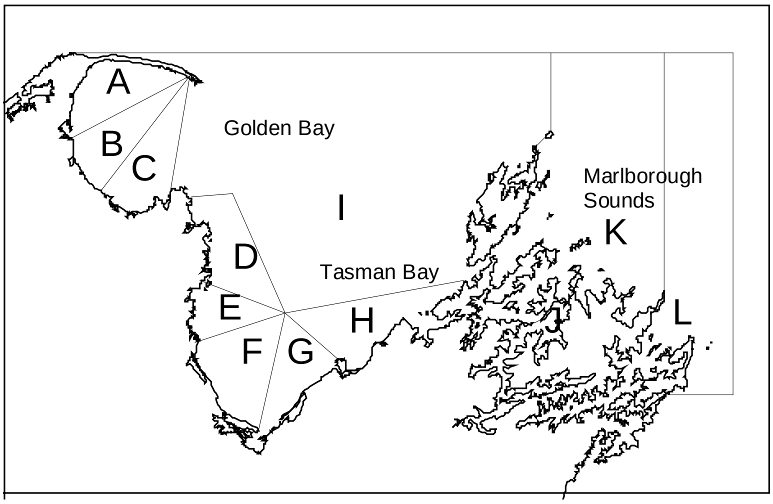
SCALLOPS Nelson/Marlborough (SCA 7)

(*Pecten novaezelandiae*)
Kuakua



1. FISHERY SUMMARY

The Nelson/Marlborough scallop fishery (SCA 7) is spread over the three regions of Golden Bay, Tasman Bay, and the Marlborough Sounds. The 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). In 2014 the TAC was reduced to 520due to consistently declining biomass for the past 10 years

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
2002–2012	827	40	40	0	747
2013 to present	520	40	40	40	400

1.1 Commercial fisheries

The commercial catch history for this fishery is quite variable with landings reaching an all time peak of 1244 tonnes in 1975. At this time there were 216 licensed vessels involved in the fishery and the minimum legal size (MLS) was 100 mm. After 1975 the fishery rapidly declined, and in 1981 and 1982 it was closed.

The fishery re-opened in 1983 with only 48 licences being issued and each vessel being allocated a defined, and equal, catch limit on an annual basis. In the same year the Ministry of Fisheries initiated a scallop enhancement programme in Golden and Tasman Bays and in 1989 a rotational fishing management strategy together with a reduction in the MLS to 90mm was also introduced in these two regions. The rotational fishing strategy worked such that the Golden and Tasman Bay regions were subdivided into 3 and 6 catch and effort reporting sectors respectively. Each year, several of the sectors in each region were opened to commercial fishing, and at the end of the season the fished sectors were reseeded and then closed to commercial fishing for at least 2 years. The new MLS of 90mm was also introduced into the Marlborough Sounds in 1989 but no enhancement or rotational fishing management strategy has ever been undertaken in this region. The Marlborough Sounds is divided into 2 catch and effort reporting sectors and the remaining portion of Golden and Tasman Bay became the final catch and effort reporting sector for SCA 7, giving 12 sectors overall.

In 1992, the SCA 7 fishery was introduced into a modified form of the Quota Management System (QMS) with an annual harvest limit of 640 t (12 t to each of the 48 licence holders, plus 64 t to Maori) initially allocated as ITQ. 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 10years the rotational fishing and stock enhancement management strategy has not been strictly adhered to and the protocol of closing entire sectors to commercial fishing on an annual rotational basis is no longer practiced, with parts of all sectors being fished wherever scallops are available. In recent years reseeding activity has also reduced due to lack of adequate funds being available

Annual dredge surveys, used to estimate biomass levels and population size structures for each sector within SCA7, are conducted before each season begins. This approach enables the fishery to concentrate in areas where scallops are predominantly above the minimum legal size, and reduces disturbance in areas where most of the population is sub-legal.

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. Catch limits for Golden/Tasman Bays are based on direct results from the biomass surveys and the actual commercial catch is set by CSEC each year within the TACC limits. For the Marlborough Sounds, where there is no enhancement or rotational fishing plan, catch limits are formally set each year in consultation between MPI, CSEC and other relevant stakeholders. The catch limits that are set are based on estimates of Current Annual Yield calculated from the biomass survey results. In 2014 an alternative yield was also estimated by applying a target exploitation rate to the projected biomass.

Overall commercial catch is set 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.

Reported landings (meatweight) 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 may differ between years.

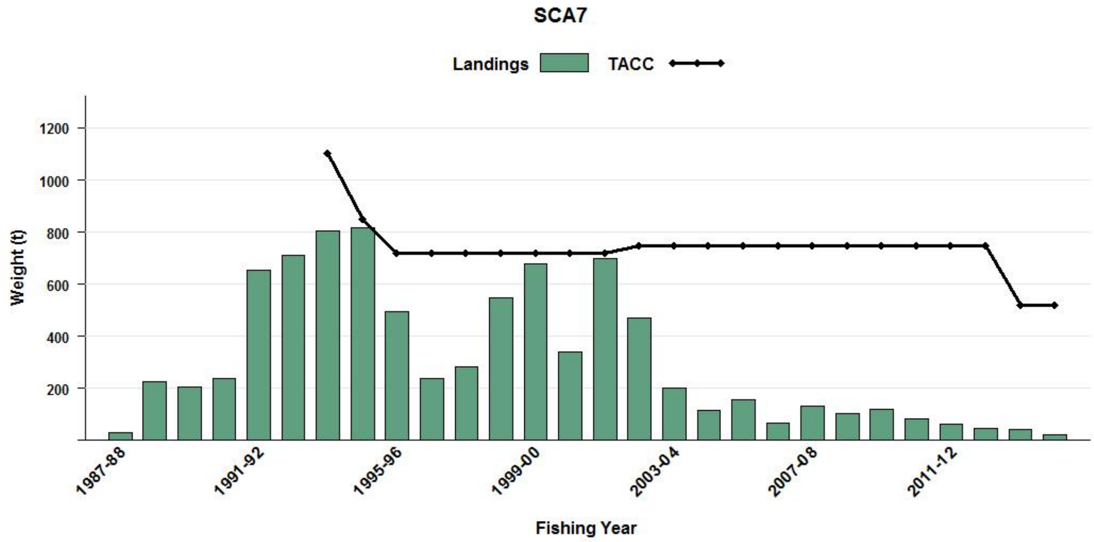


Figure 1: Historical landings and TACC for SCA7 (Nelson Marlborough).

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
2013-14	520	48	–	43		–	0	0	43	43	CELR
2014-15	520	28	–	^18	22	–	0	0	22	22	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.
^ not all catch data available at the time of writing this report

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 press) equate to about 7–18% of the commercial harvest in the areas surveyed in those years.

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 press)

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 has been conducted in the 2009–14 surveys. In 2013 only the Marlborough Sounds region was surveyed but all three regions (Golden Bay, Tasman Bay and Marlborough Sounds) were surveyed in 2014. 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 estimated efficiency of the ring-bag dredge used in the SCA 7 survey is based on limited data from two studies (Cranfield et al. 1996, Handley et al. 2004), which we assume are representative of the average efficiency of the dredge for all areas of the stock. Using these data, a non-parametric resampling with replacement (bootstrapping) method was used by Tuck & Brown (2008) to estimate dredge efficiency for SCA 7, and that method has been applied in the workup of SCA 7 survey data since 2008. This ‘bootstrapping’ method, that better accounts for uncertainty in the biomass, abundance estimates, was originally developed and used by Cryer & Parkinson (2006) to estimate dredge efficiency for SCA 1 and SCA CS, but has been shown to result in a positive bias on the estimated biomass relative to a preferred model-based method of estimating dredge efficiency (Bian et al. 2012). The bootstrapping method was used in the current SCA 7 survey analysis because it was considered there are too few data to apply the model-based method.

To examine the potential difference in dredge efficiency estimated by the two different approaches (bootstrapping versus the model-based), comparisons were made of the dredge efficiency curves generated by each approach. The curves estimated the dredge efficiency of box dredges used on silt substrates at 20 m depth in SCA CS (i.e. for conditions thought to be the most similar to those in the Marlborough Sounds beds) for scallops of different lengths. For the 90–100 mm length range (that is most influential on the estimated biomass), preliminary estimates of dredge efficiency from the bootstrapping method were 20% lower than those estimated by the model-based method. Potential underestimation of dredge efficiency by 20% using the bootstrapping method would result in a 20% positive bias on the SCA 7 biomass estimates. Adjusting for this potential bias would reduce the Marlborough Sounds 2014 start of season biomass estimate from 125 t (‘standard estimate’) to 100 t (‘adjusted estimate’).

Table 6 shows the absolute estimates and CVs, from dredge surveys, of recruited numbers, greenweight and meatweight of scallops 90mm or more in shell length in Golden and Tasman Bays and the Marlborough Sounds. These estimates are calculated using dredge efficiency that is calculated using the bootstrapping method mentioned above and are “time of survey” estimates. All data prior to 2008, the data when the bootstrapping method superseded the previous simple scalar approach, have been reanalysed using dredge efficiency calculated using the bootstrapping method as described by Tuck & Brown (2008). The estimates 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 89mm (although harvesters and processors continued to take only scallops ≥ 90 mm, the minimum legal size). From 2001 onwards 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	–	–
2013					–	–
2014	2.9	0.26	252	0.26	–	–

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	–	–
2013					–	–
2014	3.6	0.30	304	0.28	–	–

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.

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	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	–	–
2014	10.9	0.20	886	0.21	–	–

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	–	–
2014	17.4	0.20	1439	0.20	–	–

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 dredge efficiency calculated using the bootstrapping method as described by Tuck & Brown (2008) to better account for uncertainty in the start of season biomass estimates (Table 7). In 2013 the Golden Bay and Tasman Bay regions were not surveyed.

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
2013			0	0.00			0	0.00
2014	33.4	0.25	0	0.00	37.3	0.28	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	43	0.23	184	0.19	43	0.23
2014	125	0.20	22	0.18	196	0.19	22	0.11

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.

Figure 2 shows the trends in estimated recruited biomass, plotted by region and for the overall SCA7 stock, since 1998. In Golden Bay, biomass increased from 1999 to reach a peak in 2001, but rapidly decreased to 2004; biomass increased again to reach a second, smaller peak in 2007, but subsequently decreased and has remained at very low levels from 2011 to 2014. In Tasman Bay there was a similar large increase and decrease in biomass that occurred with slightly later timing: biomass increased in Tasman Bay from 2000 to reach a peak in 2002–03, but subsequently decreased and remained at very low levels from 2006 to 2014. In Marlborough Sounds, biomass generally followed an increasing trend from 1999 to 2009 (albeit with evidence of a peak in 2002), and a decreasing trend from 2009 to 2014.

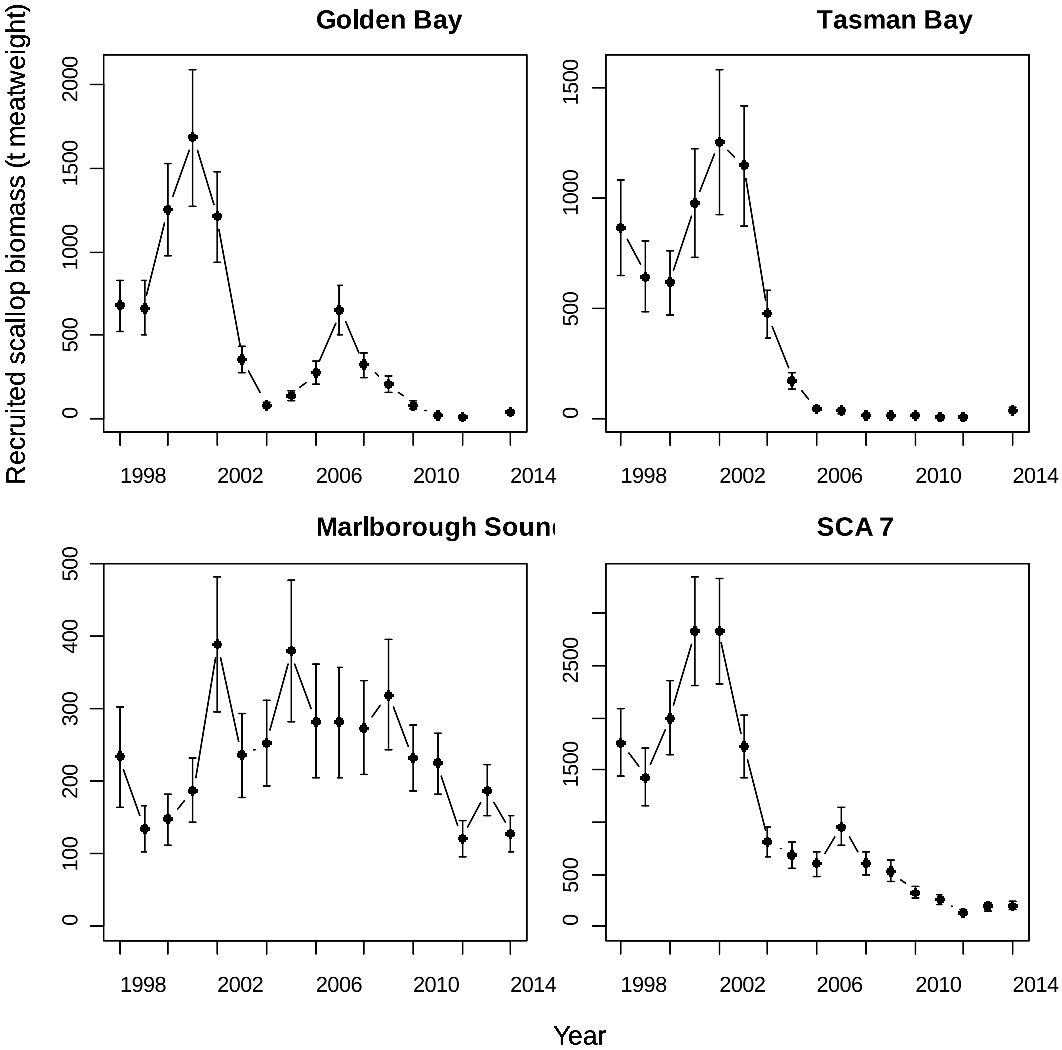


Figure 2: Trends in start of season recruited scallop biomass (t meatweight) by region and for the total SCA 7 stock, 1998–2014. Values are the estimated mean and CV of the projected recruited biomass. Note: Golden and Tasman Bays were not surveyed in 2013

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. Catch limits for Golden/Tasman Bays are based on direct results from the biomass surveys and the actual commercial catch is set by CSEC each year within the TACC limits (subject to approval by the Minister).

For the Marlborough Sounds, where there is no enhancement or rotational fishing plan catch limits are set based on estimates of Current Annual Yield calculated from the biomass survey results. In 2014 an alternative yield was also estimated by applying a target exploitation rate of 22% to the projected biomass.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 2014 season (nominally 1 September) was an estimated 125 t meatweight (standard estimate) with a CV of 20% (Williams & Bian 2012). In 2014 research was undertaken to determine if, when using the bootstrapping approach to estimate dredge efficiency, there was the potential for any bias to occur in the dredge efficiency estimates. The research suggested there is a potential to underestimate the dredge efficiency by 20%. This underestimation would result in a positive bias of 20% in the estimates of biomass. Adjusting for this potential 20% bias reduces the 2014 start of season biomass estimates for the Marlborough Sounds, from 125t to 100t (adjusted estimate). Using the standard and adjusted biomass estimates and the reference points $F_{0.1}$ of 0.553 (assumed M = 0.4) and $F_{0.1}$ of 0.63 (assumed M = 0.5) the following CAY estimates (in tonnes meatweight) were calculated for SCA 7:

		$F_{0.1}$ = 0.55	$F_{0.1}$ = 0.63	E=0.22	
B_{beg} =	125 t	53t	58t	27t	Standard estimate
B_{beg} =	100t	42t	47t	22t	Adjusted estimate

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.

Due to uncertainty in the reliability of the $F_{0.1}$ values used to esimate CAY, the Shellfish Working Group (2014) recommended using an annual exploitation rate to estimate appropriate yield for the Marlborough Sounds stocks. An empirical exploitation rate of 22% of the biomass was recommended based on an analysis of the biomass trends relative to rates of exploitation in the Marlborough Sounds, over the last 14 years. The analysis suggested that during the period of increasing biomass, from 1999 to 2008, exploitation rate was on average at a level of 22%. However, during the period 2009-2014, when biomass was observed to be declining, the exploitation rate was higher at an average of 31% (Figure 3). This suggested that, at the broad spatial scale of the 7KK-7LL sectors combined, fishing at an exploitation rate of 22% tends to result in increasing biomass (avoids biomass declines). This approach of determining an appropriate target reference point for the fishery as the exploitation rate that avoids biomass declines is used in scallop fisheries in Atlantic Canada (Smith & Hubley 2012). Expressing each of the two estimates of CAY, derived from using F_{ref} = 0.55 or 0.63, as a proportion of the recruited scallop biomass equates to 'target' fishery removal exploitation rates (*E*, catch divided by recruited biomass) of E = 0.42 and 0.47, respectively

The estimate of yield, using an exploitation rate of 22%, is 27t and 22t for the Standard and Adjusted estimates of biomass respectively. More conservative yield estimates when compared to estimates using the CAY approach.

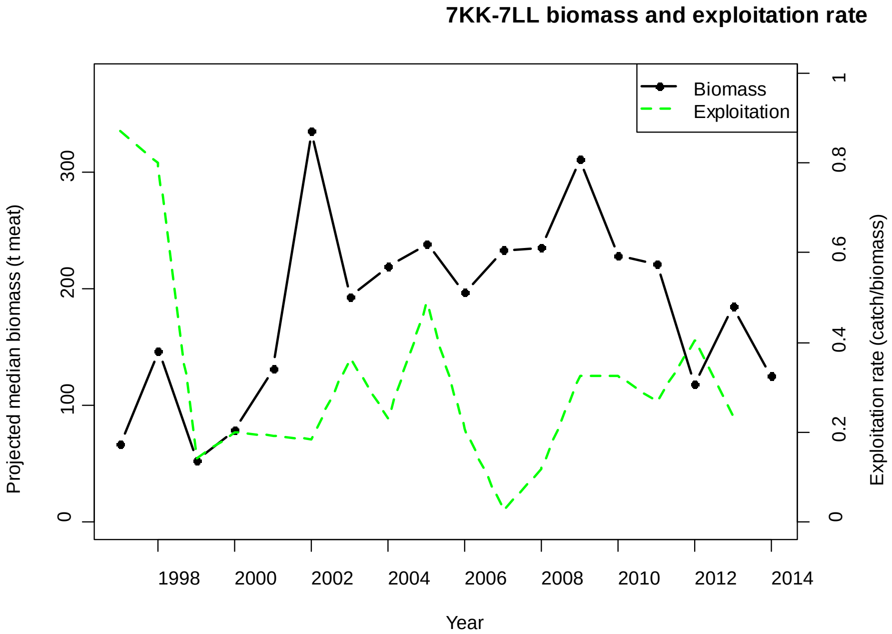


Figure 3: Trends in biomass and exploitation rate for the combined areas surveyed in sectors 7KK and 7LL in the Marlborough Sounds, 1997-2014.

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.

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

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

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 (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013).

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). 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

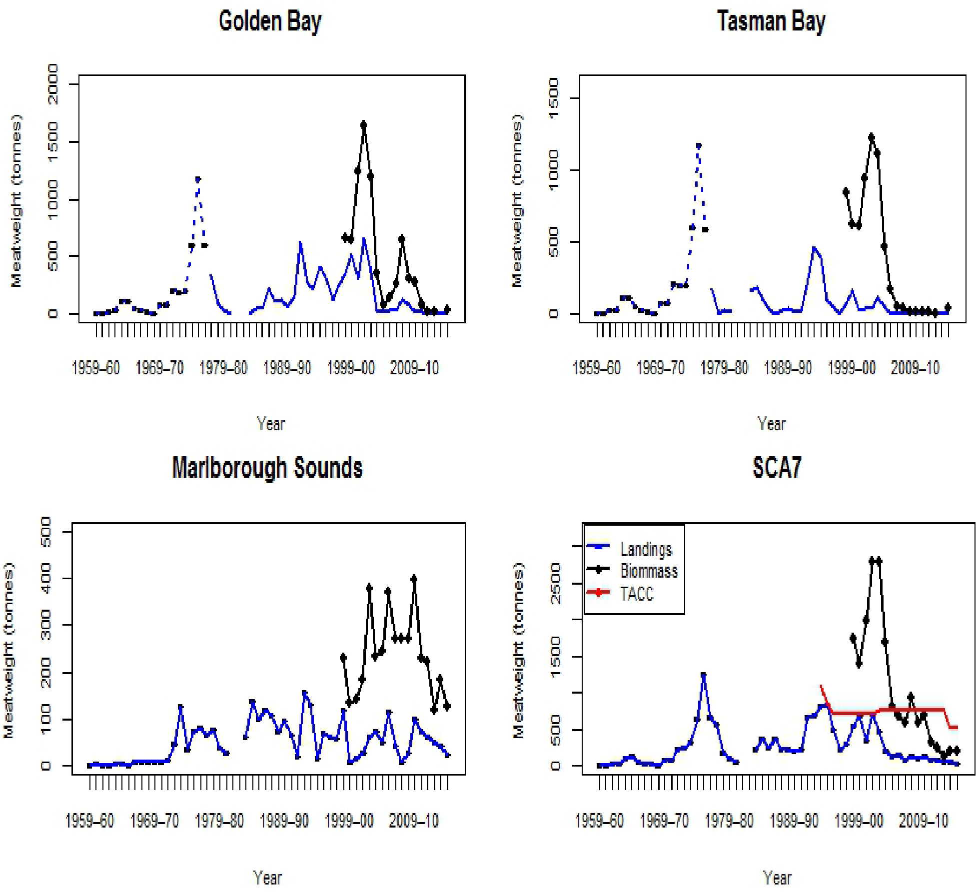
The stock structure of scallops in New Zealand waters is uncertain. For the purposes of this assessment and due to the different management regimes, Golden Bay, Tasman Bay and Marlborough Sounds are assumed to be individual and separate substocks of SCA 7.

- **Challenger scallops, SCA 7**

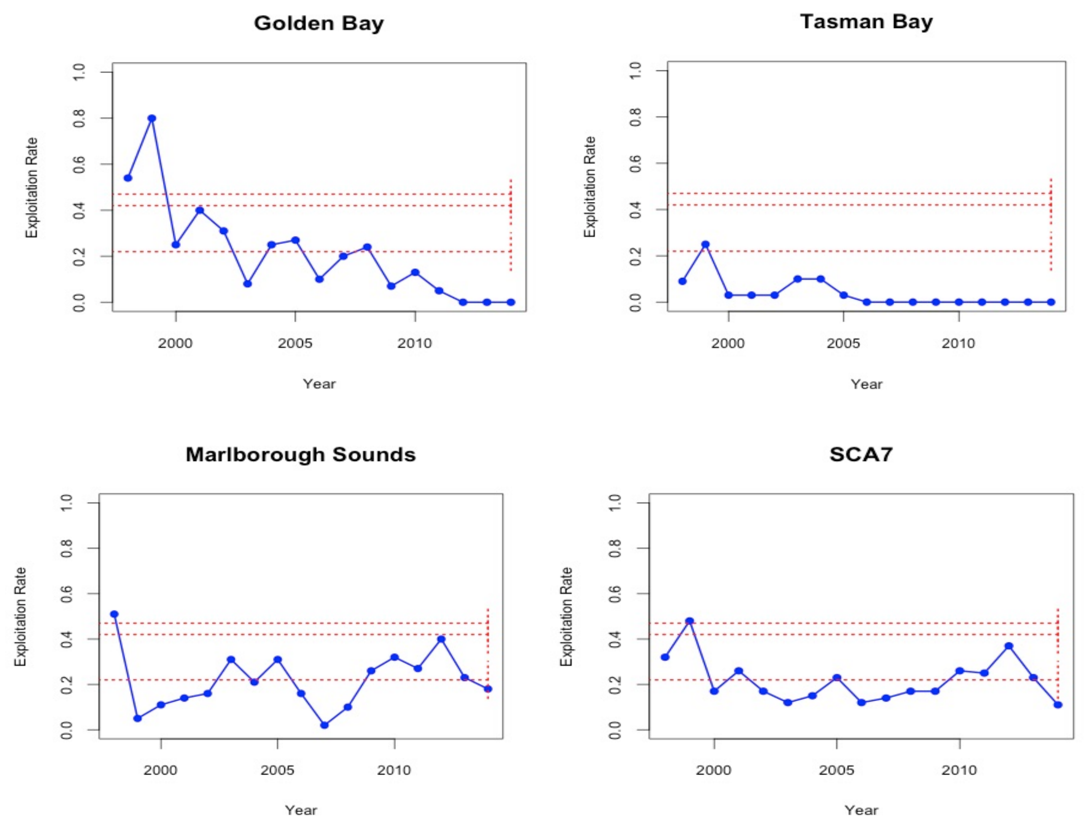
Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Marlborough Sounds: CAY estimated using two approaches. Yield also estimated using an agreed exploitation rate of 22%. Golden Bay and Tasman Bay: Estimates of biomass
Reference Points	Marlborough Sounds Target: Fishing mortality at or below $F_{0.1}$ ($F_{0.1}$ = 0.553 y^{-1} or 0.631 y^{-1} if M = 0.4 and 0.5, respectively) or, at or below an exploitation rate of 22% No targets have been set for Golden Bay or Tasman Bay All Regions: Soft Limit: 20% B_0

	Hard Limit: 10% B_0 Overfishing threshold: F_{MSY} or the equivalent exploitation rate
Status in relation to Target	Marlborough Sounds: About as Likely as Not (40-60%) to be at or below F_{target} Golden/Tasman Bays: Very Unlikely (< 40%) to be at or below F_{target}
Status in relation to Limits	Marlborough Sounds: Unknown Golden/Tasman Bays: Very Likely (> 90%) to be below the soft limit Likely (> 60%) to be below the hard limit
Status in relation to Overfishing	Marlborough Sounds: About as Likely as Not (40-60%) to be occurring Golden Bay and Tasman Bay: Unknown, due to lack of information about recreational catch

Historical Stock Status Trajectory and Current Status



Recruited (scallops 90 mm or more shell length) mean biomass estimates (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). 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.



Exploitation rate (catch divided by biomass) trends for recruited scallops by region and for the overall SCA 7 stock (solid blue lines). Horizontal lines show three 'Target' exploitation rates. The lower line is E=0.22. The top and middle lines are exploitation of 0.42 (middle 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.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Marlborough Sounds: Biomass has being overall been declining since 2009. In 2014 biomass was lower than the 2013 estimate but slightly higher than in 2012. Golden of Tasman Bays: No surveys were conducted in 2013 because of expected low abundance in these regions. In 2014 biomass may have increased slightly from the 2012 estimates. 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 an overall decline in biomass in all three regions, with Golden and Tasman Bays at very low levels.
Recent Trend in Fishing Intensity or Proxy	In Golden Bay, the commercial 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. In Tasman Bay, the peak commercial 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 commercial 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, increased to 40% in 2012–13 and dropped to 18% in the 2014-15 fishing year.
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Stock projections are not available. The 2014 survey suggested little sign of juvenile recruitment in Golden or Tasman Bays and a possible slight increase in the number of juveniles in the Marlborough Sounds. The low numbers of pre-recruit scallops (89 mm or smaller) in Golden Bay and Tasman Bay at the time of the 2014 survey suggests recruitment to the fishable biomass in those areas over the next two years is likely to be minimal.
Probability of Current Catch causing Biomass to remain below or to decline below Limits	Unknown for current catch, because recreational catch levels have not been quantified
Probability of TACC causing Biomass to remain below or to decline below Limits	Virtually Certain (> 99%) for the current TACC
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Virtually Certain (> 99%) for the current TACC

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Partial quantitative stock assessment	
Assessment Method	Biomass surveys and CAY and Exploitation rate management strategy	
Assessment Dates	Latest assessment: 2014	Next assessment: 2015
Overall Assessment Quality Rank	1 – High Quality	
Main data inputs (rank)	Biomass survey: 2014	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.

6. FOR FURTHER INFORMATION

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