New Zealand Fisheries
Assessment Report
2009/28
June 2009
ISSN 1175-1584

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New Zealand Fisheries Assessment Report 2009/28
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Published by Ministry of Fisheries
Wellington
2009

ISSN 1175-1584

McKenzie, A. (2009).
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New Zealand Fisheries Assessment Report 2009/28. 39 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

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***New Zealand Fisheries Assessment Report 2009/28*. 39 p.**

The JMA 7 jack mackerel fishery is located off the west coast of the North Island and the west coast of the upper half of the South Island. Preliminary stock assessments are presented for the two native jack mackerel species (*Trachurus declivis*, and *T. novaezelandiae*) from this area.

Each assessment includes the following observational data: (1) an early CPUE series covering 1990–1996, (2) a late CPUE series covering 1997–2005, and (3) a proportions-at-age series for 1990, 1991, 1996, and 2005.

Biomass estimates are uncertain because the catch history and CPUE indices are derived from species proportions estimates, for which the uncertainties are not incorporated into the assessments. In addition, although jack mackerel in New Zealand is hypothesised to be a single stock, the scope of the assessments is limited to JMA 7 as there are insufficient observational data available to enable a New Zealand wide stock assessment to be done.

Model results suggest that the mature virgin biomass for *T. declivis* was about 160 000 t, declining to a minimum of 37% B_0 in 1995, and then increasing to a current biomass of 53% B_0.

For *T. novaezelandiae*, difficulties were encountered in obtaining model runs that gave plausible results. Often model runs gave unreasonably high mature virgin biomasses (over 800 000 t), with essentially flat biomass trajectories. Giving very high weight to the early and late CPUE series indicated that current biomass is greater than 48% B_0. However, because of the convergence issues for the *T. novaezelandiae* assessment, no statement can be made at present on the sustainability of this fishery.

1. INTRODUCTION

This document is a report on work carried out as part of the Ministry of Fisheries project JMA200402. It covers objective 5: stock assessment for the native jack mackerel species *Trachurus declivis* (JMD) and *T. novaezelandiae* (JMN). Both species are found throughout New Zealand waters, and are thought to form a single stock; however, this initial study is limited to preliminary stock assessments for JMD and JMN in the area JMA 7 (where most catch of these is taken and most of the observational data are present).

Fundamental to any stock assessment is delineating the region in which a stock resides. Jack mackerel has historically been assessed, for management purposes, by the QMS areas given in Figure 1. However, there is little biological data to support the assignment of these as discrete stock areas. Furthermore, jack mackerel is a highly mobile fish as witnessed by the appearance of the species *Trachurus murphyi* (JMM) in New Zealand waters in about the 1980s. It seems more likely that the native species JMD and JMN form a single stock in New Zealand, and a comprehensive jack mackerel stock assessment needs to integrate observational data across areas.

In what follows, firstly, an overview will be given of the native jack mackerel fisheries in New Zealand, and what observational data are available. A suggested fruitful approach for integrating the data across all areas into a single stock assessment will be given. However, as there are insufficient observational data to do this at present, preliminary stock assessments are given for JMD and JMN in the most important area, JMA 7.

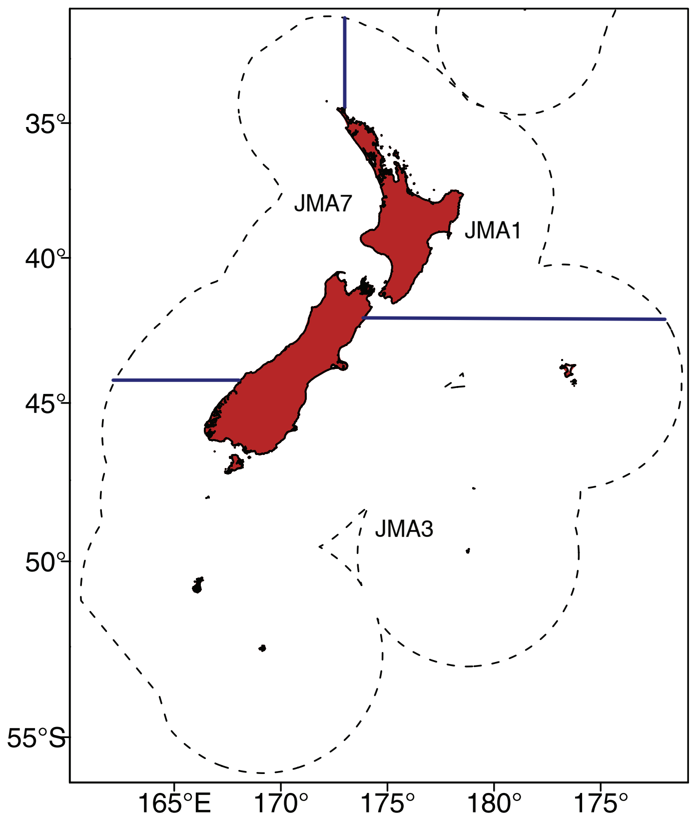

Figure 1: The location of the main management areas for jack mackerel.

2. OVERVIEW OF FISHERY AND OBSERVATIONAL DATA

In the followings section an overview is given of the nature of the jack mackerel fisheries in the three main areas (JMA 1, JMA 3, JMA 7), and what observational data are available in them. At first this is done for JMD and JMN combined, then separately for JMD and JMN.

The information and observational data come from a variety of sources (Table 1). Throughout this report, year is the fishing year, where the number is based on the year in the latter part of the fishing year, e.g., 2005 denotes the 1 October 2004 – 30 September 2005 fishing year.

Table 1: Information sources for the jack mackerel fisheries in New Zealand.

Information	Area	Source
Targeting and method	JMA 1, JMA 3, JMA 7	Ministry of Fisheries (2006)
Species mix	JMA 1, JMA 3, JMA 7	Appendix A1
Total catch history	JMA 1, JMA 3, JMA 7	Appendix A1
CPUE:		
aerial sightings (all species combined)	JMA 1	Taylor (2006)
1990 – 1996 (JMD, JMN)	JMA 7	McKenzie (2008)
1997 – 2005 (JMD, JMN)	JMA 7	McKenzie (2008)
Commercial trawl proportions-at-age:		
1974 (JMN)	JMA 1	Horn (1993)
1994, 95, 96 (JMD, JMN)	JMA 1	Taylor (1998)
2006 (JMN)	JMA 1	Appendix A2
1990, 1991 (JMD, JMN)	JMA 7	Horn (1993)
1996, 2005 (JMD, JMN)	JMA 7	Appendix A2
Research trawl proportions-at-age:		
1975, 1976 (JMN)	JMA 1	Horn (1993)
1981 (JMD, JMN)	JMA 7	Horn (1993)

2.1 Both native species (JMD and JMN) fishery summary

Examining both native species combined (Table 2) it is clear that JMA 7 has the most catch taken over the history of the fisheries (78% of the catch), and the largest amount of observational data available. In terms of significance, and having available data, JMA 7 is the best of the three areas in which to frame an initial stock assessment.

JMA 1 is of some significance at 18% of the total catch, with some observational data. However, the CPUE index is problematic as it is for all species combined (JMD, JMN, JMM). However, the proportion of JMM has been significant for only a short period of the fishery (see Appendix A1), and as an approximation the CPUE index could be treated as one for JMD and JMN combined.

In JMA 3 only 4% of the total catch is taken, and there are no observational data specific to this fishery. From a stock assessment perspective it could be ignored, or its catch combined with that of JMA 7, which is also a TCEPR trawl fishery.

Table 2: Overview of fishery data by area for JMD and JMN. The total catch history is total catch taken out of the fishery to the present.

	JMA 1	**JMA 3**	**JMA 7**
Targeting	Targeted CELR fishery	TCEPR: about half targeted, rest squid & barracouta bycatch	Targeted TCEPR
Method	Purse-seine	Mostly midwater trawl	Midwater and bottom trawl, now mostly midwater
Species mix	JMN dominates	Almost all JMD	About half JMD/JMN
Total catch history (t): JMD + JMN	120 000	27 000	500 000
CPUE	Aerial sightings 1981-2004 (all species combined)	None	JMD: 1990-1996 & 1997-2005 JMN: 1990-1996 & 1998-2005
Commercial trawl proportions-at-age	JMD: 1994, 95, 96 JMN: 1974, 94, 95, 96, 2006	None	JMD: 1990, 91, 96, 2005 JMN: 1990, 91, 96, 2005
Research trawl proportions-at-age	JMN: 1975, 76	None	JMD: 1981 JMN: 1981

2.2 JMD fisheries summary

Examining just the JMD fishery (Table 3), JMA 7 is the most important area in terms of total catch taken (84%), with the rest split between JMA 1 and JMA 3. The only area outside JMA 7 with observational data for JMD is JMA 1: a CPUE index for JMD, JMN, and JMM combined, and a proportions-at-age series for the purse-seine fishery over three years.

Table 3: Overview of JMD fishery.

	JMA 1	**JMA 3**	**JMA 7**
Targeting	Targeted CELR fishery	TCEPR: about half targeted, rest squid & barracouta bycatch	Targeted TCEPR
Method	Purse-seine	Mostly midwater trawl	Midwater and bottom trawl, now mostly midwater
Total catch history (t)	26 000	26 000	270 000
CPUE	All species combined: aerial sightings 1981-2004	None	1990-1996 & 1997-2005
Commercial trawl proportions-at-age	1994, 95, 96	None	1990, 1991, 1996, 2005
Research trawl proportions-at-age	None	None	1981

2.3 JMN fisheries summary

The JMN fishery (Table 4) has analogous observational data to JMD, but with an extra proportions-at-age observation for the purse-seine fishery in JMA 1.

Table 4: Overview of JMN fishery.

	JMA 1	**JMA 3**	**JMA 7**
Targeting	Targeted CELR fishery	TCEPR: about half targeted, rest squid & barracouta bycatch	Targeted TCEPR
Method	Purse-seine	Mostly midwater trawl	Midwater and bottom trawl, now mostly midwater
Total catch history (t)	97 000	1 000	230 000
CPUE	Aerial sightings 1981-2004 (all species combined)	None	1990-1996 & 1998-2005
Commercial proportions-at-age	1974, 94, 95, 96, 2006	None	1990, 1991, 1996, 2005
Research proportions-at-age	1975, 76	None	1981

The fisheries summaries, and the observational data available, suggest the following in terms of producing an integrated across areas stock assessment for JMD and JMN. Firstly, JMA 3 can either be ignored, or combined with JMA 7 which is also a TCEPR trawl fishery. A sequence of simpler to more complicated models in the following order is suggested.

(1) Treat JMA 7 as a single stock and do stock assessments separately for JMD and JMN.

(2) Combine JMD and JMN into a multi-stock model for JMA 7.

(3) Integrate this model with the JMA 1 area, using the proportions-at-age observations for this area to estimate a purse-seine selectivity. Include the combined CPUE index from JMA 1 in the model.

However, there is no settled methodology yet for calculating the aerial sighting CPUE index for JMA 1, or removing the JMM component from this. Hence the assessments that follow are limited to the JMA 7 area, from which most of the catch is taken and where there are the most observational data. They are to be taken as preliminary assessments in that more comprehensive assessments would draw upon a wider set of observational data, include the catch history from other areas, and potentially incorporate migration between areas.

3. PRELIMINARY STOCK ASSESSMENTS FOR JMD AND JMN IN JMA 7

Two stock assessments are presented here for the JMA 7 area: JMD and JMN. That is to say, step (1) of the three suggested modelling steps above is undertaken. A common model structure is taken for the two species, the only difference being in the length-at-age and weight-at-length parameters, and, of course, the observational data. All available observational data are incorporated into the assessments, except the 1981 research trawl proportion-at-age which is fitted outside the model assuming that the research trawl selectivity is the same as the commercial trawl selectivity.

3.1 Model structure

The observational data are incorporated into an age-based Bayesian stock assessment to estimate stock size. The stock was considered to reside in a single area, with no partition by sex or maturity. In the initial model age groups were 1–25 years, with a plus group of 25+. The model covers the period 1965–2006 (recorded catch is minimal before 1965 – see Appendix A1).

There is a single time step in the model, in which the order of processes is ageing, recruitment, and mortality (natural and fishing). Each fish is aged by one year at the start of the time step. Stock recruitment follows a Beverton-Holt relationship with a steepness of 0.924, derived from a mean value over a number of species similar to jack mackerel (Taylor 1998). Little significant difference in length-at-age is seen between males and females for JMD and JMN (Horn 1993), so no partition is made by sex in the model. Some difference in length-at-age parameters between the areas JMA 1 and JMA 7, while statistically significant and perhaps hinting at some stock separation, do not seem large enough to be important in the stock assessment (Horn 1993). Length-at-age estimates, common to all areas, are used for JMD and JMN in the model (Ministry of Fisheries 2006, p. 316); see Figure 2 for plots of the growth curves. Natural mortality is set at the value of 0.18 yr^{-1} estimated from relatively unfished populations (Horn 1993).

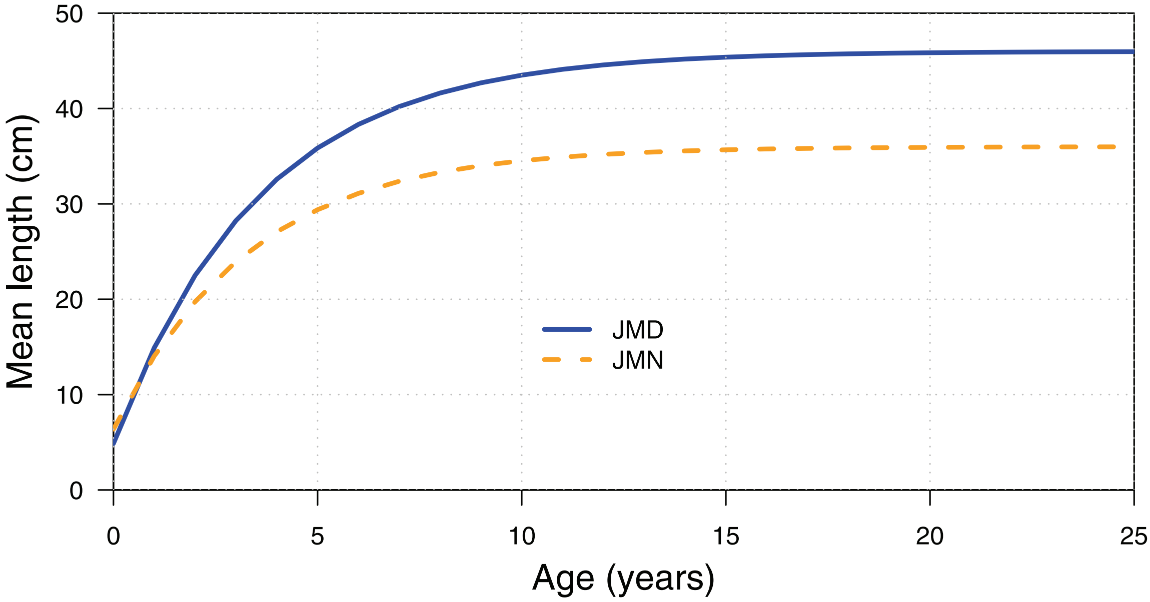

Figure 2: Growth curves for JMD and JMN.

Maturation is not explicitly modelled, but instead a proportions-mature-at-age logistic ogive is used. A preliminary analysis of maturity (Manning, NIWA, unpublished results) indicates that both males and females mature at a young age (2–4 years old), and that there may be a difference between the sexes, but for simplicity this is ignored. A single logistic curve with an a_{50} of 3 years and an a_{to95} of 6 years for both sexes and JMD and JMN is used, where a_{to95} is the difference between a_{50} and a_{95}.

The model biological parameters are summarised in Table 5.

Table 5: Fixed model biological parameters.

Parameter	Symbol	JMD value	JMN value
Steepness parameter for Beverton-Holt	h	0.924	0.924
von Bertalanffy parameters	L_∞	46.0 cm	36.0 cm
	k	0.28 yr^{-1}	0.30 yr^{-1}
	t_0	-0.40 yr	-0.65 yr
Length-weight parameters	a	0.023	0.028
[W(gm) = a L(cm)^b]	b	2.84	2.84
Natural mortality	M	0.18 yr^{-1}	0.18 yr^{-1}
Maturity ogive logistic parameters	a_{50}	3.0 yr	3.0 yr
	a_{to95}	9.0 yr	9.0 yr
Maximum fishing pressure	U_{max}	0.70	0.70

3.2 Observational data

Both the JMD and JMN models have the following observational data.

1. An early CPUE series covering 1990 to 1996, and a late CPUE series covering 1997 (1998 for JMN) to 2005. The early and late series have separate relativity scaling constants in the model (q values). There were a number of changes in the jack mackerel fishery over the years 1996 to 1999: less midwater trawling due to dolphin bycatch, marketing difficulties for JMM, withdrawal of a major company from the fishery, and changes in fleet composition. Given the number of changes in the fishery, it is problematic to delineate a particular year at which a split into early and late CPUE series should be made. However, mainly on the basis of changes in fleet composition, and taking into account changes in the unstandardised catch rates, it was decided by the Pelagic Working Group to use the split into early and late periods as already mentioned (McKenzie 2008). Note that the JMN late CPUE series starts in 1998, instead of 1997, as there is no vessel coverage for catch of JMN in 1997.

2. A commercial trawl proportions-at-age series for 1990, 1991, 1996, and 2005.

3. A research trawl proportions-at-age for 1981. This observation was not entered into the model, but the fit to it was evaluated outside the model, assuming that the research trawl selectivity is the same as the commercial trawl selectivity. A caveat on the use of these data is that the length-frequency sampling method used to obtain them was probably biased towards larger fish and the sample size was relatively small (Horn 1993).

A double half normal selectivity was applied to the CPUE indices, commercial trawl proportions-at-age series, and catch. A double half normal selectivity takes the form shown below and has the three parameters a_1 (mode), s_L, and s_R. It takes the value 1 at x = a_1, and 0.5 at $x = a_1 - s_L$ or $x = a_1 + s_R$.

$$f(x) = 2^{-[(x-a_1)/s_L]^2}, \qquad (x \le a_1)$$
$$= 2^{-[(x-a_1)/s_R]^2}, \qquad (x > a_1)$$

Unlike say the logistic selectivity, the double normal selectivity may decline after reaching a peak, which seems a plausible shape for a fast swimming species that can outrun trawl nets. A decline after a peak was forced in the model by setting a lower bound on the flatness of the right-hand limb for the double normal (i.e., s_R could go no higher then 30).

For the CPUE data a lognormal likelihood was assumed, and sufficient process error was added to bring the standard deviation of the normalised residuals (SDNR) down to one.

Multinomial likelihoods were assumed for the proportions-at-age data. The uncertainty in the proportions-at-age observations is defined by a single parameter, the effective sample size (N). Low values of N are associated with more uncertainty, higher values less. The effective sample size was guided by the requirement that the Pearson residuals have approximately a normal distribution with mean of zero and standard deviation of one, in which case the SDPR (standard deviation of the Pearson residuals) is approximately one. Relative sample sizes between years also helped to determine effective sample sizes for the Horn data from 1990 and 1991.

The observational data are summarised in Table 6.

Table 6: Observational data for the model.

Observational Data	Likelihood	Source
CPUE: early (1990–1996)	lognormal	McKenzie (2008)
CPUE: late (1997–2005)	lognormal	McKenzie (2008)
Proportions-at-age		
Commercial (1990, 1991)	multinomial	Horn (1993)
Commercial (1996, 2005)	multinomial	Appendix A2
Research trawl (1981)	-	Horn (1993)

The catches taken in the model for JMA 7 are given in Appendix A1 (JMA 7 catch history). Recreational and Maori customary catch are thought be small, so no allowance is made for them in the catch history. The 2006 catch is assumed to be the same as the 2005 catch.

3.3 Methods

Parameters which were made free in the models were: (1) the virgin biomass (B_0), (2) the relativity constants (q values) which are involved in scaling the early and late standardised CPUE indices to a biomass, (3) the three parameters defining the double normal commercial fishing selectivity, and (4) year class strengths from 1975 to 2005. The free parameters are summarised in Table 7.

Year class strength are estimated from 1975 (15 years before the earliest proportions-at-age observation) to 2005. Their prior was assumed to have a lognormal distribution with a mean of one and a c.v. of 0.6. Lower and upper bounds are set based on a 99% confidence interval for the prior.

Table 7: Free parameters for the models.

Free parameter	Prior	Number of parameters
B_0	uniform-log	1
relativity constants (q)	uniform-log	2
double normal selectivity	uniform	3
year class strengths	lognormal	31

Maximum Posterior Density (MPD) estimates were found for the free parameters in the model. The stock assessment program CASAL v2.08 (Bull et al. 2005) was used to implement and fit the models.

3.4 Preliminary JMD assessment

After some trial and error, guided by the requirement that the Pearson residuals should have approximately a normal distribution with a mean of zero and standard deviation of one, effective sample size were established for the proportions-at-age data (Table 8). The effective sample size for 1991 is not well determined as increasing its value has minimal impact on the distribution of the Pearson residuals. However, for the 1991 proportions-at-age about twice the number of otoliths and length frequencies were processed compared to 1990, so its effective sample size was set at twice that for 1990.

Table 8: Effective sample sizes (N) for JMD proportions-at-age series observations.

Fishing year	N
1990	20
1991	40
1996	80
2005	10

For both the early and late CPUE series a process error of 0.20 was added (to c.v.s of about 0.10), which gives distributions for the normalised residuals which are approximately that of a standardised normal. This process error partially reflects the likely additional uncertainty in these given that they are based on estimated species proportions, and that catchability will most likely vary between years.

The base assessment using these effective sample sizes and process errors is presented first (Table 9). Some sensitivities are made to this model run by dropping the early CPUE series, dropping the late CPUE series, and doubling all effective sample sizes (Table 9).

Model fits and diagnostics for the base assessment run are given in Figure 3 and 4. Current biomass is estimated to be 53% of virgin biomass. The model fits both CPUE series reasonably well, except for the two years in the centre (1996 and 1998). The two years for which the proportions-at-age fit well are 1991 and 1996. The residuals for the 1990 and 2005 proportions show contrasting patterns: in 1990 there are fewer young fish and more older fish in the model then observed, whereas in 2005 there tends to more young fish and fewer old fish in the model than observed. The fit to the research trawl proportions-at-age for 1981, outside the model assuming the commercial trawl selectivity, appears to be quite good (Figure 5).

Dropping the early CPUE series gave a current biomass of 75% of virgin biomass, whereas dropping the late CPUE series gave a current biomass of 30% of virgin biomass. In both cases the fits to the proportions-at-age observations did not change much, which suggests that their influence is not strong. Doubling the effective sample size for all proportions-at-age observations gave a current biomass of 66% of virgin biomass (compared to 53% in the base case). So if the weighting for the proportions-at-age series is increased the biomass trajectory is flatter.

The estimated selectivity in the base case runs into the bounds set on the parameters s_L and s_R which determine the steepness of the curve to the left and right of the mode. If the bounds on these parameters are broadened, then the estimated selectivity has a mode at one with a steep decline to the left of this (s_L = 0.02) and flat to the right (s_R = 500). However, the likelihoods for the observational data are almost the same, and the total likelihood is only slightly less (40.7 versus 40.8 in the base case). The biomass trajectory is also little different from the base case (current biomass is 52% of virgin biomass versus 53% in the base case). Although the total likelihood is only slightly less with broadened parameter bounds, these results suggest that a logistic selectivity with one less parameter to estimate may have been a better choice.

The flatness of the right-hand side of the estimated selectivity might imply, as it is contrary to expectations, that natural mortality is higher than is assumed in the model (0.18 yr^{-1}). However, although no formal confidence intervals have been calculated for the natural mortality, it seems that it is unlikely to be any higher then 0.20 (Horn 1993).

Table 9: Model fits for the preliminary JMD assessment. Shown are Maximum Posterior Density (MPD) estimates for the free parameters in the models, except for the year class strengths. Parameter estimates

that ran into their bounds are denoted by *. The less the likelihood is, the better the model fit (so a more negative likelihood is a better fit). The total likelihood should be compared only for models with the same parameters and data sets. For the model run "double N_{eff}" the effective sample size for all proportions-at-age series is doubled.

	Run	Base	Drop early CPUE	Drop late CPUE	Double N_{eff}
	B_0	158 000	216 000	143 000	202 000
	$B_{current}$	83 600	163 000	42 400	134 000
	$B_{current}$ (%B_0)	53	75	30	66
Double half normal	a_1	2.0	1.9	2.0	2.0
	s_L	1.0*	1.0*	1.0*	1.4
	s_R	30*	30.0*	30.0*	30.0*
Relativity constant	q_{early}	2.1E-05	-	2.0E-05	1.4E-05
	q_{late}	2.3E-05	1.2E-05	-	1.5E-05
Likelihoods	early CPUE	-7.3	-	-6.9	-5.4
	late CPUE	-6.9	-5.8	-	-5.8
	1990	14.8	14.1	14.4	20.5
	1991	16.4	16.5	16.5	21.1
	1996	22.9	22.7	22.7	28.1
	2005	12.6	11.6	12.5	18.1
	priors	-11.8	-1.4	-3.6	-9.4
	Total	40.8	57.7	55.8	67.3

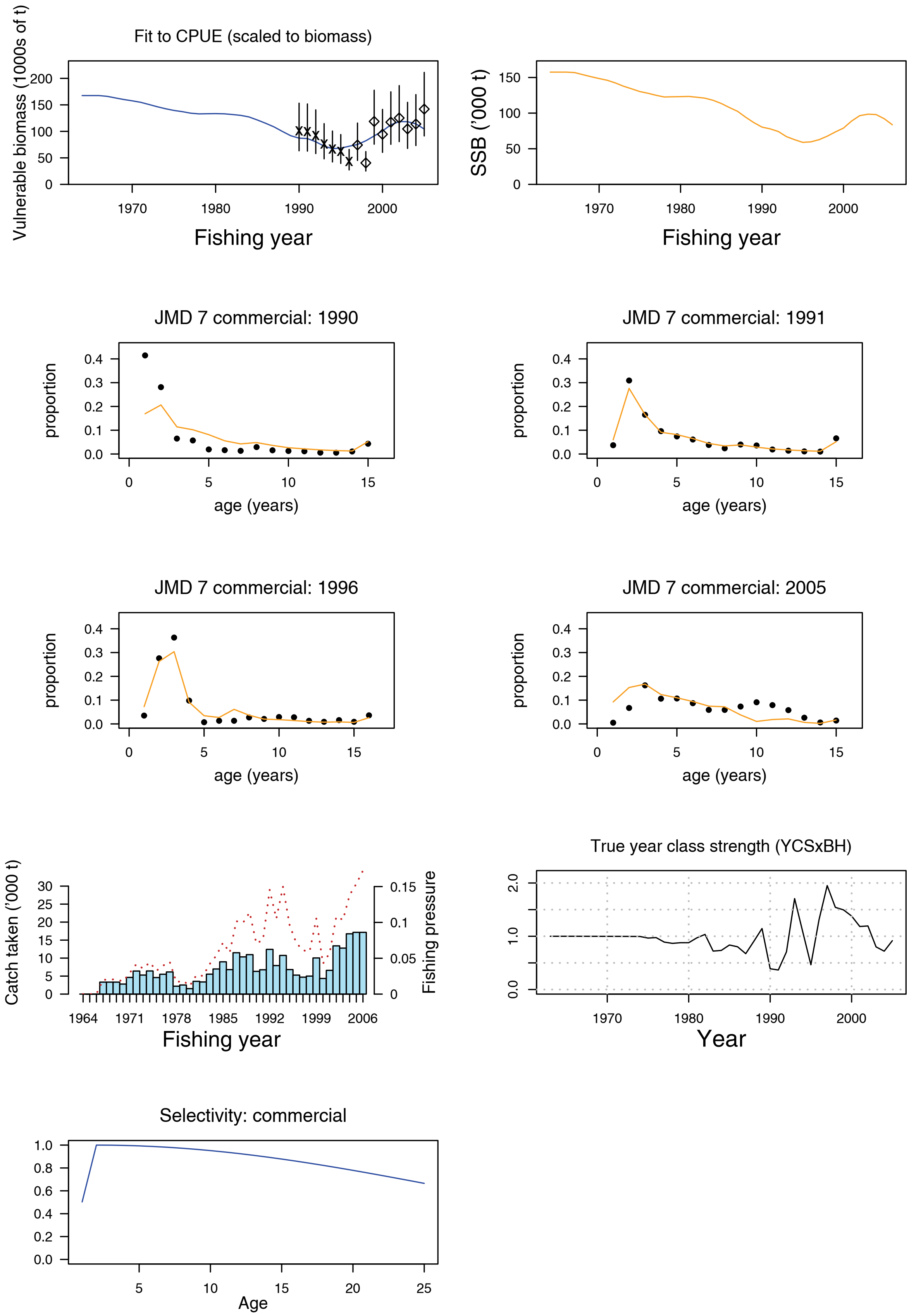

Figure 3: Fits for the base JMD assessment model in JMA 7. 95% confidence intervals are shown for the CPUE data.

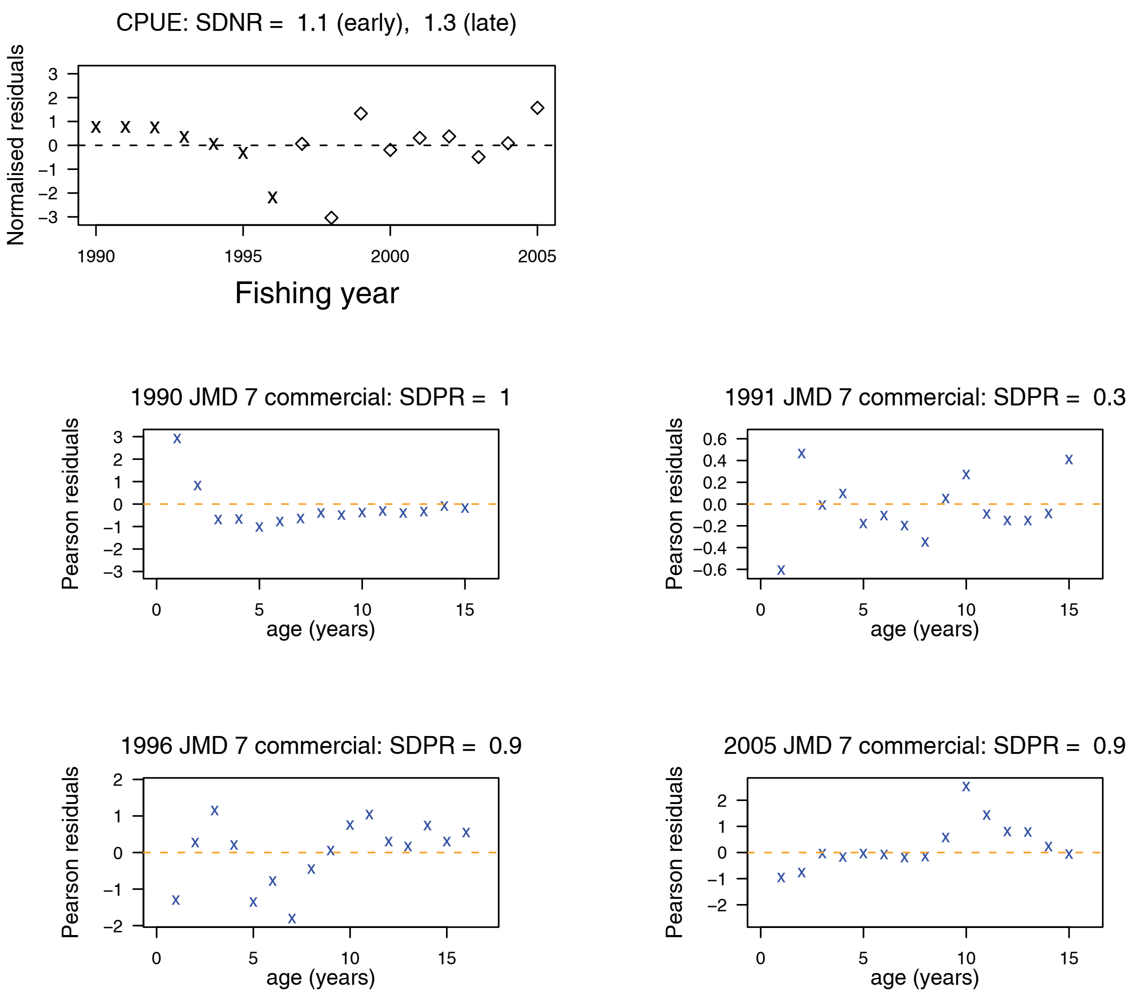

Figure 4: Some diagnostics for the base model for JMD in JMA 7.

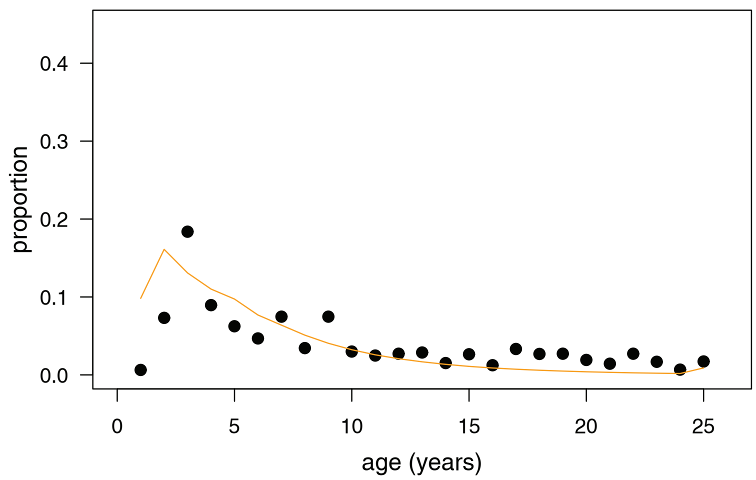

Figure 5: Fit to the 1981 research trawl JMD proportions-at-age outside the base model. The research trawl selectivity is assumed to be the same as the commercial trawl selectivity.

3.5 Preliminary JMN assessment

After some trial and error, guided by the requirement that the Pearson residuals should have approximately a normal distribution with a mean of zero and standard deviation of one, effective sample sizes were established for the proportions-at-age data (Table 10). For the 1990 Horn proportions-at-age data an effective sample size of 30 was used, with a value double that for 1991 for which about four times the number of length measurements were processed and twice the number of otoliths.

Table 10: Effective samples sizes (N) for the JMN model.

Fishing year	N
1990	30
1991	60
1996	30
2005	30

For the late (1998–2005) CPUE series, for which the c.v.s are about 0.10, a process error of 0.30 was added. For the early (1990–96) CPUE the c.v.s are already high (about 0.40), so no process error was added. In both cases this give a SDPR of about one for the initial model run.

However, this initial model did not converge well with the virgin biomass going to the upper bound of 800 000 t with a flat biomass trajectory (Table 11, Figure 6 and 7) . Experimenting with different values for the effective sample size did not give a model run which converged better. However, giving more weight to the CPUE data gave some model runs which converged, though in light of the likely high uncertainties in the CPUE indices these weights should be considered at the extreme of what is plausible.

Decreasing the process error for the late CPUE series to 0.05 gave a biomass trajectory in which the current biomass is 90% of virgin biomass (Table 11). Without process error the c.v.s for the late CPUE series are about 0.10, so with a process error of 0.05 added are still quite low. If an initial value of B_0 higher than about 200 000 t is used, then the solution for B_0 goes to its upper bound of 800 000 t, with an overall better likelihood but only slight changes in the fits to the observations.

If in addition to decreasing the process error for the late CPUE series, the c.v.s. for the early CPUE series are decreased to 0.30 (instead of about 0.40), then the current biomass is 48% of virgin (Table 11). Such a model run should not be considered a base case because the associated c.v.s for the early and late CPUE series are likely to be too low, but rather a bound on how low the biomass trajectory could reasonably go (Figure 8, 9, and 10).

The mode for the trawl selectivity for JMN model runs is between 10 and 15 years. Assuming that the trawl fishery has similar selectivities by length for JMN and JMD, then the JMN selectivity is considerably to the right of the JMD selectivity (mode of 2–3 years), even when taking into account the different growth curves (Figure 2). This would seem be driven by the proportions-at-age series for JMN which do not have as many young fish as JMD, and implies that there is a large biomass of young mature fish that is inaccessible to the fishery, but this needs further investigation.

Table 11: Model fits for the preliminary JMN assessment. Shown are Maximum Posterior Density (MPD) estimates for the free parameters in the models, except for the year class strengths. Parameter estimates that ran into their bounds are denoted by *. The less the likelihood is, the better the model fit (so a more negative likelihood is a better fit). The total likelihood should be compared only for models with the same parameters and data sets.

	Run	Initial	late CPUE p.e. = 0.05	late CPUE p.e. = 0.05, early CPUE c.v.s = 0.30
	B_0	800 000*	800 000*	110 000
	$B_{current}$	765 000	721 000	52 500
	$B_{current}$ ($\%B_0$)	96	90	48
Double half normal	a_1	10.8	7.2	15.0*
	s_L	6.9	4.3	8.3
	s_R	9.0	14.3	30.0*
Relativity constants	q_{early}	4.9E-07	4.4E-07	7.2E-06
	q_{late}	3.5E-07	3.0E-07	5.5E-06
Likelihoods	early CPUE	-2.7	-3.1	-4.1
	late CPUE	-6.6	-6.0	-6.6
	1990	23.3	24.3	24.0
	1991	28.2	28.5	28.0
	1996	20.6	21.8	21.3
	2005	16.4	16.4	16.6
	priors	-34.4	-33.8	-28.1
	Total	58.4	61.7	62.7

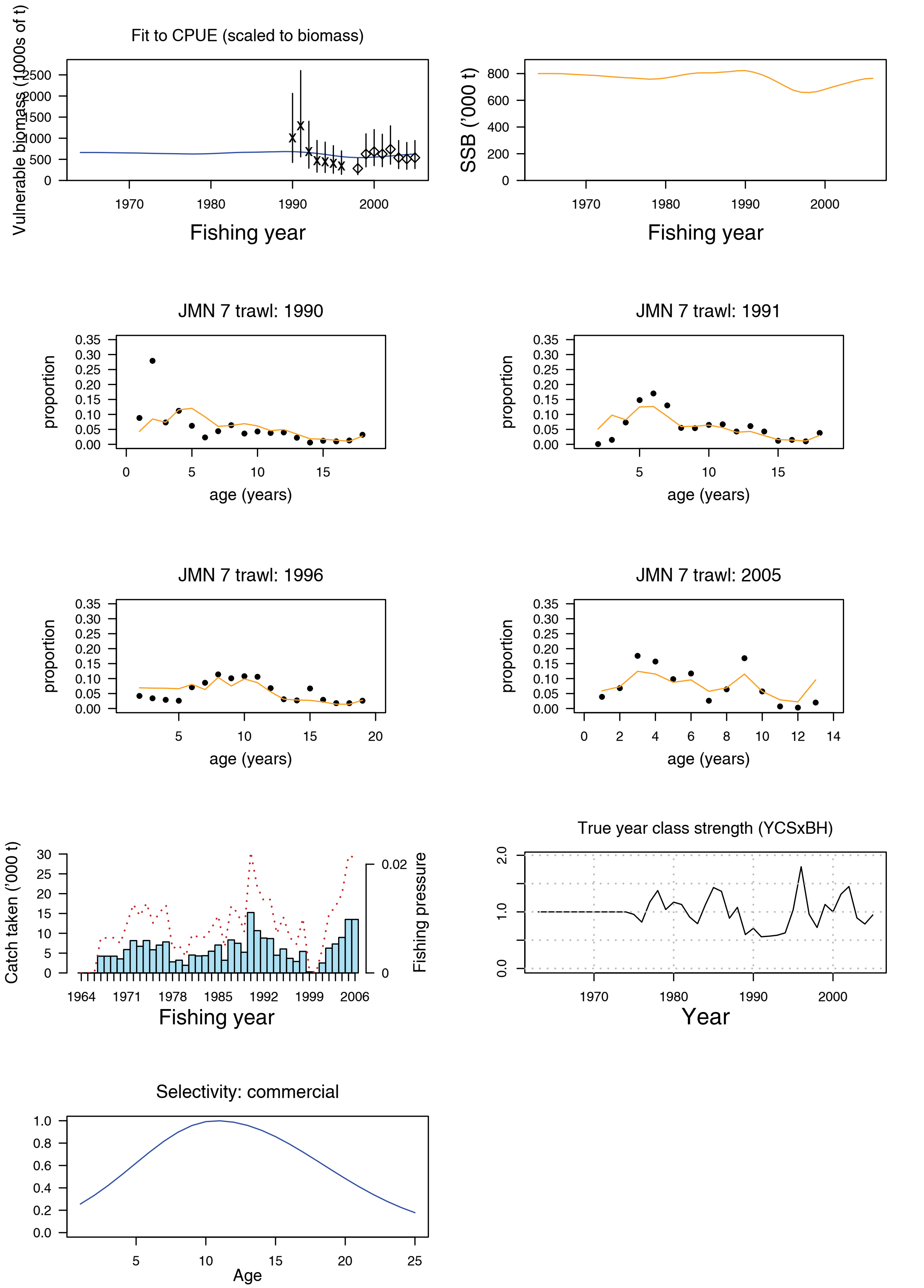

Figure 6: The initial model fits for JMN in JMA 7. 95% confidence intervals are shown for the CPUE data.

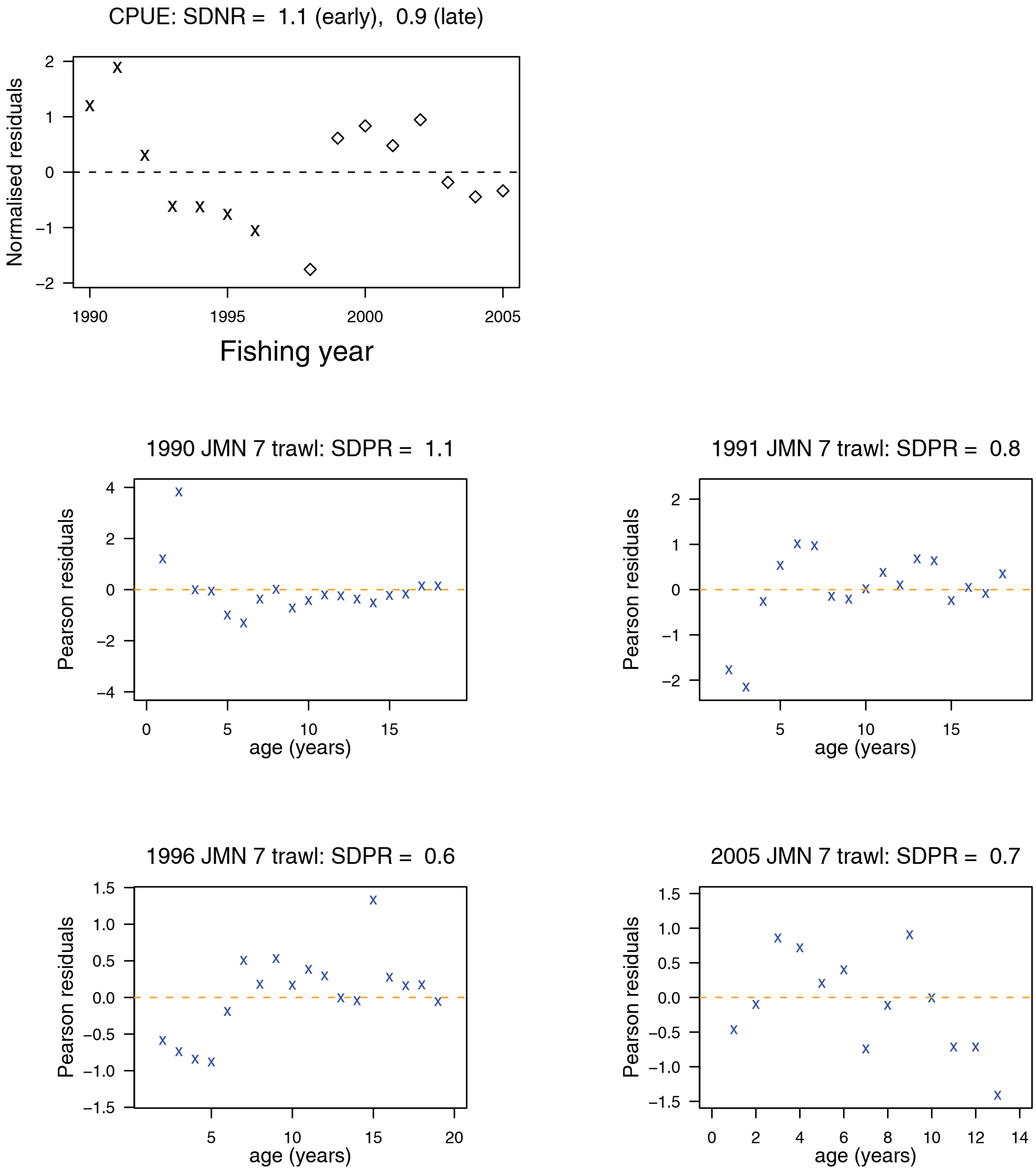

Figure 7: The initial model diagnostics for JMN in JMA 7.

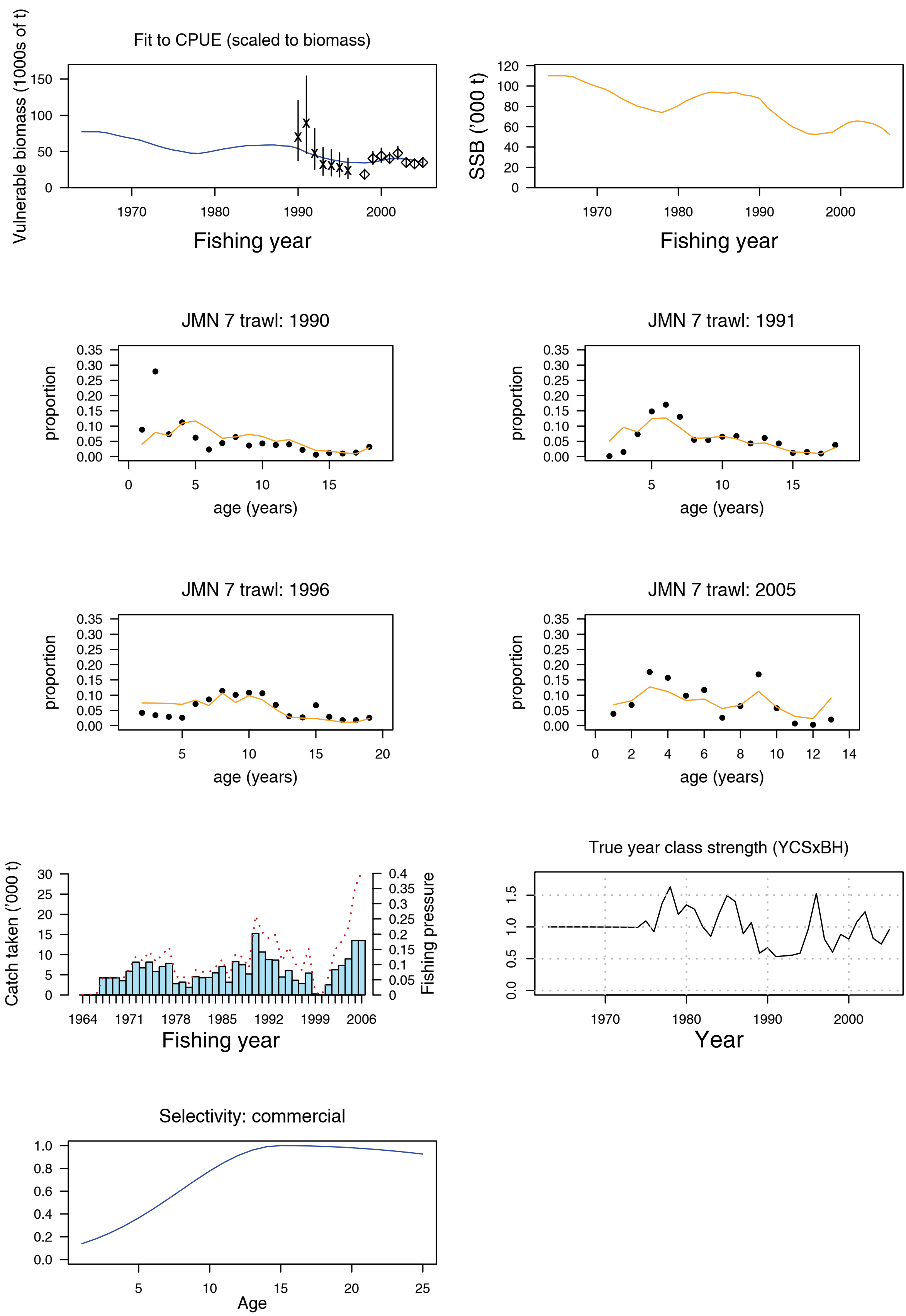

Figure 8: Model fits for JMN in JMA 7 with a forced high weighting on the early and late CPUE series. 95% confidence intervals are shown for the CPUE data.

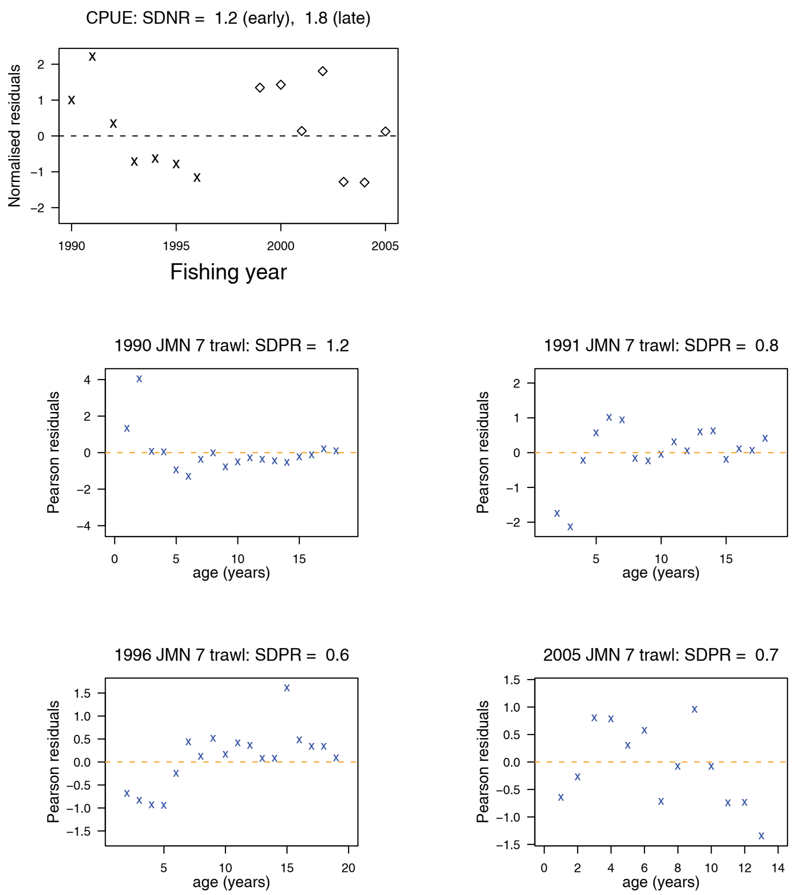

Figure 9: Diagnostics for JMN in JMA 7 with a forced high weighting on the early and late CPUE series..

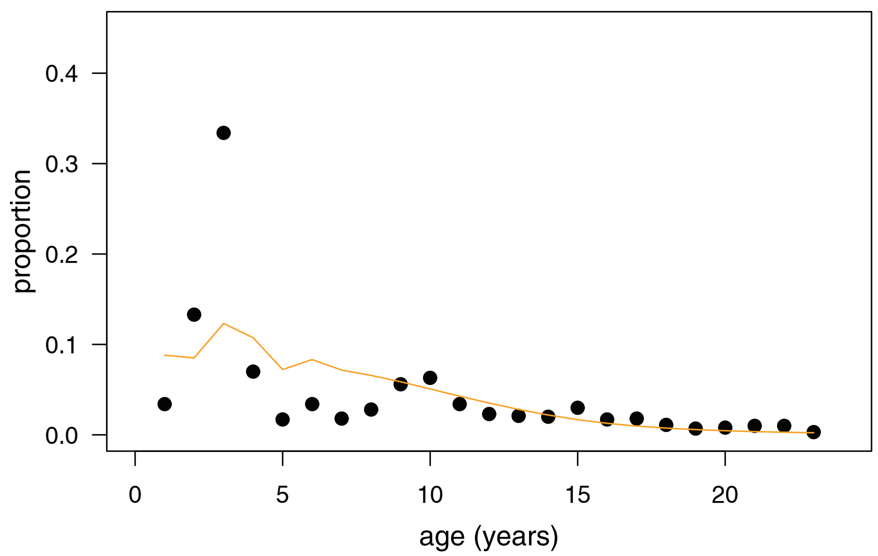

Figure 10: Fit to the 1981 research trawl JMN proportions-at-age outside the model, assuming that the research trawl selectivity is the same as the commercial trawl selectivity. This is for the JMN model with a forced high weighting on the early and late CPUE series.

4. DISCUSSION

The assessment for JMD suggests there are no sustainability issues at present for this fishery. However, the uncertainty in the parameter estimates for this preliminary assessment has not been investigated. Furthermore, not incorporated into the assessments is the uncertainty in species proportion estimates, which feed into the derived catch history and CPUE (and most likely with correlations between the two). Because of convergence issues for the JMN assessment, this assessment was not accepted by the Pelagic Working Group, and no statement can be made at present on the sustainability of the JMN fishery.

Some of the year class strengths from 1975 to 2005 are likely to be poorly estimated as there are significant gaps in the proportions-at-age series, particularly around the 1996 fishing year. These gaps cannot be filled in as there are no other otoliths available, except for 1998. However, for 1998 there were no catch weights recorded for the tows from which the otoliths were sampled, so it is not possible to scale them up appropriately in an age-length key analysis. The likely problem of poor year class estimates due to gaps in the proportions-at-age series is exacerbated by the high uncertainty in the proportions estimates (due to the low effective sample sizes for each year).

As some of the year class strengths are likely to be poorly estimated, it may be inappropriate to estimate all of them. One technique to investigate the usefulness of estimating all the year class strengths is to fit them as smoothed polynomials (Ian Doonan, NIWA, pers. comm.). Starting with an average recruitment, progressively higher degree polynomials are fitted for the year class strengths, with the likelihood components tracked for each fit. These likelihoods can be compared to each other, and to the likelihoods when all year class are estimated, to determine if there is a significant gain in model fit obtained when all year class strengths are estimated.

It may be worth reconsidering the year at which a split is assigned between the early and late CPUE series. The assumption made in the assessment models is that CPUE is linearly proportional to vulnerable biomass. However, the size of some of the yearly percentage changes in the CPUE indices indicate that at least parts of the series are not tracking abundance. For instance, the late JMD CPUE series dropped by nearly 50% from 1997 to 1998, then nearly tripled the following year. And for the late JMN CPUE series the index doubled from 1998 to 1999. There are a number of changes in the fishery over the period 1996 through to 1999 and it is problematic deciding on a precise year at which to do a split into early and late periods (McKenzie 2008). Some more investigation of patterns in the fishery may be illuminating, but a simple solution could be to simply omit the troublesome 1998 and 1999 years on the basis that neither belong cleanly to the early or late periods.

An additional area of uncertainty is stock boundaries: are there separate stocks or not? The working hypothesis, based on the mobile behaviour of jack mackerel, is that there is a single New Zealand stock for jack mackerel. However, recent research into blue mackerel and kingfish indicates a west coast North Island versus east coast North Island stock structure split, suggesting the need for explicit research into the working hypothesis for jack mackerel.

If jack mackerel do form a single New Zealand stock, then a key component to improving the preliminary assessments is the development of an aerial sightings index for the JMA 1 area. This will provide additional evidence for trends in biomass, potentially reducing uncertainty in the stock assessments. It will also allow the assessments to incorporate the catch history from JMA 1, which is small for JMD (about 10% of the total, Table 3), but much more substantial for JMN (about 30% of the total, Table 4).

5. ACKNOWLEDGMENTS

Thanks to Ian Doonan who made a number of useful suggestions for improving the document and for further work. Also thanks to the Pelagic Working Group for their contributions to the assessment. The work was funded by the Ministry of Fisheries project JMA200402.

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Appendix A1: CATCH HISTORY

The jack mackerel catch (recorded as JMA) is actually of three separate species: *Trachurus declivis* (JMD), *T. novaezelandiae* (JMN), and an invasive species *T. murphyi* (JMM). Because the commercial catch and landing are recorded under JMA, separate observer data are needed to apportion the catch amongst the three species, a complicating factor in analyses of the fishery. The following documents how the catch history was obtained for the areas JMA 1, JMA 3, and JMA 7. It mostly draws upon previously constructed catch histories, with some updates.

Recreational catch, although not well known, is thought be small relative to the commercial catch (Ministry of Fisheries, 2006, p. 315), so no recreational component is included in the catch history. The illegal activity or catch is also thought to be insignificant (Ministry of Fisheries, 2006, p. 315). No quantitative information is available on Maori customary take (Ministry of Fisheries, 2006, p. 315).

A1.1 JMA 1 catch history

Table A1: Sources for the JMA 1 catch history. Landings in the sources are for all three jack mackerel species combined.

Period	Landings	Species proportions
1944–1994	Taylor (1998)	Taylor (1998)
1995–2005	Ministry of Fisheries (2006, p. 314)	Taylor and Julian (2008)

The species proportions and landings are shown in Figures A1 and A2. The graphs show cumulative species proportions or catch. The darker shade at the bottom is JMD; following this is JMN, and lastly JMM in the lightest shade. Species proportions sum to one, and the catch sums to the total jack mackerel landings for the year. The dashed line on the catch graph shows the TAC.

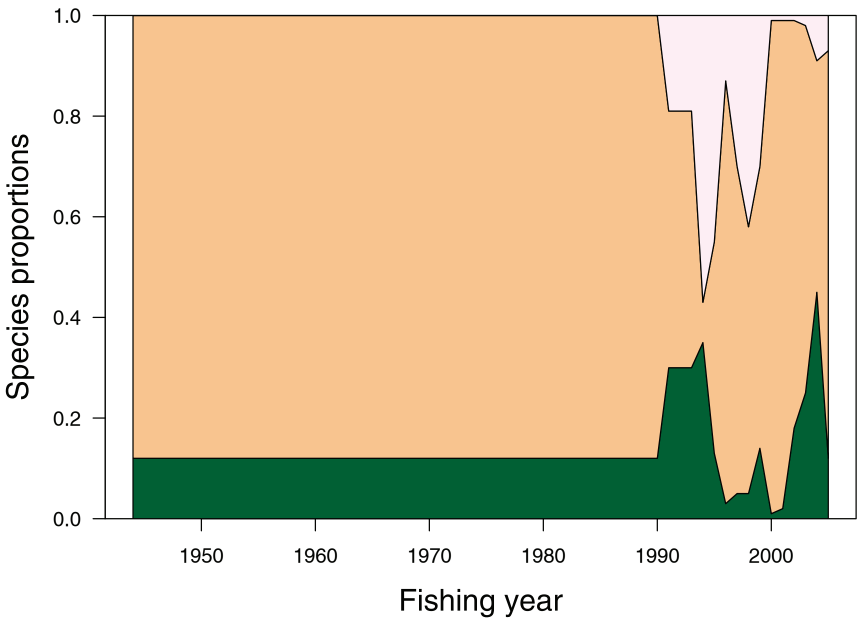

Figure A1: Species proportions for JMA 1.

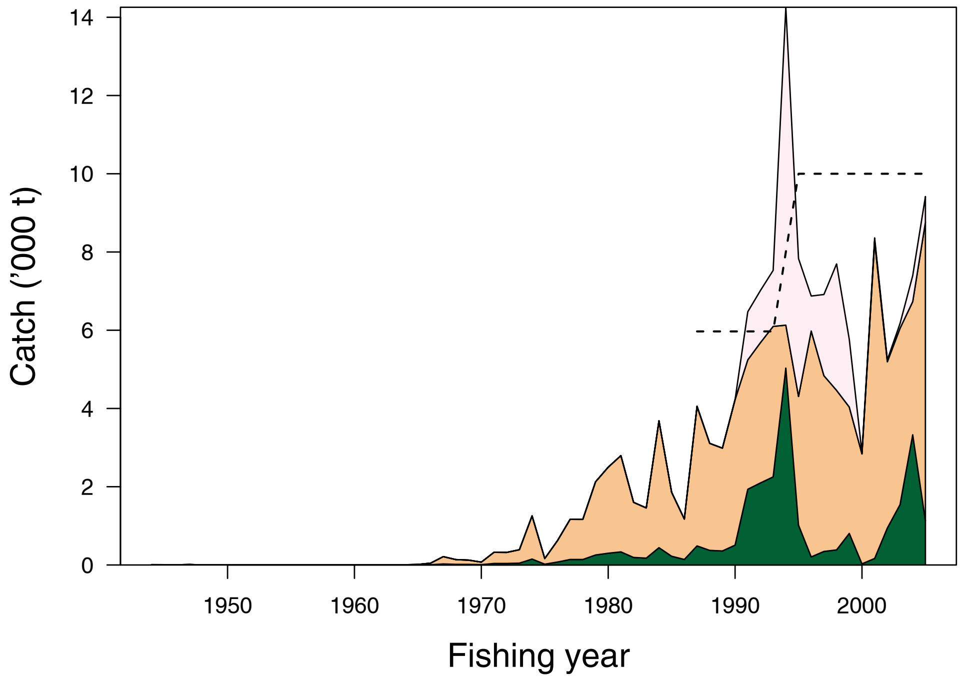

Figure A2: Catch by species for JMA 1.

Table A2: JMA 1 catch history. All landings are in tonnes.

Year	Jack mackerel landing	Proportion JMD	Proportion JMN	Proportion JMM	Estimated JMD landing	Estimated JMN landing	Estimated JMM landing
1944	8	0.12	0.88	0.00	1	7	0
1945	7	0.12	0.88	0.00	1	6	0
1946	3	0.12	0.88	0.00	0	3	0
1947	12	0.12	0.88	0.00	1	11	0
1948	0	0.12	0.88	0.00	0	0	0
1949	0	0.12	0.88	0.00	0	0	0
1950	0	0.12	0.88	0.00	0	0	0
1951	2	0.12	0.88	0.00	0	2	0
1952	0	0.12	0.88	0.00	0	0	0
1953	0	0.12	0.88	0.00	0	0	0
1954	3	0.12	0.88	0.00	0	3	0
1955	0	0.12	0.88	0.00	0	0	0
1956	0	0.12	0.88	0.00	0	0	0
1957	0	0.12	0.88	0.00	0	0	0
1958	0	0.12	0.88	0.00	0	0	0
1959	2	0.12	0.88	0.00	0	2	0
1960	0	0.12	0.88	0.00	0	0	0
1961	0	0.12	0.88	0.00	0	0	0
1962	2	0.12	0.88	0.00	0	2	0
1963	5	0.12	0.88	0.00	1	4	0
1964	5	0.12	0.88	0.00	1	4	0
1965	13	0.12	0.88	0.00	2	11	0
1966	46	0.12	0.88	0.00	6	40	0

Year	Jack mackerel landing	Proportion JMD	Proportion JMN	Proportion JMM	Estimated JMD landing	Estimated JMN landing	Estimated JMM landing
1967	213	0.12	0.88	0.00	26	187	0
1968	137	0.12	0.88	0.00	16	121	0
1969	124	0.12	0.88	0.00	15	109	0
1970	72	0.12	0.88	0.00	9	63	0
1971	324	0.12	0.88	0.00	39	285	0
1972	321	0.12	0.88	0.00	39	282	0
1973	389	0.12	0.88	0.00	47	342	0
1974	1255	0.12	0.88	0.00	151	1104	0
1975	164	0.12	0.88	0.00	20	144	0
1976	621	0.12	0.88	0.00	75	546	0
1977	1167	0.12	0.88	0.00	140	1027	0
1978	1166	0.12	0.88	0.00	140	1026	0
1979	2125	0.12	0.88	0.00	255	1870	0
1980	2499	0.12	0.88	0.00	300	2199	0
1981	2795	0.12	0.88	0.00	335	2460	0
1982	1601	0.12	0.88	0.00	192	1409	0
1983	1457	0.12	0.88	0.00	175	1282	0
1984	3684	0.12	0.88	0.00	442	3242	0
1985	1857	0.12	0.88	0.00	223	1634	0
1986	1173	0.12	0.88	0.00	141	1032	0
1987	4056	0.12	0.88	0.00	487	3569	0
1988	3108	0.12	0.88	0.00	373	2735	0
1989	2986	0.12	0.88	0.00	358	2628	0
1990	4226	0.12	0.88	0.00	507	3719	0
1991	6472	0.30	0.51	0.19	1935	3307	1230
1992	7017	0.30	0.51	0.19	2098	3586	1333
1993	7529	0.30	0.51	0.19	2251	3847	1431
1994	14256	0.35	0.08	0.57	5032	1098	8126
1995	7832	0.13	0.42	0.45	1018	3289	3524
1996	6874	0.03	0.84	0.13	206	5774	894
1997	6912	0.05	0.65	0.30	346	4493	2074
1998	7695	0.05	0.53	0.42	385	4078	3232
1999	5767	0.14	0.56	0.30	807	3230	1730
2000	2866	0.01	0.98	0.01	29	2809	29
2001	8360	0.02	0.97	0.01	167	8109	84
2002	5247	0.18	0.81	0.01	944	4250	52
2003	6172	0.25	0.73	0.02	1543	4506	123
2004	7396	0.45	0.46	0.09	3328	3402	666
2005	9418	0.12	0.81	0.07	1130	7629	659

A1.2 JMA 3 catch history

Almost all the catch for this fishery is of JMD or JMM, and it is assumed that the proportion of JMN is zero before 1986. Linear interpolation is used for the JMM proportions from a proportion of zero in 1980, when it is not thought to have been in New Zealand, to a value of one in 1986 (Taylor & Julian 2008). The proportion of JMD before 1986 is calculated as one minus the proportion of JMM. See Figure A3 and A4 for the species proportions and catch history. The graphs show cumulative species proportions or catch. The darker shade at the bottom is JMD; following this is JMN, and lastly JMM in the lightest shade. Species proportions sum to one, and the catch sums to the total jack mackerel landings for the year. The dashed line on the catch graph shows the TAC.

Table A3: Sources for the JMA 3 catch history. Landings in the sources are for all three jack mackerel species combined.

Period	Landings	Species proportions
pre 1970	assumed to be zero	-
1970–1983	Annala et al. (2003, p. 267)*	see text above
1984–2005	Ministry of Fisheries (2006, p. 314)	see text above
1986–2005	Ministry of Fisheries (2006, p. 314)	Taylor and Julian (2008)

* assumed landings for JMA 3 were 5% of total New Zealand jack mackerel landings

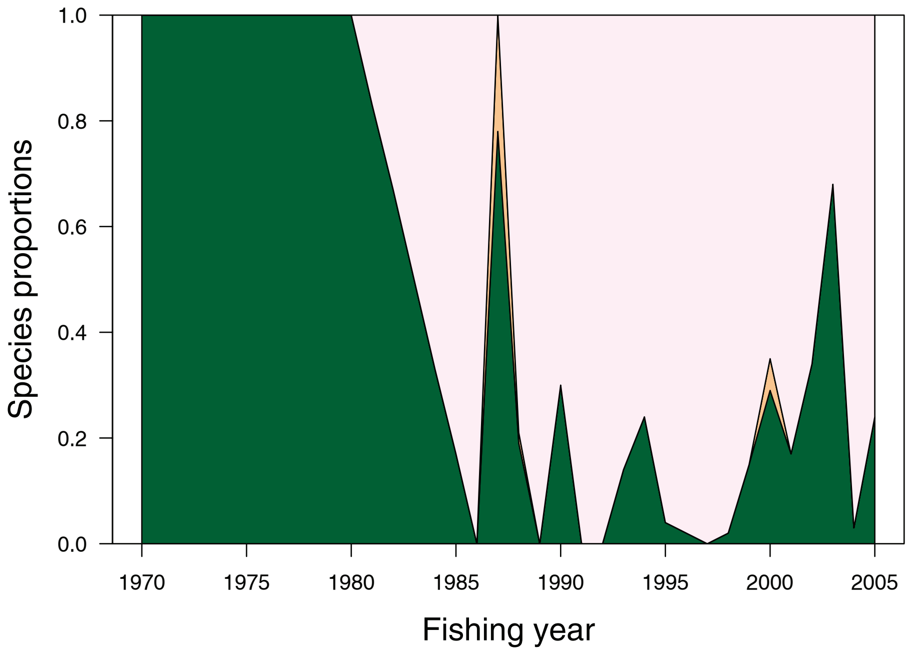

Figure A3: Species proportions for JMA 3. Very little shaded area can be seen for JMN as the associated proportions are small.

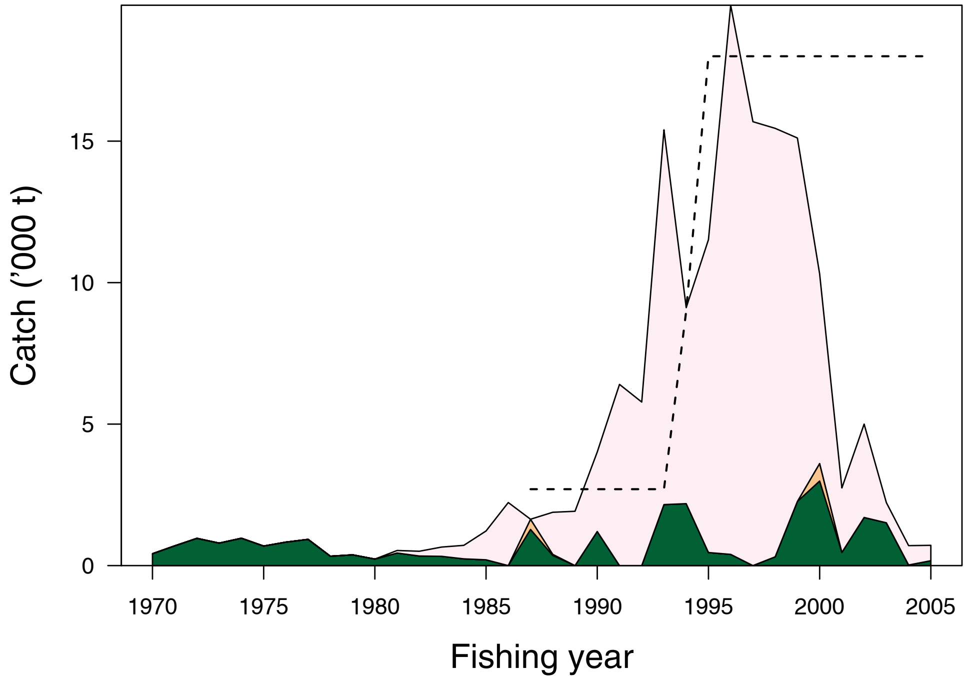

Figure A4: Catch by species for JMA 3. Very little shaded area can be seen for JMN as the associated catches are small.

Table A4: JMA 3 catch history

Year	Jack mackerel landing	Proportion JMD	Proportion JMN	Proportion JMM	Estimated JMD landing	Estimated JMN landing	Estimated JMM landing
1970	419	1.00	0.00	0.00	419	0	0
1971	697	1.00	0.00	0.00	697	0	0
1972	963	1.00	0.00	0.00	963	0	0
1973	794	1.00	0.00	0.00	794	0	0
1974	966	1.00	0.00	0.00	966	0	0
1975	690	1.00	0.00	0.00	690	0	0
1976	829	1.00	0.00	0.00	829	0	0
1977	925	1.00	0.00	0.00	925	0	0
1978	330	1.00	0.00	0.00	330	0	0
1979	379	1.00	0.00	0.00	379	0	0
1980	229	1.00	0.00	0.00	229	0	0
1981	533	0.83	0.00	0.17	444	0	89
1982	507	0.67	0.00	0.33	338	0	169
1983	654	0.50	0.00	0.50	327	0	327
1984	715	0.33	0.00	0.67	238	0	477
1985	1223	0.17	0.00	0.83	204	0	1019
1986	2228	0.00	0.00	1.00	0	0	2228
1987	1638	0.78	0.22	0.00	1278	360	0
1988	1883	0.19	0.02	0.79	358	38	1488
1989	1919	0.00	0.00	1.00	0	0	1919
1990	4013	0.30	0.00	0.70	1204	0	2809
1991	6403	0.00	0.00	1.00	0	0	6403
1992	5779	0.00	0.00	1.00	0	0	5779

1993	15399	0.14	0.00	0.86	2156	0	13243
1994	9115	0.24	0.00	0.76	2188	0	6927
1995	11519	0.04	0.00	0.96	461	0	11058
1996	19803	0.02	0.00	0.98	396	0	19407
1997	15687	0.00	0.00	1.00	0	0	15687
1998	15452	0.02	0.00	0.98	309	0	15143
1999	15111	0.15	0.00	0.85	2267	0	12844
2000	10306	0.29	0.06	0.65	2989	618	6699
2001	2744	0.17	0.00	0.83	466	0	2278
2002	5000	0.34	0.00	0.66	1700	0	3300
2003	2225	0.68	0.00	0.32	1513	0	712
2004	705	0.03	0.00	0.97	21	0	684
2005	716	0.24	0.00	0.76	172	0	544

A1.3 JMA 7 catch history

See Figures A5 and A6 for the species proportions and catch history. The graphs show cumulative species proportions or catch. The darker shade at the bottom is JMD; following this is JMN, and lastly JMM in the lightest shade. Species proportions sum to one, and the catch sums to the total jack mackerel landings for the year. The dashed line on the catch graph shows the TAC.

Table A5: Sources for the JMA 7 catch history. Landings in the sources are for all three jack mackerel species combined.

Period	Landings	Species proportions
1946–1991	Taylor (1999)	Taylor (1999)
1992–2005	Ministry of Fisheries (2006, p. 314)	Rohan et al. (2006, Table 9)

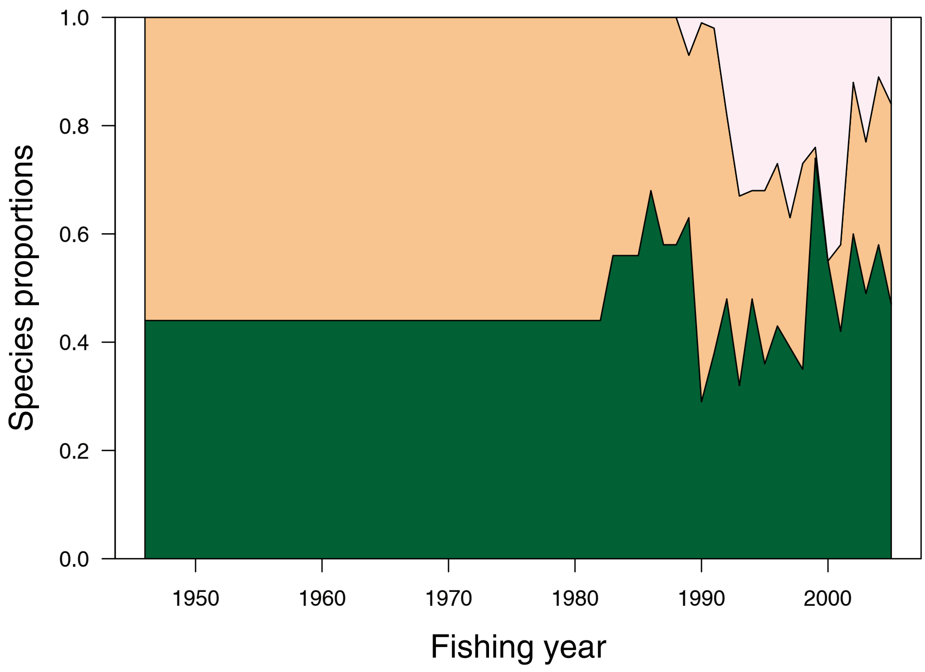

Figure A5: Species proportions for JMA 7.

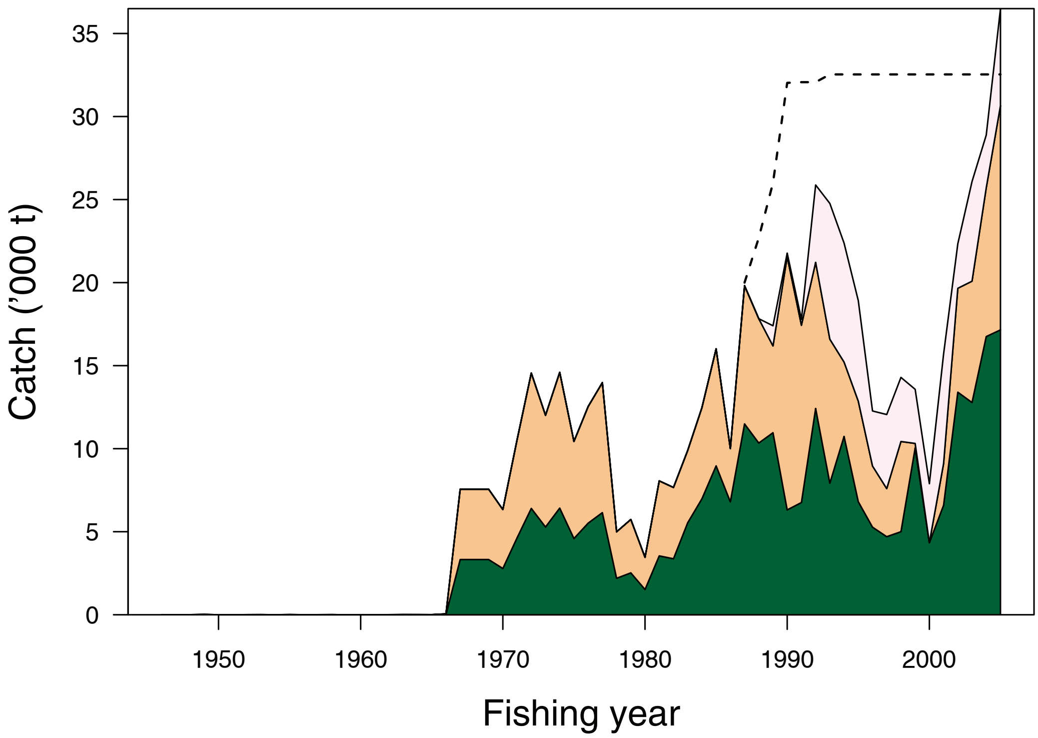

Figure A6: Catch by species for JMA 7.

Table A6: JMA 7 catch history.

Year	Jack mackerel landing	Proportion JMD	Proportion JMN	Proportion JMM	Estimated JMD landing	Estimated JMN landing	Estimated JMM landing
1946	6	0.44	0.56	0.00	3	3	0
1947	2	0.44	0.56	0.00	1	1	0
1948	4	0.44	0.56	0.00	2	2	0
1949	19	0.44	0.56	0.00	8	11	0
1950	0	0.44	0.56	0.00	0	0	0
1951	0	0.44	0.56	0.00	0	0	0
1952	7	0.44	0.56	0.00	3	4	0
1953	9	0.44	0.56	0.00	4	5	0
1954	1	0.44	0.56	0.00	0	1	0
1955	11	0.44	0.56	0.00	5	6	0
1956	2	0.44	0.56	0.00	1	1	0
1957	6	0.44	0.56	0.00	3	3	0
1958	9	0.44	0.56	0.00	4	5	0
1959	0	0.44	0.56	0.00	0	0	0
1960	4	0.44	0.56	0.00	2	2	0
1961	4	0.44	0.56	0.00	2	2	0
1962	5	0.44	0.56	0.00	2	3	0
1963	12	0.44	0.56	0.00	5	7	0
1964	10	0.44	0.56	0.00	4	6	0
1965	7	0.44	0.56	0.00	3	4	0
1966	53	0.44	0.56	0.00	23	30	0

Year	Jack mackerel landing	Proportion JMD	Proportion JMN	Proportion JMM	Estimated JMD landing	Estimated JMN landing	Estimated JMM landing
1967	7559	0.44	0.56	0.00	3326	4233	0
1968	7559	0.44	0.56	0.00	3326	4233	0
1969	7559	0.44	0.56	0.00	3326	4233	0
1970	6333	0.44	0.56	0.00	2787	3546	0
1971	10532	0.44	0.56	0.00	4634	5898	0
1972	14556	0.44	0.56	0.00	6405	8151	0
1973	12009	0.44	0.56	0.00	5284	6725	0
1974	14598	0.44	0.56	0.00	6423	8175	0
1975	10434	0.44	0.56	0.00	4591	5843	0
1976	12540	0.44	0.56	0.00	5518	7022	0
1977	13979	0.44	0.56	0.00	6151	7828	0
1978	4993	0.44	0.56	0.00	2197	2796	0
1979	5737	0.44	0.56	0.00	2524	3213	0
1980	3458	0.44	0.56	0.00	1522	1936	0
1981	8061	0.44	0.56	0.00	3547	4514	0
1982	7664	0.44	0.56	0.00	3372	4292	0
1983	9892	0.56	0.44	0.00	5540	4352	0
1984	12464	0.56	0.44	0.00	6980	5484	0
1985	16013	0.56	0.44	0.00	8967	7046	0
1986	10002	0.68	0.32	0.00	6801	3201	0
1987	19815	0.58	0.42	0.00	11493	8322	0
1988	17827	0.58	0.42	0.00	10340	7487	0
1989	17402	0.63	0.30	0.07	10963	5221	1218
1990	21776	0.29	0.70	0.01	6315	15243	218
1991	17786	0.38	0.60	0.02	6759	10672	356
1992	25880	0.48	0.34	0.18	12422	8799	4658
1993	24767	0.32	0.35	0.33	7925	8668	8173
1994	22377	0.48	0.20	0.32	10741	4475	7161
1995	18913	0.36	0.32	0.32	6809	6052	6052
1996	12270	0.43	0.30	0.27	5276	3681	3313
1997	12056	0.39	0.24	0.37	4702	2893	4461
1998	14292	0.35	0.38	0.27	5002	5431	3859
1999	13574	0.74	0.02	0.24	10045	271	3258
2000	7889	0.55	0.00	0.45	4339	0	3550
2001	15703	0.42	0.16	0.42	6595	2512	6595
2002	22338	0.60	0.28	0.12	13403	6255	2681
2003	26084	0.49	0.28	0.23	12781	7304	5999
2004	28883	0.58	0.31	0.11	16752	8954	3177
2005	36497	0.47	0.37	0.16	17154	13504	5840

Appendix A2: PROPORTIONS-AT-AGE FOR JMD AND JMN IN JMA 7: 1996 AND 2005

Here are presented the results of four catch-at-age analyses: (i) two for the JMD midwater fishery covering 1996 and 2005, and (ii) two for the JMN midwater fishery covering the 1996 and 2005 fishery.

A2.1 Sample collection

For the JMD 1995–96 midwater trawl fishery a total of 255 otoliths were available. These were collected from the end of December through to the end of February, and were predominantly from the west coast south of the North Taranaki Bight. All these otoliths were aged and used in the construction of an age-length key.

For the JMD 2004–05 midwater trawl fishery there was a total of 2125 otoliths available. These otoliths are from two separate spatial-temporal groups: (i) 1291 otoliths collected in November/December from the west coast of the North Island, and (ii) 353 otoliths collected in July from south of the Taranaki Bight. Since spatial-temporal variation in age-length keys is common it was decided to collect 200 otoliths from each group, giving a target number of otoliths of 400. Additionally, although the preliminary assessment for jack mackerel has a single area, later assessments may have two, so the grouping used provides for this future possibility. The sub-sample of 200 otoliths for each spatial-temporal grouping was achieved by randomly sampling shots within consecutive length group, i.e., the sub-sampling procedure aimed to achieve a flat distribution across lengths for the sub-sampled otoliths.

For the JMN 1995–96 midwater trawl fishery there was a total of 337 otoliths were available, these predominantly from around the North Taranaki Bight area, with some further south. All these otoliths were aged and used in the construction of an age-length key.

For the JMN 2004–05 midwater trawl fishery there are 1514 otoliths available. As for JMD these are from two separate spatial-temporal groups. However, while as with JMD there were otoliths collected in July, there was very little length data available for this or nearby months. Hence it was decided to do at catch-at-age analysis for just the summer fishery, November/December from the west coast of the North Island. A total of 400 otoliths were sub-sampled from this group.

A2.2 Data analysis

Proportions-at-age and length frequency distributions scaled to the commercial catch were produced using the catch.at.age software developed by NIWA (Bull & Gilbert 2001, Bull & Dunn 2002). The software is a library of S/S-Plus/R functions that scales the length frequency of fish from each landing up to the landing weight, sums over landings in each stratum and scales up to the total stratum catch, to yield length frequencies by stratum and overall. An age-length key is constructed from otolith data and applied to the length frequencies to yield age frequencies. The precision of each length or age frequency is measured by the mean weighted c.v. (MWCV), which is calculated as the average of the c.v.s for the individual length or age classes weighted by the proportion of fish in each class. C.v.s are calculated by bootstrapping: fish are resampled within each landing, landings are resampled within each stratum, and otoliths are simply randomly resampled.

As there is no significant difference in growth rate for male and females, the sexes are combined for the proportions-at-age and length frequency distributions (Horn 1993). All catch-at-age analyses make use of an age-length key, to which is applied a length-frequency distribution scaled by catch weight. No area strata are employed in the analyses as catch weights by separate species for area strata are not well known.

A2.3 Results

A2.3.1 JMD proportions-at-age

Table A7: The amount of coverage for JMD

Fishing year	Number of trips sampled	Number of otoliths	Numbers of fish lengths
1996	6	252	6 874
2005	7	392	14 375
2004-5	4	193	6 381
2004–05	3	200	7 611

The length distribution for December-February 1995–96 has multiple modes suggesting a great deal of inter-trip variability (Figure A7). The c.v.s are less than 30% over the main length classes, with a MWCV of 27%. The proportions-at-age show an apparently strong year class at age 3 (Figure A8).

The length distribution for 2005 has three modes: 15 cm, 28 cm, and 42 cm (Figure A9). The strong year class from the 1995–96 proportions-at-age does not show up at age 12 (Figure A10).

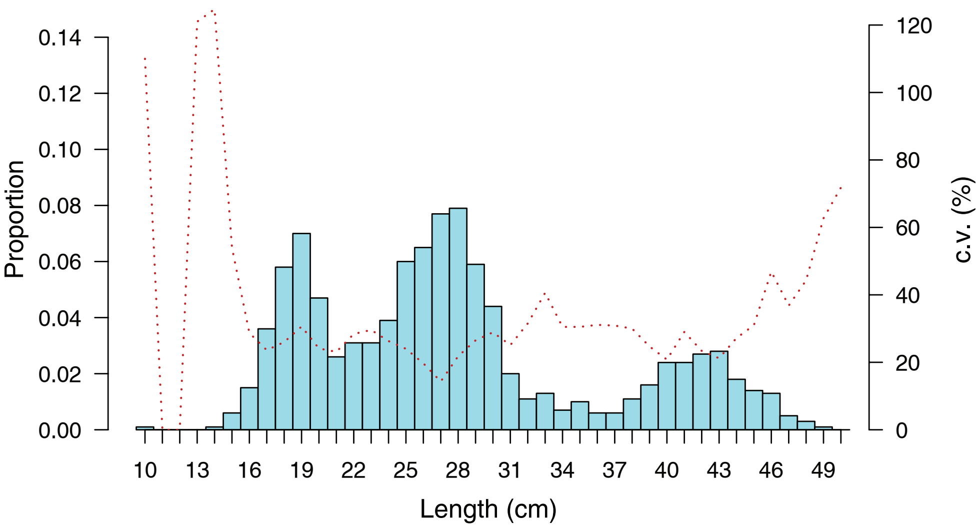

Figure A7: Length composition of the JMD midwater fishery for 1996. The dashed line represents the c.v. associated with the estimated proportion-at-length. The number of fish measured is 6874, and the MWCV is 27%.

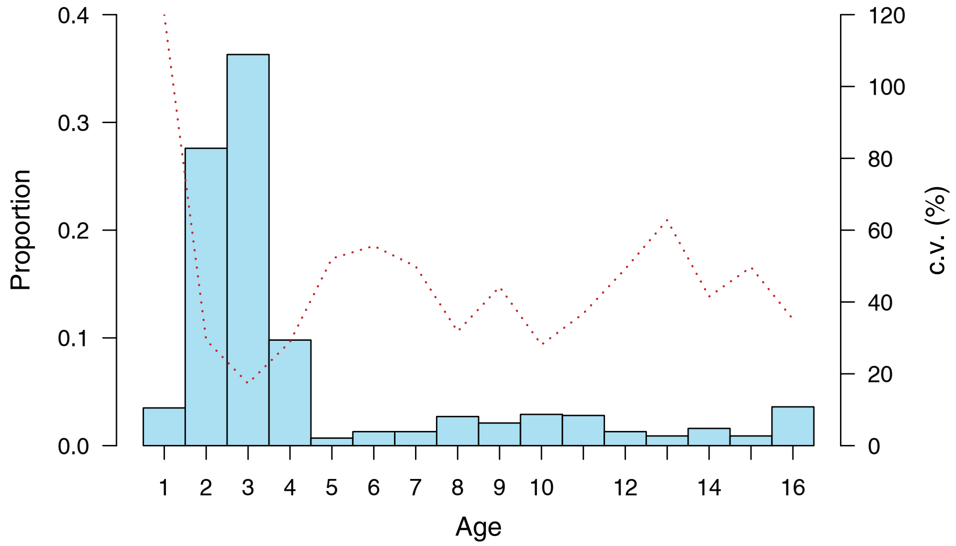

Figure A8: Age composition of the JMD midwater fishery for 1996. Age 16 is a plus group. The dashed line represents the c.v. associated with the estimates of proportions-at-age. MWCV = 35%.

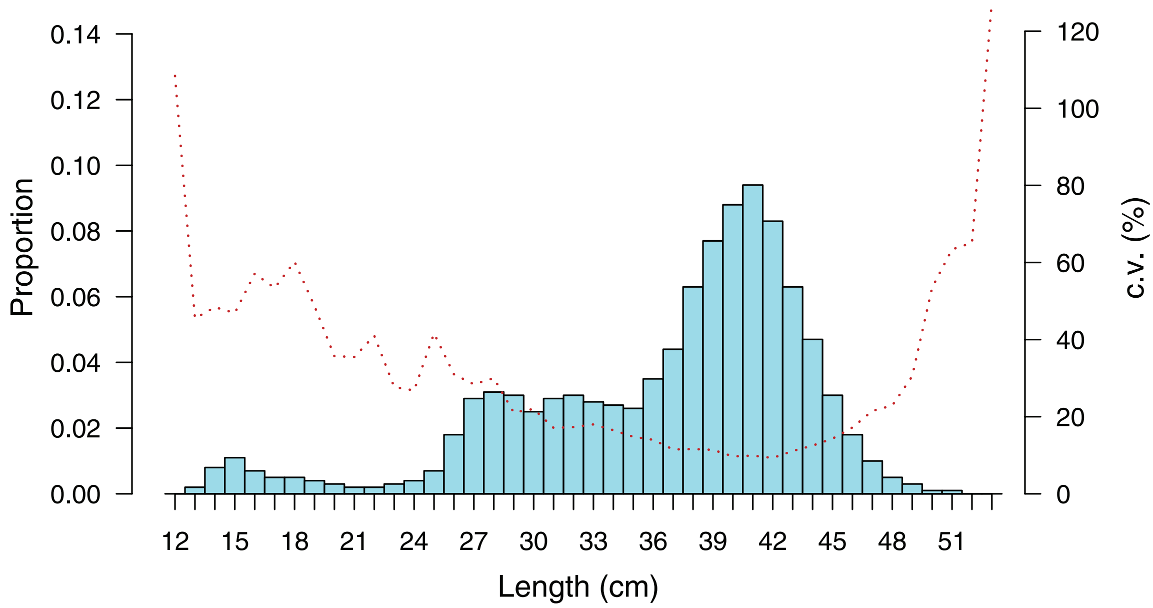

Figure A9: Length composition of the JMD midwater fishery for 2005. The dashed line represents the c.v. associated with the estimated proportion-at-length. The number of fish measured is 14375, and the MWCV is 16%.

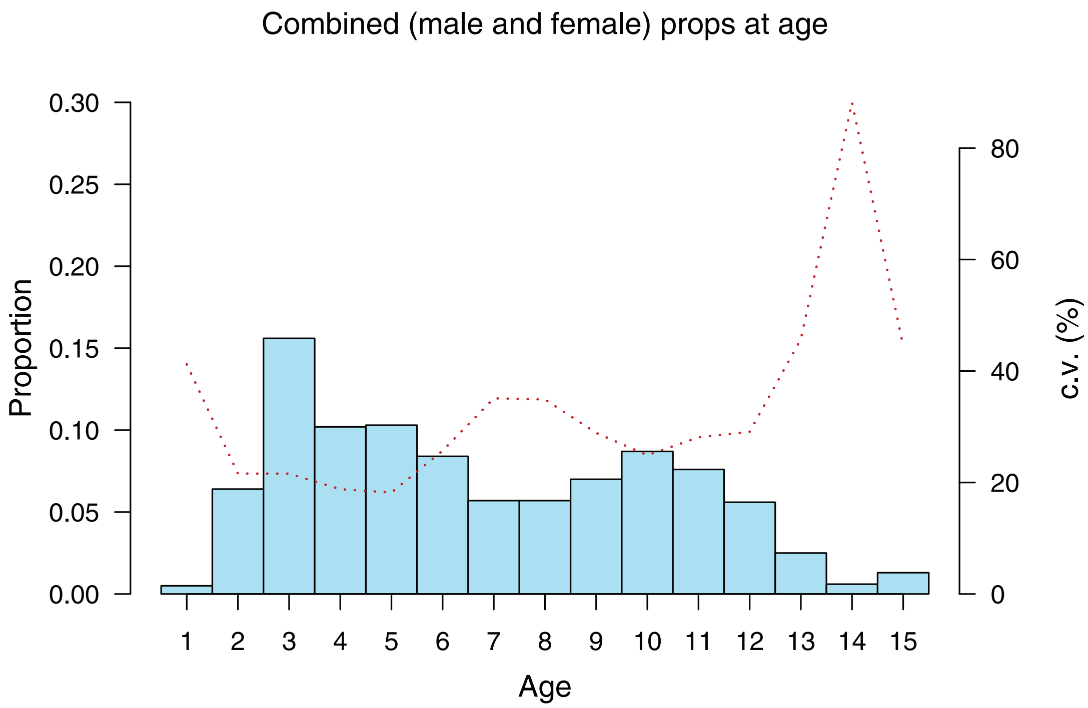

Figure A10: Age composition of the JMD midwater fishery for 2005. Age 15 is a plus group. The dashed line represents the c.v. associated with the estimates of proportions-at-age. MWCV = 29%.

A2.3.2 JMN proportions-at-age age

Table A8: The amount of coverage for JMN

Fishing year	Season	Number of trips sampled	Number of otoliths	Numbers of fish lengths
1995–96	Dec-Feb	3	325	4 384
2004–05	Nov-Dec	4	381	16 421

The length distribution for 1996 has a mode at 32 cm length (Figure A11). The c.v.s are less than 20% over the main length classes, with a MWCV of 13%. The proportions-at-age shows a strong year class strengths from ages 8 to 11, with a MWCV of 23% (Figure A12).

The length distribution for 2005 has modes at 19 cm and 32 cm length (Figure A13). The c.v.s are less than 20% over the main length classes, with a MWCV of 18%. The proportions-at-age shows a strong year class strengths at ages 9, with a MWCV of 36% (Figure A14).

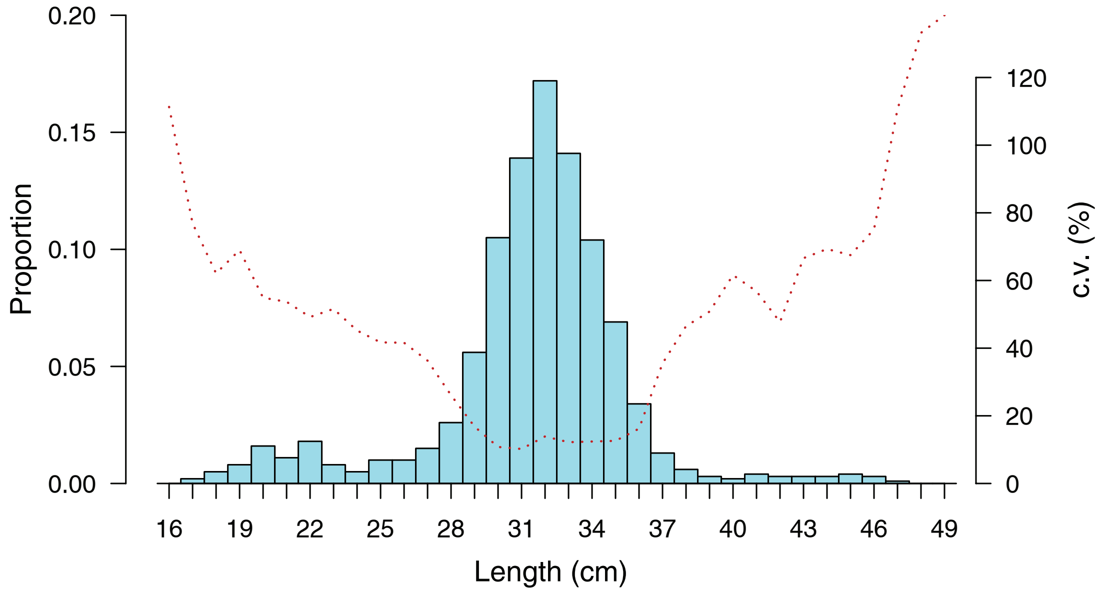

Figure A11: Length composition of the JMN midwater fishery from 1996. The dashed line represents the c.v. associated with the estimated proportion-at-length. The number of fish measured is 4 384, and the MWCV is 19%.

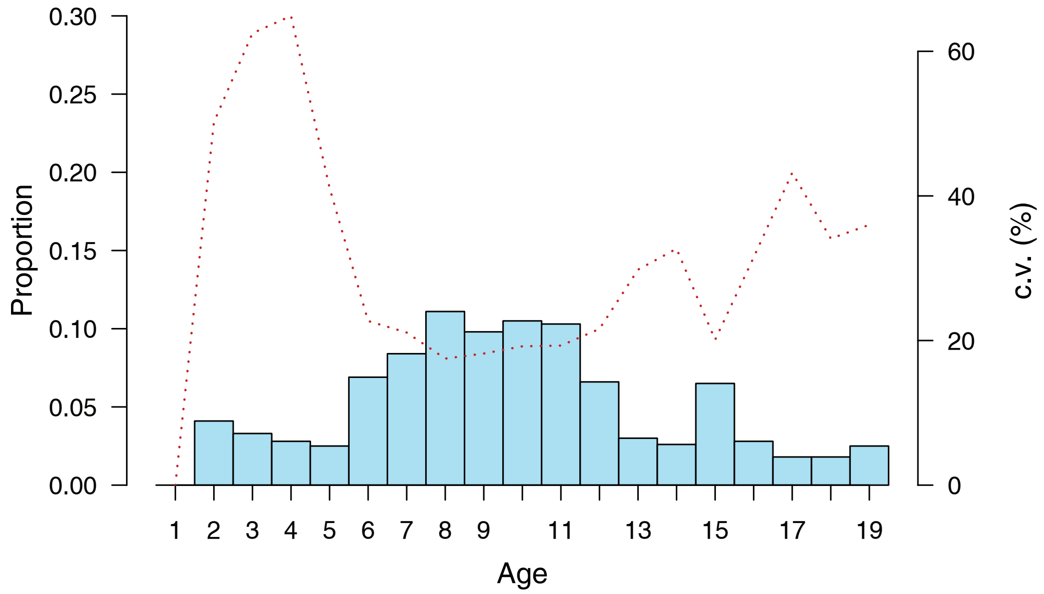

Figure A12: Age composition of the JMN midwater fishery for 1996. The dashed line represents the c.v. associated with the estimates of proportions-at-age. MWCV = 28%.

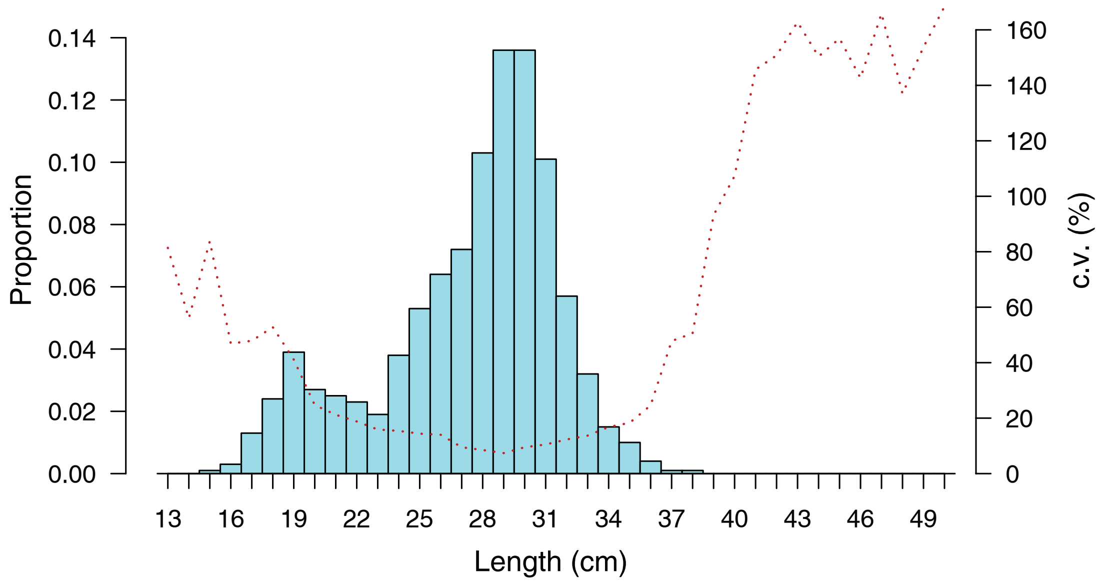

Figure A13: Length composition of the JMN midwater fishery from 2005. The dashed line represents the c.v. associated with the estimated proportion-at-length. The number of fish measured is 16 421, and the MWCV is 18%.

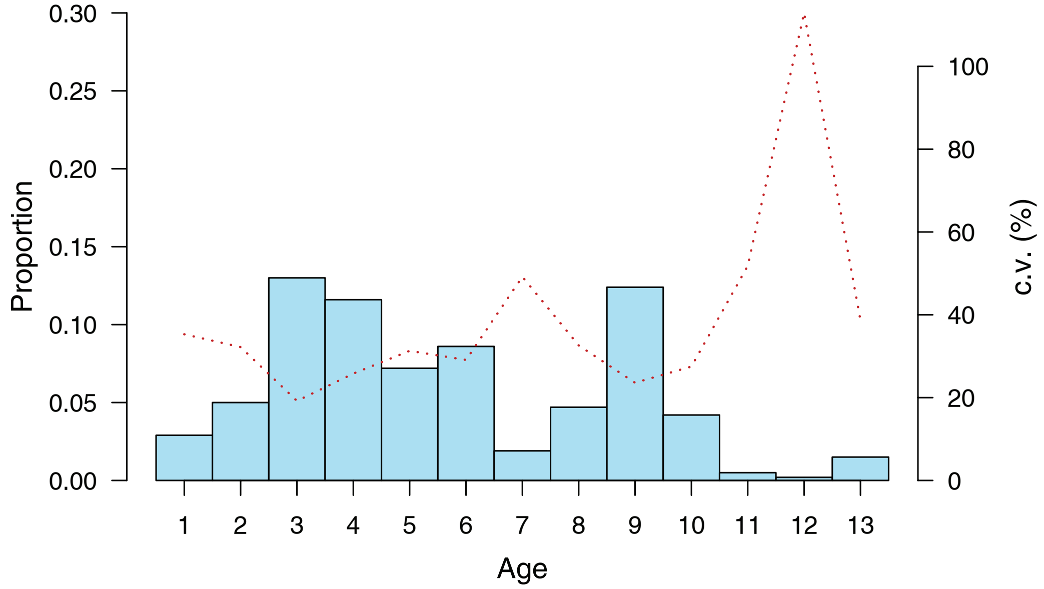

Figure A14: Age composition of the JMN midwater fishery for 2005. Age 13 is a plus group. The dashed line represents the c.v. associated with the estimates of proportions-at-age. MWCV = 36%.

Appendix A3: Proportions-at-age for JMN in JMA 1 in 2006

Here are presented the results of a catch-at-age analysis for the JMN purse-seine fishery in JMA 1 for the 2006 fishing year. This is not used in the preliminary stock assessments for jack mackerel presented in this document, which are for the JMA 7 area.

In JMA 1 jack mackerel is primarily taken as a target species by the purse-seine fishery off the Bay of Plenty and the east Northland coast (Ministry of Fisheries, Science Group, 2006, p. 313). Before 1992 the fishery was dominated by *T. novaezelandiae (*JMN), but between 1991–92 and 1995–96 the proportion of *T. s. murphyi* in the catch increased substantially. However, by 1996–97 the low value of *T. s. murphyi* resulted in less targeting of this species, and in 1999–2000 the proportion of *T. novaezelandiae* in the catch had risen to about 95%.

A3.1 Sample collection

During the 2005–06 fishing year the JMN purse-seine fishery in JMA 1 was sampled during October-November. Landings were assigned to sub-areas (e.g., Bay of Plenty) based on Ministry of Fisheries catch and effort returns. The jack mackerel length and age data was obtained from the Ministry of Fisheries *market* and *age* data bases, held by NIWA.

A3.2 Sampling coverage

Nine landings were sampled from the JMA 1 purse-seine fishery during 2005–06 for *T. novaezelandiae* (Table A9). Seven of the landings were sampled for both lengths and otoliths; two landings just for otoliths. The sampled landings accounted for 22% of the catch weight of jack mackerel taken by purse-seine during the October 2005 to June 2006 period. A total of 6290 fish were measured from the sampled jack mackerel catch of 1167 t. Otoliths were collected from all landings, and 404 otoliths were aged. The length distribution of the fish from which the otolith was taken was relatively flat over the 20–40 cm range (Figure A15).

The sampled landings were taken by two vessels, and all length samples were taken from landings in October-November 2005 from Bay of Plenty.

Table A9: Summary of landings sampled from the JMA 1 purse-seine fishery. The weight is the total landed weight for all species of jack mackerel in the landing. A dash marks fields where values are unknown.

Landing number	Landing date	Weight (t)	No. fish measured	Number of otoliths	Area fished
20056101	18-Oct-05	158.5	375	60	Bay of Plenty
20056102	25-Oct-05	190.4	861	98	Bay of Plenty
20056103	30-Oct-05	186.1	337	19	Bay of Plenty
20056104	1-Nov-05	169.5	860	50	Bay of Plenty
20056105	–	–	0	49	–
20056106	4-Nov-05	107.6	890	60	Bay of Plenty
20056107	7-Nov-05	175.1	1719	0	Bay of Plenty
20056110	–	–	0	48	–
20056111	20-Nov-05	179.9	1248	0	Bay of Plenty
			6290	404	

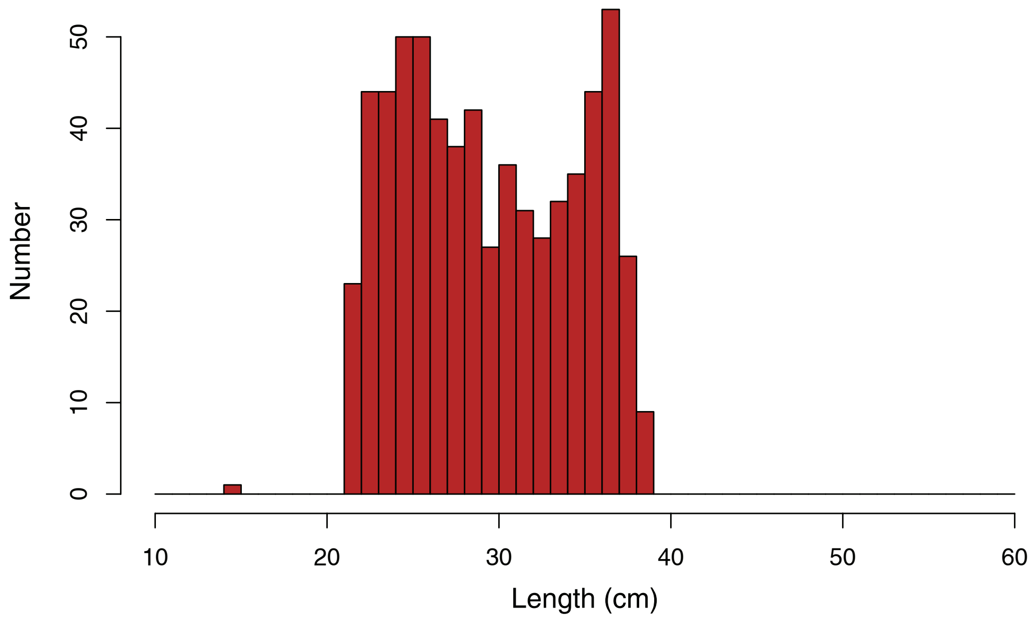

Figure A15: Length distribution for the otolith sample from the JMA 1 purse-seine fishery.

A3.3 Data analysis

Proportions-at-age and length frequency distributions scaled to the commercial catch were produced using the catch.at.age software developed by NIWA (Bull & Dunn 2002, Bull & Gilbert 2001). The software is a library of S/S-Plus/R functions that scales the length frequency of fish from each landing up to the landing weight, sums over landings in each stratum and scales up to the total stratum catch, to yield length frequencies by stratum and overall. An age-length key is constructed from otolith data and applied to the length frequencies to yield age frequencies. The precision of each length or age frequency is measured by the mean weighted c.v. (MWCV), which is calculated as the average of the c.v.s for the individual length or age classes weighted by the proportion of fish in each class. C.v.s are calculated by bootstrapping: fish are resampled within each landing, landings are resampled within each stratum, and otoliths are simply randomly resampled.

As there is no significant difference in growth rate for male and females, the sexes are combined for the proportions-at-age and length frequency distributions (Horn 1993).

A3.4 Results

The length distribution has a broad mode at 32–34 cm length, with a tail skewed to the left (Figure A16). The c.v.s are less than 20% over the main length classes, with a MWCV of 13%. The proportions-at-age shows apparently strong year classes for 1996 and 2001 (ages 10 and 5 respectively), with a MWCV of 23% (Figure A17).

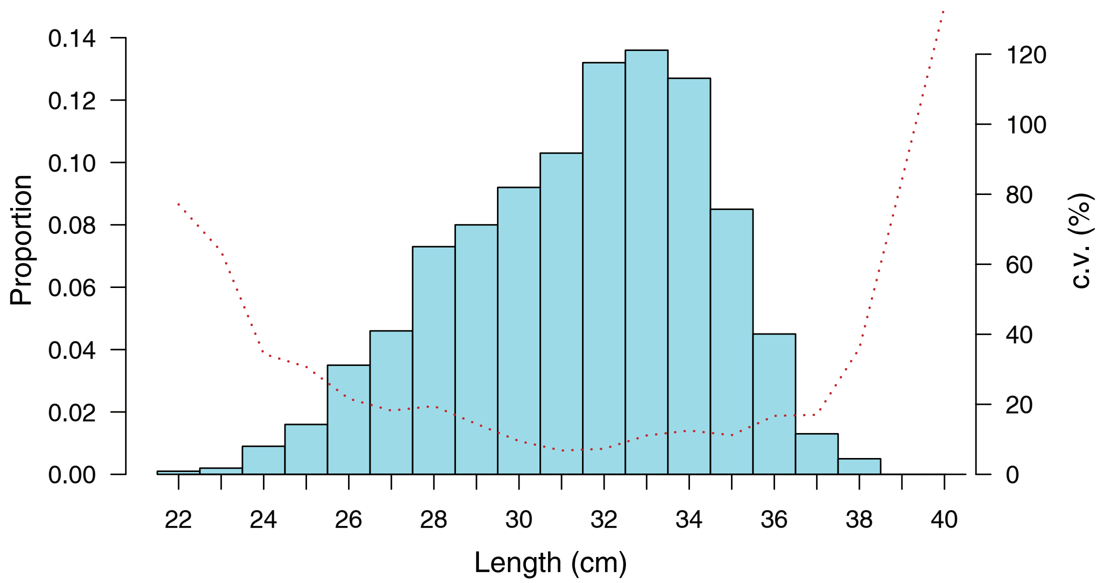

Figure A16: Length composition of the JMA 1 purse-seine catch from the 2005–06 fishing year. The dashed line represents the c.v. associated with the estimated proportion-at-length. The number of samples is 9, the number of fish measured is 6290, and the MWCV is 13%.

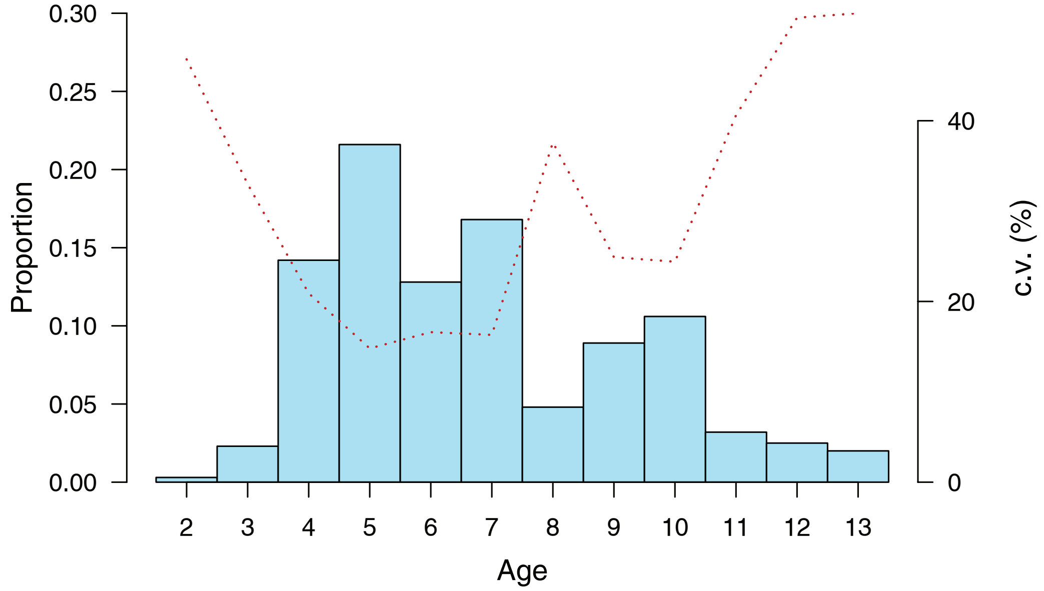

Figure A17: Age composition of the JMA 1 purse-seine fishery for 2005–06. Age 13 is a plus group. The dashed line represents the c.v. associated with the estimates of proportions-at-age. MWCV = 23%.