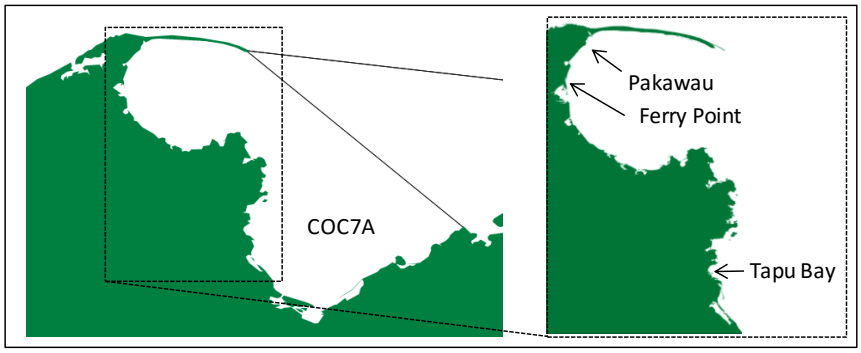
COCKLES (COC 7A) Tasman and Golden Bays

(*Austrovenus stutchburyi*)

Tuangi



1. FISHERY SUMMARY

COC 7A was introduced into the Quota Management System in October 2002 with a TAC of 1510 t; comprising a customary allowance of 25 t, a recreational allowance of 85 t, an allowance for other fishing related mortality of 10 t, and a TACC of 1390 t. These limits have remained unchanged since.

1.1 Commercial fisheries

Commercial harvesting at Pakawau Beach in Golden Bay began in 1984, but with significant landings taken only since 1986. Harvesting at Pakawau Beach has occurred every year since 1984. Cockles have also been taken commercially from Tapu Bay-Riwaka (in Tasman Bay) since 1992–93, and Ferry Point (in Golden Bay) since 1998–99. Catch statistics (Table 1) are derived from company records and QMS returns. All commercial landings have been taken by mechanical harvester. Historical landings and TACC for this stock are depicted in Figure 1.

Table 1: Reported landings (t) of cockles from all commercially harvested areas in COC 7A/7B. Landings from 1983–84 to 1991–92 are based on company records.

Fishing Year	Total Landings	TACC
1983–84	2	225
1984–85	38	225
1985–86	174	225
1986–87	230	225
1987–88	224	225
1988–89	265	300
1989–90	368	300
1990–91	535	300
1991–92	298	300
1992–93	300	336
1993–94	440	336
1994–95	326	336
1995–96	329	336
1996–97	325	336
1997–98	513	949
1998–99	552	1 130
1999–00	752	1 130
2000–01	731	1 134
2001–02	556	1 134
2002–03	569	1 390
2003–04	553	1 390
2004–05	428	1 390
2005–06	460	1 390
2006–07	337	1 390
2007–08	237	1 390
2008–09	307	1 390
2009–10	301	1 390
2010–11	348	1 390
2011–12	220	1 390
2012–13	269	1 390
2013–14	290	1 390
2014–15	263	1 390
2015–16	263	1 390

At Pakawau Beach, the fishery operated up to October 1988 under a special permit constraining annual landings to 225 t. From 1988–89 to 1997–98, the fishery operated under a commercial permit allowing an annual catch of 300 t. In 1997–98, the fishery was re-assessed and a catch limit of 913 t was set based on a *CAY* harvest strategy. This level of harvest was changed to 760 t from the 1998–99 fishing year and then 764 t for the 2000–01 fishing year. The harvest is taken from an area of about 500 ha.

The Ferry Point fishery, initiated in 1998–99, has an annual allowable catch of 334 t based on an *MCY* harvest strategy. The harvested area is about 40 ha. Reportedly, the area has not been fished since 2004. The Tapu Bay-Riwaka fishery, which was developed in 1990–91, has operated under a commercial permit limiting catches to 36 t annually. This fishery has been only lightly harvested owing largely to water quality issues and the area from which catches have been taken is probably less than 100 ha.

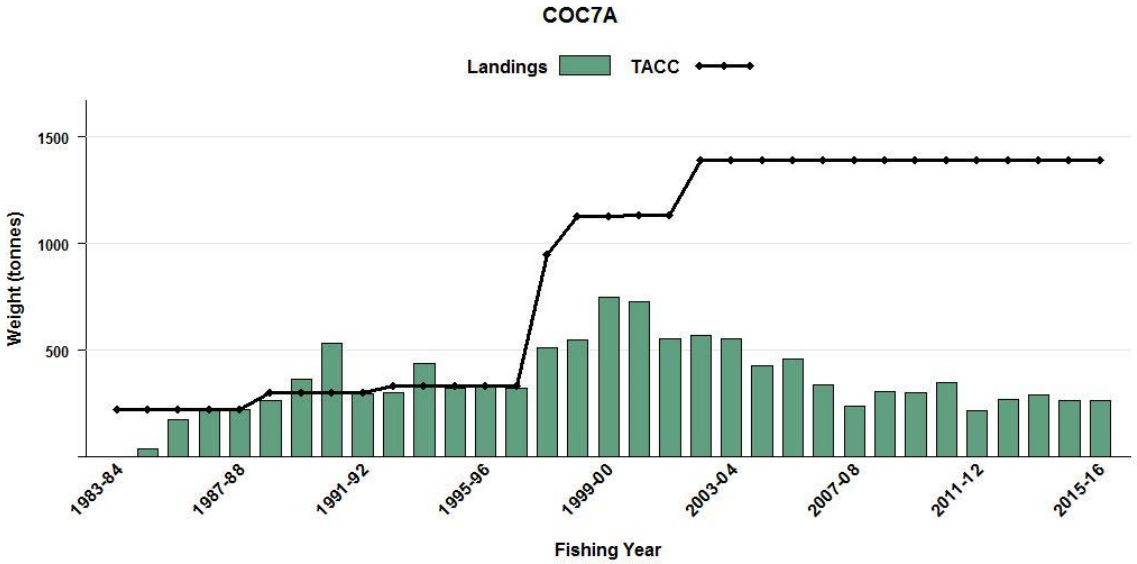


Figure 1: Total reported landings and TACC for COC 7A (Nelson Bays).

1.2 Recreational fisheries

Cockles are taken by recreational fishers, generally using hand digging. The catch limit is currently 150 cockles per person per day. Relatively large cockles (i.e., shell length over 30 mm) are generally preferred. Specific areas for recreational fishing are set aside from the commercial fishery by regulation and these include the area north of Ferry Point opposite Totara Ave and the area of Tapu Bay itself north of the fishery.

Estimates of the amateur cockle harvest from QMA 7 are available (Table 2) from a telephone and diary survey in 1992–93 (Teirney et al 1997) from national diary surveys in 1996 (Bradford 1998) and 2000 (Boyd & Reilly 2002) and from a nationwide panel survey in 2011–12 (Wynne-Jones et al 2014). Harvest weights were estimated assuming a mean weight of 25 g per cockle. The 1992–93 and 1996 estimates are very uncertain and probably underestimate actual recreational catch. The 2000 survey is considered to be a more reliable estimate of recreational harvest. The survey estimate in Wynne-Jones et al 2014 is noted in as seeming lower than expected, although this was judged as hard to gauge in a year of toxic algal blooms. The estimated numbers of cockles harvested from single beaches in the Auckland area (ranging from about 1 to 45 million per year) in Hartill et al. (2005) also suggest that the 2014 value grossly under-estimates the true value.

Table 2: Estimated numbers of cockles harvested by recreational fishers in QMA 7, and the corresponding harvest tonnage. Data from surveys were not sufficiently reliable to allow estimates of CVs. *See the text in the above paragraph for qualifying statements.

Year	QMA 7 harvest	
	Number	(t)
1992–93	166 000	4
1996	325 000	8
2000	499 000	12.5
2014*	78 751	2

1.3 Customary non-commercial fisheries

Cockles are an important Maori traditional food, but no quantitative information on the level of customary take in COC 7A/7B is available. However, Kaitiaki are now in place in many areas and estimates of customary harvest can be expected to improve.

1.4 Illegal catch

No quantitative information on the level of illegal catch is available.

1.5 Other sources of mortality

The extent of any other sources of mortality is unknown. Incidences of unexplained large-scale die-off in localised areas have been noted (e.g., at Pakawau Beach and Ferry Point in 1999). Mortality of unrecruited cockles during the mechanical harvesting process was found to be very low (Bull 1984), and disturbance and mortality of other invertebrates in the harvested areas is slight (Wilson et al 1988).

2. BIOLOGY

All references to "shell length" in this report refer to the maximum linear dimension of the shell (in an anterior-posterior axis). General cockle biology has been summarised earlier in this Plenary report. Some aspects of biology with particular relevance to COC 7A follow.

Estimates of growth and mortality have been made for cockles from Pakawau Beach (Osborne 1992, 1999, 2010), and the two early studies are summarised in Table 3. The 1992 investigation used a Walford plot of tag recapture data (Bull 1984), and measured growth after about 18 months on translocated cockles, to produce the growth parameters. A MIX analysis of the scaled length-frequency distribution from the 1992 survey enabled calculation of the proportional reduction of the 4+ and 5+ age classes to produce estimates of instantaneous natural mortality, *M* (after removal of estimated fishing mortality, *F*).

The 1999 investigation used a MIX analysis of length-frequency data from two strata in comparable surveys in 1997, 1998 and 1999 to estimate mean lengths (and proportion in the population) of the first 8 year classes. Von Bertalanffy parameters were estimated for each survey. Mean natural mortality rates were estimated (for age classes 4–7) between 1997 and 1998, and 1998 and 1999.

Table 3: Estimates of biological parameters.

Population & years		**Estimate**	**Source**
1. Natural mortality (*M*)			
Pakawau Beach (1992)		0.45 for 4+; 0.30 for 5+	Osborne (1992, 1999)
Pakawau Beach (1998)		0.4	Osborne (1999)
Pakawau Beach (1999)		0.52	Osborne (1999)
2. Weight = a (shell length)^b (weight in g, shell length in mm)			
	a	b	Osborne (1992)
Pakawau Beach (1992)	0.000017	3.78	Forrest & Asher (1997)
Ferry Point (1996)	0.00020	3.153	Stark & Asher (1991)
Tapu Bay-Riwaka (1991)	0.000150	3.249	

Table 3 [Continued]

Population & years	Estimate			Source
3. von Bertalanffy growth parameters				
	K	t_0	L_∞	
Pakawau Beach (1984–92)	0.36	0.3	49	Osborne (1992)
Pakawau Beach (1997)	0.38	0.68	48.3	Osborne (1999)
Pakawau Beach (1998)	0.4	0.68	47.4	Osborne (1999)
Pakawau Beach (1999)	0.41	0.66	47	Osborne (1999)

It was acknowledged that none of the MIX analyses converged, but the results presented were the best available fits (Osborne 1992, 1999). However, all four analyses produced very similar von Bertalanffy parameters. There is a trend of a reducing L_∞ and increasing K over the period 1992–1999, which might be expected as a result of fishing. In 2009 growth was modeled by the equation y = 11.452Ln(x) + 16.425, where y is shell width and x is age in years, this equation is only applicable to individuals 23–55 mm in shell width.

3. STOCKS AND AREAS

Little is known of the stock boundaries of cockles. The planktonic larval phase of this shellfish has a duration of about three weeks, so dispersal of larvae to and from a particular site could be considerable. Cockles are known to be abundant and widely distributed throughout Golden and Tasman Bays, and although nothing is known about larval dispersion patterns, cockles in these areas are likely to comprise a single stock. However, in the absence of any detailed information on stocks, the three currently fished sites in COC 7A are all managed as one stock.

4. STOCK ASSESSMENT

This report summarizes estimates of absolute biomass and yields for exploited and unexploited cockle populations in Tasman and Golden Bays. Stock assessments have been conducted using absolute biomass surveys, yield-per-recruit analyses, Methods 1 and 2 for estimating *MCY*, and Method 1 for estimating *CAY* (Ministry of Fisheries 2010).

Recruited cockles are considered to be those with a shell length of 30 mm or greater. This is the minimum size of cockles generally retained by the mechanical harvesters used in the COC 7A fishery. Where possible, estimates of yields from surveys are based on recruited biomass not occurring in areas of eel grass (*Zostera*), as the disturbance of these *Zostera* beds by mechanical harvesters has detrimental effects on intertidal ecology.

4.1 Estimates of fishery parameters and abundance

None available.

4.2 Biomass estimates

Biomass estimates from surveys are available for the three commercially fished areas and three other sites.

On Pakawau Beach, the surveys done in 1992 and 1997–2008 used a stratified random approach (Table 4, Figure 2). An additional southern stratum was added to the survey area in 1997 after legal definition of the fishery area, accounting for the greater survey area relative to 1992. The surveys in 1984 and 1988 covered smaller areas still. The survey area was reduced further in 2008 and 2014 to remove areas that were observed to be consistently unsuitable habitat for cockles or cockle harvesting (sand banks, soft mud and *Zostera* areas). The eight comparable surveys show total and recruited biomass to have fluctuated with no consistent trend, but the lowest value in this time series was recorded in 2014. In addition to recruited biomass (>30mm size), and vulnerable biomass (outside *Zostera* beds), reference biomass levels used for MCY calculation this year and in previous years are shown in Table 4.

Estimates of biomass are available for Tapu Bay-Riwaka in 1991 using a fixed transect approach (Stark & Asher 1991) and Ferry Point in 1996 using a stratified random approach (Forrest & Asher 1997). Both these surveys were conducted about two years prior to the commencement of commercial harvesting in those areas. The cockle resource on three other beaches in Golden Bay was assessed using stratified random surveys in 1993 (Osborne & Seager 1994). Since then both Riwaka and Ferry Point have been surveyed in 2004 and 2008 using stratified random survey designs. Results from all these surveys are listed in Table 5 and shown in Figure 2. The biomass at Riwaka and Ferry Point have generally decreased over time.

Table 4: Estimates of biomass with 95% confidence intervals where available for Pakawau Beach. Values are recruited (>30mm) and vulnerable biomass (not occurring in *Zostera* beds) and reference levels of biomass used for calculating MCY (B_0 virgin biomass, B_{av} average biomass). In 2014 vulnerable biomass was calculated differently (see Osborne 2014 for details).

	Recruited biomass				Vulnerable biomass				Assessed reference levels		
	Area	tonnes	95 % CI	CV	Area	tonnes	95 % CI	CV	B_0	B_{av}	95 % CI
1984	326	4604	1562	-	-	-	-	-	-	-	-
1988	510	5640	-	-	-	-	-	-	-	-	-
1992	588	6784	929			3586	612	8.7	3293	-	-
1997	642	7796	1628	10.7	275	3723	1331	18.2	-	3655	134
1998	642	6768	1221	9.0	317	3412	827	12.4	-	3574	176
1999	642	7502	1294	8.8	246	3058	727	12.1	-	3445	282
2000	642	7128	1237	8.9	266	2139	555	13.2	-	3184	556
2001	642	9117	1519	8.5	254	3111	712	11.7	-	3172	455
2004	642	9421	1195	6.5	307	5747	909	8.1	-	3539	817
2008	407	8285	1599	9.8	299	4954	1025	10.6	-	3716	788
2014	358	3363	561	8.5	358	3363	561	8.5	-	5686	1137

Table 5: Estimates of biomass (*t*) with 95% confidence intervals (CI) where available, and mean density (kg/m^{-2}) for cockles at various sites in Golden and Tasman Bays. Where possible, values are given for the total and recruited (≥ 30 mm) populations. *n* = number of samples in the survey.

Site	Date	Area	*n*	Total biomass			Recruited biomass		
		(ha)		*t*	CI	kg/m^2	*t*	CI	kg/m^2
Tapu Bay-Riwaka	Mar-91	306	321	~3 900	-	1.28	-	-	-
Riwaka	Feb-04	122.7	144	1 423	269	1.16	1 076	235.6	0.88
Riwaka	Mar-08	103	82	1475	257	1.44	939	178	0.9
Riwaka (excl. Tapu Bay)*	Mar-91	-	-	-	-	-	1 880	450	-
Ferry Point	Dec-96	40	552	2 617	190	5.99	2 442	191	5.6
Ferry Point	Feb-04	40	126	646	99.8	1.63	443	79	1.12
Ferry Point	Jan-08	28.2	75	662	112	2.35	470	83	1.7
Collingwood Beach	Mar-93	176	70	334	148	0.19	292	139	0.17
Takaka Beach	Mar-93	338	107	1 850	671	0.55	796	395	0.24
Rangihaeata Beach	Mar-93	197	75	473	345	0.24	438	320	0.22

* Recalculated by Breen (1996) from data in Stark & Asher (1991).

Surveys reporting on cockle abundance have also been produced for Motupipi, Golden Bay, in June 1995 (transect survey, 50 ha, 30 samples, mean density of 87 cockles per m^2, no sizes or weights recorded), and at various sites in the Marlborough Sounds in August 1986 (diver survey below mean low water only, 9 sites, main densities in Kenepuru and inner Pelorus Sounds).

Absolute virgin biomass, B_0, are assumed to be equal to estimated biomass of cockles 30 mm or over shell length from surveys conducted before, or in the early stages of, any commercial fishing. These are listed above in Tables 4 and 5. Absolute current biomass can be estimated similarly from current surveys.

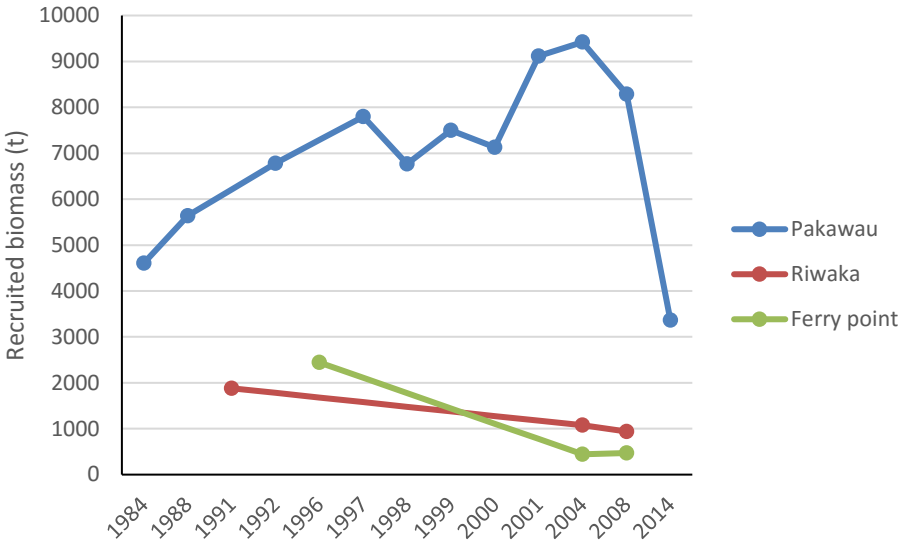


Figure 2: Recruited biomass (≥ 30 mm shell length) over time. Notably, the area surveyed over time has changed (see Tables 4 and 5) and decreased at the last time of survey (compared to previous occasions) at all three sites.

The biomass that will support the maximum sustainable yield (B_{MSY}) is not known for any of the areas fished in COC 7A.

4.3 Yield estimates and projections

Estimates of *MCY* have been made for populations of cockles in various areas, and at various times, using the equation $MCY = 0.25 * F_{ref} * B_0$ (Method 1), where F_{ref} is either $F_{0.1}$ or F_{max}. This method applies to new fisheries, or to those with only very low past levels of exploitation. The value of F_{ref} is dependent on *M*, so owing to the uncertainty of *M* a range of *MCY* estimates have been given for each stock (Table 6). For all estimates in Table 6, B_0 was taken as recruited biomass available for fishing (i.e. not in *Zostera* beds) in the survey area.

Estimates of *MCY* for Pakawau Beach have also been produced from $MCY = 0.5 * F_{REF} * B_{AV}$ (Method 2), using $F_{0.1}$, and with B_{AV} being the average of the available recruited biomass from the previous comparable surveys. For a range of *M* values, the latest estimates of *MCY* are as follows:

M	0.2	0.3	0.4
MCY	665	996	1 312

Table 6: Estimates of *MCY* (t, using $0.25 * F_{REF} * B_0$) for various cockle stocks in Tasman and Golden Bays, assuming a range of values for *M*.

Site	Date	F_{ref}	*M*			
			0.2	0.3	0.4	0.5
Pakawau Beach	1992	$F_{0.1}$	230	324	434	554
Pakawau Beach	1997	$F_{0.1}$	397	559	751	957
Pakawau Beach	2001	F_{MAX}	1 182	2 418	4 658	
Pakawau Beach	2004	$F_{0.1}$	482	683	924	
Pakawau Beach	2008	$F_{0.1}$	340	481	651	
Pakawau Beach	2014	$F_{0.1}$	665	996	1 312	
Ferry Point	1996	$F_{0.1}$	127	170	223	284
Ferry Point	1996	F_{MAX}	264	453	789	1 493
Ferry Point	2004	$F_{0.1}$	122	173	234	
Ferry Point	2008	$F_{0.1}$	111	157	212	
Riwaka	1991	$F_{0.1}$	167	224	286	-
Riwaka	2004	$F_{0.1}$	81	115	156	
Riwaka	2008	$F_{0.1}$	118	167	226	
Collingwood Beach	1993	$F_{0.1}$	20	28	37	48
Takaka Beach	1993	$F_{0.1}$	53	74	100	127
Rangihaeata Beach	1993	$F_{0.1}$	23	32	43	55

The level of risk of harvesting the populations at the estimated *MCY* levels cannot be determined for any of the surveyed areas. However, yield estimates are substantially higher when based on F_{MAX} than on $F_{0.1}$, so risk would be greater at *MCY*s based on F_{MAX}.

Estimates of *CAY* have been made in the past for cockle stocks at Pakawau Beach, Ferry Point and Riwaka, using $CAY = F_{REF}/(F_{REF} + M) * (1 - e^{-(FREF + M)}) * B_{BEG}$ (Method 1), where beginning of season biomass (B_{BEG}) is current recruited biomass available to the fishery, and F_{REF} is either $F_{0.1}$ or F_{max}. Estimates of current biomass that allow updated calculations are available in 2008 for Pakawau Beach, Ferry Point and Tapu Bay (Riwaka). The most recent estimates of *CAY* available for all stocks are listed in Table 7.

4.4 Other yield estimates and stock assessment results

$F_{0.1}$ and *CAY* were estimated from a yield per recruit (YPR) analysis using the age and length-weight parameters for Pakawau Beach cockles from Osborne (1992), and assuming size at recruitment to the fishery of either 30 or 35 mm shell length. A range of *M* values was used to produce the latest estimates in Table 8 (Osborne 2014).

Table 7: Estimates of *CAY* (t) for various cockle stocks in Tasman and Golden Bays, assuming a range of values for *M*.

Site	Date	F_{REF}	*M*			
			0.2	0.3	0.4	0.5
Pakawau Beach	2001	$F_{0.1}$	778	996	1 210	1 396
Pakawau Beach #	2001	$F_{0.1}$	1 964	2 514	3 053	3 522
Pakawau Beach	2004	$F_{0.1}$	1 202	1 555	1 910	
Pakawau Beach	2008	$F_{0.1}$	1 161	1 501	1 845	
Pakawau Beach	2014	$F_{0.1}$	638	844	1 040	
Ferry Point	1996	$F_{0.1}$	407	501	600	696
Ferry Point	2004	$F_{0.1}$	69	89	109	
Ferry Point	2008	$F_{0.1}$	88	114	140	
Riwaka	1993	$F_{0.1}$	507	615	708	
Riwaka	2004	$F_{0.1}$	138	179	220	
Riwaka	2008	$F_{0.1}$	1 161	1 501	1 845	

Calculations using total recruited biomass, rather than available recruited biomass.

Table 8: Latest estimates of $F_{0.1}$ from a yield per recruit analysis and CAY at different levels of minimum size at harvest (MSH) and natural mortality (M) (Osborne 2014).

			M		
	MSH	B_{beg}	0.20	0.30	0.40
$F_{0.1}$	30		0.23	0.34	0.46
CAY		3363	638	844	1040
$F_{0.1}$	35		0.28	0.40	0.54
CAY		2409	541	696	838
$F_{0.1}$	37		0.31	0.43	0.56
CAY		2026	489	617	732

4.5 Other factors

The areas of Golden Bay and Tasman Bay currently commercially fished for cockles are very small with respect to the total resource. Recruitment overfishing is unlikely owing to the extent of the resource protected from the fishery in *Zostera* beds, in sub-tidal areas, and in the protected areas adjacent to Farewell Spit and in other areas of Golden Bay. Cockle larvae are planktonic for about three weeks, so areas like Golden Bay and Tasman Bay probably constitute single larval pools.

Consequently, fisheries in relatively small areas (like Pakawau Beach) are likely to have little effect on recruitment. It is noted, however, that recruitment of juvenile cockles can be reduced by the removal of a large proportion of adult cockles from the area (i.e., successful settlement occurs only in areas containing a population of adult cockles).

It is also likely that growth and mortality of cockles are density-dependent. A reduction in density due to fishing could enhance the growth and survival of remaining cockles.

Because cockles begin to spawn at a shell length of about 18 mm, and the larval pools in Tasman and Golden Bays are probably massive and derive from a wide area (most of which is closed to commercial fishing), there is a low risk of recruitment overfishing at any of the exploited sites.

5. STATUS OF THE STOCKS

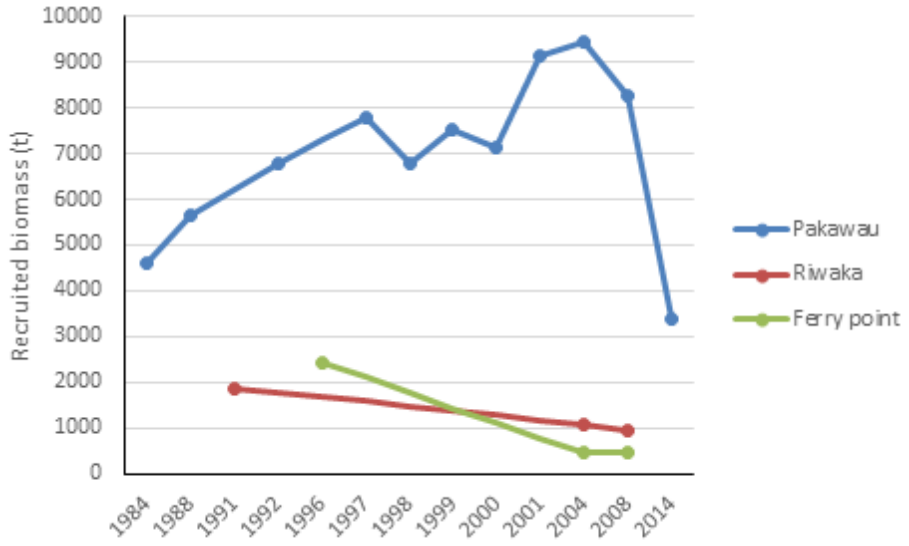
Stock structure assumptions

Little is known of the stock boundaries of cockles. Given differences in growth and mortality within and between different beds and in the absence of more detailed knowledge regarding larval connectivity, this commercial fishery area is managed as a discrete population.

COC 7A

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Survey biomass estimates for ≥ 30 mm shell length
Reference Points	Target(s): Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: - Undefined
Status in relation to Target	About as Likely as Not (40–60%) to be at or above the target (except for local depletion is some bays)
Status in relation to Limits	Unlikely (< 40%) to be below the soft limit and Very Unlikely (< 10%) to be below the hard limit
Status in relation to Overfishing	Overfishing is Very Unlikely (<10%) to be occurring

Historical Stock Status Trajectory and Current Status



Recruited biomass (≥ 30 mm shell length) over time. Notably, the area surveyed over time has changed (see Tables 4 and 5) and decreased at the last time of survey (compared to previous occasions) at all three sites.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The recruited biomass estimates of cockles from Pakawau beach have shown a general trend of increase until 2004, with the lowest

	value in 1992 (5299 t) and the highest value in 2004 (8803 t); followed by a decline to historically low levels in 2014 (3363 t),. The Ferry Point recruited biomass estimates declined from 2442 t in 1996 to 443 t and 470 t in 2004 and 2008, respectively. Riwaka total biomass estimates decreased from 1991 (1880 t) to 2008 (939 t). Notably, the area surveyed has changed over time and decreased at the last survey (compared to previous surveys) at all three sites.
Recent Trend in Fishing Mortality or Proxy	Landings since 2004–05 are intermediate compared to the history of the fishery and have fluctuated without trend between 220 and 460 t.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis		
Stock Projections or Prognosis	-	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Fishing at present levels is Very Unlikely (< 10%) to cause declines below the soft or hard limits.	
Probability of Current Catch or TACC causing Overfishing	Very Unlikely (< 10%)	
Assessment Methodology and Evaluation		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Absolute biomass estimates from quadrant surveys	
Assessment Dates	Latest assessment: 2014	Next assessment: Unknown
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Abundance - Length frequency	1 – High Quality 1 – High Quality
Data not used (rank)		
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 Ferry Point in recent years.

Fishery Interactions
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6. FOR FURTHER INFORMATION

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