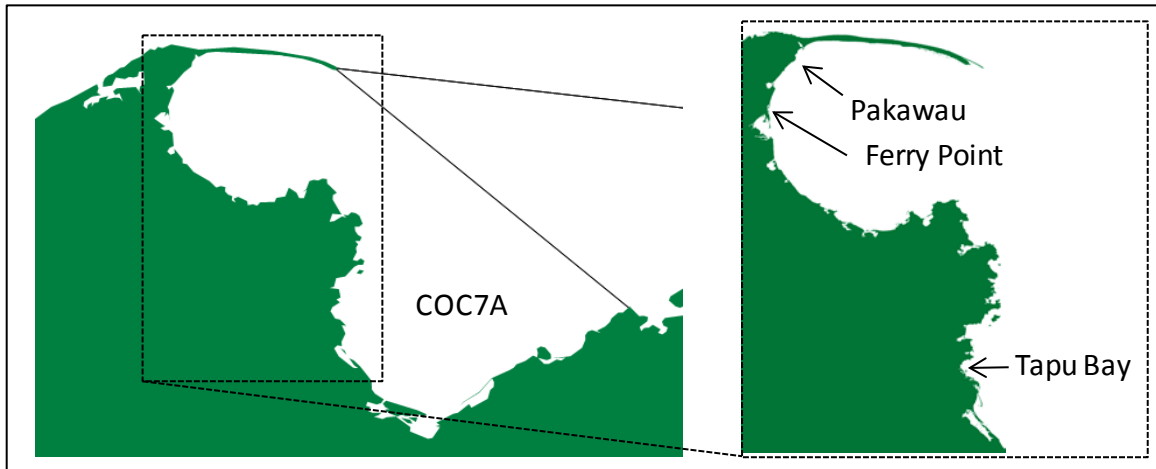


COCKLES (COC 7A) Tasman and Golden Bays
(Austrovenus stutchburyi)
 Tuangi



1. FISHERY SUMMARY

COC 7A was introduced to 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

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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.

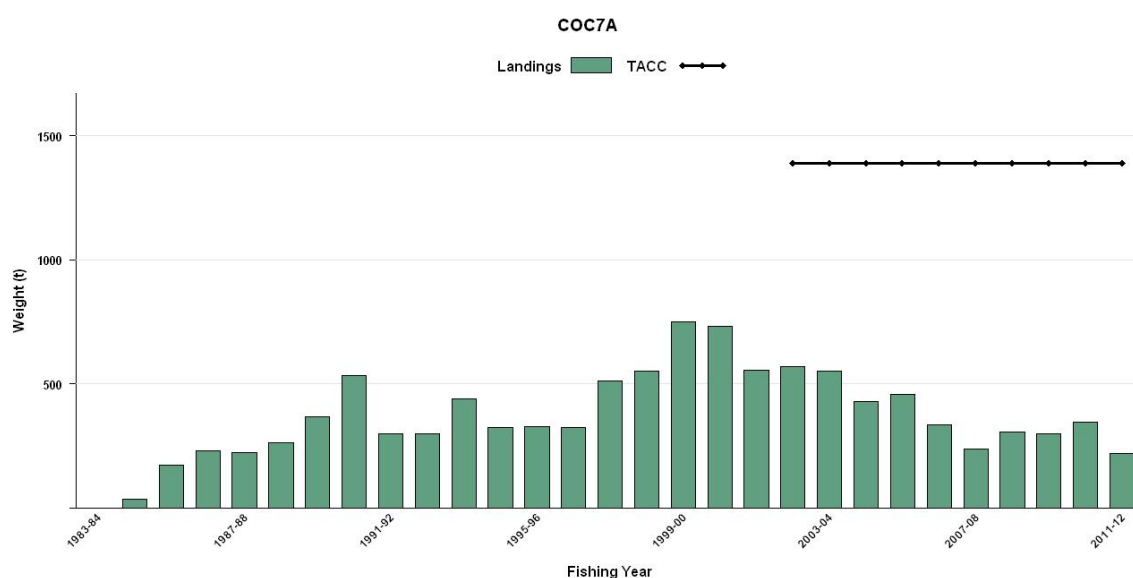


Figure 1: Historical landings and TACC for COC7A (Nelson Bays).

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 > 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 (Tierney *et al.* 1997) and from national diary surveys in 1996 (Bradford 1998) and 2000 (Boyd & Reilly 2004). Harvest weights were estimated assuming a mean weight of 25 g per cockle. The 1992-93 and 1996 estimates are very uncertain and probably under-estimate actual recreational catch. The 2000 survey is considered to be a more reliable estimate of recreational harvest.

Table 2: Estimated numbers of cockles harvested by recreational fishers in QMA 7, and the corresponding harvest tonnage. Data from both surveys were not sufficiently reliable to allow estimates of CVs.

Year	QMA 7 harvest	
	Number	(t)
1992-93	166 000	4
1996	325 000	8
2000	499 000	12.5

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 in the near future.

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
<u>1. Natural mortality (<i>M</i>)</u>				
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)
<u>2. Weight = a (shell length)^b (weight in g, shell length in mm)</u>				
	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		
<u>3. von Bertalanffy growth parameters</u>				
	<i>K</i>	<i>t</i> ₀	<i>L</i> _∞	
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

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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 $y = 11.452\ln(x) + 16.425$, 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 3 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 1988 and 1984 covered smaller areas still. The survey area was reduced in 2008 to remove areas that were observed over eight years to be consistently unsuitable habitat for cockles or cockle harvesting (sand banks, soft mud and *Zostera*). There is no apparent decline in biomass per unit area throughout the entire series of surveys. The eight comparable surveys show total and recruited biomass to have fluctuated, but with no consistent trend. Because harvesting is not permitted in areas of *Zostera*, additional estimates of recruited biomass available to harvesters are presented (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). Results from all these surveys are listed in Table 5 and shown in Figure 2. Biomass at Pakawau beach has generally increased over time and the biomass at Riwaka and Ferry Point have generally decreased over time.

Table 4: Estimates of biomass (t) with 95% confidence intervals (CI) where available, and mean density (kg/m²) for cockles on Pakawau Beach. Values are given for the total and recruited (>= 30 mm) biomass. Available biomass is recruited biomass not occurring in areas of *Zostera*. n = number of samples in the survey. Lines of data in italics represent results from the 1997-99 surveys, but using only those strata surveyed in 1992.

Date	Area (ha)	n	Total biomass			Recruited biomass		
			t	CI	kg/m ²	t	CI	kg/m ²
1984	326	-	4 604	1 562	1.41	-	-	-
1988	510	-	5 640	-	1.11	-	-	-
Nov 1992#	421	230	5 540	824	1.32	5 299	836	1.26
May 1997#	421	224	7 846	1 588	1.86	7 422	1 665	1.76
Jun 1998#	421	227	6 838	1 245	1.62	6 285	1 252	1.49
Apr-99	421	228	6 920	1 154	1.64	6 388	1 091	1.52
Mar-00	421	205	6 357	1 184	1.51	5 966	1 140	1.42
Mar-01	421	190	8 942	1 570	2.12	8 160	1 460	1.94
Feb-04	421	268	9 432	1 200	2.24	8 803	1 164	2.09
Jan-08	407	180	8 968	1 662	2.2	8 285	1 599	2.04

Prior to 1999, recruited biomass was calculated for size of >= 35 mm shell length and has been adjusted to biomass >30 mm using a length weight model.

Table 5: Estimates of biomass (t) with 95% confidence intervals (CI) where available, and mean density (kgm²) 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 (ha)	n	Total biomass			Recruited biomass		
				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	1076	235.6	0.88
Riwaka	Mar-08	103	82	1475	257	1.44	939	178	0.9
Riwaka (excl. Tapu Bay)*	Mar-91	-	-	-	-	-	1880	450	-
Ferry Point	Dec-96	40	552	2 617	190	5.99	2442	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 m², 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 biomasses, B₀, are assumed to be equal to estimated biomass of cockles >= 30 mm 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.

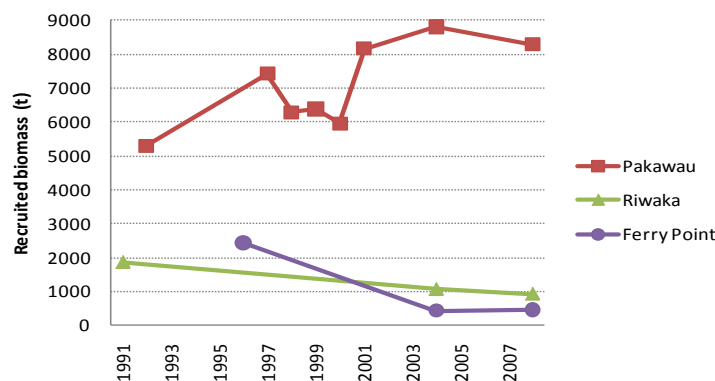


Figure 2: Recruited biomass (>= 30 mm shell length) over time

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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, MCY is as follows:

M	0.2	0.3	0.4
MCY	1182	2418	4658

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			M
			0.2	0.3	0.4	
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	
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 by 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} rather than $F_{0.1}$, 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 $CAY = F_{REF}/(F_{REF} + M) * (1 - e^{-(F_{REF} + M)}) * B_{BEG}$ (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 F_{MAX} 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 estimates in Table 8.

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	2001	F_{MAX}	1 599	2 388	2 975	-
Pakawau Beach	2004	$F_{0.1}$	1 202	1 555	1 910	
Pakawau Beach	2008	$F_{0.1}$	1 161	1 501	1 845	
Ferry Point	1996	$F_{0.1}$	407	501	600	696
Ferry Point	1996	F_{MAX}	748	1 050	1 369	1 650
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: Estimates of $F_{0.1}$ and F_{MAX} using a range of M values and two minimum harvest sizes (MHS).

F_{REF}	MHS (mm)	M			
		0.2	0.3	0.4	0.5
$F_{0.1}$	35	0.27	0.38	0.51	0.65
$F_{0.1}$	30	0.26	0.34	0.45	0.57
F_{MAX}	35	0.66	1.35	2.6	-
F_{MAX}	30	0.53	0.91	1.59	3.01

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.

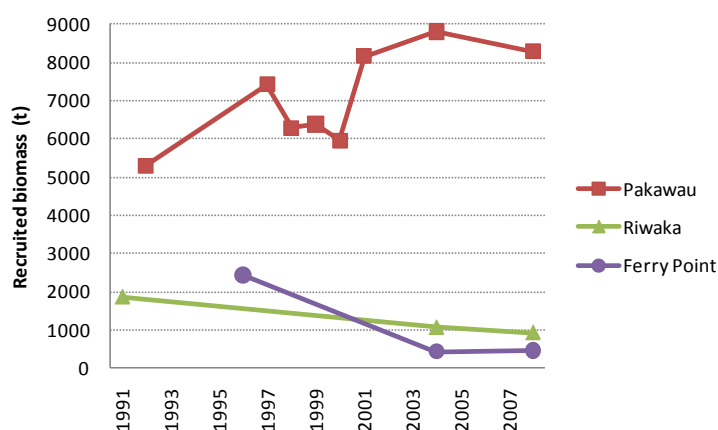
- COC7A

Stock Status	
Year of Most Recent Assessment	2008

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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
Status in relation to Target	About as Likely as Not (40-60%) to be at or above the target (except for local depletion in 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

Historical Stock Status Trajectory and Current Status



Recruited biomass (≥ 30 mm shell length) over time

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, with the lowest value in 1992 (5299 t) and the highest value in 2004 (8803 t). 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).
Recent Trend in Fishing Mortality or Proxy	Landings since 2004-5 are intermediate compared to the history of the fishery and have fluctuated without trend between 237 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 decline below Limits	Fishing at present levels is Very Unlikely (< 10%) to cause declines below the soft or hard limits.
Assessment Methodology	
Assessment Type	Level 2: Partial quantitative stock assessment
Assessment Method	Absolute biomass estimates from quadrant surveys
Main data inputs	Abundance and length frequency information
Period of Assessment	Latest assessment: 2008 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 Ferry Point in recent years.

Fishery Interactions

-

Table 9: Summary of yields, catch limits, and reported landings (t) of COC7A for the most recent fishing year.

<u>Fishstock</u> COC7A	<u>MCY ≥ 30 mm SL</u> N/A*	<u>CAY ≥ 30 mm SL</u> N/A*	<u>2011-12</u> Actual TACC	<u>2011-12</u> Reported Landings
			1 390	220

* Osborne 2010

6. FOR FURTHER INFORMATION

- Belton R.J. 1986. A resource survey of the *Chione stutchburyi* stocks in the Marlborough Sounds. Unpublished report prepared for M. Hones & B. Huntley.
- Boyd R.O., Reilly J.L. 2004. 1999/2000 National marine Recreational Fishing Survey: harvest estimates. Draft New Zealand Fisheries Research Report. Held by the Ministry for Primary Industries, Wellington.
- Bradford E. 1998. Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document 1998/16. 27 p.
- Breen P.A. 1996. Yield estimates for the Tapu Bay - Riwaka fishery for cockles (*Austrovenus stutchburyi*). Unpublished report prepared for Talley's Fisheries Ltd. (NIWA Client Report WLG1996/27).
- Breen P.A. 1997a. Yield calculations for cockles (*Austrovenus stutchburyi*) at Ferry Point, Golden Bay. Unpublished report prepared for Talley's Fisheries Ltd. (NIWA Client Report WLG1997/17).
- Breen P.A. 1997b. An evaluation of a biomass survey for cockles on Pakawau Beach, consideration of reasonable CAY estimates and consideration of increased catch. Unpublished report prepared for Westhaven Shellfish Co. Ltd. (NIWA Client Report WLG97/32).
- Bull M. 1984. A brief study of intertidal clam beds in Western Golden Bay associated with trials of a mechanical clam harvester. Unpublished Ministry for Primary Industries report. 11 p.
- Forrest B., Asher R. 1997. Ferry Point cockle survey: revised report. Unpublished report prepared for Talley's Fisheries Ltd. (Cawthron Report No. 411).
- Grange K. 1995. Biological communities of the intertidal sandflats, Motupipi, Golden Bay. Unpublished report prepared for Sealife Investments Ltd. (NIWA Client Report 1995/NEL911/1).
- Ministry of Fisheries. 2010. Report from the Fisheries Assessment Plenary, May 2010: stock assessments and yield estimates. In, p. 1158. Ministry for Primary Industries, Wellington, New Zealand
- Osborne T.A. 1992. Biomass survey and stock assessment of the New Zealand littleneck clam (*Chione stutchburyi*) on Pakawau Beach, Golden Bay. Unpublished report prepared for Westhaven Shellfish Co. Ltd. 27 p.
- Osborne T.A. 1997. Biomass survey and stock assessment of the New Zealand littleneck clam (*Chione stutchburyi*) on Pakawau Beach, Golden Bay. Unpublished report prepared for Westhaven Shellfish Co. Ltd. 16 p.
- Osborne T.A. 1998. 1998 biomass survey and stock assessment of the New Zealand littleneck clam (*Chione stutchburyi*) on Pakawau Beach, Golden Bay. Unpublished report prepared by Osborne Research Co. Ltd. for Westhaven Shellfish Co. Ltd. 23 p.
- Osborne T.A. 1999. 1999 biomass survey and stock assessment of the New Zealand littleneck clam (*Chione stutchburyi*) on Pakawau Beach, Golden Bay. Unpublished report prepared by Osborne Research Co. Ltd. for Westhaven Shellfish Co. Ltd. 15 p.
- Osborne T.A. 2001. Annual biomass survey and stock assessment of cockles on Pakawau Beach, Golden Bay - 2001. Unpublished report prepared by Osborne Research Co. Ltd. for Westhaven Shellfish Co. Ltd. 23 p.
- Osborne T.A. 2004. Annual biomass survey and stock assessment of cockles on Pakawau Beach, Golden Bay - 2001. Unpublished report prepared by Osborne Research Co. Ltd. for Westhaven Shellfish Co. Ltd..
- Osborne T.A. (2010). Biomass survey and stock assessment of cockles (*Austrovenus stutchburyi*) in area COC 7A: Tapu Bay, Ferry Point, and Pakawau. *New Zealand Fisheries Assessment Report 2010/44*.
- Osborne T.A., Seager V. 1994. Biomass survey and stock assessment of the New Zealand littleneck clam (*Chione stutchburyi*) on three beaches in Golden Bay. Unpublished report prepared for Wakatu Incorporation and Te Tau Ihu Ltd Joint Venture.
- Stark J.D., Asher R.A. 1991. Cockle resource survey Tapu Bay - Motueka River (February 1991). Unpublished report prepared by Cawthron Institute for Talley's Fisheries Ltd.
- Tierney L.D., Kilner A.R., Millar R.E., Bell J.D. 1997. Estimation of recreational catch from 1991/92 to 1993/94. New Zealand Fisheries Assessment Research Document 1997/15. 43p.
- Wilson N., Stevens J., Alspach P., Butler D. 1988. Environmental Impact Assessment. Effects of mechanical harvesting of cockles from the Pakawau/Puoponga intertidal area. Report prepared by DSIR Division of Horticulture and Processing, Fish Technology Section, Nelson, for Westhaven Shellfish Co. Ltd.