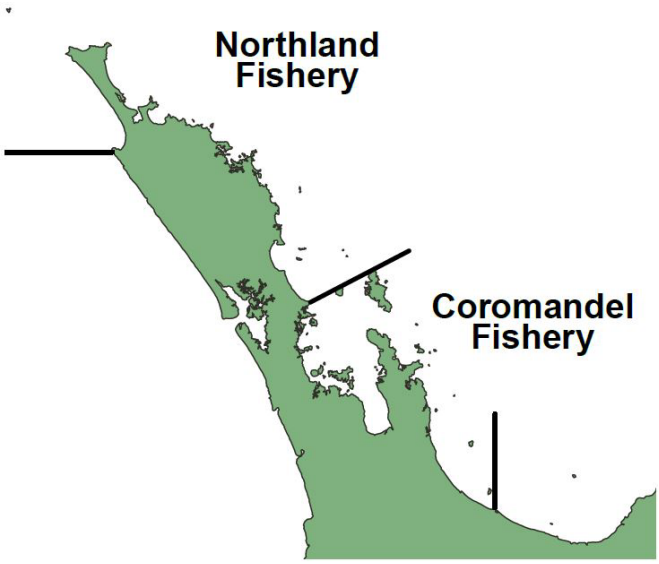
SCALLOPS Northland (SCA 1)

(*Pecten novaezelandiae*)
Kuakua, Tipa



1. FISHERY SUMMARY

Northland scallops (SCA 1) were introduced into the Quota Management System (QMS) on 1 April 1997. In 2002, the Northland Total Allowable Catch (TAC) was set at 75 t, comprising a Total Allowable Commercial Catch (TACC) of 40 t, allowances of 7.5 t each for recreational and customary fisheries, and an allowance of 20 t for other sources of mortality. Available information suggested that commercial effort had remained relatively low for over a decade, virtually ceasing between 2010 and 2014, before resuming primarily only in Bream Bay. Considering this, the TAC was reduced to 30 tonnes on 1 April 2020, comprising a TACC of 10 t, allowances of 7.5 t each for recreational and customary fisheries, and an allowance of 5 t for other mortality. Following the results of a biomass survey conducted in 2021, the Minister for Ocean and Fisheries decided to close the SCA 1 commercial and recreational fisheries on 1 April 2022 due to sustainability concerns (Fisheries New Zealand 2022). The closure does not apply to scallops taken under customary fishing authorisations, which continue to be managed by tangata kaitiaki (Table 1; all values in meatweight – muscle plus attached roe).

Table 1: Total Allowable Catch (TAC, t), customary, recreational, and other sources of mortality allowances (t), and TACC (t) declared for SCA 1.

Year	TAC	Customary	Recreational	Other mortality	TACC
1997	–	–	–	–	188
1998–1999					106
2000					60
2001					40
2002–2019	75	7.5	7.5	20	40
2020–2021	30	7.5	7.5	5	10
2022–2024	8.5	7.5	–	1	–

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, between Whangaroa Harbour and Stevenson Island, in the Cavalli Passage, Bream Bay, and along the coast between Mangawhai and Pakiri Beach. All commercial fishing has been undertaken 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 (historically) the Chatham Island fisheries. The fishing year for SCA 1 is from 1 April to 31 March. Although the Northland commercial scallop fishery is currently closed, the commercial fishing season runs from 15 July to 14 February. Until the fishery closed, the minimum legal size (MLS) was 100 mm shell length. All references to 'shell length' in this report refer to the maximum linear dimension of the shell, in an anterior-posterior axis.

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 Figure 1 and Table 2. 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.

Between 1980–81 and 2009–10, landings varied more than 20-fold from 80 t to over 1600 t greenweight (Table 2).

There was a gradual decline in landings from 69 t meatweight in 2005–06 to 10 t in 2009–10. Only 1 t and 2 t meatweight were landed in 2010–11 and 2011–12, respectively, and 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 were landed in 2013–14 and 2014–15, respectively. Consistent fishing has occurred again in Bream Bay since 2015, with 16 t meatweight landed in 2015 and an average of 6 t landed annually between 2016 and 2021; and limited fishing in Rangaunu Bay occurred in 2019 (less than 3 t meatweight landed).

Surveys carried out in 2021 showed an overall decline in the biomass and abundance in SCA 1 from historical levels, with substantive declines in many core scallop beds since the previous survey. Fisheries New Zealand considered that the biomass and abundance of scallops in SCA 1 were at levels that did not support sustainable fishing at the current catch limits and allowances and following public consultation, the fishery closed on 1 April 2022.

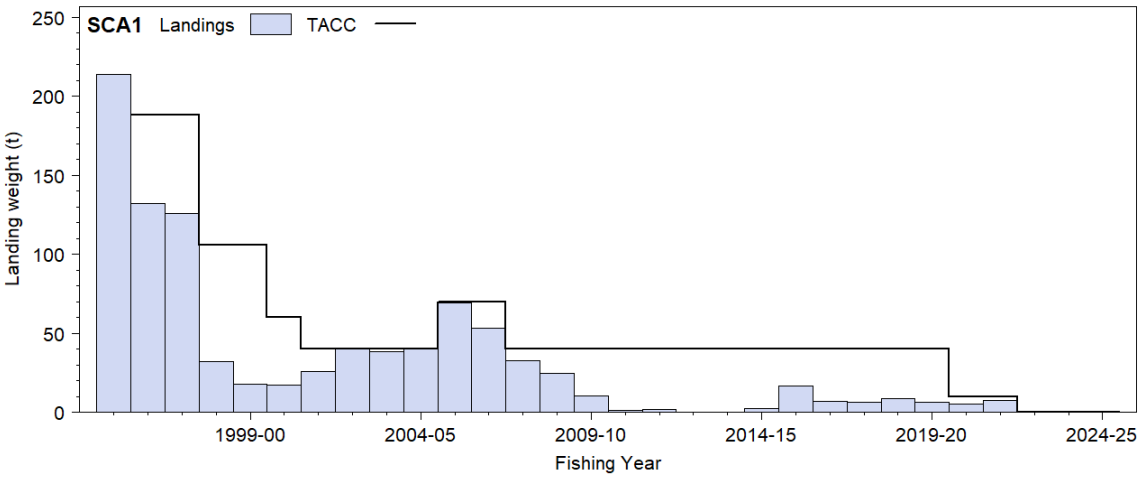


Figure 1: Landings and catch limits for SCA 1 (Northland) since 1995–96. TACC refers to the base TACC and any in-season increase in Annual Catch Entitlement and 'Landing weight' refers to meatweight.

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 prorated 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 (Green* 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	0.1	0.1	0.086	0.086	0	0
2014–15	40	320	2	2	18	18	0	0
2015–16	40	320	16	16	131	131	0	0
2016–17	40	320	7	7	55	55	0	0
2017–18	40	320	6	6	49	46	0	0
2018–19	40	320	8	8	67	67	0	0
2019–20	40	320	6	6	51	29	22	0
2020–21	10	80	5	5	37	37	0	0
2021–22	10	80	8	7	54	53	2	0
2022–23	0	0	0	0	0	0	0	0
2023–24	0	0	0	0	0	0	0	0
2024–25	0	0	0	0	0	0	0	0

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 length. 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 (Wynne-Jones et al. 2014). 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 was collected in standardised phone interviews. The national panel survey was repeated during the 2017–18 and 2022–23 fishing years using very similar methods to produce directly comparable results (Wynne-Jones et al. 2019, Heinemann & Gray 2024). The annual recreational harvest level is likely to vary substantially through time. The recreational fishery closed on 1 April 2022 at the same time as the commercial fishery.

For further information on recreational fisheries refer to section 1.2 of the Introduction – Scallops chapter.

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 greenweight).

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	148 105	0.36	16	2	Wynne-Jones et al. (2014)
2017–18	SCA 1	Panel survey	183 105	0.26	20	3	Wynne-Jones et al. (2019)
2022–23	SCA 1	Panel survey	–	–	–	–	Heinemann & Gray (2024)

1.3 Customary fisheries

The information on Māori customary harvest under the provisions made for customary fishing can be limited (Table 4). These numbers are likely to be an underestimate of customary harvest as only the catch approved and harvested in kilograms and numbers are reported in the table.

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. No reports following these criteria have been provided since 2013-14.

	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 section 1.3 of the Introduction – Scallops chapter.

1.4 Unreported catch

For information on unreported catch refer to section 1.4 of the Introduction – Scallops chapter.

1.5 Other sources of mortality

For information on other sources of mortality refer to section 1.5 of the Introduction – Scallops chapter.

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 chapter for SCA CS). The large average size of scallops in the northern parts of the Northland fishery and the consistent lack of small animals caught in dredge surveys suggests that growth rates may be high in the Far North.

For further information on biology refer to section 2 of the Introduction – Scallops chapter.

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 section 3 of the Introduction – Scallops chapter.

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 SCA 1.

Refer to section 4 of the Introduction – Scallops chapter for general information on environmental and ecosystem considerations.

5. STOCK ASSESSMENT

Until the fishery was closed in 2021–22, Northland scallops was managed using a TACC, which could 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 surveys conducted in SCA 1 commercial fishing areas were in 2007 (Williams 2008) and 2021 (Williams et al. 2024a). However, industry-based surveys of scallops in core commercial fishery areas were conducted annually between 2012 and 2017 (Williams et al. 2017) and in 2019 (J. Williams, NIWA, unpublished data). In 2024, a camera survey was conducted in June–July that mainly sampled SCA CS areas but also covered the SCA 1 Bream Bay commercial scallop beds (and the Whangarei non-commercial scallop beds at Urquharts/McKenzie/Taurikura and Smugglers bays). The 2024 camera survey provided imagery for analysis using a newly developed Artificial Intelligence (AI) method of scallop detection and sizing (Williams et al 2025).

The spatial area of key strata sampled in scallop research surveys between 1997 and 2024 in SCA 1 commercial fishery locations is shown in Figure 2.

5.1 Estimates of fishery parameters and abundance

For 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 it was lower in the period 2005–07 (mean F_{est} = 0.203 y^{-1}) (Table 5). These estimates of fishing mortality may be underestimates because they were calculated using estimates of absolute biomass derived using historical estimates of dredge efficiency; a new study of dredge efficiency in 2021 (see section 5.2 below) suggests that efficiency may be higher than estimated historically, which results in lower estimates of biomass. 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, but high densities of adult scallops within small-scale patches can be expected to contribute the greatest amount to successful reproduction (synchronous spawning and fertilisation of eggs).

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 took place in three statistical reporting areas, but none of these areas was 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 they are particularly severe for sedentary species like scallops (Orensanz et al. 2016). The nature of the relationship between CPUE and abundance is unclear but is likely to be hyperstable.

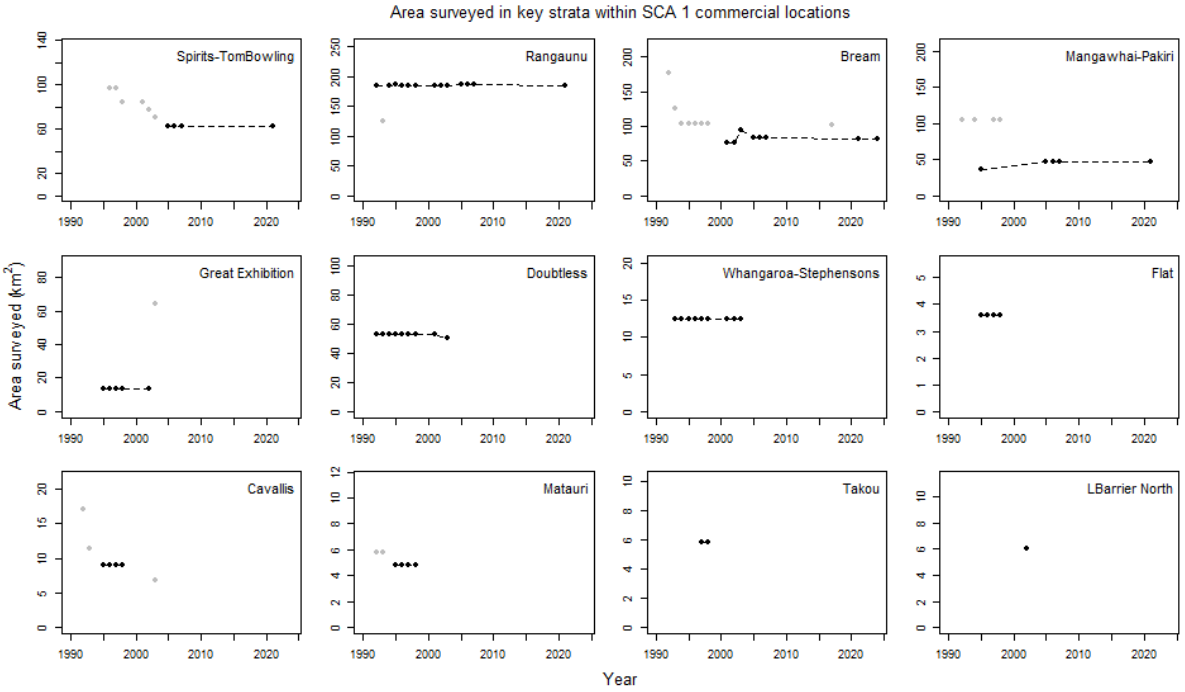


Figure 2: Spatial area (km^2) of key strata sampled in scallop research surveys between 1990 and 2024 in SCA 1 commercial fishery locations. Survey coverage has changed over time, which complicates scallop population comparisons. In preliminary work to address this problem, Williams & Bian (2021) selected a strata subset ('key strata', plotted here) to represent the most consistently surveyed areas and used this to estimate scallop biomass by commercial location (see Figure 4). Years with minimal or no change in the area surveyed within key strata are emphasised here using black symbols joined with a dashed line.

From 2012, the SCA 1 commercial scallop fishing industry (represented by NSEC) worked with NIWA to conduct industry-based stratified random dredge surveys of scallops in Bream Bay and Rangaunu Bay, two of the core areas for commercial scallop fishing in SCA 1; surveys were conducted annually from 2012 to 2016 (Williams et al. 2017) and also in 2019, with Bream Bay surveyed in 2017 (J. Williams, NIWA, unpublished data). Estimates of scallop population density in the surveyed areas are shown in Figure 3.

The 2012–2017 surveys at Bream Bay show there was an increasing trend in the abundance of pre-recruit sized scallops (< 100 mm) from 2013, but this did not result in substantive increases in recruited scallops (100 mm or larger), suggesting that relatively slow growth and/or high mortality of these scallops occurred during this period. 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 did not increase markedly in response to increasing recruitment. Incidental mortality of undersized scallops caused by dredging may have also contributed. At Rangaunu Bay, there has been no commercial scallop fishing since 2011 except for limited fishing in 2019. The industry-based surveys show that recruited abundance at Rangaunu Bay 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 Bay and especially at Rangaunu Bay, scallop densities in the 2012–2017 survey time series were low compared with peak levels previously observed in surveys from 1998 to 2007 (Williams et al. 2017).

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 2008–2011. Estimates from the 2012–2017 industry-based surveys of scallops at Bream Bay and Rangaunu Bay are not included here.

Year	Abundance		Biomass				Exploitation rate	F_{est}
	(millions)	CV	(t green)	CV	(t meat)	CV	(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

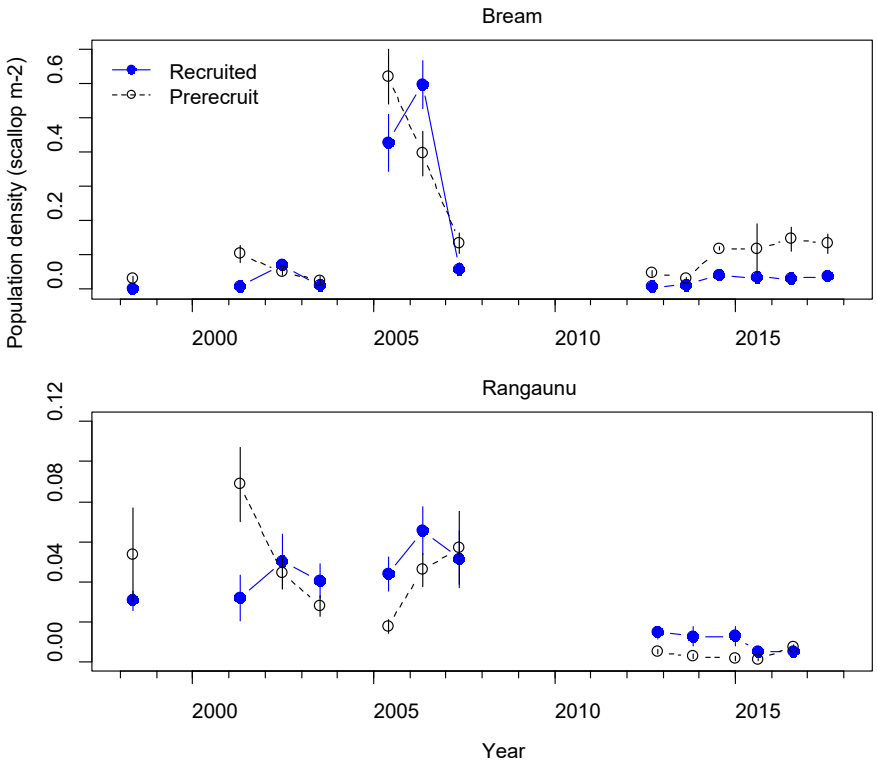


Figure 3: Scallop population density time series, 1998 to 2017. Values plotted are mean density +/- CV. Corrected for historical average dredge efficiency.

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 in the years 2008–2020 (noting that industry surveys of core areas in Bream Bay and Rangaunu Bay were conducted in 2012–2017 and 2019). The latest SCA 1 stock survey was in May 2021.

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 2021, assuming historical average dredge efficiency. – indicates no survey in a given year; there were no surveys of SCA 1 between 2007 and 2021. 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)					
Year	**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
2021	215	–	–	161	7	441

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 in SCA 1. Estimating start-of-season biomass (Table 5) 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 box dredge efficiency in SCA CS was developed by Bian et al. (2012) but has not yet been used to reanalyse the historical survey time series for SCA 1. A new study of scallop box dredge efficiency was conducted in 2021 using logistic modelling of paired dive-dredge data collected on sandy substrates in SCA CS (Marsh & Williams 2021). Results suggest dredge efficiency may be higher than estimated by Bian et al. (2012). Analysis applying the new efficiency model (Marsh & Williams 2021) in the 2021 survey analysis produced a SCA 1 start of season absolute recruited biomass of 64 t meatweight (CV = 23%), which is substantially lower than the 88 t (CV = 19%) estimated using the previous dredge efficiency model (Bian et al. 2012) (Williams et al. 2024a).

Biomass estimates at the time of the survey for the Northland fishery are shown in Table 6. It is important to note that these estimates were produced using historical average dredge efficiency for scallops 95 mm or more in shell length. 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 Beach had declined markedly since 2006, and, consequently, the overall stock biomass was far lower in 2007 than in previous years. Previously, the beds in Rangaunu Bay seemed more consistent between years, and the 2007 biomass estimate was the highest on record. The biomass in Spirits Bay/Tom Bowling Bay was higher in 2007 than in 2006 but was low compared with historical levels. Estimates of current biomass from the 2021 survey are low at Bream Bay and the lowest on record for Rangaunu and Spirits/Tom Bowling Bay.

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. The 2021 dredge efficiency study (Marsh & Williams 2021) and its application in the 2021 survey analysis (Williams et al. 2024) has improved our understanding of scallop box dredge efficiency. Further work on gear efficiency could help to reduce this uncertainty, as could 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.

Discerning trends in the abundance and biomass of recruited scallops is complicated by changes to survey coverage, the establishment of closed areas, and uncertainty about dredge efficiency in any particular year. Smith et al. (2016) noted that "The variable coverage of the survey areas over time and the different strata definitions used have resulted in a series of annual estimates that are not always comparable with respect to changes in abundance or biomass over time". To partially address this issue, historical survey data were reanalysed to estimate time-of-survey absolute biomass of recruited scallops (100 mm or larger shell length) in key (consistently sampled) strata in scallop research surveys between 1990 and 2024 in SCA 1 commercial fishery locations (Figure 3). These estimates were produced correcting for dredge efficiency using the method of Marsh & Williams (2021).

Time series of biomass estimates have also been generated for 1998–2017 from the available data collected during the industry-based surveys in 2012–2016 (Williams et al. 2017) and Bream Bay in 2017 (J. Williams, NIWA, unpublished data), and the 1998–2017 surveys (Table 7).

Dive surveys of scallops in non-commercial scallop fishing areas were conducted in June 2006 and June–July 2007 at selected key scallop beds in the Bay of Islands and at Whangarei (Williams et al. 2008, Williams 2009). For the four small beds (total area of 4.35 km^2) surveyed, start-of-season biomass of recruited scallops (100 mm shell length or larger) 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. Dive surveys of these same areas, and additional areas in Whangaroa Harbour, were conducted again in April–May 2021 (Williams & Bian 2021). For the four beds that were repeat-surveyed, the time-of-survey recruited biomass was a total of 12.4 t greenweight (0.9 t at Bay of Islands and 11.4 t at Whangarei, with CVs of 45% and 18%, respectively); minimal recruited biomass was found in Whangaroa Harbour in 2021 (2.1 t greenweight, CV = 45%). Dive survey estimates of recruited scallops in 2006–07 and 2021 in key non-commercial scallop beds are shown in Table 8. The Whangarei beds at Urquharts/McKenzie/Taurikura ('Urquharts') and Smugglers were resurveyed in the 2024 camera survey with AI detection, and the results suggest significant population recovery at Urquharts but population decline to a negligible level at Smugglers.

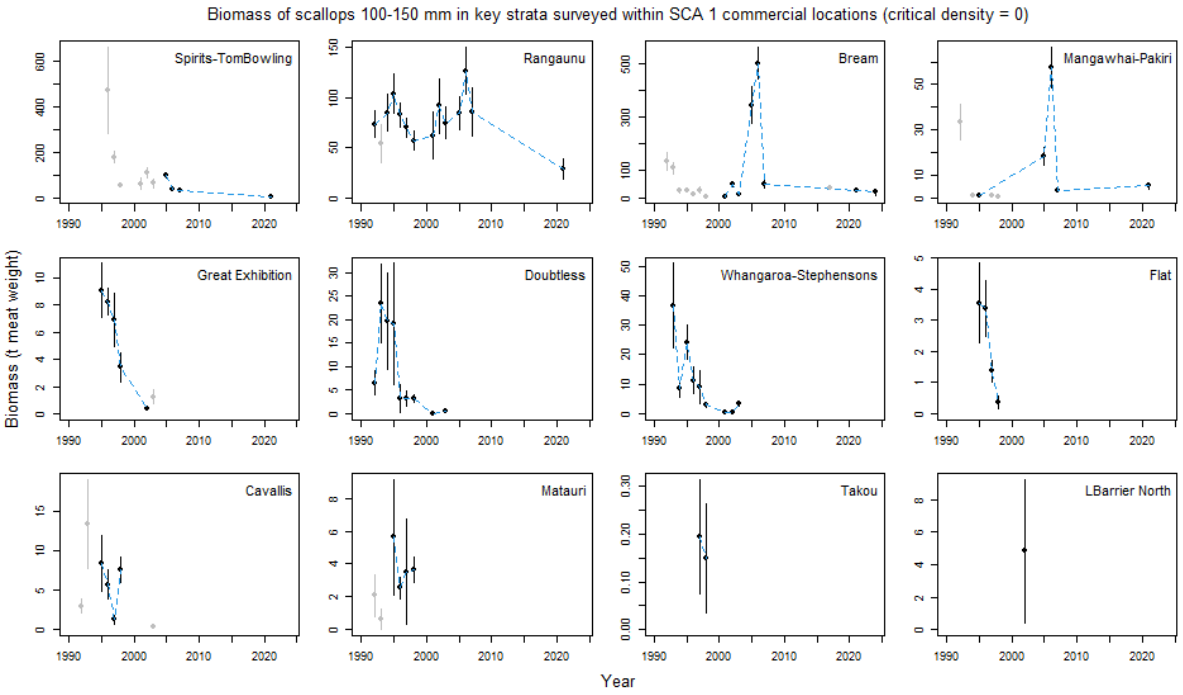


Figure 4: Time of survey estimated absolute biomass (t meatweight; mean and CV) of recruited scallops (100 mm or larger shell length) in key strata sampled in scallop surveys between 1990 and 2024 in SCA 1 commercial fishery locations. Estimates are scaled using a logistic model of dredge efficiency (Marsh & Williams 2021), except for the Bream estimate in 2024 that was derived from a camera survey and was scaled for AI detection efficiency. Overall survey coverage has changed over time, which complicates scallop population comparisons. In preliminary work to address this problem, Williams & Bian (2021) selected a strata subset ('key strata', plotted here) to represent the most consistently surveyed areas (see Figure 2). Years with minimal or no change in the area surveyed within key strata are emphasised here using black symbols joined with a dashed line.

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

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

Time series of recruited density in the non-commercial areas surveyed are shown in Figure 5, which also includes estimates from a 1993 dive survey in the Bay of Islands. Recruited densities in 2021 were low in all beds surveyed, particularly in the Bay of Islands and Whangaroa Harbour. Recruited density in the Whangarei beds in 2024 was very low at Smugglers and relatively high at Urquharts.

Table 8: Dive survey estimates of recruited scallops (100 mm or larger, at the time of the surveys) in 2006–07, 2021 and 2024* in key non-commercial scallop beds in SCA 1 (Williams et al. 2025). Stratum names: RAWH, Rawhiti; URUP, Urupukapuka; Urqu, Urquharts/McKenzie/Taurikura; SMUG, Smugglers; WROA, Whangaroa Harbour. Biomass meatweight assumes 12.5% recovery of meat weight from greenweight.

Location	Stratum	Year	Dives (n)	(scallops.m^{-2})	Density CV	Abundance (millions)	(t green)	CV	Biomass (t meat)
Bay of Islands	RAWH	2006	13	0.16	0.31	0.128	14	0.32	1.8
		2007	14	0.03	0.39	0.028	3	0.39	0.4
		2021	11	0.00	0.46	0.004	0	0.47	0.0
	URUP	2006	14	0.11	0.41	0.231	25	0.41	3.2
		2007	14	0.12	0.34	0.247	25	0.33	3.2
		2021	13	0.00	0.72	0.005	1	0.73	0.1
Whangarei	URQU	2006	12	0.06	0.55	0.034	4	0.53	0.4
		2007	19	0.03	0.49	0.019	2	0.48	0.2
		2021	18	0.10	0.23	0.064	6	0.22	0.8
		2024	23	0.25	0.22	0.155	16	0.22	2.0
	SMUG	2006	18	0.08	0.31	0.062	7	0.30	0.9
		2007	15	0.05	0.47	0.037	4	0.47	0.5
		2021	10	0.06	0.33	0.048	5	0.34	0.7
		2024	11	0.01	0.78	0.004	0.4	0.76	0.1
Whangaroa	WROA	2021	16	0.03	0.53	0.020	2	0.52	0.3

*Whangarei estimates for 2024 are from camera surveys with AI detection.

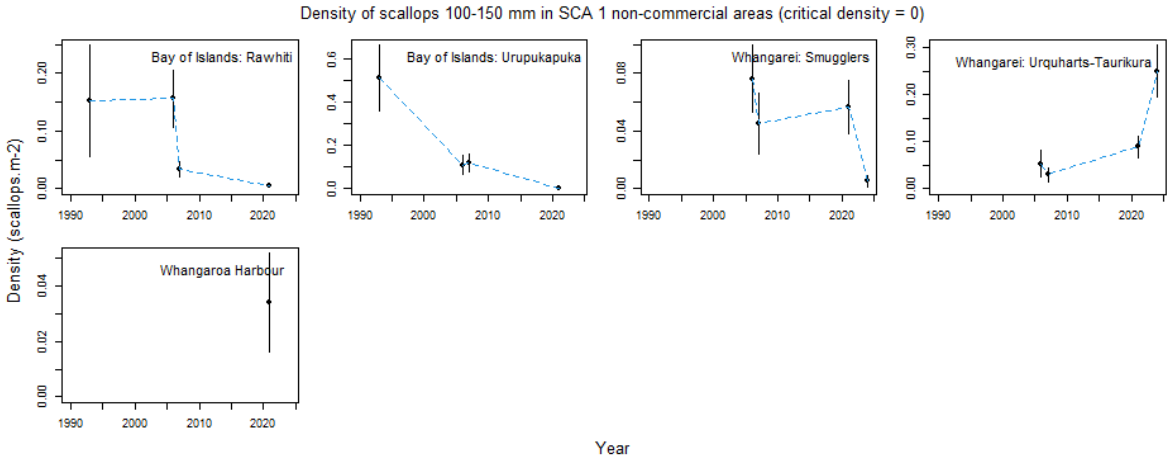


Figure 5: Time series of scallop density in Northland SCA 1 non-commercial scallop locations surveyed between 1993 and 2021 using dive surveys and in 2024 using a camera survey with AI detection. The 2024 estimates are adjusted for AI detection efficiency.

5.3 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 has been based on a *CAY* approach. Between 1998 and 2007, 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.

The most recent *CAY* estimate for SCA 1 was derived in 2007, calculated using $F_{0.1}$ = 0.943 y^{-1} and the estimated start of season absolute biomass. Advances in scallop assessment since that time (Orensanz et al. 2016, Smith et al. 2016) suggest that this estimate of $F_{0.1}$ is too high and results in overestimation of potential yield, particularly when fishing tends to focus on a small proportion of the biomass. Given these concerns, and the low current biomass, *CAY* has not been estimated for 2021. Current research is underway to inform the setting of appropriate target and limit reference points for scallops.

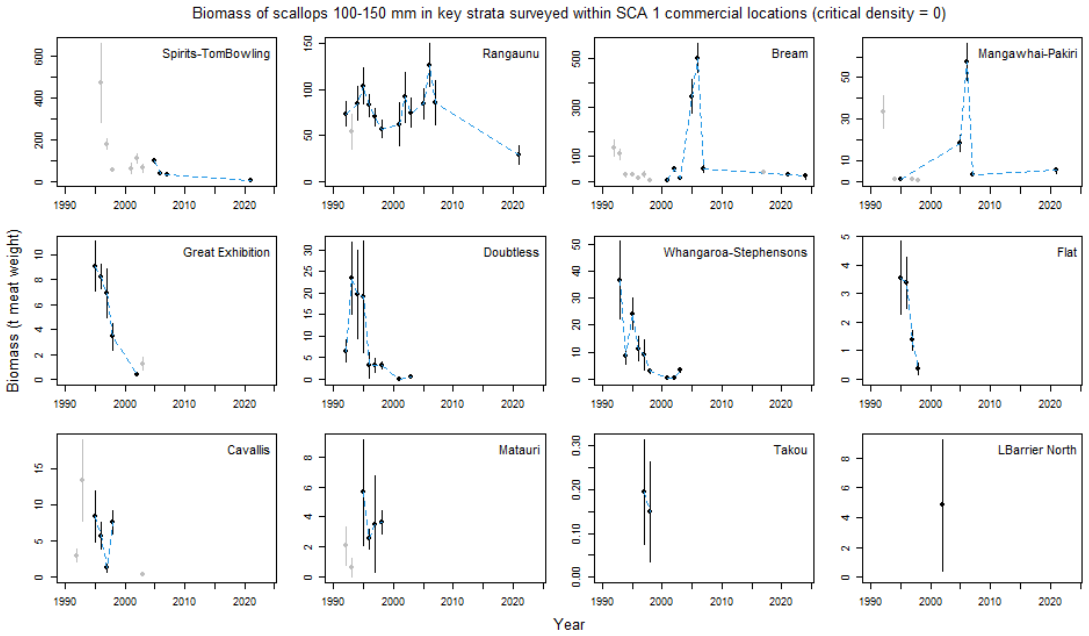
A review of reference points (management targets and limits) for scallop fisheries was undertaken in 2025; a brief summary of the review is provided in section 5 of the Introduction – Scallops chapter, and the findings will be published in a forthcoming report (Williams & Underwood, in review).

6. STATUS OF THE STOCKS

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		
Most Recent Assessment Plenary Publication Year	2021 large-scale dive and dredge surveys and 2024 limited-area camera survey	
Intrinsic productivity level	High	
Catch in most recent year of assessment	Year:	Catch:
Assessment Runs Presented	Series of biomass estimates with varying survey areas	
Reference Points	Target: Fishing mortality at or below F_{MSY} as approximated by $F_{0.1}$ 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	Unknown	
Status in relation to Limits	Unknown	
Status in relation to Overfishing	Unlikely (< 40%) – fisheries closed	

Historical Stock Status Trajectory and Current Status



Time of survey estimated absolute biomass (t meatweight; mean and CV) of recruited scallops (100 mm or larger shell length) in key strata sampled in scallop research surveys between 1990 and 2024 in SCA 1 commercial fishery locations. Estimates are scaled using a logistic model of dredge efficiency (Marsh & Williams 2021), except for the Bream estimate in 2024 that was derived from a camera survey and was scaled for AI detection efficiency. Overall survey coverage has changed over time, and years with minimal or no change in the area surveyed within key strata are emphasised here using black symbols joined with a dashed line.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The trend in stock biomass between 2007 and 2021 is unknown. For industry-based surveys of core commercial areas between 2012 and 2017, recruited densities at Bream Bay and Rangaunu Bay remained low. Recruited biomass in 2021 was 42% of the 2007 estimate. All commercial scallop beds have declined in abundance, particularly those in the Far North. Biomass at Bream Bay in 2024 was lower than in 2021. Recruited density was low in all non-commercial beds surveyed in 2021; abundance had declined considerably in the Bay of Islands but had been maintained or slightly increased in the Whangarei beds. Recruited density in the Whangarei beds in 2024 had been maintained or slightly increased inside the harbour at Urquharts bed but had substantially declined outside the harbour at Smugglers.
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 increased in Bream Bay in 2015 (16 t landed) and has continued at a consistently lower level (mean of 6 t annually between 2016 and 2020). Limited fishing occurred in Rangaunu Bay in 2019 (< 3 t landed).
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	Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unlikely (< 40%) – fisheries closed

Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment	
Assessment Method	Biomass surveys	
Assessment Dates	Latest assessment Plenary publication year: 2024	Next assessment: Unknown
Overall Assessment Quality Rank	1 – High Quality	
Main data inputs (rank)	Biomass survey: 2024	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	N/A	
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 fisheries 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.

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