ABC for South Atlantic Species: Comparing DCAC method to average landings

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DCAC

At the SSC webinar in January several options for setting ABC were discussed. The Depletion-corrected average catch (DCAC) method is presented here and is compared to the simpler 'ABC=75% average catch' option. DCAC is a method of estimating sustainable yield in data-poor situations. It is based on the assumption that catch can be divided into a sustainable yield component and an unsustainable "windfall" component (McCall 2009).

The sustainable yield is calculated as:

$$Y_{sust} = \frac{\sum C}{n+\frac{W}{Y_{pot}}}.$$

Where $\frac{W}{Y_{pot}} = \frac{\Delta}{0.4*c*M}$

and $\Delta = \frac{B_{FYR}-B_{LYR}}{B_0}$.

C=catch
W=windfall catch
Y_{sust}=sustainable yield
Y_{pot}=potential yield
n=number of years of landings data
M=natural mortality
c=tuning adjustment for relationship between
F_{msy} and M such that $F_{msy}=cM$

The DCAC method assumes B_{msy} =0.4*B0 and F_{msy} =c*M. M values were calculated using the Hoenig method that requires an estimate of maximum age for the species (Hoenig 1983). Estimates of M and c and maximum age used in these analyses are in the DCAC spreadsheet. For data poor species *delta* (Δ) is not directly calculable and may only be a "rough estimate of the reduction in vulnerable biomass, expressed as a fraction of unfished vulnerable biomass" (McCall 2009). For most of the South Atlantic species we have landings data but may not have indices of abundance or estimates of biomass. For these comparisons the assumed delta values are listed in tables. For all species the DCAC method was applied to years 1986-2007. Landings data for these years include headboat, ALS, and MRFSS data.

Comparison of DCAC to Assessment MSY

The DCAC results were compared to MSY estimates for five assessed South Atlantic species (red snapper, vermillion snapper, gag grouper, mutton snapper, and greater amberjack). Natural mortality from the stock assessment was used for M, c was assumed to be 0.8 for these analyses, and delta values were calculated from biomass estimates presented in the stock assessments. For mutton snapper, an exact estimate of biomass in 1986 was not given, so the biomass was estimated from a figure in the SAR. DCAC yield estimates were compared to estimates of MSY and OY (where available; OY=yield at 75% F_{msy}) from the assessment (Table 1). The analyses and parameters can be found on the 'delta' worksheet in the 'DCAC' workbook.

DCAC yield was smaller than estimated MSY in all species except gag grouper (Table 1). Mutton snapper was the only species where *c* could be adjusted and allow yield from DCAC=MSY.

Table 1. Comparison of MSY for assessed species to DCAC yield estimate. Natural mortality is value used in the stock assessment. Delta values were calculated from biomass estimates presented in the stock assessments.

Species	Assessment MSY	Assessment OY	DCAC Yield	% Diff between DCAC-MSY	Ratio, sum of catch to B0
red snapper	2,341,000		448,139	-422.4	0.16
mutton snapper	1,516,780	1,155,222	562,753	-169.5	0.09
gag grouper	1,238,000	1,217,000	1,520,713	18.6	1.63
vermilion snapper	1,665,270		1,380,510	-20.6	1.46
greater amberjack	2,005,000	1,968,000	1,516,516	-32.2	1.16

Why is DCAC so different from MSY?

Red and mutton snapper DCAC yield were both very different from MSY. Red snapper and mutton snapper have widely differing estimates of stock status and both have very low total (sum) catch during 1986-2007 with respect to estimated virgin biomass (Table 1) – though for completely different reasons. During 1986-2007 mutton snapper had high biomass and low F whereas red snapper had low biomass and high F. That DCAC yield was lower than MSY was not surprising for red snapper, since assessment MSY was the equilibrium MSY and stock was well below MSST and SSBmsy. Thus a lower yield is expected when the depletion correction is made. Mutton snapper MFMT was 0.34 (at 30% SPR), which was much higher than the M of 0.11. In addition, total catches during 1986-2007 were very low with respect to estimated virgin biomass, the mutton snapper assessment indicated that the biomass increased slightly during this period, and mutton was not overfished and not overfishing. Mutton snapper is perhaps under-utilized as a fishery resource. Perhaps DCAC is also not overly robust when the stock is not "depleted", i.e. when the F is much lower than MFMT, and when the sum of landings is low with respect to virgin biomass.

Comparison of DCAC to Average Landings

For this exercise, we are assuming OFL=average landings for all years (1986-2007), and ABC=75% OFL until you tell us otherwise. Using the DCAC method we found the delta value that would give us a DCAC yield that was equal to 75% all year average to use as a starting point. This potentially allows DCAC to represent ABC – with no further reduction necessary. We assumed that *F*msy=*M* (thus c=1) and that *M* was equal 0.2,. Under these parameters, the delta value where DCAC yield=ABC (75% OFL) was 0.59. If we assume M was equal to 0.15, the delta value where DCAC yield=ABC was 0.44. Using these assumptions about OFL, ABC, and DCAC, we could move forward with a baseline of OFL=average of landings for 1986-2007, ABC=75% OFL, and if we think we know more about a species, feed that information into the DCAC calculation and use that value for ABC. Additional information about stock biomass during 1986-2007 or natural mortality could be used to give better informed ABC recommendations by changing the delta and M values in the DCAC calculations. Positive delta values mean that you think biomass has decreased, negative delta values mean you think species biomass has increased during 1986-2007. The analyses can be found on the 'Comparison A' worksheet in the 'DCAC' workbook.

DCAC Yield Sensitivity to assumed *c*, *M*, and *delta* values

We explored the sensitivity of the DCAC approach by exploring a range of *M*, *c* and *delta* values, using gag grouper data for the analyses. Gag grouper had variable, but fairly constant landings during 1986-2007 (Figure 1). As stated in the McCall paper, values of *M* greater than 0.2 are not conductive to DCAC use because the depletion correction becomes too small. This was the case for the gag grouper example as well (Figure 2).

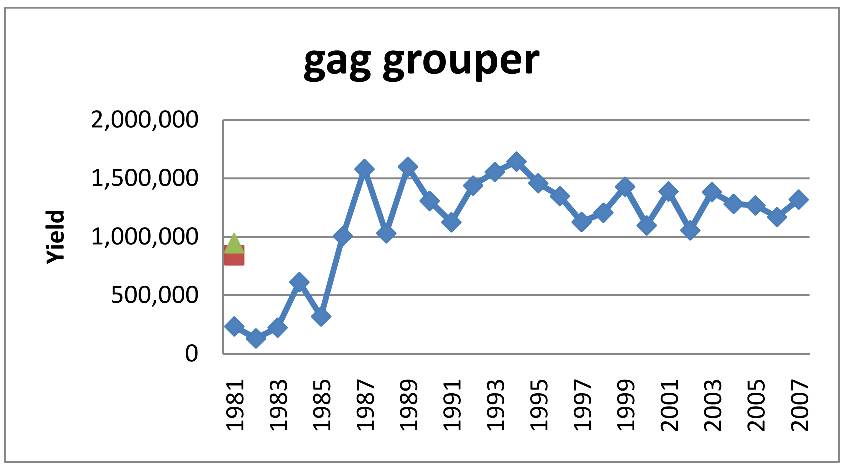

Figure 1. Landings (lbs) of gag grouper in the South Atlantic during 1981-2007. Years 1986-2007 were used in the calculation of DCAC. The green triangle represents average landings during 1998-2007 and the red square represents average landings during 1981-2007.

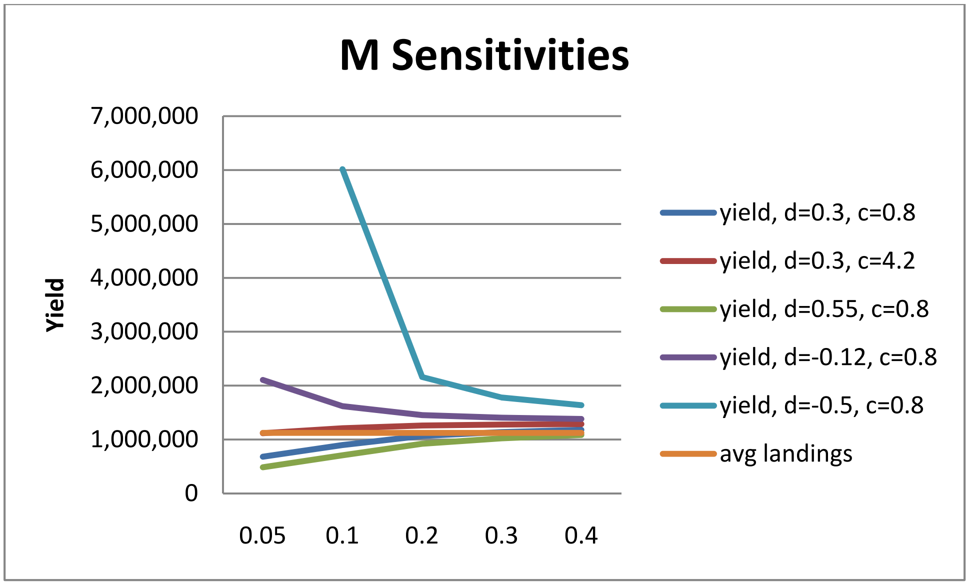

Figure 2. Each line represents the DCAC yield for gag grouper over a suite of natural mortality rates for a different combination of *delta* (*d*, in figure index) and *c* values. Natural mortality rates are on the x-axis.

DCAC yield is very sensitive to assumptions about delta. As mentioned previously, positive delta values indicate that biomass has decreased; negative delta values indicate that biomass has increased during 1986-2007. Delta values that are low and negative (i.e. -0.5) have yields that are greater, and sometimes much greater, than average landings.

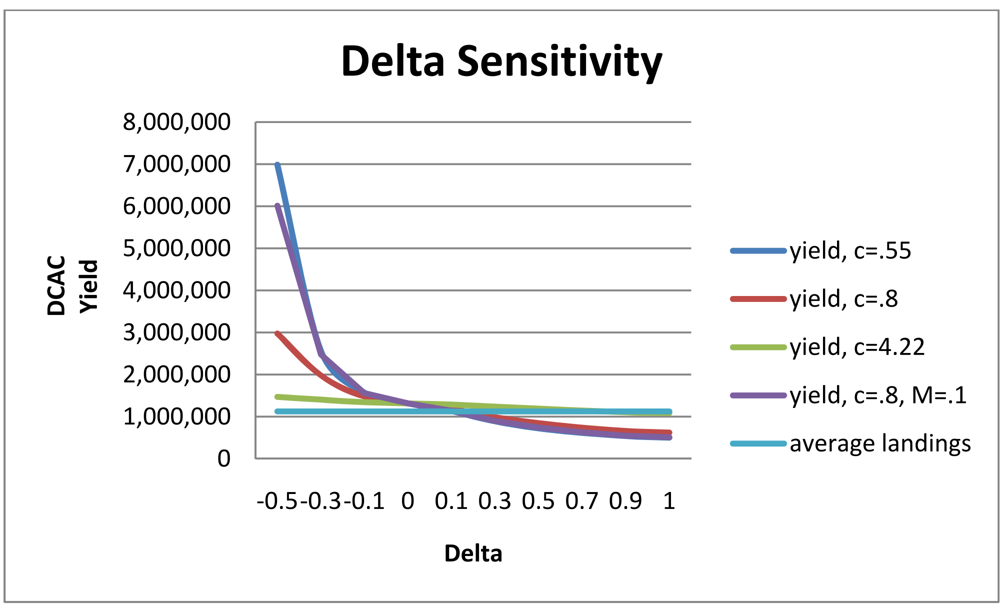

Figure 3. Each line represents the DCAC yield for gag grouper over a suite of delta values for a different combination of *M* and *c* values. Natural mortality was 0.12 unless indicated in the figure index.

DCAC yield was also very sensitive to assumptions about *c*, the "correction" factor for $F_{msy} = c*M$. As assumed c approaches 1, the DCAC yield approached average landings. See the 'Sensitivities' worksheet for the complete set of analyses and values examined.

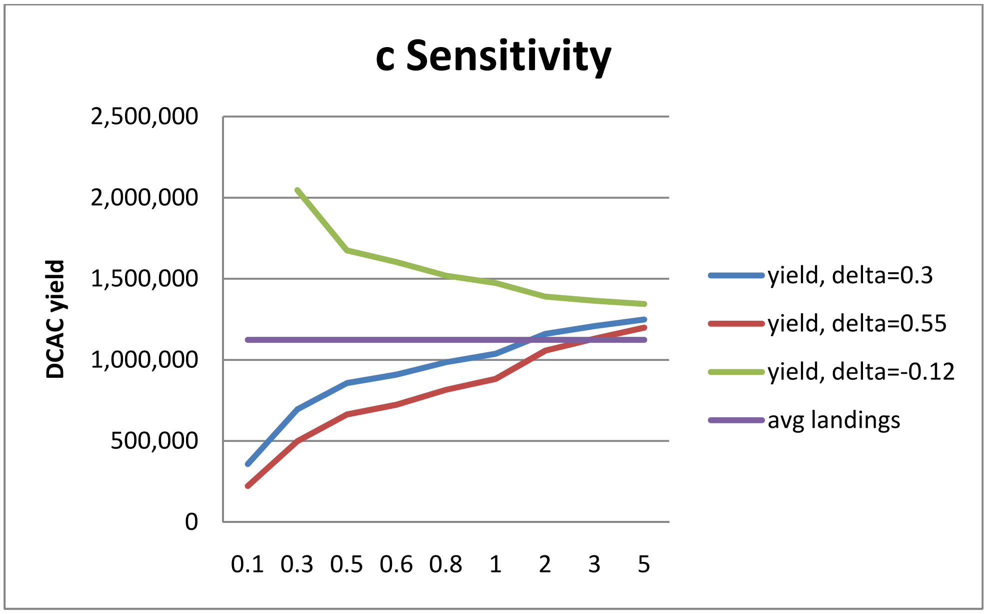

Figure 4. Each line represents the DCAC yield for gag grouper over a suite of *c* values for a different combination of *delta* values (*d*, in figure index). Values for *c* are on the x-axis. Natural mortality was assumed to be 0.14.

References

McCall, A.D. 2009. Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. ICES Journal of Marine Science. 66: 2267-2271.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin 81:898–903.