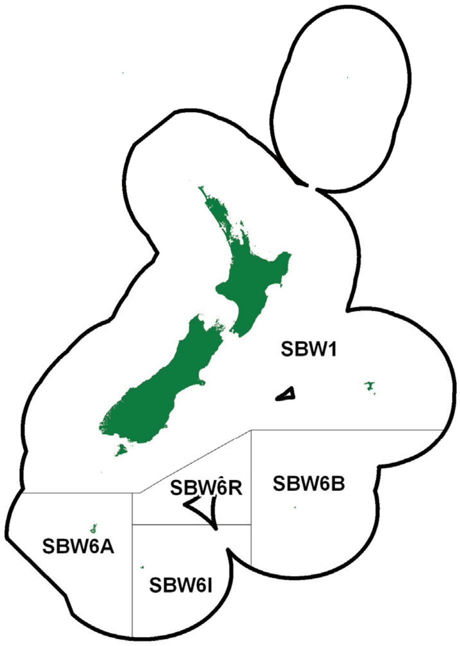
SOUTHERN BLUE WHITING (SBW)

(*Micromesistius australis*)



1. FISHERY SUMMARY

1.1 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, while Figure 1 shows the historical landings and TACC values for the main SBW stocks. 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 foreign charter vessels (predominantly Ukrainian) producing headed and gutted or dressed product.. On the Campbell Island Rise and the Bounty Platform 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 under-caught in most years since their introduction. This reflects the relatively low economic value of the fish and difficulties in both the timing and locating of aggregations experienced by operators. On the Pukaki Rise and Auckland Islands Shelf, operators generally find it difficult to justify expending time to locate fishable aggregations, given the small allocation available in these areas, the relatively low value of the product and the more certain option available to fish southern blue whiting at Campbells where aggregations are concurrent.

From 1 April 2008, the TACC for the Bounty Platform stock was increased to 9,800 t and from 1 April 2009 further increased to 14,700 t. From 1 April 2006, the TACC for the Campbell Island Rise stock was reduced from 25,000 t to 20,000 t, and from 1 April 2010 was increased to 23 000 t.

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

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

Table 2: Estimated catches (t) and actual TACCs of southern blue whiting by area from vessel logbooks and QMRs. – no catch limit in place. *, before 1997–98 there was no separate catch limit for Auckland Is. 2009–10 catches 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	‡35 140
2001–02#	2 261	8 000	29 999	30 000	230	5 500	10	1 640	32 501	‡45 140
2002–03#	7 564	8 000	33 433	30 000	508	5 500	254	1 640	41 775	‡45 140
2003–04#	3 812	3 500	23 718	25 000	163	5 500	116	1 640	27 812	‡35 640
2004–05#	1 477	3 500	19 776	25 000	239	5 500	70	1 640	21 567	‡35 640
2005–06#	3 962	3 500	26 190	25 000	58	5 500	50	1 640	30 260	‡35 640
2006–07#	4 395	3 500	19 763	20 000	1 115	5 500	84	1 640	25 363	‡30 640
2007–08#	3 799	3 500	20 996	20 000	513	5 500	278	1 640	25 586	‡30 640
2008–09#	9 863	9 800	20 483	20 000	1 377	5 500	143	1 640	31 866	‡36 948
2009–10#	15 467	15 000	19 040	20 000	4 808	5 500	157	1 640	39 477	‡42 148

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, 2 t in 2005–06, 7 t in 2006–07, 1 t in 2007–08, 21 t in 2008-09, and 5 t in 2009–10.

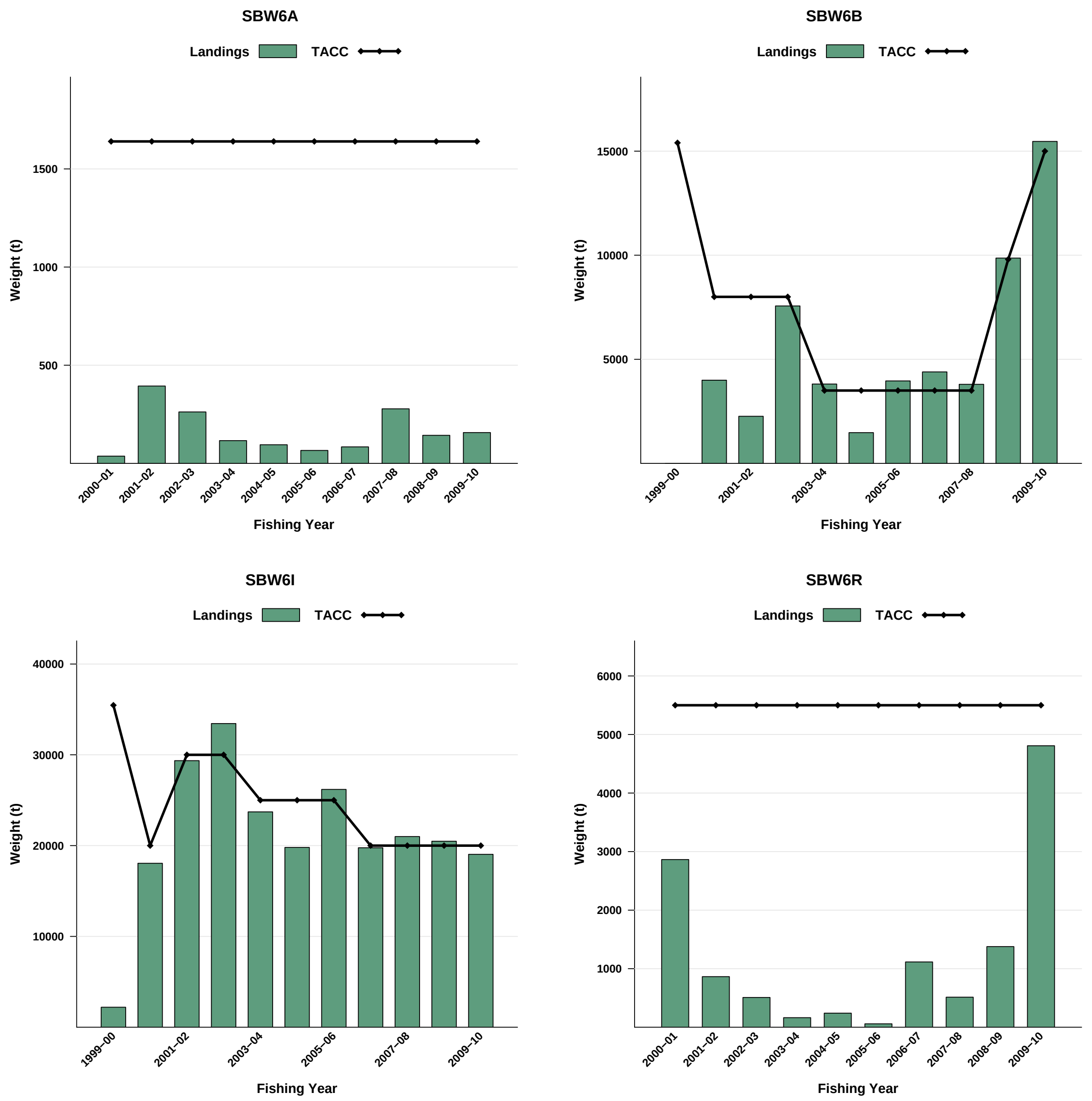


Figure 1: Historical landings and TACC for the four main SBW stocks. From top left to bottom right: SBW6A (Auckland Islands), SBW6B (Bounty Platform), SBW6I (Campbell Island Rise), and SBW6R (Pukaki Rise). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

There is no recreational fishery for southern blue whiting.

1.3 Customary non-commercial fisheries

Quantitative estimates of the level of customary non-commercial take are not available.

1.4 Illegal catches

The level of illegal and unreported catch is thought to be low. However, the operators of one vessel were convicted for area misreporting; in 2002–03, the vessel caught about 204 t on the Campbell Island Rise (SBW 6I) that were reported against quota for the Pukaki Rise (SBW 6R), and another 480 t 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. In addition, the operators of another vessel were convicted of discarding without reporting fish in 2004: crew members estimated that between 40 and 310 t of SBW were illegally discarded during a two and a half week period fishing on the Campbell Island Rise.

1.5 Other sources of mortality

Scientific observers have occasionally 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 respectively. 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 mid-water, 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 (see Table 3).

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 (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. ENVIRONMENTAL EFFECTS OF FISHING

This section is new for the May 2010 Plenary and has been considered by the Aquatic Environment Working Group (AEWG). It includes only a summary of the incidental bycatch of marine mammals and seabirds in this fishery and does not consider other potential environmental effects. A more detailed assessment of environmental effects across all fisheries will be available in the Ministry's Aquatic Environment Plenary that is under development.

4.1 Role in the ecosystem

Not discussed by the AEWG.

4.2 Incidental catch (fish and invertebrates)

Not discussed by the AEWG.

4.3 Incidental catch (seabirds and mammals)

This section provides an overview of the incidental captures of seabirds and marine mammals in the southern blue whiting fishery. Capture estimates include only those animals landed (alive, injured or dead) on fishing vessels but may not include all sources of cryptic mortality e.g. seabirds struck by the warp but not landed onboard the vessel. Various projects have estimated the total incidental captures in this fishery. This section refers to ratio estimates of incidental captures for all years and model based estimates where available (for methods see MacKenzie and Fletcher 2006, Smith & Baird 2009, Abraham et al. 2010, Thompson et al. in press a and b).

Annual observed seabird capture rates ranged from 0.00 to 1.34 per hundred tows in southern blue whiting fisheries between 1998-99 and 2007-08. Estimated means of total annual captures ranged from 0 to 9 seabirds (ratio estimated) and 4 to 8 (model estimated) with no apparent trend (Table 4). This is a small proportion of the total seabird captures.

Seabird species that were observed caught in the hoki fishery from 1998-99 to 2007-08 are (with total numbers of each species observed caught during this period); grey petrel (9), Salvin's albatross (3), cape petrels (2), seabird – large (1), and Campbell albatross (1) (Abraham et al. 2010). Note that identification to species or group level is done by observers onboard and some birds are not readily identifiable.

Annual observed fur seal capture rates ranged from 2.91 to 23.96 per hundred tows in southern blue whiting fisheries between 1998-99 and 2007-08. Estimated means of total annual captures ranged from 19 to 187 fur seals (ratio estimated) and 21 to 200 (model estimated) with no obvious trend (Table 5).

Annual observed sea lion capture rates ranged from 0.00 to 1.51 per hundred tows in southern blue whiting fisheries between 1998-99 and 2007-08. Estimates of total annual captures ranged from 0 to 12 (ratio estimated) and 1 to 14 (model estimated) sea lions and there appears to be an increasing trend (Table 6); this represents a non-trivial proportion of total sea lion mortalities.

4.4 Benthic interactions

Southern blue whiting are taken using trawls that are sometimes fished on or near the seabed but a summary has not been discussed by the AEWG.

4.5 Other considerations
Not discussed by the AEWG.

Table 4: Summary of all bird captures in the southern blue whiting trawl fishery, for 10 fishing years, with the number of tows, number of tows observed, percentage of tows observed, number of observed captures, capture rate per hundred tows, total estimated captures with 95% confidence intervals, percentage of tows included in the estimate (from Abraham et al. 2010) and model based estimates of captures with 95% confidence intervals for vessels over 28 m (from MacKenzie & Fletcher 2006).

	Observed					Ratio estimated			Model based estimate	
	Tows	No. obs	% obs	Captures	Rate	Captures (95% c.i.)		% effort in est.	Captures (95% c.i.)	
1998–99	1 250	341	27.3	1	0.29	2	(1 - 3)	98.9	8	(2 - 18)
1999–00	693	314	45.3	2	0.64	5	(2 - 9)	100.0	4	(2 -10)
2000–01	664	388	58.4	3	0.77	5	(3 - 7)	99.8	8	(4 - 15)
2001–02	1 159	334	28.8	0	0.00	1	(0 - 2)	98.2	8	(2 - 19)
2002–03	638	275	43.1	0	0.00	0	(0 - 1)	100.0	4	(0 - 10)
2003–04	740	241	32.6	0	0.00	1	(0 - 1)	100.0	6	(2 - 14)
2004–05	869	335	38.6	2	0.60	6	(2 - 11)	100.0		
2005–06	624	217	34.8	2	0.92	6	(2 - 12)	100.0		
2006–07	630	224	35.6	3	1.34	9	(3 - 18)	100.0		
2007–08	816	331	40.6	3	0.91	5	(3 - 8)	100.0		

4. STOCK ASSESSMENT

In 2009, a preliminary assessment was carried out for the Bounty Platform stock. New abundance data were available from an industry acoustic survey of the Bounty Platform carried out in August 2009, adding to data from previous industry surveys carried out in 2004, 2006, 2007 and 2008. An attempt was made to fit this time-series of industry acoustic data, along with a time series of *RV Tangaroa* acoustic surveys and catch-at-age data, in a population model. Because of the poor fit to the acoustic data the model results are not reported here, but the Working Group did provide conservative estimates of biomass (section 4.4) based only on the acoustic survey results to allow proxy yield estimates (CAY) to be determined for the management of the fishery.

A wide area acoustic survey of the Campbell Island Rise was carried out in August–September 2009. However, there was insufficient time to complete a stock assessment before a decision needed to be made on setting catch limits for the 2010–11 fishing year. Instead the Working Group provided conservative estimates of biomass based only on the acoustic survey results to allow proxy yield estimates (CAY) to be determined for the management of the fishery (section 4.5).

No new assessment is available for the Pukaki Rise stock. 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.

4.1 Estimates of fishery parameters and abundance indices
During the 2007 season an acoustic survey of the Bounty Platform was undertaken from an industry vessel (O'Driscoll *et al*. 2007). Five acoustic snapshots of the Bounty Platform were completed by the *FV Tomi Maru 87*, on which the hull-mounted transducer had been calibrated prior to the start of the survey. The first two snapshots were completed on a small aggregation containing light marks southeast of the Bounty Islands. Snapshots 3-5 were carried out 10 days later on a much more extensive aggregation further west. Snapshots 4 and 5 covered adjacent areas and were separated in time by only 3 hours so these snapshots were combined. The acoustic biomass was calculated by averaging snapshots 3 and the sum of snapshots 4+5 which equalled 157 000 t (CV = 31%). This was an order of magnitude higher than the estimates of 4+ fish from the previous wide-area survey of the Bounty Platform in 2001 and the estimates of spawning stock biomass from an industry survey of the Bounty Platform in 2004, and about 7 times higher than estimates from an industry survey in 2006 (Table 7).

Table 5: Summary of New Zealand fur seal captures in the southern blue whiting trawl fishery, for 10 fishing years, with the number of tows, number of tows observed, percentage of tows observed, number of observed captures, capture rate per hundred tows, total estimated captures with 95% confidence intervals, and percentage of tows included in the estimate (from Abraham et al. 2010) and model based estimates of captures with 95% confidence intervals (from Smith & Baird 2009, Thompson et al. in press a).

	Observed					Ratio estimated			Model based estimates of captures (95% c.i.)			
	Tows	No. obs	% obs	Captures	Rate	Captures (95% c.i.)		% effort in est.	Smith & Baird		Thompson et al.	
1998–99	1 250	341	27.3	42	12.32	157	(110 - 210)	98.9	200	(109 - 367)		
1999–00	693	314	45.3	85	27.07	187	(138 - 256)	100.0	181	(111 - 334)		
2000–01	664	388	58.4	58	14.95	99	(76 - 135)	99.8	79	(63 - 110)		
2001–02	1 159	334	28.8	13	3.89	44	(27 - 64)	98.2	118	(55 - 233)		
2002–03	638	275	43.1	8	2.91	19	(12 - 26)	100.0	53	(21 - 126)	21	(10 - 43)
2003–04	740	241	32.6	13	5.39	40	(15 - 81)	100.0	49	(25 - 95)	34	(18 - 69)
2004–05	869	335	38.6	33	9.85	86	(62 - 114)	100.0	88	(52 - 164)	78	(44 - 157)
2005–06	624	217	34.8	52	23.96	150	(97 - 217)	100.0	73	(58 - 106)	70	(56 - 102)
2006–07	630	224	35.6	13	5.80	36	(24 - 51)	100.0			25	(15 - 44)
2007–08	816	331	40.6	24	7.25	59	(45 - 77)	100.0			84	(40 - 177)

Table 6: Summary of New Zealand sea lion captures in the southern blue whiting trawl fishery, for 10 fishing years, with the number of tows, number of tows observed, percentage of tows observed, number of observed captures, capture rate per hundred tows, total estimated captures with 95% confidence intervals, and percentage of tows included in the estimate (from Abraham et al. 2010) and model based estimate of captures and strike rate with 95% confidence intervals (from Thompson et al. in press b).

	Observed					Ratio estimated			Model based estimate			
	Tows	No. obs	% obs	Captures	Rate	Captures (95% c.i.)		% effort in estimate	Captures (95% c.i.)		Strike rate (95% c.i.)	
1998–99	1 250	341	27.3	0	0.00	0	(0 - 0)	98.9				
1999–00	693	314	45.3	0	0.00	0	(0 - 0)	100.0				
2000–01	664	388	58.4	0	0.00	0	(0 - 0)	99.8				
2001–02	1 159	334	28.8	1	0.30	3	(1 - 8)	98.2				
2002–03	638	275	43.1	0	0.00	0	(0 - 0)	100.0	4	(1 - 14)	0.41	(0.13 - 12.4)
2003–04	740	241	32.6	1	0.41	3	(1 - 7)	100.0	1	(0 - 5)	0.13	(0 - 3.98)
2004–05	869	335	38.6	2	0.60	5	(2 - 10)	100.0	3	(1 - 10)	0.45	(0.17 - 8.5)
2005–06	624	217	34.8	3	1.38	9	(3 - 18)	100.0	5	(2 - 12)	0.6	(0.31 - 10.38)
2006–07	630	224	35.6	3	1.34	8	(3 - 18)	100.0	7	(3 - 16)	1.13	(0.67 - 13.98)
2007–08	816	331	40.6	5	1.51	12	(6 - 21)	100.0	14	(7 - 27)	2.39	(1.46 - 24.64)

Table 7: Estimates of biomass (t) for age 4+ fish from research acoustic surveys of the Bounty Platform in 1993–2001 (from Grimes *et al*. 2007), and of spawning stock biomass (SSB) from acoustic estimates from *FV Tomi Maru 87* in 2004, 2006, 2007 and 2008 (O'Driscoll & Dunford 2008). All estimates were calculated using the new absorption co-efficient and a new target strength relationship. Sampling CVs are given in parentheses.

Year	*Tangaroa* Age 4+ fish	*Tomi Maru 87* SSB
1993	47 087 (64%)	–
1994	20 844 (25%)	–
1995	23 480 (24%)	–
1997	31 929 (32%)	–
1999	34 194 (73%)	–
2001	16 396 (36%)	–
2004	–	13 625 (69%)
2006	–	21 667 (12%)
2007	–	157 079 (22%)
2008	–	147 709 (35%)

In August 2008 another acoustic survey was completed on *FV Tomi Maru 87* (WG-MID-2008/18). Good weather at the time of the snapshots resulted in good data collection. The vessel completed 11 transects in 2 snapshots on the 17 and 25 August. During the first snapshot the fish were more aggregated from 250 to 400 m and survey appeared to encompass most of the fish; the biomass estimate was about 229 000 t. The second snapshot may not have covered all the fish as the fish were more dispersed, in shallower water (200 to 300 m) and moving northwards; the biomass estimate was about 67 000 t. The size of fish suggests that these were the same fish that had moved anti-clockwise between the 2 snapshots.

The WG discussed whether both the estimates should be averaged as the second snapshot was likely to under-estimate the total biomass. The WG agreed that the 2008 acoustic survey confirmed the large increase in biomass observed in 2007 due to recruitment of a strong 2002 cohort. This year class is growing fairly slowly and males only average about 35 cm length (females 38 cm) at age 6. The main uncertainty in the biomass estimation comes from the uncertainty over target strength.

Estimates of biomass from acoustic surveys from the Bounty Platform, Pukaki Rise and Campbell Island Rise are shown in Table 8. These have not been calculated using the new absorption co-efficient and a new target strength relationship.

Table 8: 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 for the Campbell Island Rise. – 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
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	3.83	11.84	152.18	1.94
2004*	–	–	–	–	–	–	–	–	1.51	17.33	34.53	56.20	–
2006*	–	–	–	–	–	–	–	–	1.07	19.81	9.90	80.34	–

A standardised CPUE analysis of the Campbell Island stock was completed up until the 2002 fishing season, and the indices are shown in Table 5. 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.

4.2 Biomass estimates

(i) Campbell Island stock (2007 stock assessment)

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 9). 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 9: 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 10 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 CVs 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 CVs 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 CV of 1.5. Ageing error was assumed to be zero.

Lognormal errors, with known CVs were assumed for the relative biomass and proportions-at-age data. The CVs 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 10: Decomposed biomass estimates (t) and CVs by survey and age group used for the Campbell Island Rise stock assessment.

	Age 2		Age 3		Age 4+	
Year	Biomass	CV	Biomass	CV	Biomass	CV
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	8421	20	135 612	17
2002	3829	76	11 842	72	152 184	68
2004	17 327	16	34 527	27	56 197	38
2006	19 808	24	9900	28	80 342	32

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 11. 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 11: The distributions, priors, and bounds assumed for the various parameters being estimated in the Campbell Island Rise stock assessment. The parameters are mean and CV 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	CV / 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	28	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
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 CV 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

The WG considered only one model run, which was an update of the 2006 base case assessment, including new catch and catch at age data from the 2006 fishery and the 2006 acoustic survey indices. This run used an informed prior on *q* and included the acoustic biomass indices incorporating all surveyed strata, not just the core strata.

Table 12: Model run labels and descriptions for the base case.

Model label	Description
Base case	Lognormal prior on adult acoustic *q* and acoustic biomass series incorporating all surveyed strata

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 2).

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_{2006}, B_{2006} (as $\%B_0$), and B_{2006} (as $\%B_{1991}$).

Results

The estimated MCMC marginal posterior distributions for spawning stock biomass by year are shown for the base case in Figure 3, and the results summarised in Table 13. 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 4. 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 5). The 2004 year class is also estimated to be above average by the model, but since it appears only once in the catch-at-age data and once in the acoustic survey it is not well estimated. It is however used in the projections. Estimates of the adult acoustic *q*, the 2006 exploitation rate and *M* are given in Table 13.

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 13: Bayesian median and 90% credible intervals of B_0, B_{2006} (in '000 t), B_{2006} as a percentage of B_{1991} and of B_0, B_{1991} / B_0, adult 4+ acoustic *q*, the 2006 exploitation rate, and M for the base case run for the Campbell Island stock.

Model run	B_0	B_{2006}	B_{2006} (%B_{1991})	B_{2006} (%B_0)	B_{1991} / B_0	*q*	U_{2006}	*M*
Median	256	78	182	30	0.17	1.11	0.23	0.17
90%CI	(233–294)	(56–106)	(134–241)	(20–41)	(0.13–0.21)	(0.95–1.29)	(0.17–0.31)	(0.13–0.21)

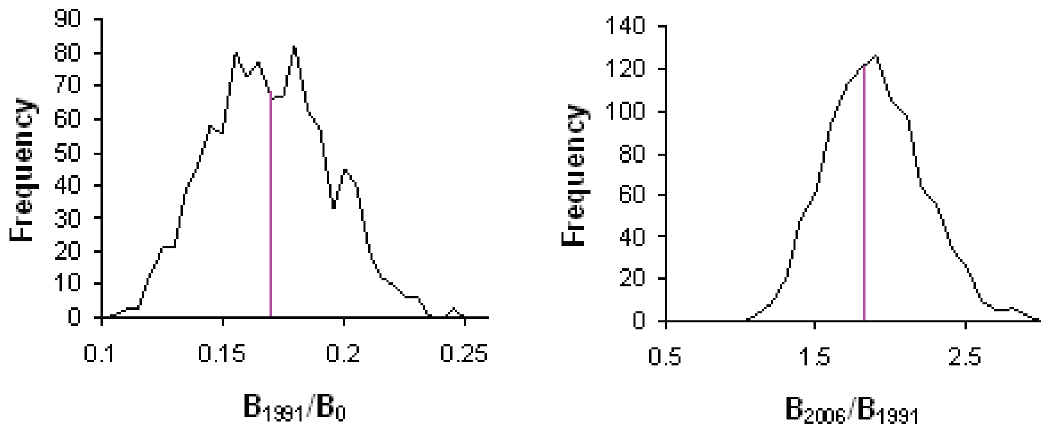


Figure 2: Posterior distributions for B_{1991}/B_0 (median 0.17) and B_{2005}/B_{1991} (median 1.82) for the Campbell Island stock for the base case.

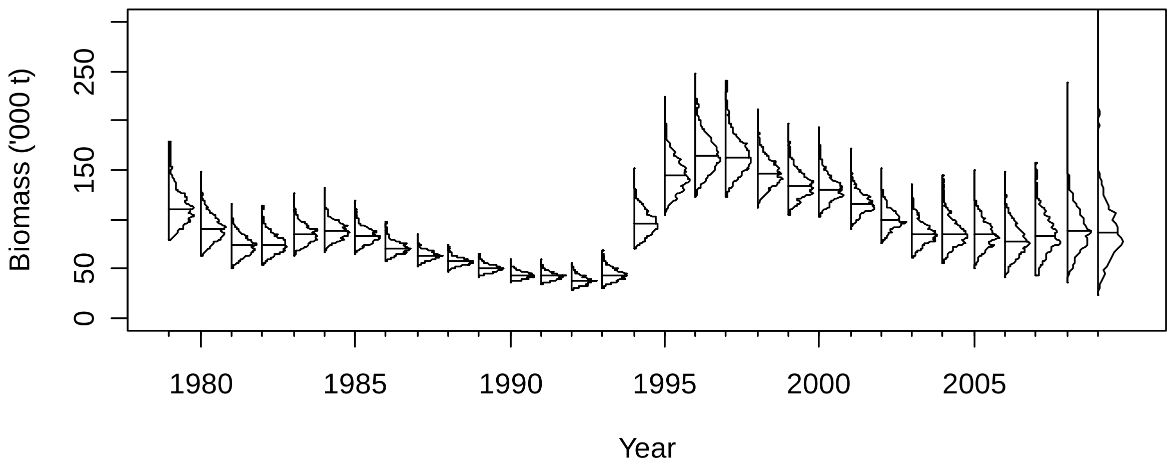


Figure 3: Estimated posterior distributions of biomass trajectories for the Campbell Island stock for the base case.

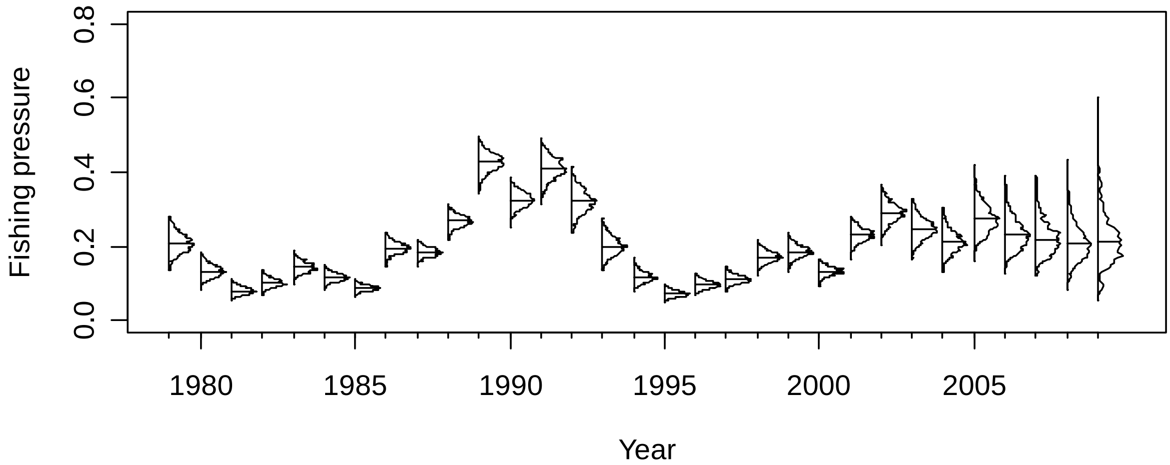


Figure 4: Estimated posterior distributions of exploitation rates for the Campbell Island stock for the base case.

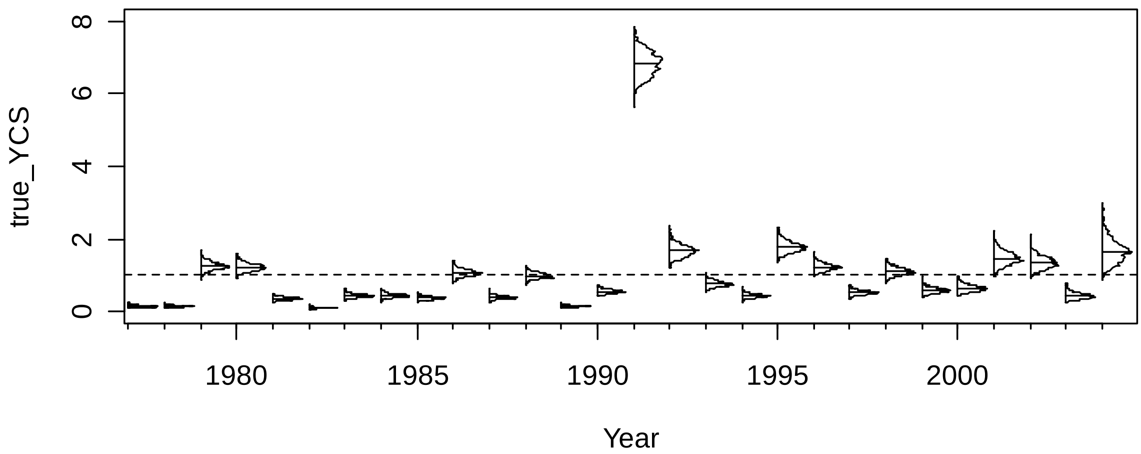


Figure 5: Estimated posterior distributions of year class strengths for the Campbell Island stock for the base case.

Projections were made assuming fixed catch levels of 20 000 per year using the MCMC samples. Recruitments were drawn randomly from the distribution of year class strengths estimated by the model over the period 1977 to 2004. The probability that the mid-season biomass for the specified year will be less than the limit reference biomass (B_{1991}) is reported in Table 14.

Table 14: Probability that the projected mid-season vulnerable biomass for 2007, 2008, and 2009 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 projected constant catch of 20 000 t for the Campbell Island stock base case run.

	Probability (B_{proj}<B_{1991})			Median biomass as percentage B_0		
Constant catch (t)	2007	2008	2009	2007	2008	2009
20 000	<0.01	<0.01	0.03	32 (21–44)	34 (21–54)	33 (19–64)

(ii) Bounty Platform stock (2004 assessment)

The assessment documented below was completed in 2004 and included data up to the 2003 season. It 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 CVs 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 6). 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 15) 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 CVs 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 CVs by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002). For the 1990–03 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 CV equal to 1.5 times the median CV from the corresponding age class in the 199002 data set. For both data sets, zero values were replaced with the value 0.001 with an associated CV 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 15: Decomposed biomass estimates (t) and CVs by survey and age group used for the Bounty Platform stock assessment.

Year	Age 2		Age 3		Age 4+	
	Biomass	CV	Biomass	CV	Biomass	CV
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 CVs were assumed for the relative biomass and proportions-at-age data. The CVs 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 1990-02 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 16. 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 CV 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 16: The distributions, priors, and bounds assumed for the various parameters being estimated for the Bounty Platform stock assessment. The parameters are mean and CV for lognormal; and mean and s.d. for normal. Note acoustic qs were treated as nuisance parameters in base case 1.

Parameter	Run	N	Distribution	Values		Bounds	
All runs				Mean	CV	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 17. 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 17: 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 6 and are summarised in Table 18. 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 7).

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 18). 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 18: 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)

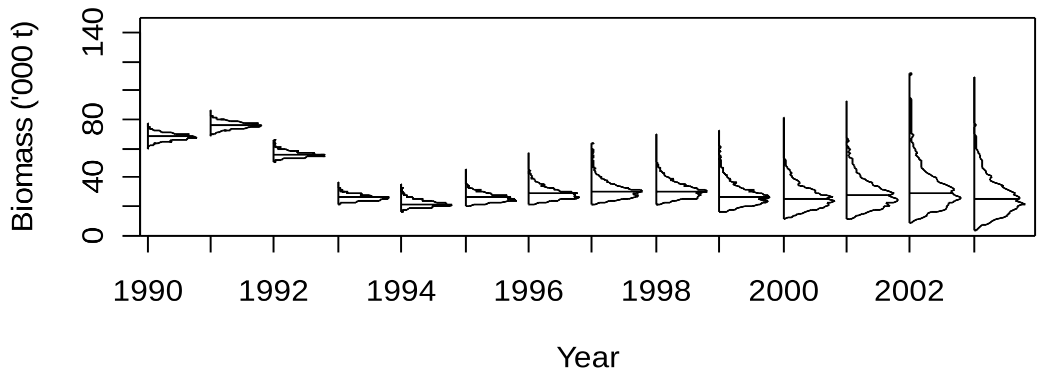


Figure 6: Estimated posterior distributions of biomass trajectories for the Bounty stock for the base case.

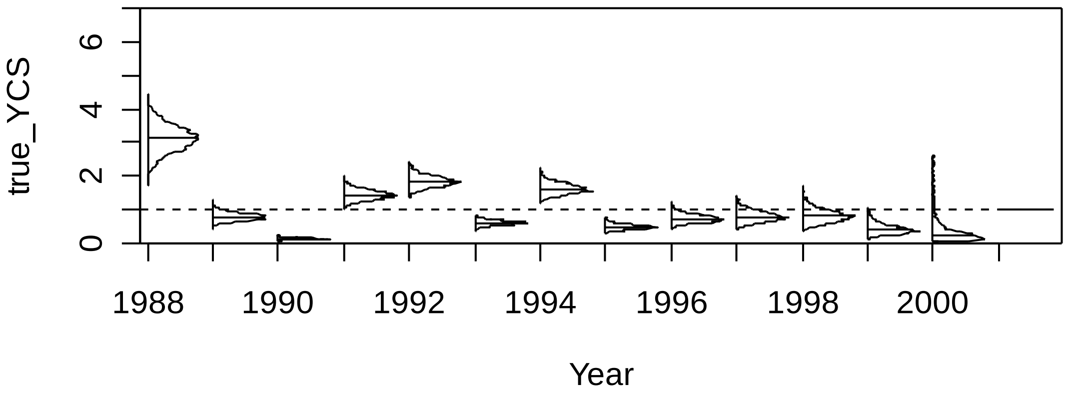


Figure 7: Estimated posterior distributions of year class strengths for the Bounty stock for the base case.

(iii) Pukaki Rise stock

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 5. 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 CVs as shown in Table 19. The proportion-at-age data are assumed to be multinomially distributed with a median sample size of 50 (equivalent to a CV of about 0.3). Details of the input parameters for the initial and sensitivity runs are given in Table 19.

Table 19: 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 *CV*	0.3	0.1, 0.5
Acoustic age 1, 2 indices *CV*	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 8000 t and 48 000 t respectively (Table 20, Figure 8). 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.

Based on the range of stock biomass modelled in the assessment, the average catch level since 2002 (380 t) is unlikely to have made much impact on stock size. 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 5000 t was taken in the spawning season.

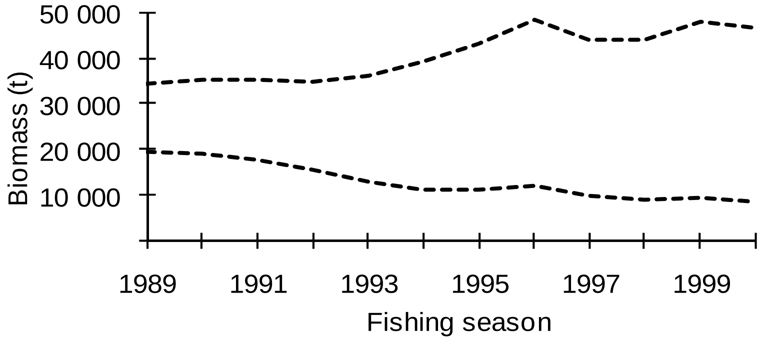


Figure 8: Mid-season spawning stock biomass trajectory bounds for the Pukaki Rise stock. Bounds based on acoustic *q* of 0.65 and 2.8.

Table 20: 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 7800 t.

4.3 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 a catch level of 20,000 t (Table 14).

Yield estimates

Estimates of sustainable yields have been calculated for the Campbell Island Rise stock. 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 in Table 21. 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 21: 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

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.

4.4 Additional stock assessment results for the Bounty Platform

In 2009, a preliminary assessment was carried out for the Bounty Platform stock. New abundance data were available from an industry acoustic survey of the Bounty Platform carried out in August 2008. The biomass estimate for the first snapshot was about 229 000 t. The biomass estimate for the second snapshot was about 67 000 t, but it may have missed some of the fish because they were more dispersed, in shallower water (200 to 300 m) and moving northwards. The WG discussed whether both the estimates should be averaged as the second snapshot was likely to under-estimate the total biomass. The WG agreed that the 2008 acoustic survey confirmed the large increase in biomass observed in 2007 due to recruitment of a strong 2002 cohort. The Working Group agreed that a very strong year class (2002) had entered the fishery, but that the size of this year class, and hence current biomass, was very uncertain. In order to provide advice on sustainable yields for the Bounty Platform stock for the 2009–10 fishing year, the Working Group agreed to provide conservative estimates of absolute abundance for the Bounty Platform stock that would be used to determine yield estimates for management of the fishery.

In August 2009 a total of six acoustic snapshots of the Bounty Platform were completed by three industry vessels (including *FV Tomi Maru 87*). Most snapshots were completed before the fish had started spawning and the biomass estimates ranged from 5 784 t to 47 377 t. O'Driscoll *et al.* (2009) explored various reasons why the 2009 biomass estimates were so much lower than in 2007 and 2008. They could find no obvious explanation but re-iterated the need to adequately survey the entire aggregation, ensure that some snapshots were carried out whilst fish were actively spawning, and recommended that 'wide area' surveys encompassing the likely adult distribution on the spawning grounds be considered. The Working Group endorsed these comments and agreed to average the biomass estimates from the two snapshots by *FV Tomi Maru 87* and the second snaphot from *FV Meridian* which equalled 36 814 t (c.v. = 0.24). The Working Group agreed that it was likely that the 2009 acoustic snapshots had considerably underestimated the biomass of SBW on the Bounty Platform.

In order to provide advice on sustainable yields for the Bounty Platform stock for the 2010–11 fishing year, the Working Group agreed to provide conservative estimates of absolute abundance for the Bounty Platform stock that would be used to determine yield estimates for management of the fishery. To provide the full range of uncertainty it agreed to provide estimates of biomass and yield based on the results of each of the 2007, 2008, and 2009 surveys. In making these calculations the Working Group assumed:

1. That the acoustic biomass estimate in each year was equal to the vulnerable biomass available in each year and was lognormally distributed.

2. That the 80% quantiles (i.e., the 10^{th} and 90^{th} percentiles) represent an adequate bound on the sampling uncertainty in the acoustic estimates.

3. That an adequate representation of uncertainty in the target strength of southern blue whiting is ±3 dB, which approximates to a doubling or halving of the resulting biomass calculated from the target strength-fish length relationship.

4. That the combined impact of possible new recruitment, growth of individuals, natural mortality over a one year time frame are negligible (i.e., that the vulnerable biomass in 2008 was unlikely to be less than that observed in 2007). Further we assume no growth after one year, and that the natural mortality is 0.2 y^{-1} over periods of more than one year.).

The absolute estimates of southern blue whiting biomass from the 2007–2009 industry acoustic surveys for the 80% intervals and with a ±3 dB uncertainty in the acoustic biomass estimates are given in Table 22.

Table 22: Absolute estimates of southern blue whiting biomass (±3 dB) from the 2007–2009 industry acoustic surveys of the Bounty Platform, ignoring a correction for the potential bias in the catchability coefficient, ***q*****.**

Year	TS multiplier		Biomass estimate	
		10th percentile	Mean	90th percentile
2007	0.5	61 580	79 790	99 790
	1.0	98 890	159 590	230 850
	2.0	229 170	319 180	420 320
2008	0.5	55 640	72 090	90 160
	1.0	89 350	144 190	208 570
	2.0	207 050	288 370	379 760
2009	0.5	14 210	18 410	23 020
	1.0	22 810	36 810	53 250
	2.0	52 870	73 630	96 960

Assuming that an appropriate exploitation rate for southern blue whiting is 0.20 (i.e., the U_{CAY} that was previously calculated for southern blue whiting on the Bounty Platform in the most recent assessment), then expected CAY proxy yields for the biomass estimates in Table 22 for the following years are given in Table 23. Yield estimates based on the mean biomass estimates, with a TS multiplier of 1.0, from the three survey years were 17 540 t from the 2007 survey, 21 080 t from the 2008 survey and 7 360 t from the 2009 survey. In considering only the results of the 2007 and 2008 surveys, the Middle Depths FAWG considered that the risk that the biomass will drop below 20%B0 in 2010 if the TAC was based on these yield estimates would be negligible.

Table 23: Approximate CAY proxy yields for southern blue whiting biomass from the 2007–2009 industry acoustic surveys of the Bounty Platform, ignoring a correction for the potential bias in the catchability coefficient, ***q*****.**

Survey year	Yield year	TS multiplier		Biomass estimate	
			10th percentile	Mean	90th percentile
2007	2008	0.5	12 320	15 960	19 960
		1.0	19 780	31 920	46 170
		2.0	45 830	63 840	84 060
	2009	0.5	8 470	11 450	14 730
		1.0	14 580	24 520	36 190
		2.0	35 910	50 650	67 210
	2010	0.5	4 400	6 840	9 520
		1.0	9 400	17 540	27 090
		2.0	26 870	38 940	52 500
2008	2009	0.5	11 130	14 420	18 030
		1.0	17 870	28 840	41 710
		2.0	41 410	57 670	75 950
	2010	0.5	6 580	9 270	12 230
		1.0	12 100	21 080	31 620
		2.0	31 370	44 690	59 650
2009	2010	0.5	2 840	3 680	4 600
		1.0	4 560	7 360	10 650
		2.0	10 570	14 730	19 390

4.5 Additional stock assessment results for the Campbell Island Rise

In August-September 2009 a wide area acoustic survey of the Campbell Island Rise was carried out using *RV Tangaroa*. The estimate of biomass from the survey was 204 539 t (c.v. 0.27) using the most recent estimates of target strength and sound absorption (NIWA Unpublished Data).

In order to provide advice on sustainable yields for the Campbell Island Rise stock for the 2010–11 fishing year, the Working Group agreed to provide conservative estimates of absolute abundance for the Campbell Island Rise stock that would be used to determine yield estimates for management of the fishery. In making these calculations the Working Group assumed:

1. That the acoustic survey biomass estimate in 2009 was equal to vulnerable biomass available in that year and had lognormally distributed errors.

2. That the 80% quantiles (i.e., the 10th and 90th percentiles) represent an adequate bound on the sampling uncertainty in the acoustic estimates.

3. That an adequate representation of uncertainty in the target strength of southern blue whiting is ±3 dB, which approximates to a doubling or halving of the resulting biomass calculated from the target strength-fish length relationship.

4. That the combined impact of possible new recruitment, growth of individuals, natural mortality over a one year time frame are negligible (i.e., that the vulnerable biomass in 2009 was unlikely to be less than that observed in 2010).

The absolute estimates of southern blue whiting biomass from the 2009 acoustic survey for the 80% intervals and with a ±3 dB uncertainty in the acoustic biomass estimates are given in Table 24.

Table 24: Absolute estimates of southern blue whiting biomass (±3 dB) from the 2009 industry acoustic survey, ignoring a correction for the potential bias in the catchability coefficient, *q*.

Year	TS multiplier			Biomass estimate
		10th percentile	Mean	90th percentile
2009	0.5	70 279	102 270	138 709
	1.0	140 559	204 539	277 418
	2.0	281 118	409 078	554 836

A conservative estimate of CAY may be made by applying the reference fishing mortality to a conservative estimate of current vulnerable biomass based directly on the acoustic survey. The working group agreed that applying a fishing mortality rate of U=0.2 to the lower 10th percentile bound of the 2009 acoustic biomass estimate was sufficiently conservative. The expected CAY proxy yields for the biomass estimates in Table 24 are given in Table 25. Note that the yields do not account for growth of the strong recent year class, nor for natural mortality in the older age classes. The 10th percentile of the biomass estimate gave a yield of 28 112 t (shaded value in Table 25).The Middle Depths FAWG concluded that the risk that the biomass will drop below 20%B0 in 2010 if the TAC was based on this yield estimate would be negligible.

Table 25: Approximate CAY proxy yields for southern blue whiting biomass from the 2009 acoustic survey, ignoring a correction for the potential bias in the catchability coefficient, *q*.

TS multiplier			Biomass estimate
	10th percentile	Mean	90th percentile
0.5	14 056	20 454	27 742
1.0	28 112	40 908	55 484
2.0	56 224	81 816	110 967

5. STATUS OF THE STOCKS

Stock Structure Assumptions

Southern blue whiting are assessed as four independent biological stocks, based on the presence of four main spawning areas (Auckland Islands Shelf, Bounty Platform, Campbell Island Rise, and Pukaki Rise), and some differences in biological parameters and morphometrics between these areas (Hanchet 1999).

The four main stocks SBW6A (Auckland Islands), SBW6B (Bounty Platform), SBW6I (Campbell Island Rise), and SBW6R (Pukaki Rise) cover the four main bathymetric features in the Subantarctic QMA6. SBW1 is a nominal stock covering the rest of the New Zealand EEZ where small numbers of fish may occasionally be taken as bycatch.

- **Auckland Islands stock**

Stock Status	
Year of Most Recent Assessment	–
Assessment Runs Presented	–
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Historical Stock Status Trajectory and Current Status [No figure available]	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Catches have fluctuated without a trend
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	No reliable indices of abundance
Trends in Other Relevant Indicators or Variables	Catch in 2007 and 2008 dominated by large (40–50 cm long) fish – no sign of recent strong year classes.

Projections and Prognosis	
Stock Projections or Prognosis	Not available
Probability of Current Catch or TACC causing decline below Limits	Unknown

Assessment Methodology		
Assessment Type	Level 4 – Low information	
Assessment Method	None	
Main data inputs	Catch history – erratic catches with no trend Limited catch-at-age data (1993–1998) and 2008.	
Period of Assessment	None	Next assessment:
Changes to Model Structure and Assumptions	Not relevant	
Major Sources of Uncertainty	No reliable time series of data available. Catches have been erratic for the past 10 years and have been taken as bycatch in other middle depth fisheries so unlikely to provide reliable CPUE indices.	

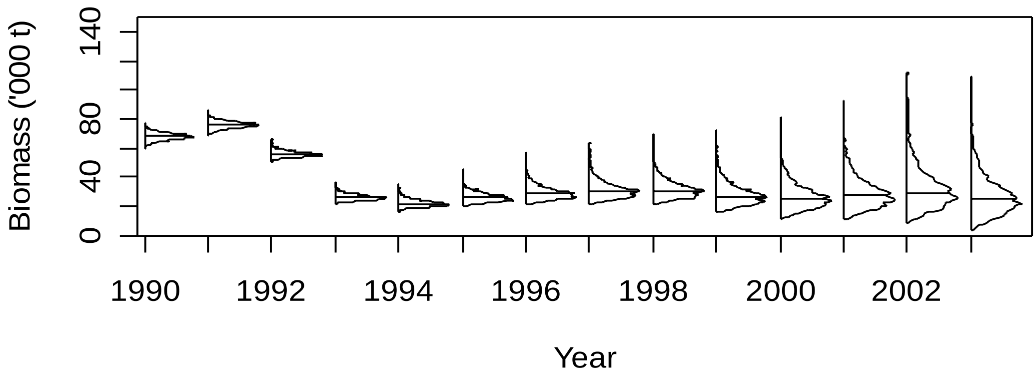
Qualifying Comments
There were several years of high catches (700–1100 t) during the mid 1990s but since then annual catches have averaged about 100 t. Good recruitment in southern blue whiting tends to be episodic and it is likely that the period of high catches was due to the presence of the strong year 1991 year class. The catches will probably remain low until a strong year class enters the fishery.

Fishery Interactions
The main incidental captures of concern at the Auckland Islands are New Zealand sea lions. There was virtually no fish bycatch when it was a target fishery during the mid 1990s.

- **Bounty Platform**

Stock Status	
Year of Most Recent Assessment	2010
Assessment Runs Presented	A matrix of biomass estimates was presented based on using acoustic survey estimates as absolute abundance under a range of assumptions
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2009} is Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	B_{2009} is Very Unlikely (< 10% probability) to be below both the Soft and Hard Limits

Historical Stock Status Trajectory and Current Status



Estimated posterior distributions of biomass trajectories for the Bounty stock for the base case (2004 stock assessment).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass was likely to have been below the target level from 1993 to 2005 but, with the recruitment of the very strong 2002 year class, the stock is now believed to be at or above pre-exploitation levels.
Recent Trend in Fishing Mortality or Proxy	Unknown.
Other Abundance Indices	The assessment is based on estimates of absolute abundance from acoustic surveys conducted on industry vessels
Trends in Other Relevant Indicators or Variables	Recruitment was estimated to be relatively low from 1995 to 2001 but was extremely high in 2002.

Projections and Prognosis	
Stock Projections or Prognosis	The biomass of the Bounty stock is expected to decrease over the next 5 years at the current catch level as the 2002 year class is fished down
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) over next 2–3 years Hard Limit: Very Unlikely (< 10%) over next 2–3 years

Assessment Methodology		
Assessment Type	Level 2 – Partial quantitative stock assessment	
Assessment Method	Proxy CAY yield based on absolute biomass estimates from aggregated acoustic surveys	
Main data inputs	Absolute biomass estimates from acoustic surveys of spawning aggregations conducted in 2007–2009	
Period of Assessment	Latest assessment: 2010	Next assessment: 2011
Changes to Model Structure and Assumptions	The last level 1 quantitative assessment based on acoustic and catch-at-age data was in 2004. No significant changes since the previous partial quantitative assessment in 2009.	
Major Sources of Uncertainty	High variability in acoustic survey biomass estimates. The surveys in 2007 and 2008 suggested biomass of 140–160 000 t, but the survey in 2009 suggested a biomass of 37 000 t. No allowance has been made in the assessment for growth, natural mortality or recruitment.	

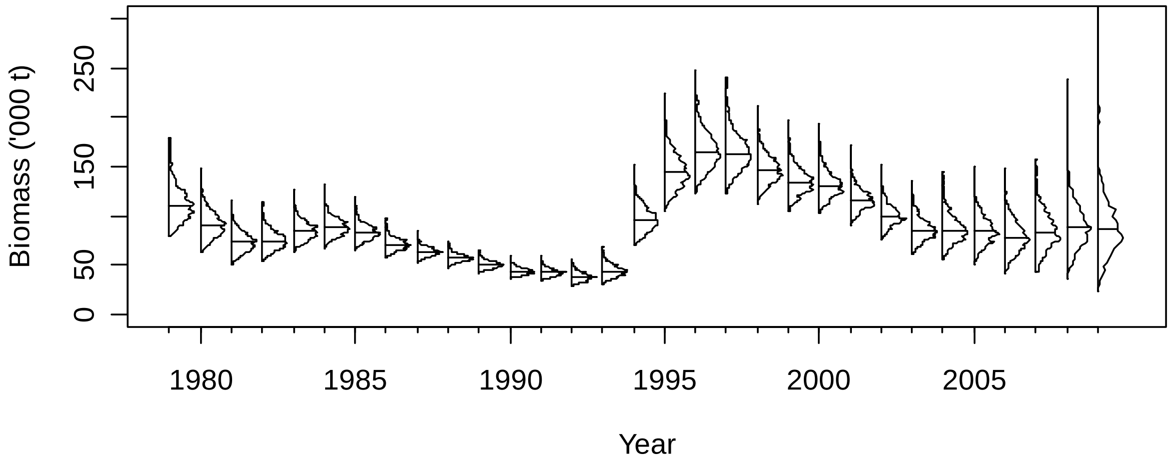
Qualifying Comments
The catch at age data for the last three years have been dominated by the strong 2002 year class. Attempts to fit the catch-at-age and time series of aggregated acoustic survey data in a population model have failed because of the high variability in the acoustic indices, and inconsistencies in some years between the age and the acoustic data. Recent work suggests that it is necessary to have a year-specific catchability (*q*) for each survey and year-specific selectivities to fit both data sets. The results of this work will be reported in next years Plenary document.

Fishery Interactions
The main incidental capture of concern is of NZ fur seals. There is virtually no fish bycatch in the fishery.

- **Campbell Island Rise**

Stock Status	
Year of Most Recent Assessment	2010
Assessment Runs Presented	A matrix of biomass estimates was presented based on absolute abundance from acoustic surveys under various assumptions
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2009} is Virtually Certain (> 99%) to be at or above the target
Status in relation to Limits	B_{2009} is Very Unlikely (< 10%) to be below both the Soft and Hard Limits

Historical Stock Status Trajectory and Current Status



Estimated posterior distributions of biomass trajectories for the Campbell Island stock for the base case (2007 stock assessment).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass was likely to have been below the management target during the mid 2000s. However, with the recruitment of the very strong 2006 year class the biomass is now believed to be at or above pre-exploitation levels.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure has reduced with the increase in stock size.
Other Abundance Indices	The current assessment is based on estimates of absolute abundance from a wide area Tangaroa acoustic survey in 2009
Trends in Other Relevant Indicators or Variables	The 2006 year class appears to be exceptionally strong, possibly even stronger than the 1991 year class.

Projections and Prognosis	
Stock Projections or Prognosis	The biomass of the Campbell stock is expected to increase over the next 1–2 years as the strong 2006 year class grows and enters the fishery. After that the biomass is likely to be gradually fished down at the current catch level.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) over next 2–3 years Hard Limit: Exceptionally Unlikely (< 1%) over next 2–3 years

Assessment Methodology		
Assessment Type	Level 2 – Partial quantitative stock assessment	
Assessment Method	Proxy CAY yield based on absolute biomass estimates from wide area acoustic survey	
Main data inputs	Absolute biomass estimates from wide area acoustic survey conducted in 2009	
Period of Assessment	Latest assessment: 2010	Next assessment: 2011
Changes to Model Structure and Assumptions	The last level 1 quantitative assessment based on acoustic and catch-at-age data was in 2006. The 2010 interim partial quantitative assessment is based entirely on the results of the acoustic survey in 2009.	
Major Sources of Uncertainty	Moderate uncertainty over the acoustic survey biomass estimates (CV =0.27). No allowance has been made in the assessment for growth, natural mortality or recruitment.	

Qualifying Comments
The biomass estimate from the 2009 acoustic survey was the highest on record for the Campbell Island stock, and about 2.5 times the previous estimate in 2006. This level of biomass is inconsistent with the previous estimates of adult biomass and year class strengths from the 2007 assessment. Although the 2006 year class appears to be exceptionally strong, it cannot fully explain the large increase in biomass estimated by the survey. The TACC was increase to 23,000 t from 1 April 2010.

Fishery Interactions
The main incidental capture species of concern is the New Zealand sea lion. There is virtually no fish bycatch in the fishery.

- **Pukaki Rise**

Stock Status	
Year of Most Recent Assessment	2002
Assessment Runs Presented	The results of three runs were presented assuming different values for the adult acoustic *q*.
Reference Points	Interim Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Current status unknown. Believed to be only lightly exploited between 1993 and 2002
Status in relation to Limits	Current status unknown. Believed to be only lightly exploited between 1993 and 2002
Historical Stock Status Trajectory and Current Status [No figure available]	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Catches over the last 10 years have fluctuated without a trend
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	No current reliable indices of abundance (wide area surveys were discontinued in 2000)
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis (2002)	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing decline below Limits	Unknown

Assessment Methodology		
Assessment Type	Level 1 – Full quantitative stock assessment	
Assessment Method	Age structured separable Sequential Population Analysis (sSPA) with maximum likelihood estimation	
Main data inputs	Abundance indices from wide area acoustic surveys Catch-at-age data	
Period of Assessment	Last assessment: 2002	Next assessment: ?
Changes to Model Structure and Assumptions	None	

Major Sources of Uncertainty	The adult acoustic *q* was estimated in the model to be 2.7 which the WG thought was unrealistically high. A run based on a more plausible value for *q* suggested the 2000 biomass was above 50% B_0.

Qualifying Comments
Fishers reported large aggregations of fish and made good catches in 2009. However, aggregation surveys by industry vessels in 2009 yielded generally low biomass estimates which were at a level consistent with that during the 1990s. The Subantarctic trawl surveys may provide an index of abundance for this stock, but this has yet to be determined. Catch at age data are available for 2007 and 2009 and suggest the catch is dominated by relatively young fish from the 2003–2006 year classes.

Fishery Interactions
There is little fish bycatch or marine mammal incidental captures in the target fishery.

Table 23: Summary of TACCs and preliminary estimates of landings (t). (1 April–31 March fishing year).

	2009–10 Actual TACC	2009–10 Landings
Area		
SBW 1 (EEZ excluding Sub-Antarctic)	8	5
Campbell Island	20 000	19 040
Bounty Platform	15 000	15 467
Pukaki Rise	5500	4808
Auckland Islands Shelf	1 640	157
Total	39 477	42 148

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