The summer flounder chronicles: Science, politics, and litigation, 1975–2000

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Abstract

The summer flounder, or fluke (*Paralichthys dentatus*) supports the most important commercial and recreational flatfish fisheries of the U.S. Atlantic coast. The stock and fishery range from Massachusetts to North Carolina. Spawning takes place during a protracted season that can extend from September to March, during an annual offshore and southern migration to the outer continental shelf off Virginia and North Carolina. The fish are con-

centrated in bays and estuaries from late spring through early autumn, when the next offshore migration begins. The assessment and management of the summer flounder fishery has been very contentious since the implementation of the joint Atlantic States Marine Fisheries Commission/Mid-Atlantic Fishery Management Council Fishery Management Plan (FMP) in 1989, when the poor status of the summer flounder stock was evident to scientists, managers, and fishermen. Amendment 2 to the FMP, approved in 1992, implemented several major regulatory provisions including annual commercial quotas and recreational harvest limits, and annually adjustable minimum landed fish sizes, minimum mesh sizes, possession limits, and seasonal closures. By 1999, fishing mortality on summer flounder had declined to its lowest level since the 1960s, and summer flounder total stock biomass was the highest since the mid-1970s. Monitoring of stock status is ongoing to reliably determine "how much fish is enough" to provide for long-term sustainability. Many changes are made annually to management measures due to differing interpretations of stock status by managers, and fishery and environmental advocacy groups. Attainment of the annual fishing mortality targets remains elusive. The multiple layers of science, management, and politics in place since 1992 continue to spark much controversy and litigation that increasingly places the management of the summer flounder fishery in the hands of the courts.

Introduction

The summer flounder, or fluke (*Paralichthys dentatus*) supports the most important commercial and recreational flatfish fisheries of the U.S. Atlantic coast. The stock and fishery range from Massachusetts to North Carolina. Small scale, coastal fishing by trawlers and pound nets during May to November has occurred in the Mid-Atlantic region since at least 1880 (Hildebrand and Schroeder, 1928; Neville et al., 1939). Large scale, offshore commercial exploitation of summer flounder began around 1920, when trawlers from New Jersey initiated exploratory winter fishing off the coasts of Virginia and North Carolina (Pearson, 1932). The fishery expanded during the 1920s and 1930s, with about 50 large trawlers participating in the offshore winter trawl fishery by 1935 (Eldridge, 1962). By 1940, commercial landings of summer flounder had reached 4,900 mt (10.8 million lb), and landings were consistently between 9,000 to 10,000 mt (20.0 to 22.0 million lb) during 1952 to 1961 (Table 1). Even today, under regulations that limit the annual commercial landings to about 5,000 mt (11.0 million lb), summer flounder is the most important commercial flatfish species, in terms of weight and value landed, in the southern New England and Mid-Atlantic regions (NOAA, 2000).

Summer flounder have historically been highly sought by sport fishermen, especially in New York and New Jersey waters. The 1965 and 1970 Salt-Water Angling Surveys (Deuel and Clark, 1968; Deuel, 1973) indicated that summer flounder was the second most frequently caught flatfish by anglers in the New England and Mid-Atlantic regions, trailing only winter flounder. The catch of winter flounder has declined greatly since the 1970s, and today summer flounder is by far the most frequently recreationally caught flatfish (USDOC, 2000).

The assessment and management of the summer flounder fishery has been very contentious since the implementation of the joint Atlantic States Marine Fisheries Commission (ASMFC)/Mid-Atlantic Fishery Management Council (MAFMC) Fishery Management Plan (FMP) in 1989. This paper briefly describes the stock and fisheries, and then provides a chronological review of the sequence of stock assessments, the FMP and subsequent Amendments, and the series of lawsuits filed by various user and advocacy groups that together constitute the recent history of the assessment and management of the summer flounder fishery. These events are considered in the context of the long-term rebuilding targets for biomass, age structure, and fishing mortality.

Distribution, biology, and stock structure

Summer flounder are distributed along the U.S. Atlantic coast, primarily from Massachusetts to North Carolina. Spawning takes place during a protracted season that can extend from September to March, during an annual offshore and southern migration to the outer continental shelf off Virginia and North Carolina (Figures 1–3). Peak spawning occurs in October and November (O'Brien et al., 1993). Newly hatched larvae are transported to coastal areas by prevailing water currents. Development of post-larvae and demersal juveniles occurs primarily within bays

Table 1. Summer Flounder Commercial Landings by State (thousands of lb) and coastwide (thousands of pounds [>000 lb], metric tons [mt])

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD+	VA+	NC+	Total '000 lb	mt
1940	0	0	2847	258	149	1814	3554	3	444	1247	498	10814	4905
1941	na	na	na	na	na	na	na	na	183	764	na	947	430
1942	0	0	193	235	126	1286	987	2	143	475	498	3945	1789
1943	0	0	122	202	220	1607	2224	11	143	475	498	5502	2496
1944	0	0	719	414	437	2151	3159	8	197	2629	498	10212	4632
1945	0	0	1730	467	270	3182	3102	2	460	1652	1204	12297	5578
1946	0	0	1579	625	478	3494	3310	22	704	2889	1204	14305	6489
1947	0	0	1467	333	813	2695	2302	46	532	1754	1204	11146	5056
1948	0	0	2370	406	518	2308	3044	15	472	1882	1204	12219	5542
1949	0	0	1787	470	372	3560	3025	8	783	2361	1204	13570	6155
1950	0	0	3614	1036	270	3838	2515	25	543	1761	1840	15442	7004
1951	0	0	4506	1189	441	2636	2865	20	327	2006	1479	15469	7017
1952	0	0	4898	1336	627	3680	4721	69	467	1671	2156	19625	8902
1953	0	0	3836	1043	396	2910	7117	53	1176	1838	1844	20213	9168
1954	0	0	3363	2374	213	3683	6577	21	1090	2257	1645	21223	9627
1955	0	0	5407	2152	385	2608	5208	26	1108	1706	1126	19726	8948
1956	0	0	5469	1604	322	4260	6357	60	1049	2168	1002	22291	10111
1957	0	0	5991	1486	677	3488	5059	48	1171	1692	1236	20848	9456
1958	0	0	4172	950	360	2341	8109	209	1452	2039	892	20524	9310
1959	0	0	4524	1070	320	2809	6294	95	1334	3255	1529	21230	9630
1960	0	0	5583	1278	321	2512	6355	44	1028	2730	1236	21087	9565
1961	0	0	5240	948	155	2324	6031	76	539	2193	1897	19403	8801
1962	0	0	3795	676	124	1590	4749	24	715	1914	1876	15463	7014
1963	0	0	2296	512	98	1306	4444	17	550	1720	2674	13617	6177
1964	0	0	1384	678	136	1854	3670	16	557	1492	2450	12237	5551
1965	0	0	431	499	106	2451	3620	25	734	1977	272	10115	4588
1966	0	0	264	456	90	2466	3830	13	630	2343	4017	14109	6400
1967	0	0	447	706	48	1964	3035	0	439	1900	4391	12930	5865
1968	0	0	163	384	35	1216	2139	0	350	2164	2602	9053	4106
1969	0	0	78	267	23	574	1276	0	203	1508	2766	6695	3037
1970	0	0	41	259	23	900	1958	0	371	2146	3163	8861	4019
1971	0	0	89	275	34	1090	1850	0	296	1707	4011	9352	4242
1972	0	0	93	275	7	1101	1852	0	277	1857	3761	9223	4183
1973	0	0	506	640	52	1826	3091	*	495	3232	6314	16156	7328
1974	*	0	1689	2552	26	2487	3499	0	709	3111	10028	22581	10243
1975	0	0	1768	3093	39	3233	4314	5	893	3428	9539	26311	11934
1976	*	0	4019	6790	79	3203	5647	3	697	3303	9627	33368	15135
1977	0	0	1477	4058	64	2147	6566	5	739	4540	10332	29927	13575
1978	0	0	1439	2238	111	1948	5414	1	676	5940	10820	28586	12966
1979	5	0	1175	2825	30	1427	6279	6	1712	10019	16084	39561	17945
1980	4	0	367	1277	48	1246	4805	1	1324	8504	13643	31216	14159
1981	3	0	598	2861	81	1985	4008	7	403	3652	7459	21056	9551
1982	18	**	1665	3983	64	1865	4318	8	360	4332	6315	22928	10400
1983	84	0	2341	4599	129	1435	4826	5	937	8134	7057	29548	13403
1984	2	**	1488	4479	131	2295	6364	9	813	9673	12510	37765	17130
1985	3	**	2249	7533	183	2517	5634	4	577	5037	8614	32352	14675
1986	0	**	2954	7042	160	2738	4017	4	316	3712	5924	26866	12186

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Table 1. Continued

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD+	VA+	NC+	Total	
												'000 lb	mt
1987	8	**	3327	4774	609	2641	4451	4	319	5791	5128	27052	12271
1988	5	0	2421	4719	741	3439	6006	7	514	7756	6770	32377	14686
1989	9	0	1878	3083	513	1464	2865	3	204	3689	4206	17913	8125
1990	3	0	628	1408	343	405	1458	2	138	2144	2728	9257	4199
1991	0	0	1124	1672	399	719	2341	4	232	3715	3516	13722	6224
1992	**	**	1383	2532	495	1239	2871	12	319	5172	2576	16599	7529
1993	6	0	903	1942	225	849	2466	6	254	3052	2894	12599	5715
1994	4	0	1031	2649	371	1269	2356	4	179	3091	3571	14525	6588
1995	5	0	1128	2325	319	1248	2319	4	174	3304	4555	15381	6977
1996	8	0	780	1664	266	928	2345	7	225	2280	4218	12721	5770
1997	3	0	745	1566	257	823	1321	5	215	2370	1501	8806	3994
1998	6	0	709	1718	263	823	1863	11	211	2616	2988	11208	5084
1999	6	0	805	1637	231	804	1918	8	234	2196	2801	10640	4826

∗ = less than 500 lb; na = not available; + = NMFS did not identify flounders to species prior to 1978 for NC and 1957 for both MD and VA and thus the numbers represent all unclassified flounders.
∗∗ = less than 500 lb; na = not available.
Sources: 1980–1999 State and Federal reporting systems; 1995–1999 NC DMF Trip Ticket System. 1940–1977, Fishery Statistics of the United States; e.g., USDOC 1984.
1978–1979, unpublished NMFS General Canvas data.

and estuaries during the following spring and summer, notably Pamlico Sound, Chesapeake Bay, and coastal New Jersey (Able and Kaiser, 1994). The fish are concentrated in bays and estuaries from late spring through early autumn, when the next offshore migration begins.

Numerous studies have been conducted on the stock structure of summer flounder along the Atlantic coast over the last fifty years. These studies have used meristic and morphometric techniques (Ginsburg, 1952; Smith and Daiber, 1977; Wilk et al.,1980; Fogarty et al., 1983), electrophoretic analysis of cell constituents (Van Housen, 1984), tagging (Westman and Neville, 1946; Poole, 1962; Hamer and Lux, 1962; Murawski, 1970; Desfosse et al., 1988; Holland, 1991; Mercer et al., 1987; Jesien et al., 1992; Monaghan, 1992), and genetic diversity as revealed by mitochondrial DNA (Jones and Quattro, 1999). The studies suggest that one to three stocks of summer flounder exist along the Atlantic coast. The joint ASMFC/MAFMC FMP for summer flounder (MAFMC, 1988) has a management unit that includes all summer flounder from the southern border of North Carolina to the U.S.-Canadian border. The management unit therefore closely follows the definition of Wilk et al. (1980) of a unit stock extending from Cape Hatteras north to New England. This unit stock is the basis of the current stock assessments (NEFSC, 2000), with an extension southward to simplify the reporting of landings.

Female summer flounder may live up to 20 years, but males rarely live more than 7 years. The natural mortality rate is assumed to be about 18% per year (an instantaneous natural mortality rate of $M = 0.2$), based on a maximum age averaged for both sexes of about 15 years. Summer flounder are among the largest and fastest growing flatfish along the Atlantic coast. They can attain total lengths of up to 12 in (30 cm) by the end of their first year of life, and most fish are fully sexually mature by age 2 at a mean length of about 16 in (42 cm) (NEFSC, 2000). Bigelow and Schroeder (1953) report that summer flounder as large as 26 lb (11.8 kg) and 37 in (94 cm) have been taken in commercial fisheries. The sport fishing world record, set in 1975, is 22 lb 7 oz (10.2 kg) (IGFA, 2000).

Commercial fishery catches

The principal gear used in commercial fishing for summer flounder is the otter trawl, which historically has accounted for over 90% of the landings. Pound nets have accounted for about 5% of the landings, with remaining small amounts taken by
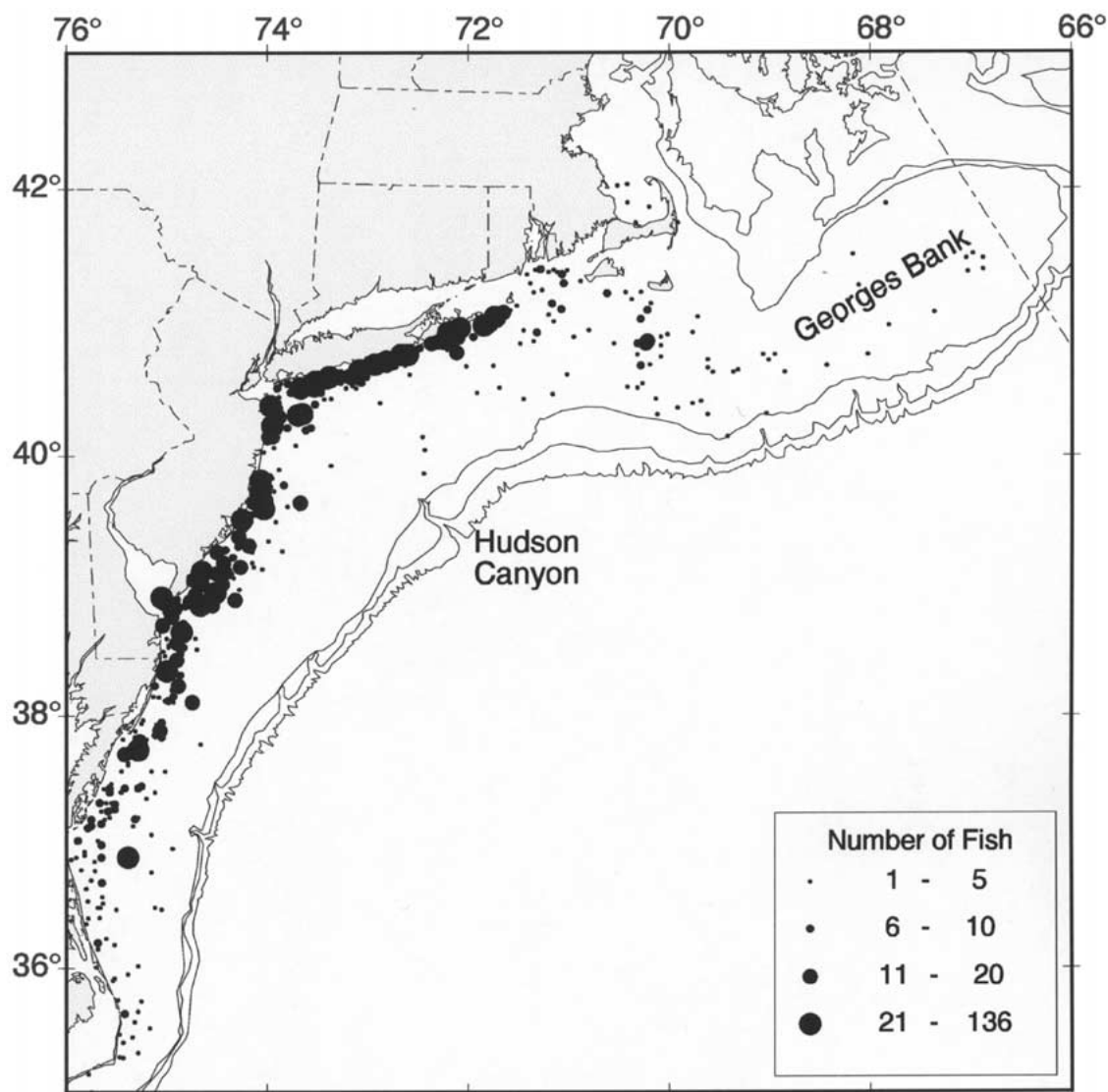
Figure 1. Distribution of summer flounder in the NEFSC autumn bottom trawl surveys, 1995–1999.

hand lines and scallop dredges. The states of North Carolina, Virginia, Rhode Island, and New Jersey account for about 80% of the commercial landings (Table 1). Commercial landings are reported by dealers purchasing summer flounder, but reporting has been mandatory only since 1994, so historical landings may be underestimates for some states. Information on the location of the catch at sea was obtained by interviews with sampled fishermen during 1963–1993. In 1994 and later years, the location of the catch at sea has been reported by fishermen in logbooks (Vessel Trip Reports; VTR). Samples of the length and age

characteristics of the commercial catch are obtained by sampling the commercial catch at the dock by port agents, and at sea by on board observers (NEFSC, 2000).

After annual harvests of between 9,000–10,000 mt (20.0–22.0 million lb) during 1952–1959, landings steadily declined during the 1960s, falling to only 3,000 mt (6.6 million lb) in 1969. Distant water fleet catches off the Atlantic coast during the 1960s were reported to be less than 1,000 mt (2.2 million lb) annually, but the true magnitude of these landings remains unknown. Domestic commercial landings of
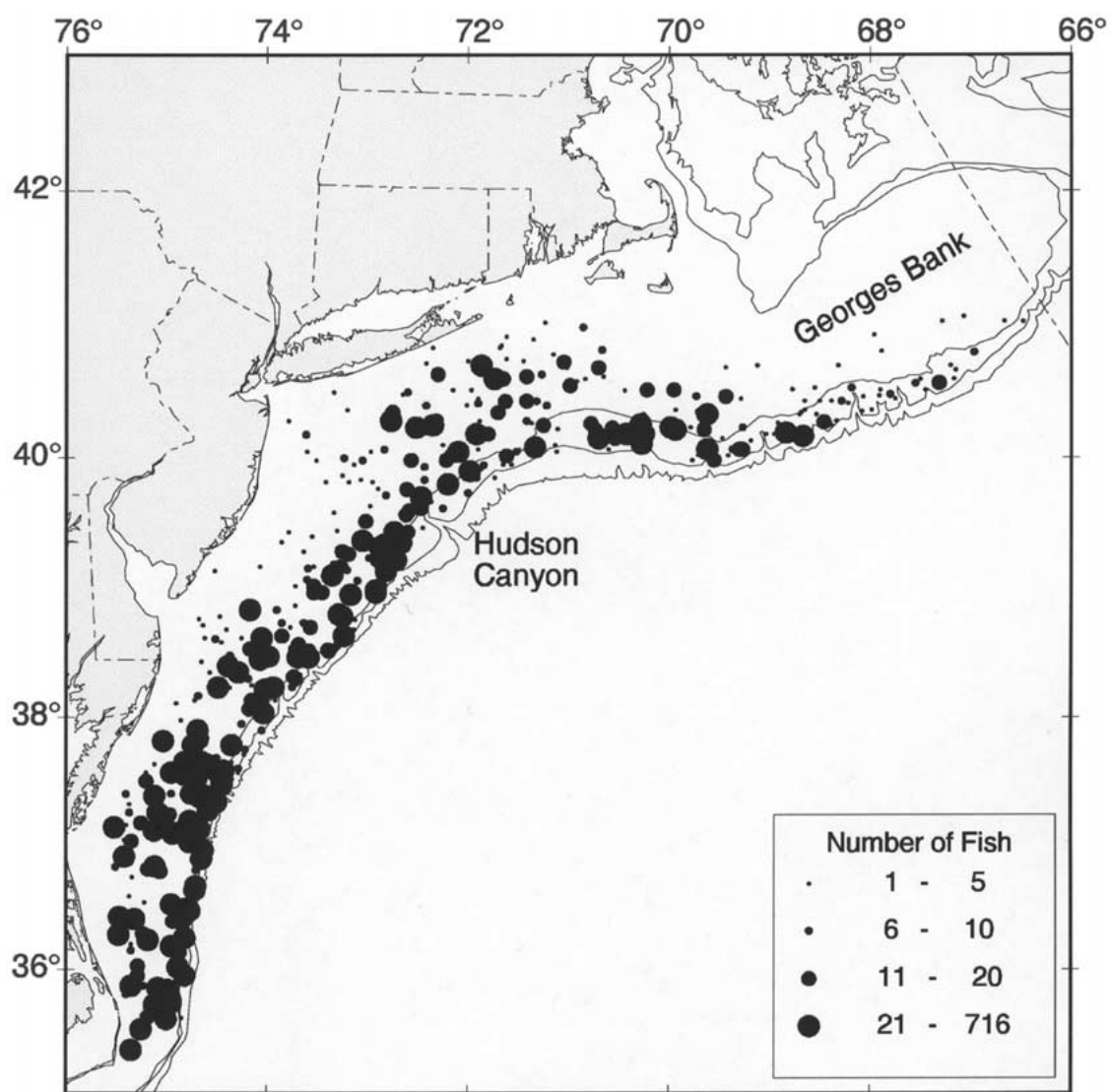
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Figure 2. Distribution of summer flounder in the NEFSC winter bottom trawl surveys, 1995–1999.

summer flounder increased in the mid-1970s, and peaked in 1979 at 17,900 mt (39.5 million lb). Landings averaged 13,100 mt during 1980–1989, reaching 17,100 mt (37.7 million lb) in 1984. Landings during the 1990s, constrained by various management measures including quotas, have been markedly lower, averaging 5,700 mt (12.7 million lb; Table 1).

Estimates of commercial fishery discards have been calculated for the years 1989–1999, using samples available from the National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) domestic observer program. Commercial

fishery discards before 1989 are assumed to have been minimal, due to the lack of a minimum mesh size, lack of a minimum landed fish size in federal waters (Exclusive Economic Zone [EEZ] waters, greater than 3 miles from shore), and the ability of fishermen to market, rather than discard, the small (< 12 in total length) summer flounder that were caught. Eighty percent of the summer flounder discarded in commercial fishing operations are assumed to be dead. During 1989–1999, commercial fishery dead discards averaged about 800 mt (1.7 million lb), about 8% of the total commercial catch in the period (Table 2).
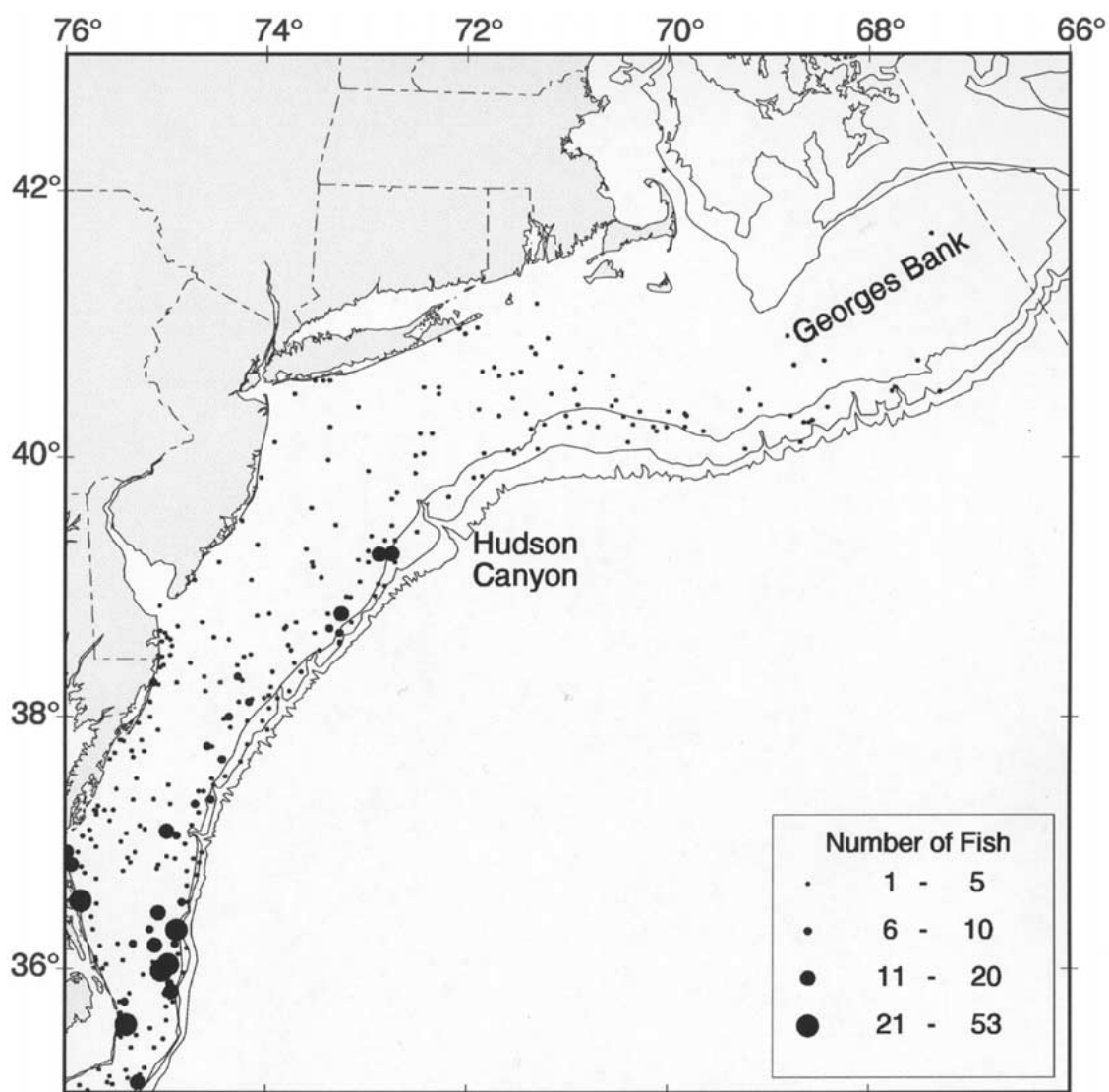
Figure 3. Distribution of summer flounder in the NEFSC spring bottom trawl surveys, 1995–1999.

Recreational fishery catches

The recreational fishery for summer flounder has typically accounted for a significant proportion of the total catch. In some years recreational landings have exceeded the commercial landings. Estimated recreational landings have historically averaged about 40 percent of the total landings. Estimates of recreational landings of summer flounder were developed from national marine angler surveys (Deuel and Clark, 1968; Deuel, 1973), which indicated landings of about 13,000 mt (28.9 million lb) in 1965 and 8,800 mt

(19.4 million lb) in 1970. These estimates were based in part on angler recall of catches made up to one year earlier; subsequent research on angler recall bias suggests that such estimates are probably overestimated by 100% (i.e., the true landings in 1970 were probably 4,400 mt (9.7 million lb); Hiett and Worrall, 1977).

The NMFS instituted a recreational fishery survey in 1979 to obtain estimates of participation, effort, and catch by recreational anglers in marine waters. A consistently estimated annual time series of recreational catch and effort is available from 1981

Table 2. Commercial and recreational landings, estimated discard, and total catch statistics (metric tons) as used in the assessment of summer flounder, Maine to North Carolina. n/a = not available

Year	Commercial			Recreational			Total		
	Landings	Discard	Catch	Landings	Discard	Catch	Landings	Discard	Catch
1981	9,551	n/a	9,551	4,573	n/a	4,573	14,124	n/a	14,124
1982	10,400	n/a	10,400	8,267	296	8,563	18,667	296	18,963
1983	13,403	n/a	13,403	12,687	376	13,063	26,090	376	26,466
1984	17,130	n/a	17,130	8,512	415	8,927	25,642	415	26,057
1985	14,675	n/a	14,675	5,665	92	5,757	20,340	92	20,432
1986	12,186	n/a	12,186	8,102	578	8,680	20,288	578	20,866
1987	12,271	n/a	12,271	5,519	522	6,041	17,790	522	18,312
1988	14,686	n/a	14,686	6,733	342	7,075	21,419	342	21,761
1989	8,125	709	8,834	1,435	45	1,480	9,560	754	10,314
1990	4,199	1,214	5,413	2,329	234	2,563	6,528	1,448	7,976
1991	6,224	1,052	7,276	3,611	429	4,040	9,835	1,481	11,316
1992	7,529	690	8,219	3,242	344	3,586	10,771	1,034	11,805
1993	5,715	846	6,561	3,484	736	4,220	9,199	1,582	10,781
1994	6,588	906	7,494	4,111	577	4,688	10,699	1,483	12,182
1995	6,977	308	7,285	2,496	714	3,210	9,473	1,022	10,495
1996	5,770	463	6,233	4,704	615	5,319	10,474	1,078	11,552
1997	3,994	326	4,320	5,378	627	6,005	9,372	953	10,325
1998	5,084	389	5,473	5,683	517	6,200	10,767	906	11,673
1999	4,826	1,548	6,374	3,804	688	4,492	8,630	2,236	10,866
Mean	8,877	768	9,346	5,320	453	5,773	14,197	922	15,119

onwards. The Marine Recreational Fisheries Statistics Survey (MRFSS) (Van Voorhees et al., 1992) collects marine fisheries data in two independent, but complementary surveys: a telephone survey of households to estimate total fishing effort, and an intercept (creel) survey at public fishing access sites to estimate catch per unit of effort by species. The telephone survey has a two month recall period, which provides more reliable data on fishing trips than the one year recall period used in the earlier marine angler surveys (Hiett and Worrall, 1977). Data from the two independent surveys are combined to produce estimates of catch by species. Length frequency samples of the recreational catch are taken in the intercept survey.

Recreational landings of summer flounder averaged 7,500 mt during 1981–1989, with a peak at 12,700 mt (28.0 million lb) in 1983. Recreational landings reached a low in 1989 at only 1,400 mt (3.1 million lb). Landings during the 1990s have averaged 3,900 mt (8.6 million lb). Over 90% of the recreational catch is taken in state waters (less than 3 miles from shore). About 85% is taken by anglers fishing from private or rental boats, with the remainder landed aboard party and charter boats, or from beaches, piers,

and jetties. Anglers in New Jersey, Virginia, and New York usually account for over 50% of the total. Estimates of the number of fish released alive are also calculated from the MRFSS data. Assuming that 10% of the summer flounder released alive die shortly thereafter, recreational fishery discard mortality has averaged about 450 mt (1.0 million lb) during 1982–1999 (the time period for which the recreational discard can be assigned to age classes), about 8% of the total recreational catch for the period (Table 2).

The stock assessments, FMP and amendments, and lawsuits

Early stock assessments

The first comprehensive stock assessment for summer flounder was completed by Chang and Pacheco (1975). Their assessment used commercial fishery catch statistics from 1950 to 1974, estimates of NEFSC survey catch at length for 1967–1974 (converted to age with age-length keys from Delaware Bay), and tag-recapture data from the studies of Poole

(1961), Hamer and Lux (1962), and Murawski (1970) for fish tagged during 1956–1962 in New Jersey, New York, Rhode Island, and Massachusetts waters. The tagging data indicated that the instantaneous fishing mortality rate (F) ranged from 0.34 to 0.55 during 1956 to 1962. Estimates of F, derived from the survey catch at age data and averaged for ages 2–10 (Chang and Pacheco, 1975), ranged from 0.33 to 0.53 during 1967 to 1973.

Chang and Pacheco (1975) also used the survey catch proportions at age to characterize the commercial and recreational fishery catch at age, and then applied virtual population analysis (VPA) (Fry, 1949) to calculate population size in numbers and weight for the 1958 through 1972 cohorts of summer flounder. Their analysis indicated about a doubling of summer flounder stock biomass between 1967 and 1974, from 41,000 mt to 74,000 mt. Chang and Pacheco (1975) used the formulation of Doi (1972) in relating their estimates of spawners, recruits, and exploitable stock size (along with assumptions of M = 0.2, full maturity at age 3, and range of full selection by the fisheries (ranging from age 1 to 3)), to derive estimates of Maximum Sustainable Yield (MSY) for summer flounder ranging between 20,000 and 22,000 mt (Table 3). Chang and Pacheco (1975) noted that their analyses would have been strengthened by more synoptic age-length data, better estimates of the recreational catch, and a longer time series of data for estimating the spawner-recruit relationship.

The second comprehensive stock assessment for summer flounder was conducted by Fogarty (1981). Fogarty's assessment presented time series of NEFSC survey indices for summer flounder through 1980 that indicated that stock abundance had been relatively low during the 1960s, increased during the early 1970s to a peak during 1974–1976, and then began to decline. In contrast, reported commercial landings had increased through the 1970s, reaching a peak of 17,900 mt in 1979. Fogarty (1981) derived growth parameters from age at length data collected on the NEFSC surveys during 1976–1979, and noted that female summer flounder attained significantly larger asymptotic size than males. Differences in longevity were also noted, with maximum ages of 7 years for males and 12 years for females, in research survey and commercial fishery samples collected during 1976–1979.

Fogarty (1981) re-analyzed data from several earlier summer flounder tagging studies and developed maximum likelihood estimates of mortality by applying the method of Paulik (1963). Fogarty's

analyses indicated fishing mortality rates ranging from 0.48 to 0.62 for summer flounder off southern New England during the early 1960s (data from Lux and Nichy, 1980) and from 0.24 to 0.58 for summer flounder off New Jersey during 1960–67 (data from Murawski, 1970). The fishing mortality rate estimated for summer flounder off North Carolina during 1973–1974 (data from an unpublished tagging study) was much lower, at about 0.1, but Fogarty concluded that this estimate was biased low due to non-reporting of tag returns.

Fogarty (1981) compiled NEFSC groundfish survey catch at age matrices for summer flounder for 1976–1979, and estimated instantaneous total mortality rates (Z) by sex using the catch curve methods of Chapman and Robson (1960) and Robson and Chapman (1961). Annual estimates of Z from the NEFSC surveys ranged from 0.67 to 2.85, with the broad range likely due to high sampling variability. With NEFSC survey age compositions pooled over the 1976–1979 period to reduce the effect of variable year class strength, Z estimates were 0.93 for females and 1.11 for males, much higher than the rates estimated for the 1960s. Fogarty (1981) calculated biological reference points for summer flounder using yield per recruit analysis assuming age at entry to the fisheries of 2 years, and M = 0.2. The fishing mortality rate providing maximum yield per recruit (Fmax) was estimated to be 0.31 for males and 0.19 for females. Given the trends in NEFSC survey biomass indices, reported commercial landings, and mortality rates calculated from the NEFSC survey data, Fogarty (1981) concluded that summer flounder were growth overfished (fishing mortality rate greater than Fmax) during the late 1970s. Using a mean annual recruitment level of 40–45 million age 1 summer flounder, Fogarty (1981) calculated equilibrium yield at Fmax to be 17,000–20,000 mt, slightly lower than the MSY estimate of Chang and Pacheco (1975; Table 3).

Stock Assessment Workshop (SAW) Assessments: 1986–1990

In July 1985, state and federal fisheries scientists and managers and members of the academic community met in Woods Hole, MA to discuss new procedures for the development and review of stock assessments for summer flounder and other species. A workshop format was proposed in which state, federal, and academic stock assessment scientists would participate in compiling the data and analyses for the

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Table 3. Chronology and summary of stock assessments conducted for summer flounder

Year	Source	Results and conclusions
1975	Chang and Pacheco (1975)	F ranged from 0.37 to 0.55 during 1956 to 1962, and from 0.33 to 0.53 during 1967 to 1973. Stock biomass doubled between 1967 and 1974, from 41,000 mt to 74,000 mt. MSY estimated to be 20,000–22,000 mt.
1981	Fogarty (1981)	Commercial landings at historical peak in 1979 (17,900 mt; 39.5 million lb). F ranged from 0.48 to 0.62 off southern New England during the early 1960s, and from 0.24 to 0.58 off New Jersey during 1960–1967. F estimated at about 0.8 during the late 1970s. Fmax estimated to be 0.31 for males and 0.19 for females. Concluded that summer flounder were growth overfished during the late 1970s. Equilibrium yield at Fmax calculated to be 17,000–20,000 mt.
1986	NEFC (1986): Third SAW	Commercial landings peaked in 1979 (17,900 mt; 39.5 million lb) and 1984 (17,100 mt; 37.7 million lb). F estimated to be about 0.7 during the late 1970s. Age composition of commercial landings shifting to younger ages by early 1980s. Fmax estimated to be 0.44 for males and 0.26 for females, assuming 25% recruitment to the fisheries at age 1 and 100% recruitment at age 2 and older. NEFSC survey biomass indices, after rising from low values in the 1960s to a peak in the mid 1970s, declined to about 50% of that peak by 1986. Discussed the potential importance of considering commercial fishery discards in future assessments.
1989	NEFC (1989): Ninth SAW	Fishery landings were comprised almost exclusively by ages 0 to 2. Fishing mortality rates in the late 1980s substantially in excess of Fmax and probably greater than F= 0.7. Stock appeared to be "overfished heavily."
1990	NEFC (1990): Eleventh SAW	Commercial landings fell dramatically between 1988 and 1989, from 14,700 mt (32.4 million lb) to 8,100 mt (17.9 million lb). Recreational landings declined even more sharply, from 6,700 mt (14.8 million lb) in 1988 to only 1,400 (3.1 million lb) mt in 1989. NEFSC survey stock biomass indices during 1989–1990 fell to low values last observed during the late 1960s. State survey indices of summer flounder recruitment at age 0 indicated that the 1988 year class had been poor. First calibrated (tuned) VPA for summer flounder. Catch at age data incorporated recommendations of a 1990 aging workshop. VPA results indicated average F = 1.4 during 1982–1988, with the 1988 year class and the total stock size in 1988 estimated to be the lowest in the series. Yield per recruit analyses estimated F0.1 = 0.14 and Fmax = 0.23 for combined sexes. SAW concluded that the stock was "over exploited and seriously depleted."
1991	NEFSC (1992): Thirteenth SAW	Commercial landings declined to 4,200 mt (9.3 million) in 1990, a decrease of about 75% from the peak in 1979. Recreational landings increased from 1,400 (3.1 million lb) mt in 1989 to 2,300 mt (5.1 million lb) in 1990, but still far below the 1983 peak of 12,700 mt (28.0 million lb). NEFSC survey stock biomass indices increased slightly from the low in 1989, and survey recruitment indices indicated that the 1989 and 1990 year classes were somewhat larger than the poor 1988 year class. Discards from the commercial fishery calculated for the first time, estimated to be 10–20% of the total commercial catch for 1989–1990, but not included in the VPA. VPA fishing mortality rates on fully recruited ages (2+) generally exceeded 1.0 between 1982–1990, with the 1990 value at F = 1.1, nearly five times the estimated value of Fmax = 0.23. Spawning stock biomass found to be low and age composition of the stock very truncated, with few fish older than age 3. Decline in fishery landings in 1989 and 1990 attributed to the recruitment of the poor 1988 year class. SAW concluded that the stock was overexploited with respect to the Amendment 1 overfishing definition, that stock size was low, and that fishing mortality needed to be reduced to rebuild the spawning stock biomass and age structure.
1993	NEFSC (1993): 16th SAW	Commercial landings increased since 1990, reaching 7,500 mt (16.5 million lb) in 1992, but still 50% lower than the peak in 1979. Recreational landings increased to 3,200 mt (7.1 million lb) mt in 1992, more than twice the 1989 record low of 1,400 mt (3.1 million lb). NEFSC survey abundance indices increased significantly from the low values of 1989, but still only about 40% of the peak values observed in the mid 1970s. Survey indices reflected improved recruitment since the poor year class of 1988. VPA results indicated that the fishing mortality had declined from peak levels in 1988–1989, but still very high at F = 1.1 in 1992. Bootstrap calculations indicated a 95% probability that fishing mortality in 1992 was higher than the target for 1993 of F = 0.53. Spawning stock biomass on 1 November 1992 estimated to be 15,000 mt, 2.5 times larger than the 1989 low of 5,600 mt. Only about 11% of the spawning stock was composed of fish aged 3 and older; at the overfishing definition level of Fmax = 0.23, about 77% of the spawning stock biomass expected to be of fish ages 3 and older. The stock was judged to be overfished, and the fishery still largely dependent on incoming recruitment. Forecasts for 1993–1995 assuming that the 1993 TAL of 9,400 mt (20.73 million lb) would be landed resulted in a forecasted fishing mortality rate in 1993 of F = 0.48, a drop of 56% from the 1992 VPA estimate of F = 1.1. Forecasts indicated that TAL of 14,400 mt (31.75 million lb) would result in meeting the target F = 0.53 in 1994. SAW was concerned that the TAL

Table 3. Continued

Year	Source	Results and conclusions
		forecast for 1994 might be optimistic, given the uncertainty of assessment, and advised adopting a TAL for 1994 lower than 14,400 mt as a risk-averse strategy to improve chances that the fishing mortality target would be met.
1994	NEFSC (1994): 18th SAW	1993 commercial landings (5,715 mt, 12.6 million lb) about 2% higher than the quota (5,600 mt; 12.35 million lb); recreational fishery exceeds the harvest limit by about 5%, at 3,484 mt (7.7 million lb). Most survey recruitment indices indicated that the size of the 1993 year class would be the smallest since the poor 1988 year class. VPA included fishery catch data for 1982–1993; calibrated with only survey indices. VPA results indicated that the fishing mortality rate had declined markedly under the first year of quota management, from a very high value of F = 1.69 in 1992 to F = 0.54 in 1993, essentially equal to the target fishing mortality of F = 0.53. Bootstrap calculations indicated an 80% probability that fishing mortality in 1993 was between 0.4 and 0.8. Spawning stock biomass on 1 November 1993 was estimated to be 14,000 mt, about 63% of the peak estimated for 1983 (22,200 mt). The estimate of spawning stock biomass for 1992, however, had been revised downward significantly from 15,000 mt in the 16th SAW assessment to 11,600 mt, an eary warning sign of assessment problems to come. The stock was judged to be overfished, and at average levels of abundance, but the results suggested that the TAL limit and other management measures had been effective in reducing fishing mortality to the target in 1993. Forecasts for 1994–1996 made assuming that the 1994 TAL of 12,100 mt (26.7 million lb) would be landed resulted in a forecasted fishing mortality rate in 1994 of F = 0.77, a increase of 43% from the 1993 VPA estimate of F = 0.54, and well above the target for 1994 of F = 0.53. Forecasts indicated that at geometric mean recruitment, a 27% decrease in landings in 1995 to 8,800 mt (19.4 million lb) would be necessary to meet the target F = 0.53. The 3.05 million lb (1,380 mt) increase in the commercial fishery quota ordered by the District Court in the Fishermen's Dock lawsuit was added to the commercial quota. After subtracting commercial fishery quota overages from 1994, the final 1995 TAL would be 10,180 mt (22.4 million lb), about 15% higher than the 18th SAW recommendation.
1995	NEFSC (1996a): 20th SAW	1994 commercial landings (6,588 mt, 14.5 million lb) reported to be about 7% below the final, adjusted quota (7,076 mt; 15.6 million lb); estimated 1994 recreational landings of 4,111 mt (9.1 million lb), 15% below the harvest limit of 4,840 mt (10.7 million lb). Together, the fisheries landed 10,699 mt (23.6 million lb), or 90% of the 1994 TAL. NEFSC survey abundance indices remained stable, near the 1991–1994 values. Survey recruitment indices indicated that the 1994 year class was larger than the 1993 year class. Alternative estimates of natural mortality (M) reviewed, M = 0.2 retained. VPA results indicated that F had declined from 1.8 in 1992 to 0.8 in 1993 and to 0.7 in 1994. Estimate for 1994 was in line with the forecast from the 18th SAW Assessment, which indicated a value of F = 0.77 if the1994 TAL were landed. Bootstrap calculations indicated an 80% probability that fishing mortality in 1994 was between 0.6 and 0.9. Spawning stock biomass on 1 November 1994 estimated to be 14,800 mt, about 67% of the peak estimated in 1983 (22,200 mt). SAW concluded that the stock was at a medium level of historic abundance and overexploited. Forecasts of the catch and stock size for 1995–1998 made assuming that the final 1995 TAL of 10,180 mt (22.4 million lb) would be landed, resulting in forecasted fishing mortality rate of F = 0.50, a decrease of 29% from the 1994 VPA estimate of F = 0.7, and below the target for 1995 of F = 0.53. Forecasts indicated that a 35% decrease in TAL to 6,600 mt (14.6 million lb) in 1996 would be necessary to meet the target F = 0.23. Historical retrospective pattern evident between the 18th and 20th SAW assessments, with the 1993 fishing mortality increasing from 0.54 to 0.83, and the 1993 spawning stock biomass estimate declining from 14,000 mt to 10,500 mt. VPA showed evidence of an internal retrospective pattern for at least the 3 most recent years (1991–1993), in which fishing mortality was underestimated and stock sizes were overestimated.
1996	NEFSC (1996b): 22nd SAW	1995 commercial landings (6,977 mt, 15.4 million lb) reported to be about 5% above the quota (6,627 mt; 14.6 million lb); estimated 1995 recreational landings of 2,496 mt (5.5 million lb), 29% below the harvest limit of 3,520 mt (7.8 million lb). Together, the fisheries landed 9,473 mt (20.9 million lb), or 93% of the 1995 TAL. NEFSC survey abundance indices increased substantially from 1995 to 1996, mainly reflecting recruitment of the 1994 year class to the adult stock. Survey recruitment indices indicated the 1995 year class was even larger than the 1994 year class, and would be the best since 1983. VPA results indicated that the fishing mortality rate on fully recruited ages (2+) had exceeded 1.0 between 1982–1995, peaking at F = 2.2 in 1992 before declining to 1.3 in 1994 and 1.5 in 1995, three times higher than the fishing mortality rate that had been forecast for 1995 by the 20th SAW Assessment. Bootstrap calculations indicated an 80% probability that fishing mortality in 1995 was between 1.3 and

Table 3. Continued

Year	Source	Results and conclusions
		1.8. Spawning stock biomass on 1 November 1995 estimated to be 15,200 mt, about 80% of the peak estimated in 1983 (18,944 mt). SAW concluded that the stock was at a medium level of historic abundance and was overexploited. Forecasts assuming that the Amendment 7 1996 TAL cap of 8,400 mt (18.5 million lb) would be landed resulted in a forecasted fishing mortality rate in 1996 of F = 0.52, a decrease of 65% from the 1995 VPA estimate of F = 1.5, and well above the new Amendment 7 target for 1996 of F = 0.41. Forecasts indicated that the TAL could rise to 9,300 mt (20.5 million lb) in 1997 and meet the target F = 0.30 in 1997. Assessment results were very controversial, with F estimates for 1994–1995 much higher than in the previous assessment. Internal retrospective pattern evident in the VPA, with a tendency for fishing mortality to be overestimated and stock size underestimated. SAW concluded that underestimation of the true catch was a plausible cause of the continuing retrospective problems of the summer flounder VPA and forecasts, and that future quotas should be set with consideration of the direction and magnitude of the analytical bias, wherein it was likely that current and forecasted fishing mortality rates would be underestimated.
1997	NEFSC (1997): 25th SAW	1996 commercial landings (5,770 mt, 12.7 million lb) reported to be about 18% above the quota (4,900 mt; 14.6 million lb; adjusted for 1995 overages); estimated 1996 recreational landings of 4,704 mt (10.4 million lb), 40% below the harvest limit of 3,360 mt (7.4 million lb). Fisheries landed a total of 10,474 mt (23.1 million lb), 27% above the final 1996 TAL of 8,260 mt (18.2 million lb). NEFSC survey abundance indices declined from 1996 to 1997; most survey recruitment indices indicated that the 1996 year class was not as large as the 1995 year class. VPA results indicated that the fishing mortality rate on fully recruited ages (2+) had peaked at F = 2.1 in 1992 before declining to 1.2 in 1994, 1.1 in 1995, and 1.0 in 1996; two times higher than the fishing mortality rate forecast for 1996 by the 22nd SAW Assessment. Spawning stock biomass on 1 November 1996 estimated to be 17,402 mt, about 92% of the peak estimated in 1983 (18,939 mt). Internal retrospective pattern evident in the VPA results, with fishing mortality underestimated and stock size overestimated for the years 1991–1993. Pattern was reversed and reduced for the 1994–1995 estimates, leading to hope of reduced retrospective bias in the assessment. New analysis indicated that Fmax for summer flounder was now 0.24, an increase of about 4% from the Eleventh SAW estimate of Fmax = 0.23. SAW concluded that the stock was at a medium level of historic abundance and was overexploited. SAW advised that if the TAL for 1997 were not exceeded, the TAL in 1998 should not exceed 6,276 mt (13.9 million lb) to meet the 1998 fishing mortality target of F = 0.24. MAFMC instead recommended a TAL on the same level as that for 1996–1997, at 8,400 mt (18.5 million lb). Although this TAL was estimated to have only a 3% chance of achieving the 1998 fishing mortality rate target, it was implemented by NMFS with the requirement that each state set aside 15% of its commercial quota allocation for a bycatch fishery. The bycatch quota allocation was expected to extend the season and reduce discard waste in the fishery, and increase the probability of achieving the target fishing mortality.
1999	Terceiro (1999): MAFMC SSC	1998 commercial landings (5,084 mt, 11.2 million lb) reported to be about 6% above the quota (4,790 mt; 10.6 million lb); estimated 1998 recreational landings of 5,683 mt (12.5 million lb), 69% above the harvest limit of 3,360 mt (7.4 million lb). Together, the fisheries landed 10,767 mt (23.7 million lb), 32% above the final 1998 TAL of 8,150 mt (18.0 million lb). Most survey abundance indices suggested increasing abundance at ages 3 and older, due to the abundance of the 1994, 1995, and 1996 year classes. VPA results indicated that the fishing mortality rate had steadily declined since 1995 and was estimated to be 0.52 in 1998, but was still about twice the FMP overfishing definition. Substantial changes in the fishery selection pattern during 1997–1998 increased the age of full recruitment from age 2 to age 3, and so fully recruited F was calculated for ages 3–4. Spawning stock biomass on 1 November 1998 was estimated to be 25,000 mt, the highest level of the 1982–1998 VPA series. Total stock biomass on 1 January 1998 was estimated to be 38,600 mt. The most recent estimates of fishing mortality and stock biomass appeared to be free of significant retrospective bias. Biological reference points were re-estimated; new analysis indicated that Fmax = 0.26, target and threshold biomass were re-estimated at B_{MSY} = 106.400 mt (234.6 million lb) and one-half B_{MSY} = 53,200 mt (117.3 million lb). The SSC concluded that the stock was overfished and overfishing was occurring. SSC advised that if the TAL for 1999 (8,295 mt; 18.3 million lb) was not exceeded, the TAL in 2000 should not exceed 7,627 mt (16.8 million lb) to meet the fishing mortality target of F = 0.26 for 2000. SSC also advised that given the stock size in 1999, even this relatively low level of fishing mortality was not projected to rebuild the stock to B_{MSY} until 2017. The MAFMC did not adopt the TAL advice, and instead proposed a TAL of 8,400 mt, estimated to have only

Table 3. Continued

Year	Source	Results and conclusions
		a 25% chance of achieving the fishing mortality rate target in 2000. While expressing some reservations over the MAFMC rationale for this TAL, the NMFS proposed a preliminary TAL of 8,400 mt (18.5 million lb) for 2000.
2000	NEFSC (2000): 31st SAW	1999 commercial landings (4,826 mt, 10.6 million lb) were reported to be about 3% below the final adjusted quota (4,990 mt; 11.0 million lb); estimated 1999 recreational landings of 3,804 mt (8.4 million lb), 13% above the harvest limit of 3,360 mt (7.4 million lb). Together, the fisheries landed 8,630 mt (19.0 million lb), 3% above the final 1999 TAL of 8,350 mt (18.4 million lb). Most survey indices of increasing abundance of age 3 and older fish, due to increased survival of the 1994 and subsequent year classes. The catch at age matrix was expanded to an age 7 and older plus group, and fully recruited F was calculated for ages 3–5. VPA results indicated that fishing mortality had peaked at F = 2.2 in 1992, had steadily declined since 1997, and was estimated to be 0.32 in 1999, about 23% higher than the FMP overfishing definition of Fmax. Bootstrap calculations indicated an 80% probability that fishing mortality in 1999 was between 0.28 and 0.38. Spawning stock biomass on 1 November 1999 was estimated to be 29,300 mt, the highest level of the 1982–1999 VPA series. The age structure of the spawning stock had expanded substantially since 1990, with 78% at ages 2 and older, and 10% at ages 5 and older. Under equilibrium conditions at Fmax, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older. Total stock biomass on 1 January increased substantially since 1991, and stable since 1994 at about 41,000 mt. The 1999 biomass was estimated to be 41,400 mt, still 23% below the FMP biomass threshold. Retrospective analysis showed that the VPA tended to underestimate the abundance of recent year classes. Biological reference points from the 1999 MAFMC SSC assessment were retained in the 2000 assessment, due to the stability of the input data. The 31st SAW concluded that the stock was overfished and overfishing was occurring with respect to the FMP Amendment 12 overfishing definition, since fishing mortality was 23% above the fishing mortality threshold and biomass was 23% below the biomass threshold of one-half B_{MSY}. SAW advised that if the TAL for 2000 (8,400 mt; 18.5 million lb) was not exceeded, the TAL in 2001 should not exceed 9,281 mt (20.5 million lb) to meet the fishing mortality target of F = 0.26 for 2001.

assessments, which would then be subject to peer review by scientists with a broad range of fisheries backgrounds. The proposed workshop format, which has become known as the Northeast Regional Stock Assessment Workshop (SAW), was a substantial departure from previous approaches to the preparation and review of the region's stock assessments. During the 1960s and 1970s, the review process consisted mainly of internal NEFSC review, with subsequent comments and recommendations made by the management bodies that were the clients for information on the status of the stocks (the New England and Mid-Atlantic Fishery Management Councils [NEFMC, MAFMC], the Atlantic States Marine Fisheries Commission [ASMFC], and the International Commission for the Northwest Atlantic Fisheries [ICNAF]). These assessments were usually published as NEFSC Reference Documents or as ICNAF Research Documents. The Chang and Pacheco (1975) and Fogarty (1981) assessments were prepared and reviewed under these procedures.

The first summer flounder assessment to be considered by the SAW was completed in May 1986, and was reviewed at the Third SAW (NEFC, 1986). This assessment was an update of the Fogarty (1981) work, with commercial fishery landings reported through 1985. Although the reported 1984 commercial landings of 17,100 mt (37.7 million lb) were near the historical peak of 17,900 mt (1979; 39.6 million lb; Table 1), the age structure of the landings was changing. After a period of stability during the late 1970s, the age structure (in numbers of fish) changed from 49% at ages 3 and 4 in 1980 to 28% in 1983, as the percentage at ages 1 and 2 increased from 46% in 1980 to 66% in 1983. Fishing mortality rates calculated from fishery and survey catch at age were estimated to be about 0.7 during the late 1970s. Estimates of Fmax from yield per recruit analysis were 0.44 for males and 0.26 for females, assuming 25% recruitment to the fisheries at age 1 and 100% recruitment at age 2 and older. NEFSC survey stock biomass indices, after rising from low values in the

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Table 4. NEFSC research trawl survey indices of abundance. Indices are stratified mean numbers (n) and weight (kg) per tow. Spring indices are for offshore strata 1–12, 61–76; autumn indices are for offshore strata 1–2, 5–6, 9–10, 61, 65, 69, and 73. Winter indices (1992 and later) are for NEFSC offshore strata 1–3, 5–7, 9–11, 13–14, 16–17, 61–63, 65–67, 69–71, 73–75. n/a = not available due to incomplete coverage

Year	Winter (n)	Winter (kg)	Spring (n)	Spring (kg)	Autumn (n)	Autumn (kg)
1967			n/a	n/a	1.35	1.25
1968			0.15	0.16	1.10	1.00
1969			0.19	0.16	0.59	0.61
1970			0.09	0.09	0.15	0.13
1971			0.22	0.28	0.42	0.27
1972			0.47	0.21	0.39	0.27
1973			0.76	0.54	0.87	0.63
1974			1.37	1.26	1.70	1.86
1975			1.97	1.61	3.00	2.48
1976			2.83	2.00	1.14	0.85
1977			2.84	1.74	2.17	1.75
1978			2.62	1.43	0.32	0.40
1979			0.40	0.35	1.17	0.94
1980			1.30	0.78	0.94	0.57
1981			1.50	0.80	0.91	0.72
1982			2.27	1.11	1.57	0.90
1983			0.95	0.53	0.90	0.47
1984			0.66	0.38	0.99	0.65
1985			2.38	1.20	1.24	0.87
1986			2.14	0.82	0.68	0.45
1987			0.93	0.38	0.26	0.28
1988			1.47	0.68	0.11	0.11
1989			0.32	0.24	0.20	0.08
1990			0.72	0.27	0.27	0.19
1991			1.08	0.35	0.51	0.17
1992	12.30	4.90	1.20	0.46	0.85	0.49
1993	13.60	5.50	1.27	0.48	0.11	0.04
1994	12.05	6.03	0.93	0.46	0.60	0.35
1995	10.93	4.81	1.09	0.46	1.13	0.83
1996	31.25	12.35	1.76	0.67	0.71	0.45
1997	10.28	5.54	1.06	0.61	1.32	0.92
1998	7.76	5.13	1.19	0.76	2.32	1.58
1999	11.06	7.99	1.60	1.01	2.42	1.66
2000	16.01	12.74	2.14	1.70	2.40	2.29

1960s to a peak in the mid 1970s, declined to about 50% of the peak by 1986 (Table 4). The Third SAW also discussed the potential importance of considering commercial fishery discards in future summer flounder assessments (Table 3).

During 1987–1990, state and federal scientists completed a large volume of work in compiling additional survey catch at age data from federal and state sources (NEFSC, Massachusetts, Virginia, and North Carolina), summarizing recreational fishery catch statistics, developing catch per unit effort (CPUE) indices from the commercial and recreational fisheries, and updating estimates of fishery and survey catch at age. This work was in support of the development of a full analytical assessment for summer flounder in the virtual, or sequential, population analysis (VPA) framework. This preliminary VPA work, and updates of the fishery landings, survey indices, and estim-

ated fishing mortality rates were reviewed by the Ninth SAW in late 1989. The Ninth SAW assessment concluded that the commercial landings were dominated by ages 0 to 2, that fishing mortality rates in the late 1980s were substantially in excess of Fmax and probably greater than F = 0.7, and that the stocks appeared to be "overfished heavily" (NEFC, 1989; Table 3).

The assessment reviewed by the Eleventh SAW in late 1990 (NEFC, 1990) was the first to incorporate a calibrated (tuned) VPA. The Eleventh SAW VPA used the relatively simple Laurec-Shepherd VPA model (Laurec and Shepherd, 1983); all subsequent summer flounder VPAs have used versions of the more complex ADAPT VPA model (Gavaris, 1988; Conser and Powers, 1989). The Eleventh SAW assessment included commercial landings and recreational catches through 1989. Reported commercial landings fell dramatically between 1988 and 1989, from 14,700 mt (32.4 million lb) to 8,100 mt (17.9 million lb). The estimate of recreational landings declined even more sharply, from 6,700 mt (14.8 million lb) in 1988 to only 1,400 (3.1 million lb) mt in 1989. NEFSC stock biomass indices during 1989–1990 had fallen to low values last observed during the late 1960s (Table 4), and NEFSC and state survey indices of summer flounder recruitment at age 0 suggested that the 1988 year class was very poor (Table 5). The VPA included fishery landings at ages 0 to 4, with ages 5 and older combined as a "plus group" (5+) for 1982–1988 (1989 ages were not yet available), and was calibrated with NEFSC spring survey catch at age, a commercial fishery CPUE at age series, and recruitment indices from surveys conducted by the states of Massachusetts, Virginia, and North Carolina. The fishery landings and survey catch at age data incorporated the latest revisions in aging protocols for summer flounder that had been recommended by a 1990 aging workshop (NOAA, 1992).

The Eleventh SAW noted that while the fishing mortality rate had varied over the 1982–1988 period, the average value of F = 1.4 indicated that the stock had been "overexploited for some years." The 1988 year class and total stock size in 1988 were estimated to be the lowest in the 1982–1988 series. Yield per recruit analyses using the partial recruitment vector and mean weights at age from the 1982–1988 catch at age series provided estimates of F0.1 = 0.14 and Fmax = 0.23 for combined sexes. Based on the VPA estimation of stock size and fishing mortality, and considering the revised biological reference points, the

Eleventh SAW concluded that the stock was "over exploited and seriously depleted" (NEFC, 1990).

The Fishery Management Plan and Amendment 1

Fishery managers along the U.S. Atlantic coast first considered the development of a fishery management plan for summer flounder in late 1977, in response to the economic importance of the commercial and recreational fisheries and the new mandate for fisheries management in the wake of the passage of the Magnuson Fishery Conservation and Management Act of 1976 (MFCMA). During early discussions about how a management program might be implemented, it was recognized that a significant portion of the summer flounder catch was harvested from state waters (less than 3 miles from shore). In 1978, state and federal fisheries managers decided that the initial management plan would be implemented under the aegis of the ASMFC, with New Jersey designated as the state with lead responsibility for the plan. The ASMFC Summer Flounder FMP was adopted in October 1982 (ASMFC, 1982). The only significant management measure in the FMP was a recommendation for a 14 in (36 cm) minimum landed size in the commercial fishery. By the end of 1987, Maine, New Hampshire, and Pennsylvania still had no minimum size regulations for summer flounder. Massachusetts, Rhode Island, Connecticut, New York, and Delaware had enacted a 14 in (36 cm) minimum size regulation, New Jersey a 13 in (33 cm) minimum size regulation, Maryland and Virginia 12 in (30 cm) minimum size regulations, and North Carolina an 11 in (28 cm) minimum size regulation.

Given that survey indices of abundance, estimates of fishing mortality, and measures of commercial and recreational fishery performance (CPUE) from the early stock assessments (Chang and Pacheco, 1975; Fogarty, 1981; NEFC, 1986) indicated that the summer flounder stock was overfished, the management process began to move towards implementation of additional regulatory measures during the mid 1980s. The MAFMC took the lead in developing a joint ASMFC/MAFMC draft FMP and held public hearings on proposed measures during 1988. The objectives of the FMP were to: (1) reduce fishing mortality on immature summer flounder; (2) increase the yield from the fishery; (3) promote compatible management regulations between the Territorial Sea and the EEZ; and (4) minimize regulations to achieve the management objectives (MAFMC, 1988). The

Table 5. Research survey indices of summer flounder recruitment at age 0

Survey	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
CT Autumn					0.00	0.24	0.17	0.08	0.02	0.00	0.03	0.04	0.01	0.08	0.13	0.02	0.07	0.03	0.00	0.04	0.11
RI Trawl	0.13	0.31	0.02	0.03	0.12	0.34	0.55	0.14	0.01	0.00	0.05	0.01	0.07	0.02	0.01	0.03	0.17	0.08	0.01	0.24	
MA Seine			3	3	1	19	5	5	2	3	11	4	0	2	1	13	7	0	12	13	
NJ Trawl									0.29	1.25	1.88	1.50	1.34	3.52	2.22	4.95	1.65	1.64	0.67	1.03	
DE: 16 ft Trawl	0.12	0.06	0.11	0.03	0.08	0.06	0.10	0.14	0.01	0.12	0.23	0.07	0.31	0.02	0.29	0.17	0.03	0.02	0.03	0.05	
DE: 30ft Trawl												1.44	0.47	0.04	2.03	0.95	0.46	0.03	0.11	0.20	
MD	4.2	3.9	2.0	10.6	5.4	5.6	16.2	4.6	0.5	1.3	2.1	3.1	3.5	1.6	8.2	5.0	2.6	3.3	5.2	3.4	4.1
VIMS Rivers only	7.6	5.1	4.3	5.2	1.9	1.1	1.3	0.4	0.5	1.0	2.6	1.4	0.5	0.5	1.1	0.7	0.6	0.7	0.2	0.4	
NC Pamlico								19.86	2.61	6.63	4.27	5.85	9.14	5.13	8.17	5.59	30.67	14.14	9.96	3.24	3.94
NEFSC Autumn			0.55	0.96	0.18	0.59	0.39	0.07	0.06	0.31	0.44	0.76	0.99	0.23	0.75	0.93	0.11	0.17	0.38	0.21	0.22

most important measures enacted by the FMP in September 1988 were: (1) a minimum landed fish size of 13 in (33 cm) total length; (2) a requirement for commercial vessels with a summer flounder landings permit to adhere to the minimum landed fish size; (3) a prohibition on retention of summer flounder by foreign fishermen; (4) annually renewable commercial fishery permits; (5) encouragement of states with minimum landed fish and minimum mesh sizes larger than required by the FMP to retain those regulations; and (6) an FMP effectiveness monitoring schedule, under which after three years of FMP implementation the Council would begin to annually examine fishing mortality rates of age 2 summer flounder, with the option to raise the minimum landed size to 14 in (36 cm) if fishing mortality rates increased. Proposed measures to require minimum mesh sizes in the commercial fishery were not approved by NMFS, due to anticipated difficulties in enforcing the mesh regulation at sea.

The Ninth SAW assessment (NEFC, 1989) indicated that summer flounder were over exploited, with fishing mortality greatly exceeding that which would provide the largest long-term equilibrium yield from the fishery. The results of the Eleventh SAW assessment (NEFC, 1990) provided further, more definitive evidence of the severity of overfishing and stock depletion, and prompted the development of Amendment 1 to the FMP in 1990 with two major proposed management measures (MAFMC, 1990). The first was a requirement in the first year following implementation of Amendment 1 for commercial fishery minimum mesh sizes of 5.5 in (140 mm) diamond or 6.0 in (152 mm) square mesh in the codend of the net for vessels retaining 500 lb or more of summer flounder. This requirement was to apply to the entire net in year 2 and subsequent years. The Amendment also proposed that nets with smaller mesh sizes be stowed, lashed down, covered, or otherwise secured when more than 500 lb of summer flounder were retained. These measures were intended to implement a minimum mesh size compatible with the 13 in (33 cm) minimum fish size enacted in the initial FMP, and to begin rebuilding the stock by providing increased protection to the recruiting 1989 and 1990 year classes of summer flounder.

The second proposed measure was an "overfishing definition" for summer flounder, which was required when Code of Federal Regulations Part 602, Guidelines for Fishery Management Plans (602 Guidelines) was enacted in July, 1989. The

602 Guidelines revised National Standards 1 and 2 of the MFCMA, which required conservation and management measures to prevent "overfishing" while achieving "optimum yield" (OY) on a continuing basis, using measures based on the "best scientific information available." Since the MFCMA did not define overfishing, nor did most FMPs, the 602 Guidelines required each FMP to define an objective and measurable definition of overfishing for each stock, and to prepare an annual Stock Assessment and Fishery Evaluation (SAFE) Report to monitor the management of each fishery. The MAFMC proposed the estimate of Fmax = 0.23 from the Eleventh SAW assessment (NEFC, 1990) as the overfishing definition. In February 1991 the NMFS notified the MAFMC that the overfishing definition had been accepted, but that the proposed mesh regulations had been disapproved, due to concerns over enforcement problems.

The FMP requirement to monitor the fishing mortality rate with regard to the overfishing definition provided the impetus for the initiation in February 1992 of a new NEFSC trawl survey. The NEFSC winter survey was designed specifically to provide improved indices of abundance for flatfish, including summer flounder, by sampling the fish during the winter when the populations are concentrated offshore. The winter survey uses a modified 36 Yankee trawl that differs from the standard trawl employed during the NEFSC 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. 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, and more accurate indices of abundance, compared to the NEFSC other surveys (Figures 1–3).

The 1991 Thirteenth SAW Assessment

By 1991, the poor status of the summer flounder stock was clearly evident to scientists, managers, and fishermen alike. The 1991 assessment, which included commercial landings and recreational catches through 1990, was reviewed at the Thirteenth SAW in December 1991 (NEFSC, 1992). Commercial landings in 1990 declined to 4,200 mt (9.3 million lb) in 1990, a decrease of about 75% from the peak in 1979,

while recreational landings in 1990 were 2,400 mt (5.3 million lb), higher than in 1989 but far below the 1983 peak of 12,300 mt (27.1 million lb). NEFSC stock biomass indices increased slightly from the low index of 1989, and survey recruitment indices indicated that the 1989 and 1990 year classes were only somewhat larger than the poor 1988 year class (Tables 4–5). The VPA again included fishery landings at ages 0 to 5+, with data for 1982–1990, and was calibrated with NEFSC spring survey catch at age, Massachusetts Division of Marine Fisheries (MADMF) spring and autumn survey catch at age, Connecticut Department of Environmental Protection (CTDEP) survey catch at age, standardized (for changes in fishing power over time) commercial fishery CPUE at age, standardized recreational fishery CPUE at age, and recruitment indices from surveys conducted by the states of Massachusetts, Delaware, Virginia, and North Carolina. Discards from the commercial fishery were calculated for the first time, and were estimated to be 10–20% of the total commercial catch, but since only two years of discard estimates were available they were not included in the VPA.

The Thirteenth SAW VPA indicated that fishing mortality rates on fully recruited ages (2+) had generally exceeded 1.0 between 1982–1990, with the 1990 value at F = 1.1, nearly five times the estimated value of Fmax = 0.23. Spawning stock biomass was low and the age composition of the stock very truncated, with few fish older than age 3. The fishery was judged to be largely dependent on incoming recruitment, and the marked decline in fishery landings between 1988 and 1990 was attributed to the recruitment of the poor 1988 year class. Forecasts of catch and stock sizes in 1991–1993 were made assuming recruitment at the geometric mean of the 1986–1990 year classes and fishing mortality at the 1990 level. The forecasts indicated that some near-term stock rebuilding might occur from the historical low in 1990, but the stock would remain lower than in any year before 1989. The Thirteenth SAW concluded that the stock was overexploited with respect to the Amendment 1 overfishing definition, that total stock size was low, and that fishing mortality rates needed to be reduced to rebuild the spawning stock biomass and age structure (Table 3).

Amendment 2 to the FMP

Amendment 2 to the FMP was drafted jointly by ASMFC and MAFMC during the summer of 1991,

and implemented in August 1992 (MAFMC, 1992). This Amendment enacted several major regulatory provisions, including commercial quotas and recreational harvest limits to be specified annually, a moratorium on commercial fishing vessel permits, a framework system of annually adjustable commercial fishery regulations including minimum landed fish size limit, minimum mesh size limits, and various other gear restrictions (e.g., requirements for stowage of nets with small mesh, other specifications for commercial nets), and a framework system of annually adjustable recreational fishery regulations including possession limits, minimum landed fish size limit, and seasonal closures. Under Amendment 2, the commercial quota was allocated to the states based on the proportion of total commercial landings in each state during 1980-1989, while the recreational fishery harvest limit was applied coast-wide.

During the first full year (1993) of management under Amendment 2, the commercial fishery minimum size remained at the 13 in (33 cm) minimum size set under Amendment 1. The minimum commercial mesh size was set at 5.5 in (140 mm) diamond or 6.0 in (152 mm) square mesh in the trawl codend for vessels retaining 100 lb or more of summer flounder. No other mesh sizes were allowed on board a vessel if this threshold was exceeded. An exemption to the mesh requirement was allowed for vessels fishing east of a irregular demarcation line drawn approximately from Pt. Judith, RI, south to Hudson Canyon at the edge of the continental shelf. During 1 November through 30 April, vessels east of this line engaged in offshore winter trawling with small (<5.5 in) mesh were allowed to retain more than 100 lb of legal sized (> 13 in) summer flounder. The recreational measures implemented in 1993 were a 14 in (36 cm) minimum landed size, a 6 fish possession limit, and a fishing season from 15 May to 30 September. These measures applied in both the federal EEZ and state waters.

Amendment 2 also implemented a stock rebuilding strategy to reduce fishing mortality to F = 0.53 (to about 50% of the F for 1990 estimated in the Thirteenth SAW assessment) in the first year of the management program (1993) and to maintain that fishing mortality in years 2 and 3 (1994–1995). In year 4 (1996) and subsequent years, the target F was to be the overfishing definition, Fmax = 0.23. To monitor the effectiveness of the FMP in attaining the annual target fishing mortality rates, a Summer Flounder Monitoring Committee (SFMC) was established, with representatives from the MAFMC, New England Fishery

Management Council (NEFMC), South Atlantic Fishery Management Council (SAFMC), NMFS Northeast Regional Office (NERO), NEFSC, ASFMC, and interested Atlantic coast states. The SFMC was charged with annually reviewing the status of the stock and the performance of the fishery, and to recommend to the ASMFC and MAFMC management measures to ensure that the annual target fishing mortality rates were not exceeded. The ASMFC/MAFMC considered these scientific recommendations in crafting final management measures for approval and implementation by NMFS.

Amendment 2 had profound effects on the assessment and management process for summer flounder. Peer reviewed stock assessments – vetted through either the SAW, MAFMC Scientific and Statistical Committee (SSC), or SMFC – were now expected to be made annually to track the effectiveness of the FMP and to set annual quotas. Scientific advice provided by the assessment peer review process was subsequently interpreted and often modified by the management and regulatory bodies in formulating annual management measures. The degree of interaction and tension between scientists and managers increased as managers sought to implement the highest quotas that could be justified by the assessment science. User and advocacy groups also began to play an increasingly larger role in influencing the annual management measure specifications. This interplay of science and management activities was to result in much ensuing controversy and, beginning in 1993, a string of litigation resulting from perceived inequities by user and advocacy groups.

The 1993 16th SAW Assessment

The stock assessment of 1993, reviewed by the 16th SAW in June 1993 (NEFSC, 1993), was the first to provide scientific advice under the management framework established by Amendment 2 to the FMP. The fisheries had started in earnest by the time the assessment was reviewed, and were operating under an interim 1993 Total Allowable Landings (TAL) of 9,400 mt (20.7 million lb) suggested by preliminary updates of the Thirteenth SAW VPA and forecast (NEFSC, 1992). The 9,400 mt TAL represented a 13% decrease from the 10,771 mt (23.7 million lb) landed in 1992 (Table 6).

The 16th SAW assessment included commercial and recreational catches and survey indices through 1992. Commercial landings in 1992 reached 7,500 mt (16.5 million lb), while recreational landings in 1992 totaled 3,400 mt (7.5 million lb). NEFSC stock biomass indices in 1992 were significantly higher than the low values of 1989, but were still only about 40% of the peak values observed in the mid 1970s (Table 4). Most of the survey recruitment indices reflected improved recruitment since the poor year class of 1988 (Table 5).

The VPA included fishery catch at ages 0 to 5+, with data for 1982–1992, and was calibrated with survey abundance indices. The commercial and recreational fishery standardized CPUE indices that were used in the 1991 Thirteenth SAW VPA were excluded because trends in the error residuals were observed in preliminary runs of the 16th SAW VPA, indicative of possible changes in catchability over time that could bias the results. Estimates of commercial fishery discards were included in the VPA catch at age for the first time, for the years 1989–1992. Another new addition to the assessment was the calculation of bootstrapped (Efron, 1982) estimates of current year spawning stock biomass and fishing mortality rate to provide managers with confidence intervals for these important parameters.

The 16th SAW VPA indicated that fishing mortality in 1992 on fully recruited ages (2+) had declined from peak levels in 1988–1989, but was still very high at F = 1.1. The bootstrap calculations indicated a 95% probability that fishing mortality in 1992 was higher than the target for 1993 of F = 0.53, suggesting that a substantial reduction in TAL would be needed in 1993 to meet the target. Spawning stock biomass on 1 November 1992 was estimated to be 15,000 mt, (2.5 times larger than the 1989 low of 5,600 mt), but only about 11% of the spawning stock was composed of fish aged 3 and older. The SAW noted that at the overfishing definition level of Fmax = 0.23, about 77% of the equilibrium spawning stock biomass would be comprised of fish ages 3 and older. The stock was judged to be overfished, and the fishery still largely dependent on incoming recruitment (Table 3).

Catch and stock size forecasts for 1993–1995 were made assuming that the TAL of 9,400 mt (20.7 million lb) would be attained in 1993, along with associated discards. This resulted in a forecasted fishing mortality rate in 1993 of F = 0.48, a drop of 56% from the 1992 VPA estimate of F = 1.1. Fishing mortality in 1994–1995 was then assumed to be the FMP target for these years of F = 0.53. The forecast was made assuming three different recruitment levels (stock size

Table 6. Summary of summer flounder initial Total Allowable Landings (TAL), reported landings, projections, and subsequent estimates of the fully recruited fishing mortality rate (F; presented for ages 2–4 for consistency across assessments; note that fully recruited F was calculated for ages 2–4 in SAW 11 to SAW 25 assessments, for ages 3–4 in the MAFMC SSC assessment, and for ages 3–5 in the SAW 31 assessments, due to changes in the partial selection at age over time). Terminal catch years presented as year T, and subsequent corresponding initial TAL and reported landings as year T+1. For example, the SAW 16 assessment included catch through 1992, and the corresponding initial TAL and reported landings for 1993 were 9,400 mt and 9,199 mt. TAL and landings in metric tons (mt)

Assessment	Terminal catch year	Forecast landings/ initial TAL	Reported landings	Terminal year F estimate	Projected year F estimate	31st SAW terminal year F estimate	31st SAW projected year F estimate	Percent difference in F (31st SAW minus assessment terminal year)	Percent difference in F (31st SAW minus assessment projection year)
	Year T	Year T+1	Year T+1	Year T	Year T+1	Year T	Year T+1		
SAW 11	1988	9,700	9,560	F88 = 1.42	F89 = 1.42	F88 = 1.93	F89 = 1.90	36%	34%
SAW 13	1990	12,330	9,835	F90 = 1.07	F91 = 1.07	F90 = 1.34	F91 = 1.32	25%	23%
SAW 16	1992	9,400	9,199	F92 = 1.08	F93 = 0.48	F92 = 1.68	F93 = 1.10	56%	129%
SAW 18	1993	12,100	10,699	F93 = 0.54	F94 = 0.77	F93 = 1.10	F94 = 1.07	104%	39%
SAW 20	1994	10,180	9,473	F94 = 0.69	F95 = 0.50	F94 = 1.07	F95 = 1.16	55%	132%
SAW 22	1995	8,400	10,474	F95 = 1.50	F96 = 0.52	F95 = 1.16	F96 = 0.88	–23%	69%
SAW 25	1996	7,162	9,372	F96 = 0.99	F97 = 0.40	F96 = 0.88	F97 = 0.63	–11%	58%
MAFMC SSC	1998	8,400	8,630	F98 = 0.46	F99 = 0.31	F98 = 0.47	F99 = 0.35	2%	13%
SAW 31	1999	8,400	n/a	F99 = 0.35	F00 = 0.24	F99 = 0.35	F00 = 0.24		
Post SAW 31	1999	12,116	n/a	F99 = 0.35	F00 = 0.39				

at age 0) for 1993–1995: at the geometric mean of the 1988–1992 year classes (33.9 million fish), and at one standard error above (50.5 million fish) and one standard error below (22.7 million fish) the geometric mean (the intervals are not symmetrical due to the logarithmic re-transformation). The alternative recruitment scenarios were intended to provide managers with an idea of the sensitivity of the forecasts to the input recruitment assumptions. The forecasts indicated that, at the geometric mean recruitment, the 1994 target F (0.53) would be achieved with a TAL of 14,400 mt (31.8 million lb). The 'one standard error below' forecast for 1994 was 12,100 mt (26.7 million lb), and the 'one standard error above' forecast was 17,000 mt (37.5 million lb).

The 16th SAW expressed concerns that the landings forecast for 1994 at the target F = 0.53 might be too optimistic, given the uncertainty of the 1993 stock size estimates, the forecasted 56% drop in F in 1993 (which seemed unlikely to some SAW participants), and the need to make assumptions about future recruitment, since no survey indices of the strength of the 1993 year class were yet available. The 16th SAW therefore recommended that the forecasts be considered with caution, and advised that adoption of a TAL for 1994 that was lower than the forecasted 14,400 mt (31.8 million lb) would be a risk-averse strategy that would improve chances that the fishing mortality target in 1994 would be met. The MAFMC and NMFS heeded the 16th SAW's concerns, and established a 12,100 mt (26.7 million lb) TAL for 1994, corresponding to the conservative (one standard error below the geometric mean) recruitment assumption for the 1993 year class (Table 6). This attempt to manage the summer flounder fishery in a risk averse fashion was the impetus for the first summer flounder lawsuit filed in 1993.

Early in 1994, it was realized that the final 1993 commercial landings (5,715 mt, 12.6 million lb) were about 2% higher than the quota (5,600 mt; 12.4 million lb), and so the commercial quota for 1994 was reduced to correct for the overage, as required under Amendment 2. The recreational fishery also exceeded its harvest limit for 1993 (by about 5%) but the overage was not subtracted from the 1994 recreational harvest limit, as Amendment 2 was silent on the matter of recreational fishery overages. Inconsistency in handling quota/harvest limit overages would prove to be a major source of continuing friction and controversy between user groups in future quota setting negotiations.

Amendments 3, 4, 5, and 6 to the FMP

Shortly after implementation of Amendment 2 in late 1992, the MAFMC developed a series of additional Amendments to address problems created by the measures in Amendment 2. Amendments 3, 4, 5, and 6 were subsequently implemented during 1993 and 1994. Amendment 3 (MAFMC, 1993a) was developed in response to concerns that the demarcation line for the small mesh exempted fishery bisected Hudson Canyon, disrupting the commercial fisheries in the area and creating enforcement problems. To resolve these problems, Amendment 3 moved the demarcation line westward to place all of Hudson Canyon in the exempted area. In addition, the possession threshold requiring the use of large mesh (= >5.5 inch diamond mesh) was increased to 200 lb during 1 November to 30 April.

Under Amendment 2 the state shares of the annual commercial quota were based on the reported landings during 1980–1989. During 1993, it was noted that during the early and mid 1980s, the state of Connecticut did not have the authority to collect landings data from offshore fishermen, nor did NMFS provide a port agent to the state. As a result, Connecticut officials contended that the State's commercial summer flounder landings during 1980–1989 were underreported, and therefore its quota share was too small. Amendment 4 (MAFMC, 1993b) increased Connecticut's share of the commercial summer flounder quota from 0.95% to 2.26%.

In 1993, the first year the summer flounder quota was implemented, many commercial fishermen who had traditionally landed their catch in their home state changed their behavior and began to land summer flounder in other states to take advantage of more favorable trip limits and/or available quota for individual states. This reduced the quota available to fishermen who traditionally landed their catch in their home states. Amendment 5 (MAFMC, 1993c) allowed two or more states, with the consent of NMFS, to transfer or combine their summer flounder commercial quota.

Fishery managers and the U.S. Coast Guard (charged with the at-sea enforcement of federal fishery regulations) had long standing concerns with the effectiveness of minimum mesh size regulations in the commercial fishery. Many fishermen, particularly those in the "mixed trawl fishery" in which a variety of small mesh sizes are traditionally used to capture squid, whiting, butterfish, and summer flounder,

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asserted that the "one mesh on board" provisions of Amendments 2 and 3 presented an undue hardship for them by limiting their fishing options once at sea. Amendment 6 to the FMP (MAFMC, 1994) allowed multiple nets onboard fishing vessels (even if the minimum mesh retention threshold was exceeded) providing such nets were appropriately stowed, so that they were not "available for immediate use."

The Fishermen's Dock et al., 1994 Lawsuit

The initial 1993 summer flounder commercial fishery quota (5,600 mt; 12.4 million lb), which represented a 25% reduction from the 1992 commercial harvest (7,529 mt; 16.6 million lb), was deemed too restrictive by many in the commercial fishing industry. Four commercial fishing industry groups, the Fishermen's Dock Cooperative of New Jersey, the Wanchese Fish Company of North Carolina, the Belford Seafood Co-operative of New Jersey, and the Seafarer's International Union of North America (the Plaintiffs), together filed a lawsuit in the U.S. District Court of the District of Columbia against the U.S. Department of Commerce (DOC), the parent agency of NMFS, to set aside the 1993 quota. The District Court was unable to hear the 1993 case until December 14, 1993, and at that time found the matter moot because the effective period of the 1993 quota was to expire on December 31, 1993.

The Plaintiffs filed a new lawsuit on April 5, 1994, in a different court, the U.S. Eastern District Court of Norfolk, Virginia, to set aside the 1994 commercial fishery quota of 7,260 mt (16.0 million lb; 60% of the TAL of 12,100 mt [26.7 million]; USDC, 1994). The Plaintiffs contended that the commercial quota for 1994 violated the MFCMA Standard 2, which requires that the best scientific information available be used in management, when the MAFMC recommended and NMFS approved the 1994 quota using a conservative assumption (one standard error below the mean; see the 16th SAW Assessment above) about recruitment in 1994 and subsequent years. The Plantiffs therefore claimed that the 1994 quota was "arbitrary and capricious." The Plaintiffs also claimed that the meetings at which the decisions on the recommended quota were made, including the 16th SAW and subsequent SFMC and MAFMC meetings, were not open to the public as required by law. After hearing motions from both parties requesting a summary judgement on the matter (wherein the judge reviews documentation presented by the parties and renders an opinion), the Court

ordered the parties to prepare further evidence for a hearing to decide the issue of whether the defendant's designees (i.e., NMFS) had used the best scientific information available in setting the 1994 summer flounder commercial fishery quota. The court hearing (bench trial) commenced on October 17, 1994.

The Chair of the SAW Summer Flounder Working Group, who led the preparation of the 16th SAW assessment that served as the basis for the 1994 quota, testified before the court as a witness for the DOC. The Chair of the SAW Working Group explained to the Court the process of compiling the fisheries and survey data, the VPA modeling exercise, and the assumptions about catch and recruitment used in making the forecast that was the basis for the 1994 quota. After hearing the testimony of scientists from both parties, the Court opined on the appropriate commercial fishery discard mortality rate, instantaneous natural mortality rate, and the degree of risk to be assumed in forecasts of catch and stock size when setting the summer flounder quota.

On November 4, 1994, the Court concluded that the NMFS had rejected the best scientific information available at the time the 1994 summer flounder quota was set. The Court also concluded that by using a conservative recruitment assumption to determine the 1994 quota, the NMFS had "acted arbitrarily and capriciously and the quota must be invalidated." In ruling in favor of the Plaintiffs, the Court ordered "that the 1994 summer flounder commercial catch quota be invalidated to the extent that it is less than 19.05 million pounds" (USDC, 1994). The NMFS was ordered to reset the quota in a manner consistent with the Court's opinion – to institute a commercial quota corresponding to the 16th SAW assessment forecast assuming geometric mean recruitment (i.e., a commercial quota of 8,640 mt (19.05 million lb), 60% of the 14,400 mt (31.7 million lb) TAL). In subsequent negotiations between the Court and the parties in the lawsuit, it was concluded that it would not be possible for the NMFS to implement the Court ordered increase during calender year 1994. It was agreed that the 3.05 million lb difference between the original 1994 commercial quota (16.0 million lb) and the Court ordered quota (19.05 million lb) would be added to the 1995 commercial fishery quota. The NMFS appealed the decision to U.S. Circuit Court of Appeals for the Fourth Circuit, and the original decision was reversed on February 4, 1996 (USCA, 1996). The NMFS declined to rescind the quota increase however, since the District Court ordered additional 3.05 million lb of

fish had been landed by the commercial fishery during 1995.

The Fishermen's Dock et al., lawsuit brought about unprecedented public consideration and scrutiny of the stock assessment data, assumptions and models, and the fishery management and quota setting process. In the aftermath, the growing mistrust and misunderstanding between the commercial fishing industry, managers, and scientists was revealed in published accounts and opinions of the lawsuit. A guest columnist in a major commercial fisheries publication, questioning the advised need for rebuilding of the summer flounder spawning stock biomass, wrote, "Given that there is a quota – an overall cap on mortality – and minimum mesh size to let the little ones go, not to mention the long-standing gripe by NMFS scientists that there need to be more old fluke in the Atlantic, it is beyond comprehension as to what exactly the problem is." That columnist further added, in reference to NMFS scientists, "... those experts do not trust the council members to necessarily do the 'conservationally correct' thing" and "Numbers and data were selectively presented to the council" (Gehan, 1995). A Cape Cod newspaper columnist wrote, "... NMFS first used a number of ultraconservative assumptions to estimate stock size, and then subtracted even more to account for 'standard error' ..." and "The art of fish stock assessments is a tough science with a poor record of success. It gets even tougher when you can't believe the people doing it have good intentions at heart" (Benjamin, 1995). In the Fishermen's Dock et al., case, the District Court found that a risk-averse approach to managing the fishery in the face of scientific uncertainty had been arbitrary and capricious. The issue of the level of risk to be used in setting the summer flounder quota was one that would be re-visited in future lawsuits.

The 1994 18th SAW Assessment

As scientists, managers, and fishermen awaited the District Court's decision in the Fishermen's Dock lawsuit, an updated stock assessment was reviewed by the 18th SAW in June 1994 (NEFSC, 1994). The 18th SAW assessment included commercial and recreational catch through 1993. This was the first summer flounder assessment in which the performance of the various management measures implemented under Amendment 2, including the commercial fishery quota and recreational fishery harvest limit, could be explicitly evaluated.

In 1993, reported commercial landings (5,715 mt, 12.6 million lb) were about 2% higher than the quota (5,640 mt; 12.4 million lb), while recreational landings (3,484 mt; 7.7 million lb) were about 7% below the harvest limit (3,760 mt; 8.3 million lb). Together, the fisheries landed 9,199 mt (20.3 million lb), or 98% of the 1993 TAL. NEFSC survey abundance indices had increased significantly from the low values of 1989, but were still only about 40% of the peak values observed in the mid 1970s, and had been stable at that level since 1991 (Table 4). Most of the survey recruitment indices indicated that the size of the 1993 year class, which had been one of the main points of contention in the Fishermen's Dock lawsuit, would be the smallest since 1988 (Table 5).

The 18th SAW VPA results indicated that the fishing mortality rate on fully recruited ages (2+) had declined markedly under the first year of quota management, from a very high value of $F = 1.69$ in 1992 to $F = 0.54$ in 1993, essentially equal to the target fishing mortality of $F = 0.53$. Spawning stock biomass on 1 November 1993 was estimated to be 14,000 mt, about 63% of the peak estimated for 1983 (22,200 mt; Table 3). The estimate of spawning stock biomass for 1992, however, had been revised downward significantly, from 15,000 mt in the 16th SAW assessment to 11,600 mt. Although the stock was judged to be overfished, and at an average level of abundance, the assessment results suggested that the TAL limit and other management measures had been effective in reducing fishing mortality to the target in 1993 (Table 3). These results were received with much satisfaction by scientists and managers, who were pleased that the 1993 target fishing mortality was achieved. The good feelings would last only until the next assessment, however. The downward revision in the estimate of the 1992 spawning stock biomass proved to be an early warning sign of future problems in the assessment.

Catch and stock size forecasts for 1994–1996 were made assuming that the 1994 TAL of 12,100 mt (26.7 million lb; Table 6) would be harvested, along with associated discards. The forecasts indicated that to meet the target $F = 0.53$ in 1995 at the geometric mean recruitment, the 1995 TAL would have to be reduced 27% to 8,800 mt (19.4 million lb). The MAFMC and NMFS accepted the 18th SAW recommendation for a 1995 TAL corresponding to the geometric mean recruitment assumption for the incoming year classes. The 3.05 million lb (1,380 mt) increase in the commercial fishery quota ordered by the District Court in the

Fishermen's Dock et al., lawsuit was added to the commercial quota. The final 1995 TAL was 10,180 mt (22.4 million lb), about 15% higher than the 18th SAW recommendation.

The 1995 20th SAW Assessment

The 20th SAW assessment included commercial and recreational catches through 1994 (NEFSC, 1996a). Reported 1994 commercial landings (6,588 mt, 14.5 million lb) were about 7% below the final, adjusted quota (7,076 mt; 15.6 million lb), while estimated recreational fishery landings were 4,111 mt (9.1 million lb), 15% below the harvest limit of 4,840 mt (10.7 million lb). Together, the fisheries landed 10,699 mt (23.6 million lb), or 90%, of the 1994 TAL. New estimation methods (incorporating different sample weighting and data quality control procedures) resulted in a revision of the time series of recreational catch for 1981–1994, with revised estimates differing from the original estimates by −32% (1984) to +2% (1991). NEFSC survey abundance indices remained stable, near the 1991–1994 values (Table 4). Most of the survey recruitment indices indicated that the 1994 year class was larger than the 1993 year class (Table 5).

The SAW reviewed alternate estimates of the rate of natural mortality (M) used in the assessment, and felt that the value of M = 0.2 used in previous assessments was still reasonable given the mean (0.23) and range (0.15–0.28) obtained from a variety of estimation methods. The 20th SAW VPA results indicated that the fishing mortality rate on fully-recruited ages (2+) had declined from 1.8 in 1992 to 0.8 in 1993 and to 0.7 in 1994. The estimate for 1994 was in line with the forecast from the 18th SAW Assessment, which had projected a value of F = 0.77 in 1994 if the 1994 TAL were landed. Spawning stock biomass on 1 November 1994 was estimated to be 14,800 mt, about 67% of the 1983 peak (22,200 mt). The 20th SAW concluded that the stock was at a medium level of historic abundance but was still overexploited (Table 3).

For the 20th SAW Assessment, a new assessment model was available to make stochastic projections that incorporated both the variability in 1994 stock size estimated by the VPA bootstrap procedure, and variability in future recruitment based on past trends. Catch and stock size forecasts for 1995–1998 were made assuming that the final 1995 TAL of 10,180 mt (22.4 million lb) would be harvested, along with

associated discards. This assumption resulted in a forecasted fishing mortality rate in 1995 of F = 0.50, a decrease of 29% from the 1994 VPA estimate of F = 0.7, and below the target for 1995 of F = 0.53. With the new stochastic model, the forecasts were made with recruitment levels (stock size at age 0) for 1995–1998 generated randomly from the VPA recruitment estimates for 1990–1994. The forecasts indicated that a 35% decrease in TAL in 1996 to 6,600 mt (14.6 million lb) would be necessary to meet the target F = 0.23 (Table 3).

The total stock size estimates of the 20th SAW assessment were lower in all years than those estimated in the 18th SAW assessment, due to the predominantly downward revisions in the recreational fishery catch estimates (in the VPA model, if all other inputs remain constant, the magnitude of the catch determines the magnitude of the stock size; fishing mortality rates may not drop, however, depending on the patterns of the changes in catch at age). This was the result expected by scientists, but the change caught some managers by surprise. Very detailed presentations of the 20th SAW assessment results at subsequent NEFSC and MAFMC public meetings were necessary to help managers and fishermen understand the changes that had been incorporated in the assessment.

Of more concern to the scientists working on the assessment were the results of a retrospective analysis of the VPA. Retrospective analysis is the examination of the consistency between successive estimates of stock size and fishing mortality rates as new data are added to the model. Either the actual results from an historical series of assessments are examined (historical retrospective), or a given analysis is repeated for an increasingly shorter time series (by truncating the end of the series) to reproduce what would have been estimated annually using the current data and method (internal retrospective). In the 18th SAW Assessment, it had been noted that the estimate of the spawning stock biomass in 1992 had been reduced significantly compared to the 16th SAW Assessment – a manifestation of an historical retrospective pattern. This historical retrospective pattern was also evident between the 18th and 20th SAW assessments, with the 1993 fishing mortality increasing from 0.54 to 0.83, and the 1993 spawning stock biomass estimate declining from 14,000 mt to 10,500 mt. The 20th SAW further noted that the summer flounder VPA showed evidence of an internal retrospective pattern for at least the three most recent years (1991–1993), in

which fishing mortality was underestimated and stock sizes were overestimated, when the terminal (last) year of data was sequentially removed from the analysis. The previous VPA results and short term forecasts had indicated that the annual fishing mortality targets were being achieved – for example, the 18th SAW VPA had indicated a 1993 F = 0.54, just 2% over the target – but the 20th SAW assessment indicated that the management measures clearly had not been successful in achieving the target (20th SAW 1993 F = 0.8). The 20th SAW noted that the VPA exhibited this retrospective pattern, but concluded that the source of the pattern could not be identified with confidence. The severity of these retrospective problems would increase in the following two assessments.

Amendment 7 to the FMP

The 18th SAW Assessment forecasts had indicated that a substantial reduction of 27% in the 1994 TAL would be needed to achieve the target fishing mortality for 1995 (F = 0.53) established by Amendment 2. While the 20th SAW Assessment was being developed and reviewed during summer 1995, it became apparent that the target fishing mortality for 1994 would not be achieved. When finalized, the 20th SAW Assessment forecast indicated that a 35% decrease from the 1995 TAL to 6,600 mt (14.6 million lb) in 1996 would be necessary to meet the target F = 0.23 (Table 3). Managers concluded that such a reduction would create unacceptable economic hardship for fishery participants. Amendment 7 to the FMP was implemented in November 1995 to revise the fishing mortality rate reduction schedule specified in Amendment 2, slowing the rate of reduction to alleviate short-term economic losses in the fishery, and allowing for a more stable TAL from one year to the next. The target fishing mortality rates were revised to be F = 0.53 in 1995, F = 0.41 in 1996, F = 0.30 in 1997, and F = 0.23 in 1998 and beyond. Amendment 7 also specified that the TAL for 1996 and 1997 could not exceed 8,400 mt (18.5 million lb) unless fishing mortality was forecast to be below F = 0.23 (MAFMC, 1995). In spite of the revision in the fishing mortality rate reduction schedule, many in the commercial fishing industry felt that the cap on TAL for 1996–1997 would be too restrictive. Commercial fishermen believed that the stock was much larger than indicated by the assessment, and that a higher TAL would in fact result in fewer discards, rather than an increased mortality rate. Meanwhile, environmental advocacy groups opposed Amendment 7 because they felt that relaxation of the mortality rate reduction schedule would serve to prolong overfishing and risk undoing the stock rebuilding that had already been achieved (Federal Register, 1995).

The 1996 22nd SAW Assessment

The 22nd SAW assessment included commercial and recreational catches through 1995 (NEFSC, 1996b). Reported 1995 commercial landings (6,977 mt, 15.4 million lb) were about 5% above the quota (6,627 mt; 14.6 million lb), and estimated 1995 recreational landings of 2,496 mt (5.5 million lb) were 29% below the harvest limit of 3,520 mt (7.8 million lb). Together, the fisheries landed 9,473 mt (20.9 million lb), or 93%, of the 1995 TAL. NEFSC survey abundance indices increased substantially from 1995 to 1996, mainly reflecting recruitment of the 1994 year class to the adult stock (Table 4). Most of the survey recruitment indices indicated that the 1995 year class was even larger than the 1994 year class, and was the best since 1983 (Table 5).

The 22nd SAW VPA results indicated that the fishing mortality rate on fully recruited ages (2+) exceeded 1.0 between 1982–1995, peaked at F = 2.2 in 1992, and declined to 1.3 in 1994 and 1.5 in 1995. This was three times higher than the fishing mortality rate forecasted for 1995 by the 20th SAW Assessment. Spawning stock biomass on 1 November 1995 was estimated to be 15,200 mt, about 80% of the peak in 1983 (18,944 mt). The 22nd SAW concluded that the stock was at a medium level of historic abundance and was overexploited. The forecasts indicated that the TAL could increase to 9,300 mt (20.5 million lb) in 1997 and meet the target F = 0.30 in 1997 (Table 3).

The results of the 22nd SAW VPA provoked outrage from managers and fishermen, who could not comprehend how the fishing mortality estimates for 1994 (F = 1.3) and 1995 (F = 1.5) could be so much higher than those calculated in the 20th SAW Assessment (F calculated at 0.7 for 1994, F forecast at 0.50 for 1995). For the scientists working on the summer flounder assessment, the 'retrospective chickens' had come home to roost. Several factors combined to produce much higher estimates of fishing mortality and much lower estimates of stock size in the 22nd SAW VPA compared to those of the 20th SAW assessment. Mathematically, the major cause of the changes was the inclusion of two additional years of survey data (1995–1996) and an additional

year of catch data (1995) in the 22nd SAW VPA. The age structure of both of these data sets indicated a much lower abundance at ages 2 and older than had been forecast, and thus a higher mortality rate and smaller stock size. Furthermore, as in the 20th SAW Assessment, an internal retrospective pattern continued to be evident in the VPA, with a tendency for fishing mortality to be underestimated and stock size overestimated. The SAW concluded that underestimation of the true catch was a plausible cause of the continuing retrospective problems in both the summer flounder VPA and the forecasts. Unreported landings and increased discarding associated with management measures implemented under Amendment 2 were identified as possible sources of the missing catches. The SAW recommended that future quotas should be set with consideration of the direction and magnitude of the analytical bias, assuming that current and projected fishing mortality rates would be underestimates. The SAW advised that further reductions in exploitation would be needed to meet even the relaxed Amendment 7 fishing mortality targets (NEFSC, 1996b).

The 1997 25th SAW Assessment

Controversy over summer flounder science continued with the completion of the 1997 25th SAW assessment. Retrospective bias in the VPAs and forecasts had caused fishing mortality to be underestimated for the most recent years of previous assessments. In addition, between the 22nd and 25th SAWs, it was apparent that there were problems in determining the age of summer flounder sampled. Intersessional work brought to light inconsistencies in age determinations for fish of the same length between NEFSC age readers (responsible for aging the Maine to Virginia commercial fishery samples and NEFSC research vessel samples) and NCDMF age readers (responsible for the North Carolina commercial fishery samples). During early 1996, cooperative research was conducted between the two agencies to resolve these problems, and eventually, all of the 1995–1997 summer flounder samples were re-aged in preparation for the 25th SAW assessment.

The 25th SAW assessment included commercial and recreational catches through 1996 (NEFSC, 1997). Reported 1996 commercial landings (5,770 mt, 12.7 million lb) were 18% above the quota (4,900 mt; 14.6 million lb; adjusted for 1995 overages), and estimated 1996 recreational landings were 4,704 mt (10.4 million lb), about 40% below the harvest limit

of 3,360 mt (7.4 million lb). Together, the fisheries landed 10,474 mt (23.1 million lb), 27% above the final, adjusted 1996 TAL of 8,260 mt (18.2 million lb). NEFSC survey abundance indices generally declined from 1996 to 1997 (Table 4). Most of the survey recruitment indices indicated that the 1996 year class was not as large as the 1995 year class (Table 5).

The 25th SAW VPA results indicated that the fishing mortality rate on fully recruited ages (2+) had peaked at F = 2.1 in 1992, and declined to 1.2 in 1994, 1.1 in 1995, and 1.0 in 1996. The 1996 F was two times higher than the fishing mortality rate that had been forecast by the 22nd SAW Assessment. Spawning stock biomass on 1 November 1996 was estimated to be 17,402 mt, about 92% of the peak in 1983 (18,939 mt). As in the 22nd SAW Assessment, a retrospective pattern was evident in the 25th SAW VPA results, with fishing mortality underestimated and stock size overestimated for the years 1991–1993. However, the pattern was reversed and reduced in magnitude for the 1994–1995 values, leading to hope that better accounting of landings and discards had reduced the retrospective bias in the assessment.

Biological reference points were re-estimated using yield per recruit analysis, as the 25th SAW concluded that recent management measures had generated substantial changes in the selection pattern of summer flounder in the fisheries. The re-estimation indicated that Fmax for summer flounder was 0.24, a slight increase from the Eleventh SAW estimate of Fmax = 0.23. The SAW concluded that the stock was at a medium level of historic abundance and was overexploited, and that fishing mortality needed to be reduced to meet the revised fishing mortality target of Fmax = 0.24 in 1998. The SAW also recommended additional measures to minimize commercial and recreational fishery discard mortality (Table 3).

Because of the forecast performance in previous assessments, three landings scenarios for 1997 were used in the catch and stock size forecasts for 1997–1999, to encompass the widely divergent views of the participants of the 25th SAW review. The fishing mortality rates assumed for 1997 were: (1) F = 0.42, assuming that the final 1997 TAL of 7,162 mt (15.8 million lb) would be landed; (2) F = 0.53, assuming that the 1997 TAL would be exceeded by about the same 25% as for the 1996 TAL, resulting in landings of 9,000 mt (19.8 million lb); and (3) F = 1.0, assuming that fishing mortality in 1997 would be the same as in 1996, generating landings of 14,300 mt (31.5 million lb). The SAW advised that if the TAL for

1997 was not exceeded (the first and most optimistic forecast scenario), the 1998 TAL should be 6,276 mt (13.9 million lb) to meet the fishing mortality target of F = 0.24. The SAW again advised that additional measures to minimize commercial and recreational fishery discards should be considered.

The MAFMC did not adopt the SAW advice with regard to the 1998 TAL, and recommended instead a TAL of 8,400 mt (18.5 million lb). Although the TAL had only a 3% chance of achieving the fishing mortality rate target in 1998 (NEFSC, 1997), it was implemented by the NMFS under pressure from the both the commercial and recreational sectors. The NMFS attempted to address the low probability of achieving the target by requiring each state to set aside 15% of its commercial quota allocation for a bycatch fishery and to implement trip limits with the objective of keeping the fishery open all year (Federal Register, 1997). The justification for this action was that the bycatch allocation was effectively a 15% reduction in the commercial quota for the directed summer flounder fishery. The bycatch quota allocation was expected to extend the season, reduce discard waste, and increase the probability of achieving the target fishing mortality.

The NRC Review

A group of North Carolina commercial fishermen was firmly convinced that the 25th SAW Assessment grossly underestimated the abundance of the summer flounder stock. These fishermen claimed that large numbers of older summer flounder were unaccounted for in the assessment, due to survey and commercial fishery sampling inadequacies. The TAL recommended by the 25th SAW to achieve the target fishing mortality rate in 1998 convinced them to take action outside of the usual channels to challenge the assessment and the quota setting process. Working through the office of Senator Lauch Faircloth of North Carolina, the North Carolina commercial fishermen were able to have a review of the summer flounder stock assessment undertaken by the National Academy of Science's National Research Council (NRC). The U.S. Congress requested this one-time study of the assessment by the NRC as part of a conference report that accompanied the Departments of Commerce, Justice, State, and the Judiciary and Related Appropriations Act of 1998. The study was subsequently expanded to reflect NMFS' desire to have the NRC assess methods for improving data for stock assess-

ments and fisheries management in general, with the summer flounder fishery and assessment to be used as a case study for this broader issue. The NRC selected a committee of fishery scientists, statisticians, and fishermen to review the 1997 25th SAW assessment, and then to review the 1999 MAFMC Scientific and Statistical Committee's (SSC) own assessment (as reported in Terceiro, 1999; see below), which was developed while the NRC review was underway. During 1999, the NRC Committee held three public meetings to learn the concerns of commercial and recreational fishermen and environmentalists related to the summer flounder assessments. The report of the NRC Committee was published in November 2000 (NRC, 2000).

The NRC Committee evaluated the summer flounder assessments using different stock assessment models to explore various summer flounder data issues. The NRC Committee's analyses showed the same general trends in fishing mortality and stock size as in the 25th SAW and SSC assessments. However, all of the alternative model estimates of stock biomass were lower than those estimated in the 25th SAW and SSC assessments. While the models varied in their annual estimates of fishing mortality over the 1982–1998 time series (probably due to the different sets of model assumptions), all of the models produced nearly the same estimate of fishing mortality for 1998, the last year of the series (about F = 0.5 in 1998, as in the 1999 SSC assessment). In effect, the results of the summer flounder assessments were validated by the NRC Committee.

The NRC Committee concluded that there was little evidence for the existence of a large number of unsurveyed large summer flounder as claimed by the commercial fishing industry. The NRC Committee recommended an increase in at sea observer sampling of the commercial fishery, to improve the estimate of commercial fishery discards. The NRC committee also recommended that data collection and management systems be implemented to allow in-season management of the recreational fishery, to avoid harvest limit overages that had hindered achievement of the management targets during the late 1990s. The NRC Committee concluded that the scientists conducting the summer flounder assessments should investigate why differences among model estimates exist and whether such differences indicated that changes were needed in the models or model assumptions. Finally, the NRC Committee concluded that managers should be aware of the uncertainty that arises from the

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choice of assessment model and should manage more cautiously, by reducing fishing mortality on summer flounder in the face of such uncertainty (NRC, 2000).

The 1997–1998 North Carolina Seafood Association et al., Lawsuits

Concurrent with the NRC review of the stock assessment, commercial fishermen in North Carolina initiated a series of three lawsuits during 1997–1998 in response to the 1997 and 1998 quotas for the commercial fishery. The North Carolina Seafood Association, Georges Seafood Inc., and the State of North Carolina together brought suit against the DOC challenging the economic evaluation of the 1997 and 1998 quotas and the deduction of 1997 quota overages in North Carolina from the 1998 quota allocation for the state (USDC, 1998). The bases of the lawsuits were twofold. First, that the DOC had submitted inadequate economic analyses (Regulatory Impact Review) in assessing the impact of the reduced quotas on the commercial fishing industry in North Carolina. Second, that the deduction of the 1997 overages came so late in 1998 (in late January and again in April) that they precluded the traditional autumn trawl fishery in North Carolina since the entire initial 1998 quota for North Carolina had already been landed by April. The Plaintiffs requested the 1997 deducted overage be reinstated to allow for an autumn 1998 fishery in North Carolina. The suits were filed in the U.S. Eastern District Court of Norfolk, Virginia, before the same judge who had presided in the 1994 Fisherman's Dock et al., lawsuit.

In a summary judgement, the District Court again ruled in favor of the Plaintiffs, finding that the DOC submitted "arbitrary and capricious" economic analyses in support of the 1997 and 1998 quotas, and had made untimely adjustments to the quota. The Court sanctioned the DOC by returning to North Carolina the 1997 overage of about 400,000 lb (181 mt) that had been deducted from the 1998 quota (USDC 1998). The DOC decided not to appeal the Court's decision and the 1997 overage was added to the 1998 North Carolina quota on October 20, 1998, thereby enabling the autumn trawl fishery to proceed in North Carolina (Federal Register, 1998a).

Amendments 8, 9, 10 and 11 to the FMP

In consideration of the multispecies nature of the demersal fisheries of the Mid-Atlantic Bight (Shepherd and Terceiro, 1994), the MAFMC amended the summer flounder FMP to add management of scup (Amendment 8) and black sea bass (Amendment 9) to the renamed Summer Flounder, Scup, and Black Sea Bass FMP (MAFMC, 1996a,b). Both amendments implemented a number of management measures (quotas and harvest limits, minimum mesh and fish sizes, permit and reporting requirements) for scup and black sea bass comparable to those previously enacted for summer flounder under Amendment 2.

Amendment 10 to the FMP made a number of changes to the summer flounder commercial fishery regulations, by requiring the minimum mesh size throughout the body of the net (not just the codend), continuing the moratorium on commercial vessel permits, removing the expiration provisions of that moratorium, prohibiting transfer of summer flounder landings at sea, and allowing the possession of summer flounder parts smaller than the minimum landed size aboard party and charter vessels (MAFMC, 1997). Amendment 11 to the FMP was developed to reallocate the commercial quota among the states by taking into consideration that different minimum fish size regulations were in effect during the time interval (1980–1989) used to set the shares. Ultimately, the MAFMC was unable to agree on a method to calculate this reallocation, and Amendment 11 was limited to a number of administrative regulations affecting vessel replacements and upgrades, permit history transfers, and permit renewals (MAFMC, 1998).

The 1998 Assessment Update: setting the TAL for 1999

By 1998, it was apparent to all involved that great controversy would continue to surround the annual quota setting process, due to questions about the validity of the science and the equity of the proposed management measures. Public participation and comment on the process had greatly increased since the implementation of the first quota in 1993. Because of the ongoing NRC review and the assistance that this review required from NEFSC staff, a new assessment of summer flounder was not conducted in 1998. Rather, the 25th SAW VPA (NEFSC, 1997) was updated to include the final 1997 and 1998 survey indices and final 1997 and preliminary 1998 catches, and new forecasts were made to determine the TAL in 1999 that would have a 50% probability of achieving the fishing mortality rate target of Fmax = 0.24. The update was performed under the auspices of the

Summer Flounder Monitoring Committee (SFMC), and they recommended a TAL for 1999 of 6,790 mt (15.0 million lb), 19% below the initial 1998 TAL of 8,400 mt (18.5 million lb). The results of the update were summarized in the minutes of the 1998 SFMC meetings, but no published document exists for the 1998 assessment update.

In addition to the inclusion of final survey indices, another important change was made to the VPA during the 1998 update. In previous assessments, the mortality rate of fish released alive in the recreational fishery had been assumed to be 25%, based on experimental results obtained for other species such as black sea bass (Bugley and Shepherd, 1991), striped bass (Diodati and Richards, 1996) and Pacific halibut (IPHC, 1988), and on indirect results from summer flounder tagging studies (Weber, 1984). Over the years, fishery managers and public advisors had contended that the release mortality rate of 25% for summer flounder was too high. As a result, the 25th SAW recommended that research be conducted to determine release mortality rates specific to summer flounder in the Northeast Region (NEFSC, 1997).

Results of three investigations of summer flounder recreational fishery release mortality rates became available during 1998 for consideration by the SFMC. All three studies suggested that a revision in the recreational release mortality rate was appropriate. Lucy and Holton (1998) reported rates ranging from 6% (field trials) to 11% (tank experiments) for summer flounder in Virginia. Malchoff and Lucy (1998) found short-term release mortality averaged 14% for New York and Virginia fish. Gearhart (1999) found an average short-term mortality rate of 7% for fish angled in Virginia and North Carolina. Given these averaged results, a recreational fishery release mortality rate of 10% was assumed for all years in the 1998 assessment update.

In the 25th SAW VPA (under the 25% release mortality rate assumption) recreational fishery discards had accounted for 14.2% of the age 0 catch and 15.5% of the age 1 catch during 1982–1996. In the 1998 update using the 10% release mortality assumption, recreational fishery discards accounted for 6.8% of the age 0 catch and 7.2% of the age 1 catch estimated for these same years. Despite this change, the total catches at ages 0 and 1 in the VPA were reduced by less than 10%, as most of the catch at these ages is landed. The new release mortality rate decreased estimates of fishing mortality on ages 0 and 1 summer flounder by about 4% and 7%, respectively. Popula-

tion numbers at age also decreased, by an average of about 4% for both age groups. This seemingly counter-intuitive result is due to the nature of the VPA model. In the final steps of the VPA calculations, population numbers are scaled to their absolute size by the magnitude of the catches. Thus, with all other important inputs such as the natural mortality rate and survey calibration indices remaining constant, reducing the estimated size of the catches at the youngest ages reduced the estimated population sizes at these ages in a nearly linear fashion.

In a series of public reviews and discussions of the updated 1998 assessment results, simplified examples were presented on the effect of changing the size of the catches at age 0 and 1 fish on the VPA population estimates. Although these effects were very small and were of little significance in terms of achieving management targets or setting the annual TAL, the changes had a very large effect on the public perception of the assessment. The ensuing exchanges between scientists, managers, media, and fishermen generated a number of published comments criticizing summer flounder science and the skills of the assessment scientists. Published remarks such as, "Mark Taursario [*sic*] provided the most bizarre fisheries management explanation of the year . . .," ". . . this means that if we find a cure for cancer and fewer of us die, there will actually be less of us alive . . .," and ". . . any model converting lower mortality into fewer fish has got to be even more screwed up than the rest of the present management system . . ." (Ristori, 1998) characterized the growing anger and mistrust between scientists, managers, and fishermen.

As a result of the opposition by the recreational and commercial fishing industries to the 1999 TAL of 6,790 mt (15.0 million lb) proposed by the SFMC, the MAFMC recommended a 1999 TAL of 9,160 mt (20.2 million lb). The NMFS found this recommendation to be unnecessarily risk-prone because the TAL had only a 3% chance of achieving the target fishing mortality rate (Federal Register, 1998b). As a result, a series of negotiations occurred between the MAFMC and the NMFS in establishing the final TAL for 1999. In the end, the NMFS approved a TAL of 8,400 mt (18.5 million lb; the same as that approved for 1998; eventually adjusted for overages to 8,295 mt), which had an 18% chance of achieving the target fishing mortality rate for 1999. As in 1998, the NMFS attempted to address the low probability of achieving the target by requiring each state to set aside the difference between the SFMC recommendation for the commercial quota

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(4,070 mt; 9.0 million lb) and the approved commercial quota (5,040 mt; 11.1 million lb) as an "incidental catch allocation," and requiring the states to implement measures to ensure allocation of each state's quota to "directed" and "incidental" fisheries (Federal Register, 1998b).

Amendment 12 to the FMP: the SFA overfishing definition

The Sustainable Fisheries Act (SFA) of 1996 amended the MFCMA (renamed the Magnuson-Stevens Fishery Conservation and Management Act; MSFCMA). The SFA made no changes to National Standard 1 of the MSFCMA, which reads: "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry." However, the SFA revised the definition of optimum yield with respect to an overfished fishery, to be the yield that provides for rebuilding to a level consistent with producing the maximum sustainable yield in such a fishery. NMFS published National Standard guidelines to help the Councils interpret the SFA in developing FMPs. These guidelines further defined the usage and meaning of the terms 'overfishing' and 'overfished,' the terms 'fishery' and 'stock,' the rebuilding schedules for overfished stocks, and exceptions for mixed-stock fisheries (Federal Register, 1998c). The NMFS guidelines also provided advice on how the Councils should define maximum fishing mortality thresholds or their proxies, minimum stock size thresholds or their proxies, and rebuilding plan time frames.

Amendment 12 to the FMP, approved in 1999, revised the overfishing definition for summer flounder to bring it into compliance with the SFA (MAFMC, 1999). Overfishing for summer flounder was defined to occur when the fishing mortality rate exceeded the threshold fishing mortality rate of F_{MSY}. Since F_{MSY} could not be reliably estimated for summer flounder, Fmax was used as a proxy for the F_{MSY} threshold, and also as a target fishing mortality rate. Based on the 1997 25th SAW assessment, the threshold and target fishing mortality rate was estimated to be Fmax = 0.24. The summer flounder stock was defined to be overfished when the biomass fell below the minimum biomass threshold of B_{MSY}. Since B_{MSY} also could not be reliably estimated, stock biomass at Fmax based on yield per recruit analysis and average recruitment was used as a proxy. Based on the 1997 25th SAW

yield per recruit analysis and the 1998 assessment update, the minimum stock biomass threshold was defined as 76,650 mt (169 million lb) and the target biomass as 153,300 mt (338 million lb). Discussions between NMFS legal staff and MAFMC staff indicated the biomass target was required to be achieved by 2006 (Christopher M. Moore, personal communication, July 8, 1999).

The NRDC et al., 1999 Lawsuit

The 1999 TAL specification was the second consecutive time that the NMFS implemented or proposed a summer flounder quota that had a very low probability of achieving the annual fishing mortality rate target. This action by NMFS generated significant critical comment from environmental advocacy groups. In 1999, the summer flounder TAL was again challenged in the courts, but this time the environmental community initiated the litigation, and the issue of risk assessment and management in the face of uncertainty took center stage.

The National Resources Defense Council (NRDC), National Audubon Society, Environmental Defense Fund, and the Center for Marine Conservation together filed suit in U.S. District Court for the District of Columbia in late January, 1999 seeking a declaratory judgement that the DOC had violated the MSFCMA in setting the 1999 summer flounder TAL at 8,400 mt, and seeking a remand for a new TAL (USDC, 1999). The NRDC and other Plaintiffs alleged that the 1999 TAL did not provide sufficient assurance that it would meet the conservation goals of the FMP. The 1996 SFA mandatory rebuilding requirements and maximum 10 year rebuilding schedule for overfished stocks, as implemented for summer flounder in Amendment 12 to the FMP (MAFMC, 1999), formed the foundation on which the lawsuit was based. The suit also alleged that the NMFS' conclusion that the proposed 1999 TAL had, "no significant environmental impact" was based on an inadequate environmental assessment, thereby violating the National Environmental Policy Act (NEPA).

The District Court upheld the 1999 TAL, finding that the MSFCMA expressed no clear intent as to the particular level of certainty that a TAL must guarantee to be lawful. The Plaintiffs immediately appealed this decision to the U.S. Court of Appeals. While acknowledging that the 1999 TAL had a low probability of achieving the target fishing mortality when considered alone, the DOC contended that two addi-

tional management measures (i.e., the Amendment 10 requirement for the minimum mesh size to apply throughout the net, and the voluntary set aside of 15% of the commercial quota for bycatch fisheries) sufficiently increased the probability of attaining the target as to make the 1999 TAL valid. The DOC further argued that the 1999 TAL would, "minimize adverse economic impacts" when compared with lower TAL options.

The Court of Appeals disagreed with the DOC arguments, stating that the agency, "must give priority to conservation measures" and that, "It is only when two different plans achieve similar conservation measures that the Service takes into consideration adverse economic consequences." The Court concluded that, "The Service offered neither analysis nor data to support its claim that the two additional measures aside from the quota would increase that assurance beyond the at-least-50% likelihood required by statute and regulation." The Court noted, "The 1999 quota is unreasonable, plain and simple," and "The disputed 1999 TAL had at most an 18% likelihood of achieving the target F. Viewed differently, it had at least an 82% chance of resulting in an F greater than the target F. Only in Superman Comics Bizarro World, where reality is turned upside down, could the Service reasonably conclude that a measure that is at least four times as likely to fail as to succeed offers a 'fairly high level of confidence.'" In ruling in favor of the Plaintiffs, the Court remanded the case to the NMFS for, "further proceedings consistent with this opinion" (USCA, 2000). In effect, the Court set a minimum standard for fishery quotas to comply with the MSFCMA, by requiring at least a 50% chance of achieving target fishing mortality rates.

The 1999 MAFMC SSC Assessment

Both the NMFS and the MAFMC were strongly criticized for not performing a full assessment of summer flounder during 1998 in support of the 1999 quota setting process. By the spring of 1999, most of the NEFSC staff work for the NRC review of the summer flounder assessment had been completed, and the Court of Appeals had provided its opinion in the NRDC et al., lawsuit. The MAFMC therefore requested that a new summer flounder assessment be prepared and reviewed in the SAW process in mid-1999, to provide a strong scientific basis for the 2000 quota setting process. Other SAW business, however, precluded such a review. Instead, the NEFSC and

MAFMC agreed that the SAW Southern Demersal Working Group would prepare the 1999 assessment, and that it would be peer reviewed by the MAFMC SSC.

During 1998 and 1999, the summer flounder aging problems noted in the 1997 25th SAW assessment were resolved. An aging workshop during February 1999 reviewed the results of an initial 1997 NEFSC/NCDMF scale exchange that had followed the 25th SAW assessment, and subsequent cooperative work performed during 1998. The workshop participants agreed that summer flounder could be aged reliably using scales by following the protocols recommended by the workshop. The participants concluded that most of the previous disagreements arose from the interpretation of the marginal increment (growth beyond the last annullus) on the scales, a problem easily resolved by considering the timing of annulus formation. Other problems related to the choice of first annulus in some fish, and disagreement over scale marks determined to be annuli by some readers and simple "checks" (non-age increment events) by other readers. Resolution of these problems increased aging agreement rates for the 1997 scale exchange test data set from 53% to 80%. It was agreed that the NEFSC and NCDMF age data through 1998 were valid for the respective components of the stock and fishery. The Workshop participants recommended regular future exchanges between NEFSC and NCDMF staff to ensure continued uniformity of summer flounder age interpretations and conventions (Bolz et al., 2000).

The 1999 assessment included commercial and recreational catches through 1998 (Terceiro, 1999). Reported 1998 commercial landings (5,084 mt, 11.2 million lb) were about 6% above the quota (4,790 mt; 10.6 million lb; adjusted for 1997 overages and court ordered 181 mt increase), and estimated 1998 recreational landings were 5,683 mt (12.5 million lb), about 69% above the harvest limit of 3,360 mt (7.4 million lb). Together, the fisheries landed 10,767 mt (23.7 million lb), 32% above the final, adjusted 1998 TAL of 8,150 mt (18.0 million lb). The NEFSC 1999 spring stock biomass index was at about 50% of the 1976–1978 peak, but 40% above the 1968–1999 time series average (Table 4). Most survey abundance indices showed increasing abundance at ages 3 and older, due to the above average abundance of the 1994, 1995, and 1996 year classes (Table 5).

The SSC concluded that there had been substantial changes in the fishery selection pattern of summer flounder during 1997–1998 as a result of manage-

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ment, with the age of full recruitment to the fisheries increasing from age 2 to age 3. Fully recruited F was therefore calculated for ages 3 and older in the 1999 assessment. The VPA results indicated that fishing mortality peaked at F = 2.2 in 1992, had steadily declined since 1995, and was estimated to be 0.52 in 1998, still about twice the FMP overfishing definition of Fmax. Spawning stock biomass on 1 November 1998 was estimated to be 25,000 mt, the highest in the 1982–1998 VPA time series. Total stock biomass had more than doubled since 1989, and was estimated to be 38,600 mt in 1998. The most recent estimates of fishing mortality and stock biomass appeared to be free of significant retrospective bias (Terceiro, 1999; Table 3).

Biological reference points re-estimated using yield per recruit analysis indicated that Fmax was now 0.26, an increase of about 8% from the 1997 25th SAW estimate of Fmax = 0.24. With the revised yield per recruit and VPA analyses, the FMP Amendment 12 target and threshold biomass were re-estimated at B_{MSY} = 106,400 mt (234.6 million lb) and one-half B_{MSY} = 53,200 mt (117.3 million lb). Due to declines in the most recent estimates of mean weight at age and a lower average recruitment from the VPA, these biomass reference points were about 30% lower than those initially published in FMP Amendment 12 (MAFMC, 1999). The SSC concluded that the stock was overfished and that overfishing was occurring with respect to the FMP Amendment 12 overfishing definition, since fishing mortality was well above the fishing mortality threshold and biomass was less than one-half B_{MSY} (Table 3).

The SSC advised that if the TAL for 1999 (8,295 mt; 18.3 million lb) was not exceeded, the TAL in 2000 should be no greater than 7,627 mt (16.8 million lb) to meet the fishing mortality target of F = 0.26 for 2000. The SSC noted that given the stock size in 1999, even this relatively low level of fishing mortality was not projected to rebuild the stock to B_{MSY} until 2017 (Table 3). This advice was endorsed by the SFMC in July, 1999 and passed on to the MAFMC in the 2000 quota setting process.

The MAFMC did not adopt the SSC and SFMC advice with regard to the 2000 TAL, and instead recommended a TAL of 8,400 mt (18.5 million lb), the same level during 1996–1999. The proposed 8,400 mt TAL was estimated to have only a 25% chance of achieving the fishing mortality rate target in 2000 (Terceiro, 1999). Citing the retrospective patterns of

previous assessments (NEFSC, 1997), the MAFMC expressed its belief that the 1999 assessment probably was subject to the same degree of terminal year retrospective bias, and so had overestimated the 1998 fishing mortality rate and underestimated both the adult stock size and abundance of the recruiting 1997 and 1998 year classes. The MAFMC and ASMFC managers also noted that the 15% commercial quota set asides for "bycatch" fisheries were still in effect, and contended that associated decreases in discards would result in a lower total catch than assumed in the assessment projections. Although expressing reservations over the MAFMC rationale, the NMFS nevertheless proposed a preliminary TAL of 8,400 mt (18.5 million lb) for 2000 (Federal Register, 2000a).

The 2000 31st SAW Assessment

The 2000 31st SAW assessment included commercial and recreational catches through 1999 (NEFSC, 2000). Reported 1999 commercial landings (4,826 mt, 10.6 million lb) were about 3% below the final adjusted quota (4,990 mt; 11.0 million lb), and estimated 1999 recreational landings were 3,804 mt (8.4 million lb), about 13% above the harvest limit of 3,360 mt (7.4 million lb). Together, the fisheries landed 8,630 mt (19.0 million lb), 3% above the final, adjusted 1999 TAL of 8,350 mt (18.4 million lb). Most survey indices continued to indicate increasing abundance of age 3 and older fish in the stock, due to increased survival of the 1994 and subsequent year classes (Tables 4–5).

The VPA catch at age matrix was expanded to include an age 7 and older plus group, and fully recruited F was calculated for ages 3–5. The VPA indicated that the fishing mortality peaked at F = 2.2 in 1992, had steadily declined since 1997, and was estimated to be 0.32 in 1999, about 23% higher than the FMP overfishing definition of Fmax (Figure 4). Spawning stock biomass on 1 November 1999 was estimated to be 29,300 mt, the highest in the 1982–1999 VPA series. The 31st SAW noted that the age structure of the spawning stock had expanded substantially since 1990, with 78% at ages 2 and older, and 10% at ages 5 and older. Under equilibrium conditions at Fmax, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older. Total stock biomass had been stable since 1994 at about 41,000 mt, but in 1999 was still 23% below the FMP biomass threshold.
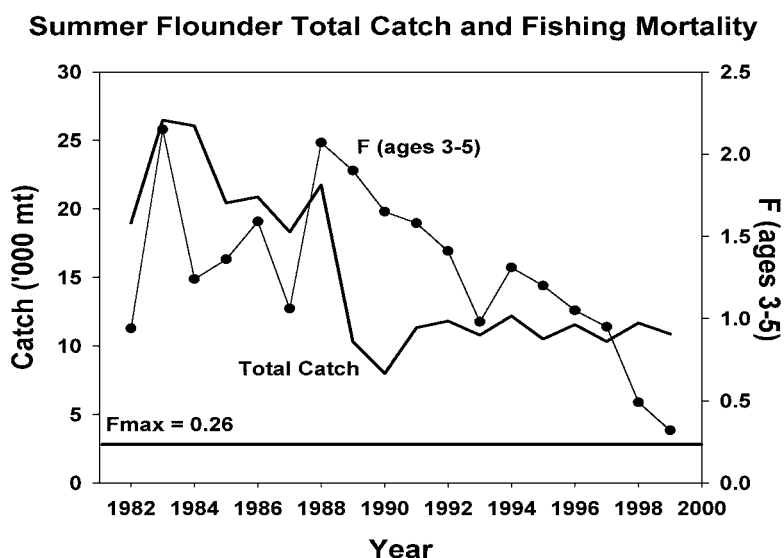
Summer Flounder Total Catch and Fishing Mortality

Figure 4. Total catch (landings and discards, thousands of metric tons) and fishing mortality rate (F, ages 3–5) for summer flounder as estimated in the 2000 31st SAW stock assessment (NEFSC 2000). Fmax = 0.26 is the FMP Amendment 12 overfishing definition fishing mortality rate target and threshold.
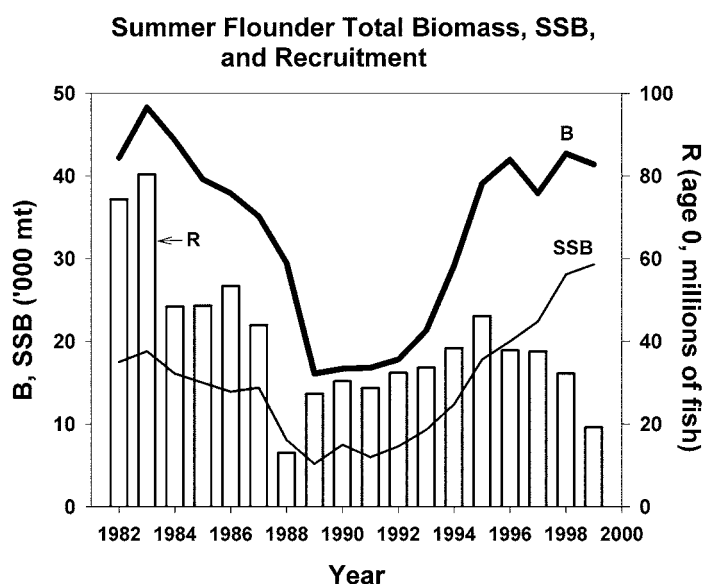
Summer Flounder Total Biomass, SSB, and Recruitment

Figure 5. Total stock biomass (B; thousands of metric tons), spawning stock biomass (SSB; ages 0–7+, thousands of metric tons), and recruitment (R; millions of fish at age 0) for summer flounder as estimated in the 2000 31st SAW stock assessment (NEFSC, 2000).

(Figure 5). Retrospective analysis showed that the VPA now tended to slightly underestimate the abundance of recent year classes. The biological reference points from the 1999 MAFMC SSC assessment were retained in the 2000 assessment, due to the stability of the input data. The 31st SAW concluded that the stock was overfished and that overfishing was still occurring with respect to the FMP Amendment 12 overfishing definition (NEFSC, 2000; Table 3). Assuming that the TAL for 2000 (8,400 mt; 18.5 million lb) was not exceeded, the 31st SAW advised the TAL in 2001 should be no more than 9,281 mt (20.5 million lb) to meet the fishing mortality target of F = 0.26 for 2001 (Table 3).

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The 2000 NRDC et al., Settlement Agreement

In May, 2000 the NMFS informed the fishing public that since the U.S. Court of Appeals had ruled in favor of the Plaintiffs in the NRDC et al., lawsuit over the 1999 TAL, the Agency considered it a matter of the "highest urgency" to address the remand of the Court. The NMFS advised of its intention to revise the 2000 TAL by August 1, 2000 to a level that had at least a 50% chance of not exceeding the F target (Federal Register, 2000b). Shortly thereafter, the Plaintiffs notified the NMFS that its interpretation of the Court decision was that: (1) NMFS was required to retroactively reset the 1999 TAL to the level achieving the target fishing mortality rate for 1999 based on the 1999 MAFMC SSC assessment; (2) NMFS had to devise a strategy for deducting the difference between the reset 1999 TAL and the reported 1999 landings from future landings; and (3) NMFS had to then ensure that the 2000 TAL had at least a 50% chance of achieving the target fishing mortality rate in 2000. Throughout the summer of 2000 (concurrent with the development and review of the 2000 31st SAW assessment) the Plaintiffs and the NMFS negotiated over how the agency might best respond to the Court's remand to the Plaintiff's satisfaction. Both parties agreed that it would be very difficult to adjust the 2000 TAL to satisfy the Court's remand, as most of the 2000 TAL had already been landed by the commercial and recreational fisheries by August.

The Plaintiffs, the NMFS, and the Court negotiated a Settlement Agreement in July, 2000 under which the NMFS agreed to set the 2001 TAL at a level that would achieve, with at least a 50% probability, the biomass that would have existed at the end of 2001 if fishing mortality in 1999–2000 had been restricted to the F target of Fmax = 0.26. Additionally, fishing mortality in 2001 could be no higher than Fmax. The NMFS published the essence of the Settlement Agreement in the Federal Register on August 2, 2000 (Federal Register, 2000c). In the August, 2000 emergency interim rule, the NMFS also stated its intention to credit any underharvest of the 2000 commercial quota by individual states to their 2001 commercial quota to help reduce the impacts on the commercial sector in 2001. The NMFS indicated that a similar overage and underage mechanism was not being established for the recreational fishery, since within season harvest limit monitoring was not in effect. The biomass target was to be specified based on the results of the 31st

SAW assessment. The NRDC et al., Settlement Agreement was finalized on September 7, 2000 (USDC, 2000).

Forecasts based on the 31st SAW assessment indicated that the biomass target consistent with the Settlement Agreement would be 67,500 mt (148.8 million lb). The SFMC reviewed the 31st SAW assessment and subsequent forecasts, and recommended an 8,125 mt (17.9 million lb) TAL for 2001, which had a 50% chance of attaining the biomass target at the end of 2001, and was expected to result in F = 0.23 in 2001, below the fishing mortality rate target. The MAFMC accepted this recommendation, and on November 28, 2000, the NMFS published a proposal to implement the 8,125 mt TAL for 2001, consistent with the earlier emergency interim rule and the NRDC et al. Settlement Agreement (Federal Register, 2000d).

The very next day, however, the ASMFC Summer Flounder Management Board met to consider the SFMC and MAFMC recommendations, and concluded that management of summer flounder fisheries in state waters (which is under the jurisdiction of the ASMFC) was not bound by the NRDC Settlement et al., Agreement. The ASMFC Board concluded that they would enact a 2001 TAL that achieved the original FMP fishing mortality target of F = 0.26, and set the TAL at 9,281 mt (20.5 million lb) as per the 31st SAW forecast. This schism between the MAFMC (federal EEZ waters, greater than 3 miles from shore) and ASMFC (state waters, 3 miles or less from shore) versions of the 2001 TAL had not been resolved by December 31, 2000, and provided the foundation for further litigation over summer flounder fishery management.

Other current controversies

A controversy developed during 2000 relating to the interpretation and reliability of analyses of summer flounder stock-recruitment dynamics, and subsequently derived biological reference points. Some scientists working on summer flounder were convinced that the stock has already been rebuilt, and that higher productivity, in terms of more frequent strong year classes, could be realized if the stock were fished harder (e.g., F = 0.6 – 0.7). This conclusion was based on an interpretation of the stock-recruitment data from the 31st SAW assessment suggesting that compensatory mechanisms were reducing recruitment
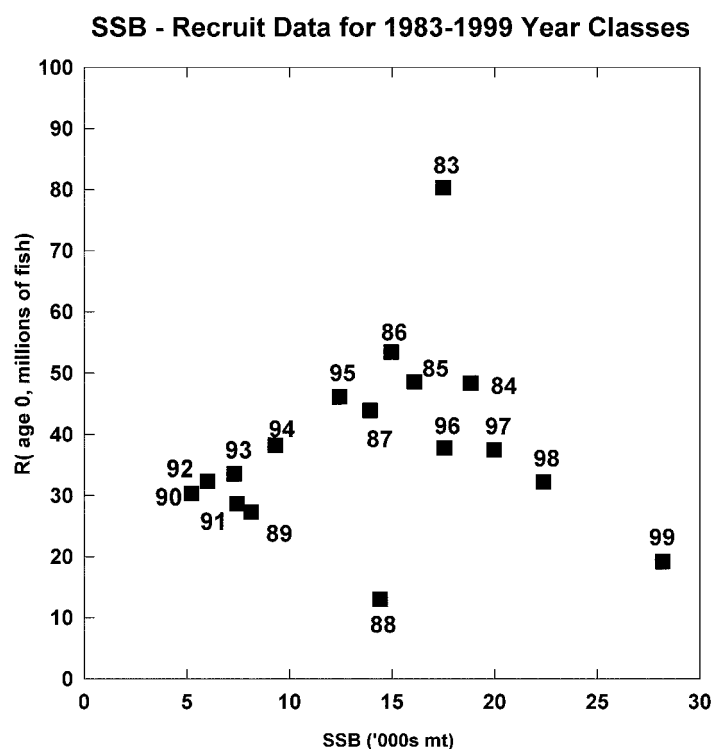
SSB - Recruit Data for 1983-1999 Year Classes

Figure 6. VPA spawning stock biomass and recruitment estimates for summer flounder, as estimated in the 2000 31st SAW stock assessment (NEFSC, 2000).

success at current spawning stock biomass levels (25,000–30,000 mt; Figure 6). Summer flounder is not a cannibalistic species, however, and so adult predation on recruits is not a likely compensatory mechanism. Furthermore, there is little evidence in growth (Figure 7) or maturation rates (Figure 8; Terceiro, 2000) developed from NEFSC survey data to suggest strong density dependent compensation in the dynamics of the summer flounder stock over the last 25 years. Other scientists therefore believe that it is premature to conclude that the full potential of the stock has yet to be realized, and feel that fishing mortality must be maintained at levels approaching that of M (e.g., F = 0.2 – 0.3) over the next several years to realize that potential.

Extreme retrospective bias in stock assessments, in cases where fishing mortality is consistently underestimated and stock size is overestimated, can contribute to the mismanagement of fisheries, and play a role in fishery and stock collapses (Hilborn and Walters, 1992; Mohn, 1993; Hutchings and Myers, 1994; Walters and Pearse, 1996). Through 1994, the performance of the summer flounder assessments in

estimating the terminal year (last year of reported catch) and forecast year (terminal year + 1) fishing mortality rates was relatively poor. An historical retrospective shows that a given year's assessment usually underestimated the terminal year and forecast year fishing mortality by 23 to 132%, when compared with current estimates (Table 6, Figure 9; the mean F for ages 2–4 is presented for consistency across assessments; note that fully recruited F was calculated for ages 2–4 in the 1990–1998 assessments, for ages 3–4 in the 1999 assessment, and for ages 3–5 in the 2000 assessment, due to changes in the distribution of fishing mortality over the age composition of the stock). Annual, internal retrospective analyses performed during each assessment suggested that underestimation of the catches, due to probable under reporting of commercial landings and underestimation of commercial and recreational fishery discards, was the most likely cause of this poor performance. The retrospective estimation of spawning stock biomass (SSB) reflects the error in the estimation of fishing mortality rates, with largest errors in 1992 and 1993, and smaller errors thereafter.
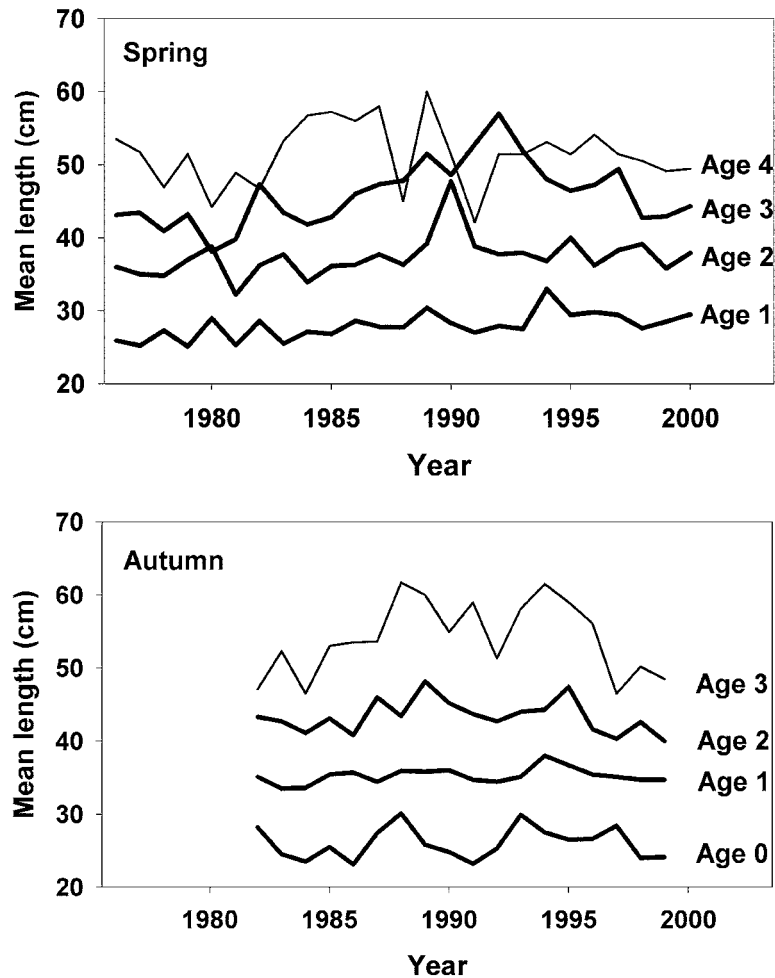
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Figure 7. Trends in mean length at age in the NEFSC spring (top, 1976–2000, ages 1–4) and autumn (bottom, 1982–1999, ages 0–3) survey catches of summer flounder.

Fortunately, the severe retrospective problems in the summer flounder assessment now appear to have been transient and limited to the early 1990s. The performance of the assessments in estimating the terminal year fishing mortality has improved since 1994, with differences between previous and current assessments of –23% to +2% (Table 6, Figure 9). Stricter monitoring of commercial landings has probably improved the accuracy of the summer flounder catches since 1994. Furthermore, limiting the calibration of the summer flounder VPA to research survey indices has eliminated the potential for bias due to unaccounted changes in catchability of fishery dependent indices, which have been implicated in cases of extreme retrospective bias (Hilborn and Walters, 1992; Hutchings and Myers, 1994; NRC,

1998). The estimation of commercial fishery discards is probably the most important current source of error in deriving the total summer flounder catch. Given an increasing stock and commercial quotas and trip limits intended to constrain fishing mortality rates to the target level, it is critical that discards be accurately determined into the future, to correctly account for all removals from the stock (NEFSC, 2000).

The performance of the forecasts has not improved as much as the VPA estimation of terminal F (Table 6). Most of the recent lackluster performance can be traced to overly optimistic expectations of the effect of management measures in controlling the recreational landings. During 1993–1994, the SFMC forecasted that recreational landings were likely to exceed the approved harvest limits, and therefore recom-
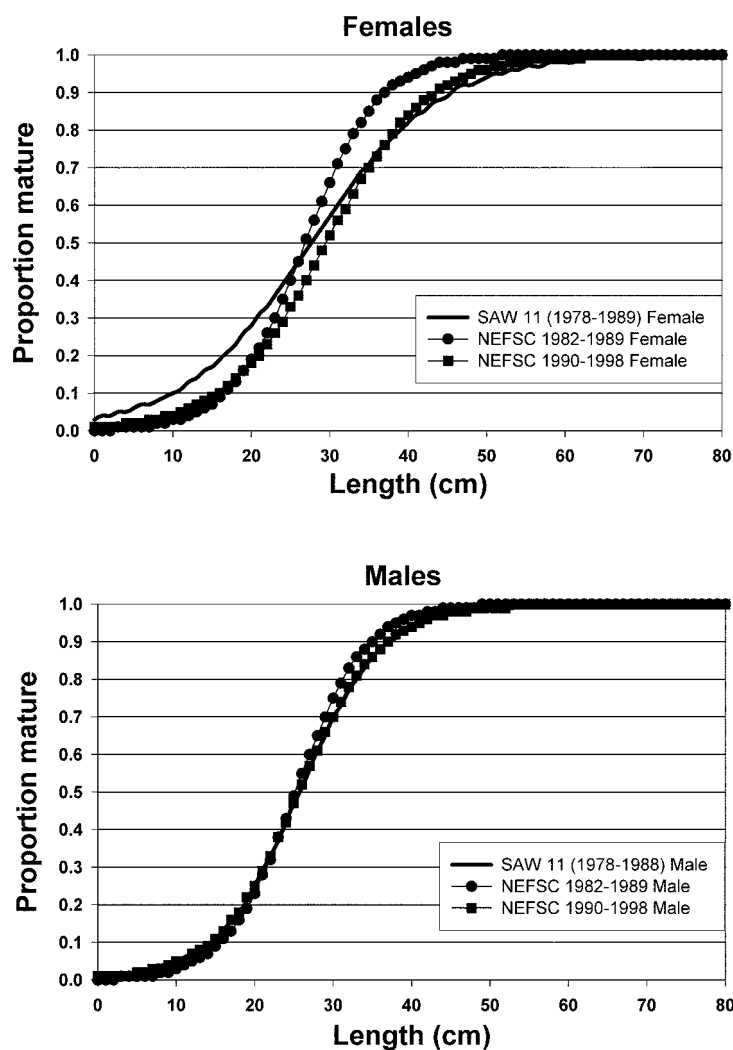
Figure 8. Proportion mature at length for summer flounder sampled in the NEFSC autumn surveys. Eleventh SAW fish were sampled during 1978–1989 and are the basis of the maturity schedule used in all stock assessments. NEFSC 1982–1989 and NEFSC 1990–1998 fish are from more recent examinations that provided comparable results (Terceiro, 2000).

mended relatively stringent possession and size limits, as well as a limited open season (Table 7). In 1993, recreational landings exceeded the harvest limit by only 5%. In 1994 and 1995, the recreational landings fell short of the harvest limit by 14% and 29%, in spite of possession limits higher than those recommended by the SFMC (Table 7). As a result, there were protracted discussions between the SFMC, ASMFC/MAFMC managers, and NMFS over the establishment of the recreational measures for 1996. The managers were very hesitant to implement restrictive possession limits in 1996 given that landings did not attain the harvest limits set in the

previous two years. The SFMC gave fairly stern warning, however, that the stock was starting to increase in abundance and that, with increasing availability of fish to the recreational fishery, the likelihood of exceeding recreational harvest limits would be much greater than in previous years unless more restrictive management measures were implemented (Moore, 1995). However, the measures actually enacted for 1996 were less restrictive than those in 1995, and proved too lenient as recreational landings in 1996 exceeded the harvest limit by more than 30% (Table 7). As the abundance of summer flounder continued to increase, especially for fish above the
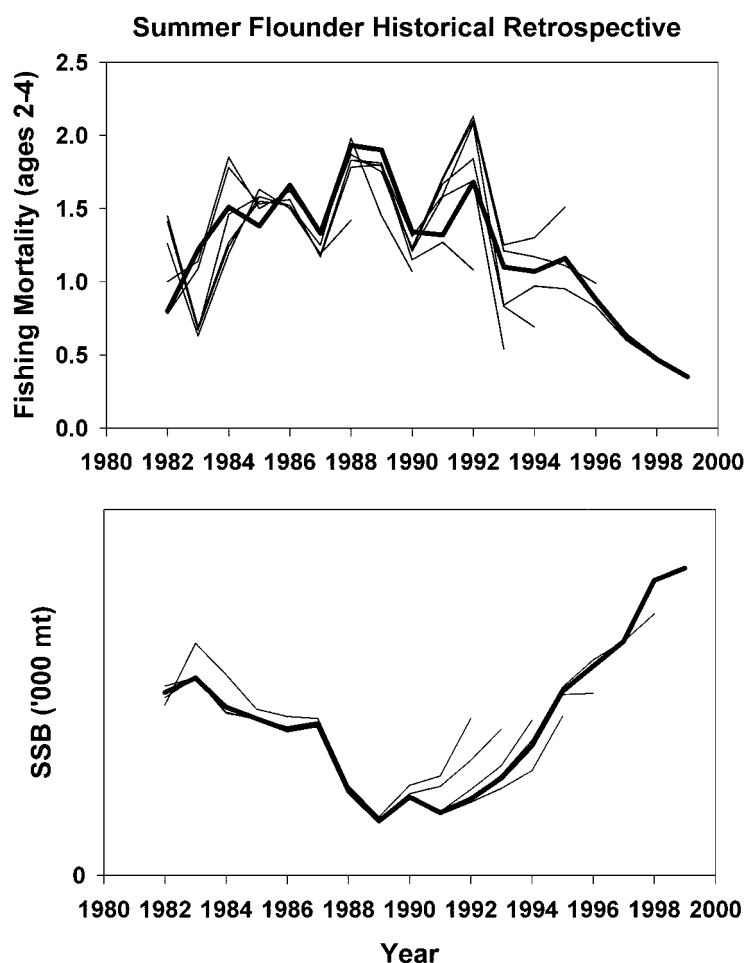
Summer Flounder Historical Retrospective

Figure 9. Historical retrospective for the 1990–2000 summer flounder stock assessments. Bold lines are the fishing mortality rate (ages 2–4, for comparability across assessments) and spawning stock biomass (SSB, '000 mt) estimates from the 2000 31st SAW stock assessment (NEFSC, 2000).

14 in (in 1996) to 15 in (in 1999) recreational fishery minimum sizes, similar scenarios occurred in setting recreational management measures for the 1997–1999 seasons. The SFMC consistently forecasted that recreational landings would likely exceed the harvest limits, and recommended that measures be enacted to achieve harvest limits in the following year (e.g., 1999). Managers, however, implemented less restrictive measures than those recommended, and subsequent recreational landings exceeded the harvest limits (Table 7). Hence, the performance of the assessment forecasts, which assumed that the recreational landings would not exceed the harvest limits, was still relatively poor for 1995–1999 (Table 6).

In making recommendations for the 2000 recreational fishery, the SFMC forecasted that the 1999 landings would exceed the 1999 harvest limit by 26%. Assuming that fishing effort and the availability of summer flounder to the recreational fishery would remain constant, the SFMC recommended measures to reduce the recreational landings by 26% in order to attain the 2000 harvest limit. The recreational fishery measures enacted for 2000 again were much more lenient than those recommended by the SFMC. The recreational landings in 2000 are projected to exceed the harvest limit by over 100%, so it is very likely that the target fishing mortality rate for 2000 (Fmax = 0.26) will be exceeded as well (Tables 6–7).

The difficulty in controlling the recreational landings has resulted in increasingly stringent management recommendations by the SFMC, even as the stock rebuilds (Table 7), in order to achieve the target fishing

Table 7. Summary of recommended and implemented management measures in the recreational fishery for summer flounder, 1993–2000

Year	Scientific recommendations			Final measures implemented			Projected landings advice ('000 mt)	Final harvest limit ('000 mt)	Final landings ('000 mt)	SAW 31 total biomass ('000 mt)
	Coastal possession limit (number fish)	Coastal minimum length (inches)	Open season	Coastal possession limit (number fish)	Coastal minimum length (inches)	Open season				
1993	6	14	5/15–9/30	6	14	5/15–9/30	1.8	1.7	1.8	21.3
1994	6	14	4/15–10/15	8	14	4/15–10/15	2.8	2.2	1.9	29.2
1995	4	14	all	6, 8	14	all	2.5	3.5	2.5	39.1
1996	None	none	none	10	14	all	5.3	3.4	4.5	42.0
1997	2, 6	14, 15	all	8	14.5	all	4.2	3.4	5.4	37.9
1998	6	15	all	8	15	all	6.1	3.4	5.8	42.7
1999	3	15	1/1–7/31, 9/1–12/31	8	15	5/29–9/11	4.3	3.4	3.8	41.4
2000	3	15	1/1–7/31, 9/1–12/31	8	15.5	5/10–10/2	7.1	3.4	n/a	47.1

mortality rate needed to rebuild the stock to the target biomass in a timely manner (e.g., by 2006). Published comments in the sportfishing media and testimony at the public meetings have urged managers to reduce the impact of recreational measures on the fishing public and industry. Still, some members of the recreational fishing community have a good appreciation of the situation. One columnist for a national sportfishing publication recently wrote, "The number of spawning age fish increased five-fold in 1999 over the 1989 level. But while the age structure has expanded, it now seems to have leveled out . . . the fishing mortality rate has declined, as one would expect from harvest restrictions under an austere recovery plan. Nevertheless, in 1999 the species was overfished by 23%, and is forecast to exceed the target for 2000 if total landings turn out as predicted . . . The government, in other words, is warning fishermen that they must continue to be patient" (Arrington, 2000).

An illustration of many other fishermen's continuing misunderstanding of the process of assessment, management advice, and implementation of that advice, as well as the contentious interactions among advocacy groups, can be found in recently published comments. Another prominent sportfishing columnist recently wrote, ". . . the increase in summer flounder spawning stock biomass has been so spectacular that it plots in an almost vertical line. Yet, stock information lags way behind current catch information and severe restrictions are required to comply with stock rebuilding goals in the plan even though everyone familiar with the fishery realizes there's no problem". and ". . . the environmentalist's lawsuit may result in disaster for those financially dependent on the summer flounder fishery while also denying casual fishermen the right to retain fine-eating fish for no good reason" (Ristori, 2000a). This was followed by, "Of course, the only way such great quantities of summer flounder could be caught by recreational fishermen is because the population is far larger than biologists have so far been able to quantify since that data lags far behind the catch reports. We know there's no problem with the rebuilding of fluke stocks, but anglers are being made victims of the management plan's success" (Ristori, 2000b).

Conclusion

In 1999, the fishing mortality on summer flounder was the lowest since the 1960s and total stock biomass was the highest since the mid-1970s (Chang and Pacheco, 1975; NEFSC, 2000). The age structure of the stock at ages 2 and older has been significantly rebuilt since 1990 (Figure 10), and substantial progress has been made in restoring the abundance of larger, older fish last evident nearly thirty years ago (Eldridge, 1962, NEFSC, 2000; Figure 11). However, summer flounder biomass in the late 1990s has stabilized at about one-half of the biomass target of B_{MSY}, and significant
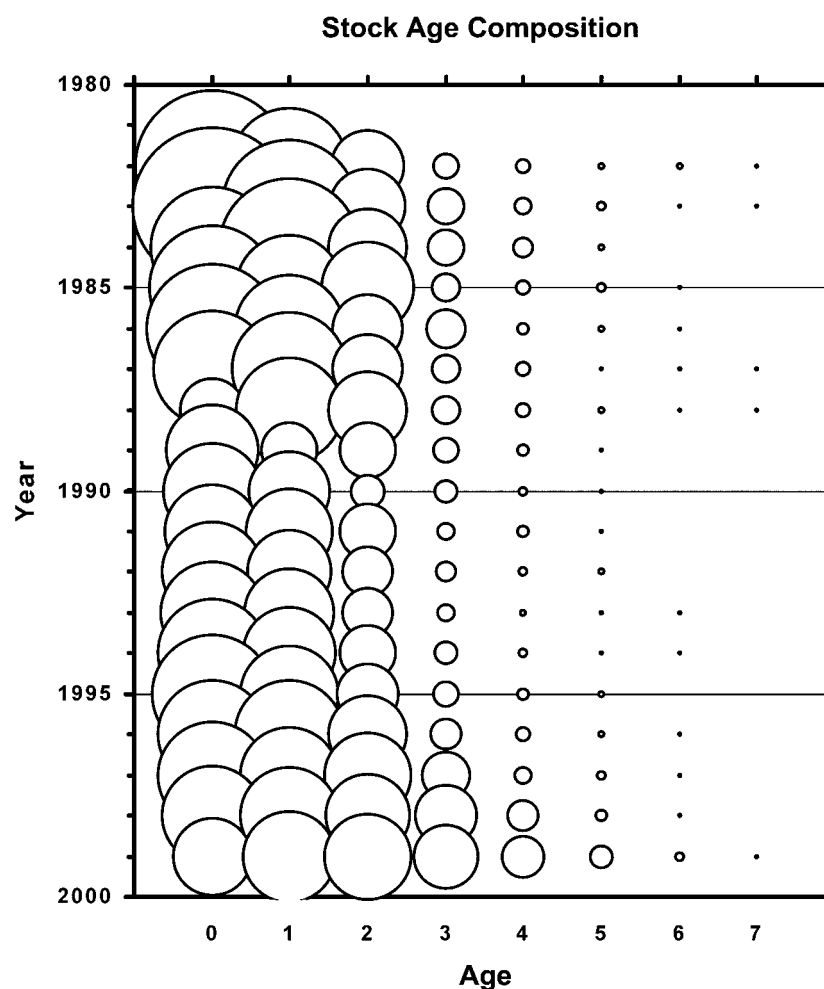
Stock Age Composition

Figure 10. Stock age composition for summer flounder, as estimated in the 2000 31st SAW stock assessment (NEFSC, 2000).

increases toward reaching the biomass target will not be possible unless either stronger recruitment occurs or fishing mortality is maintained at the relatively low levels likely present during the 1950s (Terceiro, 1999; NEFSC, 2000). Careful monitoring of stock status must continue to reliably determine "how much fish is enough" to provide for long-term sustainability at legally required levels of abundance.

Summer flounder assessment and management has become very controversial over the last decade because of the major role of both the commercial and recreational industries in the fishery and the relatively recent involvement of environmental advocacy groups. The allocation of catch to the commercial and recreational sectors will likely continue to be contentious, with each side believing that their harvest provides the best use of the resource. These conflicts

are unlikely to abate until managers better define the socio-economic objectives of summer flounder management, and link these with the resource conservation goals. Meanwhile, changes are being made to the annual management specifications owing to differing views of managers and fishery and environmental advocacy groups of the scientific basis and need for conservation measures. Attainment of the annual fishing mortality targets remains elusive. The multiple layers of science, management, and politics in place since 1992 continue to spark much controversy and litigation that increasingly places the management of the summer flounder fishery in the hands of the courts.
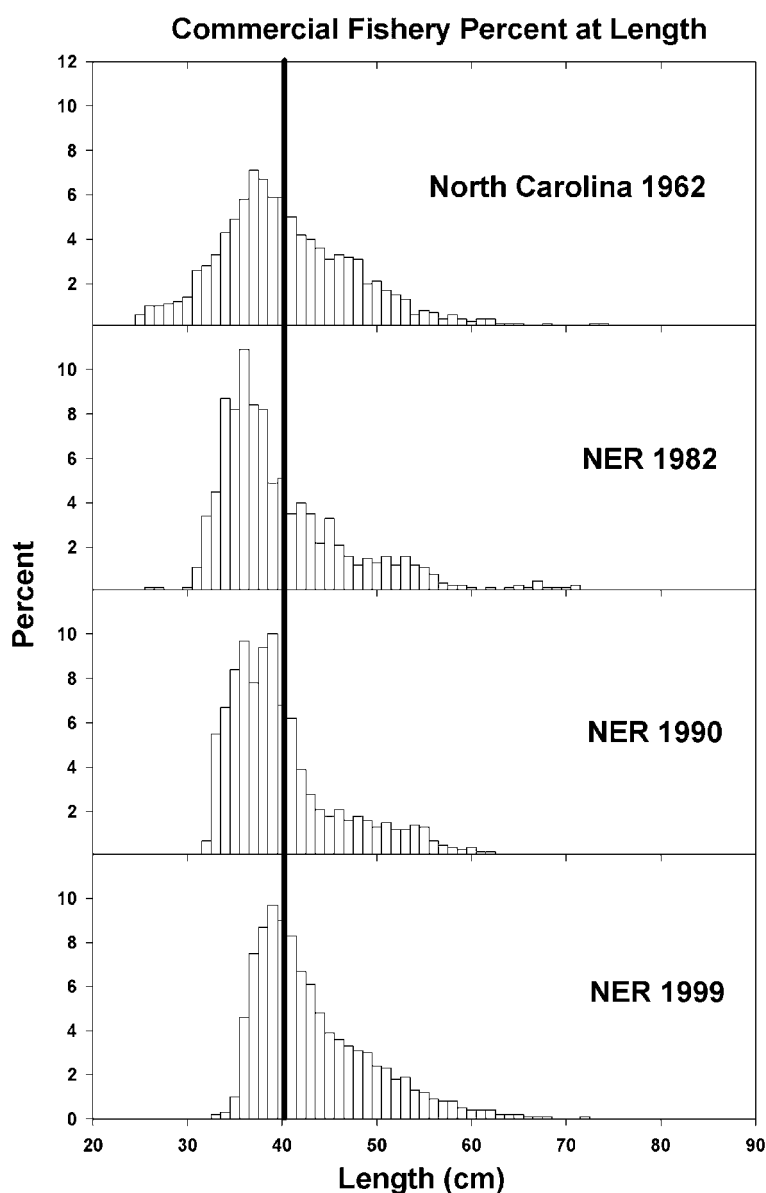
Commercial Fishery Percent at Length

Figure 11. Commercial fishery landings percent at length from North Carolina in 1962 (Eldridge 1962) and from the Northeast Region (NER, ME to VA) in 1982, 1990, and 1999. Solid vertical line is at 40 cm, about the mean length for age 2 fish.

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