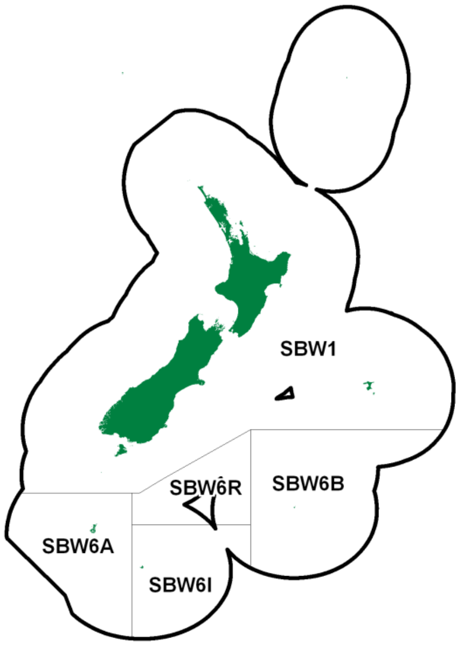
SOUTHERN BLUE WHITING (SBW)

(*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 Plateau for much of the year, but during August and September they aggregate to spawn near the Campbell Islands (Campbell Rise), on Pukaki Rise, on Bounty Plateau, and near the Auckland Islands in depths of 250–600 m. During most years, fish in the spawning fishery range between 35 and 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, and Figure 1 shows the historical landings and TACC values for the main southern blue whiting 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 was introduced for the first time in the 1992–93 fishing year with area sub-limits of 15 000 t in 6B, 11,000 t in 6I, and 6 000 t in 6R (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 November 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, and typically less than 10 t per year were reported from SBW 1 most years from 2000–01 to 2012–13 (Table 2). However, landings ranged between 21 t and 86 t from 2013–14 to 2016–17 and the TACC for SBW 1 was increased to 98 t for the 2017–18 season. Landings were 39 t in 2019–20, 71 t in 2020–21, 22 t in 2021–22 and 12 t in 2022–23.

Table 1: Reported annual landings (t) of southern blue whiting for all areas, 1971 to 1977.

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

Landings for other stocks have generally been between 20 000 t and 40 000 t since 2000, with the majority of the catch currently taken by foreign owned, New Zealand flagged vessels (predominantly large factory trawlers) producing headed and gutted or dressed frozen product and waste to fishmeal. On the Bounty Plateau, the TACC was almost fully caught in each year between 2002–03 and 2017–18, but effort and landings have been decreasing in recent years with only 788 t of the 3145 t TACC landed in 2019–20, and 1100 t and 801 t of the 2830 t TACC landed in 2020–21 and 2021–22, respectively. For 2022–23 the TACC was reduced to 2264 t with landings of 125 t, the lowest value since 1988–89. The TACC on the Campbell Rise has been increasingly under-caught since 2014–15, by as much as 27 218 t in 2020–21. Catches increased in the next two years and were 22 985 t in 2022–23 compared to the TACC of 39 200 t. On the other grounds, the catch limits have been under-caught in most years since their introduction. This reflects the economic value of these fish, the availability of alternative fishing opportunities, and difficulties experienced by operators in both timing their arrival on the grounds and locating the aggregations of fish. On the Pukaki Rise and Auckland Islands Shelf, operators have generally found it difficult to justify expending time to locate fishable aggregations, given the small allocation available in these areas, the small fish size and relatively low value of the product, and the more certain option available to fish southern blue whiting near Campbell Island where aggregations are concurrent.

Table 2: Estimated catches (t) and actual TACCs (or catch limits) 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 Islands Shelf. Landings for the 2022–23 fishing year are considered preliminary.

Fishing	SBW 6B Bounty Plateau		SBW 6I Campbell Rise		SBW 6R Pukaki Rise		SBW 6A Auckland Is.		SBW 1 Rest of NZ		Total	
year	Catch	Limit	Catch	Limit	Catch	Limit	Catch	Limit	Catch	Limit	Catch	Limit
1978†	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	9	8	24 938	35 148
2001–02#	2 262	8 000	29 999	30 000	230	5 500	10	1 640	1	8	32 502	45 148
2002–03#	7 564	8 000	33 445	30 000	508	5 500	262	1 640	16	8	41 795	45 148
2003–04#	3 812	3 500	23 718	25 000	163	5 500	116	1 640	3	8	27 812	35 648
2004–05#	1 477	3 500	19 799	25 000	240	5 500	95	1 640	9	8	21 620	35 648
2005–06#	3 962	3 500	26 190	25 000	58	5 500	66	1 640	2	8	30 278	35 648
2006–07#	4 395	3 500	19 763	20 000	1 115	5 500	84	1 640	7	8	25 364	30 648
2007–08#	3 799	3 500	20 996	20 000	513	5 500	278	1 640	1	8	25 587	30 648
2008–09#	9 863	9 800	20 483	20 000	1 377	5 500	143	1 640	21	8	31 887	36 948
2009–10#	15 468*	14 700	19 040	20 000	4 853	5 500	174	1 640	5	8	39 540	41 848
2010–11#	13 913	14 700	20 224	23 000	4 433	5 500	131	1 640	8	8	38 709	44 848
2011–12#	6 660	6 860	30 971	29 400	686	5 500	92	1 640	2	8	38 411	43 408
2012–13#	6 827	6 860	21 321	29 400	1 702	5 500	49	1 640	8	8	29 907	43 408
2013–14#	4 278§	4 028	28 607	29 400	14	5 500	47	1 640	21	8	32 967	40 576
2014–15#	7 054	6 860	24 592	39 200	34	5 500	156	1 640	29	8	31 865	53 208
2015–16#	2 405	2 940	22 100	39 200	12	5 500	181	1 640	35	8	24 733	49 288
2016–17#	2 569	2 940	19 875	39 200	11	5 500	46	1 640	86	8	22 587	49 288
2017–18#	2 423	2 377	18 334	39 200	36	5 500	202	1 640	51	98	21 046	48 815
2018–19#	1 101	3 145	15 147	39 200	36	5 500	218	1 640	33	98	16 535	49 583
2019–20#	788	3 145	26 517	39 200	3 631	5 500	182	1 640	39	98	31 157	49 583
2020–21#	1 100	2 830	11 982	39 200	71	5 500	211	1 640	71	98	13 436	49 268
2021–22#	801	2 830	19 514	39 200	33	5 500	174	1 640	22	98	20 544	49 268
2022–23#	125	2 264	22 985	39 200	40	5 500	247	1 640	12	98	23 410	48 702

† 1 April–30 September. + 1 October–30 September. ‡ 1 October 1998–31 March 2000. # 1 April–31 March.
* Reported catch total for 2009–10 does not include fish lost when FV *Oyang 70* sank on 18 August 2010.
§ In 2013, although the TACC remained at 6860 t, the ACE available to balance against catch was limited to 4028 t because 2832 t was shelved under a voluntary agreement with industry.

The TACC for the Bounty Plateau stock was increased to 9800 t for the 2008–09 season and further increased to 14 700 t for the 2009–10 and 2010–11 seasons but decreased to 6860 t for the 2011–12 season. In 2013–14, 2832 t were shelved, leaving the effective catch limit at 4028 t. The TACC for the Bounty Plateau stock was reduced to 2940 t for the 2015–16 and 2016–17 seasons, further reduced to 2377 t for the 2017–18 season, and then increased to 3145 t for the 2018–19 and 2019–20 seasons, before a reduction to 2830 t for the 2020–21 season. It was reduced again to 2264 t for the 2022–23 season and then increased to 4888 t for the 2024–25 season. The TACC for the Campbell Rise stock was reduced from 25 000 t to 20 000 t in 2006–07, where it remained until 2009–10. For the 2010–11 season the catch limit for the Campbell Rise stock was raised to 23 000 t, in 2011–12 to 29 400 t, and in 2014–15 it was raised to 39 200 t. Catch limits for Pukaki Rise and Auckland Islands Shelf have remained unchanged since 1997.

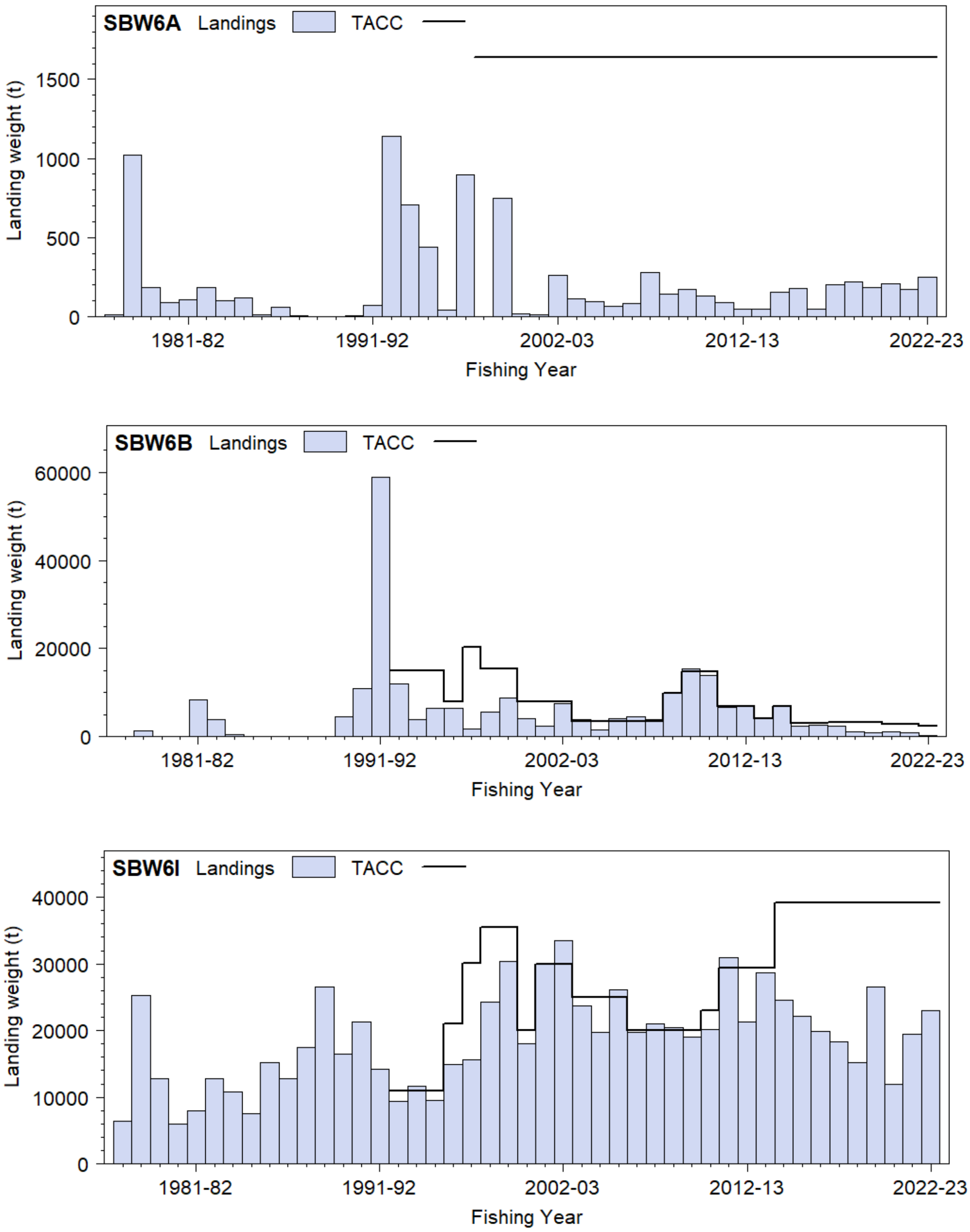


Figure 1: Reported commercial landings and TACC for the main SBW stocks. From top: SBW 6A (Auckland Islands Shelf), SBW 6B (Bounty Plateau), and SBW 6I (Campbell Rise). **[Continued on next page]**

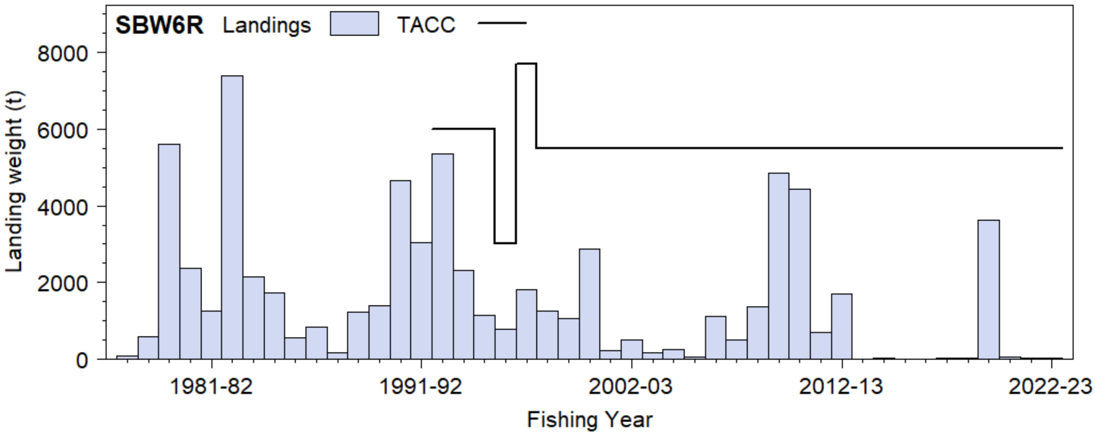


Figure 1 [Continued]: Reported commercial landings and TACC for the main SBW stocks. SBW 6R (Pukaki Rise).

1.2 Recreational fisheries
There is no recreational fishery for southern blue whiting.

1.3 Customary non-commercial fisheries
Customary non-commercial take does not occur for southern blue whiting.

1.4 Illegal catches
The level of illegal and unreported catch is thought to be low. However, in 2005 the master and operator of a vessel fishing for southern blue whiting were convicted for area misreporting 700 t. The SBW was caught in SBW 6I but was falsely reported as having been caught in SBW 6A and 6R during two trips in August and September 2002. Following on from this, the operators of a vessel were convicted for dumping quota management species. Crew estimated that between 40 and 310 t of SBW 6I were illegally discarded during the trip. Where catch returns have been revised, the corrected totals by area are given in Table 2.

1.5 Other sources of mortality
Scientific observers have occasionally reported discards of undersize fish and accidental loss from torn or burst cod-ends. The amount of possible discarding was estimated by Clark et al (2000) and Anderson (2004, 2009). Anderson (2004) quantified total annual discard estimates (including estimates of fish lost from the net at the surface) as ranging between 0.4% and 2.0% of the estimated southern blue whiting catch over all the southern blue whiting fisheries. Anderson (2009) reviewed fish and invertebrate bycatch and discards in the southern blue whiting fishery based on observer data from 2002 to 2007; an estimated 0.23% of the catch was discarded from observed vessels. The low levels of discarding occur primarily because most catch came from vessels that targeted spawning aggregations.

In August 2010, the FV *Oyang 70* sank while fishing for SBW on the Bounty Plateau. It was fishing an area between 48° 00’ S and 48° 20’ S, and 179° 20’ E and 180° between 15 and 17 August 2010, before sinking on 18 August 2010. The Ministry of Fisheries estimated that it had taken a catch of between 120 t and 190 t that was lost with the vessel.

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 a maximum age of 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. Most females also mature at age 3 or 4, at 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 Plateau, Pukaki Rise, Auckland Islands Shelf, and Campbell Rise. The Campbell 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 Plateau 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 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. Campbell Rise stock assessments estimated *M* within the model in 2016, 2020 and 2023, using an informed prior with a mean of 0.2 (see Table 3 and Roberts & Dunn 2017).

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

Fishstock				**Estimate**	**Source**
1. Natural mortality (*M*)					
			Males	Females	
Campbell Rise			0.2	0.2	Hanchet (1991)
			0.17	0.18	Roberts & Hanchet (2019)
			0.16	0.17	Doonan (2020)
			0.19	0.17	Doonan et al (in press)
2. Weight = a (length)^b (Weight in g, length in cm fork length)					
	Males		Females		
	a	*b*	*a*	*b*	
Campbell Rise	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 Plateau, Pukaki Rise, Auckland Islands Shelf, and Campbell 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 Plateau, Pukaki Rise, and Campbell 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 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 Plateau stock, the Pukaki Rise stock, the Auckland Islands Shelf stock, and the Campbell Rise stock.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

Tables and accompanying text in this section were updated for the southern blue whiting fishery 2022 Fishery Assessment Plenary (Fisheries New Zealand 2022). A more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021), online at https://www.mpi.govt.nz/dmsdocument/51472-Aquatic-Environment-and-Biodiversity-Annual-Review-AEBAR-2021-A-summary-of-environmental-interactions-between-the-seafood-sector-and-the-aquatic-environment.

4.1 Role in the ecosystem

Southern blue whiting is one of the dominant (in terms of biomass) middle depth fish species found on the Campbell Plateau and Bounty Plateau at depths between 250–600 m. Francis et al (2002) categorised southern blue whiting as part of an upper slope assemblage and estimated its distribution to be centred on about 500 m depth and latitude 51° S. During August and September, southern blue whiting form large dense spawning aggregations on the Campbell Rise and Bounty Plateau and, to a lesser extent, on the Pukaki Rise and near the Auckland Islands. The species is also found in much lower numbers on the Stewart-Snares shelf and Chatham Rise.

These stocks are characterised by highly variable year class strengths, with the strong year classes growing at a significantly lower rate than others (i.e., showing signs of density dependent growth). Their substantial abundance suggests that southern blue whiting are probably an important part of the Campbell Rise and Bounty Plateau ecosystems, but their variability suggests that these systems may function differently at different times. For instance, very large changes have been observed in the abundance of southern blue whiting on the Bounty Plateau, with a 7-fold increase between 2005 and 2007 followed by a 4-fold decrease to 2009 (Dunn & Hanchet 2011). The large increase was due to the very strong 2002 year class recruiting to the fishery, but the rapid decline is not easily explained. Whatever the reason, there are likely to be implications for the role of the southern blue whiting population in the ecosystem during such events.

4.1.1 Trophic interactions

Crustaceans and teleosts are the dominant prey groups for southern blue whiting. Stevens et al (2011) showed that in the Sub-Antarctic (and similarly from the Chatham Rise), crustaceans occurred in 70% of stomachs, mainly euphausiids (37%), natant decapods (24%), and amphipods (11%). Teleosts occurred in 32% of stomachs, mainly myctophids (10%). Salps (7%) and cephalopods (2%) were of lesser importance.

Predation by marine mammals and large teleosts is probably the main source of mortality for adults, and juveniles are frequently taken by seabirds (MPI 2013). Large hake and ling taken as bycatch in the fishery have usually been feeding on southern blue whiting, and large hoki caught during Sub-Antarctic trawl surveys have occasionally been feeding on juvenile southern blue whiting. Juvenile (90–130 mm FL) southern blue whiting were found to be the main prey item of black-browed albatross at Campbell Island during the chick rearing period in January 1997 (Cherel et al 1999) and are also regularly taken by grey-headed albatross and rockhopper penguins breeding at Campbell Island (Cherel et al 1999).

4.1.2 Ecosystem Indicators

Tuck et al (2009) used data from the Sub-Antarctic trawl survey series to derive fish-based ecosystem indicators using diversity, fish size, and trophic level. This trawl survey has run regularly using the same vessel since 1991 and covers much of the area inhabited by southern blue whiting. Tuck et al (2009) showed generally increasing trends in the proportion of threatened fish species and those with low resilience (from FishBase, Froese & Pauly 2000) and indices of fish diversity often showed positive trends. The proportion of piscivorous and demersal species and the mean trophic level generally declined over the time period, especially in areas where southern blue whiting are more common. Highly variable recruitment of dominant species like southern blue whiting may strongly influence such trends. Changes in fish size were less consistent, and Tuck et al (2009) and Tuck et al (2014) did not find size-based indicators as useful as they have been overseas. Routine measurement of all fish species in New Zealand trawl surveys since 2008 may increase the utility of size-based indicators in the future.

4.2 Bycatch (fish and invertebrates)

4.2.1 Fish

The southern blue whiting fishery is characterised by large, ‘clean’ catches of the target species with minimal fish bycatch. Anderson (2009) estimated that, for southern blue whiting target tows, southern blue whiting accounted for more than 99% of the total estimated catch recorded by observers and more than 99% of the total reported catch from the fishery based on catch and effort forms.

A total of 120 bycatch species have been recorded by observers (Anderson 2009), of which the main bycatch species have been ling, hake, and hoki, with smaller amounts of porbeagle shark, opah, silverside, and pale ghost shark (Finucci et al 2019), with a decreasing trend in hake bycatch.

Given the high proportion of target species catch, discards in this fishery are correspondingly low, composed mainly by target catch and mostly related to loss of catch during the haul (Anderson 2009).

4.2.2 Invertebrates

There is little invertebrate bycatch in this fishery even though most trawls are on or close to the seabed for at least part of the time (Cole et al 2007). Protected coral bycatch has been negligible in this fishery (Weaver 2021).

4.3 Incidental capture of protected species (seabirds, mammals, and protected fish)

Southern blue whiting trawlers occasionally capture marine mammals (pinnipeds). Vessels in the southern blue whiting fishery also interact with, and incidentally capture, seabirds and, at least in one occasion, have captured a protected shark species.

Observer data for bottom trawl fisheries bycatch of seabirds, mammals, and coral are summarised on an annual basis by the Department of Conservation Conservation Services Programme (CSP) (Weaver 2021). Coral impacts are discussed under Invertebrates (section 4.2.2).

4.3.1 Marine mammal captures

The New Zealand sea lion *Phocarctos hookeri*, is one of the rarest sea lion in the world. The estimated total population of around 10 000 sea lions in 2022 is classified by the Department of Conservation as 'Threatened - Nationally Vulnerable' under the New Zealand Threat Classification System (Baker et al 2019).

Sea lions interact with some trawl fisheries which can result in incidental capture and subsequent drowning (Smith & Baird 2005, 2007a & b, Thompson & Abraham 2010a, Thompson & Abraham 2012, Abraham & Thompson 2011, Abraham et al 2016). Since 1988, incidental captures of sea lions have been monitored by government observers on-board an increasing proportion of the fishing fleet.

Annual sea lion pup counts at breeding sites are used to index trends in the total sea lion population. The Auckland Islands/Motu Maha is the largest breeding site for sea lions: 68% of all sea lion pups are born there; 30% are born at Campbell Island/Motu Ihupuku and the remaining 2% at Stewart Island/Rakiura and the South Island/Te Waipounamu (currently restricted to the Otago and Catlins coasts). Between 1998 and 2009 the number of sea lion pups born annually at the Auckland Islands declined by 40%. In 2014, the Minister of Conservation and the Minister for Primary Industries asked officials to develop a New Zealand sea lion Threat Management Plan (NZSL TMP) which is available online: https://www.fisheries.govt.nz/protection-and-response/sustainable-fisheries/managing-our-impact-on-marine-life/new-zealand-sea-lion/.

Captures of New Zealand sea lions in the Campbell Rise southern blue whiting trawl fishery have been variable between years (Table 4). The sea lion captures are mostly males (91%). There were 21 captures in 2012–13, mostly early in the season, which led to the development of an operational plan that includes observers being placed on almost all trips and voluntary use of sea lion exclusion devices (SLEDs) on all tows in SBW 6I (MPI 2021).

The New Zealand fur seal is classified as 'Not Threatened' under the New Zealand Threat Classification System (Baker et al 2019)). Southern blue whiting has one of the highest observed capture rates of New Zealand fur seals for any observed fishery. The observed capture rate of fur seals in the southern blue whiting fishery has varied considerably between years, ranging without trend from a high of 23.96 fur seals per 100 tows in 2005–06 to a low of 0.88 fur seals per 100 tows in 2020–21 (Abraham et al 2024, Table 5). Almost all fur seals captured in this fishery have been caught at the Bounty Plateau in August and September when the southern blue whiting are in dense spawning aggregations.

Table 4: Number of tows by fishing year and observed New Zealand sea lion captures in the Campbell Island southern blue whiting trawl fisheries, 2002–03 to 2020-21. Annual fishing effort (tows), number of observed tows and observer coverage (%) in Campbell Island southern blue whiting trawl fisheries; number of observed captures and observed capture rate (captures per hundred tows) of New Zealand sea lion; estimated captures and capture rate of New Zealand sea lion (mean and 95% credible interval). Estimates are based on methods described by Abraham et al (2024), available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in this table derive from the PSC database version PSCV6. * denotes the year that standardised SLED designs were introduced.

	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
Fishing year	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	638	275	43.1	0	0.00	1	0–3	0.09	0.00–0.47
2003–04	740	241	32.6	1	0.41	3	1–9	0.41	0.14–1.22
2004–05	870	335	38.5	2	0.60	5	2–13	0.60	0.23–1.49
2005–06	624	217	34.8	3	1.38	10	3–22	1.59	0.48–3.53
2006–07*	630	224	35.6	3	1.34	15	6–30	2.36	0.95–4.76
2007–08	818	331	40.5	5	1.51	8	5–14	0.95	0.61–1.71
2008–09	1 188	300	25.3	0	0.00	1	0–7	0.10	0.00–0.59
2009–10	1 113	396	35.6	11	2.78	24	15–37	2.19	1.35–3.32
2010–11	1 171	433	37.0	6	1.39	15	8–25	1.25	0.68–2.13
2011–12	951	669	70.3	0	0.00	1	0–4	0.10	0.00–0.42
2012–13	791	791	100.0	21	2.65	21	21–21	2.65	2.65–2.65
2013–14	804	803	99.9	2	0.25	2	2–2	0.25	0.25–0.25
2014–15	673	669	99.4	6	0.90	6	6–6	0.89	0.89–0.89
2015–16	442	443	100.2	3	0.68				
2016–17	537	537	100.0	0	0.00				
2017–18	455	455	100.0	2	0.44				
2018–19	749	748	99.9	0	0.00				
2019–20	348	348	100.0	1	0.29				
2020–21	441	340	77.1	4	1.18				

Table 5: Number of tows (commercial and observed) by fishing year, observed and estimated New Zealand fur seal captures, and capture rate in southern blue whiting trawl fisheries, 2002–03 to 2020-21 (Abraham et al 2024). Estimates are available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in this table are derived from the PSC database version PSCV6.

	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
Fishing year	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	638	275	43.1	8	2.91	22	8–78	3.47	1.25–12.23
2003–04	740	241	32.6	13	5.39	36	13–122	4.88	1.76–16.49
2004–05	870	335	38.5	33	9.85	103	35–472	11.8	4.02–54.25
2005–06	624	217	34.8	52	23.96	67	52–122	10.77	8.33–19.55
2006–07	630	224	35.6	13	5.80	25	13–76	3.96	2.06–12.06
2007–08	818	331	40.5	24	7.25	110	25–600	13.41	3.06–73.35
2008–09	1 188	300	25.3	17	5.67	129	25–488	10.88	2.10–41.08
2009–10	1 113	396	35.6	16	4.04	114	20–460	10.2	1.80–41.29
2010–11	1 171	433	37.0	36	8.31	76	38–251	6.5	3.25–21.43
2011–12	951	669	70.3	25	3.74	69	25–289	7.3	2.63–30.39
2012–13	791	791	100.0	27	3.41	27	27–27	3.42	3.42–3.42
2013–14	804	803	99.9	95	11.83	97	95–116	11.98	11.74–14.34
2014–15	673	669	99.4	41	6.13	41	41–42	6.07	6.06–6.20
2015–16	442	443	100.2	51	11.51				
2016–17	537	537	100.0	11	2.05				
2017–18	455	455	100.0	17	3.74				
2018–19	749	748	99.9	11	1.47				
2019–20	348	348	100.0	8	2.30				
2020–21	441	340	77.1	3	0.88				

4.3.2 Seabird captures

Vessels are legally required to use seabird mitigation devices and also to adhere to industry Operating Procedures with regards to managing risk of environmental interactions. For protected species, capture estimates presented include all animals recovered to the deck (alive, injured, or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp or caught on a hook but not brought on board the vessel; Middleton & Abraham 2007, Brothers et al 2010).

Mitigation methods such as streamer (tori) lines, bird bafflers, and offal management are used in the southern blue whiting trawl fishery. Warp mitigation was voluntarily introduced from about 2004 and made mandatory in April 2006 (Department of Internal Affairs 2006). The 2006 notice mandated that all trawlers over 28 m in length use a seabird scaring device while trawling (being 'paired streamer lines', 'bird baffler' or 'warp deflector' as defined in the Notice).

In the 2018–19 fishing year there were 37 observed captures of birds in southern blue whiting trawl fisheries, while in 2020–21 there were only 3, at rates of 4.9 and 0.68 birds per 100 observed tows respectively (Table 6). The average capture rate in southern blue whiting trawl fisheries for the period from 2002–03 to 2020–21 is about 1.5 birds per 100 tows, a low rate relative to some other New Zealand trawl fisheries, e.g., for scampi (3.0 birds per 100 tows) and squid (11.2 birds per 100 tows) over the same years.

Overall, the impact that the southern blue whiting fisheries have on seabirds is relatively small. This can be seen in the proportions of the overall fisheries Population Sustainability Threshold (PST) that are attributable to the southern blue whiting fisheries for each species (Table 7). Observed seabird captures since 2002–03 have been dominated by grey petrels (88 of the 138 observed seabird captures since 2002–03), a negligible risk species where the southern blue whiting fisheries are estimated to be responsible for about 20% of the risk ratio (Table 7).

Table 6: Number of tows by fishing year and observed seabird captures in southern blue whiting trawl fisheries, 2002–03 to 2019–20. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Estimates are based on methods described by Abraham & Richard (2020) and are available online at https://protectedspeciescaptures.nz/PSCv6/released/. Observed and estimated protected species captures in this table derive from the PSC database version PSCV6..

	Fishing effort			Obs. captures		Est. captures		Est. capture rate	
Fishing year	Tows	No. Obs	% obs	Captures	Rate	Mean	95% c.i.	Mean	95% c.i.
2002–03	638	275	43.1	0	0.00	4	0–13	0.69	0.00–2.04
2003–04	740	241	32.6	1	0.41	8	2–19	1.03	0.27–2.57
2004–05	870	335	38.5	2	0.60	11	4–24	1.28	0.46–2.76
2005–06	624	217	34.8	1	0.46	7	1–17	1.06	0.16–2.72
2006–07	630	224	35.6	3	1.34	9	3–19	1.39	0.48–3.02
2007–08	818	331	40.5	3	0.91	10	4–21	1.19	0.49–2.57
2008–09	1 188	300	25.3	0	0.00	12	3–27	1.02	0.25–2.27
2009–10	1 113	396	35.6	11	2.78	25	14–40	2.21	1.26–3.59
2010–11	1 171	433	37.0	13	3.00	26	16–41	2.18	1.37–3.50
2011–12	951	669	70.3	3	0.45	7	3–14	0.69	0.32–1.47
2012–13	791	791	100.0	19	2.40	19	19–19	2.40	2.40–2.40
2013–14	804	803	99.9	17	2.12	17	17–17	2.12	2.11–2.11
2014–15	673	669	99.4	7	1.05	7	7–9	1.07	1.04–1.34
2015–16	442	443	100.2	6	1.35	6	6–6	1.36	1.36–1.36
2016–17	537	537	100.0	6	1.12	6	6–7	1.13	1.12–1.30
2017–18	455	455	100.0	6	1.32	6	6–6	1.32	1.32–1.32
2018–19	749	748	99.9	37	4.95	37	37–37	4.94	4.94–4.94
2019–20	348	348	100.0	3	0.86	3	3–3	0.86	0.86–0.86
2020–21	441	340	77.1	2	0.59	3	2–8	0.68	0.45–1.81

Table 7: Risk ratio for seabirds predicted by the level two risk assessment for the target southern blue whiting (SBW) fishery and all fisheries included in the level two risk assessment, 2006–07 to 2016–17, showing seabird species with a risk ratio of at least 0.001 of PST. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Population Sustainability Threshold, PST (Edwards et al 2023 where full details of the risk assessment approach can be found). The DOC threat classifications are shown (Robertson et al 2017 at http://www.doc.govt.nz/documents/science-and-technical/nztcs19entire.pdf).

	PST	Risk ratio			
Species	(mean)	SBW trawl*	Total	Risk category	DOC Threat Classification
Salvin's albatross	25 502 550	0.007	0.69	High	Threatened: Nationally Critical
Grey petrel	3 591	0.003	0.02	Negligible	At Risk: Naturally Uncommon
Campbell black-browed albatross	11 411 141	0.003	0.05	Low	At Risk: Naturally Uncommon

* SWB trawl from Richard et al (2017).

4.3.3 Protected fish species captures

The basking shark (*Cetorhinus maximus*) was classified as 'Threatened – Nationally Vulnerable' in 2016, under the New Zealand Threat Classification System (Duffy et al 2018). Basking shark has been a protected species in New Zealand since 2010, under the Wildlife Act 1953, and is also listed in Appendix II of the CITES convention. Observer reported records between 2002-03 and 2020-21 include the incidental capture of one basking shark in 2016 by the southern blue whiting fishery.

4.4 Benthic interactions

The spatial extent of seabed contact by trawl fishing gear in New Zealand's EEZ and Territorial Sea has been estimated and mapped in numerous studies for trawl fisheries targeting deepwater species

(Baird et al 2011, Black et al 2013, Black & Tilney 2015, Black & Tilney 2017, Baird & Wood 2018, and Baird & Mules 2019, 2021a, 2021b), species in waters shallower than 250 m (Baird et al 2015, Baird & Mules 2020a), and all trawl fisheries combined (Baird & Mules 2021a, 2021b). The most recent assessment of bottom-contacting commercial trawls was conducted by MacGibbon & Mules (2023).

During 1989–90 to 2020–21, about 17 700 southern blue whiting bottom-contacting trawls were reported on TCEPRs and ERS (MacGibbon & Mules 2023): about 900–2400 tows were reported annually during 1989–90 to 1991–92; 300–500 in most other years, except in 1997–98, 1998–99, 2009–10, and 2010–11 when about 700 tows were reported each year and 2019–20 to 2020–21 when fewer than 300 tows were reported each year. The total footprint generated from these tows was estimated at about 23 467 km^2. This footprint represented coverage of 0.6% of the seafloor of the combined EEZ and the Territorial Sea areas, and 1.7% of the 'fishable area', that is, the seafloor area open to trawling, in depths of less than 1600 m. For the 2020–21 fishing year, 248 southern blue whiting bottom tows had an estimated footprint of 547 km^2 which represented coverage of < 0.1% of the EEZ and Territorial Sea and < 0.1% of the fishable area (MacGibbon & Mules 2023).

The overall trawl footprint for southern blue whiting (1989–90 to 2020–21) covered 3.7% of seafloor in 200–400 m, 7.6% in 400–600 m, and 0.2% of 600–1600 m seafloor (MacGibbon & Mules 2023). In 2018–19, the southern blue whiting footprint contacted 0.1%, 0.3%, and < 0.1% of those depth ranges, respectively (MacGibbon & Mules 2023), and no effort was reported deeper than 600 m. The BOMEC areas with the highest proportion of area covered by the southern blue whiting footprint were classes F (Sub-Antarctic island shelves), I (Chatham Rise slope and shelf edge of the east coast South Island), and L (deeper waters off the Stewart-Snares shelf and around the main Sub-Antarctic islands). The 2020–21 southern blue whiting footprint covered 0.01% of the 38 776 km^2 of class F, 0.03% of the 52 008 km^2 of class I, and 0.26% of the 198 578 km^2 of class L (MacGibbon & Mules 2023).

Where trawls for southern blue whiting are fished on the bottom, they are likely to have effects on benthic community structure and function (e.g., Cole et al 2007, Rice 2006) and there may be consequences for benthic productivity (e.g., Jennings 2001, Hermsen et al 2003, Hiddink et al 2006, Reiss et al 2009). However, any consequences from southern blue whiting fishing, due to the gear type and scale of the fishery (typically less than 600 tows fished on the bottom per year), are likely to be relatively minor. A more general review of habitat interactions can be found in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021).

4.5 Other considerations

4.5.1 Spawning disruption

Fishing during spawning may disrupt spawning activity or success. Canadian research carried out on Atlantic cod (*Gadus morhua*) concluded that "Cod exposed to a chronic stressor are able to spawn successfully, but there appears to be a negative impact of this stress on their reproductive output, particularly through the production of abnormal larvae" (Morgan et al 1999). Morgan et al (1997) also reported disruption of a spawning shoal of Atlantic cod: "Following passage of the trawl, a 300-m-wide "hole" in the aggregation spanned the trawl track. Disturbance was detected for 77 min after passage of the trawl." There has been no research carried out on the disruption of spawning southern blue whiting by fishing in New Zealand, where fishing occurs almost entirely on spawning aggregations.

4.5.2 Genetic effects

Fishing, environmental changes such as altered average sea temperatures (climate change), or pollution could alter the genetic composition or diversity of a species. There are no known studies of the genetic diversity of southern blue whiting from New Zealand. Genetic studies for stock discrimination are reported above under 'Stocks and Areas' (section 3).

4.5.3 Habitat of particular significance to fisheries management

Habitat of particular significance for fisheries management does not have a policy definition (MPI 2013). Studies have identified areas of importance for spawning and juvenile southern blue whiting where distribution plots highlight hotspot areas for the 0+, 1+, immature, and adult fish

(O'Driscoll & Bagley 2003). These are the Campbell Plateau and Bounty Plateau, with minimal numbers recorded on the Chatham Rise.

5. STOCK ASSESSMENT

An updated assessment of the Campbell Island Rise stock was completed in 2023, using research time series of abundance indices from wide-area acoustic surveys from 1993 to 2022 and proportion-at-age data from the commercial fishery. New information included a wide-area acoustic survey of the Campbell Rise carried out in August–September 2022, which produced a biomass estimate of 91 968 t (Escobar-Flores et al 2023). The general purpose stock assessment program, Casal2 (Casal2 Development Team 2022), was used and the approach, which used Bayesian estimation, was the same as that adopted by Roberts & Hanchet (2019). Roberts & Hanchet (2019) introduced an initial equilibrium age structure in 1960 rather than using a non-equilibrium age structure in 1979 which was used in previous assessments (e.g., Dunn & Hanchet 2017). Therefore, year class strengths were estimated from 1958 (instead of 1977), and the catch history was extended back to 1971, the first year of reported catches (1979 previously, see Table 1). Models incorporating the change introduced by Roberts & Hanchet (2019) produced stable estimates of natural mortality when using Markov chain Monte Carlo (MCMC) methods.

A stock assessment was also completed for the Bounty Plateau stock in 2014 using data up to 2013 from local-area acoustic surveys of aggregations. The general purpose stock assessment program, CASAL (Bull et al 2012) with Bayesian estimation was used. Preliminary model runs did not provide a satisfactory fit to both the high local-area aggregation acoustic biomass estimates observed in 2007–2008 and the lower local-area aggregation biomass estimates observed since 2009. Development of the assessment then focused on evaluating models with different assumptions that allowed a comparison of the extent to which the high biomass and subsequent decline were fitted. However, these have not proven successful, and the stock assessment has been rejected by the Working Group in favour of developing a harvest control rule (HCR). An HCR that would lead to a low risk of the stock falling below the soft limit reference point was developed and used the most recent acoustic index of abundance as an absolute measure of abundance (Doonan 2017). Four further acoustic surveys were completed at the Bounty Plateau from 2014 to 2017, but surveys in 2018, 2019, 2020, 2021, and 2022 were unsuccessful. In 2022 the HCR was updated to take account of gaps in surveys (Doonan 2023). A local-area aggregation acoustic survey was completed in August 2023.

No new assessment is available for the Pukaki Rise stock due to the paucity of useful abundance data. 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.

5.1 Estimates of fishery parameters and abundance indices

(i) Bounty Plateau

Between 1993 and 2001, a series of wide-area acoustic surveys for southern blue whiting were carried out by the RV *Tangaroa*. From 2004 to 2017, a series of local-area aggregation surveys were carried out from industry vessels (O'Driscoll 2015, O'Driscoll & Dunford 2017, O'Driscoll & Ladroit 2017, O'Driscoll 2018). The fishing vessels opportunistically collected acoustic data from the Bounty Plateau fishing grounds using a random survey design over an ad hoc area that encompassed an aggregation of southern blue whiting (O'Driscoll 2015). The local-area aggregation surveys have had mixed levels of success (Table 8).

Acoustic data collected in 2005 could not be used because of inadequate survey design and acoustic interference from the scanning sonar used by the vessel for searching for fish marks. There was some concern that the surveys in 2006 and 2009 may not have sampled the entire aggregation because fish marks extended beyond the area being surveyed on some transects. However, the surveys in 2010–2012 appeared to have sampled the entire aggregation and gave a similar estimate of biomass to that in 2009. The 2013 aggregation survey was higher than the preceding four surveys, but subsequent biomass estimates have declined. Surveys in 2018, 2019, 2020, 2021, and 2022 were unsuccessful and did not produce estimates of abundance principally because surveyable aggregations of fish were not observed during the survey periods. It is likely that the attempted surveys since 2018 were too late for first spawning (the planned timing of the 2020 and 2021 surveys was disrupted by Covid) (e.g., Large et al 2021b).

Table 8: Estimates of biomass (t) for immature and mature fish from wide-area acoustic surveys of the Bounty Plateau from 1993 to 2001 (from Fu et al 2013); and mature fish from local-area aggregation surveys in 2004–2017 and 2023 (O'Driscoll 2015, O'Driscoll & Dunford 2017, O'Driscoll & Ladroit 2017, O'Driscoll 2018 Wieczorek et al in press); and the proportion of catch that occurred before the biomass estimate in each year (based on catch effort data, and sample dates for the acoustic snapshots). Sampling CVs for the surveys are given in parentheses.

	Wide-area survey estimates		Local-area aggregation survey estimates	
Year	Immature	Mature	Mature	Proportion
1993	15 269 (33%)	43 338 (58%)	–	–
1994	7 263 (27%)	17 991 (25%)	–	–
1995	0 (–)	17 945 (24%)	–	–
1997	3 265 (54%)	27 594 (37%)	–	–
1999	344 (37%)	21 956 (75%)	–	–
2001	668 (28%)	11 784 (35%)	–	–
2004	–	–	8 572 (69%)	0.73
2005	–	–	–	–
2006	–	–	11 949 (12%)	0.78
2007	–	–	79 285 (19%)	0.93
2008	–	–	75 889 (34%)	0.68
2009	–	–	16 640 (21%)	0.29
2010	–	–	18 074 (36%)	0.35
2011	–	–	20 990 (28%)	0.89
2012	–	–	16 333 (7%)	0.84
2013	–	–	28 533 (27%)	0.76
2014	–	–	11 852 (31%)	0.75
2015	–	–	6 726 (42%)	0.44
2016	–	–	6 201 (35%)	0.93
2017	–	–	7 719 (24%)	0.61
2023	–	–	12 506 (18%).	0.47

A standardised CPUE analysis was carried out for the Bounty Plateau for data up to 2002. However, the results of this analysis were not consistent with the acoustic survey estimates, and the model structure and assumptions were inadequate to reliably determine the indices or associated variance. The indices were therefore rejected by the Working Group as indices of abundance and have not been used in assessments.

(ii) Campbell Rise

Wide-area acoustic surveys of the Campbell Rise have been carried out from RV *Tangaroa* since 1995, with the most recent survey in August–September 2022 (Escobar-Flores et al 2023). The estimate of mature biomass in 2022 was similar to those from 2019 and 2016, and the 3rd highest in the time series (Table 9).

A standardised CPUE analysis of the Campbell Rise stock was completed up until the 2005 fishing season. 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.

(iii) Pukaki Rise

Wide-area surveys of the Pukaki Rise were carried out between 1993 and 2000 (Fu et al 2013) from RV *Tangaroa*, and more recently (2009 to 2012) local-area aggregation estimates were obtained by industry vessels (Table 10). The biomass estimates from the last two surveys (2010, 2012) were considered too small to be plausible (Table 10).

Table 9: Estimates of biomass (t) for immature and mature fish from wide-area acoustic surveys of the Campbell Rise 1993–2022 (from Escobar-Flores et al 2023). Sampling CVs for the surveys are given in parentheses.

	Wide-area surveys	
Year	**Immature**	**Mature**
1993	35 208 (25%)	16 060 (24%)
1994	8 018 (38%)	72 168 (34%)
1995	15 507 (29%)	53 608 (30%)
1998	6 759 (20%)	91 639 (14%)
2000	1 864 (24%)	71 749 (17%)
2002	247 (76%)	66 034 (68%)
2004	5 617 (16%)	42 236 (35%)
2006	3 423 (24%)	43 843 (32%)
2009	24 479 (26%)	99 521 (27%)
2011	14 454 (17%)	53 299 (22%)
2013	8 004 (55%)	65 801 (25%)
2016	4 456 (19%)	97 117 (16%)
2019	4 020 (18%)	91 145 (27%)
2022	5 356 (22%)	91 968 (20%)

Table 10: Estimates of biomass (t) for immature, adult mix and mature fish from wide-area acoustic surveys of the Pukaki Rise 1993–2000 (from Fu et al 2013 and O'Driscoll 2013) and local-area aggregation surveys from 2009–2012. Sampling CVs for the surveys are given in parentheses.

	Wide-area survey estimates				Local-area aggregation survey estimates		
Year	**Immature**	**Adult mix**	**Mature**	**Vessel**	**Transects**	**Area(km^2)**	**Biomass (%cv)**
1993	9 558 (25%)		26 298 (32%)		–	–	–
1994	125 (100%)	3 591 (48%)	21 506 (44%)		–	–	–
1995	0 (–)		6 552 (18%)		–	–	–
1997	1 866 (12%)		16 862 (34%)		–	–	–
2000	1 868 (62%)	8 363 (74%)	6 960 (37%)		–	–	–
2009			–	*Meridian 1*	4	50	188 (29%)
			–		5	283	9 459 (30%)
			–		5	71	6 272 (41%)
			–	*Aleksandr Buryachenko*	6	60	2 361 (12%)
			–		7	117	7 903 (26%)
			–		6	19	11 321 (38%)
2010			–	*Meridian 1*	10	364	1 085 (17%)
2012			–	*San Waitaki*	–	–	3 272 (21%)

5.2 Biomass estimates

(i) Campbell Rise stock (2023 stock assessment)

The stock assessment model

An updated stock assessment for the Campbell Rise stock was completed for the 2022–23 year (Doonan et al in press).

A two-sex, single stock and area Bayesian statistical catch-at-age model for the Campbell Rise southern blue whiting stock was implemented in Casal2 (Casal2 Development Team 2022). The model partitioned the stock into immature and mature fish with two sexes and age groups 2–15, with a plus group at age 15. The model was run for the years 1960–2022. Five year projections were run for the years 2023–2027. The annual cycle was partitioned into two time steps (Table 11). In the first time step (nominally the non-spawning season), 90% of natural mortality was assumed to have taken place. In the second time step (spawning season), fish matured and were migrated to a spawning area where fish ages were incremented; the 2-year-olds were recruited to the population, and mature fish were subjected to fishing mortality. The remaining 10% of natural mortality was then applied to the entire population following fishing. A two sex model was used because there are significant differences observed between males and females in both the proportions at age in the commercial catch for fished aged 2–4 (see later) and their mean size at age (Hanchet & Dunn 2010). The stock recruitment relationship was assumed to be Beverton-Holt with a steepness of 0.9, with the proportion of males at recruitment (at age 2) assumed to be 0.5 of all recruits.

Southern blue whiting exhibit large interannual differences in growth, presumably caused by local environmental factors but also closely correlated with the occurrence of strong and weak year classes. Hence, an empirical size-at-age matrix was used which was derived by qualitatively reviewing the empirically estimated mean sizes-at-age from the commercial catch-at-length and -age data (Hanchet & Dunn 2010). Missing mean sizes in the matrix were inferred from the relative size of their cohort and the mean growth of similar ages in other years; and cohorts with unusually small or large increments were similarly adjusted. For projections, the mean sizes-at-age were assumed to be equal to the average of the estimated sizes-at-age from 2018 to 2022 (5 years).

In general, southern blue whiting on the Campbell Rise are assumed to be mature when on the fishing ground, because they are spawning when they are fished. Hence, it was assumed that all mature fish were equally selected by fishing, and that no immature fish were selected. The maximum exploitation rate (U_{max}) was assumed to be 0.8. The proportion of immature fish that mature in each year was a logistic ogive (parameters age *A50* and *Ato95*).

The updated model was started in 1960 and assumed an equilibrium age distribution. The model estimated year class strengths back to 1958, which allowed the flexibility to fit to strongly non-equilibrium age composition observed in the commercial trawl catches since 1979. Catches for the Campbell Rise in years 1971–1977 were estimated by assuming the proportion of the catch from all areas taken at the Campbell Rise was equal to the proportion across the period 1978 to 2016–2017, following Roberts & Hanchet (2019) (see Table 12).

Table 11: 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

Table 12: Estimated catches for Campbell Rise from 1971 to 1977 (see Roberts & Hanchet 2019).

Fishing year	Estimated catch (t)
1971	7 260
1972	18 010
1973	33 856
1974	29 458
1975	1 660
1976	11 929
1977	18 453

Observations
The model was fitted to a single time series of acoustic biomass estimates and the catch-at-age data from the fishery; the time series of acoustic biomass estimates came from a wide-area survey series conducted by the research vessel *Tangaroa* for immature and for mature fish. 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 (Table 9).

Catch-at-age observations by sex were available for most years from the commercial fishery for the period 1979 to 2022. These catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age by age were estimated by bootstrap using the NIWA catch-at-age software (Bull & Dunn 2002).

Estimation
Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program Casal2 (Casal2 Development Team 2022). For initial runs only the mode of the joint posterior distribution was estimated. For the final runs presented here, the full posterior distribution was sampled using MCMC methods, based on the Metropolis-Hastings algorithm.

An initial MCMC chain was estimated using a burn-in length of 50 000 iterations, with every 1000th sample taken from the next 3 million iterations (i.e., a final sample of length 3000 was taken from the Bayesian posterior). To improve mixing at MCMC (following the approach of Roberts & Doonan 2016) the covariance matrix was recalculated empirically from the 3000 samples obtained from the initial MCMC chain and the chain started afresh with the new covariance matrix out to a length 3.0×10^6

iterations (no burn in). The initial chain was discarded. Two further chains were started independent of the first kept chain, but with random jumps from the MPD to start the chain.

Equilibrium 'virgin' biomass is equal to the population that there would have been if all the year class strengths (YCSs) were equal to one and there was no fishing. Year class strengths were estimated for all years from 1958 to 2019, under the assumption that the estimates from the model should average one.

Prior distributions and penalty functions

In general, the assumed prior distributions used in the assessment were intended to be non-informative with wide bounds (Table 13). The exceptions to this were the priors and penalties on the mature biomass catchability coefficient and on relative year class strengths. The prior assumed for the relative year class strengths was lognormal, with mean 1.0 and CV 1.3.

For a sensitivity run that estimated natural mortality, natural mortality was parameterised by the average of male and female (assumed to be lognormal with mean 0.2 and CV 0.2), with the difference estimated with an associated normal prior with mean zero and standard deviation 0.05. A sensitivity run that estimated a time-varying maturity A50 used normal priors with means at 3 and 3.23 for males and females respectively and standard deviation 1.5. 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.

Before the 2016 assessment, the log-normal prior for the wide-area acoustic survey catchability coefficient was revised following the adoption of a new target-strength and length relationship for SBW (O'Driscoll et al 2013). The revised prior had a mean of 0.54 and CV of 0.44. The old prior had a mean of 0.87 and a CV of 0.30.

Table 13: The distributions, priors, and bounds assumed for the various parameters being estimated for the Campbell Rise stock assessment.

			Values			Bounds	
Parameter	***N***	**Distribution**	**Mean**	**CV**	**S.D.**	**Lower**	**Upper**
B_0	1	Uniform-log	–	–	–	30 000	800 000
Male maturity *A50*	1	Uniform	–	–	–	0.01	4
Female maturity *A50*	1	Uniform	–	–	–	0.01	4
Male maturity *Ato95*	1	Uniform	–	–	–	0.01	4
Female maturity *Ato95*	1	Uniform	–	–	–	0.01	4
Year class strength	62	Lognormal	1.0	1.3	–	0.001	100
Wide-area catchability mature *q*	1	Lognormal	0.54	0.44	–	0.01	1.5
Wide-area catchability immature *q*	1	Uniform	–	–	–	0.01	1.5
*Natural mortality (average)	1	Lognormal	0.2	0.2	–	0.075	0.325
*Natural mortality (difference)	1	Normal	0.0	–	0.05	-0.05	0.05
§Time varying maturation *A50* male	33	Normal	3.00	–	1.50	0	6
§Time varying maturation *A50* female	33	Normal	3.23	–	1.50	0	6

*Natural mortality was estimated for a sensitivity run
§ Time varying maturation *A50* was estimated for a sensitivity run

Model runs

The Working Group considered a base case and sensitivities. The base case assumed a fixed natural mortality of 0.2 and an equilibrium age distribution in 1960. Sensitivities where only the mode of the joint posterior distribution was estimated were models with alternative assumptions of fixed natural mortality (*M*). Sensitivities taken to MCMC estimation were one estimating *M* and a second that estimated time varying maturation (Table 14).

Lognormal errors, with known CVs, were assumed for the relative biomass indices, and multinomial errors were assumed for the proportions-at-age data. However, the error terms allowed for sampling error only and additional variance, assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. This additional variance, termed process error, was estimated in the initial MPD runs using all the available data and fixed at these values for the MCMCs. Process errors were estimated separately for the proportion-at-age data using the method of Francis (2011) and for the acoustic estimates from the wide-area surveys (but was estimated to be nil for mature biomass at MPD).

Table 14: MCMC model runs, labels, and descriptions.

Model type	Model label	Description
Base case	Base	Model with equilibrium age distribution for the year 1960, YCSs estimated for years 1958–2019, catch history for years 1971–2022, natural mortality equal to 0.20.
Sensitivity	Mfree	Model Bass, but with natural mortality estimated.
Sensitivity	Tvary	Model Base, but with time varying adjustment to maturity from 1990 to 2022.

Results

The estimated MCMC marginal posterior distributions for spawning stock biomass trajectories are shown for the base case model run in Figure 2, and results for both the base model and sensitivities are summarised in Tables 15 and 16. The run suggests that the stock biomass increased above B_0 in the mid-1970s, due to strong year classes in the mid-1960s. This was followed by 20 years of below average recruitment which led to a steep decline in stock biomass. There was a large increase from 1994 to 1996 in response to the very strong 1991 year class. The population then declined until stronger 2006, 2009, and 2011 year classes recruited to the fishery. The 2015 year class is the most recent strong year class, reflected in an increase in biomass between 2018 and 2020. Exploitation rates and relative year class strengths (in terms of the year each age class entered the model at age 2) are shown in Figure 3. Estimates of the adult acoustic *q* and *M* are given in Table 16.

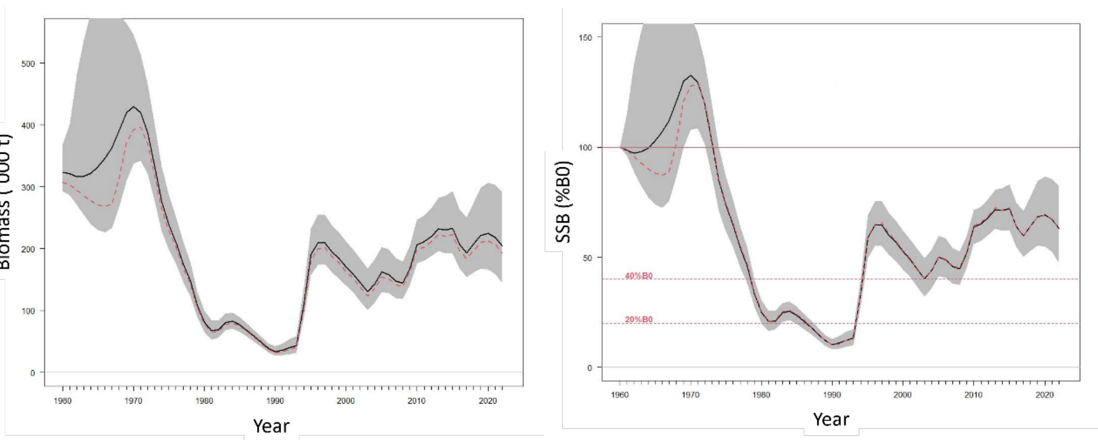


Figure 2: MCMC posterior plots of the trajectories of biomass (left) and current stock status (% B_{2022}/B_0) (right) for the Campbell Rise stock for the base case model. The shaded regions are the 95% credible intervals and the red dashed line shows the MPD result. In the right hand plot, the red dotted lines show the target (40%B₀) and soft limit (20% B₀).

Table 15: Bayesian median and 95% credible intervals of equilibrium (B_0) and current biomass (% B_0) for the base and sensitivities.

Model	B_0 (`000 t)	B_{2022} (% B_0)
Base	323 (292–369)	63 (47–82)
Mfree	319 (294–365)	58 (41–79)
Tvary	345 (310–400)	57 (42–74)

Table 16: Bayesian median and 95% credible intervals of the catchability coefficients (*q*) and natural mortality parameters for the wide-area acoustic biomass indices for the base case model run and the sensitivity cases.

	Catchability		Natural mortality	
Model	Immature	Mature	Male	Female
Base	0.23 (0.20–0.28)	0.41 (0.33–0.49)	–	–
Mfree	0.29 (0.19–0.40)	0.48 (0.34–0.62)	0.19 (0.15–0.24)	0.17 (0.13–0.21)
Tvary	0.30 (0.25–0.37)	0.39 (0.32–0.47)	–	–

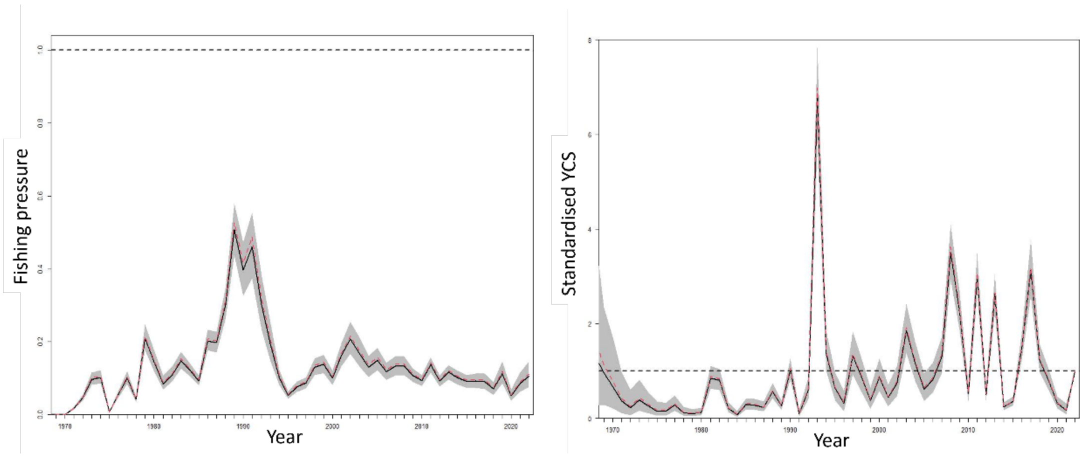


Figure 3: Estimated posterior distributions of exploitation rates (left) and relative year class strength (right) for the Campbell Rise stock for the base case model. The red dashed line in each plot shows the MPD result. Year is model year that fish enter the population at age 2.

Projections were made assuming fixed catch levels of 18 200 t (average of catches in 2020–21 to 2022–23) and 39 200 t (TACC) for the years 2023 to 2027. Projections were made using the MCMC samples, with recruitments drawn randomly from the distribution of year class strengths for the period 1960–2021 estimated by the model and applied from year 2022 onwards. An alternative recruitment distribution used estimated YCS from 2012 to 2021. For projections, the mean sizes-at-age were assumed to be equal to those from the final year of estimates (2022). This gave four scenarios.

For each scenario, the probability that the mid-season biomass for the specified year will be less than the soft limit (20% B_0) is given in Table 17. The probability of dropping below the soft limit at annual catch levels of 18 200 t is between 0 and 1% depending on recruitment distribution. Under both recruitment conditions the % B_0 is expected to decline then increase again slightly over the next 5 years but remain above the soft limit. However, if catches are at 39 200 t (TACC), then there is a 22 to 33% chance that the biomass is below the soft limit by 2027–2028 depending on recruitment conditions.

Table 17: Probability that the projected mid-season vulnerable biomass for 2022–2027 will be greater or equal to 40% B_0, less than 20% B_0, less than 10% B_0, and the median projected biomass (% B_0), at a projected catch of 18 200 t or 39 200 t, for the base case model assuming average recruitment over the period 1960–2021 for 2022+, and assuming recruitment from 2012–2021.

						Fishing year
	2022–23	2023–24	2024–25	2025–26	2026–27	2027–28
Catch 39 200 t + YCS 1960– 2021						
Median *SSB* (% *Bo*)	58	50	42	37	32	29
%[*SSB* >= 40% *Bo*]	99	83	57	43	36	33
%[*SSB* < 20% Bo]	0	0	1	11	24	33
%[*SSB* < 10% *Bo*]	0	0	0	1	6	15
Catch 39 200 t + YCS 2012– 2021						
Median *SSB* (% *Bo*)	59	52	46	42	39	36
%[*SSB* >= 40% *Bo*]	99	86	65	54	48	43
%[*SSB* < 20% Bo]	0	0	1	8	16	22
%[*SSB* < 10% *Bo*]	0	0	0	1	4	9
Catch 18 200 t + YCS 1960– 2021						
Median *SSB* (% *Bo*)	61	58	55	53	53	54
%[*SSB* >= 40% *Bo*]	100	98	92	83	78	77
%[*SSB* < 20% Bo]	0	0	0	0	0	1
%[*SSB* < 10% *Bo*]	0	0	0	0	0	0
Catch 18 200 t + YCS 2012– 2021						
Median *SSB* (% *Bo*)	62	60	59	59	59	61
%[*SSB* >= 40% *Bo*]	100	98	93	88	85	85
%[*SSB* < 20% Bo]	0	0	0	0	0	0
%[*SSB* < 10% *Bo*]	0	0	0	0	0	0

(ii) Bounty Plateau stock

A stock assessment for the Bounty Plateau stock was completed for 2014 (Dunn et al 2015). Preliminary model runs did not provide a satisfactory fit to both the high local-area aggregation acoustic biomass estimates observed in 2007–2008 and the lower local-area aggregation biomass estimates observed since 2009. Development of the assessment then focused on evaluating models with different assumptions that allowed a comparison of the extent to which the high biomass and subsequent decline were fitted. However, these have not proven successful, and the stock assessment was rejected by the Working Group and a harvest control rule was developed.

Development of harvest control rules (HCRs)

HCR2017

An HCR that would lead to a low risk of the stock falling below the soft limit reference point was developed and assumed that the most recent acoustic index was an absolute measure of abundance. This assumption was considered reasonable and conservative. In the HCR, risk was defined as the probability of the spawning stock biomass *(SSB)* being below 20% SSB_0 (the soft limit). HCR_{2017} is given by $TAC_{t+1} = p\ (B_t - C_t/ 2)$, where B_t is acoustic abundance, C_t is catch, and p is a fixed proportion.

Results of simulations for different levels of harvest (p) and assumptions of natural mortality are given in Table 18 (Doonan 2017).

HCR_{2017} for SBW 6B was applied using the abundance estimate from the industry acoustic survey completed in the 2017 fishing season (O'Driscoll 2018). HCR_{2017} depends on the values of natural mortality, *M,* and steepness, *h*, and these were specified by Fisheries New Zealand to be 0.2 y^{-1} and 0.9, respectively. HCR_{2017} gave a yield for the 2018 fishing season of 3209 t (Doonan 2018). This yield assumes that there will not be a very large cohort entering the mature population. No further work was conducted to develop or explore assumptions underlying the HCR_{2017}, e.g., what procedures should be undertaken to detect and respond to another very large recruitment event (which is excluded from the HCR_{2017}), or, whether HCR_{2017} is more robust if it is based on the end-of-year biomass rather than that at the start of the fishing season.

Table 18: Case-2: Risk for a combination of natural mortality, and levels of harvest (*p* values) with steepness, *h*, set to 0.90 and survey process CV at 0% (probability of SSB_0 being below 0.20 B_0 over a 120-year projection). Risk is the probability of SSB_0 being below 0.2 B_0 over a 120-year projection. Mean over 2 runs. Standard simulation error was about 0.0025. Acceptable risks are below the thick black border.

					p
M	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**
0.10	0.037	0.151	0.305	0.460	0.589
0.15	0.010	0.053	0.131	0.229	0.332
0.20	0.003	0.021	0.058	0.113	0.180
0.25	0.002	0.012	0.035	0.070	0.117
0.30	0.001	0.007	0.020	0.042	0.071

HCR_{2017} was adapted to take into account the effect of missing surveys on the risk of the probability of *SSB* being below 20% SSB_0, creating HCR_{2022} (Doonan 2023). The analysis was similar to that used for the HCR_{2017} (Doonan 2017) which is based on simulations. Note that all simulations assumed that the TAC was fully taken in each year.

The HCR_{2022} is based on the acoustic survey completed in year *t*. The TAC for the following year is given by HCR_{2017}, i.e., $TAC_{t+1} = p\ (B_t - C_t/ 2)$. However, if an acoustic survey is not completed in year *t*+1 (the first "gap year") or subsequent years, the TAC for year *t*+2 onwards is calculated by adjusting TAC_{t+1} with a series of factors, D1 for the first gap year (TAC for year *t+2*), D1 * D2 for the second gap year to give the TAC for year *t+3*, D1*D2*D3 for the third gap year to give the TAC for year *t+4*, and so on. By definition, the D factors are less than or equal to one.

Because the actual gap length is not known when applying HCR_{2022} in a particular year, the simulations were done in a nested way to maintain the risk at its target level as the gap gets bigger. For the gap size of one year, simulations were first run with surveys every 2^{nd} year so that D1 could be established, i.e., a repetitive grid of one-year gaps. Then simulations were run using surveys every three years (2-year gap) using the estimated D1 from above to find the value of the D2 factor. This was repeated until surveys were done every 5 years (4-year gap), to establish the value of D4. It was found that the D factors converged in value from D3. Table 19 shows the result out to a gap of 4 years; the converged value for larger gaps is 0.83. Table 20 shows how the Bounty Plateau TAC from 2018 would be adjusted given the current gap in survey data.

Table 19: M = 0.2, h = 0.9: Auxiliary discount factors (D_j) to apply to the TAC_{t+1} derived from the acoustic survey in year t, using HCR_{2022} ($p\,(Bc_t - C_t/2)$) following 1 or more gap years (years with no surveys). $TAC_{t+1+gap} = \prod_{j=1}^{gap} D_j TAC_{t+1} = \prod_{j=1}^{gap} D_j\ p\,(Bc_t - C_t/2) = k1_{t+1+gap}(Bc_t - C_t/2)$. where $k1_{t+1+gap} = p \prod_{j=1}^{gap} D_j$.

TAC for Year	Gap	p	D1	D2	D3	D4	$k1_{t+1+gap}$
t+1	0	0.235	-	-	-	-	0.24
t+2	1	0.235	0.87	-	-	-	0.20
t+3	2	0.235	0.87	0.86	-	-	0.18
t+4	3	0.235	0.87	0.86	0.828	-	0.15
t+5	4	0.235	0.87	0.86	0.828	0.83	0.12

Table 20: An example of HCR_{2022} in use over the current gap (2018 to 2022) using the 2018 TAC of 3209 t as the starting point. Note the TACC is adjusted down from the TAC to account for bycatch in non-target fisheries.

Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Gap size at calculation time		1	2	3	4	5
TAC (t)	3 209	2 792	2 401	1 993	1 654	1 373
D_i		0.87	0.86	0.83	0.83	0.83

Application of the HCR for 2024

There was a successful survey in 2023 and so the HCR to use is HCR_{2017} (Doonan 2017).

The FV *Tomi Maru 87* completed two snapshots on a spawning aggregation on 18 and 20 September 2023 (Wieczorek et al in press). The biomass estimates were 14 452 t (CV 29%) and 10 561 t (CV 24%). We used the mean of these two values for the HCR 12 506 t (CV 18 %).

The total catch was 2010 t and catch up to up to the 19 September (taken as the survey time) was 947.8 t. Hence, B_t is (12 506)/0.6 + 947.8 t = 21 791 t. The TAC for 2024 is 0.24 * (21 791 – 2010/2) = 4988 t. For the TACC, some catch will be taken off for bycatch in other fisheries.

(ii) Pukaki Rise stock

An assessment of the Pukaki Rise stock was carried out in 2002. The age structured separable Sequential Population Analysis (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 21, which differ from those in Table 10 because they were calculated with an older estimate of target strength and sound absorption. 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 22. 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 22.

Biomass estimates in the initial run, and 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 Working Group did not accept this initial run as a base case assessment but agreed to present a range of possible biomass estimates. The Plenary agreed to present a range, based on assumptions concerning the likely range of the value for the acoustic q.

Table 21: RV *Tangaroa* age 2, 3, and 4+ acoustic biomass estimates (t) for the Pukaki Rise used in the 2002 assessment. Estimates differ from those in Table 10 because they were calculated with old estimates of target strength and sound absorption.

Year	Age 1	Age 2	Age 3	Age 4+
1993	578	26 848	9 315	31 152
1994	13	1 193	6 364	35 969
1995	0	102	775	11 743
1997	22	2 838	864	34 086
2000	58	7 268	5 577	24 931

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 23, Figure 4). 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.

Table 22: 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

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.

An assessment was planned for the Pukaki Rise stock in 2014 but the Working Group did not accept that the 2012 acoustic survey provided an acceptably realistic biomass estimate for the stock, so an assessment was not possible.

Table 23: 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 × 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 Shelf 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.

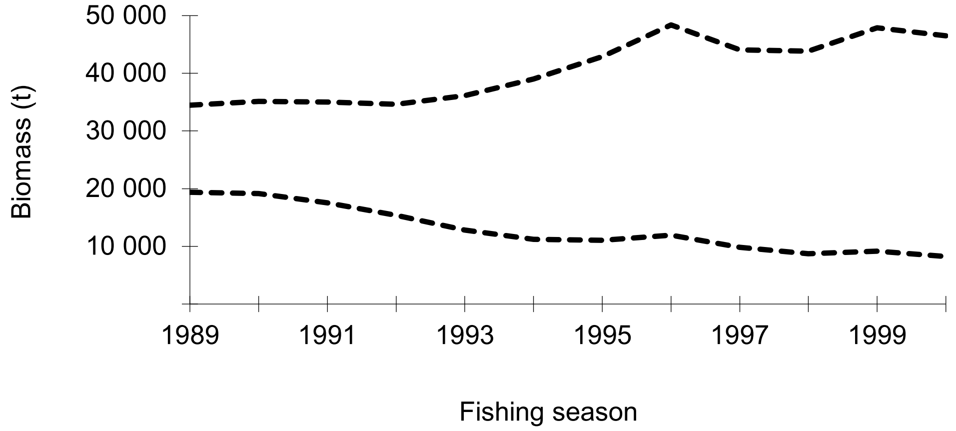


Figure 4: Mid-season spawning stock biomass trajectory bounds for the Pukaki Rise stock. Bounds based on acoustic *q* of 0.65 and 2.8.

6. FUTURE RESEARCH CONSIDERATIONS

- For Campbell Rise southern blue whiting, a candidate for further research or investigation would be to determine how to best represent mean weights-at-age in the projections given the negative relationship between year class strength and growth.
- For the Pukaki Rise, the Sub-Antarctic trawl surveys may provide an index of abundance for this stock, but this has yet to be determined.
- Future updates of the HCR for the Bounty Plateau stock could account for catch being above or below the TACC. This may require a bespoke simulation that adjusts the Di factor values to explicitly evaluate the risk given the observed sequence of catches. Alternatively, a more generic approach in which the TACC is only 50% caught in gap years could be considered.
- Explicit allowance within the HCR for a minimum catch for surveys should also be evaluated; this would require a revised simulation approach because risk is currently estimated without reference to absolute catch levels.

As more information becomes available, especially from future surveys or stock assessments, the performance of the HCR in constraining *F* should be evaluated and reported.

7. 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 and some differences in biological parameters and morphometrics between these areas (Hanchet 1999).

The four main stocks SBW 6A (Auckland Islands Shelf), SBW 6B (Bounty Plateau), SBW 6I (Campbell Rise), and SBW 6R (Pukaki Rise) cover the four main bathymetric features in the Sub-Antarctic QMA6. SBW 1 covers the rest of the New Zealand EEZ where small numbers of fish may occasionally be taken as bycatch.

- **Auckland Islands Shelf (SBW 6A)**

Stock Status		
Most Recent Assessment Plenary Publication Year	-	
Catch in most recent year of assessment	Year: -	Catch: -
Assessment Runs Presented	-	
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0	

	Hard Limit: 10% B_0 Overfishing threshold: -
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status
-

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Catches have fluctuated without 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 was dominated by large (40–50 cm long) fish - no sign of recent strong year classes.

Projections and Prognosis	
Stock Projections or Prognosis	-
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	-

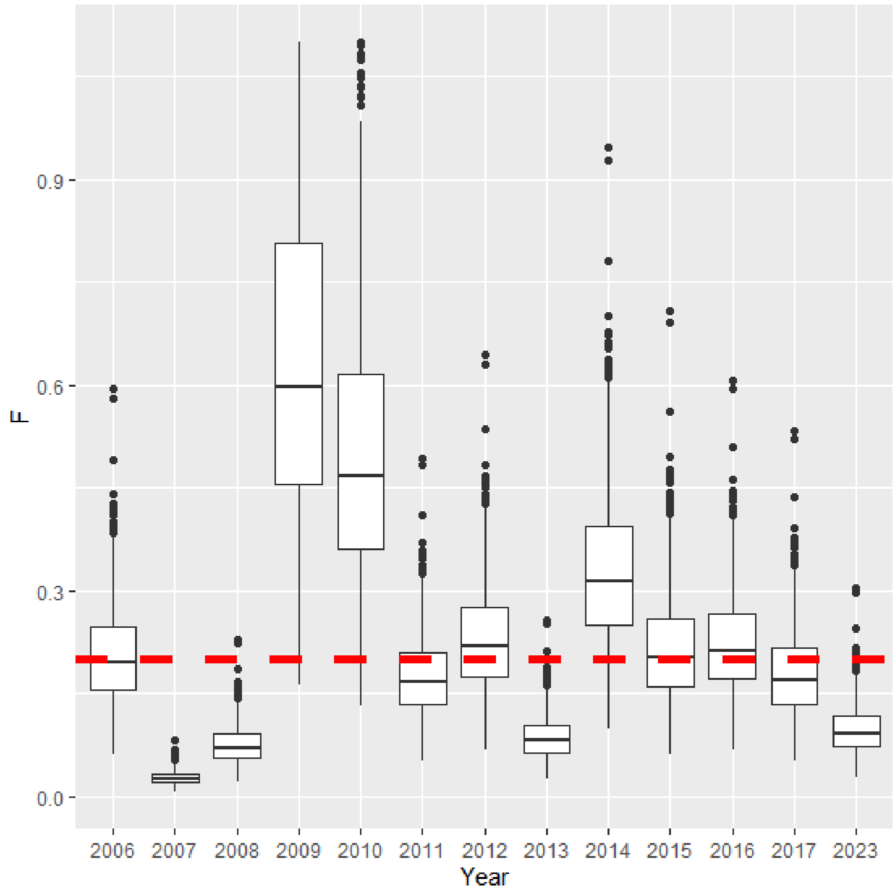
Assessment Methodology		
Assessment Type	Level 4: Low information	
Assessment Method	None	
Assessment Dates	Latest assessment Plenary publication year: -	Next assessment: Unknown
Overall assessment quality rank	-	
Main data inputs	- Catch history - erratic catches with no trend Limited catch-at-age data (1993–1998) and 2008	
Data not used (rank)	-	
Changes to Model Structure and Assumptions	-	
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. Catches will probably remain low until another strong year class enters the fishery.

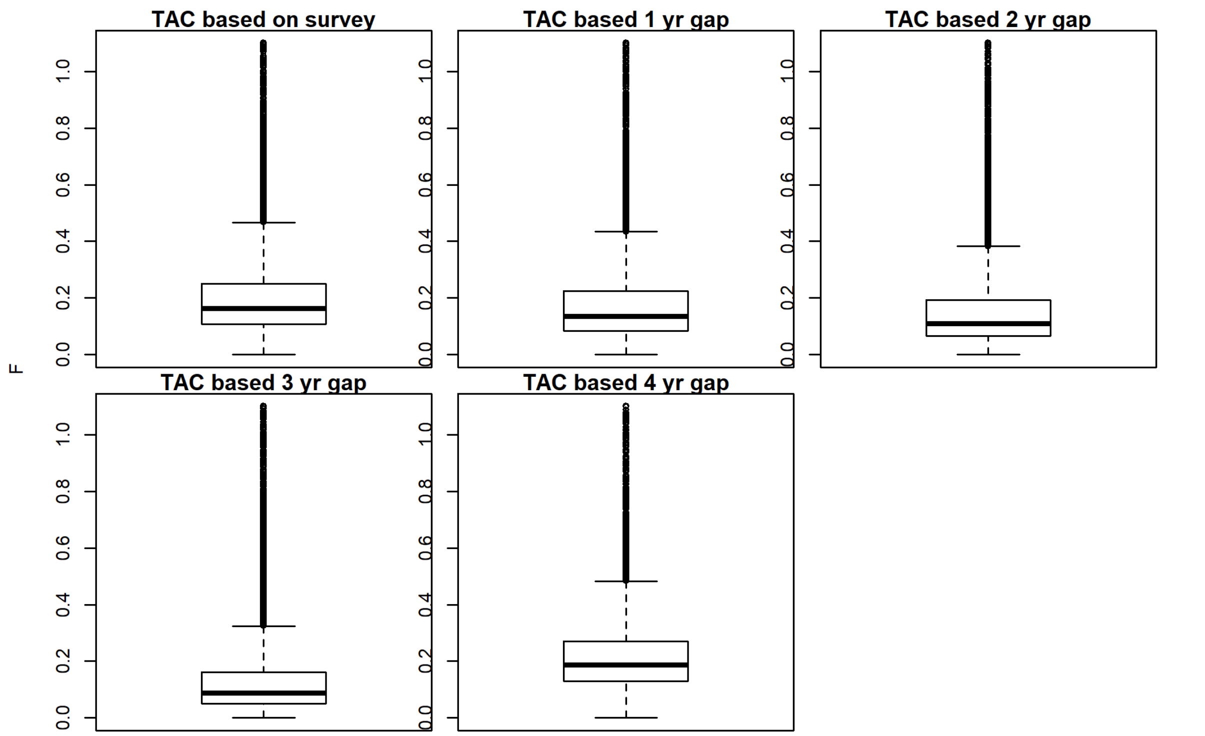
Fishery Interactions
Fish bycatch is low in the SBW target fishery. There are some interactions with New Zealand sea lions and seabirds.

- **Bounty Plateau (SBW 6B)**

Stock Status		
Most Recent Assessment Plenary Publication Year	2024	
Catch in most recent year of assessment	Year: 2022–23 (April fishing year)	Catch: 125 t
Assessment Runs Presented	Harvest control rule simulations	
Reference Points	Management Target: A fishing mortality rate calculated from the harvest control rule Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: A fishing mortality rate calculated from the harvest control rule	
Status in relation to Target	Likely (> 60%) to be below the target threshold *F*	
Status in relation to Limits	Unknown	
Status in relation to Overfishing	Overfishing is Unlikely (< 40%) to be occurring	



***F* distribution using historical data and the *q*-prior used in the simulations. Dashed red line is at the agreed target of 0.2 (i.e., *M*).**



***F* distribution from years 50 to 120, for years that had their TAC determined by a survey the previous year, using the adjustment, for a gap of 1 yr, and similarly for 2, 3, and 4 yr adjustments.**

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Intensity or Proxy	Fishing mortality is likely to have fluctuated around the target threshold *F* in recent years, but it is likely to be lower for 2023. Catches prior to 2023 season have been less than the levels indicated in HCR_{2022}.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	The 2007, 2012 and 2018 year classes appear to be above average.

Projections and Prognosis	
Stock Projections or Prognosis	With TACCs updated in line with HCR_{2017}, *F* is likely to remain relatively stable and remain at or below the target threshold.
Probability of Current Catch or TACC causing Biomass to remain below, or to decline below, Limits	Soft Limit: Unknown Hard Limit: Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Assuming the TACC is set in line with HCR_{2017} results, the TACC is unlikely (< 40%) to cause overfishing.

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Partial Quantitative Stock Assessment	
Assessment Method	Harvest Control Rule based on simulations of an age structured model	
Assessment Dates	Latest assessment Plenary publication year: 2024	Next assessment: 2026
Overall assessment quality rank	2 – Medium Quality	
Main data inputs (rank)	- Acoustic abundance indices from local-area aggregation surveys - Estimates of biological parameters	2 – Medium or Mixed Quality (uncertainty in the proportion of the spawning aggregation covered by the surveys) 1 – High Quality

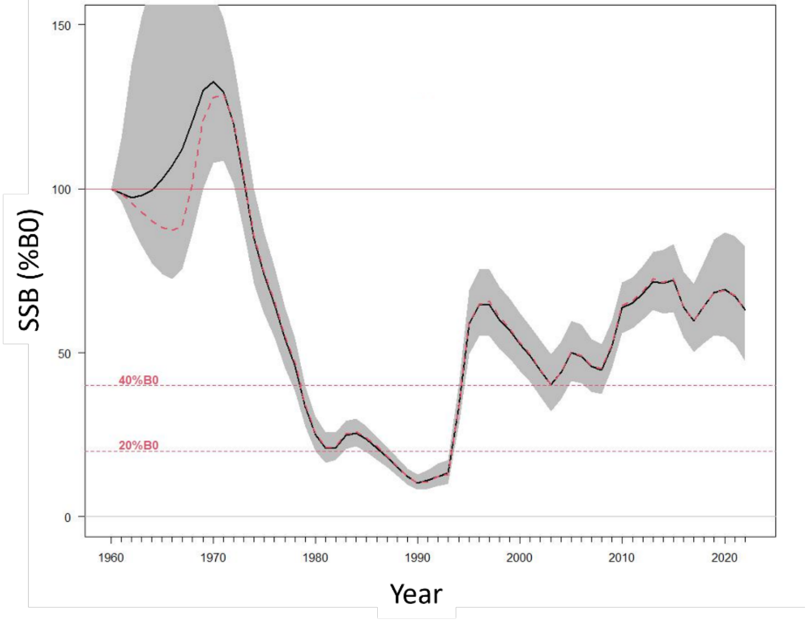
	- Estimates of acoustic target strength	1 – High Quality
Data not used (rank)	- Wide-area acoustic abundance indices - Proportions-at-age data from the commercial fisheries and trawl surveys	1 – High Quality 1 – High Quality
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- The proportion of the spawning biomass that is indexed by the local-area aggregation survey in each year is variable and uncertain. - Estimates of fishing mortality assume the catchability coefficient of the acoustic biomass estimates is known.	

Qualifying Comments
Three surveys from 2014 to 2016 showed a progressive decline in stock biomass to low levels but a slight increase in 2017. Acoustic surveys in 2018, 2019, 2020, 2021, and 2022 were unsuccessful and did not produce indices of abundance. The stock biomass in 2023 was at the same level as 2014.

Fishery Interactions
There is relatively low non-target catch in this fishery. Protected species interactions have been recorded for New Zealand fur seals and seabirds. Southern blue whiting is caught using midwater trawl gear, which sometimes interact with benthic habitats.

- **Campbell Rise (SBW 6I)**

Stock Status		
Most Recent Assessment Plenary Publication Year	2024	
Catch in most recent year of assessment	Year: 2022–23 (April fishing year)	Catch: 22 985 t
Assessment Runs Presented	Base case stock assessment model	
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{40\% B0}$	
Status in relation to Target	B_{2022} was estimated at 64% B_0 and is Very Likely (> 90%) to be at or above the target	
Status in relation to Limits	B_{2022} is Exceptionally Unlikely (< 1%) to be below soft or hard limits	
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring	

Historical Stock Status Trajectory and Current Status

Trajectory over time of spawning biomass (%B_0) for the Campbell Rise southern blue whiting stock from the start of the assessment period in 1960 to 2022. The red horizontal lines show the management target (40% B_0) and the soft limit (20% B_0). Biomass estimates are based on Base case MCMC results.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	With strong recent recruitment the biomass has increased well above the management target.
Recent Trend in Fishing Intensity or Proxy	Fishing pressure has declined with the increase in stock size.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	The 2006, 2009, 2011 and 2015 year classes appear to be very strong, but not as strong as the 1991 year class.

Projections and Prognosis	
Stock Projections or Prognosis	The biomass of the Campbell Rise stock would be expected to decrease over the next 1–5 years if catches are at the TACC (39 200 t). At current catches (18 200 t), the biomass should remain above the target (40% B_0) until 2027–28.
Probability of Current Catch or TACC causing Biomass to remain below, or to decline below, Limits	At the current catch: Soft Limit: Exceptionally Unlikely (< 1%) over next 5 years Hard Limit: Exceptionally Unlikely (< 1%) over next 5 years At the TACC: Soft Limit: Very Unlikely (< 10%) over next 3 years Hard Limit: Very Unlikely (< 10%) over next 3 years
Probability of Current Catch or TACC causing Overfishing to continue or commence	At the current catch: Very Unlikely (< 10%) At the TACC: Unlikely (< 40%)

Assessment Methodology		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Age-structured Casal2 model with Bayesian estimation of posterior distributions	
Assessment Dates	Latest assessment Plenary publication year: 2024	Next assessment: 2026
Overall assessment quality rank	1 – High Quality	

Main data inputs (rank)	- Research time series based on acoustic indices - Proportions-at-age data from the commercial fisheries and trawl surveys - Estimates of biological parameters	1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)	- Commercial CPUE	3 – Low Quality: does not track stock biomass
Changes to Model Structure and Assumptions	- The modelling framework was changed from CASAL to Casal2. - Maturity now modelled in terms of *A50* (previously proportion maturing at ages 2 to 4)	
Major Sources of Uncertainty	- Uncertainty about the size of future age classes affects the reliability of stock projections - Future mean weight at age in the projections	

Qualifying Comments
Recent catches have been consistently less than the TACC and there are no indications that the fishery is likely to change in the next few years.

Fishery Interactions
There is relatively low non-target catch in this fishery. Protected species interactions have been recorded for New Zealand sea lions, New Zealand fur seals, and seabirds. Southern blue whiting is caught using midwater trawl gear, which sometimes interacts with benthic habitats.

- **Pukaki Rise (SBW 6R)**

Stock Status		
Most Recent Assessment Plenary Publication Year	2002	
Catch in most recent year of assessment	Year: 2001–02 (April fishing year)	Catch: 230 t
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 Overfishing threshold: -	
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	
Status in relation to Overfishing	-	

Historical Stock Status Trajectory and Current Status
-

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Catches over the last 10 years have fluctuated without trend.
Recent Trend in Fishing Intensity 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 Biomass to remain below or to decline below Limits	Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	-

Assessment Methodology		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Age structured separable Sequential Population Analysis (sSPA) with maximum likelihood estimation	
Assessment Dates	Latest assessment Plenary publication year: 2002	Next assessment: Unknown
Overall assessment quality rank	-	
Main data inputs (rank)	- Abundance indices from wide-area acoustic surveys - Catch-at-age data	
Data not used (rank)	-	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	The adult acoustic *q* was estimated in the model to be 2.7 which the Working Group 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
The Sub-Antarctic trawl surveys may provide an index of abundance for this stock, but this has yet to be determined.

Fishery Interactions
There is relatively low non-target catch in this fishery. Protected species interactions and interactions with benthic habitats are negligible.

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