A Preliminary SCAA/ASPM Assessment of White Hake

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ABSTRACT

The ASPM (SCAA) methodology presented in Butterworth and Rademeyer (2008), with an adjustment to be able to incorporate data on proportions at length, is applied to white hake. In a preliminary and (for reasons of time) restricted analysis, four scenarios are consider for the period from 1963 when abundance indices first become available. These reflect the assumptions that spawning biomass in 1963 was at 25% and 50% of its pristine level, and that the catch of hake of length less than 60 cm was either all white hake or all red hake, with the latter assumption leading to somewhat more optimistic appraisals of the current status of white hake. Model fits to survey index trends are broadly reasonable, though there are some difficulties with proportions at length data which would likely be better addressed in future analyses by adopting a length-specific rather than an age-specific selectivity framework. All four scenarios considered suggest an increase in spawning biomass over the last decade, and that the current fishing mortality is less than F_{MSY}. Nevertheless the preliminary nature of all results must be stressed, particularly as time has thus far allowed only a very limited number of variants of the assessment to be investigated.

REFERENCE POINT SUMMARY

[N.B.: The ranges shown here reflect results for the four scenarios considered only, and for reasons elaborated in the text should be considered as no more than indicative, certainly not definitive.]

B^{sp}_{2006}	9	-	19
B^{sp}_{MSY}	18	-	32
$B^{sp}_{2006}/ B^{sp}_{MSY}$	0.42	-	0.76
F_{2006}	0.16	-	0.25
F_{MSY}	0.27	-	0.52

Note: Biomass units are ‘000 tons; *F* refers to age 6 where the commercial selectivity peaks.

INTRODUCTION

This paper reports preliminary assessment results for white hake using the ASPM/SCAA methodology of Butterworth and Rademeyer (2008) with the addition of a capability to incorporate fitting to proportions at length data.

Given that only a brief period has been available to undertake these evaluations, no more than a very limited exploration of alternative assessment variants has been possible (so that the effects of factors such as different stock-recruitment models and different values of M have not yet been investigated), and accordingly the results presented below should be seen as preliminary only. They do ***not*** claim to be the best possible implementation of this methodology to these data.

DATA AND METHODOLOGY

The data used for these analyses are as kindly supplied by Katherine Sosebee (NEFSC). In particular in respect of the results to follow, it should be noted that:

- Catches series commence in 1893 (see Fig. 1). The catch above 60 cm length is distinguished because at lower lengths there is uncertainty concerning the relative proportions of red and white hake. No information is available for the period 1950 to 1963, over which catches are assumed to have trended linearly.
- Proportion at age data are available only for the NEFSC surveys, and for those only for the periods 1982 to 2002/3 (2001/2 not available) for the spring/autumn surveys. They range to age 10+, but given the small sample sizes at the largest ages, the analyses following are based on a plus group at age 7.
- Proportion at length data are available for the NEFSC surveys for the periods 1963 to 2007, and for the commercial fishery for 1989 to 2006. For these, the analyses treat 20 cm as a minus group, and 100 cm as a plus group.

The ASPM (SCAA) methodology applied is described in Butterworth and Rademeyer (2008). However, to be able to incorporate the proportion at length information (though naturally only for years and series for which those data have not been combined with ageing information to provide proportions at age information), the proportions at age predicted by the model ($\widehat{p}_{y,a}$) (with is based upon age-specific selectivity) are converted to proportions at length ($\widehat{p}_{y,l}$) using the von Bertalanffy growth equation, assuming that the length-at-age distributions remain constant over time:

$$\widehat{p}_{y,l} = \sum_{a} \widehat{p}_{y,a} A_{a,l} \tag{1}$$

where $A_{a,l}$ is the proportion of fish of age *a* that fall in the length group *l* (i.e., $\sum_{l} A_{a,l} = 1$ for all ages *a*). The matrix *A* is calculated under the assumption that length-at-age is normally distributed about a mean given by the von Bertalanffy equation, i.e.:

$$L_a \sim N\left[L_\infty\left(1-e^{-\kappa(a-t_0)}\right);\theta_a^2\right] \tag{2}$$

where θ_a is the standard deviation of length-at-age *a*, which is modelled to be proportional to the expected length at age *a*, i.e.:

$$\theta_a = \beta L_\infty\left(1-e^{-\kappa(a-t_0)}\right) \tag{3}$$

For these preliminary analyses β was fixed at 0.15 (rather than estimated in the fitting process). These length at age distributions are shown in Fig. 2. The resultant term added to –ln*L* in the fitting process is:

$$-\ell\text{n}\, L^{\text{length}} = 0.1\sum_{y}\sum_{l}\left[\ell n\left(\sigma_{len}/\sqrt{p_{y,l}}\right) + p_{y,l}\left(\ell n p_{y,l} - \ell n\, \hat{p}_{y,l}\right)^2 / 2\left(\sigma_{len}\right)^2\right] \tag{4}$$

where σ_{len} is a measure related to the standard deviations of the residuals associated with the proportions at length data , which is estimated in the fitting procedure by:

$$\hat{\sigma}_{len} = \sqrt{\sum_{y}\sum_{l}\hat{p}_{y,l}\left(\ln p_{y,l} - \ln \hat{p}_{y,l}\right)^2 / \sum_{y}\sum_{l} 1} \tag{5}$$

The initial 0.1 multiplicative factor in Equation (4) is a somewhat arbitrary downweighting to allow for correlation between proportions in adjacent length groups (note that while only 10 age groups are contributing to the generation of the predicted length proportions, some 80 such proportions are available for each year between 20 and 100 cm.).

Because of the uncertainty about the species split for the hake caught of less than 60 cm, the assessments are conducted under two different assumptions:

i) all fish <60 cm caught are white hake, and

ii) no fish <60 cm caught are white hake (i.e. all are red hake).

Clearly both of these assumptions are unrealistic, but they have been chosen as extremes with the intention of bounding the range of possible results. Assumption ii) raises a problem for the fit to the commercial proportions at length data, as the assumption implies that no white hake of <60 cm are caught, but the length at age distributions in Fig. 2 make it inevitable that some of the white hake caught would be <60 cm. A fully self-consistent approach requires modelling selectivity at length instead of selectivity at age, but time has precluded this modification of the model, so that for the moment the problems to which this gives rise within a fully age-specific framework for modelling the dynamics have been ignored.

Other assumptions of these preliminary assessments are:

- M = 0.2 yr^{-1}, independent of age.
- Selectivity is freely estimated, though is precluded from sloping upward from age 6 and above.
- A Ricker stock-recruitment function is assumed.

RESULTS

First assessment attempts made considered the full catch history commencing in 1893, but convergence problems resulted. Thus instead the models were run commencing in 1963, the first year for which abundance indices are available. This requires specification of two further parameters: θ which is the B^{sp}/K^{sp} value in the starting year, and ϕ which is added to M to provide a starting age-structure. The latter was set to 0.2. Given the catch series in Fig. 1, it would clearly be unrealistic (within a singles species, unshifting regime framework) to assume that θ was close to 1 in 1963. Thus for illustrative purposes, choices of 0.25 and 0.5 have been made for this input parameter.

This then yields four scenarios overall for consideration: two starting values for B^{sp}/K^{sp} in 1963, and two extreme alternatives for the species composition of the <60 cm commercial catch. The results for each are listed in Table 1, and shown graphically in Figs 3a and b for the "Total" scenario (all catches <60 cm are white hake), and in Figs 4a and b for the other "over 60 cm only" scenario where all hake below 60 cm taken by the commercial fishery are assumed to be red hake.

DISCUSSION

There seem to be few qualitative inter-scenario differences amongst the fits to the data shown in Figs 3 and 4. Selectivity is consistently estimated to be dome shaped for the surveys, but not necessarily so for the commercial fishery. Table 1 shows that the trend information in the survey indices (to which the model fits appear broadly reasonable) tends to prefer a lower value of B^{sp}/K^{sp} in 1963, but this is near counter-balanced by the opposite tendency amongst all the other contributions to the likelihood.

The fits to the minus group in the proportions at length for the NEFSC surveys in Figs 3 and 4 are problematic, particularly for the autumn survey. For the "over 60 cm only" scenario, there is the expected difficulty for the commercial proportions at length, but also a tension seems to arise in choosing a selectivity function which can fit both the proportions at length for the earlier surveys and the proportions at age for the later surveys. Perhaps not too much should be made of these features, which could well disappear with a move to a length-specific selectivity approach.

The pattern of the estimated spawning biomass trends shown in Figs 3 and 4 are qualitatively similar, and mirror what might be expected in response to changes in the catch over time (see Fig. 1), showing increases in the 1960s and 70s as well as since the mid 1990s – periods when catches were lower. Current resource status in terms of $B^{sp}{}_{2006}/B^{sp}{}_{MSY}$ is better for the "over 60 cm only" scenarios.

No more than qualitative inferences should be drawn concerning Reference Point values from these analyses, given their preliminary and limited nature. A further difficulty is that, unlike for the Gulf of

Maine cod case (Butterworth and Rademeyer, 2008), these estimates ***do*** depend on assumptions about the abundance level in 1963, so that associated transients impact Reference Point estimates. There are some common features, such as that F_{2006} is less than F_{MSY} for all four scenarios considered. Nevertheless the ranges for Reference Point values over the four scenarios in Table 1 should be seen as no more than indicative, and certainly not definitive.

ACKNOWLEDGMENTS

We thank Katherine Sosebee (NEFSC) for provision of the data upon which the analyses reported in this paper are based. Financial support by the Associated Fisheries of Maine is acknowledged.

REFERENCE

Butterworth DS and Rademeyer RA. 2008. Statistical catch-at-age analysis *vs* ADAPT-VPA: the case of Gulf of Maine cod. GARM-III Working paper 2.2a.

Table 1: Estimates of key management estimates for the four scenarios considered. Fishing mortality *F* refers to age 6 where the commercial selectivity peaks. Note that values of *M*, *γ*, theta (*θ*) and phi (*φ*) are fixed on input. Biomass units are thousand tons.

	Total		over 60cm only	
	theta=0.25	theta=0.5	theta=0.25	theta=0.5
-lnL: overall	88.2	92.4	93.7	94.2
-lnL: Survey	-29.1	-18.9	-22.4	-13.8
-lnL:CAAsurv	-60.1	-62.3	-42.2	-44.9
-lnL:CAL	73.5	73.7	34.2	33.1
-lnL:CALsurv	90.0	88.4	115.3	111.7
-lnL:RecRes	13.9	11.6	8.8	8.1
M	0.20	0.20	0.20	0.20
h	1.97	1.75	0.98	1.14
γ	1.00	1.00	1.00	1.00
K^{sp}	62.53	83.83	48.46	41.31
B^{sp}_{2006}	11.01	18.72	9.45	13.45
B^{sp}_{2006}/K	0.18	0.22	0.20	0.33
B^{sp}_{MSY}	26.48	32.01	21.30	17.64
$B^{sp}_{2006}/B^{sp}_{MSY}$	0.42	0.58	0.44	0.76
B^{sp}_{MSY}/K	0.42	0.38	0.44	0.43
MSY	7.89	7.76	5.02	4.73
F_{MSY}	0.29	0.52	0.27	0.37
F_{2006}	0.23	0.25	0.21	0.16
Theta	0.25	0.50	0.25	0.50
Phi	0.20	0.20	0.20	0.20

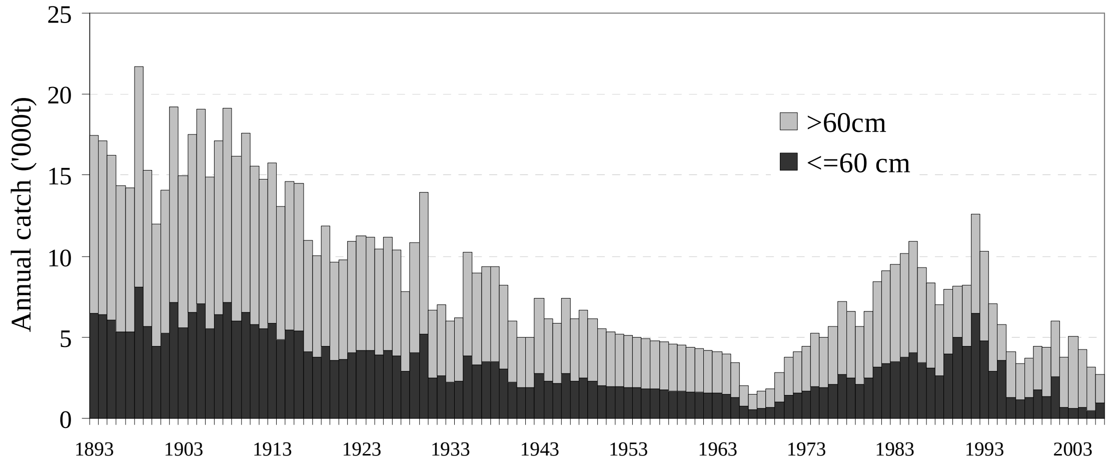

Fig. 1: Annual catches of white hake.

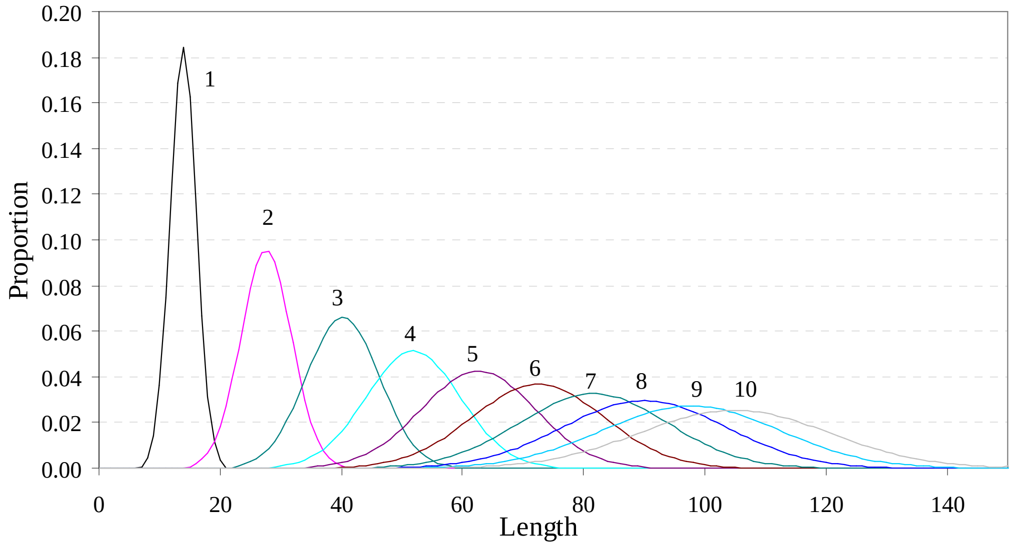

Fig. 2: Length-at-age distributions assumed.

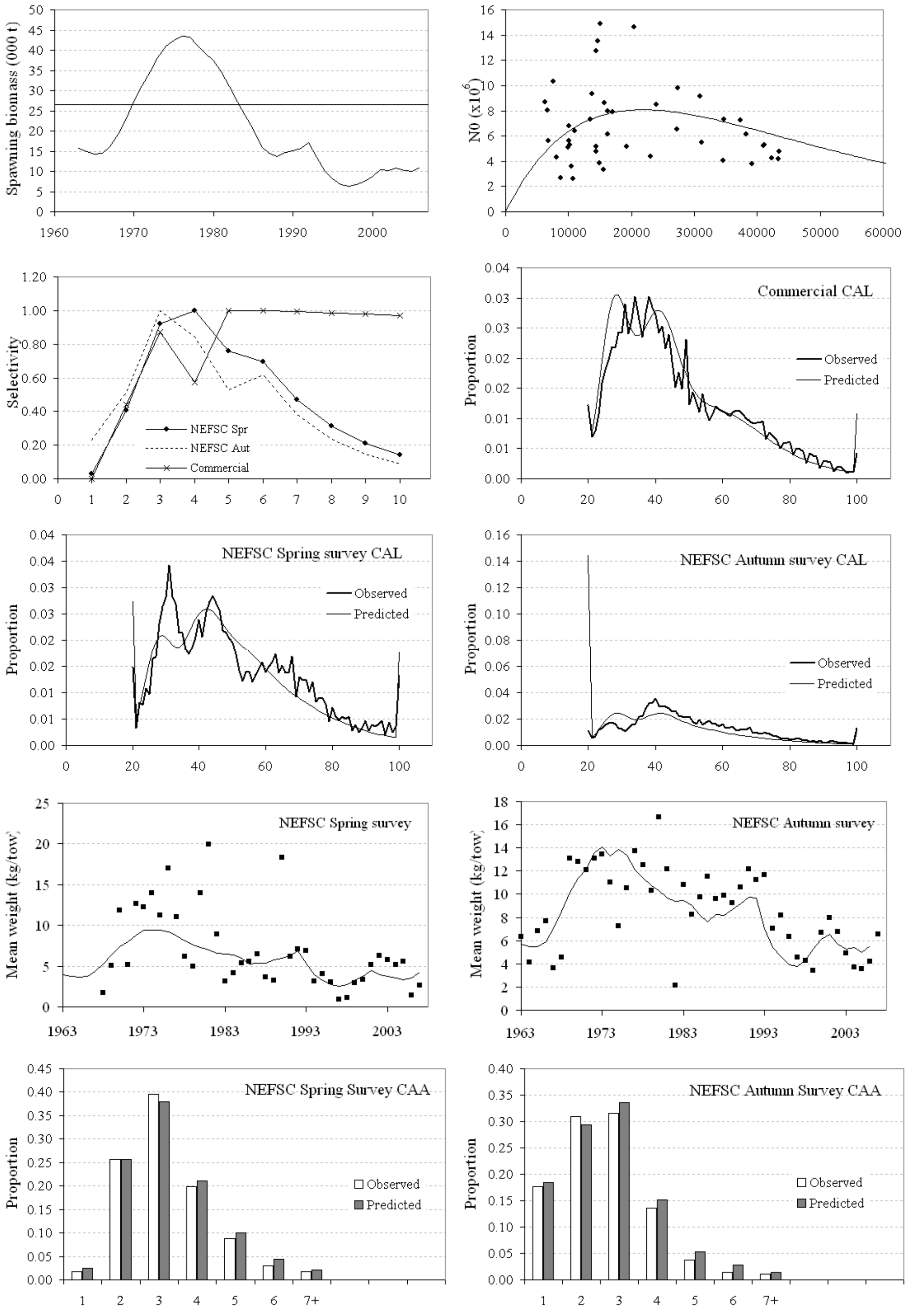

Fig. 3a: Results for the scenario assuming **all hake ≤ 60cm are white hake**, starting in 1963 with θ**=0.25**. The horizontal line in the spawning biomass plot is the estimated MSYL.

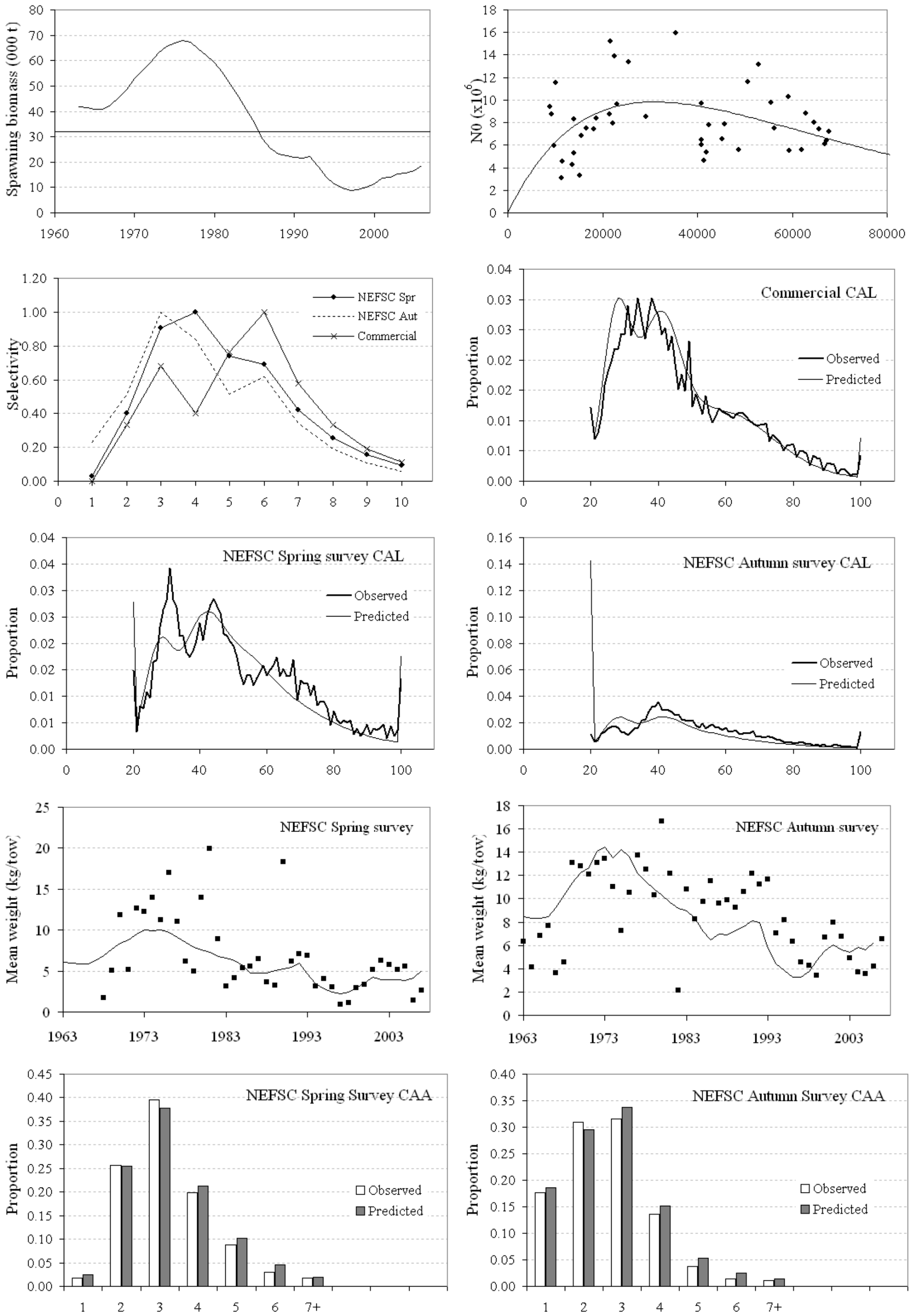

Fig. 3b: Results for the scenario assuming **all hake ≤ 60cm are white hake**, starting in 1963 with $\boldsymbol{\theta}$**=0.50**. The horizontal line in the spawning biomass plot is the estimated MSYL.

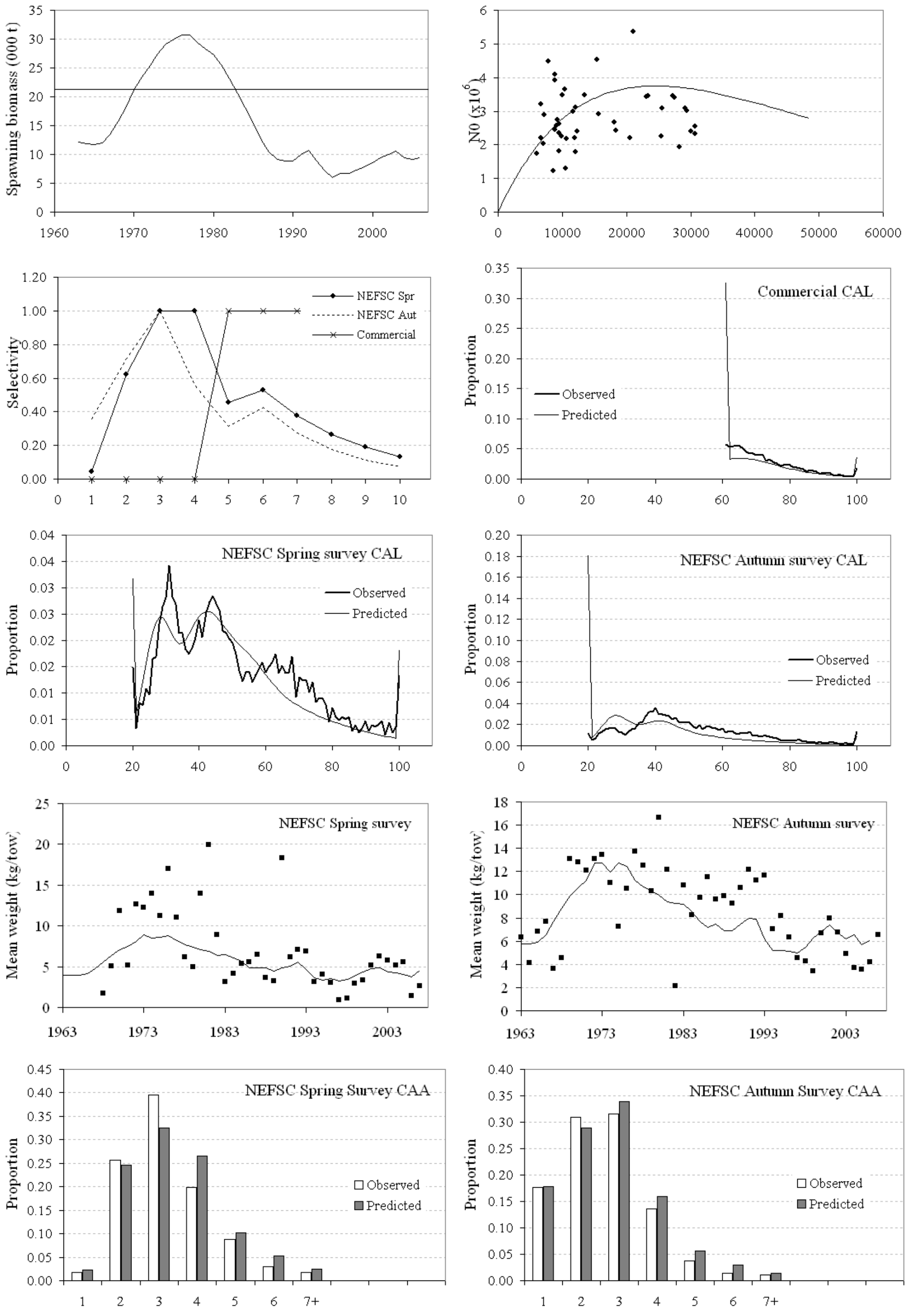

Fig. 4a: Results for the scenario assuming **no hake ≤ 60cm are white hake**, starting in 1963 with θ**=0.25**. The horizontal line in the spawning biomass plot is the estimated MSYL.

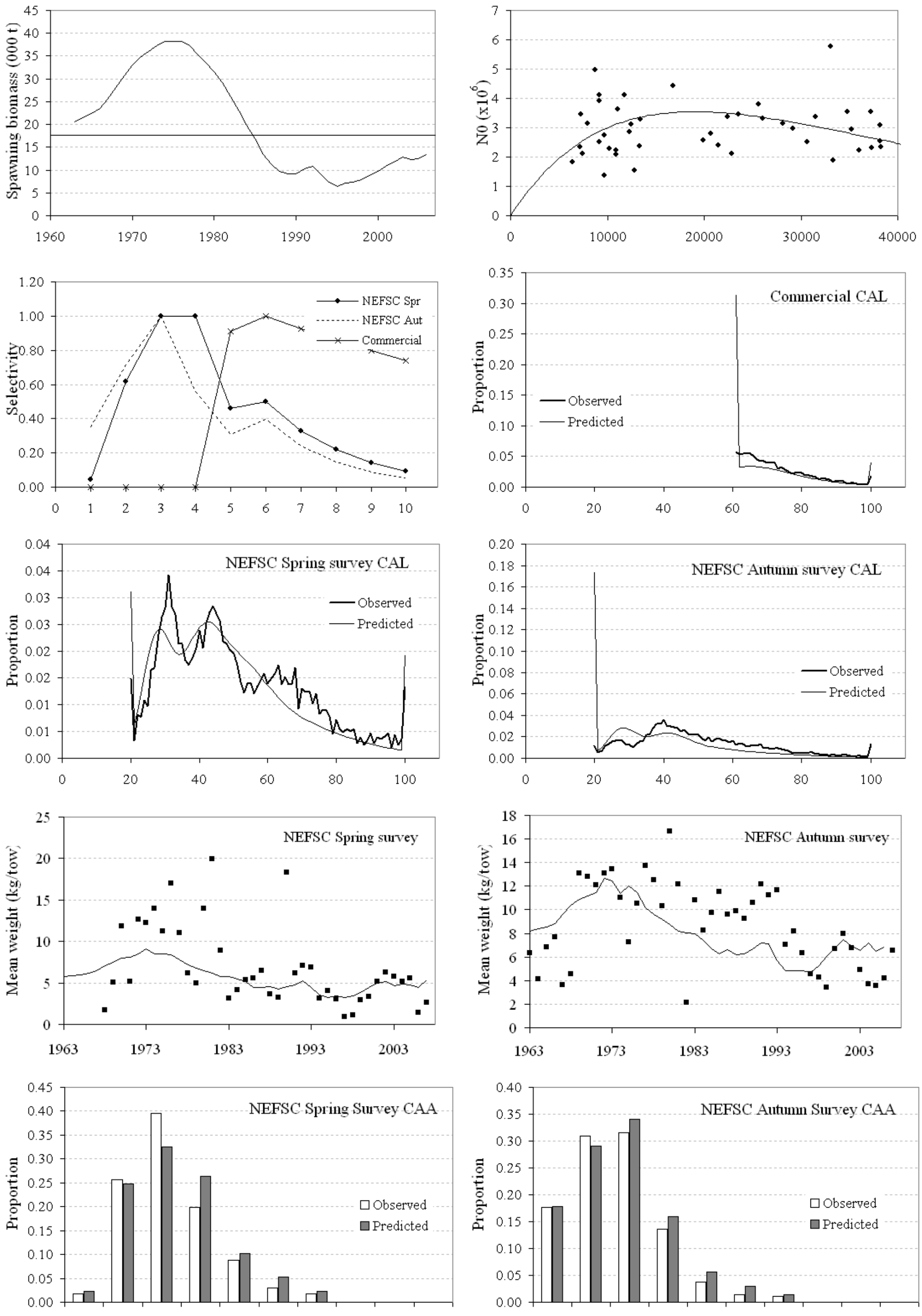

Fig. 4b: Results for the scenario assuming **no hake ≤ 60cm are white hake**, starting in 1963 with θ**=0.50**. The horizontal line in the spawning biomass plot is the estimated MSYL.