023 | 0.000 | 0.029 | 0.006 | 0.000 | 0.003 | 0.108 | 0.050 |
| 2004 | 0.013 | 0.000 | 0.013 | 0.007 | 0.000 | 0.005 | 0.024 | 0.093 |
| 2005 | 0.012 | 0.000 | 0.023 | 0.007 | 0.000 | 0.003 | 0.027 | 0.001 |
| 2006 | 0.011 | 0.000 | 0.027 | 0.007 | 0.000 | 0.003 | 0.024 | 0.000 |

**Table 3.8.13.** Sampling fractions for king mackerel by year and state for gill net gear.

| | STATE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| YEAR | FL | MS | AL | LA | TX | NC | SC | GA |
| 1981 | 0.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1982 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1983 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1984 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.038 | 0.000 | 0.000 |
| 1985 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 |
| 1986 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1987 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1988 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1989 | 0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.000 |
| 1990 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1991 | 0.011 | 0.000 | 0.000 | 0.000 | 0.000 | 0.008 | 0.000 | 0.000 |
| 1992 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1993 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| 1994 | 0.011 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1995 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1996 | 0.019 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1997 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1998 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1999 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2000 | 0.027 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2001 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2002 | 0.012 | 0.000 | 0.011 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2003 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2004 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2005 | 0.004 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2006 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table 3.8.14.** Sampling fractions for king mackerel by year and area for hook and line gears.

| | AREA | | |
|---|---|---|---|
| YEAR | ATLANTIC | GULF | MIXING |
| 1981 | 0.0000 | 0.0669 | 0.0218 |
| 1982 | 0.0000 | 0.0379 | 0.0078 |
| 1983 | 0.0031 | 0.0753 | 0.0143 |
| 1984 | 0.0164 | 0.2990 | 0.0396 |
| 1985 | 0.0094 | 0.1077 | 0.0107 |
| 1986 | 0.0167 | 0.0228 | 0.0168 |
| 1987 | 0.0138 | 0.0758 | 0.0109 |
| 1988 | 0.0265 | 0.0200 | 0.0115 |
| 1989 | 0.0125 | 0.0363 | 0.0288 |
| 1990 | 0.0158 | 0.0001 | 0.0249 |
| 1991 | 0.0254 | 0.2135 | 0.0347 |
| 1992 | 0.0156 | 0.2165 | 0.0441 |
| 1993 | 0.0090 | 0.0884 | 0.0345 |
| 1994 | 0.0056 | 0.0480 | 0.0356 |
| 1995 | 0.0065 | 0.1336 | 0.0187 |
| 1996 | 0.0110 | 0.0434 | 0.0261 |
| 1997 | 0.0061 | 0.0348 | 0.0097 |
| 1998 | 0.0120 | 0.0313 | 0.0209 |
| 1999 | 0.0114 | 0.0286 | 0.0354 |
| 2000 | 0.0174 | 0.0099 | 0.0375 |
| 2001 | 0.0169 | 0.0074 | 0.0306 |
| 2002 | 0.0071 | 0.0085 | 0.0239 |
| 2003 | 0.0092 | 0.0081 | 0.0234 |
| 2004 | 0.0059 | 0.0082 | 0.0126 |
| 2005 | 0.0036 | 0.0078 | 0.0123 |
| 2006 | 0.0046 | 0.0065 | 0.0117 |

**Table 3.8.15.** Sampling fractions for king mackerel by year and area for gill net gear.

| | AREA | | |
|---|---|---|---|
| YEAR | ATLANTIC | GULF | MIXING |
| 1981 | 0.0000 | 0.0000 | 0.0126 |
| 1982 | 0.0000 | 0.0295 | 0.0164 |
| 1983 | 0.0000 | 0.0000 | 0.0170 |
| 1984 | 0.0376 | 0.0000 | 0.0173 |
| 1985 | 0.0199 | 0.0000 | 0.0138 |
| 1986 | 0.0002 | 0.3888 | 0.0150 |
| 1987 | 0.0000 | 0.0213 | 0.0388 |
| 1988 | 0.0000 | 0.0000 | 0.0170 |
| 1989 | 0.0044 | 0.0000 | 0.0275 |
| 1990 | 0.0000 | 0.0000 | 0.0069 |
| 1991 | 0.0081 | 0.0000 | 0.0125 |
| 1992 | 0.0000 | 0.0000 | 0.0040 |
| 1993 | 0.0014 | 0.0000 | 0.0081 |
| 1994 | 0.0000 | 0.0057 | 0.0116 |
| 1995 | 0.0000 | 0.0000 | 0.0139 |
| 1996 | 0.0000 | 2.2346 | 0.0184 |
| 1997 | 0.0000 | 0.0000 | 0.0062 |
| 1998 | 0.0000 | 0.0000 | 0.0200 |
| 1999 | 0.0000 | 0.1844 | 0.0120 |
| 2000 | 0.0000 | 0.0000 | 0.0267 |
| 2001 | 0.0000 | 1.2099 | 0.0062 |
| 2002 | 0.0000 | 5.2146 | 0.0097 |
| 2003 | 0.0000 | 0.2320 | 0.0148 |
| 2004 | 0.0000 | 0.0000 | 0.0051 |
| 2005 | 0.0000 | 2.2390 | 0.0035 |
| 2006 | 0.0000 | 0.0000 | 0.0064 |

**Table 3.8.16.** Sampling frequency (in number of samples) for king mackerel by year and area for hook and line gear.

| | AREA | | |
|---|---|---|---|
| YEAR | ATLANTIC | GULF | MIXING |
| 1981 | 0 | 509 | 11,240 |
| 1982 | 0 | 685 | 2,913 |
| 1983 | 332 | 8,371 | 3,001 |
| 1984 | 1,485 | 17,898 | 8,743 |
| 1985 | 1,088 | 9,858 | 1,698 |
| 1986 | 2,376 | 722 | 4,188 |
| 1987 | 2,154 | 2,338 | 2,247 |
| 1988 | 2,989 | 857 | 1,691 |
| 1989 | 1,347 | 1,569 | 3,653 |
| 1990 | 2,704 | 3 | 6,212 |
| 1991 | 4,041 | 1,894 | 7,059 |
| 1992 | 2,709 | 3,325 | 9,292 |
| 1993 | 1,059 | 1,350 | 7,949 |
| 1994 | 477 | 2,049 | 7,375 |
| 1995 | 678 | 1,327 | 4,014 |
| 1996 | 1,051 | 1,197 | 7,551 |
| 1997 | 825 | 1,686 | 3,324 |
| 1998 | 1,709 | 822 | 5,752 |
| 1999 | 1,518 | 1,057 | 10,084 |
| 2000 | 2,134 | 1,169 | 10,028 |
| 2001 | 1,484 | 750 | 7,968 |
| 2002 | 501 | 756 | 6,038 |
| 2003 | 877 | 875 | 7,388 |
| 2004 | 636 | 833 | 3,578 |
| 2005 | 561 | 695 | 3,654 |
| 2006 | 517 | 855 | 3,909 |

**Table 3.8.17.** Sampling frequency (in number of samples) for king mackerel by year and area for gill net gear.

| | AREA | | |
|---|---|---|---|
| YEAR | ATLANTIC | GULF | MIXING |
| 1981 | 0 | 0 | 4,794 |
| 1982 | 0 | 228 | 4,168 |
| 1983 | 0 | 0 | 2,979 |
| 1984 | 114 | 0 | 3,527 |
| 1985 | 33 | 0 | 2,091 |
| 1986 | 6 | 593 | 2,829 |
| 1987 | 0 | 189 | 4,033 |
| 1988 | 1 | 0 | 2,469 |
| 1989 | 5 | 0 | 2,129 |
| 1990 | 0 | 0 | 401 |
| 1991 | 6 | 0 | 140 |
| 1992 | 0 | 0 | 242 |
| 1993 | 8 | 0 | 1,448 |
| 1994 | 0 | 2 | 130 |
| 1995 | 0 | 0 | 1,009 |
| 1996 | 0 | 52 | 1,825 |
| 1997 | 0 | 0 | 546 |
| 1998 | 0 | 0 | 1,464 |
| 1999 | 0 | 101 | 1,441 |
| 2000 | 0 | 0 | 1,257 |
| 2001 | 0 | 71 | 361 |
| 2002 | 0 | 120 | 452 |
| 2003 | 0 | 133 | 827 |
| 2004 | 0 | 0 | 312 |
| 2005 | 0 | 26 | 358 |
| 2006 | 0 | 0 | 438 |

### *3.9. FIGURES*

**Figure 3.9.1.** Regions used to aggregate landing for stock assessment king of mackerel in the GMFMC and SAFMC management areas. The mixing area is the area in green, located between the main GMFMC and SAFMC areas.

**Figure 3.9.2.** Fishing areas map of the US Gulf of Mexico and Atlantic coastline. The Gulf of Mexico grid is referred to as the (historical) "NMFS Shrimp Fishing Grid" zones and on the Atlantic side in latitude and longitude, i.e. "Lat-Long Grid" zones.

**Figure 3.9.3.** Fishing areas map of the US Gulf of Mexico "Lat-Lon".

**Figure 3.9.4.** a) Left: Enlarge map of the South grids, b) Right 1 Fishing areas map of the of the Florida east coast Atlantic coastline. These water body numbers or codes are part of greater spatial landing assignment system that spans the whole Gulf and S. Atlantic Fishery management zones.

**Figure 3.9.5.** Historical landings in metric tonnes (1mt= 2,203lb) of King Mackerel on record from 1897 through 2006.

**Figure 3.9.6.** Historical landings in metric tonnes (1mt= 2,203lb) of King Mackerel on record 1897 through 2007 (see Table 3.1 and Figure 3.1). The missing data are linear interpolated averaging the next closest neighbors. The stacked graph is cumulative also shows the total landings.

**Figure 3.9.7.** Commercial landings in metric tonnes (1mt= 2,203lb)) of King Mackerel from the US and Mexico from 1952 through 2006. The Mexican landings data was provided by the International Commission for Conservation of Atlantic Tunas (ICCAT).

**Figure 3.9.8.** The estimates of shrimping effort in the GOM fishery. The colored sections of the column represent the statistical ("Shrimp grid") areas of the Gulf (area: 1 = Stat Zones 1-9, 2 = Stat zones 10-12, 3 = Stat zones 13-17, and 4 = Stat zones 18-21).

**Figure 3.9.9.** The indices produced for the GOM using the delta-GLM method. The diamond line is the lognormal results while the box results are the gamma results. The lognormal model was determined the best by comparing the AIC values between the models.

**Figure 3.9.10.** The GOM bycatch estimates differentiated by depth zone. The blue area is the bycatch in the nearer shore (0-10 fathoms), while the yellow area is the bycatch estimate for the farthest depth zone (greater than 30 fathoms.

**Figure 3.9.11.** Ocean shrimping effort in the SA by state.

**Figure 3.9.12.** Shrimping effort (# of trips) in the Atlantic waters off Florida taken from trip tickets. This does not include the mixing zone from November 1-March 31. Data provided by the Florida Fish

and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute (FWRI) Fishery Dependent Monitoring program.

**Figure 3.9.13.** Ocean shrimping effort off the Georgia coast.

**Figure 3.9.14.** Ocean shrimping effort off the coast of North Carolina.

**Figure 3.9.15.** Ocean shrimping effort off the coast of South Carolina.

**Figure 3.9.16.** Ocean shrimping effort of the coast of the Florida no-mix zone.

**Figure 3.9.17.** The estimates of king mackerel bycatch in the south Atlantic shrimp trawl fishery. The state-specific estimates are shown in the different colors, purple for GA, light blue for FL, yellow for NC, and magenta for SC. Additional data were received at the SEDAR data workshop from the South Atlantic Shrimp System to update the effort estimates.

**Figure 3.9.18.** Length Frequency distribution of king mackerel from otter trawl surveys for the South Atlantic (upper graph) and the Gulf of Mexico (lower graph).

**Figure 3.9.19.** Sampling fractions by year, state and gear. Most fractions occurred between 0.00 and 0.25, those above 0.25 are labeled with the sampling fraction.

**Figure 3.9.20.** Sampling fractions by year, area and gear. Most fractions occurred between 0.00 and 0.25; those above 0.25 are labeled with the sampling fraction.

**Figure 3.9.21.** Number of lengths obtained by year, area and gear.

**Figure 3.9.22.** Relative length frequencies (proportion of n at length) by year for hook and line gear in the Atlantic zone.

**Figure 3.9.23.** Relative length frequencies (proportion of n at length) by year for hook and line gear in the Gulf zone. For 1990 all are 0.33.

**Figure 3.9.24.** Relative length frequencies (proportion of n at length) by year for hook and line gear in the Mixing zone

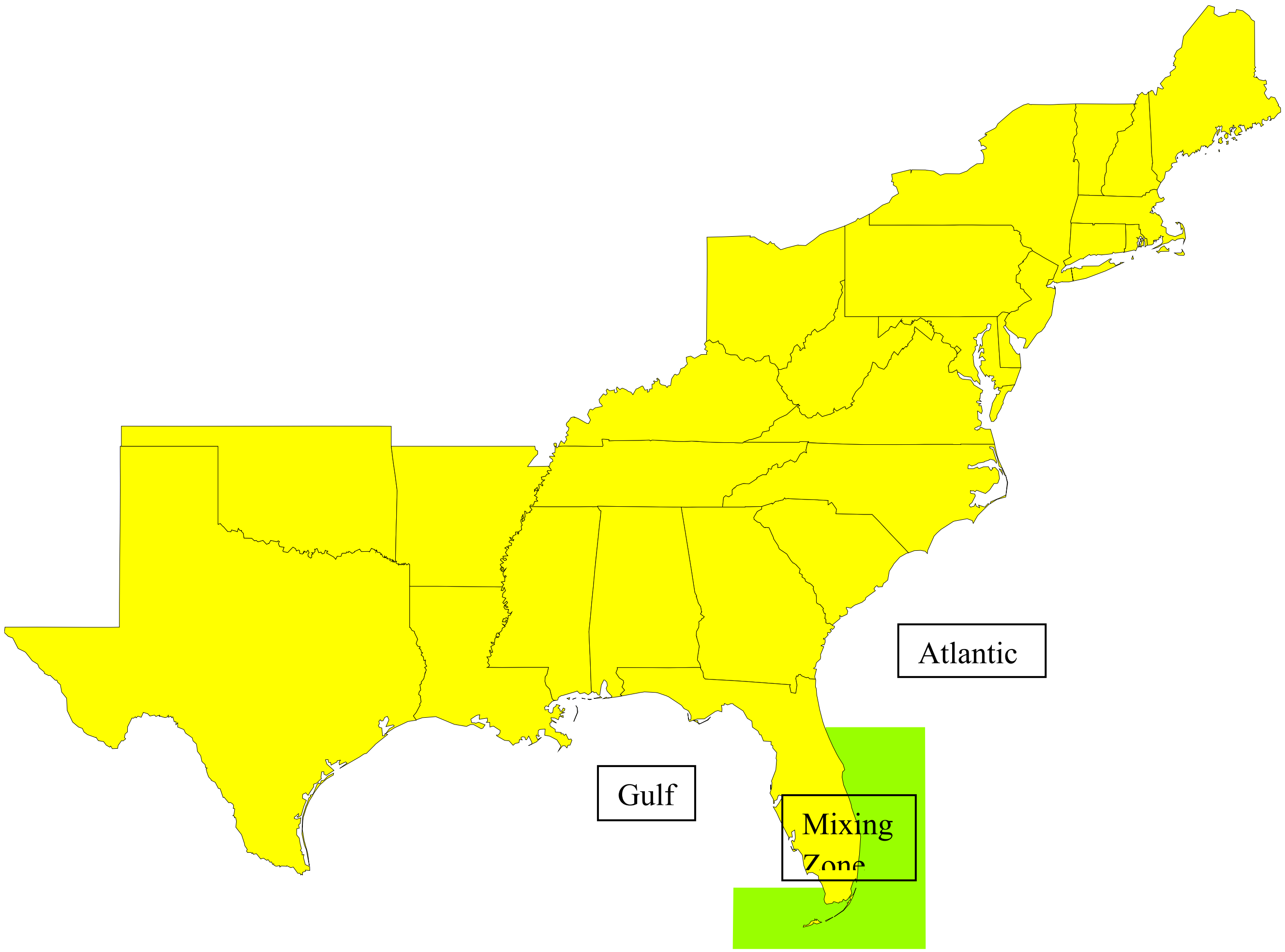



**Figure 3.9.1.** Regions used to aggregate landing for stock assessment king of mackerel in the GMFMC and SAFMC management areas. The mixing area is the area in green, located between the main GMFMC and SAFMC areas.

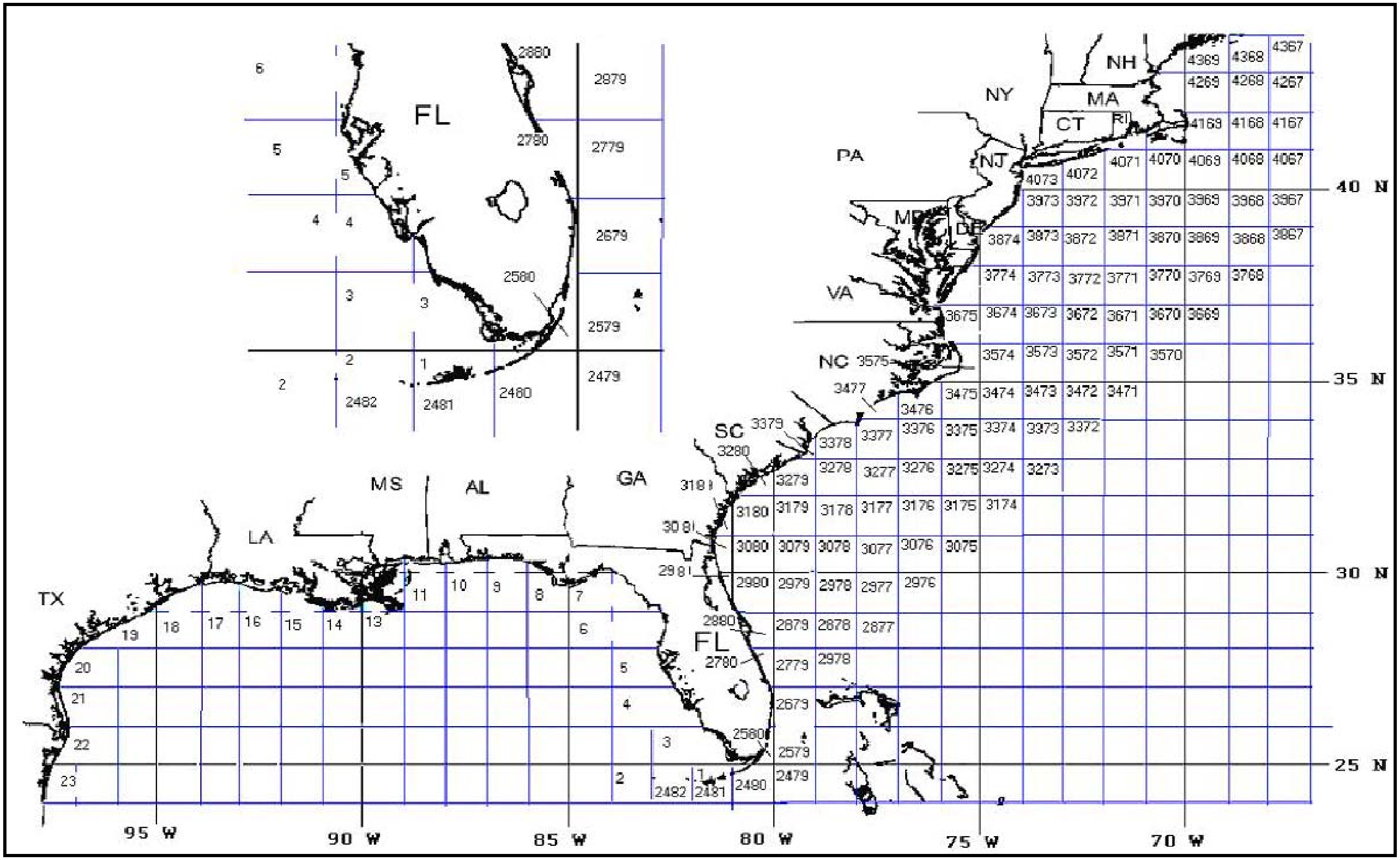



**Figure 3.9.2.** Fishing areas map of the US Gulf of Mexico and Atlantic coastline. The Gulf of Mexico grid is referred to as the (historical) "NMFS Shrimp Fishing Grid" zones and on the Atlantic side in latitude and longitude, i.e. "Lat-Long Grid" zones.

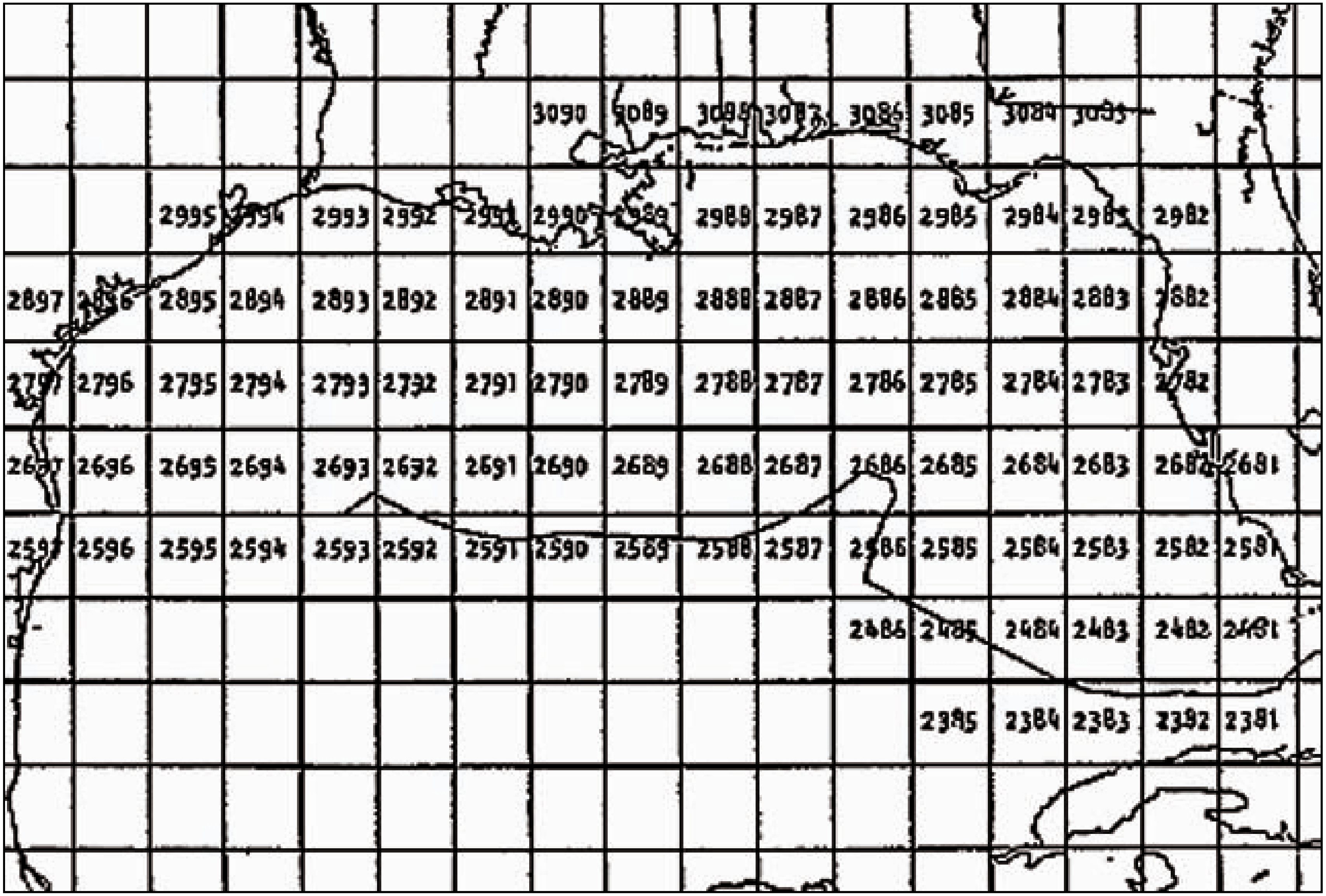
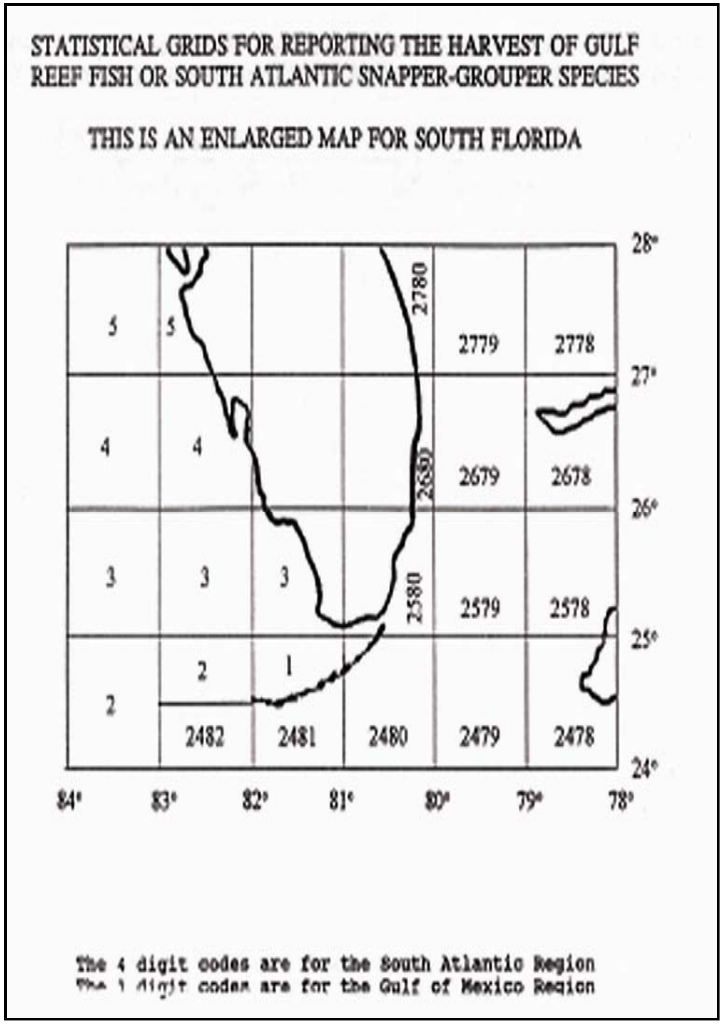



**Figure 3.9.3.** Fishing areas map of the US Gulf of Mexico "Lat-Lon".



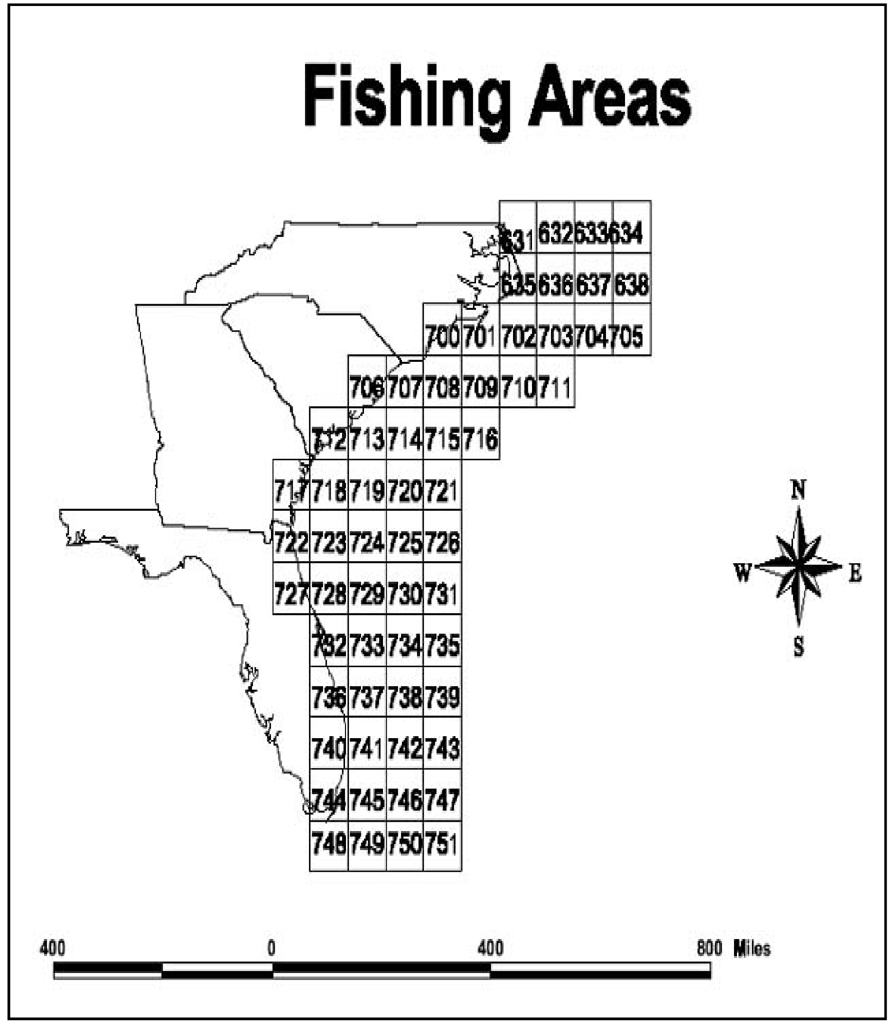




**Figure 3.9.4.** a) Left: Enlarge map of the South grids, b) Right 1 Fishing areas map of the of the Florida east coast Atlantic coastline. These water body numbers or codes are part of greater spatial landing assignment system that spans the whole Gulf and S. Atlantic Fishery management zones.

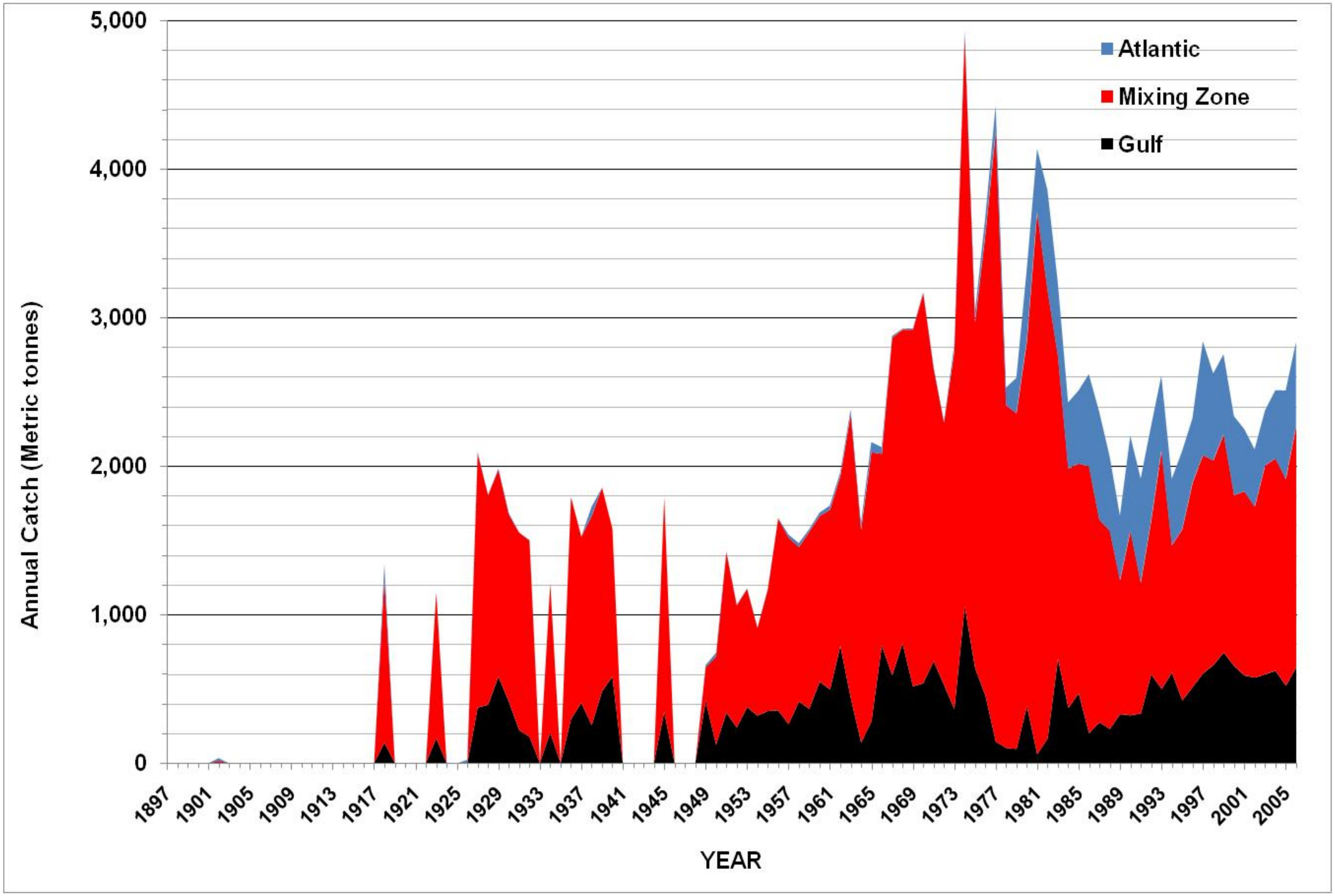



**Figure 3.9.5.** Historical landings in metric tonnes (1mt= 2,203lb) of King Mackerel on record from 1897 through 2006.

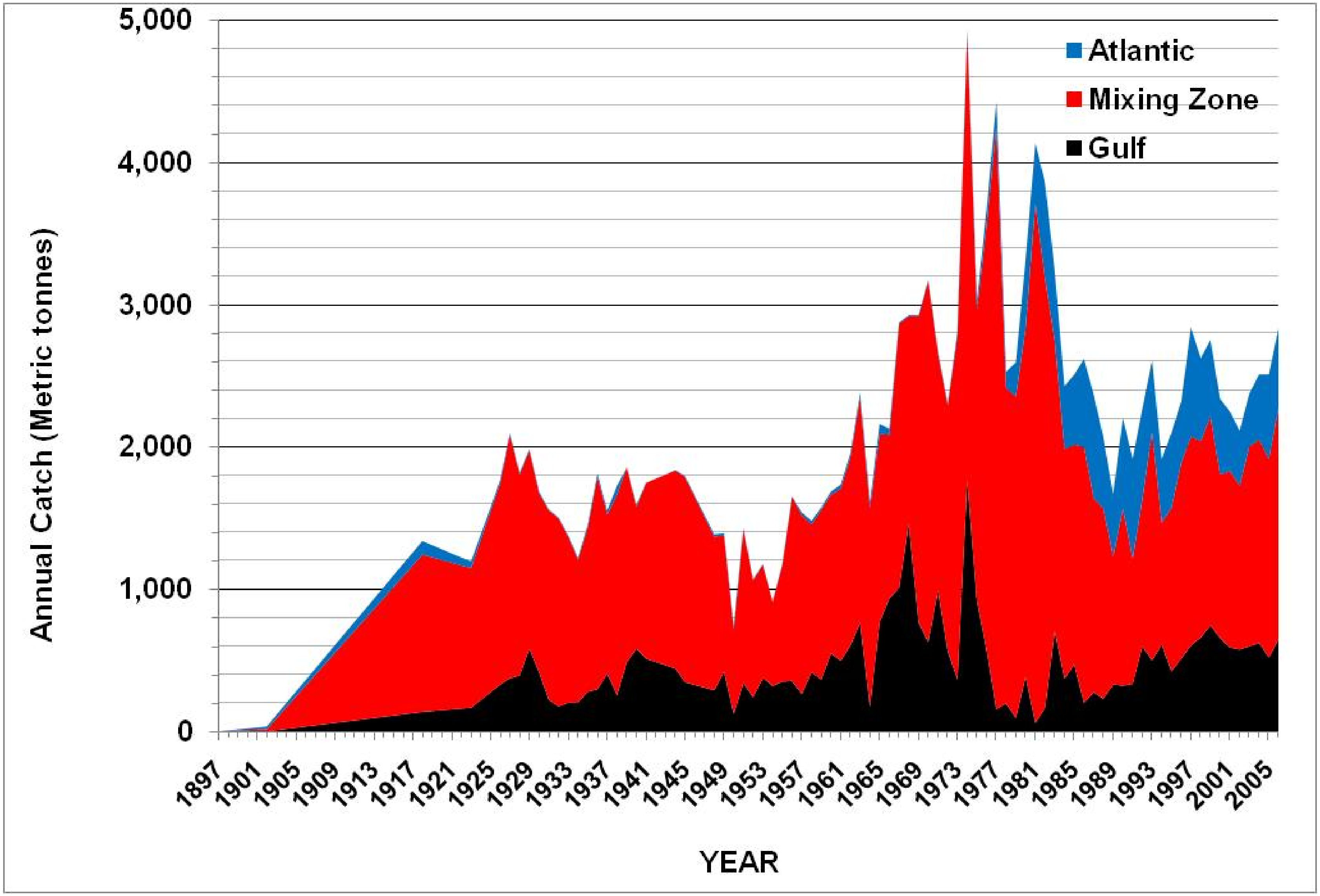



**Figure 3.9.6.** Historical landings in metric tonnes (1mt= 2,203lb) of King Mackerel on record 1897 through 2007 (see Table 3.1 and Figure 3.1). The missing data are linear interpolated averaging the next closest neighbors. The stacked graph is cumulative also shows the total landings.

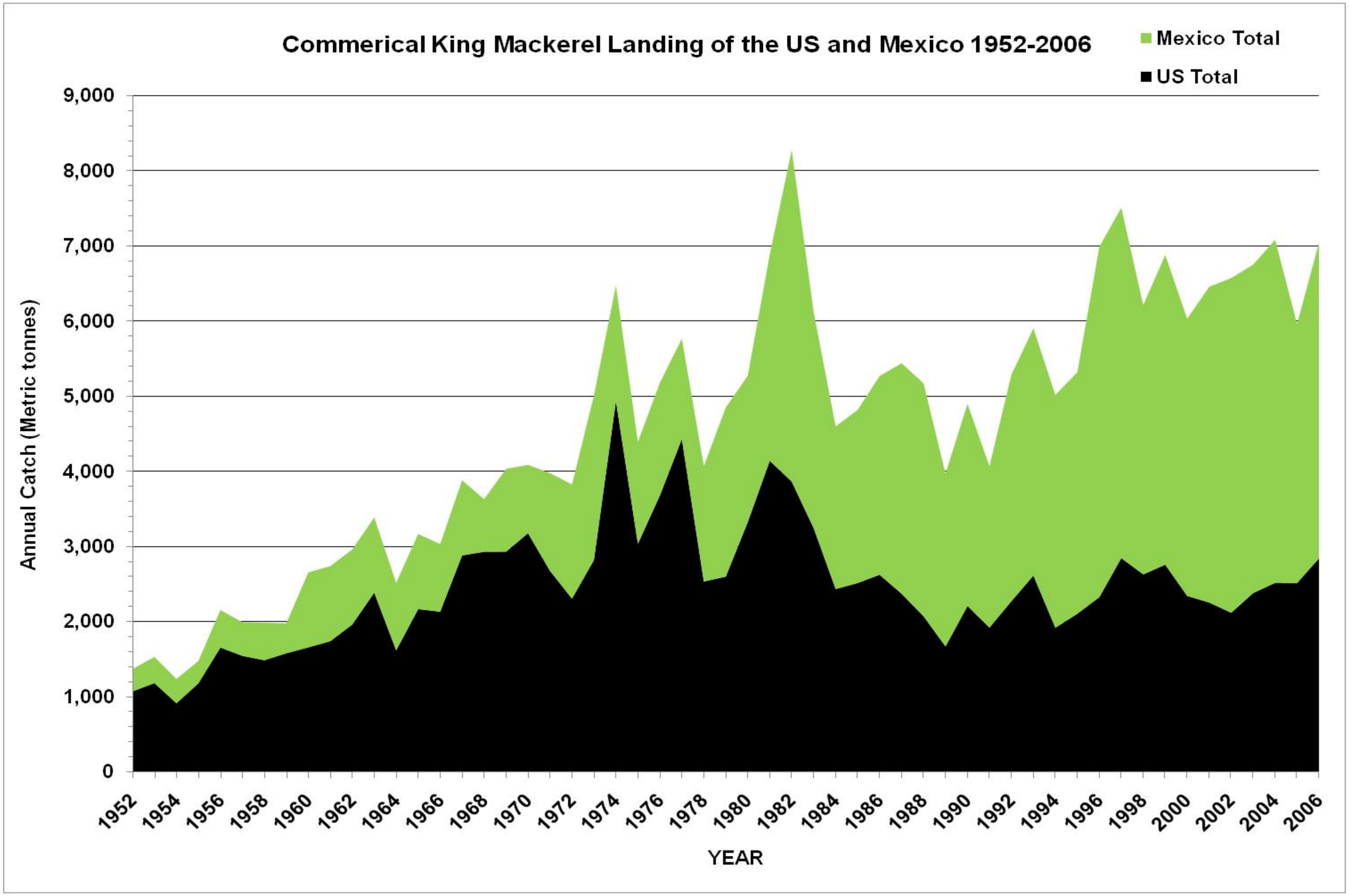



**Figure 3.9.7.** Commercial landings in metric tonnes (1mt= 2,203lb) of King Mackerel from the US and Mexico from 1952 through 2006. The Mexican landings data was provided by the International Commission for Conservation of Atlantic Tunas (ICCAT).

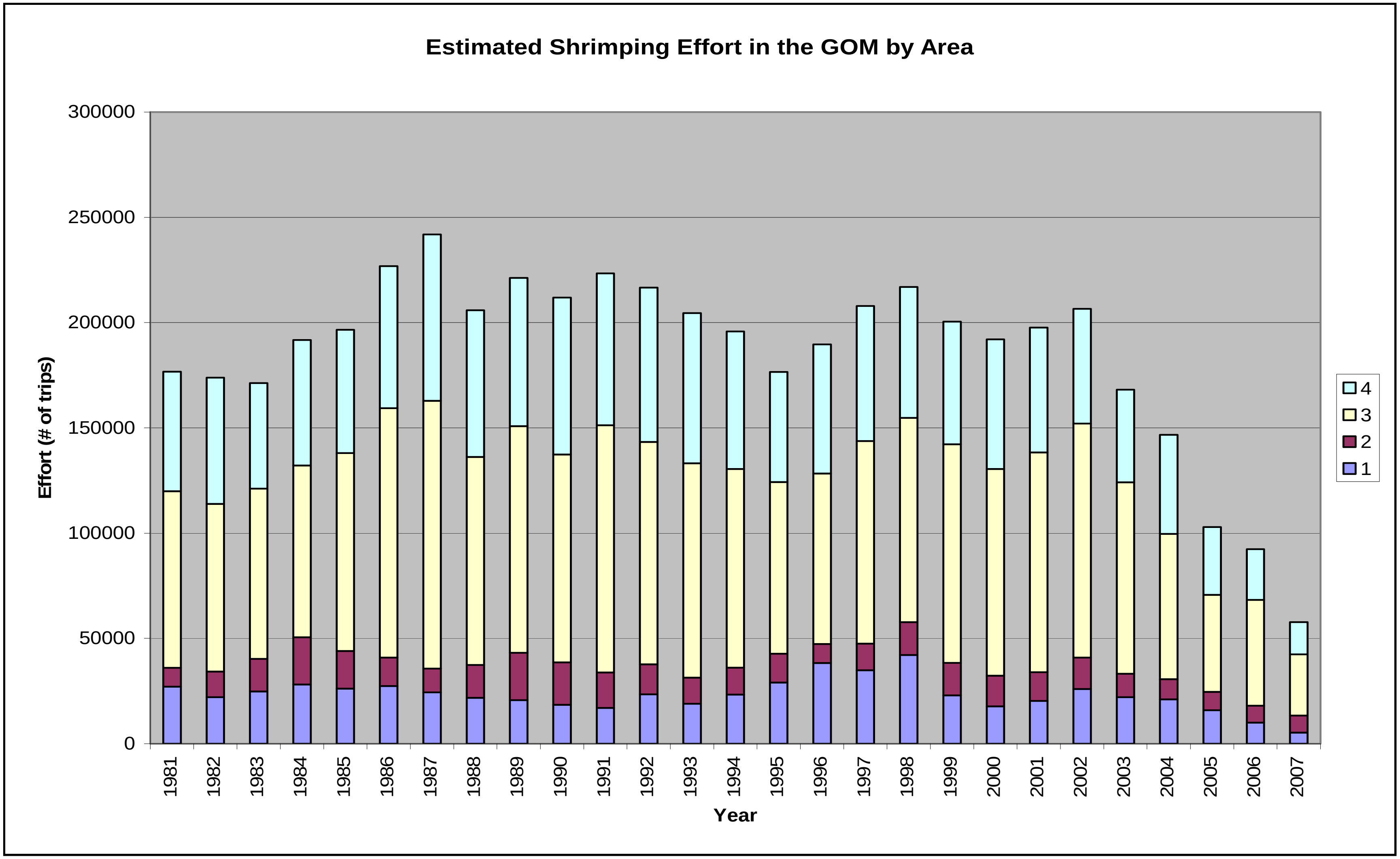



**Figure 3.9.8.** The estimates of shrimping effort in the GOM fishery. The colored sections of the columns represent the statistical areas in the gulf (area: 1 = Stat zones 1-9, 2 = Stat zones 10-12, 3 = Stat zones 13-17, and 4 = Stat zones 18-21).

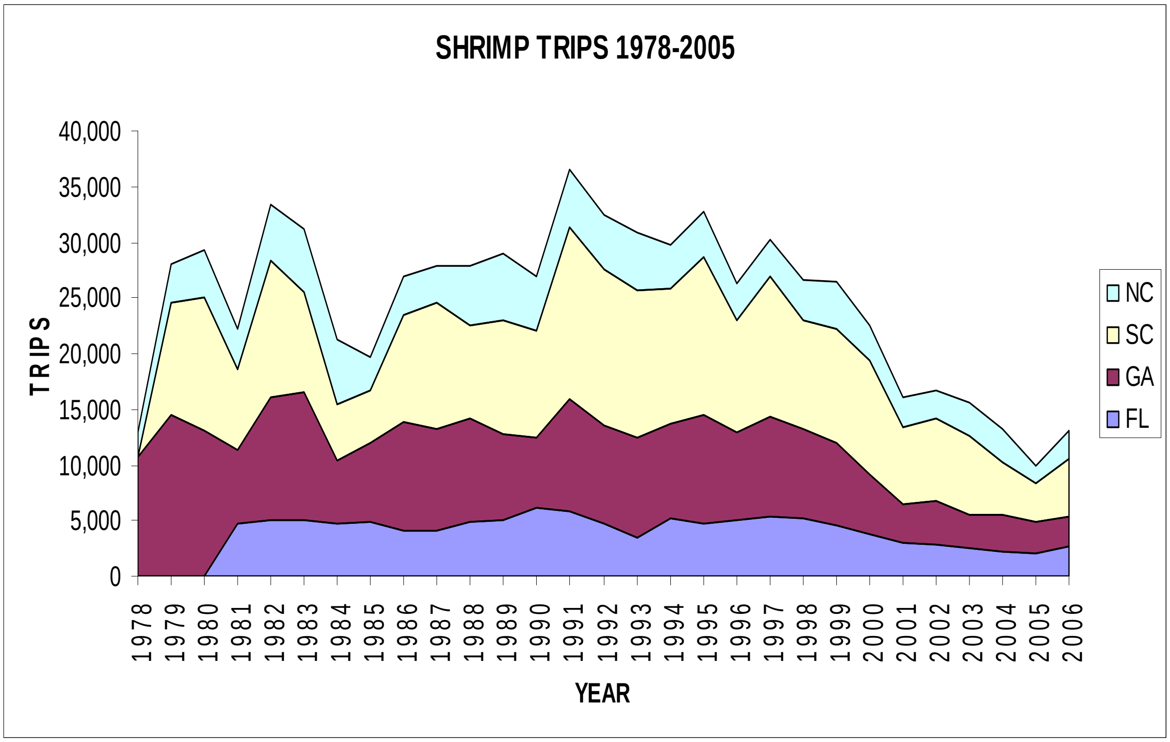



**Figure 3.9.9.** Ocean shrimping effort in the SA by state.

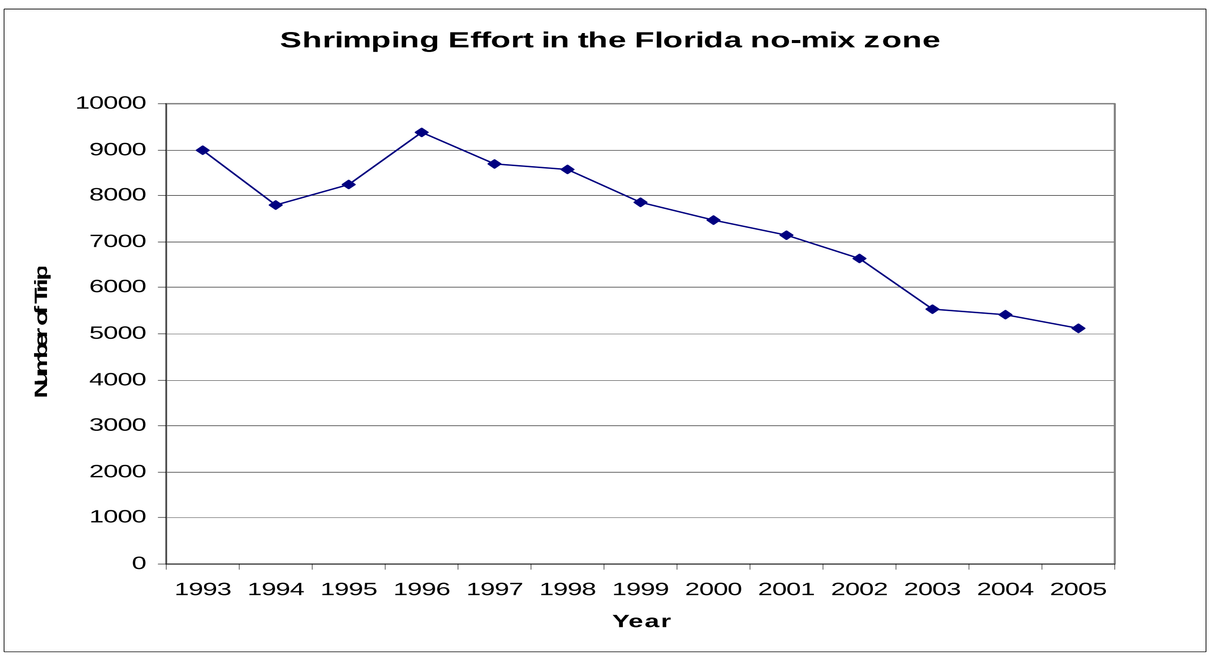



**Figure 3.9.10.** Shrimping effort (# of trips) in the Atlantic waters off Florida taken from trip tickets. This does not include the mixing zone from November 1-March 31. Data provided by the Florida Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute (FWRI) Fishery Dependent Monitoring program.

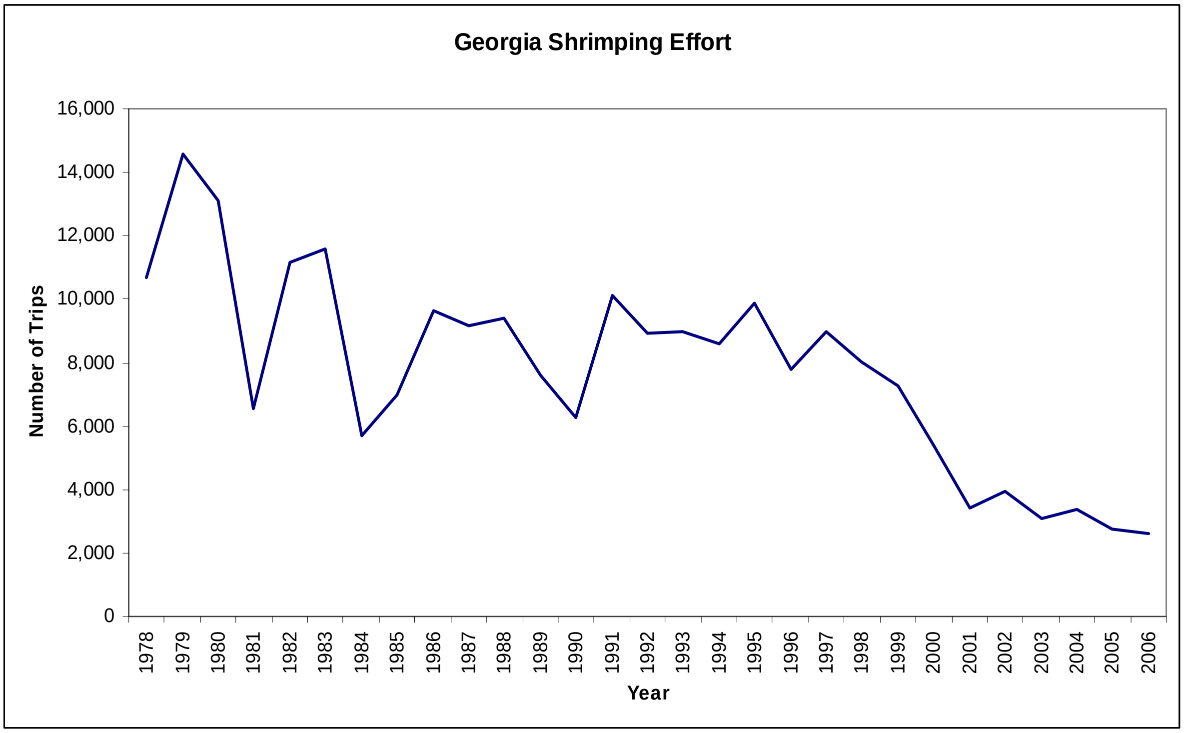



**Figure 3.9.11.** Ocean shrimping effort off the Georgia coast.

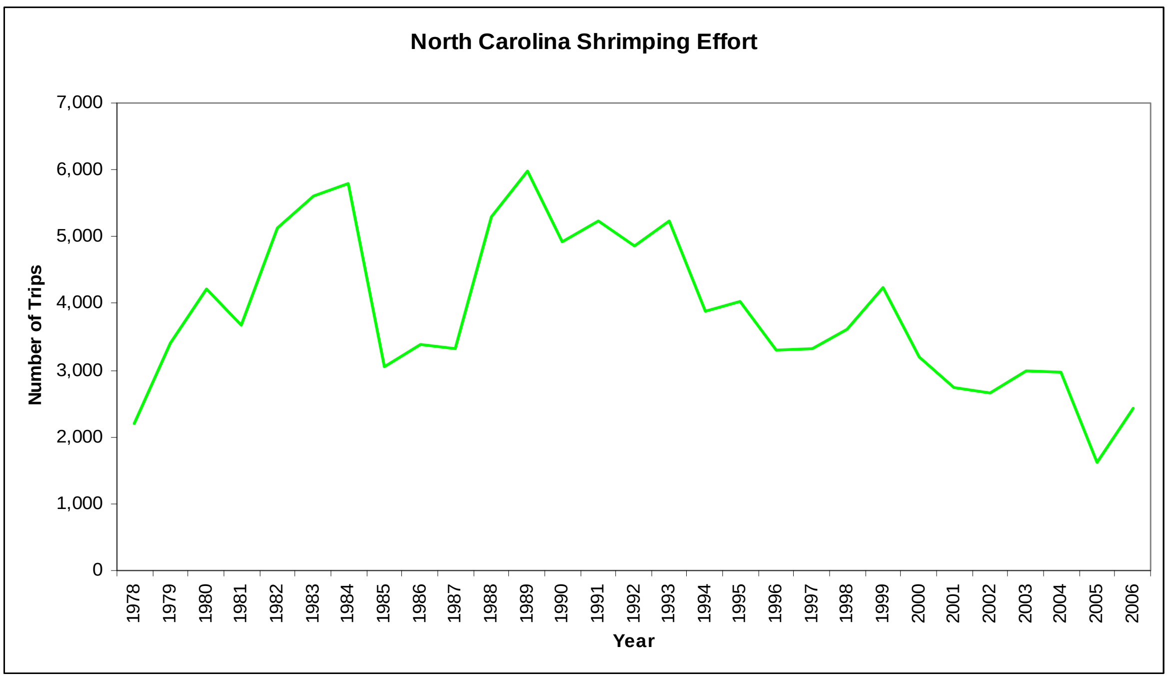



**Figure 3.9.12.** Ocean shrimping effort off the coast of North Carolina.

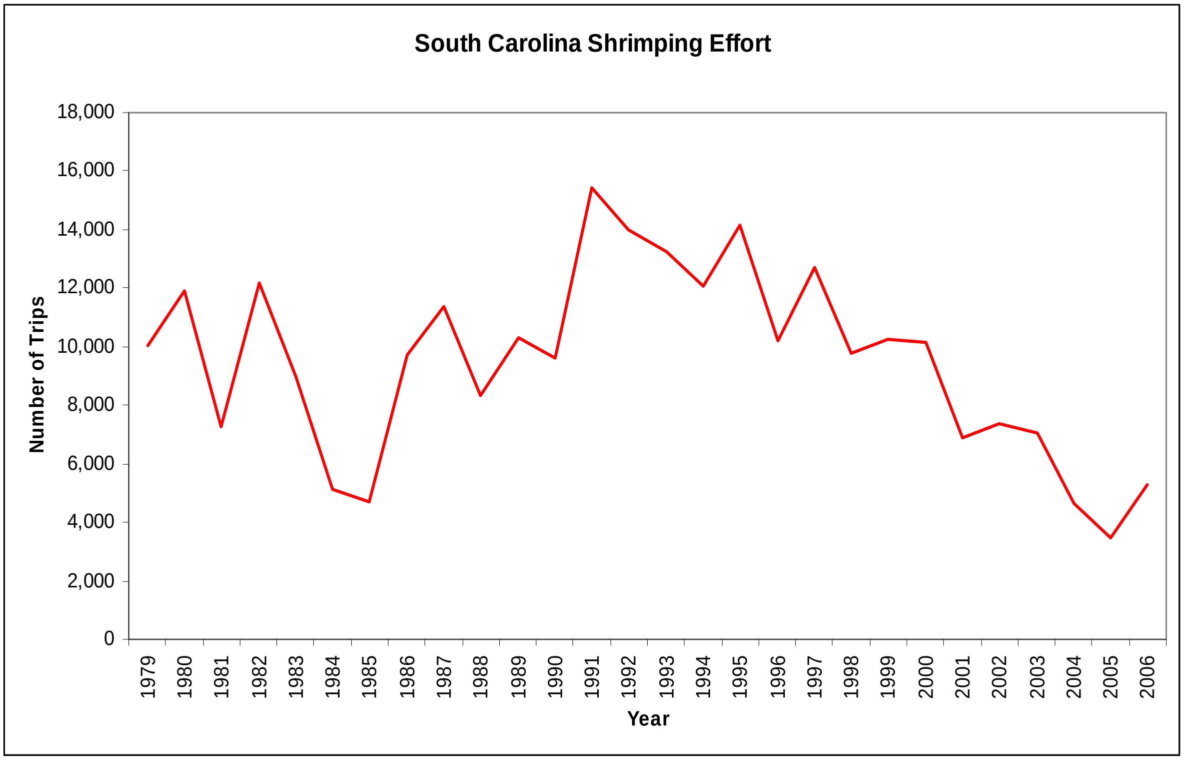



**Figure 3.9.13.** Ocean shrimping effort off the coast of South Carolina.

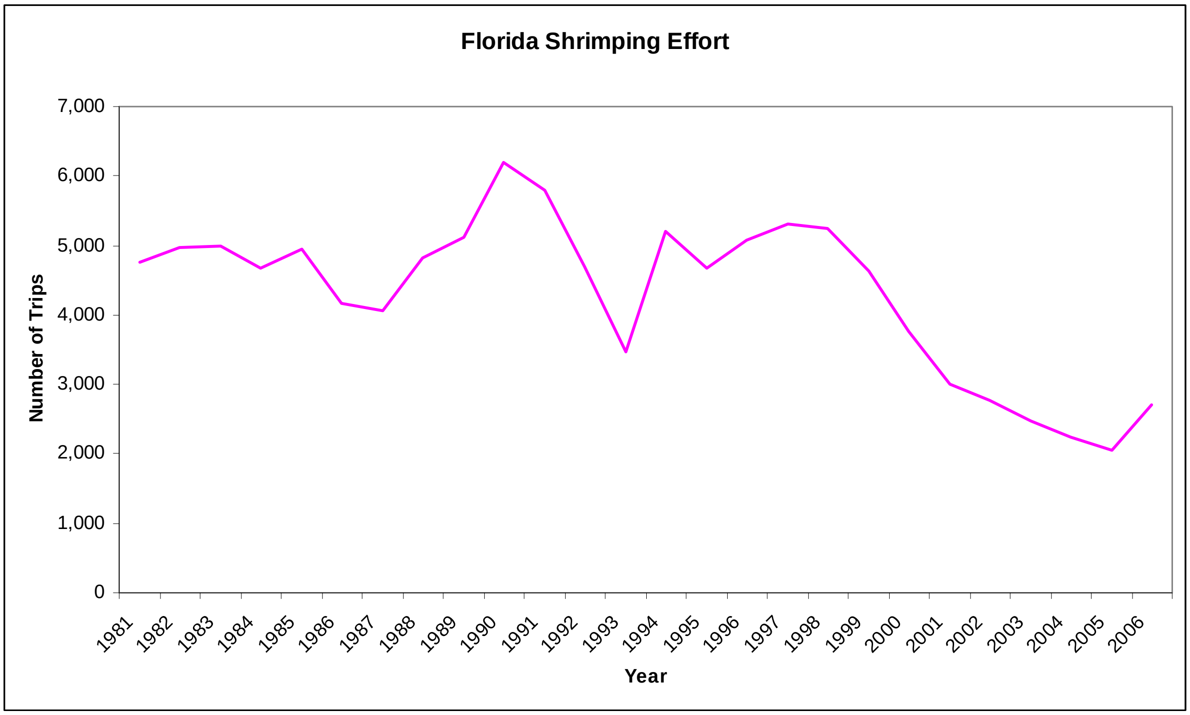



**Figure 3.9.14.** Ocean shrimping effort of the coast of the Florida no-mix zone.

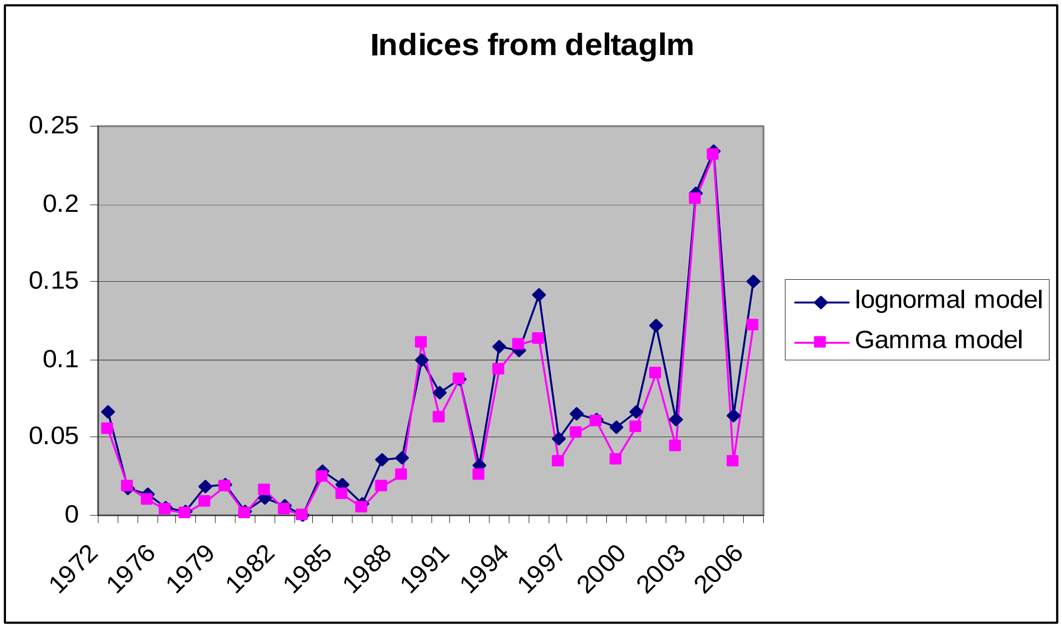



**Figure 3.9.15.** The indices produced for the GOM using the delta-GLM method. The diamond line is the lognormal results while the box results are the gamma results. The lognormal model was determined the best by comparing the AIC values between the models.

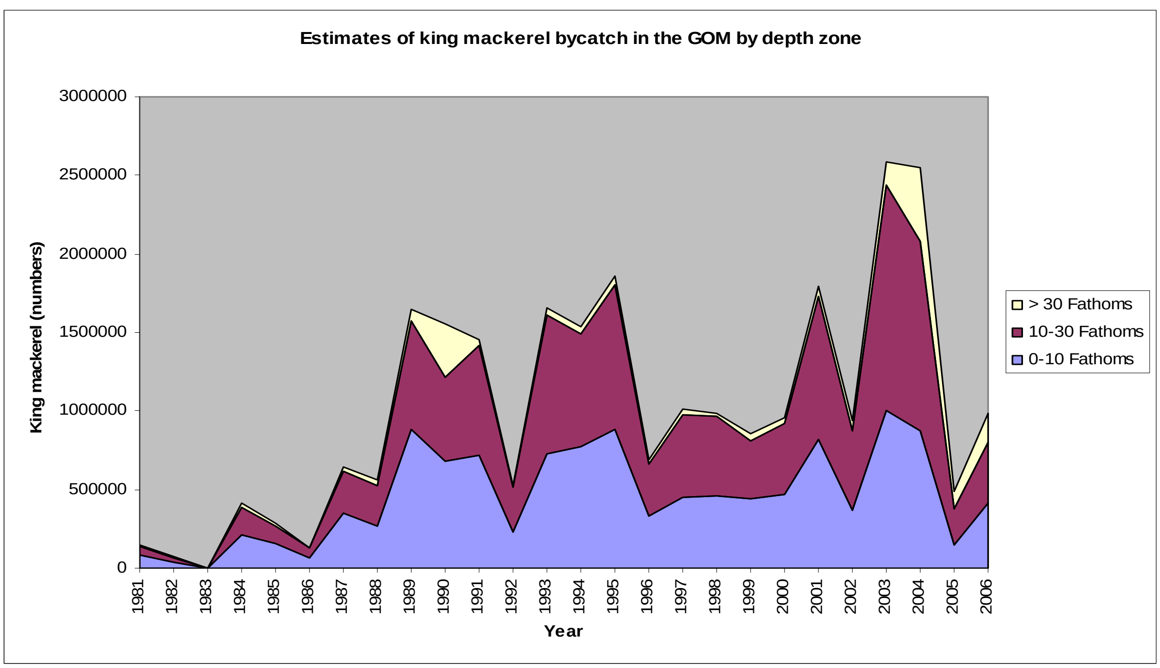



**Figure 3.9.16.** The GOM bycatch estimates differentiated by depth zone. The blue area is the bycatch in the nearer shore (0-10 fathoms), while the yellow area is the bycatch estimate for the farthest depth zone (greater than 30 fathoms)

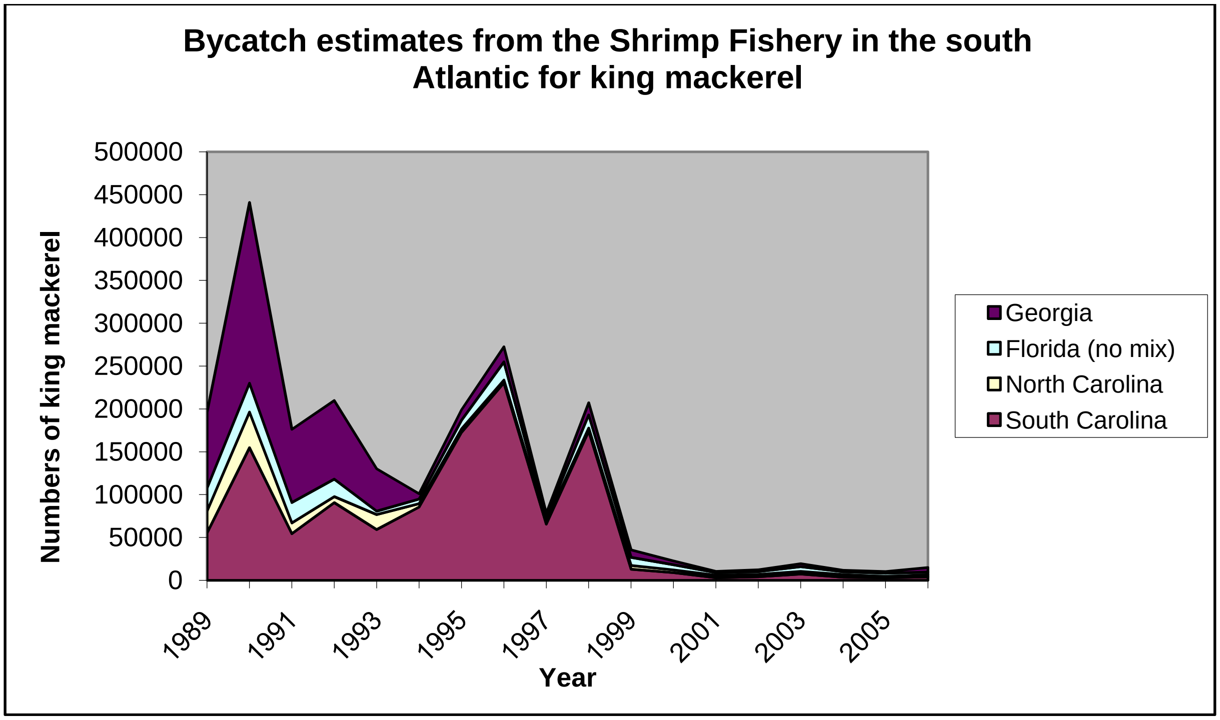



**Figure 3.9.17.** The estimates of king mackerel bycatch in the South Atlantic shrimp trawl fishery. The State-specific estimates are shown in the different colors, purple for GA, light blue for FL, yellow for NC, and magenta for SC. Additional data were received at the SEDAR data workshop from the South Atlantic Shrimp System to update the effort estimates.

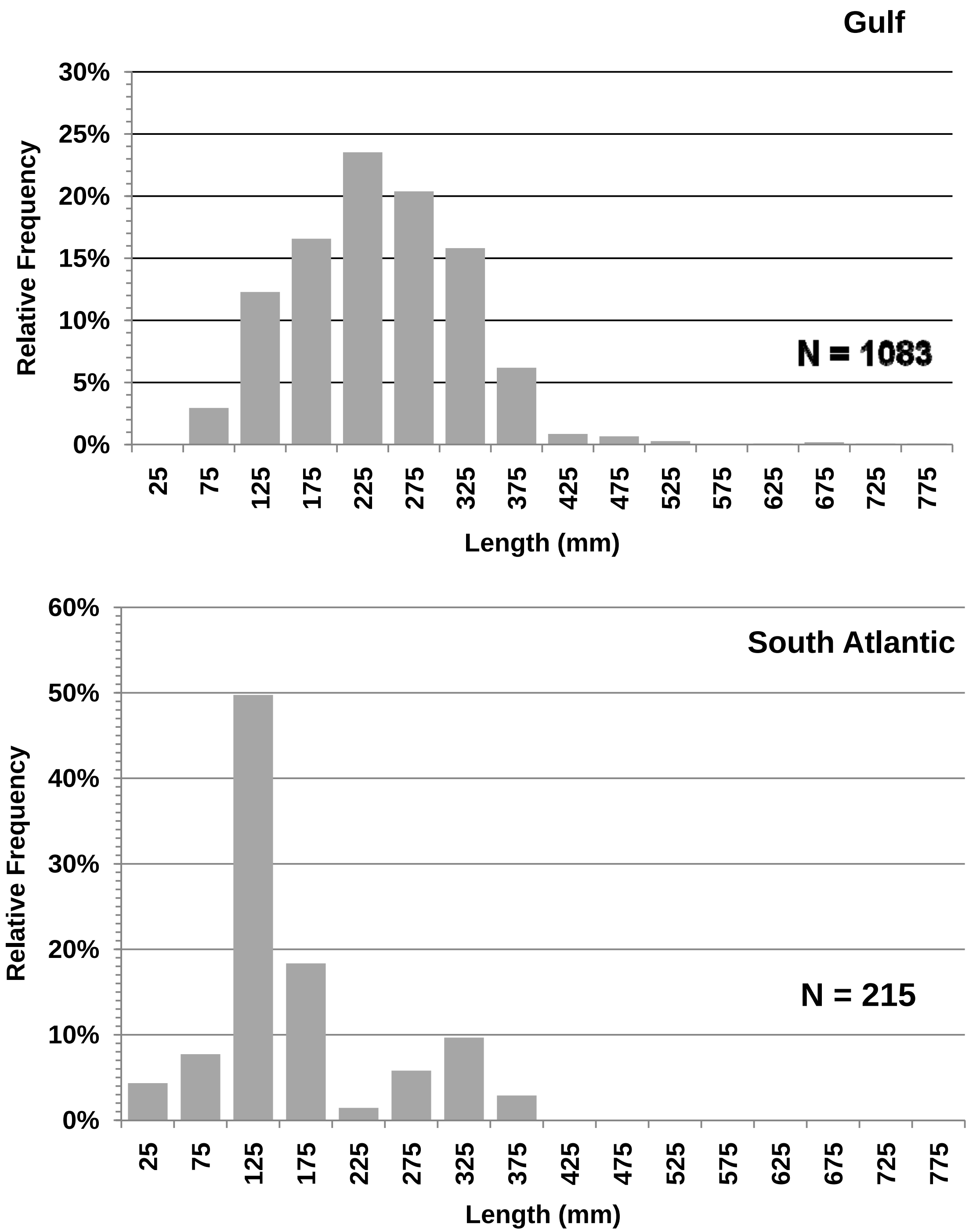



**Figure 3.9.18.** Length frequency distributions of king mackerel from otter trawl surveys for the Gulf of Mexico (upper graph) and the south Atlantic (lower graph).

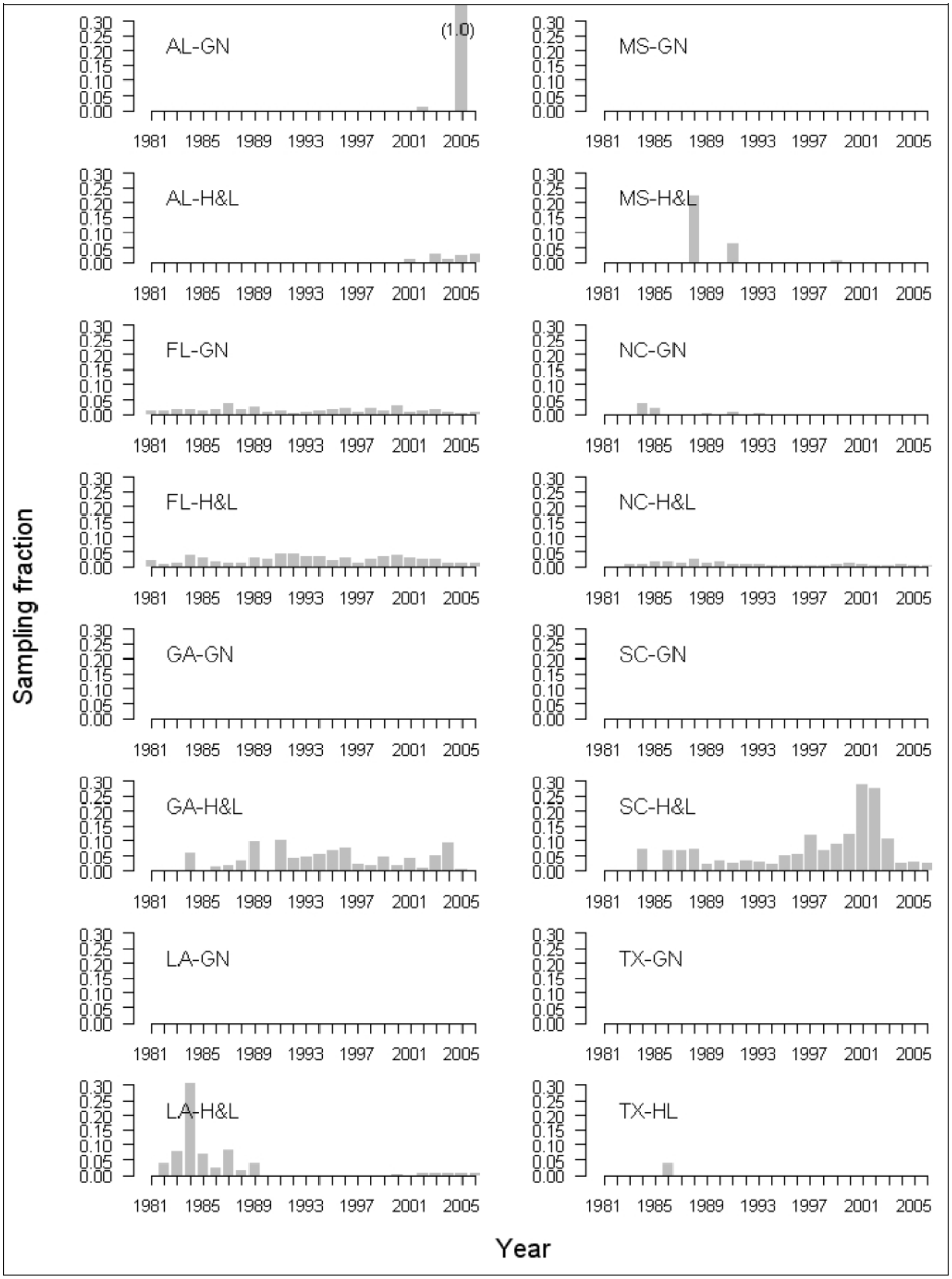



**Figure 3.16.19.** Sampling fractions by year, state and gear. Most fractions occurred between 0.00 and 0.30, those above 0.30 are labeled with the sampling fraction.

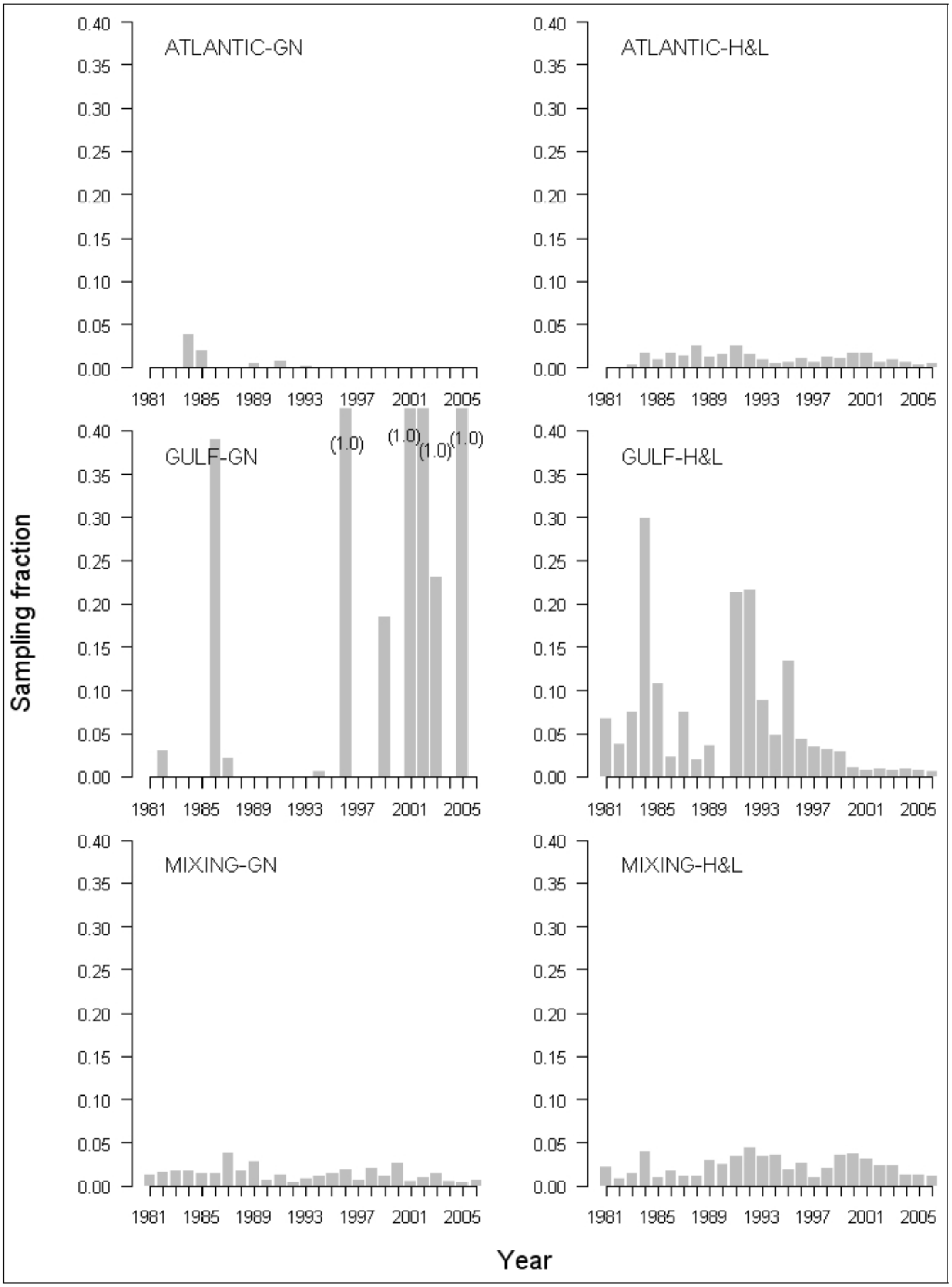



**Figure 3.16.20.** Sampling fractions by year, area and gear. Most fractions occurred between 0.00 and 0.40, those above 0.40 are labeled with the sampling fraction.

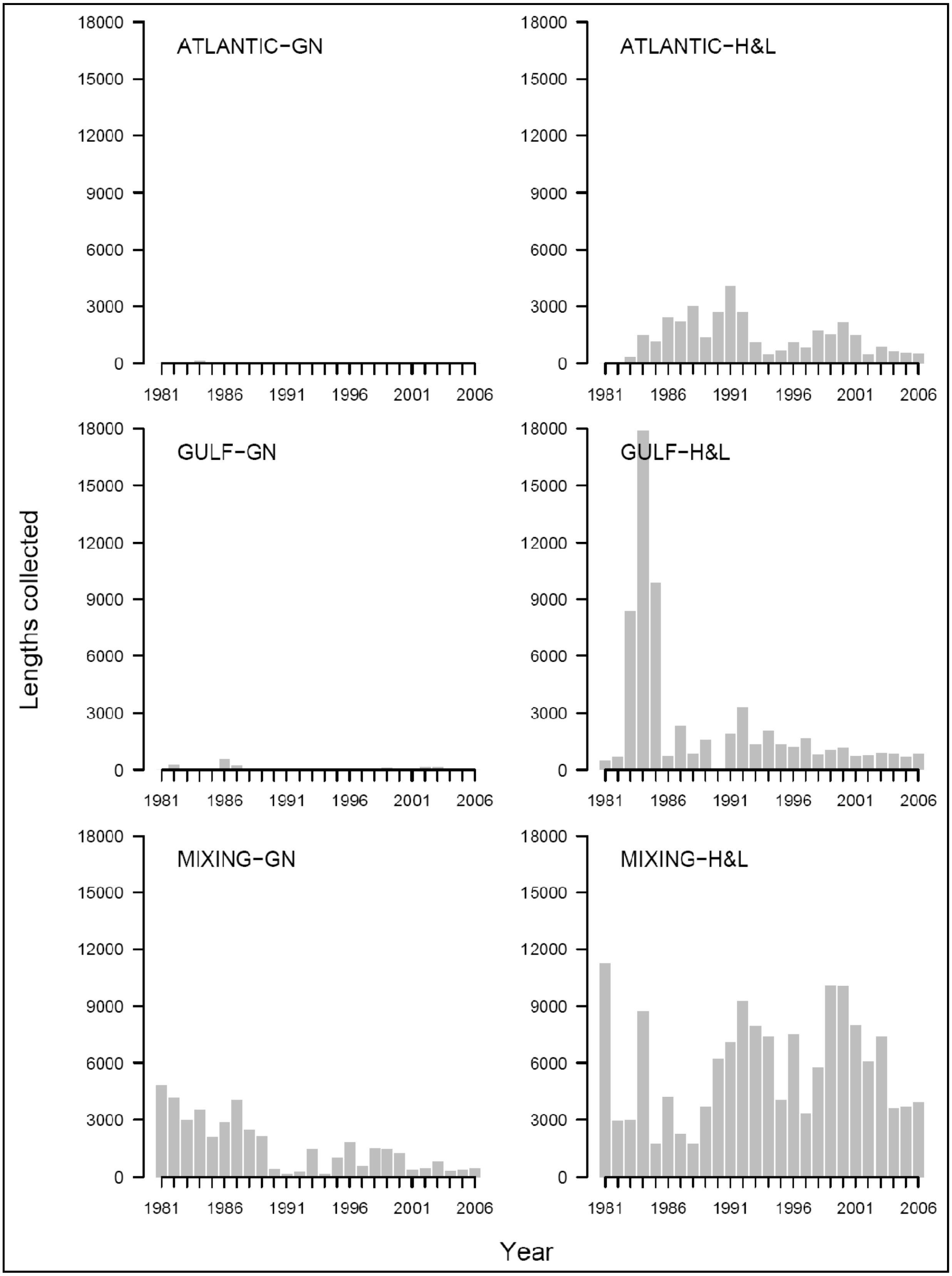



**Figure 3.16.21.** Number of lengths obtained by year, area and gear.

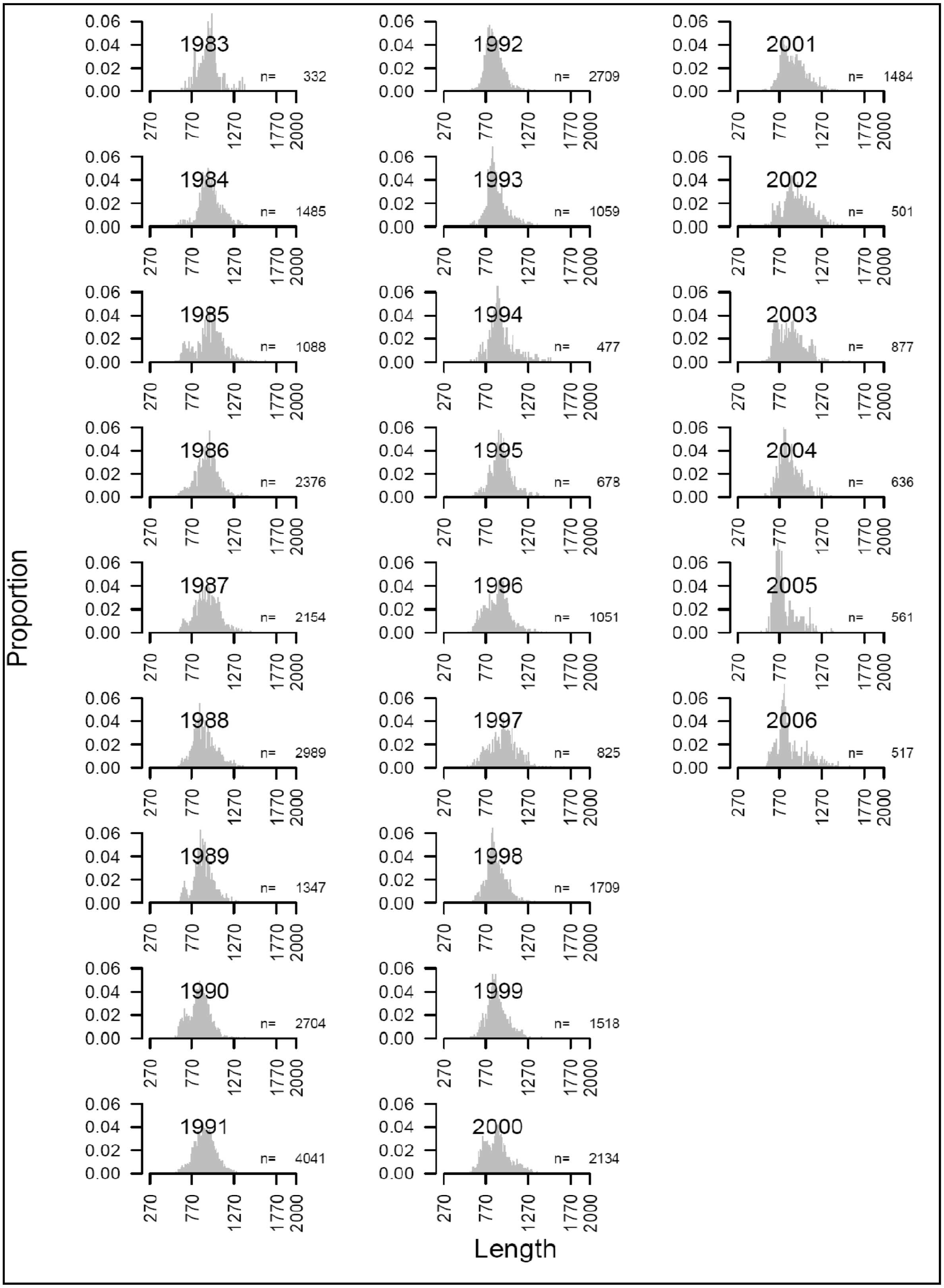



**Figure 3.9.22.** Relative length frequencies (proportion of n at length in mm) by year for hook and line gear in the Atlantic zone.

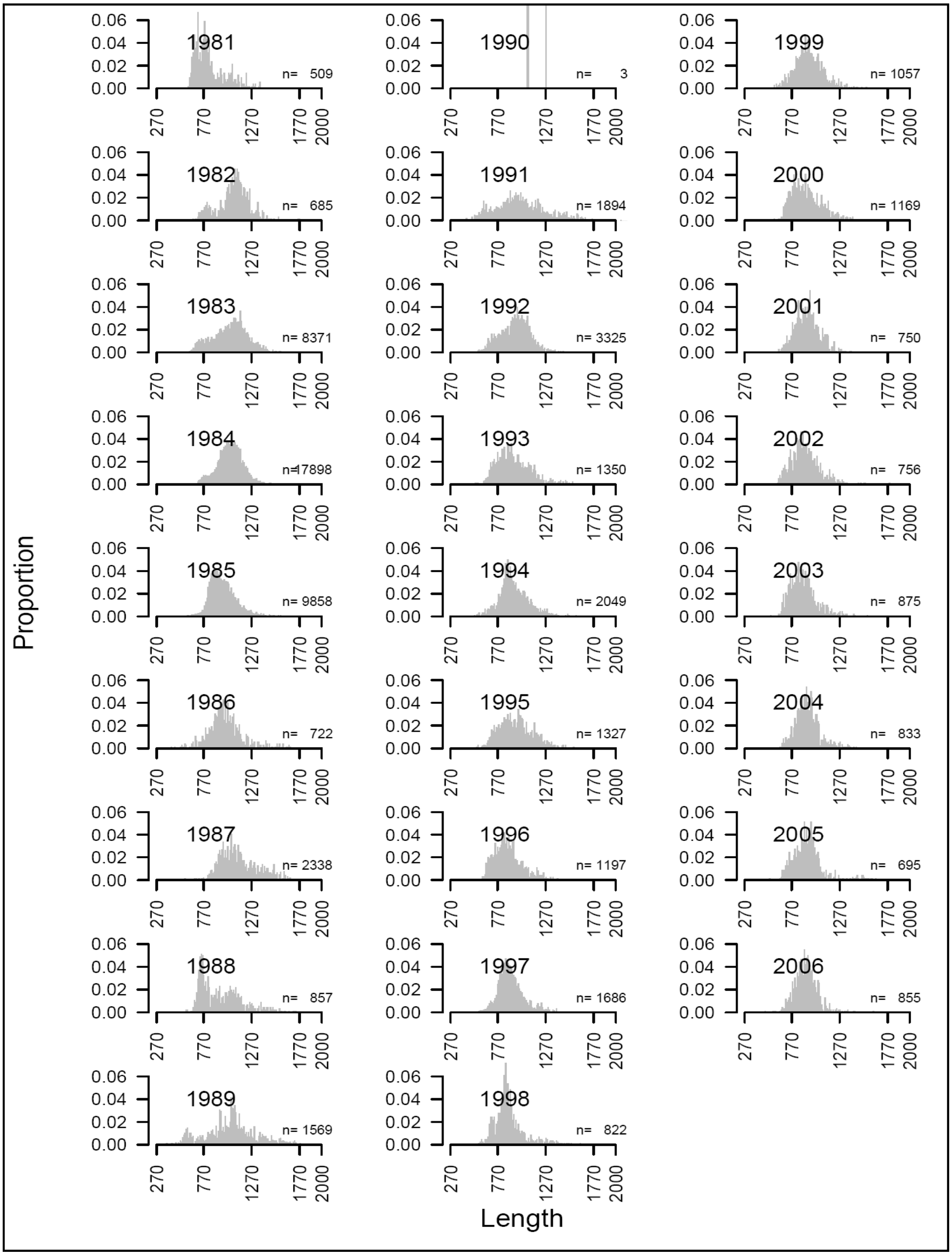


**Figure 3.9.23.** Relative length frequencies (proportion of n at length in mm) by year for hook and line gear in the Gulf zone. For 1990 all are 0.33.

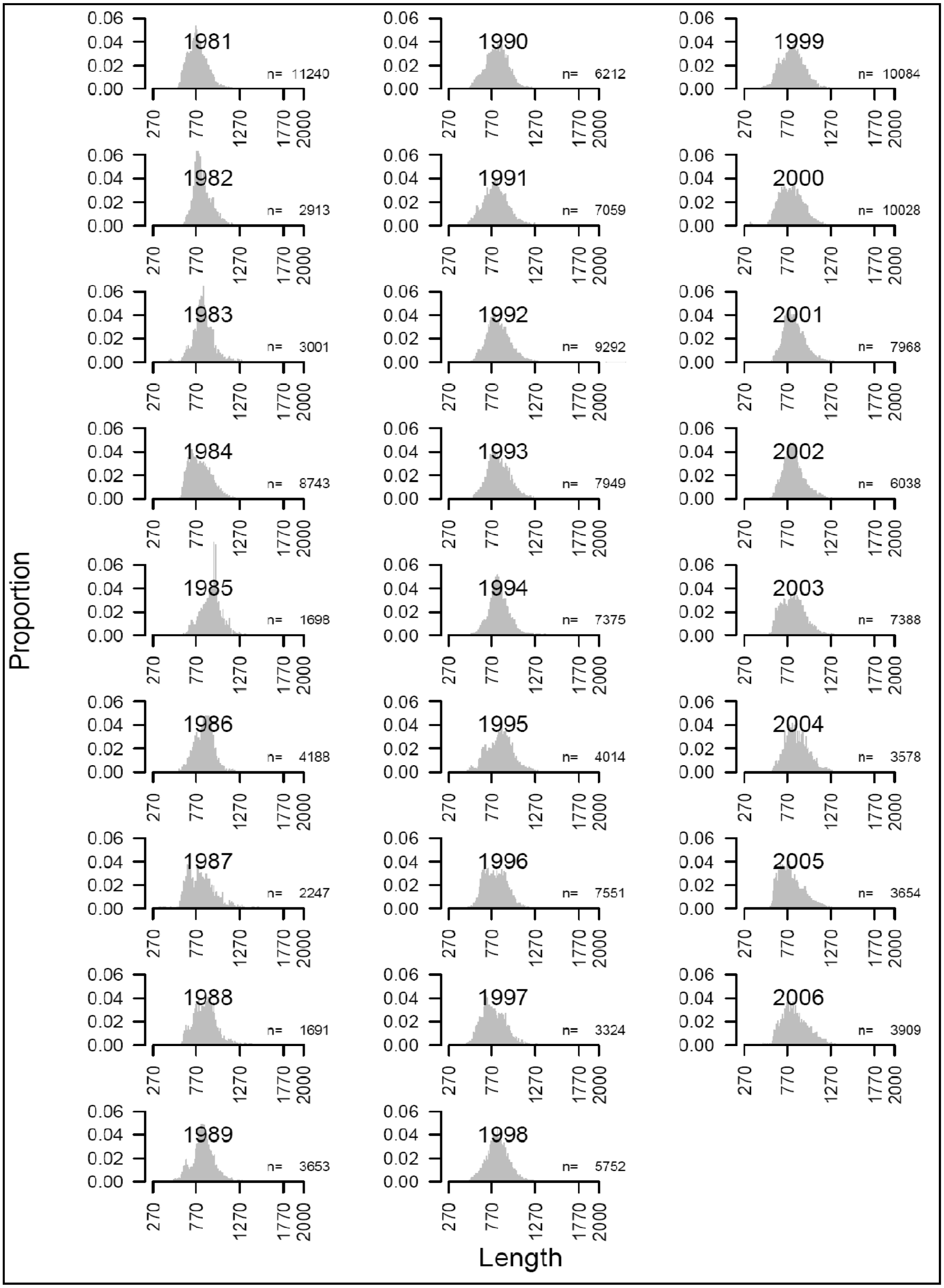



**Figure 3.9.24.** Relative length frequencies (proportion of n at length in mm) by year for hook and line gear in the Mixing zone.

## 4. RECREATIONAL FISHERY STATISTICS

### *4.1. OVERVIEW*

King mackerel (*Scomberomorus cavalla*) represent an important recreational fishery resource in the Gulf of Mexico and South Atlantic. Recreational landings of king mackerel during the most recent 5 years have averaged almost 320,000 fish annually, with an average of about 240,000 more caught and discarded. This report represents the best scientific judgment of the SEDAR 16 Data Workshop, with ideas first vetted in the Recreational Fishery Statistics Group but final decisions left to the full working group. A summary of findings are presented here along with discussion of controversies that arose during the workshop.

The Recreational Fishery Statistics Group leader was Craig Brown (NMFS – Miami). The Group participants included Jason Adriance (LADWF), Dick Brame (SAFMC AP), Ken Brennan (NMFS – Beaufort), Vivian Matter (NMFS – Miami), Patty Phares (NMFS – Miami), Ed Presley (GMFMC AP), Beverly Sauls (FL FWC), Tom Sminkey (NMFS – Silver Spring), Bill Wickers (SAFMC AP) and Bob Zales (GMFMC AP).

### *4.2. REVIEW OF WORKING PAPERS*

The Group discussed the working papers that had been submitted. Documents relevant to recreational fishery statistics included SEDAR16-DW-03, SEDAR16-DW-15, SEDAR16-DW-19, SEDAR16-DW-21, SEDAR16-DW-25, and SEDAR16-DW-28.

**<u>SEDAR16-DW-19</u>: King Mackerel Length Frequencies and Condition of Released Fish from Florida and Alabama At-Sea Headboat Observer Surveys in the Gulf of Mexico and Atlantic Ocean, 2005 to 2007**

Sauls (**SEDAR16-DW-19**) summarized data from at-sea observer surveys aboard working headboats in Florida and Alabama. Observer trips were conducted throughout the Gulf of Mexico and Atlantic Ocean portions of this region. In southeast Florida, some headboats offer drift fishing trips, which are most likely to hook pelagic species such as king mackerel. Throughout the rest of the region, headboats anchor and fish for bottom species; therefore, king mackerel are infrequently encountered. Some regular scheduled multi-day trips (36 to 48 hours) from western Florida (Pinellas County south) and the Florida Keys will fish for a mix of bottom and pelagic species, and king mackerel are more likely to be encountered in this sub-set of headboat trips. The paper summarized data on length frequency and condition of released fish from eastern Florida. Released fish were smaller than harvested fish (mean size: discards=539-553mm FL, harvested fish=725-753mm FL) and the majority of fish released were in good condition (60-72%), based on observations of the behavior of released fish at the surface immediately upon release. During discussion, it was noted that this paper could be relevant to the estimation of release mortality. Bag limits were considered to have little impact on headboat discards rates, as retained fish above the limit could be distributed among the many headboat anglers. There were concerns that observations in the Gulf of Mexico were too sparse to draw conclusions from at this time.

**<u>SEDAR16-DW-25:</u> Estimates of released king mackerel in the South Atlantic and Gulf of Mexico Headboat fishery, 2004-2006.**

The Headboat Survey recently developed computer programming to generate headboat discard estimates from logbook data for 2004-2006. Brennan summarized the methodology used to collect and estimate king mackerel discards in **SEDAR16-DW-25**. The logbook form was modified in 2004 to include a category to collect self-reported discards for each reported trip. This category is described on the form as the number of fish by species released alive and number released dead. Port agents instructed each captain on criteria for determining the condition of discarded fish. A fish is considered “released alive” if it is able to swim away on its own. If the fish floats off or is obviously dead or unable to swim, it is considered “released dead”. This self-reported data has not been validated within the Headboat Survey. The recreational working group compared the Headboat At-Sea Observer Survey data to the Headboat Survey logbook data and determined that the low sample sizes did not allow for a representative comparison. Although Observer Survey released fractions were much higher than the logbook reported discard rate, it was noted that the low sampling levels in the Observer Survey mainly occurred off Southeast Florida, an area were the fishery is expected to experience much higher release rates than elsewhere.

**<u>SEDAR16-DW-21:</u> Recreational Survey Data for King Mackerel in the Atlantic and Gulf of Mexico**

Document **SEDAR16-DW-21** was also presented and discussed. Since this document describes the methodology used to produce the recreational catch estimates and presents those estimates, the paper and the discussion is described in greater detail in sections 4.3 and 4.4. The initial MRFSS estimates presented in the document at the time of the data meeting were based upon the “old estimation” methodology for charter boat catches (that which does not utilize the more recently introduced approach of sampling for effort from a list of charter permit holders). Correction factors to adjust historical estimates in the Atlantic to those which would have been expected had the new methodology been used were not available prior to the meeting.

For the “old estimation” methodology, the Marine Recreational Fishery Statistics Survey (MRFSS) collected fishing activity data using a telephone survey of households in coastal counties (CHTS) and fishing catch per trip data by interviewing anglers at fishing access sites. This complementary design survey began in 1981 and provides a time series of king mackerel landings from 1981 - 2007 by state in the Southeastern U.S. To improve the effort estimation procedure for the charterboat mode, MRFSS tested and then implemented a new survey protocol of interviewing the charterboat operators directly (the For Hire Survey, or FHS). This survey became the official estimator of fishing effort for this mode in 2000 for the Gulf of Mexico, 2003 for East Florida, and 2005 for the rest of the Atlantic coast. The shift from one survey method to another in the time series can cause a shift in the trend of landings so it would be advantageous if the earlier effort estimates could be adjusted to more accurate annual numbers based on a relationship that could be modeled between the two surveys' results during the overlapping years. Such conversion (or "correction") factors had been developed for the Gulf of Mexico, where the FHS began earlier. Document **SEDAR16-DW-15** describes the results of this modeling for the South Atlantic.

The MRFSS CHTS pooled 3 years of charterboat trip data to produce an estimate of angler-trips per 2-month 'wave' due to a low frequency of contacts in most coastal zones. These aggregated estimates were more precise than estimates based on unpooled data, which would be highly variable and trends would be hard to recognize. However, to compare the two survey methods' results it was the unpooled estimates that were used in the first attempt at modeling originally presented to the Group. The results were reasonable but the method was questioned because it did not use the official estimates of charterboat angler effort (which were developed by pooling), which is ultimately what would need to be adjusted if a model could be described. The Group stressed that it was important that the methodology used to develop the conversion factors for the Gulf of Mexico be followed. Therefore, the entire GLM model was repeated using the CHTS 3-year pooled effort estimates and the FHS annual estimates of effort, as well as using the entire available time period of FHS data.

From 1981 to 1985, MRFSS considered charterboat and headboat as part of single mode (referred to as "party-charter", or "PC"). Thus, the conversion factors estimated with 2004-2007 charterboat data (used to calibrate 1986-2003 charterboat effort estimates) can not be used to calibrate the 1981-1985 estimates. To calibrate the 1981-1985 combined charterboat and headboat effort estimates, conversion factors will be estimated using 1986-1990 effort estimates instead of 2004-2007 to minimize possible effects of changes in the fishery over time. To do so, headboat (NMFS Headboat Survey) and original (MRFSS) charterboat effort estimates were combined (summed) into one estimate for each year and wave.

Conversion ratios were determined for the significant factors: sub-region (East Florida, North Carolina, or South Carolina & Georgia combined), area fished (Inland vs. Ocean waters), and 2-month wave (Mar.-Dec. north of FL, Jan-Dec for FL). The conversion ratios were then applied to the corresponding cell-level effort estimates (1986-2003) and the adjusted effort estimates were used to produce the adjusted king mackerel landings time series. Similarly, the PC landings estimates of king mackerel from the MRFSS, 1981-1985, were directly adjusted using the headboat + charterboat model ratios.

The Group reviewed the modified document and the revised results, and recommended the use of these conversion factors.

### <u>SEDAR16-DW-03:</u> Backcalculation of recreational catch of king mackerel from 1930 to 1980. SEFSC-SFD contribution

In Document **SEDAR16-DW-03**, recreational landings of king mackerel were reconstructed from 1930 to the beginning of the collection of recreational data (1980) by season, mixing zone (Gulf, Mixing zone and Atlantic) and mode using a combination of 3 methods: Method 1, a simple but naïve approach which linearly extrapolates the mean of the 1981-1995 effort back to zero in 1930 for each mode, season and zone and multiplies this effort by CPUE, derived from average MRFSS catch divided by effort (CPUE) for 1981-1985 or 1986-90 (for charterboats); Method 2, which uses coastal county census data to predict effort and multiplies this effort by CPUE obtained as in Method 1; and Method 3, used for headboats uses literature-derived estimates of effort multiplied by 1986-1990 CPUE. Method 3 was used only for headboats and method 2 was used preferentially over Method 1. When effort appeared to increase back in time (as for Gulf shore fishing) or when regressions between effort and census numbers were non-significant the naïve approach or linearly interpolating effort to zero in 1930 was used.

During the data workshop, the Group raised concerns that 1981-1985 CPUE values were likely underestimates of 1930-1980 CPUEs due to low relative abundance of king mackerel during 1981-1985. It was decided that the mean of the highest 5 CPUE values for the period of 1981-2006 should be used and linearly interpolated from 1977 downwards to the CPUE in 1981 to account for low recreational CPUEs in the late 1970's and early 1980's. Also, it was decided to start the Atlantic fishery at 1900 rather than 1930 as there is evidence of recreational fisheries in existence prior to 1930. In addition, recent repartitioning of the Florida Keys effort data will be conducted which will provide improved spatial resolution between the Mixing and Gulf zones. These changes will be incorporated in an addendum document which will result in changes to the absolute values of the back-calculated landings.

### <u>SEDAR 16-DW-28:</u> Review of Catch, Catch at Size, Sex ratios and Catch at Age of king mackerel from U.S. Gulf of Mexico and South Atlantic fisheries

Catch data from commercial and recreational fisheries for king mackerel are sized by sex to estimate the catch at size (CAS) by sex tables. Then the CAS data are converted to Catch-at-Age (CAA) by sex using age length keys when available, or a stochastic ageing method. A review of the size samples, age samples for ALK, sex ratios at size, and protocols applied is presented.

## *4.3. RECREATIONAL LANDINGS*

### 4.3.1. MRFSS

Recreational fishery landings estimates for king mackerel taken from the Atlantic Ocean and Gulf of Mexico are produced by the Marine Recreational Fishery Statistics Survey (MRFSS) conducted by NOAA Fisheries. Reliable estimated catch and effort statistics by fishing mode (shore, private or rental boats, charter boats and/or headboats) have been produced since 1981 for Louisiana through Maine. Texas was partially sampled by the MRFSS in 1981-1985, but has not participated in that survey since 1985.

For the Gulf of Mexico and South Atlantic (NC-LA), charter boats and headboats were combined as an estimation category for 1981-1985. In 1986 a logbook program (the Headboat Survey), already operating in the South Atlantic, was expanded to the Gulf of Mexico states to collect head boat catch and effort information via a census logbook. MRFSS discontinued sampling headboats and referred to the for-hire category simply as charter boats. For the North and Mid-Atlantic, charter boats and headboats are combined for 1981-2004. Starting in 2005, estimates are generated for headboats and charter boats separately in the North and Mid-Atlantic. In 1998, a new survey of charter boat effort, the For-Hire Survey, was initiated in the Gulf of Mexico due to lack of coverage of charter boat anglers by the MRFSS coastal household telephone survey (the component which provides effort estimates known as the traditional method). Official estimates based on these interviews began in 2000. This survey uses a directory of all known charter boats and uses a weekly telephone survey of the charter boat operators to directly obtain effort information from them, and the estimation expansion is based on the list of charter boats rather than the coastal population of households. The new survey also divides West Florida charter boats into three regions (panhandle, peninsula and Keys) in the estimation process. The For-Hire Survey was expanded to East Florida in 2003 and to the rest of the Atlantic coast starting in 2005, wave 2. This survey methodology provides better coverage, better accuracy, better stratification of charter fishing effort along the Florida coast, and provides credible annual estimates for the charter fishery.

Estimates using the coastal household telephone survey or the traditional method continue to be generated for all areas. Diaz and Phares (2004) examined both sets of estimates for 1998-2003 for the Gulf of Mexico using a generalized linear model that was standardized across a range of tempo-environmental factors. The GLM analysis provided a correction factor for each stratum, which were then applied to catch estimates prior to 1998. These corrections were used in relevant strata to adjust the expansion factors for the charter boat mode in MRFSS.

As was discussed in Section 4.2, Atlantic calibration factors were presented for East Florida and the rest of the Atlantic coast. After re-estimation following recommended changes to the methodology to make the approach more consistent with the Diaz and Phares (2004) approach, these calibration factors can be applied estimates prior to the implementation of the FHS.

MRFSS currently estimates the state of Florida by coast. West Florida includes data from the Panhandle through the Florida Keys. East Florida includes data from Miami-Dade county north to the Georgia border. In order to more precisely identify the king mackerel mixing zone (Monroe/Collier border to Volusia/Flagler), it is advisable to generate MRFSS estimates for the state of Florida by sub-regions.

### 4.3.2. Headboat Survey

The Headboat Survey has had full coverage in the S. Atlantic since 1981 and in the Gulf of Mexico since 1986. Since MRFSS produced headboat estimates from 1981-1985 in their combined charter+headboat mode, estimates from the Headboat Survey are not used until 1986 for all areas (S. Atlantic and Gulf of Mexico) in order to prevent duplication. Total catch by trip is reported in logbooks provided to all headboats in Gulf coast States and corrections for nonreporting are made by the survey. This survey was described more fully in Matter (SEDAR16-DW-21). There are no estimates for discards currently generated from this survey (discussed below).

The lack of estimates from LA from 2004-2006 was discussed. There were some concerns about using the recommendation from the HBS of substituting these years with the average LA landings from 1999-2001, given that 2004-2006 may have been abnormally low due to factors such as the initial and lingering effects of Hurricane Katrina. Ultimately, however, it was noted that the MRFSS FHS picked up these headboats in their survey from 2004-2006 since there were no HBS estimates in LA for those years. It was therefore recommended that no LA substitution be made since the catch of those boats should have been covered by the FHS.

### 4.3.3. Texas Parks & Wildlife Survey

The Texas Marine Sport-Harvest Monitoring Program by the Texas Parks and Wildlife Department (TPWD) provides estimates of charter and private fishing in Texas waters since 1983. There are no estimates of discards generated from this survey (discussed below). The survey is designed to estimate landings and effort by high-use and low-use seasons (May 15-November 20 and November 21-May 14). Estimates by wave are also calculated for NMFS so that they are compatible with MRFSS. Shore mode and headboat mode are not included in the survey.

The difference between the two sets of wave estimates provided by TPWD was discussed. This issue is described more fully in Matter (SEDAR16-DW-21). It was recommended that the high-use/low-use estimates be obtained from TPWD for all years and used in place of the wave estimates previously used. These seasonal estimates would then be allocated across months using the raw intercept data. This data is believed to be preferable because it follows the original design of the survey, even though the allocation over months would only be considered an approximation.

### 4.3.4. Historical Recreational Catches

Catches prior to 1981 were calculated according to the methodology outlined in document SEDAR16-DW-03, modified to follow the recommendations of the Group during the data meeting.

### 4.3.5. Results: Total Recreational Landings

Total recreational landings (A+B1 and B2) are shown by year, source, and zone (Atlantic no mix, Gulf no mix, and mixing zone). Note that these tables do not agree with the preliminary numbers (Matter, SEDAR16-DW-21) but reflect analyses as described above.

## *4.4. RECREATIONAL DISCARDS*

### 4.4.1. Headboat Survey

In the past, the Southeast Region Headboat Survey has provided fish kept, but has only recently developed data collection and analyses to estimate discards. In some previous SEDARs, the MRFSS charter boat data have been used to estimate discards for the headboat fishery by using MRFSS ratios of discards to landings and applying those to the catch estimates from the Headboat Survey (the Headboat Survey catch estimates are considered close to the definition of "A+B1" in MRFSS since the "B1" fish are not thought to be a significant amount on headboats). In recent years, new data have been gathered from the headboat fishery (*i.e.* Headboat Survey logbook and MRFSS At-Sea Observer program data) that may allow us to see how well the MRFSS discard rates correspond to that fishery.

The Group reviewed the percent of headboat catch that is released as estimated from headboat logbook reports (SEDAR16-DW-25) and observed directly during at-sea observer trips. Release rates were only examined for trips off southeast Florida, due to a low incidence of observed king mackerel in sampled at-sea observer trips in other areas. For the two years of available data for southeast Florida, the percentage of released fish was substantially higher (27-31%) than self-reported logbook estimates (6.8-6.9%). It was discussed that reporting rates for headboat logbooks from southeast Florida are the lowest of any region, even though a high proportion of estimated catch occurs in this region, which could explain the difference. It may also indicate that self-reported discard information is under reported in this region. Given that no other regions could be compared, there was no way to determine which reason was a factor (note: data were collected in NC, but were not available at the meeting). However, it was agreed that this information could not be used to make inferences on discard rates in other parts of the Gulf or Atlantic, due to the concentrated nature of drift-fishing methods in the headboat fishery in this particular region. The group also reviewed discard rates by state or region (in Florida), mode (charter and private vessel), and year from the MRFSS using both raw intercept data and catch estimates. Release rates were highest in the private vessel mode in all regions. Release rates from charter data were higher than estimates from self-reported logbook reports; however, logbook discard data was only collected beginning in 2004, and the one region where logbook estimates could be directly compared with at-sea observer data did indicate these estimates were low. The charter mode discard rates from the longer time series of MRFSS are responsive to historic changes in discard rates as they were impacted by changes in recreational size limits and bag limits over time. Therefore, it was decided to use the discard proportions from MRFSS charter mode catch data to estimate the headboat fishery discards over time.

### 4.4.2. Texas Parks & Wildlife Survey

The lack of discard estimates from TPWD was discussed. It was agreed that Gulf wide (FLW-LA) b2/ab1 discard ratios taken from the MRFSS would be an appropriate proxy to estimate discards from Texas. These ratios would be applied by mode and wave to the Texas data in order to fill this data gap.

## *4.5. BIOLOGICAL SAMPLING*

### 4.5.1. Sampling Intensity Length/Age/Weight

***Sampling proportions***

Sampling proportions for the recreational landings are presented in Matter (SEDAR16-DW-21). Recreational length data was obtained from the following sources (not necessarily for all years): MRFSS, HBS, TPWD, TIP, GulfFIN, Panama City lab, and Alabama charterboat study.

### 4.5.2. Length-Age distributions

The Recreational Fishery Statistics Group decided to defer to the Life History Group with respect to sampling of length-age distributions of recreational fisheries.

### 4.5.3. Adequacy for characterizing catch

The Group decided that, in general, the available biological sampling was adequate to characterize the catch. One exception was the sampling conducted at tournament sites. There were two concerns given that tournament catches are incompletely included in the recreational catch estimates and that there is no way to identify them separately from non-tournament catches. The first was that sampling may be conducted only at the weigh-in station, and that therefore there may be a bias toward larger fish. The were some anecdotal reports that indicated that tournament sampling may be conducted in a manner which is more representative the overall tournament catch, but that was not clearly established.

The second concern was that tournament catches may tend to be larger fish than those caught outside of tournaments. Anecdotal reports supported this notion. If this were the case (or if the first concern were true), then applying the relatively large tournament sample sizes to the overall catches (which include mostly non-tournament catches) could bias the length distribution high. It should be noted however, the life history group in their report recommended that the tournament samples from NC be included, because those were collected by observers with a measuring board, and evaluations by NC scientist detected no substantial differences in sampling length frequency from other samples in the fishery.

### 4.5.4. Alternatives for characterizing discards

Examination of the length distributions of recreationally landed fish prior to and following the implementation of the various minimum size limits suggests that these minimum size limits had little or no impact on the length distribution of landed catch. Similarly, the active private and charter fishermen participating in the data workshop stated that the minimum size limits have had little effect on the behavior of fishermen – primarily because smaller fish are rarely encountered. Therefore, it was concluded that fish discarded in the recreational private and charter fisheries (all recreational or only MRFSS, or Headboat?) should be sized with the same length distribution as the landed fish in these fisheries.

However, the limited available data for headboats, primarily from observed trips off southeast Florida, indicated that nearly all discarded fish were less than the minimum size. Therefore, the Group concluded that headboat discards should be sized using the size distribution of discarded fish observed during the Headboat At-Sea Observer Survey and applied back in time, with an upper limit of the distribution set at the minimum size in force at the time.

The Group also expressed concern about size samples prior to 1990 which include data collected for age sampling. It was recommended that these age samples be identified, if possible, so that they may be handled appropriately by the model. However, subsequent to the data meeting it was determined that such removal was probably not possible because documentation apparently is not available.

## *4.6. GENERAL RECOMMENDATIONS / TASKS TO BE COMPLETED*

**Task:** Break out MRFSS estimates for the FL keys and East FL south of Volusia county

**Responsibility:** Tom Sminkey

**Expected Completion Date:** FL keys estimates are already prepared; East FL estimates can be post-stratified within two weeks (status update: Tom Sminkey was assigned additional non-SEDAR tasks, which delayed completion by an additional week).

**Task:** It is recommended to adopt the new conversion factors for the Atlantic and use new charterboat method/converted estimates for both the Atlantic and the Gulf of Mexico

**Responsibility:** Tom Sminkey will provide the Atlantic conversion factors as well as the new estimates for the Keys and the split E FL area for all official MRFSS estimates (including those based on the FHS). Vivian Matter will provide new method/converted estimates for the Gulf of Mexico, Atlantic and Mixed zones in coordination with Tom Sminkey.

**Expected Completion Date:** about 2 weeks after receipt of revised MRFSS estimates

**Task:** Use MRFSS charter discard rates as a proxy for historical headboat discard rates

**Responsibility:** Vivian Matter

**Expected Completion Date:** for delivery along with the revised MRFSS estimates

**Task:** Use GOM MRFSS charter/private discard rates as a proxy for TX discard rates

**Responsibility:** Vivian Matter

**Expected Completion Date:** for delivery along with the revised MRFSS estimates

**Task:** The group recommends that the TPWD high/low season estimates be obtained and allocated across months. (If these estimates cannot be obtained, the "old estimates" will be used). The recommended method of allocation across months is proportional to observed intercept distribution in the raw data. The processing will include filling in missing estimates where coverage is incomplete.

**Responsibility:** TPWD personnel are being requested to provide a electronic version of the estimates, as well as the raw data. Vivian Matter will provide the monthly estimates and will fill in the missing estimates.

**Expected Completion Date:** for delivery along with the revised MRFSS estimates

**Task:** Reconstruction of recreational catches prior to surveys (1930-1980). The Group supports the author's recommendation to use census data when appropriate, substituting with linear extrapolation or literature estimates (headboat) as needed. Also recommended is the use of the "high 5" of MRFSS catch rates for the historical period, through 1977 (based upon a peak in gill net catches which appears to have impacted catch rates), declining thereafter to the 1980s catch rates. The group also recommends that the historical time series begin in 1900 for the Atlantic and Mixed zones, and in 1930 for the Gulf. Finally, during the period of WWII, effort estimates should be reduced to 10% of what it would otherwise have been estimated to be.

**Responsibility:** John Walter

**Expected Completion Date:** about 3-4 days after new estimates received from Vivian Matter

Details on the completion of these tasks following the data workshop, including any necessary minor modifications to recommended procedures, are included in appendices 1 and 2 and SEDAR 16-DW-03 and its addendum.

**General Recommendations:**

*Tournament catches/size samples*

The group recommends that the tournament collected size samples not be used for sizing the general recreational catch. These should only be used if a separate estimate of tournament catch (not currently available) were to be included in the assessment. An exception, as previously discussed, may be the NC tournament samples collected by observers using measuring boards.

*Size samples which include data collected for age sampling prior to 1990*

It is recommended that these age samples be identified, if possible, so that they may be handled appropriately by the model. It is expected that this will not be possible for this or future assessments, then ? can the group have a decision..

*Release Mortality Estimates*

The release mortality group determined that release mortality rates should be based upon the condition table included in document 19, and that fair, poor, and dead fish should be considered "likely to die". This results in a mortality rate of 33% of all released fish (live+dead); 20% of the live releases (B2) would be considered to later die. This is consistent estimates of the mortality of live releases (20%) found in at least one study in the literature.

The group recommends a 20% mortality be applied to estimates of live releases (such as MRFSS B2). The mortality rate of 33% should be applied if only total release estimates (live+dead) are made (such as for headboat discards).

*Sizing released/discarded fish*

The release mortality group determined that the size distribution of released fish should be treated as the same as for retained catch in the recreational fishery. However, the headboat observer data indicates that releases are almost entirely undersized. The recommendation is to use retained size distribution for recreational releases, except for headboats which should be restricted to less than minimum size.

### *4.7. RESEARCH RECOMMENDATIONS*

There is a need to characterize and quantify tournament effort and catch. It is recommended that tournaments be required to register and provide at least basic information (similar to that provided for the billfish survey). This basic information should include all catch (including releases and kept fish, whether or not they are submitted for weighout). The preferred approach would be to develop a program by which detailed trip information is collected from participating fishermen.

Future recreational fishery surveys should collect information about tournament participation in both effort and intercept components. These surveys should also include Texas fisheries in the geographic coverage, as the existing separate surveys are not comparable (which is problematic for the assessments).

Observer surveys should collect information on the initial condition of released fish. Research on post-release mortality should be encouraged. The Headboat Observer program provides useful information and should be continued.

Expand existing efforts to collect length-age samples to more completely cover the geographic range of the stocks.

## 4.8. TABLES

Table 4.1: Estimated king mackerel catches (in numbers) by zone.

| | Atlantic | | Gulf | | Mixing | | Total | |
|---|---|---|---|---|---|---|---|---|
| year | AB1 | B2 | AB1 | B2 | AB1 | B2 | AB1 | B2 |
| 1981 | 360,244 | 0 | 171,878 | 8,816 | 364,144 | 2,182 | 896,266 | 10,998 |
| 1982 | 418,410 | 0 | 774,816 | 31,178 | 440,470 | 2,320 | 1,633,696 | 33,498 |
| 1983 | 595,495 | 0 | 304,791 | 333 | 248,164 | 216 | 1,148,450 | 549 |
| 1984 | 482,332 | 826 | 324,299 | 3,325 | 279,962 | 534 | 1,086,593 | 4,685 |
| 1985 | 686,018 | 16,004 | 184,607 | 10,428 | 208,675 | 2,548 | 1,079,300 | 28,980 |
| 1986 | 669,161 | 7,422 | 150,460 | 11,770 | 208,197 | 15,683 | 1,027,818 | 34,875 |
| 1987 | 533,882 | 57,979 | 352,474 | 29,123 | 238,432 | 8,453 | 1,124,788 | 95,555 |
| 1988 | 493,714 | 13,461 | 317,316 | 26,303 | 221,174 | 38,641 | 1,032,204 | 78,405 |
| 1989 | 282,647 | 13,962 | 255,892 | 131,344 | 219,350 | 46,884 | 757,889 | 192,190 |
| 1990 | 318,862 | 7,902 | 346,430 | 92,035 | 342,625 | 31,952 | 1,007,917 | 131,889 |
| 1991 | 531,647 | 42,178 | 506,401 | 102,497 | 331,795 | 90,061 | 1,369,843 | 234,736 |
| 1992 | 629,327 | 12,922 | 293,424 | 105,682 | 284,187 | 67,916 | 1,206,938 | 186,520 |
| 1993 | 209,808 | 10,660 | 344,247 | 57,445 | 371,637 | 41,615 | 925,692 | 109,720 |
| 1994 | 245,143 | 9,266 | 372,091 | 115,067 | 375,541 | 38,339 | 992,775 | 162,672 |
| 1995 | 243,516 | 19,020 | 319,348 | 108,950 | 560,680 | 79,844 | 1,123,544 | 207,814 |
| 1996 | 177,292 | 23,924 | 375,112 | 135,391 | 473,518 | 92,707 | 1,025,922 | 252,022 |
| 1997 | 397,944 | 71,056 | 356,280 | 102,614 | 514,655 | 55,866 | 1,268,879 | 229,536 |
| 1998 | 288,476 | 25,066 | 229,076 | 64,171 | 413,185 | 86,984 | 930,737 | 176,221 |
| 1999 | 135,607 | 41,085 | 274,070 | 82,647 | 359,069 | 76,000 | 768,746 | 199,732 |
| 2000 | 291,407 | 48,265 | 346,690 | 129,904 | 351,929 | 60,071 | 990,026 | 238,240 |
| 2001 | 205,546 | 37,598 | 289,987 | 284,248 | 253,921 | 69,605 | 749,454 | 391,451 |
| 2002 | 110,814 | 22,662 | 309,295 | 170,994 | 306,446 | 79,843 | 726,555 | 273,499 |
| 2003 | 171,933 | 26,484 | 284,720 | 161,596 | 484,638 | 241,249 | 941,291 | 429,329 |
| 2004 | 158,187 | 51,832 | 284,069 | 179,749 | 306,861 | 112,537 | 749,117 | 344,118 |
| 2005 | 197,077 | 88,425 | 232,622 | 163,635 | 314,396 | 136,175 | 744,095 | 388,235 |
| 2006 | 151,266 | 33,494 | 475,427 | 541,223 | 423,920 | 176,653 | 1,050,613 | 751,370 |
| 2007 | 133,222 | 24,178 | 184,728 | 60,242 | 251,912 | 103,538 | 569,862 | 187,958 |

Table 4.2: Estimated king mackerel catches (in numbers) by source:

| | HBS | | MRFSS | | TPWD | | Total AB1 | Total B2 |
|---|---|---|---|---|---|---|---|---|
| **year** | **AB1** | **B2** | **AB1** | **B2** | **AB1** | **B2** | | |
| 1981 | | | 106,778 | 4,969 | 65,100 | 3,847 | 171,878 | 8,816 |
| 1982 | | | 716,194 | 16,138 | 58,622 | 15,040 | 774,816 | 31,178 |
| 1983 | | | 251,720 | 291 | 53,071 | 42 | 304,791 | 333 |
| 1984 | | | 277,301 | 881 | 46,998 | 2,444 | 324,299 | 3,325 |
| 1985 | | | 145,262 | 8,655 | 39,345 | 1,773 | 184,607 | 10,428 |
| 1986 | 8,834 | 2 | 124,081 | 10,188 | 17,545 | 1,580 | 150,460 | 11,770 |
| 1987 | 9,643 | 17 | 324,221 | 27,535 | 18,610 | 1,571 | 352,474 | 29,123 |
| 1988 | 9,483 | 2 | 292,530 | 22,528 | 15,303 | 3,773 | 317,316 | 26,303 |
| 1989 | 10,456 | 16 | 235,155 | 126,553 | 10,281 | 4,775 | 255,892 | 131,344 |
| 1990 | 11,255 | 304 | 321,201 | 90,925 | 13,974 | 806 | 346,430 | 92,035 |
| 1991 | 12,860 | 357 | 471,483 | 95,630 | 22,058 | 6,510 | 506,401 | 102,497 |
| 1992 | 17,928 | 3,131 | 255,151 | 97,518 | 20,345 | 5,033 | 293,424 | 105,682 |
| 1993 | 15,253 | 5,406 | 313,938 | 47,908 | 15,056 | 4,131 | 344,247 | 57,445 |
| 1994 | 19,415 | 211 | 333,915 | 105,689 | 18,761 | 9,167 | 372,091 | 115,067 |
| 1995 | 21,727 | 7 | 267,556 | 102,666 | 30,065 | 6,277 | 319,348 | 108,950 |
| 1996 | 19,820 | 236 | 318,993 | 119,450 | 36,299 | 15,705 | 375,112 | 135,391 |
| 1997 | 21,458 | 151 | 299,881 | 92,439 | 34,941 | 10,024 | 356,280 | 102,614 |
| 1998 | 14,658 | 5,381 | 185,398 | 49,465 | 29,020 | 9,325 | 229,076 | 64,171 |
| 1999 | 19,414 | 2,551 | 222,885 | 72,374 | 31,771 | 7,722 | 274,070 | 82,647 |
| 2000 | 16,229 | 395 | 311,903 | 122,021 | 18,558 | 7,488 | 346,690 | 129,904 |
| 2001 | 13,245 | 1,281 | 262,108 | 278,198 | 14,634 | 4,769 | 289,987 | 284,248 |
| 2002 | 14,653 | 3,974 | 279,082 | 161,881 | 15,560 | 5,139 | 309,295 | 170,994 |
| 2003 | 21,541 | 30,024 | 244,632 | 120,958 | 18,547 | 10,614 | 284,720 | 161,596 |
| 2004 | 17,498 | 3,063 | 251,628 | 168,121 | 14,943 | 8,565 | 284,069 | 179,749 |
| 2005 | 18,619 | 6,937 | 199,694 | 148,545 | 14,309 | 8,153 | 232,622 | 163,635 |
| 2006 | 23,711 | 8,994 | 423,196 | 509,596 | 28,520 | 22,633 | 475,427 | 541,223 |
| 2007 | 11,628 | 4,602 | 162,726 | 45,787 | 10,374 | 9,853 | 184,728 | 60,242 |

Table 4.3: Estimated king mackerel catches (A+B1, in numbers) by zone and fishery:

| | Gulf | | | | | |
|---|---|---|---|---|---|---|
| **year** | **Shore** | **Priv** | **Cbt** | **Hbt** | **Cbt/Hbt** | **All Modes** |
| 1981 | 4,978 | 74,439 | 27,699 | 8,101 | 56,661 | 171,878 |
| 1982 | 23,041 | 672,280 | 21,495 | 8,101 | 49,899 | 774,816 |
| 1983 | 32,060 | 201,848 | 16,145 | 8,101 | 46,637 | 304,791 |
| 1984 | - | 276,731 | 6,576 | 8,101 | 32,891 | 324,299 |
| 1985 | 828 | 105,331 | 4,135 | 8,101 | 66,212 | 184,607 |
| 1986 | 5,863 | 104,350 | 31,413 | 8,834 | - | 150,460 |
| 1987 | 42,824 | 220,869 | 79,138 | 9,643 | - | 352,474 |
| 1988 | 23,839 | 200,988 | 83,006 | 9,483 | - | 317,316 |
| 1989 | 9,868 | 178,691 | 56,877 | 10,456 | - | 255,892 |
| 1990 | 90,123 | 164,827 | 80,225 | 11,255 | - | 346,430 |
| 1991 | 126,686 | 251,449 | 115,406 | 12,860 | - | 506,401 |
| 1992 | 52,853 | 170,432 | 52,211 | 17,928 | - | 293,424 |
| 1993 | 61,743 | 160,299 | 106,952 | 15,253 | - | 344,247 |
| 1994 | 66,783 | 154,621 | 131,272 | 19,415 | - | 372,091 |
| 1995 | 15,612 | 156,352 | 125,657 | 21,727 | - | 319,348 |
| 1996 | 8,037 | 149,215 | 198,040 | 19,820 | - | 375,112 |
| 1997 | 14,224 | 181,910 | 138,688 | 21,458 | - | 356,280 |
| 1998 | 5,200 | 105,288 | 103,930 | 14,658 | - | 229,076 |
| 1999 | 24,727 | 132,335 | 97,594 | 19,414 | - | 274,070 |
| 2000 | 32,032 | 181,980 | 116,449 | 16,229 | - | 346,690 |
| 2001 | 51,871 | 148,801 | 76,070 | 13,245 | - | 289,987 |
| 2002 | 50,091 | 162,032 | 82,519 | 14,653 | - | 309,295 |
| 2003 | 31,885 | 166,538 | 64,756 | 21,541 | - | 284,720 |
| 2004 | 20,090 | 177,513 | 68,968 | 17,498 | - | 284,069 |
| 2005 | 38,259 | 128,621 | 47,123 | 18,619 | - | 232,622 |
| 2006 | 77,381 | 262,620 | 111,715 | 23,711 | - | 475,427 |
| 2007 | 24,350 | 88,186 | 60,564 | 11,628 | - | 184,728 |

Table 4.3 (cont.): Estimated king mackerel catches (A+B1, in numbers) by zone and fishery:

| | Mixing | | | | | |
|---|---|---|---|---|---|---|
| **year** | **Shore** | **Priv** | **Cbt** | **Hbt** | **Cbt/Hbt** | **All Modes** |
| 1981 | - | 276,977 | - | - | 87,167 | 364,144 |
| 1982 | - | 267,157 | - | - | 173,313 | 440,470 |
| 1983 | - | 184,021 | - | - | 64,143 | 248,164 |
| 1984 | - | 185,796 | - | - | 94,166 | 279,962 |
| 1985 | - | 66,977 | - | - | 141,698 | 208,675 |
| 1986 | - | 154,573 | 18,800 | 34,824 | - | 208,197 |
| 1987 | - | 121,443 | 56,094 | 60,895 | - | 238,432 |
| 1988 | - | 143,275 | 56,743 | 21,156 | - | 221,174 |
| 1989 | - | 136,662 | 50,951 | 31,737 | - | 219,350 |
| 1990 | 34,190 | 183,888 | 77,062 | 47,485 | - | 342,625 |
| 1991 | 3,243 | 221,171 | 53,424 | 53,957 | - | 331,795 |
| 1992 | 1,113 | 157,361 | 95,141 | 30,572 | - | 284,187 |
| 1993 | 2,773 | 150,168 | 180,905 | 37,791 | - | 371,637 |
| 1994 | 685 | 111,765 | 223,848 | 39,243 | - | 375,541 |
| 1995 | 2,158 | 190,958 | 337,954 | 29,610 | - | 560,680 |
| 1996 | 1,423 | 157,855 | 264,653 | 49,587 | - | 473,518 |
| 1997 | 1,138 | 218,062 | 260,455 | 35,000 | - | 514,655 |
| 1998 | 1,304 | 190,347 | 192,701 | 28,833 | - | 413,185 |
| 1999 | 2,802 | 193,090 | 136,644 | 26,533 | - | 359,069 |
| 2000 | 1,529 | 232,972 | 91,643 | 25,785 | - | 351,929 |
| 2001 | - | 147,596 | 89,493 | 16,832 | - | 253,921 |
| 2002 | 13,150 | 193,568 | 85,242 | 14,486 | - | 306,446 |
| 2003 | 1,052 | 342,157 | 127,759 | 13,670 | - | 484,638 |
| 2004 | 1,815 | 197,054 | 90,475 | 17,517 | - | 306,861 |
| 2005 | 4,389 | 161,827 | 113,314 | 34,866 | - | 314,396 |
| 2006 | 14,571 | 284,259 | 96,739 | 28,351 | - | 423,920 |
| 2007 | 1,156 | 192,404 | 42,602 | 15,750 | - | 251,912 |

Table 4.3 (cont.): Estimated king mackerel catches (A+B1, in numbers) by zone and fishery:

| | Atlantic | | | | | |
|---|---|---|---|---|---|---|
| **year** | **Shore** | **Priv** | **Cbt** | **Hbt** | **Cbt/Hbt** | **All Modes** |
| 1981 | - | 88,170 | - | - | 272,074 | 360,244 |
| 1982 | - | 147,720 | - | - | 270,690 | 418,410 |
| 1983 | - | 245,668 | - | - | 349,827 | 595,495 |
| 1984 | 2,814 | 301,371 | - | - | 178,147 | 482,332 |
| 1985 | - | 217,600 | - | - | 468,418 | 686,018 |
| 1986 | 23,233 | 339,947 | 302,703 | 1,792 | 1,486 | 669,161 |
| 1987 | 1,570 | 298,911 | 230,263 | 3,138 | - | 533,882 |
| 1988 | 8,473 | 221,705 | 260,133 | 3,099 | 304 | 493,714 |
| 1989 | 5,195 | 97,484 | 175,159 | 2,317 | 2,492 | 282,647 |
| 1990 | 17,351 | 167,236 | 132,037 | 2,017 | 221 | 318,862 |
| 1991 | 9,348 | 253,368 | 263,276 | 5,154 | 501 | 531,647 |
| 1992 | 1,622 | 285,689 | 335,418 | 4,843 | 1,755 | 629,327 |
| 1993 | 2,329 | 106,005 | 98,712 | 2,762 | - | 209,808 |
| 1994 | 10,421 | 113,155 | 118,444 | 2,285 | 838 | 245,143 |
| 1995 | 2,871 | 95,764 | 141,455 | 2,451 | 975 | 243,516 |
| 1996 | 391 | 65,925 | 108,284 | 1,576 | 1,116 | 177,292 |
| 1997 | 8,699 | 122,389 | 261,773 | 4,083 | 1,000 | 397,944 |
| 1998 | 74,058 | 71,897 | 136,478 | 4,077 | 1,966 | 288,476 |
| 1999 | 604 | 77,530 | 54,424 | 2,679 | 370 | 135,607 |
| 2000 | 879 | 208,441 | 76,689 | 5,398 | - | 291,407 |
| 2001 | 4,866 | 126,934 | 70,982 | 2,764 | - | 205,546 |
| 2002 | 10,681 | 79,148 | 19,323 | 1,662 | - | 110,814 |
| 2003 | 1,144 | 137,153 | 32,299 | 1,306 | 31 | 171,933 |
| 2004 | 3,670 | 100,892 | 50,912 | 2,713 | - | 158,187 |
| 2005 | 1,148 | 146,955 | 46,137 | 2,837 | - | 197,077 |
| 2006 | - | 107,941 | 40,292 | 3,033 | - | 151,266 |
| 2007 | 2,374 | 114,638 | 15,245 | 965 | - | 133,222 |

Table 4.4:: Estimated king mackerel catches (B2, in numbers) by zone and fishery

| | Gulf | | | | | |
|---|---|---|---|---|---|---|
| year | Shore | Priv | Cbt | Hbt | Cbt/Hbt | All modes |
| 1981 | - | 8,816 | - | - | - | 8,816 |
| 1982 | 324 | 30,854 | - | - | - | 31,178 |
| 1983 | - | - | 16 | 26 | 291 | 333 |
| 1984 | - | - | 1,260 | 1,184 | 881 | 3,325 |
| 1985 | 2,117 | 8,311 | - | - | - | 10,428 |
| 1986 | 5,863 | 5,301 | 604 | 2 | - | 11,770 |
| 1987 | 6,421 | 17,408 | 5,277 | 17 | - | 29,123 |
| 1988 | - | 23,052 | 3,249 | 2 | - | 26,303 |
| 1989 | 95,855 | 31,143 | 4,330 | 16 | - | 131,344 |
| 1990 | 71,667 | 17,568 | 2,496 | 304 | - | 92,035 |
| 1991 | 8,547 | 72,677 | 20,916 | 357 | - | 102,497 |
| 1992 | 10,372 | 75,284 | 16,895 | 3,131 | - | 105,682 |
| 1993 | 9,609 | 39,984 | 2,446 | 5,406 | - | 57,445 |
| 1994 | 2,597 | 86,380 | 25,879 | 211 | - | 115,067 |
| 1995 | 3,995 | 91,486 | 13,462 | 7 | - | 108,950 |
| 1996 | 2,244 | 113,987 | 18,924 | 236 | - | 135,391 |
| 1997 | 21,916 | 63,431 | 17,116 | 151 | - | 102,614 |
| 1998 | 451 | 49,141 | 9,198 | 5,381 | - | 64,171 |
| 1999 | 12,676 | 61,422 | 5,998 | 2,551 | - | 82,647 |
| 2000 | 21,262 | 89,869 | 18,378 | 395 | - | 129,904 |
| 2001 | 177,303 | 88,981 | 16,683 | 1,281 | - | 284,248 |
| 2002 | 55,927 | 95,305 | 15,788 | 3,974 | - | 170,994 |
| 2003 | 20,864 | 93,020 | 17,688 | 30,024 | - | 161,596 |
| 2004 | 47,556 | 113,811 | 15,319 | 3,063 | - | 179,749 |
| 2005 | 33,203 | 108,384 | 15,111 | 6,937 | - | 163,635 |
| 2006 | 276,670 | 228,155 | 27,404 | 8,994 | - | 541,223 |
| 2007 | 1,160 | 35,416 | 19,064 | 4,602 | - | 60,242 |

Table 4.4 (cont.): Estimated king mackerel catches (B2, in numbers) by zone and fishery:

| | Mixing | | | | | |
|---|---|---|---|---|---|---|
| **Year** | **Shore** | **Priv** | **Cbt** | **Hbt** | **Cbt/Hbt** | **All modes** |
| 1981 | - | 2,182 | - | - | - | 2,182 |
| 1982 | - | - | - | - | 2,320 | 2,320 |
| 1983 | - | - | - | - | 216 | 216 |
| 1984 | - | - | - | - | 534 | 534 |
| 1985 | - | 2,548 | - | - | - | 2,548 |
| 1986 | - | 15,568 | - | 115 | - | 15,683 |
| 1987 | - | 8,053 | - | 400 | - | 8,453 |
| 1988 | - | 29,386 | 8,146 | 1,109 | - | 38,641 |
| 1989 | - | 43,954 | 2,529 | 401 | - | 46,884 |
| 1990 | - | 8,699 | 21,537 | 1,716 | - | 31,952 |
| 1991 | - | 43,283 | 43,475 | 3,303 | - | 90,061 |
| 1992 | 5,567 | 37,426 | 20,780 | 4,143 | - | 67,916 |
| 1993 | 1,442 | 34,246 | 5,352 | 575 | - | 41,615 |
| 1994 | - | 24,915 | 11,642 | 1,782 | - | 38,339 |
| 1995 | 646 | 71,302 | 6,915 | 981 | - | 79,844 |
| 1996 | - | 56,502 | 35,333 | 872 | - | 92,707 |
| 1997 | - | 37,212 | 17,529 | 1,125 | - | 55,866 |
| 1998 | 4,201 | 68,037 | 13,748 | 998 | - | 86,984 |
| 1999 | - | 65,806 | 8,752 | 1,442 | - | 76,000 |
| 2000 | 4,327 | 44,023 | 9,105 | 2,616 | - | 60,071 |
| 2001 | 7,523 | 56,568 | 4,630 | 884 | - | 69,605 |
| 2002 | 16,265 | 58,150 | 4,182 | 1,246 | - | 79,843 |
| 2003 | 8,988 | 209,898 | 20,056 | 2,307 | - | 241,249 |
| 2004 | 1,876 | 98,013 | 10,503 | 2,145 | - | 112,537 |
| 2005 | 8,682 | 104,923 | 17,226 | 5,344 | - | 136,175 |
| 2006 | 31,730 | 124,380 | 16,636 | 3,907 | - | 176,653 |
| 2007 | - | 99,159 | 3,001 | 1,378 | - | 103,538 |

Table 4.4 (cont.): Estimated king mackerel catches (B2, in numbers) by zone and fishery:

| | Atlantic | | | | | |
|---|---|---|---|---|---|---|
| **year** | **Shore** | **Priv** | **Cbt** | **Hbt** | **Cbt/Hbt** | **All modes** |
| 1981 | - | - | - | - | - | - |
| 1982 | - | - | - | - | - | - |
| 1983 | - | - | - | - | - | - |
| 1984 | - | - | - | - | 826 | 826 |
| 1985 | - | 16,004 | - | - | - | 16,004 |
| 1986 | - | 7,291 | 131 | - | - | 7,422 |
| 1987 | - | 6,129 | 51,408 | 442 | - | 57,979 |
| 1988 | - | 7,953 | 5,435 | 73 | - | 13,461 |
| 1989 | 1,489 | 2,511 | 9,882 | 46 | 34 | 13,962 |
| 1990 | - | 6,338 | 1,542 | 22 | - | 7,902 |
| 1991 | 461 | 39,489 | 2,179 | 49 | - | 42,178 |
| 1992 | 586 | 11,412 | 816 | 108 | - | 12,922 |
| 1993 | 511 | 6,399 | 3,671 | 79 | - | 10,660 |
| 1994 | 1,656 | 7,607 | - | 3 | - | 9,266 |
| 1995 | - | 14,412 | 4,533 | 75 | - | 19,020 |
| 1996 | 1,109 | 15,695 | 7,025 | 95 | - | 23,924 |
| 1997 | 12,017 | 38,845 | 19,912 | 282 | - | 71,056 |
| 1998 | - | 14,417 | 9,905 | 601 | 143 | 25,066 |
| 1999 | 10,274 | 18,190 | 12,038 | 583 | - | 41,085 |
| 2000 | - | 39,433 | 8,016 | 816 | - | 48,265 |
| 2001 | - | 33,734 | 3,459 | 405 | - | 37,598 |
| 2002 | 6,226 | 14,111 | 2,126 | 199 | - | 22,662 |
| 2003 | - | 25,920 | 516 | 48 | - | 26,484 |
| 2004 | 9,049 | 40,256 | 2,400 | 127 | - | 51,832 |
| 2005 | 1,720 | 82,460 | 3,843 | 402 | - | 88,425 |
| 2006 | - | 32,685 | 746 | 63 | - | 33,494 |
| 2007 | 1,031 | 18,574 | 3,834 | 739 | - | 24,178 |

# 5. MEASURES OF POPULATION ABUNDANCE

## *5.1. OVERVIEW:*

The working group was chaired by Shannon L. Cass-Calay (SEFSC). Participants included: Kevin McCarthy (SEFSC), Pat Harris (SC DNR), Alan Bianchi (NCDMF), Geoff White (ACCSP) and Julie Defilippi (ACCSP).

The working group reviewed the following documents submitted as relative indices of abundance for the assessment of king mackerel stocks:

**Table 5.1.1.** Working documents reviewed by the SEDAR16 indices working group.

| Document # | Title | Authors |
|---|---|---|
| SEDAR16-DW-01 | Standardized Catch Rates of King Mackerel from the Southeast Shark Drift Gillnet Fishery: 1993-2007 | Carlson, J.K., K. Siegfried, and I. Baremore |
| SEDAR16-DW-04 | Standardized catch rates of king mackerel from Florida commercial trip ticket data for the Gulf and South Atlantic 1986-2007. | Walter, J. F. |
| SEDAR16-DW-08 | Abundance Indices of King Mackerel, *Scomberomorus cavalla*, collected in Fall SEAMAP Groundfish Surveys in the Western U.S. Gulf of Mexico (1972-2007) | Ingram, Jr., G. Walter |
| SEDAR16-DW-09 | Abundance Indices of King Mackerel, *Scomberomorus cavalla*, collected during SEAMAP Shallow Water Trawl Surveys in the South Atlantic Bight (1989-2006) | Ingram, Jr., G. Walter |
| SEDAR16-DW-11 | Standardized catch rates of Atlantic king mackerel (*Scomberomorus cavalla*) from the North Carolina Commercial fisheries trip ticket | Bianchi, A. and M. Ortiz |
| SEDAR16-DW-14 | Standardized catch rates of king mackerel, *Scomberomorus cavalla* from the Marine Recreational Fisheries Statistical Survey MRFSS | Ortiz, M. |
| SEDAR16-DW-16 | Standardized catch rates of king mackerel (*Scomberomorus cavalla)* from the headboat fishery in the U.S. Gulf of Mexico and U.S. South Atlantic | Cass-Calay, S.L. |
| SEDAR16-DW-20 | Data Summary of King Mackerel (*Scomberomorus cavalla*) Collected During Small Pelagic Trawl Surveys in the U.S. Gulf of Mexico, 1988 – 1996 and 2002-2007 | Ingram, Jr., G. Walter |
| SEDAR16-DW-22 | Standardized catch rates of king mackerel from the United States Gulf of Mexico, south Atlantic, and Mixing Zone commercial hook and line fisheries, 1993-2006 | McCarthy, K. |
| SEDAR16-DW-29 | King mackerel (*Scomberomorus cavalla*) larval indices of relative abundance from SEAMAP Fall plankton surveys, 1986 to 2006 | Hanisko, David S. and J. Lyczkowski-Shultz |

According to the recommendations of the last stock assessment panel (SEDAR 5) and the SEDAR 16 Terms of Reference (TOR), the 2008 assessment of king mackerel should address the mixing rates of Atlantic and Gulf of Mexico king mackerel migratory groups along the Southeast Florida coast. Proposed assessment models distinguish three major areas, i) the Atlantic-no mixing zone (north of Volusia/Flagler county line in the Atlantic coast), ii) the Gulf of Mexico-no mixing zone (north and west of the Collier/Monroe county line in the southwest coast of Florida) and iii) the "mixing zone" (region between Monroe and Volusia counties in the Southeast Florida). Therefore, indices of abundance (fishery independent and dependent) were requested for these regional areas. In addition, also following the TOR, indices of abundance were requested for the "continuity case". The continuity case is the VPA model accepted by the previous assessment panel (SEDAR 5). The continuity case demonstrates the result of updating the data contained in the model without including improvements to modeling methods, or recently developed life history functions (e.g. natural mortality, growth, fecundity etc.).

Table 5.1.2 summarizes the available indices for SEDAR16 "Continuity Case" assessments of king mackerel. The recommendations of the SEDAR16 DW index of abundance working group are also briefly summarized here, and described in detail in section 5.2.

Tables 5.1.3 summarizes the available annual indices for updated assessments (SS2, etc.) of king mackerel. Seasonal indices were also constructed, and are available in the working documents, or in addendums to the working documents. The recommendations of the SEDAR16 DW index of abundance working group are also briefly summarized here, and described in detail in section 5.2. Indices not yet completed or reviewed will be presented to the SEDAR 16 assessment workshop for review (commercial trip ticket, commercial logbook).

**Table 5.1.2.** Available relative indices of abundance for SEDAR 16 "Continuity Case" assessments of king mackerel stocks. See comments regarding methods, application and recommended use.

| | MRFSS-ATL | | MRFSS - GULF | | HB-Atl. Migratory | | HB-Gulf Migratory | |
|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. REC | |
| Region | Atl. Migratory | | Gulf Migratory | | Atl. Migratory | | Gulf Migratory | |
| Standardization | Delta-lognormal - Fishing Year - Guild selection | | Delta-lognormal - Fishing Year - Guild selection | | Delta-lognormal Fishing Year - Vessel Selection | | Delta-lognormal - Fishing Year - Vessel Selection | |
| Unit | Number | | Number | | Number | | Number | |
| Likely Applies to Ages | Ages 2-11 | | Ages 2-8 | | Ages 2-11 | | Ages 2-6 | |
| Season | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | |
| Recommended? | Cont. Case: YES Updated Models: NO | | Cont. Case: YES Updated Models: NO | | Cont. Case: YES Updated Models: NO | | Cont. Case: YES Updated Models: NO | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1972 | | | | | | | | |
| 1973 | | | | | | | | |
| 1974 | | | | | | | | |
| 1975 | | | | | | | | |
| 1976 | | | | | | | | |
| 1977 | | | | | | | | |
| 1978 | | | | | | | | |
| 1979 | | | | | | | | |
| 1980 | | | | | | | | |
| 1981 | 1.0100 | 0.5451 | 0.6701 | 0.4054 | 0.9120 | 0.3080 | 1.4620 | 0.3280 |
| 1982 | 1.3865 | 0.4517 | 0.3601 | 0.4031 | 0.7880 | 0.2970 | 0.8650 | 0.3400 |
| 1983 | 1.3498 | 0.4694 | 0.8004 | 0.3596 | 0.8450 | 0.2780 | 1.9420 | 0.3040 |
| 1984 | 1.2746 | 0.4527 | 0.4173 | 0.4014 | 0.9690 | 0.2650 | 0.6200 | 0.3510 |
| 1985 | 1.3741 | 0.4741 | 0.4266 | 0.3887 | 0.5640 | 0.2860 | 0.4450 | 0.2990 |
| 1986 | 1.9124 | 0.4105 | 0.4539 | 0.3196 | 0.7610 | 0.2730 | 0.4890 | 0.2520 |
| 1987 | 1.2688 | 0.4171 | 1.0693 | 0.2858 | 1.2870 | 0.2590 | 0.3240 | 0.2860 |
| 1988 | 0.9524 | 0.4091 | 0.6765 | 0.2985 | 0.8690 | 0.2810 | 0.3790 | 0.2770 |
| 1989 | 0.7479 | 0.4111 | 0.9378 | 0.3050 | 0.6240 | 0.2920 | 0.6120 | 0.2540 |
| 1990 | 1.1712 | 0.4099 | 1.2820 | 0.2862 | 0.7440 | 0.2770 | 0.5040 | 0.2640 |
| 1991 | 1.0889 | 0.4030 | 1.1803 | 0.2777 | 1.5450 | 0.2500 | 0.7970 | 0.2420 |
| 1992 | 1.1118 | 0.3986 | 1.2209 | 0.2655 | 1.4070 | 0.2450 | 1.0280 | 0.2340 |
| 1993 | 0.6404 | 0.4136 | 1.1378 | 0.2725 | 0.8440 | 0.2610 | 1.2300 | 0.2300 |
| 1994 | 0.5508 | 0.4124 | 1.4390 | 0.2630 | 1.0410 | 0.2570 | 1.1170 | 0.2270 |
| 1995 | 0.6582 | 0.4064 | 0.9981 | 0.2849 | 0.9350 | 0.2570 | 1.0780 | 0.2370 |
| 1996 | 0.7676 | 0.4021 | 1.3496 | 0.2708 | 0.6260 | 0.2750 | 1.6730 | 0.2240 |
| 1997 | 0.9935 | 0.4013 | 1.6397 | 0.2590 | 1.1290 | 0.2610 | 1.3170 | 0.2260 |
| 1998 | 0.8912 | 0.3995 | 0.9055 | 0.2646 | 0.9110 | 0.2690 | 1.0830 | 0.2310 |
| 1999 | 0.8238 | 0.4008 | 0.8820 | 0.2630 | 1.1630 | 0.2620 | 1.1270 | 0.2290 |
| 2000 | 1.0370 | 0.3954 | 1.1231 | 0.2558 | 1.8520 | 0.2500 | 0.9670 | 0.2350 |
| 2001 | 0.5921 | 0.4010 | 1.0189 | 0.2587 | 1.2150 | 0.2670 | 1.1520 | 0.2340 |
| 2002 | 0.7217 | 0.3999 | 1.3102 | 0.2531 | 0.9790 | 0.2730 | 1.1640 | 0.2310 |
| 2003 | 0.7497 | 0.4033 | 0.9135 | 0.2624 | 0.8380 | 0.2800 | 0.9610 | 0.2440 |
| 2004 | 0.9870 | 0.3981 | 1.0046 | 0.2598 | 0.7150 | 0.2790 | 1.0960 | 0.2400 |
| 2005 | 0.9991 | 0.3990 | 0.9180 | 0.2642 | 1.2000 | 0.2710 | 1.3780 | 0.2320 |
| 2006 | 0.9394 | 0.4059 | 1.8647 | 0.2703 | 1.2380 | 0.2690 | 1.1910 | 0.3000 |
| 2007 | | | | | | | | |

**Table 5.1.2.** Continuity Case indices, continued.

| | TPWD 1981-1985 | | TPWD 1986-2000 | | Trip Ticket - NC PIDs 8+ | | Trip Ticket Cont-Panhandle | |
|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. COM | | Fish. Dep. COM | |
| Region | Gulf Migratory | | Gulf Migratory | | North Carolina | | Panhandle FL | |
| Standardization | Delta-lognormal - Fishing Year - NOT UPDATED FOR SEDAR16 - USE AS IS | | Delta-lognormal - Fishing Year - NOT UPDATED FOR SEDAR16 - USE AS IS | | Delta-Lognormal - Fishing Year - Vessel Selection | | Lognormal - Trips selected if 50% of catch was king | |
| Unit | Number | | Number | | Weight | | Weight | |
| Likely Applies to Ages | Ages 2-8 | | Ages 2-8 | | Ages 2-11 | | Ages 3-6 | |
| Season | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jul-Oct | |
| Recommended? | Cont. Case: YES<br>Updated Models: NO | | Cont. Case: YES<br>Updated Models: NO | | Cont. Case: YES<br>Updated Models: NO | | Cont. Case: YES<br>Updated Models: NO | |
| YEAR | | | | | STDCPUE | CV | STDCPUE | CV |
| 1972 | | | | | | | | |
| 1973 | | | | | | | | |
| 1974 | | | | | | | | |
| 1975 | | | | | | | | |
| 1976 | | | | | | | | |
| 1977 | | | | | | | | |
| 1978 | | | | | | | | |
| 1979 | | | | | | | | |
| 1980 | | | | | | | | |
| 1981 | 1.0210 | 0.1000 | | | | | | |
| 1982 | 0.8744 | 0.0500 | | | | | | |
| 1983 | 1.2778 | 0.2802 | | | | | | |
| 1984 | 1.2597 | 0.2812 | | | | | | |
| 1985 | 1.0567 | 0.2871 | | | | | | |
| 1986 | | | 0.4729 | 0.3270 | | | 0.7790 | 0.0520 |
| 1987 | | | 0.8995 | 0.2975 | | | 0.5430 | 0.0370 |
| 1988 | | | 0.7193 | 0.3006 | | | 0.5180 | 0.0250 |
| 1989 | | | 0.7746 | 0.3135 | | | 0.3630 | 0.0480 |
| 1990 | | | 0.6212 | 0.3152 | | | 0.5410 | 0.0300 |
| 1991 | | | 1.5183 | 0.2807 | | | 0.5430 | 0.0230 |
| 1992 | | | 1.0878 | 0.3029 | | | 0.7440 | 0.0190 |
| 1993 | | | 0.9896 | 0.3112 | | | 0.6470 | 0.0240 |
| 1994 | | | 1.0046 | 0.3039 | 0.7000 | 0.0684 | 0.8000 | 0.0140 |
| 1995 | | | 1.0717 | 0.2983 | 0.7443 | 0.0733 | 0.7900 | 0.0180 |
| 1996 | | | 1.2325 | 0.2872 | 1.1254 | 0.0694 | 1.4350 | 0.0090 |
| 1997 | | | 0.8769 | 0.3204 | 1.0329 | 0.0604 | 1.8850 | 0.0080 |
| 1998 | | | 1.1371 | 0.3049 | 1.0559 | 0.0599 | 1.2670 | 0.0120 |
| 1999 | | | 0.9398 | 0.3222 | 0.9687 | 0.0610 | 1.4600 | 0.0100 |
| 2000 | | | 0.7206 | 0.3423 | 0.9864 | 0.0587 | 1.2800 | 0.0110 |
| 2001 | | | | | 1.0438 | 0.0574 | 1.5520 | 0.0100 |
| 2002 | | | | | 0.9071 | 0.0690 | 1.2190 | 0.0130 |
| 2003 | | | | | 0.8793 | 0.0728 | 1.0730 | 0.0130 |
| 2004 | | | | | 1.2922 | 0.0578 | 1.0190 | 0.0180 |
| 2005 | | | | | 1.2058 | 0.0627 | 1.0620 | 0.0220 |
| 2006 | | | | | 1.0581 | 0.0664 | 1.2890 | 0.0140 |
| 2007 | | | | | | | 1.1900 | 0.0250 |

**Table 5.1.2.** Continuity Case indices, continued.

| | Trip Ticket Cont-SW FL | | Trip Ticket Cont- FL Atl Coast | | Shrimp Bycatch | | SEAMAP Fall Plankton (Larval) | |
|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. COM | | Fish. Dep. COM | | Fish. Dep. COM Bycatch | | Fish. Independent | |
| Region | SW Florida | | FL East Coast | | Gulf of Mexico | | Gulf of Mexico | |
| Standardization | Lognormal - Trips selected if 50% of catch was king | | Lognormal - Trips selected if 50% of catch was king | | Delta-Lognormal | | Delta-Lognormal | |
| Unit | Weight | | Weight | | Numbers | | Numbers | |
| Likely Applies to Ages | Ages 3-8 | | Ages 2-11+ | | Ages: 0 | | Ages 1 to 11+, using partial selection | |
| Season | Nov-Dec | | Apr-Oct | | All months | | Sept - Oct | |
| Recommended? | Cont. Case: YES<br>Updated Models: NO | | Cont. Case: YES<br>Updated Models: NO | | Cont. Case: YES<br>Updated Models: NO | | Cont. Case: YES<br>Updated Models: NO | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1972 | | | | | 1.0549 | 0.4301 | | |
| 1973 | | | | | | | | |
| 1974 | | | | | 0.2755 | 0.5275 | | |
| 1975 | | | | | 0.2144 | 0.5500 | | |
| 1976 | | | | | 0.0700 | 0.7128 | | |
| 1977 | | | | | 0.0319 | 0.6672 | | |
| 1978 | | | | | 0.2846 | 0.3936 | | |
| 1979 | | | | | 0.3081 | 0.5164 | | |
| 1980 | | | | | 0.0429 | 0.5300 | | |
| 1981 | | | | | 0.1795 | 0.7878 | | |
| 1982 | | | | | 0.0894 | 0.8595 | | |
| 1983 | | | | | | | | |
| 1984 | | | | | 0.4553 | 0.5106 | | |
| 1985 | | | | | 0.3101 | 0.5094 | | |
| 1986 | 0.3850 | 0.0220 | 1.0240 | 0.0070 | 0.1243 | 0.7533 | 0.1160 | 0.5341 |
| 1987 | 0.5900 | 0.0170 | 0.9860 | 0.0070 | 0.5681 | 0.4676 | 0.3788 | 0.3219 |
| 1988 | 0.8170 | 0.0220 | 1.1690 | 0.0070 | 0.5786 | 0.4312 | 0.6130 | 0.4365 |
| 1989 | 0.7640 | 0.0140 | 1.0300 | 0.0080 | 1.5828 | 0.4062 | 0.8450 | 0.3255 |
| 1990 | 1.0000 | 0.0120 | 0.9270 | 0.0080 | 1.2579 | 0.3660 | 0.6480 | 0.3211 |
| 1991 | 1.0180 | 0.0130 | 0.8980 | 0.0070 | 1.3865 | 0.4051 | 0.7212 | 0.3181 |
| 1992 | 2.3680 | 0.0100 | 0.8330 | 0.0080 | 0.5165 | 0.3282 | 0.5960 | 0.2372 |
| 1993 | 1.0630 | 0.0120 | 0.8500 | 0.0070 | 1.7224 | 0.2405 | 1.2505 | 0.1987 |
| 1994 | 0.6630 | 0.0170 | 0.8320 | 0.0080 | 1.6751 | 0.3091 | 1.0500 | 0.2310 |
| 1995 | 0.9420 | 0.0140 | 0.7800 | 0.0080 | 2.2418 | 0.3122 | 1.9787 | 0.1947 |
| 1996 | 1.1060 | 0.0110 | 0.9650 | 0.0070 | 0.7715 | 0.3962 | 0.7407 | 0.2647 |
| 1997 | 0.9300 | 0.0130 | 0.9700 | 0.0070 | 1.0344 | 0.3549 | 1.3597 | 0.2007 |
| 1998 | 1.0310 | 0.0160 | 0.9810 | 0.0070 | 0.9711 | 0.3766 | | |
| 1999 | 0.6520 | 0.0180 | 0.9920 | 0.0070 | 0.9071 | 0.3411 | 0.9198 | 0.2249 |
| 2000 | 1.1700 | 0.0160 | 0.8630 | 0.0070 | 1.0637 | 0.3540 | 0.9219 | 0.2730 |
| 2001 | 1.2440 | 0.0160 | 0.9050 | 0.0070 | 1.9350 | 0.3483 | 1.6424 | 0.2026 |
| 2002 | 0.8850 | 0.0190 | 0.8260 | 0.0080 | 0.9723 | 0.3835 | 1.4511 | 0.2143 |
| 2003 | 1.1300 | 0.0150 | 1.0930 | 0.0070 | 3.2741 | 0.3375 | 1.1027 | 0.2190 |
| 2004 | 0.8800 | 0.0190 | 1.2940 | 0.0070 | 3.7091 | 0.3379 | 1.4780 | 0.2108 |
| 2005 | 1.4070 | 0.0150 | 0.9740 | 0.0070 | 1.0116 | 0.4308 | | |
| 2006 | 0.9550 | 0.0190 | 1.4630 | 0.0070 | 2.3792 | 0.3381 | 1.1865 | 0.2533 |
| 2007 | | | | | | | | |

**Table 5.1.3.** Available relative indices of abundance for SEDAR 16 "Updated" assessments of king mackerel stocks. See comments regarding methods, application and recommended use. Quarterly indices are available in the working documents.

| | MRFSS-Atl-No-Mix | | MRFSS-Mixing | | MRFSS-Gulf-No-Mix | |
|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. REC | |
| Region | Atlantic | | Mixing | | Gulf of Mexico | |
| Standardization | Delta-lognormal (Cal. Year) - Guild Selection | | Delta-lognormal (Cal. Year) - Guild Selection | | Delta-lognormal (Cal. Year) - Guild Selection | |
| Unit | Number | | Number | | Number | |
| Likely Applies to Ages | Ages 1-11+ | | Ages 1-11+ | | Ages 1-8 | |
| Season | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | |
| Recommended? | Updated Models: Yes | | Updated Models: Yes | | Updated Models: Yes | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1972 | | | | | | |
| 1973 | | | | | | |
| 1974 | | | | | | |
| 1975 | | | | | | |
| 1976 | | | | | | |
| 1977 | | | | | | |
| 1978 | | | | | | |
| 1979 | | | | | | |
| 1980 | | | | | | |
| 1981 | 1.1938 | 0.7227 | 0.6295 | 0.3928 | 0.7222 | 0.4241 |
| 1982 | 1.3864 | 0.6503 | 1.1808 | 0.2941 | 0.4670 | 0.4069 |
| 1983 | 1.3961 | 0.6712 | 0.6578 | 0.2840 | 0.8831 | 0.4284 |
| 1984 | 1.4869 | 0.6480 | 0.7300 | 0.2589 | 0.5010 | 0.3898 |
| 1985 | 1.3994 | 0.6111 | 0.7483 | 0.3287 | 0.5503 | 0.4170 |
| 1986 | 4.4241 | 0.5317 | 0.5412 | 0.3041 | 0.4506 | 0.3384 |
| 1987 | 1.7000 | 0.5746 | 0.5862 | 0.3228 | 1.0767 | 0.3032 |
| 1988 | 1.2020 | 0.5761 | 0.7349 | 0.2729 | 0.7099 | 0.3243 |
| 1989 | 0.9617 | 0.5647 | 0.6174 | 0.2734 | 0.9225 | 0.3324 |
| 1990 | 0.8786 | 0.5908 | 1.2406 | 0.2548 | 1.2924 | 0.3179 |
| 1991 | 1.1927 | 0.5678 | 0.9928 | 0.2601 | 1.2631 | 0.3010 |
| 1992 | 0.9460 | 0.5764 | 0.9928 | 0.2279 | 1.0016 | 0.2932 |
| 1993 | 0.5483 | 0.6448 | 1.3104 | 0.2329 | 0.9979 | 0.3014 |
| 1994 | 0.3550 | 0.6785 | 0.8391 | 0.2462 | 1.2434 | 0.2898 |
| 1995 | 0.3990 | 0.6813 | 1.1780 | 0.2398 | 1.1147 | 0.3048 |
| 1996 | 0.3421 | 0.6768 | 1.2370 | 0.2359 | 1.3220 | 0.2994 |
| 1997 | 1.1258 | 0.5692 | 1.2799 | 0.2268 | 1.4800 | 0.2850 |
| 1998 | 0.5442 | 0.6173 | 1.3425 | 0.2205 | 1.0829 | 0.2857 |
| 1999 | 0.9367 | 0.5901 | 1.2968 | 0.2147 | 0.9224 | 0.2805 |
| 2000 | 0.8109 | 0.6051 | 1.1043 | 0.2165 | 1.2133 | 0.2758 |
| 2001 | 0.4074 | 0.6604 | 0.7166 | 0.2169 | 1.1135 | 0.2799 |
| 2002 | 0.1881 | 0.7787 | 0.8728 | 0.2099 | 1.2392 | 0.2758 |
| 2003 | 0.2712 | 0.7167 | 1.6311 | 0.2050 | 0.9668 | 0.2815 |
| 2004 | 0.4623 | 0.6490 | 0.9748 | 0.2179 | 1.0191 | 0.2811 |
| 2005 | 0.8433 | 0.5771 | 1.1816 | 0.2156 | 0.8601 | 0.2900 |
| 2006 | 0.5978 | 0.6209 | 1.3829 | 0.2102 | 1.5840 | 0.2762 |
| 2007 | | | | | | |

**Table 5.1.3.** "Updated Model" indices, continued.

| | HB-Atl-no-Mix | | HB-Mixing | | HB-Gulf-no-Mix | | Trip Ticket - NC PIDs 8+ | |
|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. COM | |
| Region | Atlantic | | Mixing | | Gulf of Mexico | | North Carolina | |
| Standardization | Delta-lognormal (cal. year) - Stephens and MacCall | | Delta-lognormal (cal. year) - Stephens and MacCall | | Delta-lognormal (cal. year) - Stephens and MacCall | | Delta-Lognormal - Vessel Selection | |
| Unit | Number | | Number | | Number | | Weight | |
| Likely Applies to Ages | Ages 1-11+ | | Ages 1-11+ | | Ages 1-6 | | Ages 2-11+ | |
| Season | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | |
| Recommended? | Updated Models: Yes | | Updated Models: Yes | | Updated Models: Yes | | Updated Models: Yes, pending trip limit analysis | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1972 | | | | | | | | |
| 1973 | | | | | | | | |
| 1974 | | | | | | | | |
| 1975 | | | | | | | | |
| 1976 | | | | | | | | |
| 1977 | | | | | | | | |
| 1978 | | | | | | | | |
| 1979 | | | 1.0753 | 0.1462 | | | | |
| 1980 | 0.6274 | 0.4061 | 1.0325 | 0.1345 | | | | |
| 1981 | 1.5057 | 0.4755 | 1.1280 | 0.1325 | | | | |
| 1982 | 0.7566 | 0.4971 | 0.7568 | 0.1375 | | | | |
| 1983 | 1.2358 | 0.3873 | 0.8803 | 0.1344 | | | | |
| 1984 | 0.7693 | 0.2952 | 0.9472 | 0.1402 | | | | |
| 1985 | 0.5953 | 0.3016 | 0.7393 | 0.1552 | | | | |
| 1986 | 0.7340 | 0.2353 | 0.6605 | 0.1387 | 0.6768 | 0.1835 | | |
| 1987 | 0.8584 | 0.2353 | 0.9101 | 0.1343 | 0.6986 | 0.1749 | | |
| 1988 | 0.8159 | 0.2378 | 0.6680 | 0.1832 | 0.8086 | 0.1935 | | |
| 1989 | | | 1.0003 | 0.1604 | 0.7989 | 0.1861 | | |
| 1990 | | | 0.9439 | 0.1513 | 0.5583 | 0.1696 | | |
| 1991 | 1.1698 | 0.2416 | 1.1348 | 0.1498 | 1.3709 | 0.1564 | | |
| 1992 | 1.5170 | 0.2239 | 0.8064 | 0.1396 | 1.2335 | 0.1529 | | |
| 1993 | 0.8051 | 0.2378 | 0.9632 | 0.1274 | 0.8376 | 0.1506 | | |
| 1994 | 0.6144 | 0.2486 | 0.8236 | 0.1358 | 1.2053 | 0.1327 | 0.6603 | 0.0664 |
| 1995 | 0.6165 | 0.2318 | 0.8040 | 0.1452 | 1.2953 | 0.1343 | 0.7736 | 0.0673 |
| 1996 | 0.4636 | 0.2397 | 1.3230 | 0.1458 | 1.4368 | 0.1419 | 0.9104 | 0.0757 |
| 1997 | 1.2180 | 0.2062 | 1.4863 | 0.1264 | 1.3070 | 0.1397 | 1.1141 | 0.0556 |
| 1998 | 1.2431 | 0.2089 | 1.2120 | 0.1483 | 1.0835 | 0.1451 | 1.0966 | 0.0575 |
| 1999 | 0.9763 | 0.2178 | 0.8423 | 0.1823 | 1.2858 | 0.1496 | 1.0291 | 0.0571 |
| 2000 | 1.8537 | 0.2088 | 1.1171 | 0.1776 | 0.8897 | 0.1525 | 1.0187 | 0.0539 |
| 2001 | 1.2878 | 0.2134 | 0.9519 | 0.1773 | 0.6864 | 0.1603 | 1.0084 | 0.0568 |
| 2002 | 0.8855 | 0.2412 | 0.9213 | 0.2153 | 0.7289 | 0.1496 | 0.8466 | 0.0652 |
| 2003 | 0.9117 | 0.2273 | 1.0150 | 0.2286 | 1.0554 | 0.1528 | 1.0193 | 0.0640 |
| 2004 | 0.8958 | 0.2231 | 0.8532 | 0.2187 | 0.6537 | 0.1617 | 1.1656 | 0.0609 |
| 2005 | 1.4961 | 0.2542 | 1.5030 | 0.1879 | 1.0383 | 0.1626 | 1.2502 | 0.0581 |
| 2006 | 1.1472 | 0.2188 | 1.5007 | 0.2115 | 1.3510 | 0.1485 | 1.2452 | 0.0599 |
| 2007 | | | | | | | | |

**Table 5.1.3.** "Updated Model" indices, continued.

| | SEAMAP Fall Plankton (Larval) | | SEAMAP South Alt. Trawl | | SEAMAP Fall Groundfish | | Small Pelagic Survey | | SE Drift Gillnet Bycatch | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Independent | | Fish. Independent | | Fish. Independent | | Fish. Independent | | Fish. Dep. COM Bycatch | |
| Region | Gulf of Mexico | | South Atl. | | W. Gulf of Mexico | | Gulf of Mexico | | Mixing Zone | |
| Standardization | Delta-Lognormal | | Delta-Lognormal | | Delta-Lognormal | | Delta-Lognormal | | Delta-Lognormal | |
| Unit | Numbers | | Numbers | | Numbers | | Numbers | | Numbers | |
| Likely Applies to Ages | Ages 1 to 11+, using partial selection | | Age 1 | | Age 0 | | Age 0-2 | | Ages: ? | |
| Season | Sept - Oct | | Spring, Summer, Fall | | Oct-Nov | | Oct-Nov | | Jan-Mar; Apr-Jun; Jul-Oct; Nov-Dec | |
| Recommended? | Updated Models: Yes | | Updated Models: Yes | | Updated Models: Yes | | Updated Models: ***NO*** | | Updated Models: ***NO - unless linked to catch*** | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1972 | | | | | 0.5114 | 0.5336 | | | | |
| 1973 | | | | | 0.0000 | 0.0000 | | | | |
| 1974 | | | | | 0.1211 | 0.8999 | | | | |
| 1975 | | | | | 0.0000 | 0.0000 | | | | |
| 1976 | | | | | 0.0000 | 0.0000 | | | | |
| 1977 | | | | | 0.0000 | 0.0000 | | | | |
| 1978 | | | | | 0.0806 | 1.0931 | | | | |
| 1979 | | | | | 0.1426 | 0.9015 | | | | |
| 1980 | | | | | 0.0000 | 0.0000 | | | | |
| 1981 | | | | | 0.0000 | 0.0000 | | | | |
| 1982 | | | | | 0.0000 | 0.0000 | | | | |
| 1983 | | | | | 0.0000 | 0.0000 | | | | |
| 1984 | | | | | 0.1005 | 0.9108 | | | | |
| 1985 | | | | | 0.0454 | 0.8232 | | | | |
| 1986 | 0.1160 | 0.5341 | | | 0.0852 | 1.0797 | | | | |
| 1987 | 0.3788 | 0.3219 | | | 0.0175 | 1.4820 | | | | |
| 1988 | 0.6130 | 0.4365 | | | 0.1223 | 0.5274 | 0.0000 | 0.0000 | | |
| 1989 | 0.8450 | 0.3255 | 0.8067 | 0.2121 | 0.1013 | 0.7018 | 0.6406 | 0.6538 | | |
| 1990 | 0.6480 | 0.3211 | 2.3766 | 0.1582 | 0.1619 | 0.4086 | 1.9413 | 0.4287 | | |
| 1991 | 0.7212 | 0.3181 | 0.7036 | 0.2218 | 0.0629 | 0.5647 | | | | |
| 1992 | 0.5960 | 0.2372 | 0.8428 | 0.2413 | 0.0959 | 0.5588 | 1.5245 | 0.3509 | | |
| 1993 | 1.2505 | 0.1987 | 0.4464 | 0.2465 | 0.4243 | 0.3252 | 0.9156 | 0.3519 | 3.2954 | 0.6300 |
| 1994 | 1.0500 | 0.2310 | 0.7083 | 0.2317 | 0.1826 | 0.4797 | 1.0661 | 0.5359 | 0.9543 | 0.5800 |
| 1995 | 1.9787 | 0.1947 | 1.2262 | 0.1983 | 0.1077 | 0.6410 | 0.6505 | 0.4651 | 2.6630 | 0.4900 |
| 1996 | 0.7407 | 0.2647 | 2.2610 | 0.1681 | 0.0873 | 0.5315 | 0.3646 | 0.5753 | | |
| 1997 | 1.3597 | 0.2007 | 0.5195 | 0.2405 | 0.2086 | 0.4254 | | | | |
| 1998 | | | 1.7862 | 0.1999 | 0.2236 | 0.4126 | | | | |
| 1999 | 0.9198 | 0.2249 | 1.2129 | 0.1844 | 0.1770 | 0.3955 | | | 0.1056 | 0.4000 |
| 2000 | 0.9219 | 0.2730 | 0.8157 | 0.2211 | 0.2018 | 0.4803 | | | 0.1458 | 0.5600 |
| 2001 | 1.6424 | 0.2026 | 0.4483 | 0.2342 | 0.2524 | 0.3760 | | | 0.5977 | 0.2800 |
| 2002 | 1.4511 | 0.2143 | 0.5061 | 0.2113 | 0.1443 | 0.5355 | | | 0.6176 | 0.3300 |
| 2003 | 1.1027 | 0.2190 | 0.9889 | 0.1956 | 0.5664 | 0.2891 | | | 0.6141 | 0.4900 |
| 2004 | 1.4780 | 0.2108 | 0.6189 | 0.3574 | 0.4499 | 0.3076 | 0.3279 | 0.8666 | 0.6382 | 0.3100 |
| 2005 | | | 0.7264 | 0.4934 | 0.4909 | 0.2921 | | | 0.9635 | 0.3500 |
| 2006 | 1.1865 | 0.2533 | 1.0058 | 0.2213 | 0.3807 | 0.3687 | 0.2334 | 0.7120 | | |
| 2007 | | | | | 0.5972 | 0.2842 | 0.5059 | 0.5234 | 0.4048 | 0.9600 |

## *5.2. REVIEW OF WORKING PAPERS*

### 5.2.1. Fisheries Independent Indices

### *5.2.1.1 Gulf of Mexico SEAMAP Fall Plankton Survey*

***Methods, Coverage, Sampling Intensity and Size/Age:***

The SEAMAP (Southeast Area Monitoring and Assessment Program) Fall Plankton survey covers coastal and continental shelf waters from south Texas to south Florida and spans the majority of the spatial extent of king mackerel spawning area in the U.S. Gulf of Mexico (Figure 5.2.1.1.1). The development of the index is described in the document SEDAR16-DW-29.

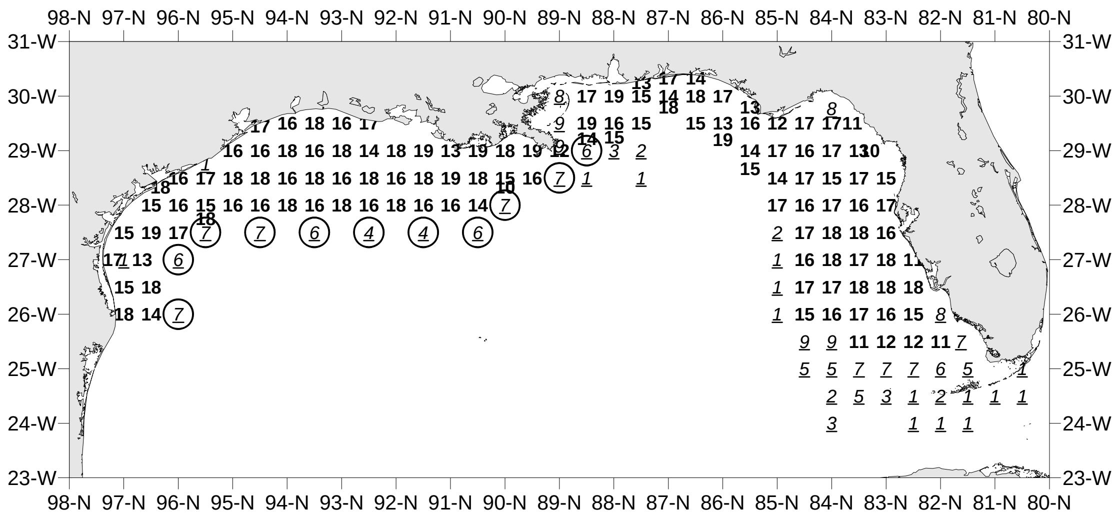



**Figure 5.2.1.1.1** SEAMAP plankton stations denoted by the number of years in which samples were taken at that location during SEAMAP Fall Plankton surveys. Underlined, italicized and circled numbers represent stations where samples were taken in fewer than 10 years of the time series and were not retained in the analysis.

The Fall Plankton survey began in 1986 and continues to be conducted annually. Due to tropical storms, the survey was cancelled in 1998 and 2005. Only bongo net samples from the 1986-1997, 1999-2004 and 2006 SEAMAP Fall Plankton surveys, taken in accordance with the sample design from stations sampled during at least ten years of the time series were used to calculate the king mackerel larval index. The index is based on approximately 110 samples each year. Catches of larvae in bongo net samples are standardized to account for sampling effort and expressed as number of larvae under 10 $m^2$ sea surface.

Larvae captured in bongo nets ranged from 1.3 to 14.1 mm body length with a mean of 3.2 mm. Relative larval abundance is used as a proxy for the abundance of spawners in the Gulf stock unit.

The standardized relative index of larval abundance was estimated using a delta-lognormal approach. The factors Y*ear*, *Region*, *Time of Day* and *Depth* were examined as possible influences on the proportion of positive occurrence and abundance of nonzero larval abundance

***Catch Rates, Uncertainty and Measures of Precision:***
The delta-log normal index and 95% confidence intervals are summarized in Figure 5.2.1.1.2 and Tables 5.1.2. and 5.1.3 The index suggests an increase in larval king mackerel abundance from 1986 to 1995. Since 1995, the relative index varies without obvious trend. Coefficients of variation ranged from 19% to 53%, and averaged 27%.

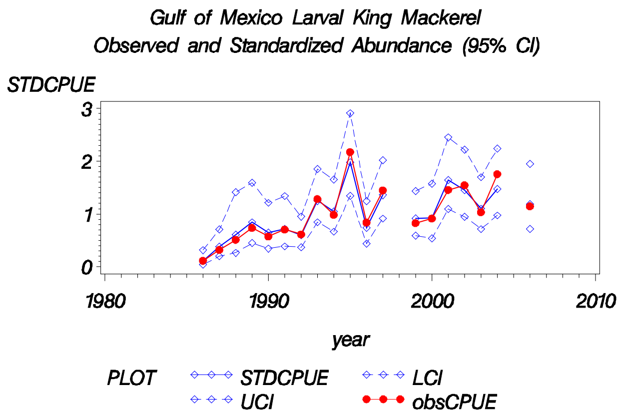



**Figure 5.2.1.1.2.** Delta-lognormal index (solid blue line open symbols) with 95% confidence intervals (dashed lines), and nominal abundance (solid red line) of Gulf of Mexico king mackerel larvae.

***Recommendations / Comments on Adequacy for assessment:***

No concerns were expressed regarding the use of this index. It is appropriate for use for all assessment methods.

### *5.2.1.2 Gulf of Mexico SEAMAP Fall Groundfish Survey*

***Methods, Coverage, Sampling Intensity and Size/Age:***
The standardization of the SEAMAP Fall Groundfish Survey index is described in SEDAR16-DW-08. The basic structure of the modern groundfish surveys (i.e. 1987-present; see SEDAR7-DW1) follows a stratified random station location assignment with strata derived from depth zones, shrimp statistical zones and time of day. At each station, trawling was done with a 40' shrimp survey trawl. Figure 5.2.1.2.1 is a figure depicting the sampling effort during this survey.

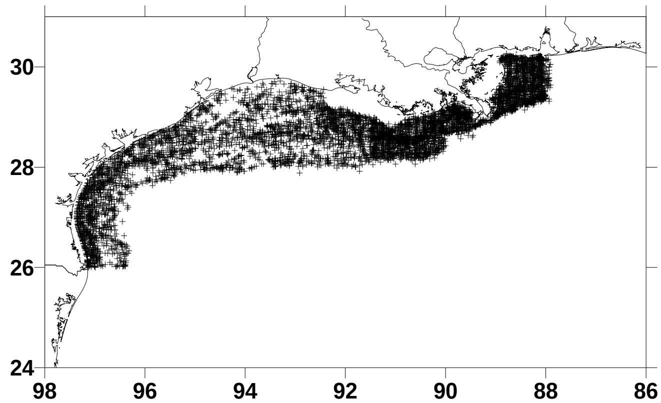



**Figure 5.2.1.2.1.** Survey effort during SEAMAP Fall Groundfish Survey.

In order to incorporate the early groundfish surveys data (i.e. 1972-1986), the data were post stratified into the aforementioned strata used in the modern survey. These strata served as the variables in each submodel of a delta-lognormal approach.

Data were collected from 7090 stations during Fall SEAMAP Groundfish Surveys in the western U.S. Gulf of Mexico from 1972-2007. The number of stations sampled per survey year ranged from 144 in 1980 to 304 in 1985. The number of specimens collected per year ranged from 0 to 215, and ranged in length from 64 to 777 mm fork length with an overall mean fork length of 249 mm. Therefore, the relative index of abundance represents "young-of-the-year" king mackerel in the western Gulf of Mexico.

The standardized index was constructed using a delta-lognormal approach. Catch rates were calculated as CPUE = number of king mackerel per trawl-hour.

***Catch Rates, Uncertainty and Measures of Precision:***

Figure 5.2.1.2.2 and Table 5.1.3 summarize the relative index of "young-of-the year" king mackerel and 95% confidence intervals. Index values generally increase throughout the time-series. Coefficients of variation were generally large, up to 148%, and averaged 46% (Table 5.1.3).

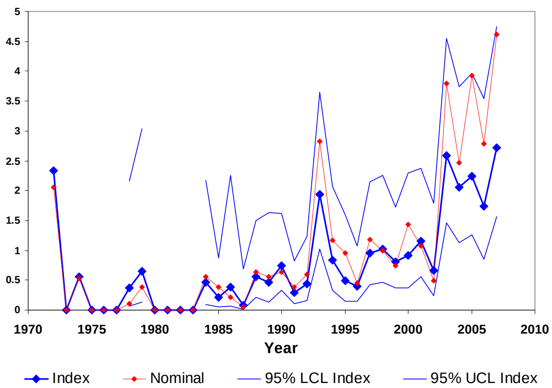



**Figure 5.2.1.2.2.** Index of relative abundance of age-0 king mackerel collected in NOAA Fisheries groundfish trawls in the Gulf of Mexico. Both the index values and the nominal values are scaled to mean of one across the time series. The thin lines represent 95% confidence limits for the scaled index values.

***Recommendations / Comments on Adequacy for assessment:***
A concern raised with this index was that of the ability of a shrimp research trawl to properly sample age-0 king mackerel. However, the group recognizes that this is a fishery-independent survey, and therefore catchability (however small) is unlikely to have changed during the time series. Therefore, the group recommends that the relative index be used for the stock assessment models as indicator or age 0 abundance trends of king mackerel in the Gulf.

For certain years, the relative index estimate is equal to zero because no king mackerel were observed, although sampling continued at a reasonable level. However, the zeros do not imply that abundance was zero, simply that it was too low to observe given absolute abundance and the low catchability of the research trawl. Therefore, the group recommends that the zeros be replaced with a low value, perhaps the minimum observed non-zero value. This index is recommended for use in updated assessment models.

### *5.2.1.3 Gulf of Mexico Small Pelagics Survey*

The standardization of the Gulf of Mexico Small Pelagics Survey index is described in SEDAR16-DW-20. The standardized index was presented to the SEDAR16 working group, and was found to be well documented and constructed using appropriate methods. However, the index was ultimately rejected for the reasons listed below.

***Recommendations / Comments on Adequacy for assessment:***
The index is summarized in Table 5.1.3. The group discussed the following concerns: a) different gear and sampling designs were used between 1996 and 2004, b) changes in spatial and depth coverage through the time series cause a lack of annual continuity. Therefore, the group does not recommend the use of this index.

However, the group strongly recommends that the survey continue using recently standardized methods and recognizes that this survey will be useful in the near future to construct relative indices for age 0-2 king mackerel, as well as other species.

### *5.2.1.4 Atlantic Shallow Water Trawl Survey*

***Methods, Coverage, Sampling Intensity and Size/Age:***
The standardization of the Atlantic Shallow Water Trawl Survey index is described in SEDAR16-DW-09, Anonymous (2007), and SEDAR13-DW1). Samples are taken by trawl from the coastal zone of the South Atlantic Bight (SAB) between Cape Hatteras, North Carolina, and Cape Canaveral, Florida (Figure 5.2.1.4.1).

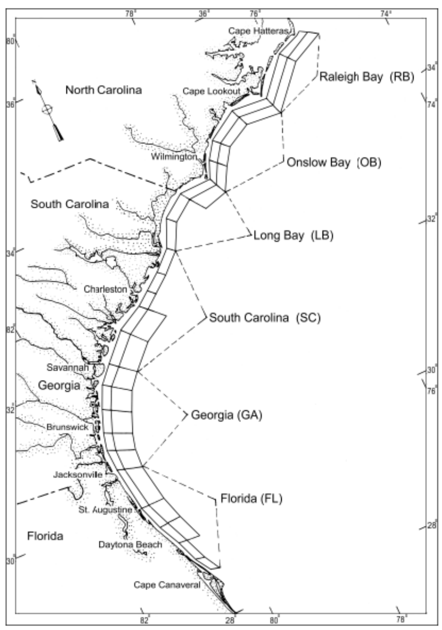



**Figure 5.2.1.4.1** Strata sampled by the SEAMAP Atlantic Shallow Water Trawl Survey.

Multi-legged cruises are conducted in spring (early April - mid-May), summer (mid-July - early August), and fall (October - mid-November). Stations are randomly selected from a pool of stations within each stratum between 4 and 10 m depth contours.

The number of stations sampled per survey year ranged from 102 in 2005 to 306 in years 2001-2003. Due to inconsistencies in survey methods, data from 1986 to 1988 were excluded. The number of specimens collected per year ranged from 270 to 4158, and generally ranged in length from 40 to 430 mm fork length. Size frequency distribution of sample king indicated that this survey catches "young-of-the-year" king mackerel.

The index was constructed using a delta-lognormal standardization procedure, where CPUE was equal to numbers of fish per trawl-hour. The variables evaluated for analyses were year, season, sampling area, depth, and the interactions season*sampling area, and depth*sampling area.

***Catch Rates, Uncertainty and Measures of Precision:***

Figure 5.2.1.4.2 and Table 5.1.3 summarize the relative annual index of abundance and 95% confidence intervals. Largely, the index varies without trend, although it is generally low after 2000. Coefficients of variation ranged from 16% to 49%, and averaged 23% (Table 5.1.3).

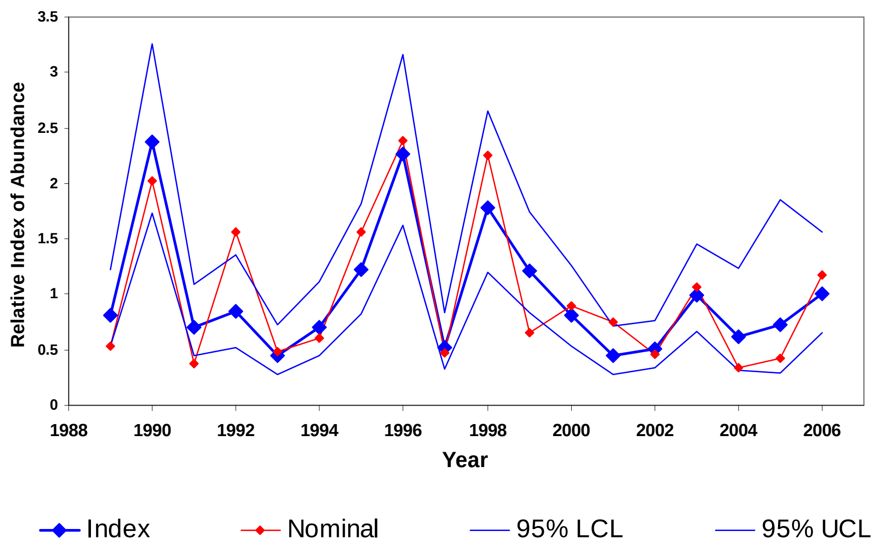



**Figure 5.2.1.4.2.** Index of relative abundance of age-0 king mackerel collected in SEAMAP shallow water trawls in the South Atlantic Bight. Both the index values and the nominal values are scaled to mean of one for the time series.

***Recommendations / Comments on Adequacy for assessment:***

A concern was raised concerning the ability of the research trawl to properly sample small king mackerel. However, the group recognizes that this is a fishery-independent survey, and therefore catchability (however small) is unlikely to have changed during the time series. Additionally, the group considered a paper by Collins et al. (1998) that reported a strong positive correlation between the number of Age-0 king mackerel sampled in the trawl, and abundance at age 1. Therefore, the group recommends that the relative index be used in stock assessment models as indicator of abundance for “young-of-the-year” Atlantic king mackerel.

## 5.2.2. FISHERIES DEPENDENT INDICES

### *5.2.2.1 Headboat Survey*

***Methods, Coverage, Sampling Intensity and Size/Age:***

The standardized index constructed for the headboat fishery is described in SEDAR16-DW-16. Catch and effort data from the Headboat survey was used to generate standardized relative indices of abundance for king mackerel in the Gulf of Mexico and South Atlantic. Rod and reel catch and effort from party (head) boats have been monitored by the NMFS Southeast Zone Headboat Survey (conducted by the NMFS Beaufort Laboratory) since 1973 in the U.S. South Atlantic and 1986 in the U.S Gulf of Mexico.

In the Atlantic region, catch and effort data are available from Cape Lookout, NC southward to the Volusia/Flagler county line in Northeast Florida from 1979-2006. Each year, approximately 2,000 to 4,000 trips are reported. In the Mixing region, data are available for the same years from the Volusia/Flagler county line to the Collier/Monroe county line. Typically, 2,000 to 9,000 trips are reported each year. In the Gulf of Mexico region, data is available from the Collier/Monroe county line to South Texas (Port Isabel) from 1986 to 2006. In this region, 3,000 to 9,000 trips are reported annually.

The standardized indices should be applied to the same size/age range of samples collected from the Headboat fishery, by region (SEDAR16-DW-13, SEDAR16-DW-07).

Eight abundance indices were constructed using the HB dataset, including “Continuity Case” indices developed using the methods of previous assessment, and “Updated Indices”. Updated indices used either a vessel selection procedure (vessels that fished 10+ years), or a trip selection procedure based on species composition (Stephens and MacCall, 2004).

All indices were estimated using a delta-lognormal approach. Factors considered for the binomial and lognormal submodels included: year, season and fishing area. When vessel effects were modeled (all updated indices), they were treated as a “repeated measure” rather than a fixed factor. Catch rates were calculated as: CPUE = Number / 1000 Anglers (Cont. Case) or CPUE = Number / 1000 Angler-Hours (Updated Indices).

***Catch Rates, Uncertainty and Measures of Precision:***

The standardized relative indices of abundance constructed for the Continuity Case are shown in Figure 5.2.2.1.1 and Tables 5.1.2. In the Atlantic, the index varies without obvious trend. In the Gulf, the relative index has generally increased since 1988. For both indices, coefficients of variation were similar, ranging from 22% to 35% (Table 5.1.2).

a) Cont. Case: Atlantic Migratory Group b) Cont. Case: Gulf Migratory Group

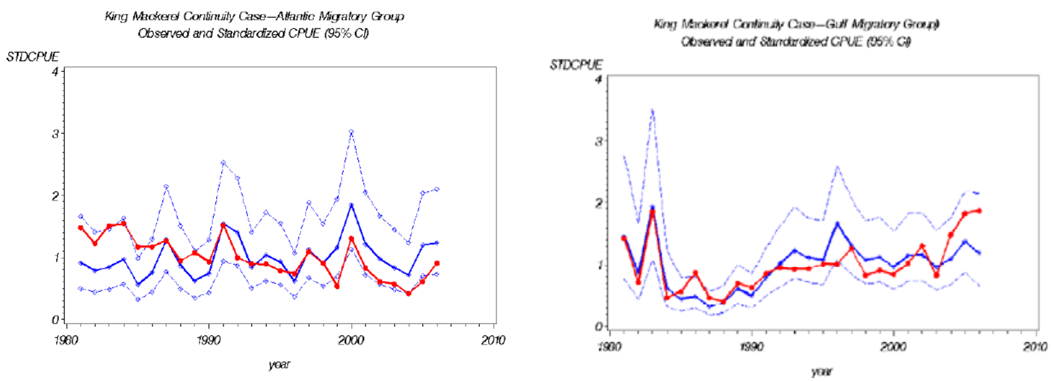



**Figure 5.2.2.1.1.** Standardized (blue) and nominal (red) CPUE with 95% confidence intervals for a) the Atlantic migratory group and the b) Gulf migratory group.

***Recommendations / Comments on adequacy for assessment:***

The working group was concerned about the effect of management regulations on the standardized index, and the effect of the trip selection procedure (Stephens and MacCall, 2004). Therefore, the group made the following recommendations:

1) Ensure that the sampling coverage annually, seasonally and by fishing area is not significantly degraded by the trip selection procedure. If the distribution of samples remains adequate, the working group recommends the use of the updated indices developed using the Stephens and MacCall (2004) trip selection.

2) Examine the impact of management regulations, particularly the bag limit. Determine what fraction of trips reach the bag limit, by year and other pertinent factors.

3) To the extent necessary and /or possible, construct indices that take into account management regulations.

4) Provide advice regarding the adequacy of the headboat index for updated assessment models.

5) The "continuity case" indices are recommended for use for continuity assessment model runs.

***Updated indices: Completed March 21, 2008.***

The working group requested an examination of the effect of bag limits on the catch rates of king mackerel. It was found that the bag limits generally do not restrict the catch rates of king mackerel by headboats (SEDAR16-AW-02).

Updated indices were constructed as per the recommendations of the working group and SEDAR 16 plenary session. These indices are summarized in Figure 5.2.2.1.2 and Table 5.1.3. A full description of the updated indices is available in SEDAR16-DW-16 Appendix 1. Largely, the indices vary without obvious trend. Coefficients of variation were largest for the Atlantic-no-mixing index, ranging from 21% to 49%, and smallest for the Gulf-no-mixing index, ranging from 13% to 19%.

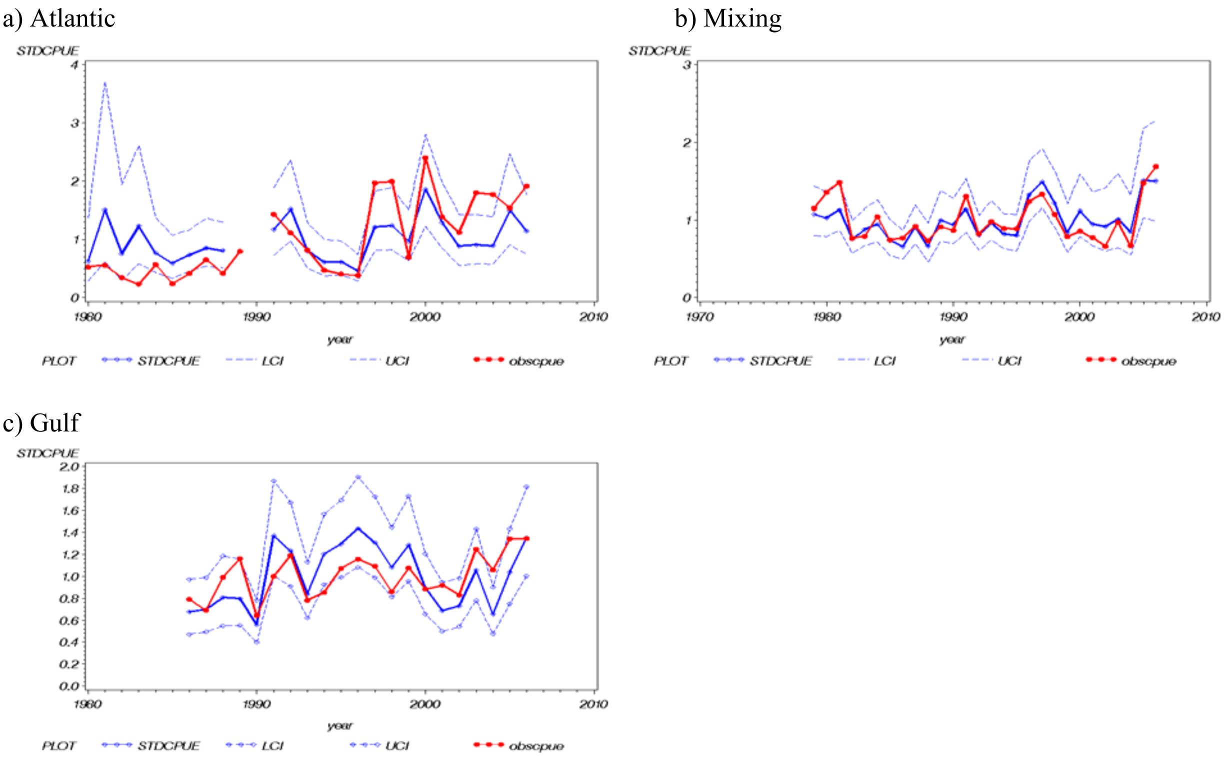



**Figure 5.2.2.1.2.** Standardized (blue) and nominal (red) CPUE with 95% confidence intervals for a) the Atlantic, b) mixing zone and c) Gulf of Mexico.

### *5.2.2.2 Marine Recreational Fisheries Statistical Survey*(MRFSS)

#### *Methods, Coverage, Sampling Intensity and Size/Age:*

Catch and effort data from the US Marine Recreational Fisheries Statistical Survey of the Atlantic coast and Gulf of Mexico (excluding Texas) were used to update the relative indices of abundance for king mackerel Gulf of Mexico and Atlantic stocks (SEDAR16-DW-14). The MRFSS data includes estimates of catch and effort from 1981 through 2007, from Louisiana through Maine. Before 1985, 1,000 to 6,000 trips were interviewed each year in the Atlantic, Mixing and Gulf regions. After 1985, 10,000 to 40,000 trips were interviewed each year.

Standardized catch rates were estimated using a Generalized Linear Mixed modeling approach assuming a delta-lognormal error distribution. The explanatory variables considered for standardization included: geographical area, seasonal trimesters, fishing target species, and mode (inshore, charter or private/rental boat). Fishing effort was estimated as the number of anglers times the number of hours fishing; nominal catch rates were defined as the total catch kept and released (AB1B2, number of fish) per thousand angler hours.

Indices of abundance were estimated for the king mackerel Gulf of Mexico and Atlantic migratory groups (Continuity Case) as well as by regions based on SEDAR5 recommendations (Updated Indices: Atlantic-no mixing, Mixing Zone and Gulf-no Mixing)

The standardized indices should be applied to the same size/age range of samples collected from the PB and CB recreational modes, by region (SEDAR16-DW-13, SEDAR16-DW-07).

***Catch Rates, Uncertainty and Measures of Precision:***

The MRFSS indices and 95% confidence intervals are summarized in Figure 5.2.2.2.1 and Tables 5.1.2. and 5.1.3. Coefficients of variation were highest for the Atlantic-no-Mixing zone, ranging from 53 to 77%. The lowest coefficients of variation were estimated for the Gulf of Mexico and mixing zone indices. They generally ranged from 20 to 40%.

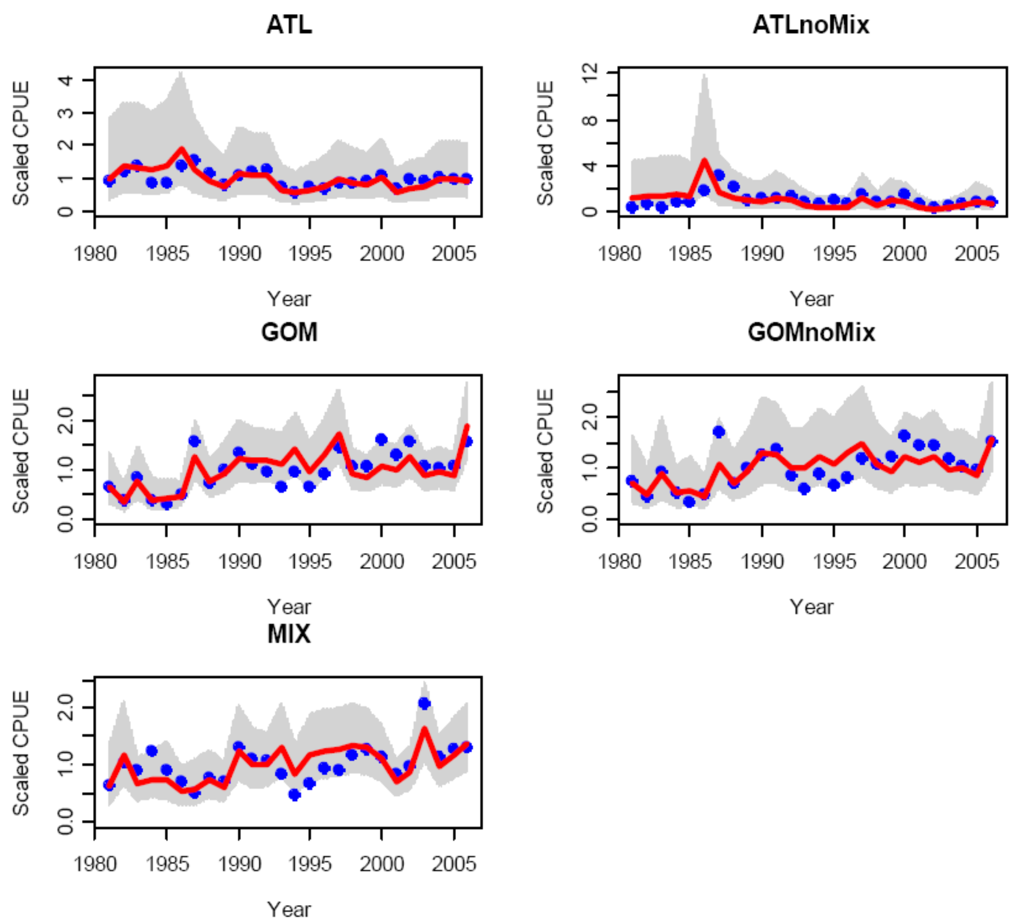



**Figure 5.2.2.2.1** Nominal and standardized CPUE trends for king mackerel stocks by migratory group (ATL, GOM) and regions (ATL no mix, GOM no mix and mixing zone). Shaded area represents estimated 95% confidence intervals.

***Recommendations / Comments on adequacy for assessment:***
The working group was concerned about the effect of management regulations on the standardized index. Therefore, the group made the following recommendations:

1) Examine the impact of management regulations, particularly the bag limit. Determine what fraction of trips reach the bag limit, by year and other pertinent factors.
2) To the extent necessary and /or possible, construct indices that take into account management regulations.
3) Provide advice regarding the adequacy of the MRFSS index for updated assessment models.
4) The "continuity case" indices are recommended for use for continuity assessment model runs.

***Updated indices:*** The bag limit was examined, and found not to limit the catch rates of king mackerel (SEDAR16-AW-02) by anglers on private and charter boats. Therefore, the indices are considered final at this time.

### *5.2.2.3 North Carolina Commercial Fisheries Trip Ticket*

***Methods, Coverage, Sampling Intensity and Size/Age:***

Catch and effort data from the North Carolina commercial fisheries was used to construct a relative index of abundance for Atlantic king mackerel, as described in the document SEDAR16-DW-11.

The Trip Ticket Program summarizes all commercial selling activity in the state of North Carolina, for both offshore and inshore fisheries from 1994 to 2007. Each observation represents the catch or sales of a single trip by species. Analyses took into account not only trips targeting mackerels, but also other coastal pelagic species likely associated with the catch of mackerels.

Only offshore trips using rod and reel and/or trolling gears, were selected for analysis. With this subset, an analysis of species composition catch was carried out to identify trips with a positive likelihood of catching king mackerel following the Stephens and MacCall (2004) approach. For the catch rate analyses, the date were further restricted to those vessels (PIDs) with a history of 8 or more years of catch reported for king mackerel. After the restrictions, the analysis dataset included 1,600 to 2,600 trip records each year.

The standardized indices should be applied to the same size/age range of samples collected from the NC commercial fishery (SEDAR16-DW-13, SEDAR16-DW-07).

Relative indices of abundance were estimated using a Generalized Linear Mixed Modeling (GLMM) approach using a delta lognormal model error distribution. The explanatory variables considered were year and season. Catch rates were calculated as: CPUE = pounds of king mackerel per trip.

***Catch Rates, Uncertainty and Measures of Precision:***

The relative index of abundance from the North Carolina commercial fisheries trip ticket fishery, and 95% confidence intervals are summarized in Figure 5.2.2.3.1 and Tables 5.1.2. and 5.1.3.

Sensitivity analyses indicate that the variability within vessels or "PID" accounts for a large proportion of the variance in nominal catch rates (Figure 5.2.2.3.1, blue lines). The evaluation of vessel ID and their catch history indicated that there is a selective set of the fleet that commonly targets king mackerel. The PID8+ index reflects these vessels. The coefficients of variation for the PID8+ index were very small, less than 10% (Tables 5.1.2 and 5.1.3).

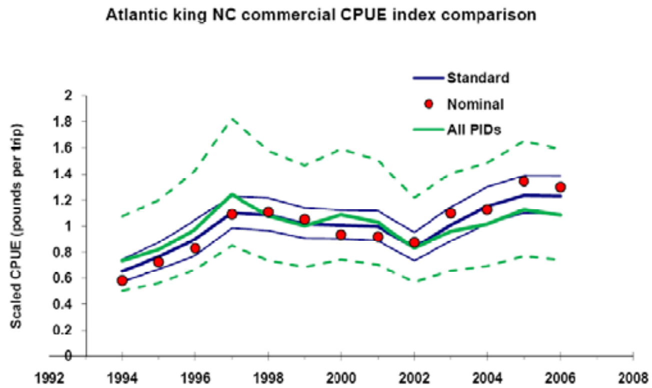



**Figure 5.2.2.3.1.** Comparison of standard indices of abundance for king mackerel estimated with all PID-vessels (green lines) or restricting the information to only those PID-vessels that have 8 or more years of reported catch of king mackerel (blue lines).

***Updated indices:*** The bag limit was examined, and found not to limit the catch rates of king mackerel (SEDAR16-AW-02) by commercial vessels of North Carolina. Therefore, the indices are considered final at this time.

***Recommendations / Comments on adequacy for assessment:***

The working group was concerned about the effect of management regulations on the standardized index. Therefore, the group made the following recommendations:

1) Examine the impact of management regulations, particularly the trip limits. Determine what fraction of trips reach the trip limit, by year and other pertinent factors.
2) To the extent necessary and /or possible, construct indices that take into account management regulations.
3) Provide advice regarding the adequacy of the NC trip ticket index for updated assessment models.
4) The “PID8+” index is recommended for use for continuity assessment model runs.

### *5.2.2.4 Florida Commercial Trip Ticket*

***Methods, Coverage, Sampling Intensity and Size/Age:***

Indices of king mackerel abundance derived from Florida commercial trip tickets were presented to the Data Workshop (SEDAR16-DW-4). Since 1984, fish dealers in Florida have been required to fill out a marine fisheries trip ticket documenting catch and effort for each commercial fishing trip that they handle or purchase from fisherman. Data from 1986 onwards is used in these indices.

The first three indices represent "continuity" case indices obtained with the same methods used for the 2003 king mackerel stock assessment. Three additional indices, one for each zone (Atlantic, Mixing and Gulf of Mexico) were constructed from Florida Trip ticket data, and intended for use in updated model runs. However, the group made substantial recommendation to improve these indices. As these indices are pending completion, the methods and results are not presented in this report.

***"Continuity cases"***

Three indices, two for the Gulf of Mexico and one for the Atlantic migratory group were constructed using similar methodology and the same SAS GLM code as the previous assessment (Ortiz, 2003, Bob Muller pers comm). The area of coverage for each index is shown in Figure 5.2.2.4.1.

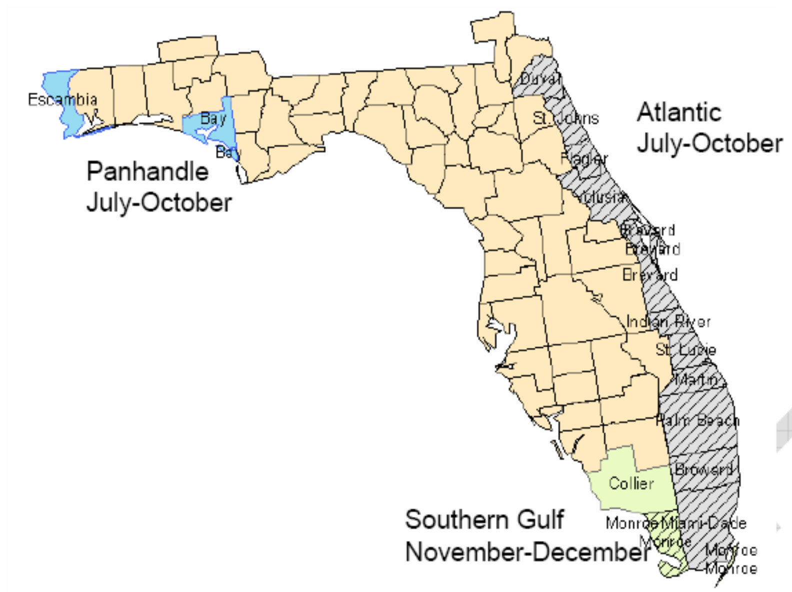



**Figure 5.2.2.4.1.** Locations and seasons for the continuity case trip ticket indices.

These indices were constructed using a lognormal model on catch rates of positive trips. Factors considered in the analysis included year, month and county. Catch rates were calculated in pounds per day, assuming that every record represents a 12 hour day if the time fished was recorded in days, or as a fraction of a 12 hour day if time fished was recorded in hours. Only single day trips and hook and line or unknown gear types were used. Months and counties included in the indices (Figure 5.2.2.4.1) follow the recommendations of the 1996 1997 MSAP (Mackerel Stock Assessment Panel) and are designed to be most representative of the migratory components of the stock and to reflect times and locations less influenced by catch restrictions and time/area closures.

As in the 2003 index, unknown gear types are included which allows extension of the time series back to 1986, as gear was not recorded prior to 1991. Unfortunately, this procedure allows the inclusion of some very high run-around gill net catches. We attempted to remove these catches by excluding data if the Studentized residuals were ≥ 3.0

The analysis data set used to construct the "Panhandle" index generally contained 100 to 800 trips per year, although 70 or fewer were available in 1986, 1987 and 1989. The "Southern Gulf" dataset contained 191 to 874 trips per year. The dataset used for the "Atlantic" index contained many more trips, 4,000 to 8,000 each year.

As in the previous assessment, The "Panhandle" index should be applied to ages 3 through 6. The "Southern Gulf" index should be applied to ages 3 through 8, and the "Atlantic" index should be applied to ages 2 – 11+.

***Catch Rates, Uncertainty and Measures of Precision:***

The continuity indices and 95% confidence intervals are summarized in Figure 5.2.2.4.2. and Table 5.1.2. Coefficients of variation were very small (typically less than 2%), in large part because these indices used lognormal models on the catch rates of positive trips (Table 5.1.2). This method generally results in lower CVs than a delta-lognormal approach.

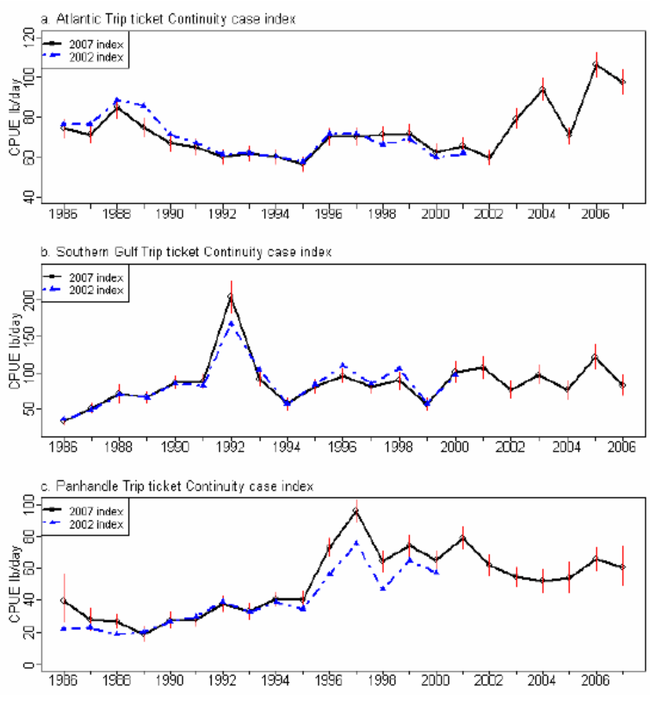



**Figure 5.2.2.4.2.** Standardized indices of king mackerel abundance for the continuity case indices.

***Recommendations / Comments on adequacy for assessment:***

The “continuity case” indices are complete and should be used for SEDAR16 continuity case assessment model runs. The working group made the following recommendations for the development of “updated” indices:

1) Examine the impact of management regulations, particularly the trip limits. Determine what fraction of trips reach the trip limit, by year and other pertinent factors.
2) To the extent necessary and /or possible, construct indices that take into account management regulations.
3) Provide advice regarding the adequacy of the trip ticket indices for updated assessment models.

If the trip ticket indices are determined to be appropriate for use, given the regulatory history, the group recommended that:

1) Revised trip ticket indices be constructed for the Atlantic, Mixing Zone and Gulf of Mexico that includes commercial effort from FL, AL and LA, GA, SC and NC as appropriate.
2) The indices should be constructed using a trip selection procedure (Stephens and MacCall, 2004) or vessel selection procedure to eliminate effort in non-pelagic habitats.
3) The indices be standardized using a delta-lognormal procedure.

The group also expressed concerns that the trip ticket data begins in different years by state (SC: 2004, GA: 2001, AL: 2002, MS; none, LA: 2000,TX: 2007). If CPUE or PPT varies by state and by year, the effects will be confounded. It is not clear how sensitive the results will be to the confounded variables.

These indices, if they can be constructed, should be presented to the SEDAR16 panel for further consideration, and may be appropriate for inclusion in updated assessment models.

### *5.2.2.5 Commercial logbook indices*

Available catch per unit effort (CPUE) data reported to the coastal logbook program from 1993 - 2006 was used to develop relative indices of abundance for king mackerel. A complete description of methodology and results are provided in SEDAR16-DW-22. However, because king mackerel were not required to be reported before 1998, and due to unavailability of the king mackerel commercial fishing regulations prior to the SEDAR 16 data workshop, the working group recommended that the commercial indices, as constructed, not be used in the king mackerel assessment, for the reasons listed below.

***Recommendations / Comments on adequacy for assessment:***

The revised commercial indices should:

1) Examine the impact of management regulations, particularly the trip limits. Determine what fraction of trips reach the trip limit, by year and other pertinent factors.
2) To the extent necessary and /or possible, construct indices that take into account management regulations.
3) An unknown level of effort and landings were reported to the coastal logbook program prior to 1998, therefore the group recommends an attempt to extend the time series (to 1993-2006) by modeling vessel effect as a repeated measure when constructing indices of abundance.
4) Provide advice regarding the adequacy of the commercial indices for updated assessment models.
5) The standardized indices should be applied to the same size/age range of samples collected commercial fishery, by region (SEDAR16-DW-13, SEDAR16-DW-07).

### *5.2.2.6. Commercial Shrimp Trawl Bycatch*

***Methods, Coverage, Sampling Intensity and Size/Age:***

NOAA Fisheries conducts a shrimp trawl bycatch research program to identify and minimize the impacts of shrimp trawling on federally-managed species in the US Gulf of Mexico and southeastern Atlantic. A relative index of abundance for "Gulf of Mexico" king mackerel was constructed using data from collected by this program, as described in SEDAR16-DW-05.

Each year, 395 to 5000 shrimping trips were observed, predominantly in the Western Gulf of Mexico. Typically, less than 100 king mackerel were observed each year (min = 0 in 1983, max = 730 in 1993). The king mackerel observed were generally quite small, and were thought to be "young-of-the-year" individuals.

The index was constructed using a delta-lognormal approach. Catch rates were calculated as number per trip.

***Catch Rates, Uncertainty and Measures of Precision:***

The relative index is summarized in Figure 5.2.2.6.1 and Table 5.1.2. Catch rates generally increase during the time series. Coefficients of variation ranged from 24 to 82%, and were typically higher in the early years of the time series (Table 5.1.2).

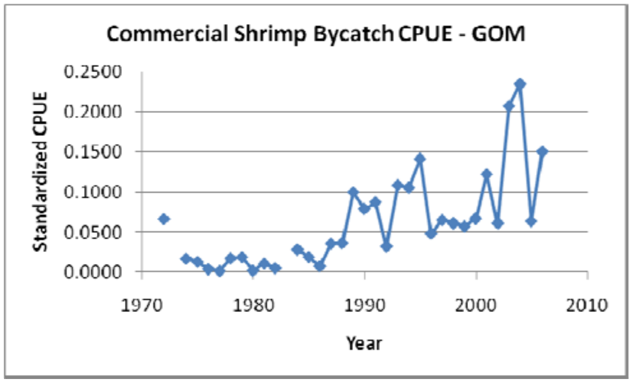



**Figure 5.2.2.6.1.** Standardized CPUE estimates from the commercial shrimp bycatch of king mackerel.

***Recommendations / Comments on adequacy for assessment:***

This index was constructed for use in continuity case models, and should be used as such. The group recommends that updated models use the fishery-independent SEAMAP trawl survey index instead.

### *5.2.2.7. Southeast Shark Drift Gillnet Fishery*

This development of the index is described in detail in SEDAR16-DW-01

The number of drift gillnet vessels has decreased from about 12 in 1990 to about 6, depending on the market value of sharks and the level of activity in other fisheries. Information on this fishery was collected using on-board NMFS-approved contract observers. The number of trips observed each year was quite small, generally ranging from 24 to 80. However, fewer than 10 trips were observed in 1993, 1995, 1998 and 2006. The size range of landed king mackerel was not reported.

***Recommendations / Comments on adequacy for assessment:***

The index is summarized in Table 5.1.3. The group discussed the reliability of this index and expressed concerns due to: a) changes in target species of the fishery from mackerels and other pelagic towards sharks in the latest years, b)sparse or a complete lack of sampling in some years, and c) continuity of series trend through the time series. The group recommended that this index be not used in the assessment models until further verification and analysis are conducted.

## *5.3. CONSENSUS RECOMMENDATIONS AND SURVEY EVALUATIONS*

### 5.3.1. Comments and recommendations for fishery-independent indices

The main topics of discussion in the WG regarding fishery independent indices were:

2) Catchability of research gear for sampling king mackerel
2) Changes in the sampling design, spatial-depth coverage, and gear modifications.

Discussion in the working group focused on the ability of the sampling gear used in these surveys to catch king mackerel. Most surveys are targeting bottom or near bottom species, and mackerels in general show more an epipelagic distribution. Another issue was changes in the survey design, spatial coverage, and in some cases, sampling gear. Unfortunately, these changes occurred without an evaluation of their effects on data products.

The working group recognized the increase in the number of fishery independent indices for king mackerel. During the last assessment (SEDAR 5) only one independent index was recommended for the Gulf king assessment. For the 2008 assessment, and following the recommendations from past review panels, at least 4 indices of abundance were presented from independent fishery surveys. Unfortunately, most were restricted to the Gulf of Mexico region, and sampled young-of-the-year individuals.

Consensus recommendations regarding usage are summarized in Table 5.1.2.

### 5.3.2. Discussion of Fishery-Dependent Indices of Abundance

The working group discussed the following topics regarding standardized indices of abundance from fishery dependent sources:

1) Impact of management regulations on the standardization and reliability of fishery dependent data, and adequacy of fishery-dependent data to construct relative indices of abundance.
2) Selection of observations with effective fishing effort towards king mackerel.

Since the implementation of the coastal pelagics FMP in 1983, king mackerel stocks have been subject to numerous management regulations, both in the recreational and commercial fisheries (***Appendix 3 – Summary of management regulations***). A 12-inch (FL) minimum size restriction was established in 1990 for commercial and recreational landings. This was later increased to 20' in 1992 and then 24' in 1999. The changes in minimum size affect both commercial and recreational indices of abundance, and because the different size regulations don't overlap in time, it is not possible to directly compare effects associated with minimum size changes during index standardization procedures. One exception is the MRFSS index, because standardized catch rates include both landed (AB1 catch) and discarded (B2) catch. The commercial and headboat indices include only landed catch. These indices could be adversely affected by changes in size limits, particularly if the fraction of discarded fish below minimum size is large.

The working group recognized that assessment models can and will take into account, minimum size changes, and can compensate for those effects within the model. Basically, these models would assume a shift in the selectivity pattern of the retained catch and adjust for changes in biomass trends accounting for the minimum size regulation, making the relative indices of abundance appropriate for use in the model.

King mackerel recreational landings are also limited by regulation is the bag limits. Bag limits were first implemented in 1986, and have varied between 2, 3 and 5 fish per angler (Appendix 3 – Summary of management regulations). Some additional allowances were made at times to allow retention of catch by captain and crew, and a doubling of the bag limit on multiday trips. Again, there is no time overlap between bag limit regulations, and therefore it is unfeasible for the standardization method to account for this factor.

Current stock assessment models for king mackerel have no direct methodology for incorporating these bag limit restrictions. Again the MRFSS index is likely to be less affected because it includes both retained and released catch. However in discussion with recreational fishers at the meeting, they point out that bag limits may influence their behavior, switching effort towards other species once the king bag limit is reached. The working group recommended that analyses be carried out to determine the impact of bag limits on MRFSS and Headboat catch rates, prior to the assessment evaluation.

Commercial and recreational fisheries have been also regulated by TAC since 1985. Commercial TACs have been further allocated between eastern and western Gulf, and by regions (northern Gulf and southern Florida partition). Because of the migratory behavior of the stock and the seasonality of the fishery, these allocations were also further restricted by trip limits and closed seasons once the corresponding allocated TAC was reached in a given region. Appendix 3 – Summary of management regulations shows the effective times of closures (by fishing year and region) for king mackerel since the 1985/86 fishing year. Trip limits of 15, 25 and 50 fish per trips have occurred, as well as limits by weight landed, from 500 lbs to 3500 lbs per trip. These regulations, aimed to control an overexploited stock, particularly in the U.S. Gulf of Mexico, created havoc for standardization of catch rates from commercial fisheries.

In past assessments, standardized catch rates were restricted to certain areas and months, mainly to avoid these trip limit and closed season effects. The group discussed several approaches that may limit or exclude trips affected by the regulations. For example, the logbook commercial index effectively excludes vessels that have smaller catches of king mackerel (accounting for less than 20% of overall landings), and those that reported sporadic catches of king mackerel (few years of history catch). A similar approach was used in the trip ticket data for North Carolina. That analysis showed that a large proportion of the observed variability in catch rates was between vessels, and significant reduction of variance was achieved when restricting to vessels with several years of catch and large component of king mackerel in their total landings. The objective of these approaches is to select sampling units (vessels) that have consistently fished for king mackerel through the time-series, and account for a large fraction of the total landings. Once identified, it is desireable to use the effort and catch of these units (including trips that did not catch king mackerel) as input for construction of relative indices of abundance.

The working group recommended that analyses be carried out to determine the impact of commercial trip limit regulations on 1) average length of a trip (when no effective fishing hour units are available), proportions of trips that reached limits by region and season, and 3) proportion of total catch that is king mackerel, by trip.

Finally, the working group discussed methods to select trips/observations from fishery dependent data that represent effort targeting king mackerel, whether or not the trip actually observed king mackerel. It is recognized that restricting data to observations with positive catches of king mackerel is likely to bias catch rates because it ignores unsuccessful fishing effort. Past assessments recommended procedures for selecting observations that represent fishing effort directed towards king mackerel, including species composition analyses, and vessel-based approaches, amongst others. Trip selection based on species composition was used to construct the Headboat recreational index, Trip ticket North Carolina commercial index, and MRFSS recreational index. The first two indices used the Stephens and MacCall (2004) species composition approach, where observations were selected according to the positive correlation of species catch composition. Diagnostics and model results indicated that, for these fisheries, this approach is effective and appropriate. Therefore, the group recommended using indices derived with this methodology. In the case of MRFSS index, the species composition approach used groups of species ("guilds") likely associated based on habitat distribution. For king mackerel, shore and shark guilds groups were excluded, while the offshore pelagic guild had the highest catch rates of king mackerel. The group recommended that similar approaches be explored for other fishery dependent indices such as the Florida commercial fisheries.

Consensus recommendations regarding usage are summarized in Tables 5.1.2. and 5.1.3.

## *5.4. RESEARCH RECOMMENDATIONS*

The index working group recommends that:

1) Fisheries Independent sampling efforts should continued and be expanded, with increased emphasis on created fisheries-independent surveys in the South Atlantic.

2) Current fisheries independent surveys sample mostly Ages 0 and 1. Programs should be developed or expanded to obtain fisheries independent abundance estimates for older king mackerel (Ages 2+) more commonly landed by the directed fisheries. These programs should not impact current fisheries-independent survey methodologies.

3) An effort should be made to estimate changes in catchability. Previous SEDAR assessments of other species have used a linear increase in catchability. Assessment model results are likely to be sensitive to the functional shape and magnitude of the change in catchability. However, these functions are not well understood.

4) Research into methods to directly accommodate regulatory changes (i.e. bag limits and trip limits) within index standardization procedures is greatly needed. A possible technique to address changes in bag/trip limits is the truncated negative binomial distribution. This technique will be examined in the future to determine its applicability to fisheries dependent indices of abundance.

5) Research to incorporate environmental variables into CPUE indices is also of potential importance.

## *5.5. ITEMIZED LIST OF TASKS FOR COMPLETION*

Also see detailed recommendations for each index (section 5.2).

### 5.5.1. SEAMAP Fall Plankton Survey

*Continuity Case and base indices are complete. For sensitivity runs,*

Construct Eastern GOM indices.

**Contact:** David S. Hanisko (NMFS Pascagoula)

**Expected Date of Completion:** April 4, 2008

### 5.5.2. SEAMAP Groundfish Survey

*None - Complete*

**Contact:** Walter Ingram (NMFS Pascagoula)

### 5.5.3. Small Pelagic Survey

*Complete – Not recommended for use at this time.*

### 5.5.4. South Atlantic Shallow Water Trawl Survey

*Construct quarterly indices.*

**Contact:** Walter Ingram (NMFS Pascagoula)

**Expected Date of Completion:** April 4, 2008

### 5.5.5. Headboat

*Complete as of March 21, 2008*
**Contact:** Shannon L. Cass-Calay (NMFS Miami)

### 5.5.6. MRFSS

*Complete as of March 15, 2008.*
**Contact:** Mauricio Ortiz (NMFS Miami)

### 5.5.7. N.C. Trip Ticket

*Complete as of March 21, 2008.*
**Contact:** Mauricio Ortiz (NMFS Miami)

### 5.5.8. FL. Trip Ticket Indices

*Continuity Case indices are complete. For updated models, see Section 5.5.9.*

### 5.5.9. Trip Ticket Indices for updated model runs

*For base runs:*

1) Examine impact of management regulations.
2) Make recommendations regarding appropriate use of trip ticket indices given management regulations.
3) If an index is possible given the management history:
    a. Include trips from all states (TX, LA, AL, FL, GA, SC, NC)
    b. Exclude effort during closures.
    c. Construct delta-lognormal indices (by region: Atl, Mix, Gulf) that use a vessel or trip selection procedure to reduce inclusion of non-targeted trips. Calculate index estimate in annual and quarterly time stamps

*For sensitivity runs:*

   d. Construct delta-lognormal index for EGOM in annual and quarterly time stamps

**Contact:** John Walter (NMFS Miami)

**Expected Date of Completion:** April 4, 2008 (Items 1-3c). May 2008 (Item 3d).

### 5.5.10. Commercial Logbook Indices

*Not used in Cont. Case. For updated base runs:*

1) Examine impact of management regulations.
2) Make recommendations regarding appropriate use of commercial indices given management regulations.
3) Any index constructed should:
    a. Exclude effort during closures.
    b. Calculate index estimates in annual and quarterly time stamps
    c. Attempt to extend time series to 1993, if appropriate.

*For sensitivity runs:*

   d. Construct delta-lognormal indices for EGOM in annual and quarterly time stamps

**Contact:** Kevin McCarthy (NMFS Miami)

**Expected Date of Completion:** April 4, 2008 (Items 1-3c). May 2008 (Item 3d).

### 5.5.11. Commercial Shrimp Trawl Bycatch

*Complete: Not recommended for use at this time.*

**Contact: Kate Siegfried (NMFS, Panama City)**

### 5.5.12. Southeast Shark Drift Gillnet Bycatch:

*Complete: Not recommended for use at this time.*

**Contact: John Carlson (NMFS Panama City)**

## *5.6. LITERATURE CITED*


ANONYMOUS. 2007. SEAMAP-SA Shallow Water Trawl Survey. Southeast Data, Assessment and Review, Document SEDAR13-DW-01.

Collins, M. R., P. J. Harris and P.P Maier. 1998. Fishery-Independent Recruitment Indices for King and Spanish Mackerels. N. Amer. J. Fish. Management. 18: 181-186.

Ortiz, M. 2003. Standardized catch rates of king (*Scomberomorus cavalla*) and Spanish mackerel (*S.maculatus)* from U.S. Gulf of Mexico and South Atlantic recreational fisheries. National Marine Fisheries Service, Southeast Fisheries Science Center, Sustainable Fisheries Division Contribution SFD-02/03-006.

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70:299-310.

## 6. APPENDICES

### Appendix 1 to the SEDAR 16 Data Workshop Recreational Data Section

# Procedures Used to Update Recreational King Mackerel Catch Following Recommendations of the SEDAR 16 Data Workshop

Vivian Matter and Patty Phares

This document was prepared in order to describe the details of the procedures used to implement the recommendations of the SEDAR 16 Data Workshop for updating King Mackerel catch information.

***1) Use the MRFSS For-Hire Survey (FHS) for Charterboat or Charterboat+Headboat modes ("new charterboat method") from MRFSS where available. Calibrate the pre-FHS traditional MRFSS estimates ("old charterboat method") to correspond to the FHS.***

The calibration factors are from Diaz and Phares (2004) for the Gulf, and Sminkey (2008) for the South Atlantic. There are no calibration factors for the Mid/North Atlantic, but the Cbt+Hbt catches are very small. *Prior assessments used the traditional MRFSS charterboat and Cbt+Hbt estimates in all regions.*

The current MRFSS charterboat or Cbt+Hbt estimates are:

Gulf: calibrated for 1981-1997; FHS for1998+

FLE: calibrated for 1981-2002; FHS for 2003+
S. Atl (GA, SC, and NC): calibrated for 1981-2003; FHS for 2004+

Mid-north Atl (VA and north): traditional MRFSS Cbt+Hbt for 1981-2003 (no calibration available); FHS for 2004+

***2) Use MRFSS estimates stratified by regions within Florida west and east coasts.***

The charterboat mode from the For-Hire Survey is stratified by the survey design, and estimates for modes and years not covered by the FHS have been post-stratified by Tom Sminkey (MRFSS). These Florida regions (fl_reg) allow the MRFSS catch estimates to be divided according to the migratory group definitions, whereas the official MRFSS coastwide FL estimates do not. *Prior assessments used coastwide FL MRFSS estimates and always assigned*

*NE FL to the same migratory group as Volusia-Dade Counties (mixing zone) and always assigned the Keys to the Gulf migratory group.*

(Note: The sum of the post-stratified estimates will not match the official MRFSS coastwide estimates.)

Florida regions in the stratified estimates:

fl_reg=1 (FLW) NW Panhandle: Escambia - Dixie Counties

fl_reg=2 (FLW) SW Peninsula: Suwannee - Collier Counties

fl_reg=3 (FLW) Keys: Monroe County

fl_reg=4 (FLE) SE: Nassau - Flagler Counties

fl_reg=5 (FLE) NE: Volusia - Miami-Dade Counties

***3) Re-estimate substitutes for MRFSS 1981, wave 1 (missing in the MRFSS survey).***

Fill in the missing estimates by using the average ratio of wave 1 to wave 2-6 MRFSS estimates from 1982-1984 by state, mode, and area after the adjustments made above (calibrated Cbt+Hbt and stratified FL).

***4) Texas. Use TPWD high/low-use season private and charterboat estimates as the standard estimates. Replace all previous estimates used to fill in missing cells in 1981-1985. Estimate live releases ("B2 catch") (not available from the TPWD survey for all years).***

TPWD high/low-use season estimates for private and charterboats are used as the basis for monthly estimates for 1983+. The division into months (by SEFSC) is in proportion to observed fish ("Fish files") from the TPWD. 1981-1982 private and charterboat are treated as "missing cells" from the TPWD survey and substitutes are calculated based on trends in 1983-1985. Although MRFSS had some private and Cbt+Hbt estimates in 1981 and 1985, these are not used (eliminate from the MRFSS data sources). *Prior assessments used TPWD estimates by wave (which are being discontinued by TPWD) and filled in for missing cells using different procedures.*

TPWD does not cover shore mode. TX shore mode was included in MRFSS in 1981-1985 but very few king mackerel were observed. A large estimate based on 1 trip in 1981 is removed as an outlier. Two other small shore mode estimates in other years are kept, but since the average is so close to 0, shore mode is assumed to be 0 for all years after MRFSS was discontinued in TX (1986+). *The only change from prior assessments for shore mode is eliminating the MRFSS outlier in 1981.*

Headboat catches for TX in 1981-1985 are calculated as the mean annual Headboat Survey landings for TX in 1986-1988 and distributed into months using the distribution of pooled estimates for 1986-1988. HBS estimates are used for TX in 1986+. *Prior assessments used headboat mode estimates from TPWD for 1983-1984 and also used them as a basis for substitutes for missing cells in 1981-1985, but TPWD headboat estimates are not provided in the high/low-use season estimates.*

Estimates of live releases ("B2 catch" in MRFSS) are not available from TPWD or the HBS but are estimated for TX using Gulf-wide (without FL Keys) MRFSS ratios of B2/A+B1 catch by year, wave and mode. The MRFSS Cbt+Hbt ratios are applied to both charterboat and headboat catch estimates in 1981-1985. If there are no corresponding MRFSS estimates (A+B1 or B2), the live releases for TX are estimated as zero. (Estimates of releases by headboats in 1986+ are discussed in Section 6.) *Prior assessments did not estimate B2 catch for TPWD and HBS estimates.*

The procedures used for updating Texas catches are described in greater detail in the appendix 2 "Procedures used to update Texas recreational king mackerel catch following recommendations of the SEDAR 16 data workshop" (Phares).

**5) Estimate live releases for the Headboat Survey (HBS).**

Estimates of live releases ("B2 catch" in MRFSS) are not officially available from the HBS. Although discards (live and dead) by trip have been reported for some trips for several years, the SEDAR 16 Data Workshop decided that these data currently might not be a sufficient basis for estimating total discards. Ratios of B2/A+B1 catch by year and state from MRFSS charterboat mode (after adjustments above) are used to estimate HBS live releases. Ratios using MRFSS estimates from LA are applied to HBS estimates for TX *Prior assessments did not estimate B2 catch for the HBS.*

**6) Do not create substitutes for missing Headboat Survey estimates in LA in 2004-2006, since MRFSS states that LA headboats were covered as charterboats by the FHS during those years.**

LA headboats are small and arguments can be made for including them in either survey. *This time period was not covered in prior assessments, so the issue did not arise.*

**7) Add substitutes for January-June 2007 in the HBS and TPWD (since these estimates are not yet available) to allow 2006/2007 fishing year estimates to be used.**

Use substitutes equal the final TPWD and HBS estimates (with adjustments above) in corresponding months of 2006. (Preliminary 2007 estimates are available for MRFSS.) *This is the usual procedure followed in prior assessments – no change.*

**8) Add a code which identifies the mixing zone for the migratory groups.**

Zone A = Atlantic migratory group: MA-GA and NE FL (Nassau-Flagler Counties)

Zone M = Mixing Zone: FLE Volusia-Dade Counties, and Monroe County (including all Headboat Survey Keys areas)

Zone G = Gulf migratory group: FLW Collier-Escambia Co., AL, MS, LA, TX

Additional Information:

1. Calibration factors for the MRFSS charterboat and Cbt+Hbt estimates (apply to pre-FHS).

Gulf :

From "Estimated conversion factors for calibrating MRFSS charterboat landings and effort estimates for the Gulf of Mexico in 1981-1997 with For-Hire Survey estimates with application to red snapper landings". Guillermo A. Diaz and Patty Phares, NMFS, August, 2004. Sustainable Fisheries Division Contribution No. SFD-2004-036

| Wave: | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Gulf, Cbt, 1986-1997, LA-AL: | | | | | | |
| area_x=5 (inshore): | 1.26 | 1.54 | 3.82 | 4.67 | 3.28 | 1.48 |
| area_x=1 (ocean<3 mi): | 0.74 | 0.75 | 1.49 | 2.28 | 0.64 | 0.52 |
| area_x=2 (ocean>3 mi): | 0.44 | 0.63 | 2.23 | 1.87 | 1.26 | 0.53 |
| Gulf, Cbt, 1986-1997, FLW (includes Monroe Co.): | | | | | | |
| area_x=5 (inshore): | 3.17 | 5.31 | 5.71 | 5.33 | 3.49 | 3.70 |
| area_x=3 (ocean<10 mi): | 0.95 | 1.10 | 1.78 | 0.70 | 0.48 | 0.98 |

| | | | | | | |
|---|---|---|---|---|---|---|
| area_x=4 (ocean>10 mi): | 0.38 | 0.58 | 0.77 | 0.73 | 0.59 | 0.55 |
| Gulf, Cbt+Hbt, 1981-85: | | | | | | |
| all areas: | 1.45 | 1.31 | 1.63 | 1.34 | 2.67 | 1.58 |

Atlantic:

From Tom Sminkey, February 2008.

(not available at this time)

**Appendix 2 to the SEDAR 16 Data Workshop Recreational Data Section**

# Procedures Used to Update Texas Recreational King Mackerel Catch Following Recommendations of the SEDAR 16 Data Workshop

Patty Phares

This document was prepared in order to describe the details of the procedures used to implement the recommendations of the SEDAR 16 Data Workshop for updating King Mackerel catch information. Estimates from TPWD, modifications and substitutes for missing cells are described. Headboat Survey estimates for 1986+ are not included.

## 1. TX Private and Charter mode landings estimates for 1983-2006, and estimation of monthly landings.

Low/high-use season King mackerel estimates for private and charter modes were provided by TPWD in approximate calendar years for 1983-2006. (The continuity case assessment uses wave estimates provided by TPWD through 2006, but wave estimates will not be provided for 2007 and later.) These estimates are comparable to Type A+B1 catch in MRFSS, assuming that Type B1 is close to zero, which is reasonable since the TPWD survey is conducted so that self-reporting of retained catch not seen by the interviewer is unnecessary and few fish are discarded dead.

Use the “Fish files” (raw data which are counts of fish by species encountered in the trip interviews, by trip) to divide the low-use (Nov 21-May 14) and high-use (May 15-Nov 20) season landings estimates (by area and mode) into months in proportion to the numbers of fish by month in the Fish files. This provides a rough estimate of landings by month, even though it is not statistically valid given the TPWD methodology.

The estimates provided by TPWD for year=YR are actually for Nov 21, YR-1 (beginning of low-use season) to Nov 20 of year=YR (end of high-use). After the low-use season estimates are divided into months, the estimates for Nov 21-30 and Dec 1-31 are moved back to the previous calendar year. This affects only a tiny portion of the king mackerel landings because almost no fish for November-December are in the Fish files.

In cases where there is no match of Fish and Landings files (by season, mode, area), the data are deleted. Only 1985, 1988 and 1998 private boat landings estimates have small portions deleted in the low use season (29, 81 and 86 fish). The observations from the Fish file with no matching landings also are very small and restricted to 1985, 1993, 1996 and 1998.

**2. Substitutes for missing boat mode landings estimates in 1981-1985.**

1981-1982 charter and private mode, and 1981-1985 headboat mode are not covered by the combination of the TPWD Survey (1983+ for charter and private boats) and Headboat Survey (1986+ for headboats).

**2.1. Do not use MRFSS boat mode estimates for TX.**

The MRFSS included TX in 1981 and 1985 for boat modes. Because the TPWD and Headboat Surveys are now the ongoing sources of estimates, the cells with no estimates in 1981-1985 are viewed as missing data in those surveys.

It is preferable to use consistent methods for all years for filling in cells with missing estimates. The use of 1981 MRFSS boat mode estimates would have multiple drawbacks:

(a) It would require filling in missing wave 4 MRFSS estimates (missing for all MRFSS estimates in TX in 1981-1985).

(b) It would include combined charter+headboat mode whereas no later years do in TX, thus requiring different methods for filling in missing headboat estimates over the 1981-1985.

(c) It would not cover 1982, thus requiring different methods for filling in 1982 charter and private modes.

(d) The available MRFSS 1981 private boat estimates for TX are much larger than all TPWD values in 1983 and later and are viewed with skepticism, especially since 1981 is early in the survey and an isolated year in its operation in TX. The wave 3 estimates alone are: Private = 39840, CBT+HBT = 1837. Substitutes for wave 4 would make the 1981 total much larger.

Of five Type A, B1 or B2 boat mode estimates for wave/mode/area cells in 1981, all but one are based on a single trip's landings of king mackerel, casting further lack of confidence in the large estimates. (The situation is similar for shore mode – see Section 3).

Thus the MRFSS boat mode estimates in 1981 will not be used as a substitute for missing TPWD estimates. (1985 MRFSS boat mode estimates are not needed since TPWD covers 1985.)

**2.2 Substitutes used.**

**(a) Charter and Private modes 1981-1982:** Use linear regressions of 1983-1985 TPWD landings on year to predict 1981 and 1982. (The 1983-1985 landings estimates are from TPWD low/high-use seasons, summed into annual estimates after division into months.)

**(b) Headboat mode, 1981-1985:** Use the mean of 1986-1988 estimates from the Headboat Survey to estimate 1981-1985. The observed estimates are 8105, 8038, 8127 (mean=8090).

The resulting annual estimates are:

| | Obsv. Landings est. | | | Linear regressions | **Predicted Landings** | |
|---|---|---|---|---|---|---|
| Year: | **1983** | **1984** | **1985** | | **1981** | **1982** |
| **Priv (a)** | 26830 | 32321 | 26281 | Land= -274.5*year + 573085 (R2=0.01) | **29300** | **29026** |
| **CBT (a)** | 16145 | 6576 | 4135 | Land= -6205*year + 12319805 (R2=0.89) | **27700** | **21495** |
| **HBT (b)** | **8100** | **8100** | **8100** | | **8100** | **8100** |
| Total | 51075 | 46997 | 38516 | | 65100 | 58621 |

**2.3 Distribute substitute annual estimates calculated in 2.2 into months using the distributions of landings estimates in following years.**

For charter and private in 1981-1982, use the monthly distribution (calculated in Section 1) of TPWD estimates in 1983-1985.

For headboat in 1981-1985, use the monthly distribution of Headboat Survey estimates in 1986-1988.

Landings estimates by month (percent landings by month, years pooled):

| | **Charterboat (TPWD** | | | | **Private (TPWD)** | | | | **Headboat (HB Survey)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1983 | 1984 | 1985 | | 1983 | 1984 | 1985 | | 1986 | 1987 | 1988 | |
| May | 0 | 0 | 586 | (2.2%) | 95 | 149 | 2272 | (2.9%) | 1234 | 899 | 508 | (10.9%) |
| June | 1125 | 375 | 0 | (5.6%) | 2538 | 4241 | 5030 | (13.8%) | 1382 | 840 | 875 | (12.8%) |
| July | 5949 | 191 | 1861 | (29.8%) | 13685 | 15036 | 13992 | (50%) | 2368 | 2823 | 3262 | (34.8%) |
| Aug | 8573 | 5437 | 1688 | (58.5%) | 8832 | 11864 | 4178 | (29.1%) | 1956 | 2603 | 2851 | (30.5%) |
| Sept | 498 | 573 | 0 | (4%) | 1163 | 1031 | 809 | (3.5%) | 1165 | 873 | 631 | (11%) |
| Oct | 0 | 0 | 0 | | 517 | 0 | 0 | (0.6%) | 0 | 0 | 0 | |
| Total landings: | | | 26850 | | | 85452 | | | 24270 | | | |

**3. Shore mode estimates.**

TPWD does not estimate shore mode. MRFSS covered shore mode in TX in 1981-1985, and because there is no other source for information about shore catches, it was decided to use MRFSS estimates. There are only three shore estimates for King mackerel in TX:

| | |
|---|---|
| 1981 wave 3 = 76132 | (This will be changed to 0) |
| 1983 wave 5 = 1995 | |
| 1984 wave 4 = 828 | (Original wave 4 estimate) |

1981, wave 3 is based on one intercept catching 11 king mackerel, all B1 (self-reported). As with the MRFSS 1981 private boat estimates, such a large shore mode estimate is viewed with extreme skepticism, especially since 1981 is early in the survey and an isolated year in its operation in TX. The Mackerel Stock Assessment Panel accepted this estimate for prior assessments, but 1981 wave 3 was before the start of the first fishing season (July 1981) and at that time did not affect the assessments. This is not the case with the current assessment.

The 1984 wave 4 estimate is the original estimate, before the replacement of all MRFSS in the early 1990s. The replacement MRFSS wave 4 estimates for all modes are missing for TX in 1981-1985. But because this is such a small estimate, it is used as the substitute for wave 4 (as was done in prior assessments).

The TX 1981-1985 shore mode estimates are small and infrequent. The total MRFSS shore mode estimates for LA and MS from 1981 to 2006 are A+B1=0 and B2=1275 (AL and FLW shore mode catches are higher). Thus the substitute TX shore mode estimates for 1986+ are 0.

**4. Estimates of fish released alive.**

Gulf-wide (FLW-LA) discard ratios (live:dead fish) using MRFSS B2/(A+B1) by year, wave and mode are used to estimate discards from Texas for private boats and charterboats in all years and headboats in 1981-1985. The discard ratio for Charter+Headboat mode applies to the separate charterboat and headboat estimates in 1981-1985. Estimation of live releases from headboats in 1986+ is discussed with the Headboat Survey discards.

In accordance with SEDAR 16 Data Workshop decisions the MRFSS data used in the ratios are:

- For-Hire Survey estimates for charterboats in 1998 and later;

- Charterboat and Charterboat+Headboat estimates for 1981-1997 calibrated to the For-Hire Survey using Diaz and Phares (2004);

- Florida west stratified or post-stratified into regions, with Monroe County removed from Gulf–wide estimates.

**5. Estimates for 2007**

Substitute preliminary January-June 2007 estimates are the corresponding months of 2006.

**6. Tables of TX recreational landings estimates.**

In addition to the following tables of estimates described above, Headboat estimates for 1986+ are provided by the Headboat Survey. Estimates of fish kept are comparable to MRFSS A+B1 catch. Estimates of fish released alive are comparable to MRFSS B2 catch.

**Table 1. Shore mode, kept fish, by year and wave** – from MRFSS, with adjustments. Estimates (including substitutes) for all other cells in all years are 0.

All B2=0 for shore mode.

month

| YEAR | 7-8 | 9-10 | Total |
|---|---|---|---|
| 1983 | | 1995 | 1995 |
| 1985 | 828 | | 828 |

**Table 2. Headboat mode, kept fish, for 1981-1985, by month.** All are substitutes based on the average of 1986-1988 Headboat Survey monthly estimates. (Estimates for 1986+ are from the NMFS Headboat Survey.)

month

| YEAR | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|
| 1981 – 1985 (each year) | 883 | 1037 | 2819 | 2471 | 891 | 8100 |

**Table 3. Estimates of TX kept fish (“A+B1”) for modes combined, by year and month. Does not include Headboat Survey estimates for 1986+.**

month

| YEAR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | | | | | 2350 | 6634 | 25720 | 27193 | 3026 | 177 | | | **65100** |
| 1982 | | | | | 2207 | 6250 | 23735 | 23486 | 2768 | 176 | | | **58622** |
| 1983 | | | | | 978 | 4700 | 22453 | 19876 | 4547 | 517 | | | **53071** |
| 1984 | | | | | 1032 | 5653 | 18046 | 19772 | 2495 | | | | **46998** |
| 1985 | | | | | 3741 | 6067 | 19500 | 8337 | 1700 | | | | **39345** |
| 1986 | | | | | 403 | 4193 | 10861 | 2088 | | | | | **17545** |
| 1987 | | | | | 2092 | 1758 | 5987 | 8378 | 364 | 31 | | | **18610** |
| 1988 | | | | | 504 | 1871 | 7709 | 5181 | | 38 | | | **15303** |
| 1989 | | | | 172 | 686 | 460 | 4222 | 3358 | 1299 | 84 | | | **10281** |
| 1990 | | | | | 123 | 2672 | 3763 | 5402 | 1969 | | 45 | | **13974** |
| 1991 | | | | 128 | 75 | 1129 | 5212 | 14120 | 1012 | 382 | | | **22058** |
| 1992 | | | | | 448 | 3781 | 7028 | 8237 | 785 | 66 | | | **20345** |
| 1993 | | | | | 527 | 895 | 6105 | 5650 | 1879 | | | | **15056** |
| 1994 | | | | 230 | 878 | 3062 | 7292 | 4325 | 1843 | 1037 | 94 | | **18761** |
| 1995 | | | | | 1136 | 2111 | 17075 | 5549 | 3841 | 353 | | | **30065** |
| 1996 | | | | | 239 | 8043 | 14984 | 8976 | 3740 | 296 | | 21 | **36299** |
| 1997 | | | 91 | | 670 | 6330 | 13497 | 12694 | 939 | 720 | | | **34941** |
| 1998 | | 136 | | 27 | 1678 | 2128 | 14437 | 9237 | 1377 | | | | **29020** |
| 1999 | | | | 81 | 910 | 4054 | 13051 | 12568 | 1090 | 17 | | | **31771** |
| 2000 | | | | 155 | 339 | 913 | 8531 | 7465 | 1108 | 47 | | | **18558** |
| 2001 | | | | | 186 | 4247 | 7743 | 1657 | 774 | 27 | | | **14634** |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | | | | | 155 | 3879 | 5810 | 4551 | 1143 | 22 | | | **15560** |
| 2003 | | | | | 1261 | 7884 | 3943 | 4820 | 294 | 345 | | | **18547** |
| 2004 | | | | 99 | 65 | 3518 | 6378 | 4040 | 765 | | 78 | | **14943** |
| 2005 | | | | | 975 | 1691 | 5517 | 4972 | 525 | 179 | 450 | | **14309** |
| 2006 | 66 | | | 328 | 383 | 9597 | 8586 | 5260 | 4273 | 27 | | | **28520** |

**Table 4. Estimates of TX kept fish ("A+B1") and live releases ("B2") by year and mode.**

(1) = from TPWD High/Low-use estimates

(2) = from MRFSS

(3) = substitute estimates of headboat mode in 1981-1985

(4) = substitute estimates of live releases (boat modes)

**Does not include Headboat Survey estimates for 1986+.**

| YEAR | A+B1 Shore (2) | Hbt (3) | Charter (1) | Private (1) | **A+B1 Total** | B2 Shore (2) | Hbt (4) | Charter (4) | Private (4) | **B2 Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | | 8101 | 27699 | 29300 | **65100** | | 0 | 0 | 3846 | **3846** |
| 1982 | | 8101 | 21495 | 29026 | **58622** | | 0 | 0 | 15039 | **15039** |
| 1983 | 1995 | 8101 | 16145 | 26830 | **53071** | 0 | 27 | 16 | 0 | **42** |
| 1984 | | 8101 | 6576 | 32321 | **46998** | | 1185 | 1260 | 0 | **2445** |
| 1985 | 828 | 8101 | 4135 | 26281 | **39345** | 0 | 0 | 0 | 1773 | **1773** |
| 1986 | | | 1751 | 15794 | **17545** | | | 0 | 1580 | **1580** |
| 1987 | | | 5089 | 13521 | **18610** | | | 76 | 1495 | **1571** |
| 1988 | | | 4644 | 10659 | **15303** | | | 251 | 3523 | **3775** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1989 | | | 1352 | 8929 | **10281** | | | 59 | 4714 | **4773** |
| 1990 | | | 3169 | 10805 | **13974** | | | 21 | 786 | **806** |
| 1991 | | | 1784 | 20274 | **22058** | | | 382 | 6128 | **6510** |
| 1992 | | | 376 | 19969 | **20345** | | | 77 | 4956 | **5033** |
| 1993 | | | 2196 | 12860 | **15056** | | | 146 | 3985 | **4131** |
| 1994 | | | 2857 | 15904 | **18761** | | | 949 | 8217 | **9166** |
| 1995 | | | 1393 | 28672 | **30065** | | | 120 | 6160 | **6280** |
| 1996 | | | 4797 | 31502 | **36299** | | | 320 | 15384 | **15704** |
| 1997 | | | 5417 | 29524 | **34941** | | | 451 | 9574 | **10025** |
| 1998 | | | 11654 | 17366 | **29020** | | | 534 | 8792 | **9326** |
| 1999 | | | 9913 | 21858 | **31771** | | | 662 | 7062 | **7724** |
| 2000 | | | 2813 | 15745 | **18558** | | | 416 | 7074 | **7490** |
| 2001 | | | 3736 | 10898 | **14634** | | | 575 | 4195 | **4770** |
| 2002 | | | 3888 | 11672 | **15560** | | | 571 | 4570 | **5140** |
| 2003 | | | 4037 | 14510 | **18547** | | | 1460 | 9155 | **10616** |
| 2004 | | | 1122 | 13821 | **14943** | | | 180 | 8383 | **8563** |
| 2005 | | | 1134 | 13175 | **14309** | | | 198 | 7955 | **8153** |
| 2006 | | | 3761 | 24759 | **28520** | | | 981 | 21651 | **22632** |

Appendix 3. Summary of management regulations for king mackerel.

## Commercial Closures by region

**W-GOM**

| open date | close date |
|---|---|
| | 5/6/1983 |
| 7/1/1983 | 3/12/1986 |
| 7/1/1986 | 2/4/1987 |
| 7/1/1987 | 11/2/1987 |
| 7/1/1988 | 12/3/1988 |
| 7/1/1989 | 10/25/1989 |
| 7/1/1990 | 10/18/1990 |
| 7/1/1991 | 9/29/1991 |
| 7/1/1992 | 10/18/1992 |
| 7/1/1993 | 10/1/1993 |
| 7/1/1994 | 9/24/1994 |
| 7/1/1995 | 9/5/1995 |
| 7/1/1996 | 8/26/1996 |
| 7/1/1997 | 8/2/1997 |
| 2/20/1998 | 3/29/1998 |
| 7/1/1998 | 8/25/1998 |
| 7/1/1999 | 8/25/1999 |
| 7/1/2000 | 8/26/2000 |
| 7/1/2001 | 11/20/2001 |
| 7/1/2002 | 10/26/2002 |
| 7/1/2003 | 9/25/2003 |
| 7/1/2004 | 10/21/2004 |
| 7/1/2005 | 11/18/2005 |
| 7/1/2006 | 10/7/2006 |

**FLWC**

| open date | close date |
|---|---|
| | 3/12/1986 |
| 7/1/1986 | 2/4/1987 |
| 7/1/1987 | 1/27/1994 |
| 7/1/1994 | 12/20/1994 |
| 2/7/1995 | 2/22/1995 |
| 7/1/1995 | 2/22/1996 |
| 7/1/1996 | 1/22/1997 |
| 7/1/1997 | 1/7/1998 |
| 2/20/1998 | 3/5/1998 |
| 7/1/1998 | 3/16/1999 |
| 7/1/1999 | 3/6/2000 |

**FLWC split into FLWC-N & FLWC-S on 4/27/00**

**FLWC-S**

| open date | close date |
|---|---|
| | 4/27/2000 |
| 7/1/2000 | 3/2/2001 |
| 7/1/2001 | 3/23/2002 |
| 7/1/2002 | 4/9/2004 |
| 7/1/2004 | 3/12/2006 |
| 7/1/2006 | |

**FLWC-N**

| open date | close date |
|---|---|
| | 4/27/2000 |
| 7/1/2000 | 11/19/2000 |
| 7/1/2001 | 11/11/2001 |
| 7/1/2002 | 12/6/2002 |
| 7/1/2003 | 11/14/2003 |
| 7/1/2004 | |

**FECZ**

| open date | close date |
|---|---|
| | 3/12/1986 |
| 4/1/1986 | 2/4/1987 |
| 4/1/1987 | 12/29/1987 |
| 4/1/1988 | 12/31/1988 |
| 4/1/1989 | 1/9/1990 |
| 4/1/1990 | 1/4/1991 |
| 4/1/1991 | 1/31/1992 |
| 4/1/1992 | 1/13/1993 |
| 2/18/1993 | 3/27/1993 |
| 4/1/1993 | 3/29/1998 |
| 4/1/1998 | 3/13/1999 |
| 4/1/1999 | |

**SA**

| open date | close date |
|---|---|
| | 11/23/1988 |
| 4/1/1989 | 3/29/1998 |
| 4/1/1998 | |

**KEYS**

| open date | close date |
|---|---|
| | 3/12/1986 |
| 4/1/1986 | 2/4/1987 |
| 4/1/1987 | 1/27/1994 |
| 4/1/1994 | 12/20/1994 |
| 2/7/1995 | 2/22/1995 |
| 4/1/1995 | 2/22/1996 |
| 4/1/1996 | 1/22/1997 |
| 4/1/1997 | 1/7/1998 |
| 2/20/1998 | 3/5/1998 |
| 4/1/1998 | 3/16/1999 |
| 4/1/1999 | 3/6/2000 |
| 4/1/2000 | 3/2/2001 |
| 4/1/2001 | 3/23/2002 |
| 4/1/2002 | 3/12/2006 |
| 4/1/2006 | |

W-GOM=western Gulf of Mexico (Texas/Mexico border to Alabama/Florida border)
FLWC=Florida west coast (ceased to exist 4/27/00; Alabama/Florida border to Collier/Monroe county border)
FLWC-N=Florida west coast north (effective 4/27/00; Alabama/Florida border to Lee/Collier county border)
FLWC-S=Florida west coast south (effective 4/27/00; Collier county)
Keys=Monroe county
FECZ=Florida east coast zone (Monroe/Dade county border to Volusia/Flagler county border)
SA=south Atlantic (Volusia/Flagler county border to North Carolina/Virginia border)

## Commercial and recreational size limits by region

**W-GOM**

| | | |
|---|---|---|
| none | | 6/30/1990 |
| 12" | 7/1/1990 | 6/30/1992 |
| 20" | 7/1/1992 | 6/30/1999 |
| 24" | 7/1/1999 | |

**FLWC**

| | | |
|---|---|---|
| none | | 6/30/1990 |
| 12" | 7/1/1990 | 6/30/1992 |
| 20" | 7/1/1992 | 6/30/1999 |
| 24" | 7/1/1999 | 4/26/2000 |

**FLWC split into FLWC-N & FLWC-S on 4/27/00**

**FLWC-N**

| | |
|---|---|
| 24" | 4/27/2000 |

**FLWC-S**

| | |
|---|---|
| 24" | 4/27/2000 |

**KEYS**

| | | |
|---|---|---|
| none | | 3/31/1990 |
| 12" | 4/1/1990 | 3/31/1992 |
| 20" | 4/1/1992 | 3/31/1999 |
| 24" | 4/1/1999 | |

**FECZ**

| | | |
|---|---|---|
| none | | 3/31/1990 |
| 12" | 4/1/1990 | 3/31/1992 |
| 20" | 4/1/1992 | 3/31/1999 |
| 24" | 4/1/1999 | |

**SA**

| | | |
|---|---|---|
| none | | 3/31/1990 |
| 12" | 4/1/1990 | 3/31/1992 |
| 20" | 4/1/1992 | 3/31/1999 |
| 24" | 4/1/1999 | |

W-GOM=western Gulf of Mexico (Texas/Mexico border to Alabama/Florida border)
FLWC=Florida west coast (ceased to exist 4/27/00; Alabama/Florida border to Collier/Monroe county border)
FLWC-N=Florida west coast north (effective 4/27/00; Alabama/Florida border to Lee/Collier county border)
FLWC-S=Florida west coast south (effective 4/27/00; Collier county)
Keys=Monroe county
FECZ=Florida east coast zone (Monroe/Dade county border to Volusia/Flagler county border)
SA=south Atlantic (Volusia/Flagler county border to North Carolina/Virginia border)

**Recreational regulation summary**

| | Fishing Year | | | Bag Limit | | Closures | |
|---|---|---|---|---|---|---|---|
| Year | Atlantic | Gulf | Size Limit | Atlantic | Gulf | Atlantic | Gulf |
| 1983-1984[1] | | | -- | -- | -- | -- | -- |
| 1984-1985[1] | | | -- | -- | -- | -- | -- |
| 1985-1986[2] | | | | | | | |
| 1986-1987 | 4/1 - 3/31 | 7/1 - 6/30 | -- | Private = 2/person/trip; Charterboat = greater of 2/person incl capt&crew or 3/person excl capt&crew | | -- | -- |
| 1987-1988 | 4/1 - 3/31 | 7/1 - 6/30 | -- | 3/person/trip | " | | Closed 12/16/87 |
| 1988-1989 | 4/1 - 3/31 | 7/1 - 6/30 | -- | 2/person/trip FL & 3 GA to SC | " | Closed 10/17/88 | Closed 12/17/88 |
| 1989-1990 | 4/1 - 3/31 | 7/1 - 6/30 | -- | 2/person/trip FL & 3 GA to SC | " | | |
| 1990-1991[3] | 4/1 - 3/31 | 7/1 - 6/30 | 12 in FL or 14 in TL | 2 FL; 3 GA-NY | Same as above[4] | | Closed 12/20/90 |
| 1991-1992 | 4/1 - 3/31 | 7/1 - 6/30 | 12 in FL or 14 in TL | 5 FL-NY | " | | Closed 01/13/92 |
| 1992-1993 | 4/1 - 3/31 | 7/1 - 6/30 | 20 in FL | 2 FL; 5 GA-NY | 2 per person including captain & crew | | -- |
| 1993 | Calendar Year | | 20 in FL | " | " | | -- |
| 1994 | Calendar Year | | 20 in FL | " | " | | -- |
| 1995 | Calendar Year | | 20 in FL | 2 FL; 3 GA-NY | " | | -- |
| 1996 | Calendar Year | | 20 in FL | " | " | | -- |
| 1997 | Calendar Year | | 20 in FL | " | 2 per person, 0 capt&crew as of 6-97 | | -- |
| 1998 | Calendar Year | | 20 in FL | " | 2 per person, 2 capt&crew as of 2-98 | | -- |
| 1999 | Calendar Year | | 24 in FL | " | 2 per person, 0 capt&crew as of 9-99 | | -- |
| 2000 | Calendar Year | | 24 in FL | " | 2 per person, 2 capt&crew as of 6-00 | | -- |
| 2001 | Calendar Year | | 24 in FL | " | " | | -- |
| 2002 | Calendar Year | | 24 in FL | " | " | | -- |
| 2003 | Calendar Year | | 24 in FL | " | " | | -- |
| 2004 | Calendar Year | | 24 in FL | " | " | | -- |
| 2005 | Calendar Year | | 24 in FL | " | " | | -- |
| 2006 | Calendar Year | | 24 in FL | " | " | | -- |
| 2007 | Calendar Year | | 24 in FL | " | " | | -- |

[1]One stock
[2]Two management groups (Atlantic & Gulf migratory) from this point forward
[3]Management area expands from TX through NC to TX through NY
[4]Redefined as daily bag limits; 1-day possession except for-hire on multi-day can have 2-day possession

## Commercial trip limits by region

**W-GOM**

| limit | start date | end date |
|---|---|---|
| none | | 6/30/2000 |
| 3,000 lbs | 7/1/2000 | |

**FLWC**

| limit | start date | end date |
|---|---|---|
| none | | 12/28/1993 |
| 50 fish | 12/29/1993 | 6/30/1994 |
| none | 7/1/1994 | 2/6/1995 |
| 125 fish | 2/7/1995 | 2/21/1995 |
| 0 (closed) | 2/22/1995 | 6/30/1995 |
| 125 fish | 7/1/1995 | 1/23/1996 |
| 50 fish | 1/24/1996 | 2/21/1996 |
| 0 (closed) | 2/22/1996 | 6/30/1996 |
| 1250 lbs | 7/1/1996 | 12/31/1996 |
| 500 lbs | 1/1/1997 | 1/21/1997 |
| 0 (closed) | 1/22/1997 | 6/30/1997 |
| 1250 lbs | 7/1/1997 | 11/27/1997 |
| 500 lbs | 11/28/1997 | 1/6/1998 |
| 0 (closed) | 1/7/1998 | 2/19/1998 |
| 500 lbs | 2/20/1998 | 3/4/1998 |
| 0 (closed) | 3/5/1998 | 6/30/1998 |
| 1250 lbs | 7/1/1998 | 1/29/1999 |
| 500 lbs | 1/30/1999 | 3/15/1999 |
| 0 (closed) | 3/16/1999 | 6/30/1999 |
| 1250 lbs | 7/1/1999 | 1/23/2000 |
| 500 lbs | 1/24/2000 | 3/5/2000 |
| 0 (closed) | 3/6/2000 | 4/26/2000 |

**FLWC split into FLWC-N & FLWC-S on 4/27/00**

**SA**

| limit | start date | end date |
|---|---|---|
| none | | 3/31/1995 |
| 3,500 lbs | 4/1/1995 | |

**FLWC-N**

| limit | start date | end date |
|---|---|---|
| 0 (closed) | 4/27/2000 | 6/30/2000 |
| 1250 lbs | 7/1/2000 | 11/11/2000 |
| 500 lbs | 11/12/2000 | 11/18/2000 |
| 0 (closed) | 11/19/2000 | 6/30/2001 |
| 1250 lbs | 7/1/2001 | 11/10/2001 |
| 0 (closed) | 11/11/2001 | 6/30/2002 |
| 1250 lbs | 7/1/2002 | 11/29/2002 |
| 500 lbs | 11/30/2002 | 12/5/2002 |
| 0 (closed) | 12/6/2002 | 6/30/2003 |
| 1250 lbs | 7/1/2003 | 10/29/2003 |
| 500 lbs | 10/30/2003 | 11/13/2003 |
| 0 (closed) | 11/14/2003 | 6/30/2004 |
| 1250 lbs | 7/1/2004 | 11/26/2006 |
| 500 lbs | 11/27/2006 | |

**FLWC-S**

| limit | start date | end date |
|---|---|---|
| 0 (closed) | 4/27/2000 | 6/30/2000 |
| 1250 lbs | 7/1/2000 | 2/19/2001 |
| 500 lbs | 2/20/2001 | 3/1/2001 |
| 0 (closed) | 3/2/2001 | 6/30/2001 |
| 1250 lbs | 7/1/2001 | 3/10/2002 |
| 500 lbs | 3/11/2002 | 3/22/2002 |
| 0 (closed) | 3/23/2002 | 6/30/2002 |
| 1250 lbs | 7/1/2003 | 3/4/2003 |
| 500 lbs | 3/5/2003 | 6/30/2003 |
| 1250 lbs | 7/1/2003 | 3/19/2004 |
| 500 lbs | 3/20/2004 | 4/8/2004 |
| 0 (closed) | 4/9/2004 | 6/30/2004 |
| 1250 lbs | 7/1/2004 | 2/24/2005 |
| 500 lbs | 2/25/2005 | 6/30/2005 |
| 1250 lbs | 7/1/2005 | 2/24/2006 |
| 500 lbs | 2/25/2006 | 3/11/2006 |
| 0 (closed) | 3/12/2006 | 6/30/2006 |
| 1250 lbs | 7/1/2006 | |

| KEYS | | | FECZ | | |
|---|---|---|---|---|---|
| **limit** | **start date** | **end date** | **limit** | **start date** | **end date** |
| none | | 3/11/1986 | none | | 3/11/1986 |
| 0 (closed) | 3/12/1986 | 3/31/1986 | 0 (closed) | 3/12/1986 | 3/31/1986 |
| none | 4/1/1986 | 2/3/1987 | none | 4/1/1986 | 2/3/1987 |
| 0 (closed) | 2/4/1987 | 3/31/1987 | 0 (closed) | 2/4/1987 | 3/31/1987 |
| none | 4/1/1987 | 12/28/1993 | none | 4/1/1987 | 12/28/1987 |
| 50 fish | 12/29/1993 | 1/26/1994 | 0 (closed) | 12/29/1987 | 3/31/1988 |
| 0 (closed) | 1/27/1994 | 3/31/1994 | none | 4/1/1988 | 12/30/1988 |
| none | 4/1/1994 | 12/19/1994 | 0 (closed) | 12/31/1988 | 3/31/1989 |
| 0 (closed) | 12/20/1994 | 2/6/1995 | none | 4/1/1989 | 1/8/1990 |
| 125 fish | 2/7/1995 | 2/21/1995 | 0 (closed) | 1/9/1990 | 3/31/1990 |
| 0 (closed) | 2/22/1995 | 3/31/1995 | none | 4/1/1990 | 1/3/1991 |
| 50 fish | 4/1/1995 | 10/31/1995 | 0 (closed) | 1/4/1991 | 3/31/1991 |
| 125 fish | 11/1/1995 | 1/23/1996 | none | 4/1/1991 | 1/30/1992 |
| 50 fish | 1/24/1996 | 2/21/1996 | 0 (closed) | 1/31/1992 | 3/31/1992 |
| 0 (closed) | 2/22/1996 | 3/31/1996 | none | 4/1/1992 | 1/12/1993 |
| 50 fish | 4/1/1996 | 10/31/1996 | 0 (closed) | 1/13/1993 | 2/17/1993 |
| 1250 lbs | 11/1/1996 | 12/31/1996 | 25 fish | 2/18/1993 | 3/26/1993 |
| 500 lbs | 1/1/1997 | 1/21/1997 | 0 (closed) | 3/27/1993 | 3/31/1993 |
| 0 (closed) | 1/22/1997 | 3/31/1997 | none | 4/1/1993 | 10/31/1993 |
| 1250 lbs | 4/1/1997 | 11/27/1997 | 50 fish | 11/1/1993 | 3/31/1994 |
| 500 lbs | 11/28/1997 | 1/6/1998 | none | 4/1/1994 | 10/31/1994 |
| 0 (closed) | 1/7/1998 | 2/19/1998 | 50 fish | 11/1/1994 | 3/14/1996 |
| 500 lbs | 2/20/1998 | 3/4/1998 | 25 fish | 3/15/1996 | 3/31/1996 |
| 0 (closed) | 3/5/1998 | 3/31/1998 | 50 fish | 4/1/1996 | 10/31/1996 |
| 1250 lbs | 4/1/1998 | 1/29/1999 | 750 lbs | 11/1/1996 | 2/28/1997 |
| 500 lbs | 1/30/1999 | 3/15/1999 | 500 lbs | 3/1/1997 | 3/31/1997 |
| 0 (closed) | 3/16/1999 | 3/31/1999 | 50 fish | 4/1/1997 | 3/28/1998 |
| 1250 lbs | 4/1/1999 | 1/23/2000 | 0 (closed) | 3/29/1998 | 3/31/1998 |
| 500 lbs | 1/24/2000 | 3/5/2000 | 50 fish | 4/1/1998 | 3/12/1999 |
| 0 (closed) | 3/6/2000 | 3/31/2000 | 0 (closed) | 3/13/1999 | 3/31/1999 |
| 1250 lbs | 4/1/2000 | 2/19/2001 | 50 fish | 4/1/1999 | 3/31/2000 |
| 500 lbs | 2/20/2001 | 3/1/2001 | 75 fish | 4/1/2000 | 10/31/2000 |
| 0 (closed) | 3/2/2001 | 3/31/2001 | 50 fish | 11/1/2000 | 3/31/2001 |
| 1250 lbs | 4/1/2001 | 3/10/2002 | 75 fish | 4/1/2001 | 10/31/2001 |
| 500 lbs | 3/11/2002 | 3/22/2002 | 50 fish | 11/1/2001 | 1/31/2002 |
| 0 (closed) | 3/23/2002 | 3/31/2002 | 75 fish | 2/1/2002 | 10/31/2002 |
| 1250 lbs | 4/1/2002 | 3/4/2003 | 50 fish | 11/1/2002 | 1/31/2003 |
| 500 lbs | 3/5/2003 | 3/31/2003 | 75 fish | 2/1/2003 | 10/31/2003 |
| 1250 lbs | 4/1/2003 | 3/19/2004 | 50 fish | 11/1/2003 | 1/31/2004 |
| 500 lbs | 3/20/2004 | 3/31/2004 | 75 fish | 2/1/2004 | 10/31/2004 |
| 1250 lbs | 4/1/2004 | 2/24/2005 | 50 fish | 11/1/2004 | 1/31/2005 |
| 500 lbs | 2/25/2005 | 3/31/2005 | 75 fish | 2/1/2005 | 10/31/2005 |

| | | | | | |
|---|---|---|---|---|---|
| 1250 lbs | 4/1/2005 | 2/24/2006 | 50 fish | 11/1/2005 | 1/31/2006 |
| 500 lbs | 2/25/2006 | 3/11/2006 | 75 fish | 2/1/2006 | 10/31/2006 |
| 0 (closed) | 3/12/2006 | 3/31/2006 | 50 fish | 11/1/2006 | |
| 1250 lbs | 4/1/2006 | | | | |

W-GOM=western Gulf of Mexico (Texas/Mexico border to Alabama/Florida border)
FLWC=Florida west coast (ceased to exist 4/27/00; Alabama/Florida border to Collier/Monroe county border)
FLWC-N=Florida west coast north (effective 4/27/00; Alabama/Florida border to Lee/Collier county border)
FLWC-S=Florida west coast south (effective 4/27/00; Collier county)
Keys=Monroe county
FECZ=Florida east coast zone (Monroe/Dade county border to Volusia/Flagler county border)
SA=south Atlantic (Volusia/Flagler county border to North Carolina/Virginia border)

# SEDAR 16

# South Atlantic and Gulf of Mexico King Mackerel

# Assessment Workshop Report

**Prepared by the SEDAR 16 Assessment**

**Workshop Panel**

**July 2008**

# 1. WORKSHOP PROCEEDINGS

## 1.1 *INTRODUCTION*

### 1.1.1 Workshop Time and Place

The SEDAR 16 Assessment Workshop was held May 5 - 9, 2008 in Miami, Florida. Two additional web-based conference calls were held to complete the presentation and discussions for the models. The calls were held on 30 May, 2008 and 17 June 2008.

### 1.1.2 Terms of Reference

1. Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations.
2. Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations.
3. Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates.
4. Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'.
5. Provide yield-per-recruit, spawner-per-recruit, and stock-recruitment evaluations.
6. Provide estimates for SFA criteria consistent with applicable FMPs, management programs, and National Standards. This may include: evaluating existing SFA benchmarks, estimating alternative SFA benchmarks; and recommending proxy values. SFA parameters shall be provided for the Gulf and Atlantic Migratory Units as currently defined using the most current mixing data.
7. Provide declarations of stock status relative to SFA benchmarks.
8. Estimate Allowable Biological Catch (ABC) based on the following criteria:

   A) Based on migratory groups and mixing zone dynamics defined using best available scientific information, provide separate ABC values for each of two management areas delineated at the Miami-Dade/Monroe County line: all fish caught north of the line allocated to the Atlantic management area and all fish caught south of the line allocated to the Gulf management area.

   B) Based on migratory groups and mixing zone dynamics as currently defined, provide separate ABC values for the Gulf and Atlantic Migratory Units based on allocating all fish in the mixing zone to the Gulf Migratory Unit (essentially the 'continuity' approach).

   C) Based on migratory groups and mixing zone dynamics as currently defined, provide separate ABC values for the Gulf and Atlantic migratory units based on allocating 50%

of the fish in the mixing zone to the Gulf Migratory Unit and 50% of the fish to the Atlantic Migratory Unit.

D) Based on migratory groups and mixing zone dynamics defined using best available scientific information, provide separate ABC values for each of two management areas delineated at the Gulf and South Atlantic Council boundaries

9. Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock 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, if appropriate, 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. Provide discussion of progress on research and monitoring recommended by SEDAR 5.
12. Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report) and prepare a first draft of the Summary Report.

### 1.1.3 List of participants

***Workshop Panel***

Harry Blanchet ........................................ GMFMC SSC/LA DWF
Craig Brown ........................................ NMFS Miami
Christine Burgess ........................................ SAFMC SSC/NC DMF
Shannon Cass-Calay ........................................ NMFS Miami
Frank Hester ........................................ DSF (SAFMC)
Kevin J. McCarthy ........................................ NMFS Miami
Robert Muller ........................................ GMFMC SAP/FL FWC
Michael Murphy ........................................ GMFMC SAP/FL FWC
Russ Nelson ........................................ NRC, Inc. (GMFMC)
Refik Orhun ........................................ NMFS Miami
Mauricio Ortiz ........................................ NMFS Miami
Clay Porch ........................................ NMFS Miami
Victor Restrepo ........................................ NMFS Miami
Steve Turner ........................................ NMFS Miami

Donald Waters ....................................................................................GMFMC AP
Bob Zales, II........................................................................................GMFMC AP

***Council Representation***
David Cupka ..........................................................................................SAFMC
William Teehan.................................................................................GMFMC/FL FWC

***Observers***
Steve Branstetter ............................................................................. NMFS SERO
Susan Gehart ................................................................................... NMFS SERO
Doug Gregory ....................................................................................GMFMC SSC
Tom Ihde ...........................................................................................Univ. of MD
Russell Hudson .......................................................................................... DSF
Albert Jones .......................................................................................GMFMC SSC
Dennis O'Hern ..........................................................................................FRA
Mike Wilberg ............................................................................................CBL

***Staff***
Tyree Davis.......................................................................................NMFS Miami
Julie Neer .......................................................................................... SEDAR
Tina Trezza ........................................................................................GMFMC
Andi Stephens ......................................................................................SAFMC
Gregg Waugh ........................................................................................SAFMC

### 1.1.4 List of Assessment Workshop Working Papers

| Document # | Title | Authors |
|---|---|---|
| **Documents Prepared for the Assessment Workshop** | | |
| SEDAR16-AW-01 | Commercial King Mackerel Sampling Fractions for North Carolina by District, | Gloeckner, David |
| SEDAR16-AW-02 | Effects of King Mackerel Fishing Regulations on the Construction of Fisheries Dependent Indices of Abundance | McCarthy, K, S. Cass-Calay, M. Ortiz, and J. Walter |
| SEDAR16-AW-03 | Commercial King Mackerel Trip | Gloeckner, David |

| | | |
|---|---|---|
| | Sampling in NC, Differences in Fishing by State District | |
| SEDAR16-AW-04 | Technical Description of the Stock Synthesis II Assessment Program | Methot, Richard D. |
| SEDAR16-AW-05 | User Manual for the Integrated Analysis Program Stock Synthesis 2 (SS2) | Methot, Richard D. |
| SEDAR16-AW-06 | Virtual Population Analyses of Gulf of Mexico and Atlantic King Mackerel Migratory Groups: Continuity Case and Sensitivity Runs (Version 1) | Cass-Calay, S. and M. Ortiz |
| SEDAR16-AW-07 | Updated Estimates of Gulf king mackerel bycatch from the U.S. Gulf of Mexico Shrimp trawl fishery | Ortiz, M. and K. Andrews |
| SEDAR16-AW-08 | Preliminary Report King Mackerel stock assessment results 2008 | Ortiz, M. R. Methot, S.L. Cass-Calay, and B. Linton |
| SEDAR16-AW-09 | Notes on the weighting of the indices for the king mackerel VPA analyses | Restrepo, V.R., S. Cass-Calay, and M. Ortiz |
| SEDAR16-AW-10 | Virtual Population Analyses of Gulf of Mexico and Atlantic King Mackerel Migratory Groups: Continuity Case and Sensitivity Runs (Version 2) | Cass-Calay, S., M. Ortiz and V.R. Restrepo |
| SEDAR16-AW-11 | Virtual Population Analyses of Gulf of Mexico and Atlantic King Mackerel Migratory Groups: Continuity Case and Sensitivity Runs (Version 3) | Cass-Calay, S., M. Ortiz and V.R. Restrepo |
| SEDAR16-AW-12 | Virtual Population Analyses of Gulf of Mexico and Atlantic King Mackerel Migratory Groups: Continuity Case and Sensitivity Runs (Version 4) | Cass-Calay, S., M. Ortiz and V.R. Restrepo |
| **Reference Documents** | | |
| SEDAR16-RD08 | THE FLORIDA KEYS WAY BACK WHEN... (*FISHING FOR KING* | Little, Jr, E.J. |

| | | |
|---|---|---|
| | *MACKEREL IN THE "GOOD OLD DAYS" OF KEY WEST'S HISTORIC SEAPORT DISTRICT)* | |
| SEDAR16-RD09 | King mackerel hooking mortality assessment | Edwards, Randy E. |

## 1.2 *PANEL RECOMMENDATIONS AND COMMENT*

Preface: Assessment Timeline

The assessment workshop for Gulf of Mexico and South Atlantic king mackerel was held in Miami, FL May 5-9, 2008. The Panel was initially provided with two main models for discussion: a statistical catch-at-age model (an updated version of Stock Synthesis) and a virtual population analysis model (VPA-2Box). The VPA, consisting of 2 migratory units (Gulf and Atlantic), was initially considered for the continuity case, while SS3, consisting of three zones (Gulf No-mix, Atlantic No-mix, and Mixing), was the original the base model under consideration. As the SS3 model was unfamiliar to most Panelists, the majority of the discussions during the workshop focused on this model, as reflected in the discussions documented below. Approximately half way through the workshop the Panel agreed that an updated VPA model should be constructed as well to use as a check of sorts for the SS3 model. To that end, the updated VPA model was initially designed to mirror as closely as possible the SS3 data inputs. At the end of the workshop, neither model had overcome the issues raised during the workshop that the Panel felt it could not recommend a preferred model and agreed that work on both the SS3 and updated VPA models should be continued and presented on a web-based conference call to be held on 30 May 2008.

On the first conference call, the results of both models were presented and discussed with the majority of the discussion again focusing on the SS3, as the Panel hoped to select it as the preferred model. Unfortunately, the inability to have a stock-recruit relationship for each migratory group, the linkage in benchmarks between the two migratory groups, questions on movement parameters, and the inability to estimate uncertainty in the parameters convinced the Panel that the SS3 model was not appropriate at that time, and they selected the VPA as the base model. The remaining portion of the first call was devoted to the VPA. The Panel agreed to hold a second conference call on 17 June 2008 to review the VPA results.

The second web-based call represented the first time the Panel as a whole had time to discuss the full suite of results from the base VPA, including projections and some sensitivities. Over the next few weeks the Panel continued to work together to refine the assessment workshop documentation and produce this report.

### 1.2.1 Discussion and Recommendations Regarding Data Modifications and Updates

#### 1.2.1.1 *Commercial*

<u>LANDINGS</u>

The AW panel noted that deep-mesh, runaround gill nets were not fished in the earlier time period, and extrapolations back in time using their landings could overestimate the portion of the catch attributed to gill nets. Therefore, it was suggested that the historical commercial landings be reconstructed without extrapolating the runaround gill net catch. It was further proposed that the reconstructed catch without this type of gill net be used as a sensitivity run. However, it was pointed out that regional gear-specific landings had to be estimated only for the years from 1962 to 1971 when these specialized deep gill nets were not in use. As a result, the issue was dismissed.

Note was made of the high reported landings from Mexico, which could affect stock status of king mackerel from the Gulf of Mexico (GOM) if the GOM and Mexican king mackerel are actually one unit stock. It was further noted that additional fishery information (size composition, catch rates, general knowledge of the fisheries) from that area were lacking or limited in duration, and that there were concerns about the quality of the available Mexican landings data (accuracy of landings reports, species identification, etc.).

During the assessment workshop modifications were made to the treatment of the historical landings data, particularly with respect to the assignment of some of the west Florida landings to the mixing area. While the commercial landings had been accounted for spatially and temporally to include a GOM zone, a mixing zone, and an SA zone, it was not evident that the DW had split the landings into Gulf and Atlantic areas that corresponded to the jurisdictions of the respective Federal Councils (split by the Florida Keys). The AW panel asked that the analysts ensure that this was done.

<u>FINFISH BYCATCH</u>

The AW accepted the DW's recommendation that the number of dead discards in the commercial finfish fisheries is considered sufficiently low (about 10-15 thousand fish per year) to be negligible enough to not include in the assessment.

<u>SHRIMP BYCATCH</u>

The AW agreed with the DW's recommendation to exclude shrimp bycatch from the mixing zone in the model since there were few observed occurrences of king mackerel bycatch by shrimp trawlers in this area, and extrapolation of these using estimated shrimp trawl effort would be highly uncertain.

Shrimp bycatch estimates in the GOM were derived from a combination of SEAMAP data and shrimp observer data. It was noted that the shrimp bycatch estimates from the GOM were very different between SEDAR 5 and SEDAR 16. The analysts proposed that this could be because all effort was used in the estimates for SEDAR 5, but for SEDAR 16, effort was only included if it was in areas that were likely to contain king mackerel. In addition, a different method of estimation was used: GLM in SEDAR 5 vs. a delta GLM in SEDAR 16 (see below).

Shrimp trawl effort was tabulated from FL trip ticket data and data provided by the NMFS Galveston lab, with king mackerel catch rates estimated from observer data (not stratified by depth). Shrimp trawl bycatch was examined using both GLM and delta-lognormal approaches, described in SEDAR 16-AW-07. Both methods used a log transformation to reduce the influence of occasional very large catches relative to the mean. The GLM approach was used in previous assessments. The delta-lognormal method first evaluates the probability of encountering king mackerel in a trawl tow, then the expected catch rate if there is at least one fish caught. In most time periods where data existed, the delta-lognormal approach provided more variable and larger estimates of bycatch.

Previous estimates of shrimp trawl effort in terms of numbers of net hours had been calculated using an estimate of two trawls per vessel throughout the period of record. In this assessment, the Vessel Operating Unit File (VOUF) data was used to estimate the mean number of nets by year, which was then used as a multiplier in the estimate of effort, rather than the constant estimate of two nets per vessel. Over the time period of 1972-2006, the average number of nets per vessel increased from an average of 1.87 to 3.1 nets. This had the effect of increasing the estimated effort and bycatch in recent years, compared to the constant estimate of 2 nets per vessel.

For Gulf of Mexico shrimp bycatch, SEDAR 16-AW-07 provided several possible methods of estimation, depending on which datasets are included (observer data from various programs and eras, research cruise data, and combinations of these) and whether GLM or delta log-normal estimates were used. The AW concluded that the best representation was probably using the delta-lognormal model that incorporates all observer data (Oregon II, old observer data, characterization, evaluation and Bycatch Reduction Device (BRD) data from the Regional Research program, and the Summer 98 Program, except that for the years 1997-2001). For those combinations of season and areas where BRDs are required, the estimates use the BRD predicted catch rates, while those season and area combinations that are not required to have BRDs use the non-BRD commercial predicted rate.

The AW recommendation to use the estimates of Gulf of Mexico shrimp bycatch put forth in SEDAR 16-AW-07 differs from the recommendation of the data workshop panel, which recommended the estimates put forth in SEDAR 16-DW-05. After comparison between the two sets of estimates, it was determined that the only major difference that could be identified in the timeframe of this SEDAR process was that the SEDAR 16-DW-05 used R code to implement the analysis, while SEDAR 16-AW-07 used SAS code. Given that the two code implementations produced different estimates, and the lead analytic team is more confident in the results produced implementing the SAS code, the AW Panel recommended going forward with those estimates for the Gulf of Mexico. The analysts will continue to examine the discrepancy between the two codes for use in future assessments.

The AW was concerned that the estimates of shrimp bycatch derived for the South Atlantic from the SEAMAP survey were likely an overestimate because SEAMAP does not use BRDs or TEDs in their trawls. There was not enough observer coverage in the South Atlantic to use observer data to derive more definitive estimates. In addition, the AW panel was also concerned because the SEAMAP data was highly variable (Figure 1.1), and the numbers of age-0 fish caught in SEAMAP trawls were low. There was some discussion on using the Gulf CPUE as a proxy for the SA and coming up with a conversion factor to correct for any bias, but there isn't enough observer data in the SA region to develop one. However, the estimates of discards using SEAMAP data were ultimately included in the model. A comment was made that the current estimates using SEAMAP may be fine since we are just trying to account for removal levels, and it should just be realized that this is a limitation of the model. Shrimp bycatch estimates from the GOM were derived from both SEAMAP and observer data. Estimates from the GOM were deemed acceptable because they also included observer data, which does include the effect of TEDs and BRDs.

A large decline in SA shrimp bycatch estimates beyond 1999 was brought into question. This was investigated and later found to contain an error. The shrimp index was updated and it became relatively flat except for a few spikes in 1996 and 1998. The implementation of BRDs may account for the decrease in bycatch seen in the shrimp fishery after the year 2000. This index should be a reasonable approximation of the catch rates, but there is no way to adjust for BRDs or TEDs or regulations.

## SIZE AND AGE COMPOSITION

There was concern about the lack of samples from North Carolina commercial fisheries, particularly the NC gill net fishery since it accounts for 6% of the landings in the South Atlantic (see SEDAR16-AW-01 and SEDAR16-AW-03). The majority of the gill net fishery in the South Atlantic occurs in the northern district of NC. To remedy the lack of samples in the future, NMFS port agents have recently been hired in both the southern and northern districts. It was noted that all commercial fisheries for each area (GOM, SA, and mixing zone) were combined and will most likely reflect the hook and line fishery. It is reasonable to assume that hook and line samples were similar across all districts in NC, so samples from the southern district were used as a proxy for the missing samples in the northern district.

The AW noted that, as with the recreational fishery, there was a portion of the landed commercial catch that was below the minimum size, especially in the mixing area in recent years (Figure 1.2). These fish could be landed due to mis-identification by harvesters, shrinkage after landing, lack of knowledge of regulations, or by error, as well as on purpose. Overall, undersized harvest seems to be in the 10-20% range in the most recent years, depending on the fishery, the region, and the year.

The AW recommended using ages 0-11+ for the age structured VPA models for both the GOM and the SA region.

#### 1.2.1.2 *Recreational*

<u>LANDINGS</u>

The DW working group recommended using a mean of the top 5 years of CPUE within the available time series (1981-2006) to estimate the historic recreational catch. Upon examination of those catches, it was noted that there were several cells (region/wave/year) with very high estimates. As a result, the AW recommended using the median of the five highest catch rates per stratum to reconstruct the recreational historical catch estimates. The series constructed using the mean can be used as a sensitivity run.

Discussion then turned to whether these estimates should even be used in the assessment. It was pointed out that the SS3 must match the catch exactly. There is no way to "downweight" the estimates of the historic portion of the landings by including CVs as a measure of uncertainty. This makes accurate estimation of historical data all the more critical. Not including a historical perspective can influence estimates of MSY. The recreational landings are on the same order of magnitude as the commercial catch. The historic estimations assume that the higher catch rates that we observed recently were the same catch rates seen historically. The effort is a linear extrapolation of what it was in the 1980s extrapolated back to zero in 1930 for the GOM and to zero in 1900 for the SA . The historical extrapolation of recreational landings estimates that at one time, the recreational fishery was bigger than the commercial fishery. Ultimately, the AW decided not to include the historic recreational data for the base case, but instead to include it as a sensitivity run.

A question arose as to whether there was any attempt to account for changes in catchability due to increases in technology. It was discussed, but it was determined to be less critical for the king mackerel fishery because these fishing locations are not habitat or bottom specific as they are for reef fish.

<u>HEADBOAT LANDINGS</u>

A comment was made that the historical catch of headboats seemed rather high because headboats did not really appear until sometime after the 1950s; however, it was noted that the headboat historical landings are actually more accurate because it is based on data from a survey of trips and harvest, with no expansion via telephone survey. There were approximately 100 headboats operating in the 1950s, but there is no information on what they were targeting at that time. This high effort data matches what fishermen have been saying: that recreational catches were high before the introduction of gill nets and decreased greatly after their introduction. It was noted that the VPA only uses data from 1981 forward, as in the continuity, and therefore does not use the historical data, but some runs from the SS3 model would. It was noted that overall, the magnitude of headboat landings is low and may not make much of a difference in the results when all mortality factors are included. The For-Hire Survey method should be used for charter boats, and calibrations should be used to recreate historical landings.

DISCARDS

There was substantial discussion of the use of discard mortality estimates. The DW recommended applying a 20% release mortality to the MRFSS fishery where fish are released alive and a 33% mortality to the headboat fishery where fish were released both dead and alive. These mortality rates were derived from observer headboat data and also match an estimate determined from a Mote Marine Laboratory project (Edwards 1996).

Ratios of number of fish per angler to the bag limit indicated that only the headboat portion of the recreational fishery seemed to have a substantial portion of their catch returned due to size; however, as noted above and in Figure 1.2, the harvest of undersized fish was not limited to that sector. Bag-limit effects seemed to be minimal for the headboat fishery where few trips reported catches close to the limit. The MRFSS data showed a larger portion of anglers meeting or exceeding the limit. It was noted that tournament catches are partially covered by MRFSS, but they are likely underrepresented.

Opinions were voiced that these discard mortalities were too high, and further comment was made that headboats cannot be compared to charter boats. It was asked how an analyst can distinguish whether fish were dead or alive when thrown back. It was noted that dead discards were added to B1 catches for MRFSS. The B2 estimate (fish that were released alive) for 2006 was also questioned. It was determined that the "high" estimates for 2006 were over multiple waves and not all from one boat inflating the estimates.

A decision was made to follow the recommendations of the DW, and it was noted that continuity runs do not include discards (B2 portions).

### 1.2.1.3. *Life History*

GROWTH

The AW participants agreed with the DW decision to separate growth by sex and migratory group using data from fish outside the mixing zone to ensure that each curve is unique to either the GOM or SA migratory groups. The samples used to develop the growth curves did not use the new size-age data from Patterson and Shepard because fish from the mixing zone could be from either migratory group. Fish age 1 and older were modeled using a von Bertalanffy growth equation. Prior to age 1, the growth was determined using a linear model because king mackerel grow at such a fast rate at this age that they do not conform to the von Bertalanffy model. Results showed that female growth differs by migratory group, but male growth does not.

## STOCK COMPOSITION

Mixing ratios were estimated based on two years of data from microchemistry and otolith studies showing an approximate 50:50 GOM to SA ratio in the mixing zone. The effective sample size was used to weight the likelihood for these data, and these weights can be explored as sensitivity runs. Tagging data is also available; however, it was not deemed appropriate to model mixing rates. John Gold's work with mitochondrial DNA also shows an approximate 50:50 ratio that supports the otolith and microchemistry estimates.

The VPA 2-Box cannot model mixing rates like the SS3 model, so assumptions on mixing ratios must be made a priori. It was suggested that mixing ratios resulting from the base SS3 run be used as a starting point for the VPA. The AW decided to consider a 50:50 mixing ratio for the VPA with the understanding that this likely varies somewhat from year to year. It was suggested to run different mixing rates as sensitivity analyses.

There was also discussion on the lack of data to separate the east and west GOM. It was suggested that a sensitivity analysis could be run excluding all fish west of the Mississippi River to see how the model reacts. The Mississippi River corresponds more to separation of several stocks in the GOM than the AL/FL line used for management purposes, and may be more instructive for this analysis. It was pointed out that oceanic current patterns could contribute to separation of east and west GOM stocks. It was suggested to run a sensitivity analysis by omitting the western GOM if time permits.

The AW reviewed information on the migratory patterns of the GOM and SA stocks. The AW agrees with the DW's view that uncertainty continues to exist about linkages and migratory patterns between migratory groups, both between the Atlantic and Gulf, and within the Gulf (Eastern Gulf / Western Gulf / Mexico). These linkages and uncertainties are reflected in Figure 2.15.1 of the DW Report. The lack of data from Mexico is also a problem. Mexico has a large fishery which could have a substantial impact on the U.S.

The AW discussed the ability of age-0 fish to migrate south from the spawning grounds. Initial runs of the SS3 model were resulting in a large portion of age-0 fish migrating to the mixing zone. This is a problem because if this does reflect reality, then most of the age-0 fish are not subject to bycatch in the shrimp fishery within their respective zones. Ultimately, the AW recommended assuming that no age-0 fish migrate south to the mixing zone from the spawning grounds.

## FECUNDITY

The AW also agreed with the DW that replacement of the older (Finucane et al. 1986) batch fecundity data with the new length-based batch fecundity and the more modern techniques used in the development of that data (see DW report, p. 26), using length-based batch fecundity data. The AW decided that use of a single function for batch fecundity at length for both migratory groups was most appropriate due to the limited numbers of samples available from the GOM (non-mixing zone), the length distribution of those samples, and the wide variation in the overall observations, especially for larger females. The AW recommended using an updated fecundity vector based on hydrated oocyte data as reported in SEDAR16-DW-06.

MATURITY

The AW continued to accept the size/age at maturity information from Finucane et al. (1986), as the DW reported that no additional size or age at maturity data were available.

LENGTH-WEIGHT RELATIONSHIP

The length-weight relationship used in SEDAR 16 differed from SEDAR 5 in that SEDAR 5 used the growth curve to determine the relationship, whereas SEDAR 16 used only observations collected outside of the mix area to estimate length-weight relationships by stock and sex groups.

NATURAL MORTALITY

The AW accepted the Lorenzen (1996) age-specific estimates of natural mortality (M) scaled to the Hoenig (1983) estimate based on maximum age for king mackerel as presented in the DW report. There was some discussion of the reason for using different base M's between regions in past assessments. Differences between regions and over time did not appear to be based on empirical data, so the AW briefly considered whether a single estimate should be used in both regions. The differences seen in the estimates reflect the current observed differences in maximum ages for king mackerel between the SA (26 years) and the GOM (24 years), which provide Hoenig (1983) estimates of 0.16 and 0.17, respectively. Using Lorenzen's function to distribute the implied lifetime cumulative mortality across fully recruited ages (age-2 and older) give estimates ranging from 0.22 and 0.23 at age 2 on the Atlantic and gulf coasts respectively, to 0.15 and 0.16 at age 20. Extrapolations to earlier ages used the assumed size of 58 cm at age 1 and the midpoint of the line segment between the origin and this point for age-0.

WEIGHT AT AGE

In the 2003 GOM (SEDAR 5) assessment there was an error in the weight-at-age vector that may have affected the reference points. The AW agreed with new weight-at-age estimates presented by the DW. It was noted that the female weights-at-age used in the VPA 2 Box model shows strikingly heavier fish at a given age in the Gulf than in the Atlantic resulting in a higher estimated fecundity at age because Gulf of Mexico females attain larger sizes overall than the South Atlantic fish and thus are larger and heavier at a given size.

#### 1.2.1.4. *Indices*

NC TRIP TICKET INDEX

It was noted that the SEDAR 5 version of the North Carolina trip ticket index was not appropriate for king mackerel since it was originally created for both Spanish and king mackerel.

In addition, the method of selecting targeted trips was suspect, and it should be replaced with the updated version approved by the SEDAR 16 DW. The updated index was accepted by the AW panel for use in the base case Atlantic stock VPA2-Box assessment and initial runs of the SS3 model. The DW expressed concern about the effect of management regulations on the standardized index; however, year and season were included as factors in the model and may have accounted for some restrictions such as seasonal closures (quota closures and associated pre-closure trip limits).

COMMERCIAL LOGBOOK INDEX

Throughout the discussion, the complexity of the management regime surrounding king mackerel harvest was discussed. The complex of stocks, with changing regulatory boundaries over the course of the year, changes in commercial trip limits in different areas and seasons, challenged the development of meaningful CPUE indices, especially for some highly constrained fisheries.

There was concern over those trips on the east coast of Florida where it appeared that the trip limit was reached and boats could then go and fish for something else influencing the commercial logbook as an accurate index of abundance. It was noted that targeting was a factor in the model. There was also discussion on the influence of trip limits varying by time and region on the overall index. Regulations sometimes cause boats to move into areas that allow larger trip limits. However, this is taken into account in the analysis as long as the fisherman accurately records where they were fishing in the log book. A combination of area and trip limit was also examined to determine if the trip limit was reached. It was determined that for some of the lowest trip limits, there was an indication of differing responses by the harvesters. However, for more liberal limits, the trip length was the major factor that was determined – i.e. there was little indication from the logbook data that vessels were changing target species. Therefore, the AW recommended that further analyses be conducted in this area, and that the most restrictive of the trip limits not be considered in the development of the final indices, where trip limits could influence the final index, based on those analyses.

For the commercial logbook index, vessels were selected by number of years that they reported landings. Those vessels that landed king mackerel for 14 years were ordered by landings, and only those vessels that accounted for 80% of the catch overall were included in the analysis. To accommodate regulatory measures, data during two closed periods was excluded.

The SS3 model can have only one index associated with each fleet in the model. Given this constraint, only one index can be applied to a given fishery for the SS3 model. The AW had to choose between using either the commercial logbook index or the North Carolina trip ticket index in the SS3 model.

There was a large difference between the nominal and standardized commercial logbook index in the SA region. The AW believed that these reflected a change from voluntary to mandatory reporting requirements in 1998. The analysts were not able to entirely remove this influence from the index, so AW group considered using the North Carolina trip ticket generated indices instead of the logbook index.

The pros and cons of both the North Carolina trip ticket index and the commercial logbook index were discussed:

NORTH CAROLINA TRIP TICKET INDEX

| Pros | Cons |
|---|---|
| • Few reporting issues<br>• Most likely reflects what is going on in the rest of the SA | • Slightly shorter time series than logbook(1994-2006)<br>• Trip duration difficult to determine<br>• Gear actually used to harvest mackerel is sometimes unclear<br>• Lacks information on the time spent fishing (Only measure of effort is the trip)<br>• Difficult to determine when multiple trips were recorded on one ticket<br>• Charter boats that sell their catch are hard to identify.<br>• Restricted to NC (lacks coverage of SA) |

COMMERCIAL LOGBOOK INDEX

| Pros | Cons |
|---|---|
| • Better measure of effort (hours fished vs. trip)<br>• Greater area of coverage (entire SA region vs. only NC)<br>• One additional year of data (1993-2006) | • Appears to be a vessel reporting effect that greatly alters the resulting index |

Ultimately, the AW decided to use the logbook data for the GOM no-mixing zone and the mixing zone, but to use the North Carolina trip ticket index for the SA no-mixing zone. The commercial logbook index was proposed as a potential sensitivity run for the SA region.

MRFSS

The AW investigated whether the bag limit may affect the ability of the MRFSS index to reflect trends in abundance. Bag limits did not appear to affect fishing behavior as fishermen frequently exceed the bag limit. It was noted that trips where it appeared that bag limits were exceeded may not be accounting for the captain and crew on the boat. However, it was noted that the MRFSS index includes both private and charter boats (private boats do not have captain and crew). It was also noted that the behavior of fishermen in the headboat and MRFSS fisheries are different, therefore discards should be treated differently in each fishery. It was also noted that CPUE may be influenced by people continuing to fish (catch and release) after they have caught their limit. However, it was pointed out that the MRFSS index is one of the only indices that include discards. The general consensus of the AW was to include the MRFSS index in base models for VPA and SS3.

There was concern over the large variability in the MRFSS index for the SA. It was pointed out that only the intercept data were used to develop this index which is different from calculating catch estimates which include the phone surveys. It was also pointed out that trips were selected in such a way that only those targeting species associated with the catch of king mackerel were included.

HEADBOAT

The AW recommended using the headboat index for the base model, but asked that data collected during closed seasons be excluded.

FALL PLANKTON SURVEY (GOM)

Fall plankton survey (also referred to as the SEAMAP ichthyoplankton survey) was used as an indicator of spawning stock biomass (SSB) for the GOM stock. Hurricane activity disrupted sampling, so there are some missing data points in the survey index. For the SS3 model, there was some discussion as to whether it should be used as an SSB or age-0 index. It was agreed to use the fall plankton survey as an index of SSB for the SS3 model as long as it was applied only to the Gulf spawning stock. However, it was pointed out that the SSB applies to all regions in the SS3 model. It was suggested that it could be called its own “fleet” as a way to work around this issue and assign it only to the GOM. Within the final base case VPA2BOX model runs, this survey was used as an index of SSB for the Gulf stock.

SHRIMP BYCATCH INDEX (GOM)

The shrimp bycatch index comes from observer coverage data in the GOM. This index was included in the continuity run and applied to age-0 fish, but it was not included in the SS3 model or the base run VPA. It was noted that the shrimp bycatch index shares the same trend seen in the fishery independent data.

SMALL PELAGICS TRAWL SURVEY (GOM)

In agreement with the DW recommendation, the AW decided not to use the small pelagic trawl survey from the GOM. Several sampling methodologies were used in an effort to determine the most effective way to sample. The survey has only been standardized since 2004, which results in only three data points for the model. The AW felt this was too short of a time series to use at this time, but that it would be useful in the future.

SOUTH ATLANTIC SHARK GILL NET INDEX

The AW agreed with the DW's recommendation not to use the South Atlantic shark gill net index because the number of drift gill net vessels in the shark fishery has decreased ,few trips were observed each year, the survey only had a small area of coverage, and changes in target species may have occurred . In addition, gill nets only make up a small percentage of the overall king mackerel landings in recent years.

SEAMAP SHALLOW WATER TRAWL (SA)

The SEAMAP shallow water trawl survey was used as an index of age-1 abundance, offset by a year, for the SA stock under SEDAR 5. However, most of the king mackerel caught during this trawl survey were 40 to 430 mm FL (S16-DW-9) and the SEDAR 16 DW recommended it as an index for age-0 king mackerel. This is the only index for ages 0 or 1 available for the SA. It was noted that there was a high degree of variability prior to 2001. As recommended by the current DW, the AW decided to use the index for mid age-0 king mackerel for both the VPA and SS3 models.

SEAMAP GROUNDFISH SURVEY (GOM)

The first data point in the SEAMAP groundfish survey index was called into question, since it appeared much higher than the rest of the index values. It was determined that there was no reason to exclude that year of data, so it remained in the index. Year-specific CV values are used in the SS3 model and can also be used in the VPA. The AW decided to include the SEAMAP groundfish survey as an index of GOM age-0 abundance.

### 1.2.2 Discussion and Critique of Each Model Considered

#### 1.2.2.1. *Continuity Case*

The AW requested an updated "continuity" run using updated input data. This was not completed during the workshop because the effort needed to develop the catch-at-age using the revised MRFSS estimates was considerable. The analyst did note however, that it would not be possible to do a strict continuity run as some of the data accuracy has been improved (i.e., indices have been updated, errors in the catch at age have been corrected, and the terminal F vector was different).

#### 1.2.2.2. *VPA vs. SS3*

The SEDAR5 assessment and review workshop panels recommended moving from the VPA models of Atlantic and Gulf king mackerel to a three area statistical model as indicated by the following quote from page 7 of the SEDAR5 Review Workshop Consensus Summary:

*"RW Panel agreed with the authors that a three-area assessment model would be more appropriate. A three-area model would allow examination of the mixing zone as a separate area with intermixing of king mackerel restricted only to that area. Assessment at a finer spatial resolution, however, is constrained by the sample sizes for statistically based catch per unit effort indices and age-length data. The RW Panel recommended that stock assessment methods that estimate fishing mortality for the oldest age class in each year back in time be evaluated as an alternative to the current VPA model. The current assessment is based on a model which estimates F in the last data year and uses a fixed F-ratio between age 9 and 10 to obtain F at age and year for those cohorts that are not represented in the last data year. Also, methods that do not assume that catch at age is known with 100% precision, like ICA, or AMCI could be tried. These methods have the advantage that they are more stable over time, especially regarding the historical stock number and F estimation for cases like the king mackerel where F is not much higher than M."*

VPA's remain a popular stock assessment technique, in part because of their long history and relative simplicity (reducing the chance of implementation errors), but also because they have many fewer estimable parameters and reach a solution much faster than their more sophisticated statistical counterparts (making them more tractable for meeting settings). Some investigators also find it advantageous that tuned VPA's place no restrictions on the degree to which the fishing mortality rate may vary from year to year and age to age. The primary drawback to VPA is its assumption that the catch of each age class in each year is known without error. When this assumption is not met, statistical catch at age models (which limit the extent to which the vulnerability of each age class can vary from year to year) often produce more reliable estimates of fishing mortality and stock abundance. Moreover, statistical catch at age models (such as Stock Synthesis) are more flexible than VPAs in that they can directly accommodate more types of data (e.g., catch at size) as well as missing data. VPA, on the other hand, requires a complete catch at age matrix, which may necessitate making somewhat arbitrary substitutions for some years. Finally, the most advanced VPAs currently in use can only accommodate two migratory units in two areas, whereas the stock synthesis model is able to accommodate a third area that represents the so called mixing zone. In summary, the Stock Synthesis model is capable of representing the two migratory units of king mackerel more realistically than the 2-area VPA and better accommodates the uncertainty in the observed catch at age data. However, the Stock Synthesis model is far more difficult to implement and requires more careful attention to diagnostics.

### **1.2.2.3.** VPA Base

<u>INITIAL RUNS</u>

The AW recommended that the catch at age for the VPA should include dead discards.

A separate catch at age will need to be reconstructed for each different mixing scenario considered. The AW recommended configuring a version of the VPA that is as close to the SS3 model as possible using a 50:50 mixing ratio. In addition, the VPA uses the same indices as SS3 including the NC trip ticket index for the SA because the concerns over the commercial logbook index were never resolved.

The AW recommended constraining fluctuations in selectivity and recruitment by applying a “patch” where the recruitment estimates for the last two years of data (2005 and 2006) are replaced by recruitment as estimated by the spawner/recruit function. The rationale for the application of this adjustment is that the only information on recruitment in these last years of the assessment is derived from indices of juveniles that have not yet been recruited to the directed fisheries. Therefore these estimates are based on less information than is available for other cohorts in the assessment. Base runs with and without this “patch” were run as a measure of sensitivity of the VPA to the inclusion of these data.

Partial catches were fit using methods of Butterworth and Geromont (1999) so that selectivity within each fishery and each index remained constant over entire time period

Fits of fishery-independent indices to predicted values in the VPA were poor compared to fishery-dependent indices. This could be an issue over a long time range, since fishery-dependent indices would be more likely to be influenced by changes in regulations, gear efficiency, and other factors that could affect catchability over the time range. Fishery-independent indices, on the other hand, are intended to be samples drawn consistently over the range of years for which that index is available, and more amenable to statistical procedures such as GLM when inconsistencies arise in those procedures.

Due to the relatively poor fits of the fishery-independent indices, the analysts and the AW examined several different methods to weight the indices (SEDAR 16-AW-09). Along with weighting the indices with the coefficient of variation from the index standardization, additional variance was added using a variety of different methods. While the AW recognizes that this does not represent a complete suite of methods, it does provide some information regarding the influence of these choices on the outcomes of the VPA. The AW and analysts examined the use of a method of weighting such that the mean value of the year-specific GLM estimate of the variance plus the added variance was approximately equal for all indices. This had the effect of improving fits for fishery-independent indices, at the expense of fishery-dependent indices, especially the commercial index which had a different trend from other indices, most notably in the last years of the assessment. However, it did have the effect of estimating very high terminal F in the GOM stock due to the high estimated shrimp trawl bycatch in 2005, which was not interpreted as a strong year-class due to the lack of harvest data later in the history of the cohort under this scenario. The Panel chose to accept the use of added variance terms that were added to each of the indices so that the overall variance associated with each index was a similar magnitude (SEDAR16-AW-09).

The group discussed how terminal F should be defined for determining the overfishing status of the two migratory groups. The use of F2006 for estimating terminal F was done in the original meeting and at a point when we were still hopeful that the SS3 model could be fully developed. The uncertainty of terminal values in the VPA model make an average of the last few years more appropriate, since the estimates in the last year are driven much more by the estimates of the indices, which do not fit well in this fishery.

#### 1.2.2.4. *Stock Synthesis 3*

INITIAL RUNS

Initially, it was thought that the SS3 model got to the last phase and hit a boundary in the number of iterations so could not converge onto a final solution. The AW recommended not using the SS3 model if the Hessian could not be inverted. Upon further exploration of the issue by the assessment team, it was determined that the model was limited by the available memory of a 32-bit operating system (OS). This portion of development of the SS3 will have to wait until the model can be run on a 64-bit OS.

The AW recommended that the SS3 model be reconfigured to accommodate applying SSB indices of abundance to specific areas (i.e. applying the SEAMAP fall plankton survey index to the GOM stock only).

It was noted that parameters of the model can be functions of environmental information. In future assessments it was recommended to investigate the relationship of temperature on migration patterns.

While the final configuration of the SS3 model examined by the AW appeared to be performing well, it was clear that the interpretation of the stock-specific population parameters would all be conditional on the population parameters of the other stock co-occurring in the mixing zone in South Florida. This created a conundrum on how to interpret the results and calculate separate management benchmarks for the two migratory groups. For this reason, and the novelty of the approach (to king mackerel), the AW panel decided that it should pursue the VPA2BOX model during this SEDAR cycle and allow the analysts more time to explore how Council-pertinent management advice can be extracted from the SS3 model.

The SS3 model had several augmentations in this version to incorporate differential growth rates, tag-recapture data (not used in the king mackerel assessment), separate population size composition from data sized composition. It also is able to incorporate movement patterns that are specific to the natal region. However, it still needs research into how to develop management benchmarks and to more efficiently incorporate uncertainty into the results.

### 1.2.3 Preferred Model, Configuration, and Summary of Model Issues Discussed

At this point, the VPA model using one per stock, with an initial estimate of 50% contribution from each stock into the mixing zone seems to be the most appropriate to move forward within the short term. However, the AW saw substantial benefits in the use of the SS3 model structure, due to its ability to accept a wide variety of input information, to allow uncertainty in harvest and index information, and to allow for missing years of data.

The use of a model such as the Stock Synthesis model presented in the AW has long-term benefits. This could be a benefit in future assessments, or if issues regarding the ability to provide estimates of variation around deterministic results and to provide management advice from the SS3 could be resolved. At the time of the AW meeting, such abilities were still not available.

### 1.2.4 Recommended Parameter Estimates

Given the time constraints of this assessment process, the Panel did not have time to discuss and formally recommend parameter estimates. Please see Section 3. Model Documentation for estimates.

### 1.2.5 Evaluation of Uncertainty and Model Precision

Given the time constraints of this assessment process, the Panel did not have time to discuss these issues.

### 1.2.6 Discussion of YPR, SPR, Stock-Recruitment

Much of the AW was focused on the methods to be used for development of the base case (VPA or SS3), and on the indices to be used as inputs. As such, little time was available to evaluate YPR parameters. The outputs from the continuity and base runs are the only information available for comparison on this topic.

The fishing mortality rate that produces 30% SPR in the long run is the overfishing benchmark accepted by both Councils under current management.

The SEDAR 5 assessment approach utilized a two-line-segment spawner-recruit curve with a segment extending from the origin to a point whose x.y coordinates were defined as the mean of the five lowest SSB values and the arithmetic mean of the recruitment series, respectively. Recruitment at higher SSB levels was equal to the arithmetic mean. In this assessment, the spawner recruit relation was formulated as a Beverton-Holt curve with a steepness equal to 0.95 and maximum recruitment at the geometric mean of the recruitment series. This change was justified because the segmented spawner-recruit curve indicated that recruitment was not sustainable even at low F levels on the Atlantic coast.

### 1.2.7 Recommended SFA Parameters and Management Criteria

The SFA parameters and management criteria are provided below in Section 3: Model Documentation (Tables 3.23 and Figures 3.42 and 3.43).

### 1.2.8 Status of Stock Declarations

The Gulf of Mexico migratory group of king mackerel is not overfished and overfishing is not occurring. The South Atlantic migratory group of king mackerel is also not overfished however there is some indication that a small amount of overfishing may be occurring (see Section 3 for further discussion).

#### 1.2.9 Recommended ABC

These estimates were not provided in time for the Panel to discuss them.

#### 1.2.10 Discussion of Stock Projections

Projections were run both with projected recruitment based on the S/R relationship and retaining the estimates for 2005-06, and by replacing the last two years of recruitment estimates with B-H predicted values. The Beverton-Holt model was fit to estimated recruitment with a steepness value of 0.95.

It should be noted that estimated recruitment for the GOM stock has been among the highest recorded over the last several years. However, for projections beyond the time period when these cohorts will be exposed to the fishery, and after they are major contributors to the spawning stock, the projections would show a decline in stock size, as cohorts of the geometric mean of historical recruitment enter and move through the fishery. This means that estimates of stock status in 2006 will not be the same as for those several years into the future, if current harvests are maintained. Note that if harvest <u>rates</u> are maintained, then projections would be less subject to variation in status, but implementing such a constant-F strategy would be difficult.

#### 1.2.11 Management Evaluation

Given the time constraints of this assessment process, the Panel did not have time to discuss these issues.

#### 1.2.12 Research Recommendations

<u>PROGRESS ON RESEARCH AND MONITORING RECOMMENDED BY SEDAR 5:</u>

The SS3 model was attempted to address the recommendation from SEDAR 5 to use a three-area age structured model with forward projection to better estimate the stock status while accounting for the population dynamics occurring in the mixing zone. In addition, the SS3 model was also an attempt to address the SEDAR 5 recommendation to account for errors in the calculation of the catch at age matrix. Unlike the VPA, which assumes the catch-at-age matrix is computed without error, the SS3 model does not use a catch-at-age matrix. Instead, it uses age and length composition data to determine age/size structure. However, ultimately the SS3 model was not selected as the preferred model because of several limitations (see section 1.2.2.4 for details).

The von Bertalanffy growth parameters by sex for both the GOM and SA migratory groups were improved. In addition, new data was incorporated into the age-length key that included a significant number of age 0 and 1 fish collected from fishery independent serves to help address the selectivity issues of fishery depended samples subject to size limits.

RESEARCH RECOMMENDATIONS FROM SEDAR 16

1. Increase observer coverage in the South Atlantic shrimp fishery to get a more accurate representation of king mackerel discard rates.

2. Increase commercial sampling of king mackerel in North Carolina, especially for the gill net fishery in the northeast region.

3. Determine whether separate stocks exist in the eastern and western portions of the GOM.

4. Determine the relationship of king mackerel off the coast of Mexico with U.S. king mackerel stocks. Given the magnitude of king mackerel landings off the coast of Mexico, this could have a large impact on the Gulf of Mexico king mackerel fishery in US waters. It could also provide a more complete evaluation of parameters such as stock size, for some or all migratory groups. Other fisheries may also be significant, such as any Cuban fisheries on the stocks.

5. Obtain detailed commercial and recreational landings information, discard information, and biological samples (age, length, weight, sex, fecundity, etc.) from king mackerel off the coast of Mexico if US king mackerel stocks are found to intermix with Mexican stocks.

6. Continue or begin research programs that conduct tagging studies, otolith microchemistry and shape analysis studies, and gather microsatellite genetic marker data to determine mixing rates of king mackerel off of south Florida during the winter months. A longer time series documenting stock composition data in the mixing zone is needed to increase the accuracy of the SS3 model.

7. Continued evaluation of tag data, ongoing otolith microchemistry and shape analysis studies, and microsatellite genetic marker data to improve estimation of stock structure and mixing proportions.

8. Investigate a method for correcting the reporting bias associated with the commercial logbook index for the South Atlantic.

9. Improve the SS3 model so that it allows for uncertainty in the landings and does not require that estimated landings match the input landings data exactly (e.g., incorporate CV estimates from MRFSS landings), the Hessian can be inverted, estimates of

uncertainty can be provided, and stock-specific management benchmarks can be produced.

10. Investigate differences in total headrope lengths of nets, along with other possible estimates of fishing power per vessel, in the function used to estimate shrimp bycatch and consider these in the GLM analysis.

### 1.2.13 References

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Geromont, H.F., and D.S. Butterworth. 2001. Possible extensions to the ADAPT VPA model applied to western North Atlantic bluefin tuna, addressing in particular the need to account for "additional variance". Col. Vol. Sci. Pap. ICCAT 52: 1663-1705.

### 1.2.14 Assessment Workshop Panel Figures and Tables

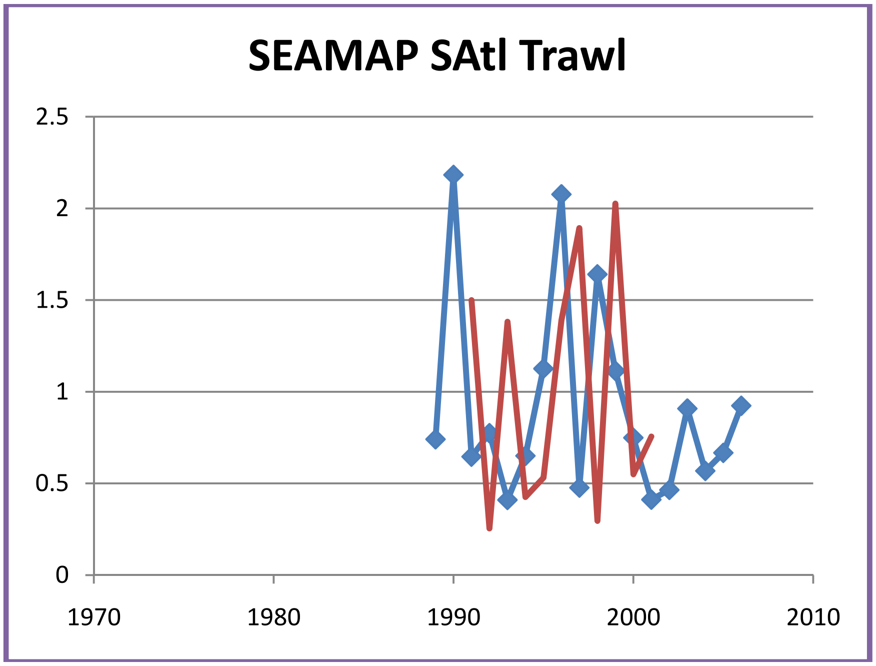


Figure 1.1. SEAMAP shallow water trawl index of king mackerel age-1 abundance in the South Atlantic region (The solid red line represents estimates from SEDAR 5. The blue line with diamonds represents updated data for SEDAR 16).

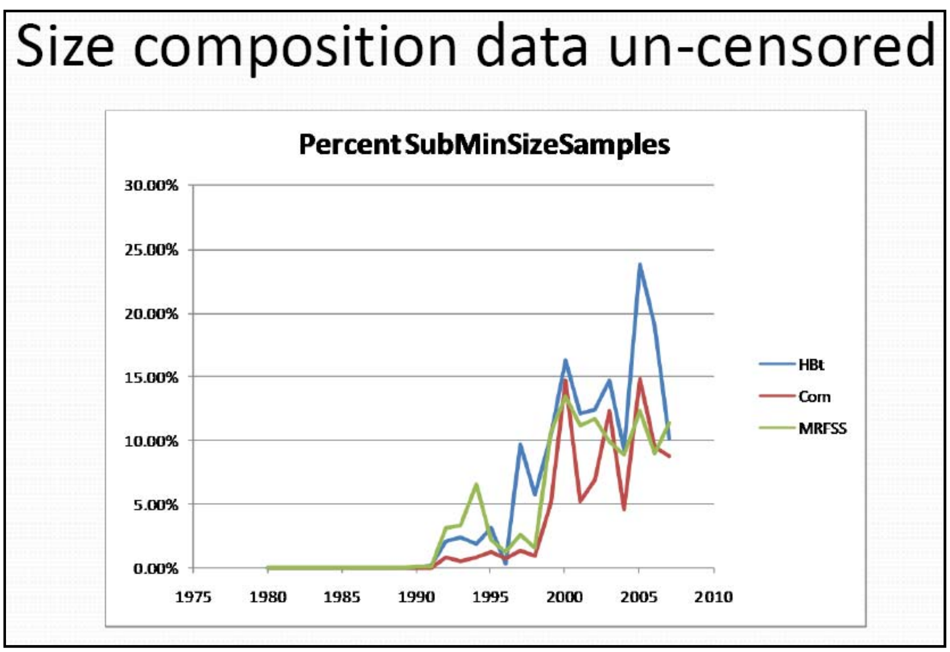


Figure 1.2. Percent of total catch that are undersized, based on the regulations in effect during the time period and area.

## 2. DATA REVIEW AND UPDATE

Inputs to the VPAs are discussed in Section 3 for each model.

## 3. STOCK ASSESSMENT MODELS AND RESULTS

The Virtual Population Analysis (VPA) results described in this document provide an update of the previous Gulf king mackerel and Atlantic king mackerel stock assessments (SEDAR5). They represent several analyses including a "Continuity Case" - maintaining the modeling approach, major assumptions and treatment of the input data from SEDAR5 while updating the time-series - as well as other analyses conducted following the decisions made by the SEDAR 16 Assessment Workshop.

### 3.1. *MODEL 1 – "CONTINUITY CASE"*

#### 3.1.1. Methods

See Section 3.1.1.3

##### 3.1.1.1. *Overview*

The "Continuity Case" is intended to demonstrate the effect of updated data inputs in isolation by maintaining continuity in the modeling approach, major assumptions and treatment of the input data while updating the time-series.

The "Continuity Case" used the software program VPA-2BOX ver. 3.0.5 May 2004 (Porch, 2003), based on the same algorithms as the FADAPT framework. This version of VPA-2BOX is included in the NOAA Fisheries Toolbox package (NFT). To ensure continuity, Atlantic and Gulf "continuity runs" were run using both FADAPT and VPA-2BOX with the same inputs and model specifications; both programs provided identical solutions and results[1].

##### 3.1.1.2. *Data Sources*

The data sources and model settings used for the "Continuity Case" are summarized in **Table 3.1**.

[1] S.L. Cass-Calay, pers. comm. NOAA Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL, 33149. Shannon.Calay@noaa.gov.

**Table 3.1.** Model settings and inputs used to construct the "Continuity Case".

| Settings/Input Series | Continuity Case |
|---|---|
| Stock Definitions | Catches and indices calculated according to the current migratory stock definition:<br>**ATL stock** - US Atlantic north of Volusia County, FL during Nov – Mar, Monroe County FL and northward during Apr– Oct.<br>**GOM stock** - US Gulf of Mexico from Texas to Collier County, FL during Apr - Oct and to Volusia County, FL during Nov- Mar. |
| Fishing Year | Like SEDAR5, catch and Indices estimated using "fishing year" definitions. ATL stock - April - March and GOM stock - July - June |
| Directed Landings/Discards | Like SEDAR5, only retained catch (AB1) for recreational fisheries. No recreational or commercial discards. Used updated series. Data start in 1981. |
| Shrimp Bycatch | Used "GLM5A" estimates developed by SEFSC (5/2008) to replicate SEDAR 5 estimation procedure. |
| Catch-at-age | Age length keys were developed using SEDAR5 methods and inputs, including the von Bertalanffy growth parameters and sex-at-size ratios (1985-1998, using 1998 sex ratios for all subsequent years). |
| Weight-at-Age | Same vector of weight at age as used in SEDAR5. |
| Indices of Abundance | Used same indices selected for SEDAR5 assessment. In general, used identical methods to update indices through 2006. |
| Index weighting | Maximum likelihood weighting with the model giving more weight to the indices that fit better |
| Natural Mortality | Like SEDAR5, constant natural mortality rate M: 0.20 for GOM king, and 0.15 for ATL king |
| Terminal Year F-at-age | Like SEDAR5, $F_{0,2006}$ and $F_{1,2006}$ were fixed relative to the estimated $F_{2,2006}$ using ratios derived from a separable VPA (2000-2006). |
| Annual F-Ratio | Like SEDAR5, for each year $F_{10}$ : $F_{11+}$ was fixed at 1.0. This implies that the fishing mortality rate on the plus group is equal to the fishing mortality rate on age 10. |

The biological functions used during the continuity runs are summarized in **Table 3.2**.

**Table 3.2.** Values of natural mortality, weight, maturity and fecundity, by age, used for the F-ADAPT and VPA2-BOX continuity cases.

| | Natural Mortality | | Weight-at-age (kg) | | Proportion Mature | | Fecundity (millions of eggs) | |
|---|---|---|---|---|---|---|---|---|
| Age | Atlantic | Gulf | Atlantic | Gulf | Atlantic | Gulf | Atlantic | Gulf |
| 0 | NA | 0.20 | NA | 0.469 | NA | 0.000 | NA | 0.024 |
| 1 | 0.15 | 0.20 | 1.263 | 1.123 | 0.548 | 0.157 | 0.155 | 0.093 |
| 2 | 0.15 | 0.20 | 1.853 | 2.005 | 0.861 | 0.529 | 0.266 | 0.229 |
| 3 | 0.15 | 0.20 | 2.486 | 3.037 | 0.924 | 0.704 | 0.406 | 0.437 |
| 4 | 0.15 | 0.20 | 3.131 | 4.144 | 0.948 | 0.856 | 0.570 | 0.714 |
| 5 | 0.15 | 0.20 | 3.767 | 5.266 | 0.970 | 0.989 | 0.753 | 1.048 |
| 6 | 0.15 | 0.20 | 4.379 | 6.364 | 0.989 | 1.000 | 0.947 | 1.425 |
| 7 | 0.15 | 0.20 | 4.955 | 7.412 | 1.000 | 1.000 | 1.149 | 1.829 |
| 8 | 0.15 | 0.20 | 5.493 | 8.319 | 1.000 | 1.000 | 1.352 | 2.247 |
| 9 | 0.15 | 0.20 | 5.986 | 9.285 | 1.000 | 1.000 | 1.553 | 2.667 |
| 10 | 0.15 | 0.20 | 6.437 | 10.106 | 1.000 | 1.000 | 1.748 | 3.079 |
| 11+ | 0.15 | 0.20 | 7.213 | 14.061 | 1.000 | 1.000 | 2.367 | 4.312 |

VPA models assume that the catch-at-age matrix is known without error. The catch-at age of the Atlantic and Gulf king mackerel stocks are summarized in **Tables 3.3 and 3.4**.

**Table 3.3.** Catch-at-age (in numbers) for Atlantic king mackerel.

| | Directed Landings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
| 1981 | 13633 | 60292 | 64301 | 115145 | 103317 | 108451 | 73666 | 105276 | 33917 | 26758 | 62377 |
| 1982 | 5714 | 11390 | 12672 | 56607 | 105516 | 149445 | 164766 | 93819 | 66322 | 52740 | 139537 |
| 1983 | 10107 | 34123 | 77181 | 100404 | 77042 | 123668 | 119771 | 143300 | 26963 | 22815 | 154643 |
| 1984 | 14436 | 8122 | 14189 | 61017 | 98677 | 142380 | 132547 | 86039 | 38250 | 25693 | 165583 |
| 1985 | 24876 | 117534 | 98381 | 34598 | 104993 | 96583 | 95992 | 226992 | 72032 | 17100 | 151460 |
| 1986 | 41651 | 74224 | 84850 | 119231 | 109629 | 85963 | 89693 | 122968 | 69290 | 18710 | 139633 |
| 1987 | 139373 | 190407 | 107954 | 102628 | 85981 | 62012 | 23146 | 57059 | 22207 | 11296 | 87717 |
| 1988 | 13984 | 161467 | 215515 | 126776 | 39802 | 41599 | 56414 | 26770 | 72153 | 22908 | 119144 |
| 1989 | 47211 | 65847 | 109443 | 97248 | 72683 | 57630 | 36024 | 26306 | 18930 | 62683 | 69582 |
| 1990 | 104520 | 109594 | 75043 | 96099 | 89306 | 70740 | 34816 | 20443 | 34883 | 20312 | 93730 |
| 1991 | 50499 | 257111 | 116424 | 62895 | 114734 | 110663 | 51756 | 50281 | 15859 | 9644 | 93896 |
| 1992 | 39018 | 178061 | 296388 | 87737 | 59266 | 56119 | 63462 | 28159 | 21040 | 18605 | 91410 |
| 1993 | 23860 | 60187 | 99594 | 119137 | 46862 | 35100 | 43097 | 53454 | 26999 | 20922 | 64370 |
| 1994 | 43688 | 107423 | 50982 | 88866 | 106194 | 52253 | 29640 | 26850 | 38609 | 22912 | 40151 |
| 1995 | 67840 | 135257 | 73517 | 53233 | 64394 | 97460 | 30395 | 21769 | 28134 | 26553 | 45073 |
| 1996 | 27824 | 151179 | 103183 | 96631 | 66290 | 56098 | 89073 | 24950 | 22042 | 17625 | 42221 |
| 1997 | 61760 | 224676 | 137777 | 95705 | 59664 | 37643 | 52940 | 58536 | 23437 | 8125 | 48245 |
| 1998 | 26937 | 127272 | 171902 | 123827 | 74526 | 43181 | 23701 | 44701 | 49382 | 6554 | 33263 |
| 1999 | 47057 | 77797 | 114833 | 140694 | 75671 | 41986 | 18563 | 18441 | 26981 | 27383 | 20102 |
| 2000 | 3514 | 221176 | 101921 | 164524 | 112157 | 48038 | 19355 | 10049 | 12291 | 28013 | 51288 |
| 2001 | 6186 | 50087 | 118696 | 77489 | 100201 | 59327 | 30521 | 14599 | 7702 | 10724 | 55201 |
| 2002 | 31876 | 51885 | 61041 | 117858 | 42919 | 60948 | 27496 | 20975 | 8422 | 2909 | 24888 |
| 2003 | 9044 | 154403 | 59793 | 86378 | 133868 | 44167 | 64272 | 33181 | 12678 | 4536 | 21211 |
| 2004 | 34120 | 100410 | 160553 | 56787 | 77178 | 107648 | 23057 | 45242 | 16173 | 9092 | 19734 |
| 2005 | 1348 | 14216 | 55614 | 132452 | 146374 | 90724 | 29504 | 62240 | 23739 | 6899 | 87596 |
| 2006 | 9812 | 116468 | 239978 | 94117 | 142335 | 20824 | 15408 | 45739 | 5070 | 19054 | 31344 |

**Table 3.4.** Catch-at-age (in numbers) for Gulf king mackerel.

| | Shrimp Bycatch | Directed Landings | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | Age 0 | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
| 1981 | 356108 | 0 | 50391 | 51144 | 44216 | 428392 | 235791 | 58227 | 44287 | 14226 | 7592 | 5313 | 13224 |
| 1982 | 331288 | 166067 | 9751 | 65542 | 213621 | 183622 | 342467 | 90285 | 41535 | 59907 | 13264 | 8775 | 76533 |
| 1983 | 310101 | 2600 | 9492 | 102918 | 270109 | 166061 | 61699 | 49021 | 31031 | 14305 | 4842 | 4591 | 14124 |
| 1984 | 470246 | 0 | 45182 | 20807 | 65611 | 321113 | 132349 | 52595 | 49778 | 19269 | 7931 | 1839 | 7575 |
| 1985 | 446584 | 0 | 13780 | 26514 | 66748 | 174752 | 123953 | 82498 | 39552 | 10389 | 7883 | 3631 | 11343 |
| 1986 | 311207 | 14755 | 55424 | 199470 | 131558 | 49015 | 69622 | 43597 | 21738 | 10296 | 5791 | 2728 | 10582 |
| 1987 | 712826 | 1339 | 27999 | 88899 | 150090 | 42995 | 57142 | 24914 | 7896 | 5849 | 8188 | 2199 | 4030 |
| 1988 | 504022 | 816 | 26809 | 46062 | 65727 | 160053 | 165593 | 60909 | 56677 | 23474 | 8360 | 5715 | 27135 |
| 1989 | 1222068 | 1000 | 115989 | 173584 | 158141 | 76439 | 74613 | 32011 | 22098 | 16023 | 8270 | 4545 | 15044 |
| 1990 | 807398 | 13944 | 48125 | 121594 | 156996 | 205458 | 51404 | 46062 | 20264 | 25970 | 9920 | 2247 | 16769 |
| 1991 | 1005278 | 2353 | 194291 | 330533 | 161343 | 92990 | 64019 | 40349 | 20108 | 6748 | 23577 | 9135 | 15548 |
| 1992 | 501309 | 774 | 98619 | 188687 | 185921 | 268585 | 90605 | 82229 | 32308 | 16217 | 26182 | 25105 | 26988 |
| 1993 | 1093016 | 1664 | 119052 | 136072 | 173923 | 192614 | 142038 | 51479 | 55831 | 26792 | 8718 | 2156 | 41754 |
| 1994 | 954911 | 710 | 154107 | 120056 | 149738 | 231319 | 218676 | 79105 | 32614 | 59179 | 29152 | 13402 | 34138 |
| 1995 | 1083320 | 2069 | 69025 | 256263 | 185202 | 113355 | 84577 | 88213 | 50946 | 21487 | 10591 | 17292 | 25746 |
| 1996 | 554116 | 0 | 67438 | 343504 | 223813 | 116603 | 68726 | 53846 | 46779 | 46305 | 18078 | 3801 | 43262 |
| 1997 | 697331 | 0 | 63889 | 268686 | 322450 | 169135 | 97767 | 43695 | 44039 | 40715 | 27301 | 10220 | 21960 |
| 1998 | 655095 | 0 | 83169 | 140340 | 248661 | 218935 | 122437 | 58717 | 31486 | 34899 | 37082 | 13118 | 13660 |
| 1999 | 586793 | 0 | 89602 | 141263 | 143686 | 183899 | 106258 | 40667 | 29184 | 15502 | 27007 | 10294 | 16535 |
| 2000 | 720777 | 31135 | 68634 | 180731 | 208913 | 159734 | 104986 | 47014 | 42169 | 16518 | 21539 | 13697 | 29045 |
| 2001 | 567341 | 64 | 62547 | 153678 | 237624 | 153873 | 80419 | 61163 | 52343 | 35193 | 16943 | 7889 | 31707 |
| 2002 | 541081 | 8935 | 91720 | 291758 | 187809 | 169334 | 93531 | 57248 | 37102 | 30974 | 17279 | 10531 | 23627 |
| 2003 | 576742 | 221 | 35757 | 183522 | 159924 | 161309 | 117104 | 66227 | 32187 | 28545 | 21245 | 15620 | 21922 |
| 2004 | 1003087 | 47706 | 32313 | 266067 | 167754 | 135413 | 76242 | 64612 | 37046 | 14913 | 20558 | 11146 | 18631 |
| 2005 | 626742 | 46870 | 20772 | 189194 | 156244 | 193882 | 103584 | 60674 | 51177 | 36660 | 13223 | 13671 | 31881 |
| 2006 | 444788 | 0 | 31992 | 209801 | 271108 | 251255 | 134308 | 77371 | 45797 | 36122 | 16240 | 9040 | 29043 |

The Atlantic continuity runs used 5 indices of abundance (**Table 3.5**) to tune the VPA estimates, while the Gulf run used 9 (**Table 3.6**). For the Gulf continuity run, 3 indices used by the previous SEDAR5 panel could not be updated during the SEDAR16 data workshop: 1) the Texas Parks and Wildlife Department, 2) Charter Boat SW FL and 3) Charter Boat NW FL indices. Thus, these are included unchanged from the estimates provided for SEDAR5. It should also be noted that the index CVs were not used directly in the model instead the index variances were estimated using a concentrated maximum likelihood procedure.

**Table. 3.5.** Indices of abundance and index settings used for the Atlantic continuity runs.

| | MRFSS-ATL | | HB-Atl. Migratory | | Trip Ticket - NC PIDs 8+ | | Trip Ticket Cont- FL Atl Coast | | SEAMAP S. Atl Trawl Survey | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. COM | | Fish. Dep. COM | | Fish. Independent | |
| Unit | Numbers | | Numbers | | Biomass | | Biomass | | Numbers | |
| Applied to Ages | Ages 2-11 | | Ages 1-8 | | Ages 2-11 | | Ages 2-8 | | Age 1 | |
| Index Timing | Mid-Year | | Mid-Year | | Mid-Year | | Beginning-Year | | Mid-Year | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1981 | 1.010 | 0.545 | 0.912 | 0.308 | | | | | | |
| 1982 | 1.386 | 0.452 | 0.788 | 0.297 | | | | | | |
| 1983 | 1.350 | 0.469 | 0.845 | 0.278 | | | | | | |
| 1984 | 1.275 | 0.453 | 0.969 | 0.265 | | | | | | |
| 1985 | 1.374 | 0.474 | 0.564 | 0.286 | | | | | | |
| 1986 | 1.912 | 0.410 | 0.761 | 0.273 | | | 1.024 | 0.007 | | |
| 1987 | 1.269 | 0.417 | 1.287 | 0.259 | | | 0.986 | 0.007 | | |
| 1988 | 0.952 | 0.409 | 0.869 | 0.281 | | | 1.169 | 0.007 | | |
| 1989 | 0.748 | 0.411 | 0.624 | 0.292 | | | 1.030 | 0.008 | 0.807 | 0.212 |
| 1990 | 1.171 | 0.410 | 0.744 | 0.277 | | | 0.927 | 0.008 | 2.377 | 0.158 |
| 1991 | 1.089 | 0.403 | 1.545 | 0.250 | | | 0.898 | 0.007 | 0.704 | 0.222 |
| 1992 | 1.112 | 0.399 | 1.407 | 0.245 | | | 0.833 | 0.008 | 0.843 | 0.241 |
| 1993 | 0.640 | 0.414 | 0.844 | 0.261 | | | 0.850 | 0.007 | 0.446 | 0.247 |
| 1994 | 0.551 | 0.412 | 1.041 | 0.257 | 0.700 | 0.068 | 0.832 | 0.008 | 0.708 | 0.232 |
| 1995 | 0.658 | 0.406 | 0.935 | 0.257 | 0.744 | 0.073 | 0.780 | 0.008 | 1.226 | 0.198 |
| 1996 | 0.768 | 0.402 | 0.626 | 0.275 | 1.125 | 0.069 | 0.965 | 0.007 | 2.261 | 0.168 |
| 1997 | 0.993 | 0.401 | 1.129 | 0.261 | 1.033 | 0.060 | 0.970 | 0.007 | 0.519 | 0.240 |
| 1998 | 0.891 | 0.399 | 0.911 | 0.269 | 1.056 | 0.060 | 0.981 | 0.007 | 1.786 | 0.200 |
| 1999 | 0.824 | 0.401 | 1.163 | 0.262 | 0.969 | 0.061 | 0.992 | 0.007 | 1.213 | 0.184 |
| 2000 | 1.037 | 0.395 | 1.852 | 0.250 | 0.986 | 0.059 | 0.863 | 0.007 | 0.816 | 0.221 |
| 2001 | 0.592 | 0.401 | 1.215 | 0.267 | 1.044 | 0.057 | 0.905 | 0.007 | 0.448 | 0.234 |
| 2002 | 0.722 | 0.400 | 0.979 | 0.273 | 0.907 | 0.069 | 0.826 | 0.008 | 0.506 | 0.211 |
| 2003 | 0.750 | 0.403 | 0.838 | 0.280 | 0.879 | 0.073 | 1.093 | 0.007 | 0.989 | 0.196 |
| 2004 | 0.987 | 0.398 | 0.715 | 0.279 | 1.292 | 0.058 | 1.294 | 0.007 | 0.619 | 0.357 |
| 2005 | 0.999 | 0.399 | 1.200 | 0.271 | 1.206 | 0.063 | 0.974 | 0.007 | 0.726 | 0.493 |
| 2006 | 0.939 | 0.406 | 1.238 | 0.269 | 1.058 | 0.066 | 1.463 | 0.007 | 1.006 | 0.221 |

**Table 3.6.** Indices of abundance and index settings used for the Gulf continuity runs.

| | MRFSS - GULF | | HB-Gulf Migratory | | Trip Ticket Cont-Panhandle ***(Rescaled to 81-06 period)*** | | Trip Ticket Cont-SW FL | | Shrimp Bycatch ***(Rescaled to 81-06 period)*** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. COM | | Fish. Dep. COM | | Fish. Dep. COM | |
| Unit | Numbers | | Numbers | | Weight | | Weight | | Numbers | |
| Applied to Ages | Ages 2-8 | | Ages 2-6 | | Ages 3-6 | | Ages 3-8 | | Ages: 0 | |
| Index Timing | Beginning-Year | | Mid-Year | | Mid-Year | | Mid-Year | | Beginning-Year | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1981 | 0.6701 | 0.4054 | 1.4620 | 0.3280 | | | | | 0.1461 | 0.7878 |
| 1982 | 0.3601 | 0.4031 | 0.8650 | 0.3400 | | | | | 0.0728 | 0.8595 |
| 1983 | 0.8004 | 0.3596 | 1.9420 | 0.3040 | | | | | | |
| 1984 | 0.4173 | 0.4014 | 0.6200 | 0.3510 | | | | | 0.3705 | 0.5106 |
| 1985 | 0.4266 | 0.3887 | 0.4450 | 0.2990 | | | | | 0.2524 | 0.5094 |
| 1986 | 0.4539 | 0.3196 | 0.4890 | 0.2520 | 0.7862 | 0.0520 | 0.3850 | 0.0220 | 0.1012 | 0.7533 |
| 1987 | 1.0693 | 0.2858 | 0.3240 | 0.2860 | 0.5480 | 0.0370 | 0.5900 | 0.0170 | 0.4624 | 0.4676 |
| 1988 | 0.6765 | 0.2985 | 0.3790 | 0.2770 | 0.5228 | 0.0250 | 0.8170 | 0.0220 | 0.4709 | 0.4312 |
| 1989 | 0.9378 | 0.3050 | 0.6120 | 0.2540 | 0.3663 | 0.0480 | 0.7640 | 0.0140 | 1.2882 | 0.4062 |
| 1990 | 1.2820 | 0.2862 | 0.5040 | 0.2640 | 0.5460 | 0.0300 | 1.0000 | 0.0120 | 1.0238 | 0.3660 |
| 1991 | 1.1803 | 0.2777 | 0.7970 | 0.2420 | 0.5480 | 0.0230 | 1.0180 | 0.0130 | 1.1284 | 0.4051 |
| 1992 | 1.2209 | 0.2655 | 1.0280 | 0.2340 | 0.7508 | 0.0190 | 2.3680 | 0.0100 | 0.4203 | 0.3282 |
| 1993 | 1.1378 | 0.2725 | 1.2300 | 0.2300 | 0.6529 | 0.0240 | 1.0630 | 0.0120 | 1.4018 | 0.2405 |
| 1994 | 1.4390 | 0.2630 | 1.1170 | 0.2270 | 0.8073 | 0.0140 | 0.6630 | 0.0170 | 1.3633 | 0.3091 |
| 1995 | 0.9981 | 0.2849 | 1.0780 | 0.2370 | 0.7973 | 0.0180 | 0.9420 | 0.0140 | 1.8245 | 0.3122 |
| 1996 | 1.3496 | 0.2708 | 1.6730 | 0.2240 | 1.4482 | 0.0090 | 1.1060 | 0.0110 | 0.6279 | 0.3962 |
| 1997 | 1.6397 | 0.2590 | 1.3170 | 0.2260 | 1.9023 | 0.0080 | 0.9300 | 0.0130 | 0.8419 | 0.3549 |
| 1998 | 0.9055 | 0.2646 | 1.0830 | 0.2310 | 1.2786 | 0.0120 | 1.0310 | 0.0160 | 0.7904 | 0.3766 |
| 1999 | 0.8820 | 0.2630 | 1.1270 | 0.2290 | 1.4734 | 0.0100 | 0.6520 | 0.0180 | 0.7383 | 0.3411 |
| 2000 | 1.1231 | 0.2558 | 0.9670 | 0.2350 | 1.2918 | 0.0110 | 1.1700 | 0.0160 | 0.8657 | 0.3540 |
| 2001 | 1.0189 | 0.2587 | 1.1520 | 0.2340 | 1.5663 | 0.0100 | 1.2440 | 0.0160 | 1.5748 | 0.3483 |
| 2002 | 1.3102 | 0.2531 | 1.1640 | 0.2310 | 1.2302 | 0.0130 | 0.8850 | 0.0190 | 0.7913 | 0.3835 |
| 2003 | 0.9135 | 0.2624 | 0.9610 | 0.2440 | 1.0829 | 0.0130 | 1.1300 | 0.0150 | 2.6647 | 0.3375 |
| 2004 | 1.0046 | 0.2598 | 1.0960 | 0.2400 | 1.0284 | 0.0180 | 0.8800 | 0.0190 | 3.0187 | 0.3379 |
| 2005 | 0.9180 | 0.2642 | 1.3780 | 0.2320 | 1.0718 | 0.0220 | 1.4070 | 0.0150 | 0.8233 | 0.4308 |
| 2006 | 1.8647 | 0.2703 | 1.1910 | 0.3000 | 1.3008 | 0.0140 | 0.9550 | 0.0190 | 1.9364 | 0.3381 |

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**Table 3.6. – Continued.**

| | SEAMAP Fall Plankton (Larval) | | Texas Parks and Wildlife Deparment | | Charter Boat SW FL | | Charter Boat NW FL | |
|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Independent | | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. REC | |
| Unit | Numbers | | Numbers | | Numbers | | Numbers | |
| Applied to Ages | SSB = Ages 1- 1+ | | Ages 2-8 | | Ages 3-8 | | Ages 2-6 | |
| Index Timing | Beginning-Year | | Beginning-Year | | Mid-Year | | Beginning-Year | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1981 | | | | | | | | |
| 1982 | | | | | | | | |
| 1983 | | | | | | | | |
| 1984 | | | | | | | | |
| 1985 | | | | | | | | |
| 1986 | 0.1160 | 0.5341 | 0.7439 | 0.2039 | | | | |
| 1987 | 0.3788 | 0.3219 | 0.8695 | 0.2009 | | | | |
| 1988 | 0.6130 | 0.4365 | 0.7834 | 0.1999 | 0.7913 | 0.0817 | 0.8929 | 0.1008 |
| 1989 | 0.8450 | 0.3255 | 0.8733 | 0.1996 | 1.0462 | 0.0817 | 0.8819 | 0.0698 |
| 1990 | 0.6480 | 0.3211 | 0.6760 | 0.2115 | 0.8940 | 0.0817 | 0.8803 | 0.0600 |
| 1991 | 0.7212 | 0.3181 | 1.5325 | 0.1689 | 0.7323 | 0.0817 | 0.9510 | 0.0600 |
| 1992 | 0.5960 | 0.2372 | 1.0679 | 0.2005 | 0.9435 | 0.0817 | 0.9989 | 0.0690 |
| 1993 | 1.2505 | 0.1987 | 1.0339 | 0.1962 | 1.0652 | 0.0817 | 0.9305 | 0.0777 |
| 1994 | 1.0500 | 0.2310 | 1.0788 | 0.1924 | 1.5274 | 0.0817 | 1.2008 | 0.0904 |
| 1995 | 1.9787 | 0.1947 | 1.3004 | 0.1764 | | | 1.2637 | 0.1262 |
| 1996 | 0.7407 | 0.2647 | 1.2896 | 0.1761 | | | | |
| 1997 | 1.3597 | 0.2007 | 1.0468 | 0.2014 | | | | |
| 1998 | | | 1.1751 | 0.1912 | | | | |
| 1999 | 0.9198 | 0.2249 | 0.9473 | 0.2151 | | | | |
| 2000 | 0.9219 | 0.2730 | 0.8052 | 0.2165 | | | | |
| 2001 | 1.6424 | 0.2026 | 0.7764 | 0.2306 | | | | |
| 2002 | 1.4511 | 0.2143 | | | | | | |
| 2003 | 1.1027 | 0.2190 | | | | | | |
| 2004 | 1.4780 | 0.2108 | | | | | | |
| 2005 | | | | | | | | |
| 2006 | 1.1865 | 0.2533 | | | | | | |

Selectivity (*S*) by age and year for each fisheries-dependent index was estimated using partial catches (CAA by year corresponding to each index of abundance). In the Atlantic , the lone fishery-independent index, the SEAMAP South Atlantic Trawl survey, was assumed to reflect the abundance of age-1 king mackerel (SEDAR16-Data Report). Therefore, for all years, $S_1$was fixed to 1.0 and $S_{2\text{-}11+}$ were fixed to 0.0. For the two fisheries independent indices in the Gulf: the Shrimp Bycatch GLM was assumed to index age-0 king mackerel ($S_0$was fixed to 1.0 and $S_{1\text{-}11+}$ were fixed to 0.0) and the SEAMAP Ichthyoplankton survey was assumed to index total egg production. For this index, the selectivity pattern was fixed at maturity*fecundity-at-age. The partial catches used to estimate selectivity for each fishery-dependent index are summarized in **Tables 3.7 and 3.8**. . Like the SEDAR5 FADAPT runs, the index selectivities were derived from the partial catches using the Powers and Restrepo (1992) method. This method allows index selectivity to vary by year and thus matches the partial catch-at-age exactly.

**Table 3.7.** Partial catches at age (numbers) used in the Atlantic continuity model runs.

| Index | Year | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NC Trip Ticket | 1981 | 2523 | 5753 | 37972 | 8720 | 10270 | 1974 | 10370 | 777 | 1015 | 1972 | 2331 |
| | 1982 | 2090 | 4833 | 1895 | 11835 | 9100 | 15352 | 9014 | 18198 | 693 | 1823 | 37146 |
| | 1983 | 1028 | 2917 | 2923 | 4295 | 8721 | 11157 | 13269 | 16206 | 2207 | 6612 | 16181 |
| | 1984 | 321 | 886 | 1720 | 2523 | 2205 | 8074 | 10561 | 7582 | 7817 | 2192 | 17118 |
| | 1985 | 4961 | 1013 | 5314 | 5537 | 4779 | 5914 | 6907 | 15444 | 8167 | 3736 | 15751 |
| | 1986 | 9193 | 4033 | 7765 | 7622 | 15599 | 9773 | 13072 | 7374 | 7333 | 1427 | 21780 |
| | 1987 | 4474 | 9105 | 21346 | 20912 | 17805 | 12867 | 5897 | 12656 | 5070 | 2793 | 19392 |
| | 1988 | 507 | 9600 | 19454 | 14509 | 5770 | 5104 | 7116 | 2865 | 7633 | 2923 | 10412 |
| | 1989 | 4192 | 13050 | 17541 | 14518 | 10479 | 10841 | 7987 | 2694 | 3981 | 7059 | 5831 |
| | 1990 | 9516 | 22930 | 17466 | 23113 | 20275 | 16029 | 8663 | 3305 | 10077 | 4037 | 13561 |
| | 1991 | 2274 | 28790 | 20688 | 11414 | 20111 | 18367 | 6019 | 10143 | 1187 | 674 | 7996 |
| | 1992 | 1610 | 20254 | 46266 | 19150 | 9390 | 7122 | 7458 | 4604 | 2546 | 1772 | 6100 |
| | 1993 | 1852 | 7968 | 14498 | 18991 | 7968 | 5254 | 5067 | 5926 | 3409 | 2213 | 5450 |
| | 1994 | 1625 | 10200 | 5958 | 9888 | 15211 | 10202 | 8876 | 4606 | 8721 | 5395 | 10196 |
| | 1995 | 1637 | 7435 | 10120 | 8749 | 10174 | 17404 | 6879 | 4147 | 4226 | 4610 | 6370 |
| | 1996 | 2751 | 13304 | 19716 | 30155 | 26209 | 16138 | 21453 | 5301 | 3909 | 5097 | 4500 |
| | 1997 | 4601 | 22989 | 19846 | 16040 | 10454 | 6752 | 7781 | 9626 | 4900 | 1435 | 6652 |
| | 1998 | 1281 | 19723 | 37962 | 25485 | 18647 | 16383 | 5169 | 7069 | 7266 | 671 | 4754 |
| | 1999 | 5405 | 16368 | 23805 | 27311 | 15601 | 10586 | 4386 | 4313 | 4302 | 2591 | 2483 |
| | 2000 | 521 | 14459 | 11178 | 22630 | 15873 | 8939 | 3400 | 3105 | 2595 | 2703 | 6013 |
| | 2001 | 975 | 6412 | 13121 | 7972 | 12898 | 9059 | 7053 | 4433 | 2705 | 1475 | 11623 |
| | 2002 | 4039 | 8275 | 10596 | 17133 | 7176 | 12444 | 3886 | 4752 | 3350 | 519 | 5645 |
| | 2003 | 543 | 14502 | 6063 | 8159 | 12667 | 3950 | 6027 | 2646 | 1737 | 326 | 2576 |
| | 2004 | 9340 | 35177 | 35466 | 15359 | 17076 | 15513 | 1822 | 7917 | 849 | 404 | 3077 |
| | 2005 | 0 | 3686 | 12693 | 32169 | 28191 | 24729 | 503 | 14581 | 3809 | 2129 | 16207 |
| | 2006 | 987 | 21437 | 36868 | 14014 | 21720 | 6625 | 3157 | 5923 | 1006 | 3150 | 7836 |
| FL Atl. Trip Ticket | 1981 | 342 | 800 | 5973 | 25943 | 21588 | 39868 | 22145 | 17505 | 17899 | 10346 | 11885 |
| | 1982 | 556 | 507 | 1956 | 7669 | 22575 | 52990 | 47988 | 16824 | 34389 | 17579 | 26406 |
| | 1983 | 251 | 1825 | 10789 | 12868 | 4260 | 4641 | 6941 | 29416 | 3874 | 296 | 44106 |
| | 1984 | 0 | 807 | 674 | 8398 | 20058 | 9444 | 8798 | 25302 | 7242 | 4499 | 21631 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1985 | 127 | 1582 | 1897 | 6895 | 18630 | 17800 | 25092 | 27639 | 5759 | 2781 | 30982 |
| | 1986 | 1397 | 1316 | 2574 | 6074 | 13236 | 20329 | 19055 | 15259 | 35341 | 2825 | 26993 |
| | 1987 | 14127 | 29753 | 25869 | 25716 | 23142 | 17538 | 6076 | 16505 | 6377 | 3146 | 25842 |
| | 1988 | 2115 | 41860 | 56207 | 33551 | 9079 | 11432 | 14558 | 7747 | 19603 | 6277 | 35064 |
| | 1989 | 6923 | 13679 | 26173 | 25001 | 19051 | 14359 | 7028 | 7451 | 4403 | 18657 | 22627 |
| | 1990 | 9574 | 17638 | 13397 | 16670 | 17319 | 15051 | 8048 | 5372 | 7351 | 4590 | 23175 |
| | 1991 | 7203 | 31084 | 15729 | 7505 | 16367 | 16554 | 9252 | 7332 | 2460 | 1310 | 15836 |
| | 1992 | 6950 | 25682 | 33819 | 8672 | 6593 | 5823 | 6212 | 3065 | 2377 | 1957 | 10700 |
| | 1993 | 5793 | 16385 | 29570 | 29005 | 8134 | 6846 | 7103 | 8694 | 4790 | 3911 | 7789 |
| | 1994 | 8141 | 21249 | 12423 | 21816 | 24513 | 10624 | 4869 | 5332 | 7304 | 4789 | 5608 |
| | 1995 | 3738 | 8387 | 8304 | 8427 | 11091 | 17666 | 6164 | 4460 | 6593 | 5300 | 8511 |
| | 1996 | 9734 | 49866 | 22834 | 17476 | 9968 | 9700 | 18156 | 5253 | 3819 | 1734 | 7039 |
| | 1997 | 11208 | 68953 | 28908 | 16801 | 9741 | 5100 | 8542 | 8473 | 2966 | 1113 | 6780 |
| | 1998 | 3566 | 20766 | 38457 | 26098 | 13662 | 5946 | 3588 | 8261 | 8654 | 1151 | 4264 |
| | 1999 | 6578 | 13987 | 24057 | 30078 | 16341 | 8309 | 3898 | 4070 | 6524 | 6824 | 4153 |
| | 2000 | 357 | 29704 | 17036 | 30740 | 20458 | 7696 | 3032 | 941 | 1519 | 4333 | 5400 |
| | 2001 | 1056 | 10599 | 29611 | 20257 | 23356 | 12799 | 3766 | 1891 | 1139 | 1814 | 5810 |
| | 2002 | 4329 | 9492 | 12644 | 26175 | 9386 | 12730 | 6326 | 4255 | 1377 | 612 | 5125 |
| | 2003 | 1111 | 25237 | 10635 | 16538 | 25530 | 8606 | 12337 | 6371 | 2269 | 785 | 4310 |
| | 2004 | 3852 | 19836 | 40530 | 13877 | 20757 | 32411 | 6493 | 11939 | 3402 | 1660 | 3447 |
| | 2005 | 734 | 2191 | 2468 | 14661 | 22937 | 10420 | 5040 | 10635 | 1962 | 11 | 34716 |
| | 2006 | 1469 | 18061 | 51973 | 22721 | 37676 | 4958 | 4143 | 15760 | 1609 | 6622 | 7123 |
| MRFSS | 1981 | 5371 | 49101 | 10705 | 56691 | 54369 | 40899 | 36702 | 70637 | 12965 | 13679 | 38720 |
| | 1982 | 2549 | 5521 | 7267 | 27836 | 62698 | 71341 | 101516 | 47711 | 30698 | 33151 | 65588 |
| | 1983 | 7001 | 27747 | 62491 | 81083 | 58870 | 68564 | 86416 | 77906 | 19358 | 3531 | 67604 |
| | 1984 | 13396 | 5692 | 9707 | 47668 | 72299 | 121614 | 88307 | 51197 | 13391 | 17356 | 102662 |
| | 1985 | 17374 | 95832 | 68358 | 13992 | 61826 | 58590 | 45060 | 138752 | 49354 | 7451 | 76074 |
| | 1986 | 16699 | 45572 | 46055 | 73158 | 48525 | 30580 | 26737 | 39422 | 16372 | 3752 | 38950 |
| | 1987 | 101310 | 124805 | 44359 | 38662 | 29153 | 19722 | 6772 | 16420 | 6610 | 3119 | 25229 |
| | 1988 | 8208 | 75243 | 89929 | 48467 | 12821 | 13691 | 19490 | 9094 | 24946 | 7643 | 41670 |
| | 1989 | 22529 | 24004 | 39715 | 35076 | 25914 | 18614 | 9496 | 9097 | 5794 | 23752 | 24331 |
| | 1990 | 72038 | 50639 | 32698 | 40125 | 36498 | 27027 | 12334 | 8315 | 11580 | 8078 | 40151 |
| | 1991 | 25208 | 123036 | 48744 | 20747 | 39819 | 39081 | 22033 | 16198 | 7140 | 4739 | 39678 |
| | 1992 | 20688 | 88573 | 137772 | 35181 | 25787 | 25524 | 29174 | 11541 | 9190 | 8231 | 41499 |
| | 1993 | 11389 | 22958 | 38155 | 46844 | 18268 | 14695 | 21389 | 26975 | 12558 | 10049 | 37530 |
| | 1994 | 27247 | 57022 | 23071 | 40985 | 46895 | 21778 | 10423 | 12383 | 15602 | 8820 | 17154 |
| | 1995 | 54193 | 101452 | 45320 | 28449 | 33344 | 45785 | 12285 | 9220 | 12668 | 12094 | 19459 |
| | 1996 | 10191 | 61357 | 43193 | 34952 | 21829 | 21133 | 32870 | 10592 | 6652 | 5402 | 16110 |
| | 1997 | 30274 | 98037 | 65409 | 46184 | 29326 | 19983 | 27962 | 31281 | 10883 | 4411 | 27710 |
| | 1998 | 12969 | 55826 | 66436 | 49455 | 28099 | 13077 | 9595 | 18362 | 21754 | 3170 | 16720 |
| | 1999 | 27503 | 38667 | 57160 | 71451 | 36952 | 18947 | 8432 | 8273 | 13131 | 14899 | 10356 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2109 | 141405 | 60507 | 91714 | 61348 | 25036 | 10382 | 4815 | 6573 | 16840 | 28809 |
| | 2001 | 3533 | 28519 | 65908 | 42932 | 55789 | 32451 | 16737 | 6702 | 3353 | 6479 | 31695 |
| | 2002 | 21117 | 30288 | 33727 | 66261 | 23195 | 30953 | 15037 | 10240 | 3095 | 1514 | 11960 |
| | 2003 | 6290 | 101580 | 39689 | 57728 | 89063 | 29455 | 42474 | 22672 | 7638 | 3225 | 12896 |
| | 2004 | 18362 | 39129 | 76091 | 24433 | 34842 | 53402 | 13044 | 22336 | 10427 | 6134 | 11361 |
| | 2005 | 589 | 6389 | 30792 | 69833 | 83611 | 44127 | 22506 | 30175 | 14622 | 4175 | 30667 |
| | 2006 | 6607 | 69153 | 138245 | 52761 | 76251 | 8289 | 7362 | 22111 | 2147 | 8545 | 14443 |
| Headboat | 1981 | 3654 | 46668 | 8337 | 52884 | 48887 | 39155 | 27001 | 59766 | 8657 | 11088 | 26911 |
| | 1982 | 1617 | 3433 | 4415 | 17035 | 18267 | 26012 | 17342 | 18012 | 6376 | 1125 | 23707 |
| | 1983 | 5894 | 19032 | 10755 | 14783 | 25412 | 31570 | 41114 | 41780 | 2934 | 1088 | 33380 |
| | 1984 | 2150 | 3656 | 6371 | 12863 | 28045 | 27464 | 44091 | 13995 | 12259 | 13727 | 37694 |
| | 1985 | 11609 | 78588 | 54013 | 6462 | 47103 | 48130 | 31688 | 134240 | 42792 | 5233 | 68933 |
| | 1986 | 299 | 1015 | 1639 | 2533 | 2355 | 3131 | 5152 | 3270 | 3027 | 1840 | 3780 |
| | 1987 | 3051 | 5549 | 4231 | 4125 | 3596 | 2418 | 710 | 1963 | 809 | 352 | 2624 |
| | 1988 | 270 | 3470 | 4532 | 3049 | 945 | 1192 | 1597 | 736 | 2118 | 615 | 3549 |
| | 1989 | 4599 | 3867 | 4092 | 3041 | 2006 | 1381 | 681 | 645 | 395 | 1709 | 1606 |
| | 1990 | 3446 | 5252 | 3110 | 3906 | 3459 | 2457 | 1104 | 689 | 885 | 567 | 2990 |
| | 1991 | 5606 | 17687 | 5284 | 1957 | 3389 | 2770 | 1373 | 915 | 277 | 169 | 1869 |
| | 1992 | 1521 | 5837 | 7360 | 1825 | 1358 | 1176 | 1272 | 569 | 394 | 319 | 1531 |
| | 1993 | 2045 | 4298 | 4346 | 4497 | 1318 | 1026 | 1084 | 1221 | 518 | 388 | 703 |
| | 1994 | 3830 | 7553 | 2653 | 3745 | 3491 | 1293 | 520 | 566 | 657 | 350 | 423 |
| | 1995 | 3036 | 4925 | 2245 | 1473 | 1784 | 2339 | 630 | 427 | 660 | 512 | 677 |
| | 1996 | 1313 | 8143 | 5626 | 4162 | 2675 | 2286 | 3541 | 1127 | 699 | 562 | 1443 |
| | 1997 | 2179 | 5781 | 2725 | 1929 | 1246 | 778 | 1220 | 1295 | 442 | 140 | 937 |
| | 1998 | 1407 | 4187 | 3895 | 2484 | 1301 | 549 | 348 | 786 | 764 | 100 | 351 |
| | 1999 | 3845 | 4841 | 3641 | 3297 | 1572 | 766 | 344 | 312 | 552 | 553 | 334 |
| | 2000 | 111 | 7811 | 2903 | 3890 | 2534 | 883 | 340 | 125 | 178 | 477 | 735 |
| | 2001 | 224 | 1654 | 3577 | 2174 | 2314 | 1126 | 407 | 169 | 96 | 129 | 546 |
| | 2002 | 1516 | 1880 | 1515 | 2829 | 938 | 1253 | 581 | 384 | 115 | 75 | 446 |
| | 2003 | 289 | 3374 | 955 | 1126 | 1631 | 469 | 611 | 303 | 108 | 44 | 154 |
| | 2004 | 964 | 2799 | 3472 | 992 | 1360 | 2071 | 431 | 790 | 278 | 158 | 294 |
| | 2005 | 4 | 823 | 3316 | 4338 | 3192 | 3077 | 1122 | 2254 | 779 | 429 | 2134 |
| | 2006 | 144 | 3376 | 6597 | 2229 | 3065 | 221 | 203 | 669 | 63 | 198 | 601 |

**Table 3.8.** Partial catches-at-age (numbers) used in the Gulf continuity model runs.

| Index | Year | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trip Ticket FL Panhandle | 1981 | 0 | 0 | 0 | 580 | 1664 | 751 | 654 | 52 | 5 | 16 | 0 | 110 |
| | 1982 | 141 | 2 | 278 | 578 | 1317 | 171 | 16 | 720 | 0 | 300 | 0 | 111 |
| | 1983 | 0 | 0 | 1288 | 3149 | 338 | 191 | 251 | 73 | 180 | 91 | 38 | 71 |
| | 1984 | 0 | 0 | 5 | 386 | 2273 | 247 | 243 | 26 | 69 | 32 | 25 | 9 |
| | 1985 | 0 | 0 | 3 | 19 | 372 | 435 | 46 | 60 | 18 | 0 | 3 | 1 |
| | 1986 | 0 | 3 | 209 | 552 | 20 | 33 | 94 | 24 | 15 | 1 | 0 | 8 |
| | 1987 | 0 | 850 | 2058 | 651 | 177 | 299 | 79 | 47 | 17 | 10 | 4 | 17 |
| | 1988 | 0 | 12 | 158 | 698 | 525 | 307 | 91 | 65 | 126 | 7 | 0 | 66 |
| | 1989 | 7 | 1482 | 4835 | 710 | 748 | 473 | 7 | 14 | 8 | 4 | 9 | 24 |
| | 1990 | 0 | 392 | 1450 | 1213 | 444 | 157 | 141 | 175 | 51 | 14 | 14 | 33 |
| | 1991 | 25 | 2567 | 3537 | 1289 | 669 | 534 | 325 | 122 | 30 | 310 | 49 | 114 |
| | 1992 | 0 | 1877 | 5316 | 2326 | 551 | 154 | 312 | 108 | 99 | 22 | 138 | 79 |
| | 1993 | 20 | 602 | 1564 | 2077 | 1538 | 674 | 263 | 407 | 190 | 73 | 20 | 551 |
| | 1994 | 0 | 3258 | 2129 | 1847 | 2423 | 1948 | 952 | 173 | 828 | 502 | 100 | 951 |
| | 1995 | 3 | 159 | 657 | 527 | 763 | 583 | 641 | 297 | 110 | 145 | 200 | 201 |
| | 1996 | 0 | 2713 | 8447 | 5536 | 1897 | 1077 | 1281 | 632 | 209 | 37 | 121 | 206 |
| | 1997 | 0 | 838 | 10705 | 10633 | 6894 | 2935 | 1197 | 1868 | 1038 | 464 | 0 | 760 |
| | 1998 | 0 | 1892 | 2013 | 3876 | 1400 | 913 | 387 | 258 | 317 | 259 | 147 | 120 |
| | 1999 | 0 | 1370 | 1973 | 2623 | 4378 | 2284 | 1100 | 561 | 546 | 803 | 240 | 414 |
| | 2000 | 0 | 565 | 2667 | 2615 | 3018 | 2595 | 676 | 901 | 231 | 518 | 473 | 856 |
| | 2001 | 0 | 407 | 1661 | 5275 | 3258 | 2285 | 1884 | 1467 | 857 | 296 | 294 | 702 |
| | 2002 | 5 | 1409 | 2492 | 2340 | 2215 | 1101 | 746 | 804 | 603 | 359 | 95 | 517 |
| | 2003 | 0 | 1078 | 6629 | 3718 | 3222 | 2477 | 1197 | 593 | 860 | 454 | 377 | 555 |
| | 2004 | 0 | 229 | 1631 | 1795 | 1044 | 702 | 774 | 344 | 138 | 260 | 136 | 160 |
| | 2005 | 1 | 63 | 859 | 409 | 395 | 230 | 127 | 149 | 56 | 53 | 44 | 77 |
| | 2006 | 0 | 215 | 1648 | 2016 | 1125 | 1112 | 825 | 551 | 615 | 131 | 122 | 415 |
| Trip Ticket SW FL | 1981 | 0 | 0 | 370 | 2602 | 10938 | 1276 | 320 | 833 | 9 | 0 | 0 | 160 |
| | 1982 | 9 | 29 | 2 | 298 | 1030 | 1604 | 811 | 48 | 148 | 65 | 0 | 6 |
| | 1983 | 0 | 182 | 0 | 4010 | 1746 | 138 | 165 | 27 | 26 | 69 | 12 | 27 |
| | 1984 | 0 | 0 | 407 | 99 | 1865 | 1499 | 1199 | 516 | 77 | 22 | 18 | 142 |
| | 1985 | 0 | 0 | 20 | 19 | 63 | 225 | 599 | 127 | 89 | 11 | 5 | 9 |
| | 1986 | 0 | 2 | 65 | 366 | 571 | 677 | 389 | 11 | 20 | 10 | 0 | 1 |
| | 1987 | 0 | 464 | 192 | 1101 | 515 | 658 | 572 | 166 | 13 | 3 | 1 | 0 |
| | 1988 | 0 | 25 | 51 | 453 | 12161 | 29305 | 6334 | 1237 | 660 | 105 | 56 | 106 |
| | 1989 | 0 | 665 | 873 | 4373 | 4740 | 2232 | 2925 | 481 | 535 | 7 | 2 | 457 |
| | 1990 | 0 | 6 | 1127 | 2835 | 13208 | 1101 | 2275 | 398 | 160 | 92 | 11 | 181 |
| | 1991 | 6 | 1906 | 7589 | 4719 | 2559 | 2267 | 1425 | 451 | 92 | 1143 | 198 | 336 |
| | 1992 | 0 | 1160 | 16981 | 18403 | 6401 | 1822 | 4160 | 1180 | 1458 | 328 | 1393 | 576 |
| | 1993 | 16 | 2237 | 14806 | 22618 | 21131 | 9836 | 3168 | 4941 | 2173 | 863 | 257 | 4464 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1994 | 0 | 3077 | 6658 | 8828 | 9549 | 4824 | 1753 | 237 | 1510 | 571 | 174 | 482 |
| | 1995 | 12 | 1963 | 6322 | 3322 | 2747 | 1526 | 1166 | 548 | 207 | 275 | 300 | 369 |
| | 1996 | 0 | 3368 | 21791 | 15072 | 4352 | 1866 | 2103 | 1136 | 297 | 57 | 224 | 273 |
| | 1997 | 0 | 1267 | 10779 | 7950 | 4252 | 1514 | 646 | 881 | 513 | 241 | 0 | 292 |
| | 1998 | 0 | 2038 | 4657 | 11966 | 4048 | 2628 | 974 | 670 | 772 | 676 | 277 | 150 |
| | 1999 | 0 | 1407 | 1940 | 2714 | 5030 | 2909 | 1268 | 646 | 547 | 925 | 175 | 375 |
| | 2000 | 0 | 1748 | 4593 | 3253 | 3115 | 1730 | 457 | 541 | 173 | 147 | 211 | 251 |
| | 2001 | 0 | 290 | 1738 | 6049 | 3466 | 2365 | 1790 | 1319 | 749 | 257 | 220 | 680 |
| | 2002 | 2 | 1055 | 2371 | 2439 | 2371 | 1152 | 724 | 823 | 553 | 273 | 101 | 420 |
| | 2003 | 0 | 429 | 2812 | 2148 | 2077 | 1887 | 937 | 476 | 697 | 342 | 295 | 321 |
| | 2004 | 0 | 356 | 2381 | 2419 | 1374 | 844 | 942 | 383 | 152 | 323 | 165 | 235 |
| | 2005 | 3 | 313 | 5342 | 2968 | 3130 | 1782 | 964 | 1266 | 431 | 319 | 269 | 539 |
| | 2006 | 0 | 213 | 3014 | 4144 | 2203 | 2063 | 1188 | 690 | 628 | 144 | 122 | 346 |
| MRFSS | 1981 | 0 | 8623 | 2211 | 6838 | 44603 | 7296 | 1982 | 1424 | 584 | 1213 | 43 | 284 |
| | 1982 | 41 | 2294 | 20672 | 44436 | 31640 | 12769 | 2357 | 1484 | 4 | 80 | 111 | 425 |
| | 1983 | 0 | 2219 | 82468 | 100999 | 6956 | 6849 | 3663 | 199 | 274 | 529 | 149 | 8383 |
| | 1984 | 0 | 30387 | 4494 | 24101 | 141601 | 22996 | 5127 | 3984 | 2868 | 1475 | 7 | 1258 |
| | 1985 | 0 | 6153 | 19907 | 23383 | 5060 | 5165 | 5718 | 2291 | 451 | 75 | 0 | 1096 |
| | 1986 | 4670 | 12061 | 51201 | 75893 | 12154 | 9769 | 9972 | 4413 | 372 | 578 | 14 | 512 |
| | 1987 | 1339 | 19962 | 71807 | 84928 | 21441 | 21361 | 9994 | 3079 | 924 | 2312 | 148 | 859 |
| | 1988 | 422 | 19082 | 38221 | 45590 | 118102 | 88705 | 22104 | 35034 | 14582 | 1169 | 744 | 11521 |
| | 1989 | 765 | 87243 | 62816 | 83944 | 22880 | 24958 | 2948 | 2673 | 1562 | 2000 | 1152 | 1596 |
| | 1990 | 5919 | 22488 | 59062 | 84579 | 60817 | 13139 | 4140 | 4002 | 4925 | 1309 | 176 | 3741 |
| | 1991 | 1415 | 153585 | 210256 | 67036 | 30427 | 19056 | 10798 | 4773 | 1764 | 8468 | 3103 | 5631 |
| | 1992 | 0 | 77546 | 87206 | 64923 | 32094 | 13104 | 13285 | 10537 | 4266 | 4007 | 8321 | 6505 |
| | 1993 | 1096 | 52310 | 51501 | 62159 | 48707 | 25110 | 8305 | 12640 | 6219 | 2206 | 576 | 11463 |
| | 1994 | 0 | 72254 | 54448 | 40880 | 49435 | 47554 | 17565 | 4654 | 15592 | 7245 | 3245 | 8509 |
| | 1995 | 1295 | 18721 | 43534 | 27129 | 26099 | 20461 | 20740 | 12250 | 4656 | 3790 | 6134 | 6440 |
| | 1996 | 0 | 30563 | 105718 | 66425 | 32468 | 22418 | 21641 | 16182 | 14459 | 5076 | 1670 | 13578 |
| | 1997 | 0 | 18947 | 100273 | 91067 | 51424 | 24988 | 11357 | 13689 | 10869 | 6236 | 1371 | 7009 |
| | 1998 | 0 | 35567 | 42376 | 81138 | 50525 | 31894 | 15436 | 8865 | 10446 | 8389 | 4124 | 3828 |
| | 1999 | 0 | 53521 | 49707 | 38955 | 50571 | 27447 | 10690 | 6721 | 4937 | 8464 | 2877 | 5020 |
| | 2000 | 0 | 29534 | 82346 | 58036 | 41257 | 25032 | 7707 | 9028 | 2310 | 4108 | 2958 | 5435 |
| | 2001 | 21 | 19036 | 40730 | 69521 | 29814 | 17230 | 13387 | 10929 | 8148 | 3821 | 1908 | 7863 |
| | 2002 | 113 | 46303 | 118677 | 62311 | 46236 | 25572 | 15296 | 13058 | 11881 | 7017 | 3404 | 8816 |
| | 2003 | 0 | 13329 | 65961 | 42314 | 35425 | 26930 | 14562 | 6858 | 8048 | 5291 | 4316 | 4803 |
| | 2004 | 3 | 14087 | 79330 | 40854 | 26550 | 17307 | 17158 | 10300 | 4174 | 6655 | 3630 | 5915 |
| | 2005 | 41 | 5855 | 63056 | 31409 | 25812 | 18018 | 12246 | 11468 | 7601 | 3658 | 2724 | 9059 |
| | 2006 | 0 | 13557 | 106707 | 95895 | 55443 | 41254 | 24629 | 17746 | 15393 | 6820 | 3184 | 11561 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Texas Parks and Wildlife Dept. | 1981 | 0 | 0 | 25451 | 96 | 9914 | 12173 | 6563 | 4479 | 547 | 162 | 1 | 1783 |
| | 1982 | 0 | 66 | 1186 | 897 | 8058 | 15590 | 5810 | 6758 | 2631 | 1 | 1199 | 1389 |
| | 1983 | 0 | 1456 | 184 | 1795 | 6448 | 11004 | 7700 | 9363 | 3335 | 629 | 2524 | 619 |
| | 1984 | 0 | 114 | 32 | 963 | 4520 | 7174 | 3764 | 2109 | 656 | 776 | 128 | 433 |
| | 1985 | 0 | 278 | 141 | 554 | 2587 | 8352 | 3606 | 6639 | 479 | 727 | 948 | 1049 |
| | 1986 | 0 | 20 | 68 | 878 | 2466 | 5816 | 4433 | 2516 | 1485 | 603 | 1141 | 385 |
| | 1987 | 0 | 417 | 254 | 870 | 7993 | 6149 | 7742 | 576 | 1699 | 805 | 817 | 160 |
| | 1988 | 0 | 611 | 61 | 1116 | 5107 | 6825 | 3320 | 2439 | 1068 | 525 | 134 | 389 |
| | 1989 | 8 | 15 | 418 | 733 | 2533 | 6414 | 2272 | 3213 | 1111 | 679 | 411 | 873 |
| | 1990 | 27 | 78 | 42 | 1699 | 5014 | 5032 | 4718 | 3833 | 187 | 1188 | 491 | 478 |
| | 1991 | 0 | 4368 | 648 | 1354 | 14653 | 18119 | 1989 | 6126 | 379 | 629 | 0 | 322 |
| | 1992 | 0 | 570 | 2338 | 3175 | 3713 | 16722 | 635 | 3226 | 169 | 1 | 1078 | 262 |
| | 1993 | 0 | 18524 | 264 | 718 | 14354 | 16667 | 9787 | 5062 | 3820 | 242 | 90 | 2200 |
| | 1994 | 1 | 69 | 317 | 647 | 4638 | 1708 | 2925 | 874 | 24 | 605 | 44 | 299 |
| | 1995 | 8 | 807 | 4020 | 3596 | 3240 | 2275 | 2255 | 1081 | 410 | 372 | 445 | 463 |
| | 1996 | 0 | 729 | 4175 | 4308 | 2628 | 1800 | 1602 | 1255 | 647 | 170 | 134 | 519 |
| | 1997 | 0 | 420 | 5271 | 11478 | 8383 | 5320 | 2657 | 2896 | 2685 | 1685 | 465 | 1629 |
| | 1998 | 0 | 604 | 3622 | 13376 | 8291 | 6512 | 3405 | 2240 | 2557 | 2178 | 956 | 680 |
| | 1999 | 0 | 637 | 1985 | 4550 | 9357 | 6503 | 2819 | 1892 | 1255 | 2294 | 555 | 976 |
| | 2000 | 0 | 931 | 3619 | 4914 | 6699 | 7329 | 2764 | 2159 | 852 | 1916 | 1238 | 1838 |
| | 2001 | 1 | 399 | 1471 | 3789 | 3081 | 2067 | 1673 | 1618 | 1006 | 501 | 313 | 1162 |
| | 2002 | 3 | 549 | 1512 | 2637 | 5200 | 6530 | 2434 | 2594 | 1217 | 565 | 428 | 1068 |
| | 2003 | 0 | 310 | 1986 | 2581 | 4088 | 5350 | 2415 | 1191 | 1214 | 661 | 612 | 908 |
| | 2004 | 0 | 611 | 4170 | 5372 | 3904 | 3700 | 3828 | 1392 | 628 | 1183 | 432 | 703 |
| | 2005 | 6 | 124 | 3054 | 2877 | 8203 | 7689 | 1987 | 3247 | 401 | 548 | 285 | 590 |
| | 2006 | 0 | 312 | 3525 | 5545 | 3324 | 16363 | 4237 | 1383 | 1425 | 861 | 438 | 1098 |
| Headboat | 1981 | 0 | 881 | 697 | 563 | 653 | 685 | 57 | 71 | 79 | 19 | 0 | 75 |
| | 1982 | 0 | 881 | 697 | 563 | 653 | 685 | 57 | 71 | 79 | 19 | 0 | 75 |
| | 1983 | 0 | 881 | 697 | 563 | 653 | 685 | 57 | 71 | 79 | 19 | 0 | 75 |
| | 1984 | 0 | 881 | 697 | 563 | 653 | 685 | 57 | 71 | 79 | 19 | 0 | 75 |
| | 1985 | 0 | 881 | 697 | 563 | 653 | 685 | 57 | 71 | 79 | 19 | 0 | 75 |
| | 1986 | 0 | 6478 | 17116 | 5713 | 1942 | 2497 | 690 | 628 | 201 | 33 | 10 | 82 |
| | 1987 | 0 | 20 | 532 | 2584 | 350 | 584 | 162 | 22 | 39 | 178 | 1 | 7 |
| | 1988 | 35 | 810 | 829 | 742 | 872 | 617 | 151 | 239 | 26 | 20 | 14 | 86 |
| | 1989 | 0 | 3767 | 6764 | 6561 | 437 | 693 | 442 | 51 | 46 | 35 | 5 | 39 |
| | 1990 | 1654 | 36 | 2820 | 7022 | 5546 | 417 | 156 | 27 | 200 | 522 | 0 | 104 |
| | 1991 | 32 | 3324 | 7372 | 2991 | 1115 | 592 | 418 | 152 | 65 | 181 | 79 | 117 |
| | 1992 | 0 | 2672 | 2853 | 5491 | 4483 | 183 | 627 | 529 | 1100 | 16 | 177 | 44 |
| | 1993 | 74 | 3473 | 2916 | 6115 | 3783 | 1277 | 502 | 300 | 144 | 39 | 17 | 281 |
| | 1994 | 0 | 909 | 2411 | 5473 | 4026 | 1229 | 708 | 108 | 257 | 175 | 36 | 146 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 11 | 1425 | 4525 | 2843 | 1053 | 433 | 419 | 145 | 53 | 53 | 40 | 30 |
| | 1996 | 0 | 1632 | 9658 | 5839 | 2656 | 1243 | 1102 | 800 | 604 | 269 | 64 | 276 |
| | 1997 | 0 | 5827 | 8174 | 3978 | 1210 | 409 | 156 | 143 | 100 | 61 | 32 | 37 |
| | 1998 | 0 | 2942 | 1778 | 2214 | 1343 | 609 | 225 | 102 | 99 | 97 | 20 | 11 |
| | 1999 | 0 | 3108 | 3807 | 2083 | 1852 | 929 | 294 | 248 | 113 | 128 | 168 | 176 |
| | 2000 | 0 | 1434 | 3110 | 2292 | 1068 | 588 | 223 | 229 | 76 | 62 | 42 | 72 |
| | 2001 | 0 | 334 | 838 | 1361 | 785 | 419 | 301 | 276 | 232 | 116 | 36 | 174 |
| | 2002 | 2 | 937 | 2076 | 788 | 520 | 309 | 147 | 123 | 107 | 63 | 38 | 59 |
| | 2003 | 0 | 522 | 2778 | 1297 | 703 | 377 | 249 | 94 | 56 | 63 | 30 | 38 |
| | 2004 | 8 | 924 | 6859 | 1861 | 1280 | 687 | 479 | 357 | 138 | 246 | 160 | 282 |
| | 2005 | 56 | 973 | 9614 | 3271 | 1364 | 880 | 373 | 287 | 222 | 67 | 70 | 225 |
| | 2006 | 0 | 143 | 4648 | 4044 | 2801 | 1073 | 473 | 370 | 185 | 211 | 49 | 181 |
| Charter Boat NW FL | 1981 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1982 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1983 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1985 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1986 | 89 | 1084 | 11365 | 10615 | 730 | 553 | 1432 | 222 | 39 | 29 | 3 | 47 |
| | 1987 | 2 | 4739 | 16825 | 16797 | 2260 | 2645 | 1109 | 478 | 93 | 206 | 24 | 119 |
| | 1988 | 54 | 2063 | 5243 | 8225 | 24431 | 13558 | 3647 | 7300 | 3599 | 335 | 438 | 2736 |
| | 1989 | 190 | 14842 | 10700 | 9568 | 3449 | 3829 | 263 | 641 | 308 | 199 | 271 | 379 |
| | 1990 | 15 | 6705 | 20301 | 13400 | 4836 | 3219 | 1071 | 950 | 671 | 473 | 93 | 487 |
| | 1991 | 268 | 29232 | 37528 | 11014 | 4793 | 2903 | 1381 | 548 | 167 | 1281 | 221 | 679 |
| | 1992 | 65 | 5864 | 24326 | 14595 | 5094 | 1473 | 1414 | 807 | 373 | 88 | 428 | 475 |
| | 1993 | 208 | 12439 | 11110 | 10395 | 7015 | 2918 | 1123 | 1210 | 737 | 360 | 100 | 1581 |
| | 1994 | 50 | 28027 | 19716 | 9313 | 9945 | 6541 | 3168 | 960 | 2433 | 1211 | 624 | 1797 |
| | 1995 | 733 | 15045 | 39300 | 25016 | 8208 | 3164 | 3295 | 1805 | 733 | 408 | 793 | 1057 |
| | 1996 | 0 | 15941 | 49029 | 30406 | 12098 | 7525 | 8648 | 5558 | 3302 | 699 | 688 | 3199 |
| | 1997 | 0 | 5227 | 29699 | 23264 | 12100 | 5012 | 2138 | 2935 | 2128 | 1121 | 220 | 1419 |
| | 1998 | 0 | 15683 | 15526 | 31692 | 13882 | 8643 | 3763 | 2046 | 3005 | 2357 | 1060 | 1260 |
| | 1999 | 0 | 17861 | 11670 | 24317 | 31158 | 11503 | 7642 | 3273 | 1806 | 3111 | 638 | 1222 |
| | 2000 | 17456 | 10705 | 32859 | 23381 | 23346 | 12110 | 3390 | 3324 | 1303 | 1792 | 1296 | 1959 |
| | 2001 | 6 | 10836 | 23638 | 35528 | 15307 | 8129 | 5801 | 4298 | 2731 | 1000 | 718 | 2757 |
| | 2002 | 37 | 11688 | 16960 | 20180 | 23656 | 8238 | 7455 | 3913 | 2851 | 1670 | 1002 | 2992 |
| | 2003 | 0 | 2686 | 11009 | 9190 | 17243 | 8686 | 4136 | 2883 | 2009 | 1319 | 931 | 1460 |
| | 2004 | 11877 | 3897 | 16152 | 14438 | 11210 | 6273 | 5821 | 2584 | 1258 | 1863 | 838 | 889 |
| | 2005 | 8498 | 1674 | 9821 | 7270 | 21933 | 5418 | 4141 | 1923 | 2911 | 738 | 1217 | 1046 |
| | 2006 | 0 | 10799 | 29588 | 39771 | 44565 | 19414 | 12663 | 5755 | 5536 | 1129 | 1212 | 3893 |
| Charter Boat SW FL | 1981 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1982 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1983 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1985 | 0 | 427 | 56 | 95 | 108 | 180 | 25 | 8 | 0 | 0 | 7 | 3 |
| | 1986 | 0 | 471 | 1809 | 3614 | 1715 | 1564 | 559 | 489 | 89 | 59 | 34 | 121 |
| | 1987 | 0 | 8 | 207 | 1382 | 286 | 646 | 437 | 0 | 0 | 0 | 0 | 0 |
| | 1988 | 6 | 75 | 127 | 113 | 100 | 37 | 8 | 45 | 12 | 9 | 8 | 15 |
| | 1989 | 0 | 3433 | 7659 | 5701 | 1846 | 1719 | 255 | 81 | 196 | 206 | 23 | 117 |
| | 1990 | 1546 | 3068 | 2494 | 3374 | 3829 | 2513 | 2417 | 1082 | 3572 | 819 | 18 | 1963 |
| | 1991 | 0 | 774 | 3539 | 3405 | 1705 | 519 | 1114 | 483 | 331 | 111 | 438 | 389 |
| | 1992 | 3 | 1485 | 11268 | 17967 | 21459 | 12902 | 13219 | 3943 | 1967 | 12101 | 3535 | 8149 |
| | 1993 | 4 | 3575 | 25156 | 18643 | 27547 | 30761 | 11256 | 15301 | 3841 | 741 | 234 | 4159 |
| | 1994 | 117 | 22064 | 11215 | 20262 | 34738 | 95033 | 18990 | 14273 | 23175 | 9933 | 4121 | 11295 |
| | 1995 | 167 | 11015 | 61577 | 47978 | 29704 | 26536 | 28509 | 18860 | 9393 | 2109 | 4043 | 10347 |
| | 1996 | 0 | 5791 | 36836 | 28302 | 23136 | 15191 | 8945 | 11102 | 17574 | 7763 | 234 | 16618 |
| | 1997 | 0 | 8963 | 36945 | 76944 | 38740 | 26443 | 12342 | 10134 | 9774 | 7508 | 3580 | 4055 |
| | 1998 | 0 | 5028 | 14690 | 23208 | 25555 | 15034 | 7333 | 3844 | 4153 | 4714 | 1776 | 2092 |
| | 1999 | 0 | 6850 | 11548 | 10666 | 12837 | 8826 | 2756 | 2717 | 1171 | 2371 | 1426 | 2069 |
| | 2000 | 955 | 5840 | 15297 | 21205 | 16175 | 11704 | 9041 | 8077 | 3148 | 3793 | 1837 | 6650 |
| | 2001 | 4 | 7510 | 19610 | 25843 | 20405 | 11109 | 8912 | 9404 | 8367 | 4083 | 1207 | 6439 |
| | 2002 | 2 | 5831 | 27049 | 16842 | 11310 | 7073 | 3438 | 2043 | 1957 | 1186 | 1062 | 1948 |
| | 2003 | 0 | 2586 | 13567 | 13033 | 11604 | 5412 | 6583 | 2363 | 1424 | 2052 | 1849 | 2365 |
| | 2004 | 5770 | 2221 | 19534 | 9621 | 7038 | 4469 | 3680 | 2638 | 1140 | 1307 | 711 | 1625 |
| | 2005 | 3054 | 1407 | 14664 | 15661 | 10916 | 10768 | 7374 | 6417 | 5659 | 1596 | 1428 | 8607 |
| | 2006 | 0 | 1280 | 13637 | 16031 | 14807 | 5663 | 2804 | 2265 | 1319 | 1759 | 256 | 1597 |

### 3.1.1.3. *Model Configuration and Equations*

Virtual population analysis (VPA) is based on a family of techniques described by Murphy (1965) and Gulland (1965). The method assumes that the catch history of any given year-class is known without error, permitting the historical abundance and fishing mortality rates to be computed deterministically from an initial estimate of the abundance or fishing mortality rate on the oldest (terminal) age of the year class. The VPA can be “tuned” to ancillary information such as indices of abundance or tagging data (Doubleday, 1981; Parrack, 1986; Gavaris, 1989). For king mackerel, VPAs have been used since the mid-1980s (Nichols, 1985; see also Section 1 of SEDAR 16 SAR).

In recent years through SEDAR5, the VPA program known as FADAPT (Restrepo, 1996) was used for king mackerel assessments. In 2008 the program VPA-2BOX (Porch et al., 1995) is being used instead because it offers more modeling options than does FADAPT, such as the ability to impose certain constraints on the solution, and the ability to model two stocks simultaneously with mixing between them. For simple applications, both FADAPT and VPA-

2BOX give the same results[2]. Like FADAPT, VPA-2BOX is based on the ADAPT model framework (Gavaris, 1989). Various implementations of ADAPT and VPA have been widely used for domestic fisheries in the United States, South Africa and Canada; as well as in several international arenas, including the International Commission of the Conservation of Atlantic Tuna (ICCAT) and the Northwest Atlantic Fisheries Organization (NAFO).

VPA-2BOX uses backwards recursion to fit age-structured models for one or two intermixing populations to catch, effort and abundance data. The basic methods are as follows (**Table 3.9**).

**Table 3.9.** Overlap and diffusion model equations describing population dynamics (stock: s, age: a, year:y, zone: j or k, A: age of plus-group, Y: most recent year in analysis).

| Equations and variables | Description |
|---|---|
| $C_{kay} = \tilde{N}_{kay} \dfrac{F_{kay}\left(1 - e^{-Z_{kay}}\right)}{Z_{kay}}$ | Catch at age *a* in year *y* from all stocks in management zone *k* |
| $Z_{kay} = F_{kay} + M_{kay}$ | Total mortality rate in zone *k* |
| $F_{kay}$ | Fishing mortality rate in zone *k* |
| $M_{kay}$ | Natural mortality rate in zone *k* |
| ***Overlap model*** | |
| $N_{s,a+1,y+1} = N_{say} \sum_{k} T_{skay} e^{-Z_{kay}}$ | Number of fish from stock *s* that are age *a*+1 at the beginning of year *y* (*a*+1<*A*) |
| $N_{s,A,y+1} = \sum_{a=A-1}^{A} N_{say} \sum_{k} T_{skay} e^{-Z_{kay}}$ | Number of fish from stock *s* that are age *A* or older at the beginning of year *y* |
| $\tilde{N}_{kay} = \sum_{s} T_{skay} N_{say}$ | Number of fish in zone *k* that are age *a* at the beginning of year *y* (all stocks combined) |
| $T_{skay}$ | Fraction of stock *s* residing in zone *k* at the beginning of year *y* |
| ***Diffusion model*** | |
| $\tilde{N}_{k,a+1,y+1} = \sum_{j} \tilde{N}_{jay} \tilde{T}_{jkay} e^{-Z_{kay}}$ | Number of fish in zone *k* that are age *a*+1 at the beginning of year *y* (*a*+1<*A*) |
| $\tilde{N}_{k,A,y+1} = \sum_{a=A-1}^{A} \sum_{j} \tilde{N}_{jay} \tilde{T}_{jkay} e^{-Z_{kay}}$ | Number of fish in zone *k* that are age *A* or older at the beginning of year *y* |
| $\tilde{T}_{kjay}$ | Fraction of population in zone *j* that moves to zone *k* at the beginning of year *y* |

[2] When the base case assessment for Gulf of Mexico king mackerel from SEDAR5 was implemented using VPA-2BOX, it gave the same results as FADAPT did in 2004 (S. Cass-Calay, pers. comm.)

Note that while mixing between two stocks is possible within the VPA-2BOX model framework, the models discussed in this paper do not allow mixing between the Gulf and Atlantic migratory groups. Instead, each migratory group is modeled independently as a separate stock.

The catch equations (**Table 3.9**) contain many variables (N, F, M and T), yet only the catches are actually observed. VPA-2BOX overcomes this problem by using a backwards recursion to determine the historical abundance and fishing mortality rate of each cohort from the observed catches and prescribed values for natural mortality and the fishing mortality rate on the last age observed for the cohort ($F_{Ay}$ or $F_{aY}$). The challenge that remains is to choose appropriate values for M, $F_{aY}$ and $F_{Ay}$. The method used for the SEDAR 16 VPA runs was to estimate these values by maximizing the model fits to indices of abundance by maximizing the log-likelihood function described in **Table 3.10**.

**Table 3.10**. Model for indices of abundance (index series: *i*, zone: *k*, age: *a*, year: *y*).

| | |
|---|---|
| $\mathcal{L}(\bar{I}) = -\sum_i \sum_k \sum_y 0.5\left(\frac{\ln\left(I_{iky}/\hat{I}_{iky}\right)}{\sigma_{iky}}\right)^2 - \ln\sigma_{iky}$ | log-likelihood term for lognormally distributed indices of abundance |
| $\hat{I}_{iky} = q_{iky}\sum_a s_{ika}\, w_{ikay}\, \widetilde{N}_{kay}$ | predicted value of index |
| $s_{ika} = \dfrac{\sum_y C_{ikay} F_{kay}/C_{kay}}{\underset{a}{\mathrm{MAX}}\left\{\sum_y C_{ikay} F_{kay}/C_{kay}\right\}}$ | availability at age (see Butterworth and Geromont, 1999) |
| $I_{iky}$ | observed value of index |
| $\sigma_{iky}$ | standard error of index on log scale |
| $q_{ikay}$ | catchability coefficient |
| $w_{ikay}$ | adjustment for weight and time of year (if needed) |
| $C_{ikay}$ | catch associated with index *i* in zone *k* |

This introduces several new variables that need to be accounted for—the index standard error σ, catchability *q*, and relative selectivity *S*. The values for σ were estimated internally using a concentrated maximum likelihood procedure. The values of *q* were assumed to be constant through time and estimated along with the other parameters. For the “Continuity Cases”, the values of *S* corresponding to each index were determined from the partial catches and partial fishing mortalities using the method of Powers and Restrepo (1992). “Partial catch” is generally defined as catch-at-age pertaining to survey area or fleet, relative to the total catch at age for all fleets combined.

#### 3.1.1.4. *Parameters Estimated*

The estimated parameters were the terminal year (2006) fishing mortality rates for each age (Terminal F's). Like the SEDAR5 and MSAP 2003 assessments, the terminal Fs for age-1 (Atlantic) or ages 0 and 1 (Gulf) were fixed relative to the estimated terminal year F at age-2 using ratios derived from a separable VPA that used the most recent seven years of data (2000-2006). For the Atlantic assessment, the Terminal Fs for ages 3 -9 were estimated, and ages 10 and 11+ were assumed to have the same terminal F as age-9. For the Gulf assessment, the Terminal Fs for ages 3 -10 were estimated, and age-11+ was assumed to have the same terminal F as age-10. These assumptions are summarized in **Table 3.11**. The model also estimated catchability coefficients for each index.

**Table 3.11.** Terminal F settings and initial guesses used for VPA "Continuity Cases".

| | Atlantic | | Gulf | |
|---|---|---|---|---|
| | Initial Value | Fixed or Estimated? | Initial Value | Fixed or Estimated? |
| Age 0 | NA | NA | - | Fixed at 208.4% of Terminal F at Age-2 |
| Age 1 | - | Fixed at 9.62% of Terminal F at Age-2 | - | Fixed at 17.7% Terminal F at Age-2 |
| Age 2 | 0.067 | Estimated | 0.0351 | Estimated |
| Age 3 | 0.213 | Estimated | 0.052 | Estimated |
| Age 4 | 0.083 | Estimated | 0.4275 | Estimated |
| Age 5 | 0.272 | Estimated | 0.3223 | Estimated |
| Age 6 | 0.052 | Estimated | 0.1982 | Estimated |
| Age 7 | 0.036 | Estimated | 0.0481 | Estimated |
| Age 8 | 0.228 | Estimated | 0.2169 | Estimated |
| Age 9 | 0.032 | Estimated | 0.3907 | Estimated |
| Age 10 | - | Fixed equal to Terminal F at Age-9 | 0.3397 | Estimated |
| Age 11+ | - | Fixed equal to Terminal F at Age-9 | - | Fixed equal to Terminal F at Age-10 |

#### 3.1.1.5. *Uncertainty and Measures of Precision*

It is possible to evaluate uncertainty using bootstrap runs of the index residuals. However, since the "Continuity Cases" were not constructed to provide management advice, no bootstrap runs were completed.

#### 3.1.1.6. *Methods Used to Compute Benchmark / Reference Points*

Benchmarks are reference points were calculated using the current management criteria[3] (**Table 3.12**). The following treatments of the data and assumptions have been used:

Terminal F ($F_{Current}$): $F_{Current}$ was estimated as the apical F for the terminal year..

[3] Management Overview, Section I, SEDAR 16 Stock Assessment Report

Current Selectivity: selectivity was computed from the geometric means of the age-specific fishing mortality values in the last five years of the VPA.

SSB: SSB is computed as the product of numbers at age at the beginning of each year, times maturity, times fecundity.

Expected spawner-recruit relationship: A two-line model. Maximum recruitment is given by the mean of the estimated recruitments for 1989-2004. The Atlantic values before 1989 were excluded following the rationale in SEDAR 5 and previous assessments that no index information was available in those years to estimate SSB and recruitment. The SSB at which recruitment starts to decline to the origin is given by the mean of the five lowest SSB estimates.

**Table 3.12.** Management criteria for the Gulf and South Atlantic regions, continuity case.

| Criteria | Current Definition | |
|---|---|---|
| | South Atlantic | Gulf of Mexico |
| MSST | 0.85(Bmsy) | 0.8(Bmsy) |
| MFMT | Fmsy = F30%SPR | Fmsy = F30%SPR |
| MSY | Yield @30%SPR | Yield @30%SPR |
| $F_{MSY}$ | Fmsy = F30%SPR | Fmsy = F30%SPR |
| OY | Yield @ F40% | Yield @ 0.85Fmsy |
| $F_{OY}$ | F40% SPR | 0.85Fmsy |
| M | 0.15 | 0.20 |

### 3.1.1.7. *Projection methods*

The "Continuity Cases" were not constructed to provide management advice. Therefore, no projections were attempted.

### 3.1.2. Model 1 Results

The purpose of the "Continuity Cases" was to demonstrate the effect of updating time series (catch and indices) without modifying modeling assumptions or life history functions (e.g. natural mortality, fecundity, growth etc). These results are not intended to be used for management advice. Therefore, a reduced set of results will be presented. The results are most properly compared to SEDAR 5 results prior to 2002.

### 3.1.2.1. *Measures of Overall Model Fit*

The model fit was assessed using the objective function, likelihood statistics (**Table 3.13)** and the fits to the indices of abundance (**Figures 3.1 and 3.2**). AIC, AICC and BIC values are also summarized in **Table 3.13**, but these are not directly comparable across model with different numbers of parameters. The fits to the Atlantic indices of abundance were quite poor (indicated by lower log likelihoods). Some Gulf indices were fit quite well (i.e. HB, MRFSS and the SW FL Trip Ticket), but others were very poorly fit (i.e. Bycatch GLM and Charterboat SW).

**Table 3.13** Loglikelihood measures of model fits to the indices of abundance and associated information criteria. The acronyms AIC, AICc and BIC refer to Akaike's Information criteria, AIC with small sample correction, and the Bayes Information Criteria. The Chi-square discrepancy statistic (Gelman et al., 1995) is approximately chi-square distributed with degrees of freedom equal to the number of data points less the number of parameters. Note that these statistics can only be compared across models that use the same data.

| Model | ATL-Continuity | | GOM-Continuity | |
|---|---|---|---|---|
| Total objective function | -33.22 | | -43.37 | |
| (with constants) | 62.35 | | 111.94 | |
| Number of parameters | 18 | | 18 | |
| Number of data points | 104 | | 169 | |
| AIC | 160.69 | | 259.87 | |
| AICC | 168.74 | | 264.43 | |
| BIC | 208.29 | | 316.21 | |
| Chi-square discrepancy | 97.38 | | 212.71 | |
| | | | | |
| Loglikelihoods (deviance) | 33.22 | | 43.37 | |
| effort data | 33.22 | | 43.37 | |
| | | | | |
| Log-posteriors | 0 | | 0 | |
| catchability | 0 | | 0 | |
| f-ratio | 0 | | 0 | |
| natural mortality | 0 | | 0 | |
| mixing coeff. | 0 | | 0 | |
| | | | | |
| Constraints | 0 | | 0 | |
| terminal F | 0 | | 0 | |
| stock-rec./sex ratio | 0 | | 0 | |
| | | | | |
| Out of bounds penalty | 0 | | 0 | |
| | | | | |
| Log Likelihoood: Indices of Abundance | 33.23 | | 43.34 | |
| Index 1 | 'NC_com_TT' | 13.59 | 'FL_TT_NW' | 6.91 |
| Index 2 | 'FL_com_TT' | 3.45 | 'FL_TT_SW' | 8.27 |
| Index 3 | 'MRFSS' | 5.91 | 'MRFSS' | 11.08 |
| Index 4 | 'HeadB' | 7.97 | 'TX_PWD' | 2.88 |
| Index 5 | 'SEAMAP' | 2.31 | 'HeadBoat' | 10.81 |
| Index 6 | NA | | 'Charter_FL_NW' | 5.22 |
| Index 7 | NA | | 'Charter_FL_SW' | 0.82 |
| Index 8 | NA | | 'Bycatch_GLM' | -4.11 |
| Index 9 | NA | | 'SEAMAP' | 1.46 |

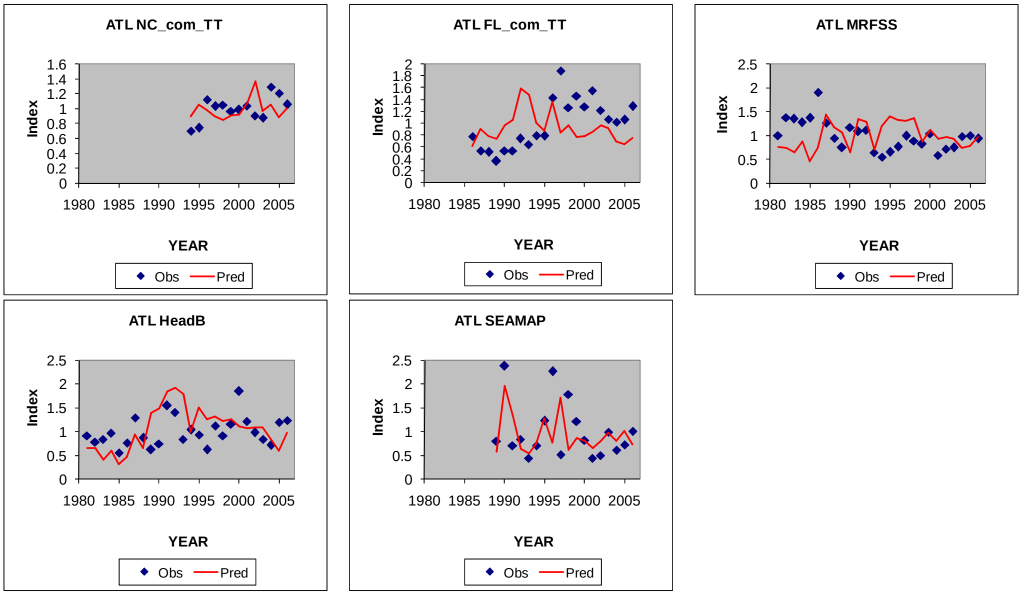


**Figure 3.1.** Fits to indices of abundance for the Atlantic “continuity case”.

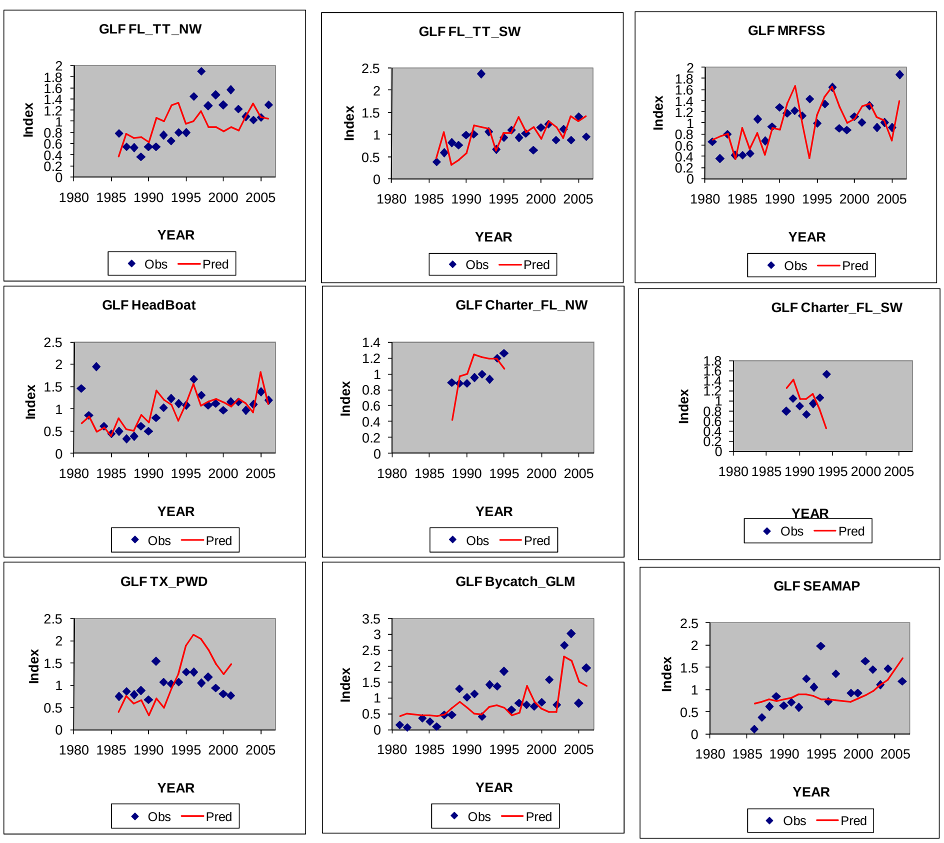


**Figure 3.2.** Fits to indices of abundance for the Gulf “continuity case”.

### 3.1.2.2. *Parameter estimates & associated measures of uncertainty*

The Terminal Year F parameter estimates for the Atlantic and Gulf "continuity cases" are summarized in **Table 3.14.** Fixed values are indicated with gray shading. No measures of uncertainty are available because no bootstraps were completed for the continuity cases.

**Table 3.14.** Final terminal year F estimates for the continuity cases. Fixed values are shaded.

| Terminal Year F | Atlantic | Gulf |
|---|---|---|
| Age 0 | Not Used | 2.084 |
| Age 1 | 0.096 | 0.177 |
| Age 2 | 0.066 | 0.031 |
| Age 3 | 0.215 | 0.046 |
| Age 4 | 0.083 | 0.426 |
| Age 5 | 0.274 | 0.337 |
| Age 6 | 0.053 | 0.208 |
| Age 7 | 0.036 | 0.077 |
| Age 8 | 0.229 | 0.040 |
| Age 9 | 0.032 | 0.400 |
| Age 10 | 0.032 | 0.362 |
| Age 11 | 0.032 | 0.362 |

### 3.1.2.3. *Stock Abundance and Recruitment*

Annual estimates of the size of the adult stock (Age 2+) are summarized in **Figure 3.3.** The continuity run suggests a larger adult population in the Atlantic, relative to the SEDAR 5 results. The Gulf estimates are comparable throughout the time-series.

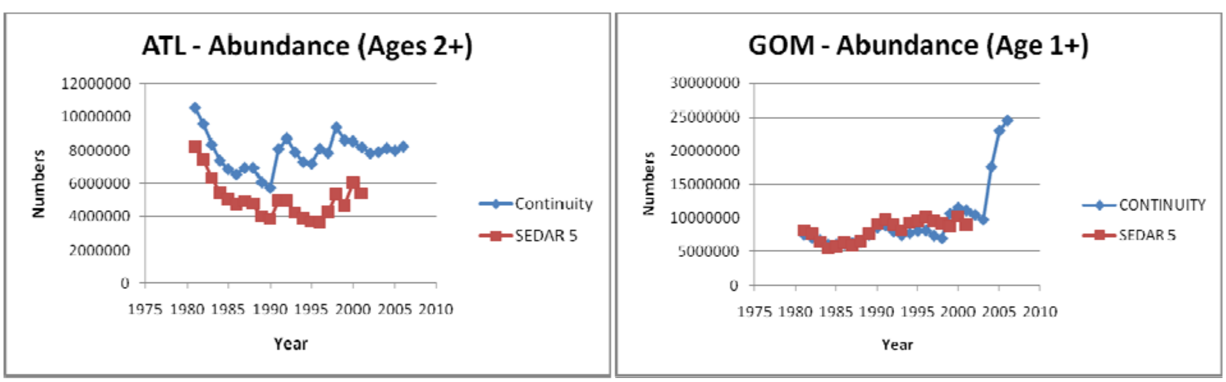


**Figure 3.3.** Comparison of annual abundance estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run.

For SEDAR 5 and VPA continuity runs, the Atlantic models began at Age 1. The estimates of recruitment at age-1 from SEDAR 5 and the continuity run are similar in magnitude (averaging 2 million) until 1997, then the continuity estimates are substantially higher than the SEDAR 5 estimates (**Figure 3.4**). In the Gulf, the recruitment estimates are roughly equal in magnitude (averaging 3.5 million) during 1981-2001, and vary largely without trend until the recent years. However, some differences are notable after 1997. Gulf recruitment estimates are markedly higher after 2003, 10.5 million on average.

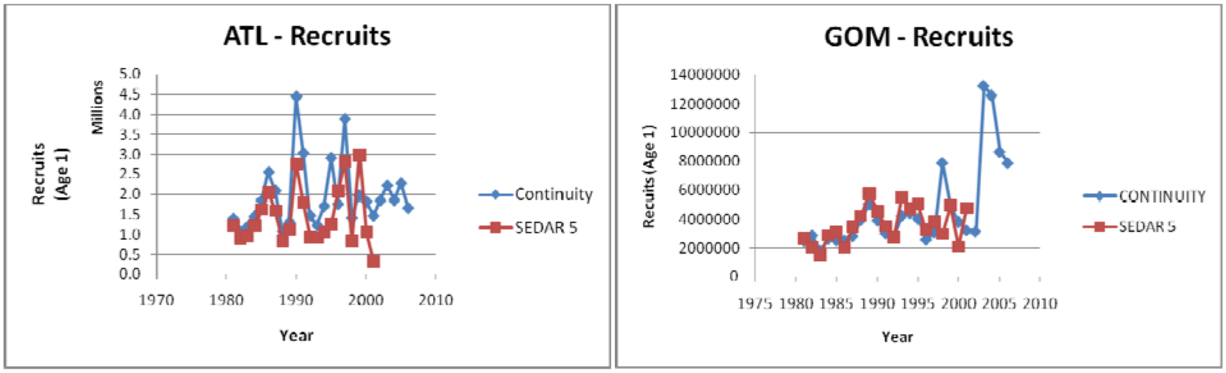


**Figure 3.4.** Comparison of annual recruitment estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run.

### 3.1.2.4. *Stock Biomass (total and spawning stock)*

The spawning stock biomass estimates for the Atlantic and Gulf continuity cases are summarized in **Figure 3.5**. During the initial years of the time series, the Atlantic spawning stock biomass was estimated to be larger than that in the Gulf. However, in the most recent years, the Gulf stock biomass increased steeply, and in 2005 and 2006, the Gulf spawning stock biomass exceeded that in the Atlantic.

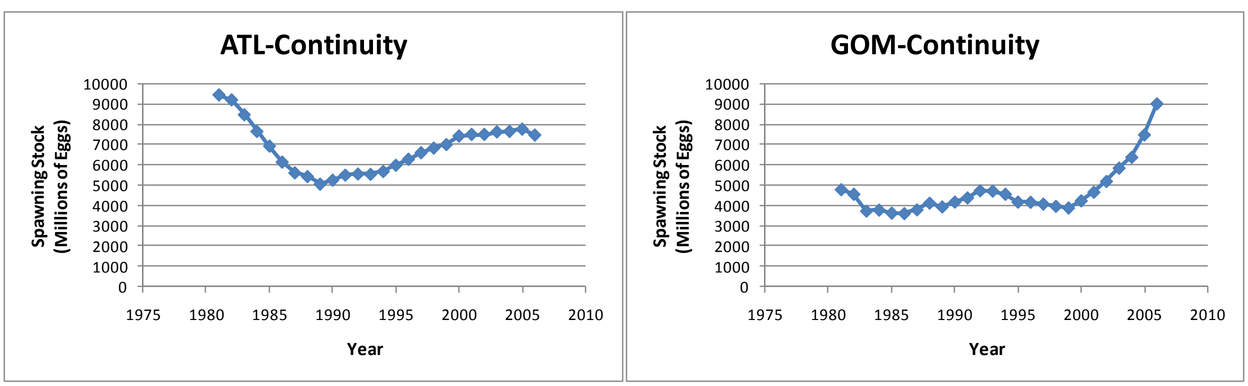


**Figure 3.5.** Spawning stock trajectories from the VPA continuity cases.

### 3.1.2.5. *Fishery Selectivity*

Fishery selectivity was estimated using the partial catches (fleet or index specific catches-at-age) using the Powers and Restrepo (1992) method which allows selectivity to vary by year, and requires the partial catches –at-age to be fit exactly. This is the same method used during previous assessments of king mackerel. For the Atlantic model, one exception was the SEAMAP trawl selectivity which was fixed at 1.0 for Age 1 and 0.0 for all other ages. The fishery selectivity estimates for the other Atlantic fleets/indices are summarized in **Table 3.15**.

**Table 3.15.** Fishing mortality and Fishery selectivity-at-age for the Atlantic continuity case.

| Year/Age | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.011 | 0.026 | 0.053 | 0.088 | 0.118 | 0.155 | 0.159 | 0.268 | 0.059 | 0.059 | 0.059 |
| 1982 | 0.006 | 0.01 | 0.006 | 0.057 | 0.102 | 0.235 | 0.35 | 0.293 | 0.255 | 0.117 | 0.117 |
| 1983 | 0.009 | 0.041 | 0.085 | 0.06 | 0.098 | 0.159 | 0.283 | 0.548 | 0.121 | 0.123 | 0.123 |
| 1984 | 0.011 | 0.009 | 0.021 | 0.085 | 0.074 | 0.249 | 0.241 | 0.318 | 0.257 | 0.154 | 0.154 |
| 1985 | 0.015 | 0.109 | 0.13 | 0.061 | 0.196 | 0.091 | 0.251 | 0.773 | 0.453 | 0.166 | 0.166 |
| 1986 | 0.018 | 0.052 | 0.101 | 0.217 | 0.26 | 0.231 | 0.109 | 0.549 | 0.536 | 0.19 | 0.19 |
| 1987 | 0.075 | 0.1 | 0.095 | 0.162 | 0.227 | 0.217 | 0.085 | 0.089 | 0.167 | 0.145 | 0.145 |
| 1988 | 0.014 | 0.11 | 0.148 | 0.146 | 0.083 | 0.155 | 0.296 | 0.127 | 0.146 | 0.246 | 0.246 |
| 1989 | 0.039 | 0.081 | 0.096 | 0.088 | 0.111 | 0.156 | 0.184 | 0.207 | 0.118 | 0.173 | 0.173 |
| 1990 | 0.026 | 0.115 | 0.119 | 0.109 | 0.103 | 0.142 | 0.126 | 0.143 | 0.436 | 0.169 | 0.169 |
| 1991 | 0.018 | 0.077 | 0.162 | 0.131 | 0.173 | 0.169 | 0.139 | 0.256 | 0.149 | 0.194 | 0.194 |
| 1992 | 0.029 | 0.078 | 0.113 | 0.168 | 0.166 | 0.114 | 0.131 | 0.099 | 0.153 | 0.247 | 0.247 |
| 1993 | 0.021 | 0.054 | 0.054 | 0.058 | 0.12 | 0.133 | 0.114 | 0.147 | 0.123 | 0.212 | 0.212 |
| 1994 | 0.028 | 0.118 | 0.056 | 0.059 | 0.063 | 0.181 | 0.15 | 0.091 | 0.143 | 0.138 | 0.138 |
| 1995 | 0.025 | 0.107 | 0.105 | 0.073 | 0.053 | 0.072 | 0.144 | 0.149 | 0.124 | 0.131 | 0.131 |
| 1996 | 0.017 | 0.069 | 0.106 | 0.186 | 0.115 | 0.056 | 0.083 | 0.16 | 0.209 | 0.101 | 0.101 |
| 1997 | 0.017 | 0.177 | 0.079 | 0.128 | 0.158 | 0.084 | 0.066 | 0.069 | 0.209 | 0.105 | 0.105 |
| 1998 | 0.021 | 0.042 | 0.189 | 0.089 | 0.132 | 0.156 | 0.066 | 0.069 | 0.072 | 0.079 | 0.079 |
| 1999 | 0.026 | 0.073 | 0.047 | 0.22 | 0.069 | 0.097 | 0.088 | 0.064 | 0.051 | 0.049 | 0.049 |
| 2000 | 0.002 | 0.156 | 0.122 | 0.083 | 0.258 | 0.054 | 0.056 | 0.06 | 0.053 | 0.066 | 0.066 |
| 2001 | 0.005 | 0.035 | 0.111 | 0.122 | 0.063 | 0.2 | 0.042 | 0.052 | 0.056 | 0.056 | 0.056 |
| 2002 | 0.019 | 0.045 | 0.052 | 0.145 | 0.087 | 0.047 | 0.127 | 0.035 | 0.036 | 0.026 | 0.026 |
| 2003 | 0.004 | 0.113 | 0.064 | 0.092 | 0.231 | 0.115 | 0.061 | 0.211 | 0.025 | 0.023 | 0.023 |
| 2004 | 0.02 | 0.059 | 0.155 | 0.076 | 0.105 | 0.278 | 0.077 | 0.053 | 0.143 | 0.021 | 0.021 |
| 2005 | 0.001 | 0.01 | 0.04 | 0.176 | 0.269 | 0.164 | 0.108 | 0.288 | 0.033 | 0.079 | 0.079 |
| 2006 | 0.006 | 0.066 | 0.215 | 0.083 | 0.274 | 0.053 | 0.036 | 0.229 | 0.032 | 0.032 | 0.032 |

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NC_com_TT
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Selectivities by age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 0.250 | 0.146 | 0.147 | 0.202 | 0.786 | 1.000 | 0.349 | 0.720 | 0.724 | 0.781 |
| 1995 | 0.181 | 0.445 | 0.367 | 0.255 | 0.397 | 1.000 | 0.869 | 0.571 | 0.699 | 0.569 |
| 1996 | 0.105 | 0.348 | 1.000 | 0.787 | 0.279 | 0.345 | 0.586 | 0.639 | 0.504 | 0.186 |
| 1997 | 0.413 | 0.258 | 0.490 | 0.634 | 0.345 | 0.220 | 0.257 | 1.000 | 0.423 | 0.330 |
| 1998 | 0.111 | 0.705 | 0.310 | 0.558 | 1.000 | 0.245 | 0.184 | 0.179 | 0.137 | 0.191 |
| 1999 | 0.359 | 0.226 | 1.000 | 0.331 | 0.572 | 0.488 | 0.351 | 0.191 | 0.109 | 0.143 |
| 2000 | 0.278 | 0.366 | 0.311 | 1.000 | 0.274 | 0.269 | 0.504 | 0.304 | 0.173 | 0.210 |
| 2001 | 0.147 | 0.401 | 0.411 | 0.265 | 1.000 | 0.315 | 0.515 | 0.647 | 0.254 | 0.388 |
| 2002 | 0.343 | 0.427 | 1.000 | 0.690 | 0.454 | 0.851 | 0.370 | 0.684 | 0.218 | 0.277 |
| 2003 | 0.484 | 0.299 | 0.397 | 1.000 | 0.472 | 0.261 | 0.769 | 0.157 | 0.077 | 0.130 |
| 2004 | 0.513 | 0.858 | 0.514 | 0.581 | 1.000 | 0.152 | 0.230 | 0.187 | 0.024 | 0.083 |
| 2005 | 0.038 | 0.134 | 0.632 | 0.769 | 0.662 | 0.027 | 1.000 | 0.079 | 0.361 | 0.217 |
| 2006 | 0.292 | 0.791 | 0.295 | 1.000 | 0.401 | 0.176 | 0.710 | 0.153 | 0.128 | 0.193 |

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FL_com_TT
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Selectivities by age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| 1986 | 0.014 | 0.045 | 0.162 | 0.461 | 0.802 | 0.339 | 1.000 |
| 1987 | 0.254 | 0.370 | 0.659 | 0.993 | 1.000 | 0.362 | 0.417 |
| 1988 | 0.374 | 0.506 | 0.505 | 0.246 | 0.556 | 1.000 | 0.479 |
| 1989 | 0.288 | 0.393 | 0.384 | 0.495 | 0.663 | 0.612 | 1.000 |
| 1990 | 0.491 | 0.564 | 0.502 | 0.530 | 0.803 | 0.777 | 1.000 |
| 1991 | 0.250 | 0.589 | 0.419 | 0.664 | 0.679 | 0.665 | 1.000 |
| 1992 | 0.606 | 0.700 | 0.897 | 1.000 | 0.640 | 0.695 | 0.582 |
| 1993 | 0.568 | 0.618 | 0.542 | 0.806 | 1.000 | 0.725 | 0.926 |
| 1994 | 0.637 | 0.372 | 0.395 | 0.398 | 1.000 | 0.670 | 0.494 |
| 1995 | 0.218 | 0.391 | 0.378 | 0.298 | 0.431 | 0.959 | 1.000 |
| 1996 | 0.676 | 0.695 | 0.999 | 0.516 | 0.289 | 0.504 | 1.000 |
| 1997 | 1.000 | 0.304 | 0.414 | 0.476 | 0.210 | 0.195 | 0.183 |
| 1998 | 0.164 | 1.000 | 0.445 | 0.572 | 0.508 | 0.238 | 0.301 |
| 1999 | 0.279 | 0.207 | 1.000 | 0.315 | 0.407 | 0.393 | 0.301 |
| 2000 | 0.443 | 0.433 | 0.327 | 1.000 | 0.183 | 0.186 | 0.119 |
| 2001 | 0.172 | 0.641 | 0.738 | 0.339 | 1.000 | 0.119 | 0.155 |
| 2002 | 0.258 | 0.334 | 1.000 | 0.591 | 0.304 | 0.906 | 0.217 |
| 2003 | 0.418 | 0.260 | 0.399 | 1.000 | 0.510 | 0.265 | 0.918 |
| 2004 | 0.139 | 0.469 | 0.222 | 0.338 | 1.000 | 0.259 | 0.166 |
| 2005 | 0.031 | 0.036 | 0.395 | 0.857 | 0.382 | 0.374 | 1.000 |
| 2006 | 0.130 | 0.591 | 0.253 | 0.919 | 0.159 | 0.122 | 1.000 |

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MRFSS
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Selectivities by age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.116 | 0.049 | 0.240 | 0.344 | 0.325 | 0.440 | 1.000 | 0.126 | 0.168 | 0.204 |
| 1982 | 0.023 | 0.017 | 0.131 | 0.283 | 0.521 | 1.000 | 0.692 | 0.547 | 0.342 | 0.256 |
| 1983 | 0.112 | 0.232 | 0.164 | 0.251 | 0.296 | 0.685 | 1.000 | 0.292 | 0.064 | 0.181 |
| 1984 | 0.028 | 0.066 | 0.314 | 0.254 | 1.000 | 0.754 | 0.890 | 0.423 | 0.487 | 0.447 |
| 1985 | 0.187 | 0.191 | 0.052 | 0.244 | 0.117 | 0.249 | 1.000 | 0.656 | 0.153 | 0.176 |
| 1986 | 0.182 | 0.312 | 0.757 | 0.655 | 0.467 | 0.184 | 1.000 | 0.721 | 0.217 | 0.302 |
| 1987 | 0.850 | 0.508 | 0.793 | 1.000 | 0.899 | 0.323 | 0.332 | 0.648 | 0.521 | 0.543 |
| 1988 | 0.502 | 0.605 | 0.545 | 0.260 | 0.497 | 1.000 | 0.420 | 0.494 | 0.802 | 0.840 |
| 1989 | 0.413 | 0.488 | 0.441 | 0.551 | 0.704 | 0.678 | 1.000 | 0.503 | 0.915 | 0.845 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1990 | 0.366 | 0.357 | 0.314 | 0.290 | 0.374 | 0.309 | 0.402 | 1.000 | 0.464 | 0.500 |
| 1991 | 0.387 | 0.715 | 0.454 | 0.633 | 0.628 | 0.621 | 0.865 | 0.706 | 1.000 | 0.860 |
| 1992 | 0.344 | 0.469 | 0.599 | 0.644 | 0.462 | 0.537 | 0.361 | 0.595 | 0.975 | 1.000 |
| 1993 | 0.167 | 0.168 | 0.184 | 0.380 | 0.451 | 0.459 | 0.603 | 0.464 | 0.824 | 1.000 |
| 1994 | 0.834 | 0.337 | 0.362 | 0.372 | 1.000 | 0.700 | 0.560 | 0.767 | 0.705 | 0.782 |
| 1995 | 1.000 | 0.808 | 0.483 | 0.339 | 0.423 | 0.724 | 0.783 | 0.694 | 0.743 | 0.704 |
| 1996 | 0.413 | 0.652 | 0.991 | 0.560 | 0.313 | 0.452 | 1.000 | 0.929 | 0.456 | 0.568 |
| 1997 | 0.794 | 0.384 | 0.635 | 0.801 | 0.460 | 0.356 | 0.376 | 1.000 | 0.585 | 0.619 |
| 1998 | 0.255 | 1.000 | 0.488 | 0.682 | 0.647 | 0.369 | 0.388 | 0.435 | 0.523 | 0.543 |
| 1999 | 0.324 | 0.207 | 1.000 | 0.300 | 0.391 | 0.358 | 0.258 | 0.223 | 0.240 | 0.228 |
| 2000 | 0.703 | 0.513 | 0.326 | 1.000 | 0.198 | 0.213 | 0.202 | 0.199 | 0.279 | 0.260 |
| 2001 | 0.183 | 0.563 | 0.617 | 0.320 | 1.000 | 0.209 | 0.217 | 0.224 | 0.311 | 0.296 |
| 2002 | 0.325 | 0.352 | 1.000 | 0.577 | 0.292 | 0.851 | 0.206 | 0.163 | 0.164 | 0.152 |
| 2003 | 0.482 | 0.278 | 0.399 | 1.000 | 0.500 | 0.261 | 0.937 | 0.098 | 0.108 | 0.093 |
| 2004 | 0.166 | 0.535 | 0.238 | 0.344 | 1.000 | 0.316 | 0.188 | 0.667 | 0.104 | 0.089 |
| 2005 | 0.029 | 0.143 | 0.602 | 1.000 | 0.518 | 0.534 | 0.908 | 0.134 | 0.311 | 0.180 |
| 2006 | 0.268 | 0.845 | 0.317 | 1.000 | 0.143 | 0.117 | 0.755 | 0.093 | 0.099 | 0.101 |

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HeadB
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Selectivities by age

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1981 | 0.019 | 0.130 | 0.045 | 0.264 | 0.366 | 0.368 | 0.383 | 1.000 |
| 1982 | 0.029 | 0.055 | 0.039 | 0.307 | 0.315 | 0.726 | 0.654 | 1.000 |
| 1983 | 0.033 | 0.144 | 0.075 | 0.056 | 0.202 | 0.254 | 0.608 | 1.000 |
| 1984 | 0.020 | 0.048 | 0.115 | 0.225 | 0.262 | 0.600 | 1.000 | 0.646 |
| 1985 | 0.015 | 0.159 | 0.156 | 0.025 | 0.192 | 0.099 | 0.181 | 1.000 |
| 1986 | 0.009 | 0.049 | 0.134 | 0.316 | 0.383 | 0.576 | 0.428 | 1.000 |
| 1987 | 0.172 | 0.306 | 0.392 | 0.686 | 1.000 | 0.894 | 0.275 | 0.321 |
| 1988 | 0.033 | 0.282 | 0.372 | 0.419 | 0.234 | 0.528 | 1.000 | 0.415 |
| 1989 | 0.756 | 0.939 | 0.709 | 0.540 | 0.601 | 0.737 | 0.685 | 1.000 |
| 1990 | 0.154 | 1.000 | 0.895 | 0.804 | 0.724 | 0.896 | 0.729 | 0.877 |
| 1991 | 0.273 | 0.719 | 1.000 | 0.553 | 0.695 | 0.575 | 0.499 | 0.631 |
| 1992 | 0.296 | 0.669 | 0.739 | 0.916 | 1.000 | 0.628 | 0.691 | 0.525 |
| 1993 | 0.467 | 0.994 | 0.606 | 0.561 | 0.872 | 1.000 | 0.738 | 0.868 |
| 1994 | 0.294 | 1.000 | 0.351 | 0.299 | 0.251 | 0.538 | 0.316 | 0.232 |
| 1995 | 0.291 | 1.000 | 0.824 | 0.515 | 0.374 | 0.445 | 0.764 | 0.747 |
| 1996 | 0.101 | 0.464 | 0.720 | 1.000 | 0.582 | 0.287 | 0.413 | 0.902 |
| 1997 | 0.133 | 1.000 | 0.341 | 0.567 | 0.727 | 0.382 | 0.332 | 0.333 |
| 1998 | 0.253 | 0.327 | 1.000 | 0.418 | 0.538 | 0.463 | 0.228 | 0.283 |
| 1999 | 0.413 | 0.880 | 0.286 | 1.000 | 0.276 | 0.343 | 0.317 | 0.211 |
| 2000 | 0.011 | 0.941 | 0.596 | 0.334 | 1.000 | 0.169 | 0.168 | 0.127 |
| 2001 | 0.044 | 0.306 | 0.880 | 0.901 | 0.382 | 1.000 | 0.146 | 0.157 |
| 2002 | 0.256 | 0.473 | 0.370 | 1.000 | 0.546 | 0.277 | 0.770 | 0.181 |
| 2003 | 0.050 | 0.875 | 0.365 | 0.425 | 1.000 | 0.435 | 0.205 | 0.685 |
| 2004 | 0.106 | 0.306 | 0.629 | 0.249 | 0.347 | 1.000 | 0.269 | 0.172 |
| 2005 | 0.000 | 0.055 | 0.226 | 0.551 | 0.563 | 0.533 | 0.393 | 1.000 |
| 2006 | 0.016 | 0.325 | 1.000 | 0.331 | 0.996 | 0.095 | 0.080 | 0.566 |

The total fishing mortality rates by age and year and the fishery selectivity estimates for the Gulf fleets/indices are summarized in **Table 3.16**. Two Gulf selectivity vectors were fixed, the SEAMAP Fall Groundfish survey (fixed to 1.0 at Age-0 and 0.0 for other ages) and the SEAMAP Ichthyoplankton survey (SSB index-Selectivity fixed equal to Fecundity*Maturity-at-age)

**Table 3.16.** Total fishing mortality and fishery selectivity-at-age for the Gulf continuity case.

| Year/Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.169 | 0.028 | 0.038 | 0.059 | 0.382 | 0.538 | 0.247 | 0.248 | 0.132 | 0.184 | 0.055 | 0.055 |
| 1982 | 0.209 | 0.006 | 0.047 | 0.222 | 0.366 | 0.602 | 0.406 | 0.28 | 0.62 | 0.174 | 0.335 | 0.335 |
| 1983 | 0.21 | 0.005 | 0.083 | 0.274 | 0.27 | 0.201 | 0.157 | 0.237 | 0.146 | 0.089 | 0.084 | 0.084 |
| 1984 | 0.215 | 0.042 | 0.015 | 0.07 | 0.608 | 0.358 | 0.263 | 0.237 | 0.227 | 0.113 | 0.044 | 0.044 |
| 1985 | 0.213 | 0.009 | 0.031 | 0.06 | 0.268 | 0.503 | 0.396 | 0.323 | 0.071 | 0.136 | 0.069 | 0.069 |
| 1986 | 0.153 | 0.037 | 0.166 | 0.214 | 0.057 | 0.162 | 0.331 | 0.171 | 0.13 | 0.051 | 0.064 | 0.064 |
| 1987 | 0.321 | 0.018 | 0.076 | 0.182 | 0.1 | 0.087 | 0.08 | 0.091 | 0.063 | 0.145 | 0.025 | 0.025 |
| 1988 | 0.151 | 0.018 | 0.036 | 0.074 | 0.3 | 0.676 | 0.126 | 0.263 | 0.423 | 0.121 | 0.142 | 0.142 |
| 1989 | 0.308 | 0.047 | 0.151 | 0.168 | 0.115 | 0.222 | 0.261 | 0.061 | 0.11 | 0.258 | 0.089 | 0.089 |
| 1990 | 0.26 | 0.018 | 0.063 | 0.198 | 0.341 | 0.106 | 0.208 | 0.262 | 0.095 | 0.092 | 0.103 | 0.103 |
| 1991 | 0.451 | 0.09 | 0.161 | 0.112 | 0.173 | 0.168 | 0.113 | 0.132 | 0.13 | 0.117 | 0.115 | 0.115 |
| 1992 | 0.221 | 0.071 | 0.118 | 0.128 | 0.275 | 0.254 | 0.338 | 0.125 | 0.149 | 1.049 | 0.177 | 0.177 |
| 1993 | 0.331 | 0.074 | 0.132 | 0.152 | 0.189 | 0.229 | 0.224 | 0.405 | 0.144 | 0.112 | 0.21 | 0.21 |
| 1994 | 0.27 | 0.07 | 0.1 | 0.21 | 0.31 | 0.339 | 0.192 | 0.216 | 1.022 | 0.231 | 0.25 | 0.25 |
| 1995 | 0.347 | 0.028 | 0.16 | 0.22 | 0.244 | 0.177 | 0.222 | 0.182 | 0.215 | 0.498 | 0.208 | 0.208 |
| 1996 | 0.266 | 0.032 | 0.188 | 0.204 | 0.21 | 0.229 | 0.164 | 0.175 | 0.251 | 0.283 | 0.334 | 0.334 |
| 1997 | 0.282 | 0.044 | 0.173 | 0.27 | 0.234 | 0.273 | 0.223 | 0.196 | 0.228 | 0.23 | 0.256 | 0.256 |
| 1998 | 0.096 | 0.049 | 0.129 | 0.24 | 0.298 | 0.265 | 0.262 | 0.247 | 0.234 | 0.334 | 0.165 | 0.165 |
| 1999 | 0.139 | 0.017 | 0.11 | 0.188 | 0.281 | 0.23 | 0.132 | 0.201 | 0.185 | 0.287 | 0.145 | 0.145 |
| 2000 | 0.241 | 0.022 | 0.043 | 0.234 | 0.329 | 0.256 | 0.151 | 0.196 | 0.167 | 0.421 | 0.231 | 0.231 |
| 2001 | 0.213 | 0.028 | 0.062 | 0.073 | 0.27 | 0.274 | 0.233 | 0.25 | 0.25 | 0.259 | 0.268 | 0.268 |
| 2002 | 0.212 | 0.048 | 0.177 | 0.1 | 0.068 | 0.262 | 0.32 | 0.216 | 0.23 | 0.187 | 0.254 | 0.254 |
| 2003 | 0.05 | 0.019 | 0.128 | 0.139 | 0.116 | 0.062 | 0.3 | 0.3 | 0.257 | 0.244 | 0.257 | 0.257 |
| 2004 | 0.096 | 0.003 | 0.19 | 0.165 | 0.167 | 0.074 | 0.044 | 0.273 | 0.221 | 0.298 | 0.195 | 0.195 |
| 2005 | 0.089 | 0.002 | 0.025 | 0.163 | 0.292 | 0.187 | 0.077 | 0.044 | 0.475 | 0.311 | 0.331 | 0.331 |
| 2006 | 0.064 | 0.005 | 0.031 | 0.046 | 0.426 | 0.338 | 0.207 | 0.077 | 0.04 | 0.4 | 0.364 | 0.364 |

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FL_TT_NW
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Selectivities by age
Year       3      4      5      6
----    -----  -----  -----  -----
1986    1.000  0.025  0.087  0.800
1987    1.000  0.525  0.579  0.321
1988    0.626  0.784  1.000  0.151
1989    0.535  0.802  1.000  0.041
1990    1.000  0.481  0.211  0.417
1991    0.637  0.884  1.000  0.649
1992    1.000  0.354  0.270  0.804
1993    1.000  0.829  0.597  0.628
1994    0.799  1.000  0.929  0.712
1995    0.382  1.000  0.746  0.982
1996    1.000  0.678  0.711  0.772
1997    0.935  1.000  0.861  0.639
```

| | | | | |
|---|---|---|---|---|
| 1998 | 1.000 | 0.509 | 0.529 | 0.463 |
| 1999 | 0.514 | 1.000 | 0.741 | 0.534 |
| 2000 | 0.463 | 0.982 | 1.000 | 0.343 |
| 2001 | 0.209 | 0.736 | 1.000 | 0.921 |
| 2002 | 0.297 | 0.215 | 0.740 | 1.000 |
| 2003 | 0.598 | 0.428 | 0.241 | 1.000 |
| 2004 | 1.000 | 0.733 | 0.385 | 0.297 |
| 2005 | 0.719 | 1.000 | 0.700 | 0.272 |
| 2006 | 0.121 | 0.683 | 1.000 | 0.794 |

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FL_TT_SW
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Selectivities by age

| Year | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|
| 1986 | 0.202 | 0.224 | 0.533 | 1.000 | 0.029 | 0.084 |
| 1987 | 0.696 | 0.627 | 0.524 | 0.962 | 1.000 | 0.071 |
| 1988 | 0.004 | 0.190 | 1.000 | 0.110 | 0.048 | 0.099 |
| 1989 | 0.194 | 0.300 | 0.279 | 1.000 | 0.056 | 0.154 |
| 1990 | 0.163 | 1.000 | 0.104 | 0.469 | 0.235 | 0.027 |
| 1991 | 0.549 | 0.797 | 1.000 | 0.671 | 0.495 | 0.298 |
| 1992 | 0.738 | 0.383 | 0.298 | 1.000 | 0.266 | 0.784 |
| 1993 | 0.552 | 0.577 | 0.441 | 0.384 | 1.000 | 0.326 |
| 1994 | 0.475 | 0.490 | 0.286 | 0.163 | 0.060 | 1.000 |
| 1995 | 0.669 | 1.000 | 0.542 | 0.496 | 0.332 | 0.352 |
| 1996 | 1.000 | 0.571 | 0.452 | 0.466 | 0.310 | 0.117 |
| 1997 | 1.000 | 0.882 | 0.635 | 0.493 | 0.587 | 0.430 |
| 1998 | 1.000 | 0.477 | 0.493 | 0.377 | 0.456 | 0.450 |
| 1999 | 0.463 | 1.000 | 0.822 | 0.535 | 0.580 | 0.852 |
| 2000 | 0.568 | 1.000 | 0.658 | 0.229 | 0.393 | 0.272 |
| 2001 | 0.231 | 0.756 | 1.000 | 0.845 | 0.782 | 0.659 |
| 2002 | 0.270 | 0.200 | 0.674 | 0.844 | 1.000 | 0.856 |
| 2003 | 0.299 | 0.239 | 0.159 | 0.677 | 0.708 | 1.000 |
| 2004 | 0.843 | 0.604 | 0.289 | 0.226 | 1.000 | 0.797 |
| 2005 | 0.555 | 0.842 | 0.576 | 0.220 | 0.196 | 1.000 |
| 2006 | 0.135 | 0.721 | 1.000 | 0.617 | 0.224 | 0.134 |

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MRFSS
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Selectivities by age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| 1981 | 0.042 | 0.229 | 1.000 | 0.419 | 0.211 | 0.201 | 0.136 |
| 1982 | 0.234 | 0.733 | 1.000 | 0.356 | 0.168 | 0.158 | 0.001 |
| 1983 | 0.650 | 1.000 | 0.110 | 0.217 | 0.114 | 0.015 | 0.027 |
| 1984 | 0.012 | 0.096 | 1.000 | 0.232 | 0.096 | 0.071 | 0.126 |
| 1985 | 0.857 | 0.764 | 0.282 | 0.763 | 1.000 | 0.681 | 0.112 |
| 1986 | 0.346 | 1.000 | 0.114 | 0.184 | 0.614 | 0.281 | 0.038 |
| 1987 | 0.597 | 1.000 | 0.486 | 0.317 | 0.313 | 0.346 | 0.097 |
| 1988 | 0.083 | 0.142 | 0.611 | 1.000 | 0.126 | 0.448 | 0.725 |
| 1989 | 0.614 | 1.000 | 0.388 | 0.835 | 0.270 | 0.084 | 0.120 |
| 1990 | 0.288 | 1.000 | 0.945 | 0.253 | 0.175 | 0.485 | 0.169 |
| 1991 | 1.000 | 0.455 | 0.553 | 0.491 | 0.297 | 0.306 | 0.333 |
| 1992 | 1.000 | 0.815 | 0.601 | 0.671 | 0.999 | 0.744 | 0.718 |
| 1993 | 0.545 | 0.593 | 0.520 | 0.441 | 0.393 | 1.000 | 0.365 |
| 1994 | 0.168 | 0.213 | 0.246 | 0.273 | 0.158 | 0.114 | 1.000 |
| 1995 | 0.483 | 0.575 | 1.000 | 0.765 | 0.929 | 0.781 | 0.832 |
| 1996 | 0.739 | 0.773 | 0.747 | 0.952 | 0.841 | 0.775 | 1.000 |
| 1997 | 0.845 | 1.000 | 0.931 | 0.915 | 0.757 | 0.796 | 0.796 |
| 1998 | 0.496 | 1.000 | 0.878 | 0.883 | 0.881 | 0.891 | 0.897 |
| 1999 | 0.500 | 0.661 | 1.000 | 0.771 | 0.449 | 0.600 | 0.764 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2000 | 0.231 | 0.765 | 1.000 | 0.718 | 0.291 | 0.495 | 0.275 |
| 2001 | 0.278 | 0.365 | 0.893 | 1.000 | 0.868 | 0.889 | 0.984 |
| 2002 | 0.819 | 0.374 | 0.212 | 0.813 | 0.970 | 0.862 | 1.000 |
| 2003 | 0.635 | 0.510 | 0.353 | 0.196 | 0.912 | 0.883 | 1.000 |
| 2004 | 0.748 | 0.530 | 0.434 | 0.221 | 0.153 | 1.000 | 0.813 |
| 2005 | 0.085 | 0.333 | 0.394 | 0.331 | 0.158 | 0.101 | 1.000 |
| 2006 | 0.151 | 0.156 | 0.908 | 1.000 | 0.640 | 0.288 | 0.164 |

--------------------
TX_PWD
--------------------
Selectivities by age

| Year | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| 1986 | 0.002 | 0.042 | 0.085 | 0.402 | 1.000 | 0.588 | 0.556 |
| 1987 | 0.009 | 0.042 | 0.749 | 0.376 | 1.000 | 0.267 | 0.739 |
| 1988 | 0.002 | 0.045 | 0.343 | 1.000 | 0.246 | 0.406 | 0.690 |
| 1989 | 0.019 | 0.041 | 0.200 | 1.000 | 0.970 | 0.468 | 0.399 |
| 1990 | 0.000 | 0.043 | 0.168 | 0.209 | 0.429 | 1.000 | 0.014 |
| 1991 | 0.007 | 0.020 | 0.571 | 1.000 | 0.117 | 0.842 | 0.154 |
| 1992 | 0.031 | 0.047 | 0.081 | 1.000 | 0.056 | 0.266 | 0.033 |
| 1993 | 0.006 | 0.015 | 0.331 | 0.631 | 1.000 | 0.864 | 0.484 |
| 1994 | 0.037 | 0.128 | 0.875 | 0.372 | 1.000 | 0.813 | 0.059 |
| 1995 | 0.359 | 0.614 | 1.000 | 0.685 | 0.814 | 0.556 | 0.590 |
| 1996 | 0.382 | 0.655 | 0.791 | 1.000 | 0.814 | 0.786 | 0.585 |
| 1997 | 0.226 | 0.641 | 0.772 | 0.990 | 0.900 | 0.856 | 1.000 |
| 1998 | 0.189 | 0.733 | 0.640 | 0.801 | 0.863 | 1.000 | 0.975 |
| 1999 | 0.103 | 0.397 | 0.952 | 0.940 | 0.609 | 0.869 | 1.000 |
| 2000 | 0.048 | 0.308 | 0.772 | 1.000 | 0.497 | 0.562 | 0.483 |
| 2001 | 0.076 | 0.151 | 0.701 | 0.911 | 0.823 | 1.000 | 0.922 |

--------------------
HeadBoat
--------------------
Selectivities by age

| Year | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 1981 | 0.335 | 0.480 | 0.372 | 1.000 | 0.155 |
| 1982 | 0.382 | 0.450 | 1.000 | 0.925 | 0.198 |
| 1983 | 0.252 | 0.256 | 0.475 | 1.000 | 0.082 |
| 1984 | 0.266 | 0.324 | 0.667 | 1.000 | 0.155 |
| 1985 | 0.296 | 0.182 | 0.359 | 1.000 | 0.099 |
| 1986 | 1.000 | 0.651 | 0.158 | 0.407 | 0.368 |
| 1987 | 0.145 | 1.000 | 0.261 | 0.285 | 0.167 |
| 1988 | 0.259 | 0.331 | 0.648 | 1.000 | 0.124 |
| 1989 | 0.845 | 1.000 | 0.095 | 0.297 | 0.519 |
| 1990 | 0.160 | 0.964 | 1.000 | 0.093 | 0.077 |
| 1991 | 1.000 | 0.580 | 0.578 | 0.435 | 0.327 |
| 1992 | 0.390 | 0.821 | 1.000 | 0.112 | 0.562 |
| 1993 | 0.529 | 1.000 | 0.692 | 0.384 | 0.408 |
| 1994 | 0.261 | 1.000 | 0.702 | 0.248 | 0.224 |
| 1995 | 0.833 | 1.000 | 0.670 | 0.269 | 0.311 |
| 1996 | 0.994 | 1.000 | 0.900 | 0.777 | 0.630 |
| 1997 | 1.000 | 0.634 | 0.318 | 0.217 | 0.151 |
| 1998 | 0.763 | 1.000 | 0.856 | 0.618 | 0.471 |
| 1999 | 1.000 | 0.924 | 0.957 | 0.682 | 0.323 |
| 2000 | 0.289 | 1.000 | 0.857 | 0.558 | 0.279 |
| 2001 | 0.235 | 0.294 | 0.968 | 1.000 | 0.804 |
| 2002 | 1.000 | 0.331 | 0.166 | 0.686 | 0.650 |
| 2003 | 1.000 | 0.584 | 0.261 | 0.103 | 0.583 |
| 2004 | 1.000 | 0.373 | 0.323 | 0.135 | 0.066 |
| 2005 | 0.374 | 1.000 | 0.600 | 0.466 | 0.139 |
| 2006 | 0.144 | 0.143 | 1.000 | 0.567 | 0.268 |

```
--------------------
Charter_FL_NW
--------------------
Selectivities by age
Year       2     3     4     5     6
----     ----- ----- ----- ----- -----
1988     0.074 0.167 0.826 1.000 0.136
1989     0.816 0.889 0.456 1.000 0.188
1990     0.625 1.000 0.474 0.392 0.286
1991     1.000 0.419 0.488 0.419 0.213
1992     1.000 0.657 0.342 0.271 0.381
1993     1.000 0.844 0.637 0.435 0.452
1994     1.000 0.797 0.812 0.617 0.469
1995     0.823 1.000 0.593 0.223 0.278

--------------------
Charter_FL_SW
--------------------
Selectivities by age
Year       3     4     5     6     7     8
----     ----- ----- ----- ----- ----- -----
1988     0.580 0.856 0.694 0.079 0.952 1.000
1989     1.000 0.461 0.847 0.344 0.037 0.223
1990     0.304 0.454 0.370 0.780 1.000 0.937
1991     0.370 0.496 0.213 0.489 0.495 1.000
1992     0.227 0.404 0.665 1.000 0.280 0.333
1993     0.147 0.243 0.446 0.441 1.000 0.186
1994     0.071 0.116 0.367 0.115 0.236 1.000
```

### 3.1.2.6. *Fishing Mortality*

Annual trends in fishing mortality are illustrated using $F_{current}$, which is defined as the maximum F-at-age in a given year that results from a 3-year geometric mean of the age-specific values that end in that year (thus $F_{current}$ for 2000 is a running average for 1998, 1999 and 2000). In the Atlantic, the SEDAR 5 and continuity run estimates of $F_{current}$ are similar in magnitude and trend until the early 1990s and tend to differ thereafter (**Figure 3.6**). The continuity run generally produced lower estimates of $F_{current}$. In the Gulf, the SEDAR 5 and continuity run estimates of apical F are similar until 1993 and tend to differ thereafter. The estimates produced by the continuity run tend to be larger than the estimates from SEDAR 5.

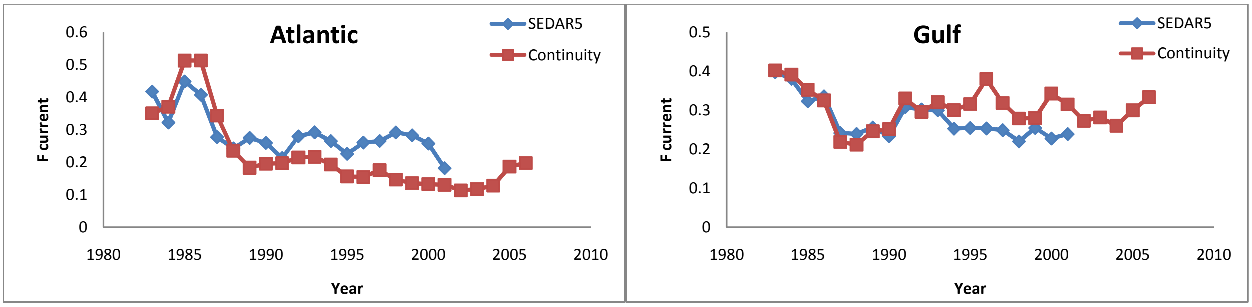



**Figure 3.6.** Comparison of fishing mortality estimates from the SEDAR 5 F-ADAPT model and the VPA-2BOX continuity run. Fcurrent is calculated from 3-year running averages.

### 3.1.2.7. *Stock-Recruitment Parameters*

There were no obvious spawner-recruit relationships for king mackerel in the Gulf or Atlantic (**Figure 3.7**), therefore it was necessary to assume a fixed S-R relationship for the calculation of management benchmarks and reference points. SEDAR 5 used a two-line (hockey-stick) S-R function constructed using data from years where recruitment and spawning stock were observed (for the continuity cases, Atl: 1989-2004 and Gulf: 1981-2004). By convention, the last two years were not used because they are estimated with high uncertainty by backwards recursive models such as VPA-2BOX. $R_{MAX}$ was set equal to the average recruitment during the years included. The SSB hinge was fixed at the mean of the five lowest observed SSB estimates in the Gulf (As per SEDAR 5). However, in the Atlantic, it was not possible to fix the SSB hinge using the SEDAR 5 logic because the resulting estimate of $F_{SPR30}$ (the proxy for $F_{MSY}$) was not estimable because it resulted in a replacement line (the inverse of the equilibrium SSB/R resulting from $F_{30\%}$) that did not intersect the expected stock-recruitment relationship. That is, $F_{30\%}$ would be unsustainable according to the two-line stock-recruitment relationship that was assumed. Therefore, for the sake of comparison with SEDAR5, a constant recruitment (equal to the mean of the included observation) was used instead. The values used for calculation of management benchmarks are summarized in **Table 3.17**.

**Table 3.17.** Stock recruitment parameters for the continuity cases.

| Region | Type | $R_{MAX}$ (Age-1) | SSB Hinge (millions of eggs) |
|---|---|---|---|
| ATL | Constant R | 2.098E+06 | 0 |
| GULF | Two line segments | 4.336E+06 | 3693.2 |

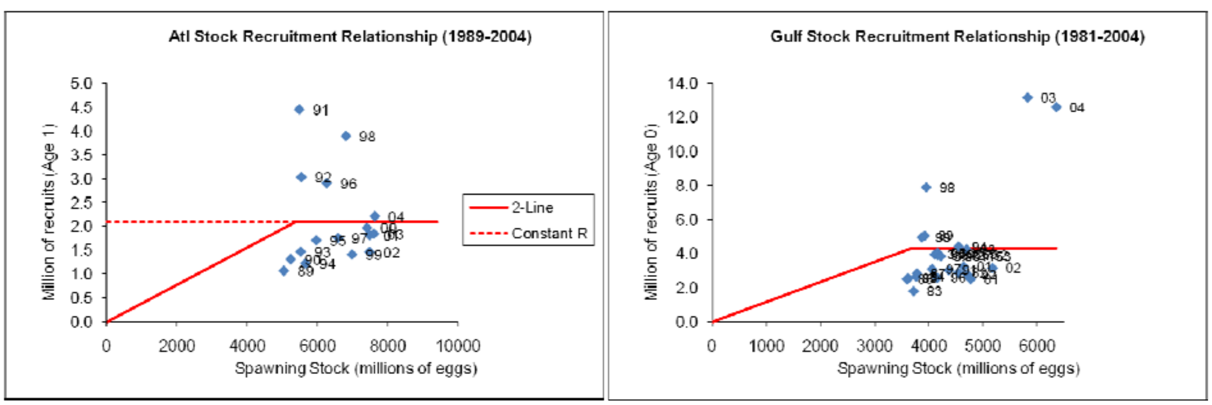



**Figure 3.7.** S-R functions fit to the results of the continuity cases. The solid line is the 2-line function fit to the data and used in the Gulf. The dashed line is the constant recruitment assumption used in the Atlantic.

### 3.1.2.8. *Evaluation of Uncertainty*

Because the continuity cases are intended to be used for management advice, no evaluations of uncertainty were completed.

### 3.1.2.9. *Benchmarks / Reference Points / ABC values*

Benchmarks and reference points are shown in **Table 3.18**.

**Table 3.18.** Management benchmarks and reference points for the continuity runs (See **Table 3.12** for an explanation of how different benchmarks were measured).

| | South Atlantic | Gulf of Mexico |
|---|---|---|
| MSST | 3833. | 6002. |
| MFMT | 0.35 | 0.29 |
| MSY (lbs) | 7.03E+06 | 1.27E+07 |
| $F_{MSY}$ | 0.35 | 0.29 |
| OY (lbs) | 6.19E+06 | 1.08E+07 |
| $F_{OY}$ | 0.21 | 0.25 |
| F 2006 | 0.27 | 0.43 |
| SSB 2006 | 7027. | 8976. |
| F 2006 / MFMT | 0.79 | 1.46 |
| SSB 2006 / MSST | 1.83 | 1.50 |

Under the continuity model, both South Atlantic and Gulf king mackerel stocks are not judged to be overfished at the beginning of the 2005/06 fishing year. Estimated fishing mortality rates during 2005/06 exceeded the maximum fishing mortality threshold in the Gulf but were below this level in the South Atlantic.

## 3.2. *MODEL 2 – BASE VPA*

### 3.2.1. Methods

### 3.2.1.1. *Overview*

The base VPA runs are intended to use all the data treatments and modeling choices agreed to by the SEDAR16 Assessment Workshop during its meeting in Miami and in subsequent conference calls and electronic mail exchanges. The VPA documentation evolved as different model and data choices were made by the Assessment Workshop Panel, sometimes based on the findings by the authors. This document (RW-01) reflects the final choices made before the Review Workshop. Readers interested in documentation of interim model runs can consult earlier versions of the document which are available from SEDAR as AW-06 (4 May), AW-10 (27 May), AW-11 (10 June) and AW-12 (27 June).

The base runs differ from the "Continuity Cases" in that they: 1) use the "50/50 mixing zone assumption" (i.e., that 50% of the fish caught in the mixing zone during Winter belong to the Gulf group and 50% to the Atlantic group); 2) include Age-0 in the Atlantic models; 3) estimate certain terminal-F (fishing mortality) parameters that had previously been fixed; 4) include updated life history information and catch-at-age information developed for, and recommended by the SEDAR 16 data workshop panel; 5) use a different method to estimate index selectivity by age from partial catches (Butterworth and Geromont, 1999); and, 6) use a different weighting scheme for the indices. Like the "Continuity Cases", the Base Runs used the software program VPA-2BOX ver. 3.0.5.

In an earlier version of this document (AW-12), VPA base runs were made with and without the application of a "recruitment patch" (replacing the 2005 and 2006 recruitments with values from the S-R relationship, and recalculating stocks sizes and F values for age 0 in 2005-2006 and age 2 in 2006 based on the input catch values). Subsequent review through correspondence by the AW Panel revealed that the use of the recruitment patch could result in unexpected and illogical results. The results in this document are presented without the recruitment patch.

#### 3.2.1.2. *Data Sources*

The general model structure and settings are discussed in **Table 3.19**.

**Table 3.19.** Model settings and inputs used to construct the VPA base runs.

| Settings/Input Series | VPA-2BOX Base Runs |
|---|---|
| Stock Definitions | Catches and indices calculated according to the 50:50 mixing zone assumption:<br>**ATL stock** - US Atlantic north of Volusia County, FL during Nov – Mar, and Monroe County FL and northward during Apr– Oct.<br>**GOM stock** - US Gulf of Mexico from Texas to Collier County, FL during Apr - Oct and to Volusia County, FL during Nov- Mar. |
| Fishing Year | Like SEDAR5, catch and Indices estimated using "fishing year" definitions. |
| Directed Landings/Discards | Used updated SEDAR 16 landings estimates. For the recreational sector, used SEDAR 16 landings, discards and release mortality estimates. As per SEDAR 16 recommendation, commercial discards were assumed to be negligible. Data for the base case VPA were prepared starting in 1981. |
| Shrimp Bycatch | Used Delta Lognormal Shrimp Bycatch estimates (SEDAR16-AW-07 for the Gulf and SEDAR16-DW-05 for the Atlantic) |
| Catch-at-age | For estimation of the CAA: updated growth von Bertalanffy parameters (SEDAR16-DW-12) by sex and stock using observations collected outside of the MIX area. CAS 2001-2006 updated, sex at size ratios updated from 1985 through 2006. ALK constructed by semester and used from 1984 to 2006, SAR only for 1981-84 years. recreational CAA adjusted to meet SEDAR 16 recommendations. |
| Weight-at-Age | Updated vector of weight at age estimated from the age samples and the updated weight-at-size relationship by sex and stock from samples from non-mixing areas. |
| Indices of Abundance | Used indices consistent with the "updated" approached recommended by SEDAR 16 for SS3 and other updated model runs. |
| Natural Mortality | Used Lorenzen M vector developed at SEDAR16 DW and AW workshops. |
| Terminal Year F-at-age | Estimating all Terminal F's for ages 0-11+ (GOM) and 1-11+ (ATL) with fixed ratio for last age class all years of 1 and using maximum likelihood estimation with lognormal error distribution for index variances. |
| Annual F-Ratio | Like SEDAR5, for each year $F_{10}$ : $F_{11+}$ was fixed at 1.0. This implies that the fishing mortality rate on the plus group is equal to the fishing mortality rate on age 10. |

The maturity series used for the VPA base runs was unchanged from the values reported in **Table 3.2**. However, the SEDAR16 DW and AW working groups constructed a new natural mortality function (Lorenzen, 1996) that varied with age and an updated fecundity-at-age vector. These biological functions are summarized in **Table 3.20**. Also, revised weight-at-age matrices were developed in five-year blocks (**Tables 3.21 and 3.22**). These weights at age are used to predict biomass in the VPA model in order to fit the indices that are calculated in weight.

**Table 3.20.** Biological functions used for VPA base runs.

| | Proportion Mature | | Fecundity (millions of female eggs) | | Natural Mortality | |
|---|---|---|---|---|---|---|
| Age | Atlantic | Gulf | Atlantic | Gulf | Atlantic | Gulf |
| 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.672 | 0.765 |
| 1 | 0.548 | 0.157 | 0.130 | 0.155 | 0.256 | 0.274 |
| 2 | 0.861 | 0.529 | 0.250 | 0.267 | 0.220 | 0.243 |
| 3 | 0.924 | 0.704 | 0.388 | 0.395 | 0.199 | 0.222 |
| 4 | 0.948 | 0.856 | 0.528 | 0.531 | 0.186 | 0.207 |
| 5 | 0.970 | 0.989 | 0.662 | 0.669 | 0.176 | 0.196 |
| 6 | 0.989 | 1.000 | 0.783 | 0.801 | 0.170 | 0.188 |
| 7 | 1.000 | 1.000 | 0.890 | 0.926 | 0.165 | 0.182 |
| 8 | 1.000 | 1.000 | 0.981 | 1.041 | 0.161 | 0.177 |
| 9 | 1.000 | 1.000 | 1.058 | 1.145 | 0.158 | 0.173 |
| 10 | 1.000 | 1.000 | 1.123 | 1.238 | 0.156 | 0.170 |
| 11+ | 1.000 | 1.000 | 1.288 | 1.524 | 0.152 | 0.162 |

**Table 3.21.** Weight-at-age (whole, kg) matrix used the Atlantic base run.

| Year | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.240 | 1.508 | 2.863 | 3.872 | 4.836 | 5.805 | 6.908 | 7.760 | 8.552 | 9.318 | 9.719 | 11.400 |
| 1982 | 0.240 | 1.508 | 2.863 | 3.872 | 4.836 | 5.805 | 6.908 | 7.760 | 8.552 | 9.318 | 9.719 | 11.400 |
| 1983 | 0.240 | 1.508 | 2.863 | 3.872 | 4.836 | 5.805 | 6.908 | 7.760 | 8.552 | 9.318 | 9.719 | 11.400 |
| 1984 | 0.240 | 1.508 | 2.863 | 3.872 | 4.836 | 5.805 | 6.908 | 7.760 | 8.552 | 9.318 | 9.719 | 11.400 |
| 1985 | 0.240 | 1.508 | 2.863 | 3.872 | 4.836 | 5.805 | 6.908 | 7.760 | 8.552 | 9.318 | 9.719 | 11.400 |
| 1986 | 0.240 | 1.195 | 2.491 | 3.542 | 4.215 | 5.011 | 5.809 | 6.788 | 7.407 | 8.140 | 7.860 | 10.197 |
| 1987 | 0.240 | 1.195 | 2.491 | 3.542 | 4.215 | 5.011 | 5.809 | 6.788 | 7.407 | 8.140 | 7.860 | 10.197 |
| 1988 | 0.240 | 1.195 | 2.491 | 3.542 | 4.215 | 5.011 | 5.809 | 6.788 | 7.407 | 8.140 | 7.860 | 10.197 |
| 1989 | 0.240 | 1.195 | 2.491 | 3.542 | 4.215 | 5.011 | 5.809 | 6.788 | 7.407 | 8.140 | 7.860 | 10.197 |
| 1990 | 0.240 | 1.195 | 2.491 | 3.542 | 4.215 | 5.011 | 5.809 | 6.788 | 7.407 | 8.140 | 7.860 | 10.197 |
| 1991 | 0.240 | 1.741 | 2.842 | 3.608 | 4.486 | 5.199 | 6.199 | 6.933 | 7.540 | 8.419 | 9.128 | 11.029 |
| 1992 | 0.240 | 1.741 | 2.842 | 3.608 | 4.486 | 5.199 | 6.199 | 6.933 | 7.540 | 8.419 | 9.128 | 11.029 |
| 1993 | 0.240 | 1.741 | 2.842 | 3.608 | 4.486 | 5.199 | 6.199 | 6.933 | 7.540 | 8.419 | 9.128 | 11.029 |
| 1994 | 0.240 | 1.741 | 2.842 | 3.608 | 4.486 | 5.199 | 6.199 | 6.933 | 7.540 | 8.419 | 9.128 | 11.029 |
| 1995 | 0.240 | 1.741 | 2.842 | 3.608 | 4.486 | 5.199 | 6.199 | 6.933 | 7.540 | 8.419 | 9.128 | 11.029 |
| 1996 | 0.240 | 1.545 | 2.990 | 4.159 | 5.293 | 6.310 | 7.448 | 7.781 | 8.798 | 9.067 | 10.243 | 12.376 |
| 1997 | 0.240 | 1.545 | 2.990 | 4.159 | 5.293 | 6.310 | 7.448 | 7.781 | 8.798 | 9.067 | 10.243 | 12.376 |
| 1998 | 0.240 | 1.545 | 2.990 | 4.159 | 5.293 | 6.310 | 7.448 | 7.781 | 8.798 | 9.067 | 10.243 | 12.376 |
| 1999 | 0.240 | 1.545 | 2.990 | 4.159 | 5.293 | 6.310 | 7.448 | 7.781 | 8.798 | 9.067 | 10.243 | 12.376 |
| 2000 | 0.240 | 1.545 | 2.990 | 4.159 | 5.293 | 6.310 | 7.448 | 7.781 | 8.798 | 9.067 | 10.243 | 12.376 |
| 2001 | 0.240 | 2.043 | 3.073 | 4.123 | 5.056 | 6.133 | 7.391 | 8.482 | 9.465 | 10.988 | 11.776 | 12.432 |
| 2002 | 0.240 | 2.043 | 3.073 | 4.123 | 5.056 | 6.133 | 7.391 | 8.482 | 9.465 | 10.988 | 11.776 | 12.432 |
| 2003 | 0.240 | 2.043 | 3.073 | 4.123 | 5.056 | 6.133 | 7.391 | 8.482 | 9.465 | 10.988 | 11.776 | 12.432 |
| 2004 | 0.240 | 2.043 | 3.073 | 4.123 | 5.056 | 6.133 | 7.391 | 8.482 | 9.465 | 10.988 | 11.776 | 12.432 |
| 2005 | 0.240 | 2.043 | 3.073 | 4.123 | 5.056 | 6.133 | 7.391 | 8.482 | 9.465 | 10.988 | 11.776 | 12.432 |
| 2006 | 0.240 | 1.508 | 2.863 | 3.872 | 4.836 | 5.805 | 6.908 | 7.760 | 8.552 | 9.318 | 9.719 | 11.400 |

**Table 3.22.** Weight-at-age (whole, kg) matrix used the Gulf base run.

| Year | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1982 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1983 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1984 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1985 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1986 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1987 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1988 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1989 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1990 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1991 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1992 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1993 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1994 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1995 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1996 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 1997 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 1998 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 1999 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 2000 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 2001 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2002 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2003 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2004 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2005 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2006 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |

VPA models assume that the catch-at-age matrix is known without error. As per the recommendation of the SEDAR16-AW panel, the catch-at-age matrices for the base VPA runs were constructed using a 50/50 mixing assumption which is defined as follows: 50% of the catch in the mixing zone in winter is of Atlantic origin, and 50% is of Gulf (**Tables 3.23. and 3.24**.)

**Table 3.23.** Catch-at-age (in numbers) for Atlantic base run. Includes dead recreational discards and shrimp bycatch.

| YEAR | AGE 0 | AGE 1 | AGE 2 | AGE 3 | AGE 4 | AGE 5 | AGE 6 | AGE 7 | AGE 8 | AGE 9 | AGE 10 | AGE 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 1572 | 40929 | 91967 | 490431 | 359065 | 159937 | 74445 | 17525 | 5139 | 2523 | 8351 | 15507 |
| 1982 | 34897 | 88275 | 56220 | 274298 | 393903 | 170238 | 67469 | 35987 | 12792 | 8784 | 30446 | 15783 |
| 1983 | 64856 | 246550 | 184379 | 234067 | 223375 | 119537 | 98117 | 17377 | 4571 | 1227 | 4499 | 32315 |
| 1984 | 60338 | 60613 | 33887 | 256122 | 252638 | 141253 | 96851 | 21031 | 2201 | 3595 | 32413 | 21815 |
| 1985 | 231157 | 69218 | 134553 | 167574 | 339599 | 206094 | 62100 | 19329 | 8846 | 6264 | 1005 | 16881 |
| 1986 | 1104 | 146195 | 286293 | 109075 | 190402 | 79391 | 58391 | 164003 | 34869 | 26607 | 27512 | 107085 |
| 1987 | 171 | 231329 | 209536 | 129585 | 89162 | 74306 | 67981 | 24842 | 80380 | 26685 | 9274 | 88328 |
| 1988 | 1297 | 21962 | 188306 | 270771 | 164366 | 47696 | 65171 | 62119 | 24525 | 82888 | 33379 | 124594 |
| 1989 | 23385 | 75982 | 100318 | 133043 | 129372 | 96741 | 64271 | 35773 | 31147 | 19153 | 65577 | 81245 |
| 1990 | 64146 | 166880 | 159263 | 98464 | 116713 | 98292 | 76958 | 34233 | 24323 | 30616 | 18295 | 95344 |
| 1991 | 25794 | 80550 | 361441 | 177752 | 93595 | 110514 | 114830 | 74359 | 49365 | 26212 | 16445 | 117714 |
| 1992 | 30063 | 41815 | 253265 | 380636 | 128437 | 83442 | 71408 | 75354 | 40497 | 25788 | 27152 | 102669 |
| 1993 | 21126 | 52521 | 75676 | 136504 | 147432 | 52545 | 37639 | 51894 | 60011 | 31136 | 20799 | 73749 |
| 1994 | 21055 | 59638 | 153657 | 83169 | 125439 | 128624 | 66221 | 30227 | 31045 | 39588 | 23865 | 48206 |
| 1995 | 40218 | 99525 | 183651 | 119362 | 85999 | 84583 | 125129 | 35526 | 29555 | 40281 | 34799 | 46256 |
| 1996 | 59534 | 66640 | 294068 | 157862 | 115708 | 66849 | 63368 | 95816 | 38594 | 23052 | 14197 | 45940 |
| 1997 | 15744 | 104769 | 280669 | 213815 | 124525 | 70935 | 48347 | 76698 | 80212 | 29690 | 11409 | 60274 |
| 1998 | 49479 | 31780 | 199182 | 240440 | 189582 | 92523 | 48052 | 29688 | 53866 | 57817 | 11148 | 37572 |
| 1999 | 32003 | 72939 | 132038 | 147317 | 169187 | 91638 | 43558 | 23088 | 17142 | 27102 | 24154 | 22189 |
| 2000 | 18381 | 17903 | 290034 | 146032 | 190138 | 112784 | 52595 | 21983 | 10509 | 13741 | 29812 | 48845 |
| 2001 | 7198 | 15128 | 81772 | 156970 | 117431 | 118936 | 89889 | 39866 | 11708 | 9313 | 8271 | 56460 |
| 2002 | 9125 | 58265 | 161012 | 103825 | 153478 | 69882 | 67433 | 37264 | 25372 | 9855 | 7550 | 27818 |
| 2003 | 15383 | 20473 | 214880 | 100530 | 107549 | 143371 | 57461 | 70612 | 37710 | 15067 | 7261 | 25253 |
| 2004 | 8185 | 50864 | 203405 | 203403 | 82847 | 84076 | 115092 | 35461 | 46820 | 22129 | 11820 | 20683 |
| 2005 | 7238 | 13391 | 321102 | 154233 | 139996 | 49147 | 40745 | 52422 | 19125 | 26862 | 10199 | 19198 |
| 2006 | 13120 | 15867 | 171738 | 302804 | 130615 | 152466 | 28085 | 25701 | 46692 | 6846 | 12034 | 39181 |

**Table 3.24.** Catch-at-age (in numbers) for Gulf base run. Includes dead recreational discards and shrimp bycatch.

| YEAR | AGE 0 | AGE 1 | AGE 2 | AGE 3 | AGE 4 | AGE 5 | AGE 6 | AGE 7 | AGE 8 | AGE 9 | AGE 10 | AGE 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 563558 | 16502 | 32123 | 216871 | 193314 | 48635 | 27492 | 21808 | 9186 | 3956 | 4478 | 14377 |
| 1982 | 243454 | 54716 | 180776 | 153648 | 207284 | 149504 | 65765 | 17918 | 17540 | 20438 | 6619 | 175346 |
| 1983 | 476064 | 91748 | 189468 | 105003 | 26340 | 44481 | 30319 | 6440 | 9090 | 4724 | 1493 | 16195 |
| 1984 | 1508666 | 20567 | 57951 | 220927 | 127844 | 36116 | 49028 | 25614 | 4755 | 918 | 1861 | 17130 |
| 1985 | 732206 | 23940 | 56050 | 94130 | 72300 | 83910 | 31470 | 12844 | 18712 | 4959 | 1902 | 17167 |
| 1986 | 815006 | 36703 | 209494 | 80517 | 34943 | 54577 | 39512 | 12383 | 2971 | 6846 | 575 | 14812 |
| 1987 | 1477266 | 99255 | 77574 | 32265 | 25616 | 29870 | 16917 | 8010 | 4597 | 3468 | 2208 | 6704 |
| 1988 | 1695068 | 46813 | 97259 | 88300 | 64139 | 31361 | 68867 | 29739 | 6050 | 13561 | 13274 | 33536 |
| 1989 | 2743625 | 122445 | 163030 | 81732 | 70834 | 52482 | 12200 | 22971 | 10889 | 4445 | 6203 | 16935 |
| 1990 | 2093282 | 104655 | 163800 | 105030 | 73158 | 35254 | 37946 | 7373 | 18872 | 8489 | 1626 | 18612 |
| 1991 | 2019187 | 182252 | 240676 | 127600 | 70578 | 39801 | 27502 | 12904 | 4475 | 19490 | 5126 | 12161 |
| 1992 | 1466838 | 65491 | 200838 | 182078 | 103020 | 54354 | 47024 | 21010 | 34006 | 9313 | 16888 | 24785 |
| 1993 | 2812413 | 60138 | 146028 | 151588 | 134914 | 62068 | 36287 | 25513 | 24429 | 13000 | 1661 | 34235 |
| 1994 | 3138105 | 126336 | 154850 | 124591 | 162044 | 117838 | 68954 | 41251 | 24627 | 19865 | 39629 | 33969 |
| 1995 | 2742216 | 47871 | 174393 | 162710 | 103136 | 64878 | 67180 | 31299 | 17621 | 7851 | 10630 | 16723 |
| 1996 | 1376113 | 87094 | 242333 | 156665 | 86928 | 53091 | 35928 | 35028 | 27723 | 12873 | 2794 | 41110 |
| 1997 | 1348322 | 54227 | 153386 | 203561 | 103652 | 71213 | 45217 | 45932 | 29291 | 21473 | 8579 | 28477 |
| 1998 | 1193085 | 58339 | 118231 | 153169 | 168698 | 71258 | 39946 | 24472 | 17403 | 20184 | 9092 | 7159 |
| 1999 | 1210741 | 45716 | 127966 | 94029 | 116636 | 88794 | 28844 | 27385 | 19486 | 22445 | 3109 | 11011 |
| 2000 | 1078106 | 64037 | 134236 | 175846 | 98004 | 63813 | 28820 | 33574 | 8830 | 14003 | 10681 | 17482 |
| 2001 | 772155 | 48512 | 145760 | 146855 | 117572 | 69132 | 47701 | 42979 | 25854 | 7766 | 6992 | 28300 |
| 2002 | 641205 | 70633 | 204402 | 130239 | 112020 | 73224 | 39778 | 30365 | 30256 | 15391 | 7387 | 21823 |
| 2003 | 1542801 | 27247 | 151935 | 158851 | 96919 | 67925 | 58810 | 25398 | 25196 | 17727 | 15759 | 17722 |
| 2004 | 2888086 | 33563 | 230128 | 129788 | 105691 | 54044 | 42874 | 37388 | 10928 | 22677 | 6758 | 14034 |
| 2005 | 1909290 | 23552 | 164254 | 175586 | 122746 | 76873 | 52471 | 41831 | 29796 | 11442 | 10628 | 27227 |
| 2006 | 923292 | 20093 | 178244 | 203485 | 158511 | 107711 | 58659 | 42905 | 28343 | 16720 | 8995 | 28893 |

The VPA base runs used the same updated indices that were developed for the SEDAR 16 SS3 runs. These are summarized in **Table 3.25 and 3.26**. Index CVs were used to estimate index variance.

**Table. 3.25.** Indices of abundance and index settings used for the Atlantic VPA base run. Indices were rescaled to the series-specific averages of the 1981-2006 time period when necessary for comparative purposes.

| | Trip Ticket - NC PIDs 8+ | | MRFSS-Atl-No-Mix | | HB-Atl-no-Mix | | SEAMAP South Alt. | |
|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. COM | | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Independent | |
| Unit | Weight | | Number | | Number | | Numbers | |
| Likely Applies to Ages | Ages 1-11+ | | Ages 1-11+ | | Ages 1-11+ | | Age 0 Mid-Year | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1981 | | | 1.194 | 0.723 | 1.506 | 0.476 | | |
| 1982 | | | 1.386 | 0.650 | 0.757 | 0.497 | | |
| 1983 | | | 1.396 | 0.671 | 1.236 | 0.387 | | |
| 1984 | | | 1.487 | 0.648 | 0.769 | 0.295 | | |
| 1985 | | | 1.399 | 0.611 | 0.595 | 0.302 | | |
| 1986 | | | 4.424 | 0.532 | 0.734 | 0.235 | | |
| 1987 | | | 1.700 | 0.575 | 0.858 | 0.235 | | |
| 1988 | | | 1.202 | 0.576 | 0.816 | 0.238 | | |
| 1989 | | | 0.962 | 0.565 | | | 0.807 | 0.212 |
| 1990 | | | 0.879 | 0.591 | | | 2.377 | 0.158 |
| 1991 | | | 1.193 | 0.568 | 1.170 | 0.242 | 0.704 | 0.222 |
| 1992 | | | 0.946 | 0.576 | 1.517 | 0.224 | 0.843 | 0.241 |
| 1993 | | | 0.548 | 0.645 | 0.805 | 0.238 | 0.446 | 0.247 |
| 1994 | 0.700 | 0.068 | 0.355 | 0.679 | 0.614 | 0.249 | 0.708 | 0.232 |
| 1995 | 0.744 | 0.073 | 0.399 | 0.681 | 0.617 | 0.232 | 1.226 | 0.198 |
| 1996 | 1.125 | 0.069 | 0.342 | 0.677 | 0.464 | 0.240 | 2.261 | 0.168 |
| 1997 | 1.033 | 0.060 | 1.126 | 0.569 | 1.218 | 0.206 | 0.519 | 0.240 |
| 1998 | 1.056 | 0.060 | 0.544 | 0.617 | 1.243 | 0.209 | 1.786 | 0.200 |
| 1999 | 0.969 | 0.061 | 0.937 | 0.590 | 0.976 | 0.218 | 1.213 | 0.184 |
| 2000 | 0.986 | 0.059 | 0.811 | 0.605 | 1.854 | 0.209 | 0.816 | 0.221 |
| 2001 | 1.044 | 0.057 | 0.407 | 0.660 | 1.288 | 0.213 | 0.448 | 0.234 |
| 2002 | 0.907 | 0.069 | 0.188 | 0.779 | 0.886 | 0.241 | 0.506 | 0.211 |
| 2003 | 0.879 | 0.073 | 0.271 | 0.717 | 0.912 | 0.227 | 0.989 | 0.196 |
| 2004 | 1.292 | 0.058 | 0.462 | 0.649 | 0.896 | 0.223 | 0.619 | 0.357 |
| 2005 | 1.206 | 0.063 | 0.843 | 0.577 | 1.496 | 0.254 | 0.726 | 0.493 |
| 2006 | 1.058 | 0.066 | 0.598 | 0.621 | 1.147 | 0.219 | 1.006 | 0.221 |

**Table. 3.26.** Indices of abundance and index settings used for the Gulf VPA base run. Indices were rescaled to the 1981-2006 time period when necessary. For the SEAMAP Groundfish Survey, values of 0.0 were replaced with the series minimum and the CV was set to the series average (SEDAR16 DW recommendation).

| | Com Logboof Gulf-No Mix | | MRFSS-Gulf-No-Mix | | HB-Gulf-no-Mix | | SEAMAP Fall Groundfish | | SEAMAP Fall Plankton (Larval) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Independent | | Fish. Independent | |
| Unit | Biomass | | Number | | Number | | Numbers | | Numbers | |
| Likely Applies to Ages | Ages 1-11+ | | Ages 1-11+ | | Ages 1-11+ | | Age 0 | | Ages 1 to 11+, using partial selection | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1981 | | | 0.722 | 0.424 | | | ***0.018*** | ***0.600*** | | |
| 1982 | | | 0.467 | 0.407 | | | ***0.018*** | ***0.600*** | | |
| 1983 | | | 0.883 | 0.428 | | | ***0.018*** | ***0.600*** | | |
| 1984 | | | 0.501 | 0.390 | | | 0.101 | 0.911 | | |
| 1985 | | | 0.550 | 0.417 | | | 0.045 | 0.823 | | |
| 1986 | | | 0.451 | 0.338 | 0.677 | 0.184 | 0.085 | 1.080 | 0.116 | 0.534 |
| 1987 | | | 1.077 | 0.303 | 0.699 | 0.175 | 0.018 | 1.482 | 0.379 | 0.322 |
| 1988 | | | 0.710 | 0.324 | 0.809 | 0.194 | 0.122 | 0.527 | 0.613 | 0.437 |
| 1989 | | | 0.923 | 0.332 | 0.799 | 0.186 | 0.101 | 0.702 | 0.845 | 0.326 |
| 1990 | | | 1.292 | 0.318 | 0.558 | 0.170 | 0.162 | 0.409 | 0.648 | 0.321 |
| 1991 | | | 1.263 | 0.301 | 1.371 | 0.156 | 0.063 | 0.565 | 0.721 | 0.318 |
| 1992 | | | 1.002 | 0.293 | 1.234 | 0.153 | 0.096 | 0.559 | 0.596 | 0.237 |
| 1993 | 0.720 | 0.132 | 0.998 | 0.301 | 0.838 | 0.151 | 0.424 | 0.325 | 1.251 | 0.199 |
| 1994 | 0.881 | 0.101 | 1.243 | 0.290 | 1.205 | 0.133 | 0.183 | 0.480 | 1.050 | 0.231 |
| 1995 | 0.990 | 0.093 | 1.115 | 0.305 | 1.295 | 0.134 | 0.108 | 0.641 | 1.979 | 0.195 |
| 1996 | 0.974 | 0.078 | 1.322 | 0.299 | 1.437 | 0.142 | 0.087 | 0.532 | 0.741 | 0.265 |
| 1997 | 1.307 | 0.069 | 1.480 | 0.285 | 1.307 | 0.140 | 0.209 | 0.425 | 1.360 | 0.201 |
| 1998 | 1.288 | 0.068 | 1.083 | 0.286 | 1.084 | 0.145 | 0.224 | 0.413 | | |
| 1999 | 1.118 | 0.065 | 0.922 | 0.281 | 1.286 | 0.150 | 0.177 | 0.396 | 0.920 | 0.225 |
| 2000 | 1.068 | 0.062 | 1.213 | 0.276 | 0.890 | 0.153 | 0.202 | 0.480 | 0.922 | 0.273 |
| 2001 | 1.055 | 0.064 | 1.114 | 0.280 | 0.686 | 0.160 | 0.252 | 0.376 | 1.642 | 0.203 |
| 2002 | 0.994 | 0.061 | 1.239 | 0.276 | 0.729 | 0.150 | 0.144 | 0.536 | 1.451 | 0.214 |
| 2003 | 0.985 | 0.069 | 0.967 | 0.282 | 1.055 | 0.153 | 0.566 | 0.289 | 1.103 | 0.219 |
| 2004 | 0.923 | 0.073 | 1.019 | 0.281 | 0.654 | 0.162 | 0.450 | 0.308 | 1.478 | 0.211 |
| 2005 | 0.732 | 0.093 | 0.860 | 0.290 | 1.038 | 0.163 | 0.491 | 0.292 | | |
| 2006 | 0.966 | 0.083 | 1.584 | 0.276 | 1.351 | 0.149 | 0.381 | 0.369 | 1.187 | 0.253 |

For most indices, selectivity (*S*) by age and year was estimated using partial catches. In the Atlantic there was one exception, the SEAMAP South Atlantic Trawl survey. This survey was assumed to index the abundance of age-0 king mackerel in October-November. Therefore, for all years $S_0$was fixed to 1.0 and $S_{1\text{-}11+}$ were fixed to 0.0. In the Gulf there were two exceptions: the Shrimp Bycatch (SEAMAP Fall Groundfish survey) GLM which was assumed to index age-0 king mackerel ($S_0$was fixed to 1.0 and $S_{1\text{-}11+}$ were fixed to 0.0) and the SEAMAP Ichthyoplankton survey which was assumed to index spawning stock biomass and the selectivity pattern was fixed at maturity*fecundity-at-age. The partial catches used to estimate selectivity for each index are summarized in **Tables 3.27 and 3.28**. The equation used to estimate selectivity was that corresponding to Butterworth and Geromont (1999) (see VPA-2BOX manual), instead of the Powers and Restrepo (1982) method. While the Powers and Restrepo approach allows selectivity at age to change every year, the Butterworth and Geromont approach computes an average selectivity pattern for the entire time period (1981-2006).

**Table 3.27.** Partial catches at age (numbers) used in the Atlantic VPA base run.

| Index | Year | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NC Trip Ticket | 1981 | 0 | 1504 | 4919 | 30522 | 32629 | 4268 | 8986 | 153 | 239 | 59 | 253 | 896 |
| | 1982 | 40 | 32852 | 1510 | 22594 | 16388 | 13275 | 8784 | 5667 | 65 | 483 | 9966 | 473 |
| | 1983 | 3190 | 10865 | 4527 | 9850 | 23330 | 15344 | 11832 | 1890 | 1837 | 216 | 160 | 2651 |
| | 1984 | 9 | 9718 | 2586 | 4024 | 16817 | 10940 | 7474 | 4426 | 569 | 248 | 94 | 4108 |
| | 1985 | 3 | 4738 | 9130 | 8532 | 16293 | 19842 | 6716 | 5081 | 2589 | 1861 | 337 | 2795 |
| | 1986 | 37 | 7342 | 17967 | 8993 | 19344 | 7595 | 5549 | 17712 | 3050 | 2968 | 3569 | 11753 |
| | 1987 | 0 | 5863 | 12365 | 26358 | 15931 | 11586 | 12582 | 5459 | 17225 | 6166 | 1896 | 18692 |
| | 1988 | 0 | 675 | 9375 | 19895 | 15397 | 5171 | 4674 | 6513 | 2661 | 7688 | 3259 | 10586 |
| | 1989 | 0 | 5295 | 10702 | 17720 | 18285 | 13207 | 9450 | 4387 | 3322 | 2463 | 5914 | 7431 |
| | 1990 | 0 | 16135 | 25230 | 16424 | 23180 | 21449 | 16264 | 7603 | 4489 | 3971 | 2054 | 12173 |
| | 1991 | 0 | 2543 | 34410 | 26931 | 13234 | 14032 | 12930 | 8360 | 4304 | 1968 | 1321 | 7701 |
| | 1992 | 0 | 1104 | 20975 | 45638 | 18942 | 9619 | 7041 | 7609 | 4714 | 2607 | 1909 | 6113 |
| | 1993 | 40 | 2951 | 8926 | 15434 | 18020 | 6128 | 4967 | 5307 | 5626 | 3317 | 1861 | 6050 |
| | 1994 | 0 | 1967 | 12133 | 9653 | 12249 | 16300 | 11453 | 4540 | 4740 | 6810 | 3873 | 7160 |
| | 1995 | 0 | 2876 | 11556 | 12118 | 8915 | 9800 | 14178 | 4550 | 3691 | 5570 | 4520 | 3979 |
| | 1996 | 0 | 9873 | 55236 | 27256 | 16837 | 8677 | 7448 | 11680 | 4204 | 1645 | 1799 | 3878 |
| | 1997 | 0 | 4228 | 21785 | 21117 | 16116 | 7627 | 5887 | 9754 | 11524 | 4418 | 1678 | 6965 |
| | 1998 | 3 | 1404 | 31524 | 48158 | 27108 | 13262 | 5260 | 3172 | 4312 | 6171 | 1412 | 2643 |
| | 1999 | 0 | 11092 | 25162 | 26338 | 27829 | 11077 | 5480 | 1996 | 1989 | 2256 | 2152 | 2026 |
| | 2000 | 0 | 336 | 18488 | 14034 | 22654 | 14703 | 7700 | 2806 | 1324 | 1473 | 3004 | 4947 |
| | 2001 | 0 | 2370 | 5690 | 13311 | 13786 | 12383 | 10541 | 4957 | 2548 | 1279 | 2197 | 8823 |
| | 2002 | 66 | 5751 | 20231 | 7612 | 11692 | 8443 | 8731 | 5227 | 3531 | 1364 | 723 | 4593 |
| | 2003 | 0 | 636 | 17661 | 6549 | 8028 | 11278 | 3812 | 5051 | 2655 | 999 | 568 | 2048 |
| | 2004 | 0 | 13848 | 48800 | 34283 | 12643 | 8865 | 12398 | 3165 | 3878 | 1932 | 730 | 1543 |
| | 2005 | 0 | 1362 | 56377 | 28686 | 21449 | 7854 | 4655 | 7552 | 2211 | 4095 | 1534 | 2906 |
| | 2006 | 0 | 962 | 28832 | 44380 | 11078 | 15692 | 1910 | 2034 | 5422 | 772 | 3436 | 8193 |
| MRFSS | 1981 | 0 | 8188 | 38184 | 130232 | 78134 | 88326 | 33724 | 4725 | 2467 | 476 | 3 | 8092 |
| | 1982 | 20446 | 34912 | 2532 | 100864 | 172443 | 68561 | 28449 | 16528 | 2047 | 6094 | 12271 | 5390 |
| | 1983 | 32513 | 147194 | 85315 | 110399 | 93197 | 42893 | 31364 | 9992 | 3 | 0 | 244 | 8459 |
| | 1984 | 42582 | 34124 | 13668 | 162449 | 137083 | 63195 | 59346 | 695 | 11 | 1548 | 23883 | 11213 |
| | 1985 | 176491 | 40223 | 76590 | 39543 | 189676 | 84440 | 28961 | 459 | 745 | 1392 | 6 | 2568 |
| | 1986 | 513 | 65220 | 108755 | 36962 | 65517 | 27845 | 16080 | 45779 | 10757 | 7323 | 7595 | 29585 |
| | 1987 | 0 | 134158 | 109577 | 49600 | 32163 | 26062 | 22879 | 7545 | 25233 | 8272 | 2589 | 26171 |
| | 1988 | 0 | 6270 | 74927 | 98384 | 54407 | 13778 | 16520 | 20673 | 7871 | 28362 | 9422 | 41576 |
| | 1989 | 0 | 30908 | 25645 | 42794 | 37957 | 26578 | 20457 | 11001 | 10208 | 6418 | 23999 | 25879 |
| | 1990 | 0 | 87568 | 50872 | 30377 | 45527 | 38966 | 28920 | 13053 | 8990 | 12983 | 8205 | 41375 |
| | 1991 | 0 | 34831 | 142445 | 48788 | 25190 | 37040 | 38765 | 24445 | 17712 | 8361 | 4856 | 42847 |
| | 1992 | 1873 | 22951 | 96435 | 143514 | 35934 | 26493 | 25760 | 30547 | 11829 | 9495 | 9606 | 42078 |
| | 1993 | 6132 | 30604 | 15722 | 44827 | 48784 | 15580 | 13635 | 23535 | 27277 | 13315 | 9402 | 37469 |
| | 1994 | 0 | 41402 | 55901 | 26393 | 42617 | 49990 | 21643 | 10632 | 12709 | 15981 | 8230 | 19727 |
| | 1995 | 0 | 70971 | 98465 | 44333 | 30418 | 31855 | 48138 | 10298 | 10192 | 16139 | 13574 | 17422 |
| | 1996 | 0 | 14772 | 73378 | 41192 | 36955 | 23884 | 25043 | 36619 | 11819 | 7313 | 6662 | 17402 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 0 | 39696 | 99371 | 69327 | 42974 | 23200 | 19162 | 34005 | 35551 | 10599 | 4641 | 29042 |
| | 1998 | 1171 | 8472 | 63201 | 71747 | 47935 | 27521 | 14212 | 10052 | 22271 | 21902 | 3326 | 17565 |
| | 1999 | 0 | 37162 | 38884 | 62541 | 72558 | 36998 | 19874 | 9041 | 8417 | 13589 | 13542 | 11789 |
| | 2000 | 0 | 6218 | 169689 | 53926 | 93018 | 52625 | 22945 | 8162 | 5013 | 7002 | 17563 | 29404 |
| | 2001 | 0 | 6051 | 28773 | 64549 | 43052 | 55512 | 43799 | 19177 | 4125 | 3745 | 3852 | 31699 |
| | 2002 | 451 | 25332 | 27811 | 34422 | 70591 | 24671 | 31116 | 15686 | 10014 | 3379 | 2635 | 12134 |
| | 2003 | 0 | 10460 | 108202 | 35760 | 57796 | 87338 | 28917 | 43866 | 22829 | 7781 | 3240 | 14605 |
| | 2004 | 0 | 22642 | 38660 | 78059 | 25506 | 36416 | 54047 | 13918 | 23516 | 10647 | 6821 | 11380 |
| | 2005 | 0 | 5774 | 155331 | 54726 | 62701 | 16299 | 15131 | 22471 | 6800 | 11469 | 3678 | 5909 |
| | 2006 | 0 | 7063 | 73389 | 145726 | 55424 | 77017 | 9423 | 9466 | 21134 | 1624 | 5421 | 15563 |
| Headboat | 1981 | 0 | 17710 | 24204 | 128409 | 58857 | 66710 | 25138 | 742 | 207 | 191 | 3830 | 7374 |
| | 1982 | 357 | 21793 | 600 | 47553 | 37759 | 11211 | 6929 | 2991 | 412 | 1191 | 7082 | 438 |
| | 1983 | 4089 | 111447 | 16974 | 31766 | 38074 | 8027 | 13794 | 1452 | 53 | 0 | 20 | 2296 |
| | 1984 | 38760 | 16159 | 7597 | 41634 | 44727 | 24793 | 22032 | 521 | 134 | 250 | 8991 | 4032 |
| | 1985 | 183115 | 26635 | 36220 | 28374 | 164470 | 73614 | 21068 | 1 | 448 | 1010 | 44 | 1951 |
| | 1986 | 68 | 6143 | 3863 | 1477 | 2885 | 1046 | 545 | 2389 | 351 | 324 | 392 | 1451 |
| | 1987 | 0 | 843 | 888 | 628 | 327 | 254 | 256 | 69 | 363 | 93 | 21 | 264 |
| | 1988 | 0 | 118 | 1497 | 1902 | 999 | 250 | 268 | 365 | 172 | 569 | 196 | 1009 |
| | 1989 | 0 | 926 | 696 | 875 | 781 | 552 | 437 | 232 | 208 | 139 | 448 | 622 |
| | 1990 | 0 | 7476 | 1533 | 883 | 1361 | 1086 | 765 | 336 | 214 | 286 | 157 | 844 |
| | 1991 | 0 | 965 | 4255 | 1330 | 629 | 968 | 986 | 603 | 439 | 199 | 107 | 1025 |
| | 1992 | 1 | 99 | 749 | 964 | 236 | 151 | 142 | 137 | 55 | 48 | 61 | 166 |
| | 1993 | 92 | 841 | 631 | 1030 | 1190 | 477 | 348 | 399 | 444 | 245 | 146 | 534 |
| | 1994 | 0 | 706 | 1645 | 623 | 1346 | 1190 | 826 | 294 | 373 | 469 | 189 | 837 |
| | 1995 | 0 | 803 | 982 | 415 | 345 | 438 | 606 | 136 | 146 | 254 | 185 | 228 |
| | 1996 | 0 | 129 | 576 | 516 | 435 | 247 | 257 | 376 | 158 | 103 | 60 | 184 |
| | 1997 | 0 | 1247 | 2497 | 1740 | 1326 | 880 | 550 | 865 | 896 | 322 | 110 | 681 |
| | 1998 | 15 | 108 | 17935 | 14123 | 9795 | 6585 | 4515 | 3020 | 6802 | 6753 | 1215 | 4048 |
| | 1999 | 0 | 965 | 430 | 634 | 478 | 199 | 132 | 55 | 77 | 83 | 114 | 70 |
| | 2000 | 0 | 63 | 1313 | 351 | 558 | 280 | 110 | 37 | 24 | 27 | 67 | 99 |
| | 2001 | 0 | 235 | 647 | 1294 | 806 | 1015 | 650 | 382 | 132 | 74 | 159 | 863 |
| | 2002 | 29 | 1614 | 1755 | 2317 | 4692 | 1778 | 2494 | 1261 | 841 | 263 | 172 | 1063 |
| | 2003 | 0 | 227 | 1304 | 309 | 437 | 630 | 178 | 286 | 145 | 49 | 22 | 108 |
| | 2004 | 0 | 717 | 742 | 982 | 302 | 399 | 602 | 175 | 279 | 147 | 79 | 212 |
| | 2005 | 0 | 57 | 1428 | 449 | 512 | 119 | 116 | 162 | 47 | 100 | 34 | 64 |
| | 2006 | 0 | 214 | 2196 | 4634 | 1369 | 1492 | 196 | 156 | 377 | 39 | 127 | 177 |

**Table 3.28.** Partial catches at age (numbers) used in the Gulf VPA base run.

| Index | Year | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial Logbook – Gulf No Mix | 1981 | 0 | 3 | 703 | 1240 | 1154 | 500 | 40 | 37 | 34 | 0 | 0 | 121 |
| | 1982 | 21 | 378 | 503 | 985 | 587 | 11 | 700 | 6 | 0 | 0 | 0 | 443 |
| | 1983 | 0 | 1065 | 3212 | 679 | 168 | 161 | 63 | 147 | 5 | 43 | 25 | 104 |
| | 1984 | 0 | 111 | 377 | 1815 | 592 | 41 | 257 | 57 | 1 | 1 | 28 | 35 |
| | 1985 | 0 | 2 | 18 | 361 | 279 | 203 | 17 | 42 | 24 | 2 | 0 | 9 |
| | 1986 | 5 | 194 | 554 | 2 | 50 | 60 | 53 | 3 | 14 | 2 | 10 | 12 |
| | 1987 | 0 | 2088 | 1309 | 252 | 167 | 199 | 73 | 55 | 24 | 12 | 5 | 26 |
| | 1988 | 8 | 279 | 692 | 341 | 166 | 77 | 226 | 68 | 11 | 35 | 33 | 120 |
| | 1989 | 0 | 6491 | 913 | 481 | 343 | 30 | 2 | 15 | 9 | 4 | 9 | 24 |
| | 1990 | 0 | 1301 | 1384 | 729 | 187 | 138 | 94 | 25 | 119 | 38 | 10 | 58 |
| | 1991 | 29 | 3172 | 3265 | 1100 | 462 | 587 | 273 | 141 | 32 | 337 | 52 | 119 |
| | 1992 | 0 | 2796 | 4525 | 2246 | 424 | 155 | 364 | 105 | 102 | 23 | 153 | 89 |
| | 1993 | 21 | 781 | 1295 | 2169 | 1540 | 582 | 257 | 494 | 155 | 73 | 22 | 591 |
| | 1994 | 0 | 4089 | 1411 | 1648 | 2335 | 2122 | 881 | 183 | 829 | 443 | 120 | 1048 |
| | 1995 | 4 | 252 | 620 | 550 | 734 | 561 | 664 | 300 | 126 | 156 | 139 | 182 |
| | 1996 | 0 | 5898 | 6904 | 4405 | 1296 | 1042 | 1265 | 753 | 168 | 44 | 108 | 273 |
| | 1997 | 0 | 2320 | 9104 | 9059 | 5377 | 2891 | 2464 | 3395 | 1121 | 319 | 0 | 1282 |
| | 1998 | 0 | 3159 | 2231 | 2914 | 1284 | 677 | 363 | 260 | 299 | 204 | 118 | 72 |
| | 1999 | 0 | 1843 | 1542 | 2780 | 3501 | 2443 | 1088 | 540 | 904 | 987 | 165 | 500 |
| | 2000 | 0 | 1005 | 2985 | 3118 | 2367 | 2038 | 541 | 1196 | 256 | 372 | 493 | 741 |
| | 2001 | 0 | 1059 | 2786 | 3346 | 2435 | 2313 | 2004 | 1698 | 1180 | 123 | 378 | 1028 |
| | 2002 | 5 | 2525 | 1848 | 2042 | 1911 | 941 | 829 | 828 | 752 | 364 | 114 | 526 |
| | 2003 | 0 | 2274 | 5758 | 3536 | 3066 | 2260 | 1235 | 602 | 961 | 506 | 414 | 543 |
| | 2004 | 0 | 539 | 1427 | 1382 | 1250 | 817 | 754 | 332 | 166 | 266 | 123 | 154 |
| | 2005 | 1 | 164 | 614 | 392 | 506 | 290 | 149 | 123 | 44 | 43 | 44 | 92 |
| | 2006 | 0 | 317 | 1728 | 1744 | 1021 | 1306 | 935 | 597 | 447 | 152 | 101 | 422 |
| MRFSS | 1981 | 1068 | 2156 | 7145 | 41847 | 14425 | 2769 | 1550 | 1880 | 1917 | 0 | 0 | 345 |
| | 1982 | 1607 | 20562 | 37782 | 37429 | 4905 | 11347 | 1992 | 30 | 0 | 0 | 90 | 571 |
| | 1983 | 94 | 77651 | 98962 | 15428 | 1927 | 6354 | 1753 | 1884 | 498 | 502 | 0 | 7633 |
| | 1984 | 39806 | 6330 | 24190 | 109998 | 43561 | 1190 | 5170 | 6204 | 42 | 16 | 87 | 1706 |
| | 1985 | 4012 | 17349 | 24319 | 5808 | 6338 | 5665 | 3442 | 111 | 58 | 0 | 0 | 2200 |
| | 1986 | 3039 | 27599 | 99309 | 17326 | 11877 | 11523 | 8244 | 1011 | 331 | 120 | 0 | 1229 |
| | 1987 | 492 | 98316 | 74412 | 18767 | 13552 | 15500 | 7199 | 4749 | 2011 | 1022 | 655 | 1478 |
| | 1988 | 3445 | 50826 | 95571 | 72928 | 44262 | 19984 | 54535 | 15909 | 3105 | 8615 | 8507 | 17588 |
| | 1989 | 517 | 113466 | 86703 | 36915 | 29287 | 10915 | 1077 | 7648 | 2337 | 1645 | 1184 | 2842 |
| | 1990 | 0 | 77131 | 89827 | 49552 | 17065 | 9350 | 6722 | 1441 | 5912 | 2009 | 358 | 4932 |
| | 1991 | 1674 | 188231 | 193026 | 55409 | 23918 | 21880 | 7291 | 5755 | 1473 | 9004 | 2887 | 5764 |
| | 1992 | 0 | 35185 | 100586 | 69668 | 28111 | 19411 | 17048 | 9532 | 18466 | 3828 | 6699 | 13261 |
| | 1993 | 1177 | 48264 | 50118 | 67882 | 50679 | 20273 | 8613 | 11863 | 6340 | 3472 | 623 | 12987 |
| | 1994 | 0 | 94133 | 43423 | 38399 | 51762 | 36049 | 18038 | 6602 | 10778 | 5930 | 6326 | 9942 |
| | 1995 | 1518 | 23527 | 34532 | 29126 | 27246 | 21292 | 21969 | 11786 | 5563 | 3956 | 4537 | 6195 |
| | 1996 | 0 | 66450 | 90163 | 53444 | 28021 | 21906 | 20218 | 16637 | 10734 | 4526 | 1561 | 16539 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1997 | 0 | 30159 | 83391 | 84134 | 43674 | 26516 | 19167 | 20989 | 10370 | 6359 | 1671 | 10800 |
| | 1998 | 0 | 48027 | 51515 | 69122 | 53603 | 26182 | 15056 | 9125 | 8550 | 5815 | 3466 | 2127 |
| | 1999 | 0 | 59123 | 45134 | 39316 | 43018 | 30448 | 11135 | 8981 | 7992 | 8628 | 1010 | 4123 |
| | 2000 | 0 | 44814 | 73905 | 66708 | 33365 | 18979 | 6433 | 10605 | 2097 | 3657 | 2887 | 4302 |
| | 2001 | 0 | 37468 | 51173 | 38974 | 25587 | 18102 | 14190 | 12556 | 9509 | 3464 | 2069 | 9316 |
| | 2002 | 137 | 59917 | 111944 | 56858 | 42353 | 24268 | 17109 | 13561 | 13095 | 6974 | 3041 | 9425 |
| | 2003 | 0 | 18165 | 63634 | 43070 | 33763 | 24194 | 15261 | 6806 | 8717 | 5210 | 4307 | 4711 |
| | 2004 | 0 | 26349 | 69598 | 36378 | 30941 | 17858 | 15349 | 10805 | 4344 | 6838 | 2792 | 4711 |
| | 2005 | 129 | 11677 | 50633 | 32972 | 32817 | 19070 | 13008 | 9591 | 6826 | 2760 | 2488 | 8976 |
| | 2006 | 0 | 22819 | 102724 | 84297 | 54069 | 47854 | 26749 | 17696 | 13102 | 7204 | 2933 | 12742 |
| Headboat | 1981 | 3 | 990 | 446 | 985 | 699 | 369 | 92 | 14 | 58 | 0 | 0 | 123 |
| | 1982 | 3 | 990 | 446 | 985 | 699 | 369 | 92 | 14 | 58 | 0 | 0 | 123 |
| | 1983 | 3 | 990 | 446 | 985 | 699 | 369 | 92 | 14 | 58 | 0 | 0 | 123 |
| | 1984 | 3 | 990 | 446 | 985 | 699 | 369 | 92 | 14 | 58 | 0 | 0 | 123 |
| | 1985 | 3 | 990 | 446 | 985 | 699 | 369 | 92 | 14 | 58 | 0 | 0 | 123 |
| | 1986 | 302 | 4068 | 20317 | 5478 | 1272 | 2051 | 1199 | 554 | 0 | 123 | 0 | 25 |
| | 1987 | 6 | 1885 | 1250 | 389 | 289 | 292 | 159 | 85 | 44 | 30 | 24 | 26 |
| | 1988 | 56 | 874 | 1058 | 927 | 666 | 191 | 286 | 174 | 42 | 58 | 55 | 57 |
| | 1989 | 4 | 4172 | 9297 | 3069 | 960 | 862 | 90 | 221 | 62 | 39 | 4 | 61 |
| | 1990 | 0 | 5219 | 7086 | 3118 | 1397 | 559 | 435 | 51 | 241 | 85 | 18 | 294 |
| | 1991 | 44 | 3493 | 7537 | 2708 | 1138 | 673 | 279 | 172 | 56 | 194 | 49 | 94 |
| | 1992 | 0 | 4153 | 5998 | 4173 | 1485 | 888 | 434 | 204 | 510 | 83 | 50 | 198 |
| | 1993 | 85 | 1701 | 7781 | 4552 | 2561 | 900 | 389 | 214 | 367 | 153 | 6 | 210 |
| | 1994 | 0 | 1450 | 6494 | 2450 | 2513 | 1054 | 544 | 220 | 297 | 199 | 81 | 176 |
| | 1995 | 23 | 930 | 4503 | 3144 | 1232 | 484 | 426 | 121 | 51 | 45 | 33 | 36 |
| | 1996 | 0 | 3565 | 9044 | 5082 | 2435 | 1162 | 1016 | 701 | 419 | 259 | 52 | 408 |
| | 1997 | 0 | 3502 | 9300 | 4833 | 1239 | 476 | 252 | 239 | 115 | 68 | 43 | 63 |
| | 1998 | 0 | 3492 | 1844 | 1731 | 1441 | 476 | 198 | 108 | 56 | 58 | 26 | 8 |
| | 1999 | 0 | 2419 | 4453 | 2113 | 1800 | 1049 | 360 | 421 | 111 | 101 | 12 | 67 |
| | 2000 | 0 | 1102 | 3262 | 2784 | 933 | 495 | 198 | 215 | 53 | 68 | 33 | 54 |
| | 2001 | 0 | 405 | 1066 | 988 | 794 | 498 | 293 | 296 | 202 | 116 | 22 | 194 |
| | 2002 | 2 | 1085 | 1975 | 756 | 505 | 312 | 165 | 105 | 102 | 64 | 33 | 64 |
| | 2003 | 0 | 608 | 2676 | 1458 | 618 | 308 | 262 | 93 | 51 | 54 | 36 | 44 |
| | 2004 | 0 | 809 | 7307 | 1827 | 1217 | 470 | 398 | 574 | 102 | 389 | 47 | 139 |
| | 2005 | 6 | 1729 | 8130 | 3939 | 1694 | 752 | 341 | 312 | 198 | 66 | 49 | 187 |
| | 2006 | 0 | 280 | 4536 | 3868 | 2815 | 1102 | 487 | 404 | 189 | 213 | 45 | 239 |

### 3.2.1.3. *Model Configuration and Equations*

The model configuration and equations are identical to those described in Section 3.1.1.3. except that:

1) Indices were weighted equally while preserving interannual variations (see document SEDAR 16-AW-09 Restrepo et al for the methodology used). This was accomplished by fixing the variance scaling parameters to the values in **Table 3.29**.

**Table 3.29**. Fixed variance scalars used to equally weight the indices of abundance.

| Region | Index | Variance Scalar |
|---|---|---|
| ATL | NC_TT | 0.574532 |
| | MRFSS_ATL_NOMIX | 0.000000 |
| | HEADBOAT_NOMIX | 0.512862 |
| | SEAMAP_SA_TRAWL | 0.525378 |
| Gulf | COM_GULF_NOMIX | 0.536934 |
| | MRFSS_GULF_NOMIX | 0.443338 |
| | HEADBOAT_GULF_NOMIX | 0.519944 |
| | SEAMAP_GROUNDFISH | 0.000000 |
| | SEAMAP_PLANKTON | 0.466586 |

2) The index vulnerabilities were estimated using partial catches fit using the method of Butterworth and Geromont (1999) rather than Powers and Restrepo (1992) method. While the Powers and Restrepo approach allows selectivity at age to change every year, the Butterworth and Geromont approach computes an average selectivity pattern for the entire time period.

3) In VPA applications, little information has accumulated for the most recent cohorts around the terminal year, such that the most recent estimates of fishing mortality (and abundance) are highly uncertain. This can result in, for example, extremely high or extremely low F values (or abundances) for different age classes in the terminal year. This can be alleviated by including a weak constraint on how much the estimated selectivity pattern is allowed to vary over a recent time period. The VPA will still estimate F (and abundance) values that will explain the catches at age exactly, but those estimates will be weakly linked through the constraint. A penalty was used to constrain changes in selectivity during the most recent three years. This penalty (SD = 0.4) was applied to ages 3 – 9. (In undocumented runs, the analysts tried SD values of 0.3, 0.4 and 0.6 and they made negligible differences)

### 3.2.1.4. *Parameters Estimated*

For the VPA base runs, the age-0 to age-10 terminal F parameters were estimated using the following initial conditions and settings (**Table 3.30**). The plus group Terminal F was fixed at the value estimated for Age-10. In addition, a catchability coefficient was estimated for each index.

**Table 3.30.** Terminal F settings and initial conditions used for the base case and sensitivity runs.

| | Atlantic | | Gulf | |
|---|---|---|---|---|
| | Initial Value | Fixed or Estimated? | Initial Value | Fixed or Estimated? |
| Age 0 | 0.15 | Estimated | 0.15 | Estimated |
| Age 1 | 0.15 | Estimated | 0.15 | Estimated |
| Age 2 | 0.15 | Estimated | 0.15 | Estimated |
| Age 3 | 0.15 | Estimated | 0.15 | Estimated |
| Age 4 | 0.15 | Estimated | 0.15 | Estimated |
| Age 5 | 0.15 | Estimated | 0.15 | Estimated |
| Age 6 | 0.15 | Estimated | 0.15 | Estimated |
| Age 7 | 0.15 | Estimated | 0.15 | Estimated |
| Age 8 | 0.15 | Estimated | 0.15 | Estimated |
| Age 9 | 0.15 | Estimated | 0.15 | Estimated |
| Age 10 | 0.15 | Estimated | 0.15 | Estimated |
| Age 11+ | - | Fixed equal to Terminal F at Age-10 | - | Fixed equal to Terminal F at Age-10 |

### 3.2.1.5. *Uncertainty and Measures of Precision*

Estimation uncertainty was determined by running 1000 non-parametric bootstraps of the index residuals. These bootstraps allow computation of the maximum likelihood estimate (MLE), bootstrap average, bias, standard error and coefficients of variation (CVs) for each parameter. In addition, bootstrapping allows the computation of upper and lower 80% confidence intervals on the annual estimates of SSB, R and F (illustrated with dashed lines in the figures below).

### 3.2.1.6. *Methods Used to Compute Benchmark / Reference Points*

Benchmarks and reference points were calculated using the proposed/alternative management criteria[4] (**Table 3.31**).

**Table 3.31.** Alternative/Proposed management criteria for the Gulf and South Atlantic regions.

| Criteria | Definition – Proposed/Alternative | |
|---|---|---|
| | South Atlantic | Gulf |
| MSST | MSST = [(1-M) or 0.5 whichever is greater]*$B_{MSY}$ | MSST = [(1-M) or 0.5 whichever is greater]*$B_{MSY}$ |
| MFMT | $F_{MSY}$ | $F_{MSY}$ |
| MSY | Yield at $F_{MSY}$ | Yield at $F_{MSY}$ |
| $F_{MSY}$ | $F_{MSY}$ | $F_{MSY}$ |
| OY | Yield at $F_{OY}$ | Yield at $F_{OY}$ |
| $F_{OY}$ | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$ | $F_{OY}$ =65%, 75%, 85% $F_{MSY}$ |
| M | 0.1603 (Base of Lorenzen M) | 0.1738(Base of Lorenzen M) |

There are a number of ways in which $F_{MSY}$ could be estimated. For example, the results of a VPA can be used to estimate a spawner-recruit relationship. That relationship, combined with the yield-per-recruit calculations, can be used to compute equilibrium recruitment, biomass and yield, under different F levels (see Sissenwine and Shepherd 1987). Thus, the VPA and the

[4] Management Overview, Section I, SEDAR 16 Stock Assessment Report

per-recruit models could, in essence, be combined into an age-structured production model. The Assessment Workshop chose not to fit freely a stock-recruitment relationship to the VPA estimates of SSB and recruitment, but rather to fix a relationship which predicted nearly-constant recruitment. In such a situation of nearly-constant recruitment, $F_{MSY}$ would be approximately equal to $F_{MAX}$, the F that maximizes yield-per-recruit. However, since recruitment is not likely to remain constant at low SSB levels, $F_{MAX}$ is likely to overestimate $F_{MSY}$.

The use of a SPR-based proxies for $F_{MSY}$ is recommended when there is no evidence of a strong stock-recruitment relationship, as is the case with Atlantic and Gulf king mackerels. The Assessment Workshop chose to continue using $F_{SPR30\%}$ as a proxy for $F_{MSY}$, as used for king mackerels since the late 1990s. Therefore, the benchmarks are measured as follows:

$F_{MSY}$: Estimated by the proxy $F_{30\%SPR}$
$B_{MSY}$ = Estimated by the equilibrium SSB resulting from fishing at $F_{30\%}$ and assuming the equilibrium stock-recruitment relationship below.
MSY = Estimated by the equilibrium yield resulting from fishing at $F_{30\%}$ and assuming the equilibrium stock-recruitment relationship below.

The following treatments of the data and assumptions have been used in making the corresponding calculations:

Current F ($F_{Current}$): $F_{Current}$ vector at age was calculated from the geometric mean of the age-specific F values for the most recent three years (2004-2006). In this document, when a single value is used for $F_{current}$, it refers to the highest value in the vector..

Current Selectivity: selectivity was computed by re-scaling the Fcurrent vector to a maximum value of 1.

SSB: SSB is computed as the product of numbers at age at the beginning of each year, times maturity, times fecundity (thus the acronym "SSB" does not really reflect spawning stock biomass, but egg production instead)

Expected spawner-recruit relationship: Assumed a Beverton-Holt relationship with a steepness of 0.95 (i.e. recruitment is nearly constant at most levels of SSB).

As an example, these are the steps followed to compute the benchmarks associated with F30%:

i) Fit the VPA model
ii) Estimate the geometric mean F at age values for 2004-2006 (current F); compute current selectivity
iii) Fit a Beverton-Holt stock recruitment relationship of the type
$$R = \frac{\alpha S}{\beta + S}$$ , fixing steepness = 0.95.
iv) Using the life history values for M, weights, maturity, fecundity, and current selectivity, calculate:

$F_{30\%SPR}$ (the F that results in egg production per recruit that is 30% of the unfished level)

$SPR_{30\%}$, the resulting egg production per recruit

$YPR_{30\%}$, the resulting yield per recruit

v) Calculate equilibrium levels for the associated benchmarks

$S = \alpha SPR_{30\%} - \beta$ , the equilibrium SSB (egg production)

$R = \frac{\alpha S}{\beta + S}$ , the equilibrium recruitment

$Y = R\, YPR_{30\%}$

### *3.2.1.7. Projection methods*

Following the recommendation of the SEDAR AW panel, projections of the population dynamics of each stock used a stock recruitment relationship estimated assuming a constant relative recruitment. The S-R relationship was defined using a fixed high steepness (0.95) and a Berverton-Holt S-R function. Maximum expected recruitment was set equal to the geometric mean of VPA estimated recruits over the years for which indices of stock and recruitment were both available (1981-2004 GOM and 1989-2004 ATL).

Projections were run to 2016 using the projection software PRO-2BOX (Porch, 2002b). To estimate the variance of the projection, 1000 bootstraps were run off the VPA results. Although the alpha and beta parameters of the S-R relationship were fixed, the predicted recruitment of each bootstrap was allowed to vary with a CV calculated from the SSB-R observations.

Seven types of projections at constant F were made for the period 2007-2016:

1. Project at $F_{Current}$
2. Project at $F_{MSY}$ (= $F_{SPR30}$)
3. Project at $F_{SPR40}$
4. Project at $F_{OY}$ (=65% $F_{SPR30}$)
5. Project at $F_{OY}$ (=75% $F_{SPR30}$)
6. Project at $F_{OY}$ (=85% $F_{SPR30}$)

The AW terms of reference require the calculation of Allowable Biological Catches (ABCs). The selection of what constitutes an ABC amongst several candidates is a management choice, so the projection results presented in a subsequent section do not identify any particular ABCs. Instead, yields (total removals) are presented for the six scenarios mentioned above. The terms of reference (Item 8) call for four sets of calculations:

A) Based on migratory groups and mixing zone dynamics defined using best available scientific information, provide separate ABC values for each of two management areas delineated at the Miami-Dade/Monroe County line: all fish caught north of the line allocated to the Atlantic management area and all fish caught south of the line allocated to the Gulf management area.

B) Based on migratory groups and mixing zone dynamics as currently defined, provide separate ABC values for the Gulf and Atlantic Migratory Units based on allocating all fish in the mixing zone to the Gulf Migratory Unit (essentially the ‘continuity’ approach).

C) Based on migratory groups and mixing zone dynamics as currently defined, provide separate ABC values for the Gulf and Atlantic migratory units based on allocating 50% of the fish in the mixing zone to the Gulf Migratory Unit and 50% of the fish to the Atlantic Migratory Unit.

D) Based on migratory groups and mixing zone dynamics defined using best available scientific information, provide separate ABC values for each of two management areas delineated at the Gulf and South Atlantic Council boundaries

Item 8B is addressed by the projections based on the "status quo" assessment where 100% of the fish in the winter mixing zone are assumed to be from the Gulf unit. Item 8C is addressed by projections from what the AW Panel has adopted as the base case.

Items 8A and 8D above ask for corresponding run streams under various yields by jurisdictional boundaries (regardless of migratory unit). Since the VPAs and projections treat each stock independently, one must infer the ABCs that would apply to a given jurisdictional boundary from the projections of each migratory group. To do this, one needs to know what fraction of each migratory unit is caught North (and South) of the jurisdictional boundaries in question. For example, consider the case where the projected yield (catch in weight) of the Atlantic migratory unit is Y(Atlantic) and for the Gulf unit is Y(Gulf). The fraction of the Atlantic unit caught North of the boundary is **Ω**(Atlantic North) and the fraction of the Gulf unit caught North of the boundary is **Ω**(Gulf North). Then the appropriate quota for North of the boundary is Y(Atlantic)* **Ω** (Atlantic North) + Y(Gulf)* **Ω**(Gulf North). The appropriate quota for south of the boundary is, correspondingly, Y(Atlantic)*(1- **Ω**(Atlantic North)) + Y(Gulf)*(1- **Ω**(Gulf North)).

In these analyses, **Ω**(Atlantic North) and **Ω**(Gulf North) are computed by use of observed catch data (averages over the last three years where of complete data, 2004-2006). Thus **Ω**(Atlantic North) = the catch in weight of Atlantic fish caught North of the jurisdictional boundary divided by the total catch in weight of all Atlantic fish.

Because 8C was accepted by the AW as the best available scientific information, this base case run is used as the starting point for calculating 8A and 8D. TOR 8A is addressed by applying the catch ratios defined using the Dade/Monroe jurisdictional boundary to the projection results from TOR 8C. Likewise, TOR 8D is addressed by applying the catch ratios defined using the current US-1/Dry Tortugas jurisdictional boundary to the projection results from TOR 8C.

### 3.2.2. Results

#### 3.2.2.1. *Measures of Overall Model Fit*

The model fit was assessed using the objective function, likelihood statistics (**Table 3.32)** and the fits to the indices of abundance (**Figures 3.8 and 3.9**). AIC, AICC and BIC values are also summarized in **Table 3.32**, but these are not directly comparable across model with different numbers of parameters. The base models did not incur any out-of-bounds penalties. The non-zero values for the constraint on terminal F were caused by a penalty applied to limit changes in vulnerability during recent years (2004-2006, Ages 3-9, SD=0.4).

**Table 3.32** Likelihood Statistics for base models. Loglikelihood measures of model fits to the indices of abundance and associated information criteria. The acronyms AIC, AICc and BIC refer to Akaike's Information criteria, AIC with small sample correction, and the Bayes Information Criteria. The Chi-square discrepancy statistic (Gelman et al., 1995) is approximately chi-square distributed with degrees of freedom equal to the number of data points less the number of parameters. Note that these statistics can only be compared across models that use the same data.

| Model | ATL-Mix50% | | GOM-Mix50% | |
|---|---|---|---|---|
| Total objective function | -29.56 | | -35.54 | |
| (with constants) | 44.87 | | 61.87 | |
| Number of parameters | 15 | | 16 | |
| Number of data points | 81 | | 106 | |
| AIC | 119.75 | | 155.74 | |
| AICC | 127.13 | | 161.86 | |
| BIC | 155.66 | | 198.36 | |
| Chi-square discrepancy | 58.79 | | 57.18 | |
| | | | | |
| Loglikelihoods (deviance) | 19.22 | | 27.3 | |
| effort data | 19.22 | | 27.3 | |
| | | | | |
| Log-posteriors | 0 | | 0 | |
| catchability | 0 | | 0 | |
| f-ratio | 0 | | 0 | |
| natural mortality | 0 | | 0 | |
| mixing coeff. | 0 | | 0 | |
| | | | | |
| Constraints | 10.34 | | 8.23 | |
| terminal F | 10.34 | | 8.23 | |
| stock-rec./sex ratio | 0 | | 0 | |
| Out of bounds penalty | 0 | | 0 | |
| | | | | |
| Log Likelihoood: Indices of Abundance | 19.23 | | 27.31 | |
| Index 1 | NC_TT | 6.47 | COM_GULF_NOMIX | 6.79 |
| Index 2 | GULF_MIX | Not Used | MRFSS_GULF_NOMIX | 11.69 |
| Index 3 | MRFSS_ATL_NOMIX | 3.22 | HEADBOAT_GULF_NOMIX | 8.33 |
| Index 4 | HEADBOAT_NOMIX | 6.55 | SEAMAP_GROUNDFISH | -4.77 |
| Index 5 | SEAMAP_SA_TRAWL | 2.99 | SEAMAP_PLANKTON | 5.27 |

The fits to the abundance indices are summarized in **Figures 3.8 and 3.9**. In the Atlantic, the fits to the indices of abundance were generally poor, although the predicted trends are roughly similar to the observed series.

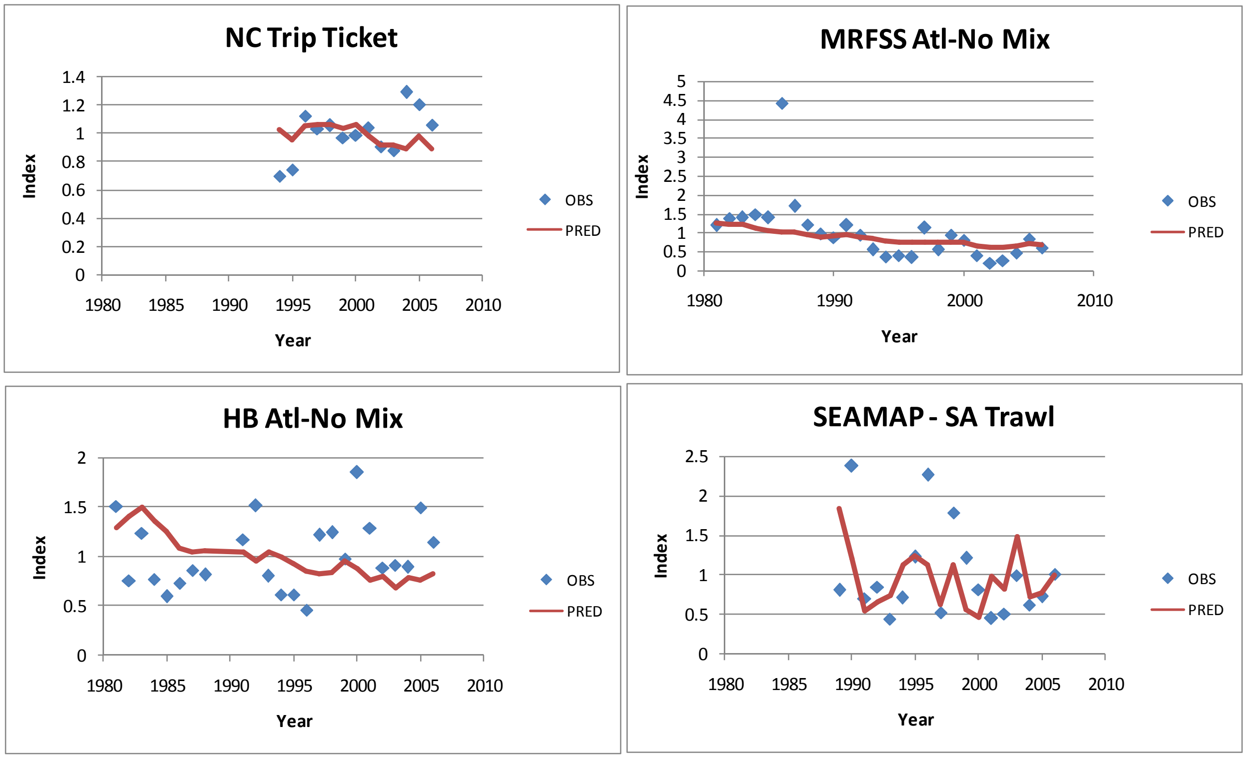



**Figure 3.8.** Fits to the indices of abundance for the Atlantic base case.

In the Gulf, the fits to the indices of abundance are generally better, particularly the fishery-independent ones that have an upward trend in recent years **(Figure 3.9)**. The Gulf of Mexico commercial index is not fit well. As per the instructions of the SEDAR 16 AW panel, the indices were weighted such that the interannual variations were preserved, but the overall variances were equal for all indices. Using this weighting scenario, it was not possible to closely fit the commercial index because it conflicts (in trend) with the majority of the other indices. However, the AW felt that the lack of fit to the fisheries-dependent indices was justified by the closer fit to the SEAMAP groundfish and Ichthyoplankton surveys. These are fisheries independent, and as such, the panel argued that they should be fit reasonably well, even at the expense of the commercial index. Because the various indices conflict in trends, the choice of how the indices are weighted has a substantial impact on the results.

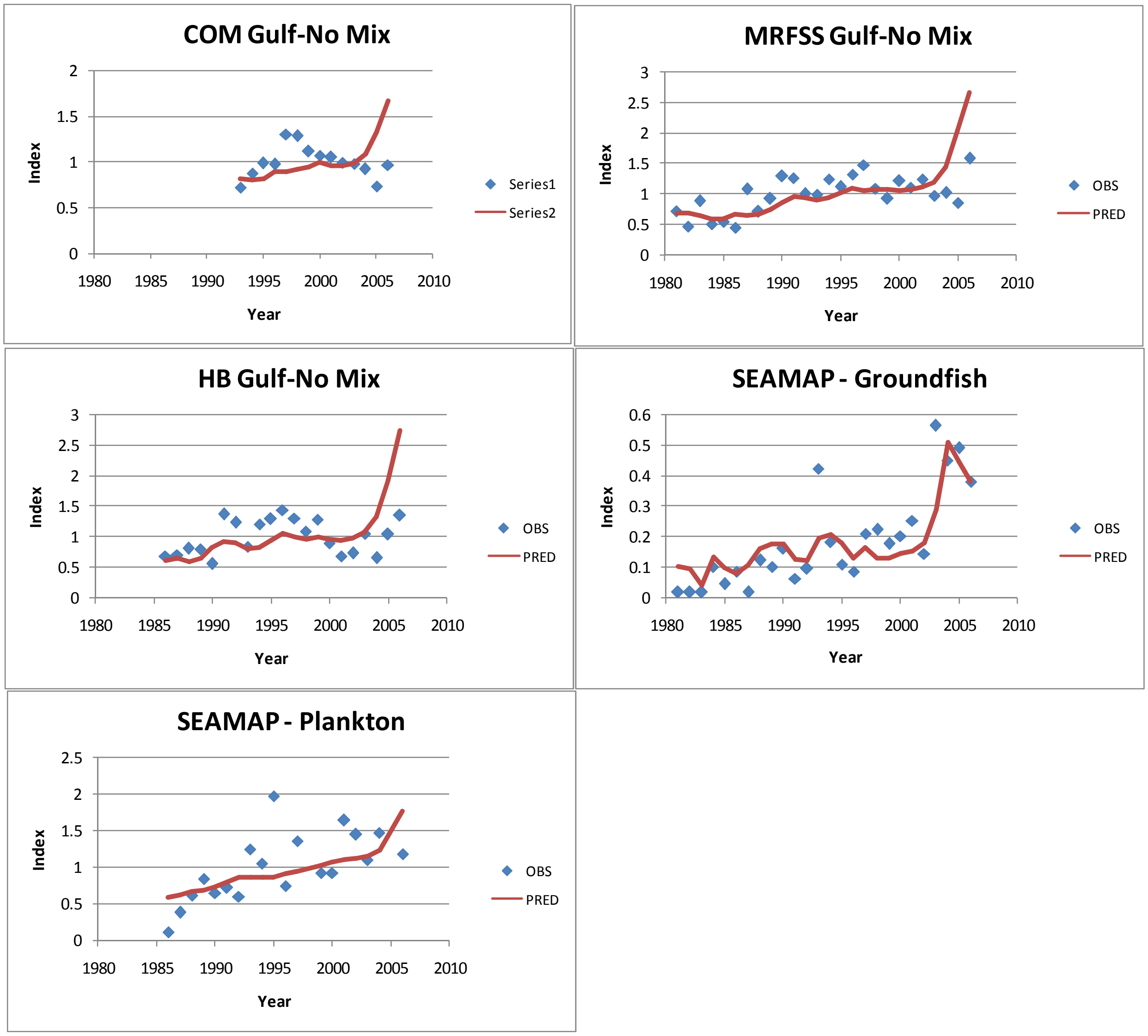



**Figure 3.9.** Fits to the indices of abundance for the Gulf base case.

### 3.2.2.2. *Parameter estimates & associated measures of uncertainty*

Parameter estimates and the associated maximum likelihood estimate (MLE), bootstrap average, bias, standard error and coefficients of variation (CVs) are summarized in **Tables 3.33 and 3.34**. In addition, upper and lower 80% confidence intervals on the annual estimates of SSB, R and F (illustrated with dashed lines) were calculated from the non-parametric bootstraps.

**Table 3.33.** Final values for estimated parameters of the Atlantic base runs.

TERMINAL AGE STRUCTURE OF POPULATION ABUNDANCE

| Age | MLE | Average of bootstraps | Bias | Std. Error | % CV |
|---|---|---|---|---|---|
| 1 | 0.240E+07 | 0.276E+07 | 0.374E+06 | 0.145E+07 | 52.4 |
| 2 | 0.142E+07 | 0.168E+07 | 0.207E+06 | 0.107E+07 | 63.6 |
| 3 | 0.919E+06 | 0.110E+07 | 0.163E+06 | 0.737E+06 | 66.9 |
| 4 | 0.127E+07 | 0.125E+07 | 0.194E+05 | 0.369E+06 | 29.6 |
| 5 | 0.456E+06 | 0.436E+06 | 0.227E+04 | 0.113E+06 | 26.0 |
| 6 | 0.322E+06 | 0.292E+06 | 0.317E+04 | 0.800E+05 | 27.4 |
| 7 | 0.895E+05 | 0.723E+05 | -0.785E+03 | 0.205E+05 | 28.4 |
| 8 | 0.840E+05 | 0.705E+05 | 0.216E+04 | 0.198E+05 | 28.1 |
| 9 | 0.995E+05 | 0.968E+05 | 0.764E+04 | 0.324E+05 | 33.5 |
| 10 | 0.301E+05 | 0.335E+05 | 0.565E+04 | 0.149E+05 | 44.5 |
| 11 | 0.281E+06 | 0.348E+06 | 0.674E+05 | 0.179E+06 | 51.5 |

TERMINAL AGE STRUCTURE OF FISHING MORTALITY RATE

| Age | MLE | Average of bootstraps | Bias | Std. Error | % CV |
|---|---|---|---|---|---|
| 0 | 0.383E-02 | 0.439E-02 | 0.535E-03 | 0.228E-02 | 52.0 |
| 1 | 0.978E-02 | 0.120E-01 | 0.263E-02 | 0.727E-02 | 60.4 |
| 2 | 0.154E+00 | 0.183E+00 | 0.320E-01 | 0.103E+00 | 56.3 |
| 3 | 0.194E+00 | 0.212E+00 | 0.118E-01 | 0.585E-01 | 27.6 |
| 4 | 0.231E+00 | 0.253E+00 | 0.119E-01 | 0.599E-01 | 23.7 |
| 5 | 0.359E+00 | 0.409E+00 | 0.167E-01 | 0.934E-01 | 22.9 |
| 6 | 0.252E+00 | 0.322E+00 | 0.212E-01 | 0.796E-01 | 24.7 |
| 7 | 0.247E+00 | 0.305E+00 | 0.906E-02 | 0.733E-01 | 24.0 |
| 8 | 0.358E+00 | 0.393E+00 | 0.846E-03 | 0.102E+00 | 25.9 |
| 9 | 0.190E+00 | 0.196E+00 | -0.810E-02 | 0.637E-01 | 32.5 |
| 10 | 0.156E+00 | 0.152E+00 | -0.410E-02 | 0.567E-01 | 37.4 |
| 11 | 0.156E+00 | 0.152E+00 | -0.410E-02 | 0.567E-01 | 37.4 |

CATCHABILITY COEFFICIENTS

| Index | MLE | Average of bootstraps | Bias | Std. Error | % CV |
|---|---|---|---|---|---|
| NC_TT | 0.497E-07 | 0.501E-07 | -0.209E-08 | 0.677E-08 | 13.5 |
| MRFSS_NoMix | 0.242E-06 | 0.235E-06 | -0.466E-07 | 0.279E-07 | 11.9 |
| HB_NoMix | 0.349E-06 | 0.342E-06 | -0.379E-07 | 0.356E-07 | 10.4 |
| SEAMAP Trawl | 0.335E-06 | 0.337E-06 | -0.455E-07 | 0.470E-07 | 13.9 |

**Table 3.34.** Final values for estimated parameters of the Gulf base runs.

TERMINAL AGE STRUCTURE OF POPULATION ABUNDANCE

| Age | MLE | Average of bootstraps | Bias | Std. Error | % CV |
|---|---|---|---|---|---|
| 1 | 0.687E+07 | 0.779E+07 | 0.159E+07 | 0.406E+07 | 52.2 |
| 2 | 0.589E+07 | 0.631E+07 | 0.118E+07 | 0.264E+07 | 41.9 |
| 3 | 0.495E+07 | 0.561E+07 | 0.760E+06 | 0.170E+07 | 30.3 |
| 4 | 0.204E+07 | 0.183E+07 | 0.249E+06 | 0.601E+06 | 32.8 |
| 5 | 0.817E+06 | 0.961E+06 | 0.635E+05 | 0.234E+06 | 24.3 |
| 6 | 0.478E+06 | 0.511E+06 | 0.402E+05 | 0.121E+06 | 23.7 |
| 7 | 0.277E+06 | 0.301E+06 | 0.261E+05 | 0.657E+05 | 21.8 |
| 8 | 0.162E+06 | 0.181E+06 | 0.236E+05 | 0.452E+05 | 25.0 |
| 9 | 0.114E+06 | 0.132E+06 | 0.233E+05 | 0.446E+05 | 33.8 |
| 10 | 0.150E+06 | 0.129E+06 | 0.166E+05 | 0.426E+05 | 32.9 |
| 11 | 0.387E+06 | 0.261E+06 | 0.254E+05 | 0.983E+05 | 37.7 |

TERMINAL AGE STRUCTURE OF FISHING MORTALITY RATE

| Age | MLE | Average of bootstraps | Bias | Std. Error | % CV |
|---|---|---|---|---|---|
| 0 | 0.853E-01 | 0.947E-01 | 0.634E-03 | 0.478E-01 | 50.4 |
| 1 | 0.296E-02 | 0.327E-02 | -0.135E-03 | 0.140E-02 | 42.9 |
| 2 | 0.313E-01 | 0.301E-01 | -0.184E-02 | 0.888E-02 | 29.5 |
| 3 | 0.853E-01 | 0.104E+00 | -0.397E-02 | 0.357E-01 | 34.2 |
| 4 | 0.160E+00 | 0.145E+00 | -0.170E-02 | 0.340E-01 | 23.4 |
| 5 | 0.185E+00 | 0.183E+00 | -0.509E-02 | 0.405E-01 | 22.2 |
| 6 | 0.176E+00 | 0.170E+00 | -0.727E-02 | 0.355E-01 | 21.0 |
| 7 | 0.216E+00 | 0.205E+00 | -0.162E-01 | 0.457E-01 | 22.3 |
| 8 | 0.203E+00 | 0.196E+00 | -0.181E-01 | 0.575E-01 | 29.4 |
| 9 | 0.973E-01 | 0.123E+00 | -0.460E-02 | 0.385E-01 | 31.3 |
| 10 | 0.862E-01 | 0.141E+00 | 0.337E-02 | 0.526E-01 | 37.2 |
| 11 | 0.862E-01 | 0.141E+00 | 0.337E-02 | 0.526E-01 | 37.2 |

CATCHABILITY COEFFICIENTS

| Index | MLE | Average of bootstraps | Bias | Std. Error | % CV |
|---|---|---|---|---|---|
| COM_NoMix | 0.532E-07 | 0.600E-07 | -0.366E-08 | 0.768E-08 | 12.8 |
| MRFSS_NoMix | 0.183E-06 | 0.203E-06 | -0.130E-07 | 0.210E-07 | 10.3 |
| HB_NoMix | 0.258E-06 | 0.270E-06 | -0.238E-07 | 0.271E-07 | 10.0 |
| SEAMAP GF | 0.296E-06 | 0.271E-06 | -0.603E-07 | 0.373E-07 | 13.8 |
| SEAMAP ICH | 0.461E-06 | 0.488E-06 | -0.574E-07 | 0.612E-07 | 12.5 |

#### 3.2.2.3. *Stock Abundance and Recruitment*

The annual estimates of number-at-age are tabulated in **Tables 3.35 and 3.36**, and in **Figure 3.10**. The abundance of king mackerel Age 1+ has declined in the Atlantic region. In the Gulf, numbers of Age 1+ king mackerel increased slowly between 1980 and 2003, then increased rapidly.

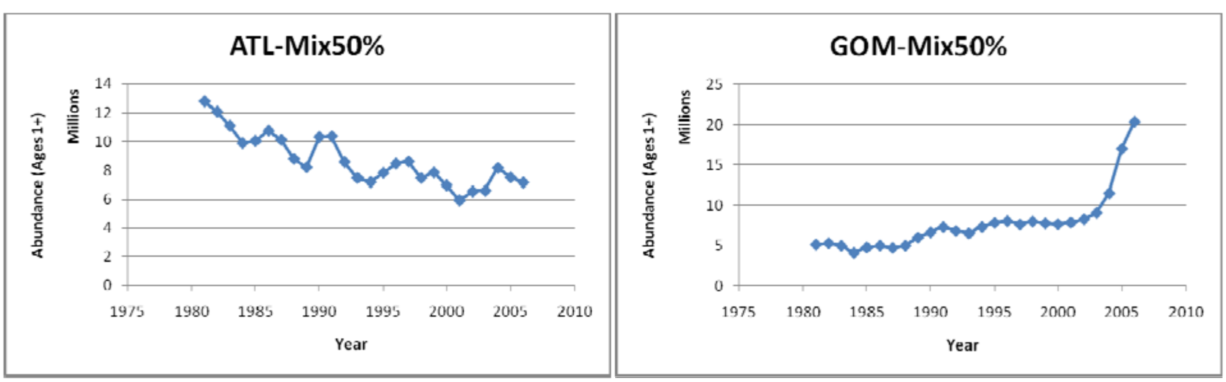



**Figure 3.10.** Annual trend in abundance (number of fish Ages 1+) for base models.

In the Atlantic, estimated recruitment at age-0 varied without obvious trend, ranging from 2.2 million in 2000 to 8.6 million in 1989 (**Figure 3.11**). In the Gulf, recruitment at age-0 has varied substantially, ranging from 2.0 million in 1983 to 22 million in 2004 (**Figure 3.11**). During recent years recruitment has been quite high, averaging 19 million since 2003. These large recruitment estimates are likely driven by the steep increase in the SEAMAP Fall Groundfish Survey which indexes the abundance of Age-0 king mackerel and has increased more than 5-fold since the early 1980s.

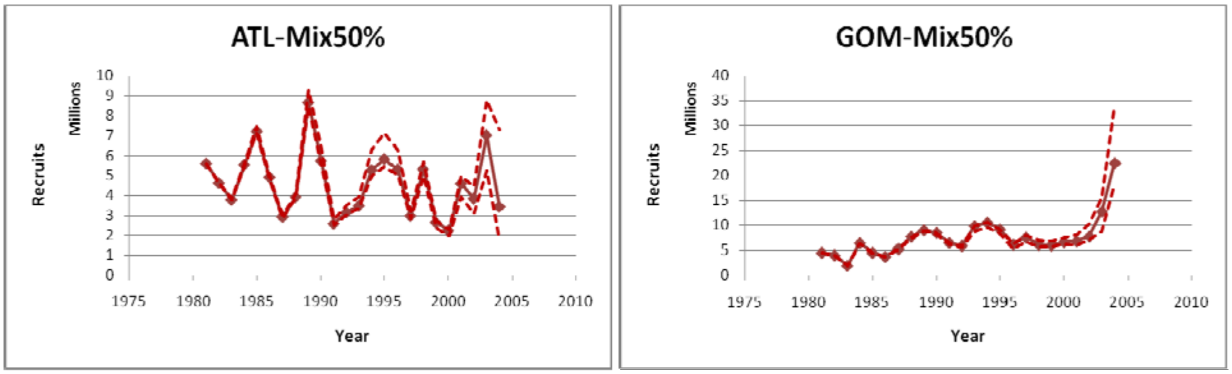



**Figure 3.11.** Annual trend in recruitment (Age-0) for base models. Upper and lower 80% confidence intervals are indicated with dashed lines. Recruitment estimates for 2005 and 2006 are not shown since they are replaced in the VPA with values from the S-R relationship**.**

**Table 3.35.** Number at age for the Atlantic base model.

| | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 5593383 | 2710452 | 3945190 | 2173141 | 1093596 | 754460 | 237837 | 1062496 | 106668 | 463557 | 92158 | 170766 |
| 1982 | 4610921 | 2855598 | 2063235 | 3082396 | 1339185 | 583719 | 486828 | 132819 | 884993 | 86060 | 393307 | 203455 |
| 1983 | 3758930 | 2330487 | 2134125 | 1604767 | 2277697 | 755897 | 334568 | 349114 | 79698 | 741489 | 65356 | 468433 |
| 1984 | 5524883 | 1874371 | 1589071 | 1547356 | 1103753 | 1688776 | 524720 | 192824 | 280115 | 63627 | 631709 | 424253 |
| 1985 | 7178154 | 2779446 | 1398465 | 1244368 | 1036952 | 687809 | 1286843 | 354272 | 144224 | 236399 | 50989 | 854626 |
| 1986 | 4902068 | 3504362 | 2091859 | 1001742 | 868384 | 554264 | 389261 | 1029155 | 282696 | 114614 | 195982 | 761223 |
| 1987 | 2906274 | 2502871 | 2585807 | 1422831 | 722288 | 548678 | 392264 | 275089 | 722361 | 208550 | 73357 | 697206 |
| 1988 | 3904312 | 1484200 | 1735818 | 1887202 | 1048715 | 518921 | 392211 | 268875 | 210486 | 540901 | 153414 | 571471 |
| 1989 | 8626111 | 1993138 | 1130185 | 1224445 | 1302042 | 721843 | 391503 | 271393 | 171116 | 156598 | 385333 | 476405 |
| 1990 | 5733484 | 4389240 | 1476980 | 817067 | 883112 | 963861 | 516917 | 271615 | 197333 | 117028 | 116009 | 603318 |
| 1991 | 2551245 | 2883301 | 3252968 | 1042717 | 580591 | 627492 | 718353 | 365836 | 198933 | 145592 | 71748 | 512524 |
| 1992 | 3119440 | 1284918 | 2162356 | 2287046 | 694141 | 397277 | 425331 | 501202 | 242101 | 124021 | 100137 | 377877 |
| 1993 | 3466691 | 1572122 | 958451 | 1508708 | 1530777 | 460031 | 257054 | 293639 | 355927 | 168847 | 82129 | 290618 |
| 1994 | 5263048 | 1755730 | 1171486 | 701281 | 1112825 | 1137419 | 337725 | 182499 | 201440 | 247797 | 115455 | 232732 |
| 1995 | 5812846 | 2673228 | 1307443 | 802743 | 499522 | 810315 | 836194 | 224480 | 127049 | 142919 | 175045 | 232194 |
| 1996 | 5294990 | 2940602 | 1983040 | 885108 | 550078 | 336857 | 602139 | 591216 | 157787 | 81008 | 84980 | 274413 |
| 1997 | 2953842 | 2662584 | 2218917 | 1328687 | 582959 | 351981 | 221501 | 450156 | 413507 | 98881 | 47966 | 252888 |
| 1998 | 5305202 | 1497574 | 1970197 | 1529698 | 895899 | 371309 | 230461 | 142752 | 311425 | 278275 | 57133 | 192155 |
| 1999 | 2622388 | 2674857 | 1131931 | 1402722 | 1036567 | 572242 | 227080 | 150576 | 93855 | 215569 | 184322 | 168971 |
| 2000 | 2207926 | 1316909 | 2007590 | 790244 | 1016283 | 707397 | 396191 | 151817 | 106519 | 64135 | 159019 | 260003 |
| 2001 | 4579475 | 1114774 | 1004182 | 1351954 | 515916 | 671633 | 490218 | 286229 | 108583 | 80995 | 42100 | 286790 |
| 2002 | 3822839 | 2333841 | 850072 | 732527 | 966023 | 322087 | 454663 | 331518 | 206164 | 81650 | 60548 | 222620 |
| 2003 | 6980102 | 1946049 | 1756362 | 538576 | 506540 | 663052 | 206377 | 322012 | 246947 | 152143 | 60608 | 210345 |
| 2004 | 3418515 | 3554155 | 1489177 | 1217288 | 350712 | 323221 | 425297 | 121721 | 208387 | 175524 | 115965 | 202491 |
| 2005 | *** | 1740207 | 2707911 | 1013260 | 814041 | 216229 | 194471 | 253856 | 70781 | 134384 | 129422 | 243099 |
| 2006 | *** | 1848046 | 1335971 | 1885841 | 691134 | 549091 | 136525 | 126881 | 167242 | 42702 | 89983 | 292357 |

**Table 3.36.** Number at age for the Gulf base model.

| | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 4488421 | 1326707 | 862115 | 1012233 | 737862 | 189403 | 121000 | 101682 | 75045 | 27834 | 151538 | 484701 |
| 1982 | 4006059 | 1718337 | 994357 | 647929 | 618066 | 426837 | 111861 | 75373 | 64971 | 54498 | 19798 | 522652 |
| 1983 | 1962367 | 1703323 | 1258927 | 621035 | 382525 | 317334 | 216502 | 33821 | 46577 | 38485 | 27260 | 294593 |
| 1984 | 6394093 | 604404 | 1215392 | 820788 | 404021 | 287281 | 220621 | 151888 | 22346 | 30745 | 28054 | 257270 |
| 1985 | 4474755 | 1996126 | 441666 | 902268 | 461410 | 214209 | 203466 | 138417 | 103352 | 14394 | 25022 | 224999 |
| 1986 | 3719810 | 1603043 | 1496844 | 297096 | 638830 | 310222 | 100768 | 140052 | 103711 | 69546 | 7595 | 194926 |
| 1987 | 5269426 | 1200873 | 1186903 | 989739 | 166530 | 487886 | 205703 | 47883 | 105494 | 84183 | 52239 | 158017 |
| 1988 | 7701647 | 1498560 | 826940 | 862627 | 763978 | 112391 | 373916 | 155072 | 32641 | 84192 | 67638 | 170265 |
| 1989 | 8990647 | 2481495 | 1098694 | 563006 | 612272 | 563408 | 64142 | 247417 | 102270 | 21837 | 58433 | 158939 |
| 1990 | 8475110 | 2418753 | 1780382 | 718353 | 378202 | 434115 | 415564 | 42094 | 185371 | 75753 | 14312 | 163212 |
| 1991 | 6435513 | 2586881 | 1748102 | 1252211 | 481897 | 241869 | 324876 | 309862 | 28394 | 138097 | 55961 | 132270 |
| 1992 | 5871846 | 1697331 | 1808686 | 1159366 | 889302 | 328406 | 162852 | 244201 | 246588 | 19711 | 98354 | 143820 |
| 1993 | 9813684 | 1781897 | 1233606 | 1241854 | 766600 | 630409 | 220835 | 92434 | 184473 | 175599 | 8136 | 167084 |
| 1994 | 10521984 | 2752917 | 1302542 | 839050 | 859690 | 502194 | 461970 | 150083 | 53928 | 132285 | 135816 | 116007 |
| 1995 | 9148162 | 2875654 | 1983355 | 885352 | 561166 | 553584 | 306544 | 320245 | 87718 | 22894 | 93125 | 145963 |
| 1996 | 6130664 | 2491653 | 2144758 | 1402075 | 564447 | 363708 | 396321 | 193173 | 238512 | 57447 | 12114 | 177602 |
| 1997 | 7539743 | 1958354 | 1818770 | 1468921 | 983471 | 380854 | 250964 | 295752 | 129224 | 174552 | 36578 | 120981 |
| 1998 | 6087322 | 2627504 | 1441833 | 1291482 | 995346 | 706370 | 248755 | 166968 | 204817 | 81608 | 127200 | 99784 |
| 1999 | 5994903 | 2054558 | 1947002 | 1026782 | 898030 | 657827 | 516088 | 169897 | 116953 | 155726 | 50241 | 177271 |
| 2000 | 6594913 | 2000583 | 1522359 | 1414432 | 738635 | 625314 | 460417 | 401390 | 116753 | 80231 | 110483 | 180162 |
| 2001 | 6753330 | 2363221 | 1465419 | 1075858 | 976326 | 512469 | 456207 | 355291 | 304087 | 89763 | 54700 | 220584 |
| 2002 | 7720627 | 2634666 | 1754601 | 1021070 | 730993 | 688095 | 358717 | 334694 | 257116 | 231187 | 68403 | 201334 |
| 2003 | 12770877 | 3169744 | 1941776 | 1196309 | 701882 | 493724 | 499303 | 261116 | 251405 | 187830 | 180387 | 202104 |
| 2004 | 22548437 | 4928554 | 2386271 | 1389228 | 816777 | 483578 | 344405 | 360335 | 194584 | 187654 | 141785 | 293337 |
| 2005 | *** | 8595460 | 3718014 | 1669051 | 997082 | 569087 | 348573 | 246462 | 266396 | 153057 | 137119 | 349969 |
| 2006 | *** | 7775395 | 6514601 | 2771612 | 1180443 | 700328 | 398256 | 241237 | 167461 | 196022 | 118280 | 378515 |

### 3.2.2.4. *Spawning Stock Biomass*

According to the base models, the spawning stock (measured by egg production) in the Atlantic decreased about 45% since 1981, while in the Gulf, the spawning stock increased roughly 2-fold from 1985 to 2001, then increased steeply after 2001, mostly due to larger than average recruitment during that time (**Figure 3.12 and Table 3.36)**. **Figure 3.13** shows the restrospective pattern in the estimates of SSB.

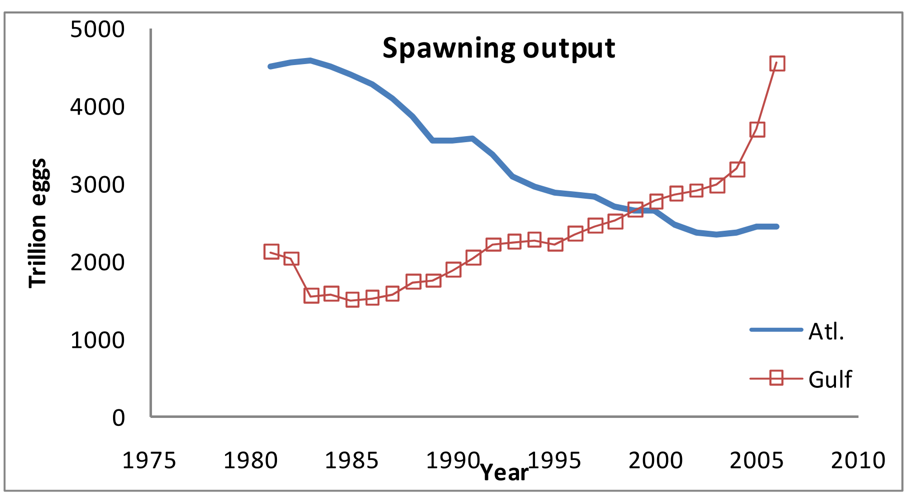



**Figure 3.12.** Annual trend in spawning stock (millions of eggs) for base models.

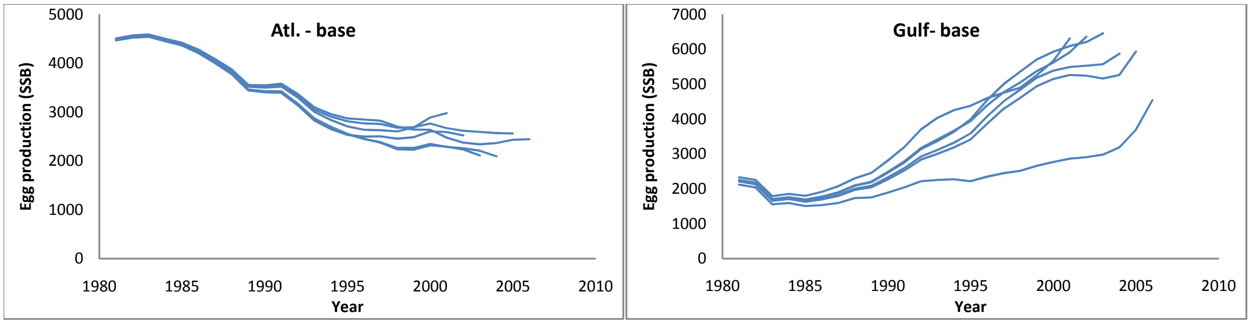



**Figure 3.13** Retrospective estimates of SSB (egg production) obtained when the same base model is re-run deleting the data from the terminal year, the last two years, and so on.

Spawning stock trajectories, as a function of the status determination criterion MSST (where MSST = (1-M) * $SSB_{SPR30}$. and M = 0.1603 in the Atlantic and 0.1738 in the Gulf of Mexico) are shown in (**Figure 3.14 and Table 3.37)**. In the Atlantic SSB/MSST declined during the time series from 2.5 in 1981 to 1.3 in 2006, and in the Gulf, SSB/MSST generally increased during the time series, from 0.87 in 1981 to about 1.8 in 2006.

According to the deterministic results, the Atlantic and Gulf migratory stocks were not overfished as of 2006, although the Gulf stock had been overfished as recently as 1996.

**Atlantic** **Gulf**

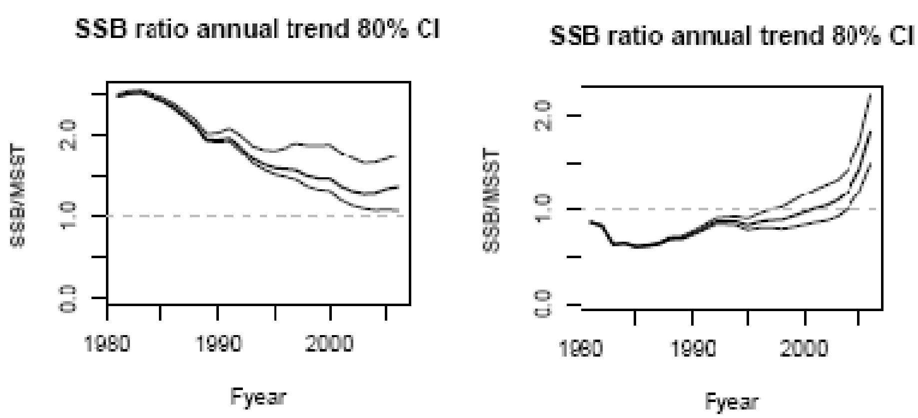



**Figure 3.14.** Annual trend in SSB/MSST for base models with upper and lower 80% confidence intervals.

**Table 3.37.** Spawning stock (millions of eggs) and SSB/MSST for the Atlantic and Gulf base runs.

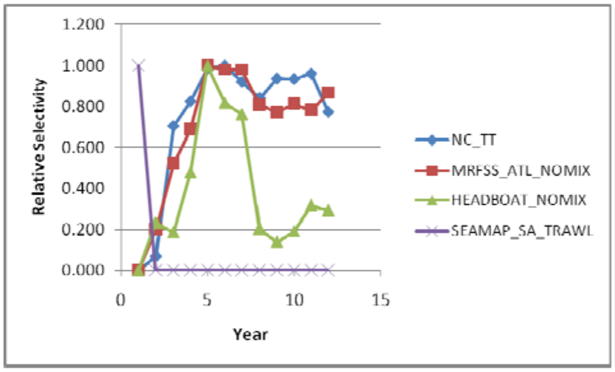
| Year | SSB ATL | SSB/ MSST ATL |
|---|---|---|
| 1981 | 4508 | 2.47 |
| 1982 | 4568 | 2.50 |
| 1983 | 4587 | 2.51 |
| 1984 | 4498 | 2.46 |
| 1985 | 4418 | 2.42 |
| 1986 | 4275 | 2.34 |
| 1987 | 4086 | 2.24 |
| 1988 | 3873 | 2.12 |
| 1989 | 3555 | 1.95 |
| 1990 | 3545 | 1.94 |
| 1991 | 3580 | 1.96 |
| 1992 | 3369 | 1.84 |
| 1993 | 3098 | 1.70 |
| 1994 | 2962 | 1.62 |
| 1995 | 2873 | 1.57 |
| 1996 | 2847 | 1.56 |
| 1997 | 2824 | 1.55 |
| 1998 | 2701 | 1.48 |
| 1999 | 2641 | 1.45 |
| 2000 | 2640 | 1.45 |
| 2001 | 2476 | 1.36 |
| 2002 | 2377 | 1.30 |
| 2003 | 2341 | 1.28 |
| 2004 | 2365 | 1.29 |
| 2005 | 2433 | 1.33 |
| 2006 | 2443 | 1.34 |

| Year | SSB Gulf | SSB/ MSST Gulf |
|---|---|---|
| 1981 | 2123 | 0.87 |
| 1982 | 2036 | 0.83 |
| 1983 | 1555 | 0.64 |
| 1984 | 1591 | 0.65 |
| 1985 | 1502 | 0.61 |
| 1986 | 1533 | 0.63 |
| 1987 | 1591 | 0.65 |
| 1988 | 1732 | 0.71 |
| 1989 | 1749 | 0.72 |
| 1990 | 1887 | 0.77 |
| 1991 | 2042 | 0.84 |
| 1992 | 2217 | 0.91 |
| 1993 | 2249 | 0.92 |
| 1994 | 2269 | 0.93 |
| 1995 | 2215 | 0.91 |
| 1996 | 2346 | 0.96 |
| 1997 | 2451 | 1.00 |
| 1998 | 2516 | 1.03 |
| 1999 | 2657 | 1.09 |
| 2000 | 2771 | 1.13 |
| 2001 | 2864 | 1.17 |
| 2002 | 2904 | 1.19 |
| 2003 | 2979 | 1.22 |
| 2004 | 3184 | 1.30 |
| 2005 | 3690 | 1.51 |
| 2006 | 4543 | 1.86 |

### 3.2.2.5. *Fishery Selectivity*

For the base models, fleet/index selectivity-at-age was estimated using the partial catches (fleet specific catch-at-age) fit using the Butterworth and Geromont (1999) method (**Figure 3.15 and Table 3.38**). This approach computes an average, constant selectivity pattern for the entire time period. It is important to note that the shrimp bycatch indices (SEAMAP Fall Groundfish Survey) were assigned a fixed selectivity equal to 1.0 for Age-0 and 0.0 for all other ages. Also, the SEAMAP Ichthyoplankton survey was used to index SSB, and assigned a fixed selectivity equal to Maturity*Fecundity-at-age.

According to the VPA base run the selectivity of the recreational fleets was generally maximal at ages 2-5. The headboat selectivity declines quickly on older ages, while the MRFSS recreational fishery continues to land (or catch and release) older king mackerel. The commercial selectivity-at-age is similar to the headboat in the Atlantic, with the exception that older fish continue to experience high vulnerability to the North Carolina TT fleet. In the Gulf, the selectivity of the commercial fleet is relatively low on the youngest ages, maximal on ages 7-8, and continues to be high through Age 11+.



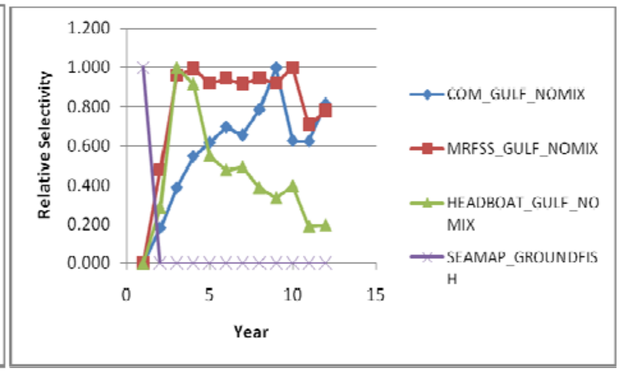




**Figure 3.15.** Fleet/Index selectivity by age for the base runs.

**Table 3.38.** Fleet/Index selectivity by age for the base runs.

| Region | Fleet/Index | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ATL | NC_TT | - | 0.069 | 0.703 | 0.824 | 0.983 | 1.000 | 0.920 | 0.841 | 0.936 | 0.934 | 0.960 | 0.772 |
| | MRFSS_ATL_NOMIX | - | 0.200 | 0.525 | 0.689 | 1.000 | 0.981 | 0.982 | 0.807 | 0.768 | 0.813 | 0.779 | 0.868 |
| | HEADBOAT_NOMIX | - | 0.234 | 0.189 | 0.479 | 1.000 | 0.817 | 0.762 | 0.205 | 0.142 | 0.192 | 0.318 | 0.294 |
| | SEAMAP_SA_TRAWL | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| GOM | COM_GULF_NOMIX | - | 0.180 | 0.386 | 0.547 | 0.616 | 0.697 | 0.655 | 0.785 | 1.000 | 0.627 | 0.624 | 0.814 |
| | MRFSS_GULF_NOMIX | - | 0.476 | 0.961 | 0.995 | 0.922 | 0.944 | 0.917 | 0.946 | 0.922 | 1.000 | 0.707 | 0.777 |
| | HEADBOAT_GULF_NOMIX | - | 0.284 | 1.000 | 0.917 | 0.552 | 0.476 | 0.493 | 0.387 | 0.335 | 0.398 | 0.191 | 0.196 |
| | SEAMAP_GROUNDFISH | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEAMAP_PLANKTON | 0.000 | 0.024 | 0.141 | 0.278 | 0.455 | 0.661 | 0.801 | 0.926 | 1.041 | 1.145 | 1.238 | 1.524 |

### 3.2.2.6. *Fishing Mortality*

Annual trends in fishing mortality are summarized in **Figure 3.16 and Table 3.39**. Figure 3.15 compares trends in fishing mortality expressed either as apical F (the highest F-at-age value in any given year) or as current F (a 3-year running mean). As expected, the apical F measure is more variable and is associated with different ages in different years. The current F measure changes more slowly and because it is a running mean, the age with which it is associated does not change constantly.

In the Atlantic, current F has increased gradually since 2000, while current F has decreased gradually since 1995 in the Gulf. A retrospective pattern of the current F estimates is shown in **Figure 3.17.**

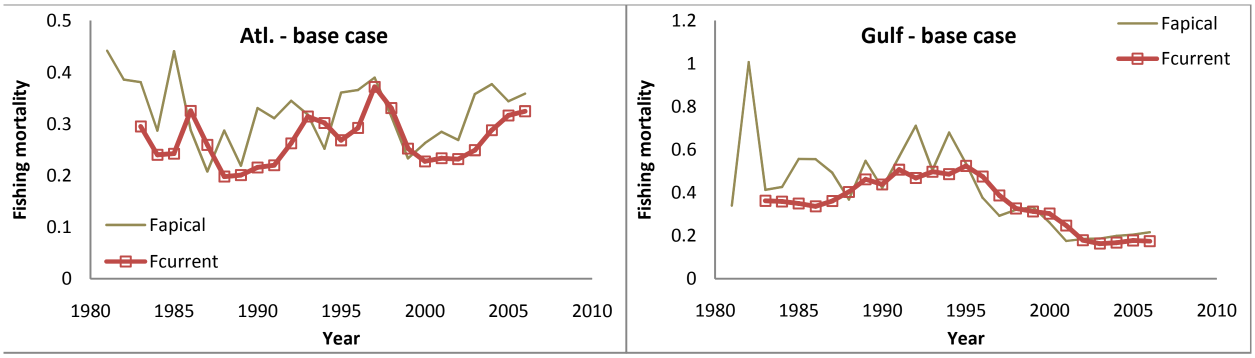



**Figure 3.16.** Annual trend in apical fishing mortality and current fishing mortality for base models. .

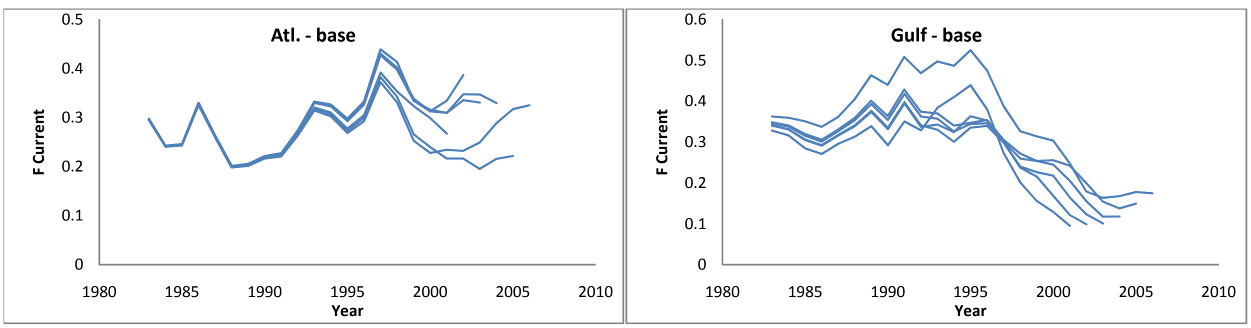



**Figure 3.17** Retrospective estimates of current fishing mortality obtained when the same base model is re-run deleting the data from the terminal year, the last two years, and so on.

The status determination criterion MFMT is estimated by $F_{SPR30}$. Usually, the values of most interest are those associated with current status so that MFMT is calculated with a selectivity vector that reflects the current situation. MFMT was calculated using the current F selectivity (based on the geometric mean F values for 2004-2006) and is used to determine if overfishing is currently occurring. Historical estimates of F can also be compared to MFMT calculated from current selectivity, but such comparison may be difficult to interpret if the ages that are fully selected change substantially. For that purpose, this document also presents values of MFMT calculated each year, to reflect historical changes in the selectivity patterns. Fishing mortality trajectories relative to MFMT (calculated on the basis of the selectivity corresponding to the mean 2004-2006 F values, or on the extant selectivity each 3-year time period) are shown in **Figure 3.18 and Table 3.39b.** In the Atlantic, F/MFMT measured with either method has generally been below 1.0. The ratio of F relative to MFMT that varies annually has an increasing trend, with values around 1.0 in the most recent years. In the Gulf, the ratios using the MFMT based on the 2004-2006 selectivity suggest that overfishing was more severe in the late 1980s and early 1990s, than if the ratios are calculated allowing MFMT to vary over time. Depending on the measure of MFMT that is used, overfishing ended for the Gulf unit in 2000 or 2001 (**Table 3.39b**).

According to the base results, overfishing is not occurring for the Gulf migratory unit. For the Atlantic migratory unit, the point estimate of current F is the same magnitude as the point estimate of MFMT.

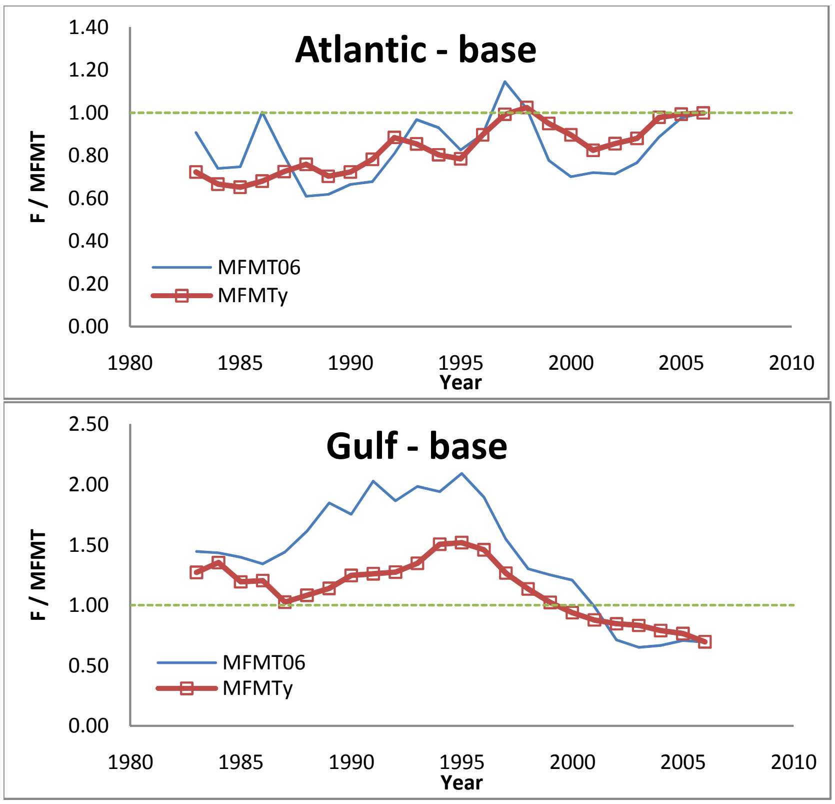



**Figure 3.18.** Annual trend in F/MFMT for base models using two different measures of MFMT. $MFMT_y$ corresponds to F30% calculated with the selectivity vector corresponding to each year's current selectivity (based on the mean F values for years y-2, y-1 and y); $MFMT_{2006}$ is calculated with the 2006 current F selectivity vector (based on F for years 2004-2006). .

**Table 3.39a.** Estimated fishing mortality matrices for base models (results shown without the Recruitment Patch).

1. Atlantic Migratory Unit

| Year/Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.000 | 0.017 | 0.026 | 0.285 | 0.442 | 0.262 | 0.413 | 0.018 | 0.054 | 0.006 | 0.103 | 0.103 |
| 1982 | 0.010 | 0.036 | 0.031 | 0.103 | 0.386 | 0.38 | 0.163 | 0.346 | 0.016 | 0.117 | 0.087 | 0.087 |
| 1983 | 0.024 | 0.127 | 0.101 | 0.175 | 0.113 | 0.189 | 0.381 | 0.055 | 0.064 | 0.002 | 0.077 | 0.077 |
| 1984 | 0.015 | 0.037 | 0.024 | 0.201 | 0.287 | 0.096 | 0.223 | 0.126 | 0.009 | 0.063 | 0.057 | 0.057 |
| 1985 | 0.045 | 0.029 | 0.113 | 0.16 | 0.441 | 0.393 | 0.054 | 0.061 | 0.069 | 0.029 | 0.022 | 0.022 |
| 1986 | 0.000 | 0.048 | 0.165 | 0.128 | 0.273 | 0.169 | 0.178 | 0.189 | 0.143 | 0.288 | 0.164 | 0.164 |
| 1987 | 0.000 | 0.11 | 0.094 | 0.106 | 0.145 | 0.159 | 0.208 | 0.103 | 0.128 | 0.149 | 0.147 | 0.147 |
| 1988 | 0.000 | 0.017 | 0.129 | 0.172 | 0.188 | 0.105 | 0.199 | 0.287 | 0.135 | 0.181 | 0.267 | 0.267 |
| 1989 | 0.004 | 0.044 | 0.104 | 0.127 | 0.115 | 0.158 | 0.196 | 0.154 | 0.219 | 0.142 | 0.203 | 0.203 |
| 1990 | 0.015 | 0.044 | 0.128 | 0.142 | 0.156 | 0.118 | 0.176 | 0.147 | 0.143 | 0.331 | 0.186 | 0.186 |
| 1991 | 0.014 | 0.032 | 0.132 | 0.207 | 0.194 | 0.213 | 0.19 | 0.248 | 0.311 | 0.216 | 0.283 | 0.283 |
| 1992 | 0.013 | 0.038 | 0.139 | 0.202 | 0.226 | 0.259 | 0.201 | 0.178 | 0.199 | 0.254 | 0.345 | 0.345 |
| 1993 | 0.008 | 0.039 | 0.092 | 0.105 | 0.111 | 0.133 | 0.173 | 0.212 | 0.201 | 0.222 | 0.318 | 0.318 |
| 1994 | 0.006 | 0.039 | 0.158 | 0.14 | 0.132 | 0.131 | 0.239 | 0.197 | 0.182 | 0.189 | 0.252 | 0.252 |
| 1995 | 0.01 | 0.043 | 0.17 | 0.179 | 0.208 | 0.121 | 0.177 | 0.188 | 0.289 | 0.361 | 0.241 | 0.241 |
| 1996 | 0.016 | 0.026 | 0.18 | 0.218 | 0.261 | 0.243 | 0.121 | 0.193 | 0.306 | 0.366 | 0.198 | 0.198 |
| 1997 | 0.007 | 0.046 | 0.151 | 0.195 | 0.265 | 0.247 | 0.27 | 0.204 | 0.235 | 0.39 | 0.296 | 0.296 |
| 1998 | 0.013 | 0.024 | 0.119 | 0.19 | 0.263 | 0.315 | 0.256 | 0.255 | 0.207 | 0.253 | 0.236 | 0.236 |
| 1999 | 0.017 | 0.031 | 0.139 | 0.123 | 0.196 | 0.191 | 0.233 | 0.181 | 0.22 | 0.146 | 0.152 | 0.152 |
| 2000 | 0.011 | 0.016 | 0.175 | 0.227 | 0.229 | 0.19 | 0.156 | 0.17 | 0.113 | 0.263 | 0.226 | 0.226 |
| 2001 | 0.002 | 0.015 | 0.095 | 0.137 | 0.285 | 0.214 | 0.222 | 0.163 | 0.124 | 0.133 | 0.238 | 0.238 |
| 2002 | 0.003 | 0.029 | 0.236 | 0.169 | 0.191 | 0.269 | 0.175 | 0.13 | 0.143 | 0.14 | 0.144 | 0.144 |
| 2003 | 0.003 | 0.012 | 0.146 | 0.23 | 0.264 | 0.268 | 0.358 | 0.27 | 0.18 | 0.113 | 0.138 | 0.138 |
| 2004 | 0.003 | 0.016 | 0.165 | 0.203 | 0.298 | 0.332 | 0.346 | 0.377 | 0.278 | 0.146 | 0.116 | 0.116 |
| 2005 | 0.003 | 0.009 | 0.141 | 0.183 | 0.208 | 0.284 | 0.257 | 0.253 | 0.344 | 0.243 | 0.089 | 0.089 |
| 2006 | 0.004 | 0.01 | 0.154 | 0.194 | 0.231 | 0.359 | 0.252 | 0.247 | 0.358 | 0.19 | 0.156 | 0.156 |

2. Gulf Migratory Unit

| Year/Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.195 | 0.014 | 0.043 | 0.271 | 0.34 | 0.33 | 0.285 | 0.266 | 0.143 | 0.168 | 0.033 | 0.033 |
| 1982 | 0.09 | 0.037 | 0.228 | 0.305 | 0.459 | 0.482 | 1.008 | 0.3 | 0.347 | 0.52 | 0.448 | 0.448 |
| 1983 | 0.413 | 0.063 | 0.185 | 0.208 | 0.079 | 0.167 | 0.166 | 0.233 | 0.238 | 0.143 | 0.061 | 0.061 |
| 1984 | 0.399 | 0.04 | 0.055 | 0.354 | 0.427 | 0.149 | 0.278 | 0.203 | 0.263 | 0.033 | 0.075 | 0.075 |
| 1985 | 0.262 | 0.014 | 0.154 | 0.123 | 0.19 | 0.558 | 0.185 | 0.107 | 0.219 | 0.466 | 0.086 | 0.086 |
| 1986 | 0.366 | 0.027 | 0.171 | 0.357 | 0.062 | 0.215 | 0.556 | 0.102 | 0.032 | 0.113 | 0.086 | 0.086 |
| 1987 | 0.493 | 0.099 | 0.076 | 0.037 | 0.186 | 0.07 | 0.094 | 0.201 | 0.049 | 0.046 | 0.047 | 0.047 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1988 | 0.368 | 0.036 | 0.142 | 0.121 | 0.097 | 0.365 | 0.225 | 0.234 | 0.225 | 0.192 | 0.239 | 0.239 |
| 1989 | 0.548 | 0.058 | 0.182 | 0.176 | 0.137 | 0.108 | 0.233 | 0.107 | 0.123 | 0.25 | 0.122 | 0.122 |
| 1990 | 0.422 | 0.051 | 0.109 | 0.177 | 0.24 | 0.094 | 0.105 | 0.212 | 0.118 | 0.13 | 0.132 | 0.132 |
| 1991 | 0.568 | 0.084 | 0.168 | 0.12 | 0.176 | 0.199 | 0.097 | 0.047 | 0.188 | 0.166 | 0.105 | 0.105 |
| 1992 | 0.428 | 0.045 | 0.133 | 0.192 | 0.137 | 0.201 | 0.378 | 0.099 | 0.163 | 0.712 | 0.206 | 0.206 |
| 1993 | 0.506 | 0.039 | 0.143 | 0.146 | 0.216 | 0.115 | 0.198 | 0.357 | 0.156 | 0.084 | 0.25 | 0.25 |
| 1994 | 0.532 | 0.054 | 0.143 | 0.18 | 0.233 | 0.297 | 0.178 | 0.355 | 0.68 | 0.178 | 0.379 | 0.379 |
| 1995 | 0.536 | 0.019 | 0.104 | 0.228 | 0.227 | 0.138 | 0.274 | 0.113 | 0.246 | 0.464 | 0.132 | 0.132 |
| 1996 | 0.376 | 0.041 | 0.136 | 0.133 | 0.186 | 0.175 | 0.105 | 0.22 | 0.135 | 0.278 | 0.287 | 0.287 |
| 1997 | 0.289 | 0.032 | 0.1 | 0.167 | 0.124 | 0.23 | 0.219 | 0.186 | 0.283 | 0.144 | 0.293 | 0.293 |
| 1998 | 0.321 | 0.026 | 0.097 | 0.141 | 0.207 | 0.118 | 0.193 | 0.174 | 0.097 | 0.312 | 0.081 | 0.081 |
| 1999 | 0.333 | 0.026 | 0.077 | 0.107 | 0.155 | 0.16 | 0.063 | 0.193 | 0.2 | 0.17 | 0.07 | 0.07 |
| 2000 | 0.261 | 0.037 | 0.104 | 0.149 | 0.158 | 0.119 | 0.071 | 0.096 | 0.086 | 0.21 | 0.111 | 0.111 |
| 2001 | 0.176 | 0.024 | 0.119 | 0.165 | 0.143 | 0.16 | 0.122 | 0.142 | 0.097 | 0.099 | 0.149 | 0.149 |
| 2002 | 0.125 | 0.031 | 0.14 | 0.153 | 0.185 | 0.124 | 0.129 | 0.104 | 0.137 | 0.075 | 0.125 | 0.125 |
| 2003 | 0.187 | 0.01 | 0.092 | 0.16 | 0.165 | 0.164 | 0.138 | 0.112 | 0.116 | 0.108 | 0.1 | 0.1 |
| 2004 | 0.2 | 0.008 | 0.115 | 0.11 | 0.154 | 0.131 | 0.146 | 0.12 | 0.063 | 0.141 | 0.053 | 0.053 |
| 2005 | 0.15 | 0.003 | 0.051 | 0.124 | 0.146 | 0.161 | 0.18 | 0.205 | 0.13 | 0.085 | 0.088 | 0.088 |
| 2006 | 0.085 | 0.003 | 0.031 | 0.085 | 0.16 | 0.185 | 0.176 | 0.216 | 0.203 | 0.097 | 0.086 | 0.086 |

**Table 3.39b**. Annual Trends in current F relative to MFMT. MFMT has been computed in two ways. $MFMT_y$ corresponds to F30% calculated with the selectivity vector corresponding to each year's current F; $MFMT_{2006}$ is calculated with the 2006 current F selectivity vector. The boxed numbers indicate years where F>= MFMT.

| **ATLANTIC** | | | | Fcurr / | Fcurr / |
|---|---|---|---|---|---|
| Year | Fcurr | MFMT06 | MFMTy | MFMT06 | MFMTy |
| 1983 | 0.29 | 0.32 | 0.41 | 0.91 | 0.72 |
| 1984 | 0.24 | 0.32 | 0.36 | 0.74 | 0.67 |
| 1985 | 0.24 | 0.32 | 0.37 | 0.75 | 0.65 |
| 1986 | 0.33 | 0.32 | 0.48 | 1.00 | 0.68 |
| 1987 | 0.26 | 0.32 | 0.36 | 0.80 | 0.73 |
| 1988 | 0.20 | 0.32 | 0.26 | 0.61 | 0.76 |
| 1989 | 0.20 | 0.32 | 0.29 | 0.62 | 0.70 |
| 1990 | 0.22 | 0.32 | 0.30 | 0.67 | 0.72 |
| 1991 | 0.22 | 0.32 | 0.28 | 0.68 | 0.78 |
| 1992 | 0.26 | 0.32 | 0.30 | 0.81 | 0.88 |
| 1993 | 0.31 | 0.32 | 0.37 | 0.97 | 0.85 |
| 1994 | 0.30 | 0.32 | 0.38 | 0.93 | 0.80 |
| 995 | 0.27 | 0.32 | 0.34 | 0.83 | 0.78 |
| 1996 | 0.29 | 0.32 | 0.33 | 0.90 | 0.90 |
| 1997 | 0.37 | 0.32 | 0.37 | 1.15 | 0.99 |
| 1998 | 0.33 | 0.32 | 0.32 | 1.02 | 1.03 |
| 1999 | 0.25 | 0.32 | 0.27 | 0.78 | 0.95 |
| 2000 | 0.23 | 0.32 | 0.25 | 0.70 | 0.90 |
| 2001 | 0.23 | 0.32 | 0.28 | 0.72 | 0.83 |
| 2002 | 0.23 | 0.32 | 0.27 | 0.71 | 0.86 |
| 2003 | 0.25 | 0.32 | 0.28 | 0.77 | 0.88 |
| 2004 | 0.29 | 0.32 | 0.29 | 0.89 | 0.98 |
| 2005 | 0.32 | 0.32 | 0.32 | 0.98 | 0.99 |
| 2006 | 0.32 | 0.32 | 0.32 | 1.00 | 1.00 |

| **GULF** | | | | Fcurr / | Fcurr / |
|---|---|---|---|---|---|
| Year | Fcurr | MFMT06 | MFMTy | MFMT06 | MFMTy |
| 1983 | 0.36 | 0.25 | 0.29 | 1.45 | 1.27 |
| 1984 | 0.36 | 0.25 | 0.27 | 1.43 | 1.35 |
| 1985 | 0.35 | 0.25 | 0.29 | 1.40 | 1.19 |
| 1986 | 0.34 | 0.25 | 0.28 | 1.34 | 1.20 |
| 1987 | 0.36 | 0.25 | 0.35 | 1.44 | 1.03 |
| 1988 | 0.40 | 0.25 | 0.37 | 1.62 | 1.08 |
| 1989 | 0.46 | 0.25 | 0.41 | 1.85 | 1.14 |
| 1990 | 0.44 | 0.25 | 0.35 | 1.75 | 1.25 |
| 1991 | 0.51 | 0.25 | 0.40 | 2.03 | 1.26 |
| 1992 | 0.47 | 0.25 | 0.37 | 1.87 | 1.27 |
| 1993 | 0.50 | 0.25 | 0.37 | 1.98 | 1.35 |
| 1994 | 0.49 | 0.25 | 0.32 | 1.94 | 1.50 |
| 1995 | 0.52 | 0.25 | 0.35 | 2.09 | 1.52 |
| 1996 | 0.48 | 0.25 | 0.33 | 1.90 | 1.46 |
| 1997 | 0.39 | 0.25 | 0.31 | 1.55 | 1.27 |
| 1998 | 0.33 | 0.25 | 0.29 | 1.30 | 1.13 |
| 1999 | 0.31 | 0.25 | 0.31 | 1.25 | 1.02 |
| 2000 | 0.30 | 0.25 | 0.32 | 1.21 | 0.94 |
| 2001 | 0.25 | 0.25 | 0.28 | 0.99 | 0.88 |
| 2002 | 0.18 | 0.25 | 0.21 | 0.71 | 0.85 |
| 2003 | 0.16 | 0.25 | 0.20 | 0.65 | 0.83 |
| 2004 | 0.17 | 0.25 | 0.21 | 0.67 | 0.79 |
| 2005 | 0.18 | 0.25 | 0.23 | 0.71 | 0.76 |
| 2006 | 0.17 | 0.25 | 0.25 | 0.70 | 0.70 |

The estimated current (2004-2006) fishing mortality rates-at-age for the base models are shown in **Figure 3.19**. These were estimated for ages 0-10. The plus group (11+) terminal F was fixed at the estimated value for age 10. The values are also tabulated in Section *3.2.2.2*.

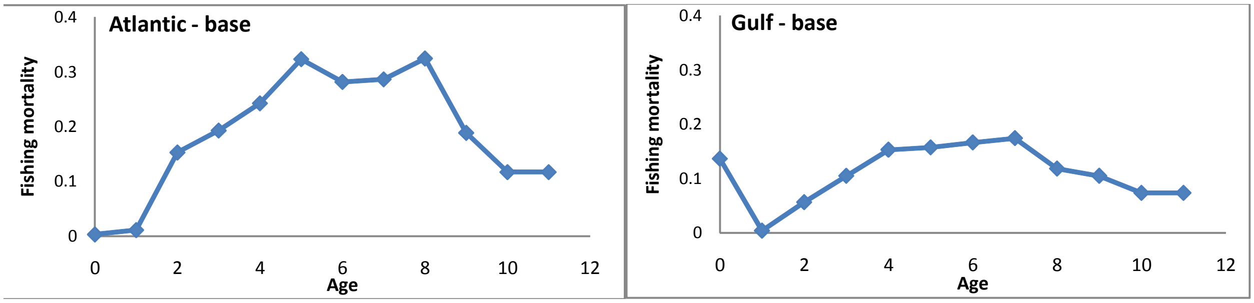



**Figure 3.19.** Terminal year (2006) fishing mortality-at-age for base models.

### 3.2.2.7. *Stock-Recruitment Parameters*

As per the instructions of the SEDAR16 AW panel, the stock recruitment relationship was modeled using a Beverton-Holt S-R function with an assumption of high steepness (0.95). Maximum recruitment was set equal to the geometric mean of VPA estimated recruits over the years for which indices of stock and recruitment were both available (1981-2004 GOM and 1989-2004 ATL) (**Figure 3.20**). The parameters of the S-R relationship are tabulated in **Table 3.40**.

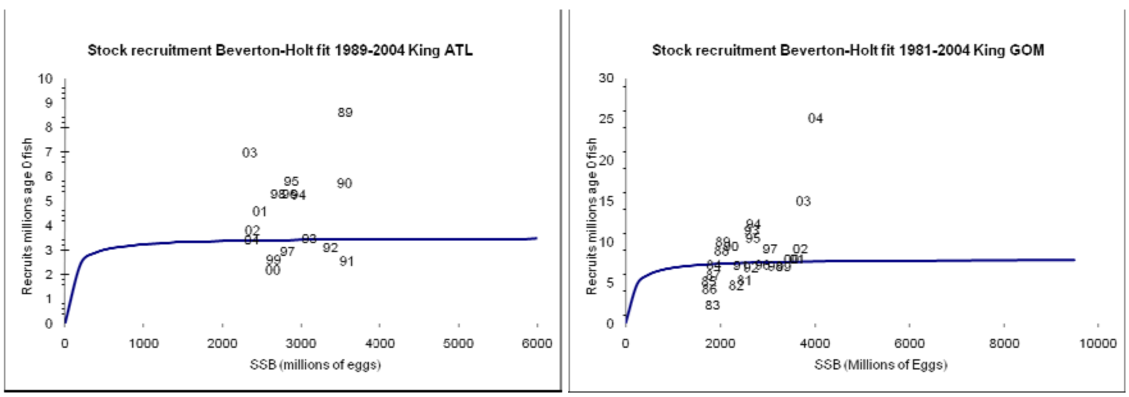



**Figure 3.20.** Beverton and Holt S-R functions fit to the results of the base models.

**Table 3.40.** Stock recruitment parameters for the base models.

| Region | Steepness | A (R0) | B (S0) | CV |
|---|---|---|---|---|
| ATL | Fixed at 0.95 | 3.46E+06 | 6453 | 0.40 |
| GULF | Fixed at 0.95 | 7.78E+06 | 11721 | 0.52 |

### 3.2.2.8. *Evaluation of Uncertainty*

To evaluate model uncertainty, 1000 bootstraps were run using the index residuals for both base and sensitivity models. The results were used to construct "phase plots" of the 2006 stock status (**Figure 3.21**). The x-axis indicates 2006 spawning stock biomass as a function of the management benchmark MSST (MSST = (1-M) *$SSB_{SPR30}$). Values less than MSST indicate that the population is overfished according to this criterion. The y-axis indicates the 2006 fishing mortality as a function of the management benchmark MFMT (= $F_{SPR30}$). Values greater than 1.0 suggest the population is experiencing overfishing according to this criterion.

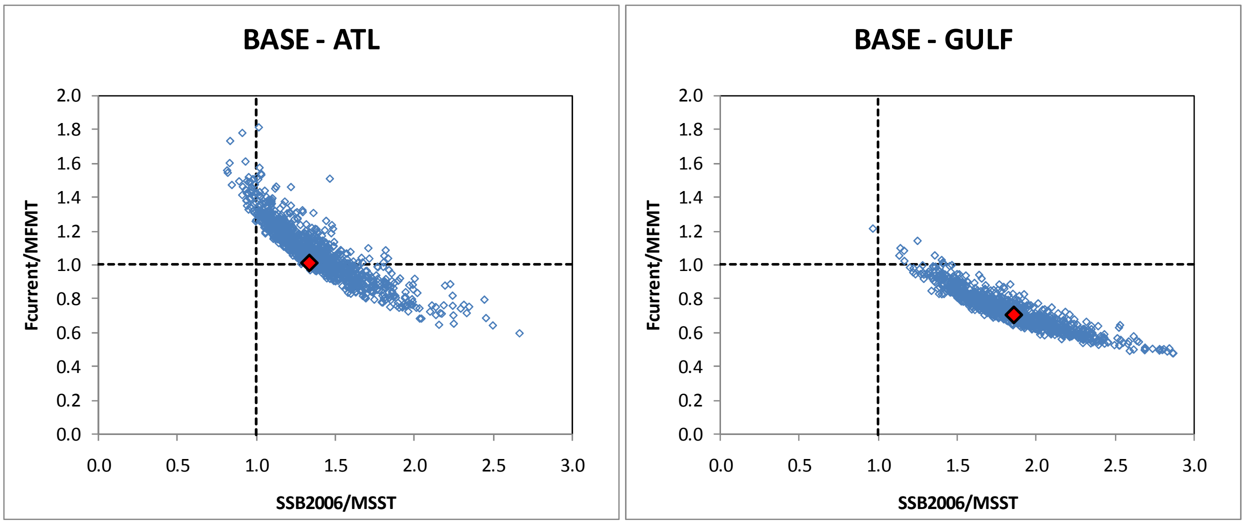



**Figure 3.21.** Phase plots of current stock status for the base The red diamond is the deterministic result, blue squares are bootstrap results.

In addition to the base runs, bootstraps analyses were completed for three sensitivity runs (**Figure 3.22**). Model inputs and settings were identical to the base case except that:

1. Sensitivity 1 was intended to examine the influence of the "Status Quo – Mixing" assumption (e.g. 100% of winter landings in mixing zone assigned to Gulf)
2. For Sensitivity 2, indices of abundance were equally weighted and each index CV was set equal to 1.0 (annual estimates of abundance weighted equally).
3. For Sensitivity 3, variance scaling parameters were estimated for each index.

The results show again that the choice of index weighting can have important implications on the perception of stock status.

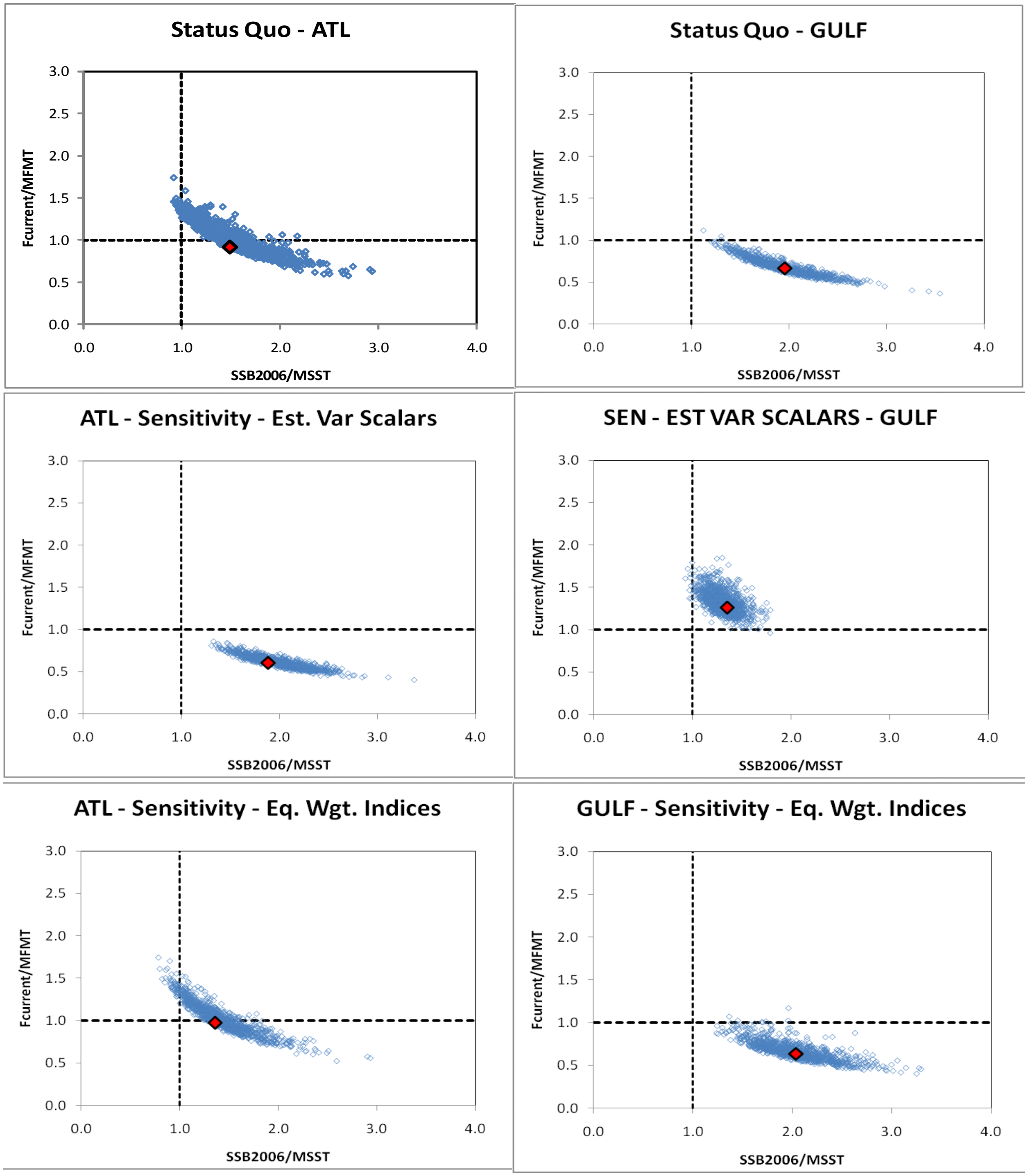



**Figure 3.22.** Phase plots of 2006 stock status from the sensitivity runs **Top:** Status Quo Mixing, **Middle:** Estimate Variance Scalars and **Bottom:** Equally Weighted Indices sensitivity runs. The red diamond is the deterministic result, black squares are bootstrap results

The bootstrap results were used to estimate the proportion of the runs that resulted in an overfished condition ($SSB_{2006}$ < MSST) and current overfishing ($F_{current}$ > MFMT). These results are summarized in **Table 3.41**. As shown in previous versions of this assessment document, the choice of how to weight the indices has a substantial impact on the perception of stock status. For example, the Gulf migratory unit's status would be assessed as undergoing overfishing with high probability if the variance scalars for the different indices were estimated, while it has a low probability of being overfished when the weighting scheme of the base case is used. See also SEDAR16-AW-09.

**Table 3.41.** Proportion of the bootstraps where $SSB_{2006}$ < MSST or $F_{current}$ > MFMT for various model runs.

| Region | Model | Prob. $SSB_{2006}$ < MSST (Overfished) | Prob. $F_{Current}$ > MFMT (Overfishing) |
|---|---|---|---|
| Atl | Base (50% - 50% Mixing) | 4.20% | 66.70% |
| | Status Quo (100% Mixing) | 2.20% | 55.30% |
| | Equal Weight Indices | 4.60% | 54.40% |
| | Estimate Variance Scalars | 0.00% | 0.00% |
| | | | |
| Gulf | Base (50% - 50% Mixing) | 0.10% | 1.00% |
| | Status Quo (100% Mixing) | 0.00% | 0.30% |
| | Equal Weight Indices | 0.00% | 0.70% |
| | Estimate Variance Scalars | 0.90% | 99.9% |

### *3.2.2.9. Benchmarks / Reference Points / ABC values*

The benchmarks and reference points for the base and sensitivity runs are summarized in **Figure 3.23** and **Tables 3.42 – 3.43**. As noted before, the results were particularly sensitive to the weighting of the indices in the VPA.

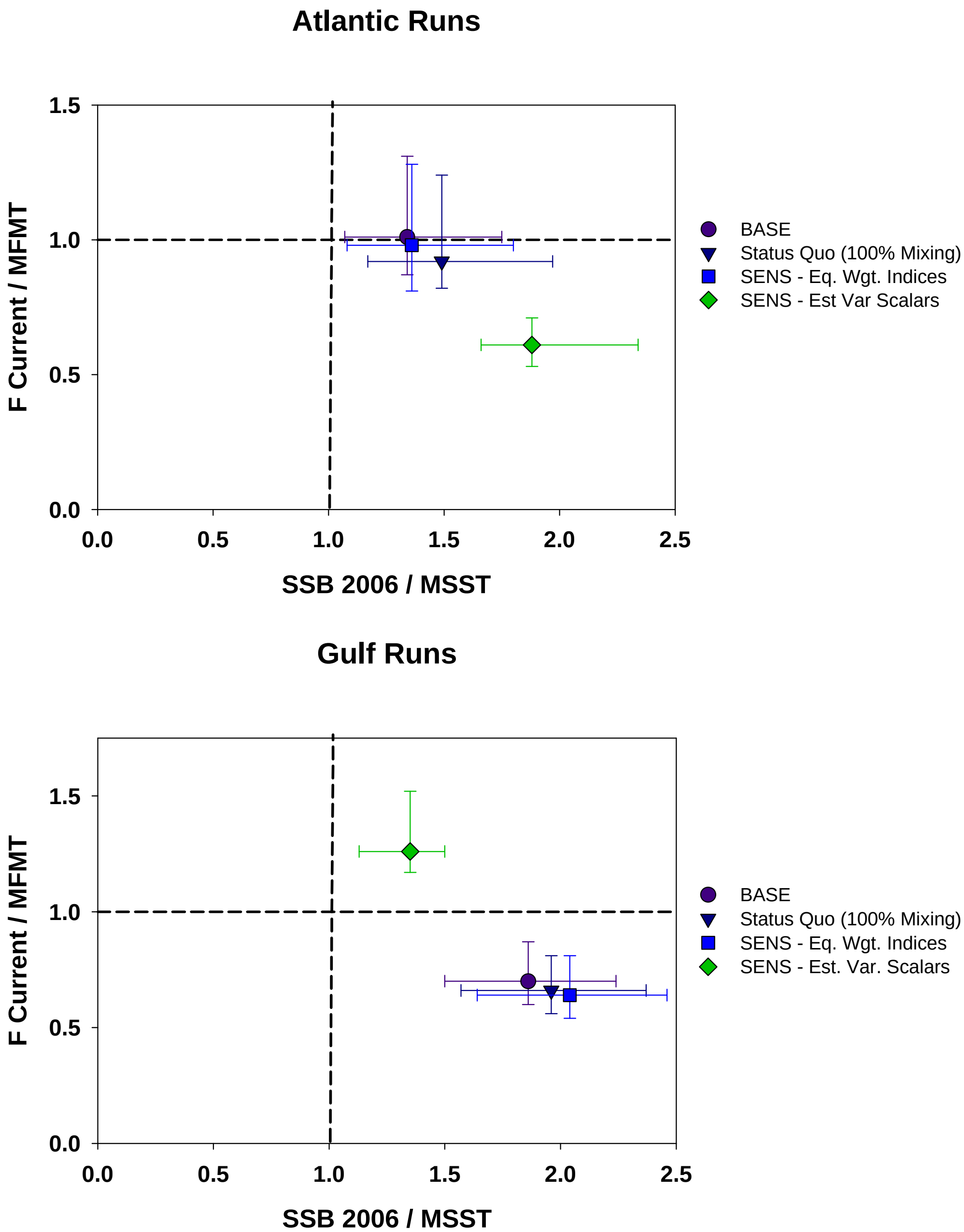



**Figure 3.23.** Phase plot showing 2006 stock status for base runs and sensitivity analyses. The errors bars indicate the 10th and 90th percentiles.

**Table 3.42.** Benchmarks / Reference Points for the Atlantic base and sensitivity runs.

| | ATL BASE - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.32 | 0.32 | 0.37 |
| F SPR40 | 0.22 | 0.22 | 0.26 |
| F 65% FSPR30 | 0.21 | - | - |
| F 75% FSPR30 | 0.24 | - | - |
| F 85% FSPR30 | 0.27 | - | - |
| Y @ SPR30 (LBS) | 8.96E+06 | 7.84E+06 | 1.17E+07 |
| S/R at F30 | 0.54 | 0.54 | 0.54 |
| S/R at F40 | 0.72 | 0.72 | 0.72 |
| S/R at 65% FSPR30 | 0.74 | - | - |
| S/R at 75% FSPR30 | 0.67 | - | - |
| S/R at 85% FSPR30 | 0.61 | - | - |
| SSB at F30 | 2176 | 2172 | 2176 |
| SSB at F40 | 2930 | 2928 | 2935 |
| SSB at 65% FSPR30 | 3029 | - | - |
| SSB at 75% FSPR30 | 2733 | - | - |
| SSB at 85% FSPR30 | 2485 | - | - |
| Y/R at F30 | 1.01 | 0.98 | 1.02 |
| Y/R at F40 | 0.90 | 0.87 | 0.92 |
| Y/R at 65% FSPR30 | 0.89 | - | - |
| Y/R at 75% FSPR30 | 0.93 | - | - |
| Y/R at 85% FSPR30 | 0.97 | - | - |
| | | | |
| M | 0.16 | 0.16 | 0.16 |
| F 2006 | 0.36 | 0.31 | 0.53 |
| F Current | 0.32 | 0.30 | 0.46 |
| SSB 2006 | 2443.0 | 1951.0 | 3203.0 |
| MFMT | 0.32 | 0.32 | 0.37 |
| MSST | 1827.5 | 1823.8 | 1827.3 |
| SSB2006/MSST | 1.34 | 1.07 | 1.75 |
| Fcurrent/MFMT | 1.01 | 0.87 | 1.31 |

| | ATL - Status Quo - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.35 | 0.35 | 0.40 |
| F SPR40 | 0.24 | 0.24 | 0.28 |
| F 65% FSPR30 | 0.23 | - | - |
| F 75% FSPR30 | 0.26 | - | - |
| F 85% FSPR30 | 0.30 | - | - |
| Y @ SPR30 (LBS) | 7.46E+06 | 6.51E+06 | 1.04E+07 |
| S/R at F30 | 0.54 | 0.54 | 0.54 |
| S/R at F40 | 0.72 | 0.72 | 0.72 |
| S/R at 65% FSPR30 | 0.74 | - | - |
| S/R at 75% FSPR30 | 0.67 | - | - |
| S/R at 85% FSPR30 | 0.61 | - | - |
| SSB at F30 | 1807 | 1804 | 1807 |
| SSB at F40 | 2432 | 2432 | 2437 |
| SSB at 65% FSPR30 | 2513 | - | - |
| SSB at 75% FSPR30 | 2267 | - | - |
| SSB at 85% FSPR30 | 2062 | - | - |
| Y/R at F30 | 1.01 | 0.99 | 1.03 |
| Y/R at F40 | 0.90 | 0.88 | 0.92 |
| Y/R at 65% FSPR30 | 0.89 | - | - |
| Y/R at 75% FSPR30 | 0.93 | - | - |
| Y/R at 85% FSPR30 | 0.97 | - | - |
| | | | |
| M | 0.16 | 0.16 | 0.16 |
| F 2006 | 0.34 | 0.31 | 0.55 |
| F Current | 0.32 | 0.31 | 0.48 |
| SSB 2006 | 2255.0 | 1766.0 | 2915.0 |
| MFMT | 0.35 | 0.35 | 0.40 |
| MSST | 1517.1 | 1514.8 | 1517.3 |
| SSB2006/MSST | 1.49 | 1.17 | 1.97 |
| Fcurrent/MFMT | 0.92 | 0.82 | 1.24 |

| | ATL - SENSITIVITY - Eq Wgt Indices - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.32 | 0.32 | 0.38 |
| F SPR40 | 0.22 | 0.22 | 0.26 |
| F 65% FSPR30 | 0.21 | - | - |
| F 75% FSPR30 | 0.24 | - | - |
| F 85% FSPR30 | 0.28 | - | - |
| Y @ SPR30 (LBS) | 9.01E+06 | 7.93E+06 | 1.19E+07 |
| S/R at F30 | 0.54 | 0.54 | 0.54 |
| S/R at F40 | 0.72 | 0.72 | 0.72 |
| S/R at 65% FSPR30 | 0.74 | - | - |
| S/R at 75% FSPR30 | 0.67 | - | - |
| S/R at 85% FSPR30 | 0.61 | - | - |
| SSB at F30 | 2191 | 2187 | 2191 |
| SSB at F40 | 2955 | 2948 | 2955 |
| SSB at 65% FSPR30 | 3050 | - | - |
| SSB at 75% FSPR30 | 2752 | - | - |
| SSB at 85% FSPR30 | 2502 | - | - |
| Y/R at F30 | 1.00 | 0.98 | 1.02 |
| Y/R at F40 | 0.90 | 0.87 | 0.92 |
| Y/R at 65% FSPR30 | 0.89 | - | - |
| Y/R at 75% FSPR30 | 0.93 | - | - |
| Y/R at 85% FSPR30 | 0.97 | - | - |
| | | | |
| M | 0.16 | 0.16 | 0.16 |
| F 2006 | 0.35 | 0.28 | 0.53 |
| F Current | 0.32 | 0.27 | 0.45 |
| SSB 2006 | 2498.0 | 1974.0 | 3375.0 |
| MFMT | 0.32 | 0.32 | 0.38 |
| MSST | 1839.7 | 1836.1 | 1839.6 |
| SSB2006/MSST | 1.36 | 1.08 | 1.80 |
| Fcurrent/MFMT | 0.98 | 0.81 | 1.28 |

| | ATL - SENSITIVITY - Est Var Scalars - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.31 | 0.30 | 0.37 |
| F SPR40 | 0.22 | 0.21 | 0.25 |
| F 65% FSPR30 | 0.20 | - | - |
| F 75% FSPR30 | 0.23 | - | - |
| F 85% FSPR30 | 0.26 | - | - |
| Y @ SPR30 (LBS) | 1.07E+07 | 9.45E+06 | 1.41E+07 |
| S/R at F30 | 0.54 | 0.54 | 0.54 |
| S/R at F40 | 0.72 | 0.72 | 0.72 |
| S/R at 65% FSPR30 | 0.76 | - | - |
| S/R at 75% FSPR30 | 0.68 | - | - |
| S/R at 85% FSPR30 | 0.62 | - | - |
| SSB at F30 | 2689 | 2686 | 2691 |
| SSB at F40 | 3623 | 3621 | 3630 |
| SSB at 65% FSPR30 | 3825 | - | - |
| SSB at 75% FSPR30 | 3434 | - | - |
| SSB at 85% FSPR30 | 3103 | - | - |
| Y/R at F30 | 0.98 | 0.96 | 0.99 |
| Y/R at F40 | 0.87 | 0.85 | 0.89 |
| Y/R at 65% FSPR30 | 0.84 | - | - |
| Y/R at 75% FSPR30 | 0.89 | - | - |
| Y/R at 85% FSPR30 | 0.93 | - | - |
| | | | |
| M | 0.16 | 0.16 | 0.16 |
| F 2006 | 0.19 | 0.17 | 0.25 |
| F Current | 0.19 | 0.17 | 0.24 |
| SSB 2006 | 4255.0 | 3742.0 | 5295.0 |
| MFMT | 0.31 | 0.30 | 0.37 |
| MSST | 2258.1 | 2255.2 | 2260.0 |
| SSB2006/MSST | 1.88 | 1.66 | 2.34 |
| Fcurrent/MFMT | 0.61 | 0.53 | 0.71 |

**Table 3.43.** Benchmarks / Reference Points for the Gulf base and sensitivity runs.

| | GULF BASE - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.25 | 0.23 | 0.29 |
| F SPR40 | 0.18 | 0.16 | 0.20 |
| F 65% FSPR30 | 0.16 | - | - |
| F 75% FSPR30 | 0.19 | - | - |
| F 85% FSPR30 | 0.21 | - | - |
| Y @ SPR30 (LBS) | 1.02E+07 | 9.28E+06 | 1.47E+07 |
| S/R at F30 | 0.45 | 0.45 | 0.46 |
| S/R at F40 | 0.61 | 0.61 | 0.61 |
| S/R at 65% FSPR30 | 0.65 | - | - |
| S/R at 75% FSPR30 | 0.58 | - | - |
| S/R at 85% FSPR30 | 0.53 | - | - |
| SSB at F30 | 2957 | 2953 | 2962 |
| SSB at F40 | 3984 | 3979 | 3993 |
| SSB at 65% FSPR30 | 4263 | - | - |
| SSB at 75% FSPR30 | 3817 | - | - |
| SSB at 85% FSPR30 | 3435 | - | - |
| Y/R at F30 | 0.71 | 0.69 | 0.76 |
| Y/R at F40 | 0.65 | 0.64 | 0.70 |
| Y/R at 65% FSPR30 | 0.63 | - | - |
| Y/R at 75% FSPR30 | 0.66 | - | - |
| Y/R at 85% FSPR30 | 0.69 | - | - |
| | | | |
| M | 0.17 | 0.17 | 0.17 |
| F 2006 | 0.22 | 0.17 | 0.29 |
| F Current | 0.17 | 0.15 | 0.24 |
| SSB 2006 | 4543.0 | 3657.0 | 5432.0 |
| MFMT | 0.25 | 0.23 | 0.29 |
| MSST | 2443.3 | 2439.8 | 2447.0 |
| SSB2006/MSST | 1.86 | 1.50 | 2.24 |
| Fcurrent/MFMT | 0.70 | 0.60 | 0.87 |

| | GULF - Status Quo - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.24 | 0.23 | 0.28 |
| F SPR40 | 0.17 | 0.16 | 0.20 |
| F 65% FSPR30 | 0.16 | - | - |
| F 75% FSPR30 | 0.18 | - | - |
| F 85% FSPR30 | 0.21 | - | - |
| Y @ SPR30 (LBS) | 1.19E+07 | 1.08E+07 | 1.72E+07 |
| S/R at F30 | 0.46 | 0.45 | 0.46 |
| S/R at F40 | 0.61 | 0.61 | 0.61 |
| S/R at 65% FSPR30 | 0.65 | - | - |
| S/R at 75% FSPR30 | 0.58 | - | - |
| S/R at 85% FSPR30 | 0.53 | - | - |
| SSB at F30 | 3434 | 3423 | 3433 |
| SSB at F40 | 4616 | 4612 | 4628 |
| SSB at 65% FSPR30 | 4968 | - | - |
| SSB at 75% FSPR30 | 4444 | - | - |
| SSB at 85% FSPR30 | 3995 | - | - |
| Y/R at F30 | 0.72 | 0.70 | 0.76 |
| Y/R at F40 | 0.65 | 0.64 | 0.70 |
| Y/R at 65% FSPR30 | 0.63 | - | - |
| Y/R at 75% FSPR30 | 0.66 | - | - |
| Y/R at 85% FSPR30 | 0.69 | - | - |
| | | | |
| M | 0.17 | 0.17 | 0.17 |
| F 2006 | 0.20 | 0.16 | 0.26 |
| F Current | 0.16 | 0.14 | 0.21 |
| SSB 2006 | 5560.0 | 4448.0 | 6655.0 |
| MFMT | 0.24 | 0.23 | 0.28 |
| MSST | 2837.5 | 2827.9 | 2836.5 |
| SSB2006/MSST | 1.96 | 1.57 | 2.37 |
| Fcurrent/MFMT | 0.66 | 0.56 | 0.81 |

| | GULF - SENSITIVITY - Eq Wgt Indices - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.27 | 0.24 | 0.31 |
| F SPR40 | 0.19 | 0.17 | 0.23 |
| F 65% FSPR30 | 0.17 | - | - |
| F 75% FSPR30 | 0.20 | - | - |
| F 85% FSPR30 | 0.23 | - | - |
| Y @ SPR30 (LBS) | 1.03E+07 | 9.06E+06 | 1.53E+07 |
| S/R at F30 | 0.45 | 0.45 | 0.46 |
| S/R at F40 | 0.61 | 0.61 | 0.61 |
| S/R at 65% FSPR30 | 0.66 | - | - |
| S/R at 75% FSPR30 | 0.59 | - | - |
| S/R at 85% FSPR30 | 0.53 | - | - |
| SSB at F30 | 3129 | 3128 | 3137 |
| SSB at F40 | 4228 | 4214 | 4228 |
| SSB at 65% FSPR30 | 4616 | - | - |
| SSB at 75% FSPR30 | 4112 | - | - |
| SSB at 85% FSPR30 | 3677 | - | - |
| Y/R at F30 | 0.68 | 0.64 | 0.72 |
| Y/R at F40 | 0.61 | 0.58 | 0.65 |
| Y/R at 65% FSPR30 | 0.59 | - | - |
| Y/R at 75% FSPR30 | 0.62 | - | - |
| Y/R at 85% FSPR30 | 0.65 | - | - |
| | | | |
| M | 0.17 | 0.17 | 0.17 |
| F 2006 | 0.23 | 0.19 | 0.36 |
| F Current | 0.17 | 0.14 | 0.24 |
| SSB 2006 | 5268.0 | 4257.0 | 6360.0 |
| MFMT | 0.27 | 0.24 | 0.31 |
| MSST | 2585.6 | 2584.1 | 2592.0 |
| SSB2006/MSST | 2.04 | 1.64 | 2.46 |
| Fcurrent/MFMT | 0.64 | 0.54 | 0.81 |

| | GULF - SENSITIVITY - Est Var Scalars - No Rec. Patch | | |
|---|---|---|---|
| MEASURE | Determ. Run | LOWER 80% CI | UPPER 80% CI |
| F SPR30 | 0.27 | 0.27 | 0.33 |
| F SPR40 | 0.20 | 0.20 | 0.24 |
| F 65% FSPR30 | 0.18 | - | - |
| F 75% FSPR30 | 0.21 | - | - |
| F 85% FSPR30 | 0.23 | - | - |
| Y @ SPR30 (LBS) | 9.14E+06 | 7.83E+06 | 1.28E+07 |
| S/R at F30 | 0.45 | 0.45 | 0.46 |
| S/R at F40 | 0.61 | 0.61 | 0.61 |
| S/R at 65% FSPR30 | 0.66 | - | - |
| S/R at 75% FSPR30 | 0.63 | - | - |
| S/R at 85% FSPR30 | 0.53 | - | - |
| SSB at F30 | 2736 | 2731 | 2738 |
| SSB at F40 | 3692 | 3679 | 3691 |
| SSB at 65% FSPR30 | 4054 | - | - |
| SSB at 75% FSPR30 | 3823 | - | - |
| SSB at 85% FSPR30 | 3222 | - | - |
| Y/R at F30 | 0.69 | 0.66 | 0.73 |
| Y/R at F40 | 0.62 | 0.59 | 0.65 |
| Y/R at 65% FSPR30 | 0.59 | - | - |
| Y/R at 75% FSPR30 | 0.61 | - | - |
| Y/R at 85% FSPR30 | 0.65 | - | - |
| | | | |
| M | 0.17 | 0.17 | 0.17 |
| F 2006 | 0.63 | 0.60 | 0.90 |
| F Current | 0.35 | 0.34 | 0.47 |
| SSB 2006 | 3053.0 | 2557.0 | 3382.0 |
| MFMT | 0.27 | 0.27 | 0.33 |
| MSST | 2260.2 | 2256.1 | 2262.5 |
| SSB2006/MSST | 1.35 | 1.13 | 1.50 |
| Fcurrent/MFMT | 1.26 | 1.17 | 1.52 |

### *3.2.2.10. Projections Base Case (TOR 8C)*

Projection results are summarized for the Atlantic and Gulf base cases, 2006-2016, in **Figures 3.24 - 3.25** and **Tables 3.44-3.45**. Projections for the Gulf are extremely optimistic, as a result of several very strong year-classes that are estimated in the VPA during the last few years. It is noted elsewhere in this document that the choice of weighting of the indices has a substantial impact on the perception of stock status. As noted in SEDAR16-AW-09, the choice of weighting also has a substantial impact on the estimates of recruitment during the last few years, in terms of fitting well or fitting poorly the SEAMAP groundfish trawl survey for the last few years.

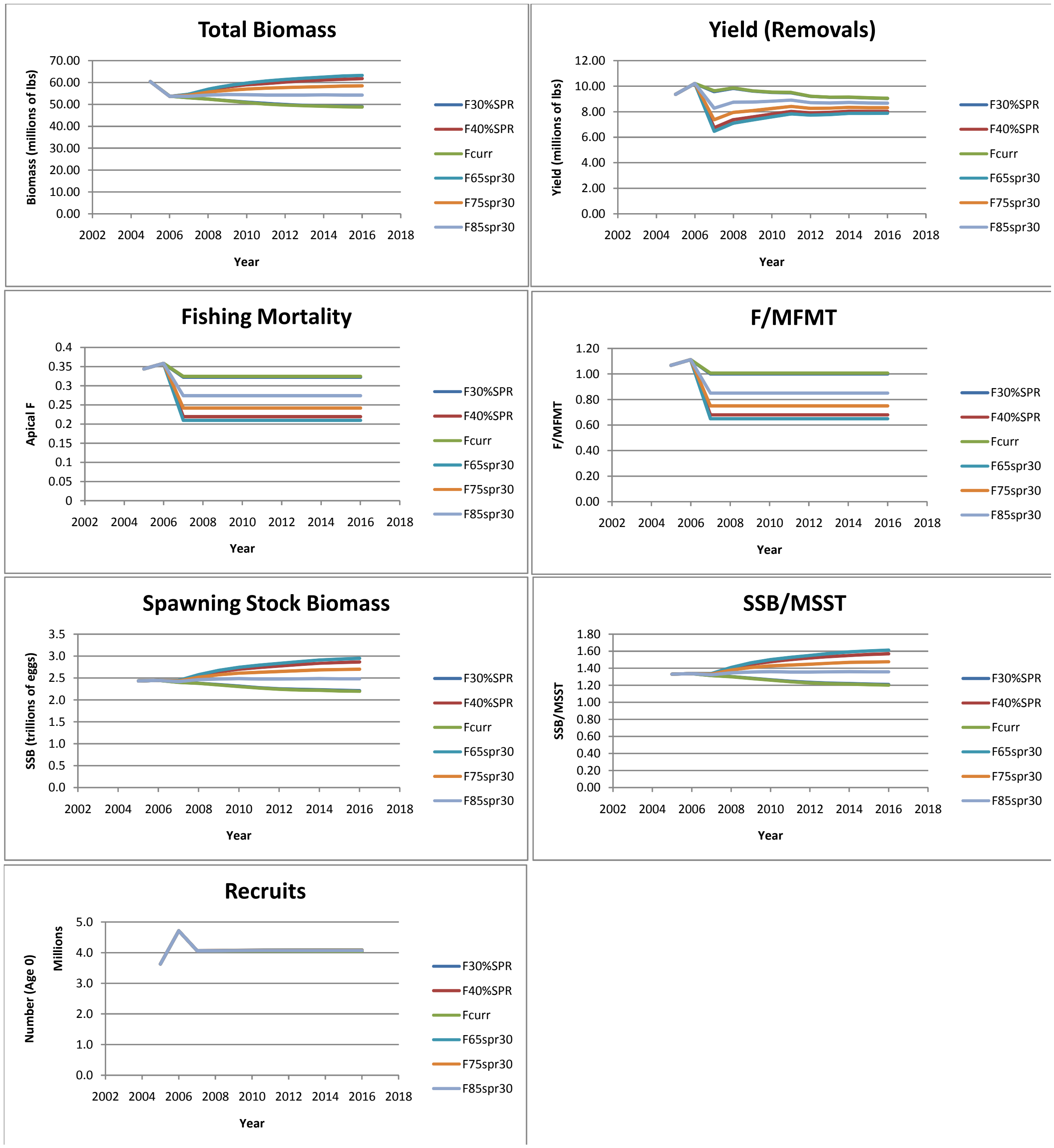



**Figure 3.24.** Projections results for the Atlantic base.

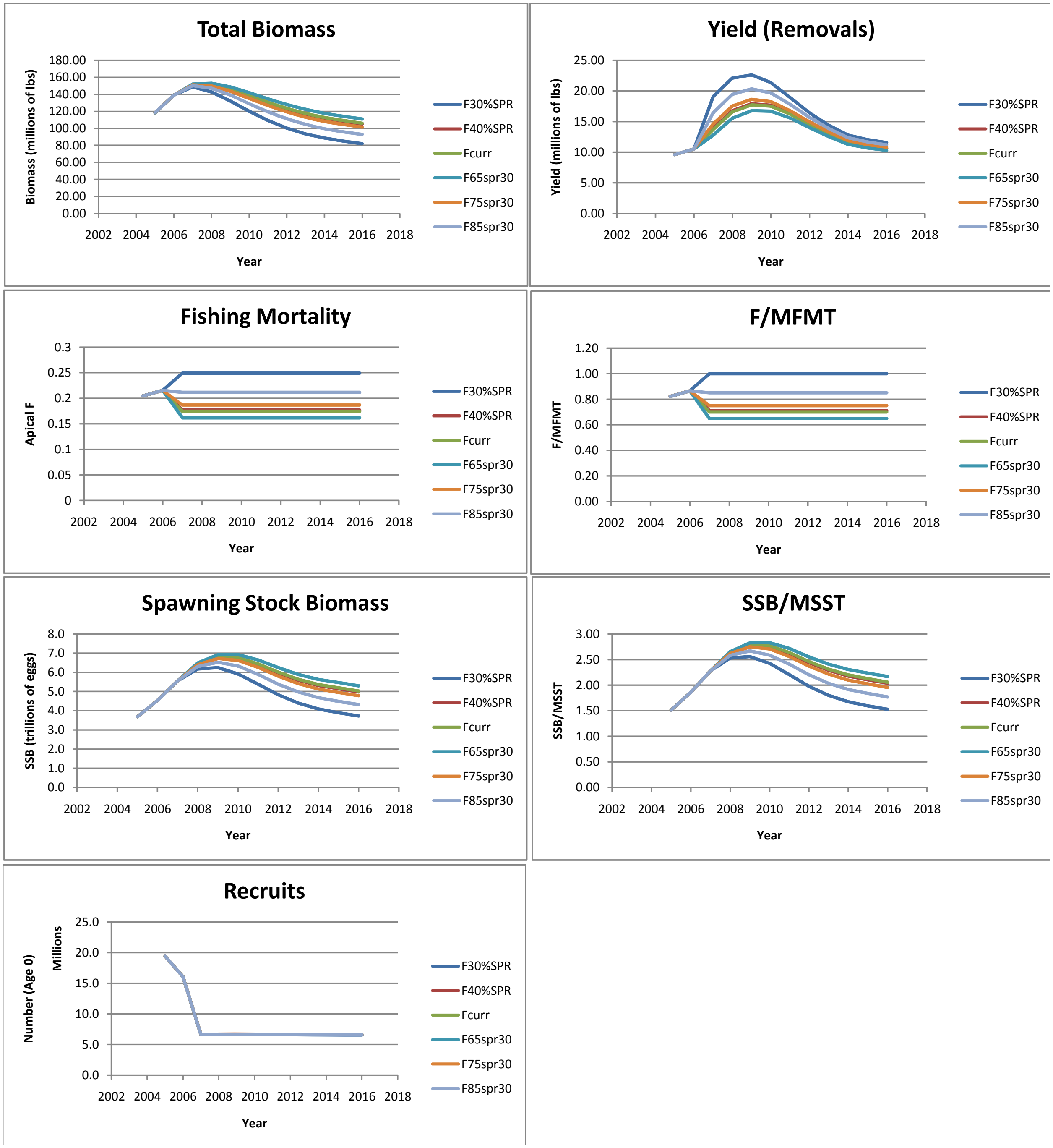



**Figure 3.25.** Projections results for the Gulf base case.

| **Table 3.44.** Projections results for the Atlantic base | **YEAR** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **TOTAL BIOMASS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 60.38 | 53.68 | 53.02 | 52.45 | 51.70 | 50.95 | 50.27 | 49.85 | 49.54 | 49.32 | 49.12 | 48.96 |
| F40%SPR | 60.38 | 53.68 | 54.50 | 56.53 | 57.96 | 58.89 | 59.52 | 60.16 | 60.69 | 61.13 | 61.44 | 61.71 |
| Fcurr | 60.38 | 53.68 | 53.00 | 52.36 | 51.59 | 50.79 | 50.09 | 49.65 | 49.34 | 49.12 | 48.90 | 48.74 |
| F65spr30 | 60.38 | 53.68 | 54.63 | 56.92 | 58.60 | 59.75 | 60.56 | 61.35 | 61.97 | 62.52 | 62.92 | 63.23 |
| F75spr30 | 60.38 | 53.68 | 54.17 | 55.60 | 56.50 | 57.01 | 57.30 | 57.63 | 57.92 | 58.16 | 58.31 | 58.44 |
| F85spr30 | 60.38 | 53.68 | 53.70 | 54.30 | 54.50 | 54.45 | 54.30 | 54.28 | 54.28 | 54.32 | 54.28 | 54.28 |
| **FISHING MORTALITY** | | | | | | | | | | | | |
| F30%SPR | 0.34 | 0.36 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| F40%SPR | 0.34 | 0.36 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| Fcurr | 0.34 | 0.36 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| F65spr30 | 0.34 | 0.36 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| F75spr30 | 0.34 | 0.36 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| F85spr30 | 0.34 | 0.36 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 |
| **RECRUITS** | | | | | | | | | | | | |
| F30%SPR | 3.63E+06 | 4.71E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 |
| F40%SPR | 3.63E+06 | 4.71E+06 | 4.06E+06 | 4.07E+06 | 4.07E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 |
| Fcurr | 3.63E+06 | 4.71E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 | 4.05E+06 |
| F65spr30 | 3.63E+06 | 4.71E+06 | 4.06E+06 | 4.07E+06 | 4.07E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 | 4.09E+06 | 4.09E+06 | 4.09E+06 |
| F75spr30 | 3.63E+06 | 4.71E+06 | 4.06E+06 | 4.07E+06 | 4.07E+06 | 4.07E+06 | 4.07E+06 | 4.07E+06 | 4.07E+06 | 4.08E+06 | 4.08E+06 | 4.08E+06 |
| F85spr30 | 3.63E+06 | 4.71E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 | 4.06E+06 |
| **SSB** | | | | | | | | | | | | |
| F30%SPR | 2433 | 2443 | 2401 | 2381 | 2346 | 2311 | 2277 | 2252 | 2237 | 2229 | 2216 | 2208 |
| F40%SPR | 2433 | 2443 | 2440 | 2558 | 2642 | 2701 | 2741 | 2775 | 2807 | 2837 | 2853 | 2867 |
| Fcurr | 2433 | 2443 | 2400 | 2377 | 2340 | 2304 | 2269 | 2243 | 2227 | 2218 | 2205 | 2196 |
| F65spr30 | 2433 | 2443 | 2444 | 2576 | 2673 | 2743 | 2792 | 2834 | 2873 | 2909 | 2928 | 2947 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F75spr30 | 2433 | 2443 | 2432 | 2518 | 2574 | 2609 | 2629 | 2647 | 2665 | 2684 | 2691 | 2698 |
| F85spr30 | 2433 | 2443 | 2419 | 2462 | 2479 | 2484 | 2479 | 2477 | 2480 | 2485 | 2482 | 2482 |
| **YIELD REMOVALS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 9.35 | 10.20 | 9.57 | 9.81 | 9.60 | 9.50 | 9.48 | 9.20 | 9.12 | 9.12 | 9.07 | 9.03 |
| F40%SPR | 9.35 | 10.20 | 6.74 | 7.37 | 7.59 | 7.81 | 8.02 | 7.90 | 7.93 | 8.02 | 8.01 | 8.02 |
| Fcurr | 9.35 | 10.20 | 9.63 | 9.86 | 9.64 | 9.53 | 9.50 | 9.22 | 9.14 | 9.14 | 9.08 | 9.05 |
| F65spr30 | 9.35 | 10.20 | 6.46 | 7.10 | 7.35 | 7.60 | 7.83 | 7.73 | 7.77 | 7.86 | 7.86 | 7.87 |
| F75spr30 | 9.35 | 10.20 | 7.37 | 7.95 | 8.09 | 8.25 | 8.42 | 8.26 | 8.27 | 8.34 | 8.32 | 8.32 |
| F85spr30 | 9.35 | 10.20 | 8.27 | 8.73 | 8.75 | 8.81 | 8.90 | 8.70 | 8.67 | 8.71 | 8.68 | 8.66 |
| **F/MFMT** | | | | | | | | | | | | |
| F30%SPR | 1.07 | 1.11 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F40%SPR | 1.07 | 1.11 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 |
| Fcurr | 1.07 | 1.11 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| F65spr30 | 1.07 | 1.11 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| F75spr30 | 1.07 | 1.11 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| F85spr30 | 1.07 | 1.11 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| **SSB/MSST** | | | | | | | | | | | | |
| F30%SPR | 1.33 | 1.34 | 1.31 | 1.30 | 1.28 | 1.26 | 1.25 | 1.23 | 1.22 | 1.22 | 1.21 | 1.21 |
| F40%SPR | 1.33 | 1.34 | 1.34 | 1.40 | 1.45 | 1.48 | 1.50 | 1.52 | 1.54 | 1.55 | 1.56 | 1.57 |
| Fcurr | 1.33 | 1.34 | 1.31 | 1.30 | 1.28 | 1.26 | 1.24 | 1.23 | 1.22 | 1.21 | 1.21 | 1.20 |
| F65spr30 | 1.33 | 1.34 | 1.34 | 1.41 | 1.46 | 1.50 | 1.53 | 1.55 | 1.57 | 1.59 | 1.60 | 1.61 |
| F75spr30 | 1.33 | 1.34 | 1.33 | 1.38 | 1.41 | 1.43 | 1.44 | 1.45 | 1.46 | 1.47 | 1.47 | 1.48 |
| F85spr30 | 1.33 | 1.34 | 1.32 | 1.35 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 |

**Table 3.45.** Projections results for the Gulf base .

| | YEAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **TOTAL BIOMASS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 118.21 | 138.94 | 148.75 | 142.79 | 132.17 | 120.13 | 109.19 | 100.13 | 93.39 | 88.47 | 84.83 | 81.84 |
| F40%SPR | 118.21 | 138.94 | 151.37 | 150.99 | 145.66 | 137.88 | 129.83 | 122.38 | 116.47 | 111.82 | 108.11 | 104.92 |
| Fcurr | 118.21 | 138.94 | 151.46 | 151.30 | 146.17 | 138.56 | 130.65 | 123.28 | 117.40 | 112.77 | 109.08 | 105.89 |
| F65spr30 | 118.21 | 138.94 | 151.92 | 152.80 | 148.70 | 142.00 | 134.75 | 127.82 | 122.22 | 117.73 | 114.09 | 110.89 |
| F75spr30 | 118.21 | 138.94 | 151.02 | 149.85 | 143.74 | 135.30 | 126.77 | 119.03 | 112.92 | 108.20 | 104.48 | 101.28 |
| F85spr30 | 118.21 | 138.94 | 150.09 | 146.98 | 138.96 | 128.97 | 119.36 | 110.98 | 104.52 | 99.65 | 95.92 | 92.79 |
| **FISHING MORTALITY** | | | | | | | | | | | | |
| F30%SPR | 0.20 | 0.22 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| F40%SPR | 0.20 | 0.22 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Fcurr | 0.20 | 0.22 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| F65spr30 | 0.20 | 0.22 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| F75spr30 | 0.20 | 0.22 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| F85spr30 | 0.20 | 0.22 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| **RECRUITS** | | | | | | | | | | | | |
| F30%SPR | 1.94E+07 | 1.61E+07 | 6.64E+06 | 6.65E+06 | 6.66E+06 | 6.65E+06 | 6.63E+06 | 6.61E+06 | 6.60E+06 | 6.58E+06 | 6.57E+06 | 6.56E+06 |
| F40%SPR | 1.94E+07 | 1.61E+07 | 6.64E+06 | 6.66E+06 | 6.67E+06 | 6.67E+06 | 6.66E+06 | 6.65E+06 | 6.64E+06 | 6.63E+06 | 6.63E+06 | 6.62E+06 |
| Fcurr | 1.94E+07 | 1.61E+07 | 6.64E+06 | 6.66E+06 | 6.67E+06 | 6.67E+06 | 6.66E+06 | 6.65E+06 | 6.64E+06 | 6.63E+06 | 6.63E+06 | 6.62E+06 |
| F65spr30 | 1.94E+07 | 1.61E+07 | 6.64E+06 | 6.66E+06 | 6.67E+06 | 6.67E+06 | 6.66E+06 | 6.66E+06 | 6.65E+06 | 6.64E+06 | 6.64E+06 | 6.63E+06 |
| F75spr30 | 1.94E+07 | 1.61E+07 | 6.64E+06 | 6.66E+06 | 6.67E+06 | 6.66E+06 | 6.66E+06 | 6.64E+06 | 6.63E+06 | 6.63E+06 | 6.62E+06 | 6.61E+06 |
| F85spr30 | 1.94E+07 | 1.61E+07 | 6.64E+06 | 6.66E+06 | 6.66E+06 | 6.66E+06 | 6.65E+06 | 6.63E+06 | 6.62E+06 | 6.61E+06 | 6.60E+06 | 6.59E+06 |
| **SSB** | | | | | | | | | | | | |
| F30%SPR | 3690 | 4543 | 5557 | 6177 | 6246 | 5919 | 5384 | 4829 | 4395 | 4089 | 3892 | 3726 |
| F40%SPR | 3690 | 4543 | 5557 | 6431 | 6792 | 6731 | 6399 | 5963 | 5592 | 5317 | 5140 | 4974 |
| Fcurr | 3690 | 4543 | 5557 | 6440 | 6812 | 6762 | 6438 | 6008 | 5640 | 5368 | 5192 | 5026 |
| F65spr30 | 3690 | 4543 | 5557 | 6485 | 6914 | 6918 | 6638 | 6238 | 5889 | 5628 | 5462 | 5299 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F75spr30 | 3690 | 4543 | 5557 | 6395 | 6715 | 6614 | 6249 | 5792 | 5409 | 5127 | 4945 | 4777 |
| F85spr30 | 3690 | 4543 | 5557 | 6307 | 6523 | 6325 | 5886 | 5383 | 4974 | 4677 | 4486 | 4317 |
| **YIELD REMOVALS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 9.61 | 10.52 | 19.11 | 22.09 | 22.62 | 21.34 | 18.92 | 16.42 | 14.39 | 12.80 | 12.06 | 11.56 |
| F40%SPR | 9.61 | 10.52 | 13.90 | 16.76 | 17.90 | 17.66 | 16.32 | 14.59 | 13.03 | 11.69 | 11.07 | 10.64 |
| Fcurr | 9.61 | 10.52 | 13.71 | 16.56 | 17.71 | 17.50 | 16.20 | 14.50 | 12.96 | 11.63 | 11.01 | 10.59 |
| F65spr30 | 9.61 | 10.52 | 12.78 | 15.54 | 16.75 | 16.68 | 15.56 | 14.00 | 12.56 | 11.29 | 10.70 | 10.30 |
| F75spr30 | 9.61 | 10.52 | 14.62 | 17.53 | 18.61 | 18.25 | 16.77 | 14.93 | 13.30 | 11.91 | 11.27 | 10.83 |
| F85spr30 | 9.61 | 10.52 | 16.44 | 19.42 | 20.32 | 19.62 | 17.77 | 15.66 | 13.85 | 12.37 | 11.68 | 11.21 |
| **F/MFMT** | | | | | | | | | | | | |
| F30%SPR | 0.82 | 0.87 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F40%SPR | 0.82 | 0.87 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 |
| Fcurr | 0.82 | 0.87 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 |
| F65spr30 | 0.82 | 0.87 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| F75spr30 | 0.82 | 0.87 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| F85spr30 | 0.82 | 0.87 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| **SSB/MSST** | | | | | | | | | | | | |
| F30%SPR | 1.51 | 1.86 | 2.27 | 2.53 | 2.56 | 2.42 | 2.20 | 1.98 | 1.80 | 1.67 | 1.59 | 1.53 |
| F40%SPR | 1.51 | 1.86 | 2.27 | 2.63 | 2.78 | 2.75 | 2.62 | 2.44 | 2.29 | 2.18 | 2.10 | 2.04 |
| Fcurr | 1.51 | 1.86 | 2.27 | 2.64 | 2.79 | 2.77 | 2.63 | 2.46 | 2.31 | 2.20 | 2.13 | 2.06 |
| F65spr30 | 1.51 | 1.86 | 2.27 | 2.65 | 2.83 | 2.83 | 2.72 | 2.55 | 2.41 | 2.30 | 2.24 | 2.17 |
| F75spr30 | 1.51 | 1.86 | 2.27 | 2.62 | 2.75 | 2.71 | 2.56 | 2.37 | 2.21 | 2.10 | 2.02 | 1.96 |
| F85spr30 | 1.51 | 1.86 | 2.27 | 2.58 | 2.67 | 2.59 | 2.41 | 2.20 | 2.04 | 1.91 | 1.84 | 1.77 |

### *3.2.2.11. Projections for the Status Quo case (TOR 8B)*

Projection results are summarized for the Atlantic and Gulf status quo cases (where 100% of the fish in the mixing zone in the winter are assumed to belong to the Gulf migratory unit), 2006-2016, in **Figures 3.26 - 3.27** and **Tables 3.46-3.47**. Again, projections for the Gulf are extremely optimistic as a result of very strong yearclasses that are estimated by the VPA in recent years.

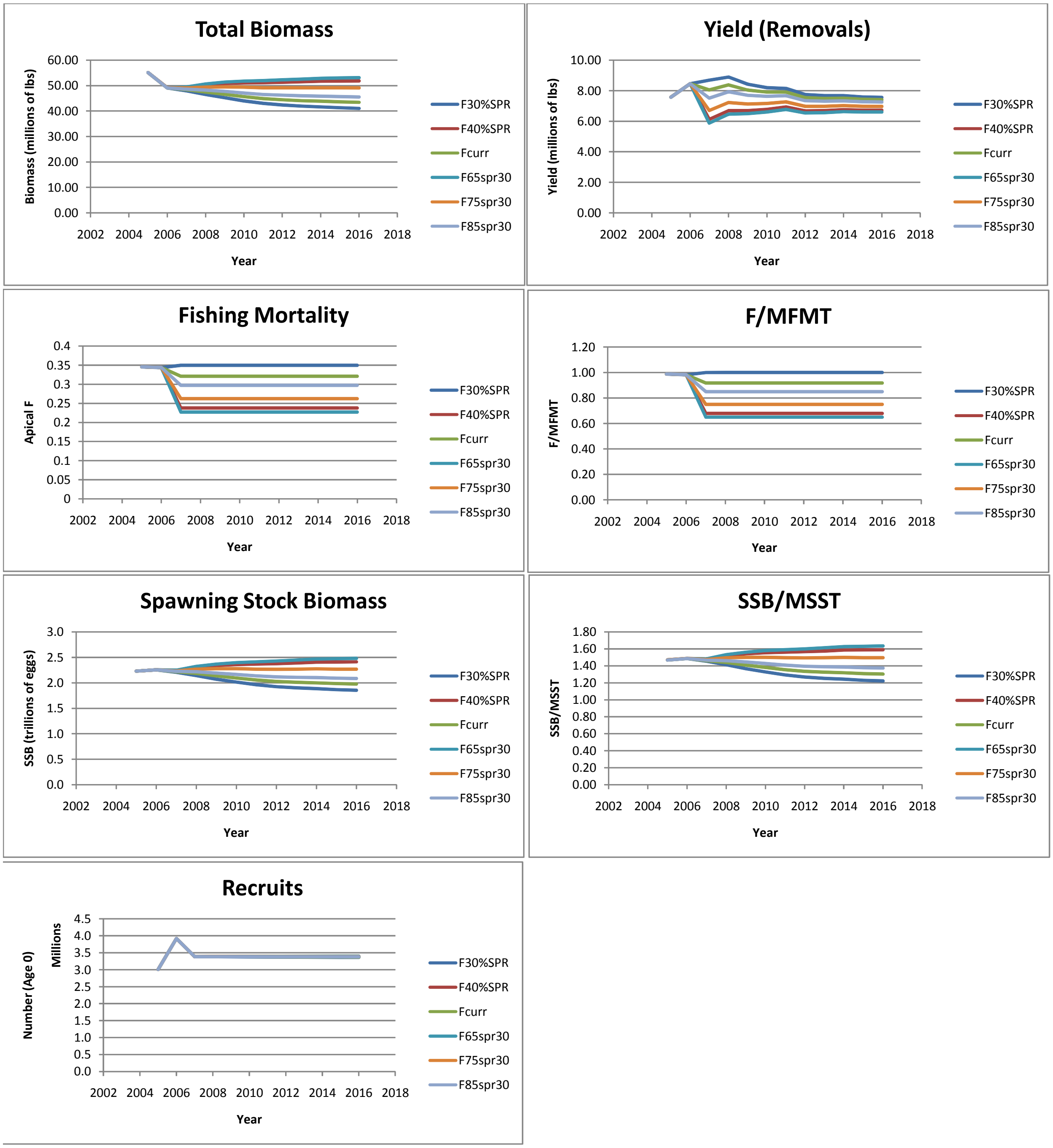



**Figure 3.26**. Projection results for the status quo case, Atlantic.

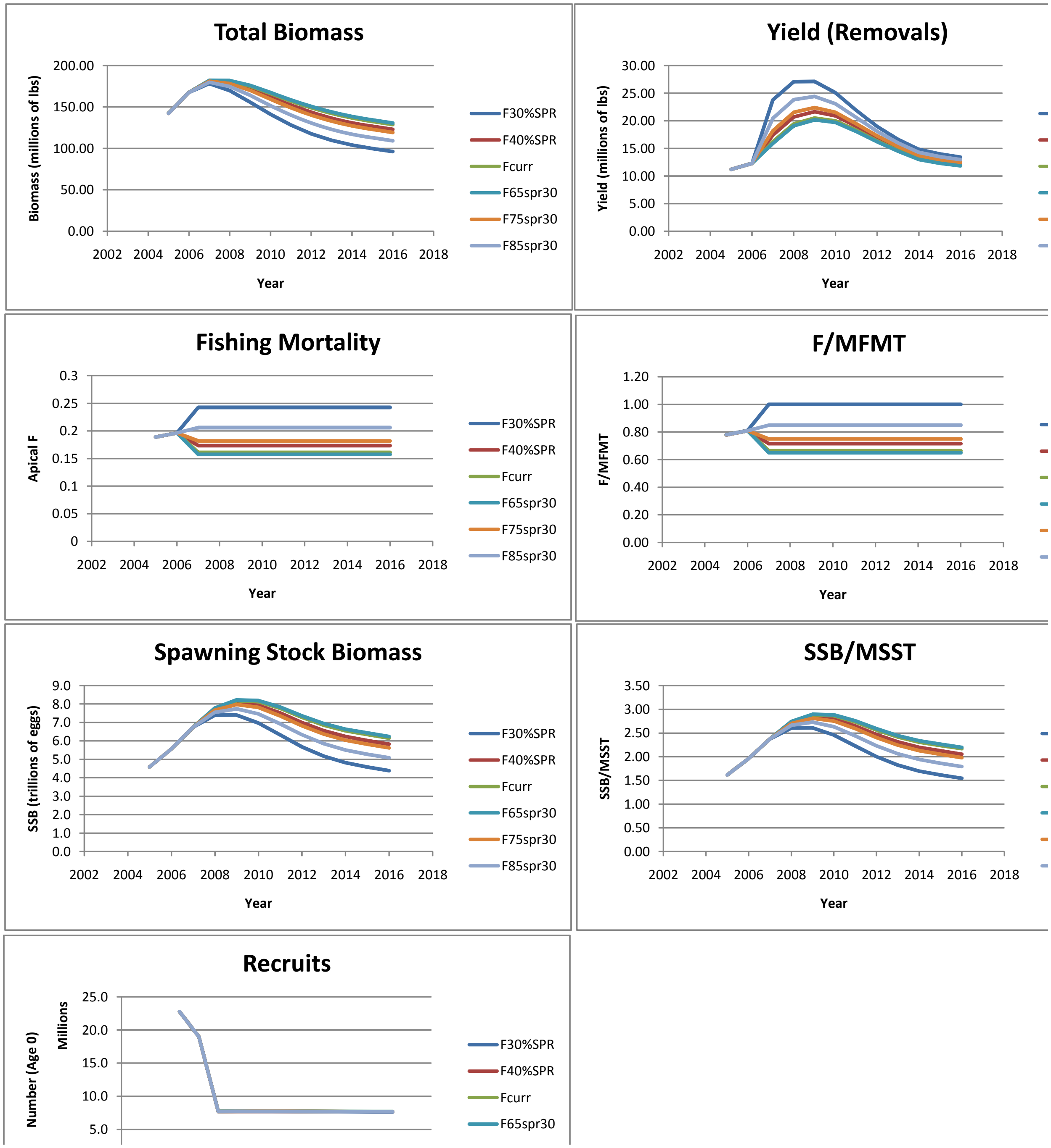



**Figure 3.27**. Projection results for the status quo case, Gulf.

**Table 3.46.** Projections results for the Atlantic status quo case

| | YEAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **TOTAL BIOMASS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 55.14 | 49.12 | 48.04 | 46.56 | 45.22 | 44.05 | 43.06 | 42.42 | 41.95 | 41.62 | 41.31 | 41.07 |
| F40%SPR | 55.14 | 49.12 | 49.36 | 50.24 | 50.79 | 51.04 | 51.10 | 51.32 | 51.50 | 51.70 | 51.76 | 51.85 |
| Fcurr | 55.14 | 49.12 | 48.37 | 47.49 | 46.56 | 45.70 | 44.91 | 44.45 | 44.09 | 43.85 | 43.61 | 43.43 |
| F65spr30 | 55.14 | 49.12 | 49.47 | 50.62 | 51.37 | 51.79 | 51.99 | 52.32 | 52.58 | 52.87 | 53.00 | 53.13 |
| F75spr30 | 55.14 | 49.12 | 49.05 | 49.41 | 49.49 | 49.36 | 49.14 | 49.10 | 49.10 | 49.14 | 49.10 | 49.07 |
| F85spr30 | 55.14 | 49.12 | 48.63 | 48.24 | 47.71 | 47.11 | 46.54 | 46.23 | 46.01 | 45.86 | 45.68 | 45.55 |
| **FISHING MORTALITY** | | | | | | | | | | | | |
| F30%SPR | 0.35 | 0.34 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| F40%SPR | 0.35 | 0.34 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| Fcurr | 0.35 | 0.34 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| F65spr30 | 0.35 | 0.34 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 |
| F75spr30 | 0.35 | 0.34 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 | 0.26 |
| F85spr30 | 0.35 | 0.34 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| **RECRUITS** | | | | | | | | | | | | |
| F30%SPR | 3.01E+06 | 3.92E+06 | 3.39E+06 | 3.38E+06 | 3.38E+06 | 3.37E+06 | 3.37E+06 | 3.37E+06 | 3.37E+06 | 3.36E+06 | 3.36E+06 | 3.36E+06 |
| F40%SPR | 3.01E+06 | 3.92E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 |
| Fcurr | 3.01E+06 | 3.92E+06 | 3.39E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 | 3.37E+06 | 3.37E+06 | 3.37E+06 | 3.37E+06 | 3.37E+06 |
| F65spr30 | 3.01E+06 | 3.92E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.40E+06 | 3.40E+06 | 3.40E+06 | 3.40E+06 |
| F75spr30 | 3.01E+06 | 3.92E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 | 3.39E+06 |
| F85spr30 | 3.01E+06 | 3.92E+06 | 3.39E+06 | 3.39E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 | 3.38E+06 |
| **SSB** | | | | | | | | | | | | |
| F30%SPR | 2230 | 2255 | 2208 | 2144 | 2073 | 2014 | 1962 | 1924 | 1901 | 1885 | 1867 | 1854 |
| F40%SPR | 2230 | 2255 | 2244 | 2306 | 2339 | 2359 | 2367 | 2376 | 2389 | 2405 | 2408 | 2412 |
| Fcurr | 2230 | 2255 | 2217 | 2184 | 2137 | 2095 | 2056 | 2027 | 2010 | 2000 | 1986 | 1976 |
| F65spr30 | 2230 | 2255 | 2248 | 2322 | 2366 | 2396 | 2411 | 2426 | 2445 | 2465 | 2471 | 2478 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F75spr30 | 2230 | 2255 | 2236 | 2269 | 2277 | 2277 | 2268 | 2264 | 2267 | 2273 | 2269 | 2268 |
| F85spr30 | 2230 | 2255 | 2225 | 2218 | 2192 | 2166 | 2137 | 2117 | 2108 | 2104 | 2092 | 2085 |
| **YIELD REMOVALS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 7.58 | 8.45 | 8.69 | 8.90 | 8.42 | 8.21 | 8.15 | 7.76 | 7.68 | 7.67 | 7.60 | 7.56 |
| F40%SPR | 7.58 | 8.45 | 6.12 | 6.70 | 6.69 | 6.78 | 6.93 | 6.68 | 6.70 | 6.76 | 6.72 | 6.72 |
| Fcurr | 7.58 | 8.45 | 8.05 | 8.38 | 8.04 | 7.91 | 7.91 | 7.55 | 7.50 | 7.50 | 7.44 | 7.41 |
| F65spr30 | 7.58 | 8.45 | 5.88 | 6.46 | 6.49 | 6.61 | 6.78 | 6.54 | 6.56 | 6.63 | 6.60 | 6.60 |
| F75spr30 | 7.58 | 8.45 | 6.70 | 7.22 | 7.13 | 7.16 | 7.27 | 6.98 | 6.98 | 7.02 | 6.98 | 6.97 |
| F85spr30 | 7.58 | 8.45 | 7.51 | 7.93 | 7.70 | 7.63 | 7.68 | 7.34 | 7.31 | 7.33 | 7.28 | 7.26 |
| **F/MFMT** | | | | | | | | | | | | |
| F30%SPR | 0.99 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F40%SPR | 0.99 | 0.98 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 |
| Fcurr | 0.99 | 0.98 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| F65spr30 | 0.99 | 0.98 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| F75spr30 | 0.99 | 0.98 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| F85spr30 | 0.99 | 0.98 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| **SSB/MSST** | | | | | | | | | | | | |
| F30%SPR | 1.47 | 1.49 | 1.46 | 1.41 | 1.37 | 1.33 | 1.29 | 1.27 | 1.25 | 1.24 | 1.23 | 1.22 |
| F40%SPR | 1.47 | 1.49 | 1.48 | 1.52 | 1.54 | 1.55 | 1.56 | 1.57 | 1.57 | 1.59 | 1.59 | 1.59 |
| Fcurr | 1.47 | 1.49 | 1.46 | 1.44 | 1.41 | 1.38 | 1.36 | 1.34 | 1.32 | 1.32 | 1.31 | 1.30 |
| F65spr30 | 1.47 | 1.49 | 1.48 | 1.53 | 1.56 | 1.58 | 1.59 | 1.60 | 1.61 | 1.62 | 1.63 | 1.63 |
| F75spr30 | 1.47 | 1.49 | 1.47 | 1.50 | 1.50 | 1.50 | 1.49 | 1.49 | 1.49 | 1.50 | 1.50 | 1.49 |
| F85spr30 | 1.47 | 1.49 | 1.47 | 1.46 | 1.44 | 1.43 | 1.41 | 1.40 | 1.39 | 1.39 | 1.38 | 1.37 |

**Table 3.47.** Projections results for the Gulf status quo case

| | YEAR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| **TOTAL BIOMASS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 142.44 | 167.51 | 178.29 | 169.78 | 156.04 | 141.29 | 128.33 | 117.77 | 109.92 | 104.17 | 99.91 | 96.39 |
| F40%SPR | 142.44 | 167.51 | 181.51 | 179.68 | 172.16 | 162.24 | 152.45 | 143.61 | 136.60 | 131.11 | 126.79 | 123.00 |
| Fcurr | 142.44 | 167.51 | 182.10 | 181.57 | 175.31 | 166.43 | 157.41 | 149.05 | 142.33 | 136.97 | 132.70 | 128.90 |
| F65spr30 | 142.44 | 167.51 | 182.26 | 182.06 | 176.15 | 167.57 | 158.75 | 150.53 | 143.90 | 138.60 | 134.33 | 130.54 |
| F75spr30 | 142.44 | 167.51 | 181.11 | 178.44 | 170.09 | 159.50 | 149.23 | 140.13 | 132.94 | 127.38 | 123.02 | 119.25 |
| F85spr30 | 142.44 | 167.51 | 179.96 | 174.89 | 164.29 | 151.90 | 140.41 | 130.58 | 123.04 | 117.33 | 112.96 | 109.26 |
| **FISHING MORTALITY** | | | | | | | | | | | | |
| F30%SPR | 0.19 | 0.20 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| F40%SPR | 0.19 | 0.20 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| Fcurr | 0.19 | 0.20 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| F65spr30 | 0.19 | 0.20 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| F75spr30 | 0.19 | 0.20 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| F85spr30 | 0.19 | 0.20 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| **RECRUITS** | | | | | | | | | | | | |
| F30%SPR | 2.28E+07 | 1.90E+07 | 7.70E+06 | 7.72E+06 | 7.72E+06 | 7.71E+06 | 7.69E+06 | 7.67E+06 | 7.65E+06 | 7.63E+06 | 7.62E+06 | 7.61E+06 |
| F40%SPR | 2.28E+07 | 1.90E+07 | 7.70E+06 | 7.72E+06 | 7.73E+06 | 7.73E+06 | 7.72E+06 | 7.71E+06 | 7.70E+06 | 7.69E+06 | 7.68E+06 | 7.67E+06 |
| Fcurr | 2.28E+07 | 1.90E+07 | 7.70E+06 | 7.73E+06 | 7.73E+06 | 7.73E+06 | 7.73E+06 | 7.72E+06 | 7.71E+06 | 7.70E+06 | 7.69E+06 | 7.69E+06 |
| F65spr30 | 2.28E+07 | 1.90E+07 | 7.70E+06 | 7.73E+06 | 7.73E+06 | 7.73E+06 | 7.73E+06 | 7.72E+06 | 7.71E+06 | 7.70E+06 | 7.69E+06 | 7.69E+06 |
| F75spr30 | 2.28E+07 | 1.90E+07 | 7.70E+06 | 7.72E+06 | 7.73E+06 | 7.73E+06 | 7.72E+06 | 7.70E+06 | 7.69E+06 | 7.68E+06 | 7.67E+06 | 7.67E+06 |
| F85spr30 | 2.28E+07 | 1.90E+07 | 7.70E+06 | 7.72E+06 | 7.72E+06 | 7.72E+06 | 7.71E+06 | 7.69E+06 | 7.68E+06 | 7.66E+06 | 7.65E+06 | 7.65E+06 |
| **SSB** | | | | | | | | | | | | |
| F30%SPR | 4590 | 5560 | 6741 | 7397 | 7402 | 6970 | 6325 | 5676 | 5171 | 4815 | 4582 | 4387 |
| F40%SPR | 4590 | 5560 | 6741 | 7707 | 8060 | 7940 | 7520 | 7000 | 6561 | 6237 | 6024 | 5829 |
| Fcurr | 4590 | 5560 | 6741 | 7765 | 8187 | 8132 | 7764 | 7277 | 6858 | 6547 | 6343 | 6151 |
| F65spr30 | 4590 | 5560 | 6741 | 7780 | 8221 | 8184 | 7830 | 7353 | 6939 | 6632 | 6431 | 6240 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F75spr30 | 4590 | 5560 | 6741 | 7668 | 7976 | 7814 | 7362 | 6821 | 6370 | 6040 | 5822 | 5625 |
| F85spr30 | 4590 | 5560 | 6741 | 7558 | 7740 | 7463 | 6926 | 6334 | 5855 | 5509 | 5282 | 5083 |
| **YIELD REMOVALS (Millions of lbs)** | | | | | | | | | | | | |
| F30%SPR | 11.20 | 12.30 | 23.79 | 27.09 | 27.12 | 25.09 | 21.89 | 18.97 | 16.64 | 14.82 | 13.98 | 13.42 |
| F40%SPR | 11.20 | 12.30 | 17.43 | 20.71 | 21.65 | 20.93 | 19.01 | 16.92 | 15.08 | 13.51 | 12.78 | 12.29 |
| Fcurr | 11.20 | 12.30 | 16.24 | 19.44 | 20.50 | 19.97 | 18.28 | 16.36 | 14.62 | 13.11 | 12.42 | 11.95 |
| F65spr30 | 11.20 | 12.30 | 15.92 | 19.10 | 20.18 | 19.70 | 18.07 | 16.19 | 14.49 | 13.00 | 12.32 | 11.85 |
| F75spr30 | 11.20 | 12.30 | 18.22 | 21.53 | 22.40 | 21.53 | 19.46 | 17.26 | 15.35 | 13.73 | 12.99 | 12.49 |
| F85spr30 | 11.20 | 12.30 | 20.48 | 23.83 | 24.43 | 23.10 | 20.59 | 18.09 | 16.00 | 14.28 | 13.49 | 12.96 |
| **F/MFMT** | | | | | | | | | | | | |
| F30%SPR | 0.78 | 0.81 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| F40%SPR | 0.78 | 0.81 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 |
| Fcurr | 0.78 | 0.81 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 |
| F65spr30 | 0.78 | 0.81 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| F75spr30 | 0.78 | 0.81 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| F85spr30 | 0.78 | 0.81 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 | 0.85 |
| **SSB/MSST** | | | | | | | | | | | | |
| F30%SPR | 1.62 | 1.96 | 2.38 | 2.61 | 2.61 | 2.46 | 2.23 | 2.00 | 1.82 | 1.70 | 1.61 | 1.55 |
| F40%SPR | 1.62 | 1.96 | 2.38 | 2.72 | 2.84 | 2.80 | 2.65 | 2.47 | 2.31 | 2.20 | 2.12 | 2.05 |
| Fcurr | 1.62 | 1.96 | 2.38 | 2.74 | 2.89 | 2.87 | 2.74 | 2.56 | 2.42 | 2.31 | 2.24 | 2.17 |
| F65spr30 | 1.62 | 1.96 | 2.38 | 2.74 | 2.90 | 2.88 | 2.76 | 2.59 | 2.45 | 2.34 | 2.27 | 2.20 |
| F75spr30 | 1.62 | 1.96 | 2.38 | 2.70 | 2.81 | 2.75 | 2.59 | 2.40 | 2.24 | 2.13 | 2.05 | 1.98 |
| F85spr30 | 1.62 | 1.96 | 2.38 | 2.66 | 2.73 | 2.63 | 2.44 | 2.23 | 2.06 | 1.94 | 1.86 | 1.79 |

### *3.2.2.12. Other Projections (TORs 8A and 8D)*

The proportions of a migratory group's landings which occurred outside of one of two management area configurations [split at Dade/Monroe border, split along US 1 (and its extension to Tortugas) in the Keys] were calculated based on average catches (in weight, commercial and recreational combined) during 2004-2006. Data are presented for the base case assumption that 50% of the fish in the mixing zone belong to the Atlantic migratory unit. These calculations assume that all recreational landings in Monroe county in the winter were from Atlantic waters (the total recreational landings in that area in the winter are low (80-90,000 kg), so error in this assumption may have little impact). **Table 3.48** shows the estimated percentages. For example, to use the Dade-Monroe management boundary: 17% of the fish caught in the Gulf migratory group should be assigned to the Atlantic side of the boundary, while 11% of the fish in the Atlantic migratory group should be assigned to the Gulf side of the boundary.

**Table 3.48**. Information used to estimate the fraction of each migratory unit that is caught North (and South) of the jurisdictional boundaries in question (Dade-Monroe boundary or Council boundary). The data used are the landings (in kg) for 2004-2006. See the text for an explanation of how these are applied.

| | **Gulf Migratory group** | | | | |
|---|---|---|---|---|---|
| | | **Dade-Monroe boundary** | | **Council boundary** | |
| | total landings | landings N of boundary | Percent | landings S and E of boundary | % landings S and E of boundary |
| 2004 | 2,286,100 | 364,794 | 16% | 437,168 | 19% |
| 2005 | 1,913,531 | 399,574 | 21% | 464,087 | 24% |
| 2006 | 2,958,600 | 462,668 | 16% | 531,122 | 18% |
| total | 7,158,231 | 1,227,036 | **17%** | 1,432,378 | **20%** |

| | **Atlantic Migratory group** | | | | |
|---|---|---|---|---|---|
| | | **Dade-Monroe boundary** | | **Council boundary** | |
| | total landings | landings S of boundary | Percent | landings S and W of boundary | Percent |
| 2004 | 3,921,921 | 390,190 | 10% | 194,654 | 5% |
| 2005 | 3,472,155 | 428,493 | 12% | 276,607 | 8% |
| 2006 | 4,009,550 | 450,446 | 11% | 232,862 | 6% |
| total | 11,403,627 | 1,269,129 | **11%** | 704,123 | **6%** |

The projected yields corresponding to TOR 8A (... provide separate ABC values for each of two management areas delineated at the Miami-Dade/Monroe County line: all fish caught north of the line allocated to the Atlantic management area and all fish caught south of the line allocated to the Gulf management area), and for TOR 8D (... ...provide separate ABC values for each of two management areas delineated at the Gulf and South Atlantic Council boundaries) are given in **Table 3.49**. For ease of comparison, the projections by migratory unit from the base case are also shown.

**Table 3.49**. Projected yields (total removals, including discards and bycatch, in million lbs) under different F strategies. The top of the table summarizes the projections by migratory unit for the base case. The middle and bottom projections show the same results, adjusted for two alternative management boundaries.

| | Atlantic Migratory group yield streams | | | | | | | Gulf Migratory group yield streams | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | F30% | F40% | Fcurrent | 65% FSPR30 | 75% FSPR30 | 85% FSPR30 | year | F30% | F40% | Fcurrent | 65% FSPR30 | 75% FSPR30 | 85% FSPR30 |
| 2007 | 9.570 | 6.742 | 9.628 | 6.462 | 7.374 | 8.267 | 2007 | 19.107 | 13.902 | 13.715 | 12.776 | 14.623 | 16.440 |
| 2008 | 9.815 | 7.366 | 9.861 | 7.101 | 7.945 | 8.733 | 2008 | 22.090 | 16.762 | 16.559 | 15.540 | 17.531 | 19.425 |
| 2009 | 9.601 | 7.586 | 9.636 | 7.352 | 8.089 | 8.748 | 2009 | 22.619 | 17.899 | 17.710 | 16.749 | 18.611 | 20.318 |
| 2010 | 9.502 | 7.807 | 9.531 | 7.597 | 8.250 | 8.812 | 2010 | 21.339 | 17.657 | 17.500 | 16.680 | 18.248 | 19.619 |
| 2011 | 9.478 | 8.018 | 9.500 | 7.829 | 8.417 | 8.904 | 2011 | 18.918 | 16.323 | 16.200 | 15.558 | 16.771 | 17.769 |
| 2012 | 9.195 | 7.901 | 9.215 | 7.727 | 8.263 | 8.697 | 2012 | 16.416 | 14.592 | 14.500 | 14.002 | 14.930 | 15.655 |
| 2013 | 9.121 | 7.932 | 9.136 | 7.767 | 8.270 | 8.671 | 2013 | 14.387 | 13.032 | 12.959 | 12.560 | 13.298 | 13.847 |
| 2014 | 9.125 | 8.023 | 9.140 | 7.864 | 8.340 | 8.715 | 2014 | 12.798 | 11.689 | 11.627 | 11.290 | 11.912 | 12.366 |
| 2015 | 9.065 | 8.012 | 9.079 | 7.859 | 8.318 | 8.677 | 2015 | 12.059 | 11.065 | 11.008 | 10.701 | 11.266 | 11.676 |
| 2016 | 9.030 | 8.018 | 9.046 | 7.871 | 8.316 | 8.660 | 2016 | 11.563 | 10.640 | 10.587 | 10.300 | 10.829 | 11.211 |

**Projections adjusted for Dade-Monroe management unit**

| | Yields North of Dade Monroe | | | | | | | Yields South of Dade Monroe | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F30% | F40% | Fcurrent | 65% FSPR30 | 75% FSPR30 | 85% FSPR30 | | F30% | F40% | Fcurrent | 65% FSPR30 | 75% FSPR30 | 85% FSPR30 |
| 2007 | 11.766 | 8.364 | 10.900 | 7.923 | 9.049 | 10.153 | 2007 | 16.912 | 12.281 | 12.442 | 11.315 | 12.948 | 14.555 |
| 2008 | 12.491 | 9.405 | 11.592 | 8.962 | 10.052 | 11.074 | 2008 | 19.415 | 14.722 | 14.829 | 13.680 | 15.425 | 17.083 |
| 2009 | 12.390 | 9.795 | 11.587 | 9.391 | 10.363 | 11.240 | 2009 | 19.830 | 15.691 | 15.759 | 14.710 | 16.337 | 17.826 |
| 2010 | 12.084 | 9.950 | 11.457 | 9.597 | 10.444 | 11.178 | 2010 | 18.756 | 15.514 | 15.574 | 14.680 | 16.053 | 17.253 |
| 2011 | 11.651 | 9.911 | 11.209 | 9.612 | 10.342 | 10.946 | 2011 | 16.744 | 14.430 | 14.491 | 13.774 | 14.845 | 15.728 |
| 2012 | 10.975 | 9.513 | 10.667 | 9.257 | 9.892 | 10.402 | 2012 | 14.636 | 12.981 | 13.049 | 12.471 | 13.301 | 13.950 |
| 2013 | 10.563 | 9.275 | 10.334 | 9.048 | 9.621 | 10.071 | 2013 | 12.945 | 11.689 | 11.761 | 11.279 | 11.947 | 12.447 |
| 2014 | 10.297 | 9.127 | 10.112 | 8.918 | 9.448 | 9.858 | 2014 | 11.626 | 10.584 | 10.656 | 10.236 | 10.804 | 11.222 |
| 2015 | 10.118 | 9.011 | 9.951 | 8.814 | 9.318 | 9.708 | 2015 | 11.006 | 10.065 | 10.135 | 9.747 | 10.265 | 10.645 |
| 2016 | 10.003 | 8.945 | 9.850 | 8.756 | 9.242 | 9.613 | 2016 | 10.591 | 9.713 | 9.782 | 9.415 | 9.903 | 10.257 |

**Projections adjusted for Council boundary management unit**

| | Yields SAFMC jurisdiction (east/north of Florida Keys-US-1) | | | | | | | Yields GMFMC jurisdiction (west/south of Florida Keys-US-1) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F30% | F40% | Fcurrent | 65% FSPR30 | 75% FSPR30 | 85% FSPR30 | | F30% | F40% | Fcurrent | 65% FSPR30 | 75% FSPR30 | 85% FSPR30 |
| 2007 | 12.818 | 9.118 | 11.793 | 8.629 | 9.857 | 11.059 | 2007 | 15.860 | 11.526 | 11.550 | 10.608 | 12.141 | 13.648 |
| 2008 | 13.644 | 10.276 | 12.581 | 9.783 | 10.975 | 12.094 | 2008 | 18.261 | 13.851 | 13.839 | 12.858 | 14.502 | 16.064 |
| 2009 | 13.549 | 10.711 | 12.600 | 10.261 | 11.326 | 12.287 | 2009 | 18.672 | 14.775 | 14.746 | 13.840 | 15.374 | 16.779 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | 13.200 | 10.870 | 12.459 | 10.477 | 11.404 | 12.207 | 2010 | 17.641 | 14.594 | 14.572 | 13.800 | 15.093 | 16.224 |
| 2011 | 12.693 | 10.802 | 12.170 | 10.471 | 11.266 | 11.924 | 2011 | 15.703 | 13.540 | 13.530 | 12.916 | 13.921 | 14.750 |
| 2012 | 11.927 | 10.346 | 11.562 | 10.064 | 10.753 | 11.306 | 2012 | 13.684 | 12.148 | 12.153 | 11.665 | 12.440 | 13.046 |
| 2013 | 11.451 | 10.063 | 11.180 | 9.813 | 10.433 | 10.920 | 2013 | 12.057 | 10.901 | 10.915 | 10.514 | 11.135 | 11.598 |
| 2014 | 11.137 | 9.879 | 10.917 | 9.650 | 10.222 | 10.665 | 2014 | 10.786 | 9.832 | 9.850 | 9.504 | 10.030 | 10.415 |
| 2015 | 10.933 | 9.744 | 10.735 | 9.528 | 10.072 | 10.492 | 2015 | 10.191 | 9.333 | 9.351 | 9.033 | 9.512 | 9.861 |
| 2016 | 10.801 | 9.665 | 10.620 | 9.458 | 9.983 | 10.382 | 2016 | 9.792 | 8.993 | 9.012 | 8.712 | 9.162 | 9.488 |

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## 4. SUBMITED COMMENTS

SOME COMMENTS ON SEDAR 16

Frank Hester, PhD

Technical Adviser DSF, Inc.

The commercial fishermen I work with and I appreciate this opportunity to offer a few comments on SEDAR 16.

U.S. fishery management through the Councils is a lengthy process. Once this Review Panel signs off on this assessment it becomes the "best science" and the allocation process that follows in the Councils has no option to revisit technical issues. Even if parts of this assessment are found to be flawed later on there is no going back, and scheduling a new SEDAR is a matter of years, so it is extremely important that this assessment is the best that can be done given the available data.

We believe that a number of issues should be addressed more fully before a final review is undertaken. Our concern was shared by many of the Assessment Workshop Panel members. However, the decision was made to proceed with the final review in order to meet an administrative deadline rather than delay the assessment until these issues could be addressed more fully.

Some issues such as further development of SS3 and completing some data analysis that is pending such as otolith reading will require considerable time and resources to complete. However, three issues that are of particular concern to us are given below and can be addressed fairly quickly. We hope this will be done during the review and our concerns resolved before SEDAR 16 is finalized, even if it means additional work after this week ends.

1. The AW Report states: *"The SEAMAP shallow water trawl survey was used as an index of age-1 abundance for the SA stock under SEDAR 5. However, most of the king mackerel caught during this trawl survey were 40 to 430 mm FL (S16-DW-9) and the SEDAR 16 DW recommended it as an index for age-0 king mackerel. This is the only index for ages 0 or 1 available for the SA. It was noted that there was a high degree of variability prior to 2001. As recommended by the current DW, the AW decided to use the index for mid age-0 king mackerel for both the VPA and SS3 models."*

However, it is not clear what is being indexed. The index correlates better with age-1 fish than age-0 fish when compared with catches by cohort. Because this is the only fishery independent index for the Atlantic migratory group we suggest a sensitivity run apply the index to age-1 to see how that affects both the model fit of the index and the base case result.

On the longer term, the actual trawl data should be restandardized with actual size (and species) distribution included as a variable in the standardization. Further, an age-length relation for small king mackerel is needed if the index is to be properly applied. Ageing by daily growth rings would be best, but this would have to be a recommendation for future work.

2. The commercial logbook index is used in the GOM base case, but not in the Atlantic base case. The fishermen are mandated to fill out logbooks and feel these data should be used. The argument against using the logbook data for the Atlantic (*"Appears to be a vessel reporting effect that greatly alters the resulting index"*) applies equally to the GOM, and there seems to be no justification in including this index in one and not the other. The simplest way to handle this issue is to do a sensitivity run for the Atlantic migratory group including the log book index. Several are available: the original in DW-22 and two variations developed during the assessment workshop.

3. The base case model predicts a very large increase in recruitment in recent years for the GOM. However, from the catches there is no indication of a large year class in 2003.

The question of how best to weight indices was addresses by several sensitivity runs (AW p21) and the added variance sensitivity run suggests this recruitment spike is dependent on how the indices are weighted rather than being representative of actual abundance. A lesser effect and in the opposite direction occurs with the Atlantic when added variance is used. This issue deserves additional scrutiny, and the discrepancy between the model result and the catch record needs to be reconciled.

# SEDAR

## Southeast Data, Assessment, and Review

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## SEDAR 16

# South Atlantic and Gulf of Mexico King Mackerel

## SECTION IV: Research Recommendations

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, Sc 29405

# 1. DATA WORKSHOP RESEARCH RECOMMENDATIONS

## *1.1 LIFE HISTORY WORKING GROUP*

1) Examine population connectivity throughout the Gulf and S. Atlantic using otolith elemental and stable isotope signatures of age-0 fish as natural tags of various regions. Otolith signatures of juvenile king mackerel collected in various resource surveys should first be examined to determine if population- or region-specific differences exist in otolith signatures, although success seems likely given the degree of classification success seen in adult mackerel whose otolith chemical signatures are integrated over several years of life, thus adding greater variance to their signatures. Once signatures are determined, the chemistry of adult cores could be sampled to examine interregional mixing between purported migratory groups (populations) in the Atlantic, eastern Gulf, western Gulf, and even Mexico.

2) Investigate and quantify mixing between eastern Gulf and western Gulf populations. The magnitude of the Mexican landings in comparison to U.S. landings from the GOM unit indicate clarification of this issue should be a priority for future assessments (see SEDAR16-DW-31).

3) Investigate / estimate the vulnerability of western Gulf fish to overfished Mexican fisheries in winter (Chavez and Arreguin-Sanchez 1995).

4) Conduct studies and monitoring that will allow estimation of natural mortality.

5) Review sampling procedures for age, length, and weight of king mackerel for both commercial and recreational fisheries to identify possible sampling biases.

6) Determine the impact of the quota sampling methodology, typically used for king mackerel in the TIP program, on growth parameter and age composition estimates; and explore methodologies for removing this potential bias.

7) Investigate the feasibility of switching from the current quota sampling design to random sampling of major strata.

8) Establish uniform, clear, consistent age and size sampling protocols.

9) Continue holding ageing workshops and training to standardize techniques and increase the ageing precision among laboratories.

10) Increase age sampling in South Carolina and Georgia and length sampling north of Florida in the Atlantic.

11) Increase sampling effort in the western Gulf (Louisiana, Texas, and Mexico) for otoliths and lengths of landed catch. Currently, there are very few samples being collected for this important component of the fishery, thus there are few data to parameterize the king mackerel population and fishery in the western Gulf.

12) Try to recover and include age and size data from Collins et al. (1989) Atlantic age and growth study in the next stock assessment of Atlantic king mackerel.

13) For the sake of standardization, request the Texas Parks and Wildlife Department to measure fork length on king mackerel in the future.

14) Establish clear priorities for added reproductive information as expanded work would involve considerable costs for a long-term sampling program.

15) If made a priority, more precisely determine 1) the extent of hydration that can be determined via routine observations in the field and 2) the timing of this phase relative to final oocyte maturation and spawning and 3) calibration of the degeneration of post-ovulatory follicles. This is needed to account for and correct a likely bias in spawning frequency estimates.

16) If made a priority, design and implement a reproductive sampling program (in concert with age sampling) on an annual basis that expands and intensifies spatial and temporal coverage (particularly adding the western Gulf of Mexico). A goal would be to provide annual estimates of spawning frequency. This would include regular training of port agents and scientific observers in macroscopic methods and additionally include a quality control component of random sub-sampling for histological comparisons.

## *1.2 COMMERCIAL STATISTICS WORKING GROUP*

Consistent and sufficient levels of observers are needed aboard shrimp vessels in both the Gulf of Mexico and the South Atlantic. The South Atlantic shrimp fishery has been woefully under sampled.

The Mackerel Stock Assessment Panel reports should be reviewed for information on the Mexican fishery.

Cooperative research with Mexican scientists is needed to understand the relationships between king mackerel exploited in Mexican and U. S. waters. Additionally participation of Mexican scientists is needed in the assessment process (both accumulation and interpretation of data as well as assessment) to better understand the linkages and the Mexican fisheries.

## *1.3 RECREATIONAL STATISTICS WORKING GROUP*

There is a need to characterize and quantify tournament effort and catch. It is recommended that tournaments be required to register and provide at least basic information (similar to that provided for the billfish survey). This basic information should include all catch (including releases and kept fish, whether or not they are submitted for weighout). The preferred approach would be to develop a program by which detailed trip information is collected from participating fishermen.

Future recreational fishery surveys should collect information about tournament participation in both effort and intercept components. These surveys should also include Texas fisheries in the geographic coverage, as the existing separate surveys are not comparable (which is problematic for the assessments).

Observer surveys should collect information on the initial condition of released fish. Research on post-release mortality should be encouraged. The Headboat Observer program provides useful information and should be continued.

Expand existing efforts to collect length-age samples to more completely cover the geographic range of the stocks.

## *1.4 INDICES OF ABUNDANCE WORKING GROUP*

The index working group recommends that:

1) Fisheries Independent sampling efforts should continued and be expanded, with increased emphasis on created fisheries-independent surveys in the South Atlantic.

2) Current fisheries independent surveys sample mostly Ages 0 and 1. Programs should be developed or expanded to obtain fisheries independent abundance estimates for older king mackerel (Ages 2+) more commonly landed by the directed fisheries. These programs should not impact current fisheries-independent survey methodologies.

3) An effort should be made to estimate changes in catchability. Previous SEDAR assessments of other species have used a linear increase in catchability. Assessment model results are likely to be sensitive to the functional shape and magnitude of the change in catchability. However, these functions are not well understood.

4) Research into methods to directly accommodate regulatory changes (i.e. bag limits and trip limits) within index standardization procedures is greatly needed. A possible technique to address changes in bag/trip limits is the truncated negative binomial distribution. This technique will be examined in the future to determine its applicability to fisheries dependent indices of abundance.

5) Research to incorporate environmental variables into CPUE indices is also of potential importance.

## 2. ASSESSMENT WORKSHOP RESEARCH RECOMMENDATIONS

1. Increase observer coverage in the South Atlantic shrimp fishery to get a more accurate representation of king mackerel discard rates.

2. Increase commercial sampling of king mackerel in North Carolina, especially for the gill net fishery in the northeast region.

3. Determine whether separate stocks exist in the eastern and western portions of the GOM.

4. Determine the relationship of king mackerel off the coast of Mexico with U.S. king mackerel stocks. Given the magnitude of king mackerel landings off the coast of Mexico, this could have a large impact on the Gulf of Mexico king mackerel fishery in US waters. It could also provide a more complete evaluation of parameters such as stock size, for some or all migratory groups. Other fisheries may also be significant, such as any Cuban fisheries on the stocks.

5. Obtain detailed commercial and recreational landings information, discard information, and biological samples (age, length, weight, sex, fecundity, etc.) from king mackerel off the coast of Mexico if US king mackerel stocks are found to intermix with Mexican stocks.

6. Continue or begin research programs that conduct tagging studies, otolith microchemistry and shape analysis studies, and gather microsatellite genetic marker data to determine mixing rates of king mackerel off of south Florida during the winter months. A longer time series documenting stock composition data in the mixing zone is needed to increase the accuracy of the SS3 model.

7. Continued evaluation of tag data, ongoing otolith microchemistry and shape analysis studies, and microsatellite genetic marker data to improve estimation of stock structure and mixing proportions.

8. Investigate a method for correcting the reporting bias associated with the commercial logbook index for the South Atlantic.

9. Improve the SS3 model so that it allows for uncertainty in the landings and does not require that estimated landings match the input landings data exactly (e.g., incorporate CV estimates from MRFSS landings), the Hessian can be inverted, estimates of uncertainty can be provided, and stock-specific management benchmarks can be produced.

10. Investigate differences in total headrope lengths of nets, along with other possible estimates of fishing power per vessel, in the function used to estimate shrimp bycatch and consider these in the GLM analysis.

## 3. REVIEW PANEL RESEARCH RECOMMENDATIONS

The assessment and data workshops have identified the most important research required to improve the assessment. Those areas of research requiring highest priority as well as some additional research are outlined below, based on the need to appreciably improve the reliability of future assessments. Where possible, this research should be completed for the next assessment.

The RW emphasized the importance of the Mexican catches. This was addressed by the AW's recommended research, to determine whether separate stocks exist in the eastern and western portions of the GOM and the relationship of king mackerel off the coast of Mexico with U.S. king mackerel stocks (DW 2 & 3; AW 3, 4 & 5). The RW considered these a priority.

An objective procedure to justify the choice of steepness value used for king mackerel modeling is required. This may be either from best fits to available data, or choice of appropriate values for similar species from a meta-analysis. It should also be investigated whether improved behavior at lower steepness values could be achieved by fitting the SR curve through an equilibrium point, rather than by limiting maximum recruitment. This applies both to reference point calculation and projections.

The RW was concerned with the accuracy of the available abundance indices. With the exception of the research to remove the suspected bias in the log-book data (AW 8), no recommendations on improving the abundance indices were made by either the DW or AW. Given the problems with the indices, research should include identifying methods which might improve collection and standardization of data used for this purpose. In particular, the RW believed that improved stock-wide fishery independent indices may be required to carry out control to the level of precision implied by management. It is also important that the commercial logbook index constructed for the Atlantic stock unit is used if possible in future assessments.

The RP recommended that the behavior of the current control rules that use per recruit $F_{30\%SPR}$ values be investigated using simulation, to ensure that they achieve management objectives as expected. A useful framework for this form of testing is known as management strategy evaluation that includes an operating model of fish population dynamics (using various plausible scenarios), fisheries scientific sampling from the population with error, fishing fleet operations and catch, stock assessment and management action as simulation components (e.g. see ICES Marine Science Symposia, 1999).

The RP endorses the AW recommendation that the discrepancy between the two programming codes R and SAS that were used in SEDAR5 and SEDAR16, respectively for estimating shrimp trawl bycatch be resolved.

If the development of the SS3 model is to continue, research programs are required that improve monitoring of the stock mixing. These include tagging studies, otolith microchemistry and shape analysis studies, and the collection of microsatellite genetic marker data to determine mixing rates (DW 1; AW 6 & 7).

Otoliths from the mixing zone need to be evaluated with shape or elemental analyses in order to assign them to one of the two stocks for use in future assessments.

The size and age maturity functions should be updated as the most recent estimates are over 20 years old.

Either the intensity of sampling for fecundity should be greatly increased, or else weight-at-age of mature fish should be used as a proxy for spawning potential.

Procedures should be investigated for incorporating uncertainty and assign utility across model structures into ABC and stock condition calculations. Most of the uncertainty in assessment outcomes is between alternative plausible model structures.

An important uncertainty for the GOM stock is whether a series of recent good recruitments that appear in some indices will contribute in the medium term to increase stock biomass of fish of a size targeted by the commercial and recreational sectors. It will take two to three years for these fish to enter the fishery and for a stock assessment to determine what the impact of those recruitments really is. Therefore, the RP recommends that an update assessment be conducted in two to three years.

The SEDAR Steering Committee should investigate the methodology currently used by the National Hurricane Center to develop consensus forecast models from varied different forecast models to determine if a similar approach is suitable for in improving estimates of stock status and medium term management forecasts with more realistic estimates of uncertainty than can be gained from an examination of internal variability within a single model.

# SEDAR

## Southeast Data, Assessment, and Review

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## SEDAR 16

# South Atlantic and Gulf of Mexico King Mackerel

## SECTION V: Review Workshop Report

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

# 1. INTRODUCTION

## 1.1. Workshop Time and Place

The SEDAR 16 Review Workshop was held August 4 - 8, 2008 in Jacksonville, Florida.

## 1.2. Terms of Reference

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 stock.
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*); recommend appropriate management benchmarks and 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 that 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, including the Summary Report, and that reported results are consistent with Review Panel recommendations[**].

8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.

9. Review the 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. Recommend an appropriate interval for the next assessment.

10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Complete and submit this report within 3 weeks of workshop conclusion.

* The review panel may request additional sensitivity analyses, evaluation of alternative assumptions, and correction of errors identified in the assessments provided by the assessment workshop panel; the review panel may not request a new assessment. Additional details regarding the latitude given the review panel to deviate from assessments provided by the assessment workshop panel are provided in the *SEDAR Guidelines* and the *SEDAR Review Panel Overview and Instructions*.

** The panel shall ensure that corrected estimates are provided by addenda to the assessment report 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.

## 1.3. List of Participants

***Reviewers***
Guillermo Diaz (Chair)............................................................NMFS S&T
Doug Gregory ............................................................GMFMC SSC/FL Sea Grant
Neil Klaer............................................................................................CIE
Paul Medley .........................................................................................CIE
Kenneth Patterson ..................................................................................CIE

***Presenters***
Shannon Cass-Calay ..........................................................NMFS - Miami
Mauricio Ortiz..........................................................................NMFS - Miami
Victor Restrepo .......................................................................NMFS - Miami

***Council-Appointed Observers***
Brian Cheuvront..........................................................................SAFMC
Ben Hartig.................................................................................SAFMC AP
Albert Jones ...........................................................................GMFMC SSC
Anne Lange ............................................................................SAFMC SSC
Robert Muller...................................................AW Rep/GMFMC SAP/FL FWC
Donald Waters .........................................................................GMFMC AP
Bob Zales, II............................................................................GMFMC AP

***Council Representation***
George Geiger (SAFMC)..................................................................FL
Michael Ray (GMFMC) ....................................................................TX

***Other Observers***

Frank Hester ........ DSF
Russell Hudson ........ DSF
Tom Ihde ........ Univ. of MD
Richard Methot ........ NMFS NWFSC
Mike Wilberg ........ CBL

***Staff***

Patrick Gilles ........ NMFS Miami
Rick Leard ........ GMFMC
Julie A. Neer ........ SEDAR
Tina O'Hearn ........ GMFMC
Andi Stephens ........ SAFMC
Gregg Waugh ........ SAFMC

## 1.4. List of Data Workshop Working Papers

| Document # | Title | Authors |
|---|---|---|
| **Documents Prepared for the Review Workshop** | | |
| SEDAR16-RW-01 | Virtual Population Analyses of Gulf of Mexico and Atlantic King Mackerel Migratory Groups: Continuity Case and Updated Runs Through July 2008 | Cass-Calay, S., M. Ortiz and V.R. Restrepo |

## Review Panel Consensus

*Executive Summary*

The assessment was well carried out and used appropriate methods. However, because of uncertainties in stock structure and incomplete data series, a substantial uncertainty in the state of the stock exists. For practical purposes, the most important of these is that it is very uncertain whether good recruitments that appear in some indices means that the available stock biomass of catchable fish in the eastern Gulf will increase in the next years. It will take two to three years for these fish to enter the fishery, at which point an update assessment should be conducted to test whether the expected increase is indeed occurring.

### Data

No concerns were raised about US data collection, but the absence of Mexican catch data from the assessment means that the absolute size of the stock can not be estimated. Nevertheless, the assessments contain useful information about trends and relative stock sizes.

It is a problem that few fishery independent surveys cover this stock, and the existing ones are not complete in their spatial or temporal coverage. While much effort has been made to analyze the fishery data to cover for this lack, such analysis cannot be a full and proper substitute for fishery independent survey data concerning a pelagic fish stock. In such stocks, fishery catch rates are often poor estimators of stock abundance

### Methods

The methods used are endorsed as the best available and appropriate for the available data. However, a minor correction to the base case was requested by the Review Panel (RP) and this was accepted by the assessment team.

### Estimates of Stock Abundance, Biomass, and Exploitation

The uncertainties around the stock assessments due to uncertainties in stock structure and the relationship of the data to the stock are such that considering only base-case assessments would not provide an adequate picture for management purposes. The RP has reviewed a wide range of interpretations of the data and could draw some firm conclusions about the state of the stocks, but other issues remain uncertain. In the face of this uncertainty the RP advocates that estimates be presented in the form of a decision table that illustrates the levels of risk associated with various catch levels.

### Population Benchmarks

The RP noted that standard methods had been used to calculate population benchmarks, and did not re-evaluate these methods. Rather, the panel identified what stock status declarations could reliably be made in the light of the uncertainties which had been identified. These declarations are provided.

Both the Gulf of Mexico (GOM) and Atlantic (ATL) spawning stock biomass levels in 2006 were above the MSST, and therefore not overfished. However, it is uncertain whether the GOM stock is currently experiencing overfishing. For the ATL stock, it is uncertain whether overfishing is occurring, but if it is, then this is at a low level.

### Methods used to project future population status and characterize uncertainty

The uncertainties in the assessments are so important that they cannot be estimated on the basis of a single assessment with stochastic projections. The RP recommends instead that the results of a number of plausible assessments be projected forwards so that the results can be used for management purposes in the form of a decision table. The Assessment Team has been asked to prepare such tables. The panel also advises on a closer assessment of the assumptions used concerning the shape of the stock-recruitment relationship at low stock sizes.

### Presentation of results

Term of reference No 7, "Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report, including the Summary Report, and that reported results are consistent with Review Panel recommendations." has not been addressed as the stock assessment report has not been drafted at the time of writing.

### Evaluation of the SEDAR process

The Panel strongly recommends that a serious effort be made to fill data gaps (e.g., better designed larval surveys, data to improve stock identification, etc.) and notably to ensure a full coverage of the stock in time and space using methods suited to measuring pelagic fish abundance, such as larval, egg production or acoustic surveys. At present levels of survey effort, the assessment results are unlikely to be precise enough to allow the Management Councils to implement the management procedures currently under discussion (such as setting ABCs for several years in the future on the basis of medium-term projections).

The RP recommended that the behavior of the current control rules be investigated using simulation, to explore whether (and if so, how) the management objectives can be attained using the information available.

The RP had concerns as to the appropriateness of assessing a resource that is apparently migratory and trans-boundary in nature in a national assessment and management structure. This is relevant as the absence of Mexican catch data is a critical source of uncertainty in terms of stock levels and selectivity; better information of the Mexican catch is needed.

### Research recommendations

The panel has provided recommendations to help address the concerns noted above and to help improve the accuracy of parameter estimation.

## SEDAR 16. South Atlantic and Gulf of Mexico King Mackerel

August, 2008

**Review Workshop Terms of Reference**

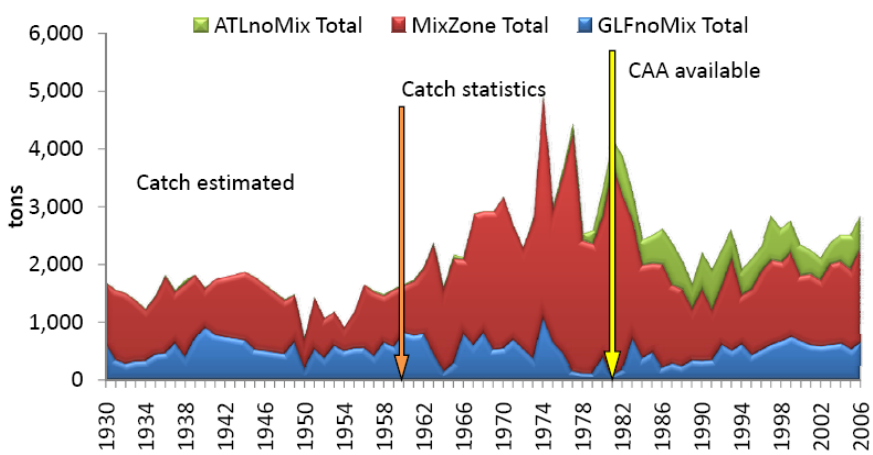
1. **Evaluate the adequacy, appropriateness, and application of data used in the assessment.**

The RP addressed issues of data quality and usage extensively during the meeting, as thoroughly as was possible in the time available and without hands-on experience.

### *1.1 Landing Data*

#### *1.1.1 Commercial*

The RP expressed concern that the exclusion of the high reported landings from Mexico may result in an incorrect interpretation of stock status if the GOM and Mexican king mackerel are actually one unit stock. The RP recognized that information on size composition, catch rates, and gears selectivity from that area were lacking and that there were concerns about the quality of the available Mexican landings data (accuracy of landings reports, species identification, etc.).




Except for the available Mexican data, no other concerns were expressed relative to the landings data. The US commercial landings had been accounted for spatially and temporally to include a GOM zone, a mixing zone, and an ATL zone. The mixing zone historically has been the source of about 60% of the total commercial landings.

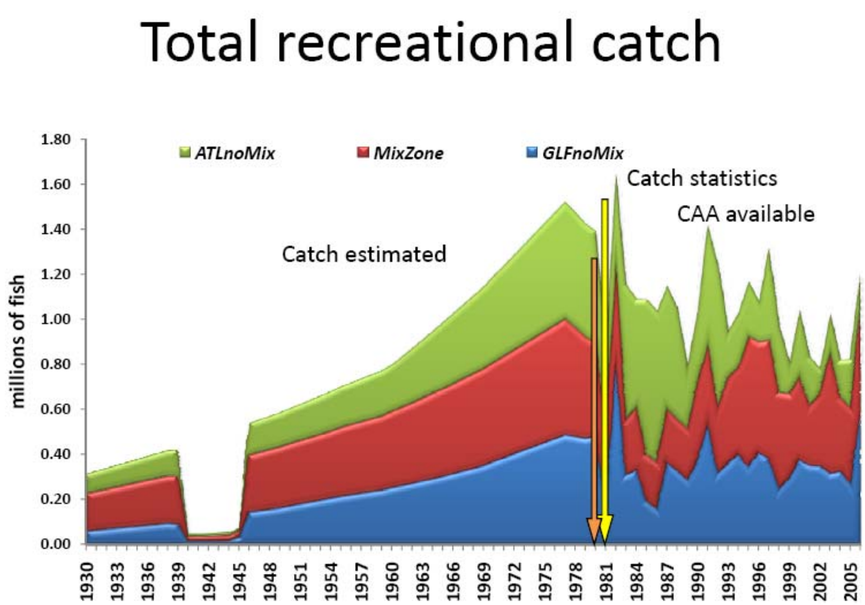
The RP accepted the AW and DW recommendation that the number of dead discards in the commercial finfish fisheries is considered sufficiently low (about 10-15 thousand fish per year) to be negligible and to not include them in the assessment.

Shrimp Bycatch: The RP agreed with the AW and DW recommendation to exclude shrimp bycatch from the mixing zone in the model since there were few observed occurrences of king mackerel bycatch by shrimp trawlers in this area, and extrapolation of these using estimated shrimp trawl effort would be highly uncertain. Shrimp bycatch estimates in the GOM were derived from a combination of SEAMAP data and shrimp observer data. The RP also concurred with the AW recommendation to use the delta-lognormal estimation of bycatch in this assessment as an improvement over the standard GLM estimation procedures. However, it should be noted that given the unbalanced nature of the data, the results are sensitive to the estimation procedure used.

### *1.1.2 Recreational*

The RP had no concerns about how the recreational landings were used in the assessment models.

The RP accepted the AW and DW recommendation to apply a 20% release mortality to the MRFSS fishery where fish are released alive and a 33% mortality to the headboat fishery where fish were released both dead and alive with the note that continuity runs do not include discards (B2 portions).



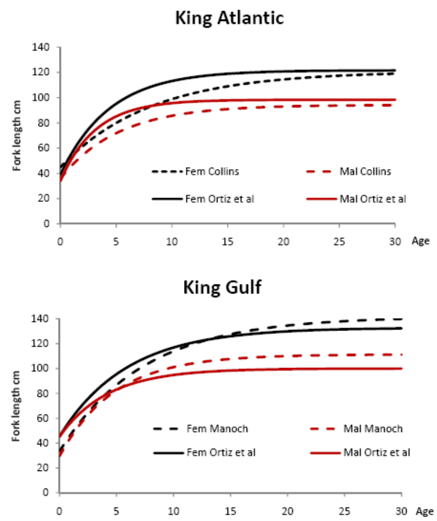

### *1.1.3 Age Composition*

The RP accepted the AW recommendation to use ages 0-11+ for both the GOM and the SA region.

## *1.2 Life History*

### *1.2.1 Growth*

Only age and length data from the non-mixing areas were used for estimating growth curves for the Atlantic and Gulf stocks. Consequently, about a third of the data used in SEDAR 5 was excluded because it was collected in the mixing zone and thus could not be assigned to a particular stock. In addition, new aging data was available and the newly estimated growth functions also took into account minimum size restrictions. As a result, the new models of growth predict faster growth rates for the Atlantic stock and slower growth rates for the Gulf stock than those estimated in SEDAR 5. The RP found the new estimated growth curves to be more appropriate to use in the assessment considering, among other factors, the need to exclude data from the mixing zone.




### *1.2.2 Stock Composition*

The RP accepted the AW recommendation to adopt a 50:50 mixing ratio as the default for the base case. The VPA 2-Box cannot model mixing rates like the SS3 model, so assumptions on mixing ratios had to be made a priori.

It was discussed that there was insufficient data to separate the east and west GOM into two stocks. The DW suggested that a sensitivity analysis could be run excluding all fish west of the Mississippi River. The RP concluded that it would not be instructive to evaluate an eastern Gulf only scenario at this stage. Sensitivity scenarios were run to conduct similar evaluations.

The appropriateness of the level of data aggregation is questionable. While at least two migratory units have been described, over 50% of the fishery is prosecuted on the stocks when they are mixed during the winter. Therefore, separate management of these stock components may not provide the best management advice for king mackerel in the southeastern US unless some mechanism can be developed to identify Gulf and Atlantic biological samples collected in the mixing zone.

It is also possible that a third management unit may also exist in the western GOM. As catches in this area are relatively small, the issue may have relatively little impact, although it should be noted that two of the abundance indices used apply to this region.

### *1.2.3 Fecundity*

The RP accepted the AW and DW recommendations to use the new length-based batch fecundity, a single function for batch fecundity at length for both migratory groups, and the updated fecundity vector based on hydrated oocyte data as reported in SEDAR16-DW-06. However, the RP noticed that the fecundity information was derived from small samples sizes (32 fish) in the GOM and an effort should be made to estimate new length-based relationship increasing the sample sizes prior to the next assessment.

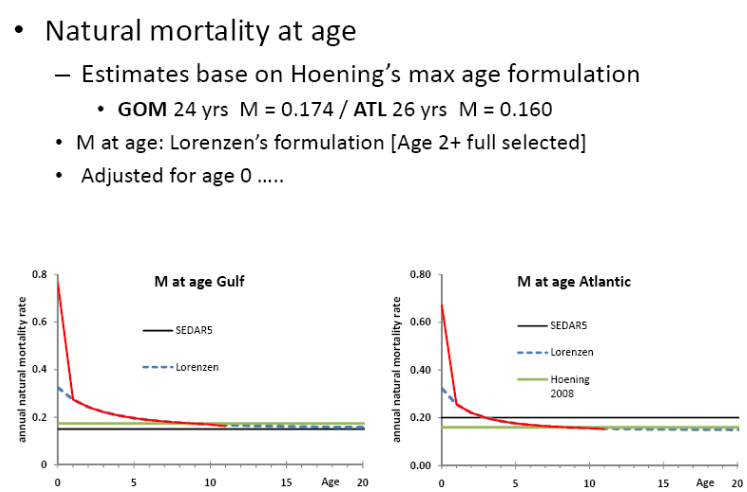
### *1.2.4 Maturity*

The RP accepted the size/age at maturity information from Finucane *et al.* (1986), but recommends these functions be updated with more recent data.

### *1.2.5 Length-Weight Relationship*

The length-weight relationship used in SEDAR 16 differed from SEDAR 5 in that SEDAR 5 used the growth curve to determine the relationship, whereas SEDAR 16 used observed data.

### *1.2.6 Natural Mortality*




The RP accepted the Lorenzen (1996) age-specific estimates of natural mortality (M) scaled to the Hoenig (1983) estimate based on maximum age for king mackerel as presented in the DW report. The RP did not investigate the sensitivity of the assessment results to the assumptions of higher natural mortality at younger ages. The differences seen in the estimates between the Atlantic and Gulf stocks reflect the current observed differences in maximum ages for king mackerel between the ATL (26 years) and the GOM (24 years), which provide Hoenig (1983) estimates of 0.16 and 0.17 year$^{-1}$, respectively. This procedure resulted in an increase in the Atlantic estimate from the 0.15 used in SEDAR 5 and in a decrease in the 0.20 Gulf estimate used in previous assessments.

### *1.2.7 Weight at Age*

The RP accepted the new weight-at-age estimates recommended by the DW and used by the AW. It was noted that the female weights-at-age used in the VPA2 Box model shows heavier fish at a given age in the GOM than in the ATL resulting in a higher estimated fecundity at age.

## 1.3 *Indices of Abundance*

### *1.3.1 North Carolina Trip Ticket Index*

The updated index was accepted by the AW panel for use in the VPA2-Box base case for the ATL stock. This index ultimately became the only commercial fishery dependent index in the base model.

### *1.3.2 Commercial Logbook Index*

Because of the complexity of the management regime throughout the last three decades, the AW had difficulty interpreting the fishery dependent indices. The AW had to choose between using either the commercial logbook index or the North Carolina trip ticket index in the SS3 model because that model can accommodate only one index per fishery. Subsequently, this approach of using only one index per fishery sector was carried forward to the VPA analyses.

There was a large difference between the nominal and standardized commercial logbook index in the ATL region. The AW believed that these reflected a change from voluntary to mandatory reporting requirements in 1998. The analysts were not able to entirely remove this influence from the index, so AW group considered using the North Carolina trip ticket index instead of the logbook index. Ultimately, the AW decided to use the logbook data for the GOM no-mixing zone and to use the North Carolina trip ticket index for the SA no-mixing zone. The AW also proposed that the ATL commercial logbook index be used as a sensitivity run for the ATL region.

### *1.3.3 Marine Recreational Fishery Statistical Survey (MRFSS)*

The AW concluded that bag limits did not appear to affect fishing behavior as fishermen frequently exceed the bag limit, and recommended the inclusion of the MRFSS CPUE index in the assessment for both VPA and SS3. There was some concern expressed by the AW over the large variability in the MRFSS index for the ATL. However, the AW determined the MRFSS index to be usable since only recreational fishing trips that were considered to potentially be able to catch king mackerel and only the intercept data were used to develop the index.

### *1.3.4 Headboat*

This index, with the AW recommendation that data collected during closed seasons be excluded, was accepted by the RP as a plausible abundance index.

### *1.3.5 Fall Plankton Survey (GOM)*

Fall plankton survey (also referred to as the SEAMAP ichthyoplankton survey) was used within the VPA model runs as an index of spawning stock biomass (SSB) for the GOM stock. The RP agreed with the decision to include this index particularly given that it was the only fishery independent index used in the assessment for the adult stock.

### *1.3.6 Shrimp Bycatch Index (GOM)*

The RP agreed with the AW that since the shrimp bycatch index is derived from the SEAMAP Groundfish survey data it was not necessary to include it as a second fishery independent recruitment index.

### *1.3.7 Small Pelagics Trawl Survey (GOM)*

The RP agreed with the DW and AW recommendation not to use the small pelagic trawl survey from the GOM, given the very short length of the time series available.

### *1.3.8 South Atlantic Shark Gill Net Index*

The RP agreed with the DW and AW recommendation not to use the South Atlantic shark gill net index because the number of drift gill net vessels in the shark fishery has decreased, few trips were observed each year, the survey only had a small area of coverage, and changes in target species may have occurred . In addition, gill nets only make up a small percentage of the overall king mackerel landings in recent years.

### *1.3.9 SEAMAP Shallow Water Trawl (ATL)*

The DW and AW recommended using the index for mid age-0 king mackerel for both the VPA and SS3 models. The SEAMAP shallow water trawl survey was used as an index of age-1 abundance for the ATL stock under SEDAR 5. However, most of the king mackerel caught during this trawl survey were 40 to 430 mm FL (SEDAR16-DW-9) and the SEDAR 16 DW recommended it as an index for age-0 king mackerel. This is the only index for ages 0 available for the ATL. It was noted that there was a high degree of variability prior to 2001.

### *1.3.10 SEAMAP Groundfish Survey (GOM)*

The AW included the SEAMAP groundfish survey as an index of GOM age-0 abundance. However, the recent four years of increased king mackerel catches in this index were of such a magnitude and had such an influence on model outcomes, the RP was concerned about relying on this sole recruitment index for predicting future population growth, particularly as its extent was limited to the western GOM. Of particular concern was that these much larger year classes had not yet be seen in the catches of the more recent younger ages in the fishery. The RP was also concerned that the three first years of the series used in the VPA had zero values and that these had been replaced by the lowest value in the series. The RP requested sensitivity runs excluding this index, then including index without the first three years of the series.

### *1.3.11 Summary of data concerns*

The lack of Mexican data means that the absolute size of the stock cannot be estimated because an important part of the catches are missing. While this lack should be remedied, useful conclusions about the state of the stock and local management implications can still be made.

The use of fecundity estimates in the estimation of spawning stock biomass is useful only if fecundity is estimated reliably and if it varies substantially with time or with size of fish. These conditions do not pertain at present because the sample size is small, no time-series is available and fecundity appears to be linear with respect to fish weight.

Stock identity is still not reliably described; for example, the affinity of the western Gulf fish to fish in other areas is not known with certainty. The assessment and management system may not be robust to such uncertainties.

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

The RW addressed assessment methodology and interpretation thoroughly.

### *2.2 Stock Assessment Models*

#### *2.2.1 Use of the Stock Synthesis Model*

Much of the AW's attention was directed at developing a new area-based model that would describe the population dynamics, migration and exploitation of the relevant stocks of king mackerel. This was perceived, according to the AW's Term of Reference 8, as required for the calculation of management parameters for GOM and ATL migratory units, and follows the recommendation of SEDAR 5.

Such a model was developed using Stock Synthesis 3 (SS3). This model is structured so as better to reflect perceptions of the life history of this stock and to estimate population parameters by maximum-likelihood fitting with respect to the available observations with a minimum of data pre-processing.

The use of the model ran into two difficulties. Firstly, it was not clear that the model could complete its calculations correctly due to hardware and operating system limitations. Secondly, the AW found that the estimates of the population parameters of the two migration groups were very strongly interdependent and could not be estimated separately.

Faced with a perceived need to produce separate management parameters for the two regions, the AW took a decision to base its advice on VPA and to abandon the use of the three-area model.

The RP considered that a conclusion to be drawn from this analysis is that independent assessment of the two migration groups is currently not possible without making arbitrary assumptions and without excluding a substantial amount of biological data. The AW did not adequately follow-up this result, which could have led to a single assessment covering both migration groups. This was because (a) inappropriate terms of reference constrained the analysis (see **Section 2.3**), and (b) data pre-processing had already been completed on a migration-group basis. Due to time constraints, this matter could not be revisited during the RW.

The RP agreed that the SS3 model requires further evaluation and testing before being used in a management context. At this stage the RP concurs with the AW that the SS3 approach was not adequate for the stock assessment, even though this method had substantial theoretical advantages and could lead to better knowledge about the reliability of fish stock assessments.

However, the exploratory use of the SS3 raises serious concerns that the management benchmarks of the two migration units cannot be estimated separately with the available data. Furthermore, as over 60% of the commercial catches and over 50% of the recreational catches are taken from the stocks when they are mixed, the possibility of assessing and managing the two units separately needs to be questioned further.

The AW decided to base its advice on a conventional two-area "virtual population analysis" (VPA) approach. Given the foregoing concerns, the RP concludes that this decision may not be appropriate.

### *2.2.2 Continuity Case VPA*

The continuity case assessment is intended to show the effects of new observations, while keeping model assumptions as unchanged as possible given the new data. The RP examined the continuity case against the criteria given in **Section 2.4**. The following table summarizes the RP conclusions.

| Criterion | Continuity case | Review Panel Conclusion |
|---|---|---|
| All relevant data to be included unless there is a clear reason for rejection, no "filled-in" observations to be used. | Yes | Acceptable |
| Data screening for high residuals and sensitivity | Not tested | Not needed for continuity case |
| Model screening to test robustness to alternative model structures | Not tested | Not needed for continuity case |
| Residual pattern screening for trends and appropriate fit | Not screened | Not needed for continuity case |
| Credibility check on exploitation pattern | Not explicitly assessed | High variability in F at last age leads to doubts on credibility of exploitation pattern in that year. |
| Credibility check on trends | New assessment shows higher biomass level in ATL in whole time-series and high recruitment in GOM in last three years. | ATL higher biomass level is probably due to new exploitation pattern, which has a much lower F at last age estimated than in SEDAR 5.<br><br>High recruitments seem due only to high values in the shrimp by-catch index in last few years. |
| Parameters estimated with reasonable precision | Not described. | Missing |
| Full documentation of input data | Yes | Good documentation |

| Criterion | Continuity case | Review Panel Conclusion |
|---|---|---|
| Structural model equations | Yes | Does not say if *q*s are conditional or are estimated as free parameters. |
| Observation error-model equations | Yes | Variance-estimating method is not fully described |
| Description of estimating algorithm | Reference to standard software | Acceptable |
| List of final parameter estimates with s.d. | Parameter s.d. and covariances not provided. | Requested by RP |
| Simulation testing of algorithm | No references made in report, but the method has been simulation tested and the documentation is available at ICCAT. | Acceptable. |
| Source code and documentation available. | References to program manual provided. | Acceptable |

The RP concluded that the continuity case was acceptable and indicated (1) the strong influence of the GOM shrimp bycatch CPUE index in creating a new perception of the state of the stock, and (b) the estimation method may be unstable in estimating selection pattern, and hence historic perceptions of stock size.

### *2.2.3 Base Case VPAs*

The AW's work led to the proposition of base case VPAs which differed from the continuity cases in the following elements:

| Element | SEDAR 5 usage | Proposed new usage | Review Panel Comment |
|---|---|---|---|
| Proportion of GOM fish in the mixing zone | Assumed 100% | Assumed 50% | This is reasonably supported by data. |
| Age-range | Not included | Include age 0 in ATL models | Acceptable |
| F-parameterizations | F on youngest ages fixed by F ratio from separable VPA. | Estimate more F parameters, with penalty function on change in F at age at sigma =0.4 on ages 3 to 9. | Acceptable |
| Life history parameters | Use available data on fecundity and growth | Use new data on fecundity and growth | Correct. |
| Natural Mortality | Fixed M at age, 0.15 for | Use size-related natural | Acceptable. |

| | | | |
|---|---|---|---|
| | ATL and 0.20 for Gulf of Mexico | mortality estimates, but with same average values. | |

Following the RP's positive evaluation of the reasons for changes from the continuity case VPAs, the Panel evaluated the assessment against the criteria in **Section 2.4**.

| **Basic evaluation of base case assessments** | | |
|---|---|---|
| **Criterion** | **Base case** | **Review Panel Conclusion** |
| All relevant data to be included unless there is a clear reason for rejection, no "filled-in" observations to be used. | Correction made | Filled-in observations used for early years of SEAMAP survey unacceptable; should be corrected (see section 2.3). |
| Data screening for high residuals and sensitivity | Not tested | Requested from assessment panel: observed versus expected, residual versus time, QQ plot. This was provided at the meeting. |
| Model screening to test robustness to alternative model structures | Not tested | See section 2.3 |
| Residual pattern screening for trends and appropriate fit | Screened in informal process but not fully documented. | There are substantial residual trends and index divergences. See section 2.3 |
| Credibility check on exploitation pattern | Not addressed | High variability in F at last age leads to very dome-shaped exploitation pattern. This is considered credible as larger fish are not commercially targeted due to lower value. |
| | | |
| Full documentation of input data | Yes | Good documentation |
| Structural model equations | Yes; Does not say if q's are conditional or are estimated as free parameters. | q's are model parameters |
| Observation error-model equations | Yes | Variance-estimating method is not fully described. |
| Description of estimating algorithm | Reference to standard software | Acceptable |
| List of final parameter estimates and s.d. | Parameter s.d. and covariances not | Requested by RP. Estimates of parameter CV s were acceptable. |

| Basic evaluation of base case assessments | | |
|---|---|---|
| | provided in AW report but CV s were made available at the meeting. | |
| Simulation testing of algorithm | No references made in report, but the method has been simulation tested and the documentation is available at ICCAT. | Acceptable. |
| Source code and documentation available. | References to program manual provided. | Acceptable |

The RP concluded that the preparation and documentation of the assessment base cases was generally of a high standard. However, the use of lowest observations to replace zero observations under assumption of a lognormal distribution was erroneous. The RP requested that the GOM base case be corrected to take this into account. ‘Corrected base case’, therefore, refers to a VPA run where the original base case was modified by deleting the first 3 years of data of the SEAMAP survey index. The additional elements concerning residual patterns were requested during the RW and are to be provided as addenda to the Assessment Workshop Report.

### *2.3 Sensitivity testing of the base cases*

The RP identified six principal issues that could affect the outcome of the assessment, as below:

***Stock Structure*** The appropriateness of the level of data aggregation is questionable. While at least two migratory units have been described, over 50% of the fishery is prosecuted on the stocks when they are mixed during the winter, so separate management of these stock components may not provide the best management advice. The panel would have liked to test a combined-area assessment, but the structure in which the data had been pre-processed made this impossible at the meeting. An appropriate research recommendation was developed.

The RP considered that the terms of reference Nos. 6 and 8, set to the assessment working group were inappropriate. Fish stock assessments need to be calculated on the basis of functional fishery units taking into account both biological and fleet operation factors. Allocation decisions between management areas should be made outside and after fish stock assessment workshops.

It is also possible that a third management unit exists in the western GOM. Although catches in this area are relatively small, two of the abundance indices used in the assessment of the entire GOM stock were derived from data in this region. If the stock structure hypothesis is incorrect, large errors in perceptions of stock size are possible.

***Exclusion of Mexico catches*** Tagging data show extensive migrations between the US GOM (and especially the Western Gulf) and Mexican waters, where a fishery also takes place. As these reported catches are of the same order as the US catches, it is necessary to include them in the GOM assessment. As no sampling data were available concerning these catches, only the landings (and not their age or length-structure) could be included. A sensitivity run was provided and shows generally similar trends in biomass and fishing mortality to the base case but at different levels. Fishing mortality is estimated as 10% higher compared to the MFMT while the $B_{MSY}$, catch forecasts, and MSST are approximately doubled.

***Use of fishery-dependent indices*** Such indices are in many areas considered inappropriate for the assessment of pelagic fish stocks, even though they are used where fishery-independent surveys are not available. The review panel questioned the use of fishery-dependent data series unless they could be shown to reflect stock abundance. The fishery-dependent indices used show surprisingly little correlation among themselves (Figures 2.3.1 and 2.3.2) adding to concerns that they may not all adequately reflect stock abundance. Two sensitivity runs were requested for each area, excluding either the fishery-dependent or the fishery-independent indices. These fits were poor, but showed wide divergence, with fishery-independent indices leading to much higher estimates of stock size ($B_{2006}$/MSST revised from 1.499 in the corrected base case down to 1.074 based on fishery-dependent indices or up to 2.773 for the fishery-independent indices). Conversely, a much higher fishing mortality is estimated using the fishery-dependent indices ($F_{2006}$/MFMT=1.477) than for the fishery-independent indices ($F_{2006}$/MFMT=0.509). For the ATL stock a paucity of data prevented similar comparison between dependent and independent indices (Note that the ATL assessment had only one fishery independent index which corresponded to age 0, therefore running the model with only that index was considered not a plausible alternative).

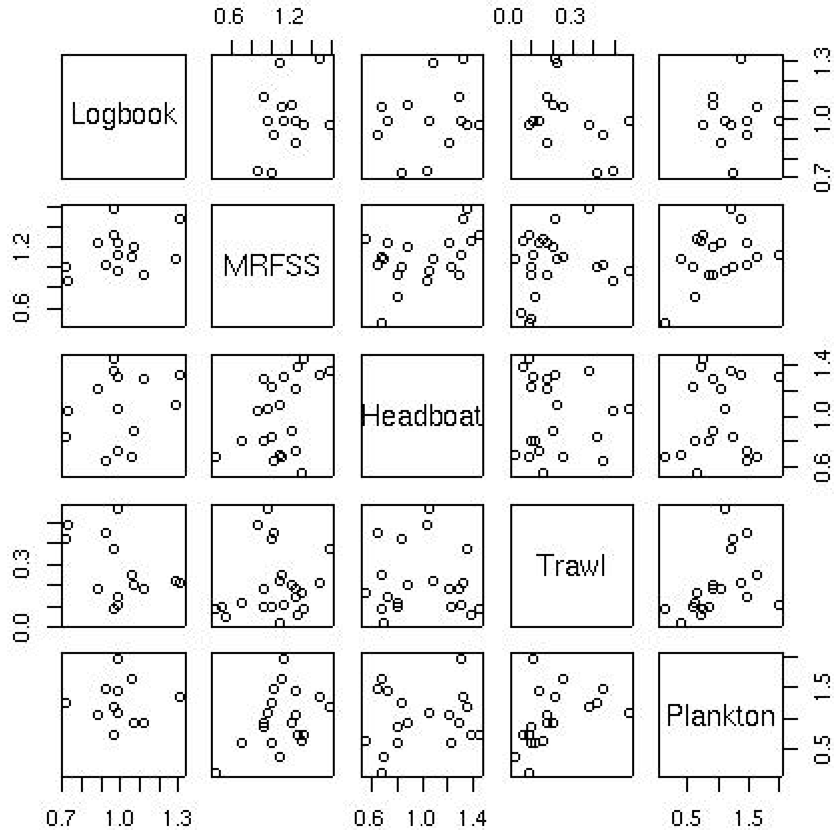



Figure 2.3.1. Pairwise scatterplots of the abundance indices used in fitting the base case for the Gulf of Mexico.

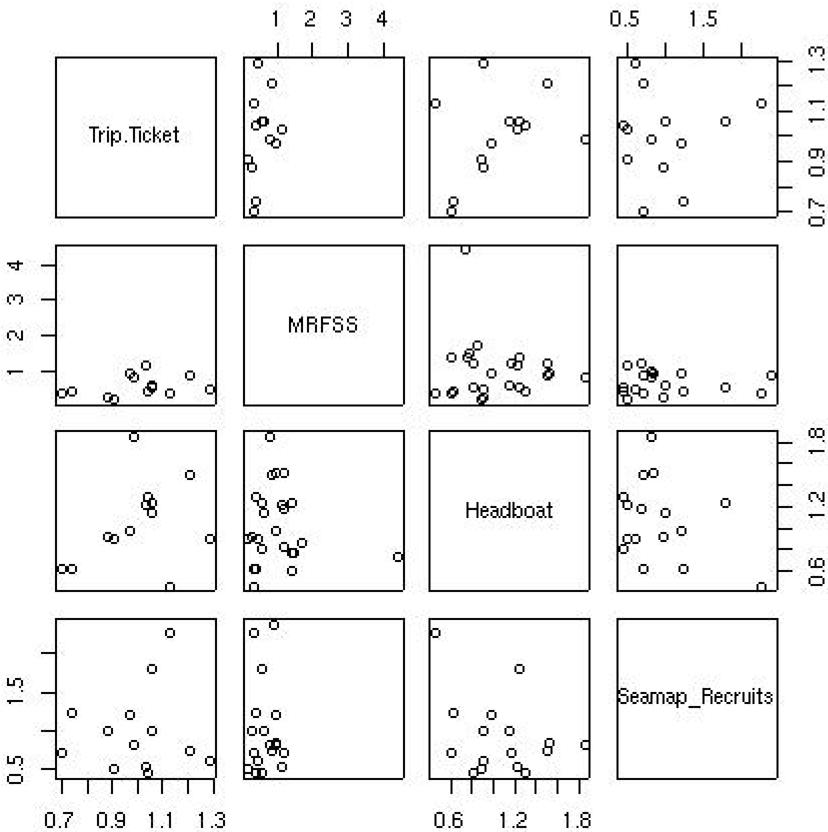



Figure 2.3.2. Pairwise scatterplots of the abundance indices used in fitting the base case for the Atlantic.

***Iterative re-weighting*** Within the range of assessments bracketed by using either fishery-independent or fishery-dependent indices, various solutions can be found according to the statistical weights assigned to the various index series. In the "base case" the indices were assigned equal overall weightings. In principle, these weightings can be estimated within the assessment model. This has the disadvantage of potential numerical instability, but the advantage that the final model fit may better coincide with the index series that appear to be more precisely estimated. The RP requested such an additional run with the purpose of evaluating the sensitivity of the base case to using model-dependent information on index precision. In this case, the assessment model estimated lower variances (and hence closer fits) to the fishery-independent indices.

***Exclusion of age 0 survey data in the GOM*** The observations of very high recruitment in the SEAMAP groundfish surveys in the western GOM have a strong influence on perceptions of stock dynamics. There are four concerns about accepting these estimates at face value:

- the high recruitments seen in the surveys do not appear as highly abundant year-classes in the catch-at-age data;
- the surveys are carried out in the western GOM whereas most of the fishery is deployed in the eastern Gulf, and there is concern that these may not be a single stock unit;
- ecological conditions may have changed in the area following the large reduction in the GOM shrimp fisheries;
- the SEAMAP trawl surveys on which they are based are not executed according to a sufficiently balanced statistical design, which results in a large sensitivity of the index to the method used in estimating inter-annual changes in abundance.

The RP wished to quantify the uncertainty introduced by these concerns by assessing the influence of these data on the assessment, either by excluding the last four years of survey estimates or by excluding the entire 0-group data series. Detailed diagnostics of the sensitivity runs are provided as addenda to the Assessment Workshop report.

***Atlantic summer commercial logbook index*** The review panel also requested to test the sensitivity of the Atlantic assessment to the use of fishery-dependent information in the mixing area in the summer months (April-October) when few Gulf fish should be present. A model fit was calculated by using the commercial fishery for the Atlantic area ("Relative Index" given in Table 11 of SEDAR16-DW-22), and the MRFSS-ATL series (Table 3.5 of the SEDAR 16 Assessment Workshop Report). This showed a 38% reduction in $F_{2006}$/MFMT and a 23% increase in $B_{2006}$/MSST. The results of this scenario are presented in Table 2.3.2 under the heading 'New Index'.

The sensitivity of the management parameters to plausible alternative assumptions is summarized in Tables 2.3.1-2.3.2.

Table 2.3.1. Management-related parameters estimated in the base case and in six sensitivity runs for the GOM stock.

| | Corrected Base | Include Mexican catches | Only Fisheries Dependent Indices | Only Fisheries Independent Surveys | Survey variances estimated iteratively | Excludes the last 5 years of SEAMAP trawl survey | Excludes Age 0 from analysis |
|---|---|---|---|---|---|---|---|
| Convergence | Yes | Yes | Yes | Somewhat sensitive to initial estimates of terminal F | Yes | Very sensitive to initial estimates of terminal F | Yes |
| F30%SPR | 0.187 | 0.210 | 0.157 | 0.151 | 0.193 | 0.156 | 0.23 |
| F40%SPR | 0.134 | 0.137 | 0.116 | 0.106 | 0.141 | 0.108 | 0.16 |
| 0.65*F30%SPR | 0.122 | 0.137 | 0.102 | 0.098 | 0.126 | 0.101 | 0.15 |
| 0.75*F30%SPR | 0.141 | 0.158 | 0.118 | 0.114 | 0.145 | 0.117 | 0.17 |
| 0.85*F30%SPR | 0.159 | 0.137 | 0.102 | 0.098 | 0.126 | 0.101 | 0.2 |
| Yield equilibrium F30%SPR | 10.827 | 29.189 | 8.627 | 9.769 | 9.802 | 10.143 | 7.763 |
| Yield equilibrium F40%SPR | 9.972 | 27.183 | 7.939 | 9.273 | 8.913 | 9.601 | 6.855 |
| Yield equilibrium 0.65*F30%SPR | 9.434 | 27.712 | 7.544 | 9.118 | 8.499 | 9.462 | 6.557 |
| Yield equilibrium 0.75*F30%SPR | 9.947 | 28.462 | 7.979 | 9.420 | 9.008 | 9.773 | 6.994 |
| Yield equilibrium 0.85*F30%SPR | 10.335 | 28.969 | 8.305 | 9.617 | 9.396 | 9.978 | 7.350 |
| MSST | 2615 | 6030 | 2447 | 2446 | 2445 | 2444 | 1532 |
| Fcurrent | 0.155 | 0.164 | 0.232 | 0.077 | 0.245 | 0.173 | 0.200 |
| B2006 | 3921 | 11350 | 2627 | 6784 | 2890 | 2649 | 3076 |
| Fcurrent/MFMT | 0.826 | 0.779 | 1.477 | 0.509 | 1.268 | 1.107 | 0.870 |
| B2006/MSST | 1.499 | 1.883 | 1.074 | 2.773 | 1.182 | 1.084 | 2.01 |

Table 2.3.2. Management-related parameters estimated in the base case and in six sensitivity runs for the ATL stock.

| | Base | Only Fisheries Dependent Indices | Only Fisheries Independent Surveys | Survey variances estimated iteratively | New index |
|---|---|---|---|---|---|
| Convergence | Yes | Yes | Yes | Yes | Yes |
| F30%SPR | 0.256 | 0.255 | 0.262 | 0.241 | 0.243 |
| F40%SPR | 0.174 | 0.173 | 0.178 | 0.168 | 0.169 |
| 0.65*F30%SPR | 0.167 | 0.166 | 0.170 | 0.157 | 0.158 |
| 0.75*F30%SPR | 0.192 | 0.192 | 0.196 | 0.181 | 0.182 |
| 0.85*F30%SPR | 0.167 | 0.166 | 0.170 | 0.157 | 0.158 |
| Yield F30%SPR | 8.964 | 8.796 | 9.001 | 8.669 | 9.908 |
| Yield F40%SPR | 8.122 | 8.012 | 8.131 | 7.824 | 8.951 |
| Yield 0.65*F30%SPR | 7.996 | 7.908 | 8.009 | 7.610 | 9.156 |
| Yield 0.75*F30%SPR | 8.375 | 8.265 | 8.397 | 8.018 | 9.557 |
| Yield 0.85*F30%SPR | 8.662 | 8.530 | 8.691 | 8.331 | 9.850 |
| MSST | 1827.506 | 1827.196 | 1826.675 | 1826.734 | 2073.946 |
| Fcurrent | 0.258 | 0.277 | 0.555 | 0.148 | 0.175 |
| B2006 | 2443.000 | 2982.000 | 1064.000 | 4026.000 | 3404.000 |
| Fcurrent/MFMT | 1.007 | 1.085 | 2.121 | 0.615 | 0.722 |
| B2006/MSST | 1.337 | 1.632 | 0.582 | 2.204 | 1.641 |

### *Conclusions*

The RP considered that the assessment was limited because of the absence of Mexican data while tagging information strongly indicates important stock mixing across the area. This is a “straddling” stock, whereby obligations concerning joint research and management exist in the UNCLOS Agreement for the implementation of the provisions of the Convention relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. Although the USA has ratified this agreement, Mexico has not yet done so although joint management and data collection concerning other stocks is already in place.

The sensitivity run including using the available landings information from the Mexican fishery shows the high sensitivity of management parameters related to absolute measures of stock size.

The uncertainty in the assessment due to missing data and to the plausible alternative assessment structures are so large that the RP did not examine the base model parametric uncertainty estimates in detail, nor the medium-term projections, because the uncertainty in providing management advice is largely due to the variability among alternative model assumptions and specifications.

The RP considered the adequacy and appropriateness of the assessment for various purposes, in the light of structural uncertainty as indicated in the sensitivity runs

| **Gulf of Mexico Stock** | | |
|---|---|---|
| **Purpose** | **Adequacy and Appropriateness** | **Reviewer's comments** |
| Estimation of absolute management benchmarks (MSST, $B_{MSY}$) related to biomass. | Inadequate. These parameters are very sensitive to the missing Mexican catches which affect the perception of the size of the stocks. | MSST is unknown, but in the range 2444 to 6030 million lbs. |
| Estimation of stock status with respect to MSST | Adequate. | The stock is above MSST. |
| Estimation of stock status with respect to MFMT | Inadequate. | The fishing mortality is estimated as between 49% below MFMT and 48% above MFMT. |
| Evaluation of general trend in stock development | Adequate. | Stock size is increasing and there is an indication of more abundant recent recruitments |
| Determination of ABC in the short term | Adequate. | Catches corresponding to F30% SPR are fairly robust to model uncertainty in the range 8.63 to 10.27 million lbs, excluding Mexican catches but including shrimp by-catches. |

| Atlantic Stock | | |
|---|---|---|
| **Purpose** | **Adequacy and Appropriateness** | **Reviewer's comments** |
| Estimation of absolute management benchmarks (MSST, $B_{MSY}$) related to biomass. | Adequate | MSST in the range 1827 to 2074 million lbs from alternative models. Bootstrap estimates of uncertainty are very tight and do not seem credible. |
| Estimation of stock status with respect to MSST | Adequate. | The stock is above MSST. |
| Estimation of stock status with respect to MFMT | Adequate. | The stock is very probably not undergoing overfishing. |
| Evaluation of general trend in stock development | Adequate. | There are trends showing a decline in biomass and over the time series. |
| Determination of equilibrium ABC | Adequate. | Catches corresponding to F30% SPR are fairly robust to model uncertainty in the range 0.24 to 0.26 million lbs. |
| Determination of ABC in the medium term | | |
| Statements of stock status with respect to management benchmarks | Adequate. | |

### *2.4 Evaluation criteria*

The RP evaluated the assessment methodology against the following criteria, which where first promulgated at SEDAR 9:

Evaluation criteria for assessments (source: SEDAR 9)

> 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.

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

The RP accepted the base cases provided by the AW for the GOM and ATL stocks as providing one of several plausible estimates of stock abundance, biomass and exploitation. However, the base cases alone do not provide sufficient information about the uncertainty of these estimates.

Gulf of Mexico stock:

- Stock abundance and biomass: The stock is estimated between 2,627 and 6,784 million lbs in 2006.
- Exploitation: The stock fishing mortality on the stock is estimated between 0.077 and 0.245 per year in 2006.

Atlantic stock:

- Stock abundance and biomass: The stock is estimated between 1,064 and 4,026 million lbs in 2006.
- Exploitation: The stock fishing mortality on the stock is estimated between 0.148 and 0.555 per year in 2006.

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

Methods used to calculate population benchmarks and management parameters followed guidelines provided by Restrepo *et al*. 1998, and proposed/alternative procedures described in Section I of the SEDAR 16 Stock Assessment Report. The VPA base cases for the Gulf of Mexico and Atlantic migratory stocks were proposed as the appropriate models to use for management advice.

The minimum spawning stock size threshold (MSST) was defined as [(1-M) or 0.5 whichever is greater]*$B_{MSY}$, the default for data-moderate situations in the guidelines. The maximum fishing mortality threshold (MFMT) was defined as $F_{MSY}$ in the proposed/alternative procedures.

$F_{30\%SPR}$ was used as a proxy for $F_{MSY}$. $B_{30\%SPR}$ yield-per-recruit calculations require a spawner-recruit relationship, and this was estimated using VPA recruitment estimates, Beverton-Holt and an assumed steepness value of 0.95.

The current selectivity pattern used for yield per recruit calculations was derived from a normalization of the current F vector. Current F was calculated from the geometric mean of the age-specific F values from VPA for the most recent three years (2004-2006). The RP recommends that in the future reference F values be calculated by averaging across ages rather than using apical F. Average F values are easier to understand.

Yield per recruit calculations also require life history values for M, weight at age, maturity and fecundity. The values used for these were the same as for the VPA.

Within the VPA and also yield per recruit calculations, SSB was computed as numbers at age times maturity times fecundity to reflect egg production rather than biomass. The RP noted that yield per recruit calculations in particular are often made in relation to biomass rather than egg production, but agreed that incorporation of fecundity information is an improvement to the more usual procedure. The RP points out that fecundity needs to be well sampled before its use as a replacement for spawning biomass in an assessment will improve the calculation of reference points (See section 1.3.10).

Proposed alternative values of optimum yield were 65%, 75%, and 85% of $F_{MSY}$.

ABC values were provided using a range of constant F projections over the period 2007-2016. The constant F values were $F_{current}$, $F_{MSY}$ (=$F_{30\%SPR}$), $F_{40\%SPR}$, 65% $F_{30\%SPR}$, 75% $F_{30\%SPR}$ and 85% $F_{30\%SPR}$. The assessment team provided this range as they believed that the selection of an appropriate ABC was a management decision.

The RP requested sensitivity tests of results using an alternative lower steepness value of 0.75.

Table 4.1 Management reference points from the Gulf of Mexico uncorrected base case using alternative steepness values

| Steepness | $F_{30\%SPR}$ | $F_{MSY}$* | $B_{30\%SPR}$ | $B_{MSY}$* |
|---|---|---|---|---|
| 0.95 | 0.25 | 0.41 | 2,941 | 1,709 |
| 0.75 | 0.25 | 0.23 | 2,393 | 2,676 |

* calculated using the Sissenwine and Shepherd (1987) approach that includes the SR relationship (not used in current management recommendations, but provided for comparison purposes).

Some reference point values are sensitive to the chosen steepness value. The RP had some concern that the recruitment estimates from VPA were uninformative about steepness, and that the default steepness value of 0.95 was arbitrarily chosen. The RP has made a research recommendation to improve the procedure for selecting an appropriate steepness value. In addition, the RP noted that a decrease in steepness produces a lower

MSST as this was based on the $B_{MSY}$ proxy of $B_{30\%SPR}$. This counter-intuitive behavior is due to the $B_{MSY}$ proxy being used, and possibly also fixing of the maximum expected recruitment level when fitting the stock recruitment relationship. The RP recommends that the behavior of the current control rules in relation to steepness be investigated using simulation as a research task, to test that the rules achieve management objectives as expected. Additionally, improved behavior at lower steepness values could be achieved by fitting the SR curve through an equilibrium point, rather than by limiting maximum recruitment.

$F_{40\%SPR}$ is considered to be an acceptable $F_{OY}$ value in other US regions and other countries for the purpose of ABC calculations. The $F_{OY}$ values of 65%, 75% and 85% of $F_{30\%SPR}$ represent different levels of conservativeness in the same range as $F_{40\%SPR}$. The use of different $F_{OY}$ values appears to have been accepted in this fishery without investigation of the properties of each through simulation testing. The RP also recommends that operational methods to exploit the fishery at $F_{OY}$ be tested by simulations.

Base case and plausible sensitivity results in Tables 2.3.1 and 2.3.2 showed that estimates of $B_{2006}$/MSST were robust, and indicated that both the GOM and ATL 2006 spawning stock biomass levels were above the MSST, and therefore not overfished. The range of plausible sensitivity results for the GOM for $F_{current}$ /MFMT was from 0.826 to 1.477 indicating that it is uncertain whether the stock is currently experiencing overfishing. For the ATL stock, $F_{current}$/MFMT plausible values were in the range of 0.615 to 1.085 indicating that if overfishing is occurring, it is at a low level. The run using the single fishery independent index was considered by the AW to be unreliable because of the limited data, and the resulting high estimate of $F_{current}$/MFMT ratio of 2.121 is not plausible. A range of possible ABC values are provided in these results, from 6.557 - 10.827 million lbs (excluding the Mexico landings) for the GOM and 7.610 - 9.908 million lbs for the ATL. The RP did not agree that the base case results provided central values within the plausible range of results examined, and have recommended that this uncertainty be incorporated into the TAC setting process.

**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, etc.).**

Projection methods followed the recommendations of the AW, using a Beverton-Holt SR function based on VPA recruitment estimates, setting maximum expected recruitment to the geometric mean of the estimated recruits over the years that they were available (1981-2004 GOM and 1989-2004 ATL), and an assumed steepness value of 0.95. To estimate projection variance, 1000 bootstraps were run, using the CV of the observations to vary predicted recruitment about the fixed SR curve. Seven different projection scenarios were examined, using different levels of future catch: $F_{current}$, $F_{MSY}=F_{30\%SPR}$, $F_{40\%SPR}$, 65%$F_{30\%SPR}$, 75%$F_{30\%SPR}$ and 85%$F_{30\%SPR}$.

The RP agreed that the bootstrap procedure is adequate for estimating parametric uncertainty for the base model and catch scenario combinations. However, most of the uncertainty in assessment outcomes is among alternative plausible model structures rather than within-model uncertainty.

Given this uncertainty across different model structures, the RP does not believe that error estimates from any single base model appropriately captures the uncertainty in the ABC and other stock condition indicators that result from this assessment.

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

The RP found that the uncertainty caused by observation error is adequately characterized. The empirical bootstrap approach is appropriate for these complex models. Uncertainty in catch estimation was not addressed in the VPA model, as it is assumed catch-at-age is known exactly. Index observation error was used as the basis for the bootstrap simulation. In SS3, other types of error can be addressed, including catchability process error. For the Atlantic stock, the RP considered that the estimated CVs of the indicators were unrealistically tight.

The current models, at least for the GOM, showed strong retrospective patterns. Retrospective patterns measure the ability of the stock assessment to forecast accurately and indicated that, in this case, there was a perceived change in productivity inconsistent over the time series. Retrospective patterns generally can be linked to some model misspecification. There are no simple solutions to this problem, and it adds to the level of uncertainty in the assessment.

Structural error needs to be addressed. It represents the difference between the model and reality, and is generally considered the most significant source of error. In this case, the RP has recommended developing a decision table with “states of nature” and the likely range of possible outcomes not exceeding the plausible range.

The RP recommended that the AW should present assessment results in the form of a decision table that represents the estimates derived from several plausible models that bracket the likely range of outcomes from the decision making. This, most importantly, considers the costs of making a decision assuming one hypothesis is true when an alternative hypothesis is closer to the real “state of nature”.

In the case of the GOM there were five models available. The alternative models (“Fishery Independent Indices Only” and “Fishery Dependent Indices Only”) were bracketed between the models featured in the table, and concern was expressed by members of the AW that the “Fishery Independent Indices Only” fit was poorly determined and unreliable.

The structure for the decision table is suggested as:

Gulf of Mexico Stock excluding Mexican catches

| Decision (ABC/TAC) Mill. Pounds | "States of Nature" | | |
|---|---|---|---|
| | Fishery Dependent Indices Only | MLE Indices Weighting | Corrected Base |
| 8.305 | $P_{11}$ | $P_{12}$ | $P_{13}$ |
| 9.396 | $P_{21}$ | $P_{22}$ | $P_{23}$ |
| 10.335 | $P_{31}$ | $P_{32}$ | $P_{33}$ |

In the case of the GOM stock, two model specifications where sensitive to initial specifications of terminal F (Fishery Independent Indices only and excluding the last 5 years of the SEAMAP groundfish survey, see Table 2.3.1) and two others were not comparable across management actions (Including Mexico catches and excluding Age 0 from the model), leaving the three possible models only.

Atlantic Stock

| Decision (ABC/TAC) Mill. Pounds | "States of Nature" | | |
|---|---|---|---|
| | MLE Indices Weighting | Base | New Index |
| 8.331 | $P_{11}$ | $P_{12}$ | $P_{13}$ |
| 8.662 | $P_{21}$ | $P_{22}$ | $P_{23}$ |
| 9.850 | $P_{31}$ | $P_{32}$ | $P_{33}$ |

In the tables above $P_{ij}$ = probability that $F_{2008}$ > MFMT which can be obtained from the bootstrap procedure for each model fit (to be completed by the AW), the decision is based on the ABC calculation (Yield equation 0.85*F30%SPR) on the allowable catch made by the council, which are produced from the models based on the formal decision rules. These are for guidance only on the final ABC recommendation from the SSC. The Base Model is considered the model closest to reality by the AW.

In future, the AW should consider developing alternative plausible hypotheses to their base case to aid the review process. The AW should consider and advise on the major uncertainties in the assessment. If a single dimension can be identified as the main source of uncertainty (e.g. steepness, productivity, weighting of abundance indices), this can be used to profile across this uncertainty for inclusion in a decision table.

**7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report, including the Summary Report, and that reported results are consistent with Review Panel recommendations.**

The stock assessment and summary report is clearly and accurately presented. However, the RP recommended that the SEDAR develops procedures that minimize the burden on the various workshops to produce documentation. The number and length of documents produced for review were extensive and complete, but clearly time consuming to produce and so extensive that it was difficult to identify the key areas which the assessment was sensitive to. An alternative approach is to develop a single document, adding, changing and editing sections as necessary so that the versions of the document represent a "snap-shot" of the current thinking. While a history of the assessment process is useful in theory, following this progression in detail is usually beyond any but a few involved intimately in the process. A good example of the updated document approach is the North Sea Herring Working Group Report (https://www.ices.dk/iceswork/wgdetailacfm.asp?wg=HAWG).

**8. Evaluate the SEDAR Process. Identify any Terms of Reference which were inadequately addressed by the Data or Assessment Workshops; identify any additional information or assistance which will improve Review Workshops; suggest improvements or identify aspects requiring clarification.**

The evaluation of the SEDAR workshops in addressing their terms of reference are in Tables 8.1 and 8.2. Overall, the workshops have conducted their work very conscientiously. They have clearly been professional and addressed almost all of the ToRs as well as might be expected. However, not all terms of reference were fully addressed.

The data workshop is required to "Evaluate the degree to which available indices adequately represent fishery and population conditions." (ToR 3) This was certainly done at a sampling / statistical level, but guidance was limited on how well these different indices reflect abundance.

The data workshop is required to "Provide maps of fishery effort and harvest." (ToR 4) These maps were not provided, although information on the spatial distribution of catch and effort was provided.

The assessment workshop ToR "Evaluate the results of past management actions and, if appropriate, probable impacts of current management actions with emphasis on determining progress toward stated management goals" was not met due to time constraints. However, the RP understand that the complexity of this task is very great and it is not feasible to be conducted in the time available.

Several data workshop ToRs (DW ToR 2, 3, 4) refer to "adequacy" of input information. The focus of the workshop was to provide the best information available, which is succeeded in doing. However, "adequacy" requires subjective judgment and is suitable for developing a base case assessment. What is also of interest to the assessment and review panels should be measures of uncertainty. Information helping identify the least reliable source of information among the catches, indices of abundance and size/age compositions or alternative inputs where "data" are estimated, might be used to develop alternative models to test for sensitivity. It should be noted that alternative models were suggested by the DW to test stock structure.

In the opinion of the RP, the AW TORs 6 and 8 contained inappropriate references to stock structure. Stock structure should be determined on scientific grounds, and is the prerogative of the DW and AW, based on the scientific evidence and expert opinion only. Other mechanisms should exist for determining how these resources are shared among stakeholders.

The RP recommended that SEDAR attempts to evaluate the effectiveness of past management actions, as this provides feedback control important to this sort of process. The management actions have been listed, but there have not been evaluations except in the sense of the impact on monitoring indices. SEDAR should also develop standardized procedures to guide AW on methodology and especially on the presentation of results. This should include for example:

- Standard residual plots including QQ plots;
- Fish stock parameters presented in a standard way, e.g. arithmetic mean across ages as recommended here;
- Results of plausible alternative model fits in the form of a decision table

Table 8.1. Review of the Data Workshop terms of reference.

| | Terms of Reference | Comments |
|---|---|---|
| 1. | Characterize stock structure and develop a unit stock definition. Provide maps of species and stock distribution. | **Met**: The available evidence on stock structure is provided and a hypothesis on population structure, including a map, is proposed. |
| 2. | Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics); provide appropriate models to describe growth, maturation, and fecundity by age, sex, or length as applicable. Evaluate the adequacy of available life-history information for conducting stock assessments and recommend life history information for use in population modeling. | **Met**: Life history information is provided and is complete. Information is provided in a form suitable for stock assessment. The data workshop provided clear recommendations on which information to use. Overall uncertainty among information was not characterized (DW Final Section 2.11). |
| 3. | Provide measures of population abundance that are appropriate for stock assessment. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics. Provide maps of survey coverage. Consider relevant fishery dependent and independent data sources; develop values by appropriate strata (e.g., age, size, area, and fishery); provide measures of precision. Evaluate the degree to which available indices adequately represent fishery and population conditions. Recommend which data sources should be | **Met except the evaluation of indices was limited**: Measures of abundance were provided, reviewed and recommendations were made on which indices were appropriate for the stock assessment. Methods used to estimate indices were documented providing appropriate area, age groups, and sampling precision relevant to indicate how the population models should reference indices. Indices were not evaluated with respect to their relationship to and ability to track overall abundance. |

| | | |
|---|---|---|
| | considered in assessment modeling. | |
| 4. | Characterize commercial and recreational catch, including both landings and discard removals, in weight and number. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible. Provide maps of fishery effort and harvest. | **Met**: Commercial and recreational catches are well described, including both discards and landings, and the adequacy of the data has been evaluated. Age, sex and length distributions have been provided where possible. |
| 5. | 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. Provide discussion of progress on research and monitoring recommended by SEDAR 5. | **Met**: Extensive research recommendations were provided covering all relevant areas. |
| 6. | Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report). | **Met**: A complete document was prepared and given to the SEDAR assessment group. |

Table 8.2. Review of the Assessment Workshop terms of reference.

| | Terms of Reference | Comments |
|---|---|---|
| 1. | Review any changes in data following the data workshop and any analyses suggested by the data workshop. Summarize data as used in each assessment model. Provide justification for any deviations from Data Workshop recommendations. | **Met**: The AW reviewed changes and recommendations from the DW. Where changes have been made, these were documented and explained. |
| 2. | Develop population assessment models that are compatible with available data and recommend which model and configuration is deemed most reliable or useful for providing advice. Document all input data, assumptions, and equations. | **Met**: The VPA implemented in VPA2Box was selected. The SS3 model which has been developed could not be completed in time, although it was considered to be more realistic description of population processes. The model has been fully documented. |
| 3. | Provide estimates of stock population parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates. | **Met**: Estimates of stock population parameters with bootstrap estimates of precision have been provided. |
| 4. | Characterize uncertainty in the assessment and estimated values, considering components such as input data, modeling approach, and model configuration. Provide appropriate measures of model performance, reliability, and 'goodness of fit'. | **Met**: The uncertainty of the different runs is assessed using a bootstrap as well as reporting standard fit diagnostics. |
| 5. | Provide yield-per-recruit, spawner-per-recruit, | **Met**: YPR, SPR were provided. SPR |

| | | |
|---|---|---|
| | and stock-recruitment evaluations. | calculations provided the reference point. A stock-recruitment model was proposed and used in the projections. |
| 6. | Provide estimates for SFA criteria consistent with applicable FMPs, management programs, and National Standards. This may include: evaluating existing SFA benchmarks, estimating alternative SFA benchmarks; and recommending proxy values. SFA parameters shall be provided for the Gulf and Atlantic Migratory Units as currently defined using the most current mixing data. | **Met**: SFA benchmarks were reviewed and calculated for the relevant stocks. |
| 7. | Provide declarations of stock status relative to SFA benchmarks. | **Met**: The stocks' status was evaluated with respect to the reference points. |
| 8. | Estimate Allowable Biological Catch (ABC) based on the following criteria:<br>A) Based on migratory groups and mixing zone dynamics defined using best available scientific information, provide separate ABC values for each of two management areas delineated at the Miami-Dade/Monroe County line: all fish caught north of the line allocated to the Atlantic management area and all fish caught south of the line allocated to the Gulf management area.<br>B) Based on migratory groups and mixing zone dynamics as currently defined, provide separate ABC values for the Gulf and Atlantic Migratory Units based on allocating all fish in the mixing zone to the Gulf Migratory Unit (essentially the 'continuity' approach).<br>C) Based on migratory groups and mixing zone dynamics as currently defined, provide separate ABC values for the Gulf and Atlantic migratory units based on allocating 50% Gulf of Mexico and South Atlantic King Mackerel of the fish in the mixing zone to the Gulf Migratory Unit and 50% of the fish to the Atlantic Migratory Unit.<br>D) Based on migratory groups and mixing zone dynamics defined using best available scientific information, provide separate ABC values for each of two management areas delineated at the Gulf and South Atlantic Council boundaries | **Met**: ABCs were calculated for the 4 stock mixing scenariosmanagement boundary scenarios. |

| | | |
|---|---|---|
| 9. | Project future stock conditions (biomass, abundance, and exploitation) and develop rebuilding schedules if warranted; include estimated generation time. Stock projections shall be developed in accordance with the following:<br><br>A) If stock is overfished:<br>F=0, F=current, F=Fmsy, Ftarget (OY),<br>F=Frebuild (max that rebuild in allowed time)<br>B) If stock is overfishing<br>F=Fcurrent, F=Fmsy, F= Ftarget (OY)<br>C) If stock is neither overfished nor overfishing<br>F=Fcurrent, F=Fmsy, F=Ftarget (OY) | **Met**: Projections have been carried out as required. No rebuilding is warranted. |
| 10. | Evaluate the results of past management actions and, if appropriate, probable impacts of current management actions with emphasis on determining progress toward stated management goals. | **Not met**: The time constraints prevented the assessment panel from evaluating past management. The RP felt that this term or reference was not realistic. |
| 11. | Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity. Provide discussion of progress on research and monitoring recommended by SEDAR 5. | **Met**: Extensive recommendations have been provided for future research. The main SEDAR 5 research recommendation, moving to a statistical catch-at-age model, was addressed. |
| 12. | Complete the Assessment Workshop Report (Section III of the SEDAR Stock Assessment Report) and prepare a first draft of the Summary Report. | **Met**: The assessment workshop report was completed. |

**9. Review the 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. Recommend an appropriate interval for the next assessment.**

The assessment and data workshops have identified the most important research required to improve the assessment. Those areas of research requiring highest priority as well as some additional research are outlined below, based on the need to appreciably improve the reliability of future assessments. Where possible, this research should be completed for the next assessment.

The RW emphasized the importance of the Mexican catches. This was addressed by the AW's recommended research, to determine whether separate stocks exist in the eastern and western portions of the GOM and the relationship of king mackerel off the coast of

Mexico with U.S. king mackerel stocks (DW 2 & 3; AW 3, 4 & 5). The RW considered these a priority.

An objective procedure to justify the choice of steepness value used for king mackerel modeling is required. This may be either from best fits to available data, or choice of appropriate values for similar species from a meta-analysis. It should also be investigated whether improved behavior at lower steepness values could be achieved by fitting the SR curve through an equilibrium point, rather than by limiting maximum recruitment. This applies both to reference point calculation and projections.

The RW was concerned with the accuracy of the available abundance indices. With the exception of the research to remove the suspected bias in the log-book data (AW 8), no recommendations on improving the abundance indices were made by either the DW or AW. Given the problems with the indices, research should include identifying methods which might improve collection and standardization of data used for this purpose. In particular, the RW believed that improved stock-wide fishery independent indices may be required to carry out control to the level of precision implied by management. It is also important that the commercial logbook index constructed for the Atlantic stock unit is used if possible in future assessments.

The RP recommended that the behavior of the current control rules that use per recruit $F_{30\%SPR}$ values be investigated using simulation, to ensure that they achieve management objectives as expected. A useful framework for this form of testing is known as management strategy evaluation that includes an operating model of fish population dynamics (using various plausible scenarios), fisheries scientific sampling from the population with error, fishing fleet operations and catch, stock assessment and management action as simulation components (e.g. see ICES Marine Science Symposia, 1999).

The RP endorses the AW recommendation that the discrepancy between the two programming codes R and SAS that were used in SEDAR5 and SEDAR16, respectively for estimating shrimp trawl bycatch be resolved.

If the development of the SS3 model is to continue, research programs are required that improve monitoring of the stock mixing. These include tagging studies, otolith microchemistry and shape analysis studies, and the collection of microsatellite genetic marker data to determine mixing rates (DW 1; AW 6 & 7).

Otoliths from the mixing zone need to be evaluated with shape or elemental analyses in order to assign them to one of the two stocks for use in future assessments.

The size and age maturity functions should be updated as the most recent estimates are over 20 years old.

Either the intensity of sampling for fecundity should be greatly increased, or else weight-at-age of mature fish should be used as a proxy for spawning potential.

Procedures should be investigated for incorporating uncertainty and assign utility across model structures into ABC and stock condition calculations. Most of the uncertainty in assessment outcomes is between alternative plausible model structures.

An important uncertainty for the GOM stock is whether a series of recent good recruitments that appear in some indices will contribute in the medium term to increase stock biomass of fish of a size targeted by the commercial and recreational sectors. It will take two to three years for these fish to enter the fishery and for a stock assessment to determine what the impact of those recruitments really is. Therefore, the RP recommends that an update assessment be conducted in two to three years.

The SEDAR Steering Committee should investigate the methodology currently used by the National Hurricane Center to develop consensus forecast models from varied different forecast models to determine if a similar approach is suitable for in improving estimates of stock status and medium term management forecasts with more realistic estimates of uncertainty than can be gained from an examination of internal variability within a single model.

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## 3. APPOINTEE STATEMENTS

(Any written comment or opinion statements submitted by appointed participants or observers)

Comments on the SEDAR 16 King Mackerel Review Workshop, August 4-8, 2008, Jacksonville, Florida

I attended the Review Workshop as an Observer from the Gulf Council SSC. My impressions of the meeting are:

1. The Review Panel Members were thoroughly knowledgeable in the techniques and tools of modern population biology. They were knowledgeable about the reports from the SEDAR 16 King Mackerel Data and Assessment Workshops, which formed the basis for discussion at the meeting.

2. The Assessment Team from the Southeast Fisheries Science Center (and one member from the Northwest Fisheries Science Center) presented the results of the Assessment Workshop in a clear and concise manner. The Team responded to requests from the Review Panel for new model runs to test the robustness of the Assessment Workshop results. These new model runs were usually available and presented to the Review Panel within a few hours.

3. The questions from the Review Panel were penetrating, but were responded to well by the Assessment Team. Both groups recognized the limitations of the data and the difficulties of reaching definitive conclusions about the status of a stock of migratory fish ranging over a wide area and subject to multiple fisheries in different areas.

4. Conflicting data trends and data gaps presented the Panel with difficult decisions. In particular, the Panel noted the conflicting trends between fishery independent data (generally increasing trends) and fishery dependent data (generally level or slightly decreasing trends). Also, the Panel noted data gaps such as the lack of catch information from the Mexican fisheries, and the lack of coverage in the eastern Gulf of Mexico of the SEAMAP Groundfish Survey (GOM) (used as an index of Gulf Group age 0 king mackerel) and considered the low nominal numbers of larvae collected in the Fall Plankton Survey (GOM) (used as an index of spawning stock biomass for the Gulf Group). Nevertheless, there was a great deal of information to consider and use in the analyses. I consider the data and analysis of SEDAR 16 an improvement over the previous assessment of king mackerel.

5. The meeting proceeded in an orderly manner. Observers listened intently during the presentations and during discussions between the Panel and Assessment Team. Observers contributed when recognized by the Chair and when appropriate. In particular, the contributions of industry observers Ben Hartig and Bob Zales were informative and helpful. During brief intermissions, such as when the Group was waiting for the results of new model runs, Observers quietly and without disturbance to the Group reviewed materials on their computers and Panel Members either reviewed materials or discussed next steps in the meeting.

6. Meeting materials (Presentations and background materials) were available on the internal network and the network functioned without problems during the meeting.

7. At the conclusion of the meeting, the Review Panel presented a short, preliminary summary of their findings.

Albert Jones
Member, Scientific and Statistical Committee (SSC)
Gulf of Mexico Fishery Management Council
August 18, 2008

# SEDAR

## Southeast Data, Assessment, and Review

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## SEDAR 16

# South Atlantic and Gulf of Mexico King Mackerel

## SECTION VI: Addenda and Post-Review Updates

SEDAR
4055 Faber Place Drive, Suite 201
North Charleston, SC 29405

# Addendum to the SEDAR 16 Review Workshop Detailing Additional Sensitivity Analyses

## 1. INTRODUCTION:

The SEDAR16 Review Workshop (RW) requested several sensitivity runs to examine the influence of different data and modeling components to the base VPA models. These runs included:

1) **On the U.S. Gulf of Mexico Base VPA Assessment model:**
   a. the use of fisheries dependent indicators of abundance only
   b. the use of fisheries independent indicators of abundance only
   c. Fitting the VPA Base model using "Maximum Likelihood Estimation" including input estimates of variability for each index of abundance (CV). The Base model had equally weighted the indices relative to one another, while preserving interannual variation through the use of scaled input CVs)
   d. restricting the VPA model to ages 1 to 11+, and removing the SEAMAP Groundfish Index that references Age 0
   e. Addition of the Mexican landings data available through ICCAT.
   f. Removing first 3 year estimates (1981-84) from the SEAMAP Groundfish Index as the RP identified those points as outliers in the Base model fit by evaluating the cumulative normalized residuals plot (qq-plots) of the indices fit.

2) **On the U.S. South Atlantic Base VPA Assessment model:**
   a. the use of fisheries dependent indicators of abundance only
   b. the use of fisheries independent indicators of abundance only
   c. Fitting the VPA Base model using "Maximum Likelihood Estimation" including input estimates of variability for each index of abundance (CV). The Base model had equally weighted the indices relative to one another, while preserving inter-annual variation through the use of scaled input CVs)
   d. Using indices of abundance for the Atlantic mix-summer area. The Base model included only indices of abundance from the non-mixing Atlantic area.

## 2. SENSITIVITY RUNS:

The methods, assumptions and results of each sensitivity run are described below.

### 2.1. U.S. Gulf of Mexico Assessment

#### 2.1.1. Fisheries Dependent Indices of abundance only (GLF_FD)

This run was identical to the GOM Base run except that only the three fisheries dependent indices of abundance were used (Commercial Logbook, Headboat and MRFSS). This change also required recalculation of the additive variance scalars used to equally weight the indices of abundance. The revised variance scalars were fixed equal to 0.303 (Com LL), 0.000 (MRFSS) and 0.271 (HB).

Trends of biomass and fishing mortality are shown in Figure 1, and fit to indices of abundance in Figure 2. For comparison, all plots show the equivalent trends of the base model and the sensitivity run. When using only fishery dependent indices, trends of biomass and fishing mortality rates are similar from 1981 to 1997. From 1998 forward, the fishery dependent indices run indicates a much lower spawning biomass, and recruitment trends compared to the base model. Also fishing mortality is much higher after 1997 with the fishery dependent only model. Fit of fishery dependent indices improved for the latest years of the available series. Estimated benchmarks and reference points and presented in Table 1. Note that these values correspond for projections of total removals (landings and dead discards, including shrimp bycatch in the dead discard fraction). The RW also requested retrospective pattern plots for all sensitivity runs, Figure 3 shows the retrospective patterns of stock size (total NAA), spawning biomass, and fishing mortality ($F_{current}$). Overall the patterns indicate that biomass, and stock size is overestimated in the latest years. As new data is available, corresponding estimates of SSB and stock size are lower than prior runs.

### 2.1.2. Fisheries Independent Indices of abundance only (GLF_FI)

This run was identical to the GOM Base run except that only the two fisheries independent indices of abundance were used (SEAMAP Fall Plankton and SEAMAP Groundfish). Also, at the request of the Review Workshop, three SEAMAP Groundfish index estimates were excluded from the time series (1981-1983). These vales had initially been estimated at 0.000, and then replaced with the minimum observed value in the time series. This change did not require recalculation of the additive variance scalars used to equally weight the indices of abundance. Therefore, like the base model, the variance scalars were fixed equal to 0.000 (Groundfish) and 0.467 (Fall Plankton).

Using only fishery independent indices of abundance estimate much higher spawning biomass and recruits (age 0) in the latest years (1997-2005) compared to the base model (Fig 4). Fishing mortality is lower than the base case, and trend of relative SSB and F are more optimistic in the latest years. Fit to indices indicate higher biomass in latest years (Fig 5). However, there is a strong retrospective pattern (Fig 6) of overestimating biomass in the last years.

### 2.1.3. Maximum Likelihood Estimation (GLF_MLE)

This sensitivity run was identical to the GOM Base run except that index variance was estimated using the concentrated maximum likelihood method where index variance ($\tilde{\sigma}^2_{iky}$ *:i =* index*, k*=zone and *y*=year) is:

$$\tilde{\sigma}^2_{iky} = \sqrt{\frac{\sum_y \left(\ln I_{iky} - \ln \hat{I}_{iky}\right)^2}{\sum_y 1.0}} \quad \text{(Lognormal distribution)}$$

and multiplicative variance scaling parameters ($\upsilon_{ik}$) were used to modify the variance ($\tilde{\sigma}^2_{iky}$) as follows.

$$\sigma_{iky}^2 = (\text{INPUT}_{iky} * \hat{I}_{iky} * \upsilon_{ik})^2 \qquad \text{if input value is a positive CV}$$

This method is analogous to iterative reweighting (Legault and Porch, 2000) and allows the relative model weightings to be estimated within the VPA minimization procedure. During this run, all multiplicative index variance scalars were estimated with the following conditions: the initial estimate was set to 1.0, and the lower and upper bounds were set to 0.0 and 2.0, respectively.

Results of biomass and recruitment trends from the MLE model are shown in Figure 7. Compared to the base model, the MLE estimated lower biomass and recruitment since 1997, translating into a higher fishing mortality in those years, and a less optimistic stock status in 2006. Fit to indices of abundance improved for the fishery dependent indices, particularly also for the latest years (Fig 8). Figure 9 show the retrospective runs, indicating and overestimation of biomass as new data is available, and underestimating the fishing mortality rates in the last year.

**2.1.4. Ages 1 to 11+**

This sensitivity run was identical to the GOM Base run except that Age 0 was removed from the model. Therefore, the total catch-at-age, indices of abundance, partial catches-at-age, natural mortality, fecundity and maturity vectors were restricted to ages 1 – 11+.The SEAMAP Groundfish index, which referenced age-0, was excluded. These changes also required recalculation of the additive variance scalars used to equally weight the indices of abundance. The revised variance scalars were fixed equal to 0.303 (Com LL), 0.000 (MRFSS), 0.272 (HB) and 0.145 (SEAMAP Fall Plankton).

Figure 10 shows the trends of SSB and recruits for the base model and the sensitivity run ages 1-11+. Note that the recruits correspond to different age classes, in the base model Age 0 fish, while in the sensitivity run Age 1. Annual estimates of SSB follow similar trend until 1990, then the Age1-11+ model increased more rapidly than the base model, but that trend shift in 2003, when the SSB of Age1-11+ run stabilizes, while for the Base model continued increasing rapidly. Trends of relative SSB and F show different picture between the base and sensitivity run. Age1-11+ SSB reference plot indicated a increasing trend, with not overfished status in the 1981-2006 period at all, while the base case showed and overfished condition from 1981 to 1997. Similarly, the trend of fishing rates, indicate that in the Age1-11+ model overfishing was only present in the early years (1981-1984). Figure 11 shows the fit to the indices of abundance, and Figure 12 the retrospective patterns of biomass, stock size and fishing mortality. These results indicate overestimation of SSB in the latest years, and underestimation of fishing mortality rates.

**2.1.5. Add Mexican Landings.**

The RW requested to run the Base case VPA model for the Gulf of Mexico stock including the Mexico catch of king mackerel as reported in the ICCAT database (www.ICCAT.int, SEDAR16-DW-31).

The ICCAT database provided catches in weight (tons) of king mackerel by year (1960-2006) for the West Tropical Atlantic area, with no gear information. In order to incorporate this catch into the GOM VPA base model, the following assumptions were made:

a) Mexican catch was assumed to have the same size and age distribution as the US GOM commercial catch for the years 1981-2006.
b) Mexican catch from ICCAT database is reported in calendar year, it was assumed that it corresponded to the same as the fishing year of the US GOM commercial catch.
c) The total Mexican catch in weight by year was converted to catch in numbers by dividing it by the mean weight of commercial US GOM catch by year. This is consistent with assumption a) above.
d) The Mexican catch in numbers was converted to catch at age using the age-proportions of the US GOM commercial catch for the same year.
e) Finally the Mexican CAA was added to CAA input for the Base GOM VPA model and run, under the same settings as the Base model.
f) No index (ices) of abundance was available for the Mexican catch or information on shrimp bycatch or dead discards.

Overall, including the Mexican catch resulted in much larger stock estimates for the GOM king unit. However, annual trends of relative biomass (SSB/MSST) and relative fishing mortality have similar patterns, with lower biomass in the 1980's-90's recovering by the 200's and higher fishing rates in the 1980-90's, declining in recent years (Fig 12). Fit to indices of abundance were similar between models (Fig 13), while the retrospective plots (Fig 14) indicated also an overestimation of SSB in the latest years and underestimation of the fishing mortality.

**2.1.6. Removing first 3 year estimates (1981-84) from the SEAMAP Groundfish Index.**

The RW requested during the workshop a normalized cumulative residual plot (qq-plot) for the indices of the Base model. This plot identified 3 outliers that corresponded to the first three years of the SEAMAP Groundfish index. These estimates corresponded to the 1981-1983 years of the SEAMAP index, which originally were estimated as zero, and then replaced for the lowest value observed in the time series (*Assessment Panel Report ref*). Based on this, the RW requested a sensitivity run removing those values.

Figure 16 shows the trends of SSB, recruits and fishing mortality of this sensitivity run. Biomass and recruitment trends were similar until 2000, when the model excluding the 1981-84 SEAMAP index values indicated a lower recruitment and lower SSB. Fishing mortality was also higher after 2000. Fit to indices are similar (Fig 17) and the retrospective plots indicated also an overestimation of SSB and underestimations of F in the latest years consistently.

**2.2. U.S. South Atlantic Assessment**

**2.2.1. Fisheries Dependent Indicators**

This run was identical to the ATL Base run except that only the three fisheries dependent indices of abundance were used (North Carolina Trip Ticket, MRFSS and Headboat). This change did not require recalculation of the additive variance scalars used to equally weight the indices of abundance.

Therefore, like the base model, the variance scalars were fixed equal to 0.574 (NC Trip Ticket) 0.000 (MRFSS) and 0.512 (HB).

Estimates of SSB and recruits followed similar trends as the Base model until 2000, thereafter the run with only fishery dependent indices shows a high recruitment in 2004 (Fig 19), followed by the lowest recruitment in 2005. This likely indicate a high uncertainty in those recruitment estimates as the VPA model does not have any index associated with young age classes for these years. Trend of relative SSB and F follow the same trends as the base model albeit there are more optimistic with the model of fishery dependent indices. Fit to indices of abundance are shown in Figure 20, most differences are in the latest years, but overall no improvement in the fitting trends. Retrospective analysis plots (Fig 21) show some overestimation of fishing mortality in the latest years, as well a high uncertainty in estimates of total stock size particularly in 2005.

### 2.2.2. Fisheries Independent Indicators

This run was identical to the ATL Base run except that only the one fishery independent index of abundance was used (SEAMAP South Atlantic Trawl Survey). Like the base model, the additive variance scalar was fixed equal to 0.525.

The VPA fitting with only one index for age 0 resulted in a poor convergence solution, with high variability depending upon model initial guess estimates. It was thus considered a model with no consistent solution and no further results were presented.

### 2.2.3. Maximum Likelihood Estimation

This sensitivity run was identical to the ATL Base run except that index variance was estimated using the concentrated maximum likelihood method described in Section 2.1.3. For this run, the multiplicative index variance scalars were estimated with the following conditions: the initial estimate was set to 1.0, and the lower and upper bounds were set to 0.0 and 2.0, respectively.

Assuming that the estimated variability of the indices of abundance was equivalent between indices and equally informative in the VPA model resulted in different trends of spawning stock biomass primarily (Fig 22). The MLE model estimated higher SSB compared to the Base model since 1997, and also higher recruitments over the same time period. This translated in a relative higher ratios of SSB over the reference MSST, and lower fishing mortality rates and F ratios. Indices fit did also varied (Fig 23), with different estimated trends for the commercial North Carolina index (NC_TT), and the recreational Headboat index. The retrospective analysis plots (Fig 24) shows an underestimation pattern for stock size and SSB in the latest years, with an overestimation of fishing mortality rates also in the latest years.

### 2.2.4. Mix-summer Indices

The RW requested a run for the ATL stock unit that add/replace indices of abundance which reflected catch and effort information from the mixing zone during the summer months (Apr-Oct) considering the hypothesis that those catch are exclusively Atlantic king mackerel fish.

The indices modified were: a) replace the Atlantic MRFSS index, which in the Base case includes only catch-effort north of Florida east coast, with an index constructed with catch and effort including Florida east coast during the April-October months. b) Adding the commercial logbook index constructed for the Atlantic stock unit. Other modifications in this sensitivity run were the addition of the partial catch at age (PCAA) for the logbook commercial index (catches of the Florida east coast Apr-Oct), and re-estimating the variance scaling parameters for all indices following same procedures as the Base model.

Including indices with catch and effort data from the mixing zone during the summer months, resulted in a more optimistic stock status for the Atlantic king mackerel. Spawning biomass trend showed a lower decline compared to the Base case, with higher values since 1990. Fishing mortality was estimated lower, particularly since 2000 (Fig 25). Figure 26 shows the fit to the indices of abundance, with different trends estimated for the commercial and recreational indices compared to the Base model. The retrospective analysis plots (Fig 27) indicated some under estimation of stock size and SSB in the latest years, with overestimation of fishing mortality rates in the equivalent end year.

Table 1. Estimated benchmarks and biological reference points for the Gulf of Mexico king mackerel stock. Base model and sensitivity runs; please refer to the text for details of each run. These estimates correspond to total removals (landings plus dead discards, including shrimp bycatch as part of the dead discard fraction).

| GOM | Base | US+Mex catch | Fishery Dependent Indices | Fishery Independent Indices | MLE | Remove Age 0 | Rem 1981/84 SeaMap index |
|---|---|---|---|---|---|---|---|
| Convergence | Yes | Yes | Yes | Somewhat sensitive to initial estimates of terminal F | Yes | Yes | Yes |
| F30%SPR | 0.190 | 0.210 | 0.157 | 0.151 | 0.193 | 0.229 | 0.187 |
| F40%SPR | 0.135 | 0.137 | 0.116 | 0.106 | 0.141 | 0.164 | 0.134 |
| 0.65*F30%SPR | 0.124 | 0.137 | 0.102 | 0.098 | 0.126 | 0.149 | 0.122 |
| 0.75*F30%SPR | 0.143 | 0.158 | 0.118 | 0.114 | 0.145 | 0.172 | 0.141 |
| 0.85*F30%SPR | 0.162 | 0.179 | 0.134 | 0.129 | 0.164 | 0.195 | 0.159 |
| Yield equ F30%SPR | 10.225 | 29.189 | 8.627 | 9.769 | 9.802 | 7.763 | 10.827 |
| Yield equ F40%SPR | 9.458 | 27.183 | 7.939 | 9.273 | 8.913 | 6.855 | 9.972 |
| Yield equ 0.65*F30%SPR | 9.178 | 27.712 | 7.544 | 9.118 | 8.499 | 6.557 | 9.434 |
| Yield equ 0.75*F30%SPR | 9.612 | 28.462 | 7.979 | 9.420 | 9.008 | 6.994 | 9.947 |
| Yield equ 0.85*F30%SPR | 9.927 | 28.969 | 8.305 | 9.617 | 9.396 | 7.350 | 10.335 |
| MSST | 2443.263 | 6030.224 | 2447.114 | 2446.139 | 2445.478 | 1532.6 | 2615.484 |
| Fcurrent | 0.133 | 0.164 | 0.232 | 0.077 | 0.245 | 0.199 | 0.155 |
| B2006 | 4543.000 | 11350.000 | 2627.000 | 6784.000 | 2890.000 | 3076 | 3921.000 |
| Fcurrent/MFMT | 0.701 | 0.779 | 1.477 | 0.509 | 1.268 | 0.87 | 0.826 |
| B2006/MSST | 1.859 | 1.883 | 1.074 | 2.773 | 1.182 | 2.01 | 1.499 |

*Yield in millions of Pounds, MSST and B2006 in millions of eggs.*

Table 2. Estimated benchmarks and biological reference points for the U.S. South Atlantic king mackerel stock. Base model and sensitivity runs, please refer to the text for details of each run. These estimates correspond to total removals (landings plus dead discards, including shrimp bycatch as part of the dead discard fraction).

| ATL | Base | Fishery Dependent Indices | MLE | Mix-Summer Indices |
|---|---|---|---|---|
| Convergence | Yes | Yes | Yes | Yes |
| F30%SPR | 0.256 | 0.255 | 0.241 | 0.243 |
| F40%SPR | 0.174 | 0.173 | 0.168 | 0.169 |
| 0.65*F30%SPR | 0.167 | 0.166 | 0.157 | 0.158 |
| 0.75*F30%SPR | 0.192 | 0.192 | 0.181 | 0.182 |
| 0.85*F30%SPR | 0.218 | 0.217 | 0.205 | 0.206 |
| Yield F30%SPR | 8.964 | 8.796 | 8.669 | 9.908 |
| Yield F40%SPR | 8.122 | 8.012 | 7.824 | 8.951 |
| Yield 0.65*F30%SPR | 7.996 | 7.908 | 7.610 | 9.156 |
| Yield 0.75*F30%SPR | 8.375 | 8.265 | 8.018 | 9.557 |
| Yield 0.85*F30%SPR | 8.662 | 8.530 | 8.331 | 9.850 |
| MSST | 1827.506 | 1827.196 | 1826.734 | 2073.946 |
| Fcurrent | 0.258 | 0.277 | 0.148 | 0.175 |
| B2006 | 2443.000 | 2982.000 | 4026.000 | 3404.000 |
| Fcurrent/MFMT | 1.007 | 1.085 | 0.615 | 0.722 |
| B2006/MSST | 1.337 | 1.632 | 2.204 | 1.641 |

*Yield in millions of Pounds, MSST and B2006 in millions of eggs.*

Table 3. Indices of abundance used for the ATL king mackerel stock sensitivity run that included/replace indices from the mix-summer area. The Logbook commercial Atlantic index was added while the MRFSS-ATL (summer months) mix and non mix area replaced the MRFSS-ATL no mix area only index from the Base case. These indices were presented and review during the SEDAR16 Data Workshop by the CPUE series working group.

| Type of Index | LogBook Com ATL | | MRFSS-ATL | |
|---|---|---|---|---|
| | Fish. Dep. COM | | Fish. Dep. REC | |
| Region | ATL no Mix area | | Atl. Migratory | |
| Standardization | Delta-lognormal vessels selected | | Delta-lognormal (fishing year) - Guild selection | |
| Unit | Weight | | Number | |
| Ages | | | Ages 2-11 | |
| Season | | | Jan-Mar; Apr-Jun; Jul-Oct; | |
| YEAR | STDCPUE | CV | STDCPUE | CV |
| 1981 | | | 1.0100 | 0.5451 |
| 1982 | | | 1.3865 | 0.4517 |
| 1983 | | | 1.3498 | 0.4694 |
| 1984 | | | 1.2746 | 0.4527 |
| 1985 | | | 1.3741 | 0.4741 |
| 1986 | | | 1.9124 | 0.4105 |
| 1987 | | | 1.2688 | 0.4171 |
| 1988 | | | 0.9524 | 0.4091 |
| 1989 | | | 0.7479 | 0.4111 |
| 1990 | | | 1.1712 | 0.4099 |
| 1991 | | | 1.0889 | 0.4030 |
| 1992 | | | 1.1118 | 0.3986 |
| 1993 | 1.379 | 0.076 | 0.6404 | 0.4136 |
| 1994 | 1.213 | 0.080 | 0.5508 | 0.4124 |
| 1995 | 1.122 | 0.088 | 0.6582 | 0.4064 |
| 1996 | 0.814 | 0.112 | 0.7676 | 0.4021 |
| 1997 | 1.115 | 0.086 | 0.9935 | 0.4013 |
| 1998 | 1.023 | 0.077 | 0.8912 | 0.3995 |
| 1999 | 1.026 | 0.079 | 0.8238 | 0.4008 |
| 2000 | 1.052 | 0.076 | 1.0370 | 0.3954 |
| 2001 | 0.910 | 0.082 | 0.5921 | 0.4010 |
| 2002 | 0.780 | 0.102 | 0.7217 | 0.3999 |
| 2003 | 0.740 | 0.106 | 0.7497 | 0.4033 |
| 2004 | 0.893 | 0.104 | 0.9870 | 0.3981 |
| 2005 | 0.995 | 0.091 | 0.9991 | 0.3990 |
| 2006 | 0.937 | 0.092 | 0.9394 | 0.4059 |

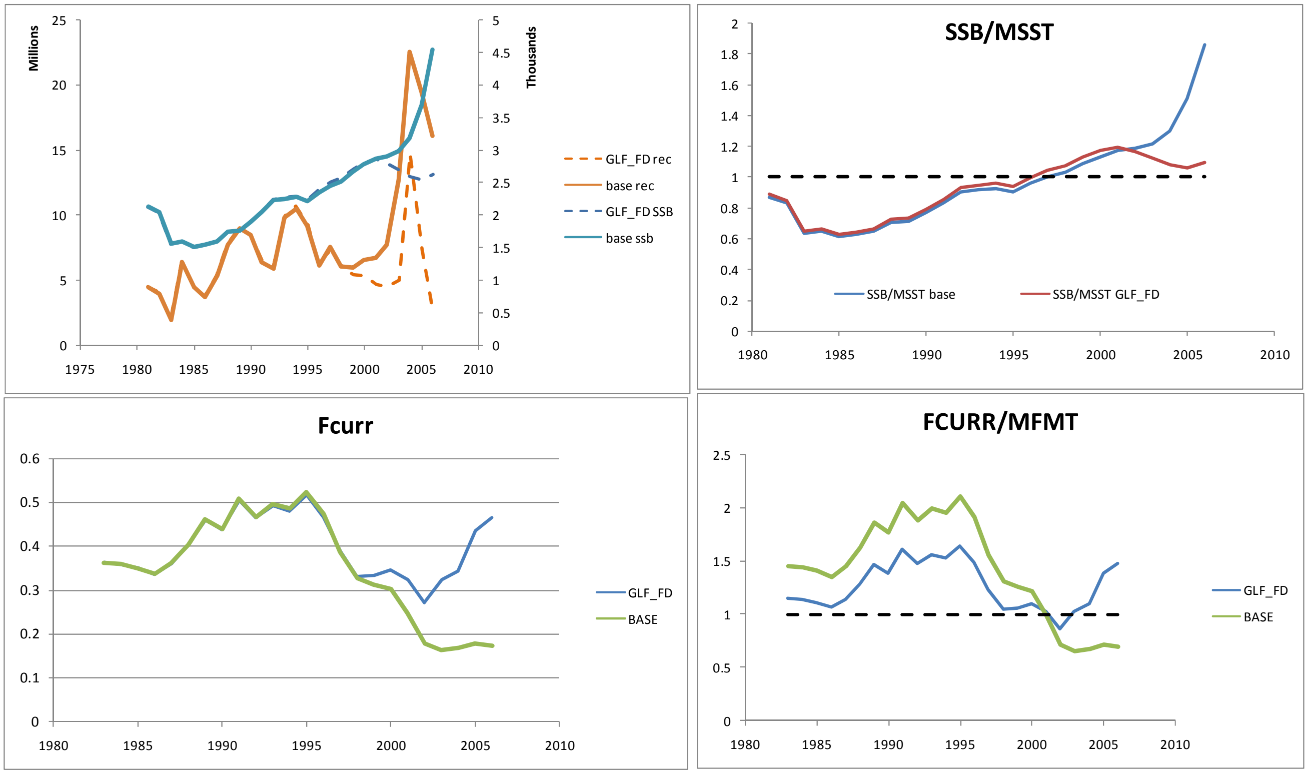



**Figure 1.** Sensitivity runs: GOM VPA base model with Fisheries Dependent indices of abundance only (GLF_FD). Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel GOM from the base model (solid line) and sensitivity run that included FD indices only. Plot top right, trends of relative SSB over MSST for base case and GLF_FD run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and GLF_FD indices, and right plot of Fcurrent over MFMT ratios.

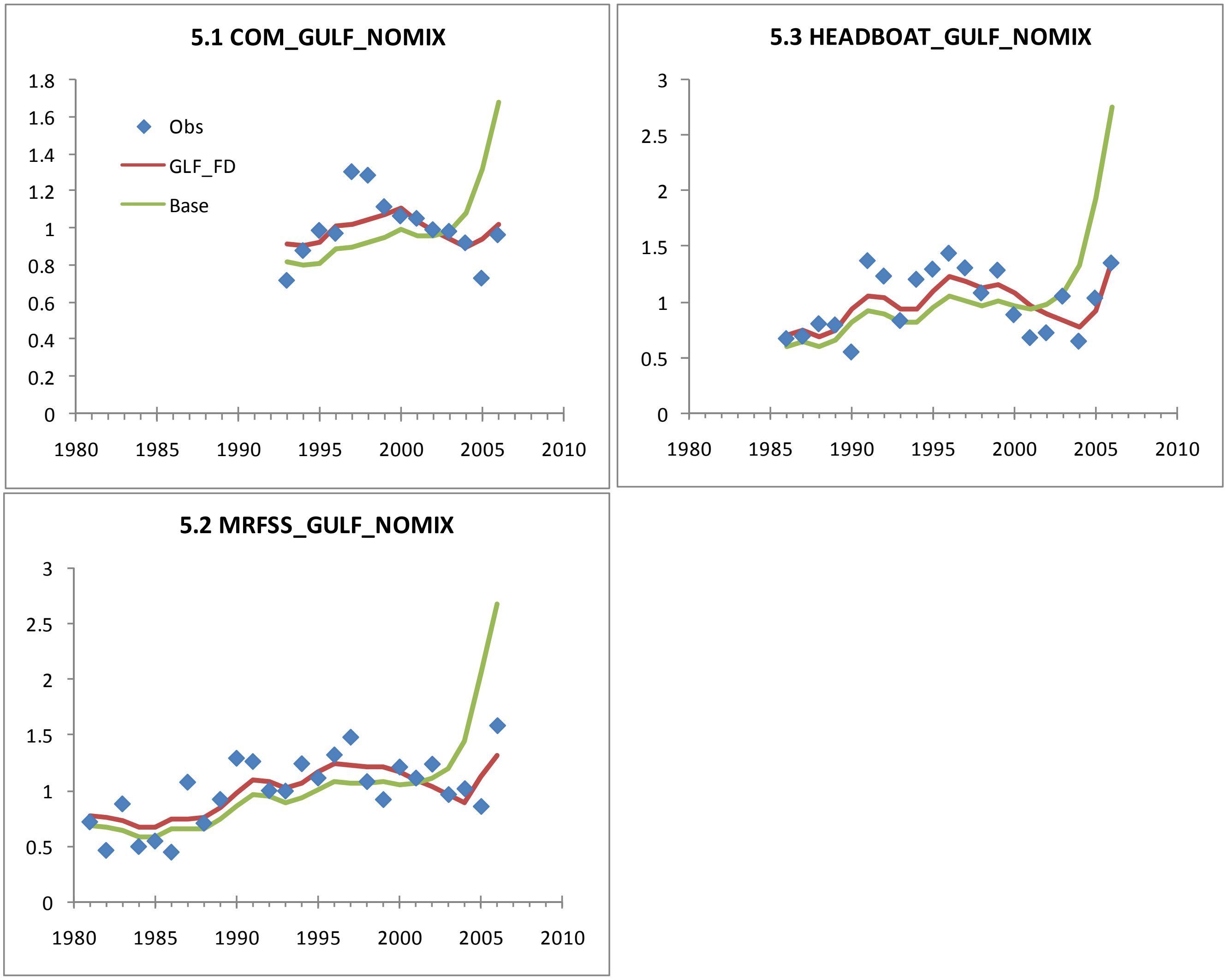



**Figure 2.** Sensitivity runs: GOM VPA base model with Fisheries Dependent indices of abundance only (GLF_FD). Fit of indices of abundance (solid lines), from the base model (green line) and the GLF_FD model (red) to the input values (blue diamonds).

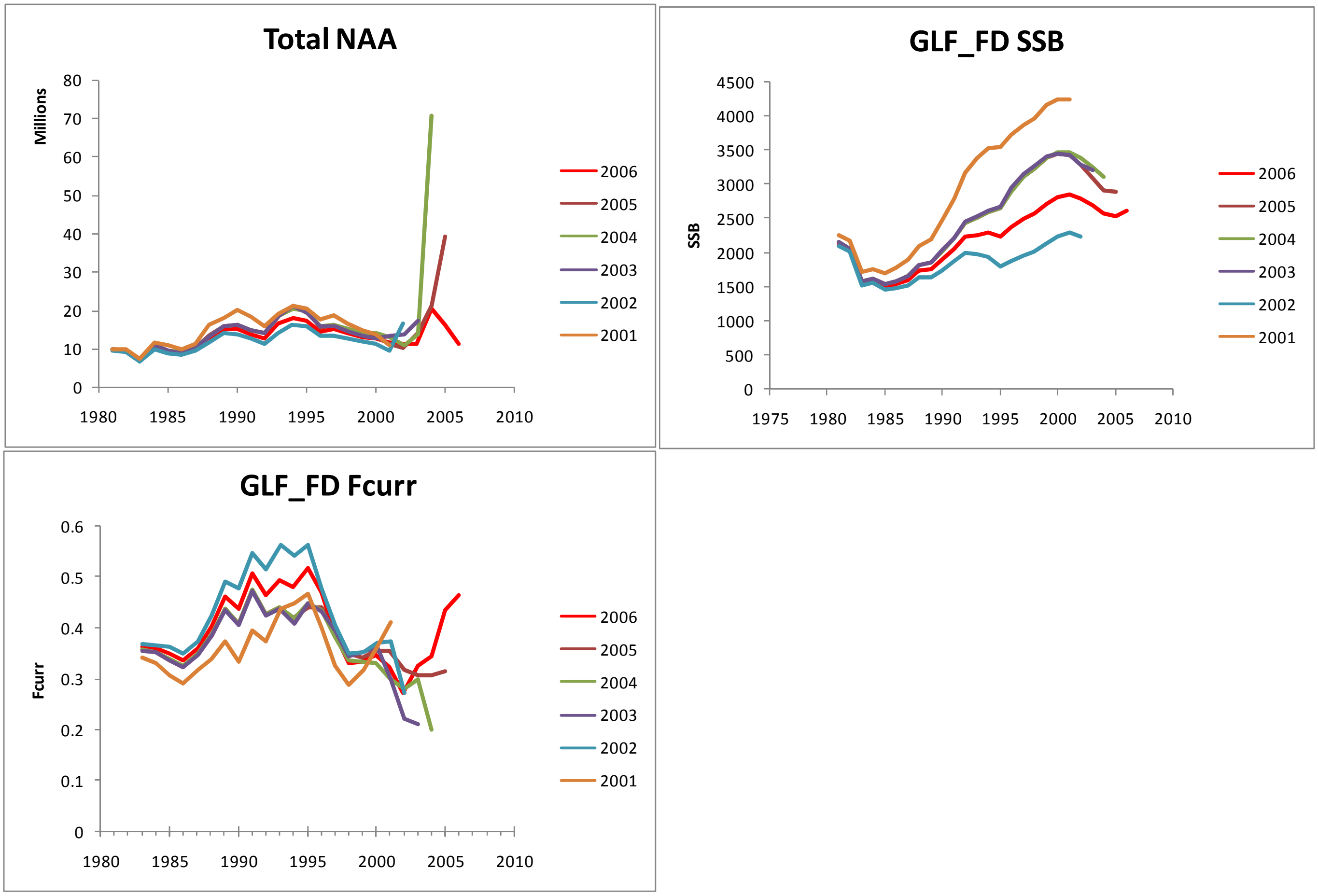



**Figure 3.** Sensitivity run GOM VPA model with Fisheries Dependent indices of abundance only (GLF_FD) retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current

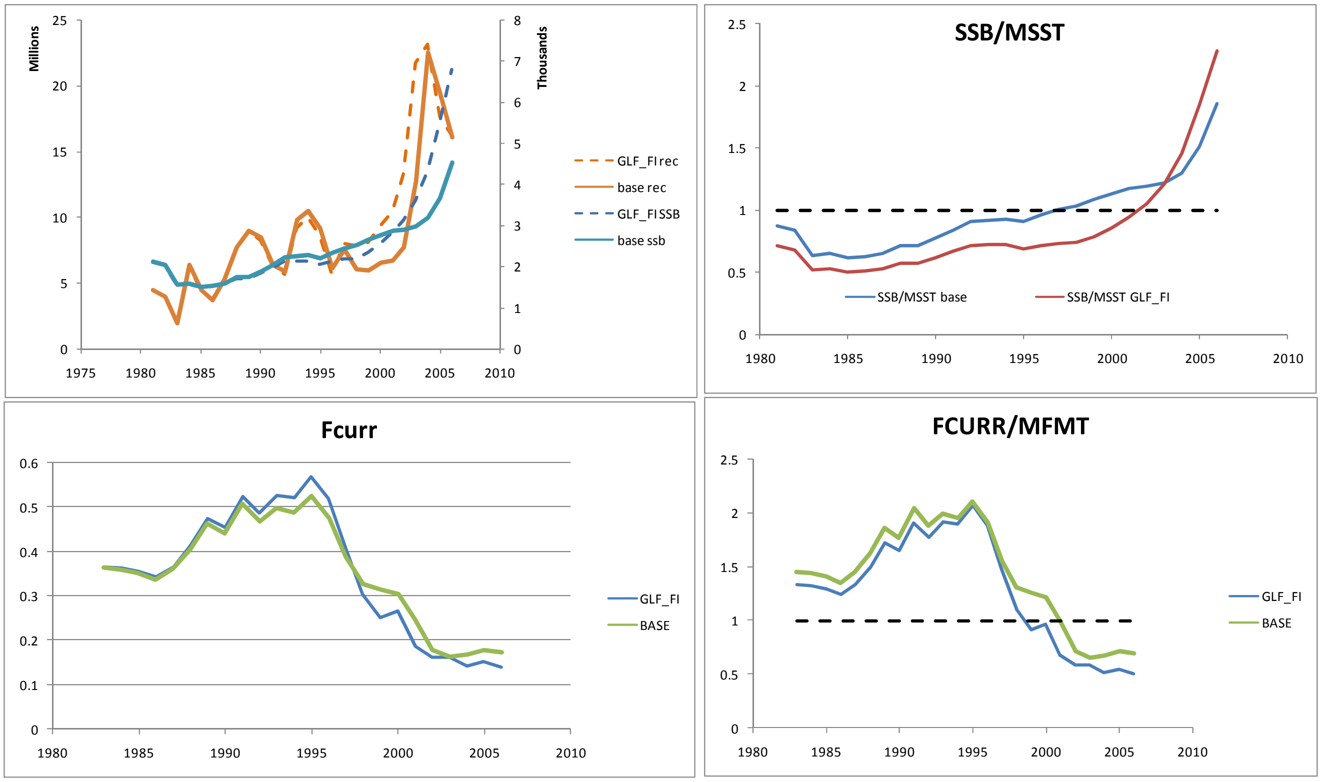



**Figure 4.** Sensitivity runs: GOM VPA base model with Fisheries Independent indices of abundance only (GLF_FI). Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel GOM from the base model (solid line) and sensitivity run that included FI indices only. Plot top right, trends of relative SSB over MSST for base case and GLF_FI run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and GLF_FI indices, and right plot of Fcurrent over MFMT ratios.

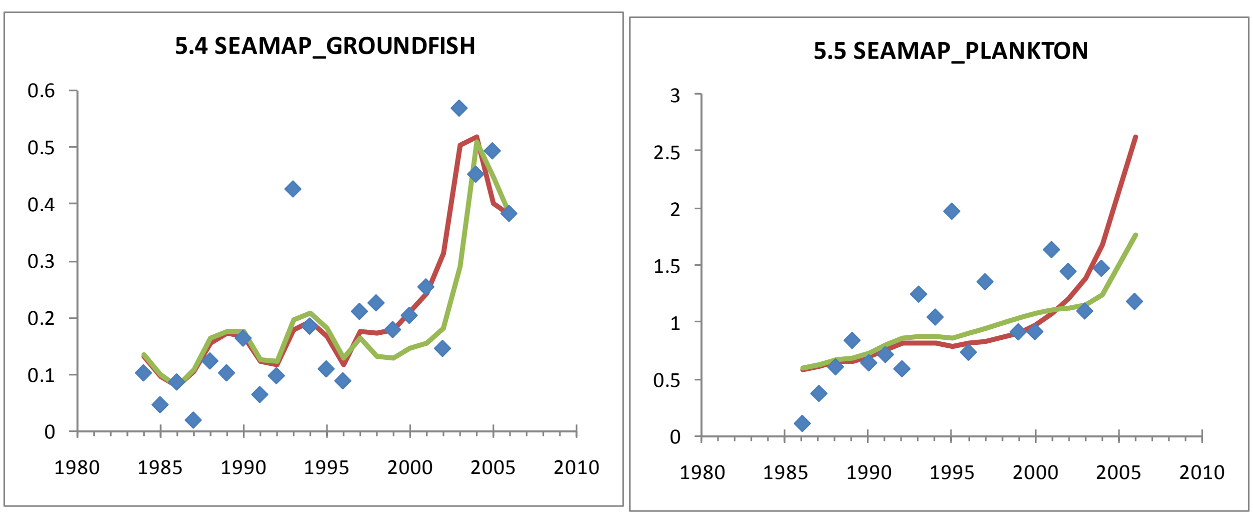



**Figure 5.** Sensitivity runs: GOM VPA base model with Fisheries Independent indices of abundance only (GLF_FI). Fit of indices of abundance (solid lines), from the base model (green line) and the GLF_FI model (red) to the input values (blue diamonds).

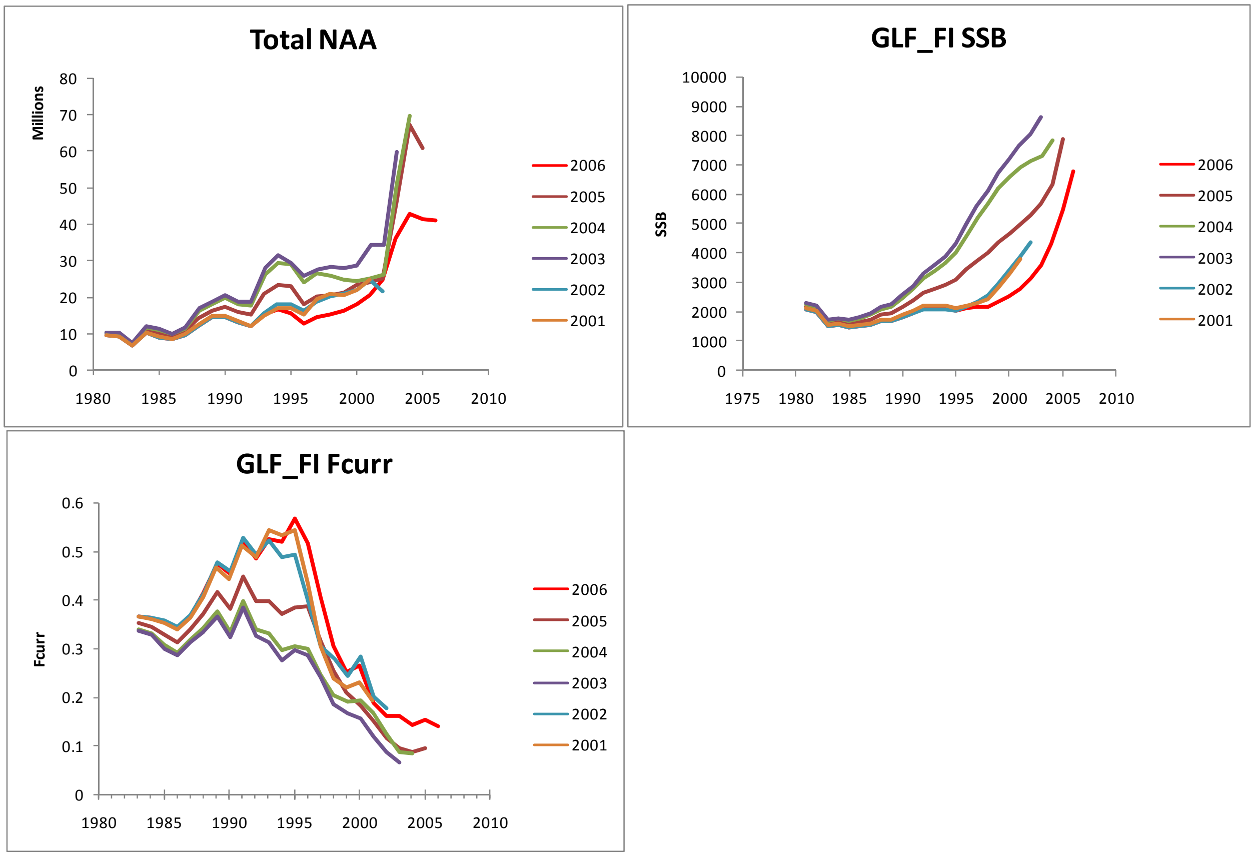



**Figure 6. Sensitivity run** GOM VPA model with Fisheries Independent indices of abundance only (GLF_FI) retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current.

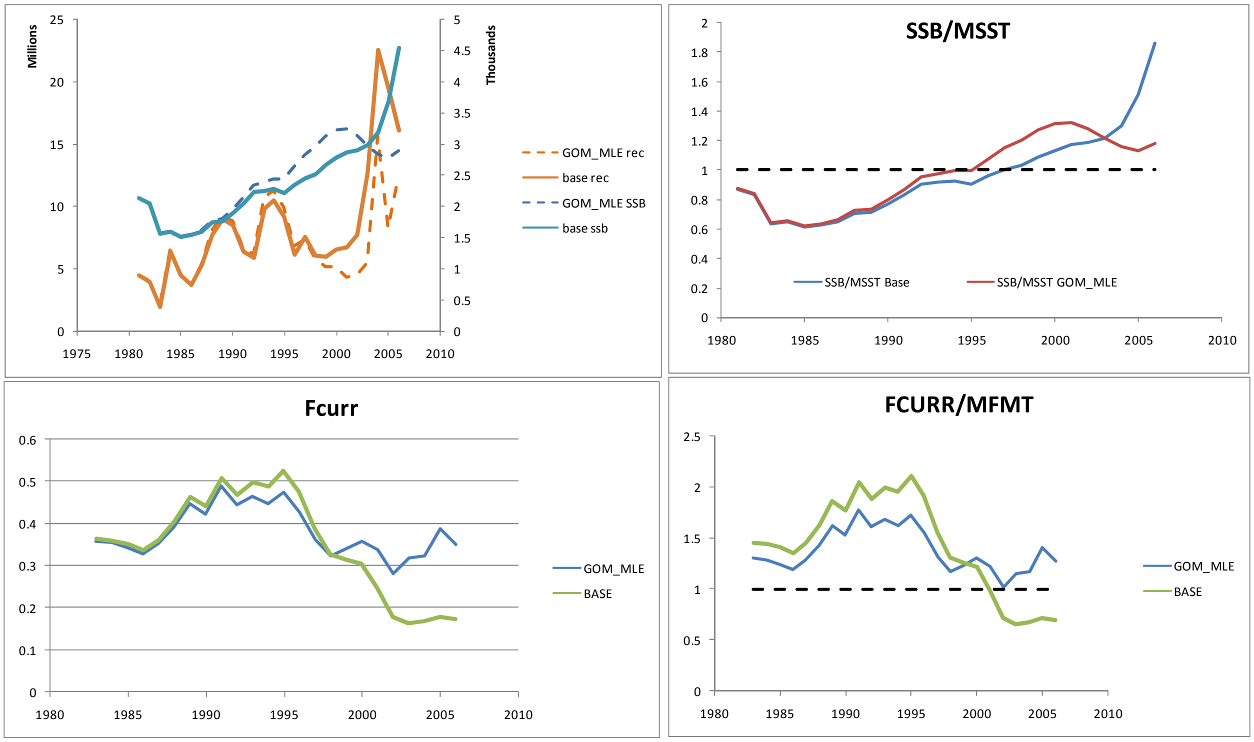



**Figure 7.** Sensitivity runs: *Base Case GOM VPA model with Maximum Likelihood Estimation (GLF_MLE) including indices estimates of variability (CV).* Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel GOM from the base model (solid line) and MLE sensitivity run. Plot top right, trends of relative SSB over MSST for base case and GLF_MLE run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and GLF_MLE run, and right plot of Fcurrent over MFMT ratios.

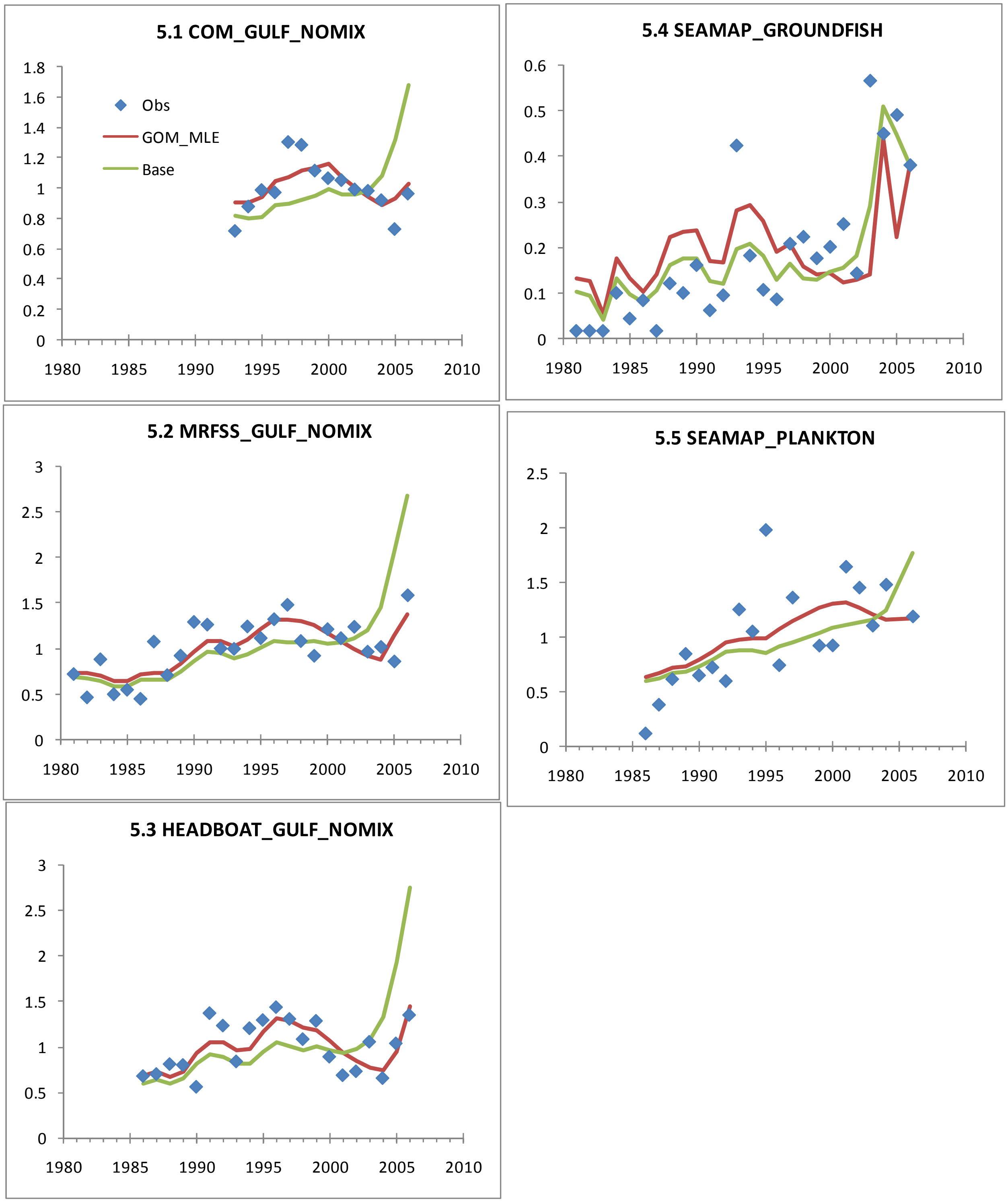



**Figure 8. Sensitivity runs:** *Base Case GOM VPA model with Maximum Likelihood Estimation (GLF_MLE) including indices estimates of variability (CV)*. **Fit of indices of abundance (solid lines), from the base model (green line) and the GLF_MLE model (red) to the input values (blue diamonds).**

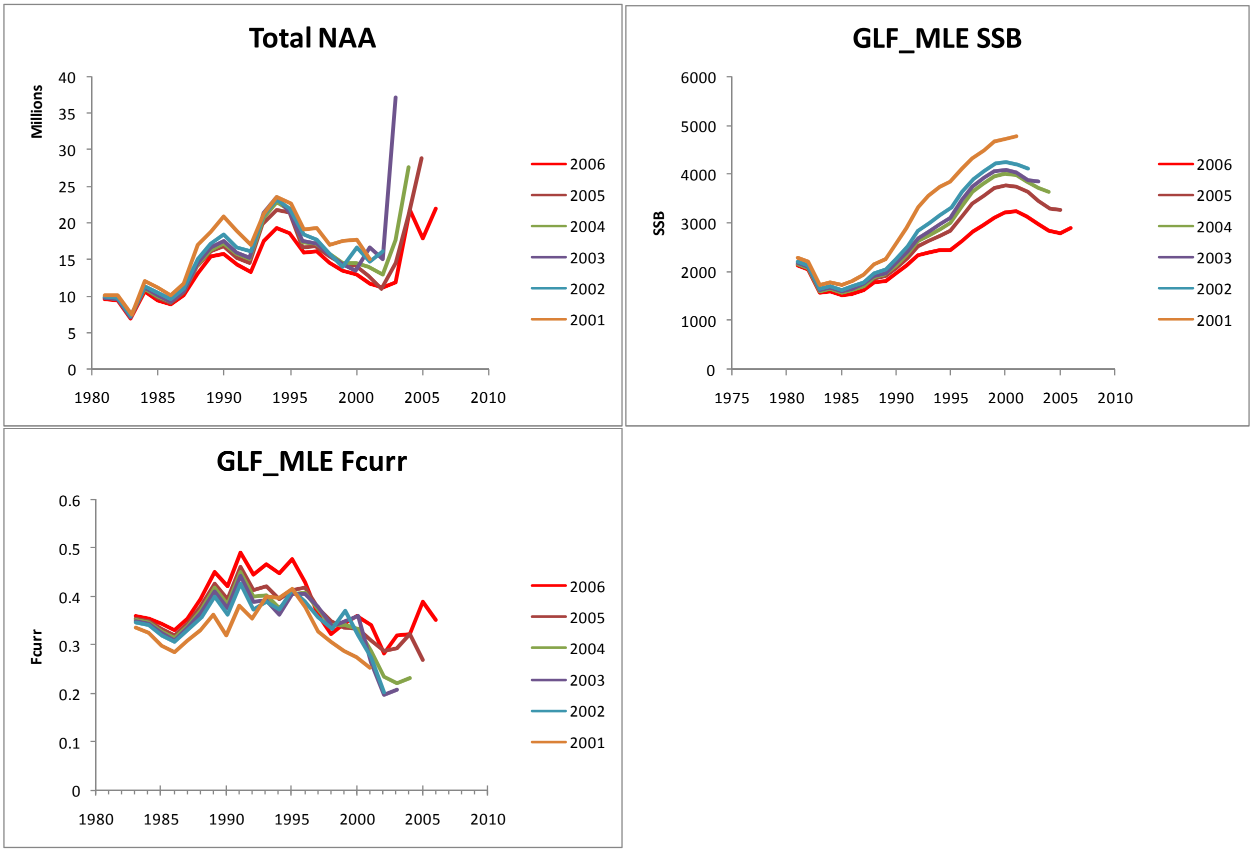



**Figure 9. Sensitivity runs:** *GOM VPA model with Maximum Likelihood Estimation (GLF_MLE) including indices estimates of variability (CV),* **retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current**

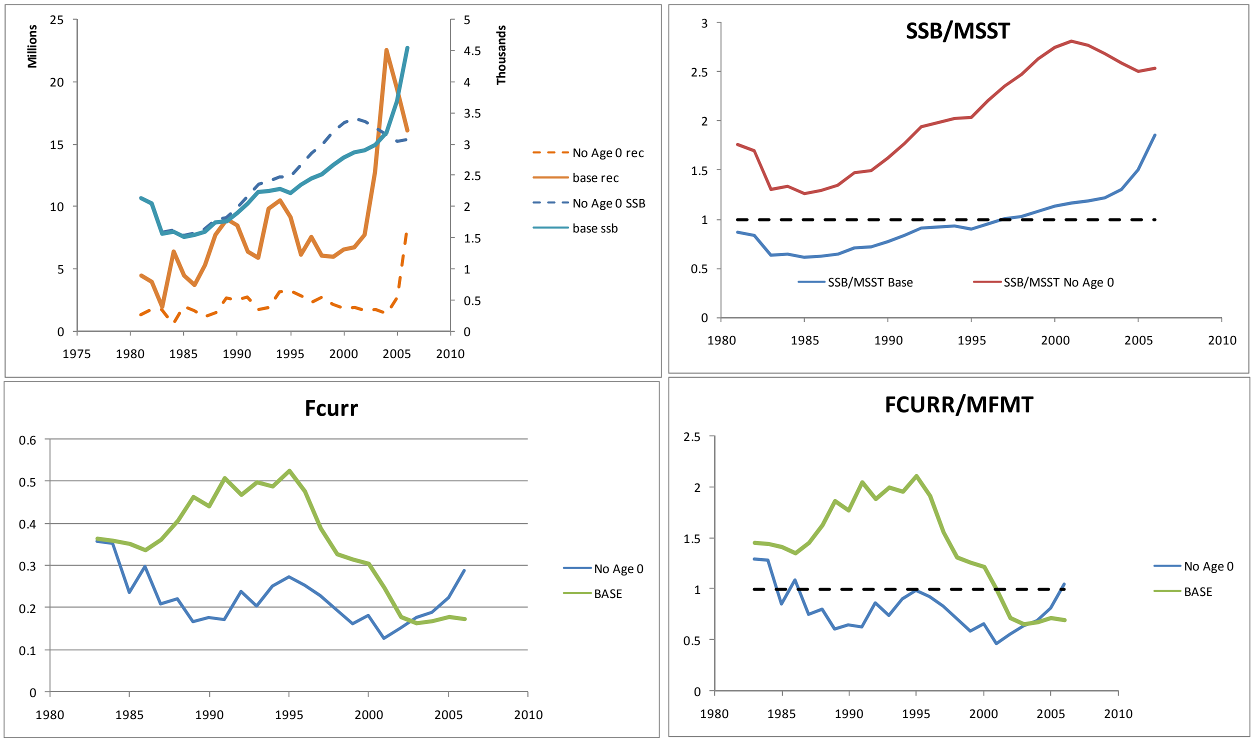



**Figure 10. Sensitivity runs:** *Base Case GOM VPA model removing Age 0 class (no Age 0) and restricting VPA model to ages 1-11+.* Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel GOM from the base model (solid line) and No Age 0 sensitivity run (recruits in sensitivity run correspond to age 1 estimates, in base case correspond to age 0 estimates). Plot top right, trends of relative SSB over MSST for base case and No Age 0 run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and No Age 0 run, and right plot of Fcurrent over MFMT ratios.

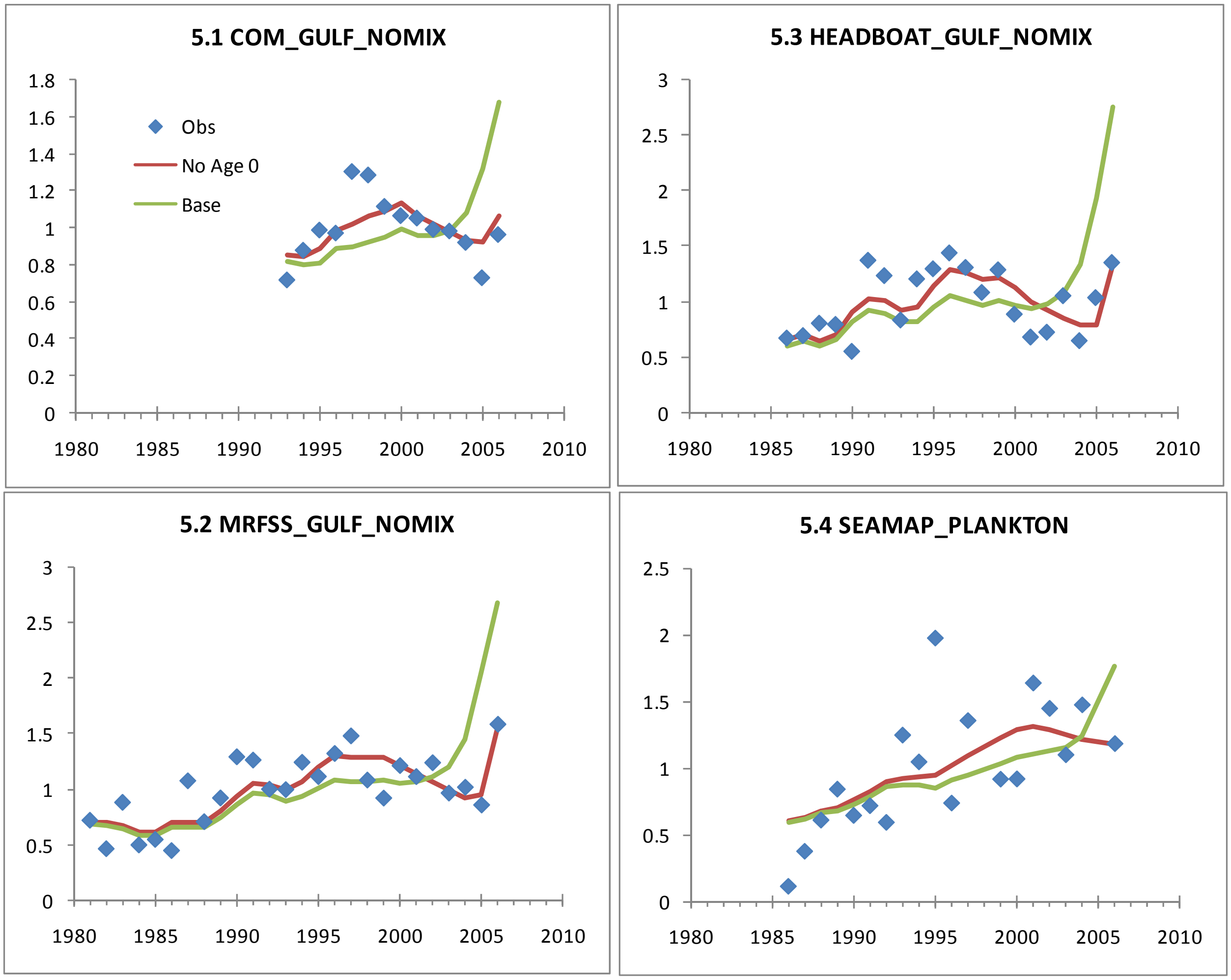



**Figure 11. Sensitivity runs:** *Base Case GOM VPA model removing Age 0 class (no Age 0) and restricting VPA model to ages 1-11+.* **Fit of indices of abundance (solid lines), from the base model (green line) and the GLF_MLE model (red) to the input values (blue diamonds).**

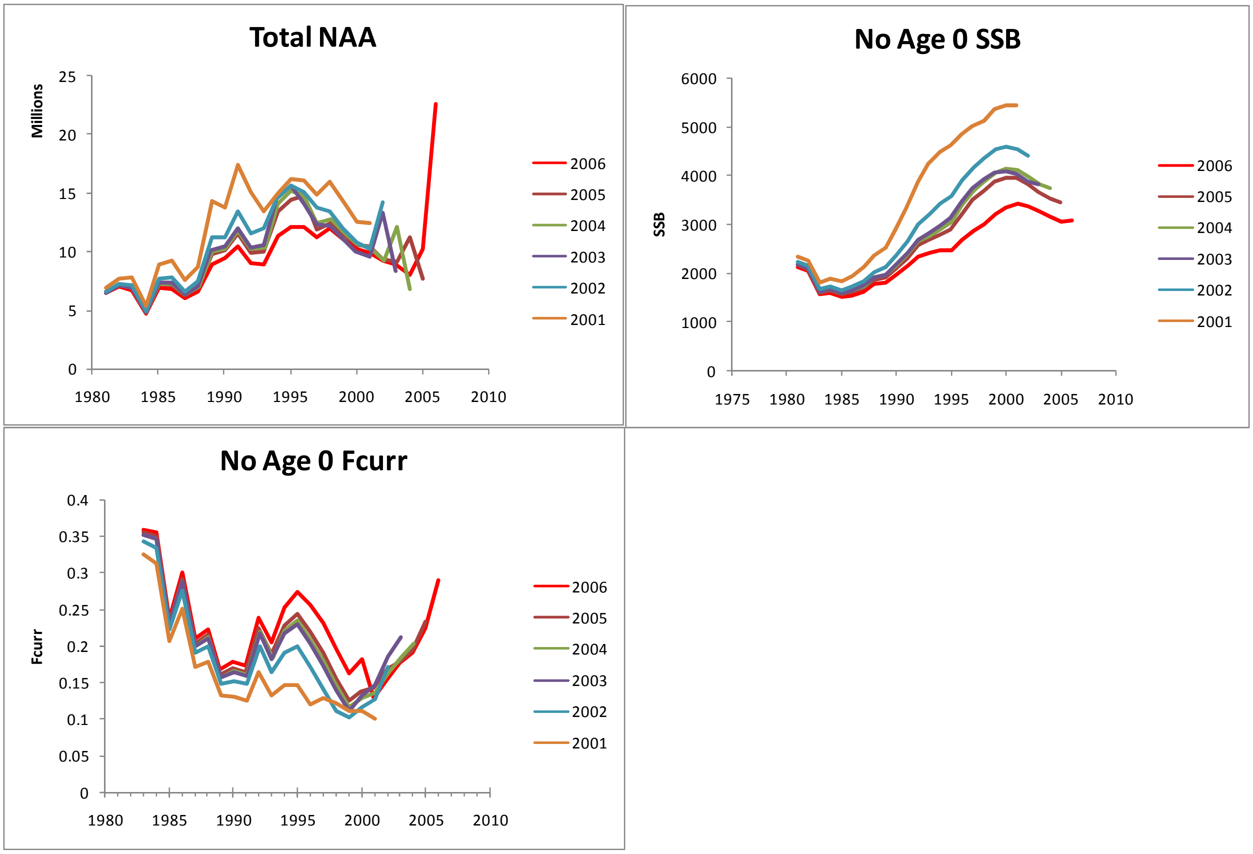



**Figure 12. Sensitivity runs:** *Base Case GOM VPA model removing Age 0 class (no Age 0) and restricting VPA model to ages 1-11+.* **Retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current.**

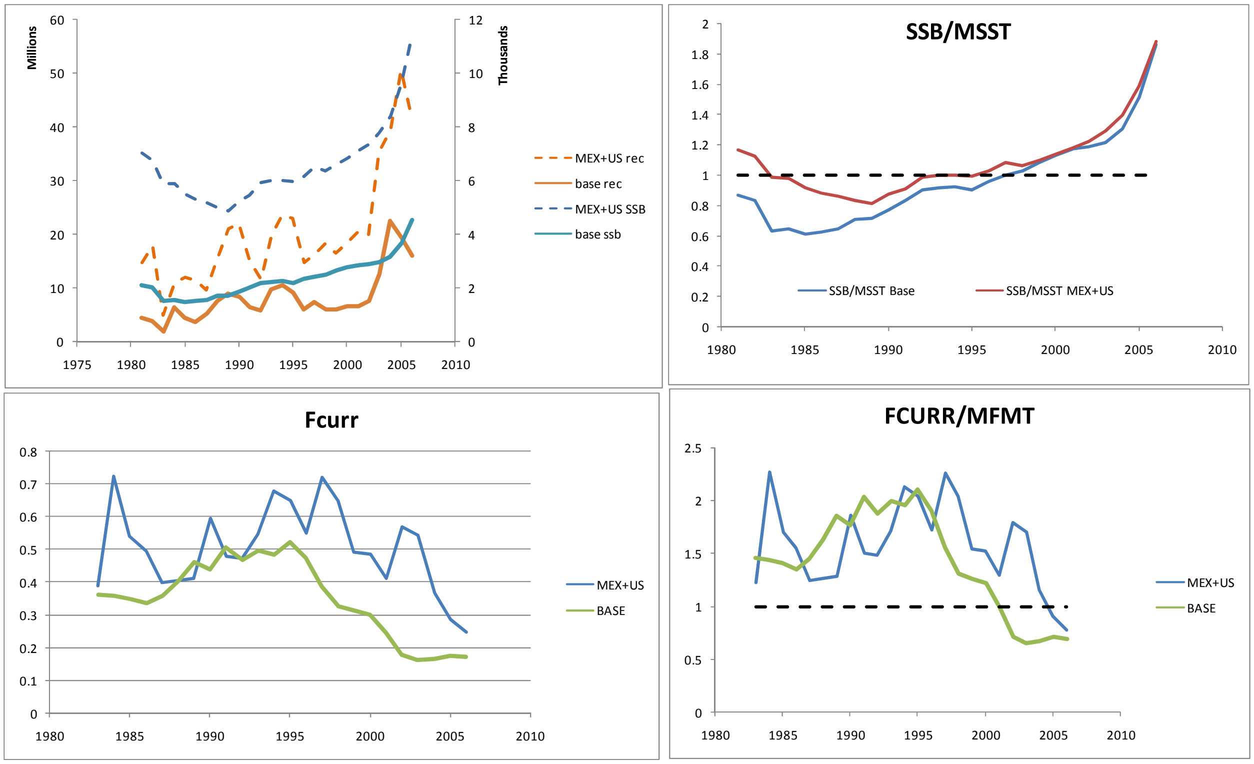



**Figure 13. Sensitivity runs: Including the Mexican catches of king mackerel in the GOM VPA base model.** Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel GOM from the base model (solid line) and sensitivity run that included Mexican catches (broken line). Plot top right, trends of relative SSB over MSST for base case and MEX+US catches run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and MEX+US catches run, and right plot of Fcurrent over MFMT ratios.

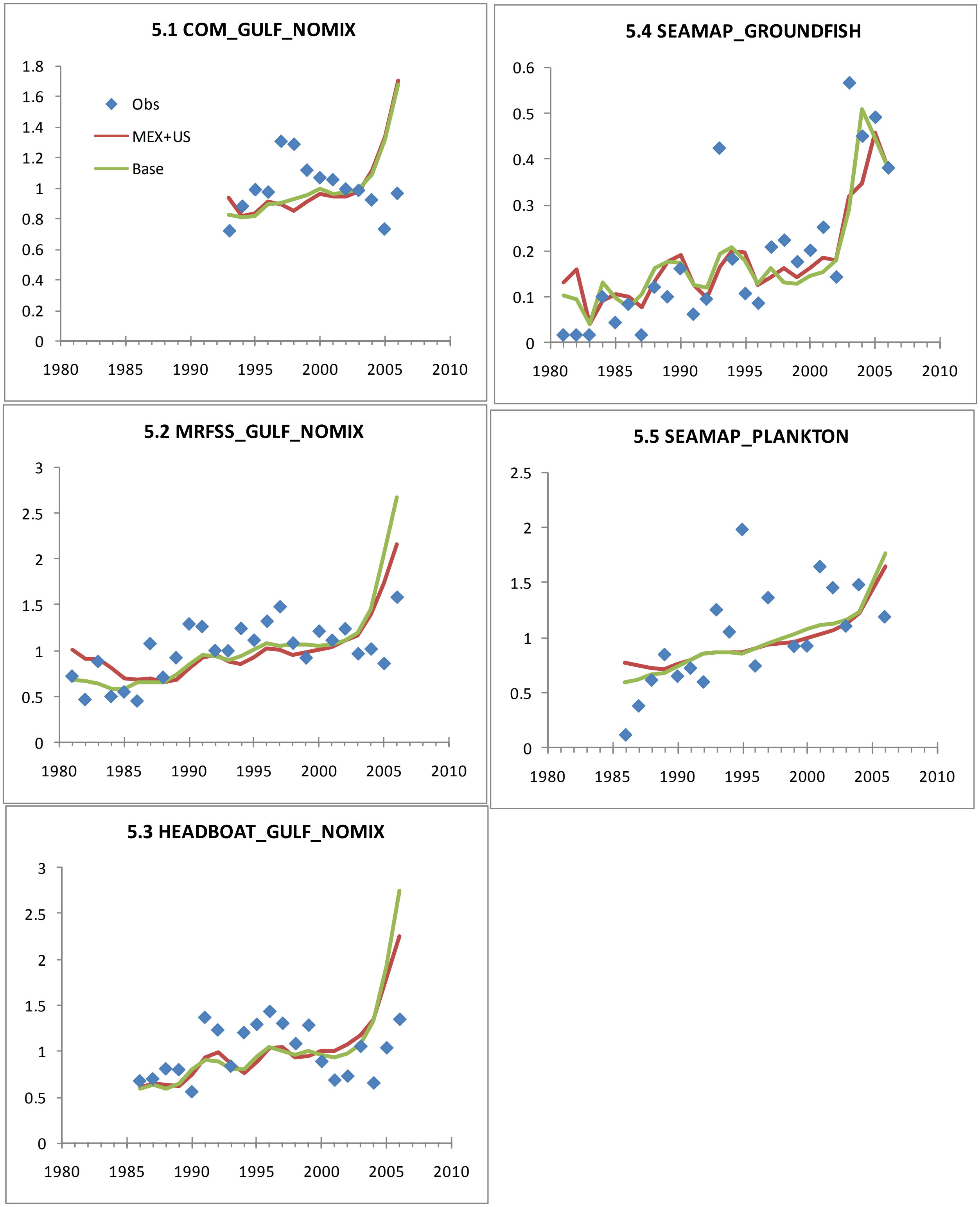



**Figure 14. Sensitivity runs: Including the Mexican catches of king mackerel in the GOM VPA base model.** Fit of indices of abundance (solid lines), from the base model (green line) and the MEX+US catches model (red) to the input values (blue diamonds).

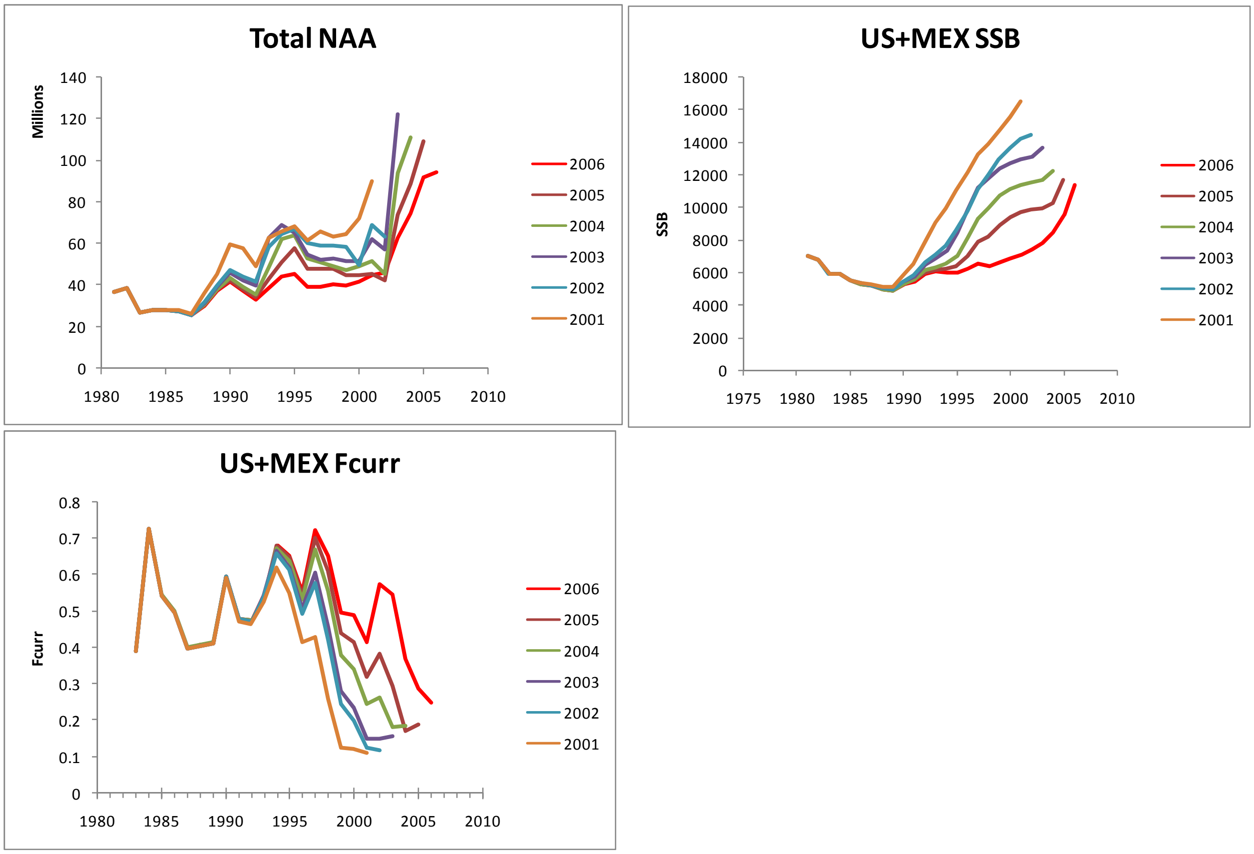



**Figure 15. Sensitivity runs: Including the Mexican catches of king mackerel in the GOM VPA base model.** Retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current.

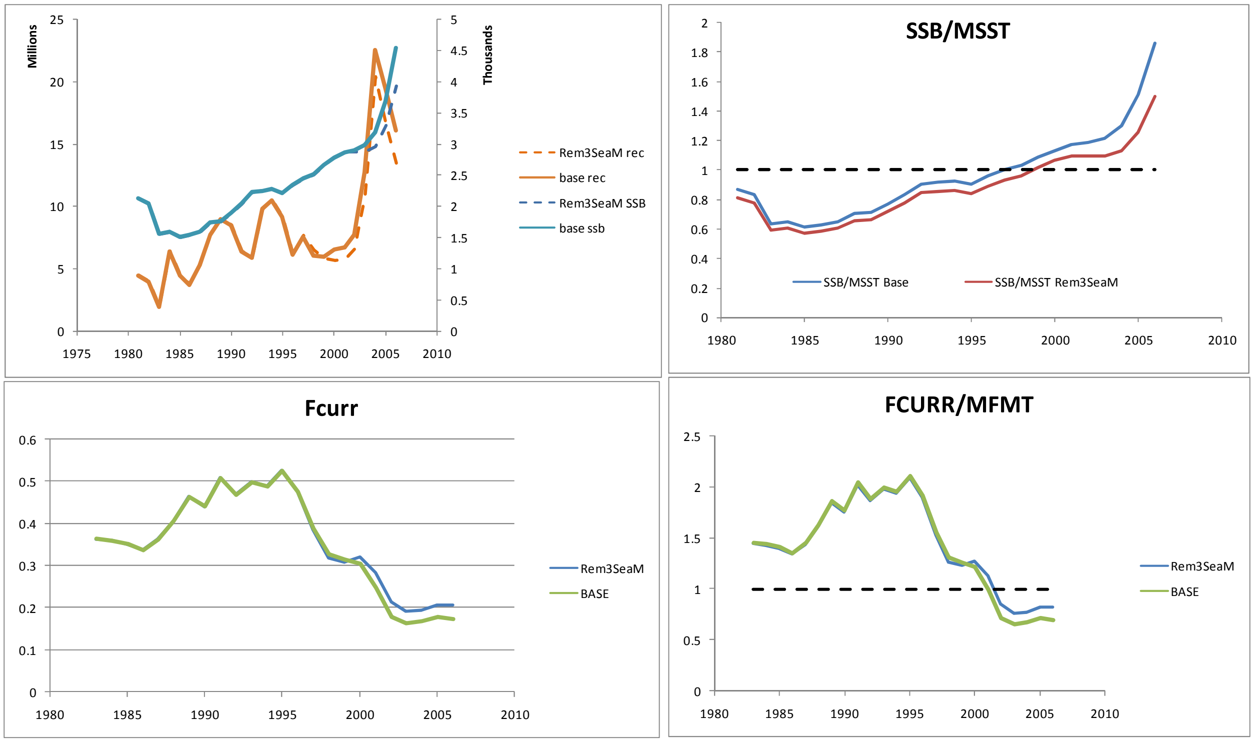



**Figure 16. Sensitivity runs:** *Base Case GOM VPA model removing first 3 year estimates (1981-1983) from the SEAMAP index of abundance (Rem3SeaM).* **Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel GOM from the base model (solid line) and Rem3SeaM sensitivity run. Plot top right, trends of relative SSB over MSST for base case and Rem3SeaM run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and Rem3SeaM run, and right plot of Fcurrent over MFMT ratios.**

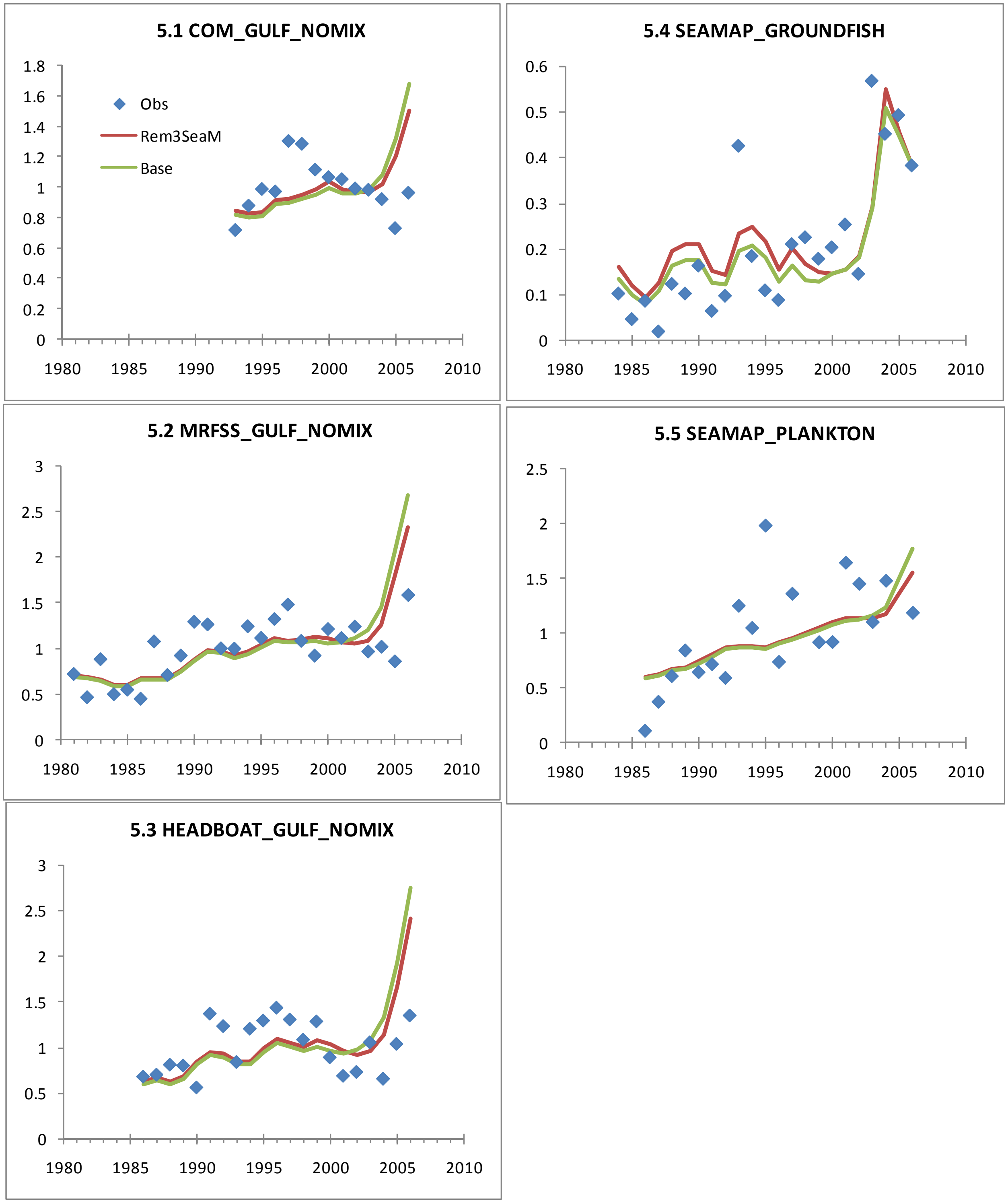



**Figure 17. Sensitivity runs:** *Base Case GOM VPA model removing first 3 year estimates (1981-1983) from the SEAMAP index of abundance (Rem3SeaM).* **Fit of indices of abundance (solid lines), from the base model (green line) and the MEX+US catches model (red) to the input values (blue diamonds).**

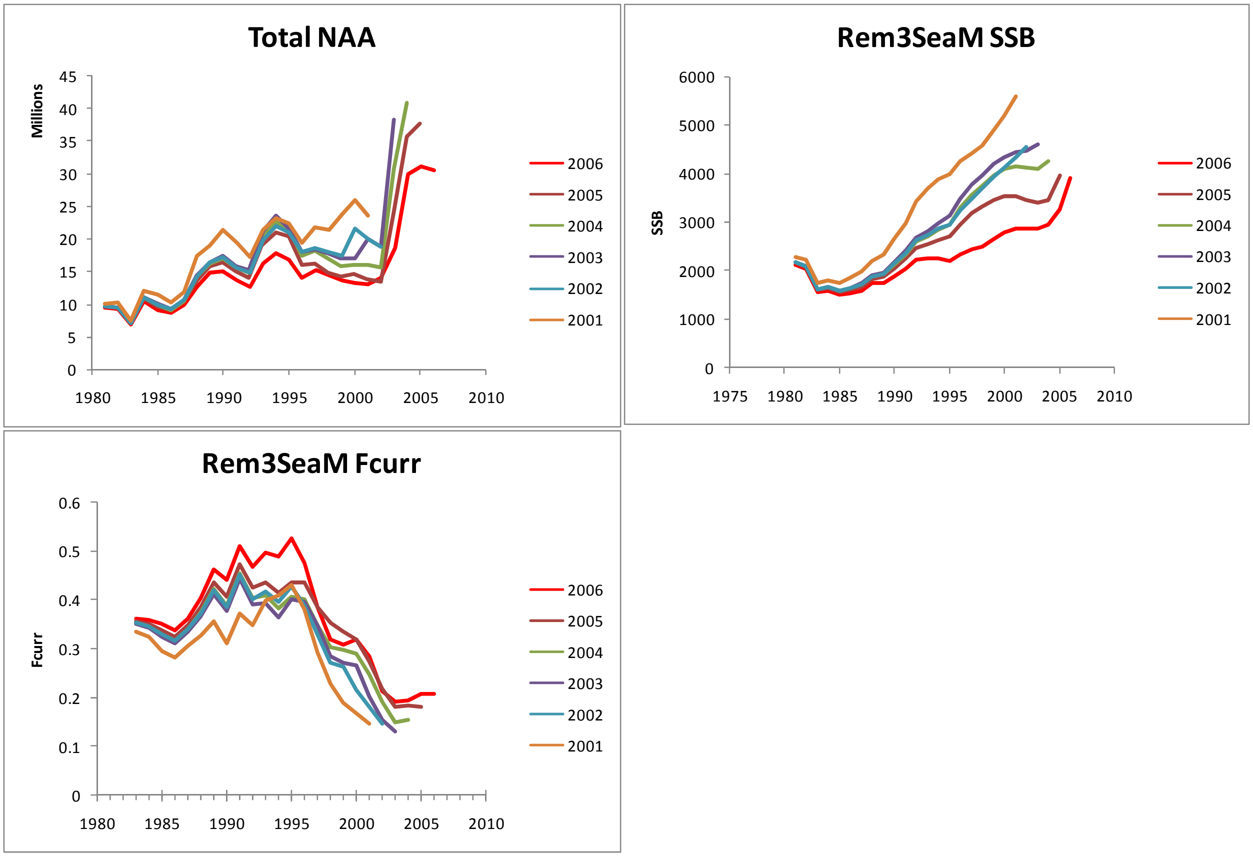



**Figure 18. Sensitivity runs:** *Base Case GOM VPA model removing first 3 year estimates (1981-1983) from the SEAMAP index of abundance (Rem3SeaM).* **Retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current.**

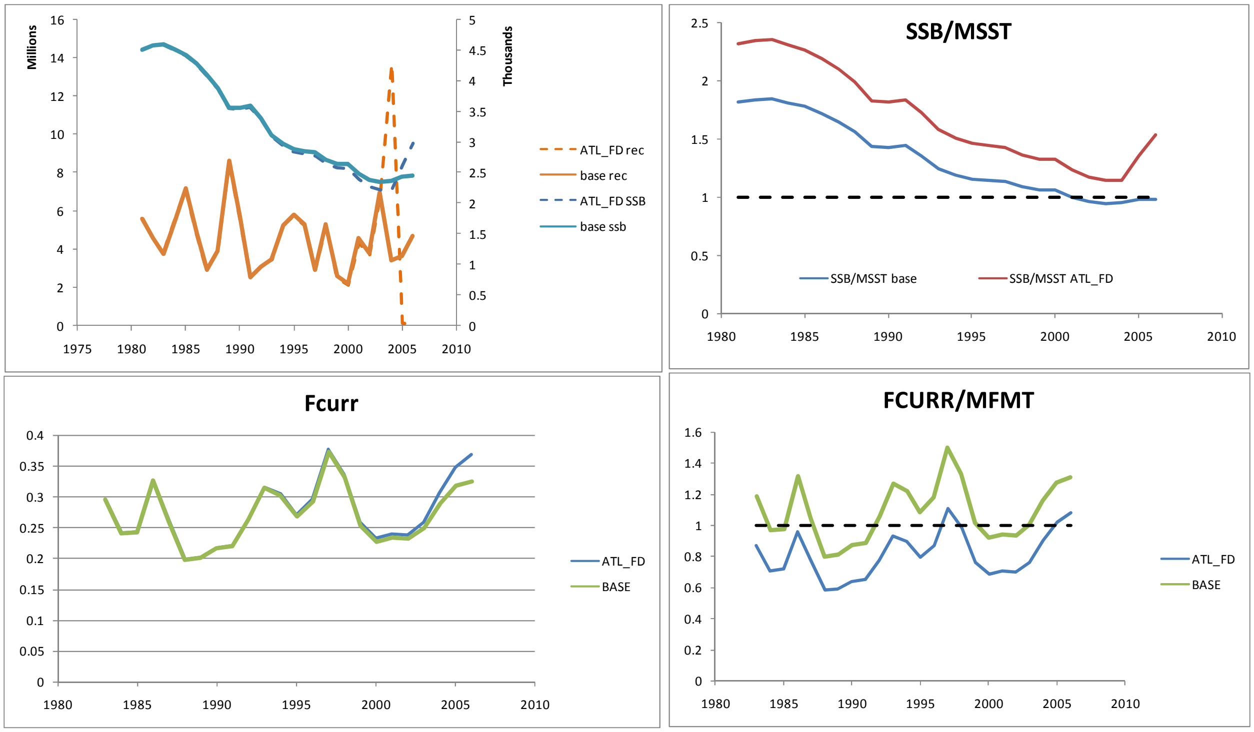



**Figure 19. . Sensitivity runs:** *Base Case ATL VPA model with Fishery dependent only indices of abundance (ATL_FD)*. **Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel Atlantic from the base model (solid line) and sensitivity run FD indices (broken line). Plot top right, trends of relative SSB over MSST for base case and ATL_FD indices run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and ATL_FD indices run, and right plot of Fcurrent over MFMT ratios.**

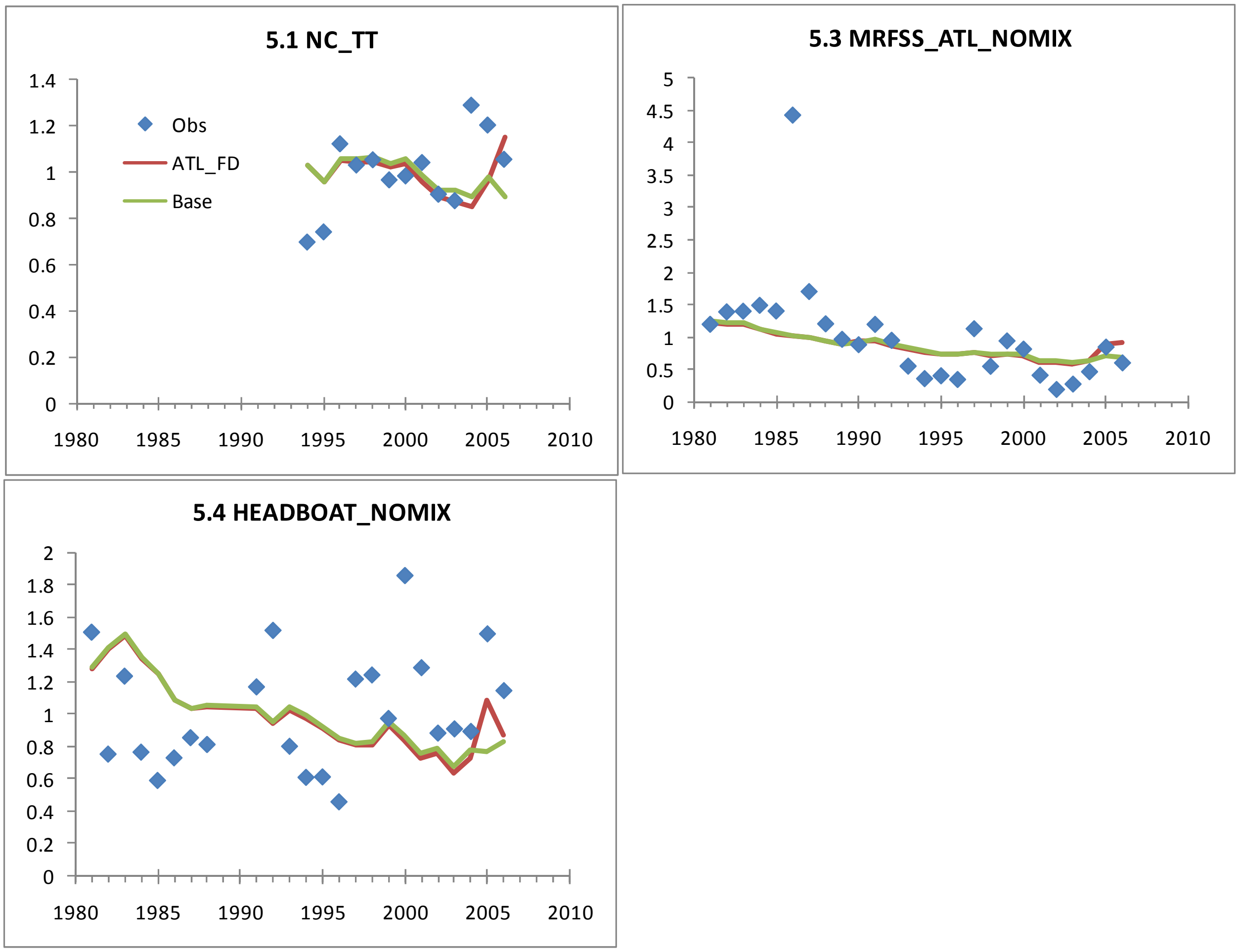



**Figure 20. Sensitivity runs:** *Base Case ATL VPA model with Fishery dependent only indices of abundance (ATL_FD)*. **Fit of indices of abundance (solid lines), from the base model (green line) and the ATL_FD model (red) to the input values (blue diamonds).**

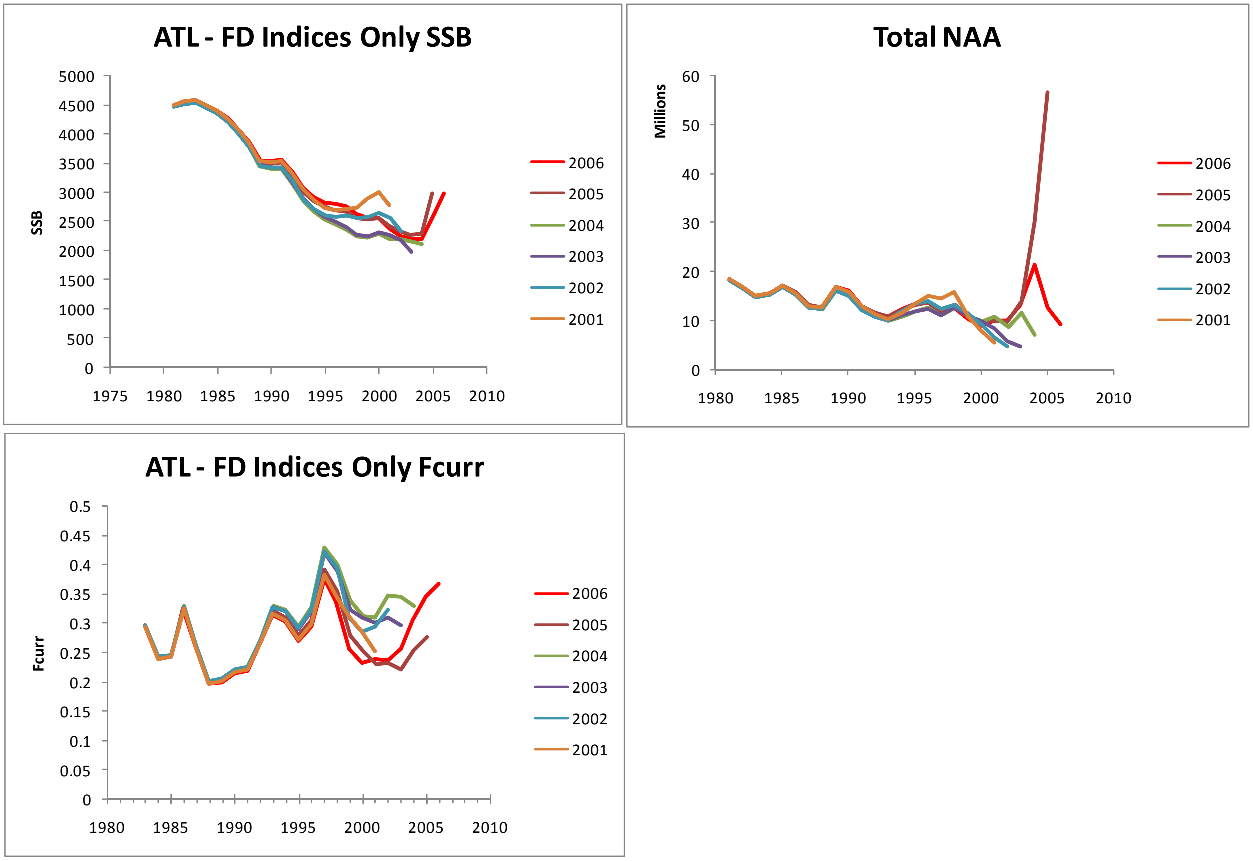



**Figure 21. ATL Sensitivity run - Fisheries dependent indices only (ATL_FD) run retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current.**

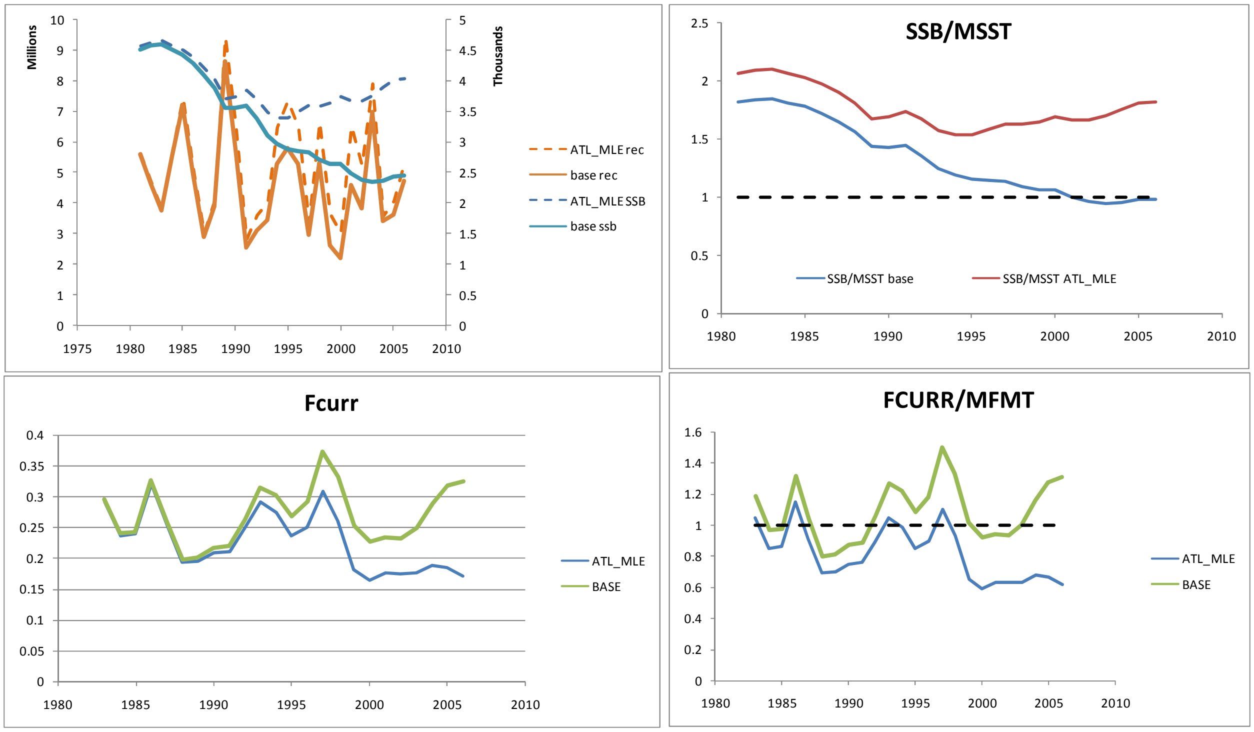



**Figure 22. Sensitivity runs:** *Base Case ATL VPA model with Maximum Likelihood Estimation (ATL_MLE) including indices estimates of variability (CV)***. Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel Atlantic from the base model (solid line) and sensitivity run ATL_MLE (broken line). Plot top right, trends of relative SSB over MSST for base case and ATL_MLE run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and ATL_MLE run, and right plot of Fcurrent over MFMT ratios.**

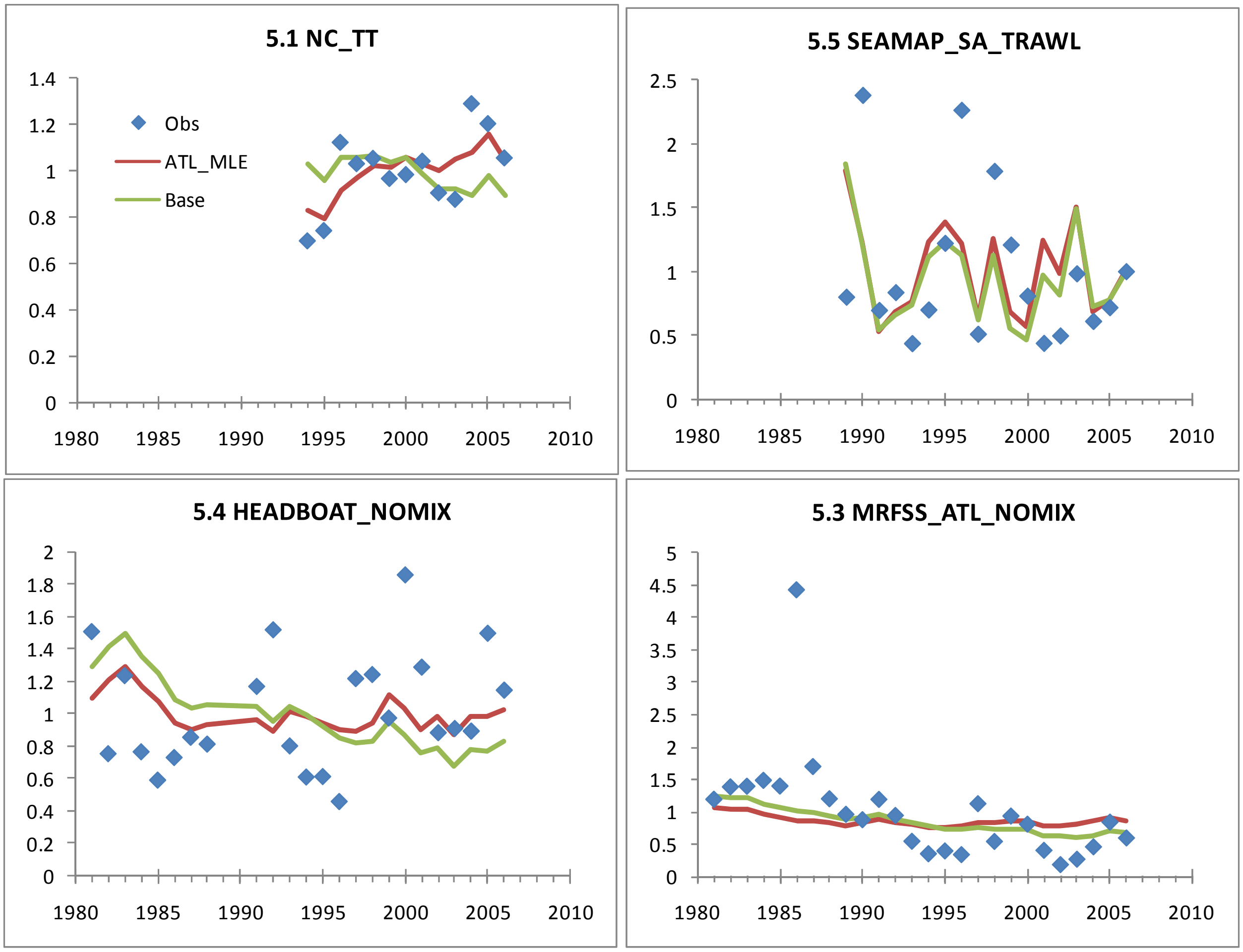



**Figure 23. Sensitivity runs:** *Base Case ATL VPA model with Maximum Likelihood Estimation (ATL_MLE) including indices estimates of variability (CV)*. **Fit of indices of abundance (solid lines), from the base model (green line) and the ATL_MLE model (red) to the input values (blue diamonds).**

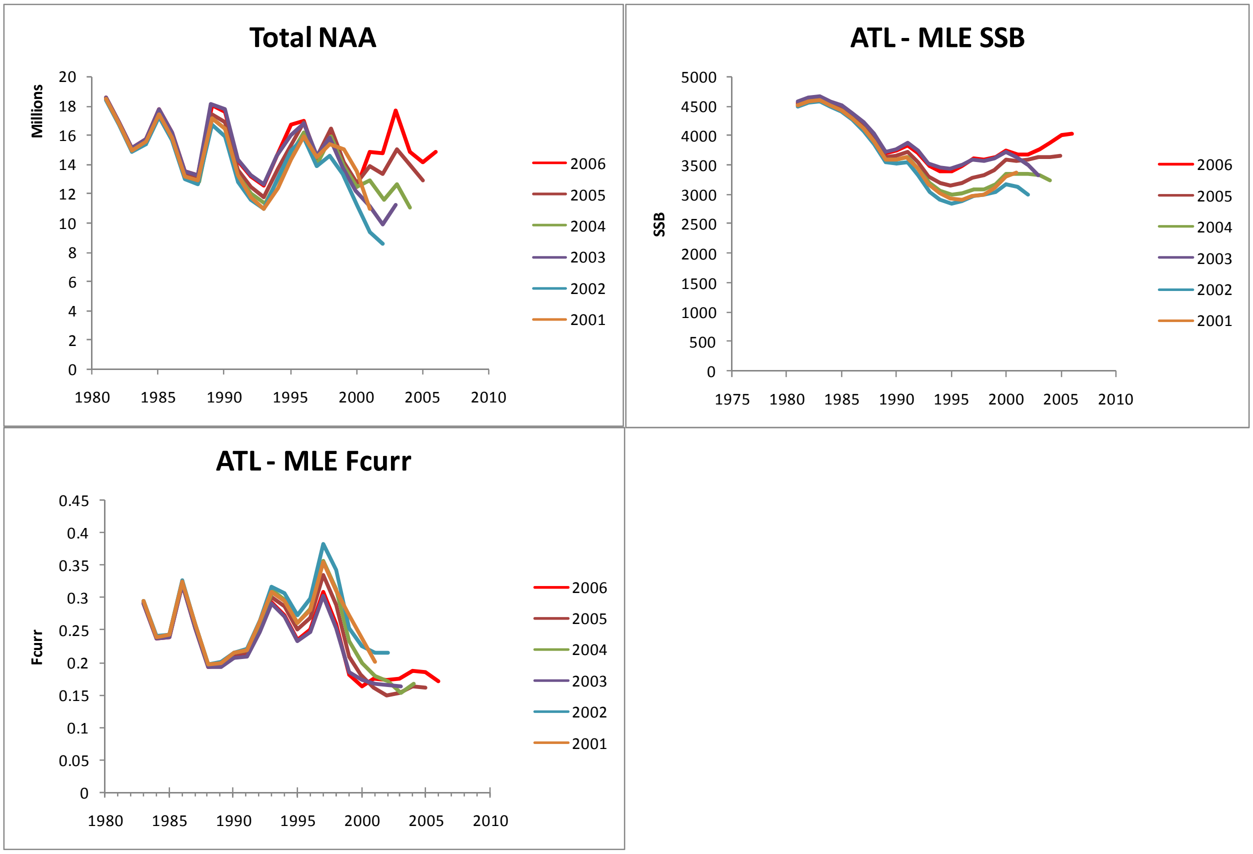



**Figure 24. Sensitivity runs:** *ATL VPA model with Maximum Likelihood Estimation (ATL_MLE) including indices estimates of variability (CV),* **retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current.**

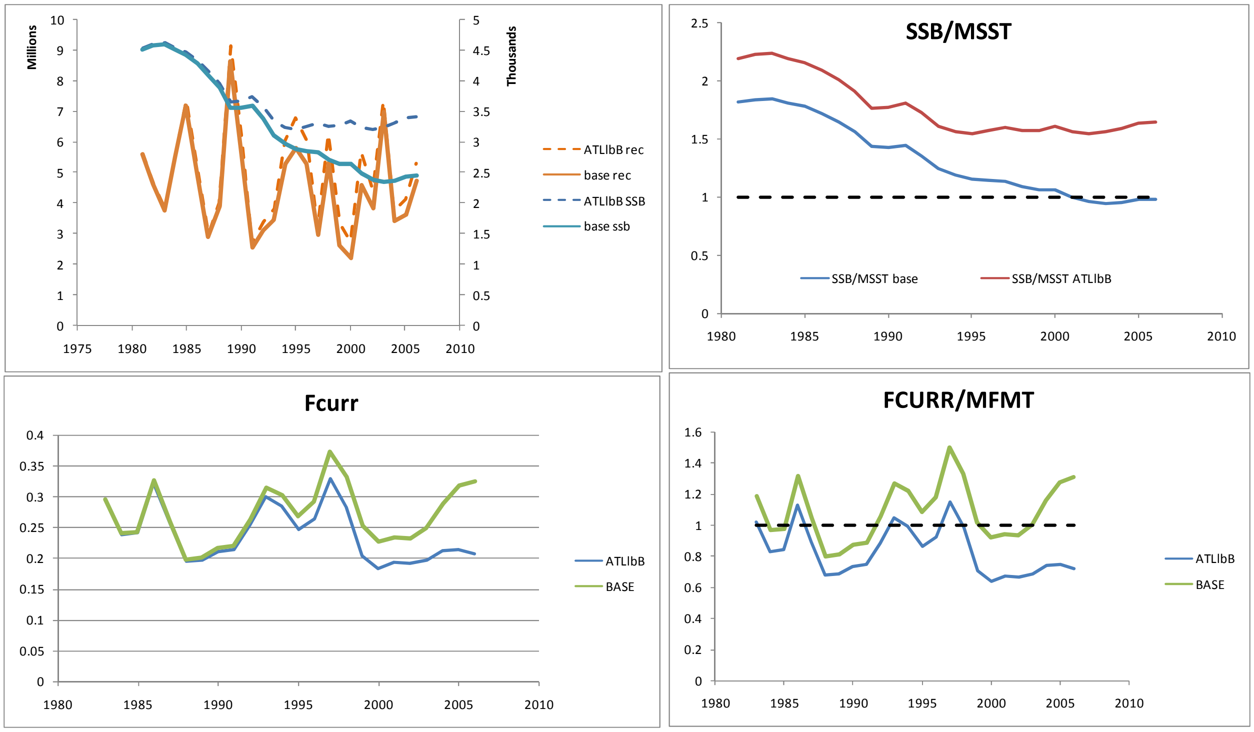



**Figure 25. Sensitivity runs Mix-summer Indices:** *Add/replace indices of abundance that included catch and effort data from the Florida east coast (Mixing zone) during the summer months (April – October) to the Base Case ATL VPA model*. **Plot top left, trends of spawning biomass (SSB) and recruits (rec) king mackerel Atlantic from the base model (solid line) and sensitivity run that included/replace indices of abundance for the mix-summer months (ATLlbB) (broken line). Plot top right, trends of relative SSB over MSST for base case and ATLlbB indices run. Plots bottom, left trends of estimated Fcurrent for the base (green line) and ATLlbB indices run, and right plot of Fcurrent over MFMT ratios.**

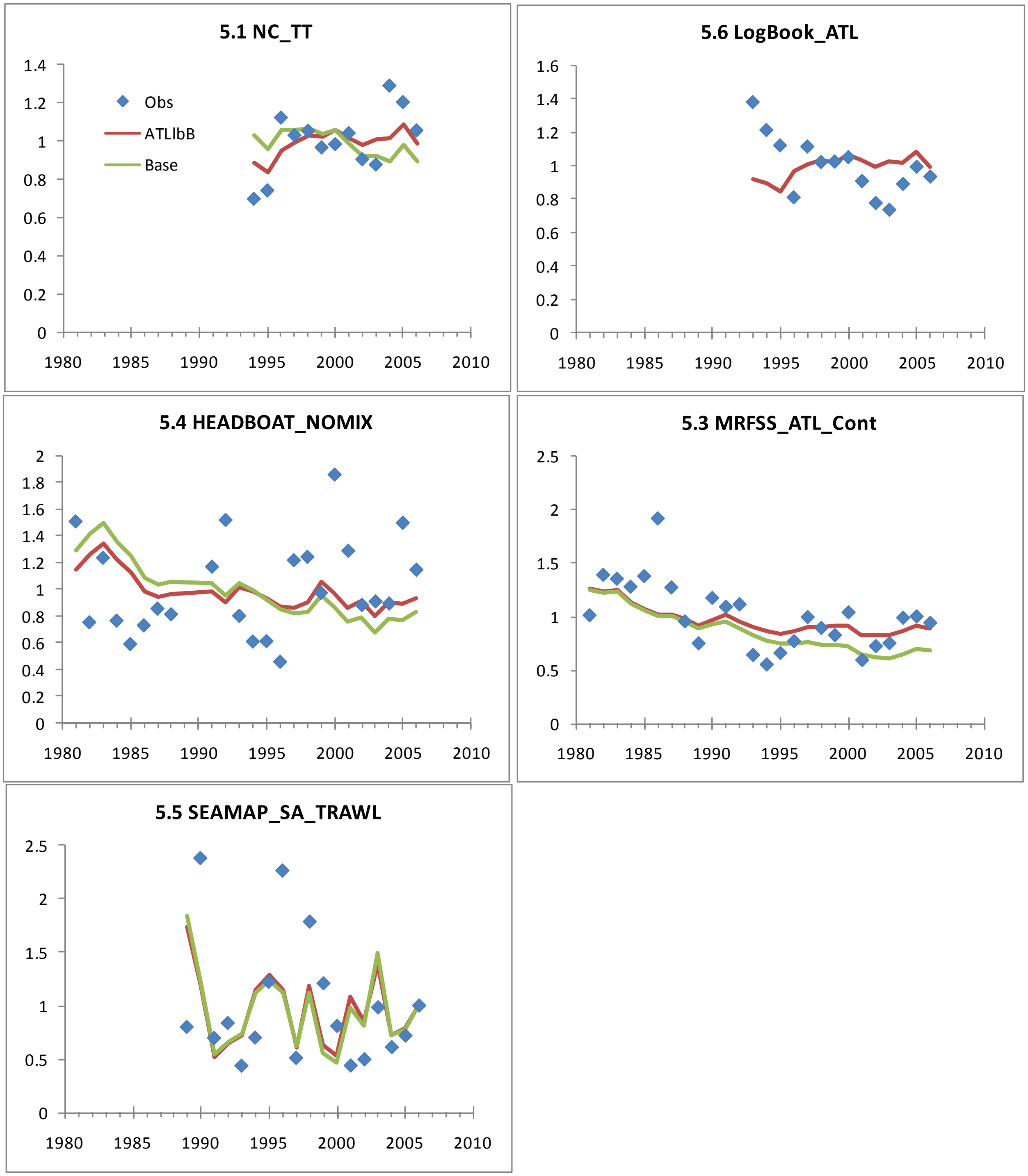



**Figure 26. Sensitivity runs Mix-summer Indices:** *Add/replace indices of abundance that included catch and effort data from the Florida east coast (Mixing zone) during the summer months (April – October) to the Base Case ATL VPA model*. **Fit of indices of abundance (solid lines), from the base model (green line) and the ATLlbB model (red) to the input values (blue diamonds). The Atlantic logbook index was added to the base model, while the MRFSS index was replace with an index including observations from the Mix-summer area.**

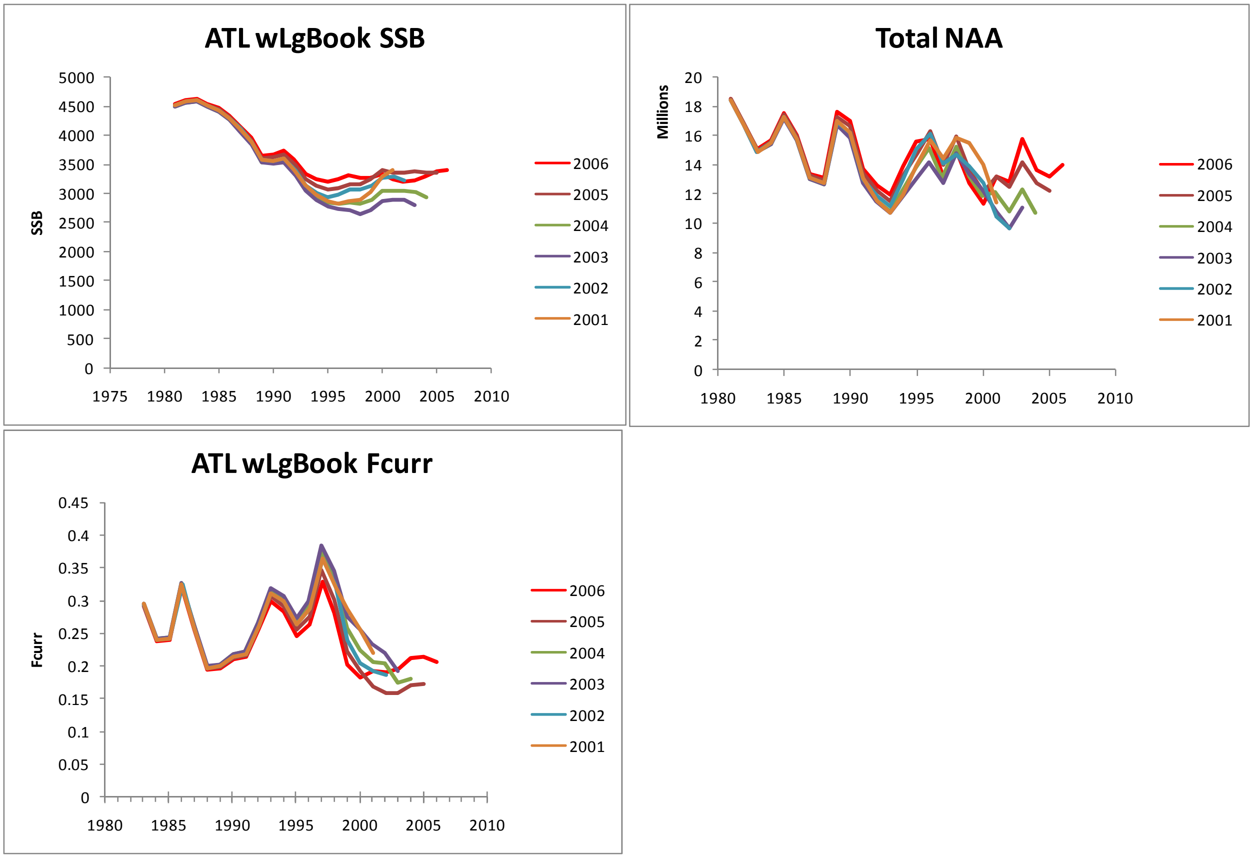



**Figure 27. Sensitivity runs Mix-summer Indices:** *Add/replace indices of abundance that included catch and effort data from the Florida east coast (Mixing zone) during the summer months (April – October) (wLgBook) run,* **retrospective analysis plots of spawning stock biomass (SSB), stock size (NAA) and F current.**

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
(727) 824-5305; FAX (727) 824-5308
http://sero.nmfs.noaa.gov

OCT 21 2008

F/SER29:AS

MEMORANDUM FOR: Bonnie Ponwith, Ph.D.
Director, Southeast Fisheries Science Center

FROM: Roy E. Crabtree, Ph.D.
Regional Administrator

SUBJECT: King Mackerel Data Request

The South Atlantic and Gulf of Mexico Fishery Management Councils (Councils) will convene their Scientific and Statistical Committees (SSCs) in late November and early December to review the results of the Southeast Data, Assessment, and Review (SEDAR) 16 king mackerel stock assessment. During this review, and in compliance with the Magnuson-Stevens Fishery Conservation and Management Act, the SSCs will be required to recommend allowable biological catch levels (ABC). To assist the SSCs during their review of the stock assessment, and Council and SERO staffs in preparing an amendment for this action, I am requesting the Southeast Fisheries Science Center provide the following data based upon the SEDAR 16 Review Workshop (RW) base model:

1. Yield projections associated with $F_{current}$, $65\%F_{30\%SPR}$ , $75\%F_{30\%SPR}$, $85\%F_{30\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$ by migratory group through 2016;
2. trends in landings and dead discards in pounds by year, fishing mode (shrimp, commercial, charter, private, and headboat), and migratory group; and
3. trends in fishing mortality and spawning stock biomass by year and migratory group.

I also request you provide the following yield projections ($F_{current}$, $65\%F_{30\%SPR}$ , $75\%F_{30\%SPR}$, $85\%F_{30\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$) through 2016 based upon the SEDAR 16 RW base model:

1. Separate yields for each of the two king mackerel management areas delineated at the Miami-Dade/Monroe County line;
2. separate yields for each migratory unit based on allocating all fish in the mixing zone to the Gulf of Mexico migratory unit; and
3. separate yields for each of the two king mackerel management areas delineated at the Gulf and South Atlantic Council boundaries.

If possible, please provide the requested data on or before November 21, 2007. If you have any questions, please call Andy Strelcheck on my staff at (727) 824-5374.

Attachment

cc: F/SER2 – Phil Steele
F/SER24 – Steve Branstetter, John McGovern, Andy Strelcheck,
GMFMC – Rick Leard
SAFMC – Gregg Waugh

**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149 U.S.A.
(305) 361-4204 Fax: (305) 361-4499

11 November 2008

MEMORANDUM FOR: Dr. Roy Crabtree
Regional Administrator

FROM: Dr. Bonnie Ponwith
SEFSC Director

SUBJECT: King Mackerel Data Request

The purpose of this Memorandum is to provide a direct response to your request dated 21 October, 2008, regarding our provision of information based upon the SEDAR-16 Review Workshop (RW) base model. In addition, this Memorandum provides information related to other analyses requested by the RW. Therefore, by providing these various sets of information to the Councils' SSCs, we should have fulfilled the SEDAR 16 terms of reference as well as the additional analyses requested by the independent reviewers.

The various information sets are contained in three Annexes, as follows:

> Annex 1: Documentation of the "Final Assessment Model" for the Gulf migratory unit, after making changes recommended by the Review Workshop.
> Annex 2: Response to your 21 October request for king mackerel stock assessment data resulting from the SEDAR 16 Review Workshop.
> Annex 3: Decision Tables recommended by the Review Workshop, portraying the probability of overfishing under different harvest levels, conditional on different assessment models.

In addition, Attachment 1 is an Excel spreadsheet that contains the results for Annexes 2 and 3, in case your office or the SSCs wish to organize the information sets with a different structure.

Please do not hesitate to contact me if you require additional clarification.

cc: A. Hohn
V. Restrepo
C. Porch
T. Brainerd
T. Jamir
J. Neer

Attachments: Annexes 1, 2 and 3 (documents); Attachment 1 (spreadsheet)

# Update of the Gulf of Mexico King Mackerel Base Assessment Model, Based on SEDAR-16 Recommendations

Mauricio Ortiz and Shannon Cass-Calay

NOAA Fisheries
Southeast Fisheries Science Center, Miami Laboratory
75 Virginia Beach Drive, Miami Florida 33149 U.S.A.

31 October, 2008

Sustainable Fisheries Division Contribution No. SFD-2008-019

## Introduction

The Virtual Population Analysis (VPA) results described in this document provide an update of the base model for the Gulf king mackerel assessment following the recommendations from the review panel of the SEDAR-16 Review Workshop (Ref Report RW[1]). Referring to the fishery-independent SEAMAP Fall Groundfish index that was used initially for the assessment, the review panel concluded that “the use of lowest observations to replace zero observations under assumption of a lognormal distribution was erroneous. The RW requested that the GOM base case be corrected to take this into account” (SEDAR 16 South Atlantic and Gulf of Mexico King mackerel. Section V: Review Workshop Report 2008). This document presents the complete results of the VPA for the updated base case GOM following the RW request. We refer to this update as the "Final model".

For completeness, this document presents the inputs and general assumptions of the Final model. These are the same as in the base model presented in SEDAR16-RW-01, except for the Fall Groundfish index (see below). Model settings and inputs as decided by the Assessment and Review Workshops are summarized in Table 1. The VPA model assumed that fish caught in the mixing zone during winter (Nov-Mar) represents a 50% mix of Atlantic and GOM king mackerel, therefore landings and dead discards from this area were split equally between stocks. The VPA model also estimated all terminal-F (fishing mortality) parameters except the plus group, which was assumed to be equal to the prior age class for all years in the assessment evaluation (1981-2006). The model fits a selectivity pattern by age for each index that is constant over time (Butterworth and Geromont 1999 formulation) estimated from the partial catch at age associated with each index of abundance. The VPA model equally weighted relative indices of abundance while preserving inter annual variations, by fixing the variance scaling parameters to the values presented in Table 2. No recruitment patch was applied in the Final. Tables 3 and 4 summarize the biological parameter inputs for the GOM Final model, while Table 5 shows the catch at age matrix input including landings and dead discards. Average proportions of dead discards by age from the last three years (2004-06) were used for projections of stock status to estimate landings only (same time period used for estimate average selectivity of current fisheries for projection purposes). Relative indices of abundance are shown in Table 6. Note that for the SEAMAP Fall Groundfish index, the first three values (years 1981-1983) were removed as per the recommendation from the review panel. The partial catches at age associated with each index are the same as those presented in Table 3.28 of the SEDAR16-RW-01 document. A penalty was used for to constrain changes in selectivity during the most recent three years. The penalty was applied to ages 3-9 (SD=0.4).

The parameters estimated by the VPA were the terminal-F values for ages 0 to 10 and a catchability coefficient for each index. Initial guess estimates of terminal-F were set a 0.15 for ages 0 to 10. Uncertainty in model fit was evaluated by running 1000 non-parametric bootstraps of the index residuals. From these bootstraps, estimates of central tendency (median and average), bias and variance (standard error, coefficient of variation, and 80% confidence limits) were calculated for estimated parameters and derived stock indicators such stock size, biomass, fishing mortality, recruitment and yields.

Following decisions by the SEDAR 16 assessment and review panels, benchmarks for the king mackerel GOM stock unit were calculated as follows:

- $F_{MSY}$: estimated by the proxy $F_{30\%SPR}$.

[1] Available from http://www.sefsc.noaa.gov/sedar/

- $B_{MSY}$: estimated by the equilibrium SSB resulting from fishing at $F_{30\%SPR}$ and assuming the equilibrium stock-recruitment relationship adopted (see paragraph below).
- MSY: estimated by the equilibrium yield resulting from fishing at $F_{30\%SPR}$ and assuming the equilibrium stock-recruitment relationship adopted.

The following treatments of the data and assumptions were used in making the corresponding calculations: Current F ($F_{current}$) vector at age was calculated from the geometric mean of the age-specific F values for the most recent three years (2004-06). In this document, when a single value is used for $F_{current}$ it refers to the highest value in the vector. Current selectivity was computed by re-scaling the $F_{current}$ vector to a maximum value of 1. Spawning stock biomass (SSB) was computed as the product of the numbers at age at the beginning of each year, times the maturity at age, times fecundity (hydrated eggs per female) at age. Thus SSB reflects egg production. The expected spawner-recruitment relationship adopted assumed a Beverton-Holt function with a steepness of 0.95 (i.e. recruitment is nearly constant at most levels of SSB) and a maximum expected recruitment equal to the geometric mean of VPA estimated recruits over the years for which indices of stock and recruitment abundance were both available (1981-2004).

Projections of stock status for FY2007-2016 (FY = fishing year) were performed under different scenarios of fishing mortality or constant catch using the same assumptions as the calculations of benchmarks. In all cases, projection scenarios began in FY2008. FY2007 was assumed to be equal to the 2006 Fcurrent estimate (see previous paragraph). Projections were run using the projection software PRO-2BOX (Porch, 2002b). To estimate the variance of the projections, 1000 VPA bootstraps were projected for each scenario, allowing lognormal random variation of the assumed stock-recruitment relationship. The variance for the stock-recruitment relationship was estimated from the deterministic VPA stock-recruitment fit.

## Results

### Measures of overall model fit

The model fit was assessed using the objective function, likelihood statistics (Table 7) and fits to the indices of abundance (Fig 3). AIC, AICC and BIC values are also summarized in Table 7, but these are not directly comparable between models with different number of observations and parameters. For comparison equivalent values are presented for the base model. The overall objective function is lower in the Final model; however the Final model has only 103 observations, compared to the base model with 106 (recall that the deletion of the first 3 years of the SEAMAP Groundfish index is the difference between the models). Overall fits of indices of abundance followed same trends between the Base and Final models, with the exception of the SEAMAP Groundfish fit which indicated higher catch rates particularly in the early years after the exclusion of the 1981/84 observations (Fig 3). Figure 4 shows the normalized cumulative residual plots or qq-plots of the Final model. Note that the q-q plots suggest that there may continue to be some outliers, particularly for the two fishery-independent indices. Overall, the final model fits continue to estimate increasing abundance, particularly in the most recent years. This result is supported by the fishery- independent indices, but such trend is not shown by the fishery dependent indices. Because of conflict in the trends of several indices, the choice of index weighting in the VPA continues to have a substantial impact on the results of the final model, as it did for the base case.

## Parameter estimates and associated measures of uncertainty

Parameter estimates and the associated maximum likelihood estimate (MLE), bootstrap average, bias, standard error and coefficient of variation (CV) are summarized in Table 8. Coefficients of variation ranged from 19% to 37% for the terminal fishing mortality rates by age, being higher for ages 0 and 1.

## Stock abundance and Recruitment

Annual estimates of stock size from the final model are tabulated in Table 9, while estimates of spawning stock (in millions of hydrated eggs) and recruitment are tabulated in Table 10 for the deterministic run. Figure 5 shows the annual trends of total biomass, spawning biomass, stock size, recruits, apical fishing mortality, and yields with estimated 80% confidence limits (broken lines) around the median value (red line) of 1000 bootstrap runs. For comparison purposes, the median value of the GOM base case is also plotted (blue line). The largest differences between the base and Final models are in the estimates of total biomass, stock size and recruits in the last 5-6 years. The Final model estimated lower numbers of recruits since 1996. That translated to lower stock size and stock biomass (also spawning stock) after 2001. As removals (yields) were the same, lower stock size estimates were compensated with higher fishing mortality rates in the latest years.

Overall trends for the Gulf stock indicated a recovery from lower stock size in the early 1980's up to late 1990's. Simultaneously, the final model estimated large recruitments during those years, which increased the stock size and spawning stock biomass to the highest levels observed in 2006, roughly twice the biomass of 1981. During recent years, recruitment has been quite high, averaging 15 million fish since 2003. These large recruitment estimates are driven by the steep increase in the SEAMAP Groundfish Survey which indexes the abundance of age-0 king mackerel and has increased more than 5-fold since the early 1980s. Spawning stock trajectories, as a function of the status determination criterion MSST are shown in Fig 2. In the Gulf of Mexico, spawning stock has increased since the early 1980's when it was below MSST (0.57 in 1985) to be above 1 since 1999. In 2006 SSB was estimated to be 1.5 times MSST (Table 10).

## Fishing mortality and selectivity

Annual estimates of fishing mortality at age are tabulated in Table 11 for the deterministic run. Figure 1 shows the annual fishing mortality trends expressed as $F_{current}$ (highest value of the geometric mean by age of the current year and the prior 2 years, thus starting in 1983). Table 12 summarizes the estimates of apical F (highest fishing mortality from the FAA vector by year), $F_{current}$, and the ratio of $F_{current}$ over MFMT. In the Gulf, fishing mortality increased from 1981 to a peak in 1995 followed by a decreased since that time. Compared to MFMT, fishing rates were above MFMT from 1981 until 2001. Since 2002, fishing mortality has been below MFMT and in 2005, it was estimated to be 83% of MFMT.
Fleet-index selectivity at age was estimated using the partial catches (fleet specific catch-at-age) and assuming the Butterworth and Geromont (1999) method that computes an average, constant selectivity pattern for the entire time period. The shrimp bycatch index and fleet were assigned a fixed selectivity equal to 1 for age 0 only, while the SEAMAP plankton survey was used to index spawning stock biomass, and assigned a fixed selectivity equal to the maturity*fecundity at age vector. Table 13 shows the estimated selectivity by age of the GOM Final model. For the commercial fisheries, maximum selectivity corresponds to age 8, but for ages 3 and older selectivity is above 0.5 (Fig 6). For the recreational fisheries, maximum selectivity corresponded to ages 3 (MRFSS) and 2 (Headboat). At older ages, the recreational headboat fishery has a lower selectivity than the commercial and MRFSS fisheries.

## Stock status

According to the deterministic results of the final model, the Gulf migratory stock was not overfished nor was overfishing occurring in 2006 (Table 14). Following the recommendations of the review panel, for status report fishing mortality was expressed as the highest value of the geometric mean of last three years (2004-06) for ages 2 through 8 only, as they represent the main ages of the directed fisheries for king mackerel stocks. Figure 7 shows the status or phase plot for FY2006. The deterministic result indicates that fishing mortality was 83% of MFMT while the spawning stock was 1.5 times greater than MSST. The results of 1000 bootstraps indicate the degree of uncertainty about the model fit. Figure 8 shows the histograms and cumulative distribution of the ratios of fishing mortality and spawning stock in 2006. Only 59 out 1001 (5.9%) runs resulted in $F_{current}$ > MFMT, and 3 out of 1001 (0.3%) runs resulted in SSB < MSST.

## Retrospective analysis

Retrospective analyses of the GOM VPA Final model were performed by sequentially removing input data from FY2006 up to FY2001. Figure 9 summarizes the retrospective patterns of stock size (Total NAA), spawning stock, $F_{current}$, and stock size by age groups (Age 0, Age1-3, Age 4-7, Age 8-10, Age 11+). There was a pattern of over-estimating stock size and spawning biomass as new information become available; correspondingly there was a pattern of under-estimating fishing mortality rates. By age group, ages 4 and older show greater differences between the retrospective runs.

Annex 1

**Table 1**. Model settings and inputs used to construct the VPA Final model.

| Settings/Input Series | VPA-2BOX GOM Final Model |
|---|---|
| Stock Definitions | Total catches calculated according to the 50:50 mixing zone assumption: **GOM stock** - US Gulf of Mexico from Texas to Collier County, FL during Apr - Oct and to Volusia County, FL during Nov- Mar. |
| Fishing Year | Like SEDAR5, catch and Indices estimated using "fishing year" definitions. July 1st to June 30th of following calendar year. |
| Directed Landings/Discards | Used updated SEDAR 16 landings estimates. For the recreational sector, used SEDAR 16 landings, discards and release mortality estimates. As per SEDAR 16 recommendation, commercial discards were assumed to be negligible. |
| Shrimp Bycatch | Used Delta Lognormal Shrimp Bycatch estimates (SEDAR16-AW-07). |
| Catch-at-age | For estimation of the CAA: updated growth von Bertalanffy parameters (SEDAR16-DW-06) by sex and stock using observations collected outside of the MIX area. CAS 2001-2006 updated, sex at size ratios updated from 1985 through 2006. ALK constructed by semester and used from 1984 to 2006, SAR only for 1981-84 years. Recreational CAA adjusted to meet SEDAR 16 Recreational panel recommendations. |
| Weight-at-Age | Updated vector of weight at age estimated from the age samples and the updated weight-at-size relationship by sex and stock from samples from non-mixing areas. |
| Indices of Abundance | Used indices consistent with the "updated" approached recommended by SEDAR 16 for SS3 and other updated model runs. |
| Natural Mortality | Used Lorenzen's M vector developed at SEDAR16 DW and AW workshops. |
| Terminal Year F-at-age | Estimating all Terminal F's for ages 0-11+ (GOM) with fixed ratio for last age class all years of 1 and using maximum likelihood estimation with lognormal error distribution for index variances. |
| Annual F-Ratio | For each year $F_{10}$ : $F_{11+}$ was fixed at 1.0. This implies that the fishing mortality rate on the plus group is equal to the fishing mortality rate on age 10. |

**Table 2**. Fixed variance scalars used to equally weight the relative indices of abundance for the GOM Final VPA model.

| Index | Variance Scalar |
|---|---|
| COM_GULF_NOMIX | 0.535411 |
| MRFSS_GULF_NOMIX | 0.441492 |
| HEADBOAT_GULF_NOMIX | 0.51837 |
| SEAMAP_GROUNDFISH | 0 |
| SEAMAP_PLANKTON | 0.464832 |

Annex 1

**Table 3**. Biological input parameters GOM king mackerel Final VPA model.

| Age | Proportion Mature | Fecundity (millions of female eggs) | Natural Mortality |
|---|---|---|---|
| 0 | 0.000 | 0.000 | 0.765 |
| 1 | 0.157 | 0.155 | 0.274 |
| 2 | 0.529 | 0.267 | 0.243 |
| 3 | 0.704 | 0.395 | 0.222 |
| 4 | 0.856 | 0.531 | 0.207 |
| 5 | 0.989 | 0.669 | 0.196 |
| 6 | 1.000 | 0.801 | 0.188 |
| 7 | 1.000 | 0.926 | 0.182 |
| 8 | 1.000 | 1.041 | 0.177 |
| 9 | 1.000 | 1.145 | 0.173 |
| 10 | 1.000 | 1.238 | 0.170 |
| 11+ | 1.000 | 1.524 | 0.162 |

**Table 4**. Weight at age (kg) matrix input GOM king mackerel Final VPA model.

| Year | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1982 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1983 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1984 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1985 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |
| 1986 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1987 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1988 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1989 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1990 | 0.424 | 1.429 | 2.630 | 3.697 | 4.953 | 6.605 | 7.425 | 8.463 | 9.388 | 10.601 | 10.791 | 14.727 |
| 1991 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1992 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1993 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1994 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1995 | 0.424 | 1.787 | 2.868 | 3.902 | 5.233 | 6.426 | 7.759 | 8.628 | 9.079 | 10.085 | 11.175 | 12.155 |
| 1996 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 1997 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 1998 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 1999 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 2000 | 0.424 | 1.989 | 3.166 | 3.912 | 4.842 | 5.877 | 6.802 | 8.342 | 10.015 | 10.783 | 11.792 | 13.103 |
| 2001 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2002 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2003 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2004 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2005 | 0.424 | 2.205 | 2.700 | 3.752 | 4.515 | 5.644 | 6.383 | 7.465 | 8.311 | 8.954 | 9.835 | 11.276 |
| 2006 | 0.424 | 1.857 | 2.817 | 3.825 | 4.825 | 6.005 | 7.062 | 8.125 | 8.942 | 10.023 | 10.786 | 12.835 |

**Table 5**. Catch at age matrix for the GOM king mackerel VPA input model. Values represent numbers of total removals (landings plus dead discards) by age and fishing year.

| YEAR | AGE 0 | AGE 1 | AGE 2 | AGE 3 | AGE 4 | AGE 5 | AGE 6 | AGE 7 | AGE 8 | AGE 9 | AGE 10 | AGE 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 563558 | 16502 | 32123 | 216871 | 193314 | 48635 | 27492 | 21808 | 9186 | 3956 | 4478 | 14377 |
| 1982 | 243454 | 54716 | 180776 | 153648 | 207284 | 149504 | 65765 | 17918 | 17540 | 20438 | 6619 | 175346 |
| 1983 | 476064 | 91748 | 189468 | 105003 | 26340 | 44481 | 30319 | 6440 | 9090 | 4724 | 1493 | 16195 |
| 1984 | 1508666 | 20567 | 57951 | 220927 | 127844 | 36116 | 49028 | 25614 | 4755 | 918 | 1861 | 17130 |
| 1985 | 732206 | 23940 | 56050 | 94130 | 72300 | 83910 | 31470 | 12844 | 18712 | 4959 | 1902 | 17167 |
| 1986 | 815006 | 36703 | 209494 | 80517 | 34943 | 54577 | 39512 | 12383 | 2971 | 6846 | 575 | 14812 |
| 1987 | 1477266 | 99255 | 77574 | 32265 | 25616 | 29870 | 16917 | 8010 | 4597 | 3468 | 2208 | 6704 |
| 1988 | 1695068 | 46813 | 97259 | 88300 | 64139 | 31361 | 68867 | 29739 | 6050 | 13561 | 13274 | 33536 |
| 1989 | 2743625 | 122445 | 163030 | 81732 | 70834 | 52482 | 12200 | 22971 | 10889 | 4445 | 6203 | 16935 |
| 1990 | 2093282 | 104655 | 163800 | 105030 | 73158 | 35254 | 37946 | 7373 | 18872 | 8489 | 1626 | 18612 |
| 1991 | 2019187 | 182252 | 240676 | 127600 | 70578 | 39801 | 27502 | 12904 | 4475 | 19490 | 5126 | 12161 |
| 1992 | 1466838 | 65491 | 200838 | 182078 | 103020 | 54354 | 47024 | 21010 | 34006 | 9313 | 16888 | 24785 |
| 1993 | 2812413 | 60138 | 146028 | 151588 | 134914 | 62068 | 36287 | 25513 | 24429 | 13000 | 1661 | 34235 |
| 1994 | 3138105 | 126336 | 154850 | 124591 | 162044 | 117838 | 68954 | 41251 | 24627 | 19865 | 39629 | 33969 |
| 1995 | 2742216 | 47871 | 174393 | 162710 | 103136 | 64878 | 67180 | 31299 | 17621 | 7851 | 10630 | 16723 |
| 1996 | 1376113 | 87094 | 242333 | 156665 | 86928 | 53091 | 35928 | 35028 | 27723 | 12873 | 2794 | 41110 |
| 1997 | 1348322 | 54227 | 153386 | 203561 | 103652 | 71213 | 45217 | 45932 | 29291 | 21473 | 8579 | 28477 |
| 1998 | 1193085 | 58339 | 118231 | 153169 | 168698 | 71258 | 39946 | 24472 | 17403 | 20184 | 9092 | 7159 |
| 1999 | 1210741 | 45716 | 127966 | 94029 | 116636 | 88794 | 28844 | 27385 | 19486 | 22445 | 3109 | 11011 |
| 2000 | 1078106 | 64037 | 134236 | 175846 | 98004 | 63813 | 28820 | 33574 | 8830 | 14003 | 10681 | 17482 |
| 2001 | 772155 | 48512 | 145760 | 146855 | 117572 | 69132 | 47701 | 42979 | 25854 | 7766 | 6992 | 28300 |
| 2002 | 641205 | 70633 | 204402 | 130239 | 112020 | 73224 | 39778 | 30365 | 30256 | 15391 | 7387 | 21823 |
| 2003 | 1542801 | 27247 | 151935 | 158851 | 96919 | 67925 | 58810 | 25398 | 25196 | 17727 | 15759 | 17722 |
| 2004 | 2888086 | 33563 | 230128 | 129788 | 105691 | 54044 | 42874 | 37388 | 10928 | 22677 | 6758 | 14034 |
| 2005 | 1909290 | 23552 | 164254 | 175586 | 122746 | 76873 | 52471 | 41831 | 29796 | 11442 | 10628 | 27227 |
| 2006 | 923292 | 20093 | 178244 | 203485 | 158511 | 107711 | 58659 | 42905 | 28343 | 16720 | 8995 | 28893 |

**Table 6**. Updated relative indices of abundance and index settings used for the GOM Final VPA model.

| | Com Logboof Gulf-No | | MRFSS-Gulf-No-Mix | | HB-Gulf-no-Mix | | SEAMAP Fall Groundfish | | SEAMAP Fall Plankton | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of Index | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Dep. REC | | Fish. Independent | | Fish. Independent | |
| Unit | Biomass | | Number | | Number | | Numbers | | Numbers | |
| Likely Applies to Ages | Ages 1-11+ | | Ages 1-11+ | | Ages 1-11+ | | Age 0 | | Ages 1 to 11+, using partial selection | |
| YEAR | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV | STDCPUE | CV |
| 1981 | - | - | 0.722 | 0.424 | - | - | - | - | - | - |
| 1982 | - | - | 0.467 | 0.407 | - | - | - | - | - | - |
| 1983 | - | - | 0.883 | 0.428 | - | - | - | - | - | - |
| 1984 | - | - | 0.501 | 0.390 | - | - | 0.101 | 0.911 | - | - |
| 1985 | - | - | 0.550 | 0.417 | - | - | 0.045 | 0.823 | - | - |
| 1986 | - | - | 0.451 | 0.338 | 0.677 | 0.184 | 0.085 | 1.080 | 0.116 | 0.534 |
| 1987 | - | - | 1.077 | 0.303 | 0.699 | 0.175 | 0.018 | 1.482 | 0.379 | 0.322 |
| 1988 | - | - | 0.710 | 0.324 | 0.809 | 0.194 | 0.122 | 0.527 | 0.613 | 0.437 |
| 1989 | - | - | 0.923 | 0.332 | 0.799 | 0.186 | 0.101 | 0.702 | 0.845 | 0.326 |
| 1990 | - | - | 1.292 | 0.318 | 0.558 | 0.170 | 0.162 | 0.409 | 0.648 | 0.321 |
| 1991 | - | - | 1.263 | 0.301 | 1.371 | 0.156 | 0.063 | 0.565 | 0.721 | 0.318 |
| 1992 | - | - | 1.002 | 0.293 | 1.234 | 0.153 | 0.096 | 0.559 | 0.596 | 0.237 |
| 1993 | 0.720 | 0.132 | 0.998 | 0.301 | 0.838 | 0.151 | 0.424 | 0.325 | 1.251 | 0.199 |
| 1994 | 0.881 | 0.101 | 1.243 | 0.290 | 1.205 | 0.133 | 0.183 | 0.480 | 1.050 | 0.231 |
| 1995 | 0.990 | 0.093 | 1.115 | 0.305 | 1.295 | 0.134 | 0.108 | 0.641 | 1.979 | 0.195 |
| 1996 | 0.974 | 0.078 | 1.322 | 0.299 | 1.437 | 0.142 | 0.087 | 0.532 | 0.741 | 0.265 |
| 1997 | 1.307 | 0.069 | 1.480 | 0.285 | 1.307 | 0.140 | 0.209 | 0.425 | 1.360 | 0.201 |
| 1998 | 1.288 | 0.068 | 1.083 | 0.286 | 1.084 | 0.145 | 0.224 | 0.413 | | |
| 1999 | 1.118 | 0.065 | 0.922 | 0.281 | 1.286 | 0.150 | 0.177 | 0.396 | 0.920 | 0.225 |
| 2000 | 1.068 | 0.062 | 1.213 | 0.276 | 0.890 | 0.153 | 0.202 | 0.480 | 0.922 | 0.273 |
| 2001 | 1.055 | 0.064 | 1.114 | 0.280 | 0.686 | 0.160 | 0.252 | 0.376 | 1.642 | 0.203 |
| 2002 | 0.994 | 0.061 | 1.239 | 0.276 | 0.729 | 0.150 | 0.144 | 0.536 | 1.451 | 0.214 |
| 2003 | 0.985 | 0.069 | 0.967 | 0.282 | 1.055 | 0.153 | 0.566 | 0.289 | 1.103 | 0.219 |
| 2004 | 0.923 | 0.073 | 1.019 | 0.281 | 0.654 | 0.162 | 0.450 | 0.308 | 1.478 | 0.211 |
| 2005 | 0.732 | 0.093 | 0.860 | 0.290 | 1.038 | 0.163 | 0.491 | 0.292 | | |
| 2006 | 0.966 | 0.083 | 1.584 | 0.276 | 1.351 | 0.149 | 0.381 | 0.369 | 1.187 | 0.253 |

**Table 7**. Likelihood statistics comparison for GOM king mackerel VPA Final and base models. Loglikelihood measures of model fits to the indices of abundance and associated information criteria. Note that the number of observations between models differs.

| Model | Final Model | Base Model |
|---|---|---|
| Total Objective Function | -46.26 | -35.54 |
| with constants | 48.39 | 61.87 |
| Number of parameters | 16 | 16 |
| Number of data points | 103 | 106 |
| AIC | 128.78 | 155.74 |
| AICC | 135.11 | 161.86 |
| BIC | 170.94 | 198.36 |
| Chi-square discrepancy | 44.41 | 57.18 |
| Loglikelihoods (Deviance) | 38.37 | 27.3 |
| effort data | 38.37 | 27.3 |
| Constrains | 7.89 | 8.23 |
| Terminal F | 7.89 | 8.23 |
| Stock-re/ sex ratio | 0 | 0 |
| Out of bounds penalty | 0 | 0 |
| Log Likelihood Indices of abundance | 38.37 | 27.31 |
| Comm_Gulf No Mix | 7.31 | 6.79 |
| MRFSS Gulf No Mix | 12.69 | 11.69 |
| Headboat Gulf No Mix | 9.59 | 8.33 |
| SEAMAP Groundfish | 3.38 | -4.77 |
| SEAMAP Plankton | 5.4 | 5.24 |

**Table 8**. Final values for estimated parameters of the GOM VPA Final model, estimates of variance based on one thousand non-parametric bootstraps of the index residuals.

## *Final VPA GOM Model*

**Terminal Age structure of population abundance**

| Age | MLE | Avg of booststraps | Bias | Std error | % CV |
|---|---|---|---|---|---|
| 1 | 5640000 | 6290000 | 995000 | 3070000 | 48.8 |
| 2 | 4900000 | 4970000 | 1280000 | 1990000 | 40.1 |
| 3 | 4350000 | 4990000 | 249000 | 1140000 | 22.9 |
| 4 | 1600000 | 1360000 | 141000 | 409000 | 30.1 |
| 5 | 614000 | 706000 | 41000 | 162000 | 23 |
| 6 | 323000 | 373000 | 22600 | 85300 | 22.9 |
| 7 | 159000 | 228000 | -6180 | 51400 | 22.6 |
| 8 | 142000 | 158000 | -2520 | 36800 | 23.2 |
| 9 | 145000 | 135000 | 2470 | 37600 | 28 |
| 10 | 160000 | 133000 | 11000 | 39100 | 29.5 |
| 11+ | 383000 | 268000 | 39300 | 95200 | 35.6 |

**Terminal Age structure of fishing mortality rate**

| Age | MLE | Avg of booststraps | Bias | Std error | % CV |
|---|---|---|---|---|---|
| 0 | 0.103 | 0.109 | 0.0000173 | 0.04 | 36.7 |
| 1 | 0.00356 | 0.00399 | -0.00073 | 0.00131 | 32.8 |
| 2 | 0.0355 | 0.0325 | -0.000172 | 0.00667 | 20.5 |
| 3 | 0.107 | 0.135 | -0.00409 | 0.0355 | 26.4 |
| 4 | 0.208 | 0.191 | -0.00251 | 0.0385 | 20.1 |
| 5 | 0.263 | 0.241 | -0.0041 | 0.0464 | 19.3 |
| 6 | 0.287 | 0.219 | 0.014 | 0.0458 | 20.9 |
| 7 | 0.243 | 0.229 | 0.0119 | 0.0442 | 19.3 |
| 8 | 0.164 | 0.187 | 0.00857 | 0.0483 | 25.8 |
| 9 | 0.0911 | 0.117 | -0.00125 | 0.0311 | 26.5 |
| 10 | 0.087 | 0.134 | -0.00736 | 0.0403 | 30 |
| 11+ | 0.087 | 0.134 | -0.00736 | 0.0403 | 30 |

**Estimates of catchability by index**

| Index | MLE | Avg of booststraps | Bias | Std error | % CV |
|---|---|---|---|---|---|
| Com no Mix | 5.33E-08 | 6.03E-08 | -3.55E-09 | 6.94E-09 | 11.5 |
| MRFSS | 1.87E-07 | 2.04E-07 | -1.24E-08 | 1.85E-08 | 9.1 |
| Headboat | 2.69E-07 | 2.80E-07 | -1.83E-08 | 2.32E-08 | 8.3 |
| SEAMAP Ground | 2.77E-07 | 2.59E-07 | -4.20E-08 | 3.06E-08 | 11.8 |
| SEAMAP Plankton | 4.68E-07 | 4.97E-07 | -5.52E-08 | 6.04E-08 | 12.2 |

**Table 9**. Numbers at age for the GOM VPA Final model.

| | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 4,487,847 | 1,326,649 | 861,939 | 1,012,106 | 737,795 | 189,395 | 120,981 | 101,667 | 75,034 | 27,830 | 151,474 | 484,493 |
| 1982 | 4,004,816 | 1,718,063 | 994,313 | 647,790 | 617,960 | 426,782 | 111,854 | 75,357 | 64,959 | 54,490 | 19,795 | 522,568 |
| 1983 | 1,962,239 | 1,702,742 | 1,258,719 | 620,999 | 382,417 | 317,248 | 216,456 | 33,816 | 46,564 | 38,475 | 27,253 | 294,514 |
| 1984 | 6,391,395 | 604,344 | 1,214,959 | 820,621 | 403,992 | 287,193 | 220,550 | 151,849 | 22,342 | 30,735 | 28,046 | 257,191 |
| 1985 | 4,472,095 | 1,994,897 | 441,621 | 901,928 | 461,274 | 214,185 | 203,392 | 138,359 | 103,319 | 14,390 | 25,013 | 224,921 |
| 1986 | 3,719,424 | 1,601,811 | 1,495,910 | 297,061 | 638,561 | 310,112 | 100,747 | 139,991 | 103,663 | 69,518 | 7,592 | 194,849 |
| 1987 | 5,267,802 | 1,200,690 | 1,185,966 | 989,007 | 166,502 | 487,667 | 205,611 | 47,866 | 105,442 | 84,143 | 52,216 | 157,947 |
| 1988 | 7,694,286 | 1,497,823 | 826,800 | 861,890 | 763,392 | 112,368 | 373,735 | 154,996 | 32,627 | 84,149 | 67,604 | 170,180 |
| 1989 | 8,987,466 | 2,478,087 | 1,098,133 | 562,895 | 611,683 | 562,929 | 64,123 | 247,268 | 102,206 | 21,825 | 58,396 | 158,840 |
| 1990 | 8,467,824 | 2,417,308 | 1,777,787 | 717,915 | 378,114 | 433,635 | 415,171 | 42,078 | 185,246 | 75,701 | 14,301 | 163,097 |
| 1991 | 6,431,419 | 2,583,534 | 1,747,014 | 1,250,171 | 481,547 | 241,798 | 324,481 | 309,537 | 28,381 | 137,992 | 55,916 | 132,164 |
| 1992 | 5,865,852 | 1,695,455 | 1,806,143 | 1,158,514 | 887,671 | 328,121 | 162,793 | 243,875 | 246,317 | 19,700 | 98,265 | 143,690 |
| 1993 | 9,795,834 | 1,779,149 | 1,232,179 | 1,239,851 | 765,914 | 629,089 | 220,600 | 92,386 | 184,200 | 175,371 | 8,127 | 166,899 |
| 1994 | 10,506,494 | 2,744,740 | 1,300,452 | 837,926 | 858,086 | 501,636 | 460,885 | 149,889 | 53,888 | 132,056 | 135,624 | 115,843 |
| 1995 | 9,132,397 | 2,868,587 | 1,977,142 | 883,712 | 560,265 | 552,282 | 306,086 | 319,348 | 87,556 | 22,861 | 92,933 | 145,662 |
| 1996 | 6,115,982 | 2,484,441 | 2,139,385 | 1,397,203 | 563,137 | 362,978 | 395,252 | 192,793 | 237,764 | 57,312 | 12,086 | 177,187 |
| 1997 | 7,689,198 | 1,951,572 | 1,813,284 | 1,464,707 | 979,570 | 379,788 | 250,364 | 294,865 | 128,906 | 173,926 | 36,465 | 120,607 |
| 1998 | 6,440,792 | 2,696,715 | 1,436,676 | 1,287,173 | 991,976 | 703,203 | 247,881 | 166,470 | 204,077 | 81,343 | 126,673 | 99,371 |
| 1999 | 5,795,505 | 2,218,106 | 1,999,622 | 1,022,737 | 894,578 | 655,086 | 513,488 | 169,173 | 116,538 | 155,105 | 50,018 | 176,486 |
| 2000 | 5,632,798 | 1,908,428 | 1,646,700 | 1,455,704 | 735,391 | 622,509 | 458,163 | 399,235 | 116,150 | 79,884 | 109,962 | 179,312 |
| 2001 | 5,702,963 | 1,917,670 | 1,395,362 | 1,173,375 | 1,009,375 | 509,835 | 453,904 | 353,422 | 302,290 | 89,258 | 54,409 | 219,408 |
| 2002 | 6,593,401 | 2,146,941 | 1,415,859 | 966,131 | 809,066 | 714,954 | 356,554 | 332,788 | 255,560 | 229,681 | 67,978 | 200,082 |
| 2003 | 10,790,938 | 2,645,720 | 1,570,975 | 930,713 | 657,890 | 557,157 | 521,369 | 259,325 | 249,815 | 186,526 | 179,119 | 200,684 |
| 2004 | 20,369,976 | 4,009,460 | 1,987,859 | 1,098,422 | 604,167 | 447,836 | 396,512 | 378,613 | 193,091 | 186,322 | 140,688 | 291,068 |
| 2005 | 16,600,606 | 7,584,351 | 3,019,205 | 1,356,615 | 764,213 | 396,355 | 319,209 | 289,619 | 281,633 | 151,806 | 135,999 | 347,110 |
| 2006 | 13,425,502 | 6,469,070 | 5,745,916 | 2,223,468 | 930,270 | 511,124 | 256,400 | 216,922 | 203,424 | 208,785 | 117,227 | 375,148 |
| 2007 | | 5,637,706 | 4,900,951 | 4,349,990 | 1,599,606 | 614,064 | 322,949 | 159,352 | 141,878 | 144,598 | 160,330 | 383,127 |

**Table 10**. Trends of Spawning stock (millions of eggs), recruits age 0, and ratio of SSB over MSST for the GOM king mackerel Final model.

| Year | Spawning Biomass | Recruits age 0 | SSB/MSST |
|---|---|---|---|
| 1981 | 2123 | 4487847 | 0.8117043 |
| 1982 | 2036 | 4004816 | 0.7784409 |
| 1983 | 1555 | 1962239 | 0.5945361 |
| 1984 | 1590 | 6391395 | 0.607918 |
| 1985 | 1502 | 4472095 | 0.5742722 |
| 1986 | 1532 | 3719424 | 0.5857423 |
| 1987 | 1590 | 5267802 | 0.607918 |
| 1988 | 1731 | 7694286 | 0.6618277 |
| 1989 | 1748 | 8987466 | 0.6683274 |
| 1990 | 1885 | 8467824 | 0.7207078 |
| 1991 | 2040 | 6431419 | 0.7799702 |
| 1992 | 2215 | 5865852 | 0.8468794 |
| 1993 | 2245 | 9795834 | 0.8583496 |
| 1994 | 2265 | 10506494 | 0.8659964 |
| 1995 | 2210 | 9132397 | 0.8449677 |
| 1996 | 2340 | 6115982 | 0.8946717 |
| 1997 | 2443 | 7689198 | 0.9340526 |
| 1998 | 2509 | 6440792 | 0.9592869 |
| 1999 | 2658 | 5795505 | 1.0162553 |
| 2000 | 2788 | 5632798 | 1.0659593 |
| 2001 | 2876 | 5702963 | 1.0996051 |
| 2002 | 2873 | 6593401 | 1.0984581 |
| 2003 | 2872 | 10790938 | 1.0980757 |
| 2004 | 2955 | 20369976 | 1.1298098 |
| 2005 | 3285 | 16600606 | 1.2559815 |
| 2006 | 3921 | 13425502 | 1.4991487 |

**Table 11**. Estimates of fishing mortality at age (FAA) for GOM Final VPA model.

| | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 0.195 | 0.014 | 0.043 | 0.271 | 0.34 | 0.33 | 0.285 | 0.266 | 0.143 | 0.168 | 0.033 | 0.033 |
| 1982 | 0.09 | 0.037 | 0.228 | 0.305 | 0.46 | 0.483 | 1.008 | 0.3 | 0.347 | 0.52 | 0.448 | 0.448 |
| 1983 | 0.413 | 0.063 | 0.185 | 0.208 | 0.079 | 0.167 | 0.166 | 0.233 | 0.239 | 0.143 | 0.061 | 0.061 |
| 1984 | 0.4 | 0.04 | 0.055 | 0.354 | 0.427 | 0.149 | 0.278 | 0.203 | 0.263 | 0.033 | 0.075 | 0.075 |
| 1985 | 0.262 | 0.014 | 0.154 | 0.123 | 0.19 | 0.558 | 0.185 | 0.107 | 0.219 | 0.466 | 0.086 | 0.086 |
| 1986 | 0.366 | 0.027 | 0.171 | 0.357 | 0.062 | 0.215 | 0.556 | 0.102 | 0.032 | 0.113 | 0.086 | 0.086 |
| 1987 | 0.493 | 0.099 | 0.076 | 0.037 | 0.186 | 0.07 | 0.094 | 0.201 | 0.049 | 0.046 | 0.047 | 0.047 |
| 1988 | 0.368 | 0.036 | 0.142 | 0.121 | 0.097 | 0.365 | 0.225 | 0.235 | 0.225 | 0.192 | 0.239 | 0.239 |
| 1989 | 0.548 | 0.058 | 0.182 | 0.176 | 0.137 | 0.108 | 0.233 | 0.107 | 0.123 | 0.25 | 0.123 | 0.123 |
| 1990 | 0.422 | 0.051 | 0.109 | 0.177 | 0.24 | 0.094 | 0.105 | 0.212 | 0.118 | 0.13 | 0.132 | 0.132 |
| 1991 | 0.568 | 0.084 | 0.168 | 0.121 | 0.176 | 0.199 | 0.097 | 0.047 | 0.188 | 0.167 | 0.105 | 0.105 |
| 1992 | 0.428 | 0.045 | 0.133 | 0.192 | 0.137 | 0.201 | 0.378 | 0.099 | 0.163 | 0.713 | 0.206 | 0.206 |
| 1993 | 0.507 | 0.039 | 0.143 | 0.146 | 0.216 | 0.115 | 0.198 | 0.357 | 0.156 | 0.084 | 0.25 | 0.25 |
| 1994 | 0.533 | 0.054 | 0.144 | 0.181 | 0.233 | 0.298 | 0.179 | 0.356 | 0.681 | 0.178 | 0.38 | 0.38 |
| 1995 | 0.537 | 0.019 | 0.104 | 0.229 | 0.227 | 0.138 | 0.274 | 0.113 | 0.247 | 0.464 | 0.133 | 0.133 |
| 1996 | 0.377 | 0.041 | 0.136 | 0.133 | 0.187 | 0.175 | 0.105 | 0.221 | 0.136 | 0.279 | 0.288 | 0.288 |
| 1997 | 0.283 | 0.032 | 0.1 | 0.168 | 0.124 | 0.23 | 0.22 | 0.186 | 0.284 | 0.144 | 0.294 | 0.294 |
| 1998 | 0.301 | 0.025 | 0.097 | 0.142 | 0.208 | 0.118 | 0.194 | 0.175 | 0.098 | 0.313 | 0.081 | 0.081 |
| 1999 | 0.346 | 0.024 | 0.075 | 0.108 | 0.155 | 0.161 | 0.064 | 0.194 | 0.201 | 0.171 | 0.07 | 0.07 |
| 2000 | 0.313 | 0.039 | 0.096 | 0.144 | 0.159 | 0.12 | 0.071 | 0.096 | 0.086 | 0.211 | 0.111 | 0.111 |
| 2001 | 0.212 | 0.029 | 0.125 | 0.15 | 0.138 | 0.161 | 0.122 | 0.142 | 0.098 | 0.099 | 0.15 | 0.15 |
| 2002 | 0.148 | 0.038 | 0.177 | 0.162 | 0.166 | 0.119 | 0.13 | 0.105 | 0.138 | 0.076 | 0.126 | 0.126 |
| 2003 | 0.225 | 0.012 | 0.115 | 0.21 | 0.177 | 0.144 | 0.132 | 0.113 | 0.116 | 0.109 | 0.1 | 0.1 |
| 2004 | 0.223 | 0.01 | 0.139 | 0.141 | 0.214 | 0.142 | 0.126 | 0.114 | 0.064 | 0.142 | 0.054 | 0.054 |
| 2005 | 0.178 | 0.004 | 0.063 | 0.155 | 0.195 | 0.239 | 0.198 | 0.171 | 0.122 | 0.086 | 0.089 | 0.089 |
| 2006 | 0.103 | 0.004 | 0.036 | 0.107 | 0.208 | 0.263 | 0.287 | 0.243 | 0.164 | 0.091 | 0.087 | 0.087 |

**Table 12**. Estimates of apical F, Fcurrent and ratio of Fcurrent over MFMT for GOM Final VPA model.

| Year | Apical F | Fcurr | Fcurr/MFMT |
|---|---|---|---|
| 1981 | 0.340 | | |
| 1982 | 1.008 | | |
| 1983 | 0.413 | 0.363 | 1.443 |
| 1984 | 0.427 | 0.360 | 1.431 |
| 1985 | 0.558 | 0.351 | 1.397 |
| 1986 | 0.556 | 0.337 | 1.342 |
| 1987 | 0.493 | 0.362 | 1.439 |
| 1988 | 0.368 | 0.405 | 1.611 |
| 1989 | 0.548 | 0.463 | 1.844 |
| 1990 | 0.422 | 0.440 | 1.750 |
| 1991 | 0.568 | 0.508 | 2.023 |
| 1992 | 0.713 | 0.468 | 1.863 |
| 1993 | 0.507 | 0.498 | 1.980 |
| 1994 | 0.681 | 0.487 | 1.939 |
| 1995 | 0.537 | 0.525 | 2.091 |
| 1996 | 0.377 | 0.476 | 1.895 |
| 1997 | 0.294 | 0.386 | 1.534 |
| 1998 | 0.313 | 0.318 | 1.265 |
| 1999 | 0.346 | 0.309 | 1.229 |
| 2000 | 0.313 | 0.319 | 1.271 |
| 2001 | 0.212 | 0.284 | 1.131 |
| 2002 | 0.177 | 0.214 | 0.852 |
| 2003 | 0.225 | 0.192 | 0.763 |
| 2004 | 0.223 | 0.195 | 0.776 |
| 2005 | 0.239 | 0.207 | 0.826 |
| 2006 | 0.287 | 0.207 | 0.825 |

**Table 13**. Estimated selectivity by age for fleet-index GOM VPA Final model.

| | Age 0 | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 | Age 6 | Age 7 | Age 8 | Age 9 | Age 10 | Age 11+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Com no Mix | 0.000 | 0.189 | 0.410 | 0.573 | 0.639 | 0.713 | 0.681 | 0.796 | 1.000 | 0.633 | 0.631 | 0.823 |
| MRFSS | 0.000 | 0.475 | 0.970 | 1.000 | 0.934 | 0.959 | 0.931 | 0.931 | 0.894 | 0.982 | 0.695 | 0.764 |
| Headboat | 0.000 | 0.280 | 1.000 | 0.917 | 0.564 | 0.483 | 0.491 | 0.378 | 0.324 | 0.388 | 0.187 | 0.192 |
| SEAMAP Ground | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| SEAMAP Plankton | 0.000 | 0.024 | 0.141 | 0.278 | 0.455 | 0.661 | 0.801 | 0.926 | 1.041 | 1.145 | 1.238 | 1.524 |

**Table 14**. Summary of GOM king mackerel stock status in 2006 Fyear.

| | N | Deterministic | Avg | Median | low 80% CL | upp 80% CL |
|---|---|---|---|---|---|---|
| **SSB2006/MSST** | | 1.498 | 1.484 | 1.471 | 1.237 | 1.725 |
| **Fcurr/MFMT** | | 0.827 | 0.834 | 0.828 | 0.714 | 0.969 |
| | | | | | | |
| **Nboots** | 1000 | | | | | |
| **N boots SSB < MSST** | 3 | | | | | |
| **N boots Fcurr > MFMT** | 59 | | | | | |

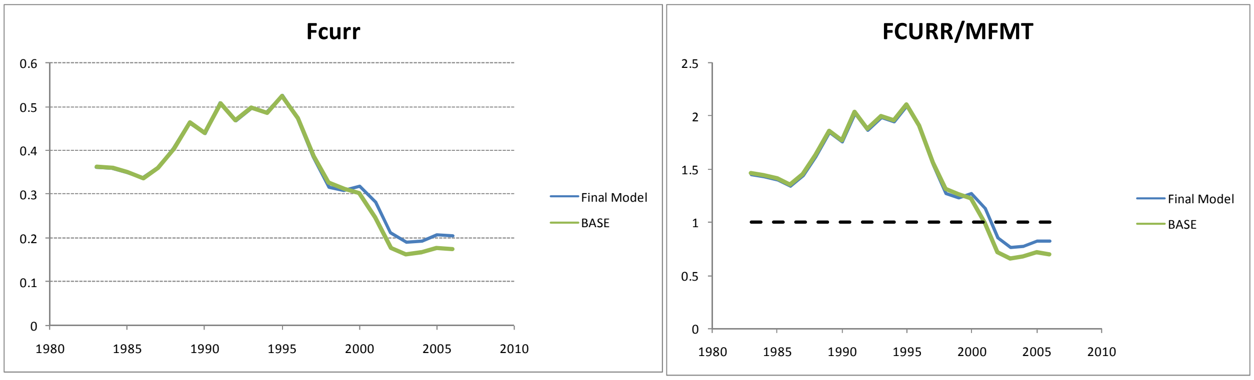



**Figure 1. Comparison of fishing mortality trends between the Base GOM VPA model and the Final VPA model GOM as recommended by the review panel SEDAR 16. Fcurr refers to annual fishing mortality rate estimated as maximum F at age of the geometric mean of F at age for the current and two prior years. Maximum fishing mortality threshold (MFMT) is the corresponding fishing at 30% SPR ($F_{30\%SPR}$).**

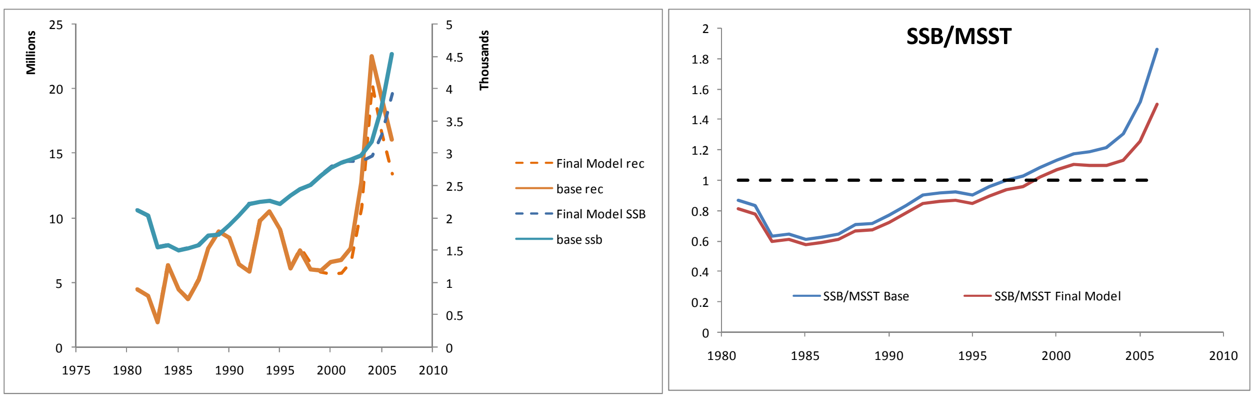



**Figure 2. Comparison of recruitment trends (left plot orange lines) in millions of recruits age 0 fish and spawning stock biomass (SSB in million of hydrated eggs) between the base GOM VPA model and the Final VPA model GOM as recommended by the review panel SEDAR 16. Minimum spawning stock threshold is estimated as one minus-natural mortality times the SSB at $F_{30\%SPR}$.**

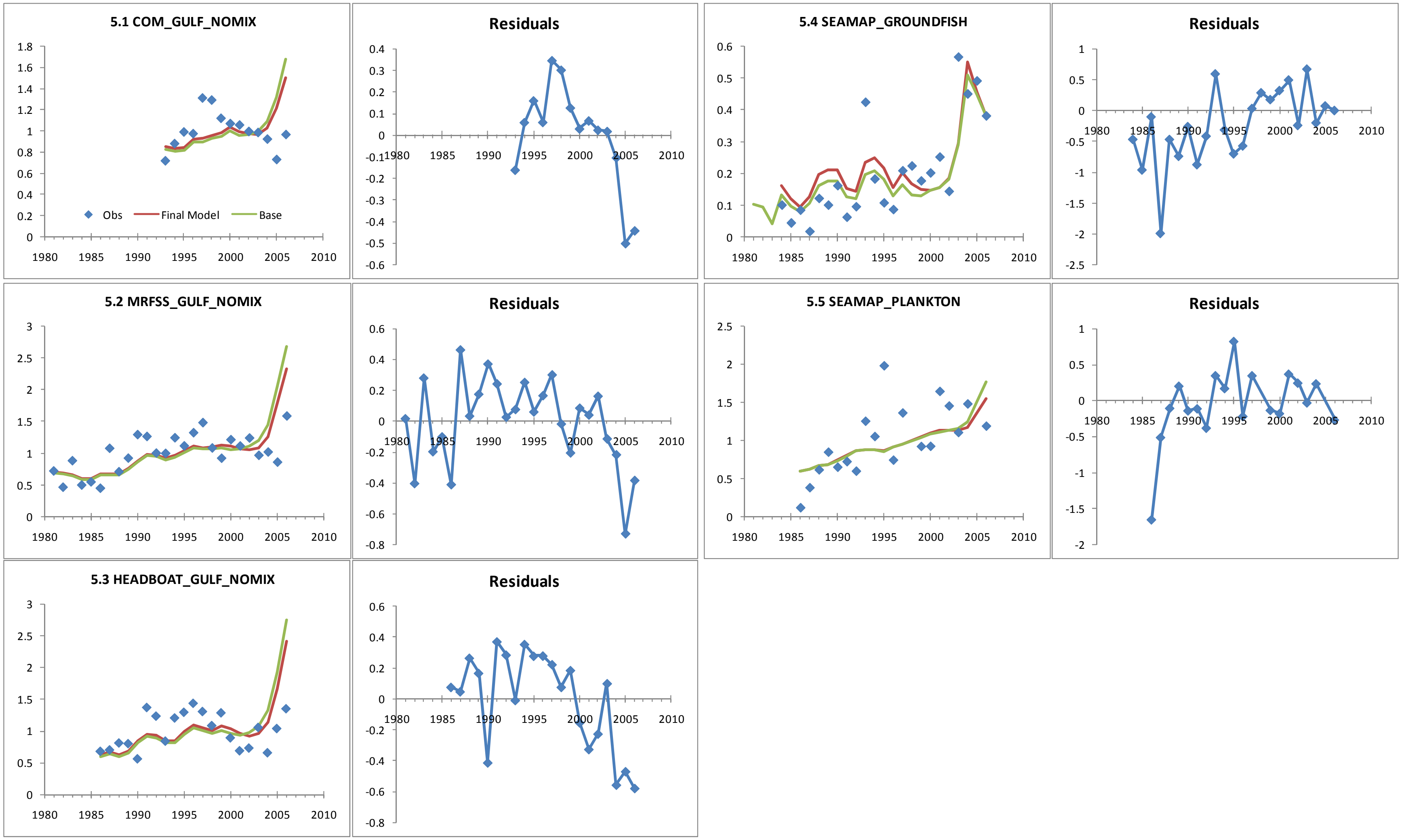



**Figure 3. Comparison of fits to relative indices of abundance between the Base GOM VPA model and the Final VPA Model as recommended by the review panel SEDAR 16. Diamond markers are the observed indices, red line represents the final model fit estimation and the green line the Base model fit estimation.**

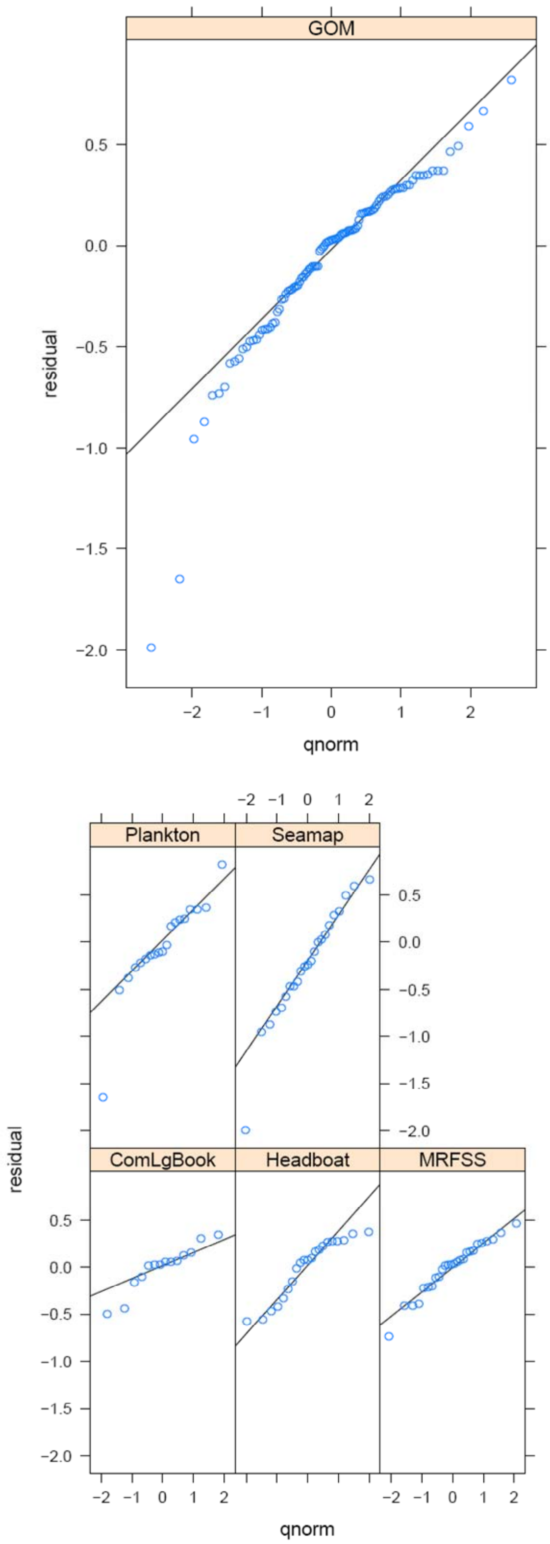



**Figure 4. Normalized cumulative residual plots (qq-plots) of the index fits by the VPA GOM Final model. Top plot shows all residuals, bottom plot shows qq-plots by index**

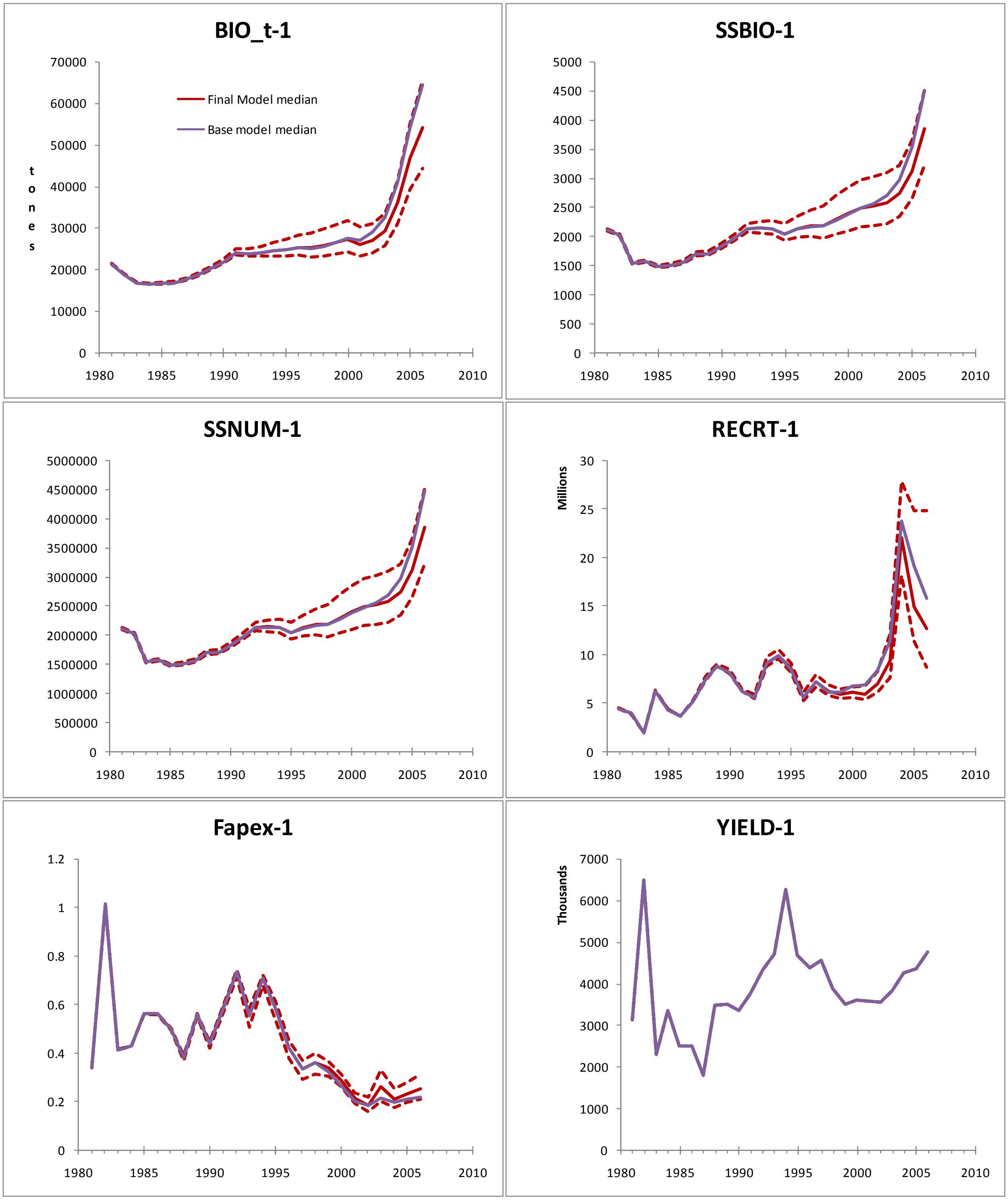



**Figure 5. Comparison of total biomass (BIO_t-1), spawning biomass (SSBIO-1), stock size (SSNUM-1), recruits (Recrt-1), apical fishing mortality (Fapex-1), and yield (Yield-1) between the Base VPA model (blue line) and the Final VPA model (red line) for the Gulf of Mexico king mackerel stock unit. Broken lines represent 95% confidence limits estimated from thousand bootstrap runs of the Final VPA model.**

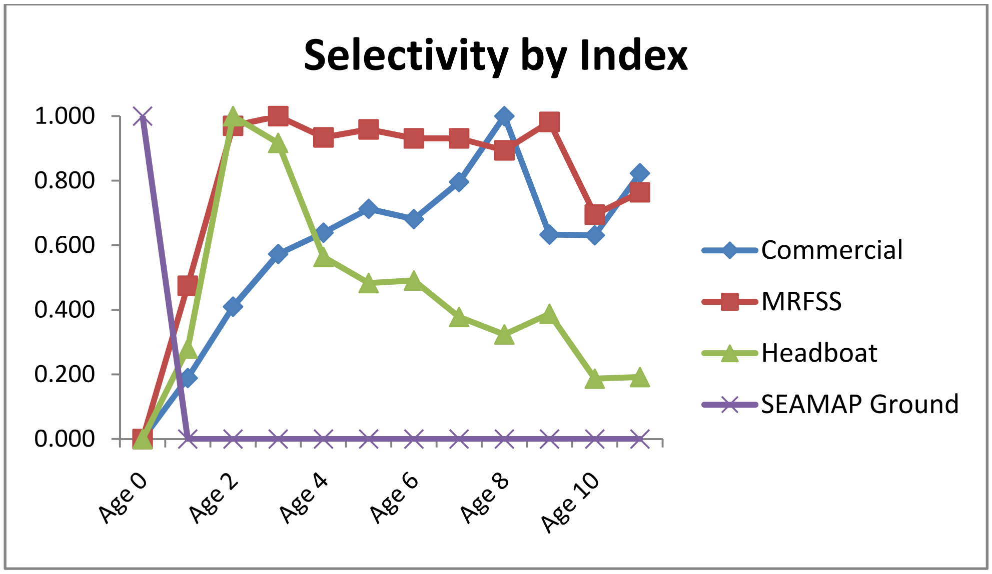



**Figure 6. Selectivity by index-fleet estimated for the GOM king mackerel stock unit by the VPA Final model.**

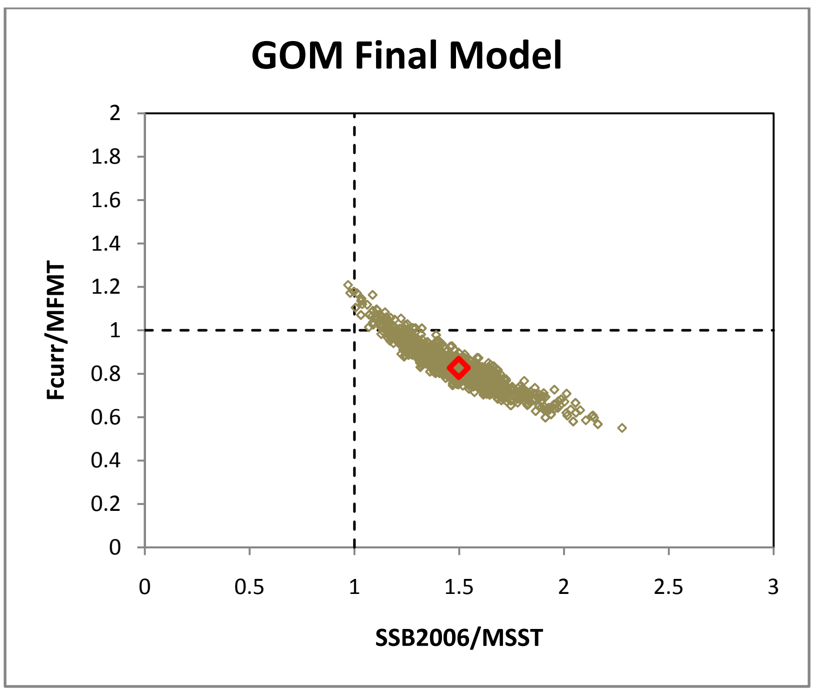
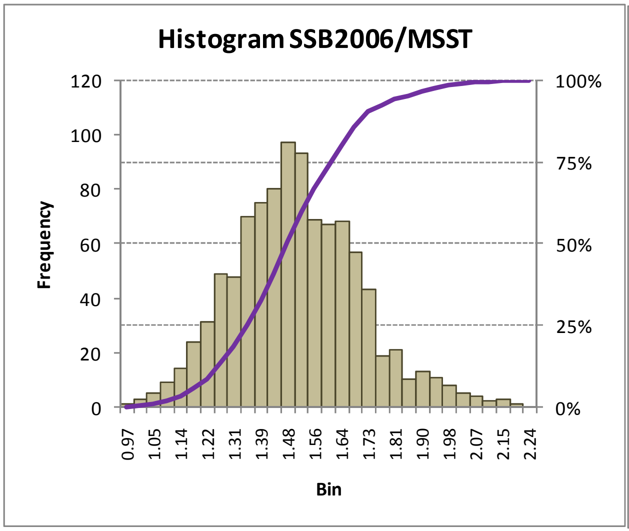



**Figure 7. Status or phase plot of the GOM king mackerel stock in 2006 FYear. The red diamond is the deterministic result, other markers are bootstrap results.**



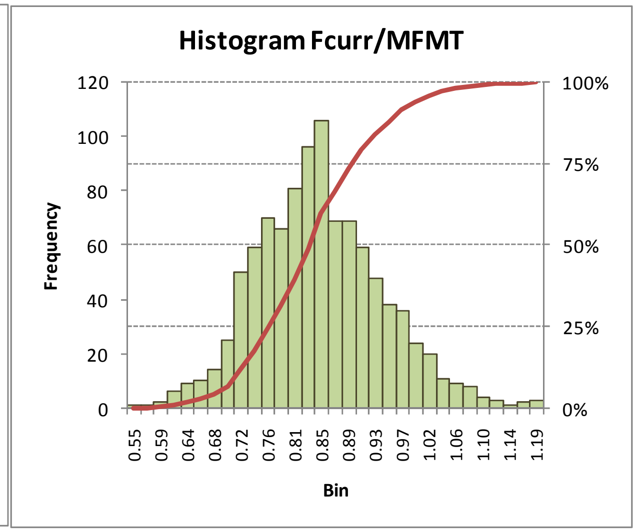




**Figure 8. Histogram and cumulative distribution of thousand bootstrap results for the ratios of spawning stock 2006 over MSST (left) and Fcurrent 2006 over MFMT for GOM king mackerel VPA Final model.**

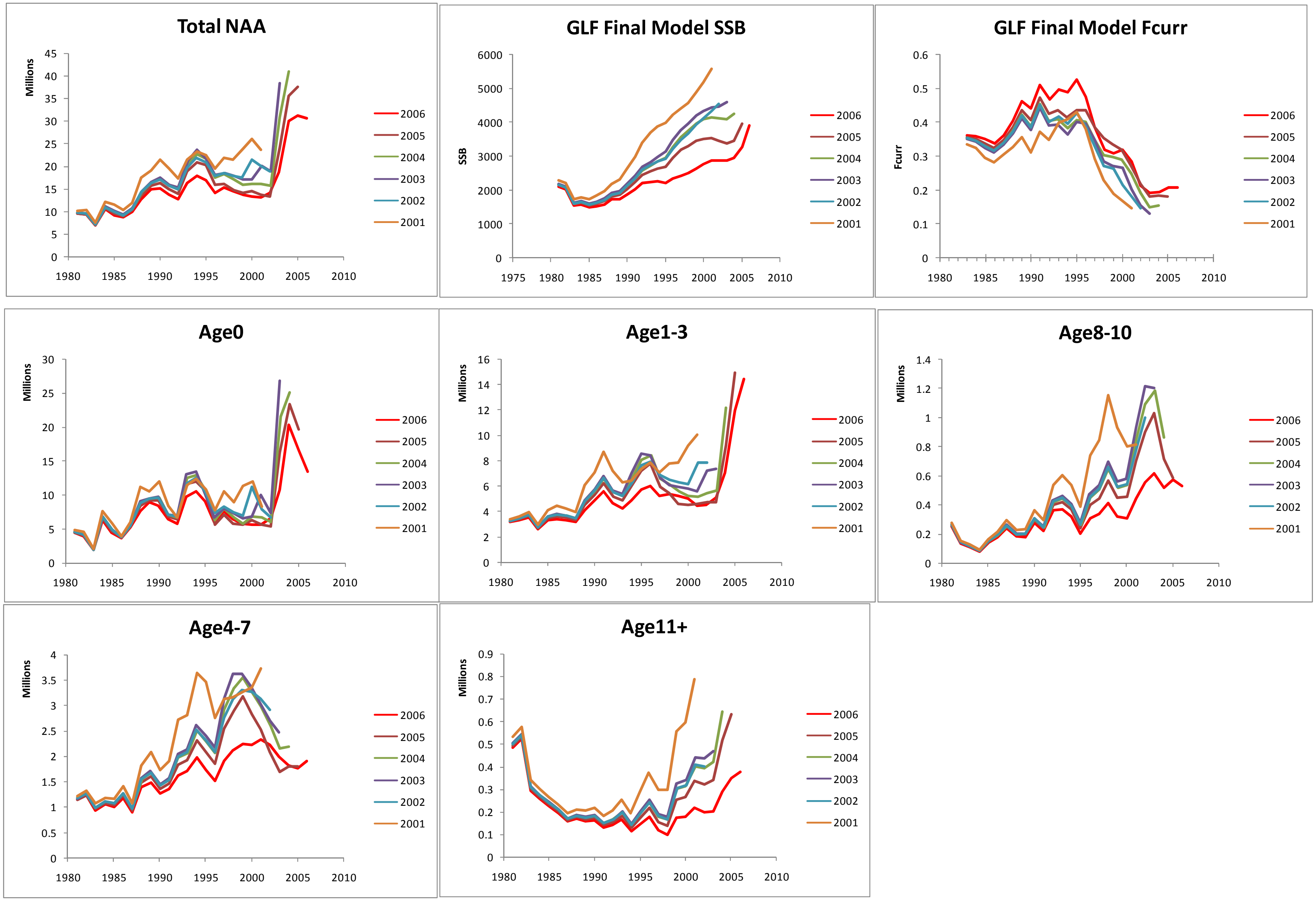



**Figure 9. Retrospective patterns GOM king mackerel Final VPA Model.**

# Annex 2

## Response to SERO's request for king mackerel stock assessment data resulting from the SEDAR 16 Review Workshop

**Request 1**: Yield projections associated with $F_{current}$, 65%$F_{30\%SPR}$, 75%$F_{30\%SPR}$, 85%$F_{30\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$ by migratory group through 2016 (See Worksheet ProjBaseModels[1]). Projection methodology is explained in document SEDAR16-RW-01. The yield vales are presented in **Table A2.1**, corresponding to landings only, starting in the 2008 fishing year. For each constant F scenario, the deterministic results are shown. In addition, the median and upper/lower 80% confidence limits estimated from 1000 bootstrap runs are presented. For all projections, F during the 2007 fishing year was assumed to be equal to the geometric mean F during 2004 - 2006 ($F_{current}$) as agreed by the SEDAR 16 RW. As approved by the RW, average proportions of dead discards by age from the last three years (2004-06) were used for projections of stock status to estimate landings only.

**Request 2**: Trends in landings, and dead discards in pounds by year, fishing mode (shrimp, commercial, charter, private and headboat), and migratory group (see worksheet "TrendsLandingsDeadDiscards", Attachment 1). The requested values, presented in **Table A2.2**, are for the 1981-2006 assessment period base model. Recall that for the base model, the catch within the mixing area during Winter (Nov.-Mar.) was split 50% among migratory units. **Tables A2.2.1**, **A2.2.2** and **A2.2.3** show estimates of landed recreational and commercial catch (i.e., no bycatch or discards are included). The assessment models, however, included estimates of dead discards from recreational fisheries (**Table A2.2.4**) and estimates of bycatch from shrimp fisheries (**Table A2.2.5**), in addition to the landed catch. Estimates of dead discards from recreational fisheries were calculated in numbers at age. For this purpose, numbers at age were converted to weight units using the average weight of landed fish. Estimates of shrimp bycatch are only available in numbers of fish of age 0. The recreational catches were estimated for two fishing modes only, Headboat and MRFSS (private, charter, etc).

**Request 3**: Trends in fishing mortality and spawning stock biomass by year and migratory group (see Worksheet "F_SSB_trends1981_06", Attachment 1). **Tables A2.3.1** and **A2.3.2** show the trends in fishing mortality and spawning stock biomass, by year and migratory group, for the base models. The deterministic result and the median and 80% confidence bounds estimated from 1000 bootstrap runs are shown. "Apical F" refers to the maximum F at age in each year, as estimated by the VPA model. $F_{current}$ was calculated as recommended by the RW as the maximum F at age from the geometric mean of the current year and the prior 2 years.

**Request 4** (items 1', 2', 3' in SERO's data request): Yield projections at $F_{current}$, 65%$F_{30\%SPR}$, 75%$F_{30\%SPR}$, 85%$F_{30\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$ for three alternative management areas delineated by: a) the Dade-Monroe county line, b) the Council boundary line, and c) allocating all fish caught in the mixing zone- winter time to the Gulf of Mexico king mackerel migratory group (see worksheet "ProjAlternTORBound", Attachment 1). Projection methodology and the approximation of different management areas are explained in document SEDAR16-RW-01. The projection results, presented in **Table A2.4.1** and **A2.4.2**, include the projected yield during 2007-2016 (landings only) for the deterministic run, by management unit. Projection scenarios start in the 2008 fishing year. F during the 2007 fishing year was assumed to be equal to the geometric mean F during 2004 - 2006 (i.e., equal to $F_{current}$).

[1] Worksheet names refer to the spreadsheet SEROrequest_Oct08_Final.xlsx, attached as **Attachment 1**.

ANNEX 2

**Table A2.1** Yield projections associated with $F_{current}$, 65%$F_{30\%SPR}$, 75%$F_{30\%SPR}$, 85%$F_{30\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$ by migratory group through 2016.

**Atlantic stock unit**

| | 2006* | 2007** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Yield landings lbs** | | | | | | | | | | | |
| **F30%SPR** | | | | | | | | | | | |
| Deterministic run | 9,852,460 | 9,277,053 | 9,453,423 | 9,248,393 | 9,153,594 | 9,131,548 | 8,860,379 | 8,787,627 | 8,794,241 | 8,736,921 | 8,703,851 |
| low CL | 9,852,460 | 8,423,864 | 7,206,912 | 7,321,553 | 7,484,695 | 7,716,180 | 7,689,725 | 7,696,339 | 7,740,431 | 7,665,474 | 7,612,563 |
| Median | 9,852,460 | 9,732,308 | 9,755,456 | 9,760,968 | 9,816,084 | 9,806,163 | 9,526,176 | 9,284,769 | 9,230,756 | 9,170,129 | 9,163,515 |
| upp CL | 9,852,460 | 11,455,221 | 13,064,595 | 12,850,747 | 12,703,037 | 12,370,139 | 11,788,119 | 11,437,584 | 11,400,105 | 11,342,785 | 11,239,168 |
| **F40%SPR** | | | | | | | | | | | |
| Deterministic run | 9,852,460 | 9,277,053 | 6,668,984 | 6,955,585 | 7,239,982 | 7,522,173 | 7,475,876 | 7,548,629 | 7,665,474 | 7,672,088 | 7,685,315 |
| low CL | 9,852,460 | 8,423,864 | 5,075,042 | 5,498,330 | 5,912,799 | 6,375,769 | 6,497,024 | 6,600,641 | 6,754,965 | 6,777,011 | 6,765,988 |
| Median | 9,852,460 | 9,732,308 | 6,894,958 | 7,328,167 | 7,772,398 | 8,125,138 | 8,093,171 | 8,058,999 | 8,071,124 | 8,044,669 | 8,079,943 |
| upp CL | 9,852,460 | 11,455,221 | 9,270,439 | 9,706,955 | 10,079,536 | 10,304,408 | 10,000,170 | 9,905,371 | 9,896,552 | 9,925,212 | 9,812,777 |
| **Fcurrent** | | | | | | | | | | | |
| Deterministic run | 9,852,460 | 9,277,053 | 9,504,129 | 9,288,076 | 9,184,459 | 9,155,799 | 8,880,221 | 8,805,264 | 8,809,673 | 8,750,148 | 8,717,079 |
| low CL | 9,852,460 | 8,423,864 | 8,395,204 | 8,132,854 | 7,938,847 | 8,024,827 | 7,879,322 | 7,824,207 | 7,797,751 | 7,674,292 | 7,691,929 |
| Median | 9,852,460 | 9,732,308 | 10,265,827 | 10,069,615 | 10,006,783 | 9,979,226 | 9,660,658 | 9,379,568 | 9,339,885 | 9,282,565 | 9,226,347 |
| upp CL | 9,852,460 | 11,455,221 | 12,564,146 | 12,714,060 | 12,703,037 | 12,557,532 | 11,863,076 | 11,607,340 | 11,605,135 | 11,428,765 | 11,331,762 |
| **F 85%SPR30** | | | | | | | | | | | |
| Deterministic run | 9,852,460 | 9,277,053 | 8,170,333 | 8,236,471 | 8,344,498 | 8,476,775 | 8,313,633 | 8,309,224 | 8,368,749 | 8,337,884 | 8,326,861 |
| low CL | 9,852,460 | 8,423,864 | 5,853,274 | 6,261,129 | 6,525,684 | 6,871,810 | 6,986,450 | 7,076,840 | 7,147,387 | 7,109,909 | 7,083,453 |
| Median | 9,852,460 | 9,732,308 | 7,898,062 | 8,261,824 | 8,571,574 | 8,819,594 | 8,724,795 | 8,581,495 | 8,569,369 | 8,550,630 | 8,564,960 |
| upp CL | 9,852,460 | 11,455,221 | 10,672,580 | 10,961,385 | 11,003,273 | 11,115,709 | 10,716,672 | 10,564,553 | 10,529,279 | 10,529,279 | 10,385,979 |
| **F 75%SPR30** | | | | | | | | | | | |
| Deterministic run | 9,852,460 | 9,277,053 | 7,290,688 | 7,497,923 | 7,718,385 | 7,943,256 | 7,850,662 | 7,892,550 | 7,985,144 | 7,978,530 | 7,980,735 |
| low CL | 9,852,460 | 8,423,864 | 5,218,342 | 5,690,132 | 6,005,393 | 6,404,430 | 6,587,413 | 6,688,826 | 6,772,602 | 6,777,011 | 6,770,397 |
| Median | 9,852,460 | 9,732,308 | 7,045,975 | 7,505,639 | 7,912,392 | 8,234,267 | 8,234,267 | 8,132,854 | 8,161,514 | 8,139,468 | 8,160,412 |
| upp CL | 9,852,460 | 11,455,221 | 9,517,357 | 9,956,077 | 10,176,539 | 10,416,843 | 10,103,787 | 9,993,556 | 10,046,467 | 9,995,760 | 9,925,212 |
| **F 65%SPR30** | | | | | | | | | | | |
| Deterministic run | 9,852,460 | 9,277,053 | 6,391,202 | 6,706,463 | 7,017,315 | 7,319,348 | 7,295,097 | 7,378,873 | 7,506,741 | 7,519,969 | 7,537,606 |
| low CL | 9,852,460 | 8,423,864 | 4,576,797 | 5,088,270 | 5,443,214 | 5,873,115 | 6,071,532 | 6,219,241 | 6,325,063 | 6,360,337 | 6,369,156 |
| Median | 9,852,460 | 9,732,308 | 6,170,740 | 6,699,849 | 7,174,945 | 7,562,959 | 7,625,791 | 7,600,437 | 7,662,167 | 7,631,302 | 7,668,781 |
| upp CL | 9,852,460 | 11,455,221 | 8,335,679 | 8,893,449 | 9,246,189 | 9,583,496 | 9,380,671 | 9,312,327 | 9,407,126 | 9,402,717 | 9,356,420 |

**Gulf of Mexico stock unit**

| | 2006* | 2007** | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Yield landings lbs** | | | | | | | | | | | |
| **Fcurrent** | | | | | | | | | | | |
| Deterministic run | 8,900,063 | 11,810,165 | 14,393,983 | 15,156,783 | 14,526,260 | 13,022,708 | 11,576,475 | 10,621,873 | 9,958,282 | 9,671,681 | 9,455,628 |
| low CL | 8,900,063 | 10,822,494 | 12,308,410 | 12,546,509 | 12,094,561 | 11,331,762 | 10,414,639 | 9,896,552 | 9,301,304 | 8,959,588 | 8,756,762 |
| Median boots | 8,900,063 | 11,972,205 | 14,408,313 | 15,134,736 | 14,594,604 | 13,677,481 | 12,446,199 | 11,655,841 | 10,921,702 | 10,544,711 | 10,317,635 |
| upp CL | 8,900,063 | 13,613,546 | 17,275,425 | 18,931,097 | 18,406,397 | 17,154,171 | 15,566,842 | 14,479,963 | 13,245,374 | 12,676,582 | 12,372,344 |
| **F30%SPR** | | | | | | | | | | | |
| Deterministic run | 8,900,063 | 11,810,165 | 17,129,920 | 17,491,478 | 16,285,549 | 14,239,659 | 12,431,869 | 11,276,646 | 10,502,824 | 10,147,879 | 9,885,529 |
| low CL | 8,900,063 | 10,822,494 | 13,399,698 | 13,734,801 | 13,071,209 | 12,098,971 | 11,053,979 | 10,299,998 | 9,680,499 | 9,387,284 | 9,089,660 |
| Median boots | 8,900,063 | 11,972,205 | 17,271,016 | 17,597,300 | 16,467,431 | 15,002,459 | 13,378,754 | 12,397,697 | 11,489,392 | 11,056,184 | 10,761,867 |
| upp CL | 8,900,063 | 13,613,546 | 22,134,414 | 23,082,402 | 21,587,668 | 19,171,401 | 16,940,322 | 15,500,704 | 14,030,220 | 13,386,470 | 12,903,658 |
| **F40%SPR** | | | | | | | | | | | |
| Deterministic run | 8,900,063 | 11,810,165 | 12,610,443 | 13,542,999 | 13,223,328 | 12,046,060 | 10,833,517 | 10,017,807 | 9,437,991 | 9,199,891 | 9,014,703 |
| low CL | 8,900,063 | 10,822,494 | 9,711,364 | 10,434,480 | 10,394,797 | 10,103,787 | 9,504,129 | 9,107,297 | 8,732,511 | 8,587,006 | 8,390,795 |
| Median boots | 8,900,063 | 11,972,205 | 12,529,974 | 13,447,097 | 13,151,678 | 12,515,644 | 11,542,303 | 10,985,636 | 10,362,830 | 10,118,117 | 9,867,892 |
| upp CL | 8,900,063 | 13,613,546 | 16,043,041 | 17,630,369 | 17,257,788 | 16,007,767 | 14,616,650 | 13,695,118 | 12,678,786 | 12,204,792 | 11,814,574 |
| **F 65%SPR30** | | | | | | | | | | | |
| Deterministic run | 8,900,063 | 11,810,165 | 11,512,541 | 12,513,440 | 12,356,911 | 11,369,240 | 10,299,998 | 9,568,063 | 9,041,159 | 8,833,924 | 8,668,577 |
| low CL | 8,900,063 | 10,822,494 | 9,389,489 | 10,125,833 | 10,081,741 | 9,940,645 | 9,334,373 | 8,977,225 | 8,617,871 | 8,432,683 | 8,262,927 |
| Median boots | 8,900,063 | 11,972,205 | 12,152,984 | 13,114,199 | 12,937,830 | 12,299,591 | 11,387,980 | 10,834,619 | 10,226,143 | 9,979,226 | 9,713,569 |
| upp CL | 8,900,063 | 13,613,546 | 15,282,446 | 16,673,563 | 16,477,352 | 15,449,997 | 14,274,933 | 13,401,903 | 12,359,116 | 11,979,921 | 11,631,590 |
| **F 75%SPR30** | | | | | | | | | | | |
| Deterministic run | 8,900,063 | 11,810,165 | 13,161,599 | 14,050,062 | 13,640,002 | 12,365,730 | 11,080,435 | 10,220,632 | 9,614,361 | 9,360,829 | 9,164,617 |
| low CL | 8,900,063 | 10,822,494 | 10,738,718 | 11,417,742 | 11,155,392 | 10,846,745 | 10,042,057 | 9,550,426 | 9,102,888 | 8,875,812 | 8,644,326 |
| Median boots | 8,900,063 | 11,972,205 | 13,889,124 | 14,721,370 | 14,278,240 | 13,365,526 | 12,226,839 | 11,503,722 | 10,804,857 | 10,481,880 | 10,160,005 |
| upp CL | 8,900,063 | 13,613,546 | 17,460,613 | 18,723,862 | 18,181,525 | 16,814,659 | 15,297,878 | 14,246,273 | 13,022,708 | 12,595,011 | 12,149,677 |
| **F 85%SPR30** | | | | | | | | | | | |
| Deterministic run | 8,900,063 | 11,810,165 | 14,777,587 | 15,496,294 | 14,790,815 | 13,214,510 | 11,715,366 | 10,732,104 | 10,053,080 | 9,755,456 | 9,532,789 |
| low CL | 8,900,063 | 10,822,494 | 12,057,083 | 12,625,875 | 12,129,835 | 11,591,907 | 10,635,101 | 9,980,328 | 9,488,697 | 9,204,301 | 8,922,109 |
| Median boots | 8,900,063 | 11,972,205 | 15,595,502 | 16,213,899 | 15,481,964 | 14,266,115 | 12,897,044 | 12,033,934 | 11,211,610 | 10,818,085 | 10,512,744 |
| upp CL | 8,900,063 | 13,613,546 | 19,612,325 | 20,637,475 | 19,713,738 | 17,939,017 | 16,111,384 | 14,918,683 | 13,534,180 | 13,066,800 | 12,548,714 |

**Table A2.2**. Trends of landings and dead discards king mackerel VPA final models.

**A2.2.1** Estimates total landings king **ATL** stock

| Fishing Year | Commercial million lbs | Recreational million lbs | Total wgt | Commercial numbers | Recreational numbers | Total numbers |
|---|---|---|---|---|---|---|
| 1981/82 | 5.142 | 4.754 | 9.896 | 480,266 | 672,661 | 1,152,928 |
| 1982/83 | 5.597 | 4.878 | 10.474 | 497,104 | 618,612 | 1,115,717 |
| 1983/84 | 3.627 | 6.353 | 9.980 | 329,327 | 828,373 | 1,157,700 |
| 1984/85 | 3.049 | 5.546 | 8.595 | 254,939 | 676,709 | 931,648 |
| 1985/86 | 3.781 | 6.215 | 9.996 | 285,533 | 876,422 | 1,161,954 |
| 1986/87 | 3.313 | 5.972 | 9.286 | 313,999 | 875,388 | 1,189,387 |
| 1987/88 | 3.730 | 3.572 | 7.301 | 392,905 | 627,079 | 1,019,983 |
| 1988/89 | 3.549 | 4.975 | 8.524 | 358,110 | 693,435 | 1,051,545 |
| 1989/90 | 3.247 | 3.404 | 6.651 | 303,412 | 477,546 | 780,959 |
| 1990/91 | 3.232 | 3.549 | 6.781 | 356,494 | 526,174 | 882,667 |
| 1991/92 | 3.186 | 6.310 | 9.496 | 337,728 | 831,938 | 1,169,667 |
| 1992/93 | 3.374 | 6.385 | 9.760 | 308,504 | 812,354 | 1,120,858 |
| 1993/94 | 2.766 | 4.245 | 7.011 | 260,266 | 427,433 | 687,698 |
| 1994/95 | 2.960 | 3.728 | 6.688 | 269,440 | 455,905 | 725,345 |
| 1995/96 | 2.675 | 4.551 | 7.225 | 223,112 | 592,380 | 815,492 |
| 1996/97 | 3.601 | 4.600 | 8.201 | 376,671 | 523,291 | 899,962 |
| 1997/98 | 3.636 | 5.490 | 9.126 | 361,157 | 664,584 | 1,025,741 |
| 1998/99 | 3.770 | 4.420 | 8.190 | 363,327 | 541,535 | 904,862 |
| 1999/00 | 2.933 | 3.149 | 6.082 | 299,869 | 409,295 | 709,165 |
| 2000/01 | 2.951 | 4.624 | 7.575 | 273,692 | 589,034 | 862,725 |
| 2001/02 | 2.853 | 3.786 | 6.638 | 236,627 | 383,171 | 619,798 |
| 2002/03 | 2.721 | 2.923 | 5.644 | 245,148 | 385,442 | 630,591 |
| 2003/04 | 2.623 | 3.903 | 6.526 | 228,115 | 489,948 | 718,063 |
| 2004/05 | 3.765 | 3.870 | 7.635 | 356,888 | 409,594 | 766,482 |
| 2005/06 | 3.187 | 3.011 | 6.198 | 297,772 | 442,298 | 740,071 |
| 2006/07 | 3.731 | 3.775 | 7.506 | 357,494 | 497,313 | 854,807 |

**Table A2.2.2** Estimates total landings king **GOM** stock

| Fishing Year | Commercial million lbs | Recreational million lbs | Total | Commercial numbers | Recreational numbers | Total numbers |
|---|---|---|---|---|---|---|
| 1981/82 | 2.894 | 2.124 | 5.018 | 449,537 | 254,017 | 703,554 |
| 1982/83 | 2.981 | 6.450 | 9.432 | 333,460 | 791,645 | 1,125,105 |
| 1983/84 | 1.786 | 1.969 | 3.755 | 294,527 | 332,643 | 627,171 |
| 1984/85 | 2.103 | 2.580 | 4.682 | 252,870 | 400,486 | 653,357 |
| 1985/86 | 2.265 | 1.668 | 3.933 | 324,790 | 195,390 | 520,179 |
| 1986/87 | 0.997 | 2.405 | 3.402 | 135,592 | 387,802 | 523,394 |
| 1987/88 | 0.591 | 1.364 | 1.956 | 73,968 | 228,302 | 302,270 |
| 1988/89 | 0.948 | 3.559 | 4.506 | 103,859 | 410,210 | 514,069 |
| 1989/90 | 1.343 | 2.254 | 3.596 | 163,674 | 420,556 | 584,230 |
| 1990/91 | 1.260 | 2.659 | 3.919 | 170,529 | 400,459 | 570,988 |
| 1991/92 | 1.448 | 2.902 | 4.350 | 180,768 | 571,667 | 752,435 |
| 1992/93 | 2.452 | 3.735 | 6.187 | 371,597 | 476,770 | 848,367 |
| 1993/94 | 1.824 | 3.657 | 5.480 | 231,819 | 511,105 | 742,923 |
| 1994/95 | 2.120 | 5.372 | 7.492 | 286,647 | 649,925 | 936,572 |
| 1995/96 | 1.840 | 3.576 | 5.416 | 247,401 | 482,121 | 729,522 |
| 1996/97 | 1.965 | 4.439 | 6.404 | 307,525 | 516,774 | 824,299 |
| 1997/98 | 2.469 | 3.662 | 6.132 | 322,152 | 477,714 | 799,866 |
| 1998/99 | 2.673 | 2.909 | 5.582 | 365,877 | 370,742 | 736,620 |
| 1999/00 | 2.271 | 2.312 | 4.583 | 283,018 | 323,146 | 606,164 |
| 2000/01 | 2.234 | 2.723 | 4.957 | 286,303 | 386,283 | 672,586 |
| 2001/02 | 2.103 | 2.827 | 4.929 | 283,148 | 400,567 | 683,715 |
| 2002/03 | 2.253 | 2.752 | 5.005 | 347,289 | 407,184 | 754,473 |
| 2003/04 | 2.290 | 2.797 | 5.087 | 311,588 | 365,081 | 676,669 |
| 2004/05 | 2.284 | 2.628 | 4.913 | 355,707 | 361,502 | 717,209 |
| 2005/06 | 2.103 | 2.992 | 5.095 | 305,755 | 414,590 | 720,345 |
| 2006/07 | 2.417 | 3.343 | 5.761 | 325,725 | 508,393 | 834,118 |

**Table A2.2.3**. Estimates recreational landings by sector king mackerel.

| Stock | Fyear | Headboat million lbs | MRFSS million | Total |
|---|---|---|---|---|
| **ATL** | 1981 | - | 4.754 | 4.754 |
| | 1982 | - | 4.878 | 4.878 |
| | 1983 | - | 6.353 | 6.353 |
| | 1984 | - | 5.546 | 5.546 |
| | 1985 | 0.010 | 6.205 | 6.215 |
| | 1986 | 0.283 | 5.689 | 5.972 |
| | 1987 | 0.207 | 3.365 | 3.572 |
| | 1988 | 0.183 | 4.792 | 4.975 |
| | 1989 | 0.176 | 3.228 | 3.404 |
| | 1990 | 0.229 | 3.320 | 3.549 |
| | 1991 | 0.251 | 6.059 | 6.310 |
| | 1992 | 0.179 | 6.206 | 6.385 |
| | 1993 | 0.161 | 4.084 | 4.245 |
| | 1994 | 0.177 | 3.551 | 3.728 |
| | 1995 | 0.137 | 4.414 | 4.551 |
| | 1996 | 0.311 | 4.289 | 4.600 |
| | 1997 | 0.168 | 5.323 | 5.490 |
| | 1998 | 0.123 | 4.298 | 4.420 |
| | 1999 | 0.151 | 2.998 | 3.149 |
| | 2000 | 0.150 | 4.474 | 4.624 |
| | 2001 | 0.102 | 3.683 | 3.786 |
| | 2002 | 0.094 | 2.830 | 2.923 |
| | 2003 | 0.075 | 3.829 | 3.903 |
| | 2004 | 0.141 | 3.728 | 3.869 |
| | 2005 | 0.184 | 2.826 | 3.011 |
| | 2006 | 0.154 | 3.621 | 3.775 |

| Stock | Fyear | Headboat million lbs | MRFSS million | Total |
|---|---|---|---|---|
| **GOM** | 1981 | 0.024 | 2.099 | 2.124 |
| | 1982 | 0.110 | 6.340 | 6.450 |
| | 1983 | 0.096 | 1.873 | 1.969 |
| | 1984 | 0.085 | 2.494 | 2.580 |
| | 1985 | 0.119 | 1.548 | 1.668 |
| | 1986 | 0.168 | 2.237 | 2.405 |
| | 1987 | 0.094 | 1.270 | 1.364 |
| | 1988 | 0.103 | 3.455 | 3.559 |
| | 1989 | 0.152 | 2.101 | 2.254 |
| | 1990 | 0.141 | 2.518 | 2.659 |
| | 1991 | 0.148 | 2.754 | 2.902 |
| | 1992 | 0.204 | 3.531 | 3.735 |
| | 1993 | 0.228 | 3.429 | 3.657 |
| | 1994 | 0.196 | 5.177 | 5.372 |
| | 1995 | 0.195 | 3.381 | 3.576 |
| | 1996 | 0.271 | 4.168 | 4.439 |
| | 1997 | 0.285 | 3.378 | 3.662 |
| | 1998 | 0.172 | 2.737 | 2.909 |
| | 1999 | 0.220 | 2.092 | 2.313 |
| | 2000 | 0.137 | 2.586 | 2.723 |
| | 2001 | 0.146 | 2.681 | 2.827 |
| | 2002 | 0.183 | 2.569 | 2.752 |
| | 2003 | 0.135 | 2.662 | 2.797 |
| | 2004 | 0.214 | 2.415 | 2.629 |
| | 2005 | 0.221 | 2.771 | 2.992 |
| | 2006 | 0.243 | 3.100 | 3.343 |

**Table A2.2.4**. Estimates dead discards for king mackerel by migratory unit.

## Dead discards numbers of fish

***All recreational fisheries only***

| Fishing Year | Gulf | Atlantic | Avg wgt Gulf | Avg wgt Atlantic | Dead disc wgt lbs Gulf | Dead disc wgt lbs Atlantic |
|---|---|---|---|---|---|---|
| 1981/82 | 2,002 | 494 | 8.35 | 7.06 | 16,721 | 3,491 |
| 1982/83 | 6,241 | 232 | 8.14 | 7.88 | 50,804 | 1,828 |
| 1983/84 | 26 | 52 | 5.91 | 7.66 | 155 | 398 |
| 1984/85 | 1,759 | 303 | 6.44 | 8.19 | 11,317 | 2,481 |
| 1985/86 | 1,999 | 2,617 | 8.53 | 7.09 | 17,042 | 18,541 |
| 1986/87 | 5,908 | 8,770 | 6.20 | 6.82 | 36,603 | 59,782 |
| 1987/88 | 7,366 | 9,324 | 5.97 | 5.69 | 43,978 | 53,060 |
| 1988/89 | 9,807 | 8,812 | 8.67 | 7.17 | 84,999 | 63,169 |
| 1989/90 | 26,236 | 6,103 | 5.35 | 7.12 | 140,462 | 43,467 |
| 1990/91 | 33,620 | 7,012 | 6.63 | 6.74 | 223,019 | 47,253 |
| 1991/92 | 31,141 | 16,604 | 5.07 | 7.58 | 157,939 | 125,827 |
| 1992/93 | 16,655 | 8,011 | 7.83 | 7.85 | 130,361 | 62,914 |
| 1993/94 | 21,886 | 7,471 | 7.15 | 9.92 | 156,441 | 74,142 |
| 1994/95 | 37,025 | 6,246 | 8.26 | 8.17 | 305,779 | 51,032 |
| 1995/96 | 32,092 | 14,357 | 7.41 | 7.67 | 237,824 | 110,189 |
| 1996/97 | 26,028 | 13,369 | 8.58 | 8.78 | 223,368 | 117,410 |
| 1997/98 | 21,158 | 19,585 | 7.66 | 8.25 | 162,057 | 161,648 |
| 1998/99 | 23,037 | 17,020 | 7.84 | 8.16 | 180,585 | 138,802 |
| 1999/00 | 20,088 | 20,356 | 7.15 | 7.69 | 143,617 | 156,468 |
| 2000/01 | 29,799 | 18,589 | 7.04 | 7.84 | 209,861 | 145,791 |
| 2001/02 | 64,614 | 25,042 | 7.05 | 9.87 | 455,569 | 247,185 |
| 2002/03 | 53,170 | 19,826 | 6.75 | 7.58 | 359,071 | 150,235 |
| 2003/04 | 41,252 | 27,671 | 7.65 | 7.96 | 315,775 | 220,264 |
| 2004/05 | 53,527 | 27,253 | 7.26 | 9.44 | 388,827 | 257,241 |
| 2005/06 | 84,446 | 38,118 | 7.21 | 6.80 | 608,938 | 259,237 |
| 2006/07 | 63,644 | 32,020 | 6.57 | 7.58 | 418,172 | 242,821 |

**Table A2.2.5**. Estimates of bycatch of king mackerel by migratory unit made by the shrimp fishery.

***Age 0 numbers of fish***

| Fishing Year | Gulf | Atlantic |
|---|---|---|
| 1981/82 | 560,714 | - |
| 1982/83 | 234,807 | - |
| 1983/84 | 447,285 | - |
| 1984/85 | 1,467,069 | - |
| 1985/86 | 725,460 | - |
| 1986/87 | 811,806 | - |
| 1987/88 | 1,476,385 | - |
| 1988/89 | 1,690,808 | - |
| 1989/90 | 2,742,900 | 23,369 |
| 1990/91 | 2,093,187 | 64,146 |
| 1991/92 | 2,014,732 | 25,742 |
| 1992/93 | 1,465,161 | 27,117 |
| 1993/94 | 2,789,829 | 13,497 |
| 1994/95 | 3,136,550 | 21,055 |
| 1995/96 | 2,739,787 | 40,141 |
| 1996/97 | 1,376,113 | 59,534 |
| 1997/98 | 1,348,322 | 15,744 |
| 1998/99 | 1,193,085 | 47,539 |
| 1999/00 | 1,210,741 | 32,003 |
| 2000/01 | 1,078,106 | 18,381 |
| 2001/02 | 772,155 | 7,198 |
| 2002/03 | 641,061 | 8,479 |
| 2003/04 | 1,542,801 | 15,383 |
| 2004/05 | 2,888,086 | 8,185 |
| 2005/06 | 1,909,170 | 7,202 |
| 2006/07 | 923,292 | 13,120 |

**Table A2.3.1**. Trends in spawning stock (eggs) and fishing mortality for **Atlantic** king mackerel.

| | SSB VPA estimated value Million hydrated eggs | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1981 | 4508 | 4496 | 4509 | 4551 |
| 1982 | 4568 | 4555 | 4569 | 4615 |
| 1983 | 4587 | 4573 | 4589 | 4640 |
| 1984 | 4498 | 4483 | 4500 | 4555 |
| 1985 | 4418 | 4400 | 4420 | 4483 |
| 1986 | 4275 | 4253 | 4277 | 4353 |
| 1987 | 4086 | 4059 | 4089 | 4182 |
| 1988 | 3873 | 3842 | 3877 | 3985 |
| 1989 | 3555 | 3520 | 3559 | 3682 |
| 1990 | 3545 | 3500 | 3550 | 3705 |
| 1991 | 3580 | 3520 | 3587 | 3797 |
| 1992 | 3369 | 3294 | 3377 | 3640 |
| 1993 | 3098 | 3010 | 3108 | 3416 |
| 1994 | 2962 | 2861 | 2973 | 3328 |
| 1995 | 2873 | 2753 | 2887 | 3307 |
| 1996 | 2847 | 2698 | 2864 | 3383 |
| 1997 | 2824 | 2643 | 2844 | 3474 |
| 1998 | 2701 | 2494 | 2722.5 | 3439 |
| 1999 | 2641 | 2410 | 2664.5 | 3433 |
| 2000 | 2640 | 2382 | 2658.5 | 3442 |
| 2001 | 2476 | 2194 | 2485.5 | 3258 |
| 2002 | 2377 | 2069 | 2374 | 3119 |
| 2003 | 2341 | 2000 | 2320 | 3008 |
| 2004 | 2365 | 1958 | 2336 | 3038 |
| 2005 | 2433 | 1973 | 2426.5 | 3102 |
| 2006 | 2443 | 1951 | 2476.5 | 3203 |

| | SSB/MSST | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1981 | 2.468 | 2.463 | 2.470 | 2.492 |
| 1982 | 2.501 | 2.495 | 2.503 | 2.528 |
| 1983 | 2.512 | 2.505 | 2.514 | 2.541 |
| 1984 | 2.463 | 2.455 | 2.465 | 2.495 |
| 1985 | 2.419 | 2.410 | 2.421 | 2.455 |
| 1986 | 2.341 | 2.330 | 2.343 | 2.383 |
| 1987 | 2.237 | 2.224 | 2.240 | 2.290 |
| 1988 | 2.121 | 2.105 | 2.124 | 2.182 |
| 1989 | 1.947 | 1.928 | 1.950 | 2.015 |
| 1990 | 1.941 | 1.917 | 1.945 | 2.028 |
| 1991 | 1.960 | 1.928 | 1.965 | 2.078 |
| 1992 | 1.845 | 1.804 | 1.851 | 2 |
| 1993 | 1.696 | 1.648 | 1.703 | 1.869 |
| 1994 | 1.622 | 1.567 | 1.629 | 1.820 |
| 1995 | 1.573 | 1.508 | 1.582 | 1.808 |
| 1996 | 1.559 | 1.478 | 1.570 | 1.849 |
| 1997 | 1.546 | 1.448 | 1.559 | 1.898 |
| 1998 | 1.479 | 1.367 | 1.493 | 1.877 |
| 1999 | 1.446 | 1.320 | 1.459 | 1.872 |
| 2000 | 1.446 | 1.305 | 1.456 | 1.883 |
| 2001 | 1.356 | 1.202 | 1.361 | 1.782 |
| 2002 | 1.302 | 1.134 | 1.300 | 1.706 |
| 2003 | 1.282 | 1.095 | 1.271 | 1.647 |
| 2004 | 1.295 | 1.074 | 1.280 | 1.657 |
| 2005 | 1.332 | 1.081 | 1.329 | 1.697 |
| 2006 | 1.338 | 1.071 | 1.357 | 1.749 |

| | F apical VPA estimate fishing mortality rate | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1981 | 0.442 | 0.440 | 0.442 | 0.443 |
| 1982 | 0.386 | 0.383 | 0.386 | 0.387 |
| 1983 | 0.382 | 0.378 | 0.381 | 0.382 |
| 1984 | 0.287 | 0.284 | 0.287 | 0.288 |
| 1985 | 0.441 | 0.437 | 0.441 | 0.442 |
| 1986 | 0.288 | 0.284 | 0.288 | 0.289 |
| 1987 | 0.208 | 0.205 | 0.208 | 0.209 |
| 1988 | 0.287 | 0.282 | 0.287 | 0.289 |
| 1989 | 0.219 | 0.213 | 0.219 | 0.220 |
| 1990 | 0.331 | 0.320 | 0.331 | 0.334 |
| 1991 | 0.311 | 0.297 | 0.311 | 0.316 |
| 1992 | 0.345 | 0.325 | 0.344 | 0.351 |
| 1993 | 0.318 | 0.293 | 0.317 | 0.326 |
| 1994 | 0.252 | 0.226 | 0.251 | 0.260 |
| 1995 | 0.361 | 0.318 | 0.360 | 0.376 |
| 1996 | 0.366 | 0.314 | 0.364 | 0.383 |
| 1997 | 0.390 | 0.320 | 0.388 | 0.416 |
| 1998 | 0.315 | 0.240 | 0.312 | 0.346 |
| 1999 | 0.233 | 0.165 | 0.230 | 0.264 |
| 2000 | 0.263 | 0.203 | 0.259 | 0.298 |
| 2001 | 0.285 | 0.248 | 0.287 | 0.305 |
| 2002 | 0.269 | 0.245 | 0.274 | 0.294 |
| 2003 | 0.358 | 0.284 | 0.362 | 0.406 |
| 2004 | 0.377 | 0.324 | 0.393 | 0.455 |
| 2005 | 0.344 | 0.296 | 0.373 | 0.458 |
| 2006 | 0.359 | 0.310 | 0.409 | 0.534 |

| | Fcurr/ MFMT | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1983 | 0.914 | 0.784 | 0.854 | 0.919 |
| 1984 | 0.745 | 0.637 | 0.695 | 0.749 |
| 1985 | 0.754 | 0.645 | 0.704 | 0.758 |
| 1986 | 1.010 | 0.863 | 0.943 | 1.016 |
| 1987 | 0.804 | 0.684 | 0.751 | 0.808 |
| 1988 | 0.613 | 0.521 | 0.572 | 0.616 |
| 1989 | 0.623 | 0.528 | 0.581 | 0.625 |
| 1990 | 0.669 | 0.566 | 0.625 | 0.672 |
| 1991 | 0.683 | 0.575 | 0.638 | 0.684 |
| 1992 | 0.815 | 0.680 | 0.762 | 0.817 |
| 1993 | 0.974 | 0.802 | 0.912 | 0.977 |
| 1994 | 0.937 | 0.758 | 0.878 | 0.940 |
| 1995 | 0.831 | 0.658 | 0.780 | 0.835 |
| 1996 | 0.906 | 0.703 | 0.852 | 0.913 |
| 1997 | 1.154 | 0.873 | 1.086 | 1.165 |
| 1998 | 1.025 | 0.746 | 0.965 | 1.043 |
| 1999 | 0.783 | 0.530 | 0.737 | 0.814 |
| 2000 | 0.705 | 0.477 | 0.666 | 0.739 |
| 2001 | 0.725 | 0.517 | 0.687 | 0.747 |
| 2002 | 0.718 | 0.551 | 0.684 | 0.740 |
| 2003 | 0.771 | 0.628 | 0.741 | 0.814 |
| 2004 | 0.893 | 0.725 | 0.877 | 0.983 |
| 2005 | 0.984 | 0.811 | 0.985 | 1.150 |
| 2006 | 1.006 | 0.869 | 1.076 | 1.306 |

**Table A2.3.2**. Trends in spawning stock (eggs) and fishing mortality for **Gulf** king mackerel.

| | SSB VPA estimated value Million hydrated eggs | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1981 | 2123 | 2103 | 2111 | 2124 |
| 1982 | 2036 | 2015 | 2023 | 2036 |
| 1983 | 1555 | 1532 | 1541 | 1556 |
| 1984 | 1590 | 1565 | 1574.5 | 1591 |
| 1985 | 1502 | 1473 | 1484 | 1503 |
| 1986 | 1532 | 1495 | 1509 | 1534 |
| 1987 | 1590 | 1543 | 1561 | 1592 |
| 1988 | 1731 | 1676 | 1697 | 1733 |
| 1989 | 1748 | 1680 | 1706 | 1751 |
| 1990 | 1885 | 1796 | 1830 | 1888 |
| 1991 | 2040 | 1929 | 1972 | 2045 |
| 1992 | 2215 | 2072 | 2126.5 | 2220 |
| 1993 | 2245 | 2070 | 2137.5 | 2252 |
| 1994 | 2265 | 2052 | 2134 | 2273 |
| 1995 | 2210 | 1932 | 2038.5 | 2220 |
| 1996 | 2340 | 1987 | 2123 | 2353 |
| 1997 | 2443 | 2006 | 2174 | 2459 |
| 1998 | 2509 | 1979 | 2185.5 | 2531 |
| 1999 | 2658 | 2036 | 2286.5 | 2700 |
| 2000 | 2788 | 2106 | 2396.5 | 2850 |
| 2001 | 2876 | 2162 | 2487 | 2968 |
| 2002 | 2873 | 2180 | 2526 | 3032 |
| 2003 | 2872 | 2226 | 2578 | 3091 |
| 2004 | 2955 | 2343 | 2728 | 3218 |
| 2005 | 3285 | 2645 | 3116 | 3644 |
| 2006 | 3921 | 3224 | 3846 | 4512 |

| SSB/MSST | | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1981 | 0.811 | 0.804 | 0.807 | 0.812 |
| 1982 | 0.778 | 0.770 | 0.773 | 0.779 |
| 1983 | 0.594 | 0.586 | 0.589 | 0.595 |
| 1984 | 0.607 | 0.598 | 0.602 | 0.608 |
| 1985 | 0.574 | 0.563 | 0.567 | 0.575 |
| 1986 | 0.585 | 0.572 | 0.577 | 0.586 |
| 1987 | 0.607 | 0.590 | 0.597 | 0.608 |
| 1988 | 0.661 | 0.641 | 0.649 | 0.662 |
| 1989 | 0.668 | 0.643 | 0.652 | 0.669 |
| 1990 | 0.720 | 0.687 | 0.700 | 0.722 |
| 1991 | 0.779 | 0.738 | 0.754 | 0.782 |
| 1992 | 0.846 | 0.792 | 0.813 | 0.849 |
| 1993 | 0.857 | 0.792 | 0.817 | 0.861 |
| 1994 | 0.865 | 0.785 | 0.816 | 0.869 |
| 1995 | 0.844 | 0.739 | 0.779 | 0.849 |
| 1996 | 0.894 | 0.760 | 0.811 | 0.900 |
| 1997 | 0.933 | 0.767 | 0.831 | 0.940 |
| 1998 | 0.958 | 0.757 | 0.835 | 0.967 |
| 1999 | 1.015 | 0.779 | 0.874 | 1.032 |
| 2000 | 1.065 | 0.806 | 0.916 | 1.089 |
| 2001 | 1.098 | 0.828 | 0.951 | 1.134 |
| 2002 | 1.097 | 0.834 | 0.966 | 1.159 |
| 2003 | 1.097 | 0.851 | 0.987 | 1.180 |
| 2004 | 1.129 | 0.896 | 1.043 | 1.227 |
| 2005 | 1.255 | 1.012 | 1.191 | 1.394 |
| 2006 | 1.498 | 1.237 | 1.471 | 1.725 |

| | F apical VPA estimate fishing mortality rate | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1981 | 0.340 | 0.340 | 0.342 | 0.343 |
| 1982 | 1.008 | 1.008 | 1.012 | 1.014 |
| 1983 | 0.413 | 0.413 | 0.414 | 0.415 |
| 1984 | 0.427 | 0.427 | 0.429 | 0.430 |
| 1985 | 0.558 | 0.558 | 0.561 | 0.563 |
| 1986 | 0.556 | 0.556 | 0.561 | 0.565 |
| 1987 | 0.493 | 0.492 | 0.499 | 0.504 |
| 1988 | 0.368 | 0.367 | 0.383 | 0.393 |
| 1989 | 0.548 | 0.548 | 0.557 | 0.563 |
| 1990 | 0.422 | 0.421 | 0.439 | 0.449 |
| 1991 | 0.568 | 0.568 | 0.586 | 0.597 |
| 1992 | 0.713 | 0.711 | 0.732 | 0.745 |
| 1993 | 0.508 | 0.505 | 0.552 | 0.584 |
| 1994 | 0.681 | 0.679 | 0.707 | 0.724 |
| 1995 | 0.537 | 0.535 | 0.582 | 0.614 |
| 1996 | 0.378 | 0.375 | 0.420 | 0.451 |
| 1997 | 0.294 | 0.292 | 0.336 | 0.369 |
| 1998 | 0.313 | 0.311 | 0.362 | 0.401 |
| 1999 | 0.346 | 0.306 | 0.339 | 0.365 |
| 2000 | 0.313 | 0.259 | 0.286 | 0.313 |
| 2001 | 0.212 | 0.191 | 0.214 | 0.239 |
| 2002 | 0.177 | 0.158 | 0.185 | 0.220 |
| 2003 | 0.225 | 0.202 | 0.263 | 0.332 |
| 2004 | 0.223 | 0.176 | 0.210 | 0.257 |
| 2005 | 0.239 | 0.195 | 0.233 | 0.279 |
| 2006 | 0.288 | 0.212 | 0.254 | 0.313 |

| Fcurr/ MFMT | | | | |
|---|---|---|---|---|
| Year | Deterministic | low CI | Median | upp CI |
| 1983 | 1.446 | 1.385 | 1.530 | 1.647 |
| 1984 | 1.434 | 1.376 | 1.520 | 1.637 |
| 1985 | 1.398 | 1.347 | 1.489 | 1.607 |
| 1986 | 1.343 | 1.294 | 1.431 | 1.544 |
| 1987 | 1.440 | 1.387 | 1.532 | 1.654 |
| 1988 | 1.613 | 1.558 | 1.726 | 1.863 |
| 1989 | 1.846 | 1.790 | 1.983 | 2.141 |
| 1990 | 1.754 | 1.713 | 1.899 | 2.053 |
| 1991 | 2.027 | 1.974 | 2.187 | 2.367 |
| 1992 | 1.866 | 1.829 | 2.032 | 2.199 |
| 1993 | 1.984 | 1.957 | 2.186 | 2.382 |
| 1994 | 1.942 | 1.924 | 2.169 | 2.373 |
| 1995 | 2.095 | 2.077 | 2.365 | 2.603 |
| 1996 | 1.898 | 1.889 | 2.159 | 2.379 |
| 1997 | 1.536 | 1.516 | 1.754 | 1.935 |
| 1998 | 1.267 | 1.233 | 1.424 | 1.570 |
| 1999 | 1.231 | 1.165 | 1.323 | 1.453 |
| 2000 | 1.273 | 1.153 | 1.290 | 1.412 |
| 2001 | 1.132 | 0.974 | 1.119 | 1.236 |
| 2002 | 0.854 | 0.738 | 0.843 | 0.942 |
| 2003 | 0.765 | 0.709 | 0.826 | 0.958 |
| 2004 | 0.778 | 0.692 | 0.810 | 0.952 |
| 2005 | 0.826 | 0.728 | 0.899 | 1.106 |
| 2006 | 0.827 | 0.714 | 0.828 | 0.969 |

**Table A2.4.1**. Yield projections at $F_{current}$, $65\%F_{30\%SPR}$, $75\%F_{30\%SPR}$, $85\%F_{30\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$ for the Final model and three alternative management areas for the Atlantic king mackerel (deterministic run, in million lbs).

**Projections Final Model**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 9.277 | 9.277 | 9.277 | 9.277 | 9.277 | 9.277 |
| 2008 | 9.453 | 6.669 | 8.170 | 7.291 | 6.391 | 9.504 |
| 2009 | 9.248 | 6.956 | 8.236 | 7.498 | 6.706 | 9.288 |
| 2010 | 9.154 | 7.240 | 8.344 | 7.718 | 7.017 | 9.184 |
| 2011 | 9.132 | 7.522 | 8.477 | 7.943 | 7.319 | 9.156 |
| 2012 | 8.860 | 7.476 | 8.314 | 7.851 | 7.295 | 8.880 |
| 2013 | 8.788 | 7.549 | 8.309 | 7.893 | 7.379 | 8.805 |
| 2014 | 8.794 | 7.665 | 8.369 | 7.985 | 7.507 | 8.810 |
| 2015 | 8.737 | 7.672 | 8.338 | 7.979 | 7.520 | 8.750 |
| 2016 | 8.704 | 7.685 | 8.327 | 7.981 | 7.538 | 8.717 |

**Projections adjusted for Dade-Monroe management unit**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 10.264 | 10.264 | 10.264 | 10.264 | 10.264 | 10.264 |
| 2008 | 11.326 | 8.079 | 9.784 | 8.726 | 7.645 | 10.906 |
| 2009 | 11.205 | 8.493 | 9.965 | 9.062 | 8.096 | 10.843 |
| 2010 | 10.915 | 8.692 | 9.941 | 9.188 | 8.346 | 10.644 |
| 2011 | 10.548 | 8.743 | 9.791 | 9.172 | 8.447 | 10.363 |
| 2012 | 9.999 | 8.495 | 9.391 | 8.871 | 8.244 | 9.871 |
| 2013 | 9.738 | 8.421 | 9.220 | 8.762 | 8.194 | 9.642 |
| 2014 | 9.612 | 8.427 | 9.157 | 8.741 | 8.218 | 9.534 |
| 2015 | 9.501 | 8.392 | 9.079 | 8.692 | 8.195 | 9.432 |
| 2016 | 9.427 | 8.372 | 9.031 | 8.661 | 8.182 | 9.366 |

**Projections adjusted for Council boundary management unit**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 11.082 | 11.082 | 11.082 | 11.082 | 11.082 | 11.082 |
| 2008 | 12.312 | 8.791 | 10.636 | 9.486 | 8.310 | 11.813 |
| 2009 | 12.192 | 9.247 | 10.842 | 9.858 | 8.807 | 11.762 |
| 2010 | 11.861 | 9.450 | 10.802 | 9.983 | 9.068 | 11.539 |
| 2011 | 11.432 | 9.480 | 10.611 | 9.940 | 9.154 | 11.211 |
| 2012 | 10.815 | 9.194 | 10.158 | 9.596 | 8.917 | 10.663 |
| 2013 | 10.516 | 9.099 | 9.957 | 9.463 | 8.850 | 10.401 |
| 2014 | 10.367 | 9.093 | 9.877 | 9.429 | 8.865 | 10.273 |
| 2015 | 10.242 | 9.052 | 9.789 | 9.372 | 8.836 | 10.159 |
| 2016 | 10.159 | 9.027 | 9.734 | 9.335 | 8.819 | 10.085 |

**Projections status quo catch Mixing-winter all GOM unit**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 7.756 | 7.756 | 7.756 | 7.756 | 7.756 | 7.756 |
| 2008 | 8.710 | 6.149 | 7.535 | 6.729 | 5.902 | 8.071 |
| 2009 | 8.221 | 6.202 | 7.335 | 6.687 | 5.990 | 7.747 |
| 2010 | 7.981 | 6.340 | 7.291 | 6.757 | 6.153 | 7.619 |
| 2011 | 7.897 | 6.543 | 7.355 | 6.905 | 6.376 | 7.617 |
| 2012 | 7.502 | 6.347 | 7.050 | 6.665 | 6.199 | 7.271 |
| 2013 | 7.423 | 6.389 | 7.026 | 6.682 | 6.252 | 7.222 |
| 2014 | 7.405 | 6.466 | 7.055 | 6.737 | 6.338 | 7.229 |
| 2015 | 7.330 | 6.442 | 7.002 | 6.702 | 6.318 | 7.167 |
| 2016 | 7.293 | 6.444 | 6.982 | 6.695 | 6.325 | 7.139 |

**Table A2.4.2**. Yield projections at $F_{current}$, 65%$F_{30\%SPR}$, 75%$F_{30\%SPR}$, 85%$F_{30\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$ for the Final model and three alternative management areas for the Gulf king mackerel (deterministic run, in million lbs).

**Projections Final Model**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 11.810 | 11.810 | 11.810 | 11.810 | 11.810 | 11.810 |
| 2008 | 17.130 | 12.610 | 14.778 | 13.162 | 11.513 | 14.394 |
| 2009 | 17.491 | 13.543 | 15.496 | 14.050 | 12.513 | 15.157 |
| 2010 | 16.286 | 13.223 | 14.791 | 13.640 | 12.357 | 14.526 |
| 2011 | 14.240 | 12.046 | 13.215 | 12.366 | 11.369 | 13.023 |
| 2012 | 12.432 | 10.834 | 11.715 | 11.080 | 10.300 | 11.576 |
| 2013 | 11.277 | 10.018 | 10.732 | 10.221 | 9.568 | 10.622 |
| 2014 | 10.503 | 9.438 | 10.053 | 9.614 | 9.041 | 9.958 |
| 2015 | 10.148 | 9.200 | 9.755 | 9.361 | 8.834 | 9.672 |
| 2016 | 9.886 | 9.015 | 9.533 | 9.165 | 8.669 | 9.456 |

**Projections adjusted for Dade-Monroe management unit**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 10.823 | 10.823 | 10.823 | 10.823 | 10.823 | 10.823 |
| 2008 | 15.258 | 11.200 | 13.164 | 11.726 | 10.258 | 12.992 |
| 2009 | 15.535 | 12.006 | 13.768 | 12.486 | 11.124 | 13.602 |
| 2010 | 14.524 | 11.772 | 13.194 | 12.170 | 11.028 | 13.067 |
| 2011 | 12.823 | 10.826 | 11.900 | 11.137 | 10.242 | 11.816 |
| 2012 | 11.293 | 9.814 | 10.638 | 10.060 | 9.351 | 10.585 |
| 2013 | 10.326 | 9.145 | 9.822 | 9.351 | 8.753 | 9.785 |
| 2014 | 9.685 | 8.677 | 9.265 | 8.858 | 8.330 | 9.234 |
| 2015 | 9.384 | 8.480 | 9.014 | 8.647 | 8.159 | 8.990 |
| 2016 | 9.162 | 8.328 | 8.828 | 8.485 | 8.024 | 8.807 |

**Projections adjusted for Council boundary management unit**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 10.005 | 10.005 | 10.005 | 10.005 | 10.005 | 10.005 |
| 2008 | 14.271 | 10.488 | 12.312 | 10.967 | 9.594 | 12.085 |
| 2009 | 14.548 | 11.252 | 12.891 | 11.690 | 10.413 | 12.683 |
| 2010 | 13.578 | 11.013 | 12.333 | 11.375 | 10.307 | 12.172 |
| 2011 | 11.940 | 10.088 | 11.080 | 10.369 | 9.535 | 10.968 |
| 2012 | 10.477 | 9.115 | 9.871 | 9.335 | 8.678 | 9.794 |
| 2013 | 9.549 | 8.467 | 9.084 | 8.650 | 8.097 | 9.026 |
| 2014 | 8.930 | 8.010 | 8.545 | 8.171 | 7.683 | 8.495 |
| 2015 | 8.643 | 7.820 | 8.305 | 7.967 | 7.518 | 8.262 |
| 2016 | 8.431 | 7.673 | 8.126 | 7.811 | 7.387 | 8.088 |

**Projections status quo catch Mixing-winter all GOM unit**

| Year | F30%SPR | F40%SPR | F 85%SPR30 | F 75%SPR30 | F 65%SPR30 | Fcurrent |
|---|---|---|---|---|---|---|
| 2007 | 14.266 | 14.266 | 14.266 | 14.266 | 14.266 | 14.266 |
| 2008 | 25.155 | 18.371 | 21.663 | 19.286 | 16.868 | 17.167 |
| 2009 | 24.956 | 19.180 | 22.068 | 20.000 | 17.805 | 18.082 |
| 2010 | 22.862 | 18.481 | 20.754 | 19.143 | 17.346 | 17.577 |
| 2011 | 19.698 | 16.685 | 18.323 | 17.176 | 15.820 | 15.999 |
| 2012 | 16.837 | 14.775 | 15.946 | 15.135 | 14.118 | 14.257 |
| 2013 | 14.601 | 13.102 | 13.986 | 13.380 | 12.586 | 12.696 |
| 2014 | 12.897 | 11.693 | 12.416 | 11.925 | 11.263 | 11.354 |
| 2015 | 12.086 | 11.039 | 11.676 | 11.244 | 10.653 | 10.734 |
| 2016 | 11.548 | 10.591 | 11.177 | 10.781 | 10.232 | 10.307 |

## Annex 3

## Decision Tables Requested by the AW

The SEDAR-16 Review Workshop (RW) considered that portraying the statistical uncertainty associated with the "base case" VPA models of king mackerel would not sufficiently capture the level of overall uncertainty in the assessment. Thus, the RW requested that decision tables be prepared for several candidate ABC values (possible decisions), showing the probability that MFMT be exceeded (possible consequences), under the base case and two alternative models (possible states of nature) for each migratory unit. While the RW discussed that the projections upon which these tables are based should not go many years into the future, SERO has requested other projection results to 2016 (see Annex 2). For the sake of easing comparisons, the decision tables herein are extended to 2016.

**Table A3.1** shows the probability of overfishing by year for each constant catch projection (TAC: 6-14 million pounds for the Atlantic migratory unit; 8-18 million pounds for the Gulf migratory unit; see also worksheet “DecisionTables” in Attachment 1). For each stock unit, the probability of overfishing (Fyear > MFMT) was estimated as the number of bootstraps for which current fishing mortality (geometric mean for current and 2 prior years) was greater than $F_{30\%SPR}$ divided by the total number of bootstraps (1000 per stock unit). Projections of constant catch started in the 2008 fishing year (for 2007, Fcurrent was assumed, i.e. the same geometric mean fishing mortality estimated for 2004-2006). The columns represent three “states of nature" chosen by the review panel to represent the uncertainty in the stock assessment evaluation.

ANNEX 3

**Table A3.1**. Probability of overfishing by year for each constant catch projection (TAC: 6-14 million pounds ATL; 8-18 million pounds GLF). The columns represent three "states of nature" chosen by the review panel to represent the structural uncertainty in the stock assessment.

**Atlantic Stock Unit**

| Fyear | Cte Catch | Base Model | New Index | MLE Indices weighting |
|---|---|---|---|---|
| 2008 | 6.0 mlbs | 0.321 | 0 | 0 |
| | 7.0 mlbs | 0.412 | 0.001 | 0 |
| | 8.0 mlbs | 0.509 | 0.005 | 0 |
| | 8.5 mlbs | 0.556 | 0.007 | 0 |
| | 9.0 mlbs | 0.603 | 0.009 | 0 |
| | 9.5 mlbs | 0.64 | 0.014 | 0 |
| | 10.0 mlbs | 0.675 | 0.02 | 0 |
| | 10.5 mlbs | 0.699 | 0.027 | 0.001 |
| | 11.0 mlbs | 0.73 | 0.034 | 0.001 |
| | 11.5 mlbs | 0.766 | 0.045 | 0.002 |
| | 12.0 mlbs | 0.786 | 0.061 | 0.004 |
| | 12.5 mlbs | 0.813 | 0.08 | 0.004 |
| | 13.0 mlbs | 0.829 | 0.096 | 0.004 |
| | 14.0 mlbs | 0.866 | 0.138 | 0.012 |
| 2009 | 6.0 mlbs | 0.04 | 0 | 0 |
| | 7.0 mlbs | 0.144 | 0 | 0 |
| | 8.0 mlbs | 0.282 | 0.002 | 0 |
| | 8.5 mlbs | 0.349 | 0.006 | 0 |
| | 9.0 mlbs | 0.429 | 0.013 | 0.001 |
| | 9.5 mlbs | 0.501 | 0.019 | 0.002 |
| | 10.0 mlbs | 0.577 | 0.037 | 0.006 |
| | 10.5 mlbs | 0.644 | 0.059 | 0.011 |
| | 11.0 mlbs | 0.702 | 0.097 | 0.015 |
| | 11.5 mlbs | 0.762 | 0.152 | 0.027 |
| | 12.0 mlbs | 0.806 | 0.202 | 0.035 |
| | 12.5 mlbs | 0.85 | 0.261 | 0.051 |
| | 13.0 mlbs | 0.883 | 0.318 | 0.069 |
| | 14.0 mlbs | 0.922 | 0.473 | 0.148 |
| 2010 | 6.0 mlbs | 0.009 | 0 | 0 |
| | 7.0 mlbs | 0.059 | 0 | 0 |
| | 8.0 mlbs | 0.189 | 0.004 | 0 |
| | 8.5 mlbs | 0.274 | 0.012 | 0.001 |
| | 9.0 mlbs | 0.36 | 0.028 | 0.006 |
| | 9.5 mlbs | 0.453 | 0.051 | 0.009 |
| | 10.0 mlbs | 0.541 | 0.09 | 0.025 |
| | 10.5 mlbs | 0.633 | 0.16 | 0.045 |
| | 11.0 mlbs | 0.711 | 0.226 | 0.08 |
| | 11.5 mlbs | 0.778 | 0.313 | 0.129 |
| | 12.0 mlbs | 0.835 | 0.403 | 0.181 |
| | 12.5 mlbs | 0.881 | 0.491 | 0.251 |
| | 13.0 mlbs | 0.909 | 0.578 | 0.322 |
| | 14.0 mlbs | 0.956 | 0.735 | 0.458 |
| 2011 | 6.0 mlbs | 0.007 | 0 | 0 |
| | 7.0 mlbs | 0.044 | 0 | 0 |
| | 8.0 mlbs | 0.163 | 0.004 | 0 |

**Gulf of Mexico Stock Unit**

| Fyear | Cte Catch | Base Model** | MLE Indices weighting | Fishery Dependent Indices Only |
|---|---|---|---|---|
| 2008 | 8.0 mlbs | 0.009 | 0.957 | 0.999 |
| | 9.0 mlbs | 0.024 | 0.967 | 0.999 |
| | 9.5 mlbs | 0.032 | 0.971 | 0.999 |
| | 10.0 mlbs | 0.038 | 0.973 | 0.999 |
| | 10.5 mlbs | 0.049 | 0.98 | 0.999 |
| | 11.0 mlbs | 0.061 | 0.982 | 0.999 |
| | 11.5 mlbs | 0.077 | 0.988 | 0.999 |
| | 12.0 mlbs | 0.1 | 0.989 | 0.999 |
| | 12.5 mlbs | 0.119 | 0.989 | 0.999 |
| | 13.0 mlbs | 0.132 | 0.99 | 0.999 |
| | 13.5 mlbs | 0.154 | 0.991 | 0.999 |
| | 14.0 mlbs | 0.165 | 0.991 | 0.999 |
| | 15.0 mlbs | 0.205 | 0.995 | 0.999 |
| | 16.0 mlbs | 0.257 | 0.996 | 0.999 |
| 2009 | 8.0 mlbs | 0 | 0.29 | 0.999 |
| | 9.0 mlbs | 0 | 0.47 | 0.999 |
| | 9.5 mlbs | 0.001 | 0.543 | 0.999 |
| | 10.0 mlbs | 0.003 | 0.62 | 0.999 |
| | 10.5 mlbs | 0.008 | 0.676 | 0.999 |
| | 11.0 mlbs | 0.013 | 0.73 | 0.999 |
| | 11.5 mlbs | 0.017 | 0.763 | 0.999 |
| | 12.0 mlbs | 0.028 | 0.801 | 0.999 |
| | 12.5 mlbs | 0.036 | 0.829 | 0.999 |
| | 13.0 mlbs | 0.051 | 0.852 | 0.999 |
| | 13.5 mlbs | 0.076 | 0.869 | 0.999 |
| | 14.0 mlbs | 0.103 | 0.887 | 0.999 |
| | 15.0 mlbs | 0.163 | 0.913 | 0.999 |
| | 16.0 mlbs | 0.241 | 0.926 | 0.999 |
| 2010 | 8.0 mlbs | 0 | 0.118 | 0.996 |
| | 9.0 mlbs | 0 | 0.262 | 0.999 |
| | 9.5 mlbs | 0 | 0.356 | 0.999 |
| | 10.0 mlbs | 0.001 | 0.444 | 0.999 |
| | 10.5 mlbs | 0.006 | 0.508 | 0.999 |
| | 11.0 mlbs | 0.007 | 0.584 | 0.999 |
| | 11.5 mlbs | 0.017 | 0.633 | 0.999 |
| | 12.0 mlbs | 0.03 | 0.701 | 0.999 |
| | 12.5 mlbs | 0.044 | 0.744 | 0.999 |
| | 13.0 mlbs | 0.066 | 0.774 | 0.999 |
| | 13.5 mlbs | 0.097 | 0.812 | 0.999 |
| | 14.0 mlbs | 0.143 | 0.832 | 0.999 |
| | 15.0 mlbs | 0.241 | 0.871 | 0.999 |
| | 16.0 mlbs | 0.357 | 0.897 | 0.999 |
| 2011 | 8.0 mlbs | 0 | 0.113 | 0.996 |
| | 9.0 mlbs | 0 | 0.254 | 0.999 |
| | 9.5 mlbs | 0 | 0.338 | 0.999 |

ANNEX 3

| Fyear | Cte Catch | Base Model | New Index | MLE Indices weighting |
|---|---|---|---|---|
| | 8.5 mlbs | 0.255 | 0.016 | 0.002 |
| | 9.0 mlbs | 0.353 | 0.038 | 0.007 |
| | 9.5 mlbs | 0.444 | 0.071 | 0.018 |
| | 10.0 mlbs | 0.538 | 0.131 | 0.037 |
| | 10.5 mlbs | 0.636 | 0.194 | 0.076 |
| | 11.0 mlbs | 0.72 | 0.281 | 0.114 |
| | 11.5 mlbs | 0.786 | 0.377 | 0.191 |
| | 12.0 mlbs | 0.854 | 0.472 | 0.264 |
| | 12.5 mlbs | 0.893 | 0.558 | 0.327 |
| | 13.0 mlbs | 0.92 | 0.646 | 0.405 |
| | 14.0 mlbs | 0.963 | 0.799 | 0.541 |
| 2012 | 6.0 mlbs | 0.006 | 0 | 0 |
| | 7.0 mlbs | 0.028 | 0 | 0 |
| | 8.0 mlbs | 0.16 | 0.004 | 0.001 |
| | 8.5 mlbs | 0.251 | 0.015 | 0.003 |
| | 9.0 mlbs | 0.346 | 0.039 | 0.008 |
| | 9.5 mlbs | 0.444 | 0.093 | 0.025 |
| | 10.0 mlbs | 0.556 | 0.161 | 0.055 |
| | 10.5 mlbs | 0.66 | 0.236 | 0.095 |
| | 11.0 mlbs | 0.743 | 0.332 | 0.16 |
| | 11.5 mlbs | 0.815 | 0.435 | 0.244 |
| | 12.0 mlbs | 0.873 | 0.54 | 0.321 |
| | 12.5 mlbs | 0.913 | 0.619 | 0.4 |
| | 13.0 mlbs | 0.944 | 0.715 | 0.476 |
| | 14.0 mlbs | 0.974 | 0.857 | 0.623 |
| 2013 | 6.0 mlbs | 0.001 | 0 | 0 |
| | 7.0 mlbs | 0.023 | 0 | 0 |
| | 8.0 mlbs | 0.152 | 0.003 | 0.001 |
| | 8.5 mlbs | 0.241 | 0.016 | 0.002 |
| | 9.0 mlbs | 0.346 | 0.05 | 0.009 |
| | 9.5 mlbs | 0.447 | 0.107 | 0.032 |
| | 10.0 mlbs | 0.567 | 0.184 | 0.061 |
| | 10.5 mlbs | 0.705 | 0.277 | 0.108 |
| | 11.0 mlbs | 0.772 | 0.379 | 0.191 |
| | 11.5 mlbs | 0.84 | 0.493 | 0.282 |
| | 12.0 mlbs | 0.905 | 0.591 | 0.364 |
| | 12.5 mlbs | 0.936 | 0.69 | 0.467 |
| | 13.0 mlbs | 0.961 | 0.784 | 0.55 |
| | 14.0 mlbs | 0.986 | 0.9 | 0.689 |
| 2014 | 6.0 mlbs | 0.001 | 0 | 0 |
| | 7.0 mlbs | 0.018 | 0 | 0 |
| | 8.0 mlbs | 0.137 | 0.003 | 0.001 |
| | 8.5 mlbs | 0.238 | 0.016 | 0.002 |
| | 9.0 mlbs | 0.358 | 0.046 | 0.016 |
| | 9.5 mlbs | 0.47 | 0.114 | 0.029 |
| | 10.0 mlbs | 0.612 | 0.207 | 0.069 |
| | 10.5 mlbs | 0.726 | 0.32 | 0.12 |
| | 11.0 mlbs | 0.81 | 0.429 | 0.223 |
| | 11.5 mlbs | 0.874 | 0.543 | 0.316 |
| | 12.0 mlbs | 0.932 | 0.658 | 0.411 |
| | 12.5 mlbs | 0.957 | 0.751 | 0.512 |
| | 13.0 mlbs | 0.973 | 0.836 | 0.597 |

| Fyear | Cte Catch | Base Model** | MLE Indices weighting | Fishery Dependent Indices Only |
|---|---|---|---|---|
| | 10.0 mlbs | 0.002 | 0.42 | 0.999 |
| | 10.5 mlbs | 0.006 | 0.49 | 0.999 |
| | 11.0 mlbs | 0.009 | 0.566 | 0.999 |
| | 11.5 mlbs | 0.021 | 0.622 | 0.999 |
| | 12.0 mlbs | 0.032 | 0.685 | 0.999 |
| | 12.5 mlbs | 0.052 | 0.733 | 0.999 |
| | 13.0 mlbs | 0.085 | 0.766 | 0.999 |
| | 13.5 mlbs | 0.125 | 0.802 | 0.999 |
| | 14.0 mlbs | 0.186 | 0.825 | 0.999 |
| | 15.0 mlbs | 0.294 | 0.866 | 0.999 |
| | 16.0 mlbs | 0.425 | 0.887 | 0.999 |
| 2012 | 8.0 mlbs | 0 | 0.115 | 0.992 |
| | 9.0 mlbs | 0 | 0.29 | 0.999 |
| | 9.5 mlbs | 0.001 | 0.371 | 0.999 |
| | 10.0 mlbs | 0.003 | 0.458 | 0.999 |
| | 10.5 mlbs | 0.008 | 0.54 | 0.999 |
| | 11.0 mlbs | 0.016 | 0.615 | 0.999 |
| | 11.5 mlbs | 0.028 | 0.682 | 0.999 |
| | 12.0 mlbs | 0.053 | 0.737 | 0.999 |
| | 12.5 mlbs | 0.087 | 0.771 | 0.999 |
| | 13.0 mlbs | 0.138 | 0.817 | 0.999 |
| | 13.5 mlbs | 0.205 | 0.838 | 0.999 |
| | 14.0 mlbs | 0.265 | 0.866 | 0.999 |
| | 15.0 mlbs | 0.402 | 0.892 | 0.999 |
| | 16.0 mlbs | 0.548 | 0.918 | 0.999 |
| 2013 | 8.0 mlbs | 0 | 0.125 | 0.986 |
| | 9.0 mlbs | 0.001 | 0.325 | 0.997 |
| | 9.5 mlbs | 0.001 | 0.411 | 0.998 |
| | 10.0 mlbs | 0.006 | 0.508 | 0.999 |
| | 10.5 mlbs | 0.011 | 0.599 | 0.999 |
| | 11.0 mlbs | 0.025 | 0.688 | 0.999 |
| | 11.5 mlbs | 0.051 | 0.738 | 0.999 |
| | 12.0 mlbs | 0.095 | 0.785 | 0.999 |
| | 12.5 mlbs | 0.151 | 0.824 | 0.999 |
| | 13.0 mlbs | 0.22 | 0.858 | 0.999 |
| | 13.5 mlbs | 0.293 | 0.882 | 0.999 |
| | 14.0 mlbs | 0.363 | 0.894 | 0.999 |
| | 15.0 mlbs | 0.538 | 0.919 | 0.999 |
| | 16.0 mlbs | 0.672 | 0.934 | 0.999 |
| 2014 | 8.0 mlbs | 0 | 0.138 | 0.986 |
| | 9.0 mlbs | 0.001 | 0.365 | 0.996 |
| | 9.5 mlbs | 0.002 | 0.463 | 0.998 |
| | 10.0 mlbs | 0.009 | 0.564 | 0.999 |
| | 10.5 mlbs | 0.017 | 0.655 | 0.999 |
| | 11.0 mlbs | 0.048 | 0.736 | 0.999 |
| | 11.5 mlbs | 0.096 | 0.798 | 0.999 |
| | 12.0 mlbs | 0.155 | 0.833 | 0.999 |
| | 12.5 mlbs | 0.229 | 0.873 | 0.999 |
| | 13.0 mlbs | 0.313 | 0.893 | 0.999 |
| | 13.5 mlbs | 0.413 | 0.908 | 0.999 |
| | 14.0 mlbs | 0.514 | 0.921 | 0.999 |
| | 15.0 mlbs | 0.663 | 0.939 | 0.999 |

ANNEX 3

| Fyear | Cte Catch | Base Model | New Index | MLE Indices weighting |
|---|---|---|---|---|
| | 14.0 mlbs | 0.996 | 0.942 | 0.765 |
| 2015 | 6.0 mlbs | 0.001 | 0 | 0 |
| | 7.0 mlbs | 0.012 | 0 | 0 |
| | 8.0 mlbs | 0.118 | 0.003 | 0.001 |
| | 8.5 mlbs | 0.236 | 0.017 | 0.002 |
| | 9.0 mlbs | 0.366 | 0.044 | 0.016 |
| | 9.5 mlbs | 0.507 | 0.121 | 0.028 |
| | 10.0 mlbs | 0.628 | 0.218 | 0.061 |
| | 10.5 mlbs | 0.747 | 0.343 | 0.146 |
| | 11.0 mlbs | 0.839 | 0.463 | 0.232 |
| | 11.5 mlbs | 0.907 | 0.59 | 0.34 |
| | 12.0 mlbs | 0.95 | 0.699 | 0.45 |
| | 12.5 mlbs | 0.971 | 0.8 | 0.544 |
| | 13.0 mlbs | 0.987 | 0.869 | 0.665 |
| | 14.0 mlbs | 0.997 | 0.961 | 0.829 |
| 2016 | 6.0 mlbs | 0.001 | 0 | 0 |
| | 7.0 mlbs | 0.009 | 0 | 0 |
| | 8.0 mlbs | 0.103 | 0.003 | 0.001 |
| | 8.5 mlbs | 0.225 | 0.012 | 0.004 |
| | 9.0 mlbs | 0.369 | 0.044 | 0.016 |
| | 9.5 mlbs | 0.525 | 0.122 | 0.026 |
| | 10.0 mlbs | 0.66 | 0.224 | 0.074 |
| | 10.5 mlbs | 0.769 | 0.374 | 0.145 |
| | 11.0 mlbs | 0.869 | 0.503 | 0.25 |
| | 11.5 mlbs | 0.923 | 0.627 | 0.363 |
| | 12.0 mlbs | 0.957 | 0.736 | 0.486 |
| | 12.5 mlbs | 0.98 | 0.829 | 0.603 |
| | 13.0 mlbs | 0.992 | 0.9 | 0.719 |
| | 14.0 mlbs | 0.998 | 0.975 | 0.873 |

| Fyear | Cte Catch | Base Model** | MLE Indices weighting | Fishery Dependent Indices Only |
|---|---|---|---|---|
| | 16.0 mlbs | 0.772 | 0.949 | 0.999 |
| 2015 | 8.0 mlbs | 0 | 0.148 | 0.984 |
| | 9.0 mlbs | 0.001 | 0.383 | 0.996 |
| | 9.5 mlbs | 0.006 | 0.509 | 0.999 |
| | 10.0 mlbs | 0.014 | 0.611 | 0.999 |
| | 10.5 mlbs | 0.032 | 0.696 | 0.999 |
| | 11.0 mlbs | 0.079 | 0.784 | 0.999 |
| | 11.5 mlbs | 0.136 | 0.834 | 0.999 |
| | 12.0 mlbs | 0.22 | 0.865 | 0.999 |
| | 12.5 mlbs | 0.31 | 0.896 | 0.999 |
| | 13.0 mlbs | 0.413 | 0.909 | 0.999 |
| | 13.5 mlbs | 0.525 | 0.925 | 0.999 |
| | 14.0 mlbs | 0.613 | 0.936 | 0.999 |
| | 15.0 mlbs | 0.76 | 0.954 | 0.999 |
| | 16.0 mlbs | 0.858 | 0.959 | 0.999 |
| 2016 | 8.0 mlbs | 0 | 0.151 | 0.987 |
| | 9.0 mlbs | 0.002 | 0.416 | 0.998 |
| | 9.5 mlbs | 0.009 | 0.539 | 0.999 |
| | 10.0 mlbs | 0.022 | 0.65 | 0.999 |
| | 10.5 mlbs | 0.049 | 0.745 | 0.999 |
| | 11.0 mlbs | 0.114 | 0.821 | 0.999 |
| | 11.5 mlbs | 0.193 | 0.852 | 0.999 |
| | 12.0 mlbs | 0.281 | 0.892 | 0.999 |
| | 12.5 mlbs | 0.399 | 0.912 | 0.999 |
| | 13.0 mlbs | 0.517 | 0.931 | 0.999 |
| | 13.5 mlbs | 0.609 | 0.942 | 0.999 |
| | 14.0 mlbs | 0.707 | 0.95 | 0.999 |
| | 15.0 mlbs | 0.829 | 0.962 | 0.999 |
| | 16.0 mlbs | 0.916 | 0.968 | 0.999 |