Summary of sensitivity analyses using the base-case penguin model

William Robinson, Éva Plagányi and Doug Butterworth
Department of Mathematics and Applied Mathematics, UCT

The following sensitivity tests to the base-case penguin model described in document MCM/2008/SWG-PEL/27 have been conducted:

0.   Sample of stratum B biomass proportions for future years

Base case: 2002 – 2006 proportions

Alternative: 1988 – 2001 proportions

1.   Spawner biomass series:

Base case: $B_y^{\text{spawner}} = \left(B_{A,y} p_{A,k} + B_{S,y} p_{S,k} \right) \Big/ B_{\max}$

Alternative: $B_y^{\text{spawner}} = \left(\dfrac{1}{3} B_{A,y} p_{A,k} + B_{S,y} p_{S,k} \right) \Big/ \left(\dfrac{1}{3} B_{A,\max} + B_{S,\max} \right)$,

where $B_{A,\max}$ and $B_{S,\max}$ are respectively the maximum anchovy and sardine spawner biomasses predicted in stratum B by the assessment model and the survey data.

2.   Survival and reproductive success functional relationships:

Base case: $S_{y,i} = S_{\max} \dfrac{\exp\left(a_i + b_i B_y + \eta_{y,i} \right)}{1 + \exp\left(a_i + b_i B_y + \eta_{y,i} \right)}, \qquad b_i \geq 0$

$S_{y,i}^{j} = \dfrac{\exp\left(\alpha_i + \beta_i B_y + \mu_{y,i} \right)}{1 + \exp\left(\alpha_i + \beta_i B_y + \mu_{y,i} \right)}, \qquad b_i \geq 0$

Alternative: $S_{y,i} = S_{\max} \dfrac{\exp\left(a_i + b_i B_y - \dfrac{c_i}{B_y} + \eta_{y,i} \right)}{1 + \exp\left(a_i + b_i B_y - \dfrac{c_i}{B_y} + \eta_{y,i} \right)}, \qquad b_i, c_i \geq 0$

$$S_{y,i}^{j} = \frac{\exp\left(\alpha_i + \beta_i B_y - \dfrac{\gamma_i}{B_y} + \mu_{y,i}\right)}{1 + \exp\left(\alpha_i + \beta_i B_y - \dfrac{\gamma_i}{B_y} + \mu_{y,i}\right)}, \qquad \beta_i, \gamma_i \geq 0$$

3.   Reproductive success index:

   Base case: Reproductive success depends on spawner biomass

   Alternative: Reproductive success depends on recruit abundance

4.   Standard deviation of random effects

   Base case: input $\sigma_\mu = 1.5$ and $\sigma_\eta = 1.5$

   Alternatives: $\sigma_\eta = 2.0$, $\sigma_\eta = 0.5$

5.   Age at maturity

   Base case: $m = 4$

   Alternative: $m = 3$

6.   Proportionality constants for moulters and breeders

   Base case: $q_B = 0.95$, $q_{M,ROB} = 0.9$

   Alternative: $q_B = 0.9$

7.   Common parameters for the two islands (but allowing separate random effects)

   Base case: all parameters estimated separately for Robben and Dassen

   Alternative: 1)   common adult survival and reproductive success relationships

               2)   common reproductive success relationship only

8.   Pelagic spawner biomass series

   Base case: Cape Columbine to Cape Point

   Alternative: West of Cape Agulhas

Selected results are presented in Figs. 1-5. Fig. 5 summarises the ratios of predicted 2018 total adult penguins under with catch (wc) and no catch (nc) scenarios for the various sensitivity tests. These proportions show the relative decrease in penguin numbers (although not the fairly large uncertainties associated with these estimates) predicted by the various model versions as attributable to fishing.
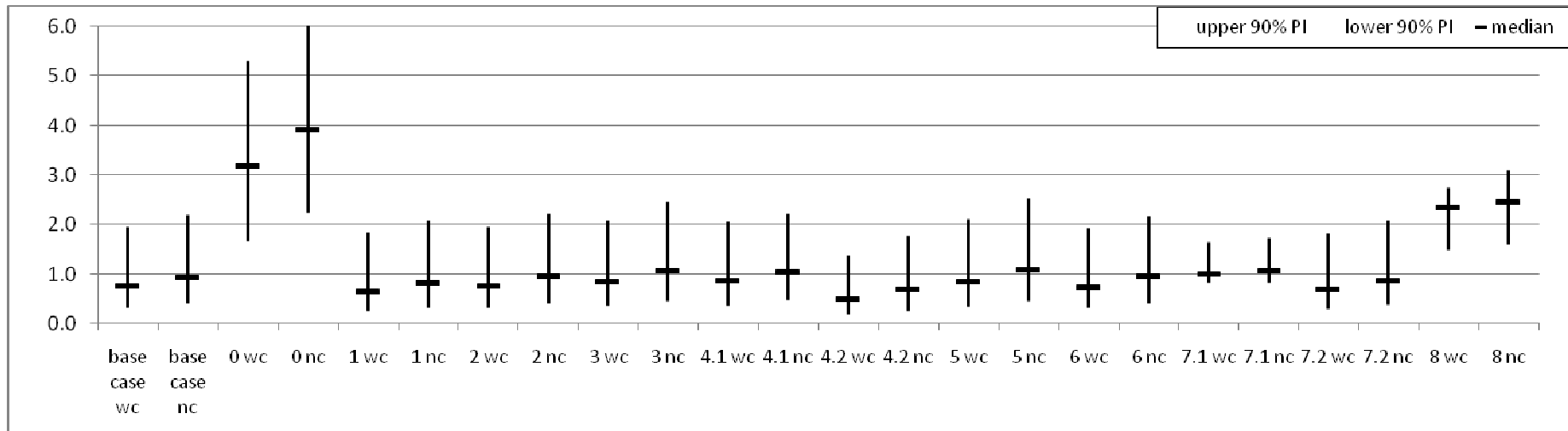
Fig. 1: Ratio of the Robben adult population in 2018 to 2008 for the base case and sensitivity tests 0 to 8 with (wc) and without (nc) catch.
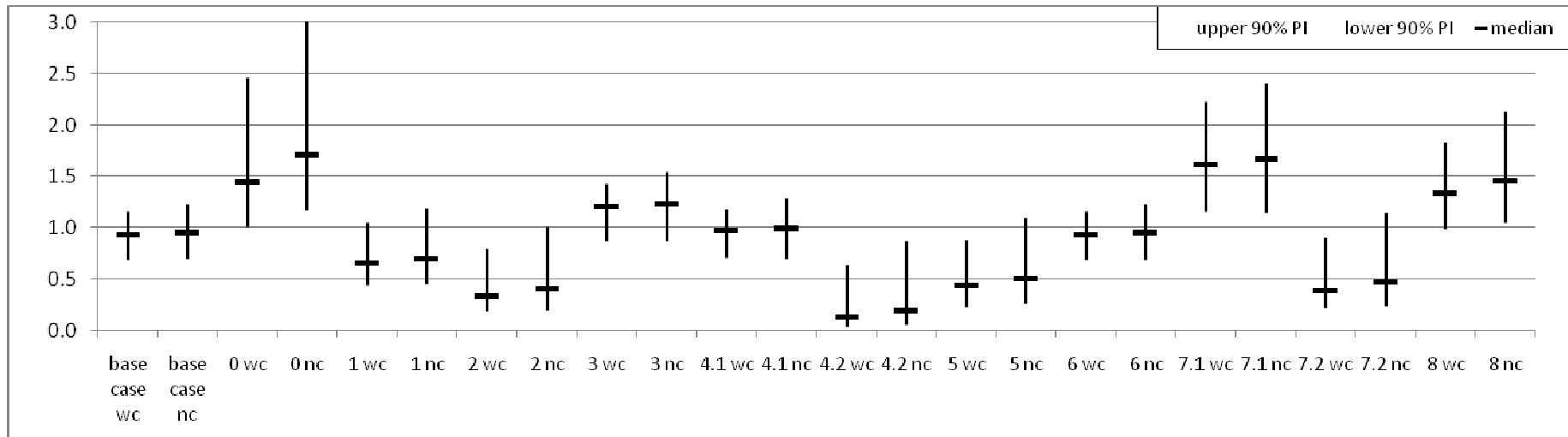

Fig. 2: Ratio of the Dassen adult population in 2018 to 2008 for the base case and sensitivity tests 0 to 8 with (wc) and without (nc) catch.
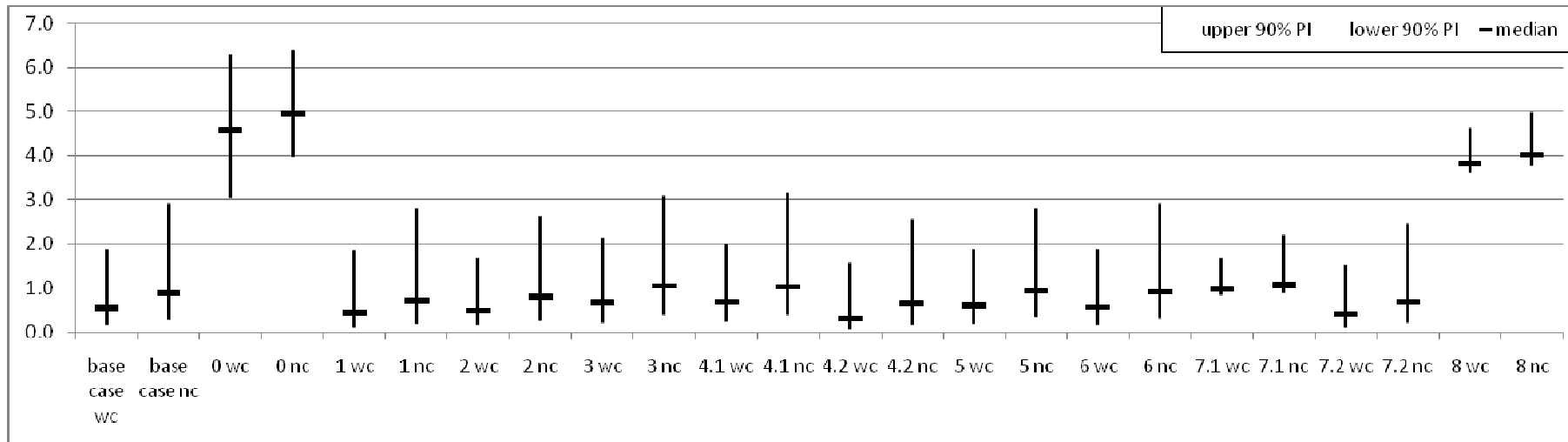
Fig. 3: Ratios of the Robben adult population in 2028 to the 1991-1998 average for the base case and sensitivity tests 0 to 8 with and without catch.
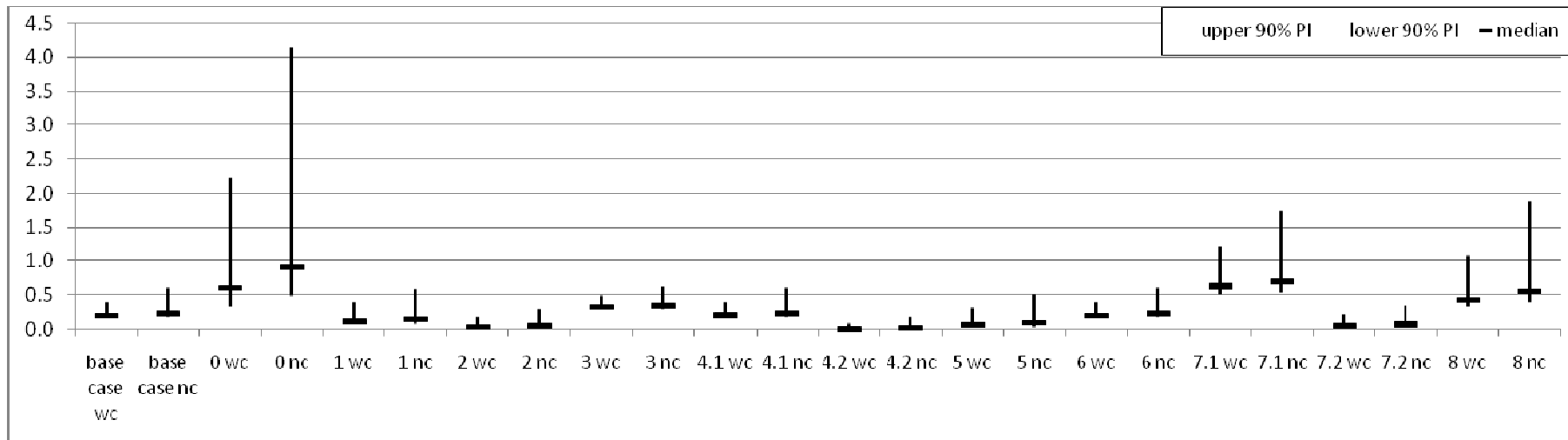

Fig. 4: Ratios of the Dassen adult population in 2028 to the 1991-1998 average for the base case and sensitivity tests 0 to 8 with and without catch.

Robben 2018 wc / nc
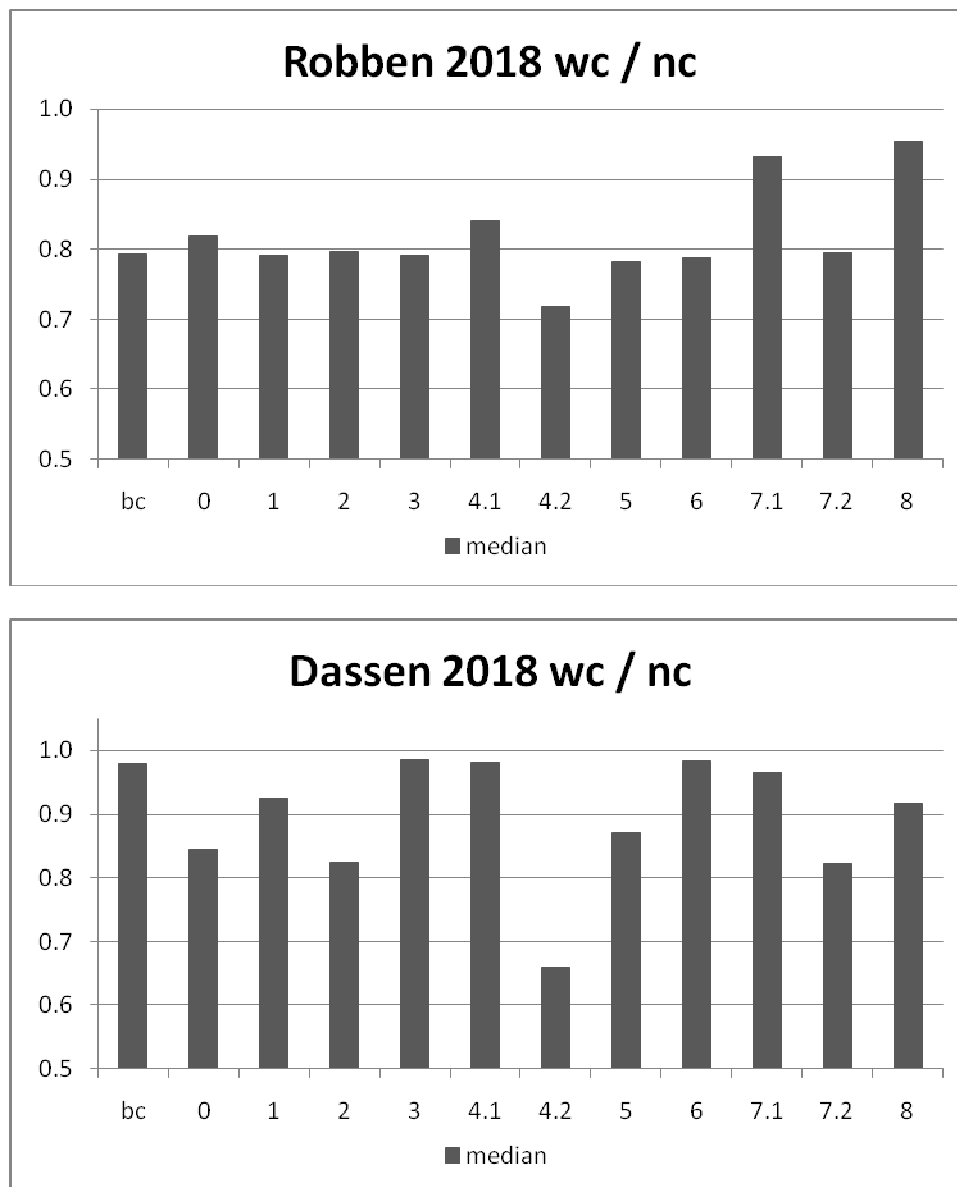

Dassen 2018 wc / nc

Fig. 5: Ratios of predicted 2018 total adult penguins under with catch (wc) and no catch (nc) scenarios for various sensitivity tests (see numbered list in text) at Robben Island (top) and Dassen Island (bottom). The proportions show the relative decrease in penguin numbers (although not the fairly large uncertainties associated with these estimates) predicted by the various model versions as attributable to fishing.