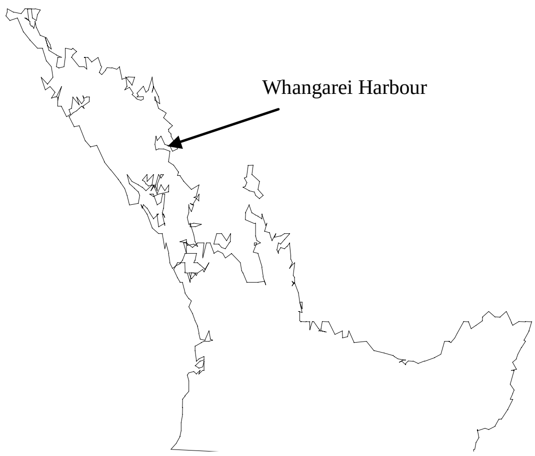
COCKLES (COC 1A) Snake Bank (Whangarei Harbour)

(*Austrovenus stutchburyi*)



1. FISHERY SUMMARY

(a) Commercial fisheries

Commercial picking in Whangarei Harbour began in the early 1980s and is now undertaken year round, with no particular seasonality. Catch statistics (Table 1) are unreliable before 1986, although it is thought that over 150 t of Snake Bank cockles were exported in 1982. There was probably some under reporting of landings before 1986, and this may have continued since. Effort and catch information for this fishery has not been adequately reported by all permit holders in the past, and there are problems interpreting the information that is available. Landed weights reported on CELRs only summed to between 52 and 91% of weights reported on LFRRs during the years 1989–90 to 1992–93. No CPUE data are therefore presented for this fishery.

Table 1: Reported commercial landings and catch limits (t greenweight) of cockles from Snake Bank since 1986–87 (from QMR/MHR records). Before COC 1A entered the QMS, the fishery was restricted by daily catch limits which summed to 584 t in a 365 day year, but there was no explicit annual restriction. A TACC of 346 t was established in October 2002 when COC 1A entered the QMS. * The figure of 566 t for 1993–94 may be unreliable.

Fishing year	Landings (t)	Limit (t)	Fishing year	Landings (t)	Limit (t)
1986–87	114	584	1996–97	457	584
1987–88	128	584	1997–98	439	584
1988–89	255	584	1998–99	472	584
1989–90	426	584	1999–00	505	584
1990–91	396	584	2000–01	423	584
1991–92	537	584	2001–02	405	584
1992–93	316	584	2002–03	237	346
1993–94	*566	584	2003–04	218	346
1994–95	501	584	2004–05	151	346
1995–96	495	584	2005–06	137	346

COC 1A was introduced to the QMS in October 2002 with a TAC of 400 t, comprising a TACC of 346 t, customary and recreational allowances of 25 t each, and an allowance of 4 t for other fishing related mortality. Before this there were eight permit holders, each allowed a maximum of 200 kg (greenweight) per day by hand-gathering. If all permit holders took their quota every day a maximum of 584 t could be taken in a 365 day year. Reported landings of less than 130 t before 1988–89 rose to 537 t in 1991–92 (about 92% of the theoretical maximum). Landings for the 1992–93 year were much reduced (about 316 t) following an extended closure for biotoxin contamination. Landings averaged 462 t between 1993–94 and 2000–2001. Landings have decreased substantially since COC 1A entered the QMS (average of 186 t), and landings in 2005–06 (137 t) were the lowest recorded since 1987–88. There is no minimum legal size for cockles, however, the mean length of the commercial harvest is about 29.5 mm and cockles smaller than 25 mm are less attractive to both commercial and non-commercial fishers.

Snake Bank is not the only cockle bed in Whangarei Harbour, but it is the only bed open for commercial fishing. There are several other cockle beds in the harbour, some on the mainland and some on other sandbanks, notably MacDonald Bank. Fishing on these other beds should be exclusively non-commercial.

(b) Recreational fisheries

The recreational fishery is harvested entirely by hand digging, and large cockles (30 mm shell length or greater) are preferred. A regional telephone and diary survey in 1993/94, and national recreational diary surveys in 1996, 1999/2000, and 2000/01 estimated the numbers of cockles harvested in QMA 1 to be 0.57–2.4 million (Table 2). It is not clear to what extent these estimates include customary take. No mean harvest weight for cockles was available, but an assumed mean weight of 25 g (as for cockles 30 mm SL or more from the 1992 Snake Bank survey) leads to a QMA 1 recreational harvest of 14–59 t (Table 2). 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 1999/2000 and 2000/01 surveys, it was considered the estimates may still be very inaccurate. No recreational harvest estimates specific to the Snake Bank fishery are available.

Table 2: Estimated numbers of cockles harvested by recreational fishers in QMA 1, and the corresponding harvest tonnage based on an assumed mean weight of 25 g. Figures were extracted from a telephone and diary survey in 1993/94, and from national recreational diary surveys in 1996, 1999/2000, and 2000/01.

Year	QMA 1 harvest (number of cockles)	CV (%)	QMA 1 harvest (t)	Source
1993/94	2 140 000	18	55	Bradford (1997)
1996	569 000	18	14	Bradford (1998)
1999/2000	2 357 000	24	59	Boyd & Reilly (2002)
2000/01	2 327 000	27	58	Boyd et al. (2004)

(c) Maori customary fisheries

In common with many other intertidal shellfish, cockles are very important to Maori as a traditional food. However, no quantitative information on the level of customary take is available.

(d) Illegal catch

Anecdotal evidence suggests there was a significant illegal catch from Snake Bank in the 1990s, with some fishers greatly exceeding their catch limits. Commercial landings, therefore, may have been under-reported. There is also good evidence that illegal commercial gathering has occurred on MacDonald Bank on a reasonable scale in the past, which could have resulted in some over-reporting of catch from Snake Bank in some years. However, no quantitative information on the level of illegal catch is available.

(e) Other sources of mortality

No quantitative information on the level of other sources of mortality is available. It has been suggested that some methods of harvesting such as brooms, rakes and “hand sorters” cause some mortality, particularly of small cockles, but this proposition has not been tested.

2. STOCKS AND AREAS

Little is known of the stock boundaries of cockles. Given the relatively extended planktonic larval phase, many populations may receive spat fall from other nearby populations and may, in turn, provide spat for these other areas. Where studies have been made, differences in growth and mortality rates have been demonstrated for cockles within and between different beds. These differences may simply reflect environmental differences in temperature and tidal elevation. In the absence of more detailed knowledge, therefore, the commercial fishery area is managed as a discrete population.

3. STOCK ASSESSMENT

Stock assessment for Snake Bank cockles has been conducted annually using absolute biomass surveys, yield per recruit (YPR), and spawning stock biomass per recruit (SSBPR) modelling. A length-based stock assessment model is being developed but the dynamics of the population are proving very difficult to replicate.

(a) Estimates of fishery parameters and abundance

Estimated and reference fishing mortality rates, and estimates of total mortality are available for Snake Bank (Table 3).

Table 3: Estimates of fishery parameters.

Population and years	Estimate	Source
1. Estimated Fishing Mortality (F_{est}, recruited size classes only)		
Snake Bank, 1991–92	1.55	Cryer (1997)
Snake Bank, 1992–93	0.62	Cryer (1997)
Snake Bank, 1995–96	0.50	Cryer (1997)
Snake Bank, 1991–96	0.89	Cryer (1997)
2. Reference Fishing Mortality (F_{ref}, recruited size classes only)		
Snake Bank, $F_{0.1}$	0.41	Cryer (1997)
Snake Bank, F_{max}	0.62	Cryer (1997)
Snake Bank, $F_{50\%}$	4.52	Cryer (1997)
3. Total Instantaneous Mortality (Z, all size classes)		
Snake Bank, 1992–93	0.46	Cryer & Holdsworth (1993)

(b) Biomass estimates

Biomass estimates for the Snake Bank cockle population from 1982–1996 were made using grid surveys. Surveys done from 1998 used a stratified random approach (Table 4). The data given here differ from those in reports before 1997 because the assumptions made when estimating biomass have changed. The surveys conducted in 1985 and 1991 did not cover the whole area of the bank, and results from these surveys have been corrected in the table by assuming that the cockle population occupied the same area of the bank in these years as it did in 1982 (the first and largest survey). It has been further assumed for the estimation of variance for the grid based surveys that samples have been taken at random from the bank, although variance estimators not requiring this assumption gave very similar results in 1995 and 1996. The post 1997 surveys also incorporated a large area of low density cockles not included in previous surveys, although this adds only a small tonnage of biomass to the total figure. In 1998 and 2000, biomass surveys were undertaken at MacDonald Bank using a stratified random approach (Table 5). Cryer et al. (2003) reported biomass estimates for several locations in Whangarei Harbour in 2002, including a new MacDonald Bank stratum (Table 5).

Between the start of the commercial fishery in 1982 and the survey in 1992, there was a consistent decline in the biomass of large cockles (>35 mm shell length) on Snake Bank. The biomass of these large individuals averaged 10.5% of its virgin level between 1991 and 1999 (range 9–17%). A decrease in the proportion and biomass of large, old individuals can be expected with the development of a commercial fishery, and the biomass of “acceptable” or “recruited” cockles (>30 mm shell length) had averaged about 43% (range 33–63%) of its virgin level over this same period. Instances of highly prolific year-classes led to peaks in recruited biomass in 1995, 1999, 2003, and 2005. It was noted that each of these peaks was lower than the previous peak. However, the large peak in current biomass (1411 t in 2007) has broken this trend, and is the highest biomass estimate since 1995.

Virgin biomass, B_0, is assumed for the purpose of this assessment to be equal to the estimated biomass of cockles >30 mm shell length in 1982 (2340 t). This biomass was estimated using length frequency distributions, a length weight regression, and a direct estimate of the biomass of cockles >35 mm shell length in 1982 (1825 t).

The biomass that will support the maximum sustainable yield, B_{MSY}, is not known; however, current biomass (of cockles 30 mm or more shell length) is 60% of B_0 (1411/2340 t).

Table 4: Estimates of biomass (t) of cockles on Snake Bank for surveys (*n*, number of stations) between 1982 and 2007. Biomass estimates marked with an asterisk (*) were made using length frequency distributions and length-weight regressions, others by direct weighing of samples sorted into three size classes. Two alternative biomass estimates are presented for 1988 because the survey was abandoned part-way through, "a" assuming the distribution of biomass in 1988 was the same as in 1991, and "b" assuming the distribution in 1988 was the same as in 1985. The 2001 result comes from the second of two surveys, the first having produced unacceptably imprecise results.

Year	*n*	Total		< 30 mm SL		≥ 30 mm SL		≥ 35 mm SL	
		Biomass	*CV*	Biomass	*CV*	Biomass	*CV*	Biomass	*CV*
1982	199	2556	–	*216	–	*2340	–	1825	~ 0.10
1983	187	2509	–	*321	–	*2188	–	1700	~ 0.10
1985	136	2009	0.08	*347	~0.10	1662	0.08	1174	~ 0.10
1988 a	53	–	–	–	–	1140	> 0.15	–	–
1988 b	53	–	–	–	–	744	> 0.15	–	–
1991	158	1447	0.09	686	0.10	761	0.10	197	0.12
1992	191	1642	0.08	862	0.10	780	0.08	172	0.11
1995	181	1480	0.07	1002	0.09	1478	0.07	317	0.12
1996	193	1755	0.07	959	0.09	796	0.08	157	0.11
1998	53	2401	0.18	1520	0.20	880	0.17	114	0.20
1999	47	3486	0.12	2165	0.12	1321	0.14	194	0.32
2000	50	1906	0.23	1336	0.24	570	0.25	89	0.32
2001	51	1405	0.17	970	0.18	435	0.17	40	0.29
2002	53	1618	0.14	1152	0.15	466	0.19	44	0.29
2003	60	2597	0.11	1567	0.15	1030	0.12	121	0.14
2004	65	1910	0.15	1364	0.17	546	0.14	59	0.22
2005	57	2592	0.18	1625	0.18	967	0.20	111	0.20
2006	57	2412	0.13	1620	0.15	792	0.13	103	0.20
2007	73	2834	0.13	1423	0.18	1411	0.15	321	0.41

Table 5: Biomass estimates (t) and approximate *CV*s by shell length size classes for cockles on MacDonald Bank. *n* = the number of samples in the survey.

Year	*n*	Total		< 30 mm SL		≥ 30 mm SL		≥ 35 mm SL	
		Biomass	*CV*	Biomass	*CV*	Biomass	*CV*	Biomass	*CV*
1998	33	6939	0.19	5261	0.18	1678	0.31	128	0.41
2000	30	6037	0.28	4899	0.29	1137	0.30	34	0.37
2002	24	2548	0.12	2010	0.14	538	0.36	61	0.46

(c) Estimation of Maximum Constant Yield (MCY)

As estimates of B_{beg} are available, CAY results are presented in preference to MCY.

(d) Estimation of Current Annual Yield (CAY)

CAY can be estimated for the current year based on a survey conducted in 2007. As fishing is conducted year round on Snake Bank, the full version of the Baranov catch equation is appropriate (Method 1, Sullivan et al., 2005), where:

Using $F_{0.1}$,

$$\begin{aligned} CAY &= F_{0.1} / (F_{0.1}+M) \times (1 - e^{-(F0.1+M)}) \times B_{beg} \\ &= 0.41 / 0.71 \times 0.5084 \times 1411 \\ &= 414 \text{ t} \end{aligned}$$

Using F_{max},

$$\begin{aligned} CAY &= F_{max} / (F_{max}+\mathrm{M}) \times (1 - e^{-(Fmax+M)}) \times B_{beg} \\ &= 0.62 / 0.92 \times 0.6015 \times 1411 \\ &= 572 \text{ t} \end{aligned}$$

This includes non-commercial catch. A range of sizes is taken commercially, starting from about 25 mm and averaging 29.5 mm; CAY estimates are sensitive to the assumed size at recruitment to the fishery (Table 6). The level of risk to the stock by harvesting the population at the estimated CAY value cannot be determined.

Table 6: Sensitivity of biomass and CAY estimates to shell length at recruitment (L_{recr}) for Snake Bank cockles.

L_{recr} (mm)	Rationale	B_{av} (91–07) (t)	B_{curr}(2007) (t)	M	$F_{0.1}$	CAY (t)
25	Smallest in catch	1722	2520	0.3	0.34	633
28	Recent selectivity	1281	1872	0.3	0.38	516
30	Historical assumption	874	1411	0.3	0.41	414
35	Largest cockles	146	321	0.3	1.00	180

(e) Other yield estimates and stock assessment results

$F_{0.1}$ and F_{max} were estimated using a yield per recruit (YPR) model using quarterly (rather than the more usual annual) increments and critical sizes (rather than ages) for recruitment to the spawning stock and to the fishery. The following input information was used: growth rate parameters from a MULTIFAN analysis of 1991–96 length frequencies; an estimate of M = 0.30 (range 0.20–0.40) from a tagging study in 1984; length weight data from 1992, 1995 and 1996 combined; size at maturity of 18 mm; and size at recruitment of 30 mm from an analysis of fisher selectivity. For the base case analysis, $F_{0.1}$ = 0.41 and F_{max} = 0.62. These estimates were neither sensitive to the length weight regression used, nor to the value of M chosen ($F_{0.1}$ = 0.38–0.45, and F_{max} = 0.56–0.69, for M = 0.20–0.40), but were more sensitive to the assumed length at recruitment ($F_{0.1}$ = 0.34 and F_{max} = 0.52 for L_{recr} = 25 mm).

(f) Other factors

Biomass and yield estimates will differ for different sizes of recruitment. Maori and recreational fishers prefer cockles of 30 mm shell length and greater, whereas commercial fishers currently prefer cockles of 25 mm and greater. Therefore, yield has been estimated for sizes of recruitment between 25 and 30 mm. As cockles become sexually mature at around 18 mm, using a size of recruitment between 25 mm and 30 mm should provide some protection against egg overfishing under most circumstances. However, using the smaller size of recruitment to estimate yield will confer a greater risk of overfishing.

As the Snake Bank cockle population may receive spat from spawnings in other parts of Whangarei Harbour, it may not be realistic to assume that the Snake Bank stock is discrete and that reduced egg production (as a result of heavy fishing mortality on medium and large sized individuals) would necessarily lead to recruitment overfishing. Spawning stock biomass per recruit (SSBPR) analysis suggests that $F_{50\%} > F_{max} > F_{0.1}$ ($F_{50\%}$ is that fishing mortality which would lead to egg production from the population at equilibrium being half of egg production from the virgin stock), except where the size at recruitment is reduced to 25 mm. Substantial reduction of egg production is therefore unlikely if fishing mortality is restrained to within $F_{0.1}$ or F_{max}, and the fishery concentrates on cockles >30 mm in length.

However, it has been demonstrated for this bank that recruitment of juvenile cockles can be reduced by the removal of a large proportion of adult cockles from a given area of substrate. Conversely, there did not seem to be heavy recruitment to the population during the years when adult biomass was close to virgin (1982–85). This would suggest that there is some optimal level of adult biomass to facilitate recruitment, although its value is not known. It would appear prudent, therefore, to exercise some caution in reducing the biomass of adult cockles. If adult biomass is driven too low, then recruitment overfishing of this population could still occur despite high levels of egg production. In addition, sporadic recruitment of juveniles will probably lead to a fluctuating biomass, suggesting that a CAY approach may be more appropriate than a constant catch approach.

Industry does not agree with the approach used to assess Snake Bank cockles for the following reasons: The stock assessment is based on a model which assumes equilibrium conditions and the fishing mortality rates calculated by this model are applied in a manner which assumes that the biomass is in equilibrium. These assumptions are very unlikely to be met and this form of management will lead to overharvest if the stock is below optimum level and will lead to underharvest when it is above optimum level. It is possible to model these populations dynamically using a length-based approach; and that such models should lead to much more robust estimates of available yield.

A length-based stock assessment model developed in 2000 (Breen, 2000) allowed for more of the natural variability of the system to be incorporated in the stock assessment. This first model did not adequately capture the detail of cockle dynamics. Further work in 2002 (McKenzie et al., 2003) did not resolve all of these problems and substantial conflict remained in the model.

Additional information on growth and the length frequency of cockles taken by the fishery was collected in 2003 and 2004 and updated in the model. Several additions and enhancements to the model were also made in an attempt to resolve the above-mentioned conflict (Cryer et al., 2004; Watson et al., 2004). As a result, the model showed an improved fit to the observed data. However, there still remained some conflict, primarily relating to annual variability in the growth increment data, in which only two years of observations were available (2002 and 2004). This was thought to be due to the existence of annual variability in recruitment, and possibly mortality, which are presently not explicitly modelled. Watson et al. (2004) therefore concluded that no further development of the model should be undertaken for 3–5 years, and that resources be concentrated more on data collection, and in particular, growth and recruitment data. Consequently, a tag-recapture experiment was started in March 2005, and additional large samples of cockles were notch-tagged and released in March 2006 and March 2007. Tagged individuals are being recovered and measured on a quarterly basis, and preliminary results suggest there may be strong seasonal variability in growth.

Although the Shellfish Working Group considered that the development of a length-based stock assessment model would be of considerable benefit to the stock assessment, the problems with the model were such that the current approach used to estimate yield for this fishery that had been agreed to by the Shellfish Fishery Assessment Working Group since 1992 would remain.

4. STATUS OF THE STOCKS

Cockles recruit to the spawning stock on Snake Bank at a size of approximately 18 mm shell length. The Snake Bank cockle population may also receive spat from other beds in the harbour. Therefore, at the current harvest size (about 30 mm shell length) there is probably a low risk of recruitment overfishing the Snake Bank population, even at high levels of fishing pressure. The risk of recruitment overfishing, however, increases as the average size of cockles harvested decreases.

The recruited biomass of cockles (>30 mm shell length) on Snake Bank declined from over 2000 t in the early 1980s to about 700 t in the early 1990s. It has since fluctuated between about 500 and 1500 t without apparent trend, falling to particularly low levels (<500 t) in 2001 and 2002. There has been a large increase (78%) in recruited biomass on Snake Bank since the last survey in 2006, but the 2007 length frequency distribution suggests that the recruitment of juveniles (under 20 mm SL) has been poor compared with recent years, and this could lead to reduced levels of adult recruitment to the fishery over the next year or two. Before October 2002 (when COC 1A was introduced to the QMS), the sum of the daily catch limits (584 t), and average landings between 1989–90 and 2001–02 (457 t) both greatly exceeded estimates of MAY (maximum average yield based on the average of CAY estimates over recent years). In October 2002, the commercial catch limit was reduced from 584 t to a TACC of 346 t. This current TACC is lower than the estimated CAY (414 t) unless a large size (35 mm SL) at recruitment is assumed, suggesting that fishing at the level of the current TACC is likely to be sustainable in the short term. Current reported landings (137 t) are less than both the TACC and the estimated CAY. Annual surveys are being used to monitor the stock closely, but it is not known if current catch limits will allow the stock to move towards a size that will support the MSY.

Yields, TACCs and reported landings are summarised in Table 7.

Table 7: Summary of yields, catch limits, and reported landings (t) of Snake Bank cockles for the most recent fishing year.

Fishstock	CAY	2005–2006 Actual TACC	2005–2006 Reported Landings
COC 1A	414	346	137

5. FOR FURTHER INFORMATION

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