

## **Appendix D. Risk assessment of proposed management alternatives for the white seabass fishery.**

One of the primary objectives of the WSFMP (White Seabass Fishery Management Plan) is to provide for future management that will promote long-term sustainability of the white seabass stock and fishery. A major proposed management feature is an annual limit on harvested biomass (i.e., pounds of fish taken). Section 5.4 of the WSFMP presents several specific alternatives for this harvest limit. In order of less restrictive (more aggressive take) to more restrictive (less aggressive take), alternatives are: A (no limit), B1, B2, D, C1, C2, C3.

One of the fundamental questions regarding the implementation of any one of these alternatives is to what extent would each of the alternatives involve risk to the sustainability of the stock and fishery? In particular, for each given alternative: under what conditions and in how many years would use of that option likely result in an overfished condition of the stock?

### Underlying uncertainty and risk

The better the available information about the stock size (e.g., abundance, biomass) the higher the harvest limit that can be allowed, with reasonable guarantee of sustainability of the stock and fishery.

Two kinds of information about stock size are most needed: a good estimate of the stock size now, and a good idea (model) of the stock dynamics (i.e., how stock size is likely to change). Both sorts of information are now highly uncertain for the white seabass stock. Precisely because of this uncertainty, several different alternatives and harvest limits have been proposed instead of a single definitive harvest limit. Each of the alternatives is based on a plausible estimate of what the underlying facts might be, but no one of these estimates represents certain knowledge.

One alternative can briefly be discussed now and will not further be analyzed. Alternative A imposes no harvest limit at all. As a result, this alternative imposes no guaranteed safeguard to prevent the stock from becoming overfished, possibly even within a single year. Alternative A represents a policy of maximum possible risk.

### Other Alternatives

Each other alternative uses a harvest limit which is equal to an estimate of Maximum Sustainable Yield (MSY). MSY is the maximum amount which, on average over different years, could in perpetuity be harvested from the stock, so long as the stock size starts out large enough. If the alternative's allowed harvest limit is no higher than the stock's actual MSY, and we are willing to assume that the stock's present initial size is sufficiently large, then use of the alternative poses no undue risk. Suppose, however, that the alternative's allowed harvest limit is higher than the stock's actual

MSY. Assume further - as our quantitative analysis below does for simplicity - that in fact the fishery takes every year an amount equal to (or anyhow close to) the harvest limit. Then it will only be a matter of time before the stock becomes overfished. Here, the term 'overfished' not only has a readily appreciated practical import but also by conventional definition (National Standard Guidelines) has a precise meaning: that stock size which is at most half the size needed to sustain an average yield equal to MSY.

Precisely how much time, to becoming overfished, depends on three inputs or assumptions: the harvest limit itself; the stock's actual status - namely present size and actual MSY; and the underlying model of stock dynamics.

### Risk analysis results

Table J-1 summarizes the results of the risk analysis. Here is how the above three inputs enter into the Table:

Since each of the alternatives makes a precautionary adjustment downward to MSY (multiplied by 0.75) for OY, we have used the OY values in the risk analysis. Each cell in the table corresponds to a given harvest limit - the one corresponding to the alternative noted at the top of the cell's column. The cell also corresponds to a given stock status. Namely, the alternative noted at the left of the cell's row corresponds to an OY value, and the stock size is assumed to be the minimum size needed to yield that OY. The cell will contain the entry 'OK' if there is no undue risk, that is, if the harvest limit (from the column alternative) is less than the actual OY (from the row alternative). However, if the column alternative's harvest limit is greater than the row alternative's OY, then the cell contains two numbers, representing number of years to overfished status. The numbers come from using two different plausible dynamics models described below.

### Model details

The two dynamics models used are of the same general kind, known as production models, or surplus yield models. Namely, absent fishing, such a model assumes that every year the stock size grows - adds extra biomass or 'yield'. When stock size is very small, yield is small. When stock size is very large, near a maximum or 'carrying capacity' value, yield again is small. However, when stock size is intermediate, yield is larger. If yield (vertical coordinate  $y$ ) is plotted against existing stock size (horizontal coordinate  $x$ ) the resulting curve is dome-shaped, with MSY = the largest value of  $y$ .

Both models are of the form  $y = m(x^p - x^{2p})$ , where  $y$  = annual yield, and  $x$  = stock size (with biomass unit chosen so that 1 = maximum possible stock size (i.e., 'carrying capacity' or 'virgin biomass')). In each cell, the smaller entry is for a value of  $p$  (very nearly  $p = 3/4$ ) such that the stock size which yields MSY will be equal to 40% of the virgin biomass. The larger entry is for the value  $p=1$ , so that the stock size which yields MSY will be equal to 50% of virgin biomass (from a suggestion of Restrepo et al.

1998).

The annual mortality coefficient ( $m$ ) of the fully recruited white seabass stock is the fraction of initial biomass which no longer lives at year's end. This choice for  $m$  comes from the following assumption suggested in the fisheries literature, namely that for smaller stock sizes (with  $0 < x < 1$ ) allowable fishing mortality may be taken equal to natural mortality. For small  $x$ , this assumption calls for gross growth to approximate twice natural mortality, so that net yield  $y$  is approximately  $mx$  (=loss by natural mortality). From various white seabass studies, the numerical value for  $m$  is 0.1. Note that both models get MSY equal to  $(m/4)$  times the virgin biomass.

Table D-1. The number of years for the white seabass stock to become overfished when management is by one alternative (Y) while stock status suits another alternative (X). OK denotes no undue risk.

Table D-1. Number of years for the white seabass stock to become overfished when management is by one alternative (Y) while stock status suits another alternative (X). OK denotes no undue risk. The two numbers represent results from two different models.						
X(actual stock status)	Y(management)					
	B1	B2	D	C1	C2	C3
B1	OK	OK	OK	OK	OK	OK
B2	65-73	OK	OK	OK	OK	OK
D	15-17	18-22	OK	OK	OK	OK
C1	3-4	4-4	6-7	OK	OK	OK
C2	2-3	3-3	4-4	19-23	OK	OK
C3	2-2	2-3	3-4	13-15	39-45	OK