DREDGE OYSTERS (OYS 7) – Nelson/Marlborough

(*Ostrea chilensis*)

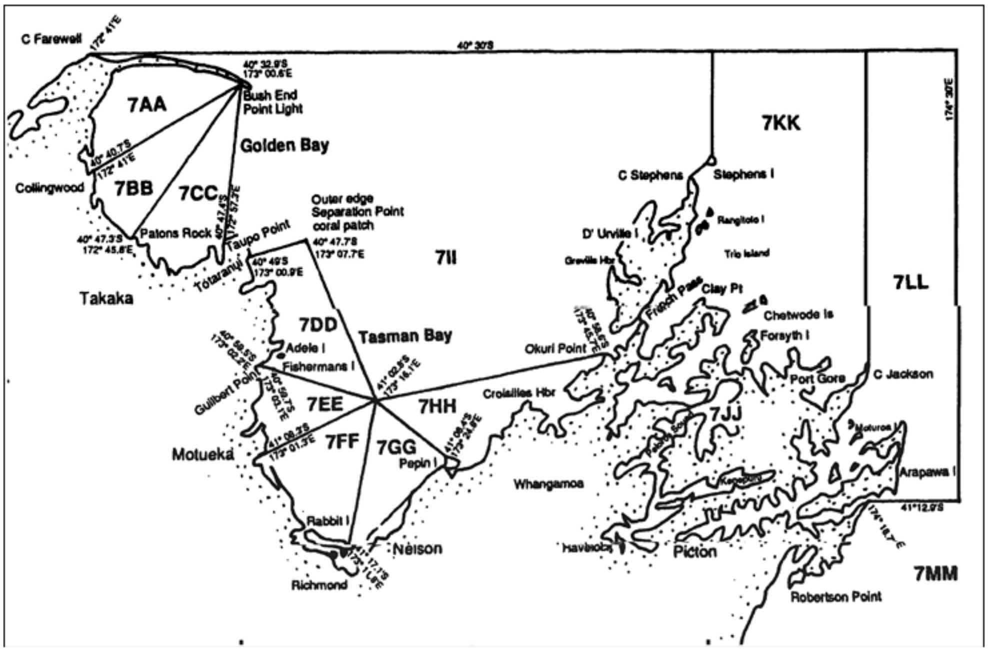


Figure 1: **Nelson/Marlborough dredge oyster (OYS 7) stock boundaries and statistical areas.**

1. FISHERY SUMMARY

OYS 7 (also referred to as the Challenger fishery) comprises 12 sectors (statistical reporting areas 7AA to 7LL, as seen in Figure 1) spanning across the Nelson/Marlborough area from Cape Farewell in the north, throughout Golden Bay, Tasman Bay, and the Marlborough Sounds, to West Head, Tory Channel in the south. OYS 7 is considered a separate fishery from OYS 7C (West Head, Tory Channel to Clarence Point) on the basis of differences in habitat and environmental parameters. OYS 7 was introduced into the QMS on 1 October 1996 with a TACC of 505 t. There is no Total Allowable Catch for this fishery (Table 1).

Table 1: Total Allowable Commercial Catch (TACC, t) declared for OYS 7 since introduction into the QMS in 1996. There is no Total Allowable Catch (TAC), and no allowances for customary fishing, recreational fishing, or for other fishing mortality (–).

Year	TAC	Customary	Recreational	Other mortality	TACC
1996–present	–	–	–	–	505

1.1 Commercial fishery

Dredge oysters in the Nelson/Marlborough area were first exploited in 1845. From 1963 to 1981 oysters were landed mainly as bycatch, first by the green-lipped mussel (*Perna canaliculus*) dredge fishery and subsequently by the scallop (*Pecten novaezelandiae*) dredge fishery (Drummond 1994a). In 1981 the Challenger scallop fishery was closed, and commercial dredge operators started targeting oysters.

Shellfish dredging in Tasman Bay, Golden Bay, and the Marlborough Sounds became a multi-species fishery with oysters, scallops, and green-lipped mussels caught together. Until 1999, oyster and scallop seasons did not overlap, and this prevented both species being landed together. Since then, a relaxation of seasonal restrictions has meant there is now potential for the seasons to overlap.

In 1983, fishery regulations and effort restrictions were updated (Drummond 1994a). Fishery regulations included a minimum size (legal sized oysters could not pass through a 58-mm internal diameter ring), an open season (1 March to 31 August), area closures, and a prohibition on dredging at night. A 500 t (greenweight) catch restriction was implemented for Tasman Bay in 1986 and extended to include Golden Bay in 1987 (Drummond 1987). The 500 t catch restriction was revoked in 1996 and a TACC of 505 t was set when oysters were brought into the Quota Management System. The commercial oyster season was extended to 12 months in 1999 and the revoked with the 6-month season now applying. Since 1 October 1999 catch has been reported by fishing year, which runs from 1 October to 30 September. Fishers had been required to land all legal sized oysters, but approval was given to return oysters to the sea as long as they were likely to survive.

From 1980, catches of oysters from Tasman Bay, Golden Bay, and the Marlborough Sounds were recorded on weekly dredge forms for each Shellfish Management Area. In 1992, the Nelson/Marlborough dredge oyster statistical areas were established (see Figure 1) by adopting the same reporting areas used by the scallop fishery. Prior to 1999, when the oyster season ran from 1 March to 31 August, catch data were presented by calendar year (see Table 3). Thereafter reported landings are given by fishing year, 1 October to 30 September. Data from 1989 to 1999 show oysters landed out of season and these data have been included in the summaries given in Tables 2–4. Most of the catch in OYS 7 comes from Tasman Bay, with small landings from Golden Bay.

In recent years, the industry has voluntarily restricted catch levels according to the biomass and distribution of the population estimated in the annual biomass survey and the economics of catch per unit effort during the season. Landings are reported in greenweight and have been negligible since 2008–09 (see Figure 2).

Table 2: Reported and adjusted catch (t, greenweight) in the Challenger fishery, 1963–88 (from Annala et al. 2001). Sourced from MAF Marine Dept. Report on Fisheries between 1963 and 1980, the FSU database between 1981 and 1986, and Quota Management System (QMS) in 1987 and 1988. Catches are adjusted to account for non-reporting of factory reject oysters (16.2% by number) and use of an incorrect conversion factor.

Year	Reported catch	Adjusted catch	Year	Reported catch	Adjusted catch	Year	Reported catch	Adjusted catch
1963	3	3	1972	65	82	1981	389	492
1964	6	8	1973	190	240	1982	432	546
1965	0	0	1974	78	99	1983	593	750
1966	24	33	1975	136	172	1984	259	328
1967	44	57	1976	392	496	1985	405	512
1968	69	87	1977	212	268	1986	527	667
1969	22	28	1978	40	51	1987	380	–
1970	74	94	1979	83	105	1988	256	–
1971	34	43	1980	160	202			

Table 3: Reported landings (t, greenweight) in the Challenger fishery for the 1989–99 oyster seasons (1 March–31 August). Data were extracted from Fisheries New Zealand database and were originally reported on Quota Monitoring Returns (QMR).

Year	QMR	Year	QMR
1989	538	1995	694
1990	206	1996	572
1991	187	1997	447
1992	290	1998	436
1993	476	1999	335
1994	584		

Table 4: Reported landings (t, greenweight) in the Challenger fishery after October 1999 when the fishing season was extended to a full year (1 October–30 September). Data were extracted from Fisheries New Zealand database and were originally reported on Quota Monitoring Returns (QMR) for 1999–00 and 2000–01 and on Monthly Harvest Returns (MHR) thereafter.

Fishing year	QMR	MHR	Fishing year	QMR	MHR
1999–00	132	–	2012–13	–	0.0
2000–01	25	–	2013–14	–	1.37
2001–02	–	1.4	2014–15	–	0.094
2002–03	–	183.0	2015–16	–	0.3
2003–04	–	97.5	2016–17	–	0.1
2004–05	–	146.8	2017–18	–	0
2005–06	–	170.9	2018–19	–	0
2006–07	–	132.1	2019–20	–	0
2007–08	–	21.0	2020–21	–	0
2008–09	–	< 0.1	2021–22	–	0
2009–10	–	0.0	2022–23	–	0
2010–11	–	5.9	2023–24	–	0
2011–12	–	0.0	2024–25	–	0

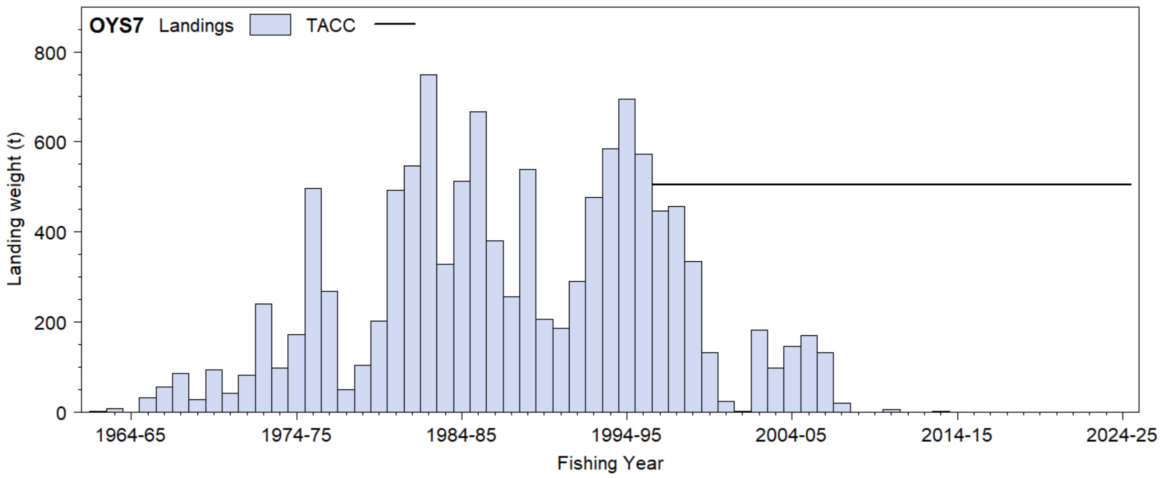


Figure 2: Landings of oysters from OYS 7 (t, green weight) from 1962-63 to present. Oyster season 1 March to 31 August for years 1963 to 1999. No seasonal restrictions from the 1999−2000 fishing year (October stock). Adjusted catch 1963−86; reported catch 1987−88; Quota Monitoring Returns (QMR) 1989–2001; and Monthly Harvest Returns (MHR) 2002 to present. TACC from 1995–96.

1.2 Recreational fishery

The recreational daily bag limit for oysters in the Challenger fishery area is 50 per person. Oysters that cannot pass through a 58-mm internal diameter solid ring are deemed legal size. The recreational season for dredge oysters in the Challenger area is all year round. Oysters must be landed in their shells. Recreational fishers take oysters in Tasman Bay and Golden Bay by diving and dredging. Estimates of recreational harvest of all species combined, including harvest reported using generic descriptions such as 'oysters' from various surveys, are given in Table 5. Harvest aggregated across species of oysters is given here because some surveys did not differentiate between species and others included a large proportion of total harvest recorded against generic codes.

1.3 Customary fisheries

There are no data available on the customary catch.

1.4 Unreported catch

There is no quantitative information on the level of unreported catch.

Table 5: Estimated numbers of oysters (all species combined) harvested by recreational fishers in OYS 7, excluding s111 approvals. Estimates are from telephone-diary survey in 1991–92, 1996, 1999–00, and 2000–01, from an access point interview survey in 2003–04 (CV is approximate), and from the national panel surveys in 2011–12, 2017–18 and 2022–23.

Survey	Numbers	CV	Reference
1991–92	38 000	0.33	Teirney et al. (1997)
1996	182 000	–	Bradford (1998)
1999–00	114 000	0.52	Boyd & Reilly (2004)
2000–01	80 000	0.46	Boyd et al. (2004)
2003–04	5 800	0.22	Cole et al. (2006)
2011–12	13 523	0.76	Wynne-Jones et al. (2014)
2017–18	3 477	1.00	Wynne-Jones et al. (2019)
2022–23	847	0.73	Heinemann & Gray (2024)

1.5 Other sources of mortality

The Nelson/Marlborough area occasionally experiences blooms of diatoms, which result in an anaerobic slime that smothers benthic fauna (Tunbridge 1962, Mackenzie et al. 1983, Bradford 1998). The level of dredge oyster mortality from this source is unknown.

Bonamia exitiosa (Bonamia) is a haemocritic, haplosporid parasite (infects mainly haemocytes or blood cells) of flat oysters and is known to infect *Ostrea chilensis* in New Zealand and Chile and various other species of *Ostrea* in other countries. Bonamia has caused catastrophic mortality in the Foveaux Strait oyster fishery and is endemic in oysters in the OYS 7 area (Hine, pers. comm.). Apicomplexa has also been identified in poor-condition oysters dredged from Tasman Bay. Apicomplexa is a group of obligate pathogens that are thought to predispose oysters to infection by Bonamia. The level of mortality caused by disease agents in OYS 7 is unknown.

Drummond & Bull (1993) reported some incidental mortality from dredging. No other data are available on incidental mortality of oysters in OYS 7 caused by fishing. A study on incidental mortality of oysters was completed by Cranfield et al. (1997); however, this work was specific to the Foveaux Strait oyster fishery so may or may not have relevance to OYS 7.

2. BIOLOGY

The biology of *O. chilensis* was summarised by Handley & Michael (2001), and further biological data were presented by Brown et al. (2008). Most of the parameters required for management purposes are based on the Foveaux Strait fishery described by Cranfield & Allen (1979).

Oysters in OYS 7 (Tasman Bay) tend to be uniformly distributed at a lower density on muddy habitat. Environmental factors such as hydrodynamics, seasonal water temperature, and riverine inputs differ substantially among the OYS 7, OYS 7C, and OYU 5 areas and these factors will influence the biological characteristics of these oyster populations.

Oyster stocks in the OYS 7 area are generally low and seasonally variable, suggesting high variability in recruitment (Osborne 1999). Challenger oysters are reported to spawn at temperatures above 12 °C (Brown et al. 2008). Compared with the Foveaux Strait fishery, in Tasman Bay and Golden Bay significantly smaller and less developed larvae have been collected in the plankton, implying that Challenger oysters appear to release their larvae into the plankton for longer periods (Cranfield & Michael 1989). Cranfield & Michael (1989) estimated that the larvae could disperse 20 km in 5–12 days, but a more recent study concluded that, although a small proportion may travel several kilometres, the majority of the larvae disperse no further than a few hundred metres from the parent population (Brown et al. 2008). Tunbridge (1962), Stead (1976), and Drummond (1994a) all pointed out that the productivity of the fishery is likely to be limited by a paucity of settlement substrate in the soft sediment habitat of Tasman Bay and Golden Bay. Brown et al. (2008) demonstrated increased oyster productivity where shell material was placed on the seabed as a settlement substrate for oyster larvae, and oyster productivity was higher in areas enhanced with brood stock.

The variability in shell shapes and high variability in growth rate between individuals, between areas within the OYS 7 fishery, and between years, require careful consideration in describing growth. Assuming that the minimum legal size of oysters could range in diameter (1/2 length + height) from 58 mm to 65 mm, data from Drummond (1994b) indicated that Tasman Bay oysters could grow to legal size in two to three years. Modelling of limited data from Tasman Bay by Brown et al. (2008) indicated that 77% of 3-year-old oysters and 82% of 4-year-old oysters would attain lengths greater than the minimum legal size of 58 mm length at the start of the fishing season. Osborne (1999) used results from a MAF Fisheries study conducted between 1990 and 1994 to construct a von Bertalanffy equation describing oyster growth in the OYS 7 fishery. Estimated biological parameters including instantaneous natural mortality (*M*) from Drummond (1994b) and growth parameters for von Bertalanffy equations from Osborne (1999) and from Brown et al. (2008) are given in Table 6. Mortality estimates by Drummond (1994b) and growth parameters given by Osborne (1999) were derived from a tagging study conducted in Tasman Bay between 1990 and 1992 (Drummond 1994a). Von Bertalanffy growth parameters of Brown et al. (2008) were estimated based on a limited data set from enhanced habitat experiments and describe growth of young oysters. Estimates of *M* based on experimental data from Foveaux Strait and Tasman Bay ranged from 0.042 (Dunn et al. 1998) to 0.92 (Drummond et al. 1994a). However, after some discussion, the Shellfish Working Group (SFWG) concluded that those figures were not realistic, and that *M* was likely to lie between 0.1 and 0.3.

Table 6: Estimated biological parameters for oysters in OYS 7. Mortality (*M*) estimates are from Drummond (1994b) and Drummond & Bull (1993). Parameters derived for von Bertalanffy equations describing growth of oysters (diameter in millimetres) in Tasman Bay are from Osborne (1999) and Brown et al. (2008).

Parameter	Estimate	Uncertainty		Source
	mean	s.d.	95% c.i.	
M	0.92	–	0.48	Drummond (1994b)
M	0.2	–	–	Drummond & Bull (1993)
k	0.99	0.16	–	Brown et al. (2008)
k	0.597	–	–	Osborne (1999)
L_{inf}	67.52	3.91	–	Brown et al. (2008)
L_{inf}	85.43	–	–	Osborne (1999)
t_0	0.11	0.02	–	Brown et al. (2008)

3. STOCKS AND AREAS

Patches of commercial densities of oysters within the OYS 7 fishery are largely restricted to Tasman Bay. The oyster population in OYS 7 is likely to be biologically isolated from populations in Foveaux Strait (OYU 5) and the Chatham Islands (OYS 4) on the basis of geographical distance. The populations in OYS 7 and OYS 7C could also be biologically distinct due to their geographical separation, potentially causing limited dispersal of larvae between the two areas.

4. STOCK ASSESSMENT

Scallop and oyster surveys that estimated oyster densities since 1959 are given in Table 7. Surveys between 1959 and 1995 used different dredges, survey designs, and methods and are not comparable. Surveys since 1996 have estimated oyster biomass concurrently with scallops from one- or two-phase, stratified random designs, but strata have not been optimised for oysters. Although surveys of oyster biomass are comparable from 1996, the high CVs limit the usefulness of these survey data to establish meaningful trends in the fishery.

Table 7: Surveys of oysters in Tasman Bay (TB), Golden Bay (GB), and the Marlborough Sounds (MS) from 1959 to present. Surveys either targeted oysters (Target species) to estimate oyster density and distribution or sampled oysters concurrently in surveys targeting scallops (Scallops), but without optimising survey designs for oysters.

Survey	Location	Target species	Survey design	Reference
1959–60	TB	Scallops	Targeted	Choat (1960)
1961	TB, GB	Oysters	Grid and targeted	Tunbridge (1962)
1969–75	TB, GB	Oysters	Targeted	Stead (1976)
1984–86	TB, GB	Oysters	Grid	Drummond (unpub. report)
1996	TB, GB, MS	Scallops	Two-phase stratified random	Cranfield et al. (1996)
1997	TB, GB, MS	Scallops	Two-phase stratified random	Cranfield et al. (1997)
1998	TB, GB, MS	Scallops	Two-phase stratified random	Osborne (1998)
1999	TB, GB, MS	Scallops	Two-phase stratified random	Breen & Kendrick (1999)
2000	TB, GB, MS	Scallops	Two-phase stratified random	Breen (2000)
2001	TB, GB, MS	Scallops	Two-phase stratified random	Horn (2001)
2002	TB, GB, MS	Scallops	Two-phase stratified random	Horn (2002)
2003	TB, GB, MS	Scallops	Two-phase stratified random	Horn (2003)
2004	TB, GB, MS	Scallops	Two-phase stratified random	Horn (2004)
2005	TB, GB, MS	Scallops	Two-phase stratified random	Horn (2005)
2006	TB, GB, MS	Scallops	Two-phase stratified random	Horn (2006)
2007	TB, GB, MS	Scallops	Two-phase stratified random	Brown (2007)
2008	TB, GB	Scallops	Two-phase stratified random	Brown et al. (2008)
2009	TB, GB, MS	Scallops	Single-phase stratified random	Williams et al. (2009)
2010	TB	Oysters	Grid and targeted	Michael (2010)
2010	TB, GB, MS	Scallops	Single-phase stratified random	Williams et al. (2010)
2011	TB, GB, MS	Scallops	Single-phase stratified random	Williams & Michael (2011)
2012	TB, GB, MS	Oysters	Single-phase stratified random	Williams & Bian (2012)
2013	MS	Scallops	Single-phase stratified random	Williams et al. (2013a)
2014	TB, GB, MS	Scallops	Single-phase stratified random	Williams et al. (2014a)
2015	TB, GB, MS	Scallops	Single-phase stratified random	Williams et al. (2015a)
2015	TB, GB, MS	Scallops	Single-phase stratified random	Williams et al. (2015b)
2017	TB, GB, MS	Scallops	Single-phase stratified random	Williams et al. (2017)
2018	MS	Scallops	Single-phase stratified random	Williams et al. (2018)
2019	MS	Scallops	Single-phase stratified random	Williams et al. (2019)
2020	TB, GB, MS	Scallops	Single-phase stratified random	Williams et al. (2021)
2021	TB, MS	Scallops	Single-phase stratified random	Williams et al. (2024)

4.1 Estimates of fishery parameters and abundance

Growth and mortality are poorly estimated for oysters from OYS 7. Growth estimates from Drummond's (1994b) mark recapture data and estimates from Osborne (1999) give von Bertalanffy parameter estimates of 79.6 and 85.4 for L_∞, and 2.03 and 0.60 for k respectively. Drummond (1994b) estimated M=0.92 (considered unlikely by the Shellfish Working Group) and M=0.17. The Shellfish Working Group considers M is most likely to lie between 0.1 and 0.3.

Estimates of the numbers of recruits (oysters unable to pass through a 58-mm ring) and pre-recruits (less than 58 mm) from Tasman Bay and Golden Bay since 1998 are given in Table 8.

Table 8: Relative estimates (millions) uncorrected for dredge efficiency of recruited and pre-recruit oysters in Tasman Bay and Golden Bay from surveys between 1998 and 2012 (no surveys since then).

	Tasman Bay				Golden Bay			
Year	**Recruits**	**CV**	**Pre-recruits**	**CV**	**Recruits**	**CV**	**Pre-recruits**	**CV**
1998	28.7	7.3	30.4	10.1	1.4	13.3	0.4	18.7
1999	24.7	8.6	39.6	13.6	1.9	23.7	1.2	24.8
2000	21.8	8.9	33.5	9.9	1.0	14.3	0.5	17.6
2001	17.8	9.0	23.1	9.1	0.4	20.1	0.4	28.1
2002	15.9	10.6	24.5	11.2	0.4	21.4	0.3	27.1
2003	12.4	9.7	34.3	13.4	0.4	27.1	0.4	27.6
2004	10.9	6.7	16.1	8.1	0.4	25.4	0.2	18.8
2005	11.3	10.2	25.2	17.7	0.3	38.8	0.3	41.6
2006	10.7	8.6	18.5	14.8	0.1	29.1	0.04	46.6
2007	14.8	14.3	6.5	19.4	0.1	32.0	0.04	32.3
2008	9.6	20.5	8.9	25.2	0.04	47.1	0.01	39.5
2009	14.7	20.0	18.8	36	–	–	–	–
2010	14.0	26.0	9.0	54	–	–	–	–
2011	8.0	48.0	19.0	61	–	–	–	–
2012	6.8	22.0	21.0	21	–	–	–	–

• Golden Bay has not been surveyed since 2009 because this area has not been targeted for commercial fishing.

4.2 Biomass estimates

Estimates of the recruited biomass (≥ 58 mm) of oysters in both Tasman Bay and Golden Bay (made from surveys of oysters and scallops combined) show a general decline from 1998 to 2012 (Table 9).

Table 9: Estimates of relative biomass (t) of recruited oysters from Tasman Bay and Golden Bay between 1998 and 2012*.

	Tasman Bay		Golden Bay		Total		Total	Exploitation rate
Year	**Biomass (t)**	**CV**	**Biomass (t)**	**CV**	**biomass (t)**	**References**	**catch**	**(catch/biomass)**
1998	2 214	7.3	113	11.5	2 327	Osborne (1999)	436	0.19
1999	2 012	8.1	151	22.1	2 163	Breen & Kendrick (1999)	335	0.15
2000	1 810	8.8	86	15.4	1 895	Breen (2000)	132	0.07
2001	1 353	9.7	25	20.3	1 378	Horn (2001)	25	0.02
2002	1 134	10.0	28	21.9	1 162	Horn (2002)	1	0.00
2003	1 019	10.0	23	26.6	1 042	Horn (2003)	183	0.18
2004	894	6.9	28	22.4	921	Horn (2004)	98	0.11
2005	932	11.3	24	30.8	956	Horn (2005)	147	0.15
2006	817	26.1	10	8.0	827	Horn (2006)	171	0.21
2007	1 275	13.5	10	31.4	1 285	Brown (2007)	132	0.10
2008	744	20.8	3	52.0	747	Tuck & Brown (2008)	21	0.03
2009	1 208	19.0	–	–	1 208	Williams et al. (2009)	0	0.00
2010	1 259	27.0	–	–	1 259	Williams et al. (2010)	0	0.00
2011	622	42.0	–	–	622	Williams & Michael (2011)	6	0.01
2012	567	23.0	–	–	567	Williams & Bian (2012)	0	0.00

* Golden Bay has not been surveyed since 2009 because this area has low densities of oysters and is not targeted for commercial fishing.

4.3 Yield estimates and projections

Drummond (1994b) estimated a MCY of 300 tonnes using Method 4 in the Guide to Biological Reference Points (see Introduction to this Plenary report), but Osborne concluded that catch levels in OYS 7 appear to be driven by the economics of the catch rates (Osborne 1999). Equation 2 of the Guide to Biological Reference Points was used to estimate *MCY* (Table 10):

$$MCY = 0.5F_{0.1}B_{AV}$$

where B_{AV} = 1191 tonnes (from relative biomass estimates from the Challenger Scallop Enhancement Company (CSEC) surveys 1998 to 2012). The natural mortality (*M*) values used in the yield calculations were restricted to the range 0.1 to 0.3. This was reduced from the previous range of 0.042 to 0.9 because the extreme values were considered, by the SFWG, to be very unlikely. These estimates are not corrected for dredge efficiency (assumed to be 100%) and are likely to be conservative.

Table 10: Estimates of $F_{0.1}$ and *MCY* 1 for *M* 0.1–0.3. MCY 1 was estimated using $F_{0.1}$1 from Osborne (1999), *MCY* 2 from $F_{0.1}$2 estimated from von Bertalanffy growth parameters estimated by Osborne (1999), growth data from Drummond (1994b) and Foveaux Strait oyster size weight data, and *MCY* 3 from $F_{0.1}$3 estimated von Bertalanffy growth parameters from GROTAG using the same growth and size weight data.

M	$F_{0.1}$1	*MCY* 1	$F_{0.1}$2	*MCY* 2	$F_{0.1}$3	*MCY* 3
0.1	0.29	173	0.17	101	0.22	131
0.2	–		–		0.38	226
0.3	0.45	268	0.38	226	0.55	327

CAY was estimated for OYS 7 using Method 1 of the Guide to Biological Reference Points assuming dredge oysters are landed over the year, and using $F_{0.1}$ estimated by three different methods, a range of assumed *M* (0.1 to 0.3), and the 2012 estimate of recruited biomass (567 t; Table 11).

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

Table 11: Estimates of *CAY* for OYS 7 using different estimates of $F_{0.1}$ over a range of assumed values for *M* (0.1–0.3), and an estimate of recruited biomass in 2012 (567 t). *CAY* 1 was estimated using $F_{0.1}$1 from Osborne (1999), *CAY* 2 from $F_{0.1}$2 estimated from von Bertalanffy growth parameters estimated by Osborne (1999) using growth data (Drummond 1994b) and Foveaux Strait oyster size weight data, *CAY* 3 from $F_{0.1}$3 estimated von Bertalanffy growth parameters from GROTAG using the same growth and size weight data.

M	$F_{0.1}$1	*CAY* 1	$F_{0.1}$2	*CAY* 2	$F_{0.1}$3	*CAY* 3
0.1	0.29	136	0.17	84	0.22	107
0.2	–		–		0.38	163
0.3	0.45	180	0.38	156	0.55	210

The risk to the stock associated with harvesting at the estimated CAYs cannot be determined.

4.4 Other yield estimates and stock assessment results
There are no other yield estimates and stock assessments.

4.5 Other factors
The Challenger dredge oyster fishery is thought to be recruitment-limited. Drummond (1994a), Stead (1976), and Tunbridge (1962) attributed the lack of dense aggregations of oysters in the Challenger fishery (compared with Foveaux Strait) to a scarcity of suitable settlement surfaces. Challenger Oyster Enhancement Company (COEC) initiated habitat enhancement trials in 2008, aimed at boosting productivity of the fishery (Brown et al. 2008), but these areas have been contacted by bottom trawl gear and there has been no monitoring to determine the effectiveness of the enhancement.

5. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

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 and Biodiversity Annual Review 2021 (Fisheries New Zealand 2022).

5.1 Role in the ecosystem
Dredge oysters (*Ostrea chilensis*) are benthic, epifaunal, sessile bivalve molluscs that have a relatively limited pelagic larval dispersal phase. They are patchily distributed around the New Zealand coast on a variety of substrates (biogenic reef, gravel, sand, mud) in intertidal to subtidal inshore waters,

commonly in depths of up to 60 m or more. Commercially exploited beds of oysters occur in Foveaux Strait (OYU 5), Tasman Bay (OYS 7), and Cloudy Bay and Clifford Bay (OYS 7C). Beds at the Chatham Islands (OYS 4) have potential for commercial exploitation. Oysters play important roles in the ecosystem that include influencing water quality by filtering phytoplankton and other suspended particles from the seawater, linking primary production with higher trophic levels, and acting as ecosystem engineers by stabilising sediments and providing structural habitat (biogenic reef) for other taxa (e.g., algae, ascidians, bryozoans, sponges, echinoderms, worms, molluscs, crustaceans, fish).

5.1.1 Trophic interactions

Oysters are active suspension feeders, consuming phytoplankton suspended in the water column. Their diet is the same as or similar to that of many other suspension feeding taxa, including other bivalves such as scallops, clams, and mussels. Oysters are probably prey for a wide range of invertebrate and fish predators, but published records of known or suspected predators are limited. Reported invertebrate predators of *O. chilensis* include brittle stars (*Ophiopsammus maculata*) (Stead 1971), starfish (*Coscinasterias calamaria* and *Astrostole scabra*) (Cranfield 1979), and flatworms (*Enterogonia orbicularis*) (Handley 2002); suspected invertebrate predators include octopus (*Pinnoctopus cordiformis*) and shell boring gastropods (*Poirieria zelandica*, *Xymeme ambiguous*, and *Xymenella pusillis*) (Brown 2012). Predators of oysters probably change with oyster size. Most mortality of oyster spat (small juveniles) during their first winter appears to result from predation by polychaetes, crabs, and gastropods (Ministry for Primary Industries 2013).

5.2 Non-target catch of fish and invertebrates

A range of non-target fish and invertebrate species are caught and discarded by dredge fisheries for *O. chilensis*. No data are available on the level or effect of this non-target catch and discarding by the fisheries. Invertebrate non-target catch data are available from dredge surveys of the oyster stocks, and the non-target catch of the fisheries is likely to be similar to that of the survey tows conducted in areas that support commercial fishing. Fish non-target catch data are generally not recorded on surveys, presumably because fish constitute a small fraction of the total non-target catch.

In OYS 7 (Tasman Bay/Golden Bay), data on the non-target catch of the 1994–2014 dredge surveys have been collected but not analysed, except for preliminary estimation of the 1998–2013 non-target catch trajectories (Williams 2014b). The surveys record the non-target catch of other target species of scallops (*Pecten novaezelandiae*) and green-lipped mussels (*Perna canaliculus*), and various other non-target catch in nine categories (Williams et al. 2014b). Analysis of the 2014 survey sampling identified a problem with the way these categorical non-target catch data have been recorded, which limits their utility (Williams 2014a).

5.2.1 Non-target catch in other oyster stocks

In OYU 5 (Foveaux Strait), Fleming (1952) sampled the macrofaunal non-target catch of oyster fishing in a ‘near virgin’ area of the fishery in 1950. More recently, presence-absence data on the non-target catch of oyster dredging have been recorded during surveys and in fishers’ logbooks (Michael 2007). Fishery-independent bycatch sampling was undertaken in February 2020, 2021, and 2022 to satisfy requirements for the Integrated Electronic Monitoring and Reporting System regulations. The frequency of dredge tows does not allow for tow-by-tow reporting of bycatch and oyster discards. These surveys described bycatch and oyster discards from fishery areas with high, moderate, and low or no fishing effort during the 2019, 2020, 2021, and 2022 oyster seasons (Michael 2022a, 2022b, 2023a).

In a specific study of the benthic macrofauna non-target catch of the 2001 oyster dredge survey in Foveaux Strait, Rowden et al. (2007) identified at least 190 putative species representing 82 families and 12 phyla; ‘commercial’ survey strata were principally characterised by the families Balanidae (barnacles), Mytilidae (mussels), Ophiodermatidae (brittle stars), Ostreidae (oysters), and Pyuridae (tunicates). For the 2007 survey of OYU 5, Michael (2007) listed the percentage occurrence of sessile and motile species caught as non-target catch in the survey dredge tows. The five most commonly caught sessile species (excluding oysters) were hairy mussels *Modiolus areolatus* (80% occurrence), barnacles *Balanus* sp. (61%), kina *Evechinus chloroticus* (61%), nesting mussels *Modiolarca impacta* (53%), and ascidians *Pyura pulla* (51%). The five most commonly occurring motile non-target catch species were brittle stars *Ophiopsammus maculata* (90% occurrence), circular saw shells (gastropods) *Astraea heliotropium* (80%), hermit crabs *Pagurus novizelandiae* (80%), eight armed starfish *Coscinasterias muricata* (63%), and brown dipple starfish *Pentagonaster pulchellus* (54%). Common non-target catch species of oyster dredge surveys in Foveaux Strait were reported by Michael (2007) and are listed below in Table 12.

Table 12: Invertebrate species commonly caught as non-target catch in dredge surveys of oysters (*O. chilensis*) in Foveaux Strait. Sourced from Michael (2007).

Type	Species
Infaunal bivalves	*Glycymeris modesta* (small dog cockle), *Tawera spissa* (morning star shell), *Tucetona laticostata* (large dog cockle), *Pseudoxyperas elongata* ('tuatua'), *Venericardia purpurata* (purple cockle)
Epifaunal bivalves	*Modioilus areolatus* (hairy mussel), *Modiolarca impacta* (nesting mussel), *Aulacomya atra maoriana* (ribbed mussel), *Barbatia novaezelandiae* (ark shell), *Pecten novaezelandiae* (scallop), *Chlamys zelandiae* (lion's paw scallop), *Neothyris lenticularis* (large lantern shell), *N. compressa* (compressed lantern shell)
Sponges	*Chondropsis* topsentii (cream sponge), *Crella incrustans* (red-orange sponge), *Dactylia palmata* (finger sponge)
Ascidians	*Pyura pachydermatina* (kaeo), *P. pulla*
Algae	Red algae spp.
Bryozoans	*Celleporaria agglutinans* (hard/plate coral), *Cinctipora elegans* (reef-building bryozoan), *Horera foliacea* (lace coral), *Hippomenella vellicata* (paper coral), *Tetrocycloecia neozelanica* (staghorn coral), *Orthoscuticella fusiformis* (soft orange bryozoan)
Barnacles and chitons	*Balanus decorus* (large pink barnacle), *Cryptochonchus porosus* (butterfly chiton), *Eudoxochiton nobilis* (noble chiton), *Rhyssoplax canaliculata* (pink chiton)
Starfish, brittlestars, and holothurians	*Coscinasterias muricata* (eight-armed starfish), *Pentagonaster pulchellus* (brown dipple starfish), *Ophiosammus maculata* (snaketail brittlestar), *Australostichopus mollis* (sea cucumber)
Crabs	*Pagurus novaezelandiae* (hermit crab), *Eurynolambrus australis* (triangle crab), *Metacarcinus novaezelandiae* (cancer crab), *Nectocarcinus* sp. (red crab)
Urchins	*Evechinus chloroticus* (kina), *Apatopygus recens* (heart urchin), *Goniocidaris umbraculum* (coarse-spined urchin), *Pseudechinus novaezelandiae* (green urchin), *P. huttoni* (white urchin), *P. albocinctus* (red urchin)
Gastropods	*Astraea heliotropium* (circular saw shell), *Alcithoe arabica* (volute), *Argobuccinum pustulosum tumidum, Turbo granosus, Cabestana spengleri, Charonia lampras*
Octopuses	*Pinnoctopus cordiformis* (common octopus), *Octopus huttoni* (small octopus)

Bycatch sampling in 2020 (Michael 2022a) found live bycatch generally accounted for a small percentage of the dredge contents, 4.0% of all the catch (including oysters) by weight. Median bycatch weight of all live bycatch species for all tows was 3.0 kg per tow. Of the weight of live bycatch combined, 83.2% was non-fish non-QMS species. Four species accounted for 60.1% of live bycatch: *Astraea heliotropium*, *Ophiopsammus maculata*, *Pyura pachydermatina*, and *Modiolus areolatus*. Relatively high catches of *P. pachydermatina* and *M. areolatus* were recorded from individual tows. Catches of QMS fish species, QMSR_ONG (Sponges), and QMSR_COZ (Bryozoans) were low, regardless of region and fishing effort. Bycatch sampling in 2021 (Michael 2022b) found the same non-fish non-QMS species accounting for 61.4% of bycatch by weight and the bryozoan *Cinctipora elegans* accounted for a further 29.1% of bycatch, mainly from one station. QMS species represented an additional 5.2%, mostly kina (*Evechinus chloroticus*, 4.89%) and sea cucumbers (*Australostichopus mollis*, < 0.1%). Bycatch was less diverse in 2022 than in previous surveys, and no large catches of sponges, bryozoans, or stalked ascidians were taken. Live bycatch was on average 4.0% of the total unsorted catch. The top ten species ranked by weight (86.2% of bycatch in 2022) were non-fish non-QMS species that are ubiquitous throughout the fishery area. Two of these species, *Astraea heliotropium* and *Modiolus areolatus,* accounted for 51.1% of all bycatch. QMS species accounted for 11.4%; kina (*Evechinus chloroticus*) accounted for 10.9%. Bycatch of bryozoans and porifera combined accounted for a further 2.4% of all bycatch. The bushy bryozoan *Othoscuticella fusiformis* accounted for most of this bycatch. Bycatch by each region and fishing effort were mostly similar and generally comprised mobile species *A. heliotropium*, *Ophiopsammus maculata*, *E. chloroticus*, and *Pagurus novaezealandie*, and the sessile species *M. areolatus* accounted for the highest catches across all effort strata and regions (Michael 2023a).

In OYS 7C (Cloudy Bay/Clifford Bay), a dredge survey of oysters in Cloudy Bay and Clifford Bay was conducted in 2006, and the survey skipper recorded qualitative comments on the non-target catch of each tow, which included 'coral', 'sticks and seaweed', shells, volutes, 'red weed', horse mussels, shell with worm, small crabs, mussels, and scallops (Brown & Horn 2006).

In OYS 4 (Chatham Islands), data on the non-target catch of a 2013 dredge survey of oysters off the north coast of Chatham Island were recorded (as estimated volumes of different non-target catch categories) but not analysed (Williams & Williams 2013).

5.3 Incidental catch of seabirds, mammals, and protected fish

There is no known incidental catch of seabirds, mammals, or protected fish species from *O. chilensis* oyster fisheries.

5.4 Benthic interactions

There are a variety of benthic habitats in the different oyster fisheries areas, which generally occur either on coarse substrates usually found in areas of high natural disturbance (Foveaux Strait, Cloudy Bay and Clifford Bay, and the Chatham Islands) or on fine substrates typical of sheltered areas (Tasman Bay). Benthic habitats within the Foveaux Strait oyster fishery area were classified by Michael (2007) and comprise a variety of sand/gravel/shell flats and waves, rocky patch reef, and biogenic areas. Cranfield et al. (1999) referred to the latter as epifaunal reefs that he defined as "tidally oriented, linear aggregations of patch reefs formed by the bryozoan *Cinctipora elegans*, cemented by encrusting bryozoans, ascidians, sponges and polychaetes". Cranfield et al. (1999, 2001, 2003) suggested that epifaunal reefs are oyster habitat, but Michael (2007, 2010) stated that commercial fishing for oysters is mainly based on sand, gravel, and shell habitats with little epifauna. In Foveaux Strait, commercial oyster dredging occurs within an area of about 1000 km^2 (although only a portion of this is dredged each year), which is about one-third of the overall OYU 5 stock area (Michael 2010). Habitats within the Cloudy Bay/Clifford Bay and the Chatham Islands fishery areas have not been defined. The benthic habitat within the Tasman Bay oyster fishery area is predominantly mud, although to some extent this may have been affected by land-based sedimentation into the bay and homogenisation of the substrate by dredging and trawling (Brown 2012).

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., 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). In New Zealand, the effects of oyster dredging on the benthos have been studied in Foveaux Strait (OYU 5) (Cranfield et al. 1999, 2001, 2003, and Michael 2007) and Tasman Bay/Golden Bay (OYS 7) (Tuck et al. 2017). The results of these studies are summarised in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2022) 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.

The effects of dredging (Fisheries New Zealand 2022) may be more severe in sheltered areas (e.g., Tasman Bay) than in exposed areas (e.g., Foveaux Strait, Cloudy Bay/Clifford Bay, Chatham Islands). Dredging damages epifauna, and erect, structured habitats, such as biogenic/epifaunal reefs, are the most sensitive to dredging disturbance. Dredging destabilises sediment/shell substrates, suspends sediments, and increases water turbidity; the sensitivity of habitats to suspended sediments and their deposition probably varies depending on the prevailing natural flow regime, being greater in muddy sheltered areas than in high flow environments. Habitats disturbed by dredging tend to become simpler, more homogenous areas typically dominated by opportunistic species. Dredging generally results in reduced habitat structure and the loss of long-lived species.

For studies of the effects of oyster dredging in Foveaux Strait, interpretation of the authors differ (Fisheries New Zealand 2022). Cranfield et al. (1999, 2001, 2003) concluded that dredging biogenic reefs for their oysters damages their structure, removes epifauna, and exposes associated sediments to resuspension such that, by 1998, none of the original bryozoan reefs remained. Michael (2007) concluded that there are no experimental estimates of the effect of dredging in the strait or on the cumulative effects of fishing or regeneration, that environmental drivers should be included in any assessment, and that the previous conclusions cannot be supported. The authors agree that biogenic bycatch in the fishery has declined over time in regularly fished areas, that there may have been a reduction in biogenic reefs in the strait since the 1970s, and that simple biogenic reefs appear able to regenerate in areas that are no longer fished (dominated by byssally attached mussels or reef-building bryozoans). There is no consensus that reefs in Foveaux Strait were (or were not) extensive or dominated by the bryozoan *Cinctipora*.

Some areas of the Foveaux Strait (OYU 5) oyster fishery are also commercially fished (potting) for blue cod (*Parapercis colias*), and Cranfield et al. (2001) presented some evidence to suggest that dredged benthic habitats and blue cod densities regenerated in the absence of oyster dredging. Bottom trawling also occurs within the OYU 5 area, but there is little overlap with the main areas fished for oysters. In OYS 7, other benthic fisheries (e.g., bottom trawl, scallop, green-lipped mussel) occur and probably also interact with oysters and their habitats.

5.5 Other considerations

5.5.1 Spawning disruption

Fishing during spawning may disrupt spawning activity or success. In the Foveaux Strait fishery, the traditional harvesting period (1 March to 31 August) occurs after the main spring and summer peaks in oyster spawning activity (Jeffs & Hickman 2000). Fishing-induced damage to oysters incurred during the period before spawning could interrupt gamete maturation. Oyster fishing also targets high-density beds of oysters, which are disproportionately more important for fertilisation success during spawning.

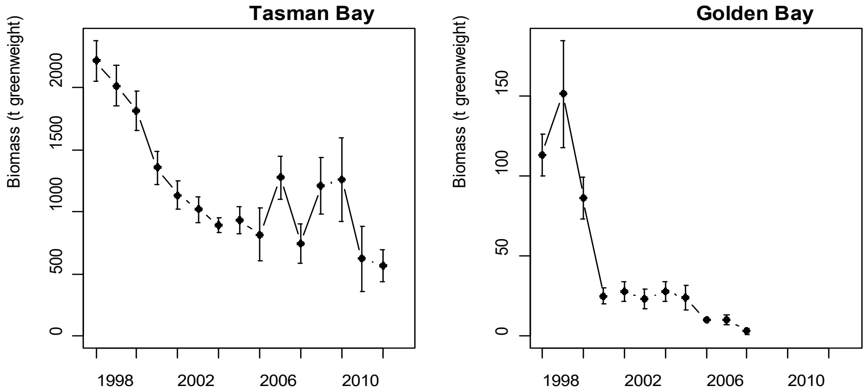
6. STATUS OF THE STOCKS

Stock structure assumptions

Current management assumes that the Challenger (OYS 7) oyster fishery is separate from the other oyster fisheries (i.e., Foveaux Strait (OYU 5), Tory Channel, Cloudy Bay, and Clifford Bay (OYS 7C), and the Chatham Islands (OYS 4)). The stock structure of OYS 7 is assumed to be a single biological stock, although the extent to which the populations in Tasman Bay, Golden Bay, and the Marlborough Sounds are separate reproductively or functionally is not known. Localised patches of oysters in commercial densities within the OYS 7 fishery are largely restricted to Tasman Bay, which is likely to be a single stock.

Stock Status		
Most Recent Assessment Plenary Publication Year	2012 - now considered out of date	
Intrinsic productivity level	Low	
Catch in most recent year of assessment	Year:	Catch:
Assessment Runs Presented		
Reference Points	Target: default = 40% B_0, with at least a 50% probability of achieving the target Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: F_{MSY}	
Status in relation to Target	Unlikely (< 40%) to be at or above the target	
Status in relation to Limits	Likely (> 60%) to be below Soft Limit Unknown relative to Hard Limit	
Status in relation to Overfishing	Unknown	

Historical Stock Status Trajectory and Current Status



Estimated (mean and CV of) recruited oyster biomass (t greenweight) in Tasman Bay and Golden Bay from 1998 to 2012. Biomass estimates uncorrected for dredge efficiency; oysters were not surveyed in Golden Bay in 2009–12.

Fishery and Stock Trends	
Trend in Biomass or Proxy	The current biomass of the OYS 7 stock is probably at its lowest level since the CSEC survey time series started in 1998. The estimated biomass of recruited oysters in Tasman Bay decreased from over 2000 t in 1998 to less than 1000 t in 2004, apparently fluctuated around that level until 2011, and was an estimated 567 t in 2012. Recruited oyster biomass in Golden Bay has shown a similar downturn, albeit with a much more rapid decline between 1999 and 2001, followed by a period of relative stability at a low level up to 2005, and a gradual decline to a negligible level in 2008. No surveys have been undertaken since 2012.
Recent trend in Fishing Intensity or Proxy	The exploitation rate on recruited oysters in OYS 7 was about 0.14 for the periods 1998–2000 and 2003–07 but was negligible in the periods 2001–02 and 2008–14.
Other Abundance Indices	The abundance of pre-recruit oysters has declined at a similar rate to the recruited abundance.
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	No projections have been conducted.
Probability of Current Catch or	Soft Limit: The TACC is higher than the maximum estimates of

TACC causing Biomass to remain below or to decline below Limits	CAY and MCY and catches at this level are Very Likely (> 90%) to cause the biomass to remain below the Soft Limit in the near term. Hard Limit: Catches at the level of the TACC are also Likely (> 60%) to cause the stock to drop below the Hard Limit in the near term.
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment - annual random stratified dredge surveys	
Assessment Method	Yields are estimated as a proportion of the survey biomass for a range of assumed values of natural mortality and with assumed dredge efficiency of 100%.	
Assessment Dates	Latest assessment Plenary publication year: 2012	Next assessment: Unknown
Overall Assessment Quality Rank	1 – High Quality	
Main data inputs (rank)	Biomass survey: 2012	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	The natural mortality (*M*) values used in the yield calculations were restricted to the range 0.1 to 0.3. This was reduced from the previous range of 0.042 to 0.9 because the extreme values were considered very unlikely.	
Major Sources of Uncertainty	Natural mortality (*M*) and dredge efficiency are poorly known but are integral parameters of the method used to estimate yield.	

Qualifying Comments
The OYS 7 dredge oyster fishery has a lack of dense aggregations of oysters (compared with Foveaux Strait); this is attributed to a scarcity of suitable settlement surface. Recruited biomass is being used as proxy for spawning biomass. Other benthic fisheries (e.g., bottom trawl, scallop, green-lipped mussel) occur in OYS 7 and probably interact with oysters and their habitat. The cause of the declines in these shellfish is unknown but is probably associated with factors other than simply the magnitude of direct removals by fishing. It may be a combination of natural (e.g., oceanographic) and anthropogenic (e.g., indirect effects of fishing, land-based) factors.

7. FOR FURTHER INFORMATION

Annala, J H; Sullivan, K J; O'Brien, C J; Smith, N W M (2001) Report from the Fishery Assessment Plenary, May 2001: stock assessments and yield estimates. Ministry of Fisheries, Wellington. 515 p.

Beentjes, M P; Baird, S J (2004) Review of dredge fishing technologies and practice for application in New Zealand. *New Zealand Fisheries Assessment Report 2004/37*. 40 p.

Boyd, R O; Gowing, L; Reilly, J L (2004) 2000–2001 national marine recreational fishing survey: diary results and harvest estimates. (Unpublished New Zealand Fisheries Assessment Research Report for the Ministry of Fisheries Project REC2000-01 held by Fisheries New Zealand, Wellington.) 92 p.

Boyd, R O; Reilly, J L (2004) 1999/2000 National Marine Recreational Fishing Survey: harvest estimates. (Unpublished New Zealand Fisheries Assessment Research Report for the Ministry of Fisheries Project REC9803 held by Fisheries New Zealand, Wellington.) 28 p.

Bradford, E (1998) Harvest estimates from the 1996 national marine recreational fisheries surveys. *New Zealand Fisheries Assessment Research Document 98/16*. 27 p. (Unpublished report held in NIWA library, Wellington.)

Breen, P A (1998) Possible harvest strategies for the Challenger dredge oyster fishery. NIWA client report WLG98/29. (Unpublished report held by NIWA library, Wellington.)

Breen, P A (2000) Survey of Scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds in May-June 2000. NIWA Client Report WLG00/52. (Unpublished report held by NIWA library, Wellington.)

Breen, P A; Kendrick, H T (1999) Survey of Scallops in Golden Bay, Tasman Bay, and the Marlborough Sounds in June 1999. NIWA Client Report. (Unpublished report held by NIWA library, Wellington.)

Brown, S (2007) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, in May 2007. NIWA Client Report NEL2007-012. 41 p. (Unpublished report held by NIWA library, Wellington.)

Brown, S; Campbell, M; Handley, S; Michael, K; Cairney, D; Bradley, A; Mormede, S (2008) Challenger oyster enhancement research programme. *NIWA Client Report NEL2008-032*. 77 p. (Unpublished report held by NIWA library, Wellington.)

Brown, S; Horn, P (2006) Preliminary estimate of dredge oyster abundance in Cloudy Bay. NIWA Client Report NEL2006-012 prepared for Talleys Fisheries Ltd. NIWA project TAL07401. 5 p. (Unpublished report held by NIWA, Nelson.)

Brown, S N (2012) Ecology and enhancement of the flat oyster *Ostrea chilensis* (Philippi, 1845) in central New Zealand. (Unpublished PhD thesis. University of Canterbury, Christchurch, New Zealand.) 218 p.

Choat, J H (1960) Scallop investigation, Tasman Bay 1959–60. *Fisheries Technical Report No. 2*. 51 p.

Cole, R; Horn, P L; Davey, N; Bradley, A (2006) An assessment of the recreational catch of scallops and dredge oysters in the Golden Bay and Tasman Bay sections of the Southern Scallop Fishery (SCA 7) for the 2003–04 fishing season. *New Zealand Fisheries Assessment Report 2006/10*. 16 p.

Cranfield, H J (1979) The biology of the oyster, *Ostrea lutaria*, and the oyster fishery of Foveaux Strait. *Rapports et Procès-verbaux des réunions. Conseil Permanent International pour l'Exploration de la Mer 175*: 44–49.

Cranfield, H J; Allen, R L (1977) Fertility and larval production in an unexploited population of oysters, *Ostrea lutaria* Hutton, from Foveaux Strait. *New Zealand Journal of Marine and Freshwater Research 11*: 239–253.

Cranfield, H J; Allen, R L (1979) Mark-recapture surveys of the Foveaux Strait dredge oyster (*Ostrea lutaria*) population. *Rapports et Procès-verbaux des réunions. Conseil Permanent International pour l'Exploration de la Mer 175*: 63–69.

Cranfield, H J; Carbines, G; Michael, K P; Dunn, A; Stotter, D R; Smith, D J (2001) Promising signs of regeneration of blue cod and oyster habitat changed by dredging in Foveaux Strait, southern New Zealand. *New Zealand Journal of Marine and Freshwater Research 35*: 897–908.

Cranfield, H J; Doonan, I J; Michael, K P (1997) Incidental mortality of Foveaux Strait Dredge oysters during dredging. Final Research Report to the Ministry of Fisheries for Project SOOY002. 17 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Cranfield, H J; Manighetti, B; Michael, K P; Hill, A (2003) Effects of oyster dredging on the distribution of bryozoan biogenic reefs and associated sediments in Foveaux Strait, southern New Zealand. *Continental Shelf Research 23*: 1337–1357.

Cranfield, H J; Michael, K P (1989) Larvae of the incubatory oyster *Tiostrea chilensis* (Bivalvia: Ostreidae) in the plankton of central and southern New Zealand. *New Zealand Journal of Marine and Freshwater Research 23*: 51–60.

Cranfield, H J; Michael, K P; Doonan, I J (1996) Biomass of Scallops in Golden Bay, Tasman Bay, and the Marlborough Sounds, 1996. (Client Report to Challenger Scallop Enhancement Company Limited.) 23 p.

Cranfield, H J; Michael, K P; Doonan, I J (1999) Changes in the distribution of epifaunal reefs and oysters during 130 years of dredging for oysters in Foveaux Strait, southern New Zealand. *Aquatic Conservation of Marine and Freshwater Ecosystems 9*: 461–483.

Department of Fisheries and Oceans (2006) Impacts of trawl gear and scallop dredges on benthic habitats, populations and communities. *DFO Canadian Science Advisory Secretariat Science Advisory Report 2006/025*. 13 p.

Drummond, K (1987) The Nelson Marlborough dredge oyster (*Tiostrea lutaria*) fishery. MAF Fisheries. (Unpublished report held by NIWA library, Wellington.)

Drummond, K (1994a) The Challenger dredge oyster *Tiostrea chilensis* fishery. Draft New Zealand Fisheries Assessment Research Document. (Unpublished report held by NIWA library, Wellington.)

Drummond, K L (1994b) Report on Tasman Bay dredge oyster productivity trials. *MAF Fisheries Central Region Internal Report 23*. (Unpublished report held by NIWA library, Wellington.)

Drummond, K; Bull, M (1993) Oyster enhancement research trials. MAF Fisheries internal memorandum, 18 August 1993. (Unpublished report held by Fisheries New Zealand, Wellington.)

Dunn, A; Cranfield, H J; Michael, K P (1998) Estimates of natural mortality of the Foveaux Strait oyster (*Tiostrea chilensis*) between 1974 and 1986. Final Research Report to the Ministry of Fisheries for Project OYS9801. 12 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Dunn, A; Michael, K P; Hine, P M; Andrew, N L; Diggles, B K; Cranfield, H J (2000) Analysis of a survey of the prevalence and intensity of *Bonamia* sp. in Foveaux Strait oysters. *New Zealand Fisheries Assessment Report 2000/32*. 28 p.

Fisheries New Zealand (2022) *Aquatic Environment and Biodiversity Annual Review 2021*. Compiled by the Aquatic Environment Team, Fisheries Science and Information, Fisheries New Zealand, Wellington New Zealand. 779 p.

Fleming, C A (1952) A Foveaux Strait oyster bed. *New Zealand Journal of Science and Technology 34B*: 73–85.

Handley, S; Michael, K (2001) Research plan for the Challenger dredge oyster fishery: A summary of existing knowledge and options for further research. NIWA Client Report CSE01402 prepared for Challenger Scallop Enhancement Company Ltd. 42 p.

Handley, S J (2002) Optimizing intertidal Pacific oyster (Thunberg) culture, Houhora Harbour, northern New Zealand. *Aquaculture Research 33*: 1019–1030.

Heinemann A; Gray, A. (2024) National Panel Survey of Recreational Marine Fishers 2022-23. *New Zealand Fisheries Assessment Report 2024/51*. 116 p.

Horn, P L (2001) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, in May 2001. NIWA Client Report CSE01403 prepared for Challenger Scallop Enhancement Company Ltd. 32 p.

Horn, P L (2002) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, in May 2002. NIWA Client Report CSE02403 prepared for Challenger Scallop Enhancement Company Ltd. 29 p.

Horn, P L (2003) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, in May–June 2003. NIWA Client Report NEL2003-014. 34 p. (Unpublished report held by NIWA library, Wellington.)

Horn, P L (2004) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, in May–June 2004. NIWA Client Report NEL2004-008. 42 p. (Unpublished report held by NIWA library, Wellington.)

Horn, P L (2005) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, in May–June 2005. NIWA Client Report NEL200-024. 35 p. (Unpublished report held by NIWA library, Wellington.)

Horn, P L (2006) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, in May–June 2006. NIWA Client Report NEL2006-005. 35 p. (Unpublished report held by NIWA library, Wellington.)

Jeffs, A; Hickman, R W (2000) Reproductive activity in a pre-epizootic wild population of the Chilean oyster, *Ostrea chilensis*, from southern New Zealand. *Aquaculture 183*: 241–253.

Kaiser, M J; Clarke, K R; Hinz, H; Austen, M C V; Somerfield, P J; Karakassis, I (2006) Global analysis of the response and recovery of benthic biota to fishing. *Marine Ecology Progress Series 311*: 1–14.

Mackenzie, A L; Gillespie, P A; Grant, W D; Juniper, S K; Chang, H; Bradstock, M (1983) An ecological investigation of a slime associated phytoplankton bloom in Tasman Bay, New Zealand. Pacific Science Association 15th Congress: programme, abstracts and congress information, Pacific Science Association. 155 p.

Michael, K P (2007) Summary of information in support of the Foveaux Strait Oyster Fishery Plan: the Foveaux Strait ecosystem and effects of oyster dredging. Final Research Report for Ministry of Fisheries project ZBD2005-04. 103 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Michael, K P (2010) Summary of information from Foveaux Strait oyster (*Ostrea chilensis*, OYU 5) strategic research 2000–09: context for the 2010 strategic research plan. *New Zealand Fisheries Assessment Report 2010/20*. 37 p.

Michael, K P (2022a) Investigating methods to quantify bycatch and oyster discards from the Foveaux Strait oyster fishery (OYU 5) for IEMRS reporting: summaries of bycatch and oysters sampled from commercial fishery areas in February 2020. *New Zealand Fisheries Assessment Report 2022/61*. 44 p.

Michael, K P (2022b) Estimates of bycatch and oyster discards from the Foveaux Strait oyster fishery (OYU 5) in February 2021, and whether these data can fulfil requirements for IEMRS reporting. *New Zealand Fisheries Assessment Report 2022/62*. 43p.

Michael, K P (2023a) Estimates of bycatch and oyster discards from the Foveaux Strait oyster fishery (OYU 5) in February 2022. *New Zealand Fisheries Assessment Report 2023/30.* 39 p.

Michael, K P; Sturman, J (2010) Challenger Pre-Season Oyster Survey of Tasman Bay, May 2010. NIWA Client Report WLG2010-33. (Unpublished report prepared for Challenger Oyster Enhancement Company Limited under NIWA project CDO01301.) 22 p.

Ministry for Primary Industries (2013) Fisheries Assessment Plenary, November 2013: stock assessments and yield estimates. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 611 p.

Osborne, T A (1998) Relative Biomass of Oysters in Golden and Tasman Bays, 1998. Client Report ORCO Report 1003. Osborne Research Company Ltd.

Osborne, T A (1999) Nelson Dredge Oyster Stock Assessment. Client Report ORCO Report 7. Osborne Research Company Ltd.

Rice, J (2006) Impacts of mobile bottom gears on seafloor habitats, species, and communities: a review and synthesis of selected international reviews. *Canadian Science Advisory Secretariat Research Document 2006/057*. 35 p.

Rowden, A A; Cranfield, H J; Mann, P J; Wood, A C L (2007) Benthic macrofauna bycatch of oyster dredging in Foveaux Strait. *New Zealand Fisheries Assessment Report 2007/10*. 26 p.

Stead, D H (1971) Observations on the biology and ecology of the Foveaux Strait dredge oyster (*Ostrea lutaria*, Hutton). *Fisheries Technical Report* 68. New Zealand Marine Department. 49 p.

Stead, D H (1976) The Dredge Fishery for Scallops, Mussels, and Oysters in Golden Bay and Tasman Bay: Survey Results 1969–1975. Fisheries Management Division, Ministry of Agriculture and Fisheries, New Zealand. (Unpublished report held by NIWA library, Wellington.)

Teirney, L D; Kilner, A R; Millar, R B; Bradford, E; Bell, J D (1997) Estimation of recreational harvests from 1991–92 to 1993–94. *New Zealand Fisheries Assessment Research Document 97/15*. 43 p. (Unpublished report held by NIWA library, Wellington.)

Tuck, I; Brown, S (2008) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2008. NIWA Client Report NEL2008-022. 37 p. (Unpublished report held by NIWA library, Wellington.)

Tuck, I D; Hewitt, J E.; Handley, S J.; Lundquist, C J. (2017) Assessing the effects of fishing on soft sediment habitat, fauna and process. *New Zealand Aquatic Environment and Biodiversity Report No.* 178. 143 p.

Tunbridge, B R (1962) Occurrence and distribution of the dredge oyster (*Ostrea sinuata*) in Tasman and Golden Bays. *Fisheries Technical Report No.* 6. 42 p.

Williams, J R; Bian, R (2012) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2012. NIWA Client Report AKL2012-032 prepared for Challenger Scallop Enhancement Company Ltd. under NIWA project CSE12301; held by NIWA, Auckland.) 65 p.

Williams, J R; Bian, R; Brown, S (2009) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2009. NIWA Client Report NEL2009-024. 37 p. (Unpublished report held by NIWA library, Wellington.)

Williams, J R; Bian, R; Carter, M; Evans, O; Hughes, R; Jordan, L; Middleton, C; Olsen, L; Stead, J (2024) Dive and dredge surveys of scallops in SCA 7, 2021. *New Zealand Fisheries Assessment Report 2024/57.* 51 p.

Williams, J R; Bian, R; Olsen, L; Stead, J (2021) Survey of scallops in SCA 7, May 2020. *New Zealand Fisheries Assessment Report 2021/09*. 54 p.

Williams, J R; Bian, R; Olsen, L; Stead, J; Tuck, I (2019) Dredge survey of scallops in Marlborough Sounds, May 2019. *New Zealand Fisheries Assessment Report 2019/69*. 50 p.

Williams, J R; Bian, R; Parkinson, D M; Roberts, C L (2015a) Survey of scallops in Golden Bay, Tasman Bay, and Marlborough Sounds, 2015. NIWA Client Report AKL2015-019 prepared for Challenger Scallop Enhancement Company Ltd. under NIWA project CSE15301. (Unpublished report held by NIWA, Auckland.) 71 p.

Williams, J R; Bian, R; Williams, C L (2013a) Survey of scallops in the Marlborough Sounds, 2013. NIWA Client Report AKL2013-015 prepared for Challenger Scallop Enhancement Company Ltd. under NIWA project CSE13301. (Unpublished report held by NIWA, Auckland.) 45 p.

Williams, J R; Bian, R; Williams, C L (2014a) Survey of scallops in Golden Bay, Tasman Bay, and Marlborough Sounds, 2014. NIWA Client Report AKL2014-027 prepared for Challenger Scallop Enhancement Company Ltd. under NIWA project CSE14301. 63 p. (Unpublished report held by NIWA, Auckland.)

Williams, J R; Hartill, B; Bian, R; Williams, C L (2014b) Review of the Southern scallop fishery (SCA 7). *New Zealand Fisheries Assessment Report 2014/07*. 71 p.

Williams, J R; Michael, K (2011) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2011. NIWA Client Report AKL2011-026. 64 p. (Unpublished report held by NIWA library, Wellington.)

Williams, J R; Michael, K; Bian, R (2010) Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2010. NIWA Client Report WLG2010-052. 60 p. (Unpublished report held by NIWA library, Wellington.)

Williams, J R.; Parkinson, D M.; Drury, J; Roberts, C L; Bian, R. Tuck, I D (2017) Survey of scallops in SCA 7, January 2017. *New Zealand Fisheries Assessment Report 2017/23*. 67 p.

Williams, J R; Parkinson, D M; MacGibbon, D J; Olsen, L; Roberts, C L (2015b) SCA 7 stock survey, November 2015. *New Zealand Fisheries Assessment Report 2015/79*. 44 p.

Williams, J R; Parkinson, D M; Olsen, L; Bian, R (2018) Dredge survey of scallops in Marlborough Sounds, January 2018. *New Zealand Fisheries Assessment Report 2018/19*. 35 p.

Williams, J R; Williams, C L (2013) Survey of oysters and scallops at the Chatham Islands, 2013. (Unpublished New Zealand Fisheries Assessment Report held by Fisheries New Zealand.) 32 p.

Wynne-Jones, J; Gray, A; Heinemann, A; Hill, L; Walton, L (2019) National Panel Survey of Marine Recreational Fishers 2017–2018. *New Zealand Fisheries Assessment Report 2019/24*. 104 p.

Wynne-Jones, J; Gray, A; Hill, L; Heinemann, A (2014) National panel survey of marine recreational fishers in 2011–12: Harvest estimates. *New Zealand Fisheries Assessment Report 2014/67*. 139 p.