

3.10 Witch Flounder

Catch and Survey Indices

After averaging approximately 1,000 mt since the 1960s, witch flounder landings peaked around 6,000 mt in 1971-72, declined to an annual average of 2,800 mt during 1973-81, and then increased sharply to over 6,000 mt in 1983-85. Landings then declined steadily to 1,500 mt by 1990, the lowest value since 1964. Landings for 1991-2000 averaged 2,200 mt annually (Figure 3.10.1). The NEFSC spring and autumn bottom trawl survey biomass indices fluctuated without trend during the mid-1960 to late 1970s. However, in the 1980s biomass declined to record low levels in the early 1990s; since the mid-1990s, biomass has remained low (Figure 3.10.1).

Stock Assessment

Witch flounder are assessed as a unit stock from the Gulf of Maine southward (NAFO Subareas 5 and 6). An analytical assessment was conducted on this species in 1999 (Wigley et al. 1999) and reviewed at SAW 29 (NEFSC 1999b). The VPA assessment used data from 1982 to 1998 with ages 1 to 11+ which included discards in the catch at age matrix. Estimates of spawning stock biomass and recruitment (age 3) from the VPA are given in Figure 3.10.2. Spawning stock biomass has decreased over the assessment time period while recruitment has increased.

Yield and Spawning Stock Biomass per Recruit Analysis

Yield and spawning stock biomass analysis was revised slightly from the 1999 assessment to fully account for the age distribution of fish within the plus group. This was accomplished by adjusting the age 11+ mean weight at age to account for the F likely to rebuild biomass and using recent catch and stock mean weights derived for the 1994-1998 period. Partial recruitment and maturation at age were consistent with the 1999 assessment. The YPR analysis was performed using ages 3 to 11+ for consistency with the age structure of the stock sizes in the projections. A sensitivity analysis was conducted using maturation at age from 1980-1982, a period of delayed maturation associated with higher biomass levels. The yield and spawning stock biomass results are presented in Table 3.10.1. The yield and spawning stock biomass per recruit analysis indicate that $F_{0.1} = 0.168$, $F_{40\%} = 0.164$ and $F_{max} = 0.358$. At $F_{40\%}$, the yield per recruit is 0.2406 kg and the spawning stock biomass per recruit is 1.602 kg. In the sensitivity run, $F_{0.1}$ and F_{max} remained unchanged, $F_{40\%}$ decreased to 0.136 and the yield per recruit and spawning stock biomass per recruit decreased to 0.226 kg and 1.439 kg, respectively (Table 3.10.2)

MSY-based Reference Points

Empirical Nonparametric Approach

If $F_{40\% msp}$ is assumed to be the proxy for F_{msy} , then the fishing mortality threshold is 0.164. The spawning stock biomass per recruit associated with this fishing mortality rate is

1.602 kg and the yield per recruit is 0.2406 kg. Since the VPA stock-recruit data for the 1982-1994 year classes revealed a negative trend, the arithmetic mean of the VPA recruitment (age 3) data was used as a proxy for recruitment at maximum sustainable yield (MSY). The mean recruitment of 12.42 million fish results in an estimate of 19,900 mt of spawning stock biomass (Bmsy proxy) and MSY of 2,990 mt (including landings and discards).

Parametric Model Approach

The spawning stock biomass and age 3 recruitment from the most recent witch flounder assessment revealed an unexplained negative stock-recruit relationship for the 1982-1994 year classes (Figure 3.10.2). This negative relationship persisted regardless of recruitment age (e.g. age 1, age 2 or age 3). To determine if a longer time series of stock-recruit data would provide a different relationship, Brodziak et al. (2001) hindcast stock-recruit data were examined. The survey-derived hindcast data for the 1963-1995 year classes did not provide evidence of a positive relationship. Given the limitations of the survey-derived hindcast data series (no survey age data prior to 1980, and a discrepancy in the magnitude between the hindcast recruitment and the VPA recruitment), the hindcast data were not utilized. Due to the negative trend in the VPA stock-recruit data, parametric modeling was not appropriate, and the Working Group agreed to accept the empirical nonparametric approach.

Reference Points

Based on the yield and spawning stock biomass per recruit analysis, the following management parameters are considered most appropriate: Bmsy = 19,900 mt, Fmsy = F40% = 0.164 (fully recruited F) and MSY = 2,990 mt. This level of yield is expected to rebuild and maintain the stock size given that average recruitment is within the range observed in the most recent assessment (Figure 3.10.3).

Projections

To evaluate the trajectories of spawning stock biomass and catch under the F40% fishing mortality rate, a stochastic age-based projection (Brodziak and Rago MS 2002) was conducted over a twelve year time period beginning in 1999. Since the last year of the VPA was 1998, the projection used estimates of total catch in 1999-2001. Annual discards for 1999-2001 were estimated by multiplying 1999-2001 annual landings by the 1998 discard:landings ratio (0.18). The 2001 landings were estimated by multiplying the 2001 January-November landings by the ratio of 2000 January-November landings to 2000 January-December. The estimated total catch in 1999-2001 was 2,505 mt, 2,878 mt, and 3,459 mt, respectively. The partial recruitment at age, maturity at age and the stock and catch mean weights are the same as used in the yield and spawning stock biomass per recruit analysis given above. Initial stock sizes in 1999 were derived from 1000 bootstrap iterations of the final VPA formulation. To capture the recruitment stochasticity in the rebuilding projections, resampling from the cumulative distribution function based on the VPA age 3 recruitment from the 1982 - 1994 year classes was used (Brodziak and

Rago MS 2002). The F in 2002 was set to the median F in 2001 (0.191). The fishing mortality rate in 2003-2010 was set to $F_{msy} = F_{40\%} = 0.164$ as derived in the YPR analysis.

The projection shows that fishing at F_{msy} (0.164) between 2003 and 2009 will result in a 76 % probability of rebuilding the spawning biomass to SBB_{msy} (19,900 mt) by 2009 (Figure 3.10.4). The projected median spawning biomass declines slightly from 28,400 mt in 2003 to 23,100 mt in 2009 (Figure 3.10.5). The projected median catch declines slightly from 4,400 mt in 2003 to 3,500 mt in 2009 (Figure 3.10.6).

Table 3.10.1. Yield and biomass per recruit of witch flounder, using current growth and maturity rates.

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The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
PC Ver.2.0 [Method of Thompson and Bell (1934)] 1-Jan-1999
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Run Date: 21- 2-2002; Time: 13:57:11.89
Witch flounder
-----
Proportion of F before spawning: .1667
Proportion of M before spawning: .1667
Natural Mortality is Constant at: .150
Initial age is: 3; Last age is: 11
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> wit311s.dat
-----
Age-specific Input data for Yield per Recruit Analysis
-----
Age | Fish Mort | Nat Mort | Proportion | Average Weights
   | Pattern   | Pattern   | Mature     | Catch   Stock
-----
 3 | .0130     | 1.0000   | .0000     | .067   .042
 4 | .0730     | 1.0000   | .0800     | .179   .114
 5 | .2330     | 1.0000   | .4500     | .264   .221
 6 | .4730     | 1.0000   | .8500     | .399   .333
 7 | 1.0000    | 1.0000   | 1.0000    | .527   .468
 8 | 1.0000    | 1.0000   | 1.0000    | .660   .595
 9 | 1.0000    | 1.0000   | 1.0000    | .868   .766
10 | 1.0000    | 1.0000   | 1.0000    | .974   .920
11+ | 1.0000    | 1.0000   | 1.0000    | 1.248  1.236
-----
Summary of Yield per Recruit Analysis for:
Witch flounder
-----
Slope of the Yield/Recruit Curve at F=0.00: --> 3.8732
F level at slope=1/10 of the above slope (F0.1): -----> .168
Yield/Recruit corresponding to F0.1: -----> .2420
F level to produce Maximum Yield/Recruit (Fmax): -----> .358
Yield/Recruit corresponding to Fmax: -----> .2669
F level at 40 % of Max Spawning Potential (F40): -----> .164
SSB/Recruit corresponding to F40: -----> 1.6017
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Listing of Yield per Recruit Results for:
Witch flounder
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FMORT  TOTCTHN  TOTCTHW  TOTSTKN  TOTSTKW  SPNSTKN  SPNSTKW  % MSP
-----
.00    .000000  .000000  7.1792   4.3601   4.7636   4.0045   100.00
.05    .15695   .13425   6.1354   3.1692   3.7230   2.8217   70.46
.10    .25205   .19992   5.5038   2.4784   3.0947   2.1377   53.38
.15    .31620   .23412   5.0785   2.0340   2.6726   1.6994   42.44
F0.1   .17    .33462   .24204   4.9565   1.9108   2.5517   1.5782   39.41
F40% .16 .33102 .24057 4.9803 1.9347 2.5753 1.6017 40.00
.20    .36264   .25220   4.7710   1.7281   2.3684   1.3987   34.93
.25    .39801   .26144   4.5374   1.5069   2.1380   1.1822   29.52
.30    .42597   .26564   4.3530   1.3409   1.9569   1.0204   25.48
.35    .44875   .26689   4.2030   1.2126   1.8103   .8958   22.37
Fmax   .36    .45193   .26690   4.1821   1.1953   1.7899   .8790   21.95
.40    .46774   .26640   4.0783   1.1110   1.6889   .7975   19.92
.45    .48388   .26491   3.9724   1.0289   1.5864   .7184   17.94
.50    .49782   .26284   3.8812   .9613   1.4984   .6536   16.32
.55    .51002   .26046   3.8014   .9048   1.4220   .5997   14.98
.60    .52084   .25794   3.7309   .8570   1.3549   .5542   13.84
.65    .53051   .25539   3.6678   .8160   1.2952   .5154   12.87
.70    .53924   .25287   3.6110   .7804   1.2419   .4819   12.03
.75    .54717   .25040   3.5595   .7493   1.1937   .4527   11.30
.80    .55444   .24802   3.5123   .7218   1.1499   .4270   10.66
.85    .56113   .24573   3.4689   .6973   1.1099   .4043   10.10
.90    .56733   .24354   3.4287   .6753   1.0732   .3840   9.59
.95    .57310   .24144   3.3914   .6555   1.0393   .3658   9.13
1.00   .57848   .23944   3.3566   .6375   1.0079   .3493   8.72
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Table 3.10.2. Yield and biomass per recruit of witch flounder using historical maturity rates.

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PC Ver.2.0 [Method of Thompson and Bell (1934)] 1-Jan-1999
-----
Run Date: 21- 2-2002; Time: 13:58:47.68
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Natural Mortality is Constant at: .150
Initial age is: 3; Last age is: 11
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
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-----
Age-specific Input data for Yield per Recruit Analysis
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 6 | .4730     | 1.0000   | .1500     | .399   .333
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 8 | 1.0000    | 1.0000   | .8200     | .660   .595
 9 | 1.0000    | 1.0000   | .9700     | .868   .766
10 | 1.0000    | 1.0000   | 1.0000    | .974   .920
11+ | 1.0000    | 1.0000   | 1.0000    | 1.248  1.236
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Witch flounder sensitivity run using 1980-1982 maturity ogive
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Listing of Yield per Recruit Results for:
Witch flounder sensitivity run using 1980-1982 maturity ogive
-----
FMORT  TOTCTHN  TOTCTHW  TOTSTKN  TOTSTKW  SPNSTKN  SPNSTKW  % MSP
-----
      .00   .00000   .00000   7.1792   4.3601   3.5826   3.5970   100.00
      .05   .15695   .13425   6.1354   3.1692   2.5748   2.4293   67.54
      .10   .25205   .19992   5.5038   2.4784   1.9775   1.7595   48.92
F40%  .14  .30006 .22645 5.1854 2.1436 1.6825 1.4388 40.00
      .15   .31620   .23412   5.0785   2.0340   1.5848   1.3345   37.10
      .17   .33462   .24204   4.9565   1.9108   1.4742   1.2179   33.86
      .20   .36264   .25220   4.7710   1.7281   1.3085   1.0464   29.09
      .25   .39801   .26144   4.5374   1.5069   1.1047   .8417   23.40
      .30   .42597   .26564   4.3530   1.3409   .9489   .6910   19.21
      .35   .44875   .26689   4.2030   1.2126   .8264   .5769   16.04
      .36   .45193   .26690   4.1821   1.1953   .8097   .5617   15.62
      .40   .46774   .26640   4.0783   1.1110   .7280   .4886   13.58
      .45   .48388   .26491   3.9724   1.0289   .6475   .4189   11.65
      .50   .49782   .26284   3.8812   .9613   .5806   .3630   10.09
      .55   .51002   .26046   3.8014   .9048   .5243   .3176   8.83
      .60   .52084   .25794   3.7309   .8570   .4764   .2801   7.79
      .65   .53051   .25539   3.6678   .8160   .4353   .2490   6.92
      .70   .53924   .25287   3.6110   .7804   .3996   .2227   6.19
      .75   .54717   .25040   3.5595   .7493   .3685   .2005   5.57
      .80   .55444   .24802   3.5123   .7218   .3411   .1815   5.04
      .85   .56113   .24573   3.4689   .6973   .3169   .1651   4.59
      .90   .56733   .24354   3.4287   .6753   .2953   .1508   4.19
      .95   .57310   .24144   3.3914   .6555   .2761   .1384   3.85
      1.00   .57848   .23944   3.3566   .6375   .2587   .1275   3.54
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Witch Flounder

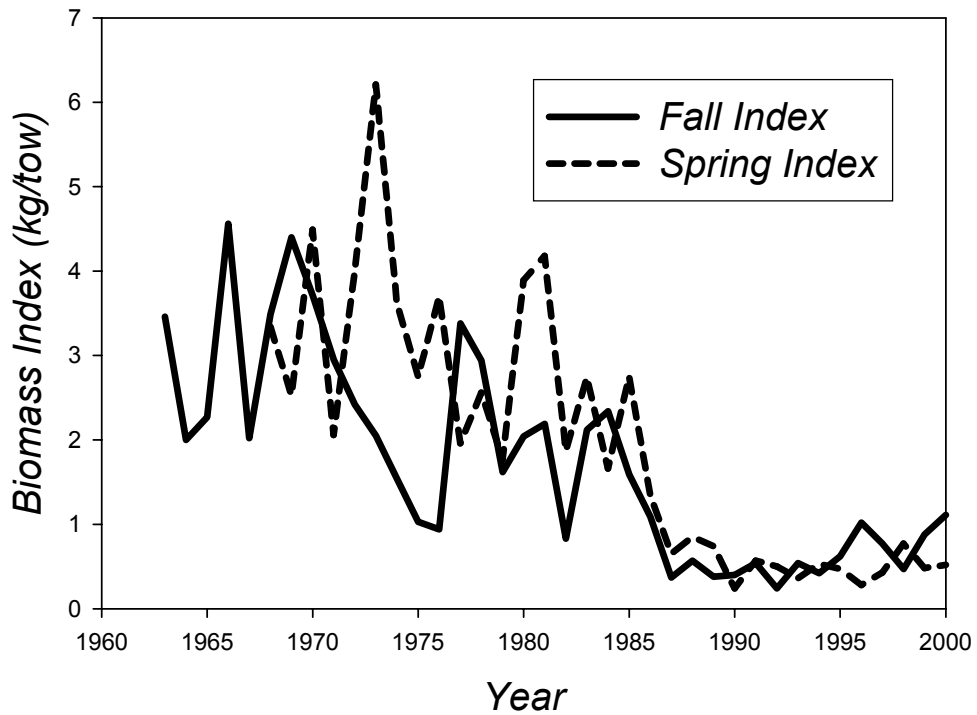
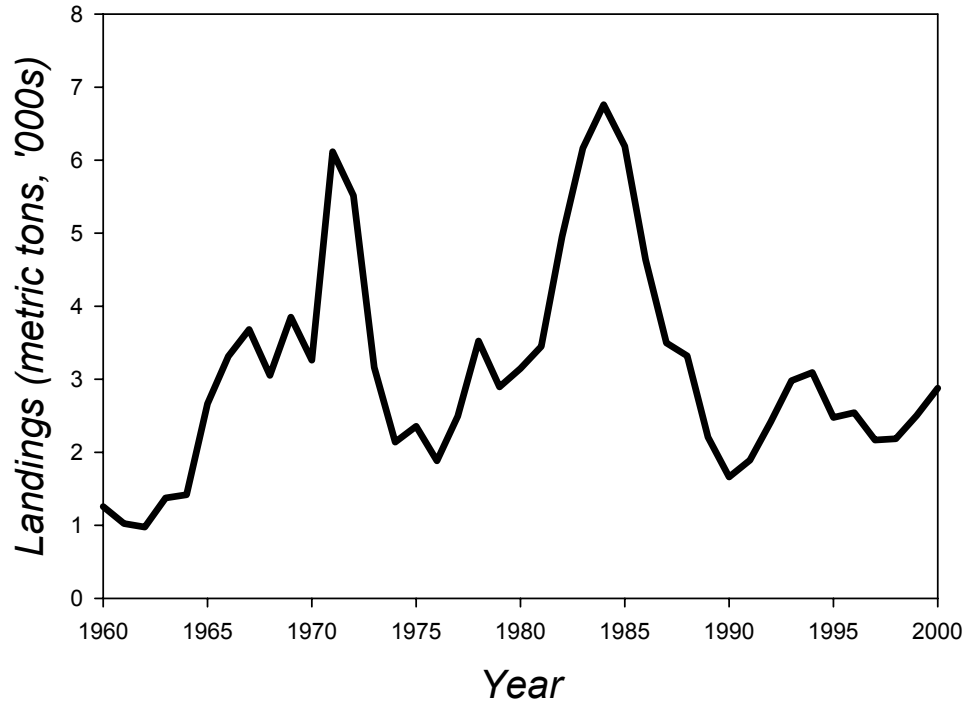
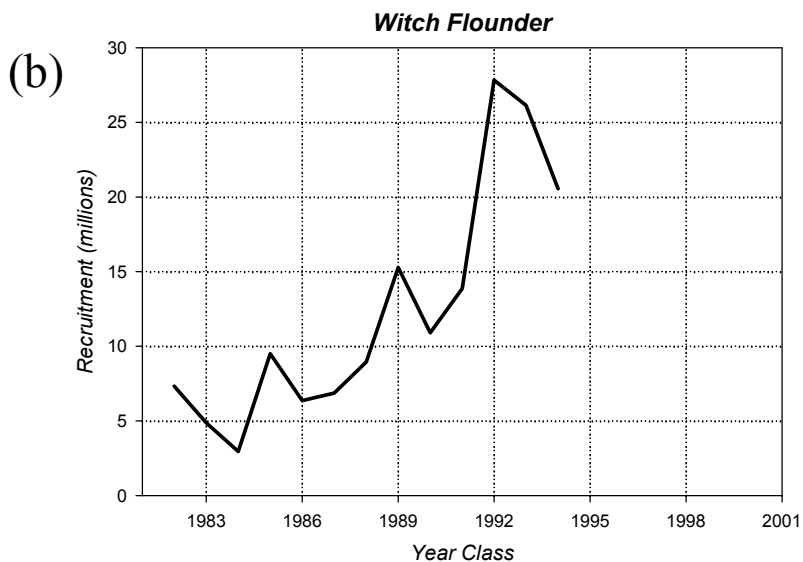
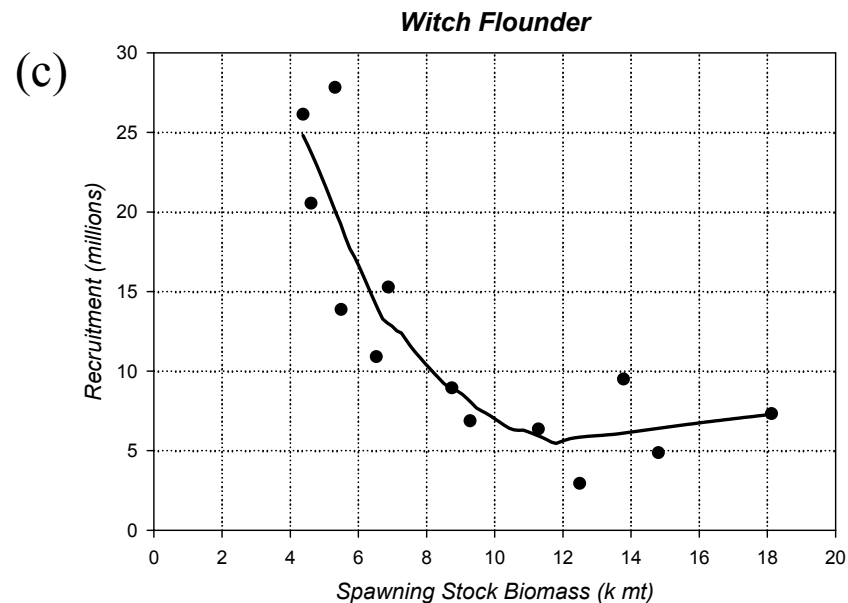
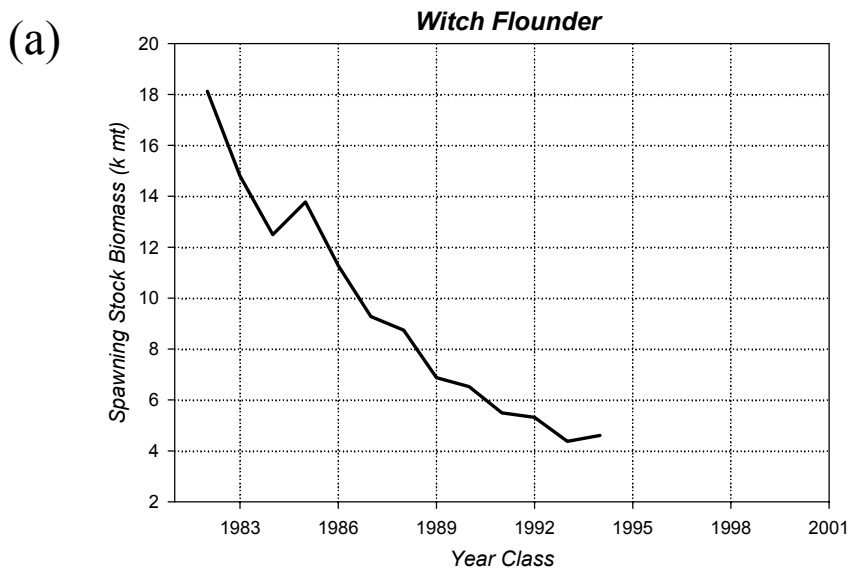


Figure 3.10.1. Landings and research vessel survey abundance indices for Witch flounder.



		F0.1	F40% MSP
F reference point		0.168	0.164
ssb per recruit at F		1.578	1.602
	Recruitment (millions)	SS Biomass at F0.1	SS Biomass at F40%
n	13	13	13
mean	12.42	19.60	19.89
min	2.95	4.66	4.73
max	27.83	43.93	44.58
10th %tile	5.17	8.16	8.28
25th %tile	6.87	10.84	11.01
50th %tile	9.50	15.00	15.22
75th %tile	15.28	24.11	24.47
90th %tile	25.02	39.49	40.08
Std Dev	7.99	12.60	12.79
CV	0.64	0.64	0.64

Figure 3.10.2. Spawning stock (a), recruitment (age 3 millions, b), and scatterplot (c) for witch 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 3.10.1). Smoother in the stock-recruitment plot is lowess with tension = 0.5.

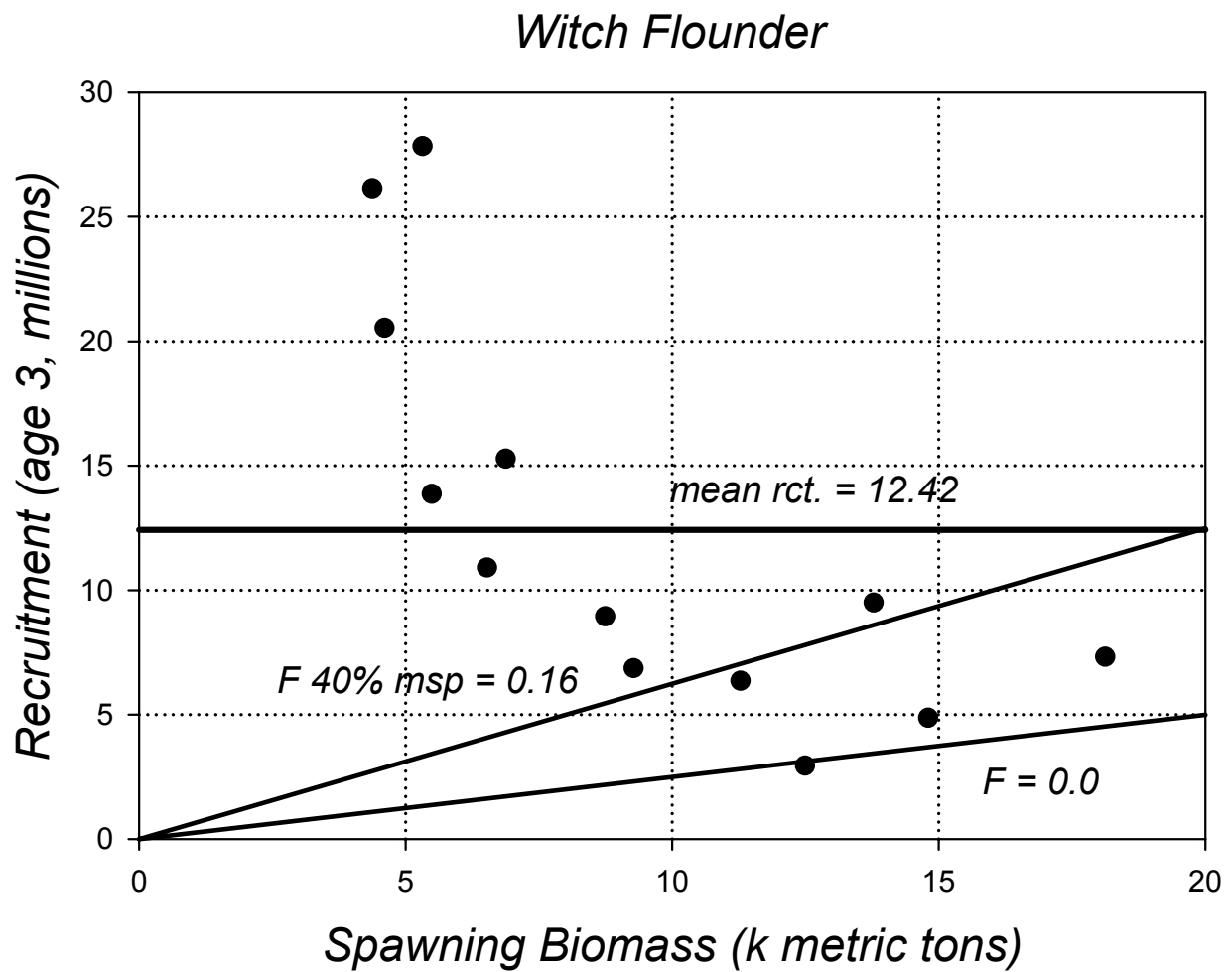


Figure 3.10.3. Stock and recruitment data for witch flounder. For the empirical non-parametric approach the mean recruitment is plotted along with the replacement lines for $F=0.0$ and $F 40\% msp = 0.16$.

Witch Flounder

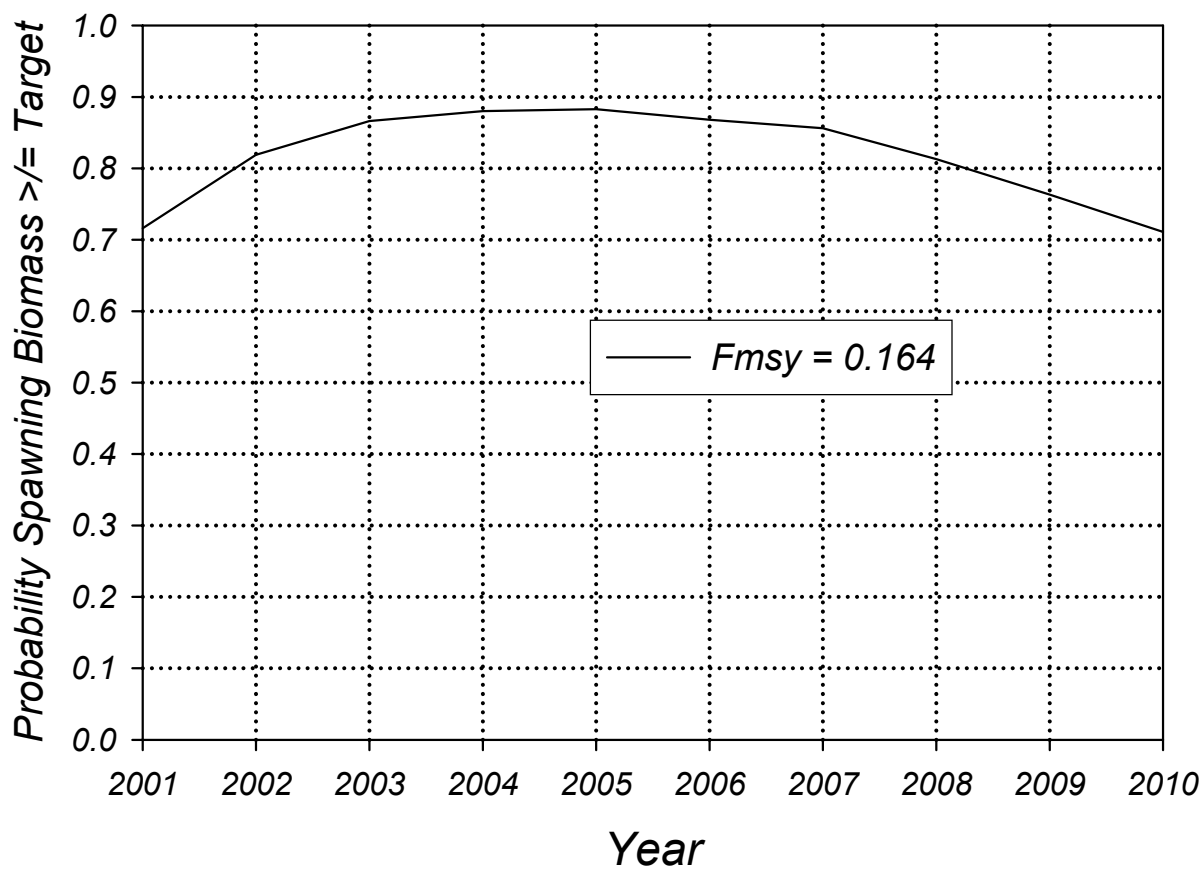


Figure 3.10.4. Probability that witch flounder spawning biomass will exceed Bmsy (19,900 mt) annually under F_{msy} .

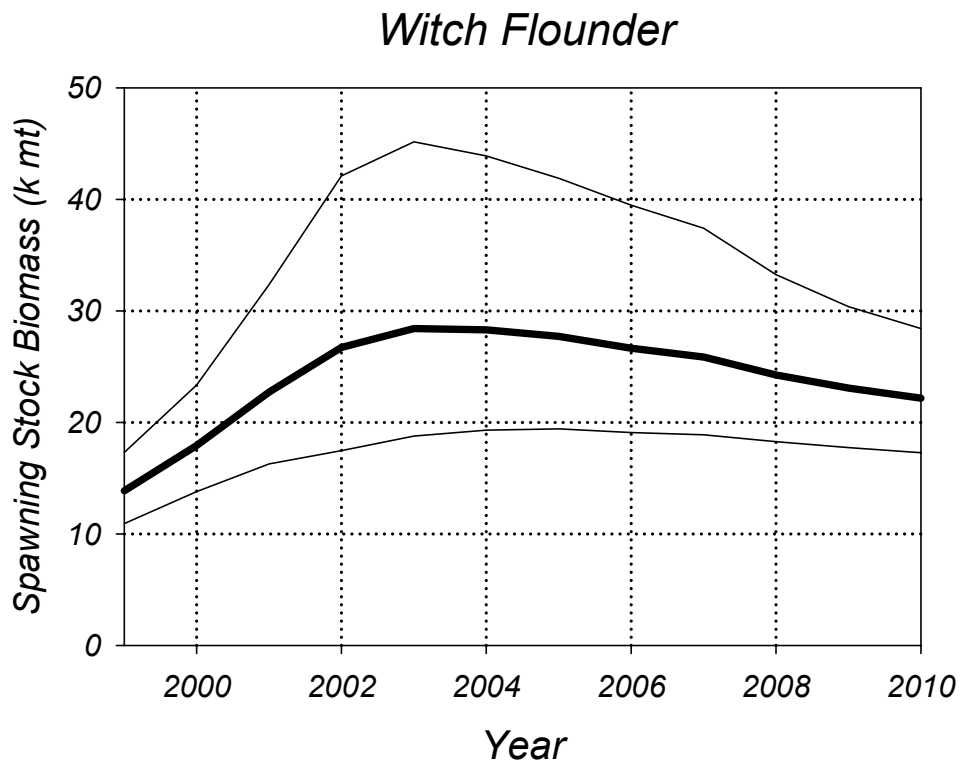


Figure 3.10.5. Median and 80% confidence interval of predicted spawning biomass for witch flounder under F_{msy} fishing mortality rates.

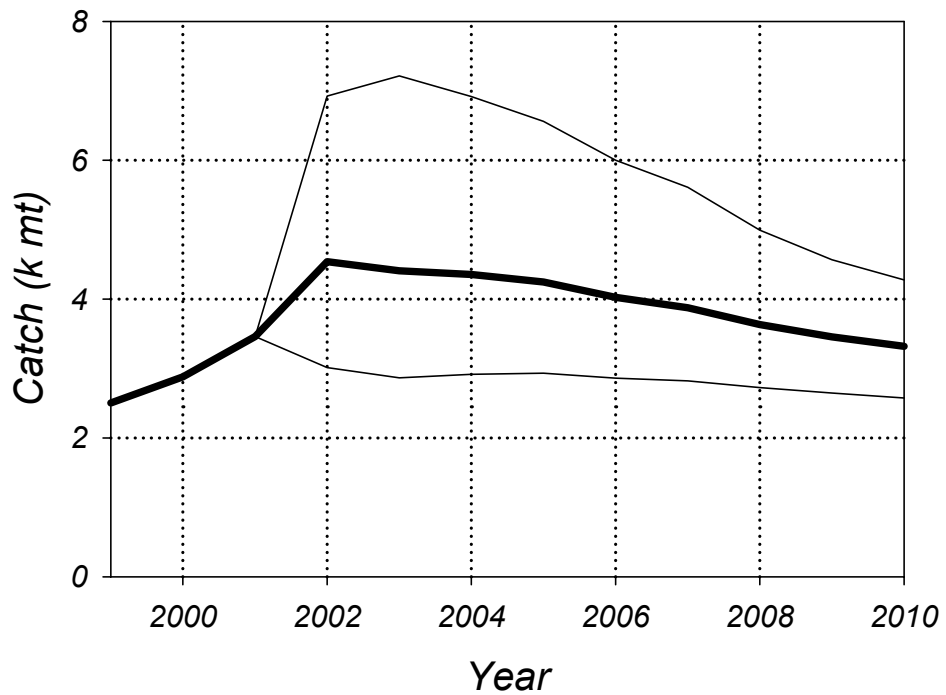


Figure 3.10.6. Median and 80% confidence interval of predicted catch for witch flounder under F_{msy} fishing mortality rates.