DISCUSSION NOTES ON OPTIONS FOR ASSESSMENT ANALYSES USING SEX-SPECIFIC CATCH-AT-SIZE AND -AGE DATA

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Background:

It has long been noted by the Swordfish Working Group that Atlantic swordfish appear to exhibit sexually dimorphic growth. Thus, methods which utilize catch-at-age from sex-aggregated growth relationships result in some bias in estimating fishing mortality rates from these data To address this, research programs were initiated so that estimates of catch-at-size and catch-at-age *by sex* could be made. The major emphasis at this SWO WG meeting is to perform that task. However, given that this task is completed, there are still a number of ways in which one can utilize the results in the assessment analyses. The following is a short discussion of some of options which might be available with a discussion of the *pros* and *cons* associated with each.

ADAPT "VPA-like" Options:

The ADAPT method of conducting a VPA for Atlantic swordfish has utilized age-specific CPUE's and catch-at-age (CAA), both of which have been estimated from sex-aggregated size-age relationships. The basis of the swordfish ADAPT applications have been a minimization of squared error between the observed and predicted CPUE to generate the initial abundance (or terminal F); and then fishing mortality rate at age is obtained from the solution to the catch equation assuming that CAA estimates are estimated without error and that M is known (although relaxation of the CAA and M assumptions have been examined to some degree by Monte Carlo simulation). This same general approach can be extended to sex-specific data, but in several importantly different ways. For example:

a) combined catch-at-age, one VPA

description: with this approach one would aggregate the male and female catches at age into a single catch at age; the CPUE data at age (presumably in numbers) would be aggregated over sex prior to standardization. Then a single ADAPT VPA is conducted with the aggregated data. This method assumes that there are no significant differences between CPUE of the sexes within an age; no assumptions are made about differences in F at age between sexes or about sex ratio at age of the population.

possible problems: the VPA will provide estimates of numbers and fishing mortality rate at age aggregated over sex; however, it is not straight forward what weight at age, maturity at age and fecundity at age vectors should be used with the sex aggregated abundance to obtain biomass and spawning biomass. Perhaps, one could assume a 50-50 sex ratio at age and then apply the appropriate vectors.

b) two sex-specific, independent VPA's

description: using sex-specific CPUE's at age, standardize separately to get female CPUE at age and male CPUE at age; conduct two independent VPA's (one for male, one for female) using the sex-specific CPUE's and sex-specific catches at age. No assumptions are made about differences in F at age between sexes or about sex ratio at age of the population.

possible problems: it is quite possible that one could end up with F's at age that are very different between sexes and with abundance sex ratios at age (particularly at recruitment and in the terminal year of a cohort) that are very different. Methods c) and d) below are an attempt to address this.

c) simultaneous, sex-specific VPA's with sex ratio at birth fixed

description: use same sex-disaggregated CAA and CPUE as in method b); fix the sex-ratio of abundance at some age, for example, by assuming that there is a 50-50 sex ratio at recruitment; the algorithm would proceed by using the normal back calculation for a cohort of one sex until the recruitment of that sex is estimated, then recruitment of the other sex is calculated fom the fixed sex ratio, finally, the abundance and F's of the cohort of the other sex are calculated going forward.

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possible problems: for those incomplete cohorts which enter the data set at older ages (in the earliest year of the catch at age data), some assumptions have to be made about sex ratio; also, the F's at age may still be quite different between sexes.

d) simultaneous, sex-specific VPA's with constant F at age between sexes

description: use same sex-disaggregated CAA and CPUE as in method b); fix the relationship between F's at age of the two sexes for some specific (contiguous) ages; the algorithm would proceed by using the normal back calculation for a cohort of one sex until the recruitment of that sex is estimated, then the fishing mortality rates of the other sex is calculated from specified relationship, finally, the abundance and F's of the cohort of the other sex are filled out using both back and forward calculation from the fixed block of F's.

possible problems: may end up with strange sex ratios.

It would seem that options b)-d) would utilize the sex-specific nature of the data more fully. Additionally, these methods (b-d) use the same data inputs; therefore, if the software is available, one could compare the results of all three. One could also compare these results to method a), however, method a) would require the CPUE's to be prepared differently.

ASPM Approaches:

There is an alternative to the ADAPT approach, and that is the Age Structured Production Model (ASPM). An example structure for this model could be based on the sex specific catch at length data, rather than age. For example, one could assume that there is a 50-50 sex ratio at recruitment, that the stock was at carrying capacity in some early year (1930?), that selectivity at size is known, and that CPUE's by size group are available. Then the the model forward projects abundance and catches at size based upon the aggregate catches and an estimated stock-recruitment relationship. The fitting criterion would be maximum likelihood with one component comparing the predicted catch at size by sex with the observed and another component comparing observed and predicted CPUE's at size by sex. One could also introduce a stochastic component into the stock-recruitment relationship to allow variability around that relationship. The key assumptions that would have to be made in this method would be the selectivity relationships; how they differ between fisheries and how they differ over time.

Discussion:

In selecting among methods b)-d) or the ASPM, we essentially have to make a choice about what we think we know: should fishing mortality rates of certain ages be equal between sexes? Can we assume a 50-50 sex ratio at birth? Should we assume fishing mortality rates for certain size groups are equal between sexes and then convert that to a fixed relationship of F at certain ages between sexes? Can we specify some selectivities? I believe some thought should be given to these kind of issues. But inevitably, several of these options will be tested. Therefore, we should be looking at several diagnostics such as the estimated sex ratio of abundances at age, the differences between F's at age by sex, and the differences between F's at size by sex.