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Investigation of alternative model structures for the estimation of natural mortality in the Campbell Island Rise southern blue whiting (*Micromesistius australis*) stock assessment (SBW 6I)

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EXECUTIVE SUMMARY

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The most recent assessment for SBW 6I (Dunn & Hanchet 2017) assumed an annual natural mortality (*M*) of 0.20 for the base case with sensitivity analyses at 0.15 and 0.25. A model run in which *M* was estimated (run 1.3), produced an *M* of 0.17 at MPD and 0.33 at MCMC. This study sought to identify an appropriate assessment model structure for the stable, unbiased estimation of *M*.

We determined how well the existing model run 1.3 performed on simulated data for which *M* was known. SimCASAL was used to generate 50 simulated datasets for *M* of 0.20. For all simulated datasets, the model produced a median *M* at MCMC greater than 0.20, with a combined posterior of $M = 0.28$ (95% intervals 0.21–0.30), indicating a strong positive bias.

The DWWG recommended an assessment of the sensitivity of *M* to the selection of prior CV (mu = 0.20 and CV = 0.20 was the base case). There was a continuous contraction of the *M* posterior towards the prior mu as the CV was reduced. Model estimates were highly sensitive to a subjective decision about the choice of prior CV.

An alternative model was developed starting from an equilibrium age structure in 1960 instead of a non-equilibrium age structure in 1979. At MCMC, this estimated *M* between 0.18 and 0.19, depending on assumptions about the catch taken from 1971–1977 in SBW 6I.

Lognormal priors on *M*, YCS and acoustic mature biomass index *q* were highly influential on *M* in the current base case. An exploratory alternative model with uniform priors also estimated *M* of 0.18 at MCMC. When tested with simulated datasets for a known *M* of 0.15, 0.20 or 0.25, this model still produced negatively biased estimates of *M*. Accounting for this bias, true *M* was highly likely to be between 0.15 and 0.25.

In summary, the combined investigations were unable to identify a model structure that produced stable and unbiased estimates of *M*. Future exploration could extend the age partition to 20+ (currently 15+) and explore the causes of conflicting information from the acoustic immature biomass index series and other observations.

Since the value of *M* strongly influences B_0, current stock status and TACC estimates, it is recommended that the assessment continues to use 0.2 with sensitivity analyses at 0.15 and 0.25 until the causes of bias can be identified and corrected.

1. BACKGROUND

The Campbell Island currently supports a fishery with a TACC of about 40 000 t. The most recent CASAL assessment model developed for this stock is detailed by Dunn & Hanchet (2017). Briefly, this model uses the commercial trawl fishery catch history from 1979 and fits to commercial trawl proportion-at-age and an acoustic survey biomass index up to and including the 2015 season.

Dunn & Hanchet (2017) conducted an investigation of the sensitivity of assessment outputs to alternative assumptions about annual natural mortality (*M*). Models with *M* fixed at 0.2 (run 1.1, the base case), 0.15 (run 2.1) and 0.25 (run 2.2) produced similar biomass trajectories, although these varied with respect to B_0 and stock status (ranging from 44% B_0 to 78% B_0). A fourth model run in which *M* was estimated (run 1.3) was also carried out in which *M* was parameterised by the average of male and female natural mortality, with another parameter giving the degree to which male *M* exceeded that of females. This produced a more optimistic estimate of stock status (90% B_0), although *M* estimates (0.33) were considered implausible by the DWWG (Table 1).

Table 1: Model run labels and descriptions for the model runs by Dunn & Hanchet (2017).

Model type	Model ID	Description	B_{2015} (%B_0)	*M*
Base case	1.1	Base case model with *M* = 0.20	62 (46–79)	-
Sensitivity	2.1	Model 1.1, but with *M* = 0.15	44 (32–58)	-
Sensitivity	2.2	Model 1.1, but with *M* = 0.25	78 (60–97)	-
Sensitivity	1.3	Model 1.1, but with *M* estimated	90 (72–109)	0.333 (0.267–0.375)

2. OBJECTIVES

The objectives of this investigation were to:

- Investigate whether *M* can be reliably estimated from simulated data sets using the existing SBW 6I model,
- Investigate potential causes of biased estimation of *M* by the SBW 6I model; and
- Identify alternative model structures that will result in the non-biased estimation of *M*.

The longer term aim of the study is to inform the selection of the base case for future SBW 6I assessments.

3. METHODS AND RESULTS

The most recent base case CASAL assessment (Dunn & Hanchet 2017) was used as the starting model for all assessment models developed in this study. Model details and methods used are described with the results obtained from each respective area of investigation.

Initial exploration of biased estimation of M

Potential biases in the estimation of *M* by model run 1.3 were assessed by running the model on simulated data for a known *M* (0.20) generated by simCASAL from model run 1.1. At MPD (200 simCASAL samples), the median estimate of *M* was 0.17 (95% interval 0.15–0.29) indicating a small negative bias. Conversely at MCMC (50 simCASAL samples, 600 000 iterations each), the model produced median *M* estimates much greater than 0.20 for all 50 simulated datasets with a combined posterior of *M* = 0.28 (95% interval 0.21–0.30) (Figure 1).

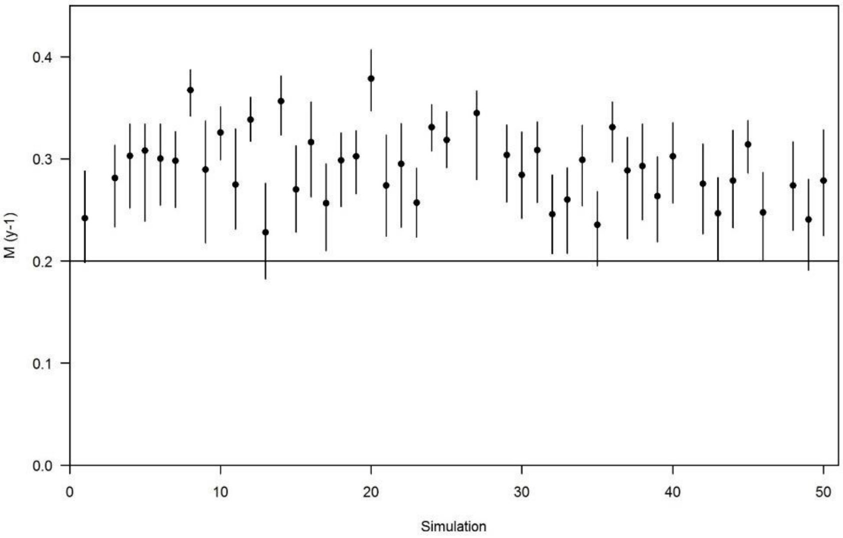

Figure 1: MCMC posteriors of M from 50 runs of model run 1.3 using simulated datasets from run 1.1 for M = 0.20 (highlighted by solid line).

Exploration of causes of bias

A likelihood profile of *M* was produced for model run 1.3. This indicated that the priors and penalties were highly influential with respect to the estimation of *M*, although these should not conflict with the observations (Figure 2, top). The profile of *M* for the acoustic immature biomass series had at least two minima and conflicted with other observations. As expected, the lognormal prior on *M* (mu = 0.20; CV = 0.20) was the most influential of the priors, although lognormal priors on YCS and acoustic mature biomass index *q* were also strongly influential. The prior on YCS will negatively bias the estimation of *M* (Figure 2).

An MCMC run was undertaken for model run 1.3, keeping the first 1100 samples (11 000 000 iterations with no burn in). The trace of *M* drifted upward along the chain indicating a lack of convergence (Figure 3). There was a simultaneous decline in the likelihood of the observations, which increased by about 20 units of negative log likelihood as *M* drifted from 0.20 to 0.35 at the end of the chain. The likelihood profile of *M* indicated that the observations, priors and penalties should prevent MCMC estimates above *M* = 0.25 (Figure 2).

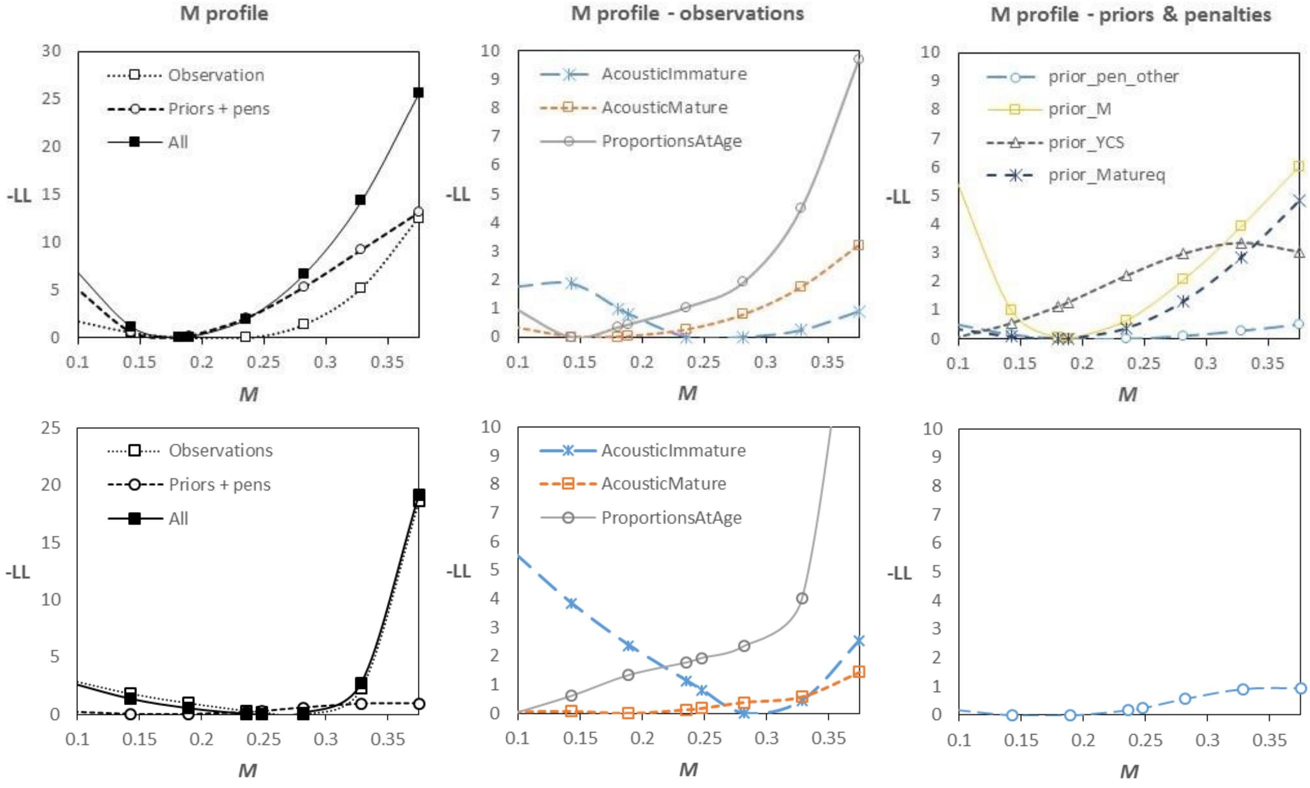

Figure 2: Likelihood profile of M with the contribution of various observations and priors/penalties aggregated (left), observations disaggregated (centre) and priors/penalties disaggregated (right) for model run 1.3 (top) and run 6.1 (bottom).

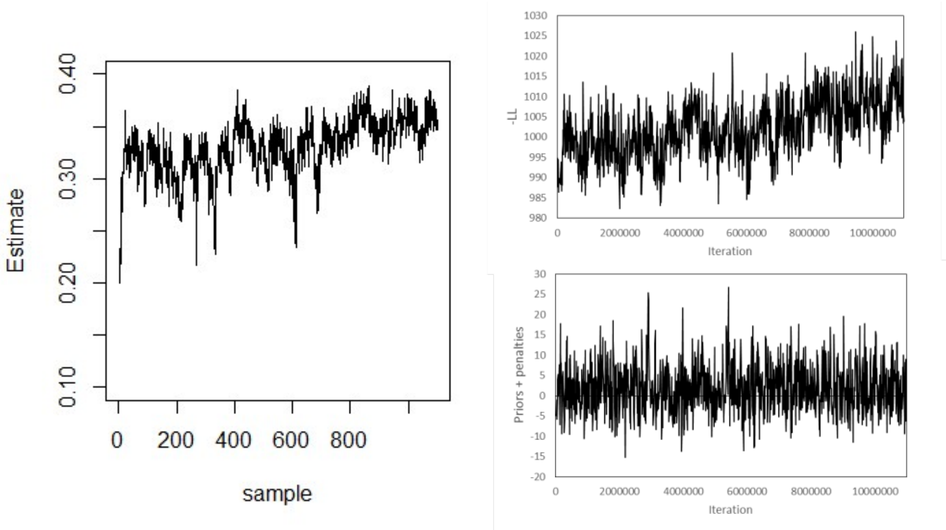

Figure 3: MCMC traces for model run 1.3 of M (left), the likelihood of observations (top right) and the contribution of priors and penalties (bottom right). For this run there was no recalculation of the covariance matrix to improve mixing.

In model run 1.3, initial numbers at ages 2–15+ in 1979 are determined by 14 C_{initial} parameters. C_{initial} parameters were positively correlated with *M* (Figure 4) and drifted up with *M* along the MCMC chain, although an approximately consistent age structure was preserved (Figure 5). The causes of this upward drift in *M* and C_{initial} is not known and this exploration was unsuccessful in obtaining a realistic or stable estimate of *M* at MCMC when C_{initial} was left unconstrained.

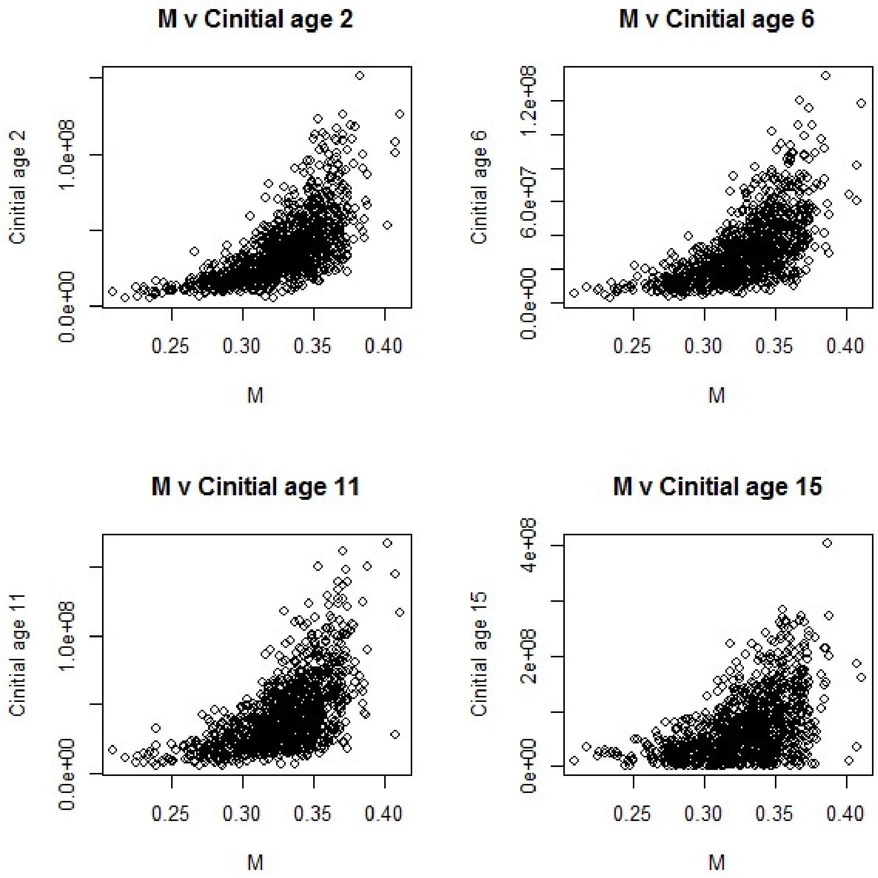

Figure 4: Scatterplots of MCMC estimates of M against Cinitial parameters for ages 2, 6, 11, 15 (representative of young, middle-aged and old fish) for model run 1.3.

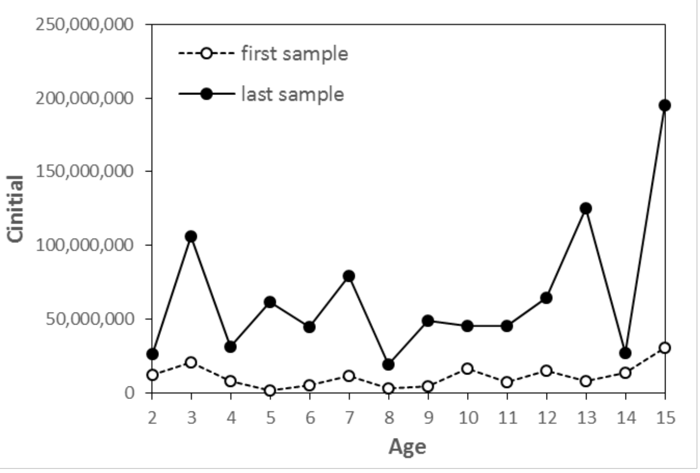

Figure 5: MCMC estimates of all 14 Cinitial parameters at the start and end of the MCMC chain for model run 1.3. The same basic age structure was obtained along the length of the chain e.g. many fish at age 15+ and few at age 8, with some expected variability comparing MCMC samples.

Adjustment of the covariance matrix

In order to address poor mixing at MCMC (see Figure 3), the covariance matrix was recalculated empirically from the first 1000 samples (10 000 000 iterations) and the chain restarted discarding the first part of the chain, keeping the next 1000 samples (10 000 000 iterations). Model run 1.3cov (as run 1.3 but with the covariance matrix recalculated as above) had greatly improved mixing with respect to the estimation of M (compare Figure 3 and Figure 6), but had no effect on M (0.33 from both runs 1.3 and 1.3cov).

An additional MCMC run was undertaken (run 1.5), which was the same as model run 1.3cov, but with a lognormal prior on C_{initial} with *mu* equal to the MPD value and CV = 1.3 (as used for YCS in this stock). The median M at MCMC was 0.19, much lower than the MCMC estimate of 0.33 from run 1.3cov.

Exploration of an alternative initial starting assumption for estimating *M*

The current base case assessment starts in 1979 (Dunn & Hanchet 2017), the year after commercial catches of SBW were first reported separately by fishery management area. This has necessitated the use of C_{initial} parameters, as variation in YCS and also catches prior to 1979 will have created a non-equilibrium age structure in the model start year.

An alternative model was developed that had the same model configuration as 1.3, except that an equilibrium age distribution was assumed in the model start year, which was now 1960 instead of 1979. Also, YCS was estimated from 1958 instead of 1977. This alternative model structure negated the requirement for estimating C_{initial} parameters, which had been identified as compromising the estimation of M at MCMC. However, it required assumptions of the proportion of reported SBW catches that were taken in SBW 6I in the period 1971–1977. Four alternative catch scenarios were assessed:

Prop0.70 – the proportion of catches at SBW 6I in 1971–1977 was equal to the proportion across the period 1978–2016 (0.70);
Prop0.19 - the proportion of catches at SBW 6I in 1971–1977 was equal to the *minimum* of any year from 1978–2016 (0.19);
Prop0.99 - the proportion of catches at SBW 6I in 1971–1977 was equal to the *maximum* of any year from 1978–2016 (0.99)
Double - the annual catch at SBW 6I in 1971–1977 was double that estimated under Prop0.70 - to account for potential under-reporting of catches in this period.

The catches in SBW 6I for each of these scenarios are tabulated in Table A1-1 alongside reported catches for all SBW FMAs. MCMC runs were then undertaken with the initial equilibrium age model structure for each of the four catch scenarios (see Table 2).

At MCMC, equilibrium age models produced estimates of M ranging from 0.17 for the Prop0.99 catch (run 4.3) and Double catch (run 4.4) scenarios to 0.19 for the Prop0.19 catch scenario (run 4.2) (see Table 2). These estimates were similar to the non-equilibrium age model with lognormal priors on C_{initial} (run 1.5) estimate of 0.19.

The YCS posteriors for the Equilibrium Age Prop0.70 model (run 4.1) are shown below (Figure 7). YCSs were below average for the period 1969–1978, average for the period 1958–1964, and approximately twice the average for 1965 and 1966. The SSB trajectory for the period 1979–2015 was similar to that of the base case from the assessment by Dunn & Hanchet (2017), although with broader credible intervals (Figure 7). A large decline in SSB was estimated during the 1970s, which lagged approximately 3 years behind the 1969–1978 period of weak YCS (Figure 8).

Table 2: Model run labels, descriptions and estimates of M from MCMC runs.

Model type	Model ID	Description	*M* (95% interval)
Uniform	1.3cov	As model run 1.3 by Dunn & Hanchet (2017), but the covariance matrix was recalculated empirically from the first part of the chain	0.332 (0.263–0.374)
Lognormal	1.5	Model 1.3cov, but lognormal prior on C_{initial}	0.185 (0.142–0.234)
Equilibrium Age Prop0.70	4.1	Model 1.3cov, but initial equilibrium age model (no C_{initial}) starting in 1960, YCS estimated from 1958, Prop0.70 estimate of catch from 1971–1977	0.178 (0.136–0.224)
Equilibrium Age Prop0.19	4.2	Model 4.1, but Prop0.19 catch estimate from 1971–1977	0.188 (0.151–0.229)
Equilibrium Age Prop0.99	4.3	Model 4.1, but Prop0.99 catch estimate from 1971–1977	0.173 (0.134–0.225)
Equilibrium Age Double	4.4	Model 4.1, but Double catch estimate from 1971–1977 (twice Prop0.70)	0.173 (0.130–0.224)

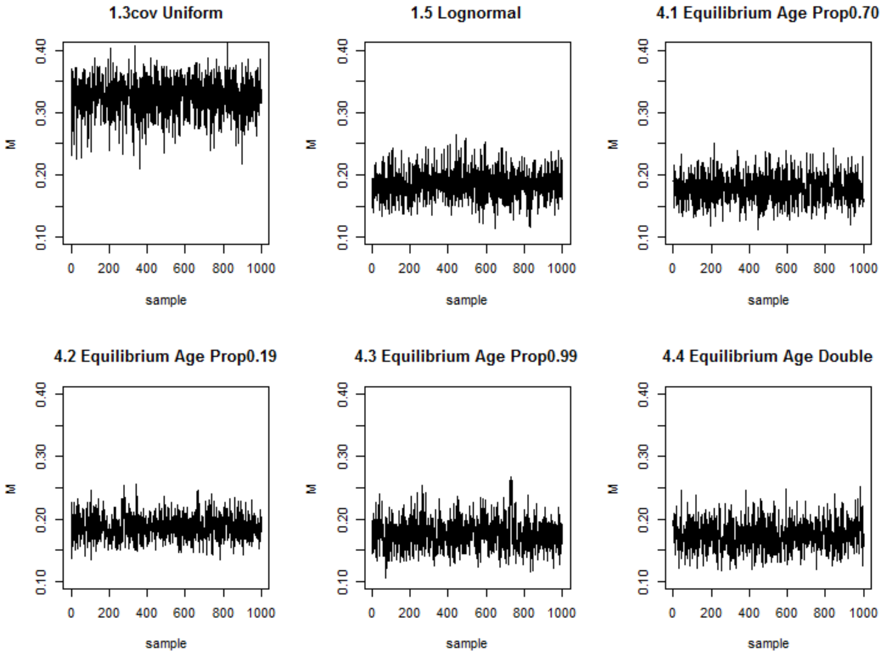

Figure 6: Traces for MCMC run estimates of M for model runs described in Table 2.

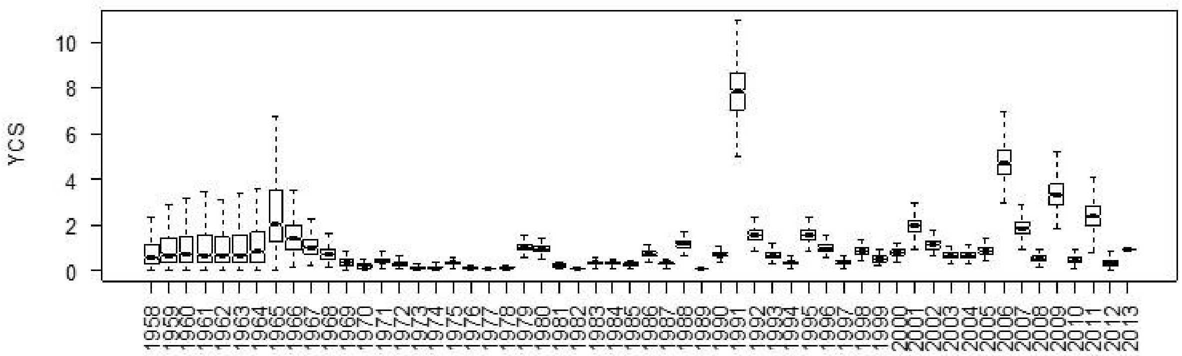

Figure 7: Distribution of YCS posteriors for the Equilibrium Age Prop0.70 model (run 4.1). Bold lines and boxes are the median and lower/upper quantiles; whiskers extend to the most extreme data point that is not more than 1.5 times the interquartile range from the box.

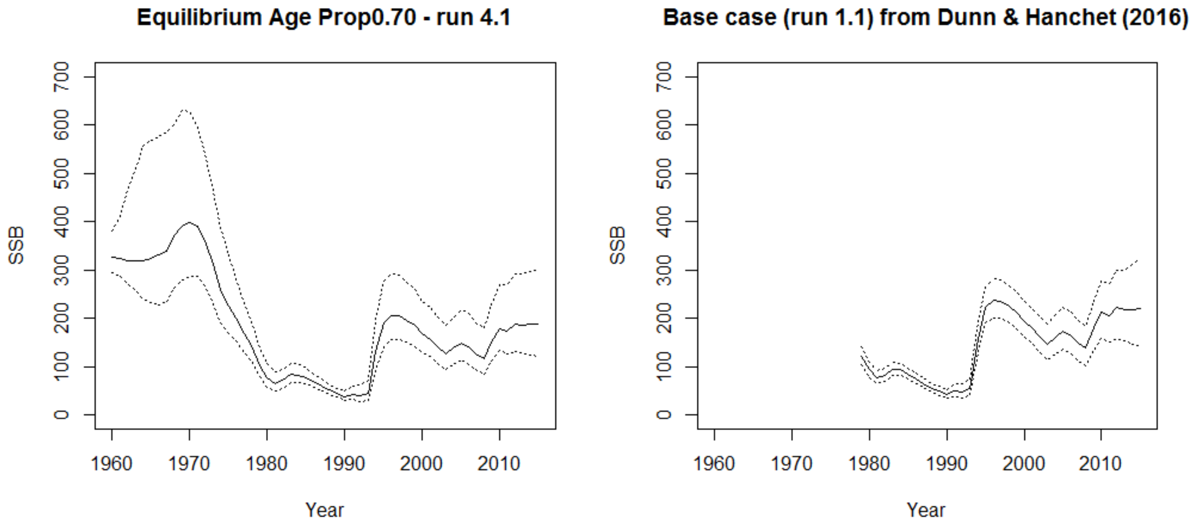

Figure 8: SSB plot for the Equilibrium Age Prop0.70 model (run 4.1) from this study (left) compared with the base case for the latest assessment by Dunn & Hanchet (2017) (right). Solid line is the median, broken lines are 95% credible intervals.

Sensitivity to the *M* prior CV

The Deep Water Working Group recommended that model run 1.3cov was rerun to explore the sensitivity of *M* to the *M* prior CV. It was suggested that using a CV of 0.15 instead of 0.20 (run 1.3cov) might prevent *M* from drifting to implausibly high values (see Table 2 and Figure 6). Five additional MCMC runs were undertaken with alternative *M* prior CVs ranging from 0.01 to 0.30 (Table 3).

The covariance matrix was recalculated empirically from the first 1000 samples (10 000 000 iterations) and the chain was restarted discarding the first part of the chain and keeping the next 1000 samples (10 000 000 iterations).

There was a continuous contraction in the *M* posterior towards the prior mu of 0.20 as the prior CV was reduced (Table 3 and Figure 9). Estimates of *M* were strongly influenced by the selection of the *M* prior CV.

Table 3: Model run labels, descriptions and estimates of M from MCMC runs.

Model ID	Description	*M* (95% interval)
1.3cov	Lognormal prior on *M*, mu = 0.20, CV = 0.20	0.332 (0.263-0.374)
5.1	Model 1.3cov, but M prior CV = 0.01	0.200 (0.197-0.204)
5.2	Model 1.3cov, but M prior CV = 0.05	0.210 (0.191-0.232)
5.3	Model 1.3cov, but M prior CV = 0.10	0.245 (0.200-0.296)
5.4	Model 1.3cov, but M prior CV = 0.15	0.305 (0.234-0.358)
5.5	Model 1.3cov, but M prior CV = 0.30	0.342 (0.285-0.390)

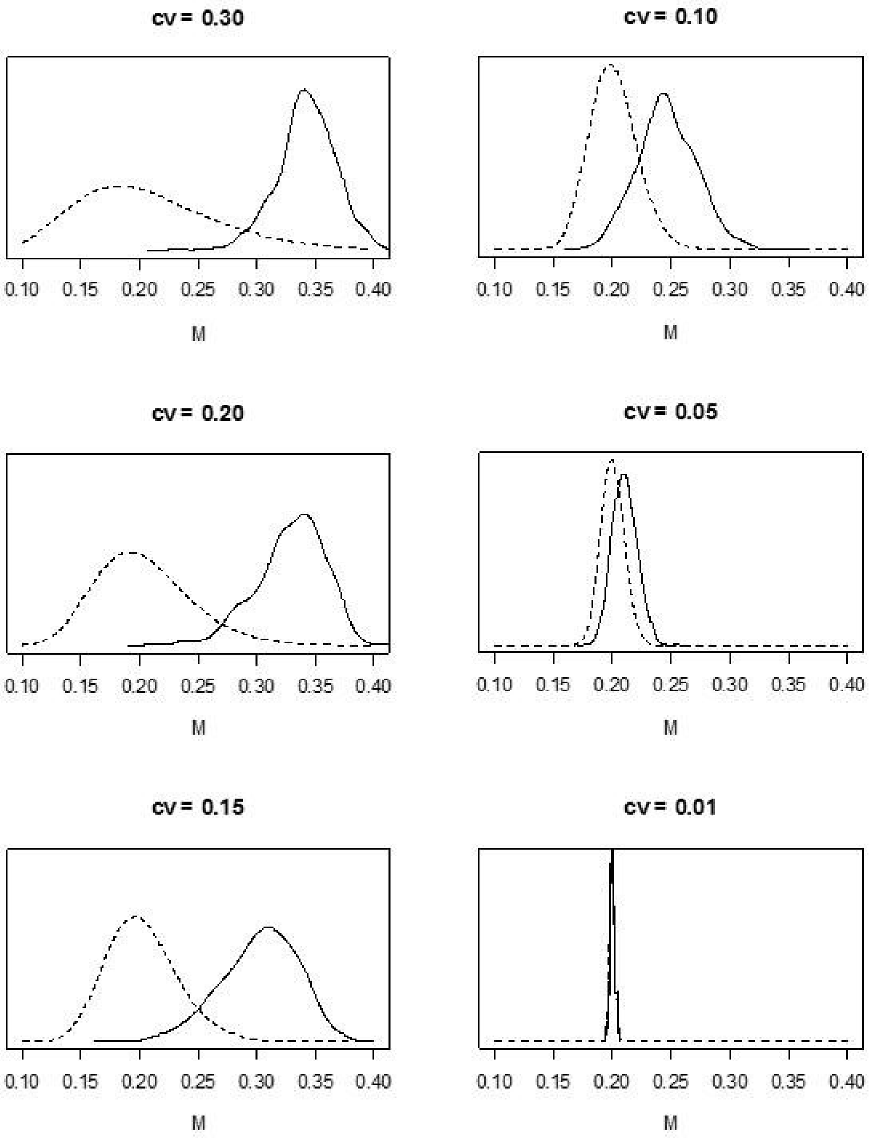

Figure 9: Sensitivity of the M posterior (solid line) to the M prior CV (dashed line); model run 1.3cov (CV = 0.20) and runs 5.1, 5.2, 5.3, 5.4 and 5.5 (CV = 0.01, 0.05, 0.10, 0.15 and 0.30, respectively).

Exploratory model minimising the influence of priors

Noting that the lognormal priors strongly influenced the estimation of *M* in all models described so far (Figure 2), an alternative model structure was sought to minimise their influence. The model structure used was as for model run 4.1, Equilibrium Age Prop0.70), but with uniform priors on *M*, YCS and acoustic mature biomass index *q* (run 6.1). A strong YCS penalty was imposed (multiplier = 100) to maintain a mean YCS close to 1. The posterior *M* was almost identical to that obtained by run 4.1 (both *M* = 0.18) (see Table 4). The likelihood profile on *M* confirmed the minimal influence of priors and penalties (Figure 2, bottom). The influence of the acoustic immature biomass index was increased and was consistent with an *M* of 0.30.

Simulated observations for a known *M* were generated using simCASAL to assess for biases in the estimation of *M* by model run 6.1. Ten simulated samples were generated for *M* values of 0.15, 0.20 and 0.25 and MCMC runs were undertaken. The covariance matrix was empirically recalculated (see above) for this MCMC run. A total of 1000 samples were collected every 1000 iterations (1 000 000 iterations in total).

M posteriors for all runs are shown in Figure 10. These were consistently below the respective value used to generate the simulated observations (Table 4) indicating a negative bias in the estimation of *M* by run 6.1 despite the use of uniform priors. The *M* posterior from the model using true observations had the greatest overlap with the combined posterior for simulated observations of 0.20 (Figure 10). Accounting for the negative bias, the true *M* is highly likely to be somewhere between 0.15 and 0.25.

Table 4: Model run labels, descriptions and estimates of M from MCMC runs of exploratory model with uniform priors on M, YCS and acoustic mature biomass index q. The model outputs from model run 4.1 are shown for comparison.

Model ID	Description	*M* (95% interval)
4.1	Lognormal prior on *M* and YCS. True observations	0.178 (0.136–0.224)
6.1	Uniform prior on *M*, YCS and acoustic mature biomass index *q*. True observations	0.177 (0.133–0.235)
6.1sim	As 6.1, but simulated observations $M = 0.15$	0.135 (0.099–0.190)
6.1sim	As 6.1, but simulated observations $M = 0.20$	0.166 (0.119–0.257)
6.1sim	As 6.1, but simulated observations $M = 0.25$	0.194 (0.141–0.268)

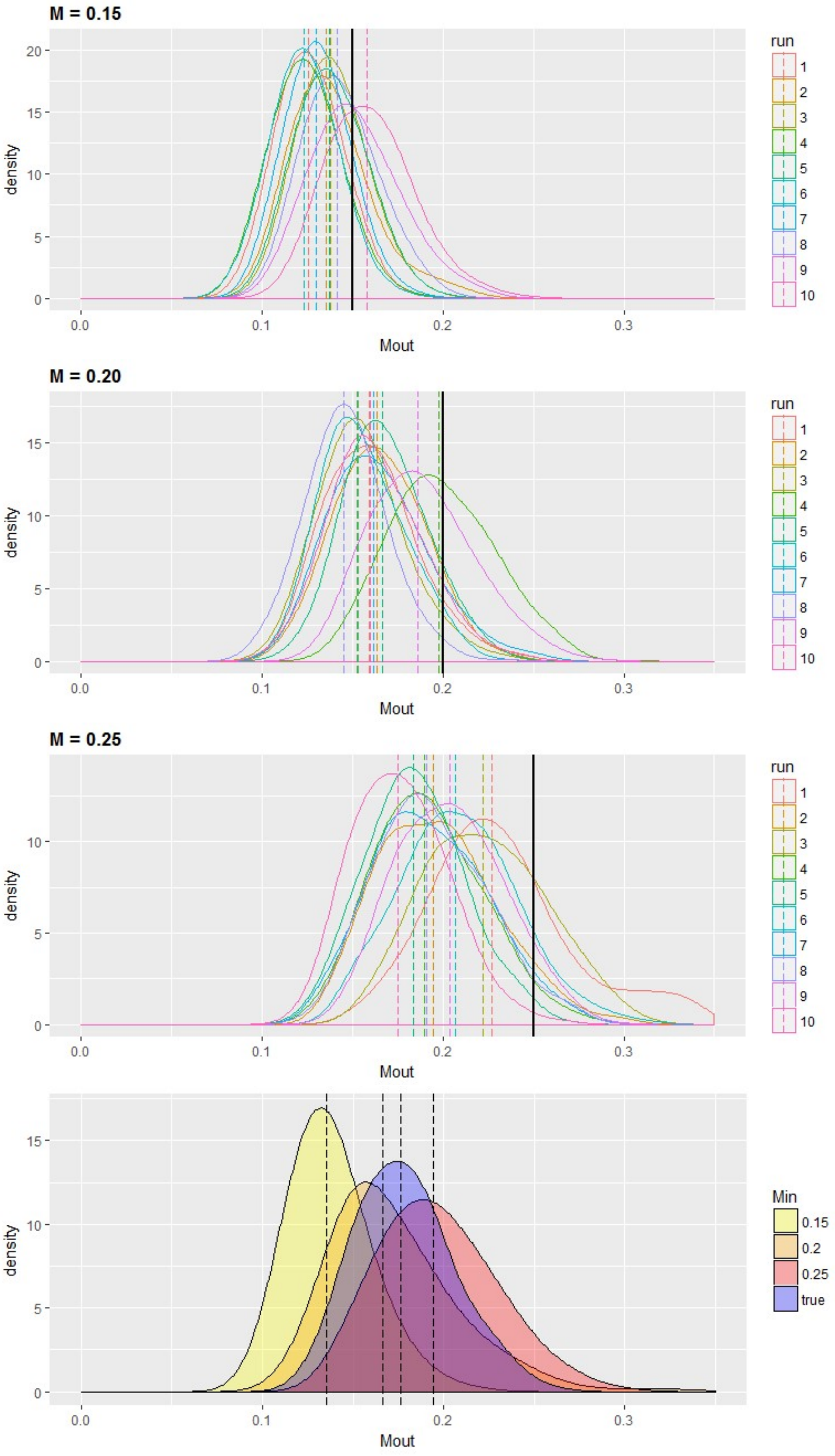

Figure 10: M posteriors for model run 6.1sim fitted to 10 alternative simCASAL generated samples of simulated acoustic biomass and commercial fishery catch-at-age observations consistent with M = 0.15 (top plot), M = 0.20 (second plot) and M = 0.25 (third plot) and the same posteriors for each value of M combined (bottom plot, M = 0.15 shaded yellow; 0.20 orange; 0.25 red) and compared with the posterior for model run 6.1 (shaded blue) which uses the true observations of acoustic biomass and commercial fishery catch-at-age. Dashed lines represent the median values of each posterior.

4. DISCUSSION

This study investigated the ability of the current assessment model (Dunn & Hanchet 2017) to reliably estimate M and investigated the potential for a number of alternative assessment model structures to produce stable and plausible estimates of M.

The contribution of the observations to the likelihood profile for run 1.3 in the most recent assessment (where M is estimated) suggests that they are relatively uninformative and that M values ranging from 0.15 to 0.25 are equally plausible (Figure 2). The combined penalties and priors were comparatively influential and consistent with M values between 0.15 and 0.20. This highlights the potential for biasing factors, including influential priors, to overwhelm the information from observations for estimating M.

A strong positive correlation between the C_{initial} parameters and M was identified as the cause of the upward-drifting trace of M in assessment model run 1.3 to implausibly high values (see Figure 3). The underlying reasons for this drift are not understood i.e., why does it occur for the MCMC run and not the MPD (model run 1.3 $M = 0.17$) (Dunn & Hanchet 2017) and why does the trace drift up and not down?

The performance of model run 1.3 was tested on simulated data where M was known. The model produced median M estimates at MCMC for all 50 simulated datasets that were greater than 0.20, with a combined posterior of $M = 0.28$ (95% intervals 0.21–0.3, Figure 1), indicating a strong positive bias.

Reducing the M prior CV (from 0.20 to 0.15 or some other value) caused the M posterior to contract towards the prior mu (Table 3 and Figure 9). The posterior of M was effectively decided by the selection of M prior CV, which is subjective. This does not appear to be an objective means of estimating M within the assessment model.

The initial equilibrium age model structure was a viable alternative to the non-equilibrium age structure currently adopted as the base case model for this stock (Dunn & Hanchet 2017). Estimating YCS back to 1958 gives the required flexibility to fit the non-equilibrium age structure observed in first year of fishing (1979) as opposed to estimating numbers at age in this year (C_{initial} in the current base case model). The commercial proportion-at-age observations were consistent with a protracted period of poor YCS extending back to at least 1970 and a declining SSB throughout the 1970s (Figure 8). This was preceded by a period of average recruitment with the strongest YCS in the mid-1960s, although individual weak and strong years could not be resolved prior to 1965 (Figure 7). This was consistent with the first year with proportion-at-age in 1979 and the use of a plus group at age 15+, since individuals born prior to 1965 would be aggregated in the plus group.

The current base case model has lognormal priors on M, YCS and acoustic mature biomass index q that should negatively bias the estimation of M relative to the information from observations (Figure 2). However, the model in which uniform priors were used (run 6.1) produced near-identical estimates of M (compared with run 4.1). Comparison of posteriors from true and simulated observations suggests that true M was highly likely to be between 0.15 and 0.25 using this model structure (Table 4 and Figure 10).

This study was unsuccessful in finding a satisfactory assessment model structure for estimating an unbiased M. Since the value of M strongly influences B_0, current stock status and TACC estimates, it is recommended that the assessment continues to use 0.2 with sensitivity analyses at 0.15 and 0.25 until the sources of biased estimation of M can be identified and corrected.

Future exploration could include extending the age partition up to 20+ (instead of 15+) to make the proportion-at-age observations more informative for M. Further investigation of the causes of conflict between the acoustic immature biomass index series and other observations may also be useful.

The technique of recalculating the covariance matrix from the first part of the chain greatly improved mixing for *M* and other parameters at MCMC (compare Figure 3 and Figure 6). This method was also effective for demographic assessments using the SeaBird demographic software (Roberts & Doonan 2016) and may be a useful technique for improving convergence at MCMC in future assessments using CASAL.

5. CONCLUSIONS

This study investigated a number of alternative model structures for producing stable and unbiased estimates of *M*. Models retaining the Dunn & Hanchet (2017) base case (with population age structure estimated in the model start year of 1979) and modifying the prior CV for *M* were trialled. The *M* posterior was highly sensitive to a subjective decision about the prior CV.

An alternative model structure starting with an equilibrium age structure in 1960 produced similar SSB trajectories to the base case of Dunn & Hanchet (2017) and plausible *M* estimates of 0.17–0.19, depending on assumptions about catch history. However, when this model was run with simulated observations for a known *M* it was found to produce negatively biased estimates of *M*. Accounting for the potential biasing effects of lognormal priors on *M*, YCS and acoustic mature biomass index *q* had virtually no effect on model estimates.

This study was unsuccessful in finding a satisfactory assessment model structure for estimating *M*. Since the value of *M* strongly influences B_0, current stock status and TACC estimates, it is recommended that the assessment continues to use 0.2 with sensitivity analyses at 0.15 and 0.25 until the sources of biased estimation of *M* can be identified and corrected. Future exploration could include extending the age partition up to 20+ (instead of 15+) to make the proportion-at-age observations more informative for *M* and to explore the conflict between the acoustic immature biomass index and other observations.

6. REFERENCES

Dunn, A.; Hanchet, S.M. (2017). Southern blue whiting (*Micromesistius australis*) stock assessment for the Campbell Island Rise up to and including the 2015 season. Draft New Zealand Fisheries Assessment Report. (Unpublished draft held by Ministry for Primary Industries.)

Roberts, J.; Doonan, I. (2016). Quantitative Risk Assessment of Threats to New Zealand Sea Lions. *New Zealand Aquatic Environment and Biodiversity Report No. 166*. 111 p.

7. APPENDIX 1

Table A1-1: Reported catches of southern blue whiting by FMA from 1978–1979 and catches in 1971–1977 calculated (bolded) according to the four catch scenarios – Prop0.70, Prop0.19, Prop0.99 and Double - described in the main body.

Year		Campbell Island				Bounty	Pukaki	Auckland	All areas
	Reported Catches	Estimated - Prop0.70	Estimated - Prop0.19	Estimated - Prop0.99	Estimated - Double	Platform - Reported	Rise - Reported	Island - Reported	– Reported
1971	–	**7 260**	**1 938**	**10 294**	**3 823**	–	–	–	10 400
1972	–	**18 010**	**4 807**	**25 538**	**9 483**	–	–	–	25 800
1973	–	**33 856**	**9 037**	**48 007**	**17 827**	–	–	–	48 500
1974	–	**29 458**	**7 863**	**41 771**	**15 512**	–	–	–	42 200
1975	–	**1 660**	**443**	**2 354**	**874**	–	–	–	2 378
1976	–	**11 929**	**3 184**	**16 915**	**6 281**	–	–	–	17 089
1977	–	**18 453**	**4 925**	**26 166**	**9 717**	–	–	–	26 435
1978	6 403	6 403	6 403	6 403	6 403	0	79	15	6 497
1978–79	25 305	25 305	25 305	25 305	25 305	1 211	601	1019	28 136
1979–80	12 828	12 828	12 828	12 828	12 828	16	5 602	187	18 633
1980–81	5 989	5 989	5 989	5 989	5 989	8	2 380	89	8 466
1981–82	7 915	7 915	7 915	7 915	7 915	8 325	1 250	105	17 595
1982–83	12 803	12 803	12 803	12 803	12 803	3 864	7 388	184	24 239
1983–84	10 777	10 777	10 777	10 777	10 777	348	2 150	99	13 374
1984–85	7 490	7 490	7 490	7 490	7 490	0	1 724	121	9 335
1985–86	15 252	15 252	15 252	15 252	15 252	0	552	15	15 819
1986–87	12 804	12 804	12 804	12 804	12 804	0	845	61	13 710
1987–88	17 422	17 422	17 422	17 422	17 422	18	157	4	17 601
1988–89	26611	26 611	26 611	26 611	26 611	8	1 219	1	27 839
1989–90	16542	16 542	16 542	16 542	16 542	4 430	1 393	2	22 367
1990–91	21314	21 314	21 314	21 314	21 314	10 897	4 652	7	36 870
1991–92	14208	14 208	14 208	14 208	14 208	58 928	3 046	73	76 255
1992–93	9 316	9 316	9 316	9 316	9 316	11 908	5 341	1143	27 708
1993–94	11 668	11 668	11 668	11 668	11 668	3 877	2 306	709	18 560
1994–95	9 492	9 492	9 492	9 492	9 492	6 386	1 158	441	17 477
1995–96	14 959	14 959	14 959	14 959	14 959	6 508	772	40	22 279
1996–97	15 685	15 685	15 685	15 685	15 685	1 761	1 806	895	20 147
1997–98	24 273	24 273	24 273	24 273	24 273	5 647	1 245	0	31 165
1998–00	30 386	30 386	30 386	30 386	30 386	8 741	1 049	750	40 926
2000–01	18 049	18 049	18 049	18 049	18 049	3 997	2 864	19	24 804
2001–02	29 999	29 999	29 999	29 999	29 999	2 262	230	10	31 114
2002–03	33 445	33 445	33 445	33 445	33 445	7 565	508	262	41 795
2003–04	23 718	23 718	23 718	23 718	23 718	3 812	163	116	27 812
2004–05	19 799	19 799	19 799	19 799	19 799	1 477	240	95	21 620
2005–06	26 190	26 190	26 190	26 190	26 190	3 962	58	66	30 278
2006–07	19 763	19 763	19 763	19 763	19 763	4 395	1 115	84	25 363
2007–08	20 996	20 996	20 996	20 996	20 996	3 799	513	278	25 587
2008–09	20 483	20 483	20 483	20 483	20 483	9 863	1 377	143	31 887
2009–10	19 040	19 040	19 040	19 040	19 040	15 468	4 853	174	39 540
2010–11	20 224	20 224	20 224	20 224	20 224	13 913	4 433	131	38 708
2011–12	30 982	30 982	30 982	30 982	30 982	6 660	701	92	38 440
2012–13	21 321	21 321	21 321	21 321	21 321	6 827	1 702	49	29 906
2013–14	28 606	28 606	28 606	28 606	28 606	4 278	71	47	33 455
2014–15	23 397	23 397	23 397	23 397	23 397	8 864	6	73	33 677
2015–16	22 100	22 100	22 100	22 100	22 100	2 405	11	90	24 624