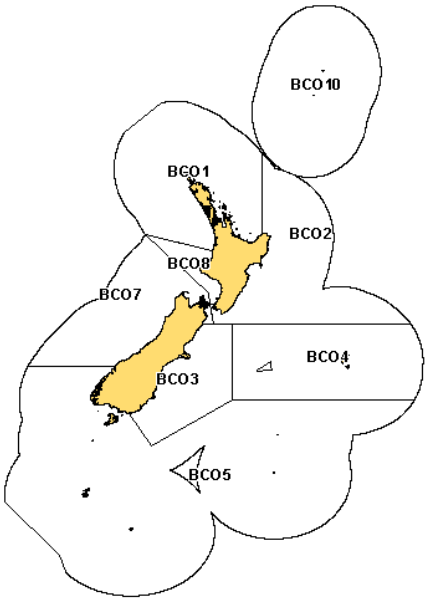
BLUE COD (BCO)

(Parapercis colias)



1. FISHERY SUMMARY

(a) Commercial fisheries

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

The fishery has had a long history. National landings of up to 3000 t were reported in the 1930s and catches of 2500 t were sustained for many years in the 1950s and 1960s. Fluctuations in annual landings since the 1930s can be attributed to World War II, the subsequent market for frozen blue cod for a short period of time and then the development of the rock lobster fishery. Annual landings of blue cod also vary with the success of the rock lobster season (traditionally many blue cod fishers were primarily rock lobster fishers). Therefore, the amount of effort in the blue cod fishery may depend on the success of the rock lobster season, with weather conditions in Southland affecting the number of 'fishable' days.

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). Similarly, the BCO 3 commercial catch is dominated by the target pot fishery, although blue cod is also taken as a small 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 area 024). Catches from BCO 3 and 5 fishstocks peak during autumn and winter and the seasonal nature of the fishery is influenced by the operation of the associated rock lobster fishery.

Total landings built up to a peak in 1985, the year before the QMS was implemented. Landings then declined up to 1989, but have since increased, coinciding with a change in the main fishing method from hand-lines to cod pots. Recent reported landings are shown in Table 1 and historical landings in Table 2.

Since 1994–95, total landings have exceeded 2000 t annually, peeking at 2501 t in 2003–04. Historically, the largest catches of blue cod have been taken in BCO 5 (1344 t in fishing year 2005–2006). The total catch from this fishery remained relatively stable from 1982 to 1993 and subsequently increased to approach the level of the TACC in 1995–96. Catches have remained stable at this higher level in recent years.

Since 1989–90, a large proportion of the total catch from the BCO 5 fishery has been taken from Foveaux Strait (statistical area 025) and catches from this area have remained relatively stable. The recent increase in total catch has been attributed to an increase in catch from the western approaches to Foveaux Strait (stat area 030) and, to a lesser extent, from off eastern Stewart Island (stat area 027). In BCO 3, catches tend to be close to the TACC of 163 t and in recent years landings have slightly exceeded the TACC. The BCO 3 target catch has remained relatively constant since the early 1990s. In other Fishstocks, landings have generally been lower than the TACC. In BCO 7, commercial landings declined in response to a reduction in TACC (to 70 t) implemented in 1995–96, but from 2000-01 annual landings in this QMA have increased steadily.

Table 1: Reported landings (t) of blue cod by Fishstock from 1983 to 2004–05 and actual TACCs (t) from 1986–87 to 2005–06.

Fishstock (QMA)	BCO 1		BCO 2		BCO 3		BCO 4		BCO 5	
FMA (s)	1 & 9		2		3		4		5 & 6	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983*	23	–	4	–	81	–	192	–	626	–
1984*	39	–	6	–	74	–	273	–	798	–
1985*	21	–	3	–	55	–	274	–	954	–
1986*	19	–	2	–	82	–	337	–	844	–
1986–87†	8	30	1	10	84	120	417	600	812	1190
1987–88†	9	40	1	10	148	140	204	647	938	1355
1988–89†	8	42	1	10	136	142	279	647	776	1447
1989–90†	10	45	1	10	121	151	358	749	928	1491
1990–91†	12	45	<1	10	144	154	409	757	1096	1491
1991–92†	10	45	1	10	135	154	378	757	873	1536
1992–93†	12	45	4	10	171	156	445	757	1029	1536
1993–94†	14	45	2	10	142	162	474	757	1132	1536
1994–95†	13	45	1	10	155	162	565	757	1218	1536
1995–96†	11	45	2	10	158	162	464	757	1503	1536
1996–97†	13	45	2	10	156	162	423	757	1326	1536
1997–98†	16	45	4	10	163	162	575	757	1364	1536
1998–99†	12	45	2	10	150	162	499	757	1470	1536
1999–00†	14	45	2	10	168	162	490	757	1357	1536
2000–01†	15	45	2	10	154	162	627	757	1470	1536
2001–02†	12	46	2	10	138	163	648	759	1477	1548
2002–03†	11	46	4	10	169	163	724	759	1497	1548
2003–04†	9	46	4	10	167	163	710	759	1556	1548
2004–05†	9	46	5	10	183	163	731	759	1473	1548
2005–06†	7	46	1	10	183	163	579	759	1344	1548

Fishstock (QMA)	BCO 7		BCO 8		BCO 10		Total	
FMA (s)	7		8		10			
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983*	91	–	53	–	0	–	1070	–
1984*	129	–	56	–	0	–	1375	–
1985*	169	–	70	–	0	–	1546	–
1986*	83	–	42	–	0	–	1409	–
1986–87†	79	110	22	60	0	10	1422	2130
1987–88†	78	126	44	72	0	10	1420	2400
1988–89†	66	131	32	72	0	10	1298	2501
1989–90†	75	136	34	74	0	10	1527	2666
1990–91†	63	136	28	74	0	10	1752	2677
1991–92†	57	136	25	74	0	10	1480	2722
1992–93†	85	136	32	74	0	10	1777	2724
1993–94†	67	95	21	74	0	10	1852	2689
1994–95†	113	95	24	74	0	10	2089	2689
1995–96†	65	70	31	74	0	10	2234	2664
1996–97†	71	70	38	74	0	10	2029	2664
1997–98†	60	70	15	74	0	10	2197	2664
1998–99†	52	70	35	74	0	10	2220	2664
1999–00†	28	70	30	74	0	10	2089	2664
2000–01†	26	70	22	74	0	10	2316	2664
2001–02†	30	70	17	74	0	10	2319	2680
2002–03†	39	70	13	74	0	10	2457	2680
2003–04†	45	70	10	74	0	10	2501	2680
2004–05†	44	70	7	74	0	10	2452	2680
2005–06†	50	70	20	74	0	10	2184	2680

* FSU data.
† QMS data.

Table 2: Reported total New Zealand landings (t) of blue cod for the calendar years 1970 to 1983. Sources MAF and FSU data.

Year	Landings
1970	1022
1971	644
1972	459
1973	846
1974	696
1975	356
1976	524
1977	383
1978	378
1979	437
1980	536
1981	696
1982	539
1983	1135

(b) Recreational fisheries

Blue cod are generally the most important recreational finfish in Marlborough, Otago, Canterbury, Southland and the Chatham Islands. Recreational catches have been obtained from diary surveys in 1991–94, 1996 and Dec 1999-Nov 2000 (Tables 3 - 5). Charter vessel catches have also been obtained separately in 1997–98 (Table 6).

Table 3: Estimated number of blue cod harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991–92, Central in 1992–93 and North in 1993–94 (Teirney et al., 1997).

		Total		
Fishstock	Survey	Number caught	CV(%)	Estimated Harvest range (t)
BCO 1	North	33 000	14	15–30
BCO 1	Central	4000	–	0–5
BCO 2	North	1000	–	0–5
BCO 2	Central	117 000	21	55–85
BCO 3	South	206 000	16	205–285
BCO 5	North	1000	–	0–5
BCO 5	South	188 000	22	150–230
BCO 7	North	2000	–	0–5
BCO 7	Central	311 000	16	145–205
BCO 7	South	62 000	21	20–40
BCO 8	North	2000	–	0–5
BCO 8	Central	124 000	35	50–110

Table 4: Results of a national diary survey of recreational fishers in 1996. Estimated number of blue cod harvested by recreational fishers by Fishstock and the corresponding harvest tonnage. The mean weights used to convert numbers to catch weight are considered the best available estimates. Harvest estimates (t) are also presented as a range to reflect the uncertainty in the estimates (from Bradford, 1998).

Fishstock	Number caught	CV(%)	Estimated harvest range (t)	Point Estimate (t)
BCO 1	34 000	11	10–20	17
BCO 2	145 000	13	70–90	81
BCO 3	217 000	11	135–165	151
BCO 5	171 000	12	120–155	139
BCO 7	356 000	9	220–260	239
BCO 8	159 000	12	70–90	79

Table 5: Results of the 1999/2000 national diary survey of recreational fishers (Dec 1999 – Nov 2000). The mean weights used to convert numbers to catch weight are considered the best available estimates. Harvest estimates (t) of blue cod are also presented as a range to reflect the uncertainty in the estimates (from Boyd & Reilly, 2002).

Fishstock	Number caught	CV(%)	Estimated harvest range (t)	Point Estimate (t)
BCO 1	37 000	31	15-30	23
BCO 2	187 000	25	121-201	161
BCO 3	1026 000	29	530-973	752
BCO 5	326 000	28	165-293	229
BCO 7	542 000	20	230-347	288
BCO 8	232 000	32	127-249	188

Table 6: Results of a national marine diary survey of recreational fishers from charter vessels, 1997–98 (November 1997 to October 1998). Estimated number of blue cod harvested by recreational fishers on charter vessels by Fishstock and the corresponding harvest tonnage. The mean weights used to convert numbers to catch weight are considered the best available estimates (James & Unwin, 2000).

Fishstock	Number caught	CV (%)	Estimated landings	Fishstock harvest (t)
BCO 1	430	18	2500	2.4
BCO 2	34	50	300	0.2
BCO 3	17 272	29	72 000	58
BCO 5	16 750	36	63 000	51
BCO 7	32 026	13	110 000	76
BCO 8	2	–	–	0.0

A key component of estimating recreational harvest from diary surveys is determining the proportion of the population that fish. The Recreational Working Group has concluded that the methodological framework used for telephone interviews produced incorrect eligibility figures for the 1996 and previous surveys. Consequently the harvest estimates derived from these surveys are considered to be considerably underestimated and not reliable. However, relative comparisons can be made between stocks within these surveys. The Recreational Working Group considered that the 2000 survey using face-to-face interviews better estimated eligibility and that the derived recreational harvest estimates are believed to be more accurate. FMA2 catches are nevertheless considered to be an over-estimate, probably because of an unrepresentative diarist sample. The 1999/2000 Harvest estimates for each Fishstock should be evaluated with reference to the coefficient of variation.

The recreational catches estimated for BCO 2, 3, 7 and 8 in 1999/2000 far exceeded the current TACCs and commercial landings in those areas. The last nationwide recreational survey was undertaken in 2001, but the results are still under review and are not currently available.

The national marine diary survey of recreational fishing from charter vessels in 1997–98 found blue cod to be the second most frequently landed species nationally, and the most frequently landed species in the South Island. Results indicate that recreational catches from charter vessels (Table 6) follow the same pattern as overall recreational catch (Tables 3 and 4). The estimated recreational catches from charter vessels in BCO 7 exceeded the 1997–98 TACC and the commercial landings in QMA 7.

During 1992–93, the amateur bag limit for blue cod was reduced and the minimum size increased from 30 cm to 33 cm for both amateur and commercial fishers (except for BCO 3). However, this was amended in 1993–94 for the Marlborough Sounds where the size limit was reduced to 28 cm. Bag limits were also reduced for the Marlborough Sounds and Paterson Inlet (Stewart Island). Recent changes to amateur size and bag limits are shown in Table 7.

Table 7: Changes to minimum legal size (MLS in cm) and amateur maximum daily limits (MDL) of blue cod by Fishstock from 1986 to present. All maximum daily limits are restricted within mixed species maximum daily bag limits which may vary between areas – (* for the in north Canterbury area only).

Fishstock	BCO 1		BCO 2		BCO 3		BCO 4		BCO 5		Sub area provisions:
QMA(s)	1 & 9		2		3		4		5 & 6		Paterson Inlet
	MLS	MDL	MLS	MDL	MLS	MDL	MLS	MDL	MLS	MDL	MLS MDL
1986	30	30	30	30	30	30	30	30	30	30	30 30
1993	33	20	33	20	30	30	33	30	33	30	33 30
1994	33	20	33	20	30	30	33	30	33	30	33 15
2001	–	–	–	–	*30	*10	–	–	–	–	– –

Fishstock	BCO 7	Sub area provisions:	BCO 8	BCO 10				
QMA(s)	7		Marlborough Sounds		8		10	
	MLS	MDL	MLS	MDL	MLS	MDL	MLS	MDL
1986	30	30	30	12	30	30	30	30
1993	33	20	33	10	33	20	33	20
1994	33	20	28	6	33	20	33	20
2001	33	10	–	–	–	–	–	–

(c) Maori customary fisheries

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

(d) Illegal catch

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

(e) Other sources of mortality

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

Cod pots covered in 38 mm mesh frequently catch undersized blue cod. It has been estimated that in Southland, 65% of blue cod caught in these pots are less than 33 cm. When returned, the mortality of these fish can be high due to predation by mollymawks following commercial boats. It is estimated by the fishing industry that up to 50% of returned fish can be taken. To reduce the problem of predation of returned undersized fish, a minimum 48 mm mesh size was introduced to BCO 5 in 1994. However, no mesh size restrictions exist in any other area.

Recreational line fishing often results in the harvest of undersized blue cod. The survival of these has been shown to be a factor of hook size. A small scale experiment showed that returned undersized fish caught with small hooks (size 1/0) experience 25% mortality, whereas those caught with large hooks (size 6/0) appear to have little or no mortality (Carbines, 1999).

2. BIOLOGY

Blue cod is a bottom-dwelling species endemic to New Zealand. Although distributed throughout New Zealand near foul ground to a depth of 150 m, they are more abundant south of Cook Strait and around the Chatham Islands. Growth may be influenced by a range of factors, including sex, habitat quality and fishing pressure relative to location (Carbines, 2004a). Size-at-sexual maturity also varies according to location. In Northland, maturity is reached at 10–19 cm total length (TL) at an age of 2 years, whilst in the Marlborough Sounds it is reached at 21–26 cm (TL) at 3–6 years. In Southland, the fish become mature between 26–28 cm (TL), at an age of 4–5 years. Blue cod have also been shown to be protogynous hermaphrodites, with individuals over a large length range changing sex from female to male (Carbines, 1998). Validated age estimates using otoliths have shown that blue cod males grow faster and are larger than females (Carbines, 2004b). The maximum recorded age for this species is 32 years.

M was estimated using the equation $M = \log_e 100/\text{maximum age}$, where maximum age is the age to which 1% of the population survives in an unfished stock. In a previous assessment, M was calculated as 0.26, using 18 years as an estimate of maximum age. However, a recent study found the max age to be 32 years old (Carbines et al., 2007), using this figure M would be calculated at 0.14. This estimate seems feasible as in lightly fished areas such as the offshore Banks Peninsula Carbines et al. (2007) Z is thought to approximate M and was calculated at 0.14 to 0.19.

Blue cod have an annual reproductive cycle with an extended spawning season during late winter and spring. Spawning aggregations have been reported within inshore and mid shelf waters. It is also likely that spawning occurs in outer shelf waters. Ripe blue cod are also found in all areas fished commercially by blue cod fishers during the spawning season. Eggs are pelagic for about five days after spawning, and the larvae are pelagic for about five more days before settling onto the seabed. Juveniles are not caught by commercial potting or lining, and therefore blue cod are not vulnerable to the main commercial fishing methods until they are mature. Recreational methods do catch juveniles

but the survival of these fish is good if they are caught using large hooks (6/0) and returned to the sea quickly.

Tagging experiments carried out in the Marlborough Sounds in the 1940s and 1970s suggested that most blue cod remained in the same area for extended periods. A more recent tagging experiment carried out in Foveaux Strait (Carbines, 2001) showed that although some blue cod moved as far as 156 km, 60.2% travelled less than 1 km. A similar pattern was found in Dusky sound where four fish moved over 20km but 65% had moved <1 km (Carbines & McKenzie, 2004). The larger movements observed during this study were generally eastwards into the fiord. The inner half of the fiord was found to drain the outer strata and had 100% residency.

Biological parameters relevant to stock assessment are shown in Table 8.

Table 8: Estimates of biological parameters for blue cod.

Fishstock	Estimate						Source
1. Natural mortality (M)							
All	0.14						estimated from values in Carbines et al. (2007)
2. Weight = a (length)^b (Weight in kg, length in cm total length)							
	Females		**Males**				
BCO 5	a = .00002	b = 2.95	a = .00001	b = 3.10			G. McGregor (unpubl. data)
3. von Bertalanffy growth parameters							
		Females			**Males**		
	L_∞	**k**	**t_0**	**L_∞**	**k**	**t_0**	
Southland (Sub area 025)	34.5	0.4	1.2	41.6	0.3	1.2	Carbines (1998)
Queen Charlotte Sound (Over all)	32.2	0.3	-0.70	*	*	*	Carbines (2000)
Inner Queen Charlotte Sound	†	†	†	41.4	0.1	-5.2	Carbines (2000)
Outer Queen Charlotte Sound	†	†	†	33.7	0.4	1.07	Carbines (2000)
Extreme Outer Queen Charlotte Sound	†	†	†	50.2	0.1	-1.9	Carbines (2000)
Pelorus Sound (Over all)	33.2	0.2	-2.0	*	*	*	Carbines (2000)
Outer Pelorus Sound	†	†	†	36.8	0.27	-0.3	Carbines (2000)
Extreme Outer Pelorus Sound	†	†	†	40.8	0.22	-0.3	Carbines (2000)

† Sub areas showed no significant difference from pooled area growth estimates.
* Pooled area growth estimates showed significant differences from sub areas.

3. STOCKS AND AREAS

There are no new data which would alter the stock boundaries given in previous assessment documents. However, tagging experiments suggest that blue cod populations may be isolated from each other and distinct within quota management areas.

It is not known if there is more than one stock of blue cod in New Zealand. The present QMAs are used as a basis for Fishstocks, except QMAs 5 and 6 and QMAs 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.

4. STOCK ASSESSMENT

For all Fishstocks there are no new data that would alter the yield estimates given in the 1996 Plenary Report. These have not changed since the 1992 Plenary Report, except for BCO 3 and BCO 5 where the MCY estimates were updated in 1995. Yield estimates are based on commercial landings data only. However, new survey data are available and are presented along with updated estimates of Z.

(a) Estimates of fishery parameters and abundance

In 1995/96, a fishery independent survey using standardised cod pots at fixed stations provided catch rate estimates for recruited blue cod in Queen Charlotte Sound, Pelorus Sound and the east coast of D'Urville Island, Marlborough Sounds (part of BCO 7) (Blackwell, 1997, 1998). In September 2001, the survey was repeated (Blackwell, 2002), with the weighted mean catch rate for recruited blue cod (total length greater than 28 cm) estimated to be 1.07 kg/pot hour (CV = 7%). The stratum mean catch

rates ranging from 0.09 kg/pot hour in the inner Pelorus Sounds to 4.54 kg/pot hour at D'Urville. The estimated catch rates from the 2001 survey were lower (in all strata) than those estimated in 1995/96 (by 36 to 87%). Catch rates were highest in the outer Marlborough Sounds areas in both surveys. A third potting survey was completed in 2004 (Blackwell 2005), in which the survey area was extended to include west D'Urville and Separation Point. In 2004 the potting catch rates by stratum for fish >30cm (MLS) had both further declined in Queen Charlotte Sound and D'Urville Island, and increased in the most outer Pelorus Sound Stratum, However, catch rates were generally similar to those obtained in 2001 and remained much lower than those obtained during the 1995 and 1996 surveys. The relative biomass of pre-recruit (under 30 cm) blue cod generally followed similar trends to recruited blue cod between 1995/96 and 2004. The relative biomass of juveniles (17−27 cm) followed a similar, but more variable pattern.

Results from a fishery independent survey off Banks Peninsula (part of BCO 3) in 2002 using cod standardised pots estimated total mean catch rates for all blue cod of 2.13 kg/pot hour (CV = 10.8%), ranging from 0.04 kg/pot hour near Akaroa Harbour entrance to 4.74 kg/pot hour for the offshore stratum located over Pompeys Rock (Beentjes & Carbines, 2003). The Banks Peninsula survey was repeated in 2005 and the estimated total mean catch rate for all blue cod was 4.43 kg/pot hour (CV = 5.7%), strata ranging from 1.02 to 7.27 kg/pot hour (Beentjes & Carbines, 2004).

A fishery independent survey of blue cod in Dusky Sound (part of BCO 5) in 2002 using standardised cod pots produced an overall mean catch rate for all blue cod of 2.69 kg/pot (CV = 6.7%). The catch rate of blue cod ≥ 30cm was 2.23 kg/pot hour (CV = 7.2%). Both the overall and catch rates for all blue cod and for fish ≥ 30cm were highest on the open coast (ie at the entrance to the Sound), being 8.42 and 5.46 kg/pot hour respectively (Carbines and Beentjes 2003).

A fishery independent survey of blue cod in North Canterbury (part of BCO 3) in 2004/05 using standardised cod pots produced an overall mean catch rate for all blue cod of 2.45 kg/pot (CV = 8.7%) for Kaikoura and 10.19 kg/pot (CV = 7.3%) for Motunau. The catch rate of blue cod ≥ 30cm was 1.91 kg/pot hour (CV = 7.9%) for Kaikoura and 5.97 kg/pot (CV = 9.8%) for Motunau (Carbines and Beentjes 2006a). Another fishery independent survey of blue cod in North Otago (also part of BCO 3) in 2005 using standardised cod pots produced an overall mean catch rate for all blue cod of 10.14 kg/pot (CV = 5.4%). The catch rate of blue cod ≥ 30cm was 8.22 kg/pot hour (CV = 5.3%).

Carbines et al. (2007) have subsequently generated age frequency distributions using age length keys derived from otolith collected during potting surveys. Using catch at age, estimates of total mortality (Z) were calculated and compared in conjunction with relative abundance estimates (CPUE [$kg.hour^{-1}$]) from potting surveys conducted in the Marlborough Sounds, Kaikoura, Motunau, Banks Peninsula, North Otago and Dusky Sound (Table 9). This also provided a new estimate of maximum age for blue cod.

Relative abundance indices from trawl surveys are available for BCO 3, BCO 5 and BCO 7, but these have not been used because of the high variance and concerns that this method may not appropriately sample blue cod populations.

A standardised CPUE analysis has been conducted on the target blue cod fishery operating in the three main statistical areas of BCO 5 (025, 027 and 030) for the 1989–90 to 1999–2000 period (Langley, 2002). The annual indices derived from the analysis indicated catch rates were constant from 1989–90 to 1994–95, increased from 1994–95 to 1997–98, and remained at the higher level for the two subsequent years (Figure 1). However, the CPUE analysis revealed different trends in the annual indices between the three statistical areas (Figure 2), with the increase in the annual indices largely attributable to an increase in catch rates from the area off eastern Stewart Island (stat area 027). Annual indices from the two other areas (025 and 030) remained relatively constant throughout the 1989–90 to 1999–2000 period.

Table 9: Summary statistics from standardized blue cod potting surveys done throughout the South Island. Presented for each survey (including sub-areas of the Marlborough Sounds and Banks Peninsular) are the mean size and age of female and male blue cod caught, the average overall survey abundance indices for all sizes of blue cod (CV), the strata range of abundance indices in the survey area, the average total mortality (from 5─8 year olds) (CV), and the range of total mortality estimates (from 5-8 year olds). (Modified from Carbines et al. (in prep.)

	Mean length		Mean age		Reported	Indices strata	Mean	Z range
Area/Year	female	Male	Female	Male	Indices kg/hr (CV)	Range kg/hr	mortality Z (CV)	(5─8 years)
D'Urville Island 2001	27.3	30.5	7.2	7.2	5.9 (10.0%)	5.90	0.47(33%)	0.34 - 0.59
Pelorus Sound 2001	***22.3***	***27.8***	***3.9***	***4.9***	***Not reported [1]***	***0.19 - 1.46***	***0.84 (23%)***	***0.88 - 1.01***
Queen Charlotte Sound 2001	***24.2***	***28.7***	***4.4***	***5.4***	***Not reported [1]***	***0.57 - 1.68***	***0.50 (23%)***	***0.38 - 0.71***
D'Urville Island 2004	27.9	30.8	6.8	6.9	Not reported [2]	4.03 - 4.68	0.55 (22%)	0.39 - 0.68
Pelorus Sound 2004	***23.6***	***28.2***	***4.5***	***4.8***	***Not reported [2]***	***0.32 - 3.03***	***0.81 (23%)***	***0.67 - 1.03***
Queen Charlotte Sound 2004	***24.4***	***28.6***	***5.8***	***5.8***	***Not reported [2]***	***0.37 - 2.04***	***0.94 (23%)***	***0.63 - 1.17***
Kaikoura 2004	31.2	33.4	8.9	8.1	2.6 (8.7%)	0.03 - 7.54	0.28 (25%)	0.27 - 0.29
Motunau 2005	25.6	29.1	5.3	4.3	10.2 (7.3%)	9.53 - 15.37	0.62 (27%)	0.46 - 0.76
Inshore Banks Peninsular 2002	***25.3***	***28.3***	***4.9***	***5.5***	***Not reported [3]***	***0.04 - 2.61***	***0.70 (35%)***	***0.53 -0.94***
Offshore Banks Peninsular 2002	36.6	37.7	10.9	10.5	Not reported [3]	2.04 - 4.74	0.15 (47%)	0.14 - 0.15
Inshore Banks Peninsular 2005	***27.1***	***32.7***	***5.4***	***6.7***	***Not reported [4]***	***1.02 - 4.16***	***0.51 (25%)***	***0.44 - 0.60***
Offshore Banks Peninsular 2005	37.3	41.2	9.0	11.4	Not reported [3]	5.68 - 7.27	0.17 (45%)	0.14 - 0.19
North Otago 2005	27.9	32.9	6.1	7.2	10.1 (5.4%)	7.45 - 14.5	0.41 (22%)	0.33 - 0.47
Dusky Sound 2002	30.1	34.7	6.9	7.6	2.7 (6.7%)	1.28 - 8.42	0.22 (18%)	0.27 - 0.31

[1] Average abundance indices were not reported specifically for these sub-areas. The overall abundance indices for the Marlborough Sounds in 2001 was 1.6 kg/hr (CV=7.0%) (Blackwell 2002), average mortality (5─8 years) was 0.54 (CV=16%).

[2] Average abundance indices were not reported specifically for these sub-areas. The overall abundance indices for the Marlborough Sounds in 2004 was 1.1 kg/hr (CV=7.0%) (Blackwell 2006), average mortality (5─8 years) was 0.71 (CV=15%).

[3] Average abundance indices were not reported specifically for these sub-areas. The overall abundance indices for Banks Peninsular in 2001 was 2.1 kg/hr (CV=10.8%) (Beentjes & Carbines 2003), average mortality (5─8 years) was 0.26 (CV=33%).

[4] Average abundance indices were not reported specifically for these sub-areas. The overall abundance indices for Banks Peninsular in 2005 was 4.4 kg/hr (CV=5.71%) (Beentjes & Carbines 2006), average mortality (5─8 years) was 0.27 (CV=26%).

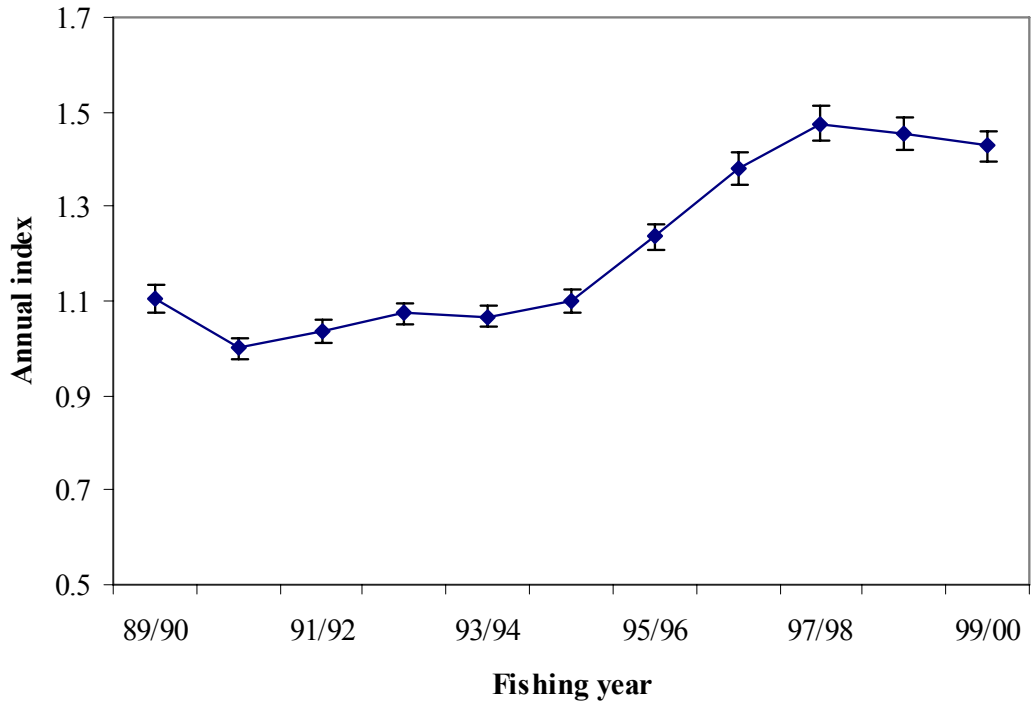


Figure 1: Annual indices from the BCO 5 standardised CPUE model (Langley, 2002).

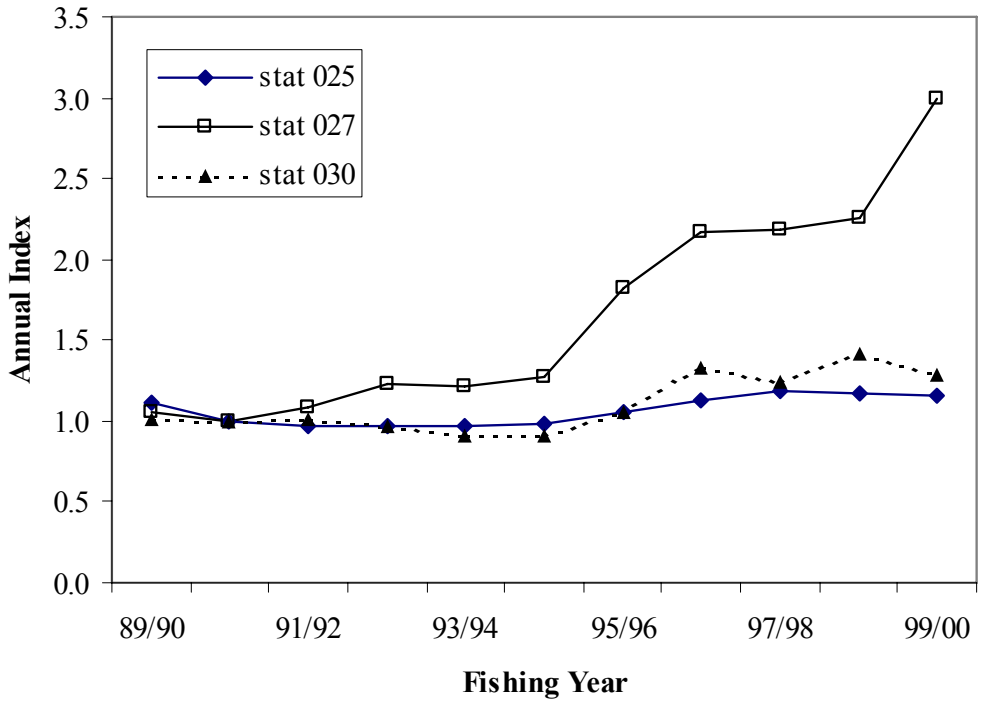


Figure 2: Annual indices for main statistical areas of BCO 5 from individual CPUE models (Langley, 2002).

(b) Biomass estimates

No estimates of current or reference biomass are available.

(c) Estimation of Maximum Constant Yield (MCY)

MCY was estimated from the equation MCY = cY_{av} (method 4) and is based on commercial catches of blue cod only. Historical blue cod catch levels were closely correlated with fishing effort, and variations in recorded catch were probably due to changed fishing patterns.

In 2007 M for blue cod was estimated at 0.14, based on the age estimate of 32 years. The value of c was set equal to 0.9 based on the estimates of M. In all areas where blue cod catches were not reported (i.e. due to bait use, non-reporting and discarding), MCY is likely to be conservative.

Yield estimates were derived on a regional basis, as follows:

(i) Auckland (BCO 1)
Y_{av} = average landings from 1983 to 1986.
MCY = 0.9 * 25 t = 23 t (rounded to 25 t)

(ii) Central (East) (BCO 2)
Y_{av} = average landings from 1983 to 1986.
MCY = 0.9 * 4 t = 4 t (rounded to 5 t)

(iii) South East (Coast) (BCO 3)
Y_{av} = average landings from 1987–88 to 1993–94. These years were chosen because of stable effort and catches.
MCY = 0.7 * 143 t = 129 t (rounded to 130 t)

(iv) South–East (Chatham Rise) (BCO 4)
Y_{av} = average landings from 1953 to 1965. These years were chosen because of stable catches after World War II and before the development of the rock lobster fishery.
MCY = 0.9 * 750 t = 675 t

(v) Southland and Sub–Antarctic (BCO 5)
Y_{av} = average landings from 1987–88 to 1993–94. These years were chosen because of stable effort unrestricted by the TACC.
MCY = 0.9 * 967 t = 870 t

(vi) Challenger (BCO 7)
Y_{av} = average landings from 1983 to 1986. These years were chosen because of stable catches.
MCY = 0.7 * 118 t = 106 t (rounded to 110 t)

(vii) Central (Egmont) (BCO 8)
Y_{av} = average landings from 1983 to 1986.
MCY = 0.7 * 55 t = 50 t

The level of risk to the stock by harvesting the population at the estimated MCY value cannot be determined.

(d) Estimation of Current Annual Yield (CAY)

No estimate of CAY is available for blue cod stocks.

Yield estimates are summarised in Table 10.

Table 10: Yield estimates (t).

Parameter	Fishstock	Estimate
MCY	BCO 1	25
	BCO 2	5
	BCO 3	130

	BCO 4	675
	BCO 5	870
	BCO 7	110
	BCO 8	50
	Total	1865
CAY	All	Cannot be determined

(e) Other factors

The target blue cod fishery is chiefly a pot fishery and there are few significant bycatch problems. However, in recent years bycatch associated with the inshore fleet of trawlers has increased in BCO 3 and BCO 7. Blue cod is only a very minor bycatch of the offshore fleet.

Before the introduction of the QMS, blue cod landings were affected by factory limits imposed in some parts of Southland, and there were economic constraints to the development of the fishery at the Chatham Islands (BCO 4).

Blue cod fishing patterns have been strongly influenced by the development and subsequent fluctuations in the rock lobster fishery, especially in the Chatham Islands, Southland and Otago. Once a labour intensive handline fishery, blue cod are now taken mostly by cod pots. The fishery had decreased in the past; however, with the advent of cod pots it rapidly redeveloped. Large areas are currently not heavily fished, and there are some areas such as the Mernoo Bank, the Puysegur Bank and South Traps which are potentially productive fisheries. Anecdotal information from recreational fishers suggests that there is local depletion in some parts of BCO 3, BCO 5 and BCO 7 where fishing has been concentrated. Both blue cod catch (Cranfield et al., 2001) and productivity (Jiang & Carbines, 2002; Carbines et al., 2004) may also be affected by disturbance of benthic habitat.

5. STATUS OF THE STOCKS

Estimates of current and reference biomass are not available.

The estimates of MCY are probably conservative because of under-reporting of catch and large fluctuations in effort caused by movement of blue cod fishers to the rock lobster fishery.

For BCO 1, 2, 3, 4, 5 and 8, recent commercial catch levels and current TACCs are considered sustainable and are probably at levels which will allow the stocks to move towards sizes that will support the MSY. The MCY for BCO 7 is based on commercial catches only and therefore does not include recreational catches made during the same base period (1983–1986). For BCO 7 it is not known if the combined recreational and commercial catches are sustainable or if they are at levels that will allow the stock to move towards a size that will support the MSY.

Summary of yields (t), TACCs (t), and reported landings (t) for blue cod from the most recent fishing year.

Fishstock	QMA		MCY	2005–06 Actual TACC	2005–06 Reported landings
BCO 1	Auckland	1 & 9	25	46	7
BCO 2	Central (East)	2	5	10	1
BCO 3	South–East (Coast)	3	130	163	183
BCO 4	South–East (Chatham Rise)	4	675	759	579
BCO 5	Southland and Sub–Antarctic	5 & 6	870	1548	1344
BCO 7	Challenger	7	110	70	50
BCO 8	Central (Egmont)	8	50	74	20
BCO 10	Kermadecs	10	–	10	0
Total			1865	2680	2184

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