G. Witch Flounder   by S. E. Wigley

1.0   Background

Witch flounder, *Glyptocephalus cynoglossus*, are assessed as a unit stock from the Gulf of Maine southward. An analytical assessment was last conducted for this species in 1999 (Wigley et al.1999) and reviewed at SAW 29 (NEFSC 1999).   The SAW 29 assessment indicated average fishing mortality (ages 7-9, unweighted) increased from 0.21 in 1982 to 0.59 in 1985, declined to 0.24 in 1990, increased to 0.86 in 1996, then declined to 0.37 in 1998.   Mean 3+ biomass declined steadily from 27,930 mt in 1982 to 7,742 mt in 1994, then sharply increased to 18,934 mt by 1998. Spawning stock biomass declined from 18,000 tons in 1982 to about 4,000 tons in 1993 and then increased sharply to 8,600 mt in 1998.   Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 38 million fish (1996 year class) with a mean of 14 million fish.

This report updates catch in 1999-2001, survey indices through spring 2002, estimates 2001 fishing mortality and 2002 spawning stock biomass, and provides projections of median landings and spawning stock biomass for two fishing mortality scenarios.   Sensitivity analyses of assessment results were conducted to evaluate the impact of mis-marked survey trawl wires and the selection of survey tuning indices.

2.0   2002 Assessment

The Fishery

The U.S. nominal catch is taken from both the Georges Bank and Gulf of Maine regions. Canadian landings from both areas have been minor (not more than 68 mt annually). Landings for 1991-2000 averaged 2,200 mt annually but increased to over 3,000 mt in 2001 (Table G1 and Figure G1).

Sampling intensity of landings during 1999 and 2001 was comparable to that of the previous decade, i.e., an average of 43 samples annually. Sampling intensity in 2000 increased to 110 samples; however 100 of these were from the small market category (Table G2). As in previous years, it was necessary to pool some quarters for some market categories.   To estimate landings at age and mean weights at age, quarter, semi-annual or annual age-length keys were applied to corresponding commercial landings length frequency data by market category. Landed weights-at-age in 1999-2001 continue to decline as observed in recent years (Table G2).

Discard estimation

Discards-at-age were updated using the same estimation methods used in the 1999 assessment. The estimation of large-mesh otter trawl discards is based upon a method which filters survey length frequency data through a commercial gear retention ogive and then through a culling ogive. A semi-annual ratio estimator of survey-filtered 'kept' index to semi-annual numbers landed was used to expand the estimated 'discard' survey index to numbers of fish discarded at length. Semi-annual numbers of fished discarded were apportioned to age using the corresponding seasonal NEFSC survey age/length key. Witch flounder discarded in the large mesh otter trawl fishery range in age from 0 to 6, with the majority at ages 4 to 5.   Estimated numbers of fish discarded at sea in 2000-2001 comprised as much as 65% of witch flounder landed, similar to that estimated for 1996 (Figure G2).

Discards in the small mesh trawl fishery for northern shrimp during 1999-2001 were estimated from

the relationship between age 3 fish in the autumn NEFSC survey and discard rate during 1993-1997. This method was used to estimate 1998 discards in the 1999 assessment due to lack of sea sampling in the shrimp fishery. For each year, the total discard weight was estimated by expanding the discard rates (mt/day fished) for 1998-2001 by the number of days fished estimated from the Vessel Trip Reports. Discarded numbers at age were derived by apportioning discard weight by the average age composition of discards in 1993-1997 and then dividing by the average 1993-1997 discard mean weights at age. Witch flounder discarded in the shrimp fishery range in age from 0 to 6, with the majority at ages 1-3. During 1999-2001, the number of fish discarded in the shrimp fishery averaged 8% of witch flounder landed (Figure G2).

The total catch at age is presented in Tables G3 and G4, and Figure G2 .

Research Vessel Survey Indices

NEFSC bottom trawl survey indices have increased since the late 1990's (Table G5, Figures G3a-b). Witch flounder abundance has reached near-record and record high levels in the spring and autumn surveys, respectively. The biomass indices have increased to levels observed in the mid-1980's. Survey age compositions are presented in Table G6. The survey mean weights and mean lengths at age show a similar decline as reported in the commercial landings. Survey maturity-at-age has decrease in 2000-2002.

3.0 Assessment Results

The VPA formulation is the same as the 1999 assessment and uses catch (landings plus discards) through 2001 and NEFSC spring and autumn survey indices through 2002 and 2001, respectively, to estimate stock sizes for ages 4 to 10. The VPA had a mean square residual of 0.76, the coefficients of variation (CVs) for estimated ages ranged between 32% and 45%, and the CVs for survey catchability coeffiecients (q) were consistent, ranging from 19% to 22%.

VPA results indicate average fishing mortality (ages 7-9, unweighted) increased from 0.21 in 1982 to 0.59 in 1985, declined to 0.24 in 1990, increased to 0.96 in 1996, then declined to 0.37 in 1999, and increased to 0.45 in 2001 (Table G7, Figure G4). Spawning stock biomass declined steadily from 18,000 mt in 1982 to 4,000 mt in 1995, and has increased to 11,300 mt in 2001 (Table G7, Figure G5). Since 1982, recruitment at age 3 has ranged from approximately 3 million fish (1984 year class) to 84 million fish (1997 year class) with a mean of 22 million fish (median of 14 million; Table G7, Figure G5). The addition of the 1995 to 1999 year classes to the stock-recruit data continued the negative trend observed in this relationship in the previous assessment.

The retrospective analysis indicates that average F was overestimated in the early to mid-1990's and underestimated in the late 1990s, but the 2000 F estimate was initially overestimated (Figure G6a). Spawning stock biomass was consistently overestimated since 1994 (Figure G6b). The retrospective analysis indicated a pattern of relatively consistent estimates of the number of age 3 recruits, with the notable exception of the 1992, 1993 and 1996 year classes, which were overestimated (Figure G6c).

Bootstrap results suggest that the estimates of F and spawning stock biomass are relatively precise with CVs of 19% and 13%, respectively. The 80% confidence interval for F_{2001}=0.45 was 0.38 and 0.59, and for SSB_{2001} = 11,300 mt the 80% confidence interval was 9,784 mt and 13,584 mt (Figure G7).

Biological Reference Points

Based on yield and spawning stock biomass per recruit analyses and the arithmetic mean of the VPA age 3 recruitment (NEFSC 2002):

SSBmsy = 19,900 mt
Fmsy = F40% = 0.164
MSY = 2,990 mt.

In 2001, spawning stock biomass was slightly above ½ SSBmsy (9,950 mt), the overfished threshold, and fishing mortality (F = 0.45) was three times higher than Fmsy, the overfishing threshold; therefore, witch flounder was not overfished but overfishing was occurring in 2001 (Figure G7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

Sensitivity Analyses

NEFSC survey tuning indices from spring 2000-2002 and autumn 2000-2001 are arbitrarily adjusted by 1.1, 1.25, and 2.0 to evaluate the sensitivity of the VPA results to the potential gear effect of the differences in survey trawl wires during these years (Figure G7). Results are summarized in Section 5.2 (Summary of Assessment Advice).

4.0 Projections

Since the stock is currently above the SSB_{MSY} target, age-structured projections used Fmsy = F40% fishing mortality rate to evaluate the trajectories of spawning biomass and catch. The projection analyses used stock and landings mean weights at age and selectivity pattern from 1998-2001, the maturity at age from 2000-2002, and recruitment re-sampled from the cumulative distribution function based on the VPA age 3 recruitment from 1982 - 1998 year classes. Initial stock sizes in 2002 were derived from 1000 bootstrap iterations of the VPA. Fishing mortality in 2002 was set to fishing mortality in 2001 with a 15% reduction (e.g. $F_{2002} = F_{2001} * 0.85$). The fishing mortality in 2003 - 2009 was set to Fmsy = F40% = 0.164.

The median catch (median landings + median discards) in 2003 is projected to be 4,370 mt and 6,260 mt in 2004. The median SSB in 2003 is projected to be 25,410 mt and 34,700 mt in 2004 (Table G8) The projected median catch and SSB in 2009 under Fmsy are 5,764 mt and 36,807 mt, respectively (Figure G8).

5.0 Panel Comments

The GARM noted the block of positive residuals in the younger ages beginning in 1991, and suggested that the survey tuning series for the younger ages could be split into two series. The GARM noted that the SSB will reach SSBmsy within a year, yet current SSB is barely above ½ SSBmsy. A yield per recruit analysis with current mean weights, maturity ogive and partial recruitment was compared with the yield per recruit analysis used to estimate biological reference points. The results of this comparison indicated that the increase in mean recruitment was a contributing factor. The mean recruitment used to calculate the biological reference points was 12.42 million fish using the 1982 to 1994 year classes. However, with the assessment update, four additional year classes are estimated. The mean recruitment increases to 22.1 million fish (median 14.5 million) when the 1982-1998 year classes are used. The GARM pointed out that the recent

above-average year classes may be poorly determined, and based on the retrospective pattern for recruitment, these year classes may be overestimated. The Panel concluded that the biological reference points are appropriate; however, the projections of SSB may be overly optimistic because future assessment updates may reveal that these year class are not as strong as they appear at this time.

6.0 Sources of Uncertainty

• Low frequency of samples across market category and quarter results in imprecise mean weights at age and estimates of numbers at age.

• Confounding of survey-based estimates of discards and use of same survey as tuning indices for VPA calibration may be a problem.

• Lack of data to support direct estimates of discards at age requires use of various surrogate survey-based methods.

• Retrospective patterns suggest that estimates of 2002 SSB may be overestimated (e.g. updated assessments may have lower estimated 2002 SSB).

7.0 Research recommendations for witch flounder

• Explore alternative VPA analyses with the survey tuning indices split into two series for the younger age groups.

8.0 References

Lange, A.M.T. and F.E. Lux. 1978. Review of the other flounder stocks (winter flounder, American plaice, witch flounder, and windowpane flounder) off the northeast United States. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 78-44, 53 pp.

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Northeast Fisheries Science Center. 2002. Final Report of the Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish. February 2002.

Northeast Fisheries Science Center. 1999. Report of the 29th Northeast Regional Stock Assessment Workshop (29th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 99-14, 347 p.

Wigley, S.E., J. K.T. Brodziak, and S.X. Cadrin. 1999. Assessment of the witch flounder stock in Subareas 5 and 6 for 1999. Northeast Fish. Sci. Cent. Ref. Doc. 99-16, 153 p.

Table G1. Witch flounder landings, discards and catch (mt, live) from Subareas 5 and 6 1960-2001.

| Year | Landings | | | | Discard | Total USA Catch (used in VPA) |
	Canada	USA [2]	Other [1]	Total		
1960	–	1255	–	1255		
1961	2	1022	–	1024		
1962	1	976	–	977		
1963	27	1226	121	1374		
1964	37	1381	–	1418		
1965	22	2140	502	2664		
1966	68	2935	311	3314		
1967	63	3370	249	3682		
1968	56	2807	191	3054		
1969	–	2542	1310	3852		
1970	19	3112	130	3261		
1971	35	3220	2860	6115		
1972	13	2934	2568	5515		
1973	10	2523	629	3162		
1974	9	1839	292	2140		
1975	13	2127	217	2357		
1976	5	1871	6	1882		
1977	11	2469	13	2493		
1978	18	3501	6	3525		
1979	17	2878	–	2895		
1980	18	3128	1	3147		
1981	7	3422	–	3449		
1982	9	4906	–	4915	48	4953
1983	45	6000	–	6045	162	6162
1984	15	6660	–	6675	100	6760
1985	46	6130	–	6431	61	6191
1986	67	4610	–	5216	25	4635
1987	23	3450	–	3819	47	3497
1988	45	3262	–	3665	60	3322
1989	13	2074	–	2384	133	2207
1990	12	1478	–	1492	184	1662
1991	7	1798	–	1805	95	1893
1992	7	2246	–	2253	171	2417
1993	10	2605	–	2615	376	2981
1994	34	2670	–	2704	422	3092
1995	11	2212	–	2223	265	2477
1996	10	2088	–	2098	454	2542
1997	7	1775	–	1782	393	2168
1998	10	1849	–	1859	335	2184
1999	19	2121	–	2140	354	2475
2000	53	2439	–	2492	547	2986
2001	32	3024	–	3047	705	3729

[1] Includes West Germany, East Germany, Poland, Spain, Japan, & the former USSR.
[2] excluding landings from Grand Banks (subarea 3).

Table G2.   Summary of USA commercial witch flounder landings (mt), number of length samples(n), number of fish measured (len)and number of age samples (age) by market category and quarter for all gear types, 1981 - 2001. The sampling ratio represents the amount of landings per length sample.

Year		Quarter 1 Small	Med.	Large	Quarter 2 Small	Med.	Large	Quarter 3 Small	Med.	Large	Quarter 4 Small	Med.	Large	All	Sampling Ratio
1981	mt	260	7	517	269	32	694	242	13	607	230	0	453	3324	
	n	.	.	.	.	1	1	.	1	.	1	.	1	5	
	len	.	.	.	.	101	103	.	89	.	105	.	100	498	
	age	.	.	.	.	.	26	.	25	.	25	.	25	101	
1982	mt	348	1	726	342	73	886	287	170	739	278	201	669	4720	
	n	5	2	6	1	2	2	2	2	6	3	4	2	37	128
	len	527	194	626	126	209	216	189	210	514	307	393	189	3700	
	age	128	55	150	30	55	50	50	50	150	81	105	50	954	
1983	mt	475	250	910	471	286	1037	298	154	758	257	169	613	5678	
	n	5	2	3	5	1	5	8	3	8	6	3	.	49	116
	len	680	232	265	685	96	520	1008	123	981	677	344	.	5611	
	age	135	30	55	131	16	125	152	0	159	180	75	.	1058	
1984	mt	462	322	1036	513	393	1000	403	248	653	429	286	586	6331	
	n	5	9	4	7	1	7	8	1	2	4	2	1	51	124
	len	804	1112	400	970	117	775	1045	106	191	615	243	91	6469	
	age	154	250	76	186	25	180	210	28	53	105	44	25	1336	
1985	mt	465	377	613	697	453	850	526	291	553	433	310	408	5976	
	n	12	1	2	5	4	7	7	7	6	8	2	4	65	92
	len	1530	105	229	657	426	698	795	800	684	824	264	349	7361	
	age	319	29	50	106	77	153	97	138	113	161	25	29	1297	
1986	mt	384	309	356	654	421	595	375	238	354	312	212	238	4448	
	n	6	3	5	5	4	5	4	3	4	5	3	2	49	90
	len	662	307	515	558	410	413	302	364	406	416	337	233	4923	
	age	123	60	89	106	97	129	63	75	100	87	75	52	1056	
1987	mt	349	211	228	432	317	387	296	203	247	298	203	202	3373	
	n	1	1	2	4	2	3	5	5	4	2	3	2	34	69
	len	85	145	200	323	228	316	354	583	400	204	261	178	3277	
	age	25	25	50	77	47	76	78	113	95	48	64	51	749	

Year		Quarter 1 Small	Med.	Large	Quarter 2 Small	Med.	Large	Quarter 3 Small	Med.	Large	Quarter 4 Small	Med.	Large	All	Sampling Ratio
1988	mt	424	304	271	436	393	389	184	176	208	140	140	131	3196	
	n	5	4	5	5	5	3	5	4	3	3	4	3	49	65
	len	335	407	465	344	544	429	396	359	295	229	402	356	4561	
	age	70	89	106	71	110	77	70	100	75	61	95	69	993	
1989	mt	230	174	148	255	264	251	98	145	156	85	107	103	2016	
	n	1	2	2	2	2	1	2	2	1	1	2	.	18	112
	len	94	201	222	230	236	27	150	206	100	125	202	.	1793	
	age	25	50	49	50	46	25	40	51	25	25	47	.	433	
1990	mt	113	125	107	147	168	147	100	119	129	84	79	85	1403	
	n	1	2	3	6	3	1	6	2	2	7	2	.	35	40
	len	134	199	199	335	296	100	349	247	145	381	201	.	2586	
	age	15	40	45	81	70	25	69	41	50	103	48	.	587	
1991	mt	71	56	58	219	151	167	192	142	184	168	108	121	1637	
	n	5	2	3	7	2	1	4	2	3	5	4	3	41	40
	len	262	224	401	537	239	125	212	165	249	300	410	274	3398	
	age	53	50	80	93	45	25	49	49	52	66	97	58	717	
1992	mt	180	86	82	466	163	174	205	115	138	212	97	116	2034	
	n	4	2	2	7	1	2	7	1	1	2	.	1	30	68
	len	259	241	185	501	125	235	477	121	117	129	.	46	2436	
	age	42	46	52	78	25	25	86	25	25	27	.	23	454	
1993	mt	350	112	110	442	192	161	263	122	150	331	96	106	2435	
	n	7	1	.	7	1	1	9	1	5	.	.	.	32	76
	len	830	100	.	741	107	100	728	85	499	.	.	.	3190	
	age	55	25	.	56	27	26	74	.	73	.	.	.	336	
1994	mt	403	143	98	505	183	154	390	122	117	383	91	80	2670	
	n	.	.	.	3	5	6	5	5	1	5	3	4	37	72
	len	.	.	.	560	532	749	356	648	105	342	368	407	4067	
	age	.	.	.	59	104	134	44	113	26	56	60	82	678	

Table G2 continued.

Year		Quarter 1 Small	Med.	Large	Quarter 2 Small	Med.	Large	Quarter 3 Small	Med.	Large	Quarter 4 Small	Med.	Large	All	Sampling Ratio
1995	mt	336	91	77	586	117	100	399	61	70	304	48	40	2212	
	n	3	3	3	6	3	5	.	.	.	2	.	1	26	85
	len	208	348	347	459	367	517	.	.	.	217	.	94	2557	
	age	53	84	89	81	75	135	.	.	.	27	.	25	569	
1996	mt	313	57	36	545	86	60	458	56	44	363	42	28	2088	
	n	5	2	3	5	2	1	5	4	4	5	3	3	42	50
	len	504	218	292	331	240	127	494	464	468	343	277	348	4106	
	age	59	45	78	53	50	26	59	86	101	60	70	69	756	
1997	mt	313	40	25	478	86	41	398	55	27	265	31	16	1775	
	n	6	3	3	9	4	3	9	3	1	9	1	1	52	34
	len	557	350	351	812	418	309	783	308	107	505	128	50	4678	
	age	77	68	70	108	73	77	98	81	20	73	18	23	786	
1998	mt	372	39	19	587	79	31	380	40	20	239	26	14	1849	80
	n	5	2	1	4	1	1	5	3	1	.	.	.	23	
	len	339	206	128	238	88	135	484	186	100	.	.	.	1904	
	age	45	50	19	30	.	29	47	22	.	.	.	.	242	
1999	mt	386	48	19	616	79	31	436	67	30	353	38	18	2121	51
	n	3	.	.	4	.	.	17	2	3	11	1	.	41	
	len	282	.	.	308	.	.	1110	201	306	775	109	.	3091	
	age	15	.	.	62	.	.	143	.	32	91	16	.	359	
2000	mt	477	53	17	583	93	27	555	89	28	451	50	16	2439	21
	n	31	2	.	47	.	.	17	1	.	5	5	2	110	
	len	2253	91	.	2445	.	.	994	105	.	308	558	217	6971	
	age	390	10	.	460	.	.	224	20	.	67	92	51	1314	
2001	mt	584	71	17	828	99	30	699	98	28	507	50	13	3024	70
	n	8	4	2	3	3	2	8	2	3	5	3	.	43	
	len	744	422	134	237	352	159	594	209	213	313	232	.	3609	
	age	125	63	42	47	48	64	126	34	46	61	48	.	704	

Table G3. Numbers ('000) at age of witch flounder in the total catch, 1982-2001.

| | | | | | | | Age | | | | | | |
Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL

Total Catch in Numbers (1000's) at Age

Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982	0.03	0.06	1.72	190.49	1064.47	1207.67	1475.40	665.20	656.00	399.50	239.40	1578.40	7478.4
1983	0.00	0.02	4.28	337.11	1346.17	1520.76	1575.12	1590.20	977.80	737.70	510.40	1675.50	10275.1
1984	0.00	0.33	0.88	146.61	1466.31	2002.70	1739.59	1486.50	1497.50	696.70	375.10	1718.80	11131.0
1985	0.00	0.34	3.47	123.58	1176.12	2118.21	1936.24	1524.90	1247.90	606.00	400.40	1359.20	10496.4
1986	0.00	0.53	3.86	22.95	377.07	1516.79	2775.35	1566.90	834.90	412.70	222.80	758.20	8492.1
1987	2.08	18.92	79.93	22.25	181.26	467.06	1280.06	1574.70	870.90	480.60	252.40	489.40	5719.6
1988	0.42	14.66	130.29	600.27	139.91	264.30	658.27	1382.70	1154.10	401.50	266.70	597.50	5610.6
1989	0.85	10.69	50.32	447.05	436.26	65.27	315.20	761.60	884.70	350.70	123.80	349.00	3795.4
1990	1.46	6.29	95.30	343.93	635.77	1108.23	257.90	276.30	475.30	336.90	82.10	179.10	3798.6
1991	3.06	17.90	23.26	441.77	407.92	872.56	581.70	238.60	247.50	295.60	317.30	260.80	3708.0
1992	2.84	44.35	159.43	399.46	1259.95	866.37	943.97	723.10	203.40	179.40	121.10	380.20	5283.6
1993	113.76	85.80	129.59	417.23	1807.93	1420.56	919.56	598.10	586.50	219.10	279.00	391.10	6968.2
1994	8.06	1368.48	496.44	41.97	1002.18	2762.60	1290.40	828.40	197.06	540.16	113.70	324.90	8974.4
1995	2.68	49.96	635.31	641.30	617.50	1197.11	1722.49	849.85	267.81	97.35	269.86	157.06	6508.3
1996	5.21	32.68	51.06	119.38	952.15	1978.27	1322.45	1431.51	263.42	215.63	57.09	113.69	6542.5
1997	8.68	74.92	104.10	104.87	1022.81	1467.20	1386.54	1016.31	592.64	83.33	49.90	70.24	5981.5
1998	49.78	391.45	268.05	219.73	619.38	1284.18	1483.99	1583.87	370.71	141.42	15.54	70.34	6498.4
1999	32.11	252.53	173.52	243.71	1079.28	1482.74	1395.00	1178.30	763.15	251.27	31.57	54.36	6937.6
2000	21.61	169.95	118.24	148.73	1395.59	1722.99	1187.30	1611.14	1027.62	623.71	94.82	212.81	8334.5
2001	12.33	96.96	65.98	160.66	1352.04	2348.48	1344.47	1671.77	1461.88	635.35	426.14	307.17	9883.2

Table G4. Mean weight (kg) at age of witch flounder in the total catch, 1982-2001.

						Age							
Year	0	1	2	3	4	5	6	7	8	9	10	11+	Total

Total Catch Mean Weight (kg) at age

Year	0	1	2	3	4	5	6	7	8	9	10	11+	Total
1982	0.000	0.002	0.038	0.152	0.242	0.329	0.421	0.550	0.727	0.886	0.983	1.406	0.662
1983	-	0.009	0.038	0.149	0.202	0.270	0.409	0.518	0.613	0.795	0.977	1.357	0.600
1984	-	0.017	0.040	0.151	0.229	0.328	0.421	0.539	0.664	0.817	0.922	1.339	0.607
1985	-	0.017	0.023	0.128	0.237	0.305	0.429	0.565	0.691	0.842	0.964	1.326	0.590
1986	0.000	0.017	0.026	0.089	0.206	0.299	0.408	0.533	0.676	0.853	0.975	1.321	0.546
1987	0.006	0.015	0.033	0.081	0.191	0.298	0.433	0.561	0.686	0.828	0.980	1.303	0.611
1988	0.004	0.006	0.017	0.045	0.203	0.311	0.434	0.538	0.668	0.819	0.980	1.326	0.592
1989	0.009	0.012	0.034	0.122	0.170	0.321	0.425	0.574	0.682	0.818	0.968	1.358	0.582
1990	0.004	0.012	0.029	0.062	0.187	0.257	0.438	0.586	0.688	0.849	1.049	1.454	0.438
1991	0.004	0.014	0.035	0.062	0.199	0.344	0.421	0.578	0.702	0.836	0.974	1.420	0.510
1992	0.003	0.007	0.026	0.103	0.230	0.379	0.459	0.614	0.739	0.822	0.882	1.243	0.458
1993	0.003	0.009	0.027	0.122	0.202	0.318	0.432	0.535	0.666	0.882	1.023	1.335	0.428
1994	0.005	0.004	0.019	0.070	0.202	0.280	0.430	0.534	0.691	0.832	0.909	1.266	0.345
1995	0.005	0.007	0.023	0.058	0.171	0.308	0.431	0.561	0.690	0.911	0.974	1.243	0.381
1996	0.004	0.019	0.031	0.061	0.155	0.234	0.425	0.554	0.708	0.856	0.974	1.232	0.389
1997	0.004	0.023	0.034	0.059	0.196	0.251	0.359	0.495	0.628	0.871	1.037	1.293	0.362
1998	0.003	0.006	0.023	0.065	0.169	0.249	0.349	0.492	0.585	0.871	0.978	1.206	0.339
1999	0.003	0.006	0.023	0.089	0.191	0.261	0.406	0.516	0.584	0.628	0.917	0.872	0.358
2000	0.003	0.006	0.024	0.083	0.185	0.207	0.359	0.450	0.533	0.633	0.677	0.925	0.359
2001	0.003	0.006	0.023	0.119	0.168	0.215	0.330	0.469	0.550	0.646	0.647	0.840	0.378
mean	0.004	0.011	0.028	0.094	0.197	0.288	0.411	0.538	0.659	0.815	0.940	1.253	0.477

Table G5. Stratified mean number per tow at age of witch flounder in NEFSC offshore
          spring and autumn bottom trawl surveys in Gulf of Maine-Georges Bank
          region (strata 22-30,36-40), 1963-2002.

| | SPRING | | AUTUMN | |
Year	Number per tow	Weight per tow	Number per tow	Weight per tow
1963	-	-	5.52	3.46
1964	-	-	2.89	2.00
1965	-	-	3.94	2.27
1966	-	-	7.80	4.56
1967	-	-	3.01	2.02
1968	4.83	3.35	4.82	3.49
1969	3.74	2.53	5.81	4.40
1970	6.39	4.49	4.89	3.71
1971	2.70	2.04	4.32	2.95
1972	5.35	4.01	3.24	2.42
1973	8.20	6.21	3.18	2.05
1974	6.23	3.62	2.38	1.58
1975	3.72	2.75	1.66	1.03
1976	5.50	3.70	1.34	0.94
1977	4.20	1.96	5.06	3.38
1978	3.87	2.56	4.04	2.94
1979	2.91	1.71	1.94	1.62
1980	8.46	3.89	2.62	2.04
1981	8.14	4.05	3.66	2.19
1982	3.64	1.87	0.99	0.83
1983	6.41	2.74	4.72	2.12
1984	3.00	1.66	4.37	2.34
1985	5.18	2.75	2.76	1.59
1986	2.07	1.35	1.59	1.09
1987	1.01	0.65	0.48	0.37
1988	1.43	0.85	1.38	0.57
1989	1.95	0.74	0.89	0.38
1990	0.63	0.24	2.00	0.40
1991	1.68	0.57	2.08	0.54
1992	1.26	0.48	0.94	0.24
1993	1.47	0.36	5.15	0.54
1994	3.13	0.53	2.21	0.42
1995	1.88	0.47	4.74	0.62
1996	1.36	0.28	5.38	1.02
1997	2.22	0.43	5.11	0.77
1998	4.27	0.77	3.70	0.47
1999	3.15	0.48	5.91	0.88
2000	3.45	0.52	6.63	1.11
2001	4.41	0.75	7.94	1.71
2002	8.10	1.62		

Note: During 1963-1984, BMV oval doors were used in the spring and autumn surveys; since 1985,
Portuguese polyvalent doors have been used in both surveys. No significant differences in
catchability were found for witch flounder, therefore no adjustments have been made (Byrne and
Forrester, 1991). No significant differences were found between research vessels, and no
adjustment have been made (Byrne and Forrester, 1991).

Spring surveys during 1973-1981 were accomplished with a 41 Yankee trawl; in all other years, a
36 Yankee trawl was used. No adjustments have been made.

Table G6.   Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys
            (Strata 22-30, 36-40), 1980-2002.

								AGE								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
Spring																
1980	0.00	0.06	0.23	0.95	1.52	0.72	1.20	1.02	0.38	0.40	0.31	0.30	0.12	0.16	1.10	8.46
1981	0.00	0.00	0.05	0.82	0.93	2.00	1.02	0.76	0.67	0.42	0.13	0.20	0.24	0.22	0.90	8.40
1982	0.00	0.04	0.01	0.56	0.57	0.34	0.21	0.64	0.41	0.08	0.26	0.15	0.03	0.03	0.30	3.64
1983	0.00	0.00	0.03	0.58	1.25	1.33	0.55	0.64	0.67	0.48	0.20	0.09	0.08	0.11	0.41	6.41
1984	0.00	0.00	0.01	0.10	0.33	0.73	0.42	0.26	0.28	0.24	0.11	0.12	0.09	0.02	0.29	3.00
1985	0.00	0.00	0.00	0.02	0.43	1.11	1.19	0.86	0.45	0.13	0.06	0.14	0.09	0.04	0.67	5.18
1986	0.00	0.00	0.00	0.00	0.04	0.24	0.53	0.43	0.17	0.18	0.07	0.04	0.08	0.05	0.25	2.07
1987	0.00	0.00	0.00	0.00	0.06	0.12	0.12	0.26	0.17	0.03	0.06	0.03	0.00	0.00	0.15	1.01
1988	0.00	0.02	0.02	0.06	0.00	0.07	0.31	0.38	0.25	0.16	0.08	0.04	0.02	0.00	0.02	1.43
1989	0.00	0.02	0.01	0.04	0.98	0.12	0.07	0.10	0.31	0.07	0.03	0.05	0.05	0.02	0.06	1.95
1990	0.00	0.01	0.00	0.04	0.09	0.32	0.02	0.02	0.02	0.06	0.01	0.00	0.01	0.00	0.03	0.63
1991	0.00	0.04	0.00	0.78	0.11	0.11	0.19	0.02	0.09	0.10	0.14	0.02	0.02	0.00	0.07	1.68
1992	0.00	0.05	0.01	0.19	0.37	0.08	0.12	0.15	0.05	0.14	0.02	0.01	0.05	0.00	0.02	1.26
1993	0.00	0.15	0.11	0.14	0.46	0.33	0.06	0.08	0.00	0.02	0.02	0.00	0.06	0.00	0.04	1.47
1994	0.00	0.10	0.71	0.53	0.64	0.83	0.16	0.03	0.02	0.06	0.01	0.00	0.00	0.02	0.02	3.13
1995	0.00	0.04	0.12	0.58	0.32	0.18	0.31	0.11	0.12	0.04	0.00	0.04	0.03	0.00	0.00	1.88
1996	0.00	0.02	0.04	0.24	0.41	0.33	0.22	0.07	0.00	0.00	0.00	0.03	0.00	0.00	0.00	1.36
1997	0.00	0.07	0.07	0.15	0.71	0.58	0.46	0.08	0.10	0.00	0.00	0.00	0.00	0.00	0.00	2.22
1998	0.00	0.11	1.06	0.73	0.41	0.79	0.70	0.21	0.15	0.08	0.00	0.00	0.00	0.03	0.00	4.27
1999	0.00	0.11	0.40	0.98	0.77	0.49	0.17	0.18	0.03	0.01	0.02	0.00	0.00	0.00	0.00	3.15
2000	0.00	0.01	0.27	1.17	0.70	0.67	0.24	0.25	0.11	0.00	0.04	0.00	0.00	0.00	0.00	3.45
2001	0.00	0.11	0.09	0.72	1.47	1.02	0.41	0.30	0.15	0.11	0.04	0.00	0.00	0.00	0.00	4.41
2002	0.00	0.02	0.06	0.87	2.69	2.23	0.81	0.70	0.35	0.20	0.10	0.02	0.00	0.03	0.04	8.10

Table G6 continued.   Stratified mean number per tow at age of witch flounder in NEFSC bottom trawl spring and autumn surveys (Strata 22-30, 36-40), 1980-2002.

	AGE															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14+	Total
Autumn																
1980	0.04	0.00	0.02	0.00	0.20	0.26	0.28	0.36	0.17	0.15	0.27	0.04	0.16	0.12	0.57	2.62
1981	0.03	0.07	0.03	0.24	0.44	0.61	0.46	0.27	0.26	0.18	0.21	0.17	0.04	0.13	0.48	3.66
1982	0.02	0.00	0.00	0.06	0.01	0.02	0.08	0.25	0.13	0.01	0.03	0.03	0.00	0.06	0.29	0.99
1983	0.00	0.01	0.01	0.49	1.60	0.78	0.51	0.47	0.11	0.10	0.12	0.09	0.02	0.00	0.42	4.72
1984	0.00	0.00	0.00	0.08	0.97	1.01	0.58	0.54	0.32	0.14	0.12	0.06	0.04	0.14	0.38	4.37
1985	0.00	0.00	0.01	0.07	0.06	0.60	0.62	0.58	0.24	0.13	0.09	0.01	0.03	0.10	0.22	2.76
1986	0.01	0.00	0.00	0.01	0.04	0.27	0.36	0.31	0.15	0.11	0.02	0.02	0.01	0.05	0.23	1.59
1987	0.00	0.00	0.02	0.01	0.00	0.02	0.05	0.18	0.07	0.00	0.01	0.00	0.02	0.00	0.08	0.48
1988	0.00	0.00	0.00	0.71	0.07	0.00	0.03	0.22	0.06	0.05	0.03	0.06	0.02	0.03	0.08	1.38
1989	0.17	0.02	0.02	0.08	0.30	0.01	0.02	0.04	0.05	0.09	0.01	0.00	0.03	0.00	0.04	0.89
1990	0.48	0.12	0.11	0.39	0.52	0.17	0.05	0.02	0.02	0.05	0.00	0.00	0.01	0.04	0.03	2.00
1991	0.22	0.02	0.17	0.67	0.35	0.27	0.15	0.09	0.06	0.02	0.04	0.03	0.00	0.00	0.00	2.08
1992	0.09	0.03	0.11	0.27	0.22	0.06	0.05	0.00	0.00	0.02	0.01	0.02	0.00	0.01	0.04	0.94
1993	2.54	0.67	0.11	0.55	0.76	0.23	0.06	0.03	0.08	0.00	0.02	0.04	0.00	0.01	0.01	5.15
1994	0.42	0.17	0.28	0.50	0.20	0.39	0.04	0.11	0.00	0.04	0.01	0.00	0.01	0.00	0.04	2.21
1995	0.51	0.21	0.80	1.57	0.86	0.49	0.22	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.01	4.74
1996	0.23	0.09	0.27	0.74	2.02	1.40	0.45	0.06	0.06	0.03	0.00	0.04	0.00	0.00	0.00	5.38
1997	0.89	0.34	1.00	0.53	0.86	0.77	0.40	0.32	0.00	0.00	0.00	0.00	0.02	0.00	0.00	5.10
1998	0.64	0.08	0.54	1.33	0.48	0.31	0.17	0.10	0.04	0.02	0.00	0.00	0.00	0.00	0.00	3.70
1999	0.32	0.53	1.17	1.51	1.06	0.58	0.36	0.28	0.06	0.03	0.01	0.00	0.00	0.00	0.00	5.91
2000	0.94	0.10	0.71	1.43	1.75	0.68	0.59	0.22	0.14	0.05	0.00	0.00	0.03	0.00	0.00	6.63
2001	0.00	0.04	0.21	0.92	3.13	1.93	0.81	0.62	0.16	0.06	0.05	0.00	0.00	0.00	0.00	7.94

Table G7. Estimates of beginning year stock size ('000 of fish), instantaneous fishing mortality (F)
         and spawning stock biomass (mt)for witch flounder estimated from virtual population analysis, 1982-2001.

Stock Size Jan 1 ('000)

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
3	15430	17856	15839	7315	4853	2936	9470	6322	6805	8941
4	12802	13104	15056	13497	6182	4155	2506	7594	5026	5538
5	9764	10032	10030	11598	10526	4971	3408	2028	6131	3736
6	7902	7284	7223	6775	8018	7652	3845	2688	1685	4249
7	4565	5433	4808	4603	4035	4326	5399	2699	2022	1211
8	2990	3312	3201	2759	2547	2019	2263	3364	1616	1484
9	2340	1965	1943	1365	1217	1418	930	877	2075	950
10	1372	1644	1007	1026	613	665	775	428	429	1473
11+	9013	5364	4580	3458	2071	1279	1724	1199	933	1206
3+	66178	65994	63687	52396	40062	29421	30320	27199	26722	28788

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	14538	10112	16169	15902	15982	18357	36749	51092	83904	67123	22643
4	7286	12142	8316	13878	13092	13645	15703	31427	43749	72079	57625
5	4388	5102	8774	6228	11372	10385	10795	12941	26048	36361	60784
6	2407	2973	3074	4988	4250	7953	7578	8100	9763	20821	29117
7	3118	1196	1706	1448	2696	2431	5559	5145	5678	7301	16673
8	821	2012	474	700	458	992	1150	3315	3335	3392	4733
9	1047	518	1188	225	354	150	304	646	2145	1917	1563
10	544	735	242	521	104	104	52	130	322	1268	1061
11+	1699	1023	686	300	204	145	233	224	720	908	1194
3+	35848	35813	40629	44190	48512	54162	78123	113020	175664	211170	195393

Table G7 continued.

Fishing Mortality

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0.01	0.02	0.01	0.01	0
3	0.01	0.02	0.01	0.02	0.01	0.01	0.07	0.08	0.06	0.05
4	0.09	0.12	0.11	0.10	0.07	0.05	0.06	0.06	0.15	0.08
5	0.14	0.18	0.24	0.22	0.17	0.11	0.09	0.04	0.22	0.29
6	0.22	0.27	0.30	0.37	0.47	0.20	0.20	0.14	0.18	0.16
7	0.17	0.38	0.41	0.44	0.54	0.50	0.32	0.36	0.16	0.24
8	0.27	0.38	0.70	0.67	0.44	0.63	0.80	0.33	0.38	0.20
9	0.20	0.52	0.49	0.65	0.45	0.45	0.63	0.56	0.19	0.41
10	0.21	0.41	0.51	0.55	0.50	0.53	0.46	0.37	0.23	0.26
11+	0.21	0.41	0.51	0.55	0.50	0.53	0.46	0.37	0.23	0.26
7-9,u	0.21	0.43	0.53	0.59	0.48	0.53	0.58	0.42	0.24	0.28

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0.06	0	0	0	0	0	0.01	0
2	0.01	0.01	0.03	0.04	0	0	0	0	0	0
3	0.03	0.05	0.00	0.04	0.01	0.01	0.01	0.01	0	0
4	0.21	0.17	0.14	0.05	0.08	0.08	0.04	0.04	0.03	0.02
5	0.24	0.36	0.41	0.23	0.21	0.17	0.14	0.13	0.07	0.07
6	0.55	0.41	0.60	0.47	0.41	0.21	0.24	0.21	0.14	0.07
7	0.29	0.77	0.74	1.00	0.85	0.60	0.37	0.28	0.37	0.28
8	0.31	0.38	0.59	0.53	0.97	1.03	0.43	0.29	0.40	0.62
9	0.20	0.61	0.67	0.63	1.07	0.91	0.70	0.54	0.38	0.44
10	0.27	0.53	0.70	0.82	0.90	0.72	0.39	0.30	0.38	0.45
11+	0.27	0.53	0.70	0.82	0.90	0.72	0.39	0.30	0.38	0.45
7-9,u	0.27	0.59	0.67	0.72	0.96	0.85	0.50	0.37	0.38	0.45

Table G7 continued.

Spawning Stock biomass ('000 mt)

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	5	2	1	4	3	3	0
4	0	88	107	367	145	78	46	96	108	6
5	55	486	483	1871	1726	768	520	326	784	88
6	423	1297	1174	2237	2451	2495	1253	896	574	531
7	1105	1858	1648	2035	1718	1856	2410	1236	958	457
8	1589	1708	1578	1468	1428	1073	1182	1881	929	870
9	1806	1336	1237	894	845	959	613	575	1491	656
10	1206	1393	772	811	499	543	630	349	373	1250
11+	11938	6632	5491	4083	2457	1489	2063	1492	1273	1598
1+	18121	14798	12490	13772	11271	9263	8721	6854	6493	5456

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	72	69
4	8	17	87	102	84	100	106	237	489	744
5	113	127	893	684	1007	912	1069	1219	1248	1743
6	340	439	903	1406	1262	1955	1893	2185	1537	2828
7	1178	407	706	587	1116	985	2142	2030	1735	2172
8	482	1142	255	379	240	481	562	1652	1482	1378
9	750	368	770	157	222	99	195	348	1183	1010
10	435	602	188	399	82	85	44	108	192	734
11+	1968	1220	753	318	211	163	256	181	609	690
1+	5274	4321	4555	4032	4222	4779	6267	7960	8548	11368

Table G8. Summary of projection input and results for witch flounder. Projected median estimates of catch (median landings + median discards), landings, discards and spawning stock biomass are provided for fishing mortality with a 15% reduction in current F ($F_{2002} = F_{2001} * .85 = 0.38$).

Projection input:

Age	Fish Mort. Pattern	Proportion Mature	Discard Fraction	Average Weights Landings	Stock	Discards
3	0.0090	0.020	1.00	0.116	0.047	0.089
4	0.0960	0.090	0.93	0.293	0.114	0.168
5	0.2500	0.250	0.75	0.335	0.207	0.194
6	0.4150	0.540	0.15	0.387	0.295	0.219
7	1.0000	0.780	0.00	0.482	0.420	0.219
8	1.0000	0.930	0.00	0.563	0.524	0.219
9	1.0000	0.990	0.00	0.695	0.635	0.219
10	1.0000	1.000	0.00	0.805	0.777	0.219
11+	1.0000	1.000	0.00	0.961	0.961	0.219

Projection results (weight reported in '000 mt)

Scenario	Year	F full	Median Catch	Median Landings	Median Discards	Median SSB
85% of F2001	2002	0.38	7.11	5.96	1.15	18.31
FMSY	2003	0.164	4.37	3.98	0.39	25.41
FMSY	2004	0.164	6.26	6.06	0.20	34.70
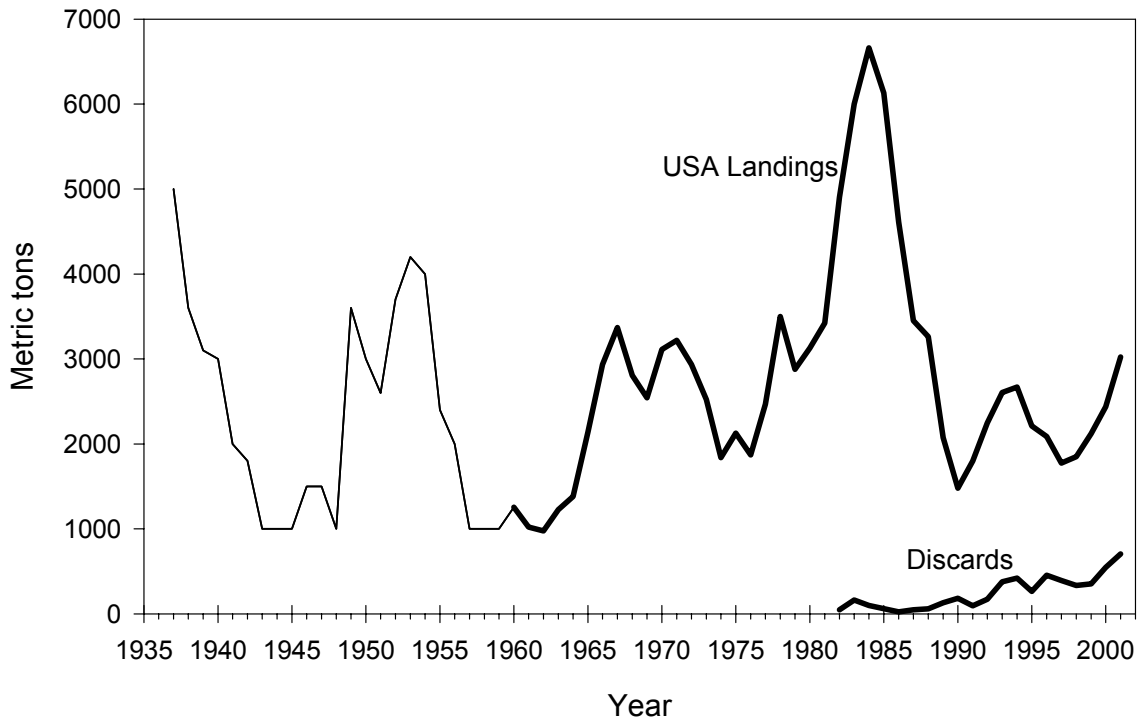
Figure G1. Historical USA witch flounder landings (mt), excluding USA landings from
the Grand Banks in the mid-1980's. The thin line represents provisional
landings data taken from Lange and Lux (1978). Discards are from the
shrimp and large-mesh otter trawl fisheries.
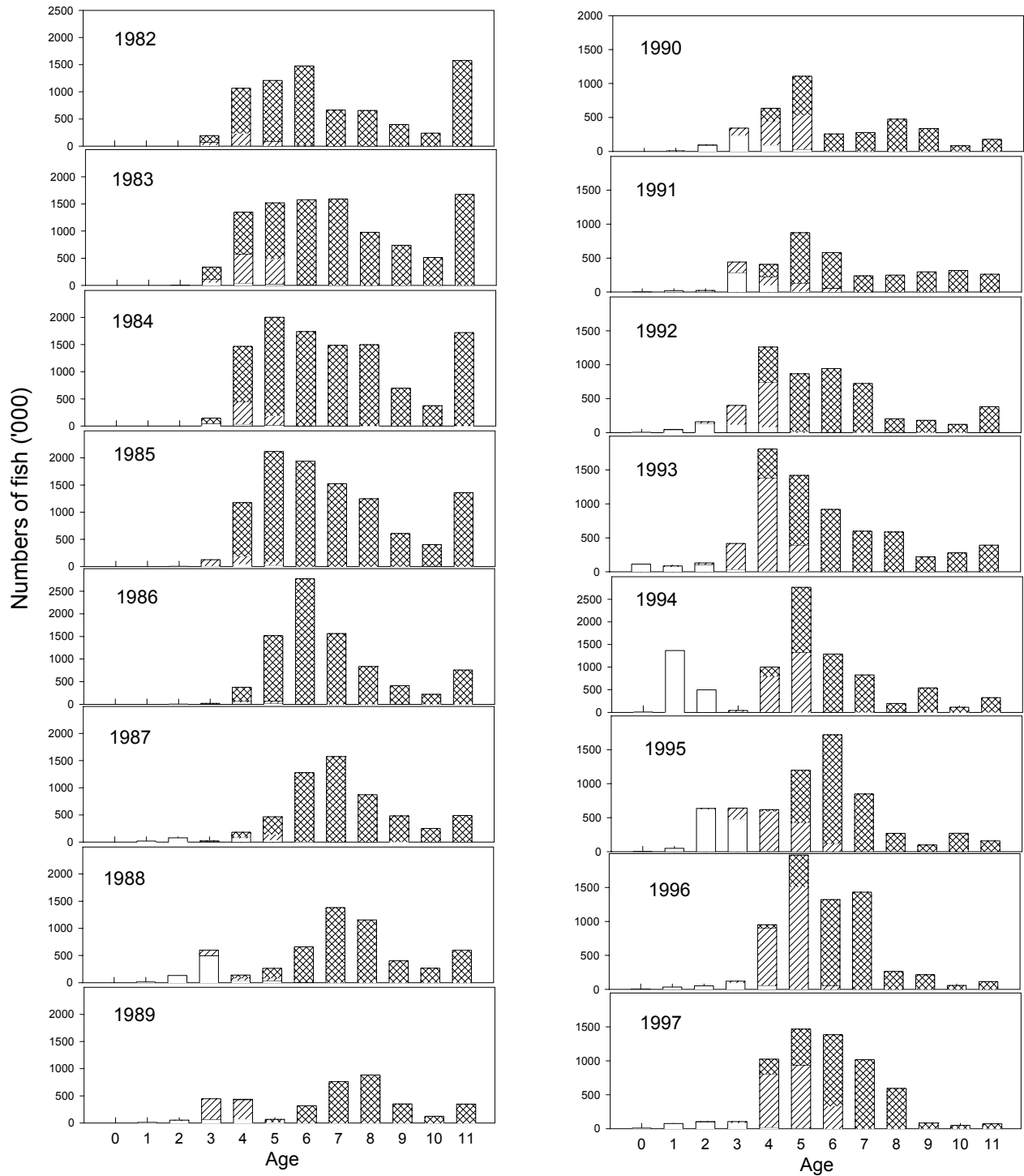
Figure G2. Number of witch flounder ('000 of fish) at age in the total catch, by
fishery, 1982-2001. Open bar represents discards in the shrimp fishery,
diagonal bar represents discards in large-mesh fishery and hatched bar
represents landings.
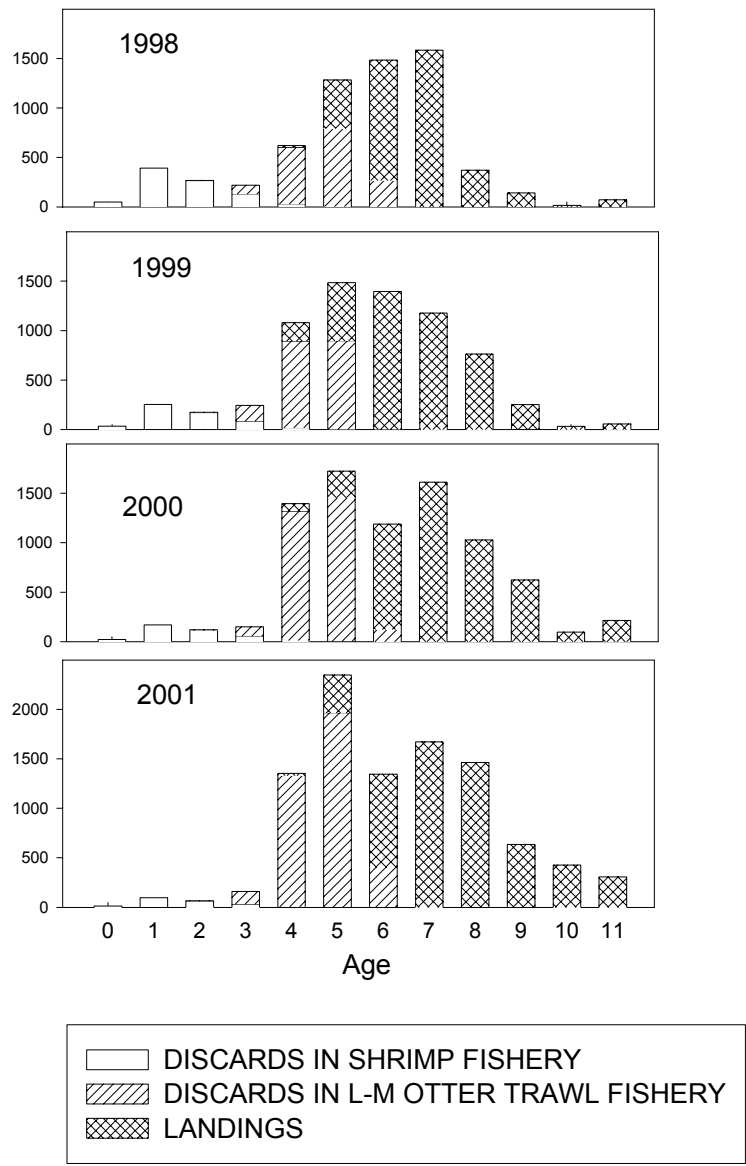
Figure G2 continued.
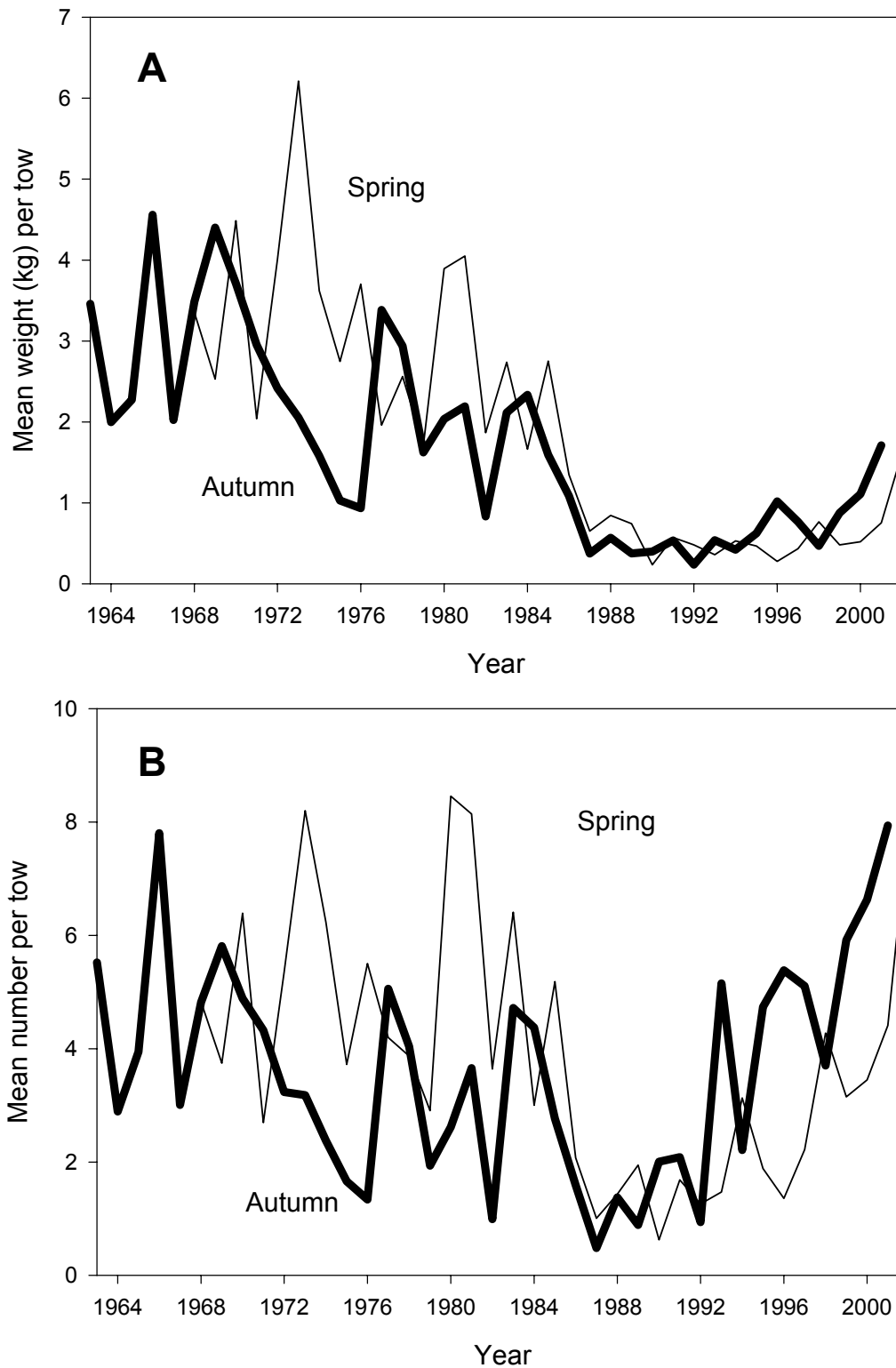
Figure G3.   Stratified mean weight (kg) per tow (A) and mean number per tow (B) of witch flounder in the NEFSC spring and autumn bottom trawl surveys, 1963-2002.
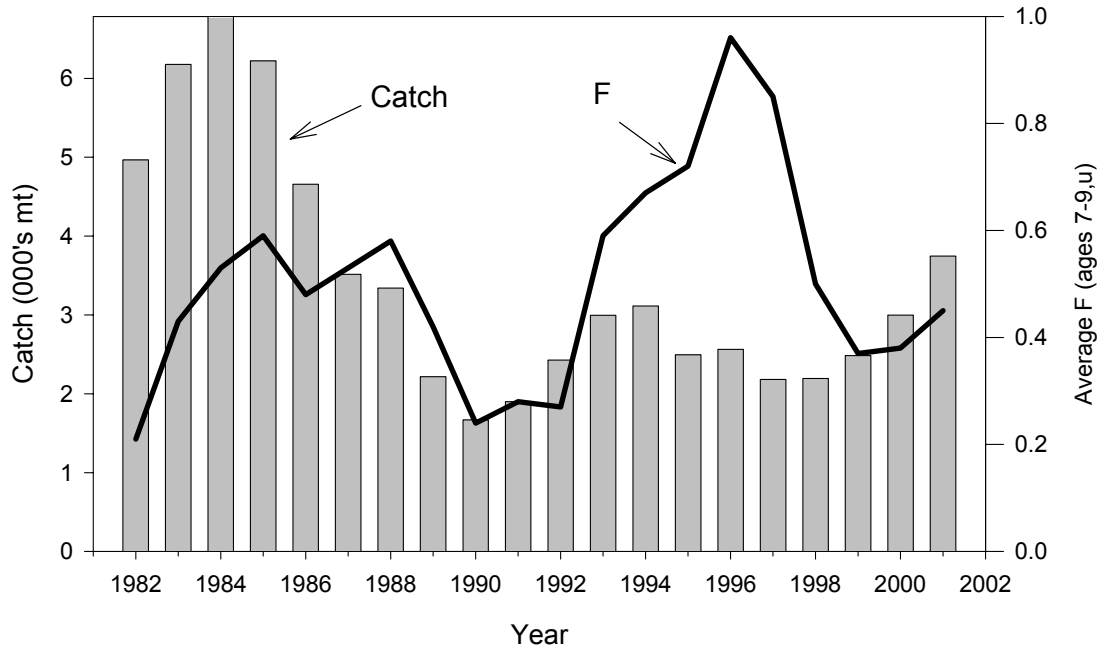
Figure G4. Trends in total catch and fishing mortality for witch flounder, 1982-2001.
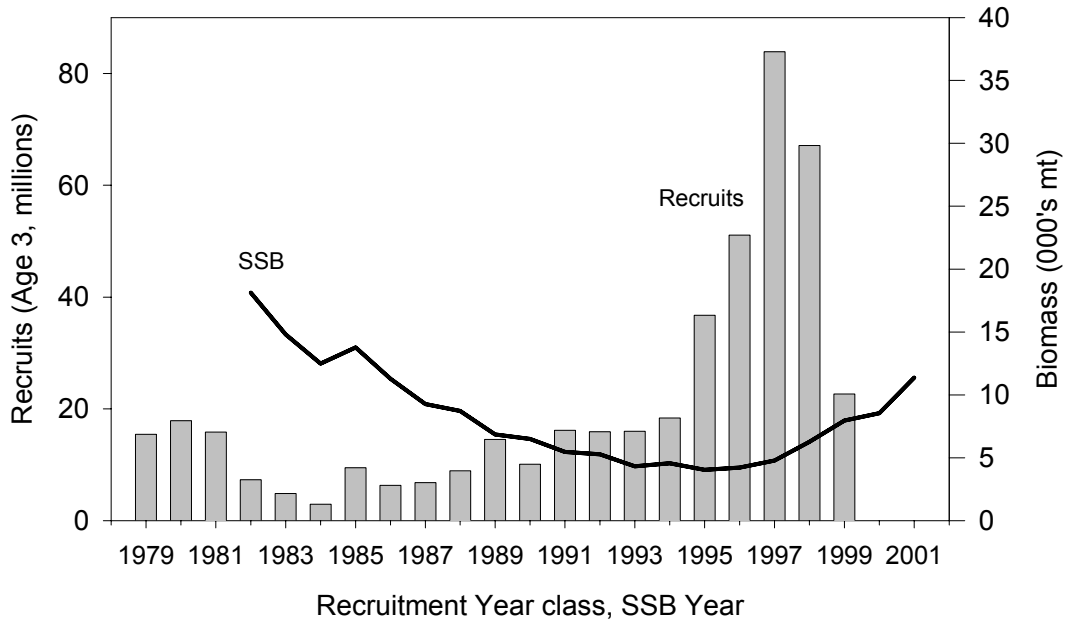
Figure G5. Trends in spawning stock biomass and recruitment (age 3) for witch flounder.

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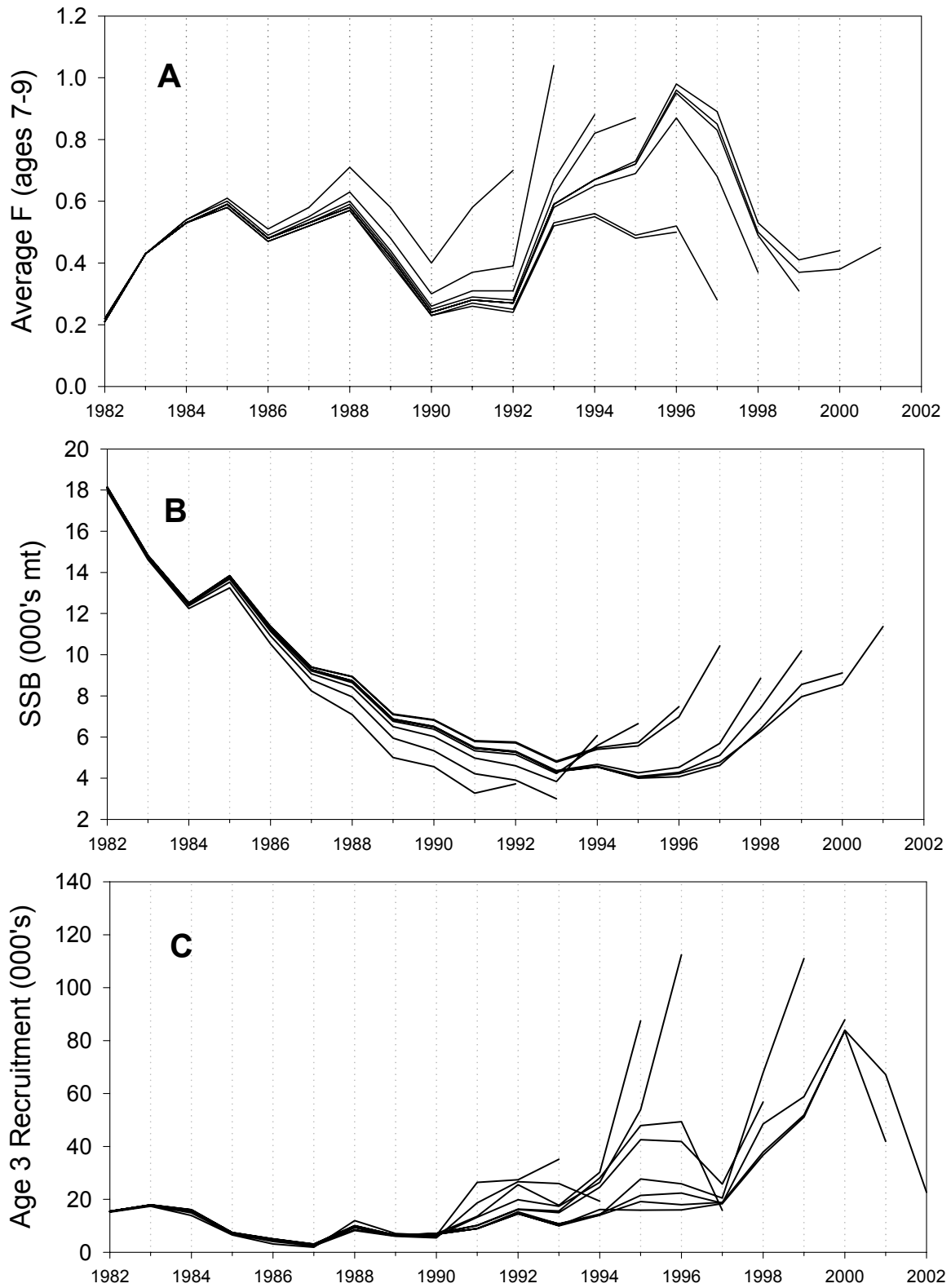
Figure G6.   Retrospective analysis results of fishing mortality(A),
             spawning stock biomass (B), and age 3 recruitment(C).

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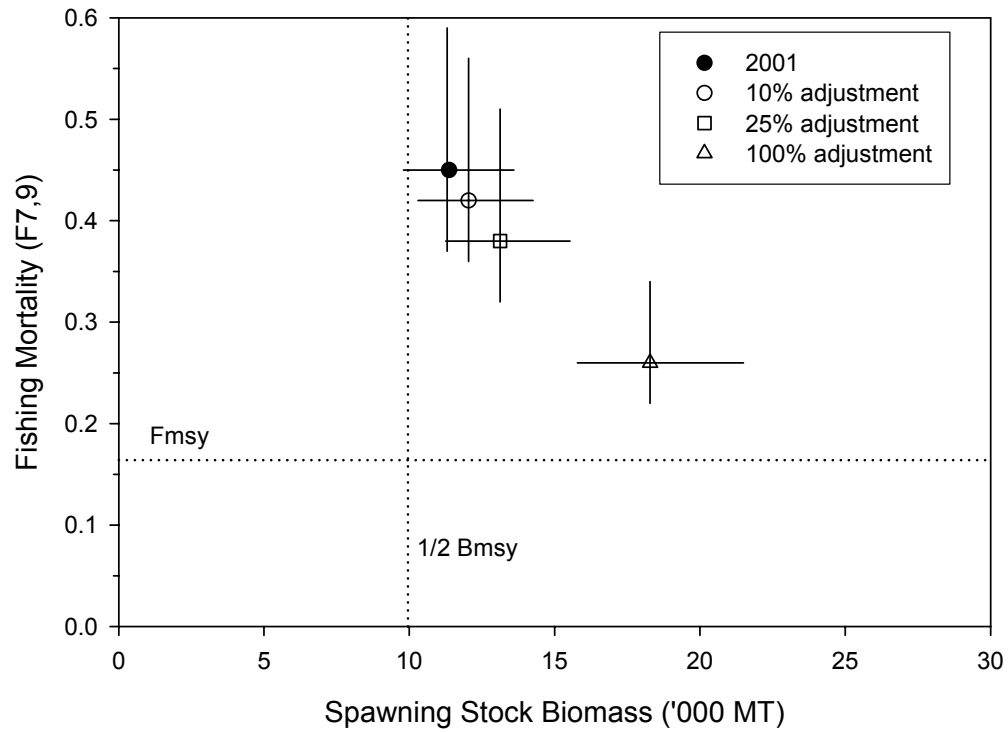
Figure G7. Stock status of witch flounder in 2001 (solid circle with 80% confidence
            intervals) and three sensitivity analyses: the open circle represents
            stock status when the 2000-2002 survey tuning indices were arbitrarily adjusted
            upward by 1.1; open square represents results when 2000-2002 survey tuning indices
            were arbitrarily adjusted by 1.25; open triangle represents results when 2002-2002
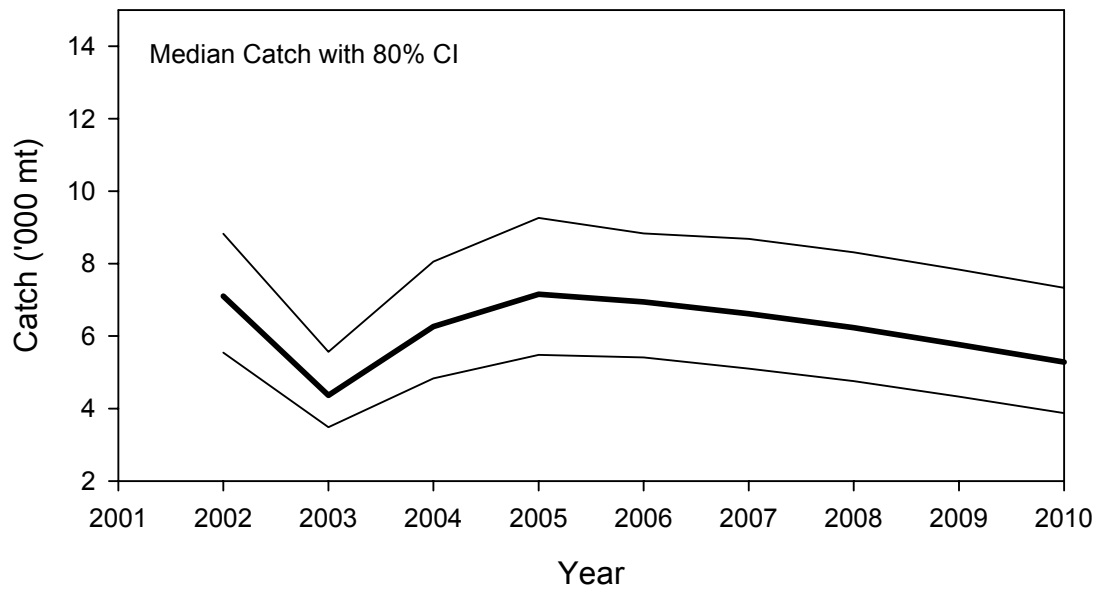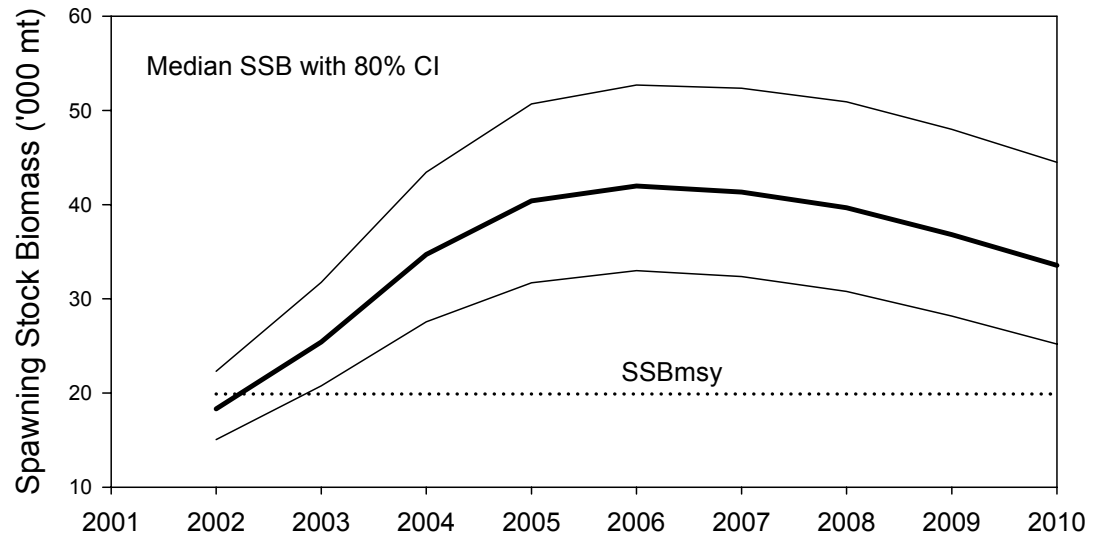   survey tuning indices were arbitrarily adjusted by 2.0.

Figure G8. Projected median spawning stock biomass ('000 mt) and median catch ('000 mt)
with 80% confidence intervals.