

Including stock-recruitment relationships in West Coast rock lobster projections

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Summary

Stock-recruitment relationships are developed and included when forward-projecting the west coast rock lobster population. This results in appreciably lower extents of resource recovery under the current TAC than when this effect is ignored.

Introduction

Recruitment is not modelled as a function of spawning biomass for the west coast rock lobster, including for projections in the base case computations. Historically recruitment is assumed to have changed linearly between a set of estimated recruitment values over time. Thus, past recruitments are estimated for each super-area for the years indicated by the following list of parameters:

Estimate $R_{1910}, x_{1920}, x_{1950}$	[3 estimable parameters]
Estimate $\bar{x} = \sum_{y=1970}^{2010}(x_y) / 11$	[1 estimable parameter]
Estimate for $y=1970, 1975, 1980, \dots, 2010$: $x_y = \bar{x}e^{\varepsilon_y - \sigma_R^2/2}$	[11 estimable ε_y parameters]

MARAM/IWS/2019/WCRL/P2 provides more details. Projections for the base case are developed by drawing future recruitment at random from the set of estimated recruitment parameters $R_{1970}, 1975, \dots, R_{2010}$. A current concern is that without any stock-recruit relationship, this approach could be providing overoptimistic results, particularly if spawning biomass falls to very low levels. This document provides initial results to aid discussion regarding the potential use of a stock-recruit relationship in future projections.

1) Stock-recruit relationships for the five super-areas

What do the S/R relationships look like for each super-area? For super-area A8+ as a first example, can one construct a sensible S/R relationship to be used when projecting into the future?

Results

Figure 1 provides plots of recruitment estimated against female spawning biomass (both as proportions of pristine levels) for each of the five super-areas. The right hand panels show this relationship for the 1970+ period only. Figure 2a shows the super-area **A8+** estimated recruitment and spawning biomass trends.

Figure 2b shows a suggested spawning stock-recruit relationship for super-area A8+ with this relationship shown in **red** – and to be applied for years 2011+ (see 2) below). The **green** line shows the average recruitment for the 1970-2010 period (and applies in the future for spawning biomasses above the hinge point shown in the Figure).

Figures 3-6 contains similar Figures to Figure 2b and 2c for the other four super-areas.

2) Projections for super-area A8+ where future R is modelled as a function of female spawning biomass

The super-area A8+ resource is projected ahead (assuming a future TAC level of 717 MT¹) where future (2011+) recruitment is modelled as a function of female spawning biomass (see Figure 2b). Results are compared with the current method of drawing future recruitment at random from the set of estimated recruitment parameters R1970...R2010.

Thus, for super-area A8+:

Step 1: Generate a future recruitment estimate drawn at random with replacement from

R1970...R2010 (as for BC method)

Step 2: if $B_{sp}/B_{sp}(K) \geq 0.15$ retain the randomly selected recruitment

If $B_{sp}/B_{sp}(K) < 0.15$ multiply the randomly selected recruitment estimate by $\frac{B_{sp}/B_{sp}(K)}{0.15}$

Results

For super-area A8+ the S/R relationship makes no difference to projections, as the spawning biomass is estimated to be relatively high and increasing (see Figures 2a and 2c).

3) Projections for super-area A7 where future R is modelled as a function of female spawning biomass

The super-area A7 resource is projected ahead (assuming a future TAC level of 86 MT¹) where future (2011+) recruitment is modelled as a function of female spawning biomass (see Figure 3b). Results are compared with the current method of drawing future recruitment at random from the set of estimated recruitment parameters R1970...R2010.

Thus, for super-area A7:

Step 1: Generate a future recruitment estimate drawn at random with replacement from

R1970...R2010 (as for BC method)

Step 2: if $B_{sp}/B_{sp}(K) \geq 0.07$ retain the randomly selected recruitment

If $B_{sp}/B_{sp}(K) < 0.07$ multiply the randomly selected recruitment estimate by $\frac{B_{sp}/B_{sp}(K)}{0.07}$

¹ Corresponding for the super-area concerned to the present global TAC of 1084 MT.

Results

The inclusion of a S/R function (as described above) makes a substantial difference to the future B75m trend – particularly at the lower 5th %ile level.

B75m(2025/2006): BC (no S/R relationship in future) = 1.272 [0.609; 2.149]

B75m(2025/2006): With a S/R relationship in future = 0.668 [0.367; 1.065]

B75m(2030/2006): BC (no S/R relationship in future) = 1.701 [0.829; 2.968]

B75m(2030/2006): With a S/R relationship in future = 0.704 [0.312; 1.191]

Figure 3c shows B75m/B75m(2006) trajectories for future CC=128 MT (corresponds to current TAC level). The blue lines (median and 5th and 95th %iles) are the BC model (which has no S/R function for future recruitment) and the red lines (medians and 5th and 95th %iles) are the model for which a S/R function is assumed for future recruitment (see Figure 3b).

4) Projections for super-area A56 where future R is modelled as a function of female spawning biomass

The super-area A56 resource is projected ahead (assuming a future TAC level of 86 MT¹) where future (2011+) recruitment is modelled as a function of female spawning biomass (see Figure 4b). Results are compared with the current method of drawing future recruitment at random from the set of estimated recruitment parameters R1970...R2010.

Thus, for super-area A56:

The average Bsp/Bsp(K) values for the 2001, 2004 and 2007 years is 0.0291.

Step 1: Generate a future recruitment estimate drawn at random with replacement from

R1970...R2010 (as for BC method)

Step 2: if Bsp/Bsp(K) >= 0.0291 retain the randomly selected recruitment

If Bsp/Bsp(K) < 0.0291 multiply the randomly selected recruitment estimate by $\frac{Bsp/Bsp(K)}{0.0291}$

Results

The inclusion of a S/R function (as described above) has some negative impact on the future B75m trend – particularly at the lower 5th %ile level.

B75m(2025/2006): BC (no S/R relationship in future) = 2.074 [1.883; 2.387]

B75m(2025/2006): With a S/R relationship in future = 1.889 [1.699; 2.200]

B75m(2030/2006): BC (no S/R relationship in future) = 2.300 [1.810; 3.108]

B75m(2030/2006): With a S/R relationship in future = 2.007 [1.520; 2.809]

Figure 4c shows B75m/B75m(2006) trajectories for future CC=86 MT (corresponds to current TAC level). The blue lines (median and 5th and 95th %iles) are the BC model (which has no S/R function for future recruitment) and the red lines (medians and 5th and 95th %iles) are the model for which a S/R function is assumed for future recruitment (see Figure 4b).

5) Projections for super-area A34 where future R is modelled as a function of female spawning biomass

The super-area A34 resource is projected ahead (assuming a future TAC level of 128 MT¹) where future (2011+) recruitment is modelled as a function of female spawning biomass (see Figure 5b). Results are compared with the current method of drawing future recruitment at random from the set of estimated recruitment parameters R1970...R2010.

Thus, for super-area A34:

The average Bsp/Bsp(K) values for the 2001, 2004 and 2007 years is 0.0595.

Step 1: Generate a future recruitment estimate drawn at random with replacement from

R1970...R2010 (as for BC method)

Step 2: if Bsp/Bsp(K) >= 0.0595 retain the randomly selected recruitment

If Bsp/Bsp(K) < 0.0595 multiply the randomly selected recruitment estimate by $\frac{Bsp/Bsp(K)}{0.0595}$

Results

The inclusion of a S/R function (as described above) again makes some difference to the future B75m trend.

B75m(2025/2006): BC (no S/R relationship in future) = 0.806 [0.722; 0.888]

B75m(2025/2006): With a S/R relationship in future = 0.782 [0.707; 0.854]

B75m(2030/2006): BC (no S/R relationship in future) = 0.860 [0.566; 1.211]

B75m(2030/2006): With a S/R relationship in future = 0.751 [0.513; 1.034]

Figure 5c shows B75m/B75m(2006) trajectories for future CC=128 MT (corresponds to current TAC level). The blue lines (median and 5th and 95th %iles) are the BC model (which has no S/R function for future recruitment) and the red lines (medians and 5th and 95th %iles) are the model for which a S/R function is assumed for future recruitment (see Figure 5b).

6) Projections for super-area A12 where future R is modelled as a function of female spawning biomass

The super-area A12 resource is projected ahead (assuming a future TAC level of 26 MT¹) where future (2011+) recruitment is modelled as a function of female spawning biomass (see Figure 6b). Results are compared with the current method of drawing future recruitment at random from the set of estimated recruitment parameters R1970...R2010.

Thus, for super-area A12:

The average $B_{sp}/B_{sp}(K)$ values for the 2001, 2004 and 2007 years is 0.01425.

Step 1: Generate a future recruitment estimate drawn at random with replacement from

R1970...R2010 (as for BC method)

Step 2: if $B_{sp}/B_{sp}(K) \geq 0.01425$ retain the randomly selected recruitment

If $B_{sp}/B_{sp}(K) < 0.01425$ multiply the randomly selected recruitment estimate by $\frac{B_{sp}/B_{sp}(K)}{0.01425}$

Results

The inclusion of a S/R function (as described above) makes a difference to the future B75m trend, particularly the projections to 2030.

B75m(2025/2006): BC (no S/R relationship in future) = 1.140 [0.912; 1.779]

B75m(2025/2006): With a S/R relationship in future = 1.139 [0.912; 1.779]

B75m(2030/2006): BC (no S/R relationship in future) = 1.207 [0.815; 1.743]

B75m(2030/2006): With a S/R relationship in future = 0.917 [0.657; 1.435]

Figure 6c shows B75m/B75m(2006) trajectories for future CC=26 MT (which corresponds to the current global TAC level). The blue lines (median and 5th and 95th %iles) are the BC model (which has no S/R function for future recruitment) and the red lines (medians and 5th and 95th %iles) are the model for which a S/R function is assumed for future recruitment (see Figure 6b).

7) Combined (over all five super-areas) projections of B75m/B75m(2006) where future R is modelled as a function of female spawning biomass

Results

B75m(2025/2006): BC (no S/R relationship in future) = 1.052 [0.831; 1.337]

B75m(2025/2006): With a S/R relationship in future = 0.890 [0.756; 1.062]

B75m(2030/2006): BC (no S/R relationship in future) = 1.107 [0.675; 1.676]

B75m(2030/2006): With a S/R relationship in future = 0.810 [0.509; 1.205]

Figure 7 shows the combined B75m/B75m(2006) trajectories for future TAC corresponds to current TAC level. The blue lines (median and 5th and 95th %iles) are the BC model (which has no S/R function for future recruitment) and the red lines (medians and 5th and 95th %iles) are the model for which a S/R function is assumed for future recruitment.

Discussion

The combined result for projections for the resource as a whole (Figure 7) show that taking account of stock-recruitment effects leads to markedly more negative expectations for the resource under continuation of the current TAC of 1084 MT. Median and 90% PIs for the biomass in 2025 relative to the 2006 baseline which were 1.052 [0.831; 1.337] for the BC model become 0.890 [0.756; 1.062], with the stock-recruitment effect incorporated, i.e. a 15% reduction in the median.

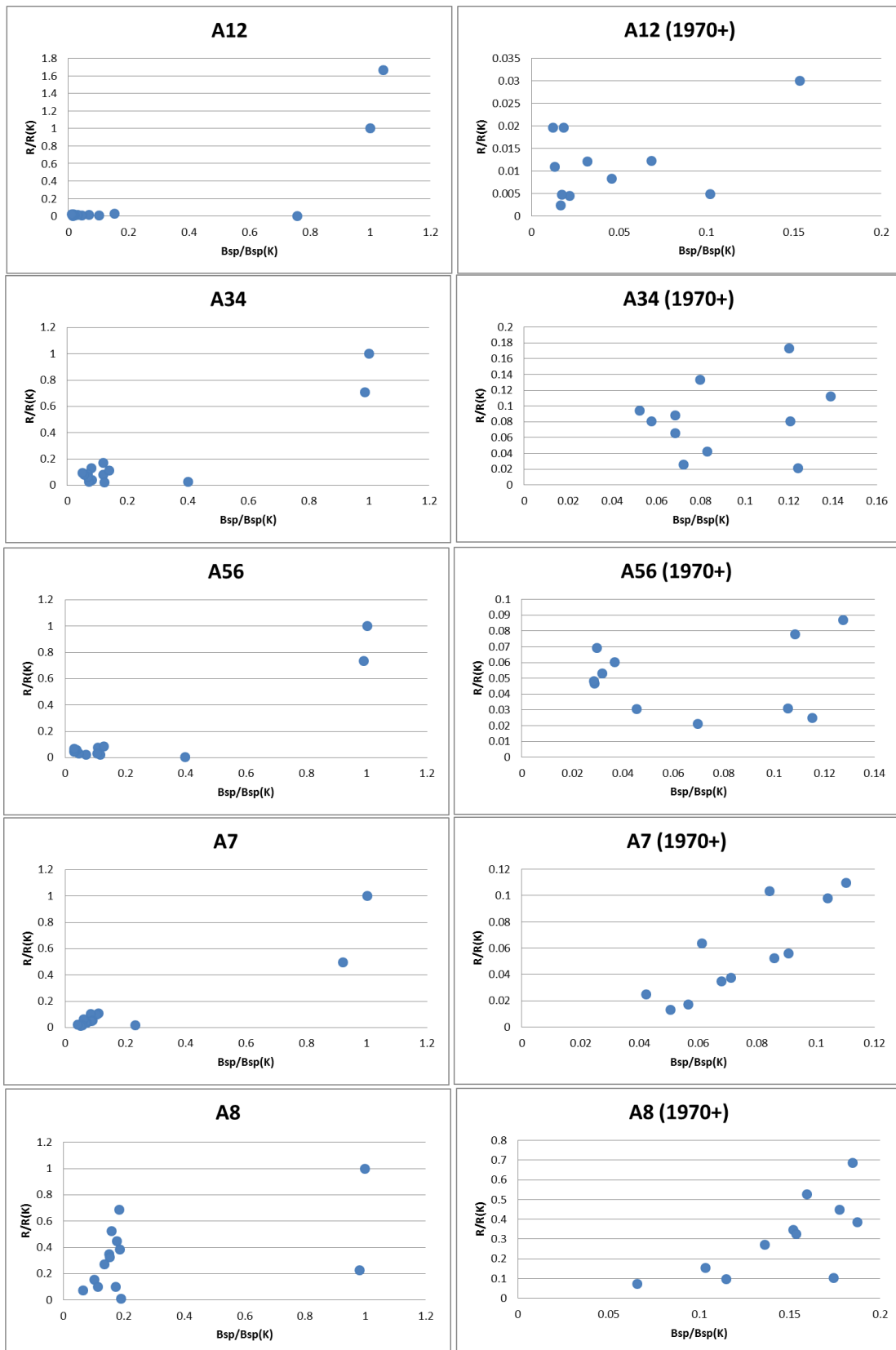


Figure 1: Plots of recruitment estimates against female spawning biomass (both as proportions of pristine levels) for each of the five super-areas. The right hand panels show this relationship for the 1970+ period only.

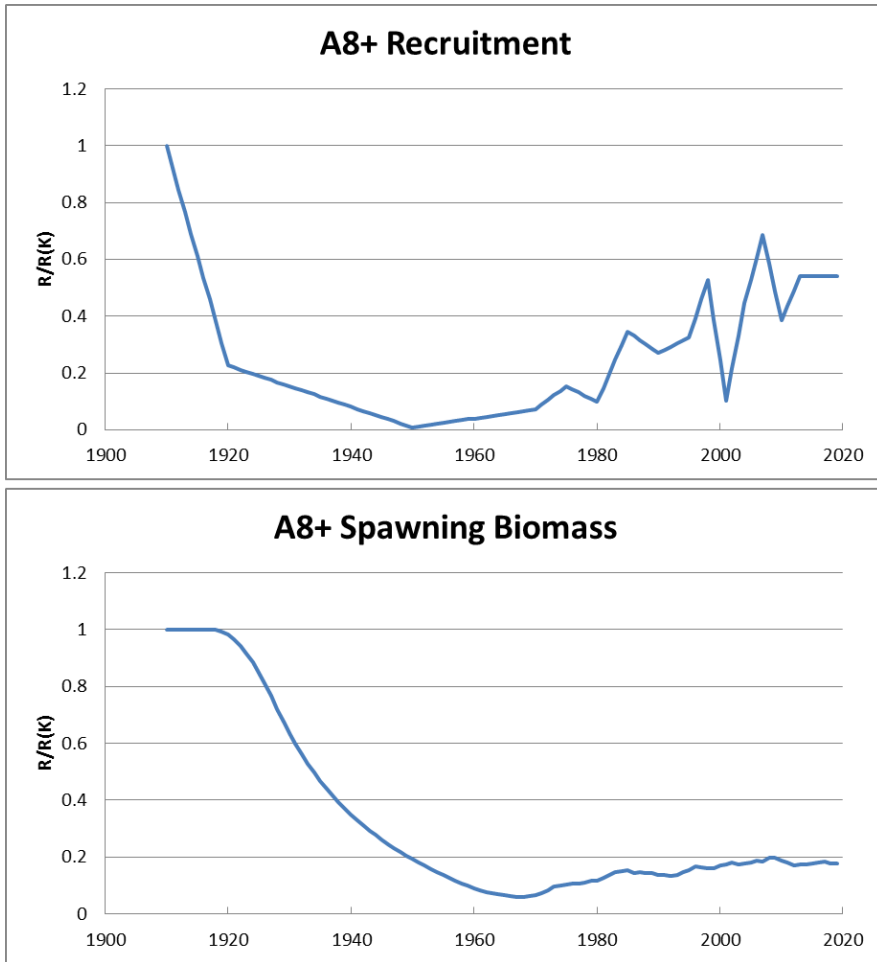


Figure 2a: Super-area A8+ estimated recruitment and spawning biomass trends.

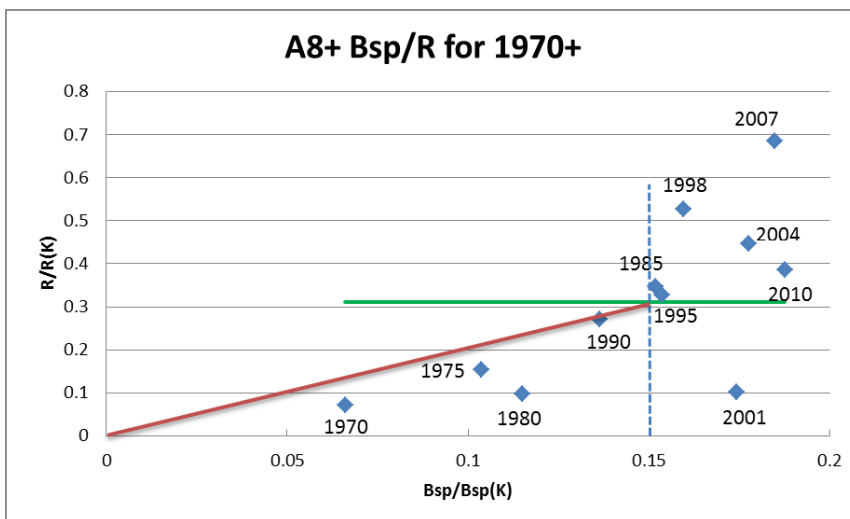


Figure 2b: Spawning stock-recruit relationship for super-area A8+ with the proposed S/R relationship (to be applied for years 2011+) shown in red. The green horizontal line is the average of the R1970...R2010 recruitment parameter estimates.

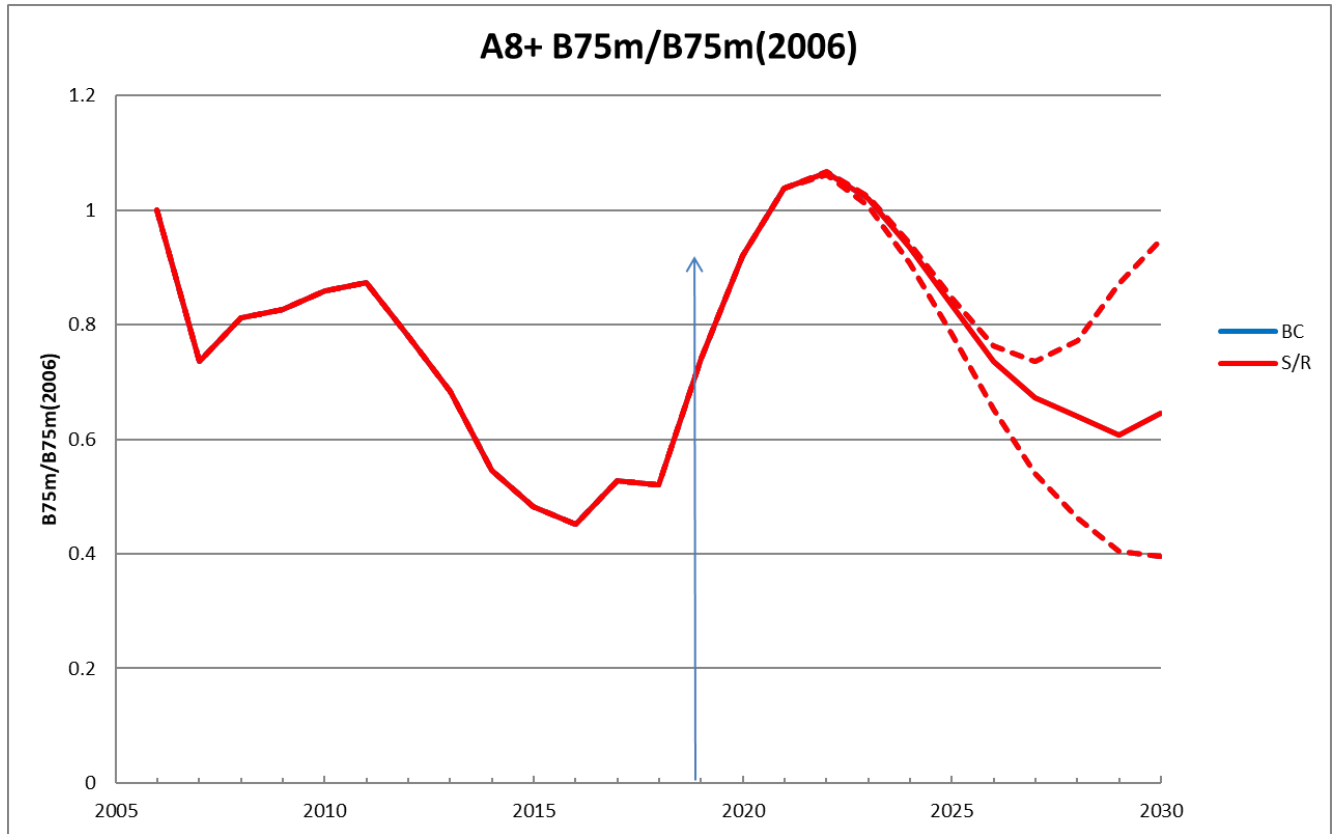


Figure 2c: Super-area A8+ B75m/B75m(2006) trajectories for a future CC=717 MT (corresponds to 2019 TAC level). The blue lines (median and 5th and 95th %iles) are for the BC model (which has no S/R function for future recruitment), and the red lines (medians and 5th and 95th %iles) are for the model for which a S/R function is assumed to apply for future recruitment (see Figure 2b above). The S/R relationship has no impact on projections in this case, so that blue and red lines overlap.

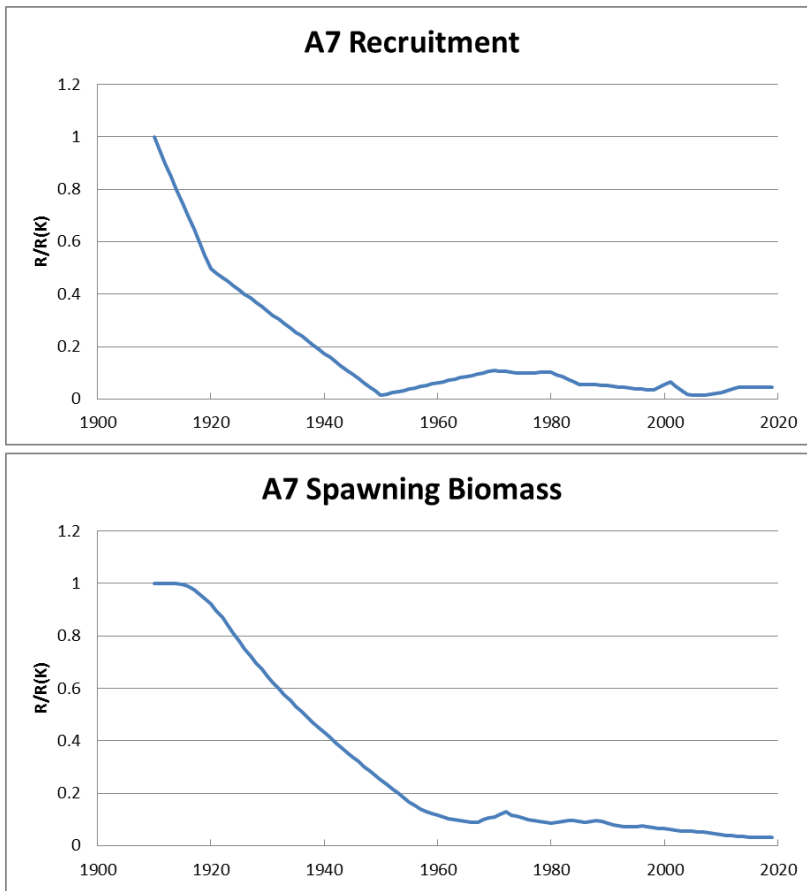


Figure 3a: Super-area **A7** estimated recruitment and spawning biomass trends.

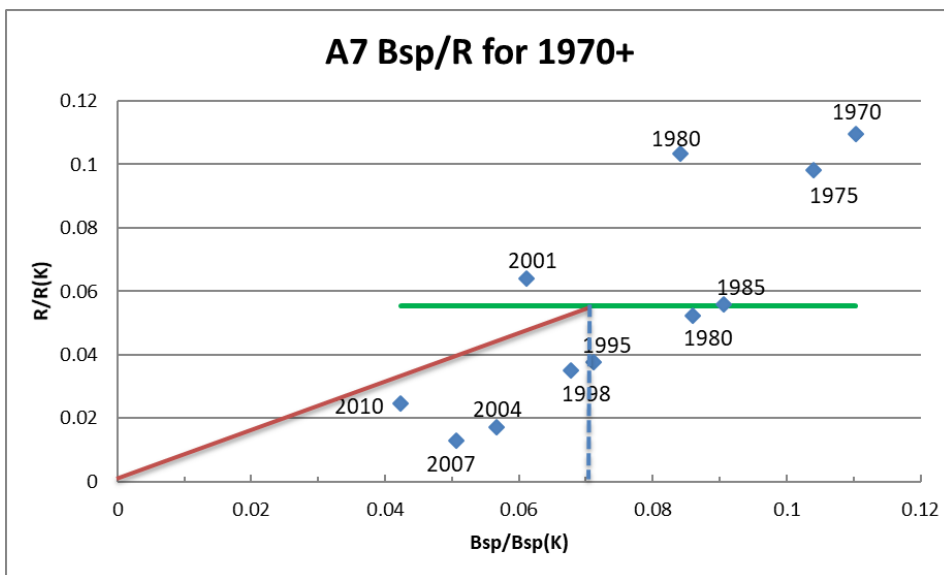


Figure 3b: Spawning stock-recruit relationship for super-area A7 with the proposed S/R relationship (to be applied for years 2011+) shown in **red**. The **green** horizontal line is the average of the R1970...R2010 recruitment parameter estimates.

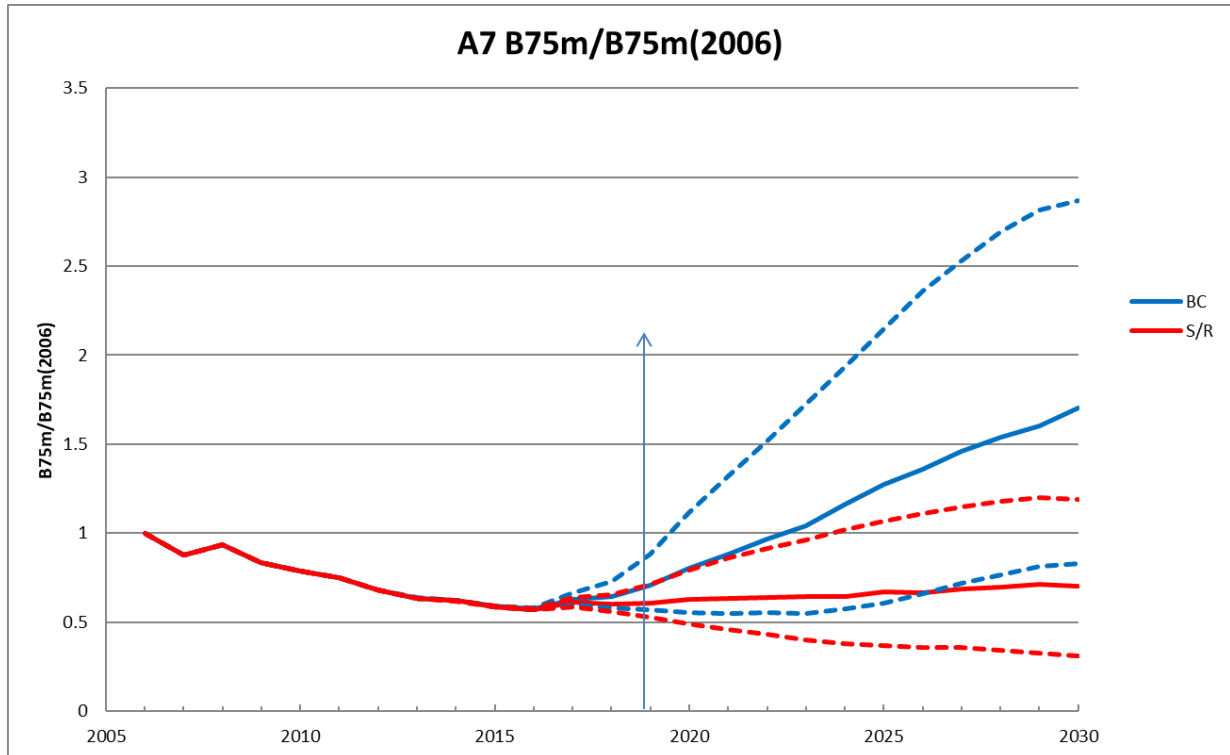


Figure 3c: Super-area A7 B75m/B75m(2006) trajectories for a future CC=128 MT (corresponds to 2019 TAC level). The blue lines (median and 5th and 95th %iles) are for the BC model (which has no S/R function for future recruitment), and the red lines (medians and 5th and 95th %iles) are for the model for which a S/R function is assumed to apply for future recruitment (see Figure 3b above).

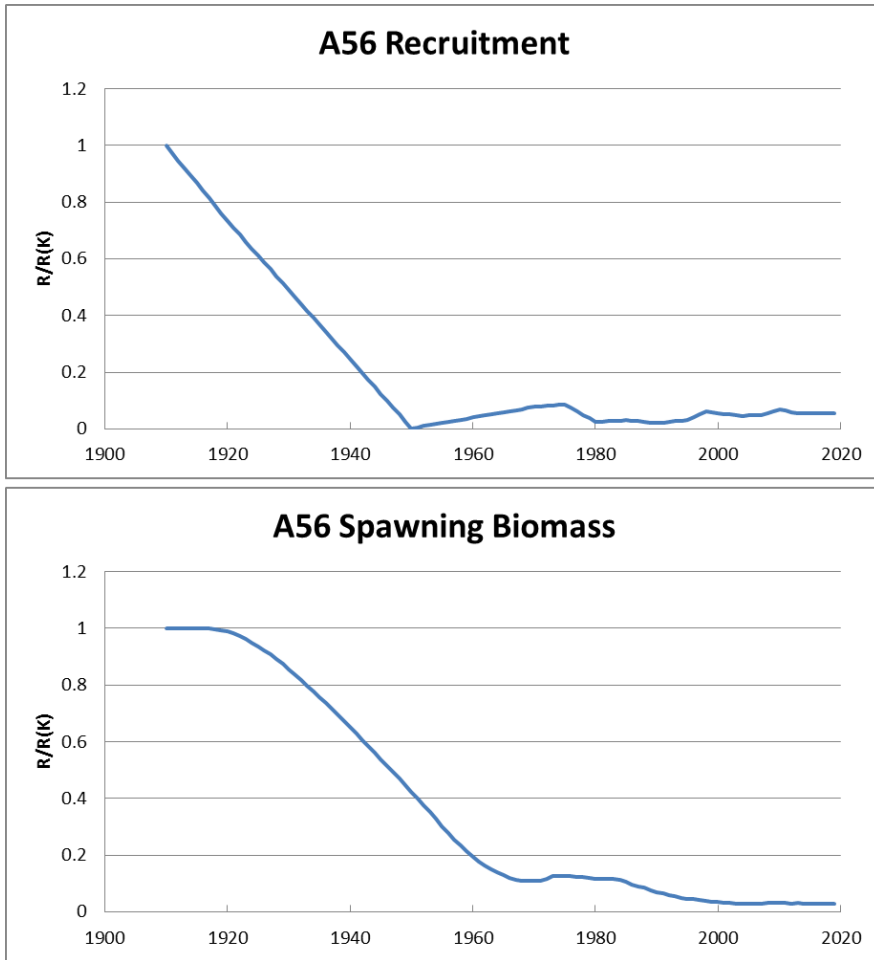


Figure 4a: Super-area **A56** estimated recruitment and spawning biomass trends.

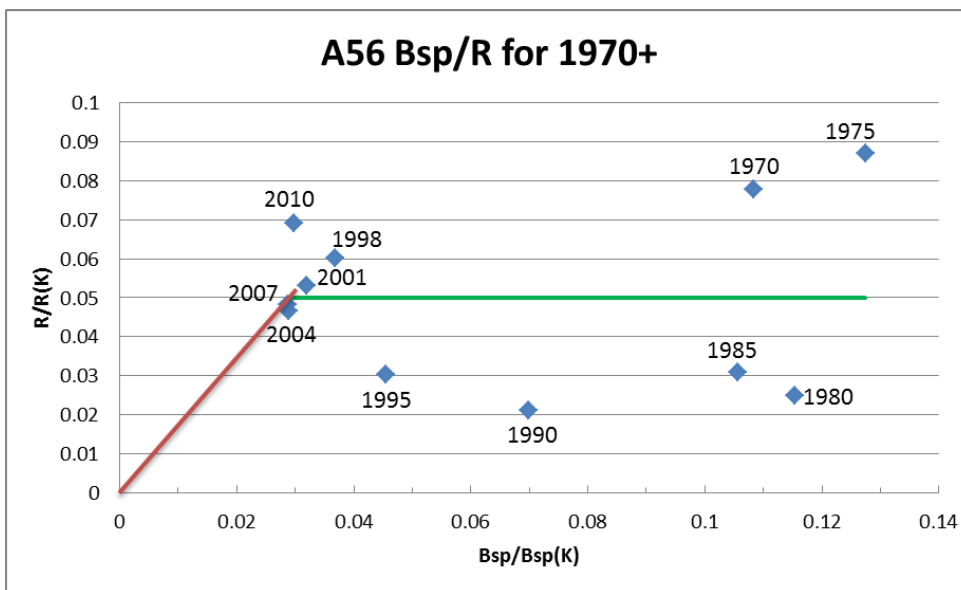


Figure 4b: Spawning stock-recruit relationship for super-area A56 with the proposed S/R relationship (to be applied for years 2011+) shown in **red**. The **green** horizontal line is the average of the R1970...R2010 recruitment parameter estimates.

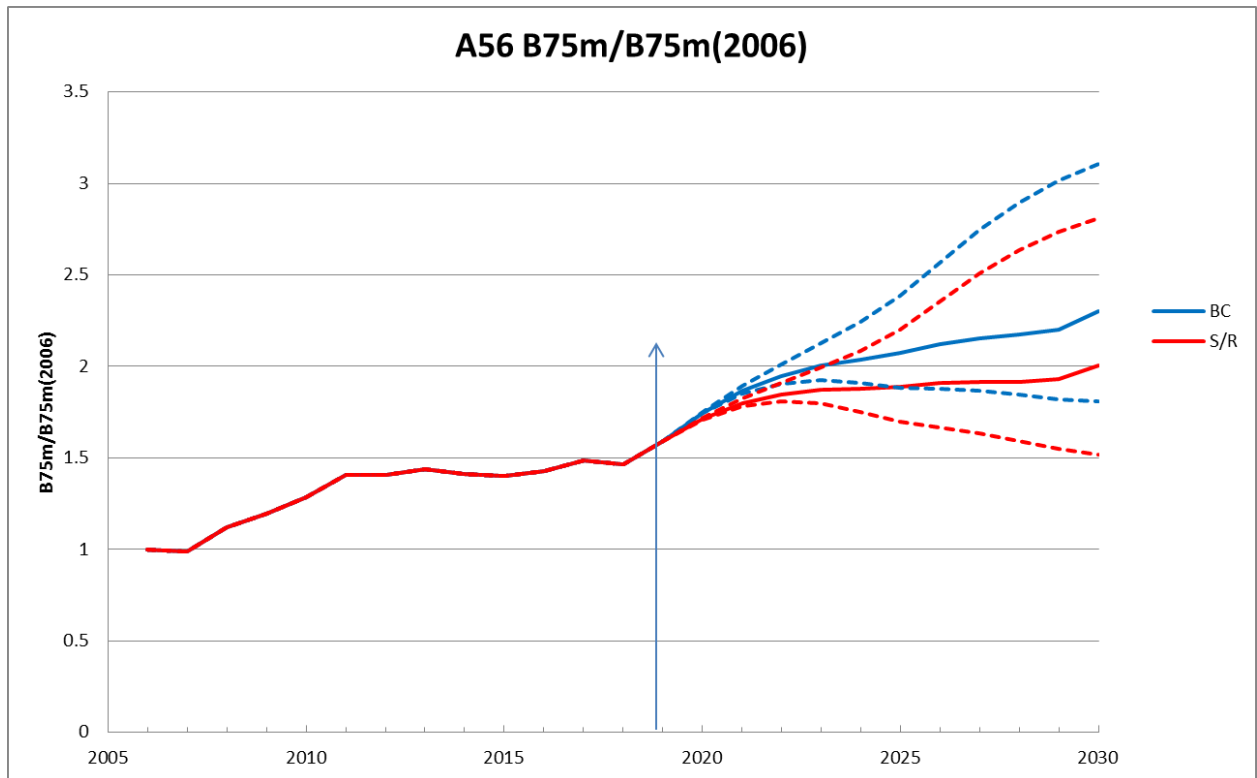


Figure 4c: Super-area A56 B75m/B75m(2006) trajectories for a future CC=86 MT (corresponds to 2019 TAC level). The blue lines (median and 5th and 95th %iles) are for the BC model (which has no S/R function for future recruitment), and the red lines (medians and 5th and 95th %iles) are for the model for which a S/R function is assumed to apply for future recruitment (see Figure 4b above).

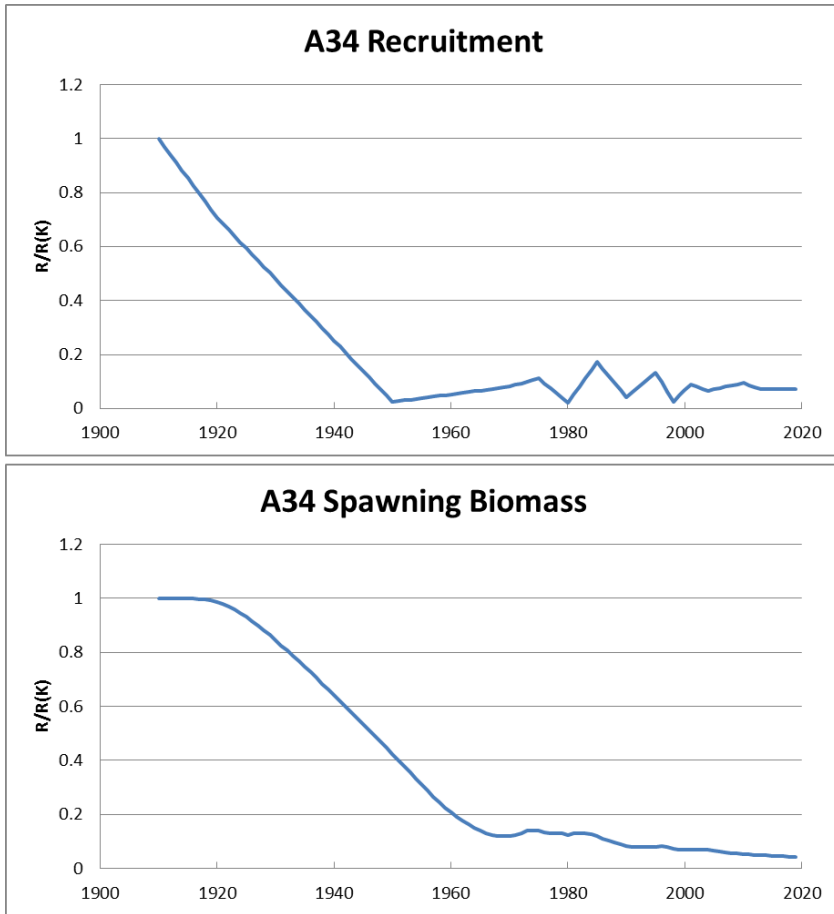


Figure 5a: Super-area **A34** estimated recruitment and spawning biomass trends.

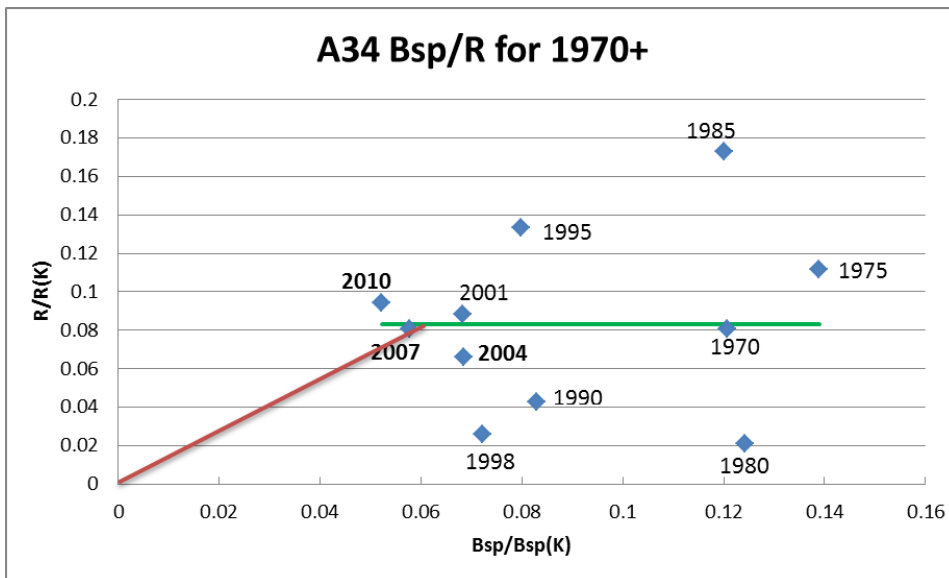


Figure 5b: Spawning stock-recruit relationship for super-area **A8+** with the proposed S/R relationship (to be applied for years 2011+) shown in **red**. The **green** horizontal line is the average of the R1970...R2010 recruitment parameter estimates.

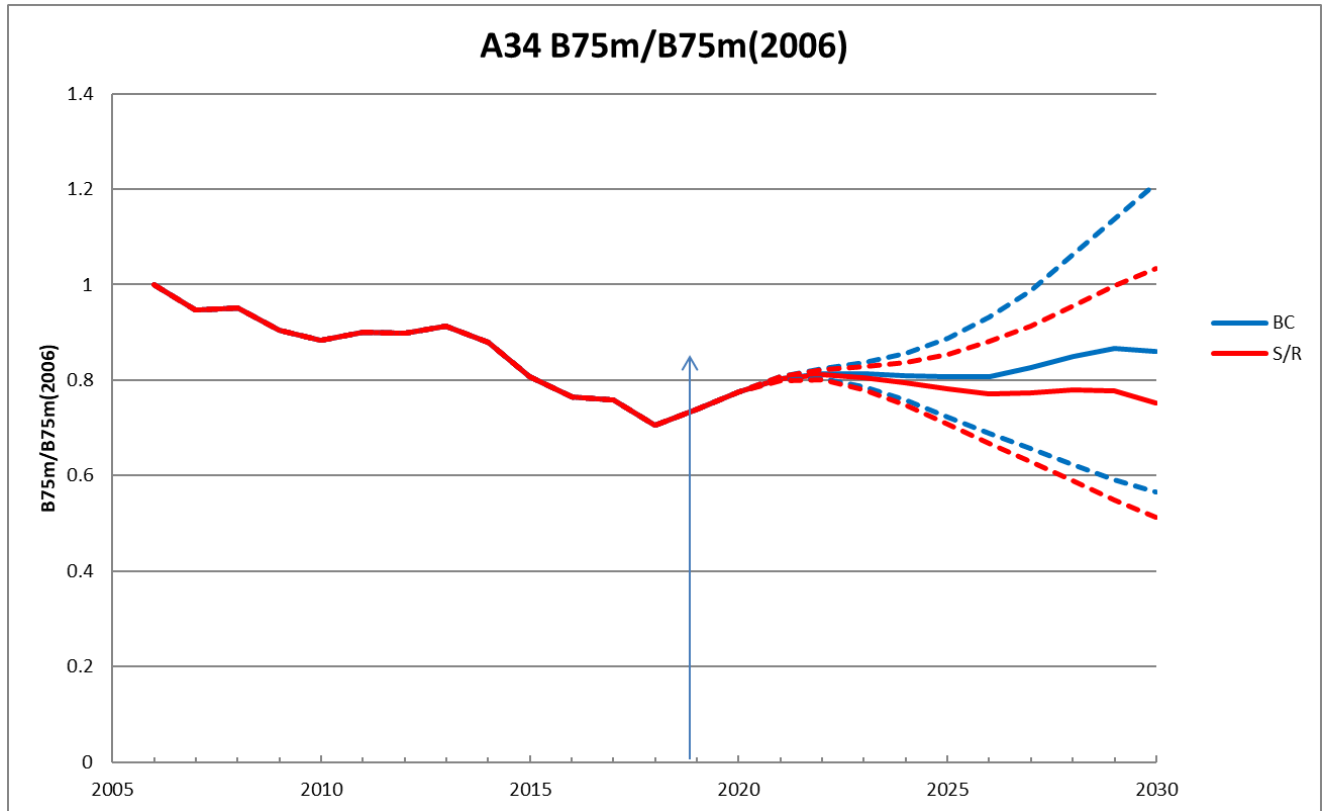


Figure 5c: Super-area A34 B75m/B75m(2006) trajectories for a future CC=128 MT (corresponds to 2019 TAC level). The blue lines (median and 5th and 95th %iles) are for the BC model (which has no S/R function for future recruitment), and the red lines (medians and 5th and 95th %iles) are for the model for which a S/R function is assumed to apply for future recruitment (see Figure 5b above).

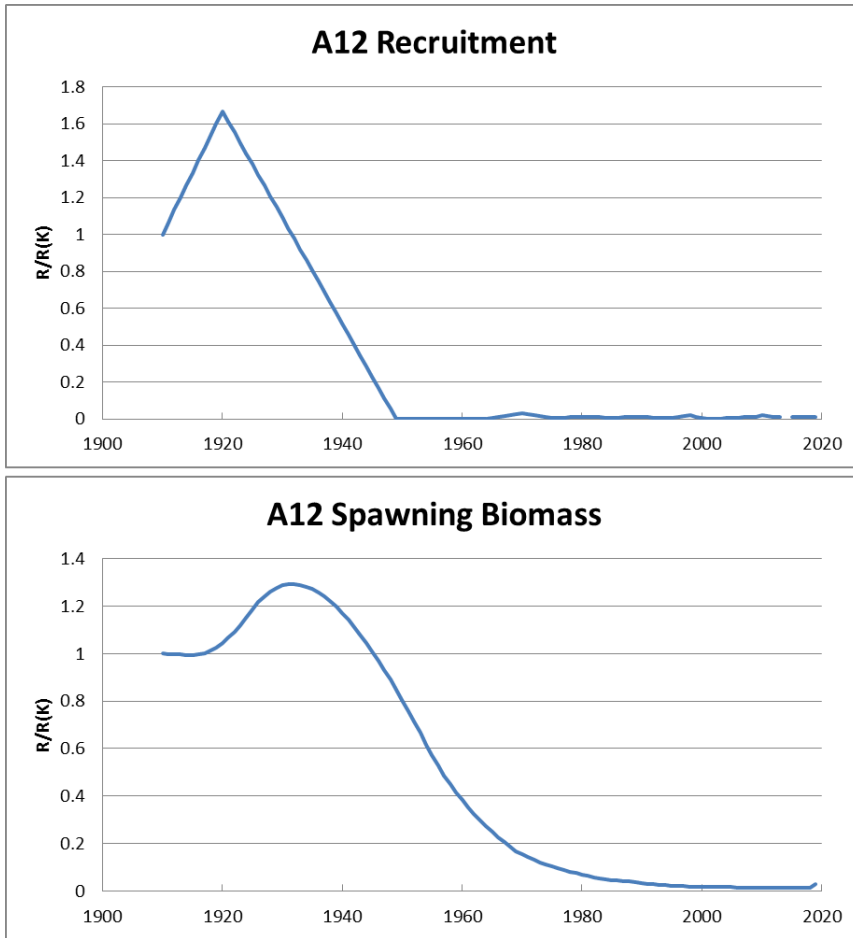


Figure 6a: Super-area A12 estimated recruitment and spawning biomass trends.

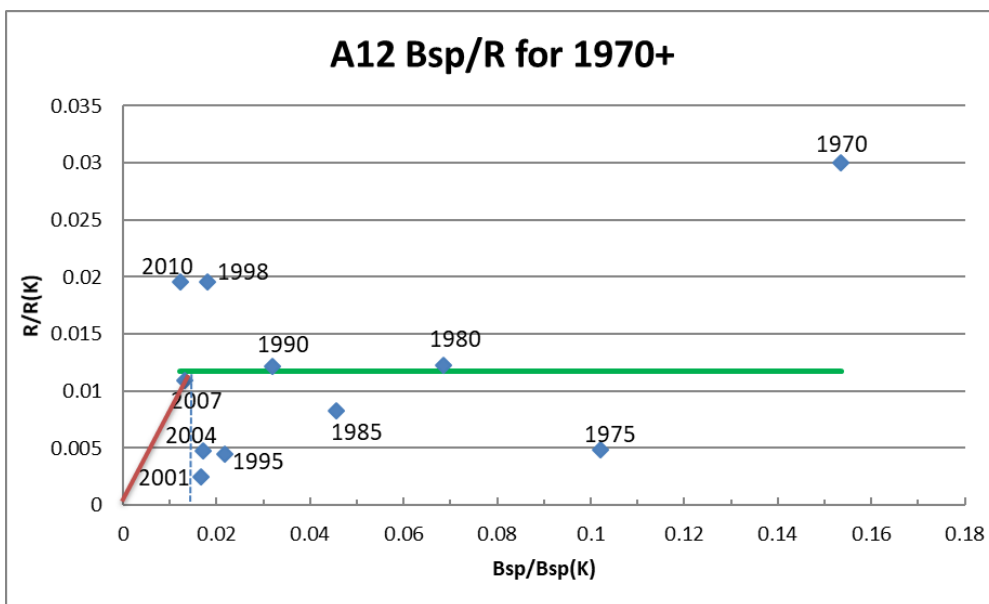


Figure 6b: Spawning stock-recruit relationship for super-area A12 with the proposed S/R relationship (to be applied for years 2011+) shown in red. The green horizontal line is the average of the R1970...R2010 recruitment parameter estimates.

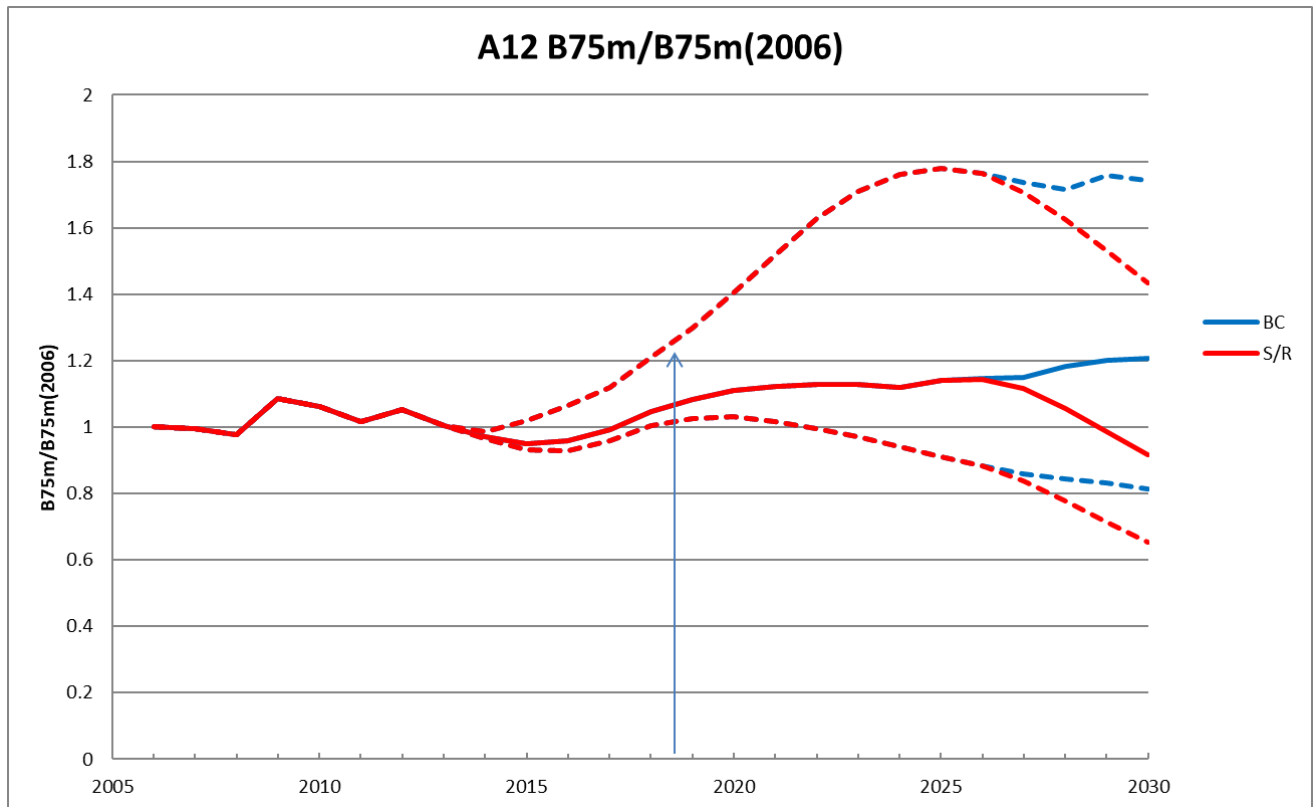


Figure 6c: Super-area A12 B75m/B75m(2006) trajectories for a future CC=26 MT (corresponds to 2019 TAC level). The blue lines (median and 5th and 95th %iles) are for the BC model (which has no S/R function for future recruitment), and the red lines (medians and 5th and 95th %iles) are for the model for which a S/R function is assumed to apply for future recruitment (see Figure 6b above).

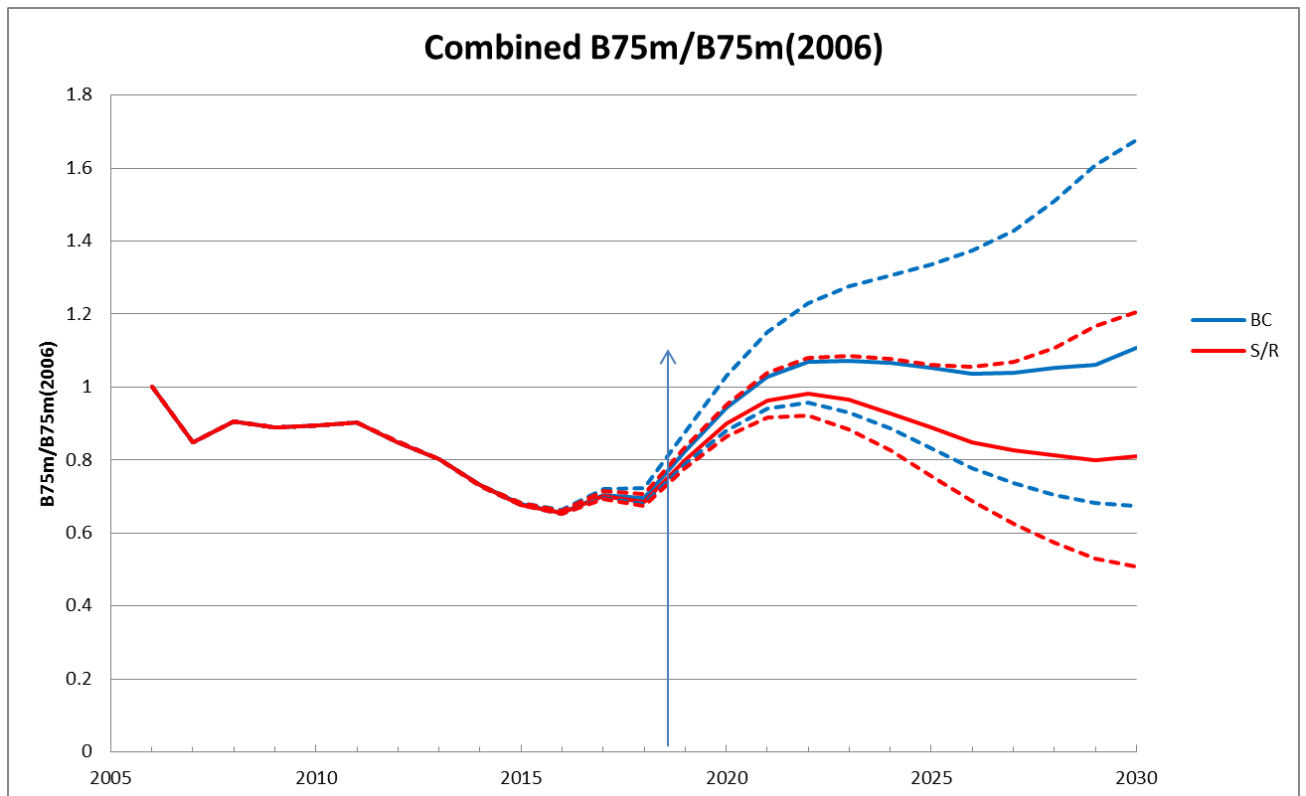


Figure 7: **Combined** B75m/B75m(2006) trajectories for a future CC corresponding to current 2019 season TAC level of 1084 MT. The blue lines (median and 5th and 95th %iles) are for the BC model (which has no S/R function for future recruitment), and the red lines (medians and 5th and 95th %iles) are for the models for which a S/R function is assumed to apply for future recruitment.