Further results from an initial simple model of the revised stock structure hypothesis for South African sardine

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Further results for the initial simple model of the revised sardine stock structure hypothesis are presented for a range of truncated normal prior distributions on the annual proportion of WTS spawned off the south coast that are passively transported to the west coast.

Introduction

de Moor (2022) presented some initial results from a simple model of the revised sardine stock structure hypothesis, excluding commercial data. The model estimated the proportion of WTS recruits from the south coast that are passively transported to the west coast with an uninformative prior $p_y \sim U(0,1)$. The estimated values for p_y varied widely, up to almost 1 in some years, with the model estimating that almost all of the peak recruitment at the turn of the century were WTS which were spawned on the south coast and passively transported to the west coast before returning to the south coast. These estimates of p_y are, however, far higher than those of 17.4% and 18% estimated by McGrath *et al*. (2020) and Coetzee pers. Comm, respectively. This document considers the impact of estimating p_y with informative priors.

Methods

The model and data are the same as that used by de Moor (2022) with $R = 2$, except that a range of informative prior distributions on the annual passive movement of WTS from the south coast to the west coast are tested:

$p_y \sim N(0.2, 0.1^2)$	$p_y \sim N(0.2, 0.2^2)$	$p_y \sim N(0.2, 0.4^2)$
$p_y \sim N(0.4, 0.1^2)$	$p_y \sim N(0.4, 0.2^2)$	$p_y \sim N(0.4, 0.4^2)$
$p_y \sim N(0.6, 0.1^2)$	$p_y \sim N(0.6, 0.2^2)$	$p_y \sim N(0.6, 0.4^2)$

All priors are truncated between [0,1].

Results and Discussion

The individual contributions to the objective function are given in Table 1 which indicate an improved fit to primarily the May/June recruit data (Figure 1) and secondly the parasite prevalence-at-length data for less informative priors on p_y. The model estimates for p_y are given in Figure 2, with the proportion passively moving now being close to the mean particularly in the pre-2000 years.

The proportion of sardine actively moving from the west to the south/east coasts are shown in Figure 3, with the numbers of 1-year olds moving south/east shown in Figure 4. In all cases the number of WTS moving from the west to the south coast since 2000[1] (substantially) exceed those of CTS moving from the west to the east coast, as expected *a priori*.

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[1] Except 2010.

The number of recruits to each coast are shown in Figure 5, with recruitment at the turn of the century being higher on the south coast / lower on the west coast for the less informative priors which estimate higher p_y values at that time (Figure 3). The increasing relative importance of WTS recruits spawned on the south coast which move to the west coast with less informative priors can also be seen in Figure 6. Model estimated spawner biomass is given in Figure 7.

Finally, Figure 8 shows that the survey selectivity is still estimated to be lower at many lengths than previously estimated (e.g. by de Moor *et al*. 2017). This will be investigated as the next step.

Another possibility that may be investigated is whether the proportion of passive movement of WTS sardine from the south to the west coasts has remained relatively constant over time, but more favourable conditions on the west coast (van der Lingen 2022) corresponded to higher survival of WTS recruits on the west coast at the turn of the century compared to other years (i.e. time varying M).

References

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Table 1. The individual contributions to the objective function at the joint posterior mode for the alternative options. The corresponding values from the baseline model of de Moor (2020a,b), "2020", are also given.

Option	Obj fn	$-lnL$	$-lnL^{Nov}$	$-lnL^{rec}$	$-lnL^{comp}$	$-lnL^{sur\,p}$	$-lnL^{prev}$	$ln(k_{ac}^{S})$	$move_y$	η_y^t	p_y	$\bar{l}_{1,y}$
2020	1147.4	1076.0	61.6	40.1	-442.9	-387.5	1804.8	-1.3	-30.8	-14.5	-	117.7
$R=2$ (de Moor 2022)	1401.1	1523.8	60.4	38.3		-389.6	1814.8	-1.3	-96.6	-24.9	-	-
$p_y \sim N(0.2, 0.1^2)$	1400.9	1568.4	64.8	56.3		-381.2	1828.5	-1.3	-95.9	-24.9	-45.4	-
$p_y \sim N(0.2, 0.2^2)$	1414.2	1541.3	65.0	40.7		-383.6	1819.2	-1.3	-96.5	-24.9	-4.5	-
$p_y \sim N(0.2, 0.4^2)$	1418.4	1527.7	62.1	37.8		-387.7	1815.5	-1.3	-96.9	-24.9	13.7	-
$p_y \sim N(0.4, 0.1^2)$	1398.7	1546.5	61.9	42.2		-382.9	1825.2	-1.3	-96.1	-24.9	-25.4	-
$p_y \sim N(0.4, 0.2^2)$	1403.1	1534.9	62.4	40.2		-385.5	1817.8	-1.3	-96.6	-24.9	-9.1	-
$p_y \sim N(0.4, 0.4^2)$	1411.5	1525.8	61.0	37.9		-388.5	1815.5	-1.3	-96.6	-24.9	8.4	-
$p_y \sim N(0.6, 0.1^2)$	1374.1	1543.5	63.3	38.9		-381.5	1822.8	-1.4	-95.4	-24.9	-47.6	-
$p_y \sim N(0.6, 0.2^2)$	1390.7	1528.4	60.4	38.7		-387.5	1816.8	-1.3	-96.6	-24.9	-15.0	-
$p_y \sim N(0.6, 0.4^2)$	1406.9	1525.4	60.2	38.3		-388.9	1815.8	-1.3	-96.5	-24.9	4.1	-

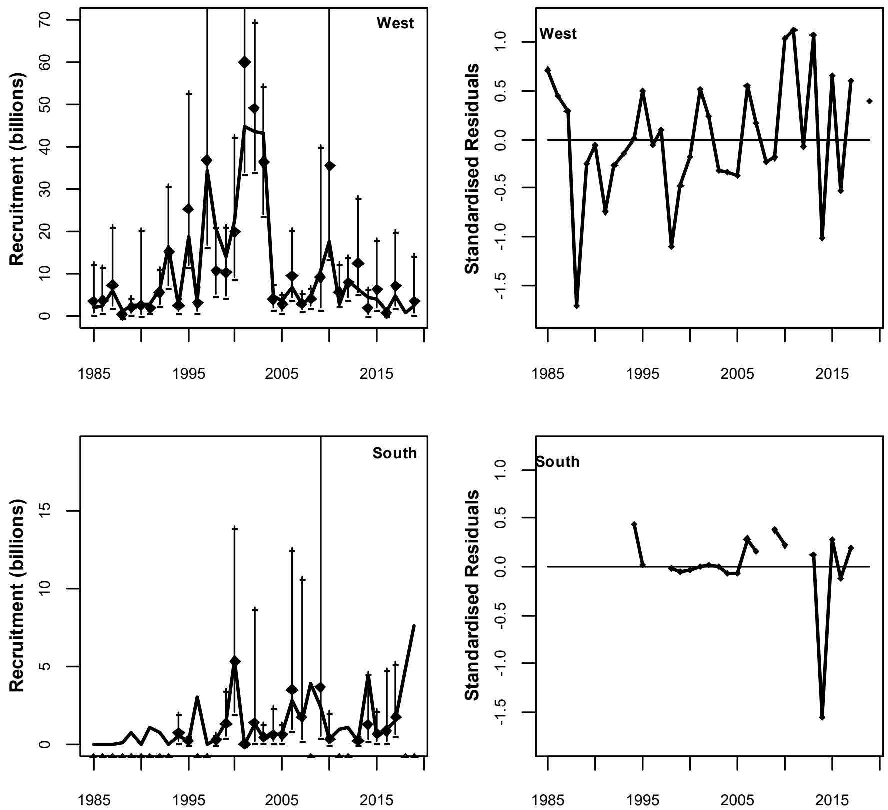

Figure 1a. Acoustic survey estimated and model predicted sardine recruitment numbers from May/June 1985 to 2019 for $R = 2$ with $p_y \sim U(0,1)$. There was no survey observation in 2018; the model predicted value corresponds to the recruitment predicted at 8th June 2018 which is the average start date of the survey from 2016, 2017 and 2019 surveys. The survey indices are shown with 95% confidence intervals. The standardised residuals from the fit are given in the right hand plots.

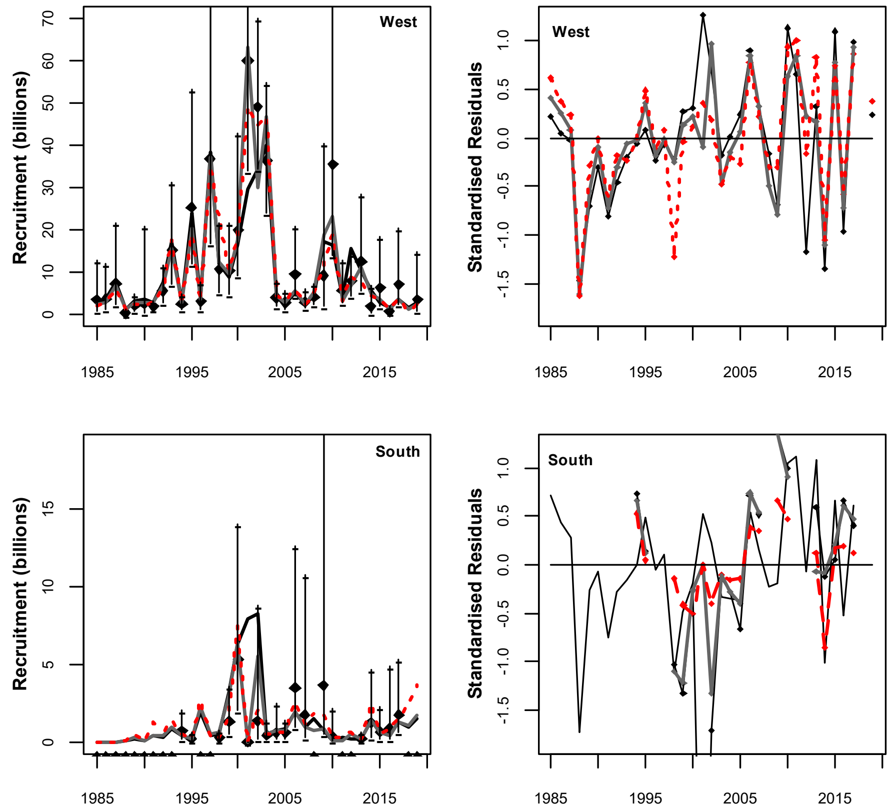

Figure 1b. As for Figure 1a, but with $p_y \sim N(0.2, SD^2)$ and $SD = 0.1$ (black), SD = 0.2 (grey) and SD = 0.4 (red).

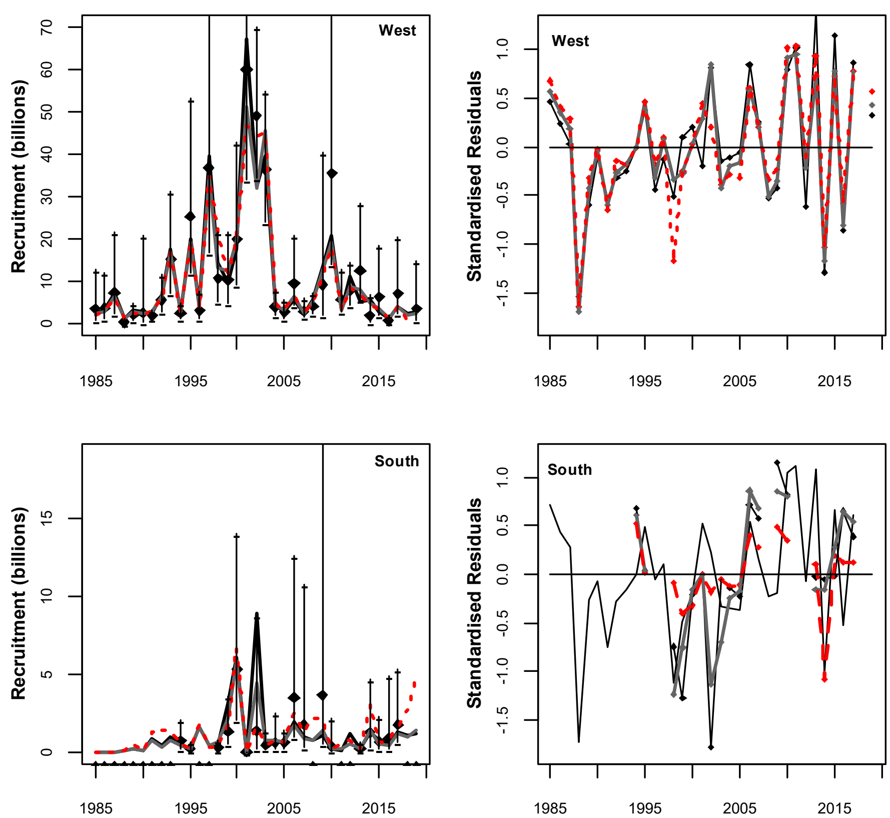

Figure 1c. As for Figure 1a, but with $p_y \sim N(0.4, SD^2)$ and $SD = 0.1$ (black), SD = 0.2 (grey) and SD = 0.4 (red).

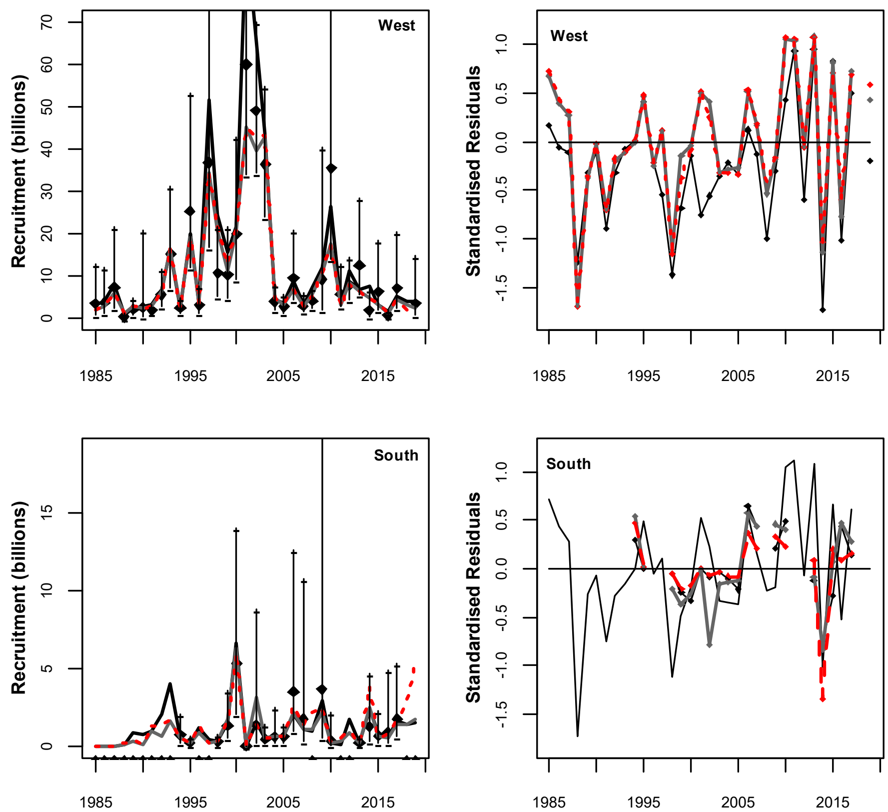

Figure 1d. As for Figure 1a, but with $p_y \sim N(0.6, SD^2)$ and $SD = 0.1$ (black), SD = 0.2 (grey) and SD = 0.4 (red).

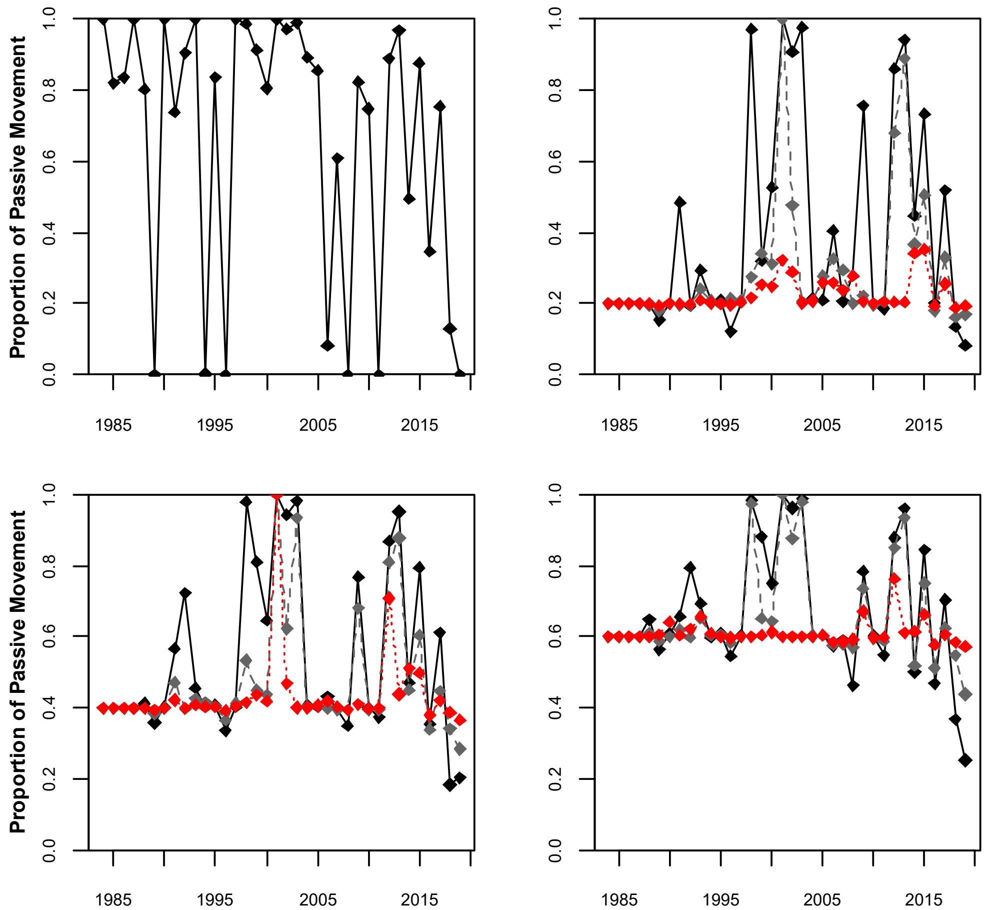

Figure 2. The model estimated proportions of WTS sardine recruits spawned on the south coast which are passively transported to the west coast for $R = 2$ and uniform prior (top left), ($p_y \sim N(0.2, SD^2)$ (top right), $p_y \sim N(0.4, SD^2)$ (bottom left) and $p_y \sim N(0.6, SD^2)$ (bottom right). The colours correspond to $SD = 0.1$ (red), SD = 0.2 (grey) and SD = 0.4 (black).

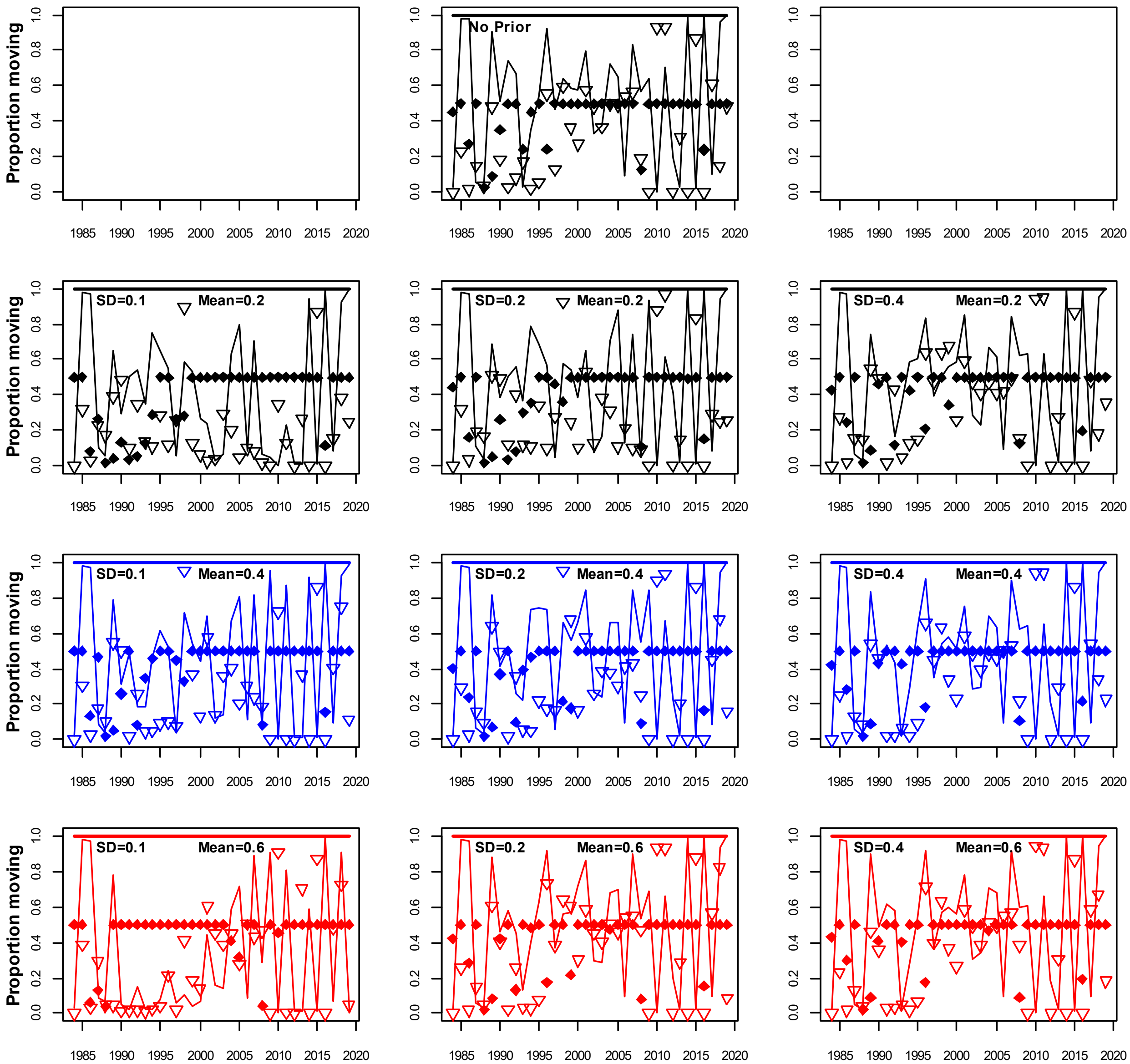

Figure 3. The model estimated proportions of age 1 CTS (♦), age 1 WTS (∇), age 2 WTS (thin line) and age 3 WTS (thick line) which are estimated to move from the west coast to the south coast from 1984 and 2019 for $R = 2$ for uniform prior (top row, de Moor 2022), $p_y \sim N(0.2, SD^2)$ (2nd row), $p_y \sim N(0.4, SD^2)$ (3rd row) and $p_y \sim N(0.6, SD^2)$ (4th row).

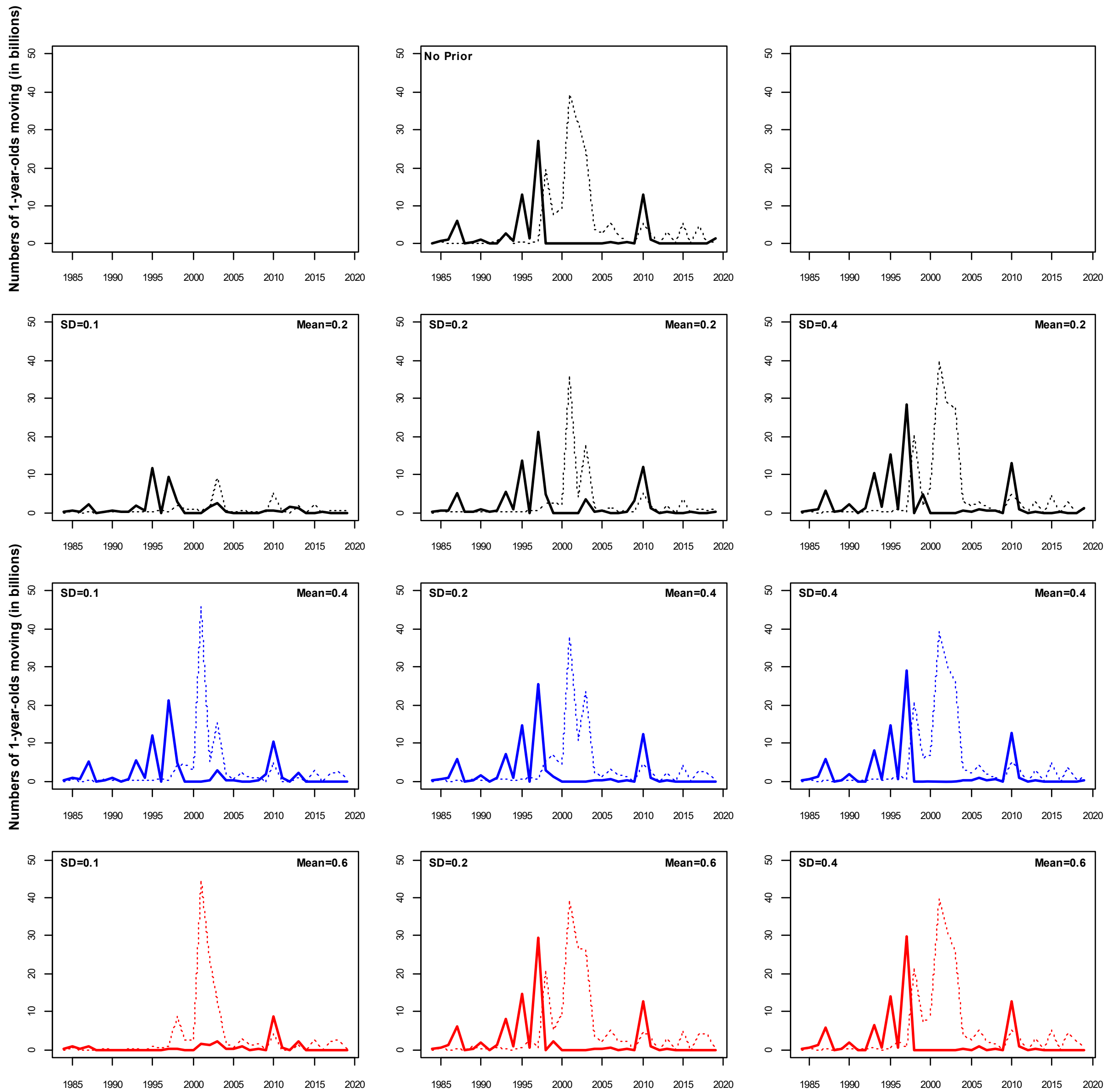

Figure 4. The model estimated numbers of age 1 CTS (solid line) and age 1 WTS (dotted line) which are estimated to move from the west coast to the south coast from 1984 and 2019 for $R = 2$ and uniform prior (top row, de Moor 2022), $p_y \sim N(0.2, SD^2)$ (2nd row), $p_y \sim N(0.4, SD^2)$ (3rd row) and $p_y \sim N(0.6, SD^2)$ (4th row). The columns correspond to different SD values.

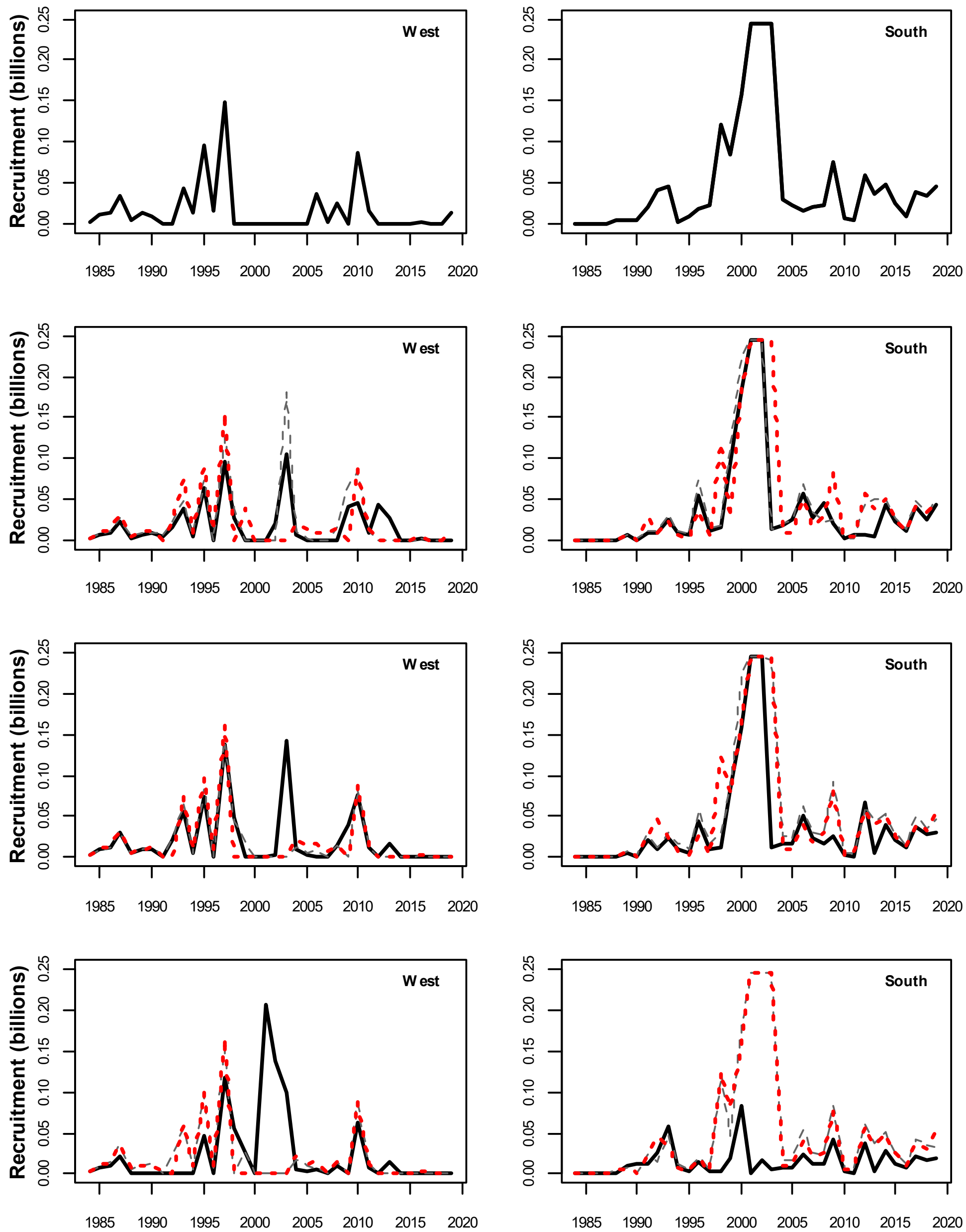

Figure 5. The model estimated recruitment on the west and south coasts from spawning on those coasts for uniform prior (top row, de Moor 2022), $p_y \sim N(0.2, SD^2)$ (2nd row), $p_y \sim N(0.4, SD^2)$ (3rd row) and $p_y \sim N(0.6, SD^2)$ (4th row) and $SD = 0.1$ (black), $SD = 0.2$ (grey dashed) and $SD = 0.4$ (red dotted).

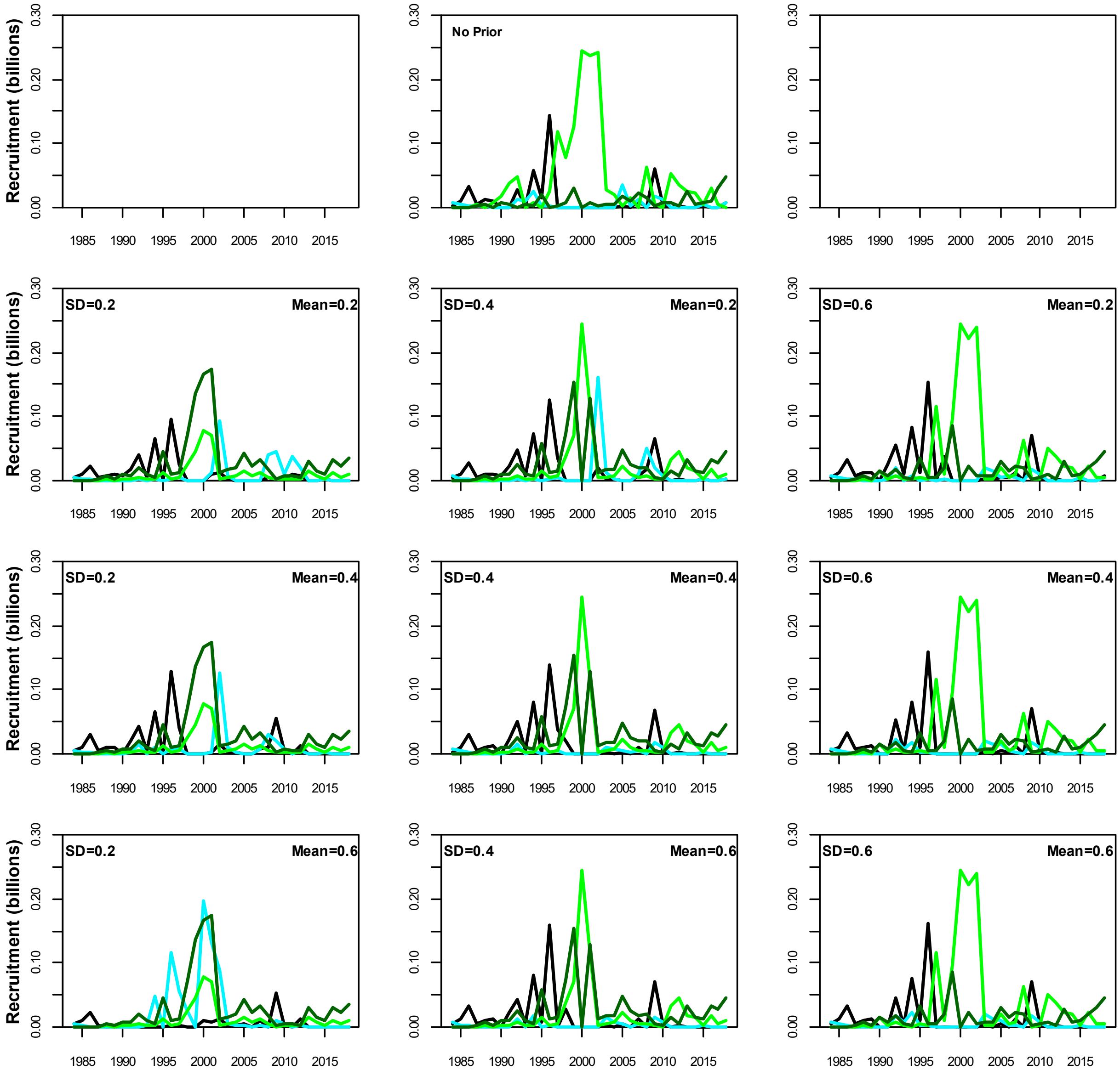

Figure 6. The model estimated CTS recruits (black) compared to WTS recruits from the west coast (turquoise) and south coast which move to the west coast (light green) and stay on the south coast (dark green) for $R = 2$ and uniform prior (top row, de Moor 2022), $p_y \sim N(0.2, SD^2)$ (2nd row), $p_y \sim N(0.4, SD^2)$ (3rd row) and $p_y \sim N(0.6, SD^2)$. The columns correspond to different SD values.

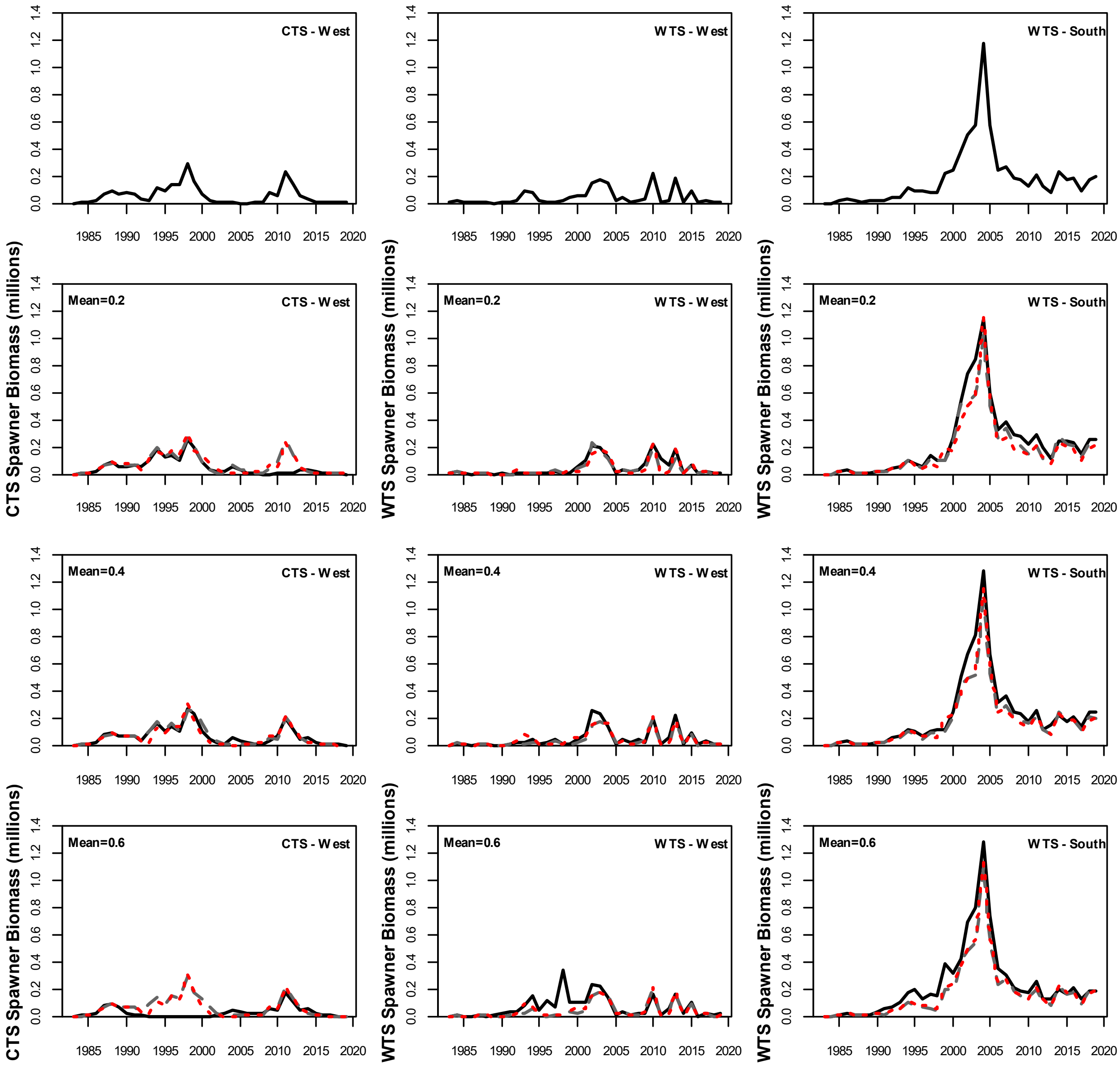

Figure 7. The model estimated spawner biomass by component and coast for $R = 2$ and uniform prior (top row, de Moor 2022), $p_y \sim N(0.2, SD^2)$ (2nd row), $p_y \sim N(0.4, SD^2)$ (3rd row) and $p_y \sim N(0.6, SD^2)$. The columns correspond to different SD values and $SD = 0.1$ (black), $SD = 0.2$ (grey dashed) and $SD = 0.4$ (red dotted).

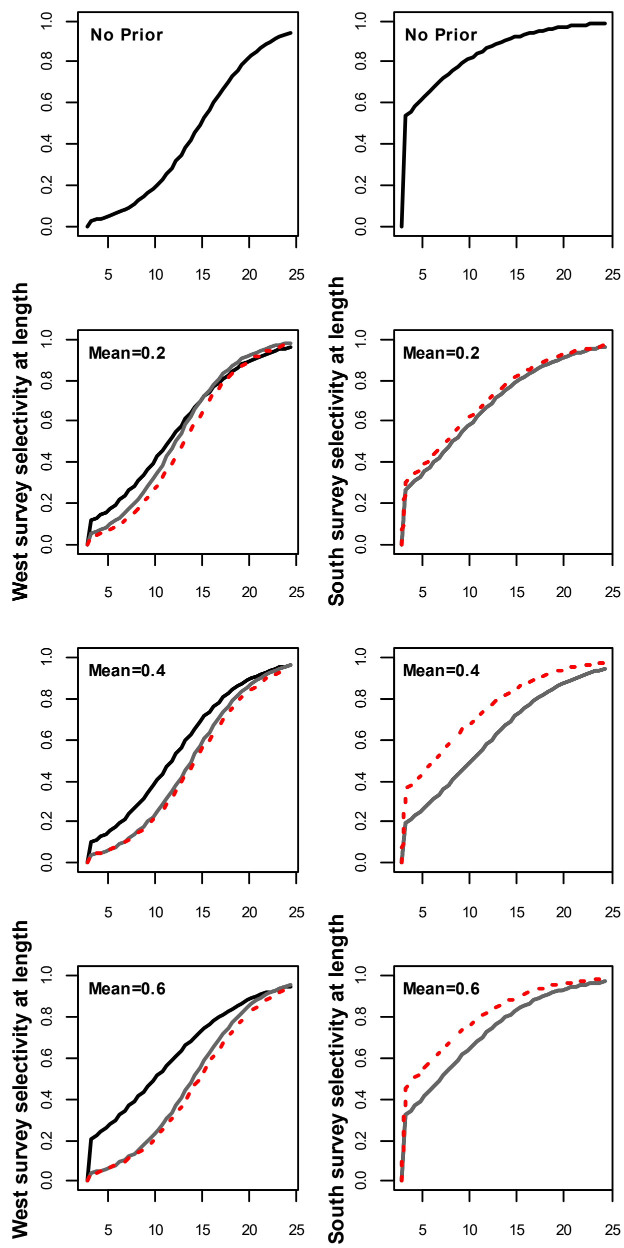

Figure 8. The model estimated November survey selectivity at length for $R = 2$ and uniform prior (top row, de Moor 2022), $p_y \sim N(0.2, SD^2)$ (2nd row), $p_y \sim N(0.4, SD^2)$ (3rd row) and $p_y \sim N(0.6, SD^2)$ and $SD = 0.1$ (black), $SD = 0.2$ (grey) and $SD = 0.4$ (red dotted).