## 3.9 Gulf of Maine - Georges Bank American Plaice

### Catch and Survey Indices

The fishery for American plaice developed in the mid-seventies (Figure 3.9.1) as other popular flounder stocks became less abundant and fisheries were more heavily regulated (Sullivan 1981). Historically, American plaice had either been discarded or used as bait (Lange and Lux 197). Commercial landings increased to a record high in 1980 and then declined to a low in 1989. Landings peaked again in 1992 as the 1987 year class recruited to the fishery and have gradually been declining since 1992 (Figure 3.9.1). Both spring and autumn bottom trawl survey indices indicate relatively higher abundance of American plaice in the early 1960s and during the late 1970s to early 1980s compared to the lower abundance during the 1990s. The stock appears to be slowly increasing since the mid-1980s (Figure 3.9.1).

### Stock Assessment

The most current assessment of Gulf of Maine-Georges Bank American plaice (O'Brien and Esteves 2001) was peer reviewed by the 32nd Northeast Regional Stock Assessment Workshop (NEFSC 2001b). The assessment includes US commercial landings and discard catch at age (9+) data from 1980-1999. The NMFS and Massachusetts Division of Marine Fisheries spring and autumn bottom trawl survey age data were used to calibrate the VPA. Estimates of SSB indicate a declining trend during 1980 to 1989 and then a gradual increase since 1989 (Fig 3.9.2a). Recruitment at age 1 has been variable with high recruitment events in 1988, 1993 and 1999 (Fig. 3.3.2b). The most recent estimates of recruitment are subject to change in subsequent assessments as more catch is taken from each of the cohorts.

### Yield and SSB per Recruit Analysis

A yield and SSB per recruit analysis conducted using recent assessment data (O'Brien and Esteves 2001) resulted in changes in the previously estimated biological reference points (Table 3.9.1). Input data for catch weight (ages 1-9+) and stock weight (ages 1-8) was derived from the long term average weight during 1980-1999 (O'Brien and Esteves 2001). Stock mean weights for ages 9+ were derived from an expanded age structure to age 24 (oldest age observed in survey) at $F = F_{40\%} = 0.166$ and $M = 0.2$. The mean weights for ages 10 to 24 were estimated from the length-weight equation (Lux 1969a) : log Weight (g) = log(-5.955) + 3.345 log Length (mm). The mean length at ages 10-24 was derived from the von Bertalanffy growth equation: Length (mm) = 675 * (1-exp(-0.15* (age-0.10) for female American plaice (Lux 1970). The partial recruitment (PR) is based on a normalized geometric mean of 1995-1998 fishing mortality and the maturity ogive is derived from pooled 1998-1999 female data (O'Brien and Esteves 2001).

The newly estimated biological reference points for $F_{40\%}$=0.166 , $F_{max}$ = 0.312 and $F_{0.1}$ = 0.174 are slightly lower than those reported in O'Brien and Esteves (2001).

**MSY-based Reference Point Estimation**

Empirical Nonparametric Approach

The stock-recruit relationship for Gulf of Maine - Georges Bank American plaice indicates a general trend of decreasing recruitment of age 1 fish with increasing spawning stock biomass at SSB less than about 25,000 mt. (Figure 3.9.2c). A review of 1980-1994 hindcasted autumn bottom trawl survey indices indicate a similar stock-recruit relationship as seen in the VPA time series (Brodziak *et al.* 2001). All hindcasted data combined (1963-1994) indicates medium recruitment at high stock sizes similar to those observed in the VPA series. Given this pattern, the recruitment expected at $SSB_{msy}$ can be considered to be the mean recruitment associated with all SSB estimates. Using $F_{40\%}$ = 0.17 as a proxy for $F_{MSY}$, the SSB/R at $F_{40\%}$ = 0.9985, and the mean recruitment of 28.61 million fish results in a $SSB_{msy}$ of 28,600 mt (Figure 3.9.2 and 3.9.3). Similarly, multiplying the yield per recruit of 0.17143 (Table 3.9.1) by mean recruitment results in a MSY estimate of 4,900 mt.

The estimate of MSY is within the range of observed landings and $SSB_{msy}$ is below the maximum SSB (46,600 mt) observed in the VPA time series.

**Parametric Model Approach**

The stock recruit relationship for the VPA time series (1980-1999) indicates an atypical negative relationship of decreasing recruitment with increasing SSB (Figure 3.9.3). Autumn survey hindcasted data, as described above, suggests that with a longer VPA time series this negative relationship would not persist. The current VPA time series of stock recruit data was therefore considered insufficient to apply to any parametric stock-recruit model.

**Reference Points**

Reference points derived from the yield per recruit analysis are : $F_{40\%}$ = 0.166, MSY = 4,900 mt and $SSB_{MSY}$ = 28,600 mt. The MSY includes commercial landings and discards.

**Projections**

Stochastic age-based projections (Brodziak and Rago 2002) were performed to forecast the probability of attaining $SSB_{MSY}$ within 10 years under an $F_{MSY}$ (0.17) and F rebuilding (0.13) strategy. Recruitment was derived from resampling of predicted recruitment from a cumulative distribution function based on observed VPA age 1 recruitment from 1981-1999. Stock and catch mean weight, maturity at age, and partial recruitment input data are the same as described above for the yield and SSB per recruit analysis. The 2000 starting year population vector was derived from 1000 bootstrap iterations of the final VPA formulation (O'Brien and Esteves 2001).

Fishing mortality in 2000 and 2001 was based on estimated total catch (US + Canada+Discards) of 5,275 mt in 2000 and 5,370 mt in 2001. Fishing mortality in 2002 was set equivalent to the F estimated in 2001 (0.33).

The projections (section 7) indicate that there is only a 15% probability of reaching $SSB_{MSY}$ (28,600 mt) by 2009 under an $F_{MSY}$ strategy (Figure 3.9.4). Under a rebuilding F=0.13, there is a 50% probability of achieving $SSB_{MSY}$ by 2009 (Figure 3.9.4-3.95). The landings are expected to decline in 2003 and subsequently increase at a low rate through 2010 (Figure 3.9.6).

Table 3.9.1. Yield and biomass per recruit of American plaice.

```
   The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
    PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
              ------------------------------------
              Run Date: 21- 2-2002;  Time: 15:02:52.24
 American plaice Gulf of Maine-Georges Bank - 2002
 ____________________________________________________________________
 Proportion of F before spawning:  .2500
 Proportion of M before spawning:  .2500
 Natural Mortality is Constant at:  .200
 Initial age is:  1; Last age is:  9
 Last age is a PLUS group;
 Original age-specific PRs, Mats, and Mean Wts from file:==> AP_LND_2.DAT
------------------------------------------------------------
 Age-specific Input data for Yield per Recruit Analysis
------------------------------------------------------------
  Age | Fish Mort  Nat Mort | Proportion | Average Weights
      |  Pattern    Pattern |   Mature   |  Catch   Stock
------------------------------------------------------------
   1  |   .0300     1.0000  |    .0000   |   .016    .010
   2  |   .1000     1.0000  |    .0300   |   .050    .029
   3  |   .1200     1.0000  |    .1700   |   .158    .087
   4  |   .4900     1.0000  |    .6000   |   .297    .228
   5  |  1.0000     1.0000  |    .9200   |   .439    .360
   6  |  1.0000     1.0000  |   1.0000   |   .618    .521
   7  |  1.0000     1.0000  |   1.0000   |   .855    .727
   8  |  1.0000     1.0000  |   1.0000   |  1.094    .960
   9+ |  1.0000     1.0000  |   1.0000   |  1.606   1.565
------------------------------------------------------------
 Summary of Yield per Recruit Analysis for:
 American plaice Gulf of Maine-Georges Bank - 2002
 ____________________________________________________________________
  Slope of the Yield/Recruit Curve at F=0.00: -->    2.5719
    F level at slope=1/10 of the above slope (F0.1): ----->    .174
      Yield/Recruit corresponding to F0.1: ----->     .1735
    F level to produce Maximum Yield/Recruit (Fmax): ----->    .312
      Yield/Recruit corresponding to Fmax: ----->     .1869
    F level at 40 % of Max Spawning Potential (F40): ----->    .166
      SSB/Recruit corresponding to F40: -------->     .9985
 ____________________________________________________________________
 Listing of Yield per Recruit Results for:
 American plaice Gulf of Maine-Georges Bank - 2002
 ---------------------------------------------------------------------------
      FMORT   TOTCTHN  TOTCTHW  TOTSTKN  TOTSTKW  SPNSTKN  SPNSTKW    % MSP
 ---------------------------------------------------------------------------
       .000    .00000   .00000   5.5167   2.7694   2.7687   2.4970   100.00
       .050    .10716   .09294   4.9830   2.0611   2.2447   1.8025    72.19
       .100    .17954   .14100   4.6232   1.6128   1.8944   1.3660    54.71
       .150    .23203   .16624   4.3627   1.3095   1.6433   1.0730    42.97
 F0.1  .174    .25222   .17346   4.2627   1.1990   1.5477    .9668    38.72
 F40%  .166    .24612   .17143   4.2929   1.2320   1.5765    .9985    39.99
       .200    .27208   .17909   4.1644   1.0943   1.4544    .8667    34.71
       .250    .30381   .18496   4.0076    .9360   1.3068    .7161    28.68
       .300    .32971   .18680   3.8799    .8160   1.1881    .6030    24.15
 Fmax  .312    .33506   .18685   3.8535    .7924   1.1639    .5808    23.26
       .350    .35135   .18632   3.7733    .7230   1.0906    .5160    20.66
       .400    .36981   .18451   3.6826    .6493   1.0089    .4477    17.93
       .450    .38579   .18197   3.6042    .5899    .9394    .3932    15.75
       .500    .39983   .17906   3.5355    .5413    .8795    .3489    13.97
       .550    .41231   .17601   3.4746    .5009    .8272    .3126    12.52
       .600    .42350   .17293   3.4199    .4670    .7812    .2823    11.30
       .650    .43364   .16992   3.3705    .4381    .7404    .2568    10.28
       .700    .44290   .16700   3.3255    .4133    .7038    .2350     9.41
       .750    .45140   .16421   3.2842    .3918    .6709    .2164     8.67
       .800    .45927   .16155   3.2460    .3729    .6410    .2003     8.02
       .850    .46657   .15902   3.2106    .3563    .6138    .1862     7.46
       .900    .47340   .15662   3.1775    .3415    .5889    .1738     6.96
       .950    .47980   .15433   3.1465    .3282    .5660    .1628     6.52
      1.000    .48582   .15216   3.1173    .3162    .5449    .1530     6.13
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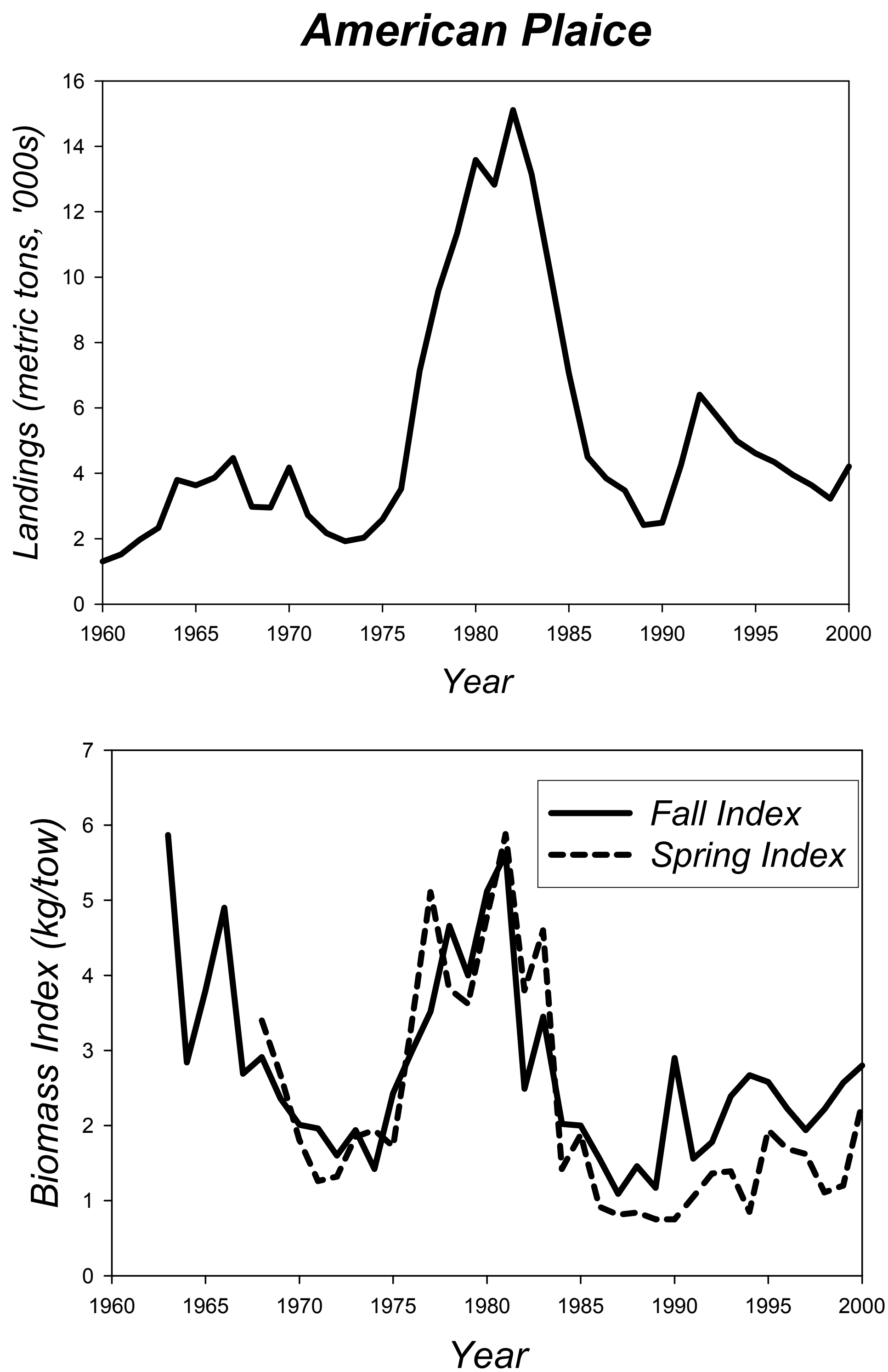
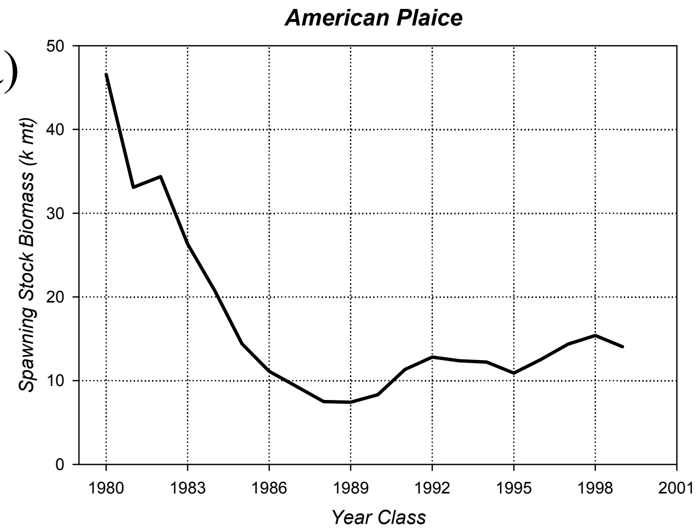



Figure 3.9.1. Landings and research vessel survey abundance indices for American plaice.

(a)

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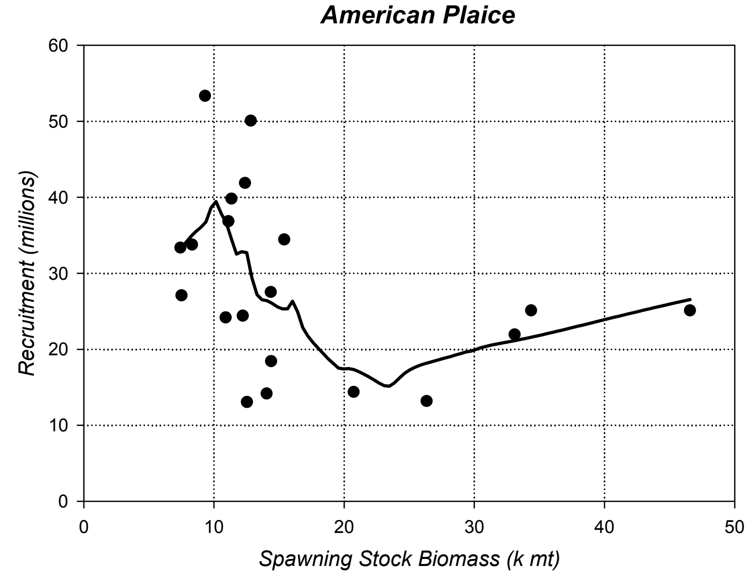


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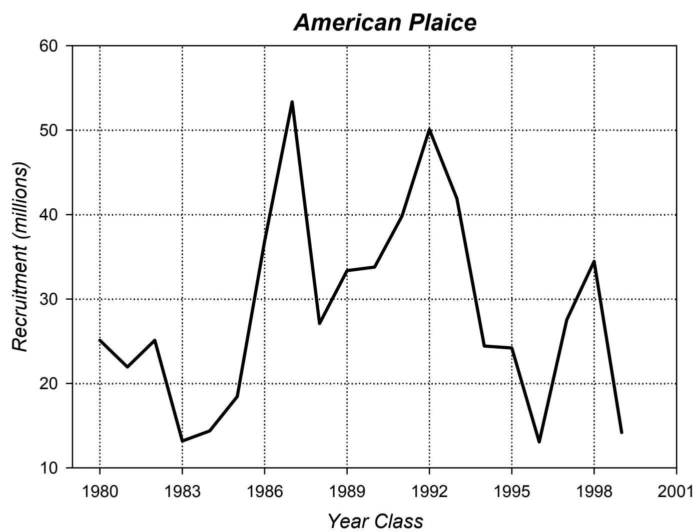


| | | F0.1 | F40% MSP |
|---|---|---|---|
| F reference point | | 0.174 | 0.166 |
| ssb per recruit at F | | 0.9668 | 0.9985 |
| | Recruitment (millions) | SS Biomass at F0.1 | SS Biomass at F40% |
| n | 20 | 20 | 20 |
| mean | 28.61 | 27.66 | 28.57 |
| min | 13.06 | 12.63 | 13.04 |
| max | 53.36 | 51.58 | 53.27 |
| 10th %'tile | 14.09 | 13.62 | 14.07 |
| 25th %'tile | 21.07 | 20.37 | 21.04 |
| 50th %'tile | 26.11 | 25.24 | 26.07 |
| 75th %'tile | 35.05 | 33.89 | 35.00 |
| 90th %'tile | 42.70 | 41.29 | 42.64 |
| Std Dev | 11.76 | 11.37 | 11.75 |
| CV | 0.41 | 0.41 | 0.41 |

Figure 3.9.2. Spawning stock (a), recruitment (age 1 millions, b), and scatterplot (c) for American plaice. 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 3.9.1). Smoother in the stock-recruitment plot is lowess with tension = 0.5.

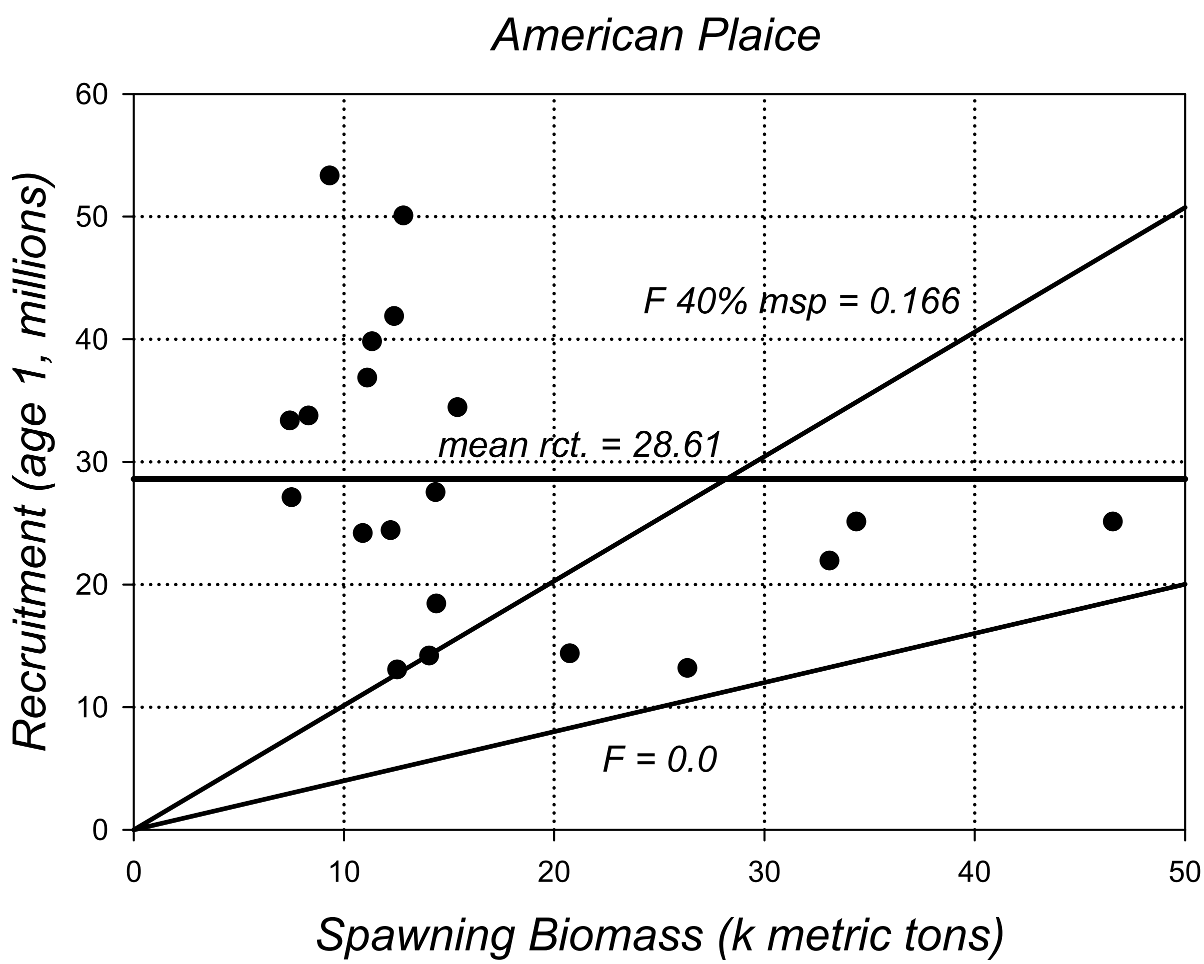


Figure 3.9.3. Stock and recruitment data for American plaice. For the empirical non-parametric approach the mean recruitment is plotted along with the replacement lines for F=0.0 and F 40% msp = 0.17.

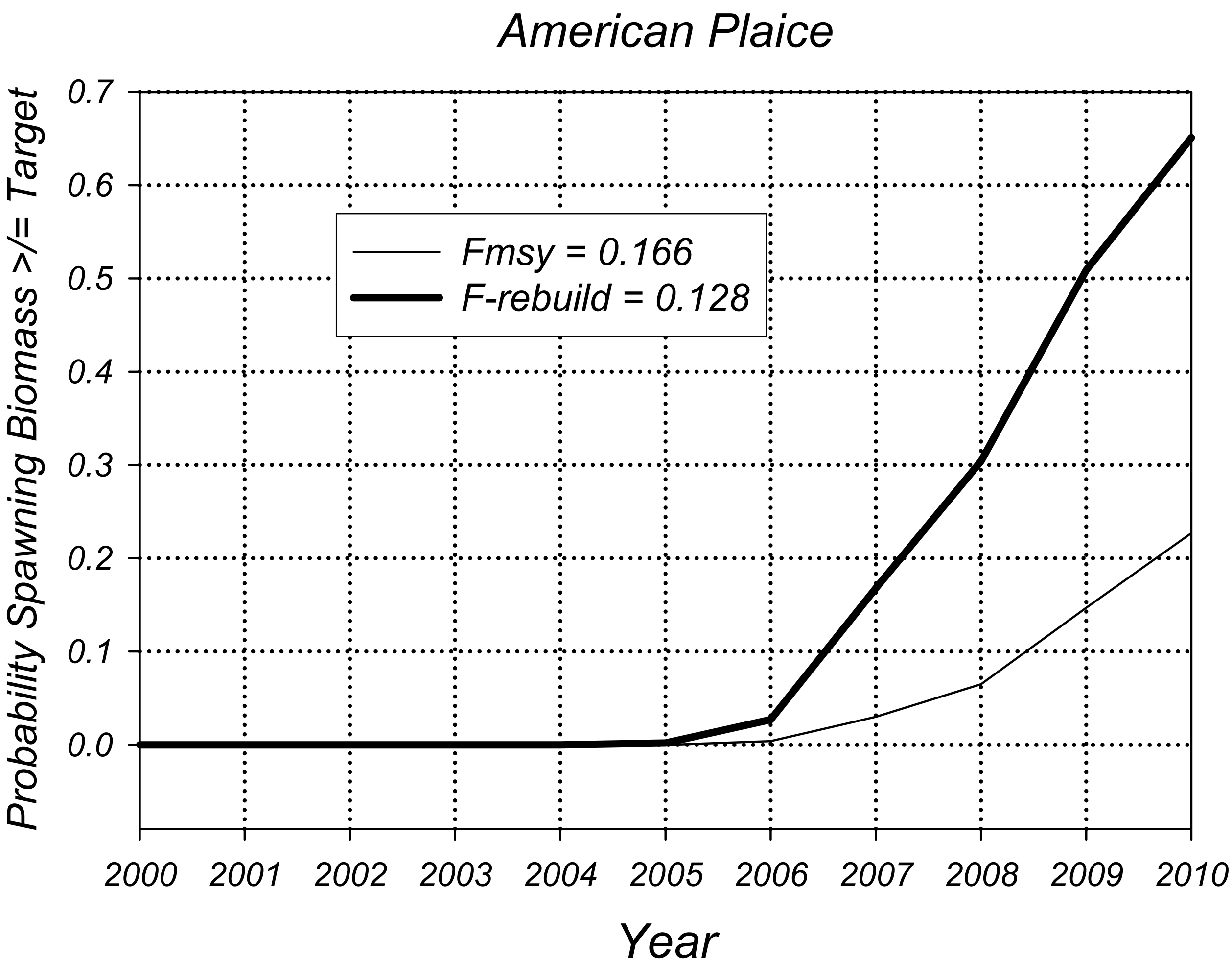


Figure 3.9.4. Probability that American plaice spawning biomass will exceed Bmsy (28,600 mt) annually under two fishing mortality scenarios: Fmsy and F required to rebuild the stock to Bmsy by 2009.

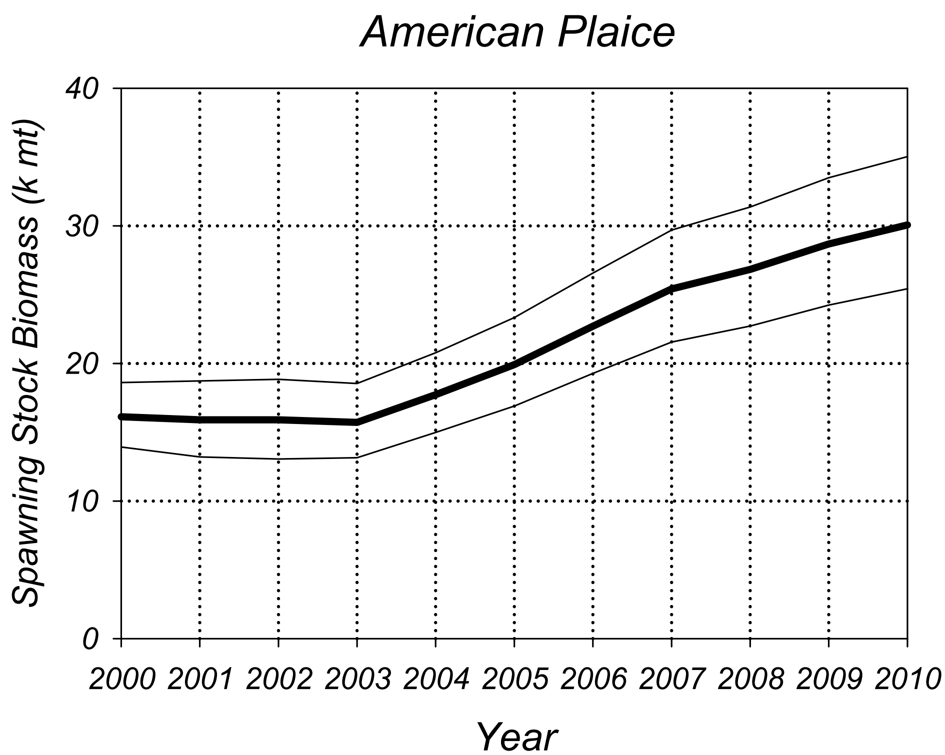


Figure 3.9.5. Median and 80% confidence interval of predicted spawning biomass for American plaice under F-rebuild fishing mortality rates.

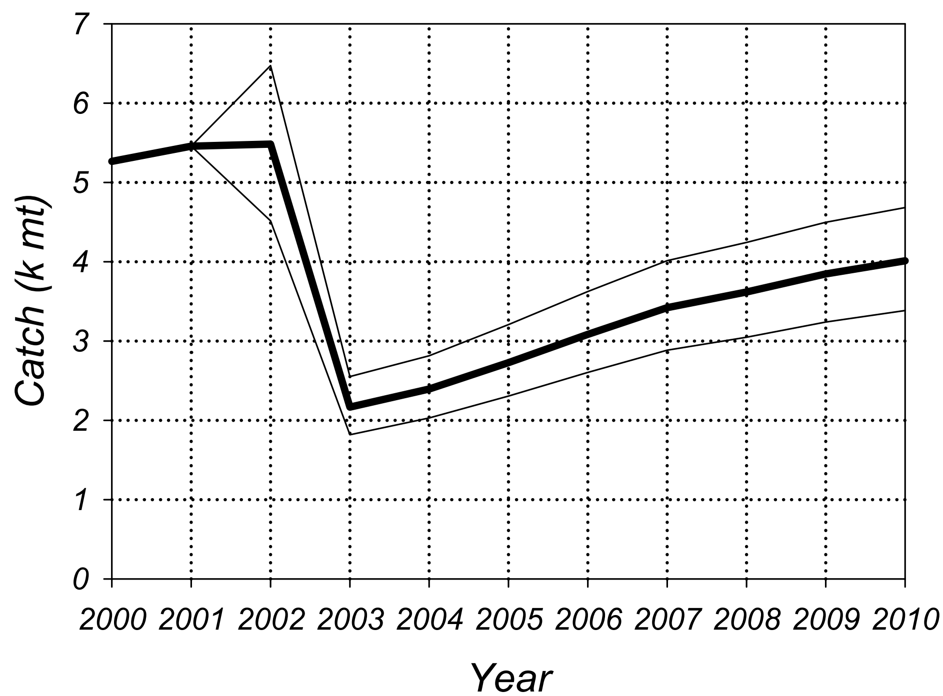


Figure 3.9.6. Median and 80% confidence interval of predicted catch for American plaice under F-rebuild fishing mortality rates.