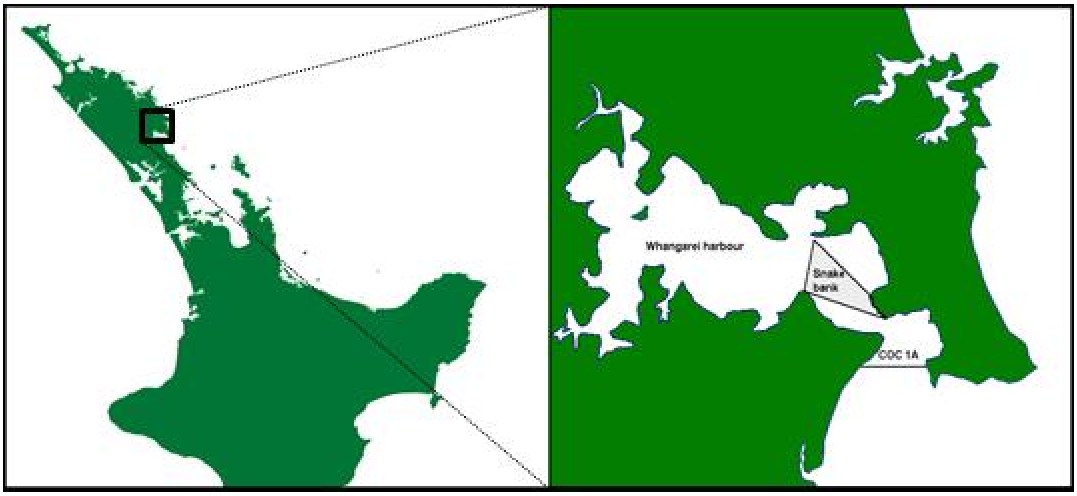
COCKLES (COC 1A) Snake Bank (Whangarei Harbour)

(*Austrovenus stutchburyi*)
Tuangi



1. FISHERY SUMMARY

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. These limits have remained unchanged since.

1.1 Commercial fisheries

Snake Bank is not the only cockle bed in Whangarei Harbour, but it is the only bed allowed for commercial fishing. Commercial fishers are restricted to hand gathering, but they routinely use simple implements such as ‘hand sorters’ to separate cockles of desirable size from smaller animals and silt. 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.

Commercial picking in Whangarei Harbour began in the early 1980s and was then 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. CPUE data are available but have not yet been analysed for this fishery.

Before entry of this stock to the QMS 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 fishing year were much reduced (about 316 t) following an extended closure for biotoxin contamination. Landings averaged 462 t between 1993–94 and 2000–01. Landings have decreased substantially since COC 1A entered the QMS (average of 108 t). Due to low biomass, the fishery closed in November 2012 and has remained closed since.

The low catch in the last few years before the closure may partly reflect reduced effort on the bank because of temporary fishery closures during incidents of sewage and stormwater overflows which adversely affected harbour water quality. The fishery was closed for these reasons for 101, 96, 167, and

96 days for the 2006–07, 2007–08, 2008–09, and 2009–10 fishing years, respectively[1]. Figure 1 shows the commercial landings and TACC values of COC 1A since 1986.

Table 1: Reported commercial landings and catch limits (t greenweight) of cockles from Snake Bank since 1986–87 (from QMR/MHR records)*.

Fishing year	Landings (t)	TACC (t)
1986–87	114	584
1987–88	128	584
1988–89	255	584
1989–90	426	584
1990–91	396	584
1991–92	537	584
1992–93	316	584
1993–94	**566	584
1994–95	501	584
1995–96	495	584
1996–97	457	584
1997–98	439	584
1998–99	472	584
1999–00	505	584
2000–01	423	584
2001–02	405	584
2002–03	237	346
2003–04	218	346
2004–05	151	346
2005–06	137	346
2006–07	111	346
2007–08	151	346
2008–09	88	346
2009–10	93	346
2010–11	64	346
2011–12	43	346
2012–13	0	346
2013–14	0	346
2014–15	0	346
2015–16	0	346
2016–17	0	346
2017–18	0	346
2018–19	0	346
2019–20	0	346

*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.

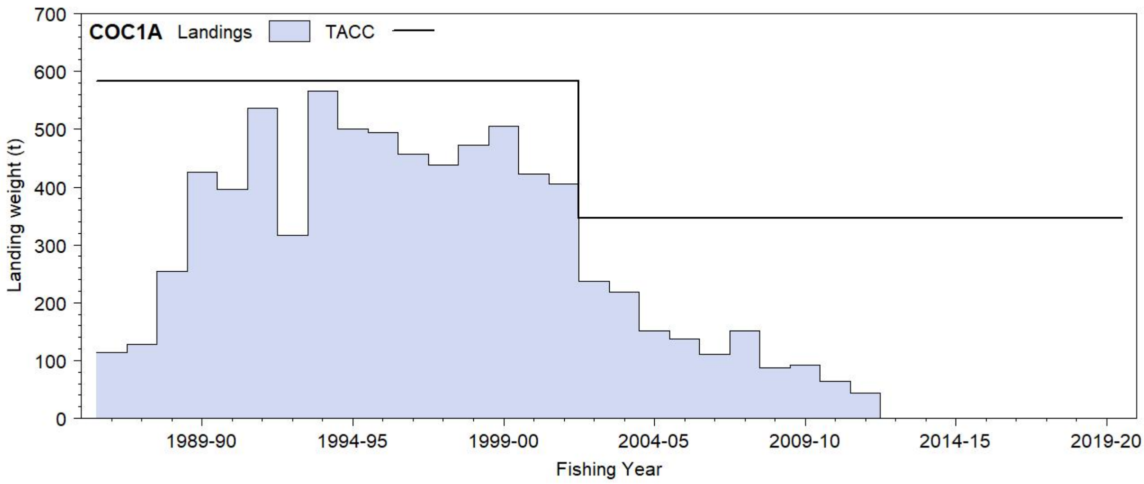


Figure 1:Reported commercial landings and TACC for COC 1A (Whangarei Harbour).

The mean length of the commercial harvest was about 29.5 mm; cockles smaller than 25 mm were less attractive to both commercial and non-commercial fishers.

[1] Statistics supplied by New Zealand Food Safety Authority in Whangarei.

1.2 Recreational fisheries

The recreational fishery is harvested entirely by hand digging, and large cockles (30 mm shell length or greater) are preferred. No recreational harvest estimates specific to the Snake Bank fishery are available.

History of the estimates of recreational catch is provided in the introductory COC Working Group report. Estimated numbers of cockles harvested by recreational fishers in QMA 1 are provided in Table 2.

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 telephone-diary surveys in 1993–94, 1996, 1999–00, and 2000–01 and the national panel survey in 2011–12 and 2017–18.

Survey	Numbers	CV (%)	Tonnes	Reference
1993–94	2 140 000	18	55	Bradford (1997)
1996	569 000	18	14	Bradford (1998)
1999–00	2 357 000	24	59	Boyd & Reilly (2002)
2000–01	2 327 000	27	58	Boyd et al (2004)
2011–12	299 765	68	7	Wynne-Jones et al (2014)
2017–18	0	0	0	Wynne-Jones et al (2019)

1.3 Customary fisheries

In common with many other intertidal shellfish, cockles are very important to Māori as a traditional food. Patuharakeke gazetted their rohe moana which covers the southern shoreline of the Whangarei harbour in 2009. Reporting of customary permits is now required but the Fisheries New Zealand customary catch database does not contain any record of Māori customary harvest of cockles from COC 1A.

1.4 Illegal catch

Anecdotal evidence suggests that 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.

1.5 Other sources of mortality

For further information on other sources of mortality, please refer to the introductory COC Working Group report.

2. BIOLOGY

Biological parameters used in this assessment are presented the general cockle section.

3. STOCKS AND AREAS

This is covered in the general cockle section.

4. STOCK ASSESSMENT

Stock assessment for Snake Bank cockles has been conducted periodically using absolute biomass surveys, yield-per-recruit (YPR), and spawning stock biomass-per-recruit (SSBPR) modelling. The stock assessments were used to estimate *CAY* and *MCY*. A length-based stock assessment model was developed for cockles but was not successful. The last stock assessment was conducted in 2009 and is now considered too old to inform the status of the stock.

4.1 Estimates of fishery parameters and abundance

Estimated and reference fishing mortality rates, estimates of total mortality and exploitation rate are available for Snake Bank (Table 3, Figure 2). Exploitation rate in 2012 and 2013 was 0% and had generally had a downward trend since 1991 (70%) except for a large peak around 2001 (93%). Exploitation rate is likely to be overestimated in the calculation below because the size of commercially harvested cockles is believed to have decreased from over 30 mm to over 28 mm shell length over time.

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)
4. Exploitation rate percentage (≥ 30 mm shell length)		

Year*	%
1991	71
1992	41
1995	34
1996	57
1998	54
1999	38
2000	74
2001	93
2002	51
2003	21
2004	28
2005	14
2006	14
2007	11
2008	8
2009	11
2012	0
2013	0

* Exploitation rate is only given in years when biomass surveys were completed and catch reporting was considered reliable (apart from in 2012 and 2013 when no catch was reported, therefore the exploitation rate percentage must be zero.

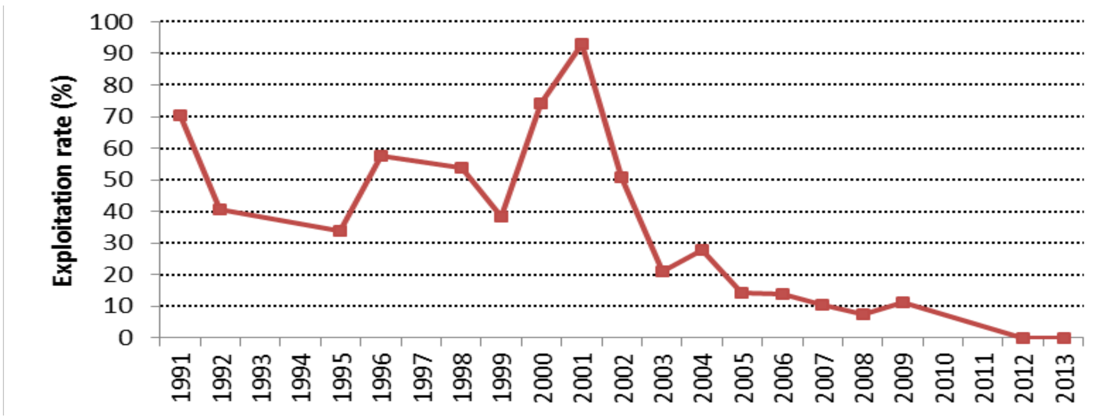


Figure 2: Exploitation rate (≥ 30 mm shell length).

4.2 Biomass estimates

Biomass estimates for the Snake Bank cockle population from 1982 to 1996 were made using grid surveys. Surveys done from 1998 used a stratified random approach (Table 4, Figure 3). 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). Northland Regional Council completed a survey in 2014 but only reported total biomass (Griffiths & Eyre 2014); this is included because it gives a recent indication of biomass in the absence of commercial fishing.

Virgin biomass, B_0, is assumed to be equal to the estimated biomass of cockles above a certain shell length in 1982. For example, if a length at recruitment of 30 mm or more was used, then a biomass of 2340 t resulted. 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).

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 (≥ 30 mm shell length) on Snake Bank. The biomass of these large individuals declined to 33% of its virgin level in 1991. A decrease in the proportion and biomass of large, old individuals can be expected with the development of a commercial fishery. The biomass of mature cockles has fluctuated since then without trend between 63 and 19% of virgin levels. The recruited biomass is likely to be underestimated in the calculation below because the size of commercially harvested cockles is believed to have decreased from over 30 mm to over 28 mm shell length over time. There was no survey that has allowed calculation of percent B_0 since 2009.

Table 4: Estimates of biomass (t) of cockles on Snake Bank for surveys (*n*, number of stations) between 1982 and 2015. Biomass estimates for the ≥ 18 mm shell length component and those marked with an asterisk (*) were made using length frequency distributions and length-weight regressions; the other size fractions were generated by direct weighing of samples. Two alternative 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. The 2007 and 2008 results differ slightly from those reported previously because they were estimated using an analytical approach more consistent with that used in other years. The column '%$B_{recruited}$' compares the biomass in the ≥ 30 mm SL to the defined B_0 for that size (22 340 t in 1982).

		Total		≥ 18 mm SL		≥ 30 mm SL		≥ 35 mm SL		
Year	*n*	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV	% $B_{recruited}$
1982	199	2 556	–	–	–	*2 340	–	1 825	~ 0.10	100
1983	187	2 509	–	2 460	0.06	*2 188	–	1 700	~ 0.10	94
1985	136	2 009	0.08	1 360	0.07	1 662	0.08	1 174	~ 0.10	71
1988 a	53	–	–	–	–	1 140	> 0.15	–	–	–
1988 b	53	–	–	–	–	744	> 0.15	–	–	–
1991	158	1 447	0.09	1 069	0.08	761	0.10	197	0.12	33
1992	191	1 642	0.08	1 355	0.07	780	0.08	172	0.11	33
1995	181	2 480	0.07	2 380	0.07	1 478	0.07	317	0.12	63
1996	193	1 755	0.07	–	–	796	0.08	157	0.11	34
1998	53	2 401	0.18	–	–	880	0.17	114	0.20	38
1999	47	3 486	0.12	2 645	0.11	1 321	0.14	194	0.32	56
2000	50	1 906	0.23	2 609	0.18	570	0.25	89	0.32	24
2001	51	1 405	0.17	1 382	0.17	435	0.17	40	0.29	19
2002	53	1 618	0.14	–	–	466	0.19	44	0.29	20
2003	60	2 597	0.11	2 385	0.31	1 030	0.12	121	0.14	44
2004	65	1 910	0.15	1 096	0.14	546	0.14	59	0.22	23
2005	57	2 592	0.18	2 035	0.15	967	0.20	111	0.20	41
2006	57	2 412	0.13	2 039	0.13	792	0.13	103	0.20	34
2007	73	2 883	0.13	2 681	0.13	1 434	0.15	329	0.42	61
2008	70	2 510	0.10	–	–	1 165	0.11	193	0.43	50
2009	75	1 686	0.15	–	–	815	0.13	88	0.19	35
2014	63	1 794	0.14	–	–	–	–	–	–	–

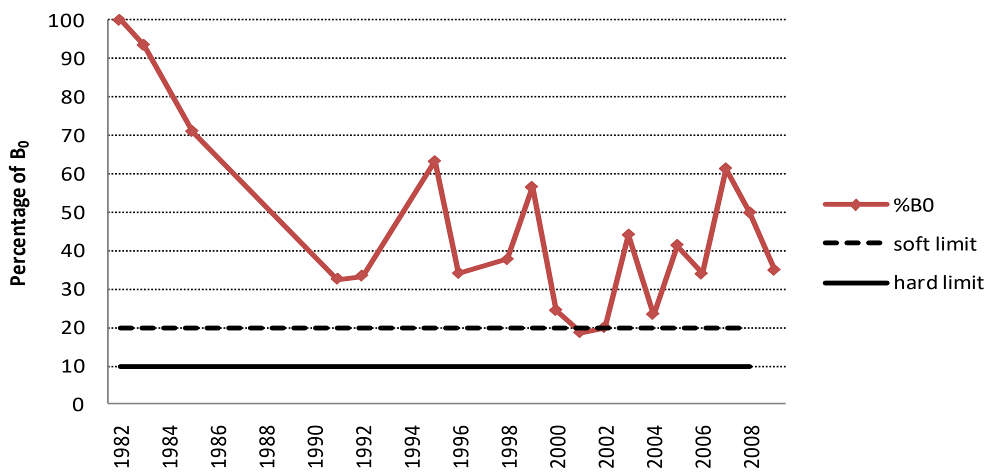


Figure 3: Recruited biomass (≥ 30 mm shell length) over time as a percentage of B_0 in relation to the hard and soft limits.

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

		Total		< 30 mm SL		≥ 30 mm SL		≥ 35 mm SL	
Year	*n*	Biomass	CV	Biomass	CV	Biomass	CV	Biomass	CV
1998	33	6 939	0.19	5 261	0.18	1 678	0.31	128	0.41
2000	30	6 037	0.28	4 899	0.29	1 137	0.30	34	0.37
2002	24	2 548	0.12	2 010	0.14	538	0.36	61	0.46

4.3 Yield estimates and projections

A range of sizes are taken commercially, selectivity seems to vary between years and *MCY* estimates are sensitive to the assumed size at recruitment to the fishery (Table 6). These are presented for two different shellfish lengths at recruitment into the fishery (when available): 30 mm, the historic size at recruitment; and 28 mm, the more recently accepted size at recruitment (Table 7). All these estimates include commercial and all non-commercial catch.

Because fishing is conducted year-round on Snake Bank, the Baranov catch equation is appropriate (Method 1, see Plenary introduction). This approach assumes that, between the start of the fishing year and when the biomass survey is started, productivity and catch cancel each other. The estimate includes non-commercial catch.

A range of sizes are taken commercially, selectivity seems to vary between years and *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} (1991–200) (t)	B_{curr}(2009) (t)	*M*	$F_{0.1}$	*MCY* (t)	*CAY* (t)
25	Smallest in catch	1 877	1 596	0.3	0.34	385	401
28	Fisher selectivity	1 409	1 265	0.3	0.38	289	349
30	Historical assumption	890	815	0.3	0.41	182	239
35	Largest cockles	145	88	0.3	1.00	30	49

4.4 Other yield estimates and stock assessment results

$F_{0.1}$ was 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, $F_{0.1} = 0.41$. Estimates were neither sensitive to the length-weight regression used, nor to the value of *M* chosen ($F_{0.1} = 0.38$–0.45 for $M = 0.20$–0.40), but were more sensitive to the assumed length at recruitment ($F_{0.1} = 0.34$ for $L_{recr} = 25$ mm).

Table 7: *MCY* and *CAY* estimates (t) for different shell lengths at recruitment (L_{RECR}). *MCY* is calculated using the equation for developing fisheries before 1995 and developed fisheries after 1995. Year labels as given in Table 4.

Year	$MCY \geq$ 28 mm SL	$MCY \geq$ 30mm SL	$CAY \geq$ 28 mm SL	$CAY \geq$ 30mm SL
1982		240		687
1983		240		642
1985		240		488
1988 a		240		335
1988 b		240		218
1991		240		223
1992		240		229
1995		206		434
1996		196		234
1998		192		258
1999		206		388
2000		193		167
2001		180		128
2002		171		137
2003	269	175	255	302
2004		169		160
2005	238	171	389	284
2006	254	171	329	233
2007	243	179	516	421
2008	293	183	584	342
2009	268	182	349	239

4.5 Other factors

Biomass and yield estimates will differ for different sizes of recruitment. Māori 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. Because 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.

The Snake Bank cockle population may receive spat from spawning in other parts of Whangarei Harbour, and 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 over 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.

A length-based stock assessment model developed in 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 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 2005). 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 (2005) therefore concluded that no further development of the model should be undertaken for three to five years, and that resources be concentrated more on data collection, in particular, growth and recruitment data. Consequently, a tag-recapture experiment was started in March 2005, and additional large samples of cockles have been notch-tagged and released annually from 2005 to 2010. Tagged individuals were recovered and measured on a quarterly basis, and preliminary results suggested 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.

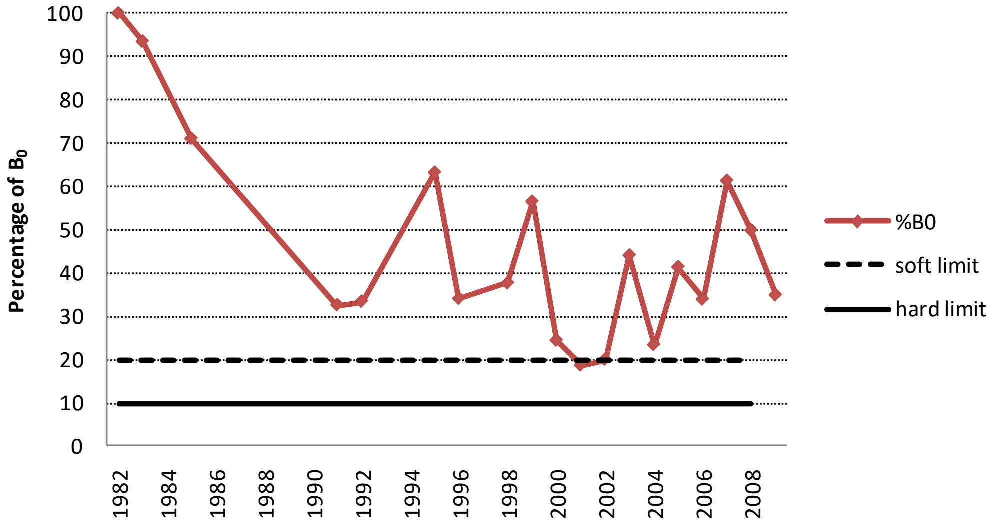
5. STATUS OF THE STOCKS

Stock structure assumptions
Snake Bank is assumed to be a single stock.

COC 1A

Stock Status	
Year of Most Recent Assessment	–
Assessment Runs Presented	–
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing Threshold: –
Status in relation to Target	Unknown
Status in relation to Limits	Unknown

Historical Stock Status Trajectory and Current Status
The current status is unknown



Recruited biomass (≥ 30 mm shell length) over time as a percentage of B_0 in relation to the hard and soft limits.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	Unknown
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	The commercial fishery has been closed since 2012.
Probability of Current Catch or TACC causing Overfishing to continue or to commence	-

Assessment Methodology and Evaluation		
Assessment Type	–	
Assessment Method	–	
Assessment Dates	Latest assessment: 2009	Next assessment: Unknown
Overall assessment quality rank	–	
Main data inputs (rank)	–	
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 the bank in the past, *e.g.* the fishery was closed for 96 days in the 2009–10 year due to poor water quality.

Fishery Interactions
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7. FOR FURTHER INFORMATION

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