Estimation of Red Snapper Recruitment

Issue Paper for Consideration by the SAFMC SSC

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Issue

Estimation of recruitment for red snapper projections

Background

In reviewing the addendum for red snapper (SEDAR 15) that corrects a transposition of two recreational catch observations and updates projections to account for the recommendation of $F_{40\% \ SPR}$ as MFMT, it was noted that recruitment drops considerably between the terminal year of estimates and the first year of projections. The terminal year of observed data is 2006, therefore exploitation estimates are available through 2006 and abundance information is available for January 1, 2007.

Exploitation in the projections is fixed at the average of 2004-2006 for 2007 and 2008 and varies according to the particular scenario thereafter. January 1 2007 population size is taken from the model estimates of abundance at age, which gives an estimate of 286 thousand recruits in 2007. Recruitment starting in 2008 is based on the stock-recruitment relationship derived for the projection analysis and results in an estimate for recruitment in 2008 of 61 thousand fish. This value is the same across all scenarios because management changes do not become effective until 2009. It is the change in estimated recruitment from 286 thousand to 61 thousand that brought this issue to attention. For comparison, the SSB in (mid-year) 2006 that produces the 2007 recruits is 197 mt and the SSB for 2007 that produces the 2008 recruits is 204 mt. The result is that recruitment drops by about 80% in 2008, whereas the SSB that produces that recruitment increases slightly.

The reason for the change in recruitment is that steepness is necessarily different between the estimated period and the projection period. To accommodate the shift to $F_{40\% \ SPR}$ as an F_{msy} proxy, steepness in the projections is fixed at 0.68 to maintain consistency with yield and abundance when the stock rebuilds. By comparison, steepness estimated by the model is 0.95. As nicely stated in the addendum report (Section 1.2.2.10), fixing steepness at the value corresponding to $F_{40\% SPR}$ provides reference points that are consistent with the rebuilding projections, and ensures that fishing a $F_{40\% SPR}$ yields MSY(as yield at $F_{40\% SPR}$) from a stock size of $SSB_{F40\% SPR}$.

While it is important to maintain consistency with equilibrium yield, stock size, and exploitation for the projection period, the change in steepness creates a break in the recruitment estimates that is difficult to explain given the abundance and SSB estimates during the assessment period. For example, the lowest estimate of recruitment is 128 thousand fish in 1994 (Table 1.3) from a 1993 SSB of 174 mt. This is more than twice the recruitment estimated for 2008. The 1997-2006 average recruitment is 298 thousand fish, which is nearly 5 times the

estimate for 2008. Over this period SSB increases from 122 mt in 1996 to 241 in 2000 (the highest observed since 1980) and then drops somewhat to 197 mt in 2006.

An associated issue that may influence the outcome for future recruitment estimation is what the SEDAR 15 Review Panel intended in recommending $F_{40\%SPR}$. Specifically, did they consider that changing the overfishing reference would lead to changes in steepness in the projections and how such changes may affect the recruitment stream? The review panel raised concerns about the high estimate of steepness provided by the model as one of their primary justifications for recommending F40%SPR as a limit reference point:

> *One of the principal difficulties with the SCA model estimate of the stock recruitment parameters is that the steepness estimate appears unrealistically high. In addition, there are no data in the assessment to adequately define the asymptote of the Beverton-Holt function and hence estimates of MSY indicators cannot be considered reliable. It may be preferable, as indicated above, to use the ratio indicators to evaluate stock status or use SPR proxies. The panel suggested that $F_{40\%}$ and $SSB_{40\%}$ proxies may be used as limit indicators.*

From this statement it seems clear that the Review Panel was uncomfortable with the productivity estimated from the high steepness and felt the MSY estimates were unreliable. They don't specifically address changing steepness in future projections that reflect the F40%SPR limit reference, perhaps because they did not consider such additional analyses during their meeting and therefore had no need to discuss such specifics. Their comments regarding rebuilding times and the dynamics at current stock levels do provide some insight that may justify an alternative approach to estimating short-term recruitment and management effects:

> *Interpretation of rebuilding times needs to be considered in the context of the very low current stock size. It is possible that stock dynamics at these apparently depleted levels may not be the same as the assumed stock recruitment relationship, which has been estimated for the whole historical time period.*

> *The panel discussed the value of projections made beyond 5-10 years. Clearly the uncertainty increases rapidly with time as the currently measured stock is replaced by model values into the future. Realistically, the projections beyond the range of the predominant age groups in the stock are highly uncertain. In this assessment, the best that can be concluded is that rebuilding times will be very long.*

A final question concerns whether the Review Panel felt a lower steepness was a more appropriate assumption than the steepness estimated in the model. They do not specifically address this question, but there was a sensitivity analysis prepared with steepness fixed at 0.60, which is very close to the steepness of 0.68 associated with $F_{40\%SPR}$. On one hand it could be argued that not choosing that run indicates that they did not believe 0.60 was any more reliable than the available estimate, but on the other hand they clearly questioned the estimate and recommended a more conservative limit reference point.

<u>Alternatives</u>

1. Retain the projections as currently estimated

This option maintains technical consistency between the stock productivity, yield, and reference points, but it creates an inconsistency in productivity between the estimation period and the projection period. It imposes a stock recruitment relationship which may be appropriate as the stock recovers but may not be appropriate in the near term, given the low abundance, as noted by the review panel.

2. Retain the model estimate of steepness for both periods

This option creates an inconsistency over the projection period, and would result in a mismatch between exploitation, abundance, and yield at equilibrium. It would resolve the short term issue with the sudden change in recruitment between 2007 and 2008, but imposes future productivity using stock-recruitment relationship parameters that the review panel clearly questioned and doubted. This would also not address the review panel comments that questioned whether stock dynamics under the current reduced abundance will be similar to stock dynamics once the stock recovers.

3. Apply the projection period steepness to the estimation period

This option would remove the inconsistency between terminal year and projection recruitment estimates and maintain long-term consistency in yield and the reference points. However, it imposes a stock-recruitment relationship that is different than that estimated by the model but is very similar to a run that was not chosen as preferred by the Review Panel. It also does not address the possibility that current stock dynamics are different than equilibrium stock dynamics.

4. Consider a hybrid approach

This option proposes that projections be prepared in two phases. The first phase would be used to establish the rebuilt stock condition and rebuilding time frame, and would be based on the $F_{40\%SPR}$ steepness as currently presented in the addendum. This maintains the necessary consistency in stock dynamics as the population rebuilds and reaches equilibrium.

The second phase would be to develop short-term projections of 5 to 10 years using either average recruitment or the steepness estimated from the model. This would resolve the issue of the drastic change in estimated recruitment for the next few years and possibly provide a more realistic estimate of potential yields in the short term. It would also accommodate the Review Panel's recommendations that projections beyond 5-10 years are highly uncertain and that current stock dynamics may be very different than equilibrium stock dynamics.

The challenge will lie in selecting the level of recruitment for the projections. If this option is chosen the SSC should provide clear guidance as to the years over which short-term recruitment will be determined.

Table 1. SSB, Steepness, and Recruitment estimates from 2005-2009, based on the model estimation period and the projection period.

YEAR	Steepness	SSB metric ton (midyear)	Recruits thousands (Age 1, Jan 1)
2005	0.95	196	274
2006	0.95	197	278
2007	0.68	204	286
2008	0.68	201	61
2009	0.68	175	60