B. SCUP

TERMS OF REFERENCE

1. Characterize the commercial and recreational catch including landings and discards.

2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates.

3. Evaluate and either update or re-estimate biological reference points as appropriate.

4. Where appropriate, estimate a TAC and/or TAL based on stock status and target mortality rate for the year following the terminal assessment year.

5. If stock projections are possible, provide short term projections (2-3 years) of stock status under various TAC/F strategies and evaluate current and projected stock status against existing rebuilding or recovery schedules, as appropriate.

INTRODUCTION

Scup**, *Stenotomus chrysops,*** are a schooling, continental shelf species of the Northwest Atlantic, distributed primarily between Cape Cod, MA and Cape Hatteras, NC (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. Larger scup (0.7-1.8 kg) tend to arrive in spring first, followed by smaller scup (Neville and Talbot 1964; Sisson 1974). Larger scup are found during summer near the mouth of larger bays and in the ocean within the 20-fathom contour; smaller scup are found in shallow areas of bays (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; NEFSC 1993). Scup can attain a maximum length of about 40 cm and a maximum age of about 20 years (Dery and Rearden 1979). Crecco *et al.* (1981) have characterized scup as slow-growing and relatively long-lived fish.

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 and another extending south from New Jersey. However, a lack of definitive 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).

The Mid-Atlantic Fishery Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC) manage scup under Amendment 8 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (FMP). The FMP defines the management unit as scup in US waters from Cape Hatteras northward to the US-Canadian border. Exploitation rates were to be reduced to 47% (F=0.72) in 1997-1999, to 33% (F=0.45) in 2000-2001, and to 21% (F=0.26) in 2002 through coast-wide commercial quotas and recreational season, size and possession limits that are established on an annual basis. Amendment 12 to the FMP established a biomass threshold for scup based on the maximum value of the 3-year moving average of the NEFSC spring bottom trawl survey index of spawning stock biomass - 2.77 kg per tow, 1977-1979. 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 F_{max}=0.26.

The Total Allowable Catch (TAC) of 9.11 million lbs (4,132 mt) established in 1997 included a commercial fishery quota of 6.00 million lbs (2,722 mt), a recreational fishery harvest limit of 1.95 million lbs (885 mt), and projected total discards of 1.16 million lbs (528 mt). The TAC decreased steadily to a low of 5.92 million lbs in 1999 and 2000 followed by a significant increase in 2001 to 8.37 million lbs (3797 mt). The 2002 TAC increased further to 12.92 million lbs with a commercial quota of 8 million lbs (3629 mt), a recreational harvest limit of 2.77 million lbs (1257 mt) and projected total discards of 2.15 million pounds (975 mt).

For 2002, the Board and Council implemented minimum mesh size regulations that vary according to net size. Large nets may have up to 25 meshes of 4.5@ in the codend, with at least 100 meshes of 5@ forward of the 4.5@ mesh. Small nets, defined as those with codends smaller than 125 meshes including extension, must have 4.5@ mesh throughout. Vessels using nets with smaller mesh may possess 500 lbs. of scup from November through April and 100 lbs. from May through October. The minimum size for scup caught by any net in the commercial fishery remains at 9@.

The ASMFC Summer Flounder, Scup, and Black Sea Bass Management Board approved Addenda V and VII on February 21, 2002 to more effectively manage the scup fishery. Addendum V was enacted to set state-by-state summer period allocations for the summer period scup fishery during 2002 and until action is taken to modify them. The quota was reallocated using 1983-1992 as the base period with updated landings data from Massachusetts.

Addendum VII was implemented to create a state-by-state conservation equivalency system for the 2002 scup recreational fishery. Under this addendum, each state from North Carolina through New Jersey (inclusive) was assigned size, bag and season regulations, while those states from Massachusetts through New York (inclusive) were required to modify their fishing effort based on the performance of their regulations in previous years. Calculations of the state specific effort necessary to achieve the 2002 harvest limit were based on the average number of fish landed from 1998-2000. The addendum also permitted individual states to separate the management of the Party and Charter Boat sector from the remainder of the recreational fishery, provided that the estimated landings for each mode had a percent standard error not greater than 30%.

THE FISHERY

Commercial Landings

US commercial landings averaged over 18,000 mt per year from 1950 to 1966 (peaking at over 22,000 mt in 1960) and declined to about 4,000 mt per year in the early 1970s (Figure B1). Landings fluctuated between 7,000 and 10,000 mt from 1974 to 1986 and have since declined to less than 2,000 mt. Landings in 2001 were 1,729 mt (3.8 million pounds) - less than 8% of the 48.5 million pound peak observed in 1960 (Table B1).

Dealers reported commercial landings in 1994-2001 by market category and not by area of catch. Procedures developed by Wigley *et al.* (1997) were used to allocate landings by market category to statistical area, based on information collected under the Vessel Trip Report (VTR) system. A monthly set of landings, which are reported in both dealer and VTR databases, are used to characterize the distribution of dealer-reported landings by statistical area. This prorating procedure contributes to uncertainty in the attribution of market category landings by area, especially if vessels that are not participating in any fishery with mandatory VTR requirements land scup from different areas than those that produce landings for participating vessels. Other sources of uncertainty include unreported landings by dealers.

About two-thirds of the commercial landings of scup for the period 1979-2001 were in Rhode Island (37%) and New Jersey (28%) (Table B2). Landings in New York composed an average of 15% of the total. Scup landings reported for Massachusetts were revised for the 31st SARC assessment for 1986-1996, increasing an average of 92% or 218 mt per year (range, 182 to 268 mt and 40 to 216%) (NEFSC 2000). MADMF staff obtained affidavits from several major scup dealers detailing previously unreported landings of scup in Massachusetts for the years 1986-1997. Most of this increase was from previously unreported landings in the hand-line gear category, generally employed from vessels of displacement less than 5 gross registered tons. These records are now included in the NMFS NER dealer landings database.

The otter trawl is the principal commercial fishing gear, accounting for an average of 74% of the total catch in 1979-2001 (Table B3). The remainder of the commercial landings is taken by floating trap (12%) and hand lines (6%), with paired trawl, pound nets, and pots and traps each contributing 2-3%.

The intensity of NER commercial fishery biological sampling in 1979-2001 is summarized in Table B4. Annual sampling intensity varied from 25-640 mt per 100 lengths. Overall sampling exceeded the informal criterion of 100 lengths sampled per 200 mt in 17 of the last 23 years. However, this alone does not indicate adequate sampling because many of these strata have substantial landings but lack samples. Commercial landings at age were not estimated for 1998-2001 because an analytical assessment was determined to be unreliable by SAW 27 (NEFSC 1998) due to concerns about commercial landings sampling and estimation of commercial discards in recent years. Estimation of commercial landings at length using the available sample data indicated that most fish in the 1997-2001 commercial landings were age-3 fish of their respective year classes (Figures B2, B3).

Commercial Discards

Estimates

The NEFSC sea sampling program has collected information on landings and discards in the commercial fishery for 1989-2001. NER 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 some contention between scientists and fishermen. Past SAW panels have recommended that research be conducted to better characterize the mortality of scup in different gear types in order to more accurately assess discard mortality (NEFSC 1995, 1997, 1998, 2000). The number of trips in which scup were landed and/or discarded is tabulated in Table B5. The NEFSC sea sampling program sampled from 7 to 91 otter trawl trips per year in which scup were landed or discarded. The number of sampled trips was especially low in 1994 and 1995 when only 7 and 18 otter trawl trips were sampled. Sample size in 2000 (72 trips) was the largest since 1992, but the number dropped to 28 sampled trips in 2001 (Table B5).

Quantifying discards from the commercial fishery is necessary for a reliable stock assessment, but low sample sizes have resulted in questionable estimates. Concern regarding the poorly estimated discards due to inadequate sampling has been addressed in at least four previous SAW meetings (NEFSC 1995, 1997, 1998, 2000). Members of these previous SARC panels commented that the uncertainty associated with the discards prevents reliable estimates of discard at age in the commercial fishery and seriously impedes the development of a reliable analytic assessment as well as forecasts of catch and stock biomass for the stock. Previous SAW panels have given recommendations for significant improvement in the precision of discard estimates. The most recent SARC that evaluated scup was especially concerned and did not consider an analytical assessment due to uncertainties in the input data, especially discard estimates (NEFSC 2000). Despite the uncertainty of the discard data, the SAW 31 panel concluded that the limited available information suggested that discarding of scup has been high throughout the time series (1989-1999), approaching or exceeding landings. The panel stated that continued unreliability in discard estimates would prevent the use of VPA and production models for producing a reliable assessment.

Given the difficulty associated with estimating commercial discards for scup, the sub-committee considered three different approaches for calculating estimates:

1. Geometric Mean Discards-to-Landings Ratio (GMDL): In previous assessments (e.g., SAW 25 (NEFSC 1997)), ratios of discards to landings by landings level (for trip landings < 300 kg (661 lbs) or => 300 kg) and half year were calculated (uncorrected geometric mean by cell) and multiplied by corresponding observed landings levels from the weigh-out database to provide estimates of discards for use as guidance in setting TAC levels for management (Table B6). Only trips with both non-zero landings and discards could be used. Geometric mean rates (retransformed, mean ln-transformed 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. N is the number of sea sample trips with both scup landings and discard, which were used to calculate the per trip discard to

landings ratios. Corresponding dealer landings are from the NEFSC database.

The number of trawl gear trips used to calculate geometric mean discard-to-landings ratios (GMDL) by half year for 1997-2001 ranged from 1 to 17 for trips < 300 kg and from 1 to 4 for trips => 300 kg (Table B6). 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 0.46 in 2001 (half year two, trips < 300 kg) to 121.71 in 1998 (half year one, trips => 300 kg). The large 1998 estimate 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 from the vessel estimated the weight. There has been debate concerning the validity of the tow weight estimate and whether or not it is representative of other vessels in the fishery. However, the observation was reported and was therefore included in the calculation of the GMDL. Estimates for 2001 were relatively low B 0.89 for half year one and 0.46 for half year two for trips < 300 kg (the latter of these was based on only two trawl gear trips) and 0.92 for half year one for trips => 300 kg.

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 in stratum). As in the GMDL method, trips are stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). N is number of sea sample trips in the stratum used to calculate the aggregate ratio (Table B7). The number of trawl gear trips used to calculate AGDL by half year for 1997-2001 ranged from 14 to 37 for trips < 300 kg and from 1 to 4 for trips => 300 kg. There are more trips available for calculation for trips < 300 kg than in the GMDL approach. The lowest AGDL ratio calculated was 0.69 in 2000(half year one, 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.

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). N is number of sea sample trips in the stratum used to calculate the mean difference in stratum, which was then applied to the landings of every trip in the NEFSC dealer 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, DELTA values will be negative. As the magnitude of discards is of primary interest, the absolute values will be considered.

The number of trawl gear trips used in the DELTA method calculations ranged from 6 to 37 for trips < 300 kg and from 1 to 4 for trips => 300 kg (Table B8). 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 discarding event is the result of one large discarding event that was discussed above.

Comparison of Methods

A summary of landings, discards, and aggregate discards to landings ratios from the three alternative methods of discard calculation are presented in Table B9. The year-to-year trends among the different approaches differed in magnitude but followed similar trends. D/L ratios in 1997 and 2001 were relatively low for all methods within each series. The large discard event in 1998 affected calculations from each method, resulting in relatively high D/L values in 1998 for each approach. The DELTA method yielded estimates that were fairly consistent with the GMDL ratios, while the AGDL estimates exhibited more variability. The working group felt most confident in the estimates produced using the GMDL approach and felt the estimates were supported by the DELTA ratios. The GMDL estimates were used for all modeling approached considered.

Estimates of GMDL from sea sampling were compared to estimates from vessel trip reports (VTR) for 1994-2001 (Table B10). VTR data were selected to include only trawl trips that reported some discard of any species. In contrast to black sea bass and New England groundfish discard data, GM D/L for scup for 1994-2001 sea sample data were 2 to 44 times greater than GM D/L for VTR data, with a single exception in 1996 for trips landing => 300 kg.

Length-frequency

The intensity of length frequency sampling of discarded scup from the sea sampling declined in 1992-1995 relative to 1989-1991 (Table B5). Sampling intensity ranged from 496 to 334 mt/100 lengths sampled in 1992-1995, failing to meet the informal criterion of 200 mt/100 lengths sampled. Sampling intensity improved to 100 mt/100 lengths in 1996, but then declined to about 240 mt/100 lengths in 1997 and 1999 and 1,071 mt/100 lengths in 1998. In 2000, sampling intensity dramatically improved to 50 mt/100 lengths. Mean weight was estimated from length frequency data and a length-weight equation, total numbers were estimated by dividing total weight by mean weight, and numbers at length were then calculated from the length-frequency distribution. Discards were dominated by fish aged 0, 1, or 2, depending on the year under consideration. There is some evidence for discarding of a strong 1994 year class based on the changes in length and age composition of discards from 1995 and 1996 (Figure B4); however, poor sampling in those years adds uncertainty to this assertion. The 1997 discard estimate is dominated by age-2 fish from the 1995 year class, probably as a result of minimum size and mesh regulations implemented in late 1996 and early 1997 (Figure B4). The 1998 and 1999 discard length samples suggest high discarding of the 1997 year class at age 1 in 1998 and at age-2 in 1999 (Figure B5). The usual discarding of age-2 fish was also high in 1998 (1996 year class) (Figure B4). The discarding of age-1 scup was lower in 1999 (1998 year class) compared to 1998 (1997 year class), which is likely a result of lower recruitment in the 1998 year class (Figure B5). The 2000 discard estimate is dominated by age-1 fish (1999 year class), suggesting high recruitment in 1999 (Figure B5). Evidence for discarding of a strong 1999 year class is further demonstrated in the 2001 discard estimates (Figure B6).

Recreational Catch

Scup is an important recreational species, with the greatest proportions of catch taken in the Southern New England states and New York. Estimates of the recreational catch in numbers were obtained from the NMFS Marine Recreational Fishery Statistics Survey (MRFSS) for 1979-2000. 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 for 1979-2000 averaged 2,018 mt per year (Table B1). The MRFSS data indicated that recreational landings have composed about 27% of the commercial and recreational total since 1979 (Figure B1). The 1998 estimate of 395 mt is the lowest of the 1979-2001 time series, and about 56% of the available 1998 harvest limit. Recreational landings in 2001 were 1,933 mt, similar to the time series average.

No length frequency distribution data on scup discards were collected in the MRFSS program. Mortality attributable to discarding in the recreational fishery has been reported to range from 0-15% (Howell and Simpson 1985) and from 0-13.8% (NEFSC 2000). Howell and Simpson (1985) found mortality rates to be positively correlated with size because of 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 between mortality rate and fish size. Discard mortality from 5 to 15% in the recreational fishery appears reasonable based on these studies. Previous assessments have assumed a recreational fishery discard mortality rate of 15% (NEFSC 1995, 1997, 1998, 2000).

Sampling intensity for lengths varied from 48 to 451 mt/100 lengths in the recreational fishery (Table B4). Sampling in all years except one from 1979 - 1987 failed to satisfy the informal criterion of 200 mt/100 lengths. This criterion was met from 1988 - 1998 when sampling intensity varied from 193 to 48 mt/100 lengths. Sampling did not meet the criteria in 1999 - 2001 with intensities ranging from 323 to 451 mt/100 lengths. 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. The 1998-2001 recreational length frequencies were not converted to age because no age-structured analyses were included in recent assessment work as a result of inadequate commercial fishery sampling. Almost all of the recreational catch is estimated to be above the 7 in (18 cm) recreational fishery minimum size limit (Figures B7, B8).

Total Catch

Estimates of total catch are given in Table B11. These estimates include commercial and recreational landings and discards. The earliest catches in the 1960-2002 time series are the least reliable due to uncertainty about the level of distant water fleet (DWF) catch, recreational catch (50% reduction from interpolations made in Mayo 1982 for 1960-1978), and commercial fishery discard (GM D/L ratio from 1989-2001 applied to all earlier years). Commercial discards for 1989-2001 were estimated using the GMDL ratio method. The working group expressed some uncertainty regarding the magnitude of the 1998 GMDL ratio, so an average of the 1997 and 1999 GMDL ratios was calculated and applied to the 1998 estimated landings to generate a discard estimate for 1998.

For years in which no discard data were collected (prior to 1989), commercial landings were raised by the GMDL ratios for 1989-2001. A discard mortality rate of 100% was assumed since there are no published estimates of commercial discard mortality rates for scup. Recreational discard estimates by weight for 1981-2001 were based on the assumptions that discarded scup occurred in the same relative proportions as illegally landed fish and that 15% of recreational discards die of hooking mortality (Howell and Simpson 1985, NEFSC 1995, 1997, 1998, 2000). Because discard lengths and weights are not collected in the MRFSS program, mean weight at size/age in the discards was set equal to mean weight at size/age of the illegal landings. Indirect estimates (by ratio to commercial landings) of recreational catch and commercial fishery discards extended the catch series back to 1960 (NEFSC 1998).

STOCK ABUNDANCE AND BIOMASS INDICES

Research Vessel Survey Indices

The fishery-independent surveys provide information about relative abundance and biomass. Indices of scup abundance and biomass have been calculated from catch-per-tow data from research vessel surveys by the Northeast Fisheries Science Center (NEFSC), Massachusetts Division of Marine Fisheries (MADMF), Rhode Island Division of Fish and Wildlife (RIDFW), Connecticut Department of Environmental Protection (CTDEP), New York Department of Environmental Conservation (NYDEC), New Jersey Bureau of Marine Fisheries (NJBMF), and the Virginia Institute of Marine Science (VIMS). Details on the methods employed in the state surveys are given in historical assessment documentation (NEFSC 1997, 1998, 2000).

NEFSC Surveys

The NEFSC spring and fall surveys provide the longest time series of fishery-independent indices for scup. NEFSC spring and fall abundance and biomass indices exhibit considerable year-to-year variability (Table B12). While biomass levels from 1979 through 2001 have been much lower than in earlier years, the 2002 spring index is the largest in the time series (Figure B9). The 2002 spring biomass index (13.46 kg/tow) is almost three times the second highest spring index, which was observed in 1978 (4.56 kg/tow). The spring abundance indices are similar; in 2002, the estimated index of spring abundance is the highest observed in the series (167.93 number/tow), about twice the 1970 index (78.50 number/tow). These dramatic increases are evident across all ages in the estimated spring numbers at age (Table B13). Though the winter survey only started in 1992, the estimated 2002 abundance and biomass indices are the largest within the series (Table B15; Figure B11). Similar to the spring estimates, numbers at age estimated for the 2002 winter survey are also exceptionally large (Table B15). Though the NEFSC fall indices have shown improvement in recent years, the 2001 fall abundance and biomass indices are much smaller than those observed in 1999 and 2000 (Table B12; Figure B10). Fall estimates of numbers at age in 2001 do not reflect relatively large values from which corresponding 2002 spring numbers at age might be expected to derive (Table B13; Figure B10).

Indices of scup spawning stock biomass per tow (SSB kg/tow) were developed from the NEFSC spring offshore strata series for use as minimum biomass indices for stock rebuilding in response to Sustainable Fisheries Act (SFA) considerations (NEFSC 1998). SAW 27 selected a 3-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 and the magnitude of the survey catch. FMP Amendment 12 defined the threshold biomass index as the maximum observed value of this 3-year moving average - 2.77 SSB kg/tow (Table B12; Figure B12). The most recent average SSB index (2000-2002) is 3.20 SSB kg/tow, which exceeds this threshold.

MADMF Survey

The MADMF spring survey catches are characterized by scup age-1 and older. The spring biomass and abundance indices have 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 and 2000 (Table B16; Figure B13). The 2001 spring index shows a decline to levels seen prior to the year 2000 increase. The MADMF fall indices are more variable than the spring indices, but also exhibit a decreasing trend in abundance and biomass over time (Table B16; Figure B14). The fall index is dominated by age-0 scup and does not reveal a strong 1997 year-class, but does indicate a strong 1999 year-class.

RIDFW Survey

The RIDFW spring survey typically catches scup age-1 and older. The spring indices show nominal levels of scup abundance through 1999 followed by a dramatic peak in 2000 (Table B17; Figure B15). The 2001 spring index exhibits a decline in abundance, though it is still larger than any other index in the time series prior to 2000. The spring biomass indices demonstrate very low scup biomass through 1999, but a significant increase is seen in 2000 and has continued to rise through 2001. The RIDFW fall survey is dominated by the presence of age-0 scup. Fall abundance indices show a general increase to its 1993 peak, followed by a steep decline in 1994 (Table B17; Figure B16). The fall survey gives evidence of a steady rise in abundance since that drop. The fall biomass trends are similar to the RI abundance patterns, giving evidence to a recent increase in biomass.

CTDEP Survey

The CTDEP spring survey is largely composed of age-1 scup, similar to the other surveys. The spring abundance indices exhibit relatively low levels through the survey period, with the exception of a dramatic peak in 2000, similar to the RIDFW spring abundance index (Table B18; Figure B17). The 2001 spring abundance and biomass indices for scup are 7.2 fish/tow and 2.85 kg/tow, respectively. Both values are lower than in 2000, but still substantially larger than any index prior to 2000. The CTDEP spring survey actually caught twice as much by weight in 2001 compared to 2000 (4,250.2 kg/120 tows in 2001 vs 2263.1 kg/120 tows in 2000; D. Simpson, pers. comm.). Numbers caught were 28,119 fish in 2001 and 36,531 fish in 2000 so the index dropped a lot more than indicated by the total catch. This is likely a result of the schooling behavior of scup, which allowed for several 'big hits' in 2001. The scup were more spread out in 2000 although there were still a few 'big hits'. Another indication of the tighter aggregation seen in the 2001 CTDEP spring survey is the % of tows where scup were present: 72% in 2000 and only 49% in 2001. The CTDEP fall survey, which is dominated by age-0 scup, indicates that scup numbers were relatively stable during the survey period, except for relatively large values in 1991, 1999, and 2000 (Table B19; Figure B18). As with the spring indices, the increases seen in 1999 and 2000 did not persist through

2001.

NJBMF Survey

The NJBMF abundance and biomass indices exhibit variable patterns over the time series. Relatively high values were observed from 1989 to 1993, lower values from 1994 to 1996/97, a peak in 1999, and a gradual decline in recent years. (Table B20; Figure B19).

VIMS Survey

The VIMS age-0 scup survey shows a general decline in abundance from relatively high levels peaking in 1990 and 1993 to relatively low levels from 1994 to 2000 (Table B21; Figure B20). The VIMS 2001 index suggests a potentially large increase in abundance.

NYDEC Survey

NYDEC provides both yearling (June-Aug) and young-of-year (Aug-Oct) indices for scup abundance. The yearling indices are generally low throughout the time series (Table B22; Figure B21A - note scale). Within the yearling series, there are three distinct peaks in relative abundance seen in 1989, 1985, and most recently in 2000. The 2000 index is the highest within the yearling indices. The YOY index shows fairly low levels over the survey periods, with periods of slightly elevated abundance levels evident in the early and late 1990s and a dramatic peak in 2000, which is the highest in the series (Table B22; Figure B21B).

Coherence Among Surveys

Previous assessment have been concerned with the conflicting pieces of evidence presented by the fishery-independent survey indices. The various indices have been inconsistent in their portrayal of relative population trends. For that reason, coherence among survey indices was evaluated in historical assessments of scup (NEFSC 1987, 1995, 1997). Correlation analyses yielded no consistent trends or patterns. Any significant correlations detected were sporadic and inconsistent between ages. The most recent SARC workshops abandoned formal correlation analyses and concluded that the various surveys likely measure different spatial and temporal components of the stock and those differences are reflected in the survey indices (NEFSC 1998, 2000). Correlation analyses were revisited in 2001 and results were similar to those found in previous assessment work (ASMFC 2001). The addition of one year of data (2001) is not expected to improve results from the correlation analyses, and so the analyses were not updated this year.

The spring indices are indicative of trends in adult biomass (age-1 and older) as indexed by mean weight per tow. Perhaps the most interesting trend is the dramatic increase observed in the 2002 NEFSC spring and winter abundance and biomass indices (Figures B9, B11). Estimates for 2002 are not yet available from the remaining surveys, but RIDFW spring biomass indices reflect a substantial increase in 2000 that continues through 2001 (Figures B15). The VIMS YOY indices also hint at an upward trend for 2001 (Figure B20). The remaining spring survey indices do not suggest an increase in scup biomass in 2001. The fall survey indices are mostly representative of age-0 fish and exhibit considerable inter-annual variability. Overall, fall indices appear to show evidence of strong recruitment in the 1999-2001 time period, which is also demonstrated in the YOY indices (VIMS and NYDEC). However, the NEFSC fall, CTDEP fall, and NYDEC YOY indices suggest

2001 recruitment was much lower than recent highs.

Spatial Patterns

Patterns in the spatial distribution of NEFSC spring survey catches were investigated to identify potential factors that may have influenced the marked increase in the 2002 NEFSC spring survey biomass and catch-at-age indices (Tables B12,B13; Figure B9). In previous years scup have been aggregated in deep water towards the northern end of their range (Figure B22). The 2001 NEFSC spring survey results exhibited a distribution similar to the historically observed patterns (Figure B23). This year, however, scup were also found in shallower water and spread from the Hudson Canyon to the mouth of the Chesapeake Bay (Figure B24). This same pattern was evident in the 2002 winter survey, though it was not as extreme. The magnitude of the 2002 spring survey catches ranged from 0.1 to 505.1 kg/tow in the 26 tows that observed scup (Figure B25). In contrast, the 2001 spring survey observed 15 positive scup tows ranging from 0.1 to 34 kg/tow. The 2002 spring survey also saw a greater number of larger scup than in most previous years, a trend reflected in many recent state surveys. The observed changes in distribution and relative biomass are attributable to changes in annual availability to the survey gear and variations in environmental conditions. Such factors have likely influenced the short-lived peaks and troughs observed in almost all of the state survey indices.

MORTALITY AND STOCK SIZE ESTIMATES

Natural Mortality

Instantaneous natural mortality (M) for scup was assumed to be 0.20 (Crecco *et al.* 1981, Simpson *et al.* 1990).

Catch Curve Analyses

In SAW 27, catch curve analyses based on the NEFSC autumn and spring surveys were used to estimate total mortality for scup (NEFSC 2000). These estimates were variable and considered imprecise. The fishery-independent surveys are thought to under-sample larger fish and so catch curve analyses based on these surveys will tend to overestimate Z. The absence of older scup from the survey catches may be due to a lack of availability and/or selectivity. The SAW 27 panel recommended research to investigate factors affecting size-specific availability to research surveys.

In 2001, both Massachusetts and Rhode Island initiated programs to age scup from commercial samples. Though the lack of a time series makes it difficult to incorporate this information into an analysis, catch curve analyses were applied to provide a general indication of current fishing mortality. The Rhode Island samples were taken from commercial fish traps. Sampled fish ranged from 1 to 8 years of age and most were age-3. Catch curve analysis yielded an estimated Z of 1.12, which corresponds to an F of 0.92 if M is assumed to be 0.20. Massachusetts provided scup age samples summarized over all fisheries and market categories. Estimates of Z ranged from 0.99 to 1.22 (F ~ 0.79 to 1.00) depending on the ages used to fit the catch curve.

Relative Exploitation Index

A relative exploitation index based on landings and spawning stock biomass was constructed to identify trends in exploitation rates. The index used total landings (1,000=s of lbs.) and the NEFSC spring SSB survey (kg/tow; three-year average) as a proxy for biomass. Relative exploitation was equal to landings divided by the SSB index and scaled by dividing by 1,000. This index reflected the mortality on age 2 and older scup because landings and catch in the SSB survey generally comprised scup ages 2 and older. Total catch and spring survey results were not used to derive an exploitation index because of the uncertainty associated with the discard estimates. To confirm observed trends in exploitation, an additional index was calculated based on total landings (1,000s of lbs.) and the NEFSC fall survey (kg/tow; three-year average).

The relative exploitation index indicated that the exploitation of scup was relatively low in the 1980=s and high in the 1990=s (Table B23; Figure B26). The low exploitation rates in the early 1980=s were consistent with Mayo=s 1983 assessment of scup. There was a general increasing trend in exploitation through the mid-1990s followed by a steady decline through 2001, the lowest observed value in the time series. Relative exploitation based on the 3-year moving average of the fall survey index also suggested a declining trend in relative exploitation since the mid-1990s, though there is evidence of a slight increase in 2000 (Figure B27).

BIOLOGICAL REFERENCE POINTS

FMP Amendment 12 defined overfishing for scup to occur when the fishing mortality rate exceeded the threshold fishing mortality rate of F_{MSY}. F_{MAX} was used as a proxy for F_{MSY} because F_{MSY} could not be reliably estimated for scup. F_{MAX} was most recently estimated to be 0.26 in SAW 27 (NEFSC 1998).

FMP Amendment 12 defined a threshold biomass index for stock rebuilding as the maximum value of a 3-year moving average of the NEFSC spring survey catch per tow of spawning stock biomass (1977-1979 = 2.77 SSB kg/tow). The most recent estimate of the average SSB index exceeds this threshold (3.20 SSB kg/tow, 2000-2002).

STOCK REBUILDING SCHEDULES

Long-Term Projections

According to the Sustainable Fisheries Act, the stock is to be rebuilt to a target biomass, which is greater than the biomass threshold, in ten years. Stock projections to assess projected stock status against existing rebuilding schedules were performed in the SAW 31 assessment using the NEFSC spring survey catch per tow at age estimates for 2000 (NEFSC 2000). The inability to estimate the absolute magnitude of F prevented an update of the previous forecast method for evaluating the SSB relative to the current biomass threshold. However, long-term projections of relative biomass were performed to get a sense of how exploitation may affect long-term population trends. The projections were based on the average of 2000-2002 NEFSC spring survey catch per tow at age estimates, offshore strata only (Table B24). The survey catch per tow at age values were projected into the next respective age in each time step, with an assumed M=0.20 and yearly recruitment at age 1 assumed equal to the long-term median catch per tow at age 1, NEFSC spring survey offshore strata (1977-2002 median = 5.15). The projections assumed different intrinsic rates of fishing mortality: F=0.00, F=0.26 (target for 2002), F=0.45 (target for 2000-2001), F=0.72 (target for 1997-1999), F=1.00, and F=2.00. Relative biomass was estimated by multiplying catch per tow at age by a partial recruitment vector and a weight at age vector (NEFSC 1995). Recruitment to the spawning stock was 13% at age 1, 75% at age 2, 99% at age 3, and 100% at ages 4 and older (NEFSC 1995). Projections were for 15 years.

Projections of relative biomass trends were dependent on the assumed fishing mortality rate (Figure B28). At F=0.00, trends in scup stock biomass showed a steady increase in the first eight years followed by a moderate decline. Long-term projections based on an assumed F=0.26 showed a moderate increase in the early years and gradually decreased to a level equivalent to approximately 40% of the peak predicted relative biomass within the time series. When fishing mortality was assumed F=0.45 or higher, relative biomass demonstrated a long-term decline.

Note that these projections were made solely to explore estimated trends in long-term relative biomass. The difficulties in estimating current fishing mortality precluded the application of reliable stock projections. Additionally, these projections assumed constant recruitment for all years. Realistically, recruitment will exhibit inter-annual variability that will affect predictions of SSB relative to the biomass threshold at a given F. Catchability differences between age groups as well as annual variability in catchability have not been accounted for in these projections. As such, consideration should be given to potential fluctuations in recruitment, changes in catchability, and environmental variation when interpreting stock projections.

CONCLUSIONS

The stock is not overfished, but stock status with respect to overfishing cannot currently be evaluated. The 2001 estimate of spawning stock biomass (2000-2002 average=3.20 SSB kg/tow), based on the 3-year moving average of the NEFSC SSB spring survey, exceeds the established biomass index threshold (2.77 SSB kg/tow). The change in stock status results from the extremely high survey observation in 2002 and it=s contribution to the calculation of the moving average. The spring survey index for 2002 is highly uncertain since the abundance of all age groups in the survey increased substantially as compared with the 2001 results. Though the relative exploitation rates have declined in recent years, the absolute value of F cannot be determined. Survey observations indicate strong recruitment and some rebuilding of age structure.

Management should continue efforts to further reduce fishing mortality rates and minimize fishery discards to rebuild the stock.

The stock can likely sustain modest increases in catches, but managers should do so with due consideration of high uncertainty in stock status determination.

Major uncertainties in estimating total catch continue to preclude an analytical stock assessment for scup. As such, the SARC concluded that a quantitative analysis of the population would be inappropriate as the basis for management decisions for scup at this time. The SARC panel expressed concerns about the failure to collect sufficient catch information that has impeded the development of scup assessments in the past. Several previous SARC panels (SAW 25, 27, 31) have concluded that new or enhanced data reporting or sampling are required to produce a reliable assessment. Members of the current panel emphasized that an analytical formulation for scup will not be feasible until the quality and quantity of the input data (biological sampling and estimates of all components of catches) are significantly improved for an adequate time series.

SARC COMMENTS

The SARC commented on possible explanations for the marked increase in the 2002 spring survey indices. In previous years scup have been aggregated in deep water towards the northern end of their range. This year, however, they were also found in shallower water and distributed from the Hudson canyon to the mouth of the Chesapeake. This same pattern was evident in the winter survey, though it was not as extreme. The 2002 spring survey also saw a greater number of larger scup than in most previous years, a trend reflected in many recent state surveys. The SARC had difficulty interpreting the spring 2002 survey results due to potential changes in the availability of the fish, performance of the gear and/or sampling variability. Availability to the survey gear and variations in environmental conditions were recognized as potential factors in the high survey values and additional analyses were recommended to evaluate their potential effects. In addition, the SARC agreed that the standard error for the survey indices should be included in the current document. Future assessments should include confidence intervals generated using stratified bootstraps.

Estimates of recreational and commercial discards were discussed at length. A number of methods were reviewed, but a consensus opinion on a satisfactory option could not be reached due to the absence of sufficiently reliable data. As a result, the SARC determined that while the document should include discards for the commercial and recreational fisheries, there was insufficient confidence in the estimates to support a production model. The SARC recognized the ongoing problems associated with discard estimates and recommended that the Scup Stock Assessment Working Group design a sampling program that would provide enough information to determine discard estimates in the future. Future documents should also include a description of the statistical properties of each method used to estimate discards to help determine which is most appropriate.

The SARC reviewed a method of estimating relative exploitation rate, fishing mortality and stock biomass using CPUE from the recreational private boat fishery. Though it was recognized as having potential for providing useful information on trends, the SARC concluded that it needed further development (e.g., consistency in the fishing mortality metric and the effort information used in CPUE indices) prior to being included in an advisory document and used as a management tool.

The SARC discussed the stock projections provided by the Scup Stock Assessment Working

Group. The age structure and recruitment rate, both derived from 2002 estimates, were determined to be inappropriate. The SARC recommended that the average age structure from 2000, 2001 and 2002 and the median recruitment rate from 1977 through 2002 be used to eliminate the bias associated with single year estimates. The SARC considered that this method of projection should be treated with caution especially beyond year one, due to uncertainties in input information.

The SARC discussed the possibility of recommending revised reference points, possibly including a revised biomass threshold or a biomass target. It was determined that, as confidence in the data used in the analytical assessment was very low, there was insufficient basis for forwarding revised reference points to the Council.

SOURCES OF UNCERTAINTY

The majority of the uncertainty pertaining to the population assessment of scup is related to biological sampling and estimates of all components of catches for scup. The main concerns include:

- NER commercial fishery biological sampling
  Inadequate sampling of strata (market categories and statistical areas) that have substantial landings of scup

- Dealer / VTR databases
  Uncertainty with method of allocation of landings by market category to statistical area
  Unreported landings by dealers

- NEFSC sea sampling
  Inadequate for developing reliable estimates of scup discards (limited sample size and questionable as to representative nature of sea sampling data for scup)
  Intensity of length frequency sampling may not be representative of discards

- Historical catch estimation
  Uncertainty about the level of distant water fleet (DWF) catch (1963-1981), recreational catch (MRFSS data not available prior to 1979), and commercial fishery discards (no sea sampling for discards prior to 1989)

- Assumption of 100% commercial discard mortality

RESEARCH RECOMMENDATIONS

1. The SARC discussed some of the reasons why the research recommendations from previous SARCs had not been adequately addressed. There is currently no mechanism for accountability, resulting in other research needs taking priority. It was suggested that summaries of research recommendations be forwarded to the NRCC for review and comment, followed by a feasibility analysis. At that point a list of priorities and perhaps assignments for research could be made. The SARC recommends that a working group be developed to assess what group would be best suited to address each research need.

2. Increased and more representative sea and port sampling of the various fisheries in which scup are landed and discarded is needed to adequately characterize the length composition of both landings and discards. The current level of sampling, particularly of the discards, seriously impedes the development of analytic assessment and forecasts of catch and stock biomass for this stock. A pilot study to develop a sampling program to estimate discards should be implemented. Expanded age sampling of scup from commercial and recreational catches is required, with special emphasis on the acquisition of large specimens.

3. Commercial discard mortality had previously been assumed to be 100% for all gear types. The committee recommends that studies be conducted to better characterize the mortality of scup in different gear types to more accurately assess discard mortality.

4. Additional information on compliance with regulations (e.g. length limits) and hooking mortality is needed to interpret recreational discard data.

5. Biological studies to investigate factors affecting annual availability of scup to research surveys and maturity schedules.

6. Investigate the statistical properties of the three commercial discard estimation approaches presented for consideration in future analyses.

7. Quantify the percentage of commercial fishery trips that had discards, but no landings, and evaluate how such trips contribute to the total commercial fishery discard estimate.

8. Continue exploration of relative biomass and relative exploitation calculations based on CPUE data from the recreational private boat fishery.

9. Explore other approaches for analyzing survey data, including bootstrap resampling methods to generate approximate confidence intervals around the survey index point estimates.

10. In the absence of reliable estimates of the catch, consideration should be given to simple forward projection models that rely on trends from the survey indices in the absence of catch information.

11. Design an optimal sampling plan that would be considered for implementation by the fishery observer sampling, recreational and commercial port sampling program.

12. Explore alternative biomass indices for development of biomass proxies for reference point determination based on multiple survey indices.

13. Evaluate the current biomass reference point and consider alternative proxy reference points such as B_{MAX} (the relative biomass associated with F_{MAX}).

14. Surveys should be evaluated to test the assumption of equal catchability at age in projections (i.e. through forward projection methods).

15. Explore alternative decision support methodologies for updating TALs directly from relative trends in abundance without relying on direct estimates of F.

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