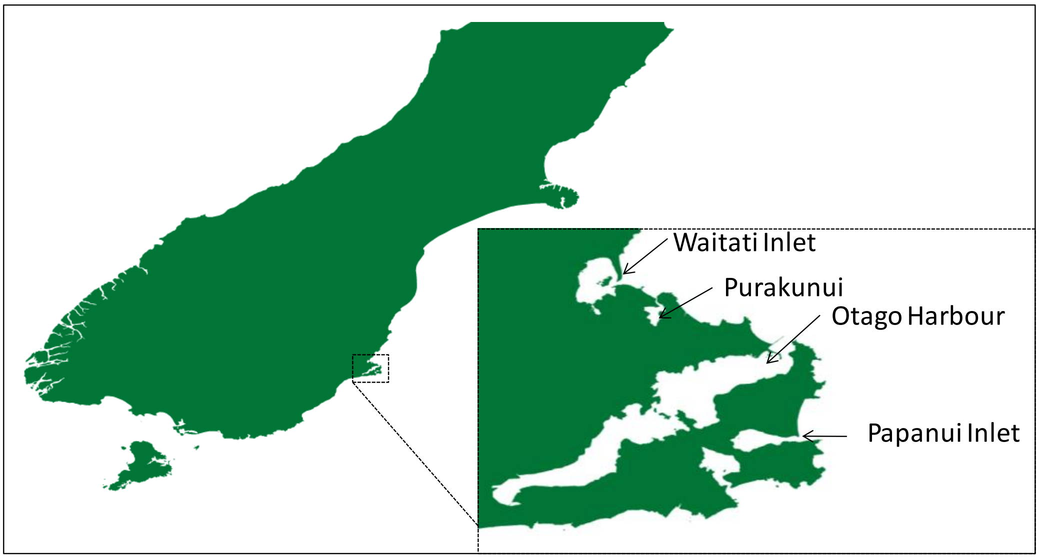
COCKLES (COC 3) Otago Peninsula
(*Austrovenus stutchburyi*)
Tuaki



1. FISHERY SUMMARY

COC 3 was introduced into the Quota Management System in October 2002 with a TAC of 1500 t; comprising of a customary allowance of 10 t, a recreational allowance of 10 t, an allowance for other fishing related mortality of 10 t, and a TACC of 1470 t. Historical catch limits can be seen in Table 1.

1.1 Commercial fisheries
Cockles are present at various locations around the Otago Peninsula but are only commercially fished from Papanui Inlet, Waitati Inlet, and Otago Harbour (under a current special permit). Commercial fishing in Papanui and Waitati Inlets began in 1983. A limit of 104 t was in effect for Papanui and Waitati Inlets combined from 1986–87 until 1991–92. From 1992–93 to 1998–99, the catch limits were 90 t for Papanui Inlet and 252 t for Waitati Inlet. In April 2000, the catch limits were increased to 427 t for Papanui Inlet and 746 t for Waitati Inlet. In 2002 when cockles entered the QMS spatial restrictions upon harvest within COC 3 were removed. Commercial landings from Papanui and Waitati Inlets are shown in Table 1. Since August 2009 cockles have been taken from Otago Harbour under a special permit in order to investigate the ecosystem effects of commercial cockle harvesting in this location. This permit states no explicit limit to the tonnage able to be taken but does delimit the area where harvest will be taken and currently expires on the 31st of December 2015.

In 1992, 35 mm shell length was the minimum size for commercial cockles. However, commercial fishers currently target cockles 28 mm or more, therefore 28 mm is used as the effective minimum size in yield calculations. CPUE data are available for this fishery, but have not been analysed.

1.2 Recreational fisheries
Cockles are taken by recreational fishers in many areas of New Zealand. The recreational fishery is harvested entirely by hand digging. Relatively large cockles are preferred.

Amateur harvest levels in FMA 3 were estimated by telephone and diary surveys in 1993–94 (Teirney et al 1997), 1996 (Bradford 1998) and 2000 (Boyd & Reilly 2002), Table 2. Harvest weights are estimated using an assumed mean weight of 25 g (for cockles over 30 mm). In 2004, the Marine Recreational Fisheries Technical Working Group reviewed the harvest estimates of these surveys and concluded that the 1993–94 and 1996 estimates were unreliable due to a methodological error. While the same error did not apply to the 1999–00 and 2000–01 surveys, it was considered the estimates may still be very inaccurate. No recreational harvest estimates specific to the COC 3 commercial fishery areas are available.

Table 1: Reported landings (t) of cockles from Papanui and Waitati Inlets, Otago, combined (FMA 3), from 1986–87 to 2011–12 based on Licensed Fish Receiver Returns (LFRR). Catch splits are provided by Southern Clams Ltd and are partially from Stewart (2005). N/A = Not Applicable [Continued on other page].

Year	Papanui catch (t)	Papanui limit (t)	Waitati catch (t)	Waitati limit (t)	Otago Harbour catch (t)	Total catch (t)	Total limit (t)
1986–87	14	–	–	–	–	14	104
1987–88	8	–	–	–	–	8	104
1988–89	5	–	–	–	–	5	104
1989–90	25	–	–	–	–	25	104
1990–91	90	–	16	–	–	106	104
1991–92	90	–	14	–	–	104	104
1992–93	90	90	92	252	–	182	342
1993–94	90	90	109	252	–	199	342
1994–95	90	90	252	252	–	342	342
1995–96	90	90	252	252	–	342	342
1996–97	90	90	252	252	–	342	342
1997–98	90	90	252	252	–	342	342
1998–99	90	90	293	252	–	383	342
1999–00	118	427	434	746	–	552	1 273
2000–01	90	427	606	746	–	696	1 273
2001–02	49	N/A	591	N/A	–	640	1 273
2002–03	52	N/A	717	N/A	–	767	1 470
2003–04	73	N/A	689	N/A	–	762	1 470
2004–05	91	N/A	709	N/A	–	800	1 470
2005–06	68	N/A	870	N/A	–	943	1 470
2006–07	0*	N/A	907	N/A	–	907	1 470
2007–08	–	N/A	760	N/A	–	760	1 470
2008–09	–	N/A	751	N/A	24	775	1 470
2009–10	–	N/A	379	N/A	441	820	1 470
2010–11	–	N/A	240	N/A	596	836	1 470
2011–12	–	N/A	358	N/A	437	795	1 470
2012-13						790	1 470
2013-14						800	1 470

*No catches have been taken from Papanui Inlet since 2006–07 because of water quality problems.

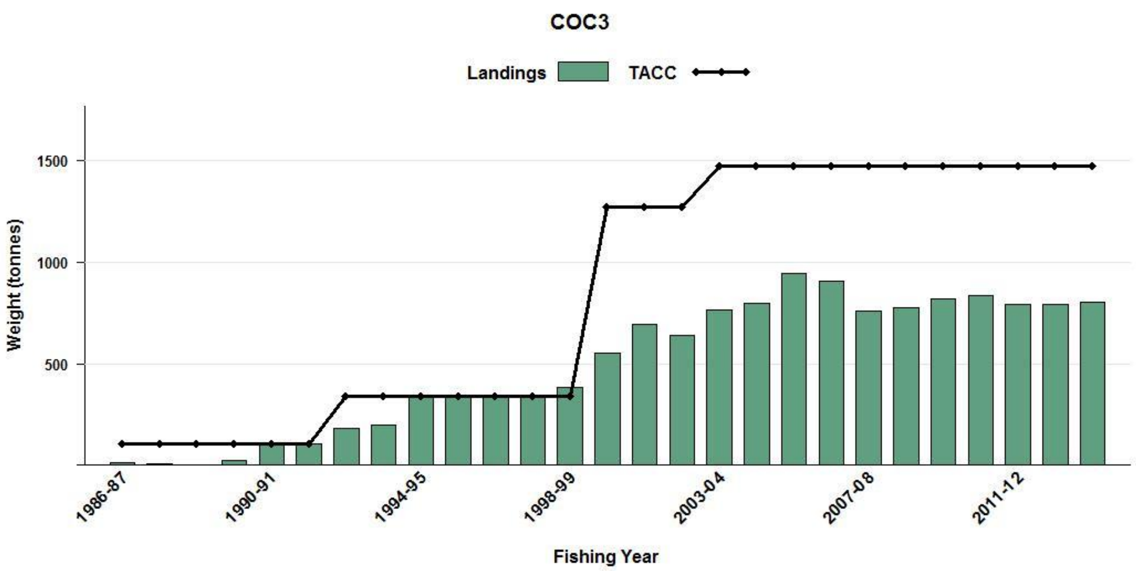


Figure 1: Reported commercial landings and TACC for COC 3 (Otago).

1.3 Customary non-commercial fisheries

Many intertidal bivalves, including cockles, are very important to Maori as traditional food, particularly to Huirapa and Otakou Maori in the Otago area. Tangata tiaki issue customary harvest permits for cockles in Otago. The number of cockles harvested under customary permits is given in Table 3, and is likely to be an underestimate of customary harvest.

Table 2: Estimated numbers of cockles harvested by recreational fishers in FMA 3, and the corresponding harvest tonnage. Figures were extracted from a telephone and diary survey in 1993–94, and the national recreational diary surveys in 1996 and 2000.

Fishstock	Survey	Harvest (*N*)	% CV	Harvest (t)
FMA 3	1993–94 South	106 000	51	2.7
FMA 3	1996	144 000	–	3.6
FMA3	2000	1 476 000	45	36.9

On 1 October 2010, on the recommendation of the Taiapure Committee, the Minister of Fisheries introduced new regulations for the East Otago Taiāpure[1]. These included a new amateur daily bag limit of 50 for shellfish, including cockles, and a ban on the commercial take of cockles from any part of the Taiapure, except for the existing sanitation areas within Waitati Inlet. The new regulations reflect the Committee's concern about fishing pressure on shellfish stocks, including cockles, within the Taiāpure.

A long-running time series of surveys suggest that there are no sustainability concerns for cockles within the Taiāpure. However, they do indicate a shift in some beds towards smaller size classes of cockle. Larger cockles are preferred by both customary and recreational fishers. The Committee hopes that reducing the bag limit and limiting the spatial extent of commercial harvest will lead to an increase in the number of large cockles.

Table 3: Number of cockles harvested under customary fishing permits.

Year	Number of cockles
1998	750
1999	0
2000	1 109
2001	1 090
2002	0
2003	2 750
2004	4 390
2005	5 699

1.4 Illegal catch

No quantitative information is available on the magnitude of illegal catch but it is thought to be insignificant.

1.5 Other sources of mortality

No quantitative information is available on the magnitude of other sources of mortality. It has been suggested that some harvesting implements, such as brooms, rakes, "hand-sorters", bedsprings and "quickfeeds" cause some incidental mortality, particularly of small cockles, but this proposition has not been scientifically investigated. High-grading of cockles is also practised, with smaller sized cockles being returned to the beds. The mortality from this activity is unknown, but is likely to be low.

[1] The Kati Huirapa Runanga ki Puketeraki application for a taiāpure-local fishery was gazetted as the East Otago Taiāpure-Local Fishery in 1999. A management committee, made up of representatives from the Runanga and various recreational, environmental, commercial, community and scientific groups, was appointed in 2001.

2. STOCKS AND AREAS

Each inlet is assumed to be an independent fishery within the stock.

3. STOCK ASSESSMENT

Stock assessments for Papanui Inlet and Waitati Inlet have been conducted using absolute biomass surveys, yield-per-recruit analyses, and Method 1 for estimating CAY (Annala et al 2003). Breen et al (1999) also estimated biomasses and yields for Otago Harbour and Purakanui. Stewart (2005, 2008a) estimated biomass and yields for Papanui and Waitati Inlets in 2004 and Waitati Inlet in 2007.

3.1 Estimates of fishery parameters and abundance

A project to estimate growth and mortality in Papanui and Waitati Inlets, Purakanui and Otago Harbour was undertaken in the late 1990s. Notched clams did not exhibit significant growth when recovered after one year, and modes in the length frequency distributions did not shift when measured over four sampling periods within a year (Breen et al 1999).

Yield-per-recruit modelling has been conducted for Papanui and Waitati inlets separately (Stewart 2005, 2008a, Jiang et al 2011). The most recent parameters used in this modelling are detailed in Table 2 of the cockle introductory section. Estimates of $F_{0.1}$ from these studies are given in Table 4 below. Exploitation rate is below 7% for Waitati, Papanui Inlet and Otago harbour (Table 4a, Figure 2).

Table 4: Estimates of fishery parameters (recruitment to this fishery is at ≥28 mm)

M	$F_{0.1}$ 2004	$F_{0.1}$ 2007	$F_{0.1}$ 2011	
			Waitati	Papanui
0.2	0.2321	0.2899	0.2600	0.2900
0.3	0.3412	0.3863	0.3900	0.4400
0.4	0.4767	0.5537	0.5300	0.6000

Table 4a: Exploitation rate % (for cockles ≥30 mm across each entire inlet)*

Year	Papanui	Waitati	Otago Hbr
1998	2	0	
2002	1	5	
2004	2	6	
2007	0	7	0
2011	0	2	4

* This measure is likely to overestimate exploitation as harvest occurs down to a size limit of 28mm.

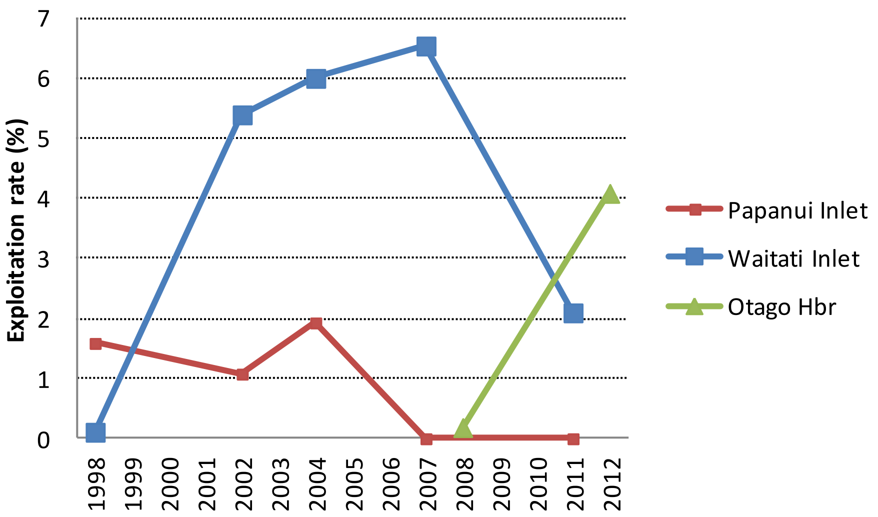


Figure 2: Exploitation rate as calculated by landings divided by biomass (≥30 mm) from whole inlets. Note: This measure is likely to overestimate exploitation as harvest occurs down to a size limit of 28 mm.

3.2 Biomass estimates

Biomass surveys have been undertaken periodically in COC 3 since 1984. The methods for the calculation of biomass have changed over time[2] which means that comparison of biomass values between times of different calculation methodologies should be done cautiously.

The Spawning stock biomass (19 mm or more, shell length) has been stable around the level of virgin biomass in Waitati Inlet (Table 5, Figure 3). In Papanui Inlet the spawning stock biomass (19 mm or more shell length) has shown a trend of gradual decline from 1984 until 2011, when it was at 73% of virgin biomass (notably no commercial harvesting has occurred in Papanui Inlet since 2006-7). The recruited biomass (30 mm or more shell length) in the sanitation areas (beds 1804 and 1805) in Otago Harbour decreased before the start of harvesting in 2008 and has decreased more since then (to 60% of virgin biomass).

Table 5: Current (±95% CI) and previous biomass estimates from COC 3*.

Papanui Inlet

Size Class	1984	1992	1998	2002	2004 Total inlet	2004 Commercial area	2011 Total inlet
>2 to 18 mm (juveniles)	65	139	33	17 ± 1.7	36 ± 2.2	13 ± 1.3	8 ± 1.4
19 – 34 mm (adults)	3 705	3 721	3 435	1 970 ± 192	2 415 ± 151	825 ± 88	1 400 ± 168
≥35 mm	2 370	1 706	2 231	2 579 ± 252	2 301 ± 273	1 847 ± 208	3 048 ± 429
≥30 mm			3 990	3 860 ± 365	3 677 ± 367	2 420 ± 271	4 025 ± 542
Total (t)	6 140	5 567	5 699	4 565 ± 424	4 752 ± 425	2 685 ± 298	4 457 ± 601

Waitati Inlet**.

Size Class	1984	1992	1998	2002	2004 Total Inlet	2004 Commercial area	2007 Total Inlet	2007 Commercial area	2011 Total Inlet
>2 to 18 mm (juveniles)	619	1 210	304	153 ± 20	257 ± 14	77 ± 4	335 ± 26	102 ± 7.5	220 ± 14
19 to 34 mm (adults)	7 614	5 198	8 519	6 653 ± 652	7 272 ± 403	2 735 ± 129	7 673 ± 591	1 284 ± 95*[3]	7 348 ± 501
≥35 mm	3 844	4 620	4 381	4 298 ± 298	4 535 ± 508	3 872 ± 384	3 941 ± 462		6 323 ± 643
≥30 mm			7 235	7 183 ± 463	7 993 ± 720	5 612 ± 681	7 107 ± 548	4 726 ± 352	11 441 ± 946
Total (t)	12 080	11 027	13 204	11 103 ± 848	12 064 ± 925	6 685 ± 517	11 948 ± 921	6 112 ± 456	13 892 ± 1149

Purkaunui Inlet			
Size Class	1998	2008	2012
(≥30 mm)	1 825		
Otago Harbour			
Size Class	1998	2008	2012
(≥30 mm)	32 975		
Otago Harbour (sanitation area, 1804)			
Size Class	1998	2008	2012
(≥30 mm)	8 901*	5 473	4 169
Otago Harbour (sanitation area 1805)			
Size Class	1998	2008	2012
, ≥30 mm	5 546*	3 526	4 093

*Wildish 1984a; Stewart et al 1992; Breen et al 1999; Wing et al 2002; Stewart, 2005; Stewart 2008a, Stewart 2008b; Jiang et al 2011; Stewart 2013. Area of current commercial beds, Papanui Inlet = 815 811 m^2. **Area of current commercial beds, Waitati Inlet = 943 986 m^2. *[3] = this value is only for ≥19 mm to <30 mm cockles. *[4] The survey of Breen et al 1999 covered a larger extent on these beds than the two subsequent surveys of Stewart 2008b and 2013.

Wildish (1984a and b) and Stewart et al (1992) separated cockles by sieving into three size classes. Breen et al (1999) measured random samples of cockles from each inlet to calculate length-weight relationships. The first method only allows estimation of biomass from predetermined size classes. By calculating size structure of populations using length to weight data, a more flexible approach is allowed where data can be matched to current commercial needs as well as to future survey results. The 1998 survey used random samples from each inlet to calculate length to weight relationships (Breen et al 1999). This method was once again used in the 2002 survey (Wing et al 2002). In the 2004 and 2007 surveys random samples from each shellfish bed were weighed and their longest axis measured (Stewart 2005, 2008a). These data were then used to generate length to weight relationships.

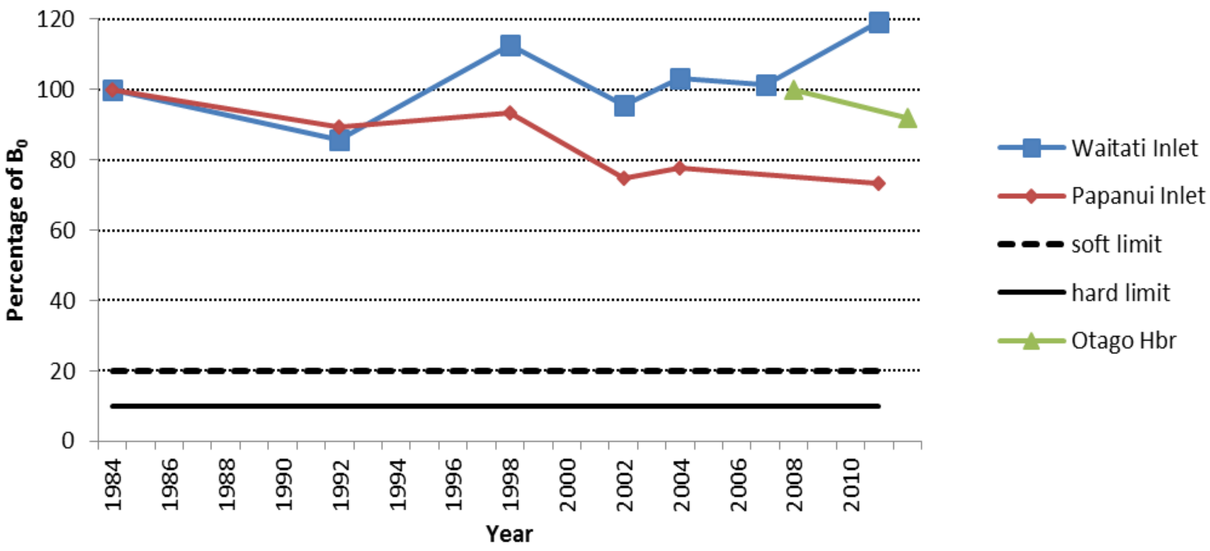


Figure 3: Biomass as a proportion of B_0 for Waitati and Papanui Inlets, this is estimated from biomass >19mm. Note: No catch has been taken from Papanui Inlet since 2006-07. Virgin biomass was taken from the Stewart 2008b survey for Otago harbour as this is the extent that has been subsequently surveyed.

3.3 Yield estimates and projections

Estimates of *MCY* are given in Table 6.

Table 6: Estimates of *MCY* (*t*) for COC 3 generated using Method 1 (Annala et al 2003) $MCY= 0.5F_{0.1}B_{AV}$, an average biomass ≥30 mm as B_0 and the 2011 estimates of $F_{0.1}$. This calculation is likely to underestimate the true *MCY*.

Location	M	1998	2002	2004	2007	2011
Waitati Inlet	0.2	941	934	1039	924	1487
Waitati Inlet	0.3	1411	1401	1559	1386	2231
Waitati Inlet	0.4	1917	1903	2118	1883	3032
Waitati Inlet (commercial)	0.2			730	614	894
Waitati Inlet (commercial)	0.3			1094	922	1342
Waitati Inlet (commercial)	0.4			1487	1252	1823
Papanui Inlet	0.2	579	560	533		584
Papanui Inlet	0.3	878	849	809		886
Papanui Inlet	0.4	1197	1158	1103		1208
Papanui Inlet (commercial)	0.2			351		259
Papanui Inlet (commercial)	0.3			532		392
Papanui Inlet (commercial)	0.4			726		535

For Waitati Inlet, *CAY* was estimated (Table 7) using Method 1 ($CAY = (F_{0.1} /Z)\ (1\text{-}\exp(-Z))B_{BEG}$) (Annala et al 2003) and biomass estimates at different times. *CAY* has been estimated at times for both the entire inlet area and a subset area where the commercial fishery has been operating for the past several years. This approach assumes that, between the start of the fishing year and when the biomass survey is started, productivity and catch cancel each other.

Table 7: *CAY* estimates (*t*) for COC 3. WI = Waitati Inlet, PI = Papanui Inlet, WIc and PIc are estimates for commercial areas only, B_{beg} = Projected biomass at the beginning of the fishing year.

				WI		WIc		PI		PIc		
Year	*M*	$F_{0.1}$	≥ SL (mm)	B_{beg}	*CAY*	B_{beg}	*CAY*	B_{beg}	*CAY*	B_{beg}	*CAY*	Reference
2011	0.2	0.26	30	11 441	2 385	6881	1434					Jiang et al 2011
2011	0.3	0.39	30	11 441	3 223	6881	1938					Jiang et al 2011
2011	0.4	0.53	30	11 441	3 948	6881	2374					Jiang et al 2011
2011	0.2	0.29	30					4 026	923	1784	409	Jiang et al 2011
2011	0.3	0.44	30					4 026	1 252	1784	555	Jiang et al 2011
2011	0.4	0.60	30					4 026	1 527	1784	677	Jiang et al 2011
2007	0.2	0.2899	28	8 378	1 920	5 261	1 206					Stewart 2008a
2007	0.3	0.3863	28	8 378	2 342	5 261	1 471					Stewart 2008a
2007	0.4	0.5537	28	8 378	2 990	5 261	1 878					Stewart 2008a
2007	0.2	0.2899	30	7 106	1 629	4 725	1 083					Stewart 2008a
2007	0.3	0.3863	30	7 106	1 986	4 725	1 321					Stewart 2008a
2007	0.4	0.5537	30	7 106	2 536	4 725	1 686					Stewart 2008a
2004	0.2	0.2321	30	9 399	1 771	6 081	1 146	4 119	776	2 454	462	Stewart 2005
2004	0.3	0.3412	30	9 399	2 367	6 081	1 532	4 119	1 038	2 454	618	Stewart 2005
2004	0.4	0.4767	30	9 399	2 984	6 081	1 930	4 119	1 308	2 454	779	Stewart 2005
2002	0.2	0.2017	30	7 183	1 193	5 364	891	3 860	641	2 322	386	Wing et al 2002
2002	0.3	0.3015	30	7 183	1 627	5 364	1 215	3 860	874	2 322	526	Wing et al 2002
2002	0.4	0.3956	30	7 183	1 960	5 364	1 464	3 860	1 053	2 322	634	Wing et al 2002
1999	0.2	0.258	30	7 235	1 498			3 990	826			Breen et al 1999
1999	0.3	0.357	30	7 235	1 848			3 990	1 019			Breen et al 1999
1999	0.4	0.457	30	7 235	2 221			3 990	1 225			Breen et al 1999

3.4 Other factors

Commercial, customary and recreational fishers target different sized cockles. Biomass and yield estimates will differ for different sizes of recruitment to the fishery. Maori and recreational fishers prefer larger cockles (45 mm shell length and greater) whereas commercial fishers currently prefer cockles of around 28–34 mm. Estimates of yields have been estimated for size of recruitment at 28 mm; however, these estimates do not consider multiple fisheries preferring different sized cockles. Depending on the management approach taken in the future in COC 3, the appropriateness of the current methods to estimate yield may need to be reviewed.

The yield estimates use information from yield-per-recruit analyses that assume constant recruitment and constant growth and mortality rates. Yield estimates will be improved when growth, mortality and recruitment variation are better known.

As cockles become sexually mature at around 18 mm, using a size of recruitment of 30 mm should provide some protection against egg overfishing under most circumstances. Certainly the increase in the biomass of small cockles (2 to 18 mm) seen in both inlets in 2004 suggests that the very poor recruitment observed by Wing et al (2002) may have been due to natural variability, and supports the conjecture that significant recruitment might occur only sporadically in the Otago fishery, as suggested by John Jillett (*pers. comm.)* and Breen et al (1999). The possibility that fishing has an effect on recruitment remains an unknown.

In other cockle fisheries it has been shown that recruitment of juvenile cockles can be reduced by the removal of a large proportion of adult cockles from a given area of substrate. This would suggest that there is some optimal level of adult biomass to facilitate recruitment, although its value is not known. To date it has not been determined whether the cockles being targeted by commercial harvesting in the Otago fishery comprise the bulk of the spawning stock or if disturbance of the cockle beds is influencing settlement.

The distribution of very small size classes (2 to 10 mm) across the various beds is variable and no consistent differences exist for this size of shellfish between commercial and non-commercial beds (Stewart 2008a). A comparison of the size/frequency histograms with fishing history for each bed would be a worthwhile exercise and may reveal more. The fact that the relationship between spawning stock and recruitment in this fishery is poorly understood remains a concern.

The very slight decrease in biomass recorded in the Stewart (2008a) survey suggests that the current level of harvest is sustainable. What is not known is if the decrease in biomass is the beginning of a long-term trend or simply the result of natural variability.

The effects of the illegal catch, the Maori traditional catch and incidental handling mortality are unknown, although illegal catch is thought to be insignificant. The impacts of the recreational fishery are probably minor compared with those from the commercial fishery.

4. STATUS OF THE STOCKS

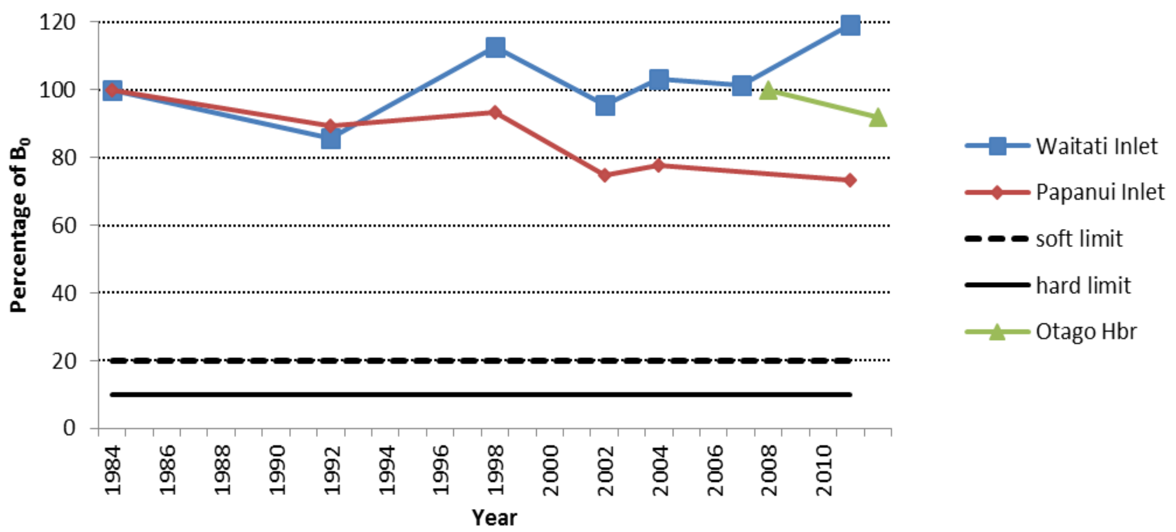
Stock structure assumptions

Each inlet is assessed separately.

COC 3

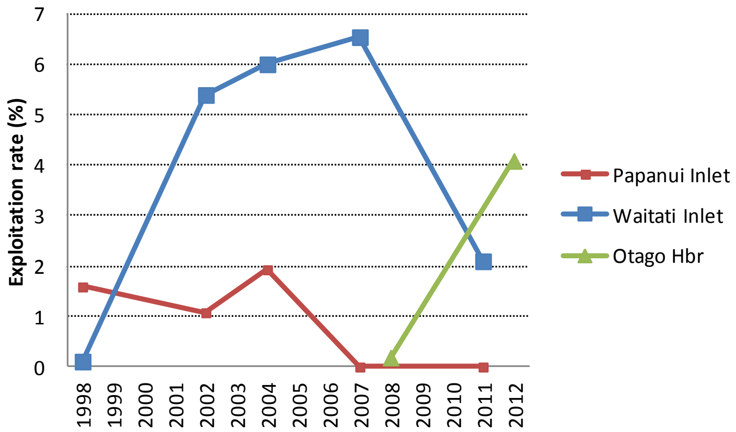
Stock Status	
Year of Most Recent Assessment	2011
Assessment Runs Presented	Survey biomass estimate for ≥ 19 mm shell length
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Likely (> 60%) to be at or above the target
Status in relation to Limits	Very Unlikely (< 10%) to be below both soft and hard limits

Historical Stock Status Trajectory and Current Status



Biomass as a proportion of B_0 for Waitati and Papanui Inlets, this is estimated from biomass > 19 mm. Note: No catch has been taken from Papanui Inlet since 2006-07. Virgin biomass was taken from the Stewart 2008b survey for Otago harbour as this is the extent that has been subsequently surveyed.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass at Waitati Inlet has been stable or increasing and has never decreased below 85% of B_0. At Papanui Inlet biomass generally decreased to approximately 70% of B_0 in 2004 but little commercial catch has come out of this inlet since. In Otago Harbour biomass has declined, but most of this occurred before harvesting starting.

Recent Trend in Fishing Mortality or Proxy	Exploitation rate has never exceeded 7% at any of the harvested sites. It is Very Unlikely (< 10%) that overfishing is occurring.  **Exploitation rate as calculated by landings divided by biomass (≥19 mm) from whole inlets (excluding Otago Harbour where it was taken from commercial beds only).**
Other Abundance Indices	
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	-
Probability of Current Catch or TACC causing decline below Limits	Fishing at recent levels is Very Unlikely (< 10%) to cause declines below soft or hard limits

Assessment Methodology		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrat surveys	
Main data inputs	Abundance and length frequency information	
Period of Assessment	Latest assessment: 2010 or 2011 (depending upon location)	Next assessment: unknown
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	

Qualifying Comments
Water quality issues have influenced the amount of time when cockles can be harvested from Papanui Inlet in recent years.

5. FOR FURTHER INFORMATION

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