# A1. SOUTHERN NEW ENGLAND - MID ATLANTIC YELLOWTAIL FLOUNDER

## INTRODUCTION

Yellowtail flounder, *Limanda ferruginea,* inhabit relatively shallow waters (20-100 m) of the northwest Atlantic from Labrador to Chesapeake Bay (Bigelow and Schroeder 1953, Scott and Scott 1988, Collette and Klein-MacPhee 2002). A fishery for yellowtail flounder developed off southern New England in the 1930s, coincident with the increased use of otter trawls, a decline in winter flounder abundance, and demand for food products during World War II (Scott 1954, Royce *et al.* 1959).

The available information on yellowtail flounder stock structure off the northeast U.S. indicates separate stocks on Georges Bank, off Cape Cod, and from southern New England to the Mid-Atlantic Bight. Distributional analyses indicate a relatively continuous distribution from the Mid Atlantic Bight to Nantucket Shoals, a concentration on Georges Bank, and a relatively separate concentration off Cape Cod (Royce *et al.* 1959). Geographic patterns of landings over time suggest that yellowtail resources on Georges Bank on off southern New England are separate harvest stocks (McBride and Brown 1980). Geographic variation indicates that yellowtail off Cape Cod comprise a separate phenotypic stock than resources to the south (Begg et al. 1999). Tagging data indicate less than 3% dispersion from Cape Cod, Georges Bank and southern New England fishing grounds, but substantial movement from the Mid Atlantic to southern New England (Royce et al. 1959, Lux 1963). Descriptive information on early life history stages and circulation patterns suggest that yellowtail spawn in hydrographic retention areas, but there may be some advection of eggs and larvae from Georges Bank and Cape Cod to southern New England and the Mid Atlantic Bight (Sinclair 1988). In conclusion, yellowtail flounder on Georges Bank appear to be a separate harvest stock, yellowtail off Cape Cod can be considered a separate phenotypic stock (with some question on the northern boundary of the stock area), but there is little evidence supporting separate stocks in southern New England and the Mid Atlantic Bight.

<u>Management History</u>
From 1950 to 1977, the International Commission for the Northwest Atlantic Fisheries managed yellowtail flounder resources in southern New England, Georges Bank and the Gulf of Maine (i.e., in ICNAF subarea 5). Gear restrictions and total allowable catch were the primary management strategies of ICNAF, but minimum fish size, fishing effort and closed area and season regulations were also regulated. Minimum trawl mesh size was 114 mm in the 1950s and 1960s. National catch quotas were implemented for southern New England yellowtail flounder from 1971 to 1976, but these were exceeded in most years.

Following the implementation of the Magnuson Fisheries Conservation and Management Act (FCMA) in 1976, U.S. yellowtail resources have been managed by the New England Fisheries Management Council (Table A1.1). Groundfish regulations included minimum cod end mesh size, minimum fish size, seasonal area closures, mandatory reporting, trip limits and annual quotas. Minimum size for yellowtail was increased from 28cm in 1982 to 30cm in 1986 and 33cm in 1989. Minimum mesh size increased from 140 mm in 1991 (diamond and square mesh) to 140mm diamond-152mm square in 1994 and to 165mm in 1999. A large area south of Nantucket Shoals was closed to fishing since December 1994. Scallop dredge vessels were limited to possession of 136kg of yellowtail flounder since 1996, and in 1999 minimum twine top mesh was increased from 203mm to 254mm to reduce yellowtail bycatch.

Assessment History

The first quantitative stock assessment of yellowtail flounder was on the southern New England - Mid Atlantic resource and fishery. Royce et al. (1959) evaluated landings, length and age composition, effort, and tagging data to conclude that fishing mortality was approximately 0.30 in the 1940s. However, retrospective estimates of F during the 1940s were substantially greater (approximately 0.6, Lux 1969). Lux (1964) concluded that the stock was not overfished during the 1950s, but age-based mortality estimates for the 1960s were high (Lux 1967[1], 1969).

Subsequent assessments of yellowtail flounder in the southern New England area excluded Mid-Atlantic catch and survey data, but indicated increasing F and declining stock size in the late 1960s (Brown and Hennemuth 1971a, 1971b; Pentilla and Brown 1973). Starting in 1974, Mid Atlantic and southern New England yellowtail resources were treated as separate assessment and management units, but analyses for each area indicated high mortality and low stock size in the 1970s (Parrack 1974, Sissenwine et al. 1978, McBride and Sissenwine 1979, McBride et al. 1980, Clark et al. 1981). In the early 1980s, there was indication of strong recruitment of yellowtail from surveys and commercial catches in both southern New England and Mid Atlantic areas, but discard rates were high and F exceeded $F_{max}$ in southern New England (McBride and Clark 1983, Clark et al. 1984, NEFC 1986).

Assessment methods used for southern New England yellowtail progressed to a calibrated VPA in the late 1980s. The 1988 assessment indicated high F in the 1970s and early 1980s and a strong 1980 cohort (F=0.60-1.48; NEFC 1989). Later stock assessments showed another dominant cohort spawned in 1987, but F continually increased through the 1980s, and the stock was depleted to record low biomass in the early 1990s (Conser et al. 1991, Rago et al. 1994). The VPA-based assessment of southern New England yellowtail was updated annually from 1997 to 1999, and assessments indicated a reduction in F in the late 1990s, but little rebuilding of stock biomass (NEFSC 1997, 1998; Cadrin 2000). In 2000, an updated VPA was attempted, but was rejected as a basis for management advice because sampling in 1999 was inadequate to estimate catch at age reliably (Cadrin 2001b). Therefore, recent assessments of southern New England yellowtail have been based on projections of observed catch from the 1999 VPA (Cadrin 2001b, NEFSC 2002). An updated assessment of the southern New England yellowtail flounder stock was prepared

[1] Although Lux (1967) is titled, "Landings per unit effort, age composition and total mortality of yellowtail flounder (*Limanda ferruginea*) in subarea 5Z," the southern New England analyses also include catch and effort data from statistical area 6.

concurrently with this assessment for the Groundfish Assessment Review Meeting (Cadrin 2002b).

An analytical assessment of Mid Atlantic yellowtail flounder has not been developed, and management advice has been based on descriptive summaries of landings and survey data. Assessments of the Mid Atlantic yellowtail resource indicated similar trends in catch and survey indices as in southern New England (NEFC 1987, 1988; NEFSC 1991, 1992, 1993; Rago 1995; Overholtz and Cadrin 1998). Based on survey biomass and exploitation ratios, the Mid Atlantic yellowtail resource was 2% of the $B_{MSY}$ proxy, and the exploitation rate greatly exceeded the $F_{MSY}$ proxy (Cadrin 2001a). An updated assessment of the Mid Atlantic yellowtail flounder stock was prepared concurrently with this assessment for the Groundfish Assessment Review Meeting (Cadrin 2002a).

## FISHERY DATA

Commercial Landings

Commercial statistics for southern New England yellowtail flounder are from statistical areas 526, 537, 538, and 539, and mid Atlantic yellowtail are from statistical areas 611-623 (Figure A1.1). U.S. commercial landings of yellowtail flounder were derived from dealer weighout reports and canvas data according to historical assessment reports (Royce et al. 1959, Brown and Hennemuth 1971, Sissenwine et al. 1978, McBride et al. 1980, McBride and Clark 1983, NEFC 1986, McBride 1989, Rago et al. 1994). Total Mid Atlantic landings from canvas data were allocated to market category according to annual proportions in the weighout database. Previous to 1994, landings were allocated to statistical area, month, and gear type according to interview data collected by port agents (Burns et al. 1983). For 1994, landings reported by dealers were allocated to stock area using fishing vessel logbook data, by fishing gear, port, and season (Wigley, et al. 1998). For 1995-1997, dealers' reported landings were prorated to stock area using a modified proration that included dealer codes (NEFSC 1998).

Landings generally increased in southern New England during the 1930s and early 1940s and the fishery expanded to the Mid Atlantic in the early 1940s, with landings of 28,000mt in 1942 (Table A1.2, Figure A1.2). Annual landings were around 10,000mt from 1943 to 1948 with approximately 10% from the Mid Atlantic. A domestic industrial fishery developed in the late 1940s. Landings decreased to less than 2,000mt in the mid 1950s. Landings increased in southern New England in the late 1950s and again expanded to the Mid Atlantic in the 1960s. A distant water fishery developed in the 1960s and total annual landings were greater than 20,000mt from 1963 to 1970. The industrial and foreign fisheries were discontinued in the early 1970s. Landings generally decreased since the 1970s, with temporary increases in the early 1980s and early 1990s. Landings in 1995 were a record low 200 mt, and the proportion of landings from the Mid Atlantic generally increased from approximately 10% in the early 1990s to greater than 20% (e.g., in 1997, 70% of landings in the stock area came from the Mid Atlantic). Landings slightly increased to greater than 1,000mt per year since 1999.

A summary of port samples (each consisting of approximately 100 lengths and 1 age sample per cm) are listed in Table A1.3. Landings at age were derived by geographic region, half-year and market category, when possible. Landings at age of southern New England yellowtail flounder are described in previous assessment documents (Conser et al. 1991; Rago et al. 1994; NEFSC 1997, 1998; Cadrin 2000; Cadrin 2002b). Mid Atlantic landings were not sampled in several half-year periods, and age distributions of southern New England landings were assumed for Mid Atlantic landings in those periods by quarter and market category (2nd half of 1975, 2nd half of 1981, 2nd half of 1986, 2nd half of 1987, 2nd half of 1988, 1st half of 1989, 2nd half of 1990), or by half and market category for 2000 and 2001. Landings at age and landed mean weights at age are reported in Table A1.4. In the early 1970s a substantial portion of landings were from older fish (e.g., 17% of 1973 landings were age-6 or older), but the age distribution of landings rapidly truncated, and the portion of age 6+ fish has generally been less than 3% since 1977.

Discarded Catch

Estimates of discards for the southern New England – Mid Atlantic yellowtail fishery for 1963-1969 were derived from interviews with vessel captains; historical discards were approximated by Brown and Hennemuth (1971a) from the 1963-1969 average discard rate (Table A1.5). Discards for 1970-1977 were also based on interview data, however yellowtail interview data were suspect from 1978 to 1982 when trip limits were imposed (McBride et al. 1980, Clark et al. 1981). Discards during 1978-1982 were estimated from observer data when available (Sissenwine et al. 1978), derived directly from field selectivity studies (McBride et al. 1980), or from application of selectivity estimates to survey size frequencies (McBride and Clark 1983). Discards for 1983 were from interview data (Clark et al. 1984). Discards at age from southern New England, 1984-1993 were from a combination of sea sampling, interviews and survey data (Conser et al. 1991, Rago et al. 1994). Discards for 1994-2001 were derived from vessel logbooks (NEFSC 1997, 1998; Cadrin 2000). Updated discard estimates for southern New England are listed in Table A1.5a. Discards of Mid Atlantic yellowtail were from interview data for 1984-1993. Mid Atlantic discards for 1994-2001 were derived from logbook data by gear for all trips that reported discards of any species (NEFSC 1998, Table A1.5b).

Discarded catch accounted for an average of 30% of total catch annually, but appears to have decreased to approximately 10% since 1995. In 1969, discards peaked at 24,000mt, 40% of the total catch that year. A substantial portion of recent discards are from the scallop dredge fishery.

Discards at age were estimated from observer lengths (Table A1.3) and survey ages 1994-2001. Discards at age of southern New England yellowtail flounder are described in previous assessment documents (Conser et al. 1991; Rago et al. 1994; NEFSC 1997, 1998; Cadrin 2000; Cadrin 2002b). Age distribution of discards in southern New England were assumed for Mid Atlantic discards for 1973 to 1993 (Table A1.6). Discards were primarily ages 1 and 2 during from the 1970s through the early 1990s, but shifted to age 2 and 3 in the early 1990s, coincident with regulated mesh size increases.

Estimates of total catch at age reflect the landings at age in that they indicate a relatively wide age distribution in the catch in the early 1970s (e.g., approximately 10% of the catch was age-6 or older from 1973 to 1975; Figure A1.3, Appendix A). Subsequent catch at age was dominated by the 1980 and 1987 cohorts, but few fish older than age-6 contributed to the catch. Mean weights at age of older fish (age 4+) generally increased in the mid 1970s, were relatively light during the mid 1980s, and generally increased in recent years (Figure A1.4). Mean weight of age-1 yellowtail generally decreased in the 1990s, presumably from discards of small yellowtail in the scallop fishery.

## ABUNDANCE AND BIOMASS INDICES

Stock Abundance and Biomass Indices

The NEFSC spring and autumn bottom trawl surveys have sampled offshore strata since 1963 and 1968, respectively (Despres et al. 1988). However, the southern–most offshore strata (61-76) were not sampled until 1967. Therefore southern strata were included in the spring survey index, 1968-2002 and the winter survey index 1992-2002 (strata 1, 2, 5, 6, 9, 10, 69, 73, 74; Figure A1.5), but excluded from the fall survey index, 1963-2001 (strata 1, 2, 5, 6, 9, 10). Nearly all yellowtail caught by the survey in the southern New England – Mid Atlantic stock area (99%) are in the spring and winter strata sets. The strata set for the NEFSC scallop survey was determined as all strata that were consistently sampled in the stock area (14, 15, 18, 19, 22-28, 30, 31, 33, 35, and 46).

Indices of abundance and biomass indicate relatively high stock size in the 1960s and early 1970s, followed by a rapid decrease in the mid 1970s (Table A1.6, Figure A1.6). Stock biomass increased temporarily in the early and late 1980s with the recruitment of the strong 1980 and 1987 cohorts. Recent distributions of yellowtail catches in surveys are illustrated in Figure A1.7. The average portion of yellowtail biomass in the Mid Atlantic region has been 45% of the total southern New England – Mid Atlantic yellowtail biomass (Figure A1.8). Age distribution of yellowtail in surveys indicates abundant cohorts in the 1960s and early 1970s, strong year classes in 1980 and 1987, and relatively truncated age structure since the early 1970s (Table A1.7, Figure A1.9).

Correspondence among survey indices was assessed using correlations among normalized observations for the VPA time series 1973-2001 [Ln(x/mean); Table A1.8]. Normalized indices of catch per tow at age are illustrated in Figure A1.10. Correlations among survey series were generally low for the winter survey, particularly for older ages, presumably because it is a short series with little contrast. Correlations between spring and fall survey series were strongest at ages 2-4 (r=0.71-0.82).

## MORTALITY AND STOCK SIZE

Virtual Population Analysis

Abundance estimates from virtual population analysis of catch at age of age-1 to age-7+, 1973-2001, were calibrated using an ADAPT algorithm (Gavaris 1988) that estimated age 2-5 survivors in 2002 and survey catchability coefficients (*q*) using nonlinear least squares of survey observation errors. Abundance at age was calibrated with survey indices of abundance: spring survey indices (age-1 to age-7+) and winter indices (age-1 to age-5) were calibrated to January abundance, and fall survey indices (age-1 to age-7+) were calibrated to mean abundance. The instantaneous rate of natural mortality (M) was assumed to be 0.2 based on tag returns (Lux 1969), relationships of Z to effort (Brown and Hennemuth 1971a), and the oldest individual sampled in the stock area (age-14). Although catches of yellowtail older than age-8 are rare in commercial or research catches, the stock has been heavily exploited for seven decades. Maturity at age for southern New England yellowtail flounder was reported by O'Brien et al. (1993) from 1985-1990 NEFSC spring survey samples. Model Residuals are plotted in Figure A1.11.

Results show that the stock was abundant in the early 1970s with a relatively wide age structure (11% of the population in 1973 was age 6 or older), but was quickly truncated by the late 1970s (<2% age 6+ from 1978 to 2001; Table A1.9, Figure A1.12c). Fishing mortality generally increase in the 1970s and 1980s to a peak of 2.3 in 1991 and 1992, averaged 1.6 during the 1990s, and appears to have decreased to 0.68 in 2000 and increased to 0.91 in 2001 (Figure A1.12a). Recruitment was generally strong in the 1970s and moderate during the 1980s, with two exceptional year classes in 1980 and 1987. Recruitment has been low during the 1990s. Spawning biomass was high in the early 1970s, decreased in the late 1970s, and increased briefly in the early and late 1980s with recruitment of the 1980 and 1987 cohorts. Spawning biomass decreased to a record low 622mt in 1994, gradually increased to 2,100mt in 2000, and decreased to 1,900mt in 2001. Retrospective analysis indicates a strong pattern of underestimating F, and overestimating SSB in recent years (Figure A1.13).

Biomass Dynamics

Given the problems in estimating recent catch at age in the southern New England area (Cadrin 2000) an age-aggregated production model (ASPIC, Prager 1994) was fit to total catch and survey biomass indices. Initial trials did not fit the winter survey biomass series, presumably because it is relatively short and does not have much contrast, nor did the model fit the catch rate data from Lux (1969). Alternative analyses that assumed that stock biomass was at the carrying capacity in 1935 had very similar results.

Results of the biomass dynamics model indicate that biomass decreased during the 1960s and early 1970s to about 10% of the biomass estimated for the early 1960s (Figure A1.14). Similar to the age-based analysis, the biomass dynamics model indicates brief periods of rebuilding in the early and late 1980s and a further decrease to extremely low biomass in the mid 1990s. However, the biomass dynamics model indicates a slightly faster rate of rebuilding in recent years than indicated by the age-based analysis.

Biological Reference Points

Yield and biomass per recruit were calculated assuming the observed partial recruitment and mean weight at age for 1994-2001 (Thompson and Bell 1934). Results are reported in Table A1.10 and illustrated in Figure A1.15. Applying the approach used to estimate MSY proxies for southern New England yellowtail (NEFSC 2002), $F_{MSY}$ is approximated as $F_{40\%}$ (0.26). The $SSB_{MSY}$ proxy is 69,500mt, calculated as the product of 40%MSP (1.129 kg spawning biomass) and average long-term recruitment (61.57 million). The average long-term recruitment was derived as the fall survey age-1 index divided by the catchability coefficient estimated by ADAPT (8.08E-5). The MSY proxy is 14,200mt, derived as the product of yield per recruit at $F_{40\%}$ (0.230 kg) and average recruitment.

Alternatively, $SSB_{MSY}$ and MSY were estimated using stochastic long-term projections assuming recent average weights at age and partial recruitment (1994-2001), and the distribution of long term recruitment. Results suggest that at an F of 0.26, the long-term average catch is 13,100mt, and long-term average SSB is 64,500mt (Figure A1.16) .

For comparison, the estimate of $B_{MSY}$ from biomass dynamics analysis is 104,700mt of total biomass, $F_{MSY}$ is 0.19 on total biomass, and MSY is 20,300mt. The Working Group accepted the deterministic estimates of MSY reference points based on consistency with estimates for other groundfish stocks (NEFSC 2002): $F_{MSY}$=0.26, $SSB_{MSY}$= 69,500mt and MSY=14,200mt.

Projections

Stochastic age-based projections that assume a 15% reduction in F from 2001 to 2002 and recruitment similar to that experienced in the last decade suggest that the stock cannot rebuild to $B_{MSY}$ by 2009 even if F in 2003-2010 is zero. If the same hindcast recruitment values used to derive the reference points are assumed for projections, there stock is expected to have approximately a 50% chance of rebuilding to $SSB_{MSY}$ by 2009 with an F of 0.08 (Figure A1.17, Appendix A). However, long-term recruitment levels are not likely in the short-term, because SSB is extremely low, and retrospective patterns indicate that projections may be overly optimistic. For comparison, stochastic projections from the biomass dynamics model at status quo F in 2002 and F=0 for 2003-2009 indicate a 25% probability of rebuilding to the ASPIC estimate of $B_{MSY}$ by 2009 (Appendix B).

## WORKSHOP DISCUSSION

Working Group Discussion

*Stock Structure* - The WG reviewed seven working papers/presentations on yellowtail stock structure. With respect to spatiotemporal patterns of abundance, the WG noted that recruitment trends of Cape Cod and southern New England yellowtail indicated possible autocorrelation, as evidenced by a common series of several years of poor recruitment that might be indicative of a common stock. The WG noted that historical tagging data indicate weak movement between the Cape Cod, Georges Bank, and other areas, but strong mixing between Mid Atlantic and southern New England areas, that might be indicative of a common Mid Atlantic-southern New England stock. The WG also noted that the fish from the Mid Atlantic and southern New England have concurrent spawning seasons, comparable lengths of 50% Maturity, and similar growth rates, and that detailed distribution plots indicated that most of the Mid Atlantic fish are found in areas closest to the boundary with the Southern New England stock (i.e., area 613). The WG noted that the Mid Atlantic and Southern New England areas were grouped together prior to the early 1970s, when they were separated to conform with ICNAF reporting conventions. The WG noted limited evidence in the literature to separate Gulf of Maine fish from the Cape Cod stock. The WG supported the major conclusion of working paper A1 that information available from the literature indicates separate yellowtail flounder stocks on Georges Bank, off Cape Cod, and in the Southern New England-Mid Atlantic Bight area.

The WG noted that NEFSC survey stratum 13 (southwestern Georges Bank) appears to be an Aoverlap@ or Atransition@ zone, with peaks in abundance over time that are characteristic of both the Georges Bank and southern New England stocks, and may be inhabited by fish from both stocks during times of abundance. The WG noted that a similar situation may exist in NEFSC stratum 10, adjacent to the Great South Channel. The WG supported the conclusions of working paper A2 that 1) there are two major groups of NEFSC survey strata based on patterns of abundance over time, with a boundary on southwestern Georges Bank, and 2) the current analyses confirm earlier conclusions of separate Aharvest stocks@ on Georges Bank and off southern New England. A correlation analysis of survey and catch data by management area generally confirmed the multivariate analysis by stratum. Survey indices and landings were strongly correlated between southern New England and the mid-Atlantic, not correlated between southern New England and Cape Cod or southern New England and Georges Bank, and moderately correlated between Georges Bank and Cape Cod.

The WG noted that previous investigators (e.g., Lux 1963) found no significant differences in meristics (e.g., fin and ray counts) among U.S. stocks, supporting the current morphometric work. The WG also noted that the results of the morphometric work coincides with the differences in growth noted between U.S. and Newfoundland stocks. The WG supported the working paper A4 conclusion that morphometric variation among U.S. yellowtail flounder groups is not sufficient for accurate classification to stock area.

The WG noted that the number of migrants per generation between the yellowtail stock areas, although probably low, is likely sufficient to prevent detection of significant genetic differences using RAPD-PCR. The WG noted that the expression of phenotypic differences may not be evident in the genome, or Mid Atlantic be very difficult to detect (many different primers may have to be tested to find one that isolates the gene responsible for a given phenotypic expression). The WG supported the conclusion of presentation A6 that, at this time, yellowtail flounder stock differentiation must be based on factors other than genetics.

The WG noted that historical stock area determinations included the mid Atlantic area as a part of the southern New England stock (e.g., Royce et al. 1959, Lux 1969) . Mid

Atlantic landings were excluded from assessments of AICNAF Area 5" yellowtail beginning in the early 1970s (e.g., Brown and Hennemuth 1971), apparently to conform to ICNAF jurisdictions and to respond to the concerns of Mid Atlantic fishermen of being subject to the ICNAF regulatory regime. The Mid Atlantic resource was assessed as a separate stock beginning in the mid 1970s/early 1980s (e.g., Parrack 1974, McBride and Brown 1980).

The current work reviewed by the WG indicates a single homogeneous genetic stock of yellowtail flounder on U.S. fishing grounds. Patterns over time in landings and survey indices suggest two harvest stocks with a boundary between Georges Bank and Southern New England. Differences in life history characteristics suggest two phenotypic stocks with a boundary off Cape Cod. The WG noted that the most important potential Amisalignments@ with respect to current or proposed stock definitions are in areas 521, 525, and 526 (and associated NEFSC survey strata 10, 13 and 25), where fish from adjacent stocks may overlap during times of abundance. However, the WG found no strong evidence in patterns of fishery landings, survey abundance indices, or life history parameters to suggest that revision of the current assignment to stock areas of these particular statistical areas or survey strata is appropriate. The WG concluded that current evidence indicates that three stock areas are appropriate for yellowtail flounder: 1) a Georges Bank stock including fish landed from NEFSC statistical areas 522, 525, 551-552, and 561-562, and associated NEFSC survey strata (i.e., the current stock definition used in U.S. and Canadian assessments), 2) a southern New England – Mid Atlantic stock including fish landed from areas 526, 533-539, 541, and 611-639, and associated NEFSC survey strata, and 3) a Cape Cod – Gulf of Maine stock including fish landed from areas 511-521, and associated NEFSC survey strata. Finally, the WG recommends that assessment scientists explore the potential to classify yellowtail in fishery and survey samples to stock in the Aoverlap/transition@ areas based on age structure characteristics.

Stock Assessment

The Working Group discussed the quality of historical canvas data and questioned if historical catch may be underreported in the Mid Atlantic region or misallocated from the Mid Atlantic to the southern New England region.

The Group examined three criteria for choosing indices of abundance for the VPA calibration: correlation with other indices, partial variance in an initial calibration that included all indices, and residual patterns. During the time series of the winter survey, 1992-2002, few age 6 and 7+ yellowtail were caught and those two indices accounted for a disproportionately large portion of the total model variance. The Working Group excluded those two indices from the calibration, because they were adding noise to the calibration. However, it was noted that the survey is designed to catch flatfish, and the indices may become useful as age structure rebuilds.

The Working Group discussed the recruitment assumptions for projections. Previous studies found significant effects of temperature on survival ratios, but the reference point working group (NEFSC 2002) found no trend in temperatures for the last decade which would suggest a reason why recruitment has been extremely low since 1987. The Group noted that the ASPIC model was more optimistic than the VPA in terms of current status, but was not optimistic in terms of projections. ASPIC projections indicate that biomass does not rebuild to Bmsy in 2009 at F=0. By comparison, age-based projections do not rebuild to target in 2009 at F= 0 unless the whole time series of recruitment values, including the hind-cast estimates are used.

The Working Group adopted the approach of the Reference Point Working Group (NEFSC 2002) for estimating MSY reference point proxies. The Group also noted that mean weights at age seem to show density dependence. Therefore, weights may decrease as the stock rebuilds. The Group also decided to account for sampling problems in recent years by averaging mean weights and partial recruitment from as many years as possible (1994-2001) to represent the current fishery in reference point calculations and projections.

## SARC DISCUSSION

The poor sampling of commercial landings in 1999 for the entire area was considered. While there is a systematic problem in collecting a biological sample without knowledge of the statistical area from which it came (e.g. the area fished is acquired from the VTR and not from an interview with the captain at the time of landing), in this situation the lack of samples is due to the 'hit-or-miss' nature of sampling low-volume landings (in 1999 the MA landings were just 240 mt). Throughout the entire time period (1973-2001) 15% of the MA cells did not have samples and SNE samples were used to characterize the catch at age. As SNE samples were applied to MA landings in some years, the SARC suggested evaluating the impact of pooling areas using years where adequate samples exist for both areas.

The SARC noted that the discard ratio used to estimate yellowtail flounder discards in the scallop fishery may not be suitable. As the scallop fishery has had trip limit regulations, the discard/kept ratio may not be as appropriate as an effort-based ratio. However, an effort-based ratio, if applied resource-wide, would overestimate discards in areas where scallop effort and yellowtail distribution do not overlap. It was suggested that an effort-based ratio be applied in the MA area, where scallop effort and yellowtail flounder distributions overlap, and a discard/kept ratio in the SNE area, where these distributions do not overlap as much.

The SARC commented on the declining mean weights at age in the commercial catch in recent years. Mean weights at age from the NEFSC survey would be informative in confirming the commercial trends observed.

The spatial coverage of the NEFSC autumn survey was not consistent over the entire time series; from 1963 to 1967 the southernmost strata used to assess the stock were not sampled. Although the restricted spatial coverage will not impact the VPA because the VPA begins in 1973, other analyses, such as hindcast estimates of recruitment and ASPIC, may be impacted. The SARC evaluated the NEFSC autumn survey indices (with and without strata 69, 73 and 74) and concluded that the trend and magnitude were similar between the two series. The SARC accepted the analyses conducted with the spatially restricted series to gain the benefits of the longer time series.

The SARC discussed the VPA retrospective analysis, which revealed a consistent pattern of underestimating F and overestimating SSB since 1995. It was agreed that the retrospective pattern was a key element to the stock assessment results and that this information should be included in the management advice because the direction of the retrospective pattern changes perspective of stock biomass and fishing mortality from year to year. However, the overfished and overfishing status is not affected by the retrospective bias.

The SARC felt that the YPR-SPR approach was appropriate for estimating biological reference points for this stock. The discussion focused on establishing the most appropriate time series of recruitment. The SARC reviewed $SSB_{MSY}$ and MSY estimates derived from four possible recruitment time series: 1) long-term (1963-2001) average; 2) VPA time-series (1973-2001) average; 3) last ten years (1992-2001) VPA average; and 4) pre-VPA hindcast (1963-1972) average. The average recruitment from the four time series ranged between 6.4 million (last ten years) and 193 million (pre-VPA hindcast) and caused a wide range in the point estimates of $SSB_{MSY}$ and MSY (Figure A1.18). Given the lack of evidence of an ecological regime shift, the SARC concluded that the most credible recruitment time series was the long-term (1963-2001) series. It was also concluded that a range of biological reference points would be useful in providing boundaries about the most credible estimate.

The SARC reviewed a stock-recruitment trajectory plot where estimates from the VPA and the hindcast analysis were represented. It was noted that what appeared to be two outliers in the VPA series would not be considered outliers when the hindcast recruitment estimates were included.

Sources of Uncertainty

- Although sampling improved in 2000 and 2001, estimates of previous catch at age (particularly 1999) may be imprecise due to poor sampling intensity. Therefore, VPA- and age-based projections may also be imprecise. Retrospective patterns may indicate inadequate sampling and misallocation of catch at age.
- Retrospective patterns indicate that VPA estimates of biomass and F are likely to be optimistic. Future VPAs may indicate a lower level of SSB and a higher F for 2001 than reported here.
- Estimates of landings and discard ratios since 1994 are based on preliminary logbook data applied on a pro rata basis, and are subject to change.

Research Recommendations

- Explore the use of effort-based and discard/kept ratios for the scallop fisheries
- Analyze the impacts of applying SNE samples to MA landings for years where adequate samples exists for both areas.
- Consider using a forward projection model that allows for error in catch at age, because of

the extremely poor sampling in 1999 and more flexible assumptions about selectivity.

- o Investigate changes in maturity at age over time.
- o Examine mean weights at age from surveys to confirm trends observed in the commercial mean weights.
- o Incorporate data from the entire stock area for the fall survey calibration index.
- o Improve sea sampling coverage for otter trawl and scallop vessels to allow for better estimation of discards.
- o Increase the sampling frequency of SNE-MA yellowtail flounder during the bottom trawl surveys.
- o Collect adequate numbers of quarterly commercial samples for length and age composition.

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