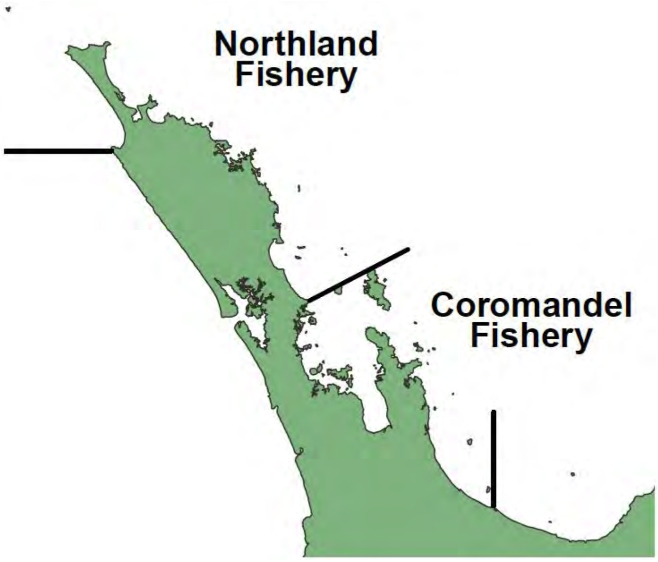
SCALLOPS NORTHLAND (SCA 1)

(*Pecten novaezelandiae*)
Kuakua, Tipa



1. FISHERY SUMMARY

Northland scallops (SCA 1) were introduced into the Quota Management System (QMS) on 1 April 1997. The Northland Total Allowable Catch (TAC) is 75 t, comprising a Total Allowable Commercial Catch (TACC) of 40 t, allowances of 7.5 t for recreational and customary fisheries, and an allowance of 20 t for other sources of mortality (Table 1; all values in meatweight – muscle plus attached roe).

Table 1: TAC, customary allowance, recreational allowance, other sources of mortality allowance and TACC (t) for SCA 1.

Year	TAC	Customary	Recreational	Other mortality	TACC
1996–present	75	7.5	7.5	20	40

1.1 Commercial fisheries

SCA 1 has supported a regionally important commercial fishery situated between Reef Point at Ahipara on the west coast and Cape Rodney at Leigh on the east coast. Fishing has been conducted within discrete beds in Spirits Bay, Tom Bowling Bay, Great Exhibition Bay, Rangaunu Bay, Doubtless Bay, Stevenson’s Island, the Cavalli Passage, Bream Bay, and the coast between Mangawhai and Pakiri Beach. All commercial fishing is by dredge, with fishers preferring self-tipping ‘box’ dredges (up to 2.4 m wide, fitted with a rigid tooth bar on the leading bottom edge) to the ‘ring bag’ designs used in Challenger and Chatham Island fisheries. The fishing year for SCA 1 is from 1 April to 31 March. The Northland commercial scallop season runs from 15 July to 14 February. The minimum legal size (MLS) is 100 mm.

Between 1980–81 and 2009–10, landings varied more than 10-fold from 80 t to over 1600 t greenweight. There was a gradual decline in landings from 68 t meatweight in 2005–06 to only 1 and 2 t in 2010–11 and 2011–12, respectively. There was no fishing in 2012–13, as voluntarily agreed by members of the Northland Scallop Enhancement Company (NSEC, representing the SCA 1 commercial scallop fishing industry), and only 86 kg and 2 t of meatweight were landed in 2013–14 and 2014–15 respectively. Significant fishing has occurred again in Bream Bay since 2015, with landings of 16 t, 7 t, 6 t and 8 t meatweight over the last 4 fishing years.

SCA 1 is managed under the QMS using individual transferable quotas (ITQ) that are proportions of the Total Allowable Commercial Catch (TACC). Catch limits and landings from the Northland fishery are shown in Table 2 and Figure 1. SCA 1 is gazetted on the Second Schedule of the Fisheries Act 1996, which specifies that, for certain 'highly variable' stocks, the Annual Catch Entitlement (ACE) can be increased within a fishing season. The TACC is not changed by this process and the ACE reverts to the base level of the TACC the following fishing year. Increases occurred in 2005–06 and 2006–07 supported by estimates of biomass derived from annual surveys.

Table 2: Catch limits and landings (t meatweight or greenweight) from the Northland fishery since 1980. Data before 1986 are from Fisheries Statistics Unit (FSU) forms. Landed catch figures come from Quota Management Returns (QMRs), Monthly Harvest Returns (MHRs), and from the landed section of Catch Effort and Landing Returns (CELRs), whereas estimated catch figures come from the effort section of CELRs and are pro-rated to sum to the total CELR landed greenweight. Catch limits for 1996 were specified on permits as meatweights, and, since 1997, were specified as a formal TACC in meatweight (Green1 assumes the gazetted meatweight recovery conversion factor of 12.5% and probably overestimates the actual greenweight taken in most years). In seasons starting in 1999 and 2000, voluntary catch limits were set at 40 and 30 t, respectively. * split by area not available; – no catch limits set, or no reported catch (Spirits).

			Landings (t)					
	Catch limits (t)		QMR/ MHR	CELR and FSU		Scaled estimated catch (t green)		
Fishing year	Meat	Green	Meat	Meat	Green	Whangarei	Far North	Spirits
1980–81	–	–	–	–	238	*	*	*
1981–82	–	–	–	–	560	*	*	*
1982–83	–	–	–	–	790	*	*	*
1983–84	–	–	–	–	1 171	78	1 093	–
1984–85	–	–	–	–	541	183	358	–
1985–86	–	–	–	–	343	214	129	–
1986–87	–	–	–	–	675	583	92	–
1987–88	–	–	–	–	1 625	985	640	–
1988–89	–	–	–	–	1 121	1 071	50	–
1989–90	–	–	–	–	781	131	650	–
1990–91	–	–	–	–	519	341	178	–
1991–92	–	–	–	168	854	599	255	–
1992–93	–	–	–	166	741	447	294	–
1993–94	–	–	–	110	862	75	787	1
1994–95	–	–	–	186	1 634	429	1 064	142
1995–96	–	–	–	209	1 469	160	810	499
1996–97	188	1 504	–	152	954	55	387	512
1997–98	188	1 504	–	144	877	22	378	477
1998–99	106	848	28	29	233	0	102	130
1999–00	106	785	22	20	132	0	109	23
2000–01	60	444	15	16	128	0	88	40
2001–02	40	320	38	37	291	14	143	134
2002–03	40	320	40	42	296	42	145	109
2003–04	40	320	38	38	309	11	228	70
2004–05	40	320	40	37	319	206	77	37
2005–06	70	560	69	68	560	559	1	0
2006–07	70	560	53	50	405	404	1	0
2007–08	40	320	33	32	242	9	197	35
2008–09	40	320	25	25	197	0	171	26
2009–10	40	320	10	10	80	0	80	0
2010–11	40	320	1	1	8	0	8	0
2011–12	40	320	2	2	16	0	16	0
2012–13	40	320	0	0	0	0	0	0
2013–14	40	320	0.01	0.01	0.086	0.086	0	0
2014–15	40	320	2	2	3	3	0	0
2015–16	40	320	16	16	83	83	0	0
2016–17	40	320	7	7	36	36	0	0
2017–18	40	320	6	6	15	15	0	0
2018–19	40	320	8	8	-	-	-	-

1.2 Recreational fisheries

Until 2006, the recreational scallop season ran from 15 July to 14 February, but in 2007 the season was changed to run from 1 September to 31 March. Fishers may take up to 20 scallops per day with a minimum legal size of 100 mm shell width. Estimates of the recreational scallop harvest from SCA 1 are shown in Table 3. The harvest estimates provided by telephone-diary surveys between 1993 and 2001 are no longer considered reliable for various reasons. A Recreational Technical Working Group concluded that these harvest estimates should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries. In response to these problems and the cost and scale challenges associated with onsite methods, a National Panel Survey was conducted for the first time throughout the 2011–12 fishing year. The panel survey used face-to-face interviews of a random sample of 30 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and harvest information collected in standardised phone interviews. The panel survey was repeated in 2017–18 using directly comparable methods (Wynne-Jones et al. 2019). The annual recreational harvest level is likely to vary substantially through time.

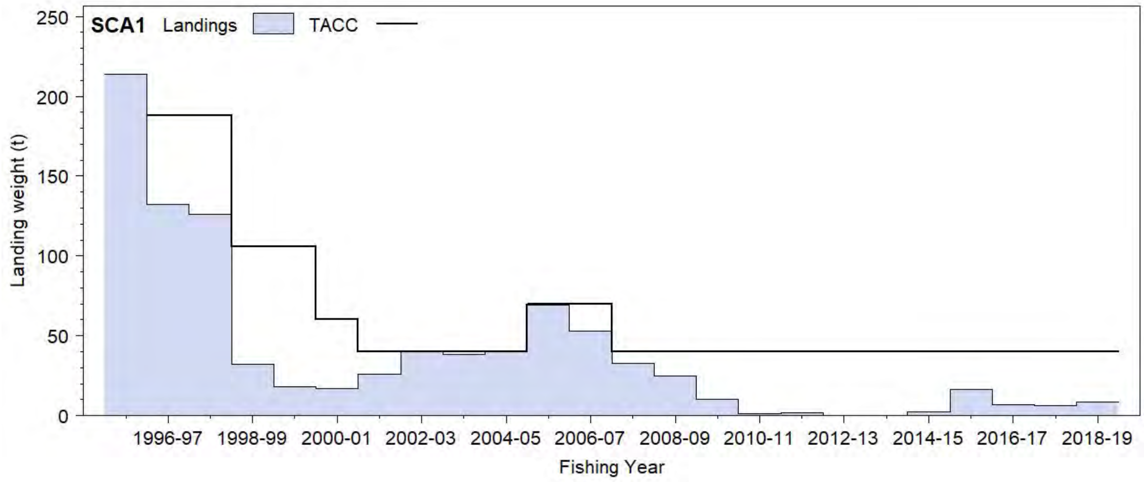


Figure 1: Landings and catch limits for SCA 1 (Northland) since 1995–96. TACC refers to the base TACC and any in-season increase in Annual Catch Entitlement and 'Weight' refers to meatweight.

Table 3: Estimates of the recreational harvest of scallops from SCA 1. Number, number of scallops; green, greenweight; meat, meatweight (assuming 12.5% recovery of meatweight from green weight).

Year	Area	Survey method	Number	CV	Green (t)	Meat (t)	Reference
1991–93	SCA 1	Phone-diary	391 000	0.17	40–60	5–8	Teirney et al. (1997)
1996	SCA 1	Phone-diary	272 000	0.18	32	4	Bradford (1998)
1999-2000	SCA 1	Phone-diary	322 000	0.32	33	4	Boyd & Reilly (2004)
2000–01	SCA 1	Phone-diary	283 000	0.49	29	4	Boyd et al. (2004)
2011–12	SCA 1	Panel survey	148 905	0.36	16	2	Wynne-Jones et al. (2014)
2017–18	SCA 1	Panel survey	148 905	0.36	16	2	Wynne-Jones et al. (2019)

For further information on recreational fisheries refer to the introductory SCA Working Group report.

1.3 Customary fisheries

Limited quantitative information on the level of customary take is available from Fisheries New Zealand. The kilograms and numbers of scallops harvested under customary permits is given in Table 4, and is likely to be an underestimate of customary harvest.

Table 4: Fisheries New Zealand records of customary harvest of scallops (reported as greenweight and numbers) taken from the Northland scallop fishery, 2006–07 to 2013–14. – no data.

	Weight (kg		Numbers	
Fishing year	Approved	Harvested	Approved	Harvested
2006–07	–	–	1 650	1 650
2007–08	–	–	1 780	1 780
2008–09	–	–	120	120
2009–10	–	–	1 200	1 200
2010–11	–	–	–	–
2011–12	130	130	600	480
2012–13	80	80	2 950	2 640
2013–14	8	8	450	450

For further information on customary fisheries refer to the introductory SCA Working Group report.

1.4 Illegal catch
For information on illegal catch refer to the introductory SCA Working Group report.

1.5 Other sources of mortality
For information on other sources of mortality refer to the introductory SCA Working Group report.

2. BIOLOGY

Little detailed information is available on the growth and natural mortality of Northland scallops, although the few tag returns from Northland indicate that growth rates in Bream Bay are similar to those in the nearby Coromandel fishery (see the Working Group report for SCA CS). The large average size of scallops in the northern parts of the Northland fishery and the consistent lack of small animals there suggests that growth rates may be high in the Far North.

For further information on biology refer to the introductory SCA Working Group report.

3. STOCKS AND AREAS

It is currently assumed for management purposes that the Northland stock is separate from the adjacent Coromandel stock, from the various west coast harbours stocks and also from the Golden Bay, Tasman Bay, Marlborough Sounds, Stewart Island and Chatham Island stocks.

For further information on stocks and areas refer to the introductory SCA Working Group report.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

In the Northland scallop stock (SCA 1), analysis of historical survey non-target catch from a localised deep area within Spirits Bay showed an unusually high abundance and species richness of sponges (Cryer et al. 2000), and led to the voluntary and subsequent regulated closure of that area to commercial fishing. There is no other local information on non-target fish and invertebrate catch for SCA1.

Refer to the introductory SCA Working Group report for general information on environmental and ecosystem considerations.

5. STOCK ASSESSMENT

Northland scallops are managed using a TACC of 40 t meatweight, which can be augmented with additional ACE after considering information about the abundance during the current fishing year. Previous in-season increases were based on the results from a pre-season biomass survey and the subsequent Current Annual Yield (CAY) estimates, using $F_{0.1}$ as a reference point. The last comprehensive biomass survey conducted in SCA 1 was in 2007. However, industry-based surveys of scallops in core commercial fishery areas have been conducted annually between 2012 and 2017 (Williams et al. 2017).

5.1 Estimates of fishery parameters and abundance
Over all of SCA 1, estimated fishing mortality on scallops 100 mm or more was in the range F_{est} = 0.33–0.78 y^{-1} (mean F_{est} = 0.572 y^{-1}) between 1997–98 and 2003–04, but was lower in the period 2005–07 (mean F_{est} = 0.203 y^{-1}) (Table 5). The level of fishing mortality in more recent years is unknown

because of the lack of surveys to estimate biomass. There is no known stock-recruit relationship for Northland scallops.

CPUE is not usually presented for scallops because it is not considered to be a reliable index of abundance (Cryer 2001). However, Management Strategy Evaluation (MSE) modelling suggested the potential for CPUE to be used as a basis for some management areas (Haist & Middleton 2010). This may or may not apply to the Northland scallop fishery.
In the absence of survey estimates of abundance from 2007 to 2011, CPUE indices were generated for SCA 1 based on the available data for the period 1991–2011 (Hartill & Williams 2014). Almost all commercial fishing during this period has taken place in three statistical reporting areas, but none of these areas has been fished continuously. In any given year, fishers tend to select the most productive area(s). A stock-wide CPUE index, produced by combining data from the different areas, suggests that the abundance of scallops throughout SCA 1 declined in the late 1990s, and then steadily increased substantially until 2005–06, after which there has been a steady decline. Such an index, however, must be regarded with caution. The limitations of CPUE as an index of abundance are well understood, but are particularly severe for sedentary species like scallops. The nature of the relationship between CPUE and abundance is unclear, but is likely to be hyperstable.

Since 2012, the SCA 1 commercial scallop fishing industry (represented by NSEC, the Northland Scallop Enhancement Company Ltd.) has worked with NIWA to conduct industry-based stratified random dredge surveys of scallops annually in Bream and Rangaunu Bays, two of the core areas for commercial scallop fishing in SCA 1 (Williams et al. 2017). In 2017, only Bream Bay was surveyed (J. Williams, NIWA, unpublished data). Estimates of scallop population density in the surveyed areas are shown in Figure 2.

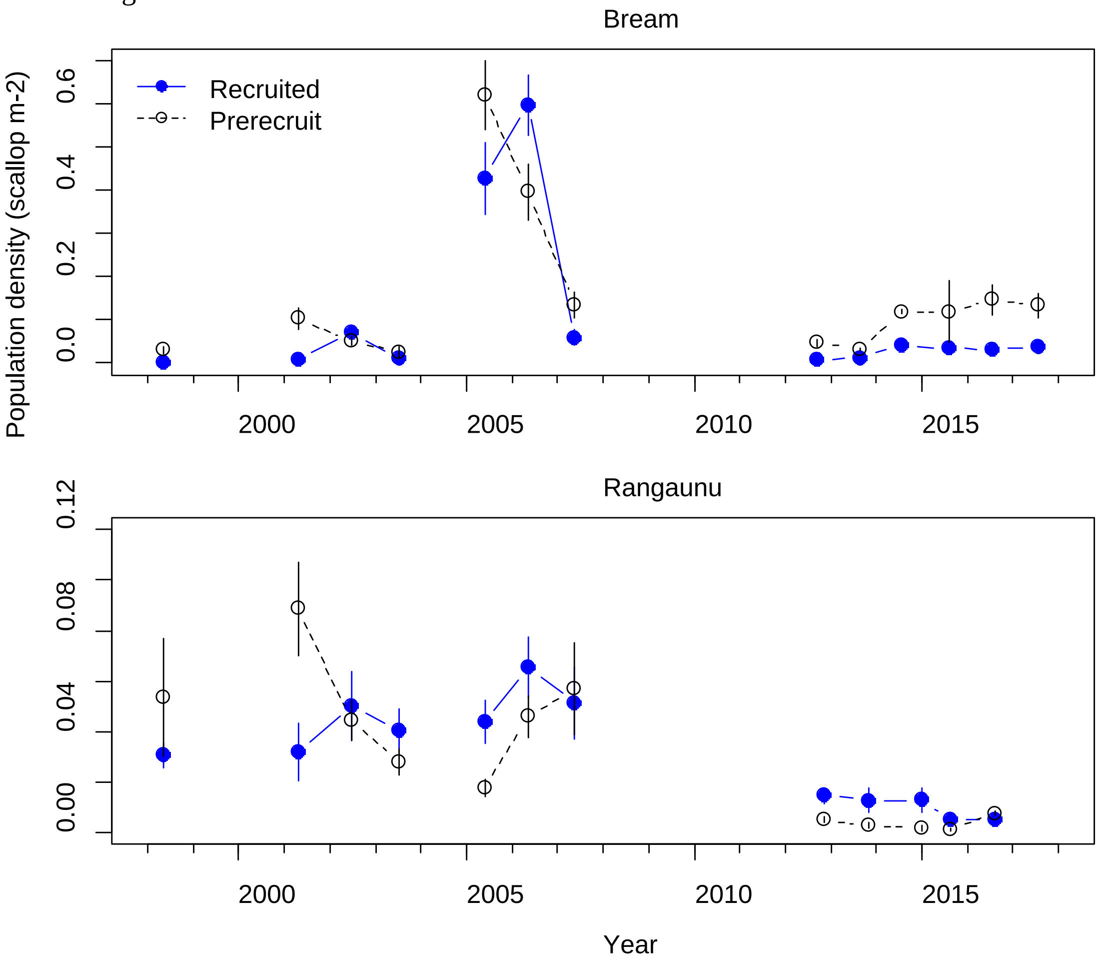


Figure 2: Scallop population density time series, 1998 to 2017. Values plotted are mean density +/- CV. Corrected for historical average dredge efficiency.

The 2012–17 surveys at Bream Bay show there has been an increasing trend in the abundance of pre-recruit sized scallops (< 100 mm) since 2013, but this has not resulted in substantive increases in recruited scallops (100 mm or larger), suggesting relatively slow growth and/or high mortality of these scallops has occurred in recent years. The relatively high commercial landings in 2015 (16 t meatweight, about 36% of the estimated total recruited biomass) in particular may explain why the recruited biomass at the time of the surveys has not increased markedly in response to increasing recruitment. Incidental mortality of undersized scallops caused by dredging may have also contributed. At Rangaunu, there has been no commercial scallop fishing since 2011. The surveys show that recruited abundance at Rangaunu was fairly stable (albeit at a low level) from 2012 to 2015, but had decreased by 2016. This may be expected given the low level of recruitment (large pre-recruits) observed in the 2012 to 2015 surveys. An increase in the abundance of large pre-recruits was evident in 2016. At Bream and especially at Rangaunu, scallop densities in the 2012–17 survey time series were low compared with peak levels previously observed in surveys from 1998 to 2007 (Williams et al. 2017).

5.2 Biomass estimates

Virgin biomass, B_0, and the biomass that will support the maximum sustainable yield, B_{MSY}, have not been estimated and are probably not appropriate reference points for a stock with highly variable recruitment and growth such as scallops.

There were reasonably regular assessments of the Northland scallop stock between 1992 and 2007 (Tables 5 and 6), in support of a CAY management strategy. Assessments were based on pre-season biomass surveys conducted by diving and/or dredging. Composite dive-dredge surveys were conducted annually from 1992 to 1997, except in 1993 when only divers were used. From 1998, surveys were conducted using dredges only. The Northland stock was not surveyed in 1999, 2000, 2004, or since 2007. Where dredges have been used, absolute biomass must be estimated by correcting for the efficiency of the particular dredges used. Previously, estimates were corrected for dredge efficiency using scalars (multipliers), which were estimated by directly comparing dredge counts with diver counts in experimental areas (e.g., Cryer & Parkinson 1999). However, different vessels were used in the most recent surveys and no trials were conducted on the efficiency of the particular dredges used. Estimating start-of-season biomass (Table 5) and yield is, therefore, difficult and contains unmeasurable as well as measurable uncertainty. For some years, the highest recorded estimate of dredge efficiency has been used, but more recent surveys have had a range of corrections applied from no correction (the most conservative) to the historical average across all studies (the least conservative). A model for estimating scallop dredge efficiency in SCA CS was developed by Bian et al. in 2012 but has not yet been used to reanalyse the historical survey time series for SCA 1.

Biomass estimates at the time of the survey for the Northland fishery are shown in Table 6. These estimates were calculated using historical average dredge efficiency for scallops 95 mm or more in shell length. Estimates of current biomass for the Northland stock are not available (the last biomass survey of the Northland fishery was in 2007), and there are no estimates of reference biomass with which to compare historical estimates of biomass. A substantial increase in biomass was observed between 2003 and 2006, which resulted in the 2006 biomass estimate being the highest recorded for Northland. In 2005 and 2006, estimates of biomass were considerably higher than those in 2003 for some beds (notably Bream Bay), but similar or lower in others. There appeared to have been a ‘shift’ in biomass away from the Far North and towards Bream Bay and Mangawhai/Pakiri Beach. This was the ‘reverse’ of the shift towards the Far North that occurred in the early 1990s. However, the 2007 survey results suggested that the biomass in Bream Bay and Mangawhai/Pakiri had declined markedly since 2006, and, consequently, the overall fishery biomass was far lower in 2007 than in previous years. The beds in Rangaunu Bay seem more consistent between years, although the 2007 biomass estimate was the highest on record. The biomass in Spirits/Tom Bowling Bays was higher in 2007 than 2006 but was low compared with historical levels.

Table 5: Estimated start of season abundance and biomass of scallops of 100 mm or more shell length in SCA 1 from 1997 to 2007 using historical average dredge efficiency; for each year the catch (reported on the 'Landed' section of CELRs), exploitation rate (catch to biomass ratio), and estimated fishing mortality (F_{est}) are also given. F_{est} was estimated by iteration using the Baranov catch equation where t = 7/12 and M = 0.50 spread evenly through the year. Abundance and biomass estimates are mean values up to and including 2003, and median values from 2005, when the analytical methodology for producing the estimates was modified. This, together with changes to survey coverage each year, make direct comparisons among years difficult. – no data. There were no surveys in 1999, 2000, 2004 or 2008–11. Estimates from the 2012–17 industry-based surveys of scallops at Bream and Rangaunu Bays are not included here.

Year	Abundance		Biomass				Exploitation rate	F_{est}
	(millions)	C.V.	(t green)	C.V.	(t meat)	C.V.	(catch/biomass)	≥100 mm
1997	34.9	0.22	3 520	0.22	475	0.22	0.27	0.62
1998	13.9	0.13	1 547	0.13	209	0.13	0.15	0.33
1999	–	–	–	–	–	–	–	–
2000	–	–	–	–	–	–	–	–
2001	8.9	0.27	871	0.27	118	0.27	0.32	0.78
2002	13.2	0.19	1 426	0.19	193	0.19	0.21	0.46
2003	9.3	0.19	1 031	0.19	139	0.19	0.28	0.66
2004	–	–	–	–	–	–	–	–
2005	51.3	0.72	5 565	0.70	753	0.71	0.09	0.19
2006	66.6	0.45	7 280	0.43	984	0.44	0.05	0.11
2007	15.1	0.47	1 637	0.45	208	0.46	0.14	0.31

Table 6: Estimated biomass (t greenweight) of scallops of 95 mm or more shell length at the time of the surveys in various component beds of the Northland scallop fishery from 1992 to 2007, assuming historical average dredge efficiency. – indicates no survey in a given year; there have been no surveys of SCA 1 since 2007. Estimates of biomass given for 1993 are probably negatively biased, especially for Rangaunu Bay (*), by the restriction of diving to depths under 30 m, and all estimates before 1996 are negatively biased by the lack of surveys in Spirits Bay (†). Totals also include biomass from less important beds at Mangawhai, Pakiri, around the Cavalli Passage, in Great Exhibition Bay, and Tom Bowling Bay when these were surveyed. Commercial landings in each year for comparison can be seen in Table 2, wherein 'Far North' landings come from beds described here as 'Whangaroa', 'Doubtless', and 'Rangaunu'. The biomass of scallops 95 mm or larger shell length has not been estimated since 2007.

						Biomass (t)
	Bream Bay	Whangaroa	Doubtless	Rangaunu	Spirits Bay	Total
1992	1 733	–	78	766	–	3 092 †
1993	569	172	77	170 *	–	1 094 *
1994	428	66	133	871	–	1 611 †
1995	363	239	103	941	–	1 984 †
1996	239	128	32	870	3 361	5 098
1997	580	117	50	1 038	1 513	3 974
1998	18	45	37	852	608	1 654
1999	–	–	–	–	–	–
2000	–	–	–	–	–	–
2001	110	8	0	721	604	1 451
2002	553	10	–	1 027	1 094	2 900
2003	86	33	3	667	836	1 554
2004	–	–	–	–	–	–
2005	2 945	–	–	719	861	4 676
2006	5 315	–	–	1 275	261	7 539
2007	795	–	–	1 391	432	2 694

Substantial uncertainty stemming from assumptions about the dredge efficiency during the surveys, rates of growth and natural mortality between the survey and the start of the fishing season, and predicting the average recovery of meatweight from greenweight remain in these stock assessments. A new model of scallop dredge efficiency (Bian et al. 2012) has helped to reduce this uncertainty, as should any future research aimed at collecting more data on scallop growth and mortality. Managing the fisheries based on the number of recruited scallops at the start of the season as opposed to recruited biomass (the current approach) could remove the uncertainty associated with converting estimated numbers of scallops to estimated meatweight.

Diver surveys of scallops were conducted in June 2006 and June–July 2007 at selected scallop beds in Northland recreational fishing areas (Williams et al. 2008, Williams 2009). For the four small beds (total area of 4.35 km^2) surveyed, start-of-season biomass of scallops over 100 mm shell length was estimated to be 49.7 t greenweight (CV of 23%) or 6.2 t meatweight in 2006, and 42 t greenweight (CV of 25%) or 5 t meatweight (CV of 29%) in 2007.

Time series of biomass estimates have also been generated for 1998–2017 from the available data collected during the industry-based surveys in 2012–16 (Williams et al. 2017) and Bream Bay in 2017 (J. Williams, NIWA, unpublished data), and the 1998–2017 surveys (Table 7).

5.3 Estimation of Maximum Constant Yield (MCY)

MCY has not been estimated for Northland scallops because it is not thought to be a reasonable management approach for highly fluctuating stocks such as scallops.

Table 7: Estimated biomass (t greenweight) of recruited scallops 100 mm or more shell length at the time of the surveys at Bream and Rangaunu Bays from 1998 to 2017, assuming historical average dredge efficiency. – indicates no survey in a given year or bay.

Year	Recruited biomass (t green)	
	Bream	Rangaunu
1998	211	475
1999	–	–
2000	–	–
2001	498	1 024
2002	259	564
2003	153	342
2004	–	–
2005	3 326	192
2006	2 514	596
2007	509	652
2008	–	–
2009	–	–
2010	–	–
2011	–	–
2012	317	36
2013	207	21
2014	394	15
2015	600	6
2016	911	61
2017	821	–

5.4 Estimation of Target Harvest (Exploitation) Rate

The estimation of Provisional Yield (PY) is no longer accepted as appropriate, and assessments since 1998 have used a CAY approach.

Yield estimates are generally calculated using reference rates of fishing mortality applied in some way to an estimate of current or reference biomass. Cryer & Parkinson (2006) reviewed reference rates of fishing mortality and summarised modelling studies by Cryer & Morrison (1997) and Cryer et al. (2004). The Shellfish Working Group recommend $F_{0.1}$ as the most appropriate reference rate (target) of fishing mortality for scallops.

Management of Northland scallops is based on a CAY approach. Since 1998, in years when biomass surveys have been conducted, catch limits have been adjusted in line with estimated start-of-season recruited biomass and an estimate of CAY made using the Baranov catch equation:

$$CAY = \frac{F_{ref}}{F_{ref} + M}(1 - e^{-(F_{ref}+M)t})B_{beg}$$

where t = 7/12 years, F_{ref} is a reference fishing mortality ($F_{0.1}$) and B_{beg} is the estimated start-of-season (15 July) recruited biomass (scallops of 90 mm or more shell length). Natural mortality is assumed to act in tandem with fishing mortality for the first seven months of the fishing season, the length of the current Northland commercial scallop season. B_{beg} is estimated assuming historical average dredge efficiency at length, average growth (from previous tagging studies), M = 0.5 spread evenly through the year, and historical average recovery of meatweight from greenweight. Because of the uncertainty over biomass estimates, growth and mortality in a given year, and appropriate reference rates of fishing mortality, yield estimates must be treated with caution.

Modelling studies for Coromandel scallops (Cryer & Morrison 1997, Cryer et al. 2004) indicate that $F_{0.1}$ is sensitive not only to the direct incidental effects of fishing (reduced growth and increased mortality on essentially adult scallops), but also to indirect incidental effects (such as additional juvenile mortality related to reduced habitat heterogeneity in dredged areas). Cryer & Morrison's (1997) yield-per-recruit model for the Coromandel fishery was modified to incorporate growth parameters more suited to the Northland fishery and estimate reference fishing mortality rates. Including direct incidental effects of fishing only, and for an assumed rate of natural mortality of M = 0.50, $F_{0.1}$ was estimated as $F_{0.1}$ = 0.943 y^{-1} (reported by Cryer et al. 2004, as 7/12 * $F_{0.1}$ = 0.550) for SCA 1, but estimates of $F_{0.1}$ including direct and indirect incidental effects of fishing were not estimated.

Consequently, the most recent CAY estimates were derived in 2007 (the year of the last biomass survey) for one scenario only.

5.4.1 CAY including direct effects on adults

By including only the direct incidental effects of fishing on scallops, Cryer et al. (2004) derived an estimate of $F_{0.1}$ = 0.943 y^{-1} (reported by Cryer et al. 2004, as 7/12 * $F_{0.1}$ = 0.550). Using this value and the 2007 start-of-season biomass estimates (median projected values), CAY for 2007–08 was estimated to be 609 t greenweight or 77 t meatweight.

These estimates of CAY would have a CV at least as large as that of the estimate of start-of-season recruited biomass (50–51%), are sensitive to assumptions about dredge efficiency, growth and expected recovery of meatweight from greenweight, and relate to the surveyed beds only. The sensitivity of these yield estimates to excluding areas of low density has not been calculated, but excluding stations with scallop density less than 0.02 m^{-2} and 0.04 m^{-2} reduced the fishery-wide time-of-survey biomass estimate by 95% and 100%, respectively. It should be noted that these low-density exclusions were calculated before correcting for average historical dredge efficiency, so these estimates are conservative. However, even if corrections for dredge efficiency were applied and no exclusions were made, the density of scallops 100 mm or more was low in all areas of the fishery surveyed in 2007. There is also additional uncertainty associated with using a point estimate of $F_{0.1}$ (i.e., variance associated with the point estimate of $F_{0.1}$ was not incorporated in the analysis).

6. STOCK STATUS

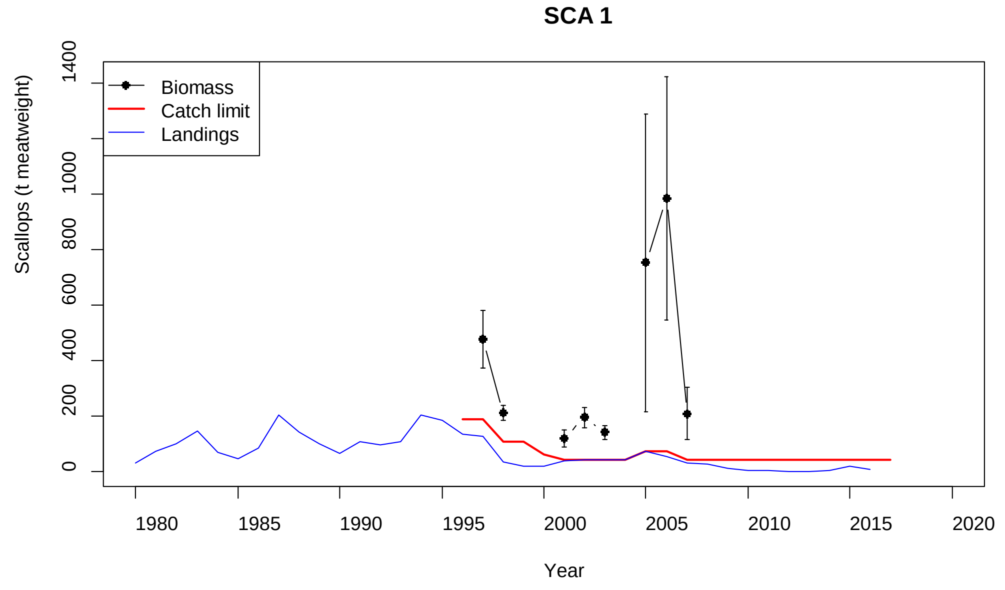
Stock structure assumptions

The stock structure of scallops in New Zealand waters is uncertain. For the purposes of the SCA 1 assessments, SCA 1 is assumed to be a single biological stock, although the extent to which the various beds or populations are separate reproductively or functionally is not known.

Stock Status	
Year of Most Recent Assessment	2007
Assessment Runs Presented	Estimate of CAY for 2007
Reference Points	Target: Fishing mortality at or below $F_{0.1}$ ($F_{0.1}$ = 0.943 y^{-1} including direct incidental effects of fishing only) Soft Limit: 20% B_0

	Hard Limit: 10% B_0 Overfishing threshold: F_{MSY} as approximated by $F_{0.1}$
Status in relation to Target	Likely (> 60%) to be at or below the target (in 2007–08, F_{est} = 0.31 y^{-1}) in 2007–08; unknown for 2018–19.
Status in relation to Limits	Unknown
Status in relation to Overfishing	Overfishing was Unlikely (< 40%) in 2007–08; unknown in 2018–19.

Historical Stock Status Trajectory and Current Status



Estimated biomass (mean and CV), catch limits, and reported landings of recruited scallops (100 mm or larger shell length) in t meatweight for SCA 1 since 1980. Biomass estimates from the annual 2012–17 industry-based surveys at Bream and Rangaunu Bays are not presented here because the surveys did not cover the full extent of the SCA 1 fishery.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The trend in stock biomass since 2007 is unknown. Industry surveys of core fishery areas, Bream Bay and Rangaunu Bay, in 2012–17 suggest biomass in those areas was low compared with estimates from the 2005–07 surveys, but biomass in Bream Bay followed an increasing trend from 2013 to 2016.
Recent Trend in Fishing Intensity or Proxy	F_{est} cannot be estimated for this fishery for recent years. Landings between 2010–11 and 2014–15 were low (between 0 and 2 t). Fishing intensity has increased in Bream Bay since 2015 (7 to 16 t).
Other Abundance Indices	CPUE is not a reliable index of abundance (Cryer 2001).
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Stock projections are not available
Probability of Current Catch causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Probability of Current TACC causing Biomass to remain below or to decline below Limits	Very Likely (> 90%) for the TACC
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Very Likely (> 90%) for the TACC

Assessment Methodology and Evaluation		
Assessment Type	Level 2: Partial quantitative stock assessment	
Assessment Method	Biomass surveys and CAY management strategy	
Assessment Dates	Latest assessment: 2007	Next assessment: Unknown
Overall Assessment Quality Rank	1 – High Quality	
Main data inputs (rank)	Biomass survey: 2007	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	Current model has been in use since 2005	
Major Sources of Uncertainty	- dredge efficiency during the survey - growth rates and natural mortality between the survey and the start of the fishing season - predicting the average recovery of meatweight from greenweight - the extent to which dredging causes incidental mortality and affects recruitment.	

Qualifying Comments
In the Northland fishery some scallop beds are persistent and others are ephemeral. The extent to which the various beds or populations are reproductively or functionally separate is not known. This fishery is managed with a CAY management strategy with a base TACC. However, the management strategy currently resembles a constant catch strategy because there have been no surveys since 2007.

Environmental and Ecosystem Considerations	
Observer coverage	No observer coverage
Non-target fish and invertebrate catch	No local information on non-target fish and invertebrate catch. A historical analysis of survey data from a deep area within Spirits Bay highlighted extreme biodiversity, and led to the closure of that area to commercial fishing (including scallop dredging).
Incidental catch of seabirds	There is no known incidental catch of seabirds from *P. novaezelandiae* scallop fisheries.
Incidental catch of mammals	There is no known incidental catch of mammals from *P. novaezelandiae* scallop fisheries.
Incidental catch of other protected species	There is no known incidental catch of protected species from *P. novaezelandiae* scallop fisheries.
Benthic interactions	There have been several studies in New Zealand to assess effects of scallop dredging on benthic habitats. Generally with increasing fishing intensity there are decreases in the density and diversity of benthic communities and, especially, the density of emergent epifauna that provide structured habitat for other fauna.

7. FOR FURTHER INFORMATION

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