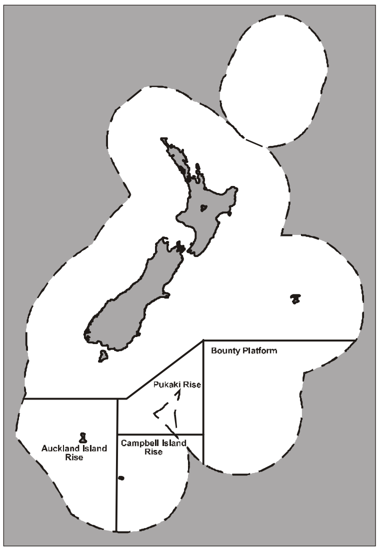
SOUTHERN BLUE WHITING (SBW)

(*Micromesistius australis*)



1. FISHERY SUMMARY

(a) Commercial fisheries

Southern blue whiting are almost entirely restricted in distribution to sub-Antarctic waters. They are dispersed throughout the Campbell Plateau and Bounty Platform for much of the year, but during August and September they aggregate to spawn near the Campbell Islands, on Pukaki Rise, on Bounty Platform, and near Auckland Islands over depths of 250–600 m. During most years fish in the spawning fishery range between 35–50 cm fork length (FL), although occasionally a smaller size class of males (29–32 cm FL) is also present.

Reported landings for the period 1971 to 1977 are shown in Table 1. Estimated landings by area from the trawl catch and effort logbooks and QMRs are given from 1978 to the present in Table 2. Landings were chiefly taken by the Soviet foreign licensed fleet during the 1970s and early 1980s, and the fishery fluctuated considerably peaking at almost 50 000 t in 1973 and again at almost 30 000 t in 1979. The Japanese surimi vessels first entered the fishery in 1986 and catches gradually increased to a peak of 76 000 t in 1991–92. A catch limit of 32 000 t, with area sub-limits, was introduced for the first time in the 1992–93 fishing year (Table 2). The total catch limit increased to 58 000 t in 1996–97 for three years. The southern stocks of southern blue whiting were introduced to the Quota Management System on 1 Nov 1999, with the TACCs given in Table 2. The fishing year was also changed to 1 April to 31 March to reflect the timing of the main fishing season. TACC changes since 2000–01 are shown in Table 2. A nominal TACC of 8 t (SBW 1) was set for the rest of the EEZ. Less than 20 t per year has been reported from SBW 1 since 2000–01.

Landings have averaged 30 000 t in the last five years, with the majority of the catch currently taken by Japanese surimi vessels and Ukrainian dressed vessels. On the Campbell Island Rise the TACC has been almost fully caught in each of the last 5 years. However, on the other grounds, the catch limits have generally been undercaught in most years since their introduction. This reflects the low economic value of the fish and difficulties in timing and locating aggregations experienced by operators. On the Bounty Platform, the amount of fishing effort in any season depends largely on the timing of the west coast hoki fishery. If there is a delayed hoki season, then the vessels remain longer on the hoki grounds and consequently miss the peak fishing season on the Bounty Platform. On the Pukaki Rise and Auckland Islands Shelf, operators find it difficult to justify expending time to locate fishable aggregations, given the small allocation available in these areas and the relatively low value of the product.

From 1 April 2003, the TACCs were reduced for two southern blue whiting stocks, from 8000 t to 3500 t for the Bounty Platform stock and from 30 000 t to 25 000 t for the Campbell Islands stock. The TACCs were slightly exceeded on the Campbell Island Rise and Bounty Platform in 2005–06. From 1 April 2006, the TACC for the Campbell Islands stock has been furher reduced to 20 000 t.

Table 1: Reported annual landings (t) of southern blue whiting from 1971 to 1977.

Fishing year	Total	Fishing year	Total
1971	10 400	1975	2 378
1972	25 800	1976	17 089
1973	48 500	1977	26 435
1974	42 200		

Table 2: Estimated catches (t) of southern blue whiting by area for the period 1978 to 2004–05 from vessel logbooks and QMRs. – no catch limit in place. *, before 1997-98 there was no separate catch limit for Auckland Is. Estimates for 2004–05 are preliminary.

	Bounty Platform		Campbell Island Rise		Pukaki Rise		Auckland Is.		Total	
Fishing year	Catch	Limit	Catch	Limit	Catch	Limit	Catch	Limit*	Catch	Limit
1978*f*	0	–	6 403	–	79	–	15	–	6 497	–
1978–79+	1 211	–	25 305	–	601	–	1 019	–	28 136	–
1979–80+	16	–	12 828	–	5 602	–	187	–	18 633	–
1980–81+	8	–	5 989	–	2 380	–	89	–	8 466	–
1981–82+	8 325	–	7 915	–	1 250	–	105	–	17 595	–
1982–83+	3 864	–	12 803	–	7 388	–	184	–	24 239	–
1983–84+	348	–	10 777	–	2 150	–	99	–	13 374	–
1984–85+	0	–	7 490	–	1 724	–	121	–	9 335	–
1985–86+	0	–	15 252	–	552	–	15	–	15 819	–
1986–87+	0	–	12 804	–	845	–	61	–	13 710	–
1987–88+	18	–	17 422	–	157	–	4	–	17 601	–
1988–89+	8	–	26 611	–	1 219	–	1	–	27 839	–
1989–90+	4 430	–	16 542	–	1 393	–	2	–	22 367	–
1990–91+	10 897	–	21 314	–	4 652	–	7	–	36 870	–
1991–92+	58 928	–	14 208	–	3 046	–	73	–	76 255	–
1992–93+	11 908	15 000	9 316	11 000	5 341	6 000	1 143	–	27 708	32 000
1993–94+	3 877	15 000	11 668	11 000	2 306	6 000	709	–	18 560	32 000
1994–95+	6 386	15 000	9 492	11 000	1 158	6 000	441	–	17 477	32 000
1995–96+	6 508	8 000	14 959	21 000	772	3 000	40	–	22 279	32 000
1996–97+	1 761	20 200	15 685	30 100	1 806	7 700	895	–	20 147	58 000
1997–98+	5 647	15 400	24 273	35 460	1 245	5 500	0	1 640	31 165	58 000
1998–00†	8 741	15 400	30 386	35 460	1 049	5 500	750	1 640	40 926	58 000
2000–01#	3 997	8 000	18 049	20 000	2 864	5 500	19	1 640	24 938	35 148 ‡
2001–02#	2 261	8 000	29 999	30 000	230	5 500	10	1 640	32 501	45 148 ‡
2002–03#	7 564	8 000	33 433	30 000	508	5 500	254	1 640	41 775	45 148 ‡
2003–04#	3 812	3 500	23 718	25 000	163	5 500	116	1 640	27 812	35 648 ‡
2004–05#	1 477	3 500	19 776	25 000	240	5 500	95	1 640	21 597	35 648 ‡
2005–06#	3 962	3 500	26 190	25 000	58	5 500	50	1 640	30 260	35 648 ‡

f 1 April-30 September. + 1 October-30 September.
† 1 October 1998-31 March 2000 # 1 April -31 March.
‡ SBW 1 (all EEZ areas outside QMA6) had a TACC of 8 t, and reported catches of 9 t in 2000–01, 1 t in 2001–02, 16 t in 2002–03, 2.6 t in 2003–04, and 9 t in 2004–05.

(b) Recreational fisheries

There is no recreational fishery for southern blue whiting.

(c) Maori customary fisheries

Quantitative estimates of the level of Maori customary take are not available.

(d) Illegal catches

The level of illegal and unreported catch is thought to be low, however, the operators of one vessel have recently been convicted for area misreporting. In 2002–03, the vessel caught about 204 tonnes on the Campbell Island Rise (SBW 6I) that were reported against quota for the Pukaki Rise (SBW 6R), and another 480 tonnes caught on the Campbell Island Rise were reported against quota for the Auckland Islands Shelf (SBW 6A). Table 2 shows corrected totals by area for 2002–03.

(e) Other sources of mortality

Scientific observers have reported discards of undersize fish and accidental loss from torn or burst codends. There is no quantitative estimate of this mortality and no estimates of discards have been considered in the stock assessments.

2. BIOLOGY

Southern blue whiting is a schooling species that is confined to sub-Antarctic waters. Early growth has been well documented with fish reaching a length of about 20 cm FL after one year and 30 cm FL after two years. Growth slows down after five years and virtually ceases after ten years. Ages have been validated up to at least 15 years by following strong year classes, but ring counts from otoliths suggest individual fish may reach 25 years.

The age and length of maturity, and recruitment to the fishery, varies between areas and between years. In some years a small proportion of males mature at age 2, but the majority do not mature until age 3 or 4, usually at a length of 33–40 cm FL. The majority of females also mature at age 3 or 4 at a length of 35–42 cm FL. Ageing studies have shown that this species has very high recruitment variability.

Southern blue whiting are highly synchronised batch spawners. Four spawning areas have been identified on Bounty Platform, Pukaki Rise, Auckland Islands Shelf, and Campbell Island Rise. The Campbell Island Rise has two separate spawning grounds to the north and south. Fish appear to recruit first to the southern ground but thereafter spawn on the northern ground. Spawning on Bounty Platform begins in mid August and finishes by mid September. Spawning begins 3–4 weeks later in the other areas, finishing in late September/early October. Spawning appears to occur at night, in midwater, over depths of 400–500 m on Campbell Island Rise but shallower elsewhere.

Natural mortality (M) was estimated using the equation $\log_e(100)$/maximum age, where maximum age is the age to which 1% of the population survives in an unexploited stock. Using a maximum age of 22 years, M was estimated to equal 0.21. The value of 0.2 is assumed to reflect the imprecision of this value. Recent Campbell Island stock assessments have estimated M within the model, using an informed prior with a mean of 0.2.

Table 3: Estimates of biological parameters for the Campbell Island Rise southern blue whiting stock.

Estimate					**Source**
1. Natural mortality (M)					
	Males		**Females**		
	0.2		0.2		Hanchet (1992)
2. Weight = a (length)^b (Weight in g, length in cm fork length)					
	Males		**Female**		
	a	**b**	**a**	**b**	
	0.00515	3.092	0.00407	3.152	Hanchet (1991)

Note: Estimates of natural mortality and the length weight coefficients are assumed to be the same for the other stocks. Observed length at age data are used for all stocks.

3. STOCKS AND AREAS

Hanchet (1998, 1999) reviewed the stock structure of southern blue whiting. He examined historical data on southern blue whiting distribution and abundance, reproduction, growth, and morphometrics. There appear to be four main spawning grounds of southern blue whiting on the Bounty Platform, Pukaki Rise, Auckland Islands Shelf, and Campbell Island Rise. There are also consistent differences in the size and age distributions of fish, in the recruitment strength, and in the timing of spawning between these four areas. Multiple discriminant analysis of data collected in October 1989 and 1990 showed that fish from Bounty Platform, Pukaki Rise and Campbell Island Rise could be distinguished on the basis of their morphometric measurements. The Plenary concluded that this constitutes strong evidence that fish in these areas return to spawn on the grounds to which they first recruit. No genetic studies have been carried out, but given their close proximity, it is unlikely that there would be detectable genetic differences in the fish between these four areas.

For the purposes of stock assessment it is assumed that there are four stocks of southern blue whiting with fidelity within stocks: the Bounty Platform stock, the Pukaki Rise stock, the Auckland Islands stock, and the Campbell Island stock.

4. STOCK ASSESSMENT

Updated estimates of biomass and yield are provided for the Campbell Island stock based on analyses using catch-at-age from the commercial fishery, acoustic survey data, and estimates of biological parameters. New information since the 2005 assessment included one year of commercial catch proportions-at-age data. In order to determine whether there was any urgent sustainability concern with the Campbell Islands stock, the Middle Depths Working Group (WG) agreed to update the 2005 base case assessment and sensitivity tests using the new proportion-at-age data.

No new assessment is available for the Bounty Platform and Pukaki Rise stocks. No assessment has been made of the Auckland Islands Shelf stock. The years given in the biomass and yield sections of this report refer to the August-September spawning/fishing season.

(a) Estimates of fishery parameters and abundance indices

Acoustic surveys of southern blue whiting have been carried out since 1993. Target strength work has continued each year as part of these acoustic surveys. Additional estimates from *in situ* data were reported in 2002, which indicate that the slope in the target strength – fish length relationship may be steeper than previously used (Dunford 2003). However, the WG was unable to resolve the inconsistencies between the various data sources (swimbladder modelling, *in situ* data, and recent results from work on northern blue whiting). Therefore it was agreed to retain the original relationship between target strength and fish length from the Northern hemisphere for blue whiting (Monstad et al., 1992) as used previously in New Zealand assessments. The WG noted that if the slope in this relationship is kept the same, the value of q changes in the model but relative abundance indices are still valid, whereas if a different slope of the relationship is used the data must be reanalysed.

A further acoustic survey of the Campbell Island stock was completed in August/September 2004 (O'Driscoll *et al.* in prep.) Two snapshots were carried out on pre-spawning and spawning aggregations on the Campbell Island Rise. The distribution of fish on the 'northern' ground during the 2004 survey was quite different to previous years. Most of the fish caught by the commercial vessels, and about 50% of the biomass from the acoustic survey, came from several aggregations to the east of the core survey area.

For the 2005 assessment, the Plenary considered two possible hypotheses regarding the observed distribution of fish outside the core area: (1) the northern aggregation had moved further east and were spawning outside the survey area; (2) the fish which previously had spawned in the northern area had been depleted and the fish observed outside of the core area represent a new unsurveyed part of the population. During the 2005 season, most fishing on the northern aggregation occurred within the usual acoustic survey area, and despite some searching few fish were found to the east. The stock assessment was run using both sets of acoustic biomass estimates (Table 4) to examine the stock status under each hypothesis. However, the first hypothesis was considered to be more plausible and was used as the base case.

Table 4: Estimates of biomass (000 t) for age 1, 2, 3 and 4+ fish from acoustic surveys of Bounty Platform, Pukaki Rise, and Campbell Island Rise, and CPUE indices. – no data. *Estimates include fish from outside the standard survey area.

Year	Bounty Platform				Pukaki Rise				Campbell Island Rise				
	1	2	3	4+	1	2	3	4+	1	2	3	4+	CPUE
1986	–	–	–	–	–	–	–	–	–	–	–	–	1.00
1987	–	–	–	–	–	–	–	–	–	–	–	–	0.91
1988	–	–	–	–	–	–	–	–	–	–	–	–	0.88
1989	–	–	–	–	–	–	–	–	–	–	–	–	1.38
1990	–	–	–	–	–	–	–	–	–	–	–	–	1.06
1991	–	–	–	–	–	–	–	–	–	–	–	–	1.30
1992	–	–	–	–	–	–	–	–	–	–	–	–	0.60
1993	8.81	6.87	1.41	62.86	0.58	26.85	9.32	31.15	1.82	71.90	14.78	24.03	1.03
1994	0.09	5.87	32.07	27.67	0.01	1.19	6.36	35.97	0.33	12.26	139.55	28.84	1.19
1995	59.28	4.86	6.66	30.77	0.00	0.10	0.78	11.74	0.00	11.18	23.23	130.54	1.23
1996	–	–	–	–	–	–	–	–	–	–	–	–	2.28

Table 4 *(Continued)*

Year	Bounty Platform				Pukaki Rise				Campbell Island Rise				
1997	1.68	4.14	24.60	37.52	0.02	2.84	0.86	34.09	–	–	–	–	2.28
1998	–	–	–	–	–	–	–	–	2.28	13.14	28.02	167.67	1.74
1999	0.43	0.75	4.97	42.72	–	–	–	–	–	–	–	–	2.55
2000	–	–	–	–	0.06	3.04	2.07	29.45	0.96	10.46	8.42	135.61	1.85
2001	0.14	2.55	6.01	21.68	–	–	–	–	–	–	–	–	1.83
2002	–	–	–	–	–	–	–	–	3.06	3.73	11.55	148.19	1.94
2002*	–	–	–	–	–	–	–	–	3.06	3.83	11.84	152.18	–
2004	–	–	–	–	–	–	–	–	1.51	14.42	18.87	17.28	–
2004*	–	–	–	–	–	–	–	–	1.51	17.33	34.53	56.20	–

A standardised CPUE analysis of the Campbell Island stock was completed up until the 2002 fishing season, and the indices are shown in Table 4. In the past there has been concern that because of the highly aggregated nature of the fishery, and the associated difficulty in finding and maintaining contact with the highly mobile schools in some years, the CPUE series may not be monitoring abundance. The indices have therefore not been used in the stock assessment since 1998. A standardised CPUE analysis was also recently carried out for the Bounty Platform. However, this analysis was based on a much more limited data set, the results were inconsistent with the acoustic survey estimates, and there was strong evidence of targeting. The indices were therefore rejected by the WG as indices of abundance and not used in the assessment.

(b) Biomass estimates

(i) Campbell Island stock

The stock assessment model

The stock assessment model partitions the Campbell Island stock into two sexes and age groups 2–11, with a plus group at age 11. There are two time steps in the model (Table 5). In the first time step 90% of natural mortality takes place. In the second time step, fish ages are incremented; the 2-year-olds are recruited to the population, which is then subjected to fishing mortality; and the remaining 10% of natural mortality.

Table 5: Annual cycle of the stock model, showing the processes taking place at each step, and the available observations. Fishing mortality (F) and natural mortality (M) that occur within a time step occur after all other processes. M, proportion of M occurring in that time step.

Period	Process	M	Length at age	Observations
1. Nov–Aug	Natural mortality	0.9	–	–
2. Sep–Oct	Age, recruitment, F, M	0.1	Matrix applies here	Proportion at age, acoustic indices

The model assumes that the fishing selectivity after age 4 is 1.0, and estimates selectivity for each sex for ages 2 to 4. Selectivities were assumed constant over all years in the fishery, and hence there was no allowance for annual changes in selectivity. In line with previous assessments no stock-recruitment relationship is assumed in the model. The proportion of males at recruitment (age 2) was assumed to be 0.5 of all recruits. As it is a spawning fishery, the maturity ogive was assumed to be the same as the selectivity ogive estimated in the model. Note that the maturity ogive is only used to report spawning stock biomass. The maximum exploitation rate (U_{max}) was set at a value of 0.7. The choice of the maximum exploitation rate has the effect of determining the minimum possible virgin biomass allowed by the model. Because of the large inter-annual differences in growth, caused by the occurrence of the strong and weak year classes, length-at-age vectors were calculated for each year, and used in the modelling. Lengths-at-age were converted to weights-at-age in the model using the length-weight relationship given in Table 3.

The model was fitted to the two series of acoustic biomass estimates of ages 2, 3, and 4+ fish given in Table 6 and the proportions-at-age data from the commercial fishery. The acoustic survey estimates were used as relative estimates of mid-season biomass (i.e. after half the catch has been removed), with associated c.v.s estimated from the survey analysis. Catch-at-age observations were available from the commercial fishery for the period 1979 to 2005. Catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age and associated c.v.s by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002). Zero values were replaced with the value 0.0002 with an associated c.v. of 1.5. Ageing error was assumed to be zero.

Lognormal errors, with known c.v.s were assumed for the relative biomass and proportions-at-age data. The c.v.s available for these data allow for sampling error only. However, additional variance assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in an initial run of the model using all the available data. A process error of 0.4 was estimated for the proportions-at-age data and was added to each observation for all subsequent model runs. The process error estimated for the acoustic indices was zero.

Table 6: Decomposed biomass estimates (t) and c.v.s by survey and age group used for the Campbell Island Rise stock assessment. *Estimates include fish from outside the standard survey area.

	Age 2		Age 3		Age 4+	
Year	**Biomass**	**c.v.**	**Biomass**	**c.v.**	**Biomass**	**c.v.**
1993	71 902	23	14 781	22	24 033	21
1994	12 259	38	139 552	37	28 841	36
1995	11 176	25	23 228	28	130 535	30
1998	13 142	20	28 022	19	167 668	18
2000	10 460	23	8 421	20	135 612	17
2002	3 732	76	11 549	72	148 189	68
*2002	3 829	76	11 842	72	152 184	68
2004	14 412	16	18 873	24	17 283	32
*2004	17 327	16	34 527	27	56 197	38

Estimation

Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program CASAL v2.07 (Bull et al. 2004). For initial runs only the mode of the joint posterior distribution was sampled. For the final runs presented here, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm.

MCMC chains were estimated using a burn-in length of 1 million iterations, with every 10 000th sample taken from the next 10 million iterations (i.e., a final sample of length 1000 was taken from the Bayesian posterior).

Equilibrium “virgin” biomass is equal to the population that there would have been if all the YCS were equal to one and there was no fishing. However, there was a period of unknown (and possibly large) catches from the Campbell Island stock before 1979, and there is high recruitment variability in the stock, so the initial 1979 biomass was allowed to differ from the equilibrium virgin biomass. The initial population in 1979 (ages 3 to 11+) was estimated for each sex. Year class strengths were estimated for all years from 1977 to 2003, under the assumption that the estimates from the model should average one.

Prior distributions and penalty functions

The assumed prior distributions used in the assessment are given in Table 7. Most priors were intended to be uninformed, and had wide bounds. However, a log-normal prior was used for natural mortality and for the acoustic survey 4+ *q*.

Table 7: The distributions, priors, and bounds assumed for the various parameters being estimated in the Campbell Island Rise stock assessment. The parameters are mean and c.v. for lognormal; and mean and s.d. for normal. *The prior for the adult (4+) acoustic *q* used for a sensitivity run. The process errors were fixed at their MPD values when carrying out the MCMCs.

Parameter	**N**	**Distribution**	**Values**		**Bounds**	
			Mean	**c.v. / s.d.**	**Lower**	**Upper**
B_0	1	Uniform-log	–	–	30 000	800 000
Acoustic *q*s age 2, 3	2	Uniform-log	–	–	0.1	2.8
YCS	27	Lognormal	1.00	1.30	0.001	100
Initial population	18	Uniform-log	–	–	2e5	2e12
Selectivity ages 2-4 (by sex)	6	Uniform	–	–	0.0001	1

Table 7 ***(Continued)***

M (average)	1	Lognormal	0.20	0.20	0.075	0.325
M (difference)	1	Normal	0.00	0.05	-0.05	0.05
Process errors	4	Uniform-log			0.0001	1
Acoustic age 4+ *q*	1	Lognormal	1.40	0.20	0.1	2.8
*Acoustic age 4+ *q*	1	Uniform-log	–	–	0.1	2.8

The informed prior for the adult (4+) acoustic *q* was obtained using the approach of Cordue (1996). Uncertainty over various factors including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were all taken into account. In addition to obtaining the bounds, a mean for each factor was also assumed. The factors were then multiplied together. This independent evaluation of the bounds on the acoustic *q* suggested a range of 0.65–2.8, with a mean of 1.4 and a c.v. of 0.2. As the 90% confidence bounds of *q* from preliminary MCMC runs extended lower than 0.65, the WG agreed to extend the lower bound to 0.1. The informed prior for the adult acoustic *q* will need to be revised in future to take account of the new estimates of the absorption coefficient, towbody motion (pitch and roll), and the target strength-fish length relationship.

The prior on natural mortality was determined by assuming that the true value could differ from the current value by about 0.05, and not more than 0.1. Natural mortality was parameterised by the average of male and female, with the difference estimated with an associated normal prior with mean zero and standard deviation 0.05. Penalty functions were used to constrain the model so that any combinations of parameters that did not allow the historical catch to be taken were strongly penalised. A small penalty was applied to encourage the estimates of year class strengths to average to 1.

Base case and sensitivity runs

The WG considered three runs, which were essentially updates of the 2005 assessment. The WG agreed that the model run using an informed prior on *q*, and which included the acoustic biomass indices incorporating all surveyed strata, provided the most plausible results. However, the WG noted that if fish had been outside the core survey area in the earlier years (Hypothesis 2) then the assessment would underestimate the level of decline in the Campbell Island stock and would consequently overestimate the available yields. The Plenary agreed that Hypothesis 1 would be reported as the base case and to report two sensitivity runs bracketing the base case assessment, one exploring the effect of an uninformed prior on the acoustic *q* and the other representing Hypothesis 2 (Table 8). The WG noted that the run which used the low acoustic biomass series based only on the core survey strata indicated that the exploitation rate had been very high in 2005 which was considered unlikely.

Table 8: Model run labels and descriptions for the base case and sensitivity runs.

Model label	Description
Base case	**Lognormal prior on adult acoustic *q*, and high acoustic biomass series**
Uninformed *q*	Uniform-log prior on adult acoustic *q*, and high acoustic biomass series
Low acoustic	Lognormal prior on adult acoustic *q*, and low acoustic biomass series

Since 2001, the Plenary has used B_{1991} as a limit reference biomass level for the Campbell Island Rise stock. Recruitment in the Campbell Island Rise stock is characterised by periods of moderate recruitment interspersed by relatively rare, extremely strong, recruitment events. Only one such event (1991 year class) has been observed within the timeframe of the model, although historical data suggests that this may have happened in the past. Given the high variability in recruitment levels, B_0 is probably not well determined. Therefore, the Plenary considered that B_{1991} may be a better limit reference point than the more commonly used 20% B_0. Based on the assumptions of the model and the available data, B_{1991} is estimated to be about 17% of B_0 and there is only a slight probability that B_{1991} exceeds 20% B_0 (Figure 1).

The Plenary agreed that the probability of falling below B_{1991} should be kept low for several reasons including: the stock biomass has only been observed at that low level once in the time series; the exceptionally strong recruitment from the 1991 year class has only been observed once in the 27 years covered by the stock assessment; and although no stock recruitment relationship is assumed in the model, the risks of poor recruitment may be higher at B_{1991} levels than at 20%B_0.

The Plenary did not have an agreed target reference biomass level or associated risk level for the Campbell Island Rise stock. The development of an appropriate target reference biomass level will be the focus of future discussions, and will require some direction from fisheries managers on the acceptable levels of risk and the harvest strategy to be applied.

For each model run, MPD fits were obtained and qualitatively evaluated. MCMC estimates of the median of the posterior and 90% credible intervals are reported for virgin biomass, B_{2005}, B_{2005} (as %B_0), and B_{2005} (as %B_{1991}).

Results

The estimated MCMC marginal posterior distributions for spawning stock biomass by year are shown for the base case in Figure 2, and the results summarised in Table 9. The run suggests that the stock biomass showed a steady decline from the early 1980s until 1993 followed by a large increase to 1996, and a decline thereafter. Exploitation rates are shown in Figure 3. The catch is dominated numerically by the 2001 and 2002 year classes, and the strong 1991, 1995, 1996, and 1998 year classes now contribute to only a small proportion of the commercial catch (Figure 4). The 2003 year class is estimated to be below average by the model, but since it appears only once in the catch-at-age data it is not well estimated, (and is not used in projections). Estimates of the adult acoustic *q*, the 2005 exploitation rate and M are given in Table 9.

The sensitivity runs show that the estimates of B_{2005} and stock status are very sensitive to the choice of acoustic biomass series but only slightly sensitive to the prior used for the acoustic *q* (Table 9).

Table 9: Bayesian median and 90% credible intervals of B_0, B_{2005} (in '000 t), B_{2005} as a percentage of B_{1991} and of B_0 , B_{1991} / B_0, adult 4+ acoustic *q*, the 2005 exploitation rate, and M for each of the three runs for the Campbell Island stock.

Model run	B_0	B_{2005}	B_{2005} (%B_{1991})	B_{2005} (%B_0)	B_{1991} / B_0
Base case	**245 (219–285)**	**68 (46–105)**	**164 (113–240)**	**28 (19–41)**	**0.17 (0.13–0.22)**
Uninformed *q*	246 (221–282)	76 (47–129)	177 (119–257)	31 (19–50)	0.18 (0.13–0.24)
Core acoustic	215 (199–244)	35 (27–51)	84 (65–117)	17 (12–24)	0.20 (0.16–0.24)

Model run	*q*	U_{2005}	*M*
Base case	**1.18 (0.99–1.35)**	**0.33 (0.23–0.45)**	**0.17 (0.13–0.21)**
Uninformed *q*	1.08 (0.78–1.33)	0.30 (0.19–0.45)	0.18 (0.14–0.23)
Core acoustic	1.16 (1.03–1.28)	0.56 (0.42–0.68)	0.18 (0.15–0.21)

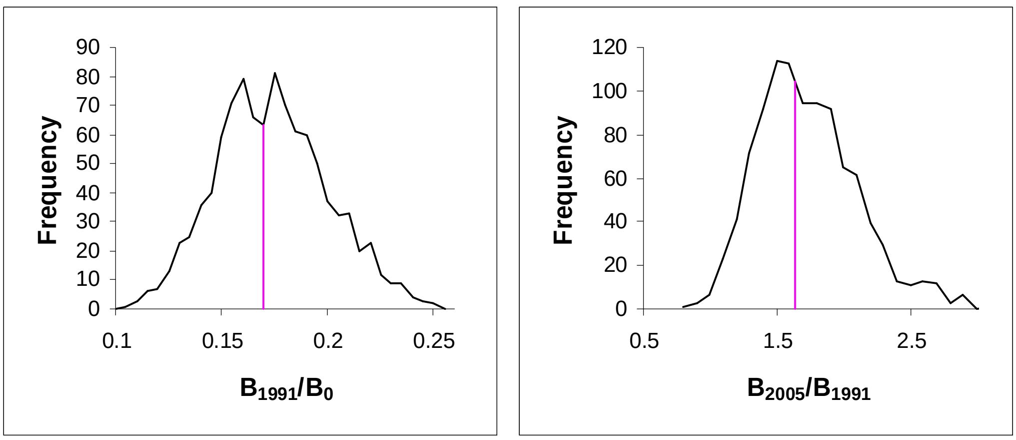


Figure 1: Posterior distributions for B_{1991}/B_0 (median 0.17) and B_{2005}/B_{1991} (median 1.64) for the Campbell Island stock for the base case.

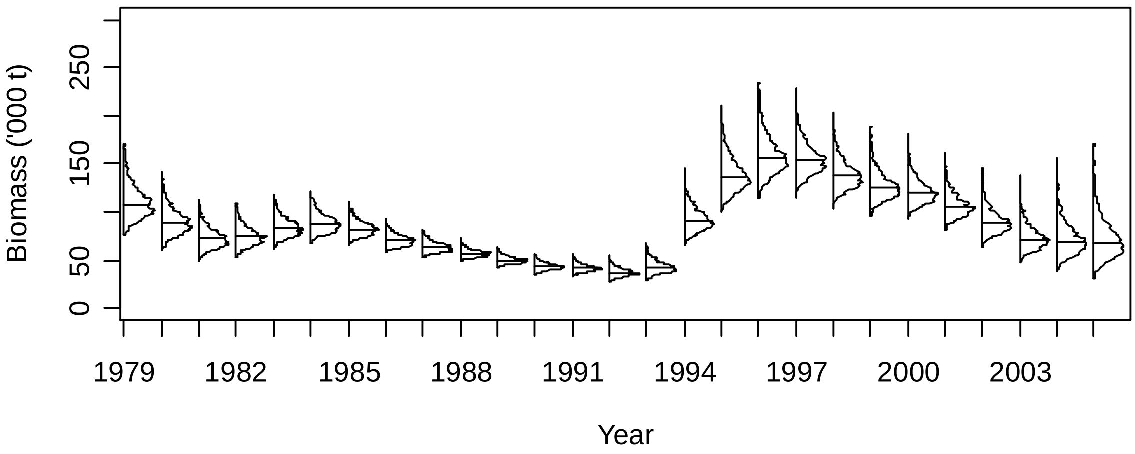


Figure 2: Estimated posterior distributions of biomass trajectories for the Campbell Island stock for the base case.

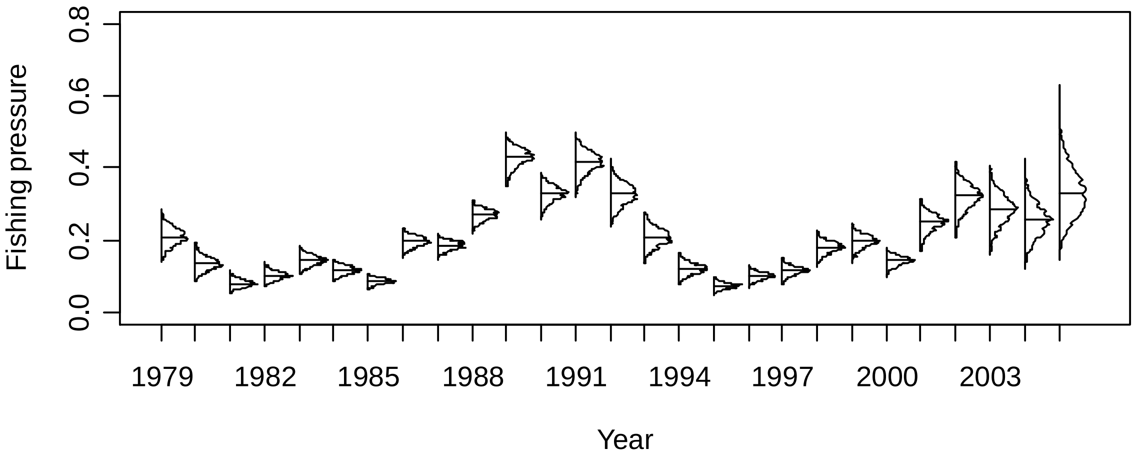


Figure 3: Estimated posterior distributions of exploitation rates for the Campbell Island stock for the base case.

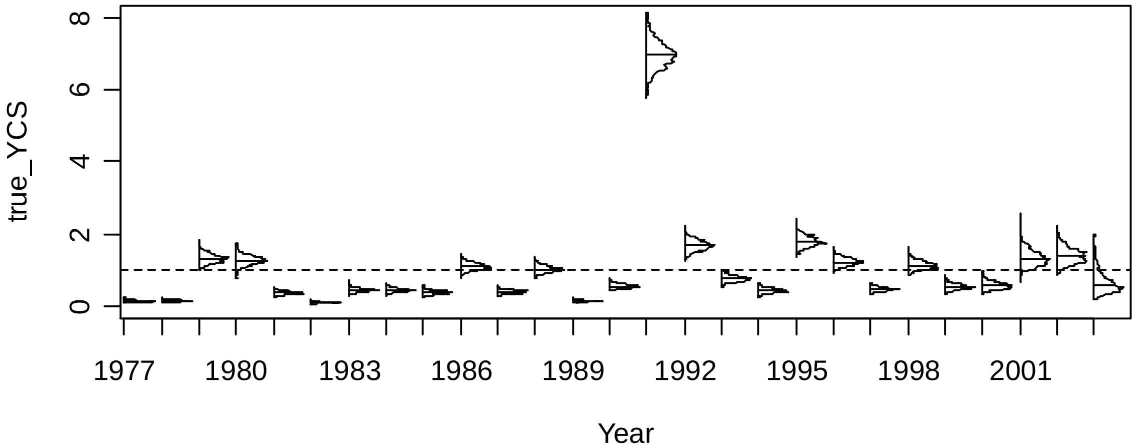


Figure 4: Estimated posterior distributions of year class strengths for the Campbell Island stock for the base case.

Projections were made assuming fixed catch levels from 10,000 to 25,000 t per year from 2006. Recruitments were drawn randomly from the distribution of year class strengths estimated by the model over the period 1977 to 2002. The probability that the mid-season biomass for the specified year will be less than the limit reference biomass is reported in Table 10. Biomass was projected to decline at the current TACC level from 27% to 20%B_0 by 2009.

The Working Group also reported projections with the TACC remaining at 25 000 t for one more year only and with varying catch levels after 2006 to determine the additional risk if TACC cuts were delayed (Table 11). Even in the absence of fishing after 2006, there was an 8% probability of the projected biomass being below B_{1991} in 2007, and this probability increased to 22% with continuing catches of 25 000 t.

Table 10: Probability that the projected mid-season vulnerable biomass for 2006, 2007, and 2008 will be less than the mid-season vulnerable biomass in 1991 and the median projected biomass as a percentage of B_0 (with 90% credible intervals) for different constant catch levels for the Campbell Island stock base case run.

	Probability (B_{proj}<B_{1991})			Median biomass as percentage B_0		
Constant catch (t)	**2006**	**2007**	**2008**	**2006**	**2007**	**2008**
10 000	0.02	0.02	0.02	29 (18–48)	32 (19–61)	35 (20–81)
15 000	0.03	0.06	0.08	28 (17–48)	29 (16–65)	30 (14–81)
20 000	0.06	0.14	0.23	27 (16–47)	26 (13–59)	25 (9–71)
25 000	0.08	0.22	0.39	27 (15–45)	23 (10–53)	20 (7–63)

Table 11: Probability that the projected mid-season vulnerable biomass for 2007, and 2008 will be less than the mid-season vulnerable biomass in 1991, and the median projected biomass as a percentage of B_0 (with 90% credible intervals) for a catch of 25,000 t in 2006 followed by constant catch levels from 0 to 25,000 t for 2007 and 2008 for the base case.

	Probability (B_{proj}<B_{1991})		Median biomass as percentage B_0	
Constant catch (t)	**2007**	**2008**	**2007**	**2008**
0	0.08	0.03	29 (14–65)	36 (19–87)
5 000	0.12	0.06	27 (13–65)	31 (16–84)
10 000	0.14	0.10	25 (13–51)	28 (14–68)
15 000	0.17	0.18	26 (12–54)	26 (11–74)
20 000	0.21	0.30	24 (11–52)	22 (7–64)
25 000	0.22	0.39	23 (10–53)	20 (7–63)

(ii) Bounty Platform stock

NIWA and SeaFIC carried out the last assessments of the Bounty Platform stock in 2002. Although they used different estimation methods and investigated a range of alternative assumptions, results of all the models were consistent in suggesting biomass was at its lowest observed level. The current assessment differs from the 2002 assessments in the following ways: two extra years of catch data, one extra year of catch-at-age data, use of the CASAL software, 2-sex model, individual c.v.s on the acoustic survey estimates and catch-at-age data, and estimation of process error. In addition, the model differs from the 2002 NIWA model in the use of Bayesian estimation and the use of a lognormal prior on the adult (4+) acoustic q,

The stock assessment model structure

The stock assessment model partitions the Bounty stock into two sexes and age groups 2–11, with a plus group at age 11. There are two time steps in the model (Table 5). In the first time step 90% of natural mortality takes place. In the second time step, fish ages are incremented; the 2-year-olds are recruited to the population, which is then subjected to fishing mortality and the remaining 10% of natural mortality.

The model assumes that the fishing selectivity after age 4 is 1.0, and estimates selectivity for each sex for ages 2 to 4. In line with previous assessments no stock-recruitment relationship is assumed in the model. The proportion of males at recruitment (age 2) was assumed to be 0.5 of all recruits. As it is a spawning fishery, the maturity ogive was assumed to be the same as the selectivity ogive estimated in the model. Note that the maturity ogive is only used to report spawning stock biomass. The maximum exploitation rate (U_{max}) was set at a value of 0.8. The choice of the maximum exploitation rate has the effect of determining the minimum possible virgin biomass allowed by the model. Because of the large inter-annual differences in growth, caused by the occurrence of the strong and weak year classes, length-at-age vectors were calculated for each year, and used in the modelling. Lengths-at-age were converted to weights-at-age in the model using the length-weight relationship given in Table 3.

Three different starting conditions were explored. In the base case, the initial numbers at age in the population in 1990 were estimated for each sex. Year class strengths were estimated for all years from 1988 to 2000. In the other two runs, the model was started at the beginning of the fishery in 1971. In one of these, the population in 1971 was assumed to be at the virgin level (i.e., at B_0). In the other, the population in 1971 was allowed to be different to virgin biomass and was estimated (B_{init}). (Note that equilibrium virgin biomass is equal to the population that there would have been if all the YCS were equal to 1 and there was no fishing.) In these two runs, year class strengths were estimated for all years from 1970 to 2000. In all three runs it was assumed that the estimates of YCS should average one.

The catch history assumed in the model runs were the revised estimates of catch by year since 1978 given in previous stock assessment documents (e.g., Hanchet et al. 2003). Annual catches from 1971 to 1977 for the Bounty Platform stock are unknown, but were assumed to be equal to the average proportion of the catch from the Bounty Platform over the period 1978 to 2003 (23% of the total).

Observations

The model was fitted to the acoustic biomass estimates of ages 2, 3, and 4+ fish (Table 11) and the proportions-at-age data from the commercial fishery. The acoustic survey estimates were used as relative estimates of mid-season biomass (i.e. after half the catch has been removed), with associated c.v.s estimated from the survey analysis. Catch-at-age observations by sex were available from the commercial fishery for the period 1990 to 2002. These catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age and associated c.v.s by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002). For the 1990-2003 model the plus group was at age 11, but for the runs back to 1971 the plus group was at age 17, which allowed the estimation of more year class strengths. A set of unsexed proportion-at-age data was also available for the period 1972 to 1977 from Russian scientists (Shpak 1977). Preliminary analysis suggested that the ages were one year too high, so to be consistent with the NZ data one year was subtracted from the age given in that paper. These ageing data were based on scale readings, and were assumed to be less precise than ages from otoliths. Each proportion-at-age was therefore arbitrarily assigned a c.v. equal to 1.5 times the median c.v. from the corresponding age class in the 1990-2002 data set. For both data sets, zero values were replaced with the value 0.001 with an associated c.v. of 2.0, and ageing error was assumed to be zero. The 1972 to 1977 period was treated as a separate fishery within the model, thus allowing fishing selectivity to be estimated for ages 2 to 4 separately for this time period.

Table 11: Decomposed biomass estimates (t) and c.v.s by survey and age group used for the Bounty Platform stock assessment.

Year	Age 2		Age 3		Age 4+	
	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.
1993	6 870	0.43	1 410	0.46	62 857	0.46
1994	5 871	0.87	32 066	0.22	27 672	0.22
1995	4 856	0.24	6 658	0.24	30 770	0.24
1997	4 144	0.12	24 598	0.35	37 518	0.35
1999	745	0.39	4 969	0.77	42 722	0.77
2001	2 551	0.28	6 010	0.35	21 677	0.35

Estimation

Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program CASAL v2.06 (Bull *et al*. 2004). For initial runs only, the mode of the joint posterior distribution was sampled. For the final runs presented here, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm.

Lognormal errors, with known c.v.s were assumed for the relative biomass and proportions-at-age data. The c.v.s available for these data allow for sampling error only. However, additional variance assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in each of the initial runs (MPDs) using all the available data. Process errors ranging from 0.37 to 0.44 were estimated for the 1990-2002 proportions-at-age data, and from 0.75 to 0.90 for the 1972 to 1977 proportion-at-age data. The process error estimated for the acoustic indices were zero for the age 4+ index, and ranged from 0.51 to 0.6 for the age 3 index and from 0.66 to 0.92 for the age 2 index. The MPD process errors were added to each observation for all subsequent MCMC runs.

MCMC chains were estimated using a burn-in length of $5*10^5$ iterations, with every 5 000th sample taken from the next $5*10^6$ iterations (i.e., a final sample of length 1000 was taken from the Bayesian posterior). Tests for autocorrelations and single chain convergence (Heidelberger & Welch 1983, Geweke 1992) were applied to resulting chains to look for evidence of non-convergence. Note that because of poor convergence, the number of iterations was doubled for the run where $B_{initial}$ was estimated (Binit.7103).

Prior distributions and penalty functions

The assumed prior distributions used in the assessment are given in Table 12. Most priors were intended to be uninformed, and had wide bounds. However, a log-normal prior was used for the acoustic survey 4+ *q*. This prior was obtained using the approach of Cordue (1996). Uncertainty over various factors including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were all taken into account. In addition to obtaining the bounds, a mean for each factor was also assumed. The factors were then multiplied together. This independent evaluation of the bounds on the acoustic *q* suggested a range of 0.5–2.5, with a mean of 1.4 and a c.v. of 0.2.

Penalty functions were used to constrain the model so that any combinations of parameters that did not allow the historical catch to be taken were strongly penalised. A small penalty was applied to encourage the estimates of year class strengths to average to 1.

Table 12: The distributions, priors, and bounds assumed for the various parameters being estimated for the Bounty Platform stock assessment. The parameters are mean and c.v. for lognormal; and mean and s.d. for normal. Note acoustic *q*s were treated as nuisance parameters in base case 1.

Parameter	Run	N	Distribution	Values		Bounds	
All runs				Mean	c.v.	Lower	Upper
B_0	1–3	1	Uniform-log	–	–	20 000	250 000
NZ select. ages 2-4 (by sex)	1–3	6	Uniform	–	–	0.0001	1
Russian select. ages 2–4	2–3	3	Uniform	–	–	0.0001	1
Process errors	1–3	4	Uniform-log			0.0001	1
Process errors (Russian age)	2–3	1	Uniform-log			0.0001	1
Acoustic 4+*q*	1–3	1	Lognormal	1.40	0.20	0.1	2.8
Acoustic *q* age 2, 3	1–3	2	Uniform-log	–	–	0.1	2.8
YCS (1988–2000)	1–3	13	Lognormal	1.00	1.30	0.01	100
YCS (1970–1987)	2–3	18	Lognormal	1.00	1.30	0.01	100
Initial population (by sex)	1	18	Uniform	–	–	5e4	2e8
B initial	2	1	Uniform-log			1 000	200 000

Model runs and sensitivity tests

The WG considered several alternative assessments and agreed to present the three model runs described in Table 13. In recent stock assessments of SBW the estimates of current biomass have been driven to a large extent by the estimate of the 4+ (adult) acoustic *q*. In the 2002 assessment of the Bounty stocks, the estimated values for this *q* were considered to be unrealistic by the WG and runs with *q* fixed (or with informed priors) were used instead. Therefore, for all runs in the current assessment the adult acoustic *q* was estimated with an informed (lognormal) prior. (The method for deriving this prior is described above). The three runs presented differ in the starting date and initial starting conditions. In the first run, which is analogous to the 2002 assessment, the model was started in 1990 and estimated the initial numbers-at-age. In the other two runs the model was started in 1971 and two alternate starting conditions were assumed. In one run the starting biomass was allowed to be different from B_0, in the other run the starting biomass was assumed to be at B_0.

For each model run, MPD fits were obtained and qualitatively evaluated. MCMC estimates of the median posterior and 90% credible intervals are reported for virgin biomass, initial biomass, B_{2003}, and B_{2003} (as $\%B_0$).

Table 13: Model run labels and descriptions for the three runs.

Model label	Description
Cinit.9003	Model starting in 1990 and estimating initial numbers-at-age
Binit.7103	Model starting in 1971 and estimating initial biomass with equilibrium age structure
B0.7103	Model starting in 1971 at virgin biomass with equilibrium age structure

Results

The base case MCMC estimates of marginal posterior distributions for spawning stock biomass by year are shown in Figure 5 and are summarised in Table 14. The results suggests that the stock biomass increased up until 1991 followed by a large decline from 1991 to 1993, as a result of the large catch of almost 60 000 t taken in 1992. Biomass increased gradually up until 1998 as the 1991 to 1994 year classes recruited into the fishery, and has since remained relatively stable at about 25 000–30 000 t. Year class strengths since 1994 have been below average, with the 2000 year class being amongst the lowest on record (Figure 6).

The biomass trajectories from the two runs covering the period 1971 onwards were generally similar, but differed in the estimates of biomass at the start and end of the period (Table 14). Under the $B_{initial}$ starting conditions, B_{1971} was 34 000 t and the current biomass was 22 000 t. Under the B_0 starting conditions, B_{1971} was much higher at 69 000 t, and the current biomass was much lower at 13 000 t. In contrast, estimates of B_{1990} were almost identical between all runs.

Table 14: Bayesian median and credible intervals of B_0, B_{2003} (in '000 t), and B_{2003} as a percentage of B_0 for the various runs.

Model run	B_0	B_{init}	B_{2003}	B_{2003} ($\%B_0$)	Adult acoustic *q*
Base case	86 (70–111)	64 (60–68)	25 (10–52)	30 (15–46)	1.35 (1.12–1.56)
Binit.7103	76 (70 – 87)	34 (27–44)	22 (10–45)	29 (14–52)	1.37 (1.16–1.54)
B0.7103	69 (65 – 75)	69 (65–75)	13 (6 – 25)	19 (8 – 33)	1.48 (1.32–1.63)

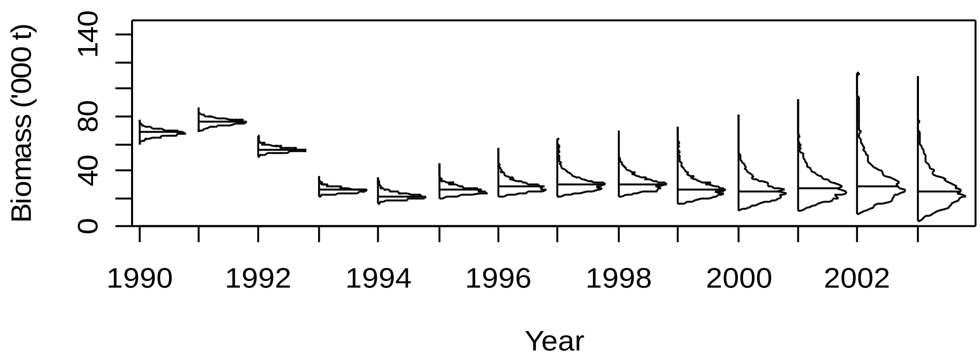


Figure 5: Estimated posterior distributions of biomass trajectories for the Bounty stock for the base case.

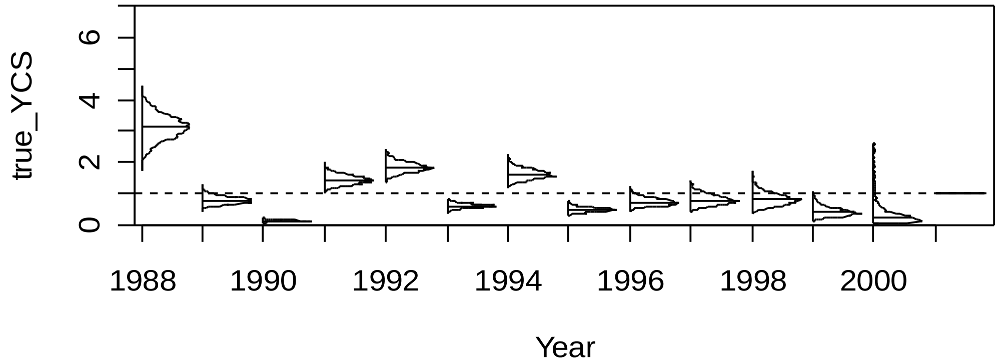


Figure 6: Estimated posterior distributions of year class strengths for the Bounty stock for the base case.

Comparison with the 2002 assessment

The results of the assessment are slightly more optimistic than those of the 2002 stock assessments for the Bounty Platform stock. The results of the more credible 2002 NIWA and SeaFIC assessments provided best estimates of B_{2001} between 15 000 and 23 000 t. In contrast, the median estimate of B_{2001} in the current assessment was 28 000 t from the base case assessment. The reason for this slightly more optimistic assessment is unclear, but could be related to the different weightings used in the assessments, the use of different priors, and several other model and error structure assumptions (e.g., 1 sex vs 2 sex model, multinomial vs lognormal error structures).

Projections

Projections were made assuming a fixed catch level of 3 500 t per year using the MCMC samples, and assuming the TACC of 3 500 t will be taken in 2003–04. Recruitments were drawn randomly from the distribution of year class strengths estimated by the model. The probability that the mid-season biomass for the specified year will be less than 20% B_0 is given for the three runs in Table 15. The probability of dropping below the threshold biomass at current catch levels is less than 10% for the base case. For the two sensitivity runs there is a 10% probability that the biomass is already at or below the threshold level, and that it will remain below that level under catches of 3 500 t. However, under average recruitment conditions the biomass is expected to increase after 2005 in all runs.

Table 15: Probability that the projected mid-season vulnerable biomass for 2005 and 2006 will be less than 20% B_0, and the median projected biomass as a %B_0, for the Bounty Platform stock, at projected catches of 3500 t.

	Probability (B_{proj}<20%B_0)			Median biomass as a% of B_0		
	2003	**2005**	**2006**	**2003**	**2005**	**2006**
Base case	0.04	0.07	0.06	36.2	36.5	38.5
Binit.7103	0.10	0.16	0.15	34.1	33.6	35.5
B0.7103	0.44	0.52	0.45	21.2	19.6	21.5

(iii) <u>Pukaki Rise stock</u>

A new assessment of the Pukaki Rise stock was carried out in 2002. The sSPA model was used to estimate the numbers at age in the initial population in 1989 and subsequent recruitment. The model estimates selectivity for ages 2, 3, and 4 and assumes that the selectivity after age 4 is 1.0. No stock-recruitment relationship is assumed in the sSPA.

Preliminary runs of the model were fitted to proportion-at-age data from 1989 to 2000, and the acoustic indices given in Table 4. The indices were fitted in the model as relative estimates of mid-season biomass (i.e., after half the catch has been removed), with the c.v.s as shown in Table 16. The proportion-at-age data are assumed to be multinomially distributed with a median sample size of 50 (equivalent to a c.v. of about 0.3). Details of the input parameters for the initial and sensitivity runs are given in Table 16.

Table 16: Values for the input parameters to the separable Sequential Population Analysis for the initial run and sensitivity runs for the Pukaki Rise stock.

Parameter	**Initial run**	**Sensitivity runs**
M	0.2	0.15, 0.25
Acoustic age 3 and 4+ indices *c.v.*	0.3	0.1, 0.5
Acoustic age 1, 2 indices *c.v.*	0.7	0.5, 1.0
Weighting on proportion–at–age data	50	5, 100
Years used in analysis	1989–2000	1979–2000
Acoustic *q*	estimated	0.68, 1.4, 2.8

Biomass estimates in the initial run and also in the sensitivity runs all appeared to be over-pessimistic because the adult (4+) acoustic *q* was very high. For example, for the initial run the 4+ acoustic *q* was estimated to be 2.7. The WG did not accept this initial run as a base case assessment, but agreed to present a range of possible biomass estimates. The Plenary also agreed to present a range, based on assumptions concerning the likely range of the value for the acoustic *q*.

Bounds for the adult (4+) acoustic *q* were obtained using the approach of Cordue (1996). Uncertainty over various factors including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were all taken into account. In addition to obtaining the bounds, a ‘best estimate’ for each factor was also calculated. The factors were then multiplied together. This independent evaluation of the bounds on the acoustic *q* suggested a range of 0.65–2.8, with a best estimate of 1.4. Clearly the *q* from the initial run is almost at the upper bound and probably outside the credible range. When the model was run fixing the acoustic *q* at 0.65 and 2.8, estimates of B_0 were 18 000 t and 54 000 t, and estimates of B_{2000} were 8 000 t and 48 000 t respectively (Table 17, Figure 7). Within these bounds current biomass is greater than B_{may}. Assuming the ‘best estimate’ of *q* of 1.4 gave B_0 equal to 22 000 t and B_{2000} equal to 13 000 t.

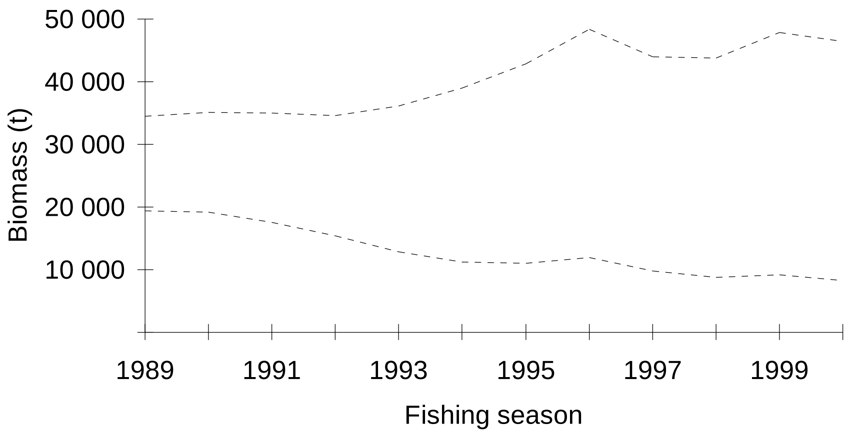


Figure 7: Mid-season spawning stock biomass trajectory bounds for the Pukaki Rise stock. Bounds based on acoustic *q* of 0.65 and 2.8.

Based on the flat trajectory of stock biomass over the period modelled in the assessment, recent catch levels do not appear to have had any impact on the biomass. A more intensive fishery or more consistent catches from year to year would seem to be required to provide any contrast in the biomass indices. This stock has been only lightly exploited since 1993, when over 5 000 t was taken in the spawning season.

Table 17: Parameter estimates for the Pukaki stock as a result of fixing the adult 4+ acoustic *q* at various values. B_{mid}, mid-season spawning stock biomass; $N_{2,1992}$ size of the 1990 year class (millions). All values in t x 10^3.

Fixing the acoustic *q* value	B_0	$B_{mid\ 89}$	$B_{mid\ 00}$	$N_{2,1992}$	$B_{mid\ 00}$ (%B_0)	$B_{mid\ 00}$ (%B_{may})
q = 0.65	54	36	48	63	88	246
q = 1.4	22	22	13	28	58	161
q = 2.8	18	19	8	23	44	123

(iv) Auckland Islands stock

No estimate of current biomass is available for the Auckland Islands Shelf stock. The acoustic estimate of the adult biomass in 1995 was 7 800 t.

(c) Other yield estimates and stock assessment results

Decision tables

As an alternative to the CAY estimates, the results have been presented in the form of decision tables. In the Campbell Island Rise assessment the probability of biomass falling below the limit biomass level (1991 biomass) is presented for alternative catch levels from 10 000 to 25 000 t (Table 10). In the Bounty assessment the probability of biomass falling below a threshold (20%B_0) is presented for a catch level of 3 500 t (Table 15).

Yield estimates

Estimates of sustainable yields have been calculated for the Campbell Island Rise and Bounty Platform stocks. Estimates of sustainable yields were made for each of the runs. Yield estimates were based on the 1000 samples from the Bayesian posterior, with yield estimates based on stochastic simulations run over 100 years (Bull et al. 2003). The simulation method of Francis (1992) was used to estimate MAY and CAY subject to the constraint that spawning stock biomass should not fall below 20% of B_0 more than 10% of the time. The estimates of B_{MAY}, MAY, and $CAY_{2006–07}$ are given for the Campbell Island stock and for the Bounty Platform stock in Table 18. MCY and B_{MCY} estimates have not been presented for the current assessment update due to the fact that the methods for calculating these reference points are currently under revision.

Table 18: Yield estimates (MAY and CAY) and associated parameters.

Model run	B_{MAY} (%B_0)	MAY (t)	U_{CAY}	$CAY_{2005–06}$ (t)
Campbell Island Rise	34	18 600	0.20	16 400
Bounty Platform	36	6 461	0.20	4 034

For the Campbell Island Rise stock the Plenary noted that the limit biomass assumed in the yield estimation simulations is 20%B_0, which is different from the use of B_{1991} for assessing risk in projections. No corresponding yield estimates based on the B_{1991} limit biomass reference point were available for consideration by the Plenary.

5. STATUS OF THE STOCKS

A new assessment is available for the Campbell Island stock. No new assessments are available for the Bounty Platform, Pukaki Rise and Auckland Islands stocks. The years given in this section refer to the August-September spawning/fishing season.

(i) Campbell Island stock

The 2005 Campbell Island stock assessment was updated by including an additional year of proportion-at-age data. For the base case, B_{2005} was estimated to be 68 000 t (90% credible interval 46 000–105 000 t), corresponding to 28%B_0 (90% credible interval 19–41%). Estimates of B_{2005} were very sensitive to the choice of series of acoustic survey estimates but only slightly sensitive to the prior used for the adult acoustic *q*.

The catch is dominated numerically by the 2001 and 2002 year classes, and the strong 1991, 1995, 1996, and 1998 year classes now contribute to only a small proportion of the commercial catch. The TACC was reduced to 20 000 t from 1 April 2006, and at this level of catch, the biomass is projected to decrease slightly over time. At this new TACC level, the probability that the biomass will drop below B_{1991} is projected to increase from 6% to 23% over the next three years (Table 10).

(ii) Bounty Platform stock

The model indicates that the median estimate of B_{2003} is 30% of B_0. At catches at the level of the current TACC (3500 t) the biomass is projected to increase slightly (Table 15). Higher yields will only be available when there is good recruitment – which occurs only sporadically in this stock (see Figure 6).

(iii) Pukaki Rise stock

Based on the flat trajectory of the abundance indices over the period modelled in the assessment, recent catch levels do not appear to have had any impact on the biomass. Greater catches would be required to provide any contrast in the abundance indices, and therefore enable better estimates of stock size. This stock has been only lightly exploited since 1993, and is likely to be above the level that will support the MAY.

(iv) Auckland Islands stock

No estimates of current biomass or yield are available. It is unknown if recent catches are sustainable or if they will allow the stock to move towards a size that will support the MSY. The only information available on stock size is from an acoustic survey in 1995.

Summary of TACCs and preliminary estimates of landings (t). (Note 1 April–31 March fishing year).

Area	2005–06 Actual TACC	2005–06 Landings
SBW 1 (EEZ excluding Sub-Antarctic)	8	na
Campbell Island	25 000	26 190
Bounty Platform	3 500	3 962
Pukaki Rise	5 500	58
Auckland Islands Shelf	1 640	50
Total	35 648	30 260

6. FOR FURTHER INFORMATION

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Bull, B.; Francis, R.I.C.C., Dunn, A.; Gilbert, D.J. (2002). CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v2.01.2003/08/01. *NIWA Technical Report 124.* 223 p.

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