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Tini a Tangaroa

Silver warehou (*Seriolella punctata*) western Chatham Rise preliminary stock assessment

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EXECUTIVE SUMMARY

McGregor, V.L. (2019). Silver warehou (*Seriolella punctata*) western Chatham Rise preliminary stock assessment.

New Zealand Fisheries Assessment Report 2019/60. 21 p.

A preliminary stock assessment model was developed for silver warehou (*Seriolella punctata*) on the western Chatham Rise using the general-purpose stock assessment program CASAL v2.30. The model was informed by relevant biological parameters, a CPUE assumed to index abundance and age composition data for five years (2001, 2005, 2010, 2013 and 2016). The CPUE was generally increasing over the time-series, while catches remained high. The model was insufficiently informed by the available data, but it was possible to estimate a minimum value for the virgin biomass as between 20 500 and 20 750 tonnes. This was the smallest virgin biomass that would support the catch history with the specified model. It was recommended a full stock assessment would require more age composition data and possibly a better understanding of the spatial dynamics of the population and the fishery with respect to fish age and growth.

1. Introduction

This document reports the results of objective 2 of Ministry for Primary Industries Project DEE2016-16. The specific project objective was to provide an estimate of stock status in relation to management reference points for SWA 3 and SWA 4 from a stock assessment model using all available data.

The New Zealand silver warehou (*Seriolella punctata*) fishery dates back to the 1960s, although recorded landings only date back to 1974 and the fishery came under the Quota Management System (QMS) in 1986. There has been no formal stock assessment for the fishery to date.

The current assessment used CASAL v2.30, a generalised age-or length-structured fish stock assessment model (Bull et al., 2012). The assessment incorporates commercial fisheries data: a CPUE index, and age composition data from the observer programme.

The fishery/stock area recommended for the assessment (McGregor, 2019) was the western Chatham Rise (WCHAT), comprising part of SWA 3 and SWA 4 (Figure 1).

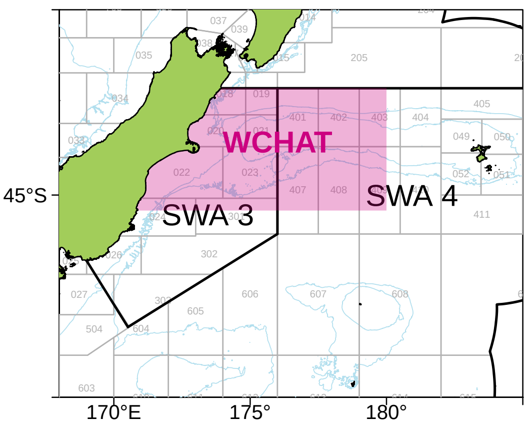


Figure 1: Boundaries of WCHAT (red shaded) (includes western Chatham Rise out to 180° longitude), a sub-area of SWA 3 and SWA 4 combined.

2. Reconstruction of catch history

While we currently have spatially explicit records of silver warehou catches (McGregor, 2016), these do not date back as far as the fishery, so some effort was required to reconstruct an appropriate catch history for the western Chatham Rise (WCHAT).

Commercial fishing for silver warehou developed in the late 1960s and early 1970s. The earliest estimated catches were total annual estimates by Paul (1980) for 1974–1978 (table 1 in Livingston (1988)). Catches were recorded by the Fisheries Statistical Unit (FSU) from 1979–1988, by vessel nationality (Ministry for Primary Industries, 2017). These data from 1979–1987 are stored complete with latitude/longitude coordinates in the NIWA '*wellfisheries*' database (the 1988 data are incomplete in the database). In 1986 silver warehou came under the QMS (Quota Management System) as three stocks comprising the areas SWA 1, SWA 3 and SWA 4 that we have today (Ministry for Primary Industries, 2017). These data from 1990 to the present day are available with latitude/longitude coordinates and stored in the Fisheries New Zealand catch-effort database '*warehou*'. Figure 2 summarises the data sources for silver warehou catches. The years requiring estimation of catches that came from WCHAT are 1974–1978 and 1988–1989.

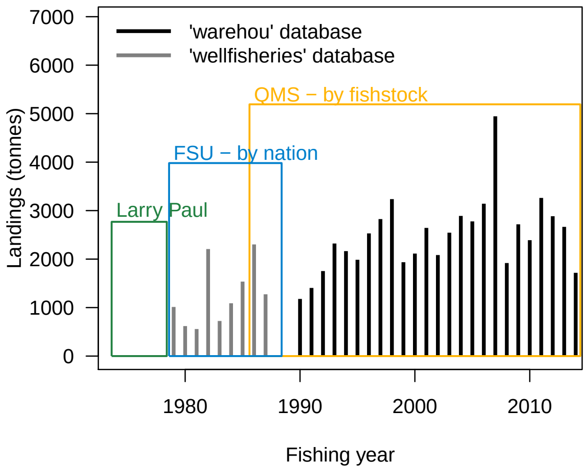


Figure 2: Historic landings data sources. 'Larry Paul' (green rectangle) are the total annual estimates by Paul (1980); 'FSU' (blue rectangle) are catches recorded by Fisheries Statistical Unit, with the grey bars within this currently stored with latitude and longitude coordinates in the NIWA '*wellfisheries*' database; QMS (gold rectangle) are recorded by fishstock through the Quota Management System, with the black bars within this recorded by latitude/longitude coordinates and stored in the Fisheries New Zealand '*warehou*' database. The grey bars and black bars are defined with latitude/longitude coordinates.

Fishing years 1988 and 1989 had catches defined by fishstock, but not by latitude and longitude. As WCHAT includes part of SWA 3 and SWA 4, we estimated the catches from these two years using the proportions of SWA 3 and SWA 4 catches that came from WCHAT in the fishing years 1990–2016. We fitted the relationship using a binomial glm with logit link, then applied the fitted model to the missing years 1988 and 1989. The fitted model provided non-biased and fairly accurate estimates of catches for the fishing years 1990–2016 (Figure 3, left figure). The resulting estimated catches for fishing years 1988 and 1989 are in Figure 3 (right figure).

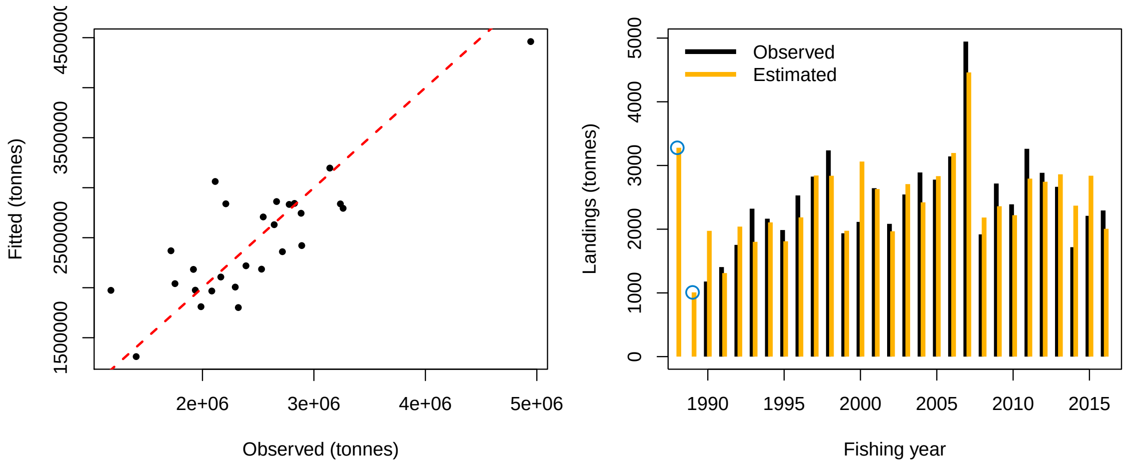


Figure 3: Observed vs. fitted catches from WCHAT fitted using binomial glm on the proportions of catch from SWA 3 and SWA 4 that were from WCHAT (left); Observed (black bars) and fitted (orange bars) catches for WCHAT including those estimated for 1988 and 1989 (right).

Landings for 1974–1978 were estimated based on the proportion of total silver warehou landings from WCHAT in fishing years 1979–2016, modelled using a binomial glm with logit link. The estimated proportions were generally unbiased (Figure 4).

The final catch histories were compared to the total landings of silver warehou from 1974–2016 and to SWA 3 and SWA 4 landings from 1984–2016 (Figure 5). They were generally between a quarter and a third of the total landings and similar but slightly less than SWA 3 landings. The full catch history for WCHAT is in Table 1. Landings up until 1974 were assumed to be zero for the stock assessment, although it is likely that small quantities of silver warehou were taken from WCHAT before then.

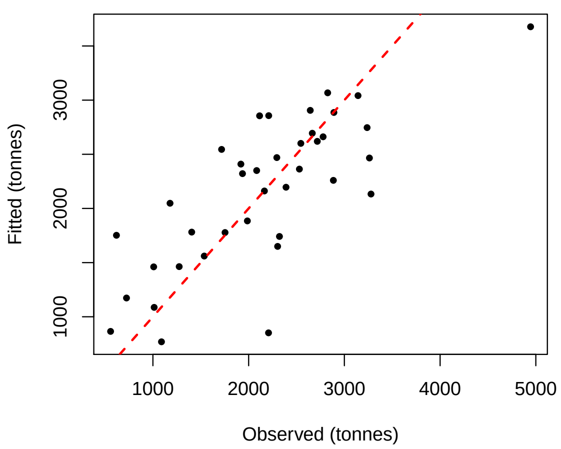


Figure 4: Observed vs. fitted catches from WCHAT using binomial glm to estimate the proportions of annual silver warehou catch that were from WCHAT.

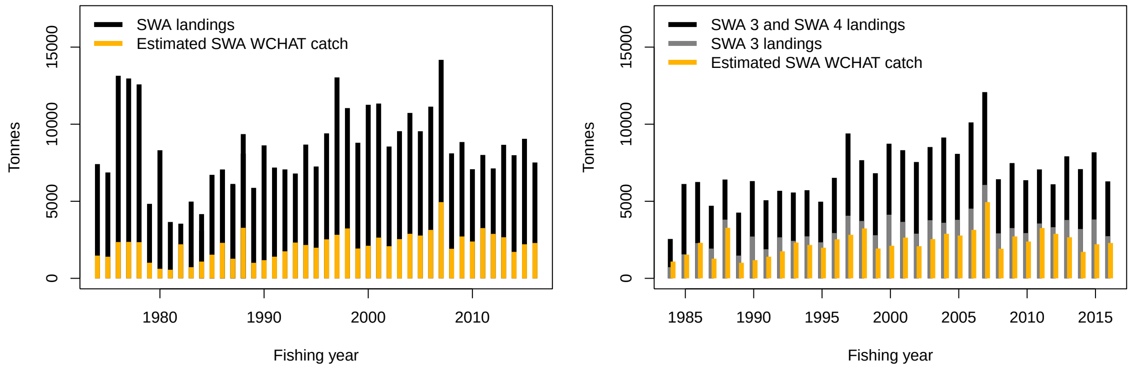


Figure 5: Catch history compared to all landings (left) and SWA 3 and 4 landings (right)

Table 1: Reconstructed catch history for silver warehou from western Chatham Rise in fishing years 1974–2016.

Year	Catch (tonnes)	Year	Catch (tonnes)
1974	1 477	1996	2 530
1975	1 403	1997	2 826
1976	2 356	1998	3 237
1977	2 365	1999	1 936
1978	2 346	2000	2 114
1979	1 013	2001	2 644
1980	619	2002	2 084
1981	558	2003	2 545
1982	2 208	2004	2 891
1983	724	2005	2 778
1984	1 089	2006	3 143
1985	1 536	2007	4 945
1986	2 303	2008	1 919
1987	1 274	2009	2 717
1988	3 278	2010	2 390
1989	1 008	2011	3 262
1990	1 179	2012	2 885
1991	1 405	2013	2 665
1992	1 754	2014	1 717
1993	2 322	2015	2 210
1994	2 165	2016	2 294
1995	1 987		

3. Model inputs

Input data series consisted of the catch history, CPUE (McGregor, 2019) and proportions-at-age (Horn & McGregor, 2018). Proportions-at-age were available for fishing years 2001, 2005, 2010, 2013, and 2016 (Figure 6). The proportions-at-age for 2005 were from only deep tows (more than 300 m) and consist entirely of fish larger than 30 cm (Figure 7) and mostly 5 years and older (Figure 8). Compared to 2001 and 2010, the 2013 and 2016 years had more fish sampled that were greater than 40 cm and older than 4 years caught in fishing depths less than 300 m (Figures 7 and 8).

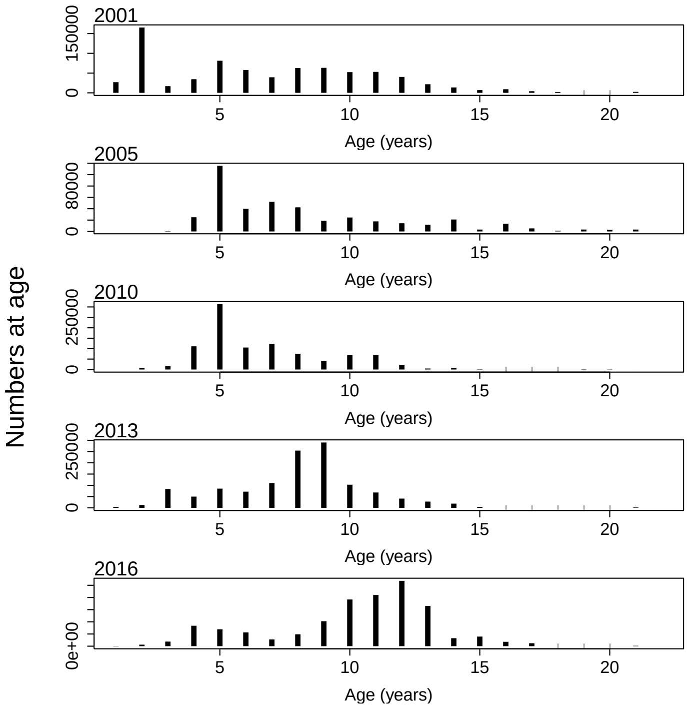


Figure 6: Age-frequency distributions for silver warehou sampled by observers during commercial trawl operations on the western Chatham Rise during all months of 2004–05 and 2009–10, and during September–February of 2000-01, 2012–13, and 2015–16.

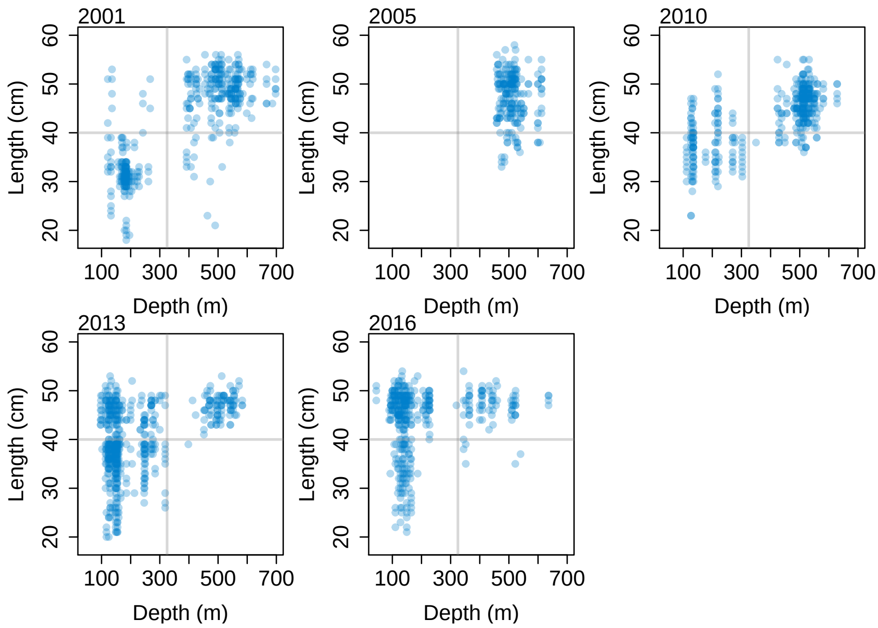


Figure 7: Length-depth distributions for silver warehou sampled by observers during commercial trawl operations on the western Chatham Rise during all months of 2004-05 and 2009–10, and during September–February of 2000–01, 2012–13, and 2015–16.

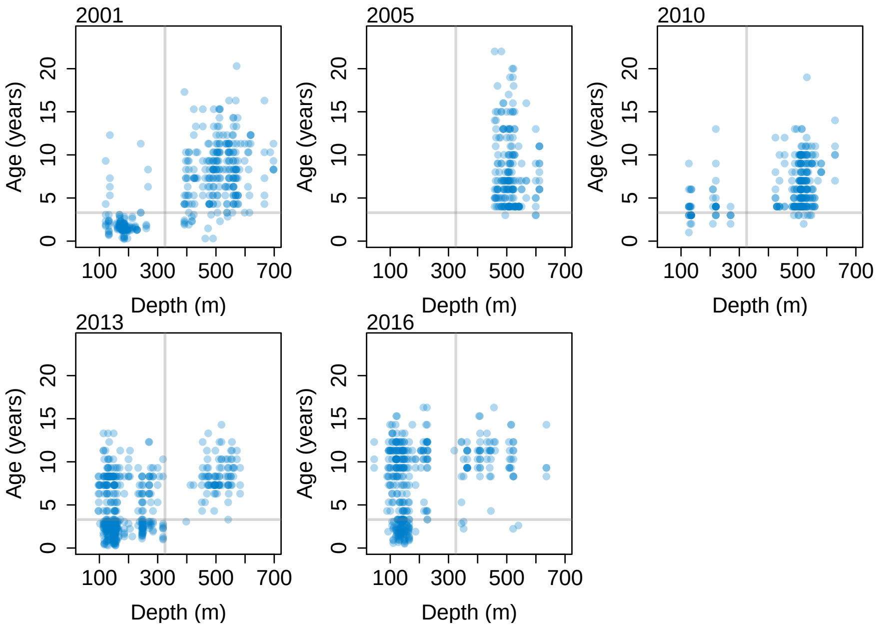


Figure 8: Age-depth distributions for silver warehou sampled by observers during commercial trawl operations on the western Chatham Rise during all months of 2004–05 and 2009–10, and during September–February of 2000–01, 2012–13, and 2015–16.

The process error added to the CPUE index was estimated following the recommendations of Francis (2011). The method involves fitting a series of data smoothers having different degrees of smoothing to the CPUE index, and calculating the CV of the residuals of the fit of the smoother to the data. An appropriate CV is chosen from the resulting plots qualitatively, and is the largest CV that still gives a smooth and good fit to the data. For this CPUE index, a process error CV of 0.14 was considered appropriate (Figure 9).

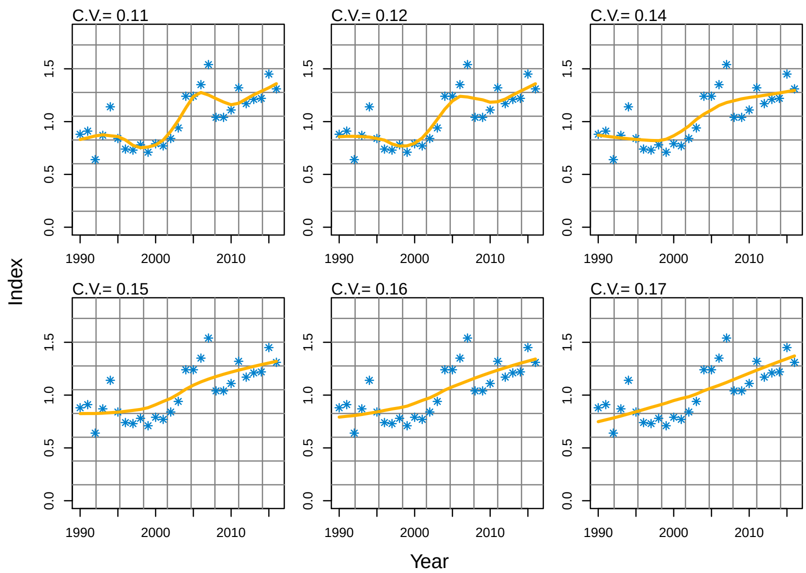


Figure 9: The fit of a data smoother (loess) to the silver warehou CPUE index using different degrees of data smoothing. The CV increases as the degree of smoothing (here the 'span' of the R function loess) increases.

The assumed errors for the proportion-at-age data were multinomial. The initial sample sizes for the proportion-at-age samples were the number of otoliths aged. These were reweighted following the method of Francis (2011) to obtain effective sample sizes (Table 2).

Table 2: Initial and reweighted (effective) sample sizes assumed for the age composition data set.

Fishing year	Initial sample size	Effective sample size
2001	299	54
2005	251	45
2010	335	61
2013	296	54
2016	301	54

3.1. Biological parameters

Estimates of biological parameters and assumed values for model parameters used in the preliminary assessment are given in Table 3. Natural mortality is a little lower than the Australian silver warehou stock assessment where M is fixed at 0.3 with sensitivities at 0.25 and 0.35 (Day et al., 2015). The steepness values of 0.84 was recommended for marine demersal fishes by Shertzer and Conn (2012).

Table 3: Biological and other input parameters used in the WCHAT silver warehou preliminary assessment.

Natural mortality				Horn and Sutton (1996)		
M	0.25					
Length-weight conversion				Tangaroa survey (1992–97)		
weight=$a(\text{length})^b$, weight (grams), length (cm)						
a	8.48E-04					
b	3.214					
von-Bertalanffy growth				McGregor (2019)		
L_∞	k	t_0				
49.8	0.382	-0.954				
Maturity ogives (proportion mature at age)						
Age (years)	2	3	4	5	6–15	
Proportion mature	0.05	0.3	0.7	0.95	1	
Miscellaneous parameters						
Stock-recruitment steepness	0.84					
Recruitment variability CV	0.7					
Ageing error CV	0.2					
Proportion spawning	1					
Maximum exploitation rate (Umax)	0.7					

4. Model structure

The stock assessment model partitioned the WCHAT population into age groups 2–14 years with a plus group at 15 years, and combined sexes. Initially the model was set up with observed ages starting at age zero, as this is the minimum age in the age-composition data. The minimum observed age was increased to 2 years to allow for the high variability of sampling for zero and one year old fish, but the model's annual cycle (Table 4) was specified to allow for age-zeros in the observations. In order to have age-zeros in the estimates, ageing was staged after fishing. The default order for CASAL is ageing first, so an additional timestep was required for this to happen. Recruitment needed to occur later than ageing, so this was put into timestep three.

The selectivity ogive was age-based and estimated in the model for both sexes combined, using the logistic ogive (Bull et al., 2012). Selectivity was assumed constant over years with no allowance for annual changes in selectivity.

The maximum exploitation rate was set relatively high at 0.7 as there was little external information from which to determine it. The choice of the maximum exploitation rate has the effect of determining the minimum possible virgin biomass allowed by the model.

Table 4: Annual cycle, showing the processes taking place at each time step, their sequence within each time step, and the available observations.

Time steps	
One	Half growth
	Half mortality (natural and fishing)
	SSB
	Remaining mortality (natural and fishing)
Two	Ageing
Three	Recruitment
	Remaining growth
Observations	
CPUE	Timestep one
	Proportion mortality 0.5
Proportion at age	Timestep one

Model parameters (Table 5) were estimated using Bayesian estimation implemented using the CASAL v2.30 software. However, only the mode of the joint posterior distribution (MPD) was estimated as this is a preliminary assessment. For a full assessment, the full posterior distribution would be sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm. Full details of the CASAL algorithms, software, and methods were detailed by Bull et al. (2012).

The error distributions assumed were multinomial for the proportions-at-age and lognormal for CPUE. Year class strengths (YCS) were estimated under the assumption that the estimates from the model must average 1. The Haist parameterisation for year class multipliers is used here (see Bull et al. (2012) for details). The model estimated YCS from 1995 with years prior to this fixed at 1. A signal in the 1995 year class would show as 5-year old fish in the 2001 proportions-at-age data and 9 year-old fish in the 2005 data, which would inform the earliest estimated YCS by two proportions-at-age. Due to the order of time-steps in the model, the year classes are estimated for the year prior to when the fish turn up at age zero in the model. YCS can not be estimated based on only old fish as older fish are more susceptible to bias through accumulated mortality. They also can not be estimated by only very young fish (less than 4 years) as they are susceptible to high variability due to the combination of schooling by size and growing quickly.

Table 5: Model estimated parameters and structure.

Parameter	Structure
B_0 (Initial biomass (t))	Uniform-log prior (30 000, 5 000 000)
q	Uniform-log prior (1e-8, 1e-3)
Selectivity (trawl fishery)	logistic with uniform prior a_{50} (1,10), a_{to95} (1,10)
YCS (year class strengths)	Lognormal prior, μ=1, CV=0.7 (0.01, 100)
	Free from 1995-2015
	Alt: free from 1981-2015

5. Model estimates

The initial model estimated B_0 at 60 100 tonnes and $B_{current}(\%B_0)$ at 71%. The fits to CPUE and proportions-at-age were reasonable, but the estimated selectivity curve was questionable as we show below.

The initial model estimated strong year classes in 1999 and 2005 (Figure 10). The 1999 year class are seen as 5-year olds in 2005, and a less apparent mode of 10-year olds in 2010 (Figure 11). The data have a stronger mode of 4-year olds in 2005 and an equally strong mode of 10-year olds in 2010. In some sensitivity runs that follow, 2000 is estimated as a strong year class which corresponds to the strong mode of 4-year olds in 2005. The strong 2005 year class is seen in the age composition data as a large mode of 4-year olds in 2010, a smaller mode of 7-year olds in 2013 and 10-year olds in 2016. In 2013 and 2016, the 8 and 11 year old modes are higher than the 7 and 10 year old modes that correspond to the high year class of 2005 (Figure 11).

The estimated selectivity curve appears to be shallower than it should be, suggesting dynamics other than gear selectivity being reflected (Figure 12). A fish that is 5 years old is nearly fully grown, and hence based on fishing gear selectivity should have much the same selectivity as any older fish. The low selectivity of 5-year olds at just over 0.2 could be due to spatial dynamics of the population and/or fishery, or it could be that the ageing data are too sparse and inconsistent to inform the model.

The model's fit to CPUE is reasonable, although the CPUE increased during the last few years of the series and the stock assessment model estimates a decline over these years (Figure 13). The estimated SSB is similar to the fitted CPUE (Figure 14).

The profile likelihood on B_0 shows that a lower limit may be reasonably well defined, but much less so for the upper limit (Figure 15). The CPUE and proportions-at-age appear compatible, however the CPUE appears to require a larger virgin biomass.

The Pearson's residuals on fits to the proportions-at-age show all residuals within the 95% confidence intervals (Figure 16). There are some trends with respect to age within each year, which are most evident in the right-hand figure with age on the x-axis and the points coloured by year. In particular, the residuals for 2001, 2013 and 2016 all declined over ages 10–14 years. In these years the model slightly underestimated the proportion of 10-year olds and slightly overestimated the proportions of 14-year olds, with a fairly smooth change in between. This could suggest natural mortality is set a little low (hence giving a shallower decline in the older proportions-at-age), but it is not a clear enough signal to inform M.

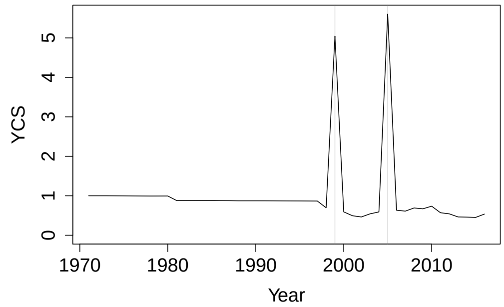


Figure 10: Estimated YCS from the initial preliminary stock assessment model. Strong year classes were estimated in 1999 and 2005.

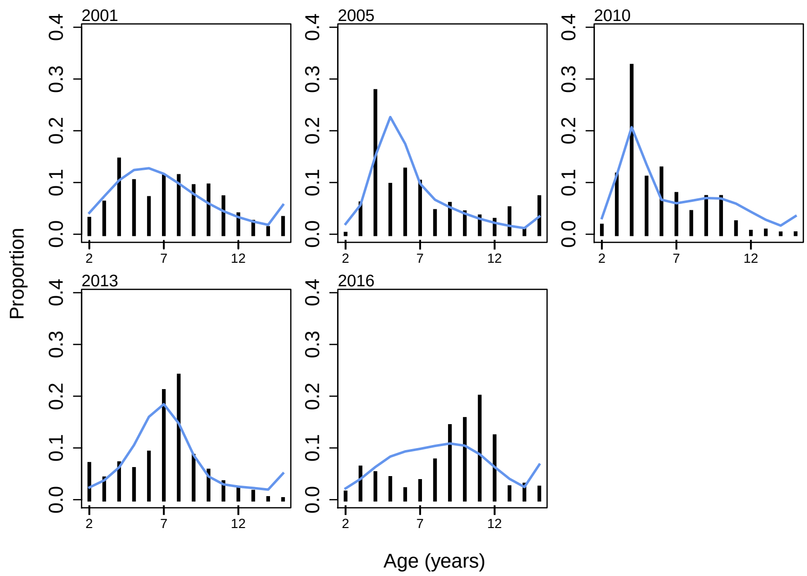


Figure 11: Fits to proportions at age from the initial preliminary stock assessment model.

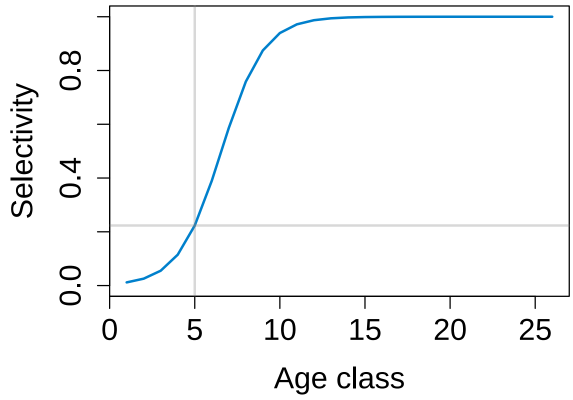


Figure 12: Estimated selectivity from the initial preliminary stock assessment model.

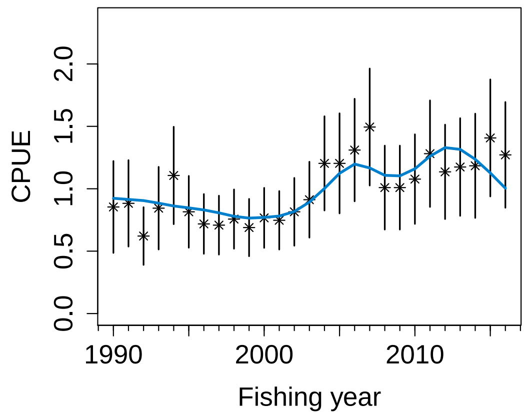


Figure 13: Fits to CPUE from the initial preliminary stock assessment model.

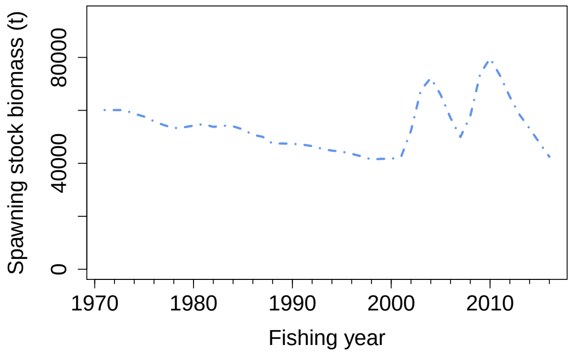


Figure 14: Estimated SSB (Spawning Stock Biomass) from the initial preliminary stock assessment model.

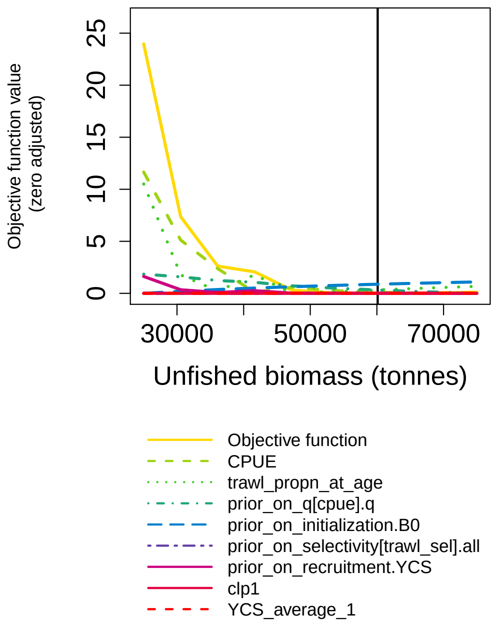


Figure 15: Profile likelihood on B_0.

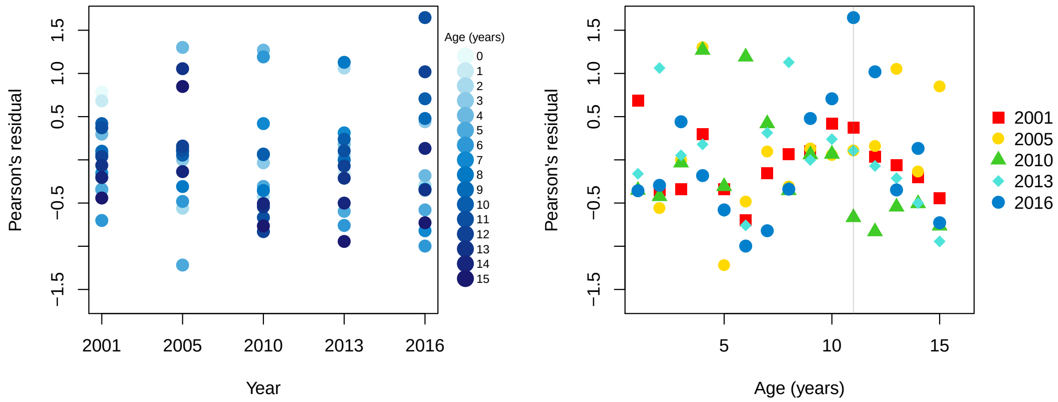


Figure 16: Pearson's residuals for proportions at age by fishing year (x-axis) with colours indicating age (left) and by age (x-axis) with colours indicating fishing year (right).

6. Model sensitivity runs

Sensitivity runs were carried out on CPUE process error, ageing error, M, and the minimum observed age. Most sensitivity runs produced similar fits to the CPUE and proportions at age, even when estimating very different values for B_0. Figure 17 highlights this further as it shows almost identical fits to the CPUE for different estimates of B_0 ranging from 50 000 tonnes to 9.6 million tonnes. The corresponding $B_{current}(\%B_0)$ ranged from 59% to 91%.

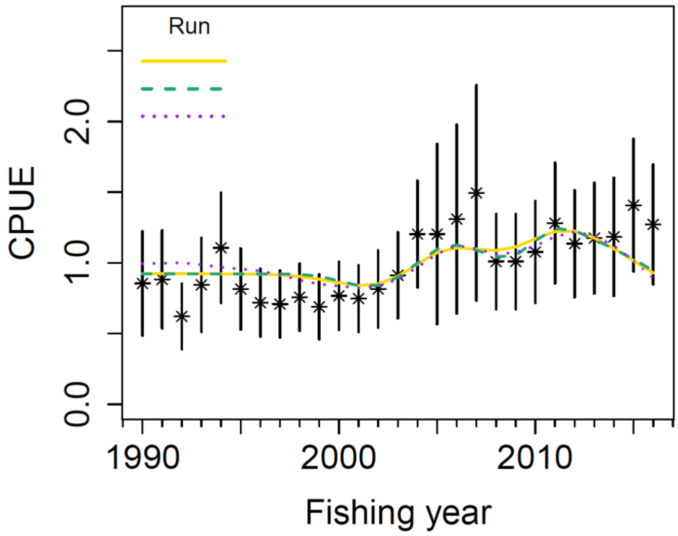
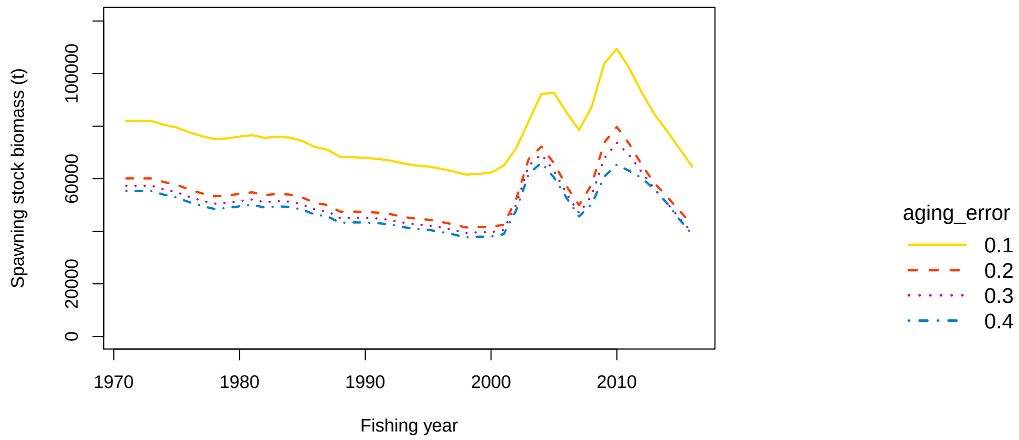


Figure 17: Model fits to CPUE from three models with very different estimates of B_0: 1e+6 tonnes (gold solid line); 9.6e+6 tonnes (green dashed line); 5e+4 tonnes (purple dotted line).

6.1. Ageing error

Sensitivity runs of the model were fitted with ageing error CV values of 0.1, 0.2, 0.3 and 0.4. Ageing error at 0.1 produced estimated SSB above those produced by the other values which were all fairly similar to each other (Figure 18). This lowest ageing error model represented the single strong year class of 1999 from the other models as two strong year classes in 1998 and 2000. The model fits to the proportions-at-age were noticeably better when ageing error was 0.1, but the fits to CPUE were very similar for all runs (Figure 19).



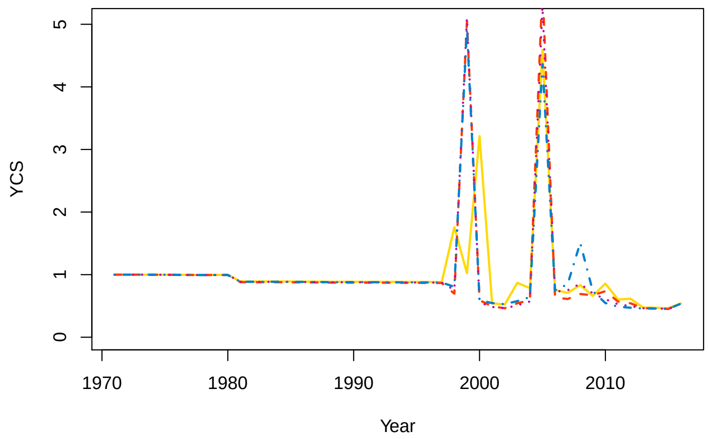


Figure 18: Model estimates of SSB (top) and true YCS (bottom) with sensitivities on ageing error (legend).

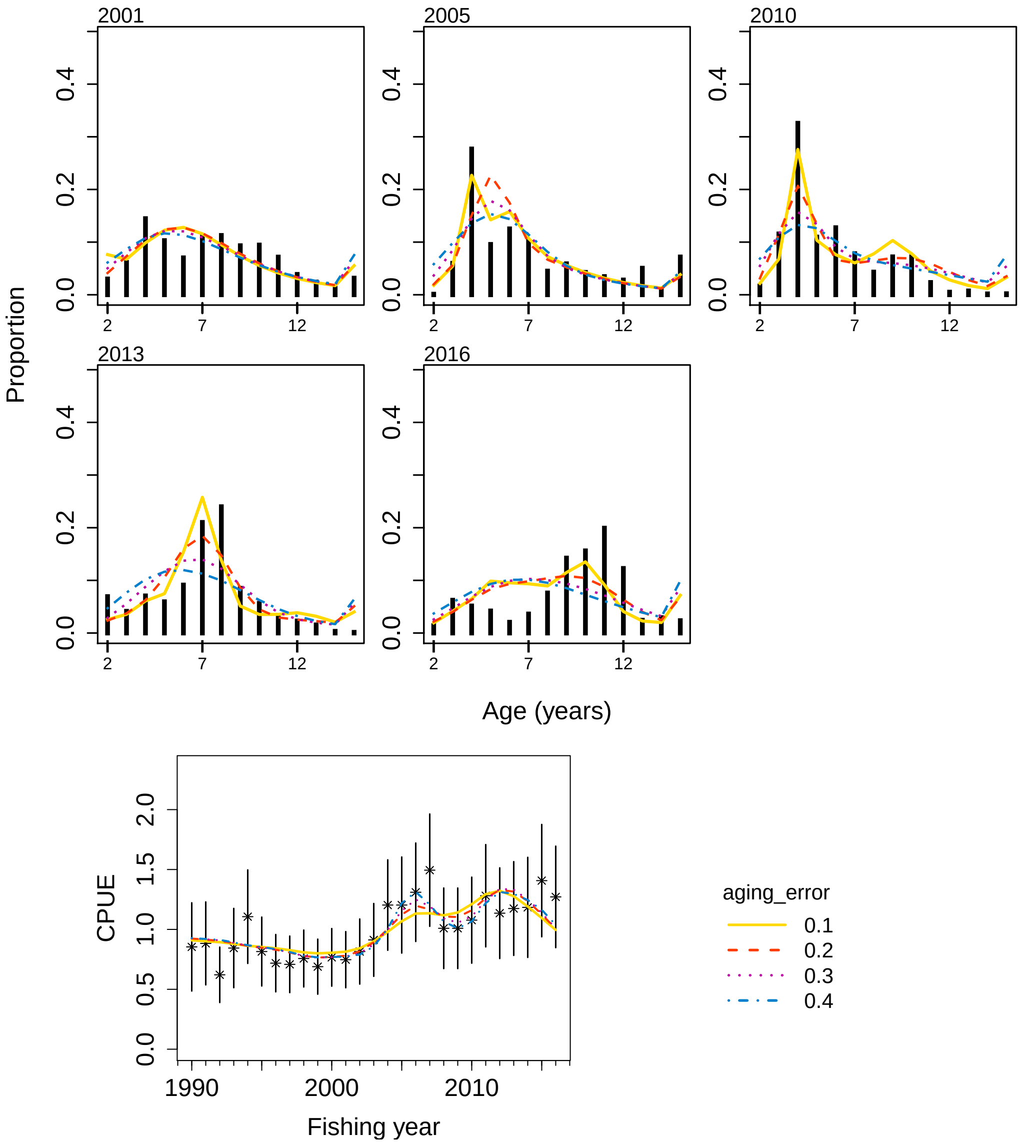
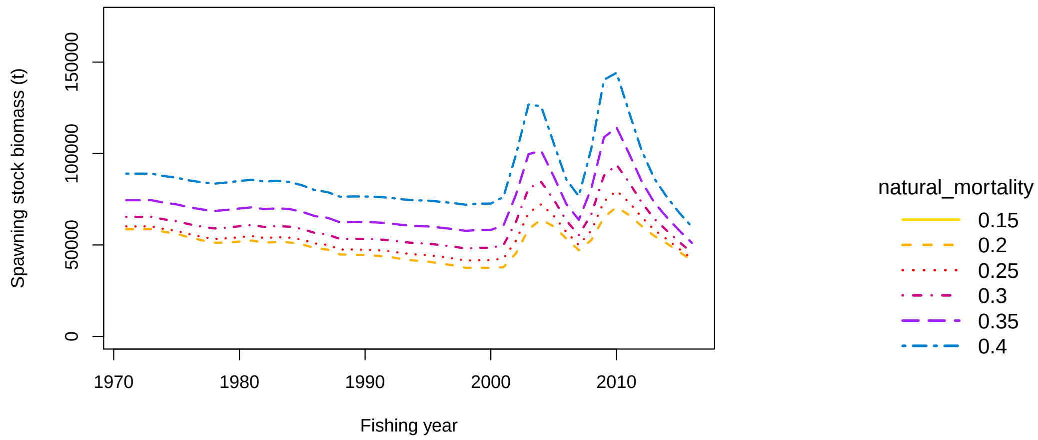


Figure 19: Model estimate fits from ageing error sensitivity runs. Model estimated proportions-at-age with observed proportions-at-age (black bars) (top) and model estimated CPUE with observed CPUE (black asterisks) and 95% confidence intervals (bottom).

6.2. Natural mortality

Sensitivity runs of the model were fitted with natural mortality M taking values 0.15, 0.2, 0.25, 0.3, 0.35 and 0.4. As M increased, SSB was shifted upward (Figure 20). This had almost no effect on estimated CPUE, proportions-at-age or YCS, except for the lowest value, $M = 0.15$ which estimated an additional strong year class in 2000 and a larger plus group in some years (Figures 20 and 21).



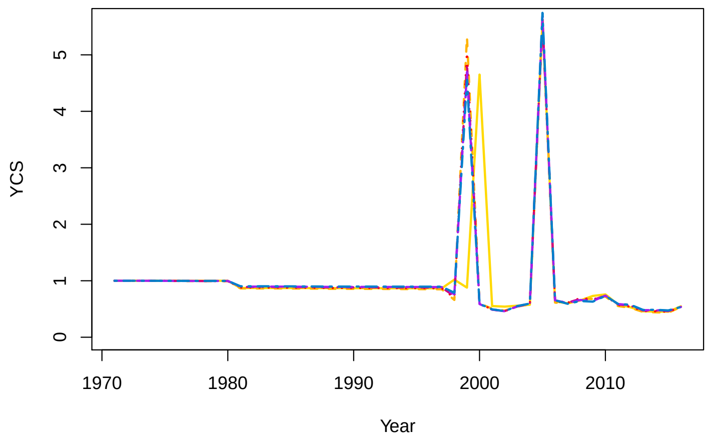


Figure 20: Model estimates of SSB (top) and true YCS (bottom) with sensitivities on natural mortality (legend).

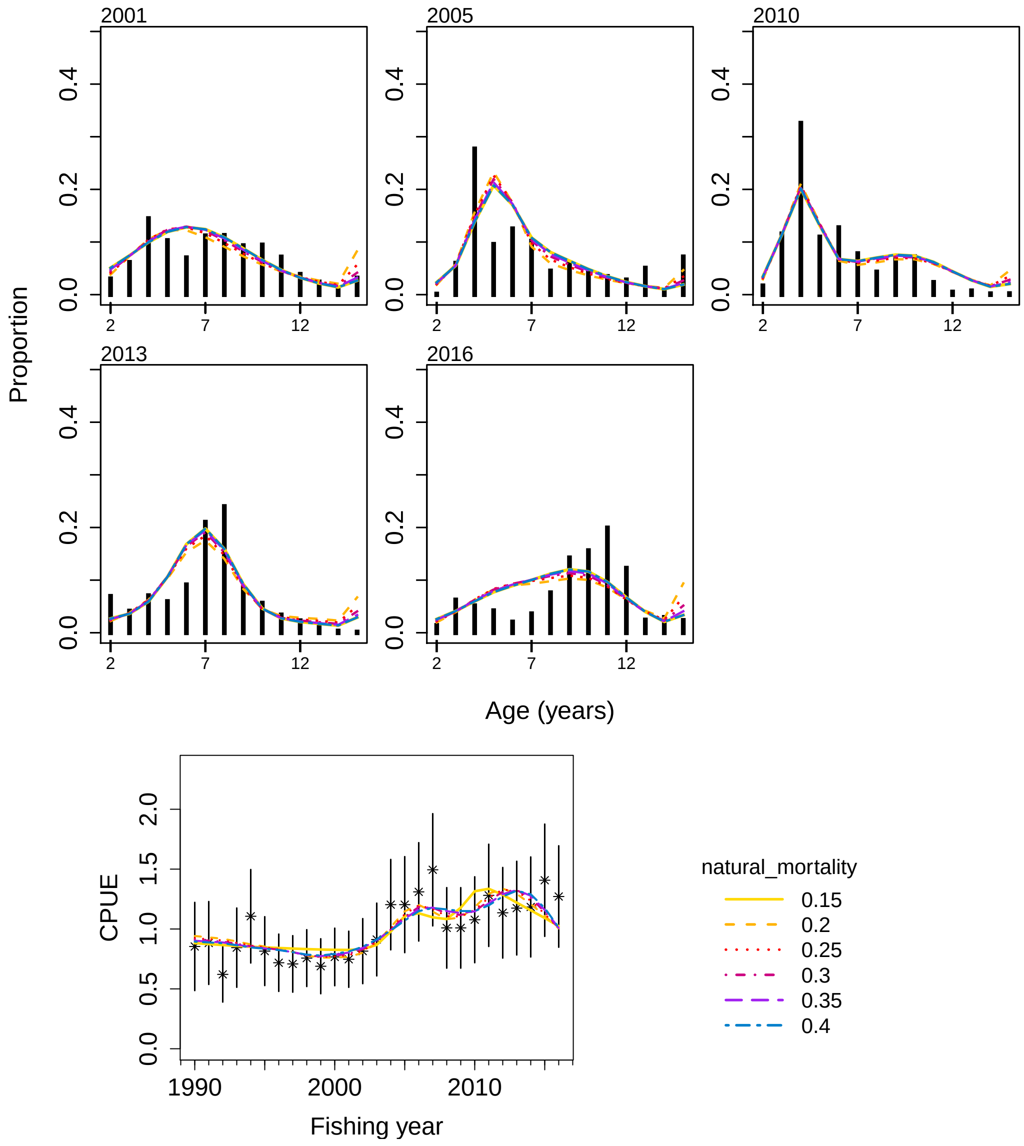


Figure 21: Model estimated proportions-at-age with observed proportions-at-age (black bars) (top) and model estimated CPUE with observed CPUE (black asterisks) and 95% confidence intervals (bottom) with model estimates from natural mortality sensitivity runs.

6.3. Increasing the minimum observed age

As the young (less than 4 years) fish are susceptible to high variability in the catches, we ran two sensitivity runs increasing the minimum age observed to 3 years and 4 years. Increasing the minimum age observed from 2 years (as it is in the initial model) to 3 years shifted the estimated SSB down and changed the fit to CPUE slightly (Figure 22). Increasing further to 4 years had almost no effect.

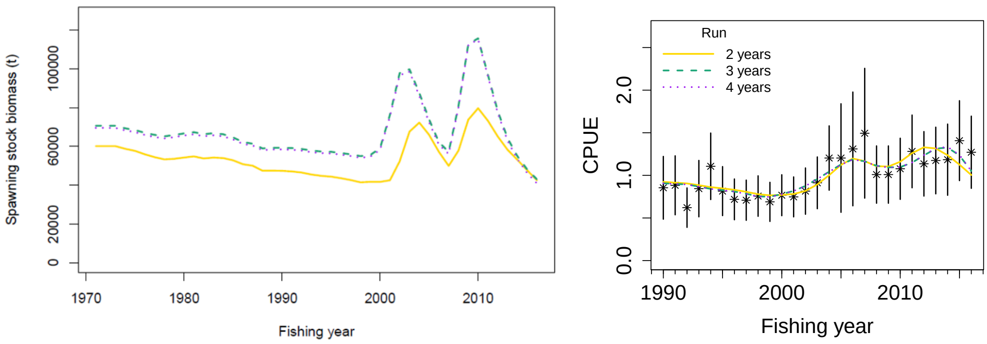


Figure 22: Estimated SSB from model with minimum observed age at 2 years (this is the initial model) (gold solid line), at 3 years (green dashed line) and at 4 years (purple dotted line) (left) and corresponding model fits to CPUE (right).

7. Estimating B_{min}

While it may not be possible to estimate an upper limit for B_0 given the current data and knowledge, it is possible to estimate the lower limit for (B_{min}). This was estimated by fitting the model with fixed B_0 at decreasing values until the catch limit penalty kicked in. B_{min} was then the lowest B_0 that could have supported the historic catches (Table 1). This resulted in B_{min} between 20 500 and 20 750 tonnes, and gave corresponding minimum estimates of $B_{current}(\%B_0)$ of between 18% and 19.1%.

8. Discussion

At this stage, the stock assessment modelling has perhaps raised more questions than answers and as such, more work is required for an acceptable stock assessment of WCHAT silver warehou.

The CPUE index was generally increasing which made the model more reliant on year class signals from the composite data, the proportions-at-age. However, the proportions-at-age data were only available for five years, one of which only included fish that were close to fully grown and mature. There was a possible shift in either fish behaviour or fishing behaviour (or both) in the 2013 and 2016 years with older fish appearing to remain in less than 300 m water. This may lend itself to a spatially explicit model, but with so few years aged there would be insufficient data to inform this level of complexity.

Natural mortality is influential in the model results, but not on the fits to the data. As there was no depletion signal in the CPUE, natural mortality would be largely linked to the tracking of year classes in the proportions-at-age data, with SSB shifted up or down such that the abundance index may still increase when catches were removed. It is possible to estimate M in a stock assessment model with length or age composition data (Lee et al., 2011), but this requires more age composition data than we currently have, and also fairly clear signals from the composition data (e.g. tracking of cohorts). Additional composition data may allow us to estimate M from the model, or it may be possible to gain some information on M through sensitivity runs varying M, and the examination of the residuals and likelihood function. There are sufficient otoliths available from WCHAT that more ageing could be done to produce age composition data for more years (McGregor, 2019).

9. Recommendations

It is recommended that further ageing is carried out on silver warehou otoliths from WCHAT to provide a more comprehensive time series of age composition data. The age samples should be analysed with respect to depth and time with the possibility of informing a spatially explicit stock assessment model. If analyses of the data show spatial shifts that would require and inform a spatial model, the current CASAL stock assessment model could be upgraded to a CASAL2 model with spatial capabilities. Investigation into information on natural mortality should follow further ageing and precede spatial analyses.

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11. References

Bull, B.; Francis, R.; Dunn, A.; McKenzie, A.; Gilbert, D.; Smith, M.; Bian, R. (2012). CASAL (c++ algorithmic stock assessment laboratory): Casal user manual v2.30–2012/03/21. *NIWA Technical Report*, 135.

Day, J.; Thomson, R.; Tuck, G. (2015). Silver warehou (*Seriolella punctata*) stock assessment based on data up to 2014. *For discussion at Slope RAG, October 2015*, https://publications.csiro.au/rpr/download?pid=csiro:EP158715dsid=DS1.

Francis, R. (2011). Data weighting in statistical fisheries stock assessment models. *Canadian Journal of Fisheries and Aquatic Sciences*, 68(6):1124–1138.

Horn, P. McGregor, V. (2018). Catch-at-age for silver warehou (*Seriolella punctata*) on the western chatham rise in the 2000-01, 2012-13 and 2015-16 fishing years. *New Zealand Fisheries Final Research Report*, Project DEE201620, Objective 1 (silver warehou parts):7p.

Horn, P. L. Sutton, C. (1996). Validated ages, growth, and productivity parameters for silver warehou (*Seriolella punctata*) off the south and east coasts of South Island, New Zealand. *Marine and Freshwater Research*, 30(3):301–312.

Lee, H.-H.; Maunder, M. N.; Piner, K. R.; Methot, R. D. (2011). Estimating natural mortality within a fisheries stock assessment model: an evaluation using simulation analysis based on twelve stock assessments. *Fisheries Research*, 109(1):89–94.

Livingston, M. E. (1988). Silver warehou New Zealand Fisheries Assessment Research Document 1988/36. *Unpublished document held by NIWA library, Wellington*.

McGregor, V. (2016). Fishery characterisation and standardised CPUE analyses for silver warehou (*Seriolella punctata*) in SWA 1, 3, and 4, 1997-98 to 2010-11. *New Zealand Fisheries Assessment Report*, 2016/07:220p.

McGregor, V. (2019). Fishery characterisation and standardised CPUE analyses for silver warehou (*Seriolella punctata*) in SWA 3, and 4, 1989-90 to 2015-16. *New Zealand Fisheries Assessment Report*, 2019/59:56p.

Ministry for Primary Industries (2017). Report from the Fisheries Assessment Plenary. Stock assessments and yield estimates. *Ministry for Primary Industries*.

Paul, L. (1980). Warehous - facts and figures. *Catch ’80 7(7):* 5–6.

Shertzer, K. W. Conn, P. B. (2012). Spawner-recruit relationships of demersal marine fishes: prior distribution of steepness. *Bulletin of Marine Science*, 88(1):39–50.