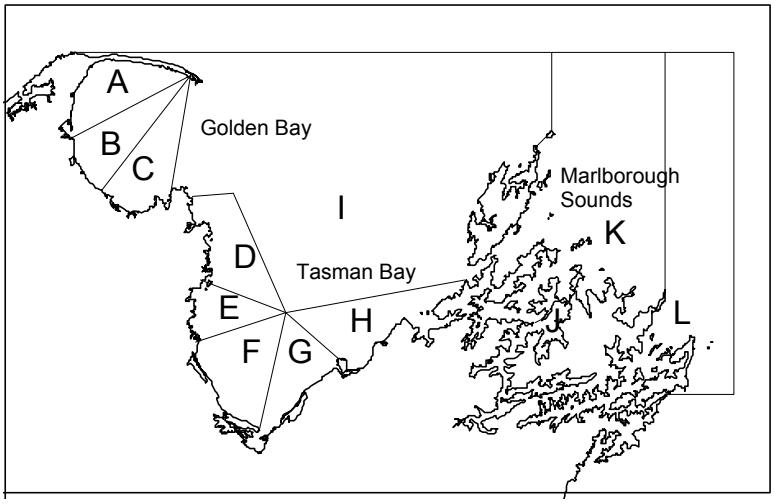
# SCALLOPS Nelson/Marlborough (SCA 7)

(*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; in 2014 the TACC was decreased to 400 t and an allowance of 40 t for other sources of fishing-related mortality was set within the TAC (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 |
| 2002–2013 | 827 | 40 | 40 | 0 | 747 |
| 2014–present | 520 | 40 | 40 | 40 | 400 |

### 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. Most of the management responsibilities for the fishery were transferred from government to industry in 1994 when the quota owners established the Challenger Scallop Enhancement Company Ltd. (CSEC) as the formal entity to self-govern the fishery subject to conditions agreed with the government. Key documents associated with CSEC self-governance of the fishery include a Memorandum of Understanding agreement (Ministry of Fisheries and CSEC 1998) and fisheries plans (CSEC 1998, 2005).

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 tonnes 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 SCA 7, 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.

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 risky, but constant exploitation rate strategies are close to optimal if the maximum rate is appropriate. Rotational fishing appears to be highly stabilising, even without enhancement; collapses occurred only when short rotation periods are combined with high fishing 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 fisheries sectors.

Over time the rotational fishing and stock enhancement management strategy has changed considerably. Rotational harvesting was formally implemented in the 1989–90 fishing year. For six years from 1989–90 to 1994–95, rotational fishing was almost entirely carried out at the sector level. In the next three years from 1995–96 to 1997–98 the sector level rotation began to break down (some fishing occurred in areas that would have been closed under sector-level rotation). From 1998–99 onwards, especially in Golden Bay, sector level rotation has not occurred and parts of sectors may be fished wherever scallops are available. In addition, reseeding activity has been significantly reduced. Annual dredge surveys, which estimate biomass levels and population size structure for each sector, 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.

CSEC submits, in consultation with MPI, a harvest plan for the Tasman/Golden Bays and the Marlborough Sounds regions of the fishery, to the Minister for approval by 15 July each year. 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 in recent years has usually occurred between September and November, although opening and closing dates are defined each year, and may differ between years. Historical landings and TACC changes are shown in Figure 1, Table 2 and Table 3.

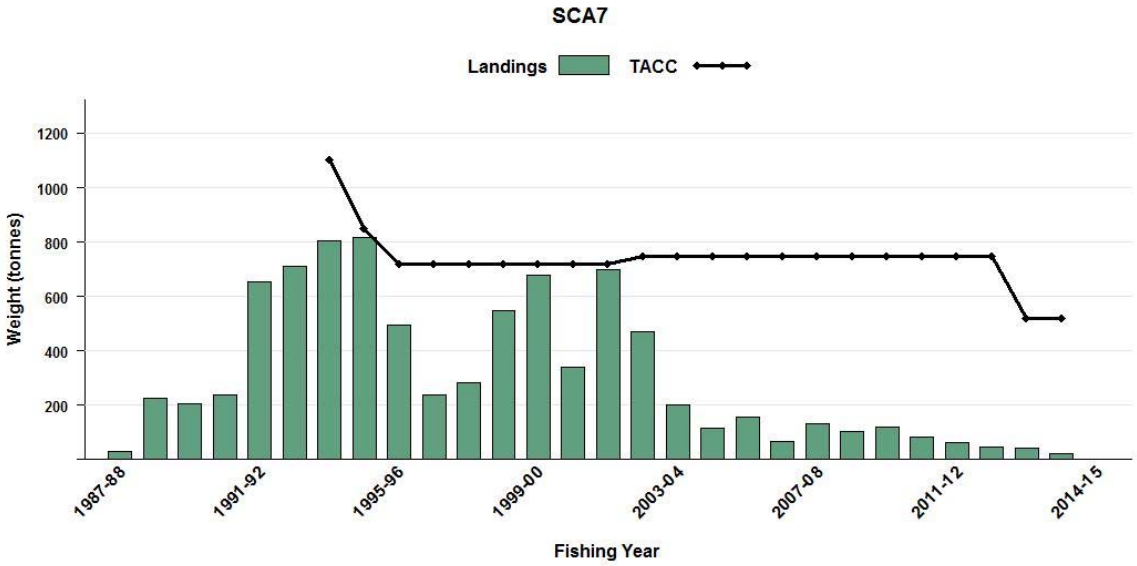



**Figure 1: Historical landings and TACC for SCA7 (Nelson Marlborough).**

**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 | 106 | – | 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 | 123 | – | 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 | 53 | – | 48 | 48 | – | 0 | 0 | 48 | 48 | CELR |
| 2013–14 | 747 | 48 | – | – | – | 43 | 0.2 | 0 | 43 | 43 | CSEC |
| 2014–15 | 400 | 30 | – | – | – | 22 | 0 | 0 | 22 | 22 | CSEC |
| 2015–16 | 400 | 23 | – | – | – | 22 | 0 | 0.8 | 21 | 22 | CSEC |

*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.

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.

## 1.2 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. CSEC consults with recreational fishers (and environmental interests) on the results of the annual biomass survey and the CSEC harvest proposals (including commercial closed areas) to seek agreement prior to submitting the Harvest Plan to the Minister. In recent years agreement has not been achieved.

Estimates of annual recreational scallop harvest from SCA 7 are shown in Table 4; note that 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. 2014) equate to about 7–18% of the commercial harvest in the areas surveyed in those years. The annual recreational harvest level is likely to vary substantially through time.

**Table 4: 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 that 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. (2014) |

## 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. Mortality of small scallops may be exacerbated by the use of dredge rings that are currently 60 mm in diameter as this may not match with the MLS of 90 mm. 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 that 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. Like other broadcast spawning marine invertebrates, scallops need to be in close proximity during spawning to ensure that sperm concentrations are sufficiently high to fertilise the eggs released; high density beds of scallops are disproportionately more important for fertilisation success during spawning. 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 grow to a shell length of about 60 mm in one year, and can reach 100 mm in about two to three years. This was typical of the pattern of growth that occurred under the initial 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 Bays 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 | $L_\infty$ | 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, 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 2009–15 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. In 2015 three surveys were conducted; a pre-fishing season survey in May (Williams et al. 2015a), an in-fishing season survey of key scallop beds in October (Williams et al. 2015b) and a post-fishing season survey in November (Williams et al. 2015c). The purpose of the November survey was to survey the accessible areas of the entire SCA 7 stock and not just survey those areas utilised by the commercial fishery, as is usually the case with the pre-fishing season surveys. With the exception of the in-season and post-season surveys in 2015, 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.**

| 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 | – | – |
| 2015 | 0.9 | 0.27 | 75 | 0.28 | – | – |

| 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 | 0.3 | 304 | 0.28 | – | – |
| 2015 | 9.2 | 0.26 | 724 | 0.26 | – | – |

# 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]**

| 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 | 0.2 | 886 | 0.21 | – | – |
| 2015 | 8.4 | 0.19 | 703 | 0.19 | – | – |

| Year | | | | | SCA 7 fishery total | |
|---|---|---|---|---|---|---|
| | RecN | RecN CV | RecG | RecG CV | Year | RecN |
| 1997 | 52.1 | 0.22 | 4 497 | 0.23 | 1997 | 52.1 |
| 1998 | 142.7 | 0.17 | 11 444 | 0.18 | 1998 | 142.7 |
| 1999 | 127.2 | 0.18 | 11 016 | 0.19 | 1999 | 127.2 |
| 2000 | 135.5 | 0.17 | 10 885 | 0.17 | 2000 | 135.5 |
| 2001 | 203.3 | 0.20 | 15 611 | 0.19 | 2001 | 203.3 |
| 2002 | 186.7 | 0.17 | 14 646 | 0.18 | 2002 | 186.7 |
| 2003 | 113.3 | 0.17 | 8 786 | 0.17 | 2003 | 113.3 |
| 2004 | 51.9 | 0.17 | 3 937 | 0.17 | 2004 | 51.9 |
| 2005 | 45.7 | 0.18 | 3 574 | 0.18 | 2005 | 45.7 |
| 2006 | 26.3 | 0.19 | 2 085 | 0.19 | 2006 | 26.3 |
| 2007 | 74.0 | 0.19 | 5 868 | 0.19 | 2007 | 74.0 |
| 2008 | 47.6 | 0.19 | 3 867 | 0.19 | 2008 | 47.6 |
| 2009 | 43.4 | 0.19 | 3 489 | 0.19 | 2009 | 43.4 |
| 2010 | 27.9 | 0.18 | 2 254 | 0.18 | 2010 | 27.9 |
| 2011 | 21.3 | 0.20 | 1 796 | 0.20 | 2011 | 21.3 |
| 2012 | 11.5 | 0.20 | 1 006 | 0.21 | 2012 | 11.5 |
| 2013 | 15.6 | 0.20 | 1265 | 0.21 | 2013 | 15.6 |
| 2014 | 17.4 | 0.2 | 1439 | 0.2 | 2014 | 17.4 |
| 2015 | 18.6 | 0.2 | 1514 | 0.2 | 2015 | 18.6 |

# 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.

## 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 CV) 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 | CV | Catch | Catch/Biomass | Biomass | CV | 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 |
| 2007 | 636 | 0.23 | 128 | 0.20 | 32 | 0.28 | 0 | 0 |
| 2008 | 313 | 0.22 | 76 | 0.24 | 15 | 0.31 | 0 | 0 |
| 2009 | 278 | 0.21 | 19 | 0.07 | 14 | 0.31 | 0 | 0 |
| 2010 | 78 | 0.27 | 10 | 0.13 | 15 | 0.27 | 0 | 0 |
| 2011 | 20 | 0.3 | 1 | 0.05 | 8 | 0.36 | 0 | 0 |
| 2012 | 9 | 0.39 | 0.2 | 0.02 | 5 | 0.42 | 0 | 0 |
| 2013 | – | – | 0 | 0 | – | – | 0 | 0 |
| 2014 | 33 | 0.25 | 0 | 0 | 37 | 0.28 | 0 | 0 |
| 2015 | 15 | 0.30 | 0 | 0 | 85 | 0.27 | 0.8 | 0.01 |

| Year | Marl. Sounds | | | | SCA 7 Total | | | |
|---|---|---|---|---|---|---|---|---|
| | Biomass | CV | Catch | Catch/Biomass | Biomass | CV | 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 | 0.36 |
| 2013 | 184 | 0.19 | 43 | 0.23 | 184 | 0.19 | 43 | 0.23 |
| 2014 | 125 | 0.20 | 22 | 0.17 | 196 | 0.19 | 22 | 0.11 |
| 2015 | 102 | 0.19 | 21 | 0.21 | 203 | 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.

In 2015, the post-season survey of the SCA 7 stock (Williams et al. 2015c) was conducted because of increasing concerns about the status of the SCA 7 fishery. The sample extent (survey coverage) covered all areas between at least 10 and 50 m depth that were appropriate to sample with a commercial dredge, and the survey stratification within these areas was based on multiple information layers. The survey design involved important engagement with fishery stakeholders within a very tight timeframe. A total of 318 valid stations (dredge tows) were sampled within 67 strata, with over 39 000 live scallops caught (Figure 2). As expected, the highest catches of recruited scallops (90 mm or larger) were from tows within key strata, primarily in the Marlborough Sounds, which represent the banks and bays that support the main scallop beds. Catches were generally low in other strata. There were minimal densities of recruited scallops outside of the previously surveyed areas, even though the extent of the November survey was over twice the area of that used in previous annual (May) surveys (e.g. Williams et al.

2015a). There were signs of recent juvenile recruitment, particularly in the Marlborough Sounds, that appeared to be stronger than normally seen in the May surveys, although comparisons are difficult to make as this could simply be a result of the different survey timing.

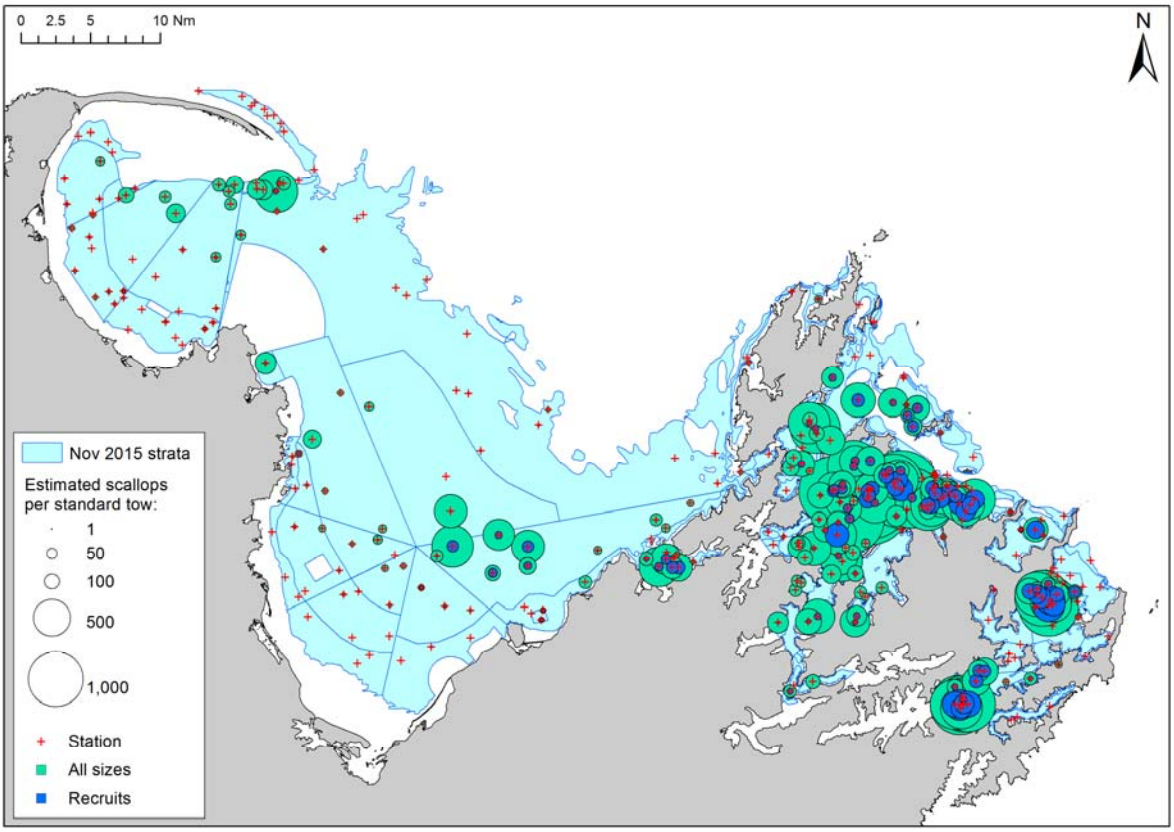



**Figure 2: Catch per standard tow, SCA 7 stock survey, November 2015. Circle area is proportional to the number of scallops caught per standard distance towed (0.4 n.miles). Dark blue shaded circles denote scallops of commercial recruited size (90 mm or larger), green shaded circles denote scallops of any size. Values are uncorrected for dredge efficiency. Polygons denote survey strata boundaries.**

The total recruited biomass in the SCA 7 area surveyed in November was 211 t (95% CI = 141–321 t, mean = 214 t, CV = 0.21) (Table 8). Recruited biomass was very sensitive to critical density thresholds (the exclusion of areas of low scallop density) (Figure 3). Excluding areas of very low density (below 0.04 $m^{-2}$), the SCA 7 biomass was 63 t meatweight, equating to only 30% of the total recruited biomass. Only small proportions of the recruited biomass were held in relatively high density scallop beds, which are particularly important for scallop stock productivity (i.e. larval production) as well as for fisheries utilisation. At the regional level, the Marlborough Sounds recruited biomass estimates gradually decreased as the critical threshold density was increased. Excluding areas where the density was less than 0.04 $m^{-2}$ reduced the Marlborough Sounds biomass to 50 t (45% of absolute biomass); using a critical density of 0.08 $m^{-2}$ reduced the biomass to 26 t (24% of the total recruited biomass) and using a high critical density of 0.2 $m^{-2}$ reduced the biomass to 5 t (4% of the total recruited biomass). The Tasman Bay recruited biomass estimates were more sensitive to the exclusion of areas of low scallop density, with only 12 t (15% of the total recruited biomass) remaining at a critical density of 0.04 $m^{-2}$, and no recruited biomass remaining at a critical density of 0.08 $m^{-2}$. The Golden Bay and 'GBTB Outer' estimates were the most sensitive to the exclusion of areas of low scallop density, with no recruited biomass remaining at a critical density of 0.04 $m^{-2}$.

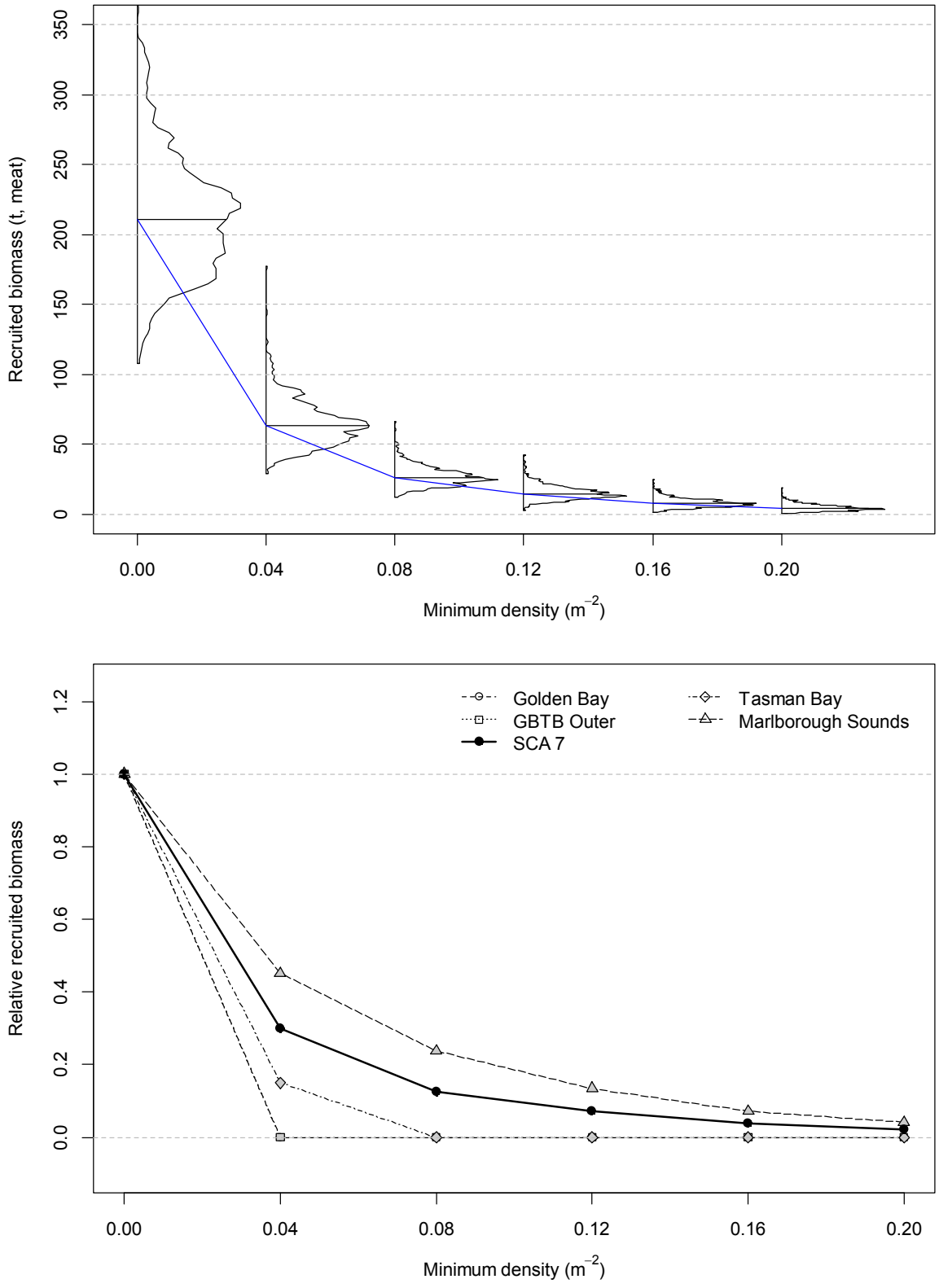



**Figure 3: Effect of excluding areas of low scallop density on recruited biomass, SCA 7, November 2015. Critical density corrections were applied after correcting for dredge efficiency. Top plot: for each minimum ('critical') density, the distribution and median (horizontal line) of the recruited biomass in SCA 7 are shown. Bottom plot: Trend in the proportion of the total recruited biomass with increasing critical density.**

**Table 8: Population estimates of scallops in SCA 7, November 2015. Estimates were produced for commercial size recruited scallops (90 mm or larger), assuming historical average dredge efficiency and predicting weight from length. The analysis used a non-parametric resampling with replacement approach to estimation (1000 bootstraps).**

| Grouping | Location | Area | Tows | Density (scallops.m$^{-2}$) | | | | Abundance (millions) | | | | Scallop weight (g) | | Biomass (t green) | | | | Biomass (t meat) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (km$^2$) | *n* | Mean | CV | Median | 95%CI | Mean | CV | Median | 95%CI | Mean | Median | Mean | CV | Median | 95%CI | Mean | CV | Median | 95%CI |
| ***RECRUITED*** | | | | | | | | | | | | | | | | | | | | | |
| Statistical Area | 7A | 89 | 12 | 0.001 | 0.76 | 0.001 | 0–0.002 | 0.077 | 0.76 | 0.071 | 0.003–0.211 | 83.4 | 83.2 | 6.4 | 0.79 | 5.9 | 0.2–18 | 0.9 | 0.79 | 0.8 | 0–2.5 |
| | 7B | 174 | 12 | 0.001 | 0.30 | 0.001 | 0.001–0.002 | 0.191 | 0.30 | 0.181 | 0.11–0.342 | 94.2 | 93.6 | 18.0 | 0.37 | 16.9 | 8.8–35.3 | 2.5 | 0.38 | 2.3 | 1.1–4.9 |
| | 7C | 217 | 17 | 0.002 | 0.36 | 0.002 | 0.001–0.004 | 0.504 | 0.36 | 0.483 | 0.212–0.915 | 83.7 | 84.3 | 42.2 | 0.37 | 40.7 | 17.9–76.6 | 5.8 | 0.36 | 5.6 | 2.4–10.5 |
| | 7I | 1279 | 43 | 0.001 | 0.48 | 0.001 | 0–0.001 | 0.771 | 0.48 | 0.733 | 0.18–1.637 | 76.3 | 76.0 | 58.8 | 0.48 | 55.7 | 13.9–126.7 | 6.9 | 0.48 | 6.5 | 1.7–14.6 |
| | 7D | 267 | 10 | 0.001 | 0.46 | 0.001 | 0–0.001 | 0.196 | 0.46 | 0.194 | 0–0.386 | 73.2 | 73.2 | 14.4 | 0.46 | 14.2 | 0–28 | 1.9 | 0.47 | 1.8 | 0–3.8 |
| | 7E | 131 | 10 | 0.002 | 0.39 | 0.002 | 0.001–0.003 | 0.217 | 0.39 | 0.211 | 0.069–0.41 | 92.0 | 91.3 | 20.0 | 0.40 | 19.3 | 6.2–37.5 | 2.6 | 0.40 | 2.5 | 0.8–5 |
| | 7F | 172 | 10 | 0.000 | 0.47 | 0.000 | 0–0 | 0.040 | 0.47 | 0.038 | 0.01–0.083 | 77.4 | 77.1 | 3.1 | 0.47 | 3.0 | 0.8–6.5 | 0.4 | 0.48 | 0.4 | 0.1–0.8 |
| | 7G | 167 | 6 | 0.004 | 0.53 | 0.003 | 0.001–0.008 | 0.606 | 0.53 | 0.554 | 0.2–1.357 | 111.1 | 111.1 | 67.3 | 0.49 | 61.6 | 25–143.1 | 8.9 | 0.50 | 8.0 | 3.3–19.6 |
| | 7H | 318 | 25 | 0.021 | 0.32 | 0.021 | 0.01–0.036 | 6.722 | 0.32 | 6.535 | 3.113–11.473 | 79.1 | 79.0 | 531.8 | 0.32 | 516.0 | 245.1–903 | 70.6 | 0.33 | 68.6 | 31.9–124.1 |
| | 7J | 95 | 17 | 0.005 | 0.31 | 0.005 | 0.002–0.008 | 0.452 | 0.31 | 0.440 | 0.215–0.767 | 74.9 | 75.0 | 33.8 | 0.31 | 33.0 | 16.5–56.8 | 4.4 | 0.32 | 4.3 | 2.1–7.6 |
| | 7K | 426 | 108 | 0.018 | 0.27 | 0.017 | 0.01–0.029 | 7.576 | 0.27 | 7.336 | 4.407–12.421 | 80.1 | 80.2 | 607.0 | 0.27 | 588.3 | 355.3–989.2 | 79.6 | 0.27 | 76.7 | 46.5–132.6 |
| | 7L | 180 | 48 | 0.016 | 0.23 | 0.016 | 0.01–0.024 | 2.882 | 0.23 | 2.824 | 1.848–4.257 | 79.5 | 79.2 | 229.1 | 0.23 | 223.8 | 147.8–339.9 | 30.0 | 0.23 | 29.3 | 18.8–46 |
| Region | GB | 480 | 41 | 0.002 | 0.29 | 0.002 | 0.001–0.003 | 0.772 | 0.29 | 0.751 | 0.411–1.275 | 86.3 | 85.4 | 66.6 | 0.29 | 64.2 | 34.9–112.5 | 9.2 | 0.31 | 8.8 | 4.6–15.6 |
| | GBTB | 1279 | 43 | 0.001 | 0.48 | 0.001 | 0–0.001 | 0.771 | 0.48 | 0.733 | 0.18–1.637 | 76.3 | 76.0 | 58.8 | 0.48 | 55.7 | 13.9–126.7 | 6.9 | 0.49 | 6.5 | 1.6–14.9 |
| | TB | 1055 | 61 | 0.007 | 0.29 | 0.007 | 0.004–0.012 | 7.781 | 0.29 | 7.521 | 4.036–12.968 | 81.8 | 81.6 | 636.5 | 0.29 | 613.6 | 332.5–1062 | 83.8 | 0.29 | 80.7 | 43.3–140.5 |
| | MS | 702 | 173 | 0.016 | 0.23 | 0.015 | 0.01–0.024 | 10.909 | 0.23 | 10.656 | 6.964–16.526 | 79.7 | 79.9 | 869.9 | 0.22 | 851.4 | 560.1–1331.5 | 114.3 | 0.23 | 111.3 | 73.6–173.3 |
| Stock | SCA 7 | 3514 | 318 | 0.006 | 0.21 | 0.006 | 0.004–0.009 | 20.233 | 0.21 | 19.783 | 13.308–30.218 | 80.7 | 80.3 | 1631.9 | 0.21 | 1588.6 | 1087.6–2440.6 | 214.2 | 0.21 | 210.7 | 141–320.7 |

Overall the SCA 7 stock continues to decline, and stock status appears to be at the lowest recorded level (Figure 4). Recruited biomass in Golden Bay and Tasman Bay sectors D–G remains at very low levels since the large declines occurred in the 2000s, and although there was some recruited biomass in Tasman Bay sector H it was generally held at low density. Recruited biomass in the Marlborough Sounds is restricted to a small number of areas mainly in the outer Sounds, and overall has continued to follow a declining trend since 2009. Recent commercial fishing (22 t in the 2015 season) has been limited almost exclusively to a few specified areas in the Marlborough Sounds. The level of recreational harvest in most years is unknown. The commercial exploitation rate in 2015 in the Marlborough Sounds was 21%, in line with the target exploitation rate of 22% associated with an increasing biomass observed between 1999 and 2008 (see Section 4.4). A minimum reference level has not been established for SCA 7, and, because spatial scale is inherently important in scallop population dynamics and fisheries, a single minimum reference level for the stock would be unsuitable. It is clear, however, that the stocks in Golden and Tasman Bays are well below desirable minimum levels, and the stock in the overall Marlborough Sounds is at the lowest recorded level in the survey time series.

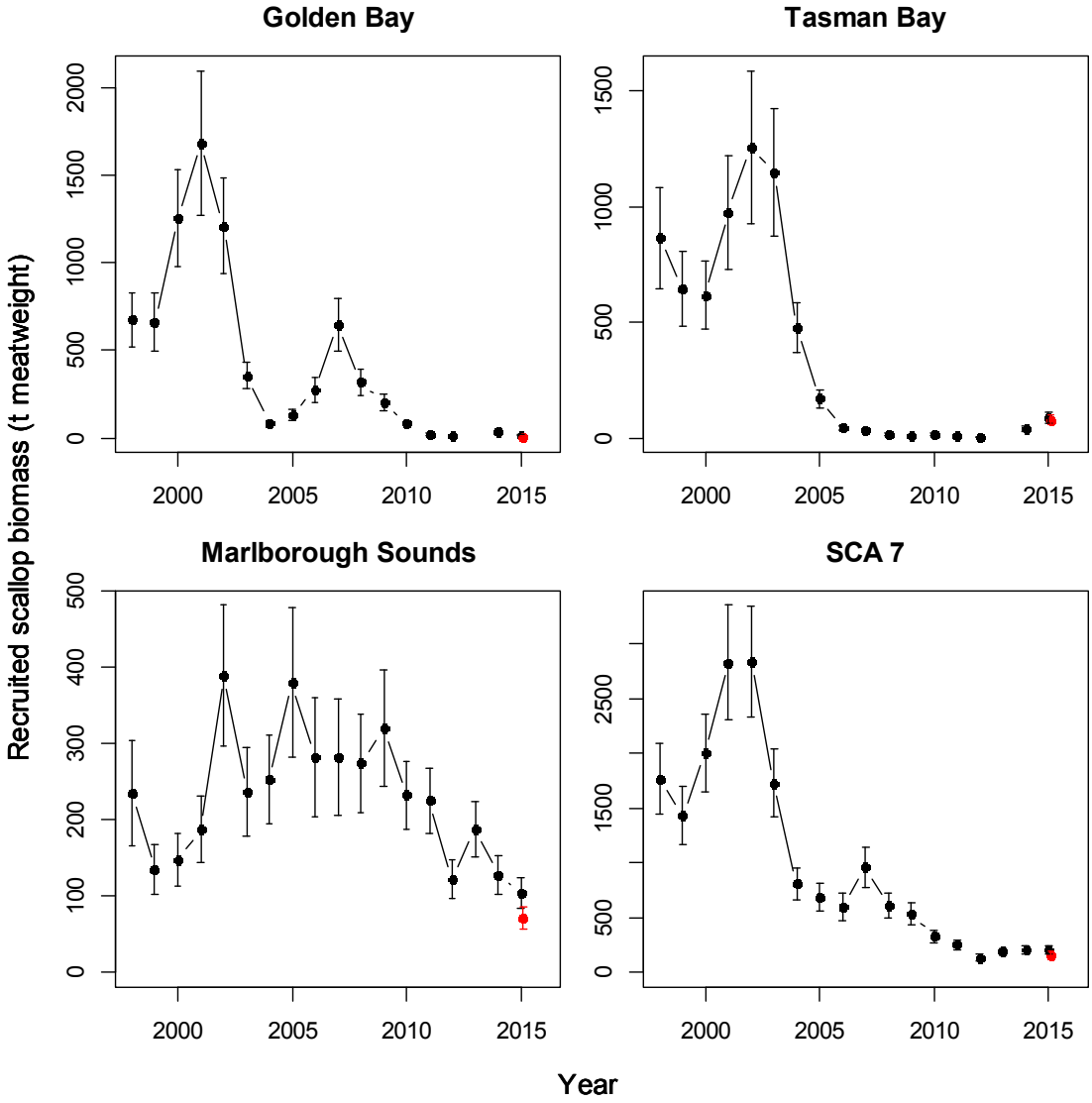



**Figure 4: Trends in projected start of season recruited scallop biomass (t meatweight) by region and for the total SCA 7 stock, 1998–2015. Estimates from the November 2015 survey (for the same strata as those surveyed in May 2015) are also shown as red symbols slightly offset from the May 2015 points. Values are the estimated mean and CV of the recruited biomass. Note: Golden and Tasman Bays were not surveyed in 2013.**

### 4.3 Estimation of Maximum Constant Yield (MCY)

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.

### 4.4 Estimation of Target Harvest (Exploitation) Rate

Historically, Current Annual Yield (CAY) has not been estimated for Golden and Tasman Bays because those areas are managed under section 14 of the Fisheries Act 1996.

For the Marlborough Sounds, CAY has historically been estimated using $F_{0.1}$ as the reference fishing mortality. Estimates of $F_{0.1}$ have been high and the Plenary agreed that this has resulted in overestimation of potential yield, particularly when fishing tends to focus on a small proportion of the biomass. The agreed new approach is to calculate an empirical target harvest (exploitation) rate based on a period when the Marlborough Sounds biomass was stable or increasing (i.e. the aim is to avoid harvest rates that tend to lead to biomass decline). The current estimate of this target is a harvest rate (catch to biomass ratio) of 0.22, which is the mean harvest rate in the period 1999–2008 (Figure 5).

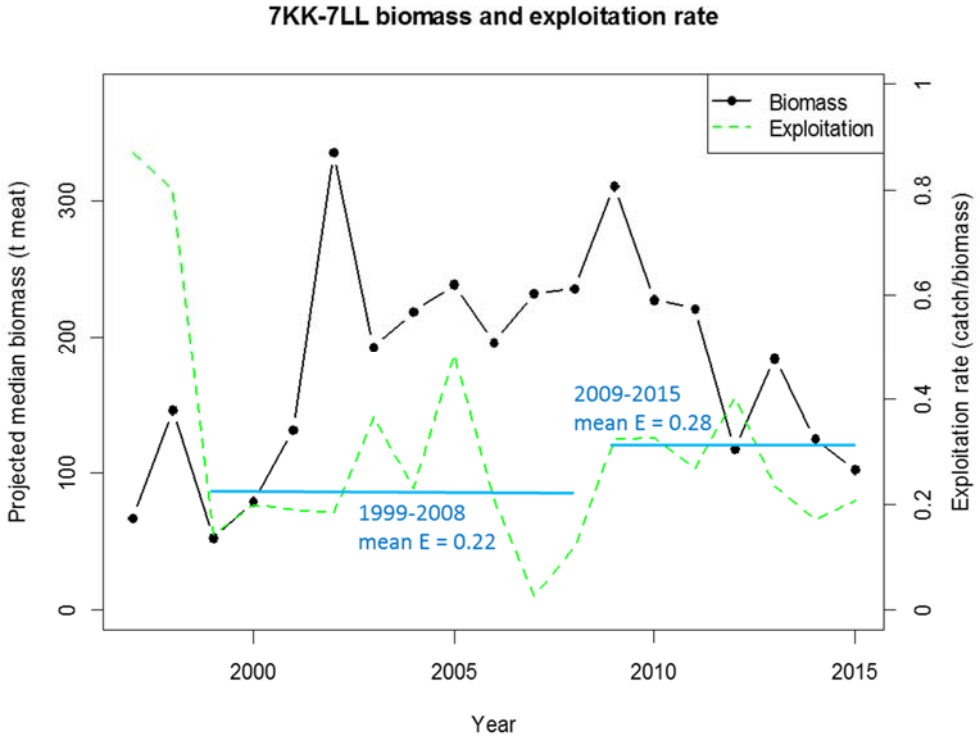



**Figure 5: Trends in biomass and harvest (exploitation) rate for the combined areas surveyed in sectors 7KK and 7LL in the Marlborough Sounds, 1997–2015. Mean harvest (exploitation) rate was 0.22 from 1999 to 2008 (associated with increasing biomass trend 1999 to 2009), and was 0.29 from 2009 to 2014 (associated with decreasing biomass trend 2009 to 2014).**

## 5. STATUS OF THE STOCKS

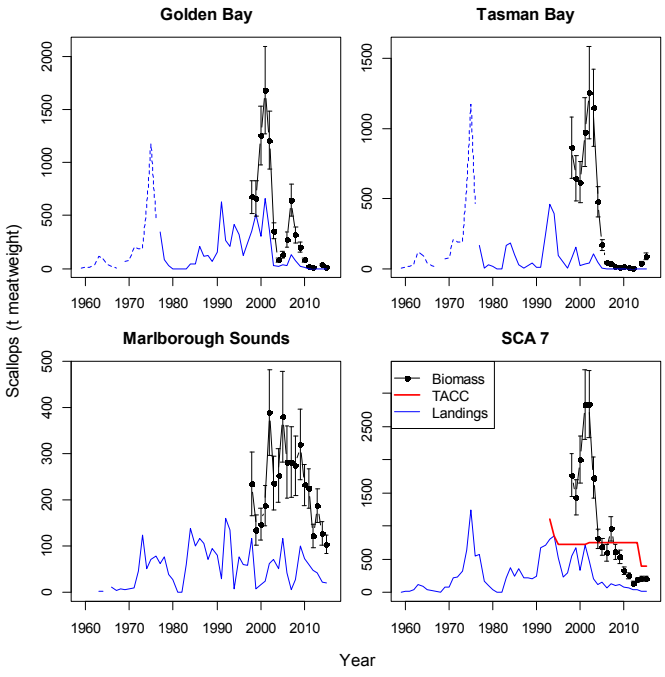
**Stock Structure Assumptions**

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.

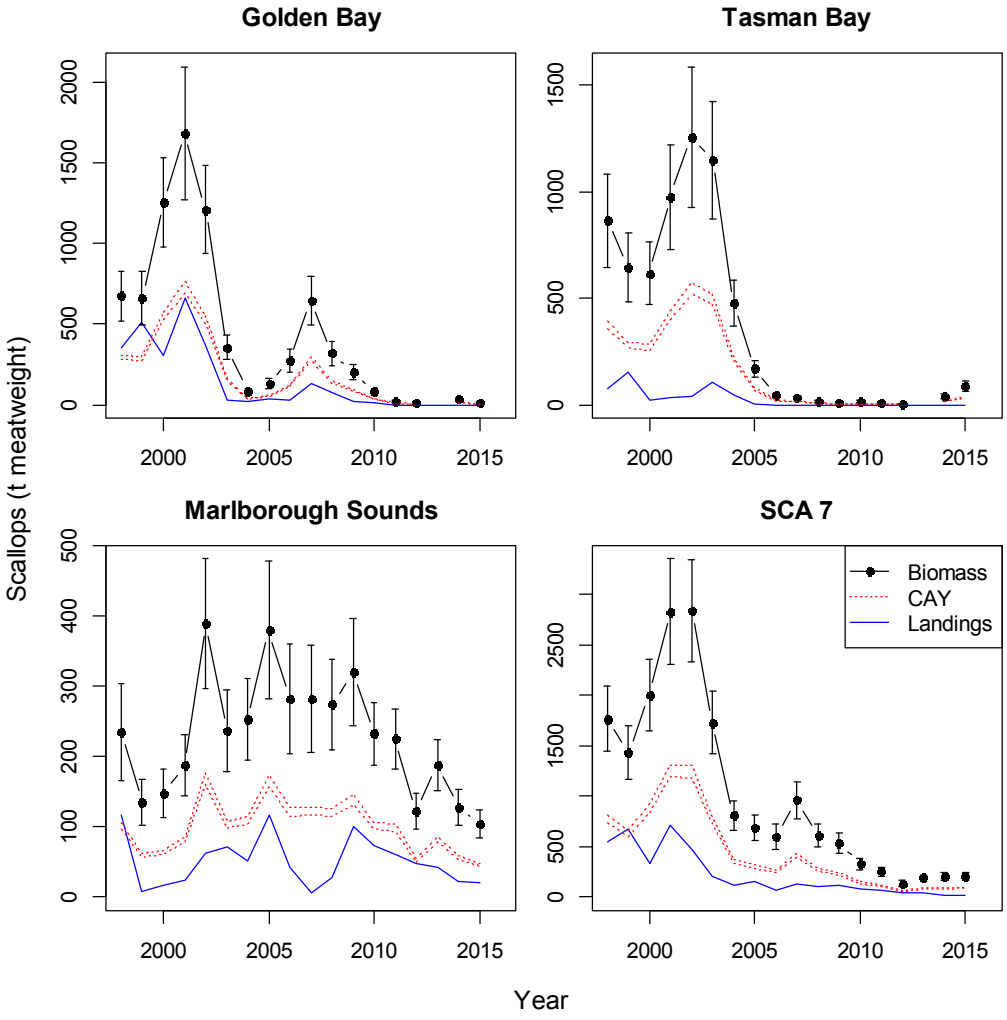
- **Challenger scallops, SCA 7**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2015 |
| Assessment Runs Presented | Biomass estimates for all areas up to 2015: Marlborough Sounds, Golden Bay and Tasman Bay |
| Reference Points | Target: Empirical target harvest (exploitation) rate: $U_{target}$ = 0.22 for Marlborough Sounds<br>No targets have been set for Golden Bay or Tasman Bay; $B_{MSY}$ assumed<br>Soft Limit: 20% $B_0$<br>Hard Limit: 10% $B_0$ |
| Status in relation to Target | About as Likely as Not (40–60%) to be at or above $U_{target}$ for Marlborough Sounds.<br>Very Unlikely (< 10%) to be at or above the biomass target for Golden Bay or Tasman Bay. |
| Status in relation to Limits | Unknown for the soft and hard limits for Marlborough Sounds<br>Very Likely (> 90%) to be below the soft limit for Golden Bay and Tasman Bay<br>Likely (> 60%) to be below the soft and hard limits for Golden Bay and Tasman Bay. |
| Status in relation to Overfishing | Overfishing is About as Likely as Not (40–60%) to be occurring in the Marlborough Sounds; Unknown for the other areas due to an unknown amount of non-commercial catch |

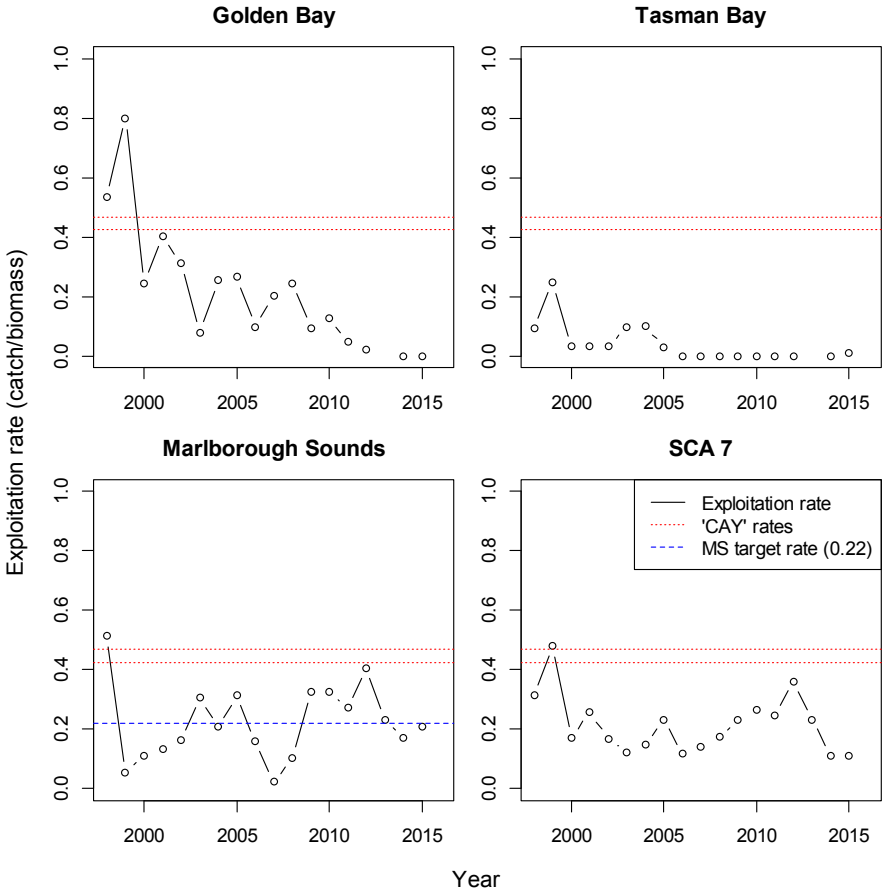
**Historical Stock Status Trajectory and Current Status**




**Recruited (scallops 90 mm or more shell length) mean (and CV 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). 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 that 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.**




**Harvest or exploitation rate (catch divided by biomass) trends for recruited scallops by region and for the overall SCA 7 stock (solid black lines). The upper two horizontal dotted lines show two 'CAY' exploitation rates of 0.47 and 0.42 representing two estimates of CAY expressed as proportions of the recruited biomass; these 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 are too high. For the Marlborough Sounds, the target harvest rate of 0.22 is shown as a horizontal dashed line; this target has been in place since 2014.**

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | Marlborough Sounds has continued to decline since about 2009 and is currently at its lowest recorded level. Golden Bay continues to be extremely low with no indication of rebuilding. Tasman Bay continues to be extremely low but slightly increasing. |
| Recent Trend in Fishing Intensity or Proxy | In the Marlborough Sounds, the estimated harvest rate (catch to recruited biomass ratio) was high at 51% in 1998 but dropped to 5% in 1999, followed by a general increase to reach 31% in 2005. The harvest rate subsequently decreased to 2% in 2007, followed by an increasing trend to reach 40% in 2012. In the years 2013 to 2015 it was in the range 17–23%.<br><br>In Golden Bay, the harvest rate 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. No |

| | |
|---|---|
| | fishing has occurred in Golden Bay since the 2012 fishing season.<br><br>In Tasman Bay, the peak harvest rate in the time series was 25% in 1999, but otherwise has been relatively low. No fishing occurred in Tasman Bay between 2006 and 2014, and there was minimal (exploratory) fishing in Tasman Bay in 2015 (harvest rate of 1%). |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicator or Variables | - |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Stock projections are not available. The success of natural settlement, survivorship on the seabed and the magnitude of incidental mortality are unknown |
| Probability of Current Catch or TAC causing Biomass to remain below or to decline below Limits | Soft Limit: Unknown<br>Hard Limit: Unknown |
| Probability of Current Catch or TAC causing Overfishing to continue or commence | About as Likely as Not (40–60%) for current catch for Marlborough Sounds; Unknown for current catches in Golden and Tasman Bays due to unknown size of recreational catch; Virtually Certain (> 99%) for the current TAC |

| **Assessment Methodology and Evaluation** | | |
|---|---|---|
| Assessment Type | Level 2 - Partial Quantitative Stock Assessment | |
| Assessment Method | Biomass surveys | |
| Assessment Dates | Latest assessment: 2015 | Next assessment: unknown |
| Overall Assessment Quality Rank | 1 – High Quality | |
| Main data inputs (rank) | Biomass survey: 2015 | 1 – High Quality |
| Data not used (rank) | N/A | |
| Changes to Model Structure and Assumptions | - Use of an empirical harvest rate ($U_{target}$) in preference to $F_{0.1}$ | |
| Major Sources of Uncertainty | - dredge efficiency (catchability and selectivity) during the survey<br>- growth rates and natural mortality between the survey and the start of the season<br>- predicting the average recovery of meatweight from greenweight for the time of the fishing season<br>- the spatial scale at which the assessment is conducted (currently, the target harvest rate is calculated at a broad scale using estimates of absolute biomass, but fishing occurs only in a few high density scallop beds that support productive fishing, and are also likely to be the most important spawning beds)<br>- the extent to which dredging causes incidental mortality and affects recruitment<br>- appropriate limit reference points for scallops | |

| Qualifying Comments |
| --- |
| The extent to which the various beds or populations are reproductively or functionally separate is not known.<br><br>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. Declines in stocks of other shellfish (oysters, mussels) have also been observed in Golden Bay and Tasman Bay. |
| **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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