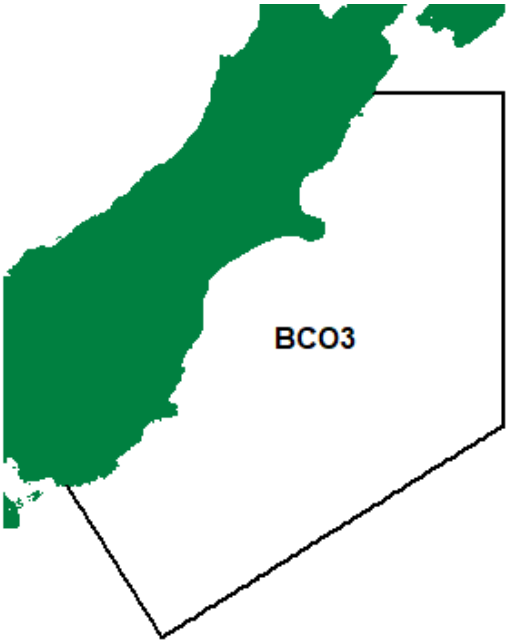
BLUE COD (BCO 3)

(Parapercis colias)
Rāwaru



1. FISHERY SUMMARY

Allowances, TACC, and TAC for BCO 3 are shown in Table 1.

Table 1: **Recreational and Customary non-commercial allowances, other mortality, TACCs, and TACs (t) for BCO 3.**

Fishstock	Recreational allowance	Customary non-commercial allowance	Other sources of mortality	TACC	TAC
BCO 3	83	20	10	130	243

1.1 Commercial fisheries

Table 2 and Table 3 provide a summary of the reported commercial catches, TACCs, and TACs for BCO 3. Landings and TACCs are plotted in Figure 1.

The BCO 3 commercial catch is dominated by the target pot fishery, although blue cod is also taken as a bycatch of the inshore trawl fisheries operating within BCO 3. Most of the catch from BCO 3 is taken in the southern area of the Fishstock (Statistical Areas 024 & 026). Catches from BCO 3 peak during autumn and winter and the seasonal nature of the fishery is influenced by the operation of the associated rock lobster fishery. The TACC for BCO 3 increased from 120 t to 163 t in a number of steps between 1986 and 2001. From 1 October 2021 the TACC was reduced to 130 t, within a TAC of 243 t (Table 1).

Table 2: Reported landings (t) of blue cod from BCO 3 from 1931 to 1982.

Year	BCO 3	Year	BCO 3	Year	BCO 3	Year	BCO 3
1931–32	55	1944	38	1957	63	1970	70
1932–33	59	1945	45	1958	57	1971	81
1933–34	26	1946	43	1959	51	1972	60
1934–35	23	1947	81	1960	48	1973	65
1935–36	34	1948	74	1961	43	1974	61
1936–37	27	1949	98	1962	37	1975	42
1937–38	31	1950	66	1963	46	1976	72
1938–39	19	1951	51	1964	83	1977	21
1939–40	33	1952	53	1965	55	1978	49
1940–41	39	1953	62	1966	35	1979	74
1941–42	30	1954	84	1967	34	1980	89
1942–43	20	1955	83	1968	69	1981	69
1943–44	31	1956	86	1969	92	1982	62

Table 3: Reported landings (t) of blue cod from BCO 3 from 1983 to present and actual TACCs (t) from 1986–87 to present. QMS data from 1986 to present. FSU data cover 1983–1986.

Fishstock FMA (s)	BCO 3 3		Fishstock FMA (s)	BCO 3 3		Fishstock FMA (s)	BCO 3 3	
	Land	TACC		Land	TACC		Land	TACC
1983	81	–	1998–99	150	162	2014–15	175	163
1984	74	–	1999–00	168	162	2015–16	169	163
1985	55	–	2000–01	154	162	2016–17	170	163
1986	82	–	2001–02	138	163	2017–18	174	163
1986–87	84	120	2002–03	169	163	2018–19	177	163
1987–88	148	140	2003–04	167	163	2019–20	180	163
1988–89	136	142	2004–05	183	163	2020–21	183	163
1989–90	121	151	2005–06	183	163	2021–22	132	130
1990–91	144	154	2006–07	177	163	2022–23	135	130
1991–92	135	154	2007–08	167	163	2023–24	142	130
1992–93	171	156	2008–09	158	163			
1993–94	142	162	2009–10	171	163			
1994–95	155	162	2010–11	183	163			
1995–96	158	162	2011–12	166	163			
1996–97	156	162	2012–13	170	163			
1997–98	163	162	2013–14	159	163			

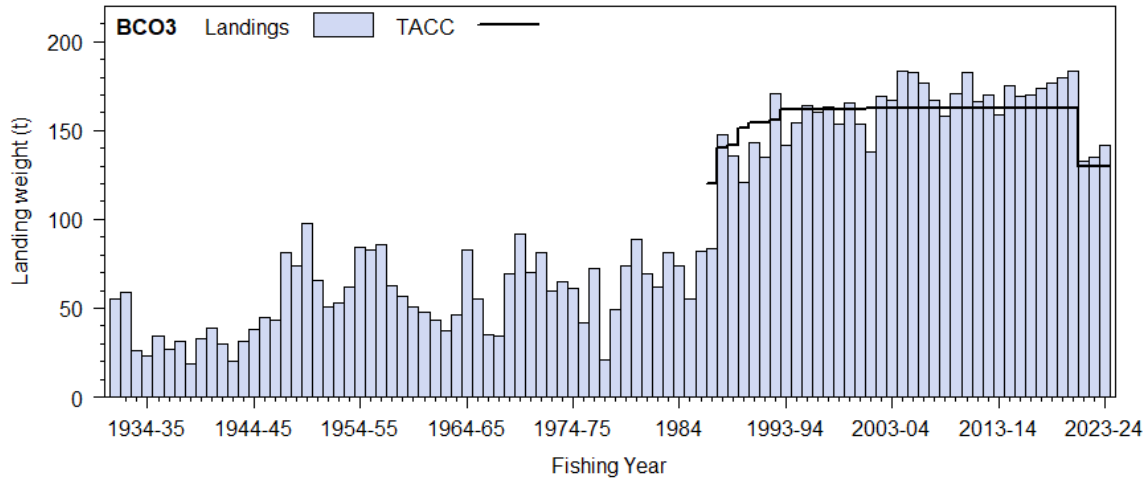


Figure 1: Reported commercial landings and TACC for BCO 3 (South East Coast).

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 BCO 3 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 (Table 4).

In 2014, the Kaikōura Marine Area in BCO 3 was established and the MLS of blue cod in this area was set at 33 cm. In 2020, an MLS of 33 cm was adopted for all of BCO 3.

In 2001, the recreational daily bag limit (DL) was reduced to 10 fish over the MLS in the North Canterbury area (BCO 3). In 2014, the DL was set at 6 in the newly established Kaikōura Marine Area (BCO 3). On 1 July 2020, the DLs for South Island stocks out to 12 nmi were revised (http://www.mpi.govt.nz/bluecod). In BCO 3 the area south of Otago Harbour mouth has a DL of 15 and the area north to Banks Peninsula has a DL of 10. From the southern side of Banks Peninsula to the Conway River, the DL is 2. North of the Conway River to the Clarence River, the DL is 10 and within the Kaikōura Marine Area the DL is 6.

Table 4: Minimum legal size (MLS in cm), blue cod specific daily bag limit (DL), and combined species daily bag limit (CDL) for BCO 3 from 1986 to present. There are two separate areas with different bag limits in BCO 3 South East (see text below for more detail).

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

1.2.2 Estimates of recreational harvest

A background to the estimation on recreational harvest of blue cod is provided in the Introduction – Blue cod chapter. Recreational harvest estimates for BCO 3 are provided in Table 5.

Table 5: Recreational harvest estimates for BCO 3 (Wynne-Jones et al 2014, 2019, Heinemann & Gray 2024). 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
Year	Method	Number of fish	Estimate (t)	CV	(t)	(t)	(t)
2011–12	Panel survey	212 552	101	0.20	26.7	3.4	131.4
2017–18	Panel survey	182 938	89	0.19	16.0	3.7	108.6
2022–23	Panel survey	90 593	51	0.24	13.9	2.1	66.9

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

For further information on other sources of mortality for blue cod refer to the Introduction – Blue cod chapter.

2. BIOLOGY

For further information on blue cod biology refer to the Introduction – Blue cod chapter. A summary of published estimates of biological parameters for BCO 3 is presented in Table 6.

Table 6: Estimates of biological parameters for BCO 3.

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	
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)

Table 6 [Continued]:

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 (2014a)
	2013	Female	0.012023	3.09201	0.97	
South Otago	2013	Male	0.008472	3.19011	0.99	Carbines & Haist (2014b)
	2013	Female	0.008617	3.1863	0.99	

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 fishery parameters and abundance

4.1.1 South Island blue cod potting surveys

Potting surveys are used to monitor blue cod populations, and within BCO 3 surveys are conducted in the Kaikoura, Motunau, Banks Peninsula, North Otago and South Otago areas (Figure 2). Surveys are generally carried out every four years and are used to monitor relative abundance and size, age, and sex structure of the separate blue cod populations. The surveys also provide an estimate of fishing mortality (F) and associated spawner-per-recruit ratios. All potting surveys in BCO 3 originally used a fixed-site design, with predetermined (fixed) locations randomly selected from a limited pool of such sites. The South Island potting surveys were reviewed by an international expert panel in 2009, which recommended that blue cod would be more appropriately surveyed using random-site potting surveys (Stephenson et al 2024). A random site is any location (single latitude and longitude) generated randomly from within a stratum. Following this recommendation, all survey series began the transition to fully random survey designs with interim sampling of both fixed and random sites allowing comparison of catch rates, length and age composition, and sex ratios between the survey designs.

Banks Peninsula

There have been five fixed-site blue cod potting surveys off Banks Peninsula (2002, 2005, 2008, 2012, and 2016), split into geographically separate inshore and offshore areas (Beentjes & Carbines 2003, 2006, 2009, Carbines & Haist 2017, Beentjes & Fenwick 2017). In 2012 and 2016, concurrent random-site potting surveys were also carried out with the intention of replacing fixed-site surveys because the random-site surveys provide a more reliable indicator of stock status. The 2021 potting survey was the firstly solely random-site survey and the third in the time series (Beentjes et al 2022b).

Inshore survey. The most recent inshore random-site survey in 2021 recorded overall catch rates of 0.49 kg pot^{-1} (CV 20%), a sex ratio of 85% male, and mean lengths of 29 and 25 cm for males and females, respectively (Table 7) (Beentjes et al 2022b). The *SPR* ratio estimates from the 2016 and the current 2021 inshore random-site surveys were considered to be unreliable because of the poor estimates of Z, but they do reflect the extremely truncated nature of the age composition (the oldest fish in 2021 was 6 years old) and indicate that *SPR* ratios are likely to be well below the target reference point of $F_{45\%SPR}$. This finding, together with the strongly skewed sex ratio toward males and very low catch rate estimates, indicates that the Banks Peninsula inshore blue cod population is

heavily overfished. Further, as nearly all females and most males currently caught will be of sub-legal size (less than 33 cm), there is also likely to be significant mortality through catch and return of undersized fish. Notwithstanding the differences in catch rates ascribed to the survey design (fixed or random), there are strong indications that inshore blue cod biomass has declined substantially between 2005 and 2021 (see Figure 4). For the 2012 random-site survey, sex ratios (all blue cod) were almost the same as those in fixed sites (about 70%), but in the 2016 random-site survey there were about 10% more males, increasing slightly in 2021 to 85% male; this indicates that male dominance in sex ratio may be increasing.

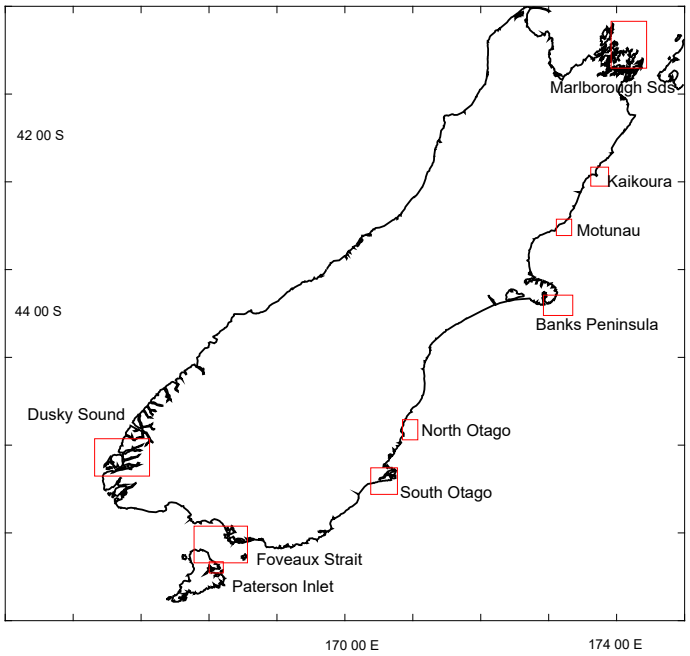


Figure 2: Map showing the nine South Island blue cod potting survey locations.

Offshore survey. The most recent offshore random-site survey in 2021 recorded overall catch rates of 1.90 kg pot^{-1} (CV 24%), a sex ratio of 66% male, and mean lengths of 37 and 34 cm for males and females, respectively (Table 7) (Beentjes et al 2022b). The 2016 and 2021 random-site survey spawner-per-recruit ratios were $F_{85\%SPR}$ and $F_{41\%SPR}$ indicating that the expected contribution to the spawning biomass over the lifetime of an average recruit was reduced to 85% and 41% of the contribution in the absence of fishing. The level of exploitation (F) of offshore blue cod stocks has therefore increased substantially in five years, and in 2021 slightly exceeded the F_{MSY} target reference point of $F_{45\%SPR}$ (Table 7). Notwithstanding the differences in catch rates that can be ascribed to the survey design (fixed or random), there were no trends in abundance until the 63% decline between the 2016 and 2021 random-site surveys (Figure 3); this decline was largest in stratum 7 (Pompey's Rock) which is the more accessible of the two offshore strata. Length distributions had fewer larger male fish in the 2021 compared with 2016 random-site surveys. Random-site surveys had similar sex ratios to overlapping fixed-site surveys in 2012 and 2016, but the 2021 survey had the highest proportion of males (66%) for any survey in the time series. There was clear evidence of modal progression of strong and weak ages classes from 2016 to 2021. The offshore blue cod population has historically been considered to be a healthy blue cod population, with a broad age structure, relatively high abundance, and a balanced sex ratio. However, between 2016 and 2021, abundance declined by 63%, age structure narrowed with fewer older age classes, there were fewer larger fish, Z increased, SPR ratio decreased, and the sex ratio is trending toward more males in the population. This indicates that the offshore blue cod population, and particularly Pompey's Rock, is now showing signs of overfishing.

Table 7: Summary statistics from standardised blue cod potting surveys of the northeast coast of the South Island (BCO 3). CPUE (catch rates) – catch per unit effort (kg pot^{-1}); CV – coefficient of variation (set based); mean length is from population scaled length. M = 0.17 in *SPR* analyses. All survey results shown are compliant with the blue cod potting manual, and the blue cod age determination protocol (Beentjes 2019, Beentjes & Page 2021, Beentjes & Miller 2021, Beentjes & Fenwick 2017, Beentjes et al 2022b, Walsh 2017). –, no valid ageing; NA, no valid *SPR* estimates in fixed sites.

	Mean length (cm)		Survey	CPUE stratum range (kg pot^{-1})	Sex ratio	
Area/Year	Female	Male	(kg pot^{-1})	(CV) all	(% male)	$F_{\%SPR}$
North Canterbury						
Kaikōura						
2004 (fixed sites)	30.3	32.5	2.62	0.60–7.97 (11.1%)	48.7	–
2007 (fixed sites)	29.8	32.5	5.00	1.91–20.45 (12.6%)	48.1	–
2011 (fixed sites)	27.5	29.1	3.66	2.14–11.44 (13.3%)	53.0	–
2011 (random sites)	28.5	29.5	2.64	0.61–8.22 (16.7%)	46.8	–
2015 (fixed sites)	25.9	27.0	2.25	1.58–5.07 (20.2%)	66.3	NA
2015 (random sites)	29.0	30.0	2.21	0.48–9.41 (18.9%)	51.7	72
2017 (random sites)	28.6	28.4	1.90	0.00–6.92 (15.9%)	44.8	42
2019 (random sites)	29.4	29.2	1.56	0.01–8.26 (10.4%)	50.0	62
Motunau						
2005 (fixed sites)	25.7	29.6	10.2	8.70–15.4 (11.4%)	76.6	–
2008 (fixed sites)	25.2	29.3	5.50	4.10–8.90 (16.1%)	77.9	–
2012 (fixed sites)	24.6	29.1	5.55	4.43–8.70 (11.8%)	71.9	–
2012 (random sites)	23.5	28.2	3.01	1.81–6.95 (19.5%)	72.1	–
2016 (fixed sites)	22.4	25.8	3.32	2.94–4.66 (12.7%)	75.5	NA
2016 (random sites)	22.2	26.5	2.48	1.10–7.24 (26.8%)	76.3	22.2
2020 (random sites)	20.2	24.8	2.07	1.41–4.54 (18.9%)	74.5	21.4
Banks Peninsula						
Inshore						
2002 (fixed sites)	25.4	28.3	1.12	0.04–2.61 (23.2%)	67.9	–
2005 (fixed sites)	27.2	32.7	2.78	1.02–4.16 (12.2%)	74.2	–
2008 (fixed sites)	25.5	29.8	1.08	0.07–2.30 (17.8%)	70.2	–
2012 (fixed sites)	24.7	28.8	1.35	0.60–1.88 (12.4%)	67.2	–
2012 (random sites)	22.8	27.3	1.23	0.33–2.89 (16.6%)	66.1	–
2016 (fixed sites)	23.2	26.5	1.26	0.57–2.12 (11.8%)	67.5	NA
2016 (random sites)	23.8	26.1	0.53	0.09–0.94 (22.2%)	81.3	NA
2021 (random sites)	25.0	29.3	0.49	0.00–0.79 (19.7%)	84.8	NA
Offshore						
2002 (fixed sites)	36.6	37.6	3.39	2.04–4.74 (19.9%)	41.8	–
2005 (fixed sites)	37.4	41.2	6.48	5.68–7.27 (9.4%)	57.2	–
2008 (fixed sites)	35.6	41.8	4.48	3.13–5.80 (13.8%)	49.8	–
2012 (fixed sites)	33.5	37.4	4.88	3.49–6.28 (17.0%)	55.9	–
2012 (random sites)	34.1	39.3	3.77	3.69–4.09 (36.2%)	59.0	–
2016 (fixed sites)	33.6	36.8	5.60	5.09–6.10 (14.1%)	65.2	NA
2016 (random sites)	36.1	41.3	5.08	5.21–4.54 (19.5%)	57.5	85.1
2021 (random sites)	33.6	36.8	1.90	1.50–3.20 (23.9%)	65.6	41.5

North Canterbury

Kaikōura

There have been four fixed-site blue cod potting surveys off Kaikōura (2004, 2007, 2011, and 2015), (Carbines & Beentjes 2006a, 2009, Carbines & Haist 2018a, Beentjes & Page 2017). In 2011 and 2015 concurrent random-site potting surveys were also carried out with the intention of replacing fixed-site surveys. Subsequently solely random-site surveys were carried out in 2017, earlier than the standard four-year cycle, to assess the impact of the November 2016 earthquake (Beentjes & Page 2018), and in 2019 (Beentjes & Page 2021). Random surveys provide a more reliable indicator of stock status than fixed-site surveys and will be used in future.

The most recent random-site survey in 2019 recorded catch rates of 1.56 kg pot^{-1} (CV 10%), sex ratio of 50% male, and mean lengths of 29.4 cm and 29.2 cm for males and females, respectively (Table 7). For the four fixed-site surveys, catch rates increased nearly two-fold from 2004 to 2007, and then declined in both 2011 and 2015, and catch rates from the last survey were the lowest of all four surveys (Table 7, Figure 4). For the four random-site surveys there was a slight decline over time with a statistically significant difference ($P<0.05$) between the mean pot catch of 2011 and 2019 surveys (Figure 4). Notwithstanding the differences in catch rates that can be ascribed to the survey design (fixed or random), blue cod biomass declined by around 50% between 2007 and 2019. The sex ratio for all blue cod was close to parity for all surveys (fixed and random), with the exception of the 2015 fixed-site survey where two-thirds of the blue cod were male (Table 7).

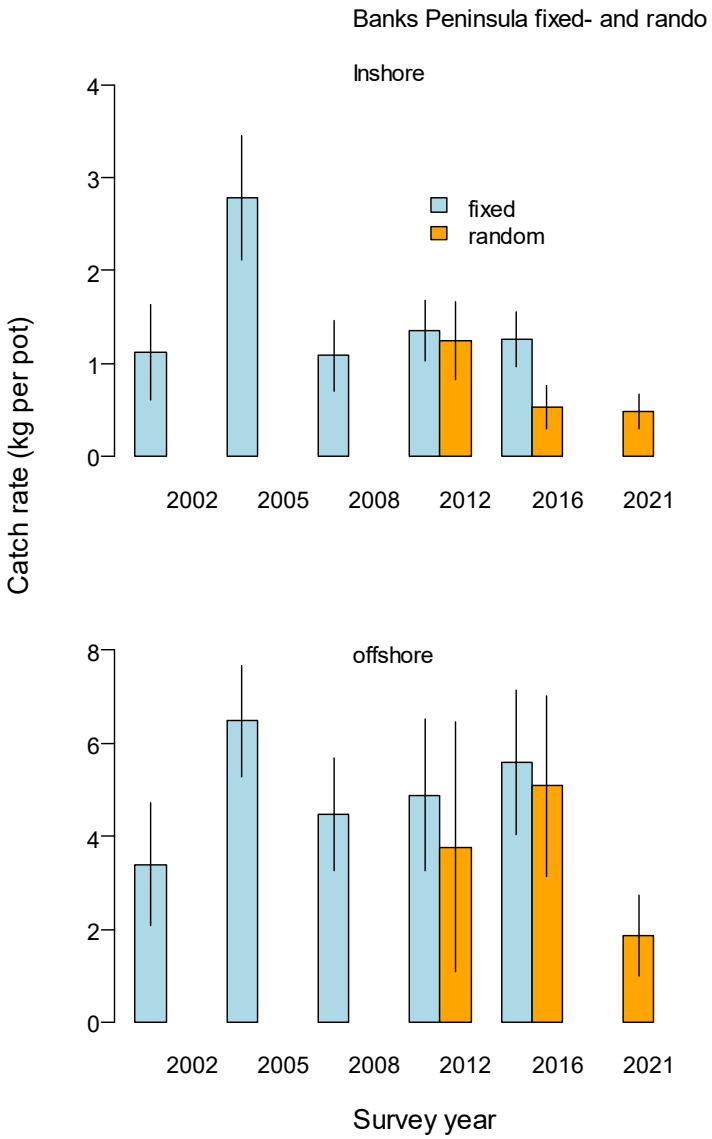


Figure 3: Banks Peninsula fixed-site and random-site potting survey catch rates of all blue cod by survey year shown for inshore and offshore populations. Error bars are 95% confidence intervals. Note the different y-axis scales for inshore and offshore (Beentjes et al 2022b).

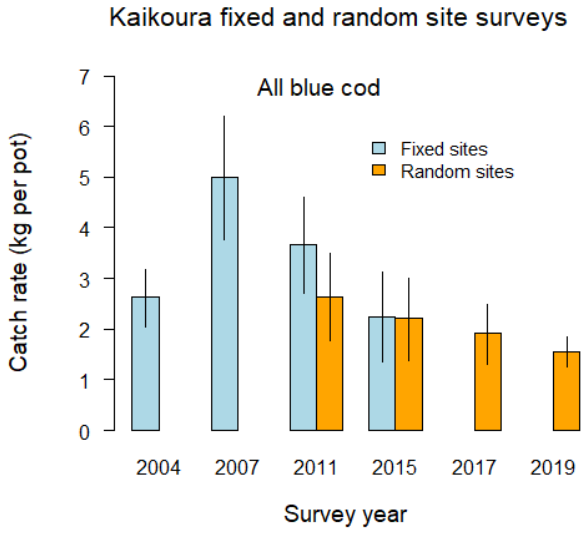


Figure 4: Kaikōura fixed-site and random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals.

Ageing is only valid for the 2015, 2017, and 2019 random-site surveys (i.e., compliant with the blue cod age determination protocol, Walsh 2017). Cohort progression of blue cod age classes is apparent over the three random-site surveys from 2015 to 2019, showing both nominally strong and weak year classes. Length frequency distributions and mean lengths were similar among the four random-site surveys with any differences due to the strong recruitment of mainly juvenile male blue cod in 2015, progressing through to strong modes in 2017 and 2019. In 2015 and 2019 the random-site survey spawner-biomass-per-recruit ratios were 72% and 62% indicating that the level of exploitation (F) of Kaikōura blue cod stocks was below the F_{MSY} target reference point of $F_{45\%SPR}$ (underexploited) (Table 7). In 2017 the random-site survey spawner-biomass-per-recruit ratio was 42%, indicating that the level of exploitation of Kaikōura blue cod stocks was above the F_{MSY} target reference point of $F_{45\%SPR}$ (over-exploited). However, because recruitment is not constant, and there are relatively few age classes represented above the age at recruitment, the point estimates of Z, F, and SPR should be treated with caution.

Motunau

There have been four fixed-site blue cod potting surveys off Motunau (2005, 2008, 2012, and 2016), (Carbines & Beentjes 2006a, 2009, Carbines & Haist 2018a, Beentjes & Sutton 2017). In 2012 and 2016 concurrent random-site potting surveys were also carried with the intention of replacing the fixed-site surveys. Subsequently, a solely random-site survey was carried out in 2020 (Beentjes & Miller 2021). Random surveys provide a more reliable indicator of stock status than fixed-site surveys and will be used in future.

The most recent random-site survey in 2020 had catch rates of 2.1 kg pot^{-1} (CV 18.9%), sex ratio of 74% male, and mean lengths of 24.8 cm and 20.2 cm for males and females, respectively (Table 7). For the four fixed-site surveys, catch rates decreased by about half in 2008 and then by half again in 2016 with a three-fold decline between 2005 and 2016 (Table 7, Figure 5). For the three random-site surveys there was a slight decline over time, but no statistically significant difference (P=0.19) between the mean pot catch of 2012 and 2020 surveys (Table 7, Figure 5). Notwithstanding the differences in catch rates that can be ascribed to the survey design (fixed or random), blue cod biomass appears to have declined by around 50% between 2005 and 2020. The sex ratio for all blue cod was around 75% male for fixed-site and random-site surveys with no trend (Table 7). Overall blue cod mean size shows a trend of declining size in both the fixed-site and random-site surveys.

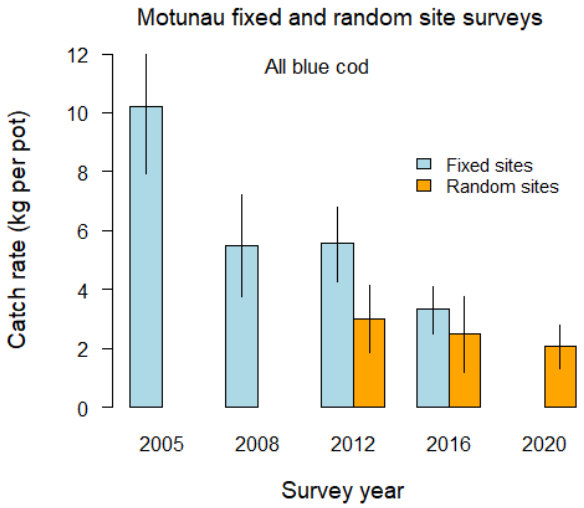


Figure 5: Motunau fixed-site and random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals.

Ageing is only valid for the 2016 and 2020 random-site surveys (i.e., compliant with the blue cod age determination protocol, Walsh 2017). Cohort progression of blue cod age classes is apparent from 2016 to 2020, showing both nominally strong and weak year classes. In 2016 and 2020 the random-site survey spawner-biomass-per-recruit ratios were 22% and 21% indicating that the level of

exploitation (F) of Motunau blue cod stocks was well below the F_{MSY} target reference point of $F_{45\%SPR}$ (overexploited) (Table 7). However, because recruitment is not constant, and there are relatively few age classes represented above the age at recruitment, the point estimates of Z, F, and SPR should be treated with caution.

The very high estimate of total mortality, truncated age composition, small size, strongly skewed sex ratio toward males, and a spawner-per-recruit ratio less than half the target indicates the current level of exploitation is unlikely to be sustainable. Further, as nearly all females and most males currently caught will be of sub-legal size (less than 33 cm from 1 July 2020), there is also likely to be significant mortality through catch and return of undersize fish.

North Otago

There have been four fixed-site blue cod potting surveys (2005, 2009, 2013, and 2018), and three random-site surveys off north Otago (2013, 2018, and 2022) (Beentjes & Fenwick 2019a, 2023a). Random-site potting surveys are intended to replace fixed-site surveys, because they provide a more reliable indicator of abundance. The 2022 north Otago survey was the first solely random-site survey for this area and hence this survey has fully transitioned to a random-site design. The 2022 random-site survey had catch rates of 1.89 kg pot^{-1} (CV 22%), a sex ratio of 77% male, and mean lengths of 30.7 cm and 26.3 cm for males and females, respectively (Table 8, Figure 6).

Fixed-site surveys. Of the four north Otago fixed-site surveys, blue cod abundance (=catch rate) was similar in 2005 and 2009, but in 2013 it more than halved with no overlap in the confidence intervals, and then declined again in 2018 by 52% from 2013 (Table 8, Figure 6) (Beentjes & Fenwick 2023a). This was also reflected in the progressive increase in the proportion of empty pots over time. The sex ratio for all fixed-site surveys was male dominated (72–76% male) with no trend. A preponderance of males is thought to indicate high fishing intensity. The fixed-site scaled length frequency distributions were similar for 2005 and 2009 but changed in 2013 and again in 2018 as biomass dropped, with the latter having relatively fewer larger fish than earlier surveys.

Table 8: Summary statistics from standardised blue cod potting surveys carried out off the southeast coast of the South Island (BCO 3). CPUE – catch per unit effort (kg pot^{-1}); CV – coefficient of variation; Mean length, from population scaled length. All north Otago survey outputs are from Beentjes & Fenwick (2023a) and south Otago survey outputs are from Beentjes & Fenwick (2023b). Total mortality (*Z*) and fishing mortality (*F*) estimates are for the default natural mortality (*M*) of 0.17, and age at recruitment of males, i.e., in 2022 the age at which males reach MLS of 33 cm, plus one year (=7 years); in 2018 the age at which males reach the MLS of 30 cm, plus one year (=6 years). CIs, 95% confidence intervals. NA, not estimated. *, no stratum 6 in 2005; **, only strata 1, 3, and 6 surveyed in 2010; –, no valid ageing.

	Mean length (cm)		Survey CPUE		Sex ratio		
Area/Year	Female	Male	(kg pot^{-1})	CPUE range (CV)	(% male)	*Z* (CIs)	*F* (CIs)
North Otago							
2005 (fixed sites)*	27.8	32.8	10.2	7.49–14.5 (7.9%)	72.5	–	–
2009 (fixed sites)	27.4	32.3	11.5	6.21–19.88 (6.6%)	73.1	–	–
2013 (fixed sites)	27.5	31.7	5.0	2.72–8.07 (12.6%)	75.9	–	–
2013 (random sites)	27.5	30.7	4.2	0.94–7.46 (13.9%)	67.8	–	–
2018 (fixed sites)	26.3	30.4	3.55	2.24–5.30 (17.7%)	72.7	NA	NA
2018 (random sites)	26.7	30.2	2.35	0.33–4.12 (14.3%)	75.2	0.46 (0.32–0.61)	0.29 (0.15–0.44)
2022 (random sites)	26.3	30.7	1.89	0.06–3.50 (22%)	76.8	0.72 (0.50–0.98)	0.55 (0.33–0.81)
South Otago							
2010 (fixed sites)**	29.4	33.6	9.7	3.30–16.90 (17.1%)	74.5	–	–
2010 (random sites)**	23.7	29.0	4.4	1.20–6.00 (17.8%)	66.9	–	–
2013 (random sites)	25.5	31.9	6.2	0.80–7.40 (19.9%)	57.4	–	–
2018 (random sites)	24.9	29.0	1.52	0.17–3.79 (28.5%)	68.4	0.40 (0.27–0.54)	0.23 (0.10–0.37)
2022 (random sites)	23.1	26.5	1.94	0.00–5.56 (16.8%)	70.3	0.45 (0.30–0.64)	0.28 (0.13–0.47)

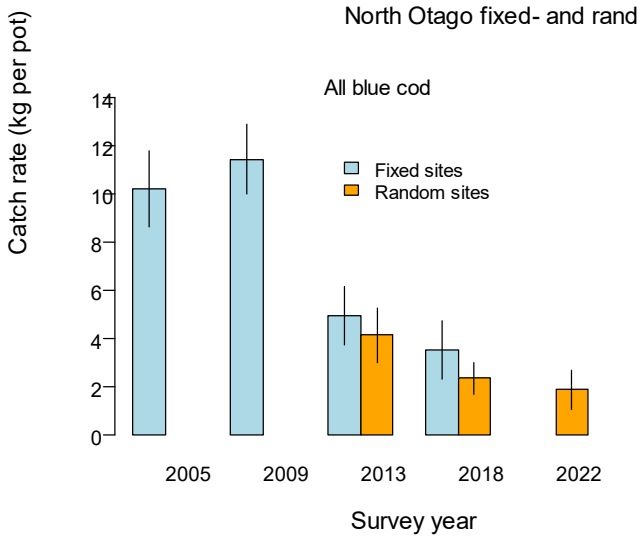


Figure 6: North Otago fixed-site and random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals.

Random-site surveys. There are three north Otago random-site surveys in the time series (2013, 2018, and 2022), and relative abundance (=catch rate) showed a similar decline to fixed-site surveys between 2013 and 2018, i.e. abundance declined by 49% between 2013 and 2018 (Table 8, Figure 6) (Beentjes & Fenwick 2023a). This was followed by a 13% decline in abundance in 2022, which was not statistically significant from the 2018 value (t-test, $p > 0.05$). These declines were mirrored in five of the six strata. The sex ratio from random-site surveys showed a large increase from 68% male in 2013, to 75% in 2018, with little change in 2022, when it was 77% male (Table 8). The length frequency distributions were similar for the three years (2013, 2018, and 2022), with the main differences occurring in the relative numbers of the pre-recruited fish. The proportion of pots with zero catch from random sites shows a progressive increase from 35% in 2013, to 43% 2018, and to 54% in 2022.

Ageing is currently only valid for the 2018 and 2022 surveys (i.e., compliant with the blue cod age determination protocol, Walsh 2017). Cohort progression indicates that these surveys are monitoring the north Otago age composition effectively.

The 2022 survey growth estimates indicate that males are on average nearly 6-years-old and females nearly 8-years-old when they reach the current MLS of 33 cm in north Otago. The relatively high age at recruitment, combined with the truncated nature of the age composition in 2022, with few fish older than 10 years of age (maximum age is 31 years), has concentrated the fishing pressure on just a few cohorts, some of which are poorly represented.

Stock status. The Inshore Finfish Working Group (8 December 2022) agreed that spawner-biomass-per-recruit (*SPR)* is no longer appropriate as an F_{MSY} target reference point for north Otago blue cod and, instead, recommended F=0.87M as an overfishing threshold, where Z and F are estimated from the male-only age composition in the population (Beentjes & Fenwick 2023a). The rationale for this decision is the same as for the 2021 Marlborough Sounds blue cod survey (see above section on Marlborough Sounds survey stock status). The 2022 north Otago random-site survey Z for males was 0.72, where M = 0.17, and age at full recruitment is 7 years of age (i.e., the age at which males reach MLS of 33 cm, plus one year), with a resulting F of 0.55 (Table 8). Relative to the target reference point of F=0.15 (F=0.87M), the estimated F of 0.55 in 2022 was nearly four times higher than this target, indicating that overfishing is occurring. Further, Z and F were larger in 2022 than 2018 (Table 8).

South Otago

There has been one fixed-site blue cod potting survey (2010) and four random-site surveys off south Otago (2010, 2013, 2018, and 2022) (Beentjes & Fenwick 2019b, 2023b). The south Otago surveys

transitioned to fully random-site design in 2013. The first survey in 2010 was designed to compare fixed- and random-site potting survey designs and included only three of the six strata (Beentjes & Carbines 2011), with catch rates in fixed sites double that from random sites (Table 8, Figure 7). The most recent random-site survey in 2022 had catch rates of 1.94 kg pot^{-1} (CV 17%), a sex ratio of 70% male, and mean lengths of 26.5 cm and 23.1 cm for males and females, respectively (Table 8, Figure 7). There was a four-fold drop in catch rates between 2013 and 2018 random-site full strata surveys with no overlap in the confidence intervals, and this was largely mirrored in the survey analyses limited to the three 2010 strata. In 2022 catch rates were slightly higher than 2018, but not significantly (Figure 7).

The sex ratio from random-site surveys has varied from 57 to 70% male (70% in 2022) with no trend (Table 8) - a preponderance of males indicating high fishing pressure. The scaled length frequency distribution shapes for the random-site full strata surveys differed among years, driven mainly by recruitment of strong or weak juvenile modes with 2013 having an especially strong juvenile mode and relatively more larger fish than other random-site surveys (see Section 4.7 Future research considerations). Ageing is currently only valid for the 2018 and 2022 surveys (i.e., compliant with the blue cod age determination protocol, Walsh 2017). Both surveys were characterised by variable recruitment with strong cohorts often followed by weak cohorts. There was clear cohort progression between 2018 and 2022 for the 3 to 7 year age classes for both sexes, but particularly for males. The age structure in south Otago closely mirrored that of north Otago in both years.

Stock status. The Inshore Finfish Working Group (17 April 2023) agreed that spawner-biomass-per-recruit (*SPR)* is no longer appropriate as a F_{MSY} target reference point for south Otago blue cod and, instead, recommended F=0.87M as an overfishing threshold, where Z and F are estimated from the male-only age composition in the population (Beentjes & Fenwick 2023b). The rationale for this decision is the same as for the most recent 2021 Marlborough Sounds blue cod survey and the 2022 north Otago survey (see above section on Marlborough Sounds survey stock status). The 2022 south Otago random-site survey Z for males was 0.45, where M = 0.17, and age at full recruitment is 7 years of age (i.e., the age at which males reach MLS of 33 cm, plus one year), with a resulting F of 0.28 (Table 8). Relative to the target reference point of F=0.15 (F=0.87M), the estimated F of 0.28 in 2022 was nearly twice the target, indicating that overfishing is occurring. Further, Z and F were larger in 2022 than 2018, although age at recruitment in 2018 was 6 years because the recreational MLS was 30 cm (Table 8).

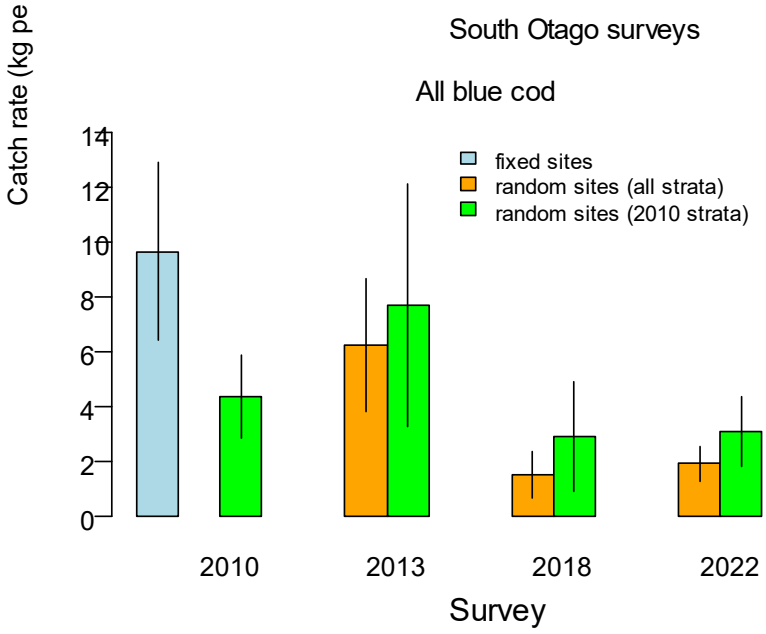


Figure 7: South Otago fixed-site and random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals. The 2010 survey used three of the six strata (1, 3, and 6), and subsequent surveys used all six strata. Catch rates are also shown for the three strata used in 2010 for the subsequent random-site surveys.

4.1.2 Trawl survey estimates

Relative abundance indices from trawl surveys are available for BCO 3 but these have not been used because of the high variance and concerns that this method may not appropriately sample blue cod populations.

4.1.3 BCO 3 CPUE analyses

The BCO 3 standardised CPUE analysis for the target blue cod potting fishery was updated in 2025 by including six more years up to 2023–24 (Beentjes & Bian 2025). The cod pot fishery accounted for about two-thirds of the total BCO 3 landings in the 35 years from 1989–90 to 2023–24, predominantly in the two southernmost Statistical Areas 024 and 026. Together these two areas represented about 90% of the total target blue cod potting fishery over the same 35 years (Figure 8). As found in the previous analyses, there was misreporting of RCO 3 landings as BCO 3, probably due to data entry errors (Starr & Kendrick 2010). This problem was again resolved before undertaking the CPUE analysis by dropping trips with landed blue cod catch greater than 100 kg and zero estimated catch.

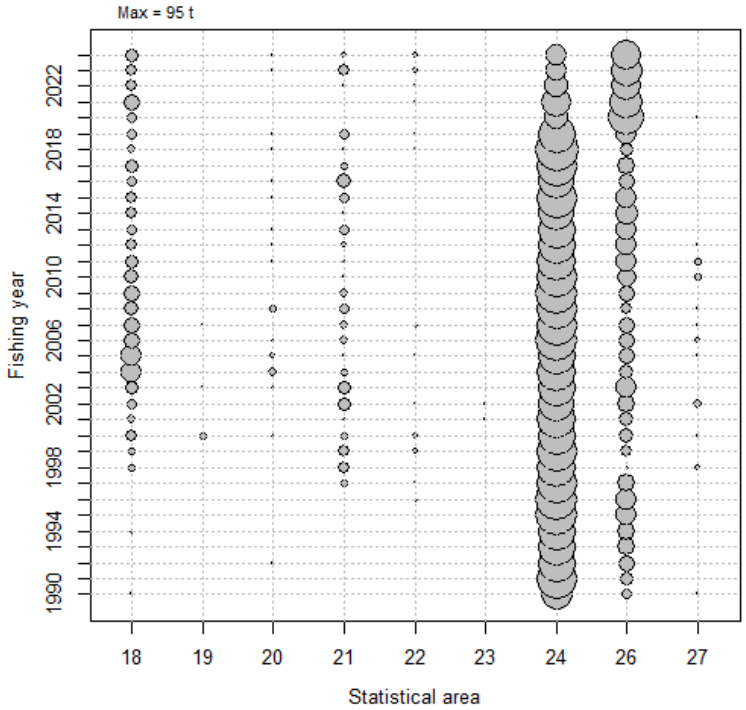


Figure 8: Distribution of landings for blue cod potting method by statistical area and fishing year from trips which landed BCO 3. Circles are proportional within each panel (Beentjes & Bian 2025).

The effort data were matched with the landing data at the trip level and the 'trip-stratum' stratification inherent in the CELR and ERS (2020 onward) data was maintained. The 2025 CPUE analysis again used only data from Statistical Areas 024 and 026, and the greater of total pots or pots in the water at midnight were selected for effort for the returns using the CELR forms. Further, trips with fewer than 4 pots per trip were dropped because of concerns around the size of catches associated with trips with so few pots. The CPUE analysis was confined to a set of core vessels that had participated consistently in the fishery for a reasonably long period (5 trips in 3 years), resulting in keeping 60 vessels representing 90% of the cod pot landings. The explanatory variables offered to the model included fishing year (forced), month, vessel, statistical area, number of pots lifted in a day, and number of days fishing in the record. A log-normal GLM model was fitted to positive blue cod catch from cod pots. There were too few unsuccessful fishing events to justify pursuing a binomial model.

The standardised CPUE model for BCO 3 (Figure 9) fluctuated but generally trended upward until 2014 after which it declined with the final indices below the series mean. The current CPUE series trends differed from the two previous analyses which did not appear to have used the greater of total pots and pots in the water at midnight, nor did they drop trips with fewer than 4 pots. The Inshore WG

(1 May 2025) agreed that the current series was more reliable. An event-based standardised CPUE index was also run using ERS event-based data (2020 to 2024) offering the following additional variables: 024 inshore, 024 offshore, 026 inshore, 026 offshore, and depth (based on NOAA R package *marmap*, GEBCO 460 m resolution bathymetry). The results were similar to the trip-based analyses for the same period.

The trends observed in the 2025 BCO 3 CPUE index corresponded well with the relative abundance indices from the north and south Otago potting surveys over the same period (Figure 9). There was good overlap of potting survey strata with the commercial cod potting spatial effort for the period 2020 to 2024 (ERS data), although with an increasing proportion of the commercial catch caught deeper between 2020 and 2024, and outside of the potting survey strata (i.e., about 30% and 50% of the catch was caught deeper than 60 m in Statistical Area 024, and deeper than 80 m in Statistical Area 026, respectively in 2024).

During 2002–03 to 2023–24, commercial catches (all methods) in BCO 3 exceeded the TACC in all but two of the 22 years, by 5% per year overall. The CPUE series shown in Figure 9 is representative of the southern portion of BCO 3 (Statistical Areas 024 and 026) and may not be applicable to those parts of BCO 3 north of Statistical Area 024.

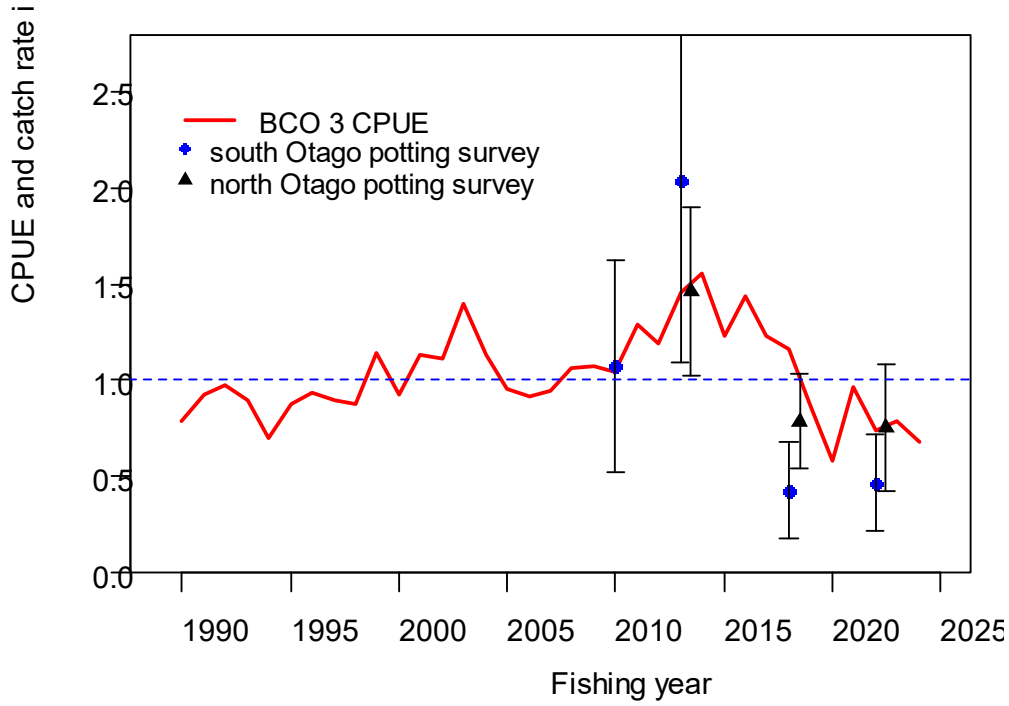


Figure 9: Comparison of BCO 3 standardised CPUE indices (1989–90 to 2023–24), and catch rate indices of recruited blue cod (33 cm and over) from random-site stratified potting surveys in south Otago (2010, 2013, 2018, 2022) and north Otago (2013, 2018, 2022) (Beentjes & Bian 2025). (Each relative series is scaled so that the geometric mean equals 1.0).

4.2 Future research considerations

Future research considerations relevant to all BCO stocks are provided in the Introduction – Blue cod chapter.

BCO 3

- Further exploration of the representativeness of these surveys for the entire stock should be evaluated (particularly with the recent development of fisheries in deeper waters), with a view to combining them with other information (such as a reanalysed CPUE series) to determine whether a full stock assessment can be undertaken.

- Analysis of fine scale effort data from the Electronic Reporting System should be included in planning for future surveys. Consideration should be given to adding additional strata if this would improve coverage of the commercial potting fishery.
- Ageing more otoliths from earlier surveys and commercial catches (if available), obtaining survey-specific estimates of size or age at maturity, and refining other biological parameters should be considered before a full stock assessment would be feasible.
- Otoliths from the 2013 south Otago survey potting survey should be re-aged under the blue cod Age Determination Protocol. Catch rates peaked in 2013 and the length distribution appears different to other surveys.
- Explore a combined spatio-temporal analysis of survey and CPUE series.
- Investigate available data for indications of serial depletion.
- Continue to monitor the stock with both surveys and CPUE analyses.
- Continue the development of a CPUE index from the ERS period.
- Explore vessel specific pot lift reporting as a means of improving grooming and clarifying the pot lift / pots in water at midnight issues.
- Explore other aspects of CPUE standardisation, including:
  - testing models excluding pot lifts (sensitivity);
  - the utility of year.area and vessel.area interactions;
  - the inclusion of other pot types or targets;
  - simplifying accounting for offshore movement in the fishery (other than estimated depth on the basis of location).

5. STATUS OF THE STOCKS

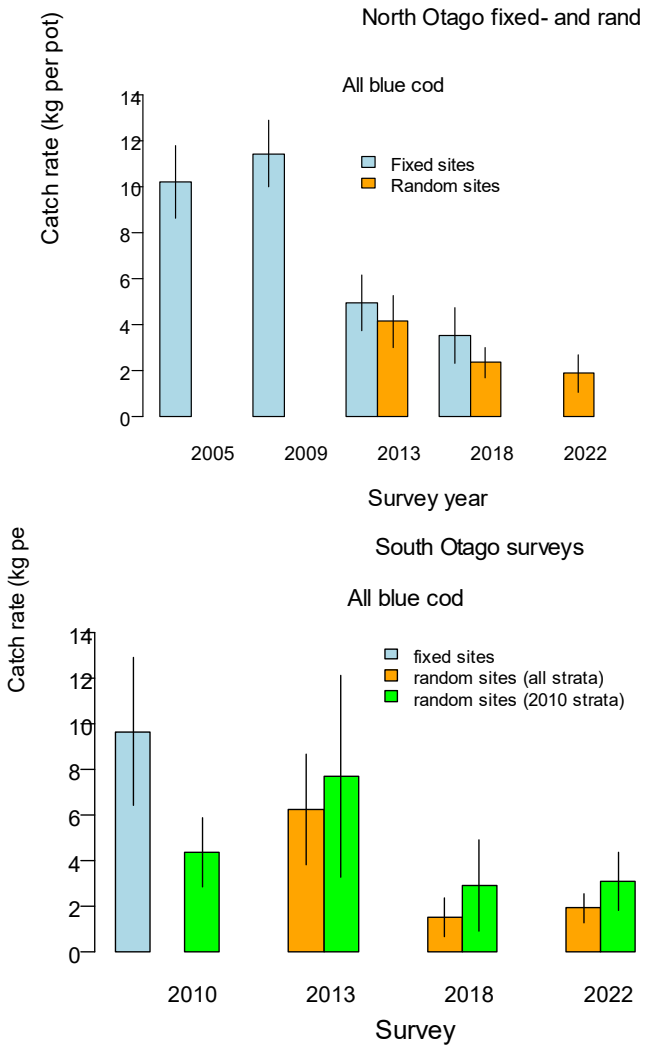
- **BCO 3 (Statistical Areas 024 and 026)**

Stock Structure Assumptions

Tagging experiments suggest that blue cod populations may be isolated from each other and there may be several distinct sub-populations within management areas. For the purposes of this summary, BCO 3 is split into two sub-areas along the Statistical Areas 022/024 boundary: Statistical Areas 018, 020, and 022 (Northern); and Statistical Areas 024 and 026 (Southern). There were insufficient data to produce a standardised CPUE series for the northern sub-area.

Stock Status		
Most Recent Assessment Plenary Publication Year	2025	
Intrinsic Productivity Level	Low	
Catch in most recent year of assessment	Year: 2023–24	Catch: 142 t
Assessment Runs Presented	North and South Otago potting surveys	
Reference Points	Target1: B_{MSY}-compatible proxy based on the potting surveys (to be determined) Target 2: $F = 0.87M = 0.87\times0.17 = 0.15$ Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F = 0.87M = 0.87\times0.17 = 0.15$	
Status in relation to Target	F estimated at 0.55 (North Otago) and 0.28 (South Otago) are Very Unlikely (< 10%) to be at or below the target	
Status in relation to Limits	Unknown	
Status in relation to Overfishing	Overfishing is Very Likely (> 90%) to be occurring	

Historical Stock Status Trajectory and Current Status



North Otago and south Otago fixed-site and random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals. For north Otago, surveys after 2005 include a new stratum (stratum 6). For south Otago, the 2010 survey used three strata, and subsequent surveys used 6 strata. Catch rates are also shown for the three strata used in 2010 for the subsequent random-site surveys. Note that the fixed-site and random-site surveys are not directly comparable. Only the random sites are included for the status of stocks evaluation; however, the fixed sites are included because they provide context, particularly for north Otago.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The north Otago and south Otago potting surveys each have three and four annual indices respectively, based on the random survey design, both of which have exhibited substantial declines between 2013 and 2018, remaining at the 2018 level in 2022. There is good overlap between the survey areas and BCO commercial fishing grounds in Statistical Areas 024 and 026, where most of the BCO 3 commercial catch is taken. Earlier fixed-site surveys also showed a decline for north Otago.
Recent Trend in Fishing Intensity or Proxy	North Otago estimated male Z and F in the 2022 were 0.72 and 0.55, and F was nearly four times higher than the target reference point of F=0.15. In 2018 Z and F were estimated at 0.46 and 0.29. South Otago estimated male Z and F in the 2022 were 0.45 and 0.28, and F was nearly twice the target reference point of F=0.15. In 2018 Z and F were estimated at 0.40 and 0.23.
Other Abundance Indices	-
Trends in Other Relevant	Standardised CPUE for cod potting in Statistical Areas 024 and

Indicators or Variables	026 combined shows a similar trend to the potting surveys, with a steep decline between 2014 and 2024.

Projections and Prognosis	
Stock Projections or Prognosis	The BCO 3 TACC was reduced by 30 t in 2021–22 and recreational bag limits were reduced from 30 to 10 in 2020. Commercial and recreational pot mesh sizes were also increased. It is not known whether these interventions will allow the stock to increase.
Probability of Current Catch or TACC causing decline Biomass to remain below or to decline below Limits	Unknown
Probability of Current Catch causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Partial Quantitative Stock Assessment	
Assessment Method	Fisheries-independent potting surveys	
Period of Assessment	Latest assessment Plenary publication year: 2023 potting survey) 2025 (CPUE analysis)	Next assessment: 2026
Overall Assessment Quality	1 – High Quality	
Main Data Inputs (Rank)	- North and south Otago potting surveys	1 – High Quality
Data not used	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Catches in deeper areas (outside the survey areas) have increased between 2020 and 2024.	

Qualifying Comments
–

Fishery Interactions
Over two thirds of BCO 3 commercial catches are taken in a target cod-potting fishery which has very little interaction with other species. Most of the remaining BCO 3 catch is taken in the inshore bottom trawl fishery operating off the east coast of the South Island, largely directed at flatfish, red cod, and tarakihi, and in the ling target pot fishery.

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