# SOUTH AFRICAN HAKE OMP REVISION

**Remember that there are two species:**

| | |
|---|---|
| ***M. capensis*** | **Shallow water** |
| ***M. paradoxus*** | **Deep water** |

## PRESENTATION OUTLINE

1) **Summarise fishery (see Hake/BG1)**

2) **Summarise Reference Case assessment results (Hake/P2 and P3)**

3) **Work quickly through questions posed (Hake/P1)**

# SPECIES DISTRIBUTION

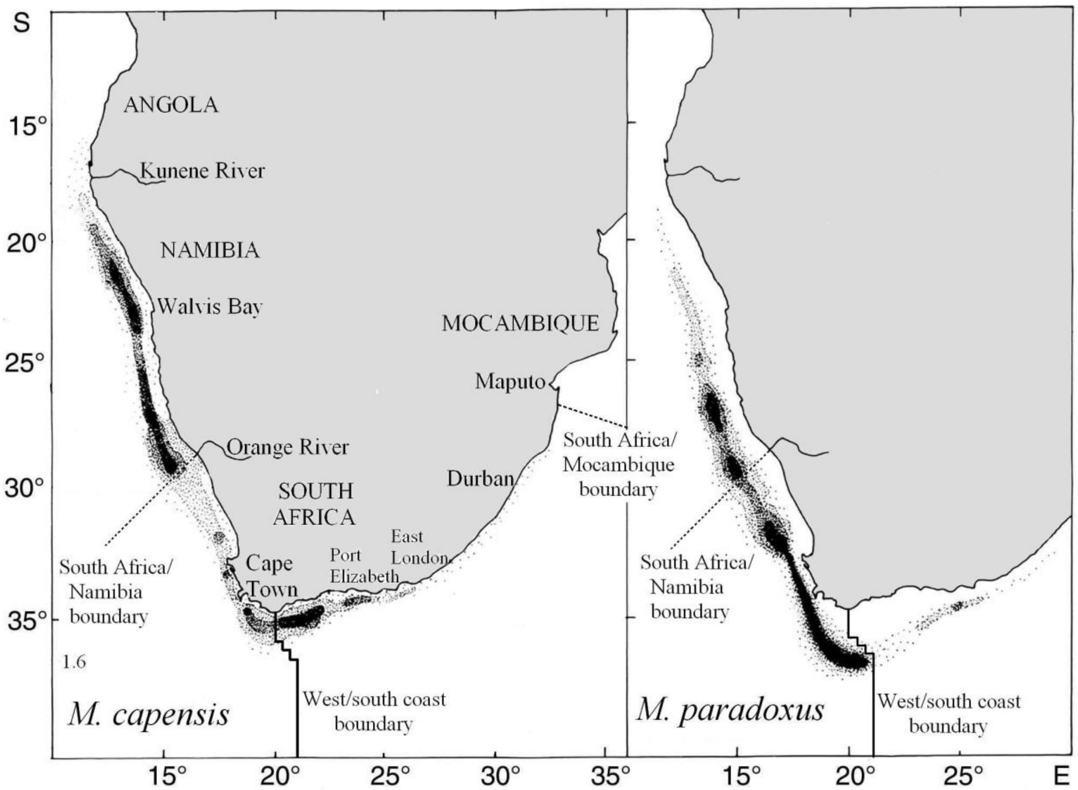



**Figure 1:** Species distribution for southern African hake (adapted from Payne 1989).

# CATCH HISTORY

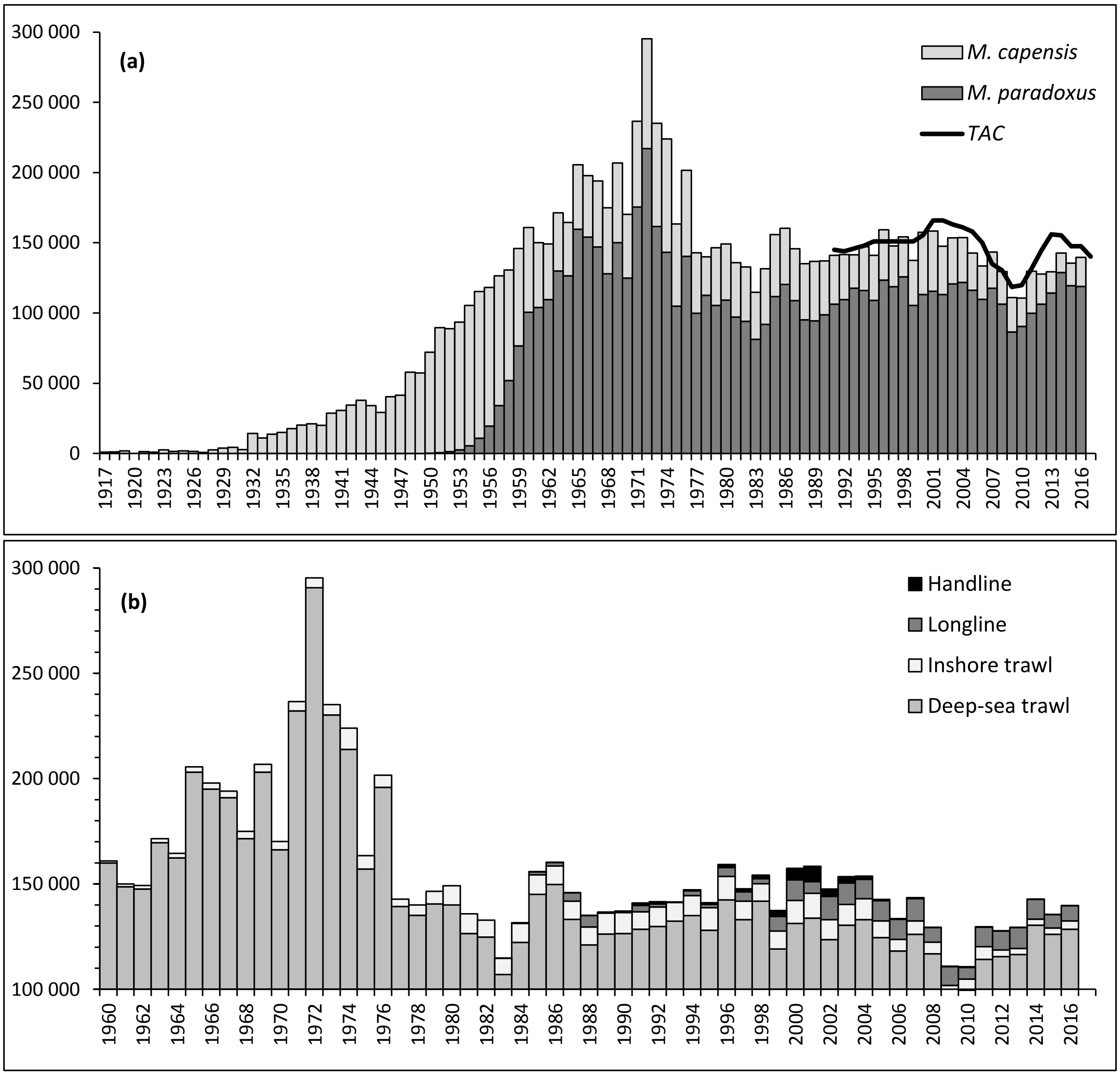



**Figure 3:** (a) Total catches (tons) of Cape hakes split by species over the period 1917 – 2016 and the TAC set each year since the implementation of the OMP approach in 1991. Prior to 1978, where the data required to split the catch by species are not available, the split is calculated using an algorithm that assumes 1958 as the centre year for the shift from a primarily *M. capensis* to a primarily *M. paradoxus* offshore trawl catch. (b) Catches of Cape hakes per fishing sector for the period 1960 – 2016. Prior to 1960, all catches are attributed to the deep-sea trawl sector.

# ? HOW ARE THE TWO SPECIES DISTINGUISHED ?

# ABUNDANCE INDICES: CPUE AND SURVEY

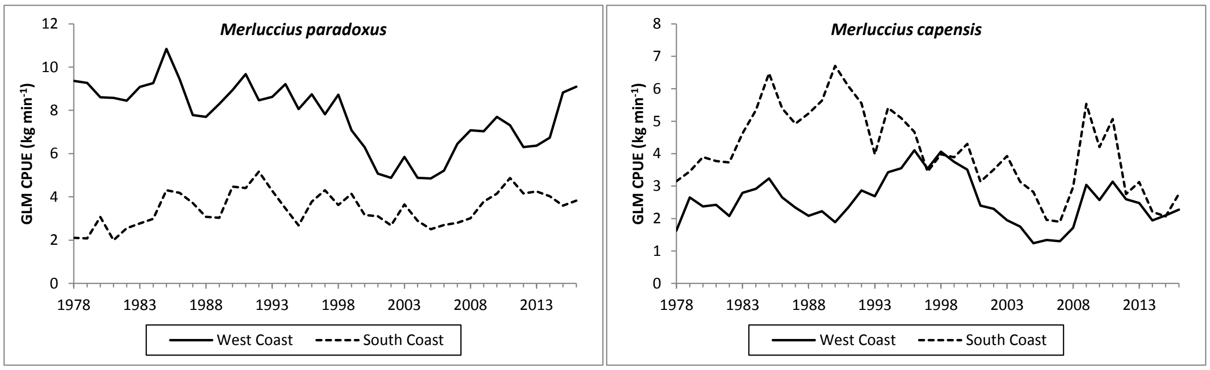



**Figure 4:** GLM-standardised deep-sea trawl CPUE (kg.min$^{-1}$) indices of hake abundance shown by species and coast

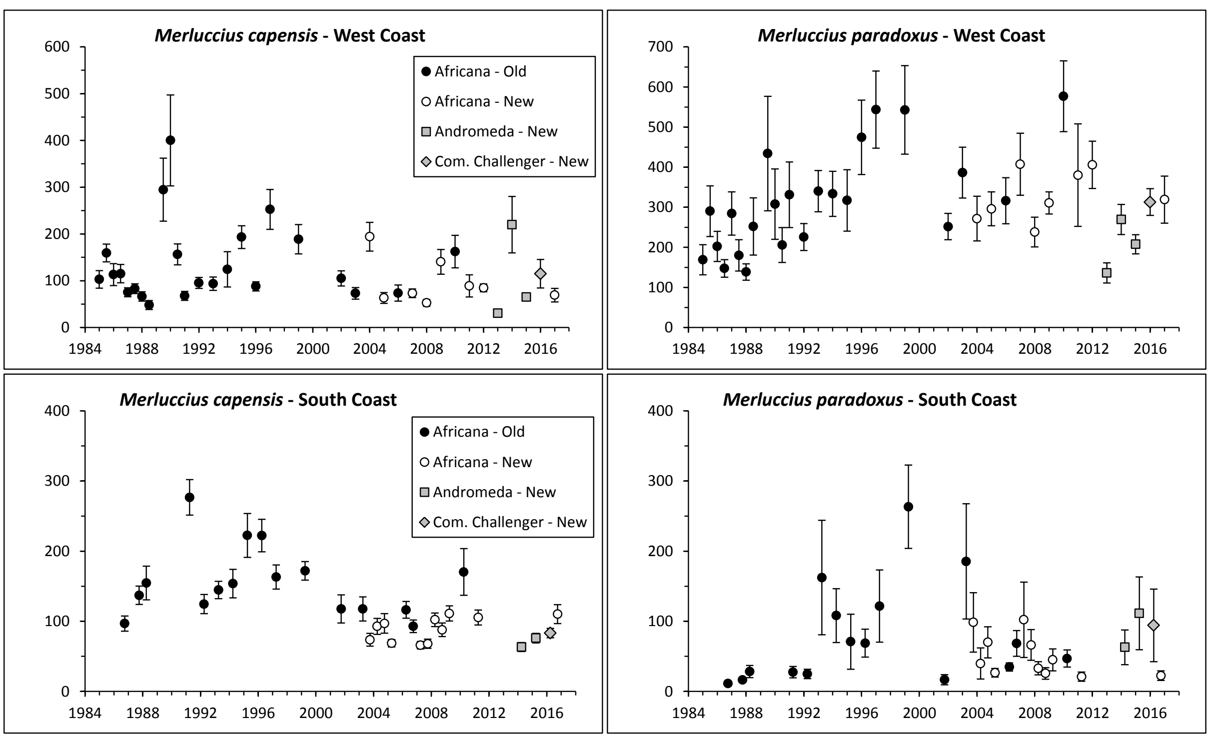



**Figure 5:** Survey-derived hake abundance estimates ('000 t ± 1 SE) shown by species and coast. The various vessel – gear combinations are indicated. Note that only surveys that extended to the 500 m isobath are shown.

# OTHER DATA

## IN PRINCIPLE BY:

- **a) COAST** always
- b) **SPECIES** only surveys
- c) **GENDER** partial and recent only

1. **Commercial proportions at length** (**NB**: NOT species disaggregated)

**2. Survey proportions at length**

**3. Age at length**

**4. Female maturity at length ogives**

**5. Weight at length**

# Hake 2017 Reference Case Assessment Results

Table B1: Estimates of management quantities for the Reference Case.

| | | 2017 RC |
|---|---|---|
| | -lnL total | -5244.1 |
| *M. paradoxus* | $K^{sp}$ | 547 |
| | $B^{sp}_{MSY}$ | 109 |
| | $B^{sp}_{2016}$ | 106 |
| | $B^{sp}_{2017}$ | 112 |
| | $B^{sp}_{2016}/K^{sp}$ | 0.19 |
| | $B^{sp}_{2017}/K^{sp}$ | 0.20 |
| | $B^{sp}_{2016}/B^{sp}_{MSY}$ | 0.97 |
| | $B^{sp}_{2017}/B^{sp}_{MSY}$ | 1.03 |
| | $MSY$ | 141 |
| *M. capensis* | $K^{sp}$ | 187 |
| | $B^{sp}_{MSY}$ | 33 |
| | $B^{sp}_{2016}$ | 119 |
| | $B^{sp}_{2017}$ | 120 |
| | $B^{sp}_{2016}/K^{sp}$ | 0.64 |
| | $B^{sp}_{2017}/K^{sp}$ | 0.64 |
| | $B^{sp}_{2016}/B^{sp}_{MSY}$ | 3.57 |
| | $B^{sp}_{2017}/B^{sp}_{MSY}$ | 3.62 |
| | $MSY$ | 79 |

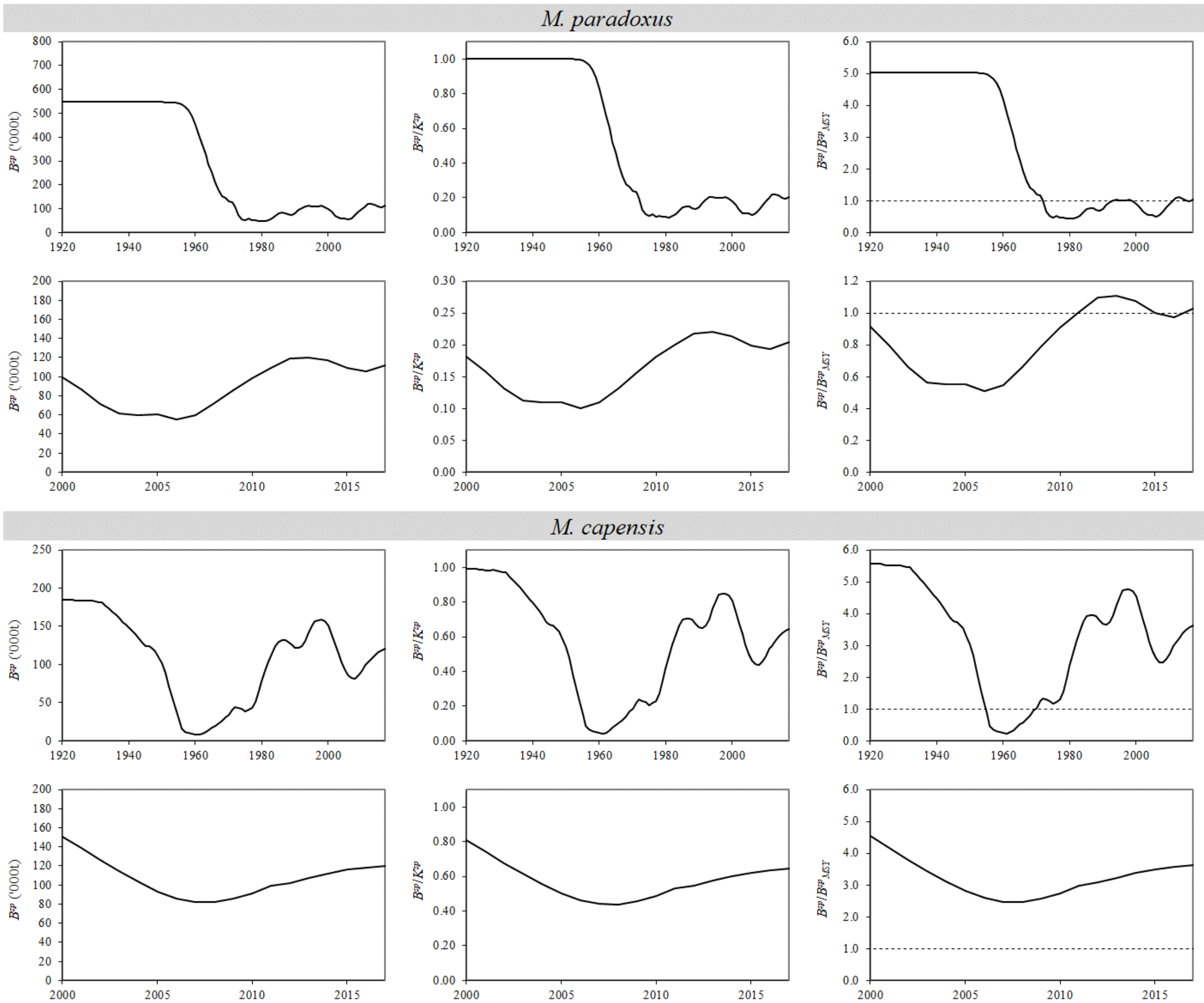



**Figure B1**: Spawning biomass trajectories (in absolute terms, and relative to pre-exploitation level and $B_{MSY}$) for the RC. The second and last rows repeat the first and third rows but with a different year range.

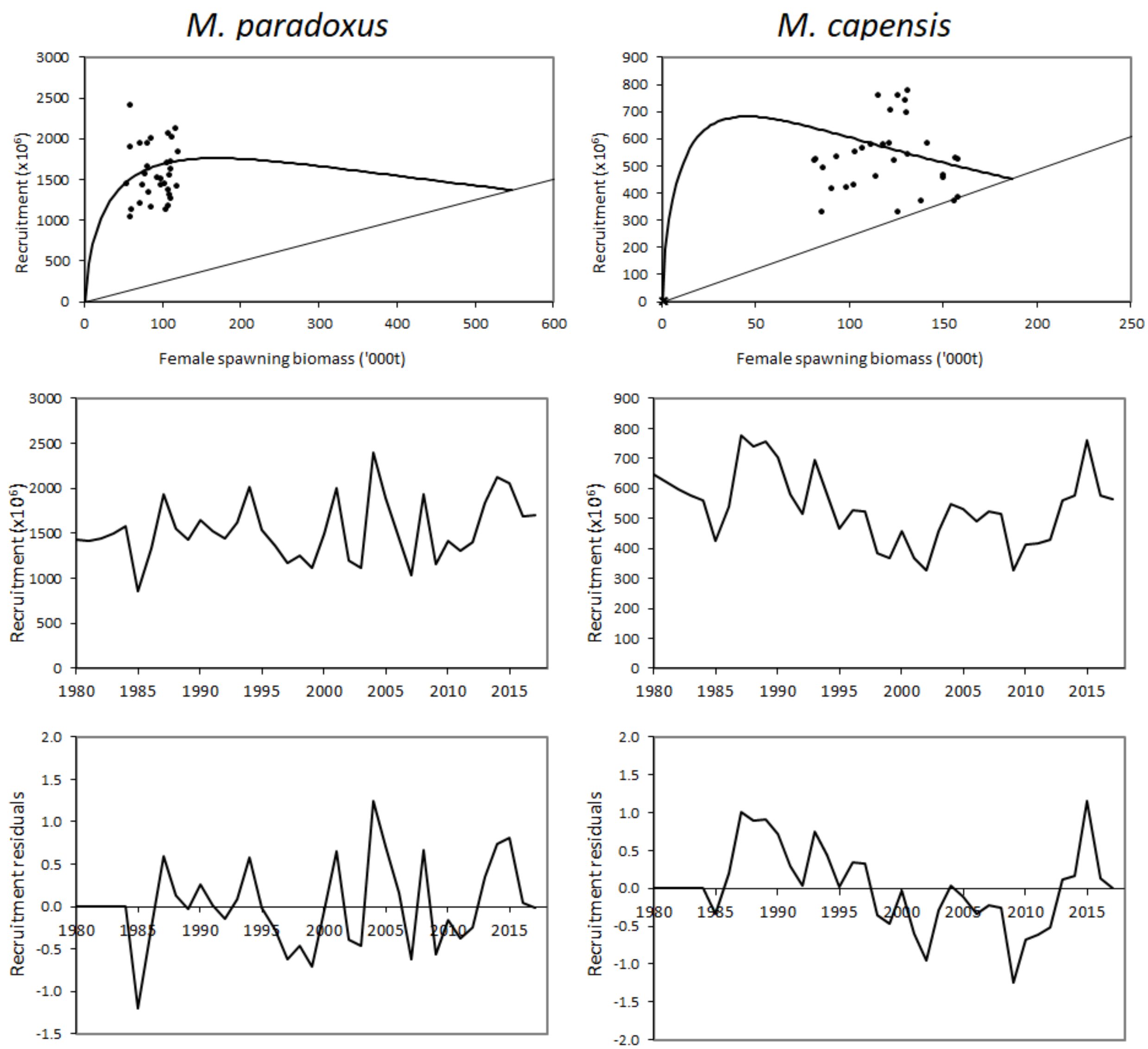



**Figure B2**: Stock-recruitment curves and recruitment trajectories for the Reference Case.

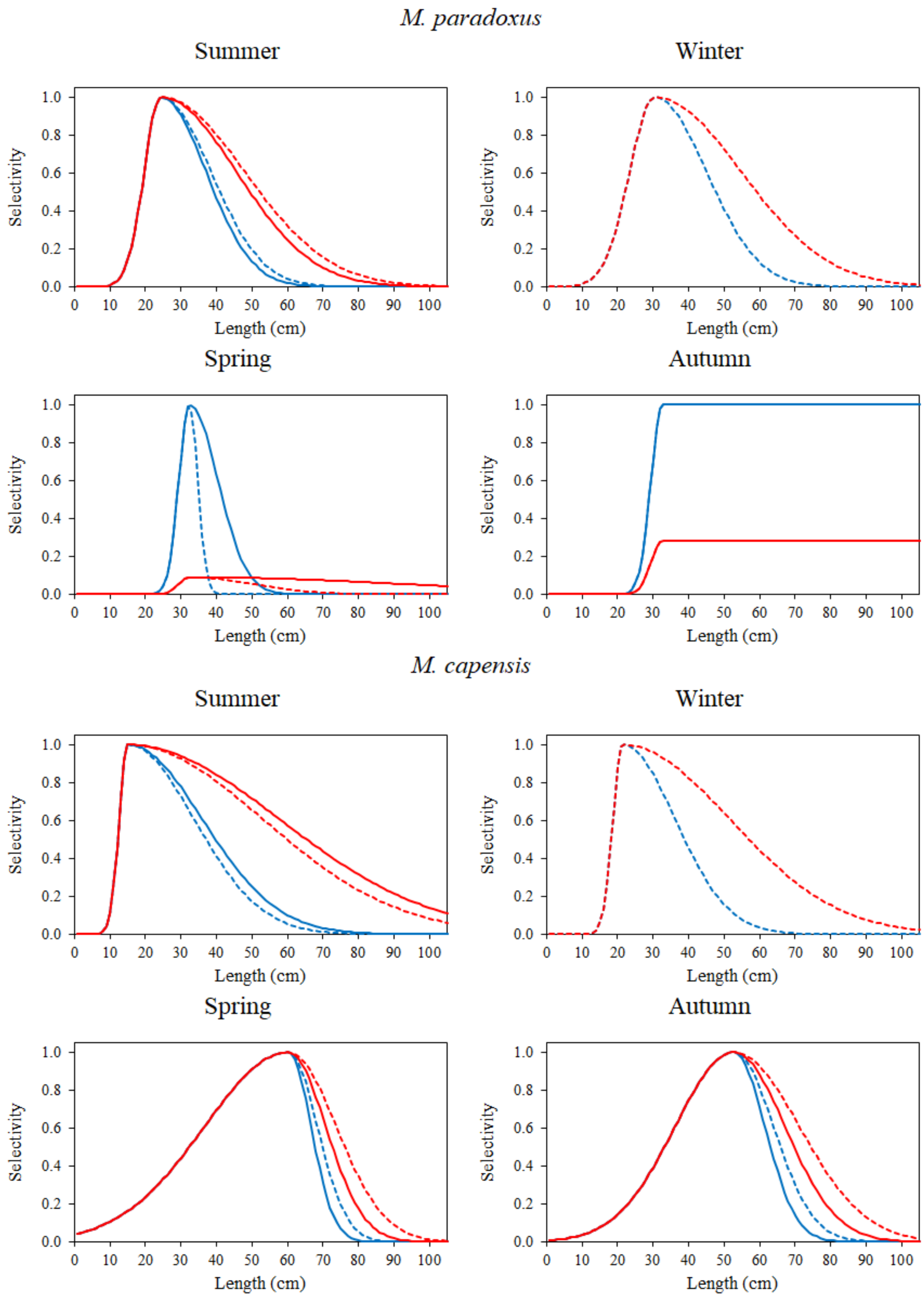



**Figure B3**: Survey selectivities-at-length for the Reference Case (blue curves for males, red curves for females, dashed curves for old gear and full curves for new gear).

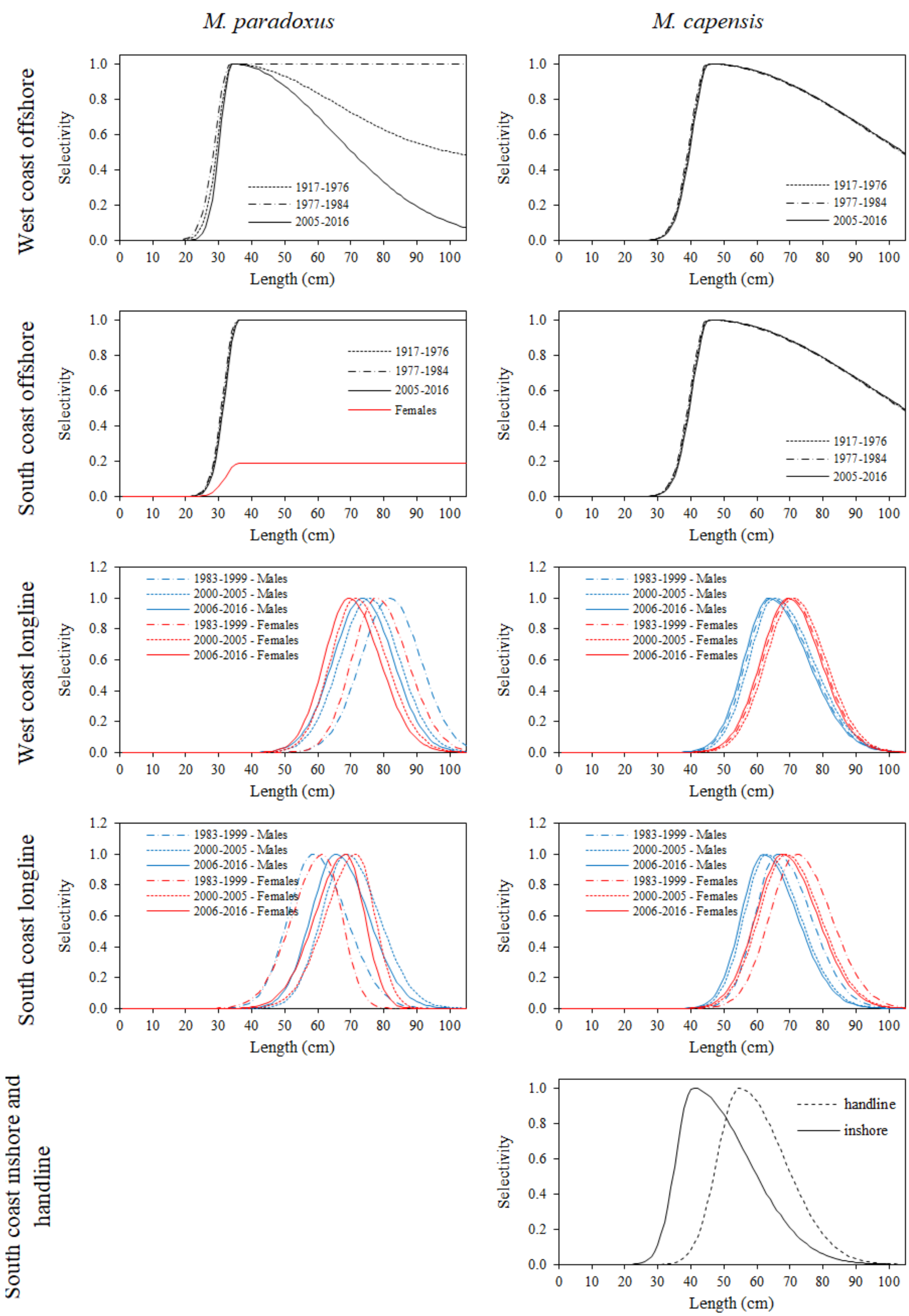



**Figure B4**: Commercial selectivities-at-length for the Reference Case (black curves for sex-aggregated, blue curves for males and red lines for females).

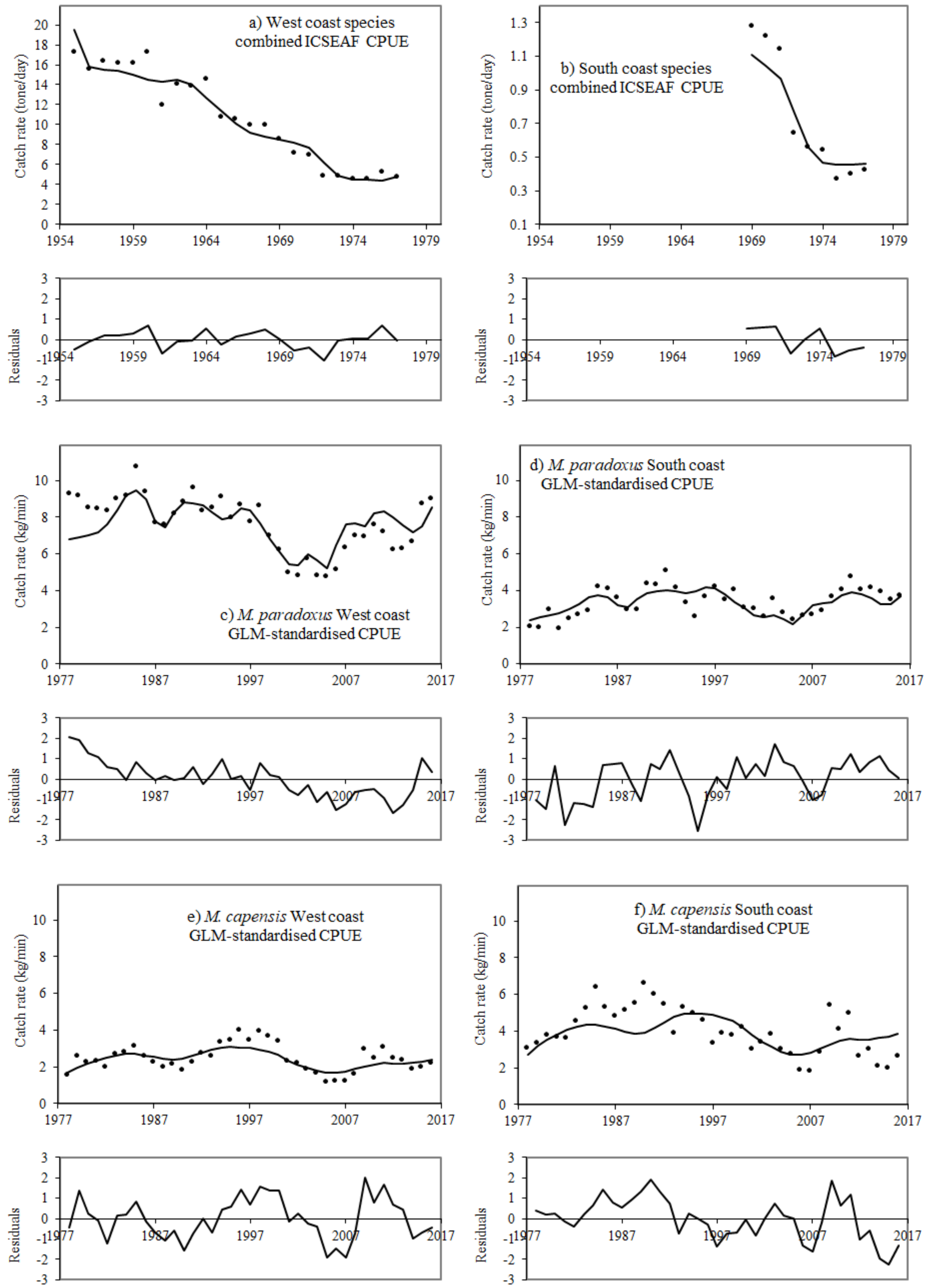
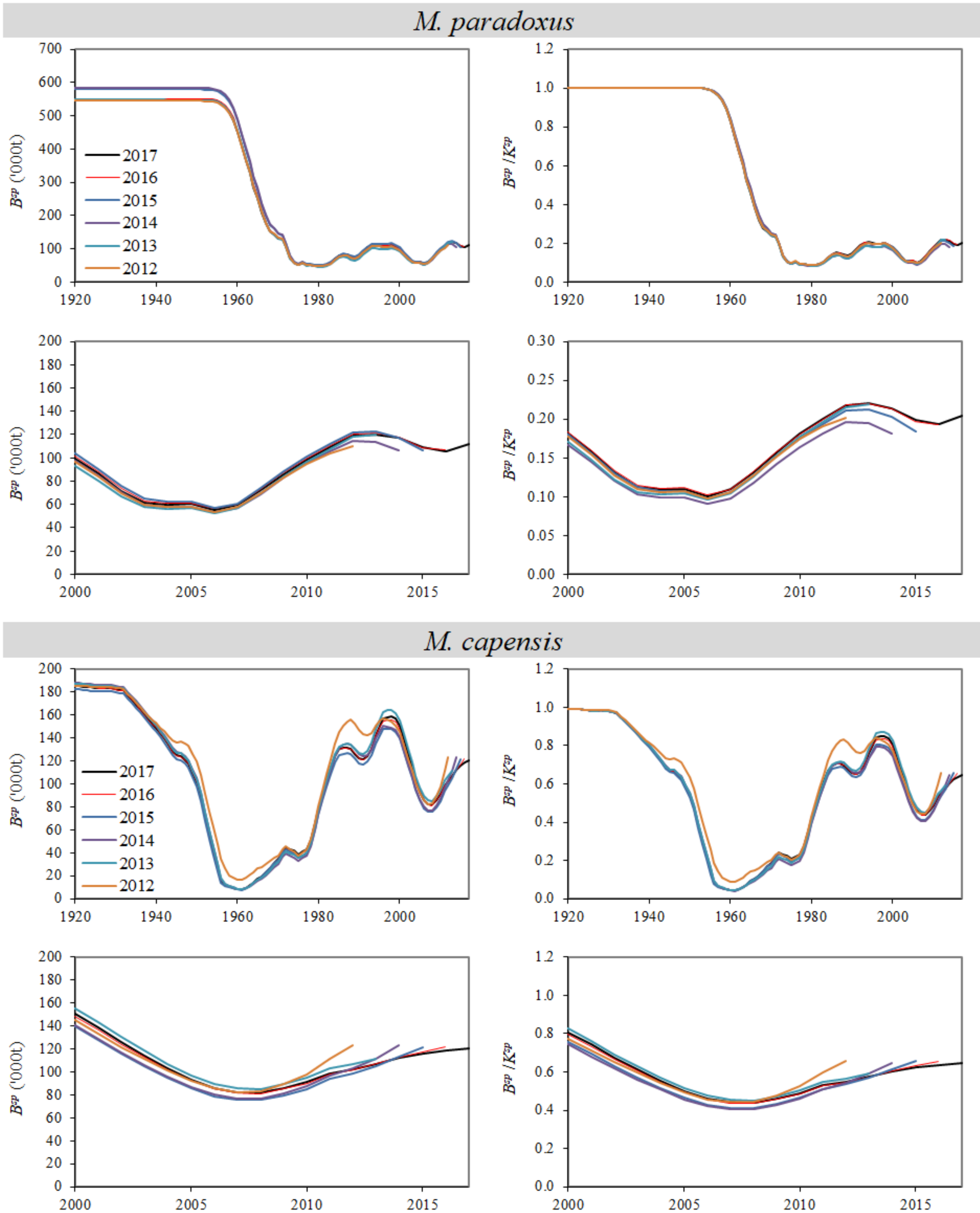



**Figure B5**: Fits to the CPUE series, with standardized residuals, for the Reference Case.

# RETROSPECTIVES – SPAWNING BIOMASS

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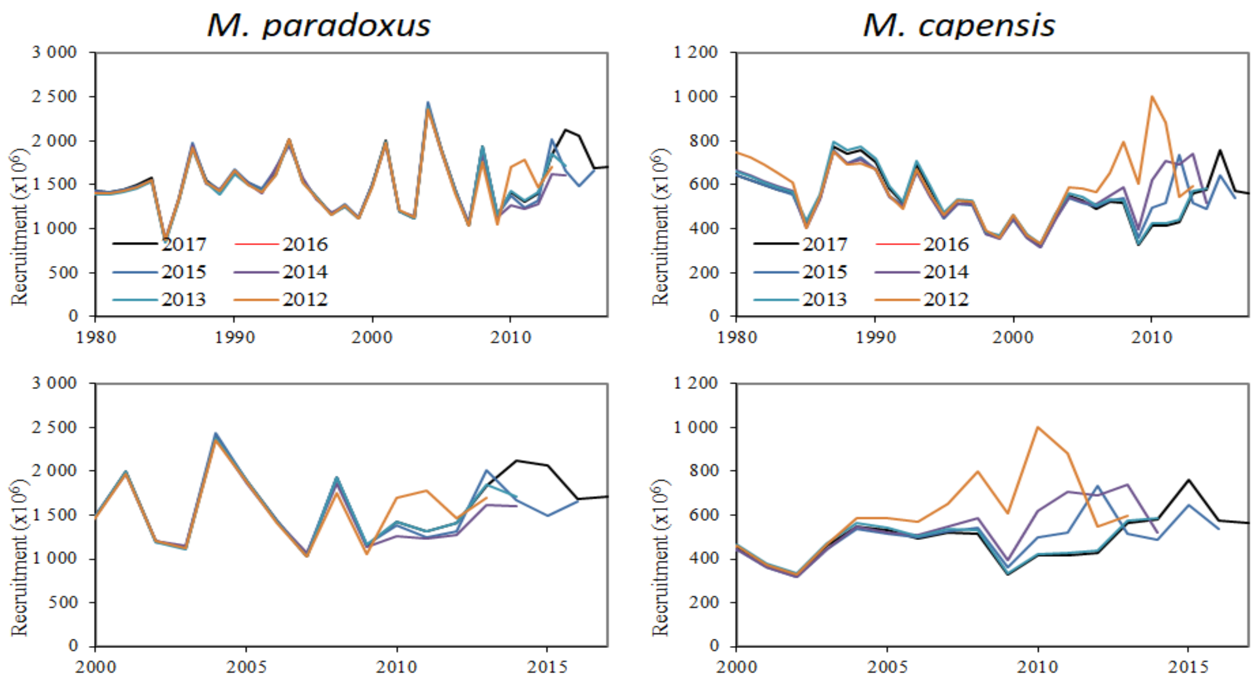


# RETROSPECTIVES: RECRUITMENT

# LIST OF QUESTIONS REGARDING THE 2018 HAKE OMP REVISION

Questions initially considered more important have been yellow highlighted

## Checks on existing assessment/operating model fits (with emphasis on the Reference Case - RC)

1) Is the new selectivity model adequate/appropriate?

*A previous Panel encouraged change to a double normal form for selectivity.*

2) Are the stock-recruitment models used adequate/appropriate, including the extent of annual variation about these relationships?

*The input $\sigma_R$ value is 0.45 (linearly down to 0.1 in the last five years of the assessment) and the output values are 0.52 and 0.56 for M. paradoxus and M. capensis respectively.*

3) Are other fit diagnostics, especially for the CPUE and survey abundance residuals, satisfactory? Is the systematic overestimation of recent south coast *M. capensis* CPUE a cause for concern?

4) Is sex-disaggregation of the model warranted given the limited sex-specific data?

5) Could the shrinkage procedure used for estimation of recent recruitments be improved?

*See MARAM/IWS/2017/Hake/P2 Section 3.6 (final paragraph) and Figure B2.*

6) Currently OMP testing projections are initiated from MPLE estimates. How might taking estimation uncertainty into account best be achieved?

*This has not been given priority previously under the assumption that uncertainty is dominated by large model structure uncertainly. Ideally estimation uncertainty could be incorporated through use of a variance-covariance matrix from the Hessian; however ADMB convergence is seldom sufficient to produce a Hessian. Should attempts be made to obtain a Hessian by fixing some estimable parameters with relatively little impact on key results at their MPLE values?*

# SOUTH COAST CAPENSIS CPUE CONCERNS

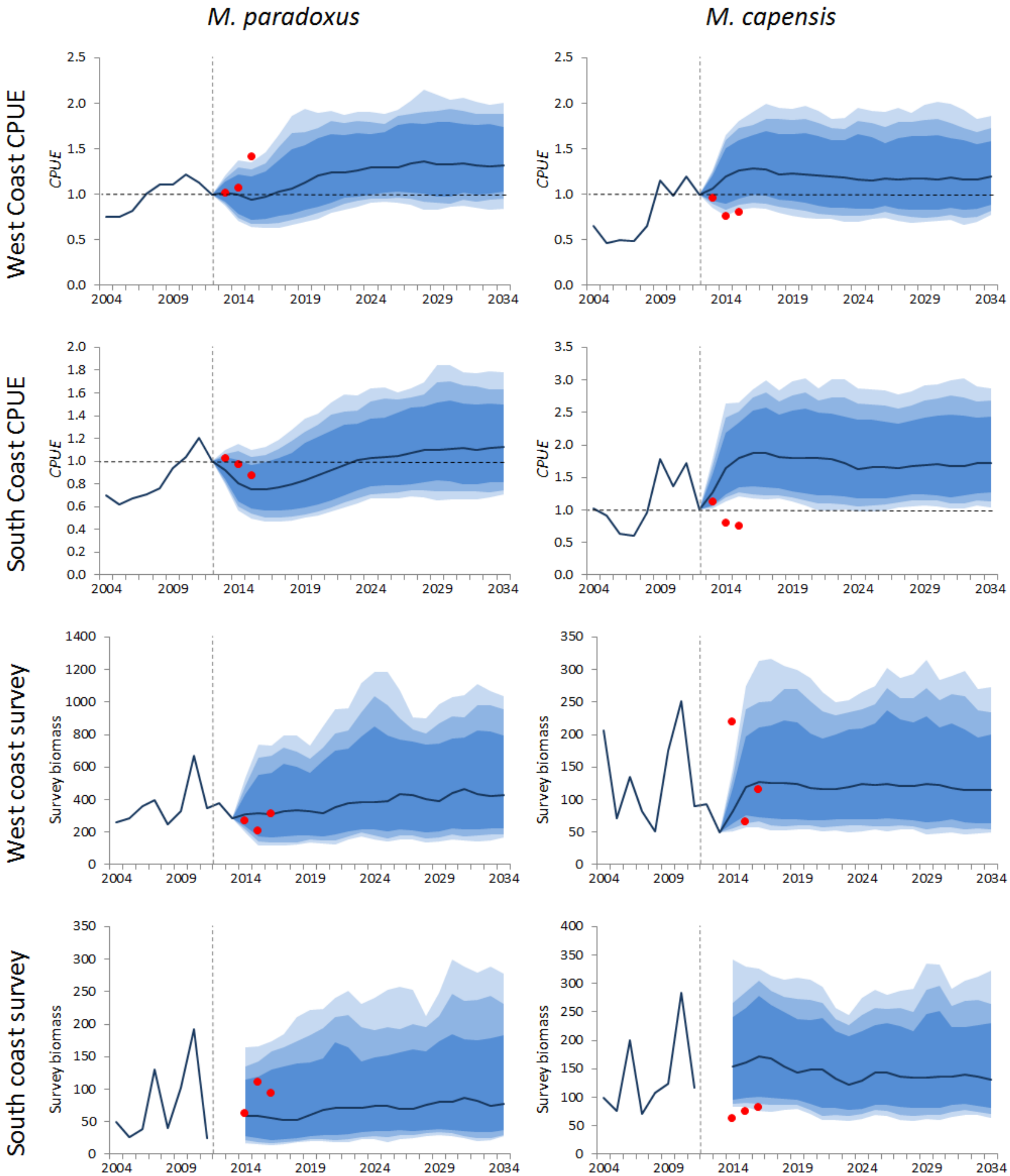


**Figure 1**: Projections (95%, 90% and 80% PI and medians) for the Reference Set under OMP-2014 compared with the most recent resource abundance index data. The red dots show the newest data points. For the survey, the newest data points are shown assuming a *q* ratio of 1 between the *Africana* and the industry vessels.

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**Checks on existing assessment/operating model fits (with emphasis on the Reference Case - RC)**

7) Was the basis for the previous Reference Set (RS) selection adequate, and if not how should future selections be made?

   *See MARAM/IWS/2017/Hake/BG2 and BG3 for the basis for the 2014 RS selection, and MARAM/IWS/2017/Hake/P4 for an update of this RS.*

8) Can the estimation of B/Bmsy be improved?

   *See MARAM/IWS/2017/Hake/P2 (Table B1) and P4 for estimates and there extent of variability. The process of MSC certification accords much attention to such estimates. How best are they summarised/improved given this variability?*

9) Was the previous set of robustness tests adequate?

   *See MARAM/IWS/2017/Hake/P5.*

# REFERERENCE SET: THREE KEY AXES OF UNCERTAINTY

## *Pre-1978 species split of the offshore trawl catches:*

Centre years for change from *M. capensis* to *M. paradoxus* preponderance in catch: 1950, 1958 and 1965.

## *Natural mortality-at-age specifications:*

Natural mortality vectors: "Mmed": $M_{2-}$=0.75 and $M_{5+}$=0.375, "Mlow": $M_{2-}$=0.6 and $M_{5+}$=0.25 and "Mhigh": $M_{2-}$=0.9 and $M_{5+}$=0.5.

## *Stock-recruitment relationships*:

Stock-recruitment relations: "Ricker": modified Ricker, "BH": Beverton-Holt, *h* estimated, and "BHmod": Beverton-Holt –see graph. (Forcing lower steepness *h* gave fits that were too poor.)

**INITIAL INTENT**

Full cross of 3 center-years x 3 natural mortality vectors x 3 stock-recruitment relationship (27 OMs)

*but then excluded*

a) Cases where only one of centre year for species split and M vector changed from central choice (to reduce total number from 27 to 15 for easier handling).

b) Dropped two cases where estimated Bmsy/K for *M. capensis* seemed unreasonably low at 0.11 .

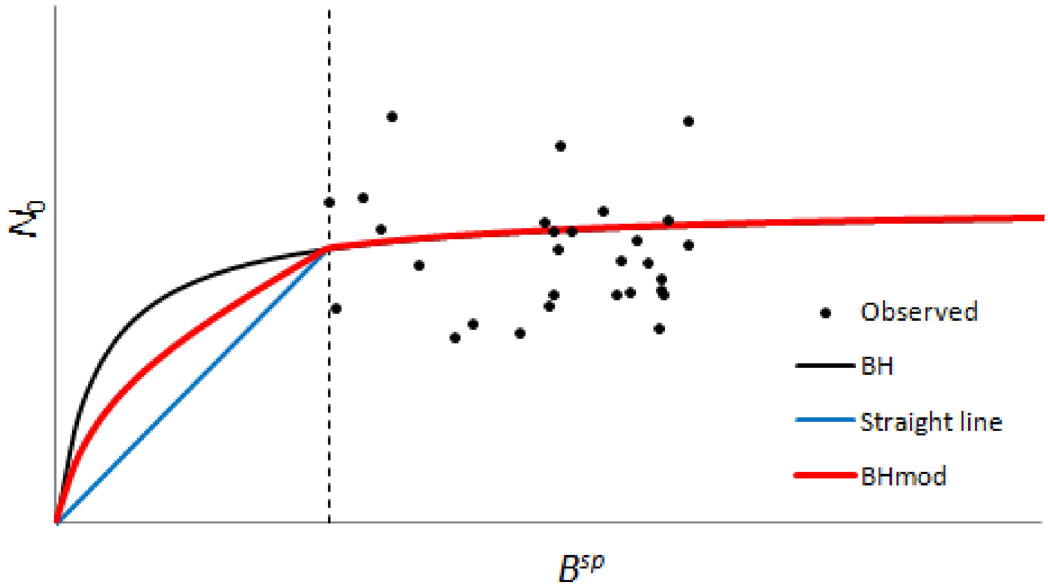


Figure 1: Schematic representation of the "BHmod" stock-recruitment curve.

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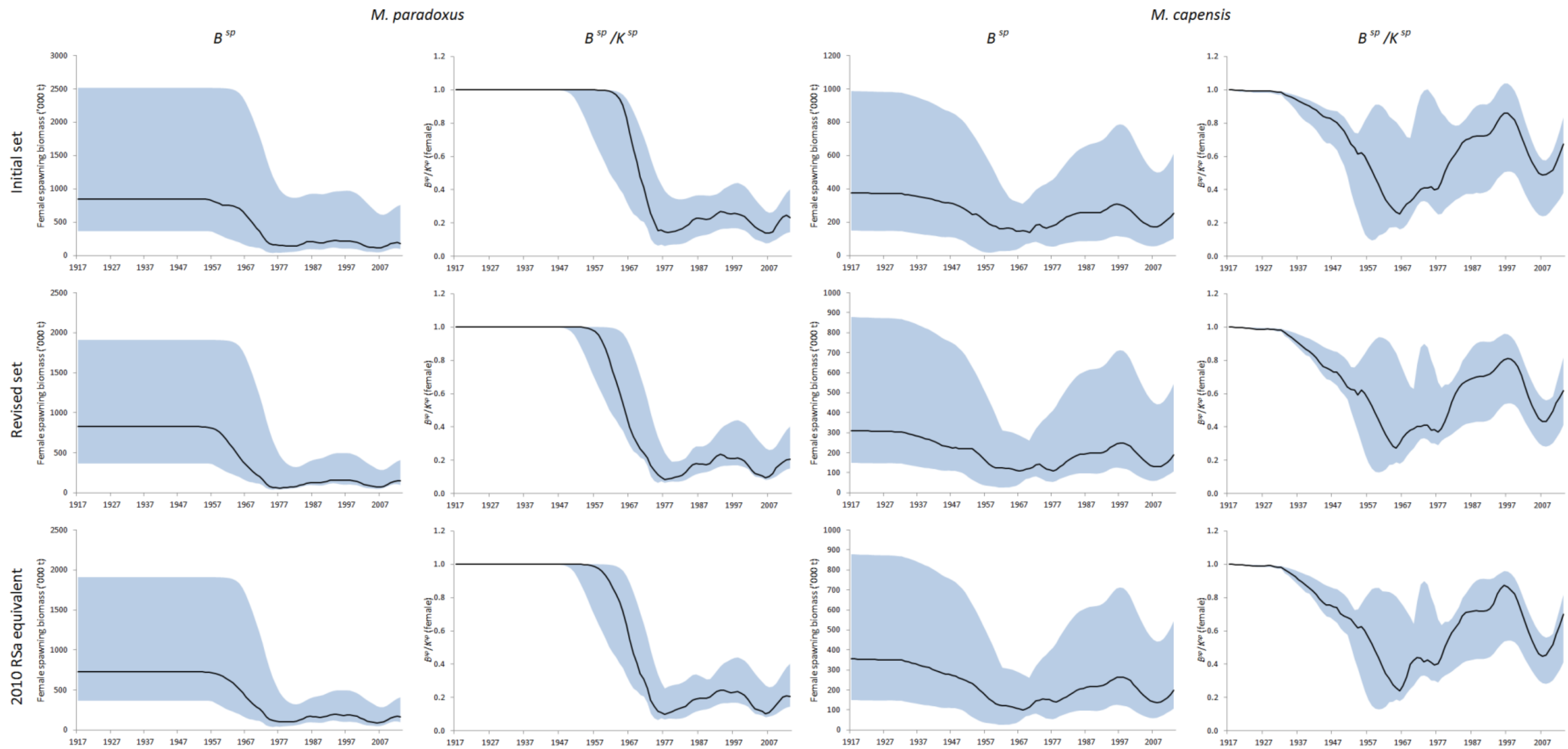
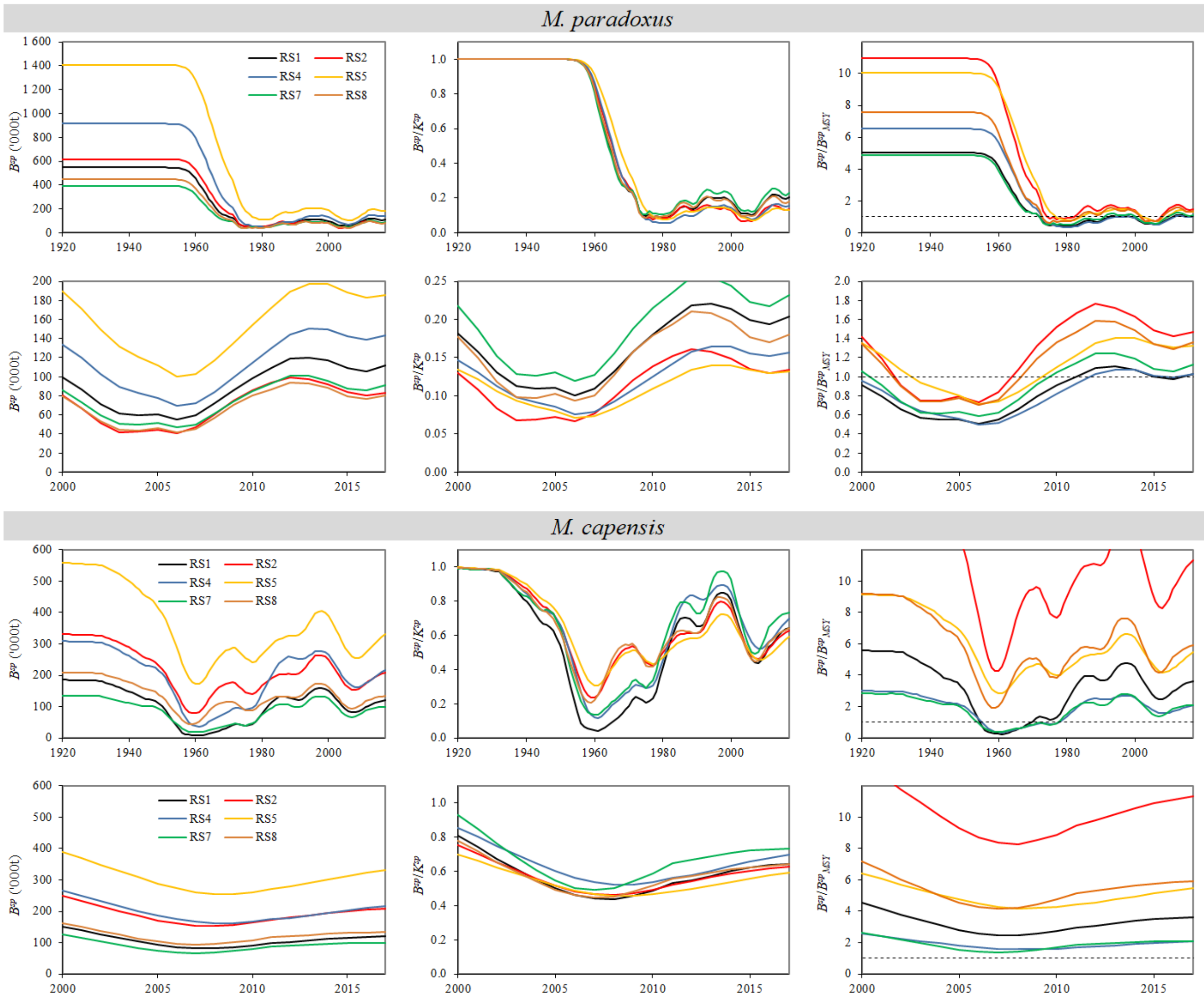
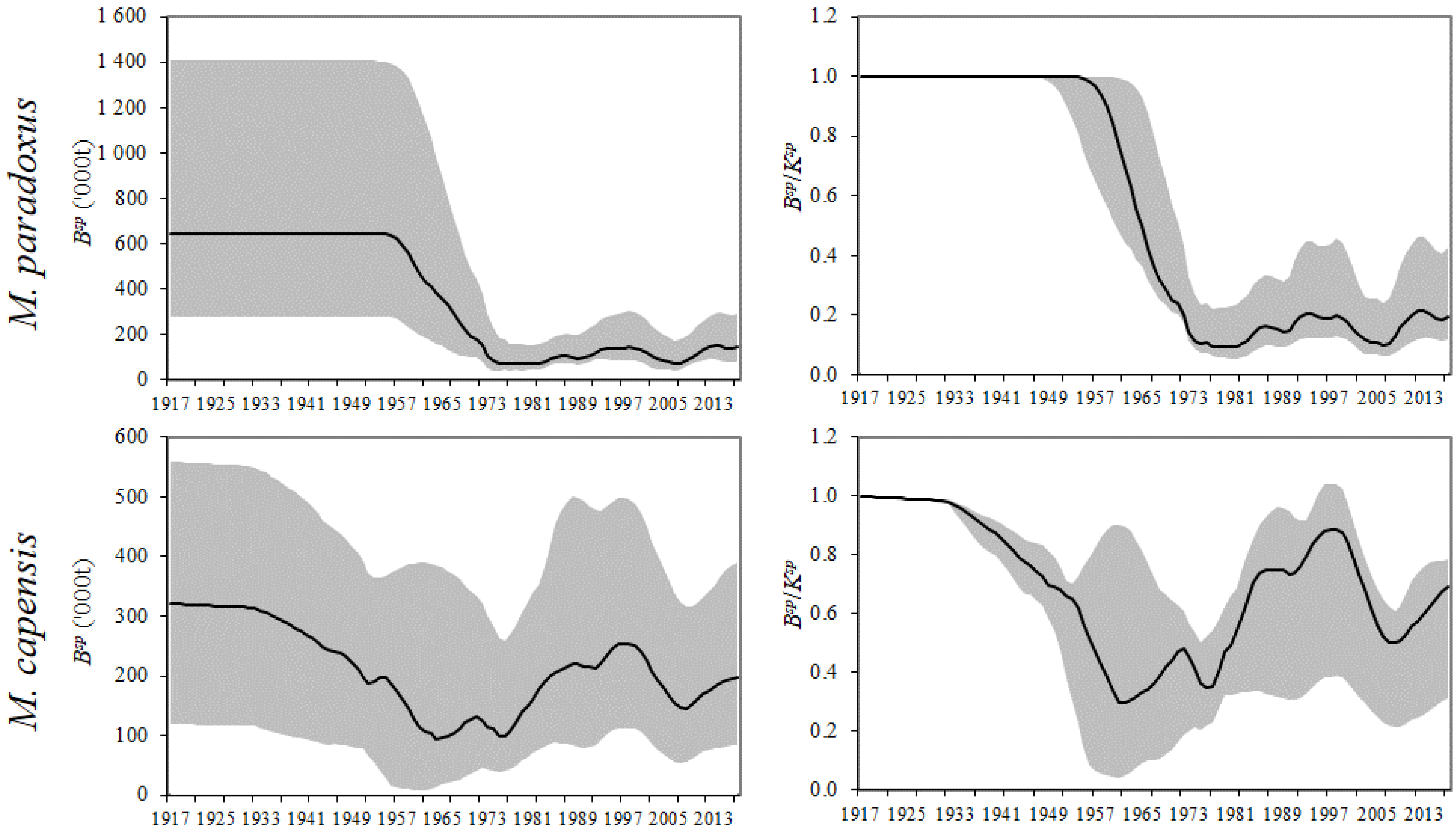



**Figure 3**: Median (black line) with minimum-maximum range (shading) spawning biomass trajectories (in absolute terms and relative to pre-exploitation level) for *M. paradoxus* and *M. capensis*, for the **27 OMs** of the ***initial*** set (first row), for the **15 OMs** of the ***revised*** set (second row), and for the set of 9 OMs most nearly equivalent to the 10 OMs used in the **2010 RSa** (third row).

# EXAMPLES FROM THE UPDATED REFERENCE SET




M. paradoxus
M. capensis
$B^{sp}$ ('000t)
$B^{sp}/K^{sp}$
1 600
1 400
1 200
1 000
800
600
400
200
0
500
300
100
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1917 1925 1933 1941 1949 1957 1965 1973 1981 1989 1997 2005 2013

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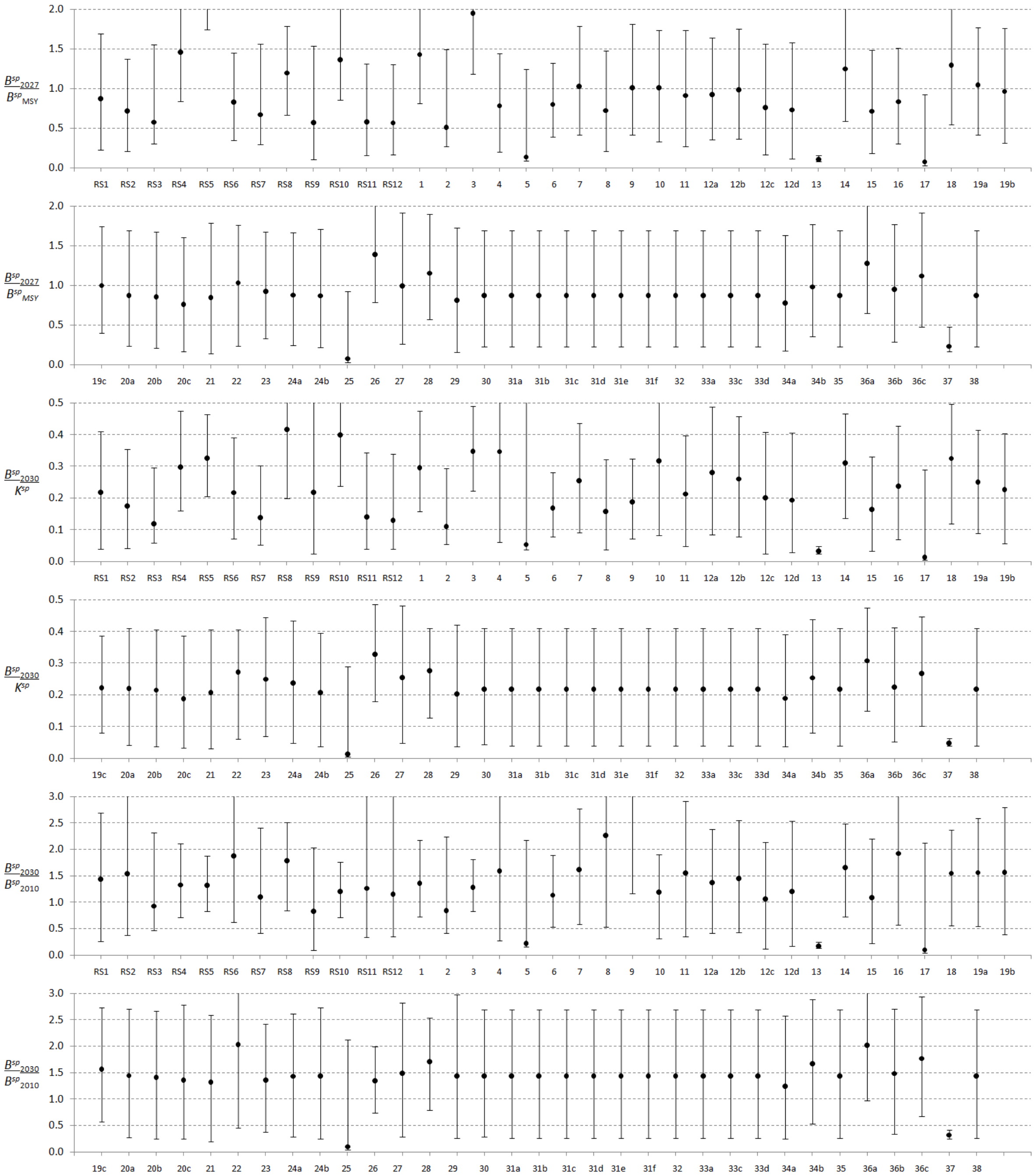

Selected a few on which to focus based on projections under a constant catch of 150 000t (plots above for *M. paradoxus*).

## LIST OF QUESTIONS REGARDING THE 2018 HAKE OMP REVISION

**Clear further possible lines of investigation into the assessment/operating models**

10) Should a change be made to use of *M*-at-age estimates from the hake predation model – an average over last 2-3 decades, or time varying by year since commencement of fishery?

*See MARAM/IWS/2017/Hake/P6.*

11) Should a penalty function on survey *q*'s be included (e.g. restrict to values below 1)?

*See MARAM/IWS/2017/Hake/P2, Table 2, indicating some estimated values of survey q's to be > 1.*

12) Should a penalty function on von Bertalanffy *Linf* values be included?

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13) How best should (differing?) *q* values for surveys be estimated given gear changes and sometime use of industry vessels?

*See MARAM/IWS/2017/Hake/P2, both the final part of section 3.2, and MARAM/IWS/2017/Hake/BG4 which includes an estimate of q for an industry vessel used for surveys relative to the research vessel (Africana) used normally.*

14) Is there a need to change to random walk models for selectivity?

*See MARAM/IWS/2017/Hake/BG5 for an example of where this has been attempted.*

15) Need the ageing error matrices used be reconsidered?

*See MARAM/IWS/2017/Hake/P2 section 3.5 for the methodology and MARAM/IWS/2017/Hake/BG6 for the matrices in current use.*

# NATURAL MORTALITY-AT-AGE SUGGESTED BY EXPLICIT HAKE PREDATION MODEL

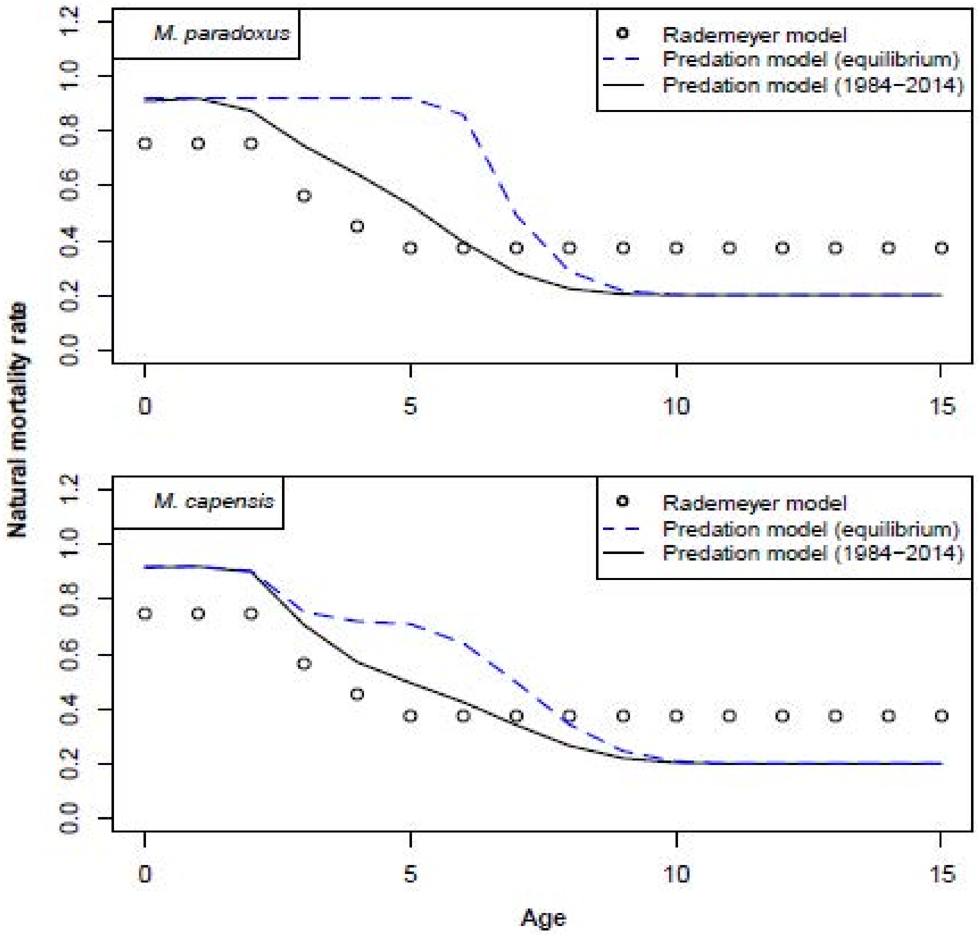


**Figure 1:** Natural mortality rates are shown for the Rademeyer and Butterworth (2014) model and the Ross-Gillespie (2016) hake predation model. The predation model mortality rates are time-varying and are shown for the pre-exploitation equilibrium (dashed blue line) and averaged over the last three decades (1984-2014) (solid black line).

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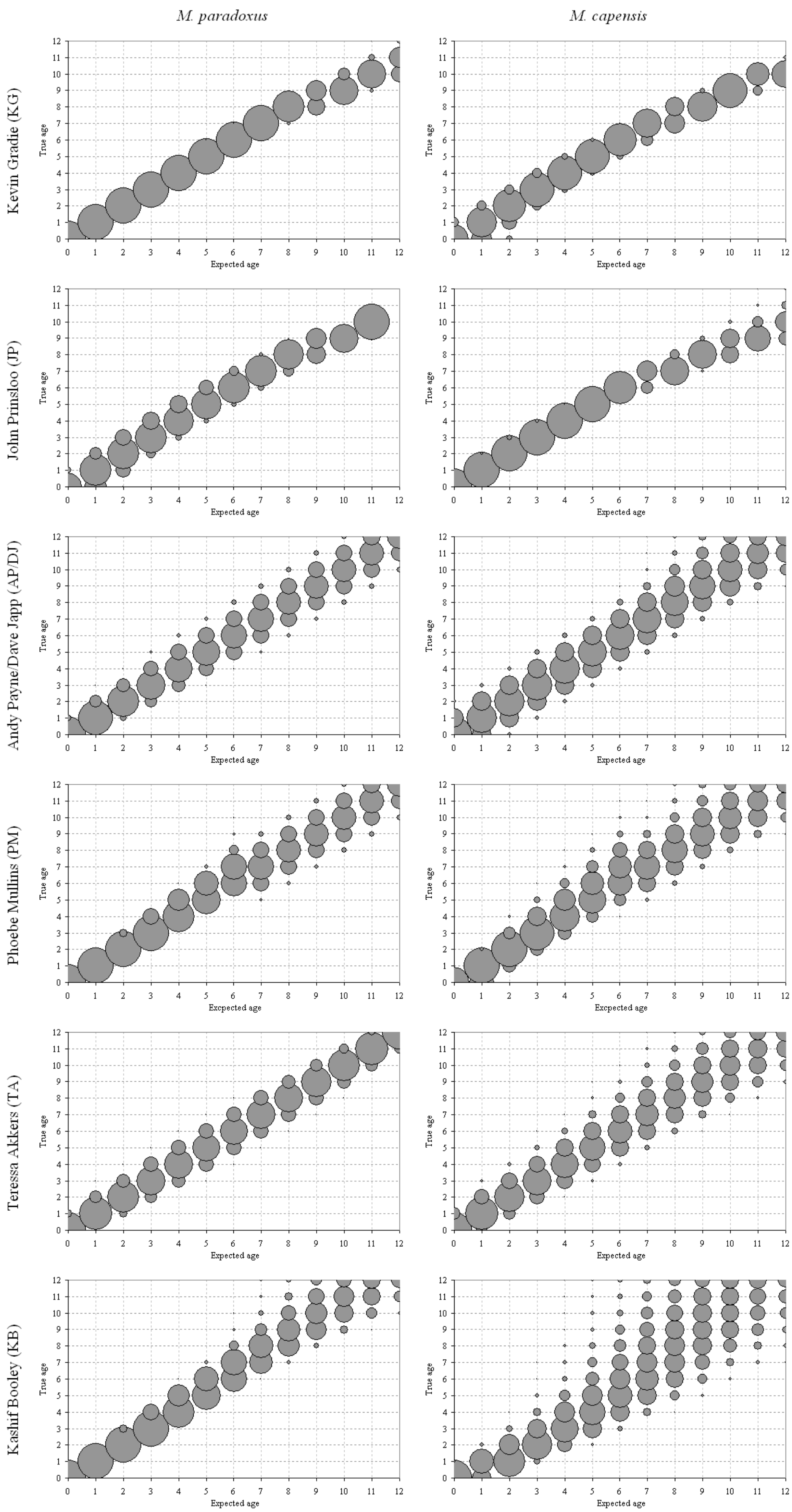


# AGEING ERROR MATRICES – TRUE *vs* EXPECTED

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**Clear further possible lines of investigation into the assessment/operating models**

16) For surveys might changing abundance estimation from the current random stratified to a geostatistical approach constitute an improvement?

*See MARAM/IWS/2017/Hake/P7 for specific suggestions, with MARAM/IWS/2017/Hake/BG7 and BG8 providing background information on the approach put forward.*

17) How best might results from the extension of surveys into deeper water be taken into account?

*See MARAM/IWS/2017/Hake/P8.*

18) How important is the incorporation of further longline catch-at-length data and the development of a longline CPUE series?

*See MARAM/IWS/2017/Hake/P2, Tables App.A.1b and 5d-i for lists of what longline data are available for use in assessments.*

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# BLUE – Random stratified    RED – Geostatistical

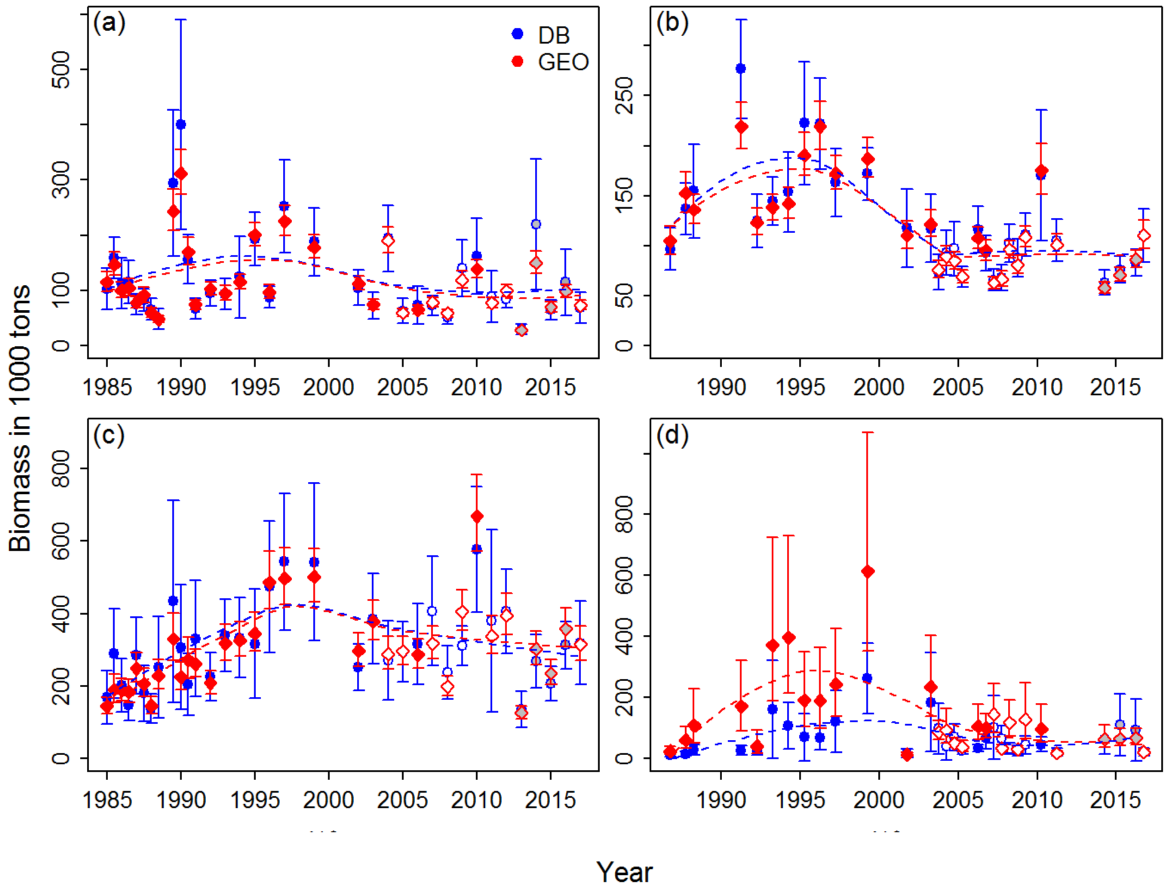


**Fig. 1.** Comparison of estimated indices of abundance (Biomass in tons) using the design-based estimator (DB) and the geostatistical delta-GLMM (GEO) for *M. capensis* along the **(a)** West Coast and (b) South Coast; and *M. paradoxus* along **(c)** the West Coast and **(d)** South Coast. Error bars denote the approximated with 95% intervals and dashed lines represent loess smoothers fitted to each index as a means to illustrate the underlying trends. Solid symbols are for the surveys conducted by the RV Africana with the old gear and open symbols with the new gear, while grey filled symbols are for the surveys conducted using a commercial vessel (by the FV Andromeda in 2013 - 2015; and in 2016 by the FV Compass Challenger in 2016) with the new gear.

**Table 1.** Means and standard deviations (sd) of estimated annual observation error CVs from the current design-based estimator and the geostatistical delta-GLMM estimator, summarized by species and seasonal west coast and south surveys.

| | | | Design-Based | | Geo-Statistical | |
|---|---|---|---|---|---|---|
| Species | Coast | Survey | mean | sd | mean | sd |
| *M. capensis* | SC | Autumn | 0.109 | 0.03 | 0.105 | 0.011 |
| *M. capensis* | SC | Spring | 0.119 | 0.025 | 0.121 | 0.012 |
| *M. capensis* | WC | Summer | 0.178 | 0.053 | 0.123 | 0.009 |
| *M. capensis* | WC | Winter | 0.164 | 0.044 | 0.148 | 0.003 |
| *M. paradoxus* | SC | Autumn | 0.369 | 0.121 | **0.625** | 0.142 |
| *M. paradoxus* | SC | Spring | 0.317 | 0.077 | **0.432** | 0.102 |
| *M. paradoxus* | WC | Summer | 0.179 | 0.052 | 0.157 | 0.009 |
| *M. paradoxus* | WC | Winter | 0.234 | 0.063 | 0.209 | 0.017 |

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16) For surveys might changing abundance estimation from the current random stratified to a geostatistical approach constitute an improvement?

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# BLACK AREA 500 - 1000m

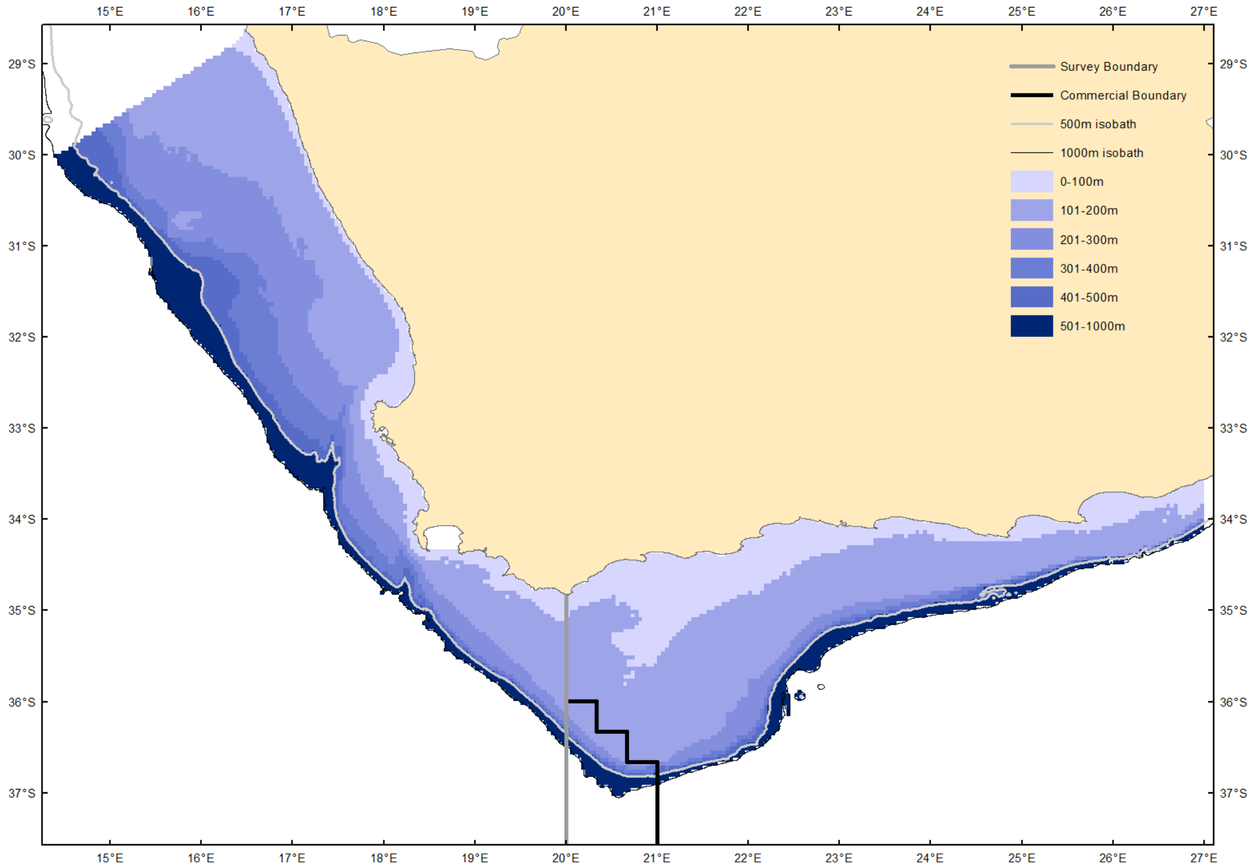


**Figure 1:** Map of South African continental shelf, including the boundary at 20°E used in surveys, the "stepped" commercial data boundary and the dark blue "deeper water" between the 500m and 1000m isobaths.

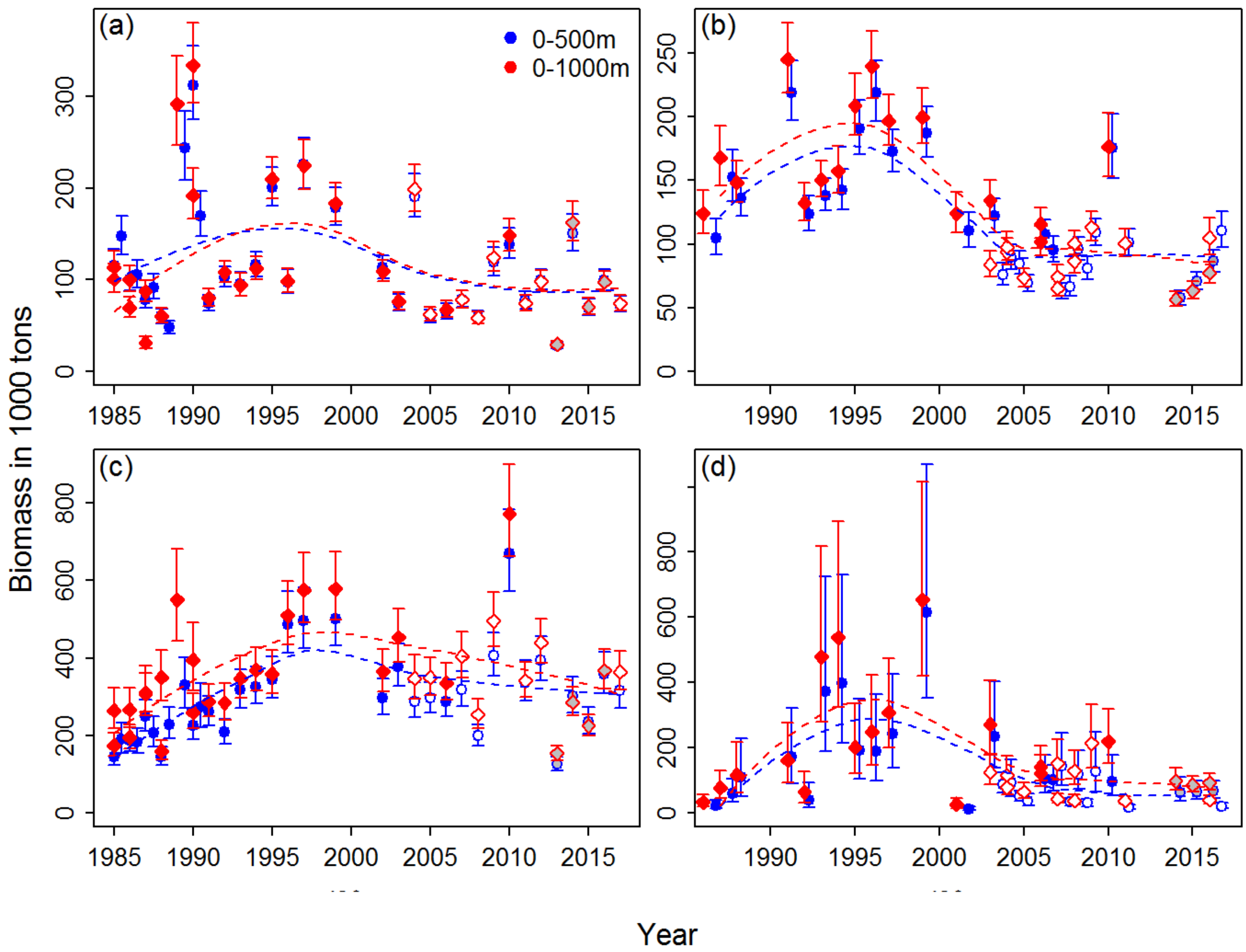


**Figure 4:** Comparison of geostatistical model-based biomass for a subset of trawls conducted within 0-500m depth contour and an extended dataset covering the 0-1000m depth contour for *Merluccius capensis* along **(a)** the West Coast and **(b)** South Coast; and *M. paradoxus* along **(c)** the West Coast and **(d)** South Coast. Error bars denote the approximated with 95% intervals and dashed lines represent loess smoothers fitted to each index as a means to illustrate the underlying trends. Solid symbols are for the surveys conducted by the RV Africana with the old gear and open symbols with the new gear, while grey filled symbols are for the surveys conducted by the FV Andromeda and in 2016 by the Compass Challenger with the new gear.

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## Possible more extensive assessment modification options

19) Should more complex stock-structure, including perhaps an extension to a transboundary assessment including Namibia be considered?

*MARAM/IWS/2017/Hake/BG1 refers to genetic evidence suggesting two stocks on M. capensis in South African waters, but one of these is relatively far north on the SA west coast that only a small component of the total SA M. capensis catch would be taken from it.*

*Regarding possible extension to Namibia, the 2016 Panel remarked that "Development of models for the entire M. capensis and M. paradoxus resources should consider hake in Namibia as well as South Africa. Unfortunately, to date this has proved to be infeasible owing to a lack of data for Namibia being shared. The Panel strongly recommends that efforts be made to allow assessment analysts to have access to all data from the entire southern African region to maximize the opportunities for progress on models that use all of the available information."*

20) Should attempts be made to allow for some explicit movement, either as the basis for an updated RC or as a robustness test?

*See MARAM/IWS/2017/Hake/BG9 for the some of the most recent work in this direction.*

21) Is there any way of independently checking the *M. paradoxus/capensis* biomass ratio implied by the assessments?

*See MARAM/IWS/2017/Hake/P2, Figure B1, which indicates and M. capensis biomass is currently similar to or greater than M. paradoxus biomass, contrary to industry's perceptions.*

# LIST OF QUESTIONS REGARDING THE 2018 HAKE OMP REVISION

## Aspects of the revision of the OMP

22) How should the different Reference Set OMs be weighted in reporting performance statistics?

*See MARAM/IWS/2017/Hake/P9 which applies an approach to weighting different models in inverse relation to the similarity of their results, which is borrowed from an approach to averaging over an ensemble of different climate change models.*

23) Should slope as well as target approaches be used in the OMP's fundamental HCR?

*See MARAM/IWS/2017/Hake/P10 which contrasts results from target- and slope-based approaches in a recent MP development process for Greenland halibut.*

24) Should HCRs that react more rapidly to the most recent data be explored further (this is a particular concern of industry)?

*See MARAM/IWS/2017/Hake/BG13 for results from an earlier investigation of this which failed to achieve success.*

25) Should HCRs that investigate the use of some recruitment index (probably from younger fish in survey) be explored further?

*Results from an earlier investigation of this which failed to achieve success (R Rademeyer, pers. commn).*

# CLIMATE CHANGE ENSEMBLE MODEL AVERAGING IDEA

## DOWNWEIGHT MODELS THAT ARE VERY SIMILAR

## Use Multi-dimensional scaling to measure inter-model "difference"

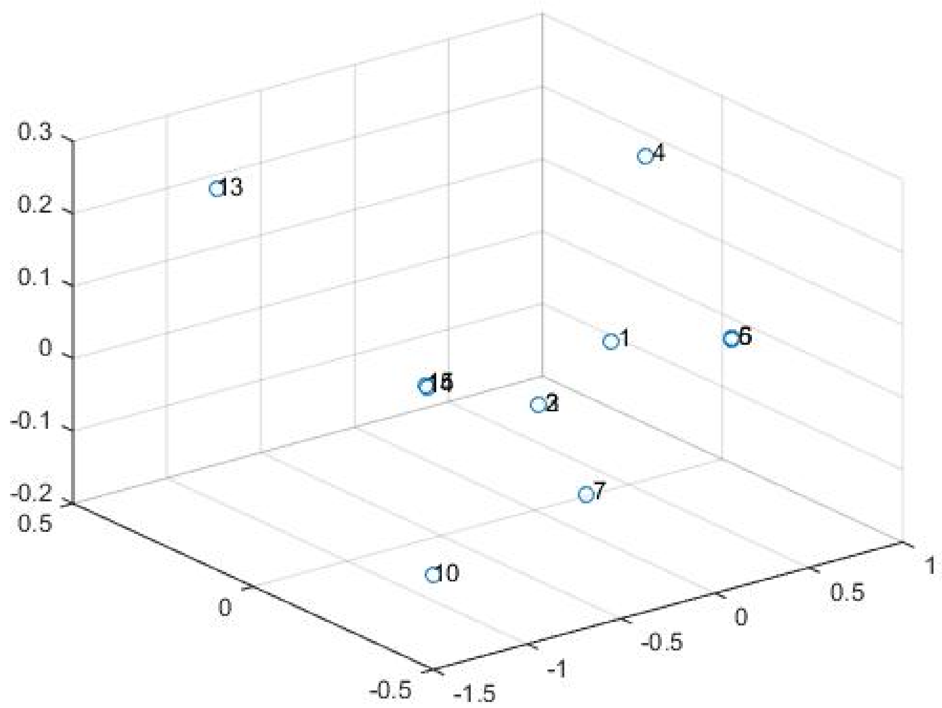


Figure 2: Views from different orientations of the same three-dimensional representation of the proximity matrix for all the RS OMs.

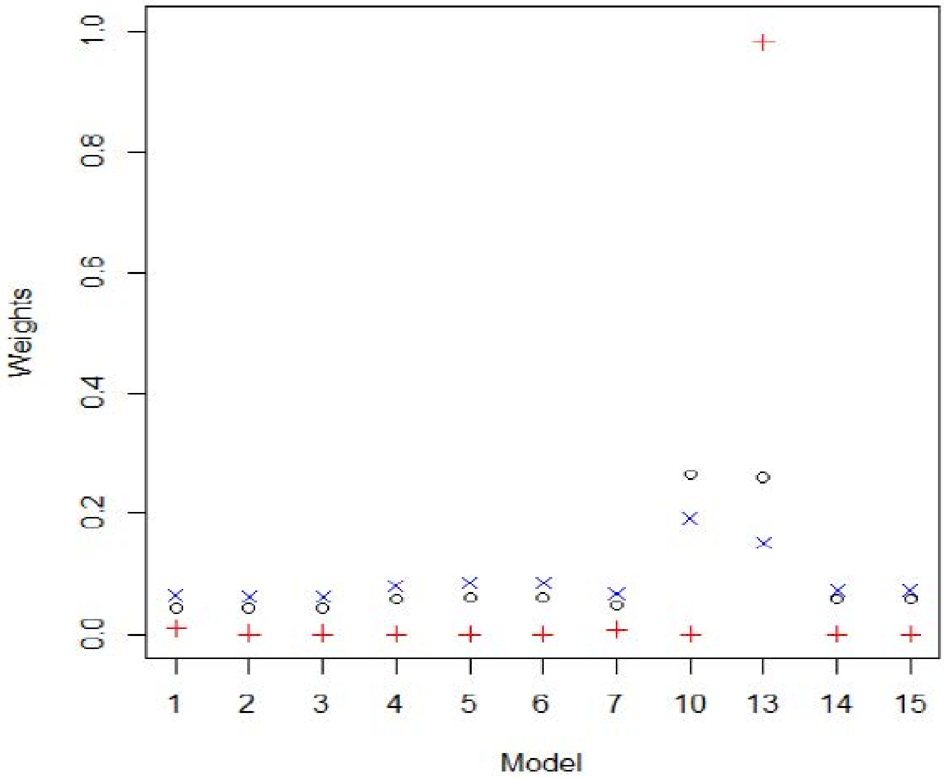


Figure 3a: MDS weights determined using the two different methods – distance averaging described in the main text (blue x) and the uniqueness weighting method described in Appendix C (black diamond) and AIC weights based on log-likelihood differences (red cross).

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# THE CURRENT HAKE OMP IS EMPIRICAL

## IT IS A VARIANT OF A TARGET-BASED APPROACH USED A COMPOSITE INDEX OF ABUNDANCE BASED OF THE MOST RECENT THREE YEARS FOR WHICH DATA ARE AVAILABLE

The formula for computing the TAC recommendation under OMP-2014 is as follows:

$$TAC_{y+1} = C_{y+1}^{para} + C_{y+1}^{cap} \tag{1}$$

with

$$C_{y+1}^{spp} = b^{spp}\left(J_y^{spp} - J_0^{spp}\right) \tag{2}$$

where

$TAC_y$ is the total TAC recommended for year *y*,

$C_y^{spp}$ is the intended species-disaggregated TAC for species *spp* year *y*,

$J_0^{spp}$ and $b^{spp}$ are tuning parameters (see Table 1), and

$J_y^{spp}$ is a measure of the immediate past level in the abundance indices for species *spp* that is available to use for calculations for year *y*.

$J_y^{spp}$ for the abundance indices is computed as follows:

$$J_y^{para} = \frac{1.0J_y^{WC\_CPUE,para} + 0.75J_y^{SC\_CPUE,para} + 0.5J_y^{WC\_surv,para} + 0.25J_y^{SC\_surv,para}}{2.5} \tag{3}$$

$$J_y^{cap} = \frac{1.0J_y^{WC\_CPUE,cap} + 0.75J_y^{SC\_CPUE,cap} + 0.5J_y^{WC\_surv,cap} + 1.0J_y^{SC\_surv,cap}}{3.25} \tag{4}$$

with

$$J_y^{WC/SC\_CPUE,spp} = \sum_{y'=y-3}^{y-1} I_y^{WC/SC\_CPUE,spp} \Bigg/ \sum_{y=2010}^{2012} I_y^{WC/SC\_CPUE,spp} \tag{5}$$

$$J_y^{WC/SC\_surv,spp} = \sum_{y'=y-2}^{y} I_y^{WC/SC\_surv,spp} \Bigg/ \sum_{y=2011}^{2013} I_y^{WC/SC\_surv,spp} \tag{6}$$

# LIST OF QUESTIONS REGARDING THE 2018 HAKE OMP REVISION

## Aspects of the revision of the OMP

26) How should the different Reference Set OMs be weighted in reporting performance statistics?

*See MARAM/IWS/2017/Hake/P9 which applies an approach to weighting different models in inverse relation to the similarity of their results, which is borrowed from an approach to averaging over an ensemble of different climate change models.*

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*See MARAM/IWS/2017/Hake/P10 which contrasts results from target- and slope-based approaches in a recent MP development process for Greenland halibut.*
*28) Should HCRs that react more rapidly to the most recent data be explored further (this is a particular concern of industry)?*
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# THANK YOU FOR YOUR ATTENTION