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Working Paper: Scup
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Scup
Text, Tables and Figures

By
Mark Terceiro

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Data Poor Stocks Working Group: Scup

Term of Reference

The following components of the Terms of Reference for the Data Poor Stocks Working Group are relevant for scup:

1. Constitute and convene a Working Group comprising NEFSC assessment scientists, and staff from NERO, NEFMC, MAFMC, and ASMFC to:

   a. Recommend biological reference points (BRPs) and measurable BRP and maximum sustainable yield (MSY) proxies for Scup.
   b. Provide advice about scientific uncertainty and risk for Scientific and Statistical Committees (SSCs) to consider when they develop allowable biological catches (ABCs) for these stocks.
   c. Comment on what can be done to improve the information, proxies or assessments for each species.

Introduction

Scup (*Stenotomus chrysops*) is a schooling, continental shelf species of the Northwest Atlantic that is distributed primarily between Cape Cod and Cape Hatteras (Morse 1978). Scup undertake extensive migrations between coastal waters in summer and offshore waters in winter. Scup migrate north and inshore to spawn in spring, with larger scup (age 2 and older) tending to arrive in spring first, followed by smaller scup (Neville and Talbot 1964; Sisson 1974). Larger scup are found during the summer near the mouth of larger bays and in the ocean within 20-fathoms, and often inhabit rough bottom areas. Smaller scup are more likely to be found in shallow, smooth bottom areas of bays during summer (Morse 1978). Scup migrate south and offshore in autumn as the water temperature decreases, arriving in offshore wintering areas by December (Hamer 1970; Morse 1978). Spawning occurs from May through August and peaks in June. About 50% of age-2 scup are sexually mature (about 17 cm total length; Morse 1978), while nearly all scup of age 3 and older are mature. Scup reach a maximum fork length of at least 41 cm and a maximum age of at least 14 years, with a likely maximum of 20 years (Dery and Rearden 1979). Tagging studies (e.g., Neville and Talbot 1964; Cogswell 1960, 1961; Hamer 1970, 1979) have indicated the possibility of two stocks of scup, one in Southern New England waters and another extending south from New Jersey waters. However, the lack of definitive locations for tag return data coupled with distributional data from the NEFSC bottom trawl surveys support the concept of a single unit stock extending from Cape Hatteras north to New England (Mayo 1982).

Section 1. Overfished and Overfishing Definitions

The Mid-Atlantic Fishery Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC) manage scup under Amendment 8 (1997) to the Summer Flounder, Scup, and Black Sea Bass (SFSCBSB) Fishery Management Plan (FMP). The FMP management unit includes all scup from Cape Hatteras, NC northward to the US-Canada border.

Amendment 8 also established a recovery plan for scup under which exploitation rates were to be reduced to 47% (F=0.72) during 1997-1999, to 33% (F=0.45) during 2000-2001, and to 21% (F=0.26) during 2002-2007. These goals were to be attained through implementation of a Total Allowable Catch (TAC) that included a commercial quota and recreational harvest limit, and other regulations including commercial fishery minimum net mesh, trap vent and fish sizes, closed areas, and recreational fishery minimum fish sizes, possession limits, and open seasons.

Amendment 12 (1998) to the FMP established a biomass threshold (a proxy for one-half BMSY) for scup based on the three-year moving average of the NEFSC spring bottom trawl survey index of Spawning Stock Biomass (SSB) during 1977-1979, which was perceived to be a period when the stock was near one-half BMSY (2.77 SSB kg per tow). The scup stock is overfished when the spawning stock biomass index falls below this value. Amendment 12 defined overfishing for scup to occur when the fishing mortality rate exceeds the threshold fishing mortality of Fmax = 0.26 (proxy for FMSY).

Broad scale Gear Restricted Areas (GRAs) for scup were implemented in November 2000 under the framework provisions of the FMP as to reduce discards of scup in small mesh fisheries for *Loligo* squid and silver hake. The regulations restricted the use of small mesh trawl gear in areas with high concentrations of small scup during the late fall and winter month. Two Northern Areas off Long Island were implemented for November through January, while a Southern Area of the mid-Atlantic coast was implemented for January through April. The size and boundaries of the GRAs were modified in late 2000 and again in 2005 in response to commercial fishing industry recommendations.

Amendment 14 (July 2007) to the FMP defined the biomass target and implemented a stock rebuilding plan for scup. The stock must be fully rebuild to the biomass target by January 1, 2015. The proxy for BMSY is two times the 3-year moving average of the NEFSC spring index of SSB during 1977-1979, or 2*2.77 = 5.54 SSB kg per tow. A constant fishing mortality rate (F) of 0.10 (9% exploitation rate) is to be applied in each year of a 7 year rebuilding period; 2008 was year 1 of rebuilding and F=0.10 was applied as the target F. Total Allowable Catch (TAC) of 4,491 mt (9.90 million lbs) and corresponding Total Allowable Landings (TAL) of 3,329 mt (7.34 million lbs) were established for 2008 to achieve the target F.

The current overfished and overfishing definitions are based on revisions to the SFSCBSB FMP through Framework 7 (October 2007), currently use the values established in Amendments 12 (1998) and 14 (July 2007), and are as follows:

"The maximum fishing mortality threshold for each of the species under the FMP is defined as FMSY (or a reasonable proxy thereof) as a function of productive capacity, and based upon the best scientific information consistent with National Standards 1 and 2. Specifically, FMSY is the fishing mortality rate associated with MSY. The maximum fishing mortality threshold (FMSY) or a reasonable proxy may be defined as a function of (but not limited to): total stock biomass, spawning stock biomass, total egg production, and may include males, females, both, or combinations and ratios thereof which provide the best measure of productive capacity for each of the species managed under the FMP. Exceeding the established fishing mortality threshold constitutes overfishing as defined by the Magnuson-Stevens Act."

"The minimum stock size threshold for each of the species under the FMP is defined as one-half BMSY (or a reasonable proxy thereof) as a function of productive capacity, and based upon the best scientific information consistent with National Standards 1 and 2. The minimum stock size threshold (one-half BMSY) or a reasonable proxy may be defined as a function of (but not limited to): total stock biomass, spawning stock biomass, total egg production, and may include males, females, both, or combinations and ratios thereof which provide the best measure of productive capacity for each of the species managed under the FMP. The minimum stock size threshold is the level of productive capacity associated with the relevant one-half MSY level. Should the measure of productive capacity for the stock or stock complex fall below this minimum threshold, the stock or stock complex is considered overfished. The target for rebuilding is specified as BMSY (or reasonable proxy thereof) at the level of productive capacity associated with the relevant MSY level, under the same definition of productive capacity as specified for the minimum stock size threshold."

Section 2. Current Biological Reference Points

The current Biological Reference Points for scup are defined as follows in SFSCBSB FMP Amendment 12:

"Overfishing for scup is defined to occur when the fishing mortality rate exceeds the threshold fishing mortality rate of FMSY. Because FMSY cannot be reliably estimated, Fmax is used as a proxy for FMSY. Fmax is 0.26 under current stock conditions. The maximum value of the spring survey index based on a three year moving average (2.77 kg/tow), would serve as a biomass threshold. BMSY cannot be reliably estimated for scup."

The original definition under Amendment 12 did not explicitly provide the time frame for the biomass threshold calculation. However, the specifics of the definition were provided in the discussion of the National Standards in another section of Amendment 12 as follows:

"... 3-year moving average of the NEFSC spring survey catch per tow of spawning stock biomass (1977-1979 average = 2.77 kg/tow)."

Amendment 14 to the SFSCBSB FMP defined a proxy for BMSY for scup as follows: "The current minimum biomass threshold is the NEFSC spring SSB 3-year index value (1977-1979) of 2.77 kg/tow. Assuming the minimum biomass threshold is a proxy for ½ BMSY, doubling that index value would be a proxy for BMSY. Specifically, NEFSC spring 3-year index value of 5.54 kg/tow would be a proxy for BMSY. "

Section 3: Background and Justification for Current Biological Reference Points

The last peer-reviewed assessment to include an analytical model was accepted in 1995 by SAW 19 (NEFSC 1995). The assessment featured a Virtual Population Analysis (VPA) modeled in the ADAPT framework (Conser and Powers 1990), included commercial and recreational landings and discards at age estimates, and used state and NEFSC abundance indices for calibration. The 1995 SAW 19 assessment indicated that the instantaneous fishing mortality rate (F) in 1993 was 1.3, and spawning stock biomass was 4,600 mt. A yield per recruit (YPR) analysis indicated that Fmax = 0.236.

The VPA was updated through 1996 and reviewed by SAW 25 (NEFSC 1997), but due to concerns over the low intensity of fishery sampling in the 1990s, uncertainty about the magnitude of commercial discards in the late 1990s, and the ongoing variability of survey indices, the VPA was not accepted as a basis for management decisions. Assessment conclusions were therefore based primarily on trends in NEFSC and state agency survey indices and catch curve analyses using those survey data. The 1997 SAW 25 was able to conclude that in 1996 scup were “over-exploited and near record low abundance levels.”

The scup assessment was next updated through 1997 and reviewed by SAW 27 (NEFSC 1998). Several configurations of a surplus production model (ASPIC; Prager 1994) were reviewed in addition to an updated VPA, but like the VPA, the ASPIC model results were not accepted due to concerns over the validity of the input fishery and survey data. An updated YPR analysis was accepted and indicated that $F_{max} = 0.26$. SAW 27 concluded that “A VPA or other analytical model formulation for scup will not be feasible until the quality of the input data, particularly the precision of discard estimates, is significantly improved.” The 1998 SAW 27 also concluded the scup was “over exploited and at a low biomass level.”

The 1998 SAW27 Panel recommended the scup assessment be based on the long-term time series of NEFSC trawl survey indices and fishery catches. The Panel noted that commercial landings were sustained near 19,000 mt annually during the mid-1950s to mid-1960s, and concluded that the stock was likely near BMSY during that period (Figure 1). The nearest subsequent peak in NEFSC survey indices occurred in the late 1970s. Commercial and total fishery catches in the late 1970s were about one-half of those in the 1950s to 1960s, and so the late 1970s were identified as a period when the stock was likely to be near one-half of BMSY (Figures 1 & 2). The Panel considered the NEFSC spring survey series to be most representative of spawning stock biomass, since older ages were better represented in the age structure than in the NEFSC fall survey or other state agency surveys. The 1998 SAW27 Panel recommended that the three-year moving average of the NEFSC spring bottom trawl survey index of Spawning Stock Biomass (SSB) during 1977-1979 (2.77 SSB kg per tow) be used as the proxy biomass threshold (one-half BMSY) and that Fmax = 0.26 be used as the proxy fishing mortality threshold (FMSY). Those recommendations were subsequently adopted for the BRPs in FMP Amendment 12.

The scup assessment was next updated through 1999 and reviewed by SAW 31 (NEFSC 2000). The assessment continued to be based on trends in research survey indices and fishery catches and indicated that the stock was “overfished” (the current survey index was much less than index based biomass threshold specified in FMP Amendment 12) and that “overfishing” was occurring (catch curve analyses indicated that F exceeded 1.0, much greater than the FMP Amendment 12 threshold of Fmax = 0.26).

The most recent peer-reviewed assessment of scup included fishery data through 2001 and was reviewed by SAW 35 (NEFSC 2002). The assessment was again based on trends in research survey indices and fishery catches, but indicated that the stock was no longer “overfished” (the NEFSC spring SSB index was above the biomass threshold specified in FMP Amendment 12), although the SAW 35 Panel concluded that “stock status with respect to the overfishing definition cannot currently be evaluated,” due to the uncertainty of F estimates derived from research survey catch curve calculations. The 2002 SAW 35 Panel found sufficient evidence to conclude that “The relative exploitation rates have declined in recent years...” and that "Survey observations indicated strong recruitment and some rebuilding of age structure."

Since 2002, the status of the stock has been monitored by the MAFMC Monitoring Committee using trends in research survey indices and fishery catches. A Relative Exploitation Index (REI) based on the annual total fishery landings and the NEFSC spring three-year average SSB index has been used as a proxy for F to monitor status with respect to overfishing and provide guidance to the specification of annual TACs. A projection of the NEFSC spring survey SSB index using assumptions about maturity, partial recruitment to the survey, and the level of future recruitment as indexed by the NEFSC spring survey at age 1 was used in FMP Amendment 14 to forecast stock rebuilding and set the Frebuild target for 2008-2105.

An update to the status monitoring metrics was completed in July 2008 to aid in the specification of fishery regulations for 2009. The update indicated that while the stock was overfished in 2007 (NEFSC spring SSB three-year average index = 1.16 kg per tow, 21% of the biomass target of 5.54 kg per tow), the exploitation rate was at about the rebuilding target rate (9%, or about F = 0.10), suggesting that overfishing was not occurring in 2007. However, the stock rebuilding rate was slower than indicated by the Amendment 14 projection, with the NEFSC spring 2007 SSB index (three-year average = 1.16 kg per tow) at only 56% of the forecast 2007 index (2.08 kg per tow).

Section 4: Need for Revision of the Current Biological Reference Points

The current stock biomass reference point relies on the index of SSB from the NEFSC spring trawl survey. Previous reviews of the scup stock assessment have indicated that while this index may be the most reliable fishery independent metric of scup SSB, it is subject to a relatively high degree of inter-annual variability and the possibility that positive and negative "availability" events will reduce the utility of the index to monitor the status of the stock for any given year, in spite of the three-year smoothing protocol (Figure 2). An example of this phenomenon took place in 2002, when an unusually high value of the NEFSC spring SSB index was recorded that did not seem to result from high abundance in 2001, nor translate into a correspondingly high value in 2003. Subsequent reviews concluded that the high 2002 index resulted mainly from increased availability of fish to the survey, rather than due to a true increase in abundance of the recorded magnitude. However, the high 2002 index lead to a change in official stock status to "not overfished" when incorporated into the three-year average SSB index calculation, and then a change back to "overfished" when the 2002 index passed out of the three-year average in 2005 (Figure 2), with accompanying volatility in the annual specification of fishery regulations.

The last four peer reviews of the assessment have rejected analytical assessment models for scup, and indicated that the estimates of F based on research survey catch curve analyses are likewise not valid. The Relative Exploitation Index (REI; total fishery landings divided by the NEFSC spring three-year SSB index) used as a proxy for F is also volatile and potentially unreliable if inter-annual changes in the SSB index are suspected to be biologically unrealistic. Finally, the NEFSC survey series using NOAA Ship *Albatross IV* sampling, on which the stock status monitoring is based, ends in fall 2008. While efforts are underway to calibrate the *Albatross IV* indices to new indices collected by the NOAA Ship *Henry B. Bigelow*, those efforts may not provide a reliable basis for stock monitoring in the short term. Managers, scientists, and other stakeholders have therefore indicated a desire for a more reliable way to monitor the status of the scup stock and inform the annual specification of fishery regulations.

Section 5: Proposed Biological Reference Points

The following section details the sequence of work that was performed in the series of Data Poor Stocks Working Group meetings during the fall of 2008 to develop the recommended final analytical model that is the basis for the proposed BRPs. The section details the two analytical modeling approaches for scup that were pursued. The first was a relatively simple approach, the AIM model, which fits relationships between single survey indices and catch times series. The second was a complex forward projecting age structured model incorporating many data components, ASAP. Because the final model requires the use of significantly more complex input fishery and research survey data than the current BRPs, a description of those data precedes the model descriptions.

Commercial Landings

US commercial landings averaged over 18,000 mt per year from 1950 to 1965 (peaking at over 22,000 mt in 1960) and declined to less than 10,000 mt per year in the late 1960s. Landings fluctuated between about 5,000 and 10,000 mt from 1970 to the early 1990s and then declined to about 1,200 mt in 2000, less than 6% of the peak observed in 1960. Commercial landings have since increased to average about 4,200 mt during 2003-2007 (Figure 1).

About eighty percent of the commercial landings of scup for the period 1979-2007 were in Rhode Island (38%), New Jersey (26%), and New York (16%; Table 1). The otter trawl is the principal commercial fishing gear, accounting for about 75% of the total catch during 1979-2007 (Table 2). The remainder of the commercial landings is taken by floating trap (11%) and hand lines (7%), with paired trawl, pound nets, and pots and traps each contributing between 1 and 4%.

Commercial Discards

The NEFSC Observer Program has collected information on landings and discards in the commercial fishery for 1989-2007. Northeast Region (ME-VA) discard estimates were raised to account for North Carolina landings. A discard mortality rate of 100% was assumed because there are no published estimates of scup discard mortality rates. This assumption is based on limited observations and is a point of contention between scientists and fishermen. Past SAW panels have recommended that research be conducted to better characterize the discard mortality rate of scup in different gear types in order to more accurately quantify the absolute magnitude of scup discard mortality (NEFSC 1995, 1997, 1998, 2000, 2002; see also Section 7 of this report “Research Recommendations”).

Quantifying discards from the commercial fishery is necessary for a reliable scup assessment, but low sample sizes in the past have resulted in uncertain estimates. Concern regarding the uncertainty of discard estimates due to inadequate observer sampling has been expressed in at least five previous SAW reviews of the scup assessment, and those reviews have recommended increases in sampling intensity to increase the accuracy and precision of discard estimates (NEFSC 1995, 1997, 1998, 2000, 2002). Despite the uncertainty of the discard data, recent SAW panels have concluded that commercial discarding of scup has been high during most of the last 20 years, generally approaching or exceeding landings (i.e., about 50% or more of the total commercial catch). Since the implementation of GRAs in 2000, estimated discards as a proportion of the total commercial catch have decreased, averaging about 35%.

Given the uncertainty associated with estimating commercial discards for scup, three different methods for calculating discard estimates have been considered in assessments since 1998:

1) Geometric Mean Discards-to-Landings Ratio (GMDL): Ratios of discards to landings by landings level (for trip landings < 300 kg (661 lbs), the "bycatch fishery"; or => 300 kg, the "directed fishery") and half year were calculated and multiplied by corresponding observed landings from the NEFSC Dealer Report database to provide estimates of discards. Geometric mean rates (re-transformed, uncorrected, mean ln-transformed Discards to Landings [D/L] per trip) were used because the distributions of landings and discards and the ratio of discards to landings on a per-trip basis in the scup fishery are highly variable and positively skewed. Observed trips with both scup landings and discard were used to calculate the per trip discard to landings ratios. Only trips with both non-zero landings and discards could be used for this approach to avoid division by zero. The number of trawl gear trips used to calculate geometric mean discard-to-landings ratios (GMDL) by half year for 1997-2007 ranged from 1 to 104 for trips < 300 kg and from 1 to 35 for trips =>300 kg, with the best sampling occurring since 2003. No trawl gear trips were available for half year two in 1997 and 1999 for trips < 300 kg and for half year two in 1997-2001 for trips => 300 kg. The GMDL calculated for half year one was used to estimate discards for half year two when no trawl gear trips were available in half year two. The GMDL ratios ranged from 0.03 in 2004 (half year two, trips => 300 kg) to 121.71 in 1998 (half year one, trips => 300 kg; Table 3).

The large 1998 "directed fishery" discard ratio and subsequent very high annual discard estimate (111,973 mt) was based on one trawl gear trip. About 93% of the discard from that trip was attributable to a single tow in which an estimated 68.2 mt (150,000 lbs.) of scup were captured. This tow was not lifted from the water and the captain of the vessel estimated the weight of the catch. There has been debate concerning the validity of the catch weight estimate and whether or not it was representative of other vessels or trips in the fishery. However, the observation was reported by a trained NEFSC observer and was therefore included in the initial calculation of the GMDL estimate of scup discards (Tables 3-4).

2) Aggregate Discards-to-Landings Ratio (AGDL): The second approach for estimating discards considered aggregate discards to landings ratios (summed D/summed L for all trips catching scup in stratum). As in the GMDL method, trips are stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). The number of trawl gear trips used to calculate AGDL by half year for 1997-2007 ranged from 14 to 254 for trips < 300 kg and from 1 to 35 for trips => 300 kg, with the best sampling occurring since 2003. There are more trips available for the AGDL calculation for trips < 300 kg than in the GMDL approach, since trips with zero landings can be used. The lowest AGDL ratio calculated was 0.00 in 2001 (no discard observed in 4 trips, half year two, trips => 300 kg). The largest AGDL was 121.71 in 1998 (half year one, trips => 300 kg) B the same as that calculated in the GMDL method. The AGDL approach generally provides higher annual estimates of scup discards, with greater inter-annual variability, than the GMDL approach.

3) Mean Differences between Landings and Discards (DELTA): Mean differences (kg) between landings and discard (D = landings - discard, per trip) were also calculated using the

same strata as the previous methods: stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). Observed trips in the stratum were used to calculate the mean difference in stratum, which was then applied to the scup landings of trips in the NEFSC Dealer Report database to calculate a discard for each trip (discard = landings -(D)). Calculating differences allows use of trips that had discards but no landings, whereas D/L ratios cannot be calculated in these situations (i.e. zero in the denominator). When discards exceed landings, the difference (D value) is negative. As the magnitude of discards is of primary interest, the absolute values are used. The number of trawl gear trips used in the DELTA method calculations ranged from 6 to 254 for trips < 300 kg and from 1 to 35 for trips => 300 kg, with the best sampling occurring since 2003. The magnitude of the DELTA values ranged from 10.7 in 2001 (half year two, trips < 300 kg) to 72707 in 1998 (half year one, trips => 300 kg). As before, this large discard estimate is the result of one large discarding event in the "directed fishery" that was discussed above. The DELTA approach generally provides lower estimates of scup discards for the "directed fishery " but slightly higher estimates for the "bycatch fishery" compared to the GMDL approach.

Since 2002 the Method 1 discard estimates (the GMDL approach) have been adopted by the MAFMC Monitoring Committee to monitor trends in fishery catch and evaluate the status of the stock, since the year-to-year trends among the different approaches differed in magnitude but followed similar trends. The large discard event in 1998 affected calculations from each method, resulting in extremely high D/L rates and subsequent discard estimates in 1998 for each approach. The DELTA method yielded estimates that were fairly consistent with the GMDL rates, while the AGDL estimates exhibited generally higher discard estimates with more variability. Previous SAW Working Groups and review panels have expressed most confidence in the estimates produced using the GMDL approach and considered the estimates to be supported by the DELTA rates. The GMDL estimates were used for all subsequent modeling approaches considered in the assessment. The 1998 estimates from all 3 computational methods was considered infeasible, and replaced by the mean of the 1997 and 1999 GMDL estimates (3,331 mt) in subsequent tabulations of catch and in subsequent modeling (Tables 3-5 & 9).

Recreational Catch

Scup is an important recreational species, with the greatest proportion of catches taken in the states of Massachusetts, Rhode Island, Connecticut and New York. Estimates of the recreational catch in numbers were obtained from the NMFS Marine Recreational Fishery Statistics Survey (MRFSS) for 1981-2007. These estimates were available for three categories: type A - fish landed and available for sampling, type B1 - fish landed but not available for sampling, and type B2 - fish caught and released. The estimated recreational landings (types A and B1) in weight during 1981-2007 averaged about 2,000 mt per year (Table 5). Since 1981, the MRFSS data indicate that the recreational landings have comprised 29% of the commercial and recreational landings total.

The estimated recreational discard in weight during 1984-2007 ranged from 6 mt in 1999 to a high of 393 mt in 2006, while averaging about 90 mt per year (Table 5). The weight of discards has been directly calculated only for those years (1984 and later) for which recreational catch at age has been compiled. In compilations of total fishery catch for earlier years, the recreational discards was assumed to be approximately 2% of the estimated recreational landings, based on the mean discard percentage for 1984-1996 (directly calculated discard weights for years prior to implementation of FMP regulations). No length frequency samples of the scup discard were collected under the MRFSS program before 2005, so recreational discards were assumed to be fish aged 0 and 1, in the same relative proportions and with the same mean weight as the landed catch less than state regulated minimum fish sizes. An inspection of discard length frequency samples from the New York recreational fishery for 1989-1991 indicated that this assumption was reasonable. Since 2005, length samples of the recreational fishery discard have been collected in the MRFSS For Hire Survey sampling. The mortality rate due to discarding in the recreational fishery has been reported to range from 0-15% (Howell and Simpson 1985) and from 0-13.8% (Williams, pers. comm.). Howell and Simpson (1985) found mortality rates were positively correlated with size, due mainly to the tendency for larger fish to take the hook deep in the esophagus or gills. Williams more clearly demonstrated increased mortality with depth of hook location, as well as handling time, but found no association with fish size. Based on these studies, a discard mortality rate in the recreational fishery of between 5% and 15% appears reasonable and has been used in previous and the current assessments.

Commercial Fishery Landings at Length and Age

The intensity of NER commercial fishery biological sampling is summarized in Table 6. Annual sampling intensity varied from 32 to 687 mt per 100 lengths, with sampling exceeding the informal threshold criterion of 200 mt per 100 lengths sampled since 1994. For this assessment, commercial fishery landings at age beginning in 1984 have been updated through 2007, with samples generally pooled by market category (pins/small, medium, large/mix, jumbo, and unclassified) by half-year (Jan-Jun, Jul-Dec), with market category samples pooled on a quarterly basis for 2004-2007. Estimates of commercial fishery landings at age (Figure 3) and mean weights at age are presented in Tables 7-8.

Commercial Fishery Discards at Length and Age

The intensity of length frequency sampling of discarded scup from the NEFSC Observer Program sampling declined in 1992-1995 relative to 1989-1991 (Table 9). Sampling intensity ranged from 489 to 335 mt per 100 lengths sampled in 1992-1995, failing to meet the informal criterion of 200 mt per100 lengths sampled. Sampling intensity improved to 100 mt per 100 lengths in 1996, but then declined to over 200 mt per100 lengths in 1997-1999. Sampling intensity has generally met the 200 mt per 100 length threshold since 1999. Mean weight of the discard was estimated from length frequency data and a length-weight equation, total numbers discarded were then estimated by dividing total weight by mean weight, and numbers at length were then calculated from the length-frequency distribution. Discards at length were aged using a combination of commercial and survey age-length keys, with discards at age dominated by fish aged 0, 1, or 2, depending on the year under consideration. Estimates of commercial fishery discards at age (Figure 4) and mean weights at age are presented in Tables 10-11.

Recreational Fishery Landings at Length and Age

In the recreational fishery, landings sampling intensity varied from 45 to 471 mt per 100 lengths. Sampling in all years except one (1984) during 1981-1987 failed to satisfy the above criterion, but since 1987 the criterion has been met except for 1999-2000 (Table 12). Numbers at length for recreational landings were determined based on available recreational fishery length frequency samples pooled by half years over all regions and fishing modes, and were converted to numbers at age by applying half year age-length keys constructed from NEFSC commercial and survey samples. Age-length keys from spring surveys and first and second quarter commercial samples were applied to numbers at length from the first half of the year, while age-length keys from fall surveys and third and fourth quarter commercial samples were applied to numbers at length from the second half of the year. Estimates of recreational fishery landings at age (Figure 5) and mean weights at age are presented in Tables 13-14.

Recreational Fishery Discards at Length and Age

As noted earlier, no length frequency distribution data on scup discard are routinely collected under the MRFSS program prior to 2005, so recreational discards were assumed to be fish less than state minimum sizes, in the same relative proportions at length as the landed catch less than the respective state minimum sizes (i.e., sub-legal fish). This assumption for the coastwide fishery is supported by discard length frequency samples from the New York recreational fishery (1989-1991) and samples collected since 2005 by the MRFSS For Hire Survey. Since 2005, the MRFSS For Hire Survey discard samples have been used in concert with the MRFSS sub-legal landed lengths to characterize the length frequency of the recreational discard. As noted earlier, a 15% discard mortality rate is assumed. Estimates of recreational fishery discards at age (Figure 6) and mean weights at age are presented in Tables 15-16.

Total Fishery Catch

Estimates of the total fishery catch at age and mean weights at age for 1984-2004 (the time series is limited by the availability of sampled fishery ages) are presented in Tables 17-18.

An extended time series of estimated total catch of scup has been estimated to provide an historical perspective of the exploitation of scup in the years before fishery aging data were available (Table 19). These estimates include commercial and recreational landings and discards. The catches before 1981 are the least reliable due to uncertainty about a) the level of domestic commercial fishery discards, b) distant water fleet (DWF) catch, and c) assumptions to estimate the recreational catch (50% reduction from interpolations made in Mayo 1982 for 1960-1978; recreational discards assumed to be 2% of the adjusted recreational landings). For years in which no observer data were collected (prior to 1989), commercial discards were estimated using the mean of Method 1 GMDL ratios for 1989-2001.

Research Vessel Survey Indices

NEFSC

The NEFSC spring and fall surveys provide long time series of fishery-independent indices for scup. The NEFSC spring and fall surveys are conducted annually during March-May and September-November, ranging from just south of Cape Hatteras, NC to Canadian waters. NEFSC spring and fall abundance and biomass indices for scup exhibit considerable inter-annual variability (Table 20). The 2002 spring SSB index (9.24 kg/tow) was about twice the second highest spring SSB index, which was observed in 1977 (4.35 kg/tow)(Figure 7). The spring numeric abundance indices are similar; in 2002, the estimated index of spring abundance is the highest observed in the series (154.86 number/tow) and about twice the 1970 index (78.50

number/tow). These dramatic increases were evident across all ages in the estimated 2002 spring numbers at age (Table 21; Figure 8). Fall survey estimates of numbers at age in 2001 did not reflect relatively large values from which corresponding 2002 spring numbers at age might be expected to derive (Table 22, Figure 9) , nor did they translate to exceptional indices of biomass or SSB in fall 2002 or spring 2003. Spring survey SSB and abundance indices decreased subsequent to 2002, but are still above the low values of the late 1990s. Fall survey abundance and biomass have been highly variable since 2002.

The NEFSC winter survey was started in 1992 primarily as a flatfish survey (used a different trawl net than the spring and fall surveys), was conducted during February, and ranged from Cape Hatteras, NC to the southwestern part of Georges Bank. The winter survey 2002 abundance and biomass indices were, like the spring survey, the largest of the time series (Table 23). Similar to the spring estimates, numbers at age estimated for the 2002 winter survey were also exceptionally large (Table 24, Figure 10). Winter survey abundance and biomass decreased subsequent to 2002, but were still above the low values of the late 1990s. The winter trawl series ended in 2007.

As noted in Sections 1-4, indices of scup SSB per tow were developed from the NEFSC spring offshore strata series for use as proxy biomass reference points. The 1998 SAW 27 panel (NEFSC 1998) selected a three-year moving average of the NEFSC spring SSB index as a representative measure of scup SSB, based on the characteristics of the survey age structure, the magnitude of the survey catch, and the trend in the extended series of commercial and total fishery catch estimated back to 1960 (Table 19, Figures 1-2). FMP Amendment 12 defined the biomass threshold reference point as the maximum (at the time) observed value of this three-year moving average: the 1978 value (mean of 1977-1979) of 2.77 SSB kg/tow (Table 20, Figure 2). FMP Amendment 14 defined the target biomass BRP as twice the threshold value of this three-year moving average, or 2 times 2.77 = 5.54 SSB kg/tow.

Massachusetts DMF

The Massachusetts Division of Marine Fisheries (MADMF) has conducted a semi-annual bottom trawl survey of Massachusetts territorial waters in May and September since 1978. Survey coverage extends from the New Hampshire to Rhode Island boundaries and seaward to three nautical miles including Cape Cod Bay and Nantucket Sound. The study area is stratified into geographic zones based on depth and area. Trawl stations are allocated in proportion to stratum area and are chosen randomly within each stratum. A 20 minute tow at 2.5 knots is made at each station with a 3/4-size North Atlantic two- seam otter trawl (11.9 m headrope, 15.5 m footrope) rigged with a 19.2 m chain sweep with 7.6 cm rubber discs. The net contains a 6.4 mm mesh codend liner to retain small fish. Approximately 95 stations are sampled during each survey. Standard bottom trawl survey techniques are used to process the catch of each species. Generally, the total weight (nearest 0.1 kg) and length frequency (nearest cm) are recorded for each species on standard trawl logs. Collections of age and growth structures, maturity observations, and pathology observations are taken.

The MADMF spring survey catches are characterized mainly by scup of ages 1 and 2, while the fall survey often captures large numbers of age 0 fish. The spring biomass and abundance indices dropped sharply from a high in the early 1980s to relatively low levels through the remainder of the time series, with the exception of spikes in 1990, 2000, and 2002, the latter event in common with the NEFSC spring trawl survey (Table 25, Figure 11). The MADMF fall indices can include large numbers of age 0 fish, and on a numeric basis are more variable than the spring indices. The fall biomass index is less variable than the spring, however, and exhibits an increasing trend since the mid 1990s (Figure 12).

Rhode Island DFW

The Rhode Island Division of Fish and Wildlife (RIDFW) has conducted an autumn and spring survey since 1979 based on a stratified random sampling design. Three major fishing grounds are considered in the spatial stratification, including Narragansett Bay, Rhode Island Sound, and Block Island Sound. Stations are either fixed or randomly selected for each stratum. To maintain continuity in the number of stations sampled per stratum each season, an alternate list is generated for substitution in the event of an unexpected hang-up or questionable bottom type. At each station, a 3/4-scale High Rise bottom trawl is towed for 20 minutes at an average speed of 2.5 knots using the R/V *Thomas J. Wright*, a 42 ft Bruno and Stillman western-rigged dragger. The net average vertical opening is estimated at 10 feet. The otter trawl doors are 2 ft by 4 ft in dimension, set 7.5 fathoms ahead of the wings of the net.

The RIDFW spring survey mainly catches scup of ages 1 and 2. The spring indices show relatively levels of scup abundance and biomass through 1999 followed by a steep increase during 2000-2002, in common with the NEFSC and MADMF indices. No scup were caught in the spring 2003 survey, but the index has since rebounded to pre-2000 levels (Table 26; Figure 11). The RIDFW fall survey is dominated by age 0 scup. Fall abundance indices show a general increase to its 1993 peak, followed by a steep decline until 1998, and a general increase since then, reaching a time series peak in 2007 (Figure 12).

Connecticut DEP

The Connecticut Department of Environmental Protection (CTDEP) trawl survey program was initiated in May 1984 and encompasses both New York and Connecticut waters of Long Island Sound. The stratified random design survey is conducted in the spring (April-June) and fall (September-October). Each survey consists of three cruises, with 40 stations sampled during each cruise, providing a sampling density of one station per 20 square nautical miles per cruise. Prior to 1990, the survey was conducted monthly from April to November.

The CTDEP spring indices exhibit relatively low levels through most of the survey period, but have increased substantially since 1999 (Table 27, Figures 11 & 13). The CTDEP fall survey, which often catches large numbers of age-0 scup, indicates that recruitment was relatively stable during most of the survey period, but fall indices have also increased substantially since 1999 (Table 28, Figures 12 & 14). The age compositions of the CTDEP spring and fall surveys generally include a higher proportion of age 2 and older fish than the other state or NEFSC surveys (Figures 13-14).

New York DEC

The New York Department of Environmental Conservation (NYDEC) initiated a small mesh trawl survey in 1985 to collect fisheries-independent data on the age and size composition of scup in local waters. This survey is conducted in the Peconic Bays, the estuarine waters which lie between the north and south forks of eastern Long Island. The 35 ft R/V *David H.*

Wallace is used to sample sixteen stations each week from May through October. Tows are 20 min in duration. The net used has a 16 ft headrope and a 19 ft footrope and is constructed of polypropylene netting with 1.5 in stretch mesh in the body and 1.25 in stretch mesh in the codend. No survey data are available for 2005.

The NYDEC survey provides age 0, 1, and 2+ indices of scup abundance. The age 0 indices are generally low over the survey period, with peaks in 2000, 2002, 2003, 2006, and 2007 that may indicate recruitment of strong cohorts in those years (Table 29). In the early years of the survey there often has not been a strong correspondence between the age 0 indices and age 1 and 2+ indices in the following years (Figure 15).

New Jersey BMF

The New Jersey Bureau of Marine Fisheries (NJBMF) conducts a stratified random bottom trawl survey of New Jersey coastal waters from Ambrose Channel south to Cape Henlopen Channel. Latitudinal strata boundaries correspond to those in the NEFSC trawl survey; longitudinal boundaries correspond to the 30, 60, and 90 foot isobaths. Each survey includes two tows per stratum plus one additional tow in each of nine larger strata for a total of 39 tows. A three-in-one trawl with a 100 ft footrope, an 82 ft headrope, 3- 4.7 in mesh throughout most of the body and a 0.25 in mesh codend liner is used. Two vessels have been used during the survey, the *F/V Amy Diane*, from 1988-1991 and the *F/V ARGO Marine* from 1991 to present. From 1991 to present, the area has been surveyed in January, April, June, August, and October; from 1988-1990, February and December surveys were incorporated instead of the January survey.

The NJBMF abundance and biomass indices exhibit variable patterns over the early part of the time series. The index reached a minimum in 1996, and has generally increased since then, reaching time series highs in numbers and biomass in 2007 (Table 29; Figure 11).

Virginia Institute of Marine Science (VIMS)

The Virginia Institute of Marine Science (VIMS) has conducted a juvenile scup survey in lower Chesapeake Bay during June-September since 1988. The VIMS age-0 scup survey shows a general decline in recruitment from relatively high levels with peaks in 1990 and 1993 to relatively low levels from 1994 to 2004, and the indication of stronger year classes in 2006 and 2007 (Table 29).

University of Rhode Island Graduate School of Oceanography (URIGSO)

University of Rhode Island Graduate School of Oceanography (URIGSO) has conducted a standardized, two-station trawl survey in Narragansett bay and Rhode Island Sound since the 1950s, with consistent sampling since 1963. Irregular length-frequency samples for scup indicate that most of the survey catch is of fish from ages 0 to 2. The aggregate numbers-based index reached a peak in the late 1970s, was relatively low during the late 1990s, reached a second peak in 2002 in common with the NEFSC, MADMF, RIDFW spring biomass indices, and has since been variable at relatively high level (Table 30, Figure 11).

Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP)

The Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey is designed to support bay-specific stock assessment activities at both a single and multispecies scale. While no single gear or monitoring program can collect all of the data necessary for quantitative assessments, ChesMMAP was designed to fulfill data gaps by maximizing the biological and ecological data collected for several recreationally and commercially important species in the bay. Total abundance and biomass indices composed mainly of age 0 and 1 fish are available since 2002, and indicate strong recruitment in 2005 and 2006 (Table 31).

Natural Mortality

Instantaneous natural mortality (M) for scup was assumed to be 0.20 (Crecco *et al.* 1981, Simpson *et al.* 1990). The largest/oldest scup sampled in NEFSC surveys (1973, 1978) were fish 38-41 cm (fork length) and 14 years old. The largest/oldest scup in NEFSC commercial fishery samples (1974) was 40 cm (fork length) and 14 years old.

Proposed Models of Fishing Mortality and Stock Size

Background Information

The 1998 SAW 27 Panel (NEFSC 1998) rejected an ADAPT VPA for scup as the basis for assessing stock status or as the basis for projections. The panel indicated that the amount of variance in the scup catch at age, particularly for the commercial discards, was unreasonably large. The Panel concluded that precision of estimates of fishing mortality and stock size from the VPA was unacceptably low and would provide an unreliable basis for any estimates of stock size and fishing mortality rates (NEFSC 1998). The SAW 27 Panel also reviewed a surplus production model for scup developed in the ASPIC framework. The Panel noted that the inability to directly estimate historical commercial fishery discards (1968-1988) and recreational catch (1968-1978) cast uncertainty on the validity of the ASPIC absolute estimates of stock biomass, fishing mortality rates, and biological reference points. Since the ASPIC analysis suffered from many of the same input data inadequacies as the VPA, the SAW 27 Panel rejected the ASPIC analysis as a basis for stock status, projections, or reference points (NEFSC 1998). State and NEFSC survey indices at age for scup are highly variable. The patterns in proportions at age in survey indices and survey catchabilities coefficients at age estimated in the VPA suggested that all ages of scup may not be equally available or susceptible to capture by survey trawl gear. As a result, the SAW 27 Panel noted that mortality estimates derived from survey catch at age indices are highly variable and may be positively biased, and are probably not a reliable basis for evaluating fishing mortality rates (NEFSC 1998). The above conclusions about the lack of reliability of surplus production, VPA, or catch curve analyses for scup, due mainly to an inability to evaluate the uncertainty of results, has been supported by subsequent SAW Panel reviews of the scup assessment (NEFSC 2000, 2002).

In the absence of reliable analytical model results for scup, the 2000 SAW 31 Panel (NEFSC 2000) developed and the MAFMC Monitoring Committee has subsequently used a

Relative Exploitation Index (REI) as a metric for the instantaneous fishing mortality rate (F). The scup REI is computed as the ratio of total fishery landings to the NEFSC spring trawl survey SSB three year average index. The REI is assumed to reflect the fishing mortality on age 2 and older scup because fishery landings and survey catch in the NEFSC spring SSB index are generally scup of ages 2 and older. The low REI values in the early 1980s were consistent with the Mayo (1982) assessment of scup (Figure 16; note that the REI is plotted on a log scale). There was a general increasing trend in the REI through the mid-1990s followed by a steady decline through 2001, with an increasing trend since 2001.

The 2000 SAW 31 Panel (NEFSC 2000) concluded that " ...catch curve analyses of survey indices indicate that F for ages 0-3 exceeds 1.0...for the 1994-1998 year classes." The 2002 SAW 35 Panel (NEFSC 2002) concluded, however, that "Though the relative exploitation rates have declined in recent years, the absolute value of F cannot be determined." In recent years, the MAFMC Monitoring Committee has used the REI as part of the assessment information used to recommend an annual Total Allowable Catch (TAC) for the stock. The MAFMC Monitoring Committee has assumed that F in 1999 was equal to 1.0 (NEFSC 2000), equating to an annual exploitation rate of 58%, which in turn equates to the 1999 REI = 62.4. An estimate of the current year exploitation rate has then been developed by assuming the same ratio between the current REI and exploitation rate, to provide advice on an appropriate level for the next year TAC.

The SAW 35 Panel (NEFSC 2002) reviewed an application of the NOAA Fisheries Toolbox model called "An Index Method," or AIM, to scup catch and survey data. That work used the extended total catch series noted earlier, and found that the NEFSC fall survey series provided a better model fit than the NEFSC spring series used as the basis for the biomass reference point and as input to the REI described earlier. The SAW 35 Panel (NEFSC 2002) noted that for scup, the AIM approach had "...considerable promise as a monitoring tool to evaluate stock trajectories and provide valuable information in interim years between analytical assessments" and "...utility in presenting an integrated picture of stock dynamics for resources where only catch statistics and survey trends are available." While this approach was not adopted by the 2002 SAW 35 Panel to monitor the status of the stock, further research using the AIM model was recommended.

As noted earlier, the most recent update of the current stock assessment approach was completed in July 2008 to inform the specification of fishery regulations for 2009. The update indicated that while the stock was overfished in 2007 (1.16 kg per tow, 21% of the biomass target of 5.54 kg per tow; Figure 16), the exploitation rate was at about the rebuilding target rate (9%; F = 0.10), suggesting that overfishing was not occurring in 2007. However, the stock rebuilding rate was slower than indicated by the FMP Amendment 14 projection, with the actual 2007 index (2006-2008 three-year average = 1.16 kg per tow) at only 56% of the forecast 2007 index (2.08 kg per tow).

An Index Method (AIM)

The AIM model (NFT 2008a) fits a relationship between time series of relative stock abundance, such as survey indices of abundance or biomass, and catch data that might include landings and discards. Underlying the approach is a linear model of population growth, which characterizes the population response to varying levels of fishing mortality. If the underlying model is valid over the range of densities observed, AIM can be used to estimate the level of relative fishing mortality at which the population is likely to be stable (e.g., a proxy for FMSY). The approach can be used to construct reference points based on relative abundance indices and catches, and to perform deterministic and stochastic projections to achieve a target stock size.

The basic calculations of the AIM model are two derived quantities, the Replacement

Ratio (RR) and Relative F (RF). Replacement ratio is the ratio between the current year observed index and a smoothed value of the index over a given number of the current and previous years (typically 3 to 5), and is a measure of the trend in abundance or biomass of the population. Relative F is the ratio of the observed catch to a centered average over a given number of years (typically 2 to 3). It should be noted that the application of any smoothing technique reflects a choice between signal and noise, with a greater degree of smoothing eliminating noise but possibly failing to detect a true change in signal (Rago 2001).

When fishing mortality rates exceed to capacity of a population to replace itself the population is expected to decline over time; likewise the population is expected to increase if fishing mortality rates are less than the capacity of a population to replace. In the AIM approach, the RR will have a stable point = 1 when the fishing mortality rate is in balance with recruitment and growth, resulting in a stable population. Robust regression techniques are used in AIM to estimate the RF ($RF_{threshold}$) corresponding to RR = 1. Values of RF in excess of $RF_{threshold}$ are therefore expected to lead to stock decline (e.g.,, fishing mortality exceeds FMSY), while RF values less than $RF_{threshold}$ would be expected to allow populations to increase. Randomization tests are used to test the null hypothesis that the input catch and survey time series represent a random ordering of observations with no underlying association, and that in turn the relationship between RR and RF is not spurious.

The AIM approach was tested with data for scup in the 2002 SAW 35 review (NEFSC 2002). An extended series of total catch beginning in 1963 and the NEFSC spring and fall biomass indices through 2001 were used as inputs. In the SAW 35 work, only the NEFSC fall series provided a statistically significant regression between the RR and RF, and results indicated that the RR first increased above 1.0 in 1996, and that the RF during 2000 was lowest of the time series. The SAW 35 work also indicted that re-examination of the reliance on the NEFSC spring survey series as the primary signal of stock abundance was warranted (NEFSC 2002).

The current AIM implementation for scup was tested over a range of degree of smoothing of both the RR and RF to explore the sensitivity of results to those inputs. Also, different lengths of the catch time series (Table 19) were tested, including extended series beginning in 1963 (the advent of the NEFSC trawl surveys), beginning in 1974 (to include the peak in NEFSC Surveys used as the basis for the current biomass reference point), and beginning in 1981 (to include the least number of assumption for catch estimates). All of the available NEFSC and state agency survey series of stock biomass and abundance were initially tested for their utility in the AIM approach.

The best (i.e., a significant model at the p = 0.10 level) simple regression fits in AIM were provided by the NEFSC fall, URIGSO, NJBMF annual, and MADMF spring survey series (Figures 17-20). The MADMF and NJBMF series are too short to serve as the sole stock index for scup in the AIM model - neither series captures the historical peaks and trends in biomass. The 1974 and later and 1981 and later AIM run configurations including suffer from the same shortcoming. The URIGSO, MADMF and NJBMF series also failed to satisfy the randomization test at the p = 0.10 level. These initial results indicated that only the NEFSC fall survey biomass index (Figures 17 and 19) provided acceptable fit statistics and other diagnostics within the AIM model framework.

In an attempt to include the recent information content of the multitude of state agency surveys as well as the historical perspective provided by the long-term NEFSC and URIGSO series, a model-based index including all of the index series in a GLM framework was developed. Alternative configurations included lognormal, Poisson, and negative binomial error distribution assumptions; "survey" was used as the classification variable, with the "year" coefficient acting as the index of abundance. The Working Group adopted the GLMALL index with Poisson error for input to AIM (Figure 21). AIM results for the GLMALL index with Poisson error showed a significant regression model ($p < 0.10$) and feasible Relative F and Replacement Ratio results (Figure 22), but a failed randomization test.

These results suggest that the most appropriate AIM model would include only the NEFSC fall survey biomass index. However, the NEFSC spring and fall *Albatross IV* time series have ended, and even if reliably calibrated indices from the *Henry B. Bigelow* series can be developed (Figure 23), they will likely not be available for at least a few years. Thus, the Working Group concluded that the AIM results provided the impetus to explore a more complex model (such as ASAP) that is better able to accommodate the numerous sources and relatively high uncertainty of both fishery and survey data for scup.

Age Structured Assessment Program (ASAP) Model

The fishery and research survey data for scup described earlier were used as input for the Age Structure Assessment Program model (ASAP) in NFT version 2.0.17 (NFT 2008b). The ASAP model is able to estimate residuals (error) for the fishery catch components as well as for the survey indices used for calibration. ASAP also can provide greater control in specifying the selection (partial recruitment) characteristics for both the fisheries and the surveys, in specifying the underlying stock-recruitment relationship, and in weighting the different likelihood components that influence the model estimation results.

Initial Runs

The fishery catch data (aggregate catches in weight for 1963-2007; catches at age in number for 1984-2004) were input as four component fisheries (commercial landings, commercial discards, recreational landings, recreational discards; in aggregate weight and as number at age) and associated mean weights at age. Natural mortality (M) was set equal to 0.2, and maturity at age was set as in the SAW 27 assessment (NEFSC 1998) with proportions mature as follows: age 0 = 0.00, age 1 = 0.13, age 2 = 0.75, age 3 = 0.99, and age 4 and older = 1.00. In the initial ALL configuration, the following research survey abundance indices at age were used: NEFSC spring ages 1-4, NEFSC fall ages 0-4, NEFSC winter ages 1-4, CTDEP spring ages 1-6+, CTDEP fall ages 0-5+, NYDEC ages 0-1, and VIMS age 0. Aggregate biomass or abundance indices from the NEFSC winter, spring, and fall, MADMF spring and fall, RIDFW spring and fall, CTDEP spring and fall, NJBMF annual, and VIMS surveys were also used as input in initial runs. Fishery selectivity was estimated for two time periods: 1984-1996 and 1997-2007, with the break roughly coinciding with the advent of substantial regulatory changes in the fisheries (Amendment 8 in 1997 and Amendment 12 in 1998). Other model options (survey CVs, stock-recruit function CVs and lambdas, etc.) were configured to provide stable and feasible results. Alternative model configurations tested included a) only NEFSC surveys, b) only STATE surveys, and c) only NEFSC and URIGSO (NEC-URI) surveys.

The four initial model configurations (ALL, NEFSC, STATE, and NEC-URI) provided comparable time series trends in SSB and F through the late 1990s: high abundance and low F in the early 1960s, a decline and then rebuilding to a period of abundance in the late 1970s, and then a decline in abundance under high Fs in the mid-1980s to mid-1990s resulting in a period of low abundance in the late 1990s. The alternatives differed substantially in the development of the stock since 2000, and in the estimate of current abundance with respect to the last peak in the late 1970s, mainly as a result of differing estimates of recruitment since the late 1990s (Figures 24-26). The STATE run provided the highest recent estimates of SSB, due to the scaling of recent large year classes (with the notable exception of 2006) about 50% higher than the ALL run and 100% higher than the NEFSC and NEC-URI runs. Comparison of the alternative estimates of SSB and F with ASAP internally calculated BRPs indicates that the stock in 2007 was about two to four times SSBMSY, with Fs at about 20-50% of FMSY (Figure 27).

Modifications to Survey Input Data

The initial runs indicated that the stock should be considered to be fully rebuilt with no overfishing. With a stock at that level of abundance, there is an expectation that both fishery and survey catches would reflect a robust age structure with significant numbers of older fish. There is evidence of expansion of the age structure of the fishery catch since about 2000 (Figures 3-6), likely reflecting the combined effects of a) increasing minimum retention sizes b) more restrictive trip limits in the fisheries, c) recent decreases in quotas/harvest limits and d) real increases in recruitment and subsequently SSB.

However, there is little evidence of substantial expansion of the age structure of the stock in the survey catches (Figures 8-10, 13, & 15), except for the CTDEP survey catches (Figure 14). Previous and current reviews of the scup research trawl survey data have noted that the catchability and/or availability of age 3 and older fish is likely reduced compared to age 0-2 fish. The NEFSC survey catches likely reflect this higher catchability of ages 0-2 relative to older fish (ages 3 and older), and aggregate biomass indices likely mainly the reflect abundance of ages 0-2, but not of ages 3 and older. Examination of the available length and age frequencies suggests the same properties likely apply to the MADMF, RIDFW, URIGSO, NYDEC, and ChesMMAP indices for scup. The CTDEP survey catches, however, are distributed across ages more in line with realistic total mortality rates, suggesting that the CTDEP survey older age indices (ages 3 and older) may be reflective of true abundance, with aggregate indices in turn more reflective of total stock biomass (Figure 14).

In attempt to resolve the inconsistent signals provided by the fishery and survey catches, a number of modifications were made to the input survey data and to the manner in which the survey data are modeled in ASAP. For the NEFSC survey indices at age, input data were limited to the ages 0-2 indices. The NEFSC long-term aggregate biomass indices were recompiled with a length cut-off at age 2 (winter = 22 cm; spring = 20 cm; fall = 23 cm; Figures 28-30), and selectivity (selex) within the ASAP model limited to ages 0/1 to 2. The consistency of rank order and trends between the original and modified NEFSC aggregate indices indicates that those series best index the abundance and biomass of ages 0/1 to 2.

For the MADMF, RIDFW, NJBMF, and URIGSO aggregate indices, selectivity within the ASAP model was also limited to ages 0/1 to 2. Alternative runs were made with different inputs and assumptions for the CTDEP indices, to test inclusion of age 3 and older indices and aggregate indices, and corrspondingly varying the selectivity of the aggregate indices. The newly modified runs are identified as:

Sep08_ALL:	All indices, all ages, aggregate index selex for ages 0/1 to 7+
SV0to2:	Use only age 0-2 indices, no aggregate indices
SV0to2_AGG0to2	Use only age 0-2 indices, aggregate indices selex for age 0/1 to 2
SV0to2_AGG0to2_CTALL:	Use all CT indices, CT aggregate indices selex for ages 0/1 to 7+

The modified runs generally provided a different recent pattern of stock biomass in relation to the early 1960s and late 1970s peaks compared to the four initial runs, and also higher recent biomass in absolute terms. The four initial run estimates of SSB in 2007 ranged from 55,000 mt to 140,000 mt (Figure 24); the four modified run estimates ranged from 90,000 mt to 180,000 mt (Figure 31). The Sep08_ALL run, which includes some additional input data series (URIGSO, ChesMMAP and updated NYDEC) and some modifications to initial settings, provided results closest to the initial ALL run.

The two modified runs with older ages excluded from both the at-age and aggregate indices (SV0to2 and SV0to2_AGG0to2) estimated higher recent recruitment and thus lower recent F and higher recent SSB than the Sept08_ALL run. The run including all ages in the CTDEP indices (SV0to2_AGG0to2_CTALL) estimated extremely high recent recruitments (three year classes > 300 million age 0 fish) and correspondingly low F and high SSB. The SV0to2_AGG0to2_CTALL run had the poorest diagnostics of the four runs, in terms of a) large residuals for many of the survey indices, b) relatively poor fits to the estimated commercial and recreational fishery aggregate discards, and c) relatively poor fits to the estimated commercial and recreational fishery discards at age. For those reasons, the SV0to2_AGG0to2_CTALL configuration was not considered further.

The other three runs had comparable residual patterns and fits to the estimated catches. Four objective function components, a) fishery total catch, b) fishery age compositions, c) survey indices (age compositions plus aggregate indices), and d) recruitment deviations, account for 99% of the total objective function for all four modified runs. With the SV0to2_AGG0to2_CTALL excluded, the remaining three runs had comparable objective function distribution and fit diagnostics. Figure 34 shows that restricting the input survey data to only the age 0-2 indices (run SV0to2) shifts more of the influence on the model solution to the fishery catch (total and age composition) components, compared to the other runs that also include aggregate indices (whether restricted to ages 0-2 or allowed to include older ages). The SV0to2 run does not include the long-term aggregate indices that are included in the Sep08_ALL and SV0to2_AGG0to2 runs, fishery independent data that increases the precision of historical stock size estimates in those runs. However, run Sep08_ALL includes indices at age 3 and older that are less likely to be reflective of true abundance than indices for ages 0-2. Therefore, by elimination of configurations with diagnostic or data fit concerns, the SV0to2_AGG0to2 run was carried forward for further examination of the sensitivity of the model to changes in configuration.

The next step was to examine the retrospective performance of the SV0t2_AGG0to2 run to judge its' potential utility to reliably monitor the stock. Six retrospective peels (a seventh, terminal year 2001 retrospective peel did not converge) indicated that the SV0to2_AGG0to2 run was stable with little retrospective pattern evident in SSB, F, or R (Figure 35).

Sensitivity to Fishery Catch Lambdas (Weighting Factors) and Time Series Length

Next, model sensitivity to fishery catch lambdas (the weighting factor on the four aggregate fishery catch components) was examined. The initial and modified runs described above were made with lambdas set at 0.10 (i.e., CV = 10%) for all four aggregate fishery catch components. Further sensitivity runs were made with lambda set at 0.10 for commercial landings and 0.20 for the commercial discards, recreational landings, and recreational discards (run CAT20); with 0.10 for commercial landings and 0.30 for the commercial discards, recreational landings, and recreational discards (run CAT30); with 0.10 for commercial landings and 0.60 for the commercial discards, recreational landings, and recreational discards (run CAT60); with 0.10 for commercial landings and lambda changing from 0.30 to 0.10 in 1981 for the commercial discards, recreational landings, and recreational discards (run CAT30to10); and with 0.10 for commercial landings and lambda changing from 0.60 to 0.30 in 1981 for the commercial discards, recreational landings, and recreational discards (run CAT60to30). The 1980/1981 time split coincides with the more reliable estimation of recreational catches.

The results of the SV0to2_AGG0to2 run configuration were sensitive to the catch lambda specifications. The 1980/1981 time split in the CAT30to10 and CAT60ro30 runs did not have an important effect on the results. However, the change from lambdas of 0.10 to lambdas of 0.20 and higher did have an important effect on SSB results, as reflected by the "shift" from the initial SV0to2_AGG0to2 and CAT30to10 runs (all recent catch lambdas set at 0.10) to the runs with recent commercial discards, recreational landings, and recreational discards lambdas set at 0.20 or higher. Results for F and R were less strongly effected. Lambdas reflecting greater uncertainty of the magnitude of commercial discards and recreational resulted in lower recent estimates of SSB, and a different relationship between current estimates and previous peaks in SSB in the 1960s and late 1970s (Figure 36-38). This result occurs because the influence of the survey indices in these run configurations is mainly restricted to ages 0-2, and so the magnitude and uncertainty of the input fishery catches has the strongest influence on estimates of recent SSB.

The input assumptions for a) the age range for which the survey indices can be considered reliable and therefore used as input, and b) the estimate or assumption for the input fishery catch uncertainty; both have strong impacts on the model results. Based on the work presented earlier, an assumption that most survey indices are likely to be reflective of true abundance only for ages 0 to 2 is appropriate - hence the subsequent work using run SV0to2_AGG0to2 as a basis. Further investigation of the precision for commercial fisher discards and recreational catches indicated that the precision of commercial fishery discards averaged (unweighted average of annual PSE) 39% for 1997-2007 (Table 4) and 32% for the entire NEFSC Observer Program sample period (1989-2007). The precision of recreational fishery landings (catch types A+B1 numbers) during 1981-2007 averaged 10%; the precision of recreational fishery discards (catch type B2 numbers) during 1981-2007 averaged 12%. A new run, BASE_Nov08, was configured to reflect this objective information about the uncertainty of the fishery catch for scup, with commercial landings lambda assumed to be 0.10, commercial discards lambda set at 0.32, recreational landings lambda set at 0.10, and recreational discards lambda set at 0.12; for all years 1963-2007. The results of the BASE_Nov08 run were similar to the sensitivity runs with commercial discard and recreational catch lambdas of 0.20 and greater, indicating that the current magnitude of SSB is about the same as in the 1960s and higher than in the late 1970s, with very low current F and several very large year classes recruiting to the stock since 2000 (Figure 39-41).

A sensitivity exercise was conducted to test the influence of the length of the catch time series modeled. The BASE_Nov08 time series includes a time series of fishery catches extended back to 1963, using ratios to extend the commercial discards (1963-1988) and recreational landings and discards (1963-1980; Table 19). The BASE81_Nov08 run was configured to include only fishery and survey data from 1981-2007, the time period for which most of the fishery catches are reported or estimated from sampling, rather than extrapolated from ratios. The shorter time series provided 10-30% lower estimates of SSB during the early 1980s, and 10-20% higher estimated of SSB since 2003, when compared to the 1963-2007 BASE_Nov08 run (Figure 42). Patterns and levels of F and R were very similar, however (Figures 43-44). The BASE_Nov08 run SSB varied from about 103,000 mt in 1963 to a time-series low of 4,100 mt in 1995 to a time-series high of 107,100 mt in 2007; Fs varied from a high of 1.13 in 1993 to a low of 0.06 in 2007; recruitment varied from a low of 32 million age 0 fish in 1996 to a high 367 million in 2007. The BASE81_Nov08 run SSB varied from a low of 4,200 mt in 1995 to a high of 122,700 mt in 2007; Fs varied from a high of 1.14 in 1994 to a low of 0.06 in 2007; recruitment varied from a low of 35 million age 0 fish in 1996 to 308 million in 2007. Biological Reference Points calculated from the BASE_Nov08 and BASE81_Nov08 runs are presented in Figure 45. Given the similarity of the results, the November 2008 Working Group decided to use to the BASE_Nov08 runs with the full 1963-2007 time series as the basis for further model development.

Sensitivity to 2002 Survey and Commercial Discard Estimates

The next step in model development was to add preliminary fishery catch at age estimates for the four fishery fleets for 2004-2006, which provided model run configuration BASE_C2006. The November 2008 Working Group reviewed the diagnostics of the BASE_C2006 run in detail, and noted that some components of the calender year 2002 survey data and the 2002 commercial fishery discard aggregate estimate provided large residuals (Figure 46-48). The unusually high values for many survey indices in 2002 has been noted previously, and is presumed to result mainly from increased availability of fish to the surveys, especially during the first half of 2002, rather than true increases in abundance (e.g., Figures 7-8 & 11). The same type of availability event may have affected the 2002 commercial fishery discard sampling, resulting in higher than usual discard rates and increased estimated discards at age in 2002 (Figure 3). To explore the sensitivity of the ASAP model for scup to these data, two new runs were configured. The first, BASE_C2006_No02SV, dropped all 2002 survey indices (spring and fall; at age and aggregate) from the model fit. The second, BASE_C2006_No02SV_NoCD02, also dropped the 2002 commercial fishery discard estimates at age and used the average of the 2001 and 2003 estimates as a substitute for the 2002 aggregate discard weight.

Figures 49-51 summarize the results of these BASE_C2006 runs. The BASE_C2006 run with fishery catch at age through 2006 provided results very similar to the BASE_Nov08 run with fishery catch at age through 2004, with SSB in 2007 estimated at just over 100,000 mt, F in 2007 estimated at about 0.05, and the large recent recruitments in 2000 and 2007 estimated at

300-400 million fish. Dropping the 2002 survey indices in the BASE_C2006_No02SV run increased the SSB in 2007 to about 125,000 mt, substantially reduced the 2002 recruitment estimate from about 296 million to 156 million fish, changed the pattern of recruitment so that the 1999 year class (212 million) was larger than the new estimate of the 2000 year class, and increased the estimated of recruitment in 2007 to about 376 million fish. Dropping the 2002 Commercial Discards at age and substituting for the high 2002 aggregate discard in weight in the BASE_C2006_No02SV_No02CD run had relatively little additional effect on results, other than eliminating the large residual for the 2002 estimate, and so the November 2008 Working Group decided to retain the original 2002 commercial fishery discard estimates in subsequent model runs.

The November 2008 Working Group extensively debated whether it was appropriate to exclude the 2002 survey data in a BASE case run for subsequent development. It was noted that the model "compensated" for the missing data, changing the rank order of recruitments over the last decade, and increasing the size of the 2007 year class. It was also noted that there may have been other abrupt, but substantial "positive availability" events that have occurred in the past (e.g, NEFSC spring survey in 1977, NEFSC fall survey in 1976, 1989, and 1999; Table 20, Figure 6), that were not being considered for exclusion from the analysis. Likewise, there may have been several abrupt, but substantial "negative availability" events that have occurred (e.g., NEFSC spring 2003, 2005, and 2007, NEFSC fall 2005), and no exclusion was being considered for those possible events. The November 2008 Working Group found it difficult to build an objective justification for the exclusion of the 2002 survey data, and so they were retained in subsequent model runs.

Alternative Assumptions for Natural Mortality (M)

A range of alternative assumptions for the instantaneous natural mortality rate (M) was tested in a series of runs derived from the BASE_C2006 run. The values ranged from 0.10 to 0.40, in runs BASE_C2006_M10 to BASE_C2006_M40. A sensitivity profile indicated that the ASAP model for scup fit best (lowest total likelihood value) at M = 0.10 (Figure 52). This was considered a counter-intuitive result, as most members of the November 2008 Working Group expected a higher value of M (e.g., in the 0.3-0.4 range) to perform better, given the maximum observed age in survey and fishery samples of 14 years, and configuration of the model with an oldest age group of 7-plus. Those expectation were not born out by the results, however, and so the November 2008 Working Group retained the initial assumption of M = 0.2 for all ages in subsequent model runs.

Update with final 2004-2007 Catches: BASE_C2007 runs

Final fishery catch at age estimates for 2004-2007 became available in mid-November 2008, after the November 2008 Working Group meeting, and model runs including these data were called BASE_C2007 runs. In the BASE_C2007 and all previous runs, the same mid-year mean weights at age were used for the total catch, January 1 total stock biomass, and June 1 SSB mean weights at age. Once the fishery catches at age were finalized through 2007, mean weights for the January 1 and SSB biomass were re-calculated using the Rivard method (NFT 2008c), to provide run BASE_C2007_RIV. As a final model tuning step, the ratio of the estimated Effective Sample Sizes (ESS) to the input ESS was calculated for the four fishery fleets, and the ratio used to adjust the ESS for the final run, BASE_C2007_T1.

Figures 53-55 summarize comparative results for the runs configured during and since the November 2008 Working Group meeting. The addition of the preliminary 2004-2006 fishery catches at age to the BASE_Nov08 run to create the BASE_C2006 run had a very minor effect on the results. The addition of the final 2004-2007 catches at age to create the BASE_C2007 run had a slightly larger effect on recent trends, increasing the SSB in 2007 from 103,000 mt to about 113,000 mt, and increasing recruitment in 2000 (from 297 million to 302 million) while decreasing recruitment in 2007 (from 364 million to 305 million). Re-calculation of the mean weights at age in the BASE_C2007_RIV run affected only the SSB estimates by increasing the recent estimates by a few percent, with the SSB in 2007 increasing from 113,000 mt to 121,000 mt. The final tuning of the ESS created the final run BASE_C2007_T1, with a slight decrease in SSB and R in recent years compared to the previous run, and an estimate of SSB in 2007 of 119,000 mt, F on age 3-7+ of 0.054, and recruitment in 2007 of 308 million fish. Run BASE_C2007_T1 has been used as the basis for subsequent calculation of the proposed biological reference points and status evaluation. Run BASE_C2007_T1 did not exhibit substantial retrospective patterns in SSB, F, or R (Figures 56-58).

Summary estimates, estimated January 1 stock size at age in numbers, and estimated fishing mortality (F) at age from the final BASE_C2007_T1 model for 1984-2007 (the years with input fishery catches at age) are provided in Tables 32-34. Spawning stock biomass (SSB) decreased from about 102,000 mt in 1963 to about 50,000 mt in 1969, then increased to about 75,000 mt during the late 1970s (Figure 53). SSB declined through the 1980s and early 1990s to only 4,000 mt in 1995. With greatly improved recruitment and low fishing mortality rates since 2000, SSB has steadily increased since to about 113,000 mt in 2007 (Table 32, Figure 53). There is an 80% chance that SSB in 2007 was between 111,204 and 130,120 mt (Figure 59). Fishing mortality calculated from the average of the currently fully recruited ages 3-7+ varied between F = 0.100 and F = 0.274 during the 1960s and 1970s (Figure 54). Fishing mortality increased steadily during the 1980s and early 1990s, peaking at F = 1.120 in 1994. Fishing mortality decreased rapidly after 1994, falling to less than F = 0.100 since 2004, with F in 2007 = 0.054 (Table 32, Figure 54). There is an 80% chance that F in 2007 was between 0.048 and 0.060 (Figure 60). Recruitment at age 0 averaged 91.4 million fish during 1963-1983, the period during which recruitment estimates are influenced mainly by the internal ASAP stock-recruitment relationship (Figure 55). Since 1984, recruitment estimates are influenced mainly by the fishery and survey catches at age, and recruitment at age 0 averaged 119.6 million fish during 1984-2007, with the 2000 and 2007 year classes estimated to be the largest of the time series, at 311.2 and 307.9 million age 0 fish (Table 32, Figures 55 and 61).

Proposed Biological Reference Points and Status using the ASAP model

Biological reference points were calculated from the BASE_C2007_T1 run configuration using the non-parametric yield and SSB per recruit/long-term projection approach recently adopted for summer flounder (NEFSC 2008a) and New England groundfish stocks (NEFSC 2008b). In the yield and SSB per recruit calculations, the most recent five year averages were used for mean weights and fishery partial recruitment (Table 35). For the projections, the cumulative distribution function of the 1984-2007 recruitments (corresponding to the period of input fishery catches at age) was randomly re-sampled to provide future recruitment estimates (mean = 117.2 million age 0 fish).

For the BASE_C2007_T1 run, the Fmax proxy for FMSY = 0.283, the proxy estimate for SSBMSY = 57,759 mt, and the proxy estimate for MSY = 16,903 mt (12,764 mt of landings, 4,139 mt of discards). The 2007 F estimate of 0.054 is 19% of FMSY = 0.283, indicating no overfishing was occurring. The 2007 SSB estimate of 119,343 mt is 107% above SSBMSY = 57,759 mt, indicating the stock was not overfished. Total catch (landings + discards) was 7,867 mt in 2007, about 47% of MSY (Table 36). Estimates of biomass and catch reference points corresponding to F35% and F40% are also listed in Table 36 for consideration as potential target reference points.

Section 6: Uncertainty and Risk for Scientific and Statistical Committees (SSCs) to Consider

The proposed ASAP model of scup population dynamics and associated BRPs should provide a more stable tool for monitoring stock status and specifying annual fishery regulations than the current NEFSC spring survey index-based model. The proposed ASAP model integrates a broad array of survey and fishery input data, and should be less sensitive to inter-annual changes in any single component of fishery or survey data than the current model. The proposed ASAP model and BRPs indicate, however, that the scup stock was well above the SSBMSY proxy and being fished at well below the FMSY proxy in 2007. This status represent a significant change from the July 2008 biomass status update using the current index-based model, which indicated that the stock was overfished in 2007 (NEFSC spring SSB three-year average index = 1.16 kg per tow, 21% of the biomass target of 5.54 kg per tow) and rebuilding more slowly than indicated by the Amendment 14 projection (see Section 3). The current REI proxy for F did indicate that F in 2007 was low (about 0.10) and overfishing was not occurring, in accord with the proposed ASAP model.

The 2007 stock abundance indicated by the proposed ASAP model is the result of historically low fishing mortality rates and historically high levels of recruitment since about 2000 (Figures 53-55). Age 0 fish comprised about 40% of the stock size in 2007 due to the large size of the 2007 year class, but the relative percentages of the age 1 and older fish are within of few percent of what might be expected in the stock if it was fished at Fmax = FMSY = 0.283 over the long-term (Figure 62). The age 7+ group comprised about 6% of the stock size in 2007. The proposed ASAP model and BRPs indicate that stock has not been fished at low levels of F long enough to accumulate as high as percentage in the age 7+ group (16%) as would be expected if fished at F = 0.05 over the long-term (Figure 62). Since 2000, a high proportion of the SSB has accumulated at ages 3 and older (those expected to be fully mature) and in the age 7+ group. The percentage of SSB in 2007 at fully (>99%) mature ages 3-6 (56%) is near what would be expected if the stock were fished at F = 0.050 over the long-term (46%), and age 7+ fish comprised about 35% of the SSB in 2007 (Figure 63).

A retrospective look at historical analytical assessments for scup shows that current ASAP estimates of SSB and R are comparable to those previously estimated for the same time period in the 1995, 1997, and 1998 assessments using ADAPT VPA; estimates of F are somewhat higher in the VPA assessments (NEFSC 1995, 1997, 1998) (Figures 64-66). The 1995 SAW19 assessment was the last accepted peer-reviewed analytical assessment. It is important to note that the analytical components of the 1997 and 1998 assessments were not accepted as valid bases for assessing the stock. The historical analyses used input fishery and research survey data time series beginning in 1984.

The proposed ASAP model and BRPs indicate that the MSY proxy for scup in terms of total catch is 16,903 mt (37.3 million lbs), with total landings of 12,764 mt (28.1 million lbs) and total discards of 4,139 mt (9.1 million lbs). The extended catch series estimated for scup (Table 19) indicates that this MSY proxy (total catch at Fmax =0.283 over the long-term) is a feasible value. Total fishery catch is estimated to have averaged about 34,000 mt (74.9 million lbs) during 1960-1965, while reported commercial landings alone averaged about 19,000 mt (41.9 million lbs) in that period (Table 19 and Figure 1).

While the proposed long-term MSY estimate appears feasible given historical evidence from the fishery, managers may wish to take an adaptive approach to the specification of TAC/TALs in the short-term. Total fishery landings over the last five years (2003-2007) have averaged 7,368 mt (16.2 million lbs). If F40% = 0.177 were adopted as fishing mortality rate target for scup, the corresponding annual target total landings would be 13,134 mt (29.0 million lbs), an increase of 78% over the recent five year average. Instead of an immediate increase to the target F40% TAL, an incremental increase of 20% percent per year in the TAL toward the target level would facilitate an evaluation of the performance of the new assessment model and BRPs in monitoring stock status, while reducing the risk to the stock due to rapidly increased catch.

Section 7. Research Recommendations

1) Continuation of at least the current levels of at-sea and port sampling of the commercial and recreational fisheries in which scup are landed and discarded is critical to adequately characterize the quantity, length and age composition of the fishery catches.
2) The commercial discard mortality rate was assumed to be 100% in this assessment. Experimental work to better characterize the discard mortality rate of scup captured by different commercial gear types should be conducted to more accurately quantify the magnitude of scup discard mortality.
3) Current research trawl surveys are likely adequate to index the abundance of scup at ages 0 to 2. However, the implementation of new standardized research surveys that focus on accurately indexing the abundance of older scup (ages 3 and older) would likely improve the accuracy of the stock assessment.

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Table 1. Commercial landings (mt) of scup by state. One mt was landed in DE in 1995, included with MD 1995 total. Eight mt was landed in PA in 2004 included with MD 2004 total. Landings include revised Massachusetts landings for 1986-1997.

Year	ME	MA	RI	CT	NY	NJ	MD	VA	NC	Total
1979		782	3,123	92	1,422	2,159	21	397	589	8,585
1980	1	706	2,934	17	1,294	2,310	32	531	599	8,424
1981		523	2,959	44	1,595	2,990	9	1,054	682	9,856
1982		545	3,203	25	1,473	1,746	2	1,042	668	8,704
1983		672	2,583	49	1,103	2,536	13	536	302	7,794
1984		540	2,919	32	904	2,217	6	673	478	7,769
1985		387	3,583	41	861	1,493	17	74	271	6,727
1986		875	2,987	67	893	1,895	14	273	172	7,176
1987	5	735	2,162	301	911	1,817		232	113	6,276
1988	9	536	2,832	359	687	1,334	1	127	58	5,943
1989	32	579	1,401	89	603	1,219	1	45	15	3,984
1990	4	696	1,786	165	755	1,005	4	75	81	4,571
1991	16	553	2,902	287	1,223	1,960	15	56	69	7,081
1992		655	2,676	193	1,043	1,475	17	73	127	6,259
1993		556	1,332	148	729	1,822	10	76	53	4,726
1994		354	1,514	142	688	1,456	7	92	139	4,392
1995		310	1,045	90	511	1,084	2	20	11	3,073
1996		436	773	99	377	1,141	20	72	27	2,945
1997		676	486	50	376	596	1	2	1	2,188
1998		435	361	44	282	758	5	4	7	1,896
1999		300	581	44	206	361		13		1,505
2000		161	461	65	287	232		1		1,207
2001		149	734	45	297	479	1	24		1,729
2002		330	1,668	4	714	419		25	13	3,173
2003		407	1,730	64	839	1,033	21	253	58	4,405
2004		353	1,562	116	865	862	21	203	249	4,231
2005		515	1,553	149	989	880	1	130	50	4,266
2006		493	1,653	135	1,096	632	0	36	17	4,062
2007		501	1,785	118	1,054	714	1	10	13	4,196
mean	11	509	1,906	106	830	1,332	10	212	187	5,074

Table 2. Commercial landings (mt) of scup by major gear types. Midwater paired trawl landings are combined with other gears during 1994 and later. Landings include revised Massachusetts landings for 1986-1997.

Year	Otter trawl	Paired trawl	Floating trap	Pound net	Pots and traps	Hand lines	Other gear	Total mt
1979	6,387	146	1,305	429	26	215	77	8,585
1980	6,192	160	1,559	194	8	303	8	8,424
1981	7,836	79	1,291	246	49	306	49	9,856
1982	6,563	104	1,514	244	9	226	44	8,704
1983	5,861	398	850	390	8	265	22	7,794
1984	5,617	272	1,266	295	8	287	24	7,769
1985	4,856	417	1,022	229	5	182	16	6,727
1986	5,163	540	629	332	9	493	10	7,176
1987	4,607	237	590	193	213	423	13	6,276
1988	4,142	166	1,052	53	44	396	90	5,943
1989	3,174	89	193	74	104	334	16	3,984
1990	3,205	200	505	60	239	340	22	4,571
1991	5,217	152	988	40	258	395	31	7,081
1992	4,371	94	934	67	303	450	40	6,259
1993	3,865	46	166	25	202	402	20	4,726
1994	3,416		331	79	76	340	150	4,392
1995	2,204		331	42	57	215	224	3,073
1996	2,196		229	8	120	374	18	2,945
1997	1,491		86	12	104	489	6	2,188
1998	1,379		11	4	98	390	14	1,896
1999	1,005		140	30	77	184	69	1,505
2000	773		56		78	205	95	1,207
2001	1,088		229	65	52	215	80	1,729
2002	2,084		220		221	450	198	3,173
2003	2,777		723		168	445	292	4,405
2004	3,767		20		121	196	127	4,231
2005	3,475		117		174	448	52	4,266
2006	3,422		106		201	291	42	4,062
2007	3,332		181		279	373	31	4,196
mean	3,775	207	574	141	114	332	65	5,074

Table 3. Summary NEFSC Domestic Observer program data for scup. Geometric mean discards to landings ratios (GMDL; retransformed, mean ln-transformed D/L per trip) are stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). N is number of sea sample trips with both scup landings and discard, which are used to calculate the per trip discard to landings ratios. Corresponding dealer landings are from the NEFSC database.

1997		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.8957	17	258	231	0.8221	4	1,244	1,023
HY 2	0.8957	0	279	250	0.8221	0	413	340
Total			537	481			1,657	1,362

1998		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	2.401	7	196	471	121.71	1	920	111,973
HY 2	3.126	10	281	878	121.71	0	496	60,368
Total			477	1,349			1,416	172,341

1999		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	1.742	6	245	427	3.766	2	785	2,956
HY 2	1.742	0	178	310	3.766	0	299	1,126
Total			423	737			1,084	4,082

Table 3 continued .

2000		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	4.5818	13	196	898	0.6018	2	655	394
HY 2	3.5001	1	292	1,022	0.6018	0	63	38
Total		14	488	1,920		2	718	432

2001		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.8916	10	180	160	0.9185	4	1,013	930
HY 2	0.4606	2	307	141	0.9185	0	290	266
Total		14	487	302		4	1,303	1,197

2002		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	2.6088	11	423	1,104	0.0653	2	1,484	97
HY 2	3.4522	12	829	2,862	3.6028	3	437	1,574
Total		23	1,252	3,965		5	1,921	1,671

Table 3 continued .

2003		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.1371	9	315	43	0.2560	2	2,473	633
HY 2	1.4299	4	921	1,317	0.2304	5	696	160
Total		13	1,236	1,360		7	3,169	793

2004		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.3370	40	344	116	0.1685	25	2,353	396
HY 2	0.4200	64	868	365	0.0309	10	550	17
Total		104	1,212	480		35	2,903	413

2005		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.7354	31	292	215	0.0732	7	2,390	175
HY 2	0.2740	67	850	233	0.0563	2	694	39
Total		98	1,142	448		9	3,084	214

Table 3 continued .

2006		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.6621	37	472	313	0.0740	10	1,814	134
HY 2	0.8573	40	814	698	0.2631	10	921	242
Total		77	1,286	1,010		20	2,735	377

2007		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.4821	41	461	222	0.2628	10	2,177	572
HY 2	0.9404	54	892	839	0.3389	7	666	226
Total		95	1,353	1,061		17	2,843	798

Table 4. A summary of landings, discards, and geometric mean discards to landings ratio (GMDL), 1997-2007.

Year	Landings (mt)	GMDL Discards (mt)	GMDL D:L ratio	GMDL Discards PSE (%)
1997	2,188	1,843	0.84	61
1998	1,896	173,690	91.61	32
1999	1,507	4,819	3.20	9
2000	1,207	2,352	1.95	48
2001	1,729	1,499	0.87	32
2002	3,173	5,636	1.78	95
2003	4,405	2,153	0.49	41
2004	4,231	893	0.21	25
2005	4,226	662	0.16	29
2006	4,062	1,387	0.34	27
2007	4,196	1,859	0.44	26

Table 5. Total catch (mt) of scup from Maine through North Carolina. Landings include revised Massachusetts landings for 1986-1997. Commercial discards for 1984-1988 calculated as the geometric mean ratio of discards to landings numbers at age for 1989-1993. Commercial discards estimate for 1998 is the mean of 1997 and 1999 estimates.

Year	Commercial Landings	Commercial Discards	Recreational Landings	Recreational Discards	Total Catch
1981	9,856	n/a	2,636	n/a	12,492
1982	8,704	n/a	2,361	n/a	11,065
1983	7,794	n/a	2,836	n/a	10,630
1984	7,769	2,158	1,096	30	11,053
1985	6,727	4,184	2,764	54	13,729
1986	7,176	2,005	5,264	87	14,532
1987	6,276	2,537	2,811	38	11,662
1988	5,943	1,657	1,936	31	9,567
1989	3,984	2,229	2,521	39	8,773
1990	4,571	3,909	1,878	38	10,396
1991	7,081	3,530	3,668	78	14,357
1992	6,259	5,668	2,001	47	13,975
1993	4,726	1,436	1,450	28	7,640
1994	4,392	807	1,192	37	6,428
1995	3,073	2,057	609	13	5,752
1996	2,945	1,522	978	20	5,465
1997	2,188	1,843	543	8	4,582
1998	1,896	3,331	397	14	5,638
1999	1,505	4,819	856	6	7,186
2000	1,207	2,352	2,469	55	6,083
2001	1,729	1,499	1,933	165	5,326
2002	3,173	5,636	1,644	137	10,590
2003	4,405	2,153	3,848	158	10,564
2004	4,231	893	1,923	134	7,181
2005	4,266	662	1,153	165	6,246
2006	4,062	1,387	1,331	185	6,965
2007	4,196	1,859	1,655	157	7,867
mean	4,820	2,506	1,991	72	9,102

Table 6. Summary of the landed fish sampling intensity for scup in the NER (ME-VA) commercial fishery.

Year	No. of samples	No. of lengths	NER Landings (mt)	Sampling intensity (mt/100 lengths)
1979	10	1,250	8,585	687
1980	26	3,478	8,424	242
1981	16	2,005	9,856	492
1982	81	9,896	8,704	88
1983	72	7,860	7,794	99
1984	60	6,303	7,769	123
1985	31	3,058	6,727	220
1986	54	5,467	7,176	131
1987	61	6,491	6,276	97
1988	85	8,691	5,943	68
1989	46	4,806	3,984	83
1990	46	4,736	4,571	97
1991	31	3,150	7,081	225
1992	33	3,260	6,259	192
1993	23	2,287	4,726	207
1994	22	2,163	4,392	203
1995	22	2,487	3,073	124
1996	61	6,544	2,945	45
1997	37	3,732	2,188	59
1998	41	4,022	1,896	47
1999	56	6,040	1,505	25
2000	22	2,352	1,207	51
2001	40	3,934	1,729	44
2002	26	2,587	3,173	123
2003	78	6,681	4,405	66
2004	144	13,172	4,231	32
2005	124	9,324	4,266	46
2006	152	12,506	4,062	32
2007	198	15,704	4,196	27

Table 7. Commercial fishery scup landings (000s) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	1	2691	6114	7090	5793	1418	536	251	1	0	0	23895
1985	79	3245	6767	7696	2640	346	520	159	0	0	0	21452
1986	9	301	12321	4773	1004	75	106	337	5	0	0	18931
1987	2	1679	9952	10399	1725	177	124	21	18	0	1	24098
1988	17	423	7709	9526	2424	58	127	39	0	0	0	20323
1989	17	1484	4943	7071	685	22	69	24	0	0	0	14315
1990	0	247	10203	6781	1022	355	149	2	0	0	0	18759
1991	0	2412	12956	10202	2161	409	193	0	0	0	0	28334
1992	21	1577	10883	3737	3797	1243	138	0	0	0	0	21396
1993	1	230	6558	6877	1500	1143	124	0	0	0	0	16432
1994	0	1052	13544	6358	836	82	39	0	0	0	0	21911
1995	0	2198	8345	2878	891	248	31	0	0	0	0	14591
1996	0	346	6343	1640	770	469	62	0	0	0	0	9630
1997	0	131	2080	4089	732	84	97	0	0	0	0	7213
1998	0	340	1453	2373	1092	381	2	0	0	0	0	5641
1999	0	1	1148	2688	527	117	0	0	0	0	0	4481
2000	0	0	661	2144	511	15	0	0	0	0	0	3331
2001	0	31	1635	3033	695	46	6	1	1	0	0	5448
2002	0	124	1219	5051	2132	392	5	0	0	0	0	8922
2003	0	185	863	4627	3323	856	34	0	0	0	0	9889
2004	0	1	844	2406	2826	2089	296	40	4	14	0	8520
2005	0	31	683	1558	2361	2515	807	92	3	3	0	8053
2006	0	89	2233	2231	1119	1477	1219	366	28	3	0	8765
2007	0	91	2787	1390	680	940	590	124	12	0	0	9275

Table 8. Commercial fishery scup landings mean weights (kg) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	0.033	0.155	0.190	0.293	0.344	0.398	0.767	1.044	1.545	0.000	0.000	0.288
1985	0.043	0.134	0.197	0.293	0.409	0.517	0.739	1.042	0.000	0.000	0.000	0.272
1986	0.036	0.140	0.219	0.357	0.676	0.670	1.010	1.246	1.616	0.000	0.000	0.302
1987	0.034	0.136	0.203	0.244	0.407	0.544	0.747	1.194	1.068	0.000	0.000	0.237
1988	0.044	0.123	0.201	0.263	0.441	0.636	0.715	0.982	0.000	0.000	0.000	0.263
1989	0.025	0.144	0.188	0.275	0.367	0.651	0.721	1.036	0.000	0.000	0.000	0.240
1990	0.000	0.140	0.189	0.246	0.367	0.518	0.842	0.846	0.000	1.096	0.000	0.230
1991	0.000	0.187	0.194	0.263	0.389	0.511	0.729	0.000	0.000	0.000	0.000	0.241
1992	0.039	0.173	0.199	0.325	0.419	0.503	0.859	0.000	0.000	1.096	0.000	0.280
1993	0.031	0.140	0.197	0.261	0.442	0.510	0.782	0.000	0.000	0.000	0.000	0.272
1994	0.000	0.203	0.193	0.259	0.430	0.663	0.742	0.000	0.000	0.000	0.000	0.224
1995	0.000	0.161	0.209	0.295	0.396	0.480	0.724	0.000	0.000	0.000	0.000	0.236
1996	0.000	0.206	0.200	0.325	0.468	0.554	0.784	0.000	0.000	0.000	0.000	0.264
1997	0.000	0.227	0.253	0.300	0.386	0.529	0.749	0.000	0.000	0.000	0.000	0.303
1998	0.000	0.200	0.254	0.313	0.459	0.556	0.748	0.000	0.000	0.000	0.000	0.336
1999	0.000	0.075	0.220	0.323	0.497	0.748	0.000	0.000	0.000	0.000	0.000	0.328
2000	0.000	0.000	0.221	0.367	0.504	0.674	0.000	0.000	0.000	0.000	0.000	0.360
2001	0.000	0.229	0.265	0.346	0.476	0.562	0.779	1.003	1.003	0.000	0.000	0.340
2002	0.000	0.231	0.281	0.339	0.465	0.577	0.748	0.000	0.000	0.000	0.000	0.370
2003	0.000	0.228	0.308	0.402	0.505	0.635	0.844	0.000	0.000	0.000	0.000	0.447
2004	0.000	0.182	0.313	0.398	0.518	0.591	0.812	1.002	1.370	1.674	0.000	0.496
2005	0.000	0.196	0.269	0.362	0.471	0.652	0.809	1.044	1.099	1.311	0.000	0.529
2006	0.000	0.213	0.283	0.344	0.460	0.591	0.727	0.915	1.108	1.314	0.000	0.463
2007	0.000	0.217	0.265	0.353	0.470	0.646	0.768	0.894	1.077	1.697	0.000	0.452

Table 9. Summary of sampling for scup in the NEFSC Observer Program. OT =number of otter trawl trips sampled with scup discard lengths. H1 = first half year; H2 = second half year. GMDL reflects the estimate of discard based on applying geometric mean observed ratios of discards to landings by trip, stratified by landings level (< 300 kg per trip, = > 300 kg per trip) to reported dealer landings (from Table 4).

Year	OT	Lengths			GMDL Discard	Intensity
	trips	H1	H2	Total	(mt)	(mt/100 lengths)
1989	61	4,449	2,910	7,359	2,229	30
1990	52	2,582	781	3,363	3,909	116
1991	91	1,237	1,780	3,017	3,530	117
1992	53	1,158	0	1,158	5,668	489
1993	29	275	154	429	1,436	335
1994	7	99	119	218	807	370
1995	18	162	383	545	2,057	377
1996	27	1,093	435	1,528	1,522	100
1997	45	750	1	751	1,843	245
1998	33	618	64	682	3,331	488
1999	35	586	89	675	4,819	714
2000	62	3,981	762	4,743	2,352	50
2001	67	1,231	229	1,460	1,499	103
2002	65	1,422	866	2,288	5,636	246
2003	72	925	284	1,209	2,153	178
2004	80	1,948	1,051	2,999	893	30
2005	73	797	1,159	1,956	662	34
2006	47	1,486	777	2,263	1,387	61
2007	59	1,313	1,058	2,371	1,859	78

Table 10. Commercial fishery scup discards (000s) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	78	10847	6367	924	21	0	0	0	0	0	0	18237
1985	52773	13093	6534	1060	10	0	0	0	0	0	0	73470
1986	78	1180	14040	602	3	0	0	0	0	0	0	15903
1987	78	6814	12215	1366	5	0	0	0	0	0	0	20478
1988	1552	1698	9242	1339	10	0	0	0	0	0	0	13841
1989	387	8943	13603	813	28	0	0	0	0	0	0	23774
1990	822	8269	17249	2801	0	0	0	0	0	0	0	29141
1991	1794	17231	5397	1733	5	0	0	0	0	0	0	26160
1992	38804	10023	26380	72	0	0	0	0	0	0	0	75279
1993	5386	1549	6960	224	0	0	0	0	0	0	0	14119
1994	6858	3099	3422	74	0	0	0	0	0	0	0	13453
1995	1855	50174	335	108	14	0	0	0	0	0	0	52486
1996	199	3009	5990	691	21	1	0	0	0	0	0	9911
1997	1	618	8250	1871	0	0	0	0	0	0	0	10740
1998	18	17524	11849	1127	247	57	0	0	0	0	0	30822
1999	1338	2563	18123	3139	691	201	0	0	0	0	0	26055
2000	853	11206	4890	1475	55	57	0	0	0	0	0	18536
2001	3536	4232	2647	355	281	207	57	0	0	0	0	11315
2002	9561	22393	5834	4431	518	571	75	0	0	0	0	43383
2003	1480	1578	3779	937	752	503	93	0	0	0	0	9122
2004	545	1397	1423	1176	220	187	8	0	0	0	0	4956
2005	480	893	1879	516	79	47	15	0	0	0	0	3909
2006	4809	8083	2354	642	53	13	16	0	0	0	0	15970
2007	1412	3936	5370	1420	94	41	87	0	0	0	0	12360

Table 11. Commercial fishery scup discards mean weights (kg) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	0.033	0.108	0.125	0.198	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.118
1985	0.033	0.108	0.125	0.198	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.057
1986	0.033	0.108	0.125	0.198	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.126
1987	0.033	0.108	0.125	0.198	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.124
1988	0.033	0.108	0.125	0.198	0.222	0.000	0.000	0.000	0.000	0.000	0.000	0.120
1989	0.039	0.060	0.111	0.198	0.217	0.000	0.000	0.000	0.000	0.000	0.000	0.094
1990	0.026	0.121	0.137	0.187	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.134
1991	0.057	0.127	0.163	0.207	0.252	0.000	0.000	0.000	0.000	0.000	0.000	0.135
1992	0.033	0.078	0.136	0.243	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.075
1993	0.026	0.106	0.154	0.269	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.102
1994	0.024	0.068	0.122	0.198	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.060
1995	0.038	0.037	0.229	0.310	0.331	0.000	0.000	0.000	0.000	0.000	0.000	0.039
1996	0.033	0.110	0.169	0.240	0.268	0.532	0.000	0.000	0.000	0.000	0.000	0.154
1997	0.020	0.028	0.137	0.362	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.170
1998	0.092	0.069	0.147	0.224	0.418	0.564	0.000	0.000	0.000	0.000	0.000	0.108
1999	0.010	0.037	0.158	0.398	0.599	0.690	0.000	0.000	0.000	0.000	0.000	0.183
2000	0.044	0.076	0.195	0.299	0.486	0.768	0.000	0.000	0.000	0.000	0.000	0.127
2001	0.015	0.063	0.168	0.345	0.500	0.670	0.944	0.000	0.000	0.000	0.000	0.108
2002	0.035	0.064	0.201	0.361	0.524	0.757	1.071	0.000	0.000	0.000	0.000	0.123
2003	0.022	0.091	0.212	0.315	0.537	0.784	0.878	0.000	0.000	0.000	0.000	0.236
2004	0.029	0.109	0.166	0.268	0.371	0.453	0.750	0.000	0.000	0.000	0.000	0.180
2005	0.019	0.090	0.154	0.267	0.416	0.652	0.912	0.000	0.000	0.000	0.000	0.153
2006	0.026	0.086	0.166	0.217	0.313	0.549	0.755	0.000	0.000	0.000	0.000	0.087
2007	0.041	0.094	0.163	0.282	0.342	0.597	0.770	0.000	0.000	0.000	0.000	0.148

Table 12. Summary of the landed fish sampling intensity for scup in the recreational fishery (MRFSS sampling).

Year	No. of lengths	Estimated landings (A + B1) (mt)	Sampling intensity (mt/100 lengths)
1981	642	2,636	411
1982	1,057	2,361	223
1983	1,384	2,836	205
1984	943	1,096	116
1985	741	2,764	373
1986	2,580	5,264	204
1987	777	2,811	362
1988	2,156	1,936	90
1989	4,111	2,521	61
1990	2,698	1,878	70
1991	4,230	3,668	87
1992	4,419	2,001	45
1993	2,206	1,450	66
1994	1,374	1,192	87
1995	822	609	74
1996	526	978	186
1997	399	543	136
1998	286	397	139
1999	265	856	323
2000	524	2,469	471
2001	1,038	1,933	186
2002	1,006	1,644	163
2003	2,508	3,848	153
2004	1,802	1,923	107
2005	1,794	1,153	64
2006	2,217	1,331	60
2007	2,262	1,655	73

Table 13. Recreational fishery scup landings (000s) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	23	3036	1353	570	182	219	442	86	51	30	66	6058
1985	431	4478	3054	1330	788	441	137	33	0	0	115	10807
1986	538	4353	15570	2617	845	431	87	5	4	57	315	24822
1987	77	2299	4686	1261	824	598	112	0	0	11	46	9914
1988	9	1001	2229	1824	460	216	123	92	20	0	86	6060
1989	311	3978	3371	823	86	235	154	13	0	50	148	9169
1990	169	1352	5091	1102	147	112	36	7	2	3	22	8043
1991	299	4838	3797	3319	700	210	19	0	2	20	68	13272
1992	99	1850	4457	530	672	84	12	6	8	7	30	7755
1993	46	1245	3051	908	254	133	2	2	0	2	7	5650
1994	31	1473	1840	691	95	88	21	6	0	0	0	4245
1995	15	613	1399	225	89	20	3	3	0	0	0	2367
1996	9	351	1467	812	365	54	10	15	0	0	0	3083
1997	32	52	983	562	168	63	33	17	6	0	0	1916
1998	13	223	257	415	248	19	13	23	0	0	0	1211
1999	61	469	2169	359	182	11	0	0	0	0	0	3251
2000	6	912	3443	2113	641	129	0	0	0	0	0	7244
2001	0.3	514	1511	1705	806	244	101	218	0	0	0	5099
2002	7	70	688	1635	1005	179	24	39	0	0	0	3647
2003	0.3	75	1723	2655	3127	1407	350	115	0	0	0	9452
2004	0.9	45	284	1551	1441	1166	470	32	0	0	0	4990
2005	0	13	100	513	700	845	349	26	0	0	0	2546
2006	1	50	658	819	404	431	541	46	0	1	0	2951
2007	3	47	456	1347	775	378	605	206	26	1	0	3844

Table 14. Recreational fishery scup landings mean weights (kg) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	0.044	0.117	0.266	0.373	0.472	0.557	0.678	0.825	0.912	1.002	1.145	0.274
1985	0.038	0.125	0.253	0.340	0.573	0.718	0.913	1.087	0.000	0.000	1.673	0.270
1986	0.052	0.101	0.234	0.374	0.534	0.654	0.801	0.912	1.003	1.003	1.638	0.261
1987	0.029	0.105	0.242	0.381	0.548	0.698	0.737	0.000	0.000	1.003	3.808	0.302
1988	0.026	0.142	0.240	0.325	0.497	0.663	0.794	1.144	1.099	0.000	1.532	0.330
1989	0.035	0.123	0.234	0.376	0.433	0.653	0.696	0.657	0.000	1.003	1.332	0.235
1990	0.057	0.128	0.208	0.325	0.461	0.567	0.761	0.939	1.088	1.202	1.947	0.225
1991	0.064	0.150	0.275	0.361	0.474	0.714	0.675	0.000	1.003	1.003	1.305	0.271
1992	0.092	0.140	0.240	0.373	0.454	0.598	0.804	0.859	1.311	1.003	2.117	0.256
1993	0.087	0.135	0.226	0.336	0.460	0.524	0.912	0.827	0.000	1.026	1.100	0.242
1994	0.054	0.180	0.281	0.357	0.467	0.674	0.905	1.430	0.000	0.000	0.000	0.274
1995	0.065	0.155	0.279	0.450	0.557	0.756	1.044	1.311	0.000	0.000	0.000	0.279
1996	0.093	0.171	0.231	0.368	0.540	0.772	0.876	1.383	0.000	0.000	0.000	0.314
1997	0.083	0.110	0.253	0.299	0.510	0.684	0.819	1.342	0.779	0.000	0.000	0.318
1998	0.072	0.121	0.211	0.312	0.491	0.866	1.066	1.950	0.000	0.000	0.000	0.337
1999	0.095	0.173	0.274	0.451	0.635	0.900	0.000	0.000	0.000	0.000	0.000	0.298
2000	0.075	0.138	0.296	0.424	0.544	0.825	0.000	0.000	0.000	0.000	0.000	0.345
2001	0.092	0.220	0.344	0.485	0.637	0.776	0.875	1.127	0.000	0.000	0.000	0.490
2002	0.110	0.152	0.296	0.427	0.618	0.795	0.932	1.427	0.000	0.000	0.000	0.481
2003	0.092	0.161	0.314	0.416	0.536	0.720	0.908	1.499	0.000	0.000	0.000	0.512
2004	0.094	0.151	0.325	0.437	0.523	0.575	0.858	0.748	0.000	0.000	0.000	0.527
2005	0.000	0.112	0.270	0.384	0.516	0.679	0.881	1.098	0.000	0.000	0.000	0.588
2006	0.092	0.151	0.304	0.411	0.525	0.695	0.883	0.999	0.000	1.311	0.000	0.536
2007	0.111	0.152	0.313	0.418	0.509	0.672	0.882	0.935	1.056	1.322	0.000	0.551

Table 15. Recreational fishery scup discards (000s) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	Metric tons
1984	2	255	0	0	0	0	0	0	0	0	0	257	30
1985	40	417	0	0	0	0	0	0	0	0	0	457	54
1986	100	807	0	0	0	0	0	0	0	0	0	907	87
1987	12	357	0	0	0	0	0	0	0	0	0	369	38
1988	2	219	0	0	0	0	0	0	0	0	0	221	31
1989	24	308	0	0	0	0	0	0	0	0	0	332	39
1990	36	284	0	0	0	0	0	0	0	0	0	320	38
1991	31	505	0	0	0	0	0	0	0	0	0	536	78
1992	17	325	0	0	0	0	0	0	0	0	0	342	47
1993	8	204	0	0	0	0	0	0	0	0	0	212	28
1994	4	203	0	0	0	0	0	0	0	0	0	207	37
1995	63	135	0	0	0	0	0	0	0	0	0	198	13
1996	44	222	0	0	0	0	0	0	0	0	0	266	20
1997	163	10	0	0	0	0	0	0	0	0	0	173	8
1998	80	139	0	0	0	0	0	0	0	0	0	219	14
1999	208	0	0	0	0	0	0	0	0	0	0	208	6
2000	20	561	25	0	0	0	0	0	0	0	0	606	55
2001	0.3	484	325	0	0	0	0	0	0	0	0	809	165
2002	14	199	381	55	0	0	0	0	0	0	0	649	137
2003	1	168	550	63	0	0	0	0	0	0	0	782	158
2004	7	232	242	211	0	0	0	0	0	0	0	692	134
2005	5	88	232	135	44	46	11	0	0	0	0	561	165
2006	1	143	644	66	0	0	0	0	0	0	0	854	185
2007	20	185	375	124	20	2	1	0	0	0	0	727	

Table 16. Recreational fishery scup discards mean weights at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	0.044	0.117	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.116
1985	0.038	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.117
1986	0.052	0.101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.096
1987	0.029	0.105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.103
1988	0.026	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.141
1989	0.035	0.123	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.117
1990	0.057	0.128	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.120
1991	0.064	0.150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.145
1992	0.092	0.140	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.138
1993	0.087	0.135	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.133
1994	0.054	0.180	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.178
1995	0.063	0.065	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.064
1996	0.075	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.075
1997	0.043	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045
1998	0.061	0.068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.065
1999	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.028
2000	0.075	0.087	0.189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.091
2001	0.092	0.194	0.218	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.204
2002	0.110	0.155	0.238	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.211
2003	0.092	0.141	0.215	0.251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.202
2004	0.094	0.149	0.206	0.233	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.194
2005	0.035	0.114	0.215	0.311	0.481	0.698	0.810	1.110	0.000	0.000	0.000	0.294
2006	0.092	0.148	0.229	0.243	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.216
2007	0.067	0.127	0.220	0.322	0.408	0.567	0.000	0.000	0.000	0.000	0.000	0.215

Table 17. Total fishery scup catch (000s) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	104	16829	13834	8584	5996	1637	978	337	52	30	66	48447
1985	53323	21233	16355	10086	3438	787	657	192	0	0	115	106186
1986	725	6641	41931	7992	1852	506	193	342	9	57	315	60563
1987	169	11149	26853	13026	2554	775	236	21	18	11	47	54859
1988	1580	3341	19180	12689	2894	274	250	131	20	0	86	40445
1989	739	14712	21917	8707	799	257	223	37	0	50	148	47590
1990	1027	10152	32543	10684	1169	467	185	9	2	3	22	56263
1991	2124	24986	22150	15254	2866	619	212	0	2	20	68	68302
1992	38941	13775	41720	4339	4469	1327	150	6	8	7	30	104772
1993	5441	3228	16569	8009	1754	1276	126	2	0	2	7	36414
1994	6893	5827	18806	7123	931	170	60	6	0	0	0	39816
1995	1933	53120	10079	3211	994	268	34	3	0	0	0	69642
1996	252	3928	13800	3143	1156	524	72	15	0	0	0	22890
1997	196	811	11313	6522	900	147	130	17	6	0	0	20042
1998	111	18226	13559	3915	1587	457	15	23	0	0	0	37893
1999	1607	3033	21440	6186	1400	329	0	0	0	0	0	33995
2000	879	12679	9019	5732	1207	201	0	0	0	0	0	29717
2001	3537	5261	6118	5093	1782	497	164	219	1	0	0	22671
2002	9582	22786	8122	11172	3654	1142	104	39	0	0	0	56601
2003	1481	1823	7007	6629	8432	3041	564	156	5	14	0	29152
2004	553	1675	2793	5344	4487	3442	774	72	4	14	0	19158
2005	465	1025	2894	2722	3184	3453	1182	119	3	3	0	15050
2006	4811	8365	5889	3758	1576	1921	1776	412	28	4	0	28540
2007	1435	4259	8988	5552	2279	1101	1633	796	150	13	0	26206

Table 18. Total fishery scup catch mean weights (kg) at age.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1984	0.036	0.117	0.168	0.288	0.348	0.419	0.727	0.988	0.924	1.002	1.145	0.222
1985	0.033	0.116	0.179	0.289	0.446	0.629	0.775	1.050	0.000	0.000	1.673	0.122
1986	0.050	0.104	0.193	0.351	0.611	0.656	0.916	1.241	1.344	1.003	1.638	0.236
1987	0.031	0.112	0.174	0.253	0.452	0.663	0.742	1.194	1.068	1.003	3.727	0.206
1988	0.033	0.122	0.169	0.265	0.449	0.657	0.754	1.096	1.099	0.000	1.532	0.223
1989	0.037	0.087	0.147	0.277	0.369	0.653	0.704	0.903	0.000	1.003	1.332	0.165
1990	0.032	0.123	0.164	0.239	0.379	0.530	0.826	0.918	1.088	1.195	1.947	0.179
1991	0.058	0.138	0.201	0.278	0.409	0.580	0.724	0.000	1.003	1.003	1.305	0.206
1992	0.033	0.099	0.164	0.329	0.424	0.509	0.854	0.859	1.311	1.004	2.117	0.131
1993	0.027	0.121	0.184	0.270	0.445	0.512	0.784	0.827	0.000	1.026	1.100	0.200
1994	0.024	0.125	0.189	0.267	0.434	0.669	0.799	1.430	0.000	0.000	0.000	0.174
1995	0.039	0.044	0.219	0.306	0.409	0.501	0.752	1.311	0.000	0.000	0.000	0.088
1996	0.042	0.122	0.190	0.317	0.487	0.577	0.796	1.327	0.000	0.000	0.000	0.221
1997	0.049	0.066	0.168	0.318	0.409	0.595	0.767	1.342	0.779	0.000	0.000	0.231
1998	0.067	0.072	0.160	0.287	0.458	0.570	1.024	1.950	0.000	0.000	0.000	0.149
1999	0.016	0.058	0.173	0.368	0.565	0.718	0.947	1.538	0.000	0.000	0.000	0.212
2000	0.045	0.081	0.235	0.371	0.524	0.798	0.947	1.538	0.000	0.000	0.000	0.205
2001	0.015	0.091	0.240	0.392	0.553	0.712	0.896	1.126	0.000	0.000	0.000	0.253
2002	0.035	0.066	0.223	0.360	0.515	0.701	1.024	1.427	0.000	0.000	0.000	0.186
2003	0.022	0.099	0.247	0.376	0.501	0.708	0.893	1.337	1.241	0.000	0.000	0.396
2004	0.030	0.116	0.230	0.374	0.512	0.578	0.839	0.889	1.370	1.674	0.000	0.412
2005	0.019	0.096	0.190	0.346	0.480	0.659	0.832	1.056	1.099	1.311	0.000	0.433
2006	0.026	0.089	0.233	0.335	0.472	0.614	0.775	0.924	1.108	1.313	0.000	0.253
2007	0.042	0.099	0.205	0.350	0.477	0.653	0.810	0.905	1.073	1.668	0.000	0.316

Table 19. Extended series of total fishery catch. Catches in metric tons (mt). To estimate commercial discards for 1960-1988, D/L ratio for 1989-1997 = 0.504 applied to commercial landings. To estimate recreational catch for 1960-1980, 50% of the Mayo 1982 estimates were included.

Year	Comm. Land.	Comm. Disc.	DWF Land.	Rec Catch	Total Catch
1960	22236	11198	0	3765	37,199
1961	20944	10548	0	3716	35,208
1962	20831	10491	0	3667	34,989
1963	18884	9510	5863	3528	37,785
1964	17204	8664	459	3341	29,668
1965	15785	7950	2089	3265	29,089
1966	11960	6023	823	2474	21,280
1967	8748	4406	896	1879	15,929
1968	6630	3339	2251	1473	13,693
1969	5149	2593	485	1107	9,334
1970	4493	2263	288	1003	8,047
1971	3974	2001	889	853	7,717
1972	4203	2117	1647	796	8,763
1973	5024	2530	1783	1118	10,455
1974	7106	3579	958	1,388	13,031
1975	7623	3839	685	1,403	13,550
1976	7302	3677	87	1,183	12,249
1977	8330	4195	28	1,398	13,951
1978	8936	4500	3	1,256	14,695
1979	8585	4324	0	1,198	14,107
1980	8424	4242	16	3,109	15,791
1981	9,856	4964	1	2,636	17,457
1982	8,704	4383	0	2,361	15,448
1983	7,794	3925	0	2,836	14,555
1984	7,769	2158	0	1,126	11,053
1985	6,727	4184	0	2,818	13,729
1986	7,176	2005	0	5,351	14,532
1987	6,276	2537	0	2,849	11,662
1988	5,943	1657	0	1,967	9,567
1989	3,984	2229	0	2,560	8,773
1990	4,571	3909	0	1,916	10,396
1991	7,081	3530	0	3,746	14,357
1992	6,259	5668	0	2,048	13,975
1993	4,726	1436	0	1,478	7,640
1994	4,392	807	0	1,229	6,428
1995	3,073	2,057	0	622	5,752
1996	2,945	1,522	0	998	5,465
1997	2,188	1,843	0	551	4,582
1998	1,896	3,331	0	411	5,638
1999	1,505	4,819	0	862	7,186
2000	1,207	2,352	0	2,524	6,083
2001	1,729	1,499	0	2,098	5,326
2002	3,173	5,636	0	1,781	10,590
2003	4,405	2,153	0	4,006	10,564
2004	4,231	893	0	2,057	7,181
2005	4,266	662	0	1,318	6,246
2006	4,062	1,387	0	1,516	6,965
2007	4,196	1,859	0	1,812	7,867

Table 20. NEFSC spring and fall trawl survey indices for scup. Strata set includes only offshore strata 1-12, 23, 25, and 61-76 for consistency over entire time series. Strata set excludes inshore strata 1-61 that are included in the 1984 and later indices at age in Table 22.

Year	Spring No./tow	Spring Kg/tow	Spring SSB kg/tow	Spring SSB 3-yr avg	Fall No./tow	Fall Kg/tow
1963					2.12	1.21
1964					118.70	2.23
1965					3.84	0.62
1966					2.00	0.41
1967					29.38	1.46
1968	59.21	2.25	0.94		14.35	0.54
1969	2.26	0.40	0.39	0.88	99.41	4.48
1970	78.50	3.01	1.30	1.09	10.34	0.22
1971	70.91	2.41	1.57	1.28	7.730	0.25
1972	49.80	2.30	0.98	1.21	40.56	2.34
1973	3.62	1.19	1.09	1.38	22.82	0.93
1974	30.28	3.24	2.06	1.92	9.94	1.01
1975	14.01	3.12	2.61	1.73	52.21	3.40
1976	4.09	0.63	0.53	2.50	161.14	7.35
1977	42.46	4.48	4.35	2.49	32.69	1.71
1978	39.85	3.49	2.59	2.77	12.17	1.32
1979	22.42	1.95	1.38	1.69	15.77	0.61
1980	9.31	1.31	1.09	1.12	11.05	0.92
1981	14.72	1.16	0.89	1.00	67.14	3.01
1982	7.88	1.16	1.02	0.65	25.47	1.17
1983	0.80	0.29	0.03	0.46	4.59	0.34
1984	8.52	0.51	0.33	0.24	24.03	1.22
1985	14.67	0.80	0.37	0.68	68.30	3.56
1986	11.74	1.30	1.33	0.98	46.19	1.66
1987	10.82	1.21	1.24	1.10	5.76	0.15
1988	25.41	1.26	0.73	0.66	5.75	0.09
1989	1.63	0.12	0.00	0.35	94.05	3.37
1990	1.17	0.39	0.34	0.26	16.53	0.83
1991	12.61	0.75	0.45	0.32	9.52	0.43
1992	6.79	0.40	0.21	0.32	16.19	1.12
1993	2.93	0.33	0.31	0.18	0.43	0.04
1994	1.54	0.09	0.03	0.15	3.59	0.11
1995	2.90	0.22	0.12	0.06	24.72	0.91
1996	0.53	0.03	0.02	0.08	4.46	0.23
1997	0.91	0.11	0.11	0.06	16.92	0.88
1998	40.04	0.87	0.05	0.08	25.35	0.69
1999	1.70	0.12	0.09	0.08	85.23	2.07
2000	6.71	0.33	0.11	0.25	99.33	4.79
2001	13.03	0.80	0.54	3.30	20.28	1.11
2002	154.86	13.46	9.24	3.31	95.62	3.79
2003	6.01	0.28	0.15	3.74	28.18	0.80
2004	57.58	2.84	1.82	0.69	10.38	0.27
2005	19.22	0.55	0.10	1.32	4.50	0.07
2006	5.71	2.10	2.04	0.76	96.41	1.92
2007	10.60	0.36	0.14	1.16	41.52	2.21
2008	9.68	1.44	1.30			

Table 21. NEFSC spring trawl survey stratified mean number of scup per tow at age. Strata set includes only offshore strata 1-12, 23, 25, and 61-76, corresponding to the spring survey indices in Table 20.

Spring	Age														
Year	0	1	2	3	4	5	6	7	8	9	10	11	Total	age 2+	age 3+
1977		6.62	32.08	3.54	0.16	0.04	0.01	0.01					42.46	35.84	3.76
1978		26.90	4.67	6.50	1.31	0.32	0.12	0.03					39.85	12.95	8.28
1979		15.63	4.04	0.88	1.28	0.37	0.06	0.13	0.02	0.01			22.42	6.79	2.75
1980		2.39	5.61	0.57	0.17	0.25	0.15	0.08	0.08	0.01			9.31	6.92	1.31
1981		10.78	2.16	1.15	0.17	0.14	0.05	0.15	0.12				14.72	3.94	1.78
1982		3.80	1.77	1.39	0.38	0.17	0.13	0.07	0.07	0.10			7.88	4.08	2.31
1983		0.70	0.03	0.06				0.01					0.80	0.10	0.07
1984		6.14	1.97	0.22	0.12	0.07							8.52	2.38	0.41
1985		12.11	2.32	0.20	0.04								14.67	2.56	0.24
1986		1.05	10.26	0.43									11.74	10.69	0.43
1987		4.57	3.60	1.81	0.74	0.04	0.02	0.03	0.01				10.82	6.25	2.65
1988		16.74	8.36	0.17	0.03	0.01	0.03	0.07					25.41	8.67	0.31
1989		0.79	0.74	0.09	0.01								1.63	0.84	0.10
1990		0.12	0.30	0.30	0.18	0.09	0.13	0.05					1.17	1.05	0.75
1991		10.61	0.70	1.11	0.19								12.61	2.00	1.30
1992		5.72	0.88	0.07	0.05	0.06	0.01						6.79	1.07	0.19
1993		0.61	2.02	0.17	0.11	0.02							2.93	2.32	0.30
1994		1.34	0.16	0.04									1.54	0.20	0.04
1995		2.29	0.44	0.11	0.05	0.01							2.90	0.61	0.17
1996		0.44	0.05	0.03	0.01								0.53	0.09	0.04
1997		0.17	0.64	0.10									0.91	0.74	0.10
1998		39.90	0.12	0.02									40.04	0.14	0.02
1999		1.03	0.67										1.70	0.67	0.00
2000		5.93	0.71	0.07									6.71	0.78	0.07
2001		7.90	5.03	0.08		0.02							13.03	5.13	0.10
2002		109.01	15.60	26.67	3.27	0.31							154.86	45.85	30.25
2003		5.08	0.79	0.07	0.06								6.01	0.92	0.14
2004		38.69	16.15	1.31	0.82	0.60							57.58	18.89	2.74
2005		18.26	0.81	0.13	0.02								19.22	0.96	0.15
2006		1.56	0.51	0.80	0.35	0.70	1.69	0.10					5.71	4.15	3.64
2007		9.73	0.41	0.44	0.00	0.01	0.01						10.60	0.87	0.46

Table 22. NEFSC fall trawl survey stratified mean number of scup per tow at age. Strata set includes offshore strata 1-12, 23, 25, 61-76, and inshore strata 1-61.

Fall						Age									
Year	0	1	2	3	4	5	6	7	8	9	10	11	Total	age 2+	age 3+
1984	47.64	9.20	0.34	0.03	0.01		0.01						59.96	0.39	0.05
1985	61.22	11.53	1.10	0.26	0.06	0.05							74.71	1.47	0.37
1986	70.19	6.58	0.57		0.01								77.36	0.58	0.01
1987	49.93	29.85	0.46	0.01									80.45	0.47	0.01
1988	47.44	15.95	0.67	0.10									64.22	0.77	0.10
1989	176.37	25.92	0.66	0.03									202.99	0.69	0.03
1990	77.45	9.21	0.75	0.04									87.46	0.79	0.04
1991	151.62	12.51	0.07	0.02									164.24	0.09	0.02
1992	25.92	14.51	1.66	0.04	0.02								42.15	1.72	0.06
1993	46.78	9.76	0.32										56.86	0.32	0.00
1994	39.54	3.92	0.04	0.01									43.52	0.05	0.01
1995	33.04	2.61	0.08	0.01									35.74	0.09	0.01
1996	24.42	2.86	0.43	0.01									27.73	0.44	0.01
1997	46.91	0.61	0.02		0.01								47.66	0.03	0.01
1998	57.73	9.64	0.09	0.03	0.01								67.50	0.13	0.04
1999	96.06	9.77	1.37	0.07	0.01								107.28	1.45	0.08
2000	98.72	20.60	3.14	0.48	0.11	0.07							123.12	3.80	0.66
2001	91.84	10.32	1.82	0.12	0.04	0.01							104.15	1.99	0.17
2002	180.09	43.31	0.90	0.35	0.04	0.01							224.70	1.30	0.40
2003	53.70	5.66	2.30	1.33	0.82	0.20	0.02						64.02	4.67	2.37
2004	41.83	33.46	1.14	1.70	0.39	0.12	0.04	0.01					78.69	3.40	2.26
2005	27.26	7.94	1.02	0.14	0.04	0.04							36.43	1.23	0.21
2006	146.85	20.08	0.92	0.07	0.05	0.01	0.03	0.01					168.02	1.09	0.17
2007	113.95	40.28	0.60	0.24	0.05	0.03	0.05	0.02					155.22	0.99	0.39

Table 23. NEFSC 1992-2007 Winter trawl survey indices of abundance for scup, offshore survey strata 1-12 and 61-76.

Year	Mean number per tow	Mean kg per tow
1992	65.56	2.87
1993	25.71	2.73
1994	17.09	0.66
1995	69.50	2.26
1996	18.28	1.19
1997	13.90	0.32
1998	46.92	1.20
1999	15.04	0.71
2000	24.21	1.33
2001	55.49	1.58
2002	267.83	7.56
2003	24.16	0.49
2004	380.59	3.82
2005	84.74	1.96
2006	201.96	3.72
2007	101.08	2.95
Mean	88.25	2.21

Table 24. NEFSC 1992-2007 winter trawl survey stratified mean number of scup per tow at age, offshore survey strata 1-12 and 61-76. The 1992, 1993, and 1996 lengths are aged with the corresponding annual spring survey age-length key.

Winter	Age											
Year	0	1	2	3	4	5	6	7	8	Total	age 2+	age 3+
1992		59.78	4.93	0.20	0.09	0.10	0.46			65.56	5.78	0.85
1993		2.51	22.05	0.56	0.57	0.02				25.71	23.19	1.15
1994		16.31	0.73	0.02	0.02	0.01				17.09	0.78	0.05
1995		67.35	1.94	0.15	0.01	0.01	0.02	0.01		69.50	2.15	0.21
1996		12.94	5.31	0.03	0.01					18.28	5.34	0.04
1997		13.27	0.52	0.11						13.90	0.64	0.11
1998		45.62	0.75	0.22	0.21	0.08	0.03	0.01		46.92	1.30	0.55
1999		12.48	2.41	0.12	0.02	0.01				15.04	2.56	0.15
2000		20.28	3.21	0.68	0.03			0.01		24.21	3.93	0.72
2001		48.54	6.48	0.36	0.09	0.02				55.49	6.95	0.47
2002		257.08	7.44	2.96	0.33	0.01	0.01			267.83	10.75	3.31
2003		23.77	0.28	0.07	0.03		0.02			24.16	0.39	0.11
2004		380.22	0.29	0.07	0.01					380.59	0.37	0.08
2005		80.03	4.62	0.09						84.74	4.71	0.09
2006		198.52	2.64	0.66	0.03	0.04	0.07			201.96	3.44	0.80
2007		99.18	1.86	0.02	0.02					101.08	1.90	0.04

Table 25. MADMF trawl survey mean number of scup per tow and mean weight (kg) per tow for spring (survey regions 1-3) and fall (survey regions 1-5). Time series revised in 2008 to account for stratum area changes effective in 2006.

	Spring		Fall	
Year	No./Tow	Kg/tow	No./Tow	Kg/Tow
1978	90.08	31.71	1859.40	14.82
1979	76.14	18.05	1150.16	12.20
1980	189.82	41.39	1183.02	12.53
1981	298.53	17.63	971.87	14.34
1982	10.46	0.98	2153.76	9.17
1983	25.29	3.51	1623.13	12.90
1984	17.90	6.53	963.49	12.29
1985	67.02	3.40	647.63	12.09
1986	44.17	7.35	773.61	9.15
1987	6.05	1.37	561.61	7.72
1988	13.98	2.09	1396.86	14.15
1989	13.32	2.02	580.73	7.77
1990	144.06	21.45	1128.07	7.21
1991	28.73	6.05	1150.71	10.18
1992	14.49	2.52	2440.96	11.54
1993	19.13	4.23	1023.11	10.06
1994	9.71	2.85	820.31	9.84
1995	49.29	2.76	507.02	4.11
1996	5.18	0.68	1019.96	9.15
1997	3.22	0.71	921.21	7.25
1998	1.37	0.21	709.61	6.94
1999	11.61	1.93	1212.23	18.07
2000	307.00	18.02	867.00	11.63
2001	7.28	2.37	1205.60	9.89
2002	281.36	18.77	1137.64	8.32
2003	0.22	0.07	3209.61	14.87
2004	41.71	13.04	1483.56	10.07
2005	9.32	3.25	4005.89	21.53
2006	92.97	22.41	1231.49	9.46
2007	13.30	2.03	1774.23	11.65
2008	145.72	27.89		
Mean	65.76	9.27	1323.78	11.03

Table 26. RIDFW trawl survey mean number of scup per tow and mean weight (kg) per tow for spring and fall.

	Spring		Fall	
Year	No./Tow	Kg/tow	No./Tow	Kg/Tow
1981	12.49	0.40	196.22	2.54
1982	0.43	0.04	63.87	0.70
1983	3.59	0.32	173.63	2.75
1984	13.24	0.88	589.68	10.57
1985	8.30	0.41	74.27	1.51
1986	1.78	0.33	340.06	4.20
1987	0.04	0.01	314.20	4.73
1988	0.23	0.04	804.00	7.10
1989	0.17	0.04	326.86	6.62
1990	0.64	0.15	527.31	5.66
1991	2.93	0.57	655.69	16.62
1992	1.88	0.61	1105.51	9.10
1993	1.12	0.06	1246.35	8.90
1994	2.08	0.53	236.12	3.66
1995	4.33	0.53	423.02	5.03
1996	0.52	0.07	184.73	3.83
1997	1.93	0.15	597.90	6.04
1998	0.15	0.03	150.38	1.89
1999	0.38	0.07	832.22	12.39
2000	84.05	3.54	588.73	9.11
2001	29.68	5.08	1139.17	11.07
2002	174.80	10.28	716.12	9.27
2003	0.00	0.00	1181.83	11.38
2004	2.59	0.45	1616.24	9.58
2005	2.95	1.63	2216.72	21.35
2006	53.12	3.90	765.90	11.26
2007	1.95	0.24	2410.00	23.76
2008				
Mean	15.01	1.12	721.36	8.17

Table 27. CTDEP spring trawl survey mean number of scup per tow at age, total mean number per tow, and total mean weight (kg) per tow.

							Age								Total	Total	Age
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	No./Tow	Kg/Tow	2+
1984	0.49	1.31	0.59	0.30	0.08	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	2.80	0.64	2.31
1985	2.94	2.00	0.33	0.24	0.05	0.02	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.00	5.61	1.22	2.71
1986	4.44	1.65	0.99	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.40	0.78	2.79
1987	0.43	1.65	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.37	1.76
1988	1.18	0.30	0.51	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.32	0.88
1989	5.63	0.56	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	0.63	0.62
1990	2.56	2.06	0.21	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.61	2.30
1991	4.25	1.44	1.26	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.09	0.94	2.80
1992	0.39	1.21	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.48	1.36
1993	0.04	2.29	0.19	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.49	2.49
1994	0.81	2.03	0.93	0.10	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.88	0.58	3.09
1995	12.94	0.39	0.20	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.24	0.65	0.64
1996	5.20	2.48	0.07	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.25	0.73	2.56
1997	3.16	2.61	1.68	0.06	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	0.75	4.39
1998	10.07	0.58	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25	0.75	0.76
1999	2.71	1.75	0.16	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	0.56	2.02
2000	124.51	17.18	4.24	0.20	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.46	4.56	21.71
2001	1.65	18.99	1.57	0.25	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20	2.85	20.84
2002	49.15	66.61	123.25	17.44	1.29	0.10	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	257.91	13.16	208.76
2003	0.14	4.05	3.28	4.96	0.61	0.07	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	13.12	2.28	12.98
2004	0.01	3.97	8.96	4.90	8.21	0.76	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.00	26.92	3.93	26.90
2005	1.16	1.28	1.06	1.51	1.27	1.94	0.22	0.05	0.00	0.00	0.00	0.00	0.00	0.00	8.49	1.65	7.33
2006	18.48	23.72	5.63	2.07	2.56	3.16	2.90	0.53	0.01	0.00	0.00	0.00	0.00	0.00	59.06	10.41	40.58
2007	7.51	15.86	5.84	1.49	0.55	0.54	0.54	0.39	0.07	0.01	0.00	0.00	0.00	0.00	32.80	3.32	25.29

Table 28. CTDEP fall trawl survey mean number of scup per tow at age, total mean number per tow, and total mean weight (kg) per tow.

	Age											Total	Total	Age
Year	0	1	2	3	4	5	6	7	8	9	10	No/Tow	Kg/Tow	2+
1984	7.99	1.04	0.78	0.52	0.28	0.09	0.02	0.00	0.00	0.00	0.00	10.72	1.36	1.69
1985	25.01	4.71	0.40	0.59	0.19	0.04	0.03	0.00	0.00	0.00	0.00	30.97	2.50	1.25
1986	13.06	9.98	2.50	0.19	0.01	0.01	0.01	0.00	0.00	0.00	0.00	25.76	2.95	2.72
1987	12.47	4.17	1.25	0.58	0.06	0.01	0.01	0.00	0.00	0.00	0.00	18.55	1.79	1.91
1988	31.89	5.71	1.82	0.24	0.03	0.00	0.00	0.00	0.00	0.00	0.00	39.69	2.27	2.09
1989	40.88	22.60	1.51	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	65.08	3.65	1.60
1990	54.34	7.74	6.95	0.40	0.03	0.01	0.01	0.00	0.00	0.01	0.00	69.49	5.00	7.41
1991	291.58	17.03	1.76	1.04	0.15	0.01	0.00	0.00	0.00	0.00	0.00	311.57	8.30	2.96
1992	50.91	26.58	5.54	0.40	0.29	0.01	0.01	0.00	0.00	0.00	0.00	83.74	4.96	6.25
1993	74.06	1.83	1.02	0.12	0.01	0.01	0.00	0.00	0.00	0.00	0.00	77.05	3.72	1.16
1994	90.76	1.12	0.46	0.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	92.53	3.33	0.65
1995	32.46	26.52	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.13	4.63	0.15
1996	51.50	8.56	1.37	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	61.47	3.68	1.41
1997	31.79	8.68	0.63	0.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	41.28	2.49	0.81
1998	90.40	12.24	0.54	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	103.27	4.50	0.63
1999	498.18	30.93	8.35	0.19	0.02	0.01	0.00	0.00	0.00	0.00	0.00	537.68	22.72	8.57
2000	250.39	261.45	8.32	0.79	0.14	0.01	0.00	0.00	0.00	0.00	0.00	521.10	30.76	9.26
2001	140.51	16.90	18.42	1.61	0.19	0.03	0.00	0.00	0.00	0.00	0.00	177.66	11.28	20.25
2002	259.90	47.62	23.32	16.81	0.67	0.33	0.05	0.00	0.01	0.00	0.00	348.70	23.69	41.18
2003	52.91	15.35	32.07	22.39	26.44	2.49	0.54	0.02	0.02	0.00	0.00	152.23	28.95	83.96
2004	251.05	4.13	8.34	15.08	5.98	6.25	0.53	0.07	0.01	0.02	0.00	291.46	16.31	36.28
2005	373.32	32.56	8.14	2.44	4.01	1.50	1.69	0.33	0.06	0.00	0.00	424.05	13.79	18.17
2006	52.16	51.02	9.52	2.34	0.26	0.35	0.38	0.68	0.04	0.00	0.00	116.75	10.49	13.57
2007	319.89	118.06	29.34	5.93	0.90	0.23	0.30	0.31	0.31	0.03	0.00	475.30	24.15	37.35

Table 29. NYDEC trawl survey indices at ages 0, 1 and 2 and older (2+); NJBMF trawl survey mean number of scup per tow and mean weight (kg) per tow; VIMS age0 index.

	NYDEC Trawl			NJBMF Trawl		VIMS
Year	Age 0	Age 1	Age 2+	No/tow	Kg/tow	Age 0
1987	0.33	3.43	0.09			
1988	1.19	1.96	0.05			2.07
1989	0.67	11.02	0.04	72.75	2.75	3.07
1990	5.32	1.30	0.14	74.72	3.77	4.92
1991	13.17	2.31	0.22	200.61	6.17	1.90
1992	15.25	1.54	0.06	227.70	7.16	0.65
1993	0.29	0.72	0.04	256.91	5.21	3.36
1994	6.11	0.36	0.06	86.45	3.30	0.90
1995	0.61	7.49	0.03	27.13	2.08	0.39
1996	0.42	0.94	0.15	30.81	1.04	0.54
1997	20.23	0.74	0.20	52.09	3.82	0.21
1998	73.22	1.46	0.05	220.05	4.88	0.50
1999	35.85	2.25	0.03	209.10	10.30	0.27
2000	186.07	16.73	1.02	260.97	6.56	0.13
2001	83.01	2.99	1.22	163.37	4.32	1.34
2002	346.32	5.47	6.01	565.96	25.65	0.24
2003	266.56	0.38	1.35	804.08	10.19	0.96
2004	40.82	0.92	0.70	449.12	11.70	0.46
2005	n/a	n/a	n/a	147.98	4.19	1.11
2006	122.23	3.12	0.35	943.63	16.52	1.58
2007	109.47	4.18	0.61	1185.54	38.27	2.99
Mean	66.36	3.47	0.62	314.68	8.84	1.38

Table 30. University of Rhode Island Graduate School of Oceanography (URIGSO) trawl survey indices for scup (total catch number).

Year	Number
1963	80
1964	181
1965	100
1966	124
1967	686
1968	217
1969	142
1970	146
1971	523
1972	345
1973	689
1974	543
1975	1243
1976	2591
1977	1806
1978	1112
1979	1033
1980	510
1981	952
1982	478
1983	1477
1984	1374
1985	1411
1986	1062
1987	809
1988	762
1989	2386
1990	953
1991	1841
1992	654
1993	1775
1994	471
1995	682
1996	628
1997	516
1998	551
1999	1830
2000	3978
2001	3225
2002	5380
2003	2047
2004	468
2005	857
2006	4473
2007	2889

Table 31. VIMS ChesMMAP trawl survey indices for scup. Indices are maximum seasonal values (usually July or September) minimum swept area estimates.

Year	Total N	Total B	Age 0 N	Age 1 N
2002	477,359	77,307	324,291	154,625
2003	624,210	61,501	93,089	500,176
2004	2,166,993	146,627	89,384	1,975,035
2005	3,402,832	197,762	1,864,624	673,437
2006	1,318,855	109,652	1,180,618	566,905
2007	894,289	23,183	0	894,289
2008	52,317	3,488	n/a	n/a
Mean	1,480,756	102,672	592,001	794,078

Table 32. Summary results for 1984-2007 from the 2008 assessment final model BASE_C2007_T1.

Year	SSB (mt)	Recruits (Age 0; 000s)	F(age 3-7+)
1984	18,151	108,158	0.533
1985	17,010	78,360	0.608
1986	15,953	60,241	0.779
1987	13,531	48,392	0.676
1988	10,621	91,460	0.701
1989	8,894	66,774	0.695
1990	9,438	114,796	0.673
1991	9,211	100,966	1.027
1992	7,928	39,496	1.068
1993	6,147	45,406	1.109
1994	4,428	75,827	1.120
1995	3,993	36,349	0.920
1996	5,103	30,377	0.758
1997	5,609	87,276	0.487
1998	6,772	123,306	0.329
1999	12,367	217,853	0.206
2000	25,727	311,243	0.149
2001	51,511	194,937	0.080
2002	72,536	114,487	0.186
2003	76,533	108,778	0.111
2004	81,638	171,236	0.079
2005	93,754	116,828	0.061
2006	105,645	219,752	0.057
2007	119,343	307,943	0.054

Table 33. January 1 population number (N, 000s) estimates for 1984-2007 from the 2008 assessment final model BASE_C2007_T1.

	Age							
Year	0	1	2	3	4	5	6	7+
1984	108158	61923	30650	8353	3465	3014	4824	13099
1985	78360	80287	40534	14126	4100	1637	1423	8775
1986	60241	56693	49486	16395	6531	1780	710	4704
1987	48392	44866	36176	21410	6555	2350	641	2148
1988	91460	36323	29465	16671	9319	2643	947	1201
1989	66774	69016	24120	13772	7049	3672	1041	887
1990	114796	49652	44341	10620	5925	2780	1448	794
1991	100966	84717	31624	19059	4624	2402	1127	935
1992	39496	72016	49032	10527	5990	1289	670	611
1993	45406	26601	37486	12722	3136	1615	347	365
1994	75827	31708	14804	11151	3641	810	417	196
1995	36349	55377	19198	5296	3162	929	207	163
1996	30377	25410	31416	6090	1802	999	293	122
1997	87276	22335	15998	12939	2438	670	371	158
1998	123306	65699	14356	8195	6455	1218	335	268
1999	217853	94257	44254	8205	4802	3786	714	358
2000	311243	170265	67634	28464	5449	3191	2515	716
2001	194937	247527	128258	47186	20013	3832	2244	2280
2002	114487	156810	192914	96113	35619	15111	2893	3428
2003	108778	68584	55407	47367	65005	24205	10264	4313
2004	171236	86609	51990	39723	34636	47549	17705	10695
2005	116828	138009	67886	39371	30017	26177	35936	21519
2006	219752	94532	109412	52530	30297	23101	20146	44303
2007	307943	177299	74375	83856	40578	23407	17848	49939

Table 34. Fishing mortality (F) estimates for 1984-2007 from the 2008 assessment final model BASE_C2007_T1.

	Age							
Year	0	1	2	3	4	5	6	7+
1984	0.098	0.224	0.575	0.512	0.550	0.551	0.551	0.501
1985	0.124	0.284	0.705	0.571	0.634	0.635	0.636	0.564
1986	0.095	0.249	0.638	0.717	0.822	0.822	0.823	0.710
1987	0.087	0.220	0.575	0.632	0.708	0.709	0.709	0.623
1988	0.082	0.209	0.561	0.661	0.731	0.732	0.732	0.649
1989	0.096	0.242	0.620	0.643	0.730	0.731	0.731	0.637
1990	0.104	0.251	0.644	0.632	0.703	0.703	0.704	0.622
1991	0.138	0.347	0.900	0.957	1.077	1.078	1.079	0.945
1992	0.195	0.453	1.149	1.011	1.111	1.112	1.113	0.994
1993	0.159	0.386	1.012	1.051	1.154	1.154	1.155	1.032
1994	0.114	0.302	0.828	1.061	1.166	1.166	1.167	1.040
1995	0.158	0.367	0.948	0.878	0.952	0.953	0.955	0.861
1996	0.108	0.263	0.687	0.715	0.789	0.789	0.790	0.703
1997	0.084	0.242	0.469	0.495	0.494	0.494	0.490	0.460
1998	0.069	0.195	0.359	0.335	0.334	0.334	0.331	0.311
1999	0.046	0.132	0.241	0.209	0.209	0.209	0.207	0.193
2000	0.029	0.083	0.160	0.152	0.152	0.152	0.151	0.139
2001	0.018	0.049	0.089	0.081	0.081	0.081	0.081	0.075
2002	0.312	0.840	1.204	0.191	0.186	0.187	0.185	0.180
2003	0.028	0.077	0.133	0.113	0.113	0.113	0.112	0.104
2004	0.016	0.044	0.078	0.080	0.080	0.080	0.079	0.074
2005	0.012	0.032	0.056	0.062	0.062	0.062	0.061	0.058
2006	0.015	0.040	0.066	0.058	0.058	0.058	0.058	0.054
2007	0.016	0.044	0.073	0.055	0.055	0.055	0.055	0.051

Table 35. 2008 assessment Biological Reference Point input data.

Natural Mortality (M) = 0.20

Proportion of mortality before spawning = 0.417

Age	Selectivity on F	Selectivity on M	1-Jan Stock Weights	Catch Weights	1-Jun SSB Weights	Maturity
0	0.21	1.00	0.017	0.028	0.025	0.00
1	0.58	1.00	0.051	0.100	0.089	0.13
2	1.00	1.00	0.142	0.221	0.205	0.75
3	0.91	1.00	0.283	0.356	0.343	0.99
4	0.90	1.00	0.418	0.488	0.476	1.00
5	0.90	1.00	0.564	0.642	0.629	1.00
6	0.90	1.00	0.735	0.830	0.813	1.00
7+	0.90	1.00	1.041	1.041	1.041	1.00

Table 36. Proposed biological reference points and status evaluation for scup from 2008 final assessment model BASE_C2007_T1.

SCUP: final model "BASE_C2007_T1" Mean R = 117.2 million age 0 fish

BRP		Y/R	SSB/R	SSBproxy	Catchproxy	Landproxy	Discproxy
Fmax	0.283	0.146	0.499	57,759	16,903	12,764	4,139
F35%	0.207	0.142	0.683	80,280	16,615	13,236	3,379
F40%	0.177	0.138	0.780	92,044	16,161	13,134	3,027

BRP	SSBproxy	SSB07	%SSBproxy		Catch	Catch07	%Catchproxy
Fmax	57,759	119,343	207%		16,903	7,867	47%
F35%	80,280	119,343	149%		16,615	7,867	47%
F40%	92,044	119,343	130%		16,161	7,867	49%

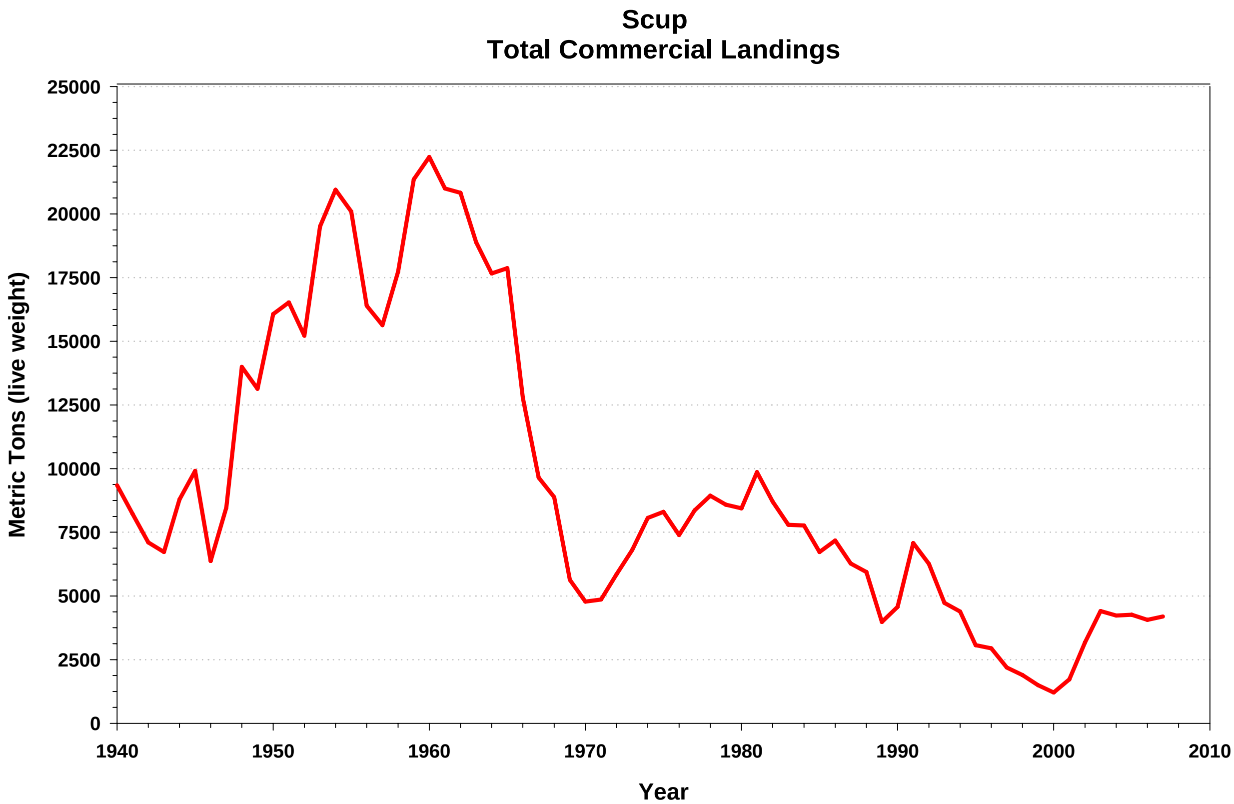

Figure 1. Total commercial fishery landings for scup.

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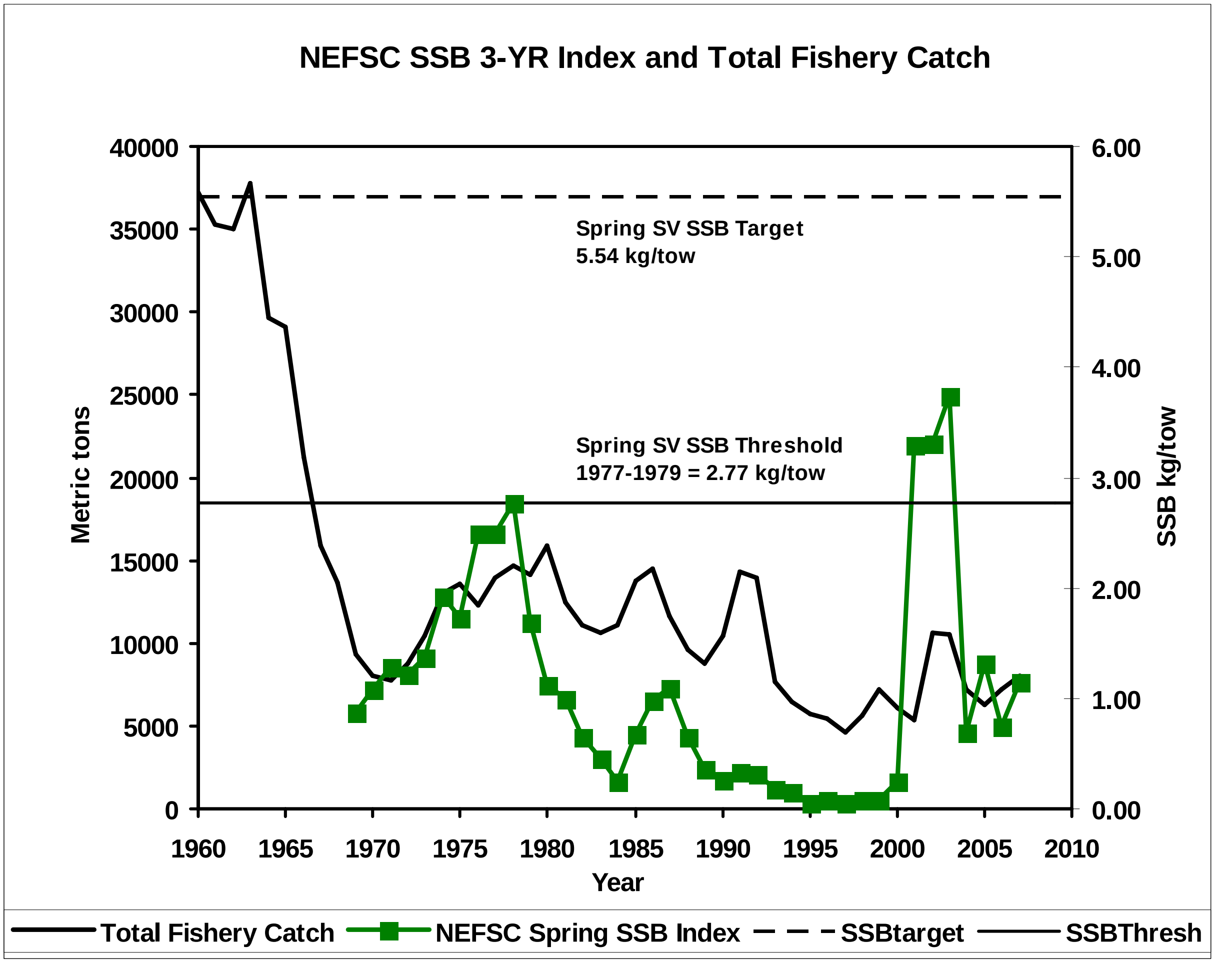

Figure 2. NEFSC Spring survey indices of scup spawning stock biomass per tow (SSB kg/tow) used as proxy biomass Biological Reference Points.

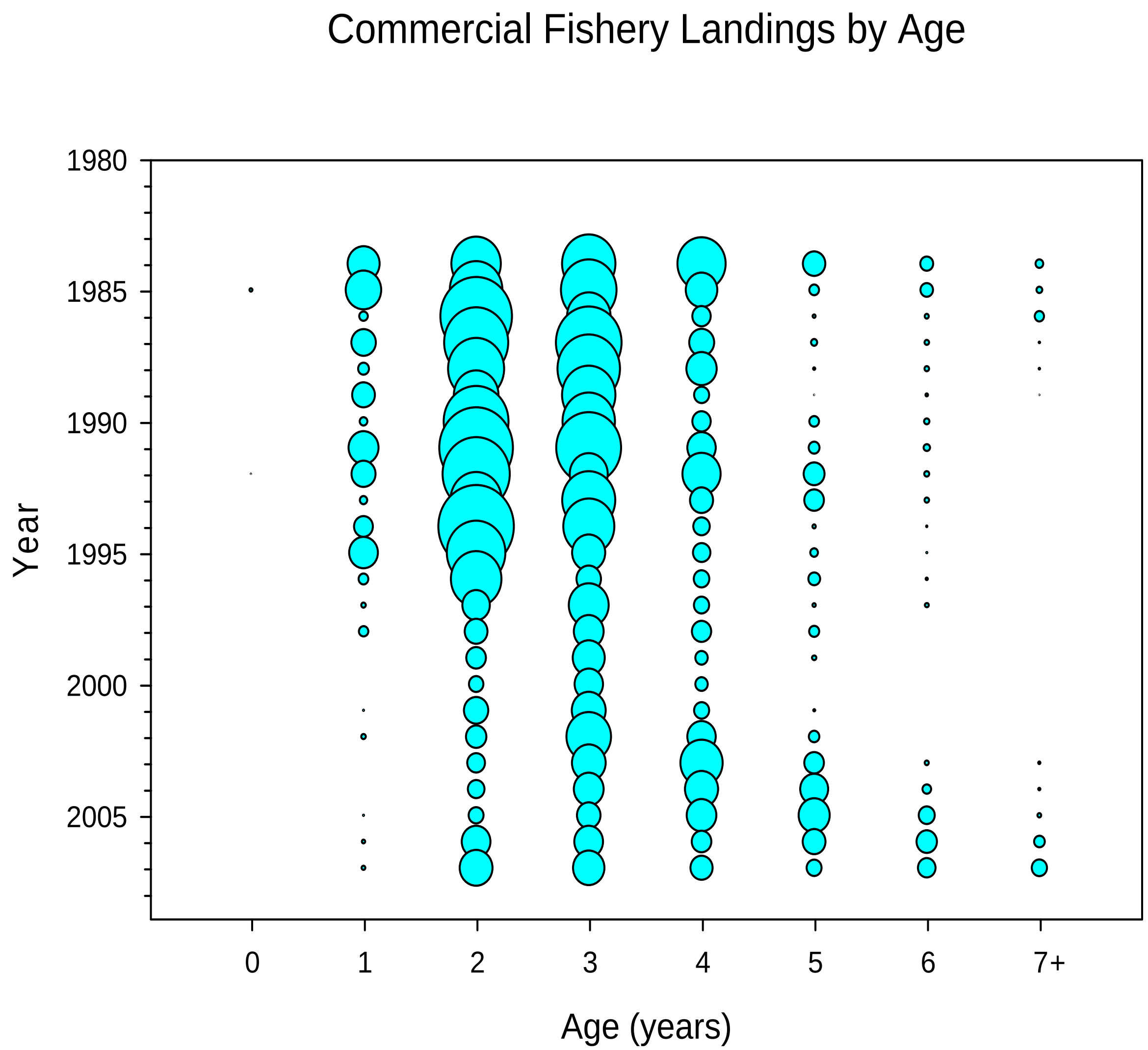

Figure 3. Commercial fishery landings by age for scup.

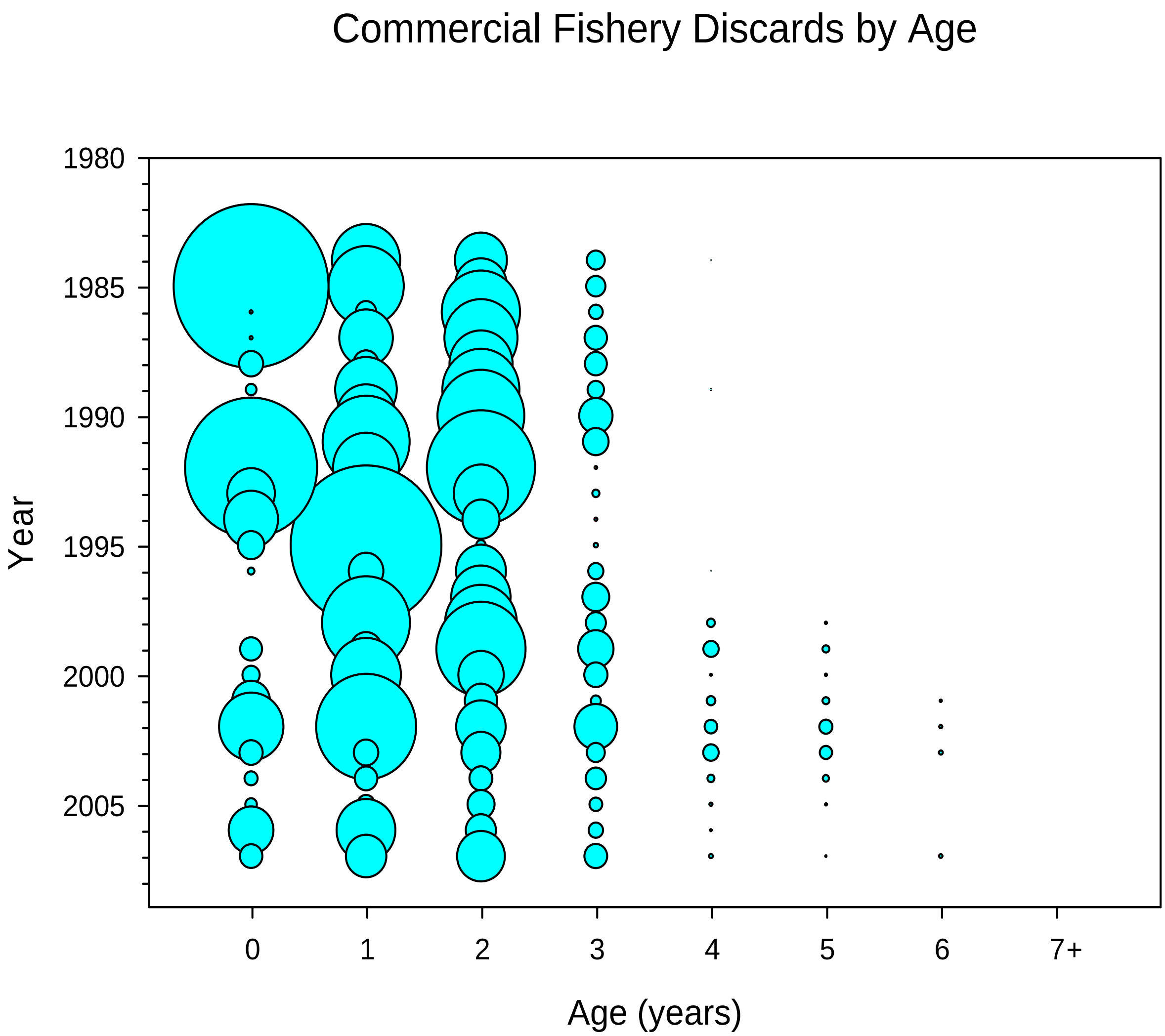

Figure 4. Commercial fishery discards by age for scup.

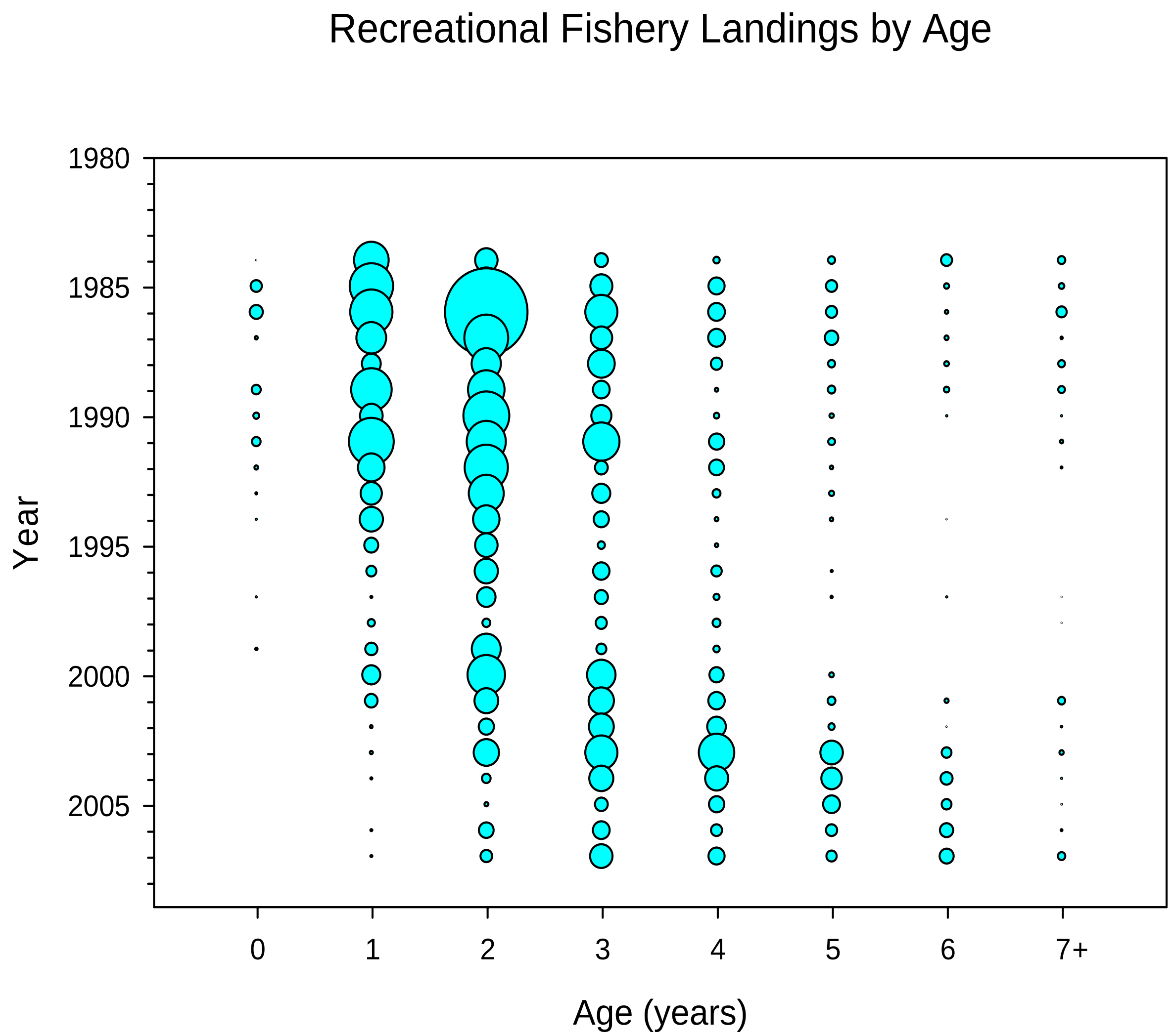

Figure 5. Recreational fishery landings by age for scup.

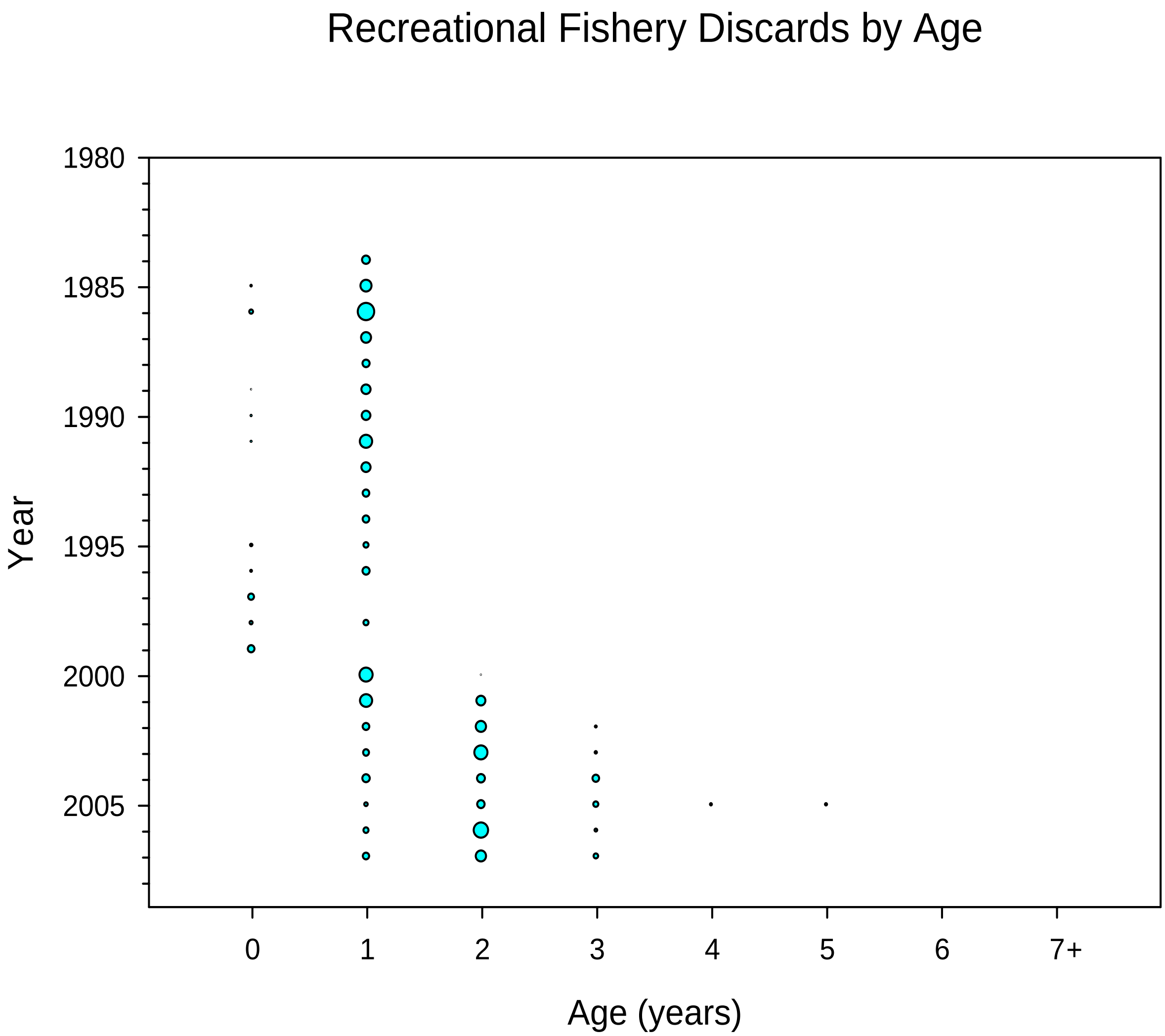

Figure 6. Recreational fishery discards by age for scup.

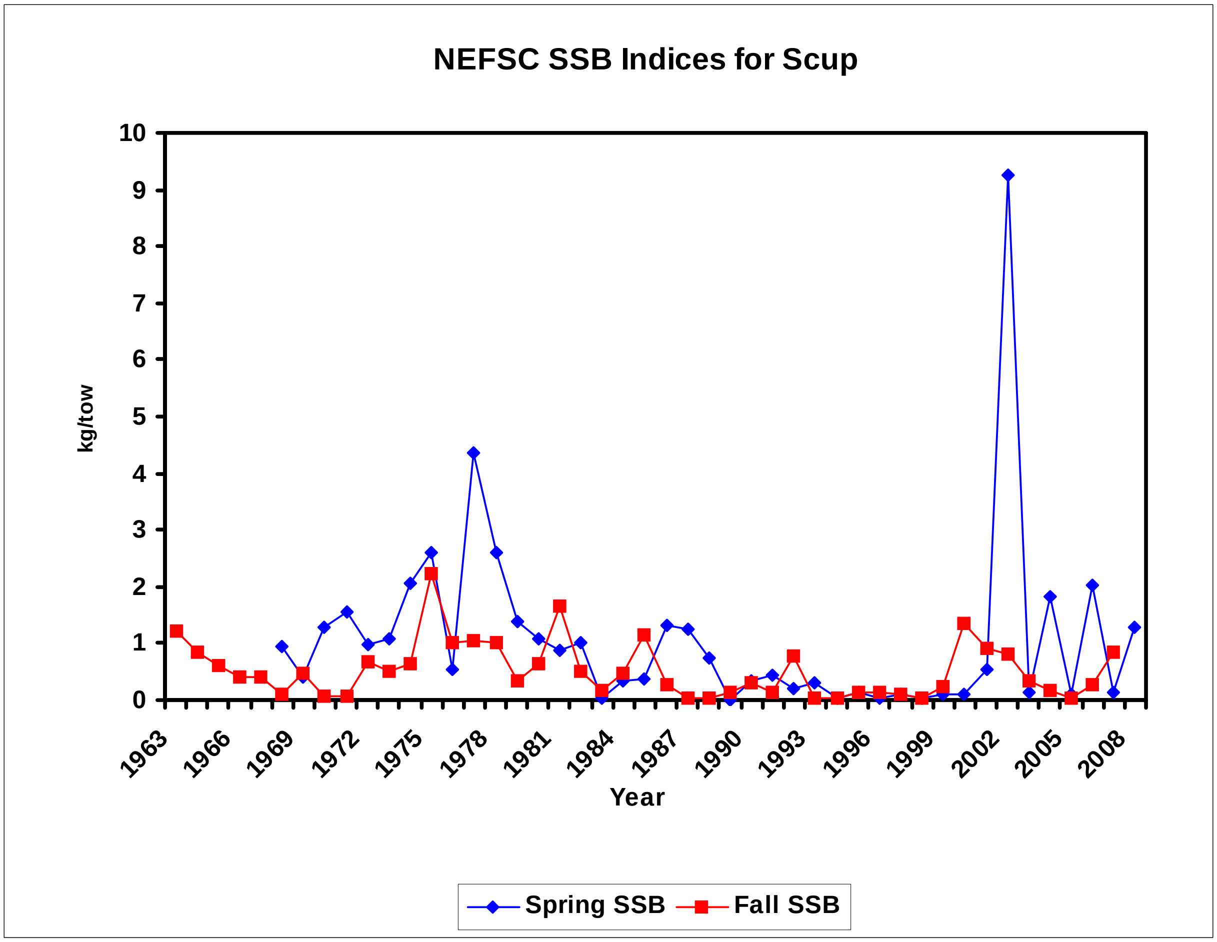

Figure 7. NEFSC SSB indices for scup.

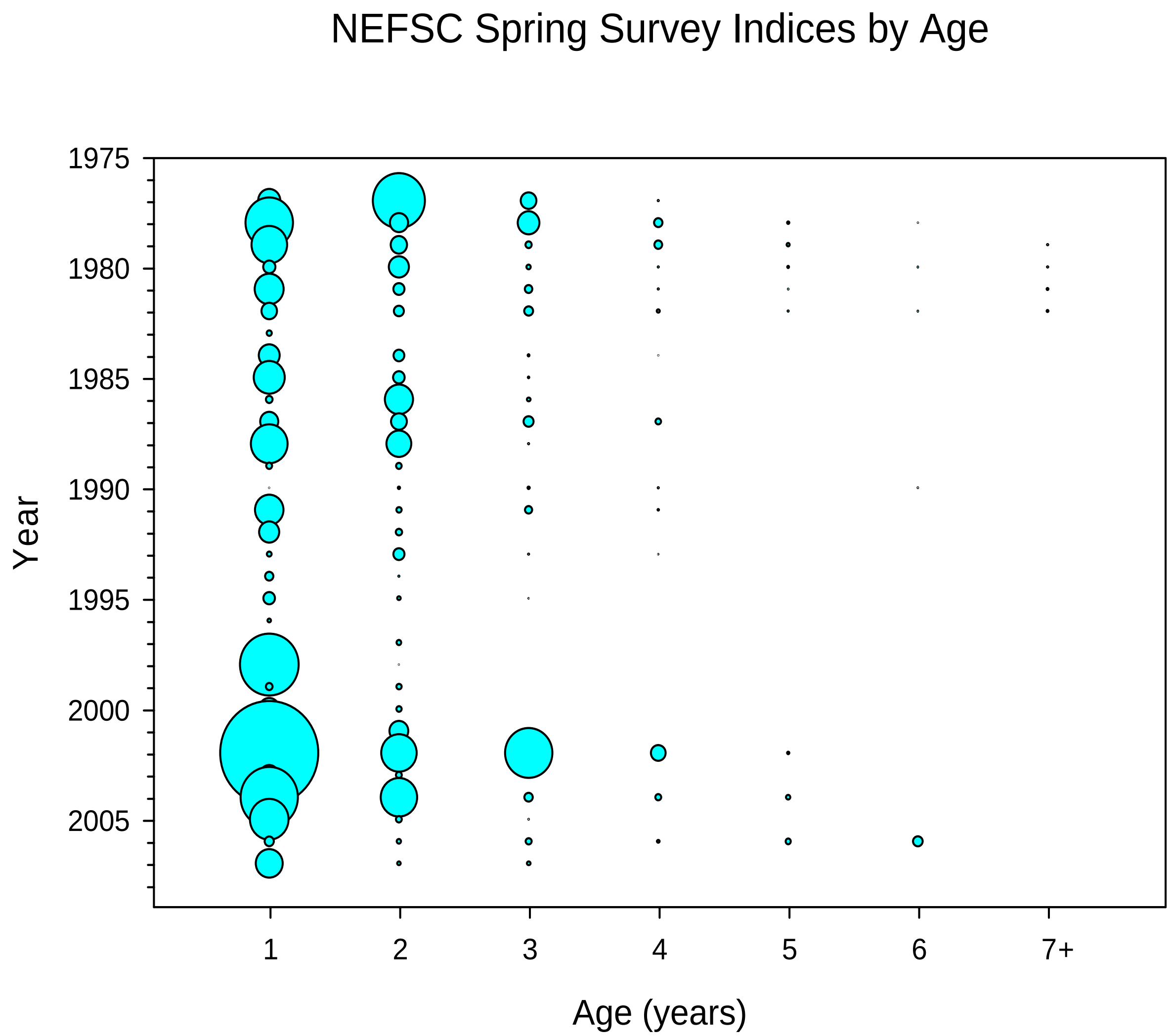

Figure 8. NEFSC Spring survey indices by age for scup.

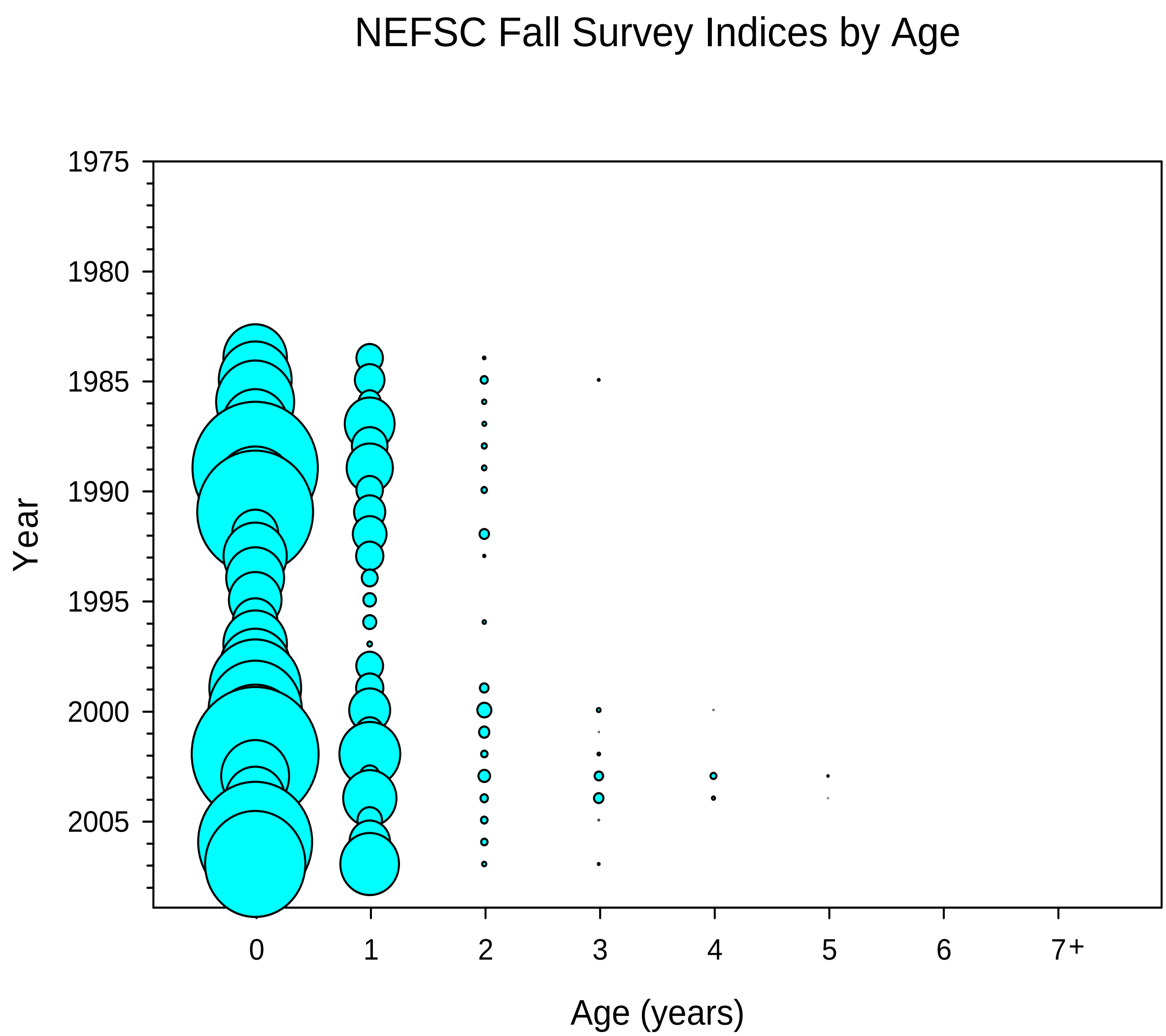

Figure 9. NEFSC Fall survey indices by age for scup.

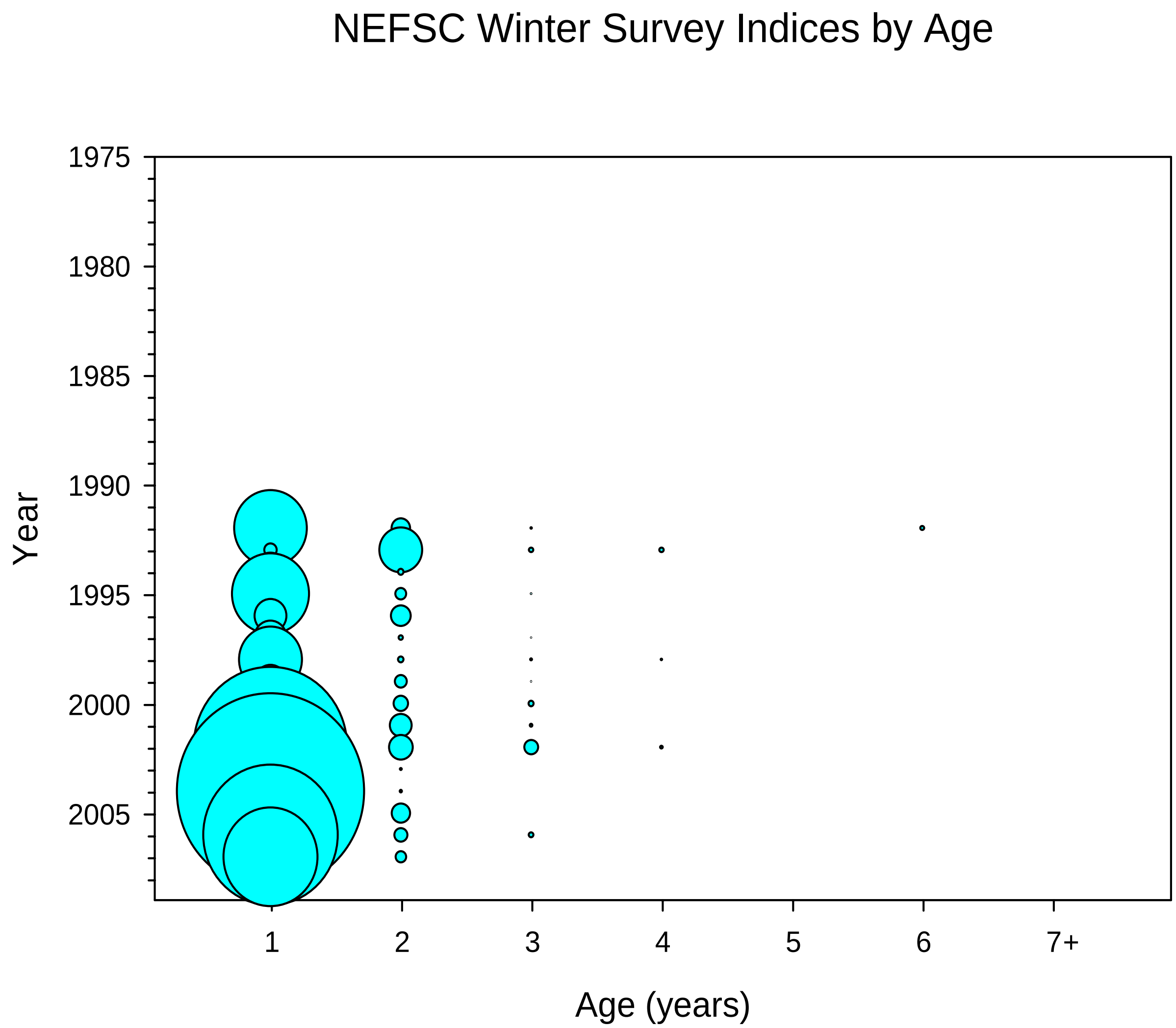

Figure 10. NEFSC Winter survey indices by age for scup.

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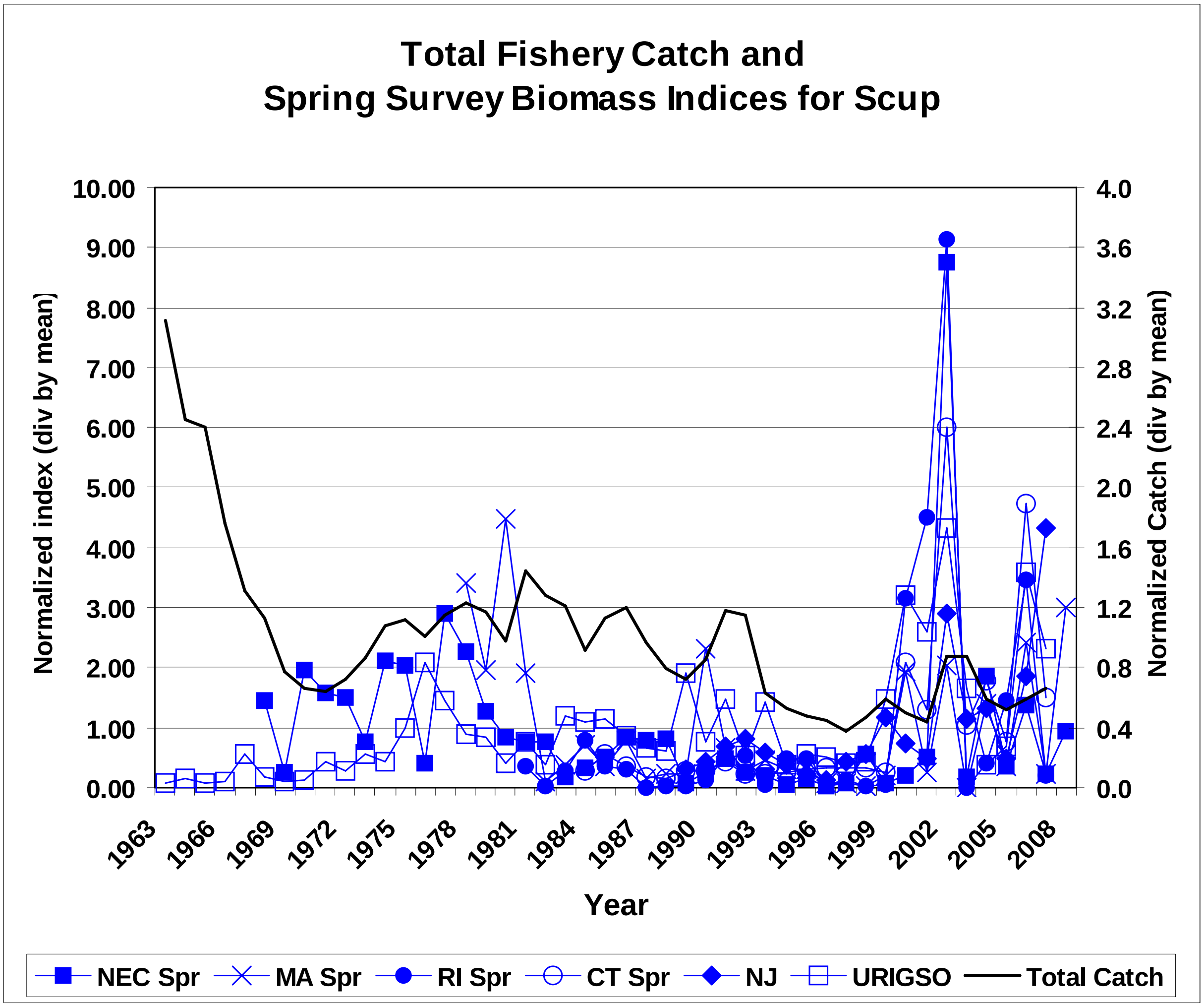

Figure 11. Research survey indices for scup: Spring

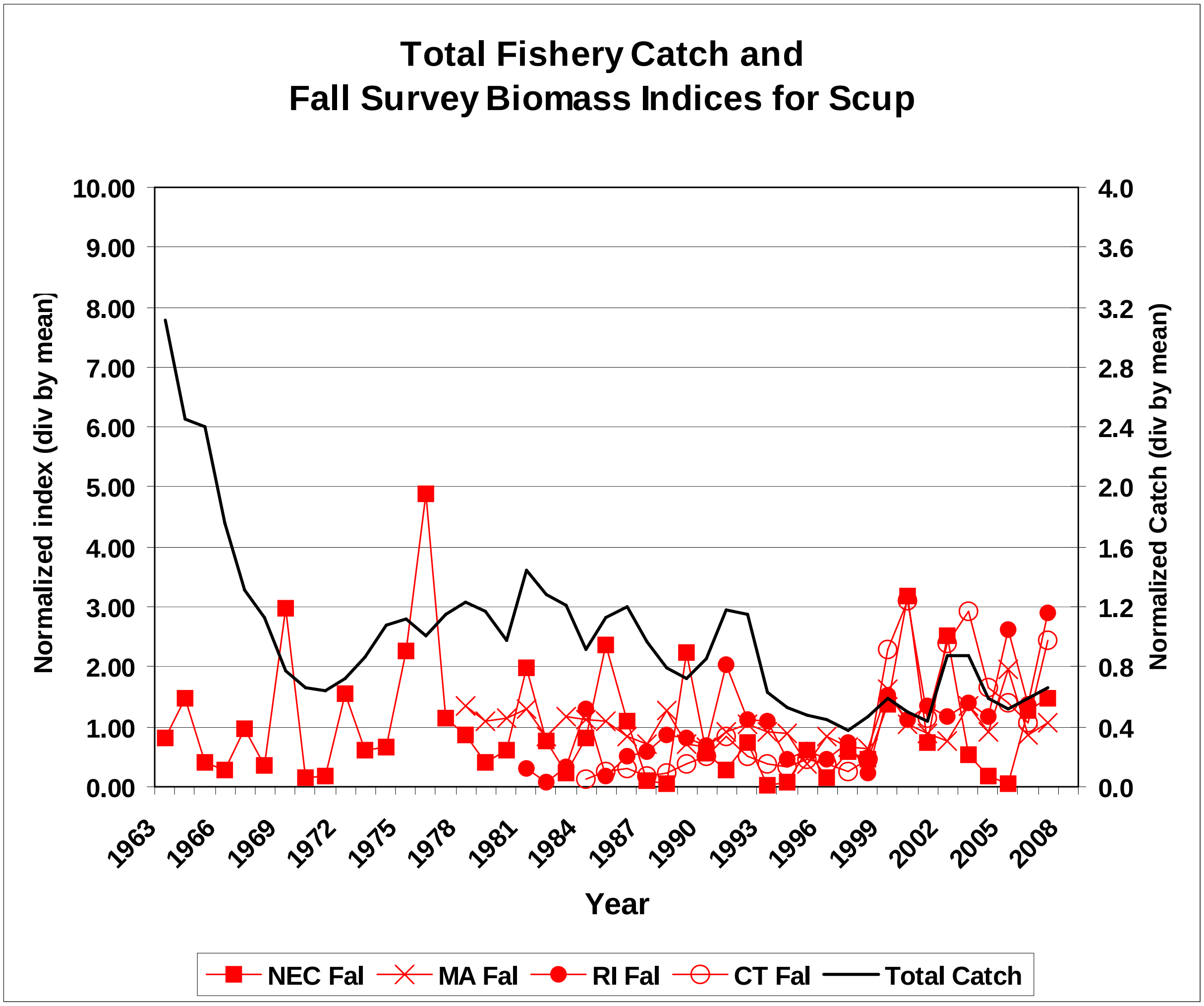

Figure 12. Research survey indices for scup: Fall

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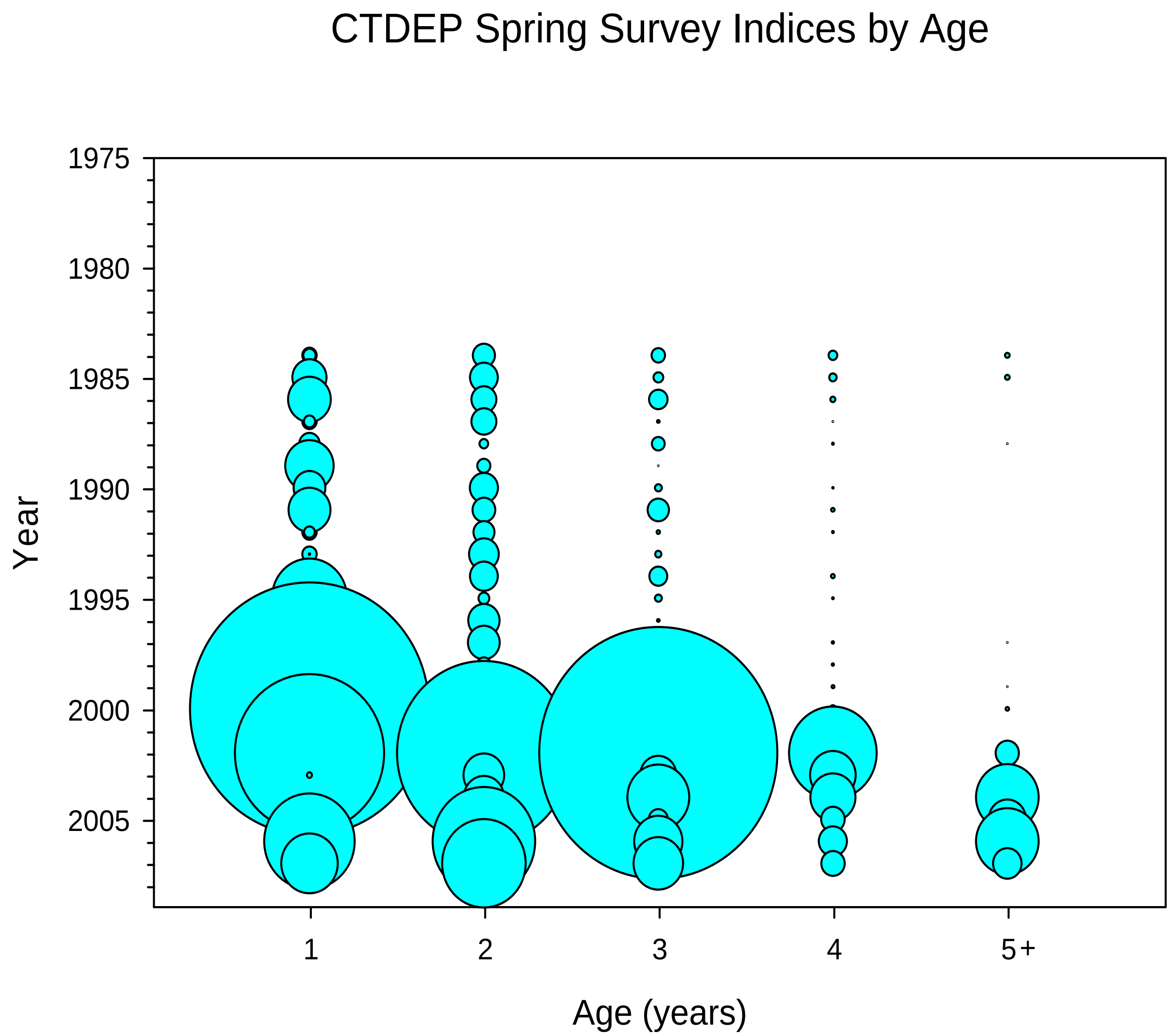


Figure 13. CTDEP Spring survey indices by age for scup.

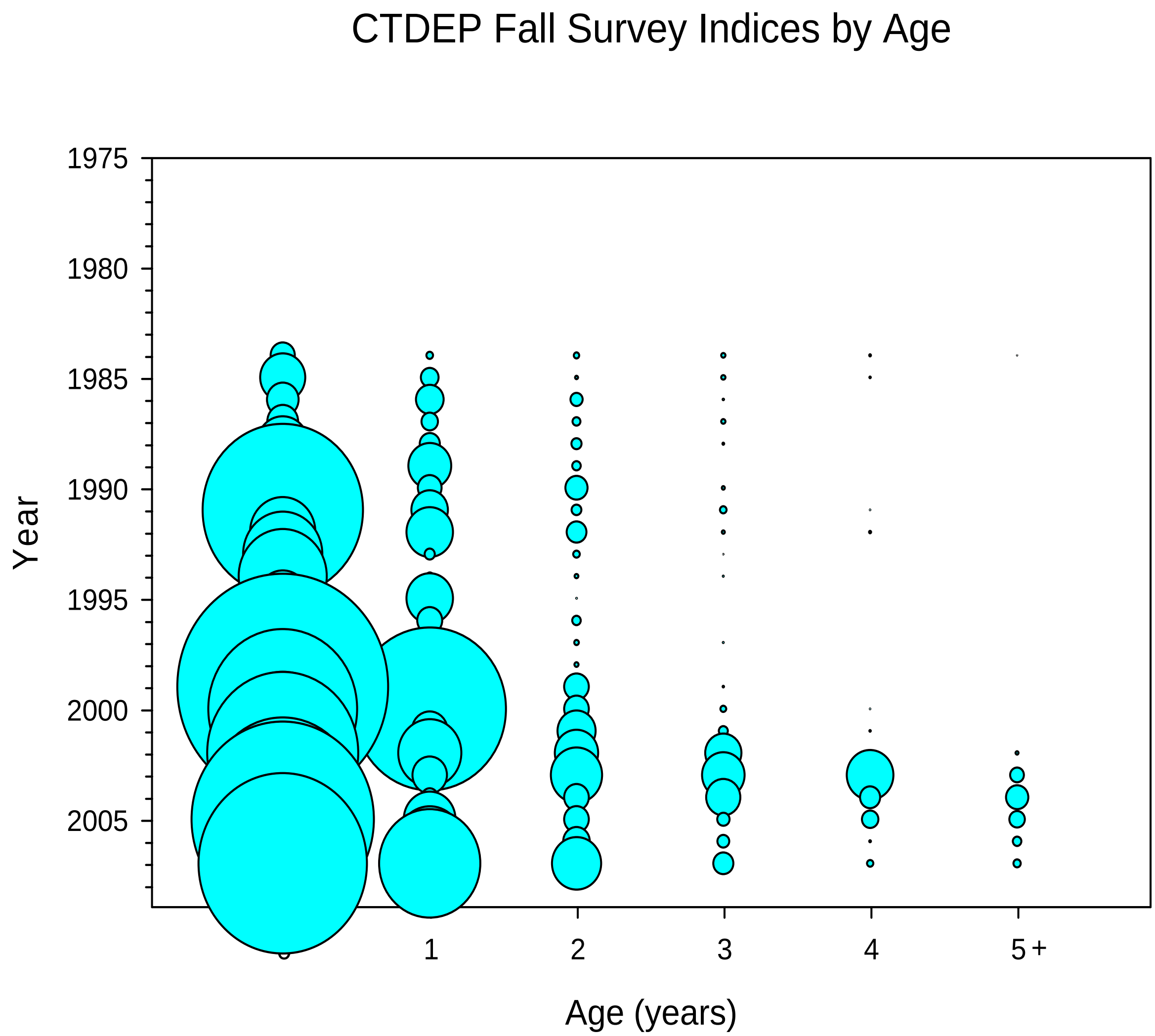


Figure 14. CTDEP Fall survey indices by age for scup.

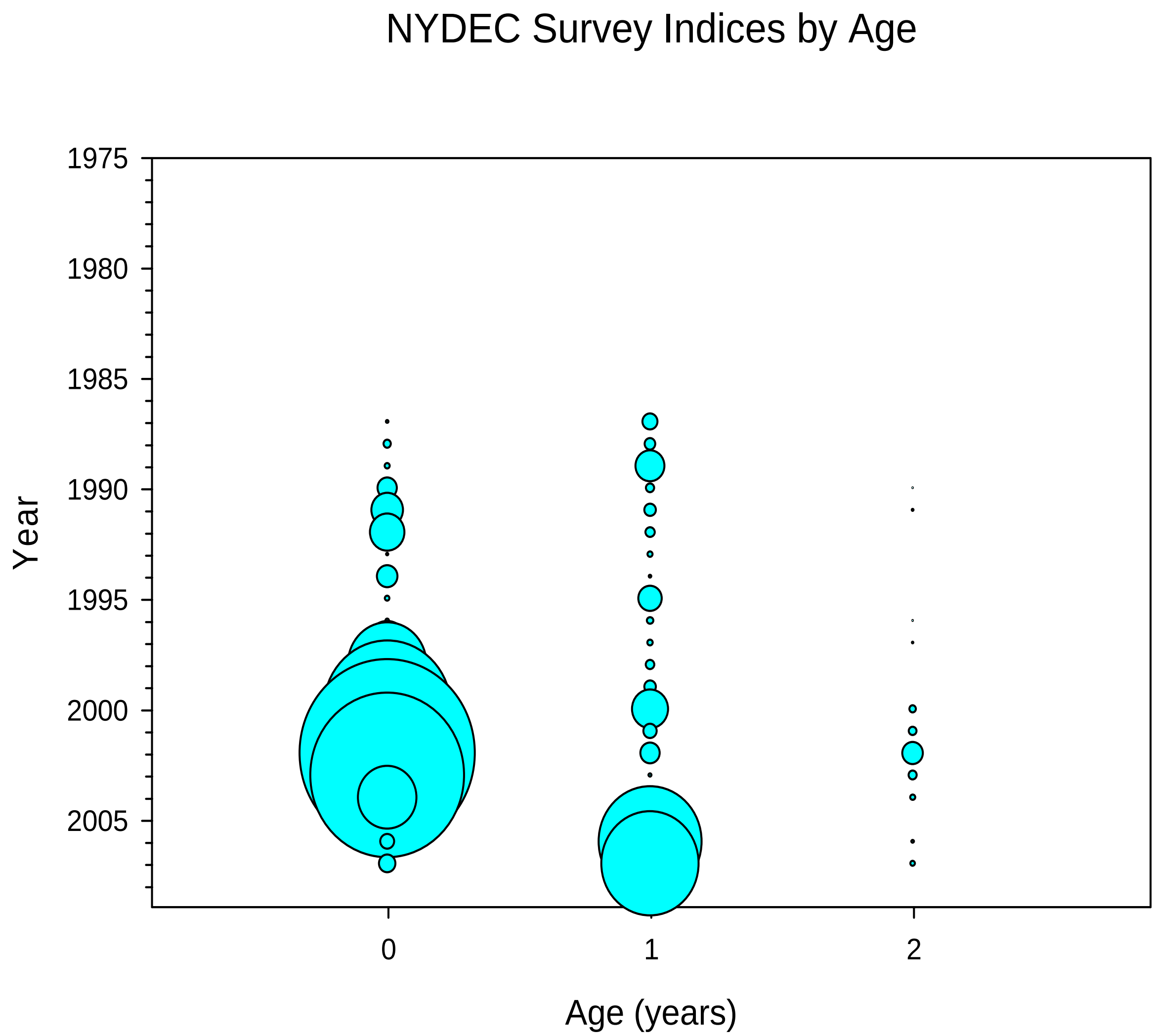


Figure 15. NYDEC survey indices by age for scup.

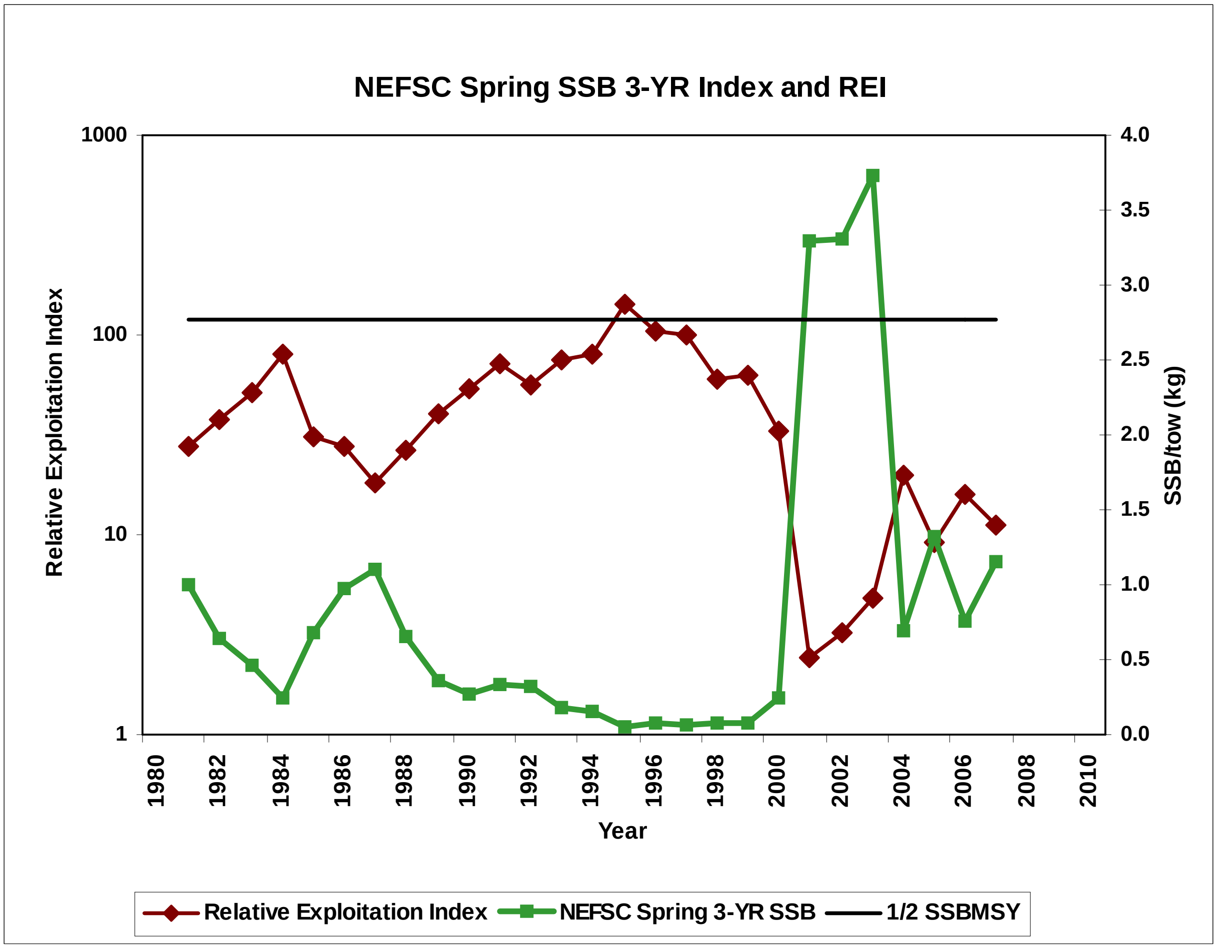


Figure 16. NEFSC Spring survey 3-year average SSB index (biomass metric) and Relative Exploitation Index (REI; fishing mortality rate metric).

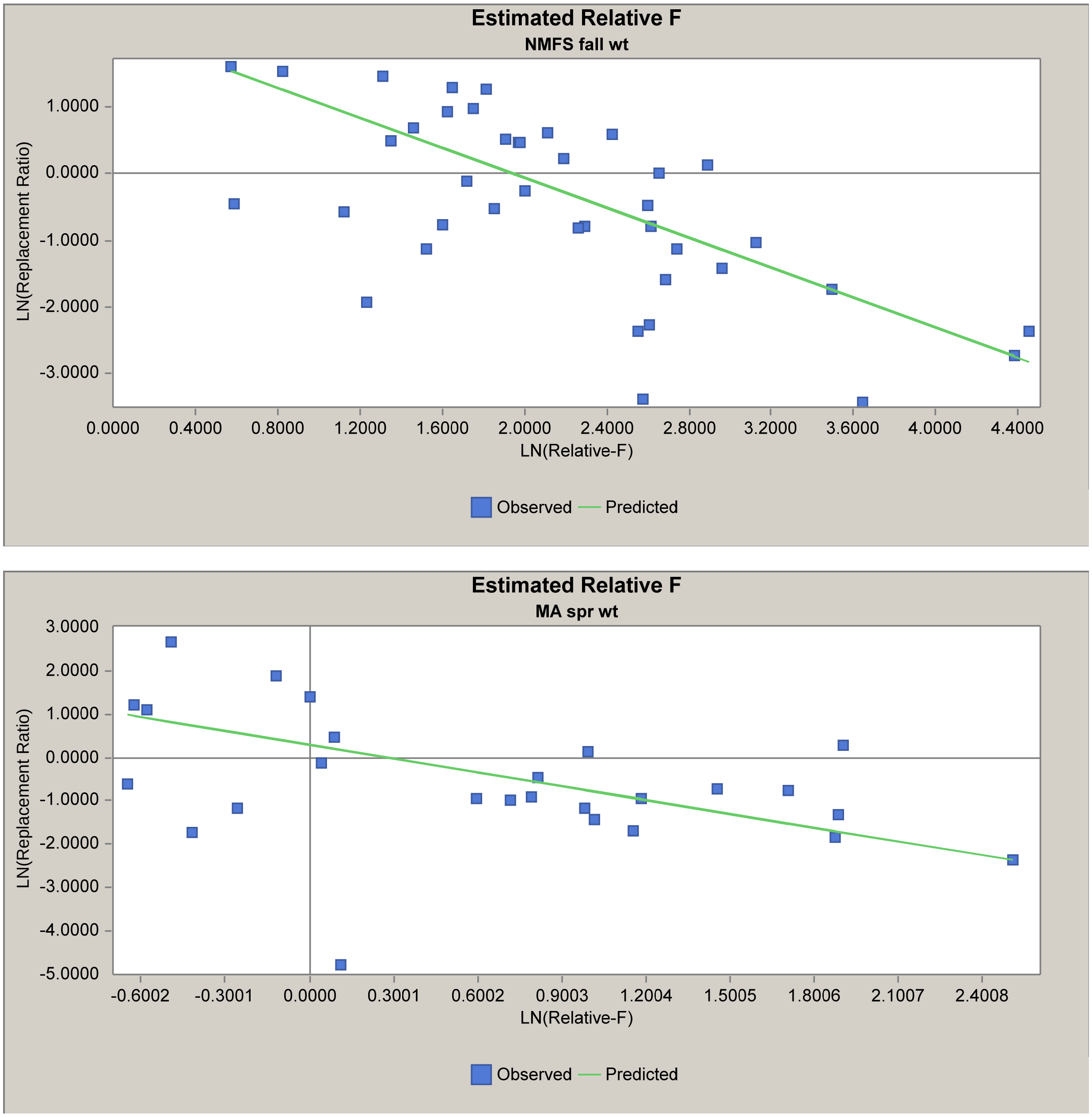
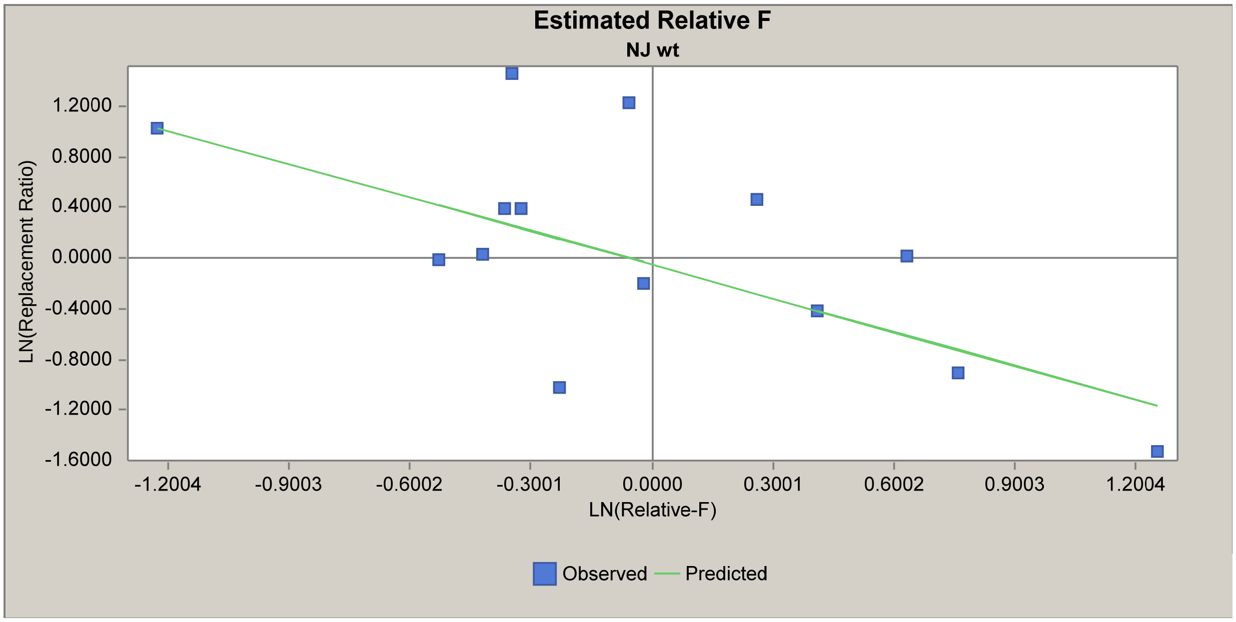


Figure 17. AIM results for the NEFSC Fall and MADMF Spring survey indices.



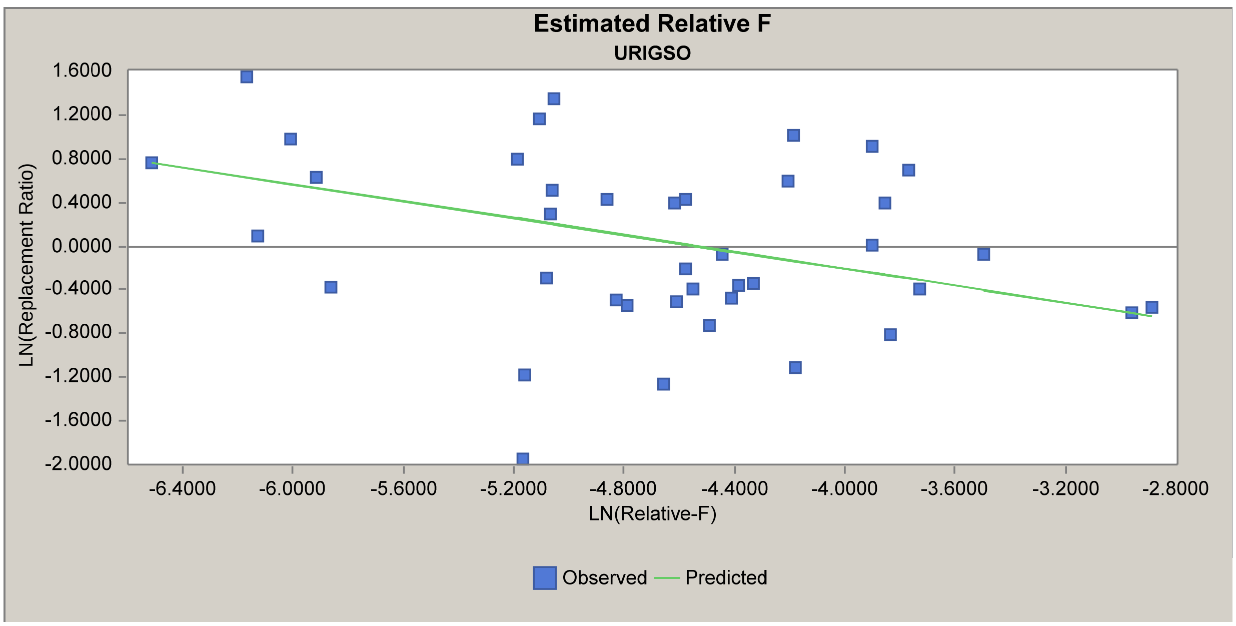


Figure 18. AIM results for the NJBMF Annual and URIGSO indices.

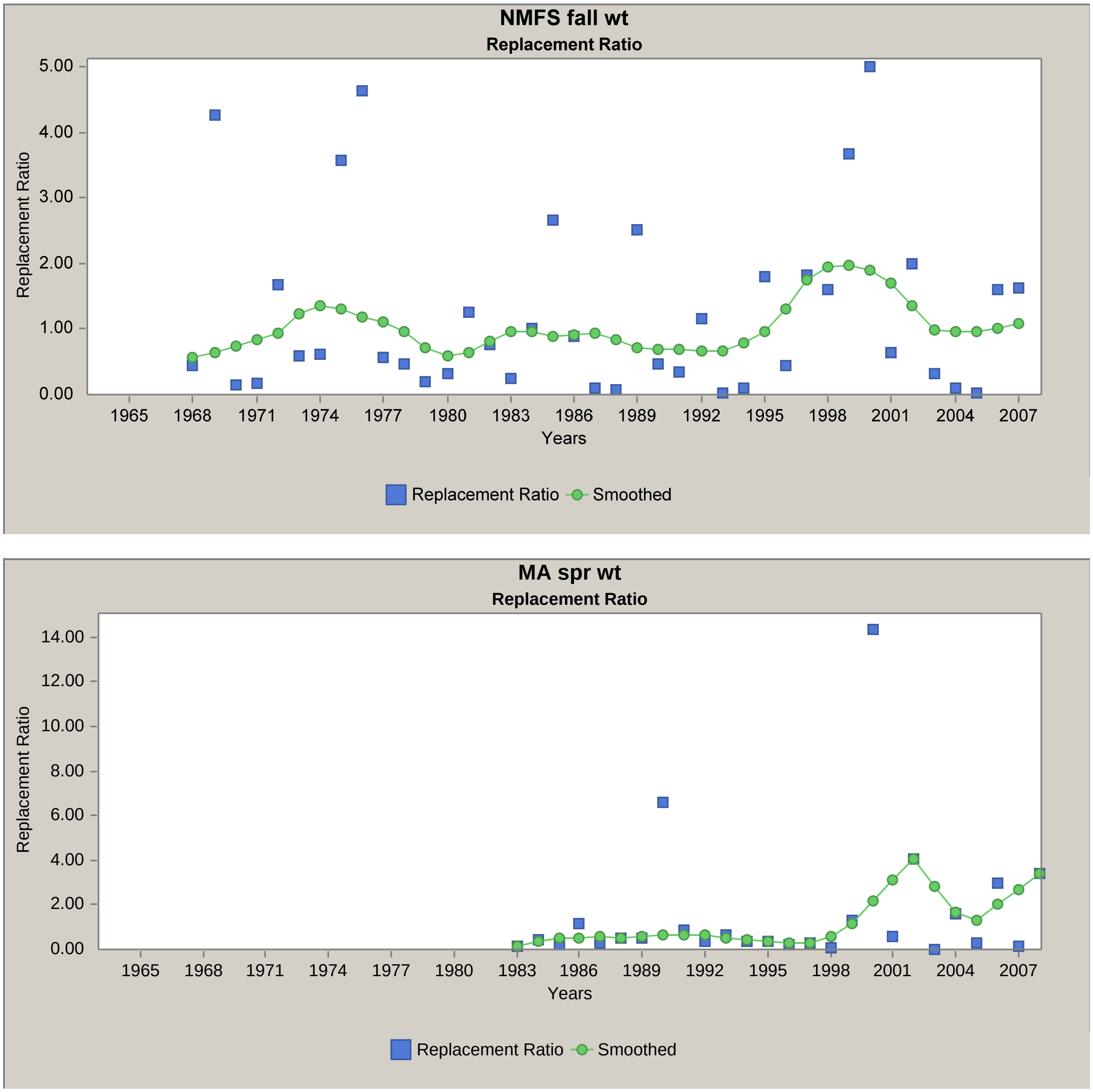


Figure 19. AIM replacement ratio results for NEFSC Fall and MADMF Spring indices.

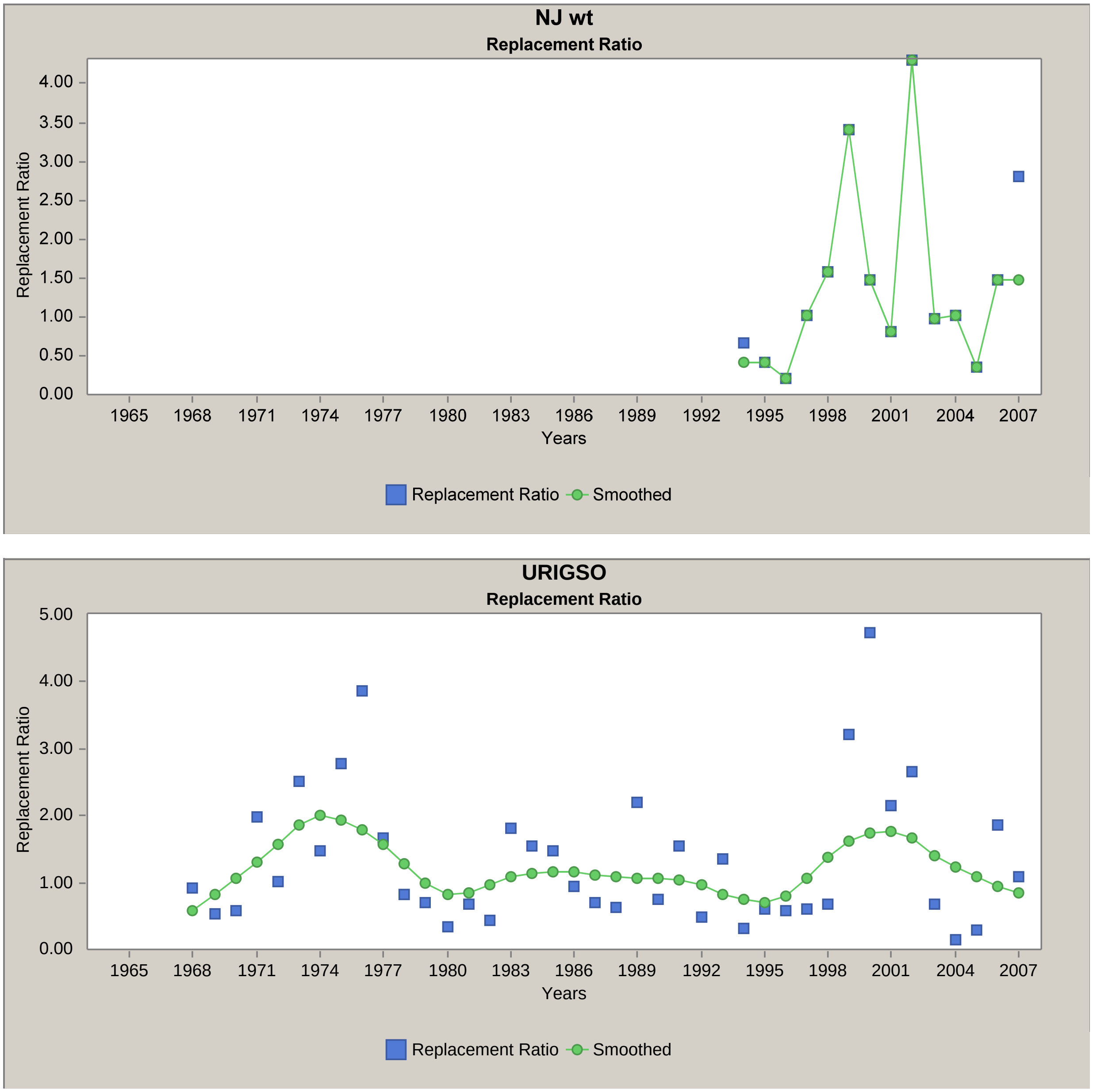


Figure 20. AIM replacement ratio results for NJBMF Annual and URIGSO indices.

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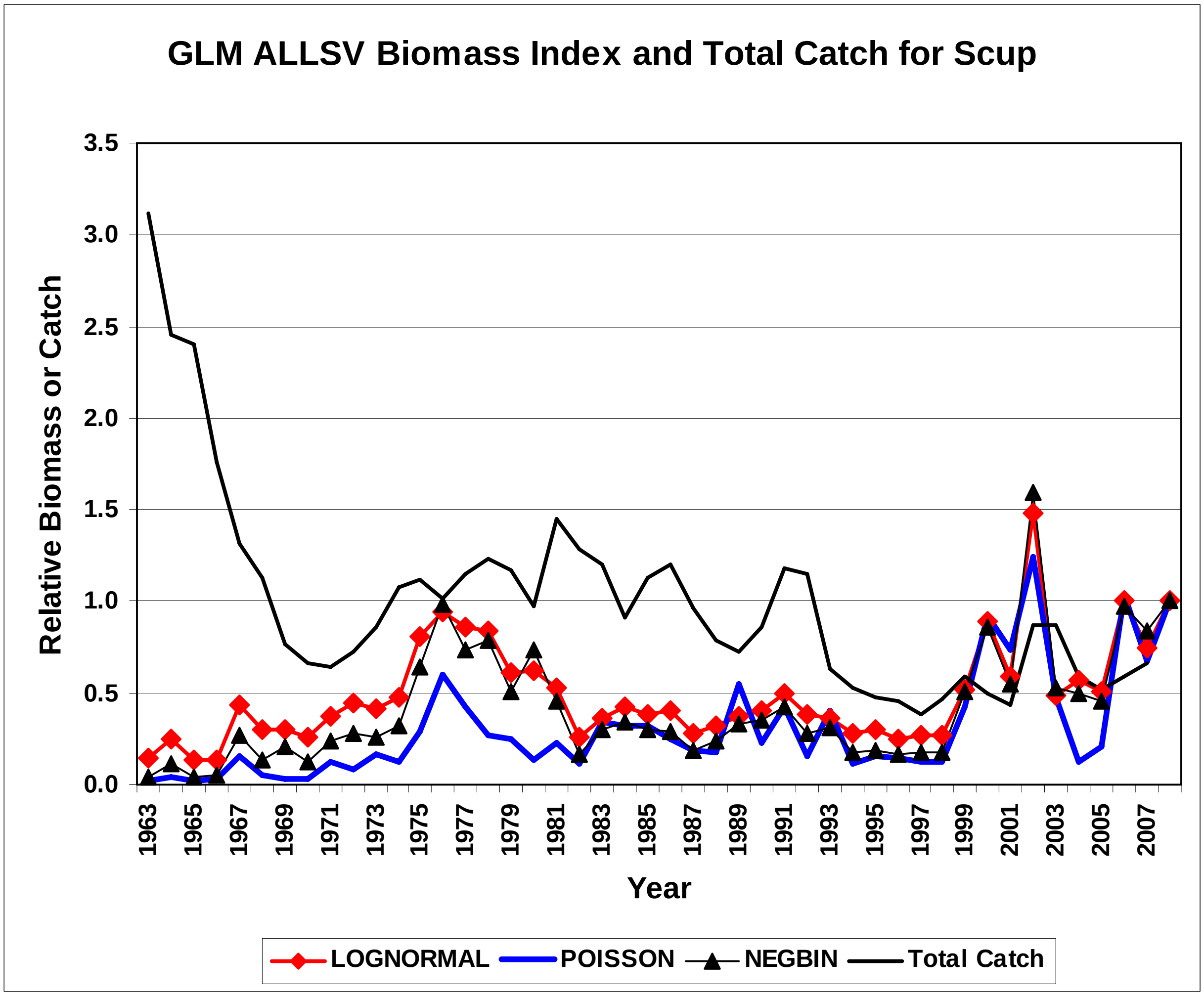
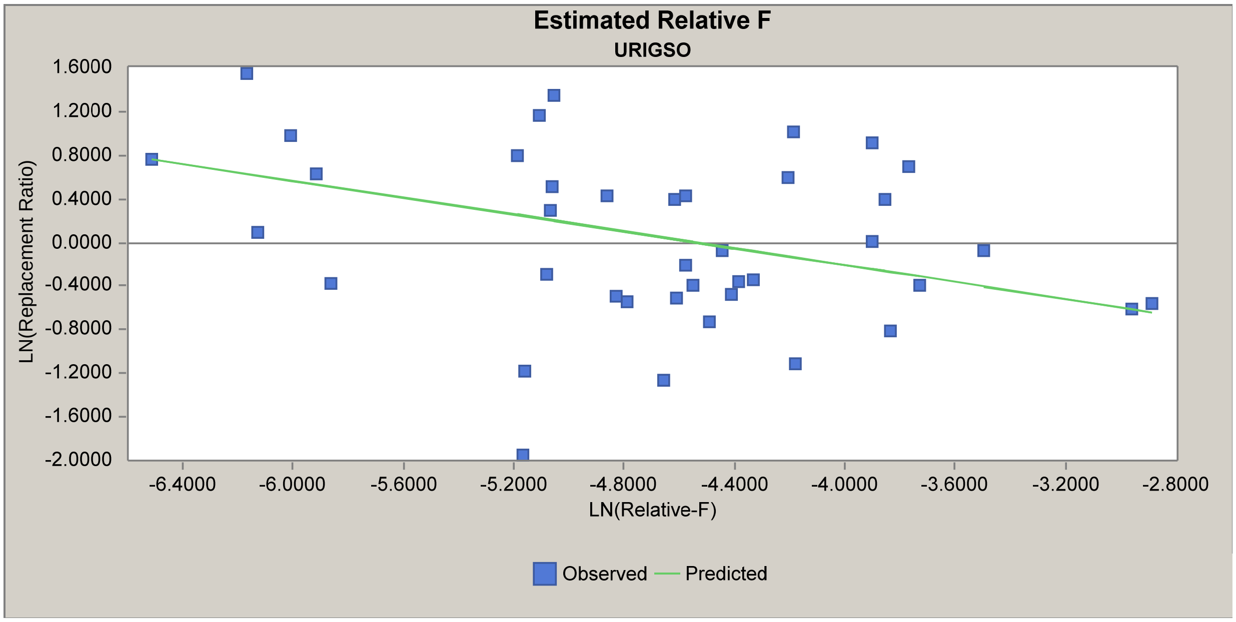


Figure 21. GLM-based biomass index for scup. The Poisson-assumption index was adopted as AIM input.



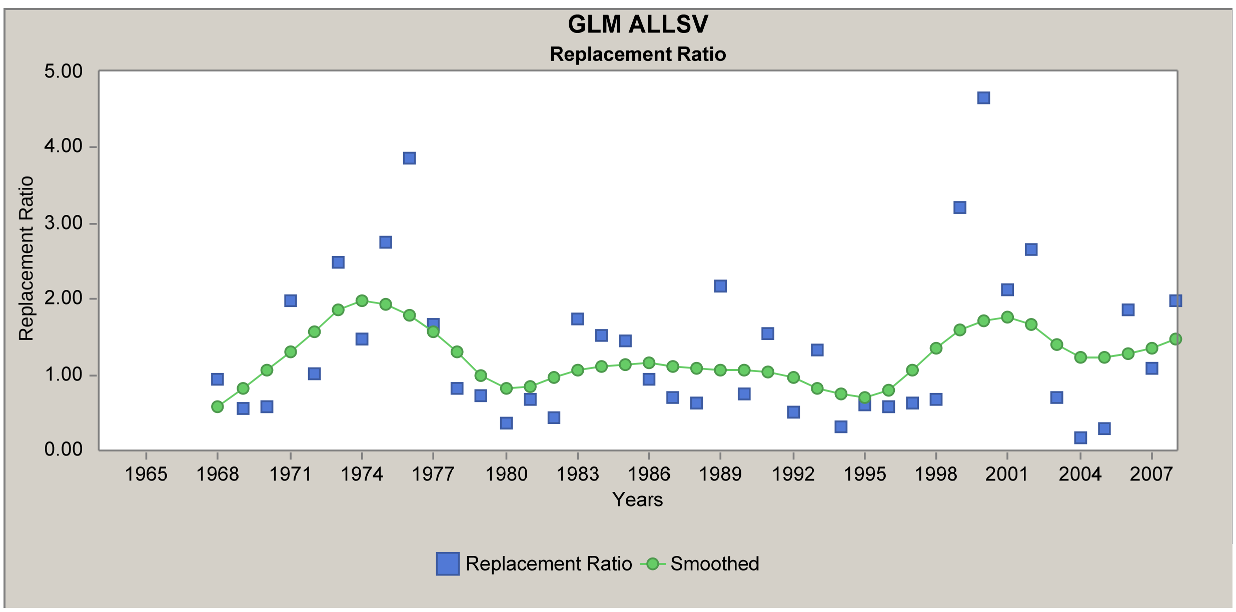


Figure 22. AIM results for the GLM based biomass index for scup.

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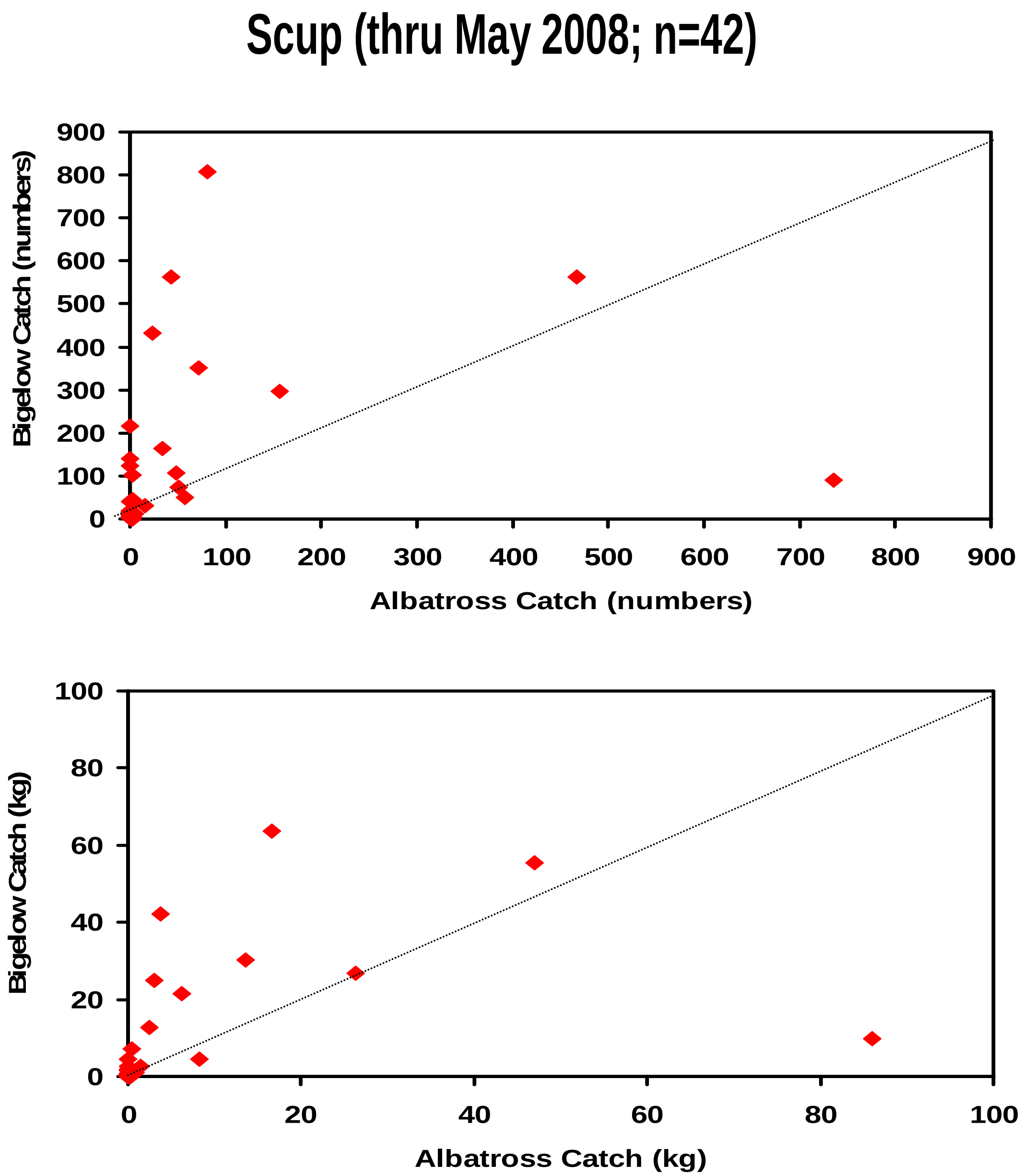

Figure 23. Preliminary NEFSC Survey calibration results for scup.

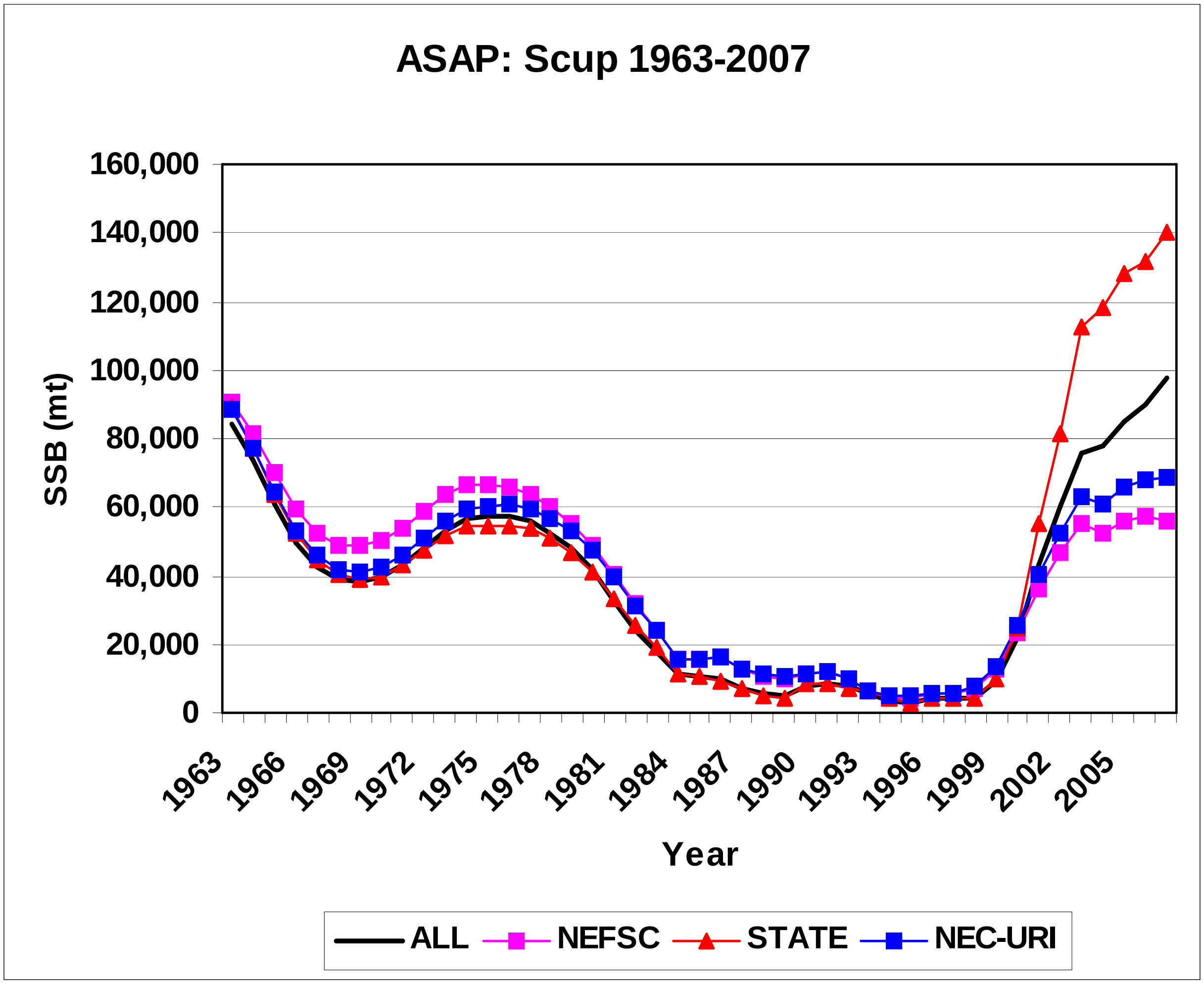

Figure 24. ASAP SSB estimates for the initial four alternative model configurations.

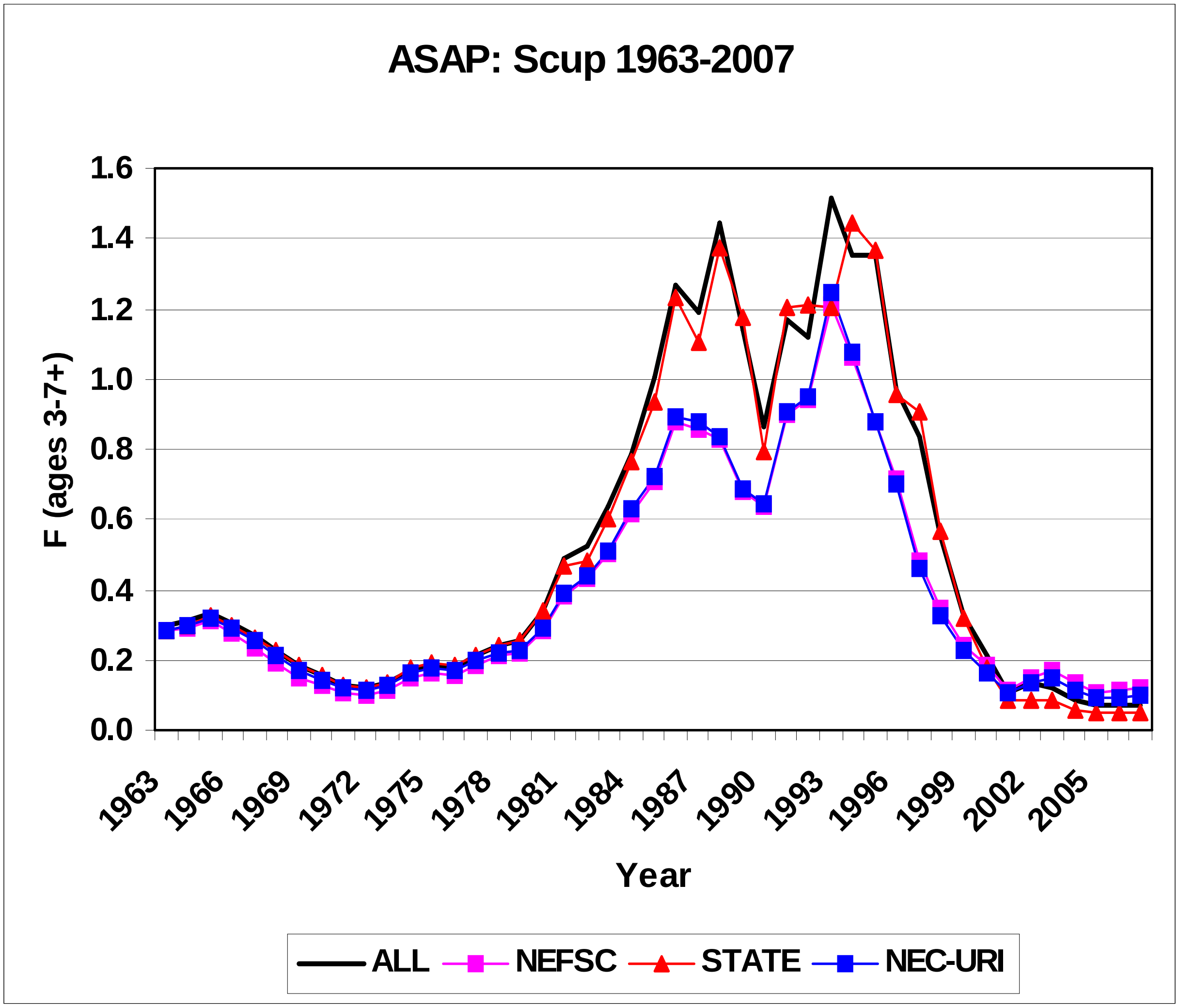

Figure 25. ASAP F estimates for the initial four alternative model configurations.

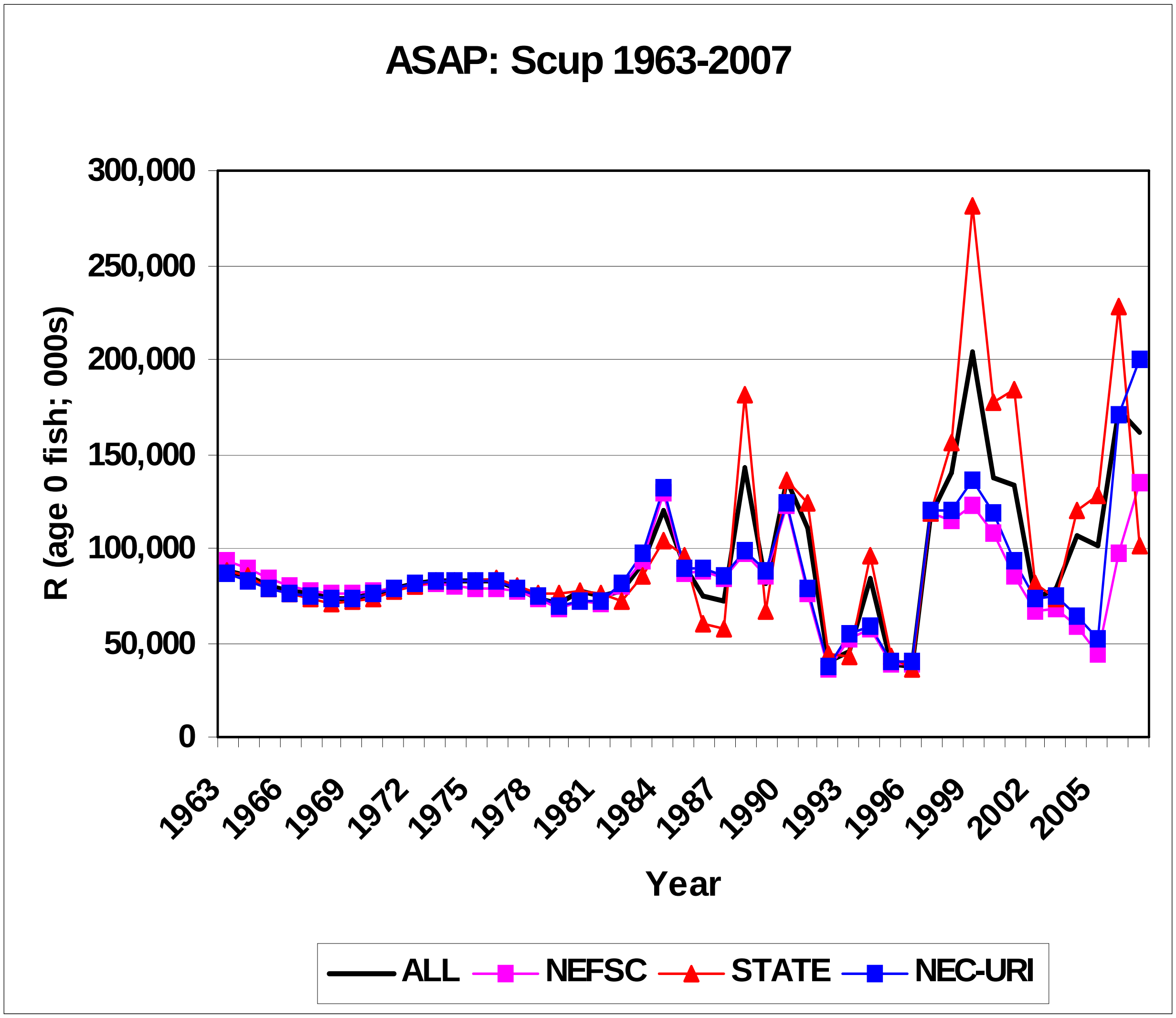

Figure 26. ASAP R (recruitment at age 0) estimates for the initial four alternative model configurations.

RUN ID	SSB63	SSB07	Fhighest	F07	Rhighest	R07	SSBMSY	MSY	FMSY	CATCH07
ALL	84,300	97,700	1.5	0.07	205	161	35600	12300	0.27	8026
NEFSC	90,500	56,300	1.21	0.12	135	135	33000	11000	0.25	8026
STATE	89,000	140,300	1.44	0.05	281	101	35900	12500	0.27	8026
NEC-URI	88,400	68,600	1.25	0.10	200	200	33300	11600	0.27	8026

	SSB07/SSBMSY	F07/FMSY	CAT07/MSY
ALL	2.74	0.26	0.65
NEFSC	1.71	0.48	0.73
STATE	3.91	0.19	0.64
NEC-URI	2.06	0.37	0.69

Figure 27. Initial ASAP results for four alternative run configurations (see text).

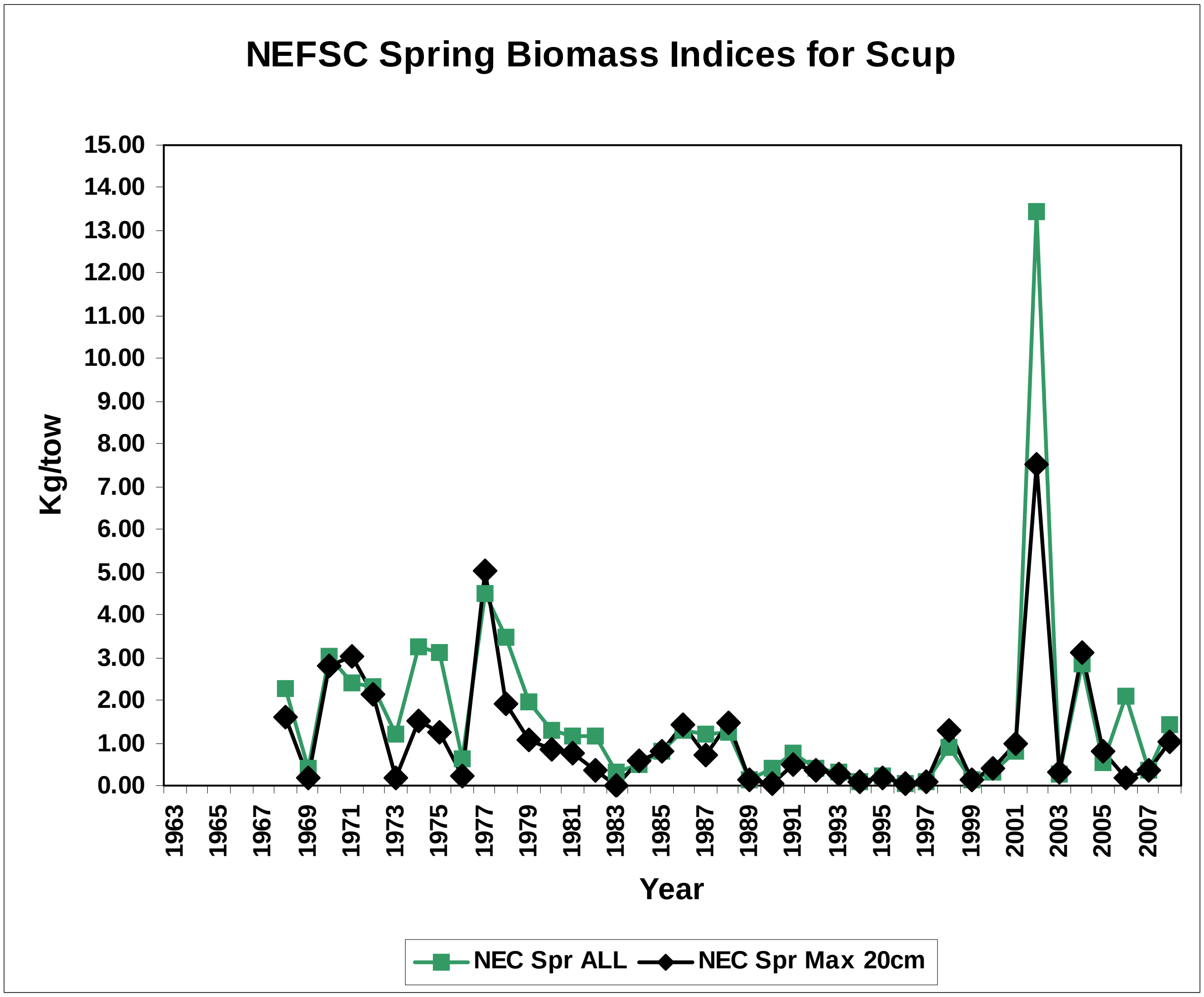

Figure 28. NEFSC Spring trawl survey biomass indices for scup: all sizes, and with a maximum length of 20 cm.

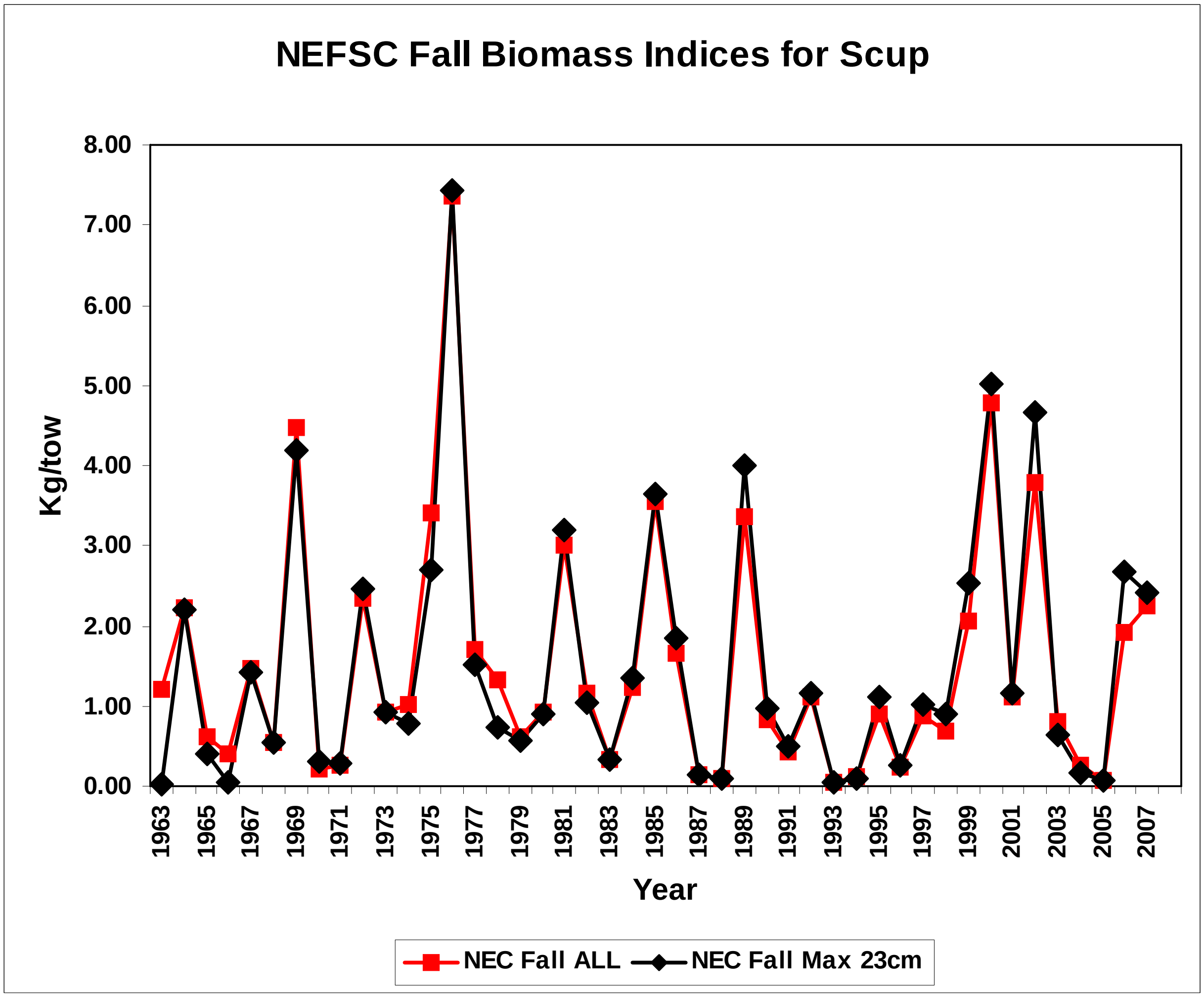

Figure 29. NEFSC Fall trawl survey biomass indices for scup: all sizes, and with a maximum length of 23 cm.

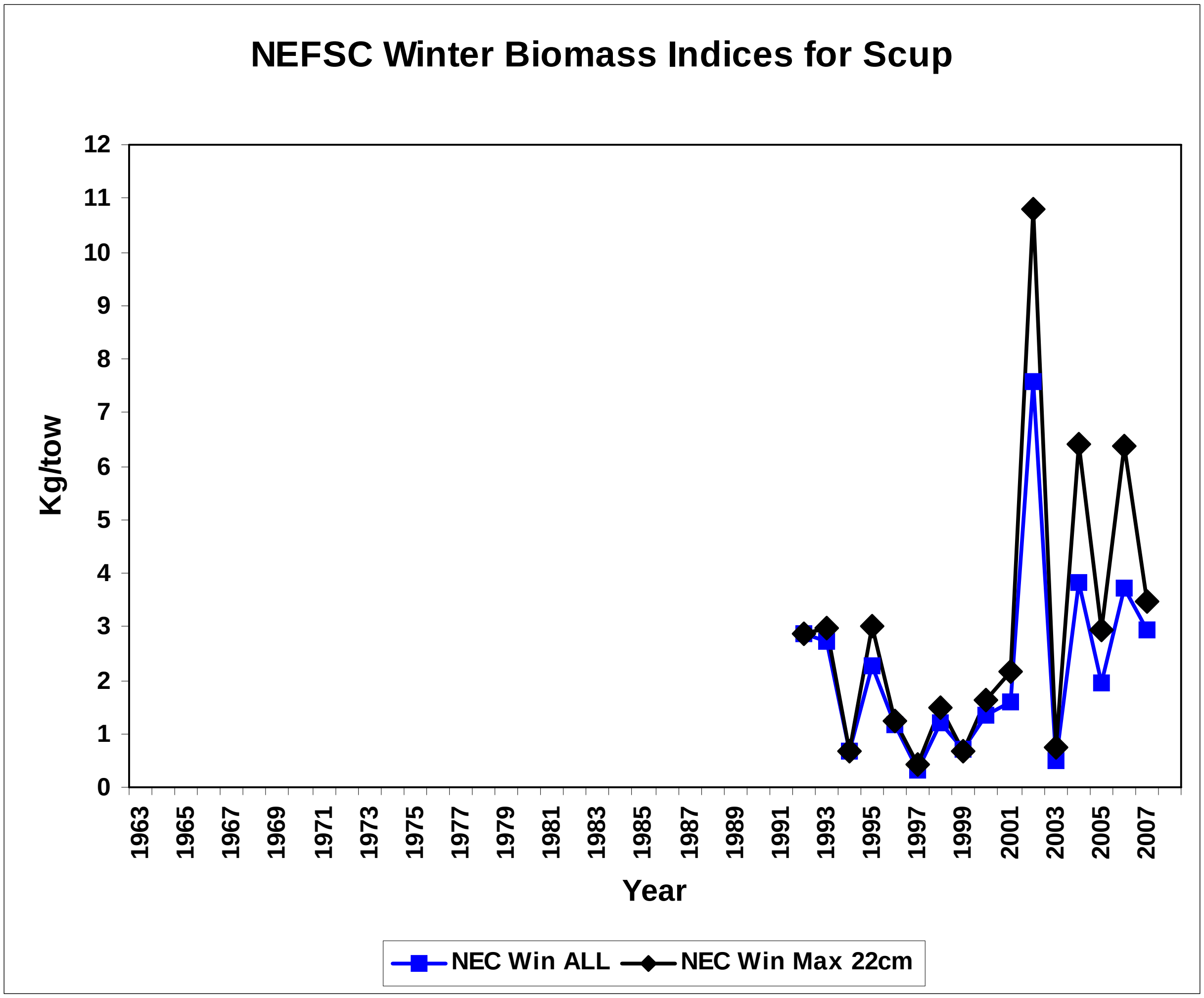

Figure 30. NEFSC Winter trawl survey biomass indices for scup: all sizes, and with a maximum length of 22 cm.

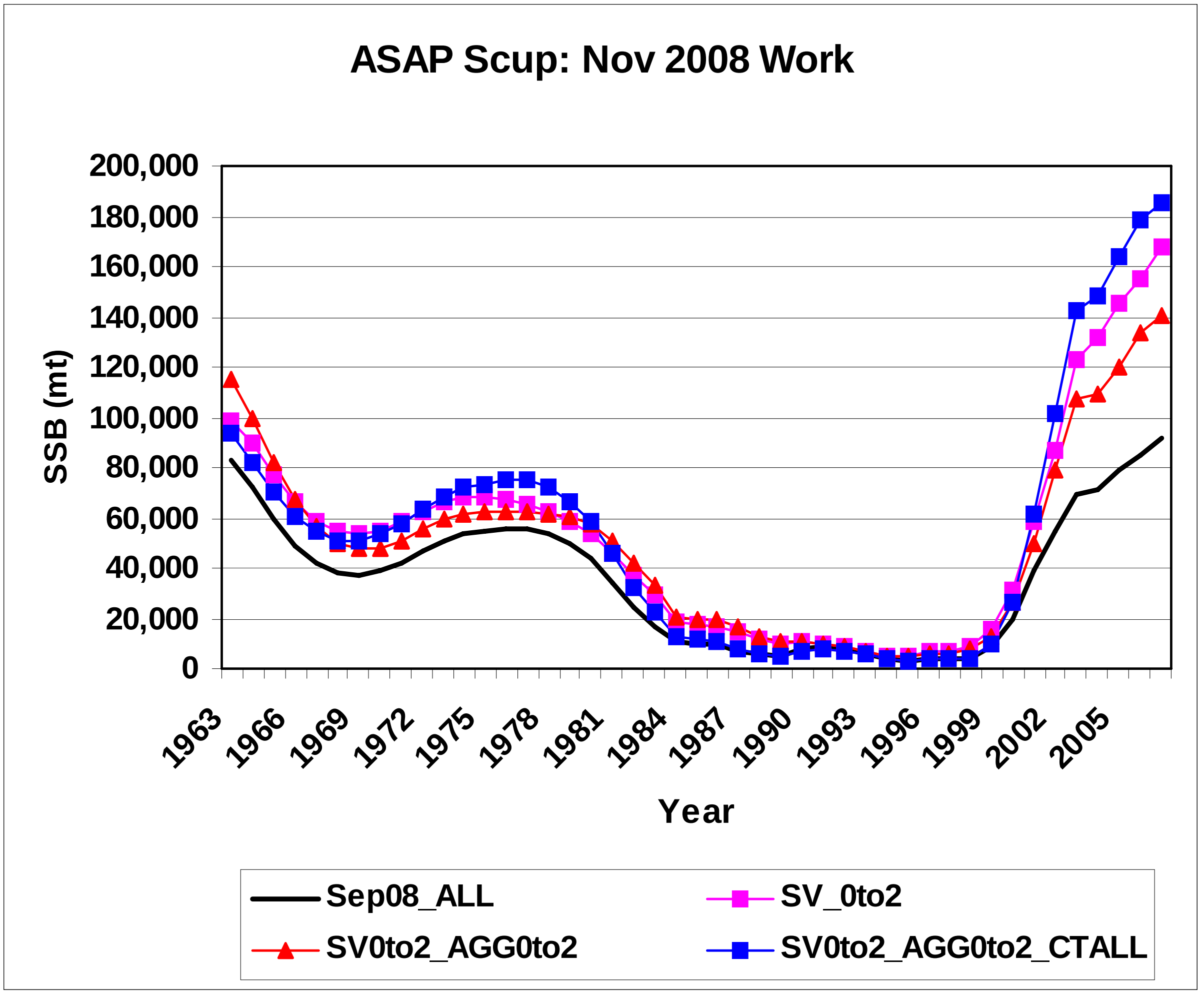

Figure 31. ASAP SSB estimates for the modified model configurations.

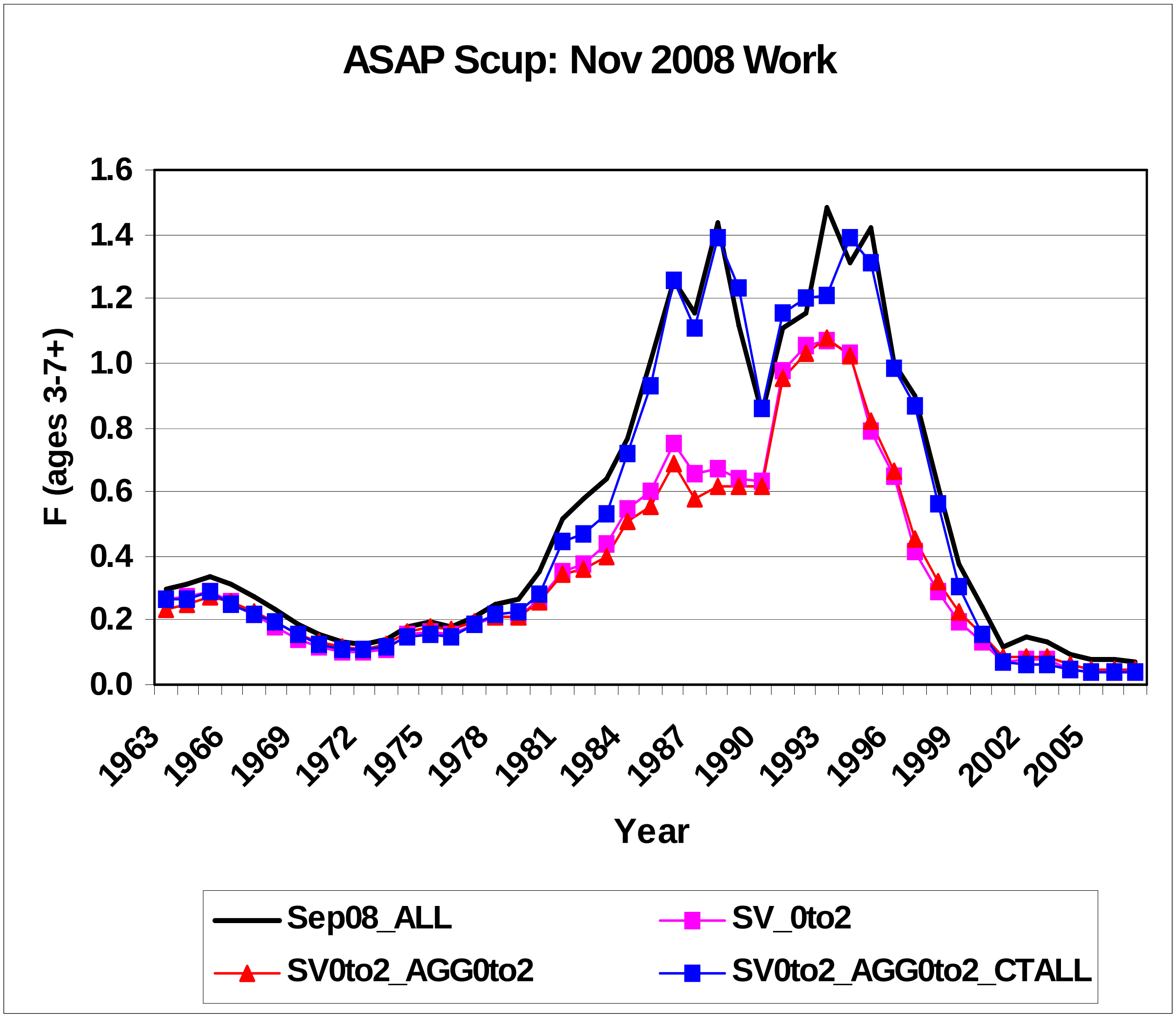

Figure 32. ASAP F estimates for the modified model configurations.

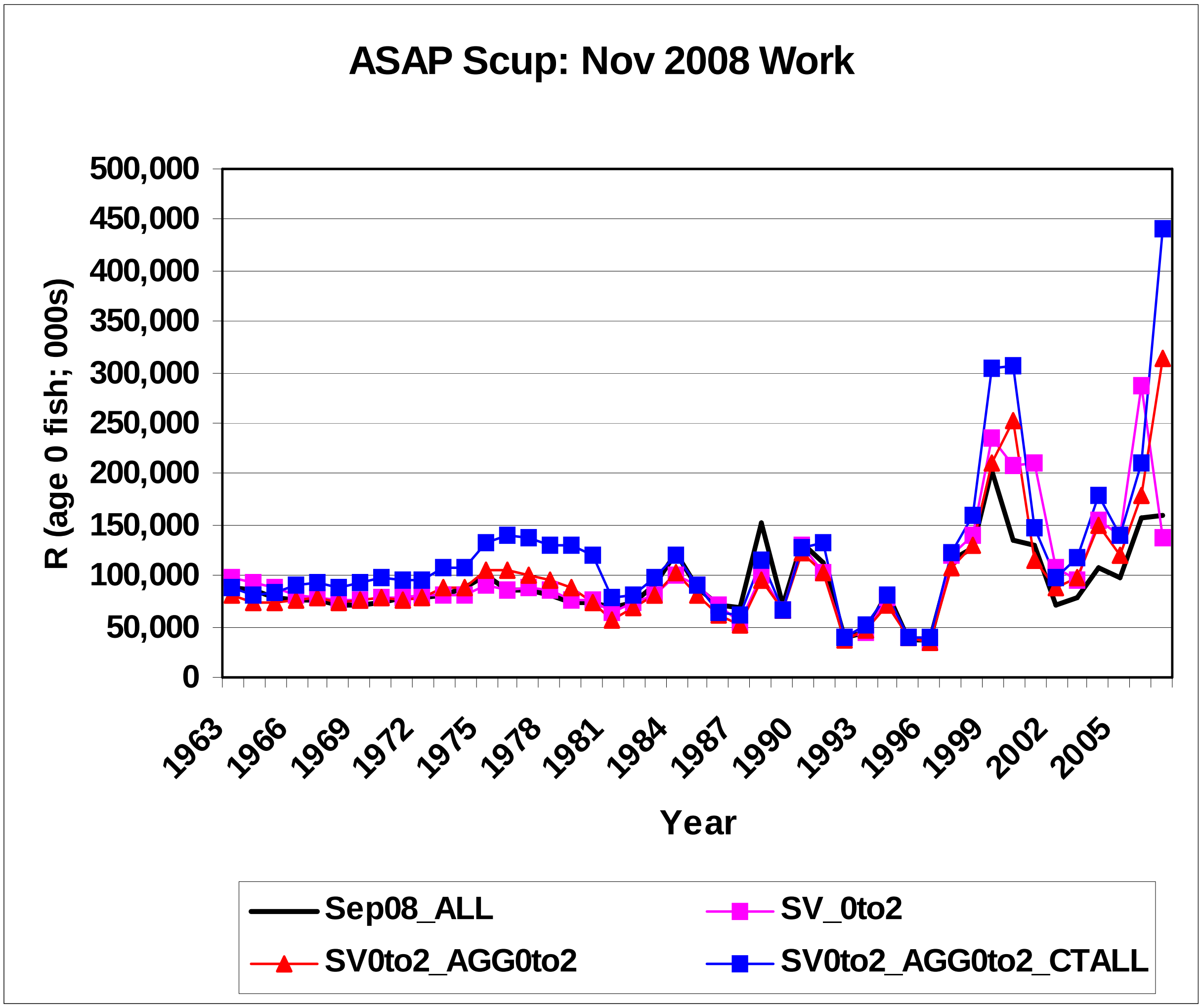

Figure 33. ASAP R (recruitment at age 0) estimates for the modified model configurations.

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Objective Function Summary

Absolute RUN ID	Fishery Total Catch	Fishery Age Comp	Survey Indices	Rec Devs	Total
Sep08_ALL	1052	1997	6354	518	9921
SV0to2	1013	1929	2473	528	5943
SV0to2_AGG0to2	1025	1967	5403	537	8932
SV0to2_AGG0to2_CTALL	1159	1996	5597	553	9305

Percent RUN ID	Fishery Total Catch	Fishery Age Comp	Survey Indices	Rec Devs	Total
Sep08_ALL	11%	20%	64%	5%	100%
SV0to2	17%	32%	42%	9%	100%
SV0to2_AGG0to2	11%	22%	60%	6%	100%
SV0to2_AGG0to2_CTALL	12%	21%	60%	6%	100%

Figure 34. Objective function summary for the ASAP modified runs.

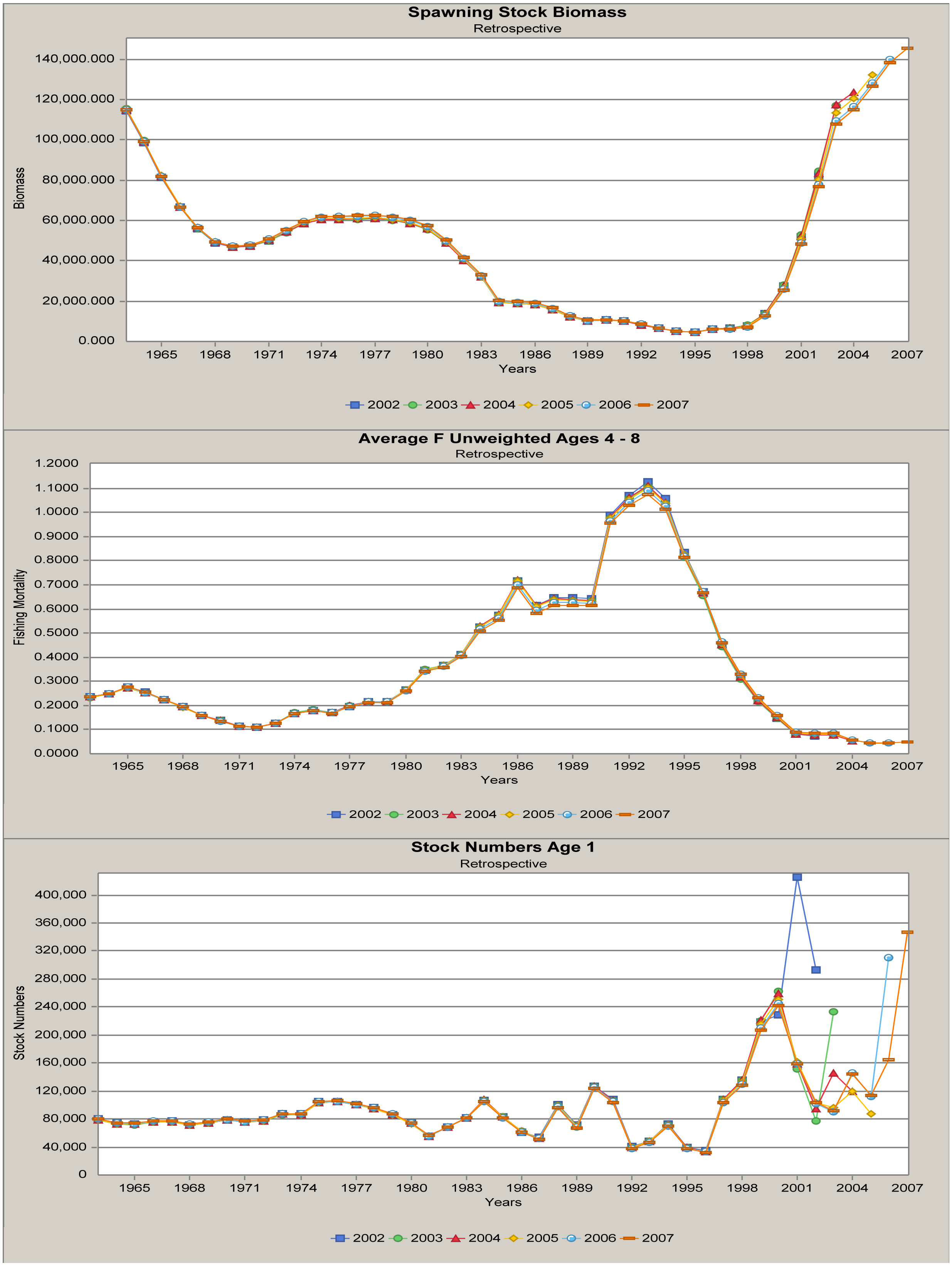


Figure 35. Retrospective runs for run SV0to2_AGG0to2.

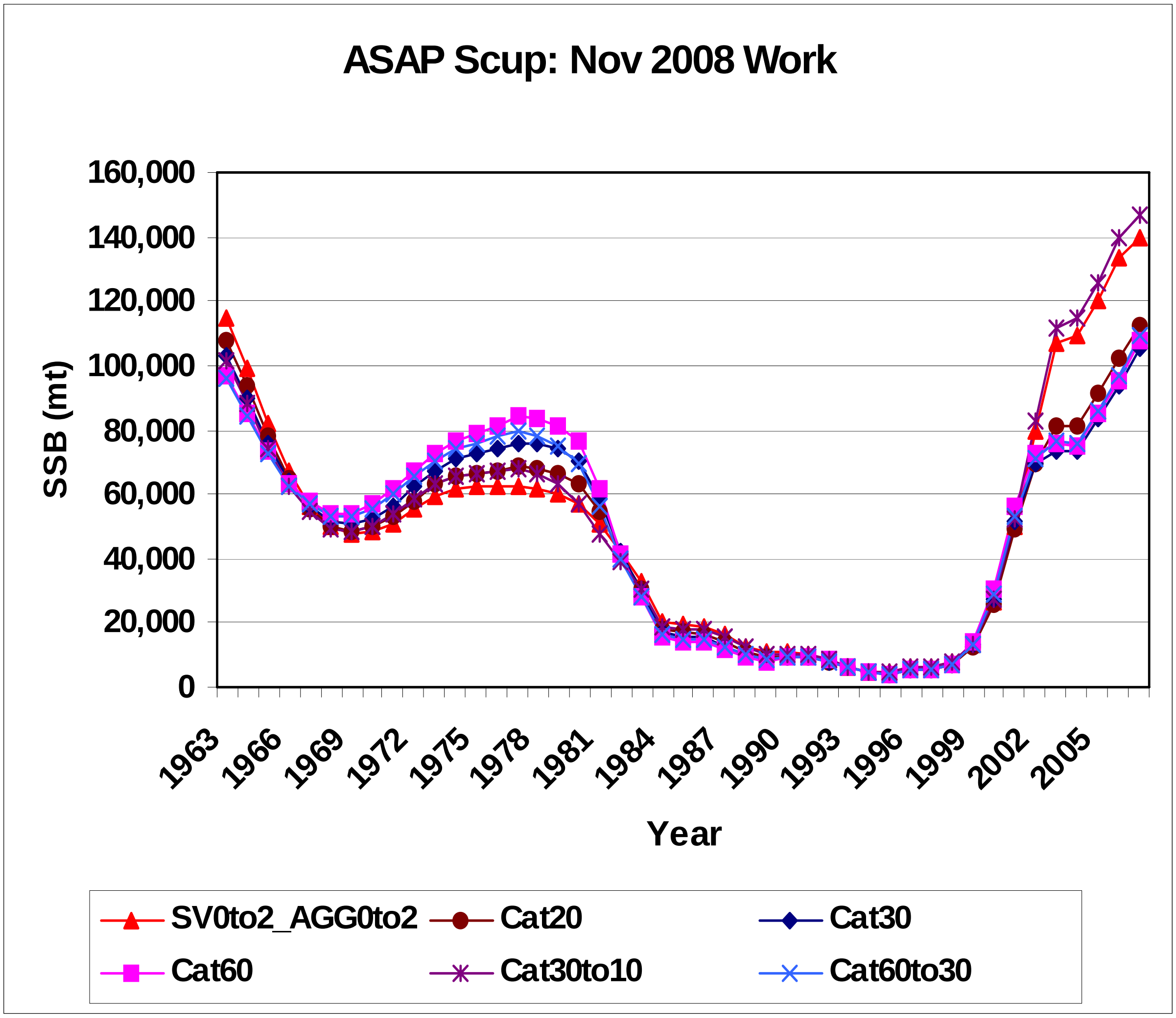


Figure 36. Sensitivity of the SV0to2_AGG0to2 ASAP results to different assumptions about the uncertainty of fishery catch estimates: estimates of SSB.

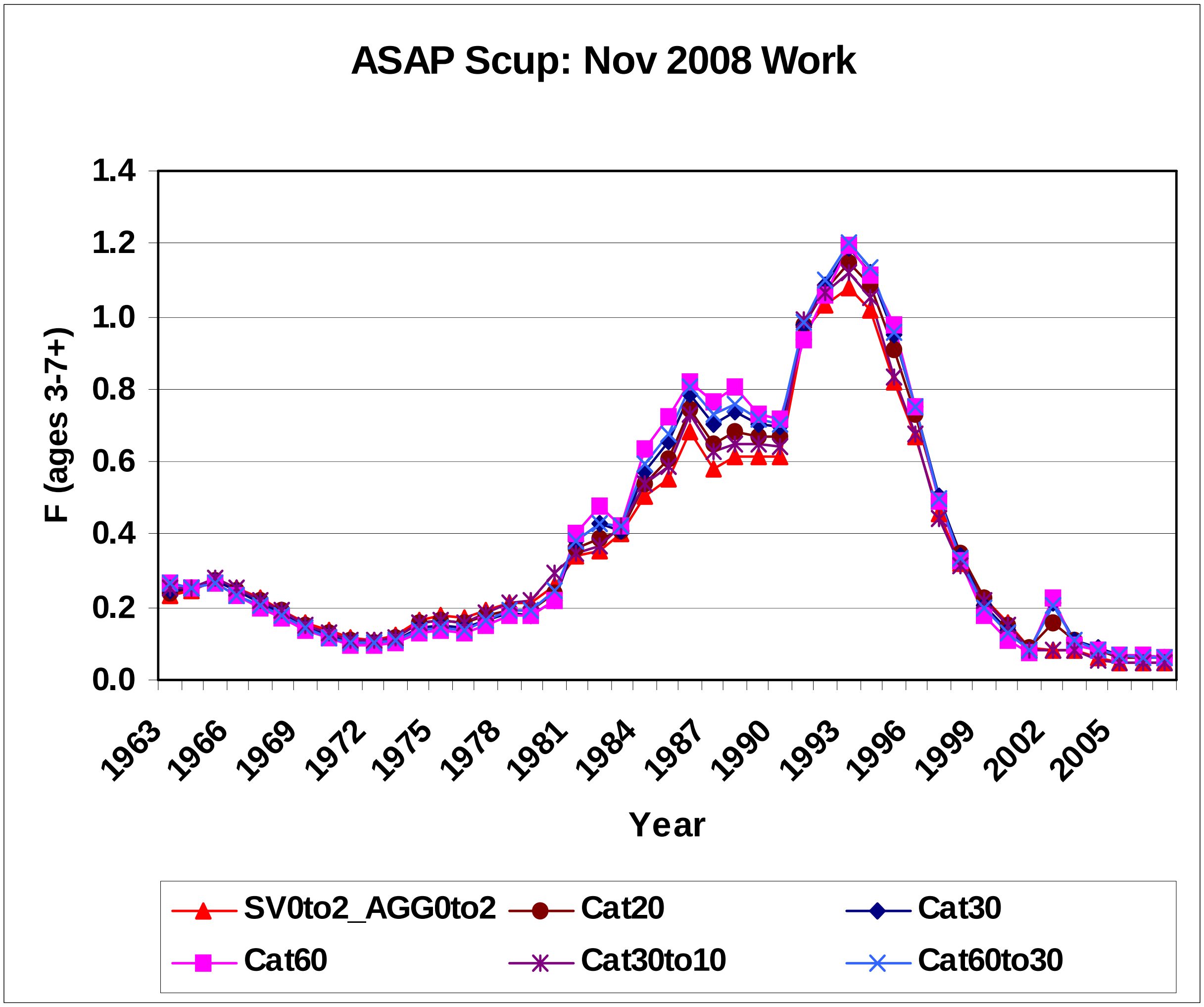


Figure 37. Sensitivity of the SV0to2_AGG0to2 ASAP results to different assumptions about the uncertainty of fishery catch estimates: estimates of F.

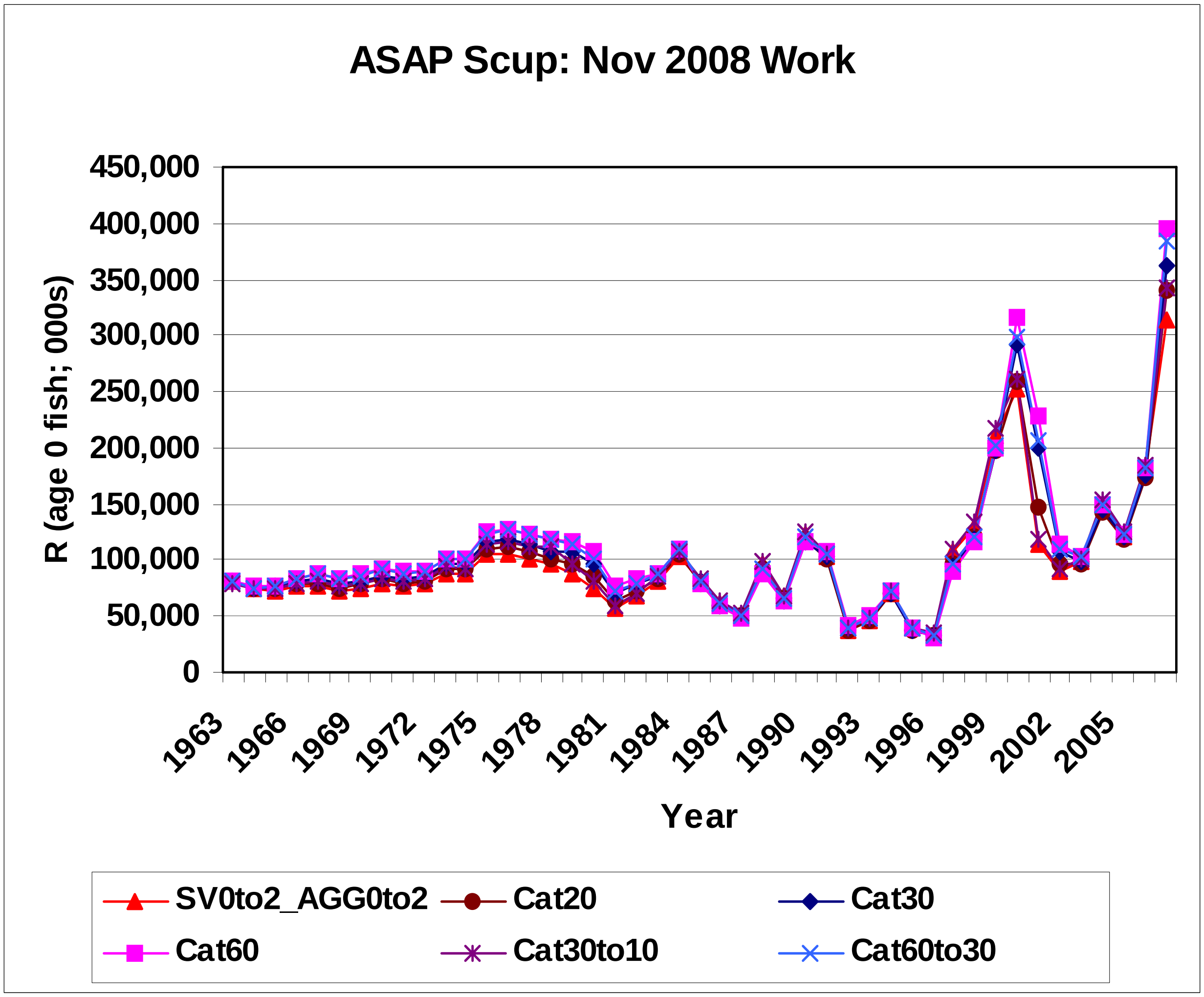


Figure 38. Sensitivity of the SV0to2_AGG0to2 ASAP results to different assumptions about the uncertainty of fishery catch estimates: estimates of F.

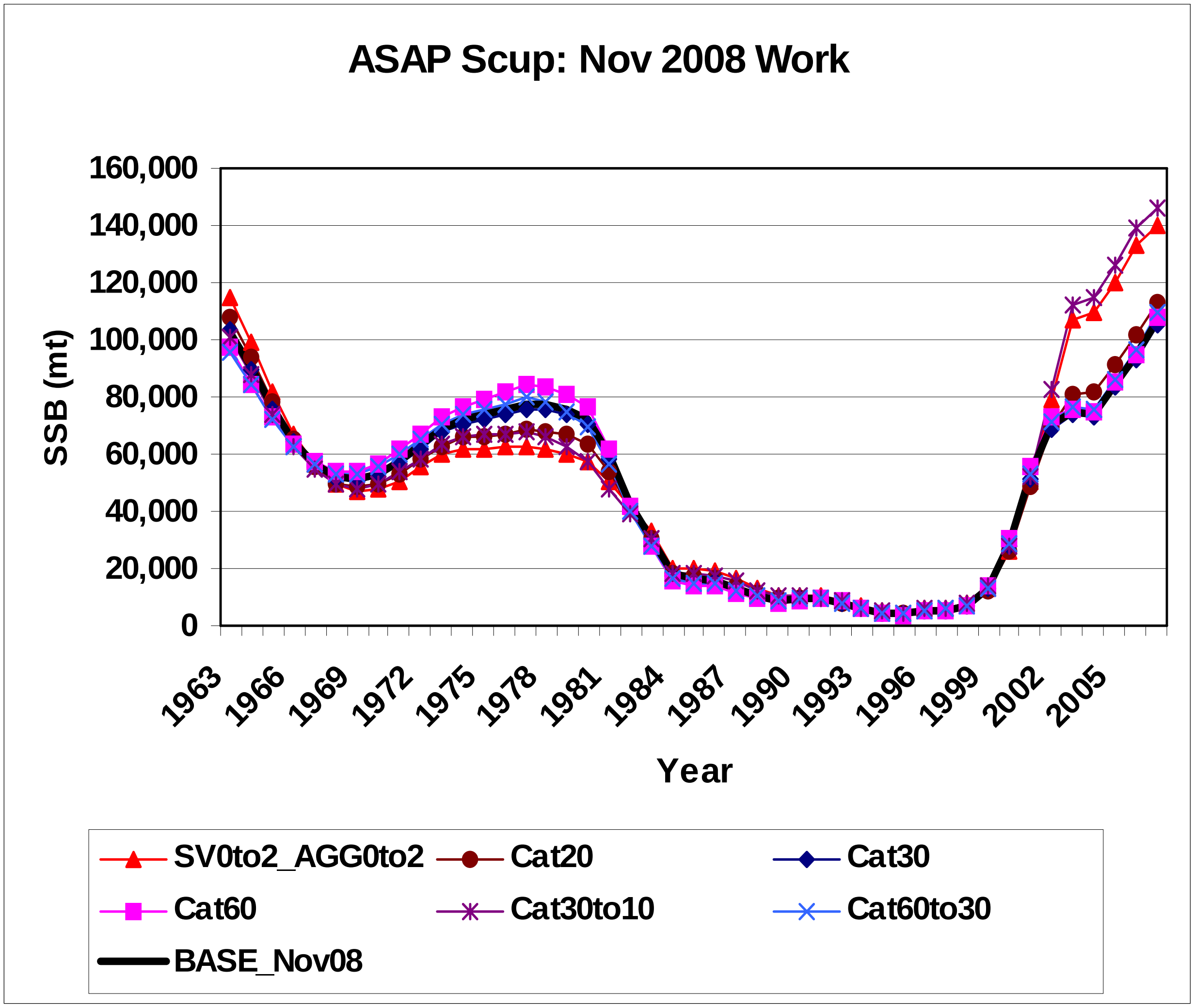


Figure 39. Comparative ASAP results for different assumptions about the uncertainty of fishery catch estimates: estimates of SSB from the BASE_Nov08 run.

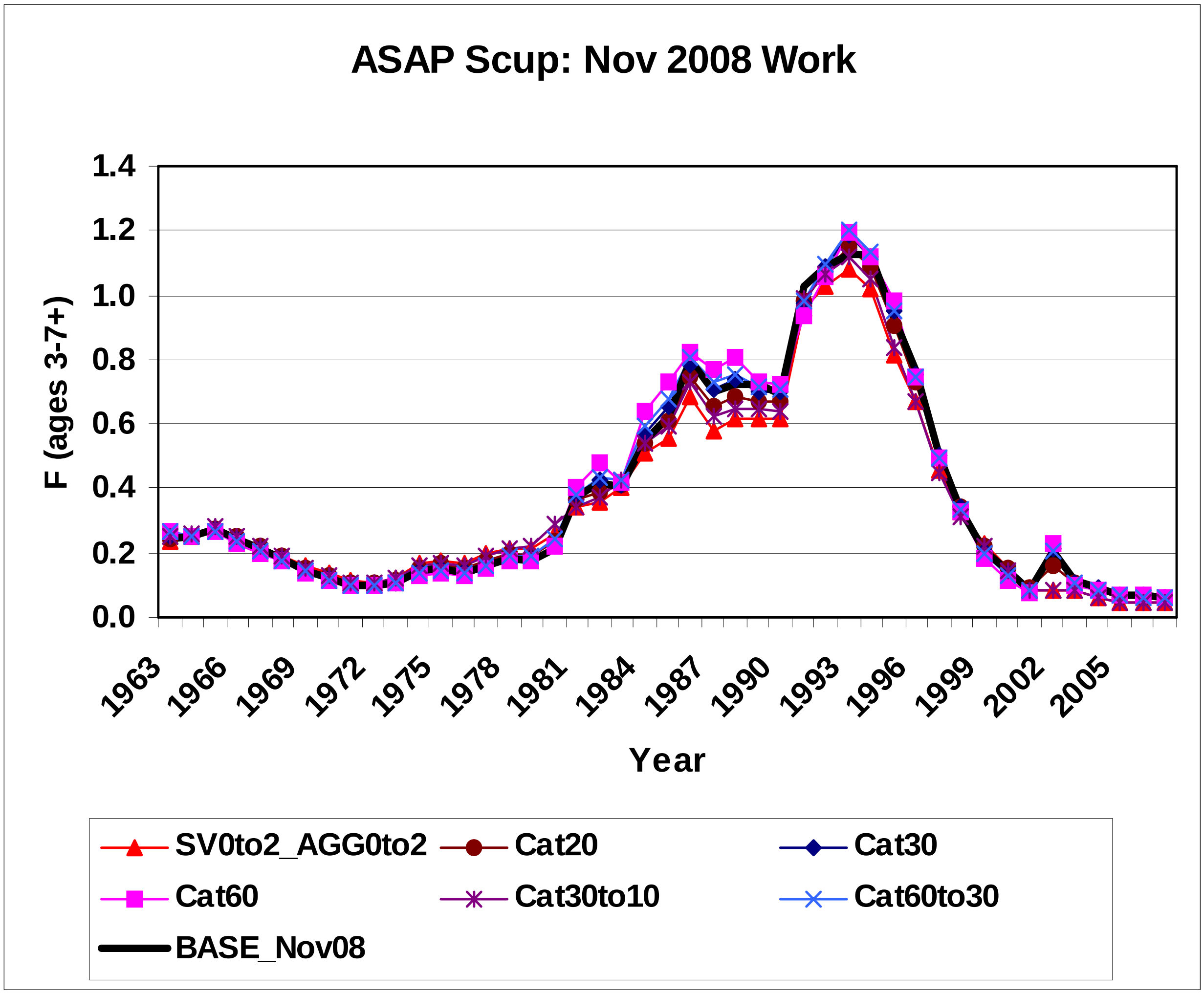


Figure 40. Comparative ASAP results for different assumptions about the uncertainty of fishery catch estimates: estimates of F from the BASE_Nov08 run.

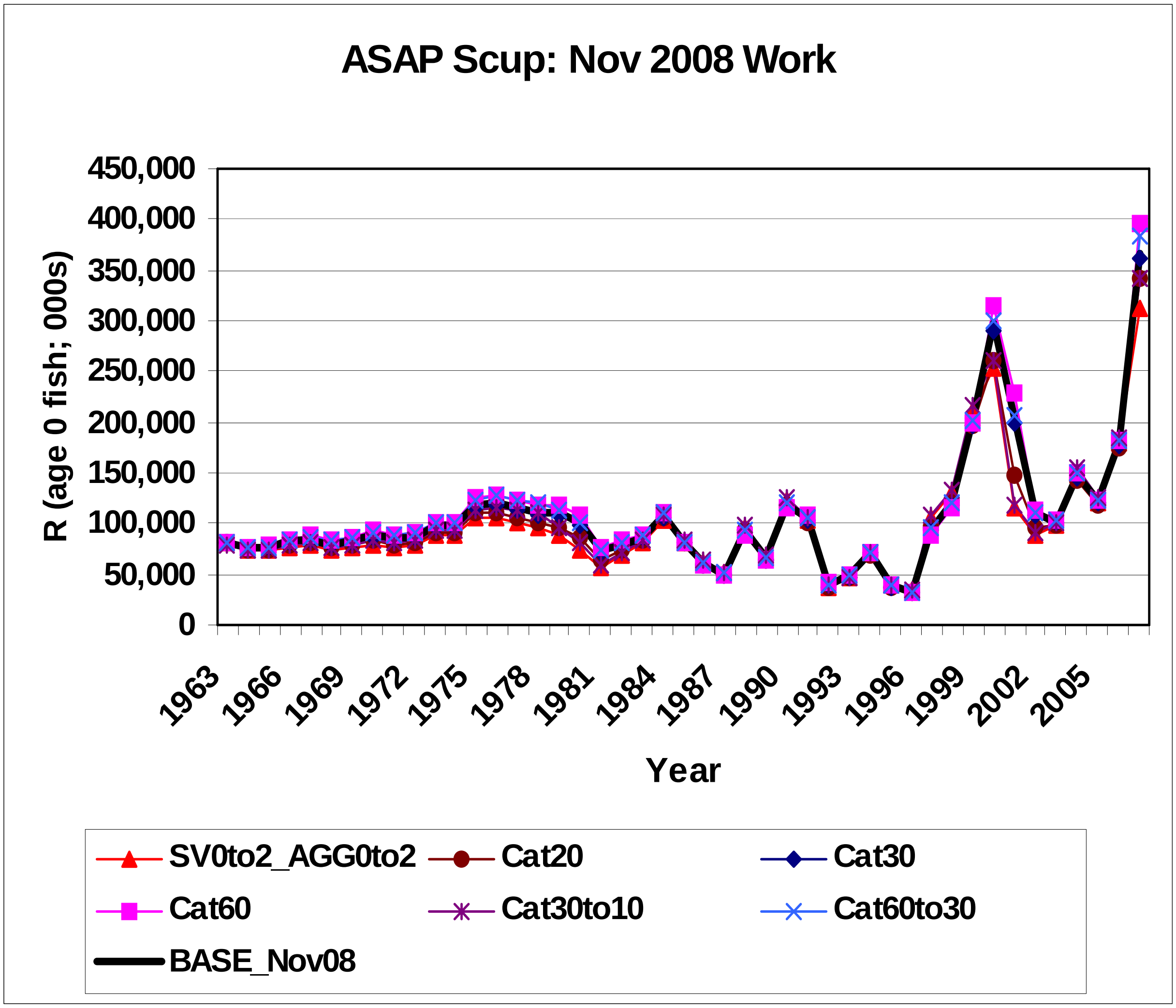


Figure 41. Comparative ASAP results for different assumptions about the uncertainty of fishery catch estimates: estimates of R from the BASE_Nov08 run.

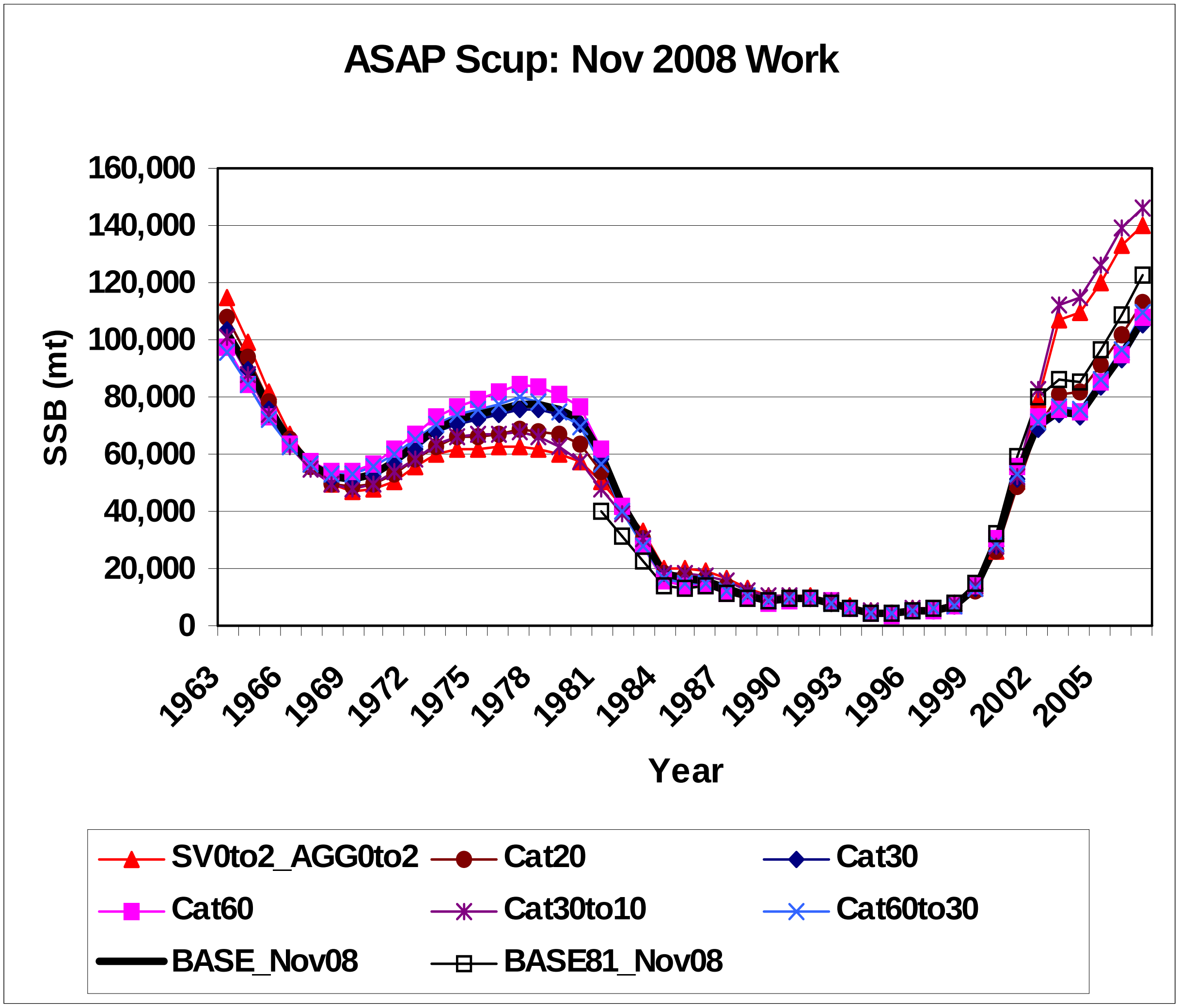


Figure 42. Comparative ASAP results for effect of 1981-2007 time series in run BASE81_Nov08: estimates of SSB.

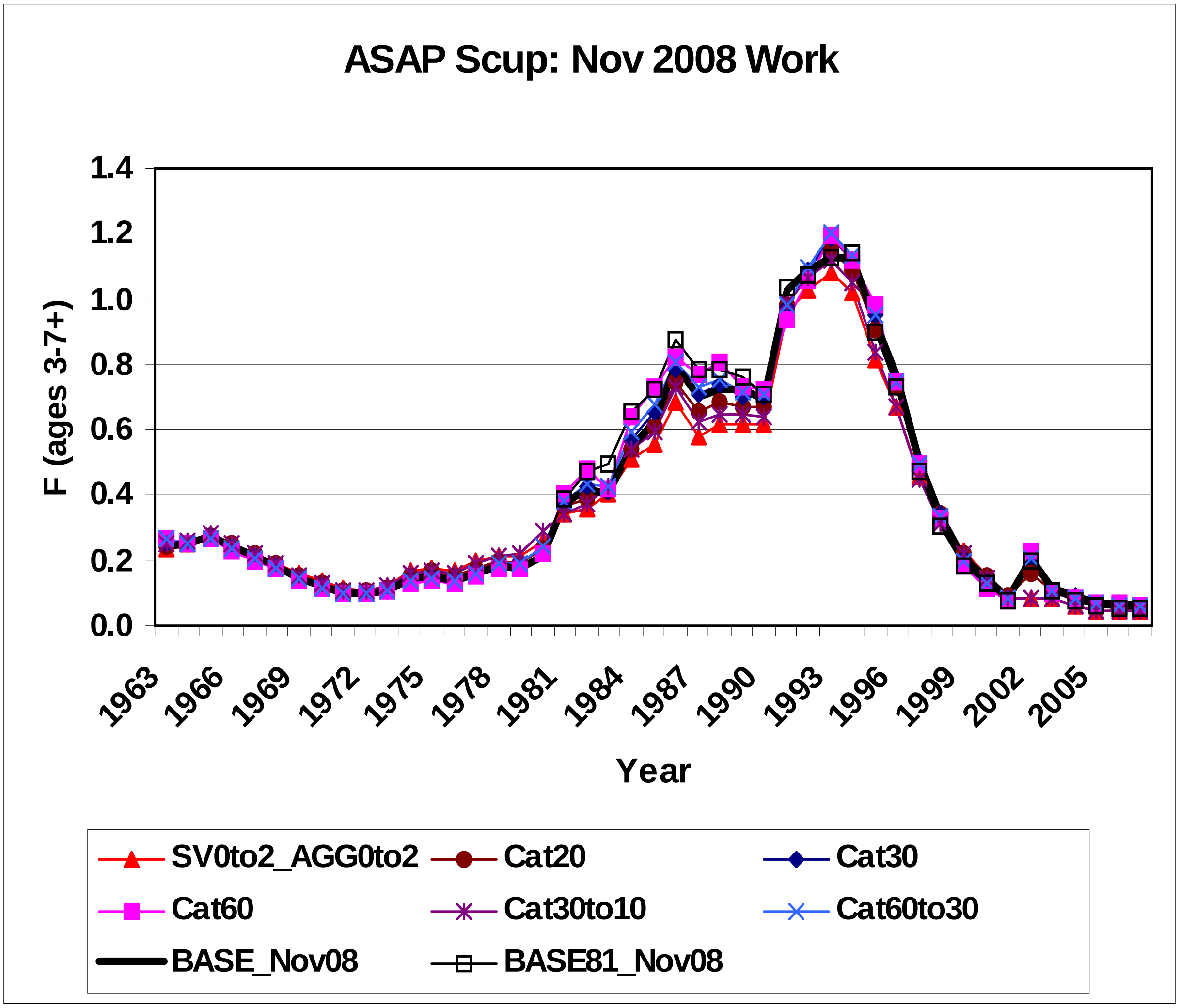


Figure 43. Comparative ASAP results for effect of 1981-2007 time series in run BASE81_Nov08: estimates of F.

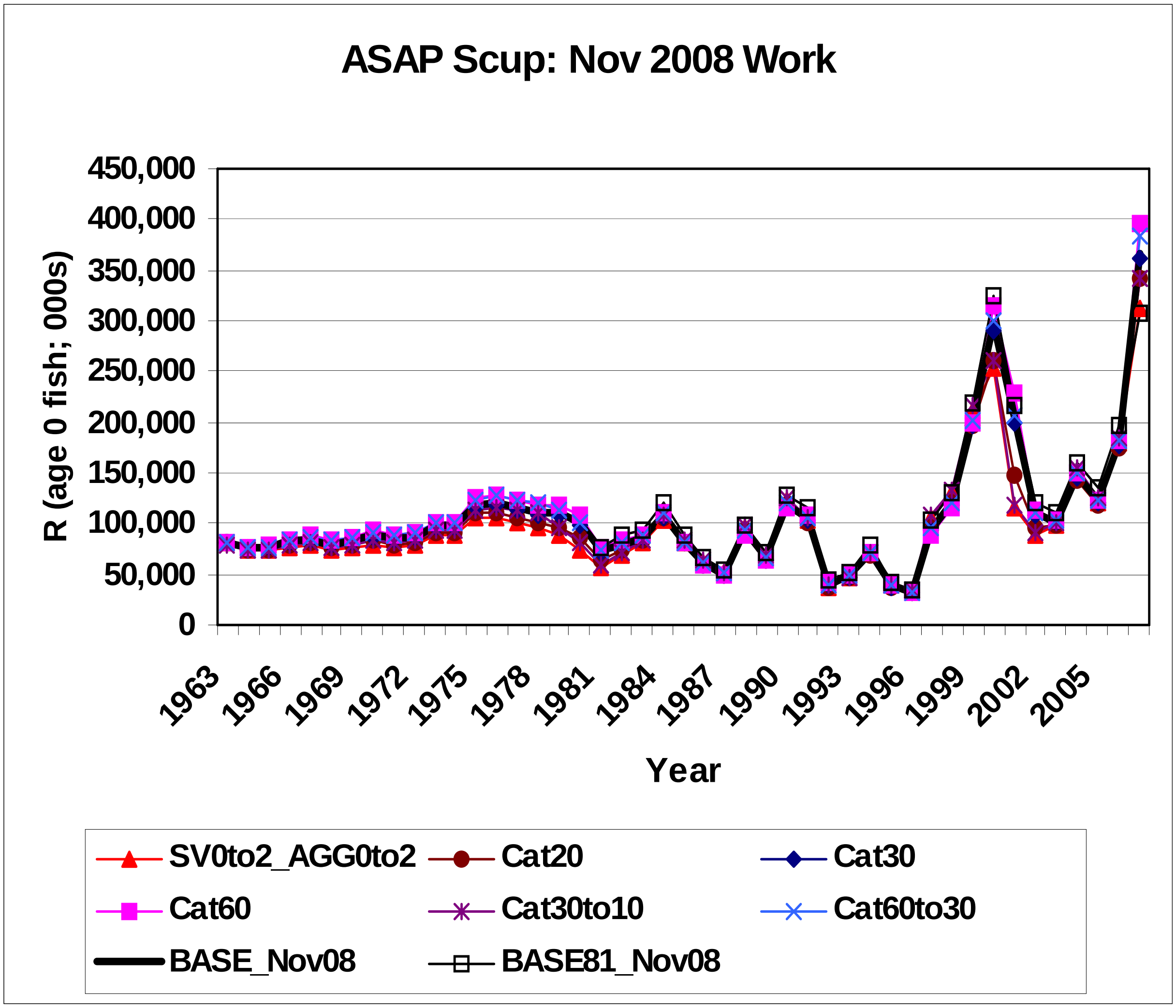


Figure 44. Comparative ASAP results for effect of 1981-2007 time series in run BASE81_Nov08: estimates of R.

SCUP: ASAP "BASE_Nov08" model — **Mean R = 119.2 million age 0 fish**

BRP		Y/R	SSB/R	SSB	Catch	Land	Disc
Fmax	0.272	0.155	0.552	62,630	17,601	13,330	4,271
F35%	0.202	0.151	0.745	85,425	17,349	13,823	3,526

SCUP: ASAP "BASE81_Nov08" model — **Mean R = 125.4 million age 0 fish**

BRP		Y/R	SSB/R	SSB	Catch	Land	Disc
Fmax	0.292	0.163	0.547	66,142	19,743	15,202	4,541
F35%	0.213	0.158	0.746	91,119	19,440	15,735	3,705

SCUP: ASAP "BASE_Nov08" model

BRP	SSB	SSB07	%SSBMSY	Catch	Catch07	%MSY
Fmax	62,630	107,129	171%	17,601	8,026	46%
F35%	85,425	107,129	125%	17,349	8,026	46%

SCUP: ASAP "BASE81_Nov08" model

BRP	SSB	SSB07	%SSBMSY	Catch	Catch07	%MSY
Fmax	66,142	122,671	185%	19,743	8,026	41%
F35%	91,119	122,671	135%	19,440	8,026	41%

Figure 45. Biological reference points and stock status from ASAP model results, for the full 1963-2007 time series (BASE_Nov08) and shorter 1981-2007 (BASE81_Nov08) time series. Fishing mortality rates (F) for both models were about 0.06, about one-quarter of the Fmax proxy for FMSY.

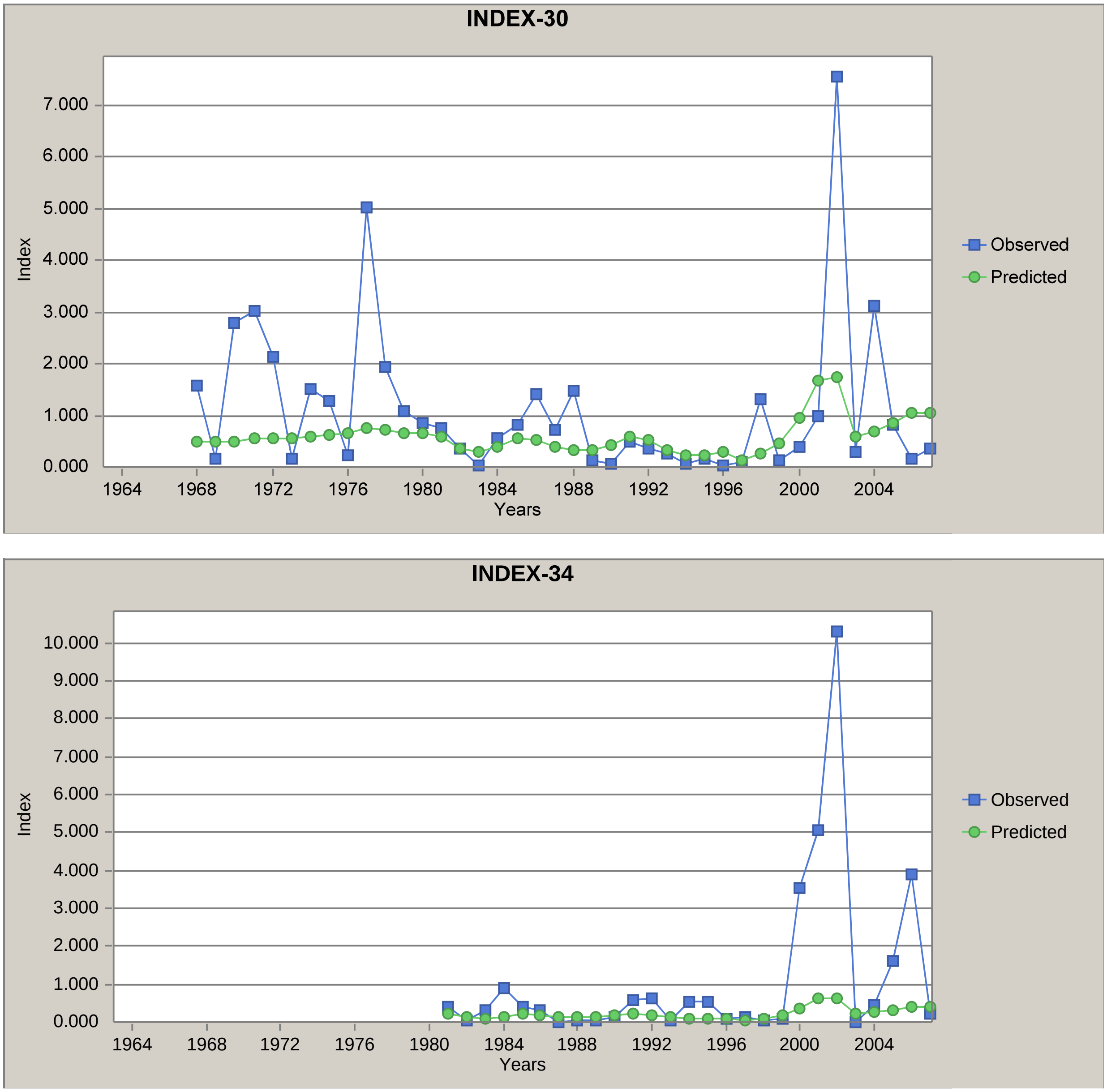
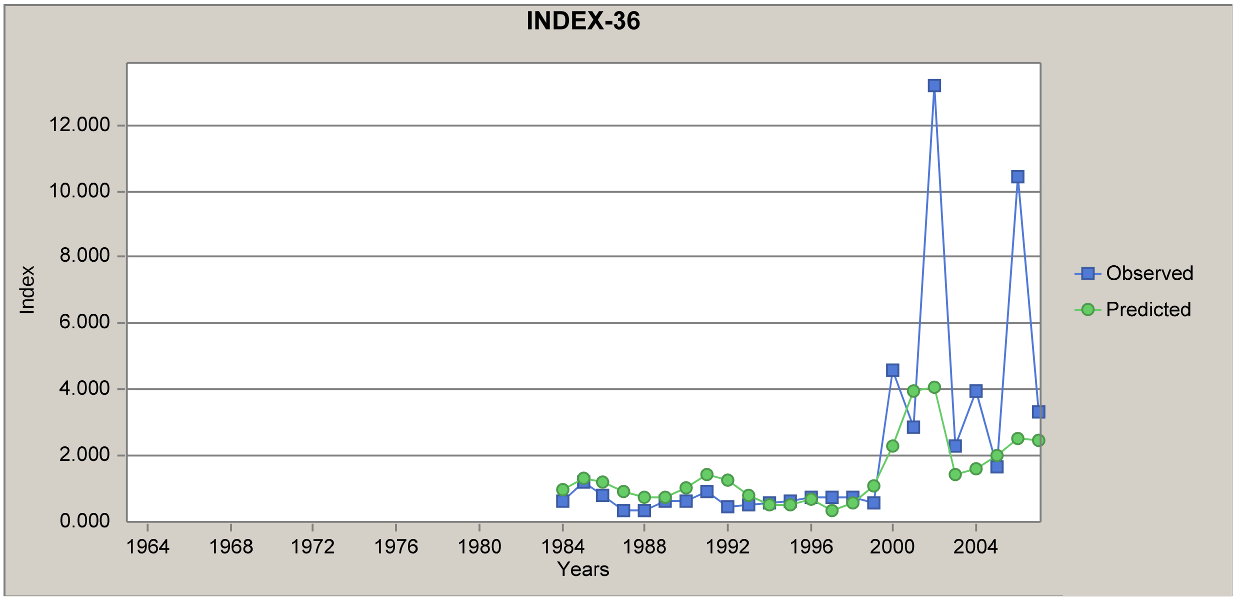


Figure 46. ASAP model BASE_C2006 run fits for the NEFSC Spring survey aggregate biomass index for ages 1-2 (top - Index 30) and RIDFW Spring survey biomass index for ages 1-2 (bottom - Index 34) showing the large residuals for the 2002 indices.



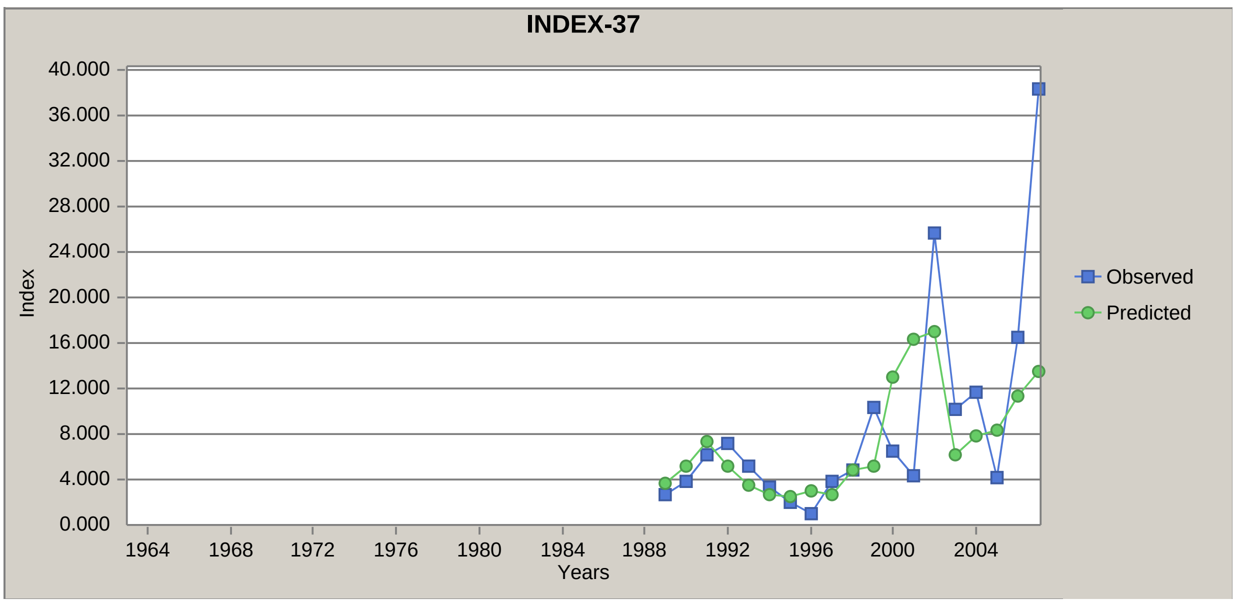


Figure 47. ASAP model BASE_C2006 run fits for the CTDEP Spring survey aggregate biomass index for ages 1-2 (top - Index 36) and NJBMF Annual survey biomass index for ages 1-2 (bottom - Index 37) showing the large residuals for the 2002 indices.

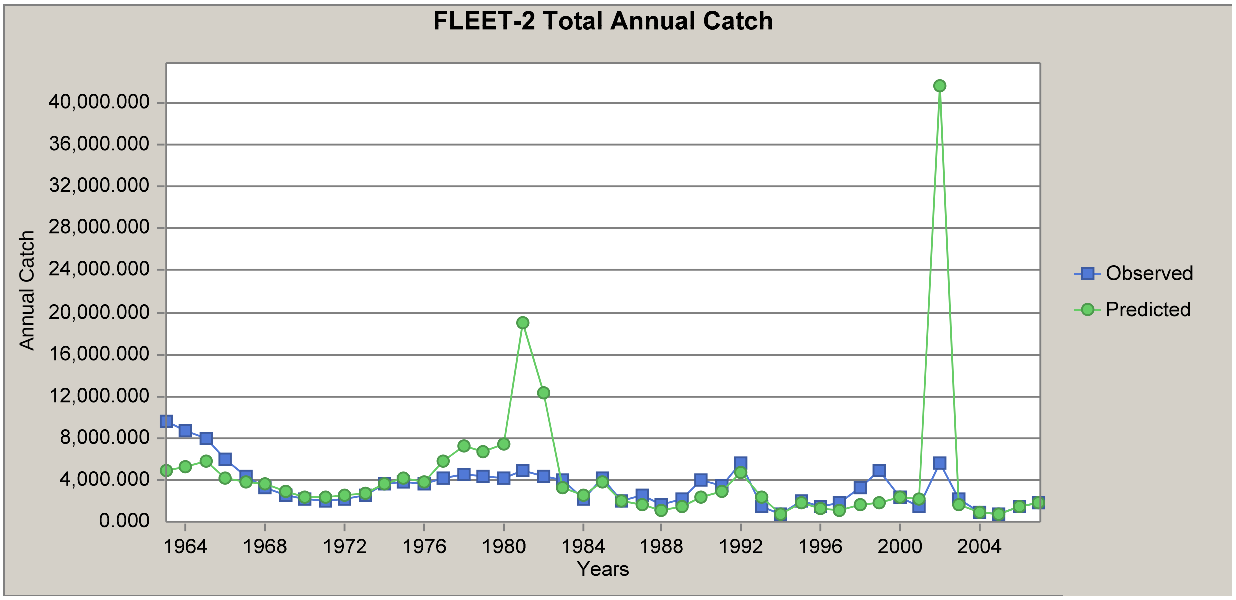


Figure 48. ASAP model BASE_C2006 run fit for Commercial Fishery Aggregate Discards showing the large residual for the 2002 estimate.

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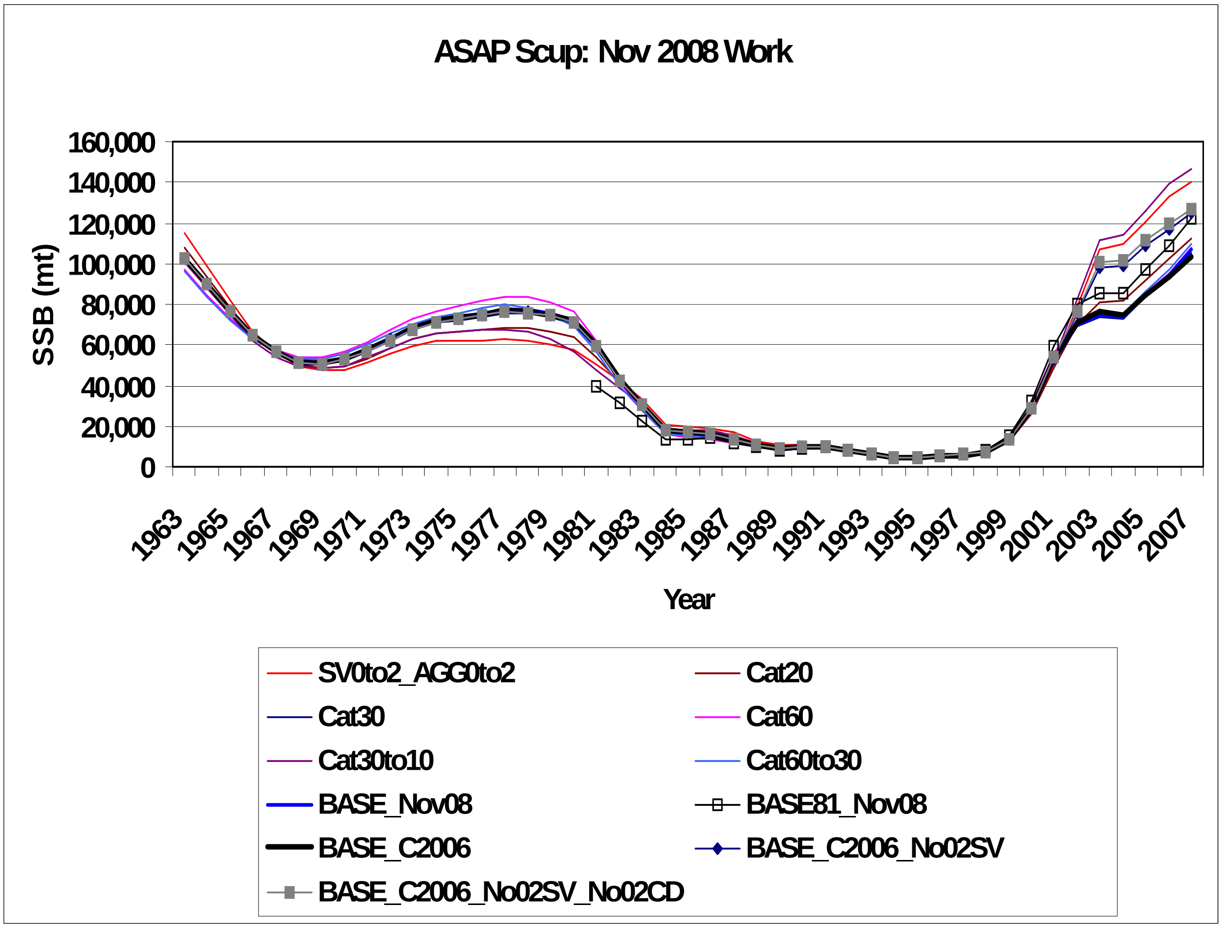

Figure 49. Comparative results of estimated SSB in ASAP runs for scup: effect of 2002 survey and commercial discard input data.

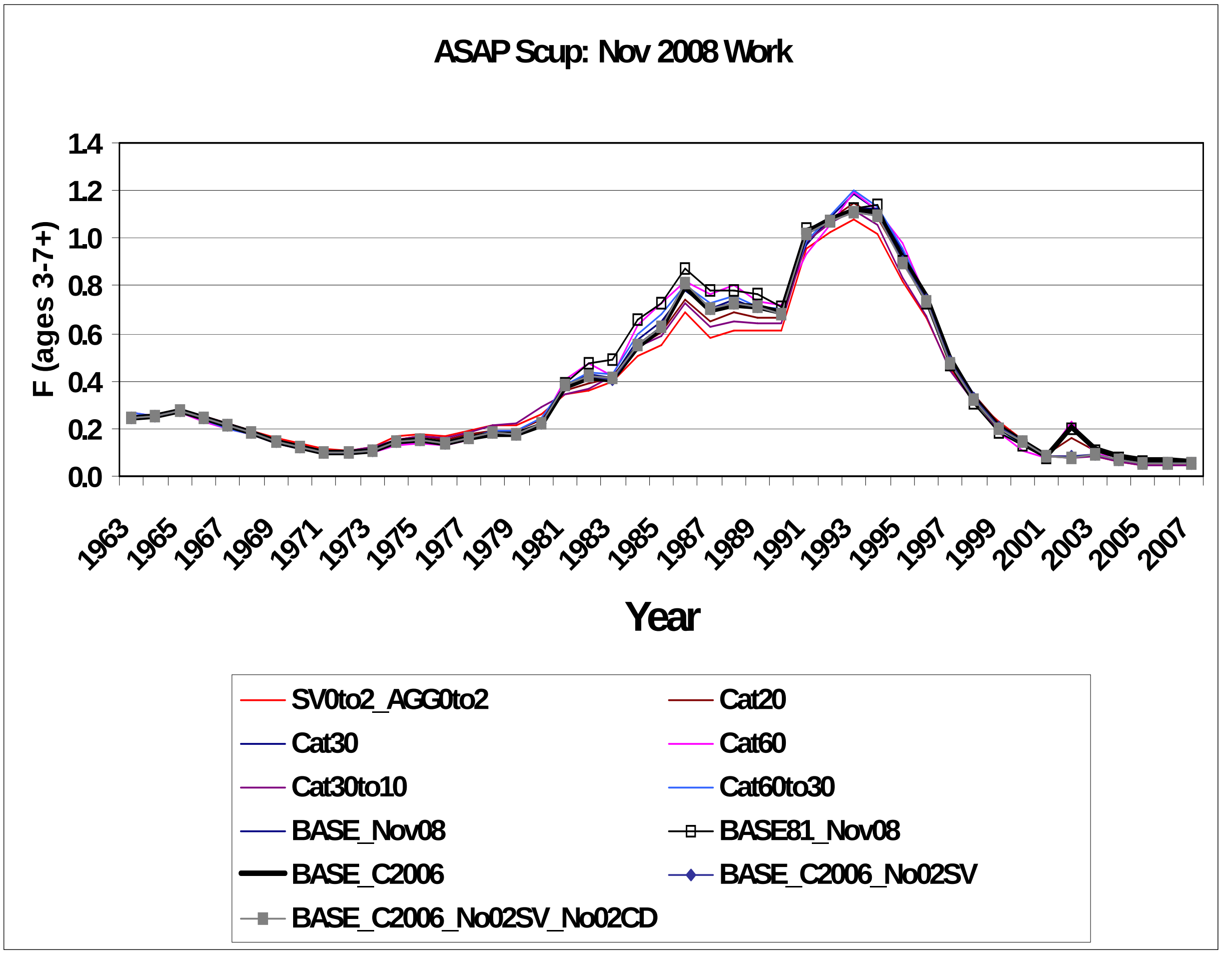

Figure 50. Comparative results of estimated F in ASAP runs for scup: effect of 2002 survey and commercial discard input data.

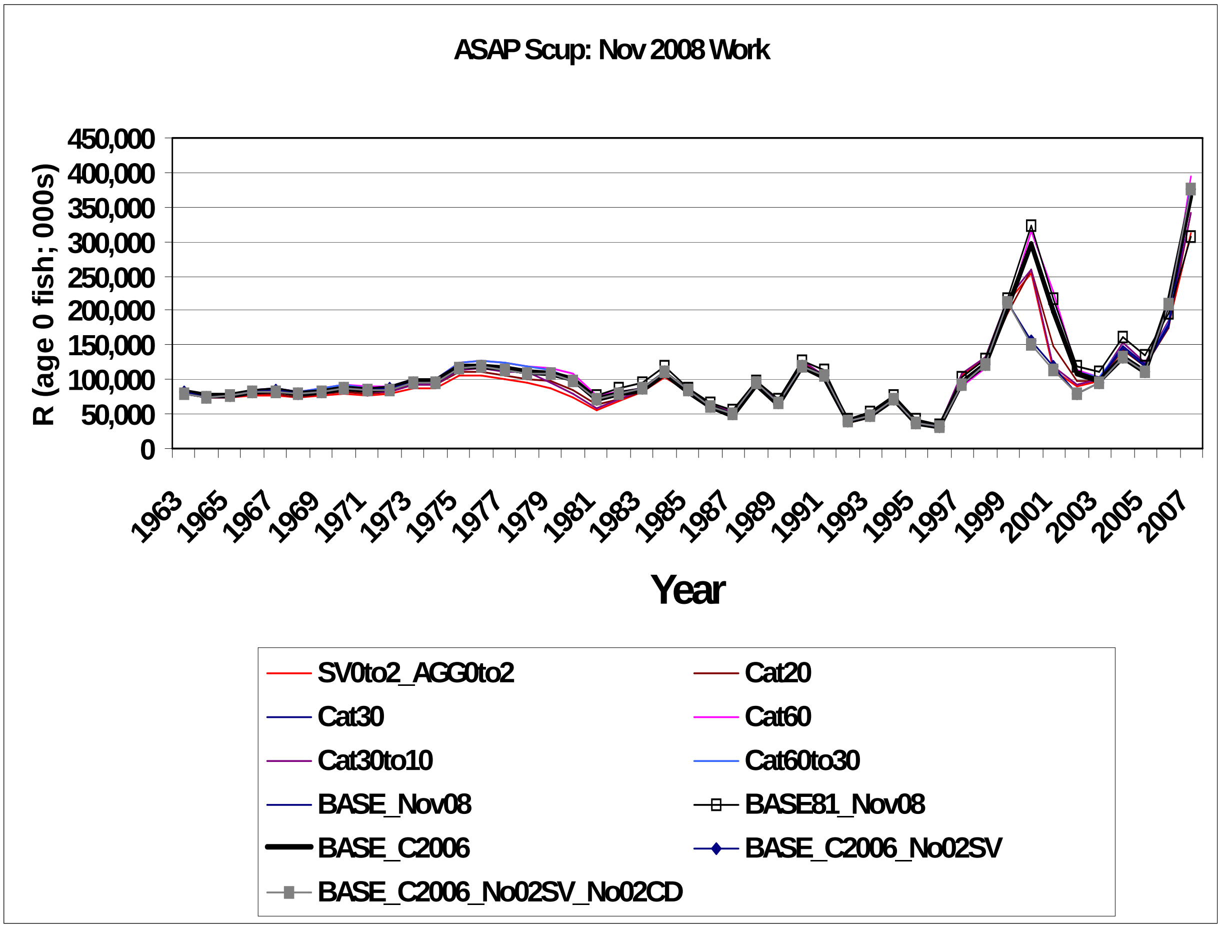

Figure 51. Comparative results of estimated recruitment in ASAP runs for scup: effect of 2002 survey and commercial discard input data.

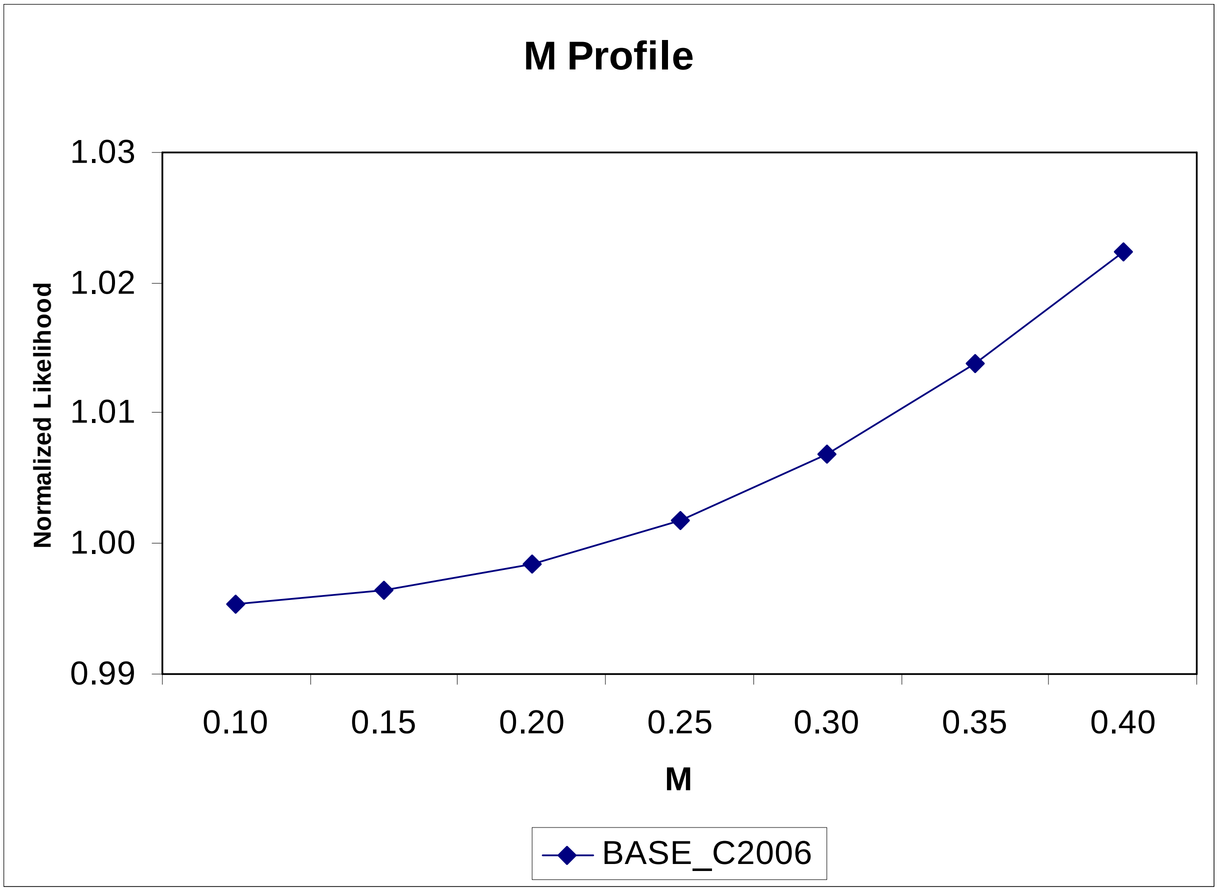

Figure 52. Sensitivity profile of the assumption for natural mortality (M) for the ASAP BASE_C2006 model configuration.

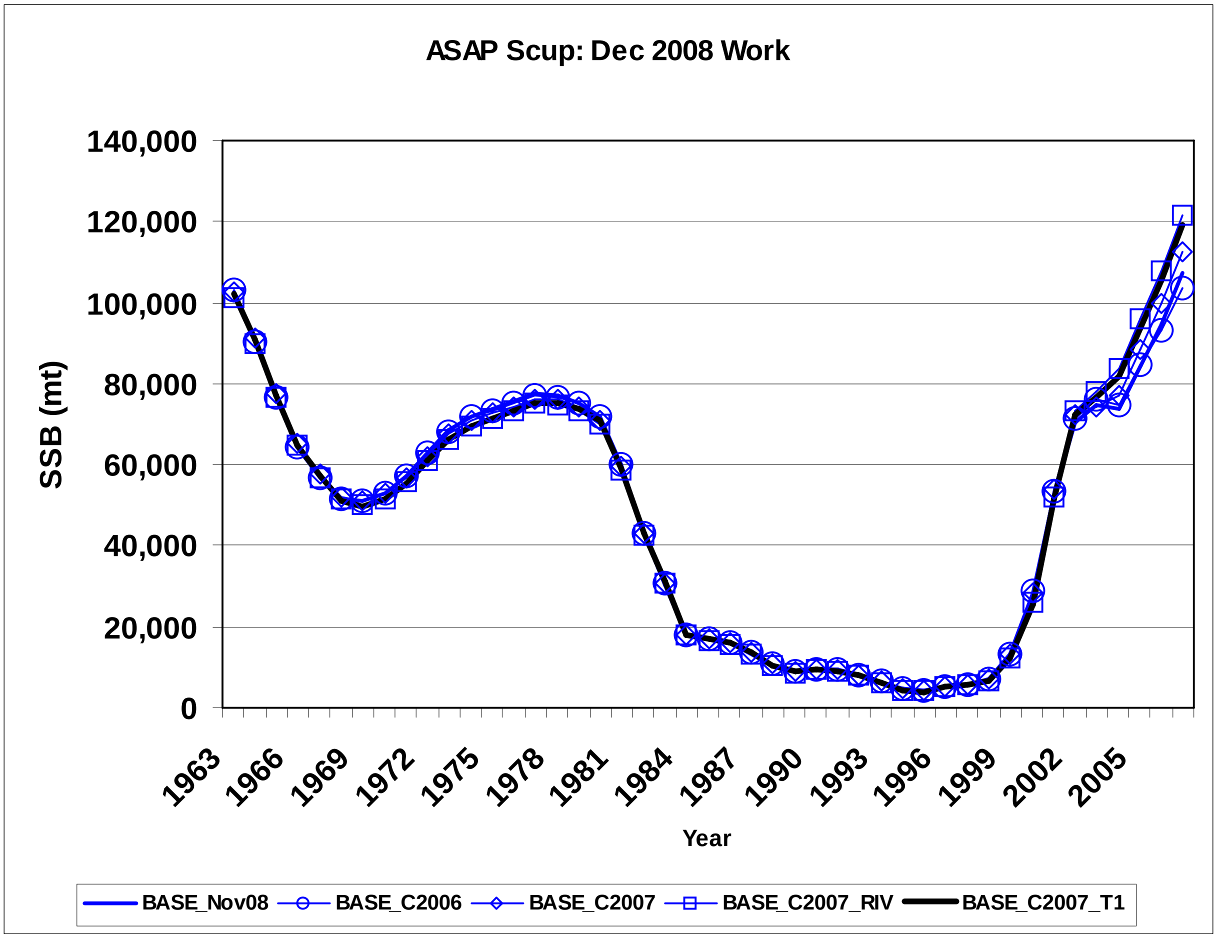

Figure 53. Comparative results of estimated SSB in ASAP runs for scup: run BASE_C2007_T1 (solid black line) is the basis for biological reference points and status evaluation.

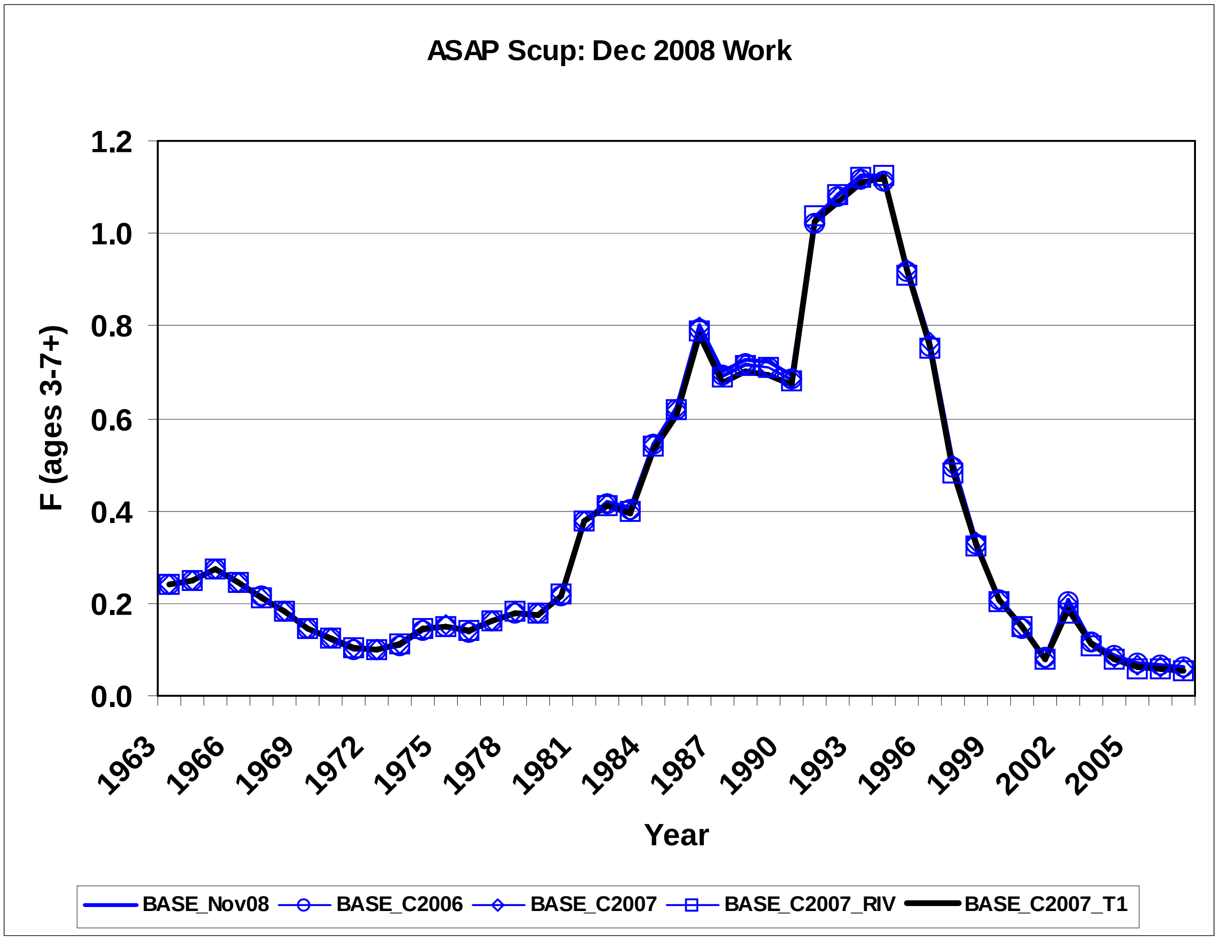

Figure 54. Comparative results of estimated F in ASAP runs for scup: run BASE_C2007_T1 (solid black line) is the basis for biological reference points and status evaluation.

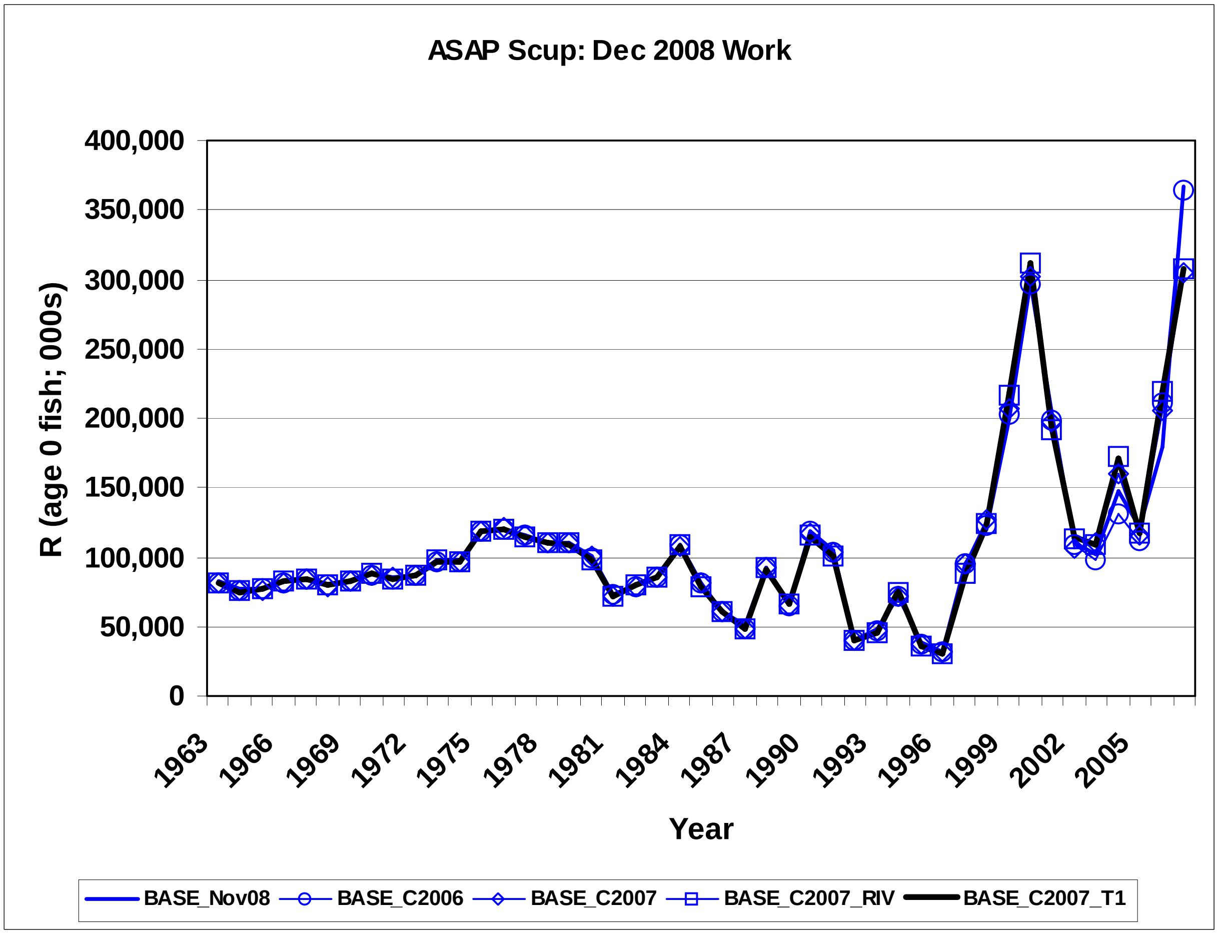

Figure 55. Comparative results of estimated recruitment in ASAP runs for scup: run BASE_C2007_T1 (solid black line) is the basis for biological reference points and status evaluation.

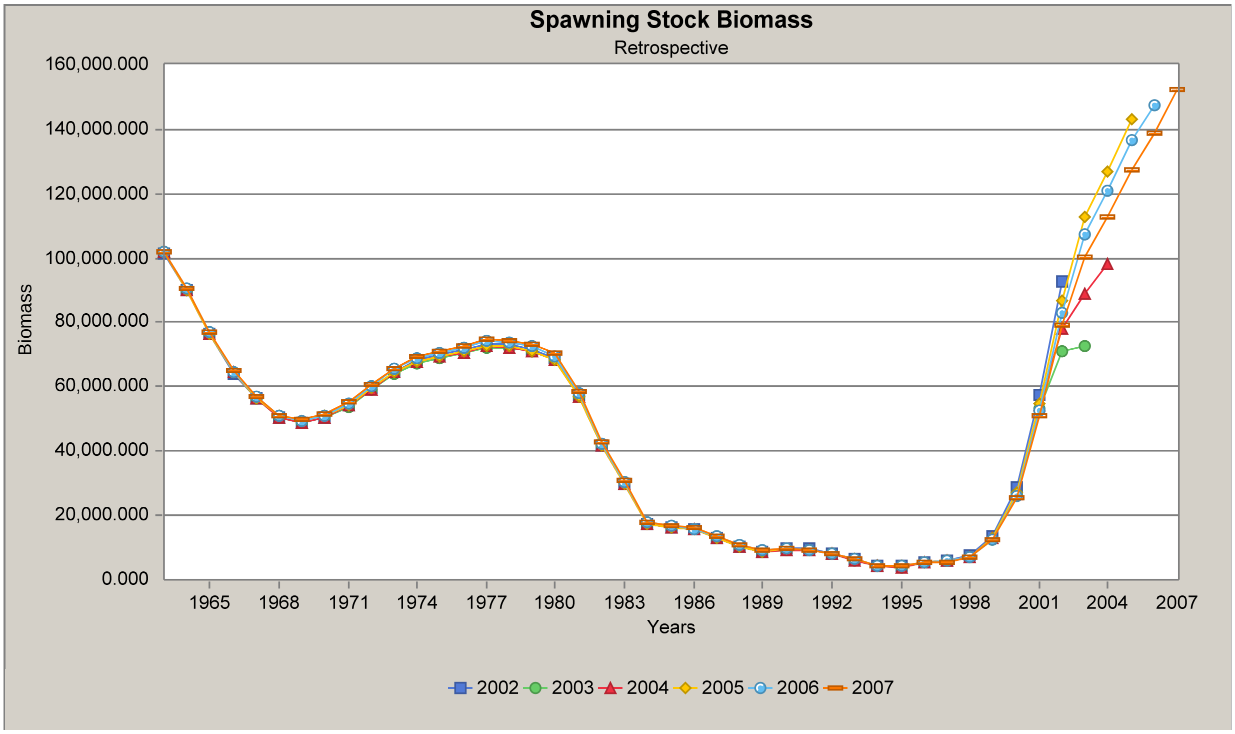

Figure 56. Retrospective analysis for SSB from Scup ASAP final run BASE_C2007_T1.

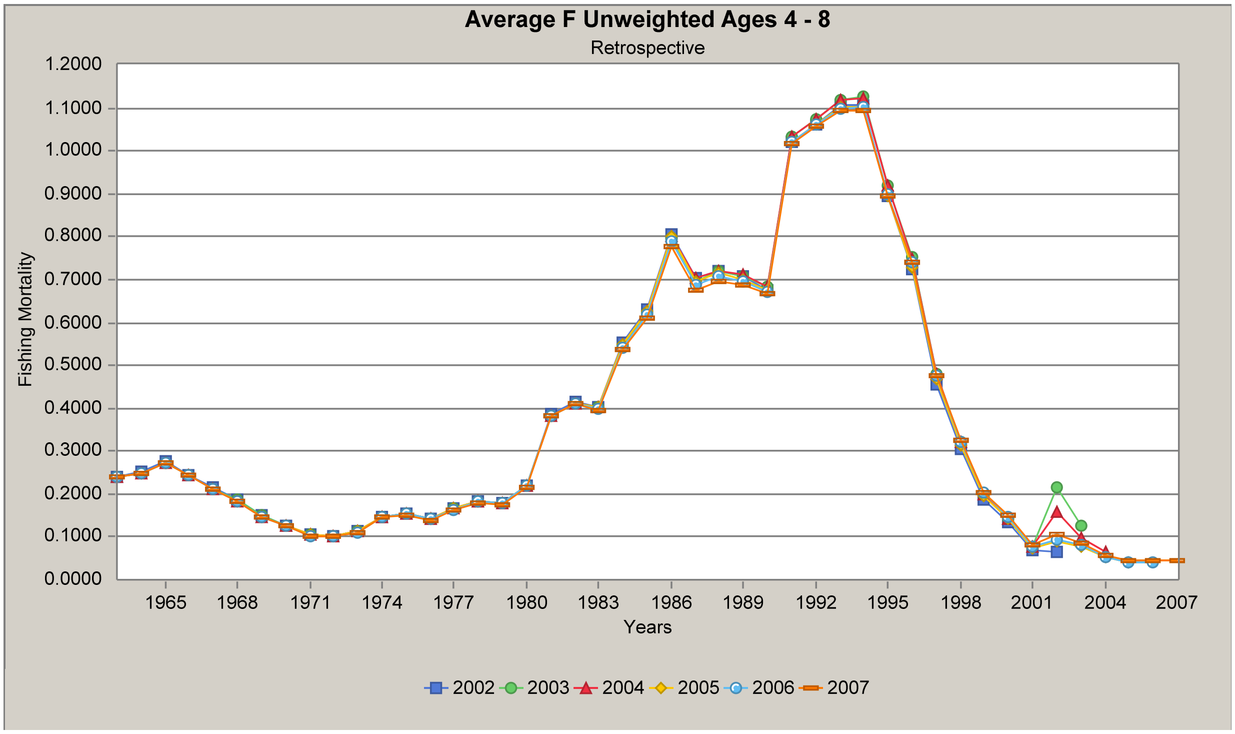

Figure 57. Retrospective analysis for fishing mortality (F) from Scup ASAP final run BASE_C2007_T1.

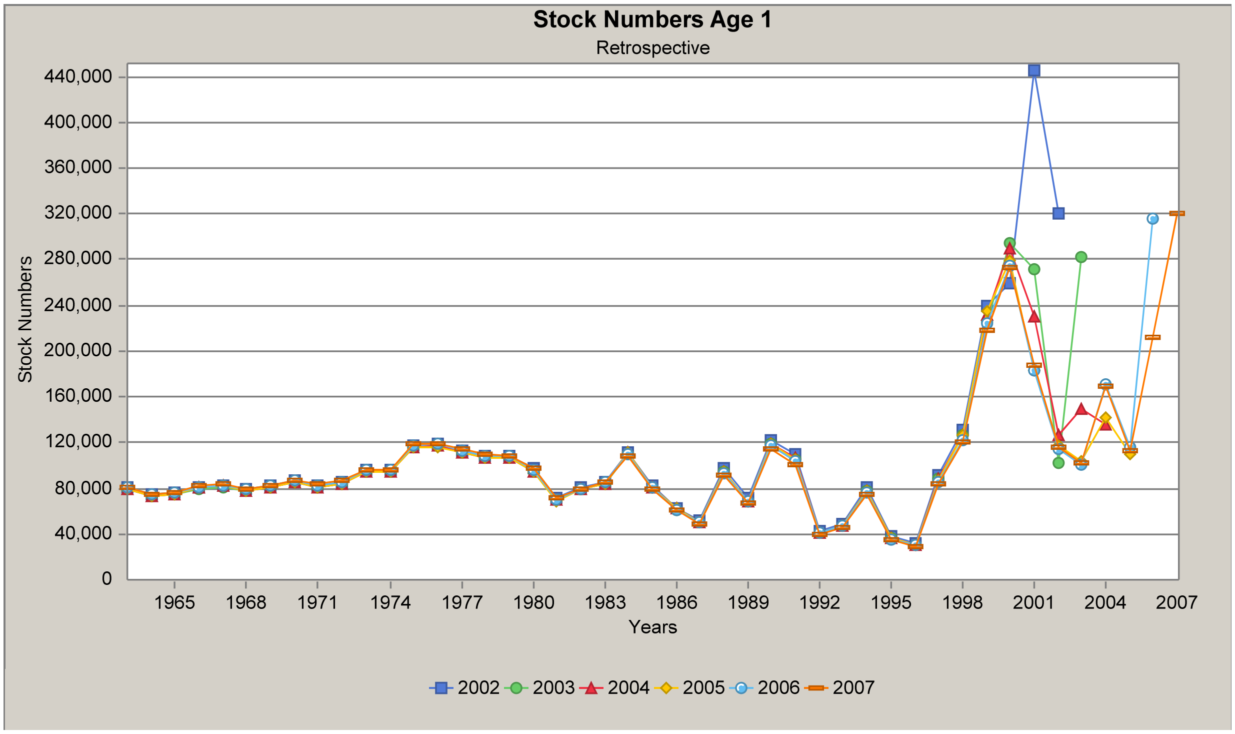

Figure 58. Retrospective analysis for recruitment at age 0 from Scup ASAP final run BASE_C2007_T1. Note that model coded age 1 is true age 0.

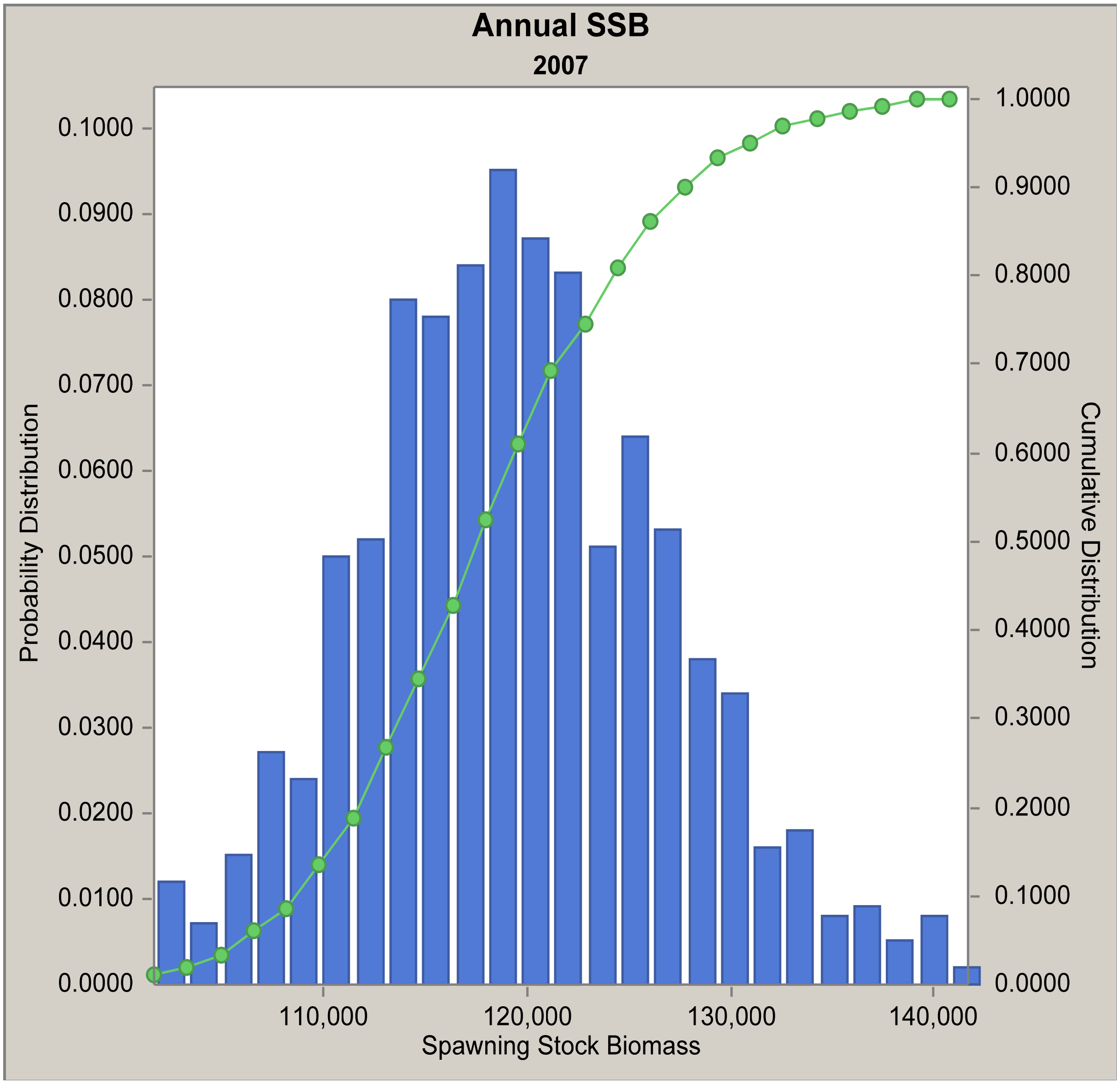

Figure 59. MCMC distribution of SSB in 2007 from the 2008 assessment final model BASE_C2007_T1.

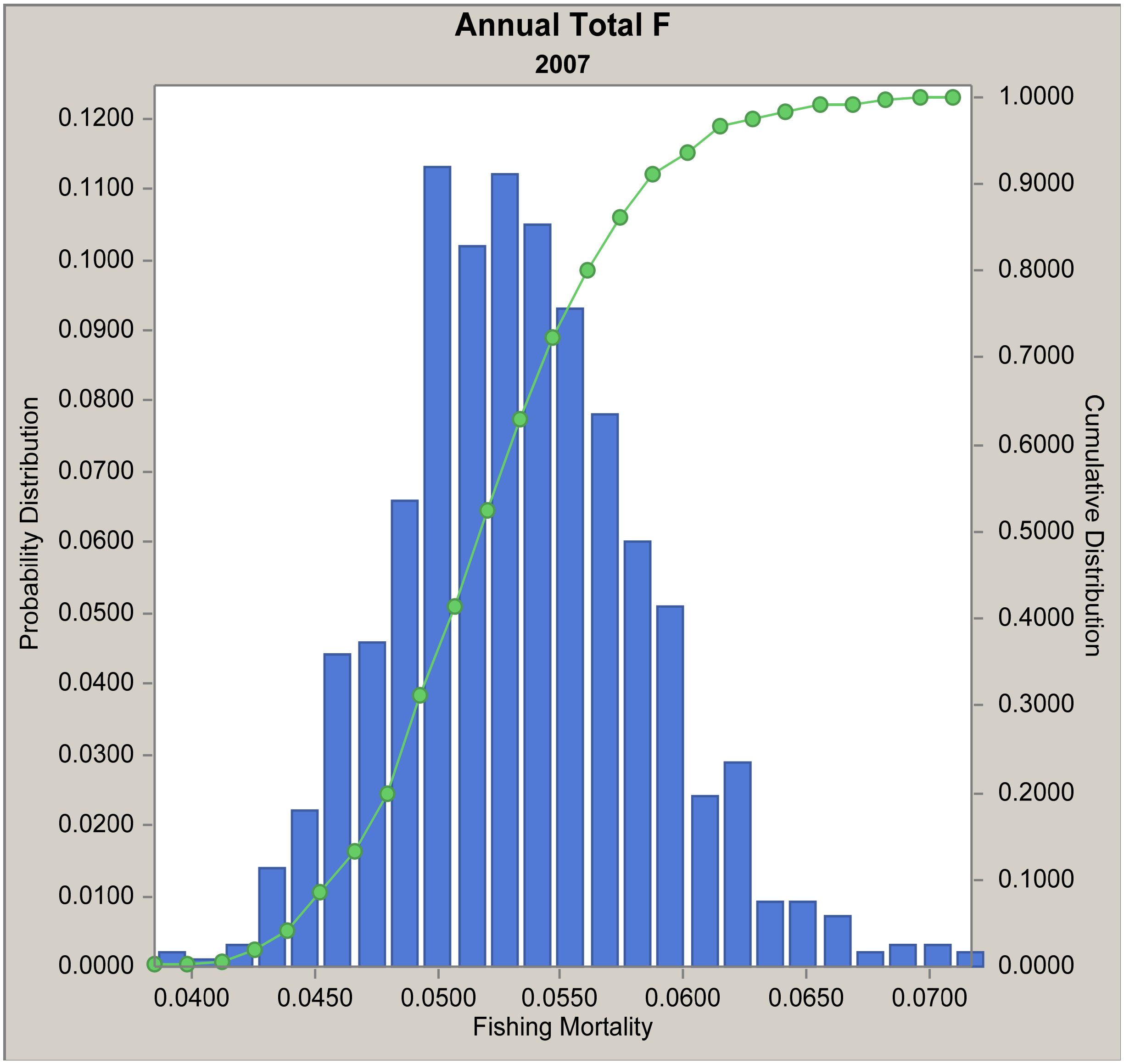

Figure 60. MCMC distribution of F in 2007 from the 2008 assessment final model BASE_C2007_T1.

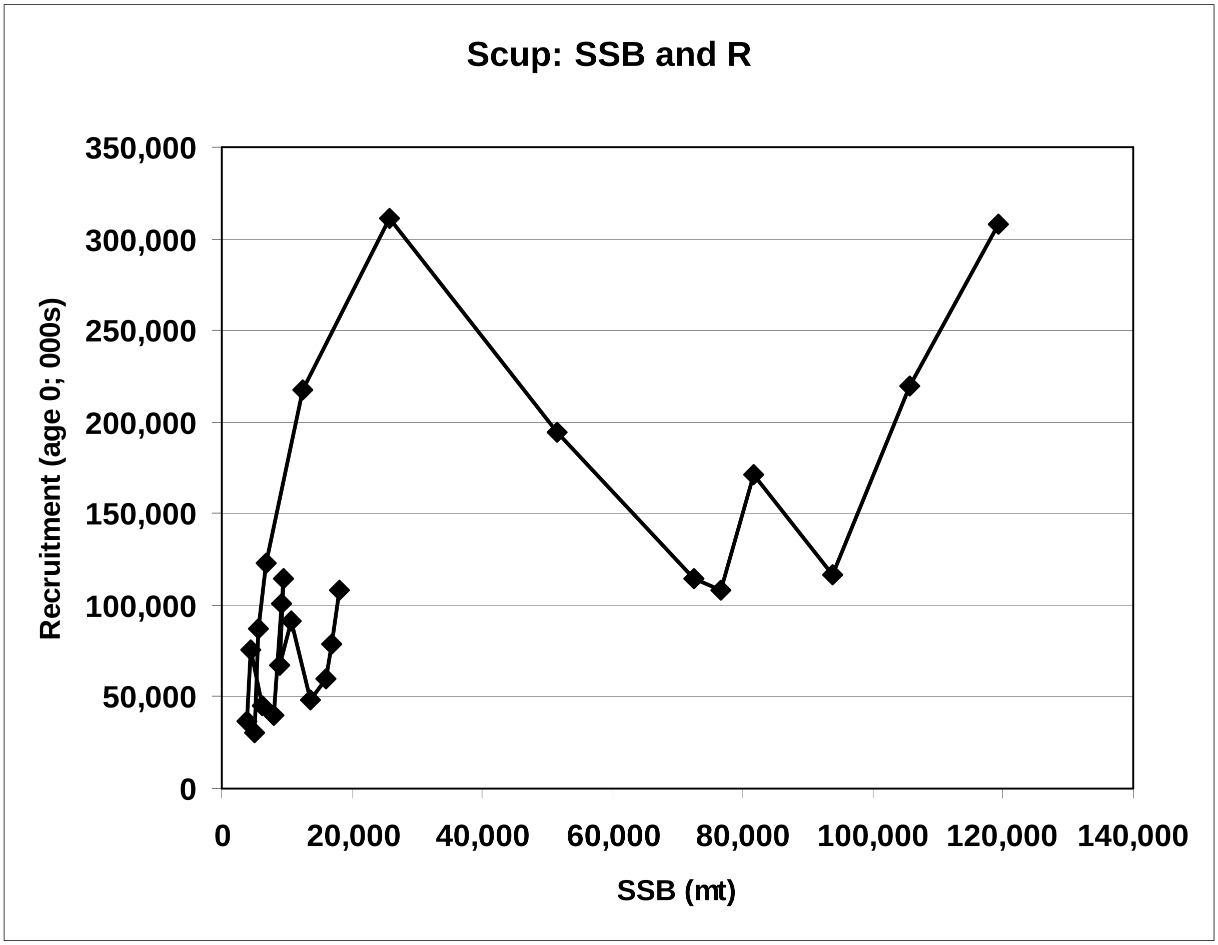

Figure 61. Spawning stock biomass (SSB; metric tons) and recruitment (age 0; 000s) estimates for scup from the 2008 assessment final model BASE_C2007_T1.

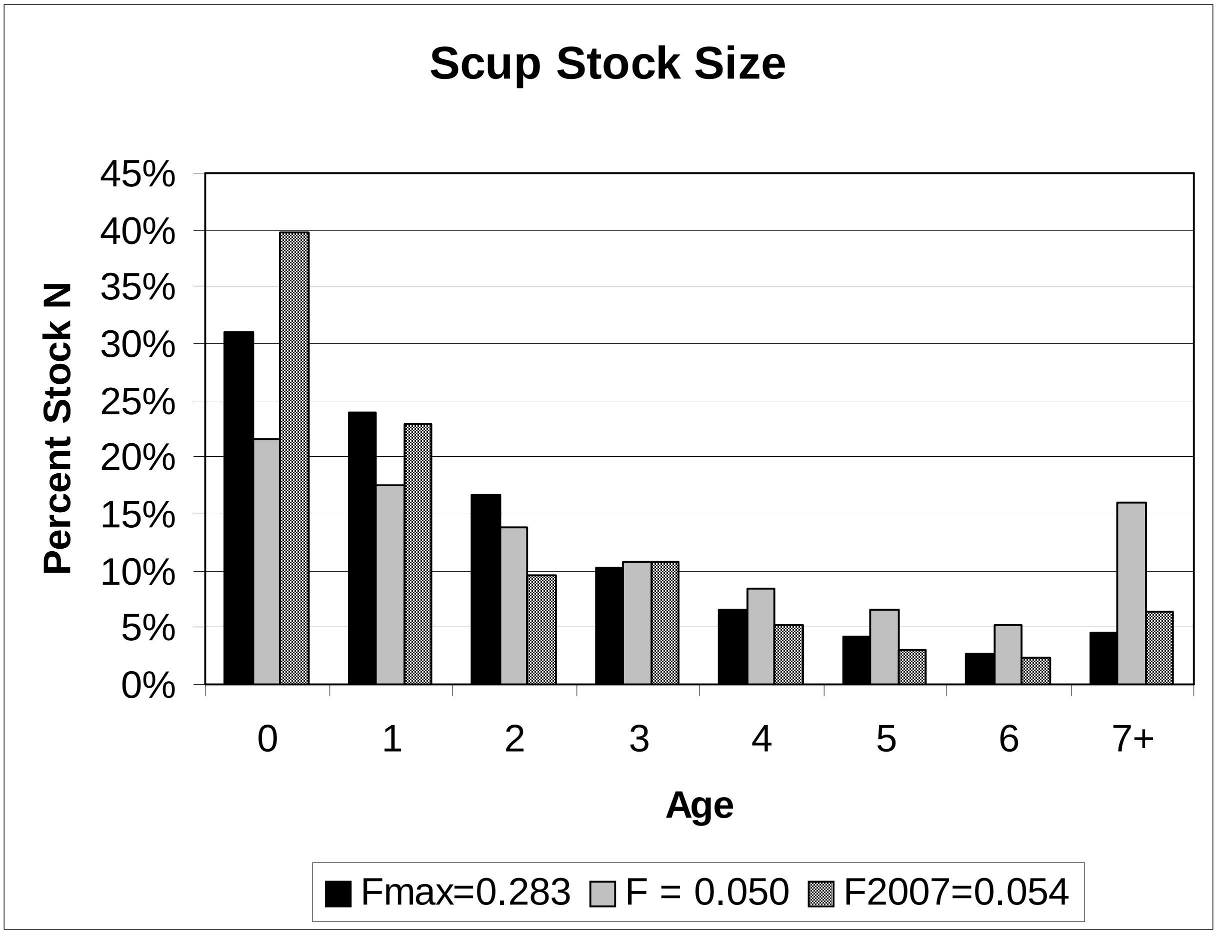

Figure 62. Percentage of scup stock size in numbers expected if the stock were fished at Fmax = FMSY = 0.283 or F = 0.050 over the long-term, compared with stock size percentages estimated for 2007 at F = 0.054.

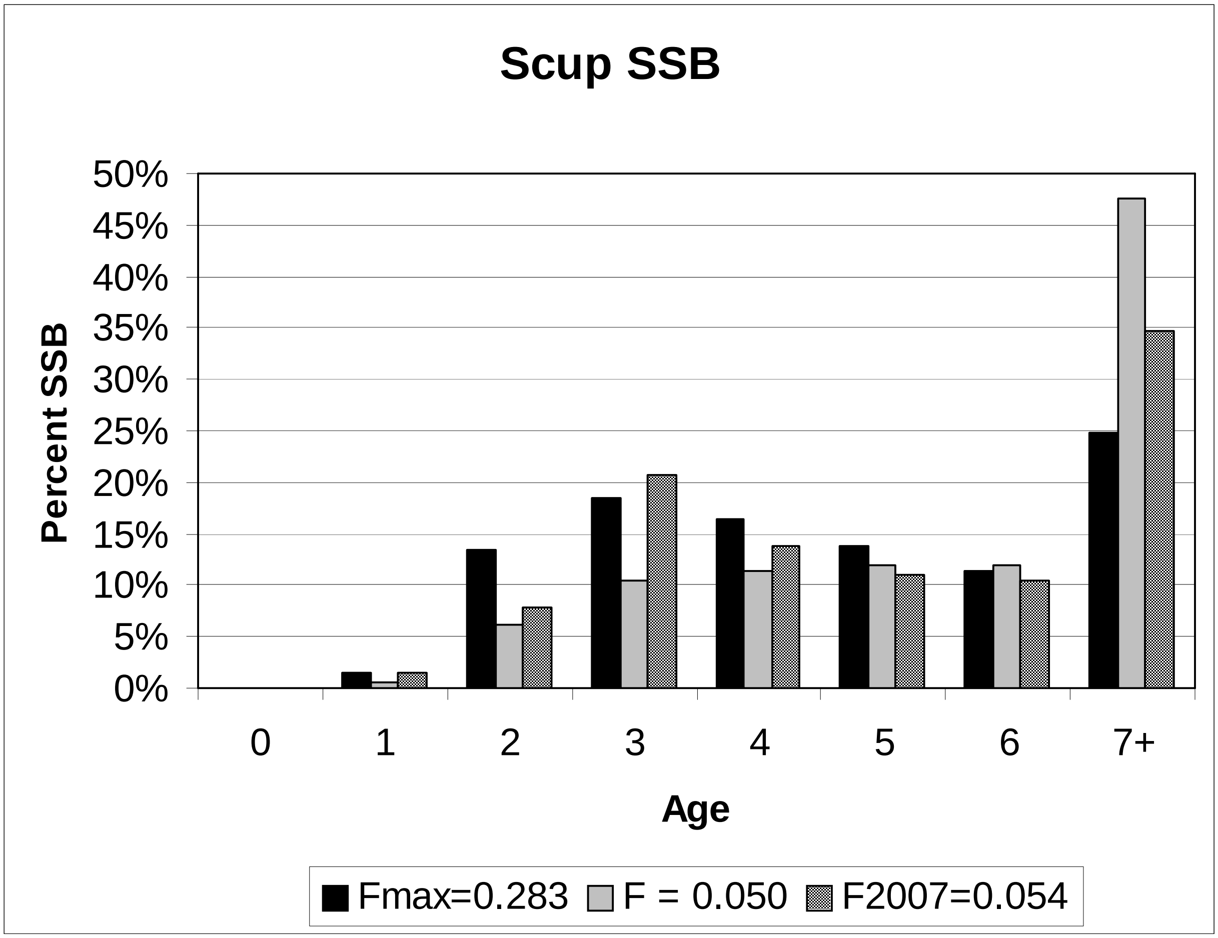

Figure 63. Percentage of SSB in weight expected if the stock were fished at Fmax = FMSY = 0.283 or F = 0.050 over the long-term, compared with SSB percentages estimated for 2007 at F = 0.054. Fish at ages 3 and older are fully (>99%) mature.

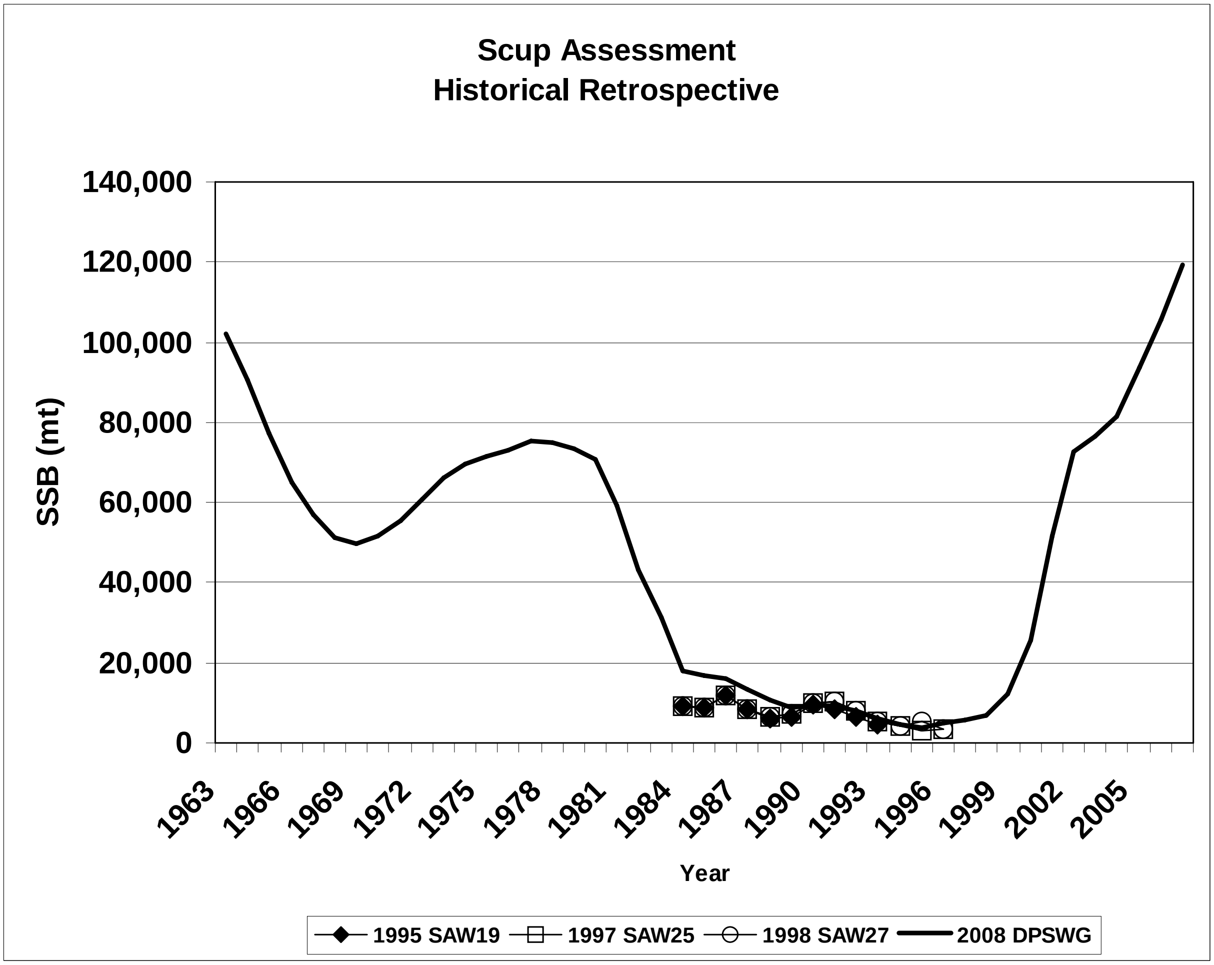

Figure 64. Historical retrospective of previous analytical assessments for scup: SSB. The 1995 SAW19 assessment was the last accepted peer-reviewed assessment. For the 1997 SAW25 and 1998 SAW27 assessments, the analytical components were not accepted as valid bases for assessing stock status. The SAW19, SAW25, and SAW27 analyses used the ADAPT VPA model for data beginning in 1984, while the 2008 DPSWG assessment uses the ASAP model for data beginning in 1963.

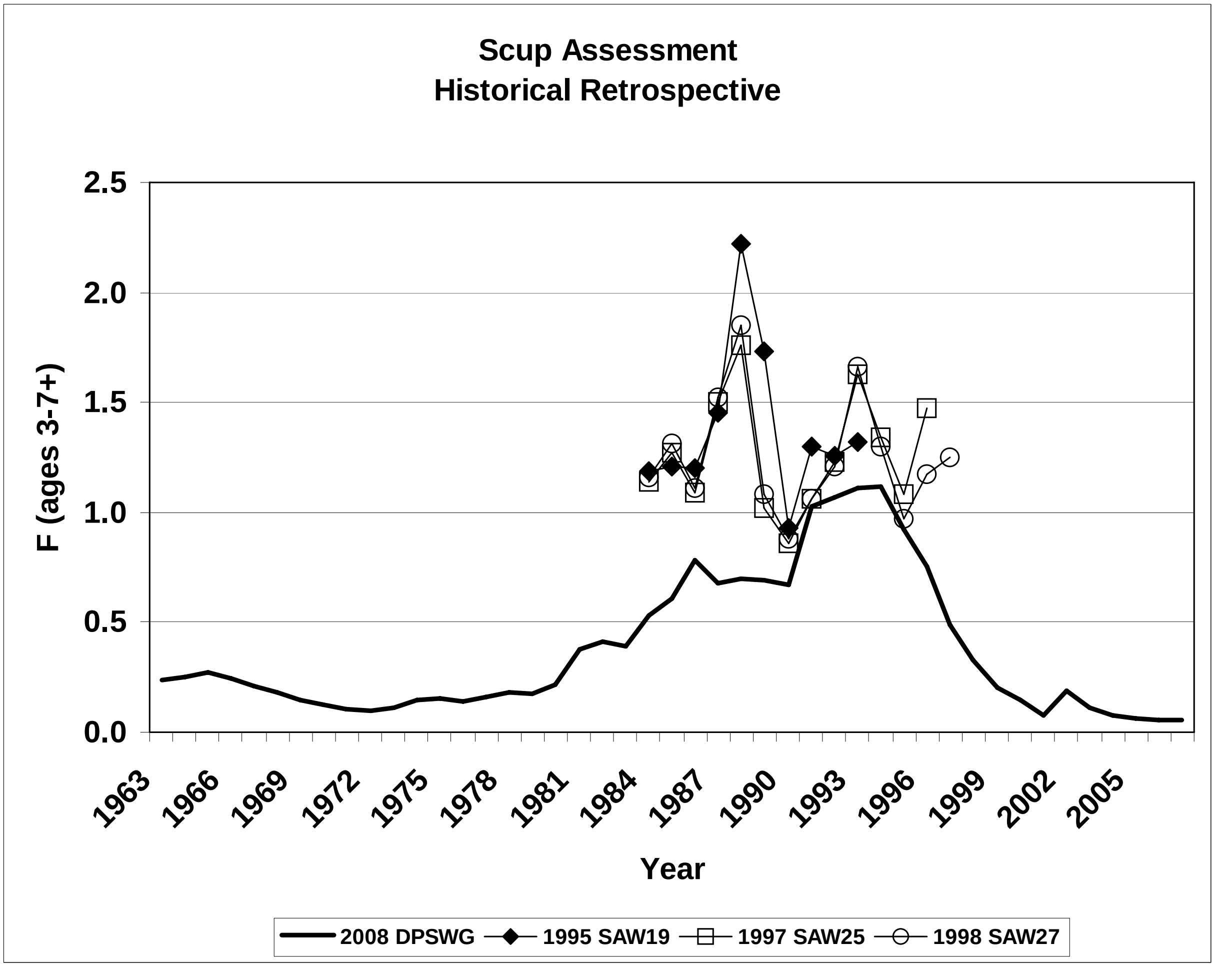

Figure 65. Historical retrospective of previous analytical assessments for scup: Fishing mortality (F). The 1995 SAW19 assessment was the last accepted peer-reviewed assessment. For the 1997 SAW25 and 1998 SAW27 assessments, the analytical components were not accepted as valid bases for assessing stock status. The SAW19, SAW25, and SAW27 analyses used the ADAPT VPA model for data beginning in 1984, while the 2008 DPSWG assessment uses the ASAP model for data beginning in 1963.

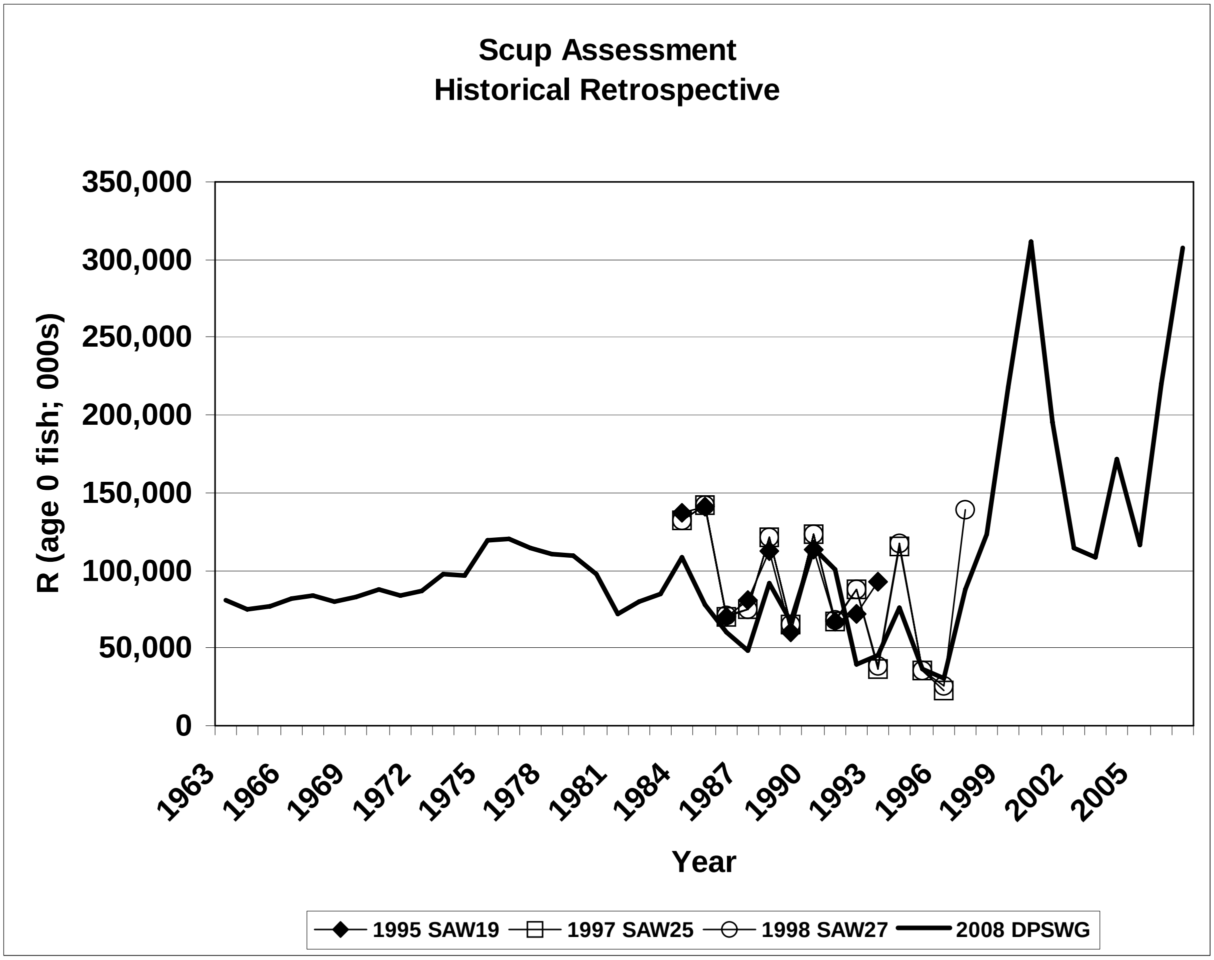

Figure 66. Historical retrospective of previous analytical assessments for scup: Recruitment at age 0 (R). The 1995 SAW19 assessment was the last accepted peer-reviewed assessment. For the 1997 SAW25 and 1998 SAW27 assessments, the analytical components were not accepted as valid bases for assessing stock status. The SAW19, SAW25, and SAW27 analyses used the ADAPT VPA model for data beginning in 1984, while the 2008 DPSWG assessment uses the ASAP model for data beginning in 1963.