A. SUMMER FLOUNDER

TERMS OF REFERENCE

The following terms of reference were addressed for summer flounder:

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,

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

INTRODUCTION

For assessment purposes, the previous definition of Wilk *et al*. (1980) of a unit stock extending from Cape Hatteras north to New England has been accepted. The joint Mid-Atlantic Fishery Management Council (MAFMC) Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan (FMP) for summer flounder has as a management unit all summer flounder from the southern border of North Carolina, northeast to the U.S.-Canadian border. A recent summer flounder genetics study (Jones and Quattro, 1999) revealed no significant population subdivision centered around Cape Hatteras.

Amendment 1 to the FMP in 1990 established the overfishing definition for summer flounder as fishing mortality rate equal to $F_{max,}$ initially estimated as 0.23 (NEFC 1990). Amendment 2 in 1992 set target fishing mortality rates for summer flounder for 1993-1995 (F = 0.53) and 1996 and beyond (F_{max} = 0.23). Major regulations enacted under Amendment 2 to meet those fishing mortality rate targets included: 1) an annual fishery landings quota, with 60% allocated to the commercial fishery and 40% to the recreational fishery, based on the historical (1980-1989) division of landings, with the commercial allocation further distributed among the states based on their share of commercial landings during 1980-1989, 2) commercial minimum landed fish size limit at 13 in (33 cm), as established in the original FMP, 3) a minimum mesh size of 5.5 in (140 mm) diamond or 6.0 in (152 mm) square for commercial vessels using otter trawls that possess 100 lb (45 kg) or more of summer flounder, with exemptions for the flynet fishery and vessels fishing in an exempted area off southern New England (the Northeast Exemption Area) during 1 November to 30 April, 4) permit requirements for the sale and purchase of summer flounder, and 5) annually adjustable regulations for the recreational fishery, including seasons, a 14 in (36 cm) minimum landed fish size, and possession limits.

Amendment 3 to the FMP revised the western boundary of the Northeast Exemption Area to $72^0$30'W (west of Hudson Canyon), increased the large mesh net possession threshold to 200 lbs during 1 November to 30 April, and stipulated that only 100 lbs could be retained before using a large mesh net during 1 May to 31 October. Amendment 4 adjusted Connecticut's commercial landings of summer flounder and revised the state-specific shares of the commercial quota accordingly. Amendment 5 allowed states to transfer or combine the commercial quota. Amendment 6 allowed multiple nets on board commercial fishing vessels if properly stowed, and changes the deadline for publication of overall catch limits and annual commercial management measures to 15 October and the recreational management measures to 15 February.

The results of previous assessments indicated that summer flounder abundance was not increasing as rapidly as projected when Amendment 2 regulations were implemented. In anticipation of the need to drastically reduce fishery quotas in 1996 to meet the management target of F_{max}, the MAFMC and ASMFC modified the fishing mortality rate reduction schedule in 1995 to allow for more stable landings from year to year while slowing the rate of stock rebuilding. Amendment 7 to the FMP set target fishing mortality rates of 0.41 for 1996 and 0.30 for 1997, with a target of F_{max} = 0.23 for 1998 and beyond. Total landings were to be capped at 8,400 mt (18.51 million lbs) in 1996-1997, unless a higher quota in those years provided a realized F of 0.23. Amendment 12 in 1999 defined overfishing for summer flounder to occur when the fishing mortality rate exceeds the threshold fishing mortality rate of F_{MSY}. Since F_{MSY} could not be reliably estimated for summer flounder, F_{max} = 0.24 was used as a proxy for F_{MSY}, and was also defined as the target fishing mortality rate. The stock was defined to be overfished when the total stock biomass falls below the minimum biomass threshold of one-half of the biomass target, B_{MSY}. Because B_{MSY} could not be reliably estimated, the biomass target was defined as the product of total biomass per recruit and contemporary (1982-1996) median recruitment, estimated to be 153,350 mt (338 million lbs), with the biomass threshold defined as 76,650 mt (169 million lbs). In a recent stock assessment (Terceiro 1999), those references points were updated using recent estimates of median recruitment (1982-1998) and mean weights at age (1997-1998), providing a biomass target of 106,444 mt (235 million lbs) and biomass threshold of 53,222 mt (118 million lbs). The Terceiro (1999) reference points were retained in the 2000 and 2001 stock assessments (NEFSC 2000, MAFMC 2001a) because of the stability of the input data. Concurrent with the development of the 2001 assessment, the MAFMC and ASMFC convened the ASMFC Summer Flounder Overfishing Definition Review Committee to review the reference points. The work of the Committee was reviewed by the MAFMC Scientific and Statistical Committee (SSC) in August 2001. The SSC recommended that the F_{MSY} proxy of F_{max} = 0.26 remain for 2002, and endorsed the recommendation of SARC 31

(NEFSC 2000) which stated that "...the use of F_{max} as a proxy for F_{MSY} should be reconsidered as more information on the dynamics of growth in relation to biomass and the shape of the stock recruitment function become available (MAFMC 2001b).

The 2001 stock assessment (MAFMC 2001a) found that the fishing mortality rate had declined from 1.32 in 1994 to 0.30 in 2000, about 15% higher than the FMP overfishing definition. Total stock biomass in 2000 was estimated to be 46,400 mt, 13% below the FMP biomass threshold. Therefore, the stock was found to be overfished and overfishing was occurring relative to the FMP reference points.

FISHERY DATA

Commercial Fishery Landings

Total U.S. commercial landings of summer flounder from Maine to North Carolina peaked in 1979 at nearly 18,000 mt (40 million lbs, Table A1). The reported landings in 2001 of 4,916 mt (about 10.8 million lbs) were about 1% over the adjusted 2001 quota of 4,875 mt (10.7 million lbs). Since 1980, 70% of the commercial landings of summer flounder have come from the Exclusive Economic Zone (EEZ; greater than 3 miles from shore). The percentage of landings attributable to the EEZ was lowest in 1983 and 1990 at 63% and was highest in 1989 at 77%. Large variability in summer flounder landings exist among the states, over time, and the percent of total summer flounder landings taken from the EEZ has varied widely among the states.

Northeast Region Commercial Fishery Landings

Annual commercial landings data for summer flounder in years prior to 1994 were obtained from trip-level detailed landings records contained in master data files maintained by the NEFSC (the weighout system; 1963-1993) and from summary reports of the Bureau of Commercial Fisheries and its predecessor the U.S. Fish Commission (1940-1962). Beginning in 1994, landings estimates were derived from mandatory dealer reports under the current NMFS Northeast Region (NER) summer flounder quota monitoring system.

Prior to 1994, summer flounder commercial landings were allocated to NEFSC 3-digit statistical area according to interview data (Burns *et al. In* Doubleday and Rivard 1983). For 1994-2001, dealer landings were allocated to statistical area using fishing Vessel Trip Reports (VTR data) according to the general procedures developed by Wigley *et al.* (1997), in which a matched set of dealer and VTR data is used as a sample to characterize the statistical area distribution of monthly state landings. Since the implementation of the annual commercial landings quota in 1993, the commercial landings have become concentrated during the first calender quarter of the year, with about 46% of the landings taken during the first quarter in 2001.

The distribution of 1992-2001 landings by three-digit statistical area is presented in Table A2. Areas 537-539 (Southern New England), areas 611-616 (New York Bight), areas 621, 622, 625, and 626 (Delmarva region), and areas 631 and 632 (Norfolk Canyon area) have generally accounted for over 80% of the NER commercial landings. In 2001, these areas accounted for 95% of the NER commercial landings. A summary of length and age sampling of summer flounder landings collected by the NEFSC commercial fishery port agent system in the NER is presented in Table A3. For comparability with the manner in which length frequency sampling in the recreational fishery has been evaluated, sampling intensity is expressed in terms of metric tons of landings (mt) per 100 fish lengths measured. The sampling is proportionally stratified by market category (jumbo, large, medium, small, and unclassified), with the sampling distribution generally reflecting the distribution of commercial landings by market category. Overall sampling intensity has improved markedly since 1995, from 165 mt per 100 lengths to 30-40 mt per 100 lengths, and temporal and geographic coverage has generally improved as well.

The age composition of the NER commercial landings for 1994-2001 was generally estimated semiannually by market category and (usually) 1-digit statistical area (e.g., area 5 or area 6), using standard NEFSC procedures (market category length frequency samples converted to mean weights by length-weight relationships; mean weights in turn divided into landings to calculate numbers landed by market category; market category numbers at length apportioned to age by application of age-length keys, on semiannual area basis). For 2000 and 2001, sampling was generally sufficient to make quarterly estimates of the age composition in area 6 (in some cases, by division) for the large and medium market categories.

NER landed numbers at age were raised to total NER (general canvas) commercial landings when necessary by assuming that landings not accounted for in the weighout/mandatory reporting system had the same age composition as that sampled, as follows: calculate proportion at age by weight; apply proportions at age by weight to total NER commercial landings to derive total NER commercial catch at age by weight; divide by mean weights at age to derive total NER commercial landed numbers at age (Table A4). The proportion of large and jumbo market category fish in the NER landings has increased since 1996, while the proportion of small market category landings has become very small. The mean size of fish landed in the NER commercial fishery has been increasing since 1993, and was about 1.01 kg (2.2 lbs) in 2001, typical of an age 3 summer flounder (Table A5).

North Carolina Commercial Fishery Landings

The North Carolina winter trawl fishery accounts for about 99% of summer flounder commercial landings in North Carolina. A separate landings at age matrix for this component of the commercial fishery was developed from North Carolina Division of Marine Fisheries (NCDMF) length and age frequency sampling data. The NCDMF program samples about 10% of the winter trawl fishery landings annually, at a rate of between 53 and 5 mt of landings per 100 lengths measured (Table A6). All length frequency data used in construction of the North Carolina winter trawl fishery landings at age matrix were collected in the NCDMF program; age-length keys from NEFSC commercial data and NEFSC spring survey data (1982-1987) and NCDMF commercial fishery data (1988-2001) were combined by appropriate statistical area and semiannual period to resolve lengths to age. Fishery regulations in North Carolina also changed between 1987 and 1988, with increases in both the minimum mesh size of the codend and minimum landed fish size taking effect. It is not clear whether the change in regulations or the change in keys, or some combination, is responsible for the decreases in the numbers of age-0 and age-1 fish estimated in the North Carolina commercial fishery landings since 1987. Landed numbers at age and mean weights at age from this fishery are shown in Tables A7-A8.

Commercial Fishery Discards

In a previous assessment, analysis of variance of the fishery observer data for summer flounder was used to identify stratification variables for an expansion procedure to estimate total landings and discards from fishery observer data kept and discard rates (weight per day fished) in the commercial fishery. Initial models included year, quarter, fisheries statistical division (2-digit area), area (divisions north and south of Delaware Bay), and tonnage class as main effects, with quarter and division emerging (along with year) as consistently significant main effects without significant interaction with the year (NEFSC 1993). The estimation procedure expands transformation bias-corrected geometric mean catch (landings and discards) rates in year, quarter, and division strata by total days fished (days fished on trips landing any summer flounder by any mobile gear, including fish trawls and scallop dredges) to estimate fishery landings and discards. The use of fishery effort as the multiplier (raising factor) allows estimation of landings from the fishery observer data for comparison with dealer reported landings, to help judge the potential accuracy of the procedure and/or sample data.

For strata with no fishery observer sampling, catch rates from adjacent or comparable strata were substituted as appropriate (except for Division 51, which generally has very low catch rates and negligible catch). Estimates of discard are stratified by 2 gear types (scallop dredge and trawl and others) for years when data are adequate (1992-2001). Estimates at length and age are stratified by gear only for 1994-2000, again due to sample size considerations. Only 11 fish were sampled from the sea scallop dredge fishery 2001, and so the scallop dredge discards were assumed to have the same length and age composition as the trawl fishery discards in 2001.

While estimates of catch rates from the NER fishery observer data are used in this assessment to estimate total discards, information on catch rate is also reported in the VTR data. A comparison of discard to total catch ratios for the fishery observer and VTR data sets for trawl and scallop dredge gear indicated similar discard rates in the trawl fishery from the two data sources, while discard rates in the scallop dredge fishery were often higher in the fishery observer data. Overall fishery observer and VTR discard to total catch ratios for 1994-2000 were generally within 10% of each other; 2001 was an exception, with an overall discard to total catch ratio of 45% in the fishery observer data and 29% in the VTR data (Tables A9-A10).

The change from the interview/weighout data reporting system to the VTR/mandatory dealer report system required a change in the estimation of effort (days fished) used as a multiplier with the fishery observer geometric mean discard rate in the procedure used to estimate total discard for 1994-2001. An initial examination of days fished and catch per unit effort (CPUE; landings per day fished) for cod conducted at SAW 24 (NEFSC 1997a) compared these quantities as reported in the full weighout and VTR data sets (DeLong *et al.*, 1997). This comparison indicated a shift to a higher frequency of short trips (trips with one or two days fished reported), and to a mode at a lower rate of CPUE. It was not clear at SAW 24 if these changes were due to the change in reporting system (units reported not comparable), or real changes in the fishery, and so effort data reported by the VTR system were not used quantitatively in the SAW 24 assessments. In the SAW 25 assessment for summer flounder (NEFSC 1997a), a slightly different comparison was made. The port agent interview data for 1991-93 and merged dealer/VTR data for 1994-1996 (the matched set data), which under each system serve as the "sample" to characterize the total commercial landings, were compared in relative terms (percent frequency). For summer flounder, the percent frequency of short trips (lower number of days fished per trip) increased during 1991-1996, but not to the degree observed for cod, and the mode of CPUE rates for summer flounder increased in spite of lower effort per trip. For the summer flounder fishery, these may reflect actual changes in the fishery, due to increasing restrictions of allowable landings per trip (trip landings limits might lead to shorter trips) and increasing stock size (higher CPUE). As for cod, however, the influence of each of these changes (reporting system, management changes, stock size changes) has not been quantified. Total days fished in the summer flounder fishery were comparable between 1989-1993 period and 1994. With increasing restrictions on the fishery in 1995-2001 (lower landings quota, higher stock size, and thus increasing impact of trips limits and closures), total days fished declined relative to the early 1990s. Questions will remain about the accuracy of the VTR data . However, because the effort measure is critical to the estimation of discards for summer flounder, the VTR data were used as the best data source to estimate summer flounder fishery days fished for 1994-2001.

Two adjustments were made to the dealer/VTR matched data subset days fished estimates to fully accounted for summer flounder fishery effort during 1994-2001. First, the landings to days fished relationship in the matched set was assumed to be the same for unmatched trips, and so the days fished total in each discard estimation stratum (2-digit area and quarter) was raised by the dealer to matched set landings ratio. This step in the estimation accounted for days fished associated with trips landing summer flounder, and provided an estimate of discard for trips landing summer flounder.

Given the restrictions on the fishery however, there is fishing activity which results in summer flounder discard, but no landings, especially in the scallop dredge fishery. The days fished associated with these trips was accounted for by raising strata discard estimates by the ratio of the total days fished on trips catching any summer flounder (trips with landings and discard, plus trips with discard only) to the days fished on trips landing summer flounder (trips with landings and discard), for VTR trips reporting discard of any species (DeLong *et al.* 1997). For this step, it is necessary to assume that the discard rate (as indicated by the fishery observer data, which includes trips with discard but no landings, and which is used in previous estimation procedure steps) is the same for trips with only discard as for trips which both land and discard.

The expansion procedure provided fishery observer data estimates of landings ranging from +35% (1996) to -69% (2001) of the reported landings in the fisheries, with discard ranging from 41% (1990) to 6% (1995) of the reported landings. Total discards estimated for 2000 and 2001 were 18% and 16% of the reported landings. Scallop dredge fishery discard to landed ratios are much higher than trawl fishery ratios, purportedly because of closures and trip limits. Thus, although the scallop dredge landings are less than 5% of the total, the discard is of the same order of magnitude as that in the trawl fishery.

These discard estimates were based only on the days fished data for ports in the NER during

1989-1996, and so it was necessary to raise the discard estimate to account for discarding which occurs in components of the commercial fishery outside the NER reporting system (i.e., NER state reporting systems such as Connecticut and Virginia, and North Carolina) for those years. To determine the proper raising factor, landings accounted for by the NER reporting system (which result from the fishing effort on which the fishery observer discard estimate is based) were compared with total NER landings, plus that portion of North Carolina landings removed from the EEZ (it is assumed that only the North Carolina fishery in the EEZ would experience significant discard, as mesh regulations in state waters have resulted in very low discards in state waters since implementation of the regulation in 1989; R. Monaghan, pers. comm.). Since 1996, all states' landings and are included in the NER dealer reporting system, so no raising is necessary to account for missing landings. As recommended by SAW 16 (NEFSC 1993), a commercial fishery discard mortality rate of 80% was assumed to develop the final estimate of discard mortality (Table A11).

Existing fishery observer data were used to develop estimates of commercial fishery discard for 1989-2001. However, adequate data (e.g., interviewed trip data, survey data) are not available for summer flounder to develop discard estimates for 1982-1988. Discard numbers were assumed to be very small relative to landings during 1982-1988 (because of the lack of a minimum size limit in the EEZ), but to have increased since 1989 with the implementation of fishery regulations under the FMP. It is recognized that not accounting directly for commercial fishery discards would result in an underestimation of fishing mortality and population sizes in 1982-1988.

NEFSC fishery observer length frequency samples were converted to sample numbers at age and sample weight at age frequencies by application of NEFSC survey length-weight relationships and fishery observer, commercial fishery, and survey age-length keys. Sample weight proportions at age were next applied to the raised fishery discard estimates to derive fishery total discard weight at age. Fishery discard weights at age were then divided by fishery observer mean weights at age to derive fishery discard numbers at age. Classification to age for 1989-1993 was done by semiannual (quarters 1 and 2 pooled, quarters 3 and 4 pooled) periods using NEFSC fishery observer age-length keys, except for 1989, when first period lengths were aged using combined commercial (quarters 1 and 2) and NEFSC spring survey age-length keys. For 1994-2001, only NEFSC winter, spring, and fall survey age-length keys were used. Fishery observer sampling intensity is summarized in Table A11. Estimates of discarded numbers at age, mean length and mean weight at age are summarized in Tables A12-A14.

The reason for discarding in the trawl and scallop dredge fisheries has been changing over time. During 1989 to 1995, the minimum size regulation was recorded as the reason for discarding summer flounder for over 90% of the observed trawl and scallop dredge tows. In 1999, the minimum size regulation was provided as the reason for discarding for 61% of the observed trawl tows, with quota or trip limits given as the discard reason for 26% of the observed tows, and high-grading for 11% of the observed tows. In the scallop fishery in 1999, quota or trip limits was given as the discard reason for over 90% of the observed tows. During 2000-2001, minimum size regulations were identified as the discard reason for 40-45% of the observed trawl tows, quota or trip limits for 25-30% of the tows, and high grading for 3-8%. In the scallop fishery during 2000-2001, quota or trip limits was given as the discard reason for over 99% of the observed tows. As a result of the increasing impact of trip limits, fishery closures, and high grading as the reasons for discarding, the age structure of the summer flounder discards has also changed, with more older fish being discarded (Table A12).

Recreational Fishery Landings

Summary landings statistics for the recreational fishery (catch type A+B1) as estimated by the National Marine Fisheries Service (NMFS) Marine Recreational Fishery Statistics Survey (MRFSS) are presented in Tables A15-A16. Recreational fishery landings decreased 29% by number and 26% by weight from 2000 to 2001, although the fishery still landed 162% (5,250 mt, 11.6 million lbs) of the 3,250 mt (7.2 million lbs) harvest limit established for 2001.

The length frequency sampling intensity for the recreational fishery for summer flounder was calculated by MRFSS subregions (North - Maine to Connecticut; Mid - New York to Virginia; South - North Carolina) on a metric tons of landings per hundred lengths measured basis (Burns *et al. In* Doubleday and Rivard, 1983). For 2001, aggregate sampling intensity averaged 123 mt of landings per 100 fish measured, an improvement over 2000 (Table A17).

MRFSS sample length frequency data, NEFSC commercial age-length data, and NEFSC survey age-length data were examined in terms of number of fish measured/aged on various temporal and geographical bases. Correspondences were made between MRFSS intercept date (quarter), commercial quarter, and survey season (spring and summer/fall) on temporal bases, and between MRFSS subregion, commercial statistical areas, and survey depth strata on geographic bases in order to integrate data from the different sources. Based on the number, size range, and distribution of lengths and ages, a semiannual (quarters 1 and 2, quarters 3 and 4), subregional basis of aggregation was adopted for matching of commercial and survey age-length keys with recreational length frequency distributions for conversion of the lengths to ages.

The recreational landings historically have been dominated by relatively young fish. Over the 1982-1996 period, age 1 fish accounted for an average of over 50% of the landings by number; summer flounder of ages 0 to 4 accounted for an average of over 99% of landings by number. No fish from the recreational landings were determined to be older than age 7. With increases in the minimum size during 1997-2001 (to 14.5 in [37 cm] in 1997, 15 in [38 cm] in 1998-1999, generally 15.5 in [39 cm] in 2000, and various state minimum sizes from 15.5 [38 cm] to 17.5 in [44 cm] in 2001), reductions in fishing mortality, and patterns in recruitment to the stock, the age composition of the recreational landings now includes mainly fish at ages 2 and 3. The number of summer flounder of ages 4 and older landed by the recreational fishery in 2000 (11% of the landings by number) and 2001 (13%) was the highest since 1983 (Table A18).

Small MRFSS intercept length sample sizes for larger fish resulted in a high degree of variability in mean length for older fish, especially at ages 5 and older. Attempts to estimate length-weight relationships from MRFSS biological sample data for use in estimating weight at age provided unsatisfactory results. As a result, quarterly length (mm) to weight (g) relationships from Lux and Porter (1966), which are employed in the conversion of length to weight in NEFSC compilation of commercial fishery statistics for summer flounder, were used to calculate annual mean weights at age from the estimated age-length frequency distribution of the landings.

Recreational Fishery Discards

MRFSS catch estimates were aggregated on a subregional basis for calculation of the proportion of live discard (catch type B2) to total catch (catch types A+B1+B2) in the recreational fishery for summer flounder. Examination of catch data in this manner shows that the live discard has varied from about 18% (1985) to about 81% (1999, 2001) of the total catch (Table A19).

To account for all removals from the summer flounder stock by the recreational fishery, some assumptions about the biological characteristics and hooking mortality rate of the recreational live discard needed to be made, because no biological samples are taken from MRFSS catch type B2. In previous assessments, data available from New York Department of Environmental Conservation (NYDEC) surveys (1988-92) of New York party boats suggested the following for this component (Mid-Atlantic subregion, anglers fishing from boats) of the recreational fishery: 1) nearly all (>95%) of the fish released alive were below the minimum regulated size (during 1988-92, 14 in [36 cm] in New York state waters), 2) nearly all of these fish were age 0 and age 1 summer flounder, and 3) age 0 and 1 summer flounder occurred in approximately the same proportions in the live discard as in the landings. It was assumed that all B2 catch would be of lengths below regulated size limits, and so either age 0 or age 1 in all three subregions during 1982-1996. Catch type B2 was therefore allocated on a subregional basis in the same ratio as the annual age 0 to age 1 proportion observed in the landings during 1982-1996. Mean weights at age were assumed to be the same as in the landings during 1982-1996.

The minimum landed size in federal and most state waters increased to 14.5 in (37 cm) in 1997, to 15.0 in (38 cm) in 1998-1999, and to 15.5 in (39 cm) in 2000. Applying the same logic employed to classify the 1982-1996 recreational released catch to size and age for 1997-2000 implied that the recreational fishery released catch included fish of ages 2 and 3. Investigation of data from the CTDEP Volunteer Angler Survey (VAS, 1997-1999) and American Littoral Society (ALS, 1999), comparing the length frequency of released fish in those programs with the MRFSS data on the length frequency of landed fish less than the minimum size, suggested this assumption was valid for 1997-1999 (MAFMC 2001a). The CTDEP VAS and ALS data, along with data from the NYDEC Party Boat Survey (PBS) was used to validate this assumption for 2000. For 1997-2000 it was therefore assumed that all B2 catch would be of lengths below regulated size limits, and so of ages 0 to 3. Catch type B2 was therefore allocated on a sub-regional basis in the same ratio as the annual age 0 to age 3 proportions observed in the landings at lengths less than 37 cm in 1997, 38 cm in 1998-1999, and 39 cm in 2000 (Table A20).

In 2001, many states adopted different combinations of minimum size and possession limits to meet management requirements. As a result, minimum sizes for summer flounder ranged from 15.5 in (39 cm) in Federal, VA, and NC waters, 16 in (41 cm) in NJ, 16.5 in (42 cm) in MA, 17 in (43 cm) in MD and NY, to 17.5 in (44 cm) in CT, RI, and DE. Examination of data provided by MD sport fishing clubs, the CTDEP VAS, the ALS, and the NYDEP PBS indicated that the basic assumption that fish released are those smaller than the minimum size remained valid. Thus for 2001, catch type B2 was characterized by the same proportion at length as the landed catch less than the minimum size in the respective states. Due to sample size considerations, lengths and B2 catch were aggregated to semi-annual, subregional strata to calculate the expanded discards at length. The number of age 1 fish discarded in the recreational fishery in 2001 was the most since 1996 (Table A20).

Studies conducted cooperatively by NEFSC and the state of Massachusetts to estimate hooking mortality for striped bass and black sea bass suggest a hooking mortality rate of 8% for striped bass (Diodati and Richards 1996) and 5% for black sea bass (Bugley and Shepherd, 1991). Work by the states of Washington and Oregon with Pacific halibut (a potentially much larger flatfish species, but otherwise morphologically similar to summer flounder) found "average hooking mortality...between eight and 24 percent" (IPHC, 1988). An unpublished tagging study by the NYDEC (Weber MS 1984) on survival of released sublegal summer flounder caught by hook-and-line suggested a total, non-fishing mortality rate of 53%, which included hooking plus tagging mortality as well as deaths by natural causes (i.e., predation, disease, senescence). Assuming deaths by natural causes to be about 18%, (an instantaneous rate of 0.20), an annual hooking plus tagging mortality rate of about 35% can be derived from the NYDEC results. In the SARC 25 (NEFSC 1997b) and earlier assessments of summer flounder, a 25% hooking mortality rate was assumed reasonable for summer flounder released alive by anglers.

Two more recent investigations of summer flounder recreational fishery release mortality suggest that a lower release mortality rate is appropriate. Lucy and Holton (1998) used field trials and tank experiments to investigate the release mortality rate for summer flounder in Virginia, and found rates ranging from 6% (field trials) to 11% (tank experiments). Malchoff and Lucy (1998) used field cages to hold fish angled in New York and Virginia during 1997 and 1998, and found a mean short term mortality rate of 14% across all trials. Given the results of these release mortality studies conducted specifically for summer flounder, a 10% release mortality rate was adopted in the Terceiro (1999) and has been retained in subsequent assessments (NEFSC 2000, MAFMC 2001a).

Ten percent of the total B2 catch at age is added to estimates of summer flounder landings at age to provide estimates of summer flounder recreational fishery discard at age (Table A20), total recreational fishery catch at age in numbers (Table A21) and mean weights at age (Table A22). The number of fish discarded and assumed dead in the recreational fishery (2.3 million fish, 1,184 mt) was 43% by number and 23% by weight of the total landed (5.2 million fish, 5,250 mt) in the recreational fishery in 2001.

Total Catch Composition

NER total commercial fishery landings and discards at age, North Carolina winter trawl fishery landings and discards at age, and MRFSS recreational fishery landings and discards at age totals were summed to provide a total fishery catch at age matrix for 1982-2001 (Table A23; Figure A1). The percentage of age-3 and older fish in the total catch in numbers has increased in recent years from only 4% in 1993, to about 40% during 1998-2001. Overall mean lengths and weights at age for the total catch were calculated as weighted means (by number in the catch at age) of the respective mean values at age from the NER commercial (Maine to Virginia), North Carolina commercial, and recreational (Maine to North Carolina) fisheries (Tables A24-A25; Figure A2). The recreational fishery share of the total summer flounder catch has increased since 1995 (Figure A3).

BIOLOGICAL DATA

Aging

Work performed for the SAW 22 assessment (NEFSC 1996b) indicated a major expansion in the size range of 1-year old summer flounder collected during the 1995 and 1996 NEFSC winter bottom trawl surveys, and brought to light differences between ages determined by the NEFSC and NCDMF fishery biology staffs. Age structure (scale) exchanges were performed after the SAW 22 assessment to explore these aspects of summer flounder biology. The results of the first two exchanges, which were reported at SAW 22 (NEFSC 1996b), indicated low levels of agreement between age readers at the NEFSC and NC DMF (31 and 46%). In 1996, research was conducted to determine inter-annular distances and to back-calculate mean length at age from scale samples collected on all NEFSC bottom trawl surveys (winter, spring and fall) in order to compare with NCDMF samples. While mean length at age remained relatively constant from year to year, inter-annular distances increased sharply in the samples from the 1995-1996 winter surveys, and increased to a lesser degree in samples from other 1995-1996 surveys as well. As a result, further exchanges were suspended pending the resolution of an apparent aging problem.

Age data from the winter 1997 bottom trawl survey, aged utilizing both scales and otoliths by only by one reader, indicated a similar pattern as the previous two winter surveys (i.e., several large age 1 individuals) from scale readings, and some disagreement between scale and otolith ages obtained from the same fish. Because of these problems, a team of five experienced NEFSC readers was formed to re-examine the scales aged from the winter survey. After examining several hundred scales, the team determined that re-aging all samples from 1995-1997, including all winter, spring, and fall samples from the NEFSC and MA DMF bottom trawl surveys and all samples from the commercial fishery, would be appropriate. The age determination criteria used remained the same as developed at the 1990 summer flounder workshop (Almeida *et al.* 1992) and described in the standard aging manual utilized by NEFSC staff (Dery 1997). Only those fish for which a 100% consensus of all group members could be reached were included in the revised database, however. The data from the re-aged database were used in analyses in the SAW 25 assessment (NEFSC 1997b).

A third summer flounder aging workshop was held at NEFSC in February, 1999, to continue the exchange of age structures and review of aging protocols for summer flounder (Bolz *et al.* 2000). The participants of the latest workshop concluded that the majority of aging disagreements in recent NEFSC-NCDMF exchanges arose from the interpretation of marginal scale increments due to highly variable timing of annulus formation, and from the interpretation of first year growth patterns and first annulus selection. The workshop recommended regular samples exchanges between NEFSC and NCDMF, and further analyses of first year growth.

Maturity

The maturity schedule for summer flounder used in the 1990 SAW 11 and subsequent stock assessments through 1999 was developed by the SAW 11 Working Group using NEFSC Fall Survey maturity data for 1978-1989 and mean lengths at age from the NEFSC fall survey (G. Shepherd, NEFSC, personal communication; NEFC 1990; Terceiro 1999). The SAW 11 work indicated that the median length at maturity (50th percentile, L_{50}) was 25.7 cm for male summer flounder and 27.6 cm for female summer flounder, and 25.9 cm for the sexes combined. Under the aging convention used in the SAW 11 and subsequent assessments (Smith *et al.* 1981, Almeida *et al.* 1992, Szedlmayer and Able 1992, Bolz *et al.* 2000), the median age of maturity (50th percentile, A_{50}) for summer flounder was determined to be 1.0 years for males and 1.5 years for females. Combined maturities indicated that 38% of age-0 fish are mature, 72% of age-1 fish are mature, 90% of age-2 fish are mature, 97% of age-3 fish are mature, 99% of age-4 fish are mature, and 100% of age-5 and older fish are mature at peak spawning time in the autumn. The maturities for age-3 and older were rounded to 100% in the SAW 11 and subsequent assessments.

In the series of summer flounder assessments, it has been noted that the maturity schedules have been based on simple gross morphological examination of the gonads and therefore may not accurately reflect (i.e., may overestimate) the true spawning potential of the summer flounder stock (especially for age-0 and age-1 fish). It should also be noted, however, that spawning stock biomass (SSB) estimates based on age-2 and older fish show the same long term trends in SSB as estimates which include age 0 and 1 fish in the spawning stock. A research recommendation that the true spawning contribution of young summer flounder to the SSB be investigation has been included in summer flounder stock assessments since 1993 (NEFSC 1993). In light of the completion of a URI study to address this research recommendation, the maturity data for summer flounder for 1982-1998 were examined in the 2000 assessment (NEFSC 2000) to determine if changes in the maturity schedule were warranted.

The research at the University of Rhode Island (URI) by Drs. Jennifer Specker and Rebecca Rand Merson (hereafter referred to collectively as the "URI 1999" study) attempted to address the issue of the true contribution of young summer flounder to the spawning stock. The URI 1999 study examined the histological and biochemical characteristics of female summer flounder oocytes (1) to determine if age-0 and age-1 female summer flounder produce viable eggs, and (2) to develop an improved guide for classifying the maturity of summer flounder collected in NEFSC surveys (Specker *et al.* 1999, Merson *et al.* In press, Merson *et al.* In review). The URI study examined 333 female summer flounder (321 aged fish) sampled during the NEFSC Winter 1997 Bottom Trawl Survey (February 1997) and 227 female summer flounder (210 aged fish) sampled during the NEFSC Autumn 1997 Bottom Trawl Survey (September 1997), using radioimmunoassays to quantify the biochemical cell components characteristic of mature fish.

To provide an increased sampled size for the calculation of length- and age-based maturity schedules, the fish in the URI study sampled from the NEFSC Winter and Autumn 1997 Surveys were combined, with the ages of the fish from the Winter Survey reduced by 1 year to reflect their age at spawning during the previous (1996) autumn. For this combined sample, the NEFSC and URI maturity criteria disagreed for 13% of the aged fish, with most (10%) of the disagreement due to

NEFSC mature fish classified as immature by the URI histological and biochemical criteria. Of the 531 female summer flounder in the combined age sample, the URI criteria indicated that 15% of the age-0 fish were mature, 82% of the age-1 fish were mature, 97% of the age-2 fish were mature, and 100% of the age 3 and older fish were mature. When the proportions of fish mature at length and age were estimated by probit analysis, the URI 1999 criteria a median length at maturity (50th percentile, L_{50}) of 34.7 cm for female summer flounder, with proportions mature at age of age-0: 30%, age-1: 68%, age-2: 92%, age-3: 98%, age-4: 100%., with a median age of maturity (50th percentile, A_{50}) of about 0.5 years.

SARC 31 (NEFSC 2000) considered 5 options for the summer flounder maturity schedule for the 2000 stock assessment:

1) No change, use the maturity schedule for combined sexes as in the SAW 11 and subsequent assessments (the schedule presented below is rounded to 0.38, 0.72, 0.90, 1.00, 1.00, and 1.00 as in the SAW 25 and Terceiro (1999) assessment analyses).

2) Consider only age-2 and older fish of both sexes in the SSB.

3) Knife edged, age-1 and older maturity for both sexes. This would eliminate age-0 fish of both sexes from the SSB, and assume that the proportions mature at age-1 "round" to 100%.

4) NEFSC 1982-1989, 1990-1998 for both sexes, assuming a 1:1 sex ratio to average proportions for a combined schedule.

5) NEFSC 1982-1989, 1990-1998 for males, URI 1999 for females, assuming a 1:1 sex ratio to average proportions for a combined schedule.

SARC 31 concluded that some contribution to spawning from ages 0 and 1 should be included, eliminating options 2 and 3. The differences among remaining options 1, 4, and 5 were considered to be relatively minor, and so the SAW 11 schedule (Option 1) was retained for the 2000 (NEFSC 2000), 2001 (MAFMC 2001a), and current (2002) assessment. SARC 31 recommended that more biochemical and histological work, for both male and female summer flounder, should be done for additional years to determine if the results of the URI 1999 study will be applicable over the full VPA time series. SARC 31 also noted the need for research to explore whether the viability of eggs produced by young, first time spawning summer flounder is comparable to the viability of eggs produced by older, repeat spawning summer flounder.

RESEARCH SURVEY ABUNDANCE AND BIOMASS INDICES

NEFSC Spring

Long-term trends in summer flounder abundance were derived from a stratified random bottom trawl survey conducted in spring by NEFSC between Cape Hatteras and Nova Scotia since

1968 (Clark 1978). NEFSC spring survey indices (Tables A26-A27) suggest that total stock biomass last peaked during 1976-1977, and in 2002 was now about 15% above that peak, and at a new historical high (Figure A4). Age composition data from the NEFSC spring survey indicate a substantial reduction in the number of ages in the stock between 1976-1990 (Table A27). Between 1976-1981, fish of ages 5-8 were captured regularly in the survey, with the oldest individuals aged 8-10 years. Between 1982-1986, fish aged 5 and older were only occasionally observed in the survey, and by 1986, the oldest fish observed in the survey were age 5. In 1990 and 1991, only three ages were observed in the survey catch, and there was an indication that the 1988 year class was very weak. Since 1991, the survey age composition has expanded significantly. There is strong evidence in the 1998-2002 NEFSC spring surveys of increasing abundance of age-3 and older fish, due to increased survival of the 1994 and subsequent year classes (Table A27). Mean lengths at age in the NEFSC spring survey are presented in Table A28.

NEFSC Autumn

Summer flounder are caught frequently in the NEFSC autumn survey at stations in the inshore strata (< 27 meters = 15 fathoms = 90 feet) and in the band of offshore strata of 27-55 meters depth (15-30 fathoms, 90-180 feet), at about the same magnitude as in the spring survey (Table A26). Furthermore, the autumn survey catches age-0 summer flounder in abundance, providing an index of summer flounder recruitment (Tables A29 & A48, Figure A7). Fall survey indices suggest improved recruitment since the late 1980s, and evidence of an increase in abundance at age-2 and older since 1995. The NEFSC autumn surveys indicate that the 1995 year class of summer flounder was the most abundant in recent years, and that subsequent, weaker year classes are experiencing increased survival (Table A29). Mean lengths at age in the NEFSC autumn survey are presented in Table A30.

NEFSC Winter

A new series of NEFSC winter trawl surveys was begun in February 1992 specifically to provide improved indices of abundance for flatfish, including summer flounder. This survey targets flatfish during the winter when they are concentrated offshore. A modified 36 Yankee trawl is used in the winter survey that differs from the standard trawl employed during the spring and autumn surveys in that 1) long trawl sweeps (wires) are added before the trawl doors, to better herd fish to the mouth of the net, and 2) the large rollers used on the standard gear are absent, and only a chain "tickler" and small spacing "cookies" are present on the footrope.

Based on a comparison of summer flounder catches during the winter surveys with recent spring and autumn surveys, the design and conduct of the winter survey (timing, strata sampled, and the use of the modified 36 Yankee trawl gear) has resulted in greater catchability of summer flounder compared to the other surveys. Most fish have been taken in survey strata 61-76 (27-110 meters; 15-60 fathoms), off the Delmarva and North Carolina coasts . Other concentrations of fish are found in strata 1-12, south of the New York and Rhode Island coasts, in slightly deeper waters. Significant numbers of large summer flounder are often captured along the southern flank of Georges Bank (strata 13-18).

Indices of summer flounder abundance from the winter survey indicated stable stock size during 1992-1995, with indices of stratified mean catch per tow in number ranging from 10.9 in

1995 to 13.6 in 1993. The NEFSC winter survey index for 1996 increased by 290% over the 1995 value, from 10.8 to 31.2 fish per tow. The largest increases in 1996 catch per tow occurred in the Mid-Atlantic Bight region (offshore strata 61-76), where increases in catch per tow of up to an order of magnitude over the 1995 level occurred in several strata, with the largest increases in strata 61,62, and 63, off the northern coast of North Carolina. Most of the increased catch in 1996 consisted of age-1 summer flounder from the 1995 year class. In 1997, the index dropped to 10.3 fish per tow, due to the lower numbers of age-1 (1996 year class) fish caught. The Winter 2002 survey kg per tow index is the highest of the 1992-2002 series (Tables A26 & A31, Figure A4). As with the other two NEFSC surveys, there is strong evidence in recent winter surveys of increased abundance of age-3 and older fish relative to earlier years in the time series, due to the abundance of the 1995 year class and increased survival of subsequent year classes (Table A32). Mean lengths at age in the NEFSC winter survey are presented in Table A33.

Massachusetts DMF

Spring and fall bottom trawl surveys conducted by the Massachusetts Division of Marine Fisheries (MADMF) show a decline in abundance in numbers of summer flounder from recent high levels in 1986 to record lows in 1990 (MADMF fall survey), and 1991 (MADMF spring survey). In 1994, the MADMF survey indices increased to values last observed during 1982-1986, but then declined substantially in 1995, although the indices remain higher than the levels observed in the late 1980s . Since 1996, both the MADMF spring and fall indices have increased substantially to values last observed during 1982-1986 (Tables A34-A35, Figure A5). The MADMF also captures a small number of age-0 summer flounder in a seine survey of estuaries, and these data are available as an index of recruitment (Tables A36 & A48, Figure A9).

Connecticut DEP

Spring and fall bottom trawl surveys are conducted by the Connecticut Department of Environmental Protection (CTDEP). The CTDEP surveys show a decline in abundance in numbers of summer flounder from high levels in 1986 to record lows in 1989. The CTDEP surveys indicate recovery since 1989, and evidence of increased abundance at ages 2 and older since 1995. The 2000 and 2001 spring indices were the highest of the 16 year time series, and the 2001 autumn index was the highest of the series (Tables A37-A38, Figure A6). An index of recruitment from the autumn series is available (Tables A38 & A48, Figure A7).

Rhode Island DFW

A standardized bottom trawl survey has been conducted during the spring and fall months in Narragansett Bay and state waters of Rhode Island Sound by the Rhode Island Department of Fish and Wildlife (RIDFW) since 1979. Indices of abundance at age for summer flounder have been developed from the autumn survey data using NEFSC autumn survey age-length keys. The 1988 and 1991 year classes are the weakest in recent years in this time series, and the index shows the 1984-1987, 1999, and 2000 year classes to have been the strongest. The autumn survey was at or near a time-series high during 1999-2000 (Table A39, Figure A5). A new series of indices was developed from a set of fixed stations sampled monthly during 1990-2000. Age-1 indices from this series indicate that strong year classes recruited to the stock in1996, 1999, and 2000, with age 2+ abundance peaking in 2000 (Table A40). Recruitment indices are available from both the autumn and monthly fixed station surveys (Table A39-A40 & A48, Figure A9).

New Jersey BMF

The New Jersey Bureau of Marine Fisheries (NJBMF) has conducted a standardized bottom trawl survey since 1988. Indices of abundance for summer flounder incorporate data collected from April through October. NJBMF supplied annual total mean number per tow indices and associated annual length frequency distributions; lengths were converted to age using the corresponding annual NEFSC combined spring and fall survey age-length keys. Indices of the 1995 year class at age-0 and at older ages in subsequent years through 1999 indicate that it is the strongest of the 1988-2001 time series. Indices of the 1996-2001 year classes are below the time series average. The NJBMF survey indices show evidence of increased abundance at age-2 and older in the 1995-2000 surveys, but a decline in 2001 (Table A41, Figure A6). Recruitment indices are available from the NJBMF survey (Tables A41 & A48, Figure A7).

Delaware DFW

The Delaware Division of Fish and Wildlife (DEDFW) has conducted a standardized bottom trawl survey with a 16 foot headrope trawl since 1980, and with a 30 foot headrope trawl since 1991. Recruitment indices (age 0 fish; one index from the Delaware estuary proper, one from the inland bays) have been developed from the 16 foot trawl survey data for the 1980 to 2001 year classes. Indices for age-0 to age-4 and older summer flounder have been compiled from the 30 foot headrope survey. The indices incorporate data collected from June through October (arithmetic mean number per tow), with age 0 summer flounder separated from older fish by visual inspection of the length frequency. The 16 foot headrope survey indices suggest poor recruitment in 1988 and 1993, and improved recruitment in 1994-1995 (Tables A42-A43 & A48). The 16-foot trawl Estuary index indicates below average recruitment since 1995, except for 2000 (Figure A9). The 16-foot trawl Inland Bays index indicates above average recruitment during 1998-2000, and poor recruitment in 2001. The 30 foot headrope survey indices suggest stable stock sizes over the 1991-2001 time series, with strong recruitment in 1991, 1994, 1995, and 2000 (Table A44, Figure A6).

Maryland DNR

The Maryland Department of Natural Resources (MDDNR) has conducted a standardized trawl survey in the seaside bays and estuaries around Ocean City, MD since 1972. Samples collected during May to October with a 16 foot bottom trawl have been used to develop a recruitment index for summer flounder for the period 1972-2001. This index suggests that weakest year class in the time series recruited to the stock in 1988, and the strongest in 1972, 1983, 1986, and 1994. The 2000 and 2001 indices were about average (Tables A45 & A48, Figure A8).

Virginia Institute of Marine Science

The Virginia Institute of Marine Science (VIMS) conducts a juvenile fish survey using trawl gear in Virginia rivers and the mainstem of Chesapeake Bay. The time series for the rivers extends from 1979-2001. With the Bay included, the series is available only since 1988, but many more stations are included. Trends in the two time series are very similar. An index of recruitment developed from the rivers only series suggests weak year classes recruited to the stock in 1987 and 1999, with strongest year classes recruiting during 1980-1984, and 1990. Recruitment indices since

1990 have been below the time series average (Tables A46 & A48, Figure A8).

North Carolina DMF

The NCDMF has conducted a stratified random trawl survey using two 30 foot headrope nets with 3/4" mesh codend in Pamlico Sound since 1987. An index of recruitment developed from these data suggests weak year classes in 1988 and 2000, and strongest year classes in 1987, 1992, and 1996, and 2001 (Tables A47-A48, Figure A8). The survey normally takes place in mid-June, but in 1999 was delayed until mid-July. The 1999 index therefore inconsistent with the other indices in the time series, and the 1999 value was excluded from the VPA calibration in the SARC 31 assessment (NEFSC 2000).

ESTIMATES OF MORTALITY AND STOCK SIZE

Natural Mortality Rate

The instantaneous natural mortality rate (M) for summer flounder was assumed to be 0.2 in all analyses, although alternative estimates of M were considered in the SAW 20 assessment (NEFSC 1996a). In the SAW 20 work, estimates were derived with the methods described by 1) Pauly (1980) using growth parameters derived from NCDMF age-length data and a mean annual bottom temperature (17.5^{o}C) from NC coastal waters, 2) Hoenig (1983) using a maximum age for summer flounder of 15 years, and 3) consideration of age structure expected in unexploited populations (5% rule, 3/M rule, e.g., Anthony 1982). SAW 20 (NEFSC 1996a) concluded that M = 0.2 was a reasonable value given the mean (0.23) and range (0.15-0.28) obtained from the various analyses, and that value for M has been used in all subsequent assessments.

ASPIC Model

The non-equilibrium surplus production model incorporating covariates (ASPIC; Prager 1994, 1995) can be used to estimate maximum sustainable yield (MSY) and other management benchmarks. An ASPIC analysis applied to summer flounder using various state and federal agency survey biomass indices (the 1998 analysis) was previously reviewed by the NEFMC Overfishing Review Panel (Applegate *et al.* 1998). Based on total weighted mean squared error (MSE), the NEFSC spring and autumn biomass indices gave the best fit to the data in that analysis. However, the Overfishing Review Panel concluded that biological reference points estimated in the 1998 analysis for summer flounder were unreliable, due to the short time series of reliable catch estimates and lack of dynamic range in the input data (Applegate *et al.* 1998).

An ASPIC analysis using projected catch and NEFSC survey biomass indices through 1999 was reviewed in the 1999 assessment (Terceiro 1999). Model results were examined for sensitivity by employing the Monte Carlo search routine and by initializing the values of MSY (10,000 to 50,000 mt) and the intrinsic rate of increase ® ; 0.12 to 1.25) over a broad range, with the ratio of initial to current biomass (B1 ratio) assigned a starting value of 0.50. Overall, the 1999 ASPIC model results for summer flounder were sensitive and suggested the possibility of numerous local minima in the sums of squared errors (SSE) response surface. The Monte Carlo search algorithm was employed in an attempt to provide a better search of the SSE response surface, and the this procedure with restarts gave a range of estimates of MSY from 19,000 mt to 58,000 mt and of r from 0.49 to 1.08. Due to the number of restarts to reach convergence (>25) and the probable number of local minima, these results also appeared to be sensitive. Due to the unstable nature of the results, biological reference points for summer flounder estimated by the 1999 ASPIC analysis were considered to be unreliable, and the ASPIC analysis has not been repeated in this assessment.

Virtual Population Analysis and Tuning

Fishing mortality rates in 2001 and stock sizes in 2002 were estimated using the ADAPT method for calibration of the VPA (Parrack 1986, Gavaris 1988, Conser and Powers 1990) as implemented in the NEFSC FACT version 1.50 VPA. As recommended by the MAFMC S&S Committee during the review of the Terceiro (1999) assessment, and by the recent National Research Council review of the summer flounder assessment (NRC 2000), ages 0-6 were included in the analysis as true ages, with ages 7 and older combined as a plus group. An instantaneous natural mortality rate of M = 0.2 was assumed for all ages in all years, as noted earlier. Maturities at age for all years were 38% for age-0, 72% for age-1, 90% for age-2, and 100% for ages 3 and older, as noted earlier. Stock sizes in 2002 were directly estimated for ages 1-6, while the age 7+ group was calculated from Fs estimated in 2001. Fishing mortality on the oldest true age (6) in the years prior to the terminal year was estimated from back-calculated stock sizes for ages 3-6. Fishing mortality on the age 7+ group was assumed equal to the fishing mortality for age 6. Winter, spring, and mid-year (e.g., RIDFW monthly fixed station, DEDFW, and NJBMF) survey indices and all survey recruitment (age-0) indices were compared to population numbers of the same age at the beginning of the same year. Fall survey indices were compared to population numbers one year older at the beginning of the next year. Tuning indices were unweighted.

A number of exploratory VPA runs using different combinations of research survey tuning indices were considered to examine the sensitivity of the summer flounder VPA. The inclusion of each index was considered based on a pre-calibration correlation analysis among all indices, a post-calibration correlation analysis among the indices and resulting VPA estimates of stock size, and an examination of the VPA diagnostics including the partial variance accounted for by each index, patterns in residuals, and the mean squared residual (MSR) of the calibrated solution. Survey indices with trends that did not reasonably match corresponding patterns in abundance as estimated by other indices and/or the VPA, as evidenced by poor correlation, high partial variance in tuning diagnostics, or patterns in residuals, were eliminated from the VPA tuning configuration.

The run chosen as final (run F35_2) includes more indices (n=41) than were used in the 2000 (NEFSC 2000) and 2001 (MAFMC 2001a) assessments (n= 35). The MADMF seine survey recruitment index, MADMF spring survey age 2 index, RIDFW fall survey age 2 and age 3 indices (tuned to ages 3 and 4), the RIDFW fall and monthly fixed station survey age 0 indices, and the DEDFW 16 foot trawl Estuary age 0 indices that were excluded from the previous assessments are included in the current VPA based on consideration of the above analyses and criteria. One index which was included in the last VPA calibration, the RIDFW monthly fixed station survey age 1 index, was excluded this time.

A summary of the input catch and comparison with VPA estimated catch biomass is presented in Table A49. The final 2002 assessment VPA (run F35_2), including input data and assumptions, solution statistics, residuals, and estimates of F at age, stock number, and biomass at age is presented in Table A50.

VPA Estimates of Fishing Mortality Rates

The annual partial recruitment of age-1 fish decreased from near 0.50 during the first half of the VPA time series to less than 0.30 since 1994; the partial recruitment of age-2 fish has decreased from 1.00 in 1993 to 0.78 during 1999-2001 (Table A50). These decreases in partial recruitment at age are in line with expectations given recent changes in commercial and recreational fishery regulations. For these reasons, summer flounder are currently considered to be fully recruited to the fisheries at age 3, and fully recruited fishing mortality is expressed as the unweighted average of fishing mortality at age for ages 3 to 5.

Fishing mortality on fully recruited ages 3-5 summer flounder was high for most of the VPA time series, varying between 0.9 and 2.2 during 1982-1998 (55%-83% exploitation), far in excess of the current overfishing definition, $F_{threshold} = F_{target} = F_{max} = 0.26$ (21% exploitation). The fishing mortality rate has declined substantially since 1998 and was estimated to be 0.27 (22% exploitation) in 2001, marginally above the overfishing definition (Table A50, Figure A10).

VPA Estimates of Stock Abundance

Summer flounder spawn in the late autumn and into early winter (peak spawning on November 1), and age 0 fish recruit to the fishery the autumn after they are spawned. For example, summer flounder spawned in autumn 1987 (from the November 1, 1987 spawning stock biomass) recruit to the fishery in autumn 1988, and appear in VPA tables as age 0 fish in 1988. This assessment indicates that the 1982 and 1983 year classes were the largest of the VPA series, at 74 and 80 million fish, respectively. The 1988 year class was the smallest of the series, at only 13 million fish. The 2000 year class is estimated at 39 million fish, above the 1982-2001 median of 36 million. The 2001 year class is currently estimated to be below average, at 27 million fish (Table A50, Figure A11).

Total stock biomass has increased substantially since 1989, and in 2001 total stock biomass was estimated to be 42,900 mt, the highest since 1983, but still 19% below the current biomass threshold (Table A50, Figure A11). Spawning stock biomass (SSB; Age 0+) declined 72% from 1983 to 1989 (18,800 mt to 5,200 mt), but has increased seven-fold, with improved recruitment and decreased fishing mortality, to 38,200 mt in 2001 (Table A50, Figure A11). In general, the abundance of summer flounder of ages 2 and older has increased substantially since the early 1990s (Figure A12). The age structure of the spawning stock has thus also expanded, with 72% at ages 2 and older, and 14% at ages 5 and older. Under equilibrium conditions at F_{max}, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older (Figure A13). Recent recruitment per unit of SSB has been lower than that observed during the early 1980s (Figure A14).

Precision of VPA Estimates

A bootstrap procedure (Efron 1982) was used to evaluate the precision of the final VPA estimates with respect to random variation in tuning data (survey abundance indices). The procedure does not reflect uncertainty in the catch-at-age data. Five hundred bootstrap iterations were used to generate distributions of the 2001 fishing mortality rate and total stock biomass. Histogram plots of the distribution of the terminal year VPA estimates indicate the amount of uncertainty by visually depicting variability. The cumulative probability can be used to evaluate the risk of making a management decision based on the estimated value. It expresses the probability (chance) that the fishing mortality rate was greater than a given level when measurement errors are considered (e.g., some target fishing mortality rate). For stock biomass, the cumulative plot indicates the probability that it was less than a given level (e.g., some desired minimum stock biomass).

The precision and bias of the 2001 fishing mortality rates, 1 January 2002 stock sizes, 1 November 2001 spawning stock biomass, and 1 January 2001 total stock biomass estimates are presented in Table A51. Bias was less than 5% for all parameters estimated. The bootstrap estimate of the 2001 total stock biomass was relatively precise, with a corrected CV of 7%. The bootstrap mean (43,160 mt) was slightly higher than the VPA point estimate (42,875 mt). The bootstrap results suggest a high probability (>90%) that total stock biomass in 2001 was at least 39,300 mt, reflecting only variability in survey observations (Table A51, Figure A15).

The corrected coefficients of variation for the Fs in 2001 on individual ages were 21% for age 0, 17% for age 1, 15% for age 2, 14% for age 3, 20% for age 4, 28% for age 5, 12% for age 6, and 12% for ages 7 and older. The distribution of bootstrap Fs was not strongly skewed, resulting in the bootstrap mean F for 2001 (0. 2804) being about equal to the point estimate from the VPA (0.2734). There is a 80% chance that F in 2001 was between about 0.24 and 0.32, given variability in survey observations (Table A51, Figure A15).

Retrospective Analysis of VPA

Retrospective analysis of the summer flounder VPA was carried out for terminal catch years 1996-2001. In the retrospective configuration, only the NEFSC surveys and MADMF, RIDFW, and CTDEP fall surveys are included in the calibration of terminal year + 1 stock size estimates, to duplicate the 2002 assessment. Expansion of the catch at age to ages 7 and older caused convergence problems for retrospective VPA configurations in the years 1996-1997. In order to account for the very low stock sizes at ages 5-7+ as indicated by survey indices during 1996-1997, given the estimates of catch at those ages, the VPA estimates unreasonable fishing mortality rates for age 5 in 1996 and ages 5-7+ in 1997 (Table A52, Figure A16). There were no convergence problems for the years 1982-1995, or for the 1998-2001 terminal years.

The retrospective analysis indicates a pattern of underestimation of fully recruited F (ages 3-5) for 1998-2000, following the pattern observed in the last two assessments (NEFSC 2000, MAFMC 2001a). Fishing mortality was underestimated by 31% for 1998, by 45% for 1999, and by 23% for 2000, relative to the current VPA estimates. Spawning stock biomass has been overestimated since 1996, ranging from 5% for 1998 to 23% for 1997. Summer flounder recruitment at age-0 has been underestimated since 1996, ranging from 8% for 1996 to 40% for 1997 (Table A52, Figure A16).

BIOLOGICAL REFERENCE POINTS

The calculation of biological reference points based on yield per recruit for summer flounder using the Thompson and Bell (1934) model was detailed in the 1990 SAW 11 assessment (NEFC 1990). The 1990 analysis estimated $F_{max} = 0.23$. In the 1997 SAW 25 assessment (NEFSC 1997b), an updated yield per recruit analysis reflecting the partial recruitment pattern and mean weights at age for 1995-1996 estimated that $F_{max} = 0.24$. The analysis in the Terceiro (1999) assessment, reflecting partial recruitment and mean weights at age for 1997-1998, estimated that Fmax = 0.263 (Figure A17).

The Overfishing Definition Review Panel (Applegate *et al.* 1998) recommended that the MAFMC base MSY proxy reference points on yield per recruit analysis, and this recommendation was adopted in formulating the current, FMP Amendment 12 reference points (see Introduction), based on the 1999 assessment (Terceiro 1999). The 1999 assessment yield per recruit analysis indicated that $F_{threshold} = F_{target} = F_{max} = 0.263$, yield per recruit (YPR) at F_{max} was 0.55219 kg/recruit, and January 1 biomass per recruit (BPR) at Fmax was 2.8127 kg/recruit. The median number of summer flounder recruits estimated from the 1999 VPA for the 1982-1998 period was 37.844 million fish. Based on this recruitment, maximum sustainable yield (MSY) was estimated to be 20,897 mt (46 million lbs) at a biomass (B_{MSY}) of 106,444 mt (235 million lbs). The biomass threshold, one-half B_{MSY}, was therefore estimated to be 53,222 mt (118 million lbs). Based on the stability of the input data, the SARC concluded that an update of the summer flounder biological reference points was not warranted at this time, and so the Terceiro (1999) estimates have been retained in this assessment.

PROJECTIONS

Stochastic projections were made to provide forecasts of stock size and catches in 2002-2004 consistent with target reference points established in the FMP. The projections assume that recent patterns of discarding will continue over the time span of the projections. Different patterns that could develop in the future due to further trip and bag limits and fishery closures have not been evaluated. The partial recruitment pattern (including discards) used in the projections was estimated as the geometric mean of F at age for 1999-2001, to reflect recent conditions in the fisheries. Mean weights at age were estimated as the geometric means of 1999-2001 values. Separate mean weight at age vectors were developed for the January 1 biomass, landings, and discards.

One hundred projections were made for each of the 500 bootstrapped realizations of 2002 stock sizes from the final 2002 VPA, using algorithms and software described by Brodziak and Rago (MS 1994) as implemented in FACT 1.50. Recruitment during 2002-2004 was generated randomly from a cumulative frequency distribution of VPA recruitment series for 1982-2001 (median recruitment = 35.613 million fish). Other input parameters were as in Table A53; uncertainty in partial recruitment patterns, discard rates, or components other than survey variability was not reflected.

Stochastic projections which assume the adjusted 2002 quota of 10,991 mt will be landed estimate a median (50% probability) F = 0.32 and a median total stock biomass on January 1, 2003 of 57,600 mt, above the current biomass threshold of one-half B_{MSY} = 53,222 mt. (Table A53, Figures A18-A19). There is a 95% probability that the target F for 2002 (i.e., F_{max} = 0.26) will be exceeded. Landings of 10,580 mt and discards of 1,508 mt in 2003 provide a median F = 0.26 and a median total stock biomass level on January 1, 2004 of 65,600 mt (Table A53, Figures A18-A19). Landings of 12,179 mt (26.9 million lbs) and discards of 1,692 mt (3.7 million lbs) in 2004 provide a median F in 2004 = 0.26 (Table A53, Figure A19.)**.**

CONCLUSIONS

<u>Assessment Results</u>

The summer flounder stock is overfished and overfishing is occurring relative to the current biological reference points. The fishing mortality rate has declined from 1.32 in 1994 to 0.27 in 2001 (Figure A10) marginally above the current overfishing definition reference point ($F_{threshold}$ = F_{target} = F_{max} = 0.26; Figure A19). There is an 80% chance that the 2001 F was between 0.24 and 0.32 (Figure A15). The estimate of F for 2001 may understate the actual fishing mortality; retrospective analysis shows that the current assessment method tends to underestimate recent fishing mortality rates (e.g., by about 1/3 over the last three years).

Total stock biomass has increased substantially since 1989, and in 2001 was estimated to be 42,900 mt, 19% below the current biomass threshold (53,200 mt) (Figures A11 & A19). There is an 80% chance that total stock biomass in 2001 was between 39,300 and 46,900 mt (Figure A15). Spawning stock biomass (SSB; Age 0+) declined 72% from 1983 to 1989 (18,800 mt to 5,200 mt), but has increased seven-fold, with improved recruitment and decreased fishing mortality, to 38,200 mt in 2001 (Figure A11). Comparison with previous assessments shows a tendency to slightly overestimate the SSB in recent years. The age structure of the spawning stock has expanded, with 72% at ages 2 and older, and 14% at ages 5 and older (Figure A13). Under equilibrium conditions at F_{max}, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older.

The arithmetic average recruitment from 1982 to 2001 is 40 million fish at age 0, with a median of 36 million fish. The 2000 year class is estimated at 39 million fish. The 2001 year class is currently estimated to be below average, at 27 million fish (Figure A11). It should be noted that retrospective analysis shows that the current assessment method tends to underestimate the abundance of age 0 fish (e.g., by about 20% over the last three years). Recent recruitment per unit of SSB has been lower than that observed during the early 1980s (Figure A14).

Stochastic forecasts only incorporate uncertainty in 2002 stock sizes due to survey variability and assume current discard to landings proportions. If landings in 2002 are 10,991 mt (24.2 million lbs) and discards are 1,700 mt (3.7 million lbs), the forecast estimates a median (50% probability) F in 2002 = 0.32 and a median total stock biomass on January 1, 2003 (equivalent to December 31, 2002) of 57,600 mt, above the biomass threshold of ½ B_{MSY} = 53,200 mt. (Figure A19). Landings of 10,580 mt (23.3 million lbs) and discards of 1,508 mt (3.3 million lbs) in 2003 provide a median

F in 2003 = 0.26 and a median total stock biomass level on January 1, 2004 of 65,600 mt (Table A53, Figures A18-A19). Landings of 12,179 mt (26.9 million lbs) and discards of 1,692 mt (3.7 million lbs) in 2004 provide a median F in 2004 = 0.26 (Table A53, Figure A19.).

During each of the past six years the recreational fishery has exceeded its harvest limit and, for the entire period, exceeded the limit by 58%. During the same period the commercial fishery exceeded its harvest limit by 5%. These excesses result in a fishing mortality that exceeds the target. Given that there is a persistent retrospective underestimation of fishing mortality, managers should consider adopting a lower TAL than that implied by the current overfishing threshold.

SARC COMMENTS

The SARC discussed the procedure for selecting survey indices used in the summer flounder VPA. The use of state surveys, which cover only a small component of the stock, was questioned. It was noted that YOY surveys may be variable due to the low numbers of fish caught per tow. The SARC requested that the standard error also be shown with the survey indices in the future. Whether differences in state surveys truly measure different trends in different components of the stock or whether differences are simply due to variation among surveys was questioned. It was noted that the F on age 2 fish in recent years was higher than the average F for ages 3-5.

The SARC commented on the presence of a retrospective pattern in the VPA. Discussion focused on whether removals were underestimated in either the commercial discard estimates or by an underestimation of the discard mortality rate in the commercial and/or recreational sectors. The SARC concluded that the tendency for F to be underestimated in the retrospective pattern should not be quantitatively adjusted in the assessment but rather stated as a qualitative concern in the management advice.

The SARC discussed whether the use of an assumption of 10% discard mortality for the recreational catch was appropriate. The discard mortality rate may vary spatially, and may not represent longer term mortality associated with capture and release.

The SARC questioned the appropriateness of setting the F target equal to the threshold. Under these circumstances, when the estimate of F is equal to the target, there is a 50% chance that the threshold is exceeded. With the retrospective pattern in this stock the current F is thus likely to be above the target. However the SARC noted that changing the F_{MSY} proxy and threshold was not a term of reference for this meeting. The proxy used for biological reference points will be re-evaluated for all stocks by a formal committee in the near future. The SARC discussed whether new information exists to warrant updating the values of the biological reference points. It was noted that the combined effect of increases in partial recruitment and decreases in the mean weight at ages 0 and 1 in recent years resulted in no change in F_{max}. However, decreases in biomass per recruit combined with a decrease in the median recruitment would decrease the B_{MSY} proxy by 16%. The SARC questioned the decrease in mean weights at age 0 and the appropriateness of using catch mean weights for estimating B_{MSY}. The SARC pointed out that the apparent decrease in catch mean weights at age was likely due to changes in the fishery, and not reflective of real changes in the population since survey mean weights do not show the same decrease. Therefore the SARC concluded that changes in input data to the yield per recruit analysis did not justify a change in the reference points at this time.

The SARC was questioned on how to handle late data such as survey indices which are provided after the working group has met and developed an assessment for SARC review. The SARC agreed that data provided after the working group meeting should not be given special consideration and should be excluded from the assessment. The working group meeting is the appropriate place for anyone to contribute data and suggestions to the assessment, thereby allowing appropriate consideration and review by the SARC.

RESEARCH RECOMMENDATIONS

The SARC made the following recommendations:

1) Expand the NEFSC fishery observer program for summer flounder, with special emphasis on a) comprehensive areal and temporal coverage, b) adequate length and age sampling, and c) continued sampling after commercial fishery areal and seasonal quotas are reached and fisheries are limited or closed, and d) sampling of summer flounder discard in the scallop dredge fishery. Maintaining adequate observer coverage will be especially important in order to monitor a) the effects of implementation of gear and closed/exempted area regulations, both in terms of the response of the stock and the fishermen, b) potential continuing changes in "directivity" in the summer flounder fishery, as a results of changes in stock levels and regulations, and c) discards of summer flounder in the commercial fishery once quota levels have been attained and the summer flounder fishery is closed or restricted by trip limits.

2) Evaluate the amount of observer data needed to reliably estimate discards of summer flounder in all components of the fishery.

3) Conduct further research to better determine the discard mortality rate of recreational and commercial fishery summer flounder discards.

4) Develop a program to annually sample the length and age frequency of summer flounder discards from the recreational fishery.

5) RIDFW monthly fixed station survey length frequencies are currently converted to age using length cut-offs points. Investigate the utility of applying the appropriate NEFSC or MADMF age-length keys to convert the RIDFW monthly fixed station survey lengths to age.

6) Explore the possibility of weighting survey indices used in VPA calibration by the areal coverage (e.g., in square kilometers) of the respective seasonal surveys.

7) Explore the sensitivity of the VPA calibration to the addition of 1 and/or a small constant to values of survey series with “true zeros.”

8) Statistically analyze changes in mean weights at age in the catch and NEFSC surveys. Determine if using mean weights at age in the survey are more appropriate for estimating the B_{MSY} proxy. Explore the sensitivity of the mean weights of the catch and partial recruitment pattern from a longer time series (1997 to 2001) to the re-estimated B_{MSY} proxy.) As the NEFSC fall survey age structure expands, investigate the use of survey mean weights at age for stock weights at age in yield per recruit, VPA, and projection analyses.

9) Monitor changes in life history (growth and maturity) as the stock rebuilds.

10) Evaluate use of a forward calculating age-structured model for comparison with VPA. Forward models would facilitate use of expanding age/sex structure and allow inclusion of historical data. If sex-specific assessments are explored, the implications on YPR should also be investigated.

11) Explore the sensitivity of the VPA results to separating the summer flounder stock into multiple components.

12) Evaluate trends in the regional components of the NEFSC surveys and contrast with the state surveys that potentially index components of the stock.

Major Sources of Assessment Uncertainty

The SARC identified the following major sources of uncertainty in the summer flounder assessment:

1) The landings from the commercial fisheries used in this assessment assume no under reporting of summer flounder landings. Therefore, reported landings from the commercial fisheries should be considered minimal estimates.

2) The recreational fishery landings and discards used in the assessment are estimates developed from the Marine Recreational Fishery Statistics Survey (MRFSS). While the estimates of summer flounder catch are considered to be among the most reliable produced by the MRFSS, they are subject to possible error. The proportional standard error (PSE) of estimates of summer flounder total landings in numbers has averaged 7%, ranging from 26% in 1982 to 3% in 1996, during 1982-2001.

3) The intensity of fishery observer sampling of the commercial scallop dredge fishery (outside of exempted area fisheries) was particularly low in 2001. This level of observer coverage likely was insufficient to accurately characterize summer flounder discards.

4) The length and age composition of the recreational discards are based on data from a limited geographic area (Long Island, New York, 1988-1992; Connecticut, 1997-2001, New York party boats 2000-2001, ALS releases focused in New York and New Jersey, 1999-2001). Sampling of recreational fishery discards on a annual, synoptic basis is needed.

LITERATURE CITED

Almeida, F.P., R.E. Castaneda, R. Jesien, R.C. Greenfield, and J.M.Burnett, 1992. Proceedings of the NEFC/ASMFC Summer Flounder, *Paralichthys dentatus*, Ageing Workshop. NOAA Tech. Memo. NMFS-F/NEC-89. 7p.

Anthony, V. 1982. The calculation of $F_{0.1}$: a plea for standardization. Northwest Atlantic Fisheries Organization, Serial Document SCR 82/VI/64, Halifax, Canada.

Applegate, A., S. Cadrin, J. Hoenig, C. Moore, S. Murawski, and E. Pikitch. 1998. Evaluation of existing overfishing definitions and recommendations for new overfishing definitions to comply with the Sustainable Fisheries Act. Overfishing Definition Review Panel Final Report. 179 p.

Bolz, G., R. Monaghan, K. Lang, R. Gregory, and J. Burnett. 2000. Proceedings of the summer flounder aging workshop, 1-2 February 1999, Woods Hole, MA. NOAA Tech. Memo. NMFS-NE-156. 15 p.

Brodziak, J., and P. Rago. MS 1994. A general approach for short-term Stochastic projections in age-structured fisheries assessment methods. Population Dynamics Branch, Northeast Fisheries Science Center, Woods Hole, MA 02543.

Bugley, K., and G. Shepherd. 1991. Effect of catch-and-release angling on the survival of black sea bass. N. Amer. J. Fish. Mgmt. 11:468-471.

Burns, T.S., R. Schultz, and B.E. Brown. 1983. The commercial catch sampling program in the northeastern United States. In Doubleday, W.G., and D. Rivard [ed.]. 1983. Sampling commercial catches of marine fish and invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 66: 290 p.

Clark, S.H. 1978. Application of bottom-trawl survey data to fish stock assessments. NOAA, NMFS, Woods Hole Laboratory Reference Document No. 78-21. 13 p.

Conser, R.J. and J.E. Powers. 1990. Extension of the ADAPT VPA tuning method designed to facilitate assessment work on tuna and swordfish stocks. Int. Comm. Conserv. Atlantic Tunas, Coll. Vol. Sci. Pap. 32: 461-47.

DeLong, A., K. Sosebee, and S. Cadrin. 1997. Evaluation of vessel logbook data for discard and CPUE estimates. SAW 24 SARC Working Paper Gen 5. 33 p.

Dery, L. M. Summer flounder, *Paralichthys dentatus*. *In:* Almeida, F. P., and T. F. Sheehan, eds. Age determination methods for northwest Atlantic species. http://www.wh.whoi.edu/fbi/age-man.html (February 1997).

Diodati, P.J., and R.A. Richards. 1996. Mortality of striped bass hooked and released in salt water. Trans. Am. Fish. Soc. 125(2):300-307.

Efron, B. 1982. The jackknife, the bootstrap, and other resampling plans. Phila. Soc. for Ind. and Appl. Math. 38.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Canadian Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc. 88/29. 12 p..

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. U.S. 81: 898-902.

IPHC. 1988. Annual Report, 1987. International Pacific Halibut Commission. Seattle, Washington. 51 p.

Jones, W.J., and J. M. Quattro. 1999. Genetic structure of summer flounder (*Paralichthys dentatus*) populations north and south of Cape Hatteras. Marine Biology 133: 129-135.

Lucy, J.A., and T.D. Holton. 1998. Release mortality in Virginia's recreational fishery for summer flounder, *Paralichthys dentatus*. Virginia Marine Resource Report Number 97-8, 48 p.

Lux, F.E., and L.R. Porter. 1966. Length-weight relation of the summer flounder (*Paralichthys dentatus* (Linneaus). U.S. Bureau Comm. Fish., Spec. Sci. Rept. Fish., No. 531, 5 p.

Malchoff, M.H., and J. Lucy. 1998. Short-term hooking mortality of summer flounder in New York and Virginia. Interim report for Cornell Univ/DEC Project MOU 000024, 6 p.

Merson, R.R., M. Terceiro, and J.L. Specker. In review. Length and age at maturity of the summer flounder *Paralichthys dentatus* (L.). J. Fish. Biol.

Merson, R.R., C.S. Casey, B. Soffientino, C. Martinez, M. Chandlee, and J.L. Specker. In Press. Oocyte development in summer flounder (*Paralichthys dentatus*): seasonal changes and steriod correlates. J. Fish. Biol.

Mid-Atlantic Fishery Management Council. (MAFMC). 2001a. SAW Southern Demersal Working Group 2001 Advisory Report: Summer Flounder. 12 p.

Mid-Atlantic Fishery Management Council. (MAFMC). 2001b. SSC Meeting - Overfishing Definition. July 31-August 1, 2001. Baltimore, MD. 10 p.

National Research Council (NRC). 2000. Improving the collection, management, and use of marine fisheries data. National Academy Press, Washington, DC. 222 p.

Northeast Fisheries Center (NEFC). 1990. Report of the Eleventh NEFC Stock Assessment

Workshop Fall 1990. NEFC Ref. Doc. No. 90-09. 121 p.

Northeast Fisheries Science Center (NEFSC). 1993. Report of the 16th Northeast Regional Stock Assessment Workshop (16th SAW). NEFSC Ref. Doc. No. 93-18. 116 p.

Northeast Fisheries Science Center (NEFSC). 1996a. Report of the 20th Northeast Regional Stock Assessment Workshop (20th SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 95-18. 211 p.

Northeast Fisheries Science Center (NEFSC). 1996b. Report of the 22nd Northeast Regional Stock Assessment Workshop (22nd SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 96-13. 242 p.

Northeast Fisheries Science Center (NEFSC). 1997a. Report of the 24th Northeast Regional Stock Assessment Workshop (24th SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 97-12. 291 p.

Northeast Fisheries Science Center (NEFSC). 1997b. Report of the 25th Northeast Regional Stock Assessment Workshop (25th SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 97-14. 143 p.

Northeast Fisheries Science Center (NEFSC). 2000. Report of the 31st Northeast Regional Stock Assessment Workshop (31st SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 00-15. 400 p.

Parrack, M.L. 1986. A method of analyzing catches and abundance indices from a fishery. Int. Comm. Conserv. Atlantic Tunas, Coll. Vol. Sci. Pap. 24: 209-221.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. int. Explor. Mer 42: 116- 124.

Prager, M.H. 1994. A suite of extensions to a non-equilibrium surplus-production model. Fishery Bulletin, U.S. 92:374-389.

Prager, M.H. 1995. Users manual for ASPIC: a stock-production model incorporating covariates. SEFSC Miami Lab. Doc. MIA-92/93-55.

Smith, R.L, L.M. Dery, P.G. Scarlett, and A. Jearld, Jr. 1981. Proceedings of the summer flounder (*Paralichthys dentatus*) age and growth workshop, 20-21 May 1980, Northeast Fisheries Center, Woods Hole, Massachusetts. NOAA Tech. Memo. NMFS- F/NEC-11. 30 p.

Specker, J., R.R. Merson, C. Martinez, and B. Soffientino. 1999. Maturity status of female summer flounder and monkfish. URI/NOAA Cooperative Marine Education and Research Program (CMER) Final Report, Award Number NA67FE0385. 9 p.

Szedlmayer, S.T., and K.W. Able. 1992. Validation studies of daily increment formation for larval and juvenile summer flounder, *Paralichthys dentatus*. Can. J. Fish. Aquat. Sci. 49:1856-1862.

Terceiro, M. 1999. Stock assessment of summer flounder for 1999. Northeast Fisheries Science Center Reference Document 99-19, 178 p.

Thompson, W.F., and F.H. Bell. 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific halibut) Comm. 8: 49 p.

Weber, A.M. MS 1984. Summer flounder in Great South Bay: survival of sublegals caught by hook-and-line and released. New York State Department of Environmental Conservation, Division of Marine Resources. Stony Brook, NY. 27 p.

Wigley, S., M. Terceiro, A. DeLong, and K. Sosebee. 1997. Proration of 1994-96 commercial landings of cod, haddock, and yellowtail flounder. SAW 24 SARC Working Paper Gen4. 32 p.

Wilk, S.J., W. G. Smith, D.E. Ralph and J. Sibunka. 1980. The population structure of summer flounder between New York and Florida based on linear discriminate analysis. Trans. Am. Fish. Soc. 109:265-271.