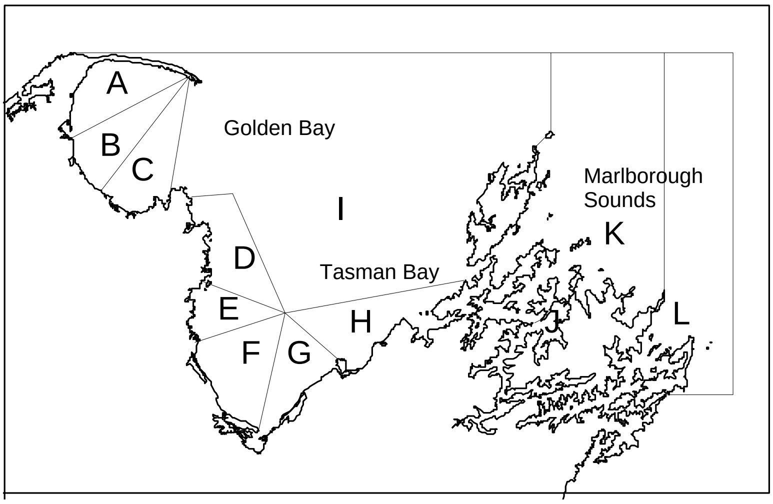
SCALLOPS Nelson/Marlborough (SCA 7)

(*Pecten novaezelandiae*)
Kuakua



1. FISHERY SUMMARY

The SCA 7 fishery was introduced into a modified form of the Quota Management system (QMS) in 1992 and in 1995 an annual TACC was set at 720 t. In 2002 the TACC was increased to 747 t and a TAC set with allowances made for customary and recreational fishing (Table 1).

Table 1: Total Allowable Commercial Catch (TACC, t) declared for SCA 7 since introduction into the QMS in 1992.

Year	TAC	Customary	Recreational	Other Mortality	TACC
1995–2002	–	–	–	–	720
2002–present	827	40	40	0	747

1.1 Commercial fisheries

The Nelson/Marlborough scallop fishery (SCA 7), often also referred to as the ‘Southern’ or ‘Challenger’ fishery, is comprised of 12 sectors (see A–L in the map above) spread across three regions: Golden Bay, Tasman Bay, and the Marlborough Sounds. Up to 1980, the fishery was managed with a combination of gear restrictions, closed areas and seasons, and a 100 mm size limit, together with limitations on the number of entrants (from 1977). Landings reached an all time peak of 1244 t in 1975, when there were 216 licensed vessels involved in the fishery. The fishery then rapidly declined, and in 1981 and 1982 the fishery was closed. Only 48 licences were issued when it re-opened in 1983, with each vessel being allocated a defined, and equal, catch limit on an annual basis. A scallop enhancement programme was initiated in the same year. By 1989 the success of the enhancement programme enabled rotational fishing in Golden and Tasman Bays (Sectors A–I). Under the rotational fishing strategy, several sectors were opened to fishing each year, and were re-seeded following fishing down. Rotational fishing was accompanied by a reduction in the minimum legal size to 90 mm.

In 1992 when SCA 7 was introduced into the QMS an annual harvest limit of 640 t (12 t to each of the 48 licence holders, plus 64 t to Maori) was initially allocated as Individual Transferrable Quota. Provision was also made for any additional quota in excess of the 640 t to be allocated to the Crown for lease, with preference being given to existing quota holders.

In October 1995, legislation was passed in which annual quotas were determined as a fixed proportion of the TACC rather than being allocated as a fixed tonnage. This provided for greater flexibility in changing the TACC. A statutory Enhancement Plan was also introduced at this time, to provide for ongoing enhancement of the fishery. The legislation was modified to enable a transition towards the enhancement programme being implemented by the Challenger Scallop Enhancement Company (CSEC) rather than the Ministry of Fisheries. In 1996, because of the rotational fishing and stock enhancement management strategy being used to manage the stocks in SCA7, the fishery was placed on the Third Schedule to the Fisheries Act 1996 and was, therefore, able to have an alternative TAC set under section 14 of the Act.

Over the last 10 years, the rotational fishing and stock enhancement management strategy has changed considerably. Reseeding activity has been significantly reduced and closing entire sectors to commercial fishing on an annual rotational basis is no longer practised. Now parts of all sectors are fished wherever scallops are available. Annual dredge surveys, used to estimate biomass levels and population size structures for each sector, are conducted before each season begins. This approach informs the current strategy and enables the fishery to concentrate in areas where scallops are predominantly above the minimum legal size.

Separate catch limits are set each year (by CSEC in consultation with MPI) for the Tasman/Golden Bays and the Marlborough Sounds regions of the fishery. The actual commercial catch is set by CSEC within the TACC limits based on knowledge of:

- the biomass in the three regions,
- any adverse effects of fishing on the marine environment being avoided, remedied or mitigated,
- providing for an allowance for non-commercial fishing,
- a biotoxin monitoring programme being maintained, and
- the ratio of legal to non-legal sized fish that are above pre-set levels.

All commercial fishing is by dredge, with fishers using “ring bag” dredges rather than the “box” dredge designs used in the northern (Coromandel and Northland) fisheries. Vessels in the SCA 7 fishery tow one or two ring bag dredges up to 2.4 m in width with heavy tickler chains (there are no teeth or tines on the leading bottom edge of the dredges in the SCA 7 fishery, unlike those of the fixed tooth bars used on dredges in the northern fisheries).

Reported landings (in meatweight; i.e., processed weight, being the adductor muscle plus attached roe) from the Challenger scallop fishery are listed in Tables 2 and 3. The fishing year applicable to this fishery is from 1 April to 31 March. Commercial fishing usually occurs from August to December, although opening and closing dates are defined each year, and may differ between years. Historical landings and TACC changes are shown in figure 1.

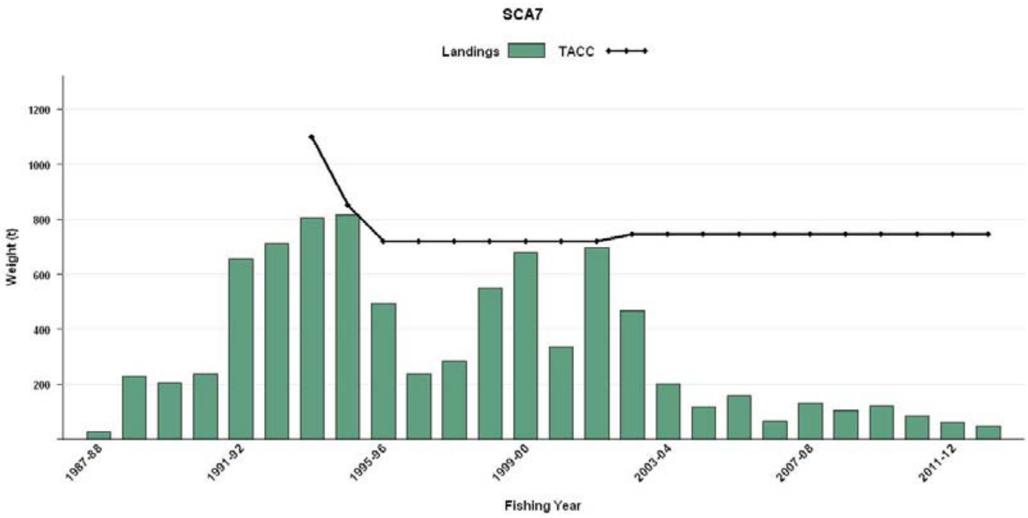


Figure 1: Historical landings and TACC for SCA7 (Nelson Marlborough).

Table 2: Reported landings (t, meatweight) of scallops from SCA 7 from 1959–60 to 1982–83. The fishery was closed for the 1981–82 and 1982–83 scallop fishing years. Landings are presented by region (GB, Golden Bay; TB, Tasman Bay; MS, Marlborough Sounds) and total, except before 1977 when landings were reported by the Golden Bay and Tasman Bay combined area (Gold/Tas). Data source: King & McKoy (1984).

Year	Gold/Tas	GB	TB	MS	Total
1959–60	1	–	–	0	1
1960–61	4	–	–	2	7
1961–62	19	–	–	0	19
1962–63	24	–	–	< 0.01	24
1963–64	105	–	–	2	107
1964–65	108	–	–	2	110
1965–66	44	–	–	< 0.5	44
1966–67	23	–	–	8	32
1967–68	16	–	–	7	23
1968–69	1	–	–	8	9
1969–70	72	–	–	6	78
1970–71	73	–	–	7	80
1971–72	206	–	–	10	215
1972–73	190	–	–	46	236
1973–74	193	–	–	127	320
1974–75	597	–	–	36	632
1975–76	1172	–	–	73	1244
1976–77	589	–	–	79	668
1977–78	–	342	168	63	574
1978–79	–	86	4	76	166
1979–80	–	32	30	40	101
1980–81	–	0	14	27	41
1981–82	–	–	–	–	–
1982–83	–	–	–	–	–

Table 3: Catch limits and reported landings (t, meatweight) of scallops from SCA 7 since 1983–84. The fishery was closed for the 1981–82 and 1982–83 scallop fishing years, and was subsequently managed under a rotationally enhanced regime. Two catch limits are presented: TACC, Total Allowable Commercial Catch; MSCL, Marlborough Sounds catch limit (a subset of the TACC, or a subset of the Annual Allowable Catch in 1994–95). Landings data come from the following sources: FSU, Fisheries Statistics Unit; MHR, Monthly Harvest Returns (Quota Harvest Returns before October 2001); CELR, Catch Effort Landing Returns; CSEC, Challenger Scallop Enhancement Company. Landings are also presented by region (GB, Golden Bay; TB, Tasman Bay; MS, Marlborough Sounds) and best total (believed to be the most accurate record) for the SCA 7 fishstock. –, no data.

	Catch limits		Landings				Landings by region and best total				
Year	TACC	MSCL	FSU	MHR	CELR	CSEC	GB	TB	MS	Best total	Source
1983–84	–	–	225	–	–	–	< 0.5	164	61	225	FSU
1984–85	–	–	367	–	–	–	45	184	138	367	FSU
1985–86	–	–	245	–	–	–	43	102	100	245	FSU
1986–87	–	–	355	–	–	–	208	30	117	355	FSU
1987–88	–	–	219	29	–	–	113	1	105	219	FSU
1988–89	–	–	222	228	–	–	127	23	72	222	FSU
1989–90	–	–	–	205	125	–	68	42	95	205	Shumway & Parsons (2006)
1990–91	–	–	–	237	228	–	154	8	66	228	CELR
1991–92	–	–	–	655	659	–	629	9	20	659	CELR
1992–93	–	–	–	712	674	–	269	247	157	674	CELR
1993–94	*1 100	–	–	805	798	–	208	461	129	798	CELR
1994–95	*850	70	–	815	825	–	415	394	16	825	CELR
1995–96	720	73	–	496	479	–	319	92	67	479	CELR
1996–97	#720	61	–	238	224	231	123	47	61	231	CSEC
1997–98	#720	58	–	284	265	299	239	2	58	299	CSEC
1998–99	#720	120	–	549	511	548	353	78	117	548	CSEC
1999–00	720	50	–	678	644	676	514	155	7	676	CSEC
2000–01	720	50	–	338	343	338	303	19	16	338	CSEC
2001–02	720	76	–	697	715	717	660	32	25	717	CSEC
2002–03	747	–	–	469	469	471	370	39	62	471	CSEC
2003–04	747	–	–	202	209	206	28	107	71	206	CSEC
2004–05	747	–	–	117	112	118	20	47	51	118	CSEC
2005–06	747	–	–	158	156	156	35	5	116	157	CSEC
2006–07	747	–	–	67	66	68	26	0	43	68	CSEC
2007–08	747	–	–	134	183	134	128	0	6	134	CSEC
2008–09	747	–	–	103	137	104	76	0	28	104	CSEC
2009–10	747	–	–	120	120	–	19	0	101	120	CELR
2010–11	747	–	–	85	85	–	10	0	74	85	CELR
2011–12	747	–	–	62	61	–	1	0	60	61	CELR
2012–13	747	–	–	48	48	–	0	0	48	48	CELR

*Annual Allowable Catch (AAC); TACCs came into force 1 October 1995.
#Initial industry controlled catch limit was 350 t in 1996-97, 310 t in 1997-98, and 450 t in 1998-99.

1.2 Recreational fisheries

Recreational fishers harvest scallops from SCA 7 by dredge and by diving. The recreational fishing season runs from 15 July to 14 February. In October 1995 the recreational bag limit was increased from 20 to 50 scallops, and the minimum legal size was reduced from 100 mm to 90 mm, as part of the statutory enhancement programme agreement. Recreational fishers have access to both the wild and enhanced scallop populations, and are not subject to the area closures experienced by the commercial fishery. Each year the commercial and recreational sectors jointly review the prospects for the recreational fishery based on pre-season abundance and yield estimates from CSEC dredge surveys. Following those discussions a number of non-commercial areas are routinely established to supplement the various regulatory closures, which apply to the commercial fishery only.

Estimates of annual recreational scallop harvest from SCA 7 are shown in Table 4; note the estimates provided by telephone diary surveys are no longer considered reliable for various reasons (for more information, see Ministry for Primary Industries 2013: pp 1101-1105 of the snapper section of the Fisheries Assessment Plenary 2013). The estimates from a creel survey in 2003–04 (Cole et al. 2006) and a panel survey in 2011–12 (Wynne-Jones et al. in review) equate to about 7–18% of the commercial harvest in the areas surveyed in those years; the panel survey (Wynne-Jones et al. in review) was still under review at the time this report was written, but appears to provide plausible results.

Table 3: Estimates of the annual recreational harvest of scallops from SCA 7. Number, number of scallops; meat, meatweight (assuming 12.5% recovery of meat weight from green weight). GB/TB, Golden Bay/Tasman Bay. The estimates provided by telephone diary surveys are no longer considered reliable for various reasons. The 2011–12 estimate assumes a 12.5% recovery of meat from greenweight; note the panel survey was still under review at the time this report was written, but appears to provide plausible results.

Year	Area	Survey method	Number	CV	Meat (t)	Reference
1992–93	SCA 7	Telephone diary	1 680 000	0.15	22	Teirney et al. (1997)
1996	SCA 7	Telephone diary	1 456 000	0.21	19	Bradford (1998)
1999–00	SCA 7	Telephone diary	3 391 000	0.20	44	Boyd and Reilly (2002)
2000–01	SCA 7	Telephone diary	2 867 000	0.14	37	Boyd et al. (2004)
2003–04	GB/TB	Creel survey	860 000	0.05	9	Cole et al. (2006)
2011–12	SCA 7	Panel survey	796 164	0.23	11	Wynne-Jones et al. (in review)

1.3 Customary fisheries
Scallops were undoubtedly used traditionally as food by Maori, although quantitative information on the level of customary take is not available.

1.4 Illegal catch
There is no quantitative information on the level of illegal catch.

1.5 Other sources of fishing mortality
The extent of other sources of fishing mortality is unknown. Incidental mortality of scallops caused by ring-bag dredging is unknown for the Challenger fishery, although studies conducted in the Coromandel fishery showed that mortality was quite high (about 20–30% mortality for scallops that are returned to the water. i.e. just under the MLS of 90 mm) for scallops encountered by box dredges. Stochastic modelling suggested that the incidental mortality caused by dredging substantially changed the shape of yield-per-recruit curves for Coromandel scallops, causing generally asymptotic curves to become domed, and decreasing estimates of F_{MAX} and $F_{0.1}$. Other field experiments and modelling suggest that dredging reduces habitat heterogeneity, increases juvenile mortality, makes yield-per-recruit curves even more domed, and decreases estimates of F_{MAX} and $F_{0.1}$ even further. Incidental mortality of scallops may also result from bottom trawling, although the extent of this is unknown. Observational monitoring of *P. novaezelandiae* spat released in the first three years of enhancement (1984–86) in Golden Bay suggested spat survival was higher in areas closed to trawling (Bradford-Grieve et al. 1994).

2. BIOLOGY

Pecten novaezelandiae is a functional hermaphrodite that breeds generally in early summer (although partial spawning can occur from at least August to February). Most scallops mature by the end of their first year, but they contribute little to the spawning pool until the end of their second year. Year 1 scallops contain about 500 000 eggs, whereas year 4 and 5 scallops can contain over 40 million. Scallop veliger larvae spend about three weeks in the plankton. They then attach to algae or some other filamentous material with fine byssus threads. When the spat reach about 5 mm they detach and take up the free-living habit of adults, usually lying in depressions on the seabed and often covered by a layer of silt. Although adult scallops can swim, they appear to move very little (based on underwater observations, the recovery of tagged scallops, and the persistence of morphological differences between adjacent sub-populations).

The relatively high fecundity, and likely variability in the mortality of larvae and pre-recruits, could lead to high variability in natural annual recruitment. This variability is a characteristic of scallop populations worldwide.

All references to "shell length" in this report refer to the maximum linear dimension of the shell, in an anterior-posterior axis. Scallops in the outer Pelorus Sound grew to a shell length of about 60 mm in one year, and can reach 100 mm in two years. This is typical of the pattern of growth that occurs under the rotational fishing strategy in Tasman and Golden Bays as well. Growth slows during the winter, and was found to vary between years (it is probably influenced by water temperature, food availability, and scallop density). Growth rings form on the shell during winter, but also at other times, precluding the use of ring counts as accurate indicators of age. Experience with enhanced stocks in Tasman and Golden Bay has indicated that scallops generally attain a shell length of 90 mm in just under two years, although, in conditions where food is limiting, almost three years may be required to reach this size.

From studies of the ratio of live to dead scallops and the breakdown of the shell hinge in dead scallops, Bull (1976) estimated the annual natural mortality rate for two populations of adult scallops in the Marlborough Sounds (Forsyth Bay and North West Bay in Pelorus Sound) to be 23% (M = 0.26) and 39% (M = 0.49). From a tagging study conducted in Golden and Tasman Bays from 1991 to 1992, Bull & Drummond (1994) estimated the mortality of 0+ and 1+ scallops to be about 38% (M = 0.21) per year, and the mortality of 2+ scallops to be 66% (M = 0.46). These studies suggest that average natural mortality in the Challenger fishery is quite high (Table 5), and most previous stock assessments have assumed $M = 0.5\ y^{-1}$ (instantaneous rate). Incidences of large-scale die-off in localised areas have been observed (e.g., mortality associated with storms in 1998).

Table 5: Estimates of biological parameters

		Estimates	Source
1. Natural mortality, M		*M*	
Pelorus Sound		0.26, 0.49	Bull (1976)
Golden & Tasman Bays		0+ & 1+, 0.21	Bull & Drummond (1994)
Golden & Tasman Bays		2+, 0.46	Bull & Drummond (1994)
2. Growth			
Age-length relationship	Age (y)	SL (mm)	
Pelorus Sound	1	60	Bull (1976)
Pelorus Sound	2	97	Bull (1976)
Pelorus Sound	3	105	Bull (1976)
Pelorus Sound	4	111	Bull (1976)
von Bertalanffy parameters	L_∞	K	
	144	0.40	Data of Bull (1976), analysed by Breen (1995)

3. STOCKS AND AREAS

Scallops inhabit waters of up to about 60 m deep (apparently up to 85 m at the Chatham Islands), but are more common in depths of 10 to 50 m on substrates of shell gravel, sand or, in some cases, silt. Scallops are typically patchily distributed at a range of spatial scales; some of the beds are persistent and others are ephemeral. The extent to which the various beds or populations are reproductively or functionally separate is not known. Whether or not scallops in Tasman Bay and Golden Bay constituted a single genetic stock before enhancement began, is unknown. Enhancement in the Marlborough Sounds has been limited, but could have contributed towards homogenising stocks. Water movements eastward through Cook Strait could have enabled a degree of genetic mixing between Tasman/Golden Bay and Marlborough Sounds stocks before any enhancement began. It is currently assumed for management that the SCA 7 stock is made up of three individual substocks (Golden Bay, Tasman Bay, and Marlborough Sounds) that are separate from the Northland and Coromandel stocks and from the various west coast harbours, Stewart Island and Chatham Island areas.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance

Scallop abundance and biomass in the main commercial scallop beds in the Challenger fishery have been estimated annually since 1994 using a two-phase stratified random dredge survey (Table 6), although no second-phase sampling was conducted in the 2009–13 surveys. In 2013, only the Marlborough Sounds substock was surveyed: Golden Bay and Tasman Bay were not surveyed because of the expected low abundance of scallops in those bays. Surveys since 1998 are essentially comparable, in that they used the same fishing gear and covered quite similar areas. Earlier surveys covered smaller areas, although these would generally have included the areas of main recruited scallop densities. Surveys up to 1995 used the “MAF” dredge, while from 1997 the “CSEC” dredge was used. In 1996, both dredges were used, with data from the CSEC dredge being used for the biomass analysis. The efficiencies of the two dredges at a single site in each of Golden Bay, Tasman Bay, and the Marlborough Sounds were not significantly different. The mean efficiency at these sites (based on a comparison of diver and dredge transects) were 0.58, 0.66, and 0.85, respectively. The values in Table 6 are absolute estimates, produced by reanalysing the historical survey data using a revised analytical procedure described by Tuck & Brown (2008) to better account for uncertainty in the biomass estimates (Table 6).

Estimates in Table 6 use a recruit size of ≥ 90 mm (the commercial size limit) up to 1995. A yield per recruit analysis in 1995 indicated that 89 mm was the optimal harvest size, so from 1996 to 2000, recruit estimates were calculated using this value (although harvesters and processors continued to take only scallops ≥ 90 mm, the minimum legal size). In 2001, a recruit size of ≥ 90 mm was again used.

Table 6: Absolute estimates and CVs of recruited numbers of scallops 90 mm or more shell length (RecN, millions), recruited greenweight (RecG, t), and recruited meatweight (MtWt, t) in Golden Bay, Tasman Bay, the Marlborough Sounds, and for the SCA 7 fishery total, from dredge surveys in May-June of each year. Golden Bay and Tasman Bay were not surveyed in 2013. Values in this table were derived by reanalysing the historical survey data using a revised analytical procedure described by Tuck & Brown (2008) to better account for uncertainty in the time of survey biomass estimates. These estimates do not include Croisilles Harbour in Tasman Bay. – value not estimated. [Figure continued on next page].

Year						Golden Bay
	RecN	RecN CV	RecG	RecG CV	MtWt	MtWt CV
1997	40.1	0.24	3 471	0.25	437	0.29
1998	55.7	0.18	4 605	0.19	584	0.24
1999	60.4	0.20	5 323	0.20	673	0.25
2000	87.8	0.18	6 896	0.18	872	0.24
2001	151.5	0.22	11 510	0.21	1 456	0.26
2002	106.6	0.18	8 326	0.18	1 053	0.24
2003	28.9	0.18	2 269	0.17	287	0.23
2004	5.6	0.20	432	0.20	55	0.25
2005	10.9	0.20	871	0.20	110	0.25
2006	10.3	0.20	858	0.20	109	0.25
2007	55.6	0.20	4 411	0.20	557	0.24
2008	27.0	0.20	2 198	0.20	278	0.25
2009	13.6	0.23	1061	0.23	146	0.23
2010	6.5	0.25	510	0.24	–	–
2011	1.5	0.35	120	0.36	–	–
2012	0.8	0.42	64	0.42	–	–

Table 6 [Continued]: Absolute estimates and CVs of recruited numbers of scallops 90 mm or more shell length (RecN, millions), recruited greenweight (RecG, t), and recruited meatweight (MtWt, t) in Golden Bay, Tasman Bay, the Marlborough Sounds, and for the SCA 7 fishery total, from dredge surveys in May-June of each year. Values in this table were derived by reanalysing the historical survey data using a revised analytical procedure described by Tuck & Brown (2008) to better account for uncertainty in the time of survey biomass estimates. These estimates do not include Croisilles Harbour in Tasman Bay. – value not estimated.

Year						Tasman Bay
	RecN	RecN CV	RecG	RecG CV	MtWt	MtWt CV
1997	3.1	0.25	245	0.25	31	0.29
1998	66.2	0.19	5 108	0.18	645	0.23
1999	55.3	0.21	4 724	0.21	602	0.27
2000	36.3	0.18	3 027	0.18	386	0.23
2001	37.8	0.18	2 977	0.18	378	0.23
2002	55.3	0.18	4 272	0.18	544	0.23
2003	67.9	0.18	5 192	0.18	661	0.23
2004	31.8	0.18	2 386	0.18	304	0.24
2005	13.1	0.19	1 012	0.19	129	0.23
2006	2.4	0.19	186	0.19	24	0.23
2007	1.6	0.22	131	0.22	17	0.27
2008	0.8	0.32	58	0.32	7	0.35
2009	1.1	0.32	88	0.31	11	0.31
2010	1.6	0.26	125	0.26	–	–
2011	0.7	0.36	63	0.36	–	–
2012	0.5	0.39	42	0.40	–	–

Year						Marlborough Sounds
	RecN	RecN CV	RecG	RecG CV	MtWt	MtWt CV
1997	9.0	0.23	781	0.24	99	0.29
1998	20.8	0.25	1 731	0.25	220	0.29
1999	11.6	0.18	969	0.19	123	0.23
2000	11.4	0.19	962	0.19	122	0.24
2001	14.0	0.20	1 124	0.20	143	0.24
2002	24.8	0.21	2 048	0.22	260	0.26
2003	16.6	0.21	1 325	0.21	168	0.26
2004	14.5	0.19	1 120	0.19	142	0.24
2005	21.6	0.20	1 690	0.20	214	0.25
2006	13.6	0.22	1 041	0.22	132	0.27
2007	16.7	0.23	1 326	0.23	169	0.28
2008	19.8	0.21	1 611	0.21	205	0.26
2009	28.6	0.23	2 321	0.24	281	0.24
2010	19.8	0.19	1 606	0.19	–	–
2011	19.1	0.20	1 615	0.21	–	–
2012	10.1	0.21	885	0.22	–	–
2013	15.6	0.20	1265	0.21	–	–

For comparability with previous years, the 2012 estimates do not include the 2012 survey strata 8 or 19 in the previously unsurveyed outer (deeper) region of Golden and Tasman Bays.

Year						SCA 7 fishery total
	RecN	RecN CV	RecG	RecG CV	MtWt	MtWt CV
1997	52.1	0.22	4 497	0.23	568	0.26
1998	142.7	0.17	11 444	0.18	1 450	0.20
1999	127.2	0.18	11 016	0.19	1 399	0.21
2000	135.5	0.17	10 885	0.17	1 380	0.20
2001	203.3	0.20	15 611	0.19	1 977	0.22
2002	186.7	0.17	14 646	0.18	1 857	0.20
2003	113.3	0.17	8 786	0.17	1 116	0.19
2004	51.9	0.17	3 937	0.17	501	0.20
2005	45.7	0.18	3 574	0.18	453	0.20
2006	26.3	0.19	2 085	0.19	264	0.22
2007	74.0	0.19	5 868	0.19	742	0.22
2008	47.6	0.19	3 867	0.19	490	0.22
2009	43.4	0.19	3 489	0.19	444	0.19
2010	27.9	0.18	2 254	0.18	–	–
2011	21.3	0.20	1 796	0.20	–	–
2012	11.5	0.20	1 006	0.21	–	–
2013	15.6	0.20	1265	0.21	–	–

For comparability with previous years, the 2012 estimates do not include the 2012 survey strata 8 or 19 in the previously unsurveyed deeper region of Golden and Tasman Bays.

This fishery operates with a feedback loop that checks the reliability of the biomass survey. At the end of each commercial season, landings from each sector fished are compared with the survey biomass estimates for the sector.

4.2 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.

Start of season (nominally 1 September) absolute recruited biomass is estimated each year from a pre-season dredge survey, which is usually conducted in May. Estimates were derived by reanalysing the historical survey data using a revised analytical procedure described by Tuck & Brown (2008) to better account for uncertainty in the start of season biomass estimates (Table 7).

Table 7: Projected recruited biomass (and c.v.) of scallops (90 mm or longer shell length) at the nominal start of season (1 September) in the survey years, 1997 to present. Golden Bay and Tasman Bay were not surveyed in 2013. Estimates were derived using the revised analytical procedure described by Tuck & Brown (2008). For each year, the catch (reported on the 'Landed' section of CELRs) and exploitation rate (catch to recruited biomass ratio) are also given. Biomass and catch are in t meatweight.

Year	Golden Bay				Tasman Bay			
	Biomass	c.v.	Catch	Catch/Biomass	Biomass	c.v.	Catch	Catch/Biomass
1997	432	0.26	239	0.55	38	0.27	2	0.05
1998	659	0.22	353	0.54	847	0.25	78	0.09
1999	642	0.24	514	0.80	626	0.25	155	0.25
2000	1236	0.21	303	0.25	606	0.23	19	0.03
2001	1640	0.24	660	0.40	945	0.25	32	0.03
2002	1186	0.22	370	0.31	1225	0.25	39	0.03
2003	354	0.22	28	0.08	1110	0.24	107	0.10
2004	79	0.23	20	0.25	468	0.22	47	0.10
2005	132	0.21	35	0.27	169	0.21	5	0.03
2006	265	0.25	26	0.10	43	0.24	0	0.00
2007	636	0.23	128	0.20	32	0.28	0	0.00
2008	313	0.22	76	0.24	15	0.31	0	0.00
2009	278	0.21	19	0.07	14	0.31	0	0.00
2010	78	0.27	10	0.13	15	0.27	0	0.00
2011	20	0.3	1	0.05	8	0.36	0	0.00
2012	9	0.39	0.2	0.02	5	0.42	0	0.00

Year	Marl. Sounds				SCA 7 Total			
	Biomass	c.v.	Catch	Catch/Biomass	Biomass	c.v.	Catch	Catch/Biomass
1997	98	0.26	58	0.59	572	0.20	299	0.52
1998	228	0.29	117	0.51	1737	0.17	548	0.32
1999	132	0.24	7	0.05	1404	0.19	676	0.48
2000	143	0.22	16	0.11	1969	0.17	338	0.17
2001	185	0.23	25	0.14	2798	0.18	717	0.26
2002	378	0.24	62	0.16	2787	0.18	471	0.17
2003	232	0.24	71	0.31	1692	0.18	206	0.12
2004	246	0.24	51	0.21	797	0.17	118	0.15
2005	370	0.25	116	0.31	675	0.18	157	0.23
2006	272	0.26	43	0.16	580	0.21	68	0.12
2007	273	0.27	6	0.02	940	0.19	134	0.14
2008	270	0.23	28	0.10	597	0.18	104	0.17
2009	396	0.22	101	0.26	690	0.18	120	0.17
2010	228	0.19	74	0.32	321	0.19	85	0.26
2011	221	0.19	60	0.27	248	0.18	61	0.25
2012	120	0.22	48	0.40	131	0.21	48	0.37
2013	184	0.19	–	–	184	0.19	–	–

For comparability with previous years, the 2012 estimates do not include the 2012 survey strata 8 or 19 in the previously unsurveyed outer (deeper) region of Golden and Tasman Bays, nor stratum 16 (Croisilles Harbour)

In addition to estimates of absolute biomass, the biomass at different commercial threshold ('critical') densities (in the range 0–0.2 scallops m^{-2}) is also estimated each year.

4.3 Yield estimates and projections

MCY has not been estimated for SCA 7 scallops because it is not thought to be a reasonable management approach for highly fluctuating stocks such as scallops.

Historically, CAY has not been estimated for Golden and Tasman Bays because those areas operate under a fishing plan that involves enhancement and rotational fishing. Under legislation (section 14 of the Fisheries Act 1996), the catch limit for those parts of the fishery can be set at a level other than at the Maximum Sustainable Yield. However, New Zealand's Harvest Strategy Standard incorporates section 14 stocks, including those that are enhanced or rotationally fished, and it requires that (modified) MSY-related targets should nevertheless be set.

There is no enhancement or rotational fishing plan for the Marlborough Sounds, so harvest levels need to be set there each year. For the Marlborough Sounds, CAY was calculated using Method 1(Ministry for Primary Industries 2012):

$$CAY = \left(1 - e^{-(F_{ref})}\right) B_{beg}$$

where B_{beg} is the projected (i.e., 1 September) recruited meatweight biomass estimate and F_{ref} is $F_{0.1}$. This equation is appropriate where fishing occurs over a short period of the year.

The projected absolute recruited biomass estimate for the Marlborough Sounds at the start of the 2012 season (nominally 1 September) was an estimated 120 t meatweight with a CV of 22% (Williams & Bian 2012). Using this value and the range in $F_{0.1}$ of 0.553 (assumed M = 0.4) to 0.63 (assumed M = 0.5) gives CAY estimates (in tonnes meatweight) as follows:

		$F_{0.1}$ = 0.55	$F_{0.1}$ = 0.63
B_{beg} =	120 t	51 t	56 t

These estimates of CAY would have a CV at least as large as that of the estimate of start-of-season recruited biomass, are sensitive to assumptions about dredge efficiency, growth, expected recovery of meatweight from greenweight, and relate to the surveyed beds only. The level of risk to the putative Marlborough Sounds scallop substock of fishing at the estimated CAY level has not been determined.

The actual catch limit (MSCL in Table 3) is usually set at, or close to, the level of recruited relative meatweight biomass as determined in the pre-season abundance survey. This approach usually produces a value in the middle of the CAY range.

4.4 Other yield estimates and stock assessment results

A simulation modelling study of the Challenger scallop fishery examined the effects of catch limits, exploitation rate limits, rotational fishing, and enhancement (Breen & Kendrick 1997). The results suggested that constant catch strategies are not safe, but constant exploitation rate strategies are safe, if the maximum rate is appropriate. Rotational fishing appears to be highly stabilising, even without enhancement; collapses occurred only when the short rotational periods are combined with high intensity. Three-year rotation appears to be safer than two-year rotation. Enhancement appears to improve safety, catch, and biomass, and slightly reduces the population variability. The conclusions from this study underpinned the agreed rotational and enhancement management framework for the fishery. However, the theory of rotational fishing assumes that scallops, and habitats important for scallops, are distributed approximately evenly among the areas (sectors) to be fished rotationally; this is probably an invalid assumption for the SCA 7 fishery sectors.

$F_{0.1}$ was estimated for the Challenger fishery from a yield per recruit analysis using a size at recruitment of 90 mm and assumed values of M of 0.40 and 0.50 (Breen & Kendrick 1999). $F_{0.1}$

was 0.553 and 0.631, respectively[1]. For similar values of minimum size and natural mortality, Cryer (1999) estimated $F_{0.1}$ to be 0.469 and 0.508 in the northern scallop fishery. Consequently, $F_{0.1}$ for the Challenger fishery is assumed to be in the range 0.47 to 0.63[2].

Scallop meatweight recovery (meatweight divided by greenweight) is variable among areas, years, and weeks within the fishing season but in general appears to be highest from scallops in parts of Golden Bay (e.g., sector A) and lowest from those in Tasman Bay (e.g., sector D). Using data on the commercial landings of recruited scallops in the period 1996–2008, the mean annual meatweight recovery was 13.8% for Golden Bay, 11.8% for Tasman Bay, and 13.2% for the Marlborough Sounds. An analysis of meatweight recovery data at the time of the survey and during the fishing season for the years 1996–2007 showed meatweight recovery measured at the time of the survey could not be used to predict meatweight recovery during the fishing season.

5. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This is a new section that was reviewed by the Aquatic Environment Working Group for the November 2013 Fishery Assessment Plenary. A broader summary of information on a range of issues related to the environmental effects of fishing and aspects of the marine environment and biodiversity of relevance to fish and fisheries is available in the Aquatic Environment & Biodiversity Annual Review (www.mpi.govt.nz/Default.aspx?TabId=126&id=1644) (Ministry for Primary Industries 2012).

5.1 Role in the ecosystem

Scallops (*Pecten novaezelandiae*) are subtidal, benthic, epifaunal, sedentary, bivalve molluscs, which have a pelagic larval dispersal phase. They are found patchily distributed at a range of scales in particular soft sediment habitats in inshore waters of depths generally to 50 m and exceptionally up to 85 m. They exhibit relatively fast growth, high mortality, and variable recruitment. The rates of these processes probably vary in relation to environmental conditions (e.g., temperature, water flow, turbidity, salinity), ecological resources (e.g., food, oxygen, habitat), and with intra- and inter-specific interactions (e.g., competition, predation, parasitism, mutualism), and the combination of these factors determines the species distribution and abundance (Begon et al 1990). Scallops are considered to be a key component of the inshore coastal ecosystem, acting both as consumers of primary producers and as prey for many predators; the scallops themselves can also provide structural habitat for other epifauna (e.g., sponges, ascidians, algae).

5.1.1 Trophic interactions

Scallops are active suspension feeders, consuming phytoplankton and other suspended material (benthic microalgae and detritus) as their food source (Macdonald et al 2006). Their diet is the same as, or similar to, that of many other suspension-feeding taxa, including other bivalves such as oysters, clams, and mussels.

Scallops are prey to a range of invertebrate and fish predators, whose dominance varies spatially. Across all areas, reported invertebrate predators of scallops include starfish (*Astropecten polyacanthus*, *Coscinasterias calamaria*, *Luidia varia*), octopus (*Pinnoctopus cordiformis*), and hermit crabs (*Pagurus novaezelandiae*), and suspected invertebrate predators include various carnivorous gastropods (e.g., *Cominella adspersa* and *Alcithoe arabica*); reported fish predators of scallops include snapper (*Pagrus auratus*), tarakihi (*Nemadactylus macropterus*), and blue cod (*Parapercis colias*), and suspected fish predators include eagle rays (*Myliobatis tenuicaudatus*) and stingrays (*Dasyatis* sp.) (Morton & Miller 1968, Bull 1976, Morrison 1998, Nesbit 1999).

[1] The F values reported by Breen & Kendrick (1999) are instantaneous Fs.

[2] The F values reported by Cryer (1999) are not instantaneous Fs.

Predation varies with scallop size, with small scallops being generally more susceptible to a larger range of predators.

5.2 Incidental catch (fish and invertebrates)

A range of non-target fish and invertebrate species are caught and discarded by dredge fisheries for *P. novaezelandiae* scallops. No data are available on the level or effect of this incidental catch (bycatch) and discarding by the fisheries. Bycatch data are available, however, from various dredge surveys of the scallop stocks, and the bycatch of the fisheries is likely to be similar to that of the survey tows conducted in areas that support commercial fishing.

Species or groups that have been caught as incidental catch in the box dredges and ring-bag dredges used in surveys of commercial scallop (*P. novaezelandiae*) fishery areas in New Zealand are shown in Table 8. Catch composition varies among the different fishery locations and through time.

In the Coromandel scallop stock (SCACS), a photographic approach was used in the 2006 dredge survey to provisionally examine bycatch groups (Tuck et al 2006), but a more quantitative and comprehensive study was conducted using bycatch data collected in the 2009 dredge survey (Williams et al 2010), with survey catches quantified by volume of different component categories. Over the whole 2009 survey, scallops formed the largest live component of the total catch volume (26%), followed by assorted seaweed (11%), starfish (4%), other live bivalves (4%), coralline turfing algae (1%) plus other live components not exceeding 0.5%. Dead shell (identifiable and hash) formed the largest overall component (45%), and rock, sand, and gravel formed 8%. Categories considered to be sensitive to dredging were caught relatively rarely. Data on the bycatch of the 2010 and 2012 surveys of SCA CS were also collected but not analysed; those data have been loaded to the MPI database ‘scallop’ for potential future analysis (Williams & Parkinson 2010, Williams et al 2013b).

In the Northland scallop stock (SCA 1), analysis of historical survey bycatch 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.

In the Southern scallop stock (SCA 7), data on the bycatch of the 1994–2013 surveys have been collected but not analysed, except for preliminary estimation of the 1998–2013 bycatch trajectories (Williams et al 2013a).

Table 8: Species or groups categorised by bycatch type caught as incidental catch in dredge surveys of commercial scallop (*P. novaezelandiae*) fishery areas in New Zealand.

Type	Species or groups
habitat formers	sponges, tubeworms, coralline algae (turf, maerl), bryozoa
starfish	*Astropecten*, *Coscinasterias*, cushion stars, carpet stars
bivalves	dog cockles, horse mussels, oysters, green-lipped mussels, *Tawera*
other invertebrates	anemones, crabs, gastropods, polychaetes, octopus, rock lobster
fish	gobie, gurnard, John dory, lemon sole, pufferfish, red cod, sand eel, snake eel, stargazer, yellowbelly flounder
seaweed	*Ecklonia*, other brown algae, green algae, red algae
shell	whole shells, shell hash
substrate	mud, sand, gravel, rock
other	Rubbish

5.3 Incidental catch (seabirds, mammals, and protected fish)

There is no known bycatch of seabirds, mammals or protected fish species from *P. novaezelandiae* scallop fisheries.

5.4 Benthic interactions

It is well known that fishing with mobile bottom contact gears such as dredges has impacts on benthic populations, communities, and their habitats (e.g., see Kaiser et al 2006, Rice 2006). The effects are not uniform, but depend on at least: "the specific features of the seafloor habitats, including the natural disturbance regime; the species present; the type of gear used, the methods and timing of deployment of the gear, and the frequency with which a site is impacted by specific gears; and the history of human activities, especially past fishing, in the area of concern" (Department of Fisheries and Oceans 2006). The effects of scallop dredging on the benthos are relatively well-studied, and include several New Zealand studies carried out in areas of the northern fisheries (SCA 1 and SCA CS) (Thrush et al 1995, Thrush et al 1998, Cryer et al 2000, Tuck et al 2009, Tuck & Hewitt 2012) and the Golden/Tasman Bay region of the southern (SCA 7) fishery (Tuck et al 2011). The results of these studies are summarised in the Aquatic Environment & Biodiversity Annual Review (Ministry for Primary Industries 2012), and are consistent with the global literature: 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.

5.5 Other considerations

5.5.1 Spawning disruption

Scallop spawning occurs mainly during spring and summer (Bull 1976, Williams & Babcock 2004). Scallop fishing also occurs during these seasons, and is particularly targeted in areas with scallops in good condition (reproductively mature adults ready to spawn). Fishing also concentrates on high density beds of scallops, which are disproportionately more important for fertilisation success during spawning (Williams 2005). Fishing, therefore, may disrupt spawning by physically disturbing scallops that are either caught and retained (removal), caught and released, not caught but directly contacted by the dredge, or not caught but indirectly affected by the effects of dredging (e.g., suspended sediments).

5.5.2 Habitat of particular significance to fisheries management

Habitat of particular significance for fisheries management (HPSFM) does not have a policy definition (Ministry for Primary Industries 2012) although work is currently underway to define one. Certain features of the habitats which scallops are associated with are known to influence scallop productivity by affecting the recruitment, growth and mortality of scallops, and therefore may in the future be useful in terms of identifying HPSFM. Scallop larval settlement requires the presence of fine filamentous emergent epifauna on the seabed, such as tubeworms, hydroids, and filamentous algae, hence the successful use of synthetic mesh spatbags held in the water column as a method for collecting scallop spat. Survival of juveniles has been shown to vary with habitat complexity, being greater in more complex habitats (with more emergent epifauna) than in more homogeneous areas (Talman et al 2004). The availability of suspended microalgae and detritus affects growth and condition (Macdonald et al 2006). Suspended sediments can reduce rates of respiration and growth, the latter by 'diluting' the food available; scallops regulate ingestion by reducing clearance rates rather than increasing pseudofaeces production. Laboratory studies have demonstrated that suspended sediments disrupt feeding, decrease growth and increase mortality in scallops (Stevens 1987, Cranford & Gordon 1992, Nicholls et al 2003).

6. STATUS OF THE STOCKS

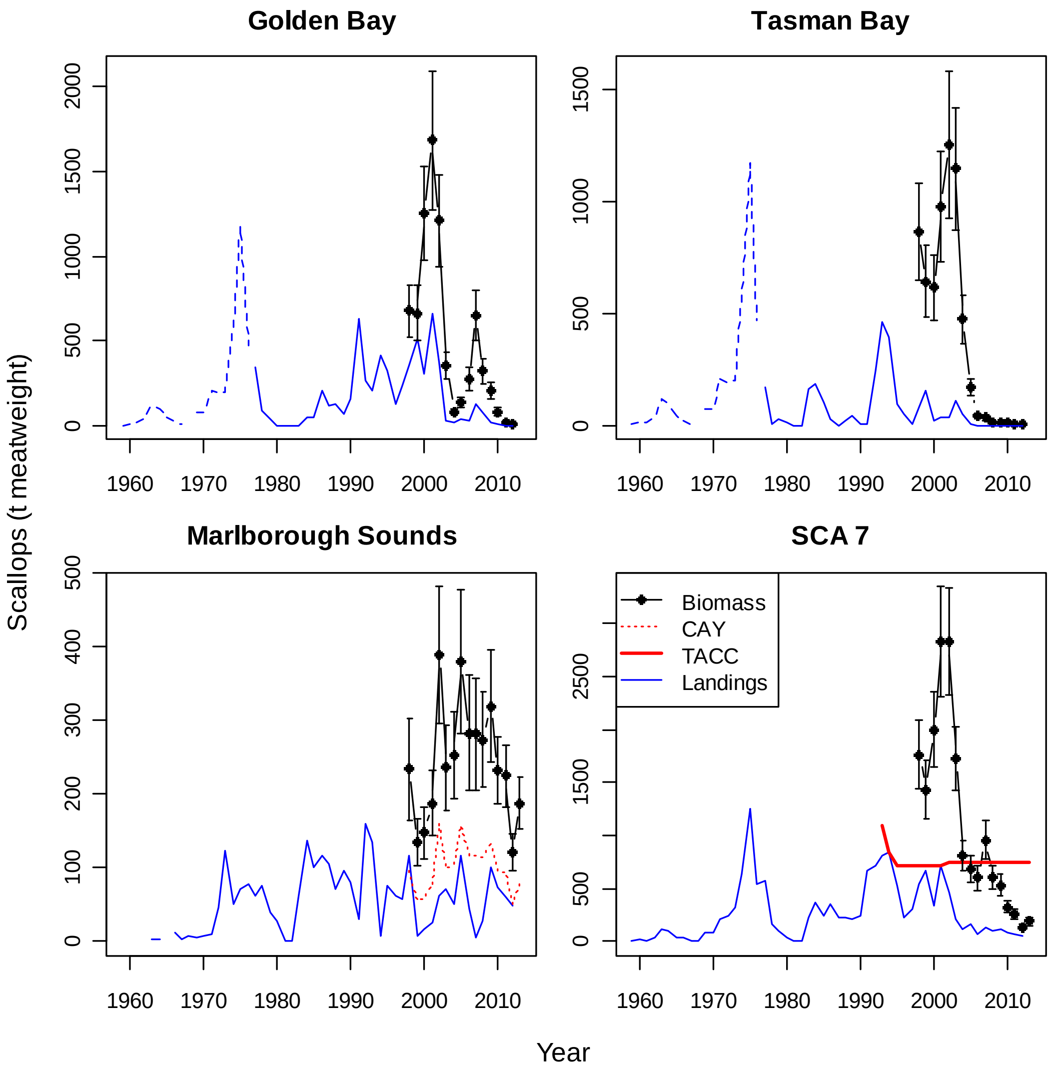
Stock Structure Assumptions

The stock structure of scallops in New Zealand waters is uncertain. For the purposes of this assessment and due to the different management regimes, Golden Bay, Tasman Bay and Marlborough Sounds are assumed to be individual and separate substocks of SCA 7.

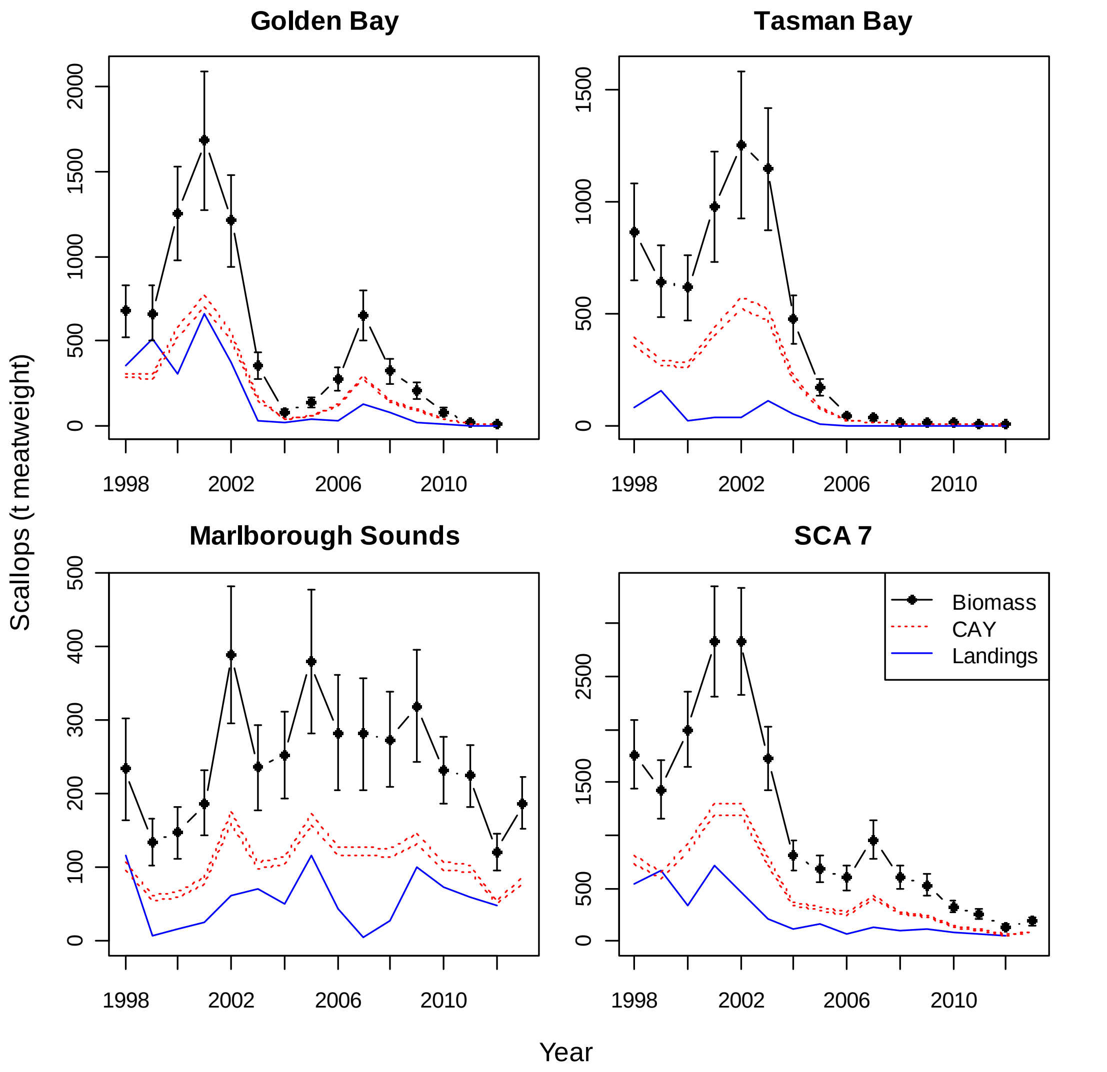
- **Challenger scallops, SCA 7**

Stock Status	
Year of Most Recent Assessment	2013
Assessment Runs Presented	Two approaches to estimating CAY for Marlborough Sounds in 2013. Estimates of biomass for Golden Bay and Tasman Bay in 2012 (these areas were not surveyed in 2013).
Reference Points	Target: Fishing mortality at or below $F_{0.1}$ for Marlborough Sounds ($F_{0.1}$ = 0.553 y^{-1} or 0.631 y^{-1} if M = 0.4 and 0.5, respectively). No targets have been set for Golden Bay or Tasman Bay; B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: F_{MSY}
Status in relation to Target	Likely (> 60%) to be below F_{target} for Marlborough Sounds Very Unlikely (< 10%) to be at or above the biomass target for Golden Bay or Tasman Bay
Status in relation to Limits	About as Likely as Not (40-60%) to be below the soft limit and Unlikely (< 40%) to be below the hard limit for Marlborough Sounds Very Likely (> 90%) to be below the soft limit for Golden Bay and Tasman Bay Likely (> 60%) to be below the hard limit for Golden Bay and Tasman Bay
Status in relation to Overfishing	Overfishing is Unlikely (< 40%) to be occurring for Marlborough Sounds and Unknown for Golden Bay and Tasman Bay

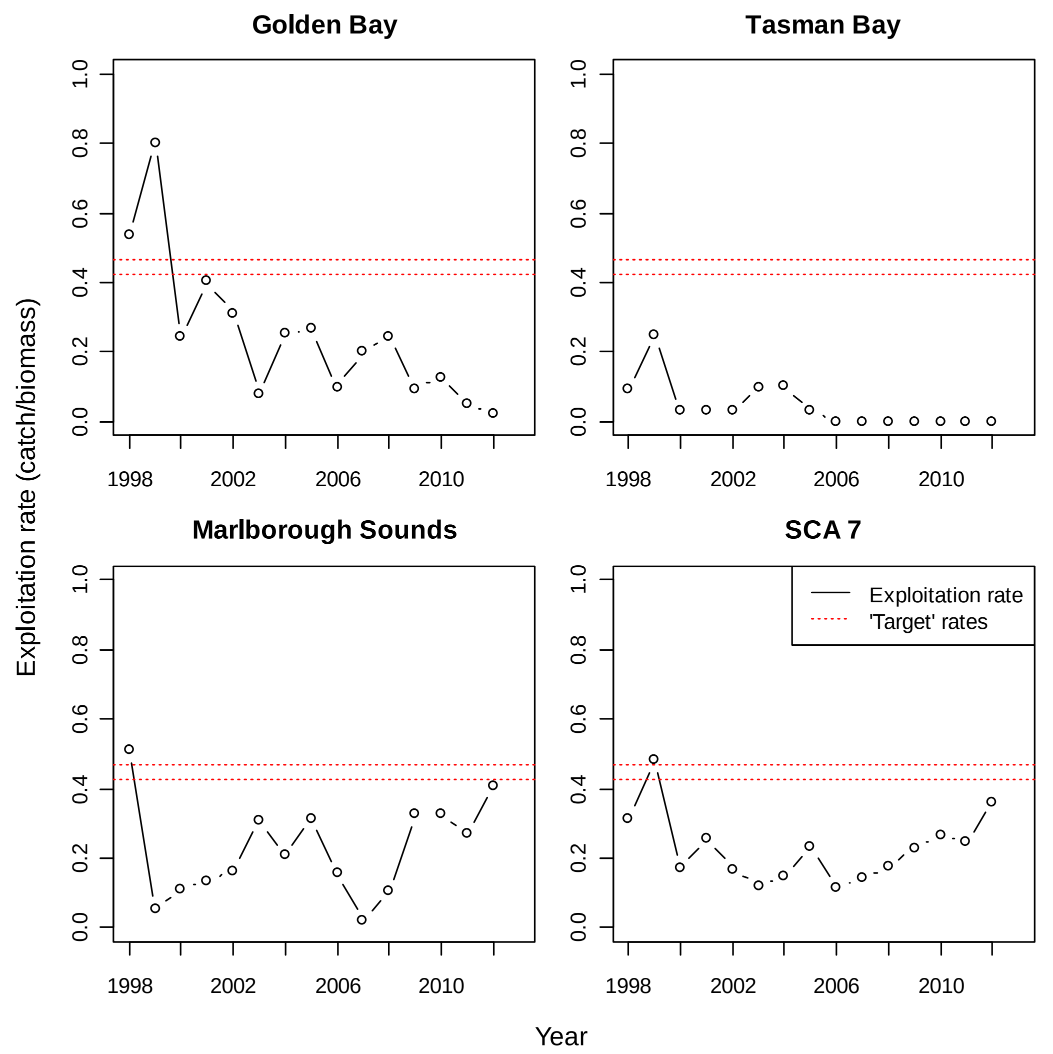
Historical Stock Status Trajectory and Current Status



Recruited (scallops 90 mm or more shell length) mean (and C.V. of) biomass estimates (closed symbols with error bars joined by solid black line), TACC (solid red line), and reported landings (solid blue line) in t meatweight for the three regions of the fishery and the overall SCA 7 stock since 1959 (landings before 1977 from Golden and Tasman Bays were reported as combined values from the two bays, shown as a dotted blue line). CAY (using $F_{0.1}$ = 0.553) for the Marlborough Sounds since 1998 is also shown (dotted red line). Estimates of biomass from surveys before 1998 are not presented because the surveys did not cover the full extent of the SCA 7 fishery. Scale differs between plots. Note the fishery was closed for the 1981–82 and 1982–83 scallop fishing years, and was subsequently managed under a rotationally enhanced regime.



Trends in the SCA 7 stock from 1998–2013. Plots show start of season recruited scallop biomass estimates and CVs (closed symbols with error bars joined by solid black line), CAY estimated retrospectively using $F_{0.1}$ = 0.553 (lower dotted red line) and $F_{0.1}$ = 0.631 (upper dotted red line), and reported landings (solid blue line) by region and for the overall SCA 7 stock. All values in t meatweight. Golden Bay and Tasman Bay were not surveyed in 2013.



Exploitation rate (catch divided by biomass) trends for recruited scallops by region and for the overall SCA 7 stock (solid black lines). Horizontal lines show two 'Target' exploitation rates of 0.42 (lower dotted red line) and 0.47 (upper dotted red line) representing two estimates of CAY expressed as proportions of the recruited biomass. The two estimates of CAY were calculated retrospectively for all areas using target fishing mortalities of $F_{0.1}$ = 0.553 and 0.631 based on assumed natural mortality rates of M = 0.4 and M = 0.5, respectively. It has been recognised that these estimates of the target fishing mortality $F_{0.1}$ used in the calculation of CAY may be too high.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass in the Marlborough Sounds region, which was the only region surveyed in 2013, increased slightly over the 2012 level. No surveys were conducted in Golden of Tasman Bays in 2013 because of expected low abundance in these regions. In all three substocks of SCA 7, estimated recruited scallop biomass generally increased from the late 1990s to reach peak levels around 2001–02. Since then there has been a substantial biomass decline in both Golden Bay and Tasman Bay, and current biomass in both regions is at historically low levels. Biomass in the Marlborough Sounds has exhibited a steady overall decline since 2009.
Recent Trend in Fishing Intensity or Proxy	In Golden Bay, the exploitation rate (catch to biomass ratio) on scallops 90 mm or more was high in the period 1998–99 (54–80%), followed by a decreasing trend with fluctuation

	from 2000, and was very low (2%) in 2012–13. In Tasman Bay, the peak exploitation rate in the time series was 25% in 1999, but otherwise has been relatively low. No fishing has occurred in Tasman Bay since 2005. In the Marlborough Sounds, the exploitation rate was 51% in 1998 but dropped to 5.5% in 1999, followed by a general increase to reach about 31% in 2005. Exploitation in the Marlborough Sounds subsequently decreased to only 2% in 2007–08, but there has been an increasing trend since then, reaching a high of 40% in 2012–13.
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Stock projections are not available. There is some evidence of a slight increase in the number of juveniles in the Marlborough Sounds from the 2013 survey. The low numbers of pre-recruit scallops (89 mm or smaller) in Golden Bay and Tasman Bay at the time of the 2012 survey suggests recruitment to the fishable biomass in those areas over the next two years is likely to be minimal. High densities of scallop spat were observed in mesh spatbags in Golden Bay in March 2012, suggesting larval abundance was high, but the success of natural settlement and survivorship on the seabed is unknown.
Probability of Current Catch causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown for current catch Hard Limit: Unknown for current catch
Probability of TACC causing Biomass to remain below or to decline below Limits	Very Likely (> 90%) for the current TACC
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Partial quantitative stock assessment	
Assessment Method	Biomass surveys and CAY management strategy	
Assessment Dates	Latest assessment: 2013	Next assessment: 2014
Overall Assessment Quality Rank	1 – High Quality	
Main data inputs (rank)	Biomass survey: 2013	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	None since the 2008 assessment when the survey workup methodology was revised. CAY model for Marlborough Sounds has been in use since 1997.	
Major Sources of Uncertainty	These include assumptions about: dredge efficiency during the survey, growth rates and natural mortality between the survey and the start of the season, predicting the average recovery of meatweight from greenweight and the extent to which dredging causes incidental mortality and affects recruitment.	

Qualifying Comments
The extent to which the various beds or populations are reproductively or functionally separate is

not known. The Golden Bay and Tasman Bay regions of SCA 7 operate under a fishing plan that involves enhancement and rotational fishing, although these activities have been minimal in recent years. Recent work for MPI includes a review of factors affecting the SCA 7 fishery (Williams et al 2013), and modelling of the effects of scallop spat enhancement on scallop catches in Golden Bay and Tasman Bay (Tuck & Williams 2012). The cause of the major declines in the scallop populations of Golden Bay and Tasman Bay is unknown, but a comparison of landings in relation to the CAY at the broad scale of the three substocks within SCA 7 suggest the downturn is probably exacerbated by factors other than simply the magnitude of direct removals of scallops by fishing. It has been recognised, however, that the estimates of the target fishing mortality $F_{0.1}$ used to calculate CAY may be too high. Nevertheless, declines in stocks of other shellfish (oysters, mussels) have also been observed. In addition to direct fishing mortality, a combination of other anthropogenic (e.g., land-based influences, indirect effects of fishing) and natural (e.g., oceanographic) drivers may have affected the productivity of the SCA 7 fishery. To address the system complexity, NIWA have been engaging with fishery endusers to inform the development of an ecosystem model, working towards an ecosystem approach to fisheries management (EAFM) for Golden and Tasman Bays, with a view to potentially restoring sustainable fisheries production in the long term. A review of information on drivers of shellfish fisheries production in Golden and Tasman Bays and knowledge gaps was coordinated by NIWA and presented to stakeholder workshops in 2012 and 2013 (NIWA in prep).
Fishery Interactions
Bycatch data are collected routinely during the annual surveys. Bycatch can include dredge oysters, green-lipped mussels, and a range of other benthic invertebrates. The bycatch of the fishery is likely to be similar to that of the survey.

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