3.7 Cape Cod yellowtail flounder

Catch and Survey Indices

Catches of Cape Cod yellowtail flounder peaked in the late 1970s followed by a decline in the 1980s and have remained low (Figure 3.7.1). All four research survey abundance indices for Cape Cod yellowtail flounder show an overall decline and rebuilding pattern from the early 1980s to present (Figure 3.7.1). The increasing stock size in recent years is difficult to explain considering the high exploitation rates thought to be occurring based on the most recent stock assessment.

Stock Assessment

The most recent assessment for Cape Cod yellowtail flounder was reviewed as part of the 2001 review of 19 Northeast groundfish stocks conducted by Northeast Fisheries Science Center staff (Northern Demersal and Southern Demersal Working Groups 2001). The stock was analyzed with virtual population analysis (VPA). The VPA assessment used data for years 1985 through 1999 and ages 1 through 6+ 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 3.7.2. Recruitment has been nearly independent of spawning stock size overall, however the recruitment series is dominated by a single large events, the 1987 year class.

Yield and Spawning Stock Biomass per Recruit

The fishing mortality reference points F(0.1) and F40%MSP given in Figure 3.7.2 were calculated for this exercise using ages 1 through 6+ in order to be consistent with the projections described below, and thus may differ slightly from previously reported values (Table 3.7.2). From the yield per recruit analysis, F(0.1)=0.231 and Fmax=0.528 (both are fully recruited Fs). From the spawning stock biomass per recruit analysis, F40%MSP=0.214 (fully recruited F) with an associated spawning stock biomass per recruit of 1.0680 kg.

Empirical Nonparametric Approach

If F40%MSP is assumed to be an adequate proxy for Fmsy, then the fishing mortality threshold is 0.214. This fishing mortality rate produces 1.068 kg of spawning stock biomass per recruit and 0.2165 kg of yield per recruit (including discards). Since the VPA estimates of recruitment does not increase with increasing spawning stock size, the mean of all recruitments is assumed to be representative of recruitment levels expected at maximum sustainable yield (MSY). Thus, recruitment of 7.85 million fish results in an estimate of 8,400 mt of spawning stock biomass (Bmsy proxy) and 1,700 mt of yield (MSY proxy) assuming that all fish caught are landed.

Parametric Model Approach

Maximum likelihood fits of the 12 parametric stock-recruitment models to the Cape Cod yellowtail flounder data from 1985-1998 are listed below (Table 3.7.1, see Table 2.1.2 for model acronyms). Note that the historical stock and recruitment data did not match well with the VPA data (Figure 3.7.3), and so no parametric models using hindcast recruitment priors were

considered. 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, PRK, and PARK are not considered. Of the remaining models, the first criterion is not satisfied for models PRBH and PRABH due to steepness being estimated at its boundary condition of 1.0. The fourth criterion is not satisfied for models RK and ARK as the estimates of Fmsy are twice as large as the estimate of FMAX (0.528). The fifth criteria is not satisfied by model ABH given the short time period of data (14 years). The only remaining model, BH, estimates Smsy at nearly half the nonparametric proxy of 8,400 mt and thus is not considered. Thus, no parametric model fits were considered to be appropriate for Cape Cod yellowtail flounder (see Figure 3.7.4 for plots of parametric fits).

Reference Points

Based on the rejection of all parametric model fits, the following management parameters are considered most appropriate: Bmsy proxy=8,400 mt, Fmsy proxy=0.214 (fully recruited F), and MSY=1,700 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 2.0, 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.

Projections

Given that all the parametric model fits were rejected, projections were conducted by resampling observed recruitments using a cumulative distribution function to allow predicted recruitment values between those observed to occur. Since the last year in the VPA was 1999, catch for 2000 and 2001 were estimated using the 2000 US landings, 2000 US landings from Jan-Nov (7,062 mt), 2001 US landings in Jan-Nov in 2000 by gear type, and the average US discard:landings ratio for 1995-1999 (15.6%). The 2000 catch estimate is 2,354 mt and the 2001 catch estimate is 2,571 mt. For 2002, the fishery was assumed to fish at the median rate projected for 2001 (2.047 fully recruited F). For the first projection, for years 2003 through 2009, the fishery was assumed to fish at a rate of F40%MSP (0.214 fully recruited F). Under these assumptions, there is a 13.3% chance that the spawning biomass in 2009 will be at least as large as the Bmsy proxy (Figure 3.7.5). Thus, a rebuilding F must be calculated. The constant fishing mortality rate for years 2003 through 2009 was found that produced a 50% probability the spawning biomass in 2009 will be at least as large as the Bmsy proxy. This constant F was found to be 0.139 (fully recruited F) which generated a 50.3% probability of achieving the spawning biomass goal (Figure 3.7.5). Based on these projections, the median fishing mortality rate in 2001 was 2.047 which must be decreased 93% to the rebuilding F level of 0.139. Under the rebuilding F, the median spawning stock biomass in 2009 will be 6,900 mt with an 80% confidence interval of 6,100 mt to 8,600 mt (Figure 3.7.6). The associated median catch will be 1,400 mt with an 80% confidence interval of 1,200 mt to 1,700 mt (Figure 3.7.7).

Table 3.7.1. Summary of parametric fits for Cape Cod yellowtail flounder.

Cape Cod Yellowtail Flounder

	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior
	0	0	0	0	0	0	0	0	0	0	0	0
	BH	ABH	PBH	PABH	PRBH	PRABH	P2BH	P2ABH	RK	ARK	PRK	PARK
Posterior Probability												
Odds Ratio for Most Likely Model Normalized Likelihood												
Model AIC Ratio	0	0	0	0	0	0	0	0	0	0	0	0
	BH	**ABH**	**PBH**	**PABH**	**PRBH**	**PRABH**	**P2BH**	**P2ABH**	**RK**	**ARK**	**PRK**	**PARK**
Number_of_data_points	14	14	14	14	14	14	14	14	14	14	14	14
Number_of_parameters	3	4	3	4	3	4	3	4	3	4	3	4
Fit_negloglikelihood	32.6521	32.3295	33.8297	33.1961	32.8685	32.8563	33.2378	35.5944	33.1894	32.4656	37.9647	36.3346
Penalty_steepness	0	0	0.727911	-0.334412	0	0	3.74079	-1.62222	0	0	0	0
Penalty_slope	0	0	0	0	0	0	0	0	0	0	4.59894	-0.120112
Penalty_unfished_R	0	0	0	0	-0.180217	-0.179228	-0.08469	-0.189339	0	0	0	0
Negative_loglikelihood	32.6521	32.3295	34.5576	32.8617	32.6883	32.6771	36.8939	33.7828	33.1894	32.4656	42.5636	36.2145
Bias-corrected_AIC	73.7043	77.1034	76.0593	78.8367	74.1371	78.157	74.8756	83.6332	74.7788	77.3757	84.3294	85.1136
Diagnostic Comments	Smsy well below non-parametric proxy	auto-correlation implies long period forcing	insufficient information for steepness prior	insufficient information for steepness prior	steepness at boundry of 1	steepness at boundry of 1	insufficient information for steepness prior	insufficient information for steepness prior	Fmsy>> Fmax	Fmsy>> Fmax	insufficient information for slope prior	insufficient information for slope prior
Parameter Point Estimates **********												
MSY	2.008	2.475	3.206	4.591	1.742	1.741	1.735	1.388	1.839	2.043	55891.000	0.525
FMSY	0.470	0.415	0.375	0.340	0.525	0.525	0.485	0.280	1.465	1.180	0.600	0.270
SMSY	4.627	6.425	9.173	14.438	3.611	3.608	3.878	5.267	1.415	1.947	101965.00	2.062
alpha	8.45769	10.91	14.7462	22.2218	7.09551	7.0997	7.23484	7.58127	2.80473	2.58121	1.83892	0.885876
expected_alpha	8.96835	11.5946	15.8054	24.1227	7.53779	7.54235	7.71103	11.1742	2.98802	2.75584	2.08424	2.64375
beta	0.149475	0.477534	1.02708	2.26831	4.27E-06	0.0050366	0.0897127	1.39428	-0.759707	-0.555828	-1.01E-05	-0.380285
steepness	0.974	0.938	0.906	0.867	1.000	0.999	0.982	0.784	N/A	N/A	N/A	N/A
R_at_input_SMAX	8.21	9.96	12.23	15.29	7.10	7.09	7.11	5.93	1.85	4.10	31.45	1.81
expected_R_at_input_SMAX	8.71	10.58	13.11	16.59	7.54	7.53	7.58	8.74	1.97	4.38	35.64	5.40
unfished_S	22.44	28.66	38.35	57.07	18.95	18.95	19.23	18.85	4.98	6.41	278224.00	4.91
unfished_R	8.40	10.73	14.36	21.37	7.10	7.10	7.20	7.06	1.87	2.40	104187.00	1.84
sigma	0.342422	0.348875	0.372469	0.405171	0.347756	0.347797	0.35705	0.880825	0.355818	0.36184	0.500452	1.47877
phi	N/A	0.293138	N/A	0.493203	N/A	0.0461746	N/A	0.89135	N/A	0.370318	N/A	0.961539
sigmaw	N/A	0.333549	N/A	0.352464	N/A	0.347426	N/A	0.399291	N/A	0.336115	N/A	0.406172
last_residual_R	N/A	-0.260495	N/A	-0.761572	N/A	0.89756	N/A	4.08344	N/A	-0.60565	N/A	5.9353
last_logresidual_R	N/A	-0.03215	N/A	-0.091228	N/A	0.119431	N/A	0.717765	N/A	-0.073216	N/A	1.36424
expected_lognormal_error_	1.06038	1.06275	1.07183	1.08554	1.06233	1.06235	1.06582	1.47392	1.06535	1.06765	1.1334	2.98434
prior_mean_steepness	N/A	N/A	0.75	0.75	N/A	N/A	0.75	0.75	N/A	N/A	N/A	N/A
prior_se_steepness	N/A	N/A	0.07	0.07	N/A	N/A	0.07	0.07	N/A	N/A	N/A	N/A
prior_mean_slope	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.79	0.79
prior_se_slope	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.34	0.34
prior_mean_unfished_R	N/A	N/A	N/A	N/A	7.05	7.05	7.05	7.05	N/A	N/A	N/A	N/A
prior_se_unfished_R	N/A	N/A	N/A	N/A	0.33	0.33	0.33	0.33	N/A	N/A	N/A	N/A

Table 3.7.2. Yield and biomass per recruit of Cape Cod 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: 19- 2-2002;  Time: 13:41:13.00
 CAPE COD 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:  6
 Last age is a PLUS group;
 Original age-specific PRs, Mats, and Mean Wts from file:
 ==> C:\groundfish\ypr\ccyt_ypr.dat
-------------------------------------------------------------
 Age-specific Input data for Yield per Recruit Analysis
-------------------------------------------------------------
  Age | Fish Mort  Nat Mort | Proportion | Average Weights
      |  Pattern    Pattern |   Mature   |  Catch   Stock
-------------------------------------------------------------
   1  |  0.0200     1.0000  |   0.0000   |  0.048   0.048
   2  |  0.1100     1.0000  |   0.0800   |  0.263   0.263
   3  |  0.6500     1.0000  |   0.8100   |  0.382   0.382
   4  |  1.0000     1.0000  |   1.0000   |  0.493   0.493
   5  |  1.0000     1.0000  |   1.0000   |  0.588   0.588
   6  |  1.0000     1.0000  |   1.0000   |  1.056   1.056

-------------------------------------------------------------
 Summary of Yield per Recruit Analysis:
 _____________________________________________________________
  Slope of the Yield/Recruit Curve at F=0.00: -->    2.6001
    F level at slope=1/10 of the above slope (F0.1): ----->          0.231
      Yield/Recruit corresponding to F0.1: ----->    0.2214
    F level to produce Maximum Yield/Recruit (Fmax): ----->          0.528
      Yield/Recruit corresponding to Fmax: ----->    0.2455
    F level at 40 % of Max Spawning Potential (F40): ----->   0.214
      SSB/Recruit corresponding to F40: -------->    1.0680
_____________________________________________________________
1
 Listing of Yield per Recruit Results for:
 ------------------------------------------------------------------------------
      FMORT   TOTCTHN  TOTCTHW  TOTSTKN  TOTSTKW  SPNSTKN  SPNSTKW    % MSP
 ------------------------------------------------------------------------------
       0.00   0.00000  0.00000   5.5167   3.1973   3.3453   2.6704    100.00
       0.10   0.21691  0.15544   4.4373   2.1221   2.2682   1.6168     60.54
       0.20   0.32679  0.21209   3.8928   1.6043   1.7261   1.1164     41.81
 F0.1  0.23   0.35074  0.22136   3.7745   1.4958   1.6086   1.0126     37.92
 F40%  0.21   0.33789  0.21655   3.8380   1.5538   1.6716   1.0680     39.99
       0.30   0.39382  0.23458   3.5623   1.3061   1.3982   0.8325     31.17
       0.40   0.43937  0.24309   3.3389   1.1156   1.1776   0.6537     24.48
       0.50   0.47261  0.24545   3.1768   0.9850   1.0185   0.5330     19.96
 Fmax  0.53   0.48035  0.24553   3.1392   0.9559   0.9817   0.5062     18.96
       0.60   0.49812  0.24506   3.0531   0.8909   0.8979   0.4471     16.74
       0.70   0.51847  0.24351   2.9551   0.8204   0.8030   0.3835     14.36
       0.80   0.53517  0.24153   2.8750   0.7657   0.7263   0.3348     12.54
       0.90   0.54921  0.23949   2.8081   0.7223   0.6628   0.2966     11.11
       1.00   0.56123  0.23753   2.7511   0.6870   0.6093   0.2658      9.95
       1.10   0.57170  0.23573   2.7018   0.6577   0.5636   0.2406      9.01
       1.20   0.58092  0.23410   2.6585   0.6330   0.5239   0.2195      8.22
       1.30   0.58915  0.23262   2.6201   0.6118   0.4891   0.2016      7.55
       1.40   0.59655  0.23128   2.5856   0.5934   0.4584   0.1863      6.97
       1.50   0.60327  0.23007   2.5545   0.5773   0.4310   0.1729      6.48
       1.60   0.60941  0.22895   2.5261   0.5630   0.4064   0.1612      6.04
       1.70   0.61507  0.22792   2.5001   0.5501   0.3842   0.1509      5.65
       1.80   0.62030  0.22696   2.4761   0.5385   0.3641   0.1417      5.31
       1.90   0.62516  0.22605   2.4539   0.5280   0.3456   0.1334      4.99
       2.00   0.62970  0.22520   2.4332   0.5184   0.3288   0.1259      4.71
```

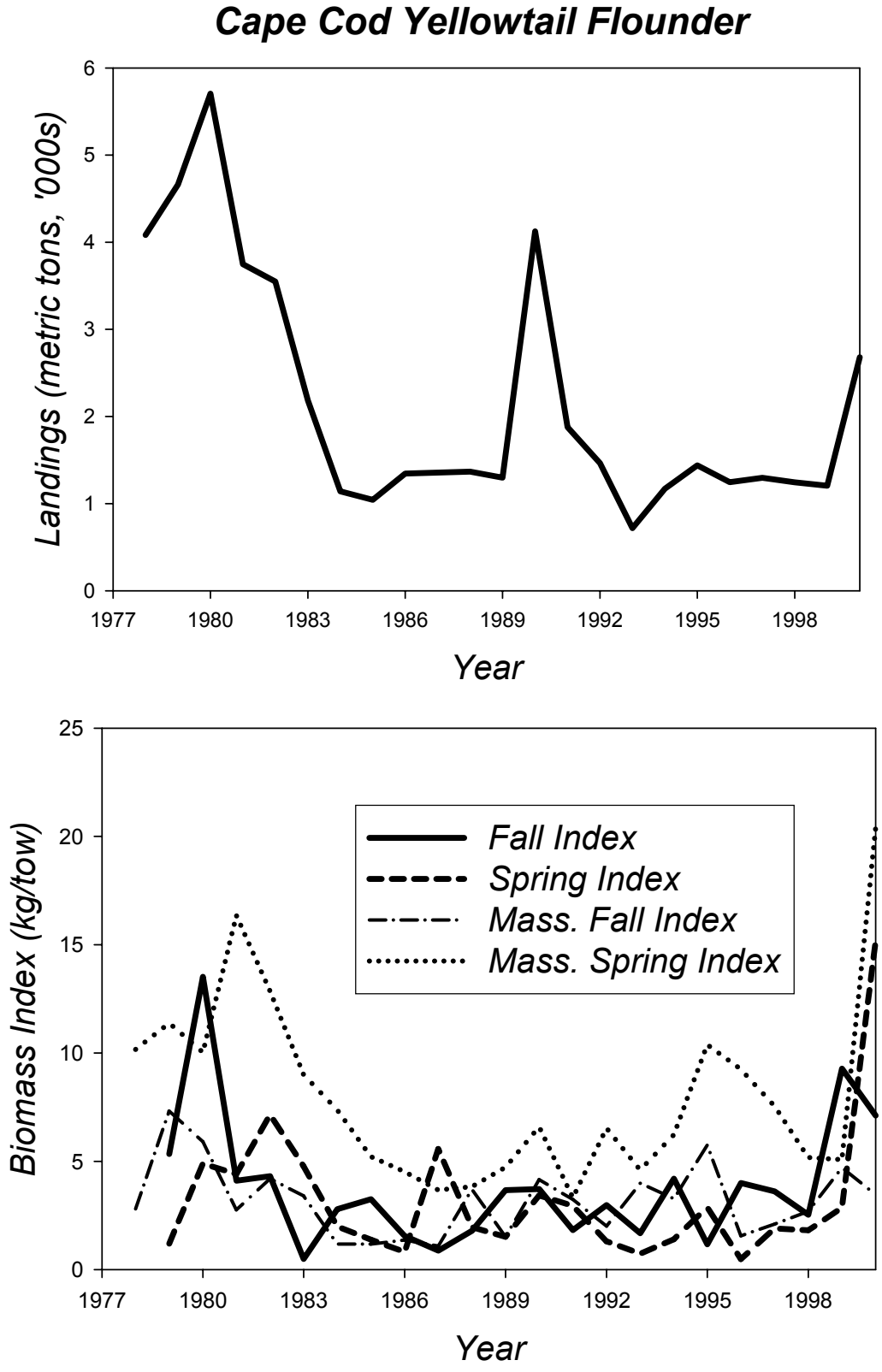
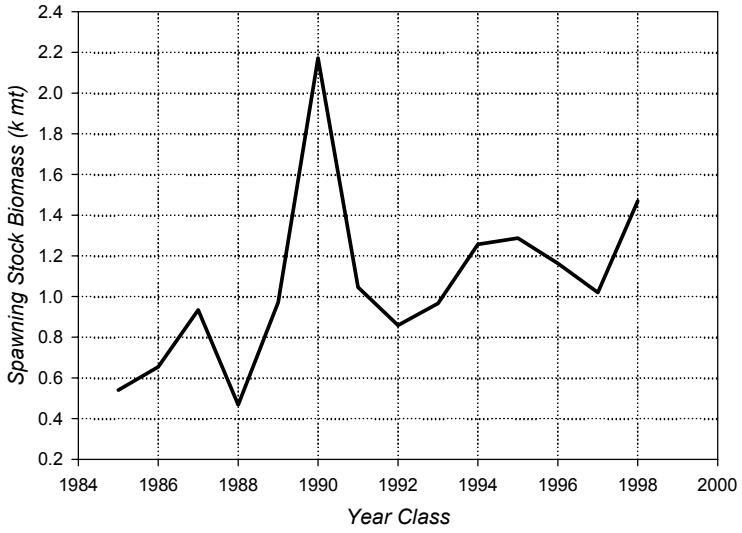


Figure 3.7.1. Landings and research vessel survey abundance indices for Cape Cod yellowtail flounder.

(a)



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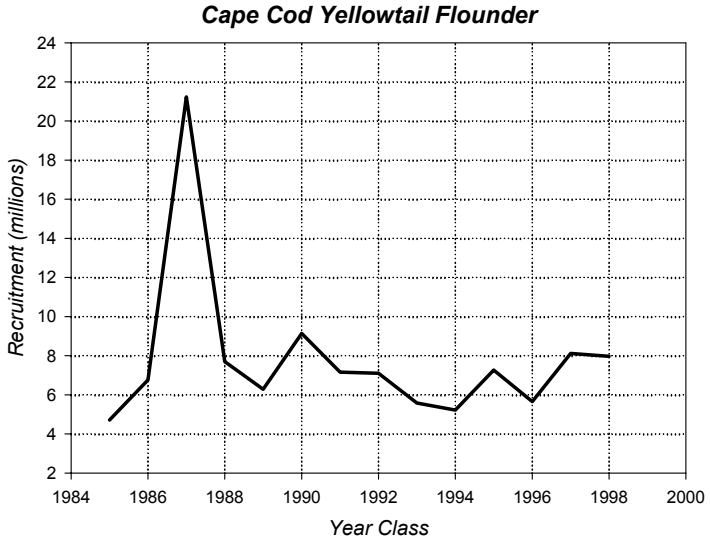

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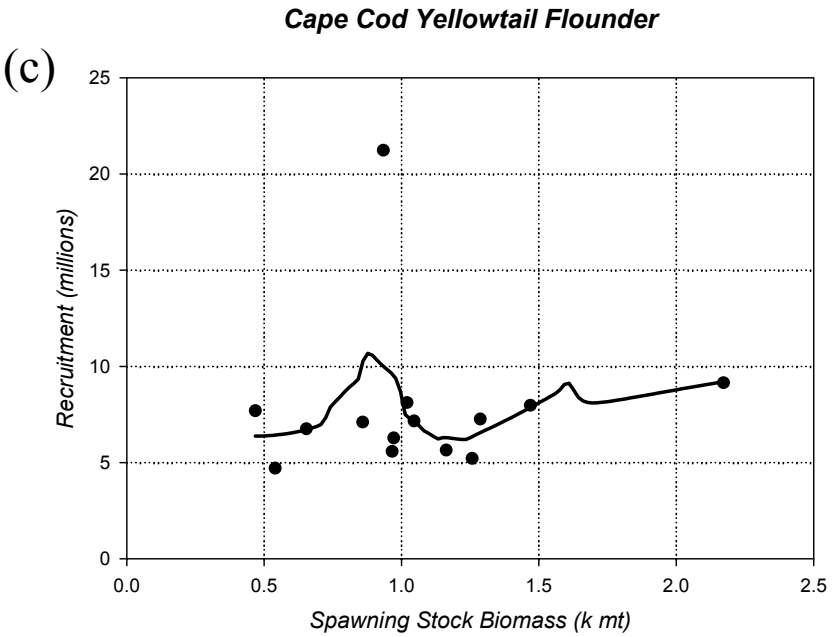

		F0.1	F40% MSP
F reference point		0.231	0.214
ssb per recruit at F		1.013	1.068
	Recruitment (millions)	SS Biomass at F0.1	SS Biomass at F40%
n	14	14	14
mean	7.85	7.95	8.38
min	4.71	4.77	5.03
max	21.23	21.50	22.67
10th %'tile	5.33	5.39	5.69
25th %'tile	5.81	5.88	6.20
50th %'tile	7.13	7.22	7.61
75th %'tile	7.90	8.00	8.44
90th %'tile	8.84	8.95	9.44
Std Dev	4.04	4.09	4.32
CV	0.52	0.52	0.52

Figure 3.7.2. Spawning stock (a), recruitment (age 1 millions, b), and scatterplot (c) for Cape Cod 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 3.7.2). Smoother in the stock-recruitment plot is lowess with tension = 0.5.

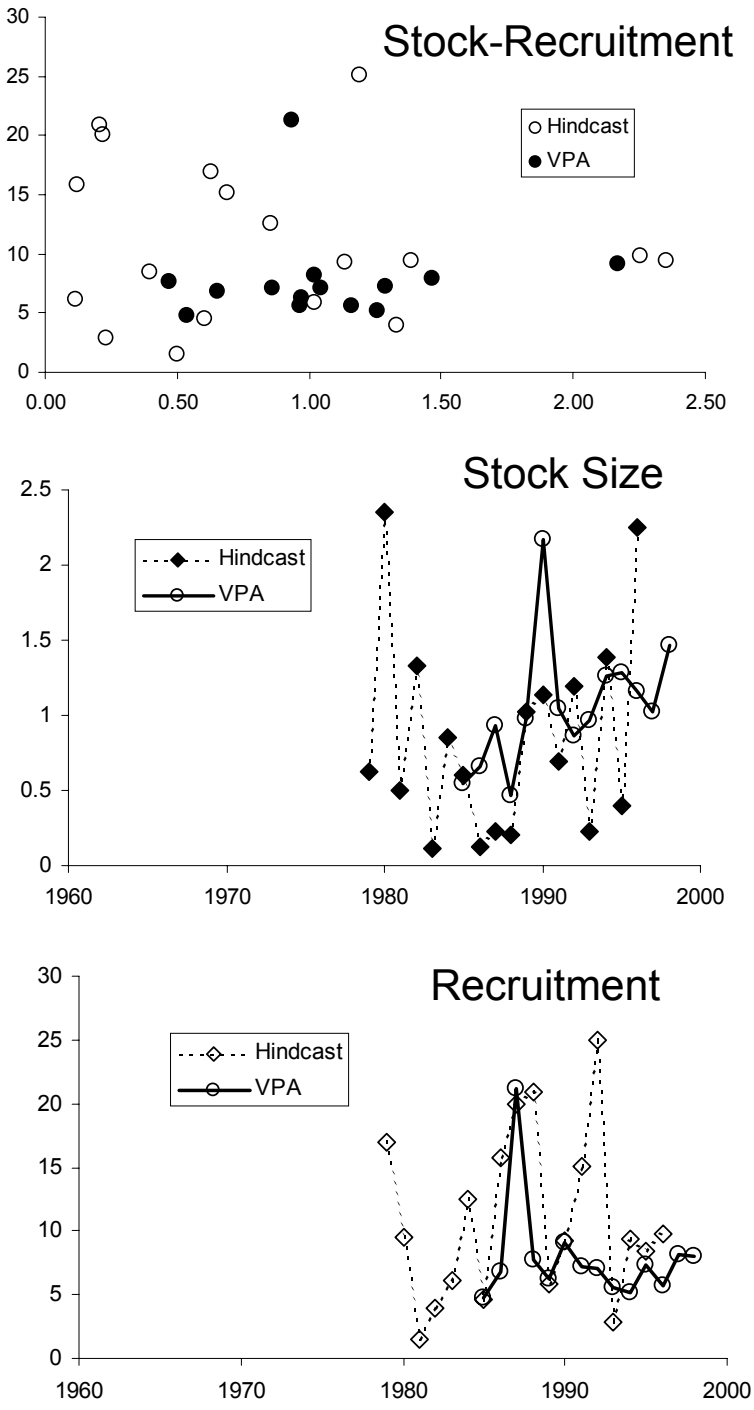

Figure 3.7.3. Comparison of stock and recruitment data from virtual population analysis (VPA) and hindcast for Cape Cod yellowtail flounder.

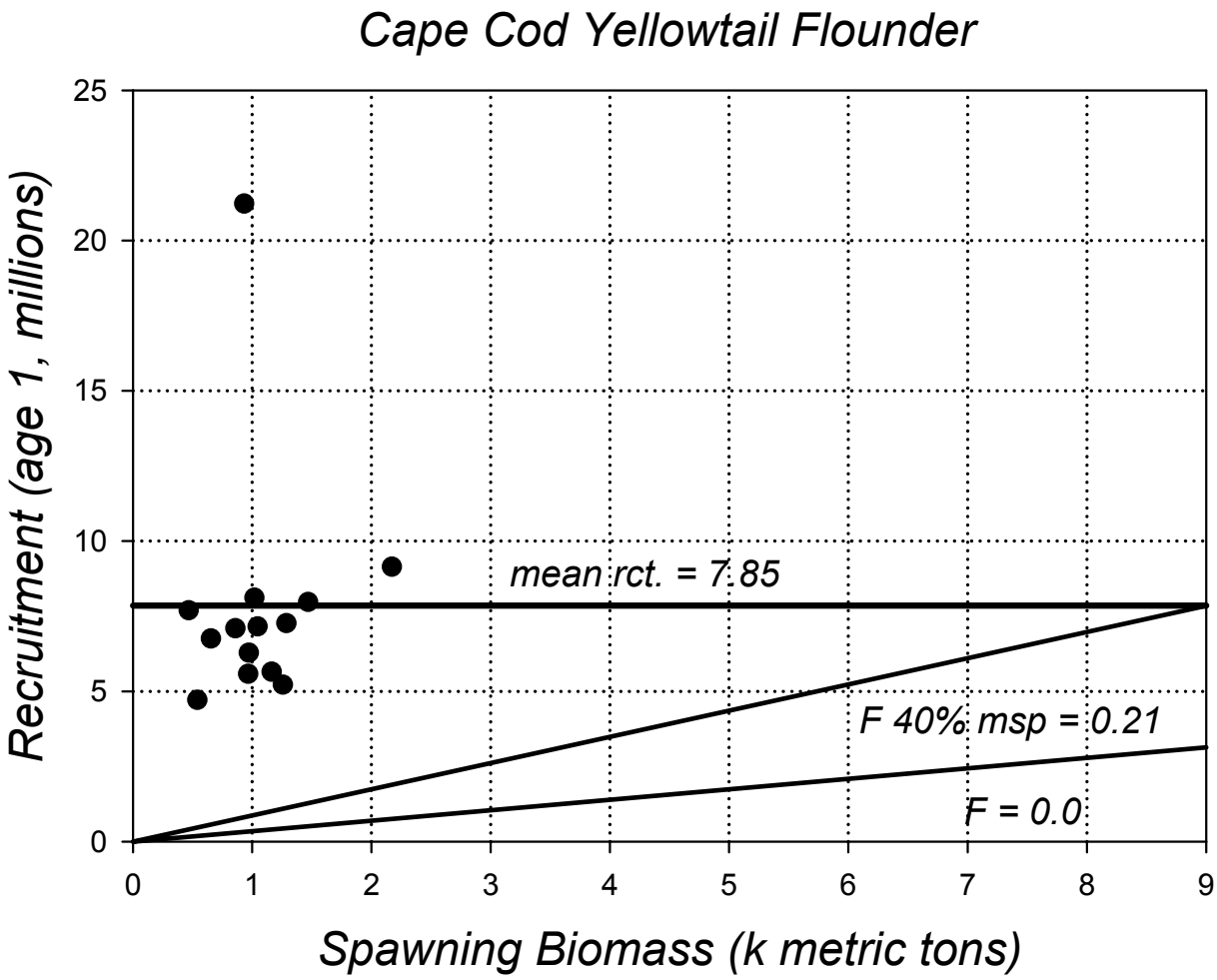

Figure 3.7.4. Stock and recruitment data for Cape Cod yellowtail flounder. For the empirical non-parametric approach the mean recruitment is plotted along with the replacement lines for F=0.0 and F 40% msp = 0.21.

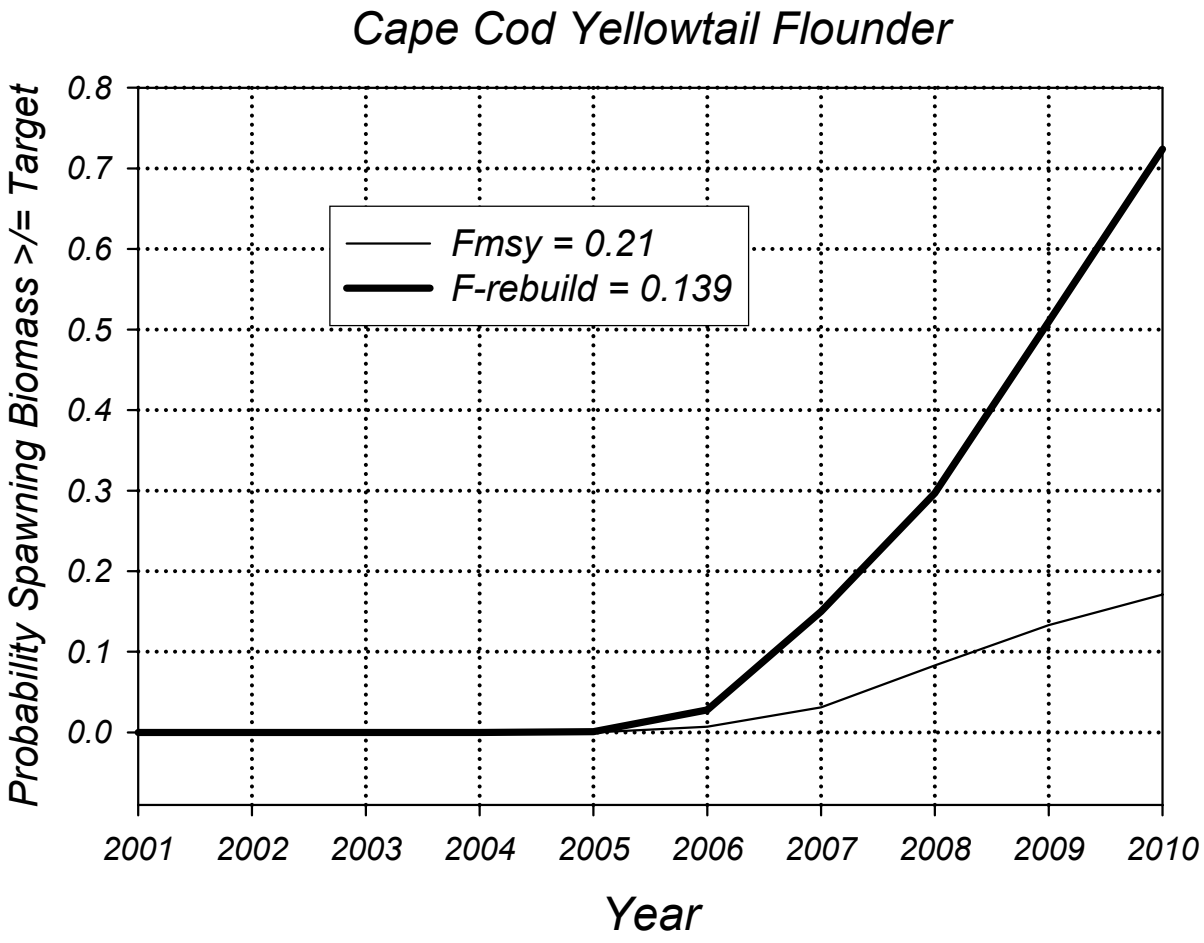

Figure 3.7.5. Probability that Cape Cod yellowtail spawning biomass will exceed Bmsy (8,400 mt) annually under two fishing mortality scenarios: Fmsy and F required to rebuild the stock to Bmsy by 2009.

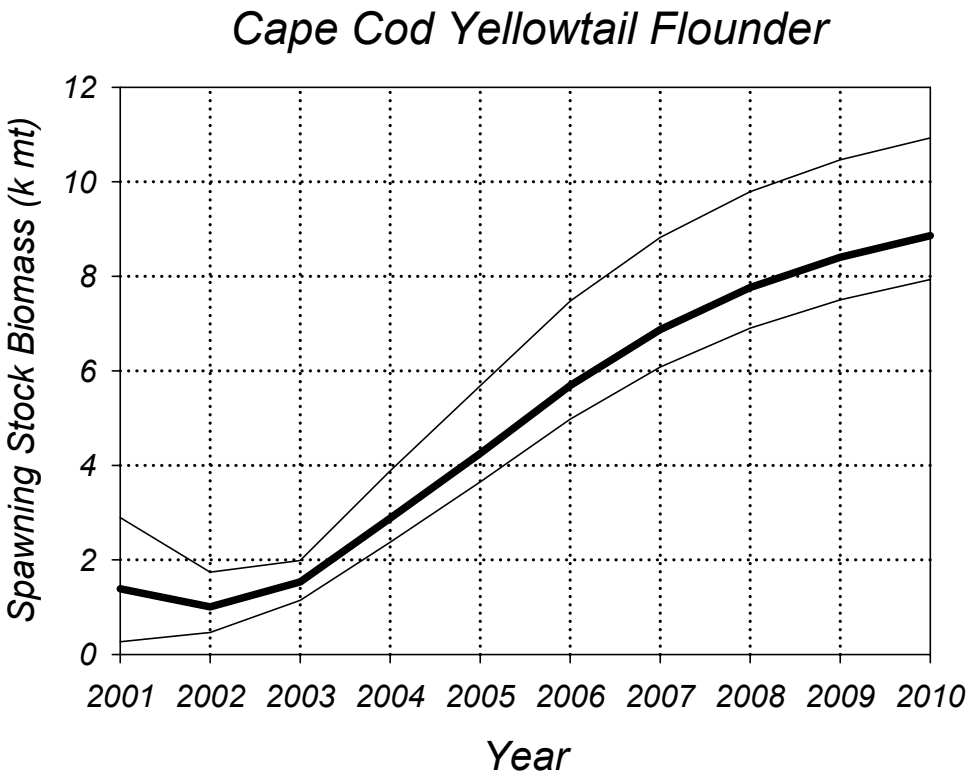

Figure 3.7.6. Median and 80% confidence interval of predicted spawning biomass for Cape Cod yellowtail under F-rebuild fishing mortality rates.

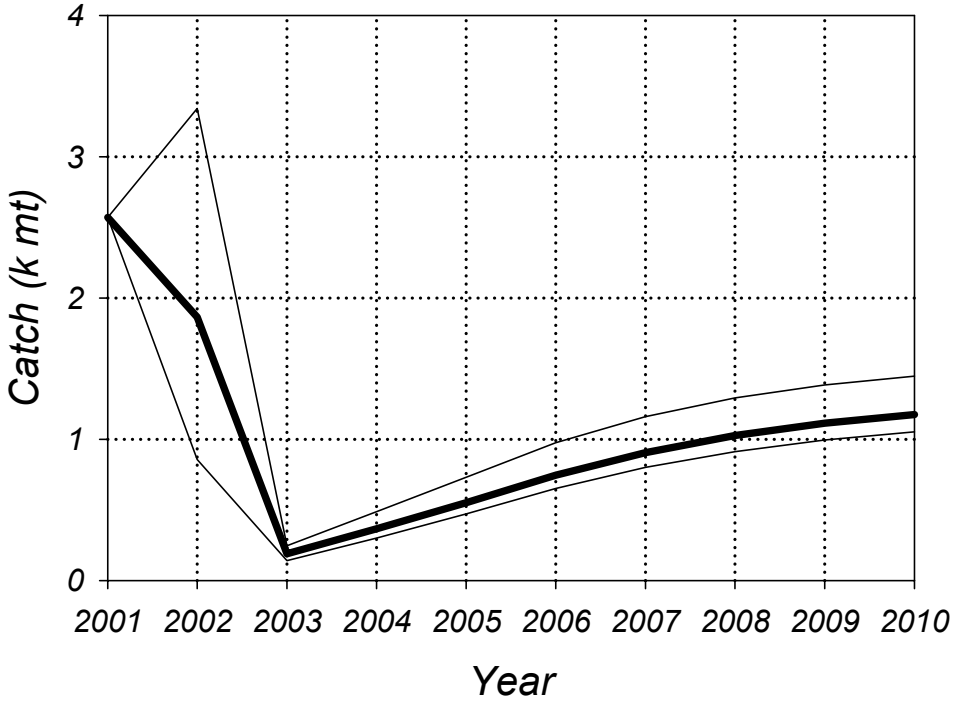

Figure 3.7.7. Median and 80% confidence interval of predicted catch for Cape Cod yellowtail under F-rebuild fishing mortality rates.