3.11 Southern New England winter flounder

Catch and Survey Indices

After reaching an historical peak of nearly 12,000 metric tons (mt) in 1966, then declining through the 1970s, total U.S. commercial landings again peaked at 11,200 mt in 1981, and then steadily declined to a record low of 2,200 mt in 1994. Commercial landings have increased since 1994 to about 3,900 mt in 2000. Commercial fishery discards are generally about 5-10% of the commercial landings, and were estimated to be about 270 mt in 2000. Recreational landings reached a peak of 5,800 mt in 1984, but declined dramatically thereafter, and were estimated at about 530 mt in 2000. Recreational discards are small in relation to the other components of the catch, and were estimated at only 24 mt in 2000. The total catch of Southern New England winter flounder varied between 12,000 to 16,000 in the early 1980s, declined through the 1980s to about 4,000 mt by 1994, and was about 4,700 mt in 2000 (Figure 3.11.1). NEFSC research survey indices dropped from the beginning of the time series in the 1960s to a low point in the early to mid- 1970s, then rose to a peak by the early 1980s. Following several years of high indices in the early 1980s, NEFSC abundance indices reached near- or record low levels in the late 1980s- early 1990s. NEFSC survey indices have generally increased since 1993, and are currently at about 50% of the peak levels seen in the mid-1960s and early 1980s (Figure 3.11.1). Massachusetts Division of Marine Fisheries (MADMF) research survey indices steadily declined from a peak in 1979 to a low in 1992, and then increased to moderate levels in the late 1990s (Figure 3.11.1).

Stock Assessment

The Southern New England/Mid-Atlantic Bight stock complex of winter flounder was last fully assessed by SAW 28 in 1998, with catches through 1997 (NEFSC 1999a). The assessment is for the entire stock complex, which includes several inshore spawning aggregations that individually may not demonstrate the same trend in abundance as the complex. Fully recruited (ages 4-6) fishing mortality in 1997 was estimated at 0.31, and total stock biomass in 1997 was estimated to be 17,900 mt. Reference points were estimated by a surplus production model in the SAW 28 assessment. Bmsy (total stock biomass) was estimated to be 27,810 mt, and MSY was estimated to be 10,200 mt, Fmsy was estimated to be biomass weighted F = 0.37 (equivalent to fully recruited F of 0.59), and the FMP Amendment 9 ten year rebuilding target biomass weighted fishing mortality was estimated to be $F_{target10}$ = 0.24 (equivalent to fully recruited F of 0.33). Projections for Southern New England winter flounder through 1999 were reviewed as part of the 2001 review of 19 Northeast groundfish stocks conducted by the NEFSC staff (Northern Demersal and Southern Demersal Working Groups 2001). Projections based on 1998 and 1999 total catch indicated that fully recruited F (age 4-6) was still at about 0.30 in 1999, and total stock biomass was estimated to be about 25,300 mt. The fishing mortality reference points F(0.1) and F40% given in Figure 3.11.2 were calculated for this exercise using ages 1 through 7+ in order to be consistent with the projections described below, and thus may differ slightly from previously reported values (see appendix for yield per recruit analysis results).

Empirical Nonparametric approach

If F40% is assumed to be an adequate proxy for Fmsy, then the fishing mortality threshold is 0.206. This fishing mortality rate produces 1.1063 kg of spawning stock biomass per recruit and 0.2462 kg of yield per recruit (including discards; Figure 3.11.2). Since the VPA estimates of recruitment increase with increasing spawning stock size, the mean of the top 5 value of spawning stock biomass is assumed to be representative of recruitment levels expected at maximum sustainable yield (MSY). Thus, recruitment of 42.31 million fish results in an estimate of 46,810 mt of spawning stock biomass (Bmsy proxy) and 10,420 mt of total yield (including discards; Figure 3.11.2).

Parametric Model Approach

Maximum likelihood fits of the 10 parametric stock-recruitment models to the Southern New England winter flounder VPA estimates for 1982-1998 are listed below (Table 3.11.1). The model acronyms are: BH = Beverton-Holt, ABH = Beverton-Holt with autoregressive errors, PBH = Beverton-Holt with steepness prior, PABH = Beverton-Holt with steepness prior and autoregressive errors, PRBH = Beverton-Holt with recruitment prior, PRABH = Beverton-Holt with recruitment prior and autoregressive errors, RK = Ricker, ARK = Ricker with autoregressive errors, PRK = Ricker with slope at the origin prior, PARK = Ricker with slope at the origin prior and autoregressive errors. The six hierarchical criteria are applied to each of the models to determine the set of candidate models.

The ABH model does not satisfy criterion 1 because the estimate of steepness is on the boundary of the feasible range. The second criterion is not satisfied by the BH, PBH, RK, and PRK models because their point estimates of MSY are above the maximum observed landings value of 15,800 mt. All remaining models satisfy criterion 3. The remaining models also satisfy the fourth criterion because F_{MAX}=0.89. The remaining autoregressive models PABH, PRABH, ARK, and PARK, do not satisfy criterion 5 because their power spectra imply long-term forcing beyond the length of the stock-recruitment time series (Figure 3.11.3). The last remaining model is the PRBH model which satisifies criteria 3 through 6. Thus, the PRBH model is the only candidate parametric model for Southern New England winter flounder.

The results of using the PRBH model as the best fit parametric model are shown below (Figures 3.11.4-3.11.7). The standardized residual plot of the fit of the PRBH model to the stock-recruitment data shows that the standardized residuals generally lie within ± two standard deviations of zero (Figure 3.11.4), with the exception of the 1992 data point.

In the equilibrium yield plot (Figure 3.11.5), the yield surface is relatively flat in the neighborhood of the point estimate of F_{MSY} = 0.32. The point estimates of S_{MSY} (30,100 mt) and MSY (10,600 mt) appear consistent with the nonparametric proxy estimate of S_{MSY} and previous estimates of MSY. The stock-recruitment plot (Figure 3.11.6) shows that recruitment values near S_{MSY} are roughly 45 million fish which is consistent with the long-term average of the observed recruitment series when spawning biomass was high, during the early 1980s.

Parameter uncertainty plots show histograms of 5000 MCMC sample estimates of MSY, S_{MSY}, and F_{MSY} drawn from the posterior distribution of the MLE based on an uninformative prior. For MSY, the 80 percent credibility interval was (9,500, 11,200) with a median of 10,400 mt (Figure 3.11.7). For S_{MSY}, the 80 percent credibility interval was (25,500, 32,100) with a median of 28,900 mt. For F_{MSY}, the 80 percent credibility interval was (0.305, 0.355) with a median of 0.325. Overall, the point estimates of MSY and S_{MSY} were slightly larger than the medians of the MCMC samples.

Reference Points

Based on the conformance of the recruitment-biomass per recruit analysis and the parametric stock-recruitment relationship, the following management parameters are considered most appropriate: Bmsy = 30,100 mt (spawning stock biomass), Fmsy = 0.32 (fully recruited F), and MSY = 10,600 mt (including commercial and recreational landings and discards). Catch equal to or exceeding this estimate of MSY was removed from the stock during the early 1980s, but at a spawning stock biomass (10,000-15,000 mt) of about 50% of the Bmsy level, and at much higher fully recruited fishing mortality rates (F = 0.45-0.77) than the Fmsy level.

Projections

Given that the Beverton and Holt model with a prior on recruitment (set at the mean of the recruitment (42.31 million) produced by the spawning stock biomass present during the early 1980s (>10,000 mt)) was assumed to be the most appropriate fit for the VPA stock and recruitment data, projections were conducted with this relationship. Since the last year in the VPA was 1997, total catch for 1998-2001 was estimated using 1998-2000 commercial and recreational landings and discard estimates, 2001 commercial landings for January-November raised to an annual total, 2001 commercial discards assumed to be 7% of the 2001 commercial landings, and 2001 preliminary recreational landings and discards estimates. The 2000 total catch estimate is 4,711 mt and the 2001 total catch estimate is 4,746 mt. For 2002, the fishing mortality rate was assumed to be the same as that estimated for 2001, F = 0.251. For years 2003 through 2009, the fishery was assumed to fish at a rate of Fmsy (0.32, fully recruited F). Under these assumptions, there is a 45% chance that the spawning stock biomass will be at least as large as Bmsy by 2009 (see Figures 3.11.8-3.11.10. for projection results). A second projection indicates that fishing mortality would need to be reduced to F = 0.30 during 2003 through 2009 to provide at least a 50% chance that spawning stock biomass will reach Bmsy by 2009.

Table 3.11.1. Stock-recruitment model comparisons for southern New England winter flounder.

Southern New England Winter Flounder Model Comparison										
SMAX =	14.8									
	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior
	0	0	0	0	1.0000	0.0	0	0	0	0
	BH	ABH	PBH	PABH	**PRBH**	PRABH	RK	ARK	PRK	PARK
Posterior Probability	0.00	0.00	0.00	0.00	**1.00**	0.00	0.00	0.00	0.00	0.00
Odds Ratio for Most Likely Model					1.00					
Normalized Likelihood	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Model AIC Ratio					1					
	BH	**ABH**	**PBH**	**PABH**	**PRBH**	**PRABH**	**RK**	**ARK**	**PRK**	**PARK**
Number_of_data_points	17	17	17	17	17	17	17	17	17	17
Number_of_parameters	3	4	3	4	3	4	3	4	3	4
Negative_loglikelihood	57.3304	54.4788	55.9922	53.8859	61.6136	57.7619	57.3451	55.336	59.7565	56.1928
Bias-corrected_AIC	122.507	120.291	122.557	121.841	125.772	121.797	122.536	122.005	124.919	125.295
Diagnostic Comments	MSY exceeds max observed landings & SMSY substantially exceeds proxy	Steepness parameter at boundary of feasible range	MSY exceeds max observed landings & SMSY substantially exceeds proxy	Power spectrum dominant frequency exceeds 1/2 time series length	**Most Likely Model**	Power spectrum dominant frequency exceeds 1/2 time series length	MSY exceeds max observed landings	Power spectrum dominant frequency exceeds 1/2 time series length	MSY and SMSY are outside credible range	Power spectrum dominant frequency exceeds 1/2 time series length
Parameter Point Estimates										
***********************										
MSY	24.8351	7.73735	21.6966	9.71019	10.606	10.4364	17.1342	8.24175	32407.8	1.79024
FMSY	0.265	0.905	0.27	0.345	0.32	0.37	0.44	0.755	0.35	0.26
SMSY	85.9627	7.10725	73.6515	25.4992	30.1439	25.4559	34.7668	9.28666	83823.1	6.32069
alpha	125.526	25.5949	107.923	41.6089	47.5356	43.2341	1.41779	2.06335	1.15144	0.812791
expected_alpha	131.789	29.4582	113.324	44.7586	50.4245	46.8443	1.48866	2.29786	1.21789	2.57165
beta	29.5672	6.641E-06	24.2383	5.30601	7.39754	4.63312	-2.57E-02	-1.06E-01	-1E-05	-0.117795
RMAX	41.8728	25.5948	40.9151	30.6282	31.6939	32.9265	41.7365	24.2483	46.8016	5.83601
expected_RMAX	43.9621	29.4582	42.9627	32.9467	33.6201	35.676	43.8226	27.0042	49.5028	18.465
Prior_mean			0.8	0.8	42.314	42.314			0.79	0.79
Prior_se			0.09	0.09	4.95	4.95			0.18	0.18
Z_Myers	0.75	1.00	0.75	0.84	0.82	0.87				
sigma	0.312	0.530	0.313	0.382	0.344	0.400	0.312	0.464	0.335	1.518
phi		0.88		0.71		0.74		0.82		0.98
sigmaw		0.25		0.27		0.27		0.27		0.28
last log-residual R		-0.419		-0.422		-0.510		-0.479		0.872
expected lognormal error term	1.050	1.15	1.05	1.08	1.06	1.08	1.05	1.11	1.06	3.16

Table 3.11.2. Results of yield and spawning stock biomass per recruit analyses for Southern New England winter flounder.

```
The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
        PC Ver.1.1 [Method of Thompson and Bell (1934)] 1-OCT-1991
                ----------------------------------------
                Run Date: 21- 2-2002;  Time: 11:08:52.02
     SNE/MAB WFL: SARC 28 PR, Mean Weights, 7+
     _____________________________________________________________________
     Proportion of F before spawning:  .2000
     Proportion of M before spawning:  .2000
     Natural Mortality is Constant at:  .200
     Initial age is:  1; Last age is:  7
     Last age is a PLUS group;
     Original age-specific PRs, Mats, and Mean Wts from file:
     ==> YPR28_7.DAT
    ------------------------------------------------------------
     Age-specific Input data for Yield per Recruit Analysis
    ------------------------------------------------------------
      Age | Fish Mort  Nat Mort | Proportion | Average Weights
          |  Pattern    Pattern |   Mature   |  Stock   Catch
    ------------------------------------------------------------
       1  |   .0200     1.0000  |    .0000   |   .067    .134
       2  |   .2500     1.0000  |    .0000   |   .264    .388
       3  |   .6100     1.0000  |    .5300   |   .430    .508
       4  |  1.0000     1.0000  |    .9500   |   .540    .612
       5  |  1.0000     1.0000  |   1.0000   |   .657    .754
       6  |  1.0000     1.0000  |   1.0000   |   .817    .941
       7+ |  1.0000     1.0000  |   1.0000   |  1.113   1.135

    ------------------------------------------------------------
     Summary of Yield per Recruit Analysis for:
     SNE/MAB WFL: SARC 28 PR, Mean Weights, 7+
     _____________________________________________________________________
      Slope of the Yield/Recruit Curve at F=0.00: -->    2.8970
        F level at slope=1/10 of the above slope (F0.1): ----->     .253
          Yield/Recruit corresponding to F0.1: ----->     .2626
        F level to produce Maximum Yield/Recruit (Fmax): ----->     .890
          Yield/Recruit corresponding to Fmax: ----->     .3023
        F level at 40 % of Max Spawning Potential (F40): ----->     .206
          SSB/Recruit corresponding to F40: -------->    1.1063
     _____________________________________________________________________
    1
     -----------------------------------------------------------------------------
     Listing of Yield per Recruit Results for:
     SNE/MAB WFL: SARC 28 PR, Mean Weights, 7+
     -----------------------------------------------------------------------------
          FMORT   TOTCTHN  TOTCTHW  TOTSTKN  TOTSTKW  SPNSTKN  SPNSTKW    % MSP
     -----------------------------------------------------------------------------
           .000    .00000   .00000   5.5167   3.3129   3.2239   2.7665   100.00
           .050    .13317   .11028   4.8535   2.6281   2.5682   2.0908    75.57
           .100    .22266   .17569   4.4087   2.1821   2.1307   1.6529    59.75
           .150    .28717   .21679   4.0886   1.8711   1.8179   1.3494    48.78
           .200    .33606   .24365   3.8466   1.6435   1.5831   1.1287    40.80
     F40%  .206    .34115   .24621   3.8214   1.6203   1.5587   1.1063    39.99
           .250    .37451   .26170   3.6566   1.4708   1.4002    .9624    34.79
     F0.1  .253    .37656   .26258   3.6465   1.4618   1.3905    .9537    34.47
           .300    .40565   .27406   3.5032   1.3359   1.2536    .8334    30.13
           .350    .43146   .28266   3.3763   1.2280   1.1336    .7311    26.43
           .400    .45326   .28869   3.2694   1.1401   1.0334    .6483    23.44
           .450    .47197   .29295   3.1778   1.0672    .9485    .5803    20.98
           .500    .48824   .29597   3.0984   1.0059    .8756    .5236    18.93
           .550    .50256   .29811   3.0286    .9537    .8123    .4758    17.20
           .600    .51528   .29961   2.9668    .9088    .7569    .4350    15.72
           .650    .52669   .30065   2.9115    .8697    .7079    .3999    14.45
           .700    .53699   .30136   2.8617    .8354    .6643    .3693    13.35
           .750    .54635   .30182   2.8165    .8050    .6252    .3426    12.38
           .800    .55492   .30210   2.7753    .7780    .5899    .3190    11.53
           .850    .56280   .30225   2.7374    .7537    .5580    .2981    10.78
     Fmax  .890    .56870   .30230   2.7091    .7359    .5344    .2829    10.23
           .900    .57008   .30230   2.7024    .7317    .5289    .2794    10.10
           .950    .57684   .30228   2.6701    .7118    .5023    .2627     9.49
          1.000    .58314   .30220   2.6400    .6936    .4779    .2475     8.95
     -----------------------------------------------------------------------------
```

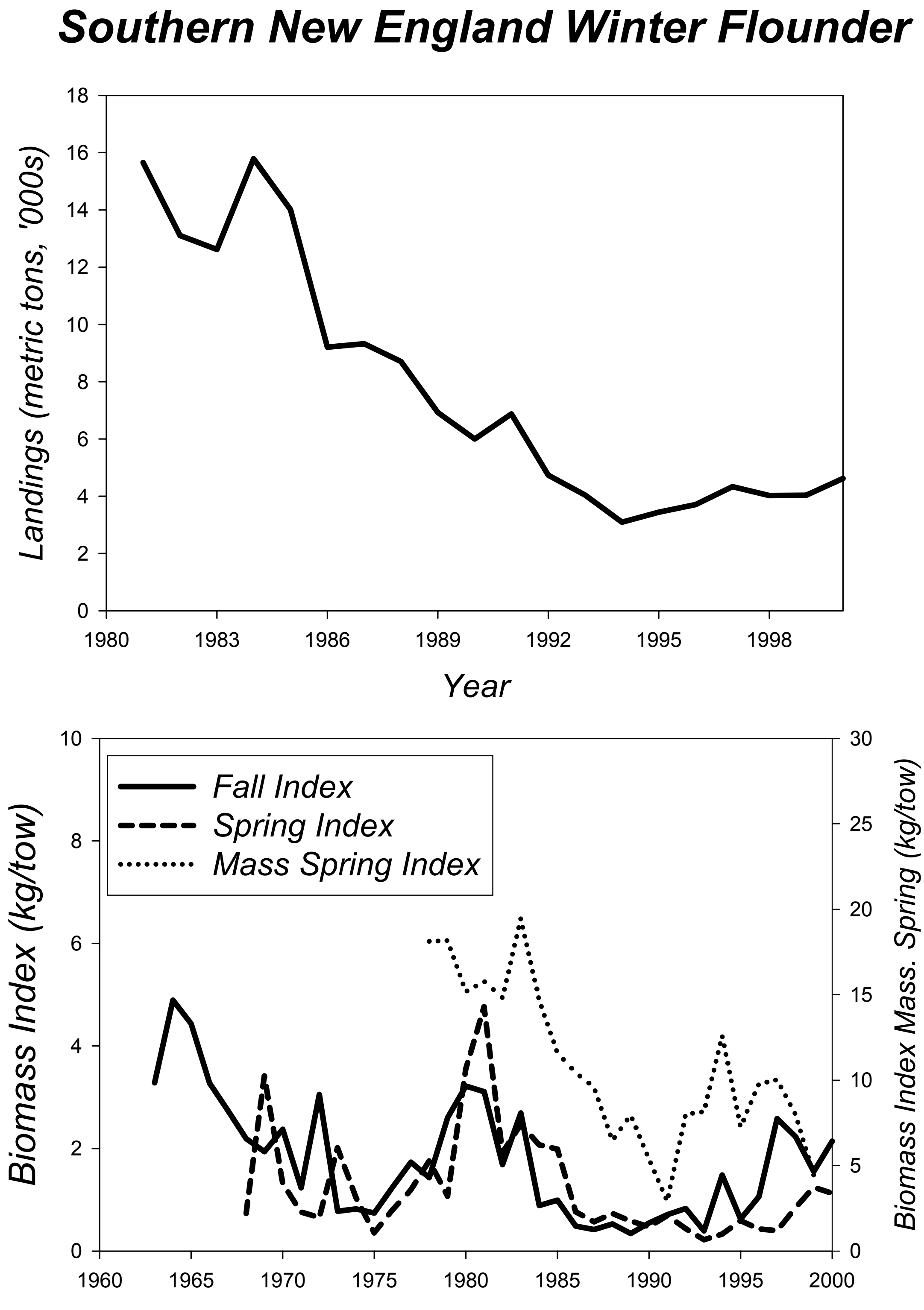
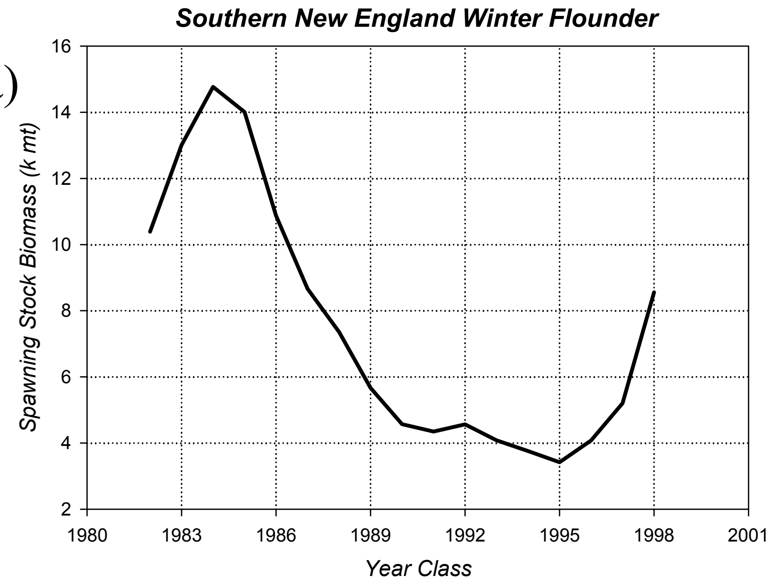
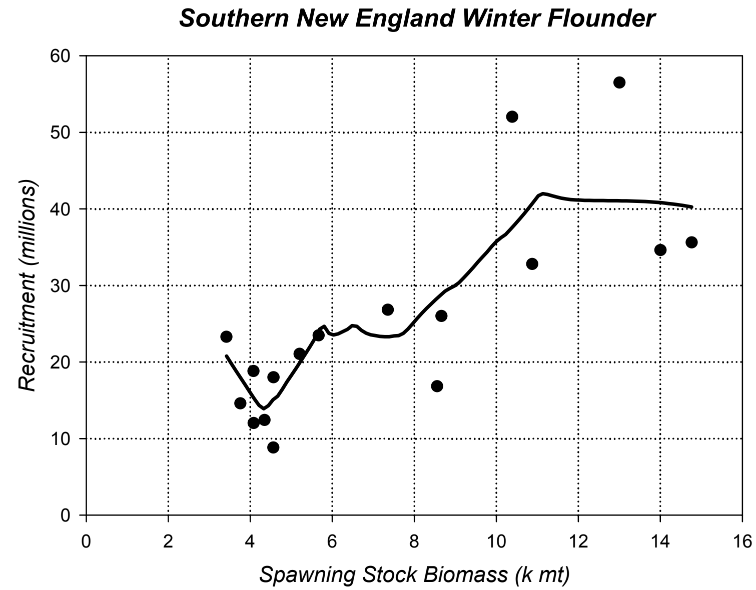


Figure 3.11.1. Landings and research vessel survey abundance indices for Southern New England winter flounder.

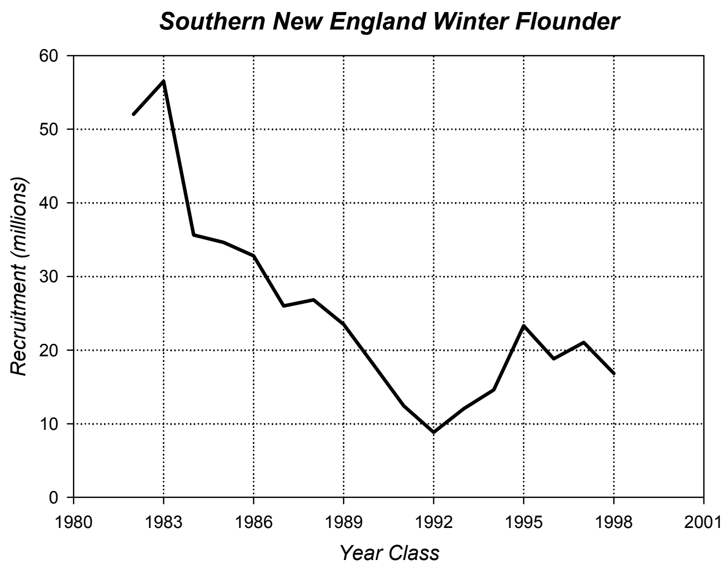
(a)



(c)



(b)



		F0.1	F40% MSP
F reference point		0.253	0.206
ssb per recruit at F		0.9624	1.1063
	Recruitment (millions)	SS Biomass at F0.1	SS Biomass at F40%
n	17	17	17
mean	25.51	24.55	28.23
min	8.83	8.50	9.77
max	56.51	54.38	62.51
10th %'tile	12.26	11.80	13.57
25th %'tile	16.84	16.20	18.63
50th %'tile	23.29	22.41	25.76
75th %'tile	32.81	31.57	36.29
90th %'tile	42.18	40.59	46.66
Std Dev	13.37	12.87	14.79
CV	0.52	0.52	0.52
For Top 5 Values of SSB			
Mean	42.31	40.72	46.81
Median	35.62	34.28	39.40

Figure 3.11.2. Spawning stock (a), recruitment (age 1 millions, b), and scatterplot (c) for Southern New England winter flounder. Data are the calculated spawning stock biomasses for various recruitment scenarios multiplied by the expected SSB per recruit for F0.1 and F40% MSP, assuming recent patterns of growth, maturity and partial recruitment at age (Table 3.11.2). Smoother in the stock-recruitment plot is lowess with tension = 0.5.

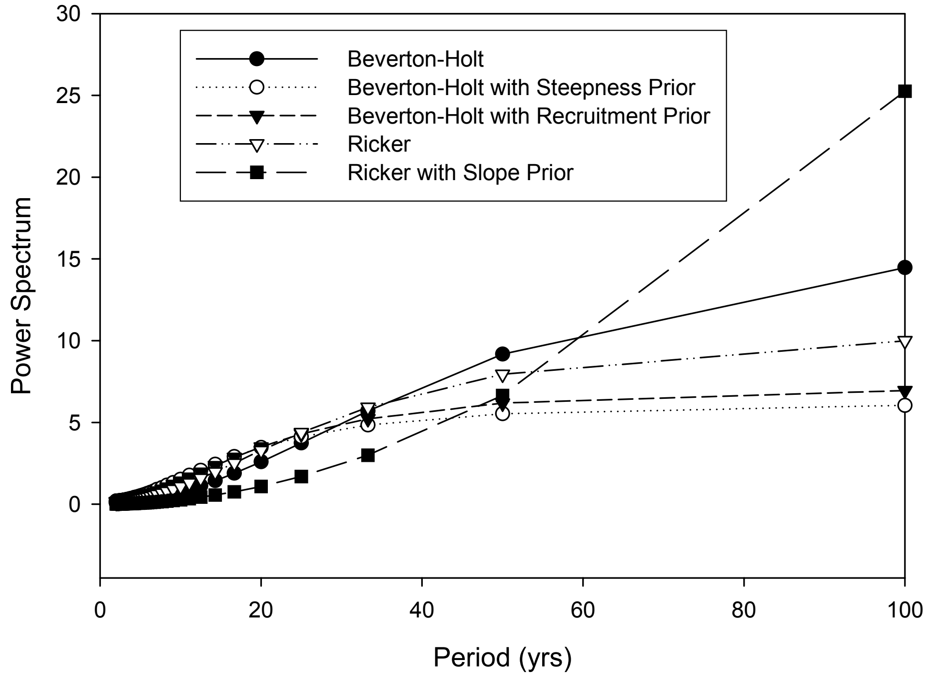


Figure 3.11.3. Southern New England winter flounder periodicity of environmental forcing for autoregressive stock-recruitment models.

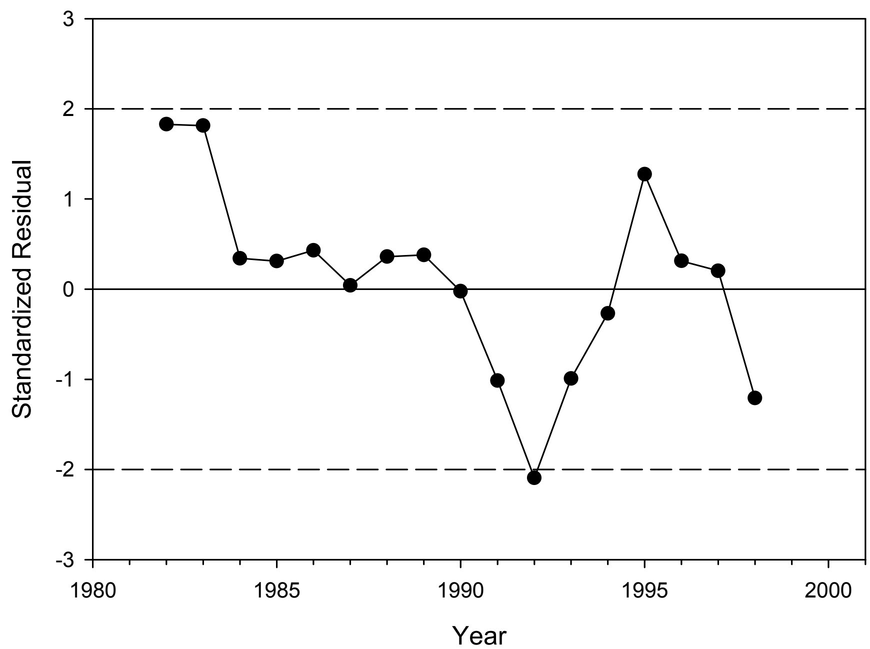


Figure 3.11.4. Southern New England winter flounder standardized residuals for the most likely stock-recruitment model

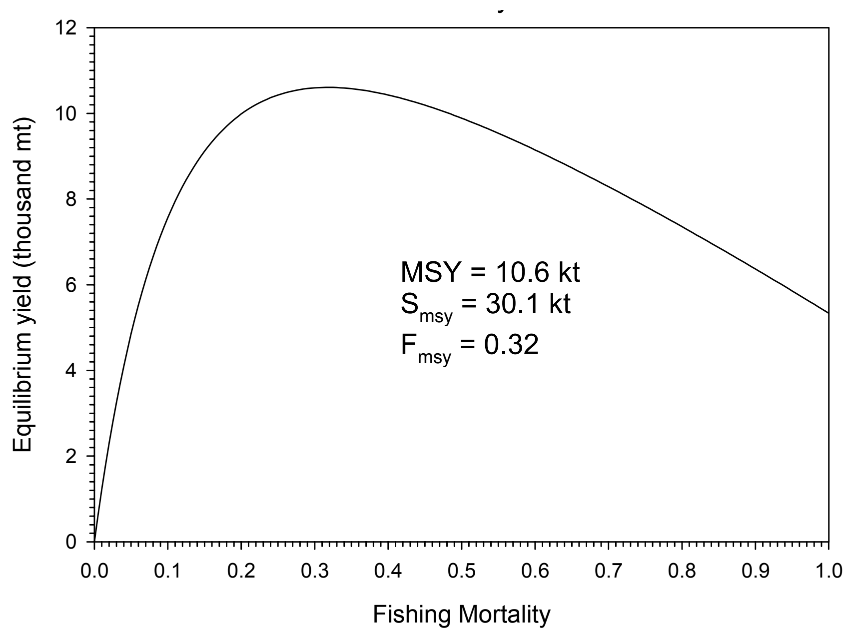


Figure 3.11.5. Southern New England winter flounder equilibrium yield vs. F for the most likely stock-recruitment model.

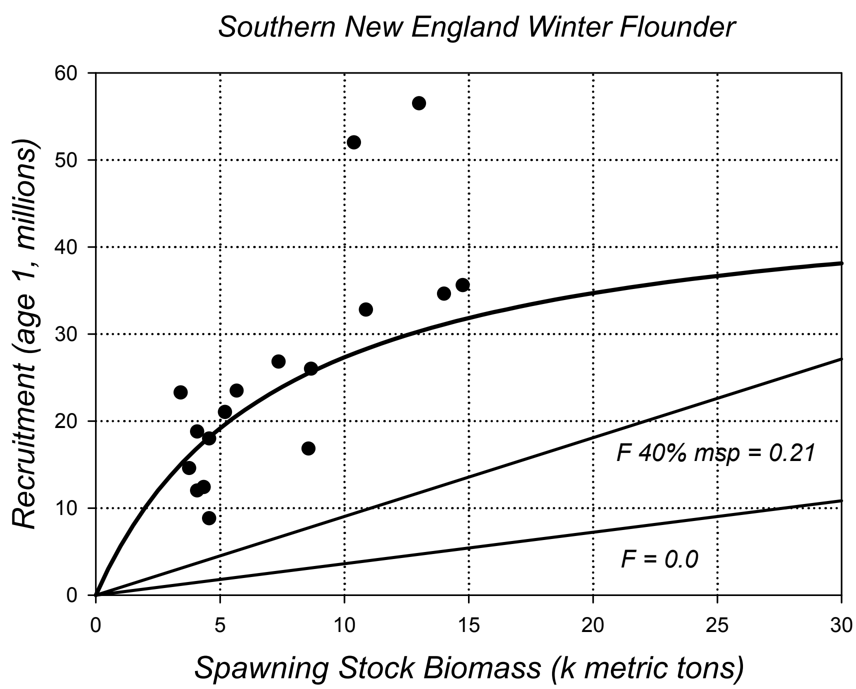


Figure 3.11.6. Stock recruitment relationship for best fit parametric model for Southern New England winter flounder. Stock-recruitment data points are overplotted, along with the predicted S-R line and replacement lines for F=100% msp=0.00 and F40%msp = 0.21.

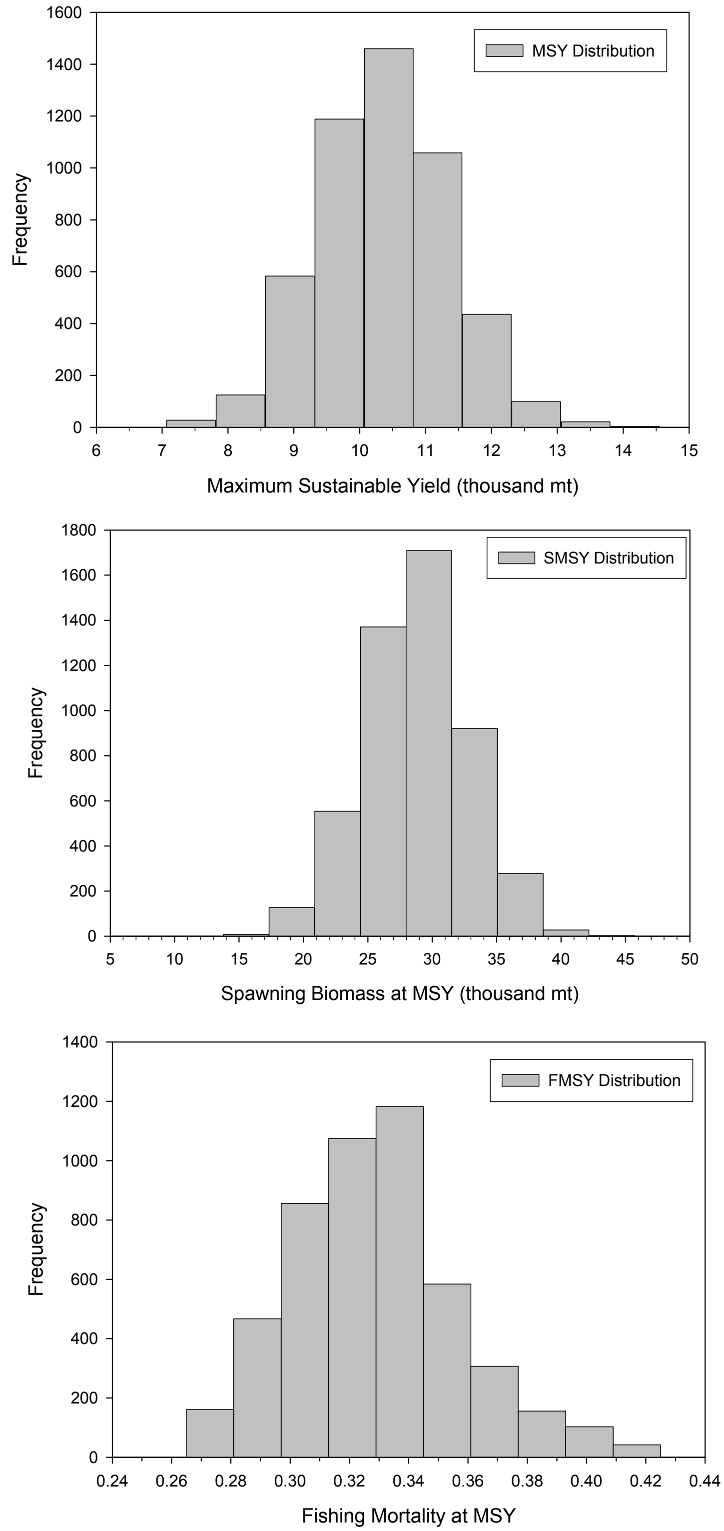


Figure 3.11.7. Histograms of uncertainty in MSY, BMY and FMSY from 5000 MCMC evaluations of best fit parametric model for Southern New England winter flounder.

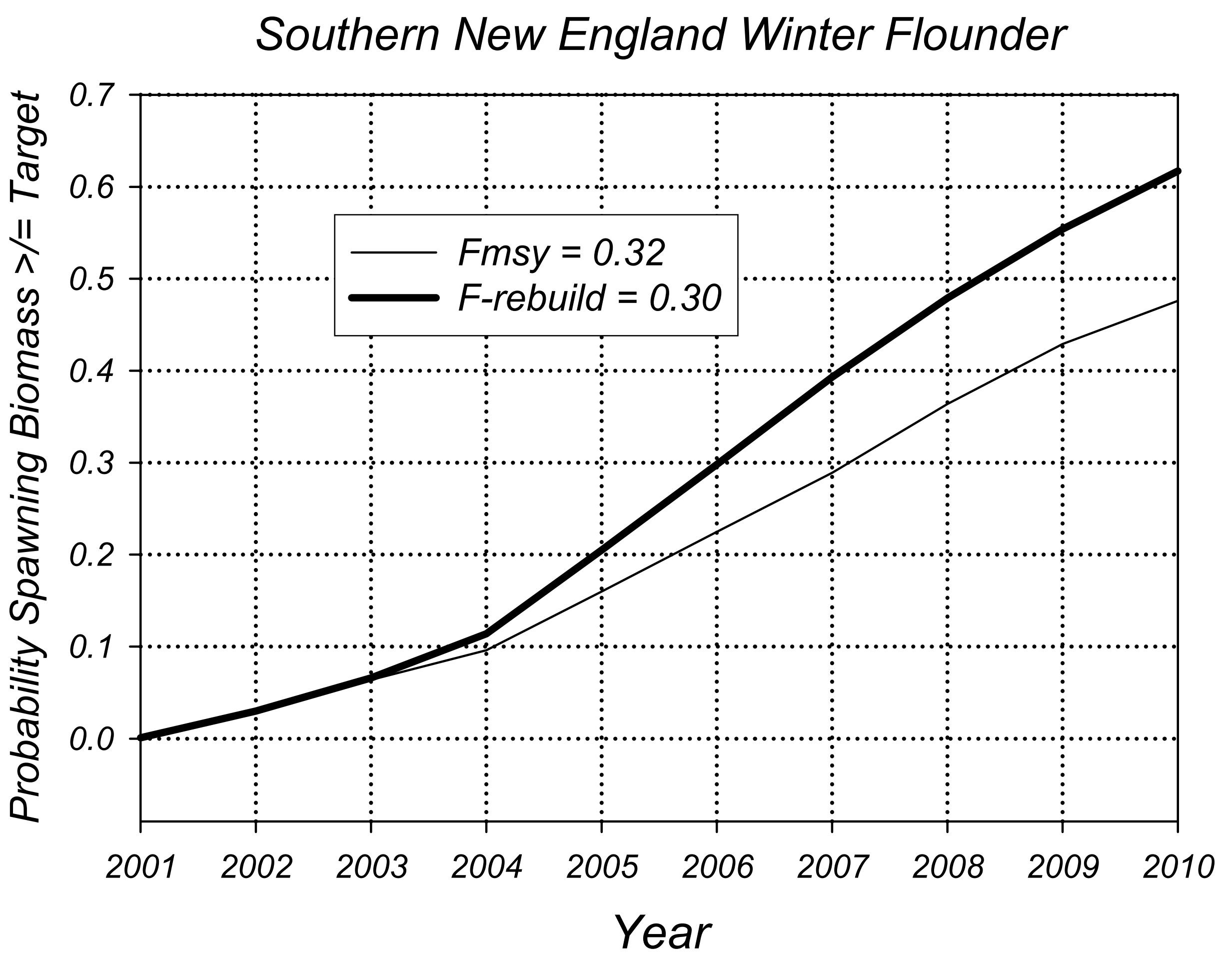


Figure 3.11.8. Probability that Southern New England winter flounder spawning biomass will exceed Bmsy (30,100 mt) annually under two fishing mortality scenarios: Fmsy and F required to rebuild the stock to Bmsy by 2009.

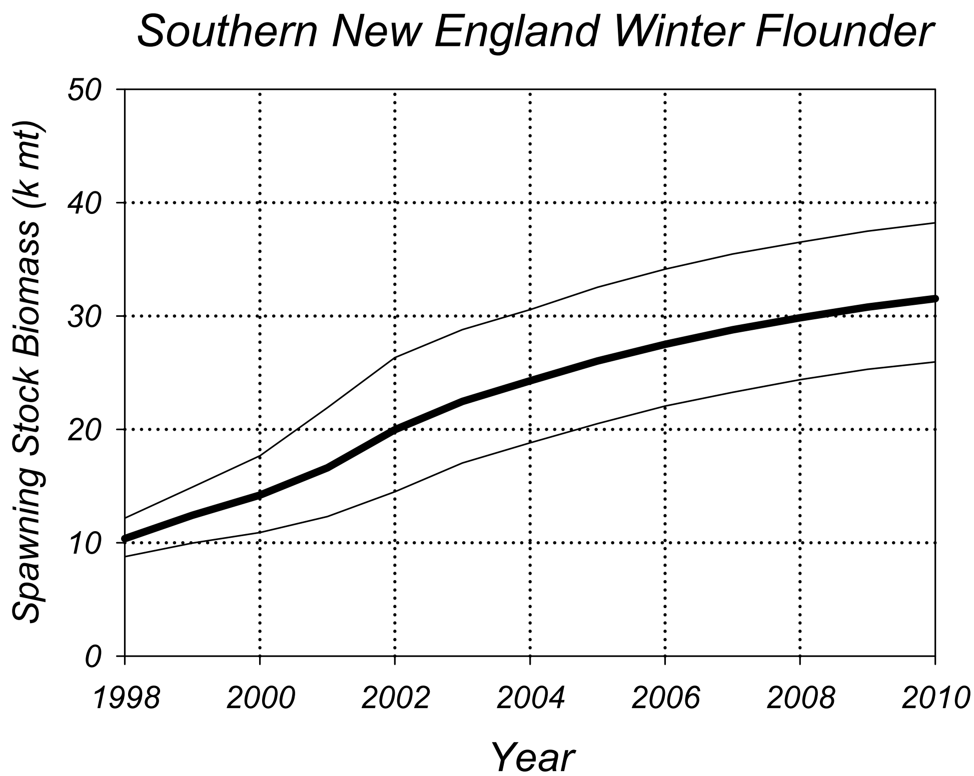


Figure 3.11.9. Median and 80% confidence interval of predicted spawning biomass for Southern New England winter flounder under F-rebuild fishing mortality rates.

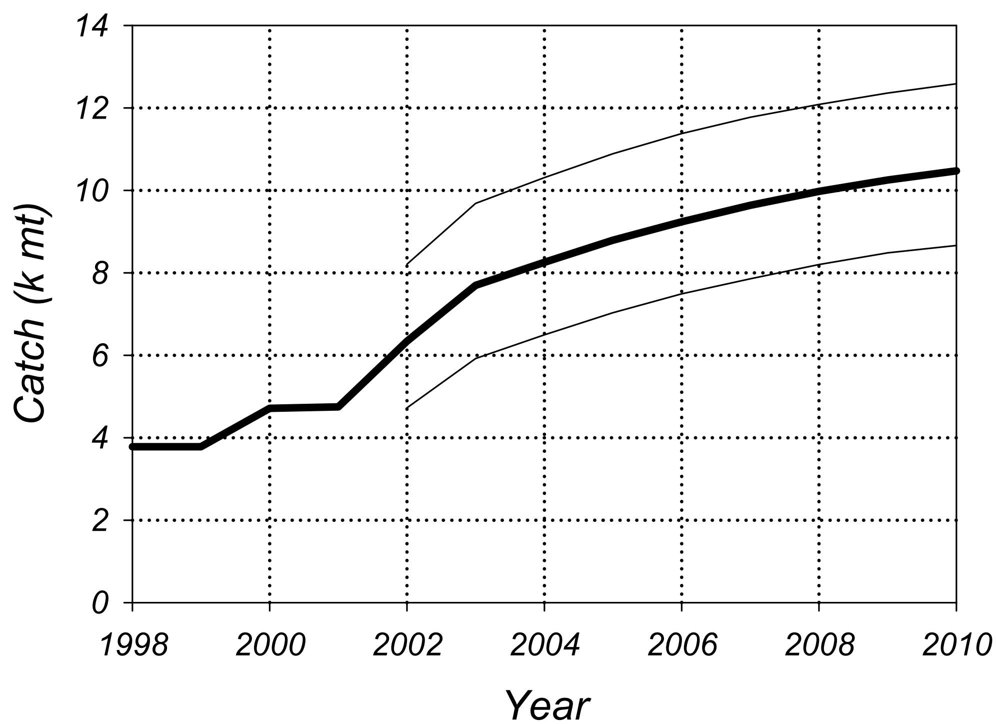


Figure 3.11.10. Median and 80% confidence interval of predicted catch for Southern New England winter under F-rebuild fishing mortality rates.