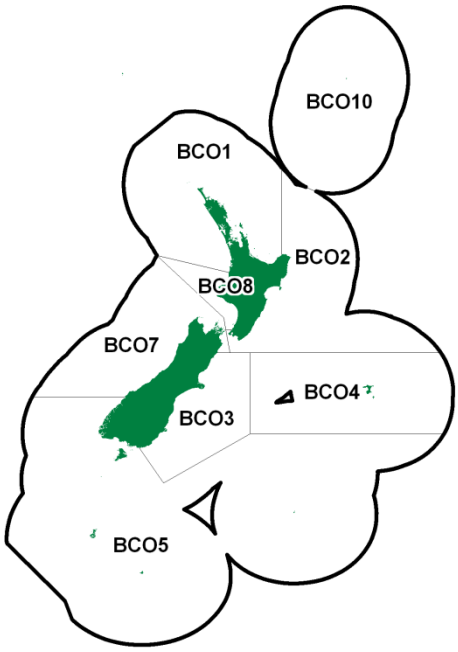
BLUE COD (BCO)

(Parapercis colias)
Rāwaru



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 blue cod by Fishstock.

Fishstock	Recreational allowance	Customary non-commercial allowance	Other sources of mortality	TACC	TAC
BCO 1*	–	–	–	46	–
BCO 2*	–	–	–	10	–
BCO 3	83	20	10	130	243
BCO 4	20	10	40	759	829
BCO 5	85	20	20	800	925
BCO 7	58	27	14	58	157
BCO 8	188	2	2	34	226
BCO 10*	–	–	–	10	–

* allowances and TAC not set

1.1 Commercial fisheries

Blue cod is predominantly an inshore domestic fishery with very little deepwater catch. The major commercial blue cod fisheries in New Zealand are off Southland and the Chatham Islands, with smaller but regionally significant fisheries off Otago, Canterbury, the Marlborough Sounds, and Wanganui.

The fishery has had a long history. National landings of up to 2400 t were reported in the 1930s and landings of over 1500 t were sustained for many years in the 1950s and 1960s (see Table 2). Fluctuations in annual landings since the 1930s can be attributed to World War II, the subsequent market for frozen blue cod for a short period of time, and then the development of the rock lobster fishery. Annual landings of blue cod also vary with the success of the rock lobster season. Traditionally many blue cod fishers were primarily rock lobster fishers. Therefore, the amount of effort in the blue cod fishery tended to depend on the success of the rock lobster season, with weather conditions in Southland affecting the number of 'fishable' days.

Total landings averaged 574 t in the 1970s before building up to 1546 t in 1985, the year before the QMS was implemented. Landings then declined to 1989 but have since increased, coinciding with a change in the main fishing method from hand lines to cod pots. Historical landings are given in Table 2, recent

reported landings are given in Table 3, and Figure 1 shows the historical landings and TACC values for the five main BCO Fishstocks. FSU landings 1970 to 1983 are given in Table 4.

Table 2: Reported landings (t) for the main QMAs from 1931 to 1982.

Year	BCO 1	BCO 2	BCO 3	BCO 4	BCO 5	BCO 7	BCO 8
1931–32	29	0	55	148	719	4	4
1932–33	12	0	59	111	726	1	5
1933–34	24	5	26	1 055	792	3	2
1934–35	17	5	23	1 306	1057	0	4
1935–36	18	23	34	1 197	284	44	2
1936–37	3	7	27	755	113	61	0
1937–38	2	8	31	793	172	81	0
1938–39	2	3	19	686	94	57	0
1939–40	1	4	33	715	135	68	0
1940–41	3	7	39	320	177	72	0
1941–42	2	5	30	189	128	54	0
1942–43	3	5	20	204	139	65	0
1943–44	4	12	31	212	221	80	0
1944	3	10	38	216	552	88	0
1945	8	6	45	102	634	109	0
1946	11	9	43	175	715	116	2
1947	8	22	81	278	955	153	1
1948	7	24	74	623	852	88	2
1949	37	6	98	390	929	82	3
1950	5	5	66	485	1005	94	1
1951	4	9	51	494	873	74	2
1952	5	7	53	543	889	95	3
1953	7	20	62	682	414	114	2
1954	5	9	84	603	385	112	2
1955	4	8	83	355	405	79	3
1956	1	7	86	636	656	77	2
1957	2	5	63	1185	581	61	2
1958	2	4	57	892	542	71	2
1959	1	2	51	1158	492	71	1
1960	1	4	48	903	757	65	2
1961	1	2	43	871	590	55	3
1962	1	9	37	550	668	65	3
1963	1	12	46	633	621	60	4
1964	1	107	83	495	462	70	3
1965	1	18	55	742	296	59	2
1966	1	395	35	13	337	79	6
1967	1	437	34	0	518	74	5
1968	1	312	69	0	494	105	2
1969	6	232	92	8	361	60	1
1970	0	402	70	39	432	70	8
1971	1	105	81	36	375	44	2
1972	0	137	60	3	194	63	1
1973	1	127	65	4	571	68	11
1974	0	67	61	1	486	61	16
1975	0	5	42	2	232	58	14
1976	0	103	72	17	254	58	17
1977	2	3	21	46	208	87	19
1978	0	9	49	14	197	104	12
1979	0	17	74	13	217	98	16
1980	1	1	89	1	403	62	18
1981	1	2	69	40	494	79	23
1982	7	0	62	13	356	68	34

During the fishing years 1994–95 to 2017–18, total landings exceeded 2000 t annually, peaking at 2501 t in 2003–04. In 2018–19 landings dropped to 1844 t and in 2020–21, when the overall TACC was reduced to 1893 t, 1748 t were landed. Historically, the largest catches of blue cod have been taken in BCO 5 (1556 t in fishing year 2003–04). The total landings from this fishery remained relatively stable from 1982 to 1993 and subsequently increased to approach the level of the TACC in 1995–96. Landings have been declining since 2003–04, and the TACC was lowered to 1239 t in 2011–12 and 880 t in 2020–21. In 2018–19, less than 1000 t of landings were recorded for the first time since 1991–92, landings declining to 627 t in 2023–24.

Table 3: Reported landings (t) of blue cod by Fishstock from 1983 to present and actual TACCs (t) from 1986–87 to present. QMS data from 1986 to present. FSU data cover 1983–1986. [Continued on next page]

Fishstock	BCO 1		BCO 2		BCO 3		BCO 4		BCO 5	
FMA (s)	1 & 9		2		3		4		5 & 6	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983	23	–	4	–	81	–	192	–	626	–
1984	39	–	6	–	74	–	273	–	798	–
1985	21	–	3	–	55	–	274	–	954	–
1986	19	–	2	–	82	–	337	–	844	–
1986–87	8	30	1	10	84	120	417	600	812	1 190
1987–88	9	40	1	10	148	140	204	647	938	1 355
1988–89	8	42	1	10	136	142	279	647	776	1 447
1989–90	10	45	1	10	121	151	358	749	928	1 491
1990–91	12	45	< 1	10	144	154	409	757	1 096	1 491
1991–92	10	45	1	10	135	154	378	757	873	1 536
1992–93	12	45	4	10	171	156	445	757	1 029	1 536
1993–94	14	45	2	10	142	162	474	757	1 132	1 536
1994–95	13	45	1	10	155	162	565	757	1 218	1 536
1995–96	11	45	2	10	158	162	464	757	1 503	1 536
1996–97	13	45	2	10	156	162	423	757	1 326	1 536
1997–98	16	45	4	10	163	162	575	757	1 364	1 536
1998–99	12	45	2	10	150	162	499	757	1 470	1 536
1999–00	14	45	2	10	168	162	490	757	1 357	1 536
2000–01	15	45	2	10	154	162	627	757	1 470	1 536
2001–02	12	46	2	10	138	163	648	759	1 477	1 548
2002–03	11	46	4	10	169	163	724	759	1 497	1 548
2003–04	9	46	4	10	167	163	710	759	1 556	1 548
2004–05	9	46	5	10	183	163	731	759	1 473	1 548
2005–06	7	46	1	10	183	163	580	759	1 346	1 548
2006–07	6	46	4	10	177	163	747	759	1 382	1 548
2007–08	6	46	3	10	167	163	779	759	1 277	1 548
2008–09	7	46	8	10	158	163	787	759	1 391	1 548
2009–10	8	46	7	10	171	163	691	759	1 210	1 548
2010–11	7	46	8	10	183	163	781	759	1 296	1 548
2011–12	6	46	8	10	166	163	753	759	1 215	1 239
2012–13	9	46	7	10	170	163	739	759	1 207	1 239
2013–14	9	46	8	10	159	163	720	759	1 208	1 239
2014–15	11	46	7	10	175	163	796	759	1 132	1 239
2015–16	9	46	6	10	169	163	758	759	1 099	1 239
2016–17	12	46	10	10	170	163	741	759	1 152	1 239
2017–18	8	46	12	10	174	163	752	759	1 027	1 239
2018–19	9	46	9	10	177	163	744	759	827	1 239
2019–20	8	46	7	10	180	163	732	759	926	1 239
2020–21	9	46	7	10	183	163	703	759	788	800
2021–22	4	46	3	10	132	130	720	759	800	800
2022–23	4	46	5	10	135	130	783	759	745	800
2023–24	6	46	8	10	142	130	776	759	627	800

Fishstock	BCO 7		BCO 8		BCO 10		Total	
FMA (s)	7		8		10			
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983	91	–	53	–	0	–	1 070	–
1984	129	–	56	–	0	–	1 375	–
1985	169	–	70	–	0	–	1 546	–
1986	83	–	42	–	0	–	1 409	–
1986–87	79	110	22	60	0	10	1 422	2 130
1987–88	78	126	44	72	0	10	1 420	2 400
1988–89	66	131	32	72	0	10	1 298	2 501
1989–90	75	136	34	74	0	10	1 527	2 666
1990–91	63	136	28	74	0	10	1 752	2 667
1991–92	57	136	25	74	0	10	1 480	2 722
1992–93	85	136	32	74	0	10	1 777	2 724
1993–94	67	95	21	74	0	10	1 852	2 689
1994–95	113	95	24	74	0	10	2 089	2 689
1995–96	65	70	31	74	0	10	2 234	2 664
1996–97	71	70	38	74	0	10	2 029	2 664
1997–98	60	70	15	74	0	10	2 197	2 664
1998–99	52	70	35	74	0	10	2 220	2 664
1999–00	28	70	30	74	0	10	2 089	2 664
2000–01	26	70	22	74	0	10	2 316	2 664
2001–02	30	70	17	74	0	10	2 319	2 680
2002–03	39	70	13	74	0	10	2 457	2 680
2003–04	45	70	10	74	0	10	2 501	2 680
2004–05	44	70	7	74	0	10	2 452	2 680
2005–06	50	70	20	74	0	10	2 184	2 680
2006–07	69	70	34	74	0	10	2 413	2 680
2007–08	59	70	22	74	0	10	2 313	2 680
2008–09	58	70	18	74	0	10	2 427	2 680
2009–10	59	70	16	74	0	10	2 162	2 680
2010–11	51	70	16	74	0	10	2 342	2 681

Table 3 [Continued]:

Fishstock FMA (s)	BCO 7 7		BCO 8 8		BCO 10 10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
2011–12	54	70	10	34	0	10	2 214	2 332
2012–13	71	70	12	34	0	10	2 215	2 332
2013–14	58	70	12	34	0	10	2 174	2 332
2014–15	68	70	8	34	0	10	2 198	2 332
2015–16	60	70	4	34	0	10	2 096	2 332
2016–17	65	70	5	34	0	10	2 155	2 332
2017–18	71	70	4	34	0	10	2 049	2 332
2018–19	64	70	14	34	0	10	1 844	2 332
2019–20	57	70	3	34	0	10	1 914	2 332
2020–21	55	70	3	34	0	10	1 748	1 893
2021–22	48	70	1	34	0	10	1 709	1 860
2022–23	39	58	< 1	34	0	10	1 711	1 848
2023–24	34	58	1	34	0	10	1 594	1 848

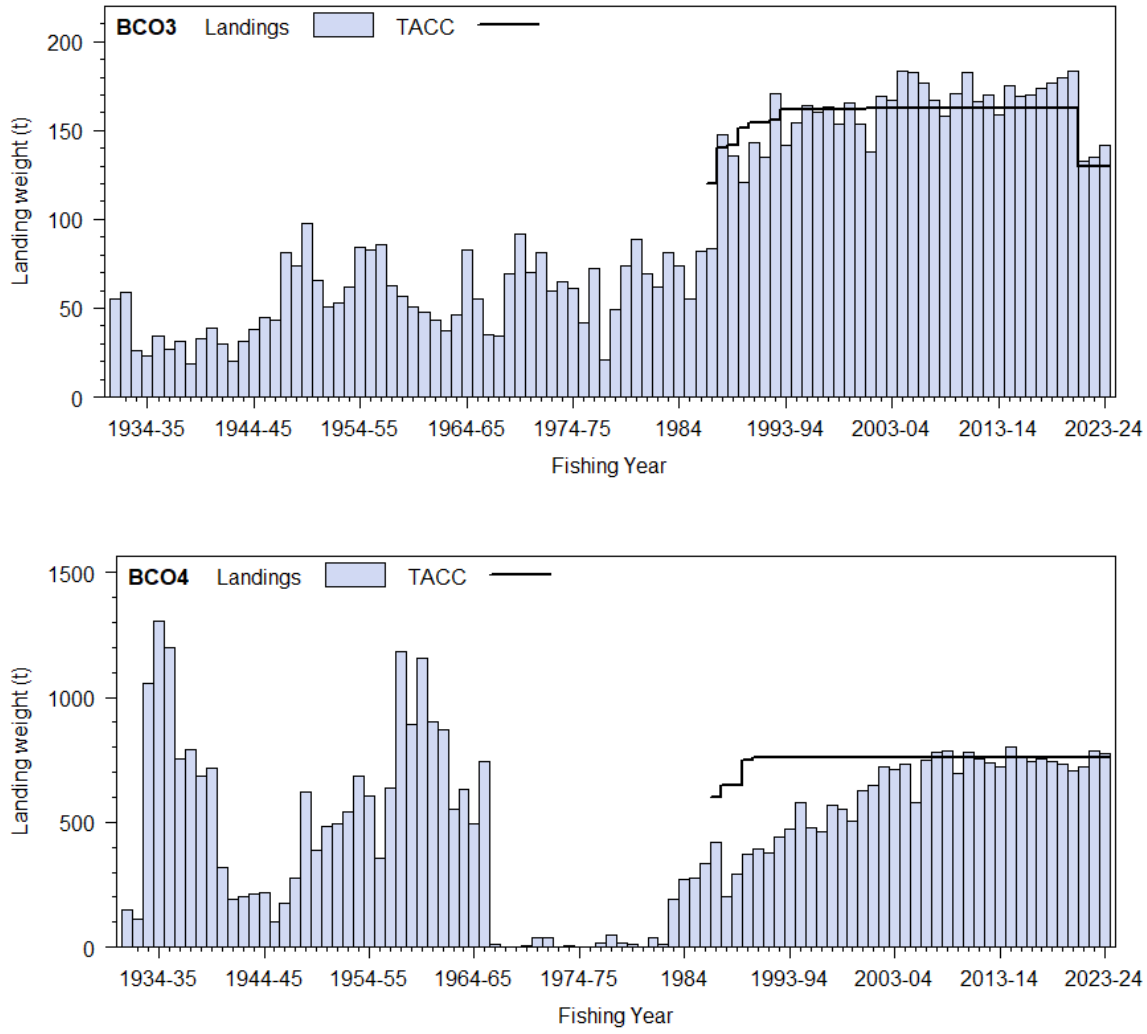


Figure 1: Reported commercial landings and TACC for the five main BCO stocks. From top: BCO 3 (South East Coast) and BCO 4 (South East Chatham Rise). [Continued on next page]

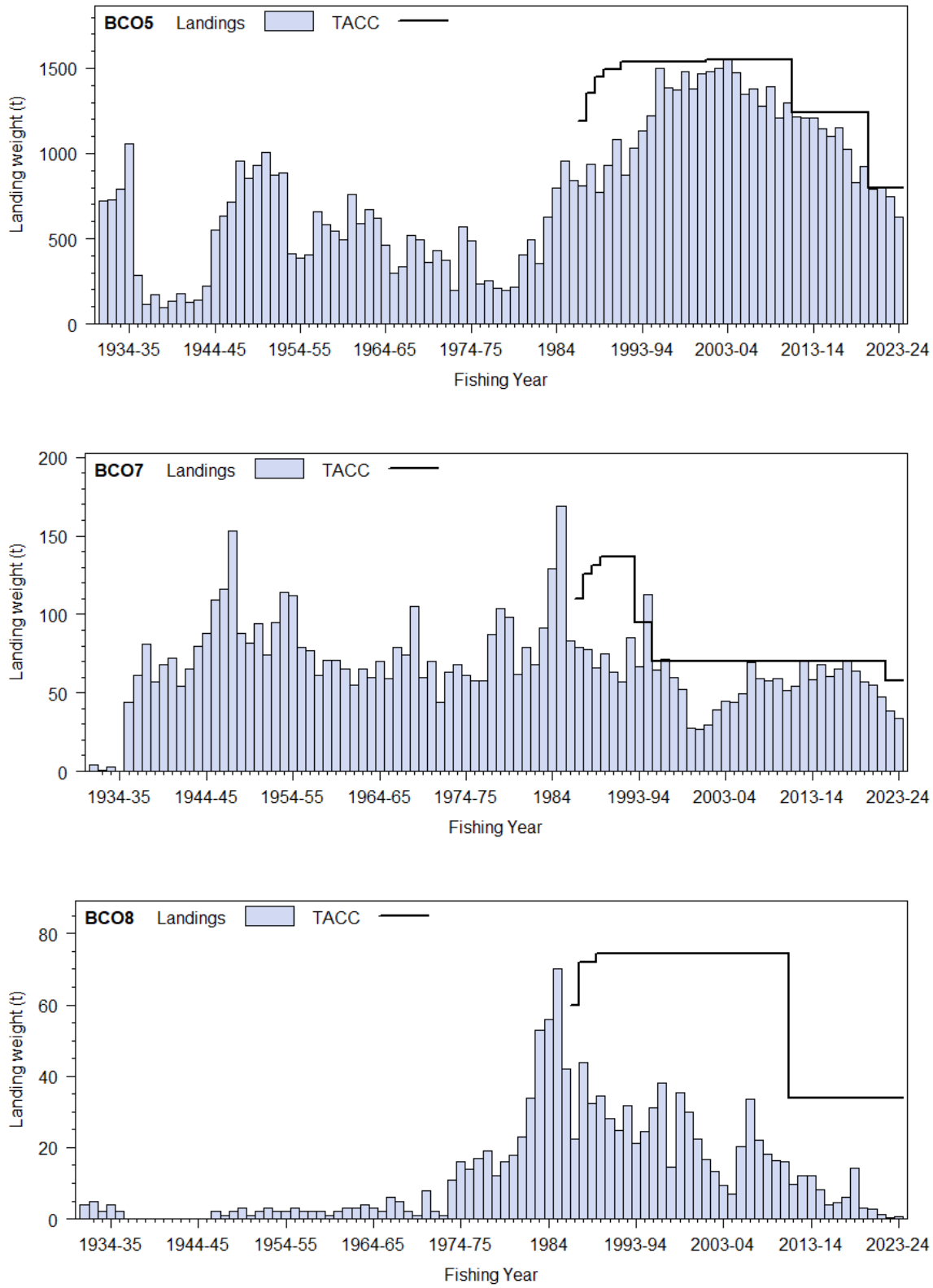


Figure 1 [Continued]: Reported commercial landings and TACC for the five main BCO stocks. From top: BCO 5 (Southland), BCO 7 (Challenger) and BCO 8 (Central Egmont).

Table 4: Reported total New Zealand landings (t) of blue cod for the calendar years 1970 to 1983. Sources MAF and FSU data.

Year	Landings
1970	1 022
1971	644
1972	459
1973	846
1974	696
1975	356
1976	524
1977	383
1978	378
1979	437
1980	536
1981	696
1982	539
1983	1 135

1.2 Recreational fisheries

Blue cod are the most important recreational finfish in Marlborough, Otago, Canterbury, Southland, and the Chatham Islands. Blue cod are taken predominantly by line fishing, but also by longlining, set netting, potting, and spearfishing. The current allowances within the TAC for each Fishstock are shown in Table 1.

1.2.1 Management controls

The main methods used to manage recreational harvests of blue cod are minimum legal size (MLS) limits, method restrictions, and daily bag limits. Daily bag limits are specified as either blue cod specific (DL) or a combined species limit (CDL). The main management controls have changed over time and vary by Fishstock (Table 5). In addition, there have been temporary and seasonal closures in the Marlborough Sounds and several Fiordland sounds.

Table 5: Minimum legal size (MLS in cm), blue cod specific daily bag limit (DL), and combined species daily bag limit (CDL) by Fishstock from 1986 to present. Slot = slot limit (legal size range). * DS = Doubtful Sounds, TS = Thompson Sound, BS = Bradshaw Sound. C = inner sounds closed. # excluding Challenger East. † bag limit of 6 inside Te Whaka ā Te Wera Mātaitai Reserve. There are two separate areas with different bag limits in each of BCO 3 South East and BCO 5 Southland (see text below for more detail). [Continued on next page]**

Fishstock	BCO 1		BCO 2		BCO 3 South East (Otago)		BCO 3 North Canterbury		BCO 3 Kaikōura Marine Area		BCO 4 South East (Chatham Is.)	
Area	Auckland		Central (East)									
	MLS	CDL	MLS	CDL	MLS	CDL	MLS	DL	MLS	DL	MLS	CDL
1986	30	30	30	30	30	30	30	30	N/A	N/A	30	30
1993	33	20	33	20	30	30	30	30	N/A	N/A	30	30
1994	33	20	33	20	30	30	30	30	N/A	N/A	30	30
2001	33	20	33	20	30	30	30	10	N/A	N/A	30	30
2008	30	20	33	20	30	30	30	10	N/A	N/A	30	30
2014	30	20	33	20	30	30	30	10	33	6	30	30
2017	30	20	33	20	30	30	30	10	33	6	30	30
2020	30	20	33	20	33	10/15	33	2	33	6	33	15

Fishstock	BCO 5 Southland & Fiordland (External)		BCO 5 Paterson Inlet †		BCO 5 Fiordland internal (excl. DS, TS, BS*)		BCO 5 DS, TS, BS*		BCO 7 Challenger West & South		BCO 7 Challenger East (incl. Marlborough Sounds)	
Area												
	MLS	CDL	MLS	DL	MLS	DL	MLS	DL	MLS	DL	MLS	DL
1986	30	30	30	30	33	20	33	20	30	30	30	12
1993	33	30	33	30	33	20	33	20	33	20	33	10
1994	33	30	33	15	33	20	33	20	33	20	28	6
2001	33	30	33	15	33	20	33	20	33	20	28	6
2003	33	30	33	15	33	20	33	20	33	20	30	3
2005	33	30	33	15	33	20	C**	C**	33	20	30	3
2008	33	30	33	15	33	20	C**	C**	33	20	C**	C**
2011	33	30	33	15	33	20	C**	C**	33	20	#SLOT 30–35	2
2014	33	20	33	15	33	20	C**	C**	33	20	#SLOT 30–35	2
2015	33	20	33	15	33	3	33	1	33	20	33	2
2017	33	20	33	15	33	3	33	1	33	20	33	2
2020	33	15/10	33	15	33	3	33	1	33	10	33	2

Table 5 [Continued]:

Fishstock	BCO 8		BCO 10	
Area	Central (West)		Kermadec	
	MLS	DL	MLS	CDL
1986	30	30	30	30
1993	33	20	33	20
2014	33	10	33	20
2017	33	10	33	20
2020	33	10	33	20

1.2.2 Estimates of recreational harvest

The first recreational harvest estimates for blue cod were provided by offsite telephone-diary surveys conducted between 1991 and 2001 (Bradford 1998, Teirney et al 1997, Boyd et al 2004). These estimates are no longer considered to be reliable by the Marine Amateur Fishing Working Group (MAFWG), because the method was prone to 'soft refusal' bias during recruitment of potential participants and overstated catches during reporting (Wright et al 2004). The recreational harvest estimates provided by the 2000 and 2001 telephone-diary surveys were also thought to be implausibly high for many species by the MAFWG.

Concerns over these estimates led to the development of an alternative maximum count aerial-access onsite method that provides a more direct means of estimating recreational harvests for suitable fisheries. The maximum count aerial-access approach combines data collected concurrently from two sources: a creel survey of recreational fishers returning to a subsample of ramps throughout the day; and an aerial survey count of vessels observed to be fishing at the approximate time of peak fishing effort on the same day. The ratio of the aerial count in a particular area to the number of interviewed parties who claimed to have fished in that area at the time of the overflight was used to scale up harvests observed at surveyed ramps, to estimate harvest taken by all fishers returning to all ramps. The methodology is further described by Hartill et al (2007).

This aerial-access method was first employed, optimised for snapper (SNA), in the Hauraki Gulf in 2003–04. It was then extended to survey the wider SNA 1 fishery in 2004–05 and to other areas (SNA 8) and other species, including blue cod in BCO 7 in 2005–06 (Davey et al 2008). The estimates for BCO 7 in 2005–06 may not be accurate for two reasons. A large proportion of the fishing effort observed during aerial surveys of the outer Marlborough Sounds was from launches and other vessels that would not have returned to the surveyed boat ramps, because they would have returned to other access points and often on following days. A significant proportion of the boats fishing in the inner Marlborough Sounds may also have returned to a bach/crib rather than a surveyed ramp. For both these situations it was therefore necessary to assume that the catch and effort of these boats would have been the same as that reported by boats returning to surveyed boat ramps on the same day, which may not have been the case. A repeat aerial-access survey was conducted in BCO 7 over the 2015–16 fishing year (Hartill et al 2017) and this was considered by the Marine Amateur Fisheries Working Group to be more reliable than the initial survey because a greater number of days were surveyed in this year, and a pilot survey was undertaken to determine where boats fishing in the inner Marlborough Sounds had originated from, which led to interviews being conducted at two extra high traffic ramps in this area. The recreational harvest from BCO 7 in 2015–16 was about half that in 2005–06 (Table 6), almost with all the decrease being in the Marlborough Sounds.

In response to the cost and scale challenges associated with onsite methods, in particular the difficulties in sampling other than trailer boat fisheries, offsite approaches to estimating recreational fisheries harvest have been revisited. This led to the implementation of a national panel survey during the 2011–12 fishing year (Wynne-Jones et al 2014). The panel survey used face-to-face interviews of a random sample of 30 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and harvest information in standardised phone interviews. The national panel survey was repeated during the 2017–18 and 2022–23 fishing years using very similar methods to produce directly comparable results (Wynne-Jones et al 2019; Heinemann & Gray 2024). Recreational catch estimates from the three national panel surveys are given in Table 6. Note that national panel survey estimates do not include recreational harvest taken on charter vessel trips or under s111 general approvals. National surveys have not included BCO 4.

Table 6: Recreational harvest estimates for blue cod stocks. The aerial-access survey ran from December to November but are denoted by the January calendar year. The national panel surveys ran throughout the October to September fishing years but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys (for the panel survey harvest estimates). Amateur charter vessel (ACV) and recreational take from commercial vessels under s111 general approvals as reported, with Total the sum of NPS, ACV and s111. ACVs have only been required to report harvest for BCO 1 since 2020–21, but other BCO stocks since 2010–11.

				Harvest survey		ACV	s111	Total
Stock	Year	Method	Number of fish	Estimate (t)	CV	(t)	(t)	(t)
BCO 1	2012	Panel survey	18 312	7.9	0.20	0.1	1.0	9.1
	2018	Panel survey	14 532	6.6	0.18	0.2	0.6	7.3
	2023	Panel survey	1 699	0.9	0.32	0.1	0.1	1.1
BCO 2	2012	Panel survey	53 631	26	0.19	0.1	1.1	27.3
	2018	Panel survey	47 835	28	0.26	1.0	1.1	30.0
	2023	Panel survey	33 031	18	0.40	0.4	0.5	18.7
BCO 3	2012	Panel survey	212 552	101	0.20	26.7	3.4	131.4
	2018	Panel survey	182 938	89	0.19	16.0	3.7	108.6
	2023	Panel survey	90 593	51	0.24	13.9	2.1	66.9
BCO 5	2012	Panel survey	72 316	44	0.24	15.9	17.2	76.8
	2018	Panel survey	129 916	62	0.22	18.4	15.1	95.7
	2023	Panel survey	97 419	53	0.18	19.8	21.5	94.6
BCO 7	2006	Aerial-access	–	149	0.16			
	2012	Panel survey	175 917	75	0.17	3.8	1.0	79.5
	2016	Aerial-access	–	75	0.15			
	2018	Panel survey	122 620	60	0.13	3.7	1.0	64.3
	2023	Panel survey	59 597	30	0.17	2.5	0.9	33.3
BCO 8	2012	Panel survey	88 146	48	0.37	1.0	0.1	48.7
	2018	Panel survey	59 182	29	0.21	2.0	0.2	31.0
	2023	Panel survey	18 101	8	0.26	0.2	0.0	8.0

1.2.3 Charter vessel harvest

The national marine diary survey of recreational fishing from charter vessels in 1997–98 found blue cod to be the second most frequently landed species nationally and the most frequently landed species in the South Island. Results indicated that recreational harvests from charter vessels (Table 7) follow the same pattern as overall recreational harvest (Table 6). The estimated recreational harvests from charter vessels in BCO 7 exceeded the 1997–98 TACC and the commercial landings in QMA 7.

Table 7: Results of a national marine diary survey of recreational fishers from charter vessels, 1997–98 (November 1997 to October 1998).*

Fishstock	Number caught	CV	Estimated landings (number of fish killed)	Point Estimate (t)
BCO 1	430	0.18	2 500	2.4
BCO 2	34	0.50	300	0.2
BCO 3	17 272	0.29	72 000	58
BCO 5	16 750	0.36	63 000	51
BCO 7	32 026	0.13	110 000	76
BCO 8	2	–	–	0

*Estimated number of blue cod harvested by recreational fishers on charter vessels by Fishstock and the corresponding harvest tonnage. The mean weights used to convert numbers to harvest weight were considered the best available at the time (James & Unwin 2000).

1.3 Customary non-commercial fisheries

No quantitative data on historical or current blue cod customary non-commercial catch are available. However, bones found in middens show that blue cod was a significant species in the traditional Māori take of pre-European times.

1.4 Illegal catch

No quantitative data on the levels of illegal blue cod catch are available.

1.5 Other sources of mortality

Blue cod have in the past been used for bait within the rock lobster fishery. Pots are either set specifically to target blue cod or have a bycatch of blue cod that is used for bait. However, these fish are frequently not recorded and the quantity of blue cod used as bait cannot be accurately determined.

Cod pots covered in 38 mm mesh frequently catch undersized blue cod. It has been estimated that in Southland, 65% of blue cod caught in these pots are less than 33 cm. (The commercial MLS was increased from 30 cm to 33 cm in 1994.) When returned, the mortality of these fish can be high due to predation by mollymawks following commercial boats. It is estimated by the fishing industry that up to 50% of returned fish can be taken by birds. To reduce the problem of predation of returned undersized fish, a minimum 48 mm mesh size was introduced to BCO 5 in 1994. However, no mesh size restrictions existed in any other area. An experiment conducted by Glen Carbines on commercial vessels in 2015 to quantify the reduction in undersized blue cod caught in pots with the alternative mesh size showed that almost all retained undersized fish were dead when returned to the water. Even though blue cod are not subject to barotrauma, because they have no swim bladders, the high mortality was the result of undersized blue cod being returned after the catch had been processed. In 2018 the mesh size in BCO 5 was increased to 54 mm, and on 1 July 2020 the mesh size for all areas was increased to 54 mm.

Recreational line fishing often results in the harvest of undersized blue cod. The survival of these fish has been shown to be a factor of hook size. A small-scale experiment showed that returned undersized fish caught with small hooks (size 1/0) experience 25% mortality, whereas those caught with large hooks (size 6/0) appear to have little or no mortality (Carbines 1999). With the increase in MLS from 30 cm to 33 cm in July 2020 throughout the South Island waters, the number of undersized blue cod returned by recreational fishers has increased to the extent that in some places considerably more fish are caught and returned than are kept.

2. BIOLOGY

Blue cod is a bottom-dwelling species endemic to New Zealand. Although distributed throughout New Zealand near foul ground to a depth of 150 m, they are more abundant south of Cook Strait and around the Chatham Islands. Growth may be influenced by a range of factors, including sex, habitat quality, and fishing pressure relative to location (Carbines 2004a). Size-at-sexual maturity also varies according to location. In Northland, maturity is reached at 10–19 cm total length (TL) at an age of 2 years, whereas in the Marlborough Sounds it is reached at 21–26 cm TL at 3–6 years. In Southland, the fish become mature at 26–28 cm TL, at an age of 4–5 years. Blue cod have also been shown to be protogynous hermaphrodites, with some individuals over a large length range changing sex from female to male (Carbines 1998). Blue cod are a diandric species where males either develop directly from the undifferentiated state without sex inversion (primary males) or begin life as female and become male following sex inversion (secondary males) (Beentjes 2021). Validated age estimates using otoliths have shown that blue cod males grow faster and are larger than females (Walsh 2017). The maximum recorded age for this species is about 32 years.

Recruitment in blue cod is highly variable between years with subpopulations closer to each other having similar age compositions, and strong and weak recruitment events are spatially linked (Beentjes 2021). The key processes that drive recruitment strength appear to be acting on a large spatial scale and are likely to be density-independent, due to environmental fluctuations.

An M of 0.17 was based on the empirical age distribution from the offshore Banks Peninsula survey in 2016, aged using the blue cod age determination protocol. The M estimate is based on the 1% tail of the distribution, which was 27 years, not the maximum age. The default M for blue cod was changed from 0.14 to 0.17 in April 2019 following the recommendation of the Inshore Working Group. Biological parameters relevant to stock assessment are shown in Table 8.

Blue cod have an annual reproductive cycle with an extended spawning season during late winter and spring. Spawning has been reported within inshore and mid-shelf waters. It is also likely that spawning occurs in outer-shelf waters. Ripe blue cod are also found in all areas fished commercially by blue cod fishers during the spawning season. Batch fecundity was estimated by Beer et al (2013). Eggs are pelagic for about five days after spawning, and the larvae are pelagic for about five more days before settling onto the seabed. Juveniles (less than about 10 cm TL) are not caught by commercial potting or lining, and therefore blue cod are not vulnerable to the main commercial fishing methods until they are mature. The commercial potting mesh size of 54 mm allows fish of about 33 cm and below to escape.

Recreational methods do catch juveniles, but, since this species does not have a swim bladder, the survival of these fish is good if they are caught using large hooks (6/0) (which do not result in gut hooking) and returned to the sea quickly (Carbines 1999).

Table 8: Estimates of biological parameters for blue cod. These estimates are survey specific and reflect varying exploitation histories and environmental conditions. Only von Bertalanffy growth parameters derived from otoliths aged using the Age Determination Protocol for Blue Cod (Walsh 2017) are included in this table.

Fishstock	Estimate	Source
1. Natural mortality (*M*)		
All	0.17	Doonan (2020)

2. von Bertalanffy growth parameters

	Females			Males			
Survey/year	L_∞	K	t_0	L_∞	k	t_0	
Dusky Sound (2014)	46.7	0.129	-1.8	50.3	0.222	0.638	Beentjes & Page (2016)
Kaikōura (2015)	40.7	0.174	-1.12	52.3	0.171	-0.27	Beentjes & Page (2017)
Banks Peninsula (2016)	50.2	0.116	-2.07	58.7	0.134	-1.21	Beentjes & Fenwick (2017)
Marlborough Sounds (2017)	32.2	0.52	0.83	39.9	0.37	0.69	Beentjes et al (2018)
Paterson Inlet (2018)	40.0	0.20	-4.31	46.8	0.21	0.215	Beentjes & Miller (2020)

3. Weight = a(length)^b (Weight in g, length in cm total length).

Area			a	b	R^2	
Kaikōura	2011	Male	0.011793	3.09246	0.97	Carbines & Haist (2012b)
	2011	Female	0.007042	3.23949	0.95	
Motunau	2012	Male	0.01490	3.03796	0.98	Carbines & Haist (2012b)
	2012	Female	0.01384	3.05982	0.97	
Banks Peninsula	2012	Male	0.019138	2.98181	0.98	Carbines & Haist (2012a)
	2012	Female	0.016939	3.02644	0.96	
North Otago	2013	Male	0.01093	3.10941	0.98	Carbines & Haist (2014b)
	2013	Female	0.012023	3.09201	0.97	
South Otago	2013	Male	0.008472	3.19011	0.99	Carbines & Haist (2014c)
	2013	Female	0.008617	3.1863	0.99	
Fiordland	2002	Male	0.007825	3.1727	0.97	Carbines & Beentjes (2003)
(Dusky Sound)	2002	Female	0.00506	3.2988	0.98	
Stewart Island	2010	Male	0.00663	3.2469	0.98	Carbines & Haist (2014a)
(Paterson Inlet)	2010	Female	0.00663	3.2469	0.98	
Marlborough	2017	Male	0.00674	3.218	0.96	Beentjes et al (2018)
Sounds	2017	Female	0.00648	3.238	0.94	

Tagging experiments carried out in the Marlborough Sounds in the 1940s and 1970s suggested that most blue cod remained in the same area for extended periods. A more recent tagging experiment carried out in Foveaux Strait (Carbines 2001) showed that although some blue cod moved as far as 156 km, 60% travelled less than 1 km. A similar pattern was found in Dusky Sound where from a total of 61 recaptures, four fish moved over 20 km but 65% had moved less than 1 km (Carbines & McKenzie 2004). The larger movements observed during this study were generally eastwards into the fiord. The inner half of the fiord was found to drain the outer strata and had 100% residency.

The preliminary results of a mitochondrial DNA analysis (Smith 2012) suggest that the Chatham Island blue cod are likely to be genetically distinct from mainland New Zealand fish. Over larger distances the mainland New Zealand blue cod appear to show a pattern of Isolation-by-Distance or continuous genetic change among populations. However, there is no evidence that blue cod are genetically distinct around the New Zealand mainland (Gebbie 2014).

3. STOCKS AND AREAS

The FMAs are used as a basis for Fishstocks, except FMAs 5 and 6, and FMAs 1 and 9, which have been combined. The choice of these boundaries was based on a general review of the distribution and relative abundance of blue cod within the fishery.

There are no data that would alter the current stock boundaries. However, tagging experiments suggest that blue cod populations may be geographically isolated from each other, and there may be several distinct sub-populations within each management area (particularly those occurring in sounds and inlets).

4. STOCK ASSESSMENT

4.1 Estimates of abundance

Blue cod stocks within BCO 3, BCO 4, BCO 5 and BCO 7 are monitored through a combination of potting surveys (Beentjes 2019) and commercial CPUE (specific details provided in the individual stock chapters). A fully quantitative stock assessment has been completed for BCO 5 (Doonan 2020), but a more recent update was not accepted (Doonan & McKenzie 2024). CPUE based management procedures have also been developed for BCO 5 but have not been formally adopted for management.

No stock assessments are available for BCO 1, BCO 2, BCO 8 or BCO 10.

4.2 Other factors

Blue cod fishing patterns have been strongly influenced by the development and subsequent fluctuations in the rock lobster fishery, especially in the Chatham Islands, Southland, and Otago. Once a labour-intensive hand-line fishery, blue cod are now taken mostly by cod pots. The fishery had decreased in the past; however, with the advent of cod pots it rapidly redeveloped. Anecdotal information from recreational fishers suggests that there is local depletion in some parts of BCO 3, BCO 5, and BCO 7 where fishing has been concentrated. Blue cod abundance (Carbines & Cole 2009), catch (Cranfield et al 2001), and productivity (Jiang & Carbines 2002, Carbines et al 2004) may also be affected by disturbance of benthic habitat.

4.3 Future research considerations

All BCO stocks

- Explore the consequences of different mechanisms of sex change in blue cod in terms of how it might affect reference points as well as population parameters (Z, M, growth rates) through simulation studies.
- Explore the potential of tank experiments to understand the drivers of sex change in blue cod.
- Re-age otoliths from historical surveys (offshore Banks area) using new protocols with the aim to provide estimates of M.
- Investigate the potential of non-invasive approaches to sex blue cod from marine reserves (ultrasound, blood chemistry?).
- Investigate the potential for genetics for ageing (and sex) for marine reserves or closed areas.
- Re-examine the selectivity priors, including collecting more information about the effects of changing mesh size regulations on fishing behaviour and CPUE. This applies across all BCO fisheries.

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