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Stock assessments of hoki, hake and ling using alternative catch histories

New Zealand Fisheries Assessment Report 2018/14

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EXECUTIVE SUMMARY

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Alternative catch histories (versions 42, 43 and 44) derived from Sea Around Us databases suggest that under-reported catches were considerable for some New Zealand fishstocks. Estimated discards (and other forms of catch under-reporting) are often but not always taken into account in New Zealand stock assessments. To examine the implications of this postulated under-reporting, additional assessments of hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*) and ling (*Genypterus blacodes*) stocks were completed using three alternative catch histories. The assessments were for both hoki stocks (HOK 1 east, HOK 1 west), the three hake biological stocks (HAK 1 Sub-Antarctic, HAK 4 Chatham Rise, HAK 7 west coast South Island (WCSI)), and the three largest ling biological stocks (LIN 3&4 Chatham Rise, LIN 5&6 Sub-Antarctic, LIN 7 WCSI).

For hoki, the alternative catch histories were generally higher than the catches used in the base model. Relative to the base model the estimated virgin and current absolute biomasses and the current fishing intensities were estimated to be slightly higher when using the alternative catch histories; however, the trends in the current $\%B_0$ were virtually identical for the base model and all alternative models. For the base model, the eastern stock current $\%B_0$ was estimated to be 60% B_0, and for the alternative catch histories 58–59% B_0. For the western stock current biomass was estimated to be 59% B_0 for the base model, and for the alternative catch histories 55–57% B_0.

For hake, the alternative catch histories were higher than the base catches in all but two years (1990 and 1991). Relative to the base models, the estimated virgin and current biomasses were slightly higher when using catch versions 43 and 44, and much higher when using version 42. The estimates of current stock status (current $\%B_0$) were however more similar to those from the base models, particularly for Chatham Rise hake (HAK 4). Only the current $\%B_0$ for Sub-Antarctic hake (HAK 1) with catch version 42 differed from the base model value by more than 5% of B_0. Catch history version 42 is considered to be unrealistically high, due to the resulting extremely low values of q (the estimated catchability coefficient for trawl surveys for hake and other species), which are not credible.

For ling, the alternative catch histories were generally higher than the base, except for the late 1970s and early 1980s when catches were higher in the base models. Relative to the base models, the estimated virgin and current biomasses tended to be slightly higher when using the alternative catch histories; in the reported model runs B_0 was up to 24% higher, and current biomass was up to 36% higher. However, the estimates of current stock status (current $\%B_0$) were similar to those from the base models.

1. INTRODUCTION

Under-reported catches (comprising fish that were discarded or lost at sea, or landed but not reported) are often but not always taken into account in New Zealand stock assessments. When they are not incorporated, there could be some implications for assessed stock sizes and past fishing intensity estimates. A recent report (Simmons et al. 2016) claimed that the actual catch from all New Zealand fisheries combined was about 2.7 times the amount reported to the FAO on behalf of New Zealand for the period 1950–2010, and at least 2.1 times the amount reported since the introduction of the Quota Management System (QMS) in 1986.

The work presented here comprises additional assessments runs for hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*) and ling (*Genypterus blacodes*) stocks, using alternative catch histories derived from Sea Around Us (SAU, www.seaaroundus.org) databases v42, v43 and v44, which were all constructed based on information supplied by Simmons and colleagues. The assessments are for both hoki stocks (HOK 1 east, HOK 1 west), the three hake biological stocks (HAK 1 Sub-Antarctic, HAK 4 Chatham Rise, HAK 7 west coast South Island (WCSI)), and the three largest ling biological stocks (LIN 3&4 Chatham Rise, LIN 5&6 Sub-Antarctic, LIN 7 WCSI).

This report fulfils part of the the objectives of Project DEE2016-09 "To update the stock assessment of hake, including biomass estimates and sustainable yields", and Project DEE2016-10 "To update the stock assessment of ling, including biomass estimates and sustainable yields", funded by the Ministry for Primary Industries (MPI). Those projects required that the base case assessment models for each of stocks HAK 4, HAK 7, and LIN 7 be run using alternative catch histories provided by MPI from the SAU databases. Additional work for HOK 1 east, HOK 1 west, HAK 1, LIN 3&4, and LIN 5&6 was funded by MPI under Project SEA2017-01.

2. METHODS

The stock assessments for all species and stocks were Bayesian assessments implemented using the general-purpose stock assessment programme CASAL v2.30 (Bull et al. 2012). Estimates are provided of biomass trajectories, stock status trajectories, and fishing intensities (catch divided by vulnerable biomass) by year. For hoki fishing intensities are measured as catch in numbers divided by the number of fish in the population immediately before the first fishery of the year.

Catch histories were provided by MPI (P. Mace, pers. comm.) and were extracted from SAU databases v42, v43 and v44 (Table 1). These versions had total catches for the entire New Zealand region by species to 2010 for v42 and v43, and to 2013 for v44. To extrapolate catches to more recent years, for v42 and v43, the average "under-reporting ratio" (i.e., version catch:Plenary catch) for 2008–2010 was used, and for v44, the average "under-reporting ratio" for 2011–2013 was used. Subsequently, it was also necessary to prorate between stocks (and fisheries within stocks) of each species using historical ratios for each year (i.e., for each year, the total catch from each of the SAU versions was apportioned amongst stocks in the same ratio as in catch histories developed for previous assessments of these stocks). Alternative catch histories by species-stock are presented in the Results section below.

The assessment models that were re-run with each of the alternative catch histories were the base case models from the most recently reported assessments of each species-stock. These models have been described in full in the following documents: HOK 1 (McKenzie 2018), HAK 1 (Horn 2015), HAK 4 and HAK 7 (Horn 2017), LIN 3&4 (McGregor 2015), LIN 5&6 (Roberts 2016), and LIN 7 (Dunn & Ballara 2018). Unless stated in the species-specific sections below, the catch history and the range of years that the model included were the only changes (relative to the base model) that were made in the re-run models.

Table 1: Catch histories for hoki, hake and ling, for the New Zealand region, from the three versions of the SAU database (v42, v43 and v44), and as presented in Ministry for Primary Industries (2017) plenary based on QMS reports, and used in stock assessment. Values in bold have been derived, see text for details.

Year	Hoki				Hake				Ling			
	Plenary	**v 42**	**v 43**	**v 44**	**Plenary**	**v 42**	**v 43**	**v 44**	**Plenary**	**v 42**	**v 43**	**v 44**
1950	0	4 036	0	0	0	4 036	0	0	0	977	1 052	1 052
1951	0	4 019	0	0	0	4 019	0	0	0	575	680	680
1952	0	4 139	0	0	0	4 139	0	0	0	773	712	712
1953	0	4 209	34	34	0	4 209	148.0	148.0	0	568	654	654
1954	0	4 943	50	50	0	4 943	0.6	0.6	0	667	668	668
1955	0	4 790	140	140	0	4 596	0	0	0	388	482	482
1956	0	5 566	132	132	0	5 330	0	0	0	471	402	402
1957	0	5 799	124	124	0	5 558	0	0	0	481	472	472
1958	0	4 912	92	92	0	4 912	0	0	0	643	528	528
1959	0	6 601	154	154	0	6 341	0.4	0.4	0	780	472	472
1960	0	6 939	170	170	0	6 939	0.5	0.5	0	448	524	524
1961	0	5 793	220	220	0	5 793	0.9	0.9	0	554	588	588
1962	0	5 524	300	300	0	5 524	2.4	2.4	0	560	536	536
1963	0	5 768	252	252	0	5 768	1.4	1.4	0	573	512	512
1964	0	6 440	252	252	0	6 207	2.4	2.4	0	698	546	546
1965	0	6 910	272	272	0	6 682	16.8	16.8	0	685	508	508
1966	0	7 880	294	294	0	7 655	1.0	1.0	0	450	462	462
1967	0	8 268	140	140	0	8 051	0	0	0	433	406	406
1968	0	10 630	110	110	0	10 350	0	0	0	560	406	406
1969	0	10 120	190	190	0	10 119	0	0	0	638	488	488
1970	0	11 924	828	828	0	11 618	0	0	0	921	610	610
1971	0	14 490	822	822	0	14 152	0	0	0	1 014	628	628
1972	9 000	19 948	17 872	17 872	0	19 948	0	0	0	1 642	1 252	1 252
1973	9 000	21 799	17 316	17 316	0	21 281	236	236	945	2 077	3 160	3 160
1974	11 000	26 622	31 970	31 970	0	25 863	254	254	1 776	2 606	2 376	2 376
1975	46 000	20 678	82 220	82 220	382	20 361	764	764	11 899	2 487	7 878	7 878

Table 1 ctd.

Year	Hoki				Hake				Ling			
	Plenary	**v 42**	**v 43**	**v 44**	**Plenary**	**v 42**	**v 43**	**v 44**	**Plenary**	**v 42**	**v 43**	**v 44**
1976	67 000	31 906	133 544	133 544	5 774	30 916	11 548	11 548	26 218	3 123	12 024	12 024
1977	98 000	53 536	202 245	201 734	19 466	42 546	38 932	38 932	35 091	4 684	12 434	12 434
1978	8 000	26 694	20 945	20 457	1 294	19 948	2 588	2 588	13 011	2 101	7 604	7 604
1979	24 000	45 487	49 356	49 336	5 710	26 536	11 420	11 420	10 663	3 238	15 280	15 280
1980	28 000	47 965	55 440	55 439	4 700	26 688	9 544	9 544	7 921	2 763	13 382	13 382
1981	33 000	61 088	65 609	65 609	3 834	31 995	7 668	7 668	6 258	4 665	13 480	13 480
1982	32 000	62 866	58 223	58 223	2 400	31 656	4 364	4 364	5 205	6 156	10 798	10 798
1983	40 000	75 811	66 902	66 902	1 495	37 147	2 432	2 432	6 274	7 607	9 930	9 930
1984	50 000	93 480	78 138	78 128	2 011	44 083	3 094	3 094	7 696	8 072	11 840	11 840
1985	44 000	75 830	62 397	62 397	2 034	38 405	2 906	2 906	6 953	7 205	9 933	9 933
1986	99 000	126 003	133 023	133 019	3 098	44 773	3 833	3 833	7 205	9 120	9 607	9 607
1987	175 000	209 015	226 350	226 341	4 977	58 140	5 330	5 330	6 940	13 964	8 955	8 955
1988	255 600	220 985	318 750	318 750	4 678	62 808	5 861	5 861	7 901	18 069	9 876	9 876
1989	203 500	248 863	254 545	254 545	10 737	64 075	10 759	10 759	8 404	17 419	10 126	10 126
1990	210 000	213 474	248 779	247 059	11 618	51 565	9 240	9 186	9 028	13 246	10 585	10 569
1991	215 000	239 102	247 178	245 868	11 547	48 695	11 134	10 982	13 506	14 174	15 447	15 435
1992	215 100	262 552	243 252	239 257	8 178	49 591	9 359	9 276	17 778	24 368	19 811	19 753
1993	195 000	240 058	228 197	216 991	13 126	44 952	15 051	14 712	19 065	23 386	21 579	21 574
1994	191 000	261 946	227 614	211 438	7 358	38 287	8 561	8 398	15 961	21 714	18 507	18 510
1995	174 000	220 469	196 504	186 962	14 658	45 754	17 165	16 424	19 841	21 816	22 566	22 567
1996	209 900	271 093	233 597	217 056	15 914	46 248	18 456	18 317	21 428	19 111	24 193	24 194
1997	246 000	306 751	272 127	260 855	12 990	46 256	15 941	15 750	22 522	26 292	26 304	26 308
1998	269 100	346 738	308 540	294 249	14 354	52 892	18 833	18 249	23 145	25 455	26 886	26 869
1999	244 500	301 390	278 565	265 076	15 127	50 052	20 804	19 404	21 034	24 569	25 165	25 137
2000	242 000	305 211	288 149	270 898	13 225	43 476	18 214	17 128	21 615	25 099	25 860	25 619
2001	229 800	283 252	259 224	257 931	14 098	43 177	17 831	17 789	20 552	21 729	24 102	24 072
2002	195 500	250 292	226 562	226 392	11 778	41 135	14 761	14 723	19 561	24 136	23 276	23 280

Table 1 ctd.

Year	Hoki				Hake				Ling			
	Plenary	**v 42**	**v 43**	**v 44**	**Plenary**	**v 42**	**v 43**	**v 44**	**Plenary**	**v 42**	**v 43**	**v 44**
2003	184 600	258 558	219 084	209 523	11 543	49 216	22 977	15 770	18 903	24 999	23 023	22 456
2004	135 800	186 288	159 270	153 627	13 649	43 667	19 180	18 151	18 760	23 054	22 875	22 310
2005	104 200	162 762	119 251	119 155	13 347	33 530	17 259	17 221	17 189	18 091	20 084	20 087
2006	104 300	159 538	124 783	118 066	9 938	33 796	14 453	13 618	14 184	19 867	17 768	17 452
2007	101 000	142 082	114 272	114 181	10 559	32 944	14 768	14 721	16 102	22 055	20 025	20 031
2008	89 300	131 831	103 748	103 645	5 881	25 010	9 092	9 052	16 264	17 567	18 111	18 114
2009	88 900	124 090	103 353	103 258	10 164	28 352	14 687	14 635	13 137	14 230	15 804	15 807
2010	107 300	147 686	125 331	125 192	4 631	20 957	6 987	6 960	12 609	16 279	15 387	15 390
2011	118 800	**168 240**	**138 299**	137 681	5 701	**21 982**	**8 551**	8 658	12 337	**14 205**	**15 545**	15 076
2012	130 000	**184 101**	**151 338**	148 112	6 385	**24 619**	**9 577**	9 724	12 953	**14 915**	**15 271**	15 699
2013	131 600	**186 367**	**153 200**	152 543	7 378	**28 448**	**11 067**	11 104	14 339	**16 511**	**16 905**	16 696
2014	146 300	**207 185**	**170 313**	**168 606**	5 693	**21 951**	**8 539**	**8 628**	**13 313**	**15 330**	**15 696**	**15 699**
2015	161 600	**228 852**	**188 124**	**186 238**	8 248	**31 803**	**12 372**	**12 500**	**13 266**	**15 275**	**15 640**	**15 643**
2016	136 700	**193 590**	**159 137**	**157 542**	4 722	**18 207**	**7 083**	**7 156**	–	–	–	–
2017	160 000	**226 586**	**186 262**	**184 394**	–	–	–	–	–	–	–	–

3. HOKI

Hoki is assessed using a two-stock model with eastern (E) and western (W) stocks, with each of these stocks having a spawning fishery (sp) and two non-spawning fisheries (nsp1, nsp2). These two stocks are considered to encompasses the entire fishery for hoki with total catches given in the Fisheries Assessment Plenary (Ministry for Primary Industries 2017).

3.1 Model runs

For the most recent assessment in 2017 there was a single base case run 1.1, with the catch history as shown in Table 2. The base case catches for each fishing year are used to apportion the total annual catch in each of the three SAU alternative hoki catch histories (v42, v43 and v44 in Table 1) across the six model fisheries. Before 1972, the mean yearly proportion for the three years 1972–1974 are used.

Table 2: Hoki base case catches (t) by fishery and fishing year (1972 means fishing year 1971–72), as used in the 2017 assessment.

	Fishery						
Year	Ensp1	Ensp2	Wnsp1	Wnsp2	Esp	Wsp	Total
1972	1 500	2 500	0	0	0	5 000	9 000
1973	1 500	2 500	0	0	0	5 000	9 000
1974	2 200	3 800	0	0	0	5 000	11 000
1975	13 100	22 900	0	0	0	10 000	46 000
1976	13 500	23 500	0	0	0	30 000	67 000
1977	13 900	24 100	0	0	0	60 000	98 000
1978	1 100	1 900	0	0	0	5 000	8 000
1979	2 200	3 800	0	0	0	18 000	24 000
1980	2 900	5 100	0	0	0	20 000	28 000
1981	2 900	5 100	0	0	0	25 000	33 000
1982	2 600	4 400	0	0	0	25 000	32 000
1983	1 500	8 500	3 200	3 500	0	23 300	40 000
1984	3 200	6 800	6 700	5 400	0	27 900	50 000
1985	6 200	3 800	3 000	6 100	0	24 900	44 000
1986	3 700	13 300	7 200	3 300	0	71 500	99 000
1987	8 800	8 200	5 900	5 400	0	146 700	175 000
1988	9 000	6 000	5 400	7 600	600	227 000	255 600
1989	2 300	2 700	700	4 900	7 000	185 900	203 500
1990	3 300	9 700	900	9 100	14 000	173 000	210 000
1991	17 400	14 900	4 400	12 700	29 700	135 900	215 000
1992	33 400	17 500	14 000	17 400	25 600	107 200	215 100
1993	27 400	19 700	14 700	10 900	22 200	100 100	195 000
1994	16 000	10 600	5 800	5 500	35 900	117 200	191 000
1995	29 600	16 500	5 900	7 500	34 400	80 100	174 000
1996	37 900	23 900	5 700	6 800	59 700	75 900	209 900
1997	42 400	28 200	6 900	15 100	56 500	96 900	246 000
1998	55 600	34 200	10 900	14 600	46 700	107 100	269 100
1999	59 200	23 600	8 800	14 900	40 500	97 500	244 500
2000	43 100	20 500	14 300	19 500	39 000	105 600	242 000

	Fishery						
Year	Ensp1	Ensp2	Wnsp1	Wnsp2	Esp	Wsp	Total
2001	36 200	19 700	13 200	16 900	34 800	109 000	229 800
2002	24 600	18 100	16 800	13 400	24 600	98 000	195 500
2003	24 200	18 700	12 400	7 800	41 700	79 800	184 600
2004	17 900	19 000	6 300	5 300	41 000	46 300	135 800
2005	19 000	13 800	4 200	2 100	27 000	38 100	104 200
2006	23 100	14 400	2 300	4 700	20 100	39 700	104 300
2007	22 400	18 400	4 200	3 500	18 800	33 700	101 000
2008	22 100	19 400	6 500	2 200	17 900	21 200	89 300
2009	29 300	13 100	6 000	3 800	15 900	20 800	88 900
2010	28 500	13 500	6 700	5 600	16 400	36 600	107 300
2011	30 500	12 800	7 500	5 200	13 300	49 500	118 800
2012	28 400	14 700	9 100	6 600	15 400	55 800	130 000
2013	29 900	11 800	6 500	7 600	18 600	57 200	131 600
2014	27 200	11 700	10 600	9 300	17 300	70 200	146 300
2015	32 300	12 500	9 100	7 300	19 800	80 600	161 600
2016	28 900	11 600	3 400	3 300	19 600	69 900	136 700
2017	28 900	11 600	8 500	8 200	19 600	83 200	160 000

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2017}) are listed for each model run in Table 3. Biomass trajectories can be compared in Figures 1 and 2. Fishing intensity rates over time (Figure 3) are presented as catch in numbers divided by the number of fish in the population immediately before the first fishery of the year. MCMC median estimates of spawning stock biomass, biomass as a percentage of B_0, and fishing intensity for each modelled year are listed in Tables 4–7.

Table 3: Hoki east and west stocks. Estimates of spawning biomass (medians of marginal posterior, with 95% credible intervals in parentheses). $B_{current}$ is the biomass in mid-season 2017.

	B_0('000 t)		$B_{current}$('000 t)		$B_{current}$(%B_0)	
Run	E	W	E	W	E	W
Base case	547 (455, 684)	1031 (824, 1594)	328 (223, 492)	611 (338, 1263)	60 (44, 79)	59 (40, 84)
Version 42	722 (602, 891)	1270 (1046, 1695)	415 (279, 622)	696 (394, 1218)	58 (43, 79)	55 (36, 76)
Version 43	624 (504, 797)	1173 (952, 1590)	371 (248, 556)	665 (369, 1189)	59 (42, 79)	56 (37, 79)
Version 44	621 (517, 750)	1171 (960, 1621)	364 (244, 527)	670 (377, 1254)	59 (43, 78)	57 (37, 80)

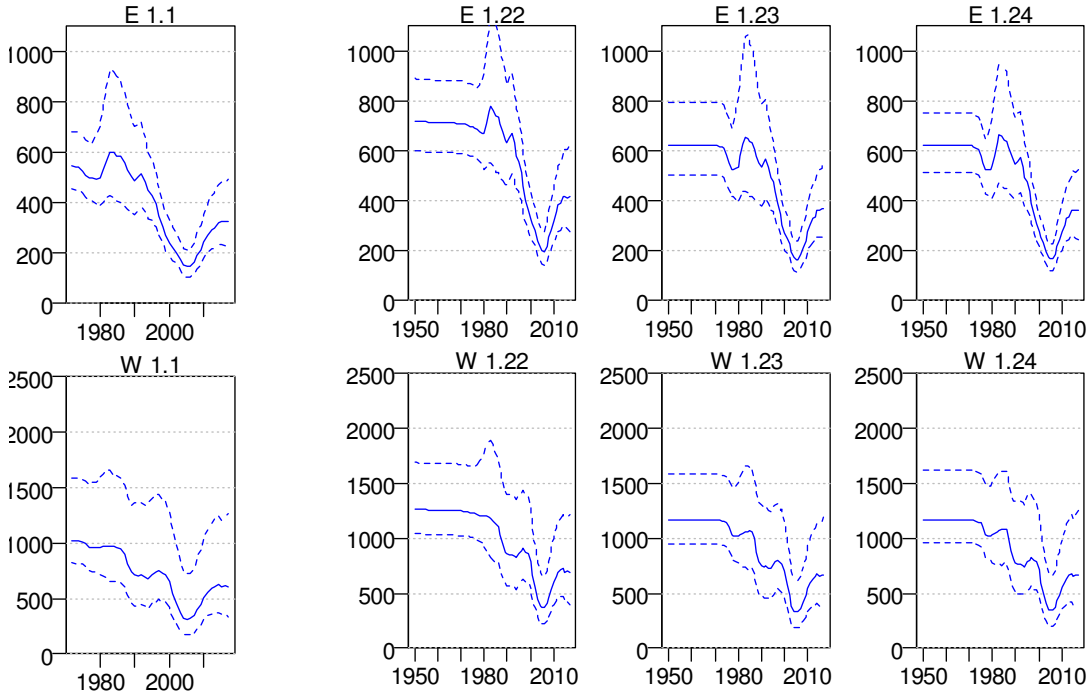


Figure 1: Estimated spawning-biomass trajectories from the MCMC runs, showing medians (solid lines) and 95% credible intervals (broken lines) by run for E (upper panels) and W (lower panels). Run 1.1. is the base model run; runs 1.22, 1.23, 1.24 refer to the catch history versions v42, v43, and v44 respectively.

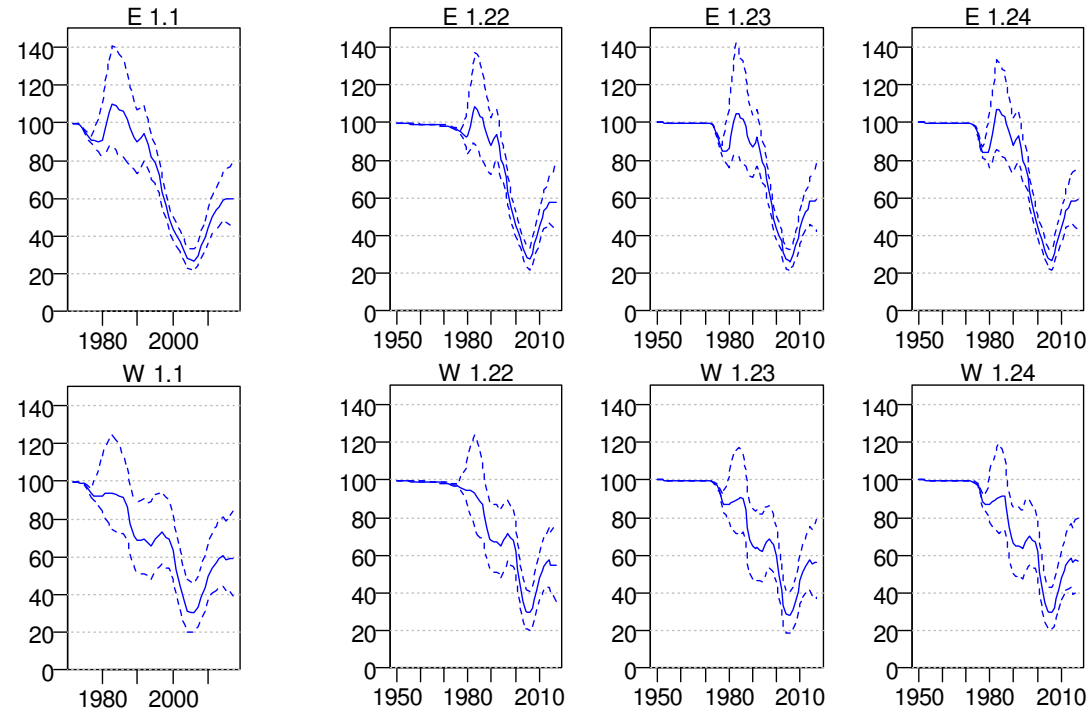


Figure 2: As in Figure 1, but plotted as $\%B_0$.

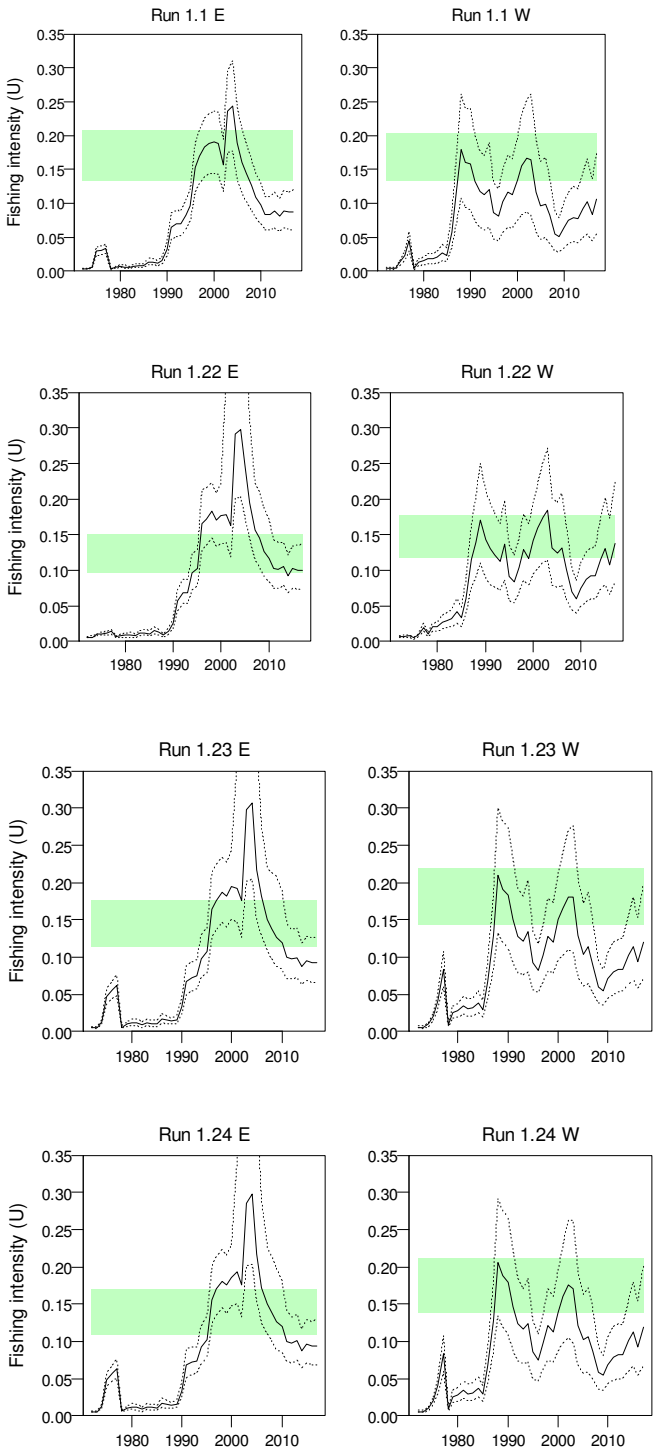


Figure 3: Fishing intensity, U (from MCMCs), plotted by stock. Shown are medians (solid black line) with 95% credible intervals (dotted lines). Also shown shaded in green is the management range where the upper bound is the reference level U35% B_0 and the lower bound U50% B_0 which are the fishing intensities that would cause the spawning biomass to tend to 35% B_0 and 50% B_0, respectively. Run 1.1. is the base model run; runs 1.22, 1.23, 1.24 refer to the catch history versions v42, v43, and v44 respectively.

Table 4: Hoki east stock — Estimated absolute spawning stock biomass (SSB, thousands of tonnes) and SSB as a percentage of B_0, by model year. –, years when landings were assumed to be zero.

Year	SSB				Percentage B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1950	–	721	–	–	–	99.9	–	–
1951	–	720	–	–	–	99.8	–	–
1952	–	719	–	–	–	99.7	–	–
1953	–	719	624	621	–	99.6	100.0	100.0
1954	–	718	624	621	–	99.5	100.0	100.0
1955	–	717	624	621	–	99.4	100.0	100.0
1956	–	717	624	621	–	99.3	100.0	100.0
1957	–	716	624	621	–	99.2	100.0	100.0
1958	–	716	624	621	–	99.2	100.0	100.0
1959	–	715	624	621	–	99.1	100.0	100.0
1960	–	715	624	621	–	99.0	100.0	100.0
1961	–	714	624	621	–	99.0	100.0	100.0
1962	–	714	623	621	–	99.0	100.0	100.0
1963	–	714	623	621	–	99.0	100.0	100.0
1964	–	714	623	621	–	98.9	100.0	100.0
1965	–	714	623	621	–	98.9	100.0	100.0
1966	–	713	623	621	–	98.8	100.0	100.0
1967	–	713	623	621	–	98.7	100.0	100.0
1968	–	712	623	621	–	98.6	100.0	100.0
1969	–	711	623	621	–	98.5	100.0	100.0
1970	–	710	623	621	–	98.4	99.9	99.9
1971	–	709	623	621	–	98.2	99.9	99.9
1972	546	706	620	617	99.7	97.9	99.4	99.4
1973	544	704	617	614	99.4	97.6	98.9	98.9
1974	542	700	610	607	99.0	97.0	97.8	97.7
1975	527	696	583	580	96.2	96.4	93.5	93.4
1976	512	691	555	552	93.6	95.7	89.0	88.8
1977	499	686	528	524	91.2	95.0	84.6	84.3
1978	498	677	528	525	90.6	93.7	84.6	84.2
1979	495	670	529	527	90.0	92.6	85.1	84.5
1980	497	672	538	539	90.5	93.0	86.6	86.5
1981	532	708	578	581	96.7	98.4	92.6	93.5
1982	576	755	629	633	105.3	105.6	100.5	102.1
1983	602	777	654	666	109.9	108.5	105.0	106.8
1984	599	764	651	661	109.5	106.8	104.9	106.7
1985	584	743	640	646	107.0	103.6	102.7	104.2
1986	583	737	634	641	106.6	102.5	101.6	103.7
1987	557	708	608	616	102.0	98.4	97.9	99.5
1988	533	675	578	590	97.2	93.9	93.2	95.4
1989	506	643	551	562	92.4	89.5	89.0	90.6
1990	491	631	539	545	89.7	87.8	86.8	88.0
1991	504	657	556	560	92.3	91.4	89.4	90.5
1992	517	673	570	574	94.9	93.7	91.9	92.7
1993	485	632	535	535	88.8	87.8	86.0	86.5

Year	SSB				Percentage B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1994	448	577	492	492	81.7	80.3	79.0	79.5
1995	431	560	477	477	78.8	77.9	76.3	76.9
1996	396	513	439	440	72.1	71.3	70.4	70.9
1997	349	459	392	393	63.8	63.7	62.8	63.3
1998	306	404	345	347	56.0	56.1	55.3	56.0
1999	270	362	306	310	49.5	50.2	49.0	49.8
2000	241	327	272	277	44.1	45.5	43.5	44.6
2001	223	308	252	256	40.9	42.7	40.4	41.3
2002	204	284	231	233	37.4	39.5	37.0	37.5
2003	174	242	195	197	31.7	33.6	31.2	31.9
2004	155	215	173	176	28.3	29.9	27.6	28.3
2005	149	203	166	169	27.3	28.3	26.7	27.3
2006	147	197	164	167	26.9	27.4	26.4	26.9
2007	164	220	184	187	30.1	30.6	29.7	30.3
2008	192	255	215	218	35.1	35.4	34.6	35.1
2009	214	284	242	244	39.3	39.6	38.7	39.2
2010	244	323	276	277	44.8	45.0	44.1	44.7
2011	272	356	306	307	50.0	49.7	49.1	49.6
2012	293	384	330	331	53.9	53.4	52.9	53.3
2013	302	392	339	339	55.6	54.6	54.3	54.7
2014	323	418	363	362	59.1	57.9	58.1	58.4
2015	327	419	367	364	60.0	58.0	58.8	58.7
2016	327	415	368	364	60.0	57.5	58.8	58.8
2017	328	415	371	364	60.1	57.8	59.1	58.9

Table 5: Hoki west stock — Estimated absolute spawning stock biomass (SSB, thousands of tonnes) and SSB as a percentage of B_0, by model year. –, years when landings were assumed to be zero.

Year	SSB				Percentage B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1950	–	1 269	–	–	–	99.9	–	–
1951	–	1 268	–	–	–	99.8	–	–
1952	–	1 267	–	–	–	99.7	–	–
1953	–	1 265	1 173	1 171	–	99.6	100.0	100.0
1954	–	1 264	1 173	1 171	–	99.5	100.0	100.0
1955	–	1 263	1 173	1 171	–	99.5	100.0	100.0
1956	–	1 262	1 173	1 171	–	99.4	100.0	100.0
1957	–	1 261	1 173	1 171	–	99.3	100.0	100.0
1958	–	1 261	1 173	1 171	–	99.2	100.0	100.0
1959	–	1 260	1 173	1 171	–	99.2	100.0	100.0
1960	–	1 259	1 173	1 171	–	99.1	100.0	100.0
1961	–	1 258	1 173	1 171	–	99.1	100.0	100.0
1962	–	1 258	1 173	1 171	–	99.1	100.0	100.0
1963	–	1 258	1 173	1 171	–	99.0	100.0	100.0
1964	–	1 257	1 173	1 171	–	99.0	100.0	100.0
1965	–	1 257	1 173	1 171	–	99.0	100.0	100.0
1966	–	1 256	1 173	1 171	–	98.9	100.0	100.0
1967	–	1 256	1 173	1 171	–	98.9	100.0	100.0
1968	–	1 254	1 173	1 171	–	98.8	100.0	100.0
1969	–	1 253	1 173	1 171	–	98.7	100.0	100.0
1970	–	1 251	1 173	1 171	–	98.5	99.9	99.9
1971	–	1 249	1 173	1 170	–	98.4	99.9	99.9
1972	1 029	1 245	1 168	1 165	99.8	98.1	99.5	99.5
1973	1 026	1 241	1 162	1 159	99.5	97.7	99.0	99.0
1974	1 023	1 237	1 154	1 151	99.2	97.4	98.3	98.3
1975	1 017	1 236	1 143	1 140	98.6	97.3	97.4	97.4
1976	1 000	1 232	1 110	1 107	96.9	97.0	94.5	94.5
1977	966	1 219	1 039	1 036	93.6	95.8	88.5	88.5
1978	963	1 212	1 023	1 018	92.5	94.9	87.0	86.8
1979	966	1 207	1 021	1 024	92.6	94.7	86.9	86.9
1980	968	1 210	1 028	1 033	92.6	94.5	87.2	87.2
1981	979	1 203	1 037	1 050	93.5	94.5	88.0	88.3
1982	978	1 196	1 047	1 058	93.9	93.9	88.9	89.3
1983	979	1 184	1 058	1 069	93.4	92.7	89.6	90.3
1984	973	1 152	1 062	1 079	93.0	90.7	89.8	90.8
1985	967	1 130	1 069	1 081	92.6	88.9	90.5	91.6
1986	955	1 114	1 064	1 079	91.9	87.3	90.1	91.4
1987	899	1 039	995	1 010	86.4	81.5	84.5	85.6
1988	811	954	877	889	77.7	74.6	74.6	75.5
1989	739	873	793	812	71.2	69.0	67.7	69.2
1990	712	862	760	775	68.9	67.9	65.0	66.3
1991	708	856	746	765	68.7	67.5	63.9	65.3
1992	712	852	750	764	69.3	67.3	64.2	65.2
1993	697	837	734	753	67.2	65.9	62.8	64.3

Year	SSB				Percentage B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1994	682	825	726	742	65.9	65.1	62.2	63.4
1995	720	863	769	786	69.8	68.3	65.6	67.2
1996	740	884	788	807	71.5	70.1	67.4	69.3
1997	754	911	808	823	73.0	71.8	68.9	70.5
1998	732	881	782	798	70.4	69.4	66.7	68.3
1999	718	867	768	787	69.6	68.3	65.7	67.2
2000	654	791	699	720	63.3	62.4	59.7	61.8
2001	548	669	580	599	53.1	52.7	49.8	51.2
2002	462	561	486	506	44.8	44.3	41.7	43.2
2003	373	450	389	405	36.1	35.4	33.3	34.6
2004	323	387	337	352	31.2	30.5	28.9	30.3
2005	318	377	332	345	30.8	29.8	28.6	29.6
2006	319	373	334	348	30.8	29.5	28.4	29.8
2007	347	405	363	376	33.7	31.9	31.1	32.1
2008	395	462	419	434	38.3	36.5	35.8	37.1
2009	449	532	479	487	43.6	41.9	40.8	41.7
2010	512	607	550	563	49.9	47.8	47.0	48.2
2011	557	662	598	605	54.0	51.9	51.0	52.0
2012	590	693	631	637	57.2	54.4	53.9	54.7
2013	611	716	656	665	59.2	56.3	56.1	57.3
2014	630	731	678	685	60.9	57.5	57.7	58.6
2015	609	696	654	659	58.8	54.6	55.4	56.5
2016	617	702	670	674	59.4	55.1	56.6	57.5
2017	611	696	665	670	59.0	54.6	56.5	57.2

Table 6: Hoki east stock — Estimated fishing intensiy (catch in numbers divided by population in numbers immediately before the first fishery in the year), by model year.

Year	Fishing intensity				Year	Fishing intensity			
	Base	v42	v43	v44		Base	v42	v43	v44
1972	0.003	0.006	0.006	0.006	1995	0.096	0.102	0.107	0.103
1973	0.003	0.006	0.006	0.006	1996	0.153	0.166	0.164	0.156
1974	0.005	0.010	0.013	0.013	1997	0.169	0.172	0.175	0.171
1975	0.030	0.011	0.047	0.048	1998	0.183	0.183	0.187	0.181
1976	0.031	0.012	0.056	0.057	1999	0.188	0.170	0.182	0.176
1977	0.033	0.014	0.062	0.063	2000	0.191	0.177	0.195	0.186
1978	0.003	0.007	0.006	0.007	2001	0.188	0.178	0.192	0.193
1979	0.005	0.008	0.010	0.010	2002	0.157	0.163	0.175	0.175
1980	0.007	0.009	0.012	0.012	2003	0.236	0.291	0.298	0.285
1981	0.006	0.009	0.012	0.012	2004	0.244	0.298	0.307	0.298
1982	0.005	0.008	0.009	0.009	2005	0.189	0.245	0.217	0.217
1983	0.007	0.012	0.012	0.012	2006	0.160	0.195	0.182	0.172
1984	0.008	0.012	0.011	0.012	2007	0.144	0.157	0.150	0.150
1985	0.008	0.011	0.010	0.010	2008	0.126	0.146	0.138	0.139
1986	0.013	0.015	0.017	0.017	2009	0.109	0.126	0.126	0.126
1987	0.013	0.013	0.015	0.015	2010	0.098	0.117	0.119	0.120
1988	0.012	0.009	0.014	0.014	2011	0.084	0.103	0.100	0.100
1989	0.015	0.014	0.016	0.016	2012	0.084	0.101	0.097	0.098
1990	0.032	0.025	0.033	0.033	2013	0.089	0.105	0.099	0.101
1991	0.065	0.057	0.067	0.068	2014	0.081	0.093	0.087	0.088
1992	0.070	0.069	0.072	0.072	2015	0.089	0.102	0.095	0.096
1993	0.070	0.069	0.075	0.073	2016	0.087	0.100	0.092	0.094
1994	0.082	0.096	0.097	0.092	2017	0.087	0.100	0.092	0.094

Table 7: Hoki west stock — Estimated fishing intensiy (catch in numbers divided by population in numbers immediately before the first fishery in the year), by model year.

Year	Fishing intensity				Year	Fishing intensity			
	Base	v42	v43	v44		base	v42	v43	v44
1972	0.004	0.007	0.006	0.006	1995	0.086	0.091	0.092	0.086
1973	0.004	0.007	0.006	0.006	1996	0.081	0.084	0.082	0.075
1974	0.004	0.008	0.010	0.010	1997	0.103	0.104	0.103	0.098
1975	0.013	0.005	0.021	0.021	1998	0.117	0.129	0.128	0.121
1976	0.023	0.009	0.041	0.041	1999	0.112	0.117	0.120	0.113
1977	0.044	0.019	0.083	0.083	2000	0.134	0.141	0.150	0.139
1978	0.004	0.010	0.009	0.009	2001	0.155	0.159	0.166	0.161
1979	0.013	0.020	0.026	0.026	2002	0.167	0.174	0.181	0.176
1980	0.015	0.020	0.028	0.028	2003	0.164	0.185	0.181	0.170
1981	0.018	0.027	0.034	0.034	2004	0.117	0.131	0.129	0.121
1982	0.018	0.029	0.031	0.030	2005	0.096	0.124	0.104	0.102
1983	0.021	0.032	0.032	0.031	2006	0.099	0.131	0.114	0.106
1984	0.027	0.042	0.038	0.037	2007	0.082	0.101	0.090	0.088
1985	0.023	0.033	0.029	0.029	2008	0.055	0.070	0.060	0.059
1986	0.057	0.060	0.067	0.067	2009	0.051	0.060	0.055	0.055
1987	0.112	0.115	0.129	0.128	2010	0.065	0.075	0.071	0.069
1988	0.180	0.139	0.210	0.206	2011	0.075	0.087	0.080	0.079
1989	0.160	0.171	0.191	0.188	2012	0.079	0.093	0.084	0.082
1990	0.158	0.143	0.183	0.179	2013	0.077	0.093	0.084	0.082
1991	0.133	0.130	0.151	0.147	2014	0.092	0.115	0.102	0.101
1992	0.118	0.122	0.128	0.124	2015	0.103	0.130	0.114	0.112
1993	0.112	0.113	0.122	0.116	2016	0.084	0.108	0.094	0.093
1994	0.120	0.136	0.134	0.124	2017	0.106	0.138	0.120	0.119

3.2 Conclusions – Hoki

The alternative catch histories were generally higher than the MPI plenary catch history used in the base model (Figure 4). Relative to the base model, the virgin biomass and the time series of absolute biomasses were also estimated to be slightly higher when using the alternative catch histories (Figure 5). B_{2017} was estimated to be about 9–13% higher for both stocks in the alternative runs, except for the eastern stock with catch version 42 where estimated current biomass was 27% higher.

However, the stock status ($\%B_0$) trends were virtually identical for all four cases for both stocks (Figure 5). For the base model, the eastern stock current biomass was estimated to be 60% B_0, and for the alternative catch histories 58–59% B_0. For the western stock current biomass was estimated to be 59% B_0 for the base model, and for the alternative catch histories 55–57% B_0.

Estimates of fishing intensity were generally slightly higher for the alternative catch histories relative to the base case, although this varied over time (Figure 5).

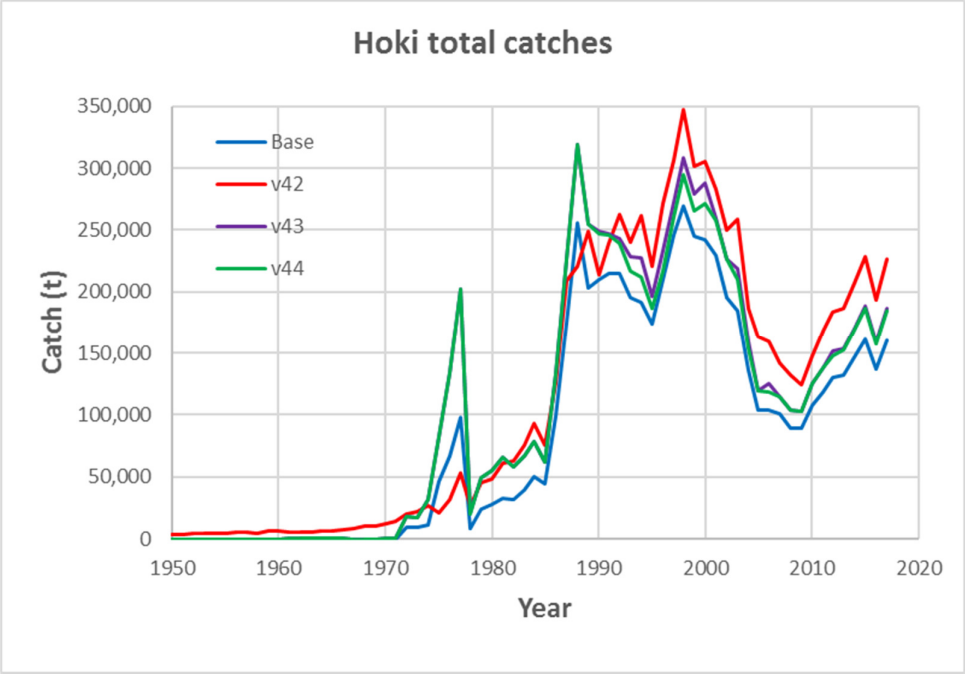


Figure 4: Total catch histories used in the hoki base case assessment and in the assessments using the three alternative SAU datasets.

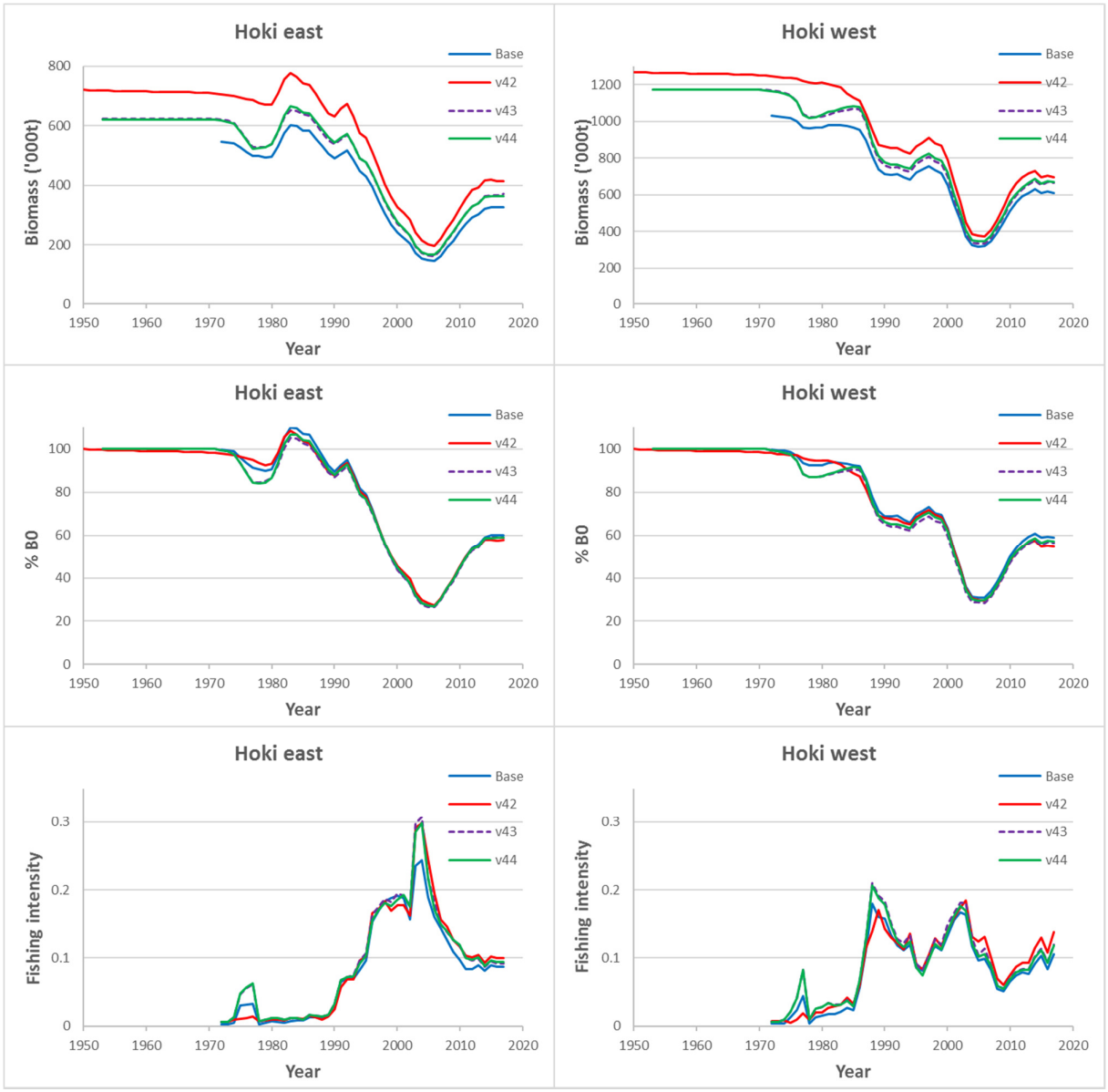


Figure 5: Median biomass trajectories, stock status trajectories, and estimated fishing intensity for the eastern and western hoki stocks from the base case assessment and the assessments using the three alternative SAU datasets.

4. HAKE

Hake are assessed as three individual biological stocks. The Chatham Rise stock is considered to include the whole of the Chatham Rise (i.e., HAK 4 and the western end of the Chatham Rise that forms part of the HAK 1 management area). The Sub-Antarctic stock is considered to contain hake in the remaining Puysegur, Southland, and Sub-Antarctic regions of the HAK 1 management area. The WCSI stock is considered to include all hake off WCSI (i.e., the HAK 7 management area, but excluding the Cook Strait and Marlborough coast regions).

4.1 HAK 1 (Sub-Antarctic)

The Sub-Antarctic hake stock is modelled with catches taken by a single trawl fishery. Catch histories assumed for all model runs are listed in Table 8.

Table 8: Hake, Sub-Antarctic — Catch history used in the previous base case model (Base), and alternative catch histories derived from SAU database versions 42, 43 and 44 that were used in the revised model runs. These values are derived from Table 1 by prorating between stocks (and fisheries within stocks) of each species using historial ratios for each year. All values in tonnes. –, landings assumed to be zero.

Year	Base	v42	v43	v44	Year	Base	v42	v43	v44
1950	–	332	–	–	1984	722	15 827	1 111	1 111
1951	–	330	–	–	1985	525	9 913	750	750
1952	–	340	–	–	1986	818	11 822	1 012	1 012
1953	–	346	–	–	1987	713	8 329	764	764
1954	–	406	–	–	1988	1 095	14 702	1 372	1 372
1955	–	378	–	–	1989	1 237	7 382	1 240	1 240
1956	–	438	–	–	1990	1 897	8 553	1 533	1 524
1957	–	457	–	–	1991	2 381	9 994	2 285	2 254
1958	–	404	–	–	1992	2 810	16 694	3 151	3 123
1959	–	521	–	–	1993	3 941	11 195	3 748	3 664
1960	–	571	–	–	1994	1 596	7 561	1 691	1 658
1961	–	476	–	–	1995	1 995	5 735	2 152	2 059
1962	–	454	–	–	1996	2 779	8 313	3 317	3 292
1963	–	474	–	–	1997	1 915	7 847	2 704	2 672
1964	–	510	–	–	1998	2 958	9 485	3 377	3 273
1965	–	549	–	–	1999	2 854	9 203	3 825	3 568
1966	–	629	–	–	2000	3 108	9 677	4 054	3 812
1967	–	662	–	–	2001	2 820	8 545	3 529	3 520
1968	–	851	–	–	2002	2 444	8 766	3 146	3 138
1969	–	832	–	–	2003	2 777	11 674	5 450	3 741
1970	–	955	–	–	2004	3 223	10 382	4 560	4 315
1971	–	1 164	–	–	2005	2 592	6 355	3 271	3 264
1972	–	1 640	–	–	2006	2 541	8 696	3 719	3 504
1973	–	1 750	19	19	2007	1 711	5 672	2 543	2 535
1974	–	2 127	21	21	2008	2 329	9 364	3 404	3 389
1975	120	6 396	240	240	2009	2 446	6 770	3 507	3 495
1976	281	1 505	562	562	2010	1 927	8 861	2 954	2 943
1977	372	813	744	744	2011	1 319	4 966	1 932	1 956
1978	762	11 747	1 524	1 524	2012	1 900	7 295	2 838	2 882
1979	364	1 692	728	728	2013	1 859	7 183	2 794	2 804
1980	350	1 987	711	711	2014	1 800	7 433	2 892	2 922
1981	272	2 270	544	544					
1982	179	2 361	325	325					
1983	448	11 132	729	729					

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2014}) are listed for each model run in Table 9. Biomass trajectories can be compared in Figure 6. Fishing intensities over time (Figure 7) are presented as the proportion of catch divided by vulnerable biomass. MCMC median estimates of spawning stock biomass and biomass as a proportion of B_0 are listed in Table 10, and fishing intensities for each modelled year are listed in Table 11.

Table 9: Hake, Sub-Antarctic — Bayesian median and 95% credible intervals of B_0, B_{2014}, and B_{2014} as a percentage of B_0 for the four model runs.

Model run	B_0		B_{2014}		B_{2014} (%B_0)	
Base case	59 290	(44 040–94 040)	37 990	(19 740–70 310)	60.4	(43.6–77.6)
Version 42	167 790	(144 950–215 560)	72 870	(41 010–129 630)	43.0	(28.0–61.2)
Version 43	75 810	(56 870–114 810)	43 980	(24 660–81 960)	57.9	(41.6–76.4)
Version 44	70 450	(53 840–111 230)	39 980	(22 530–78 080)	56.7	(41.3–76.2)

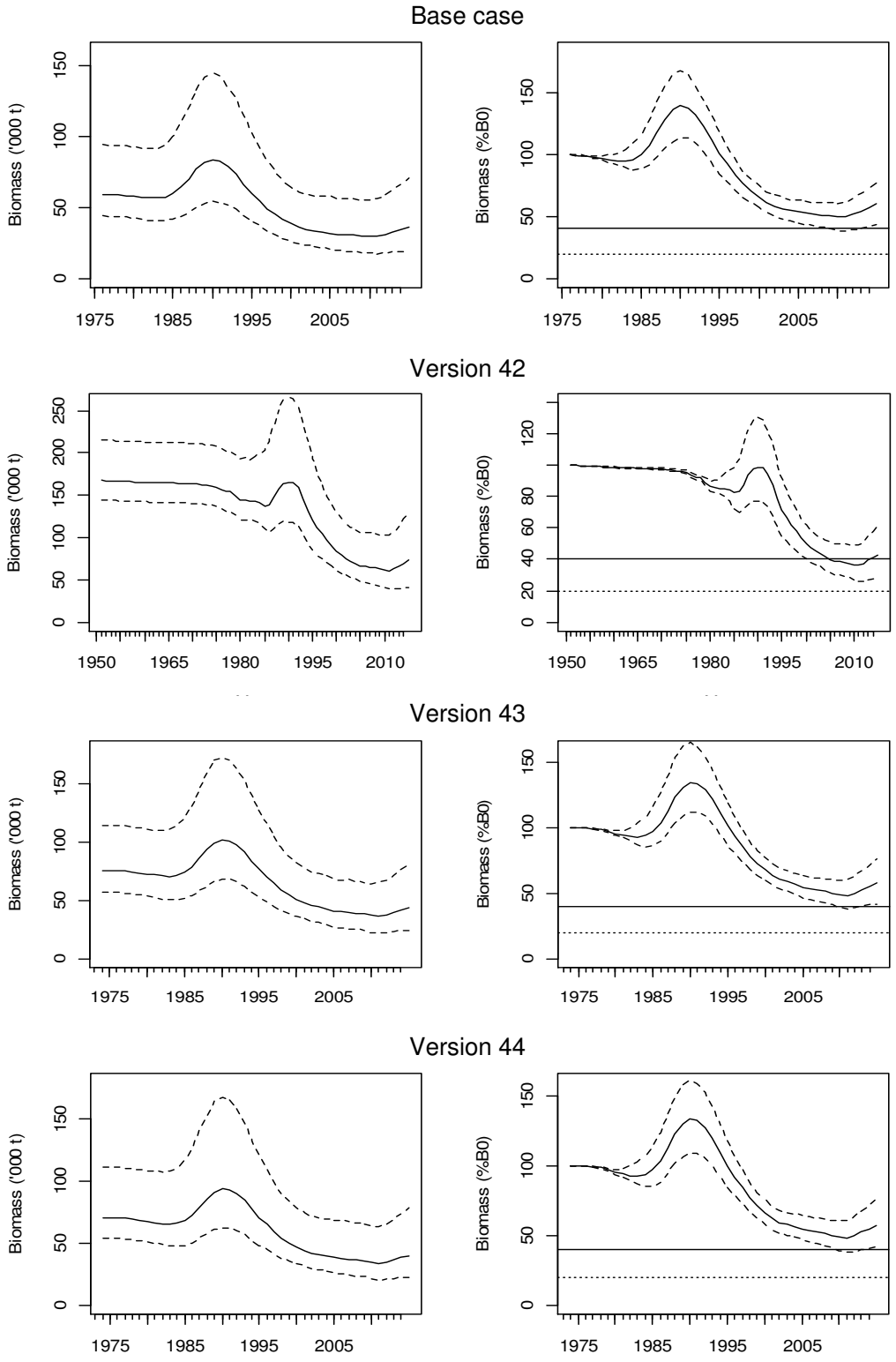


Figure 6: Hake, Sub-Antarctic — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0. Note that the x-axis year scale varies between model runs.

Base case Version 42

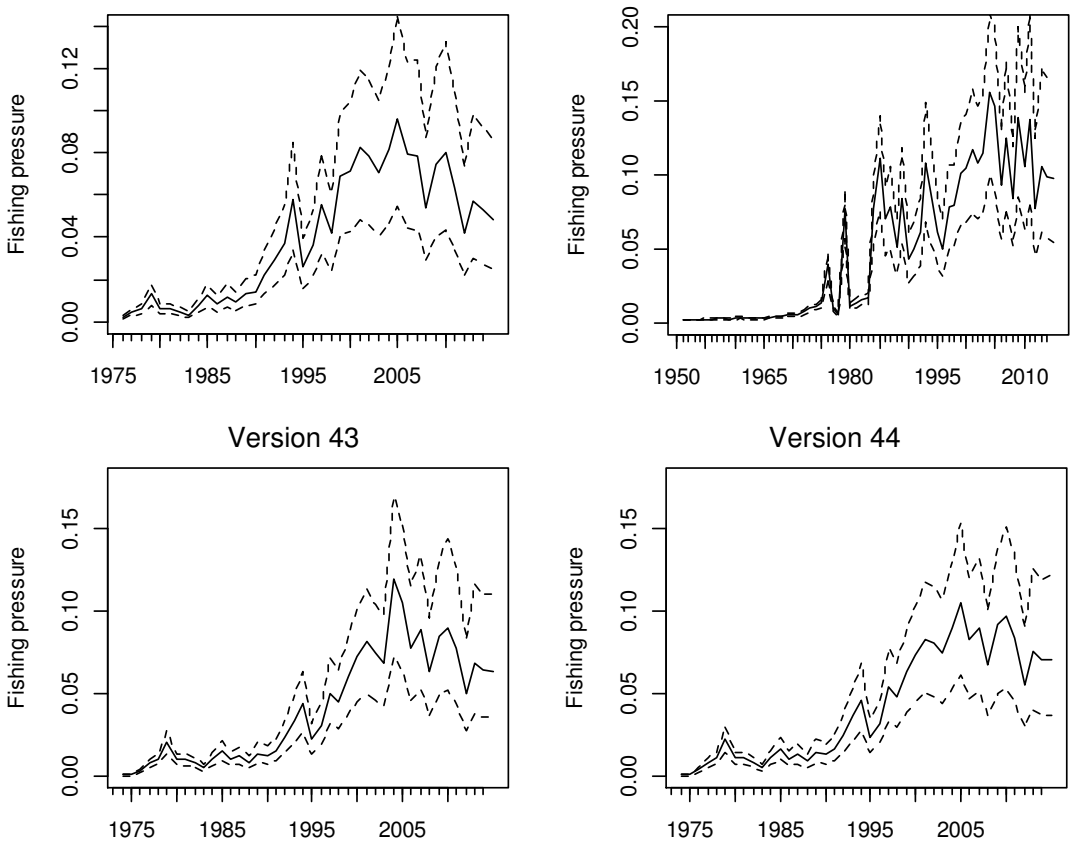


Figure 7: Hake, Sub-Antarctic — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines). Note that the *x*-axis year scale varies between model runs.

Table 10: Hake, Sub-Antarctic — Estimated absolute spawning stock biomass (SSB, t) and SSB as a proportion of B_0, by model year. –, years when landings were assumed to be zero.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1950	–	167 644	–	–	–	1.000	–	–
1951	–	167 350	–	–	–	0.998	–	–
1952	–	167 072	–	–	–	0.997	–	–
1953	–	166 810	–	–	–	0.995	–	–
1954	–	166 543	–	–	–	0.993	–	–
1955	–	166 290	–	–	–	0.992	–	–
1956	–	166 037	–	–	–	0.990	–	–
1957	–	165 793	–	–	–	0.989	–	–
1958	–	165 599	–	–	–	0.988	–	–
1959	–	165 405	–	–	–	0.987	–	–
1960	–	165 157	–	–	–	0.985	–	–
1961	–	164 954	–	–	–	0.984	–	–
1962	–	164 833	–	–	–	0.983	–	–
1963	–	164 722	–	–	–	0.983	–	–
1964	–	164 602	–	–	–	0.982	–	–
1965	–	164 465	–	–	–	0.981	–	–

Table 10 ctd.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1966	–	164 292	–	–	–	0.980	–	–
1967	–	164 084	–	–	–	0.979	–	–
1968	–	163 795	–	–	–	0.977	–	–
1969	–	163 451	–	–	–	0.975	–	–
1970	–	163 104	–	–	–	0.973	–	–
1971	–	162 638	–	–	–	0.970	–	–
1972	–	161 900	–	–	–	0.966	–	–
1973	–	160 953	75 799	70 436	–	0.960	1.000	1.000
1974	–	159 912	75 782	70 418	–	0.954	1.000	1.000
1975	59 238	156 812	75 667	70 303	1.000	0.935	0.998	0.998
1976	59 056	154 100	75 327	69 949	0.997	0.919	0.994	0.993
1977	58 767	154 099	74 778	69 387	0.992	0.919	0.987	0.985
1978	58 267	149 538	73 760	68 366	0.984	0.892	0.973	0.971
1979	57 757	144 599	72 740	67 244	0.975	0.863	0.960	0.955
1980	57 138	144 007	71 890	66 401	0.965	0.859	0.948	0.943
1981	56 823	143 042	71 105	65 589	0.959	0.853	0.938	0.931
1982	56 690	143 025	70 597	65 379	0.957	0.853	0.931	0.928
1983	57 331	141 017	71 640	66 127	0.968	0.841	0.945	0.939
1984	59 786	137 391	74 461	68 261	1.009	0.820	0.982	0.969
1985	64 079	139 044	78 894	72 831	1.082	0.829	1.041	1.034
1986	70 188	147 099	86 109	79 021	1.185	0.877	1.136	1.122
1987	76 951	157 947	93 839	85 505	1.299	0.942	1.238	1.214
1988	81 783	163 968	99 472	91 004	1.381	0.978	1.312	1.292
1989	83 627	165 676	101 988	93 524	1.412	0.988	1.345	1.328
1990	82 277	164 803	100 954	92 668	1.389	0.983	1.332	1.316
1991	78 688	158 974	97 625	89 401	1.328	0.948	1.288	1.269
1992	73 293	146 601	91 704	84 229	1.237	0.874	1.210	1.196
1993	66 354	131 577	84 131	77 154	1.120	0.785	1.110	1.095
1994	59 904	120 252	77 049	70 512	1.011	0.717	1.016	1.001
1995	54 637	111 778	70 826	65 006	0.922	0.667	0.934	0.923
1996	49 314	104 079	64 809	59 346	0.832	0.621	0.855	0.843
1997	45 023	96 646	59 469	54 308	0.760	0.576	0.785	0.771
1998	41 818	90 164	55 052	50 360	0.706	0.538	0.726	0.715
1999	38 767	84 277	51 140	46 889	0.654	0.503	0.675	0.666
2000	36 304	79 125	47 936	43 916	0.613	0.472	0.632	0.623
2001	34 349	75 364	45 659	41 778	0.580	0.450	0.602	0.593
2002	33 351	72 680	44 309	40 445	0.563	0.434	0.585	0.574
2003	32 596	69 374	42 837	39 639	0.550	0.414	0.565	0.563
2004	31 752	66 150	40 932	38 497	0.536	0.395	0.540	0.547
2005	31 052	65 376	40 178	37 669	0.524	0.390	0.530	0.535
2006	30 574	64 924	39 604	37 004	0.516	0.387	0.522	0.525
2007	30 332	64 194	38 978	36 226	0.512	0.383	0.514	0.514
2008	29 900	62 923	38 212	35 302	0.505	0.375	0.504	0.501
2009	29 297	61 226	37 096	34 117	0.495	0.365	0.489	0.484
2010	29 407	60 863	36 875	33 861	0.496	0.363	0.486	0.481
2011	30 573	62 626	38 057	34 791	0.516	0.374	0.502	0.494
2012	32 406	66 186	40 121	36 652	0.547	0.395	0.529	0.520
2013	34 245	69 689	42 080	38 627	0.578	0.416	0.555	0.548
2014	36 021	72 869	43 982	39 981	0.608	0.435	0.580	0.568

Table 11: Hake, Sub-Antarctic — Estimated fishing intensity (catch divided by vulnerable biomass), by model year. –, years when landings were assumed to be zero.

Year	Fishing intensity				Year	Fishing intensity			
	Base	v42	v43	v44		Base	v42	v43	v44
1950	–	0.0020	–	–	1984	0.0122	0.1106	0.0149	0.0162
1951	–	0.0020	–	–	1985	0.0083	0.0698	0.0094	0.0103
1952	–	0.0020	–	–	1986	0.0117	0.0778	0.0116	0.0128
1953	–	0.0021	–	–	1987	0.0092	0.0512	0.0080	0.0087
1954	–	0.0024	–	–	1988	0.0131	0.0843	0.0133	0.0144
1955	–	0.0023	–	–	1989	0.0143	0.0426	0.0117	0.0127
1956	–	0.0026	–	–	1990	0.0224	0.0497	0.0147	0.0159
1957	–	0.0027	–	–	1991	0.0295	0.0605	0.0229	0.0245
1958	–	0.0024	–	–	1992	0.0373	0.1074	0.0335	0.0362
1959	–	0.0031	–	–	1993	0.0577	0.0814	0.0436	0.0462
1960	–	0.0034	–	–	1994	0.0264	0.0609	0.0217	0.0232
1961	–	0.0029	–	–	1995	0.0361	0.0502	0.0301	0.0312
1962	–	0.0027	–	–	1996	0.0551	0.0776	0.0503	0.0544
1963	–	0.0029	–	–	1997	0.0418	0.0790	0.0448	0.0482
1964	–	0.0031	–	–	1998	0.0688	0.1013	0.0598	0.0633
1965	–	0.0033	–	–	1999	0.0716	0.1048	0.0722	0.0734
1966	–	0.0038	–	–	2000	0.0824	0.1165	0.0812	0.0827
1967	–	0.0040	–	–	2001	0.0788	0.1079	0.0743	0.0805
1968	–	0.0052	–	–	2002	0.0709	0.1143	0.0682	0.0742
1969	–	0.0051	–	–	2003	0.0815	0.1557	0.1192	0.0896
1970	–	0.0058	–	–	2004	0.0961	0.1459	0.1052	0.1053
1971	–	0.0071	–	–	2005	0.0795	0.0925	0.0779	0.0826
1972	–	0.0100	–	–	2006	0.0788	0.1250	0.0890	0.0899
1973	–	0.0108	0.0003	0.0003	2007	0.0542	0.0839	0.0627	0.0670
1974	–	0.0132	0.0003	0.0003	2008	0.0744	0.1384	0.0848	0.0913
1975	0.0020	0.0399	0.0031	0.0034	2009	0.0798	0.1052	0.0903	0.0974
1976	0.0047	0.0097	0.0074	0.0079	2010	0.0636	0.1376	0.0772	0.0837
1977	0.0063	0.0052	0.0098	0.0106	2011	0.0423	0.0774	0.0496	0.0548
1978	0.0129	0.0755	0.0203	0.0219	2012	0.0572	0.1057	0.0683	0.0756
1979	0.0062	0.0116	0.0099	0.0107	2013	0.0529	0.0984	0.0639	0.0702
1980	0.0061	0.0137	0.0098	0.0106	2014	0.0484	0.0974	0.0631	0.0700
1981	0.0048	0.0157	0.0076	0.0082					
1982	0.0032	0.0164	0.0046	0.0050					
1983	0.0078	0.0766	0.0102	0.0110					

4.2 HAK 4 (Chatham Rise)

The Chatham Rise hake stock is modelled with catches taken by two trawl fisheries, one each for the eastern and western Rise. Catch histories assumed for the four model runs are listed in Table 12.

Table 12: Hake, Chatham Rise — Catch history used in the previous base case model (Base), and alternative catch histories derived from SAU database versions 42, 43 and 44 that were used in the revised model runs. These values are derived from Table 1 by prorating between stocks (and fisheries within stocks) of each species using historial ratios for each year. All values in tonnes. –, landings assumed to be zero.

Year	Base		v42		v43		v44	
	west	east	west	east	west	east	west	east
1950	–	–	248	232	–	–	–	–
1951	–	–	247	231	–	–	–	–
1952	–	–	254	238	–	–	–	–
1953	–	–	258	242	–	–	–	–
1954	–	–	303	285	–	–	–	–
1955	–	–	282	265	–	–	–	–
1956	–	–	327	307	–	–	–	–
1957	–	–	341	320	–	–	–	–
1958	–	–	302	283	–	–	–	–
1959	–	–	389	365	–	–	–	–
1960	–	–	426	400	–	–	–	–
1961	–	–	356	334	–	–	–	–
1962	–	–	339	318	–	–	–	–
1963	–	–	354	332	–	–	–	–
1964	–	–	381	357	–	–	–	–
1965	–	–	410	385	–	–	–	–
1966	–	–	470	441	–	–	–	–
1967	–	–	494	464	–	–	–	–
1968	–	–	635	596	–	–	–	–
1969	–	–	621	583	–	–	–	–
1970	–	–	713	669	–	–	–	–
1971	–	–	869	815	–	–	–	–
1972	–	–	1 224	1 149	–	–	–	–
1973	–	–	1 306	1 225	14	14	14	14
1974	–	–	1 588	1 489	16	15	16	15
1975	80	111	4 264	5 917	160	222	160	222
1976	152	336	814	1 799	304	672	304	672
1977	74	1 214	162	2 653	148	2 428	148	2 428
1978	28	6	432	92	56	12	56	12
1979	103	506	479	2 352	206	1 012	206	1 012
1980	481	269	2 731	1 527	977	546	977	546
1981	914	83	7 627	693	1 828	166	1 828	166
1982	393	203	5 184	2 678	715	369	715	369
1983	154	148	3 826	3 677	250	241	250	241
1984	224	120	4 910	2 631	345	185	345	185
1985	232	312	4 381	5 891	331	446	331	446
1986	282	80	4 075	1 156	349	99	349	99
1987	387	122	4 521	1 425	414	131	414	131
1988	385	189	5 169	2 538	482	237	482	237
1989	386	418	2 304	2 494	387	419	387	419
1990	309	689	1 305	2 911	234	522	233	519
1991	409	503	1 761	2 165	403	495	397	488
1992	718	1 087	5 839	8 840	1 102	1 668	1 092	1 654
1993	656	1 996	2 370	7 212	794	2 415	776	2 360
1994	368	2 912	1 713	13 554	383	3 031	376	2 973
1995	597	2 903	1 789	8 700	671	3 264	642	3 123

Table 12 ctd.

Year	Base		v42		v43		v44	
	west	east	west	east	west	east	west	east
1996	1 353	2 483	4 111	7 544	1 641	3 011	1 628	2 988
1997	1 475	1 820	6 575	8 113	2 266	2 796	2 239	2 762
1998	1 424	1 124	8 649	6 827	3 080	2 431	2 984	2 355
1999	1 169	3 339	3 132	8 945	1 302	3 718	1 214	3 468
2000	1 155	2 130	3 962	7 307	1 660	3 061	1 561	2 879
2001	1 208	1 700	3 768	5 303	1 556	2 190	1 553	2 185
2002	454	1 058	1 856	4 326	666	1 552	664	1 548
2003	497	718	2 443	3 530	1 141	1 648	783	1 131
2004	687	1 983	2 029	5 857	891	2 573	843	2 435
2005	2 585	1 434	5 694	3 159	2 931	1 626	2 924	1 622
2006	184	255	697	966	298	413	281	389
2007	270	683	956	2 417	428	1 084	427	1 080
2008	259	901	1 041	3 620	378	1 316	377	1 310
2009	1 069	832	2 863	2 228	1 483	1 154	1 478	1 150
2010	231	159	1 048	721	349	241	348	240
2011	822	118	3 207	460	1 247	179	1 263	181
2012	70	154	234	514	91	200	92	203
2013	215	164	752	574	293	223	294	224
2014	65	150	230	530	89	206	90	208
2015	62	174	366	1 027	142	400	144	404
2016	110	230	424	888	165	345	167	349

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2016}) are listed for each model run in Table 13. Biomass trajectories can be compared in Figure 8. Fishing intensities over time (Figure 9) are presented as the proportion of catch divided by vulnerable biomass. MCMC median estimates of spawning stock biomass and biomass as a proportion of B_0 are listed in Table 14, and fishing intensity for each modelled year are listed in Table 15.

Table 13: Hake, Chatham Rise — Bayesian median and 95% credible intervals of B_0, B_{2016}, and B_{2016} as a percentage of B_0 for the four model runs.

Model run	B_0		B_{2016}		B_{2016} (%B_0)	
Base case	32 620	(28 420–39 600)	16 000	(11 770–23 120)	49.4	(40.9–59.8)
Version 42	144 420	(114 420–313 160)	64 510	(41 470–159 460)	44.1	(35.1–55.2)
Version 43	45 830	(38 940–76 120)	22 980	(16 240–45 840)	50.0	(41.6–61.4)
Version 44	44 820	(37 220–50 170)	22 550	(15 380–47 720)	50.1	(40.8–62.9)

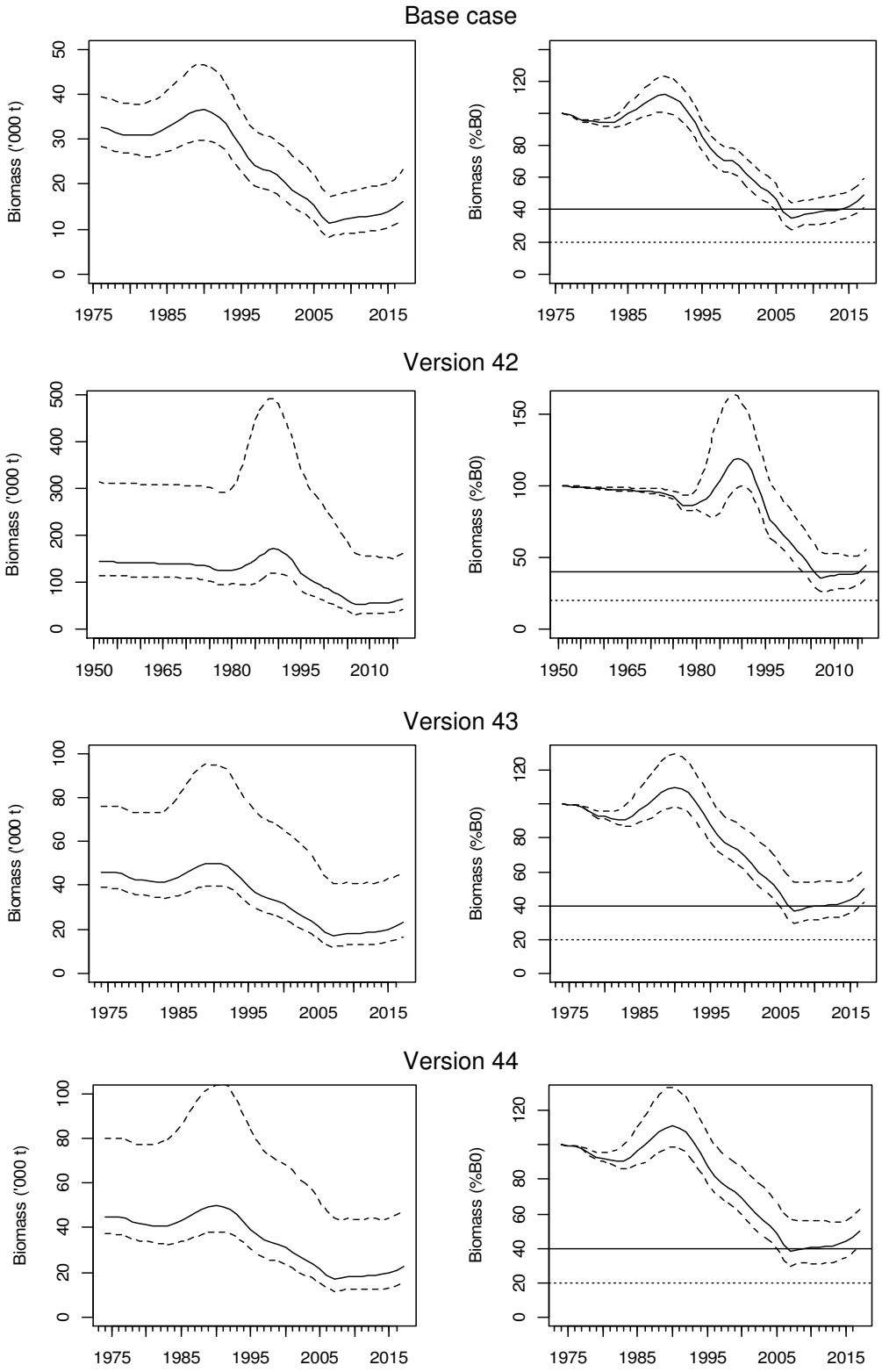


Figure 8: Hake, Chatham Rise — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0. Note that the *x*-axis year scale varies between model runs.

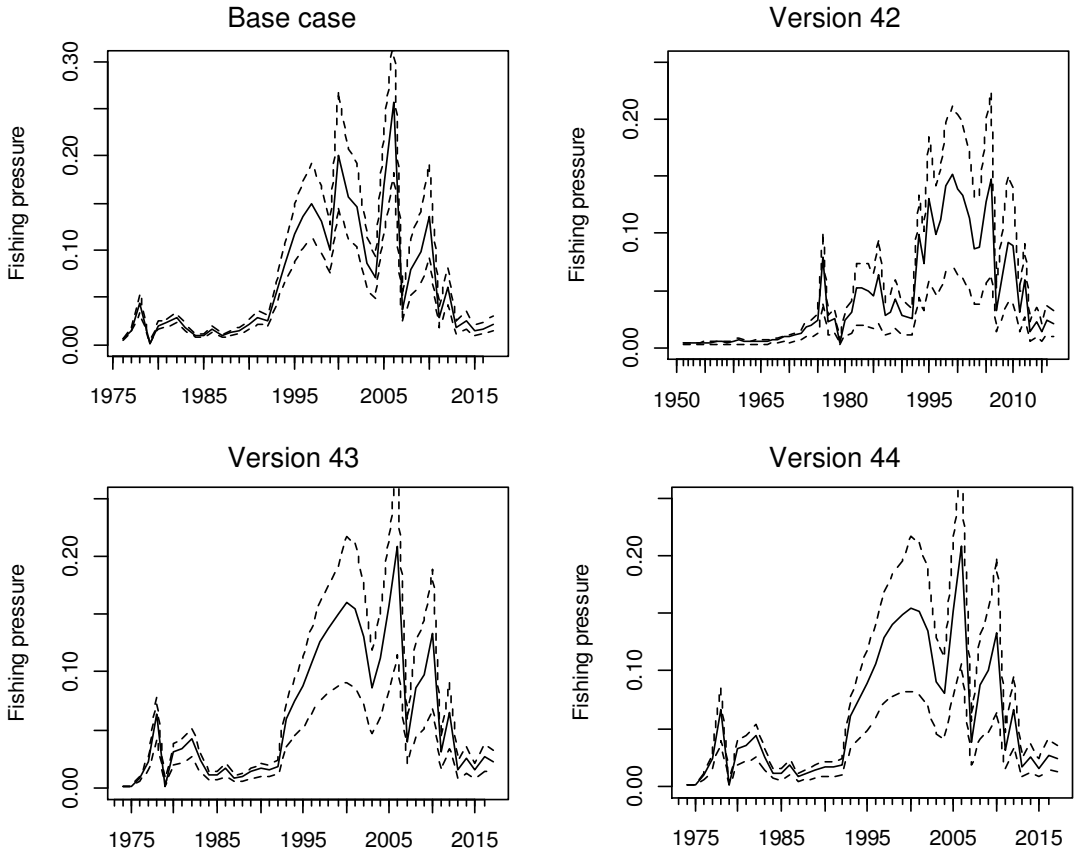


Figure 9: Hake, Chatham Rise — Estimated median trajectory of fishing intensities (with 95% credible intervals shown as dashed lines). Note that the *x*-axis year scale varies between model runs.

Table 14: Hake, Chatham Rise — Estimated absolute spawning stock biomass (SSB, t) and SSB as a proportion of B_0, by model year. –, years when landings were assumed to be zero.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1950	–	144 053	–	–	–	1.000	–	–
1951	–	143 668	–	–	–	0.997	–	–
1952	–	143 294	–	–	–	0.995	–	–
1953	–	142 933	–	–	–	0.992	–	–
1954	–	142 563	–	–	–	0.990	–	–
1955	–	142 205	–	–	–	0.987	–	–
1956	–	141 863	–	–	–	0.985	–	–
1957	–	141 511	–	–	–	0.982	–	–
1958	–	141 212	–	–	–	0.980	–	–
1959	–	140 914	–	–	–	0.978	–	–
1960	–	140 547	–	–	–	0.976	–	–
1961	–	140 236	–	–	–	0.974	–	–
1962	–	140 028	–	–	–	0.972	–	–
1963	–	139 850	–	–	–	0.971	–	–
1964	–	139 666	–	–	–	0.970	–	–
1965	–	139 461	–	–	–	0.968	–	–
1966	–	139 211	–	–	–	0.966	–	–
1967	–	138 917	–	–	–	0.964	–	–

Table 14 ctd.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1968	–	138 520	–	–	–	0.962	–	–
1969	–	138 049	–	–	–	0.958	–	–
1970	–	137 555	–	–	–	0.955	–	–
1971	–	136 906	–	–	–	0.950	–	–
1972	–	135 908	–	–	–	0.943	–	–
1973	–	134 625	45 816	44 813	–	0.935	1.000	1.000
1974	–	133 149	45 792	44 790	–	0.924	0.999	0.999
1975	32 537	128 674	45 624	44 622	1.000	0.893	0.996	0.996
1976	32 255	124 461	45 063	44 064	0.991	0.864	0.984	0.983
1977	31 512	123 604	43 575	42 584	0.968	0.858	0.951	0.950
1978	31 043	124 337	42 611	41 650	0.954	0.863	0.930	0.929
1979	30 972	125 572	42 404	41 510	0.952	0.872	0.926	0.926
1980	30 816	127 949	41 845	41 044	0.947	0.888	0.913	0.916
1981	30 785	130 555	41 408	40 693	0.946	0.906	0.904	0.908
1982	30 937	134 476	41 485	40 836	0.951	0.934	0.905	0.911
1983	31 653	140 076	42 371	41 687	0.973	0.972	0.925	0.930
1984	32 621	147 411	43 757	43 228	1.003	1.023	0.955	0.965
1985	33568	155 019	45 287	44 879	1.032	1.076	0.988	1.001
1986	34 621	161 380	46 886	46 560	1.064	1.120	1.023	1.039
1987	35 700	168 471	48 630	48 291	1.097	1.170	1.061	1.078
1988	36 418	170 960	49 790	49 444	1.119	1.187	1.087	1.103
1989	36 555	168 028	50 122	49 661	1.124	1.166	1.094	1.108
1990	35 932	164 413	49 736	49 331	1.104	1.141	1.086	1.101
1991	34 930	158 796	48 490	48 033	1.074	1.102	1.058	1.072
1992	33 341	146 998	46 123	45 678	1.025	1.020	1.007	1.019
1993	30 964	132 928	42 835	42 341	0.952	0.923	0.935	0.945
1994	28 226	120 047	39 620	39 131	0.868	0.833	0.865	0.873
1995	25 733	109 770	36 990	36 569	0.791	0.762	0.807	0.816
1996	23 986	103 912	35 243	34 734	0.737	0.721	0.769	0.775
1997	23 099	99 011	34 117	33 526	0.710	0.687	0.745	0.748
1998	22 913	94 345	32 995	32 415	0.704	0.655	0.720	0.723
1999	21 975	89 359	31 425	30 863	0.675	0.620	0.686	0.689
2000	20 311	84 217	29 455	29 023	0.624	0.585	0.643	0.648
2001	18 813	78 499	27 378	27 102	0.578	0.545	0.598	0.605
2002	17 538	73 244	25 700	25 216	0.539	0.508	0.561	0.563
2003	16 659	68 322	23 923	23 635	0.512	0.474	0.522	0.527
2004	15 148	61 546	21 382	21 564	0.466	0.427	0.467	0.481
2005	12 663	54 633	18 345	18 583	0.389	0.379	0.400	0.415
2006	11 339	51 285	16 845	16 934	0.349	0.356	0.368	0.378
2007	11 653	51 895	17 255	17 281	0.358	0.360	0.377	0.386
2008	12 135	52 937	17 800	17 765	0.373	0.367	0.388	0.396
2009	12 355	53 528	18 039	18 051	0.380	0.372	0.394	0.403
2010	12 569	54 247	18 243	18 245	0.386	0.377	0.398	0.407
2011	12 852	54 688	18 632	18 568	0.395	0.380	0.407	0.414
2012	12 965	54 728	18 734	18 659	0.398	0.380	0.409	0.416
2013	13 309	55 542	19 145	19 112	0.409	0.386	0.418	0.426
2014	13 794	57 251	19 901	19 788	0.424	0.397	0.434	0.442
2015	14 748	60 156	21 186	20 906	0.453	0.418	0.462	0.467
2016	16 000	64 507	22 980	22 549	0.492	0.448	0.502	0.503

Table 15: Hake, Chatham Rise — Estimated fishing intensity (catch divided by vulnerable biomass), by model year. –, years when landings were assumed to be zero.

Year	Fishing intensity				Year	Fishing intensity			
	Base	v42	v43	v44		Base	v42	v43	v44
1950	–	0.0034	–	–	1984	0.0097	0.0444	0.0112	0.0114
1951	–	0.0034	–	–	1985	0.0159	0.0635	0.0169	0.0174
1952	–	0.0035	–	–	1986	0.0092	0.0279	0.0085	0.0086
1953	–	0.0036	–	–	1987	0.0128	0.0315	0.0102	0.0103
1954	–	0.0042	–	–	1988	0.0147	0.0421	0.0137	0.0137
1955	–	0.0039	–	–	1989	0.0217	0.0281	0.0161	0.0163
1956	–	0.0046	–	–	1990	0.0284	0.0261	0.0157	0.0160
1957	–	0.0048	–	–	1991	0.0259	0.0250	0.0186	0.0186
1958	–	0.0042	–	–	1992	0.0534	0.0985	0.0597	0.0603
1959	–	0.0055	–	–	1993	0.0855	0.0737	0.0756	0.0756
1960	–	0.0060	–	–	1994	0.1177	0.1308	0.0882	0.0892
1961	–	0.0050	–	–	1995	0.1356	0.0996	0.1070	0.1060
1962	–	0.0048	–	–	1996	0.1502	0.1113	0.1263	0.1288
1963	–	0.0050	–	–	1997	0.1316	0.1413	0.1377	0.1406
1964	–	0.0054	–	–	1998	0.1004	0.1519	0.1497	0.1495
1965	–	0.0058	–	–	1999	0.2011	0.1388	0.1598	0.1542
1966	–	0.0067	–	–	2000	0.1557	0.1338	0.1549	0.1514
1967	–	0.0070	–	–	2001	0.1462	0.1139	0.1306	0.1349
1968	–	0.0091	–	–	2002	0.0860	0.0859	0.0866	0.0900
1969	–	0.0089	–	–	2003	0.0707	0.0875	0.1124	0.0801
1970	–	0.0102	–	–	2004	0.1685	0.1277	0.1567	0.1513
1971	–	0.0125	–	–	2005	0.2565	0.1472	0.2084	0.2087
1972	–	0.0177	–	–	2006	0.0362	0.0318	0.0399	0.0382
1973	–	0.0191	0.0006	0.0006	2007	0.0800	0.0661	0.0858	0.0880
1974	–	0.0234	0.0007	0.0007	2008	0.0982	0.0922	0.0982	0.1004
1975	0.0059	0.0796	0.0085	0.0089	2009	0.1364	0.0889	0.1325	0.1337
1976	0.0155	0.0220	0.0224	0.0233	2010	0.0287	0.0311	0.0303	0.0305
1977	0.0435	0.0252	0.0629	0.0660	2011	0.0608	0.0591	0.0646	0.0658
1978	0.0010	0.0039	0.0015	0.0015	2012	0.0174	0.0140	0.0158	0.0163
1979	0.0206	0.0242	0.0302	0.0318	2013	0.0257	0.0224	0.0245	0.0251
1980	0.0228	0.0307	0.0343	0.0352	2014	0.0155	0.0134	0.0148	0.0153
1981	0.0282	0.0526	0.0424	0.0432	2015	0.0163	0.0238	0.0261	0.0271
1982	0.0177	0.0517	0.0242	0.0248	2016	0.0214	0.0205	0.0225	0.0235
1983	0.0092	0.0498	0.0112	0.0116					

4.3 HAK 7 (WCSI)

The WCSI hake stock is modelled with catches taken by a single trawl fishery. Catch histories assumed for all model runs are listed in Table 16. There was no single accepted base case model for the WCSI hake assessment (Horn 2017). Two alternative runs were reported; the more optimistic one fitted to a CPUE series, and the more pessimistic one fitted to a trawl survey series. Re-runs using both these models are presented below.

For both of the WCSI hake model runs using catch history v42 it was necessary to increase the upper bound for the prior on B_0. If this was not done, virtually all the estimates of B_0 were at the previous bound of 350 000 t. The upper bound was increased to 650 000 t for these runs.

Table 16: Hake, WCSI — Catch history used in the previous hake WCSI base case model (Base), and alternative catch histories derived from SAU database versions 42, 43 and 44 that were used in the revised model runs. These values are derived from Table 1 by prorating between stocks (and fisheries within stocks) of each species using historial ratios for each year. All values in tonnes. –, landings assumed to be zero.

Year	Base	v42	v43	v44	Year	Base	v42	v43	v44
1950	–	3 224	–	–	1984	945	20 715	1 454	1 454
1951	–	3 210	–	–	1985	965	18 221	1 379	1 379
1952	–	3 306	–	–	1986	1 918	27 719	2 373	2 373
1953	–	3 362	118	118	1987	3 755	43 865	4 022	4 022
1954	–	3 948	0	0	1988	3 009	40 399	3 770	3 770
1955	–	3 671	0	0	1989	8 696	51 895	8 714	8 714
1956	–	4 258	0	0	1990	8 741	38 796	6 952	6 911
1957	–	4 440	0	0	1991	8 246	34 774	7 951	7 843
1958	–	3 924	0	0	1992	3 001	18 218	3 438	3 408
1959	–	5 065	0	0	1993	7 059	24 175	8 094	7 912
1960	–	5 543	0	0	1994	2 971	15 460	3 457	3 391
1961	–	4 628	1	1	1995	9 535	29 529	11 078	10 600
1962	–	4 413	2	2	1996	9 082	26 279	10 487	10 408
1963	–	4 607	1	1	1997	6 838	23 721	8 175	8 077
1964	–	4 959	2	2	1998	7 674	27 931	9 945	9 637
1965	–	5 338	13	13	1999	8 742	28 773	11 960	11 155
1966	–	6 115	1	1	2000	7 031	22 530	9 439	8 876
1967	–	6 431	0	0	2001	8 346	25 561	10 556	10 531
1968	–	8 268	0	0	2002	7 498	26 187	9 397	9 373
1969	–	8 083	0	0	2003	7 404	31 568	14 738	10 115
1970	–	9 280	0	0	2004	7 939	25 399	11 156	10 557
1971	–	11 305	0	0	2005	7 298	18 323	9 431	9 411
1972	–	15 934	0	0	2006	6 892	23 438	10 023	9 444
1973	–	17 000	189	189	2007	7 660	23 899	10 713	10 679
1974	–	20 659	203	203	2008	2 583	10 985	3 993	3 976
1975	71	3 784	142	142	2009	5 912	16 491	8 543	8 513
1976	5 005	26 798	10 010	10 010	2010	2 282	10 327	3 443	3 429
1977	17 806	38 918	35 612	35 612	2011	3 462	13 349	5 193	5 258
1978	498	7 677	996	996	2012	4 299	16 576	6 448	6 547
1979	4 737	22 014	9 474	9 474	2013	5 171	19 938	7 756	7 782
1980	3 600	20 442	7 310	7 310	2014	3 387	13 758	5 352	5 408
1981	2 565	21 405	5 130	5 130	2015	5 966	23 884	9 291	9 388
1982	1 625	21 434	2 955	2 955	2016	2 860	11 037	4 293	4 338
1983	745	18 511	1 212	1 212					

4.3.1 Model with CPUE abundance series

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2016}) are listed for each model run in Table 17. Biomass trajectories can be compared in Figure 10. Fishing intensities over time (Figure 11) are presented as the proportion of catch divided by vulnerable biomass. MCMC median estimates of spawning stock biomass and biomass as a proportion of B_0 are listed in Table 18, and fishing intensity for each modelled year are listed in Table 19.

Table 17: Hake, WCSI CPUE — Bayesian median and 95% credible intervals of B_0, B_{2016}, and B_{2016} as a percentage of B_0 for the four model runs fitting to the CPUE relative abundance series.

Model run	B_0		B_{2016}		B_{2016} (%B_0)	
Base case	92 100	(81 410–131 360)	46 550	(29 190–87 710)	50.3	(34.6–73.6)
Version 42	372 350	(338 160–454 220)	175 200	(114 020–301 790)	47.0	(33.1–68.1)
Version 43	120 960	(107 390–142 010)	63 390	(41 890–102 730)	52.2	(36.7–74.3)
Version 44	118 250	(103 070–175 150)	62 500	(38 570–115 270)	52.4	(35.9–74.6)

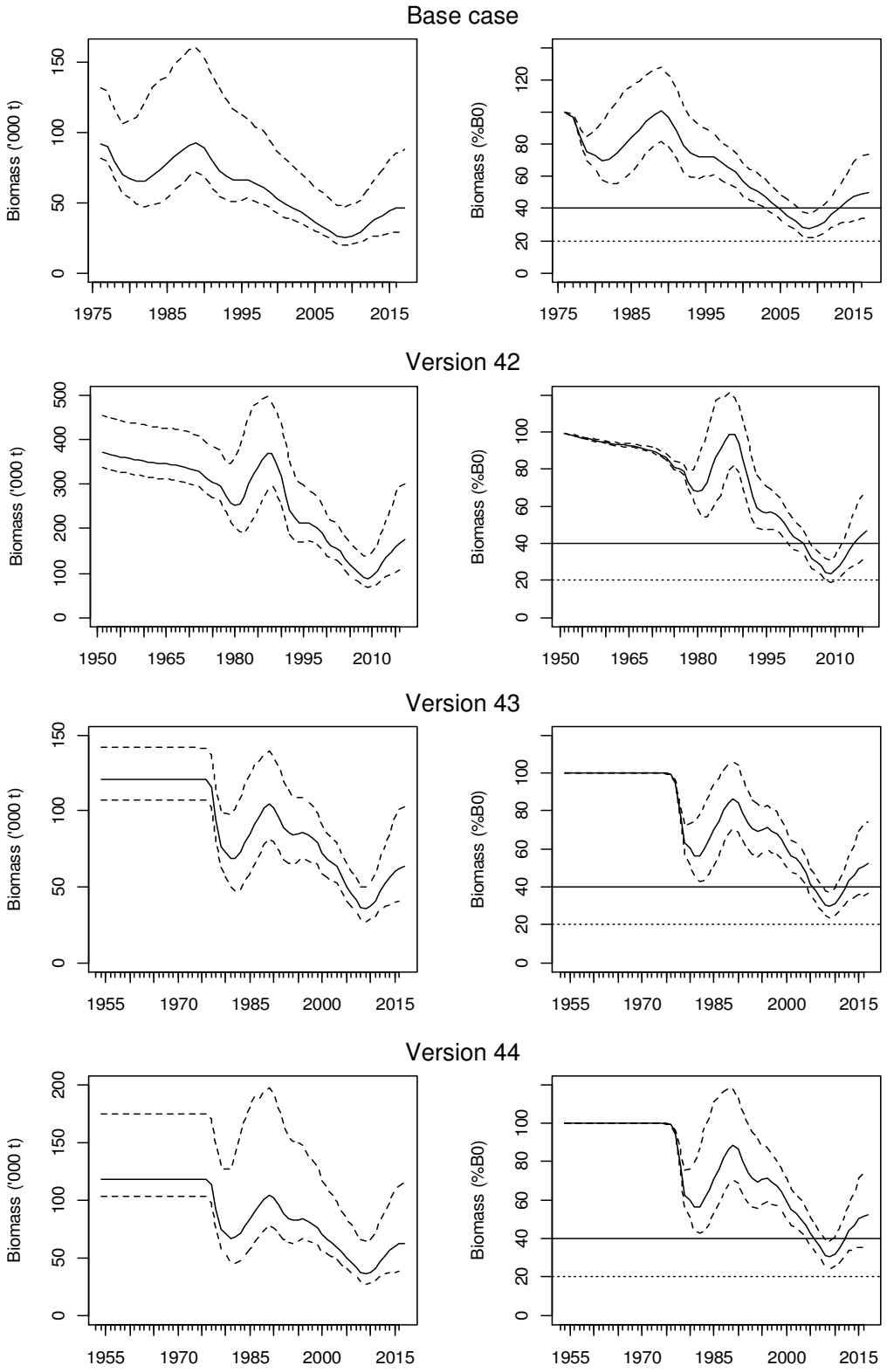


Figure 10: Hake, WCSI CPUE — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0. Note that the *x*-axis year scale varies between model runs.

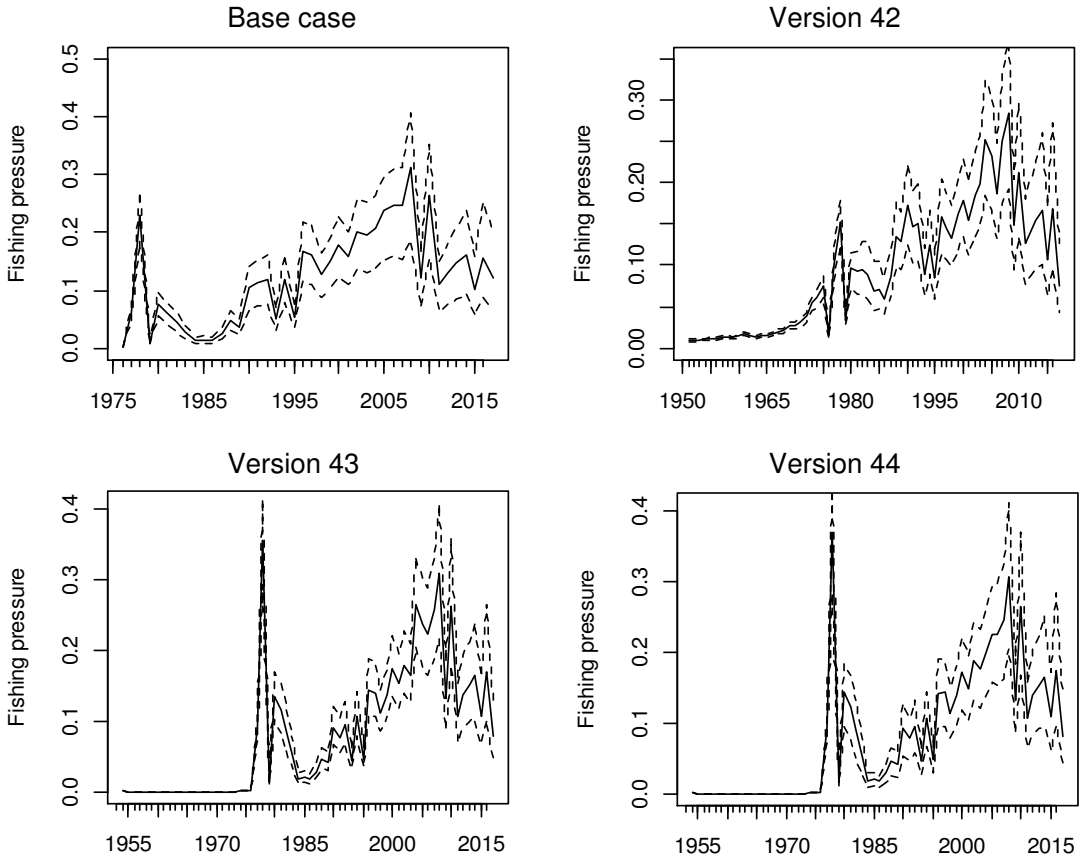


Figure 11: Hake, WCSI CPUE — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines). Note that the *x*-axis year scale varies between model runs.

Table 18: Hake, WCSI CPUE — Estimated absolute spawning stock biomass (SSB, t) and SSB as a proportion of B_0, by model year. –, years when landings were assumed to be zero.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1950	–	370 867	–	–	–	1.000	–	–
1951	–	368 039	–	–	–	0.992	–	–
1952	–	365 509	–	–	–	0.986	–	–
1953	–	363 240	120 905	118 196	–	0.979	1.000	1.000
1954	–	360 997	120 855	118 146	–	0.973	1.000	1.000
1955	–	358 911	120 868	118 158	–	0.968	1.000	1.000
1956	–	356 973	120 880	118 170	–	0.963	1.000	1.000
1957	–	354 946	120 891	118 181	–	0.957	1.000	1.000
1958	–	353 352	120 901	118 191	–	0.953	1.000	1.000
1959	–	351 711	120 909	118 199	–	0.948	1.000	1.000
1960	–	349 541	120 916	118 206	–	0.942	1.000	1.000
1961	–	347 828	120 922	118 212	–	0.938	1.000	1.000
1962	–	346 884	120 927	118 217	–	0.935	1.000	1.000
1963	–	346 123	120 930	118 220	–	0.933	1.000	1.000
1964	–	345 233	120 933	118 223	–	0.931	1.000	1.000
1965	–	344 127	120 930	118 220	–	0.928	1.000	1.000
1966	–	342 630	120 927	118 217	–	0.924	1.000	1.000
1967	–	340 813	120 931	118 221	–	0.919	1.000	1.000

Table 18 ctd.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1968	–	338 236	120 935	118 225	–	0.912	1.000	1.000
1969	–	335 207	120 939	118 229	–	0.904	1.000	1.000
1970	–	332 103	120 942	118 232	–	0.895	1.000	1.000
1971	–	327 914	120 944	118 235	–	0.884	1.000	1.000
1972	–	321 172	120 946	118 237	–	0.866	1.000	1.000
1973	–	312 580	120 861	118 153	–	0.843	1.000	1.000
1974	–	302 857	120 691	117 982	–	0.817	0.998	0.998
1975	92 068	300 340	120 535	117 821	1.000	0.810	0.997	0.997
1976	89 602	295 328	115 787	112 974	0.973	0.796	0.958	0.956
1977	78 812	272 686	94 227	91 476	0.856	0.735	0.779	0.774
1978	69 573	256 629	76 858	74 224	0.756	0.692	0.636	0.628
1979	67 174	252 968	73 086	71 062	0.730	0.682	0.604	0.601
1980	64 898	255 901	68 429	66 784	0.705	0.690	0.566	0.565
1981	65 653	272 861	68 857	67 648	0.713	0.736	0.570	0.572
1982	69 244	299 310	72 819	71 475	0.752	0.807	0.602	0.605
1983	73 410	323 025	78 921	77 515	0.797	0.871	0.653	0.656
1984	78 346	338 803	84 828	83 781	0.851	0.914	0.702	0.709
1985	82 174	356 010	90 787	89 783	0.893	0.960	0.751	0.760
1986	86 844	368 497	97 055	96 352	0.943	0.994	0.803	0.815
1987	90 438	368 013	101 811	101 325	0.982	0.992	0.842	0.857
1988	92 130	349 813	105 001	104 387	1.001	0.943	0.868	0.883
1989	89 097	316 380	102 416	102 124	0.968	0.853	0.847	0.864
1990	80 678	276 246	95 655	95 192	0.876	0.745	0.791	0.805
1991	72 747	242 118	89 344	87 975	0.790	0.653	0.739	0.744
1992	68 470	222 779	85 553	84 095	0.744	0.601	0.708	0.711
1993	66 423	213 568	84 011	82 276	0.721	0.576	0.695	0.696
1994	66 107	212 163	85 154	82 803	0.718	0.572	0.704	0.701
1995	66 176	211 945	86 113	83 961	0.719	0.571	0.712	0.710
1996	63 151	207 350	83 979	81 563	0.686	0.559	0.695	0.690
1997	60 369	200 497	82 105	79 446	0.656	0.541	0.679	0.672
1998	57 089	189 252	78 792	75 752	0.620	0.510	0.652	0.641
1999	52 335	173 148	72 542	70 160	0.568	0.467	0.600	0.594
2000	48 543	161 918	67 958	65 356	0.527	0.437	0.562	0.553
2001	46 438	156 860	66 173	62 814	0.504	0.423	0.547	0.531
2002	43 510	149 040	63 979	59 223	0.473	0.402	0.529	0.501
2003	39 782	133 189	57 600	54 955	0.432	0.359	0.476	0.465
2004	36 078	118 065	50 358	50 167	0.392	0.318	0.417	0.424
2005	32 768	109 970	46 046	45 823	0.356	0.297	0.381	0.388
2006	29 552	102 156	41 808	41 669	0.321	0.275	0.346	0.353
2007	26 107	90 972	36 788	36 912	0.284	0.245	0.304	0.312
2008	25 099	87 845	35 729	35 648	0.273	0.237	0.296	0.302
2009	26 478	94 249	37 691	37 643	0.288	0.254	0.312	0.318
2010	28 923	104 572	40 806	40 993	0.314	0.282	0.338	0.347
2011	33 464	119 998	46 789	46 822	0.363	0.324	0.387	0.396
2012	37 807	134 516	52 374	52 121	0.411	0.363	0.433	0.441
2013	40 822	145 904	56 232	56 098	0.443	0.393	0.465	0.475
2014	43 901	159 197	60 115	60 097	0.477	0.429	0.497	0.508
2015	45 873	168 099	62 140	61 701	0.498	0.453	0.514	0.522
2016	46 548	175 197	63 385	62 495	0.506	0.472	0.524	0.529

Table 19: Hake, WCSI CPUE — Estimated fishing intensity (catch over vulnerable biomass), by model year. –, years when landings were assumed to be zero.

Year	Fishing intensity				Year	Fishing intensity			
	Base	v42	v43	v44		Base	v42	v43	v44
1950	–	0.0097	–	–	1984	0.0141	0.0715	0.0198	0.0204
1951	–	0.0098	–	–	1985	0.0136	0.0597	0.0176	0.0179
1952	–	0.0101	–	–	1986	0.0256	0.0871	0.0281	0.0287
1953	–	0.0104	0.0011	0.0011	1987	0.0480	0.1346	0.0451	0.0457
1954	–	0.0122	0.0000	0.0000	1988	0.0371	0.1283	0.0405	0.0410
1955	–	0.0115	0.0000	0.0000	1989	0.1051	0.1728	0.0911	0.0926
1956	–	0.0134	0.0000	0.0000	1990	0.1131	0.1474	0.0770	0.0778
1957	–	0.0140	0.0000	0.0000	1991	0.1193	0.1500	0.0941	0.0943
1958	–	0.0125	0.0000	0.0000	1992	0.0490	0.0898	0.0442	0.0448
1959	–	0.0161	0.0000	0.0000	1993	0.1184	0.1258	0.1056	0.1059
1960	–	0.0178	0.0000	0.0000	1994	0.0528	0.0845	0.0470	0.0474
1961	–	0.0149	0.0000	0.0000	1995	0.1674	0.1586	0.1432	0.1422
1962	–	0.0143	0.0000	0.0000	1996	0.1617	0.1455	0.1391	0.1431
1963	–	0.0149	0.0000	0.0000	1997	0.1279	0.1336	0.1105	0.1143
1964	–	0.0161	0.0000	0.0000	1998	0.1497	0.1618	0.1364	0.1387
1965	–	0.0174	0.0001	0.0001	1999	0.1783	0.1795	0.1740	0.1711
1966	–	0.0200	0.0000	0.0000	2000	0.1577	0.1545	0.1521	0.1495
1967	–	0.0212	0.0000	0.0000	2001	0.1998	0.1851	0.1788	0.1874
1968	–	0.0274	0.0000	0.0000	2002	0.1957	0.1978	0.1653	0.1769
1969	–	0.0270	0.0000	0.0000	2003	0.2073	0.2528	0.2659	0.1978
1970	–	0.0313	0.0000	0.0000	2004	0.2370	0.2332	0.2365	0.2261
1971	–	0.0385	0.0000	0.0000	2005	0.2472	0.1874	0.2242	0.2256
1972	–	0.0552	0.0000	0.0000	2006	0.2473	0.2512	0.2576	0.2465
1973	–	0.0605	0.0017	0.0018	2007	0.3131	0.2842	0.3090	0.3079
1974	–	0.0757	0.0019	0.0019	2008	0.1222	0.1490	0.1331	0.1322
1975	0.0009	0.0144	0.0013	0.0014	2009	0.2631	0.2117	0.2636	0.2640
1976	0.0614	0.0998	0.0917	0.0956	2010	0.1088	0.1262	0.1061	0.1066
1977	0.2308	0.1536	0.3552	0.3710	2011	0.1298	0.1408	0.1367	0.1389
1978	0.0081	0.0338	0.0144	0.0152	2012	0.1458	0.1541	0.1499	0.1534
1979	0.0767	0.0965	0.1357	0.1428	2013	0.1602	0.1665	0.1640	0.1658
1980	0.0619	0.0934	0.1167	0.1221	2014	0.1007	0.1066	0.1060	0.1087
1981	0.0453	0.0955	0.0859	0.0895	2015	0.1569	0.1676	0.1690	0.1732
1982	0.0279	0.0890	0.0479	0.0495	2016	0.1221	0.0755	0.0781	0.0809
1983	0.0120	0.0696	0.0182	0.0187					

4.3.2 Model with trawl survey abundance series

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2016}) are listed for each model run in Table 20. Biomass trajectories can be compared in Figure 12. Fishing intensities over time (Figure 13) are presented as the proportion of catch divided by vulnerable biomass. MCMC median estimates of spawning stock biomass and biomass as a proportion of B_0 are listed in Table 21, and fishing intensities for each modelled year are listed in Table 22.

Table 20: Hake, WCSI survey — Bayesian median and 95% credible intervals of B_0, B_{2016}, and B_{2016} as a percentage of B_0 for the four model runs fitting to the trawl survey relative abundance series.

Model run	B_0		B_{2016}		B_{2016} (%B_0)	
Base case	79 190	(73 000–87 990)	20 490	(14 640–30 880)	25.7	(19.1–36.5)
Version 42	326 940	(306 040–347 360)	78 980	(59 860–111 610)	24.1	(18.8–33.1)
Version 43	105 020	(96 540–117 260)	27 620	(20 110–41 800)	26.3	(20.0–37.8)
Version 44	101 060	(92 870–122 890)	26 460	(18 890–41 340)	26.0	(19.4–38.2)

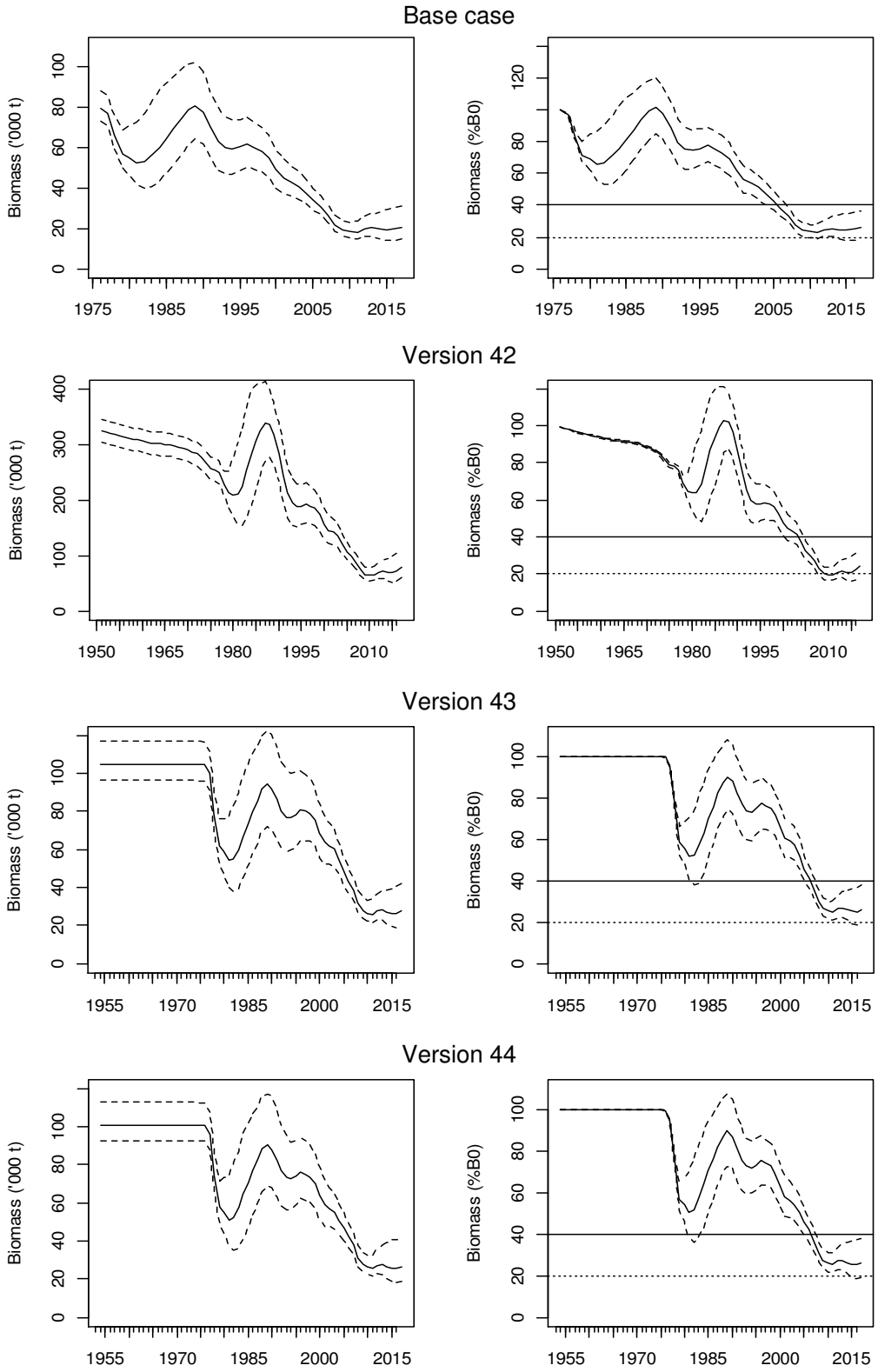


Figure 12: Hake, WCSI survey — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0. Note that the *x*-axis year scale varies between model runs.

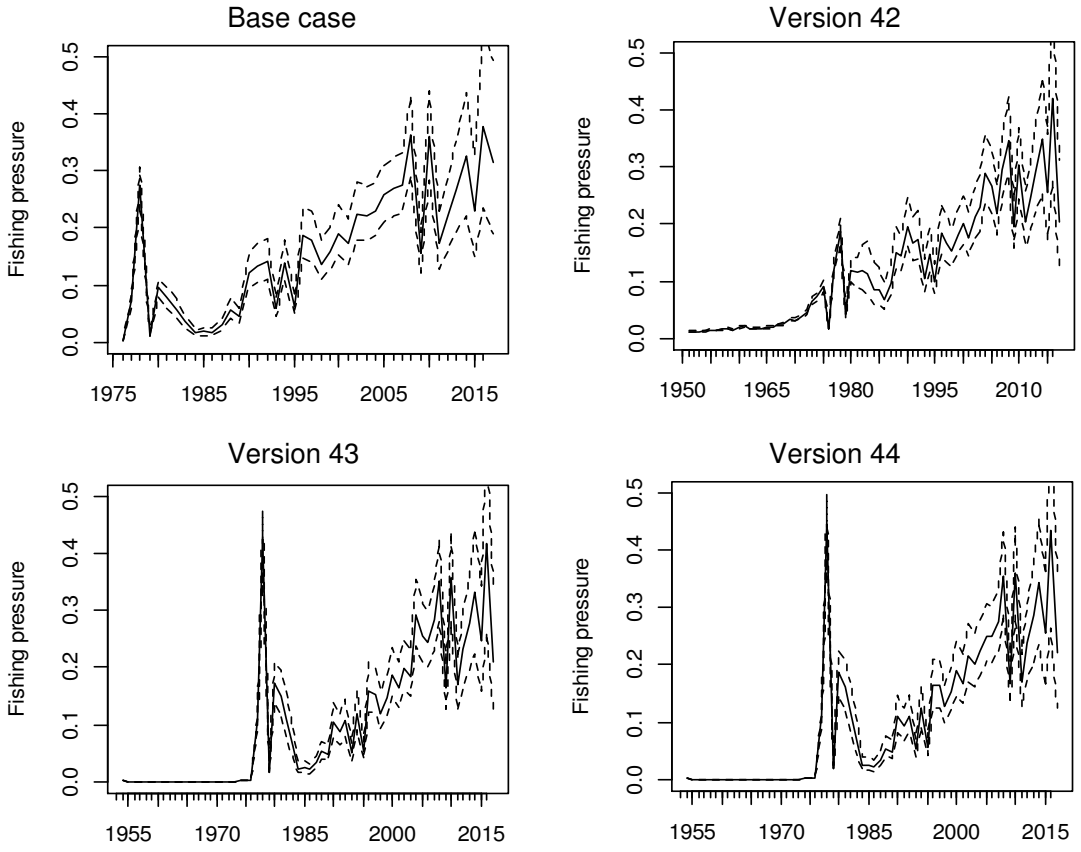


Figure 13: Hake, WCSI survey — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines). Note that the *x*-axis year scale varies between model runs.

Table 21: Hake, WCSI survey — Estimated absolute spawning stock biomass (SSB, t) and SSB as a proportion of B_0, by model year. –, years when landings were assumed to be zero.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1950	–	325 448	–	–	–	1.000	–	–
1951	–	322 624	–	–	–	0.991	–	–
1952	–	320 101	–	–	–	0.984	–	–
1953	–	317 851	104 968	101 003	–	0.977	1.000	1.000
1954	–	315 635	104 919	100 954	–	0.970	1.000	1.000
1955	–	313 575	104 931	100 966	–	0.964	1.000	1.000
1956	–	311 645	104 943	100 978	–	0.958	1.000	1.000
1957	–	309 626	104 955	100 989	–	0.951	1.000	1.000
1958	–	308 040	104 965	100 999	–	0.947	1.000	1.000
1959	–	306 395	104 973	101 008	–	0.941	1.000	1.000
1960	–	304 223	104 980	101 015	–	0.935	1.000	1.000
1961	–	302 532	104 986	101 021	–	0.930	1.000	1.000
1962	–	301 607	104 990	101 025	–	0.927	1.000	1.000
1963	–	300 847	104 994	101 028	–	0.924	1.000	1.000
1964	–	299 958	104 996	101 031	–	0.922	1.000	1.000
1965	–	298 852	104 993	101 028	–	0.918	1.000	1.000
1966	–	297 354	104 991	101 026	–	0.914	1.000	1.000
1967	–	295 537	104 995	101 030	–	0.908	1.000	1.000

Table 21 ctd.

Year	SSB				Proportion B_0			
	Base	v42	v43	v44	Base	v42	v43	v44
1968	–	292 952	104 999	101 034	–	0.900	1.000	1.000
1969	–	289 903	105 002	101 037	–	0.891	1.000	1.000
1970	–	286 777	105 005	101 040	–	0.881	1.000	1.000
1971	–	282 566	105 008	101 043	–	0.868	1.000	1.000
1972	–	275 828	105 010	101 045	–	0.848	1.000	1.000
1973	–	267 247	104 925	100 960	–	0.821	1.000	1.000
1974	–	257 516	104 755	100 790	–	0.791	0.998	0.998
1975	79 150	255 036	104 608	100 635	1.000	0.784	0.997	0.996
1976	76 728	250 088	99 839	95 873	0.969	0.768	0.951	0.949
1977	65 857	227 847	78 488	74 491	0.832	0.700	0.748	0.738
1978	56 826	212 549	61 652	57 688	0.718	0.653	0.587	0.571
1979	54 692	209 494	58 925	54 928	0.691	0.644	0.561	0.544
1980	52 428	210 702	54 713	51 169	0.662	0.647	0.521	0.507
1981	53 173	225 181	55 279	52 252	0.672	0.692	0.527	0.517
1982	56 064	253 152	59 615	57 466	0.708	0.778	0.568	0.569
1983	59 696	283 397	66 151	64 443	0.754	0.871	0.630	0.638
1984	64 174	307 272	73 221	70 923	0.811	0.944	0.698	0.702
1985	69 046	325 485	79 983	77 162	0.872	1.000	0.762	0.764
1986	74 003	337 666	86 125	83 005	0.935	1.038	0.820	0.822
1987	78 354	335 285	91 697	88 251	0.990	1.030	0.874	0.874
1988	80 526	317 148	94 805	90 791	1.017	0.974	0.903	0.899
1989	77 675	284 319	92 258	87 912	0.981	0.874	0.879	0.870
1990	70 356	245 109	86 159	82 121	0.889	0.753	0.821	0.813
1991	62 968	212 957	80 170	76 595	0.796	0.654	0.764	0.758
1992	59 683	195 243	76 974	73 589	0.754	0.600	0.733	0.729
1993	59 106	188 543	76 579	73 114	0.747	0.579	0.730	0.724
1994	60 299	188 509	78 471	74 263	0.762	0.579	0.748	0.735
1995	61 715	191 671	80 991	76 188	0.780	0.589	0.772	0.754
1996	60 154	188 174	80 042	75 057	0.760	0.578	0.763	0.743
1997	58 287	184 737	79 006	73 695	0.736	0.568	0.753	0.730
1998	54 775	174 114	75 482	70 232	0.692	0.535	0.719	0.695
1999	49 124	156 691	69 055	63 814	0.621	0.481	0.658	0.632
2000	44 690	145 374	63 768	59 010	0.565	0.447	0.608	0.584
2001	42 776	141 999	62 200	56 836	0.540	0.436	0.593	0.563
2002	40 627	135 837	60 320	54 759	0.513	0.417	0.575	0.542
2003	37 610	121 734	54 954	51 170	0.475	0.374	0.524	0.507
2004	33 998	106 761	47 993	46 844	0.430	0.328	0.457	0.464
2005	30 324	98 523	43 477	42 578	0.383	0.303	0.414	0.422
2006	26 467	88 749	38 355	37 882	0.334	0.273	0.365	0.375
2007	21 920	74 126	31 663	31 510	0.277	0.228	0.302	0.312
2008	19 341	65 832	27 911	27 677	0.244	0.202	0.266	0.274
2009	18 364	64 375	26 426	26 093	0.232	0.198	0.252	0.258
2010	18 086	65 089	25 922	25 563	0.229	0.200	0.247	0.253
2011	19 530	69 618	27 722	27 312	0.247	0.214	0.264	0.270
2012	20 251	71 320	28 318	27 741	0.256	0.219	0.270	0.275
2013	19 648	69 254	27 181	26 511	0.248	0.213	0.259	0.262
2014	19 417	68 981	26 416	25 745	0.245	0.212	0.252	0.255
2015	19 891	71 983	26 379	25 526	0.251	0.221	0.251	0.253
2016	20 486	78 983	27 621	26 457	0.259	0.243	0.263	0.262

Table 22: Hake, WCSI survey — Estimated fishing intensity (catch over vulnerable biomass), by model year. –, years when landings were assumed to be zero.

Year	Fishing intensity				Year	Fishing intensity			
	Base	v42	v43	v44		Base	v42	v43	v44
1950	–	0.0112	–	–	1984	0.0177	0.0846	0.0243	0.0253
1951	–	0.0113	–	–	1985	0.0168	0.0680	0.0208	0.0215
1952	–	0.0117	–	–	1986	0.0311	0.0968	0.0330	0.0341
1953	–	0.0120	0.0013	0.0013	1987	0.0572	0.1511	0.0522	0.0544
1954	–	0.0142	0.0000	0.0000	1988	0.0438	0.1443	0.0464	0.0485
1955	–	0.0133	0.0000	0.0000	1989	0.1224	0.1957	0.1034	0.1091
1956	–	0.0155	0.0000	0.0000	1990	0.1333	0.1680	0.0877	0.0921
1957	–	0.0163	0.0000	0.0000	1991	0.1404	0.1727	0.1068	0.1113
1958	–	0.0145	0.0000	0.0000	1992	0.0578	0.1045	0.0505	0.0527
1959	–	0.0188	0.0000	0.0000	1993	0.1378	0.1461	0.1200	0.1233
1960	–	0.0207	0.0000	0.0000	1994	0.0605	0.0987	0.0532	0.0550
1961	–	0.0174	0.0000	0.0000	1995	0.1863	0.1829	0.1597	0.1628
1962	–	0.0167	0.0000	0.0000	1996	0.1769	0.1673	0.1536	0.1633
1963	–	0.0174	0.0000	0.0000	1997	0.1367	0.1516	0.1199	0.1282
1964	–	0.0188	0.0000	0.0000	1998	0.1582	0.1810	0.1458	0.1537
1965	–	0.0203	0.0001	0.0002	1999	0.1894	0.2000	0.1856	0.1883
1966	–	0.0234	0.0000	0.0000	2000	0.1713	0.1757	0.1649	0.1678
1967	–	0.0247	0.0000	0.0000	2001	0.2227	0.2127	0.1974	0.2139
1968	–	0.0320	0.0000	0.0000	2002	0.2206	0.2285	0.1835	0.2022
1969	–	0.0317	0.0000	0.0000	2003	0.2281	0.2885	0.2907	0.2229
1970	–	0.0367	0.0000	0.0000	2004	0.2570	0.2652	0.2557	0.2495
1971	–	0.0453	0.0000	0.0000	2005	0.2695	0.2172	0.2433	0.2493
1972	–	0.0651	0.0000	0.0000	2006	0.2762	0.2944	0.2841	0.2757
1973	–	0.0718	0.0020	0.0021	2007	0.3643	0.3467	0.3527	0.3552
1974	–	0.0903	0.0022	0.0023	2008	0.1548	0.1967	0.1653	0.1663
1975	0.0010	0.0173	0.0015	0.0016	2009	0.3592	0.3023	0.3580	0.3615
1976	0.0721	0.1194	0.1084	0.1127	2010	0.1726	0.2046	0.1689	0.1703
1977	0.2738	0.1855	0.4258	0.4448	2011	0.2205	0.2476	0.2326	0.2384
1978	0.0100	0.0416	0.0187	0.0200	2012	0.2677	0.2922	0.2765	0.2855
1979	0.0952	0.1182	0.1733	0.1855	2013	0.3262	0.3496	0.3320	0.3429
1980	0.0780	0.1156	0.1504	0.1617	2014	0.2299	0.2553	0.2453	0.2555
1981	0.0574	0.1193	0.1113	0.1195	2015	0.3770	0.4199	0.4165	0.4338
1982	0.0354	0.1117	0.0618	0.0656	2016	0.3139	0.2027	0.2093	0.2223
1983	0.0152	0.0857	0.0229	0.0241					

4.4 Conclusions – Hake

The alternative catch histories in SAU versions 43 and 44 were generally higher, but often only slightly so, than the MPI plenary catch history used in the base model (Figure 14). SAU version 42 was much higher (generally by a factor of about 3–4, but sometimes much greater) than the base model catch history (Figure 14).

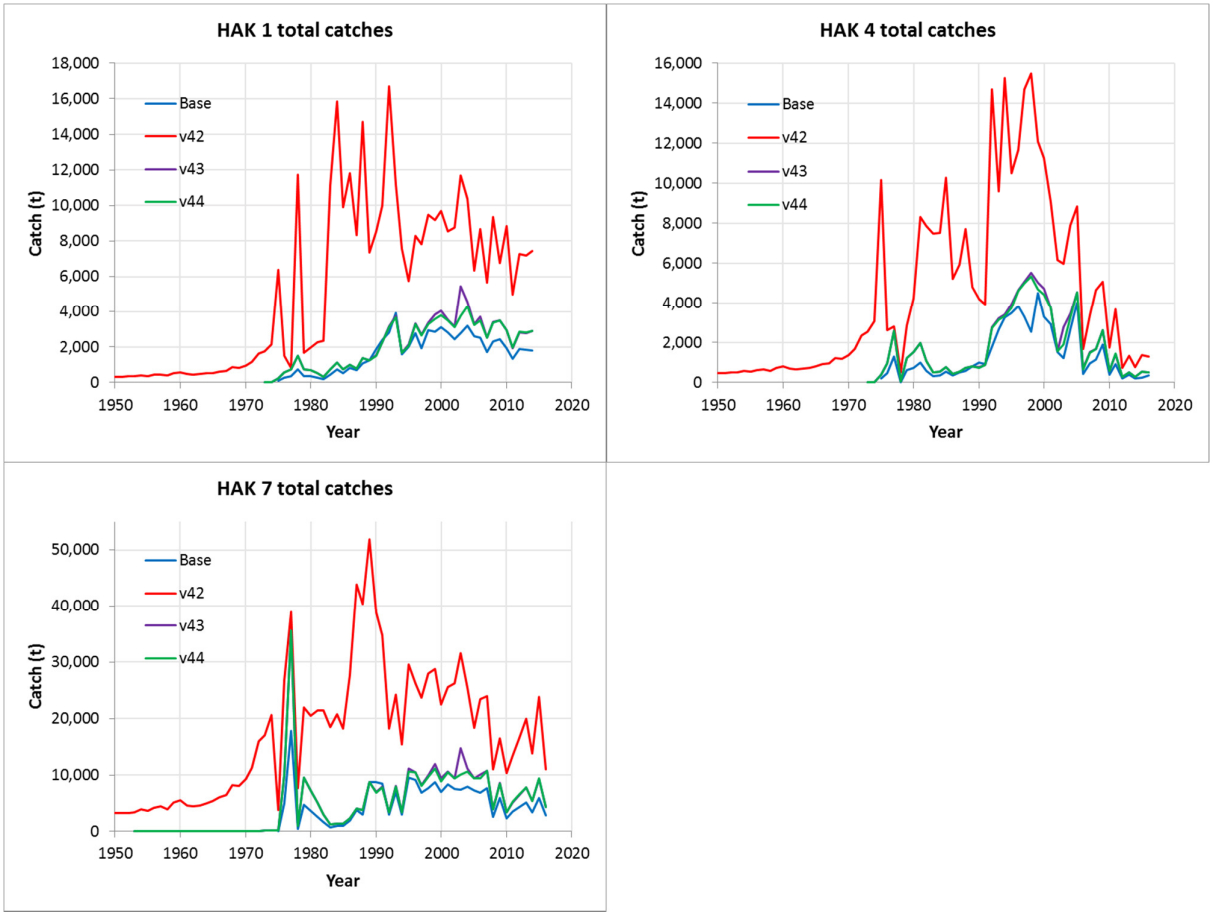


Figure 14: Total catch histories used in the hake base case assessments and in the assessments using the three alternative SAU datasets, for each of the three biological stocks.

The impacts from using the three alternative catch histories were generally similar for all the hake stocks (Figure 15 and 16). Relative to the base models, estimated virgin and current absolute biomasses were slightly higher when using catch versions 43 and 44, and much higher when using version 42. The estimates of $\%B_0$ (stock status) were, however, similar to those from the base models throughout the time series, with the exception of Sub-Antarctic hake (HAK 1) where version 42 produced moderately lower estimates of $\%B_0$, particularly in recent years. Catch version 42 was the only case where estimates of the current absolute biomass and current $\%B_0$ differed from the base case by more than 5%.

Fishing intensities were also generally considerably higher over the entire time series for version 42 for Sub-Antarctic hake, but were mostly within the range of the time series of fishing intensities for the other alternative catch histories (Figures 15 and 16).

Catch history version 42 is considered to be unrealistically high. When using this history, the trawl survey catchability (q) values for all the modelled stocks are tightly grouped around the lower bound of the prior set for this parameter (i.e, 0.01). The prior distribution for q has most of its density centred around 0.1; a real value one-tenth of this is believed to be most unlikely. The estimated size of the WCSI hake virgin biomass (300 000–400 000 t) when using version 42 is also considered to be impractically high for the geographical area of the stock (Figure 16).

The implications for the likely current status of the hake stocks are slight if either of catch versions 43 or 44 were to be used to represent fishery extractions rather than the catch history used in the base model runs. However, versions 43 and 44 both indicate that estimates of absolute biomass throughout the duration of the fishery are about 10–35% higher than those estimated from the base models, while fishing intensities trends are more variable but overall similar (Figures 15 and 16).

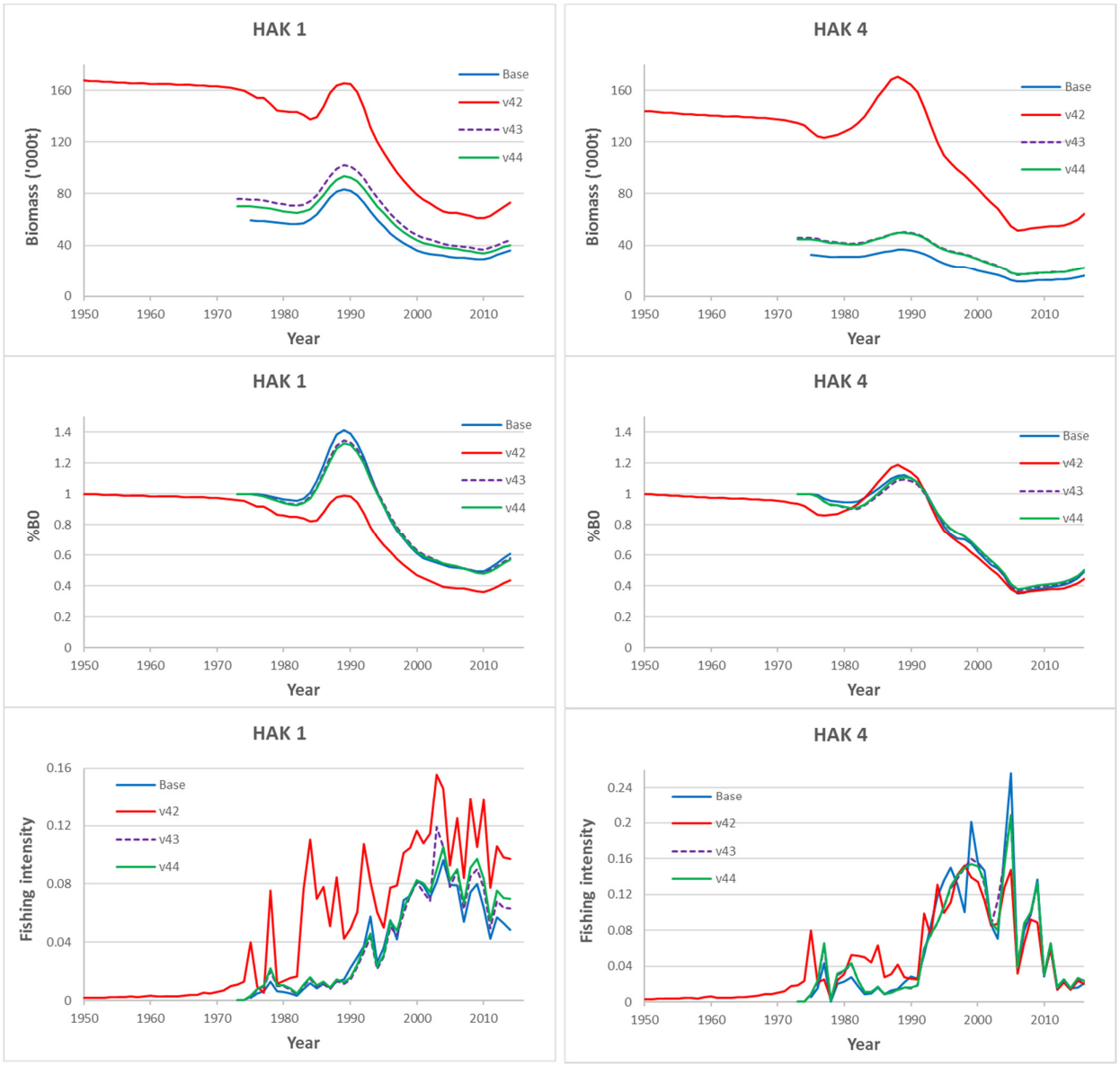


Figure 15: Median biomass trajectories, stock status trajectories, and estimated fishing intensity for the Sub-Antarctic (HAK 1) and Chatham Rise (HAK 4) hake stocks from the base case assessments and the assessments using the three alternative SAU datasets.

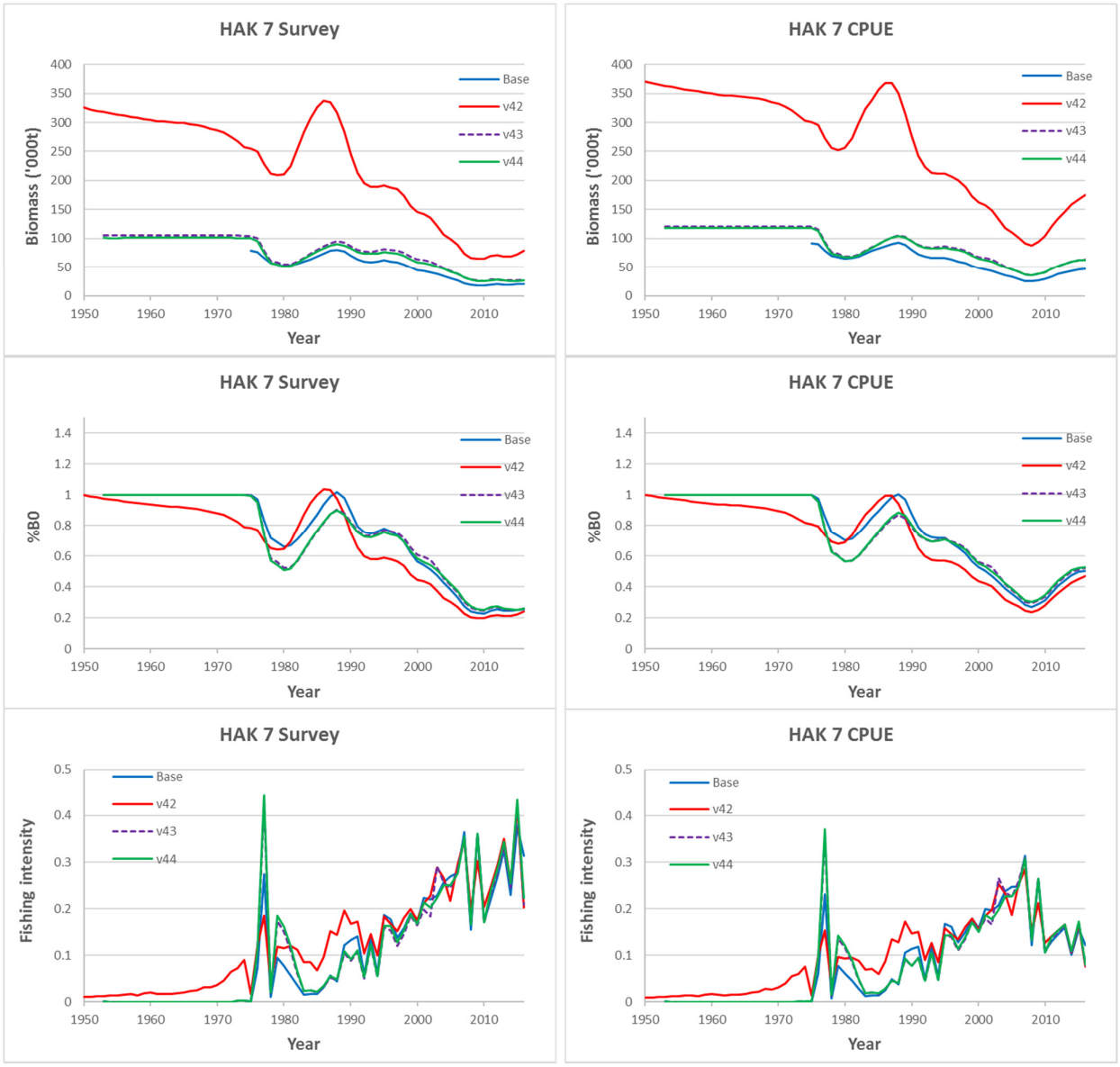


Figure 16: Median biomass trajectories, stock status trajectories, and estimated fishing intensity for the WCSI (HAK 7) hake stock from the 'Survey' and 'CPUE' assessments and the assessments using the three alternative SAU datasets.

5. LING

Ling are assessed and managed as six stocks, of which three have been managed using scientific advice from quantitative population models (Ministry for Primary Industries 2017). These are Chatham Rise (LIN 3&4), Southern Plateau (LIN 5&6 excluding the Bounty Plateau), and the west coast South Island (LIN 7 excluding Cook Strait).

5.1 LIN 3&4 (Chatham Rise)

The LIN 3&4 stock is modelled with catches taken by trawl and longline fisheries. Catch histories assumed for all model runs are listed in Table 23.

Table 23: Ling, Chatham Rise — Catch history used in the 2015 stock assessment model runs (Base), and alternative catch histories derived from SAU database versions 42, 43 and 44 that were used in the revised model runs. These values are derived from Table 1 by prorating between stocks (and fisheries within stocks) of each species using historial ratios for each year. All values in tonnes. Catches prior to 1973 were negligible and assumed to be zero.

	Base		v42		v43		v44	
Year	trawl	longline	trawl	longline	trawl	longline	trawl	longline
1973	250	0	550	0	836	0	836	0
1974	382	0	561	0	511	0	511	0
1975	953	8 439	199	1 765	631	5 587	631	5 587
1976	2 100	17 436	250	2 076	963	7 996	963	7 996
1977	2 055	23 994	274	3 203	728	8 502	728	8 502
1978	1 400	7 577	226	1 224	818	4 428	818	4 428
1979	2 380	821	723	249	3 411	1 176	3 411	1 176
1980	1 340	360	467	126	2 264	608	2 264	608
1981	673	160	502	119	1 450	345	1 450	345
1982	1 183	339	1 399	401	2 454	703	2 454	703
1983	1 210	326	1 467	395	1 915	516	1 915	516
1984	1 366	406	1 475	438	2 164	643	2 164	643
1985	1 351	401	1 154	342	1 591	472	1 591	472
1986	1 494	375	1 905	478	2 006	504	2 006	504
1987	1 313	306	2 419	564	1 551	361	1 551	361
1988	1 636	290	4 829	856	2 639	468	2 639	468
1989	1 397	488	2 938	1 026	1 708	597	1 708	597
1990	1 934	529	2 660	728	2 126	581	2 122	581
1991	2 563	2 228	2 561	2 226	2 791	2 426	2 789	2 424
1992	3 451	3 695	4 355	4 663	3 541	3 791	3 530	3 780
1993	2 375	3 971	2 735	4 574	2 524	4 220	2 523	4 219
1994	1 933	4 159	2 423	5 214	2 065	4 444	2 066	4 444
1995	2 222	5 530	2 365	5 887	2 447	6 089	2 447	6 089
1996	2 725	4 863	2 357	4 206	2 984	5 325	2 984	5 325
1997	3 003	4 047	3 408	4 592	3 409	4 594	3 410	4 595
1998	4 707	3 227	5 062	3 470	5 346	3 665	5 343	3 663
1999	3 282	3 818	3 752	4 365	3 843	4 471	3 839	4 466
2000	3 739	2 779	4 247	3 157	4 376	3 253	4 336	3 222
2001	3 467	2 724	3 634	2 855	4 031	3 167	4 026	3 163
2002	2 979	2 787	3 630	3 396	3 500	3 275	3 501	3 275
2003	3 375	2 150	4 391	2 797	4 044	2 576	3 944	2 513
2004	2 525	2 082	3 045	2 511	3 021	2 491	2 946	2 429
2005	1 913	2 440	1 970	2 512	2 186	2 789	2 187	2 789
2006	1 639	1 840	2 251	2 527	2 013	2 260	1 977	2 220

Table 23 ctd.

	Base		v42		v43		v44	
Year	trawl	longline	trawl	longline	trawl	longline	trawl	longline
2007	2 322	1 880	3 135	2 538	2 846	2 304	2 847	2 305
2008	2 350	1 810	2 511	1 934	2 589	1 994	2 590	1 995
2009	1 534	2 217	1 664	2 405	1 848	2 672	1 849	2 672
2010	1 484	2 257	1 909	2 903	1 804	2 744	1 805	2 745
2011	1 191	2 046	1 358	2 332	1 390	2 388	1 441	2 475
2012	1 407	2 190	1 609	2 504	1 647	2 564	1 693	2 636
2013	1 113	2 543	1 267	2 896	1 298	2 965	1 282	2 928
2014	1 340	2 250	1 528	2 566	1 565	2 628	1 565	2 628
2015	1 064	1 608	1 214	1 834	1 243	1 878	1 243	1 878

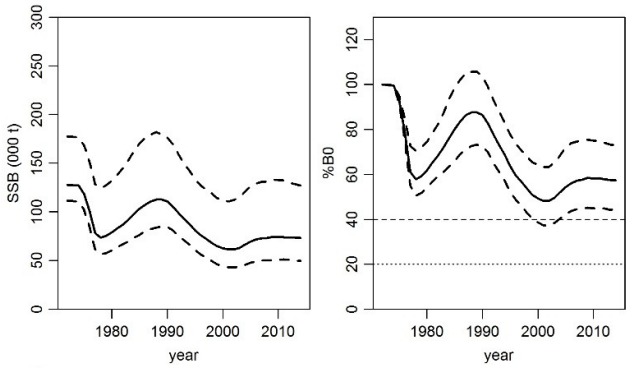
The most recent stock assessment was in 2014–15, for which there was a "base" model run. SAU alternative catch histories were apportioned to fleets according to the catch-by-gear ratios from the 2015 assessment model.

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2014}) are listed for each model run in Table 24. Biomass trajectories can be compared in Figure 17. Fishing intensities over time (Figure 18) are presented as the proportion of catch divided by vulnerable biomass. MCMC median estimates of spawning stock biomass and biomass as a percentage of B_0 are listed in Table 25, and fishing intensities for each modelled year are listed in Table 26.

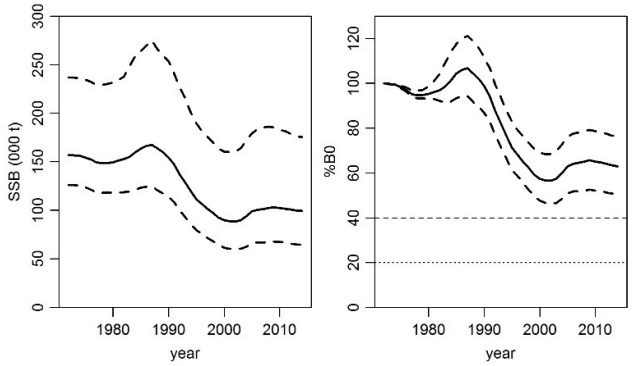
Table 24: Ling, Chatham Rise — Bayesian median and 95% credible intervals of B_0, B_{2014}, and B_{2014} as a percentage of B_0 for the four different catch histories (Base (2015) assessment, and SAU versions 42, 43, and 44). Following Ministry for Primary Industries (2017), biomasses have been rounded to the nearest 100 t.

Model run	B_0	B_{2014}	B_{2014} (%B_0)
Base	127 600 (111 500–177 300)	73 200 (49 900–127 100)	57 (44–73)
Version 42	157 000 (126 200–237 000)	99 200 (64 300–175 700)	63 (50–76)
Version 43	152 400 (126 200–221 200)	93 700 (62 800–161 900)	61 (49–74)
Version 44	150 800 (125 300–223 100)	92 000 (60 900–166 600)	61 (48–76)

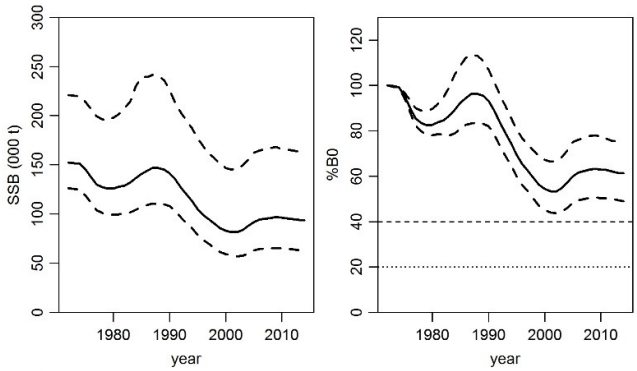
Base assessment model



Version 42



Version 43



Version 44

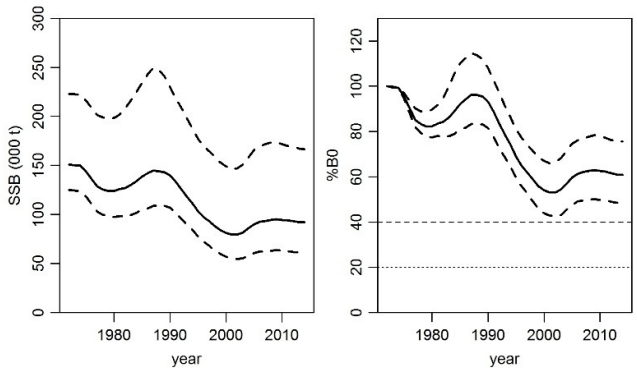
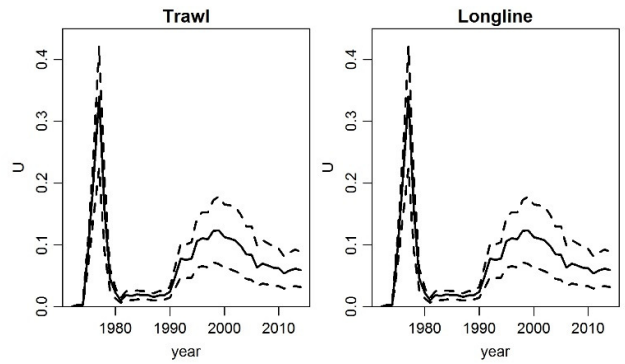


Figure 17: Ling, Chatham Rise — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0.

Base assessment model



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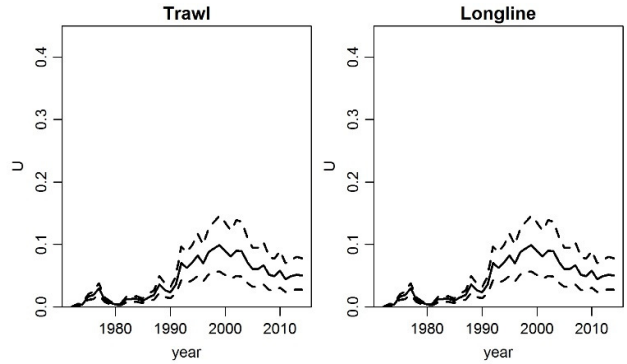
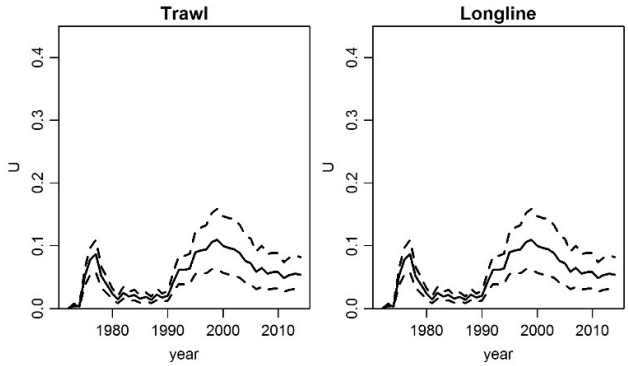


Version 43



Version 44

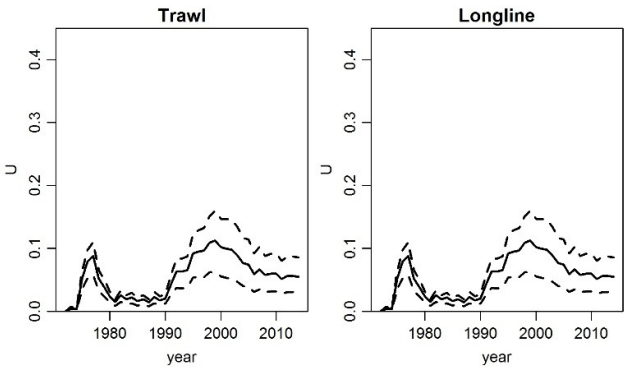


Figure 18: Ling, Chatham Rise — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines). Trawl and Longline occur in the same part of the partition and therefore are the same (see Bull et al. 2008).

Table 25: Ling, Chatham Rise — Estimated absolute spawning stock biomass (SSB, 000 t) and SSB as a percentage of B_0, by model year.

	SSB				Percentage B_0			
Year	Base	v42	v43	v44	Base	v42	v43	v44
1972	127.6	157.0	152.4	150.8	100.0	100.0	100.0	100.0
1973	127.4	156.5	151.7	150.1	99.8	99.7	99.5	99.5
1974	127.1	156.1	151.3	149.7	99.6	99.4	99.2	99.2
1975	118.2	154.2	145.4	143.9	92.6	98.2	95.4	95.4
1976	100.5	152.3	137.5	135.9	78.7	97.0	90.3	90.1
1977	78.0	149.4	130.1	128.5	61.2	95.1	85.4	85.2
1978	73.6	148.7	127.2	125.5	57.8	94.7	83.5	83.2
1979	75.5	148.8	125.7	123.9	59.2	94.8	82.4	82.2
1980	78.9	149.6	126.0	124.1	61.7	95.3	82.7	82.4
1981	83.2	151.5	127.8	125.8	65.2	96.2	83.9	83.5
1982	87.0	152.7	128.9	126.8	68.3	96.9	84.6	84.3
1983	91.9	155.2	132.1	130.2	72.0	98.5	86.5	86.1
1984	97.7	159.6	136.4	134.0	76.0	101.2	89.2	88.9
1985	103.1	163.6	140.6	138.5	80.1	104.3	92.4	91.9
1986	107.2	166.4	144.1	142.1	83.5	106.0	94.5	94.2
1987	110.8	167.4	147.1	144.9	86.4	106.7	96.4	96.3
1988	112.5	163.8	146.7	144.3	87.6	104.3	96.2	96.1
1989	112.5	159.6	145.2	142.9	87.6	102.0	95.4	95.4
1990	110.6	154.5	141.6	140.1	86.4	98.7	93.1	93.1
1991	105.6	147.2	135.4	133.5	82.7	94.1	88.8	88.7
1992	98.9	137.1	127.2	125.8	77.7	87.5	83.8	83.4
1993	92.9	128.5	120.3	118.5	73.1	82.1	79.1	78.7
1994	87.6	119.8	113.2	111.4	68.8	76.6	74.7	74.3
1995	81.3	111.6	105.2	103.6	63.7	71.3	69.5	68.9
1996	76.2	106.6	99.1	97.6	59.7	68.1	65.4	64.9
1997	72.3	101.7	94.6	93.3	56.9	65.1	62.4	62.0
1998	68.4	97.3	90.3	88.5	53.9	62.4	59.4	58.9
1999	64.9	92.5	85.7	84.0	51.0	59.3	56.3	55.8
2000	62.8	89.8	83.2	81.2	49.2	57.4	54.4	54.1
2001	61.5	88.7	81.4	79.5	48.2	56.6	53.3	53.1
2002	61.5	88.5	81.6	79.7	48.4	56.5	53.3	53.0
2003	63.0	90.0	83.8	81.7	49.6	57.5	54.7	54.4
2004	66.4	94.2	88.0	85.9	52.1	60.0	57.2	56.9
2005	69.6	99.0	91.9	90.0	54.5	63.0	60.0	59.7
2006	71.8	100.7	94.3	92.5	56.1	64.1	61.5	61.3
2007	72.9	101.3	95.4	93.3	57.2	64.5	62.3	62.1
2008	73.3	102.2	96.1	94.3	57.6	65.1	62.9	62.6
2009	74.2	103.3	96.9	95.1	58.4	65.8	63.3	63.0
2010	74.1	102.4	96.2	94.4	58.2	65.1	63.0	62.7
2011	74.0	101.7	95.7	94.2	58.3	64.7	62.7	62.3
2012	73.7	100.8	94.9	93.4	57.9	64.1	62.1	61.7
2013	73.5	99.6	94.1	92.3	57.5	63.4	61.5	61.0
2014	73.2	99.2	93.7	92.0	57.4	63.0	61.3	60.8

Table 26: Ling, Chatham Rise — Estimated fishing intensity (catch divided by vulnerable biomass), by model year.

Year	Base	v42	v43	v44
1972	0.0000	0.0000	0.0000	0.0000
1973	0.0020	0.0036	0.0056	0.0056
1974	0.0030	0.0037	0.0035	0.0034
1975	0.0929	0.0161	0.0521	0.0528
1976	0.2093	0.0193	0.0784	0.0794
1977	0.3402	0.0296	0.0869	0.0881
1978	0.1552	0.0123	0.0516	0.0523
1979	0.0454	0.0070	0.0382	0.0388
1980	0.0229	0.0042	0.0237	0.0241
1981	0.0106	0.0043	0.0146	0.0148
1982	0.0185	0.0124	0.0253	0.0257
1983	0.0177	0.0125	0.0191	0.0194
1984	0.0196	0.0127	0.0216	0.0221
1985	0.0186	0.0098	0.0156	0.0160
1986	0.0189	0.0153	0.0185	0.0189
1987	0.0159	0.0190	0.0139	0.0142
1988	0.0183	0.0362	0.0222	0.0227
1989	0.0185	0.0268	0.0172	0.0176
1990	0.0238	0.0232	0.0201	0.0206
1991	0.0498	0.0356	0.0419	0.0427
1992	0.0777	0.0705	0.0617	0.0630
1993	0.0753	0.0628	0.0617	0.0633
1994	0.0778	0.0709	0.0639	0.0656
1995	0.1061	0.0827	0.0898	0.0920
1996	0.1109	0.0696	0.0927	0.0949
1997	0.1090	0.0877	0.0943	0.0968
1998	0.1227	0.0939	0.1058	0.1088
1999	0.1236	0.0989	0.1094	0.1123
2000	0.1127	0.0899	0.0996	0.1018
2001	0.1103	0.0811	0.0968	0.0996
2002	0.1071	0.0904	0.0945	0.0976
2003	0.0982	0.0889	0.0884	0.0883
2004	0.0850	0.0718	0.0762	0.0767
2005	0.0835	0.0605	0.0718	0.0743
2006	0.0632	0.0610	0.0585	0.0593
2007	0.0698	0.0670	0.0648	0.0668
2008	0.0665	0.0513	0.0558	0.0578
2009	0.0631	0.0494	0.0579	0.0597
2010	0.0621	0.0578	0.0578	0.0595
2011	0.0536	0.0447	0.0484	0.0516
2012	0.0586	0.0489	0.0530	0.0561
2013	0.0614	0.0515	0.0554	0.0564
2014	0.0591	0.0500	0.0538	0.0551

5.2 LIN 5&6 (Sub-Antarctic)

The LIN 5&6 stock is modelled with catches taken by a trawl and two longline fisheries. Catch histories assumed for all model runs are listed in Table 27.

Table 27: Ling, Sub-Antarctic — Catch history used in the 2015 stock assessment model runs (Base), and alternative catch histories derived from SAU database versions 42, 43 and 44 that were used in the revised model runs. These values are derived from Table 1 by prorating between stocks (and fisheries within stocks) of each species using historial ratios for each year. Longline fisheries are "home" (H) and "spawn" (S). All values in tonnes. Catches prior to 1973 were negligible and assumed to be zero.

	Base			v42			v43			v44		
Year	trawl	lineH	lineS	trawl	lineH	lineS	trawl	lineH	lineS	trawl	lineH	lineS
1973	500	0	0	1 099	0	0	1 672	0	0	1 672	0	0
1974	1 120	0	0	1 644	0	0	1 498	0	0	1 498	0	0
1975	900	118	192	188	25	40	596	78	127	596	78	127
1976	3 402	190	309	405	23	37	1 560	87	142	1 560	87	142
1977	3 100	301	490	414	40	65	1 098	107	174	1 098	107	174
1978	1 945	494	806	314	80	130	1 137	289	471	1 137	289	471
1979	3 707	1 022	1 668	1 126	310	507	5 312	1 465	2 390	5 312	1 465	2 390
1980	5 200	0	0	1 814	0	0	8 785	0	0	8 785	0	0
1981	4 427	0	0	3 300	0	0	9 536	0	0	9 536	0	0
1982	2 402	0	0	2 841	0	0	4 983	0	0	4 983	0	0
1983	2 778	5	1	3 368	6	1	4 397	8	2	4 397	8	2
1984	3 203	2	0	3 459	2	0	5 073	3	0	5 073	3	0
1985	4 480	25	3	3 826	21	3	5 274	29	4	5 274	29	4
1986	3 182	2	0	4 057	3	0	4 274	3	0	4 274	3	0
1987	3 962	0	0	7 298	0	0	4 680	0	0	4 680	0	0
1988	2 065	6	0	6 095	18	0	3 331	10	0	3 331	10	0
1989	2 923	10	2	6 146	21	4	3 573	12	2	3 573	12	2
1990	3 199	9	4	4 400	12	6	3 516	10	4	3 511	10	4
1991	4 534	392	97	4 530	392	97	4 937	427	106	4 933	427	106
1992	6 237	566	518	7 871	714	654	6 399	581	531	6 381	579	530
1993	7 335	1 238	474	8 448	1 426	546	7 795	1 316	504	7 793	1 315	504
1994	5 456	770	486	6 839	965	609	5 829	823	519	5 830	823	519
1995	5 348	2 355	338	5 693	2 507	360	5 889	2 593	372	5 889	2 593	372
1996	6 769	2 153	531	5 855	1 862	459	7 412	2 357	581	7 412	2 357	581
1997	6 923	3 412	614	7 856	3 872	697	7 859	3 873	697	7 860	3 874	697
1998	6 032	4 032	581	6 487	4 336	625	6 851	4 580	660	6 847	4 577	659
1999	5 593	2 721	489	6 394	3 111	559	6 549	3 186	573	6 542	3 183	572
2000	7 089	1 421	1 161	8 053	1 614	1 319	8 297	1 663	1 359	8 220	1 648	1 346
2001	6 629	818	1 007	6 949	857	1 056	7 708	951	1 171	7 698	950	1 169
2002	6 970	426	1 220	8 492	519	1 486	8 190	501	1 434	8 191	501	1 434
2003	7 205	183	892	9 373	238	1 160	8 632	219	1 069	8 420	214	1 042
2004	7 826	774	471	9 437	933	568	9 363	926	564	9 132	903	550
2005	7 870	276	894	8 103	284	920	8 995	315	1 022	8 996	315	1 022
2006	6 161	178	692	8 462	244	950	7 568	219	850	7 433	215	835
2007	7 504	34	651	10 130	46	879	9 198	42	798	9 201	42	798
2008	6 990	329	821	7 470	352	877	7 701	362	905	7 703	363	905
2009	5 225	276	432	5 669	299	469	6 296	333	521	6 297	333	521
2010	4 270	864	313	5 492	1111	403	5 191	1 050	381	5 193	1 051	381
2011	4 404	567	169	5 020	646	193	5 140	662	197	5 328	686	204
2012	4 384	934	376	5 013	1 068	430	5 132	1 093	440	5 276	1 124	453
2013	6 234	135	340	7 098	154	387	7 268	157	396	7 178	155	391
2014	4 900	550	330	5 589	627	376	5 722	642	385	5 724	642	385
2015	5 986	592	223	6 828	675	254	6 991	691	260	6 992	692	260

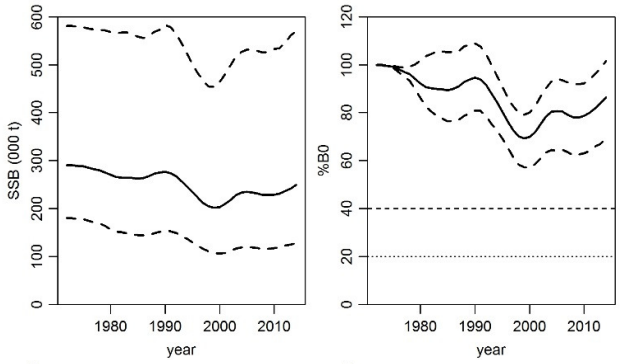
The most recent stock assessment was in 2014–15, for which there were "reference" and "base" model runs; the sensitivity runs conducted here were to the "base" case (Ministry for Primary Industries 2017). SAU alternative catch histories were apportioned to fleets according to the catch-by-gear ratios from the 2015 assessment model.

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2014}) are listed for each model run in Table 28. Biomass trajectories can be compared in Figure 19. Fishing intensities over time (Figure 20) are presented as the proportion of catch divided by vulnerable biomass. Note that CASAL reports the fishing intensity as "fishing pressure", defined as the maximum proportion of fish taken from any element of the partition in the area affected by the fishery; if two fisheries impact the same part of the partition (i.e., the same ages of fish at the same time) then the maximum is across both fisheries, and is therefore the same for both fisheries (Bull et al. 2008). MCMC median estimates of spawning stock biomass and biomass as a proportion of B_0 are listed in Table 29, and fishing intensities for each modelled year are listed in Table 30.

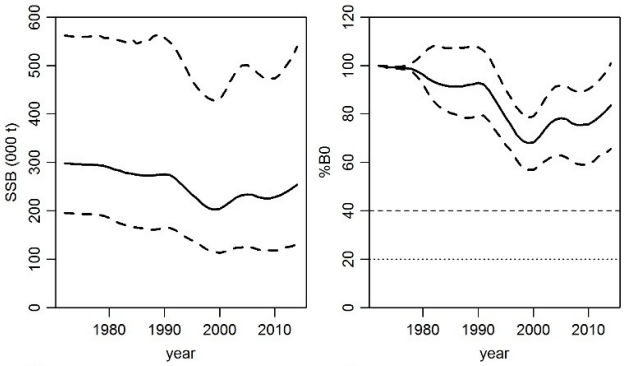
Table 28: Ling, Sub-Antarctic — Bayesian median and 95% credible intervals of B_0, B_{2014}, and B_{2014} as a percentage of B_0 for the four different catch histories (Base (2015) assessment, and SAU versions 42, 43, and 44). Following Ministry for Primary Industries (2017), biomasses have been rounded to the nearest 100 t.

Model run	B_0	B_{2014}	B_{2014} (%B_0)
Base	290 700 (180 456–581 000)	249 300 (128 500–569 700)	86 (69–102)
Version 42	298 000 (195 700–561 500)	254 200 (130 700–538 900)	83 (66–101)
Version 43	300 900 (195 600–589 000)	253 700 (129 700–567 200)	84 (66–101)
Version 44	311 900 (196 700–587 900)	263 600 (132 700–571 800)	85 (66–101)

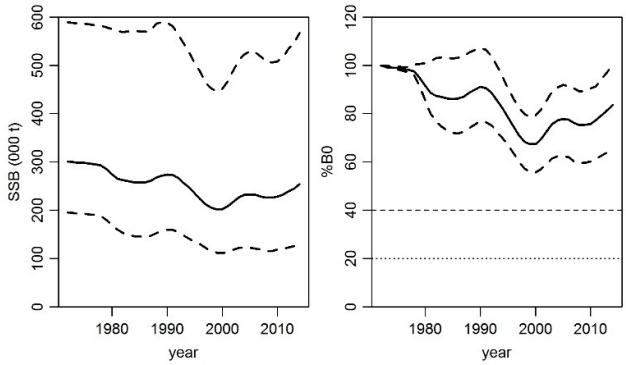
Base assessment model



Version 42



Version 43



Version 44

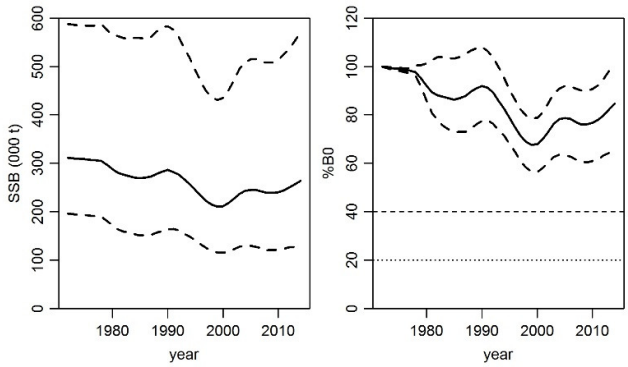
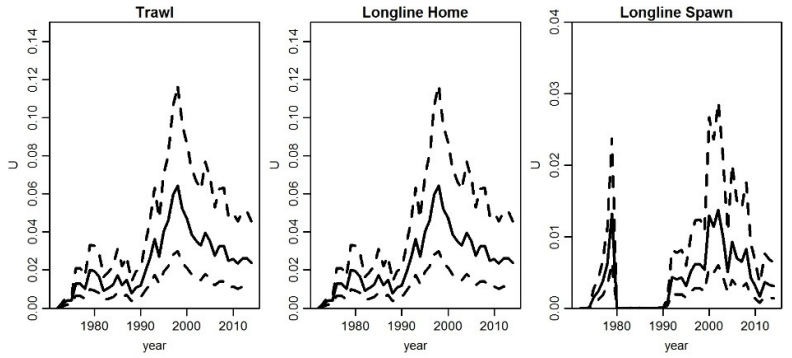
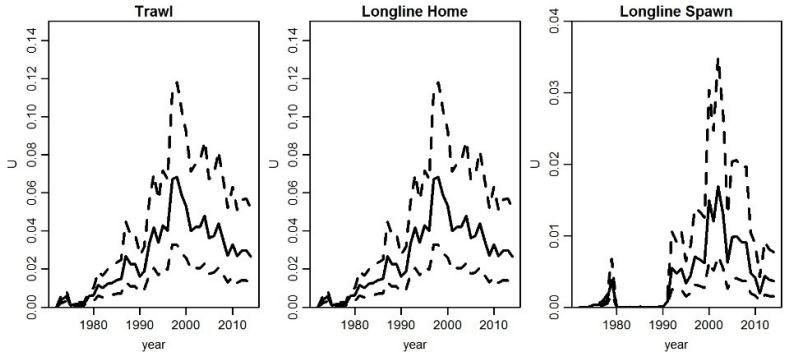


Figure 19: Ling, Sub-Antarctic — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0.

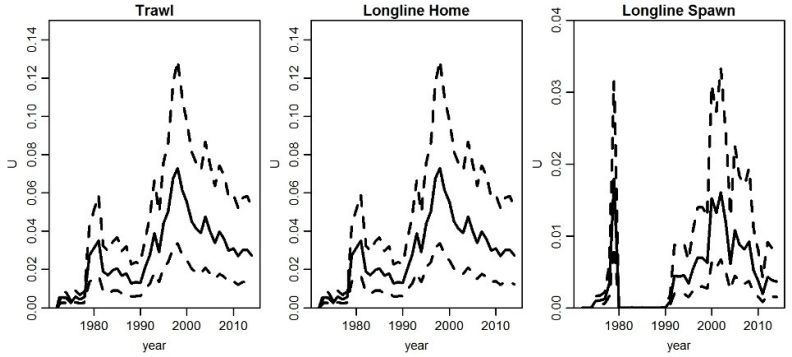
Base assessment model



Version 42



Version 43



Version 44

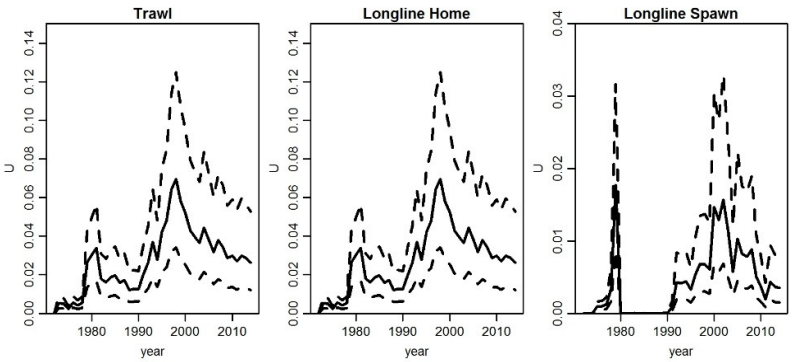


Figure 20: Ling, Sub-Antarctic — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines). Trawl and Longline Home occur in the same part of the partition and therefore are the same (see Bull et al., 2008).

Table 29: Ling, Sub-Antarctic — Estimated absolute spawning stock biomass (SSB, '000 t) and SSB as a percentage of B_0, by model year. –, years when landings were assumed to be zero.

	SSB				Percentage B_0			
Year	Base	v42	v43	v44	Base	v42	v43	v44
1972	290.7	298.0	300.9	311.9	100.0	100.0	100.0	100.0
1973	290.2	297.0	299.4	310.4	99.8	99.7	99.5	99.5
1974	289.3	295.6	298.2	309.2	99.5	99.2	99.1	99.1
1975	288.4	295.5	297.7	308.7	99.2	99.2	98.9	99.0
1976	285.1	295.3	296.4	307.5	98.1	99.1	98.5	98.5
1977	281.8	294.9	295.1	306.3	97.0	98.9	98.2	98.2
1978	279.6	294.1	292.9	304.6	96.1	98.6	97.5	97.7
1979	275.0	292.6	285.0	297.2	94.2	97.6	94.8	95.1
1980	270.5	289.7	274.5	288.0	92.2	96.2	91.6	92.1
1981	266.2	285.2	265.1	280.9	90.7	94.5	88.6	89.3
1982	264.8	282.6	262.3	276.8	90.2	93.3	87.4	88.1
1983	264.2	278.4	260.3	273.4	89.9	92.4	86.8	87.6
1984	263.8	276.5	258.2	270.9	89.8	91.8	86.3	86.8
1985	262.3	274.3	257.1	269.6	89.4	91.3	86.0	86.3
1986	263.7	273.4	258.2	270.9	89.9	91.5	86.3	86.9
1987	267.8	272.0	260.8	273.2	90.9	91.3	87.0	87.8
1988	272.7	273.0	267.5	278.6	92.7	91.9	88.7	89.6
1989	274.9	274.5	271.5	282.8	93.9	92.2	90.0	91.0
1990	277.1	275.6	273.9	286.4	94.7	92.8	91.1	91.9
1991	273.8	274.0	272.8	282.4	93.9	92.2	90.6	91.3
1992	267.7	267.1	267.1	276.7	91.7	89.7	88.8	89.3
1993	257.3	255.7	256.6	267.0	88.1	85.9	85.6	85.9
1994	246.5	244.9	246.9	256.8	84.6	82.4	82.4	82.7
1995	235.1	233.7	234.9	244.6	80.5	78.5	78.6	78.9
1996	222.8	224.6	223.3	233.8	76.4	75.3	74.8	75.0
1997	211.6	213.1	212.6	222.6	72.7	71.5	71.1	71.4
1998	204.5	205.8	205.4	214.3	70.2	69.0	68.4	68.9
1999	202.0	202.7	202.0	210.7	69.3	67.9	67.3	67.7
2000	203.1	203.9	202.3	211.7	69.8	68.2	67.3	68.0
2001	209.8	210.6	208.5	218.3	71.9	70.4	69.4	70.0
2002	218.8	219.5	217.6	227.6	75.3	73.5	72.6	73.1
2003	228.3	227.2	226.6	237.6	78.4	76.2	75.7	76.4
2004	233.4	231.7	231.9	243.5	80.3	77.7	77.3	78.2
2005	234.8	233.7	232.5	245.1	80.7	78.3	77.8	78.7
2006	233.9	232.6	232.2	244.7	80.5	77.8	77.4	78.4
2007	231.0	228.1	228.5	242.0	79.2	76.2	76.1	77.0
2008	228.6	226.0	226.4	239.1	78.1	75.3	75.3	76.0
2009	228.1	225.5	225.9	238.8	77.9	75.5	75.3	76.1
2010	228.7	228.4	228.3	240.3	78.6	75.7	75.8	76.7
2011	231.5	232.2	232.2	244.6	79.9	77.0	77.3	78.0
2012	236.9	238.0	238.6	250.6	81.8	78.9	79.3	79.8
2013	242.0	246.1	244.6	256.8	84.0	81.0	81.4	82.3
2014	249.3	254.2	253.7	263.6	86.5	83.5	83.6	84.7

Table 30: Ling, Sub-Antarctic — Estimated fishing intensity (catch divided by vulnerable biomass), by model year. Longline Home occurs in the same timestep as Trawl and is therefore the same as Trawl (see Bull et al. 2008); LineS, Longline Spawn.

	Base		v42		v43		v44	
Year	Trawl	LineS	Trawl	LineS	Trawl	LineS	Trawl	LineS
1972	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1973	0.0017	0.0000	0.0037	0.0000	0.0056	0.0000	0.0054	0.0000
1974	0.0039	0.0000	0.0056	0.0000	0.0051	0.0000	0.0049	0.0000
1975	0.0038	0.0014	0.0008	0.0003	0.0025	0.0009	0.0024	0.0009
1976	0.0130	0.0024	0.0015	0.0003	0.0058	0.0010	0.0056	0.0010
1977	0.0128	0.0038	0.0016	0.0005	0.0044	0.0013	0.0042	0.0012
1978	0.0102	0.0063	0.0016	0.0010	0.0057	0.0035	0.0055	0.0034
1979	0.0202	0.0132	0.0058	0.0038	0.0275	0.0180	0.0265	0.0177
1980	0.0193	0.0000	0.0063	0.0000	0.0313	0.0000	0.0303	0.0000
1981	0.0166	0.0000	0.0116	0.0000	0.0351	0.0000	0.0338	0.0000
1982	0.0091	0.0000	0.0102	0.0000	0.0189	0.0000	0.0181	0.0000
1983	0.0106	0.0000	0.0122	0.0000	0.0169	0.0000	0.0161	0.0000
1984	0.0122	0.0000	0.0126	0.0000	0.0196	0.0000	0.0186	0.0000
1985	0.0172	0.0000	0.0141	0.0000	0.0207	0.0000	0.0196	0.0000
1986	0.0121	0.0000	0.0149	0.0000	0.0167	0.0000	0.0158	0.0000
1987	0.0149	0.0000	0.0267	0.0000	0.0181	0.0000	0.0172	0.0000
1988	0.0077	0.0000	0.0224	0.0000	0.0128	0.0000	0.0121	0.0000
1989	0.0108	0.0000	0.0225	0.0000	0.0134	0.0000	0.0128	0.0000
1990	0.0117	0.0000	0.0161	0.0000	0.0130	0.0000	0.0124	0.0000
1991	0.0189	0.0008	0.0189	0.0008	0.0209	0.0009	0.0199	0.0008
1992	0.0265	0.0043	0.0335	0.0055	0.0276	0.0045	0.0262	0.0043
1993	0.0363	0.0041	0.0418	0.0047	0.0389	0.0043	0.0370	0.0042
1994	0.0271	0.0043	0.0339	0.0054	0.0291	0.0046	0.0277	0.0044
1995	0.0402	0.0031	0.0428	0.0033	0.0441	0.0034	0.0422	0.0033
1996	0.0461	0.0051	0.0400	0.0044	0.0504	0.0055	0.0480	0.0054
1997	0.0597	0.0062	0.0671	0.0071	0.0676	0.0070	0.0643	0.0068
1998	0.0644	0.0061	0.0684	0.0067	0.0730	0.0070	0.0694	0.0068
1999	0.0521	0.0054	0.0592	0.0062	0.0614	0.0063	0.0581	0.0061
2000	0.0473	0.0130	0.0532	0.0149	0.0552	0.0152	0.0522	0.0147
2001	0.0387	0.0114	0.0400	0.0120	0.0450	0.0132	0.0429	0.0129
2002	0.0353	0.0137	0.0421	0.0169	0.0413	0.0161	0.0395	0.0157
2003	0.0329	0.0099	0.0423	0.0130	0.0392	0.0118	0.0366	0.0112
2004	0.0397	0.0051	0.0478	0.0062	0.0476	0.0061	0.0443	0.0057
2005	0.0352	0.0093	0.0364	0.0098	0.0402	0.0108	0.0385	0.0103
2006	0.0274	0.0070	0.0375	0.0099	0.0338	0.0088	0.0316	0.0082
2007	0.0324	0.0065	0.0438	0.0091	0.0398	0.0081	0.0379	0.0078
2008	0.0327	0.0082	0.0352	0.0091	0.0361	0.0092	0.0343	0.0088
2009	0.0248	0.0043	0.0271	0.0048	0.0299	0.0052	0.0286	0.0051
2010	0.0257	0.0031	0.0330	0.0041	0.0310	0.0038	0.0298	0.0037
2011	0.0235	0.0017	0.0267	0.0020	0.0271	0.0019	0.0270	0.0020
2012	0.0261	0.0036	0.0296	0.0043	0.0300	0.0043	0.0298	0.0043
2013	0.0263	0.0032	0.0298	0.0038	0.0304	0.0038	0.0288	0.0037
2014	0.0238	0.0031	0.0266	0.0037	0.0273	0.0036	0.0264	0.0035

5.3 LIN 7 WC (West Coast South Island)

The LIN 7WC stock is modelled with catches taken by trawl and longline fisheries. Catch histories assumed for all model runs are listed in Table 31. The most recent stock assessment was in 2016–17, for which there was no most-likely "base" model run, but three equally plausible alternative model runs (Ministry for Primary Industries 2017). SAU alternative catch histories were apportioned to fleets according to the catch-by-gear ratios from the 2017 assessment model. The trawl and longline catches are those scaled up to the total catches for each stock (the assessment apportions all catches, which includes some by other gears e.g., setnet, to either trawl or longline).

Table 31: Ling, West Coast South Island — Catch history used in the 2017 stock assessment model runs (Base), and alternative catch histories derived from SAU database versions 42, 43 and 44 that were used in the revised model runs. These values are derived from Table 1 by prorating between stocks (and fisheries within stocks) of each species using historial ratios for each year. All values in tonnes. Catches prior to 1973 were negligible and assumed to be zero. For the stock assessment model runs, the catches for the assessment year (2017) were assumed to be the same as those for 2016.

Year	Base		v42		v43		v44	
	trawl	longline	trawl	longline	trawl	longline	trawl	longline
1973	85	20	187	44	284	67	284	67
1974	144	40	211	59	193	54	193	54
1975	401	800	84	167	265	530	265	530
1976	565	2 100	67	250	259	963	259	963
1977	715	4 300	95	574	253	1 524	253	1 524
1978	300	323	48	52	175	189	175	189
1979	539	360	164	109	772	516	772	516
1980	540	305	188	106	912	515	912	515
1981	492	300	367	224	1 060	646	1 060	646
1982	675	400	798	473	1 400	830	1 400	830
1983	1 040	710	1 261	861	1 646	1 124	1 646	1 124
1984	924	595	998	643	1 464	942	1 464	942
1985	1 156	302	987	258	1 361	356	1 361	356
1986	1 082	362	1 380	462	1 453	486	1 453	486
1987	1 105	370	2 035	682	1 305	437	1 305	437
1988	1 428	291	4 215	859	2 304	469	2 304	469
1989	1 959	370	4 119	778	2 395	452	2 395	452
1990	2 205	399	3 033	549	2 423	439	2 420	438
1991	2 163	364	2 161	364	2 355	396	2 354	396
1992	1 631	661	2 058	834	1 673	678	1 669	676
1993	1 609	716	1 853	825	1 710	761	1 710	761
1994	1 136	860	1 424	1 078	1 214	919	1 214	919
1995	1 750	1 032	1 863	1 099	1 927	1 136	1 927	1 136
1996	1 838	1 121	1 590	970	2 012	1 227	2 013	1 227
1997	1 749	1 077	1 985	1 222	1 986	1 223	1 986	1 223
1998	1 887	1 021	2 029	1 098	2 143	1 160	2 142	1 159
1999	2 146	1 069	2 453	1 222	2 513	1 252	2 510	1 250
2000	2 247	923	2 553	1 049	2 630	1 080	2 605	1 070
2001	2 304	977	2 415	1 024	2 679	1 136	2 676	1 135
2002	2 250	810	2 741	987	2 644	952	2 644	952
2003	1 980	807	2 576	1 050	2 372	967	2 314	943
2004	2 013	814	2 427	982	2 408	974	2 349	950
2005	1 558	871	1 604	897	1 781	996	1 781	996
2006	1 753	666	2 408	915	2 153	818	2 115	804
2007	1 306	933	1 763	1 260	1 601	1 144	1 601	1 144
2008	1 067	1 170	1 140	1 250	1 176	1 289	1 176	1 289

Table 31 ctd.

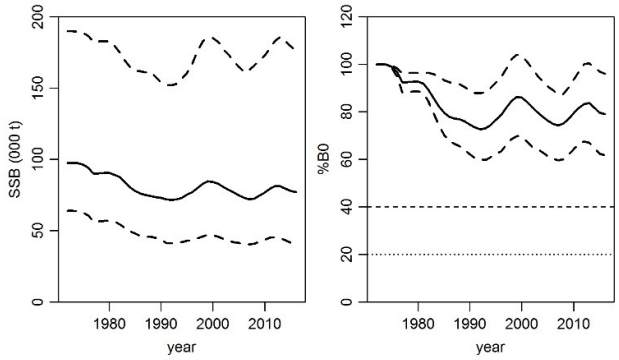
Year	Base		v42		v43		v44	
	trawl	longline	trawl	longline	trawl	longline	trawl	longline
2009	1 089	1 009	1 182	1 095	1 312	1 216	1 313	1 216
2010	1 346	1 063	1 731	1 367	1 636	1 292	1 637	1 293
2011	1 733	1 011	1 975	1 152	2 023	1 180	2 096	1 223
2012	1 744	976	1 994	1 116	2 042	1 143	2 099	1 175
2013	1 915	1 045	2 181	1 190	2 233	1 218	2 205	1 203
2014	1 721	1 411	1 620	1 357	1 658	1 390	1 659	1 390
2015	1 786	1 358	1 780	1 320	1 823	1 351	1 823	1 351
2016	1 780	1 160	1 904	1 311	1 949	1 342	1 950	1 342

Estimates of virgin spawning stock biomass (B_0) and current biomass (B_{2017}) are listed for each model run in Table 32. Biomass trajectories can be compared in Figures 21–23. Fishing intensities over time (Figures 24–26) are presented as the proportion of catch divided by vulnerable biomass. MCMC median estimates of spawning stock biomass and biomass as a percentage of B_0 are listed in Table 33, and fishing intensities for each modelled year are listed in Table 34. The MCMC chains for the LIN 7WC assessment model runs were problematic but were considered acceptable for the base assessment at the time it underwent peer review (Dunn & Ballara 2018), and the same result was obtained here. However, the chain for run 44a (Table 32) was notably poor (the chain did not converge, and the estimated credible intervals for absolute biomass were unacceptably wide) and would very likely not have been accepted for management advice. Consequently, no results for run 44a are presented here.

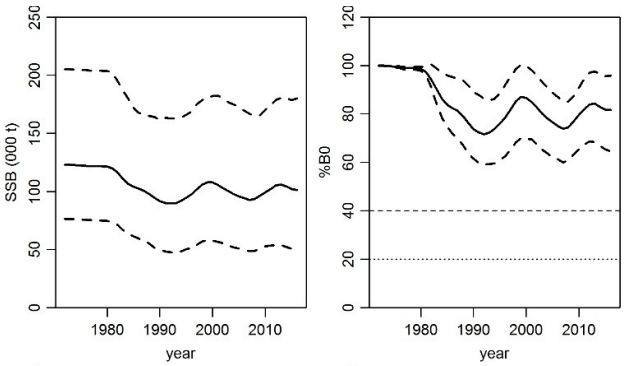
Table 32: Ling, West Coast South Island — Bayesian median and 95% credible intervals of B_0, B_{2017}, and B_{2017} as a percentage of B_0 for the three assessment models runs (suffixed a, b, and c), and for the four different catch histories (Base (2017) assessment, and SAU versions 42, 43, and 44). Following Ministry for Primary Industries (2017), biomasses have been rounded to the nearest 100 t.

Model run	B_0	B_{2017}	B_{2017} (%B_0)
Base a Combined CPUE	99 300 (63 500–198 200)	77 400 (39 600–183 000)	79 (61–96)
Version 42a	112 900 (76 400–205 100)	101 100 (49 900–180 200)	82 (64–96)
Version 43a	110 200 (72 100–201 900)	85 000 (44 100–183 000)	77 (59–94)
Base b Lognormal CPUE	69 300 (51 600–122 000)	46 300 (26 100–98 000)	66 (50–83)
Version 42b	79 900 (59 200–130 600)	52 500 (28 200–106 000)	66 (48–84)
Version 43b	75 100 (57 300–112 800)	48 200 (27 200–86 000)	64 (47–81)
Version 44b	82 000 (58 800–146 100)	54 400 (28 400–116 400)	66 (48–83)
Base c Lognormal CPUE, M=0.18	62 800 (48 900–114 500)	34 000 (19 500–84 100)	54 (39–74)
Version 42c	75 200 (57 600–113 600)	41 600 (23 800–80 600)	55 (41–73)
Version 43c	76 100 (57 900–115 500)	42 200 (24 600–80 400)	56 (42–71)
Version 44c	70 600 (56 600–117 700)	37 200 (23 000–83 900)	53 (40–73)

Base assessment model



Version 42



Version 43

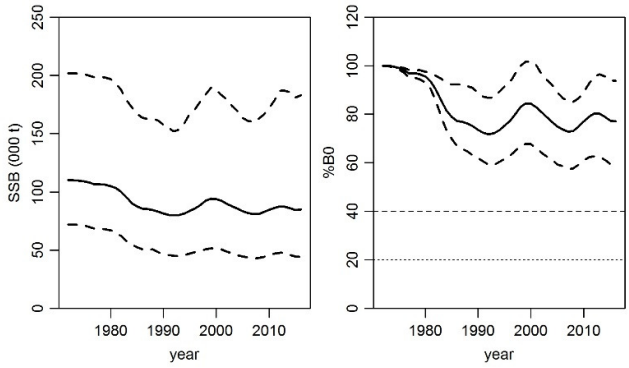
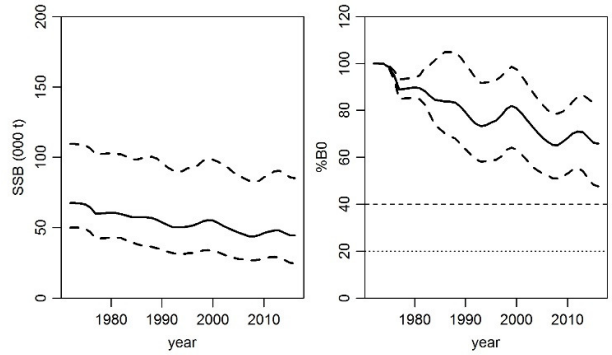


Figure 21: Ling, West Coast South Island, Combined CPUE model — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0.

Base assessment model



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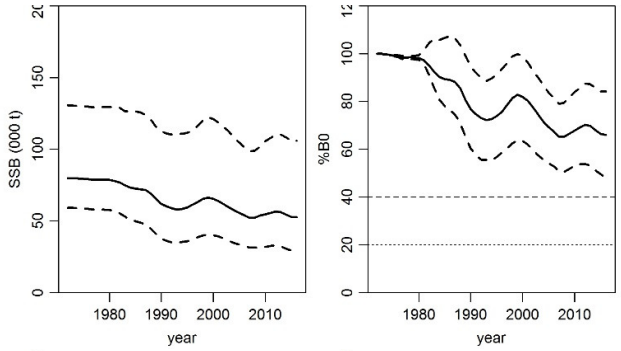

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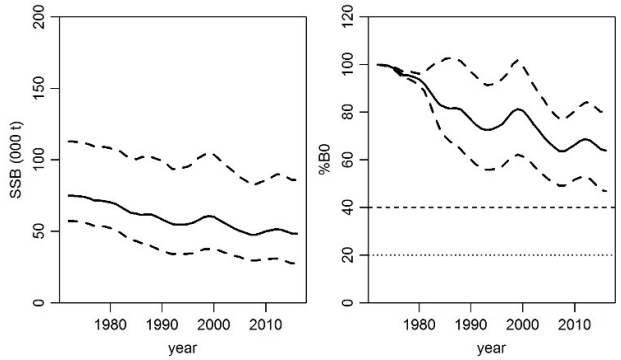


Version 44

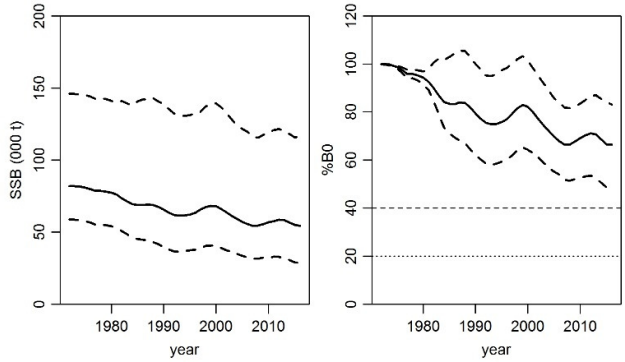
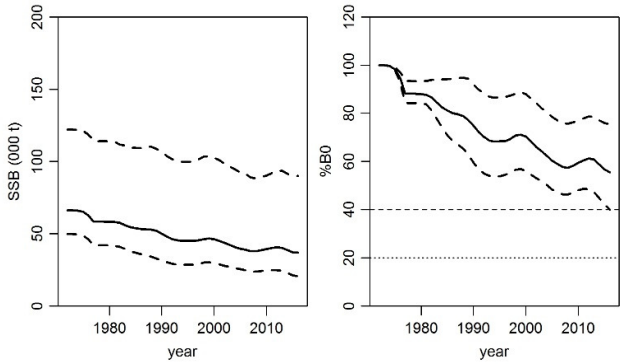


Figure 22: Ling, West Coast South Island, Lognormal CPUE model — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0.

Base assessment model



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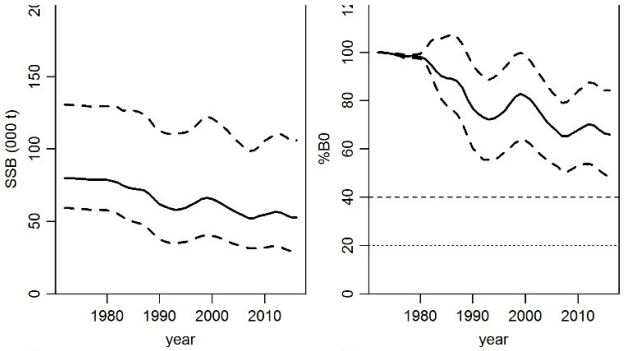

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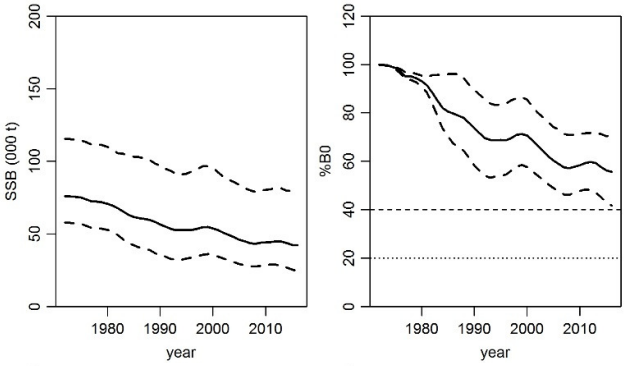

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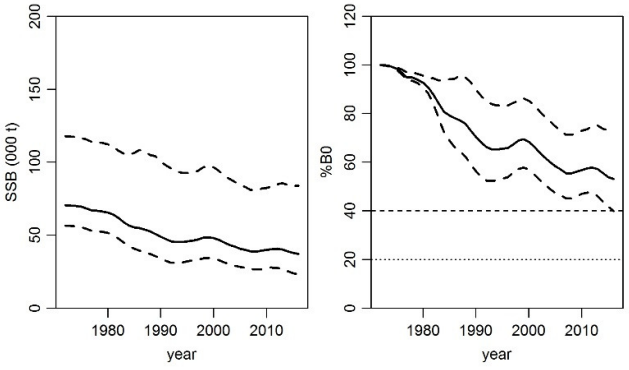
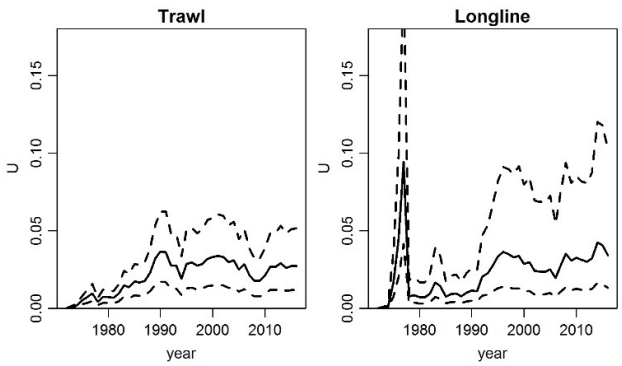


Figure 23: Ling, West Coast South Island, Lognormal CPUE & M=0.18 model — Estimated median trajectories (with 95% credible intervals shown as dashed lines) for absolute spawning biomass and biomass as a percentage of B_0. Horizontal lines in the right panels show the management target of 40% B_0 and the soft limit of 20% B_0.

Base assessment model



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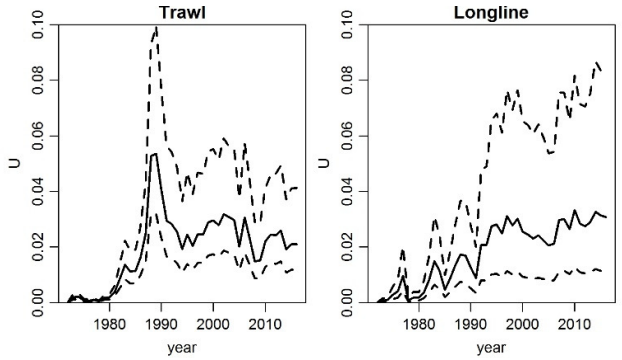

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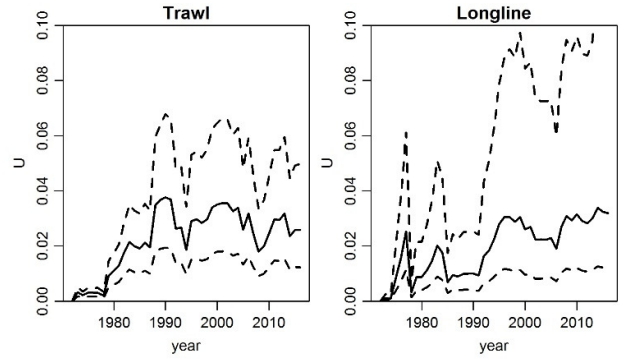
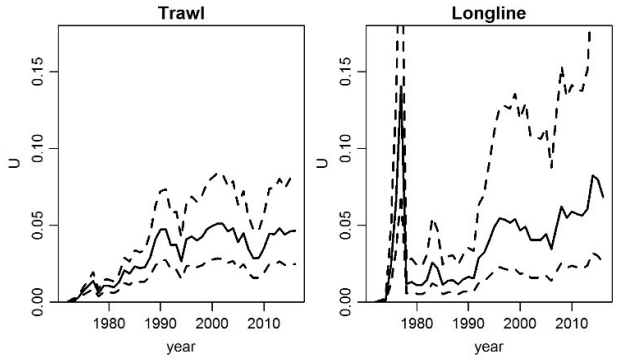


Figure 24: Ling, West Coast South Island, Combined CPUE model — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines).

Base assessment model



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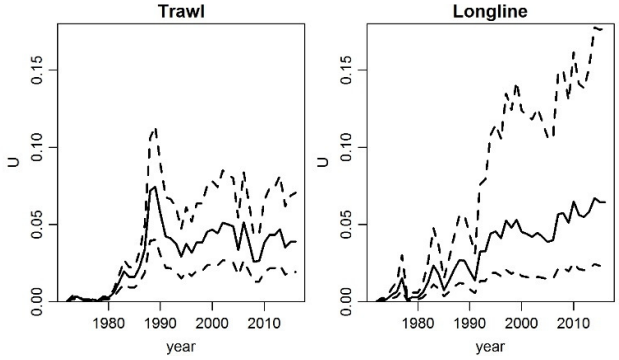

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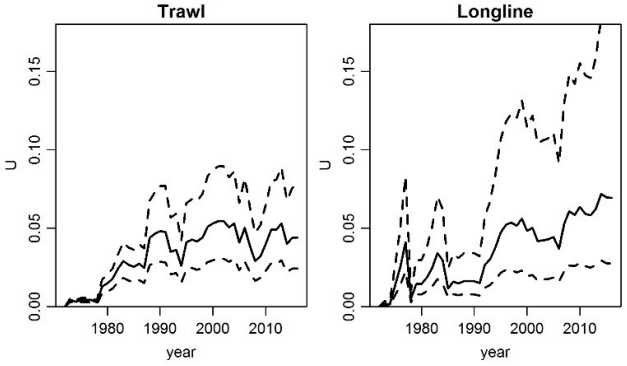

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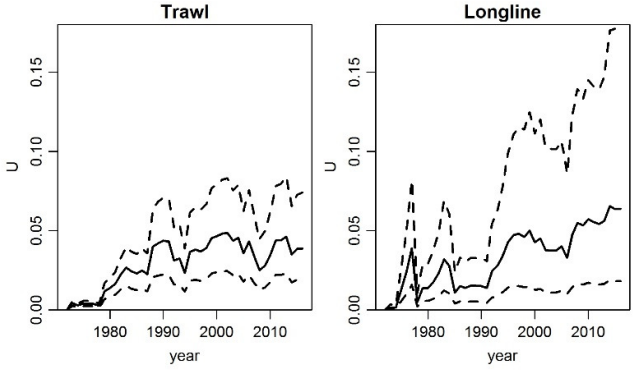
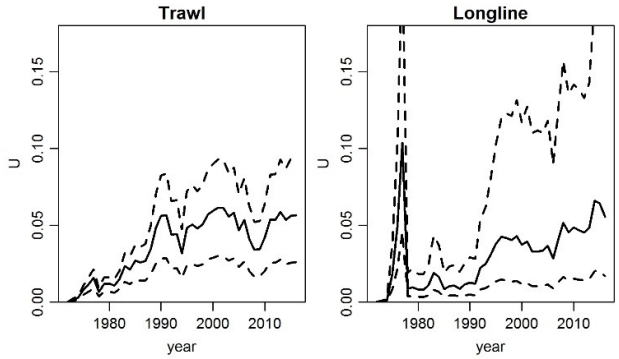


Figure 25: Ling, West Coast South Island, Lognormal CPUE model — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines).

Base assessment model



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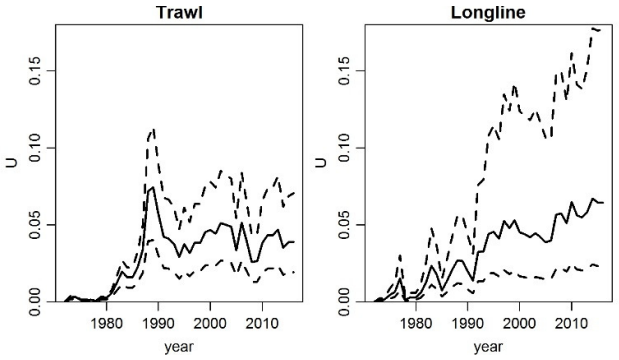

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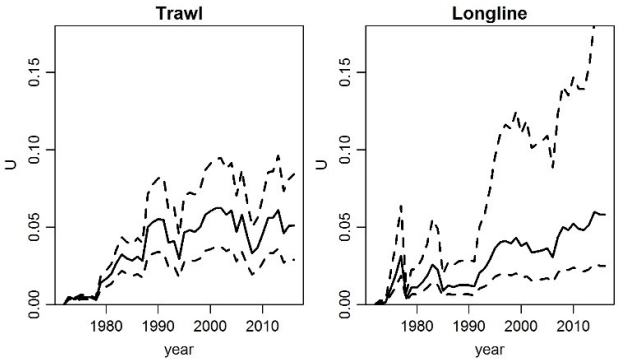

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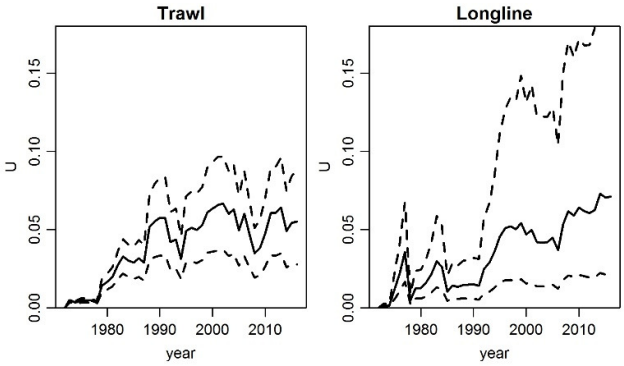

Figure 26: Ling, West Coast South Island, Lognormal CPUE & M = 0.18 model — Estimated median trajectory of fishing intensity (with 95% credible intervals shown as dashed lines).

Table 33: Ling, West Coast South Island — Estimated absolute spawning stock biomass (SSB, '000 t) and SSB as a percentage of B_0, by model year.

Combined CPUE

	SSB			Percentage B_0		
Year	Base	v42	v43	Base	v42	v43
1972	99.3	122.9	110.2	100.0	100.0	100.0
1973	99.3	122.8	110.0	99.9	99.9	99.8
1974	99.1	122.6	109.7	99.8	99.7	99.6
1975	98.2	122.3	109.0	98.8	99.5	99.0
1976	95.9	122.1	108.0	96.6	99.3	98.1
1977	91.8	121.6	106.6	92.4	98.9	96.8
1978	92.0	121.6	106.6	92.6	99.0	96.9
1979	92.2	121.6	106.0	92.8	98.9	96.4
1980	92.2	121.3	105.0	92.8	98.6	95.5
1981	91.3	119.9	103.2	92.0	97.3	93.6
1982	88.6	116.1	100.1	89.6	94.2	90.2
1983	85.3	110.5	95.4	85.9	90.1	85.7
1984	82.1	106.5	90.2	82.6	86.3	81.6
1985	79.9	104.0	87.4	80.0	83.8	78.9
1986	77.9	102.3	85.7	78.6	82.3	77.2
1987	77.1	100.5	85.4	77.7	81.3	76.8
1988	76.9	97.7	84.3	77.4	79.0	76.2
1989	75.5	94.4	83.1	76.5	76.2	75.1
1990	74.0	91.5	81.5	75.0	73.7	73.6
1991	72.6	90.0	80.2	73.6	72.4	72.3
1992	72.4	89.7	79.9	72.9	71.6	71.7
1993	72.9	89.7	80.3	73.3	72.3	72.2
1994	74.5	92.0	81.5	74.6	73.9	73.4
1995	76.4	94.6	83.7	76.4	75.9	75.3
1996	78.6	97.8	85.9	78.5	78.6	77.2
1997	81.0	101.7	88.7	81.5	81.7	80.0
1998	84.7	105.7	92.7	84.9	85.3	83.0
1999	86.3	107.9	94.2	86.4	87.0	84.5
2000	86.1	107.8	93.8	86.1	86.5	84.4
2001	84.5	105.4	92.2	84.3	85.0	82.8
2002	82.1	102.8	89.7	82.3	82.6	80.8
2003	80.3	100.2	87.7	80.3	80.1	78.6
2004	78.5	97.5	85.7	78.6	78.2	76.7
2005	76.7	95.8	83.6	76.7	76.6	74.9
2006	74.9	94.3	81.9	75.5	75.0	73.7
2007	74.1	92.7	80.8	74.7	73.8	72.7
2008	74.9	93.5	80.9	75.3	74.5	73.2
2009	77.1	96.3	82.7	77.2	77.0	74.9
2010	79.4	99.1	84.6	79.6	79.6	77.1
2011	81.1	102.2	86.4	82.0	82.1	78.9
2012	82.9	105.1	87.7	83.9	83.9	80.4
2013	82.7	105.9	87.3	83.9	84.3	80.3
2014	81.1	104.4	86.0	81.9	82.8	78.9
2015	79.0	101.9	84.4	79.9	81.7	77.4
2016	78.1	101.1	85.0	79.2	81.6	77.0

Table 33 ctd.

Lognormal CPUE

	SSB				Percentage B_0			
Year	Base	v42	v43	v44	Base	v42	v43	v44
1972	69.3	79.9	75.1	82.0	100.0	100.0	100.0	100.0
1973	69.2	79.7	74.9	81.8	99.9	99.8	99.7	99.8
1974	69.1	79.5	74.7	81.6	99.7	99.6	99.4	99.5
1975	68.1	79.3	74.0	80.9	98.3	99.2	98.5	98.7
1976	65.9	79.0	73.0	79.9	95.1	99.0	97.2	97.5
1977	61.8	78.5	71.6	78.6	89.2	98.3	95.4	95.8
1978	61.9	78.6	71.7	78.7	89.5	98.4	95.5	95.9
1979	62.2	78.5	71.2	78.2	89.8	98.4	94.8	95.3
1980	62.3	78.5	70.3	77.4	90.0	98.2	93.8	94.3
1981	62.5	78.0	69.1	76.0	89.8	97.2	92.0	92.7
1982	61.8	76.7	67.2	73.5	88.6	95.2	89.0	90.1
1983	60.3	74.9	64.9	71.4	86.4	92.3	85.6	86.7
1984	59.6	73.2	62.9	69.4	84.8	90.3	83.1	84.2
1985	59.5	72.5	62.3	68.8	84.3	89.3	82.0	83.5
1986	59.2	72.1	61.5	68.7	84.3	89.0	81.4	83.3
1987	59.2	71.6	61.9	69.2	84.2	88.1	81.8	84.0
1988	58.9	69.0	61.7	68.8	83.7	85.3	81.1	83.7
1989	57.5	65.2	60.3	67.5	82.1	80.6	79.2	81.9
1990	55.5	62.0	58.4	65.8	79.5	76.9	76.9	79.5
1991	53.5	60.1	56.5	63.5	77.0	74.7	74.7	77.2
1992	52.2	59.0	55.2	62.0	74.9	73.1	73.1	75.5
1993	51.4	57.8	54.6	61.3	74.2	72.3	72.5	74.9
1994	51.7	58.4	54.7	61.8	74.5	72.7	72.8	75.0
1995	52.4	59.5	55.2	62.3	75.3	73.9	73.7	75.8
1996	53.2	61.3	56.1	63.4	76.4	75.7	74.9	77.1
1997	54.5	63.2	57.9	65.7	78.7	78.5	77.5	79.3
1998	56.4	65.4	60.0	67.4	81.1	81.4	80.2	81.7
1999	57.1	66.2	60.6	68.3	82.5	82.8	81.2	83.0
2000	56.6	65.5	60.1	68.0	81.8	81.9	80.6	82.2
2001	55.5	63.8	58.0	66.0	79.6	80.2	78.2	79.8
2002	53.2	61.6	55.8	63.6	76.8	77.5	75.0	77.0
2003	51.7	59.4	53.8	61.2	74.2	74.3	72.4	74.4
2004	49.9	57.3	51.8	59.1	71.7	71.5	69.6	72.1
2005	48.0	55.5	50.3	57.2	69.3	69.3	67.3	69.8
2006	46.8	53.8	49.0	55.7	67.3	67.4	65.4	67.9
2007	45.8	52.2	47.7	54.4	65.9	65.3	63.7	66.4
2008	45.7	52.4	47.6	54.5	65.8	65.2	63.6	66.4
2009	46.7	53.8	48.7	55.7	67.2	66.6	65.0	67.8
2010	47.8	54.7	50.0	56.8	68.8	67.7	66.3	69.2
2011	49.0	55.7	50.7	57.7	70.5	69.1	67.9	70.4
2012	49.8	56.5	51.5	58.7	71.6	70.2	68.7	71.1
2013	49.4	56.2	51.0	58.3	71.3	69.7	68.2	70.6
2014	48.0	54.3	49.7	56.6	68.9	67.9	66.3	68.6
2015	46.5	52.8	48.5	55.1	66.8	66.5	64.5	66.5
2016	46.3	52.5	48.2	54.4	66.3	66.0	63.9	66.4

Table 33 ctd.

Lognormal CPUE & M = 0.18

	SSB				Percentage B_0			
Year	Base	v42	v43	v44	Base	v42	v43	v44
1972	62.8	75.2	76.1	70.6	100.0	100.0	100.0	100.0
1973	62.7	75.1	75.9	70.4	99.9	99.8	99.7	99.7
1974	62.6	74.9	75.7	70.1	99.7	99.5	99.4	99.4
1975	61.6	74.6	75.0	69.4	98.1	99.2	98.5	98.4
1976	59.3	74.4	73.9	68.4	94.4	98.8	97.1	96.9
1977	55.0	73.8	72.4	66.9	87.5	98.1	95.1	94.8
1978	54.9	73.8	72.4	66.9	87.5	98.1	95.1	94.7
1979	54.9	73.8	71.8	66.3	87.5	98.0	94.3	93.9
1980	54.8	73.6	70.8	65.4	87.4	97.8	93.1	92.6
1981	54.7	73.0	69.4	64.1	87.1	97.0	91.4	90.7
1982	54.0	71.1	67.7	61.9	85.9	94.9	88.6	87.8
1983	52.7	69.1	65.4	59.0	83.6	91.6	85.1	84.1
1984	51.1	67.0	63.3	56.6	81.5	88.9	82.1	80.6
1985	50.2	65.9	61.7	55.4	80.1	87.3	80.6	79.2
1986	49.3	64.8	60.9	54.7	78.9	86.2	79.7	78.0
1987	48.9	63.5	60.3	53.8	78.0	84.3	78.9	77.2
1988	48.2	60.8	59.6	52.6	77.3	80.5	77.9	75.8
1989	47.1	56.9	58.4	50.8	75.4	75.4	75.9	73.2
1990	45.6	53.6	56.7	48.9	72.9	71.3	73.8	70.5
1991	43.9	51.8	55.2	47.3	70.5	69.0	71.7	68.1
1992	42.5	50.3	53.7	45.8	68.2	66.5	69.7	66.3
1993	41.7	49.0	52.7	45.2	67.0	64.8	68.8	65.2
1994	41.4	48.6	52.5	45.3	66.6	64.3	68.6	65.2
1995	41.4	48.6	52.7	45.8	66.4	64.5	68.8	65.5
1996	41.4	49.2	52.8	46.2	66.6	65.4	68.8	65.9
1997	41.7	50.1	53.6	47.1	67.7	66.7	69.7	67.2
1998	42.6	51.4	54.6	48.2	69.0	68.5	71.0	68.9
1999	43.0	51.9	54.8	48.6	69.5	69.2	71.4	69.4
2000	42.6	51.5	53.8	48.2	68.7	68.7	70.6	68.4
2001	41.6	50.2	52.5	46.7	66.9	67.2	68.7	66.4
2002	40.2	48.6	50.9	44.9	64.7	65.1	66.4	64.1
2003	39.0	46.7	49.2	43.4	62.7	62.7	64.3	61.9
2004	37.8	45.2	47.7	42.1	61.1	60.5	62.1	60.1
2005	36.8	44.2	46.1	40.7	59.2	59.3	60.3	58.5
2006	35.9	43.1	45.0	39.9	57.8	57.9	58.9	57.0
2007	35.0	42.0	43.8	38.8	56.6	56.0	57.4	55.5
2008	34.9	41.6	43.3	38.8	56.1	55.6	57.1	55.3
2009	35.6	42.5	44.0	39.4	57.0	56.8	57.8	56.1
2010	36.3	43.3	44.3	40.0	58.1	57.6	58.4	56.7
2011	36.8	44.1	44.6	40.5	59.1	58.4	59.3	57.5
2012	37.3	44.5	45.0	40.7	59.5	59.0	59.8	57.9
2013	37.0	44.1	44.7	40.3	58.9	58.5	59.3	57.2
2014	35.8	43.0	43.7	38.9	57.0	57.0	57.6	55.5
2015	34.5	41.9	42.5	37.8	55.1	55.9	56.2	53.9
2016	34.0	41.6	42.2	37.2	54.1	55.5	55.6	53.1

Table 34: Ling, West Coast South Island — Estimated fishing intensity (catch divided by vulnerable biomass), by model year.

Combined CPUE

	Base		v42		v43	
Year	Trawl	Longline	Trawl	Longline	Trawl	Longline
1972	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1973	0.0011	0.0004	0.0019	0.0007	0.0033	0.0011
1974	0.0018	0.0008	0.0021	0.0010	0.0022	0.0009
1975	0.0050	0.0154	0.0008	0.0028	0.0031	0.0086
1976	0.0072	0.0412	0.0007	0.0042	0.0030	0.0158
1977	0.0095	0.0874	0.0010	0.0096	0.0030	0.0253
1978	0.0040	0.0071	0.0005	0.0009	0.0021	0.0032
1979	0.0072	0.0078	0.0017	0.0018	0.0092	0.0087
1980	0.0072	0.0066	0.0019	0.0018	0.0110	0.0088
1981	0.0066	0.0065	0.0038	0.0038	0.0130	0.0112
1982	0.0092	0.0087	0.0084	0.0081	0.0176	0.0146
1983	0.0145	0.0155	0.0136	0.0150	0.0215	0.0202
1984	0.0133	0.0132	0.0112	0.0115	0.0199	0.0175
1985	0.0171	0.0068	0.0114	0.0047	0.0192	0.0068
1986	0.0165	0.0083	0.0164	0.0086	0.0212	0.0095
1987	0.0173	0.0088	0.0249	0.0132	0.0195	0.0089
1988	0.0226	0.0071	0.0528	0.0173	0.0348	0.0099
1989	0.0313	0.0094	0.0536	0.0169	0.0368	0.0100
1990	0.0361	0.0107	0.0408	0.0128	0.0377	0.0100
1991	0.0358	0.0100	0.0295	0.0089	0.0369	0.0093
1992	0.0273	0.0185	0.0282	0.0206	0.0264	0.0163
1993	0.0271	0.0205	0.0253	0.0207	0.0266	0.0185
1994	0.0189	0.0249	0.0192	0.0274	0.0187	0.0226
1995	0.0284	0.0300	0.0245	0.0282	0.0290	0.0280
1996	0.0290	0.0330	0.0204	0.0248	0.0297	0.0306
1997	0.0268	0.0319	0.0246	0.0311	0.0284	0.0304
1998	0.0279	0.0300	0.0244	0.0277	0.0297	0.0287
1999	0.0310	0.0310	0.0289	0.0302	0.0340	0.0305
2000	0.0319	0.0262	0.0296	0.0255	0.0350	0.0260
2001	0.0329	0.0272	0.0279	0.0245	0.0356	0.0270
2002	0.0323	0.0220	0.0318	0.0231	0.0355	0.0223
2003	0.0291	0.0217	0.0307	0.0243	0.0326	0.0223
2004	0.0303	0.0216	0.0297	0.0224	0.0339	0.0223
2005	0.0242	0.0233	0.0201	0.0206	0.0259	0.0229
2006	0.0277	0.0179	0.0306	0.0212	0.0318	0.0190
2007	0.0210	0.0253	0.0229	0.0297	0.0243	0.0270
2008	0.0173	0.0322	0.0149	0.0301	0.0180	0.0309
2009	0.0174	0.0281	0.0152	0.0265	0.0199	0.0293
2010	0.0211	0.0297	0.0220	0.0333	0.0245	0.0315
2011	0.0266	0.0286	0.0245	0.0284	0.0297	0.0291
2012	0.0263	0.0277	0.0242	0.0275	0.0294	0.0282
2013	0.0284	0.0295	0.0259	0.0289	0.0318	0.0300
2014	0.0256	0.0394	0.0191	0.0327	0.0236	0.0339
2015	0.0266	0.0375	0.0210	0.0314	0.0258	0.0325
2016	0.0268	0.0317	0.0210	0.0307	0.0259	0.0319

Table 34 ctd.

Lognormal CPUE

	Base		v42		v43		v44	
Year	Trawl	Longline	Trawl	Longline	Trawl	Longline	Trawl	Longline
1972	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1973	0.0014	0.0006	0.0027	0.0011	0.0044	0.0017	0.0041	0.0016
1974	0.0024	0.0012	0.0031	0.0015	0.0030	0.0014	0.0028	0.0013
1975	0.0069	0.0235	0.0012	0.0044	0.0041	0.0138	0.0038	0.0131
1976	0.0100	0.0630	0.0010	0.0065	0.0041	0.0254	0.0038	0.0241
1977	0.0135	0.1360	0.0014	0.0151	0.0041	0.0410	0.0038	0.0388
1978	0.0057	0.0113	0.0007	0.0014	0.0028	0.0052	0.0026	0.0049
1979	0.0101	0.0125	0.0024	0.0029	0.0125	0.0143	0.0116	0.0135
1980	0.0102	0.0106	0.0028	0.0028	0.0150	0.0145	0.0138	0.0137
1981	0.0093	0.0104	0.0055	0.0060	0.0177	0.0185	0.0163	0.0174
1982	0.0128	0.0138	0.0121	0.0127	0.0239	0.0243	0.0220	0.0229
1983	0.0199	0.0246	0.0197	0.0235	0.0291	0.0339	0.0266	0.0318
1984	0.0180	0.0209	0.0159	0.0181	0.0267	0.0295	0.0243	0.0277
1985	0.0226	0.0108	0.0158	0.0075	0.0252	0.0115	0.0230	0.0108
1986	0.0215	0.0131	0.0224	0.0137	0.0273	0.0159	0.0249	0.0150
1987	0.0222	0.0136	0.0337	0.0206	0.0247	0.0147	0.0225	0.0138
1988	0.0289	0.0109	0.0718	0.0269	0.0439	0.0162	0.0398	0.0151
1989	0.0401	0.0141	0.0743	0.0264	0.0463	0.0161	0.0420	0.0151
1990	0.0460	0.0158	0.0574	0.0199	0.0480	0.0161	0.0435	0.0149
1991	0.0463	0.0148	0.0421	0.0138	0.0476	0.0151	0.0430	0.0139
1992	0.0362	0.0277	0.0411	0.0323	0.0349	0.0265	0.0313	0.0243
1993	0.0366	0.0309	0.0375	0.0329	0.0362	0.0303	0.0324	0.0278
1994	0.0261	0.0381	0.0290	0.0441	0.0260	0.0377	0.0232	0.0342
1995	0.0398	0.0464	0.0375	0.0454	0.0409	0.0471	0.0366	0.0427
1996	0.0416	0.0519	0.0315	0.0411	0.0427	0.0523	0.0380	0.0472
1997	0.0391	0.0513	0.0383	0.0526	0.0415	0.0534	0.0369	0.0480
1998	0.0414	0.0492	0.0382	0.0477	0.0441	0.0516	0.0390	0.0460
1999	0.0463	0.0515	0.0451	0.0529	0.0508	0.0559	0.0451	0.0498
2000	0.0481	0.0443	0.0467	0.0453	0.0530	0.0482	0.0465	0.0427
2001	0.0495	0.0467	0.0442	0.0438	0.0543	0.0501	0.0482	0.0450
2002	0.0490	0.0386	0.0511	0.0420	0.0546	0.0418	0.0485	0.0378
2003	0.0444	0.0383	0.0499	0.0445	0.0505	0.0422	0.0435	0.0372
2004	0.0467	0.0385	0.0489	0.0420	0.0529	0.0429	0.0455	0.0375
2005	0.0375	0.0416	0.0335	0.0387	0.0407	0.0442	0.0357	0.0400
2006	0.0429	0.0324	0.0513	0.0399	0.0503	0.0367	0.0432	0.0327
2007	0.0328	0.0463	0.0391	0.0564	0.0386	0.0526	0.0337	0.0474
2008	0.0272	0.0592	0.0257	0.0574	0.0290	0.0607	0.0251	0.0549
2009	0.0278	0.0522	0.0265	0.0510	0.0322	0.0584	0.0279	0.0532
2010	0.0339	0.0557	0.0382	0.0648	0.0398	0.0634	0.0345	0.0572
2011	0.0431	0.0540	0.0434	0.0560	0.0489	0.0591	0.0438	0.0553
2012	0.0428	0.0532	0.0432	0.0549	0.0489	0.0582	0.0438	0.0541
2013	0.0467	0.0568	0.0469	0.0585	0.0530	0.0623	0.0461	0.0561
2014	0.0424	0.0768	0.0351	0.0672	0.0398	0.0717	0.0349	0.0653
2015	0.0445	0.0742	0.0387	0.0645	0.0437	0.0696	0.0385	0.0635
2016	0.0447	0.0637	0.0389	0.0643	0.0440	0.0691	0.0386	0.0637

Table 34 ctd.

Lognormal CPUE & M = 0.18

	Base		v42		v43		v44	
Year	Trawl	Longline	Trawl	Longline	Trawl	Longline	Trawl	Longline
1972	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1973	0.0016	0.0005	0.0031	0.0009	0.0049	0.0013	0.0048	0.0015
1974	0.0028	0.0010	0.0035	0.0012	0.0033	0.0011	0.0033	0.0012
1975	0.0079	0.0197	0.0014	0.0035	0.0046	0.0106	0.0046	0.0120
1976	0.0115	0.0531	0.0011	0.0052	0.0046	0.0195	0.0045	0.0220
1977	0.0157	0.1145	0.0016	0.0120	0.0045	0.0314	0.0045	0.0356
1978	0.0066	0.0095	0.0008	0.0011	0.0031	0.0040	0.0031	0.0045
1979	0.0119	0.0106	0.0027	0.0023	0.0139	0.0109	0.0139	0.0124
1980	0.0119	0.0090	0.0032	0.0023	0.0167	0.0111	0.0167	0.0126
1981	0.0109	0.0089	0.0062	0.0048	0.0197	0.0141	0.0198	0.0161
1982	0.0151	0.0119	0.0137	0.0101	0.0267	0.0185	0.0268	0.0212
1983	0.0236	0.0212	0.0221	0.0188	0.0324	0.0257	0.0327	0.0297
1984	0.0215	0.0182	0.0180	0.0145	0.0298	0.0224	0.0302	0.0261
1985	0.0275	0.0094	0.0182	0.0060	0.0283	0.0088	0.0288	0.0102
1986	0.0262	0.0115	0.0259	0.0109	0.0308	0.0123	0.0316	0.0143
1987	0.0272	0.0120	0.0392	0.0167	0.0281	0.0113	0.0288	0.0133
1988	0.0358	0.0097	0.0842	0.0221	0.0501	0.0124	0.0516	0.0146
1989	0.0501	0.0126	0.0877	0.0218	0.0532	0.0124	0.0551	0.0147
1990	0.0579	0.0141	0.0688	0.0167	0.0550	0.0125	0.0574	0.0150
1991	0.0587	0.0135	0.0509	0.0116	0.0547	0.0116	0.0572	0.0140
1992	0.0460	0.0255	0.0498	0.0273	0.0398	0.0205	0.0419	0.0249
1993	0.0462	0.0287	0.0459	0.0282	0.0411	0.0235	0.0436	0.0291
1994	0.0330	0.0355	0.0357	0.0383	0.0294	0.0290	0.0311	0.0361
1995	0.0503	0.0435	0.0465	0.0403	0.0464	0.0364	0.0491	0.0454
1996	0.0529	0.0492	0.0393	0.0365	0.0481	0.0402	0.0510	0.0509
1997	0.0500	0.0489	0.0477	0.0464	0.0469	0.0411	0.0497	0.0520
1998	0.0529	0.0473	0.0478	0.0421	0.0500	0.0395	0.0527	0.0501
1999	0.0594	0.0505	0.0571	0.0472	0.0578	0.0430	0.0611	0.0543
2000	0.0619	0.0438	0.0590	0.0408	0.0604	0.0377	0.0632	0.0469
2001	0.0641	0.0463	0.0562	0.0395	0.0621	0.0399	0.0656	0.0497
2002	0.0638	0.0382	0.0646	0.0382	0.0623	0.0335	0.0666	0.0418
2003	0.0578	0.0380	0.0625	0.0413	0.0579	0.0343	0.0601	0.0415
2004	0.0603	0.0386	0.0613	0.0392	0.0608	0.0349	0.0629	0.0420
2005	0.0484	0.0419	0.0421	0.0364	0.0468	0.0363	0.0496	0.0447
2006	0.0555	0.0326	0.0639	0.0372	0.0579	0.0303	0.0599	0.0367
2007	0.0424	0.0468	0.0485	0.0531	0.0445	0.0433	0.0468	0.0535
2008	0.0353	0.0599	0.0319	0.0544	0.0331	0.0499	0.0347	0.0616
2009	0.0359	0.0530	0.0328	0.0483	0.0368	0.0480	0.0385	0.0588
2010	0.0440	0.0562	0.0477	0.0601	0.0456	0.0522	0.0476	0.0640
2011	0.0560	0.0541	0.0538	0.0518	0.0558	0.0486	0.0605	0.0618
2012	0.0560	0.0526	0.0542	0.0504	0.0561	0.0481	0.0607	0.0604
2013	0.0613	0.0567	0.0592	0.0541	0.0610	0.0515	0.0640	0.0625
2014	0.0561	0.0770	0.0444	0.0618	0.0458	0.0597	0.0491	0.0730
2015	0.0594	0.0750	0.0486	0.0601	0.0506	0.0581	0.0542	0.0704
2016	0.0599	0.0648	0.0493	0.0600	0.0511	0.0580	0.0551	0.0710

5.4 Conclusions – Ling

The impacts from using the three alternative catch histories (Figure 27) were broadly similar for all the ling stocks. Catches from alternative catch histories v42, v43, and v44 were generally higher (particularly for LIN 3&4) than the base (assessment) estimates, except for the catches in the late 1970s and early 1980s, which were higher in the base models due to the Japanese and Korean longline fisheries operating at the time and are accounted for in the base model assessments. Overall, relative to the base models, the estimated virgin and current biomasses tended to be slightly to moderately higher when using the alternative catch histories (Figures 28–30). For v42, the B_0 was estimated to be up to 24% larger, and current biomass up to 36% larger, than estimated by the base model; for v43, these values were 21% and 28%; for v44, these values were 18% and 26%. The estimates of current stock status (current $\%B_0$) were however almost identical to those from the base models (Figures 28–30).

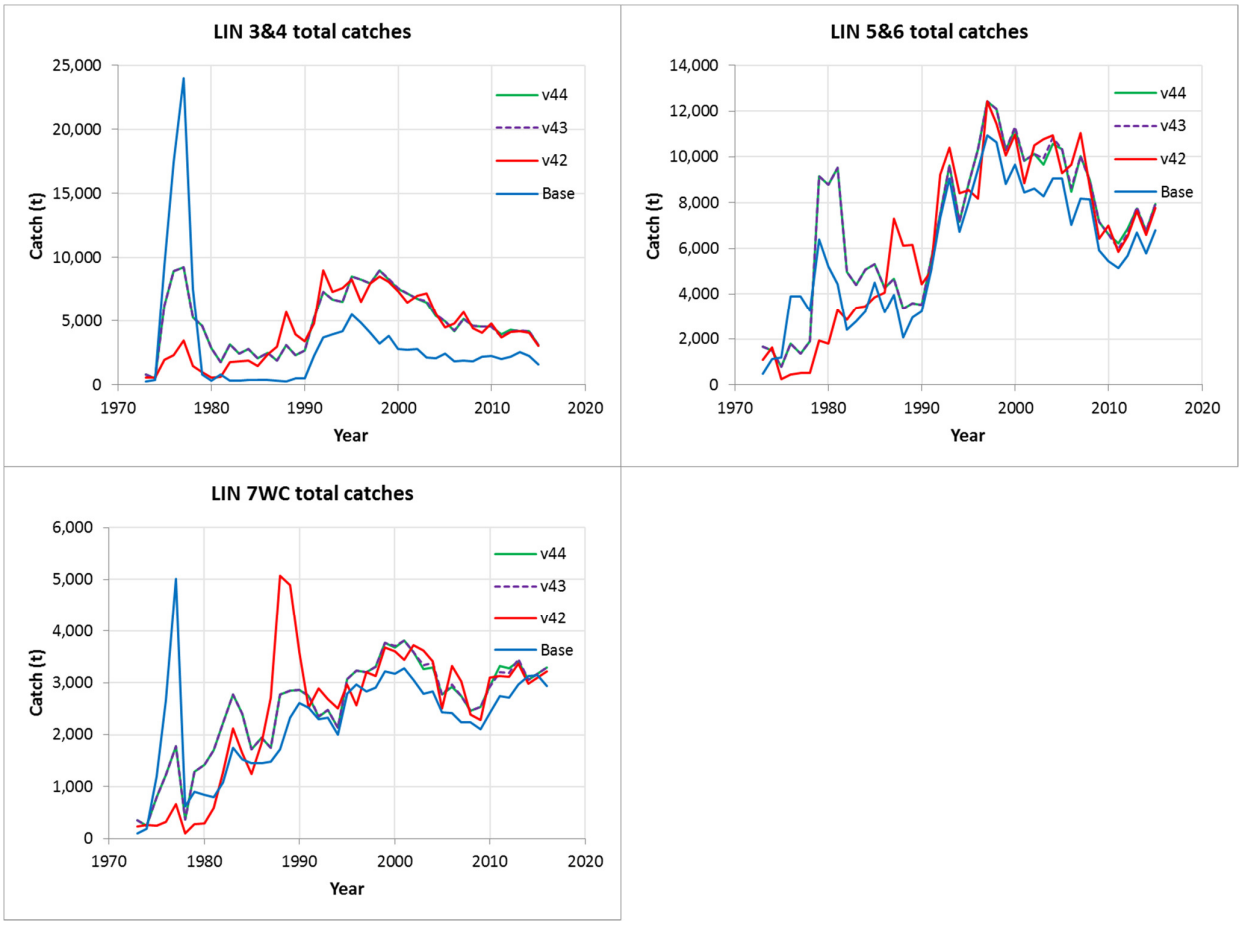

Figure 27: Total catch histories used in the ling base case assessments and in the assessments using the three alternative SAU datasets, for each of the three biological stocks.

Fishing intensity rates were generally similar over time for all model runs (Figures 28–30), with the following exceptions. For the West Coast South Island trawl fishery, a spike in fishing intensity in the late 1980s seems to have slightly accelerated a reduction in biomass and $\%B_0$. For the Chatham Rise and West Coast South Island longline fisheries, the base model had extremely high fishing intensities in the late 1970s and 1980s (resulting in a temporary reduction in biomass) due to the high catches over that period, as recorded in the MPI Fisheries Assessment Plenary (Ministry for Primary Industries 2017, pages 677–678), but not picked up in the SAU databases.

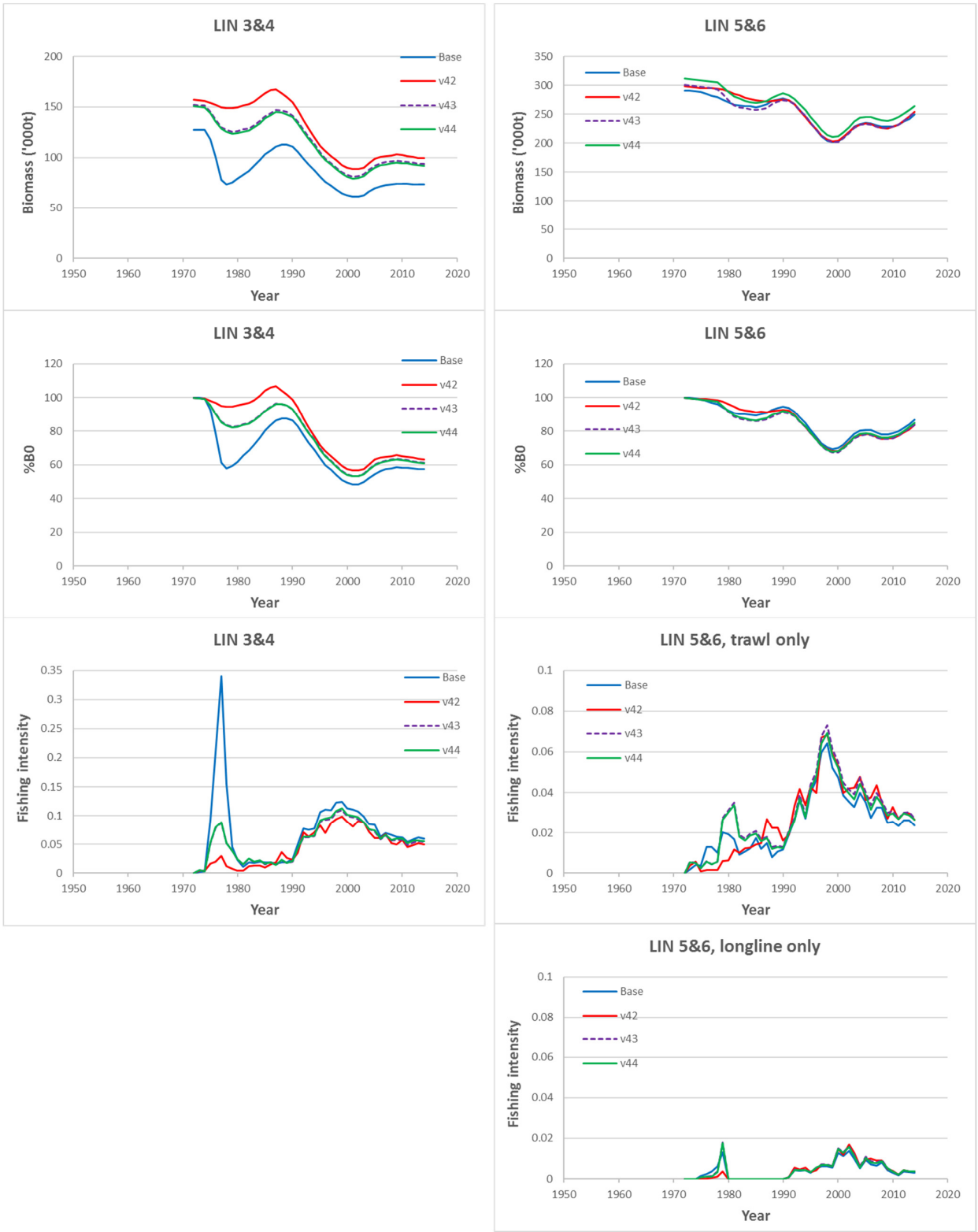

Figure 28: Median biomass trajectories, stock status trajectories, and estimated fishing intensities for the Chatham Rise (LIN 3&4) and Sub-Antarctic (LIN 5&6) ling stocks from the base case assessments and the assessments using the three alternative SAU datasets.

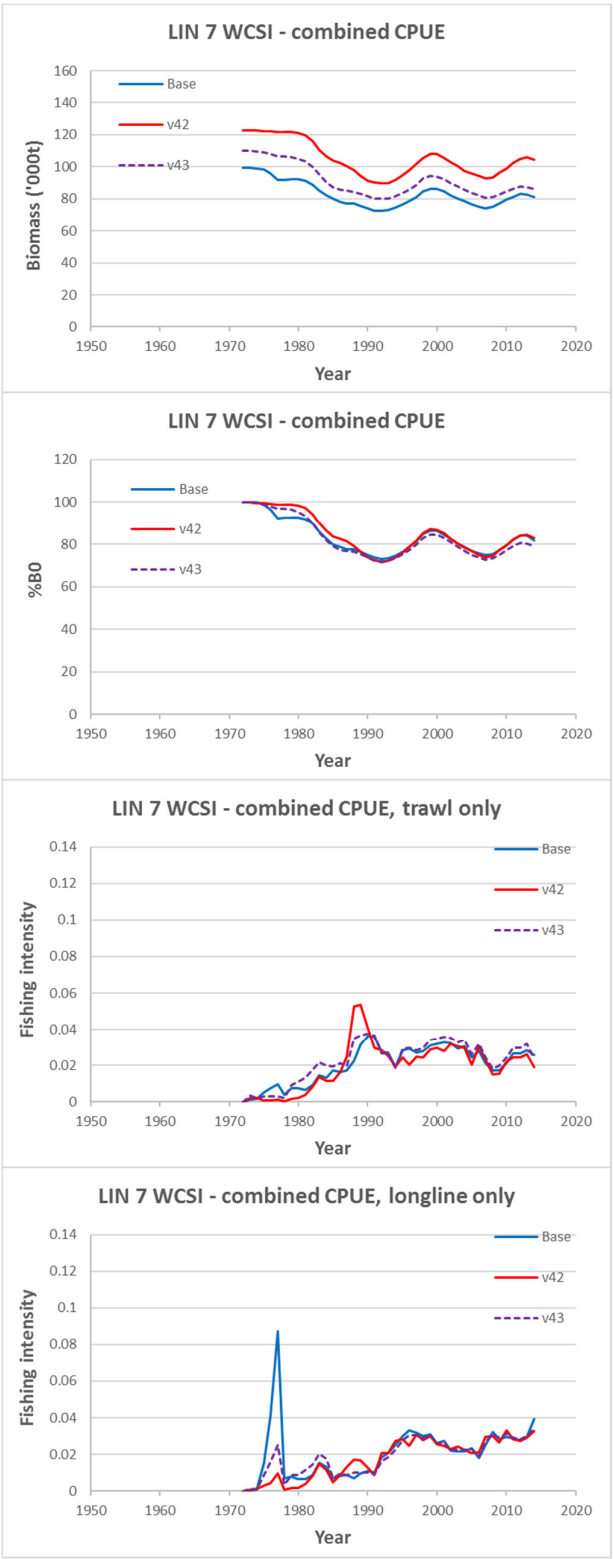

Figure 29: Median biomass trajectories, stock status trajectories, and estimated fishing intensity for the WCSI (LIN 7WC) ling stock from the base case 'combined CPUE' assessment and similar assessments using the alternative SAU v42 and v43 datasets. Note: The comparable assessment using the v44 dataset was not reported (see Section 5.3).

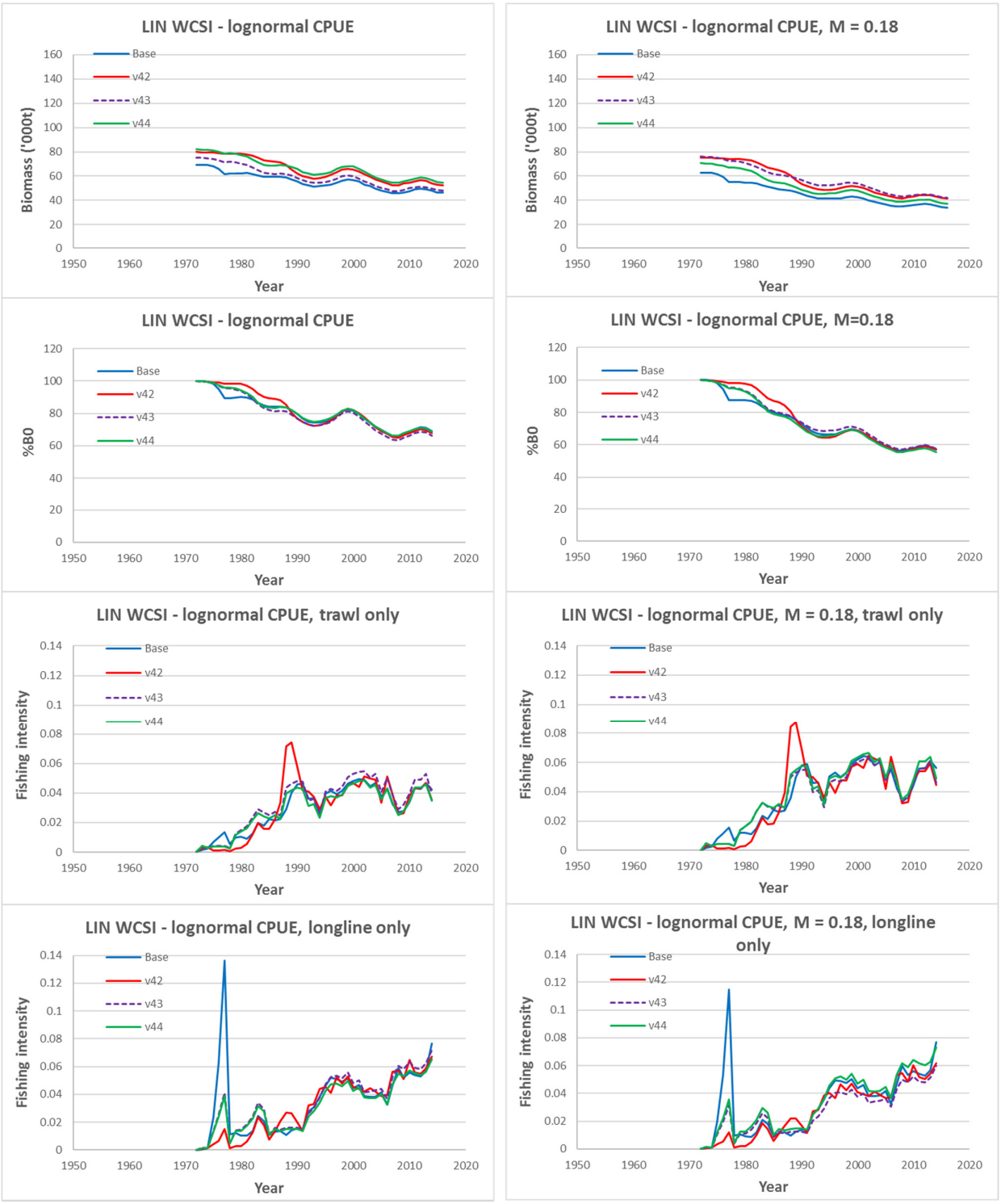

Figure 30: Median biomass trajectories, stock status trajectories, and estimated fishing intensity for the WCSI (LIN 7WC) ling stock from the base case 'lognormal CPUE' and 'lognormal CPUE with *M* = 0.18' assessments and similar assessments using the three alternative SAU datasets.

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