Estimating the uncertainty of sea scallop reference points

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#5

The current sea scallop overfishing threshold using the yield-per-recruit reference point Fmax as the Fmsy proxy.

The overall Fmax of 0.29 was last calculated during SARC-45. The uncertainty surrounding this calculation was not evaluated, however.

Fmax depends on a number of parameters, each of which contains some uncertainty:

- SH/MW parameters a and b
- Growth parameters K and L_∞
- Natural mortality M
- Selectivity parameters α and β
- Discard mortality and cull size
- Incidental fishing mortality

Monte-Carlo method of estimating uncertainty in Fmax

1. Uncertainties among the parameters is evaluated, taking into account correlation structure, when applicable

2. Reasonable probability distributions for each parameter are determined, based on (1)

3. Parameters are repeatedly drawn randomly from these distributions. For each group of parameters, F_{max} is estimated. Confidence intervals of the estimate of F_{max} can then be constructed.

SH/MW parameters

$$MW = \exp(a + b*\ln(SH))$$

Parameters a and b and their variance well estimated from data from R/V survey.

Estimates of a and b are highly negatively correlated.

SH/MW varies with season and depth, but these should not affect Fmax provided that most of the variation is in a rather than b.

Parameters -a and b are simulated as correlated normals, with means and covariances as estimated in SARC-45

Von Bertanlaffy growth parameters

Growth parameters K and L_∞ estimated in SARC-45.
Variances also estimated, but likely are underestimated due to "model error".
These parameters are also negatively correlated.

Parameters K and L_∞ are simulated as negatively correlated normals, with means and covariances as estimated in SARC-45

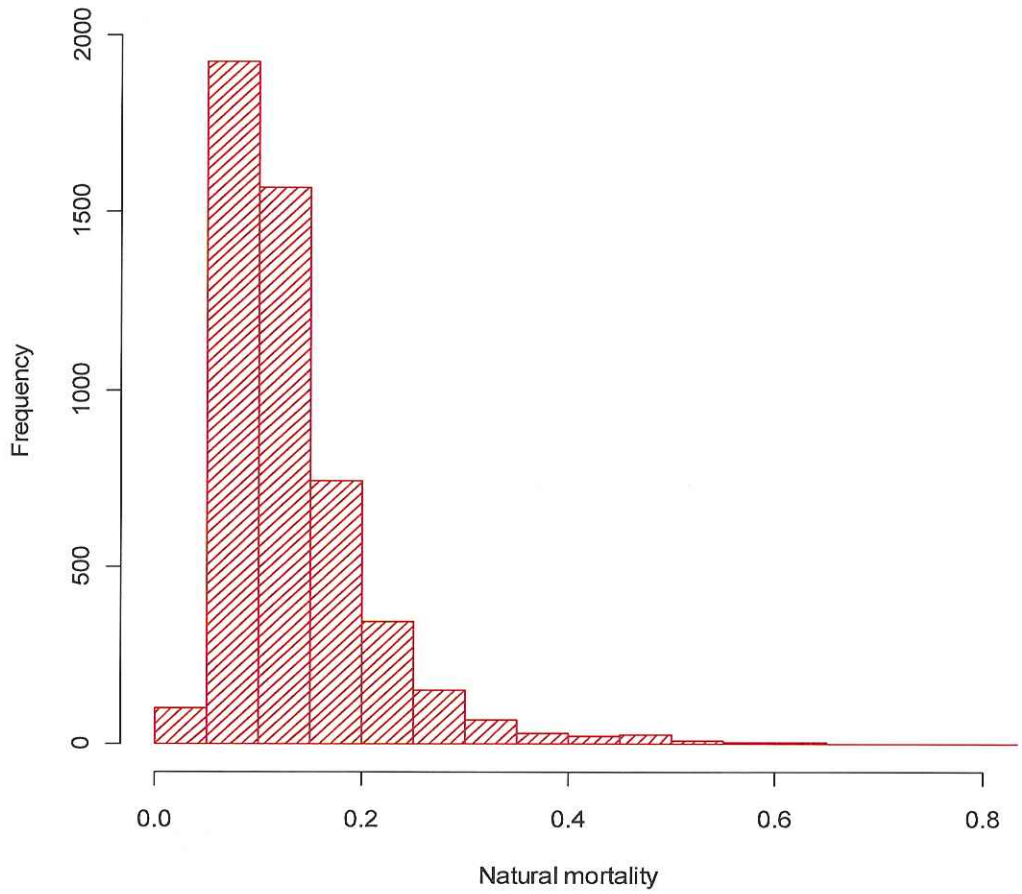
Natural Mortality M

Estimated as M = 0.1 by Merrill and Posgay (1964), based on clapper ratio analysis

M = R/S, where R is the ratio of "clappers" to live scallops, and S is the separation time of a clapper
Although there are a number of uncertainties to this estimate, probably the greatest is the value of S. Merrill and Posgay estimated S = 33 weeks, with no error estimate. A standard error of 15 weeks was used as an educated guess.
S is simulated as Gamma distributed, with specified mean and standard deviation, and M = R/S

The expected M is about 0.13, higher than the 0.1 estimated by Merrill and Posgay.

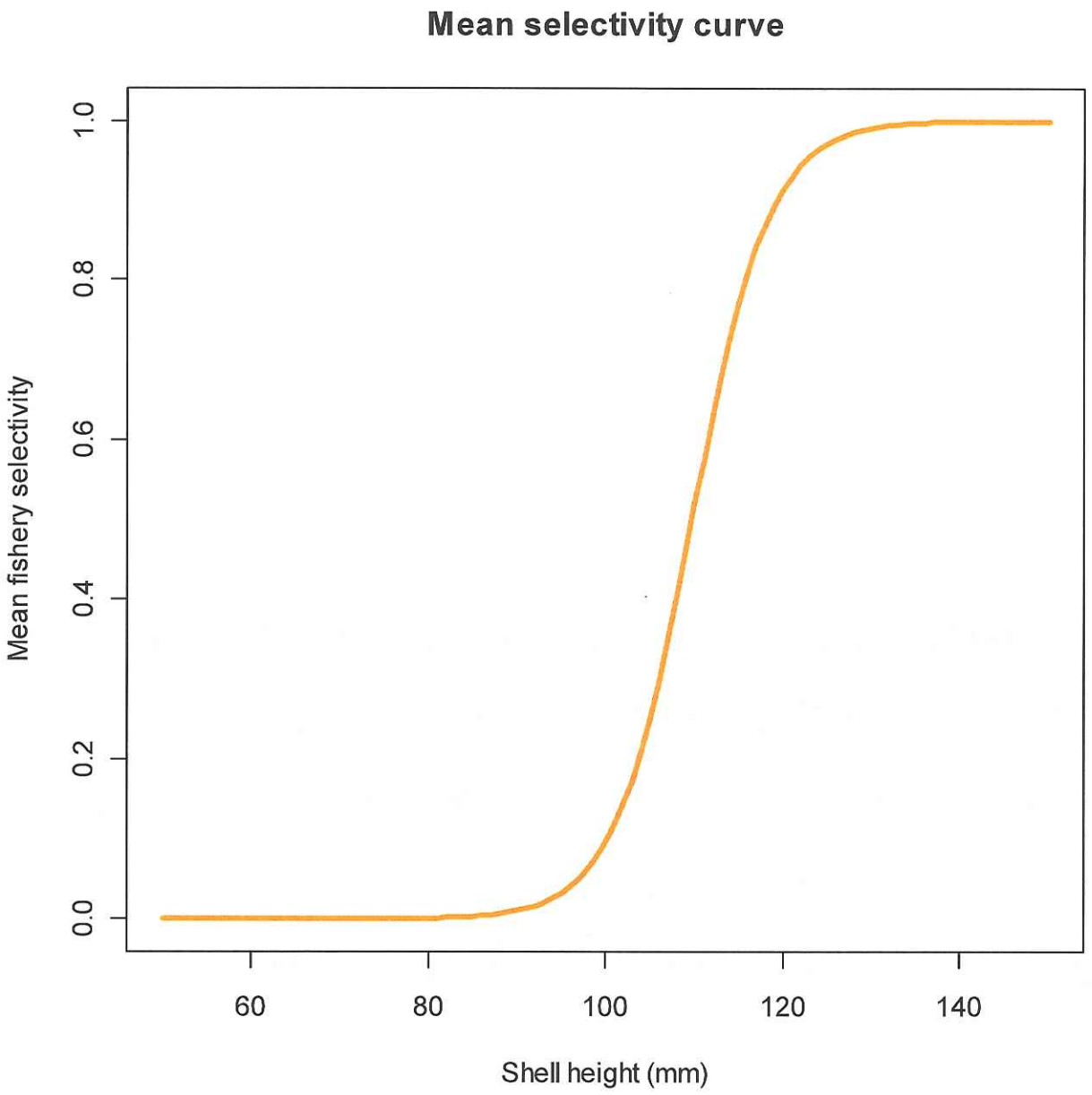
Uncertainty in the denominator biases calculations based on point estimates



Selectivity parameters

Selectivity estimated as a logistic curve by CASA model used in SARC-45. Variance and covariances also estimated by CASA. These selectivities are similar to the estimated 4" ring selectivity, but somewhat shifted to the right, due to targeting and discarding.

Used CASA estimates for mean and covariances of selectivity


Mean selectivity curve
Mean fishery selectivity
0.0
0.2
0.4
0.6
0.8
1.0
60
80
100
120
140
Shell height (mm)

Discard mortality & cull size

Cull size is reasonably well estimated at 90mm, based on observer data

Discard mortality is estimated at 0.2, but with considerable uncertainty.

Discard mortality is modeled with a gamma distribution, with mean 0.2 and standard deviation 0.15. Cull size is kept fixed

Incidental mortality

Estimates of incidental mortality are based on two studies (Caddy 1973, Murawski&Serchuk 1989), and on estimates of dredge efficiency. Current estimates are 0.15 for Georges Bank and 0.04 for Mid-Atlantic.

Model these as gammas, with specified mean and CVs of 75%.

Management/Implementation Uncertainty

The fishing mortalities that actually occur may be different than intended. Estimates of fishing mortality from CASA carry standard errors of 0.01 – 0.02. However, CASA is estimating past fishing mortality rates, rather than projecting forward, as is required in management. Estimates from the SAMS model (using bootstrapped initial conditions and stochastic recruitment) indicate fishing mortality estimates from SAMS have a standard error of ~0.04. Actual implementation error is likely higher – perhaps as high as 0.06.

Management/Implementation Uncertainty

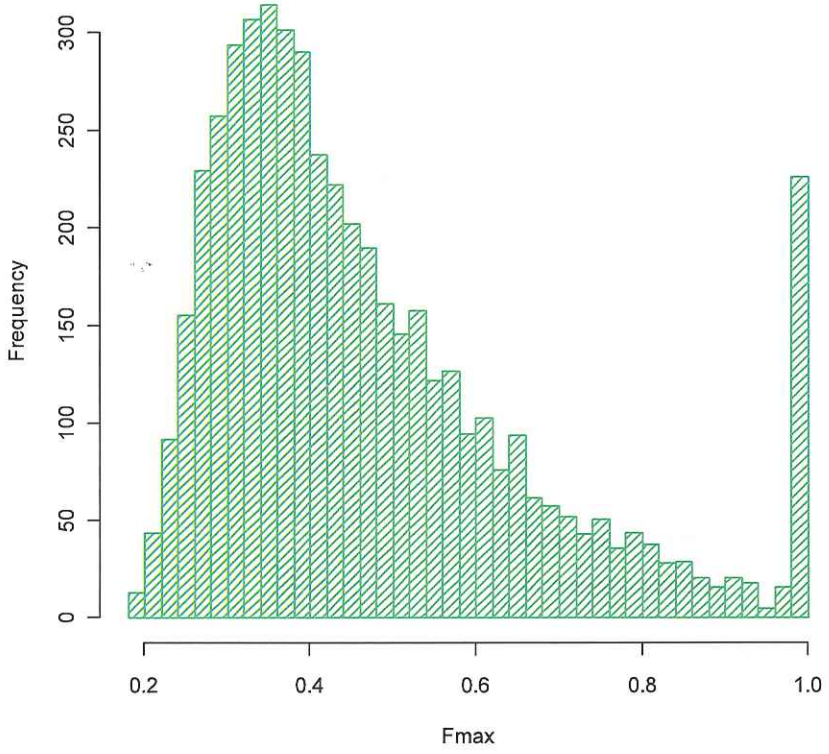
The probability of overfishing at a given target F was calculated using

$$p(OF|\text{Target F}) = \sum p(F|\text{Target F})*p(OF|F)$$

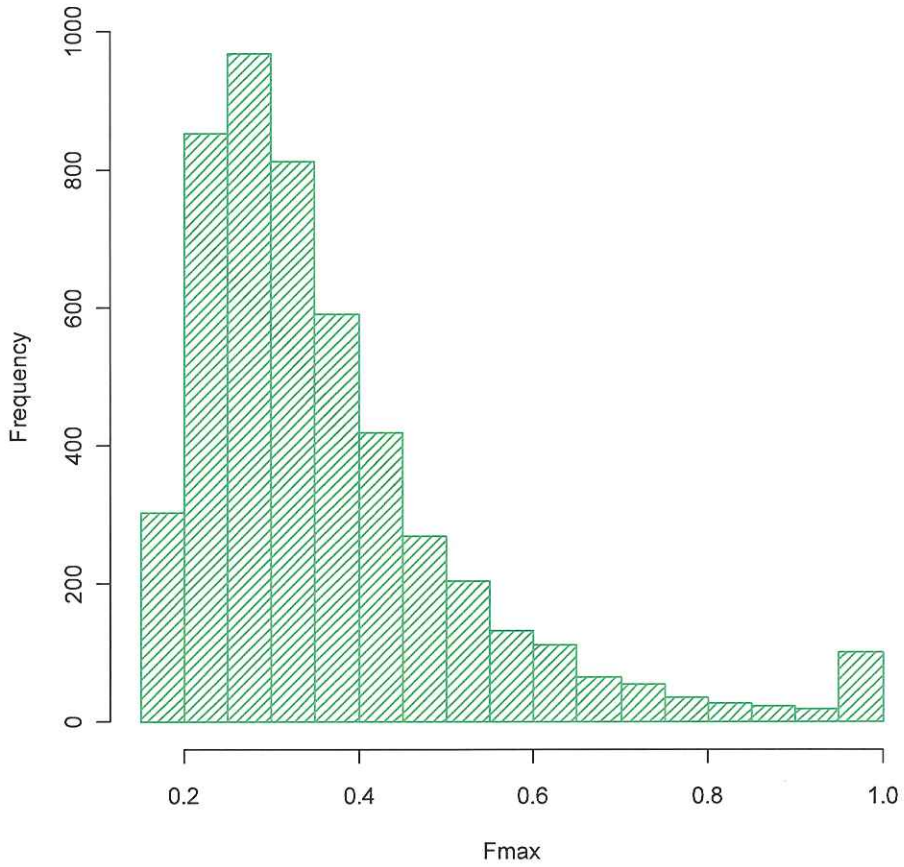
p(F|Target F) was assumed normal with
S.E. = 0.04 or 0.06

The expected yield loss at a given fishing mortality was calculated similarly

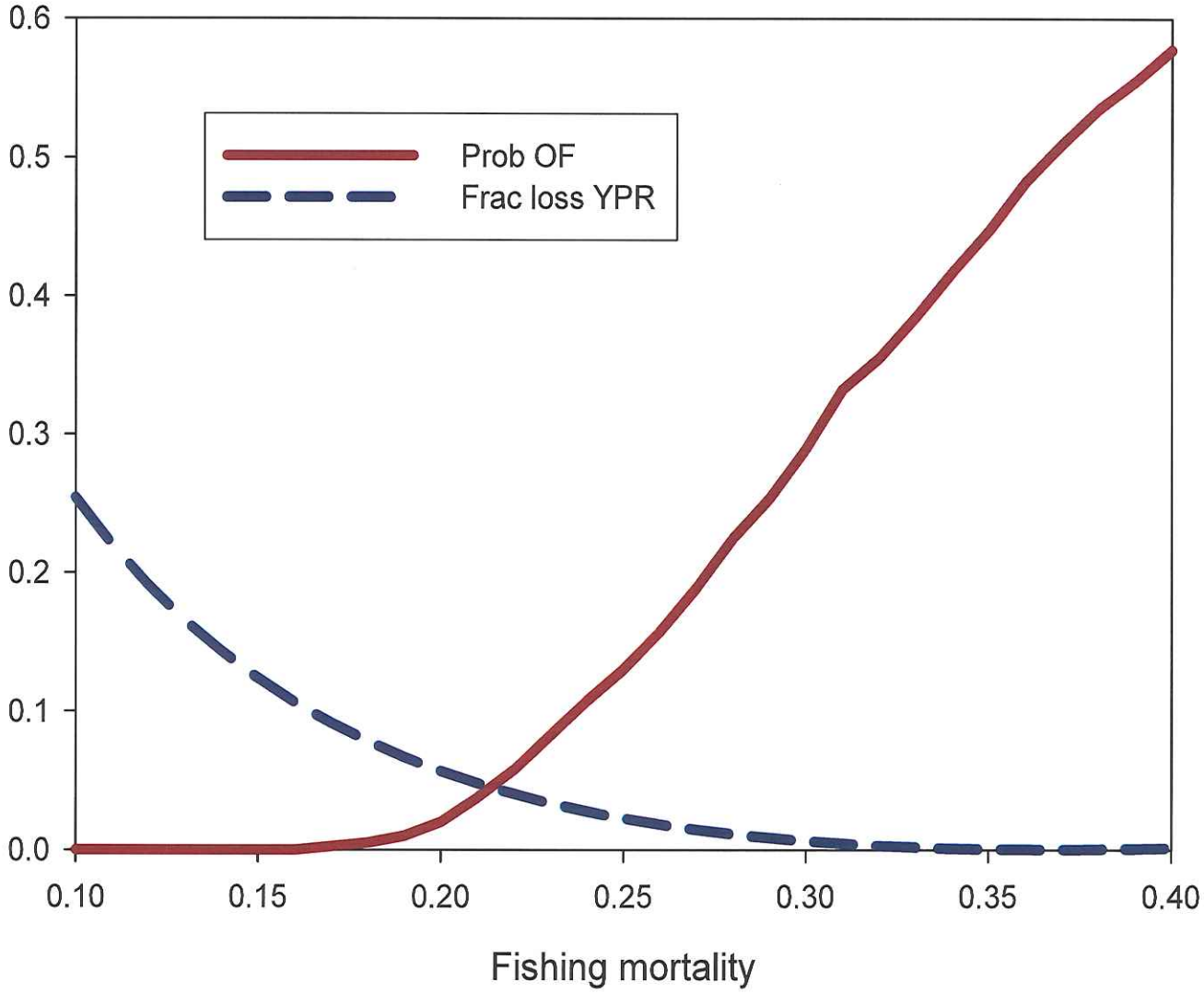
Results



Mid-Atlantic



Georges Bank


0.6
0.5
0.4
0.3
0.2
0.1
0.0
Prob OF
Frac loss YPR
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Fishing mortality

The PDT recommended an ABC fishing mortality for which:
(1)the probability of overfishing is equal to 0.25 or
(2) the fishing mortality where the expected loss of YPR is 1%, whichever is less

This works out to be $F_{ABC} = 0.28$
which has a probability of overfishing of 0.225 and a loss of YPR of 1.09%, see Table 2 in Document 3

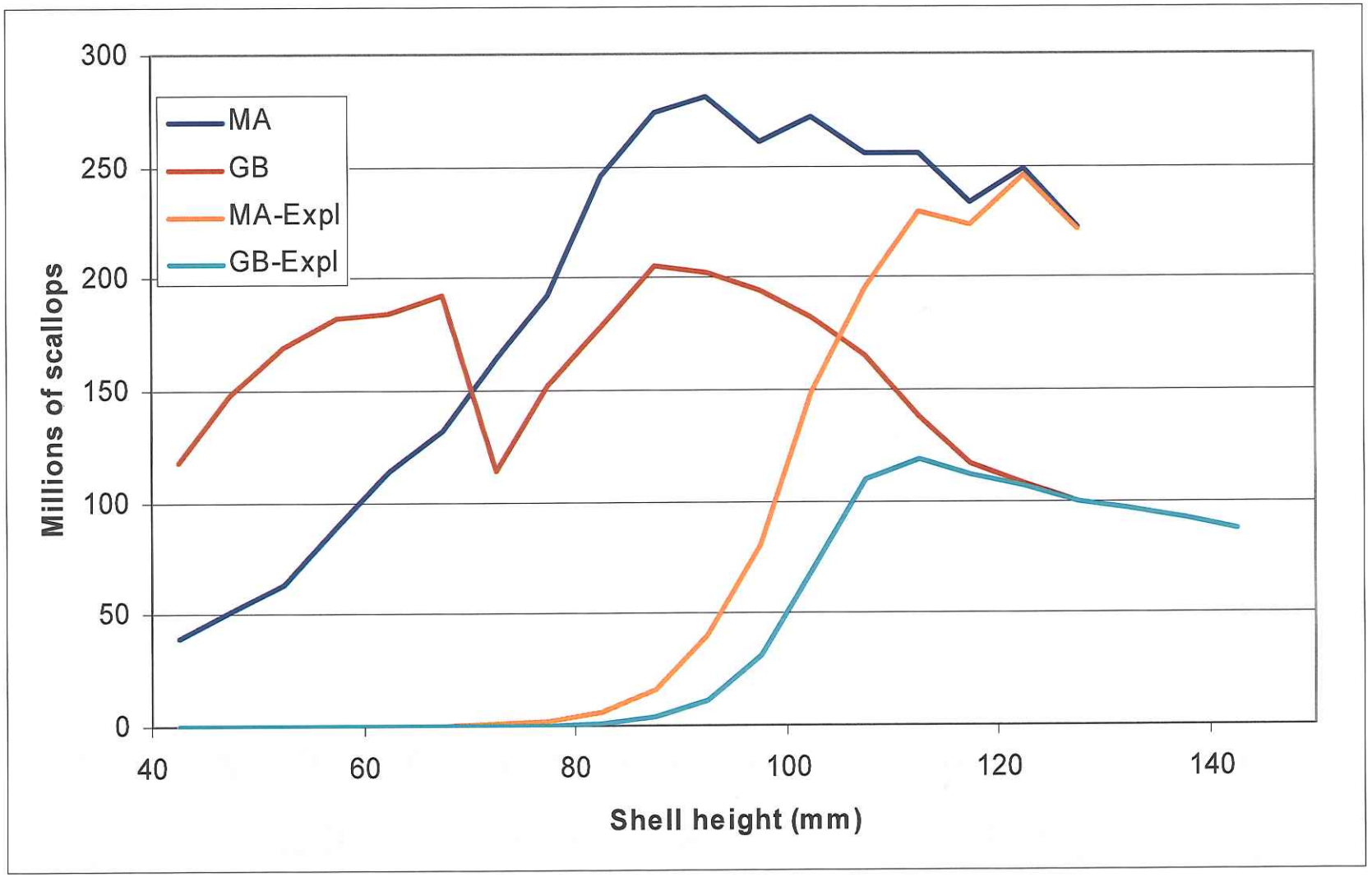
Calculation of ABC in 2010 for sea scallops

Actual landings at a given F depends on spatial distribution of fishing mortality

For the purposes of these calculations, I assumed that fishing mortality will be spatially uniform in each region, but that the Mid-Atlantic will be fished harder than Georges Bank, consistent with the pattern for all recent years except 2006

Spatial considerations can be taken into account when setting target fishing mortality

2009 sea scallop populations by shell height



ABC landings, mortal discards + incidental fishing mortality, and total catch, assuming F = 0.28

Region	ABC Landings	ABC Disc	ABC
MA	17430	1553	18983
GB	8182	1809	9992
ALL	**25613**	**3363**	**28975**