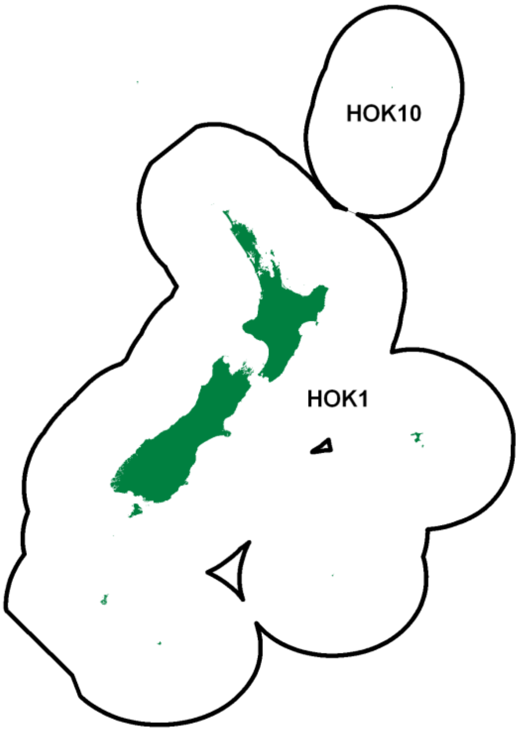
HOKI (HOK)

(*Macruronus novaezelandiae*)
Hoki



1. FISHERY SUMMARY

Allowances, TACCs, and TACs are shown in Table 1.

Table 1: Recreational and Customary non-commercial allowances, other mortality, TACCs, and TACs (t) for hoki by Fishstock.

Fishstock	Recreational allowance	Customary non-commercial allowance	Other sources of mortality	TACC	TAC
HOK 1	20	20	1 100	110 000	111 140
HOK 10*	–	–	–	10	–

* allowances and TAC not set

1.1 Commercial fisheries

Historically, the main fishery for hoki operated from mid-July to late August off the west coast of the South Island (WCSI) where hoki aggregate to spawn. The spawning aggregations begin to concentrate in depths of 300–700 m around the Hokitika Canyon from late June, and further north off Westport later in the season. Fishing in these areas continues into September in some years. Starting in 1988, another major fishery developed in Cook Strait, where separate spawning aggregations of hoki occur. The spawning season in Cook Strait runs from late June to mid-September, peaking in July and August. Spawning hoki are also taken from other spawning grounds off the east coast South Island (ECSI) and late in the season at Puysegur Bank. Catches from Puysegur are currently low, but catches from the ECSI have increased since 2019 and are now higher than those from Cook Strait.

Outside the spawning season, when hoki disperse to their feeding grounds, substantial fisheries have developed since the early 1990s on the Chatham Rise and in the Sub-Antarctic. These fisheries usually operate in depths of 300–800 m. The Chatham Rise fishery generally has similar catches over all months except in July-September, when catches are lower due to the fishery moving to the spawning grounds. In the Sub-Antarctic, catches have typically peaked in April-June. Out-of-season catches are also taken from Cook Strait and the east coast of the North Island, but these are small by comparison.

The hoki fishery was developed by Japanese and Soviet vessels in the early 1970s. Catches peaked at 100 000 t in 1977 but dropped to less than 20 000 t in 1978 when the EEZ was declared and quota limits were introduced (Table 2). From 1979 on, the hoki catch increased to about 50 000 t until an increase in the TACC from 1986 to 1990 saw the fishery expand to a maximum catch in 1987–88 of about 255 000 t (Table 3 and Table 4).

Table 2: Reported trawl catches (t) by fleet from 1969 to 1987–88, 1969–1983 by calendar year, 1983–84 to 1987–88 by fishing year (Oct-Sept). Source - FSU data.

				New Zealand		
Year	**USSR**	**Japan**	**South Korea**	**Domestic**	**Chartered**	**Total**
1969	–	95	–	–	–	95
1970	–	414	–	–	–	414
1971	–	411	–	–	–	411
1972	7 300	1 636	–	–	–	8 936
1973	3 900	4 758	–	–	–	8 658
1974	13 700	2 160	–	125	–	15 985
1975	36 300	4 748	–	62	–	41 110
1976	41 800	24 830	–	142	–	66 772
1977	33 500	54 168	9 865	217	–	97 750
1978*	2 028†	1 296	4 580	678	–	8 581
1979	4 007	8 550	1 178	2 395	7 970	24 100
1980	2 516	6 554	–	2 658	16 042	27 770
1981	2 718	9 141	2	5 284	15 657	32 802
1982	2 251	7 591	–	6 982	15 192	32 018
1983	3 853	7 748	137	7 706	20 697	40 141
1983–84	4 520	7 897	93	9 229	28 668	50 407
1984–85	1 547	6 807	35	7 213	28 068	43 670
1985–86	4 056	6 413	499	8 280	80 375	99 623
1986–87	1 845	4 107	6	8 091	153 222	167 271
1987–88	2 412	4 159	10	7 078	216 680	230 339

* Catches for foreign licensed and New Zealand chartered vessels from 1978 to 1984 are based on estimated catches from vessel logbooks. Few data are available for the first 3 months of 1978 because these vessels did not begin completing these logbooks until 1 April 1978.

† Soviet hoki catches are taken from the estimated catch records and differ from official MAF statistics. Estimated catches are used because of the large amount of hoki converted to meal and not recorded as processed fish.

Table 3: TACC, voluntary catch limits (prior to shelving), total ACE generated, and industry shelving agreements by year (t). The voluntary eastern and western catch limits represent the limits prior to any shelving of ACE.

Year	TACC	Eastern catch limit	Western catch limit	Total HOK 1 ACE generated[1]	Industry shelving of ACE
2001–02	200 000	70 000	130 000	200 000	–
2002–03	200 000	70 000	130 000	203 943	–
2003–04	180 000	70 000	110 000	180 000	–
2004–05	100 000	60 000	40 000	100 000	–
2005–06	100 000	60 000	40 000	100 251	–
2006–07	100 000	60 000	40 000	100 493	–
2007–08	90 000	65 000	25 000	90 000	–
2008–09	90 000	65 000	25 000	90 682	–
2009–10	110 000	60 000	50 000	111 872	–
2010–11	120 000	60 000	60 000	124 666	–
2011–12	130 000	60 000	70 000	135 770	–
2012–13	130 000	60 000	70 000	135 650	–
2013–14	150 000	60 000	90 000	153 959	–
2014–15	160 000	60 000	100 000	167 572	–
2015–16	150 000	60 000	90 000	150 000	–
2016–17	150 000	60 000	90 000	161 205	–
2017–18	150 000	60 000	90 000	166 075	–
2018–19	150 000	60 000	90 000	164 730	20 000 (from western)
2019–20	115 000	60 000	55 000	115 000	–
2020–21	115 000	60 000	55 000	122 259	20 000 (split evenly eastern/western)
2021–22	110 000	65 000	45 000	110 000	10 000 (from east)
2022–23	110 000	65 000	45 000	119 165	10 000 (from eastern/western)
2023–24	110 000	65 000	45 000	113 465	-
2024–25	110 000	65 000	45 000	116 428	-

[1] Total ACE comprises the TACC plus any underfishing ACE generated pursuant to the ACE carryforward provisions set out in section 67A of the Fisheries Act 1996. In the year immediately following a TACC decrease, section 67A precludes the allocation of any underfishing ACE.

From 1986 to 1990, surimi vessels dominated the catches and took about 60% of the annual WCSI catch. However, after 1991, the surimi component of catches decreased and processing to head and gut, or to fillet product increased, as did "fresher" catch for shore processing. The hoki fishery now operates throughout the year, producing high quality fillet product from both spawning and non-spawning fisheries. No surimi has been produced from hoki since 2002. Since 1998, twin-trawl rigs have operated in some hoki fisheries, and trawls made of spectra twine (a high strength twine with reduced diameter resulting in reduced drag and improved fuel efficiencies) were introduced to some vessels in 2007–08.

Between 2012–13 and 2017, Precision Seafood Harvest (PSH) technology was tested in the hoki fishery. This included a prototype trawl system called a Modular Harvest System (MHS) that aimed to target specific species and fish size, as well as enabling fish to be landed in much better condition than traditional trawls. Approval to use MHS gear in the hoki, hake, and ling fisheries was granted in 2018. During the 2017–18 fishing year, seven vessels used the gear to target hoki and caught 9595 t (7% of the total hoki catch). The MHS catch increased to 17 127 t (14% of the total catch) in 2018–19 but has subsequently decreased due to a change in preference of product from fillet to block and unavailability of materials for MHS codends. In 2023–24, only 32 t (0.03% of the total catch) was taken with MHS.

Annual catches ranged between 175 000 t and 215 000 t from 1988–89 to 1995–96, increasing to a peak of 269 000 t in 1997–98, when the TACC was over-caught by 19 000 t. Catches subsequently declined, tracking the TACC as it was reduced to address poor stock status, reaching a low of 89 000 t in 2008–09, then increasing again up to 161 500 t in 2014–15 following increases in the TACC as stock status improved (Table 4). The TACC was reduced to 150 000 t in 2015–16 and catches in the next four years were below this level (Table 4). The fishing industry voluntarily shelved 20 000 t of western ACE in 2018–19, leading to an effective lowering of the western catch limit in that year to 70 000 t. The TACC was further reduced to 115 000 t in 2019–20 when the annual catch was 107 700 t. In 2020–21, the TACC remained the same, but available ACE (allowing for shelving and carry-forward) was 52 984 t in the west and 60 899 t for the east, with an annual catch of 100 819 t. The TACC for 2021–22 was reduced to 110 000 t and there was also an industry agreement that in the 2021–22 fishing year, allowing for 10 000 t shelving, catches would be limited to 100 000 t (plus any carryover) with a catch split of 45 000 t from the western stock areas and 55 000 t for the eastern stock areas. Allowing for shelving and carryover, ACE available to fishers in 2022–23 and 2023–24 was 108 110 t and 113 476 t respectively

Table 4: Reported catch (t) from QMS and estimated catch (t), for HOK 1 from 1986–87 to present. Reported catches are from the QMR and MHR systems. Estimated catches include TCEPR and CELR data (from 1989–90), LCER data (from 2003–04), NCELR data (from 2006–07), TCER, and LTCER data (from 2007–08), and ERS-trawl data (from 2017–18). Catches from 1986–87 to 1999–00 are rounded to the nearest 500 t.

Year	Estimated catch	Reported catch	Year	Estimated catch	Reported catch
1986–87	158 000	175 000	2006–07	97 790	101 009
1987–88	216 000	255 000	2007–08	87 815	89 318
1988–89	208 500	210 000	2008–09	87 598	88 805
1989–90	210 000	210 000	2009–10	105 105	107 209
1990–91	215 000	210 000	2010–11	115 782	118 805
1991–92	215 000	215 000	2011–12	126 184	130 108
1992–93	195 000	215 000	2012–13	127 962	131 575
1993–94	191 000	195 000	2013–14	143 705	146 344
1994–95	174 000	190 000	2014–15	156 471	161 528
1995–96	210 000	168 000	2015–16	136 087	136 719
1996–97	246 000	194 000	2016–17	138 555	141 567
1997–98	269 000	230 000	2017–18	131 504	135 418
1998–99	244 500	234 000	2018–19	116 700	122 459
1999–00	242 000	237 000	2019–20	102 586	107 737
2000–01	230 625	229 858	2020–21	97 513	100 819
2001–02	200 054	195 492	2021–22	90 174	91 668
2002–03	182 560	184 659	2022–23	102 582	105 556
2003–04	133 764	135 784	2023–24	103 981	107 054
2004–05	102 885	104 364			
2005–06	101 984	104 385			

Note: Discrepancies between QMS data and actual catches from 1986 to 1990 arose from incorrect surimi conversion factors. The estimated catch in those years has been corrected from conversion factors measured each year by Scientific Observers on the WCSI fishery. Since 1990 the new conversion factor of 5.8 has been used, and the total catch reported to the QMS is considered to be more representative of the true level of catch.

The pattern of fishing has changed markedly since 1988–89 when over 90% of the total catch was taken in the WCSI spawning fishery. This has been due to a combination of TACC changes and redistribution of fishing effort. The WCSI fishery accounted for 28.7% of the total hoki catch in 2022–23 and was the second largest hoki fishery in New Zealand behind the Chatham Rise (CR) (Table 5). Cook Strait (CS) catches peaked at 67 000 t in 1995–96, were relatively stable in the range 15 000 t to 25 000 t from 2004–05 to 2019–20, but have decreased to between 10 000 and 14 000 t in the last three years. At the same time catches from the ECSI spawning fishery doubled from around 5000 t in 2011–12 to 2017–

18 to around 10 000 t from 2018–19 to 2022–23, increasing further to over 15 000 t in 2023–24. The Chatham Rise was the largest hoki fishery in 2022–23 and 2023–24 contributing about 35% of the total catch. Catches from the Sub-Antarctic (SA) peaked at over 30 000 t from 1999–2000 to 2001–02 but have been variable since, ranging between about 6000 t and 20 000 t over the past 21 years (Table 5). Catches from other areas are at relatively low levels (Table 5).

Table 5: Estimated total catch (t) (scaled to reported QMR or MHR) of hoki by area 1988–89 to present. Catches from 1988–89 to 1997–98 are rounded to the nearest 500 t and catches from 1998–99 to present are rounded to the nearest t. Unrep. is catch with no location information.

Fishing	Spawning fisheries					Non-spawning fisheries				Total
year	WCSI	Puysegur	Cook Strait	ECSI	Sub-Antarctic	Chatham and ECSI	ECNI	WCNI	Unrep.	Catch
1988–89	188 000	3 500	7 000	–	5 000	5 000	–	–	–	208 500
1989–90	165 000	8 000	14 000	1 058	10 000	12 388	–	–	–	210 000
1990–91	154 000	4 000	26 500	2 574	18 000	28 910	–	–	–	215 000
1991–92	105 000	5 000	25 000	2 541	34 000	46 548	–	–	–	215 000
1992–93	98 000	2 000	21 000	1 050	26 000	43 446	2 000	–	3 000	195 000
1993–94	113 000	2 000	37 000	1 547	12 000	21 663	2 000	–	1 000	191 000
1994–95	80 000	1 000	40 000	3 192	13 000	35 815	1 000	–	–	174 000
1995–96	73 000	3 000	67 000	3 659	12 000	46 285	3 000	–	2 000	210 000
1996–97	91 000	5 000	61 000	5 038	25 000	52 399	5 000	–	1 000	246 000
1997–98	107 000	2 000	53 000	4 579	24 000	74 094	4 000	–	3 000	269 000
1998–99	94 565	2 874	45 240	3 237	23 780	71 700	2 315	62	134	244 540
1999–00	102 723	2 880	43 192	4 080	33 772	54 282	1 387	98	4	242 421
2000–01	102 235	6 798	36 298	4 759	30 076	47 042	2 035	147	–	229 847
2001–02	92 720	5 322	23 976	5 485	30 175	36 637	1 147	39	–	195 501
2002–03	73 860	5 948	36 713	9 812	20 199	36 659	929	532	8	184 662
2003–04	45 112	1 158	41 034	7 821	11 635	27 969	880	126	–	135 735
2004–05	33 111	5 548	24 833	4 827	6 244	29 090	522	37	–	104 212
2005–06	38 989	1 437	21 803	2 148	6 732	32 575	686	8	–	104 378
2006–07	33 328	408	20 113	2 967	7 661	35 851	667	8	–	101 004
2007–08	20 931	308	18 470	5 294	8 708	34 949	640	17	–	89 317
2008–09	20 548	233	17 535	3 480	9 807	36 585	588	25	–	88 801
2009–10	36 349	272	17 880	1 943	12 275	37 864	618	7	–	107 208
2010–11	48 373	1 176	14 937	2 157	12 655	37 915	1 588	2	–	118 803
2011–12	54 532	1 308	15 859	4 405	15 743	37 372	858	31	–	130 108
2012–13	56 219	955	19 396	5 445	14 098	34 402	1 051	9	–	131 575
2013–14	69 400	778	18 400	3 613	19 927	32 889	1 326	9	–	146 342
2014–15	78 705	1 875	20 100	4 250	16 378	39 444	766	11	5	161 535
2015–16	68 877	1 056	18 378	5 311	6 639	35 530	888	20	–	136 698
2016–17	65 962	1 209	16 084	5 440	13 157	38 957	826	6	–	141 568
2017–18	55 533	1 133	21 473	4 924	15 431	35 779	1 141	4	–	135 418
2018–19	46 464	1 268	20 349	10 605	9 061	33 533	1 177	4	–	122 459
2019–20	43 927	349	16 909	9 658	8 039	28 011	844	6	–	107 735
2020–21	35 142	448	12 524	9 655	9 136	33 161	746	7	–	100 819
2021–22	31 559	566	10 151	9 690	8 340	30 689	623	6	–	91 663
2022–23	30 316	160	13 711	10 908	12 890	36 916	650	2	1	105 554
2023–24	32 469	227	11 943	15 508	7 753	38 429	706	–	1	107 035

Since the 2021 stock assessment, fisheries were defined, within which the exploitation patterns were more consistent, following the review work of Langley (2020). The main regions (WCSI, Chatham Rise, Sub-Antarctic, and Cook Strait) were split into fisheries, with estimation of length and age frequencies produced for each fishery. The WCSI region was split into three fisheries spatially: WC_north, WC_south, and WC_inside (Figure 1), where 'inside' relates to inside the 25 nautical mile (nm) limit. The WCSI WC_north sub-fishery has been the largest WCSI fishery in most years, with most of the recent declines in catch occurring in this fishery. Fish size is smaller in the north, and substantially larger fish are caught inside the 25 nm line. The Sub-Antarctic region was structured spatially as SA_auck (Auckland Islands), SA_snares (the Stewart-Snares shelf), and SA_suba (the remaining SA area) (Figure 1) based on fish size. The SA_snares sub-fishery is the largest Sub-Antarctic fishery in most years. The smallest hoki are on the Stewart-Snares shelf, medium-sized fish are around the Auckland Islands, and most of the catch in the rest of the Sub-Antarctic comprises large females. The Chatham Rise region was structured using depth, with depth greater than or equal to 475 m defined as CR_deep, and shallower than 475 m as CR_shallow, because larger fish are predominantly found in deeper water. The CR_deep sub-fishery makes up most of the Chatham Rise catch in each year. Cook Strait catches from spawning months (June-September) made up the CS fishery, and catches from these areas outside the spawning months were included in the CR fisheries. In the 2024 stock assessment, the ECSI spawning area was redefined to a larger area (Figure 1), with ECSI catches from spawning months

(July-September) making up the ECSI spawning fishery, and catches from these areas outside these months included in the CR fisheries (Figure 1). In the 2024 stock assessment, the Puysegur catches from June to September were included in the WC_north fishery; catches from Puysegur outside these spawning months were included in the SA_snares fishery. These changes were retained for the 2025 assessment. A table of catches by fishing year and fishery as defined for the 2025 stock assessment is presented under the Stock Assessment section of this report (see Table 19).

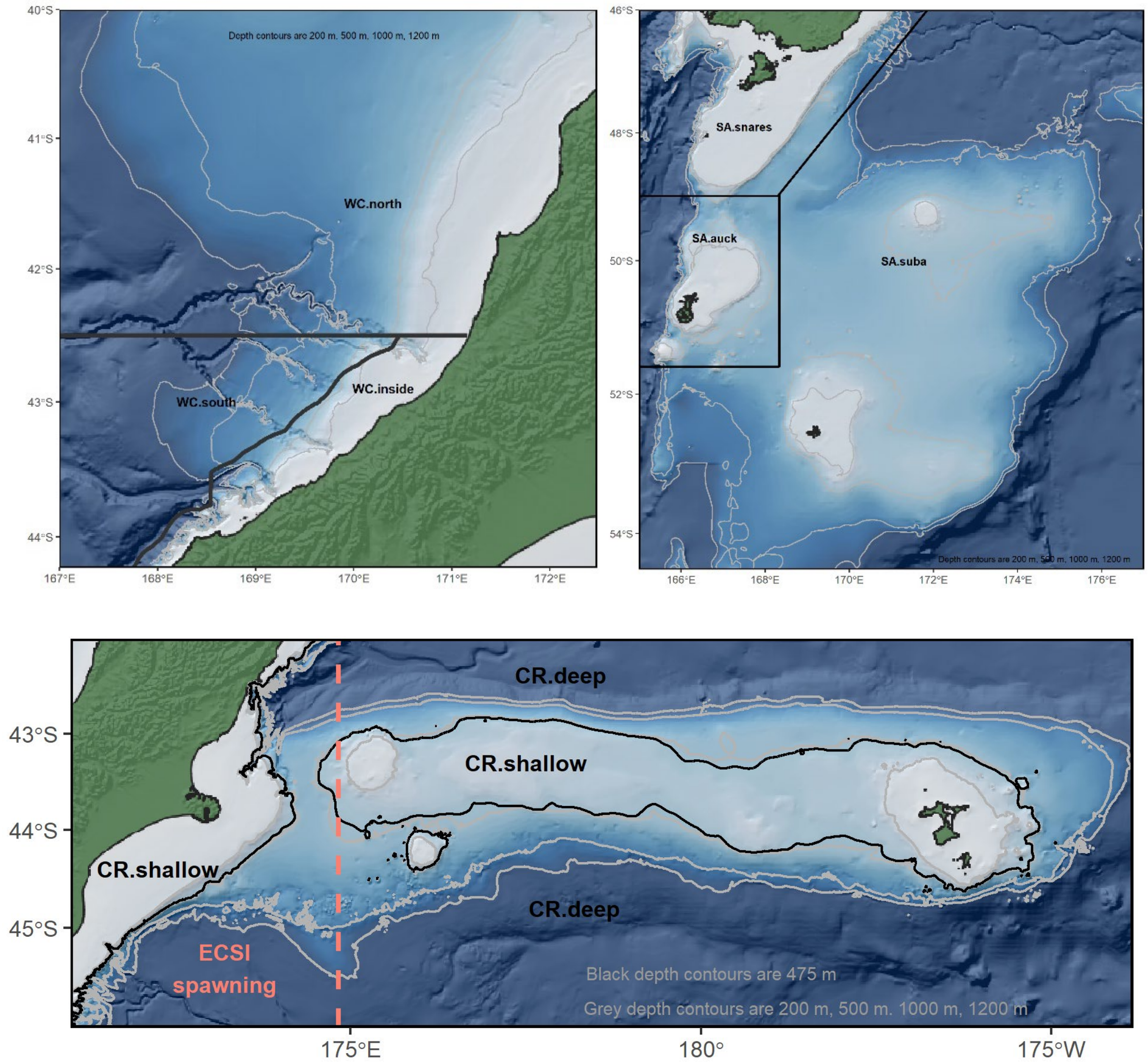


Figure 1: Spatial definitions for WC (WCSI) fisheries (top left), SA (Sub-Antarctic) fisheries (top right), and CR (Chatham Rise) and ECSI spawning fisheries (bottom) as defined for the 2024 stock assessment. North: WC.north; South Out: WC.south; South In: WC.inside; Stewart-Snares (Snares) shelf: SA.snares; Auck Is: SA.auck; Sub-Antarctic: SA.suba; Shallow: CR.shallow; Deep: CR.deep; ECSI: EC.spawn.

From 1999–2000 to 2001–02, there was a redistribution in catch from eastern stock areas (Chatham Rise, ECSI, east coast North Island (ECNI), and Cook Strait) to western stock areas (WCSI, Puysegur, and Sub-Antarctic) (Table 6). This was initially due to industry initiatives to reduce the catch of small fish in the area of the Mernoo Bank but, from 1 October 2001, was part of an informal agreement with the Minister responsible for fisheries that 65% of the catch should be taken from the western fisheries to reduce pressure on the eastern stock. This arrangement ended following the 2003 hoki assessment in 2002–03, which indicated that the eastern hoki stock was less depleted than the western stock and effort was shifted back into eastern areas, particularly Cook Strait. Since 2004–05 there have been a series of agreements, including limiting catch below the TACC and voluntary catch splits between western and eastern fishing grounds (Table 3). The split between eastern and western catches has been close to the agreed catches in most years. In 2022–23 and 2023–24, eastern and western catches (including carry forward) were below catch limits for both eastern and western stock areas. Figure 2a shows the reported landings and TACC for HOK 1, and Figure 2b shows the eastern and western catch components of this stock since 1988–89.

Table 6: Percentages of total catch for different fisheries.

Fishing	Spawning fisheries		Non-spawning fisheries	
Year	West	East	West	East
1988–89	-	-	-	-
1989–90	80.3	7.5	5.8	6.4
1990–91	63.0	14.9	8.0	14.1
1991–92	50.1	12.8	14.5	22.6
1992–93	51.2	11.9	13.3	23.6
1993–94	61.5	19.3	6.1	13.1
1994–95	45.9	21.6	7.8	24.7
1995–96	35.9	30.1	6.6	27.4
1996–97	39.4	24.7	9.0	26.9
1997–98	40.2	18.5	9.6	31.8
1998–99	39.6	17.5	10.0	32.8
1999–00	43.4	17.9	14.1	24.6
2000–01	47.0	16.2	13.6	23.2
2001–02	49.9	13.9	15.7	20.5
2002–03	43.0	23.9	11.4	21.6
2003–04	33.8	34.4	9.0	22.8
2004–05	37.0	26.7	6.2	30.1
2005–06	38.5	21.1	6.7	33.7
2006–07	33.2	20.6	7.8	38.4
2007–08	23.6	23.4	10.0	43.1
2008–09	23.3	20.6	11.2	44.9
2009–10	34.0	16.5	11.6	37.9
2010–11	41.6	11.6	10.7	36.0
2011–12	42.6	13.3	12.4	31.7
2012–13	43.1	15.8	11.1	30.1
2013–14	47.7	12.5	13.9	26.0
2014–15	49.5	12.6	10.5	27.3
2015–16	51.1	15.2	5.0	28.8
2016–17	47.2	12.8	9.5	30.5
2017–18	41.7	17.0	11.5	29.8
2018–19	38.8	24.2	7.6	29.5
2019–20	41.0	23.1	7.6	28.4
2020–21	35.1	20.5	9.3	35.1
2021–22	35.0	19.7	9.1	36.1
2022–23	28.8	21.7	12.3	37.2
2023–24	30.5	24.5	7.3	37.7

Total Allowable Commercial Catch (TACC) and area restrictions

The TACC for HOK 1 has been 110 000 t since 1 October 2021, with an agreed catch split arrangement of 65 000 t from eastern stock areas and 45 000 t from western stock areas. This TACC applied to all areas of the EEZ (except the Kermadec FMA which had a TACC of 10 t). With the allowance for other mortality at 1100 t and 20 t allowances for customary and recreational catch, the 2023–24 TAC was 111 140 t. The ACE that was available to fishers (following voluntary shelving of ~10 000 t and carry forward totalling ~8 200 t) was 113 465 t (Table 3).

Vessels larger than 46 m in overall length may not fish inside the 12 nautical mile (nm) Territorial Sea, and there are other various vessel size restrictions around some parts of the coast. On the WCSI, a 25-nm line closes much of the hoki spawning area in the Hokitika Canyon, and most of the area south to the Cook Canyon, to vessels larger than 46 m overall length. In Cook Strait, the whole spawning area is closed to vessels over 46 m overall length. In November 2007 the Government closed 17 Benthic Protection Areas to bottom trawling and dredging, representing about 30% of the EEZ and including depths that are outside the depth range of hoki.

The fishing industry introduced a Code of Practice (COP) for hoki target trawling in 2001 with the aim to protect small fish (less than 60 cm). The main components of this COP were: 1) a restriction on fishing in waters shallower than 450 m; 2) a rule requiring vessels to 'move on' if there are more than 10% small hoki in the catch; and 3) seasonal and area closures in spawning fisheries. The COP was superseded by Operational Procedures for Hoki Fisheries, also introduced by the fishing industry from 1 October 2009. The Operational Procedures aim to manage and monitor fishing effort within four industry Hoki Management areas where there are thought to be high abundances of juvenile hoki (Narrows Basin of Cook Strait, Canterbury Banks, Mernoo Bank, and Puysegur). These areas are closed to trawlers over 28 m targeting hoki, with increased monitoring when targeting species other than hoki. There is also a general recommendation that vessels move from areas where catches of juvenile hoki (now defined as less than 55 cm total length) comprise more than 20% of the hoki catch by number.

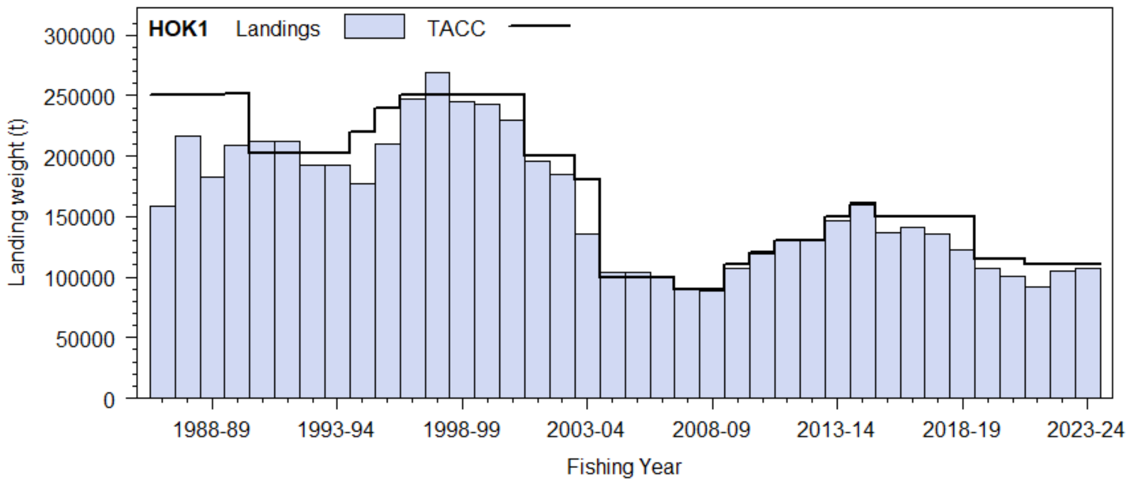


Figure 2a: Reported commercial landings and TACCs for HOK 1 since 1986–87. Note that this graph does not show data prior to entry into the QMS.

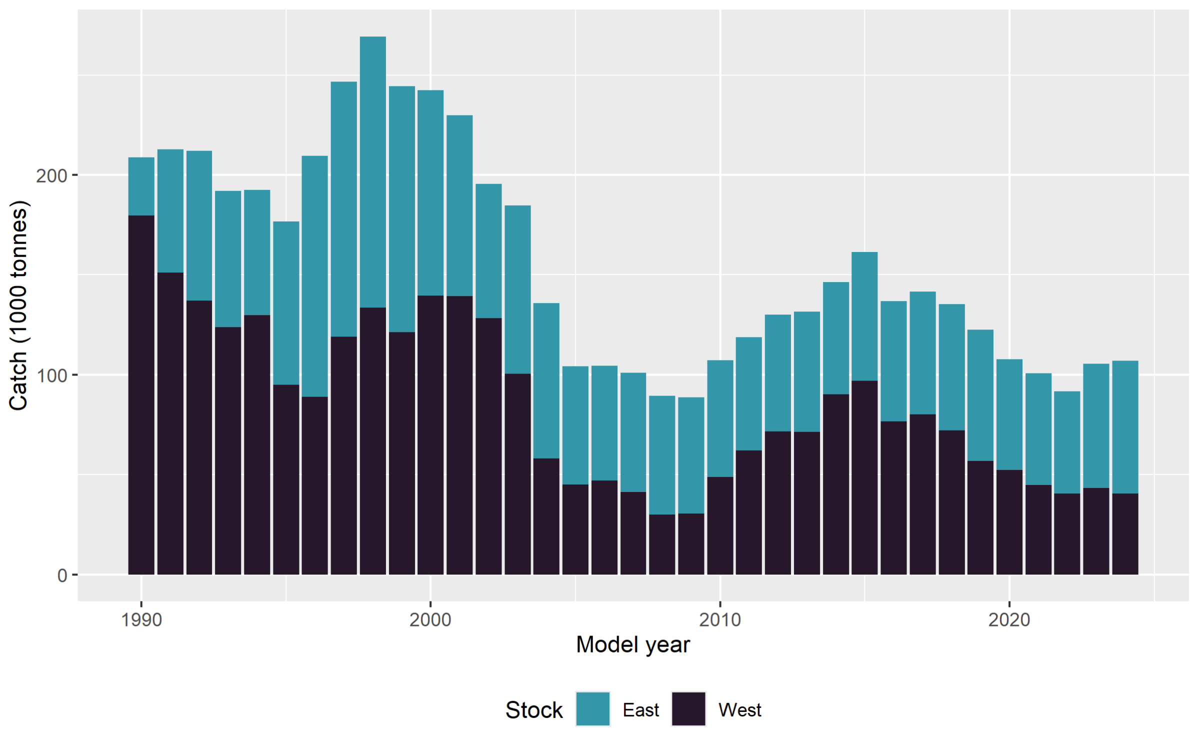


Figure 2b: The eastern and western components of the total HOK 1 landings since 1988–89. Note that these figures do not show data prior to entry into the QMS.

From 2018–19 to 2021–22 there was agreement from industry to close certain fishing grounds to target fishing for hoki to allow spawning to occur undisturbed at peak times (Operational Procedures version 18). Seasonal spawning closures were:

- WCSI inside the 25-nm line: between 0000 h 18 July and 2400 h 24 July.
- WCSI outside the 25-nm closure, shallower than 800 m, between Kahurangi Point in the north and the boundary between FMAs 5 and 7 in the south: between 0000 h 25 July and 2400 h 31 July.
- Cook Strait: Entire fishery between 0000 h 1 August and 2400 h 7 August.

- Pegasus: between 0000 h 1 September and 2400 h 7 September.

In 2022–23 and 2023–24 there were no seasonal spawning area closures.

2023–24 hoki fishery

The overall reported catch of 107 036 t was 1480 t higher than the reported catch in 2022–23, and 2964 t lower than the TACC of 110 000 t (Table 3). Total ACE available to fishers (allowing for voluntary shelving of ~10 000 t and carryforward) was 113 465 t (Table 3). Relative to 2022–23, catches in 2023–24 increased in the Chatham Rise, WCSI, and ECSI and decreased in Cook Strait and Sub-Antarctic.

The WCSI catch increased by 2152 t, to 32 469 t in 2024 (2023–24). Catches from inside the 25-nm line made up 31% of the total WCSI catch in 2024, a decrease in proportion from 34% in 2023, and 10% lower than the peak of 41% of the catch taken from inside-the-line in 2004. From 2011 to 2019, fishing off the WCSI began in May (with most pre-June catch from inside the 25-nm line) and continued into September; but from 2020 to 2024 very little catch was taken in May. Most (76%) of the WCSI catch in 2024 was taken by midwater trawl. Twin trawls accounted for about 27% of the bottom trawl catch and 6% of the WCSI catch overall. Overall unstandardised catch rates decreased slightly from 2023, with a median catch rate in all midwater tows targeting hoki of 4.4 t per hour in 2024.

The WCSI catch in 2024 was dominated by fish from 60 to 110 cm total length (TL) from the 2011 to 2020 year classes (ages 4–13), with a few very small (30–40 cm) fish from the 2023 year-class caught at age 1. Previous comparisons showed that fishing inside the 25-nm line catches a higher proportion of larger fish (greater than 80 cm) than fisheries outside the line; this was seen again in 2024. From 2000 to 2004, the sex ratio of the WCSI catch was highly skewed, with many more females caught than males. In 2005 to 2011, as the catch of younger fish increased, the sex ratio reversed with more males than females caught. Since 2012, the proportion of females has increased again and the sex ratio of the WCSI catch in 2024 was about 63% female. The mean length-at-age for hoki off the WCSI increased from the start of the fishery to the mid-2000s but has since decreased.

The Chatham Rise fishery caught 38 429 t in 2023–24, an increase of 1513 t from 2022–23 and was the largest New Zealand hoki fishery in 2023–24. The Chatham Rise fishery occurs mainly during October to June (98.6% of the catch). Over 99% of the 2023–24 Chatham Rise catch was taken in bottom trawls. Almost none of the Chatham Rise catch is now taken using the Modular Harvest System (MHS) (treated as a separate method to bottom trawls). The CR_deep sub-fishery accounted for 88% of the Chatham Rise catch in 2023–24. The median unstandardised catch rate in bottom trawls targeting hoki in CR_deep was 1.4 t per hour, which was lower than the catch rate in 2022–23. The length frequency distributions in the CR_shallow and CR_deep sub-fisheries for both male and female hoki had modes at 50–90 cm, corresponding to fish from the 2022 to 2018 year classes. The CR_shallow sub-fishery has proportionally more small fish by number, with about 80% of the CR_shallow catch less than 65 cm.

The catch from Cook Strait in 2024 (2023–24) was 11 943 t, a decrease of 1768 t from that in 2023. Peak catches were from mid-July to mid-September. Almost all catch is taken by midwater trawls, with no MHS catch in 2024. Unstandardised catch rates in Cook Strait continued to be high; the median catch rate in midwater tows targeting hoki increased from 12.3 t in 2023 to over 25 t per hour in 2024. A broad size range of hoki was caught in 2024, with the main modes at ages 3–13 (2021 to 2011 year classes). As for the WCSI, the mean length-at-age in the Cook Strait fishery increased until the mid-2000s and has subsequently declined.

The catch from the Sub-Antarctic decreased by 5137 t from 2022–23 to 7753 t in 2023–24. Almost all of the catch was taken in bottom trawls. About half of the catch (48%) was taken in the SA_suba sub-fishery, with 32% from SA_auck and 20% from SA_snares. The median unstandardised catch rate in bottom trawls targeting hoki was 1.6 t per hour in SA_suba in 2023–24, higher than that on the CR_deep, but unstandardised catch rates were lower in SA_snares (at 0.7 t per hour) and SA_auck (1.1 t per hour). The 2023–24 SA_suba sub-fishery observed catch had a broad mode from 70 to 110 cm, corresponding to fish from the 2009–2019 year classes. There was an increased proportion of hoki less than 80 cm from the 2018–2020 year classes in the SA_auck and SA_snares sub-fisheries, and SA_snares also caught fish less than 60 cm from the 2021 and 2022 year-classes.

The catch from the redefined ECSI spawning fishery area in 2024 (2023–24) was 15 508 t, an increase of 4600 t from that in 2023. This made it the third largest hoki fishery in 2023–24. Catches were taken from July to September, with a peak in early September. Two thirds of the catch is taken by bottom trawls. The median catch rate in midwater tows targeting hoki was 7.8 t per hour in 2024, with median 2.8 t per hour taken from bottom tows targeting hoki. A broad size range of hoki from 50 to 110 cm was caught in the ECSI in 2024, but there was a higher proportion of smaller, younger fish taken than in Cook Strait, with the main modes at ages 3–8 (2021 to 2016 year classes).

Catches from Puysegur and from ECNI in 2023–24 both increased slightly from those in in 2022–23, to 227 t and 706 t respectively.

Recent trends in standardised CPUE (McGregor-Tiatia & Ballara in prep) have varied by area but are all at or above the long-term average and have been relatively stable on the Chatham Rise for the last 16 years. The WCSI CPUE were similar in 2023–24 to 2022–23. The Sub-Antarctic Snares and Auckland Islands CPUE were lower in 2023–24. The Cook Strait CPUE was higher in 2023–24, lower in 2022–23, and this series is generally quite variable. CPUE in ECSI increased in 2023–24 and generally increased from 2000.

1.2 Recreational fisheries
Recreational fishing for hoki is negligible.

1.3 Customary non-commercial fisheries
The level of this fishery is believed to be negligible.

1.4 Illegal catch
No information is available about illegal catch, but it is believed to be negligible.

1.5 Other sources of fishing mortality
There are a number of potential sources of additional fishing mortality in the hoki fishery. In the years just prior to the introduction of the EEZ, when large catches were first reported, and following the increases of the TACC in the mid-1980s, it is likely that high catch rates from the west coast South Island spawning fishery resulted in burst bags, loss of catch, and some mortality. Although burst bags were recorded by some scientific observers, the extent of fish loss has not been estimated; however, the occurrence was at a sufficient level to result in the introduction of a code of practice to minimise losses in this way. Based on observer records from the period 2000–01 to 2006–07, Ballara et al (2010) and Anderson et al (2019) found that fish lost from the net during landing accounted for 0–14.5% of the non-retained catch each year in the hoki, hake, and ling fishery.

- The use of escape panels or windows part way along the net (developed to avoid burst bags) may also in itself result in some mortality of fish that pass through the window. It is believed that such devices are not currently used in the fishery.
- The development of the fishery on younger hoki (2 years and over) on the Chatham Rise from the mid-1990s, and the prevalence of small hoki in catches off the WCSI in some years, may have resulted in some unreported mortality of small fish.
- Overseas studies indicate that large proportions of small fish can escape through trawl meshes during commercial fishing and that the mortality of escapees can be high, particularly among species with deciduous scales (scales that shed easily) such as hoki. Selectivity experiments in the 1970s indicated that the 50% selection length for hoki for a 100-mm mesh cod-end is about 57–65 cm total length (Fisher 1978, as reported by Massey & Hore 1987). Research using a twin-rig trawler in June 2007 estimated that the 50% selection length was somewhat lower at 41.5 cm with a selection range (length range between 25% and 75% retention) of 14.3 cm (Haist et al 2007). Applying the estimated retention curve to scaled length frequency data for the Chatham Rise fishery suggested that between 47 t (in 1997–98) and 4287 t (in 1995–96) of hoki may have escaped commercial fishing gear each year. More recent research comparing the

selectivity of 100 mm and MHS cod-ends in June 2017 suggested similar mean 50% selection lengths of about 48–49 cm for both gears, but with the MHS gear having a narrower selection range (11.7 cm compared with 14.8 cm for a 100-mm cod-end) (Millar et al 2023). Net-damaged adult hoki have been recorded in the WCSI fishery in some years indicating that there may be some survival of escapees. The extent of damage and resulting mortality of fish passing through the net is unknown.

These sources of additional fishing mortality are not incorporated in the current stock assessment.

2. BIOLOGY

Hoki are widely distributed throughout New Zealand waters from 34° S to 54° S, from depths of 10 m to over 900 m, with greatest abundance between 200 m and 600 m. Large adult hoki are generally found deeper than 400 m, whereas juveniles are more abundant in shallower water. In the January 2003 Chatham Rise trawl survey, exploratory tows with midwater gear over a hill complex east of the survey area found low density concentrations of hoki in midwater at 650 m over depths of 900 m or greater (Livingston et al 2004). The proportion of larger hoki outside the survey grounds is unknown. Commercial data also indicate that larger hoki have been targeted over other hill complexes outside the survey areas of both the Chatham Rise and Sub-Antarctic (Dunn & Livingston 2004) and have also been caught as bycatch by tuna fishers over very deep water (Bull & Livingston 2000).

The main spawning grounds on the WCSI and in Cook Strait are considered to comprise fish from separate stocks, based on the geographical separation of these spawning grounds and a number of other factors (see Section 3 "Stocks and areas" below). The spawning area off the east coast of the South Island (ECSI) are also considered to comprise hoki from the eastern stock. Catches from the ECSI are comprised of smaller fish than those from the Cook Strait fishery.

Hoki migrate to spawning grounds in Cook Strait, WCSI, Puysegur, and ECSI areas in the winter months. Throughout the rest of the year the adults are dispersed around the edge of the Stewart-Snares shelf, over large areas of the Sub-Antarctic and Chatham Rise, and to a lesser extent around the North Island. Juvenile fish (2–4 y) are found on the Chatham Rise throughout the year.

Hoki spawn from late June to mid-September, releasing multiple batches of eggs. In recent years, spawning has occurred in early June off the WCSI. They have moderately high fecundity with a female of 90 cm TL spawning over 1 million eggs in a season (Schofield & Livingston 1998). Not all hoki within the adult size range spawn in a given year. Winter surveys of both the Chatham Rise and Sub-Antarctic have found notable numbers of large hoki with no gonad development, at times when spawning is occurring in other areas. Histological studies of female hoki from the Sub-Antarctic in May 1992 and 1993 estimated that 67% of hoki aged 7 years and older on the Sub-Antarctic would spawn in winter 1992, and 82% in winter 1993 (Livingston et al 1997). A similar study repeated in April 1998 found that a much lower proportion (40%) of fish aged 7 and older was developing to spawn (Livingston & Bull 2000). Reanalysis of the 1998 data showed that there is a correlation between stratum and oocyte development (Francis 2009). A method developed to estimate proportion spawning from summer samples of post-spawner hoki in the Sub-Antarctic, indicated that approximately 85% of the hoki aged 4 years and older from 2003 and 2004 had spawned (Grimes & O'Driscoll 2006, Parker et al 2009).

The main spawning grounds are centred on the Hokitika Canyon off the WCSI and in Cook Strait Canyon. The planktonic eggs and larvae move inshore by advection or upwelling (Murdoch et al 1990, Murdoch 1992) and are widely dispersed north and south with the result that 0+ and 1-year-old fish can be found in most coastal areas off the South Island and parts of the North Island. The major nursery ground for juvenile hoki aged 2–4 years is along the Chatham Rise, in depths of 200 to 600 m. The older fish disperse to deeper water and are widely distributed in the Sub-Antarctic and on the Chatham Rise. Analyses of trawl survey (1991–2002) and commercial data suggest that a significant proportion of hoki move from the Chatham Rise to the Sub-Antarctic as they approach maturity, with most movement between ages 3 and 7 years (Bull & Livingston 2000, Livingston et al 2002). Based on a comparison of

RV *Tangaroa* trawl survey data, on a proportional basis (assuming equal catchability between areas), 80% or more of hoki aged 1–2 years occur on the Chatham Rise. Between ages 3 and 7, this drops to 60–80%. By age 8, 35% or fewer fish are found on the Chatham Rise compared with 65% or more in the Sub-Antarctic. A study of the observed sex ratios of hoki in the two spawning and two non-spawning fisheries found that in all areas, the proportion of male hoki declines with age (Livingston et al 2000). There is little information at present to determine the season of movement, the exact route followed, or the length of time required, for fish to move from the Chatham Rise to the Sub-Antarctic. Bycatch of hoki from tuna vessels following tuna migrations from the Sub-Antarctic showed a northward shift in the incidence of hoki towards the WCSI in May-June (Bull & Livingston 2000). The capture of net-damaged fish on Pukaki Rise following the WCSI spawning season where there had been intense fishing effort in 1989 also provides circumstantial evidence that hoki migrate from the WCSI back to the Sub-Antarctic post-spawning (Jones 1993).

Growth is fairly rapid with juveniles reaching about 27–35 cm TL at the end of the first year. There is evidence for changing growth rates over time. In the past, hoki reached about 45, 55, and 60–65 cm TL at ages 2, 3, and 4, respectively, but in the mid-2000s length modes were centred at 50, 60, and 70 cm TL for ages 2, 3, and 4. Recently growth has slowed and is intermediate between these two levels. Although smaller spawning fish are taken on the spawning grounds, males appear to mature mainly from 60–65 cm TL after 3–5 years, whereas females mature at 65–70 cm TL. From the age of maturity, the growth of males and females differs. Males grow up to about 115 cm TL, whereas females grow to a maximum of 130 cm TL and up to 7 kg weight. Horn & Sullivan (1996) estimated growth parameters for the two stocks separately (Table 7). McGregor-Tiatia & Langley, (in prep a) re-estimated growth parameters by stock using survey, observer, and market sampling data from 1988–2023. Fish from the eastern stock sampled in Cook Strait are smaller on average at all ages than fish from the WCSI. Maximum age is from 20 to 25 years, and the instantaneous rate of natural mortality in adults is about 0.22 to 0.30 per year.

Ageing error may cause problems in the estimation of year class strength. For example, the 1989 year class appeared as an important component in the catch-at-age data at older ages, yet this year class is believed to have been extremely weak in comparison with the preceding 1988 and 1987 year classes. An improved ageing protocol was developed to increase the consistency of hoki age estimation, and this has been applied to the survey data from 2000 onwards and to catch samples from 2001 (Francis 2001). Data from earlier samples, however, are still based on the original ageing methodology. Estimates of biological parameters relevant to stock assessment are shown in Table 7.

Table 7: Estimates of fixed biological parameters.

Fishstock		**Estimate**	**Source**
1. Natural mortality (M)	Females	Males	
HOK 1	0.25	0.30	Sullivan & Coombs (1989)
2. Weight = a (length)^b (Weight in g, length in cm total length)			
	Both stocks		
	a	b	
HOK 1	0.00479	2.89	Francis (2003)
HOK 1 (both stocks – non spawning)	0.00417	2.92	McGregor-Tiatia & Langley (in prep a)
Spawning			
HOK 1 (Western Stock) (female)	0.00500	2.89	McGregor-Tiatia & Langley (in prep a)
HOK 1 (Western Stock) (male)	0.00526	2.87	McGregor-Tiatia & Langley (in prep a)
HOK 1 (Eastern Stock) (female)	0.00394	2.95	McGregor-Tiatia & Langley (in prep a)
HOK 1 (Eastern Stock) (male)	0.00448	2.92	McGregor-Tiatia & Langley (in prep a)

3. von Bertalanffy growth parameters	Female			Male			
	K	t_0	L_∞	K	t_0	L_∞	
HOK 1 (Western Stock)	0.213	-0.60	104.0	0.261	-0.50	92.6	Horn & Sullivan (1996)
HOK 1 (Eastern Stock)	0.161	-2.18	101.8	0.232	-1.23	89.5	Horn & Sullivan (1996)
HOK 1 (Western Stock)	0.177	-1.71	108.0	0.233	-1.23	96.4	McGregor-Tiatia & Langley (in prep a)
HOK 1 (Eastern Stock)	0.153	-2.62	107.0	0.198	-2.23	93.9	McGregor-Tiatia & Langley (in prep a)

Length-weight conversion parameters were re-estimated by McGregor-Tiatia & Langley (in prep a) giving values for non-spawning (both stocks), spawning (western stock), and spawning (eastern stock) fish by sex (Table 7). Von Bertalanffy growth parameters were also updated to reflect differences in growth rates by stock and sex. Previously defined growth parameters were from Horn & Sullivan (1996) based on observations from the spawning fisheries in 1988–1994 and these were used in the 2025 asssessment due to timing of availability of the new parameters. While the new parameters are an improvement on the Horn & Sullivan (1996) parameters, the working group recommended further work to understand and potentially resolve the effect of differences in observed growth rates of fish on the spawning grounds vs non-spawning grounds. Generally, larger fish for a given age were observed on the spawning grounds.

3. STOCKS AND AREAS

Morphometric and ageing studies have found consistent differences between adult hoki taken from the two main dispersion areas (Chatham Rise and Sub-Antarctic), and from the two main spawning grounds in Cook Strait and WCSI (Livingston et al 1992, Livingston & Schofield 1996b, Horn & Sullivan 1996). These differences demonstrate that there are possibly two sub-populations of hoki. Whether or not they reflect genetic differences between the two sub-populations, or they are just the result of environmental differences between the Chatham Rise and Sub-Antarctic, or of size-based movement between stock areas, is not known. No genetic differences have been detected with selectively neutral markers (Smith et al 1981, 1996), but a low exchange rate between stocks could reduce genetic differentiation. Results of a genetics study indicate that there appears to be little genetic differentiation between hoki within the New Zealand EEZ although differences were detected between New Zealand and Tasmanian hoki (Koot et al 2021).

Two pilot studies appeared to provide support for the hypothesis of spawning stock fidelity for the Cook Strait and WCSI spawning areas. Smith et al (2001) found significant differences in gill raker counts, and Hicks & Gilbert (2002) found significant differences in measurements of otolith rings, between samples of 3-year-old hoki from the 1997 year class caught off the WCSI and in Cook Strait. However, when additional year classes were sampled, differences were not always detected (Hicks et al 2003). If there are differences in the mean number of gill rakers and otolith measurements between stocks, due to high variation, large sample sizes would be needed to statistically detect these (Hicks et al 2003). Francis et al (2011) carried out a pilot study to determine whether analyses of stable isotopes and trace elements in otoliths could be useful in testing stock structure hypotheses and the question of natal fidelity. However, none of the six trace elements or two stable isotopes considered provided evidence of unambiguously differentiated stocks.

The DWWG has assessed the two spawning groups as separate stock units (Figure 3). The west coast of the North Island and South Island and the area south of New Zealand including Puysegur, Stewart-Snares shelf, and the Sub-Antarctic has been taken as one stock unit (the ‘western stock’). The area of the ECSI, Mernoo Bank, Chatham Rise, Cook Strait, and the ECNI up to North Cape has been taken as the other stock unit (the ‘eastern stock’). The two stocks are assumed to mix as juveniles on Chatham Rise.

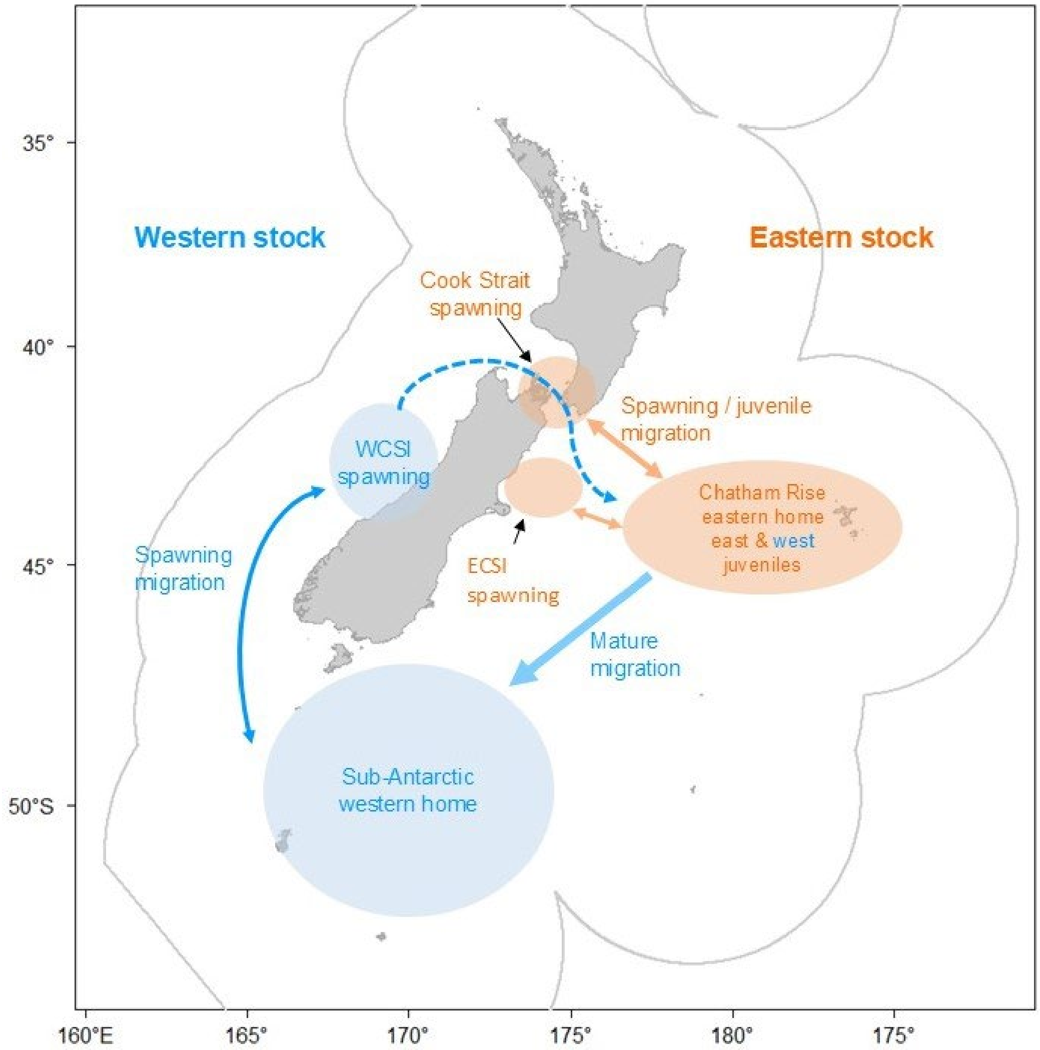


Figure 3: Hoki juvenile nurseries, spawning grounds, and assumed migration routes for the eastern and western stocks.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

The figures and tables in this section were updated and additional text included for the May 2025 Fishery Assessment Plenary. This summary is from the perspective of the hoki fishery; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (Aquatic environment and biodiversity annual review (AEBAR) | NZ Government (mpi.govt.nz)).

4.1 Role in the ecosystem

Hoki is the species with the highest biomass in the bottom fish community of the upper slope (200–800 m), particularly around the South Island (Francis et al 2002) and is considered to be a key biological component of the upper slope ecosystem. Understanding the predator-prey relationships between hoki and other species in the slope community is important, particularly because substantial changes in the biomass of hoki have taken place since the fishery began (Horn & Dunn 2010). Other metrics such as ecosystem indicators may also provide insight into fishery interactions with target and non-target fish populations (e.g., Tuck et al 2014). For example, changes in growth rate can be indicative of density-dependent compensatory mechanisms in response to changes in population density.

4.1.1 Trophic interactions

On the Chatham Rise, hoki is a benthopelagic and mesopelagic forager preying primarily on lantern fishes and other midwater fishes and natant decapods with little seasonal variation (Clark 1985a, b, Dunn et al 2009a, Connell et al 2010, Stevens et al 2011). Hoki show ontogenetic shifts in their feeding preferences. Larger hoki (over 80 cm) consume proportionately more fish and squid than smaller hoki (Dunn et al 2009a, Connell et al 2010). The diet of hoki overlaps with that of alfonsino, arrow squid, hake, javelinfish, Ray's bream, and shovelnose dogfish (Dunn et al 2009a). Hoki are prey to several piscivores, particularly hake but also stargazers, smooth skates, several deepwater shark species, and ling (Dunn et al 2009a). The proportion of hoki in the diet of hake averages 38% by weight and declined from 1992 to 2008, possibly because of a decline in the relative abundance of hoki on the Chatham Rise between 1991 and 2007 (Dunn & Horn 2010). There is little information about the size of hoki eaten by predators (i.e., specifically whether the hoki are large enough to have recruited to the fishery or not), but this could be an important factor in understanding the interaction with the fishery.

Hoki are a key prey species of New Zealand fur seals off the west coast South Island and New Zealand sea lions at the Auckland Islands (Boren 2010; Meynier et al 2009). Roberts et al (2022) found that some of the demographic rates of New Zealand sea lions at the Auckland Islands, including annual pup survivorship, were correlated with an index of the local availability of hoki based on trawl survey data from 300–500m depth, although noted that this was based on a relatively small number of trawl stations each survey year.

4.1.2 Ecosystem Indicators

Tuck et al (2009) used data from the Sub-Antarctic and Chatham Rise trawl survey series to derive fish-based ecosystem indicators using diversity, fish size, and trophic level. Species-based indicators appeared the most useful in identifying changes in the marine ecosystem correlated with fishing intensity; Pielou's evenness appears the most consistent, but the Shannon-Wiener index, species richness, and Hill's N1 and N2 also showed some promise (Tuck et al 2009). Trends in diversity in relation to fishing are not necessarily downward and depend on the nature of the community. Size-based indicators did not appear as useful for New Zealand trawl survey series as they have been overseas, and this may be related to the requirement to consider only measured species. In New Zealand, routine measurement of all fish species in trawl surveys was implemented in 2008 and this may increase the utility of size-based indicators in the future.

Between 1992 and 1999 the growth rates of all year classes of hoki increased by 10% in all four fishery areas, but it is unclear whether this was a result of reduced competition for food within and among cohorts or some other factor (Bull & Livingston 2000). The abundance of mesopelagic fish, a major prey item for hoki, has the potential to be an indicator of food availability. Recent research using acoustic backscatter data collected during trawl surveys has shown no clear temporal trend in mesopelagic fish biomass on the Chatham Rise between 2001 and 2009, but a decline in the Sub-Antarctic area from 2001 to 2007, followed by an increase in 2008 and 2009. The abundance of mesopelagic fish is consistently much higher on the Chatham Rise than in the Sub-Antarctic, with highest densities observed on the western Chatham Rise and lowest densities on the eastern Campbell Plateau (O'Driscoll et al 2011a). Spatial patterns in mesopelagic fish abundance closely matched the distribution of hoki. O'Driscoll et al (2011a) hypothesise that prey availability influences hoki distribution, but that hoki abundance is being driven by other factors such as recruitment variability and fishing. There was no evidence for a link between hoki condition and mesopelagic prey abundance and there were no obvious correlations between mesopelagic fish abundance and environmental indices.

4.2 Non-target fish and invertebrate catch

Non-target fish and invertebrate catch and discards were examined for the hoki, hake, ling, silver warehou, and white warehou trawl fisheries from 2002–03 to 2021–22 (Finucci et al 2024). Hoki accounted for about 73% of the total estimated catch from the observed tows in the target fisheries since 2002–03. The remainder of the observed catch comprised ling (5.9%), hake (5.7%), silver warehou (3.9%), javelinfish (2.0%), unspecified rattails (1.6%), spiny dogfish (1.5%), and white warehou (1.1%), plus a range of other (mainly non-QMS) species including various species of sharks, skates and dogfishes, rattails, and other bony fishes. Arrow squid was the ninth most common non-target species by weight (0.5% of the catch) and the only invertebrate in the top 30 non-target taxa. Other invertebrate groups frequently observed included warty squid and a range of sponges, echinoderms, crustaceans, and molluscs.

Total estimated annual non-target catch ranged from about 15 000 to 30 000 t in the five years since the last assessment (Anderson et al 2019) and was considerably lower in the most recent years (from 2019–20), most likely reflective of reduced fishing effort during the COVID pandemic. Non-target catch during this period comprised lower levels of QMS species (6800–12 200 t) than non-QMS fish species (9200–17 500 t). Estimated total annual discards since 2016–17 have ranged from 2700 to 7300 t and were mainly non-QMS fish species. Discarding of target species (hoki, hake, ling, silver warehou, white warehou) was generally low but highly variable, ranging from 11 t to about 2650 t, with no more than 100 t reported annually since 2016–17. Discards of QMS species and non-QMS fish species followed a similar pattern to that of non-target catch (for the years in common) and have declined over time. Discards of non-QMS species, and total discarding declined significantly over the 20-year period. Of the non-target catch species/species groups examined, one species (gemfish) showed a significant increasing trend in non-target catch over time (consistent with increased abundance), and two species groups (sharks and slickheads) showed significant decreasing trends over time. The annual discards ratio (kilogram of discards/kilogram of target species catch) was highest in early years of the time period (between 0.07 and 0.12), peaking in 2008–09 at 0.17 and has declined since to estimates generally between 0.03 and 0.05. The hoki, hake, ling, silver warehou, and white warehou fishery is complex, and changes in fishing practice are likely to have contributed to variability between years (Ballara & O'Driscoll 2015b).

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

For protected species, capture estimates presented here include all animals recovered to the deck (alive, injured, or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp but not brought on board the vessel, Middleton & Abraham 2007).

4.3.1 Marine mammal captures

New Zealand fur seal captures

The New Zealand fur seal was classified in 2008 as 'Least Concern' by the International Union for Conservation of Nature (IUCN) and in 2010 as 'Not Threatened' under the New Zealand Threat Classification System (Lunquist et al 2025). The marine mammal risk assessment undertaken by Fisheries New Zealand estimated the New Zealand fur seal to be the second most impacted species from commercial fisheries with annual captures of 1024 (949 – 1105 95% credible interval) (MacKenzie et al 2022).

Vessels targeting hoki incidentally catch fur seals (Thompson & Abraham 2010a, Baird 2011, Abraham et al 2016 & 2021, Abraham & Richard 2019, MacKenzie et al 2022). Capture rates have fluctauted but remained relatively stable since 2009–10 with the main driver behind a decrease in total estimated captures being a reduction in effort (Table 8). Observed captures have occurred mostly off the west coast South Island and in the Cook Strait. Estimated captures of New Zealand fur seals in the hoki fishery have accounted for approximately 39% of all fur seals estimated to have been caught by trawling in the EEZ between 2002–03 and 2022–23 for those fisheries modelled.

New Zealand sea lion captures

The New Zealand (or Hooker's) sea lion was classified in 2008 as 'Vulnerable' by IUCN and in 2019 as 'Nationally Vulnerable' under the New Zealand Threat Classification System (Baker et al 2019) (having formerly been classed 'Nationally Critical' by Baker et al 2016). This species has been recently reclassified from 'Nationally Vulnerable' to 'Threatened – Nationally Endangered' (Lundquist et al 2025). There are contrasting pup production trends at different breeding colonies. Pup production declined at the main colonies on the Auckland Islands from a peak in 1999 to a low in 2009 and appear to have stabilised thereafter. At Campbell Islands, pup production increased rapidly from low numbers in the early 1990s and appear to have plateaued since around 2010. Newly established breeding populations on Stewart Island and the New Zealand mainland appear to be rapidly increasing. The total species' population size was estimated to be slightly less than was estimated for 2015, although with high uncertainty. However, this did not use a full update to the mark-recapture data, which are the most informative data for the estimation of survivorship and breeding rates (Roberts & Edwards, 2023).

Table 8: Number of tows by fishing year and observed and estimated New Zealand fur seal captures in hoki trawl fisheries. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Estimates are based on methods described by Abraham & Richard (2020).

Fishing	Fishing effort			Observed captures		Estimated captures	
year	Tows	Observed tows	% observed	Number	Rate	Mean	95% c.i.
2002–03	27 787	2 593	9.3	45	1.74	840	683–1 029
2003–04	22 521	2 342	10.4	56	2.39	751	607–924
2004–05	14 541	2 134	14.7	120	5.62	511	420–617
2005–06	11 590	1 775	15.3	62	3.49	346	273–434
2006–07	10 603	1 755	16.6	29	1.65	266	203–345
2007–08	8 786	1 876	21.4	58	3.09	239	186–303
2008–09	8 176	1 661	20.3	37	2.23	199	148–263
2009–10	9 965	2 066	20.7	30	1.45	193	142–254
2010–11	10 405	1 724	16.6	24	1.39	186	136–246
2011–12	11 332	2 579	22.8	33	1.28	181	136–235
2012–13	11 696	4 516	38.6	60	1.33	185	143–234
2013–14	12 945	3 974	30.7	32	0.81	164	123–216
2014–15	13 593	3 611	26.6	42	1.16	177	134–228
2015–16	12 637	3 469	27.5	42	1.21	170	129–222
2016–17	12 951	2 908	22.5	37	1.27	163	123–210
2017–18	13 781	4 766	34.6	41	0.86	186	139–245
2018–19	12 042	3 463	28.8	21	0.61	193	138–266
2019–20	9 510	3 892	40.9	21	0.54	116	79–163
2020–21	8 754	3 701	42.3	27	0.73	106	73–148
2021–22	9 143	3 851	42.1	64	1.66	129	102–165
2022–23	9 921	3 882	39.1	37	0.95	120	85–169

New Zealand sea lions are rarely captured by vessels trawling for hoki; since 2002–03 there have been three observed captures during fishing seasons with 9–41% of observer coverage (Abraham et al 2016), and all were near the Auckland Islands. The spatial overlap of the fisheries with the foraging distribution of sea lions is low, and observer coverage in these fisheries has been high. The spatial risk assessment model of Large et al (2019) estimated very low capture rates (median 0 per year) of sea lions, with high certainty (upper 95% CI = 1).

Common dolphin captures

Three common dolphins have been observed captured in the hoki trawl fishery since 2002–03 .

4.3.2 Seabird captures

Vessels targeting hoki incidentally catch seabirds. Capture rates for seabirds are estimated using a hierarchical mixed-effects generalised linear model (GLM), (Abraham et al 2016, Abraham & Richard 2017, 2018, 2020) and a multi-species seabird risk assessment model applying the SEFRA (spatially explicit fisheries risk assessment) framework is used (Edwards et al 2023). The SEFRA allows Fisheries New Zealand to estimate fisheries impacts across all commercial fisheries for all seabird species and relate the cumulative fisheries impact to an impact threshold that reflects the ability of the species to sustain impacts while still achieving a defined population recovery or stabilisation outcome (in the absence of other anthroprogenic threats including from fisheries outside the New Zealand EEZ).

Annual observed seabird capture rates have ranged between 1.3 and 4 per 100 tows in the hoki fishery over the time period 2002–03 to 2022–23, with little apparent trend (Table 9). These figures represent summed totals across all seabird species and all methods of capture. To determine changes for particular species of interest or within particular subsets of the hoki fishery, more detailed analysis will be required.

Observed seabird captures in hoki fisheries since 2002–03 have been dominated by six species: Salvin's, southern Buller's, and New Zealand white-capped albatrosses make up 45%, 27%, and 22% of the albatrosses captured, respectively; and sooty shearwaters, white-chinned petrels, and cape petrels make up 58%, 23%, and 6% of other birds, respectively (Table 10). The highest proportions of captures have been observed off the east coast of the South Island (50%), on the Stewart-Snares shelf (20%), on the

Chatham Rise (11%), and off the west coast of the South Island (9%). In the 2022–23 fishing year, there were 116 observed captures of all birds in hoki trawl fisheries. Observed captures were of white-chinned petrel (23), Salvin's albatross (22), southern Buller's albatross (17), sooty shearwater (17), New Zealand white-capped albatross (13), Westland petrel (6), short-tailed shearwater (5), grey petrel (3), Cape petrel (3), mottled petrel (2), fairy prion (2), petrels, prions, and shearwaters (1), northern royal albatross (1), and Campbell black-browed albatross (1). It was estimated by a statistical model that there were a total of 294 (95% c.i.: 251–342) captures in hoki trawl fisheries. These numbers should be regarded as only a general guide on the distribution of captures because observer coverage is not uniform across areas and may not be representative. The spatial risk assessment is designed to correct for potential bias arising from spatially non-representative data. The seabird risk assessment approach identifies twenty seabird species with a risk above negligible from commercial fisheries in New Zealand (Edwards et al 2023). The large freezer fishery group (for which hoki target fishery makes up a significant component but does not represent all hoki target fisheries) contibutes towards the cumulative commercial fisheries risk score (see Table 10). The two species for which the hoki fisheries are responsible for the highest risk are southern Buller’s albatross (large freezer fishery mean risk score 0.351, i.e., 29% of the cumulative species risk score 1.19) and Salvin’s albatross (large freezer fishery mean risk score 0.217, i.e., 31% of the cumulative species risk score 0.69). For southern Buller’s albatross threats from commercial fisheries alone in New Zealand were considered large enough to have an impact on the population’s long term sustainability, the large freezer (comprised off larger offshore vessels with a meal plant and/or freezer) fisheries group was responsible for about a third of this risk (Edwards et al 2023).

Table 9: Number of tows by fishing year and observed and estimated New Zealand seabird captures in hoki trawl fisheries. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Estimates are based on methods described by Abraham & Richard (2020).

Fishing	Fishing effort			Observed captures		Estimated captures	
year	Tows	Observed tows	% observed	Number	Rate	Mean	95% c.i.
2002–03	27 787	2 593	9.3	82	3.16	781	668–908
2003–04	22 521	2 342	10.4	32	1.37	521	438–614
2004–05	14 541	2 134	14.7	43	2.01	356	294–430
2005–06	11 590	1 775	15.3	53	2.99	338	273–414
2006–07	10 603	1 755	16.6	23	1.31	309	242–391
2007–08	8 786	1 876	21.4	28	1.49	226	175–288
2008–09	8 176	1 661	20.3	37	2.23	260	202–328
2009–10	9 965	2 066	20.7	53	2.57	341	273–421
2010–11	10 405	1 724	16.6	54	3.13	318	262–386
2011–12	11 332	2 579	22.8	58	2.25	366	299–446
2012–13	11 696	4 516	38.6	100	2.21	328	272–395
2013–14	12 945	3 974	30.7	157	3.95	442	378–512
2014–15	13 593	3 611	26.6	82	2.27	434	364–514
2015–16	12 637	3 469	27.5	48	1.38	308	251–373
2016–17	12 951	2 908	22.5	59	2.03	359	300–429
2017–18	13 781	4 766	34.6	142	2.98	389	335–448
2018–19	12 042	3 463	28.8	80	2.31	301	254–355
2019–20	9 510	3 892	40.9	125	3.21	267	230–310
2020–21	8 754	3 701	42.3	123	3.32	254	219–294
2021–22	9 143	3 851	42.1	115	2.99	256	219–298
2022–23	9 921	3 882	39.1	116	2.99	294	251–342

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

To understand changing fisheries risk over time as affected by changes in mitigation uptake, vessel behaviour, or gear configuration, it will be necessary to disaggregate the seabird risk assessment to examine trends for subsets of the fishery and species of interest. Of particular relevance, the seabird risk assessment includes estimates of cryptic mortality (i.e., deaths that are not counted among observable captures) whereas the captures estimation does not. In trawl fisheries, it is thought that for every observed seabird capture on a trawl warp, there may be several additional cryptic deaths (due to bird carcasses falling off the warps unobserved), but the true multiplier is uncertain. In contrast, seabird captures in the net have a much lower cryptic mortality multiplier, and some birds are released alive.

For this reason, even a relatively constant total capture rate (as in Table 9) may conceal substantial changes in total deaths and population level risk at the species level, if the ratio of net captures to warp captures has changed in this period.

Table 10: Outputs of the New Zealand seabird risk assessment for all at-risk seabirds. Risk ratios are shown for the hoki fishery in isolation and cumulatively for all commercial fisheries. The risk ratio is an estimate of annual fishery related deaths as a proportion of the Population Sustainability Threshold, PST (see Richard et al 2017, 2020). The Department of Conservation threat classifications are also given (Robertson et al 2017 at http://www.doc.govt.nz/documents/science-and-technical/nztcs19entire.pdf).

		Risk ratio			
Species name	**PST(mean)**	**Large Freezer***	**TOTAL**	**Risk category**	**DOC Threat Classification**
Southern Buller's albatross	613	0.351	1.19	Very High	At Risk: Naturally Uncommon
Salvin's albatross	2 551	0.217	0.69	High	Threatened: Nationally Critical
NZ white-capped albatross	5 367	0.054	0.50	High	At Risk: Declining
Black petrel	521	0.000	0.49	High	Threatened: Nationally Vulnerable
Westland petrel	392	0.033	0.38	High	At Risk: Naturally Uncommon
Chatham Island albatross	225	0.018	0.27	Medium	At Risk: Naturally Uncommon
Flesh-footed shearwater	1 691	0.001	0.22	Medium	Threatened: Nationally Vulnerable
Northern Buller's albatross	889	0.034	0.19	Medium	At Risk: Naturally Uncommon
Gibson’s albatross	256	0.00	0.16	Medium	Threatened: Nationally Critical
Antipodean albatross	241	0.00	0.16	Medium	Threatened: Nationally Critical
White-chinned petrel	18 098	0.011	0.09	Low	Not threatened
Southern royal albatross	595	0.010	0.08	Low	Threatened: Nationally Vulnerable
Northern giant petrel	189	0.042	0.08	Low	At risk: Recovering
Campbell black-browed albatross	1 211	0.012	0.05	Low	At Risk: Naturally Uncommon
Spotted shag	5 692	0.00	0.04	Low	Threatened: Nationally Vulnerable
Northern royal albatross	270	0.00	0.04	Low	Threatened: Nationally Vulnerable
Light-mantled sooty albatross	378	0.00	0.03	Low	Threatened: Nationally Vulnerable
Grey-headed albatross	311	0.00	0.03	Low	Threatened: Nationally Vulnerable
Snare’s cape petrel	1 142	<0.001	0.02	Low	At Risk: Naturally Uncommon
King shag	29	0.00	0.01	Low	Threatened: Nationally Endangered

*Risk ratio Large Freezer comes from Edwards et al (2023).

4.3.3 Protected fish species captures

Basking shark

The basking shark (*Cetorhinus maximus*) was classified as ‘Endangered’ by IUCN in 2013, as ‘Threatened – Nationally Vulnerable’ in 2016, under the New Zealand Threat Classification System (Duffy et al 2018) and as ‘Vulnerable’ in the New Zealand-specific IUCN assessment in 2019 (Finucci et al 2019). Basking shark has been a protected species in New Zealand since 2010, under the Wildlife Act 1953 and is also listed in Appendix II of the CITES convention.

Basking sharks are caught occasionally in hoki trawls (Francis & Duffy 2002, Francis & Smith 2010, Ballara et al 2010, Finucci et al 2022) (Table 11). Capture rates from observer data showed that the highest rates and catches occurred in 1989 off the WCSI and in 1987–92 off the ECSI. Smaller peaks in both areas were observed in the late 1990s and early 2000s, but captures have been few since then (Table 11).

Research to improve the understanding of the interactions between basking sharks and fisheries was reported by Francis & Sutton (2012), Francis (2017) and Finucci et al (2022). Most basking sharks have been captured in spring and summer, nearly all have come from FMAs 3, 5, 6, and 7, and most are large mature males (Finucci et al 2022). It is not known whether the low numbers of captures more recently are a result of different operational methods used by the fleet, a change in regional availability of sharks, a decline in basking shark abundance or a combination of these (Francis 2017). Of a range of fisheries and environmental factors considered, vessel nationality stood out as a key factor in high catches in the late 1980s and early 1990s (Francis & Sutton 2012). Basking shark captures in Sub-Antarctic trawl fisheries from 2008 to 2021 were associated with relatively strong ocean currents (Finucci et al 2022). A New Zealand fisheries risk assessment for chondrichthyans identified basking shark as having a low (but non-negligible) risk from fishing (Edwards et al 2025).

Table 11: Total number of tows, number and percentage of observed tows, and number of observed (1988–89 to 2022–23) and fisher-reported (since 2010 –11 when protection began; in parentheses) basking shark captures in the hoki target trawl fishery, extracted from the Centralised Observer Database and Enterprise Data Warehouse. Observed trawls used bottom trawl (BT) and midwater trawl (MW) fishing methods while fisher-reporting also incudes one capture in Precision Bottom Trawl (PRB). Note that duplicate records have not been removed here (i.e., the same interaction may have been recorded by both an observer and fisher).

Fishing year	Tows	No. observed	% observed	No. observed captures	Fishing year	Tows	No. observed	% observed	No. observed captures (fisher reported)
1988–89	8 341	2 213	26.5	10	2006–07	10 603	1 755	16.6	0
1989–90	15 656	2 246	14.3	0	2007–08	8 786	1 876	21.4	0
1990–91	21 859	2 495	11.4	4	2008–09	8 176	1 661	20.3	0
1991–92	21 873	2 246	10.3	2	2009–10	9 965	2 066	20.7	0
1992–93	22 583	2 311	10.2	0	2010–11	10 405	1 724	16.6	0 (2)
1993–94	21 704	2 959	13.6	3	2011–12	11 332	2 579	22.8	0 (0)
1994–95	26 141	1 550	5.9	2	2012–13	11 696	4 516	38.6	0 (2)
1995–96	31 886	2 148	6.7	2	2013–14	12 945	3 974	30.7	3 (4)
1996–97	37 263	1 241	3.3	2	2014–15	13 593	3 611	26.6	0 (1)
1997–98	38 406	3 159	8.2	14	2015–16	12 637	3 469	27.5	0 (4)
1998–99	32 324	3 560	11.0	7	2016–17	12 951	2 908	22.5	0 (2)
1999–00	33 070	4 844	14.6	3	2017–18	13 781	4 766	34.6	0 (0)
2000–01	32 073	5 716	17.8	4	2018–19	12 042	3 463	28.8	1 (1)
2001–02	27 234	6 333	23.3	1	2019–20	9 510	3 892	40.9	1 (2)
2002–03	27 787	2 593	9.3	0	2020–21	8 754	3 701	42.3	0 (1)
2003–04	22 521	2 342	10.4	0	2021–22	9 143	3 851	42.1	1 (1)
2004–05	14 541	2 134	14.7	0	2022–23	9 921	3 882	39.1	0 (1)
2005–06	11 590	1 775	15.3	0					

4.4 Benthic interactions

The spatial extent of seabed contact by trawl fishing gear in New Zealand's EEZ and Territorial Sea has been estimated and mapped in numerous studies for trawl fisheries targeting deepwater species (Baird et al 2011, Black et al 2013, Black & Tilney 2015, Black & Tilney 2017, Baird & Wood 2018, and Baird & Mules 2019, 2021a, 2021b), species in waters shallower than 250 m (Baird et al 2015, Baird & Mules 2021a, 2021b), and all trawl fisheries combined (Baird & Mules 2021a, 2021b, MacGibbon & Mules 2023, MacGibbon et al 2024). The most recent estimates of the deepwater trawl footprint was for the period 1989–90 to 2023–24 and was completed using a combination of fisher reported and Geospatial Position Reporting (GPR) data by MPI.

The only target method of capture in the hoki fishery is trawling using either bottom (demersal) or midwater gear. Baird & Wood (2012) estimated that trawling for hoki accounted for 20–40% of all tows on or near the sea floor reported on TCEPR forms 1989–90 to 2005–06, and Black et al (2013) estimated that hoki trawling has accounted for 30% of all tows reported on TCEPR forms between 1989–90 and 2009–10. Between 2006–07 and 2010–11, 93% of hoki catch was reported on TCEPR forms. In the early years of the hoki fishery, vessels predominantly used midwater trawls because most of the catch was taken from spawning aggregations off the WCSI. Outside the spawning season, bottom trawl gear is used on the Chatham Rise and Sub-Antarctic fishing grounds (Table 12). Twin trawls were used to catch almost half of the TACC in some years. This gear is substantially wider than single trawl gear and catches more fish per tow than single trawl gear. The relationship between total catch and bottom impact of twin trawls has, however, not been analysed. As year-round fishing increased, vessels increased fishing effort on the Chatham Rise and in the Sub-Antarctic, and the bottom trawl effort increased to a peak between 1997–98 and 2003–04. Effort has declined substantially in all areas since 2005–06, largely as a result of TACC reductions but has increased again with increases in TACCs. Midwater trawling peaked in 1995–96 to 1996–97 in Cook Strait and on the Chatham Rise 1996–97 to 1997–98 but declined in all areas from 1997–98. Overall, midwater trawling has declined by about 90% since the peak in 1997 and bottom trawling by about 70% since the peak in 2000 (Table 12).

During 1989–90 to 2023–24, about 471 000 bottom-contacting hoki trawls were reported on TCEPRs, TCERs, and ERS. The total footprint generated from these tows was estimated at about 166 595 km^2. This footprint represented coverage of 4.1% of the seafloor of the combined EEZ and the Territorial Sea areas and 12% of the 'fishable area', that is, the seafloor area open to trawling, in depths of less than 1600 m. In the 2023–24 fishing year, almost 8500 hoki tows resulted in a trawl footprint of 21 459 km^2, equivalent to 0.5% of the EEZ and Territorial Sea and 1.5 % of the fishable area. The annual estimated footprint of the hoki fishery peaked in 2002–03 at 51 500 km^2 (estimated using fisher reported data only) and since has reduced substantially. Estimates for the last five fishing years have been relatively stable, fluctuating between a low of 19 510 km^2 in 2019–20 and a high of 22 126 km^2 in 2022–23 (all estimated using combination of fisher reported and GPR data).

The overall trawl footprint for hoki (1989–90 to 2020–21) covered 19% of the seafloor in 200–400 m, 28% of 400–600 m seafloor, and 28% of the 600–800 m seafloor (MacGibbon & Mules 2023). The hoki footprint contacted 0.5%, 6%, and 3% of those depth ranges in 2023-24, respectively.

Bottom trawling for hoki, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) and there may be consequences for benthic productivity (e.g., Jennings et al 2001, Hermsen et al 2003, Hiddink et al 2006, Reiss et al 2009). These are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021).

Table 12: Summary of number of hoki target trawl tows (TCEPR and ERS-trawl only) in the hoki fishery from fishing years (FY) 1989–90 to present. (MW, midwater trawl; BT, bottom trawl).

Fishery Season	WCSI/ Puysegur Spawning		Cook Strait/ ECSI Spawning		Sub-Antarctic Non-spawn		Chatham Rise/ECSI Non-spawn		All areas combined		%
Method	**MW**	**BT**	**MW**	**BT**	**MW**	**BT**	**MW**	**BT**	**MW**	**BT**	**BT**
FY											
1989–90	7 849	1 184	1 077	150	36	2 109	39	1 902	9 001	5 345	37
1990–91	7 340	1 552	2 245	138	81	3 927	938	3 380	10 604	8 997	46
1991–92	5 608	1 403	1 788	206	117	5 442	427	5 363	7 940	12 414	61
1992–93	5 465	1 766	1 634	73	442	4 915	1 005	5 209	8 546	11 963	58
1993–94	8 011	1 603	1 932	250	562	2 039	1 268	3 352	11 773	7 244	38
1994–95	7 219	1 482	2 054	780	419	2 329	2 148	5 738	11 840	10 329	47
1995–96	5 698	1 987	3 290	1 965	415	2 506	2 225	7 387	11 628	13 845	54
1996–97	7 568	1 854	3 643	1 951	337	3 423	2 269	8 703	13 817	15 931	54
1997–98	6 978	1 514	2 466	1 255	165	4 376	3 716	10 902	13 325	18 047	58
1998–99	5 472	2 093	2 099	795	420	3 659	2 362	11 230	10 353	17 777	63
1999–00	5 468	2 250	1 999	642	516	5 943	2 651	9 222	10 634	18 057	63
2000–01	6 228	2 496	1 977	539	667	5 448	904	9 498	9 776	17 981	65
2001–02	4 988	3 059	1 140	555	132	6 449	854	7 438	7 114	17 501	71
2002–03	4 613	2 909	2 150	750	96	4 407	463	8 810	7 322	16 876	70
2003–04	4 274	1 877	1 855	952	78	3 023	342	6 345	6 549	12 197	65
2004–05	2 534	1 308	1 465	348	68	1 428	332	4 759	4 399	7 843	64
2005–06	1 783	1 504	1 020	216	74	719	140	4 655	3 017	7 094	70
2006–07	1 147	752	919	356	25	1 194	57	4 495	2 148	6 797	76
2007–08	813	492	394	738	36	925	74	3 851	1 317	6 006	82
2008–09	689	354	747	368	38	927	11	3 694	1 485	5 343	78
2009–10	1 181	612	797	207	56	1 251	118	4 231	2 152	6 301	75
2010–11	1 507	913	544	129	62	1 245	52	4 009	2 165	6 296	74
2011–12	1 573	1 185	842	238	70	1 202	68	4 240	2 553	6 865	73
2012–13	1 819	1 001	1 033	266	6	1 373	158	4 007	3 016	6 647	69
2013–14	2 318	1 092	1 016	162	12	1 872	127	3 884	3 473	7 010	67
2014–15	2 716	1 225	975	105	89	1 620	193	4 267	3 973	7 217	64
2015–16	2 696	1 510	842	143	10	834	82	4 016	3 630	6 503	64
2016–17	2 361	1 894	730	201	24	1 278	98	4 092	3 213	7 465	70
2017–18	2 103	2 025	842	102	81	1 728	57	3 574	3 083	7 429	71
2018–19	2 956	961	1 324	279	12	830	64	2 534	4 356	4 604	51
2019–20	2 553	711	985	375	5	692	22	2 450	3 565	4 228	54
2020–21	1 764	647	737	487	2	927	72	3 121	2 575	5 182	67
2021–22	1 837	895	708	570	8	758	48	3 173	2 601	5 396	67
2022–23	1 744	542	856	782	14	1 173	60	4 009	2 674	6 506	71
2023–24	1 864	608	850	791	4	752	27	4 828	2 745	6 979	72

Note: Spawning fisheries include WCSI (Jun–Sep), Cook Strait (Jun–Sep), Puysegur (Jul–Dec), ECSI (Jul–Sep). Non-spawning fisheries include ECSI (Oct–Jun), Chatham Rise (Oct-Sep), Sub-Antarctic (Oct-Sep). TCER, CELR, and North Island tows are excluded.

4.5 Other factors

4.5.1 Spawning disruption

Fishing during spawning may disrupt spawning activity or success. Although there has been no research on the disruption of spawning hoki by fishing in New Zealand, the hoki quota owners voluntarily ceased fishing some defined spawning grounds for certain periods on the WCSI, Pegasus Canyon (ECSI), and Cook Strait as a precautionary measure from the 2004 to 2009 spawning seasons with the intention of assisting stock rebuilding. This closure was lifted in the 2010 spawning season because the biomass of the western stock was estimated to have rebuilt to within the management target range, but seasonal spawning closures were reintroduced from 2018–19 to 2021–22 (see Section 1).

4.5.2 Habitat of particular significance to fisheries management

Fisheries New Zealand have developed guidelines on the identification of habitats of particular significance for fisheries management (Habitats of particular significance for fisheries management | NZ Government), and is in the process of reviewing available evidence for the development of an online register of habitats. Studies of potential relevance have identified areas of importance for spawning and juveniles (O'Driscoll et al 2003). Areas on Puysegur Bank, Canterbury Bight, Mernoo Bank, and Cook Strait have been subject to non-regulatory measures to reduce fishing mortality on juvenile hoki (Deepwater Group 2011).

5. RECRUITMENT, ENVIRONMENTAL VARIABILITY, AND CLIMATE CHANGE

This section was last updated in May 2024.

Recruitment dynamics are challenging to assess or predict because of the many underlying drivers that vary over time and space. Stock size, demographic and trait composition, condition and distribution of spawning fish, and the spatio-temporal dynamics of trophic and environmental interactions all influence recruitment processes. Annual variations in hoki recruitment have considerable impact on this fishery and a better understanding of the influence of environmental variables on recruitment patterns would be very useful for the future projection of stock size under different climate change scenarios and different environmental conditions.

New Zealand waters are becoming warmer and more acidic due to the emission of anthropogenic carbon dioxide (Law et al 2018a, Law et al 2018b) and, as in other parts of the world, some fish distributions will be or already are changing. The link between climate, oceanographic conditions, and hoki recruitment is still not well understood. Analyses by Francis et al (2006) do not support conclusions drawn by Bull & Livingston (2001) that model estimates of recruitment to the western stock are strongly correlated with the southern oscillation index (SOI). Francis et al (2006) noted that there is a correlation of -0.70 between the autumn SOI and annual estimates of recruitment (1+ and 2+ fish) from the Chatham Rise trawl survey but found this difficult to interpret because the survey is considered to be an index of the combined recruitment to both the eastern and western stocks. Dunn et al (2009b) supported some climate variable effect on hoki recruitment, but remained equivocal about its strength or form. A more recent analysis by Roberts et al (2022) found that hoki year class strength estimates of the eastern stock (but not the western stock) were correlated with sea conditions off the west coast South Island, with increased recruitment in years of deep mixed layer depth and low SST, consistent with the negative correlation with SST obtained by Bull & Livingston (2001). Bradford-Grieve & Livingston (2011) collated and reviewed information on the ocean environment off the WCSI in relation to hoki and other spawning fisheries. The authors noted that understanding of the underlying mechanisms and causal links between the WCSI marine environment and hoki recruitment remain elusive. However, concern remains about the environmental changes projected for shallow waters on the distribution of hoki early life stages, as this area will experience greater change than offshore environments (Cook et al 2024; Butler et al 2023).

New Zealand research trawl data indicate that small hoki (< 30 cm TL) are absent at bottom temperatures above about 15 °C and occur most frequently at 13–14 °C, whereas adults prefer cooler bottom water temperatures of about 6–10 °C (Dunn et al 2022). Surface water temperature has no clear relationship to hoki occurrence. Gunn et al (1989) hypothesised that hoki spawning and migration off Tasmania was influenced by water temperature, with spawning starting once temperatures dropped to 13–14 °C. Off Australia, colder water temperatures during winter have been thought to be conducive to higher year class strength (Pecl et al 2014).

A baseline report summarising trends in climatic and oceanographic conditions in New Zealand that are of potential relevance for fisheries and marine ecosystem resource management identified a reciprocal correlation between northern gemfish and hoki year class strength (Hurst et al 2012). An updated chapter on oceanic trends in the Aquatic Environment & Biodiversity Annual Review 2021 (Fisheries New Zealand 2021) examines a recent review of temperature trends in New Zealand waters by Sutton & Bowen (2019). It notes that the effects of recent warmer temperatures (e.g., the high surface temperatures off the WCSI during the 2016 and 2017 spawning seasons, marine heatwaves, and general warming of the Tasman Sea) on fish distribution, growth, or spawning success have yet to be determined.

The state of knowledge of climate change-associated predictions for components of New Zealand's marine environment that are most relevant to fisheries has been documented (Cummings et al 2021). Past and future projected changes in coastal and ocean properties, including temperature, salinity, stratification and water masses, circulation, oxygen, ocean productivity, detrital flux, ocean acidification, coastal erosion and sediment loading, and wind and waves are reviewed. Fish stock responses to climate change effects on these coastal and ocean properties are discussed, as well as their likely impact on the fisheries sector, where known.

A range of decision support tools in use overseas were evaluated with respect to their applicability for dissemination of the state of knowledge on climate change and fisheries. Three species, for which there was a relatively large amount of available information, were chosen for further analysis. These were pāua, snapper, and hoki (shellfish, inshore, and middle-depths/deepwater fisheries, respectively). An evaluation of the sensitivity and exposure of hoki to climate change-associated threats, based on currently available published literature and expert opinion, assessed hoki vulnerability as 'low' (Cummings et al 2021).

Recent work on the growth rate of fish exposed to temperature increases showed that the stochasticity of recruitment and density dependence overrides the background influence of global warming (Neubauer et al 2023). It was concluded that extreme or catastrophic events such as marine heatwaves may have a greater influence on recruitment and biomass than the incremental changes of background warming (Neubauer et al 2023).

Another recent study of hoki growth found that fishing and environmental factors initially promote individual fish growth but may then heighten the sensitivity of stocks to environmental change (Morrongiello et al 2021). Regional-scale wind and temperature affected growth of tarakihi and snapper, whereas deepwater hoki and ling growth was sensitive to the Interdecadal Pacific Oscillation (Morrongiello et al 2021).

No substantive changes in hoki spatial occurrence have been reported to date. Models predicting the spatial distribution of hoki at the end of the 21st Century, in response to changes in average water temperature and productivity predicted by the New Zealand Earth Systems Model, suggested some reduction in hoki occurrence on the Chatham Rise, but the overall change in hoki distribution was expected to be negligible in the short to medium term (Dunn et al 2022).

Brooks (2020) used ecological niche modelling (Maxent) to predict current and future hoki distribution around New Zealand. The models were trained on catch data from the Fisheries New Zealand research trawl database and remote-sensed environmental data. Under more severe climate change scenarios, hoki habitat was predicted to contract to the south Chatham Rise and sub-tropical convergence zone around southern New Zealand and be lost from the west coast South Island. The main predictors of these changes were sea surface temperature and salinity.

An analysis by Roberts et al (2022) developed a hoki Spatial Population Model (SPM) model which predicted range shifts of juvenile hoki about the Subantarctic region based on the relationship with bottom temperature and a warming trend since 2016. These movements were characterised as a spreading out across middle depths of the Subantarctic region, rather than a simplistic southward shift with warming.

The effects of climate change on the temperature of surface waters are reasonably well determined in New Zealand because the data are derived from satellite records (Ministry for the Environment & Stats NZ 2019, Law et al 2018b). However, deriving temperature from hoki fisheries depths 200–800 m below the sea surface is hampered by a lack of data from subsurface waters, and the correlation between surface and bottom temperatures at hoki depths is often weak. This data gap is being addressed in part by the MOANA project by placing thermal sensors on fishing vessels (https://www.moanaproject.org/). Temperature data collected from the NIWA trawl surveys show that marine heatwaves mainly seem to influence water temperatures above the mixed layer depth (R. O'Driscoll, NIWA, pers. comm.). However, unexplained warming has been detected in the Tasman Sea to 800 m depth off the west coast South Island from XBT profiles (Sutton & Bowen 2019). Argo floats that transmit temperature and salinity profiles down to depths of 2000 meters to satellites every 10 days are also used around New Zealand. Argo data show an unprecedented shift in ocean currents has been affecting the Chatham Rise, which is experiencing nearly continuous heatwave conditions detected at depth (Sutton et al 2024) and a decline in primary productivity since 2019 of -9.2% per year (Pinkerton et al 2024). While the effects on Hoki and the wider food web are uncertain, these changes may have negative implications for fish stocks.

6. STOCK ASSESSMENT

The most recent stock assessment was completed in 2025. The 2025 assessment updated the 2022, 2023 and 2024 assessments (McGregor et al 2023, McGregor et al 2024, McGregor & Langley 2025, McGregor-Tiatia & Langley in prep b) which included recommendations from a review of input data and model assumptions completed between 2018 and 2020 (Dunn & Langley 2018, Langley 2020). The general-purpose stock assessment programme, CASAL (Bull et al 2012), was used to perform the analyses of assessments up until 2022. The 2023 assessment was updated to use Casal2 (Doonan et al 2016) and Casal2 was also used in the 2025 assessment (McGregor-Tiatia & Langley in prep b).

Survey abundance indices are shown in Table 13. The sub-Antarctic trawl survey core biomass in November-December 2024 was 61.5% higher than that in 2022, and the highest estimate since 1993, with the abundance of hoki ages 3 and older increasing by 64.5%. Several modes were present in the hoki scaled length frequency distribution in 2024, including a small mode of age 1 fish (2023 year-class), but few age 2 fish (2022 year-class). The 2019 year-class was abundant at age 5. The Chatham Rise trawl survey biomass in January 2024 was 1% lower than that in 2022. The relative biomass of recruited hoki (ages 3+ years and older) on the Chatham Rise in 2024 increased (by 18%) from that in 2022. There was an average estimate for 2+ hoki (2021 year-class) and the abundance estimate for 1+ hoki (2022 year-class) was one of the lowest estimates from the Chatham Rise time series.

The acoustic estimate from the WCSI survey in winter 2024 was slightly higher than in 2018 but still considerably lower than any estimates preceding 2018. The trawl estimate from the WCSI survey is not used in assessment, but the biomass in core strata in 2024 decreased from 2021 and was similar to that in 2018. The acoustic survey biomass in Cook Strait in winter 2023 was only 37% of the equivalent index from the 2021 survey, and the lowest in the time series. In contrast, the acoustic abundance index of hoki for Pegasus Canyon (on the ECSI) in 2023 was the highest in the time series. The acoustic survey in 2023 was the first to yield a higher acoustic abundance index for Pegasus Canyon than for Cook Strait.

CPUE is not used in the stock assessment because it does not accurately index abundance over the long term.

Table 13: Abundance indices ('000 t) used in the stock assessment (* data new to this assessment). Years are fishing years (1990 = 1989–90). – no data. Biomass estimates are for all age classes in core survey area. Trawl survey Sub-Antarctic December index is for age 3++ and Trawl survey Chatham Rise January index is for age 2++.

Year	Acoustic survey WCSI Winter[1]	Trawl survey Sub-Antarctic December[2]	Trawl survey Sub-Antarctic April[3]	Trawl survey Chatham Rise January[4]	Acoustic survey Pegasus Canyon Winter[6]	Acoustic survey Cook Strait Winter[5]
1988	266	–	–	–		–
1989	165	–	–	–		–
1990	169	–	–	–		–
1991	227	–	–	–		88
1992	229	78	68	119		–
1993	380	87	–	153		283
1994	–	96	–	132		278
1995	–	–	–	115		194
1996	–	–	89	125		92
1997	445	–	–	155		141
1998	–	–	68	82		80
1999	–	–	–	84		114
2000	263	–	–	57		–
2001	–	56	–	60		102
2002	–	38	–	52	60	145
2003	–	37	–	48	45	104
2004	–	12	–	38		–
2005	–	14	–	67		59
2006	–	18	–	73	17	60
2007	–	13	–	62		104
2008	–	43	–	61	20	82
2009	–	44	–	119		166
2010	–	53	–	78		–
2011	–	–	–	67		141
2012	283	44	–	84		–
2013	233	55	–	66	64	168
2014	–	–	–	95		–
2015	–	29	–	–		204
2016	–	–	–	59		–
2017	–	31	–	–		102
2018	123	–	–	85		–
2019	–	30	–	–	55	91
2020	–	–	–	61		–
2021	–	31	–	–	102	159
2022	–	–	–	89		–
2023	–	48	–	–	103	58
2024	116*	–	–	94		–
2025	–	79*	–	–	–	–

1. survey_WC_abundance
2. survey_SA_summer_abundance (truncated at age 3)
3. survey_SA_autumn_abundance
4. survey_CR_summer_abundance (truncated at age 2)
5. survey_CS_spawning_abundance
6. survey_ECSI_spawning_abundance

6.1 Methods

Model structure

The general-purpose stock assessment programme, Casal2 (Doonan et al 2016), was used to perform the stock assessment modelling. As with previous assessments, the model used in the 2024–25 assessment was a total catch-history age-based model. The model partitioned the population into two sexes, 18 age groups (1 to 17 and a plus group, 18+), two stocks (eastern (E) and western (W)), and four areas (Chatham Rise (CR), west coast South Island (WC), Sub-Antarctic (SA), and Cook Strait (CS)). It is assumed that the adult fish of the two stocks do not mix: those from the western stock spawn off the west coast South Island and spend the rest of the year in the Sub-Antarctic; the eastern fish move between their spawning ground, Cook Strait/ECSI, and their home ground, the Chatham Rise. Juvenile fish from both stocks live on Chatham Rise, but natal fidelity is assumed in the base model (i.e., all fish spawn in the area in which they were spawned). There is little direct evidence of natal fidelity for hoki, though its life history characteristics would indicate that 100% natal fidelity is unlikely (Horn 2011).

The base model is partitioned into mature and immature fish. The proportion mature was defined using an assumed logistic ogive, set to be the same for both stocks, with a_{50} and a_{to95} parameters of (3, 3) for male and (4, 4) for female. The main reason maturity was assumed rather than estimated is because the observations of mature fish-at-age are different in different sub-fisheries of the spawning fishery, with no overall proportion mature-at-age calculated. There are three autumn observations in the Sub-

Antarctic of proportions of females that will spawn that year, but these were not fitted because the proportions mature in the base model were not estimated.

The model's annual cycle divides the fishing year into five time steps and includes four types of migration (Table 14). The first type of migration involves only newly spawned fish, all of which are assumed to move from the spawning grounds (Cook Strait/ECSI and the west coast South Island) to arrive at the Chatham Rise at time step 2 and approximate age 1.6 y. The second affects only young western fish, some of which are assumed to migrate, at time step 3, from the Chatham Rise to the Sub-Antarctic. The last two types of migrations relate to spawning. Each year fish migrate from their home ground (the Chatham Rise for eastern fish, the Sub-Antarctic for western fish) to their spawning ground (Cook Strait/ECSI for eastern fish, the west coast South Island for western fish) at time step 4. At time step 1 in the following year all spawners return to their home grounds.

The above describes the two-stock model structure. A single-stock model was also constructed in the 2024 assessment and updated in 2025 as a sensitivity analysis to the combined predictions of the two-stock model. The spatial and fishery structure remained the same, and once fish migrated from the Chatham Rise to the Sub-Antarctic they did not return, hence they became effectively 'western stock' fish. The key difference between the single-stock model and the two-stock model was one vector of year class strengths in the single-stock model. The data used in both models was the same. In general, the single-stock model produced similar fits to composition and abundance data and estimated lower levels of biomass in the western spawning and non-spawning grounds.

Table 14: Annual cycle of the assessment two-stock model, showing the processes taking place at each time step, their sequence within each time step, and the available biomass observations. Any fishing and natural mortality within a time step occurred after all other processes, with half of the natural mortality occurring before and after the fishing mortality. An age fraction of, say, 0.25 for a time step means that a 2+ fish was treated as being of age 2.25 in that time step, etc. The last column ('Prop mort') shows the proportion of that time step's total mortality that was assumed to have taken place when each observation is made.

					Observations	
Step	Approx. months	Process	M fraction	Age fraction	Label	Prop mort
1	Oct-Nov	post-spawning migrations: WC→SA, CS→CR	0.17	0.25	–	
2	Dec-Mar	recruitment at age 1+ to CR (for both stocks)	0.33	0.60	survey_SA_summer_abundance	0.5
		non-spawning fisheries (CR, SA)			survey_CR_summer_abundance	0.6
3	Apr-Jun	migration: CR->SA	0.25	0.90	survey_SA_autumn_abundance	0.1
4	End Jun	spawning migrations: SA→WC, CR→CS	0.00	0.90		
5	Jul-Sep	increment ages	0.25	0.00	survey_CS_spawning_abundance	0.5
		spawning fisheries (WC, CS, ECSI)			survey_WC_abundance	0.5

Data and error assumptions

Six series of abundance indices were used in the assessment (Table 13). New data were available from a trawl survey in Sub-Antarctic in Summer 2024/2025 and an acoustic survey of WCSI in Winter 2024 (Devine et al in prep., MacGibbon et al in prep.). The age data used in the assessment (Table 15) were similar to those used in the 2024 assessment, but with one additional year of data. There were two more years of age data available for the ECSI spawning fishery (2023 and 2024) that were not used in the assessment due to inconsistencies in sampling compared to the earlier part of this series. It should be possible to bring these data into the assessment models when there are more years of age data from this fishery and the 2023 and 2024 data are further analysed to ensure consistency through the time series.

The error distributions assumed were multinomial (Bull et al 2012) for the at-age data and lognormal for all other data. The weight assigned to each data set was controlled by the effective sample size for each observation, calculated from the observation error, and a reweighting procedure for the data sets following Francis (2011).

Two components of CVs were used for the biomass indices. The 'total' CVs represent an estimate of the total uncertainty associated with these data. For the trawl survey indices, these were calculated as the sum of an observation-error CV (which was calculated using the standard formulae for stratified random surveys, e.g., Livingston & Stevens 2002), and an additional 'process' error CV, which was set at 0.1 for the Chatham Rise and Sub-Antarctic summer and autumn surveys (note that CVs are added as squares: $CV_{total}^2 = CV_{process}^2 + CV_{observation}^2$). The CVs of the biomass indices are shown in Table 16.

Table 15: Age data used in the assessment. Years are model years (1990 = 1989–90). All age data from 2022–2023 and the 2024 survey_CR_summer_age data are new inputs for the 2024 assessment. Age data follow the revised fishery stratification (see Table 17). Data from Puysegur spawning fishery were first included in 2021 and were absorbed within WCSI_north fishery in the 2024 assessment due to small catches. ECSI spawning fishery was included for the first time in the base models in the 2024 assessment due to increased catches.

Area	Label	Data type	Years	Source of age data
WC	fishery_WC_inside_age	Catch-at-age	2000–2010, 2012–2024	Otoliths
	fishery_WC_north	Catch-at-age	1988–2024	Otoliths
	fishery_WC_south_age	Catch-at-age	1988–2024	Otoliths
SA	fishery_SA_auck_age	Catch-at-age	2001, 2003, 2004, 2006–2024	Otoliths
	fishery_SA_snares_age	Catch-at-age	2001, 2006–2024	Otoliths
	fishery_SA_suba_age	Catch-at-age	2001, 2002, 2003, 2009, 2010, 2012, 2016, 2018–2024	Otoliths
	survey_SA_summer_age	Trawl survey	1992–1994, 2001–2010, 2012–2013, 2015, 2017, 2019, 2021, 2023, 2025	Otoliths
	survey_SA_autumn_age	Trawl survey	1992, 1996, 1998	Otoliths
CS	fishery_CS_spwn_age	Catch-at-age	1990–2005, 2007–2010, 2014–2024	Otoliths
CS	Fishery_ECSI_spwn_age	Catch-at-age	2003, 2004, 2006, 2008, 2019, 2022	Otoliths
CR	fishery_CR_deep_age	Catch-at-age	2001–2024	Otoliths
	fishery_CR_shallow_age	Catch-at-age	1999–2019, 2001–2024	Otoliths
	survey_CR_summer_age	Trawl survey	1992–2014, 2016, 2018, 2020, 2022, 2024	Otoliths

Table 16: Coefficients of variation (CVs) used with biomass indices in the assessment. Total CVs include both observation error CVs and process error CVs. Observation error CVs are shown for CR_summer, SA_summer, and SA_autumn, and the process error CVs set to 0.1 for MPD (Mode of the Posterior Distribution) runs. Total CVs shown here for CS, ECSI and WC. Years are fishing years (1990 = 1989–90).

survey_CR_summer_abundance	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Observation	0.08	0.10	0.10	0.08	0.10	0.08	0.11	0.12	0.12	0.10	0.11	0.09
survey_CR_summer_abundance	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2016	2018
Observation	0.12	0.11	0.08	0.11	0.11	0.15	0.14	0.10	0.15	0.10	0.14	0.16
survey_CR_summer_abundance	2020	2022										
Observation	0.14	0.10										
survey_SA_summer_abundance	1992	1993	1994	2001	2002	2003	2004	2005	2006	2007	2008	2009
Observation	0.07	0.06	0.09	0.13	0.16	0.14	0.13	0.12	0.13	0.11	0.16	0.14
survey_SA_summer_abundance	2012	2013	2015	2017	2019	2021	2023	2025				
Observation	0.15	0.15	0.13	0.17	0.11	0.12	0.09	0.22				
survey_SA_autumn_abundance	1992	1996	1998									
Observation	0.08	0.09	0.11									
survey_CS_spawning_abundance	1991	1993	1994	1995	1996	1997	1998	1999	2001	2002	2003	2005
Total	0.41	0.52	0.91	0.61	0.57	0.40	0.44	0.36	0.30	0.34	0.34	0.32
Observation	0.12	0.15	0.14	0.12	0.09	0.12	0.10	0.09	0.12	0.12	0.17	0.11
survey_CS_spawning_abundance	2007	2008	2009	2011	2013	2015	2017	2019	2021	2023		
Total	0.46	0.30	0.39	0.35	0.30	0.33	0.36	0.36	0.41	0.38		
Observation	0.26	0.06	0.11	0.14	0.15	0.18	0.17	0.12	0.15	0.11		
survey_ECSI_spawning_abundance	2002	2003	2006	2008	2013	2019	2021	2023				
Total	0.33	0.47	0.63	1.07	0.74	0.92	0.30	0.53				
Observation	0.19	0.16	0.19	0.11	0.28	0.21	0.19	0.15				
survey_WC_abundance	1988	1989	1990	1991	1992	1993	1997	2000	2012			
Total	0.60	0.38	0.40	0.73	0.49	0.38	0.60	0.28	0.34			
Observation	0.12	0.15	0.06	0.10	0.17	0.07	0.10	0.14	0.15			
survey_WC_abundance	2013	2018	2024									
Total	0.35	0.46	0.53									
Observation	0.18	0.15	0.14									

For the acoustic indices, the total CVs were calculated using a simulation procedure intended to include all sources of uncertainty (O'Driscoll 2002). The observation-error CVs were calculated using standard formulae for stratified random acoustic surveys (e.g., Coombs & Cordue 1995) and included only the uncertainty associated with between-transect (and within-stratum) variation in total backscatter.

The observation CVs for the otolith-based, at-age data were calculated by a bootstrap procedure, which included an explicit allowance for age estimation error. The age ranges used in the model varied amongst data sets (Table 17). In all cases, the last age for these data sets was treated as a plus group.

Table 17: Age ranges used for at-age data sets.

	Age range (y)	
Data set	**Lower**	**Upper**
survey_SA_autumn_age	2	15+
survey_CR_summer_age	2	13+
survey_SA_summer_age	3	15+
survey_CR_SHI_age	2	9+
survey_SA_SHI_age	2	10+
Survey_SA_AEX_age	2	6+
Spawning fisheries	2	18+
Non-spawning fisheries	1	18+

The catch for each year was divided among the 10 fisheries in the model according to area and month (Table 18). This division was based on estimated catch data from the catch and effort logs, and the resulting values were then scaled up to sum to the HOK 1 MHR total. The method of dividing the catches (Table 5) was the same as that used in the 2024 assessment. The catches used in the model (Table 19) were unchanged, except for revisions to the previously assumed catch for 2024.

For the 2024–25 fishing year, catches by fishery were defined to be the same as the 2023–24 fishing year based on industry advice.

Table 18: The division of annual catches by area and months into the 10 model fisheries. The small amount of catch reported from the west coast North Island and Challenger areas, typically about 100 t per year, has been distributed pro rata across all fisheries.

Fishery	Description	Areas/months
CR_deep	Chatham Rise deep (effort depth ≥ 475 m), non-spawning	CR (excluding ECSI spawning), CS (Oct-May), ECNI, ECSI (Oct-Jun)
CR_shallow	Chatham Rise shallow (effort depth < 475 m), non-spawning	CR(excluding ECSI spawning), CS (Oct-May), ECNI, ECSI (Oct-Jun)
CS	Cook Strait spawning	CS (Jun-Sep)
ECSI	ECSI spawning	ECSI (Jul-Sep)
SA_auck	Sub-Antarctic Auckland Islands, non-spawning	Sub-Antarctic Auckland Islands
SA_snares	Sub-Antarctic Snares shelf, non-spawning	Sub-Antarctic Snares, Puysegur (Oct-May)
SA_suba	Sub-Antarctic excluding Auckland Islands and Snares shelf, non-spawning	Sub-Antarctic
WC_inside	WCSI south of 42.5° S inside the line	West coast inside
WC_north	WCSI north of 42.5° S and includes inside the line	West coast north, Puysegur (Jun-Sep)
WC_south	WCSI south of 42.5° S outside the line	West coast south

Further assumptions

Two key outputs from the assessment are B_0—the average equilibrium spawning stock biomass that would have occurred over the period of the fishery had there been no fishing—and the time series of year class strengths (YCSs). For example, the YCS for 1970 comprised fish spawned in the winter of 1970 that first arrived in the model in area Chatham Rise at age 1.6 y, in about December 1971, which was in model year 1972. Associated with B_0 was an estimated mean recruitment, R_0, which was used, together with a Beverton-Holt stock-recruit function and the YCSs, to calculate the recruitment in each year. The first five YCSs (for years 1970 to 1974) and the last two years were set equal to 1 (because of the lack of at-age data for the early years and the lack of coverage from at-age data for the most recent years), but all remaining YCSs were estimated. When it came to projections, the last two years were no longer set at 1; they were sampled from earlier year classes as is the case for future recruitment in projections. The model corrects for bias in estimated YCSs arising from ageing error. YCSs were constrained to average to 1 over the estimated years, so that R_0 may be thought of as the average recruitment over that period. R_0 and a set of YCSs were estimated separately for each stock.

The B_0 for each stock was calculated as the spawning biomass that would occur given no fishing and constant recruitment, R_0, and the initial biomass before fishing (B_{INIT}) was set equal to B_0. The steepness of the stock-recruitment relationship was assumed fixed at 0.75 for both stocks (Francis 2009).

Table 19: Model catch history (t) by fishery and fishing year (1972 means fishing year 1971–72), as used in this assessment. Years are fishing years (1990 = 1989–90). The 2024 catch is assumed, based on industry advice.

Year	CR_ deep	CR_ shallow	CS_ spwn	ECSI_ spwn	SA_ auck	SA_ snares	SA_ suba	WC_ inside	WC_ north	WC_ south	Total
1972	3 500	500						1 700	3 300	10	9 010
1973	3 500	500						1 700	3 300	10	9 010
1974	5 200	800						1 700	3 300	10	11 010
1975	31 300	4 700						3 400	6 600	10	46 010
1976	32 200	4 800						10 200	19 700	100	67 000
1977	33 100	4 900						20 500	39 400	100	98 000
1978	2 600	400						1 700	3 300	10	8 010
1979	5 200	800						6 100	11 800	10	23 910
1980	7 000	1 000						6 800	13 100	10	27 910
1981	7 000	1 000						8 500	16 400	100	33 000
1982	6 100	900						8 500	16 400	100	32 000
1983	8 700	1 300			1 300	1 700	400	9 100	17 410	100	40 010
1984	8 700	1 300			1 700	2 300	600	12 100	23 210	100	50 010
1985	8 700	1 300			1 500	1 900	500	10 300	19 710	100	44 010
1986	14 800	2 200			3 500	4 700	1 100	24 800	47 700	200	99 000
1987	14 800	2 200			6 800	9 000	2 200	47 700	91 900	300	174 900
1988	7 100	1 100	7 400		10 300	13 700	3 300	72 500	139 600	500	255 500
1989	5 500	800	5 700		8 200	11 000	2 600	57 800	111 400	400	203 400
1990	9407	4 011	14 675	1 058	660	9 646	1596	1 765	86 316	79 716	208 851
1991	24 847	5 099	29 160	2 574	1 748	8 244	6 798	1 180	77 359	55 711	212 720
1992	35 878	12 117	24 509	2 541	2 496	17 039	11 252	754	69 226	36 355	212 167
1993	35 405	10 114	21 721	1 050	3 635	14 258	7 492	1 039	85 480	11 799	191 994
1994	18 152	7 158	35 602	1 547	865	8 562	2 246	1 647	98 312	18 293	192 384
1995	32 386	11 341	34 918	3 192	2 089	7 254	4 375	2 384	55 008	23 840	176 787
1996	38 978	18 739	59 279	3 659	1 666	9 249	2 379	4 244	45 538	25 907	209 639
1997	47 592	19 104	55 883	5 038	6 573	11 467	4 074	7 992	67 787	21 242	246 752
1998	61 561	24 402	45 007	4 579	9 149	10 181	6 263	7 769	73 109	27 202	269 222
1999	55 130	25 287	39 608	3 237	7 983	11 238	5 211	7 218	52 787	36 827	244 526
2000	40 659	18 931	39 283	4 080	13 985	13 820	6 377	14 136	67 195	23 952	242 419
2001	37 041	16 383	32 420	4 759	11 391	12 690	7 039	21 574	49 303	37 257	229 858
2002	29 964	10 177	21 620	5 485	9 018	7 456	14 209	21 825	50 450	25 298	195 501
2003	26 963	13 004	34 339	9 812	7 921	3 485	9 152	16 479	44 103	19 401	184 659
2004	22 723	8 343	38 818	7 821	4 778	2 604	4 687	18 784	15 184	11 995	135 736
2005	25 081	6 389	23 032	4 827	2 654	2 293	1 399	7 893	21 242	9 459	104 269
2006	23 997	11 237	19 836	2 148	1 232	4 843	883	5 220	19 001	15 985	104 383
2007	32 303	6 534	17 796	2 967	1 780	5 388	651	3 109	23 936	6 541	101 006
2008	31 872	6 601	15 587	5 294	2 801	4 557	1 525	914	17 085	3 082	89 317
2009	32 579	7 292	14 836	3 480	2 201	6 394	1 326	1 151	16 837	2 705	88 801
2010	33 692	6 972	15 697	1 943	2 527	8 365	1 550	2 933	31 173	2 357	107 209
2011	32 948	9 846	11 646	2 157	3 272	7 805	1 657	7 509	36 552	5 411	118 802
2012	33 802	7 412	12 876	4 405	2 973	11 195	1 988	8 487	36 479	10 492	130 108
2013	31 400	8 183	15 266	5 445	4 257	7 819	2 518	6 858	35 649	14 181	131 575
2014	30 945	7 075	14 596	3 613	5 784	7 406	7 115	10 355	44 435	15 019	146 343
2015	36 886	7 262	16 162	4 250	4 575	9 370	3 013	13 388	51 146	15 477	161 528
2016	29 848	9 537	15 432	5 311	2 406	2 716	1 644	16 172	38 321	15 333	136 720
2017	34 802	8 355	12 739	5 440	2 494	6 046	4 923	16 764	33 299	16 706	141 567
2018	31 313	9 021	18 060	4 924	3 693	4 917	7 008	17 087	19 352	20 045	135 419
2019	29 907	6 181	18 972	10 605	2 441	4 367	2 494	14 990	15 369	17 134	122 460
2020	25 895	4 766	15 101	9 658	3 013	3 906	1 211	13 728	18 207	12 250	107 736
2021	31 262	4 126	11 044	9 655	4 105	3 702	1 539	9 985	12 422	12 981	100 821
2022	28 784	4 345	8 335	9 690	3 052	2 704	2 625	9 748	10 701	11 682	91 666
2023	34 386	4 890	12 014	10 898	5 065	2 582	5 285	10 321	7 851	12 267	105 557
2024	34 327	6 048	10 703	15 508	2 495	1 544	3 746	10 089	7 123	15 451	107 035
2025	34 327	6 048	10 703	15 508	2 495	1 544	3 746	10 089	7 123	15 451	107 035

In the 2025 assessment, an additional year class was estimated from the 2024 assessment, the 2021 year class. This year class was seen in the Sub-Antarctic survey in 2025 as 3-year-olds, the Chatham Rise survey and non-spawning fisheries in 2024 as 2-year-olds and in the 2024 spawning fishery as 3-year-olds. While also seen in the 2023 spawning fisheries as 2-year-olds and 2023 non-spawning fisheries as 1-year-olds, these observations are very uncertain and do not reliably inform recruitment. The 2025 assessment does not have sufficient information to estimate the 2022 year class.

In all model runs, natural mortality (*M*) by sex was assumed to be constant over time, and the same for each stock, with female $M = 0.22$ y^{-1} and male $M = 0.30$ y^{-1}. The lower female M value was also used in the 2024 assessment and defined on the basis of parameter sensitivity analyses and to improve patterns in sex by age class. Assessments prior to 2024 set female $M = 0.25$ y^{-1}.

The model used 17 selectivity ogives (11 for the eastern and western spawning and non-spawning fisheries and six for the trawl surveys on the Chatham Rise and Sub-Antarctic) and two migration ogives (Chatham Rise to Sub-Antarctic migration, defined separately for males and females).

Prior distributions were assumed for all parameters. Bounds for the acoustic catchability parameters were calculated by O'Driscoll et al (2016) (who called them overall bounds); for YCS, bounds were set at the 0.001 and 0.999 quantiles of their distributions (Table 20). Prior distributions for all other parameters were assumed to be uniform, with bounds that were wide enough so as not to affect point estimation, or, for some ogive parameters, deliberately set to constrain the ogive to a plausible shape.

Table 20: Assumed prior distributions for key parameters. Parameters are bounds for uniform; mean (in natural space) and CV for lognormal; and mean and SD for normal and beta.

Parameter	Description	Distribution	Values		Reference
recruitment[E].YCS	year-class strengths (E)	lognormal	1	0.95	Francis (2004a)
recruitment[W].YCS	year-class strengths (W)	lognormal	1	0.95	Francis (2004a)
q[survey_CS_spawning_q].q	catchability, CS acoustic survey	lognormal	0.55	0.90	O'Driscoll et al (2016)
q[survey_WC_spawning_q].q	catchability, WC acoustic survey	lognormal	0.39	0.77	O'Driscoll et al (2016)

The final models, which were taken to MCMC, are summarised in Table 21. 'Base: two stocks' was considered the base model and was a two-stock model, with the Single Stock model a sensitivity analysis to the assumed stock structure of Base: two stocks.

Table 21: Characteristics for final model runs.

Model	Main assumptions
Base: two stocks	Two spawning stocks, that spawn on the CS and WC. Recruits from both stocks reside on CR as juveniles. Western-spawned fish migrate to SA (estimated ogive; further testing of this parameterisation required). Mature WC-stock fish migrate from SA to WC to spawn and mature CR-stock fish from CR to CS to spawn. After spawning, all mature fish return (WC to SA and CS to CR).
Single Stock	One spawning stock, that spawns on the CS and WC. Recruits from both spawning grounds reside on CR as juveniles. A fixed estimated proportion of fish by sex determined fish that migrate to SA. These fish effectively become 'western stock' fish as they never return to the CR. Mature fish migrate from SA to WC to spawn and similarly from CR to CS to spawn. After spawning, all mature fish return (WC to SA and CS to CR). This model has one stock but retains the spatial, temporal, and fishery structure of the base model.

Bayesian posterior distributions were estimated for models in Table 21 using a Markov chain Monte Carlo (MCMC) approach. For models 'Base: two stocks' and Single Stock, 3 chains of length 2 million were completed, with adaptive step size allowed during the 2 million samples. The initial burn-in samples of each chain were discarded with the number of samples considered to be burn-in estimated based on the acceptance converging to between 0.25 and 0.35. The same parameter transformations and re-estimation of the covariance matrix to improve MCMC performance were used as in the 2024 assessment. The Sub-Antarctic selectivity parameter a_{50} and corresponding catchability (q) remained to be poorly estimated. In the final 'Base: two stocks' estimation of the q pushed against its upper bound of 0.95 and a fairly flat posterior distribution was produced. It was demonstrated in the 2024 assessment that this could be resolved by fixing either the a_{50} or q and as these parameters were 89% correlated this did not impact on the results or uncertainty in the MCMC outputs. Further work is required in the next assessment to resolve this estimation and it is linked to other concerns identified in movement of fish from the Chatham Rise to the Sub-Antarctic and spatial definitions of the Sub-Antarctic fisheries.

Calculation of fishing intensity and B_{MSY}

Due to complications in calculating fishing intensity (U) when there are multiple fisheries and stocks, a simplified version was calculated as the catch in biomass divided by the estimated spawning stock biomass (*SSB*). For a given stock and run, the corresponding reference fishing intensities were estimated using the same equation (catch/*SSB*), and by running the model to equilibrium using a range of constant future catch levels, until the stock level at equilibrium was sufficiently close to the stock level reference point.

The 2025 assessment was conducted in two steps. First, a set of initial model runs was carried out to generate point estimates (which estimate the Mode of the Posterior Distribution). Their purpose was to investigate model structure and assumptions to decide which runs to carry forward as final runs. The final runs used MCMC parameter estimation.

Deterministic B_{MSY} estimates are no longer calculated, for the following reasons. First, it assumes a harvest strategy that is unrealistic in that it involves perfect knowledge (current biomass must be known exactly, to calculate the target catch) and annual changes in TACC (which are unlikely to happen in New Zealand and not desirable for most stakeholders). Second, it assumes perfect knowledge of the stock-recruitment relationship, which is very poorly known (Francis 2009). Third, the closeness of B_{MSY} to the soft limit permits the limit to be breached too easily and too frequently, given, for example, a limited period of low recruitment. Fourth, it would be very difficult with such a low biomass target to avoid the biomass occasionally falling below 20% B_0, the default soft limit according to the Harvest Strategy Standard.

Instead, the target range of 35% B_0 to 50% B_0 is used as a proxy for the likely range of credible B_{MSY} estimates.

6.2 Results

Model estimates are presented for the spawning stock biomass (Table 22), year class strengths (Figure 4), fishing intensity (Figure 5), and biomass trajectories with projections (Figure 6). The current western biomass was estimated to be 39% B_0 (median value for the Base: two stock model). Outputs from sensitivities are presented in Table 23.

Table 22: Estimates of spawning biomass ('000 tonnes) (medians of marginal posterior, with 95% confidence intervals in parentheses). B_{2025} is the biomass in mid-season 2025. See Table 21 for the associated run numbers.

Model	Stock	B_0 ('000t)	B_{2025} ('000t)	B_{2025}/B_0
Base: two stocks	East	727 (676, 785)	396 (284, 540)	55 (41, 70)
	West	1 176 (1 131, 1 223)	456 (356, 572)	39 (31, 47)
	Total	1 903 (1 807, 2 008)	855 (719, 1 020)	45 (40, 51)
Single Stock	Total	1 959 (1 903, 2 022)	866 (720, 1036)	44 (38, 51)

Fishing intensity for the western stock was estimated to be at or near all-time highs in 2002–2003 and is now substantially lower (Figure 5). For the eastern stock, fishing intensity peaked in 1999 and then again in 2004–2005 and is now lower. Estimates of fishing pressure for the combined stocks agree between the single stock and Base: two stock models (Figure 5) suggesting fishing pressure estimates are robust to assumed stock structure.

Biomasses of both stocks were at their lowest points from about 2004 to 2006 (lowest values being at about 30% B_0 for the eastern stock and 20% B_0 for the western stock) (see Figure 6), after the western stock experienced seven consecutive years of poor recruitment from 1995 to 2001 inclusive and the eastern stock had below average recruitment over the same period (Figure 4). Both stocks then increased to above the target range of 35–50% B_0, then declined, with the eastern stock towards the top of the management target range and the western stock towards the midpoint of the target range. The western stock has steadily increased from 2019–2025.

Recruitment to the western stock following the 1995–2001 period of poor recruitment remained low for two more years, then was estimated to have been above average for about five years before dropping again, with recruitment below average for 2011–2019. Western recruitment was above average in 2019 and below average in 2020 and 2021. Eastern recruitment for 2019–2021 has been above average but uncertain. The single stock recruitment was estimated at about average level for 2019–2021. The combined stock's recruitment estimates were very similar between the single stock and base: two stock models with largest differences in the most recent years when recruitment to the fisheries is fairly uncertain. This suggests that generally, recruitment to the combined hoki stock is robust under the single- verse two-stock structure assumptions.

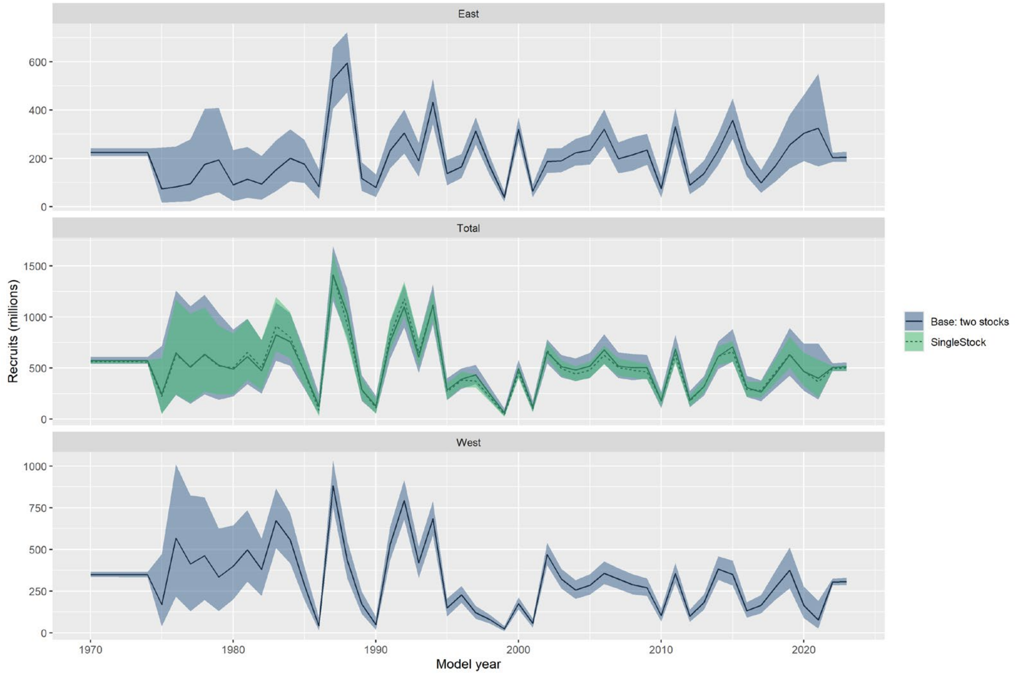


Figure 4: Recruits (millions) for eastern (top), total (middle) and western (bottom) stocks from Model 1 (blue) and Single Stock (green) from MCMC samples. Shaded areas are 95% CSI; solid lines are median values. Years are model years (1990 = 1989–90).

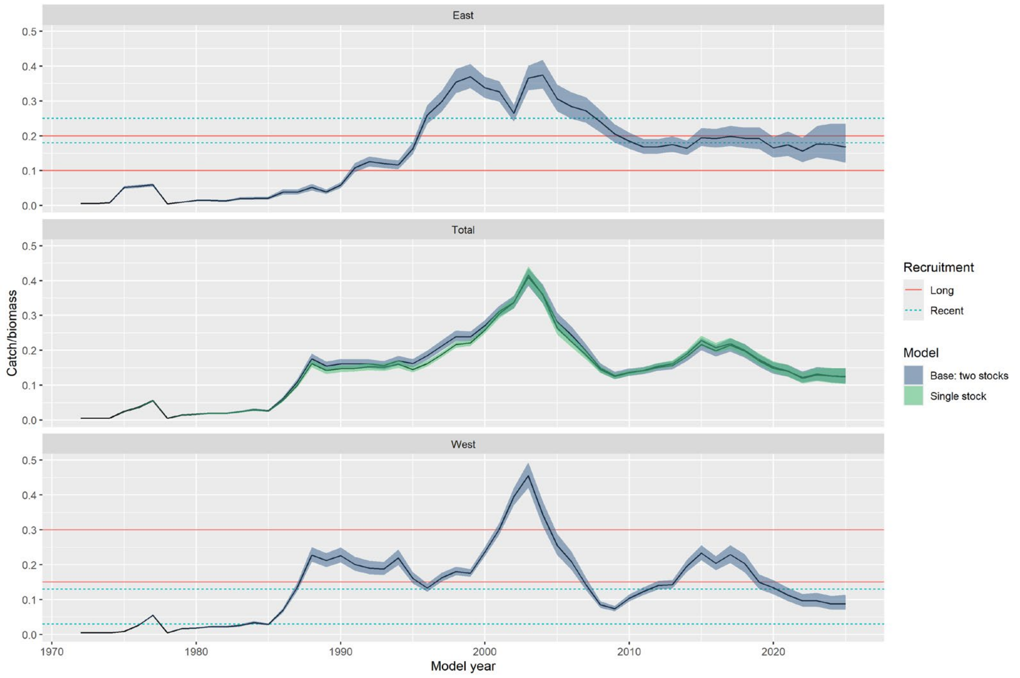


Figure 5: Fishing intensities, *U* (from MCMCs) for Model 1 (blue) and Single Stock (green), plotted by stock. Shown are medians (solid black line) with 95% confidence intervals (shaded area). Also shown with horizontal lines is the management range where the upper bound is the reference level $U_{35\%B_0}$ and the lower bound $U_{50\%B_0}$ which are the fishing intensities that would cause the spawning biomass to tend to 35% B_0 and 50% B_0, respectively, under recent recruitment (dashed) or long-term recruitment (solid). Reference *U* values were estimated in the 2022 assessment. Biomass is spawning stock biomass (SSB).

6.3 Sensitivities

A number of sensitivities were conducted at the MPD level. The results of key parameter and structural sensitivities are shown in Table 23. Sensitivities were also carried out with the new estimated parameters for growth and length to weight conversion. However, as these were exploratory, the results are not included in Table 23.

Of the parameter sensitivities on the Base: two stock model, the greatest effect on stock status was from natural mortality sensitivities. Increasing natural mortality on females while keeping natural mortality on males corresponds to Model 2023A of the previous assessment.

The sensitivities to the single stock model responded in a similar way to the Base: two stock model, with natural mortality causing the largest differences (Table 23).

Table 23: MPD sensitivities. Biomass estimates are in tonnes. Total estimates for 2-stock model sensitivities are the sum of the estimates for the East and West stocks.

	East		West		Total	
Model description	B_0	B_{2024}/B_0	B_0	B_{2024}/B_0	B_0	B_{2024}/B_0
Base: M(male)=0.30, M(female)=0.22, h=0.75, maturation logistic (male)=2,2; (female)=3,3	760 570	62.04	1 174 860	39.08	1 935 430	48.10
Base: M(male)=0.25, M(female)=0.17	793 687	50.55	1 305 950	27.10	2 099 637	35.97
Base: M(male)=0.35, M(female)=0.27	769 521	75.92	1 194 840	45.68	1 964 361	57.53
Base: h=0.70	737 771	69.40	1 182 020	32.12	1 919 791	46.45
Base: h=0.80	703 192	73.28	1 107 360	34.55	1 810 552	49.59
Base: maturation logistic (male)=1,2; (female)=2,3	818 490	67.21	1 219 500	40.29	2 037 990	51.10
Base: maturation logistic (male)=3,2; (female)=4,3	691 862	55.9	1 123 690	37.74	1 815 552	44.66
Single Stock: M(male)=0.3, M(female)=0.225; h=0.75; Maturation: logistic (male)=2,2 (female)=3,3; cv.process_error=0.10					1 993 760	46.55
Single Stock: M(male)=0.30, M(female)=0.25					2 143 400	34.49
Single Stock: M(male)=0.35, M(female)=0.					2 020 510	56.42
Single Stock: M(male)=0.25, M(female)=0.					2 039 450	45.61
Single Stock: h=0.70					1 939 220	48.60
Single Stock: h=0.80					2 101 190	50.72
Single Stock: maturation logistic (male)=1,2; (female)=2,3					1 862 630	44.84
Single Stock: maturation logistic (male)=3,2; (female)=4,3					1 993 760	46.55

6.4 Projections

Five-year projections were carried out from ‘Base: two stocks’ and the Single Stock model for two recruitment scenarios. Model estimates of recruitment for 1975–2020 (Base: two stocks) and 1975–2021 (Single Stock) were used. Future recruitments (2021 onwards for Base: two stocks and 2022 onwards for Single Stock) were randomly selected based on two scenarios: (i) recruitments estimated for 2011–2020 (Base: two stocks) 2011–2021 (Single Stock) (recent recruitment), and (ii) recruitments estimated for 1975–2021 (Base: two stocks) 1975–2021 (Single Stock) (long-term recruitment). Future annual catch scenarios were assumed constant at the TACC of 110 000 tonnes (45 000 tonnes western stock, 65 000 tonnes eastern stock). These future catches were apportioned by fishery using proportions from the average of the 2020–2024 fishing years. The projections indicated that the eastern biomass would remain constant under long-term recruitment and decline over the next 5 years under recent recruitment but would likely remain within the target range (see Figure 6, Table 24 and Table 25). The western biomass was projected to increase under long-term recruitment to above the target range and remain constant and within target range under recent recruitment (see Figure 6, Table 24 and Table 25). Total biomass in both the Single Stock model and Base: two stocks model was projected to increase under long-term recruitment and remain constant under recent recruitment.

For both eastern and western stocks, the estimated probability of being less than the soft or the hard limit at the end of the five-year projection period was less than 5% (Table 25). This was also the case for the combined stocks in both Base: two stocks and the Single Stock model.

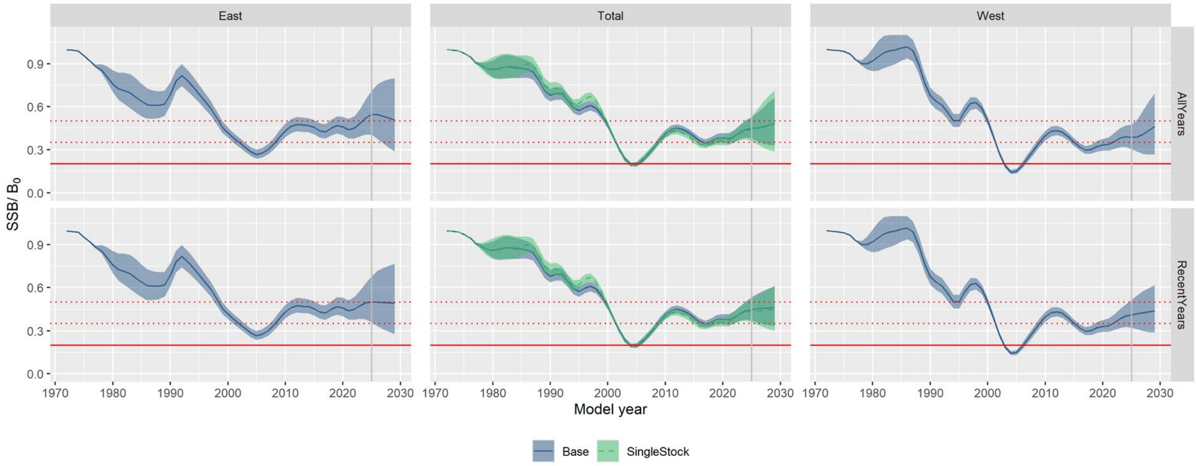


Figure 6: Projected spawning biomass (as % B_0) from Base: two stocks (blue) and Single Stock (green) under two recruitment scenarios: recent 2011–2020 (Base: two stocks) 2011–2021 (Single Stock) (bottom); long-term 1975–2021 (Base: two stocks) 1975–2021 (Single Stock) (top), for eastern stock (left), total (middle), and western stock (right), with catches assumed at the current TACC (110 000 tonnes). The horizontal dotted red lines represent the target management range of 35–50% B_0. The horizontal solid red line shows 20% B_0. Shaded areas give 95% CIs, and central line gives median SSB/B_0.

Table 24: Projected median *SSB* (% B_0) for 2025 to 2029 from the base models (Base: two stocks), assuming future estimated catch levels of 110 000 tonnes (65 000 tonnes eastern stock, 45 000 tonnes western stock) or 110 000 tonnes (60 000 tonnes eastern stock, 40 000 tonnes western stock), and with recruitment levels randomly selected from: 2011–2020 (Base: two stocks); 2011–2021 (Single stock) estimates (recent recruitment); 1975–2021 (long-term recruitment). kt: '000 tonnes.

Model	Recruitment	Catch	Stock	2025	2026	2027	2028	2029
Base: two stocks	Long-term	110 kt	Total	45	45	46	47	48
		65 kt	East	55	55	53	52	51
		45 kt	West	39	39	41	44	46
	Recent	110 kt	Total	45	45	46	46	46
		65 kt	East	50	50	50	50	49
		45 kt	West	41	42	43	43	44
Single Stock	Long-term	110 kt	Total	44	45	46	47	49
	Recent	110 kt	Total	44	44	44	45	45

Table 25: Projected probabilities (to two decimal places) from Base: two stocks and Single Stock of *SSB* being below, within, or above various levels of % B_0 for 2025 to 2029, assuming future estimated catch levels of 110 000 tonnes (65 000 tonnes eastern stock, 45 000 tonnes western stock) and with recruitment levels randomly selected from 2011–2020 (Base: two stocks); 2011–2021 (Single stock) estimates (recent recruitment).

	2025	2026	2027	2028	2029
EAST Base: two stocks					
P (SSB<10% B_0)	0.00	0.00	0.00	0.00	0.00
P (SSB<20% B_0)	0.00	0.00	0.00	0.00	0.00
P (SSB<35% B_0)	0.02	0.04	0.07	0.09	0.11
P (35≤SSB<50% B_0)	0.47	0.45	0.44	0.42	0.41
P (SSB≥50% B_0)	0.51	0.51	0.50	0.49	0.48
WEST Base: two stocks	0.00	0.00	0.00	0.00	0.00
P (SSB<10% B_0)	0.00	0.00	0.00	0.00	0.00
P (SSB<20% B_0)	0.00	0.00	0.00	0.00	0.00
P (SSB<35% B_0)	0.09	0.11	0.13	0.13	0.13
P (35≤SSB<50% B_0)	0.86	0.79	0.71	0.66	0.62
P (SSB≥50% B_0)	0.04	0.1	0.16	0.21	0.25
ALL Base: two stocks					
P (SSB<10% B_0)	0.00	0.00	0.00	0.00	0.00
P (SSB<20%B_0)	0.00	0.00	0.00	0.00	0.00
P (SSB<35% B_0)	0.01	0.01	0.03	0.04	0.04
P (35≤SSB<50% B_0)	0.88	0.80	0.73	0.68	0.64
P (SSB≥50% B_0)	0.12	0.19	0.24	0.29	0.31

ALL Single Stock					
P (*SSB*<10% B_0)	0.00	0.00	0.00	0.00	0.00
P (*SSB*<20%B_0)	0.00	0.00	0.00	0.00	0.00
P (*SSB*<35% B_0)	0.01	0.04	0.07	0.09	0.10
P (35≤*SSB*<50% B_0)	0.92	0.84	0.74	0.68	0.63
P (*SSB*≥50% B_0)	0.06	0.12	0.19	0.24	0.27

6.5 Management Strategy Evaluation

In 2023, a Management Strategy Evaluation (MSE) was undertaken for hoki (Langley 2023). The operating model for the MSE was based on the 2022 base case stock assessment model and assumed eastern and western recruitments equivalent to those for 2001–2020, a period characterised by lower recruitment for the western stock relative to long term recruitment. The MSE evaluated a range of Harvest Control Rules (HCRs), including alternative target biomass levels and corresponding catch levels. The HCRs specified a base level of catch for the eastern and western fisheries when the respective stock units were assessed to be within the target biomass range and varied the level of catch proportionally when the stock was below or above the target biomass range. The initial set of HCRs reaffirmed the current target biomass range of 35–50% SB_0; the lower bound ensuring the stock had a very low risk of declining below the soft limit (20% SB_0). A range of other performance indicators were derived to evaluate the individual HCRs, including average annual fishery catches, variability in annual catches, magnitude and frequency of catch adjustments and relative CPUE, and average fish weight by fishery.

For the final set of HCRs, the base levels of catch yielded average total annual catches of about 112–118 kt, approximately partioned 47 kt Chatham Rise, 40–46 kt WCSI, 10 kt Sub-Antarctic, and 15 kt Cook Strait. Those scenarios yielded average stock sizes close to the upper range of the target biomass (i.e., 45–50% SB_0). However, there is considerable variability in catches between years due to variability in annual recruitments and the precision of the simulated annual assessments. The study highlighted the need to make frequent large changes to fishery catch allocations to maintain the stock within the target biomass range. HCRs that yielded lower levels of total catch (approximately 100 kt) resulted in higher overall biomass levels and less frequent large changes in annual catches.

The robustness of the MSE results, including the selection of specific HCRs, is dependent on the fundamental stock structure assumptions of the assessment model, particularly the assumption of separate eastern and western stocks with a common nursery ground on the Chatham Rise (natal fidelity). Alternative stock assumptions may influence the potential yields from key fisheries, in particular the impact of the Chatham Rise catches on the magnitude of recruitment to the western fisheries.

The 2023 Plenary did not adopt an HCR for the management of the hoki fishery. Instead, the results of the MSE were considered useful to inform managers regarding the likely level of yields available from the hoki fishery and the scale of management response required to maintain the stock at the optimal target biomass levels. The adoption of a specific HCR would require wider consultation to fully evaluate the relative trade-offs between stock outcomes (informed by key performance indicators). Implementation of a specific set of HCRs would also require the specification of a set of breakout rules for managing the stock beyond the scope of the current operating model, e.g., in response to a sustained period of low recruitments.

7. FUTURE RESEARCH CONSIDERATIONS

Modelling:

- Explore alternative spatial and movement hypotheses, including evidence for density-dependent movement from CR, spatial and temporal structure of the sub Aantarctic fisheries, and separation of maturity from migration to the spawning grounds for both the single stock and two stock models.
- Explore differences in Cook Strait acoustic catchability between models and how these relate to corresponsing selectivity ogives.
- Explore environmental drivers of recruitment and the spatial distribution of the hoki stock, explicitly considering new information on temperature at depth that has been collected within

the Moana project.
- Explore spatial and temporal variability in length-weight relationships and growth by sex. Some trends in mean size-at-age (growth rates) are not accounted for in the model. This affects the conversion of catches in tonnes to mortality in numbers.
- Investigate sensitivities to maturity,noting that previous studies have been conducted to estimate the average percentage of mature fish not migrating to spawn.
- Investigate the appropriateness of age based selectivity ogives shared by sex in non-spawning fisheries where growth rates vary by sex.
- Explore alternative model structures in conjunction with ways of making better use of fishery dependent data (e.g., CPUE or industry collected length data), for example by examining whether it can be used to track young fish when they leave the Chatham Rise and arrive at the Stewart-Snares shelf. The size of fish indexed by the CPUE also needs to be considered.
- Investigate the potential effects of cryptic mortality, focusing on years of high juvenile abundance where density-dependent effects may occur, in the light of recent work documented by Millar et al (2023).
- Re-estimate the management target range fishing intensity, last updated in the 2022 assessment.
- Investigate the assumptions regarding inclusion of the ECSI acoustic biomass indices.
- In years without a stock assessment, resources could be applied to model development

Data collection:
- More and better quality abundance data including length frequencies, otoliths, and gonad stages need to be collected from the Pegasus Canyon and surrounding areas to determine the importance or relevance of these areas, including enabling the development of a consistent index of hoki abundance. Any temporal or areal differences in the availability of hoki in the Cook Strait and Pegasus spawning fisheries could then be integrated into the model. Collect additional data (LFs and otoliths) required to fill identified information gaps (e.g., otolith samples from the SA and ECSI, targeted sampling for larger vessels (40 to 46 m) in CS and WCSI inside). This could be through shore based, observer or industry based sampling.
- Review the design, implementation and utility of the west coast South Island acoustics survey.
- Review the timing and duration of the ECSI acoustic survey.
- Analyse maturity at age data outside of the model and test for year and potentially spatial effects.
- Analyse ECSI age composition and sampling to understand differences in 2023 and 2024 data compared to the earlier part of this series.

8. STATUS OF THE STOCKS

Stock structure assumptions

Hoki are assessed as two intermixing biological stocks, based on the presence of two main areas where simultaneous spawning takes place (Cook Strait and the WCSI), and observed and inferred migration patterns of adults and juveniles:

- Adults of the western stock occur off the west coast of the North and South islands and the area south of New Zealand including Puysegur, Stewart-Snares shelf, and the Sub-Antarctic;
- Adults of the eastern stock occur off the east coast of the South Island, Cook Strait, and the ECNI up to North Cape;
- Juveniles of both biological stocks occur on the Chatham Rise including Mernoo Bank.

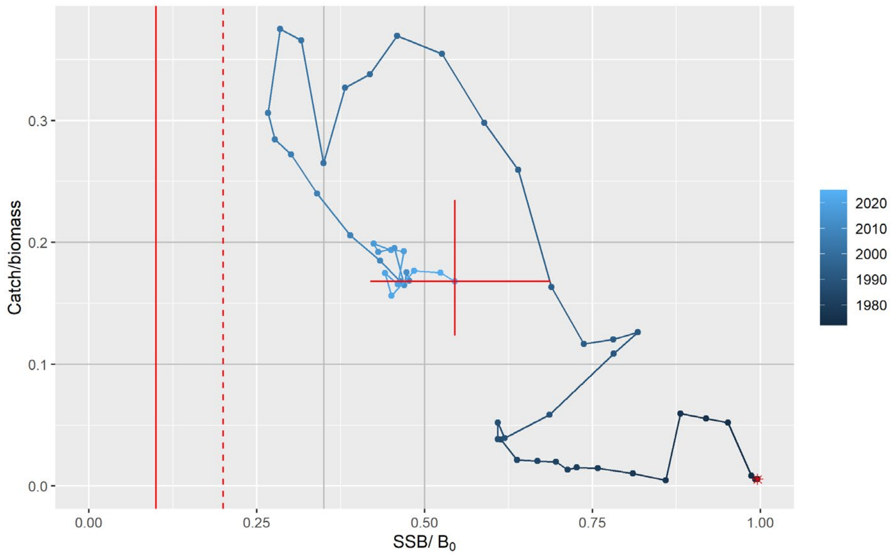
Both of these biological stocks lie within the HOK 1 Fishstock boundaries.

The tables below are based on the Base 2-stock model. However, the single stock model, which does not have the same stock structure assumptions, generally confirms the results below.

- **Eastern Hoki Stock**

Stock Status		
Most Recent Assessment Plenary Publication Year	2025	
Intrinsic productivity level	Medium	
Catch in most recent year of assessment	Year: 2023–24	Catch: 66 587 t
Assessment Runs Presented	Two stock base case: Base: two stock	
Reference Points	Target: 35–50% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{35\%B0}$	
Status in relation to Target	B_{2025} was estimated to be 55% B_0. Very Likely (> 90 %) to be above the lower end of the target range About as Likely as Not (40–60%) to be above the upper end of the range	
Status in relation to Limits	B_{2025} is Exceptionally Unlikely (< 1%) to be below both the Soft and Hard Limits	
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring	

Historical Stock Status Trajectory



Trajectories over time of fishing intensity (*U*; Catch/mid season SSB) and relative spawning biomass (SSB/SS*B₀*), for the eastern hoki stock from the start of the assessment period in 1972 (represented by a red asterisk) to 2025 (centre of red cross). The red solid vertical line at 10% *B₀* represents the hard limit, the red dashed line at 20% *B₀* is the soft limit, and the grey lines represent the management target ranges in biomass and fishing intensity, with fishing intensity estimated in the 2022 assessment using long-term recruitment. Biomass and fishing intensity estimates are medians from MCMC results. Red cross represents 95% CIs for 2025.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass has fluctuated with no trend since 2016–17.
Recent Trend in Fishing Intensity or Proxy	Fluctuating without trend since 2016–17
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	- The trawl survey of the Chatham Rise in 2024 suggested a below average 2022 year class, which is not included in the model.

Projections and Prognosis	
Stock Projections or Prognosis	The eastern stock is projected to remain within or above the target range over the next five years, with current catches or catch limits.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	For current catch or agreed catch limit: Soft Limit: Very Unlikely (< 10%) Hard Limit: Exceptionally Unlikely (< 1%)
Probability of Current Catch causing Overfishing to continue or to commence	For current catch: Very Unlikely (< 10%)

Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Age-structured Casal2 model with Bayesian estimation of posterior distributions	
Assessment Dates	Latest assessment Plenary publication year: 2025	Next assessment: 2027
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Research time series of abundance indices (trawl and acoustic surveys) - Proportions-at-age data from the commercial fisheries and trawl surveys - Estimates of fixed biological parameters	1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)	- Commercial CPUE	3 – Low Quality: does not track stock biomass over the long term
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Stock structure and migration patterns, in particular the migration from the Chatham Rise to the Sub-Antarctic - The split of recruitment between the eastern and western stocks for recent year classes - Growth and maturity data parameter estimates have not been updated since the 1990s - Relationship between the Cook Strait and the ECSI spawning areas.	

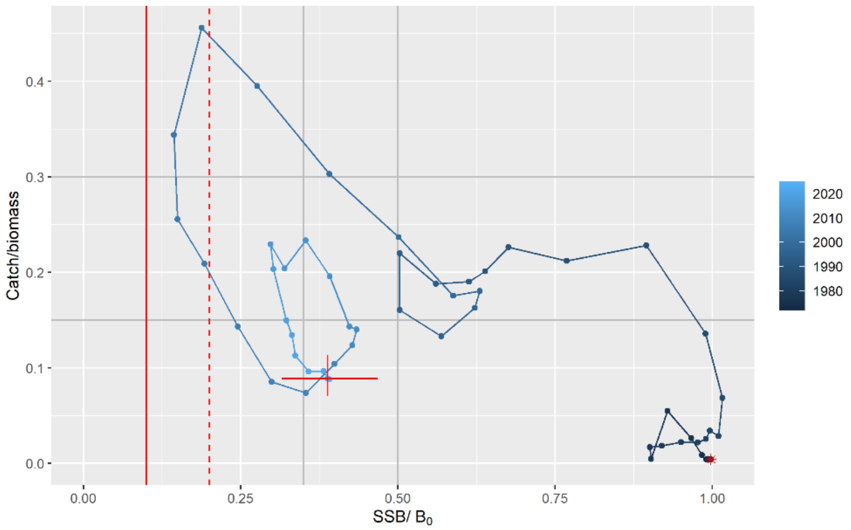
Qualifying Comments
-

Fishery Interactions
Hoki, hake, ling, silver warehou, and white warehou are frequently caught together, and trawl fisheries targeting these species are, as of 2018, considered one combined trawl fishery. The main non-target species caught in the combined fishery off the west coast South Island and Sub-Antarctic are rattails, javelinfish, and spiny dogfish. Incidental captures of protected species have been recorded for New Zealand fur seals, basking sharks, and seabirds. The only target method of capture in the hoki fishery is trawling using either bottom or midwater gear. Bottom trawling is likely to have effects on benthic community structure and function.

- **Western Hoki Stock**

Stock Status		
Most Recent Assessment Plenary Publication Year	2025	
Intrinsic productivity level	Medium	
Catch in most recent year of assessment	Year: 2023–24	Catch: 40 449 t
Assessment Runs Presented	Two stock base case: Base: two stock	
Reference Points	Target: 35–50% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{35\%B0}$	
Status in relation to Target	B_{2025} was estimated to be 39% B_0. Likely (> 90%) to be above the lower end of the target range Very Unlikely (< 10%) to be above the upper end of the target range	
Status in relation to Limits	B_{2025} is Very Unlikely (< 10%) to be below the Soft Limit and Exceptionally Unlikely (< 1%) to be below the Hard Limit	
Status in relation to Overfishing	Overfishing is Unlikely (< 40%) to be occurring	

Historical Stock Status Trajectory



Trajectories over time of fishing intensity (*U;* Catch/mid season SSB) and relative spawning biomass (SSB/SS*B₀*), for the western hoki stock from the start of the assessment period in 1972 (represented by a red asterisk) to 2025 (centre of red cross). The red solid vertical line at 10% *B₀* represents the hard limit, the red dashed line at 20% *B₀* is the soft limit, and the grey lines represent the management target ranges in biomass and fishing intensity, with fishing intensity estimated in the 2022 assessment using long-term recruitment. Biomass and fishing intensity estimates are medians from MCMC results. Red cross represents 95% CIs for 2025.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass has been increasing from 2021 to 2025.
Recent Trend in Fishing Intensity or Proxy	Declining since 2016–17
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	- The trawl survey of the WCSI northern area showed a decrease in abundance from 2021 to 2024 and was similar to that in 2018.

Projections and Prognosis	
Stock Projections or Prognosis	The western stock is projected to remain within the target range over the next five years, with current catches or catch limits and recent recruitment.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	For current catch or agreed catch limit: Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	For current catch or agreed catch limit: Unlikely (< 40%)

Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Age-structured Casal2 model with Bayesian estimation of posterior distributions	
Assessment Dates	Latest assessment Plenary publication year: 2025	Next assessment: 2027
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Research time series of abundance indices (trawl and acoustic surveys)	1 – High Quality
	- Proportions-at-age data from the commercial fisheries and trawl surveys	1 – High Quality
	- Estimates of fixed biological parameters	1 – High Quality
Data not used (rank)	- Commercial CPUE	3 – Low Quality: does not track stock biomass
	- WCSI trawl survey biomass estimate	3 – Low Quality: not considered to index spawning biomass
	- Some years of fishery age data	3 – Low quality: currently not used as it was not thought to be representative of the fishery
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Stock structure and migration patterns, in particular the migration from the Chatham Rise to the Sub-Antarctic - The split of recruitment between the eastern and western stocks for recent year classes - Growth and maturity data parameter estimates have not been updated since the 1990s - Estimation of q from Sub-Antarctic survey	

Qualifying Comments
-

Fishery Interactions
Hoki, hake, ling, silver warehou, and white warehou are frequently caught together, and trawl fisheries targeting these species are, as of 2018, considered one combined trawl fishery. The main non-target species caught in the combined fishery off the west coast South Island and Sub-Antarctic are rattails, javelinfish, and spiny dogfish. Incidental captures of protected species have been recorded for New Zealand fur seals, basking sharks, and seabirds. The only target method of capture in the hoki fishery is trawling using either

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