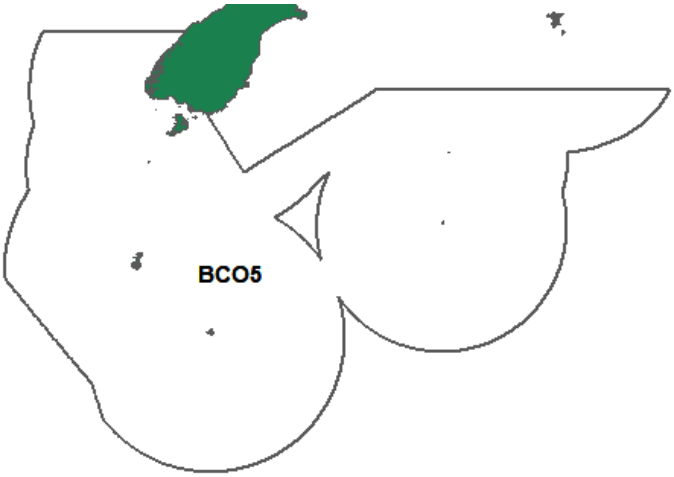
BLUE COD (BCO 5)

(Parapercis colias)
Rāwaru



1. FISHERY SUMMARY

Allowances, TACC, and TAC for BCO 5 are shown in Table 1.

Table 1: **Recreational and Customary non-commercial allowances, other mortality, TACCs, and TACs (t) for BCO 5 from 1 October 2024.**

Fishstock	Recreational allowance	Customary non-commercial allowance	Other sources of mortality	TACC	TAC
BCO 5	62	20	15	580	677

1.1 Commercial fisheries

Table 2 and Table 3 provide a summary of the reported commercial catches, TACCs, and TACs for BCO 5. Landings and TACCs are plotted in Figure 1.

The commercial catch from the BCO 5 fishery is almost exclusively taken by the target cod pot fishery operating within Foveaux Strait and around Stewart Island (Statistical Areas 025, 027, 029, and 030). Catches from BCO 5 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 5 increased from 1190 t to 1536 t in a number of steps between 1986 and 1991, was increased to 1548 t in 2001, but reduced to 1239 t in 2011, to 800 t in 2020 and 580 t in 2024 (Table 1).

Table 2: Reported landings (t) of blue cod from BCO 5 from 1931 to 1982.

Year	BCO 5	Year	BCO 5	Year	BCO 5	Year	BCO 5
1931–32	719	1944	552	1957	581	1970	432
1932–33	726	1945	634	1958	542	1971	375
1933–34	792	1946	715	1959	492	1972	194
1934–35	1057	1947	955	1960	757	1973	571
1935–36	284	1948	852	1961	590	1974	486
1936–37	113	1949	929	1962	668	1975	232
1937–38	172	1950	1005	1963	621	1976	254
1938–39	94	1951	873	1964	462	1977	208
1939–40	135	1952	889	1965	296	1978	197
1940–41	177	1953	414	1966	337	1979	217
1941–42	128	1954	385	1967	518	1980	403
1942–43	139	1955	405	1968	494	1981	494
1943–44	221	1956	656	1969	361	1982	356

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 5 are shown in Table 1.

Table 3: Reported landings (t) of blue cod from BCO 5 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 5 5 & 6		Fishstock FMA (s)	BCO 5 5 & 6	
	Landings	TACC		Landings	TACC
1983	626	–	2004–05	1 473	1 548
1984	798	–	2005–06	1 346	1 548
1985	954	–	2006–07	1 382	1 548
1986	844	–	2007–08	1 277	1 548
1986–87	812	1 190	2008–09	1 391	1 548
1987–88	938	1 355	2009–10	1 210	1 548
1988–89	776	1 447	2010–11	1 296	1 548
1989–90	928	1 491	2011–12	1 215	1 239
1990–91	1 096	1 491	2012–13	1 207	1 239
1991–92	873	1 536	2013–14	1 208	1 239
1992–93	1 029	1 536	2014–15	1 132	1 239
1993–94	1 132	1 536	2015–16	1 099	1 239
1994–95	1 218	1 536	2016–17	1 152	1 239
1995–96	1 503	1 536	2017–18	1 027	1 239
1996–97	1 326	1 536	2018–19	827	1 239
1997–98	1 364	1 536	2019–20	926	1 239
1998–99	1 470	1 536	2020–21	788	800
1999–00	1 357	1 536	2021–22	800	800
2000–01	1 470	1 536	2022–23	745	800
2001–02	1 477	1 548	2023–24	627	800
2002–03	1 497	1 548	2024–25		580
2003–04	1 556	1 548			

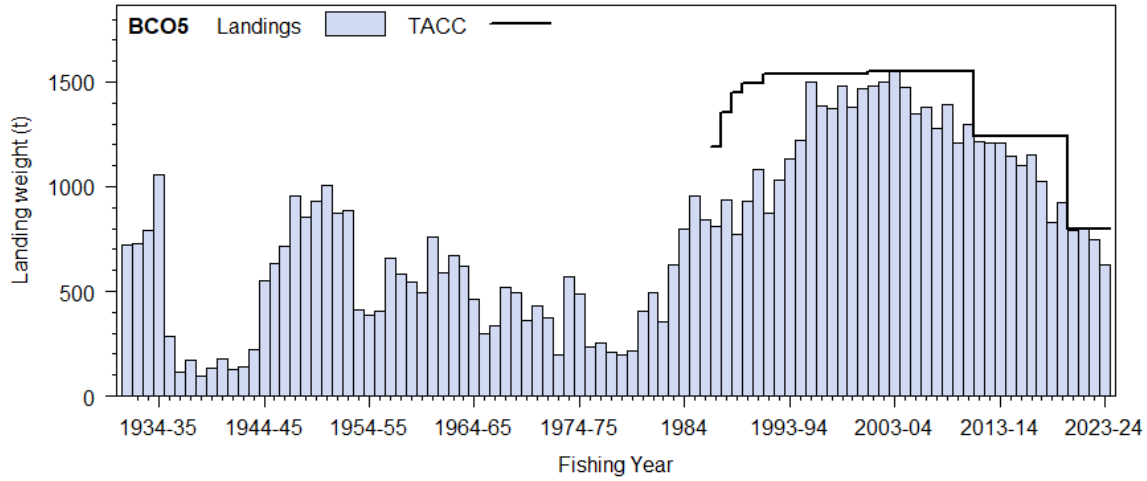


Figure 1: Reported commercial landings and TACC for BCO 5 (Southland).

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 addition, there have been temporary and seasonal closures in several Fiordland sounds.

During 1992–93, the national minimum legal size (MLS) for blue cod increased from 30 cm to 33 cm for both amateur and commercial fishers, with the exception of BCO 3 and BCO 4 (South-East management area).

In 2014, the DL was reduced to 20 in Southland and the external waters of the Fiordland marine area (BCO 5). Before these changes, the DL in Paterson's Inlet (BCO 5) was reduced from 30 to 15 in 1994. In 2005, new commercial and recreational rules were introduced to the internal waters of the Fiordland Marine Area and Doubtful Sound, Thompson Sound, and Bradshaw Sound were closed to all blue cod fishing for 10 years. The closure was lifted in 2015 to allow recreational blue cod fishing and the new DL within Doubtful, Thompson and Bradshaw Sounds was set at 1.

On 1 July 2020, the DLs for South Island stocks out to 12 nm were revised (http://www.mpi.govt.nz/bluecod). In BCO 5 there are two areas with DLs of 10 and one with a DL of 15. The restrictions in the fiords and sounds remained unchanged.

Table 4: Minimum legal size (MLS in cm), blue cod specific daily bag limit (DL), and combined species daily bag limit (CDL) for BCO 5 from 1986 to present. * DS = Doubtful Sounds, TS = Thompson Sound, BS = Bradshaw Sound. C = inner sounds closed. † bag limit of 6 inside Te Whaka ä Te Wera Mātaitai Reserve. There are two separate areas with different bag limits in BCO 5 Southland (see text below for more detail).**

Fishstock Area	BCO 5 Southland & Fiordland (External)		BCO 5 Paterson Inlet †		BCO 5 Fiordland internal (excl. DS, TS, BS*)		BCO 5 DS, TS, BS*	
	MLS	CDL	MLS	DL	MLS	DL	MLS	DL
1986	30	30	30	30	33	20	33	20
1993	33	30	33	30	33	20	33	20
1994	33	30	33	15	33	20	33	20
2001	33	30	33	15	33	20	33	20
2003	33	30	33	15	33	20	33	20
2005	33	30	33	15	33	20	C**	C**
2008	33	30	33	15	33	20	C**	C**
2011	33	30	33	15	33	20	C**	C**
2014	33	20	33	15	33	20	C**	C**
2015	33	20	33	15	33	3	33	1
2017	33	20	33	15	33	3	33	1
2020	33	15/10	33	15	33	3	33	1

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 5 are provided in Table 5.

Table 5: Recreational harvest estimates for BCO 5 (Wynne-Jones et al 2019, 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.

Year	Method	Number of fish	Harvest survey Estimate (t)	Harvest survey CV	ACV (t)	s111 (t)	Total (t)
2011–12	Panel survey	72 316	44	0.24	15.9	17.2	76.8
2017–18	Panel survey	129 916	62	0.22	18.4	15.1	95.7
2022–23	Panel survey	97 419	53	0.18	19.8	21.5	94.6

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 5 is presented in Table 6.

Table 6: Estimates of biological parameters for BCO 5.

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)
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	
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	

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 5 surveys are conducted in the Foveaux Strait, Patterson Inlet and Dusky Sound 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 nine geographically 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 5 (except Foveaux Strait) 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 2009). 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. Random sites were the only site type used in Foveaux Strait, and all other areas except Dusky Sound have now transitioned to solely random-site surveys.

Foveaux Strait

There have been four random-site surveys in Foveaux Strait (2010, 2014, 2018, and 2023) (Beentjes & Miller 2024). The most recent random-site survey in 2023 had blue cod catch rates of 2.41 kg pot^{-1} (CV 21%), sex ratio of 52% male, and mean lengths of 32.0 cm and 28.5 cm for males and females, respectively (Table 7). Mean ages of males and females were 5.9 y and 6.2 y, respectively.

Survey abundance (total blue cod mean catch rate) from the four random-site surveys significantly increased between 2010 and 2014, with no change in 2018, followed by a decline of 57% in 2023 (Figure 3). Catch rates in Foveaux Strait, in 2018, were by far the highest of all South Island random-

site surveys, but in 2023 they were similar or only marginally higher. The sex ratio has varied from 47 to 52% male with no trend (Table 7). The scaled length frequency distributions and mean length of all blue cod were remarkably similar for all four surveys, although in 2023 the proportion of small males was less than in previous years. Ageing is valid for all four surveys (i.e., compliant with the blue cod age determination protocol, Walsh 2017). The age structure of both males and females was generally similar among the four surveys with only minor differences in the strength of some cohorts. Most fish were between 4 and 8 years of age, with relatively few fish over 10 years, particularly males. The relatively high age at recruitment, combined with the truncated nature of these age compositions, with few fish older than 10 years of age for a species that has a maximum age of 31 years, concentrates the fishing pressure on just a few cohorts, some of which are poorly represented.

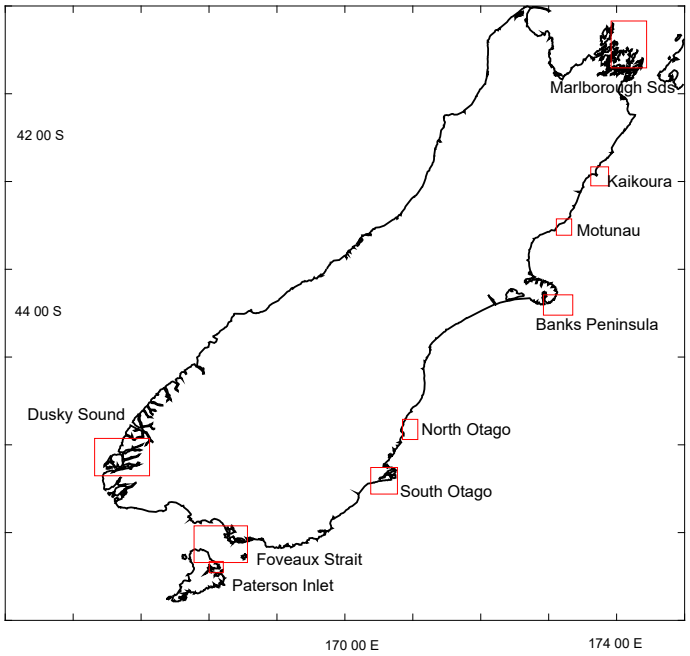


Figure 2: Map showing the nine South Island blue cod potting survey locations.

Stock status. The Inshore Finfish Working Group (16 November 2023) agreed that spawner-biomass-per-recruit (*SPR)* is no longer appropriate as an F_{MSY} target reference point for Foveaux Strait 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 & Miller 2024). 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 2023 Foveaux random-site survey Z for males was 1.18, where M = 0.17, and age at full recruitment is 7 years of age (i.e., the age at which males reach minimum legal size of 33 cm, plus one year), with a resulting F of 1.01 (Table 7). Relative to the target reference point of F=0.15 (F=0.87M), the estimated F of 1.01 in 2023 was nearly seven times higher than this target, indicating that overfishing is occurring. Fishing mortality was between 4 and 6 times higher than the target in the previous three surveys, with no trend (Table 7).

Paterson Inlet

There have been three fixed-site (2006, 2010, 2014) and three random-site blue cod potting surveys in Paterson Inlet (2010, 2014, and 2018) (Carbines 2007, Carbines & Haist 2014a, 2018, Beentjes & Miller 2020). Random-site potting surveys have replaced fixed-site surveys because they provide a more reliable indicator of abundance. All surveys have included the Ulva Island Marine Reserve as an additional stratum but all results given here exclude the marine reserve. The most recent random-site survey in 2018 recorded catch rates of 1.5 kg pot^{-1} (CV 18%), sex ratio of 67% male, mean lengths of 29.6 cm for males and 27.2 cm for females, and mean ages of 5.3 years males and 6.1 years for females (Table 7). Neither the fixed-site nor random-site survey time series show any clear indications of a change in relative abundance, size, or sex ratio, although there was a large increase in abundance

between 2010 and 2014 for the random-site series (Figure 4). More random-site surveys are required before trends can be reliably identified. Ageing is only valid for the 2018 random-site survey, which is compliant with the blue cod age determination protocol (Walsh 2017). In 2018, using a default *M* of 0.17, estimated fishing mortality (*F*) was 0.08, and the associated spawner-biomass-per-recruit ratio (*SPR*) was 68% (95% confidence interval 49–100%) (Table 7). The point estimates of *Z*, *F,* and *SPR* in 2018 should be treated with caution because the traditional catch curve did not follow the ideal straight-line descending limb, suggesting that the assumption of constant recruitment had been violated.

Table 7: Summary statistics from standardised blue cod potting surveys carried out off the south and southwest coast of the South Island (BCO 5). Mean length, mean age, and sex ratios are from population scaled length and age. Foveaux Strait survey—all results are from Beentjes et al (2024); Paterson Inlet survey excludes Ulva Island Marine Reserve—all results are from Carbines (2007), Carbines & Haist (2014a, 2018), Beentjes & Miller (2020); Dusky Sound excludes Five Fingers Marine Reserve – all results from Carbines & Beentjes (2003, 2011a) and Beentjes & Page (2016). Only mean ages and $F_{\%SPR}$ based on otoliths aged with the Age Determination Protocol (Walsh 2017) are included in this table. Spawner biomass per-recruit ($F_{\%SPR}$) is based on total mortality (*Z*) for female age at full recruitment, and *M* = 0.14 for Dusky Sound and *M*= 0.17 for Paterson Inlet. $F_{\%SPR}$ is no longer a valid target reference point for Foveaux Strait as of 2023. 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., age at which males reach minimum legal size plus one year. CPUE, catch per unit effort (kg pot^{-1}); CV, coefficient of variation; –, no valid ageing; CI, 95% confidence intervals.* - excluding marine reserves.

	Mean length		Mean age		CPUE	CPUE range (CV)	Sex ratio			
Area/Year	Fem	Male	Fem	Male	(kg pot^{-1})		% male	$F_{\%SP}$	*Z* (CIs)	*F* (CIs)
Foveaux Strait										
2010 (random sites)	27.7	30.4	5.8	5.2	5.25	0.81–14.14 (12.7%)	47.2		1.1 (0.6–1.7)	0.92 (0.4–1.5)
2014 (random sites)	27.7	30.3	6.0	4.9	7.57	0.31–16.22 (11.6%)	48.0		0.91 (0.6–1.4)	0.74 (0.4–1.2)
2018 (random sites)	28.4	30.6	6.8	5.7	5.66	4.01–8.40 (20.5%)	50.7		0.80 (0.5–1.1)	0.63 (0.3–1.0)
2023 (random sites)	28.5	32.0	6.2	5.9	2.41	0.05–6.59 (20.9%)	51.7		1.18 (0.7–1.8)	1.01 (0.6–1.6)
Paterson Inlet										
2006 (fixed sites*)	26.9	32.8	–	–	4.80	1.47 – 8.42 (11.9%)	55.5	–		
2010 (fixed sites*)	27.5	32.2	–	–	4.20	1.50 – 6.60 (11.1%)	75.1	–		
2010 (random sites*)	25.9	29.0	–	–	0.82	0.23 – 1.40 (24.1%)	61.5	–		
2014 (fixed sites*)	26.9	32.3	–	–	4.80	1.05 – 7.66 (12.9%)	75.3	–		
2014 (random sites*)	27.0	29.9	–	–	1.94	0.44 – 2.73 (19.9%)	67.5	–		
2018 (random sites)	27.2	29.6	6.1	5.3	1.51	0.59–2.72 (17.7%)	67.0	68.0		
Dusky Sound										
2002 (fixed sites)	29.9	34.7	–	–	2.95	1.29–8.43 (10.8%)		–		
2008 (fixed sites*)	32.2	37.9	–	–	4.20	2.49 – 8.13 (5.8%)		–		
2014 (fixed sites*)	32.6	35.2	8.1	6.9	3.22	1.87–9.20 (11.9%) (*11.9%)		48.3		
2014 (random sites*)	32.3	33.8	8.2	6.5	2.61	2.04–4.99 (8.6%) (*8.5%)		49.0		

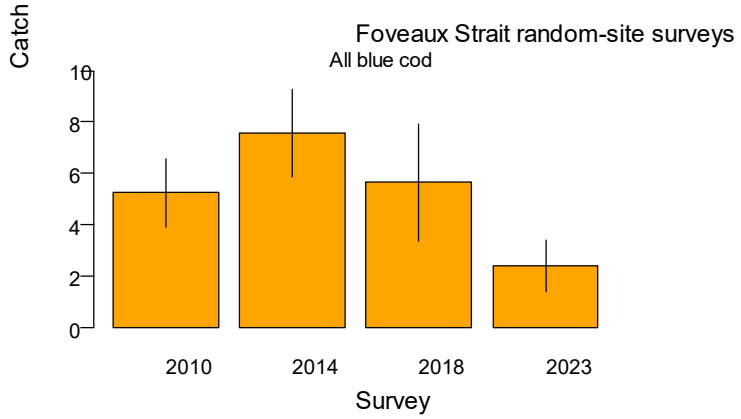


Figure 3: Foveaux Strait random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals.

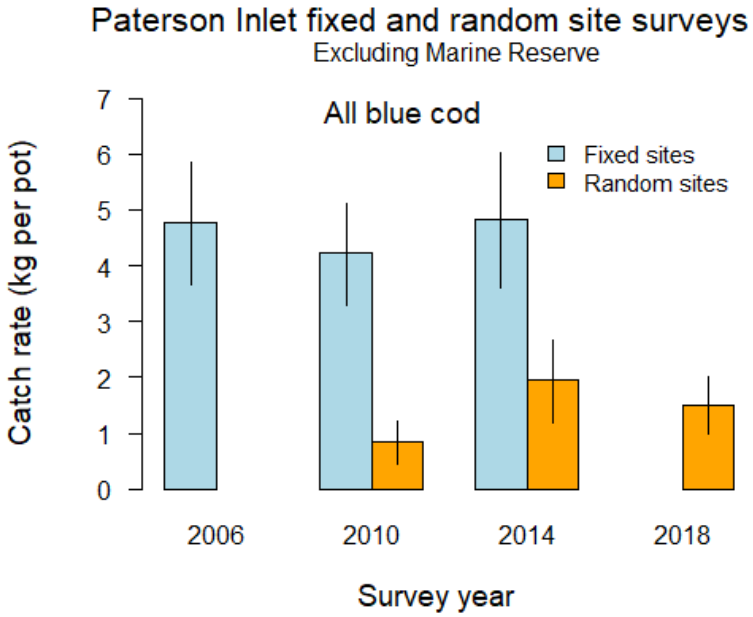


Figure 4: Paterson Inlet random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals.

Dusky Sound

Three blue cod potting surveys have been carried out in Dusky Sound. The surveys in 2002 and 2008 were both fixed-site surveys, whereas, in 2014, independent fixed-site and random-site surveys were carried out concurrently.

In 2002 the overall mean catch rates for all blue cod from fixed sites were 2.65 kg pot^{-1} (CV = 9.2%) and 1.81 kg pot^{-1} for recruited blue cod ≥ 33 cm (CV = 8.7%). Catch rates were highest on the open coast (i.e., at the entrance to the sound, Carbines & Beentjes 2003). The 2008 fixed-site survey catch rates were 4.2 kg pot^{-1} (CV = 5.8%) for all blue cod and 3.15 kg pot^{-1} (CV = 5.9%) for recruited blue cod, considerably higher than in 2002 and again highest catch rates were in the open coast stratum (Carbines & Beentjes 2011a). In 2014 the fixed-site catch rates had declined to 3.22 kg pot^{-1} (CV = 11.9%) and 2.35 kg pot^{-1} (CV = 11.9%), respectively, with highest catch rates on the open coast. The 2014 random-site catch rates were less than from fixed sites and were 2.61 kg pot^{-1} (CV = 8.6%) for all blue cod and 1.92 kg pot^{-1} (CV = 9.6%) for recruited blue cod, also with catch rates highest on the open coast (Beentjes & Page 2017). Overall scaled length and age distributions were similar between the fixed- and random-site surveys but the sex ratio favoured females in fixed sites (39% male) and was close to parity in random sites (52% male). Fixed-site surveys may not be suitable for monitoring the Dusky Sound blue cod population, but at least one more dual fixed- and random-site survey is required before moving exclusively to random-site surveys.

Total mortality (Z) for blue cod from the 2014 random-site survey was estimated at 0.25 with spawner-biomass-per-recruit (full recruitment at 8 years for females) estimated at $F_{49\%}$. Mortality estimates from the 2002 and 2008 surveys should not be used due to a recent change in the age determination protocol for blue cod.

4.1.2 Trawl survey estimates

Relative abundance indices from trawl surveys are available for BCO 5, 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 5 CPUE analyses

An updated fishery characterisation and standardised CPUE analyses was carried out for BCO 5 from 1989–90 to 2022–23 (34 years) (Beentjes et al 2024).

The main fishing methods for blue cod in BCO 5 have been cod pot (CP), rock lobster pot (RLP) and bottom trawl (BT), with cod pot predominantly the main method used in all statistical areas, accounting for 97% of the catch over the 34 years with no trends over time. The blue cod pot catch was reported using CELR paper forms until 2019–20 when the fishery transitioned to Electronic Reporting System (ERS-potting). The bulk of the blue cod catch has been landed into Bluff, Riverton, and Stewart Island ports. The port of landing is not recorded in the ERS but can be determined from the variable 'trip end position'. The main landing states for blue cod from method cod potting has consistently been headed and gutted (HGU), followed by gutted (GUT), and filleted with skin on (FIL), with relatively little blue cod landed in the green state (GRE).

The BCO 5 blue cod potting fishery operates throughout the year with no clear seasonal trends in the landings for any of the BCO 5 statistical areas over the time series, nor was there any change when transitioning to the ERS-potting reporting. There were also no clear changes in fishing behaviour after changing to electronic reporting in 2019–20, i.e., number of statistical areas, number of fishing days, and landed catch per trip in BCO 5 did not change.

The cod potting fleet size in BCO 5 peaked in 1994 with over 75 vessels actively fishing, but has since steadily declined with around 35 vessels fishing in 2021–22 and 2022–23. The bulk of the cod pot landings have historically been taken from Statistical Areas 025, 027, 030, and 029 which have contributed 50%, 21%, 20% and 6% of the catch respectively, over the 34-year time series (Figure 5). The landings from 025 have declined steadily since 2006, with the contribution dropping to 34% of BCO 5 landings in 2022–23 (Figure 5). Landings from 027, 029 and 030 have fluctuated with no clear trend over the last 25 years, although catch from 029 has been increasing over the last four years. Effort (pot lifts) in Statistical Area 025 peaked in the 1990s, before dropping by more than half by 2003, after which it was generally stable before a steep drop off in effort after 2019–20 (Figure 6).

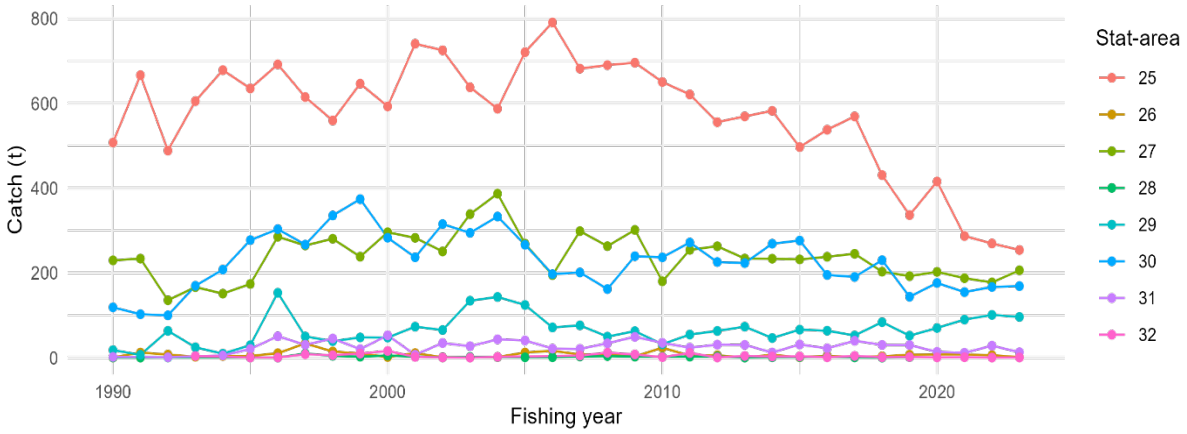


Figure 5: Landings (t) of blue cod from BCO 5 for method cod pot (CP) by statistical area, from 1989–90 to 2022–23.

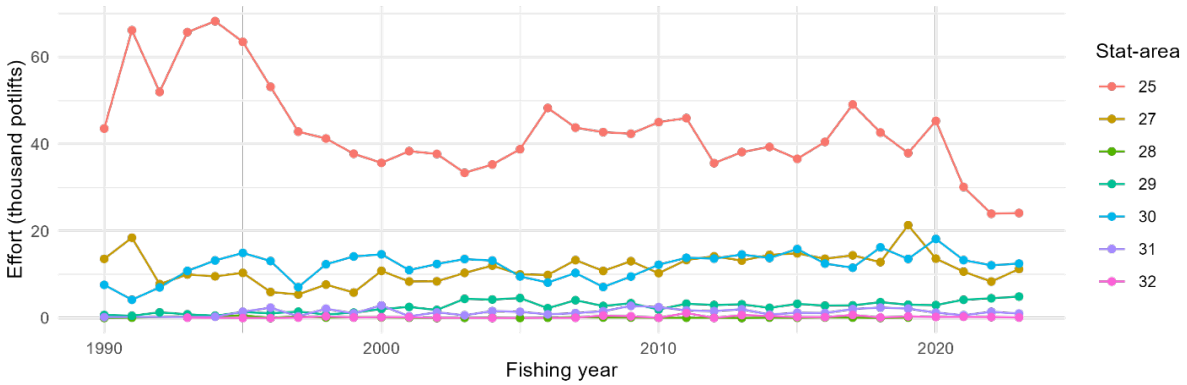


Figure 6: Effort (pot lifts) by statistical area in BCO 5 for method cod pot from 1989–90 to 2022–23.

A range of standardised CPUE series were explored using Generalised Linear Models, both for individual and combined Statistical Area groups (Beentjes et al 2024). These series showed similar patterns in recent years, with CPUE increasing between 2018–19 and 2021–22, and then decreasing in 2022–23 (except Statistical Area 025, which was stable in 2022–23). There were concerns that the recent (since 2018–19) trends observed in the series were confounded with spatial shifts in the fishery, especially when also considering age composition data from the commercial fishery (Beentjes & Bian 2024), and potentially the change in reporting forms to ERS. Therefore the modelled CPUE series may be masking declines in abundance. This, and other aspects of model performance (see below) resulted in the Plenary rejecting the stock assessment for Statistical Area 025.

4.1.4 Stock Assessment

BCO 5 Stock Assessment (Southland)
The first fully quantitative stock assessment for blue cod in BCO 5 was carried out in 2013 (Haist et al 2013). A custom-built length-based model using Bayesian estimation was fitted separately to data from Statistical Areas 025, 027, and 030. A second stock assessment was completed in 2019 as an age-based Bayesian model and the assessment was conducted using NIWA's CASAL2 assessment package (Doonan 2020). Again, the model was fitted separately to data from Statistical Areas 025, 027, and 030.

A third assessment was undertaken in 2024 (Doonan & McKenzie 2024) using the same model structure as the 2019 assessment. Based on size composition and spatial proximity of the catch, Statistical Area 029, which was previously excluded from the assessment, was combined with the adjacent Statistical Area 027, so that separate stock assessment models were initially explored for Statistical Area 025, 027 & 029, and 030.

For Statistical Area 027 plus Statistical Area 029, the attempted assessment indicated that the current status of the stock was well above target, which was considered implausible given the long history of the fishery and anecdotal reports from fishers. The large proportion of older fish in commercial catches during the 2022–23 fishing year is thought, in part, to be the result of fishers fishing previously lightly fished areas in deeper water further offshore. For Statistical Area 030, recent catch sampling indicated that there were older fish in the western portion, but it is not possible to create western and eastern catch and effort histories prior to the introduction of the Electronic Reporting System in 2019 because of the lack of positional data in the earlier paper forms.

A stock assessment model for Statistical Area 025 was completed, implementing fast and slow growing growth morphs to improve fits to the length data. The model without sex transition failed to fit to the recent decline to very low levels in the proportion of females (a new trend since the last assessment), and a model with sex transition required further work. Other issues included model diagnostics and the YCS trend. Ultimately these issues and concerns over the CPUE series (section 4.1.3.3) meant that the assessment was rejected by the Plenary.

Estimates of relative abundance, sex ratio and fishing mortality from the Foveaux Strait potting survey were used to complete a partial quantitative stock assessment for Statistical Area 025.

2019 Stock assessment

Model structure
The stock assessment model was aged-based with the population partitioned into six categories: male and female combined with three growth morphs (Doonan 2020). The growth morphs were fast, medium, and slow growth. Each morph had a normal length distribution at each age and they were constrained to combine into a normal length distribution-at-age with the same spread of length-at-age as observed in potting survey catches. Because fish cannot unambiguously be assigned to any one growth morph, observed data for each morph are not available. The pot fishery operates under a minimum legal size (MLS) and the morph construct helps the model 'remember' length distributional changes as a cohort grows past the MLS; i.e., once a cohort is completely recruited into the fishery, its length distribution is asymmetrical.

There are three fisheries: commercial line, commercial pot, and recreational line. Each fishery was modelled with a selectivity ogive and a retention ogive (Table 8), so catch data were a function of the selectivity ogive and landings data were a function of the product of selectivity and retention ogives. There were three time blocks for the pot fishery selectivity: pre-1994, 1994 to 2017, and 2018 onwards. These periods mirror the changes in regulations starting with the change in MLS (30 to 33 cm) in 1994 and the change in commercial pot mesh sizes in 2018. Discard mortality was assumed for fish that were caught but not landed.

Table 8: Model selectivity and retention ogives by fishery, their parametric form, and parameter values if fixed or data fitted in the model to inform their estimation. AF, age frequency data; LF, length frequency data.

Ogives	Type	Parameters if fixed or data to inform
Selectivity		
Commercial line fishery	Logistic	50% selected at 280 mm; 95% selected at 305 mm
Commercial pot fishery ≤ 1993	Logistic	Mesh size trial LF
Commercial pot fishery 1994–2017	Logistic	Logbook sampling LF
Commercial pot fishery ≥ 2018	Logistic	2015 pot experiment & commercial AF
Recreational fishery	Logistic	Recreational catch LF
Survey	Logistic	Survey AF
Retention		
Commercial line fishery	Knife-edge	MLS (300 mm)
Commercial pot fishery ≤ 1993	Knife-edge	MLS (300 mm)
Commercial pot fishery 1994–2017	Knife-edge	MLS (330 mm)
Commercial pot fishery ≥ 2018	Knife-edge	MLS (330 mm)
Recreational fishery ≤ 1993	Knife-edge	MLS (300 mm)
Recreational fishery ≥ 1994	Knife-edge	MLS (330 mm)

Spawning stock biomass (*SSB*) is measured as the total mature biomass. A Beverton-Holt stock recruitment relationship was assumed. The CV of recruitment residuals was fixed at 0.6 and the steepness was assumed to be 0.75. Recruitment residuals were estimated for 1980–2014. Fish recruited to the model at age 1+ with 50% of fish recruiting as females. The populations were initialised at unexploited equilibrium conditions in 1900.

The informed prior distributions for model parameters are given in Table 9. Other parameters had uniform priors.

Table 9: Assumed informed prior distributions for model parameters.

Model parameters	Distribution	Parameters/ bounds
Recruitment variation	Lognormal	CV: 0.60

As a sensitivity test, sex change was modelled as a dynamic process, with the proportion of females transitioning to males as a function of age. Because there was little indication from the pot survey age data that sex change was occurring in the mature population, it was concluded that sex change probably occurred in the period before maturation. The sex ratio for mature fish was assumed to be 1:1.

Data

Separate data sets were compiled and analysed for Statistical Areas 025, 027, and 030. The data available for each of these areas differ, and few data were available for the remainder of the BCO 5 statistical areas. Data for Statistical Areas 025, 027, and 030, when combined, represent 92% of the recent commercial fishery landings. The general categories of data used in the stock assessment models included: landings, fishery length frequency data (LF), fishery and survey age frequency data (AF), abundance indices from standardised CPUE (all areas) and from fishery independent potting surveys (Statistical Area 025 only), and biological information on natural mortality, growth, and maturation.

Historical time series of BCO 5 landings were constructed for three gear types: commercial hand-line fishing, commercial pot fishing, and recreational line fishing. Additionally, non-reported blue cod catch used as bait in the CRA 8 rock lobster fishery was estimated and included with the commercial landings, and customary catch estimates were included with the recreational harvest. The constructed catch

history prior to 2012 was the same as that used in the 2013 stock assessment (Haist et al 2013) and is presented in Figure 7.

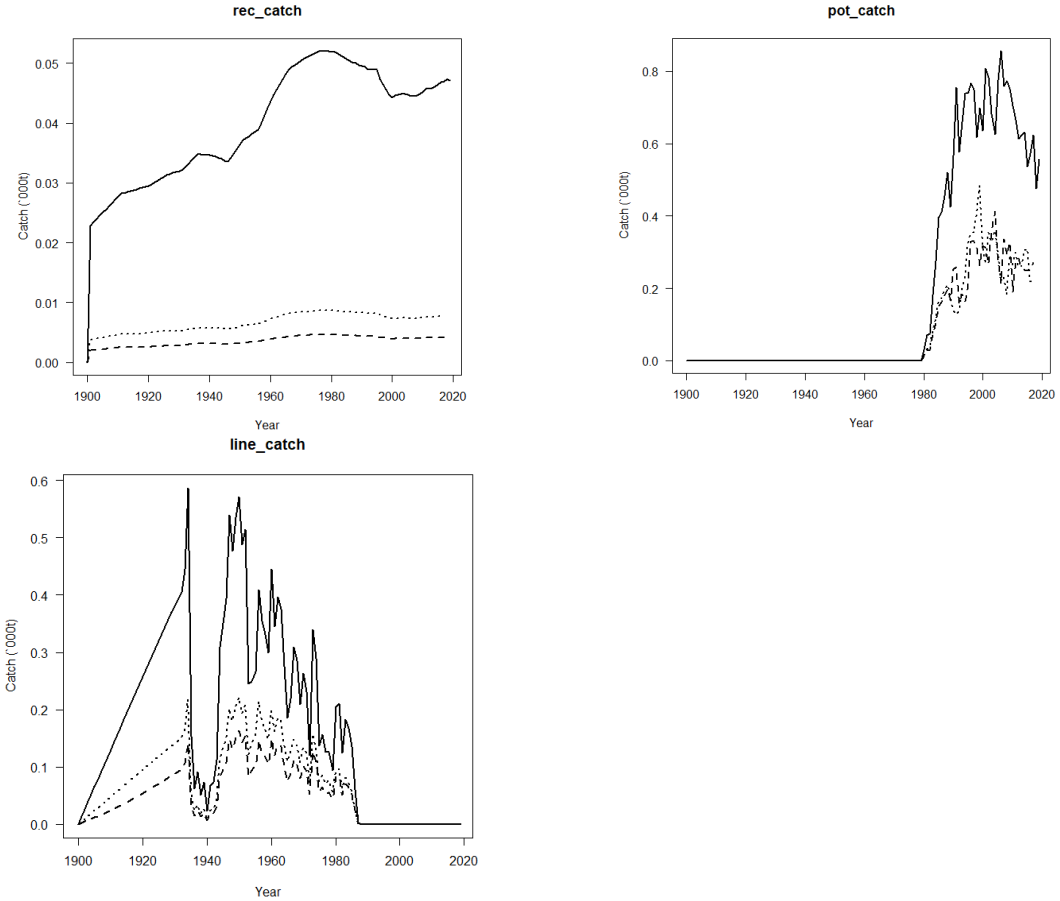


Figure 7: Constructed catch history used in the assessments by fishery and Statistical Areas 025 (solid line), 027 (dashed line), & 030 (dotted line).

Commercial landings data were available from 1931 (Warren et al 1997) and these were linearly decreased back to 1900, when the fishery was assumed to begin. The 1989–90 to 2011–12 average proportion of the total BCO 5 catch in each statistical area was used to prorate the earlier landings estimates to statistical area. A time series of non-reported blue cod used as bait in the rock lobster fishery was developed based on a 1985 diary study (Warren et al 1997), in conjunction with CRA 8 rock lobster landings.

A time series of recreational blue cod harvest was developed based on the 1991–92 and 1996 diary survey estimates of BCO 5 recreational catch. The average blue cod catch per Southland resident was estimated from the survey data and, assuming a constant per capita catch rate, was extrapolated to a time series using Southland District population census data.

Commercial fishery LF data were collected through a commercial fishers logbook project and a shed sampling project from 2009 to 2011. The shed sampling was sex-specific whereas the logbook sampling was not. Mean size of fish from the shed samples were smaller than those from the logbook programme (for Statistical Areas 025 and 027; there were no shed samples from Statistical Area 030), due to these data being from the last catch of the day, which was likely to be from inshore waters close to the sheds (so the fish would not spoil), where exploitation rates were higher. The logbook LF data were fitted to model predictions of the commercial catch size distribution for 2010, and, as a sensitivity, the logbook LFs were replaced by the shed LFs.

Recreational fishery LFs were obtained from a 2009–10 study of the Southland recreational blue cod fishery (Davey & Hartill 2011). This study included a boat ramp survey (Bluff, Riverton/Colac Bay,

and Halfmoon Bay) and a logbook survey of charter and recreational vessels. Blue cod measured through the boat ramp programme were assumed to represent the landings, and fish measured through the logbook programme were assumed to represent the catch. Only the logbook data were fitted in the model.

Length frequency data from a blue cod mesh-size selectivity study, conducted by MAF in 1986 at Bluff and Stewart Island, were available. The LF from pots fitted with the then-standard 38 mm mesh were assumed to represent the size composition of the BCO 5 commercial pot fishery catch before the 1994 pot regulation changes. In preparation for a further change in mesh size regulations in 2018, different mesh sizes were trialled at various sites close to land in 2015 (Glen Carbines, pers. comm.). The data for the new mesh sizes were fitted to the 2018 size frequency. Both experiments did not catch a representative sample of the larger fish given the restricted range of sites used. Consequently, the model was fitted to just the left-hand limb (LHS) because its use was for catch selectivity estimation.

Length frequency data were also available from random stratified potting surveys conducted in Statistical Areas 025 and 030 in 2010, 2014, and 2018. These surveys also provide age frequency (AF) data by sex. There are two stock abundance estimates: fishery-based standardised CPUE estimates (Table 10), and pot survey estimates of abundance. The data fitted in the models for each statistical area are shown in Table 11, and the assumed error structure of each data series is shown in Table 12.

Table 10: Standardised CPUE indices for Statistical Areas 025, 027, and 030, for fishing years 1990–2018.

	Statistical Area				Statistical Area		
Fishing Year	**025**	**027**	**030**	**Fishing Year**	**025**	**027**	**030**
1990	1.01	0.59	1.04	2005	1.32	1.25	1.24
1991	0.81	0.62	0.97	2006	1.26	1.18	1.27
1992	0.79	0.66	1.00	2007	1.09	0.96	1.14
1993	0.80	0.85	0.89	2008	1.02	0.88	0.95
1994	0.81	0.61	0.65	2009	1.03	0.88	1.04
1995	0.84	0.91	0.69	2010	0.90	0.82	1.01
1996	0.97	1.07	0.70	2011	0.98	1.01	0.86
1997	1.08	1.24	1.15	2012	0.98	0.98	0.81
1998	1.06	1.13	1.20	2013	0.96	0.92	0.91
1999	0.96	1.11	1.32	2014	1.00	0.84	0.96
2000	1.12	1.32	1.13	2015	0.93	0.92	0.96
2001	1.23	1.65	1.18	2016	0.92	0.97	0.85
2002	1.31	1.75	1.35	2017	0.92	1.01	0.89
2003	1.27	1.51	1.35	2018	0.76	0.90	0.82
2004	1.23	1.63	1.23				

Table 11: Data series fitted in the stock assessments for Statistical Areas 025, 027, and 030. AF is age frequency data; LF is length frequency data.

Data type	**Series**	**Statistical Area 025**	**Statistical Area 027**	**Statistical Area 030**
AF data	Survey	✓	–	–
	Pot fishery	✓	✓	✓
LF data	Logbook	✓	✓	✓
	Mesh selectivity trials (1986)	data common to all areas		
	Recreational catch	data common to all areas		
	Mesh selectivity trials (2015)	data common to all areas		
Abundance Index	CPUE	✓	✓	✓
	Survey	✓	–	–

Table 12: Assumed distributions for data fitted in the models. AF, age frequency data; LF, length frequency data. N, effective sample size [Continued next page].

Data type	**Distribution**	**Parameters**
Survey abundance	Lognormal	CV: 0.20
Survey AF	Multinomial	N: 100
Pot fishery AF 2018	Multinomial	N: 100
2019	Multinomial	N: 5
CPUE	Lognormal	CV: 0.10
Logbook LF	Multinomial	N: 100

Table 12 [Continued]:

Mesh size trials LF (1986)	Multinomial	N: 20
Mesh size trials LF (2015)	Multinomial	N: 20
Recreational catch LF	Multinomial	N: 100
Ages	Off-by-one, binominal	P: 0.086
Sensitivities		
Shed samples LF	Multinomial	N: 100

Further assumptions

Age data to estimate sex-specific von Bertalanffy growth parameters were available from the random-stratified potting surveys and the commercial AFs. The same growth model was assumed for all areas. For males, the L_∞ parameter was not well estimated because data were sparse at L_∞ due to fishing pressure. Male L_∞ was therefore estimated within the model. The potting surveys also had maturity data which gave maturity as logistic with A_{50} of 4.1 y and A_{50to95} of 2.47 y for both sexes.

Biomass estimates

The assessment was conducted in two steps. First, a set of initial exploratory model runs was carried out generating point estimates (MPD runs, which nominally estimate the mode of each posterior distribution). The purpose of the MPD runs was to decide which sets of assumptions should be carried forward to the final runs and to quantify the sensitivities of the MPD to the assumptions used. The final runs were fully Bayesian, estimating posterior distributions for all quantities of interest. The base-case model run consisted of separate stock assessments for Statistical Areas 025, 027, and 030, with the results combined to provide results for BCO 5. Natural mortality was fixed at 0.17.

The MPD $B_{CURRENT}$ (% B_0) for the base case was estimated at 31.2%. When M was set at 0.15, $B_{CURRENT}$ was 29.4%, and when M was set to 0.19, it was 33.1%. The largest change occurred when the LF data from the logbook programme were replaced with data from the shed sampling programme; this reduced $B_{CURRENT}$ to 23.9%. The latter was considered unlikely, because the shed length data have a lower proportion of large fish than the logbook data because of the differences in the way the fish were sampled. The logbook length data were preferred by the working group. Other sensitivities model runs included:

Sensitivity	**$B_{CURRENT}$ (% B_0)**
Commercial discard mortality of 50%	31.6
Sex change in model (also single growth path)	32.0
Single growth path	31.6
Single stock assessment	33.0

Bayesian posterior distributions were estimated for the base-case model using a Markov chain Monte Carlo (MCMC) approach. For each run a chain of 1 million was completed and the chains thinned to produce a posterior sample of 1000. BCO 5 summary statistics are calculated by summing across Statistical Areas 025, 027, and 030, and BCO 5 catch is calculated assuming these areas account for 92% of the BCO 5 stock. The model estimates are summarised in Table 13 (estimates of spawning biomass), Figure 8 (biomass trajectories), and Figure 9 (recruitment trajectories).

Table 13: Estimates of BCO 5 unfished spawning stock biomass and current spawning stock biomass as a percentage of the unfished level for the final runs (medians of marginal posterior distributions, with 95% confidence intervals in parentheses). B_0 is calculated assuming Statistical Areas 025, 027, and 030 represent 92% of the BCO 5 blue cod stock.

Run	**B_0 (000 t)**	**$B_{CURRENT}$ (% B_0)**
base	21(20,23)	36 (31,41)

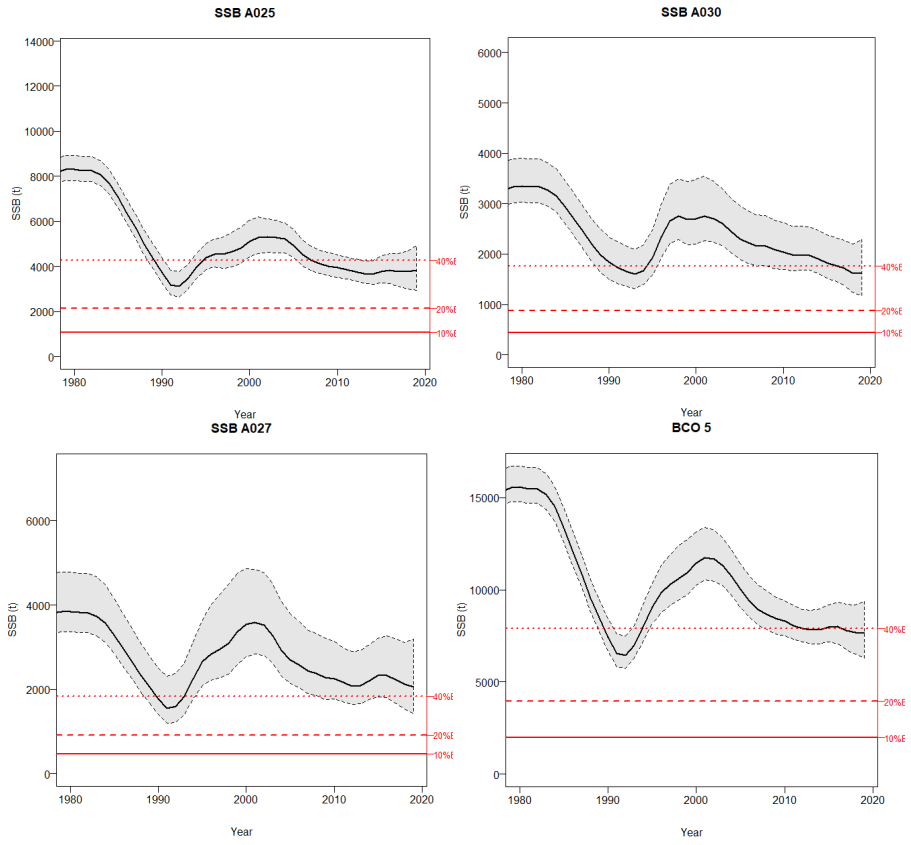


Figure 8: Median estimates of spawning biomass for Statistical Areas 025, 027, and 030, and the three areas combined, for the base-case model runs, 1980–2019.

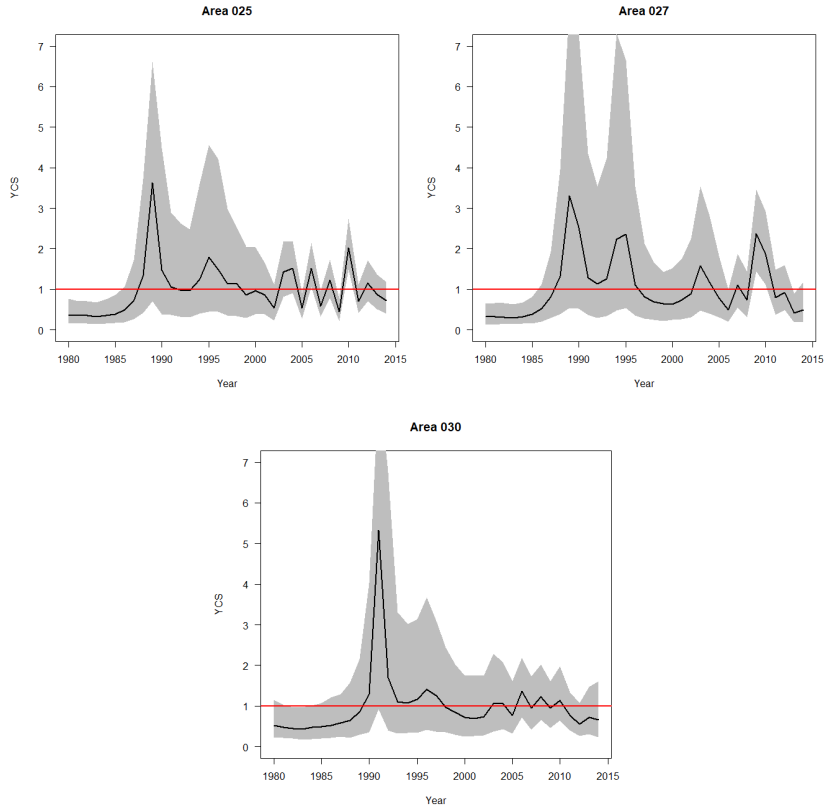


Figure 9: Year Class Strength (YCS) from the base-case runs for Statistical Areas 025, 027, and 030, for 1980–2014. Medians are shown by the black line and the shaded areas show the 95% range limits.

Yield estimates and projections

Ten-year stock projections were conducted for the three statistical areas at constant catch levels, with summary statistics calculated at the end of 5 and 10 years. These are based on the MCMC results. In the stock assessment, the 2018–19 commercial catch level was set at the average of the years (2015–16, 2016–17, and 2017–18). This level of catch was also used in projections based on current catch for the years 2019–20 onwards, and the 2018–19 catch was recalculated based on returns-to-date (as of 8 November 2019) of 804.8 t, which was allocated to the assessment areas based on their fraction of catch to the total. An alternative catch scenario was simulated with commercial catch reduced by 20%.

Recruitment was simulated by randomly re-sampling (with replacement) from the 2005–14 recruitment deviates, applied to the stock-recruitment relationship. Summary statistics were calculated for the BCO 5 QMA by summing B_0 and projected biomass estimates across the three statistical areas.

The projections indicate that under the assumptions of commercial catch at current levels and recruitment at recent levels, the BCO 5 biomass is likely to decline gradually over the next 10 years (Figure 10). Although the spawning stock sex ratio is variable among the sensitivity trials, by 2013 and through the projection period, the sex ratio remains relatively constant. The probabilities of the projected spawning stock biomass (2018 and 2023) being below the hard limit of 10% B_0 or the soft limit of 20% B_0, or above the target of 40% B_0, are presented in Table 14, for the base-case model with recent recruitment for the sensitivity runs with recent recruitment and commercial catch at current levels and with a reduction of 20%. With catches at current levels, the probability of the stock being less than either the soft or hard limit over the next five years is negligible.

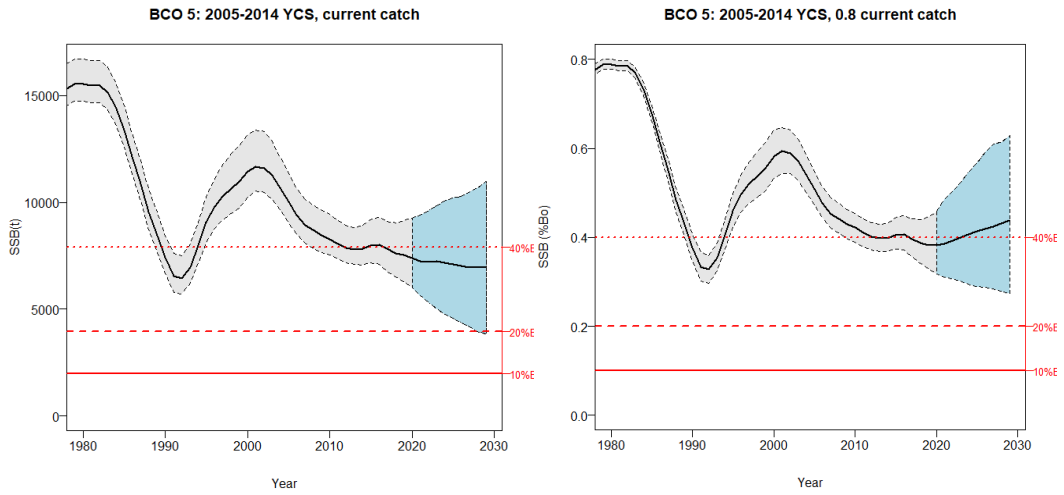


Figure 10: Projected BCO 5 spawning biomass (% B_0) assuming recent recruitment and catch at current levels and at 80% of current levels for the base-case run. Median estimates are shown as solid lines and 95% confidence intervals as shaded polygons. Projections start in 2020.

Table 14: Probabilities of *SSB* being below B_0 reference levels in 2019, 2024, and 2029 at alternative catch levels for the base-case projections.

Run			**Base**
Recruitment	**Recent**	**Recent**	**Recent**
Catch Level	TACC	Current	80% of Current
$P(B_{2019} < 0.1\ B_0)$	NA	0	0
$P(B_{2019} < 0.2\ B_0)$	NA	0	0
$P(B_{2019} >= 0.4\ B_0)$	NA	0.279	0.269
5 year projection			
$P(B_{2024} < 0.1\ B_0)$	NA	0	0
$P(B_{2024} < 0.2\ B_0)$	NA	0.004	0
$P(B_{2024} >= 0.4\ B_0)$	NA	0.286	0.535
10 year projection			
$P(B_{2029} < 0.1\ B_0)$	NA	0	0
$P(B_{2029} < 0.2\ B_0)$	NA	0.024	0.001
$P(B_{2029} >= 0.4\ B_0)$	NA	0.301	0.69

Management procedure to set TACC

On the basis of the 2019 stock assessment (Doonan 2020), the TAC for BCO 5 was reduced to 925 t, with a TACC of 800 t. Given recent poor recruitment and biomass declines estimated in the assessment model, a management procedure was developed in 2021 to monitor and manage the fishery between stock assessments on the basis of CPUE. According to the Medium Term Research Plan, the stock assessment for BCO 5 should be updated every 5 years. The harvest control rule was developed by industry stakeholders in consultation with Fisheries New Zealand and the Inshore Working Group, and robustness testing was undertaken using simulations based on the 2019 stock assessment model. Although reviewed and accepted by both the Working Group and the 2021 Stock Assessment Plenary, this Harvest Control Rule has not been formally adopted for the management of BCO5.

The harvest control rule relates CPUE (in kg per potlift) to TACC levels (Figure 11), leading to further reductions below the current 800 t TACC should CPUE decline further. The rule is meant to safeguard against further declines in biomass and minimise the risk of the fishery declining below limit reference points (i.e., 0.2 × SSB_0). Increases in catch include a latent year on CPUE increases; increases in CPUE from one year y to the next (y+1) are only realised if CPUE is still higher in the subsequent year (y+2). Any reductions in CPUE lead to immediate reductions in the TACC.

Simulation-testing of the control rule was carried out using a model that was modified from the 2019 stock assessment model to amalgamate all data (CPUE, composition data, catch) into a single area stock assessment. The revised operating model mirrored trends seen in the sum of the three single area models run by Doonan (2020), and the model was deemed adequate by the Plenary to test the robustness of the harvest control rule. The stakeholder-proposed rule was compared with a series of alternative control rules and constant catch levels to elicit its relative performance and risk. Recent estimated recruitment (2007–2016) was used as a basis for simulations, which represents some of the lowest recruitment in the model-estimated recruitment time series—simulation results could therefore be regarded as conservative because they assume that the recent low recruitment levels will continue.

Simulation testing concluded that the BCO 5 harvest control rule showed a low risk of reaching stock levels near limit reference points (Table 15, Figure 12), but also showed that the TACCs specified in the rule would lead to slow rebuilding of the stock based on the most recent 10 years of year class strength estimates, with a 46% change of rebuilding back to 40% SSB_0 by 2040 under the rule and recent recruitment.

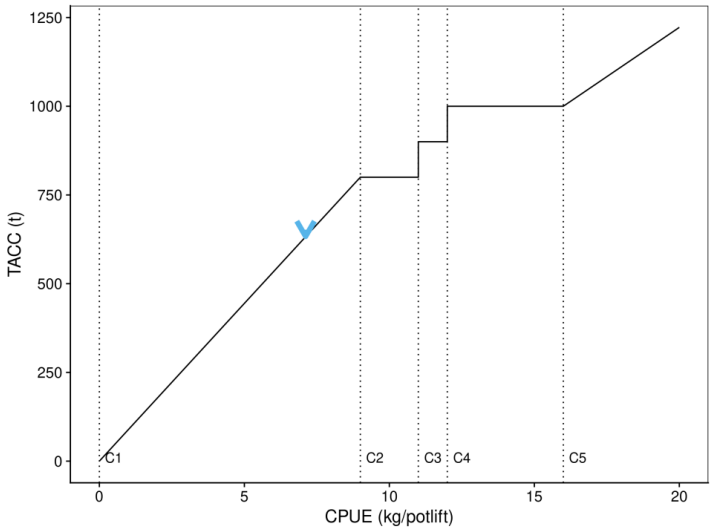


Figure 11: Harvest control rule relating the commercial TACC (t) to catch per unit effort (CPUE, kg per potlift). The control rule is defined by CPUE parameters C1–C5 as well as corresponding TACC levels. The 2020 CPUE level is indicated by the light-blue arrow, suggesting a further reduction in TACC may be necessary to reduce fishing impacts under reduced current productivity.

Table 15: Probabilities of stock size being above 0.4 SSB_0 by 2025, 2030, and 2040, and the risk of the stock declining below 0.2 SSB_0 by 2025 or at any time between 2020 and 2040 under application of the harvest control rule using the 10 most recent years of estimated year class strength.

	BCO 5 rule	TACC 800 t
P(SSB_{2025}>0.4 SSB_0)	0.23	0.15
P(SSB_{2030}>0.4 SSB_0)	0.37	0.26
P(SSB_{2030}>0.4 SSB_0)	0.46	0.32
P(SSB_{2025}<0.2 SSB_0)	<0.01	0.05
P(SSB_{2021}-SSB_{2040}<0.2 SSB_0)	<0.01	0.13

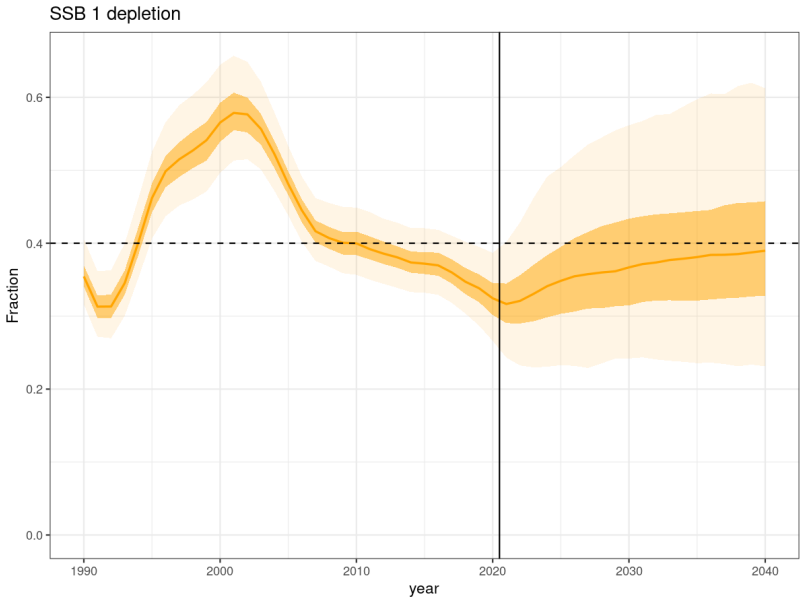


Figure 12: Stock trajectories estimated by the operating model used for harvest control rule estimation up to 2020, with median (dark yellow), inter-quartile range (yellow), and 95% confidence bounds (tan). After 2020, trajectories show posterior medians of simulations under recent recruitment and application of the BCO 5 harvest control rule, compared with fixed total commercial catch (TCC) levels at the current TACC (800 t), recent catch (1000 t), and 600 t.

Breakout rules

To apply the harvest control rule, CPUE will be standardised and monitored annually, including standard diagnostics to ensure that changes in the fishery do not undermine the assumed relationship between CPUE and available biomass. Catch information will be used to monitor the spatial distribution of the fishery through time to determine whether this has changed. Trends and diagnostics will be presented annually to the Working Group to ensure that CPUE continues to reflect abundance and is therefore usable as input for the harvest control rule. The decision rule will be fully evaluated as part of the next stock assessment (2024). Catch and effort data collected from the recently-introduced Electronic Reporting System (ERS) will be monitored annually to determine whether there have been changes in reporting that affect the comparability of these data with data from CELR forms.

4.2 Future research considerations

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

<u>BCO 5</u>

- Explore stock assessment model sensitivity runs including a survey only model (Statistical Area 025), and the use of sex specific SSB.
- Continue development of the sex change model.
- Consider interviewing fishers with systematic and structured surveys to identify potential changes in fishing (and reporting) behaviour that might affect the relationship between the CPUE indices and abundance (including changes in environmental and spatial patterns). If there is evidence of increasing catchability, possible changes to the assessment include splitting

vessel identifiers by time period(s) or including an additional parameter for representing increasing catchability.
- As more ERS data (or other information on spatial patterns in the fisheries) becomes available investigate using spatial models for the Statistical Area 025, 030 and 027 + 029 stock assessments.
- Future catch-at-age programmes for Statistical Areas 030 and 027+029 should include spatial strata that are consistent with spatially structured models recommended for these areas, informed by improved understanding of spatial patterns within the fishery (above).
- Review all data available (including length compositions) on recreational harvest to inform inclusion of this component of removals within stock assessment models.
- Further investigation should be conducted to identify correlations between blue cod recruitment estimates and key environmental variables to improve understanding of recruitment dynamics.

BCO 5 Control rule
- Consider a wider family of future harvest control rules.
- Try to define an optimal control rule based on input from stakeholders. Output a range of indicators of importance to stakeholders in a form that makes it easier to inform trade-offs.
- Explore other forms of breakout rules.

5. STATUS OF THE STOCKS

- **BCO 5**

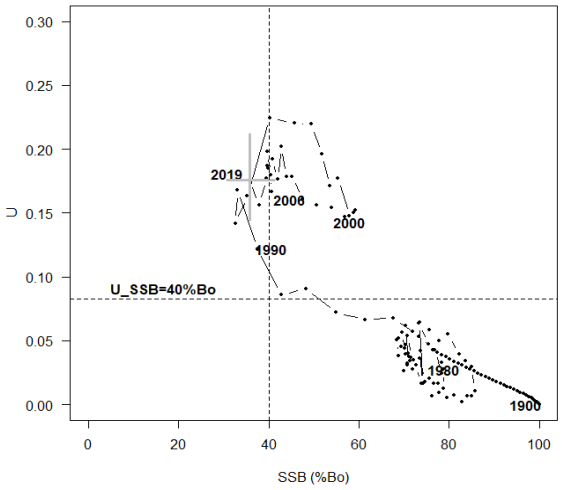
A stock assessment model for Statistical Area 025 was completed in 2024 but concerns over the recent trend in the CPUE series (section 4.1.3.3) and the 2024 assessment of Statistical Area 025 (section 4.1.4) meant that the assessment was rejected by the Plenary, so the Stock Status for BCO 5 was based on the 2019 assessment. Estimates of relative abundance, sex ratio and fishing mortality from the Foveaux Strait potting survey were used to complete a partial quantitative stock assessment for Statistical Area 025 in 2024.

Stock Structure Assumptions

Tagging experiments suggest that blue cod populations may be isolated from each other and there may be several distinct populations within management areas. For the purposes of this summary, blue cod in Statistical Areas 025, 027, and 030 of BCO 5 are treated as a unit stock. Dusky Sound and Paterson Inlet are assumed to contain discrete populations of BCO, which are monitored with potting surveys.

Stock Status		
Most Recent Assessment Plenary Publication Year	2020	
Intrinsic Productivity Level	Low	
Catch in most recent year of assessment	Year: 2017–18	Catch: 1 025 t
Assessment Runs Presented	One base-case model	
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $U_{40\%SB}$	
Status in relation to Target	B_{2019} was estimated to be 36% B_0; and is Unlikely (< 40%) to be at or above the Management Target	
Status in relation to Limits	B_{2019} 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 Likely (> 60%) to be occurring	

Historical Stock Status Trajectory and Current Status



Annual spawning biomass and fishing mortality compared with $SSB_{40\%}$ and the corresponding fishing mortality reference.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass has been decreasing since about 2000.
Recent Trend in Fishing Intensity or Proxy	The exploitation rate has been above the target since 1990.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	There have been four random-site potting surveys in Foveaux Strait (2010, 2014, 2018, and 2023) with no clear trend in catch rates until a 57% decline in 2023. Fishing mortality in 2023 was nearly seven times higher than the target reference fishing mortality of 0.15, indicating that overfishing is occurring.

Projections and Prognosis	
Stock Projections or Prognosis	BCO 5 biomass is expected to decline over the next 5 to 10 years at current catch levels.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	For current catch in the next 3–5 years: Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	The current catch (average of 2015–16 to 2017–18), which is lower than the TACC, is Likely (> 60%) to cause overfishing to continue.

Assessment Methodology and Evaluation		
Assessment Type	Level 1 - Full Quantitative Stock Assessment	
Assessment Method	Age-based model with Bayesian estimation of posterior distributions	
Assessment Dates	Latest assessment Plenary publication year: 2020	Next assessment: 2028
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- CPUE time series - Proportions-at-length and -at-age from commercial catch for 2017–18 and 2018–19, 2021–22 and 2022–23	1 – High Quality 1 – High Quality

	-Proportions-at-length from commercial catch for 2010 - Relative biomass and proportions-at-length and at-age from potting surveys - Estimates of biological parameters - Potting survey abundance estimates	2 – Medium or Mixed Quality: sampling potentially unrepresentative 1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)	Shed sampling LF by sex; only used in a sensitivity	3 – Low Quality: sampling potentially unrepresentative of the overall population
Changes to Model Structure and Assumptions	- Changed from length-based to age-based model - Maturity ogive age-based - *M* assumed to be 0.17 instead of 0.14 - No sex change assumed in base case	
Major Sources of Uncertainty	- Year classes prior to 2000 - Lack of adequate catch-at-age data - Lack of contrast in age data and CPUE - Relationship between abundance and sex change dynamics	

Qualifying Comments
There have been potential changes in fisher behaviour that are not captured in the assessment; for example, changes in responses to new pot mesh sizes and changes in areas fished (local versus long distance). Also, anecdotal information suggests that some fishers have modified their fishing behaviour to maintain catch rates in a manner that cannot be standardised. Specifically, they move pots after each lift instead of re-setting them in the same place. It is not known to what degree this behaviour was adopted by core fleets in each statistical area, but this behaviour may have biased recent CPUE high, thereby masking declines in abundance. An assessment for BCO5 was attempted in 2024 but was not successful. An assessment for Statistical Area 025 was achieved but rejected by the Plenary due to concerns with the recent CPUE and the assessment model.

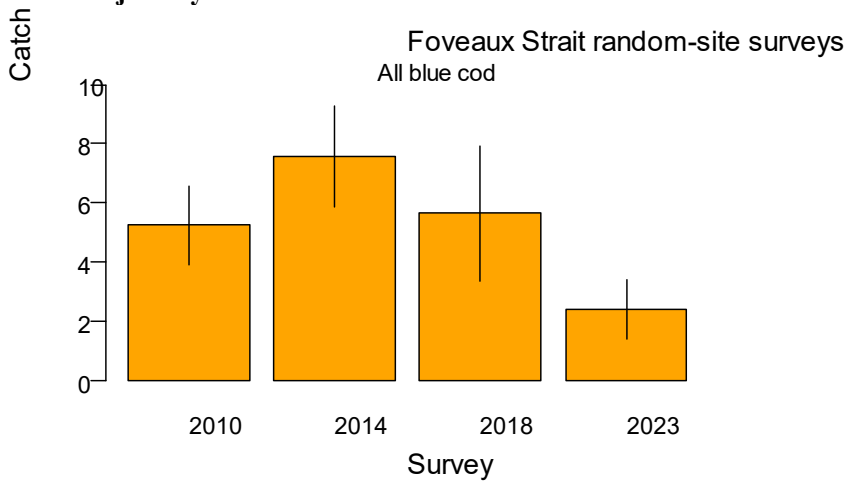
Fishery Interactions
Historically, significant quantities of blue cod, taken by potting, were used as bait in the commercial rock lobster fishery. Since 1996, reporting of blue cod used for bait is mandatory and included as part of the commercial catch reporting. Some blue cod are landed as bycatch in rock lobster pots and oyster dredges.

- **BCO 5 - Statistical Area 025**

Stock Status		
Most Recent Assessment Plenary Publication Year	2024	
Intrinsic Productivity Level	Low	
Catch in most recent year of assessment	Year: 2022–23	Catch: 301.3 t (258.2 t commercial, 43.1 t recreational)
Assessment Runs Presented	Foveaux Strait Potting Survey	
Reference Points	Target1: 40% B0 Target 2: $F = 0.87M = 0.87*0.17 = 0.15$ Soft Limit: 20% B_0	

	Hard Limit: 10% B_0 Overfishing threshold: $F = 0.87M = 0.87*0.17 = 0.15$
Status in relation to Target	Very Unlikely (< 10%) to be at or below Target 2. $F = 1.01$
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



Foveaux Strait random-site potting survey catch rates of all blue cod by survey year. Error bars are 95% confidence intervals.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The total biomass estimates have declined with each consecutive survey since 2014, with the largest decline between 2018 and 2023.
Recent Trend in Fishing Intensity or Proxy	F was estimated at 0.74 in 2014, 0.63 in 2018 and 1.01 in 2023. F was seven times the target reference point of F=0.15 in 2023.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

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: 2024	Next assessment: 2028
Overall Assessment Quality	1 – High Quality	
Main Data Inputs (Rank)	- Foveaux Strait Potting Survey	1 – High Quality
Data not used	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	

Qualifying Comments
This assessment applies only to Statistical Area 025. The proportion of total BCO 5 commercial catch coming from 025 has declined from 50% to around 30%, beginning around 2010.

Fishery Interactions
Historically, significant quantities of blue cod, taken by potting, were used as bait in the commercial rock lobster fishery. Since 1996, reporting of blue cod used for bait is mandatory and included as part of the commercial catch reporting. Some blue cod are landed as bycatch in rock lobster pots and oyster dredges.

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