3.6 Southern New England yellowtail flounder

Catch and Survey Indices

Exploitation of Southern New England yellowtail flounder began in the mid 1930s with catches peaking in the 1960s followed by a decline in the 1970s and 1980s and have remained low since 1993 (Figure 3.6.1, Lux 1969b). Both research survey abundance indices for Southern New England yellowtail flounder show a rapid decline in the early 1970s followed by low levels except for two peaks due to large year classes 1980 and 1987 (Figure 3.6.1). It is thought that the large catches of the 1960s reduced the population abundance so much that the reduced catches in the 1980s were still associated with high fishing mortality rates. The stock appears to be increasing at a slow rate according to the most recent stock assessment.

Stock Assessment

The most recent VPA assessment for Southern New England yellowtail flounder was reviewed as part of the 2000 assessment of 11 Northeast groundfish stocks conducted by Northern Demersal Working Group (NEFSC 2000). The stock was analyzed with virtual population analysis (VPA), with supporting analysis provided by surplus production modeling. The VPA assessment used data for years 1973 through 1998 and ages 1 through 7+ and was felt to be representative of stock dynamics for the time period. Plots of stock and recruitment estimates from the VPA are provided in Figure 3.6.2. Recruitment has increased somewhat with increasing spawning stock size overall, however the recruitment series is dominated by two large events, the 1980 and 1987 year classes.

Yield and Spawning Stock Biomass per Recruit

The fishing mortality reference points F(0.1) and F40%MSP given in Figure 3.6.2 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 (Table 3.6.2). From the yield per recruit analysis, F(0.1)=0.242 and Fmax=1.5 (both are fully recruited Fs). From the spawning stock biomass per recruit analysis, F40%MSP=0.269 (fully recruited F) with an associated spawning stock biomass per recruit of 1.1095 kg.

Empirical Nonparametric Approach

If F40%MSP is assumed to be an adequate proxy for Fmsy, then the fishing mortality threshold is 0.269. This fishing mortality rate produces 1.1095 kg of spawning stock biomass per recruit and 0.2215 kg of yield per recruit (including discards). The strong correlation between the VPA and hindcast stock and recruitment data led to use of hindcast recruitment from the period 1963-1972 in addition to the VPA recruitment data. With this combined dataset, there did not appear to be a relationship between spawning stock size and recruitment. Thus, the mean of the entire time series is assumed to be representative of recruitment levels expected at maximum sustainable yield; this recruitment level is 40.7 million fish. Multiplying this recruitment level by the per recruit biomasses associated with F40%MSP results in a Bmsy proxy of 45,200 mt and an MSY proxy of 9,000 mt assuming that all fish caught are landed.

Parametric Model Approach

Maximum likelihood fits of the 24 parametric stock-recruitment models to the Southern New England yellowtail flounder data from 1973-1999 are listed below (Table 3.6.1, see Table 2.1.2 for model acronyms). The six hierarchical criteria are applied to each of the models to determine the set of candidate models.

The priors for the Beverton and Holt steepness parameter and Ricker slope parameter from Myers et al (1999) were thought to be insufficient for the yellowtail stocks as the only data sets used to develop the prior were Georges Bank and Southern New England yellowtail stocks. Thus, models PBH, PABH, P2BH, P2ABH, P2HCBH, P2HCABH, PRK, PARK, P2RK, P2ARK, P2HCRK, and P2HCARK are not considered. Of the remaining models, the first criterion is not satisfied for models ABH and PRABH, due to steepness being estimated at its boundary condition of 1.0. The fifth criteria is not satisfied by any of the remaining autoregressive error models. Models RK and PRRK are also not considered due to estimated Smsy values below historical catches of 20,00 mt. Models BH and PRBH have maximum recruitment levels below the mean of the VPA recruitment data (26 million fish) and well below the mean of the hindcast 1963-1972 recruitment data (77 million fish; Figure 3.6.4), so are not considered.

Given the two candidate models (PRHCBH and PRHCRK), the AIC criterion assigns the greatest probability to the PRHCBH model. The odds ratio of PRHCBH being true to PRHCRK being true is over 4:1. Thus, there is a clear basis for choosing between these two parametric models for Southern New England yellowtail flounder.

The results of using the PRHCBH model as the best fit parametric model are shown below (Figures 3.6.5-3.6.8). The standardized residual plot of the fit of the PRHCBH model to the stock-recruitment data shows that the standardized residuals generally lie within ± two standard deviations of zero (Figure 3.6.4), with the exception of the 1987 year class.

In the equilibrium yield plot (Figure 3.6.6), the yield surface is relatively flat in the neighborhood of the point estimate of Fmsy=0.320. This estimate of Fmsy is greater than the calculated values for F(0.1) (0.242) and F40%MSP (0.269), which are traditional proxies for Fmsy. This difference is most likely due to the high growth rate, strong resiliency, and current partial recruitment pattern for this stock. For comparison, Fmsy generates approximately 36% of maximum spawning potential. The point estimates of Smsy (64,200 mt) and MSY (14,800 mt) appear consistent with the nonparametric proxy estimate of Smsy, once the hindcast stock and recruitment data are considered, and previous estimates of MSY. The stock-recruitment plot (Figure 3.6.7) shows that expected recruitment values near Smsy are around 65 million fish, which is within the maximum observed range from the VPA data and below the average of the 1963-1972 hindcast recruitments.

Parameter uncertainty plots show histograms of 5000 MCMC sample estimates of MSY, Smsy, and Fmsy drawn from the posterior distribution of the MLE (Figure 3.6.8). For MSY, the 80 percent credibility interval was (12,900, 16,400) with a median of 14,700 mt. For Smsy, the 80 percent credibility level was (55,900, 71,000) with a median of 63,300 mt. For Fmsy, the 80 percent credibility level was (0.260, 0.400) with a median of 0.330. Overall, the point estimates of MSY, Smsy and Fmsy were nearly identical to the medians of the MCMC samples.

Reference Points

Based on the conformance of the recruitment-biomass per recruit analyses and the parametric stock-recruitment relationship, the following management parameters are considered most appropriate: Bmsy=45,200 mt, Fmsy=0.269 (fully recruited F), and MSY=9,000 mt (including discards). This level of yield is expected by building the stock size through reduced fishing mortality, relative to historical levels that were above 1.0, increased survivorship of young fish relative to the historical use of much smaller mesh size when peak catches were taken, and an expectation that on average recruitment will stay within the range predicted by the most recent stock assessment. The median recruitment, stock-recruitment scatterplot, and replacement lines under F=0 and F=0.269 are given in Figure 3.5.9.

Projections

No projections were considered to truly represent the potential rebuilding rate of this stock due to the recent history of low recruitment during the past ten years. The largest recruitment in this period was 16.4 million fish, which under no fishing would only produce 45,500 mt of spawning biomass in equilibrium. Thus, until recruitment increases from this recent history, rebuilding is not expected to occur.

Table 3.6.1. Summary of parametric fits for Southern New England yellowtail flounder.

Southern New England Yellowtail Flounder

	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior
	0	0	0	0	0	0	0	0	1	0	0	0
	BH	ABH	PBH	PABH	PRBH	PRABH	P2BH	P2ABH	**PRHCBH**	PRHCABH	P2HCBH	P2HCABH
Posterior Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.80**	0.00	0.00	0.00
Odds Ratio for Most									**1.00**			
Normalized Likelihood	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.803	0.000	0.000	0.000
Model AIC Ratio	0	0	0	0	0	0	0	0	4.077565	0	0	0
	BH	**ABH**	**PBH**	**PABH**	**PRBH**	**PRABH**	**P2BH**	**P2ABH**	**PRHCBH**	**PRHCABH**	**P2HCBH**	**P2HCABH**
Number_of_data_points	25	25	25	25	25	25	25	25	25	25	25	25
Number_of_parameters	3	4	3	4	3	4	3	4	3	4	3	4
Fit_negloglikelihood	102.372	96.679	102.653	98.2818	102.605	96.8514	103.002	98.2964	104.158	100.641	104.158	100.737
Penalty_steepness	0	0	-1.51557	-1.3962	0	0	-1.33299	-1.39452	0	0	-1.73985	-1.70931
Penalty_slope	0	0	0	0	0	0	0	0	0	0	0	0
Penalty_unfished_R	0	0	0	0	2.07324	2.04498	2.12351	2.02848	2.57088	2.57576	2.57064	2.57106
Negative_loglikelihood	102.372	96.679	101.137	96.8856	104.678	98.8964	103.793	98.9303	106.729	103.217	104.989	101.599
Bias-corrected_AIC	211.887	203.359	212.448	206.564	212.353	203.703	213.147	206.593	215.458	211.283	215.460	211.474
Diagnostic Comments	predicted R at high S below mean from VPA	steepness at boundry of 1	insufficient information for steepness prior	insufficient information for steepness prior	predicted R at high S below mean from VPA	steepness near boundry of 1	insufficient information for steepness prior	insufficient information for steepness prior	**model selected**	auto-correlation implies long period forcing	insufficient information for steepness prior	insufficient information for steepness prior
Parameter Point Estimates												
********************************												
MSY	5.116	2.975	5.778	3.089	4.002	4.079	3.849	3.530	14.767	15.838	14.742	14.987
FMSY	0.415	0.740	0.360	0.370	0.445	0.700	0.375	0.370	0.320	0.385	0.320	0.335
SMSY	18.21	7.11	22.91	11.99	13.53	10.10	14.79	13.70	64.20	59.64	64.09	62.84
alpha	24.9821	12.1636	30.4655	16.0301	18.9398	16.8273	19.8265	18.3126	83.1063	80.454	83.1844	82.5691
expected_alpha	46.685	25.5137	57.7461	31.5299	35.8123	35.5559	38.2677	35.1647	170.955	171.921	171.122	169.108
beta	2.99261	0.0016858	5.38337	2.64026	1.84024	0.0936947	3.15866	3.01346	18.8216	11.9751	19.0081	17.352
steepness	0.853	1.000	0.797	0.808	0.877	0.992	0.813	0.808	0.754	0.823	0.752	0.767
R_at_input_SMAX	23.87	12.16	28.12	15.40	18.41	16.80	18.90	17.49	64.31	67.84	64.23	65.04
expected_R_at_input_SMAX	44.61	25.51	53.29	30.29	34.82	35.50	36.48	33.59	132.29	144.97	132.12	133.22
unfished_S	66.30	33.74	79.12	41.82	50.70	46.58	51.84	47.78	211.70	211.19	211.73	211.68
unfished_R	23.90	12.16	28.52	15.08	18.28	16.79	18.69	17.23	76.32	76.14	76.33	76.31
sigma	1.11827	1.21718	1.13089	1.16316	1.12874	1.22319	1.14681	1.14232	1.20107	1.23235	1.20109	1.19742
phi	N/A	0.691706	N/A	0.587218	N/A	0.690169	N/A	0.564674	N/A	0.541224	N/A	0.49319
sigmaw	N/A	0.879023	N/A	0.941494	N/A	0.885163	N/A	0.942776	N/A	1.03626	N/A	1.04166
last_residual_R	N/A	-4.51754	N/A	1.36882	N/A	-8.3114	N/A	1.04412	N/A	-2.33657	N/A	0.290101
last_logresidual_R	N/A	-0.464844	N/A	0.197604	N/A	-0.736558	N/A	0.147077	N/A	-0.267026	N/A	0.0387421
expected_lognormal_error_	1.86874	2.09754	1.89546	1.96692	1.89085	2.11299	1.93013	1.92024	2.05706	2.13688	2.05713	2.04808
prior_mean_steepness	N/A	N/A	0.75	0.75	N/A	N/A	0.75	0.75	N/A	N/A	0.75	0.75
prior_se_steepness	N/A	N/A	0.07	0.07	N/A	N/A	0.07	0.07	N/A	N/A	0.07	0.07
prior_mean_slope	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
prior_se_slope	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
prior_mean_unfished_R	N/A	N/A	N/A	N/A	17.36	17.36	17.36	17.36	76.94	76.94	76.94	76.94
prior_se_unfished_R	N/A	N/A	N/A	N/A	3.03	3.03	3.03	3.03	5.18	5.18	5.18	5.18

Table 3.6.1. (continued) Summary of parametric fits for Southern New England yellowtail flounder.

Southern New England Yellowtail Flounder

	RK	ARK	PRK	PARK	PRRK	PRARK	P2RK	P2ARK	**PRHCRK**	PRHCARK	P2HCRK	P2HCARK
	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior
	0	0	0	0	0	0	0	0	1	0	0	0
Posterior Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.20**	0.00	0.00	0.00
Odds Ratio for Most Likely Model									**4.08**			
Normalized Likelihood	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.197	0.000	0.000	0.000
Model AIC Ratio	0	0	0	0	0	0	0	0	1	0	0	0

	RK	**ARK**	**PRK**	**PARK**	**PRRK**	**PRARK**	**P2RK**	**P2ARK**	**PRHCRK**	**PRHCARK**	**P2HCRK**	**P2HCARK**
Number_of_data_points	25	25	25	25	25	25	25	25	25	25	25	25
Number_of_parameters	3	4	3	4	3	4	3	4	3	4	3	4
Fit_negloglikelihood	101.207	97.191	102.737	98.8742	102.685	99.1561	103.539	100.24	105.563	102.301	105.713	102.452
Penalty_steepness	0	0	0	0	0	0	0	0	0	0	0	0
Penalty_slope	0	0	1.2304	0.190776	0	0	0.736879	0.248412	0	0	0.0853812	-0.072571
Penalty_unfished_R	0	0	0	0	2.24219	2.3225	2.05584	2.10177	2.56489	2.56491	2.56434	2.56443
Negative_loglikelihood	101.207	97.191	103.967	99.065	104.927	101.479	106.332	102.59	108.128	104.865	108.363	104.943
Bias-corrected_AIC	209.558	204.382	212.617	207.748	212.513	208.312	214.222	210.479	218.269	214.601	218.569	214.903
Diagnostic Comments	Smsy less than historical catch	auto-correlation implies long period forcing	insufficient information for slope prior	insufficient information for slope prior	Smsy less than historical catch	auto-correlation implies long period forcing	insufficient information for slope prior	insufficient information for slope prior		auto-correlation implies long period forcing	insufficient information for slope prior	insufficient information for slope prior
Parameter Point Estimates *******************************												
MSY	5.167	4.936	4.702	2.240	7.171	7.569	6.305	5.575	27.731	27.686	25.236	23.624
FMSY	1.390	1.590	0.595	0.440	0.785	0.935	0.525	0.450	0.485	0.485	0.420	0.380
SMSY	8.50	7.53	12.96	7.63	16.52	15.67	18.94	18.69	88.09	87.94	89.01	89.85
alpha	1.94408	2.01712	1.35695	1.07473	1.58107	1.70706	1.24533	1.09724	1.17225	1.16978	1.02812	0.932069
expected_alpha	3.4364	3.53262	2.58319	2.53485	3.00184	3.22082	2.47408	2.23624	2.6275	2.60716	2.327	2.12669
beta	-	-0.135617	-0.074083	-0.114385	-0.060997	-0.065405	-4.91E-02	-0.047144	-1.03E-02	-0.010295	-9.62E-03	-0.009171
steepness	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R_at_input_SMAX	0.19	0.08	2.12	0.12	6.16	5.26	9.48	9.27	107.09	106.90	96.90	90.61
expected_R_at_input_SMAX	0.34	0.14	4.03	0.28	11.69	9.92	18.83	18.88	240.02	238.26	219.32	206.75
unfished_S	24.57	22.40	32.09	18.32	42.65	41.70	46.15	44.91	212.73	212.73	212.92	212.89
unfished_R	8.86	8.07	11.57	6.60	15.37	15.03	16.64	16.19	76.69	76.69	76.76	76.75
sigma	1.06737	1.05865	1.13471	1.31001	1.13236	1.12682	1.17172	1.19332	1.27052	1.26606	1.27816	1.28446
phi	N/A	0.521656	N/A	0.680215	N/A	0.49713	N/A	0.518425	N/A	0.482133	N/A	0.495733
sigmaw	N/A	0.903193	N/A	0.960255	N/A	0.977718	N/A	1.02043	N/A	1.10919	N/A	1.11552
last_residual_R	N/A	-2.48565	N/A	3.54602	N/A	-0.725116	N/A	2.94852	N/A	2.27151	N/A	3.39797
last_logresidual_R	N/A	-0.281867	N/A	0.62456	N/A	-0.090741	N/A	0.488144	N/A	0.353184	N/A	0.588985
expected_lognormal_error_	1.76762	1.75132	1.90368	2.35859	1.89861	1.88677	1.98668	2.03807	2.24142	2.22877	2.26334	2.28169
prior_mean_steepness	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
prior_se_steepness	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
prior_mean_slope	N/A	N/A	0.79	0.79	N/A	N/A	0.79	0.79	N/A	N/A	0.79	0.79
prior_se_slope	N/A	N/A	0.34	0.34	N/A	N/A	0.34	0.34	N/A	N/A	0.34	0.34
prior_mean_unfished_R	N/A	N/A	N/A	N/A	17.36	17.36	17.36	17.36	76.94	76.94	76.94	76.94
prior_se_unfished_R	N/A	N/A	N/A	N/A	3.03	3.03	3.03	3.03	5.18	5.18	5.18	5.18

Table 3.6.2. Yields and biomass per recruit of Southern New England yellowtail flounder

```
The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
PC Ver.2.0 [Method of Thompson and Bell (1934)] 1-Jan-1999
----------------------------------------
Run Date: 27- 2-2002;  Time: 11:03:34.61
SNE YELLOWTAIL FLOUNDER - 2002
```

Proportion of F before spawning: 0.4167
Proportion of M before spawning: 0.4167
Natural Mortality is Constant at: 0.200
Initial age is: 1; Last age is: 7
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> C:\groundfish\ypr\snyt_ypr.dat

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	0.0100	1.0000	0.1300	0.130	0.130
2	0.1200	1.0000	0.7400	0.318	0.318
3	0.5300	1.0000	0.9800	0.398	0.398
4	1.0000	1.0000	1.0000	0.473	0.473
5	1.0000	1.0000	1.0000	0.636	0.636
6	1.0000	1.0000	1.0000	0.785	0.785
7	1.0000	1.0000	1.0000	1.029	1.029

Summary of Yield per Recruit Analysis:

```
Slope of the Yield/Recruit Curve at F=0.00: -->    2.4632
  F level at slope=1/10 of the above slope (F0.1): ----->           0.242
    Yield/Recruit corresponding to F0.1: ----->    0.2155
  F level to produce Maximum Yield/Recruit (Fmax): ----->           1.500
    Yield/Recruit corresponding to Fmax: ----->    0.2423
  F level at 40 % of Max Spawning Potential (F40): ----->   0.269
    SSB/Recruit corresponding to F40: -------->    1.1095
```

1
Listing of Yield per Recruit Results for:

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	0.00	0.00000	0.00000	5.5167	3.2011	4.0669	2.7739	100.00
	0.10	0.21199	0.14794	4.4618	2.1891	3.0065	1.7792	64.14
	0.20	0.31949	0.20335	3.9290	1.7041	2.4686	1.3074	47.13
F0.1	0.24	0.35009	0.21547	3.7779	1.5721	2.3154	1.1799	42.54
F40%	0.27	0.36742	0.22148	3.6925	1.4990	2.2287	1.1095	40.00
	0.30	0.38515	0.22695	3.6052	1.4255	2.1400	1.0389	37.45
	0.40	0.42984	0.23748	3.3860	1.2476	1.9163	0.8688	31.32
	0.50	0.46250	0.24215	3.2265	1.1254	1.7529	0.7527	27.14
	0.60	0.48763	0.24405	3.1046	1.0370	1.6273	0.6690	24.12
	0.70	0.50770	0.24464	3.0077	0.9702	1.5270	0.6060	21.85
	0.80	0.52421	0.24461	2.9284	0.9182	1.4445	0.5569	20.08
	0.90	0.53811	0.24433	2.8619	0.8764	1.3752	0.5176	18.66
	1.00	0.55004	0.24394	2.8051	0.8421	1.3158	0.4853	17.50
	1.10	0.56045	0.24355	2.7558	0.8135	1.2641	0.4582	16.52
	1.20	0.56964	0.24319	2.7124	0.7890	1.2185	0.4351	15.69
	1.30	0.57784	0.24286	2.6738	0.7679	1.1779	0.4152	14.97
	1.40	0.58524	0.24258	2.6391	0.7494	1.1414	0.3976	14.34
	1.50	0.59197	0.24234	2.6076	0.7331	1.1082	0.3821	13.78
Fmax	1.50	0.59200	0.24234	2.6075	0.7330	1.1081	0.3821	13.77
	1.60	0.59813	0.24214	2.5789	0.7184	1.0780	0.3683	13.28
	1.70	0.60380	0.24197	2.5525	0.7052	1.0502	0.3557	12.82
	1.80	0.60906	0.24182	2.5281	0.6933	1.0245	0.3444	12.41
	1.90	0.61395	0.24170	2.5054	0.6823	1.0007	0.3340	12.04
	2.00	0.61853	0.24159	2.4842	0.6722	0.9785	0.3244	11.69

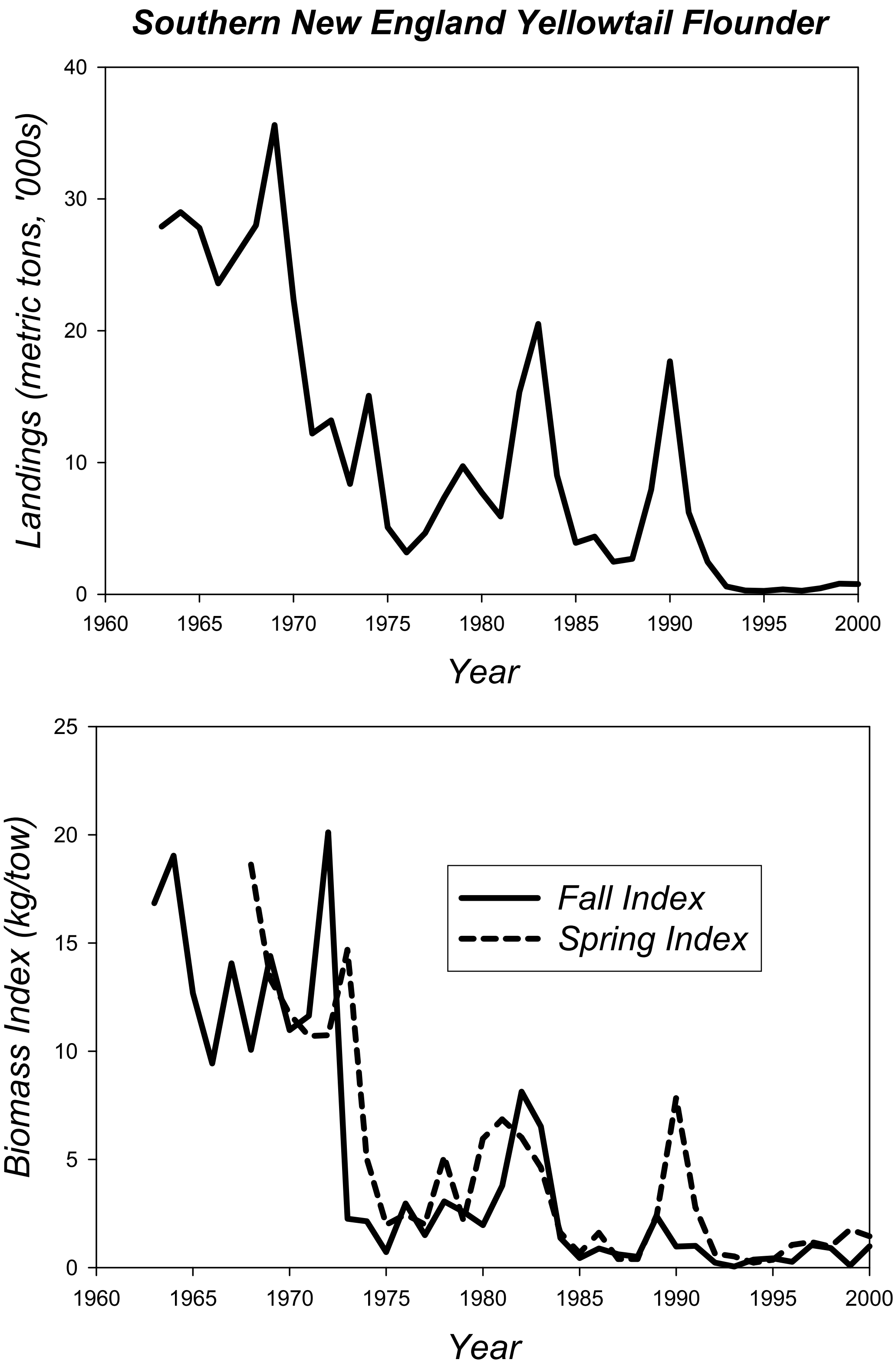
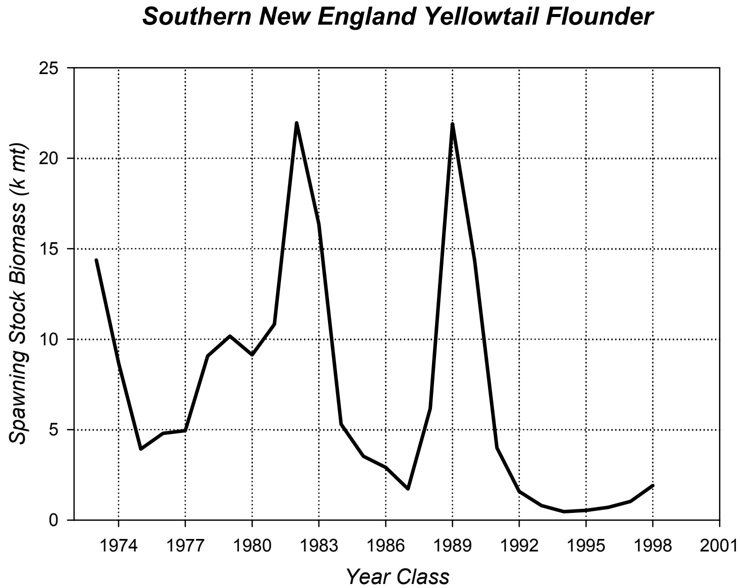
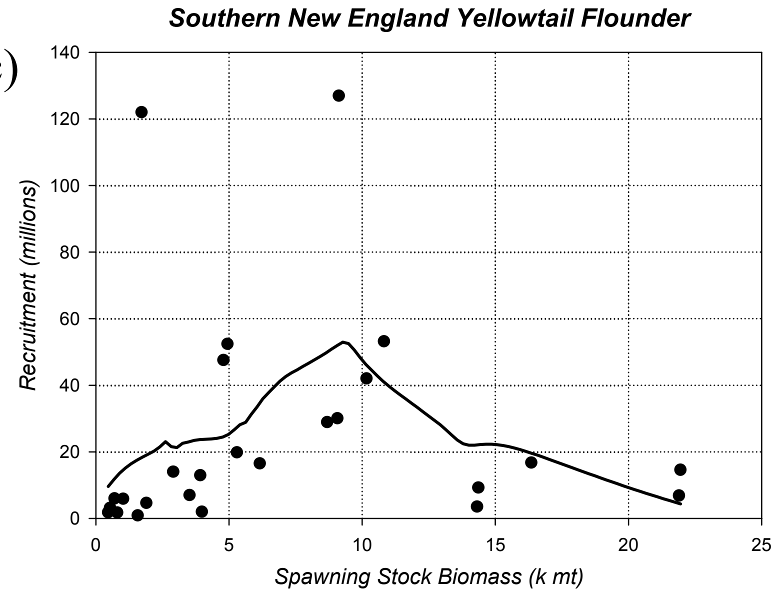


Figure 3.6.1. Landings and research vessel survey abundance indices for Southern New England yellowtail flounder.

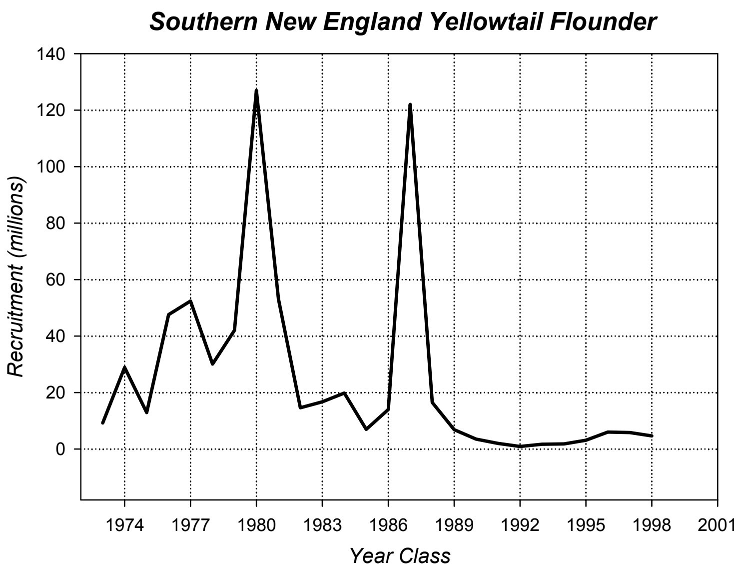
(a)



(c)



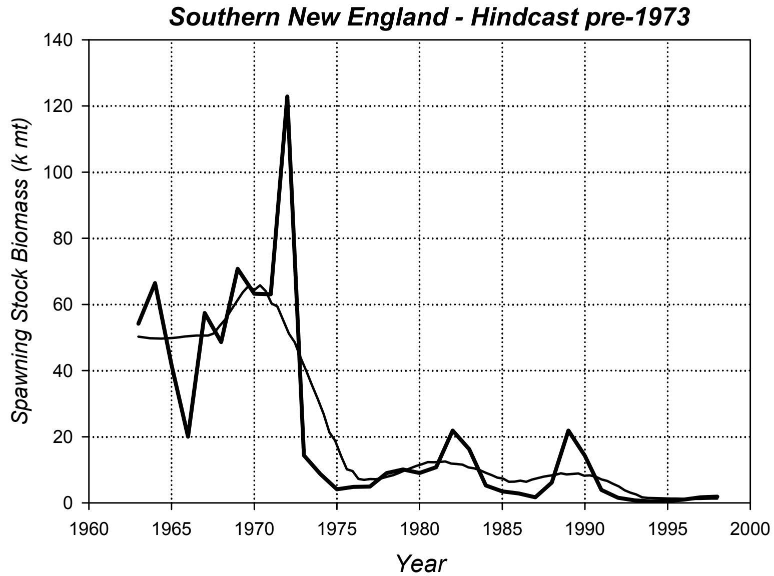
(b)



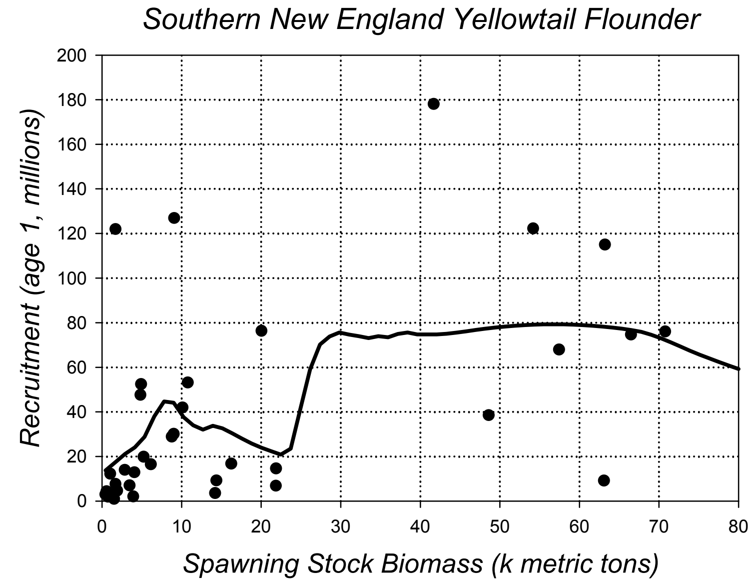
		F0.1	F40% MSP
F reference point		0.242	0.269
ssb per recruit at F		1.1799	1.1095
	Recruitment (millions)	SS Biomass at F0.1	SS Biomass at F40%
n	26	26	26
mean	25.01	29.51	27.75
min	0.88	1.04	0.98
max	126.93	149.77	140.83
10th %'tile	1.89	2.23	2.10
25th %'tile	4.94	5.83	5.49
50th %'tile	13.46	15.89	14.94
75th %'tile	29.78	35.14	33.05
90th %'tile	52.78	62.28	58.56
Std Dev	33.41	39.42	37.07
CV	1.34	1.34	1.34
For Top Quartile of SSB			
Mean	20.88	24.63	23.16
Median	14.61	17.24	16.21

Figure 3.6.2. Spawning stock (a), recruitment (age 1 millions, b), and scatterplot (c) for Southern New England yellowtail 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 3.6.2). Smoother in the stock-recruitment plot is lowess with tension = 0.5.

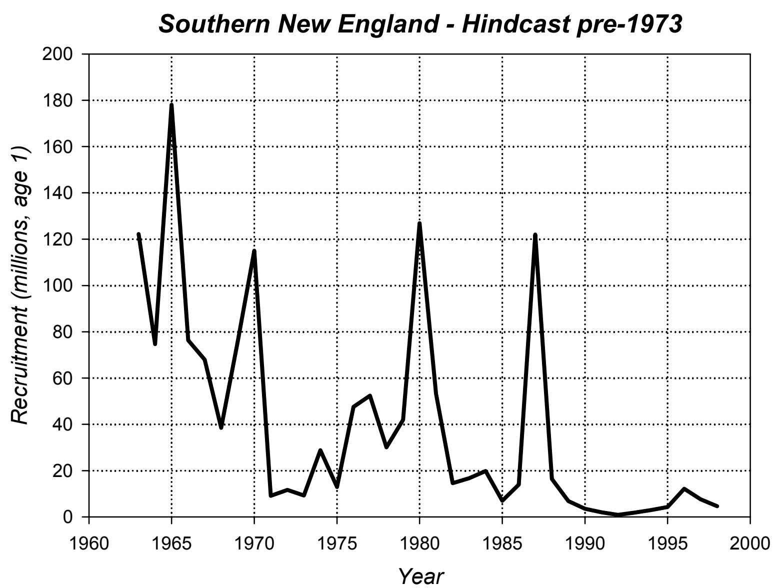
(a)



(c)



(b)



		F0.1	F40%MSP
F reference point		0.242	0.269
ssb per recruit at F		1.1799	1.1095
	Recruitment (millions)	SS Biomass at F0.1	SS Biomass at F40%
n	35	35	35
mean	40.72	48.05	45.18
min	0.91	1.07	1.01
max	178.05	210.08	197.55
10th %'tile	3.21	3.78	3.56
25th %'tile	8.36	9.86	9.28
50th %'tile	16.73	19.74	18.56
75th %'tile	60.53	71.42	67.16
90th %'tile	119.20	140.64	132.25
Std Dev	45.24	53.38	50.19
CV	1.11	1.31	1.23
For Top Quartile of SSB			
Mean	77.01	90.87	85.45
Median	74.66	88.09	82.84
For Hindcast Recruitment			
Mean	76.94	90.78	85.37

Figure 3.6.3. Spawning stock (a), recruitment (age 1 millions, b), and scatterplot (c) for Southern New England yellowtail flounder using hindcasts data prior to 1973. 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 3.6.2). Smoother in the stock- recruitment plot is lowess with tension = 0.5. Smoother for the spawning stock biomass plot (a) is 0.3.

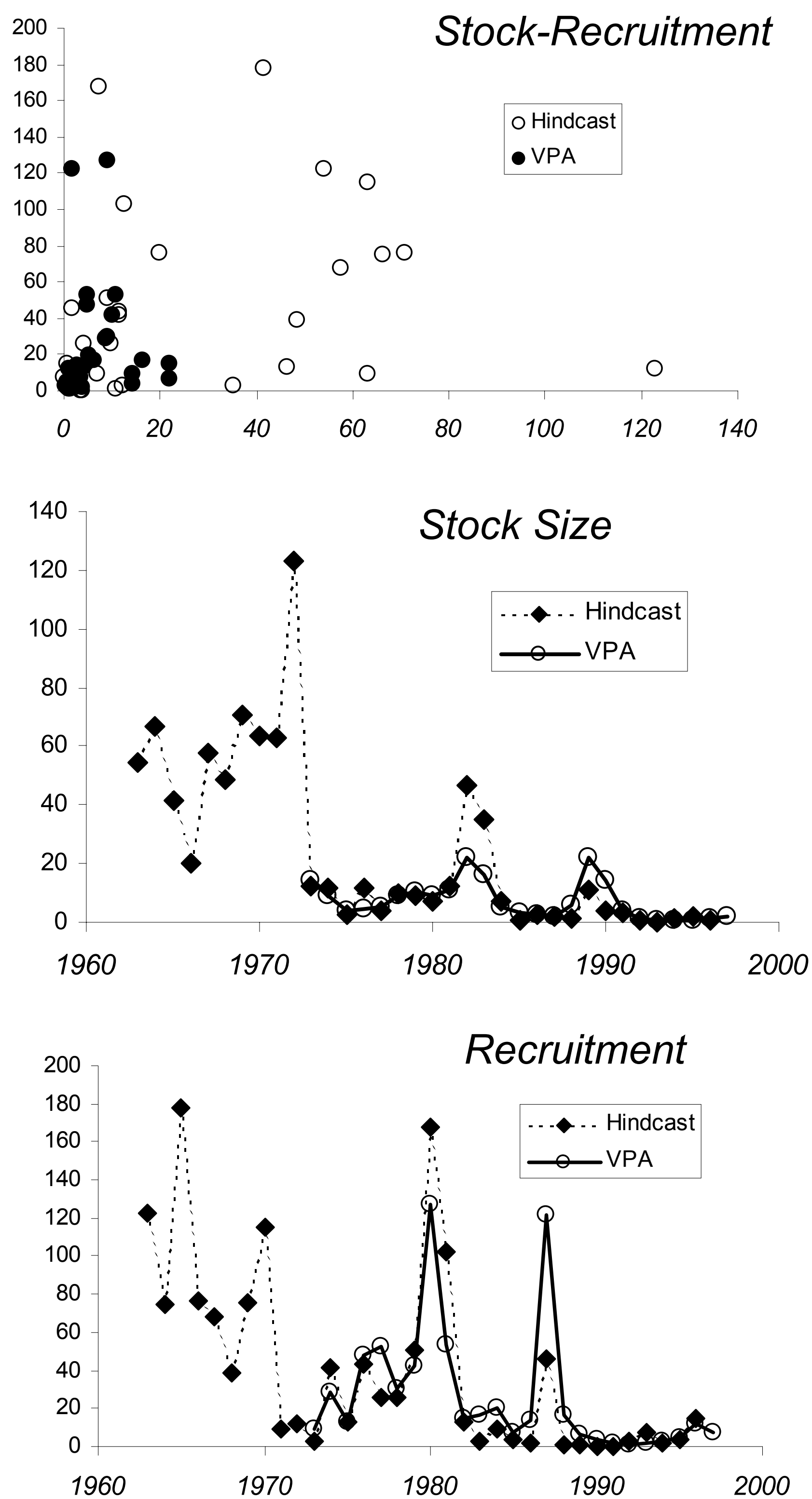


Figure 3.6.4. Comparison of stock and recruitment data from virtual population analysis (VPA) and hindcast for Southern New England yellowtail flounder.

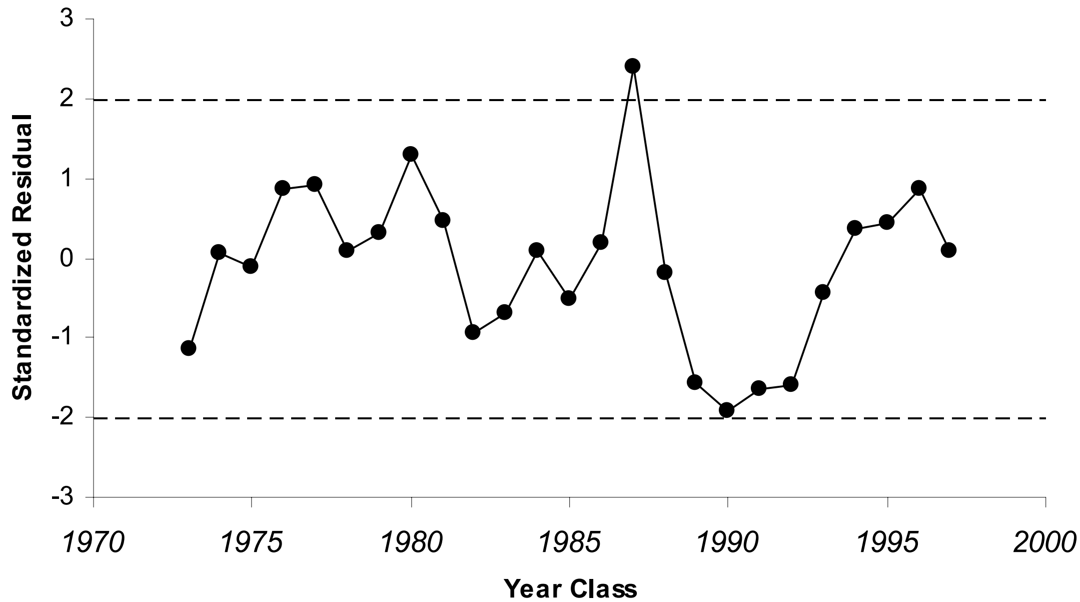


Figure 3.6.5. Standardized residuals from best fit parametric model for Southern New England yellowtail flounder

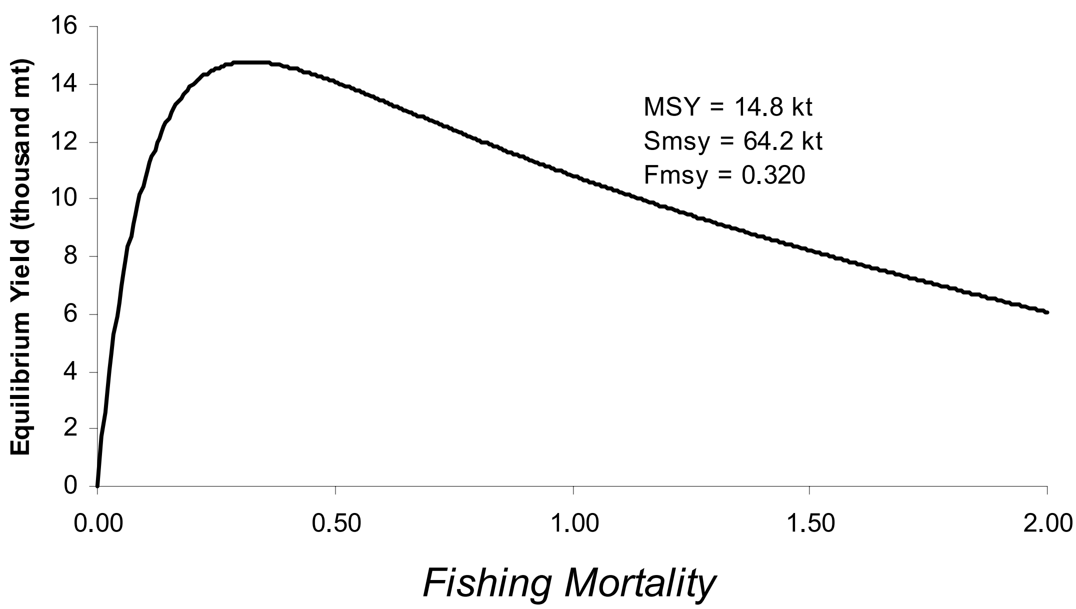


Figure 3.6.6. Equilibrium yield from best fit parametric model for Southern New England yellowtail flounder.

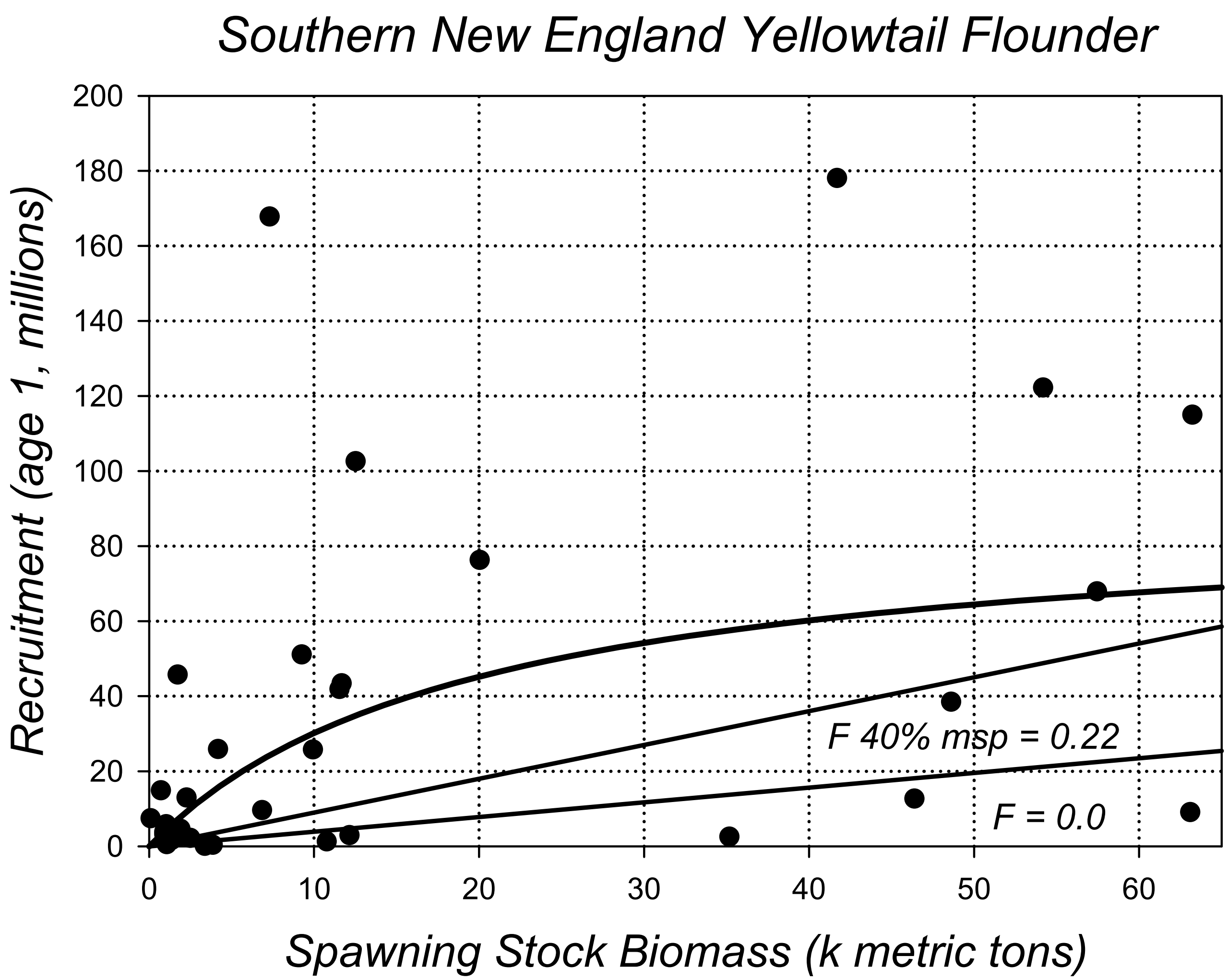


Figure 3.6.7. Stock recruitment relationship for best fit parametric model for Southern New England yellowtail flounder. Hindcast stock-recruitment data points are overplotted, along with the predicted S-R line and replacement lines for F=100% msp=0.0 and F40% msp=0.22.

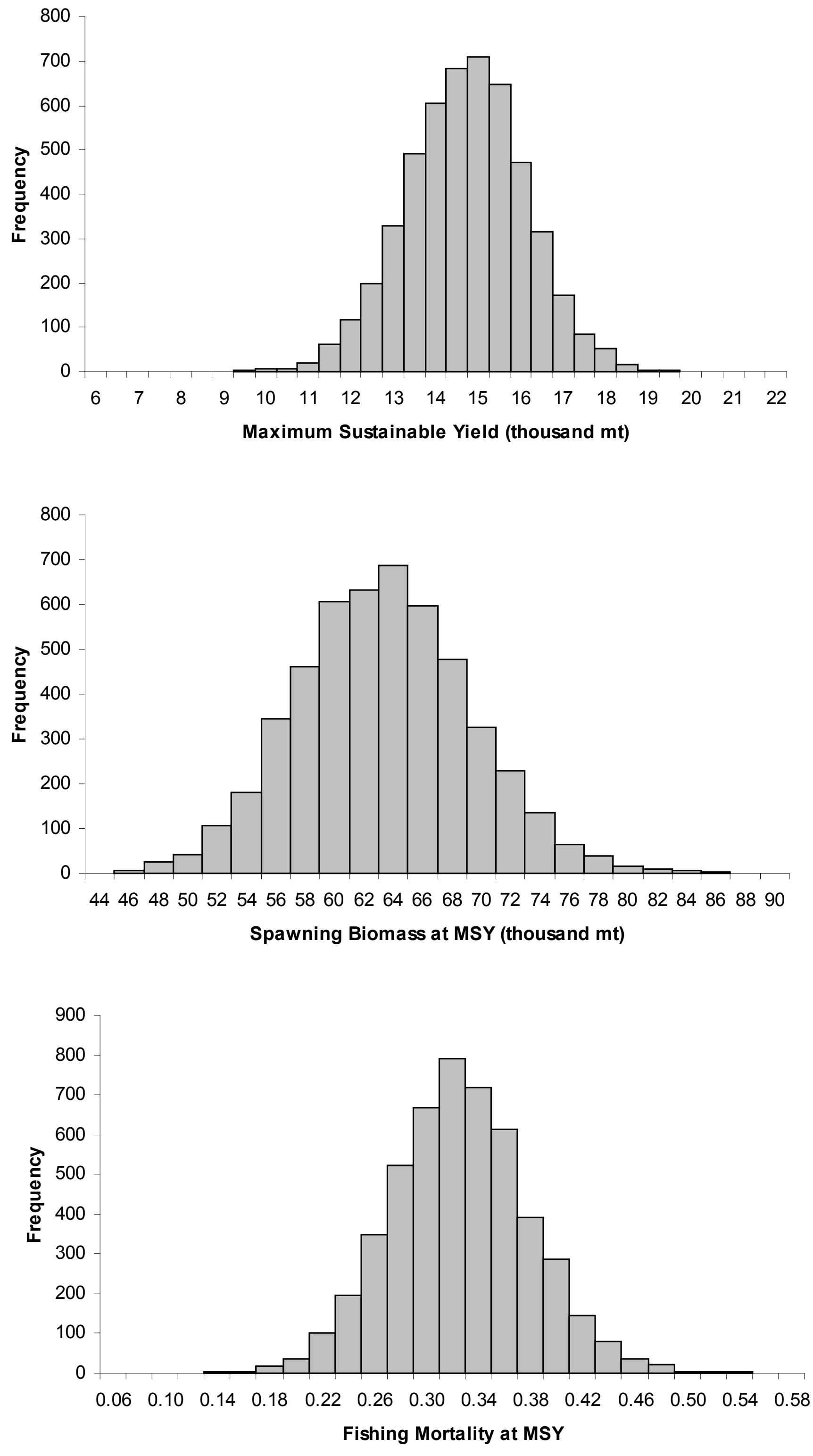


Figure 3.6.8. Histograms of uncertainty in MSY, Bmsy, and Fmsy from 5000 MCMC evaluations of best fit parametric stock-recruitment model for Southern New England yellowtail flounder.

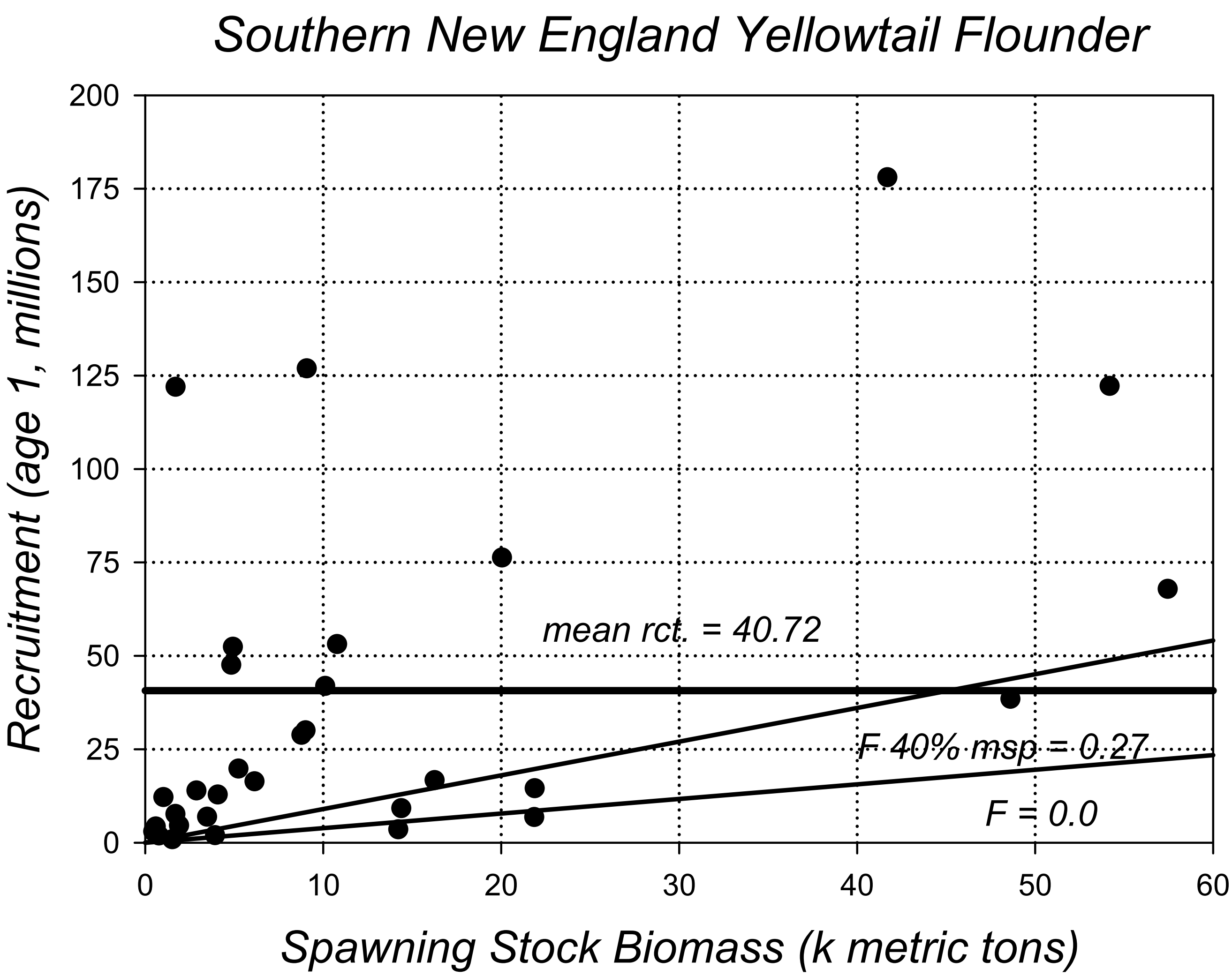


Figure 3.6.9. Stock and recruitment data for Southern New England yellowtail. For the empirical non-parametric approach the mean recruitment for all spawning stock biomss is plotted, along with replacement lines for F=0.0 and F 40% msp = 0.269.